NSF-PHY News

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Division of Physics, NSF

HEPAP
October 22, 2009

NSF Budget

	FY 2008 Actual	FY 2009 Omnibus	FY 2009 ARRA	FY 2010 Request	Change over FY 2009	
Research & Related Activities	**$4,853.24**	**$5,183.10**	**$2,500.00**	**$5,733.24**	**$550.14**	**10.6%**
Education & Human Resources	766.26	845.26	100.00	857.76	12.50	1.5%
MREFC	**166.85**	**152.01**	**400.00**	**117.29**	**-34.72**	**-22.8%**
Agency Operations & Award Management	282.04	294.00	0.00	318.37	24.37	8.3%
National Science Board	3.82	4.03	0.00	4.34	0.31	7.7%
Office of Inspector General	11.83	12.00	2.00	14.00	2.00	16.7%
Total, National Science Foundation	**$6,084.04**	**$6,490.40**	**$3,002.00**	**$7,045.00**	**554.60**	**8.5%**

Change over FY 2008: +961M, +15.8%

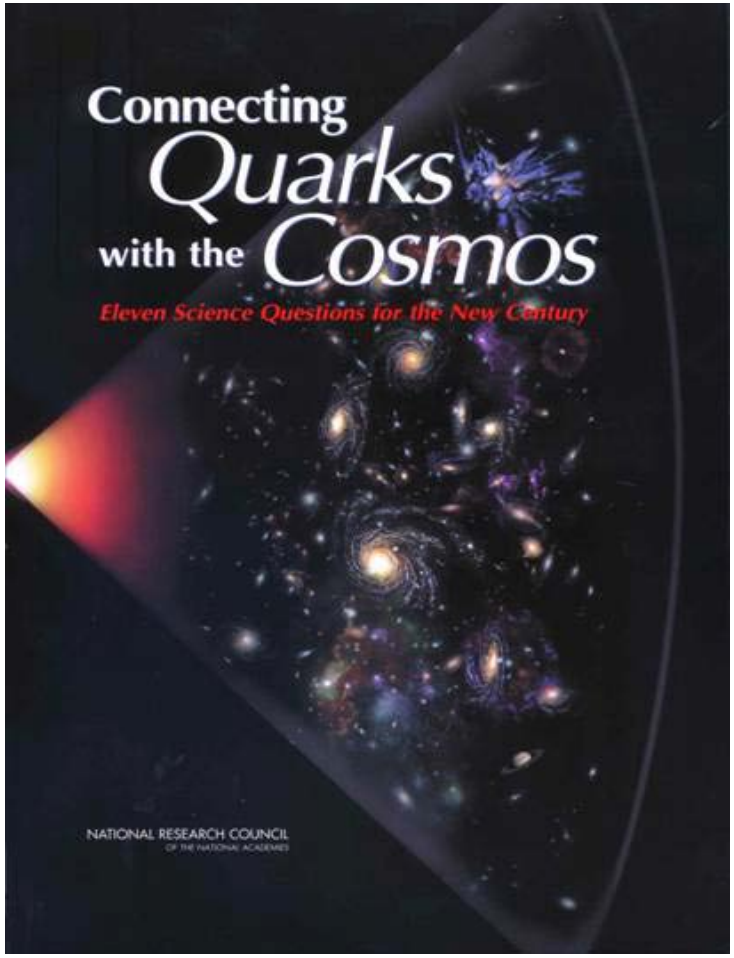
R&RA Budget

	FY 2008 Actual	FY 2009 Omnibus	FY 2009 ARRA	FY 2010 Request	Change over FY 2009	
Biological Sciences	$613.42	$653.81	$260.00	$733.00	$79.19	12.1%
Computer and Information Sci & Eng	535.26	573.74	235.00	633.00	59.26	10.3%
Engineering *(less SBIR/STTR)*	531.23	564.94	215.00	632.00	67.06	11.9%
SBIR/STTR	109.07	119.21	50.00	132.52	13.31	11.2%
Geosciences	757.87	807.13	347.00	909.00	101.87	12.6%
Math & Physical Sciences	**1,171.13**	**1,255.96**	**490.00**	**1,380.00**	**124.04**	**9.9%**
Social, Behavior, & Economic Sciences	215.18	229.80	85.00	257.00	27.20	11.8%
Office of Cyberinfrastructure	185.15	199.28	80.00	219.00	19.72	9.9%
Office of International Sci & Eng	47.77	44.03	14.00	49.00	4.97	11.3%
Office of Polar Programs	447.13	470.67	174.00	516.00	45.33	9.6%
Integrative Activities	238.56	263.03	550.00	271.12	8.09	3.1%
U.S. Arctic Research Commission	1.47	1.50	-	1.60	0.10	6.7%
Research & Related Activities	**$4,853.24**	**$5,183.10**	**$2,500.00**	**$5,733.24**	**$550.14**	**10.6%**

MPS Budget

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA	FY 2010 Request	Change over FY 2009 Current Plan	
					Amount	Percent
Astronomical Sciences	$217.90	$228.62	$85.80	$250.81	$22.19	9.7%
Chemistry	194.62	211.35	103.00	238.60	27.25	12.9%
Materials Research	262.55	282.13	106.90	308.97	26.84	9.5%
Mathematical Sciences	211.75	226.18	98.00	246.41	20.23	8.9%
Physics	251.64	274.47	96.30	296.08	21.61	7.9%
Office of Multidisciplinary Activities	32.67	33.21	-	39.13	5.92	17.8%
Total, MPS	**$1,171.13**	**$1,255.96**	**$490.00**	**$1,380.00**	**$124.04**	**9.9%**

Physics of the Universe Context



What is dark matter?

What is dark energy?

How did the universe begin?

Was Einstein right about gravity?

How have ν shaped the universe?

What are nature's most energetic particles?

Are protons stable?

Are there new states of matter at exceedingly high density/energy?

Are there additional dimensions?

How were elements Fe to U made?

Is a new theory needed at the highest energies and EM Fields?

Physics of the Universe

Summary of Recommendations

Ready for Immediate Investment and Direction Known

Dark Energy

* NASA and DOE will develop a Joint Dark Energy Mission (JDEM). This mission would best serve the scientific community if launched by the middle of the next decade. Studies of approaches to the JDEM mission undertaken now will identify the best methodology.
* A high-priority independent approach to place constraints on the nature of Dark Energy will be made by studying the weak lensing produced by Dark Matter. This is a scientific goal of the ground-based Large-aperture Synoptic Survey Telescope (LSST). Significant technology investments to enable the LSST are required, and NSF and DOE will begin technology development of detectors, optical testing, and software algorithms leading to possible construction with first operations in 2012. NASA will contribute their expertise as appropriate.
* Another priority method to constrain Dark Energy will be to use clusters of galaxies observed by ground-based Cosmic Microwave Background (CMB) and space-based X-ray observations. A coordinated NSF and NASA effort using this technique will provide independent verification and increase the precision of the overall measurements.

Dark Matter, Neutrinos, and Proton Decay

* NSF will be the lead agency for concept development for an underground facility. NSF will develop a roadmap for underground science by the end of 2004.
* NSF and DOE will work together to identify a core suite of physics experiments. This will include research and development needs for specific experiments, associated technology needs, physical specifications, and preliminary cost estimates.

Gravity

* NSF, NASA, and DOE will strengthen numerical relativity research in order to more accurately simulate the sources of gravitational waves.
* The timely upgrade of Laser Interferometer Gravitational wave Observatory (LIGO) and execution of the Laser Interferometer Space Antenna (LISA) mission are necessary to open this powerful new window on the universe and create the new field of gravitational wave astronomy.

Next Steps for Future Investments

Origin of Heavy Elements

* DOE and NSF will generate a scientific roadmap for the proposed Rare Isotope Accelerator (RIA) in the context of existing and planned nuclear physics facilities worldwide.
* DOE and NSF will develop a roadmap that lays out the major components of a national nuclear astrophysics program, including major scientific objectives and milestones, required hardware and facility investments, and an optimization of large-scale simulation efforts.

Birth of the Universe Using Cosmic Microwave Background

* The three agencies will work together to develop by 2005 a roadmap for decisive measurements of both types of CMB polarization. The roadmap will address needed technology development and ground-based, balloon-based, and space-based CMB polarization measurements.

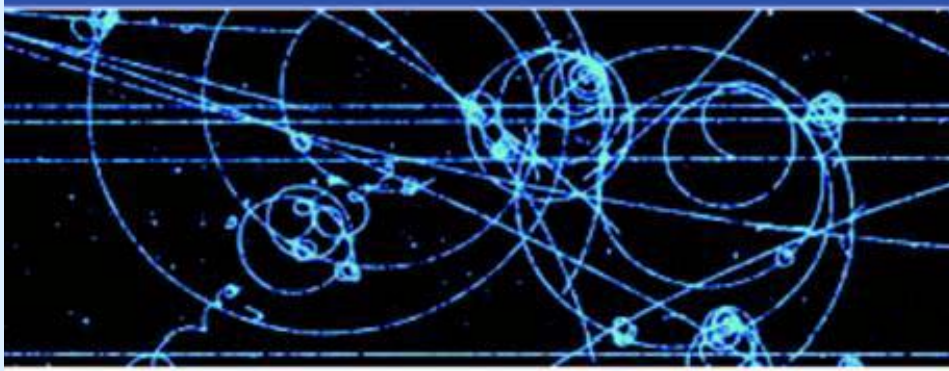
High Density and Temperature Physics

* In order to develop a balanced, comprehensive program, NSF will work with DOE, NIST, and NASA to develop a science driven roadmap that lays out the major components of a national High Energy Density Physics (HEDP) program, including major scientific objectives and milestones and recommended facility modifications and upgrades.
* NNSA will add a high energy high-intensity laser capability to at least one of its major compression facilities in order to observe and characterize the dynamic behavior of high-energy-density matter.
* DOE and NSF will develop a scientific roadmap for the luminosity upgrade of the The Relativistic Heavy Ion Collider (RHIC) in order to maximize the scientific impact of RHIC on High Energy Density (HED) physics.

A 21ST CENTURY FRONTIER FOR DISCOVERY

THE PHYSICS OF THE UNIVERSE

A STRATEGIC PLAN FOR FEDERAL RESEARCH AT THE INTERSECTION OF PHYSICS AND ASTRONOMY



POU – The PHY Program

1. What is dark matter?	1. CDMS, Xe, LUX, Liq AR TPC, theory
2. What is dark energy?	2. ACT, SPT, theory, KICP
3. How did the universe begin?	3. QUIET, ACT, SPT, theory, KICP
4. Was Einstein right about gravity?	4. AdvLIGO, theory, numerical relativity
5. How have Ѵs shaped the universe?	5. LBNE, double beta decay, Double Chooz, Daya Bay, theory
6. What are nature's most energetic particles?	6. Auger, Veritas, Milagro, KICP
7. Are protons stable?	7. Proton decay, theory
8. Are there new states of matter at exceedingly high density/energy?	8. RHIC, petawatt laser experiments, LHC, KITP
9. Are there additional dimensions?	9. LHC, theory, KITP
10. How were elements Fe to U made?	10. NSCL, FRIB, theory, JINA
11. Is a new theory needed at the highest energies and EM Fields?	11. Theory, KITP

DUSEL Vision

- **DUSEL is being envisioned as a unique, dedicated international underground education & research center that would support a set of potentially transformational experiments in multiple disciplines.**
- **The U.S. particle, nuclear, and astrophysics communities have selected DUSEL as central to their national programs.**
- **The engineering, geology and biology communities are proactively engaged, and are part of all aspects of DUSEL planning.**

Cosmic Questions for DUSEL

- Of what is the Universe made?
- What is Dark Matter?
- What are neutrinos telling us?
- Where did the antimatter go?
- Are protons unstable?
- How did the universe evolve?

The Vetting of DUSEL

1985 1994 2000 2005 2010

Seattle Neutrino Pre-Town Meeting, Sept 2000

Oakland DNP Town Meeting, Oct. 2000

Nuclear Science Advisory Committee, March 2001

Bahcall Committee report, March 2001

SNOWMASS July 2001

Quarks to the Cosmos 2002

NP LRP 2002

NeSS 2002

Neutrino Facilities Report 2003

EarthLab 2003, HEPAP LRP 2003

DOE Facilities 2003

NSF DUSEL Reorganization 2004

Neutrino Matrix 2004

1st S-1 Workshop

S-2 Awards

Physics of the Universe 2004

EarthScope 2005

CDRs Review

S-1 Complete

Site-selection

HEPAP 2006

EPP2010

Dark Matter SAG 2006

NuSAG 2005, 2006

NSAC LRP

P5

NSF Review

NSF Review

S4 Awards

PASAG

PDR

NSB Approves PDR

P5 Recommendations

- **Report approved by HEPAP at their May 2008 meeting in Washington**
- **From Executive Summary:**

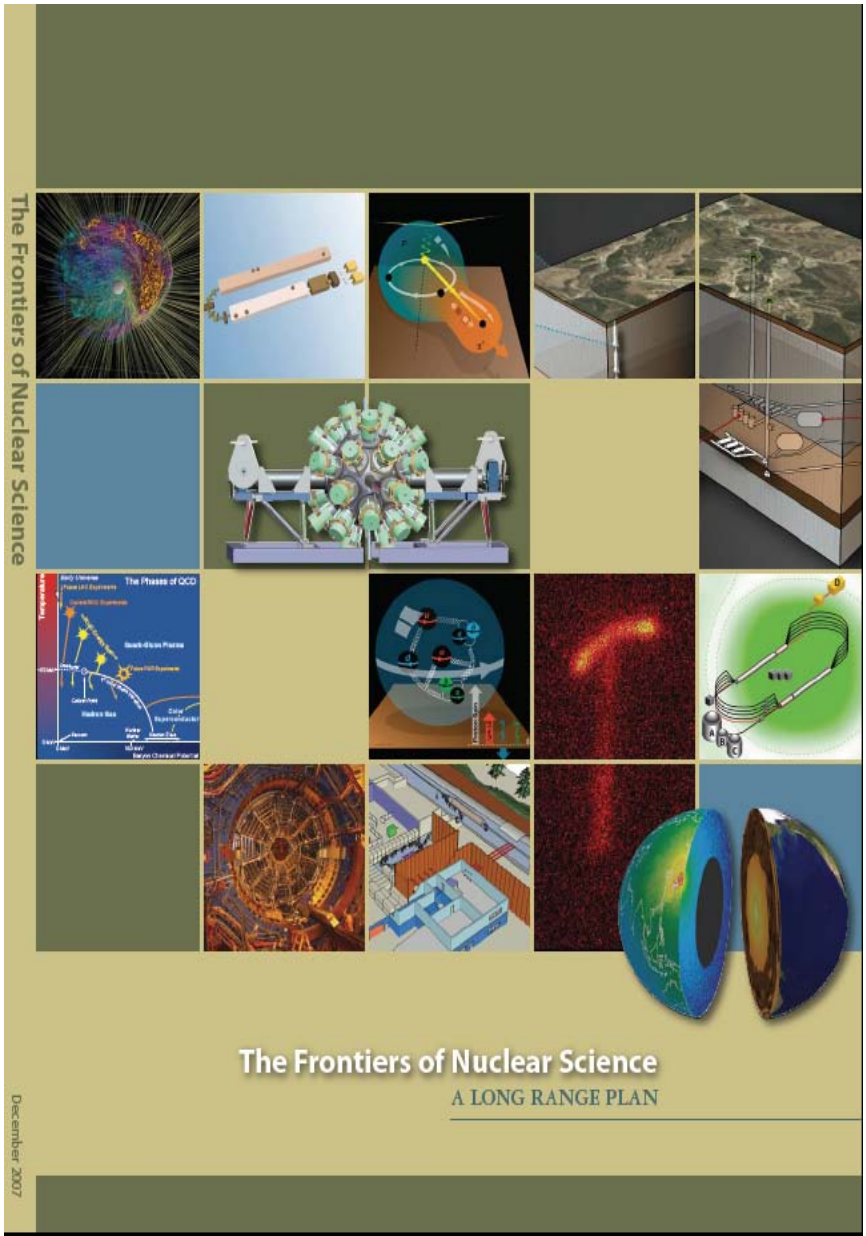
> ***"The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL laboratory and a high-intensity neutrino source at Fermilab."***
>
> ***"The panel endorses the importance of a deep underground laboratory to particle physics and urges NSF to make this facility a reality as rapidly as possible. Furthermore the panel recommends that DOE and NSF work together to realize the experimental particle physics program at DUSEL."***

- **Fermilab/DUSEL program recommended by P5 constitutes the primary element of the on-shore U.S. particle physics program during the coming decade**

Nuclear Science Advisory Committee (NSAC)

- **NSAC charged by DOE and NSF in July 2006 with developing a long range (ten year) plan.**
- **From Dec 2007 report, Overview and Recommendations:**

"We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet-unseen violations of time-reversal symmetry, and other key ingredients of the New Standard Model of fundamental interactions. <u>Construction of a Deep Underground Science and Engineering Laboratory is vital to U.S. leadership in core aspects of this initiative</u>."



DUSEL Solicitation Process

- **Initiated at Town Meeting at NSF, March 2004**
- **Solicitation 1 (S1):**
  - **Define site-independent science scope and infrastructure needs; unify the community (awarded Jan 2005)**
- **Solicitation 2 (S2):**
  - **Develop conceptual designs (8 received, 2 awarded, September 2005)**
- **Solicitation 3 (S3):**
  - **Site selection to initiate facility design for 1 potential MREFC candidate (4 received, 1 awarded – Homestake, U.C. Berkeley)**
  - **$15M total over three years, starting in September 2007**
- **Solicitation 4 (S4):**
  - **Initiate technical designs for candidates for the DUSEL suite of experiments**
  - **$15M total over three years, beginning in FY09**
  - **25 proposals received January 9, 2009; reviewed spring 2009, just awarded**

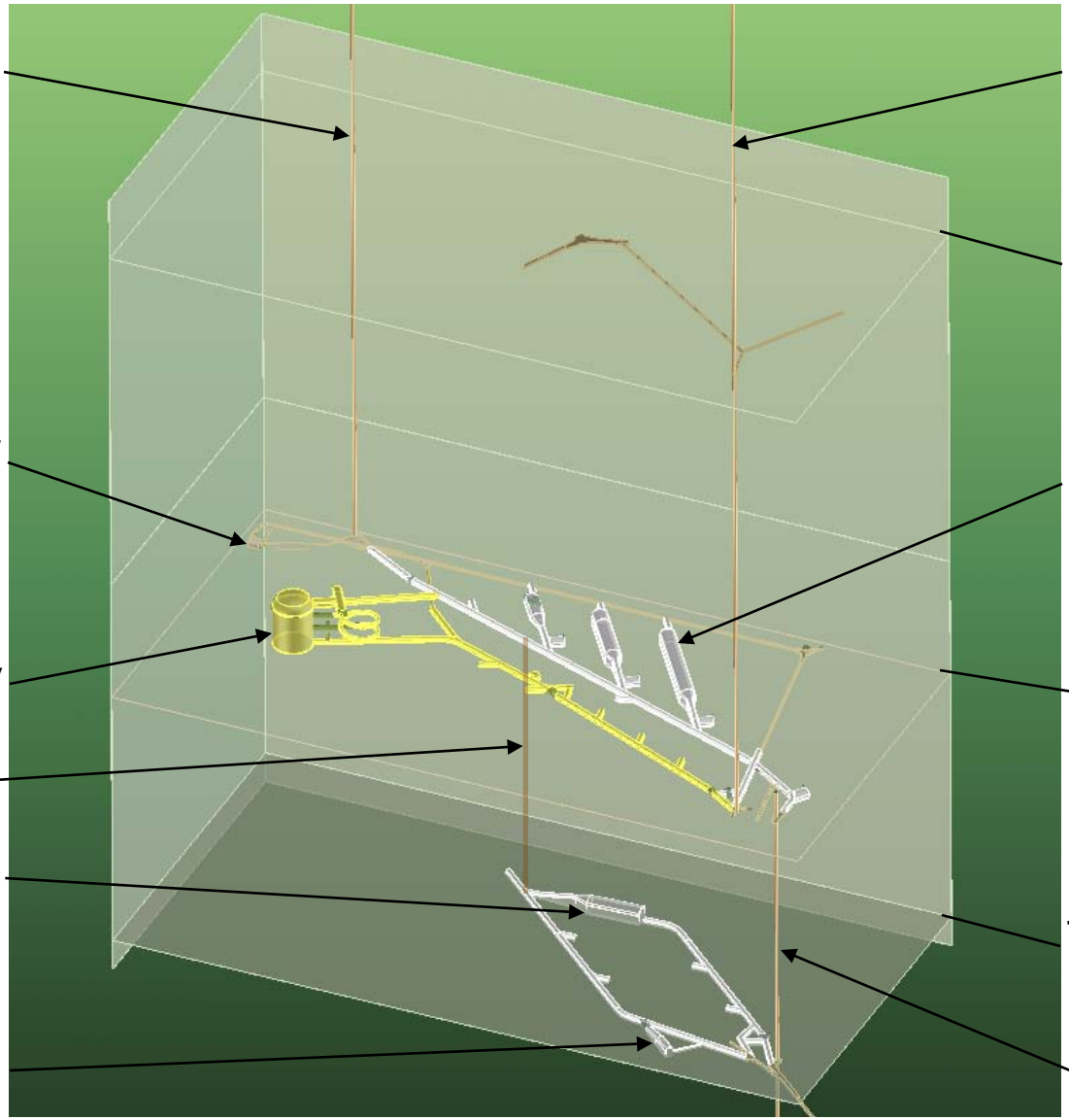
NSF/DOE Collaboration (JOG)

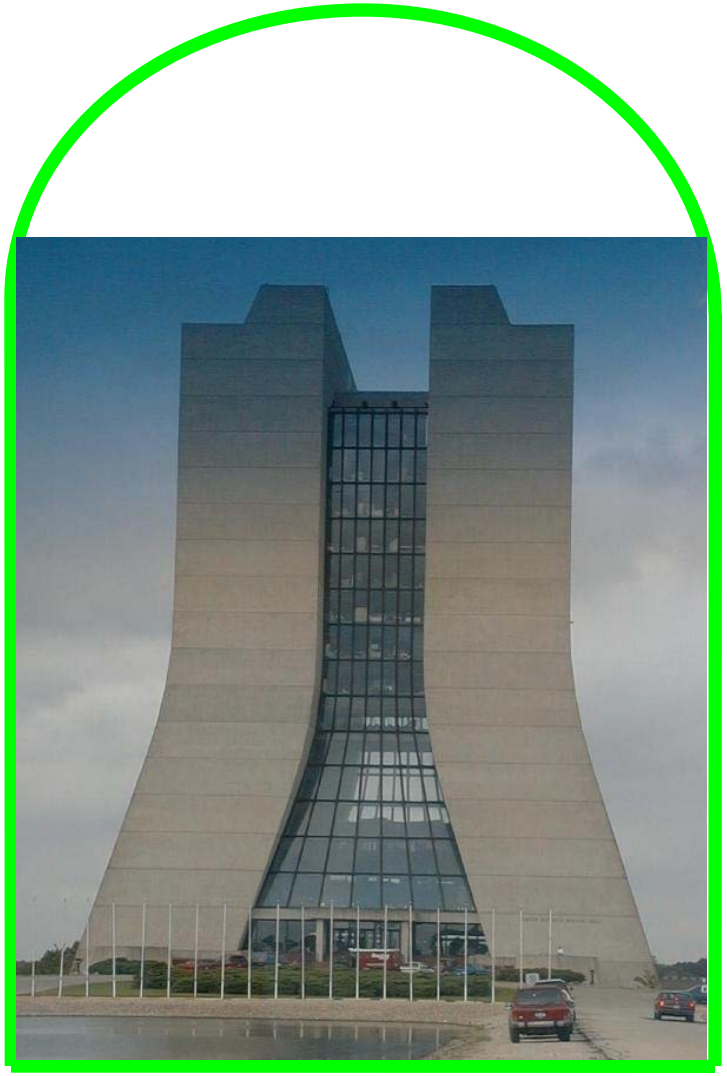
- **NSF/DOE agreed to establish DUSEL Physics Joint Oversight Group (JOG) immediately after release of P5 report (May ’08)**
- **Representation from NSF/PHY, DOE/OHEP, DOE/ONP**
- **Builds on successful NSF & DOE collaboration on Large Hadron Collider (LHC) in high energy physics**
- **Will jointly coordinate & oversee DUSEL experimental physics program**
- **Meeting quarterly**
- **Agencies consult, and participate as observers, on all reviews of DUSEL and related experiments**

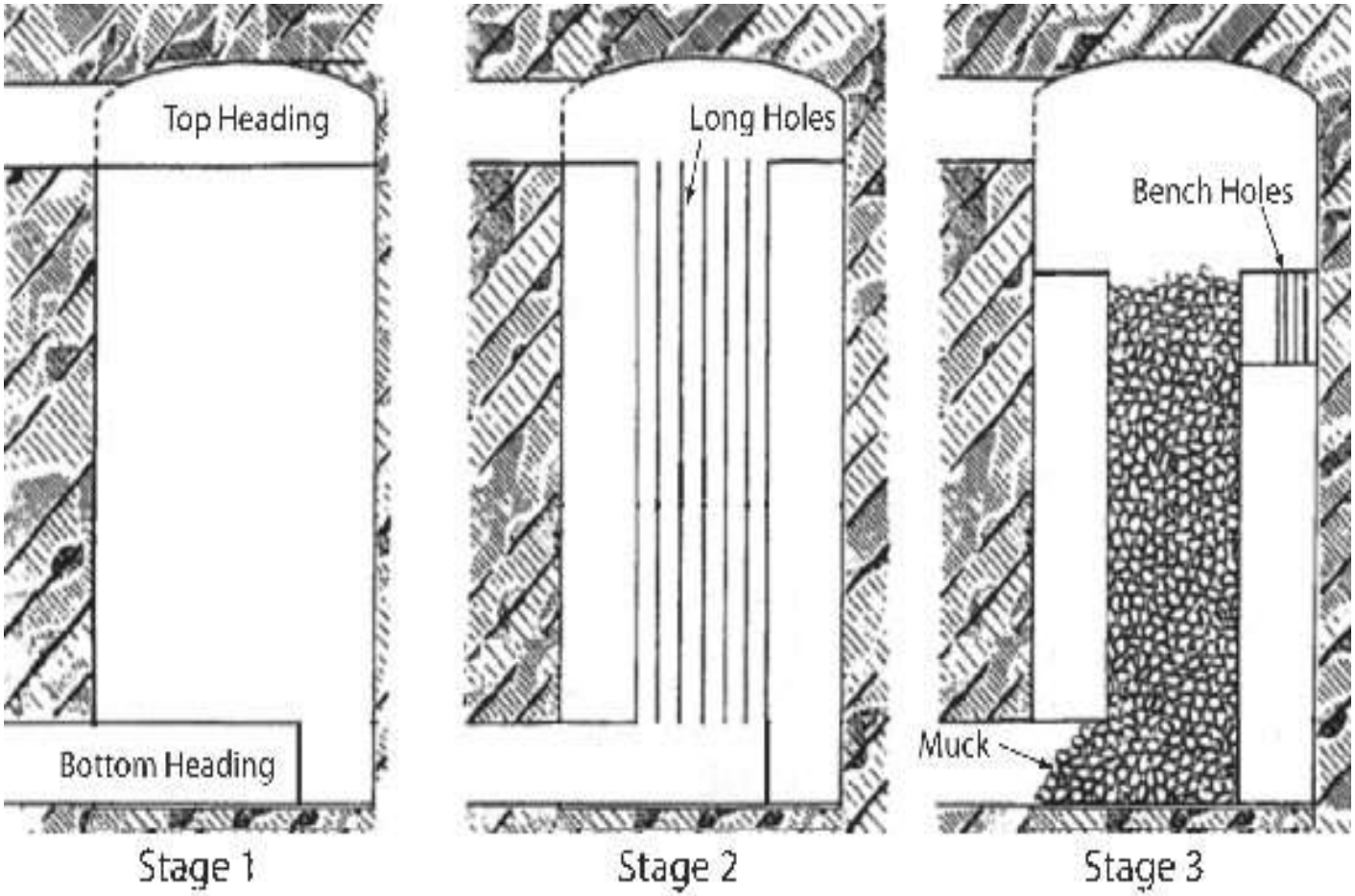
Inter-Agency Letter of Intent & Transmittal

- **Joint Statement of Intent from DUSEL Physics JOG signed by 3 JOG co-chairs in August**
  - **Director of NSF Physics Division**
  - **Associate Directors for DOE OHEP & NP**
  - **MoU in approximately 1 year**
- **Transmittal letter to OMB signed by NSF Director and DOE Under Secretary for Science (August 3, 2009)**
  - **Close coordination of evolving design**
  - **Joint review process**
  - **Expressed commitment to completing baseline plan**

Currently Envisioned DUSEL Laboratory Design






Top Heading
Bottom Heading
Stage 1
Long Holes
Stage 2
Bench Holes
Muck
Stage 3

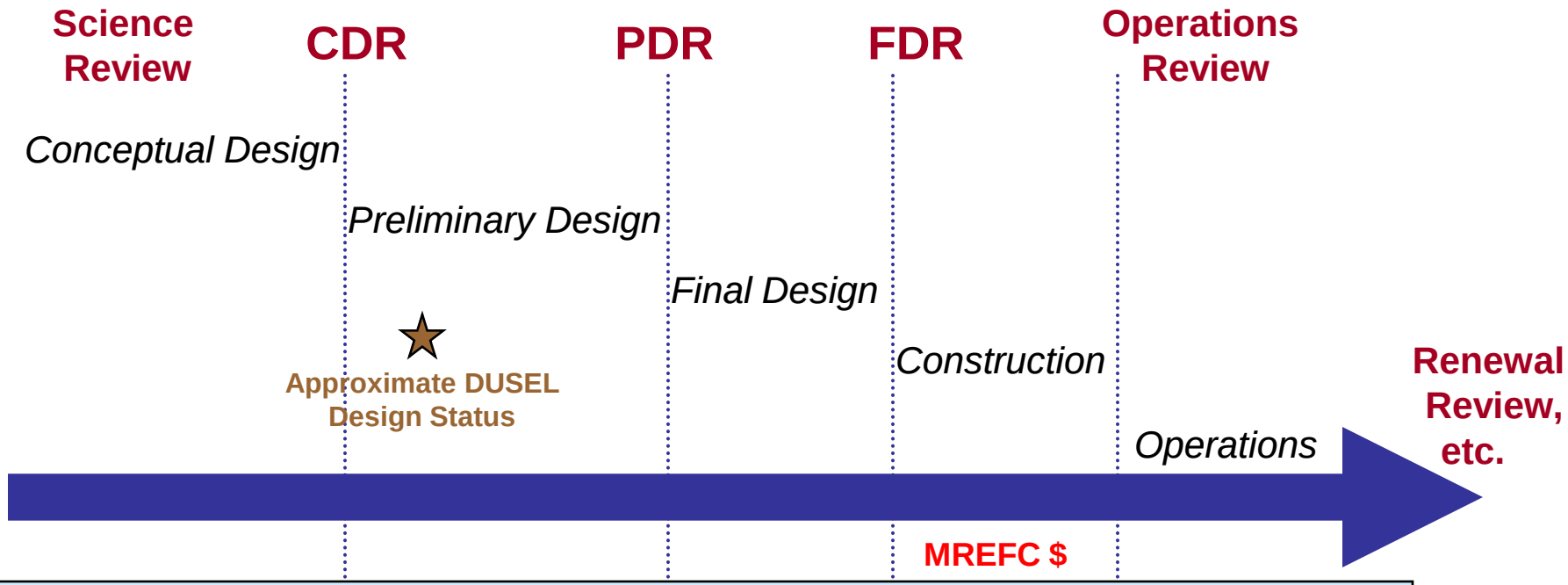
Sanford Laboratory Development

Sanford Laboratory physics program in preparation.

Being initiated in Davis Cavern.

	Conceptual Design Stage	Readiness Stage	Board Approved Stage	Construction
Budget evolution	Concept development – Expend approximately 1/3 of total pre-construction planning budget Develop construction budget based on conceptual design Develop budget requirements for advanced planning Estimate ops $	Preliminary design Expend approx 1/3 of total pre-construction planning budget Construction estimate based on prelim design Update ops $ estimate	Final design over ~ 2 years Expend approx 1/3 of total pre-construction planning budget Construction-ready budget & contingency estimates	Expenditure of budget and contingency per baseline Refine ops budget
	Funded by R&RA or EHR $			**MREFC $**
Project evolution	***Conceptual design*** Formulation of science questions Requirements definition, prioritization, and review Identify critical enabling technologies and high risk items Development of conceptual design Top down parametric cost and contingency estimates Formulate initial risk assessment Initial proposal submission to NSF Initial draft of Project Execution Plan	***Preliminary Design*** Develop site-specific preliminary design, environmental impacts Develop enabling technology Bottoms-up cost and contingency estimates, updated risk analysis Develop preliminary operations cost estimate Develop Project Management Control System Update of Project Execution Plan	***Final Design*** Development of final construction-ready design and Project Execution Plan Industrialize key technologies Refine bottoms-up cost and contingency estimates Finalize Risk Assessment and Mitigation, and Management Plan Complete recruitment of key staff	***Construction per baseline***
		Proponents development strategy defined in Project Development Plan		Described by Project Execution Plan
	NSF oversight defined in Internal Management Plan, updated by development phase			
Oversight evolution	Merit review, apply 1st and 2nd ranking criteria MREFC Panel briefings Forward estimates of Preliminary Design costs and schedules Establishment of interim review schedules and competition milestones Forecast international and interagency participation and constraints Initial consideration of NSF risks and opportunities Conceptual design review	**MREFC Panel recommends and NSF Director approves advance to Readiness** NSF Director approves Internal Management Plan Formulate/approve Project Development Plan & budget; include in NSF Facilities Plan Preliminary design review and integrated baseline review Evaluate ops $ projections Evaluate forward design costs and schedules Forecast interagency and international decision milestones NSF approves submission to NSB	**NSF approves submission to NSB** Apply 3rd ranking criteria NSB prioritization OMB/Congress budget negotiations based on Prelim design budget Semi-annual reassessment of baseline and projected ops budget for projects not started construction Finalization of interagency and international requirements	**Congress appropriates funds** Final design review, fix baseline Congress appropriates MREFC funds & NSB approves obligation Periodic external review during construction Review of project reporting Site visit and assessment

NSF Pre-Construction Planning Process



DOE Translation:

CD 0	CD 1	CD 2	CD 3	CD 4
Approve mission need	Approve alternate selection and cost range	Approve performance baseline	Approve construction start	Approve operations start

Overview of DUSEL Status

- **Homestake site selection made only ~ 2 years ago**
- **Enormous progress has been made, on all fronts**
- **Community is now developing a Preliminary Design**
- **Will provide basis for consideration as an NSF MREFC construction project**
- **Current goal is a baseline design that lays out the community vision for DUSEL**

Design of DUSEL Facility & Infrastructure

- First NSF annual review of the DUSEL Design Project held at U.C. Berkeley in January 2009
  - 25-member multi-disciplinary expert panel
- Recommended a proposal be submitted to NSF by UCB for funds to complete Preliminary Design
- Proposal submitted May 2009, reviewed by NSF
- Panel recommended to the NSF that proposal "must be funded"
- Put forward for consideration by the National Science Board in August/September 2009

NSB Resolution

- **Signed September 24, 2009 by NSB Chair:**

RESOLVED, that the National Science Board authorized the Director, at his discretion, to make an award to the University of California at Berkeley for preliminary design of the Deep Underground Science and Engineering Laboratory (DUSEL) for an amount not to exceed $29,092,000 for 24 months.

Furthermore, the Board shall receive a status report twice per year on the preliminary design from NSF management during the lifetime of the award. The first report is expected at the February 2010 Board meeting. DUSEL will be included in the NSF large facilities portfolio review at the May 2010 National Science Board meeting. National Science Board approval shall be requested by the Director for any DUSEL planning and design awards subsequent to this award.

Furthermore, the Board directs NSF management to undertake a broad independent review of DUSEL to establish its priority so that it can inform the May 2011 portfolio review.

Developing the DUSEL Experimental Program: S4

- **DUSEL experimental designs being developed in parallel with that of facility**
- **Solicitation 4 (S4): called for proposals to develop designs and pursue targeted R&D for potential candidates for the DUSEL suite of experiments**
- **Proposal deadline January 9, 2009**
  - **Up to $5M/year for up to 3 years**
- **25 proposals received, of which 15 were in physics**
- **300 senior researchers named, 91 institutions**
- **S4 does not represent a final down-select**

S4 Proposal Review

- **15 physics proposals reviewed by high level panel of 12 experts at NSF on June 10-12, 2009**
- **Panel recommended 9 proposals to NSF for funding**
- **NSF concurred**
- **Close attention paid to programmatic depth, diversity:**
  - **Dark matter**
  - **Neutrino-less double-beta decay**
  - **Large water Cerenkov detector**
  - **Underground accelerator**
  - **Assaying sub-facility**
- **Total physics awards: $21M over 3 years**

BIO, GEO, ENG S4 Proposals

- **Seven proposals from engineering and geo/geo-bio were selected for funding:**
  - **Fracture processes**
  - **Coupled processes**
  - **Subsurface imaging and sensing**
  - **Fiber optic strain monitoring**
  - **CO_2 sequestration**
  - **Eco-hydrology & deep drilling**

NSF remains committed to a rich, diverse, and multi-disciplinary DUSEL research program.

DUSEL Target Timeline

- **January ’09: NSF Project Review #1**
- **February ’10: NSF Project Review #2**
- **December ’10: NSF Preliminary Design Review (PDR)**
  - **Project baseline**
- **Spring ’11: Presentation of DUSEL MREFC proposal to NSB**

Above targets an October 2012 construction start.

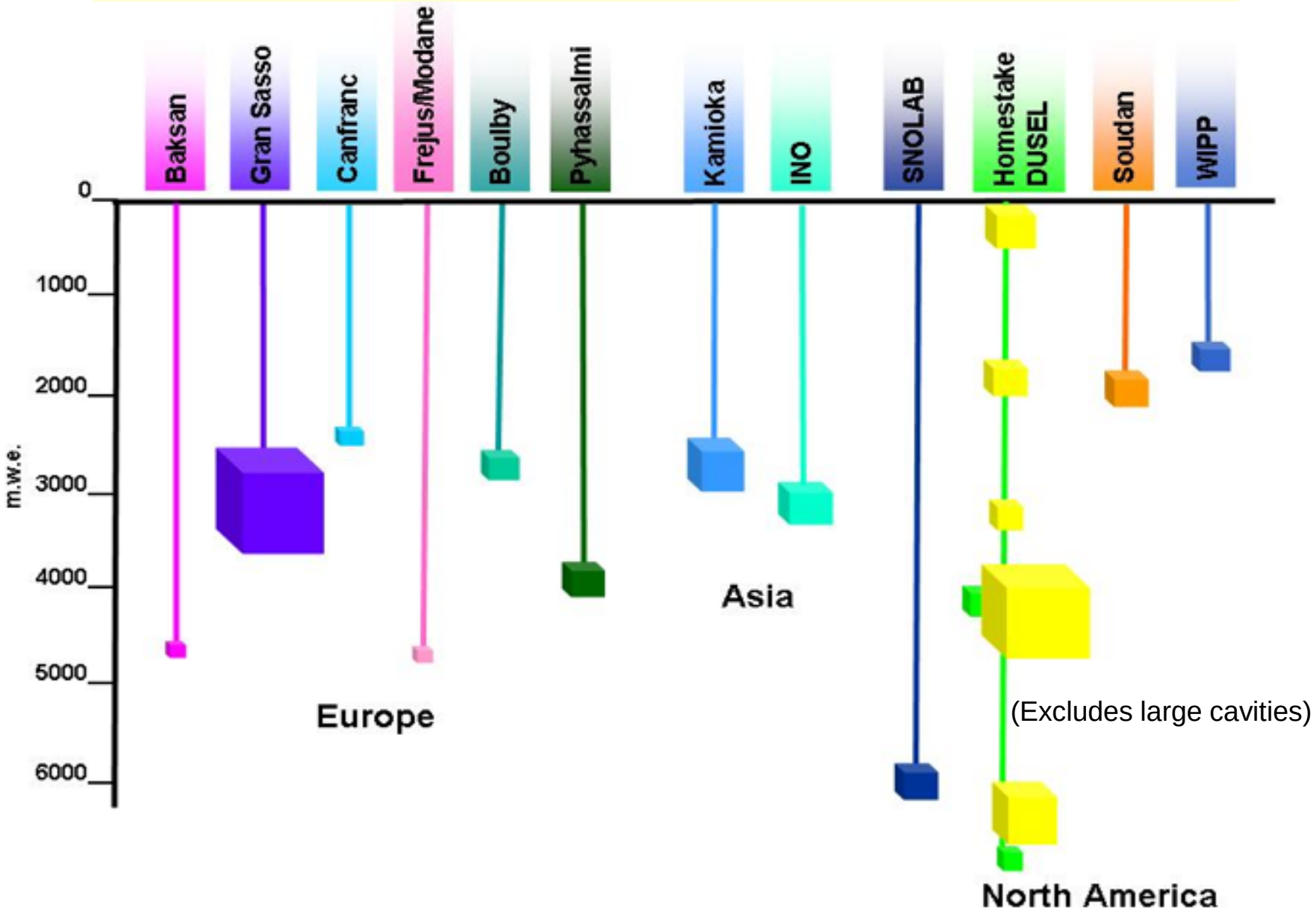
Note on International Involvement

- **NSF interested in establishing DUSEL as a facility of intrinsically international character**
- **NSF and DOE will be actively pursuing international partnerships, and welcomes such collaborative discussions with our colleagues at any time**
- **Mounting of experiments by foreign sponsors envisioned as an inherent component of the DUSEL program**
  - **Design, construction, operations, data analysis**

Conclusions

- Frank Wilczek (Physics, 2004) has said that *"only the LHC stands a real chance of breaking the existing paradigm"* and Nature has named it *"the unstoppable collider"*.
- I have been for decades one of the most strenuous supporters of the LHC. However I believe that we cannot predict where and if the next major discoveries/surprises may come from. Ultimately the LHC and the other experiments are fighting together, like did David and Goliath.
- The discovery of SUSY may be a real "bonanza" for the present (and future) colliders but its relation to the now credible dark matter is by no mean obvious or granted.
- Likewise the neutrino sector may reserve for us incredible new discoveries. Proton decay will never be observable with accelerators. Gravitational waves are about to be discovered in the laboratory and in space.
- Events from the sky and underground have an immense role to play in the future. Now that LHC is on the verge of operation, European physics and CERN have the obligation of concentrating some of the efforts and funding also on a broader range of other activities in the framework of a wider collaborative effort with the rest of the world.

Worldwide Underground Research



Closing Remarks

- **DUSEL project is aggressively moving toward establishing a baseline design**
- **Will allow its consideration as an MREFC construction candidate**
- **Research program, education & outreach, and impressive local support provide unusually strong foundation for the design of a very special facility**
- **<u>The community is now specifying their vision of what DUSEL will be</u>**