Update on the Deep Underground Science & Engineering Laboratory (DUSEL)

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(also for Richard Fragaszy (ENG), David Lambert (GEO))
P5 Meeting
Fermilab
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Outline

• Overview, scientific program
• Solicitation process
• Site selection process & results
• DUSEL FY07/08 R&D
• Moving forward

Acronyms:
MREFC = Major Research Equipment and Facilities Construction funding line at NSF
MPS = NSF Mathematical and Physical Sciences Directorate
NIOSH = National Institute for Occupational Safety & Health
EPA = Environmental Protection Agency
PNA = Particle and Nuclear Astrophysics program
EPP = Experimental Particle Physics program
DUSEL Overview

• Joint initiative within NSF between Physics (lead), Engineering, and Geosciences
  – Biology currently serving in advisory capacity
• Science and engineering program driven by physics, being designed to accommodate a broad, evolving multidisciplinary program
• New opportunity for growth, diversity, interdisciplinary research
• Addresses worldwide need for extensive space at depth, for all programs, over multiple decades
• Intrinsically strong program for education, outreach
• Will enable new, long-term partnerships among disciplines, organizations: public, private, international
• Transformational, high-risk/high-reward, visionary facility & program
• #1 priority for new project start in Physics Division
Bahcall report (2001): NSF-DOE sponsored ad hoc committee of scientists strongly recommended that Homestake Mine be converted to a national underground laboratory.

NSAC Long-Range Plan (2002): Strongly supported development of an underground laboratory to enable some aspects of nuclear research, e.g., double beta decay.

NESS 2002: An NSF sponsored conference on Underground Science showcases the wide variety of science that would be enabled with an underground laboratory.

Connecting Quarks to the Cosmos (2003): Known as Turner Report, NRC panel recommended development of an underground laboratory to enable a number of fundamental science experiments.

HEPAP Long-Range Plan (2003): Supported development of an underground laboratory to enable some aspects of high energy research, e.g., long baseline neutrino detector and proton decay

Neutrinos and Beyond (2003): Known as Barish Report, NRC panel emphasized neutrino physics in international context, finding the need for a DUSEL-scale capability.

EarthLab 2003: An NSF sponsored report of the GeoSciences and GeoEngineering opportunities that would be enabled by an underground laboratory.

DOE 20-yr. Facility Plan: Includes physics experiments that would utilize DUSEL.

Physics of the Universe—A Strategic Plan for Federal Research at the Intersection of Physics and Astronomy (NSTC) 2004: Strongly supported development of an underground laboratory.

The Neutrino Matrix (Four APS Divisions) 2004: In every instance the need for suitable underground detector facilities emerges.

Quantum Universe—The Revolution in 21st Century Particle Physics, 2004: NSF-DOE HEPAP Sub Panel report identifies key science drivers and indicates need for DUSEL to address key questions

DUSEL Scientific Program

- Multidisciplinary, diverse suite of experiments:
- Life at Depth
  - Study of subsurface biosphere, isolated underground life forms
  - Life at high temperature, pressure, microbial activity at low respiration rates; associated genomic features
  - Lower campus: platform to drill deeper – 12000ft (120°C)
- Rock at depth
  - Large scale rock mechanics, slippage mechanisms
  - Scale/stress dependence of rock properties
  - Drilling; excavation; tunneling; fracture
- Fluid flow and transport at depth
  - Applications include stability of water supplies, hazardous waste disposal, geothermal power, remediation of contaminated groundwater
  - Studies of rock/water interface; high pressure, chemical/thermal gradients, etc
- Mineral resources and environmental geochemistry
DUSEL Scientific Program

• Very low level counting facility, experiments
  – Low background, underground physics, cosmogenics
  – Applications to homeland security

• Science, technology and engineering innovation
  – Novel microorganisms, analytic techniques for geomicrobiology, drilling and excavation technology, environmental remediation, subsurface imaging, …
  – Creation of pure crystals without cosmic ray induced “impurities”
  – Basic research in underground and mining safety
  – Excavation of very large stopes at depth; rock fracture at depth

• Neutrino physics
  – Neutrino-less double beta decay
  – Solar neutrinos
  – CP violation, long baseline experiment
  – Neutrino mixing angles
  – Nuclear astrophysics, low cross section measurements

• Dark matter searches
• Proton decay
• Supernovae neutrino observations
Three-tier process, announced to community March 2004:

Solicitation 1 (S1): January 2005, $400k awarded for site-independent study to:

- Bernard Sadoulet, UC Berkeley, Astrophysics/Cosmology, Chair
- Eugene Beier, U. of Pennsylvania, Particle Physics
- Charles Fairhurst, U. of Minnesota, Geology/Engineering
- Tullis Onstott, Princeton, Geomicrobiology
- Hamish Robertson, U. Washington, Nuclear Physics
- James Tiedje, Michigan State, Microbiology

Charged by NSF with:

- Organizing a dialogue within the community about a multidisciplinary DUSEL
- Determine whether there is a compelling justification for such a lab
- If there is, to specify the infrastructure required for such a laboratory that will address the needs of a broad cross section of science over the next 20-30 years and complement other facilities worldwide
S1 Findings


• Rec1: Strong support for pursuit of deep underground science
  – We recommend that the U.S. strengthen its research programs in subsurface sciences to become a world leader in the multidisciplinary exploration of this important new frontier.

• Rec2: Develop a cross-agency Deep Science Initiative in US
  – The Deep Science Initiative should be coordinated with other national initiatives and take full advantage of international collaboration opportunities.

• Rec3: A Deep Underground Science and Engineering Lab
  – The U.S. should complement the nation’s existing assets with a flagship world-class underground laboratory providing access to very great depth (6000 mwe) and ample facilities at intermediate depths (3000 mwe) currently not available in the U.S.
Solicitation 2

• Solicitation 2 (S2): 8 proposals rec’d to develop DUSEL sites
• April 2005 Panel selected Henderson, Homestake as most promising
• 15 September 2005: Two $500k awards:
  – SUNY Stony Brook for Henderson Mine, Empire, CO – C.K. Jung, PI
  – UC Berkeley for Homestake Mine, Lead, SD – K. Lesko, PI
• Site-specific conceptual designs developed
• Conceptual designs submitted to NSF in June 2006, reviewed by panel August 2006 at NSF
Solicitation 3

- Third solicitation (S3) published September 29, 2006
- Open competition
- Proposal deadline 09 January 2007, four proposals received
- Goal was to select single site, if at least one is considered to be viable, to develop technical design of facility. Prepare for MREFC consideration.
- Chosen site would receive up to $5M award per year for up to three years via cooperative agreement for design development
- Review process designed with great care
- Proposals exhaustively reviewed by broad interdisciplinary 22-member expert panel
- Review included site visits & reverse site visits
S3 Panelists

• S3 Panel composition:
  – Chair (particle physicist)
  – HEP (2)
  – NP (2)
  – BIO (2)
  – GEO (2)
  – Cost, schedule, management (2)
  – Engineering/geotechnical/underground construction (4)
  – Environment (1 – EPA)
  – Safety (2 – running accelerator facility + NIOSH)
  – E&O (1+)
  – Foreign (4 – Japan, LNGS/Italy, Britain/Boulby, Canada)
  – Mining Industry/Operations (1)

• Appropriately broad, spans required space; deep technical knowledge, expertise
Cost Consultant

- Cost consultant with lifetime experience in underground construction contracted by NSF
  - Tasked with evaluating each proposal’s estimated underground construction costs, plan
  - Cost, schedule, contingency, risk, cost & schedule methodology, time of performance, etc.
  - Based on submitted proposal and backup material
  - Not a member of panel, no site selection vote; made no recommendations to Panel
  - Objective analysis used as input for Panel consideration and deliberations
S3 Process

• I: Initial Panel meeting: 08-09 February, Arlington, VA
  – Welcomes
  – Discussion of process
  – Charge(s)
  – Discussion of S1 findings
  – Initial discussion of each proposal by panelists

• II: Site visits: 08-15 March
  – All four sites visited
  – One day per site
  – Subset of panel (12) with appropriate expertise + 4 NSF reps
  – First-hand evaluation of site-specific issues, characteristics:
    • Engineering and underground construction, rock and other site characteristics, safety, environment, access/egress, etc.
  – Each visit consisted of presentations by teams, Q&A, tours of sites
S3 Process

- **III: Second Panel meeting**: 19-22 April, Washington, DC
  - Debriefings on findings from independent expert cost analyst, Site Visit Sub-Panel findings
  - Reverse site visits:
    - Presentations to Panel by teams, Q&A, discussion
    - Three hours per team
  - Panel deliberations and voting
  - Initial discussion and first draft of Panel Report
Site Selection Criteria

• Taken from S3:

“The guiding principle governing the review process for the proposals in response to this solicitation is to select and develop the site-specific plan that shows the greatest potential for development of a world-leading DUSEL at the best cost/risk value to the government, and that would enable the science and engineering activities defined by the relevant communities...”.

• Five basic review criteria categories, taken from S3:
  – Intellectual Merit
  – Broader Impacts
  – Suitability of the Site
  – Facility Design
  – Strength of the Proposing Teams

National Science Board Review Criteria
1. **Suitability of the Site**

a. Ability of the site to support the facility needs at the surface, and the depth and size of experimental halls proposed and future expansions
b. Subsurface characterization: geological, geotechnical, radiation backgrounds, hydrological, thermal, etc.
c. Access to underground labs – people and cargo capacity – max size, weight, rate
d. Availability of Services – power, cooling water, HVAC (normal and emergency)
e. Location of site
   i. Proximity to airport, roads, etc.
   ii. Availability of schools, hospitals, local housing, food services, etc.
   iii. Availability of, or ability to attract, technical, scientific, engineering and other Laboratory personnel
f. Other considerations
   i. Implications or possible consequences of sharing the proposed site with a non-DUSEL entity
   ii. Excavation and infrastructure needs and requirements
   iii. Overall facility cost; overall facility risk
   iv. Time scale for availability for science and engineering

**g. Environmental, permitting and legal issues**

**h. Local government and community/regional relations; relations with property owners**
2. Facility Design

a. Quality of the facility design and the design plan, and the ability of the Proposing Team to carry out the design in an efficient, cost-effective, timely and sensible fashion

3. Strength of the Proposing Teams

a. Qualifications of the Proposing Team to realize the facility development and construction project, the running of the DUSEL Laboratory and the scientific and engineering program
b. Quality of the Science and Engineering Plan and Initial Suite of Experiments
c. Quality of the plan for Broader Impacts, and Education and Public Outreach
d. Quality of the Health and Safety Plan
e. Quality of the overall Project Plan and Project Execution Plan, the transition plan from construction to operations, and the operations plan
f. Quality of cost and schedule estimates, and the risk assessments and their mitigation
g. Quality of the Proposing Team’s connections with the multidisciplinary and international DUSEL user/collaborating communities
- All Panel votes were taken by secret ballot
- Panel unanimously voted to recommend the Homestake proposal to the NSF for funding on first straw vote and final vote
  - Option to vote for no site was not exercised by any Panelist
- After careful consideration of this and the proposals and other review material, the DUSEL Program Directors (PHY, GEO, ENG) forwarded the Homestake proposal to the NSF for funding
- Reviewed in detail by NSF Director’s Review Board
- Announcement Tuesday, July 10
Scope of S3 Award

- S3 selection constitutes commitment to site and design team only
- Award intended to prepare DUSEL for MREFC consideration
- Not a commitment to construction
- Also beyond scope of S3:
  - Management organization for the DUSEL
  - Further development of initial suite of experiments, associated R&D and project planning
  - Ultimate construction and operations plan or team
- These will be decided in subsequent steps or solicitations
- MREFC funding would require approval of the National Science Board, NSF Director, the Administration and Congress
Depth vs. Volume Underground

- 300L R&D, E&O
- 2000L Geo Level
- 3800L Geo Level
- 4850L Major Campus
- 7400L Major Campus
- 8000L Geo Lab
Aerial View

Homestake and Lead Aerial Photo

- Water Treatment Plant
- Open Cut
- Yates Shops
- Yates Complex
- Lead
- Ross Complex
- 1 km
- 300L Portal
DUSEL at Homestake

Deep Underground Science and Engineering Laboratory at Homestake, SD

- Six and a half Empire State Buildings for scale
- Shallow Lab
- Mid-level
- Deep Campus

- Physics
- Astrophysics
- Geoscience
- Engineering
- Biology

J. Kotcher

P5 Meeting, Fermilab, September 24-25, 2007
Homestake Mine

- South Dakota Science and Technology Authority (SDSTA) owns land (footprint and below) outright and in perpetuity
- Future use dedicated to research and education
DUSEL-related R&D Funding

- NSF Physics Division encouraged submission of DUSEL-related R&D proposals for FY07
  - Targeted detector R&D for underground applications
- Joined by DOE HEP and NP
  - $3.1M (NSF) + $0.6M (DOE) = $3.7M FY07
- Proposals were submitted to both agencies; reviewed, prioritized by joint DOE/NSF panel in March ’07
  - Collaboration between NSF PNA, EPP, & NP and DOE HEP, NP
- Final awards being processed
- NSF Geomechanics & Geotechnical Systems Program also funding DUSEL-related R&D. Proposals reviewed in April ’07, 3 awards made (2 collaborative), ~ $900k total (over 3 years)
- Programs will continue in FY08
Some Candidate DUSEL Physics R&D Topics

- Dark Matter Detection
- Neutrino-less Double Beta Decay
- Nuclear Astrophysics
  - accelerator-based cross-section measurements
- Geoneutrinos
- Solar and Supernovae Neutrinos
- Low Background Counting Facilities (LBCF) and Common Infrastructure
- Long Baseline Neutrinos and Proton Decay
  - “Megaton” applications, water cerenkov, liquid argon, underground engineering for large caverns, etc.
Moving Forward

- S3 Cooperative Agreement finalized, first phase of award will go out in FY07
- DUSEL Town Meeting – November 2-4, 2007, Washington
  - Formal roll-out of Deep Science report
  - Communities will generate priorities, needs for initial suite of experiments
  - All disciplines participating
- Fourth solicitation (S4, in preparation) that will call for proposals to develop project plans for initial suite of experiments
  - Complex process, under discussion
  - Anticipated support same as S3: up to $5M/yr for up to 3 yrs
  - $0.5-1.0M from engineering
  - Independent of ’08 DUSEL R&D (for physics)
- MPS Advisory Committee Sub-Panel on Facilities asked by MPS AD for evaluation/recommendation to move DUSEL from Horizon Phase to Readiness Phase in MREFC process
  - Currently under consideration
DUSEL Facility & Program Planning

• Project is at conceptual phase, planning will evolve as technical designs develop over next few years

• For early planning purposes:
  – Earliest construction start FY11
  – ~ $500M for initial phase MREFC: ~ half to facility, half to experiments
    • R&D for “Megaton” applications supported; construction envisioned for following phase
  – Partnerships with DOE, others will be sought
  – Input from design work will be integrated as project matures

• Some significant variables influencing start:
  – Evolution of very complex facility design, interleaving and readiness of expts
  – Implementation of new partnership, management, oversight schemes for this unique endeavor
    – Community support
    – Politics

• MPS has agreed to shoulder facility M&O costs
  – Other Directorates asked to support their research programs only
  – Details being worked out within Division, Directorate
Events in South Dakota

- **Town Meeting with Delegations in SD 9/13**
  - Organized by Senator Thune
    - Senator Johnson’s office (ill) and Representative Herseth Sandlin also present
  - Attended by MPS AD (Chan), NSF PHY PD & OLPA, state senators, SDSTA, Board of Regents, university presidents, local business people, other stakeholders
  - Discussions on moving ahead with Homestake DUSEL
  - Rapid City and Lead, NSF trip underground
  - Intensity, breadth of support impressive
Homestake Re-entry, Interim Laboratory

- SDSTA began mine re-entry late July
  - Initial step in re-entry, dewatering, infrastructure refurbishment
  - Reached 2200 level mid-August; 2450 & 1250 pumping stations active in next few months

- Homestake Interim Laboratory (EIP)
  - SDSTA holds total $124M for Laboratory development
    - $70M private benefactor, $44M state SD, $10M HUD
    - Education center, 4850L, + deep (6000+)
  - Initial allotment ($65M) was contingent on site selection, other factors – partially secured, remainder in final approval stages
  - Plan includes refurbishment of experimental area at 4850 level (Davis cavern). Beneficial occupancy scheduled by end CY08.
    - Higher elevations perhaps earlier
  - Decoupled from MREFC process, but important part of facility and program planning
Concluding Remarks

- Site selection allows planning for a U.S. underground science program to take on a new, focused approach
- Facility design at Homestake and program planning by the community underway
  - Town Meeting November 2-4, Washington, DC
- Community support is a critical component for seeing this project through to a launch
• Backup Slides
Homestake Proposal Team

Kevin Lesko PI - UC Berkeley
Bill Roggenthen co-PI - South Dakota School of Mines and Technology
University of California Berkeley
    Willi Chinowsky - E&O
Black Hills State University
    Ben Sayler - E&O
Brown University
    Bob Lanou - Physics
Lawrence Berkeley National Laboratory
    Dick DiGennaro - Project Manager
    Liz Exter - Project Team
    Dave Plate - Project Team
    Dianna Jacobs - Project Team
    Joe Wang - Earth Science & Engineering
    Marty White - ES&H
South Dakota School of Mines and Tech
    Sookie Bang - Biology
    Ziggy Hladysz - Mining Engineering
University of Utah
    Bill Pariseau - Mining Engineering
University of Wisconsin
    Herb Wang - Earth Science & Engineering

South Dakota Science and Technology Authority
    Dave Snyder - Executive Director
    Thomas C. Adam - Member SDSTA Board
    Dan Farrington - Consultant /University Liaison
    Laurie Gehner - Executive Assistant/Archivist SDSTA
    Kathy Hart - Consultant/Geology/Archives
    Greg King - Property Development Manager SDSTA
    Gary Lillehaug - Consultant/Electrical
    John Marks - Consultant/Ventilation
    Chuck Michael - Senior Principal - Short Elliot and Hendrickson Consultant
    Bob Morcom – TSP Consultant
    Tom Regan - Consultant/Safety
    Trudy Severson - Assistant to the Director, SDSTA
    John Scheetz - Consultant/water
South Dakota Department of Environment and Natural Resources
    Steve Pirner, Secretary DENR
South Dakota Geological Survey
    Derric Iles, State Geologist
South Dakota Office of State Engineer
    Bill Noordermeer, Project Engineer
Homestake DUSEL in Context

- 300L R&D, E&O
- 2000L Geo Level
- 3800L Geo Level
- 4850L Major Campus
- 7400L Major Campus
- 8000L Geo Lab
DUSEL Campus Development Summary

Homestake
Deep Underground Science and Engineering Laboratory

Conceptual plan to develop four primary campus locations for research:

1. Surface campus at Yates Complex
2. Near-surface campus at 300 Level
3. Mid-level campus at 4850 Level
4. Deep-level campus at 7400 Level

Infrastructure will be maintained for access to additional, selected levels for bio- and geo-sciences and for unique experiments that require specific or isolated sites.
Depth vs Volume Underground

Generic DUSEL expectation

First suite

FY08 Activities

• Beneficial occupancy at 4850 ~ end CY08
  – Higher elevations perhaps earlier
• NSF Physics will be doing another R&D call in FY08 with DOE NP/HEP
• NSF ENG will continue in FY08 to fund DUSEL related rock mechanics and geohydrology research
  – $500-$1,000k expected range of support
  – Opportunities exist for co-funding with DOE or other federal agencies on subjects of mutual interest
Geomechanics Related DUSEL AWARDS

• “Collaborative Research: Towards the Transparent Earth”
  – CMMI-0727726, Steve Glaser, UC Berkeley, PI
  – CMMI-0727921, William Roggenthen, SCSM&T, PI
  – Seismic observatory at Homestake
  – Acoustically monitor rock kinematics during dewatering and construction activities

• “Time-Dependent Instability in Rock Masses: Understanding Prediction and Prevention”
  – CMMI-0653942, John Kemeny, University of Arizona, PI
  – development of methods for monitoring rock structures, interpreting results and predicting failure

• Total ~ $900k