NSF News

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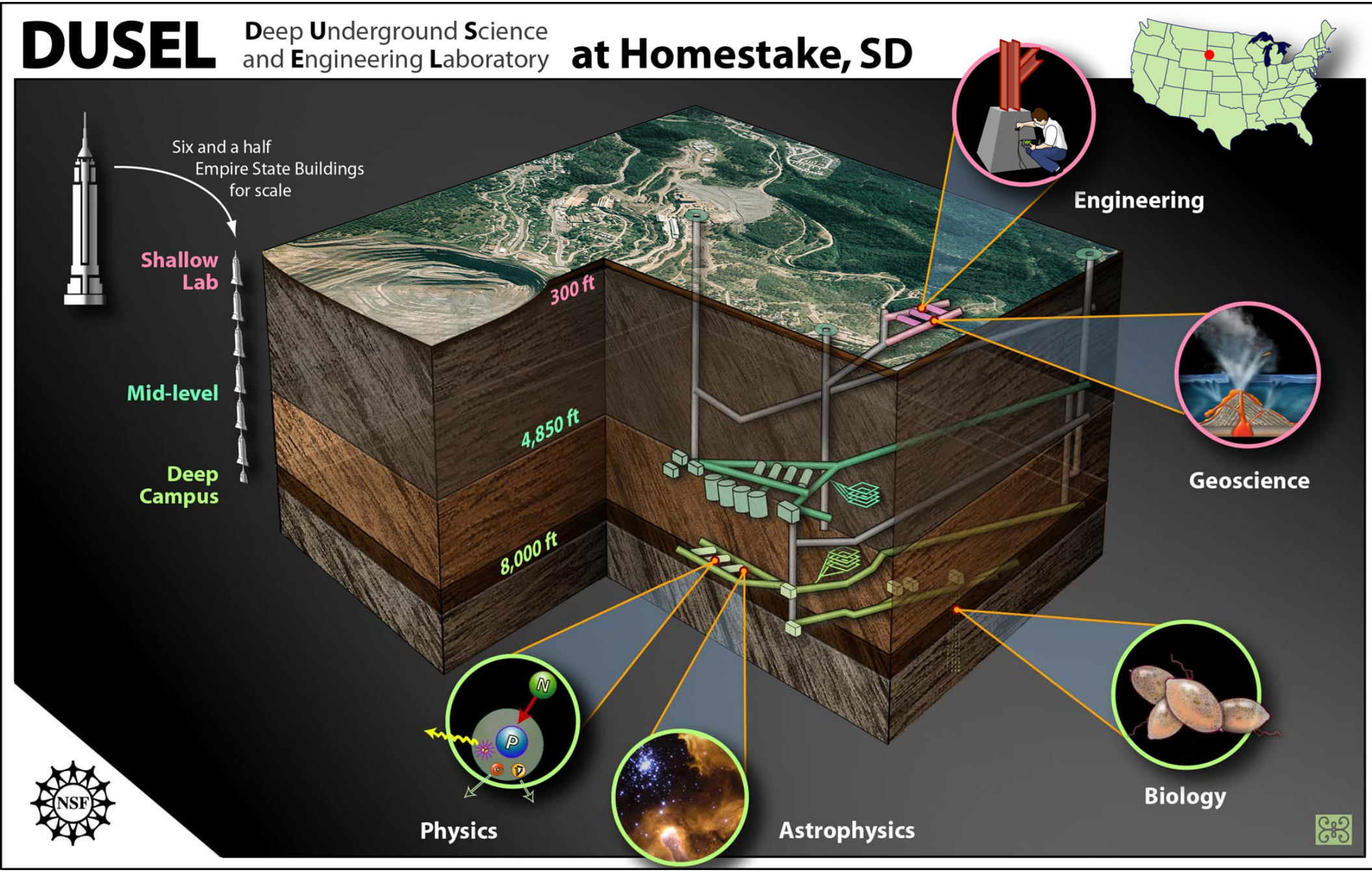
TOPICS

- Budget information
- People
- Major Projects
- DUSEL
- ASPERA

Major Projects

- Projects Under Construction
  - IceCube
  - AdvLIGO
- New Project in Preliminary Design
  - DUSEL (long baseline neutrino, Dark Matter, proton decay, neutrinoless double beta decay, low-energy nuclear reactions, supernovae/primordial neutrinos)
- Proposed Upgrade
  - LHC Detectors


DUSEL
Deep Underground Science and Engineering Laboratory
at Homestake, SD
Six and a half Empire State Buildings for scale
Shallow Lab
Mid-level
Deep Campus
300 ft
4,850 ft
8,000 ft
Engineering
Geoscience
Biology
Physics
Astrophysics
N
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Cosmic Questions for DUSEL

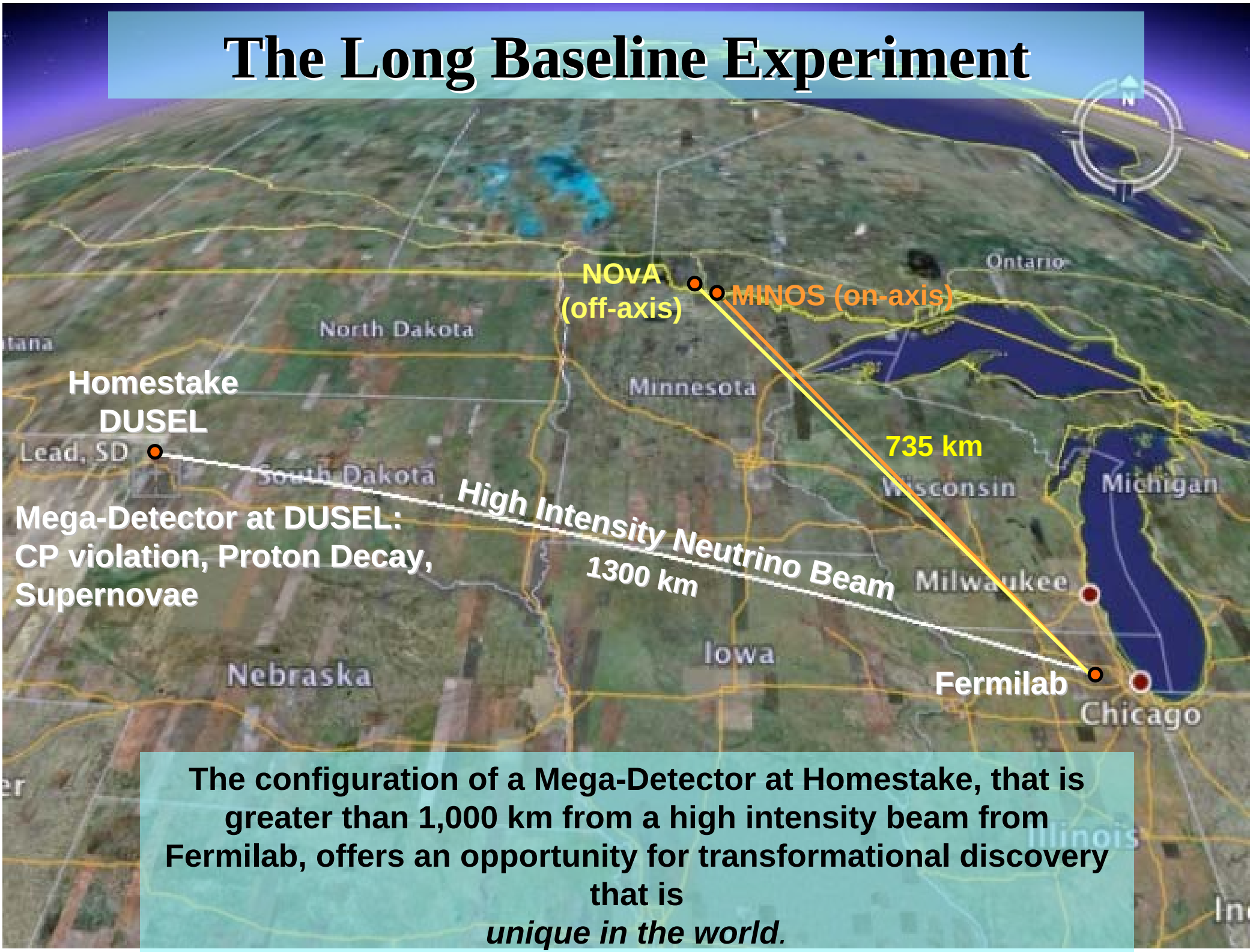
- Of what is the Universe made?
- What is Dark Matter?
- What are neutrinos telling us?
- Where did the antimatter go?
- Are protons unstable?
- How did the universe evolve?

DUSEL Physics Experiments

- The aforementioned questions are addressed at DUSEL via a variety of experimental probes:
  - Direct Detection of Dark Matter
  - Neutrino-less Double-Beta Decay
  - Nuclear Astrophysics
    - Accelerator-based cross-section measurements
  - Solar Neutrinos
  - Long Baseline Experiment, Proton Decay, and Supernovae Remnants (Mega-Detector)

DUSEL MREFC funding would support the construction of forefront experiments in nuclear, particle, and astro-physics in partnership with DOE-HEP & NP and international partners.

The Long Baseline Experiment



The configuration of a Mega-Detector at Homestake, that is greater than 1,000 km from a high intensity beam from Fermilab, offers an opportunity for transformational discovery that is
unique in the world.

Community Planning Activities & Reports

- **Community Activities, Advisory Committee Reports**
  - **Bahcall report (2001)**
  - **Nuclear Science Advisory Committee (NSAC) Long-Range Plan (2002, 2007)**
  - **International Workshop on Neutrinos and Subterranean Science (NESS, 2002)**
  - **High Energy Physics Advisory Committee (HEPAP) Long-Range Plan (2003)**
  - ***EarthLab* (2003)**
  - **DOE 20-yr. Facility Plan (2003)**
  - **The Neutrino Matrix (Four APS Divisions, 2004)**
  - **Quantum Universe – The Revolution in 21st Century Particle Physics (2004)**
  - ***Deep Science* (2006)**
  - **The Frontiers of Nuclear Science: A Long Range Plan (2007), Nuclear Science Advisory Committee (NSAC).**
  - **Particle Physics Project Prioritization Panel (P5): A Strategic Plan for the Next Ten Years (2008)**
- **National Research Council, National Science and Technology Council Reports**
  - **Connecting Quarks to the Cosmos (2003)**
  - **Neutrinos and Beyond (2003)**
  - **Physics of the Universe – A Strategic Plan for Federal Research at the Intersection of Physics and Astronomy (2004)**
  - **Revealing the Hidden Nature of Space and Time (*EPP2010*, 2006)**

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.

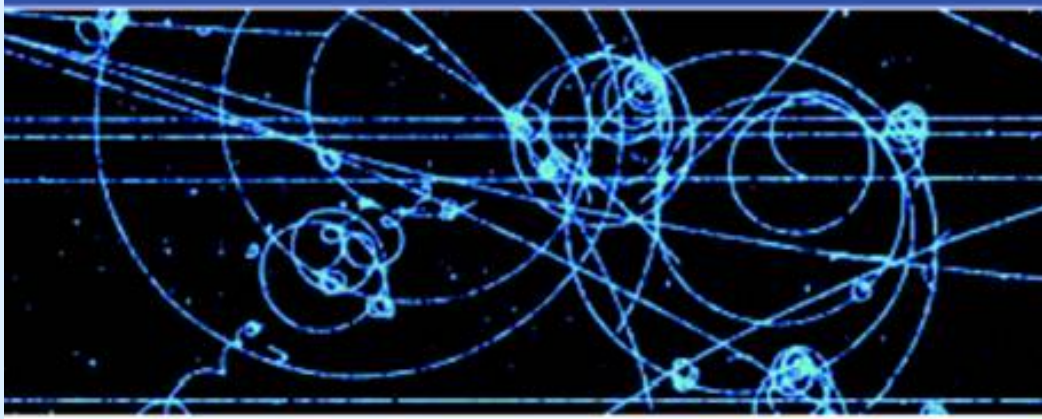
High Density and Temperature Physics

- 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

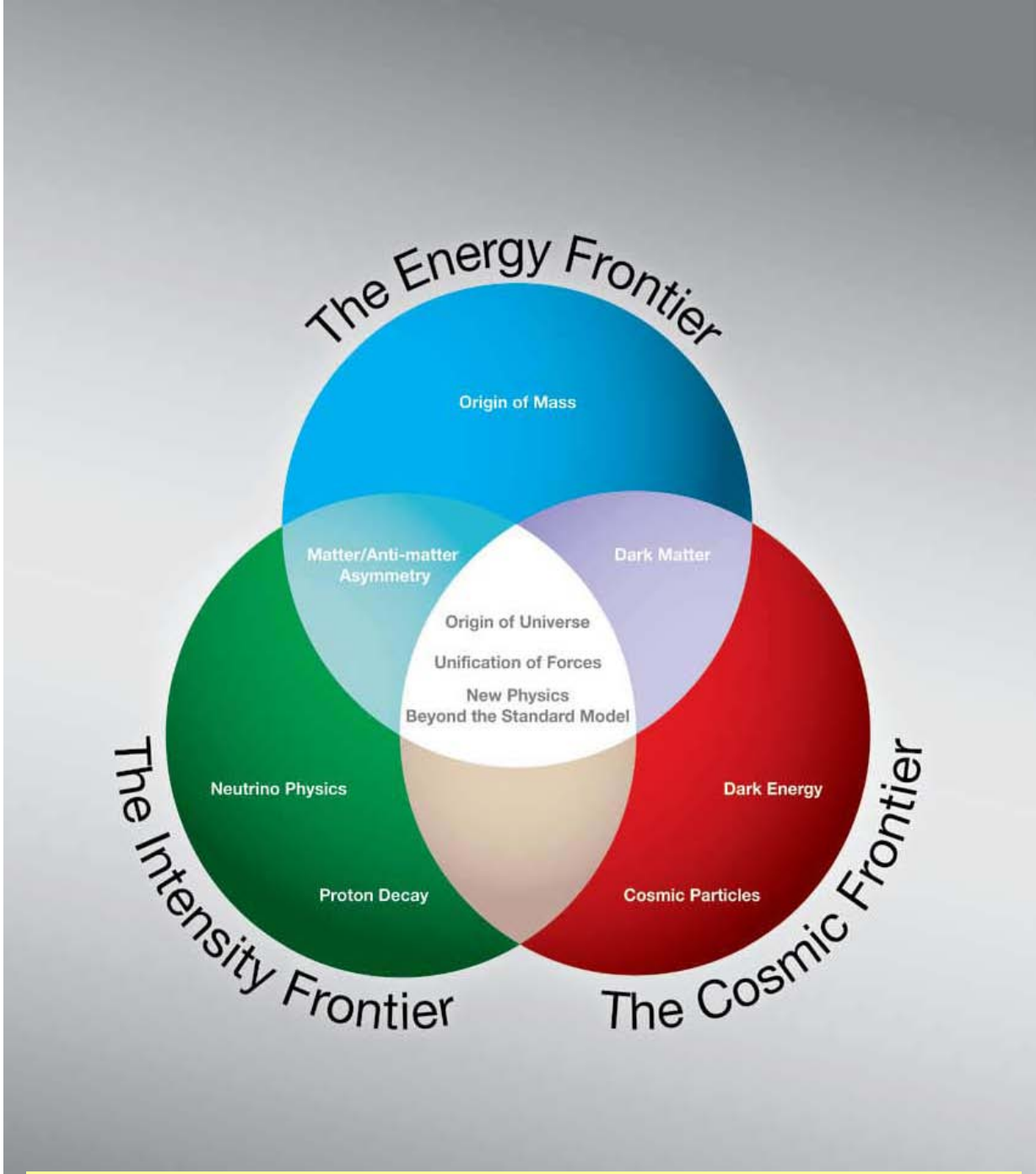
THE PHYSICS OF THE UNIVERSE

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



Particle Physics Project Prioritization Panel (P5)

- **The Particle Physics Project Prioritization Panel (P5) is a sub-panel of the High Energy Physics Advisory Panel (HEPAP).**
- **Charged in Jan 2008 by NSF and DOE with recommending a 10-year road map for particle physics.**



The three frontiers of research in particle physics, as expressed by the P5 Panel, which form an interlocking framework that addresses fundamental questions about the laws of nature and the cosmos.

P5 Recommendations

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

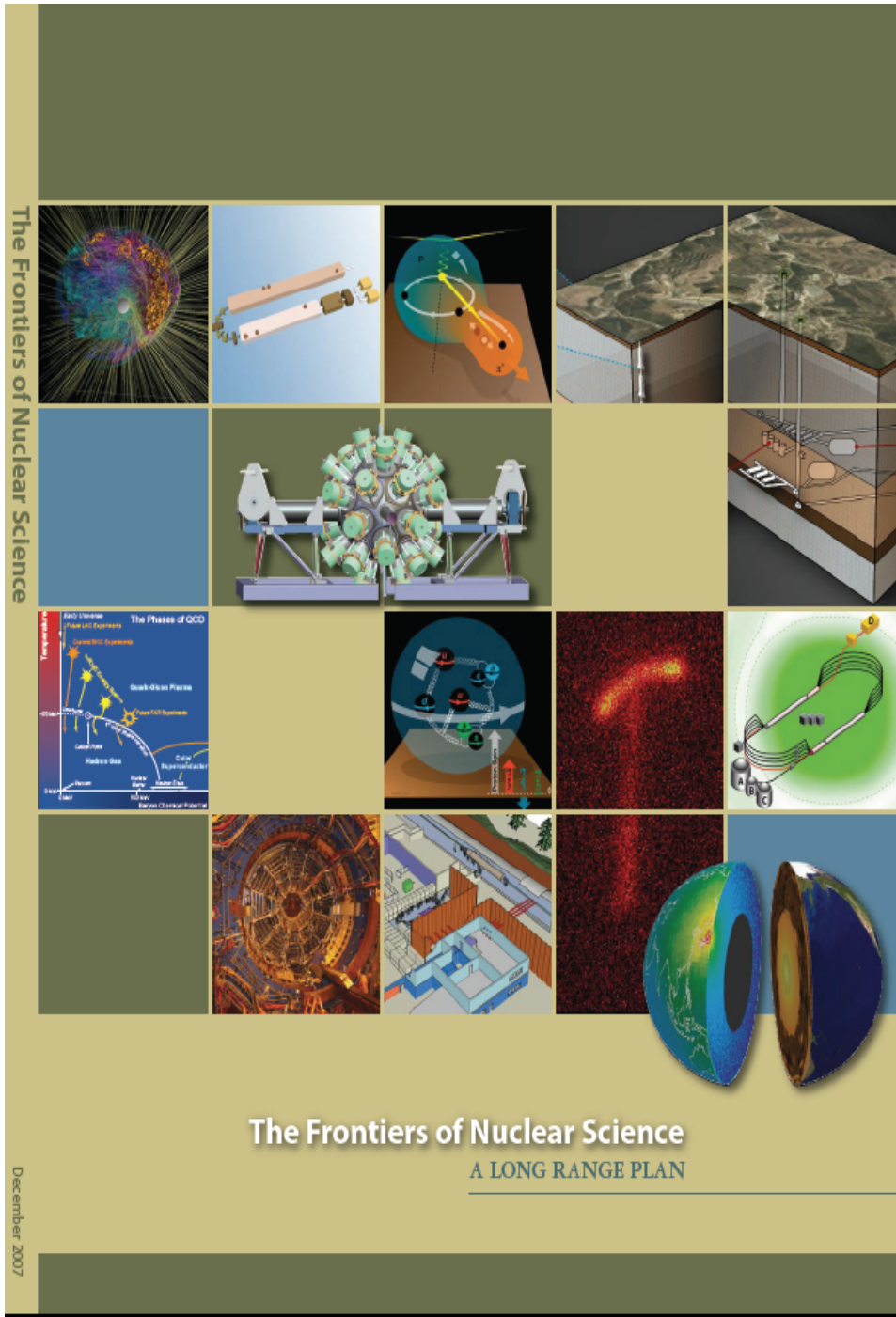
> ***"The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL laboratory and a high-intensity neutrino source at Fermilab."***
>
> ***"The panel endorses the importance of a deep underground laboratory 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

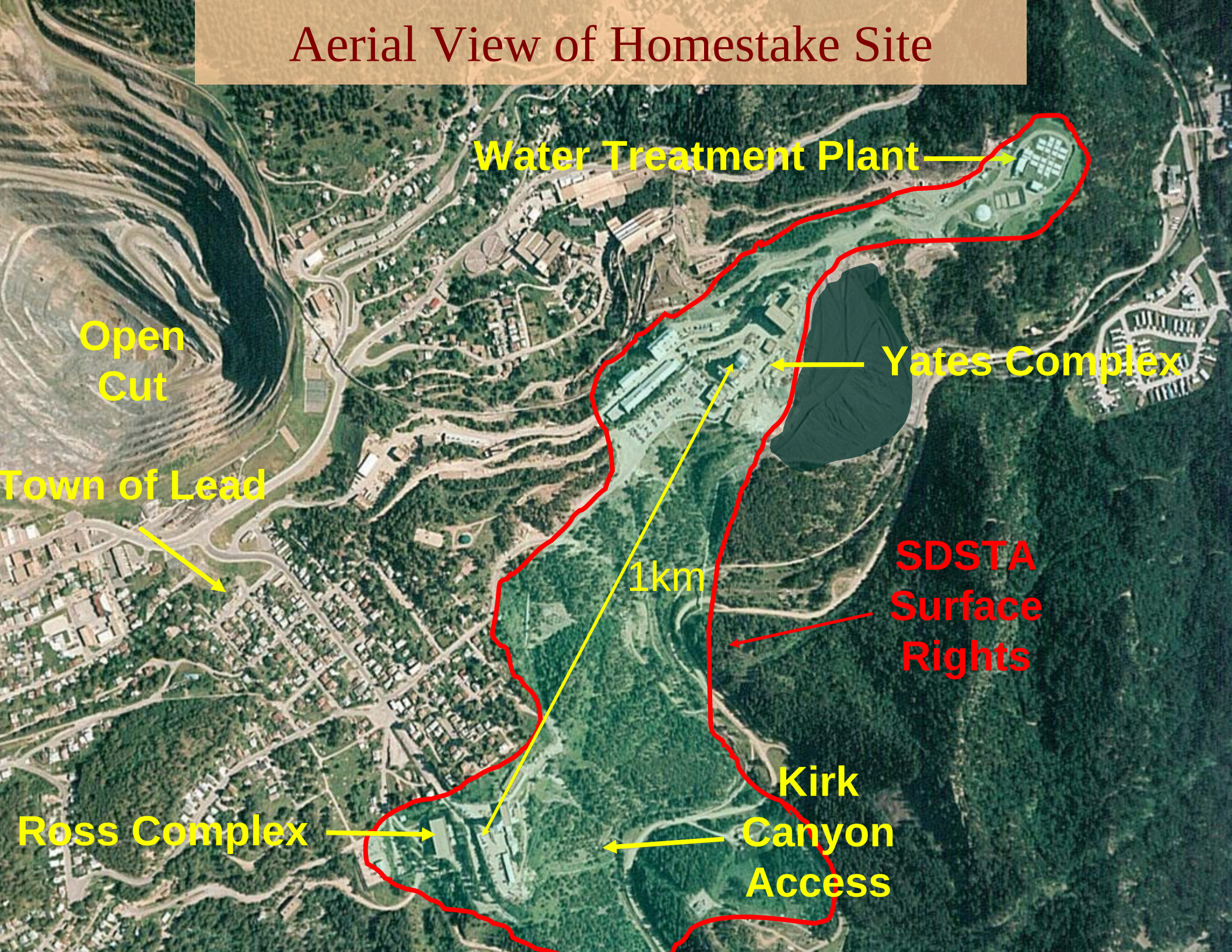
- Initiated at Town Meeting at NSF, March 2004.
- Solicitation 1 (S1): define site-independent science scope and infrastructure needs; unify the community (awarded Jan 2005).
- Solicitation 2 (S2): develop conceptual designs for one or more sites (two awarded, Sep 2005).
- Solicitation 3 (S3): facility design for an MREFC candidate (one awarded – Homestake, U.C. Berkeley).
  - $15M total over three years, starting in September 2007.
- Solicitation 4 (S4, in clearance): technical designs for candidates for the DUSEL suite of experiments.
  - $15M total over three years.

S3 & S4 enable costs to be estimated for infrastructure, experiments & operations.

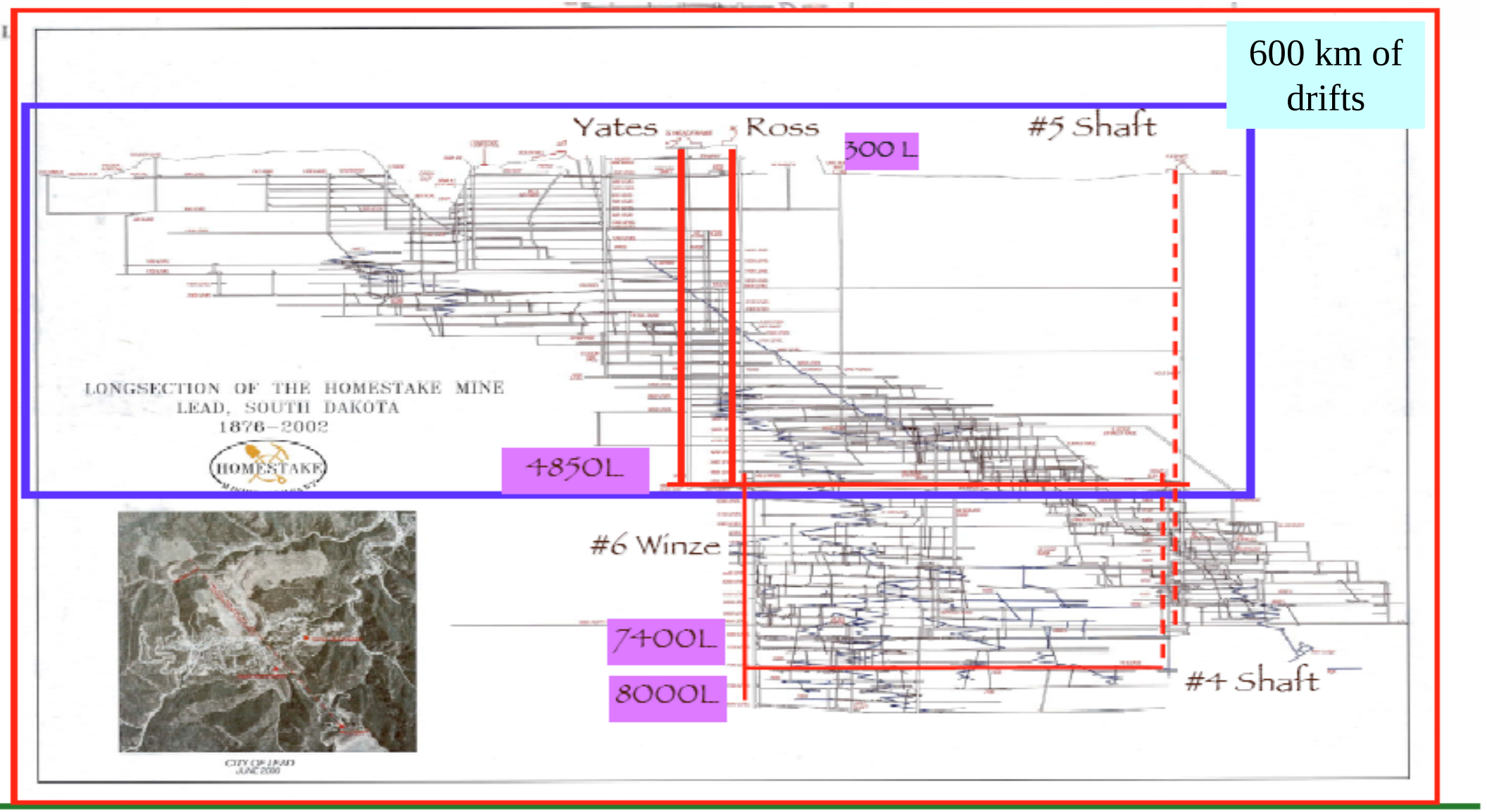
Solicitation 3: DUSEL Site Selection

- Goal was to select single site and team to develop technical design of the facility.
- Four proposals were reviewed by multidisciplinary 22-member expert panel.
- Review included site visits & reverse site visits.
- Panel unanimously voted by secret ballot to recommend the Homestake proposal to the NSF for funding. NSF concurred.
- Cooperative agreement to University of California, Berkeley in Sep 07. Total award $15M over 3 years to start design work.

Aerial View of Homestake Site



Homestake Mine Workings



- **South Dakota Science and Technology Authority (SDSTA) owns land (footprint and below) outright and in perpetuity.**
- **Future use dedicated to research and education.**

Recent/Future DUSEL Events

- **2 November 2007, DUSEL Town Meeting, National Academy of Sciences, Washington, D.C., following selection of Homestake as site for design development**
- **3-4 November 2007, DUSEL Community Workshop, Washington, D.C.**
  - 220 participants
- **20-26 April 2008, DUSEL Homestake Workshop, Lead, SD**
  - 350 participants
- **16-18 July 08: Internal project review of facility**
- **8 September 2008, DUSEL Physics JOG MOU drafted**
- **17 November 2008, lifecycle funding plan submitted by PHY**
- **9 January 2009, Deadline for S4 proposals**
- **28 – 30 January, NSF Review of DUSEL facility baseline plan**
- **CY 2009, EIS for DUSEL (dominated by megaton detector)**
- **CY 2009, Geotechnical Board to advise on large detector caverns**

Status of Sanford Laboratory

- SDSTA holds $124M for development of Sanford Laboratory.
  - $70M private benefactor (Sanford), $44M state SD, $10M HUD.
- Will fund:
  - Education center.
  - Refurbishment of 4850L & 7400L (partial).
  - O&M of Sanford Laboratory activities.
- Initial allotment ($60M) released, in use.
  - As with this allotment, release of remaining funds is conditional.
- Key staffing underway, including Laboratory Director.
- SDSTA began mine re-entry late July 2007.
  - Dewatering began 21 April 2008.
- Beneficial occupancy of 4850L scheduled CY09.
- Decoupled from MREFC process, but integrated into DUSEL facility planning.

Astroparticle Physics Projects

- **Gravitational Waves: LIGO/AdvLIGO (GEO, VIRGO, TAMA, 11 countries)**
- **Cosmological Neutrinos: IceCube (NSF-OPP, Germany, Sweden, Belgium)**
- **Underground Physics: DUSEL (DOE-HEP, NP)**
- **Dark Matter: CDMS, XENON, WARP, ZEPLIN, DRIFT, COUPP (NSF-AST, DOE-HEP, INFN, PPARC, Germany, Poland)**
- **Cosmic Rays: AUGER, HiRes, TA, Veritas, Milagro (NSF-AST, DOE-HEP, Japan, Korea, Canada, Ireland, Smithsonian, 17 more countries)**
- **Neutrinos: Borexino, Double Chooz, CUORE (DOE-NP, INFN, France, Germany, Brazil, Japan, Russia, Spain, UK)**
- **Structure of the Universe: ACT, SPT (NSF-AST, OPP)**
- **B-Mode Polarization of CMB: QUIET (NSF-AST)**
- **Origin of the Elements: NSCL (DOE-NP)**

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.

A New Kind of Global Collaboration Paradigm?

- ASPERA meeting last week brought together EU, US, Canada, Russia, Japan, China, India
- US is very strong in astro-particle physics, but everyone agrees international collaboration is essential for field
- Multiple major discovery experiments allow each region to have a key role
- In the case of underground lab activities, an international discussion group(s) could identify the most cost effective way to get science results and keep regions active in field.
- This could also be done more broadly, e.g., via the proposed OECD astro-particle physics activity
- This represents a multi-experiment, distributed international collaboration model different from centralized CERN, ITER, and SS models