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# DUSEL Town Meeting, Workshop and future directions

## Town Meeting Nov 2
## Workshop Nov 3-4
## Conclusions and Future

As Chair of the S1 group

Bernard Sadoulet, UC Berkeley, Astrophysics/Cosmology
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

# DUSEL: A new phase

Publication of the site independent ("S1")report
Choice of Homestake as the site of study for a potential Deep Underground Science and Engineering Laboratory in the US of DI

## Public event at the National Academy of Sciences Nov 2

to describe to agency officials, members of government and congress, press and other interested parties the potential of DUSEL
175 people (120 scientists)
Organized and funded by INPAC

## Weekend workshop, November 3-4

195 scientists
40 geo/bio/engineers
Organized by INPAC, funded in part by NSF

## Meeting at OSTP/OMB November 5

Requested by Jack Marburger
- Homestake: Lesko, Medley
- S1: Sadoulet
- NSF: Chan,Dehmer,Kotcher, Frasgazy

# Friday November 2

http://cosmology.berkeley.edu/DUSEL/Town_meeting_DC07/

## Description of the great opportunities of Deep Underground Science and Engineering

History Joe Dehmer
Hitoshi Murayama: Physics/Astrophysics Education?Outreach
Tullis Onstott: Earth Sciences/Biology/Engineering

### International aspects: Art MacDonald

We need more space at depth
We need space for Geo,Enginering and Bio

### S1 recommendations Hamish Robertson

### Interests of agencies NSF (MPS,GEO,EMG) DOE (HEP,NP,BES)

## Homestake

Selection process and what next? Jon Kotcher

### Partnership

Senator Thune
Representative of Senator Johnson
Congresswoman Herseth-Sandlin
**Governor Rounds** (SUSEL \$70+\$46M)
Vice Chanc. Burnside (UC Berkeley) Pres. Ruch(South Dakota Sc.Mines)

### The S3 Design process

Kevin Lesko, R. Di Gennaro, Jose Alonso

# The S1 report

http://www.deepscience.org/ or http://www.dusel.org/

## Findings:

Deep Underground Science is an essential component of research at the frontier

Not only true for physics, astrophysics but also biology earth sciences and engineering

Strong benefit for society

## Programmatic findings

Chronic need for underground space worldwide, especially at the deeper depth

The US need a world class deep underground multidisciplinary laboratory

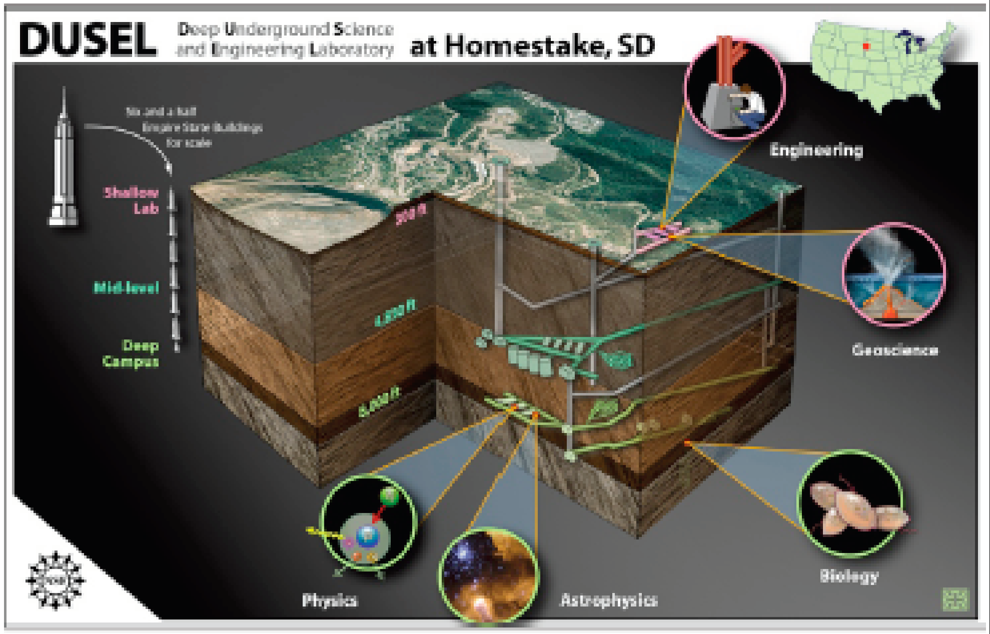
## Recommendations

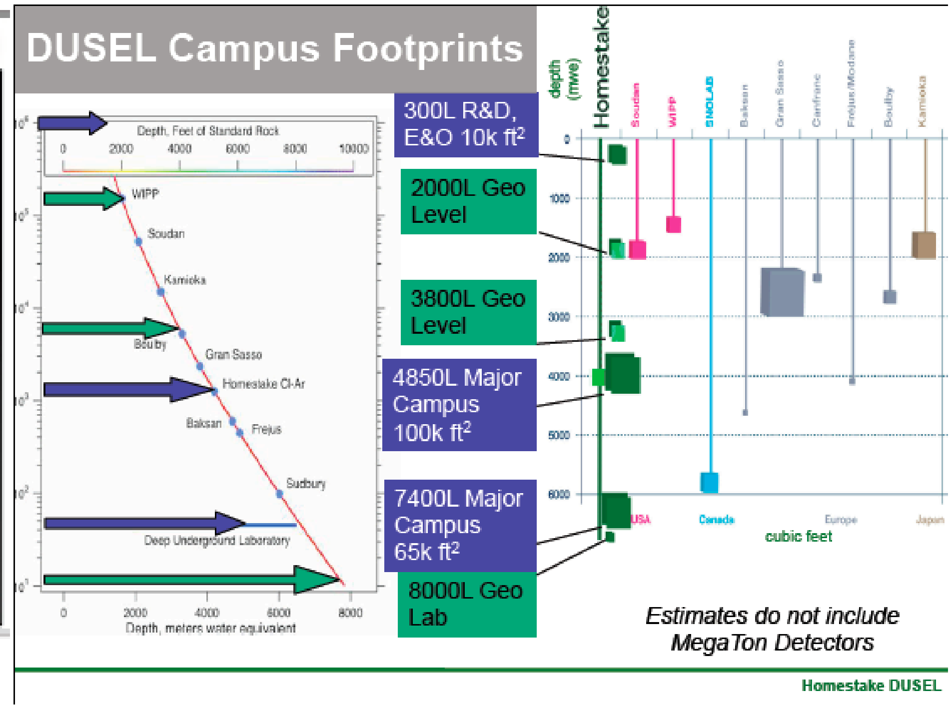
The US should strengthen its underground research

Call for a cross-agency multidisciplinary initiative optimally using facilities both in the US and in the world.

Construction ASAP of a **Deep Underground Science and Engineering Laboratory.** The U.S. should complement the nation's existing assets with a flagship world-class underground laboratory providing access to very great depth ( 6000 meters water equivalent) and ample facilities at intermediate depths (3000 meters water equivalent) currently not available in the U.S

# Kevin Lesko: Homestake




## S3 study of the DUSEL facility:

a variety of levels with 3 major campuses

## Interim facility funded by State and private donor

Space at 4850 ft level 2008

"Sanford Underground Science and Engineering Laboratory":SUSEL

Keep water below 4850 ft -> 2011

# The Nov 2-3 Workshop

http://cosmology.berkeley.edu/DUSEL/Town_meeting_DC07/

## Goal: focus on the next phase!

The science component of the MREFC: "the first suite of experiments" (ambiguous as we will see)
Basic idea: ≈$500M $250M facility, $250M (NSF part of) experiments

## Organized around disciplinary and cross cutting working groups
## => white papers about 5 pages:

- Science 1-2 pages
- Priority for first suite of experiments 1/2 page
- Roadmap (overall scale/scope, size of collaborations, rough order of magnitude of equipment and staff costs + time frame,) 1 page
- Including the science likely to be done before/during DUSEL at other facilities
- R&D needs 1/2 page
- How to arrive at realistic cost and schedules. 1/2 page
- E&O (beyond the standard aspects) 1/2 page
- How should the subfield organize itself for this new phase? What aspects of the S4 process are critical to this subfield? What type of interaction do you need with the S3 design? 1 page.

# P5/NSAC

**P5 (HEPAP)** Abe Seiden:

P5 in 2006 constructed a Roadmap for Particle Physics, which included priorities for various projects.

DUSEL was in our second priority group, after the ILC.

We were particularly pleased with the strategy of having approximately 1/2 of the initial funding being allocated to the first round of experiments, which included absolutely first rate science.

This included the search to directly detect dark matter scattering on materials and the search for neutrino-less double beta decay.

We reviewed the progress of DUSEL in September 2007 and were delighted to see that a potential location for the lab has been chosen and that the lab is receiving strong local support.

We reaffirm the importance of the science program which motivates DUSEL and which is making excellent progress in parallel.

**NSAC:** John Wilkerson

DUSEL is an essential component of the long range plan

# The Science case is strong

## Strong enthusiasm for the science

Flagships: Dark matter and neutrinoless double beta decay
Geo-microbiology

Momentum building up for the excavation of a cavity for a 100kT module as R&D for proton decay/neutrino oscillation. Likely international collaboration.

Some rising interest in n-nbar: needs scientific review + delicate issue of neutron source

See in additional materials

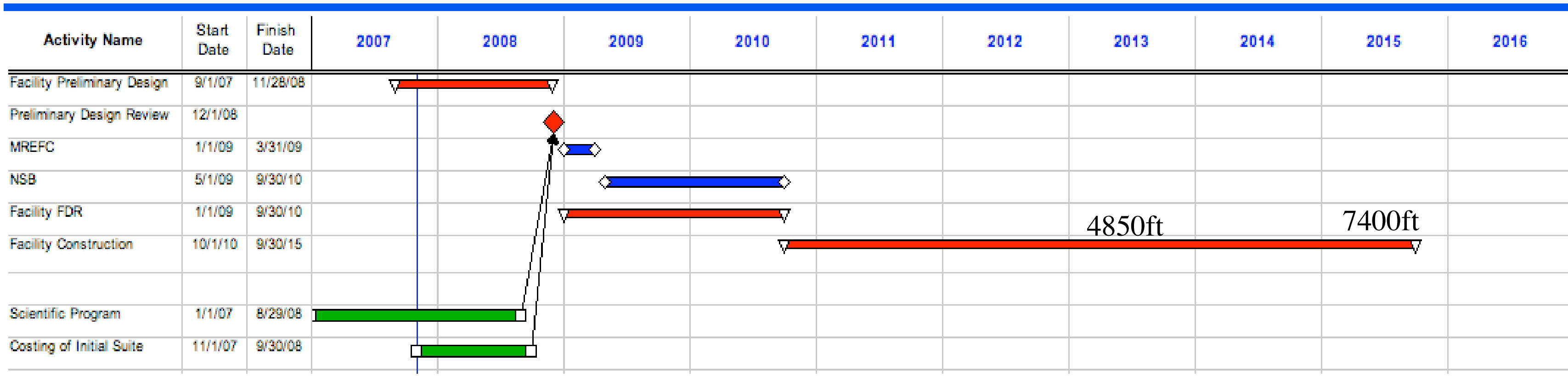
White paper are coming in!

## Estimated cost of superset of projects proposed by the working groups (compilation by Kevin Lesko and B.S. )

| | |
|---|---|
| $520,000,000 | Physics/Astrophysics |
| $120,000,000 | Bio/Earth Sciences /Engineering |
| $10,000,000 | Common Usage |
| $650,000,000 | Total Initial Suite Experiments |

Very rough estimates,
NSF cannot do it alone (other agencies, international partners)
Some difficult choices ahead.
At least clear evidence that there is a need for such a facility.

# Reflection on time scales




## Sobering: Even in best scenario

MREFC proposal ready by Dec 08 (present goal of S3)
Mar 09 NSB decision
Funding FY 11
2013 significant access to 4850 ft
2015 access 7400 ft

## If we insist on having the science with facility, the science program has to be defined by Dec 08.

## How can we fulfill the requirements of MREFC?

Preliminary design report ≈ CD2 Lehman type review
Main idea is control of costs and schedule

# NSF pre-construction planning process

Mark Coles

**Science Review** — **CDR** — **PDR** — National Science Board Decision — **FDR** — **Operations Review** — **Renewal Review, etc.**

*Conceptual Design*

*Preliminary Design*

*Final Design*

*Construction*

*Operations*

**R&RA $** | **R&RA $** | **R&RA $** | **MREFC $** | **R&RA $**

**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 |

# Fitting into the MRFC framework

## Need to define in detail a science program by Dec 2008. A number of difficulties:

- Impossible to do this at the required level (PDR) with most experiments (≥$500M of experiments to baseline)
- Does not make any sense to fix now what will be installed in best case in 2013 and 2015. Take advantage of an experiment construction time shorter than that of the facility to take into account input from previous experiments and maximize the scientific output
- Compatibility with SAG process
- We also need time to raise the additional $300-400M ( DOE, other agencies and international collaboration)

## A possible solution: Define an "initial scientific program"

Determine as accurately as possible a scientific envelope costing in some details a representative set of initial experiments. Make assumptions about other contributions, add contingency and make room for new ideas.

Then live within this scientific envelope. Contingency shared by all experiments.

Is this compatible with MREFC rules and the definition of a construction project? Mark Coles stated at the workshop that there could be some flexibility…

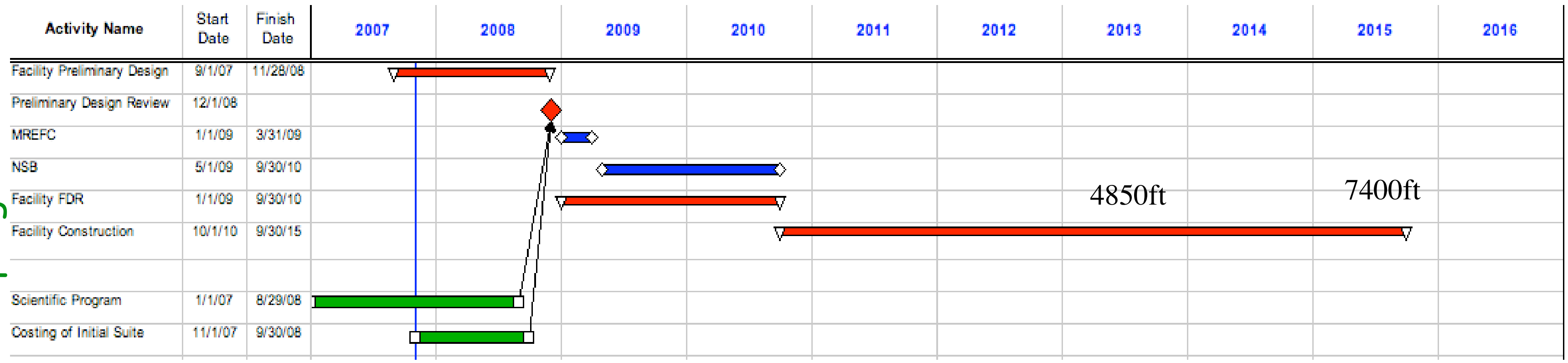
## We have to be creative!

Could be also 2 stage MREFC 2011-2013 phase and 2016 phase

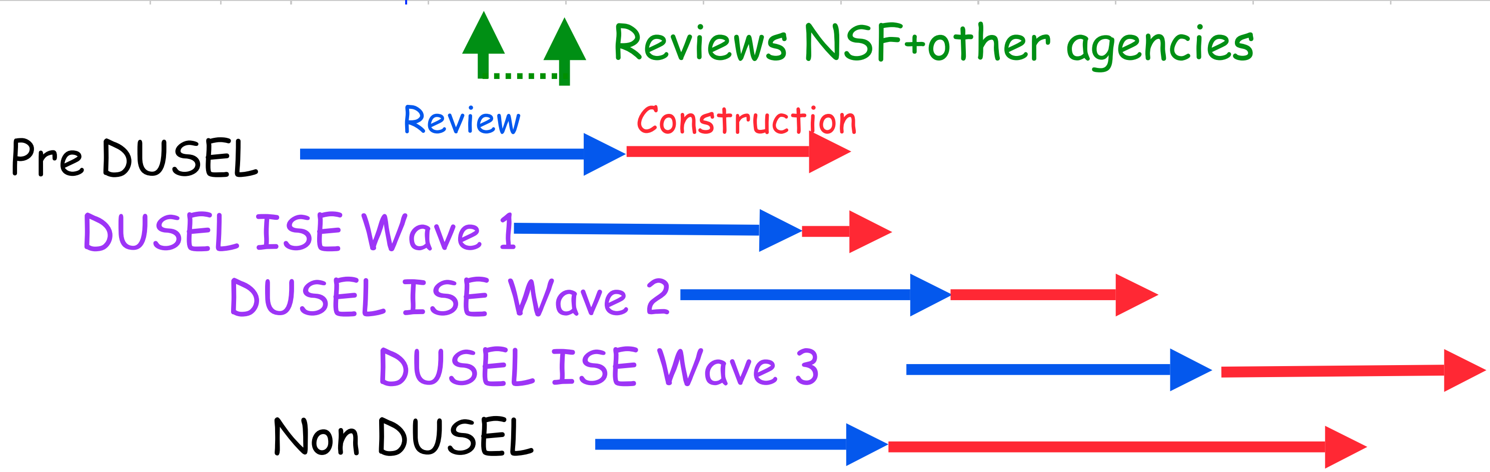
# Possible Review Process

## in framework of costing scientific program through representative experiments

Science program definition




Experiment selection

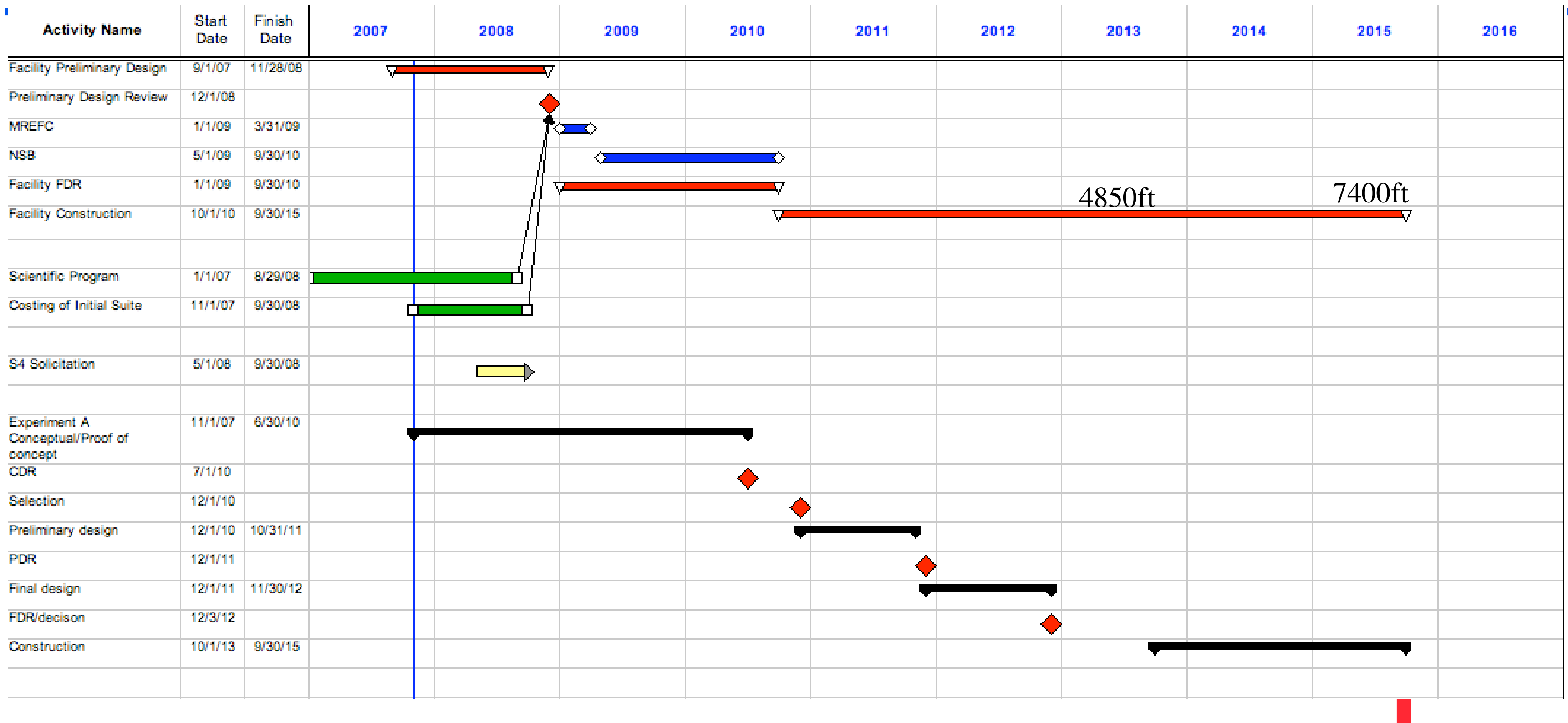



**Solicitation 4 (S4) competition in Spring 08**

**Essential to bring experiments to CDR≈CD1, PDR≈CD2, FDR≈CD3**

Real rounds of down-select at the CDR and PDR

# Matching time of facility availability




## An example:

an experiment to be ready when 7400 ft becomes available

## There is not a lot of time!

# Community Self Organization

## What we witnessed at the workshop:

The underground community is mobilizing to put forward a credible scientific program for a MREFC on a very short time scale (Dec 08).

## Organization:

- Working groups by subfields => scientific strategy
  e.g. representative set of experiments
- In the middle of self selection of overall coordinators
  to pull together the scientific component of the proposal
- Cross cutting working groups looking at common functions:
  eager to implement the synergies inherent to DUSEL

## Work with the agencies to define a coherent MREFC strategy

# How to Maximize DUSEL Potential?

## Push Pre-DUSEL science

Our ultimate goal is Science, not building a facility. We need to push the frontier as aggressively as possible.

At all existing facilities including SNOLab and SUSEL

Experience with depth and with site

The Science that we well get in the coming years is essential to inform the program

- Potential discoveries could change drastically course of action
- Explore the capabilities of our technologies

  e.g. at each new levels of sensitivity we discover new forms of backgrounds and try to mitigate them

Balance the short term and the long term

- Do not cut the short/medium term program for the long term
- Do not down select technologies too early: what is promising now may not be up to the job in 8 years from now
- Long term R&D is essential

## Begin to realize the other promises of DUSEL ASAP

Multi-disciplinary aspects (see in "additional material" B groups)

Inter-agency + international cooperation

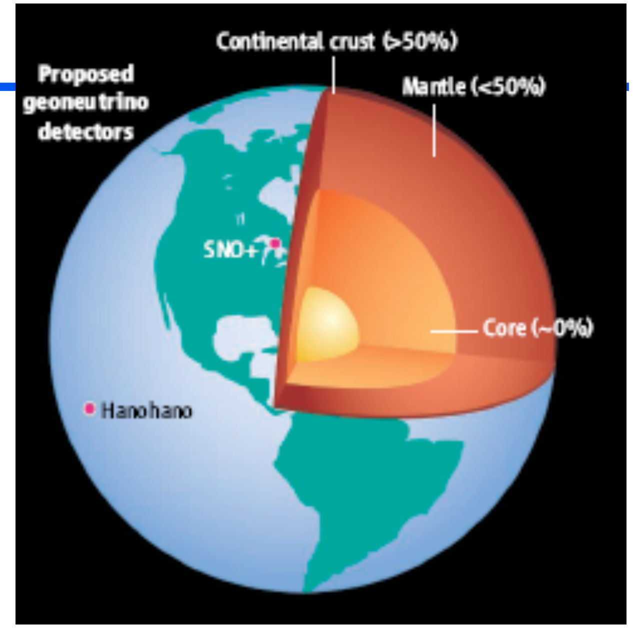
E&O etc…

How?? "Virtual laboratory"

" Center for Deep Underground Science and Engineering"

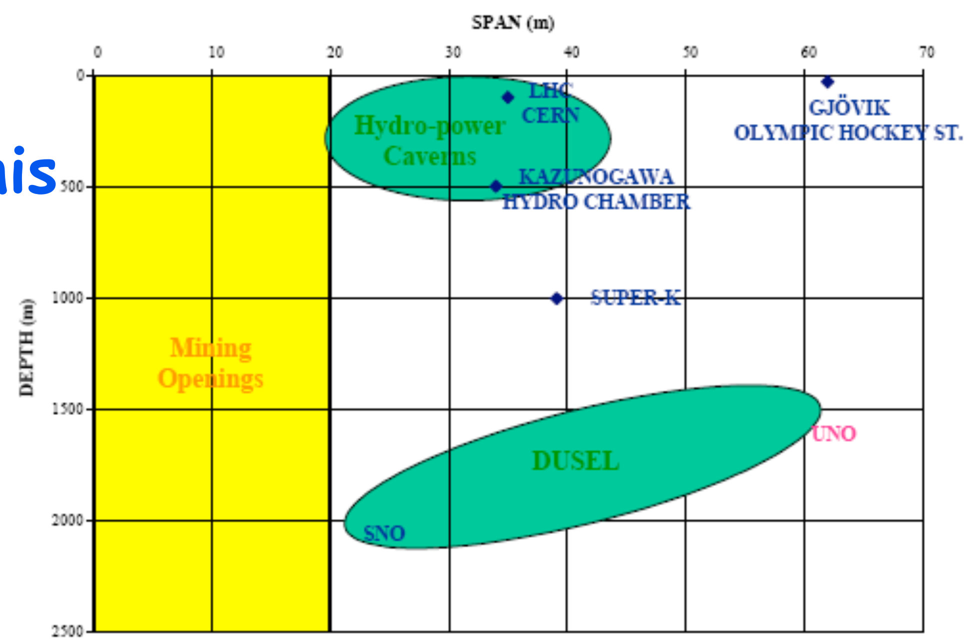
# Synergies

## Geoneutrinos & Transparent Earth




## Cavity Engineering & Mega Detector

## Instrumentation




## But we need to work on this

- Buddy system
- Teleconferenced seminars
- Educational workshop
- Work Workshop

# Conclusions

## The underground community is mobilizing

to put forward a credible scientific program for a MREFC on a very short time scale (Dec 08).

## We have to be creative in the definition of a MREFC strategy

which optimizes the science (allowing us to fold in the results and experience of the pre-DUSEL program)

which is compatible with a construction project (control of costs and schedules)

## We need a close partnership between NSF and DOE

Unique scientific opportunities complementing the accelerator and space frontiers. We should seize them!

The underground science community is increasing rapidly!

NSF cannot do it alone…

We need the project management expertise of the DOE labs, both for

- the definition of the initial scientific program: realistic costing (short time scale)
- the design of the various waves of the initial suite of experiments.

Cross agency group (≈ Joint Oversight Group)

## We need to push at the same time

The scientific frontier at currently available underground sites

The preparation of DUSEL which is at least 5-7 years away!

# Additional material

# S1 Scientific Findings

- **Deep underground science is an essential component of research at the frontier.** Underground experiments are critical to addressing some of the most compelling problems of modern science and engineering; and long-term access to dedicated deep underground facilities is essential.

- **Disciplines in transformation.** Deep underground experiments have for some time constituted an important component of physics and astrophysics. Biologists, earth scientists and engineers have long made observations underground and have in recent years also recognized the extraordinary potential of deep long-term underground experiments.

- **Benefits to Society.** Investment in deep underground experiments can yield important societal benefits. Underground construction, resource extraction, management of water resources, environmental stewardship, mine safety and national security are prominent examples. By creating a unique multidisciplinary environment for scientific discovery and technological development, a deep underground laboratory will inspire and educate the nation's next generation of scientists and engineers.

# S1 Programatic Findings

- **Worldwide need for underground space.** The rising interest in deep underground science; the diversification of underground disciplines; the increase in the number of underground researchers; and the increased size, complexity and duration of experiments all point to a rapidly rising demand for underground laboratory space worldwide. The opening of numerous facilities outside the U.S. attests to the gap between supply and demand, especially at very great depth.

- **Need for a U.S. world-class deep multidisciplinary facility.** The U.S. is among the very few developed countries without a deep underground facility (≥ 3000 m.w.e). In an international environment where deep underground space is at a premium, a U.S. Deep Underground Science and Engineering Laboratory would provide critical discovery opportunities to U.S. and foreign scientists, place the U.S. in a stronger strategic position in deep underground science, and maximize the benefits of underground research to the nation.

# S1: 3 RECOMMENDATIONS: Rec 1

- **Strong support for deep underground science.** The past decade has witnessed dramatic scientific returns from investments in physics and microbiology at great depths. Underground research is emerging as a unique and irreplaceable component of science, not only in physics and astrophysics, but also in biology, earth sciences and many disciplines of engineering. 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.

# RECOMMENDATION 2

- **A cross-agency Deep Science Initiative.** In order to broaden underground research and maximize its scientific impact, we recommend that the U.S. science agencies collaborate to launch a multidisciplinary Deep Science Initiative. This initiative would allow the nation to focus the whole range of underground expertise on the most important scientific problems. It would aim at optimizing the use of existing or new underground facilities and at exploiting the complementary aspects of a variety of rock formations. The Deep Science Initiative should be coordinated with other national initiatives and take full advantage of international collaboration opportunities.

# RECOMMENDATION 3

- **A Deep Underground Science and Engineering Laboratory.** The U.S. should complement the nation's existing assets with a flagship world-class underground laboratory providing access to very great depth (approximately 2200 meters, or 6000 meters water equivalent) and ample facilities at intermediate depths (approximately 1100 meters or 3000 meters water equivalent) currently not available in the U.S. Such a Deep Underground Science and Engineering Laboratory (DUSEL) should be designed to allow evolution and expansion over the next 30 to 50 years. Because of this long lifetime, the initial investment must be balanced with the operating costs. For maximum impact, the construction of DUSEL should begin as soon as possible.

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

# MREFC process

# Findings of the working groups

# Fields: Key Findings

## A1 Low energy neutrinos

Important science: Solar neutrinos, mixing matrix, Supernova, geo-neutrinos.
Variety of readiness levels

## A2 Neutroliness Double Beta decay

Flagship science
1 ton, 3 leading isotopes: Ge, Xe, Tl (Gran Sasso). Strong case for two experiments in the US.
Need Production isotope, material storage underground

## A3 Long baseline, Nucleon decay

Important science: 3 potential technologies: 1.5 ≈ ready
Neutrino oscillation needs a beam from FNAL
Need R&D to establish readiness
We should consider one 100kT Cavity+ instrumentation for the initial suite
n-nbar: needs scientific review + delicate issue of neutron source

## A4 Dark Matter

Flagship science: Goal $\leq 10^{-46}$ $cm^2$/nucleon
Exciting time: new technologies still being proposed
Possibility of discovery in the next few years, pre-DUSEL and LHC
We need full exploration of technologies! At least 2 experiments
Although some technologies are ready for rough costing, down selection in 2008 is too early
Need R&D for Phase II in particular directionality

## A5 Underground Accelerators

Strong case to measure reactions near Gamow peak $^{12}C$ $(\alpha\gamma)$, $^{12}C$ $(^{12}C\ \gamma)$
Complementarity to Luna: Ion beam? Close to readiness.

# Fields : Key Findings

## A6. A7. A8.

Started together, new people, information about Homestake, bring in Henderson community

## A7. A8. Earth Science/Engineering

Fundamental science + strong importance for applications
(e.g. C sequestration)

3 experiments

- scale effects: use the large size of Homestake (fiber optics)
- fracture experiment: large blocks ($2-5M/yr over 10 yrs) in drifts.
  =>coupled processes (including bio)
- large cavity engineering

Synergy: geoneutrinos, large cavern, instrumentation.

Some costing possible within 12 months

## A6. Biology:

Input from Homestake , USDA (bio fuel)

Fundamental, flagship science: high likelihood of important discoveries

3 basic experiments

- Need to characterize first micro-biological environment + impact of mining, flooding
- Borehole to 16,200 ft drilling from 8000ft (technology available)
- Pristine fracture zones accessible from shallower levels, extension of tunnels 100-200ft to non impacted zones; biological manipulations.

New technologies e.g.,for life detection (NASA Ames)

# Cross Cutting: Key Findings

## B1 Low radioactivity

Information gathering: timeline/capacity low background counting
New technologies for ultra low counting
Fabrication of ultra low radioactivity materials

Low background counting at DUSEL ( in addition to SUSEL and other facilities)
Need for new techniques: e.g. radiochemical methods
Beta counting for C14, tritium: broad applications (Archeology?)
Coordination with other sites, ILIAS (Europe)? Volume of material that need to be counted.
Staff needed for integration
S4 to define needed infrastructure, capability?

## B2.Target of opportunities and new ideas

15 science topics: do not fit in "A disciplines", but
potentially interesting science
specific uses of characteristics of Homestake
Process?
Eligible for S4 $

N-nbar $170-340M with #5 shaft: Special review needed

# Cross Cutting: Key Findings

## B3. Instrumentation/Synergy

How to start seriously synergy across field ASAP
Buddy system, Seminars
Workshops Educational/ "Snowmass like"

## B4. Theory

How should the theory effort be structured
local group: in order to attract senior members, needs to be 10-20
virtual group: internet based seminars/interactions, +summer/winter workshops focused on science goals of the laboratory
2nd model in the short run?
+ Yearly summer school for graduate students / postdocs , interdisciplinary
Profit from experience of Santa Fe Institute

## B5. Infrastructure

Large interest in details
Facility infrastructure S1 report not widely known
how to finish it, update it, externally review it?

# Cross Cutting: Key Findings

## B6. Management

Good agreement with S1
Instrumentation and R&D managed by facility or by collaborations?
Safety review
Regulatory, PR aspects of the neutron source for n-nbar experiemnt

## B7. E&O

Roadmap for 3 years: "R&D"
We witness clear influx of young people into DUSEL