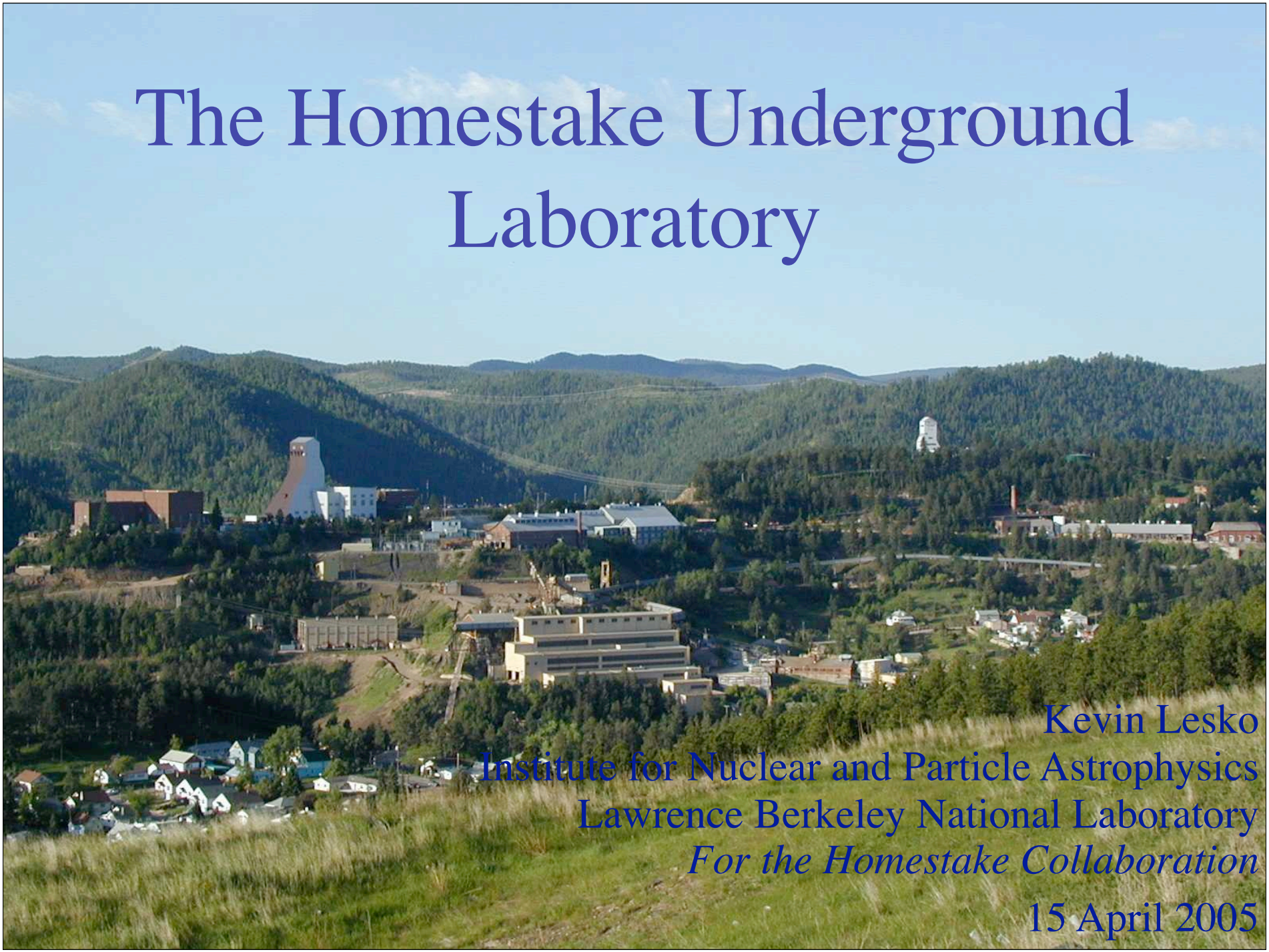
The Homestake Underground Laboratory



Kevin Lesko
Institute for Nuclear and Particle Astrophysics
Lawrence Berkeley National Laboratory
For the Homestake Collaboration

15 April 2005

Outline of Presentation

- Progress in Developing Homestake
  - Title
  - Reentry
  - 4850 lab
  - Design of the Deep Lab
- Science Opportunities at Homestake
  - 4850 ll Deep Lab
    - Earth Science
    - Physics
    - Biology
    - Engineering
    - Outreach
- Summary and Outstanding Issues

SDSTA = South Dakota Science and Technology Authority

Outline of Presentation

- Progress in Developing Homestake
  - Title
  - Reentry
  - 4850 lab

  } SDSTA Conversion Plan
  - Design of the Deep Lab
- Science Opportunities at Homestake
  - 4850 ll Deep Lab
    - Earth Science
    - Physics
    - Biology
    - Engineering
    - Outreach
- Summary and Outstanding Issues

SDSTA = South Dakota Science and Technology Authority

Outline of Presentation

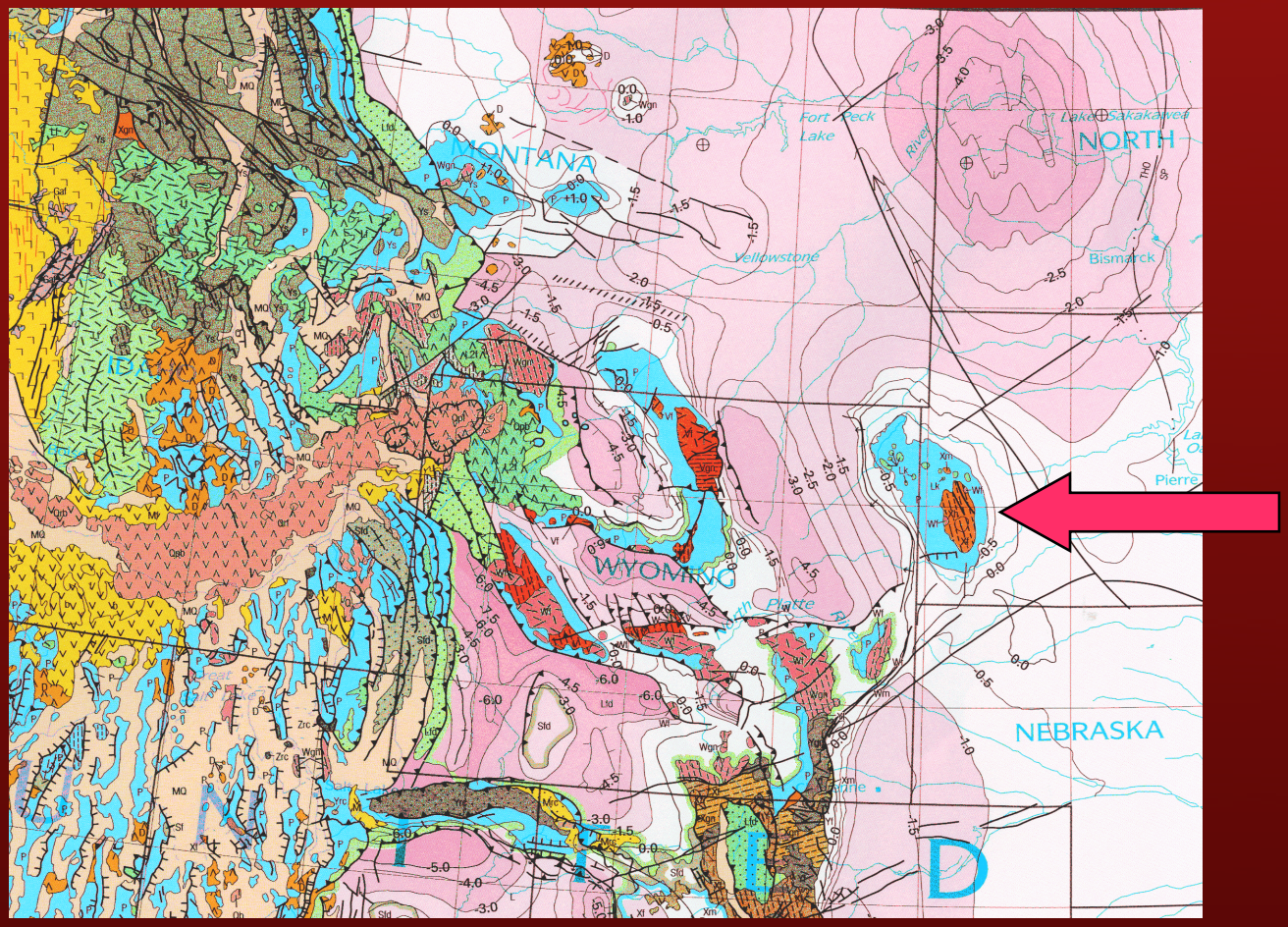
- Progress in Developing Homestake
  - Title
  - Reentry
  - 4850 lab
  - Design of the Deep Lab

  } SDSTA Conversion Plan

  } S-2, S-3 Solicitation Responses
- Science Opportunities at Homestake
  - 4850 ǁ Deep Lab
    - Earth Science
    - Physics
    - Biology
    - Engineering
    - Outreach
- Summary and Outstanding Issues

SDSTA = South Dakota Science and Technology Authority

Where is Homestake?
& Is there a 'there there'*?



- Fly to Rapid City, ~ 60 mi to lively Lead-Deadwood Community
- Railhead at Whitewood, ~ 15 mi away
- Interstate 90 (E-W) & US 85 (N-S)

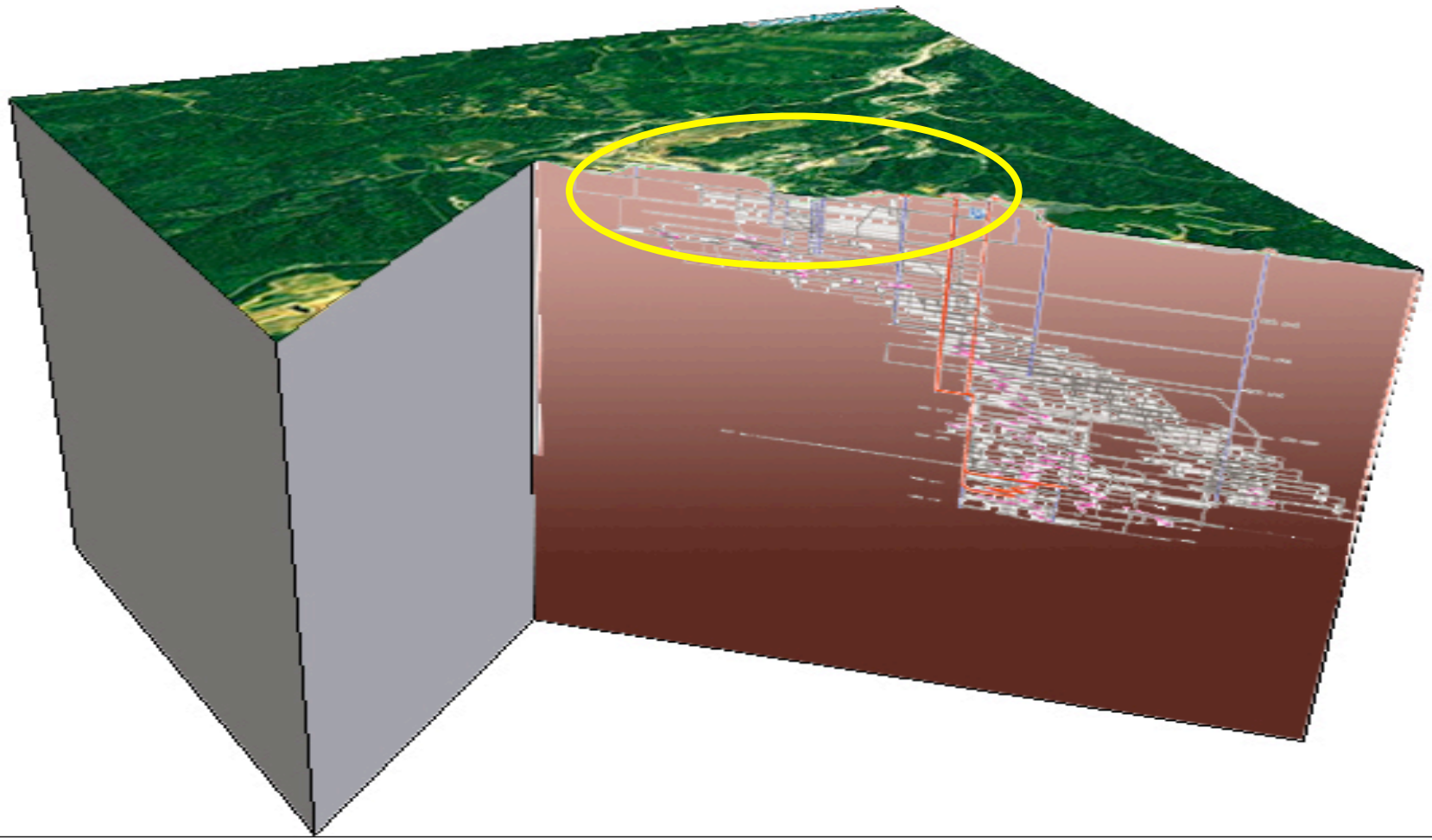
* apologies to Gertrude Stein

Description of the Homestake Site

- 125 year history of mining at Homestake
- Well documented site (maintenance, geology, hydrology, mineralogy, geochemistry, …)
- ~ 60 levels spanning the rock mass from the surface to 8150 feet below ground
- 600 km of drifts at roughly 150 ft intervals
- Interconnection by ramps, winzes, and shafts
- Drill Core Archive transferred *in toto* to SDSTA
- ~ 500 acres of surface campus
- Extensive non-mineralized areas not penetrated by boreholes or drifts (virgin territory available)

Description of the Homestake Site

- 125 year history of mining at Homestake
- Well documented site (maintenance, geology,



Description of the Homestake Site

- Existing Infrastructure
  - Well maintained hoisting system, ventilation, pumping systems, and office buildings
  - Rock handling capability (~7000 tons/day)
  - Locations for waste disposal
  - skip to the surface
  - dispose/store underground
  - Water Permits Initiated
- Attributes
  - Mechanical stability
  - Early access
  - "Lots room to grow"
  - Multiple egress (safety)
  - Not encumbered by routine mining operations

Description of the Homestake Site

- Attributes

– Well-characterized large volume of rock - only pleasant surprises

– Varied rock types - *interesting*

– Low water inflow - *700 gpm*, ~1/2 to 2/3 from upper surface flows

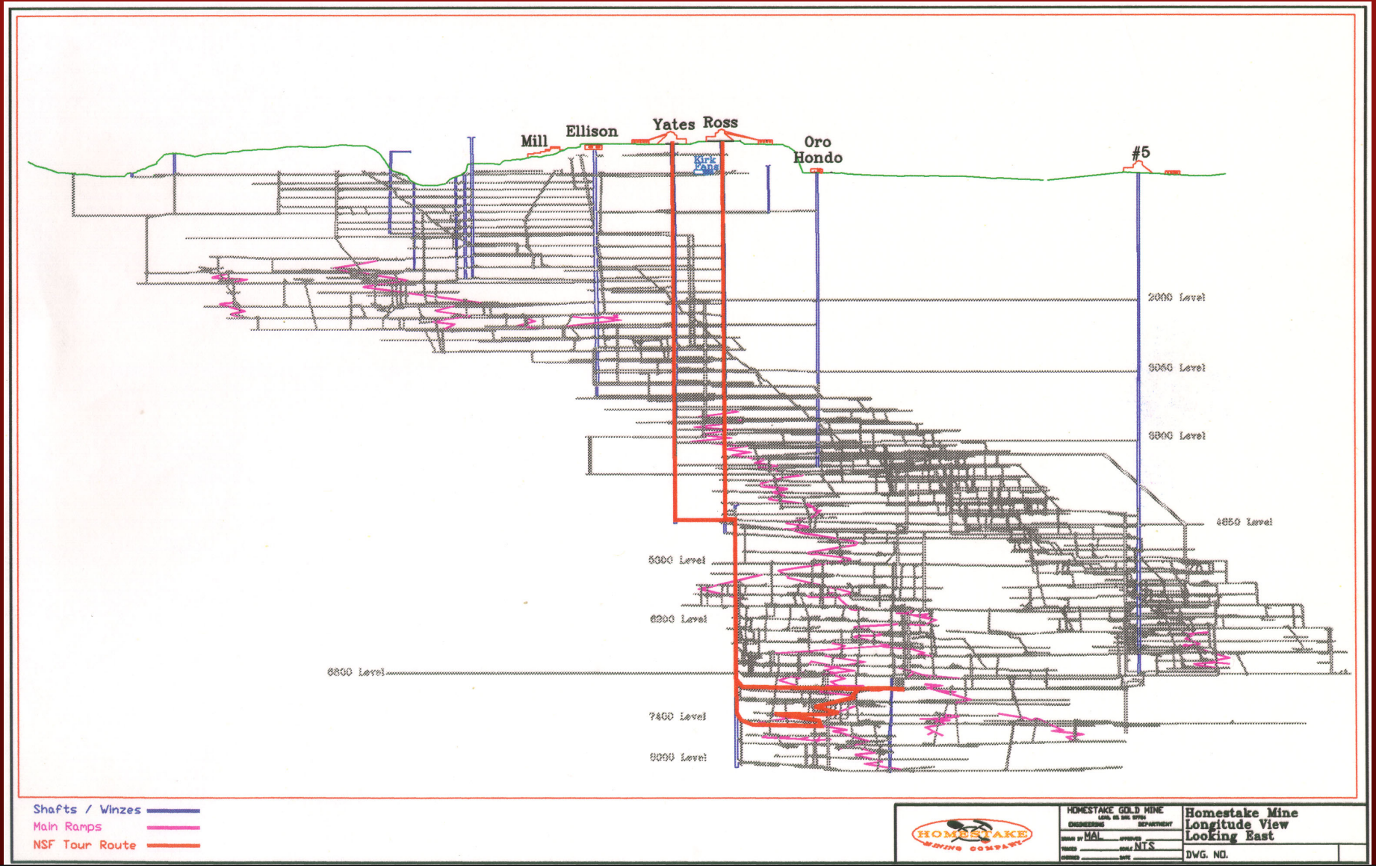
– Low radioactivity - air measured to be ~ 1 - 5 pCi/l

– Initial studies favorable for large cavities at depth

– Many existing cavities & rooms suitable for conversion to science applications early!

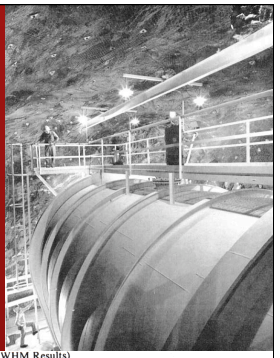
– Existing examples and additional studies using existing cores supporting that large cavities can be created at depth for long periods (decades)

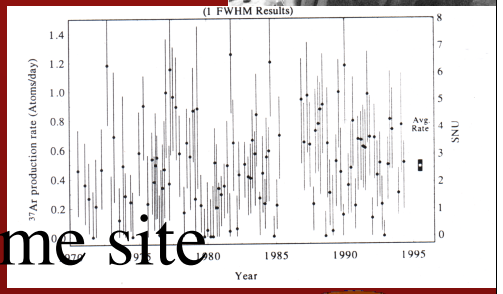
Expedient access to 32 cubic kilometers of rock mass, existing access to depths of 8150 feet, many existing spaces and excavations suited for science in the near term

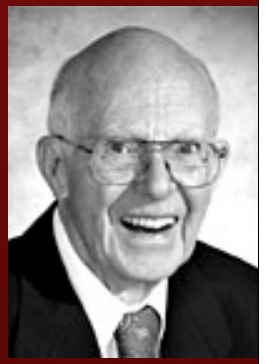


History of Homestake

- Mining for first 125 years
- Hosted world's first solar neutrino detector
- Proposed as NUSEL site Neutrino pre-town meeting, September 2000
- Endorsed by Bahcall Committee 2001 as prime site
- Mining Operations ceased 2001
- Nobel Prize Awarded to Davis and Koshiba 2002
- Capped and Sealed 2003
  - Clean up and and closure documentation by EPA representative (State's DENR)
  - Moth balled surface equipment, preserved many spares and infrastructure components: lifts, cages, transformers, surface buildings, pumps…
  - Pumping ceased







Recent History (cont.)

- Accumulation of water in the mine started when pumping was stopped, Spring 2003, *current level ~ 6800 level*
- Ventilation of the mine altered to preserve infrastructure
- Selected by NSF siting report, May 2003, as the best site for a deep lab.
- Jan 2004, "Agreement in Principle" between Barrick and SDSTA to transfer mine
- Feb 2004, SD legislature enacts enabling and appropriation legislation to effectuate the transfer and provisions in the "Agreement"
- March 2004, New NSF 3 step process announced, previous siting report voided.

Recent History (cont.)

- July 2004, SD funds $14.3M to enable site transfer and operate the SDSTA
- Dec 2004, SDSTA Conversion Plan Vetted by panel of scientists and mining experts
- Feb 2005
  - SDSTA approves development of the Implementation Plan for 4850 lab
  - Barrick confirms 4850 lab satisfies the "Agreement"
  - SDSTA initiates application for water permits
  - S-2 proposal submitted

Near Future

- May 2005, 4850 Lab Implementation Plan to be submitted to the SDSTA Board
  - Defines/identifies initial candidates, re-entry plan, costs, operating costs, management structures, etc.
- June 2005
  - Plan to be accepted by SDSTA
  - LOIs to be requested for 4850 lab
- July 2005, Funds for 4850 lab to be confirmed
- Aug 2005, Water permits received, 1st round of S-2 workshops

Near Future

- October 2005
  - Transfer of site to be completed
  - Begin work on site rehabilitation and 4850 lab access
- Jan 2006, 2nd round of S-2 workshops
- May 2006, 4850 lab ready for construction of new experimental chambers and tailored reuse of existing space
- Nov 2006, Complete modifications of 4850 lab and begin experiments.

Further in the Future

- 2007 Completion of S-2 process
- 2007 Active Scientific, Engineering, and Outreach Programs at Homestake: surface to 4850.
- 2008 S-3 process for creation of deep laboratory at 7400 and deeper at Homestake
- 2009 funding for DUSEL using 4850 lab as a beach head

Homestake Conversion Plan & its Review

Homestake Conversion Plan & its Review

- Examined a variety of options and defined the necessary steps to:
  - Reestablish redundant safe access underground at Homestake
  - Deal with the accumulated water and continuing inflows
  - Inspect, upgrade and maintain the critical infrastructure
  - Establish realistic costs and schedules

Homestake Conversion Plan & its Review

- Examined a variety of options and defined the necessary steps to:
  - Reestablish redundant safe access underground at Homestake
  - Deal with the accumulated water and continuing inflows
  - Inspect, upgrade and maintain the critical infrastructure
  - Establish realistic costs and schedules
- Plan prepared by a well-respected, experienced mining engineering firm, Dynatec

Six Options Examined

- 1-Series, basic access, essential maintenance
- 1a: safe access to 4850 and above, hold water ~ 5000 level
- 1b: safe access to 4850 and above, hold water at anticipated level ~ 6200
- 1c: safe access to 4850 and above, dewater the complete facility
- 2 Series, access with upgrades and improvements
- 2a: hold water at ~ 5000
- 2b: hold water at ~ 6200
- 2c: dewater the facility

Six Options Examined

Option #	Underground Development Cost ($)	Surface Development Costs ($)	Total costs ($)	Schedule (Months)	Annual Operating Costs
1a	9,049,000	900,000	9,949,000	5	3,700,000
1b	9,746,000	1,300,000	11,046,000	5	3,800,000
1c	21,237,000	1,400,000	22,637,000	13	4,100,000
2a	22,741,000	1,300,000	24,041,000	9	3,700,000
2b	28,904,000	1,300,000	30,204,000	15	4,100,000
2c	40,043,000	4,900,000	44,943,000	15	4,200,000

Current plan has continued to be refined:

- Current Duration: ~ 12 Months
- Capital Costs: ~ $10 to 15M (from SD controlled funds)
- Annual Operating Costs: ~ $3M (SD controlled funds)
- Full Maintenance on a both shafts and cross on the 4850
- Access and Beneficial Occupancy: surface to 4850
- Initial focus stationary experiments on existing space
- Isolate future deep work from experimental areas
- Collect and eject upper water, begin work on deep water.

Six Options Examined

Option #	Underground Development Cost ($)	Surface Development Costs ($)	Total costs ($)	Schedule (Months)	Annual Operating Costs
1a	9,049,000	900,000	9,949,000	5	3,700,000
1b	9,746,000	1,300,000	11,046,000	5	3,800,000
1c	21,237,000	1,400,000	22,637,000	13	4,100,000
2a	22,741,000	1,300,000	24,041,000	9	3,700,000
2b	28,904,000	1,300,000	30,204,000	15	4,100,000
2c	40,043,000	4,900,000	44,943,000	15	4,200,000

NB: to complete the rehabilitation, including complete dewatering, providing safe access to 8000 feet:

$50 M

15 month

Additional Room Construction:

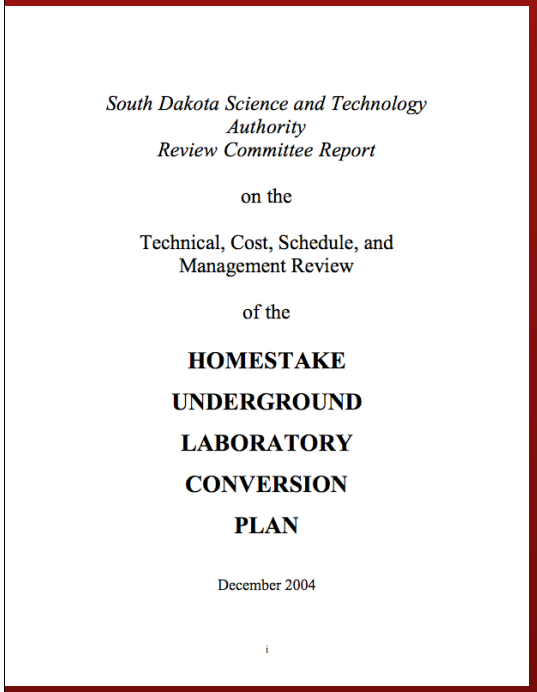
Competitively priced, would use fraction of original hoisting capacity of the mine (7000 T/day)

Initial engineering studies support massive room construction feasible at 7400 level

Identified excavated rock disposal sites

Water permits initiated

Conversion Plan Review: Dec 2004



South Dakota Science and Technology Authority
Review Committee Report

on the

Technical, Cost, Schedule, and Management Review

of the

HOMESTAKE UNDERGROUND LABORATORY CONVERSION PLAN

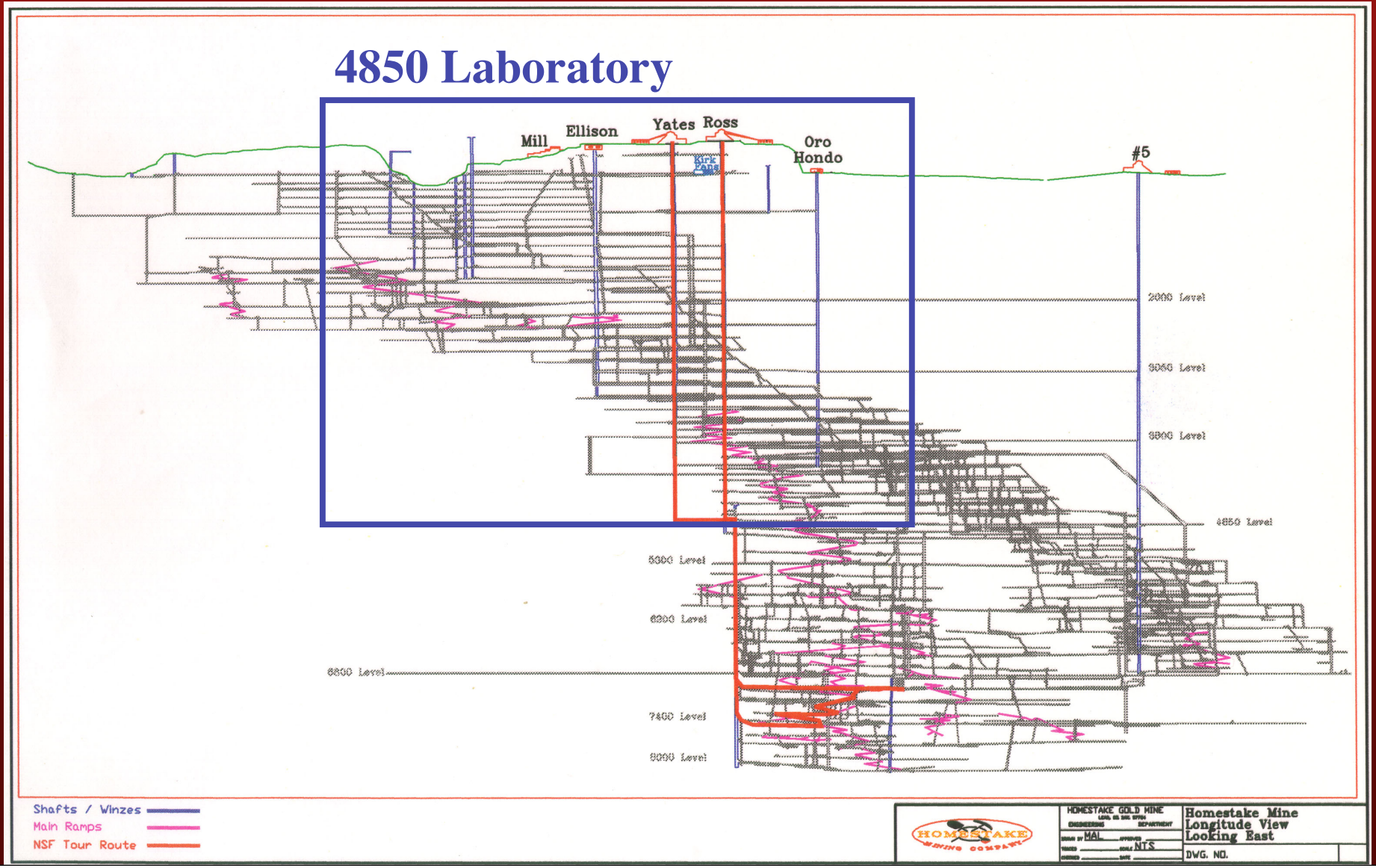
December 2004

i

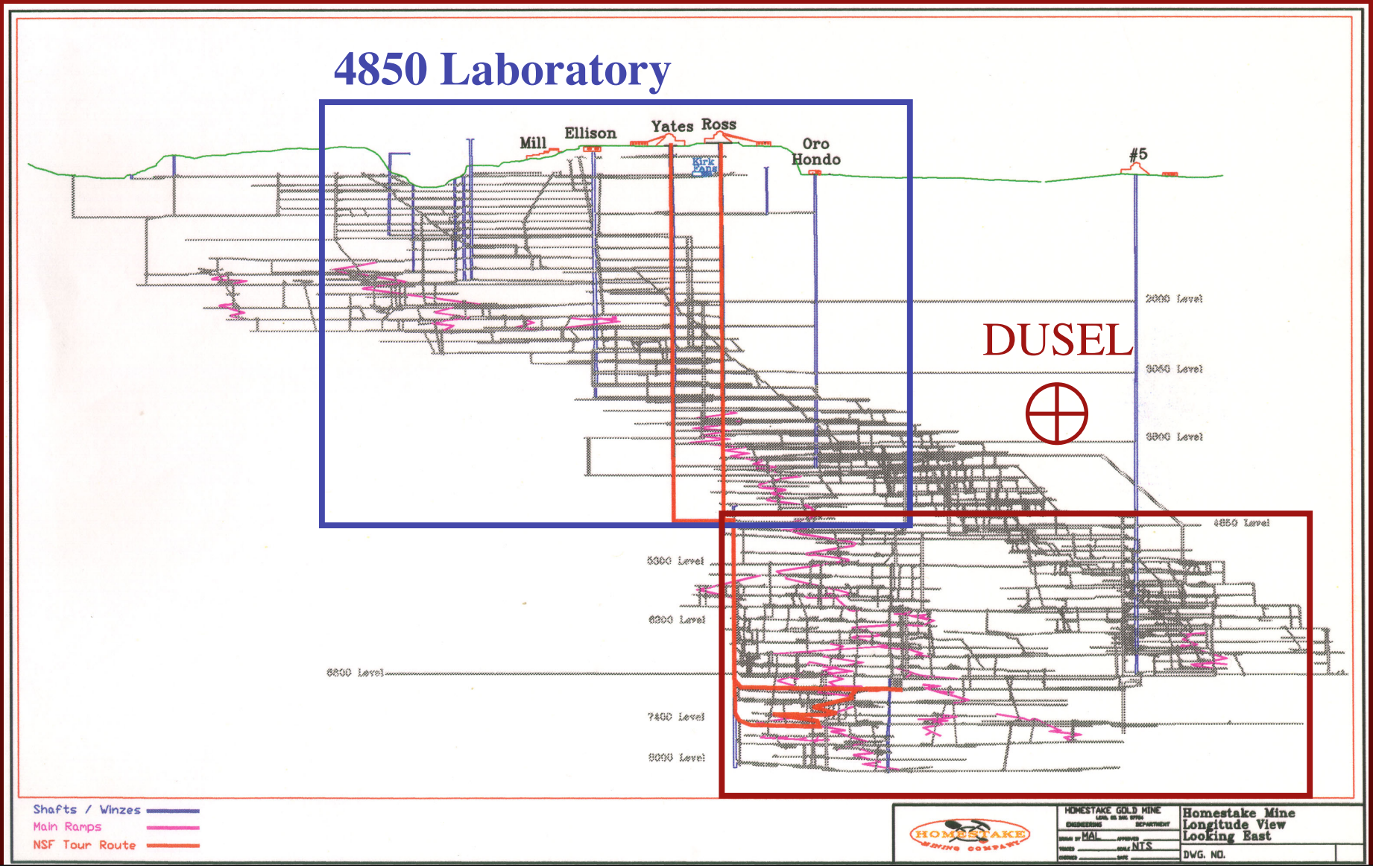
- The plan for Conversion Project is advanced and comprehensive. The steps to regain beneficial occupancy underground and to deal with the water are well understood, estimated and scheduled. …
- A variety of options for obtaining access were evaluated. There is strong consensus that the Conversion Project should initially focus on developing access to the 4850-foot level and above. …
- There exists an equally strong consensus that the Conversion Project should expeditiously address the flooding of the mine and at least halt the advance of water at its level in the facility when access is gained and before the utility of the 4850-foot level is compromised. …
- It is appropriate to begin planning in the near future for the integration of science, construction and operation of the facility at the 4850-foot level and establishing the necessary management and oversight functions from within the Authority and from the scientific community. …

http://neutrino.lbl.gov/Homestake/S2_Supporting_Documents/

Expedient access to ~20 cubic kilometers of rock mass, depths to 4850 feet, many existing spaces and excavations suited for science in the near term



Expedient access to ~20 cubic kilometers of rock mass, depths to 4850 feet, many existing spaces and excavations suited for science in the near term



Science Underground

- The following is a short version of the very strong, very deep case for building DUSEL.
- Need to thank all the S-1 PIs and contributors for defining the science case
- I present here a few examples of the world-class physics and earth science that Homestake will accommodate
- It is not meant to be the full justification nor the full spectrum of the investigations that would use DUSEL.

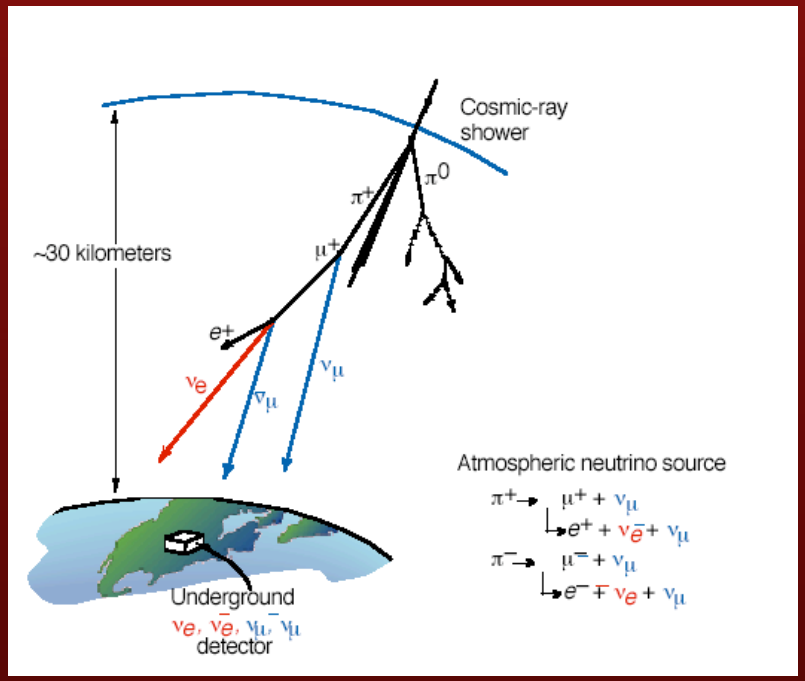
Why Physicists Go Underground?

Why Physicists Go Underground?

To get away from Backgrounds & People!

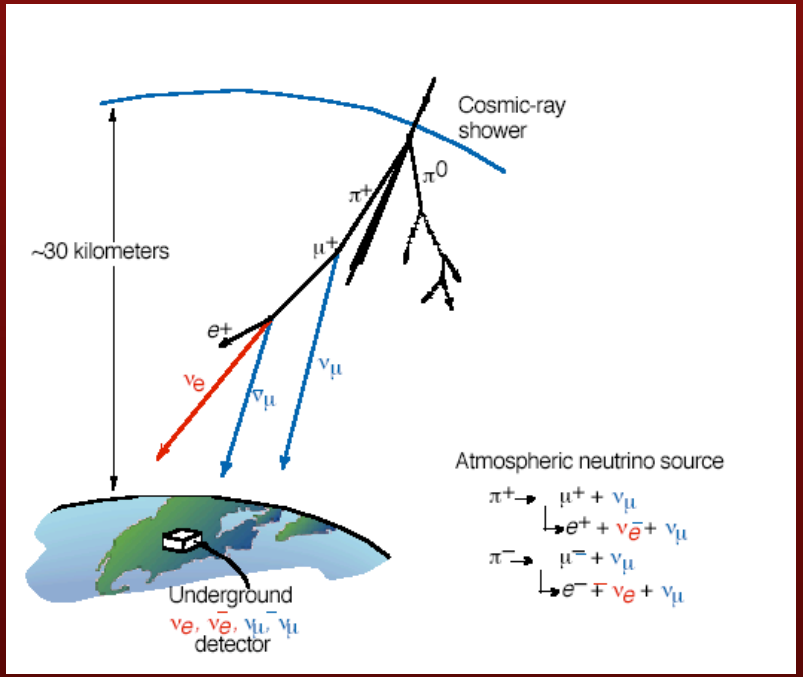
Why Physicists Go Underground?

To get away from Backgrounds & People!



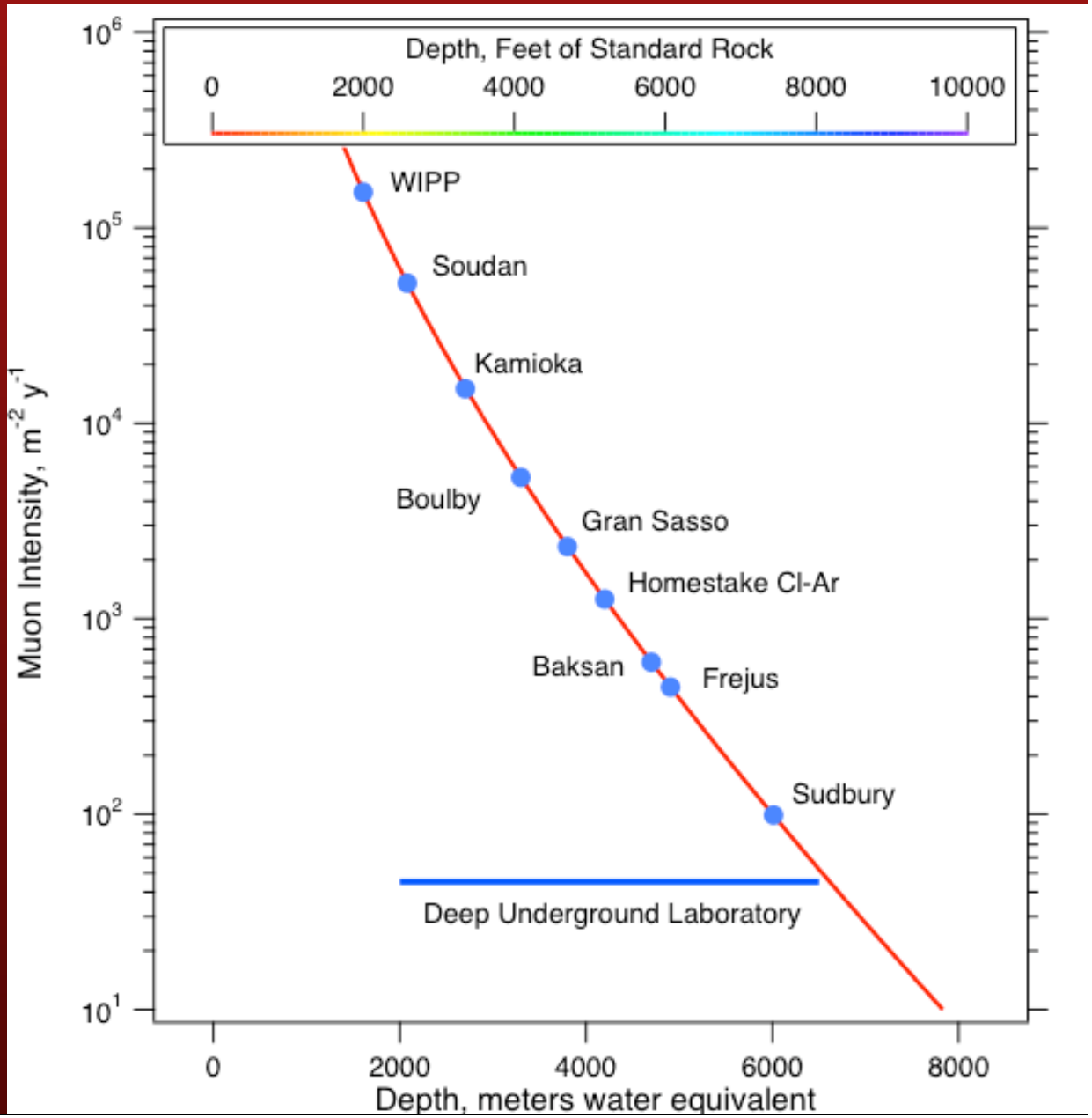
Why Physicists Go Underground?

To get away from Backgrounds & People!



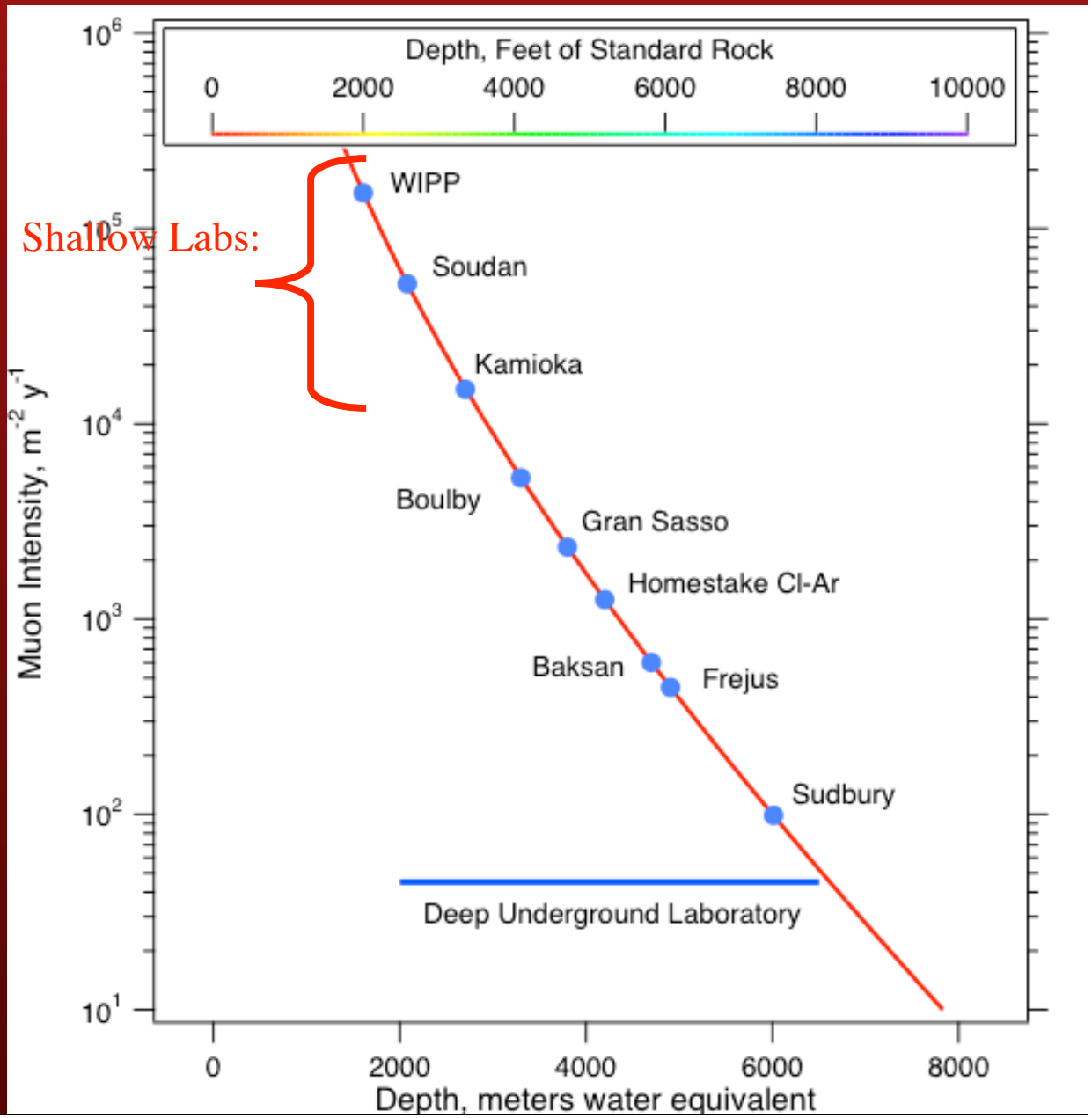
Why Physicists Go Underground?

To get away from Backgrounds & People!



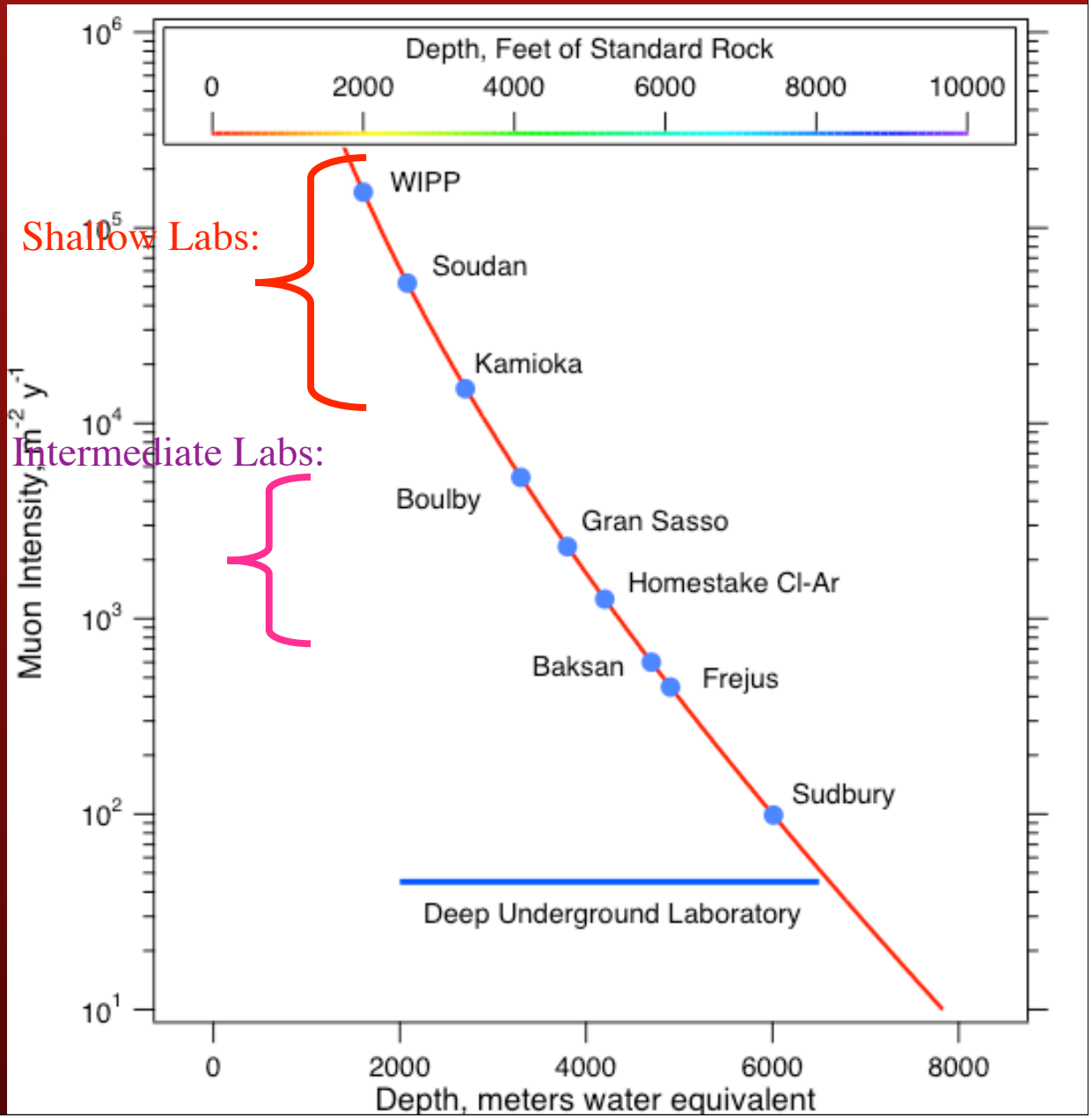
Why Physicists Go Underground?

To get away from Backgrounds & People!



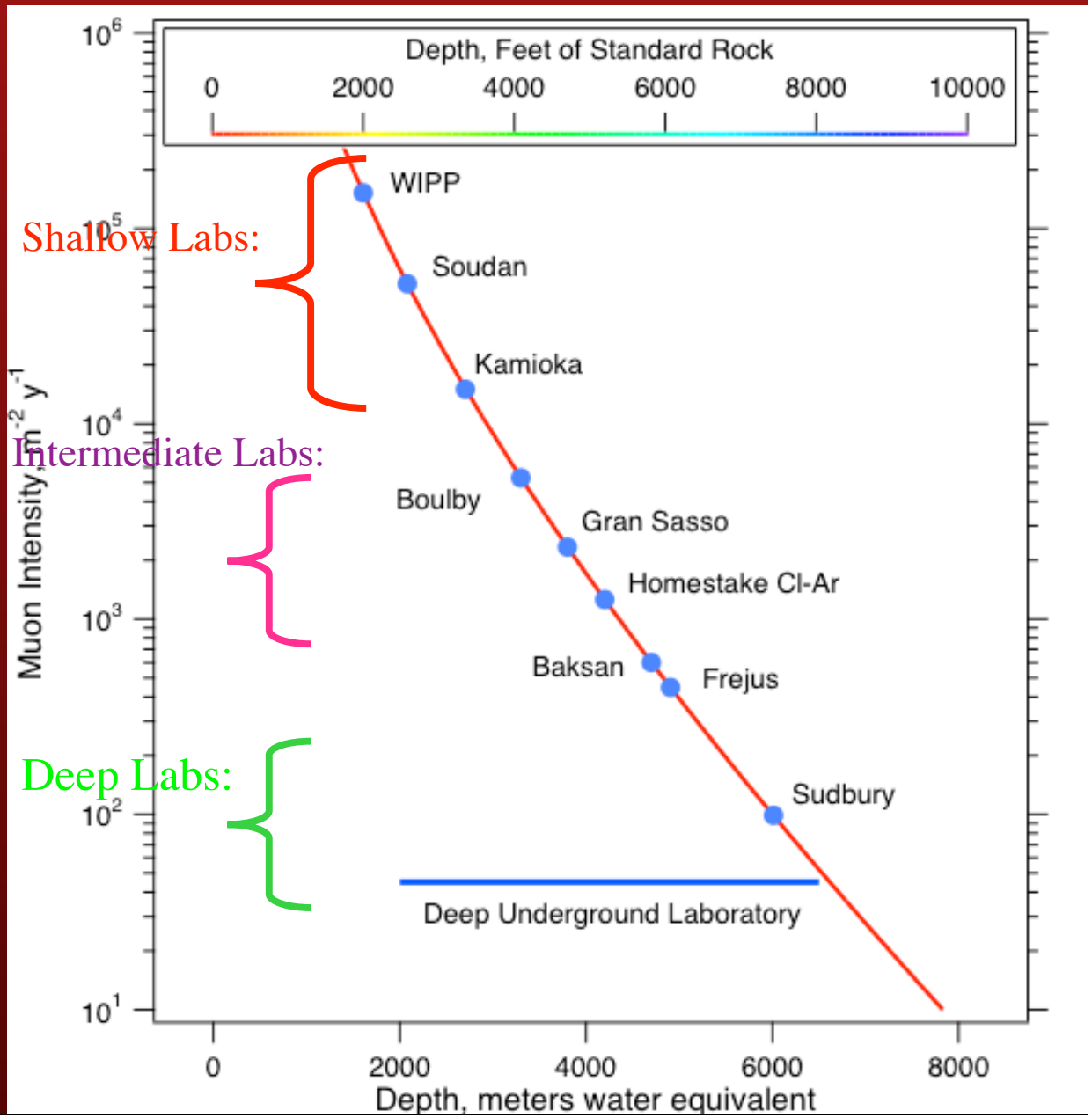
Why Physicists Go Underground?

To get away from Backgrounds & People!



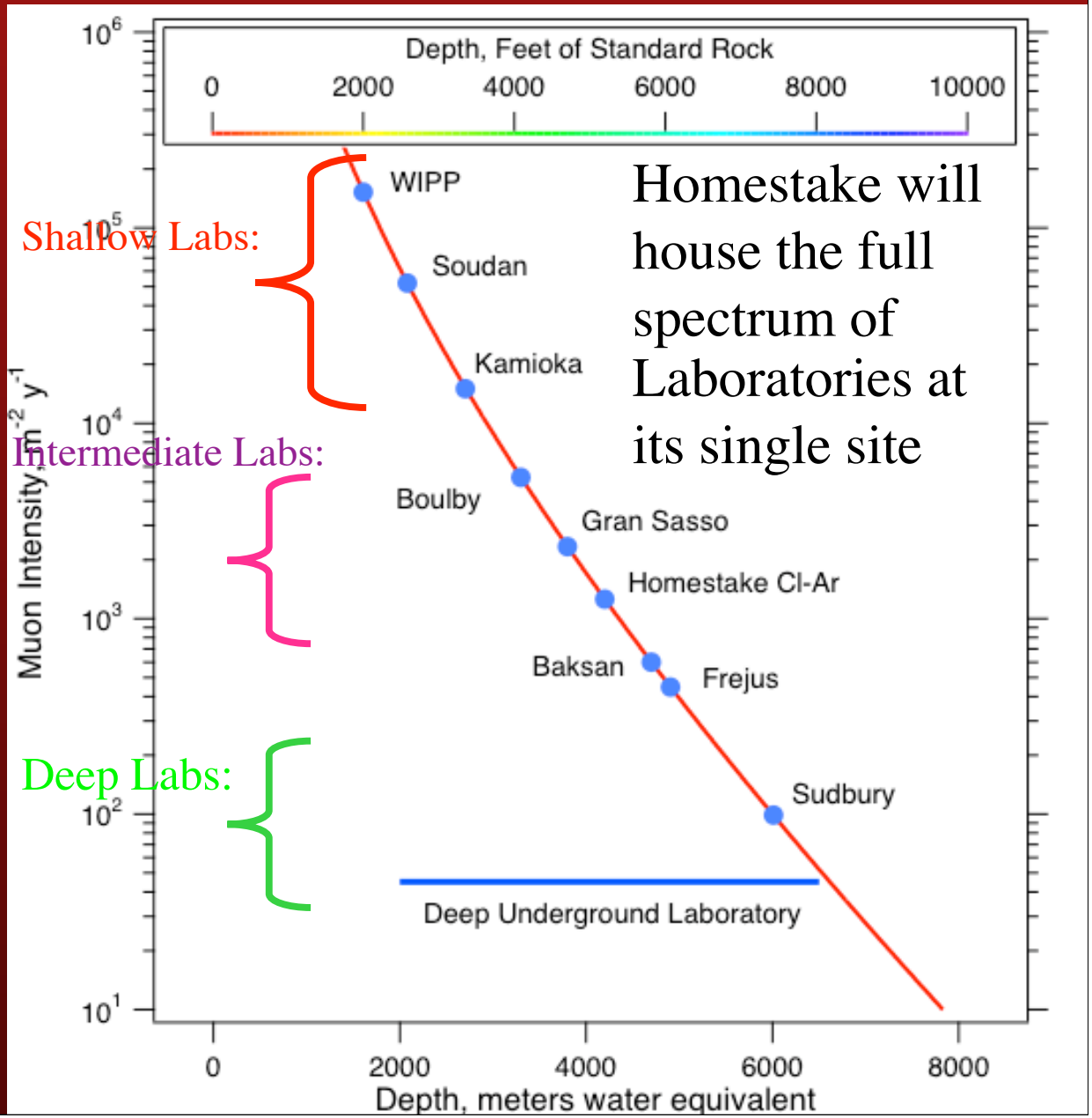
Why Physicists Go Underground?

To get away from Backgrounds & People!



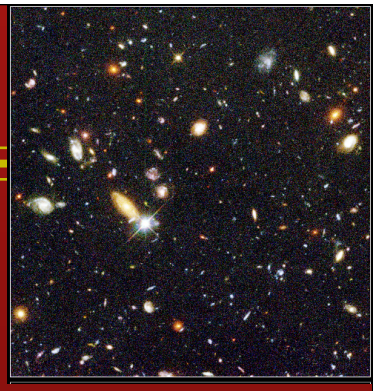
Why Physicists Go Underground?

To get away from Backgrounds & People!



Homestake will house the full spectrum of Laboratories at its single site

What is the Dark Matter?



- Compelling evidence for DM
  - Spiral Galaxy Rotational Curves
  - Galactic Cluster Velocities
  - Gravitational Lensing
  - "Great Attractor" evidence within Large Clusters
  - CMBR Large Scale Structure

$\Omega_C = 35\%$

- Types of DM
  - Dark Baryons
    - Big Bang Nucleosynthesis
    - CMB Structure
    - Quasar Light Absorption by Gas Clouds
    - Counting Stars

$\Omega_{baryon} = 4\%$

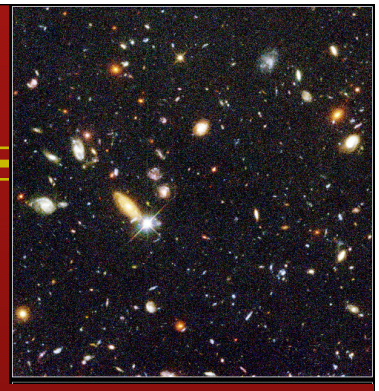
$\Omega_{baryon} = 1.3\%$

  - Exotic Dark Matter

$\Omega_{exotic} = \sim 30\%$

- Experiments require 1 ct/kg/day -> 1 ct/100kg/year

What is the Dark Matter?



- Compelling evidence for DM
  - Spiral Galaxy Rotational Curves
  - Galactic Cluster Velocities
  - Gravitational Lensing
  - "Great Attractor" evidence within Large Clusters
  - CMBR Large Scale Structure

$\Omega_C = 35\%$

- Types of DM
  - Dark Baryons
    - Big Bang Nucleosynthesis
    - CMB Structure
    - Quasar Light Absorption by Gas Clouds
    - Counting Stars

$\Omega_{baryon} = 4\%$

$\Omega_{baryon} = 1.3\%$

  - Exotic Dark Matter

$\Omega_{exotic} = \sim 30\%$

- Experiments require 1 ct/kg/day -> 1 ct/100kg/year

Neutrinos are the first source of DM!

Neutrino Physics (ν Properties and affects on evolution of the Universe)

- Neutrino Masses & Neutrino Mixing
- Neutrinoless ββ decay
- Solar Neutrinos
- Atmospheric Neutrinos
- Long Base Line Experiments & Reactor Experiments
- Supernovae
- Potential CP violation and Leptogenesis

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

Maki-Nakagawa-Sakata-Pontecorvo

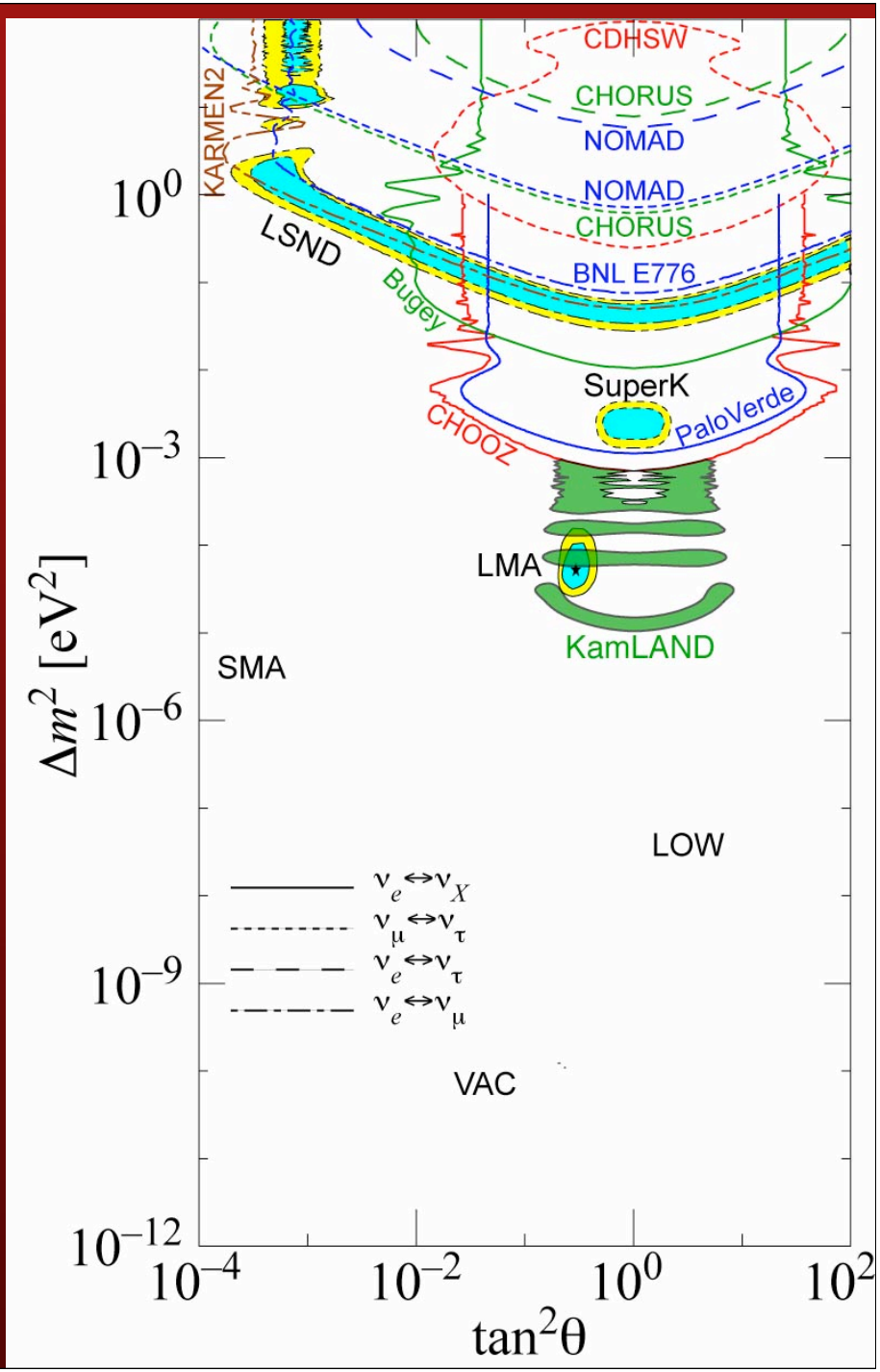
$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix} \times \begin{pmatrix} \cos\theta_{13} & 0 & e^{-i\delta_{CP}}\sin\theta_{13} \\ 0 & 1 & 0 \\ -e^{i\delta_{CP}}\sin\theta_{13} & 0 & \cos\theta_{13} \end{pmatrix} \times \begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \times \begin{pmatrix} 1 & 0 & 0 \\ 0 & e^{i\alpha/2} & 0 \\ 0 & 0 & e^{i\alpha/2+i\beta} \end{pmatrix}$$

Super-K

- Reduced ν_e MSW space by 7 orders of magnitude
- No dark side ν_e ($\tan^2\theta 12<1$) and non-maximal
- LMA (confirmed by KamLAND - assuming CPT)
- Strong Evidence for matter affects
- Massive neutrinos
- Large mixing angles for θ_{12} and θ_{23} & small Δm^2_{12} and Δm^2_{23}

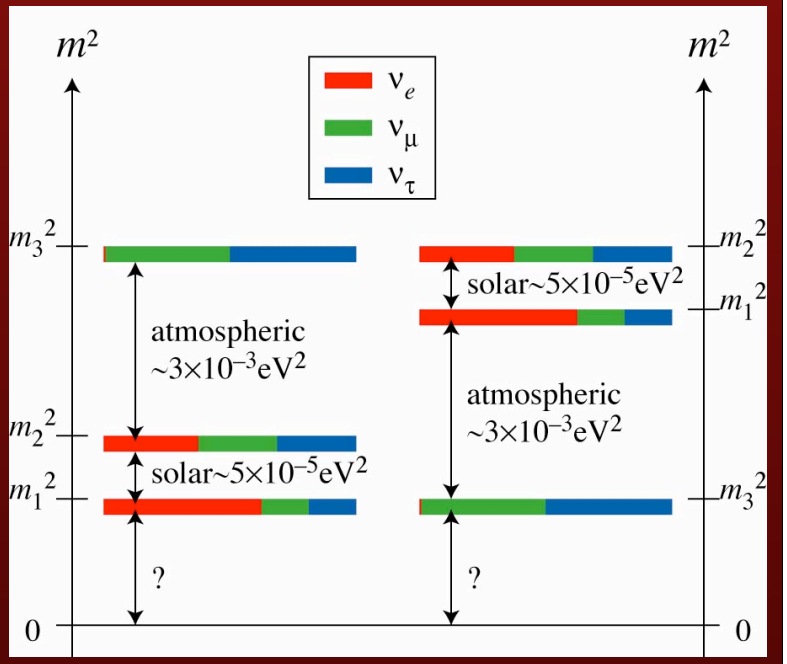
Super-K

- Reduced ν_e MSW space by 7 orders of magnitude
- No dark side ν_e ($\tan^2\theta 12<1$) and non-maximal
- LMA (confirmed by KamLAND - assuming CPT)
- Strong Evidence for matter affects
- Massive neutrinos
- Large mixing angles for θ_{12} and θ_{23} & small Δm^2_{12} and Δm^2_{23}



Remaining Questions for Neutrinos

- Neutrino Mass Scale
- MNSP Matrix Elements
  - θ_{13} - size of angle and possible CP violation
  - θ_{12} and other elements - Unitarity, number of νs, solar physics
  - Mass hierarchy
  - Verify Oscillations
- Sterile Neutrinos (other types of ν)?
- CP violation?
- Neutrino Nature
  - Majorana or Dirac



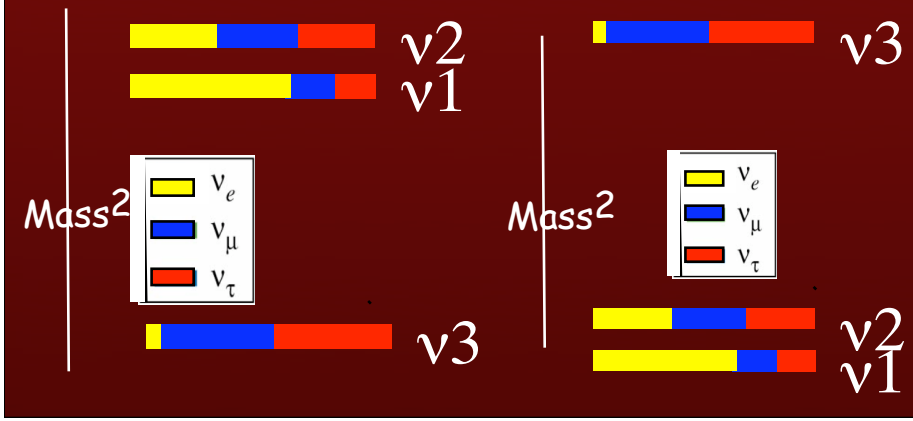
Why Double Beta Decay?

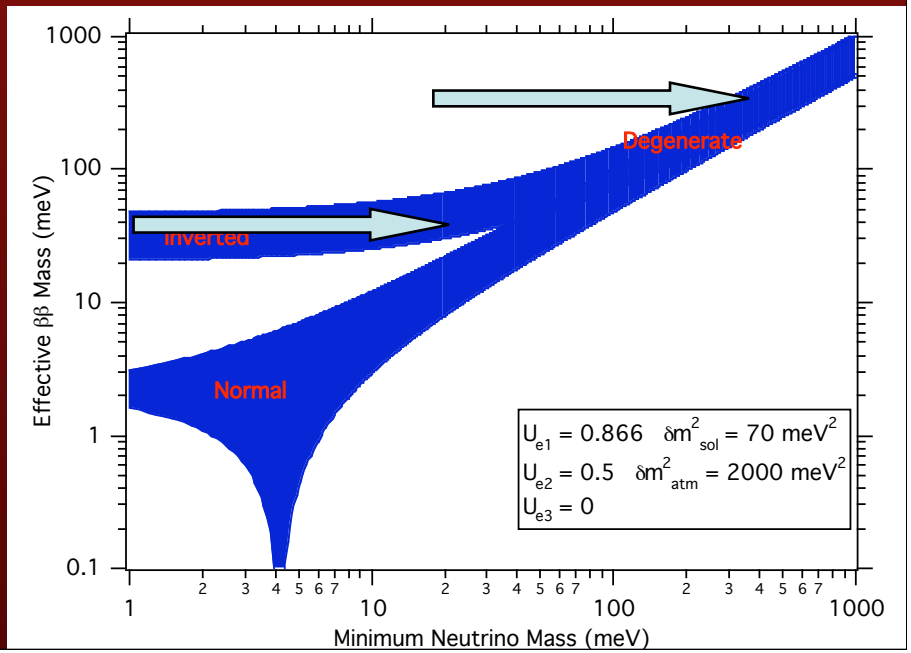
Neutrino Masses, Mixing, & Nature?

- Oscillation experiments indicate νs are massive, set **relative** mass scale, and **minimum** absolute mass.
- β decay + cosmology set maximum for the absolute mass scale.
- One ν has a mass in the range: 45 meV $< m_\nu <$ 2200 meV
- ββ experiments can determine the absolute mass scale and only way to establish if neutrinos are Dirac or Majorana (their own anti-particle)

Dirac or Majorana

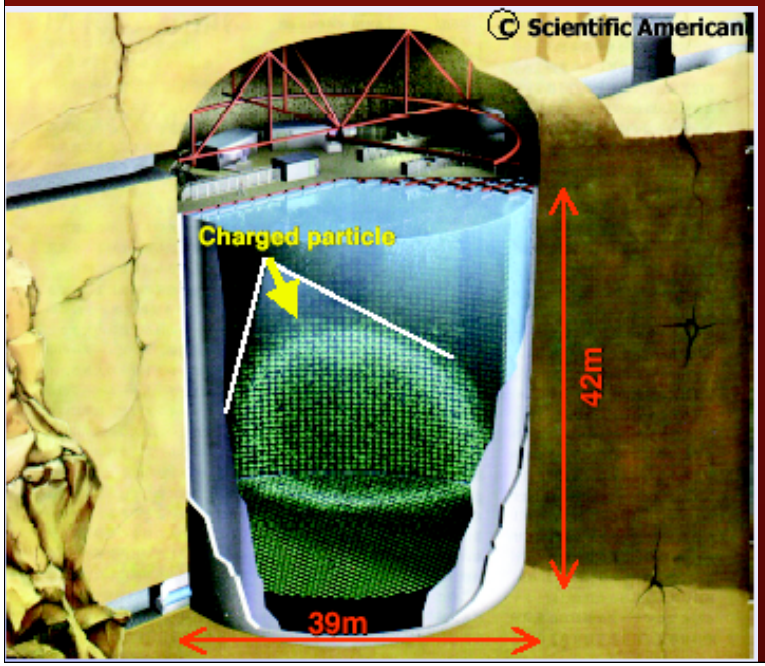
$$\begin{pmatrix} \nu_\uparrow \\ \nu_\downarrow \\ \bar{\nu}_\downarrow \\ \bar{\nu}_\uparrow \end{pmatrix} \quad \text{or} \quad \begin{pmatrix} \nu_\uparrow \\ \nu_\downarrow \end{pmatrix}$$





Proton Decay and Long Baseline ν Studies

- At this point: PDK is (one of) the longest-lived, unanswered question in (non-accelerator) physics
- Neutrino Oscillations and CP violation extremely interesting and exciting, focus of many National Studies

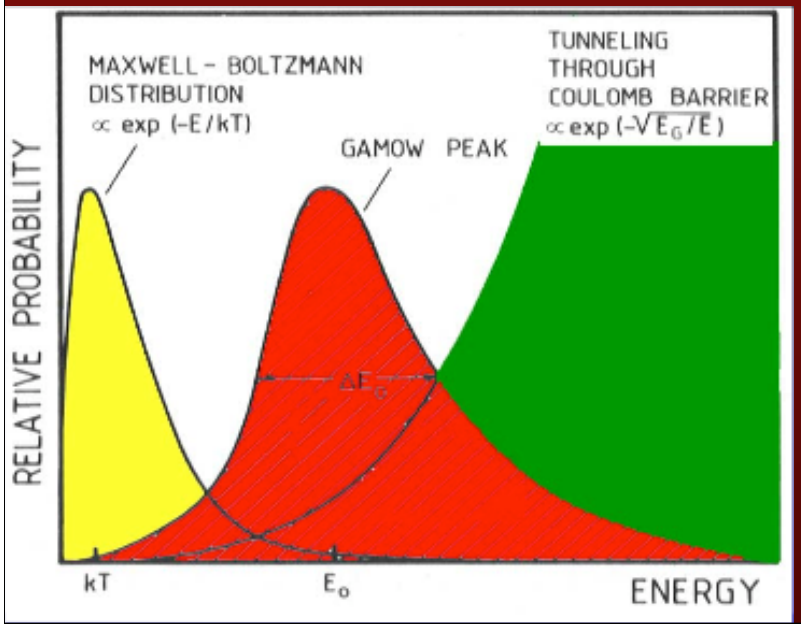


- Multipurpose detectors: PDK, ν mixing, ν mass, cosmic observation - large physics output!
- Could be ready 5 years after start of a laboratory effort.
- Interest of many national labs and HEP community

Nuclear Astrophysics/ Nucleosynthesis

- A>60 formation in Supernovae, ν interactions
- Sources of neutrons for s-, r- processes
- Details of Lower Mass Nucleosynthesis
- pp chain
- CNO

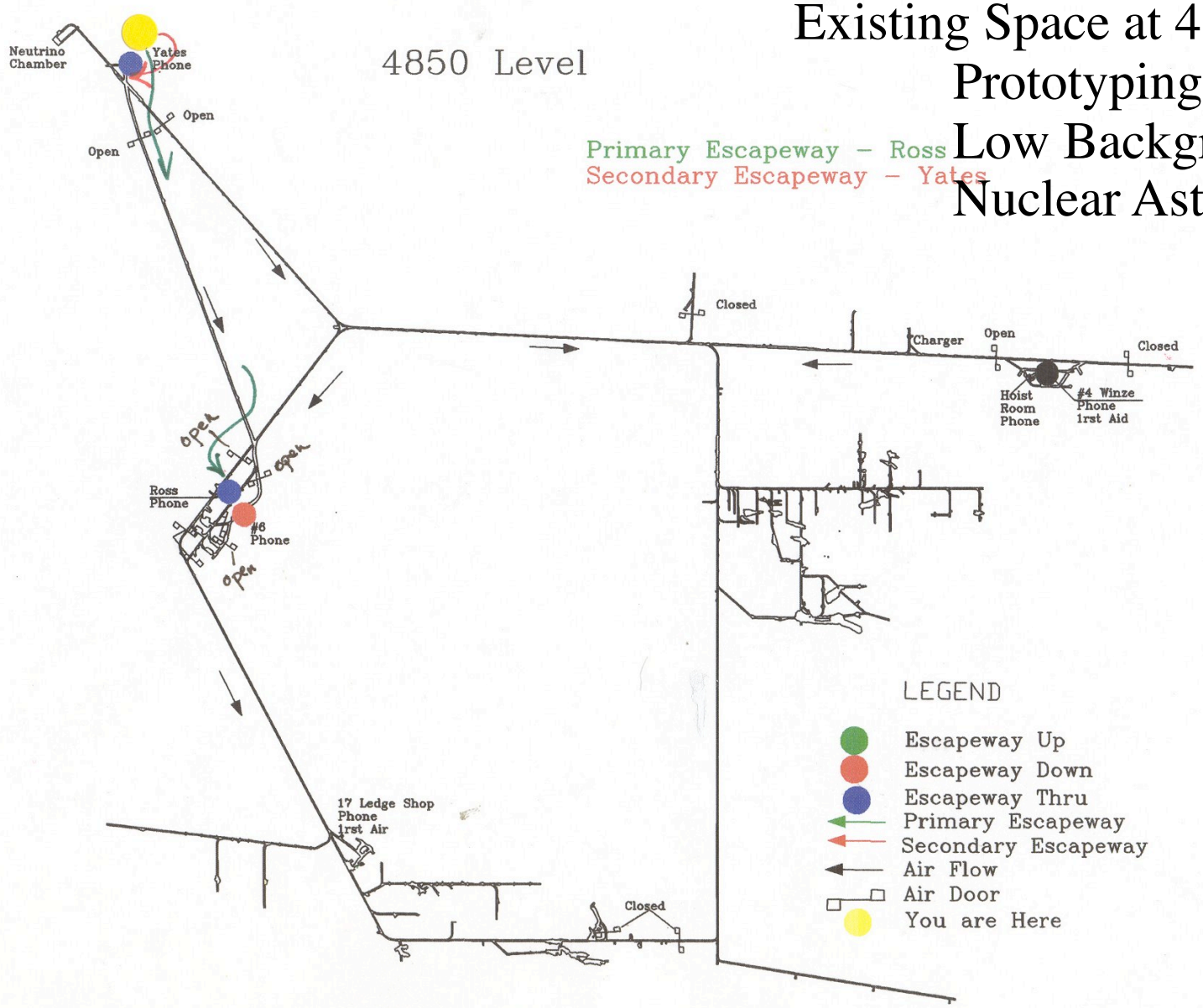
$^{3}He(^{3}He,2p)^{4}He$
$^{3}He(\alpha,\gamma)^{7}Be$
$D(^{3}He,p)^{4}He$
$D(p,\gamma)^{3}He$
$^{7}Be(p,\gamma)^{8}B$
$^{14}N(p,\gamma)^{15}O$
$^{12}C(\alpha,\gamma)^{16}O$
…



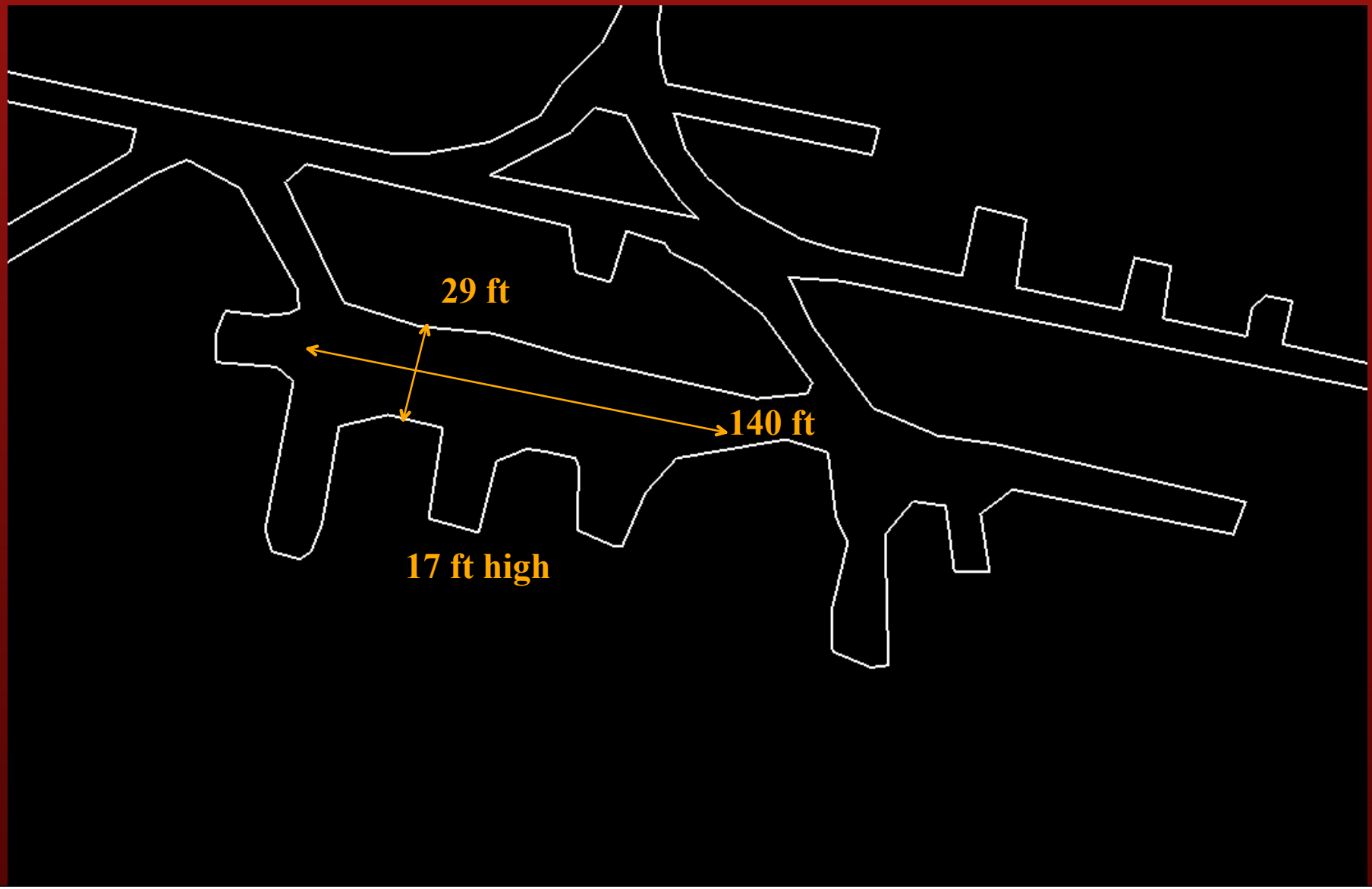
- Bright Prospects for Domestic Program in Nuclear Astrophysics in an Underground Laboratory
  - Complementary energy and current designs to existing facilities
  - Deeper site enables a more ambitious experimental program

Plan of 4850 level

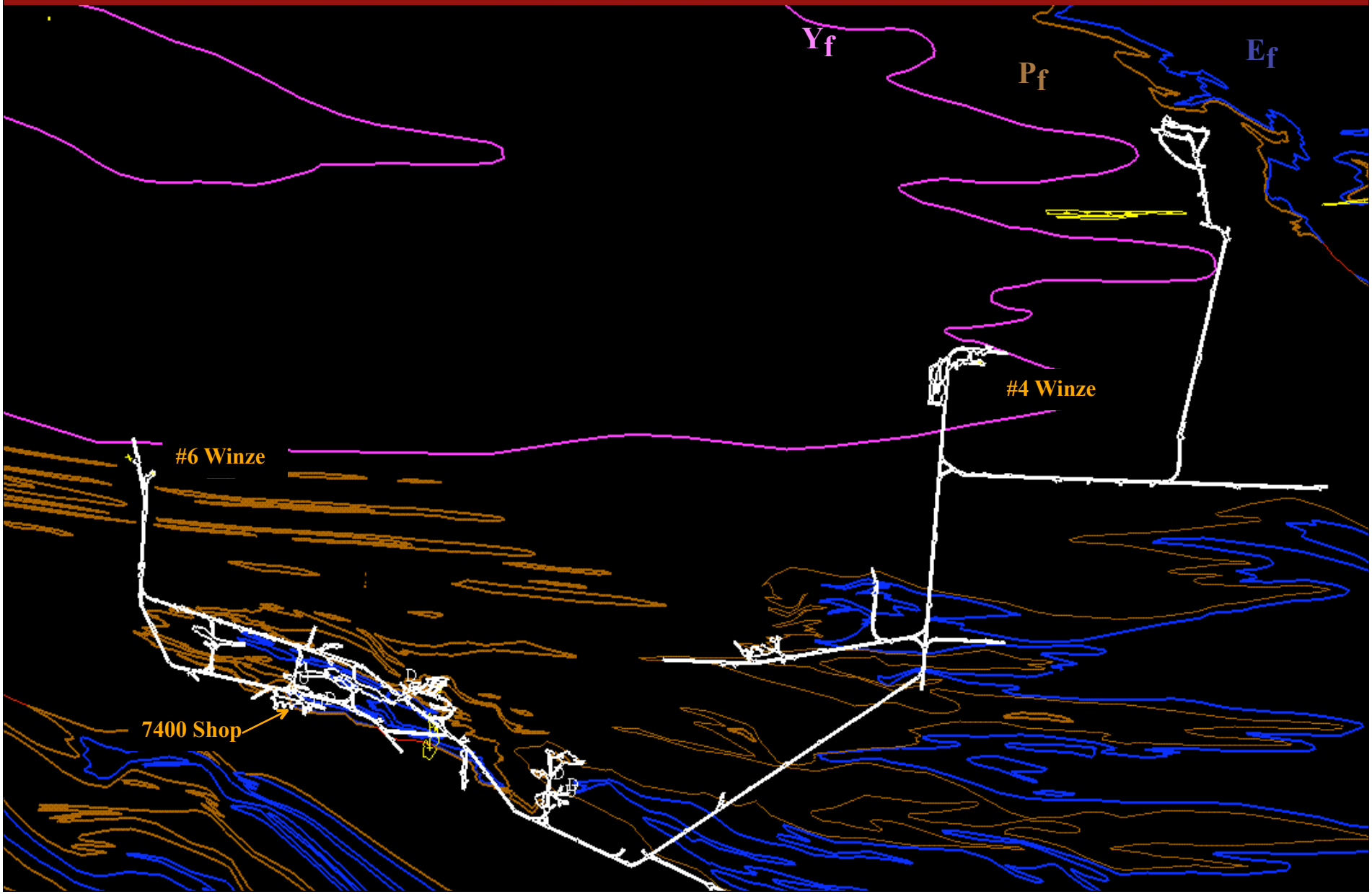
Existing Space at 4850 for:
- Prototyping
- Low Background Labs
- Nuclear Astrophysics

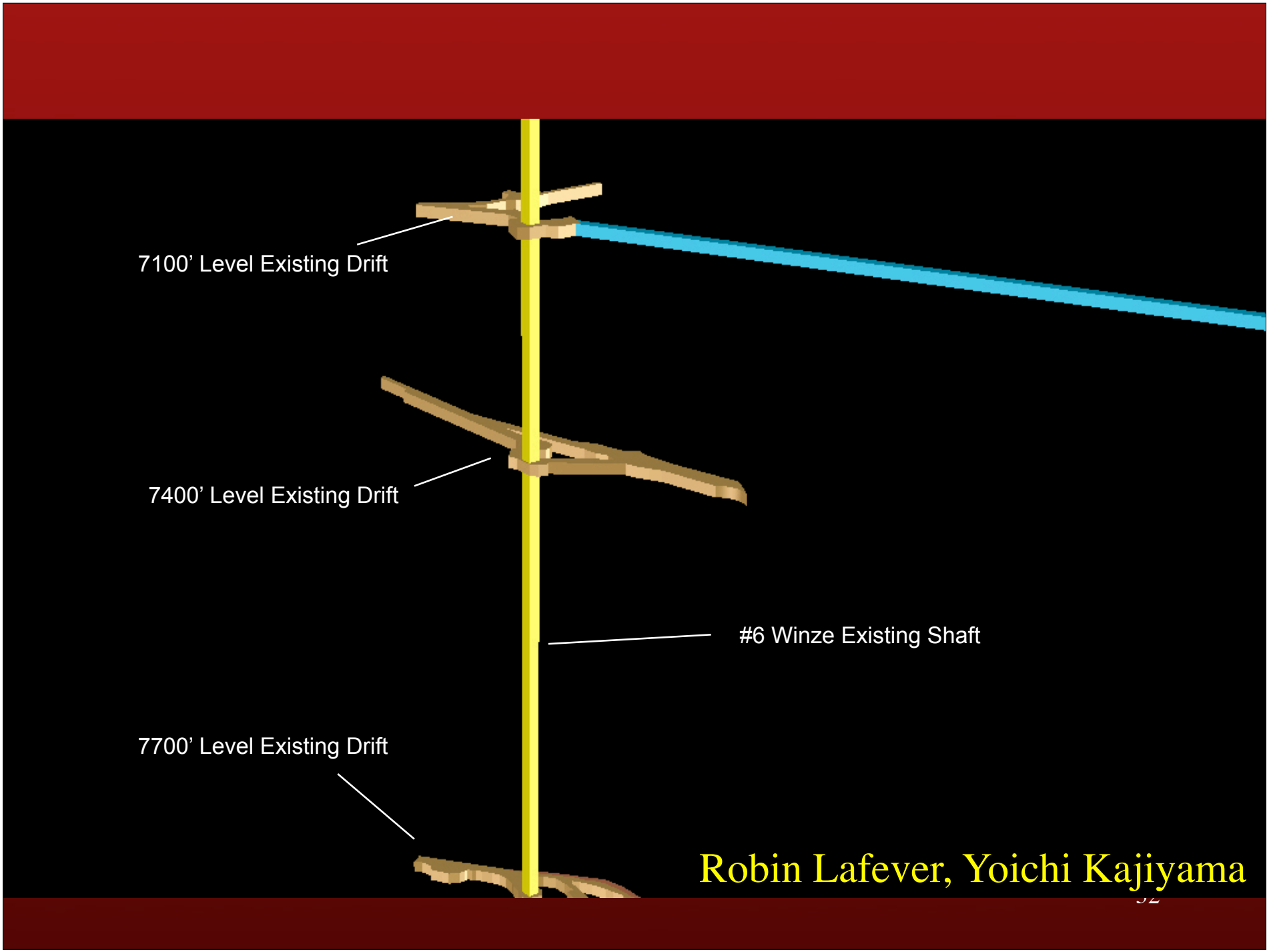


Homestake Mine 7400 Shop



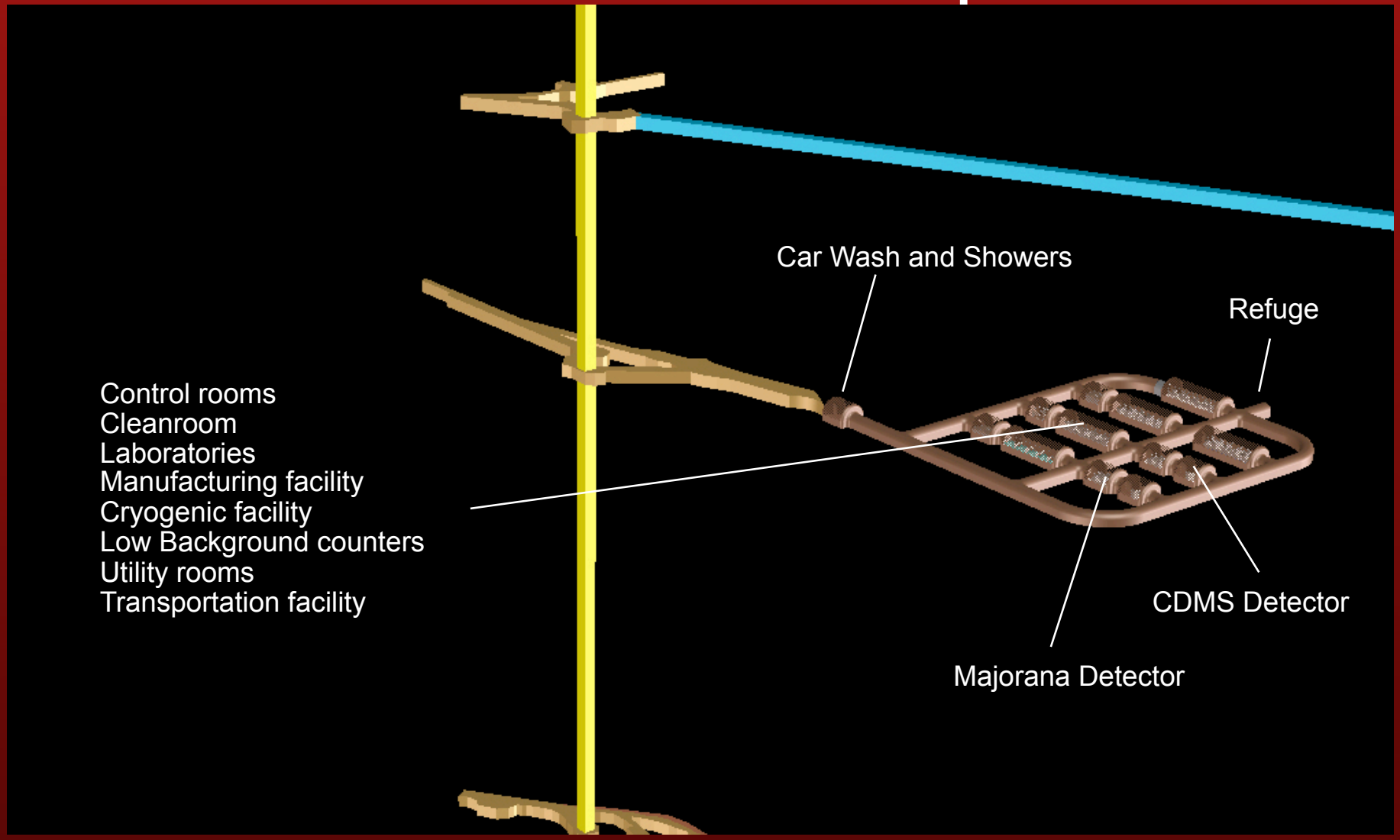
Homestake Mine 7400



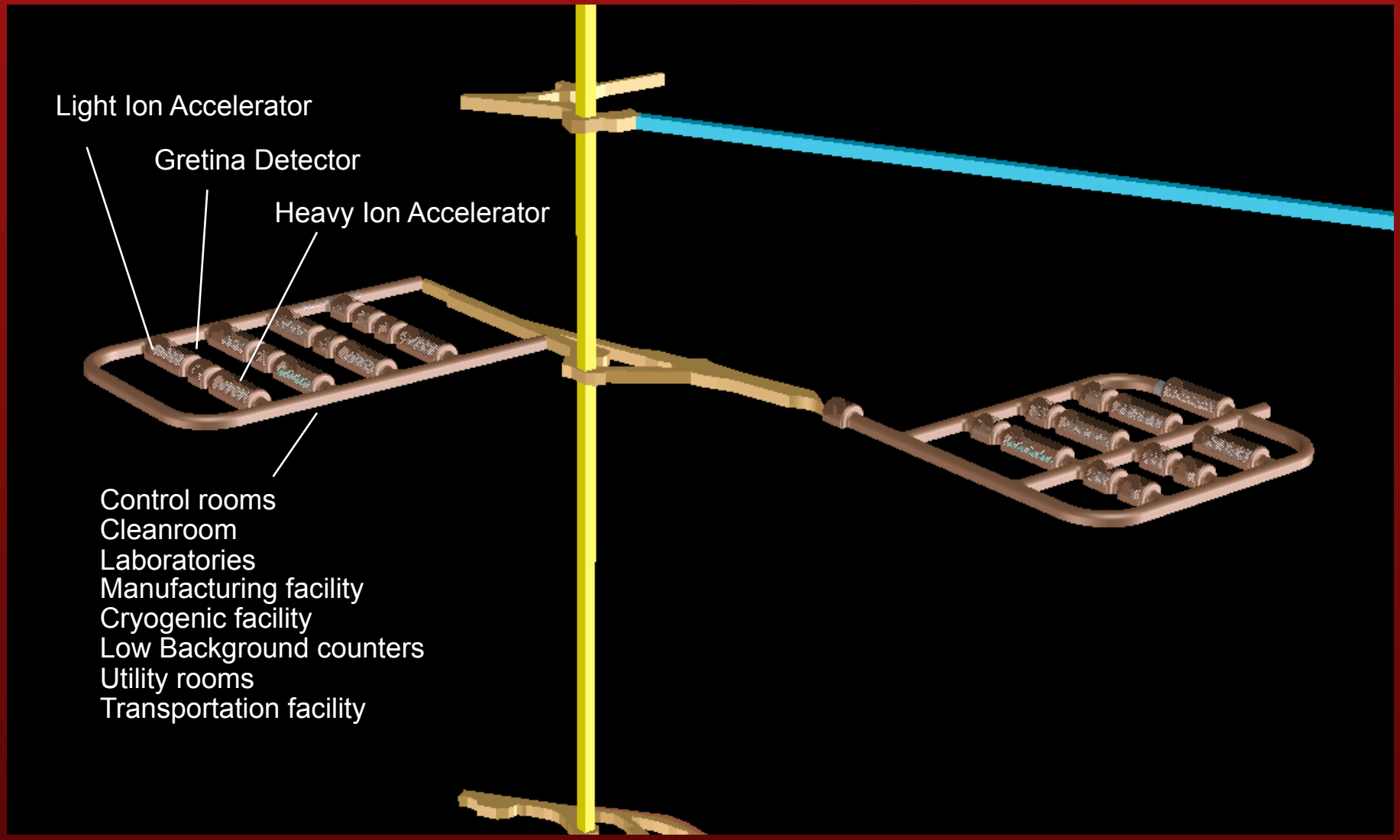


Robin Lafever, Yoichi Kajiyama

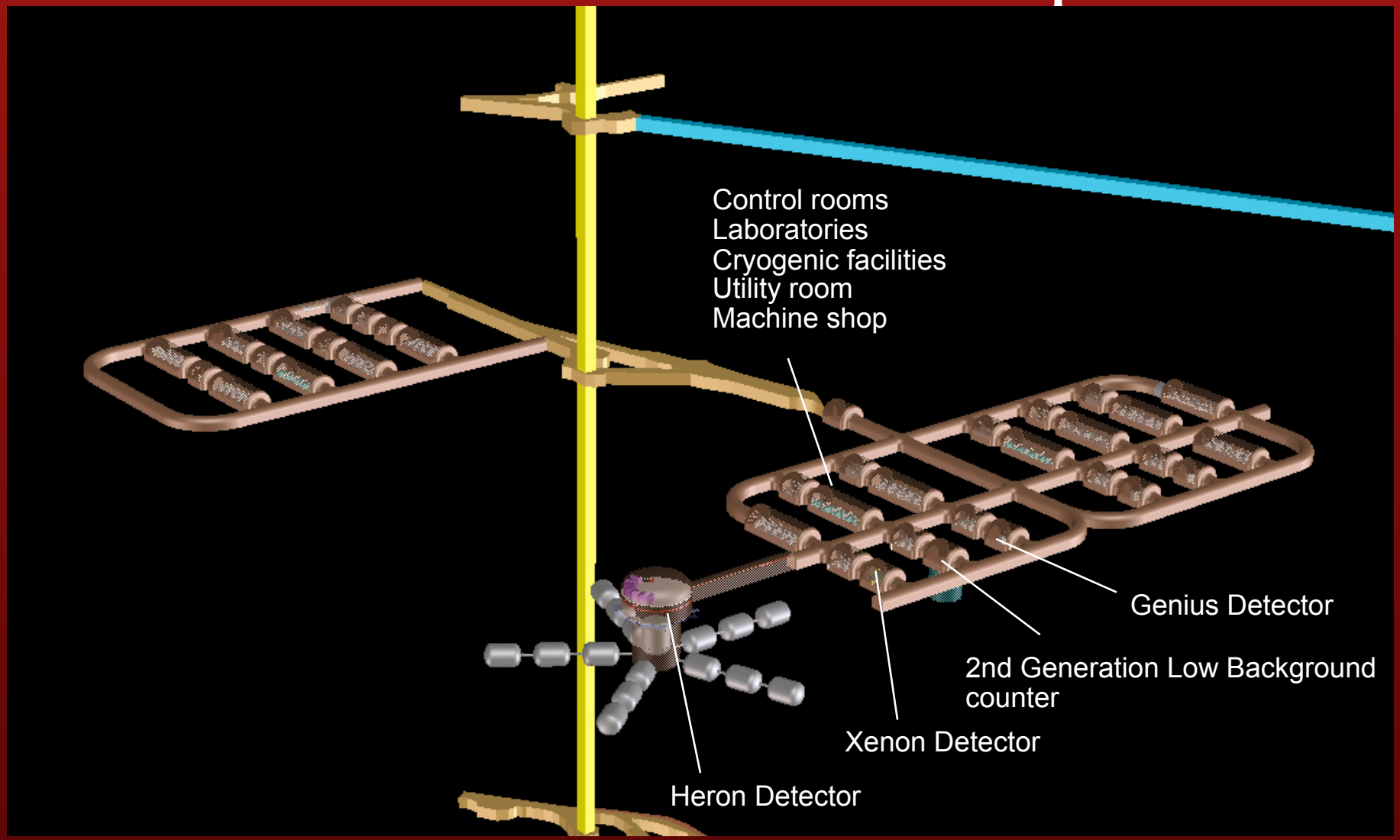
Initial Clean Campus



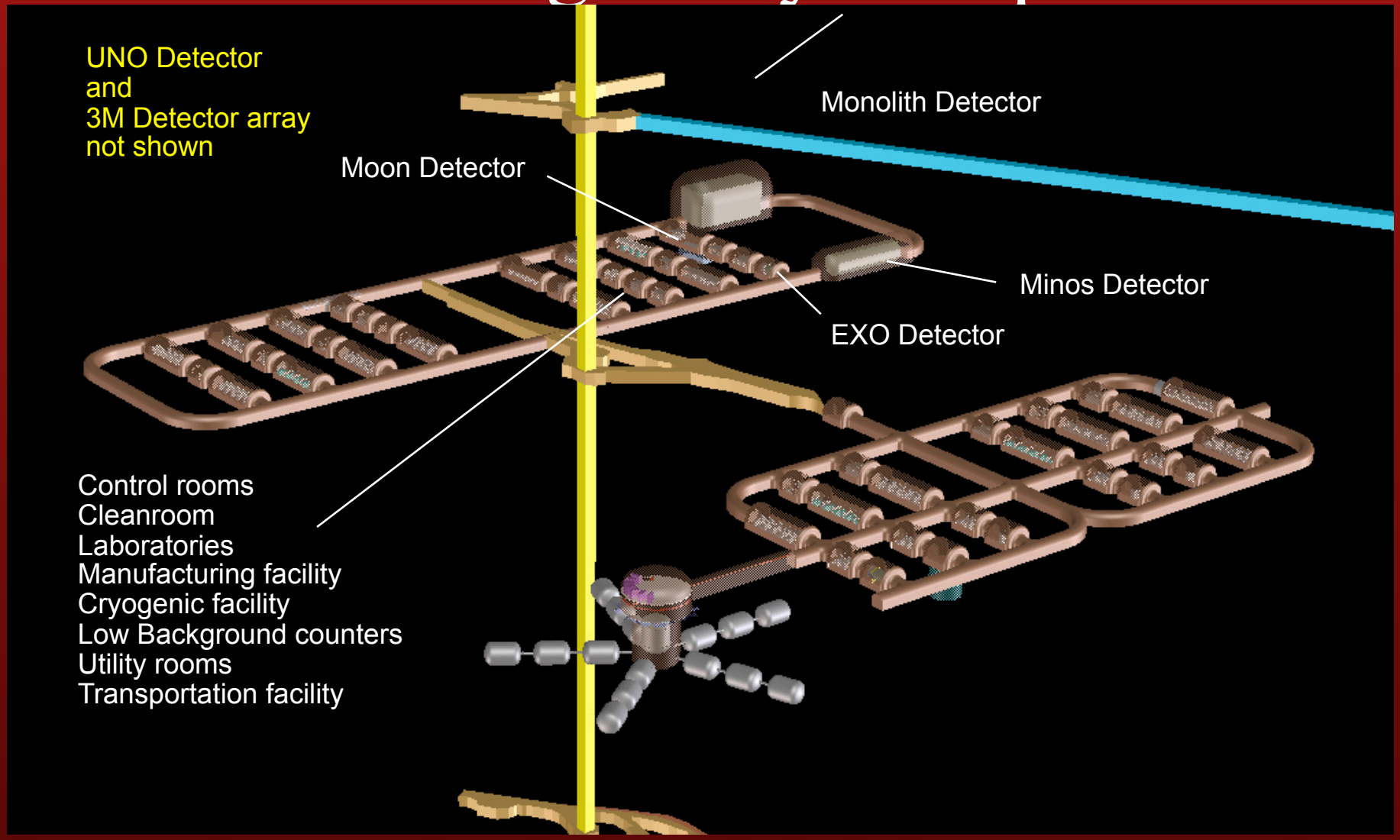
Initial "Dirty" Campus



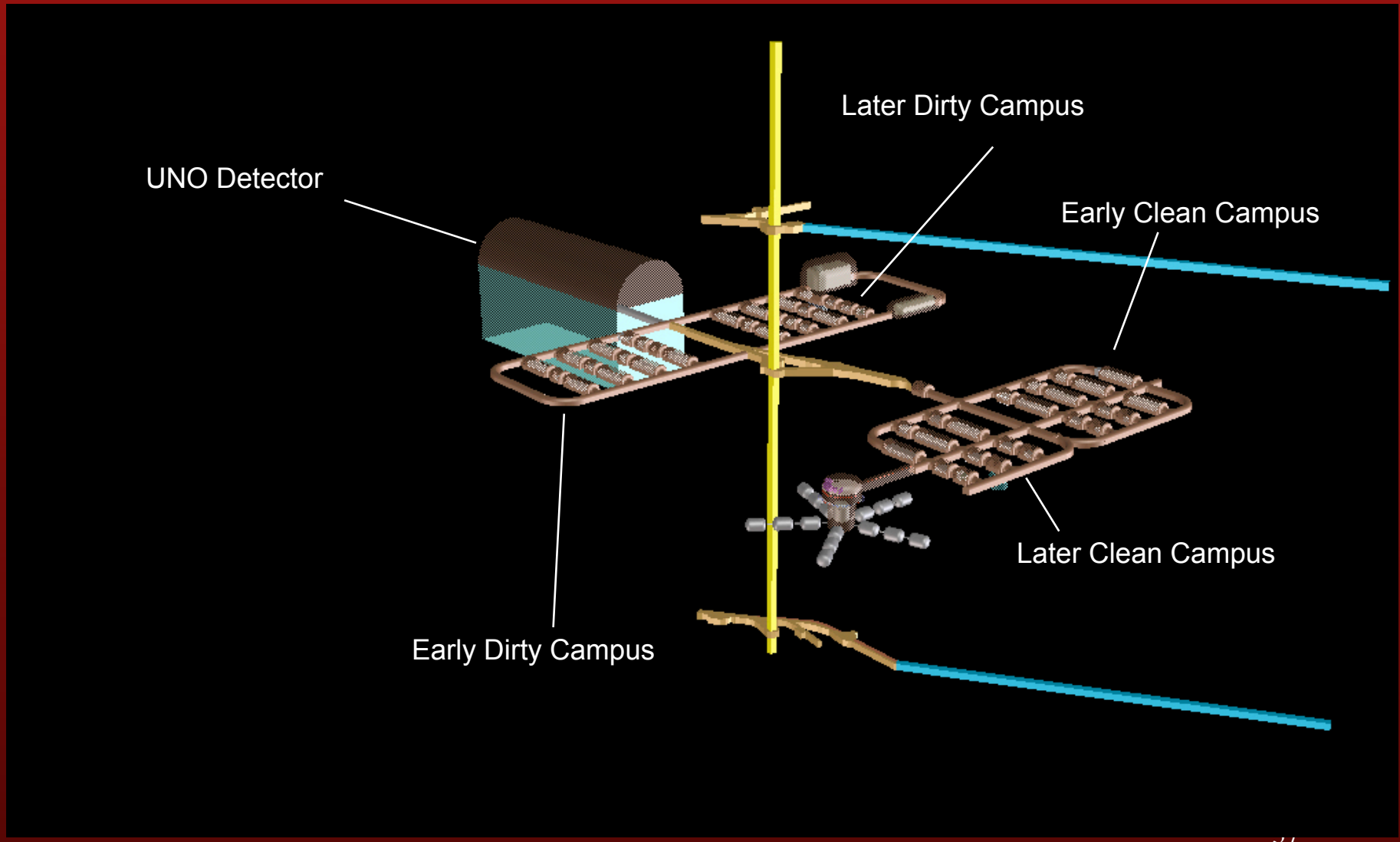
Additional Clean Campus



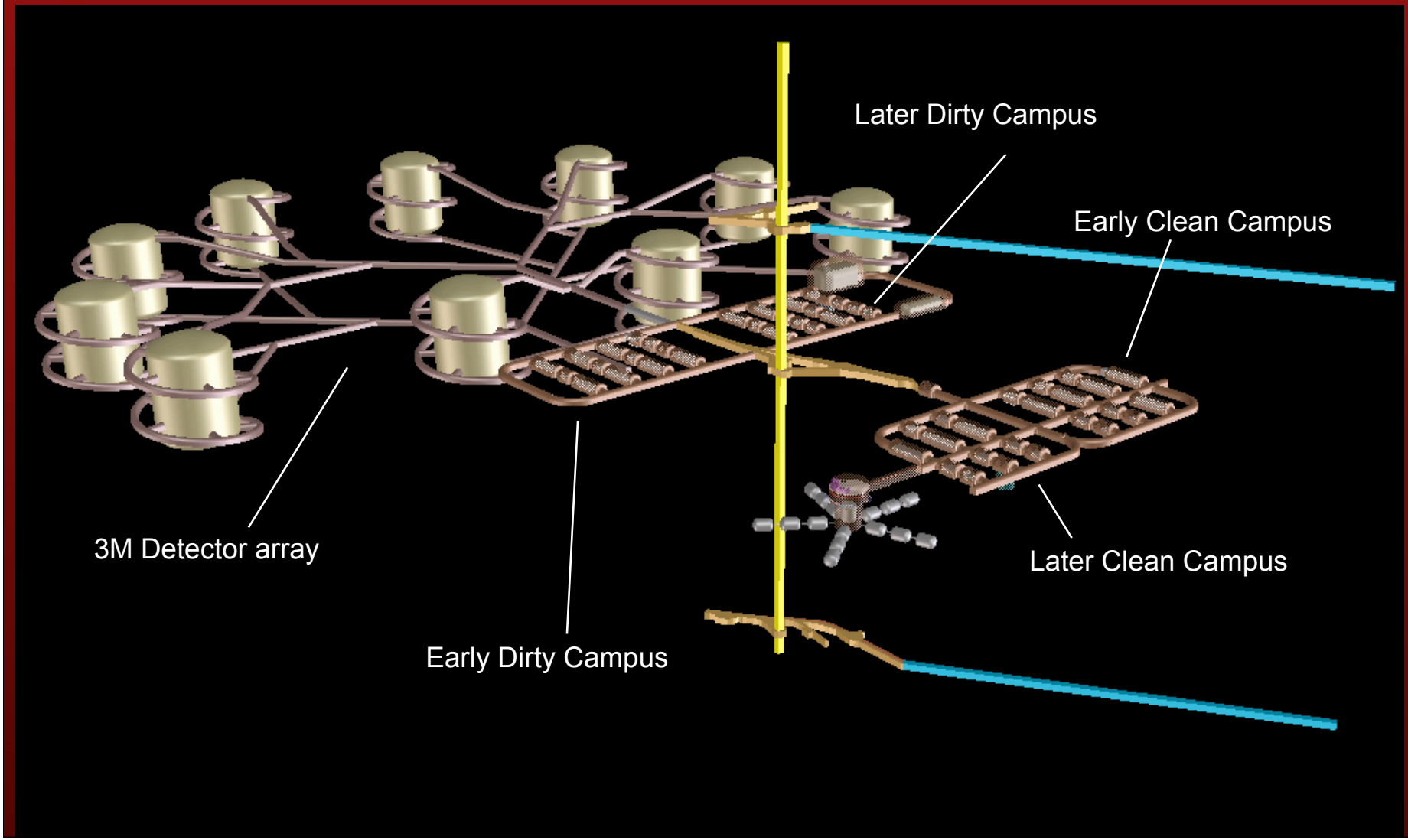
Evolving Dirty Campus



Evolving Campus with PDK



Evolving Campus with Multiple Chambers



Who Can Use it?

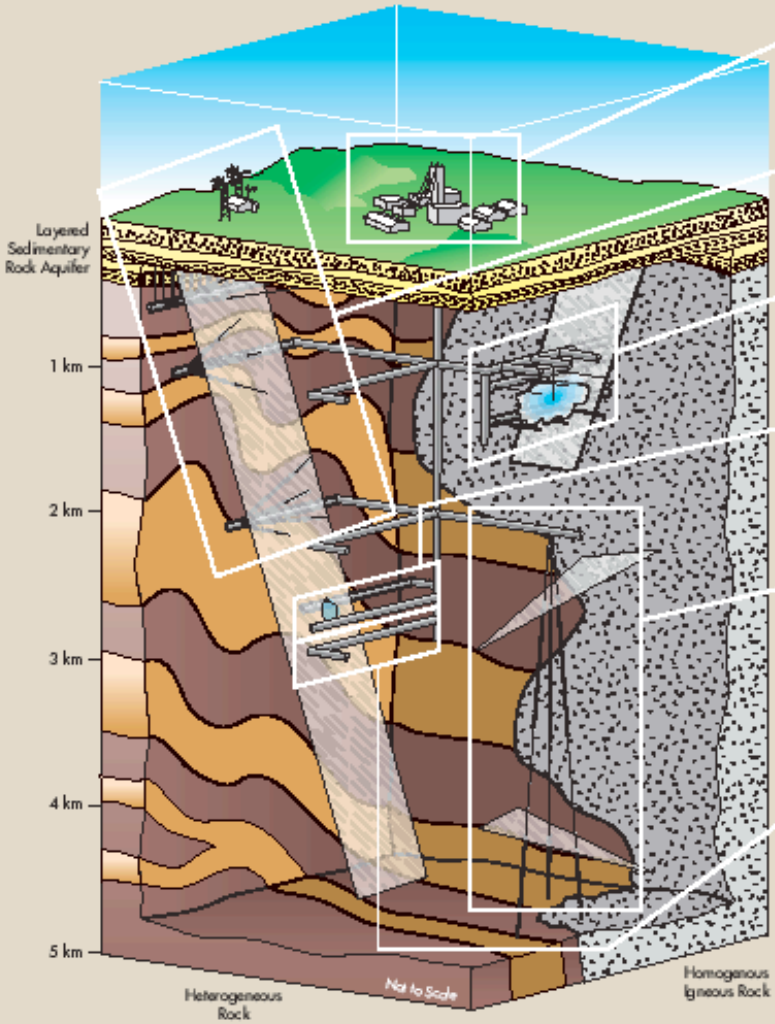
Near Term:

- Cosmic Rays Studies
- Low Level Counting
- Prototyping, Materials Production for
  - Double Beta Decay
  - Dark Matter
- Next Generation Dark Matter
- Next Generation Double Beta Decay
- Nuclear Astrophysics
- Begin work on Proton Decay & Long Baseline

Longer Term:

- Continued operation of DM, DBD
- Solar Neutrinos
- CP violation Long Baseline
- PDK
- Supernovae monitors

Why Earth Scientists Go Underground?



Surface Lab for core, water, gas…

Deep Flow and Paleoclimate Lab

Induced Fracture and Deformation

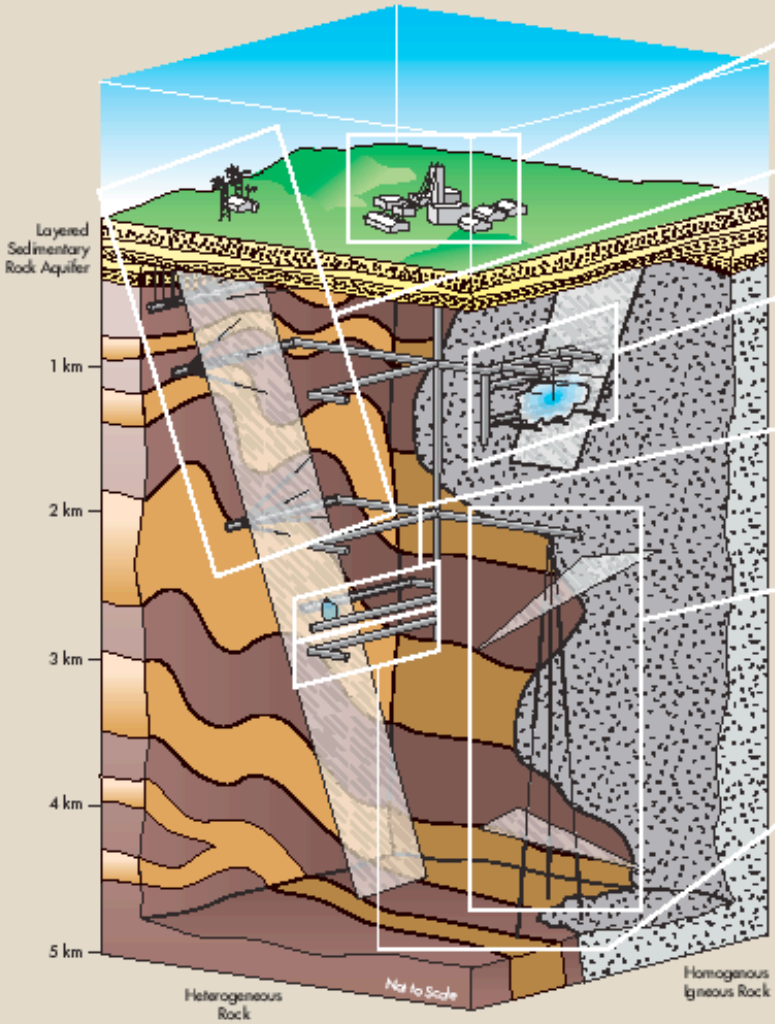
Deep Coupled Processes

Ultradeep Life and Biochemistry

Deep Seismic

They need a Huge Sandbox

Why Earth Scientists Go Underground?



Surface Lab for core, water, gas…

Deep Flow and Paleoclimate Lab

Induced Fracture and Deformation

Deep Coupled Processes

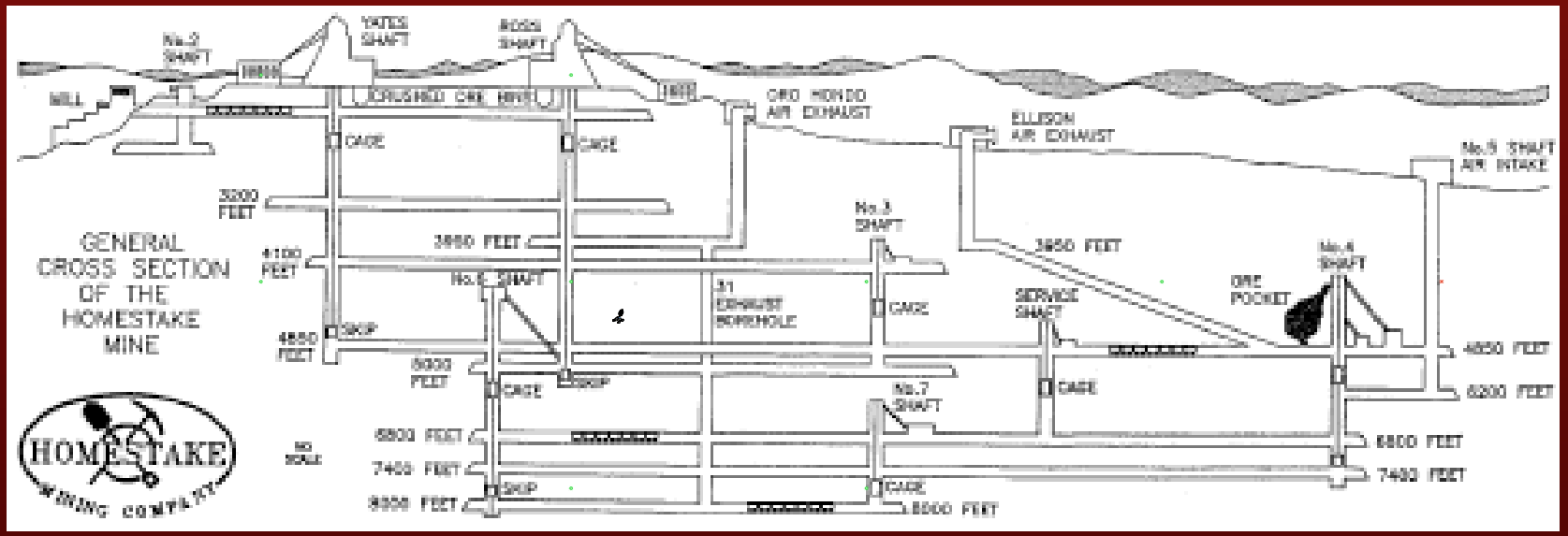
Ultradeep Life and Biochemistry

Deep Seismic

They need a Huge Sandbox

Use of Other Shafts and Layers

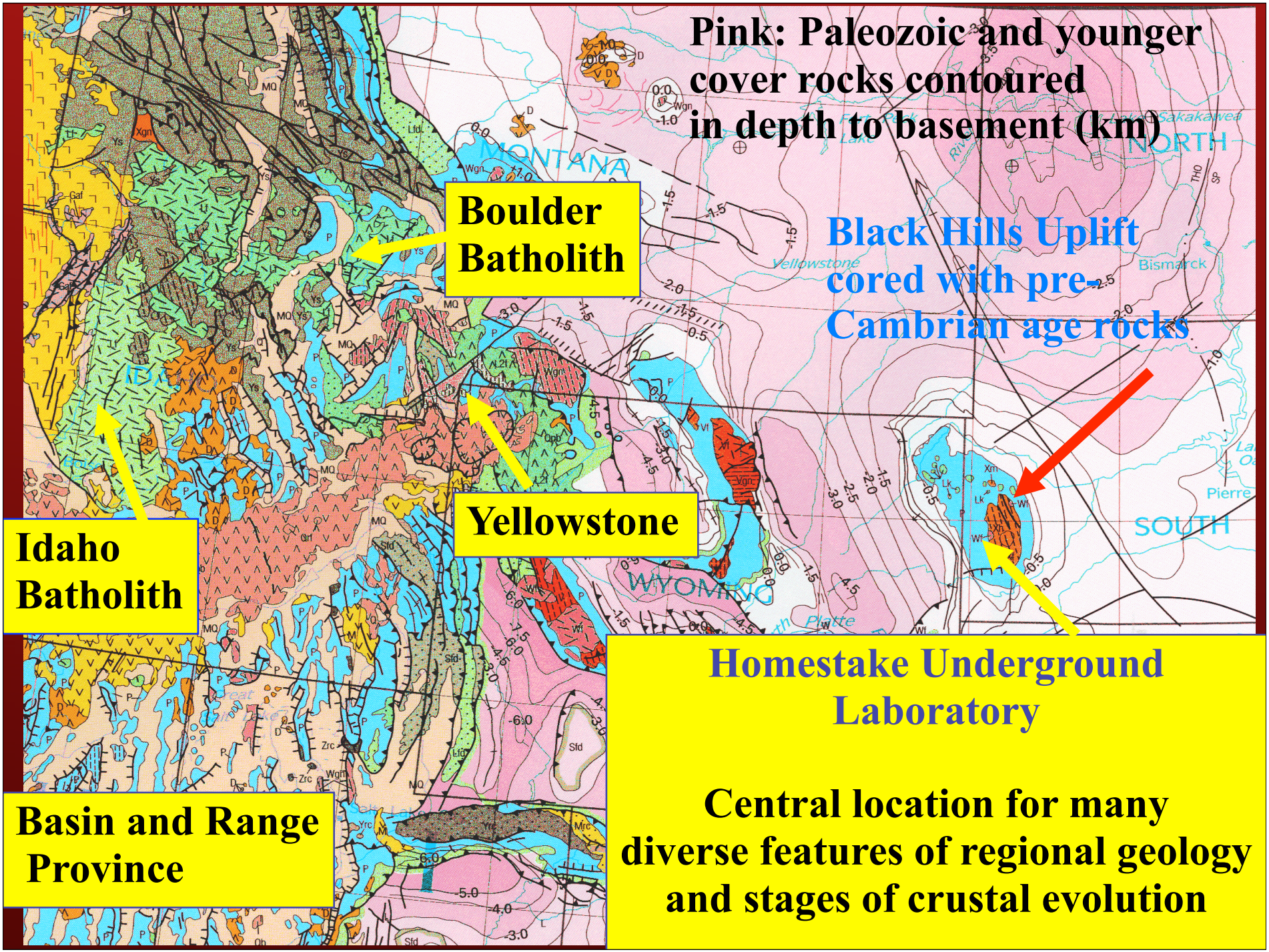
- Seepage and Fracture Mapping
- Mine-Scale Network of Seismic Stations (in a quite zone)
- Kilometer Loops as Antennas
- Cosmic Ray Imaging
- Low background counting / atmospheric sampling



Earth Science Underground Testing

(Examples for Comparison)

	Homestake	Stripa - Swe.	WIPP	Yucca Mt.
Depth	8,000 ft	1,100 ft	2,000 ft	1,000 ft
Duration	~ 30 yr	2 - 10 yr	3 yr.	4 - 8 yr.
Rock	Metamorphic	Granite	Salt	Tuff
Levels	~ 57	1 - 2	1	2
Mission	Research	Research	TRU	HLW Storage
Repository Facility	Gold Mine	Iron Mine	New Shafts	New Ramps


Pink: Paleozoic and younger cover rocks contoured in depth to basement (km)
Boulder Batholith
Black Hills Uplift cored with pre-Cambrian age rocks
Yellowstone
Idaho Batholith
Homestake Underground Laboratory
Basin and Range Province
Central location for many diverse features of regional geology and stages of crustal evolution

Precambrian Geology

- ~ 2 billion year old rock
- Metamorphic rocks
  - muscovite- and/or biotite phyllite/schist, dolomite
  - metaclastics, iron-formation, and amphibolite
- Metamorphic grade ranges from lower greenschist (western part) to middle amphibolite facies (eastern part).
- Complexly deformed geologic terrain.

Geologic Events

- Intrusion - rhyolites and phonolites ~53 my
- Regional uplift and erosion ~65 my
- Deposition beginning in middle Cambrian
- Uplift and erosion
- Metamorphism ~ 1.75 by
- Metamorphism~1.84 by
- Deposition ~ 1.9 by

Environments of deposition

Poorman deposition

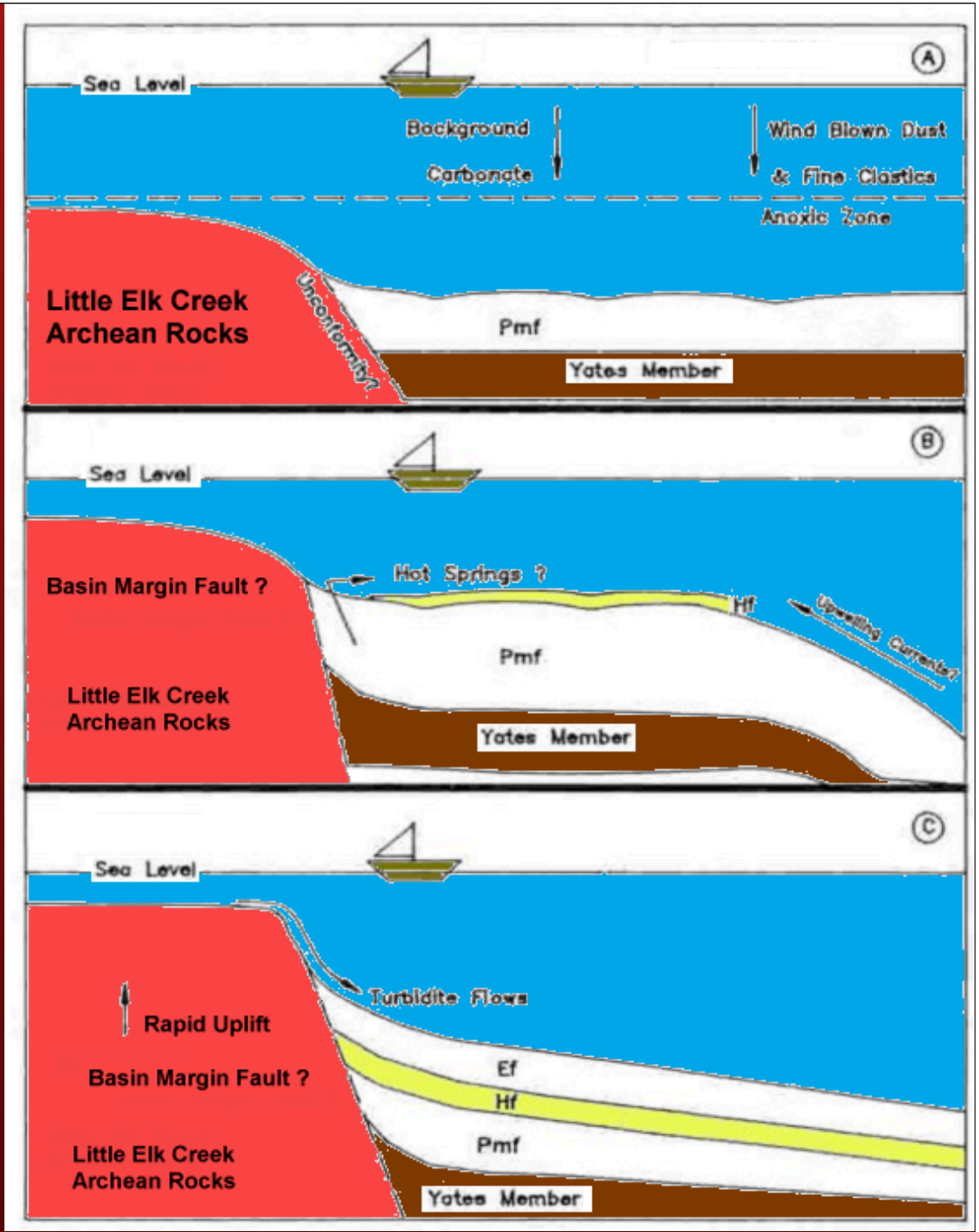
– base (Yates Member) - metamorphosed tholeiitic basalt – *lower laboratory location*

upper Poorman lithologies -- metamorphic equivalents of chemical precipitates and fine-grained clastics

Homestake deposition

Ellison deposition

after Rogers, 1990



Environments of deposition

Poorman deposition

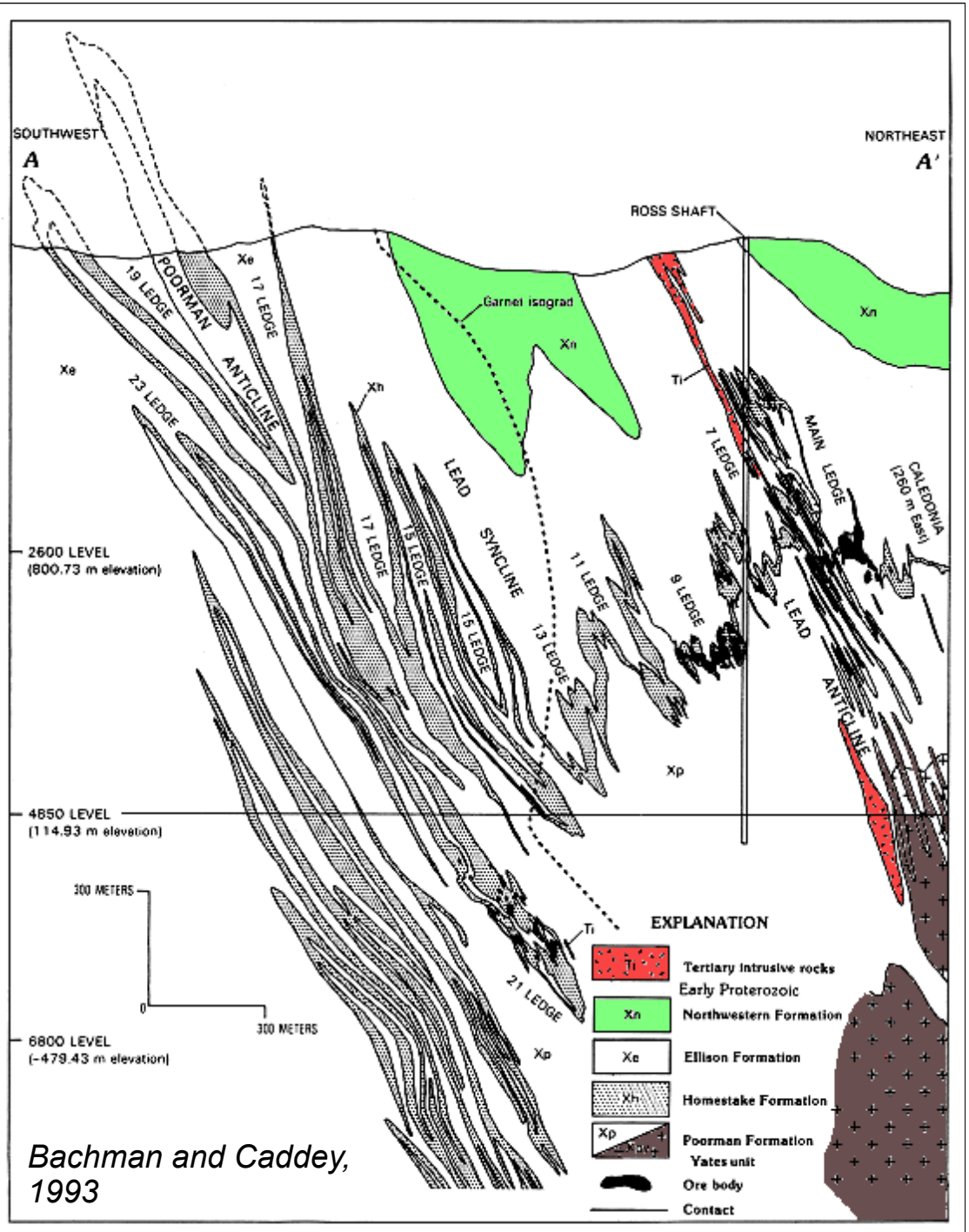
– base (Yates Member) - metamorphosed tholeiitic basalt – *lower laboratory location*

upper Poorman lithologies -- metamorphic equivalents of chemical precipitates and fine-grained clastics

Homestake deposition

Ellison deposition

after Rogers, 1990



Bachman and Caddey, 1993

Who Can Use it?

Near Term:

- Surface to 4850 hydrology, geology, geochemistry
- Rock deformation studies using drifts and shafts
- Studies of the cratonic crust through 20 km^3
- Searches for life and exotic biology including initial microbial investigations
- Investigations of flow path delineation in heterogeneous geological settings & ground water studies/models
- Characterizations of facture mapping, stress measurements and ground water chemistry
- Thermal-mechanical-hydrological couplings across many orders of magnitude in scale

Longer Term:

- Systematic searches for and characterizations of life
- Long term and large scale characterizations and expts.
- Carbon Sequestration

What Would the Scientific Environment be Like?

- Science is the primary host: not mining, not making profit, not military, not residual waste disposal. Science sets the priorities.
- Facility will be developed to promote this function: safety, integrity of data, easy of construction and operation of long-lived experiments, provide special environments.
- Synergism with many other experiments at DUSEL
- The large site will be dynamic and evolve as the experimental needs evolve and expand.
- Significant Outreach & Education integrated into Lab

What Would the Environment not be Like?

- Anecdote: SNO, installed 250,000 lbs. of PSUP. 1 tram/week, 1 side rail,
  - Limited product, limited personnel, limited response to surprises
  - Excellent safety, excellent relations between host and parasite, but it is clear who is the parasite
- Power outages
- Lost data fibers
- Access restrictions
- Material +
- Bonus' established by productivity

How Big a Cavity? For Sure

- Precambrian uplift
  - Archean igneous and early Protozoic age sedimentary and volcanic rock
  - Low seismic activity (5 out of a scale of 1 to 5)
  - 100 years of geological "experience" extending from surface to 8000 feet.
  - Non-gassy environment (no methane)
  - Existing stable excavations at 4850, 7400, and deeper
  - Homestake have experience with 16m stopes, good ground stability record recently.

6 Winze: 160 x 25 x 12 feet

Yates station: 90 x 15 x 9 + 160 x 16 x 9 +

Winze 4: 270 x 12 x 10

80 x 17 x 9

6 Winze drill shop: 70 x 50 x 10

How Big a Cavity? For Sure

- Precambrian uplift
  - Archean igneous and early Protozoic age sedimentary and volcanic rock
  - Low seismic activity (5 out of a scale of 1 to 5)
  - 100 years of geological "experience" extending from surface to 8000 feet.
  - Non-gassy environment (no methane)
  - Existing stable excavations at 4850, 7400 and deeper
  - Homestake have experience with 16m sto good ground stability record recently.

6 Winze: 160 x 25 x 12 feet

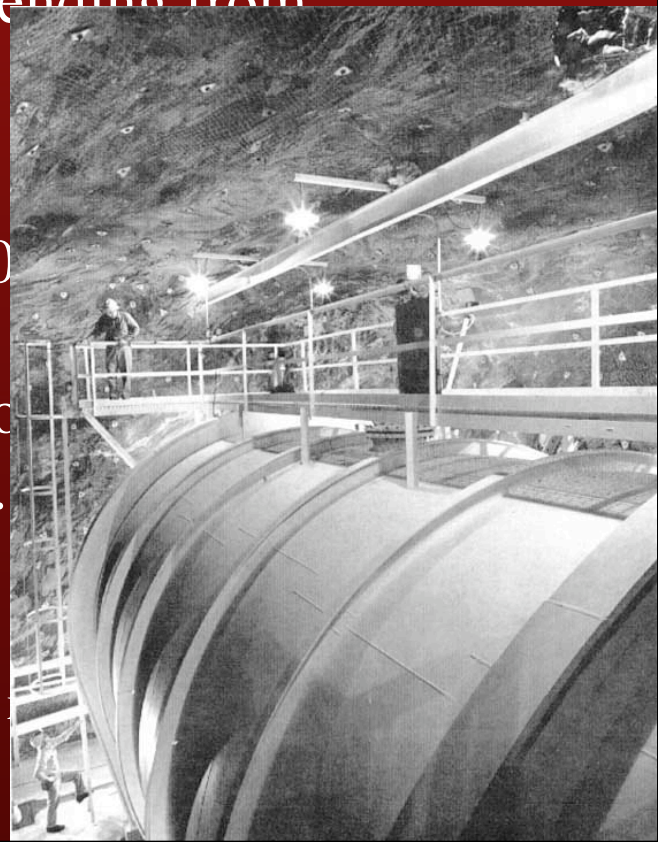
Yates station: 90

9 +

Winze 4: 270 x 12 x 10

80 x 17

6 Winze drill shop: 70 x 50 x 10



Large Room Stability Evaluations

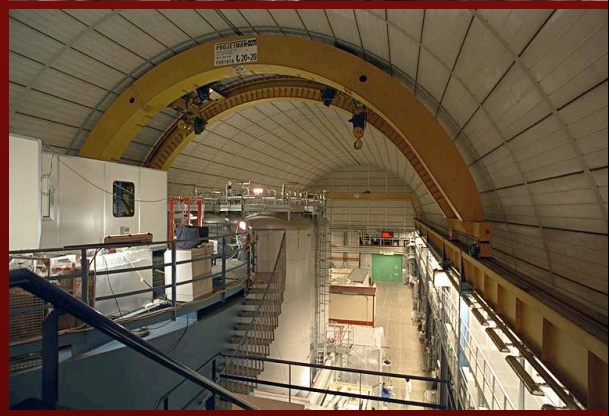
Homestake

- Vertical Crater Retreat (45-61 m high) evaluations, Pariseau *et al.,* BOM, 1985

- 61 m dia. x 122 m cylinders, stable at 4850' and 6800', might not at 8000', Johnson and Tesarik, NIOSH, 2000 (3D models available in 2002)

- Linear arrays of 50 m dia. x 50 m cylinders with 100 m spacing are stable at 4850', Callahan *et al*., RESPECT, 2001

Gran Sasso



Aberle et al. 2001

Advantages enjoyed by Homestake

- Expedient access to depth: 4850 level by 2006, 8000 feet with additional ~ 1 or 2 years work.
- Competent Rock capable of supporting large rooms for decades.
- Wide spectrum of depths, much of which has been cored.
- Reduced risks and uncertainties
  - Core - know much about the rock qualities already
  - History - now what to expect
  - Existing access - expedient use for science and engineering
- Massive campus potential above and below ground.
- Accommodate a huge spectrum of scientific and engineering problems of foremost interest.
- Excellent education and outreach opportunities.
- Truly extraordinary local support.

Status of the Core

- Of immediate scientific use/interest
- Provides critical information about future designs/plans

- Core from west core shed moved to new site.
- Core slated for compression in east shed 90% complete.
- 20% of core from east shed is palletized and moved to new site.
- New metal shelves purchased and 15% of core re-racked.
- Current inventory comprises 700,000 feet of core from surface and underground.
- Description and protocols published on web site; core request form completed.
- Spreadsheet and inventory almost current with move.
- Available for immediate integration with DUSEL.

Challenges facing Homestake

- Title
- Water
- Permitting

Common to Most Sites

Addressed in the Conversion Plan

Progress already on Title and Permits

- Vertical Access
  - Not significant for mining
  - Impacts can be reduced with Planning and form-factors

Challenges facing Homestake

- Title
- Water
- Permitting

Common to Most Sites

Addressed in the Conversion Plan

Progress already on Title and Permits

- Vertical Access
  - Not significant for mining
  - Impacts can be reduced with Planning and form-factors

Challenges facing Homestake

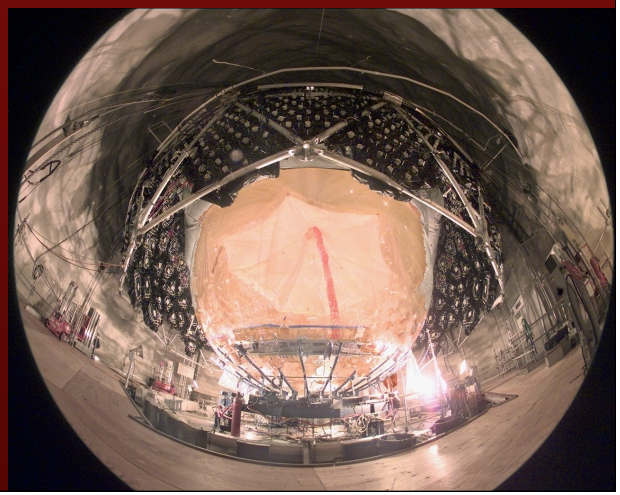
- Title
- Water
- Permitting

Common to Most Sites

Addressed in the Conversion Plan

Progress already on Title and Permits

- Vertical Access
  - Not signifi
  - Impacts ca anning and form-facto



Dewatering Homestake

- Pumping of water is common in mining - natural & mining-introduced.
- Homestake's water inflow is well characterized, ~700 gpm is small in comparison to many mines, ~2/3 from above 5300 level. "Surface water"
- Pine Creek Tungsten mine, 5,200 gpm, crosses under a creek bed in granite. Other mines documented with even larger flows. 700 gpm is a "drop in the bucket".

Concerns: *Addressed in the Conversion Plan and the Review:*

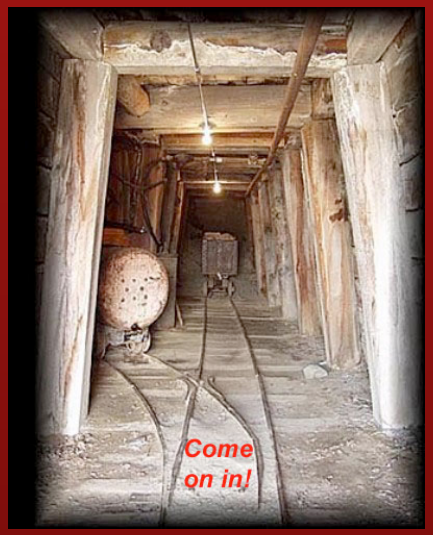
Loss of Infrastructure - near neutral pH, still water, Plan includes inspection and replacement of ground support, but a lot is not anticipated due to water intrusion.

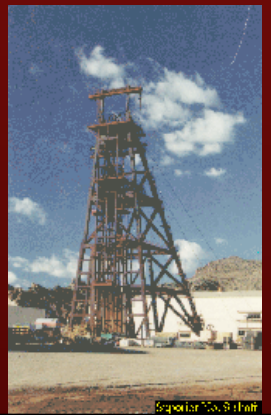
Loss of Access - 4850 easily viable until 2008. With implementation of Conversion Plan and diversion of surface water, water would not reach 4850 until 2010 or later. Plan addresses how to dewater the entire facility (costs and schedule)

Loss of Science - water flow has been inward for the last century and will continue to be inward. It has always been the case that science would have to "drill out" of the effected cone. In fact, studies of biology along inflows is interesting in itself.

Dewatering Mines

- *Distinguish* Differences between sudden catastrophic damages and gradual changes associated with pump stoppages.
- *Examples:*
- *Orphan Girl Mine* - Butte, Montana – 6 or more shut-downs between 1875-1956
- *Superior Copper* - Superior, Arizona – reopened 1989-1997 after 3-year flooding, planned 2014 reopening
- *Agnico Eagle's Goldex Mine* - Quebec - Dewatered a deep facility to reopen ore deposits
- *West Driefontein 6 shaft* - South Africa - after 1967 flood, dewatered and placed back in operation, used for microbiological coring and sampling





Summary: Goals of Homestake

- Large, Comprehensive Laboratory
- Emphasize the synergistic benefits of situating fields together in a single site
- Emphasize the cost benefits of a single site tailored for science, engineering, & outreach and education
- Develop a campus that can evolve with the decades of science and engineering
- Emphasize the nature fit for education and outreach opportunities of such a campus at this ideal location.

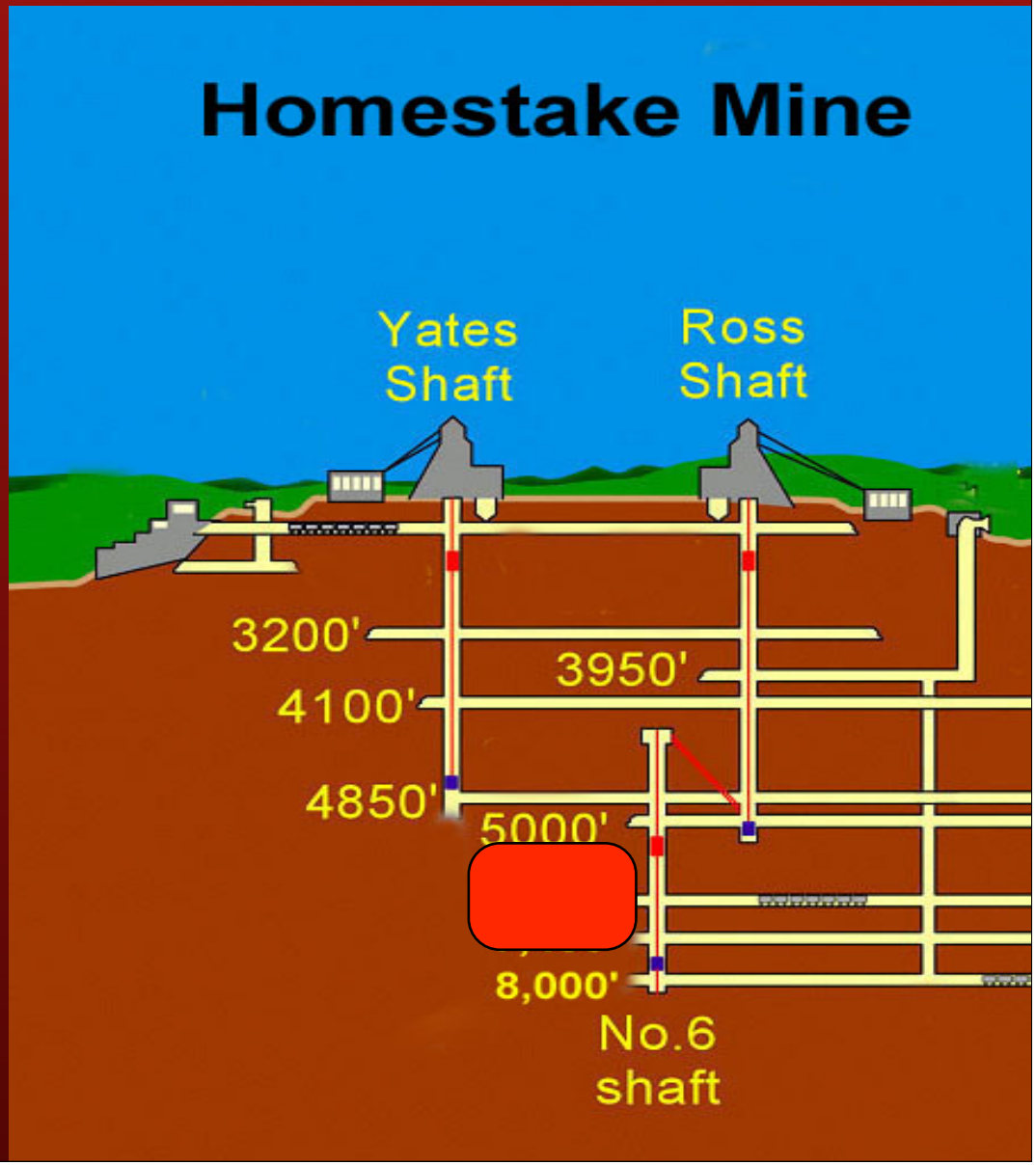
Summary: Why Homestake?

- Large Site: can accommodate nearly all the science
  - Deep, Large, Shallow, Heterogeneous
  - DM, Neutrinos, LBL, Geology, Engineering, Biology
  - Corresponding synergism and support
  - Earlier access than many (most) sites, plan to begin science and education and outreach before S-3
- Lower risks, long history and geology record
- Extraordinary local support
- EPSCoR State
- Potentially best time to science
- Long-term site for science
- Arguably lower capital costs

Summary: Homestake local support and significant progress

South Dakota has:

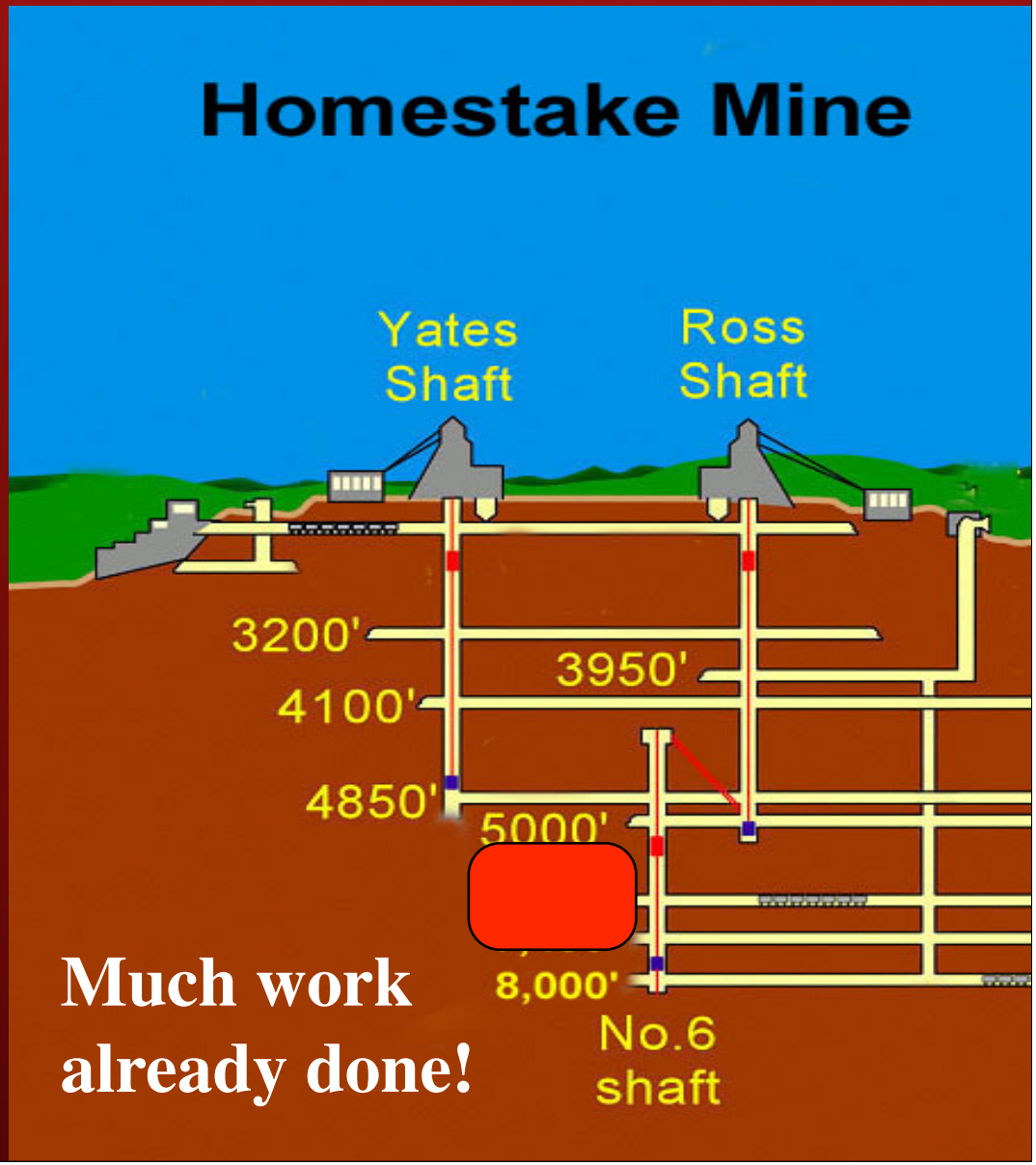
- Land transfer agreement with Barrick
- Environmental approval from State Environmental
- Authority to bond process ~ $100M
- Estimate to de-water mine
- A governor who has made this his highest priority
- Established state indemnification
- Strong local support
- Pledged ~$25 M from State



Summary: Homestake local support and significant progress

South Dakota has:

- Land transfer agreement with Barrick
- Environmental approval from State Environmental
- Authority to bond process ~ $100M
- Estimate to de-water mine
- A governor who has made this his highest priority
- Established state indemnification
- Strong local support
- Pledged ~$25 M from State



Summary: progress to date - 4850 Laboratory to be Established as part of Conversion Plan to *preserve* Homestake for NSF's DUSEL

- Establish upper "campus" at 4850 level and above
- Investigate hydrologic system at higher levels
- Begin some longer-term rock mechanics experiments
- Accommodate prototypes and common-use modules such as low background counting
- Accommodate physics experiments that are now ready for implementation
- Initial Education and Outreach efforts

Summary: Additional expansion of Homestake as part of DUSEL - Establish lower campus and upgraded facility as part of the NSF's DUSEL process

- Additional coring and engineering studies for deep lab
- Install deep experiments and programs
- Ongoing physics experiments at 4850
- Ongoing hydrologic investigations, coupled-processes experiments, geochemical investigations
- Searches for limits-of-life, geobiology
- Continued, expanded Outreach and Education efforts

You can find many of the documents **briefly** summarized here at:

http://neutrino.lbl.gov/Homestake

Thanks to Joe Wang, Bob Lanou, Bill Roggenthen, Dave Snyder, and the entire Homestake Collaboration in the preparation of this presentation