Kimballton Underground Research Facility

R. Bruce Vogelaar

www.kimballton.org

first, a little background history…

KIMBALLTON

Kimballton Laboratory

- an underground science and engineering opportunity

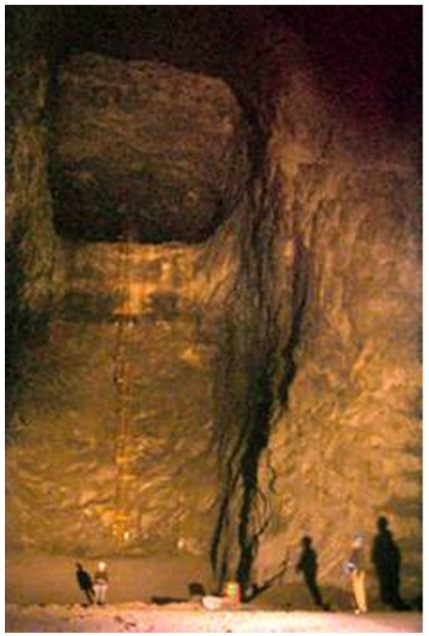
R. Bruce Vogelaar
Nov 11, 2004
vogelaar@vt.edu
Virginia Tech

National and International Underground Science and Engineering Programs have been very successful and well funded.

Need for a new US underground facility identified by:

National Academy of Sciences
National Research Council
Nuclear Science Advisory Committee LRP

Major Regional Opportunity



http://www.phys.vt.edu/~kimballton

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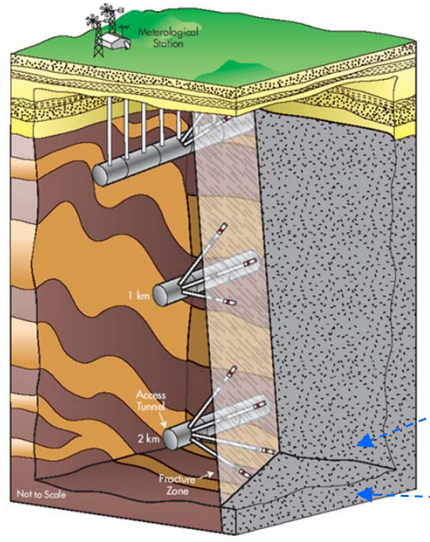
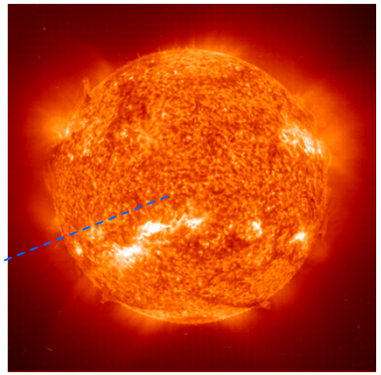
Deep Underground **Science and Engineering** Laboratory (DUSEL) Motivation (a la NSF)

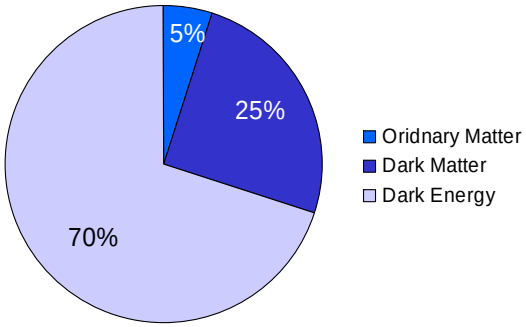
- Geosciences
- Engineering
- Geobiology

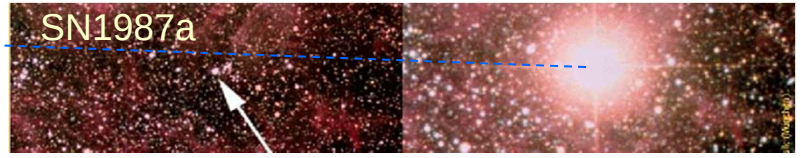
- Neutrino Physics
- Dark Matter Search
- Nucleon Decay
- National Security
- Outreach



from EarthLab Report







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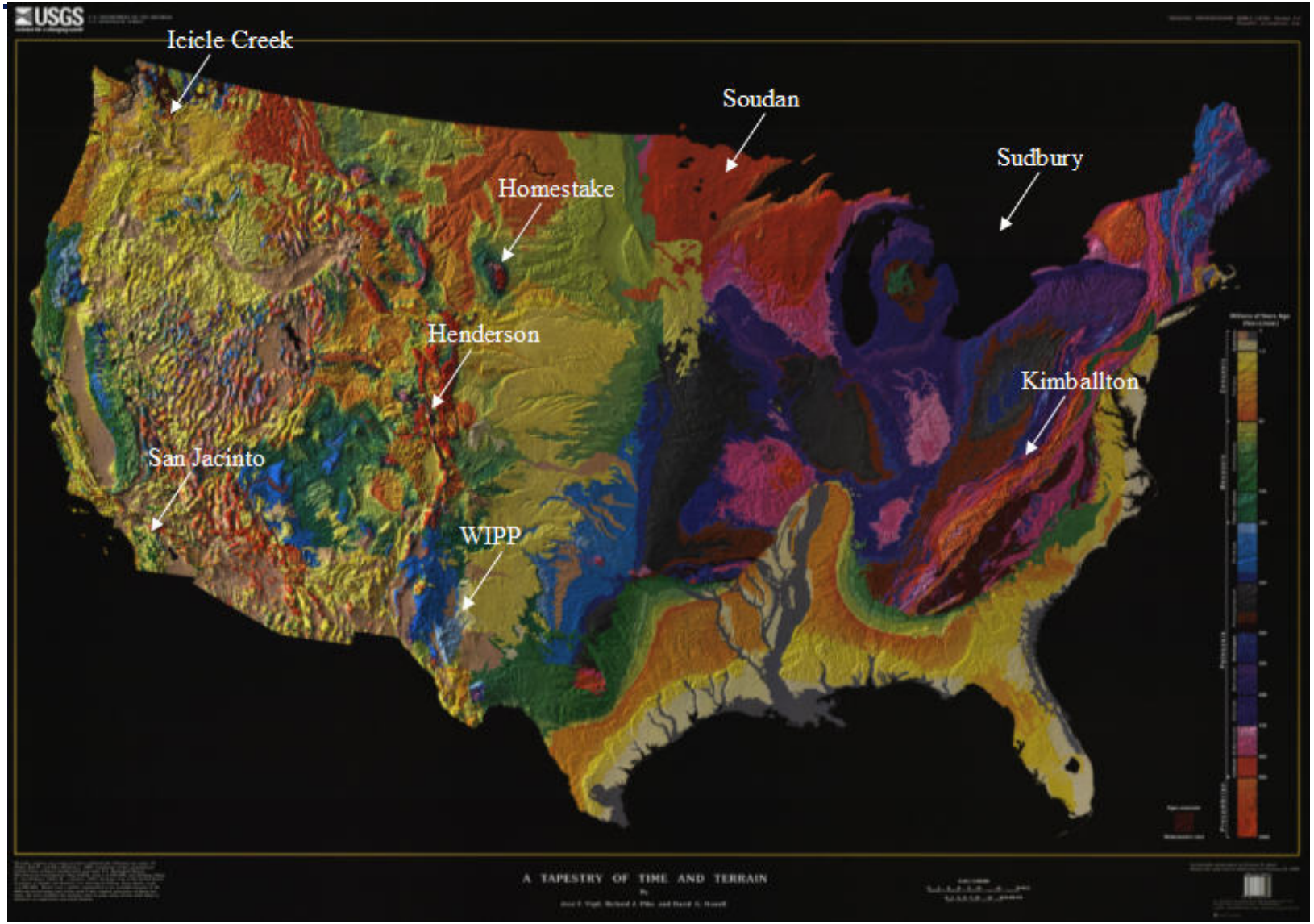
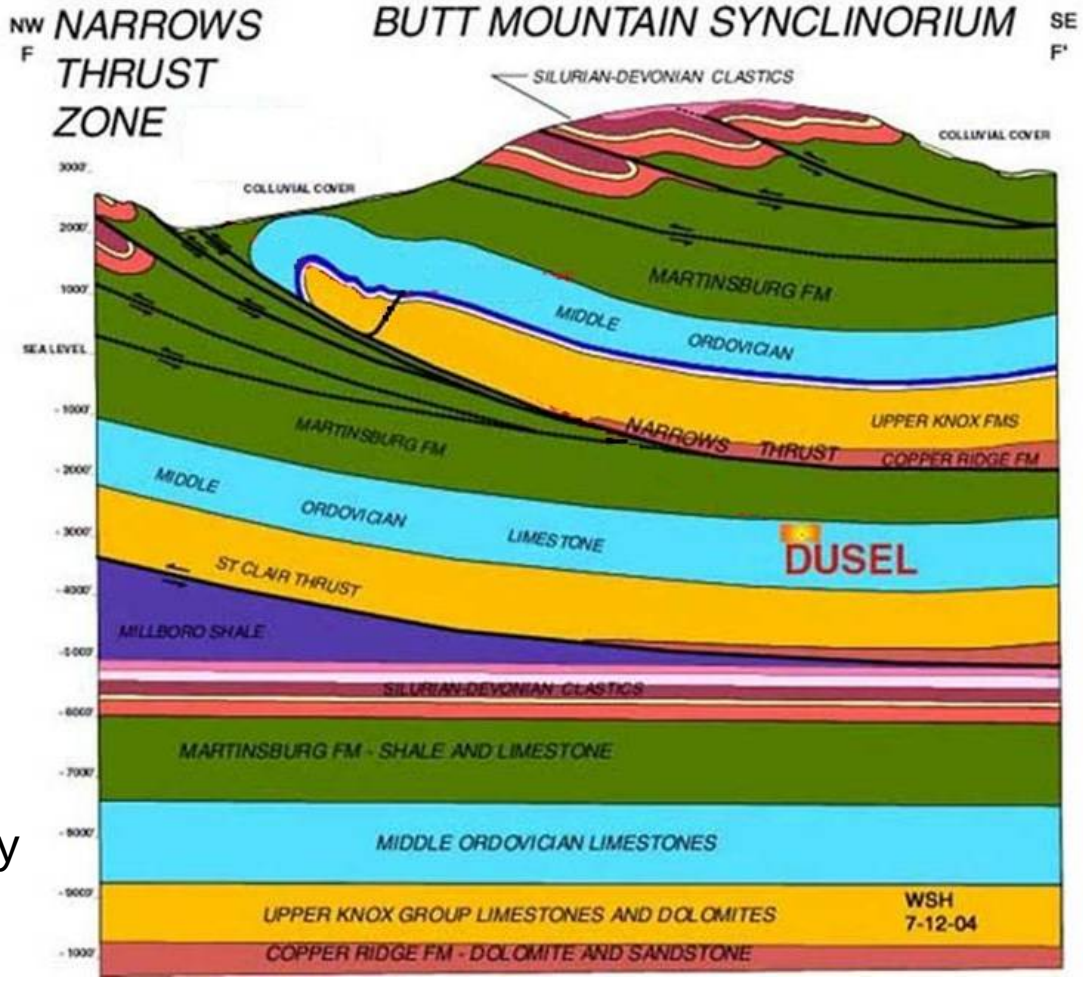
Potential Sites

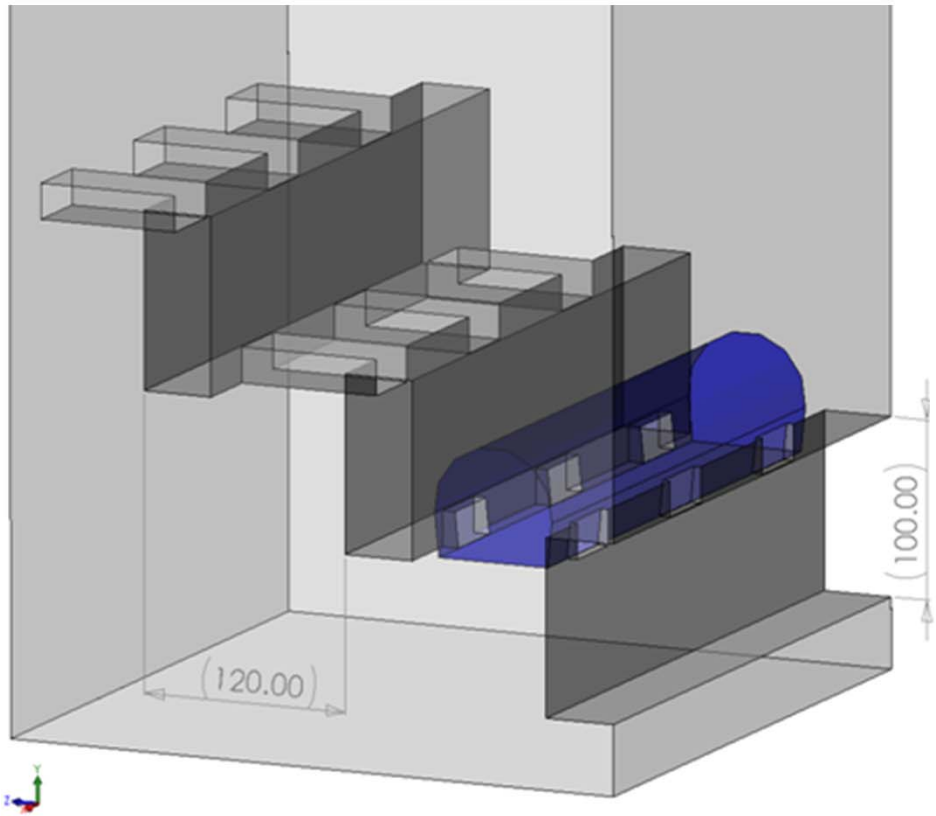


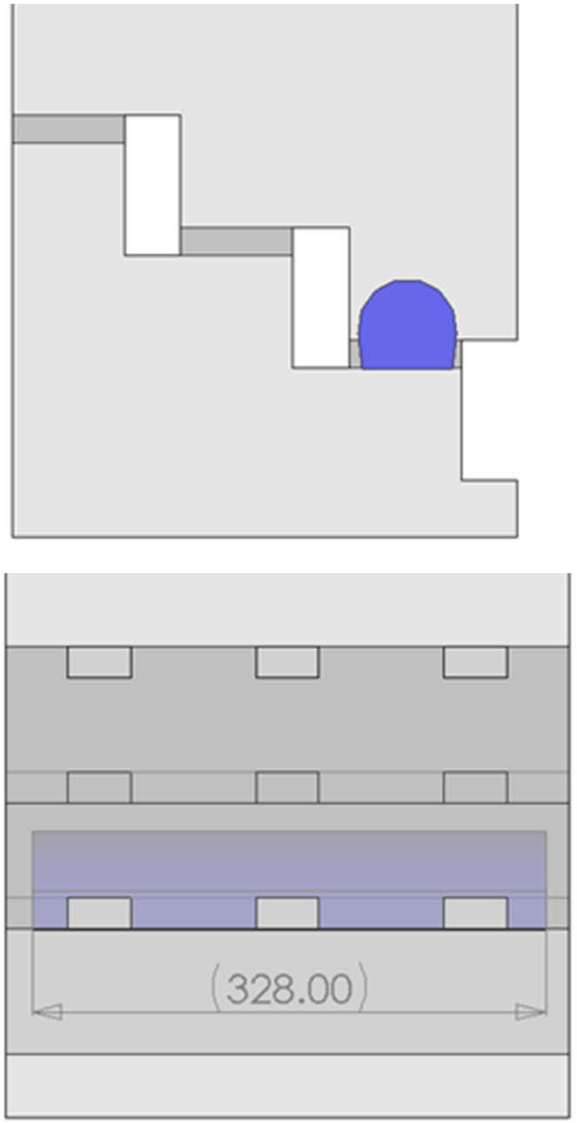
Kimballton Advantages

- *only* proposed site in sedimentary rock;
- environmentally friendly;
- short time to first-science;
- heterogeneous known geology;
- dormant fault;
- repeating geologic layers;
- local major research university;
- excellent climate, power and transportation;
- outreach to Appalachia & mining communities;
- support from local community



Kimballton Interior





dimensions in feet

Backgrounds in Kimballton

- Kimballton (limestone) (Bq/kg)
  - $^{40}K \rightarrow 18\pm1, 13\pm1$
  - $^{226}Ra \rightarrow 1.2\pm0.1, 1.9\pm0.2$
  - $^{226}Th \rightarrow 0.6\pm0.1, 0.9\pm0.2$
- Radon concentration
  - $^{222}Rn < 14.8$ Bq/m^3

- Gran Sasso (Dolomite rock) (Bq/kg)
  - $^{40}K \rightarrow 15$
  - $^{226}Ra \rightarrow 5$
  - $^{226}Th \rightarrow 0.3$
- Radon concentration
  - $^{222}Rn \rightarrow 40 – 70$ Bq/m3

Rock Strength:

~150 MPa

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Kimballton Science Team

over 150 researchers from 28 organizations, including 63 active senior researchers listed on the S2 proposal

CNA Consulting
Draper Aden & Associates
Duke University
Georgia Tech
Iowa State University
Michigan Technological University
Naval Research Laboratory
National Inst. Standards & Tech.
New Mexico Tech
MIT
North Carolina State University
Oak Ridge National Laboratory
Penn State University
Princeton University
Purdue University
Radford University
Schnabel Engineering
Technical Univ. Munich
University of Alaska
University of Alberta
University of Hawaii
University of Missouri-Rolla
University of North Carolina
University of Minnesota
University of Oklahoma
University of Tennessee
Virginia Commonwealth Univ.
Virginia Tech

KIMBALLTON

"Conceptual Design for DUSEL at Kimballton, Virginia"

PI: Mark McNamee (Virginia Tech)

co-PI: Robert Bodnar (Virginia Tech)

co-PI: Herbert Einstein (Massachusetts Institute of Technology)

co-PI: Robert Hatcher (University of Tennessee)

co-PI: Raju Raghavan (Virginia Tech)

co-PI: R. Bruce Vogelaar (Virginia Tech)

Solicitation 2 DUSEL proposal (submitted to NSF Feb 28, 2005)

If you have trouble viewing an item in your browser, first try downloading and using a local copy; otherwise, contact: vogelaar@vt.edu

Submitted Proposal

Project Summary
Project Description and References
Budget and Justification
Facilities
List of PIs and 57 Senior Collaborators
Biographical Sketches of PI and co-PIs
Biographical Sketches of Senior Collaborators
Letters of Support
---Vice President of Research, VT
---Virginia Senators
---Virginia Representatives
---Forest Service
---Giles County Board of Supervisors
---New River Valley Planning District Commission
---Blacksburg Partnership
---Giles Rural Development Alliance
Links to Letters from Senior Collaborators

Appendices: (available only on web) --- (check for updates)

A Existing Surface Infrastructure
B Kimballton Geology (seismic imaging)
C Geotechnical Evaluation
D Environmental Assessment
E *Supplementary* Science Book (why especially Kimballton) (Bio/Geo/Engineering, Physics)
F Safety and Health Plan
G Permitting
H Risk Analysis
I *Preliminary* Design & Constructability , and Code Review
J Education and Outreach
K S2 Costs and Timeline
L NRL-VT Kimballton Low-Background Facility
M Links to Documents included by reference (ie: S1 Science Book, Earth Lab, etc)

Combined pdfs:

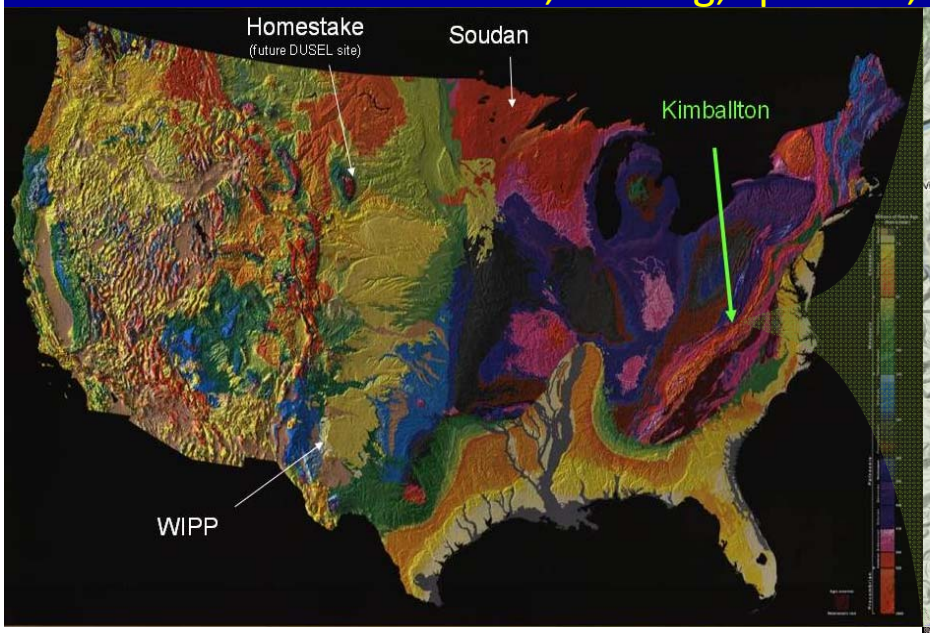
Project Summary, Project Description, List of Senior Collaborators, Letters of Support
(does not include letters from Senior Collaborators, see link above)

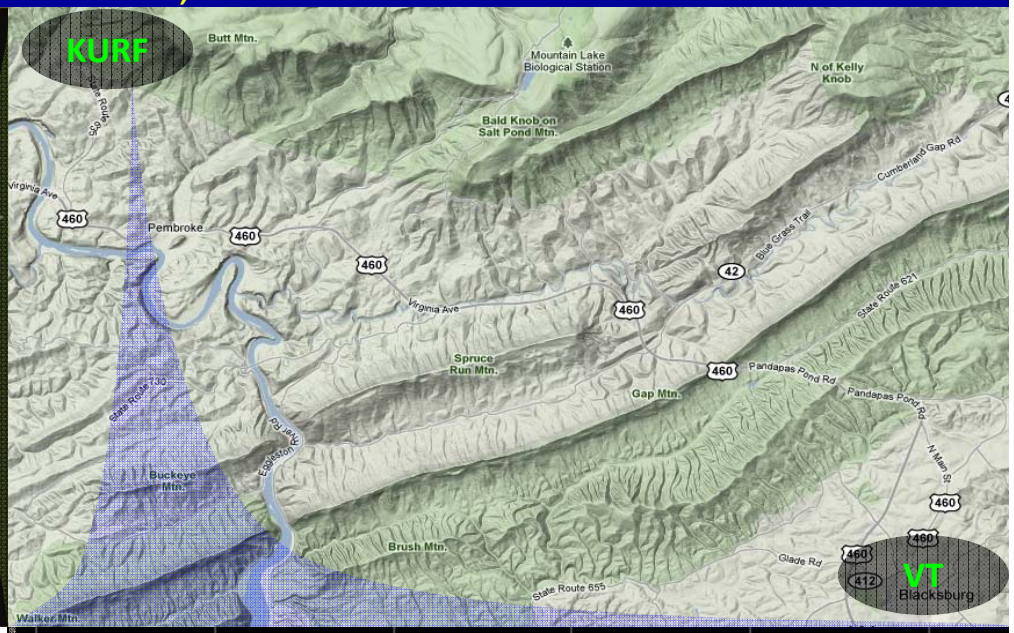
All Appendices (25 MB)

While not selected for DUSEL we continued on a more modest level…

Kimballton Underground Research Facility

an ideal, existing, spacious, low-cost, drive-in location

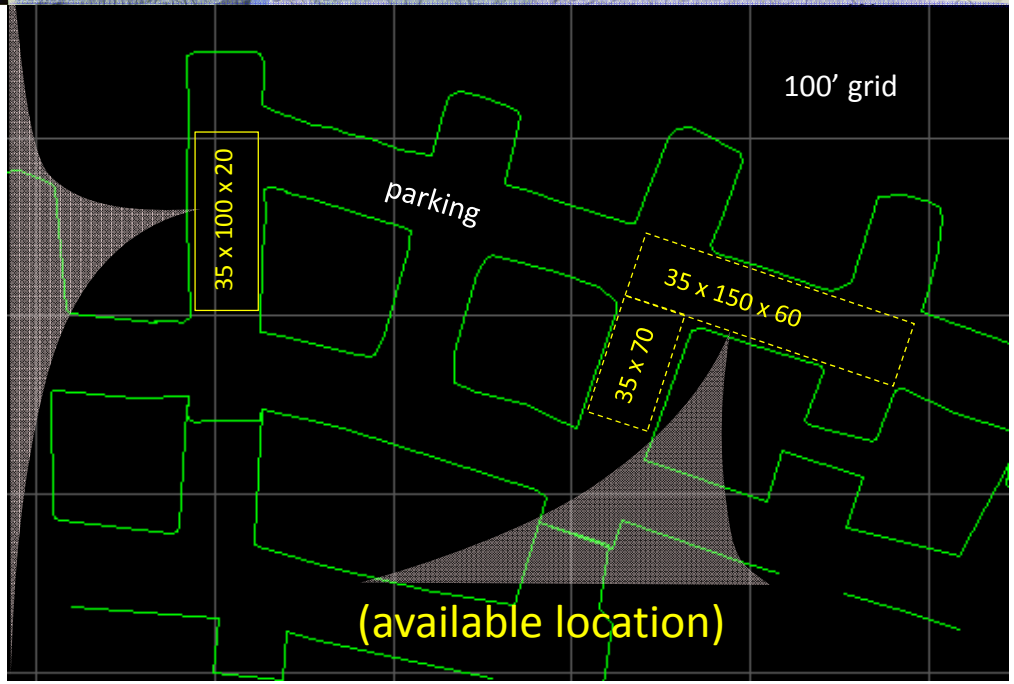




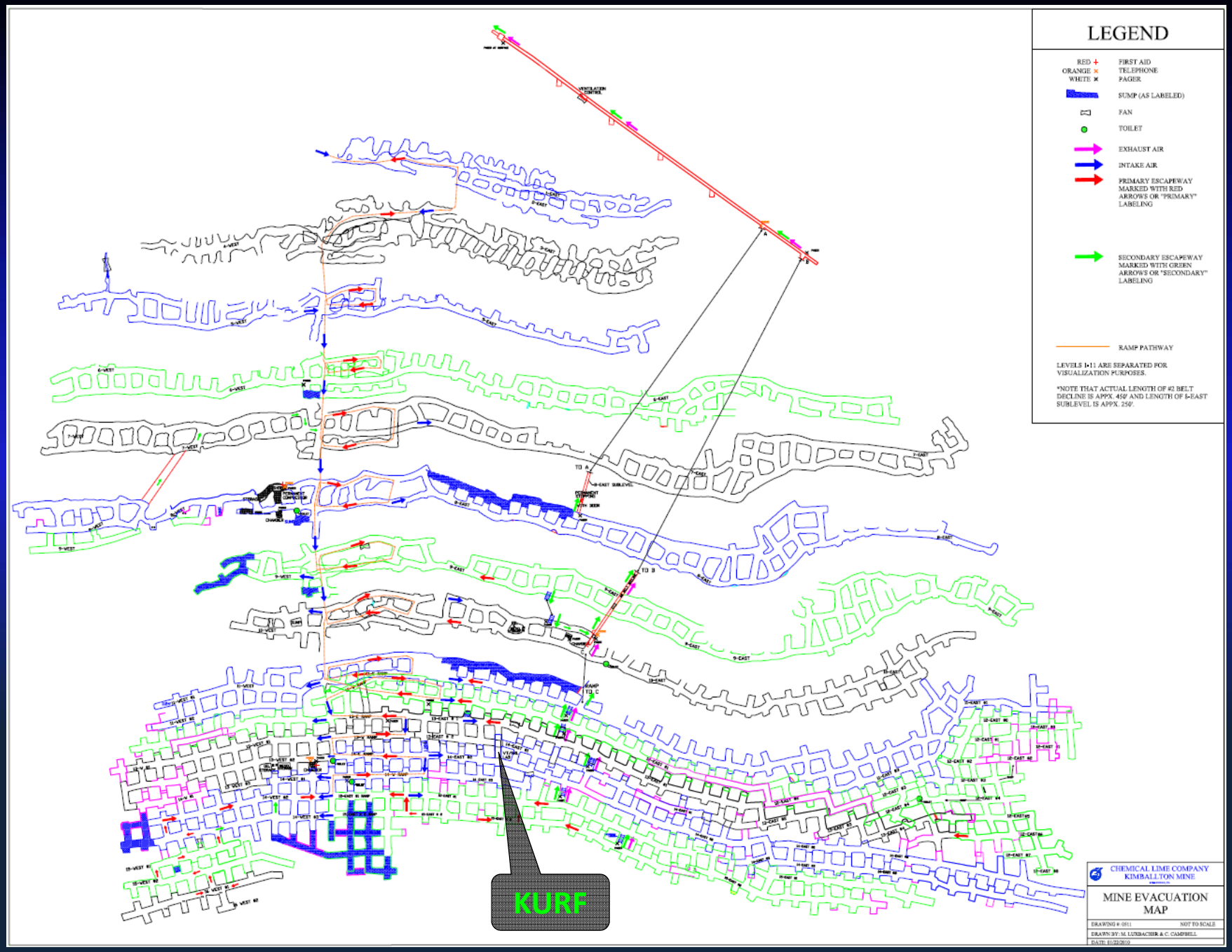
KURF

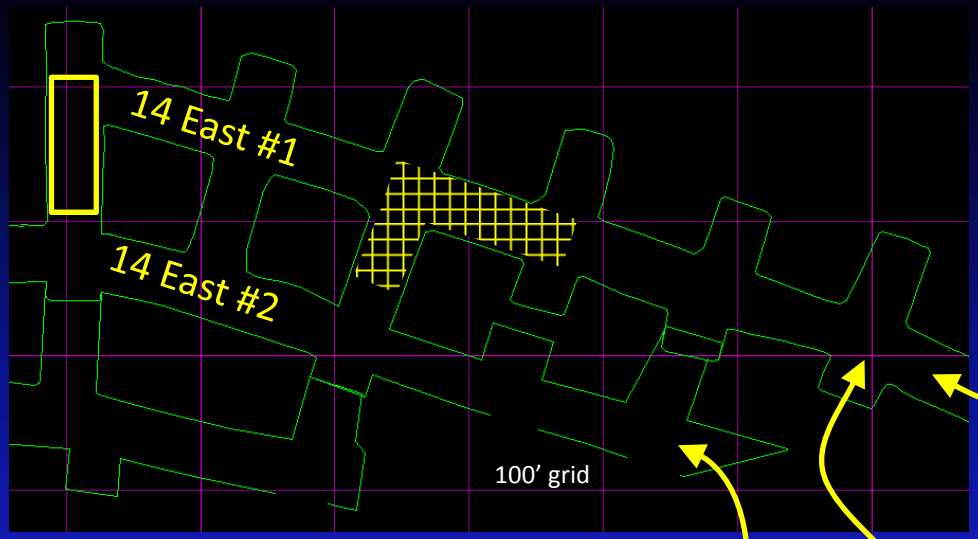
- 30 minutes from Virginia Tech, 3.5 hrs from TUNL
- no additional bureaucracy for foreign researchers
- operating limestone mine
  (*blast @ 11:00 pm demonstrably not a problem*)
- drive-in access (eg: roll-back truck, motor coach)
- space: 50+ miles of drifts (all 40'w x 20' ↔ 100'h)
- 1700' overburden (2300' current mine max)
- laboratory built in 2007 (35' x 100' x 22')
- fiber optic internet, LN_2, 480/220/110 V power
- ample water, filtered air, 55 ^{o}F constant temp
- low Rn, low rock background
- ~ 0.004 muons m $^{-2}$ s $^{-1}$ sr $^{-1}$

www.kimballton.org



Portal region and typical drive-in access


LEGEND
RED + FIRST AID
ORANGE × TELEPHONE
WHITE ✖ PAGER
SUMP (AS LABELED)
FAN
TOILET
EXHAUST AIR
INTAKE AIR
PRIMARY ESCAPEWAY MARKED WITH RED ARROWS OR "PRIMARY" LABELING
SECONDARY ESCAPEWAY MARKED WITH GREEN ARROWS OR "SECONDARY" LABELING
RAMP PATHWAY
LEVELS 1-11 ARE SEPARATED FOR VISUALIZATION PURPOSES.
*NOTE THAT ACTUAL LENGTH OF #2 BELT DECLINE IS APPX. 450' AND LENGTH OF 8-EAST SUBLEVEL IS APPX. 250'.
KURF
CHEMICAL LIME COMPANY
KIMBALLTON MINE
MINE EVACUATION MAP
DRAWING #: 0011
NOT TO SCALE
DRAWN BY: M. LUNDACHER & C. CAMPBELL
DATE: 11/22/2010



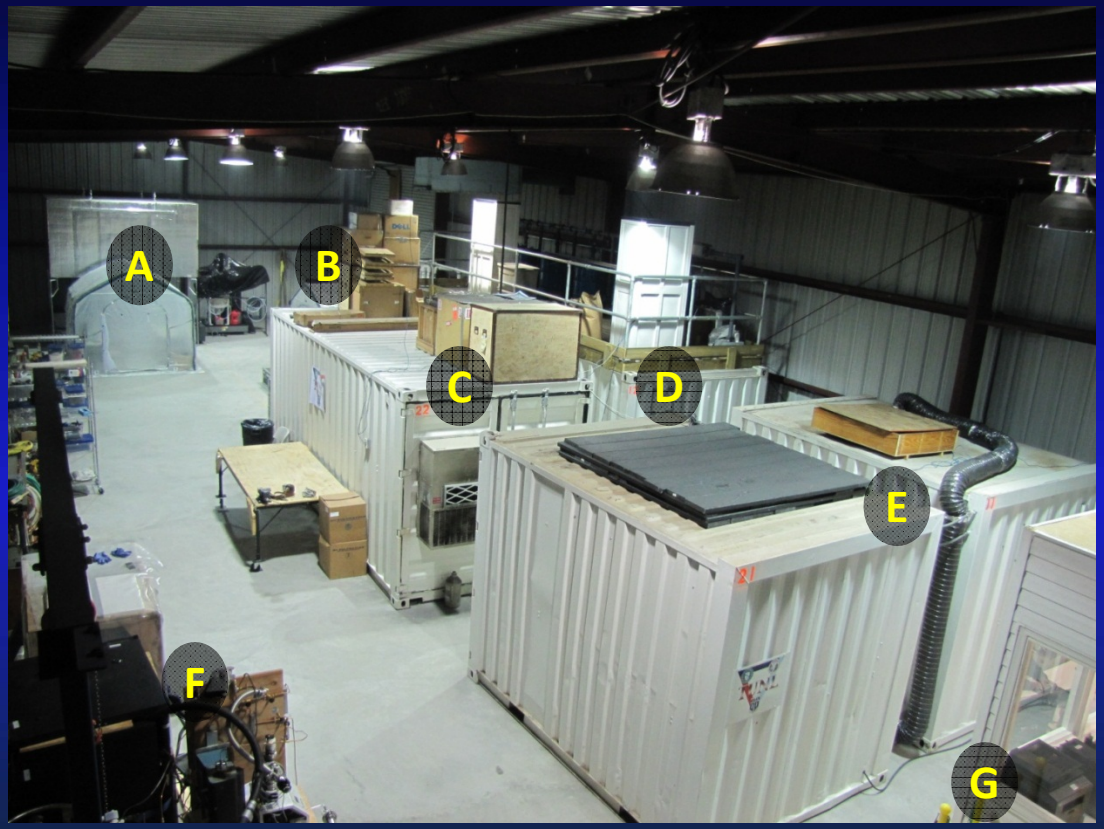
looking down 14 East #2
(top of escape-way ladder from 15th level seen on left)

looking down 14 East #1
(40 ft wide, 90 ft high typ.)
tripod is **600 ft** from KURF
(seen in the background)

escape-way ladder
to 13th level

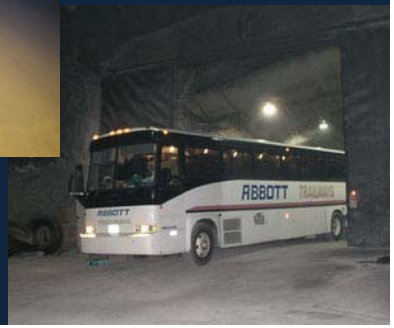
Building KURF (for < $200k; funds from Provost, College of Science, Research Division)

Current KURF *Users*



A. mini-LENS (Low Energy Neutrino Spectroscopy)
   Virginia Tech, Louisiana State University, BNL
B. Neutron Spectrometer
   University of Maryland, NIST
C. $\beta\beta$ Decay to Excited States
   Duke University
D. HPGe Low-Bkgd Screening
   North Carolina State University, University of North Carolina, Virginia Tech
E. MALBEK (Majorana $0\nu\beta\beta$)
   University of North Carolina
F. ^{39}Ar Depleted Argon
   Princeton University
G. Office

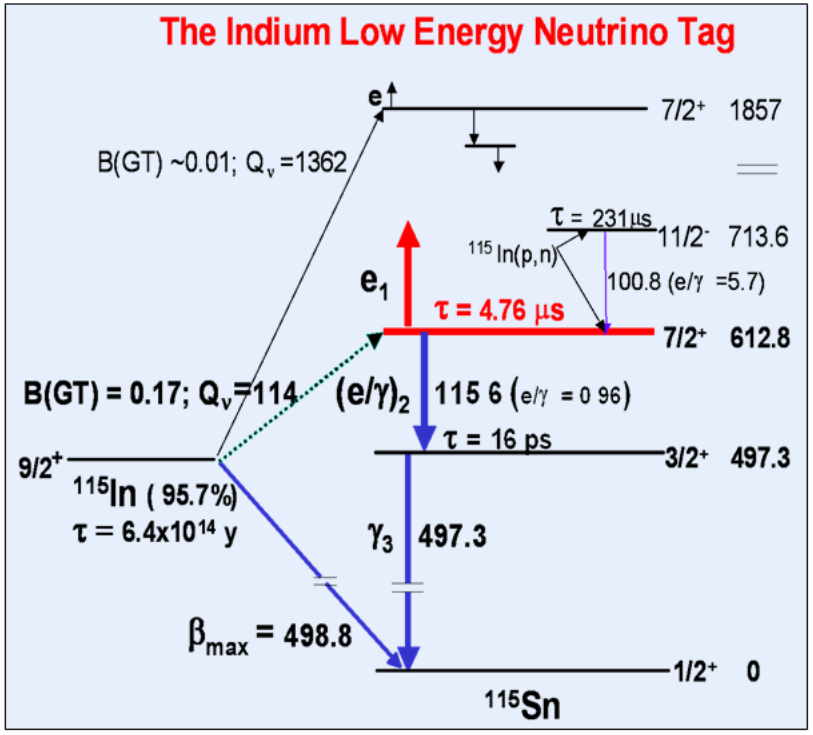
Sub-set of users for biannual training

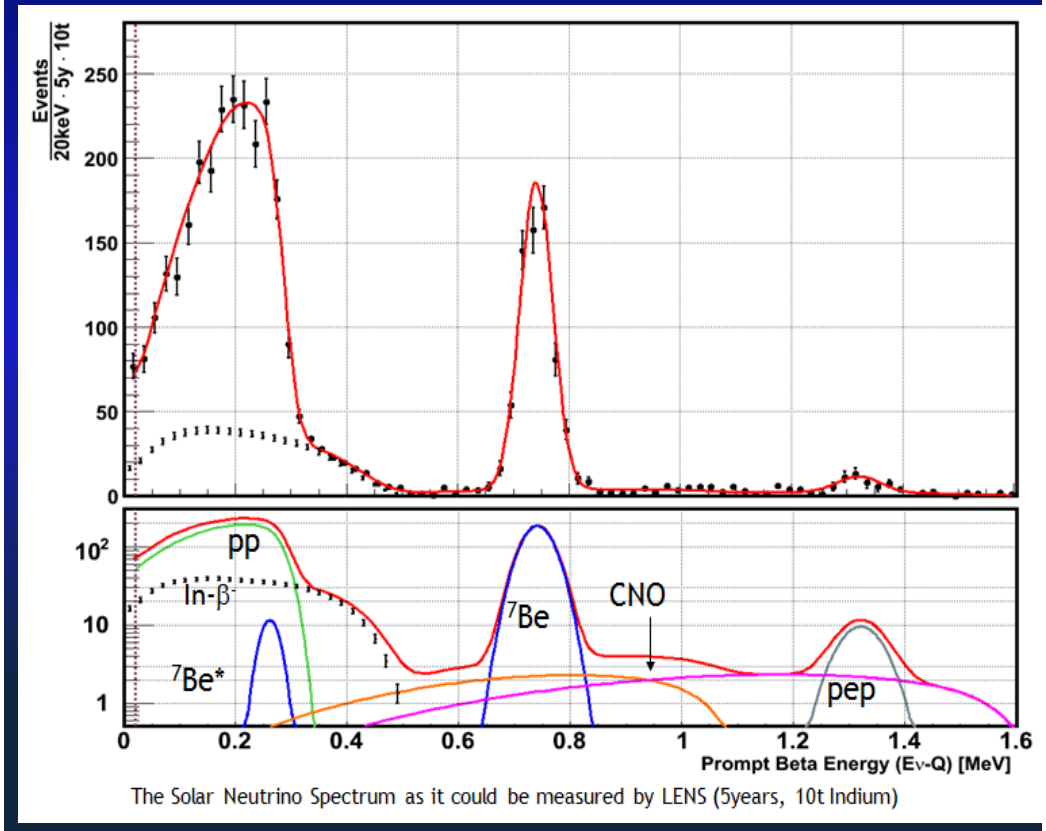


LENS

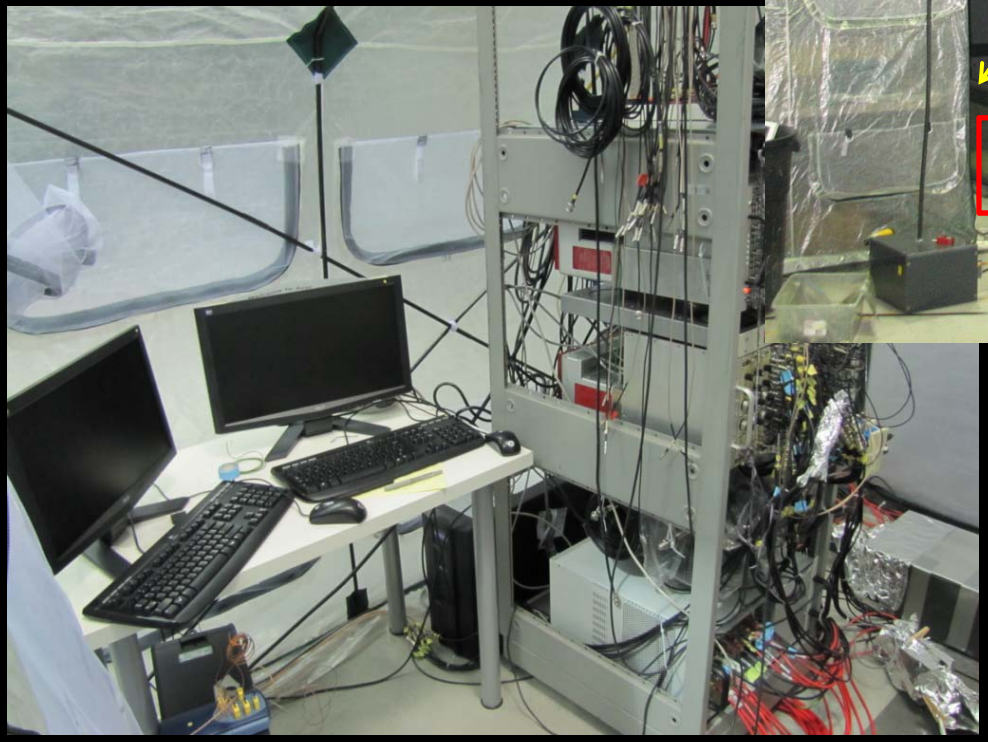
The ν_e-capture on ^{115}In

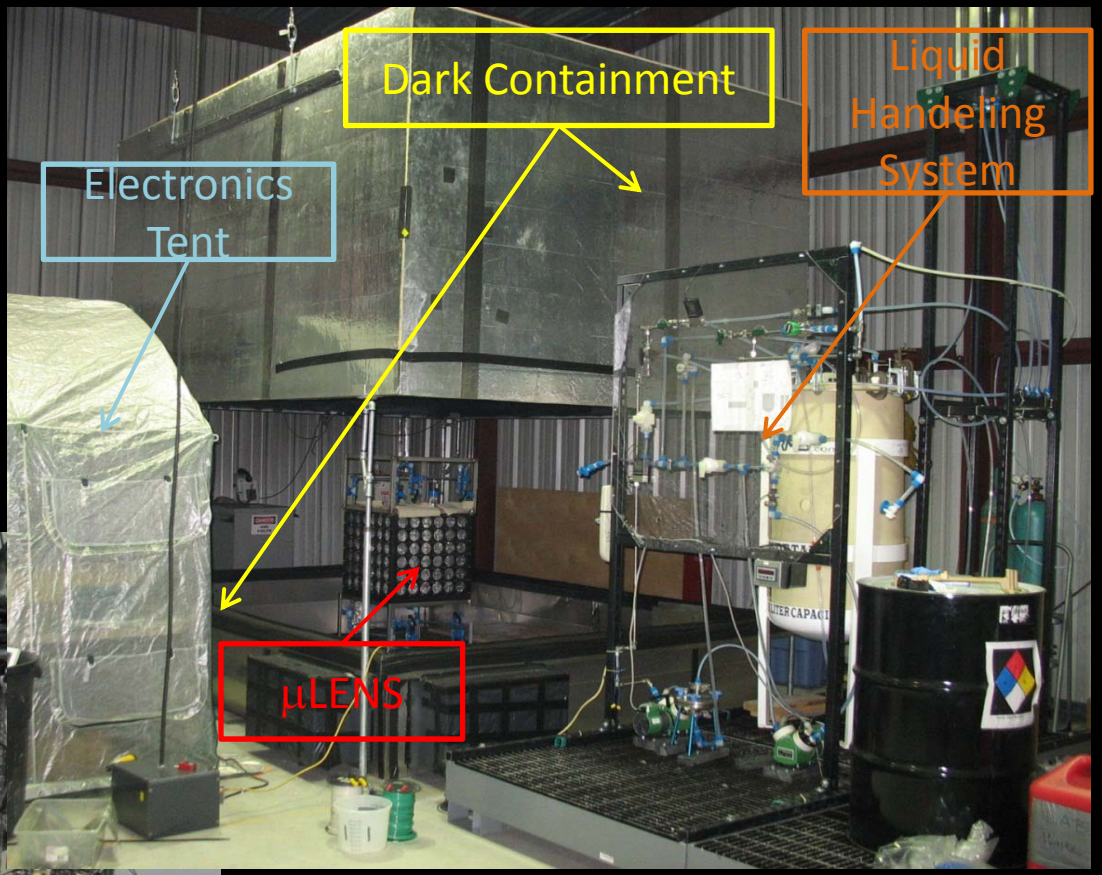
$$\nu_e + {}^{115}In \rightarrow \underbrace{e^-}_{\text{Prompt}\ (E=E_\nu - 114\ \text{keV})} + \underbrace{\gamma + (\gamma / e^-)}_{\text{Delayed Tag}\ (\tau=4.76\,\mu s,\ E_{Tag}=614\ \text{keV})} + {}^{115}Sn$$





The Solar Neutrino Spectrum as it could be measured by LENS (5years, 10t Indium)





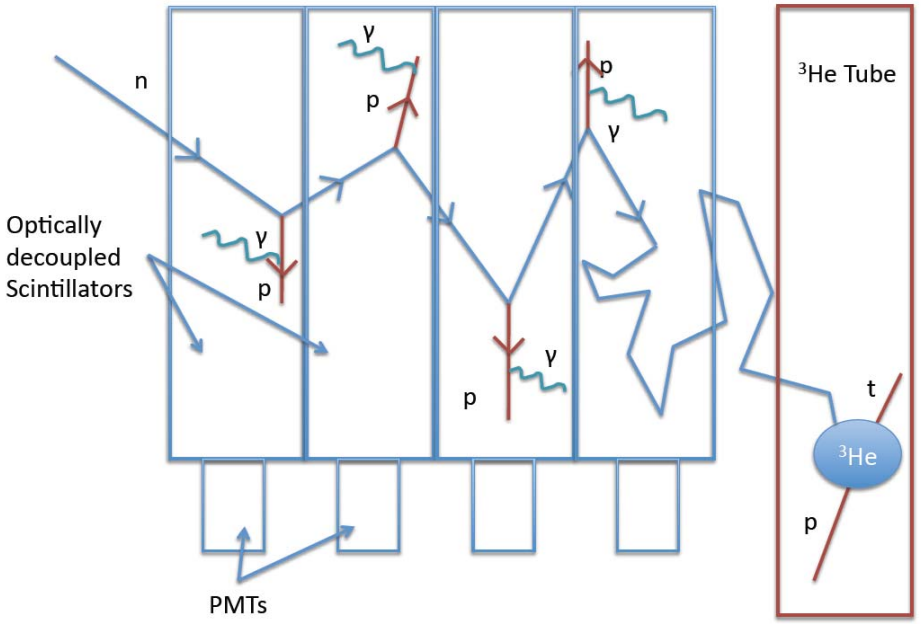
VirginiaTech
Invent the Future®

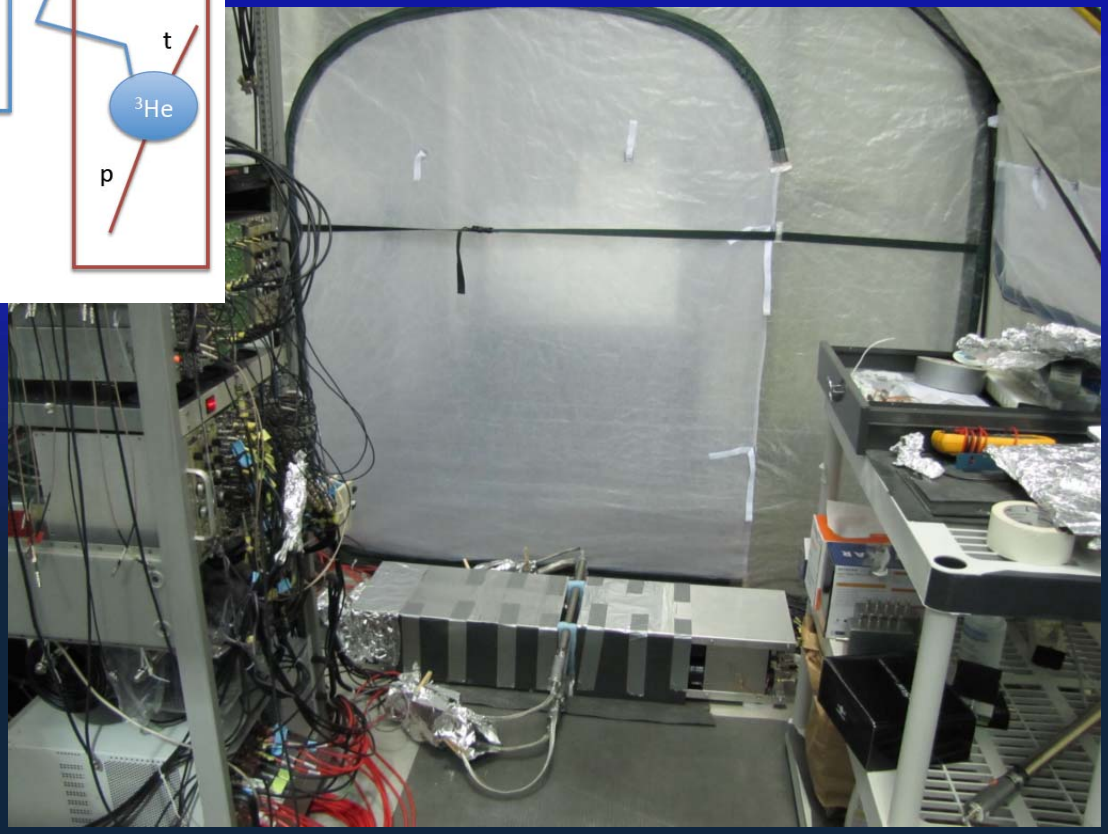
The UMD-NIST Fast Neutron Spectrometer

T. Langford, E. J. Beise, H. Breuer
University of Maryland
C. Heimbach, J. Nico
National Institute of Standards and Technology
April 13, 2011

NIST

Revised Neutron Detection





DOUBLE-BETA DECAY OF ^{150}Nd TO EXCITED FINAL STATES

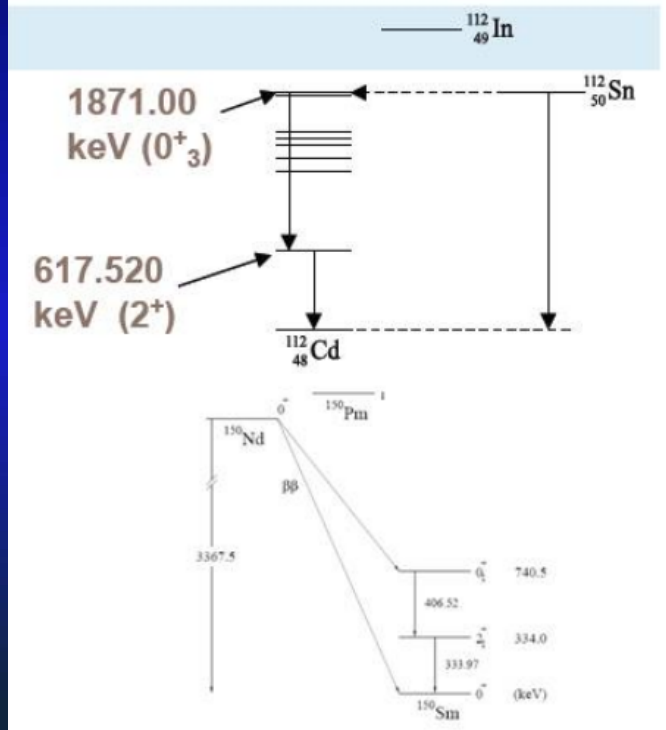
APS Division of Nuclear Physics
Santa Fe, NM
November 5, 2010

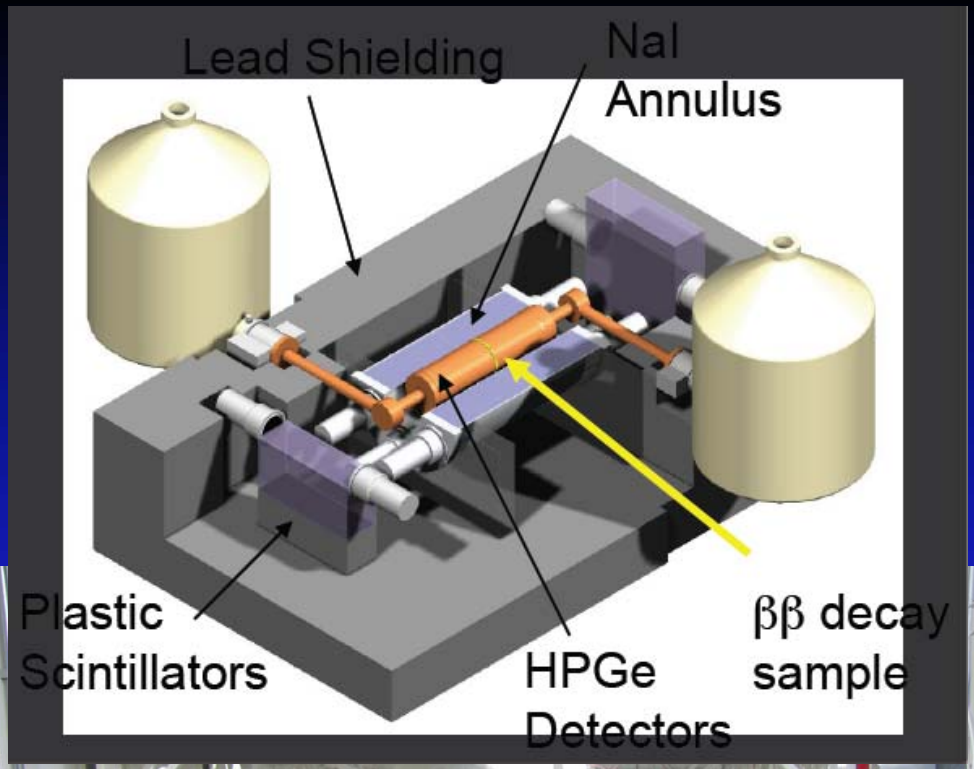
M.F. Kidd*, J. H. Esterline, S. W. Finch, W. Tornow

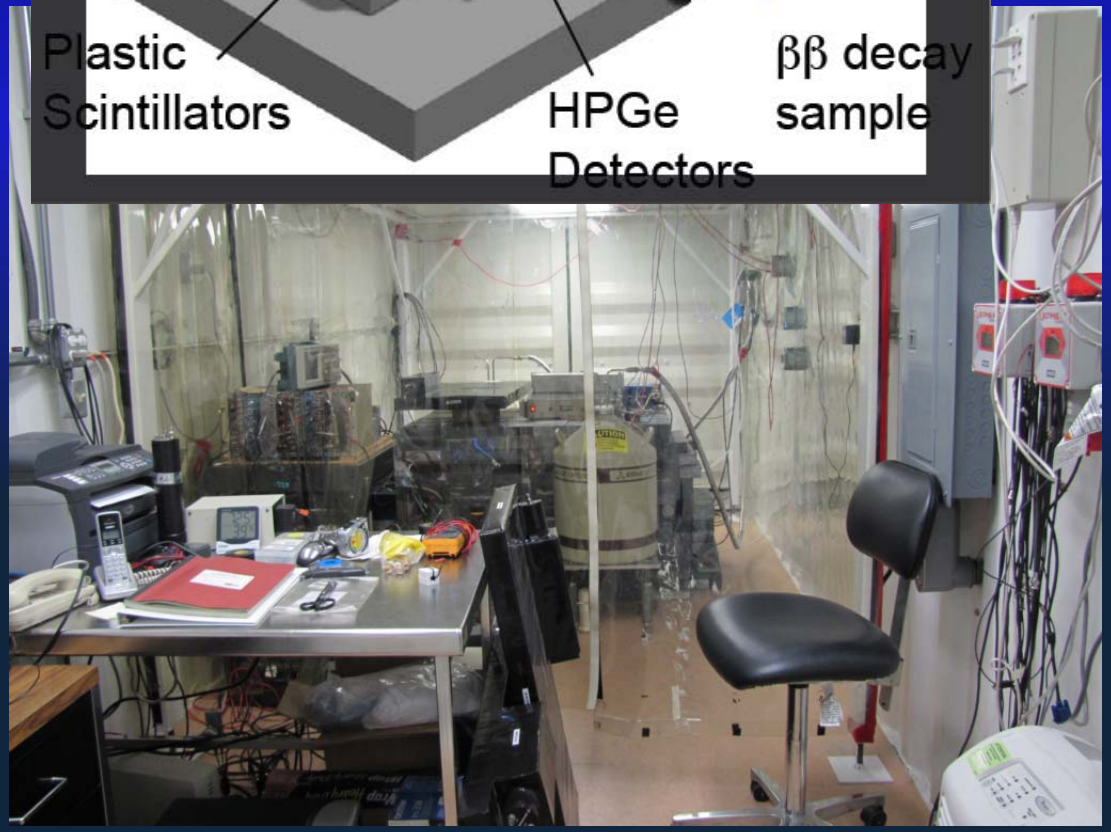
LAUR 10-07157

*now at Los Alamos National Laboratory
mkidd@lanl.gov

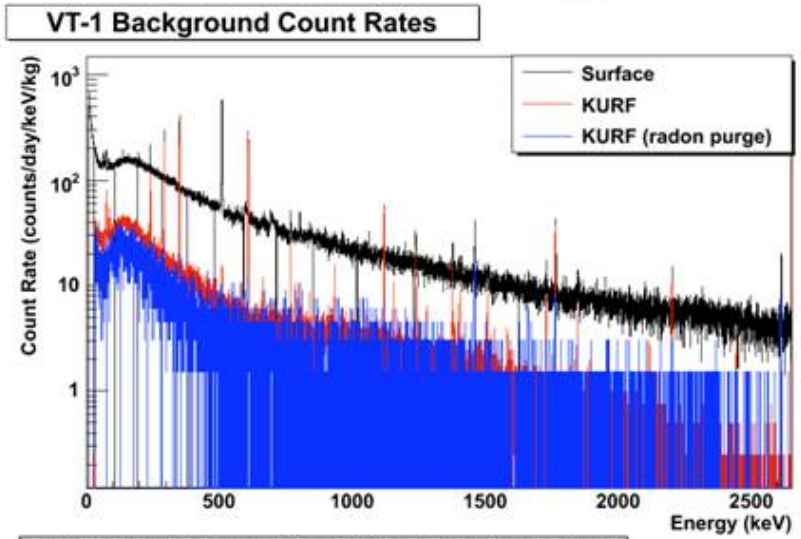
Look for coincident cascade gamma:

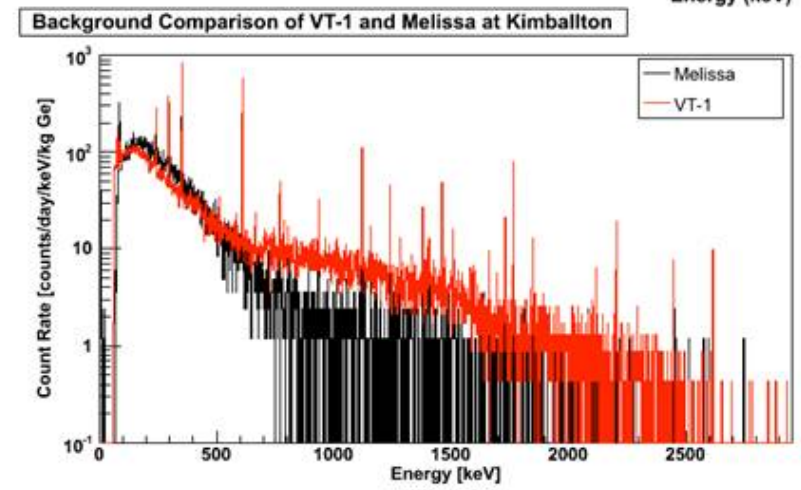


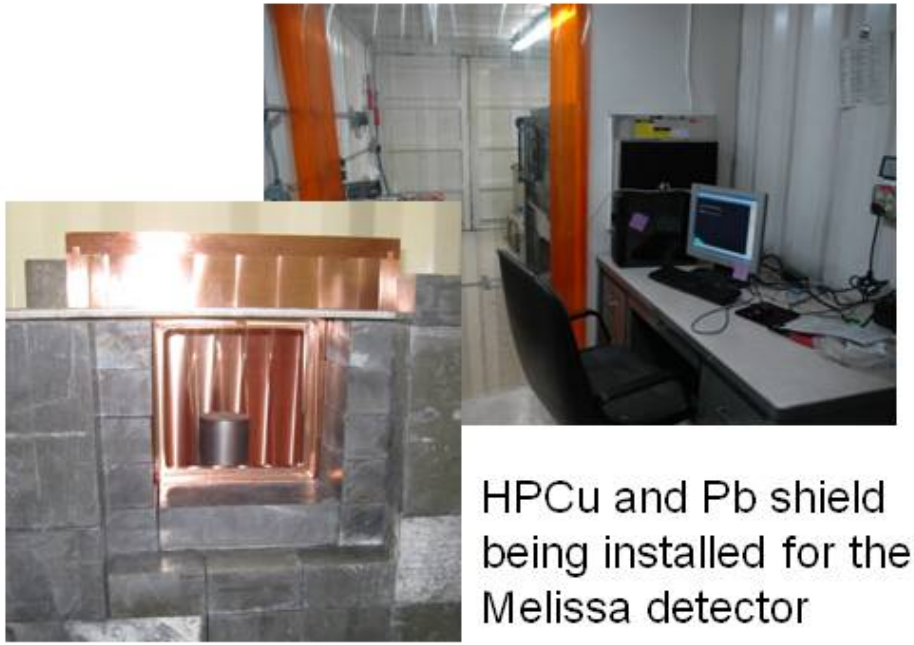




"VT-1" and "Melissa" Low-Background Detectors





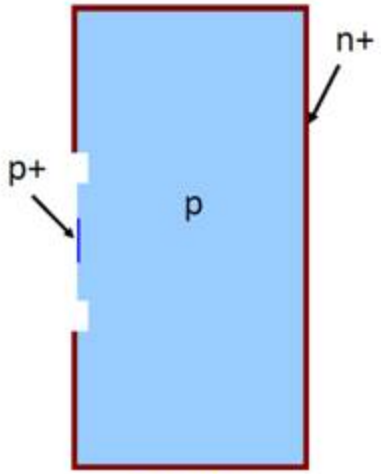


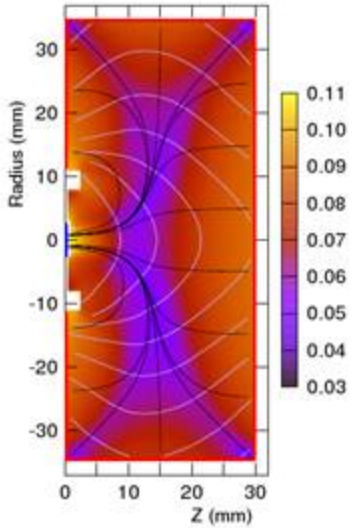
HPCu and Pb shield being installed for the Melissa detector

Species	E [keV]	Melissa	VT-1	Surface
^{214}Pb	352	840	60	100
^{214}Bi	609	470	30	100
^{40}K	1460	30	30	30
^{208}Tl	2614	4	10	70
Integral (cpd/kg)	**40-2700**	**40k**	**7.3k**	**380k**

PPC Detectors

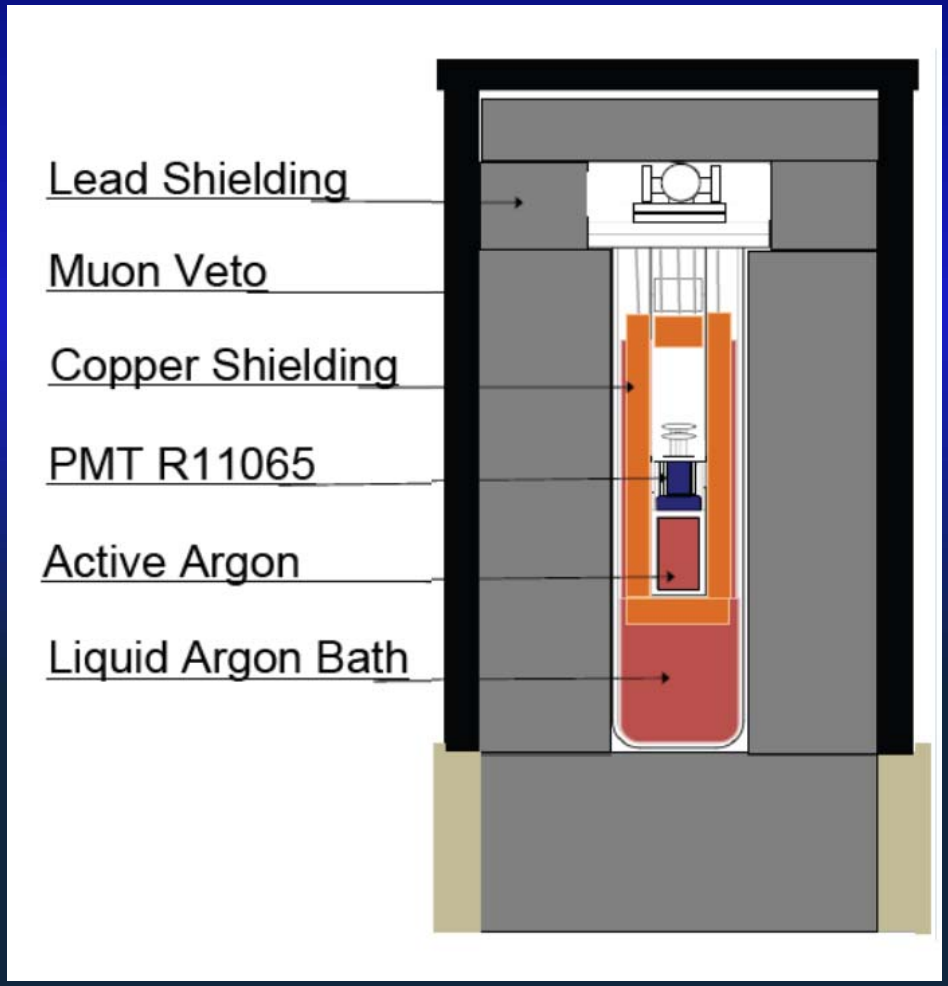
UNC (Majorana Collaboration)





P-type Point Contact HPGe detectors

^{39}Ar depleted Argon

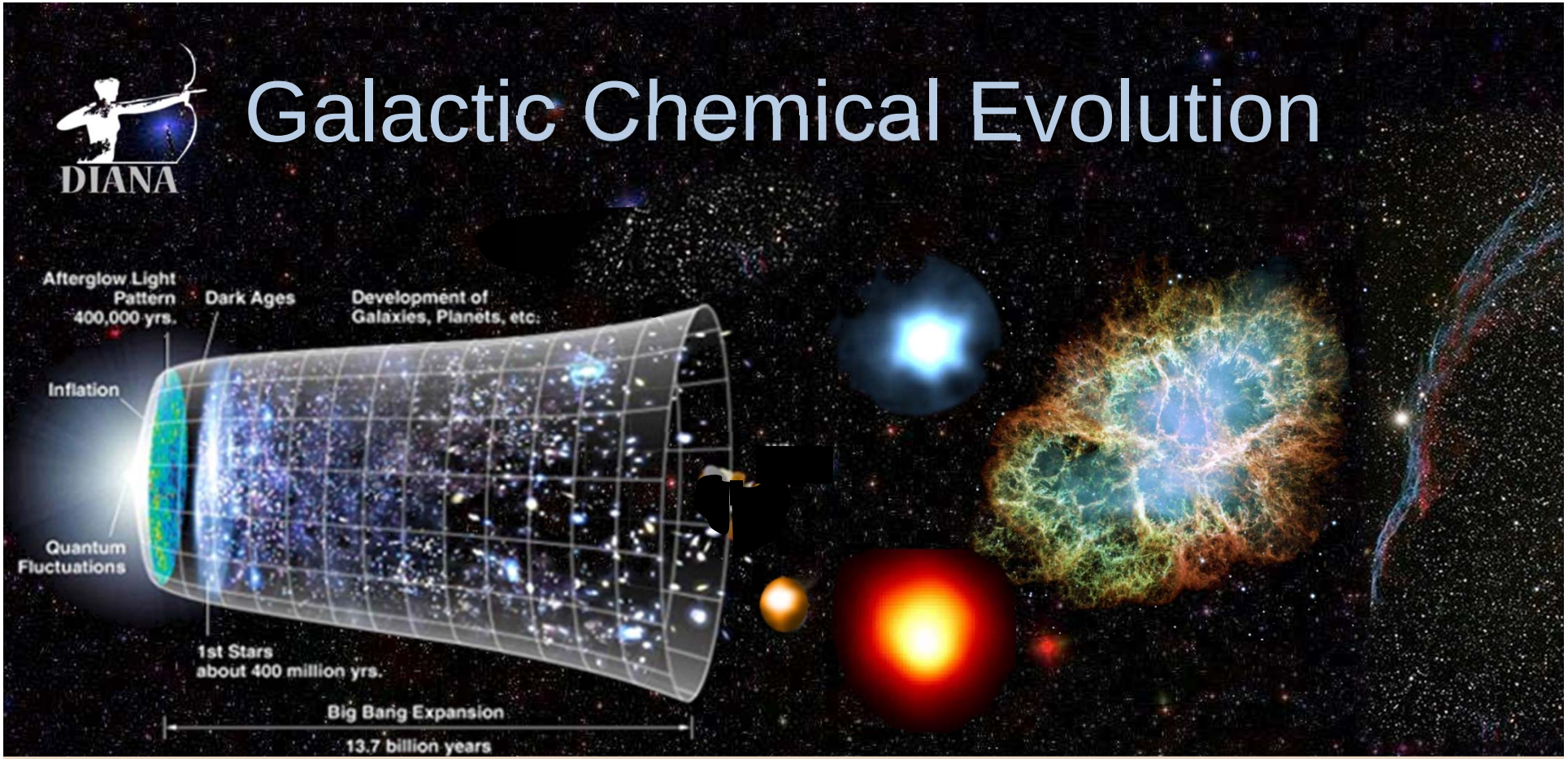


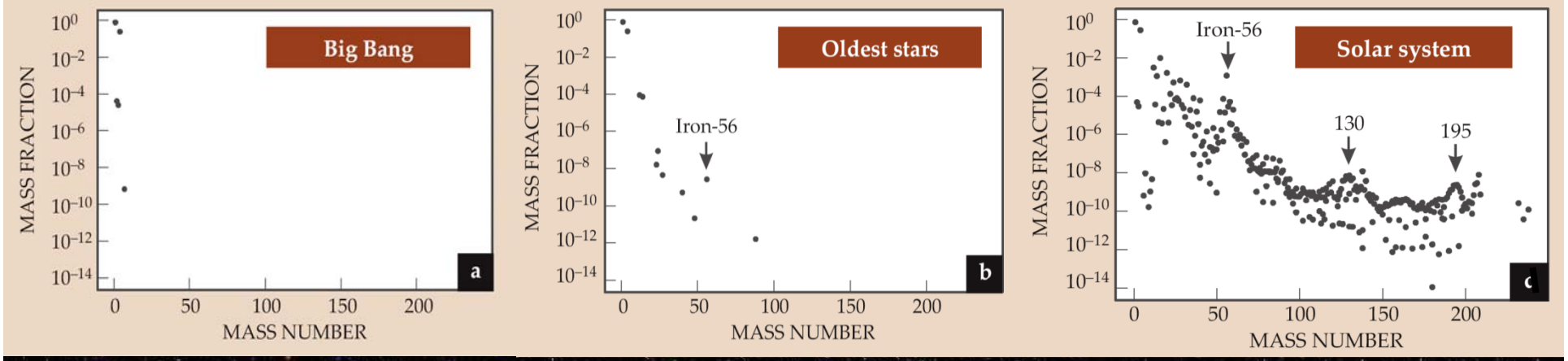
Possible future directions?

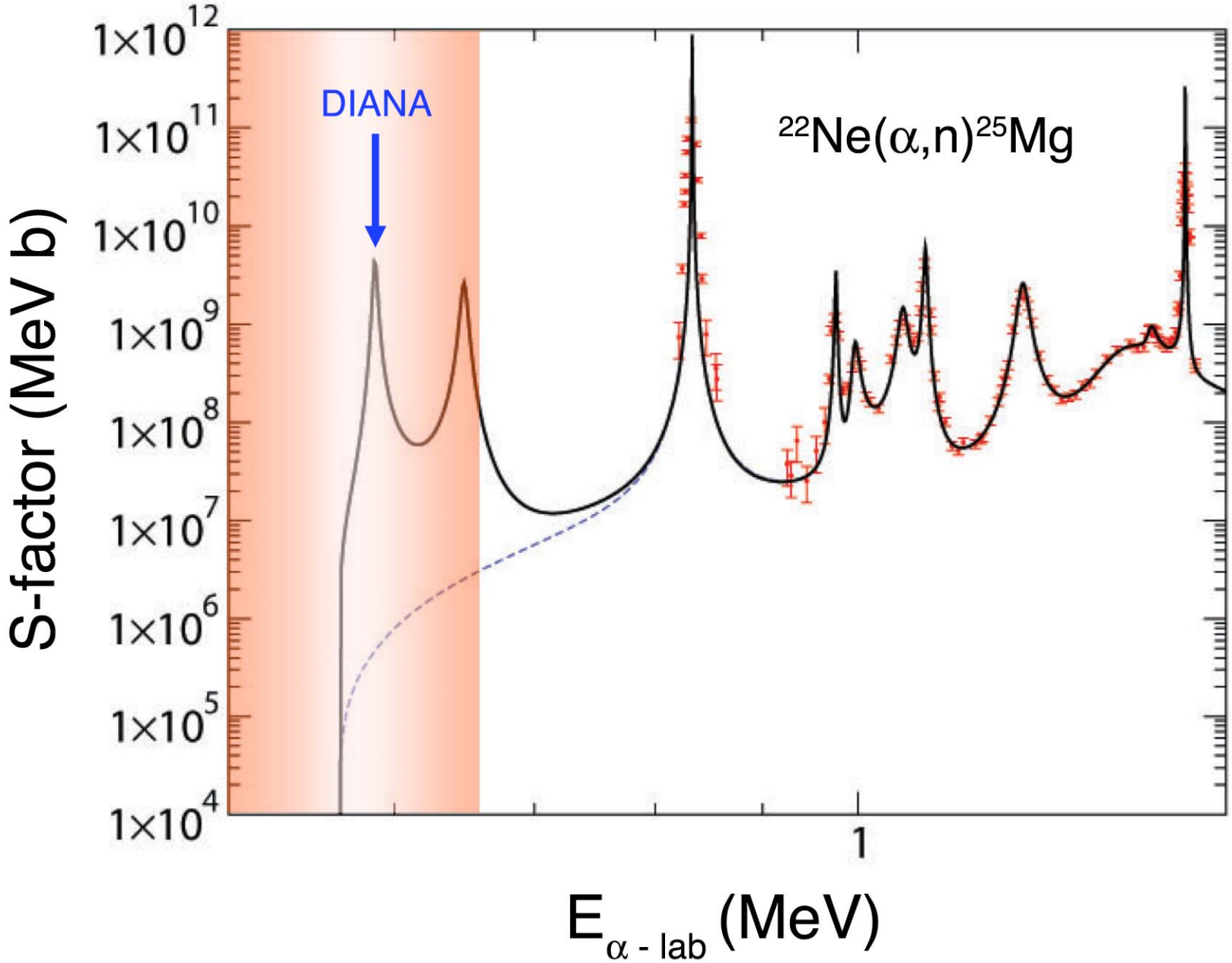
LENS?

Nuclear Astrophysics?

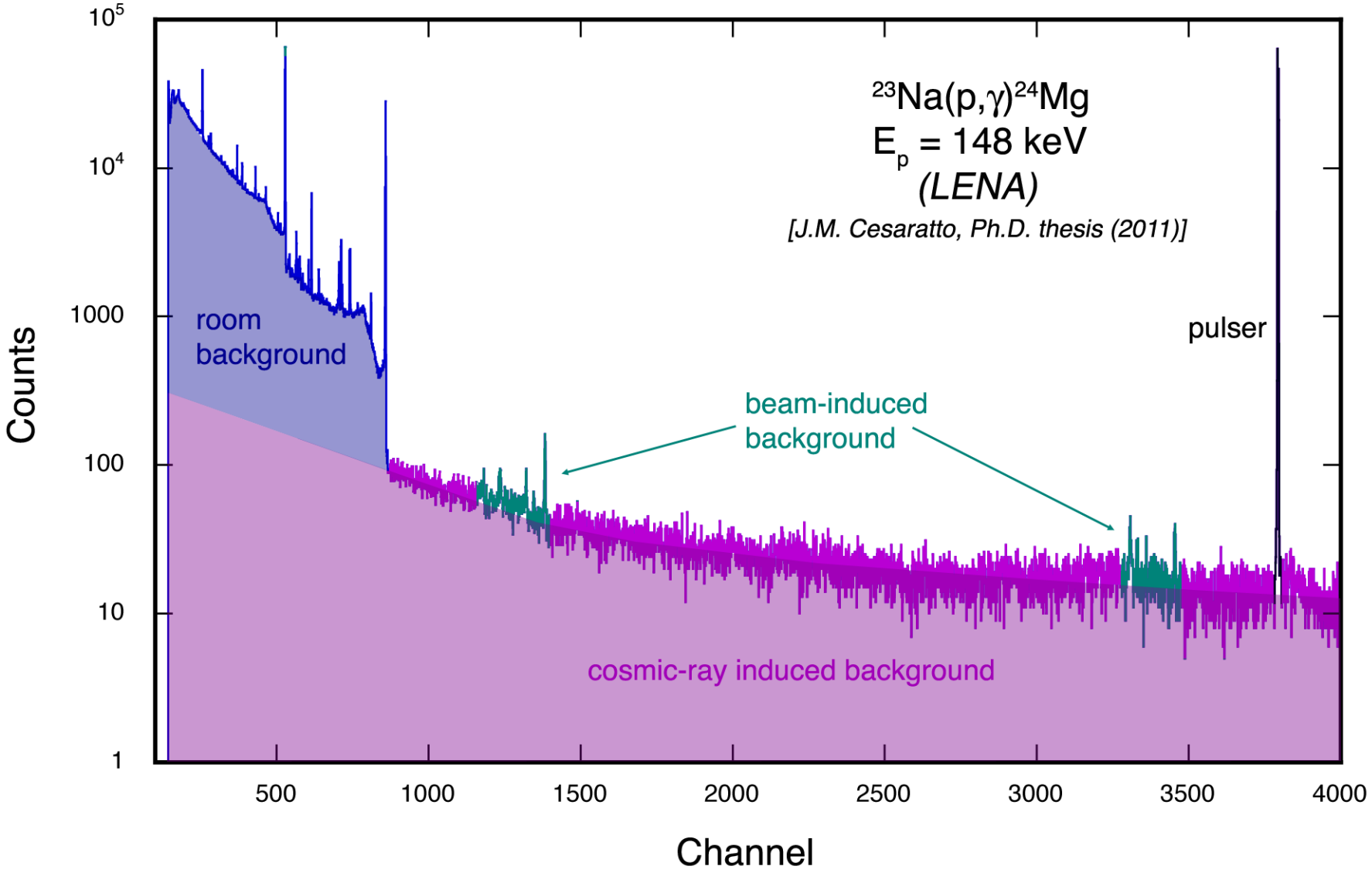
Galactic Chemical Evolution



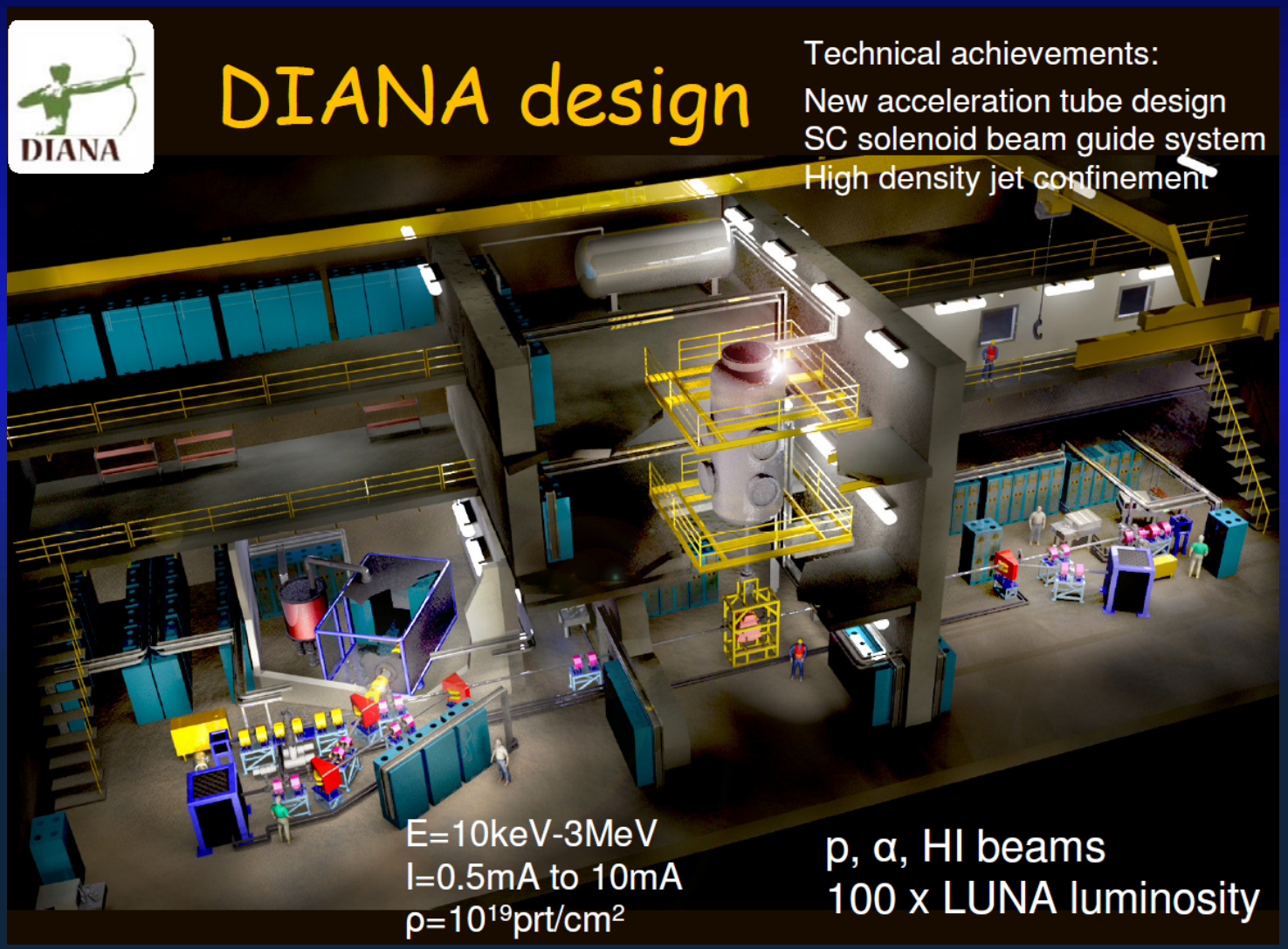



DIANA
$^{22}Ne(\alpha,n)^{25}Mg$
S-factor (MeV b)
1×10^{12}
1×10^{11}
1×10^{10}
1×10^{9}
1×10^{8}
1×10^{7}
1×10^{6}
1×10^{5}
1×10^{4}
1
$E_{\alpha\text{ - lab}}$ (MeV)

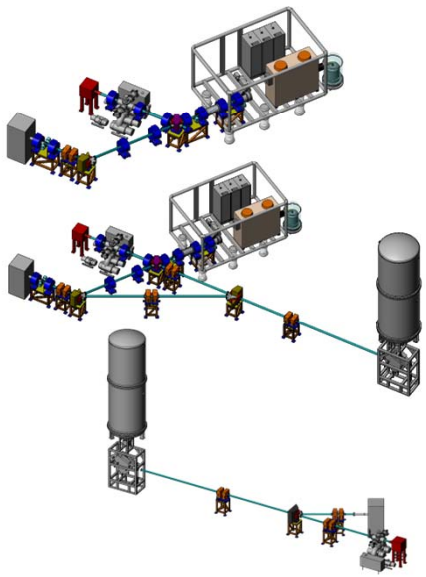
The situation above-ground

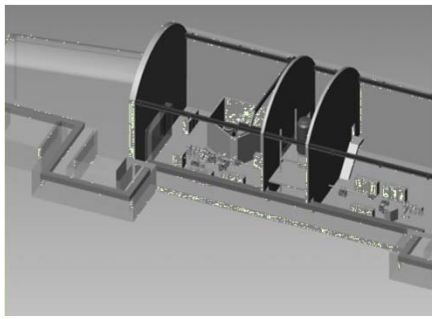


Artist Concept of Complete Facility



DIANA – Cost Summary





3 Phase Approach

mid-2017

Phase 1 : Low Energy Experiment Equipment
$11.3M Cost (Excluding Cavity & Installation)

early-mid 2018

Phase 2 : High Energy Experiment Equipment
$8.2M Cost (Excluding Cavity & Installation)

Phase 3 : High Energy Experiment Expansion
$6M Cost (Excluding Cavity & Installation)

Three Phase Implementation: Total Costs
High & Low Energy Experiment Equipment: $25.5M
High & Low Energy Experiment Installation: $6.5M
DUSEL Cavity and Infrastructure Installation: $43.3M
DIANA at DUSEL Total Costs: $75.3M

Other uses? Please contact us.