

FESAC Meeting Minutes - March 12-13, 2019
North Bethesda, Maryland

TUESDAY, MARCH 12, 2019

Welcome and Introductory Remarks – Dr. Don Rej, FESAC Chair

- Welcome to all FESAC members.
- This is a continuation of our last meeting and discussion of Phase 1 of the FES Long-Range Plan for the FES program.

News from the Office of Science - Dr. Stephen Binkley, Deputy Director for Science Programs, Office of Science

- The title of this presentation is “International Science Collaborations and Science Infrastructure—Accelerating Scientific Discovery”
- Thanks for attending.
- I will discuss the focus on international collaborations across the Office of Science and the senior policy changes, including steps to implement the policies.
- The budget was rolled out yesterday; Dr. Van Dam will have a presentation with more detail. The budget will roll out more completely in a week.
- 10,000 of the 36,000 researchers who use our 27 user facilities are international.
- There are 62 SC international agreements, spanning 16 foreign countries and partner entities (including EURATOM, ITER, and IEA)
- 17 more international agreements are under development. We are presently extending to the Czech Republic, Poland, and the UK.
- We have many international collaborations through national laboratories; agreements are approved at the DOE/SC level.
- 1600 U.S. scientists work at CERN (the largest foreign contingent there).
- We hope to use the CERN model at Fermilab and South Dakota for LBNF/DUNE.
- EAST is one of the more successful collaborations with China. This is a model. W7-X has also gone very well.
- I will discuss the goal of pursuing mutually beneficial collaborations that advance and accelerate scientific discovery:
 - Quid pro quo equals mutual benefit to both sides (parity in intellectual and financial contributions; scientific credit)
 - Mutual respect of intellectual property rights

- Openness, transparency, respect for individuals (institutions, funding, and people)
 - For peaceful purposes (recognize that some technologies have dual use)
 - Community engagement and buy-in (validated per peer review)
 - Use of rigorous project management, where appropriate (SC has a successful track record, reflective of a strong project management culture)
 - Governed by formal, Government-to-Government Agreements when appropriate (intellectual property, access, funding, and national security)
- A Deputy Secretary memorandum is aimed at dual use technologies. DOE is not unfamiliar with this problem, being the home of the nuclear weapons program. Of interest are quantum technologies and quantum computing, including cryptography applications. Another example in systems biology is gene editing, with potential for human health, but also other activities. These are the two easiest examples to grasp. The Deputy Secretary made a policy decision to systematically understand DOE programs and their technology, identify risks and liabilities in these areas, and take the necessary steps to protect information.
 - With that policy objective, how do we go about implementing it? We plan to tap into the intellectual expertise of the DOE national laboratories. Each laboratory has a CRO. What are the risks? What are the mitigations? In 6-12 months, there will be a list of technologies and implementation steps.
 - Presently, only four countries (Korea, Pakistan, China, and Russia) have issues.
 - How we extend to university programs is TBD. 20% of the SC budget is at universities.
 - The second policy decision from SC, decided a month ago, is to put measures in place so people who come to our institutions and are funded by Talent programs (e.g., 1000 Talent) may not receive funding from both a foreign government and the U.S. government. The policy does not say these people cannot have jobs at our institutions, just not funded simultaneously. We are figuring out how to implement this at national laboratories. Again, solutions are expected in the six to eight month time frame.
 - It will be challenging to extend this to universities (which are included in the Deputy Secretary memorandum). Initially, we are reaching out to the

four universities that do laboratory oversight – the University of California, Stanford, and others). We are working with senior leadership at those universities to understand the issues from their perspective. Then, we plan to tailor the implementation of the policy in the least disruptive manner to the university culture. We are also reaching out to APS, AAAS, ACS, and other professional societies. We are casting a broad net to gather stakeholders.

Q&A: Dr. Binkley

Comment. Dr. Rej: Thanks for a great presentation.

Q. Dr. Wirth: Will this also be extended to international graduate students?

A. Dr. Binkley: Regarding the talent program, we will work with the universities to see what the issues are from their perspective. This is not an issue with the EU. With China, we single out support from the 1000 Talent Program, if not tied to a talent program.

Q. Dr. Wirth: How does the U.S. interpret foreign fellowships? The Talent program tries to bring back established scientists.

A. Dr. Binkley: The talent program supports scientists in the U.S. The devil is in the details. Sometimes, they list participation in a Talent program in the past, but ceased. How do we handle that?

Q. Dr. Cauble: I am on the advisory committee for a German facility trying to answer the same questions. Does this apply to research as well as technology?

A. Dr. Binkley: Yes.

Q. Dr. Cauble: When the study is completed, will the document be public?

A. Dr. Binkley: Yes. Also, DOE is not doing this in a vacuum in the Federal government. We are working with NIST, NIH, etc... Also, we have had discussions with foreign countries, mostly the EU, the UK, and France. NNSA labs are involved. The policies cover all 17 laboratories. However, implementation will occur most rapidly in the SC laboratories. I have looked closely at over seven laboratories; NNSA laboratories already have good policies in place, compatible with the direction that the overall policy is headed.

FES Perspective - Fusion Energy Sciences Program Update - Dr. James Van Dam, Acting Associate Director for Fusion Energy Sciences

➤ Thanks and good morning. A special thanks to Steve Binkley.

We are having more frequent FESAC meetings. We hope FESAC does not mind as these meetings are important.

Budget Updates

- Only the top level budget has been released that goes down to the level of the Office of Science. The details will come out next week. The Office of Science budget is \$5.5 billion; \$500 million is budgeted for Exascale, \$169 million for quantitative science, \$71 million for machine learning and artificial intelligence, and \$25 million to support leadership in U.S. based microelectronics.
- The full administration budget request for FY 2020 is expected to be released next week.

Programmatic Updates

- We provided a list of FY 2019 funding opportunity announcements
- Near-term opportunities underway
 - DIII-D
 - NSTX-U
 - Theory/simulation
 - International
 - Materials
 - General plasma science
 - HEDLP
- Items being pursued
 - Enabling R&D
 - Nuclear science
 - HEDLP
 - Private/public partnership pilot program
- Office of Science Quantum Information Science (QIS) PIs kickoff meeting (January 31-February 1 2019)
- FES is exploring opportunities in QIS
 - Held a roundtable May 1-2, 2018 (QIS)
 - 6 compelling priority research opportunities identified
 - Solicitation issued to competitively select pilot projects in QIS
- Machine/Learning Artificial Intelligence Workshop – April 30 - May 2, 2019. Attendance is by invitation only due to cost. The findings of the workshop will be summarized in a report and submitted to FES and ASCR.
- Fusion energy systems studies recent developments
 - liquid metal plasma-facing components
 - National Fusion Energy Systems Study team completed a two-year examination to identify concepts and provide feedback about R&D

on the path toward demonstrated viability. Details can be found in an upcoming issue of Fusion Science and Technology

- A new three-year study was just launched and will examine aspects of the NAS Burning Plasma Report
- The U.S. Japan project arrangement for high energy density science was signed on January 23, 2019.
- LaserNetUS was established in response to the National Academy report recommendations, and the first meeting was held in January in Rockville, MD.
- The 39th U.S. - Japan Bilateral CCFE meeting was held on March 6, 2019. Next year will be the 40th anniversary of this program. We are seeking two volunteers to work on producing the 40th anniversary report. Congratulations to KSTAR; it just celebrated its 10th anniversary.

ITER updates

- DOE leadership visited the ITER site in 2018. Dr. Bigot has accepted the Council's offer of a second 5-year term as Director General, to begin in March 2020.
- Tokamak complex takes shape
- Tokamak building rises
- Sub sector assembly tool installation is in final phase
- Tokamak pit is being prepared for the first tokamak components
- First machine component brought into the ITER tokamak pit
- Diagnostic building is ready for systems installation
- Installation of U.S. in-kind hardware at ITER was done in August 2018

Program Planning

- NAS burning plasma report
 - Final report (December 2018)
 - Report at this meeting from National Academy BP panel leaders
 - Decadal assessment of plasma science continues onward (has many federal sponsors)
 - Opportunities in Intense Ultrafast Lasers - reaching for the brightest light (NAS, 2018)
 - Long-range strategic planning activity for the FES program was launched in FY 2019.
 - Long range planning activities:
 - FES is grateful that the community and APS-DPP are undertaking the challenge of long range planning for national programs.

- FES is here to help
 - Speakers from the HEP and NP communities will describe their respective program activities at this meeting.
- 2018 Committee of Visitors (COV)
 - Following approval of the COV report at the December 2018 FESAC meeting, the report was sent to the Director of the Office of Science.
 - FES has prepared a written response to the recommendation
 - Will not go through DOE concurrence process
 - After DOE approval, will be posted on the FESAC web page
 - The next COV will assess the FES response.

Q&A: Dr. Van Dam

Q. Professor White: Thanks for the presentation. What will the funding support for M7 cover? Are you not funding Kessel and FESS to do analyses for the planning activities?

A. Dr. Van Dam: That group will be involved in the community long range planning activity. If you need something from him you should talk to him; by funding I mean, for example, if you need to rent a space.

Q. Dr. Knowlton: Does FES have a response to Mike Maul's NAS BP report?

A. Dr. Van Dam: This is part of the community planning. I expect that FESAC will look at the report very carefully. We have launched the FES studies team. That is in line with recommendations in the burning plasma report. We think it is an excellent, ambitious report.

Q. Dr. Groebner: Tell us more about MPEX and a fusion neutron source.

A. Dr. Van Dam: It will be a linear facility for high heat exposure and resembles the PSI facility in the Netherlands. There was a neutron radiation workshop last year. We are looking at site visits.

Progress and Plans for the APS/DPP Community Planning Process (CPP) - Dr. Nate Ferraro, Princeton Plasma Physics Laboratory

- This is a critical opportunity for Fusion Energy and Plasma Physics; we are excited and are committed to make this process successful.
- We have already consulted with organizers of the High Energy Physics and Nuclear Physics planning processes, announced the outline of our process, solicited nominations for Program Committee members, and started the event planning.
- We hope to produce specific recommendations for four topical areas and four cross-cutting areas.

- We plan to deliver recommendations to FESAC by March 1, 2020.
- Program Committee members have been approved by DPP; most have accepted to serve.
- We have started to plan events. We seven cannot do this by ourselves, so we have commitments from several institutions for logistical support.
- Google group <https://groups.google.com/forum/#!forum/dpp-cpp>
- Web site <https://sites.google.com/pppl.gov/dpp-cpp>
- Relation to NAS Decadal Study: This and the FES process must yield consistent results! Earl Scime gave an invited talk to Decadal Study Committee. A joint event is scheduled for April 18 at PPPL (after the Sherwood Conference). Both processes must be consistent with the NAS BP report.
- We see the DPP-CPP process as a continuation of the Madison/Austin process.
- We want the NAS BP report to serve as a framework for MFE strategic planning. Our planning must be consistent with those main recommendations. Initiatives in this process should contribute to the NAS report goals.
- Program Committee:
 - Topical areas
 - o MFE
 - o Fusion Materials and Technology
 - o HEDP
 - o Discovery Science
 - Cross-cutting
 - o Theory/Computation
 - o Measurement and Diagnostics
 - o Enabling Technology
 - o Workforce Development.
- The Program Committee (PC) will organize and lead workshops, recruit people for subgroups, solicit white papers, and synthesize community input into reports.
- Confirmed on PC for MFE: Dan Brunner (CFS), Cami Collins, Brian Grierson, Walter Guttenfelder, Chris Hegna, Chris Holland, Jerry Hughes, Rich Magee, Saskia Mordijck, Jerry Navratil, Craig Petty, and Matt Reinke
- Candidate MFE expert groups: power handling, steady state operation, transients, control, BP physics, and global context (including ITER).
- Crosscutting areas represent the “glue” between different topical areas in FES.

- MFE proposals can be pre-conceptual to facilitate achieving consensus. Proposals could emphasize scope, rather than design. Proposals could remain agnostic on whether they require new or upgraded infrastructure.
- Community involvement: white papers, advocacy and expert groups, technical expertise to evaluate proposals, advance maturity of initiatives, and participation in workshop discussions.
- We are seeking to create a process that will deliver a consensus strategic plan with technically assessed, prioritized recommendations.
- Schedule:
- Spring/pre-workshop town halls and get buy-in on the process and goals.
- Summer/workshop #1 to hear proposals for initiatives and launch working groups to evaluate proposals.
- Fall/workshop #2 to hear revised initiatives and prioritize proposals.
- Winter/ Snowmass joint activity with all topical groups, to coordinate and finalize feedback.
- Before Workshop #1, provide a quad chart for people to present information.
- Possible issue: Could FES provide support for conceptual design effort? The issue is that there is uneven capability for developing designs and initiatives.
- January 2020 is the likely time for a Snowmass type meeting.

Q&A: Dr. Ferraro

Comment. Dr. Rej: There has been impressive progress in only three months. Keep up the good work.

Q. Dr. Greenfield: Contradicting Don, I am concerned. 1999 and 2002 Snowmass meetings were very large endeavors. The second one was very successful. There is a difference with the current process. Snowmass meetings had large process before the meetings, with people spending large fractions of time. Secondly, you have too many levels of management compared to Snowmass before; that may eliminate the ability of people to advocate and discuss technical content, since it seems that your organizers are not allowed to have opinions until the end of the process. We heard about this at the November 2018 APS meeting; the community is still not involved. I have concern about time passing. We need to prepare to do a good job.

A. Dr. Ferraro: We are deeply aware of the challenging process and are tasked with looking at the entire FES portfolio. It has been challenging to come up with a process and the entire scope involving the entire community. We are not underestimating it, we are recognizing it. We are doing our best

subject to parameters. There is a short time to maximize opportunity we have. Almost all PC members accepted immediately.

Q. Dr. Demers: A large part of this process will be communication. What about using videoconferencing earlier in the process for the community? Town hall attendance can be limited.

A. Dr. Solomon: Video conferencing will play a major role; we will use VC for meetings.

Q. Dr. Groebner: What about advocacy groups? Will they pitch big hardware?

A. Dr. Ferraro: Anything they want to advocate—big hardware, other ideas, etc... is acceptable. We want to set up a forum for grassroots discussions, for people to advocate their ideas in front of the community.

Q. Professor White: Coordination with the Decadal Study has some concerns. We want ideas to come to our activity. Also, we have to answer our charge, which is broad, but not as broad as the Decadal Study. Will you enforce agreement with them?

A. Dr. Ferraro: No enforcement, but awareness and communication. Yes, different scope, but there is overlap in some of the topical areas. We will communicate our input to them and hope for vice versa.

A. Dr. Solomon: Not enforcement, but we want to avoid contradictory statements.

Q. Professor Terry: You were emphatic about being consistent. That is the top down objective. What if the decadal diverges; what do you do?

A. Dr. Ferraro: We are not forcing the process to adopt the BP report recommendations or the Decadal report recommendations. But, we hope that there is community agreement to use the BP report as a framework for MFE planning. We do not want to have to go back and redo it.

Q. Professor Terry: If there is no consensus, will you design a longer process, or just collapse the wave function?

A. Dr. Ferraro: We might have to go to a less granular level to get consensus. That would be our first strategy. If it affects our timeline, we will try to stick to our timeline. FESAC wants our consensus recommendations.

Q. Dr. Ma: There has been much mention of the BP report; also, other reports—e.g. the Brightest Light Initiative. Our community is still seeking solutions for that. What is the forum for addressing that?

Q. Dr. Rapp: You have proposed a good structure. But, the timeline is short for reaching consensus. Will you use community workshop reports (PMI, transients, and simulation)? Also, NAS reports? If you go totally grassroots and unbox the reports, it will take too long.

A. Dr. Nathan Howard: We will definitely use all reports: FESAC, NAS, and community workshops. We want to leverage recent reports, not rehash old talking points, but evaluate new initiatives.

A. Dr. Solomon: Working groups will evaluate, not necessarily advocate new ideas.

A. Dr. Sarff: When we met with HEP and NP representatives, they emphasized the importance of having a grassroots beginning. Some of this comes from a model that we have been pointed to. But of course, we have starting points of existing reports. We are following the HP and NP guidance.

Comment. Dr. Rapp: You want input from advocacy and initiatives fairly soon. They might be in different stages of maturity.

A. Dr. Howard: We will solicit white papers. We will come up with a template, with details to be answered. If they can answer those details, then they are at some level of maturity.

Q. Dr. Patello: The uneven capability issue was mentioned by Dr. Ferraro. What is meant by requesting FES support? Also, concerning the comment about workshop #1—expert groups to evaluate initiatives, you should have concepts for how to evaluate initiatives at a higher level, so all expert groups will use the same criteria.

A. Dr. Ferraro: There is uneven capability. Larger institutions have an advantage, such as LDRD funds to develop initiatives, whereas smaller institutions do not and cannot compete in the marketplace of ideas. Even with larger institutions, how much of their funding can be spent on this? In a general sense, it would be helpful to have money set aside for developing designs. I am not sure if it is our place to request such funding from FES. As for evaluation of initiatives, we will deal with this as we set up expert groups, so that we have common evaluations. Of course, expert groups will look at different things, so they might have different factors to consider.

Q. Professor Pedersen: You said you do not want strong advocates on the committees. They might hijack the process. On the other hand, it might look from the outside as if you are repressing people with strong opinions. You have to deal with them somehow, and have a strategy. I am not sure myself, except not to use those words.

A. Dr. Ferraro: We are sensitive to that. We are not excluding these people. We want strong participation by everyone, including those with strong advocacy. We are not afraid of hijacking the process, but avoiding the perception of conflict of interest when we write the final report. We will make sure those people participate in the workshops and have their ideas included in the report.

A. Dr. Solomon: Actually, the advocates are driving the process. Expert groups and advocacy groups will be interacting and almost partnering.

A. Dr. Lumsdaine: I am concerned that there will not be enough time for FESAC to form the subcommittee and produce the report by December 2020. Is there any way to compress it? We should try to produce something before the Administration changes. We should interleave FESAC and the community work to have running start.

Comment. Dr. Rej: I agree. This came up at the December 2018 FESAC meeting. What will FESAC do for a year? Not just sit around, but also not interfere. Dr. Don Geesaman will tell you what Nuclear Physics did. For example, FESAC members attending various workshops (Bright Light Workshop at the end of March); Bob Cauble and Tammy Ma will attend as invited experts, but also a non-HED expert will attend (Rajesh Maingi), not just as an observer but a participant. Dr. Geesaman will also tell us the right time to form the FESAC subcommittee.

Comment. Dr. Lumsdaine: Gaps in the community feedback will be a challenge for FESAC.

Q. Professor Wendt: DPP has the lowest percentage of women membership of all APS divisions. Given that this process is forward looking, please comment on how you constructed the program committee, taking into account inclusion, and looking at workforce development down the line.

A. Dr. Ferraro: Admittedly, DPP has abysmal statistics. We limited ourselves to the nominations received. I and Carolyn Kuranz are on the DPP Women in Plasma Physics Committee.

A. Dr. Sarff: Lauren Garrison and Carolyn are on the PC.

Q. Dr. Verboncoeur: Dr. Terry has concerns about consensus. Can we redefine consensus? We do not want major disagreements with other studies. Consensus might better be defined as being able to get to decision points, and then allowing divergent paths from there.

A. Dr. Howard: We would like to use the NAS BP report as a starting point, but then go from there. We will evaluate community thoughts about this report. We might shift 20-30 degrees away from that report.

Comment. Dr. Verboncoeur: There should be consensus on how to get to decision points.

Q. Professor Carter: (at the Decadal Study meeting in Washington, DC today): Following up on Anne White's question about coordination, it is challenging due to the NAS process. What we can share before the report's release. On the MFE side, it makes sense for the Decadal committee (led by me) to pay close attention to the community planning process and incorporate those ideas for the Decadal Study. For non MFE, the Decadal

Study might provide information to the FES process. The Decadal Study is aiming for the report release in the fall of 2019, ahead of Snowmass. So, we can take that output into Snowmass. We have 150 white papers here; it is not necessary to duplicate that in the FES process.

A. Dr. Sarff: Dr. Scime gave a presentation to the Decadal Committee. It was clear that they are interested in coordinating. The Decadal charge was set up so they are not to touch the BP report recommendations. There are no details yet on how to do this coordination. Parts that overlap most strongly on the center of gravity of the Decadal Study are still coming onboard. Troy Carter has been very open with us to coordinate about MFE. Maybe that is the easier one to do. I hope the Decadal Study can help us figure out this coordination. The Decadal Study is not constrained to plasma science, although this is a center of gravity; it will include MFE. Troy Carter commented that it is the same set of people in the community who are providing white papers. How can we merge this? We have no answer yet, other than recognizing that it must be done. We are acutely aware that it must be done.

Q. Dr. Greenfield: Following up on Diane Demers' comments about remote collaboration tools, based on my experience, it is very good for some things (BPO webinars, one person communicating to large group). It works less well for large groups. Be careful not to over rely on it. Real meetings are still important. Also, I am still concerned about the decision-making process that will lead to final recommendations. There are too many levels of management.

A. Dr. Solomon: Even the seven of us struggle on videoconference. We are aware of the limitations. As for decision making, no one gets special power; it comes from the community. We will distribute the report so the community can comment (maybe by chits).

Comment. Dr. Rej: NP and HEP also got feedback.

Q. Lauren Garrison (via Zoom): How will we have expert groups come to agreement? What criteria will be used?

A. We will pull on technical work done by the community in recent years. Also, one working group in the Madison/Austin process looked at metrics and criteria, and laid the groundwork.

Q. Dr. Demers: Want perspectives from multiple people. NAS reports had specific scopes, which are not the same as for this planning activity. The NAS process had healthy debate and tension. I argue that we should not start from those reports, since they had different scope. But instead, draw from the dialogue that led to those reports.

Q. Professor White: FESAC is supposed to do the long range plan, and the community will give us input. How will you do that?

A. Dr. Solomon: Our perspective, from David Newman, is that it is in the community's interest to take the process as far as possible, thus enabling a smooth handoff to FESAC. Some things might hinder us: e.g. getting to a decision point but not beyond. We will take it to the point that we can.

Comment. Dr. Rej: For a smooth transition, we will hear from Professor Lankford (HEPAC chair) and Professor Ritz (by Zoom, P5 subcommittee chair). We can learn from our colleagues.

A. Dr. Solomon: We had discussions both with HEP and NP community leaders, and also FACA leaders. They provided lists of strategic possibilities, from which their FACAs could choose.

Comment. Dr. Rapp: We might end up in a contentious FESAC process (as before) if the community falls short.

Comment. Dr. Rej: The final P5 report also actually went back to the community, which was allowed to endorse it (and about 1400 people did). NP did this differently.

Comment. Dr. Patello: FESAC members will find it useful to listen in on meetings by videoconference.

Q. Dr. Lumsdaine: A prioritized list means hard choices, which means strong disagreements. This might have to happen in the FESAC subcommittee, or will the community impose discipline for hard choices?

A. Dr. Solomon: Do not forget that this process is not done at the end of the FESAC report. NP in particular has a continuous process that provides opportunities for agreement, even with tough decisions. They see a future for themselves, maybe not right away, but down the line. It is not a one-off and done.

A. Dr. Ferraro: We are planning for success (prioritization).

Comment. Dr. Lumsdaine: I hope that private public partnerships will be included in the process.

Q. Dr. Trask: I like the emphasis on templating the structure. Is there a repository for guiding activities like this? We should leverage expertise in other areas or prior examples. These are common tasks. There should be optimal ways, from our social science colleagues.

A. Dr. Sarff: Not much guidance was given by the program committee for the Madison and Austin meetings. So some ideas were mature, others were not. When we did the FESAC Future Facilities charge, we provided a template (which did not include budget); the community responded quickly with an impressive set of concepts. So, I am optimistic. We should explore best practices. A quad chart is one.

Comment. Dr. Rej: I remember that committee. MFE folks were blown away with the quality of maturity of the high power laser concept.

Q. Dr. Newman: Completing the community part of the process in a year is actually fast. Even if do not complete prioritization, it will still be successful. Fundamentally, FES will eventually make the funding decisions. We may not get community consensus before FESAC—but this will be a repeating process. If FESAC pulls from what the community says is important, the community will be satisfied.

Comment. Dr. Rej: Templates for the white papers are important. Costs may be pre-conceptual; perhaps, we should use a cost range. We can come in with a basis of estimate, so the cost range can be somewhat justified.

NAS Report on Opportunities in Intense Ultrafast Lasers: Reaching for the Brightest Light - Professor Howard Milchberg, University of Maryland

- There are three pillars of the Extreme Light Infrastructure (ELI) project.
- There is a three-page summary of the NAS laser report.
- LaserLab-Europe started off as LaserNet-EU.
- Petawatt class lasers = above 100 TW.
- Combine PW lasers with x-rays or relativistic electrons or protons.
- 1999-2000: first petawatt laser (built at LLNL).
- It is eye-opening to visit the three ELI sites. They are impressive buildings.
- Two 10-PW lasers are now operational in Hungary. The Romanian facility mostly focused on nuclear physics. The Czech facility is multi-purpose.
- ELI are stand-alone lasers. Combining intense lasers with existing infrastructure is essential for the U.S. to have leadership.
- What is the ballpark cost for a multi-PW laser? ~\$100M. High intensity sources (BELLA) are less expensive than high energy sources (NIF).
- What are the benefits of co-location with existing facilities? Intensity boost. Multi-mode probes (e.g., x-rays).
- There will be a Plasma Science Facilities Workshop at Maryland on May 20-21. NSF, DOE-SC, ONR, AFOSR are sponsors. Earl Scime and I are co-chairs. Almost all the program committee members are from HEDLP, except Mark Kushner.
- LaserNetUS = facilities built up by hook or by crook. There is not necessarily one dedicated grant to build them. There are funds operation and upgrades, and travel and supplies.

Q&A: Dr. Milchberg

Q. Dr. Cauble: Is there an official connection between the BLI workshop and FES planning?

A. Dr. Milchberg: It is unofficial.

Comment. Dr. Rej: It is part of the FES HEDLP program.

Q. Professor Carter: Cross-agency stewardship was a recommendation. We do not want to constrain funding agencies, but how do we fulfill this recommendation?

A. Dr. Milchberg: Somebody has to take the lead. DOE was natural to identify for this role. Then, scientists get involved. The process has to follow the content (science). Intense ultrafast laser research attracts students, and then agencies come along for the ride. That is the usual way things happen.

Comment. Dr. Phil Bucksbaum (remotely from Naples, Italy): There is clearly a need for coordination among SC program offices, from HEP (accelerators), BES (facility steward), NSF (plasma community), and NNSA-sponsored labs (with interesting facilities for co-location). An example from the AMO Decadal Study: NSF and DOE-BES are co-sponsors. Coordination is key. Clearly, the interest level has been demonstrated to be high.

Experience in Long-range Planning for the Nuclear Physics Program - Dr. Donald Geesaman, Argonne National Laboratory

- From 2012-2015, I was chair of NSAC (both DOE and NSF).
- I have personally participated in five of these LRPs.
- Typically, there has been 15-18 years between a recommendation and starting a funded project with Congressional support.
- I participated in the 1983 LRP at age 33. (Currently, I am 69.)
- Demonstration is key to a bench scientist, that the program office listened to LRPs and helped deliver major initiatives.
- Our recommendations are about capabilities, not a particular machine or site. We allow the program office to issue a solicitation.
- Lab directors go to the Hill together and support the LRP.
- Your charge assumes continuing funding for ITER. Once, a program manager assumed that the electron accelerator would be built, so we did not mention it. Congress got very confused.
- The 2015 LRP had EIC. I convened a panel chaired by Ed Temple for a cost estimate. This was very helpful because there is always someone who thinks we can do it on the cheap.
- Choose subcommittee members so everyone feels they have a champion on the subcommittee.

- Have we left the field in a state that is sustainable?
- Some LRPs were asked for interim reports to fit with congressional budget schedules. But, in 2014 the charge did not include that.
- There was a joint meeting of the APS-DNP with the Japanese Physical Society in Hawaii in October 2014.
- It was a resolution meeting in an isolated place. The first part was open, and the second part was closed. We froze the wording of the recommendations.
- The draft report was reviewed by wise women and men (not as rigorous as the NAS process).
- Many of the topical areas in NP are identified with a major facility. Fundamental Symmetries has no facility or institution, so they discussed how to get visibility. We had one ad hoc meeting on simulations.
- We copied (freely adapted) words from white papers for the LRP.
- P5 was asked to comment on the individual projects. The LRP was not. We find it unhelpful to have each individual project as a recommendation.
- Recommendations from the last LRP are all being implemented.
- There were lower cost initiatives in theory, gamma ray tracking, and accelerator R&D.
- We can set priorities under the pressure of budgets.
- We had no votes, except for details on the choice of words. (In previous LRPs, we had votes on the relative priorities of various initiatives.)
- Leptogenesis: neutrino-less double beta decay could provide evidence for explaining the preponderance of matter over antimatter in the universe.
- EIC will tell us the role of gluons. It is expensive, so it was deferred a while, since both RHIC and J Lab had recently been upgraded, and the community wanted to run them.
- NP had no major capital equipment funding in 2014 and 2015, which you can't do. You need seed corn.
- Concerning international context, we do not duplicate capabilities elsewhere.
- The LRP has to be aspirational. The 2013 NSAC report described how to implement the LRP in a more constrained budget environment.
- The LRP has never recommended closing facilities. Ad hoc NSAC committees responding to specific charges have done so.
- NSAC defined modest growth as 1.6% above inflation.
- We saw NSF as the home for midscale instrumentation support.
- A flat budget of \$600M is still a lot of money. With that budget, we should be able to plan a sustainable program.

- The 2014 P5 did not have the ILC as the first priority, and I think that was a major reason why that report was well received. FES has a similar issue with ITER, fitting it in the budget scenarios.
- Give serious thought about how to build trust between funding agencies and the community.
- NP does its Decadal Survey out of phase of its LRP. The Decadal study follows the priority recommendations of the LRP, just fleshes them out.
- We held the Resolution Meeting at Outer Banks, NC, where the Wright Brothers flew at Kitty Hawk.
- Do the FES long range planning now, so you are set up to do it again later.

Q&A: Dr. Geesaman

Comment. Dr. Rej: The LRP is different from P5 in that NSAC starts writing assignments early.

Q. Dr. Greenfield: Do you assume access to international facilities, or just read their papers?

A. Dr. Geesaman: We have a series of projects lined up, so the next project might catch roll off from the preceding one. Of course, there is no guarantee due to the vagaries of congressional appropriations. But we need to be prepared.

A. SNS rolled off, and five nano-centers were ready to go.

Q. Dr. Groebner: Is LRP continuous, or episodic?

A. Dr. Geesaman: The latter. After 2007, the next one was 2015. It is bad to do the LRP when your budget is going down. The 2013 budget faced a precipitous drop; there is no way to inspire a community when budgets are dropping! We have a very good corporate memory of what happened before. If do your LRPs too close together, not much has changed. We have a different ad hoc committee for each LRP. There are winners and losers in the prioritization process, but the community has lined up behind the LRP for 30 years. You have to convince the community what is good science. People start moving to other projects when they see how it is going.

Q. Dr. Groebner: How did you get to the point of a culture and an institutional memory?

A. Keep in mind how you will do things again as you do it now.

Q. Dr. Newman: I understand why you have trust now. What about 30 years ago? How did you overcome trust issues in the community?

A. Dr. Geesaman: My boss in 1983 voted for RHIC, and a year later became director of LAMPF, the losing facility at LANL!

Q. Professor White: The FES community has tension between application and science. Is this tension in your field? What about private public partnerships in NP?

A. Dr. Geesaman: NP is discovery science, so no. We take credit for applications, but they do not directly drive the LRP. It did indirectly help FRIB as a contributing factor, for isotope production, which is now NP's responsibility. There are only two things the government is allowed to see: money (for other countries) and isotopes.

Comment. Dr. Rej: Isotopes, and maybe advanced computing and FES, are the only examples of public private partnerships I can think of.

A. Dr. Geesaman: And accelerators. But, your charge is qualitatively different. I agree.

Q. Professor Terry: You have maintained a healthy balance between laboratories and universities. That is a concern for us, about the role of universities going forward. Has that been specifically addressed in the LRP, to have healthy balance?

A. Dr. Geesaman: There are six accelerator facilities, with roles in science areas and workforce development that are always called out in LRPs. Upgrades for these (such as the national superconducting cyclotron laboratory) are also included. This has been discussed both in the science section and the workforce development section.

Q. Dr. Patello: What is the role of agency members in a 16-member committee? Did they set priorities or just observe?

A. Dr. Geesaman: Observers. Sometimes, we asked Tim Hallman questions. Tim explicitly forbade his people to speak. The value of having them in the room was so they understood nuances of the discussion—but I did not want them to speak. I only allowed some private comments to me about what might have been missed.

Q. Professor Carter: Building trust. Winners and losers, there are other opportunities for losers at international facilities. Losers participate in winning projects.

A. Dr. Geesaman: Generally, the losers represent powerful physics capabilities, so a project going forward would be foolish not to involve them. NP appreciates this point of view. ANL competed with Michigan State for FRIB; we lost. NP encouraged them to include ANL in the project, and it has happened.

Q. Dr. Rej: What about universities? There was a consolidation of facilities (Yale, MIT, Cornell, Texas A&M).

A. Dr. Geesaman: Generally, the scientists realized that scientific opportunities were larger at other facilities, and to compete they needed to

move or upgrade their own facilities. Nuclear astrophysics measurements need very long beam time; there is not enough time at labs, but it can be done at universities, and they have become proficient at it.

Q. Dr. Cauble: The LRP recommendations sound too broad. Were facilities the main drivers?

A. Dr. Geesaman: But, it is a natural process to build, exploit, and then move on to new facilities. Neutrino-less double beta decay was pushed by universities.

Q. Dr. Lumsdaine: In your schedule, there is only 12 months from the charge to the Resolution Meeting—probably thanks to institutional memory. Is that the whole story? How could we shorten our process?

A. Dr. Geesaman: Do not wait until the community process is over to put together the FACA subcommittee. They listen more carefully. Yes, HEP did it better than NP, and they took two years. NP did it in six months once, but that was not preferred. Unless there is a decision that needs to be made now, or some opportunity will be lost, I think you should take your time and use this opportunity.

Q. Dr. Lumsdaine: What about conflict of interest issues?

A. Dr. Geesaman: We knew the conflicts. We worked hard to quantitatively balance people associated with certain interests. We let them vote! But, when NSAC considers the report, we have to be careful.

Q. Dr. Knowlton: What are the different roles of NSF and DOE in your process?

A. Dr. Geesaman: The NSF motto is: We only respond to proposals (except for facilities). They are less willing to commit to budget projections or to provide budget information. NP and NSF funding are comparable. In the past, NSF funded Michigan State at \$10M/year; the importance of that work was always mentioned in the LRP. When Michigan State moved away from NSF funding, we talked about how to find another project for the NSF funding; eventually however, we settled on midscale instrumentation. In 1983, the NSF budget was one third the NP budget; now it is 6%. It is almost the same in as-spent dollars now as in 1979. So, the NSF budget is much less consequential. NSF program directors work hard to find projects where NSF can have an identity.

A. Dr. Geesaman: I suggested to the panel that recommending specific physics capabilities was better than recommending a certain facility.

Q. Dr. Groebner: In our community, scientists are associated with a device.

A. Dr. Geesaman: It is the same in NP. J Lab has 1500 users, 900 from the U.S. NP has distinct communities! The MIT accelerator closed down in 2005, leaving only Jefferson Laboratory.

Q. Dr. Groebner: Do the local people just support the machine, or also perform experiments?

A. Dr. Geesaman: The latter.

Q. Dr. Newman: Science or facilities?

A. Dr. Geesaman: Every facility is interested to propagate its own future, so they sell their science case. But, it is looked at carefully by the whole community.

Q. Dr. Newman: Concerning the lab-university divide, does the significant NSF funding historically make the difference?

A. Dr. Geesaman: It is important to have two funding sources. Some clever people play them off against each other! For the LRP to reflect both the science NSF is doing and what DOE is doing is important. But, NSF and DOE agree what the fundamental problems are—the same as in the NP Decadal survey. Certain facilities may exist only at certain universities or labs, but the science issues are universal.

Q. Professor Terry: Are there perils with budget scenarios?

A. Dr. Geesaman: Priorities under a constrained budget are different from those without constraints. We want the funding agencies to understand that we made choices. Make sure they understand the priorities in a realistic budget. Don't fool the community that priorities in the blue sky budget will determine it.

Q. Dr. Demers: You said that continuity is important to retain expertise. Do you explicitly consider continuity in the LRP? We are struggling with that with FES.

A. Dr. Geesaman: Not explicitly. We don't demand continuity. But, it is easy to show its advantages, especially in expertise. It is in the background of our thinking. I understand why you are struggling.

PUBLIC COMMENTS:

Dr. Rej: please keep public comments to 5 minutes each.

Mickey Wade

- Our field is at an historic moment. Many things are conspiring positively, so we can move forward aggressively. But, also time is a great threat. Presidential budgets have been a threat. How do we respond? The NAS BP report is a rallying cry. We have invested in ITER enormously—not just hardware, but much physics effort. We have had much time and effort in science, also technology. This leverages us to get to a burning plasma as soon as possible. Also, the NAS recommends a development program for a low-capital-cost pilot plant. International programs simply

look at extensions of current technology, whereas the NAS encourages us to use advanced technology developed in the U.S. to build at lower cost than larger devices.

- Over the last 15 years, we have been a science program. We have made enormous steps to predict what will happen in future fusion energy devices. We are ready to take the next step.
- The NAS sets us up to do that. The most important statement is: Now is the right time for the U.S. to make plans to develop electricity from fusion for future U.S. energy needs.
- Keep doing fusion science, but apply to energy needs. We have an audience. Capitalize on it.

Mike Zarnstorff (for Steven Cowley)

- The NAS report is beneficial. It provides a good basis for going forward.
- It is important to identify during the community process what are key new facilities, to lay the basis for a compact pilot plant in the future. We should explore new designs for new facilities to keep the field fresh and the U.S. competitive.
- It is important to set up a national design team to put proposals on a common costing and design basis, either for the community process or the FESAC process. It is hard to judge concepts at the pre-conceptual stage.

Allan Stone (HEP)

- There are resources: My colleague Michael Cooke and I. Also in NP.
- My job now is to solve problems. I have been dealing with the implementation of P5. I manage the budget, at the macro and micro levels.
- P5 has been enormously successful, but it also has faults. The implementation could have been better. Understanding the total cost of the program is vital, not just knowing the tools. Will you have the workforce? It is not scalable by inflation. The labs are using old infrastructure. We should leverage with what already exists.
- We had a young clamoring P5 contingent in our community—not just assistant professors, but also graduate students and postdocs.

Steffi Diem

- There is an early career fusion scientists' forum. I am one of the organizers. I will read our statement. It concerns two of the NAS

recommendations. We are also considering other recommendations. The statement is posted on the FIRE website.

Martin Greenwald

- The messages for both FESAC and those organizing the community activities are that they have to work together closely.
- First message: Imbue everyone with a sense of urgency. There is support at high DOE levels and support in Congress. The Madison and Austin workshops had a sense of urgency. Harness that. If not, the window of opportunity will close. Other countries are building facilities, initiating programs—many of which were first articulated in the U.S. but not acted on. The long range context for our program is important and has to be weighed, but the plan and activities have to be actionable and timely. Don't let our focus on what we might do in 20 years keep us from considering what to do in the next five years. The danger is that we have a program that needs breadth and depth, but we get absorbed in the twist of field lines for a machine twenty years from now.

Matt Miller

- I amplify the earlier comment about tension between science and practicality. We want to see fusion become part of the zero carbon portfolio. I am pleased by the NAS comments about a small compact reactor. Capital cost is not the best metric; total cost is better. But, the planning process must involve an expanded community, beyond those who plan long-term science activities. What you are embarking on is more than a long-range science program.
- I recommend to all the recently published biography of the Wright Brothers. This industry is at a Wright Brothers moment. They turned an art into a science. They turned powered flight from possible to inevitable.

WEDNESDAY, MARCH 13, 2019

NAS Report on a Strategic Plan for U.S. Burning Plasma Research - Professor Michael Mauel, Columbia University

- The FESAC TEC report was immensely important for our panel, since it described revolutionary ideas to reduce cost and accelerate progress.
- We had a great committee!

- What set our readiness for fusion in 2004? We had a design and a test-size prototype. But, now we are building the real thing.
- Two main recommendations:
 - The U.S. should remain an ITER partner as the most cost-effective way to gain experience with a burning plasma at the scale of a power plant
 - The U.S. should start a national program of accompanying research and technology leading to the construction of a compact pilot plant which produces electricity from fusion at the lowest-possible capital cost
- Not just achieving $Q=20$, but achieving it and controlling it = a research facility. Establish the knowledge of a large scale facility.
- We are putting down a stake in the ground for the U.S. to pursue a small pilot plant (smaller than ITER), whereas other countries envision something larger than ITER.
- Our committee was not able to identify what are the cost effective programs, facilities, etc... That is left for the DPP/FESAC planning activity.
- The DOE graph about maturation of technology misses the international aspect (slide 20).
- Personal comments about the Decadal study and FES planning:
 - Fusion is a big part of the Decadal study. There has been immense progress since the last Decadal study.
 - The frontiers of burning plasma research require plasma science, materials science, etc...
 - Innovations to accelerate fusion and lower the cost are important.
- The NAS report did not flesh out the details of near and mid-term priorities
- FESAC charge: The NAS said nothing about the broader FES mission to steward plasma science. But, we did recommend that now is the right time to embrace the energy goal. This strategic guidance from the NAS goes beyond advancing the scientific foundation. We are not just developing knowledge, but applying it.

Q&A: Professor Mauel

Comment. Dr. Rej: It is really clear what the next steps must be.

Comment. Dr. Greenfield: Excellent report, very useful. There may actually be a chance to develop community consensus with this as a starting point.

Q. Professor Terry: You singled out the FES structure for change. What about NSF?

A. Professor Mauel: We did not spend much time thinking about NSF support for the mission of developing fusion as an energy source. We did discuss the importance of partnerships to develop basic science and technology. We discussed FES partnerships with BES, etc...

Q. Professor Terry: It was striking yesterday that NP has a partnership with NSF. Fusion has struggled with establishing such a partnership.

A. Professor Mauel: We see partnerships as important, perhaps to do nuclear science.

Q. Professor Terry: The DOE report shows that universities are decreasing to zero. Is that healthy? Wisconsin does research in internal combustion engines to reduce particulates; this is continuing, important research.

A. Professor Mauel: That graphic was hotly debated. How did this DOE report partition things? It was a cartoon. But, when things get commercialized, the fraction of lab and university research does decrease. The point we are making is that fusion is no longer in the Discovery stage, and there is growing industry interest.

Q. Dr. Rapp: Now is the right time to engage the energy mission, is what you said. A compact pilot plant is different from the international community. Substantial R&D is needed. Did you discuss tradeoffs between the urgency to get electricity production versus technology development?

A. Professor Mauel: We did not discuss urgency. Some colleagues feel we have to go fast to make a change in climate change. But, that was not part of our charge. We considered the challenges. We see no way to do it faster than what we suggest. We are not too late in the race for clean energy. It is a marathon.

Q. Professor Carter: Your committee has done an amazing job. I look forward to working on this. How should universities be engaged in the program?

A. Professor Mauel: The community has to weigh in on these questions. Our report did not answer this. My own personal opinion is that fusion has been so successful that the scale of our research is growing. Almost all ways to make progress in fusion will be through partnerships with something larger. HEP has made that transition quite successfully. We have to do the same thing in MFE. University folks can also get involved with industry. The success of fusion is motivating this change. But, the importance of a diverse university community and its ideas are essential. I have built small fusion experiments. I no longer look forward to that. Now, we want to collaborate with national centers that have real impact on where fusion is going.

Q. Professor Carter: What are your thoughts on coordination with the Decadal study and FESAC?

A. Professor Mauel: I am not quite sure. You guys on the Decadal panel have a big task; you have to listen and discuss, but you cannot reveal your findings until the end. You should incorporate the best ideas.

Q. Dr. Reyes: Most feedback I heard was positive, which surprised me! What were the weaknesses and shortcomings pointed out to you? Is there any theme that the panel did not consider? Then, FESAC can consider this.

A. Professor Mauel: I cannot discuss private conversations. But, what more could we have done to make the report clearer or engage the community? I am not sure—we worked hard. But, I think the community should have learned from this process. The Madison and Austin workshops were incredible. Thanks to Mickey Wade. After the Austin meeting, the organizers selected conveners to write technical white papers—those were even more important. There were technical analyses with references and statements that we could quote. That was an important step. They were not peer reviewed of course, but were very useful for us. The details in those white papers were specific, and therefore helpful.

Q. Professor Pedersen: It is an outstanding report, with a real vision. You did not try to decide details (aspect ratio for example), and that was useful to get consensus. We can learn from your process. But, let me ask about one place where you might have been too specific: focus on size, rather than reducing capital cost. The latter is what would really benefit fusion. It blocks out progress that fusion devices are too expensive. Maybe small is what is needed to be lower capital cost.

A. Professor Mauel: That is a fair comment. But, we need details. We need to do design studies. Capital cost is of course the preeminent thing. We said compact because in most discussions about what follows ITER, lower capital cost is compact. But, there might be innovation.

Q. Professor Pedersen: There is a correlation, but it is not one to one.

A. Professor Mauel: We debated whether to include the balance of plant for the cost of electricity. There may be innovations there too.

Comment. Professor Pedersen: Correct. What is impressive about the ITER site is not the size of the tokamak, but the amount of concrete!

Q. Dr. Cauble: Concerning the DOE graphic, this shows technology. What about the science piece? Does that become less important as time goes on?

A. Professor Mauel: I like what you are saying. We used the graphic to illustrate the growing importance of industry.

Q. Dr. Cauble: The report has two major recommendations: stay with ITER; do something completely different. The latter—just to be different from the

EU and Asia. What is the timescale? A power plant is a multi-decade issue. The two recommendations seem disconnected.

A. Professor Mauel: Doing something different was not what the committee intended. We want to produce fusion at the lowest capital cost, with advanced physics and engineering, the knowledge we have. This research has to be done in parallel, since it is more advanced.

Comment. Dr. Lumsdaine: It is an exciting report. The DOE graphic misses the technological Valley of Death, in going from university/lab to industry, often for reasons unrelated to market capacity or technological understanding.

Comment. Dr. Knowlton: I see a continuing role for innovation even as we move into maturity.

Q. Dr. Wirth: Thanks to Mike and Mel for chairing the committee. They were able to take divergent points of view and reach consensus. You co-lead Snowmass and now the NAS study. Do you have any advice for FESAC and the community activities to ensure we do not lose momentum?

A. Professor Mauel: Thanks. For DPP and FESAC, please recruit young, bright, energetic people! This takes me back to Snowmass 20 years ago when I was their age. Twenty years ago was a different time. Congress had told us to get out of ITER. We were aimless. We tried to recover by establishing a science basis for ITER. We presented to the Charlie Kennel FESAC panel. But, fusion is totally different today. Not a 40% cut. The biggest experiment was almost built. There was a big U.S. budget. The strategy was looking to fusion. The times are different. Jerry Navratil and Ned Sauthoff organized the second Snowmass, which was more successful. It analyzed technology options of specific proposals: they were science and technology focused, and we compared options. This led us to where we are today. So, my advice is to keep it focused on science and technology options. Compare them side by side. Not just vague crosscutting themes, but specific options of what to do.

Q. Dr. Verboncoeur: Concerning the DOE graphic, I don't buy the doom for universities! Look at the piñata graph as a distribution function of participant level, and a distribution function of technology development. I think the statement "the time is now" is crucial to articulate. It guides how the money flows. Carbon is an important driver. Energy is very cheap now and for the foreseeable future, with new techniques. Carbon runs counter to that. But, we need to argue science readiness and technology readiness, which are two elements.

A. Professor Mauel: Our committee talked about engineering science. There is a science of engineering, especially for first of a kind things.

Q. Dr. Verboncoeur: How do we articulate that the time is now?

A. Professor Mael: These comments are from our executive summary. That statement is the second sentence. It is based on the scientific and technical readiness of our field.

Q. Dr. Verboncoeur: I understand the articulation as someone in the field. But, how can we articulate to those outside our field?

A. Professor Mael: Enthusiasm of industry and other nations speaks with hands and dollars! Now is the right time.

Comment. Professor White: Concerning university involvement, MIT gets Early Career awards in nuclear engineering. Please let the APP-CPP crosscutting group on workforce development consider the role of universities.

Q. Dr. Demers: We got a black eye because we did not produce energy soon enough, so we became a science program and are accepted as such. But, if we shift back to energy too soon, will we lose public support?

A. Professor Mael: The panel did not shift from a science program, but we are embracing a broader program, with technology to support production of electricity. Not just burning plasma science, but also materials, AI and advanced algorithms, computer science, control science, etc... are needed. We had a misstep in our program in the 1990s—we were proposing something that was too expensive.

Comment. Dr. Demers: We need continuity in science funding. We are advocating new technologies, new operating scenarios, and new control methods, to get to a lower-cost pilot plant.

Q. Dr. Groebner: Your report mentions an intermediate device. What questions should it answer?

A. Professor Mael: The report tried to address those. Power density has to go up, and the way to do that is to increase the magnetic field. That is a route. But, then that has to be compatible with the first wall. Run at higher bootstrap fraction? What is the role of 3D fields? We mention these, but we did not answer them.

A. Dr. Trask: I appreciate the specific goals you laid out. Our private company works by prioritizing our research. We face tension between deep dives versus moving forward with particular goals. I express my support for specific goals to direct the research, which are translatable to non-specialists. Building a pilot plant is a specific enough goal to lend direction to the program and prioritize other research.

A. Professor Mael: You said that very well.

Experience of the Particle Physics Project Prioritization Panel (P5) in Strategic Planning - Professor Andrew Lankford, University of California, Irvine

- Michael Cooke (HEP) provided valuable support during P5.
- *Snowmass on the Mississippi* (one week) did not prioritize activities; the aim was to ask and answer hard questions. It produced a 358-page resource book that conveyed the health and diversity of the U.S. program in an international context (<http://www.slac.stanford.edu/econf/C1307292>)
- Scenario B integrated over ten years was only \$500M higher than Scenario A.
- We have always had an EU representative and one from Japan on our panels, but this time we doubled up on both.
- We wanted a panel that met all requirements, but still as small as possible.
- We chose not to constitute the panel before the Snowmass meeting, to prevent lobbying. Steve Ritz as P5 chair was announced at the Snowmass meeting.
- We adopted an icon that represents the intertwined nature of the five thrusts.
- Large projects were defined as >\$150M. Large-scale involvement in the International Linear Collider in Japan could not be pursued due to budgetary constraints. LHC was the highest priority in the short term, but then LBNF was to become the highest priority. We wanted to involve international scientists in the formative stage of LBNF, not just ask for operating funds later.
- We considered the staging of projects to fit in the budget.
- We balanced project size and projected science output to ensure scientific return on investment and also a stable research career path.
- We tried not to take a parochial view of our field.
- We had an elevator speech and a two-page brochure.
- We had annual Hill visits, done primarily by young scientists.
- Glenn Crawford told me to anticipate a question from FESAC about why the P5 report was successful.
- We put more emphasis on community involvement with the recent P5 process.
- Steve Ritz led an important effort to consider what would be important to each stakeholder community.

- The U.S. Congress strongly supports DOE's efforts to advance the P5 strategy.
- The report presented a strategic plan, a well-balanced, scientifically-compelling program, not strictly a prioritization of projects.

Q&A: Professor Lankford

Q. Professor Walker: You had a detailed rollout. How was that valuable?

A: Dr. Ritz: You need the report to hit at the right time in the budget process. It is not good if it is old news, nor if it is too close to budget decisions. We discussed when would be the right time, then we worked against that deadline. The community needed to understand it, quickly (very important); Federal agencies had to understand the contents of the report so they were ready to brief Congress and staffers. We needed to line up materials to have precision in the message.

Q. Professor Wendt: Was coordination with a Decadal study a factor in your process?

A. Professor Lankford: We had no recent Decadal study in our field. The last one advocated the U.S. hosting the ILC, but when the costs were understood, the Administration wound down that effort. So, the recent Decadal study was not in play. We are planning a Decadal study for HEP soon.

A. Dr. Cooke: The next HEP Decadal study is scheduled the same as the next HEP P5. They might integrate well, since the Decadal study is broader and the NAS could comment on the role of particle physics with respect to other sciences. Also, the NAS could look at the content of the next Snowmass process and weigh in on the most-exciting scientific opportunities for discovery, to have a broader look at what goes into the Snowmass process. We do not want to lose community direct input into the P5 process.

Q. Dr. Trask: What about the periodicity of conducting long-range planning processes? What is optimal?

A. Dr. Stone: Andy Lankford explained why we had to do the last P5 when we did it. I look at our budget planning out to 2040. We are delivering on 14 line-item construction projects identified in P5. Our project profiles will turn over in 2024-2025. We want to continue that progress. So, we need advice to inform the 2024 budget cycle, so we need it by the first quarter of 2022, so community planning can start in 2021.

A. Professor Lankford: That describes a sensible process, but outside changes may drive an earlier process.

A. Dr. Stone: I am also trying to follow the Pat Dehmer model.

Q. Dr. Cauble: Slides 47-49 were very helpful. Could they be available to all of us?

Comment. Dr. Rej: We will post Andy's slides.

A. Dr. Ritz: Since Pat Dehmer's name was mentioned, let me discuss stakeholders. Before we started, we talked with the agencies. You can pave potholes with reports that have no effect. So we asked what would make a great report. Pat told us: This was do or die for us; no pressure! She told us to make it a short report; keep it brief. We had the advantage of referring readers to the Snowmass documents. She recommended using a scientific editor. He did not rewrite things, but he found things that were not understandable to general readers. We were told to make the program executable. We organized the report to be useable to staffers. We were told to make it science driven. We were told not to be afraid to change direction if it is well motivated. What made it effective was that we clearly stated our criteria, and we circulated those to the community.

Comment. Professor Pedersen: We are under time pressure. Take slides 8 and 32. Concerning slide 8: One to one with what we should be doing. Compelling science questions—perfect for us. Concerning slide 32: If we do a graph like this for the world fusion community, there will be much green; but for the U.S. program, we will see why we have had a tough time recently in the U.S. (cancel NCSX, shut down C mod). These two slides were compelling to me. We should follow your pattern.

Comment. Dr. Reyes: I agree with Professor Pedersen. Concerning that table with checkmarks, ILC and LHC have the most. Nevertheless, there was not much happening with ILC, due to the Japanese government. The P5 report was successful in spite of that. How did you do it?

A. Professor Lankford: The ILC is a multi-billion-dollar project. We had Scenario C (unconstrained). We had prior experience with a large expensive project being cancelled (SSC). At that time, Dr. Brinkman instituted a billion-dollar speed bump: no project may cost more than \$1B; if it does, it must be broken into pieces. The Chinese are now proposing a circular electron-ion collider at the same energy. ILC participation was small in Scenario A, more in B, and larger but undefined in C.

A. Dr. Ritz: We did not recommend ILC as a major project.

A. Dr. Stone: Without getting into inside baseball, no one in the world can do everything; we have to do things on a global scale. We did an agreement for the U.S. to participate in the LHC, and the EU to participate in LBNF. We leveraged LBNF against existing capabilities at Fermilab.

A. Dr. Ritz: The LHC and LBNF could not have peak funding at the same time, so we had a clear plan and rationale for how to phase them.

Comment. Professor Carter: A large project that has to survive more than one administration must be on firm grounds.

Q. Dr. Patello: Our community planning committee expressed concern about uneven maturity of concepts. Your process asked for cost estimates and profiles. Did you have a different quality of proposals?

A. Dr. Ritz: Yes, that is true with the CAGE process that NSF uses. When you give a budget scenario to a committee, it is intended to force the committee to confront priorities. We did not think we were deciding an actual program for an agency to carry out. They have a massively hard job to manage real issues. Cost matters for prioritization. Low ball costs can mess up strategic planning.

Q. Dr. Patello: Let me clarify. We are talking about quality of the input; designs and cost estimates.

A. Dr. Ritz: Yes. Also, it has to do with what stage the project is at. The more you know, the better the estimate. We systematically gathered information from the different projects so we could try to put them on the same footing.

A. Professor Lankford: We appreciated variation in the technical maturity of the ideas. We relied on the panel's expertise to weigh them. But, I felt we had no one trying to game the system. We went back to groups with questions about their input. There was much back and forth.

A. Dr. Stone: This has to do with implementation. FESAC will have to consider whether to use a \$50 million threshold for consideration as P5 used. I have already been on a one-year campaign alerting people to use LDRD and startup money to figure out what you want to propose to do. With a thousand flowers blooming, the quality differs.

A. Professor Lankford: We had a general recommendation that if a project was much different from P5, or its cost was much different, it would have to be reconsidered.

A. Dr. Ritz: We did not consider small projects. But, we did express the importance of small experiments, and we set aside a chunk of money each year (we taxed ourselves) under all scenarios to have a range of experiments.

Q. Dr. Rapp: You formed the panel after Snowmass. Is that the best way forward? Dr. Geesaman told us that one element to find consensus was that panel members should participate in the town hall meetings early.

A. Professor Lankford: There are pros and cons of engaging early. Some of our panel members were not at Snowmass, but they saw the presentations later. But, I wanted to prevent the lobbying process so Snowmass would not be interfered with. I am not confident on which is the best procedure. The

panel members were not even discussed until after Snowmass; they were not secret!

Q. Professor. Terry: You considered whole range of projects from large to small. This is very important for us. Was that pressure from constituencies, to mitigate risk, to provide opportunities for young people, or for science drivers?

A. Professor Lankford: We tried to maximize the science. We emphasized interdependence of parts of the program on each other. We also had the short-baseline neutrino program, to complement the large baseline program. DOE and NSF have different characters. DOE has national laboratories with strong facility orientation; DOE can do things that NSF cannot. NSF is interested in science goals. Also, there was the continuous flow of results issue. It took too long to get the Higgs boson results!

Q. Dr. Newman: Our DPP process is much informed by yours. Concerning slide 23 on criteria, when did you tell these to the community?

A. Professor Lankford: After the three large meetings, so halfway through our process. It was in the Snowmass charge as well. It took us some discussion to come up with these criteria.

A. Dr. Ritz: We thought after preliminary findings for a midterm report, but later thought better of that.

A. Professor Lankford: Midway through the process releasing the criteria worked, but they could have been published earlier.

Q. Dr. Newman: On different community groups not trusting each other, did you have an issue?

A. Dr. Ritz: It is difficult to remember events in the past that were once far in the future. Yes, there were issues. We put effort into listening to people, communicating, and how to take concerns into account. But, we could not say in which direction we were heading. It was a balancing act. We spent much time on the phone. Constant engagement built trust. Also, Snowmass helped—everyone talking with each other over a year and then at Snowmass helped.

Q. Dr. Newman: Was there agency funding for the input work - for developing ideas?

A. Dr. Stone: Agency funding went to Snowmass and workshops. It is difficult to answer about funding to develop ideas. In the past, we had no uniform process for this; we will be more careful going forward.

Q. Dr. Groebner: Regarding community buy-in and trust, and winners and losers, why did they accept the final report?

A. Professor Lankford: There was a mix of reasons. The Snowmass process was important for participants to appreciate the full richness of the field: it

opened their eyes. Also, transparency and a methodical process after Snowmass helped with acceptance. The report satisfied people. There were virtually no objections about programs that were terminated.

A. Dr. Ritz: There were people who were unhappy. We explained the rationale for tough decisions; that helped. That is why the criteria were important. Also, there was a growing understanding that our field was fractious; no project had complete support; but, the choice was getting nothing at all. There was frank discussion at Snowmass and good rationale for tough choices. Unhappy people saw the greater good.

A. Dr. Cooke: Steve Ritz kept the HEP community in mind. He discussed the criteria with HEPAP. The town halls were very open. The HEP community was one of the audiences for the report. The P5 panelists were encouraged to be ambassadors and give talks about the report and how the panel came to consensus on the difficult decisions. At Snowmass, people were encouraged not to be fractious. Those with concerns had the opportunity to talk with the agency and the P5 panel.

A. Dr. Ritz: We worked by consensus—that was very important. Even if only person on the panel had a serious objection, we worked through it, knowing that the question would come up in the community. We worked through differences with fair discussion in good faith, to arrive at an answer we could also support.

Q. Dr. Kuranz: Was there anything specific you did at Snowmass, maybe how you structured it, to build trust and consensus?

A. Professor Lankford: Steve Ritz was a group leader at Snowmass. I held a town hall meeting at Snowmass. The community wanted to hear from us, but we kept turning it back; we wanted to hear from them.

A. Dr. Ritz: We had a whole session on why our community is fractious. Donna, who later became president of APS, came to talk with us. We wrote summary documents about what important ideas emerged from the process. That was a good first step.

A. Dr. Stone: We launched a community meeting a year before Snowmass. A set of working groups were put together, even including an education and outreach working group. They met for a year to get full input from the community on those topical areas.

A. Dr. Ritz: Yes, that was a year-long effort. We are looking to shorten it. The key is to have a panel that does not represent constituencies (that is U.S. Congress), but look at the big field. We had to function by consensus, by coming to a common understanding.

Q. Dr. Wayne Solomon (General Atomics): Regarding slide 23 on the level of maturity of projects, some even at CD-0 were baselined. How would you

have proceeded without that? How do you accurately develop costs absent that?

A. Professor Lankford: Cost estimating is always a challenge. The DOE system puts out incredible effort to develop a reliable cost, with large contingency (perhaps reflecting technical maturity). Only then does it become a real project. It is better to get reasonable cost estimates. What would be the cost sharing between DOE and NSF? There are uncontrollable factors. HEP gave us guidance along the way; Mike Procaro in particular. We tried to get a sense from that of what would be achievable.

A. Dr. Ritz: Also, we had panel members who had experience being on cost and schedule reviews.

Q. Dr. Solomon: Concerning the timing for prioritization, was there an attempt to roll out the prioritization ahead of the roll out of the whole package?

A. Dr. Ritz: We had a midterm report in our charge. We chose that opportunity to describe the sum of things proposed, and their total cost—which exceeded scenarios by billions—and described our criteria. That is all we presented then.

A. Professor Lankford: We did not want to put it out until the whole process was complete. When we rolled it out, we expected it to be successful. HEPAP had seen it 1-2 weeks in advance, but there was no advance discussion - just feedback from FESAC members to Steve Ritz and me (private). We word-smithed late into the process. Once it was public, we wanted to be ready for the follow-up.

A. Dr. Ritz: Our science editor was Jim Dawson. We brought him to the last meeting where we word-smithed the recommendations.

Q. Dr. John Sarff (University of Wisconsin): I have the impression that your proposed projects were almost all in the SC critical decision process already. What happens if brand new projects come up?

A. Dr. Stone: From 1996-2015, HEP spent about \$2T on projects. From 2016-2019, we spent another \$1T on projects, due in part to the success of the P5 plan. When the P5 report came out in May 2014, only six of the recommended projects were at CD-0+. Now, we are at CD-0+ for an additional eight recommended projects, and with FY 2019 appropriations, we have finished funding nine of these projects.

A. Dr. Ritz: CD is a DOE process. NSF has a different process.

A. Dr. Stone: LBNE had CD-1, but it had to be reformulated because of the P5 report.

Q. Dr. Ferraro: If you saw our plans, did anything stick out as bad ideas or good ideas?

A. Professor Lankford: I would be happy to look at your presentation, which I missed yesterday. I cannot say with confidence what will map to your community; each community is different.

A. Dr. Ritz: Like science and textbooks, this leaves the impression that we knew what we were doing—which was not the case! We looked into the abyss. It is really hard. Missing from the slide about being successful is LUCK. Be sure you are lucky.

Comment. Dr. Ferraro: That is terrifying.

Comment. Dr. Rej: I would like to recognize five of you who are coming off FESAC this June. Many thanks to Drs. Greenfield, Groebner, Neilson, Rapp, and Wendt. We heard a lot; we will have another FESAC meeting about next steps. P5 and NP have differences; we can discuss them.

The meeting was adjourned at Noon.

Certified as Correct by:



Dr. Donald J. Rej, FESAC Chair

Date
May 28, 2019