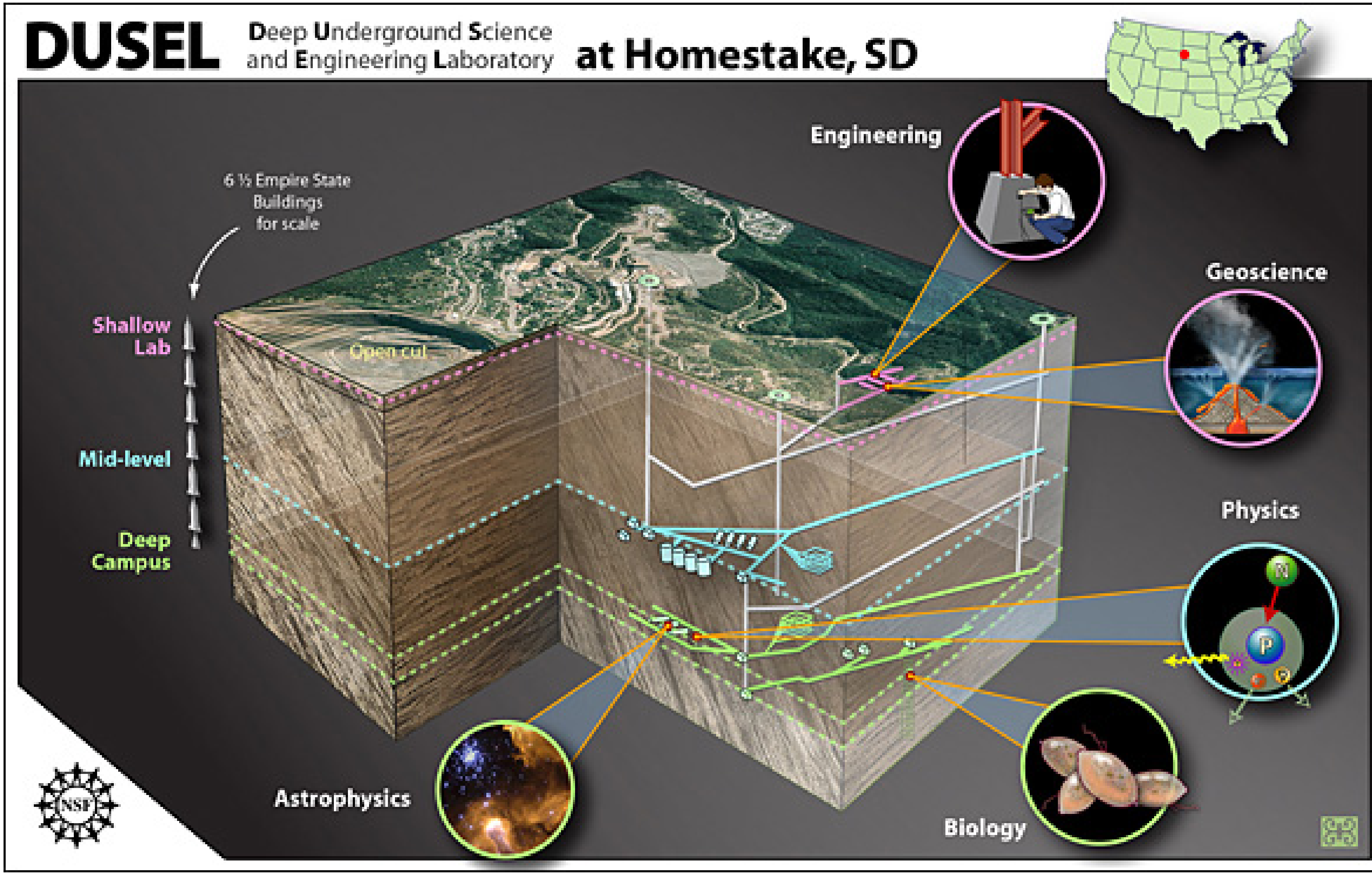


Neutrino Telescope Workshop

Venice – 11 March 2009

Kenneth Lande –

University of Pennsylvania

DUSEL "Megaton" Multi-Module Detector Array Plan

1) Array of 100-150 kiloton fiducial mass H_2O Cerenkov Detectors at DUSEL (4200 mwe)

2) 1300 km long ν_μ beam - FNAL → DUSEL (0.7 → 1.2 → 2.0 Megawatt FNAL beam)

3) Eventual addition of ~ 100 kt liquid Argon tracking detector

Scientific Goals

With FNAL neutrinos

1) Measure θ_{13}, (if not previously determined)

2) Determine neutrino mass ordering

3) Look for non-zero δ_{CP}

Non-accelerator

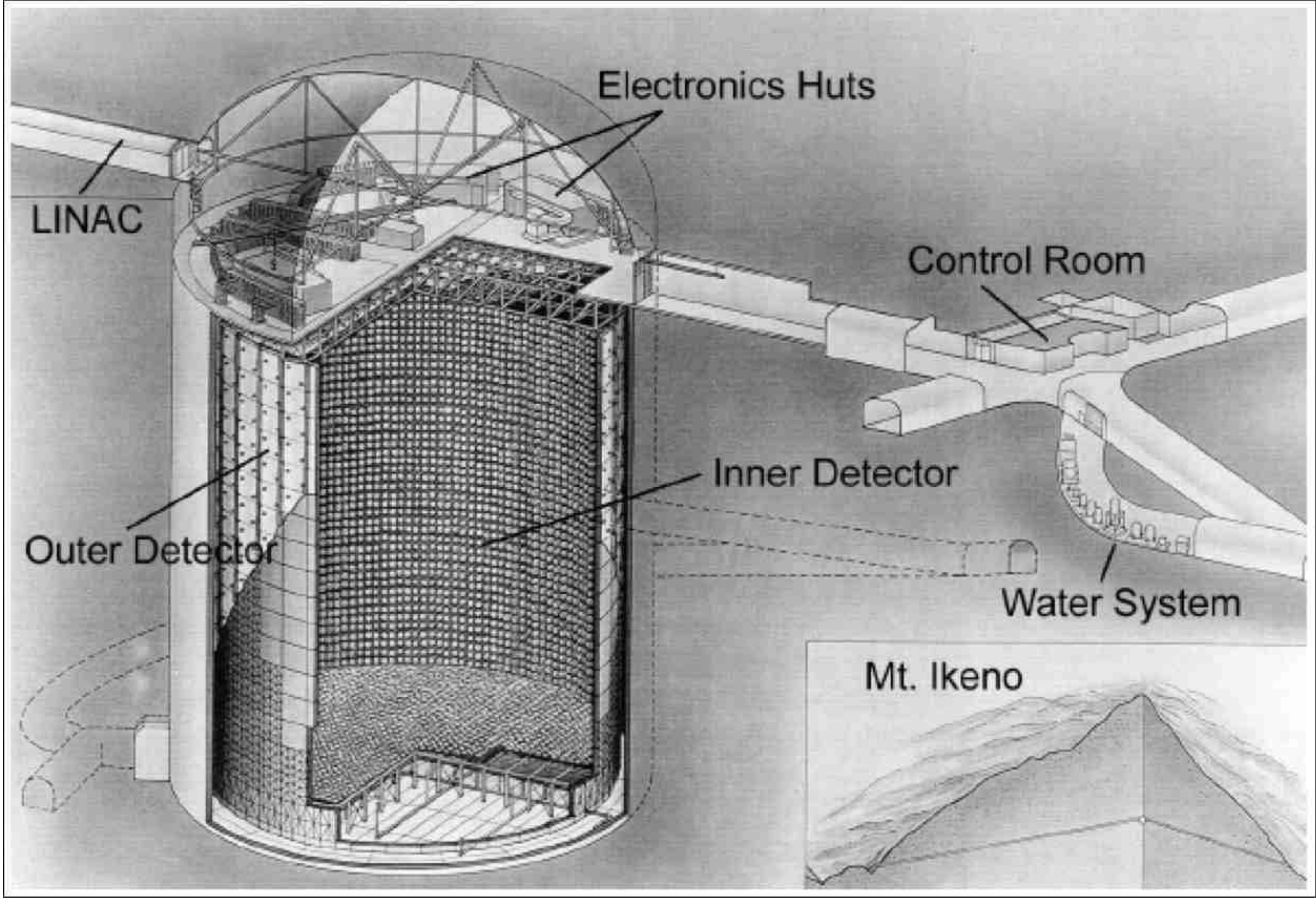
1) Proton Decay

2) Relic SN neutrinos

3) Prompt SN ν

4) Atmospheric ν's

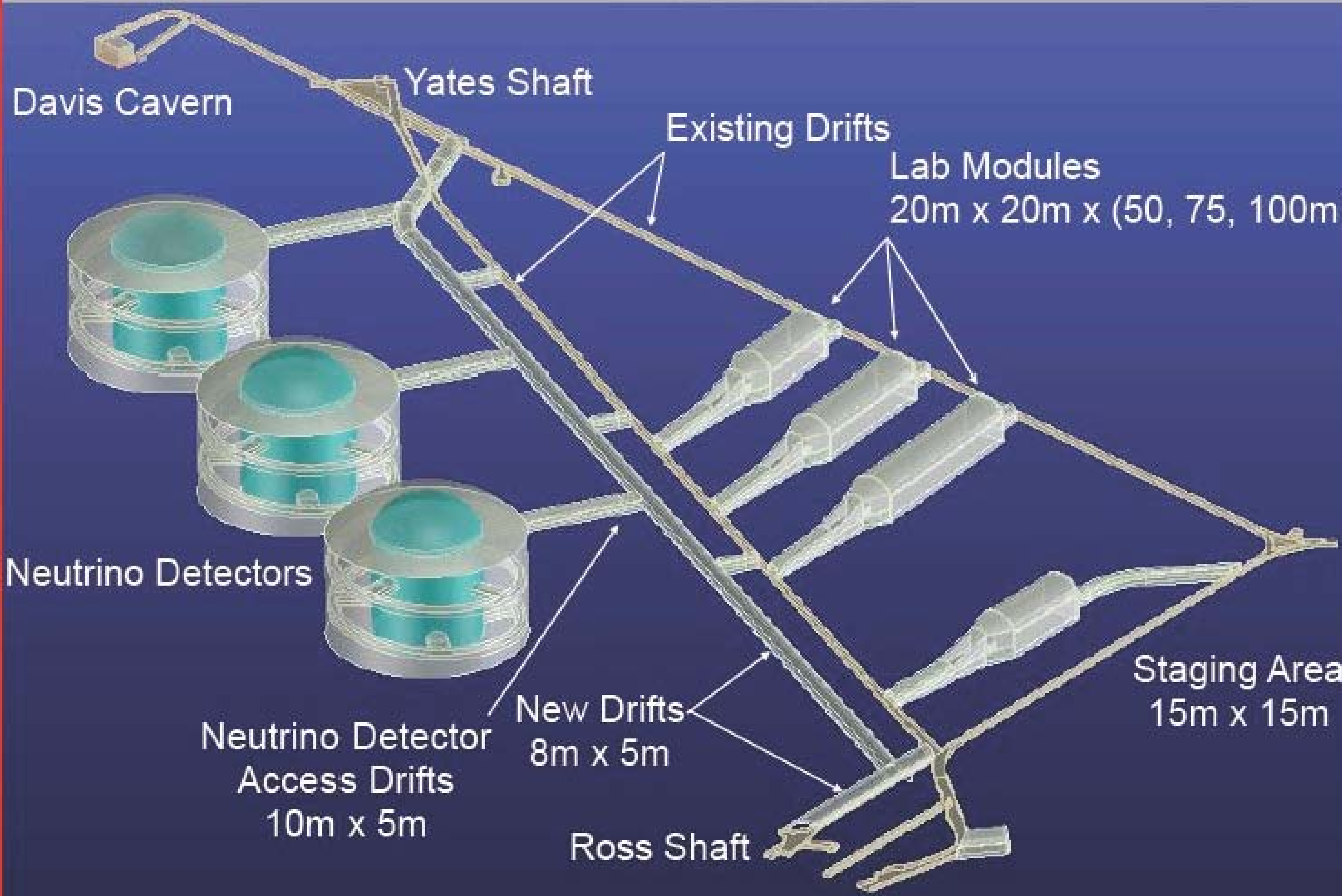
5) Solar Neutrinos



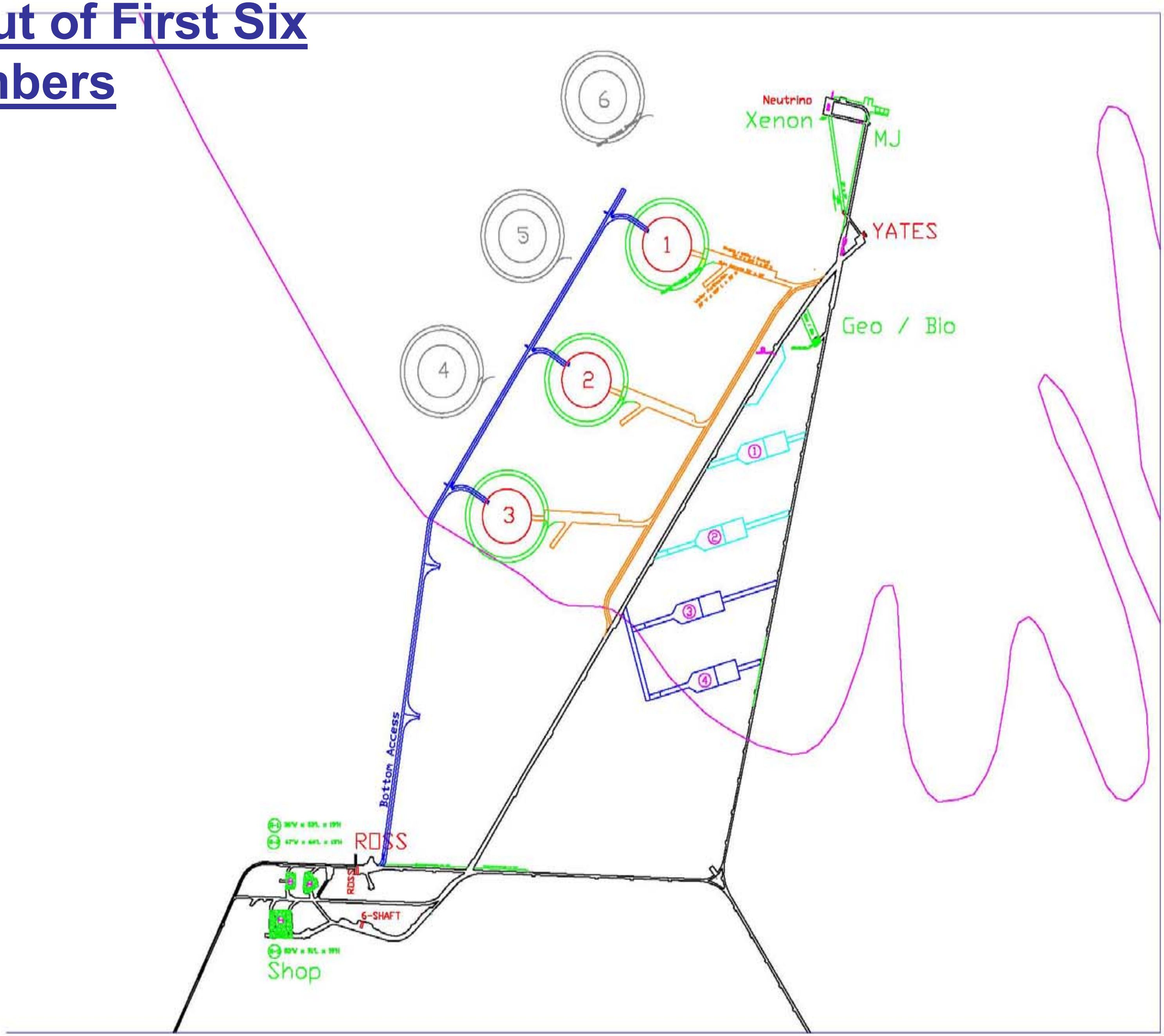
S-K Detector: 40 m dia. x 40 m high

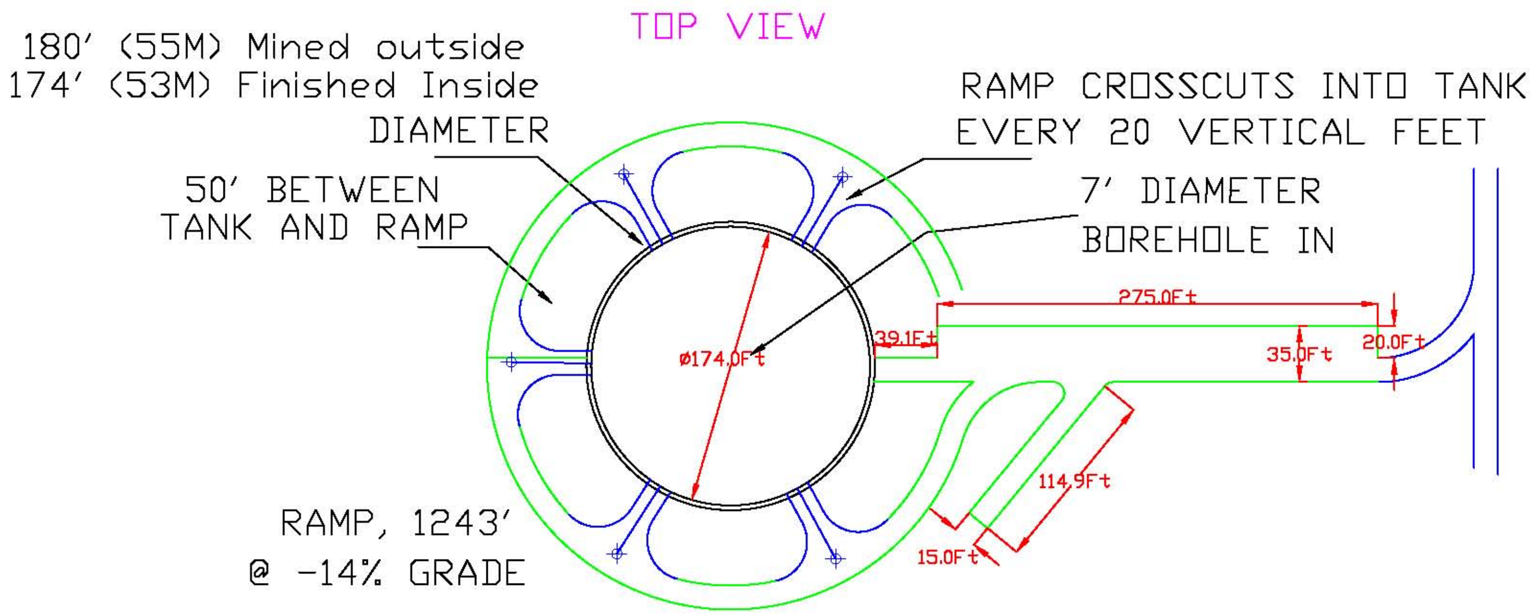
DUSEL Detector modules: 50-60 m dia x 50-60 m high

4850 Level Conceptual Layout



Layout of First Six Chambers

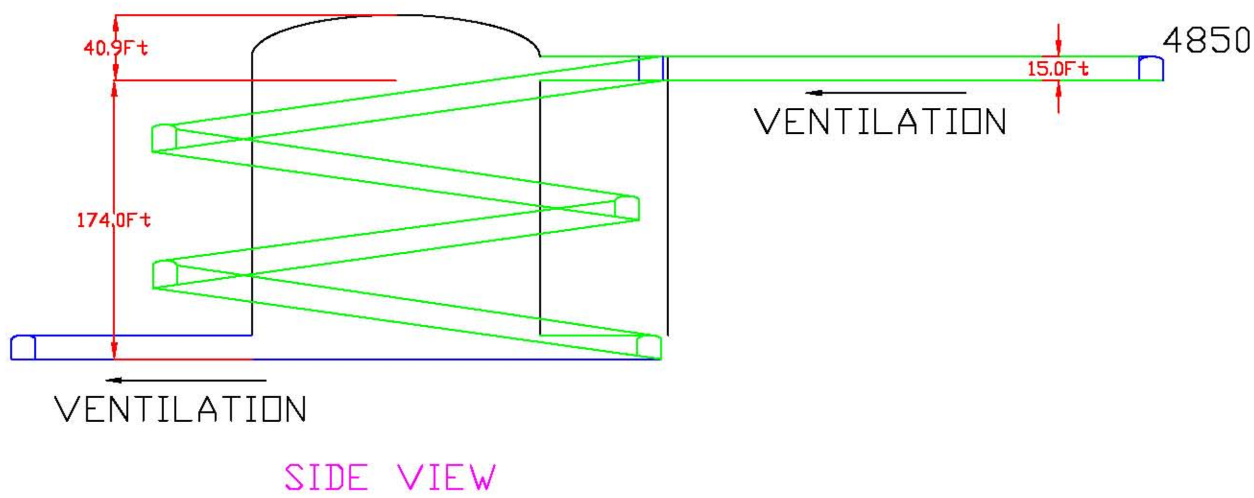




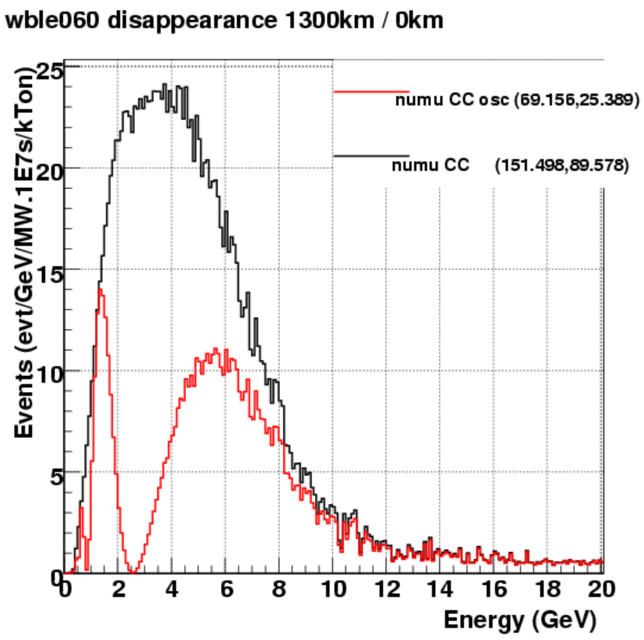
Single DUSEL

water Cerenkov module

55m diameter



ν_μ Disappearance after 1300 km (FNAL $\rightarrow$DUSEL)



Total event rate with 300 kT
and
2 MW is
~200000 cc evts/yr★
(no oscillations, raw events)

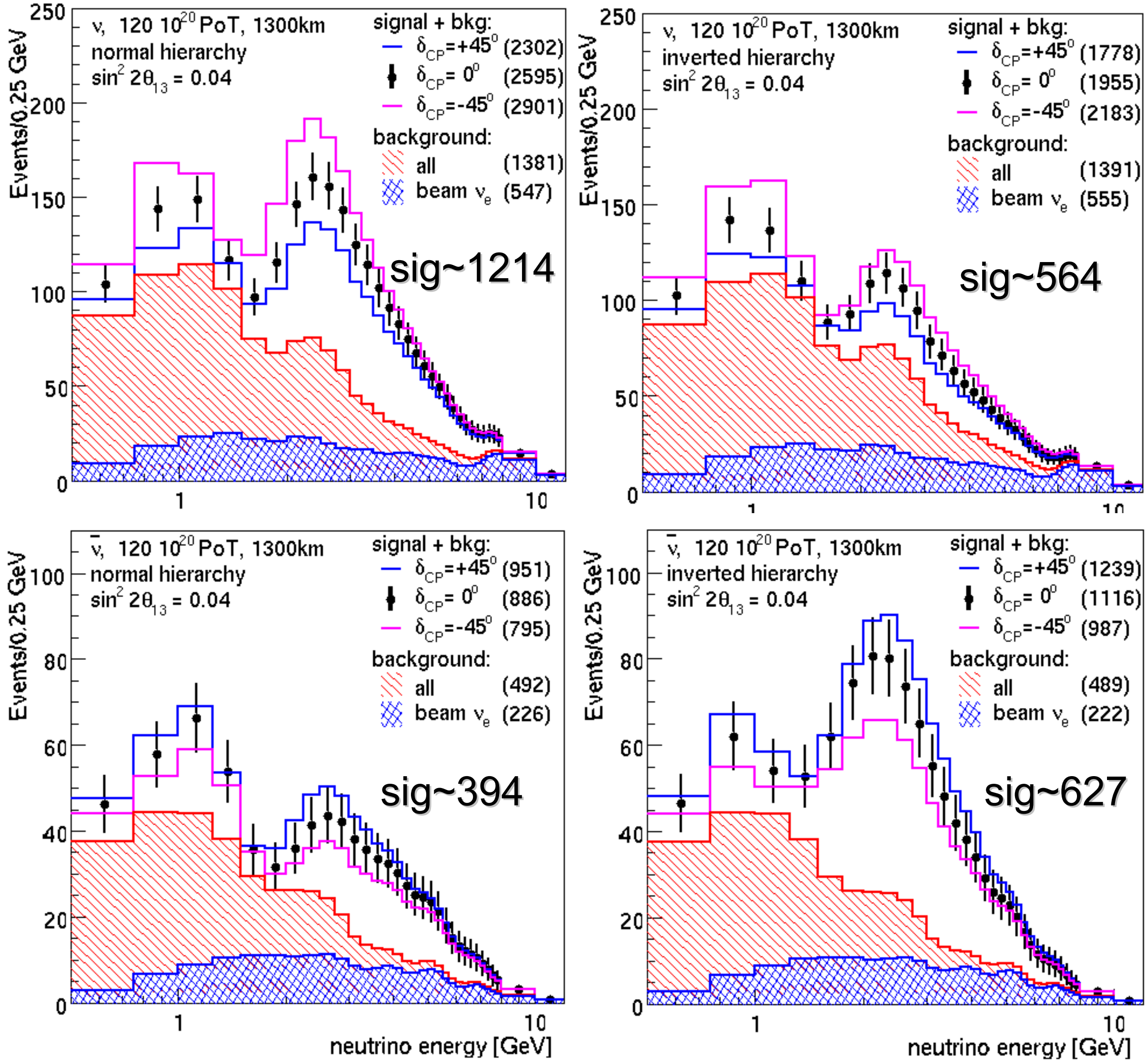
Study: http://nwg.phy.bnl.gov/fnal-bnl

★ yr~2x10^7 sec

$(-\ \delta_{cp} = -45°,\ -\ \delta_{cp} = +45°)$

Normal **Mass Ordering** Reversed

ν_e appearance signal
300 kT detector and
10^{20} Protons (60 GeV)
on Target at FNAL

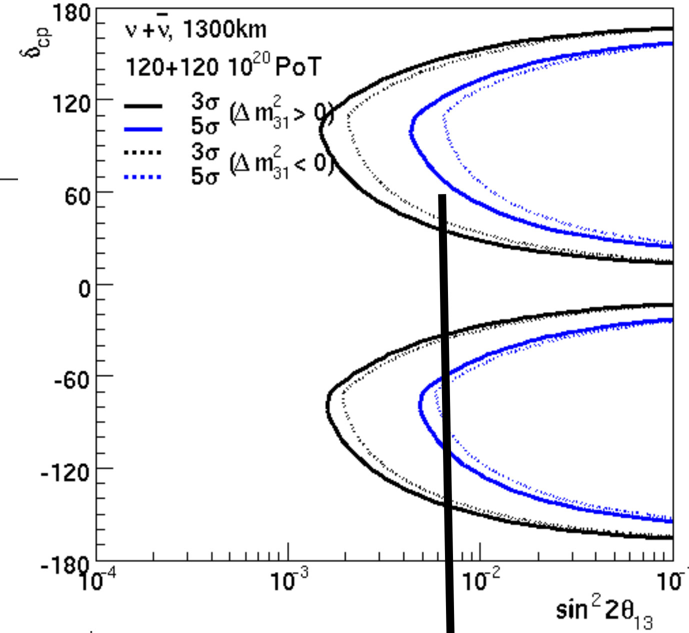


Mark Dierckxsens(UChicago), Mary Bishai(BNL)

Ultimate Reach

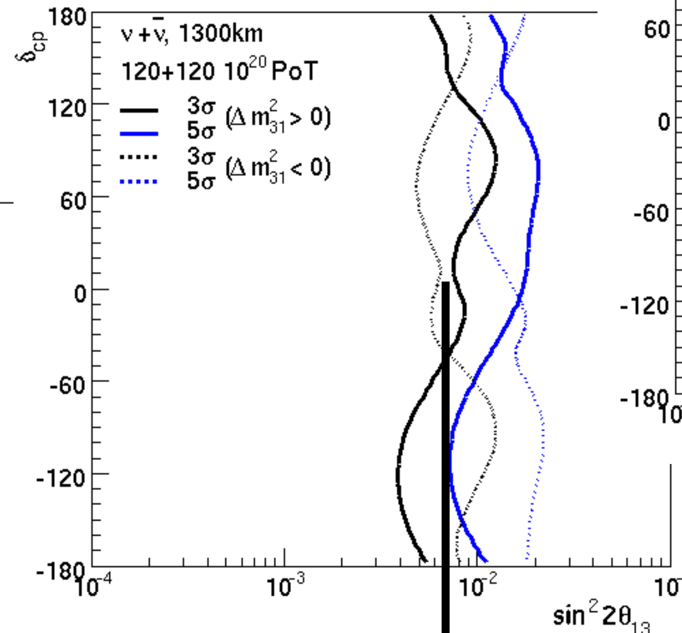
60 GeV, 2MW, 3+3 yrs, 300kT

CP Violation

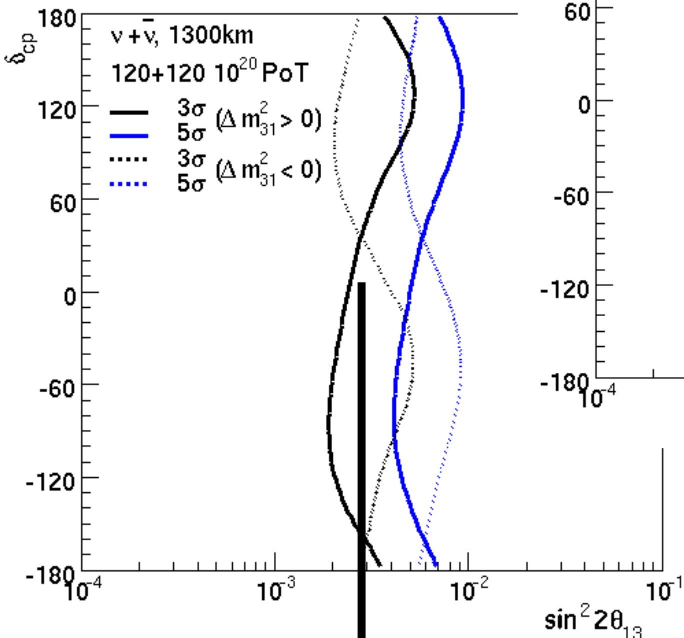


0.007

Mass ordering



θ□□



0.003

0.007 50% coverage at 3 sigma

stat+ 5%syst

Mark Dierckxsens(UChicago), Mary Bishai(BNL)

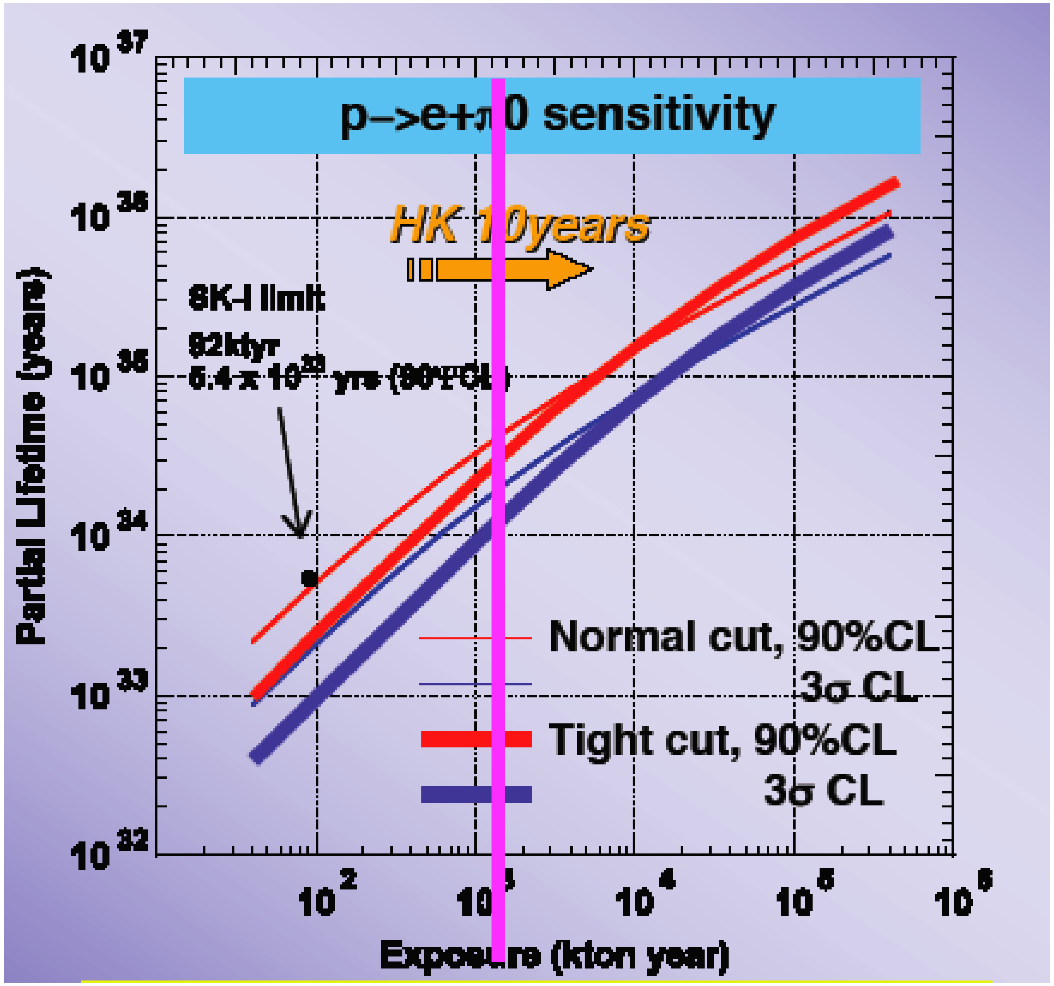
Nucleon Decay

- Large body of work by HyperK, and UNO.
- Background levels for $e^+ + \pi^o$ mode

  3.6/MTon-yr (normal)

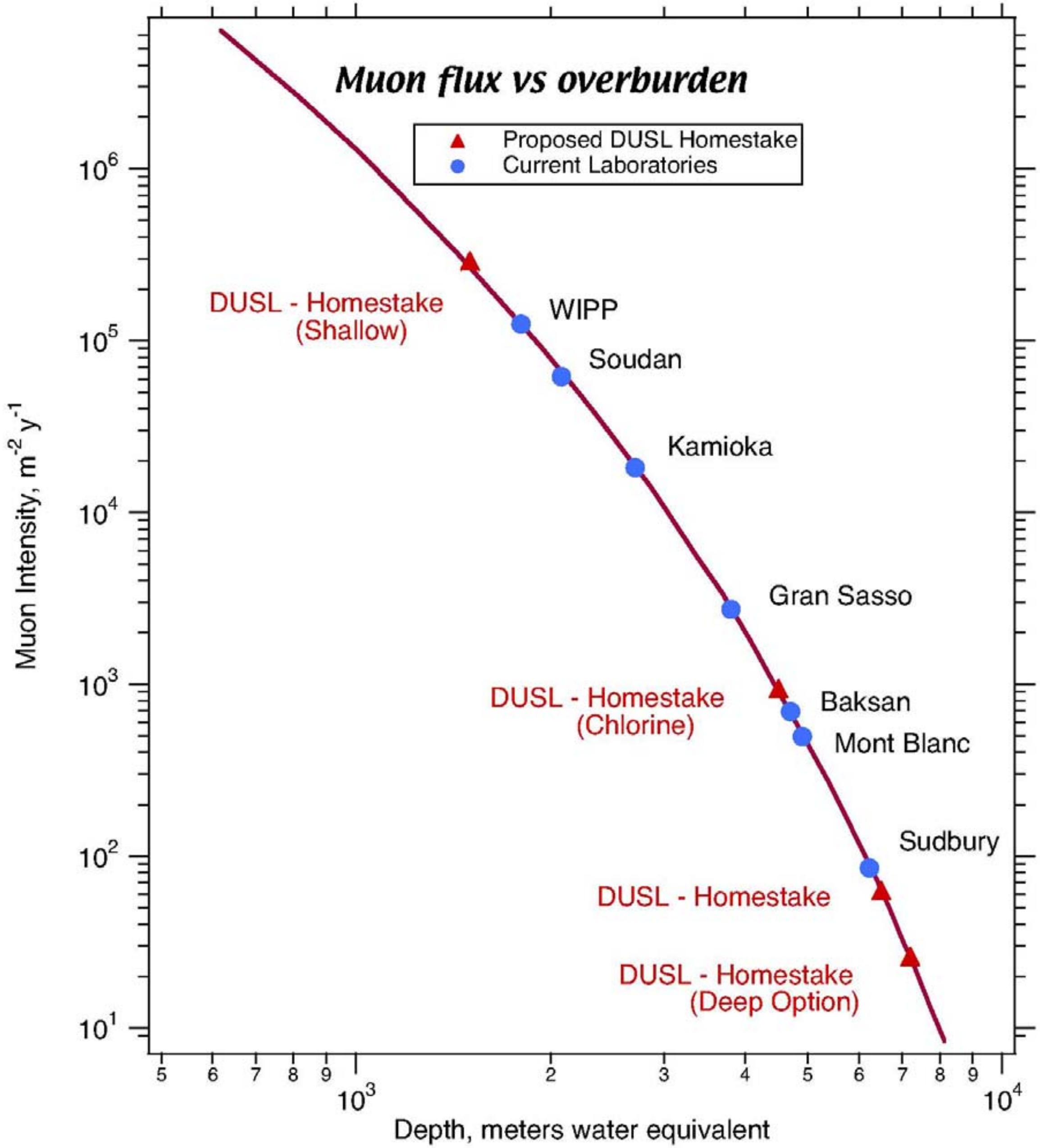
  0.15/MTon-yr (tight)

Expected Sensitivity on K-ν mode is about ~8x10^{33} yr



Ref: Shiozawa (NNN05)

300 kilotons x 10 yrs $\Rightarrow$ 10^{35} proton yrs


Muon flux vs overburden
Proposed DUSL Homestake
Current Laboratories
DUSL - Homestake (Shallow)
WIPP
Soudan
Kamioka
Gran Sasso
DUSL - Homestake (Chlorine)
Baksan
Mont Blanc
Sudbury
DUSL - Homestake
DUSL - Homestake (Deep Option)
Muon Intensity, m^{-2} y^{-1}
Depth, meters water equivalent
10^1
10^2
10^3
10^4
10^5
10^6
5
6
7
8
9
2
3
4

Uranium, Thorium, and Potassium Values from the Homestake Core Archive*

Core / Core Location	U (ppm) ±(5 – 10)%	Th (ppm) ±(5 – 10)%	K (%) ±(1 – 2)%
Core #11537 **Yates Member** - vertical hole starting at 4850L (1/2 way between Ross and Yates Shafts) – multiple core samples measured	0.160 0.55	0.20 0.30	1.54 2.12
Core #11553 **Yates Member** drilled from 4850L – multiple samples measured	0.21 0.19	0.30 0.19	1.12 0.92
Core #15537 **Poorman** Formation Horizontal hole at 7200L	0.080	0.25	0.010
Core #15532 **Yates**/**Poorman** from 7300L to 7450L – multiple core samples measured	0.080 0.085	0.25 0.25	0.104 0.125
Core #18627 **Yates Member** drilled from 7400L – multiple core samples measured	0.18 0.49	0.24 0.20	1.01 0.57
Cores #15680 - 820, 17581 - 822, 11553 - 059, 11537 - 180: **Rhyolite dikes** – averaged from four samples	8.6	10.8	2.9

*Al Smith, LBNL Low Background Counting Facility
For other than the **rhyolite dikes** these values are a factor of **10 to 20 lower than typical granites**

DUSEL Megaton Detector depth specification paper – Dec 2008- provides depth requirement for each of the scientific goals

Conclusion: 4200 mwe provides the necessary Cosmic Ray μ flux reduction

Fermilab-TM-2424-E, BNL-81896-2008-IR, LBNL-1348E

Report on the Depth Requirements for a Massive Detector at Homestake

Katsushi Arisaka,[1] Adam Bernstein,[2] Mary Bishai,[3] E. Blaufuss,[4] Edward Blucher,[5] N. Bowden,[2] Charles Bower,[6] Carl Bromberg,[7] J. Busto,[8] Jean E. Campagne,[9] Daniel Cronin-Hennessy,[10] David B. Cline,[1] Steven Dazeley,[2] Milind V. Diwan,[3] Farshid Feyzi,[11] Bonnie Fleming,[12] Hugh Gallagher,[13] Maury Goodman,[14] G. Hallewell,[8] Thomas Kafka,[13] Richard Kadel,[15] D. Kaminski,[16] Albrecht Karle,[17] Edward Kearns,[18] Joshua Klein,[19] William Kropp,[20] Kenneth Lande,[19] Charles Lane,[21] Francesco Lanni,[3] C. Laughton,[22] David Lissauer,[3] Byron Lundberg,[22] William Mann,[13] Jelena Maricic,[21] Marvin Marshak,[10] Christopher Mauger,[23] Robert McKeown,[24] Mark Messier,[6] William Miller,[10] Sanjib Mishra,[25] William Morse,[3] Stuart Mufson,[6] James Musser,[6] James Napolitano,[16] S.Ouedraogo,[2] Thomas Patzak,[26] Zarko Pavlovic,[23] Rob Plunkett,[27] Ronald Poling,[10] Regina Rameika,[27] Mayly Sanchez,[14] Niki Saolidou,[22] Kate Scholberg,[28] Terry Simon,[29] Michael Smy,[20] Jacob Schneps,[13] Henry Sobel,[20] Gregory Sullivan,[4] Robert Svoboda,[30] Manni Tripathi,[30] Jon Urheim,[6] Mark Vagins,[31] Rick Van Berg,[19] Brett Viren,[3] Christopher Walter,[28] Hanguo Wang,[1] G. Zeller,[23] A. Zghiche,[32] and Robert Zwaska[22]

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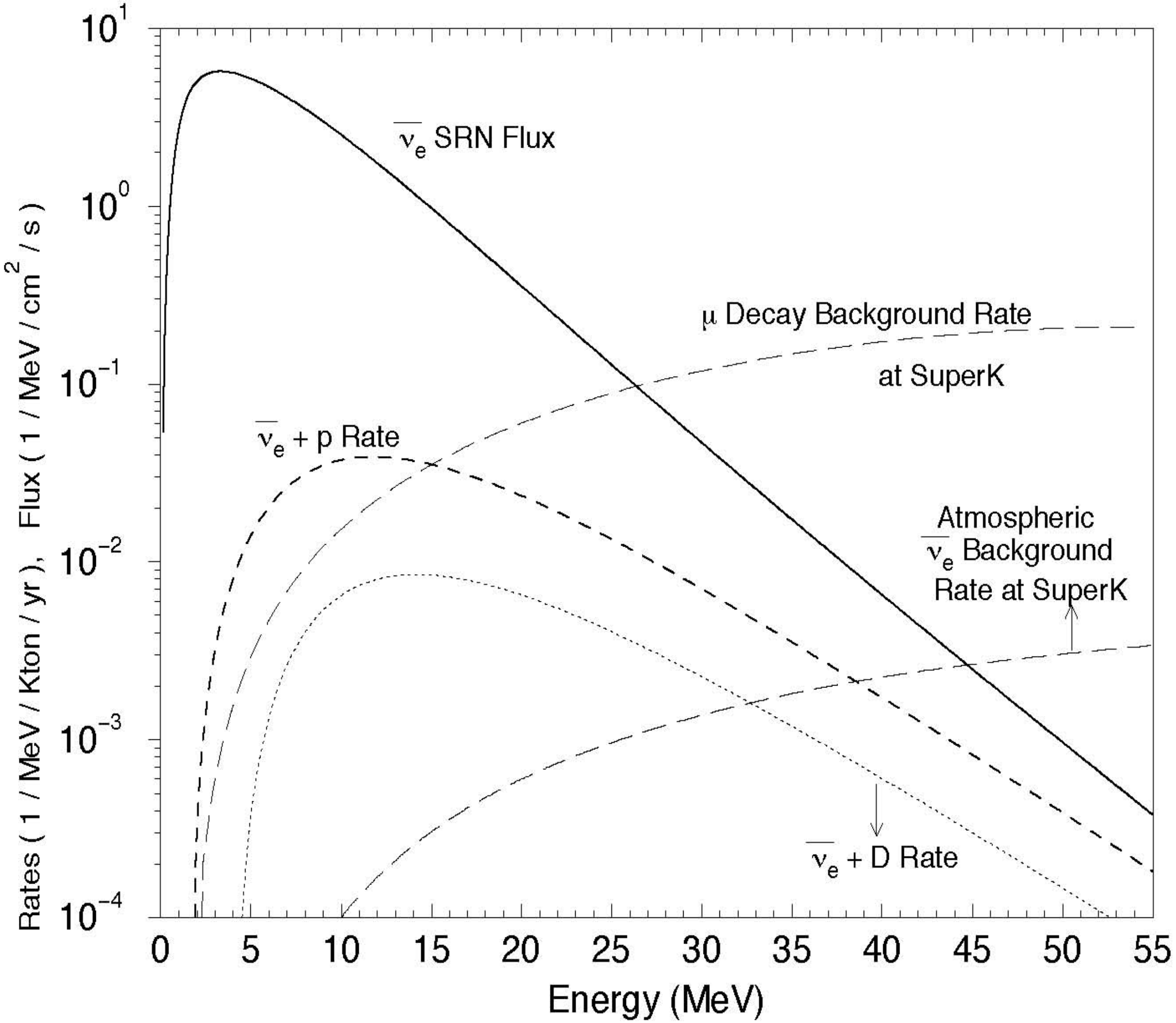
[12]*Department of Physics, Yale University, New Haven, CT 06520*
[13]*Physics Department, Tufts University, Medfard, MA 02155*
[14]*Argonne National Laboratory, Argonne, IL 60439*
[15]*Physics Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA*
[16]*Rensselaer Polytechnic Institute, Troy, NY 12180*

- **<u>North American Power Reactor Map</u> – DUSEL ~ 500 km from nearest reactors – reactor $\bar{\nu}_e$ flux ~ 1/30 of that at S-K**



Relic SN $\bar{\nu}_e$ flux at SK –

note: μ decay bkgnd ~ 20 lower at DUSEL
Reactor $\bar{\nu}_e$ flux ~ 30 lower at DUSEL

SN neutrino burst detection

- 1) For SN in our Galaxy expect ~10^5 events in 10 seconds (300 kiloton)
- 2) For SN in M31 expect about 10-15 events in 10 seconds (300 kilotons)

The DUSEL H_2O Cerenkov Modules are enlarged versions of the SK detector.

	S-K	DUSEL	Why?
Diameter	40 m	55 – 65 m	Rock strength
Height	40 m	55 – 65 m	PMT strength
Fiducial volume	22 kT	3 x (100 –170 kT)	Larger & multiple Modules
PMT dia.	50 cm	25 – 30 cm	Higher photocathode efficiency, stronger, smaller volume, improved timing and position determination

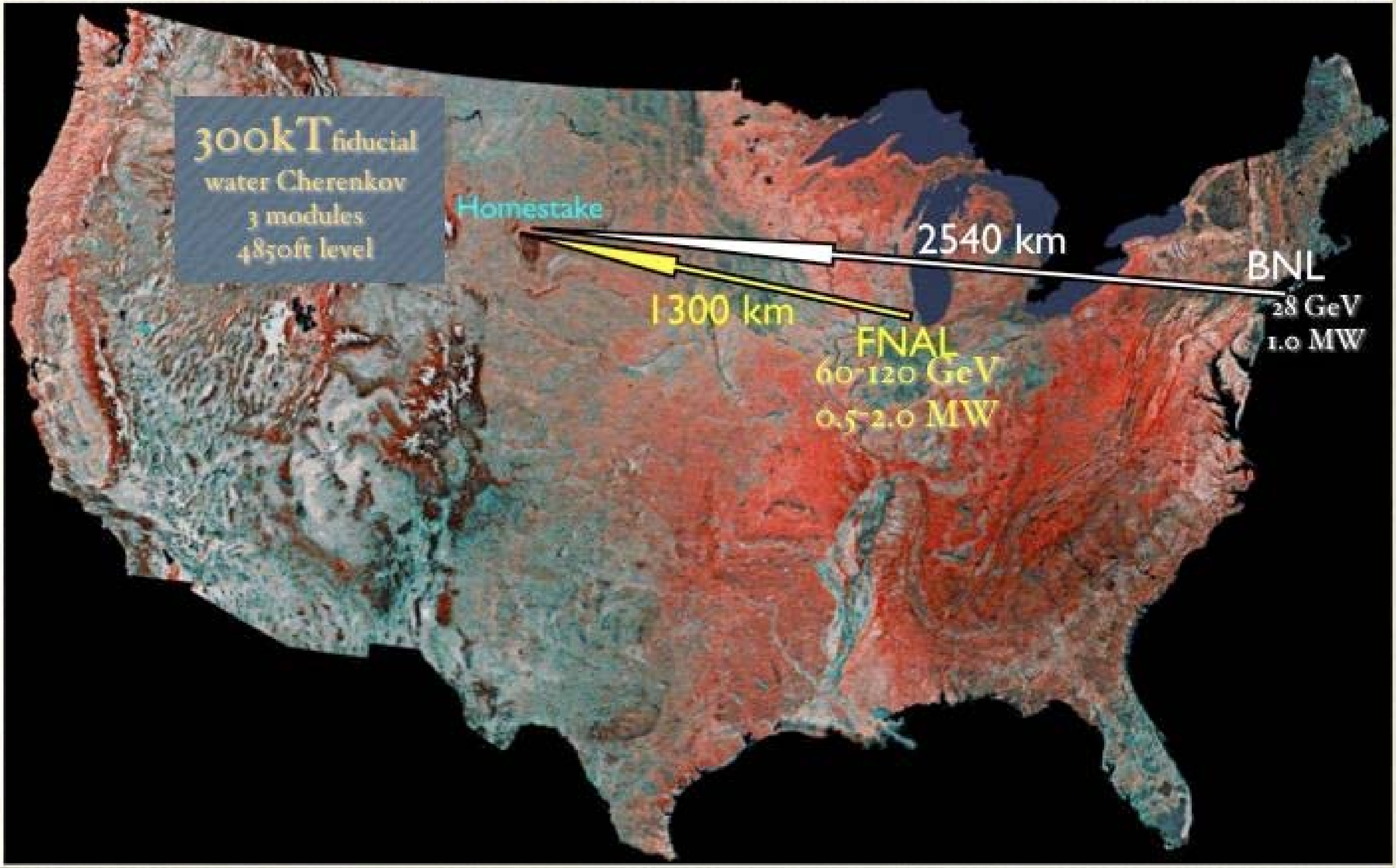
DUSEL Detector Construction

1) Excavate chambers
2) Install water tight liner
3) Mount PMTs – all materials compatible with Gd
4) Fill with purified water
5) Connect electronics
6) LOOK!

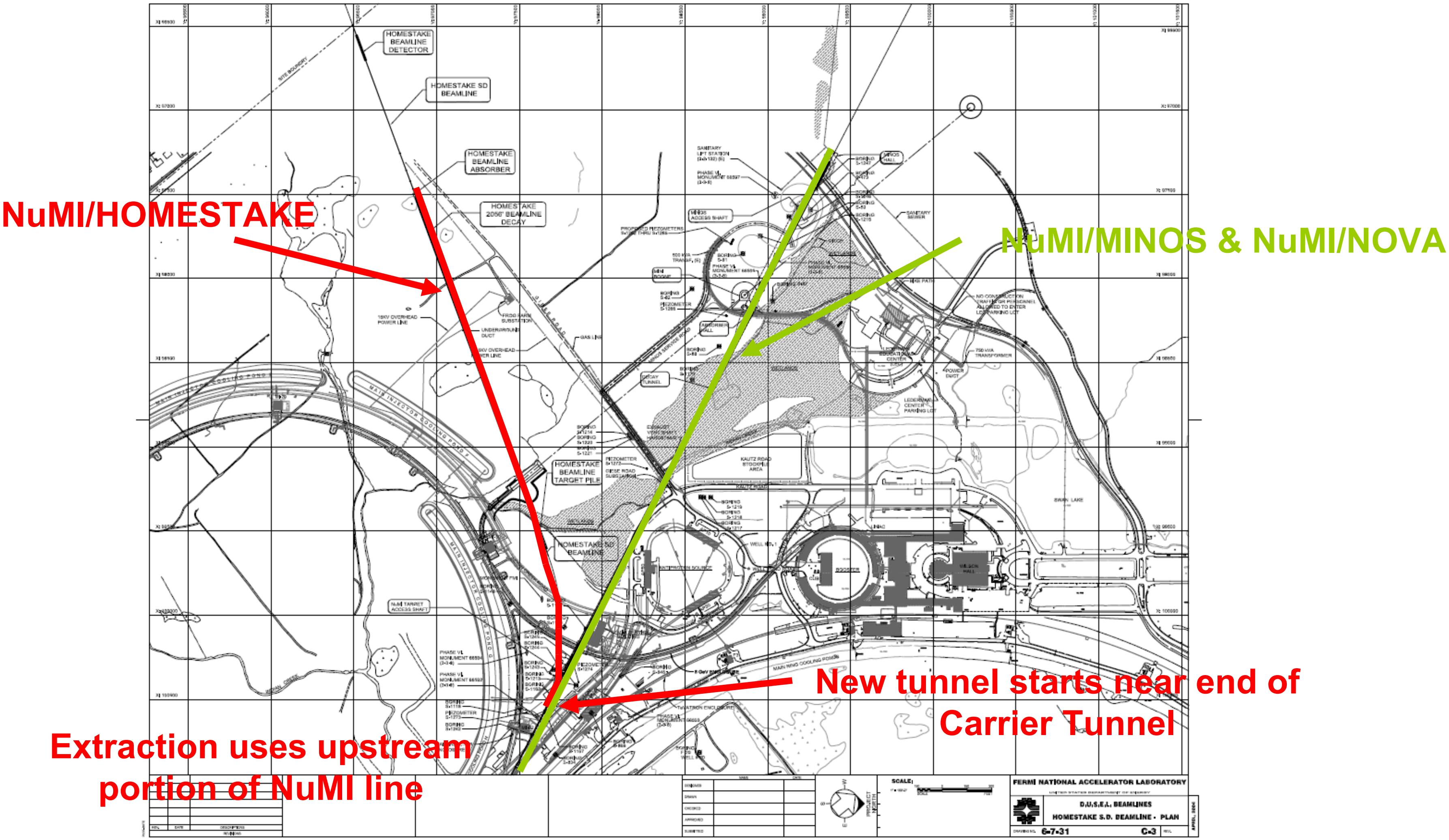
Technically Driven Timetable

1) 9/2009-12/2010-Rock strength studies
2) 1/11-12/11 – Construct access & rock removal tunnels
3) 1/12 - 3/16 – Excavate
4) 4/16 - 3/17 – Install PMTs & water fill module 1 – turn on after 4/17
5) 4/17 - 3/18 – Install PMTs & water fill module 2 – turn on after 4/18
6) 4/18 - 3/19 – Install PMTs & water fill module 3 – turn on after 4/19
7) **Financial timetable - ???**

The concept originated ~2002 after SuperK and Kamland discoveries.

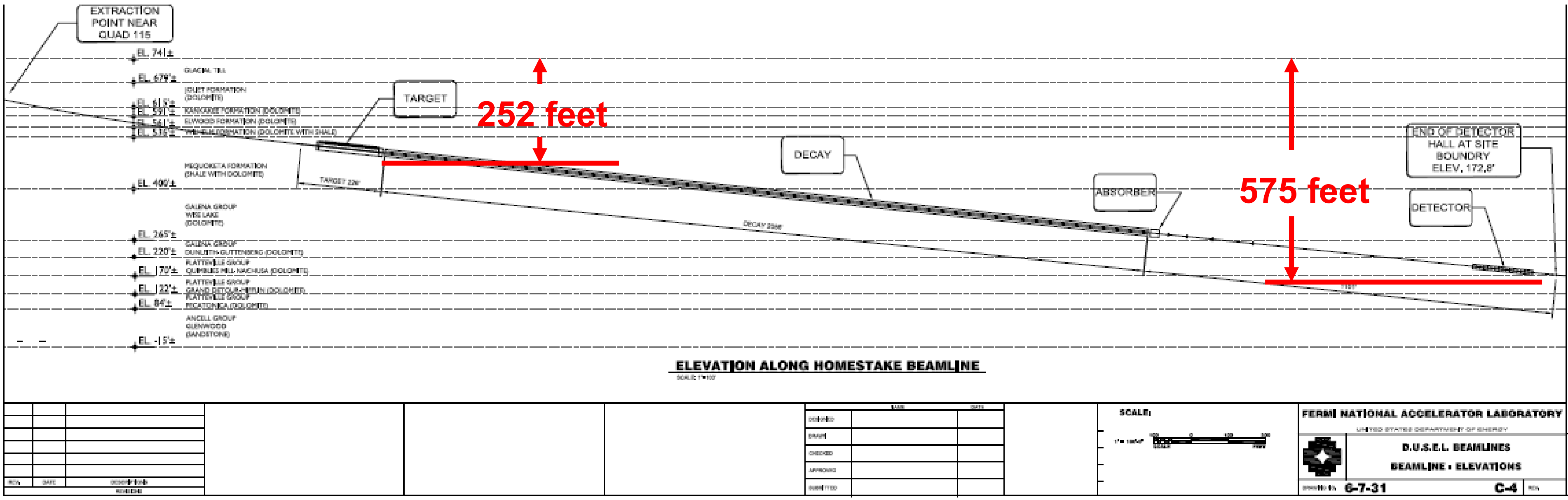


Location of the Homestake Beamline



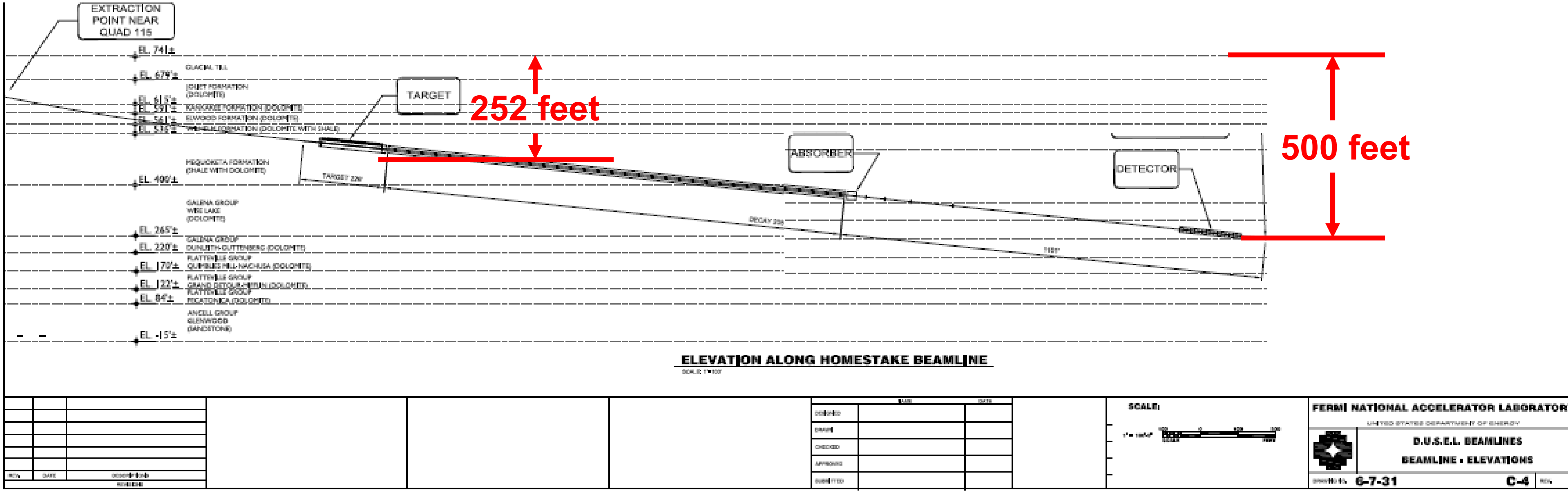
Location of the Homestake Beamline

First Elevation View of the Homestake Beamline



This elevation view of the Homestake Beamline (-5.84^{o}) is drawn to take the detector to the site boundary at Kirk Road. The maximum decay pipe length available in this configuration is about 627m (compare to NuMI at 675m). The detector hall (and shaft) is about 575 feet deep (compare to MINOS at about 336 feet). This is still in the Galena-Platteville but deep.

Second Elevation View of the Homestake Beamline



This elevation view of the Homestake Beamline (-5.84°) is drawn with the decay pipe limited to 400m. This shortens the beamline by 741 feet, and lifts The detector hall (and shaft) by about 75 feet (500 feet deep). Overall, this configuration will be cheaper to build and is probably adequate.

Where will we be in 10 years?

1) SN burst detection - ≥ 3 detectors – Japan, U.S., Canada, Europe, India

2) Proton Decay ≥ 3 detectors – Japan, U.S., Canada, Europe, India

3) Neutrino beam base lines:

a) 295 km – T2K
b) 730 km – FNAL-Soudan & CERN – Gran Sasso
c) 1300km – FNAL-DUSEL
d) +????