



NSCL & FRIB Briefing of NSAC

November 17, 2014

C. Konrad Gelbke: NSCL Operations and Science Opportunities (NSF)
Thomas Glasmacher: FRIB Project and Early Science Opportunities (DOE)
Michigan State University



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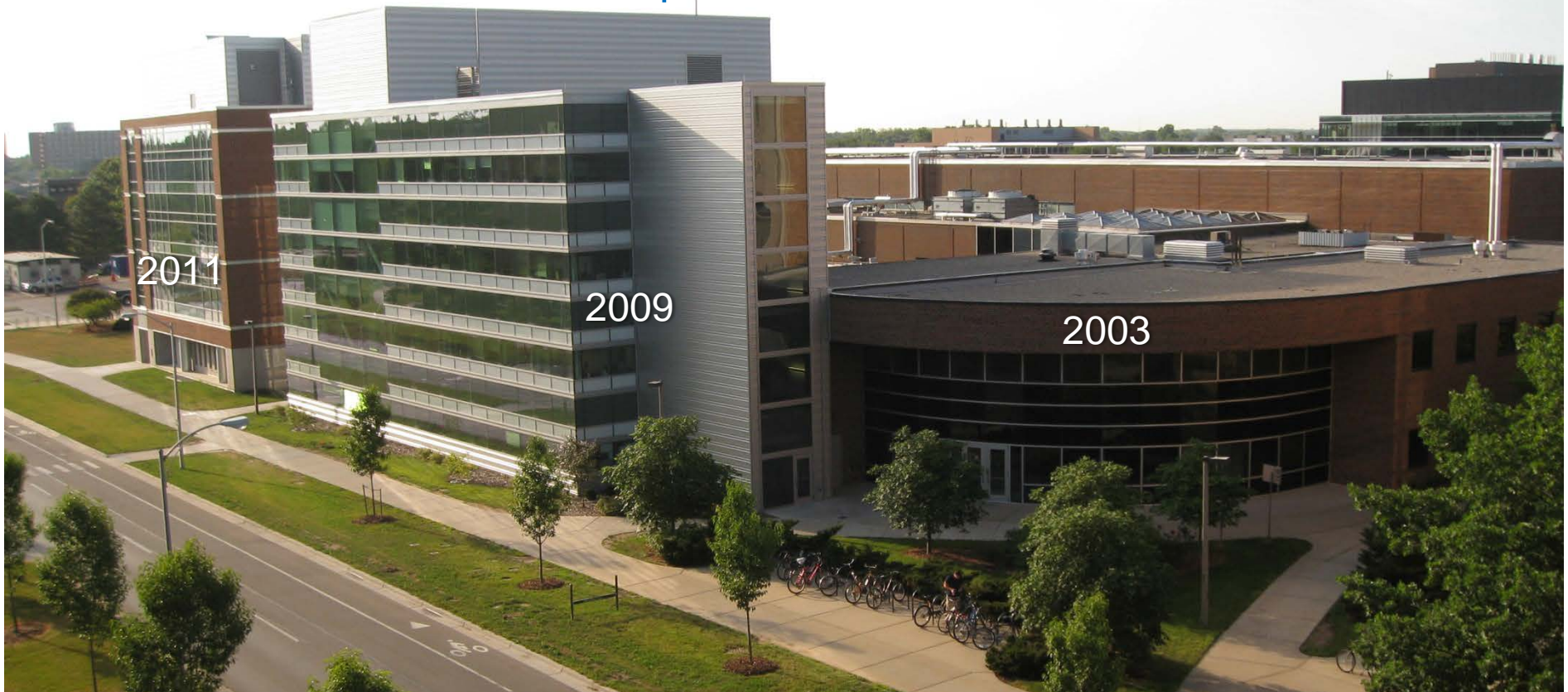
U.S. DEPARTMENT OF
ENERGY

Office of Science

NSCL / FRIB Laboratory

598 employees, incl. 42 faculty, 77 graduate and 87 undergraduate students
as of November 5, 2014

- NSCL is funded by the U.S. National Science Foundation to operate a flagship user facility for rare isotope research and education in nuclear science, nuclear astrophysics, accelerator physics, and societal applications
- FRIB will be a national user facility for the U.S. Department of Energy Office of Science – when FRIB becomes operational, NSCL will transition into FRIB



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DOE/NSF coordination via FRIB Joint Oversight Group

DOE, NSF, and MSU Partnership

Cost-effective use of federal funds

Well-defined roles and objectives with a shared vision

- **NSF:** Operate the nation's current RIB flagship facility for users, enable world-leading research, and educate the next generation of scientists
 - Important stewardship role for NSCL's *evolving* infrastructure that will merge into the FRIB laboratory once the FRIB construction project is completed
 - Issue: 4,500 hrs. of operations for users; ReA3 improvements; build & commission ReA6-12 plus priority instruments ISLA, Solenoid Spectrometer
- **DOE:** Construct the world's premier rare isotope user facility
 - Coordinate development of equipment with NSF and ensure seamless transition into user operations (key instruments include SECAR, GRETA, HRS, ...)
- **MSU:** Responsible partner with strong commitment to users, NSF, and DOE
 - MSU has committed to (and delivers) a \$94.5 M cost share to the FRIB project. In addition, MSU has committed to contributions worth well over \$320 M (original commitment: \$220 M)
- **DOE and NSF coordination via FRIB Joint Oversight Group (JOG)**
 - **Reduced capacity world-wide, accentuated by closure of HRIBF at ORNL and reduced research at GSI, presents a great opportunity for NSCL to play a preeminent role on the world-stage**
 - Large impact of NSF investments: cutting edge research with beams from NSCL's CCF now leads to world-leading science on day one of FRIB operations



NSCL/FRIB Status Update

NSF:

- Funding at \$22.5 M in FY2014 is well below the *minimum-need level of \$25 M for FY2014*, which had been recommended by an NSF-appointed expert peer review committee and authorized by the National Science Board
- 4,500 hrs of CCF + ReA3 operations for research requires a minimum of \$26 M in FY2016

MSU:

- FY2014: \$2.5 M in support of NSCL operations, \$3.4 M for upgrades and projects, and \$0.8 M for ReA3 completion – commitment ends after FY2015
- Approx. \$5.2 M in support of ReA6 phase I (proof-of principle bottom-up cryomodule with two $\beta=0.85$ cavities and one solenoid) – commitment ends Dec. 2014
- Approx. \$25 M for SRF High Bay (over two years) in support of SRF R&D and cryomodule production
- MSU has granted permission to plan office addition phase 3 (6 stories, approx. \$30 M)

FRIB:

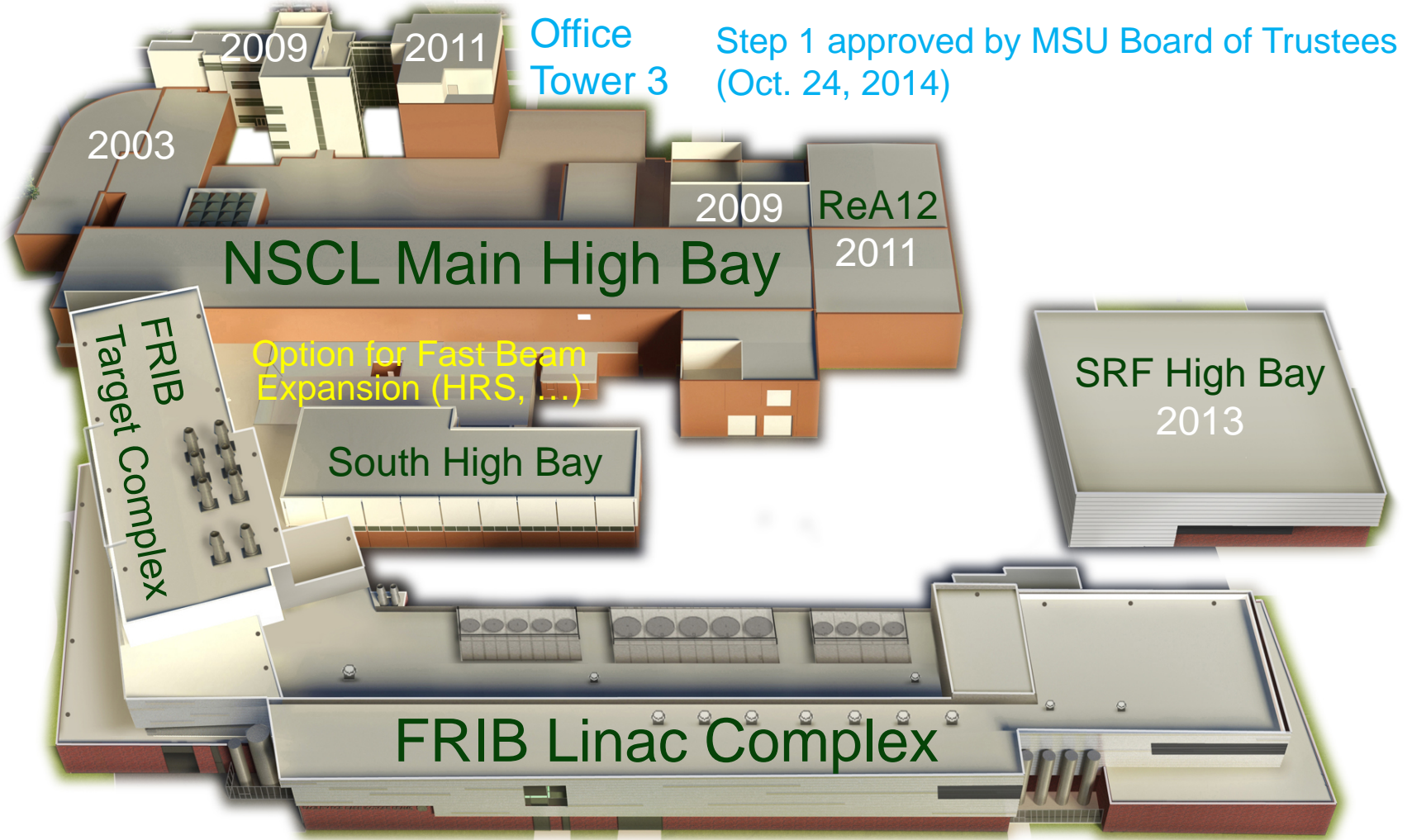
- March 2014: Start of civil construction (8 weeks ahead of schedule)
- August 2014: DOE approves CD-3b

The future looks extremely bright – but increased NSF funding is needed for operations and to complete ReA6-12 upgrade



Laboratory Building Plan

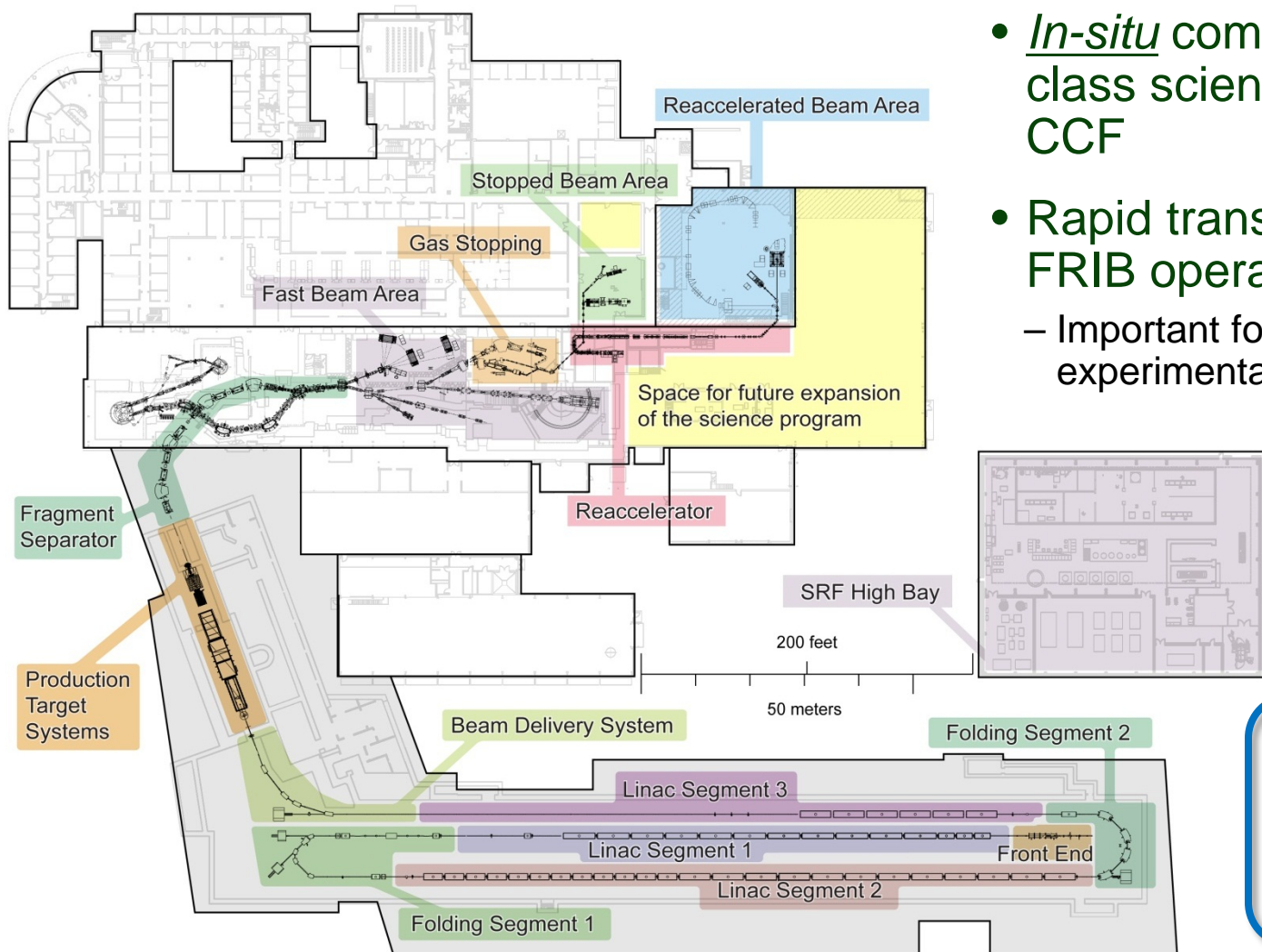
MSU investments exceed initial commitment to address emerging user needs



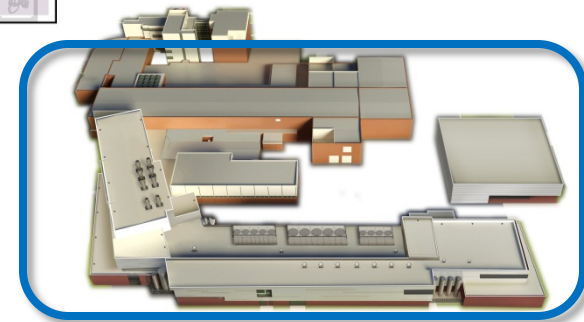
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NSCL-FRIB Integration Plan

Minimal disruption of world-leading science and education program



- *In-situ* commissioning and world-class science with beams from CCF
- Rapid transition from CCF to FRIB operations (≤ 14 months)
 - Important for graduate program in experimental nuclear science



Users are developing new experimental apparatus to address emerging scientific opportunities – new, MSU-funded SRF High Bay frees up the needed space for this new equipment



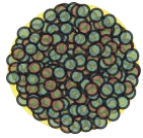
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ReA6-12 should be started immediately

C.K. Gelbke, NSAC 11/17/2014, Slide 6

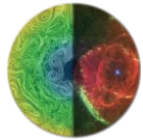
NSCL Science Is Aligned with National Priorities

Articulated by National Research Council RISAC Report (2006), NSAC LRP (2007), NRC Decadal Survey of Nuclear Physics (2012), "Tribble Report" (2013)



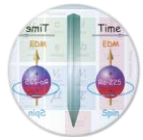
Properties of nuclei – NUCLEI SciDAC, FRIB Theory Center (Hannah Chair + 3 new positions)

- Develop a predictive model of nuclei & their interactions – Anticipate new LQCD effort
- Many-body quantum problem: intellectual overlap to mesoscopic science, quantum dots, atomic clusters, etc. – developing strong ties to new Computational Science Department



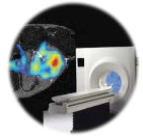
Astrophysical processes – JINA-CEE (1 new faculty, +1 new position)

- Origin of the elements in the cosmos
- Explosive environments: novae, supernovae, X-ray bursts ...
- Properties of neutron stars



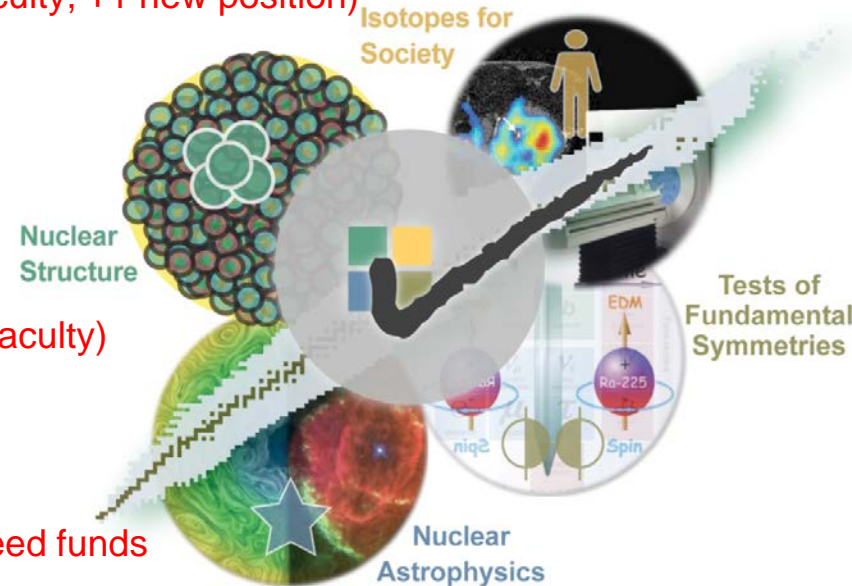
Tests of fundamental symmetries – (1 new faculty)

- Effects of symmetry violations are amplified in selected rare isotopes



Societal applications and benefits – MSU seed funds

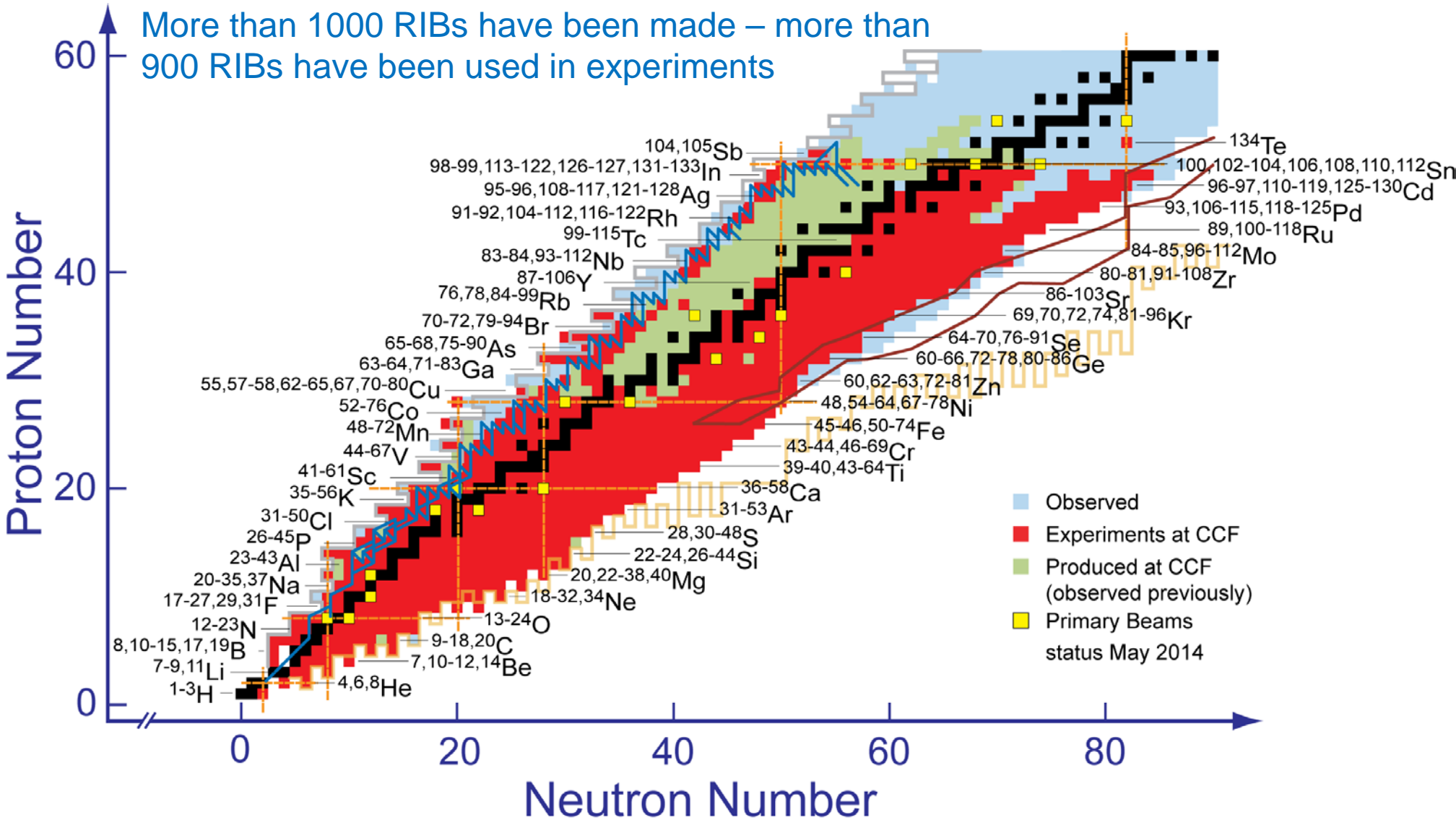
- Bio-medicine, energy, material sciences – Varian, isotope harvesting, ...
- National security – NNSA



Reaping benefits from recent investments while creating future opportunities

Exotic Beams Produced in Flight at NSCL's CCF

Opportunities for world-leading research *and new developments at the cutting edge*



National Science Foundation
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New equipment immediately benefits research with beams from CCF *and* will have lasting benefits for research at FRIB

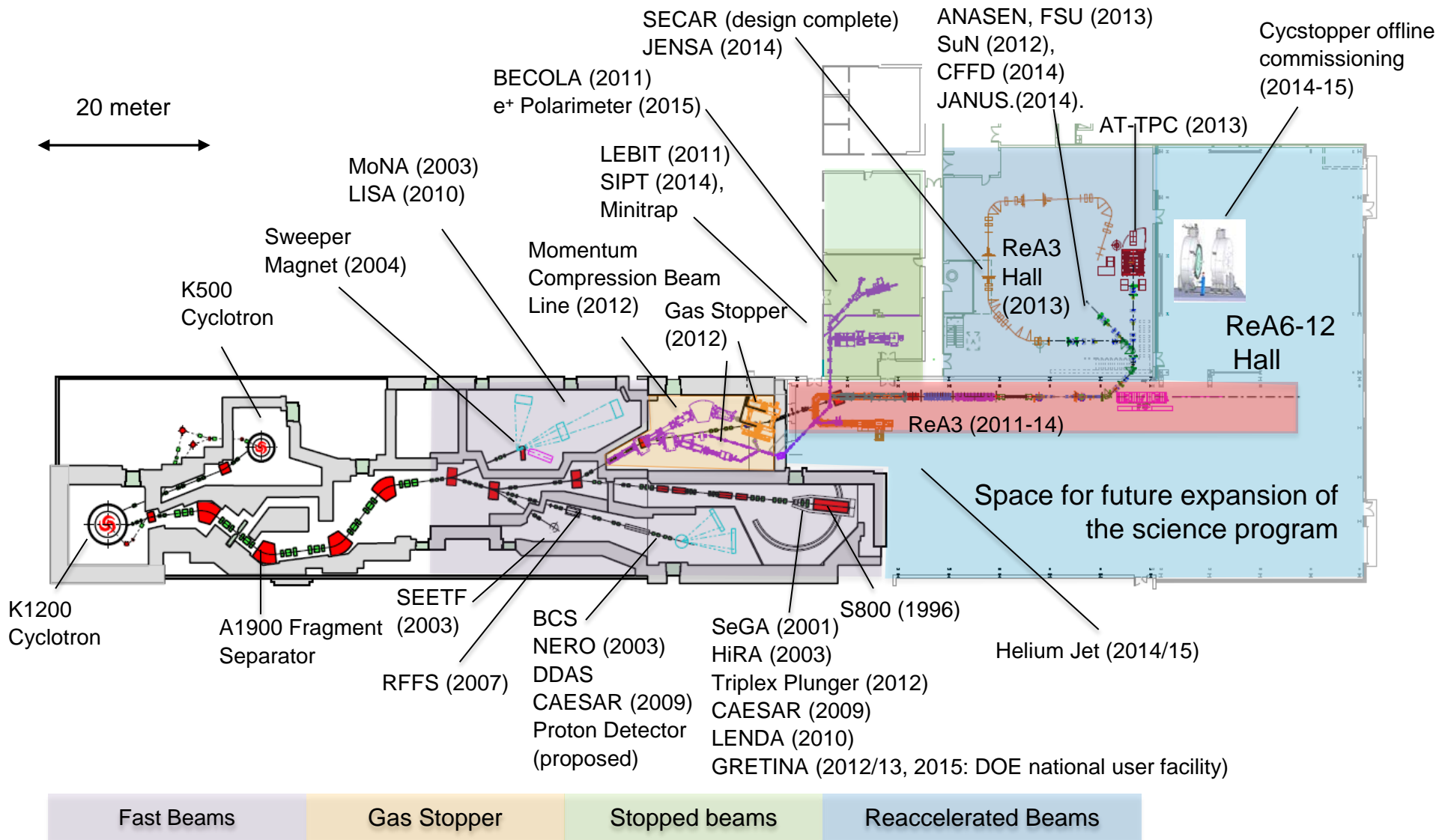
C.K. Gelbke, NSAC 11/17/2014, Slide 8

World-Leading Science with Beams from NSCL's CCF while FRIB Is Being Built

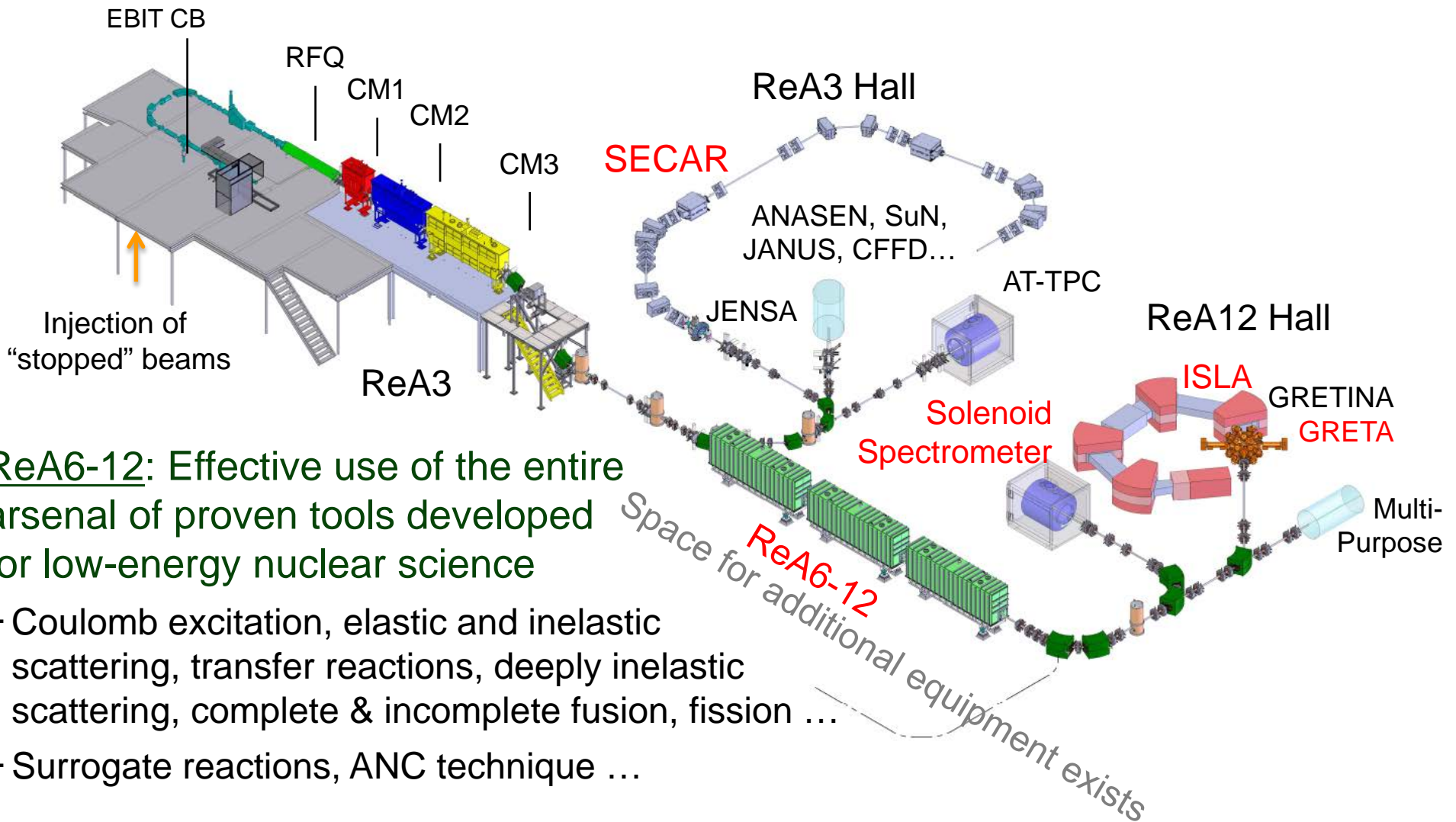
- NSCL is the only facility world-wide that combines chemistry independent in-flight production of rare isotopes with stopping and reacceleration capability
 - Development of new and often unique primary beams (^{76}Ge , ^{82}Se , ^{96}Zr , ...) provides access to regions of the nuclear chart not easily accessible elsewhere
- Recent investments in state-of-the art experimental equipment provides superb opportunities to do world-unique rare isotope research with the (modest intensity) beams from the coupled cyclotrons
 - The combination of GRETINA and the S800 spectrograph continues to push the envelope for nuclear structure studies via in-beam γ -ray spectroscopy. After highly successful GRETINA campaign in 2012-13, GRETINA will return to NSCL in 2015
 - World-unique opportunities for reaccelerated beams of rare isotopes with modern suite of instruments (JENSA, AT-TPC, ANASEN, SuN, JANUS, CFFD, Gretina, ...)*
 - Precision physics with keV-beams and innovative new equipment (BECOLA, SIPT)*
 - Developing capability for commensal rare-isotope harvesting ...
- It makes perfect sense to expand the existing lead by upgrading the energy reach for reaccelerated beams
 - Construction of ReA6-12 is a high priority for the NSCL/FRIB user community – reaffirmed at recent Town Meeting (Texas A&M University, August 21-23, 2014)



NSF Plays a Critical Stewardship Role for Maintaining and Evolving Cutting-Edge Equipment



ReA6-12: World-Unique – Can Be Built without Interrupting Research with ReA3



ReA6-12: Effective use of the entire arsenal of proven tools developed for low-energy nuclear science

- Coulomb excitation, elastic and inelastic scattering, transfer reactions, deeply inelastic scattering, complete & incomplete fusion, fission ...
- Surrogate reactions, ANC technique ...

NSCL Funding Needs

Opportunity for NSF NP to assert world-leading nuclear science for coming decades

- 4,500 hrs CCF+ReA3 operations: \$26 M in FY2016 + inflation for out-years (slope approx. 1000 hrs. per \$1 M)
- Investments appropriate to NSF (costs are rough estimates):
 - Next-generation EBIT ion source (will also mitigate single point failure): \$3.9 M
 - Increase bunch separation (currently 16 ns) with minimal beam loss: \$1 M
 - Completion of CM4 (ReA6): \$2 M
 - Construction of ReA9-12: \$8 M
 - Beamlines, shielding & infrastructure to accommodate GRETINA, ISLA ... : \$5 M
 - ISLA: \$10-12 M (estimate two years/4 FTE years of R&D and 4 years of construction)
- Investments appropriate to DOE:
 - SECAR
 - High Rigidity Spectrometer (HRS) + High Bay
 - GRETA
 - Isotope harvesting



Summary and Perspective

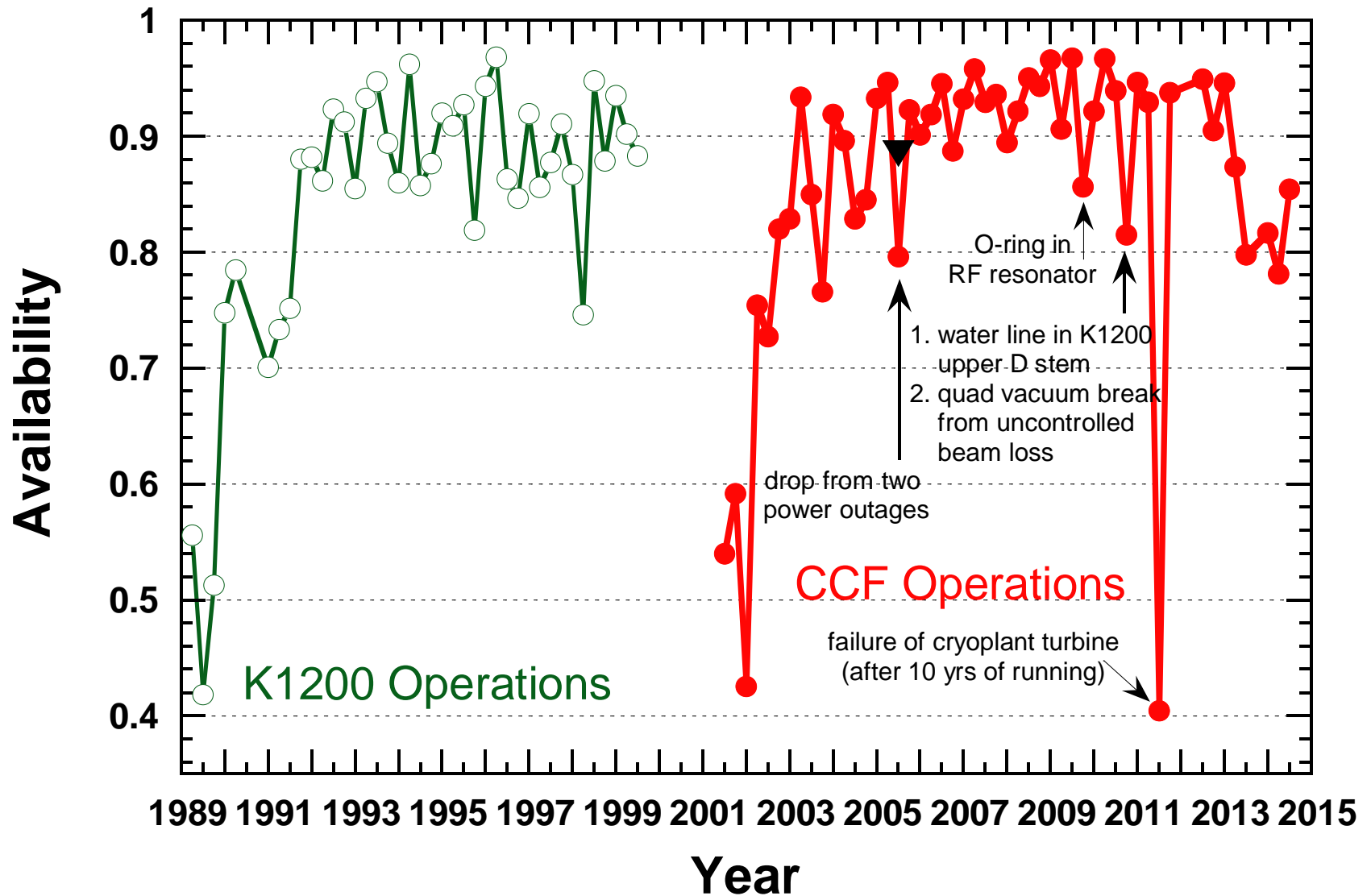
- NSCL is the Nation's flagship facility for rare isotope science and user operations – funded by NSF and fully aligned with national priorities
- Research at NSCL continues to be of high quality and high productivity
 - Effective mentoring of graduate students, postdocs and faculty, and continued implementation of the diversity plan
 - Initial steps toward an FRIB Theory Center, an emerging national effort with strong ties to high performance computing – critical for a high-impact science with FRIB
- Emerging risk: severely constrained operating funds make it increasingly difficult to update and maintain equipment – prerequisites for high CCF availability and high user satisfaction
- Emerging opportunity: world-wide shortage of capacity can propel NSCL to play a preeminent role on the world-stage with adequate funding for operations
- ReA6-12 energy upgrade and equipment have been a high priority for users with a compelling science case, but this will require additional funds
 - A world-leading capability for reaccelerated beams above the Coulomb barrier should be implemented immediately so that it can be used for science with beams from NSCL's CCF and be ready for world-leading research with beams from FRIB on day one



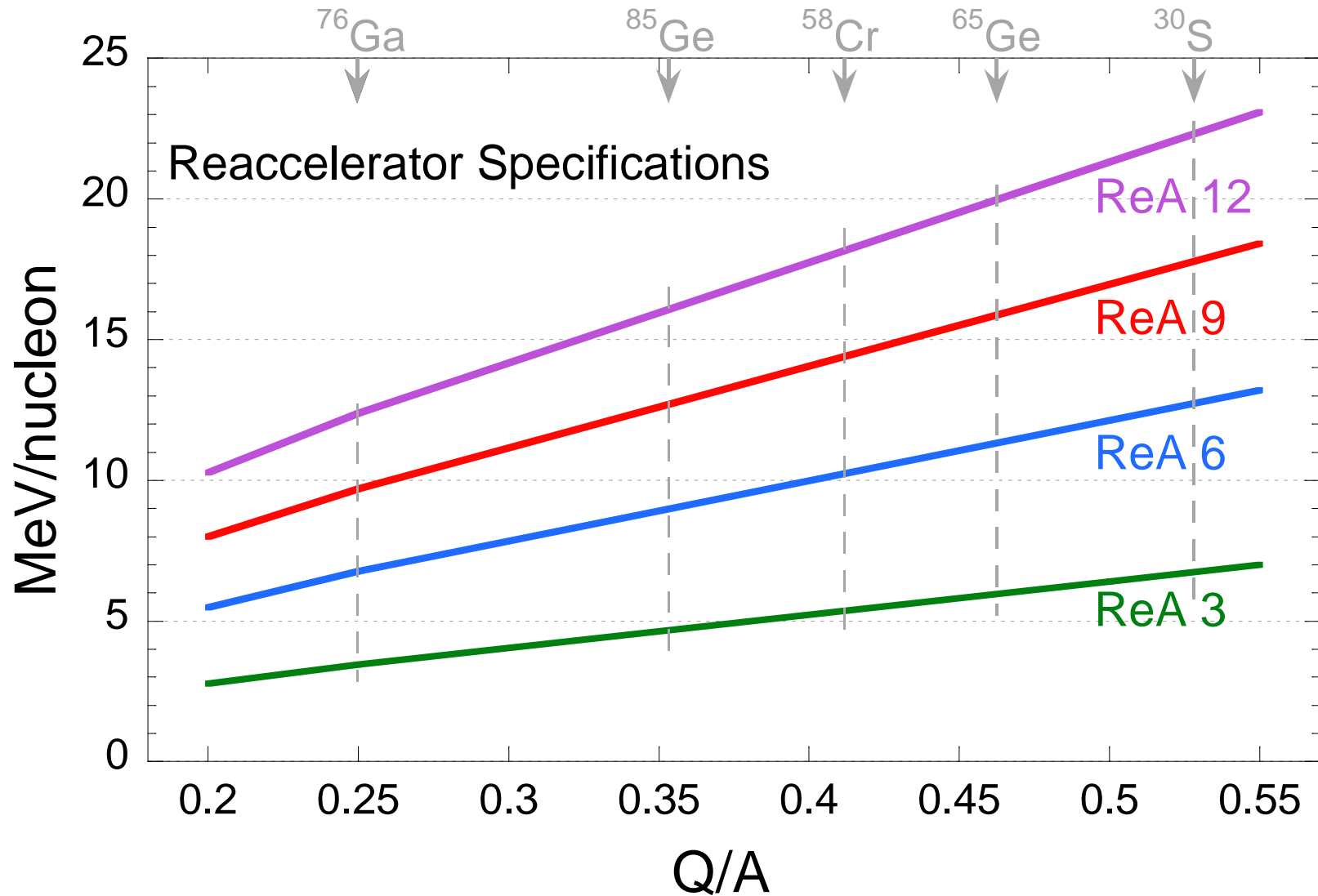
Appendix and Backup Slides



NSCL K1200 and CCF Availability



Reaccelerator Performance Specifications



FY2014 NSCL Operations Costs and Funding

Details have been shared with OMB/OSTP and NSF

- FY2014 NSF Funding
 - NSF funding at \$22.5 M
 - NSF A1900 spare funded at \$ 490 K
- FYI 2014 cost of 'bare' operations (no improvements or upgrades): \$25 M
 - Required MSU operations support: \$2.5 M
- Additional MSU supported improvements and capability upgrades: \$3.4 M
 - EBIT cooler buncher and stopped beam facility enhancements (\$ 0.9 M)
 - Cycstopper off-line test set-up (\$1 M)
 - AT-TPC integration and improvements (\$ 0.24 M)
 - ReA low energy beam lines (\$ 0.33 M)
 - Helium purifier (\$ 0.26 M)
 - ReA3 cryoline extension (\$ 0.37 M)
 - Operations projects (\$0.28 M)
- Plus \$0.8 M for ReA3 completion (previous MSU commitment)



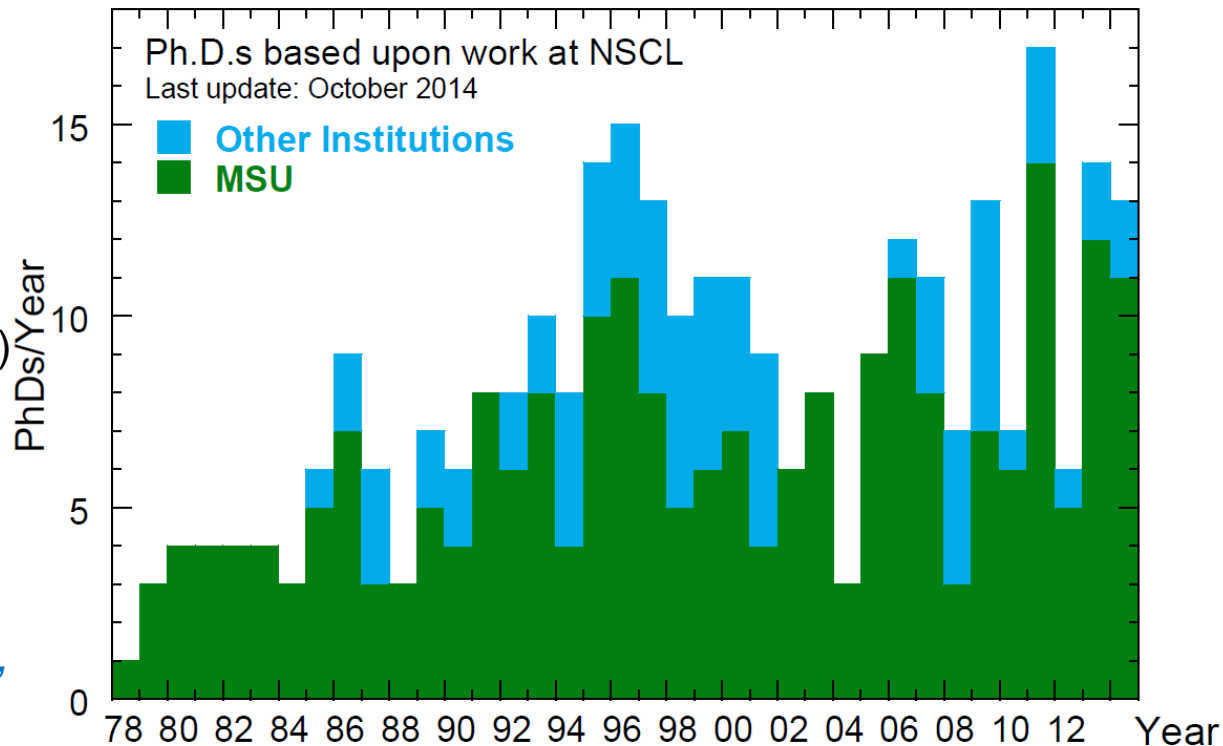
Strong Commitment to Education

Nuclear physics, nuclear astrophysics, nuclear chemistry, accelerator physics & engineering

- NSCL *employs* approximately 150 students throughout the year, nearly half of them are graduate students working towards an advanced degree
 - Hands-on training and interaction with world-leading scientists on a daily basis
 - Top ranked nuclear physics graduate program educates over 10% of the nation's nuclear science Ph.D.s ($\approx \frac{3}{4}$ from U.S.) on average more than one year faster than national average
 - Cooperative agreement supports approximately half of NSCL's graduate students
- Strong engagement in REU, CEU, and PAN programs
- Strong outreach program
 - Tours for over 3,300 visitors, plus over 900 open house visitors
 - Developing educational app (tablets)
 - Co-sponsored (with Yale U) the publication of "Blazing the Trail"

"The education, and particularly the mentoring programs, for postdocs and graduate students are a model for other institutions."

NSF Site review report (2014)



Strong Commitment to User Community

NSCL User Group has merged into FRIB Users Organization – over 1380 members

- User needs and high user satisfaction are important drivers of NSCL planning
 - Monthly phone conferences with NSCL Operations Subcommittee* of FRIB Users Organization
 - *Michael Carpenter, (ANL); Mark Riley (FSU), Krzysztof Rykaczewski (ORNL), Michael Smith (ORNL, ex. off.)
 - CCF availability > 90%, highly successful GRETINA campaign, user feedback
- Joint Meeting of ATLAS, HRIBF, NSCL, GRETINA, and FRIB Users, Aug. 18-20, 2011, MSU:

– The progress made on ReA3 is important, and we support further increases in energy and preparations for the experimental program in the near term ...



- Low energy nuclear science community meeting at ANL, Aug. 17-18, 2012
 - Resolution: *We reaffirm in the strongest possible terms the scientific vision of FRIB ...*
- Low-energy community meeting at MSU, Aug. 23-24, 2013

– Resolution: “The Low Energy Nuclear Physics Community recommends that agencies support operation[s] ... We endorse efforts to explore multi-user capabilities...”

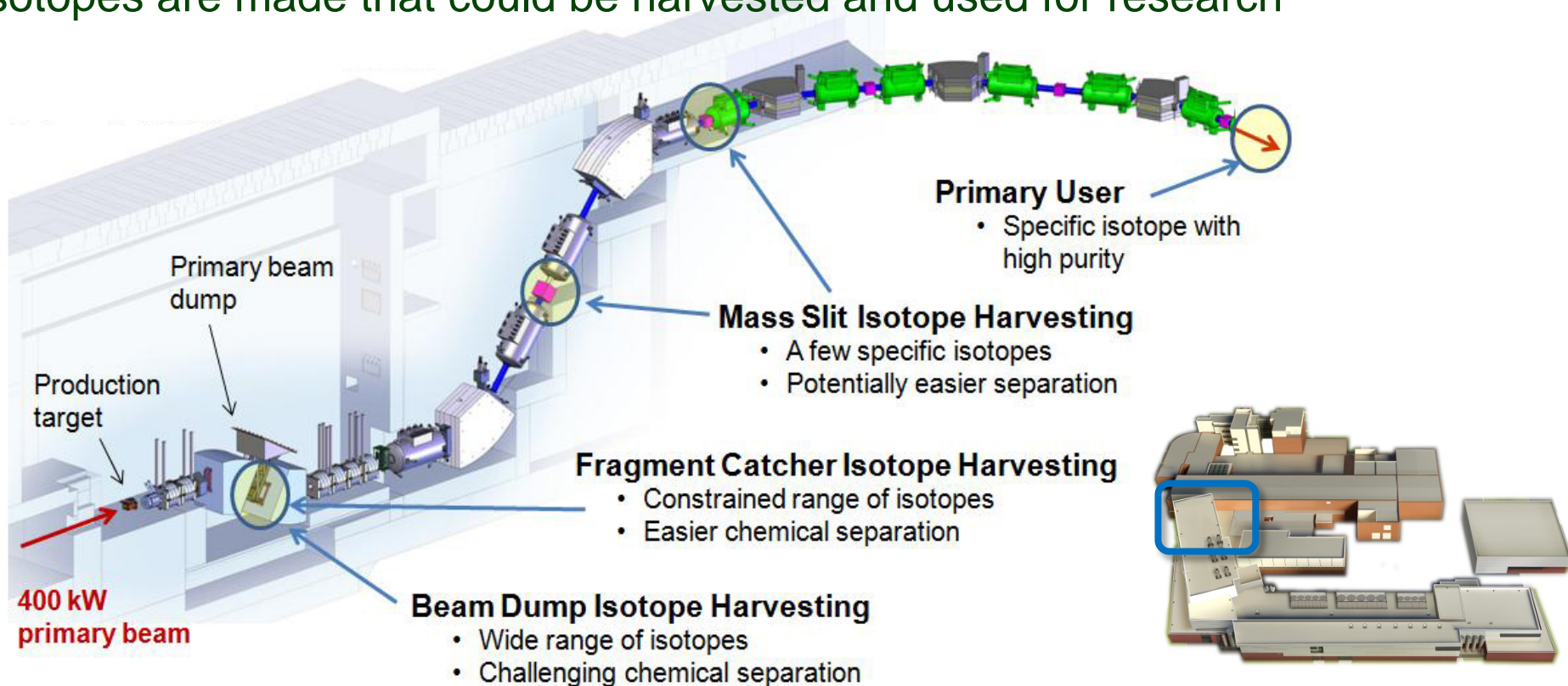


Low-energy community meeting at Texas A&M University, Aug. 21-23, 2014:
Strong support for FRIB and ReA12

Built-in Provisions for Isotope Harvesting

Opportunity for DOE: seminal development work could be initiated at CCF

- High-power in-flight production target and three-stage high-acceptance high-resolution fragment separator – rare isotope beams of high purity
- During production of a primary rare-isotope beam, often hundreds of other isotopes are made that could be harvested and used for research



Important opportunities for cross-disciplinary and applied research