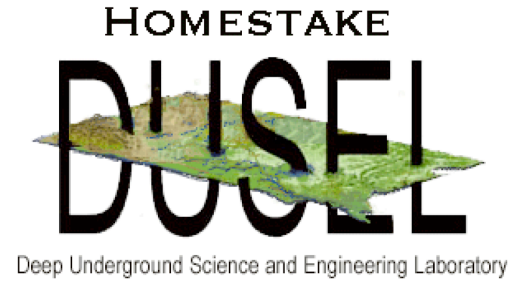


October 3, 2009 DUSEL Science Workshop



Vertical Experiments Group

*Yuri Kamyshkov, University of Tennessee
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Vertical Experiments proposed for DUSEL

- ❖ **NNbar Experiment Matter to Antimatter Transformation**: SD Universities, NCSU, IU, UT, CSUDH, CNA Engineers, NIST, LANL, ORNL, KEK, PNPI, ILL, JINR + Theory group (contact Yuri Kamyshkov/UT)
- ❖ **Gravity Waves Detection by Atomic Interferometry**: Stanford U, SDSMT, NASA/Ames, + Theory Group (contact Mark Kasevich / Stanford U.)
- ❖ **Facility for Study Physics of Cloud Formation**: SDSMT, US, UK, Germany, Israel, Japan, Argentina, China, and Russia (contact person John Helsdon /SDSMT)
- ❖ **Mirror Matter Transformation Search**: PNPI, IPNI, JINR/Russia, ILL/France, INFN/Italy (contact person Anatoly Serebrov/PNPI)
- ❖ **Study of Diurnal Earth rotation**: (contact person Bill Roggenthen/SDSMT) →E&O project

Unique for DUSEL. Exists nowhere in the world!

→ DUSEL Vertical Facility Collaboration

Shaft requirements for different experiments

Scope of Vertical Shaft Facility S4 proposal

Experiment →	[1] NNbar Search	[2] Atom Interferometry	[4] Mirror n Search	[3] Cloud Physics	[5] Diurnal Rotation
Description ↓					
Shaft length	1.5 km	1 - 4 km	1.5 km	0.1 – 0.5 km	0.1 – 1.5 km
Tube diameter	4 - 7 m	0.3 m	4 - 7 m	3 - 5 m	1 m
Straightness [†]	< 10 cm	< 5 cm	< 10 cm	< 50 cm	< 10 cm
Verticality	< 50 mrad	< 10 mrad	< 50 mrad	< 100 mrad	< 10 mrad
Pressure	10 μ Pa	< 0.1 μ Pa	10 μ Pa	0.3-1.0 atm	(10 μ Pa)
Mag. Shield	~ 1 nT	~ 1 nT	~ 1 nT	N/A	N/A
Purpose of experiment	$n \rightarrow \bar{n}$ appearance	gravity wave detection	neutron disappearance	atmos. physics facility	E&O facility

- **Facility development:**

- availability of the vertical shafts or new shafts
- measurement of vertical shaft parameters
- generic questions of the vertical experiments construction and engineering
- cost estimate

Our VSF S4 proposal was not supported.

Should we walk away from DUSEL ?

Other non-S4 proposals ? New future proposals ?

To whom this question is addressed ?

What should be the answer ?

NSF criteria:  current,  transformational,  world-leading

There should be a path for becoming *current*

How to become current (for discussion)

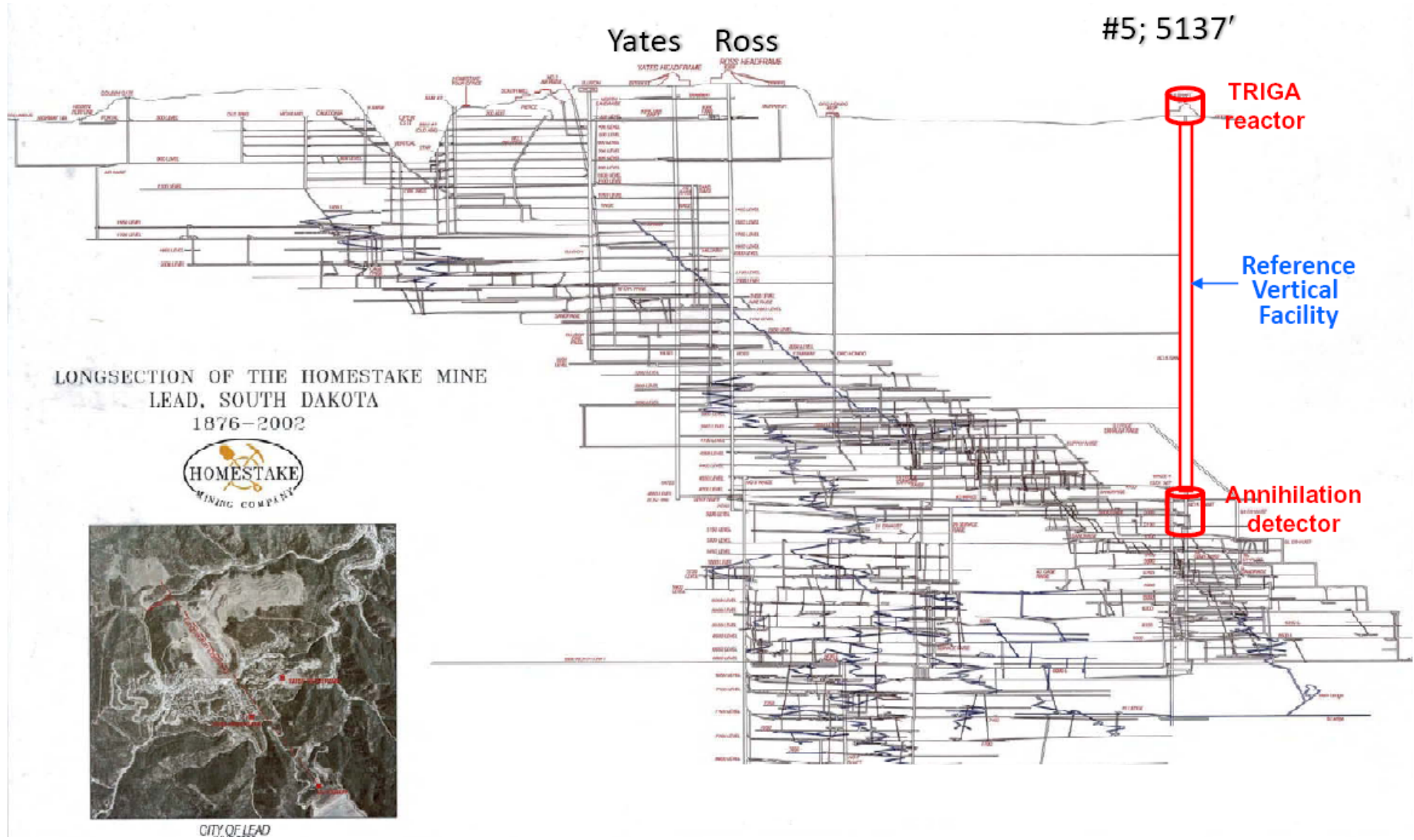
- PAC proposed by DUSEL community with the charge defined by community
- DUSEL PAC should be recognized by NSF/DOE
- Non-S4 and New Proposals approved by PAC can seek for R&D support through NSF/DOE
- In interactions with PAC the proposals can be transformed, fit, staged, descoped, reduced, redirected, ... or rejected. It should be an interactive process. Users should know whom they can talk with.
- PAC helps Lab to create vision of long-range research program flexible and adoptive to new ideas
- PAC interacts and coordinates with HEPAP, NSAC, and other advising panels
- Lab helps PAC and individual proposals by providing information, engineering consultations, cost estimate, support in initial measurements (like EIP), ...
- PAC and Lab help new proposals through CD0 – CD1 stages of development
- “Non-S4 and New Ideas Workshop” (Janet Conrad) as discussion forum

Let me use as an example a vertical experiment proposal for neutron \rightarrow antineutron transformation search to illustrate the interactions and functions we are looking for

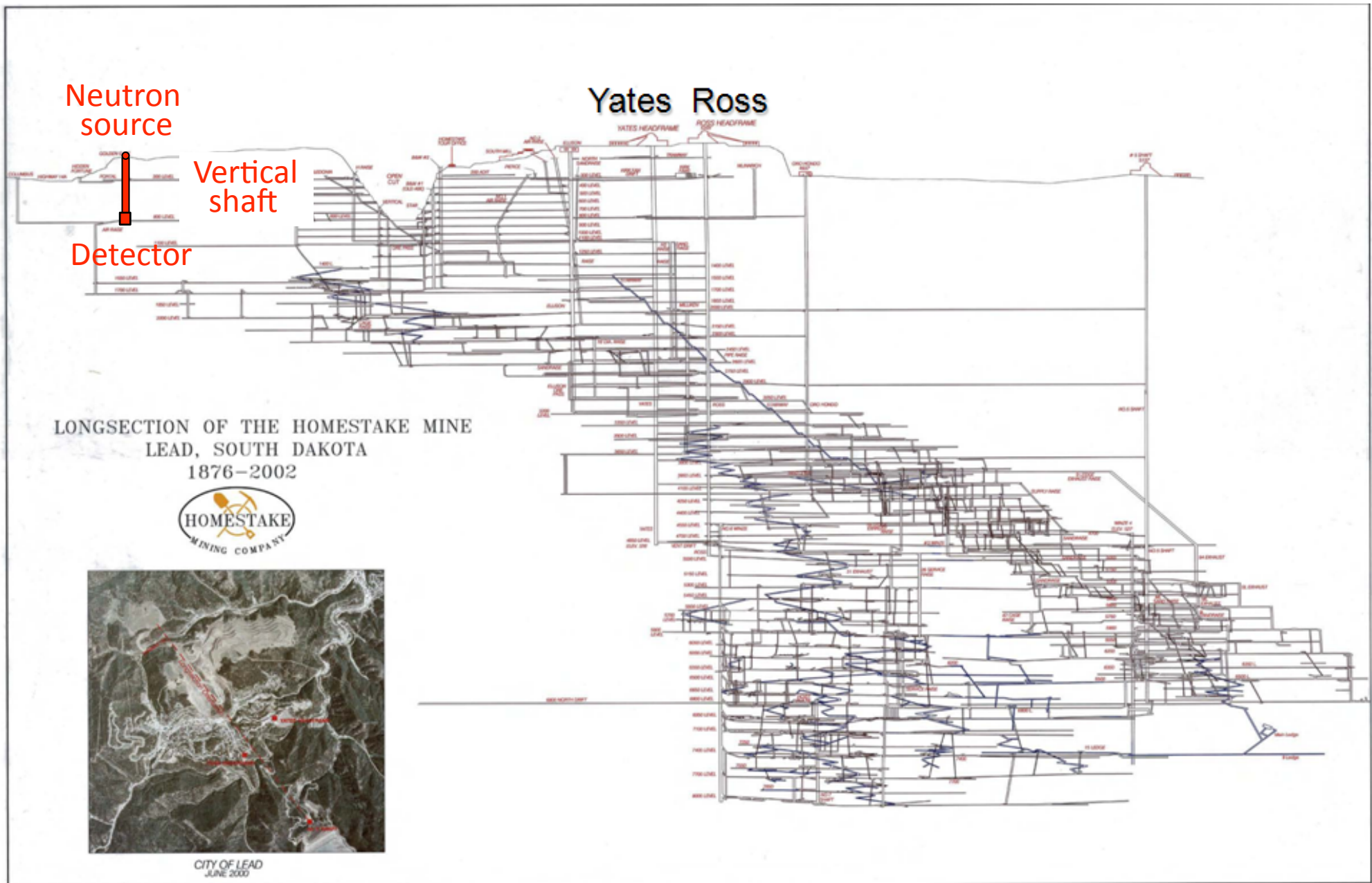
I hope it might be similar model for other

- vertical experiments
- non-S4 experiments
- new and future proposed experiments

Ultimate configuration that matches ambitious sensitivity goals



Reduced configuration



The Neutron Source can be e.g.

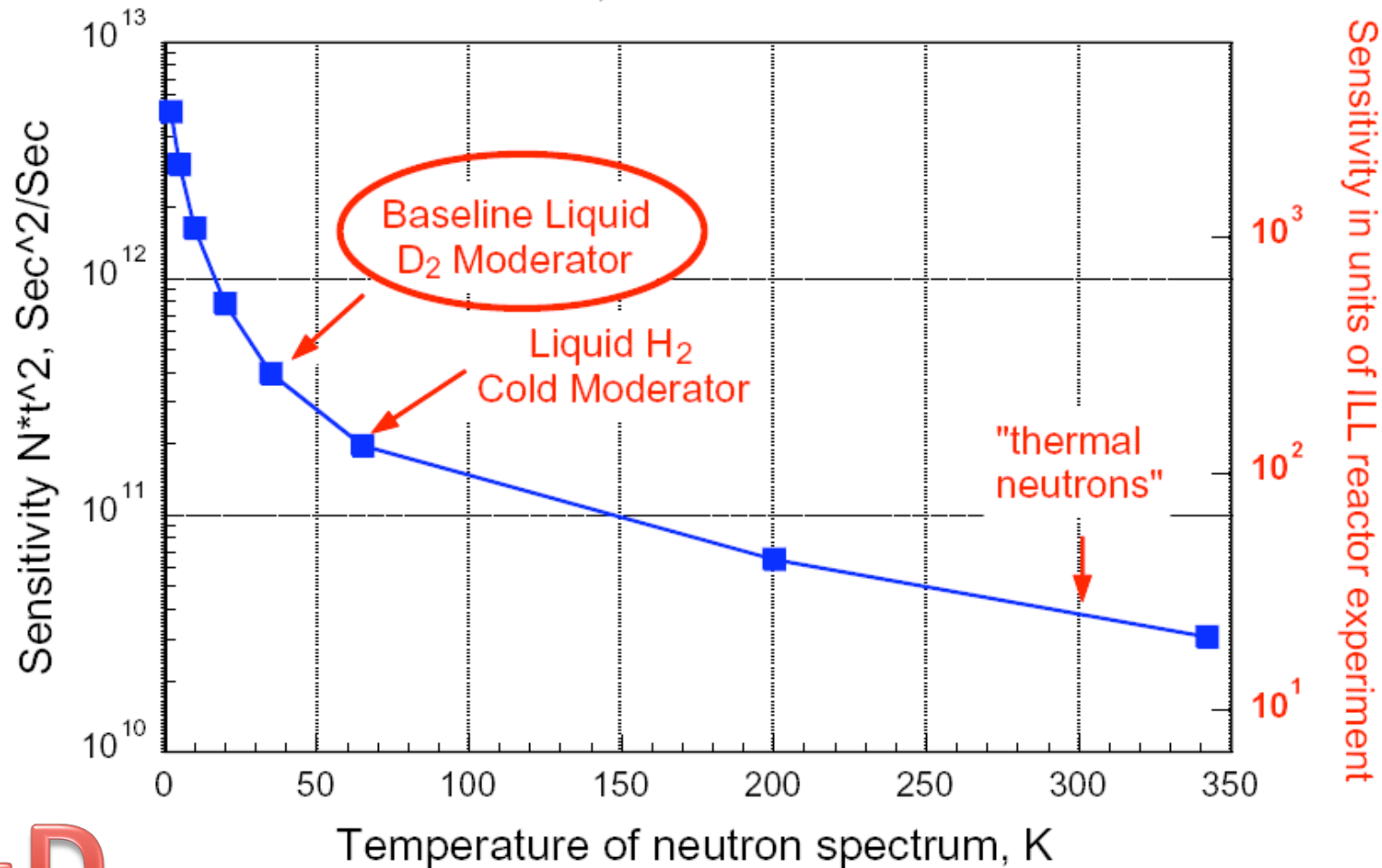
- ❑ d-t generator(s): $D + T \rightarrow {}^4\text{He} + n$
- ❑ RFQ accelerator of *p* or *d* with nuclear target
- ❑ high-current cyclotron with spallation target

Reduced NNbar approach:

- ⇒ no reactor
- ⇒ neutron source (R&D)
- ⇒ much smaller cost (still need estimate)
- ⇒ still unique experiment for underground lab
- ⇒ still no background when 1 detected event = discovery
- ⇒ path for study and development of higher sensitivity
- ⇒ still need study for available shafts or new construction (R&D)
- ⇒ still need generic understanding of vertical construction/engineering (R&D)
- ⇒ use high tech for sensitivity enhancement (R&D)
- ⇒ still need R&D for magnetic shielding, supermirrors, ...
- ⇒ modest initial sensitivity goal :
factor of $\times 50$ sensitivity improvement
rather than $\times 1000$

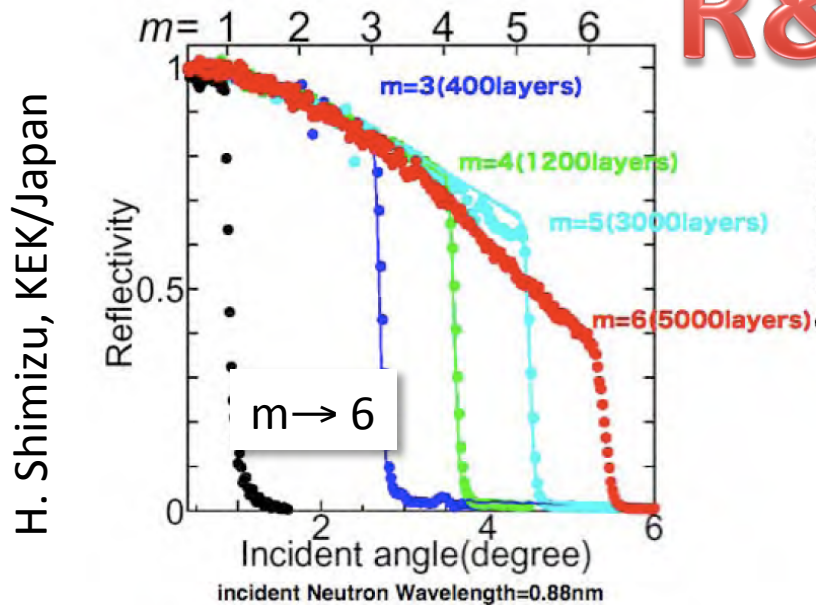
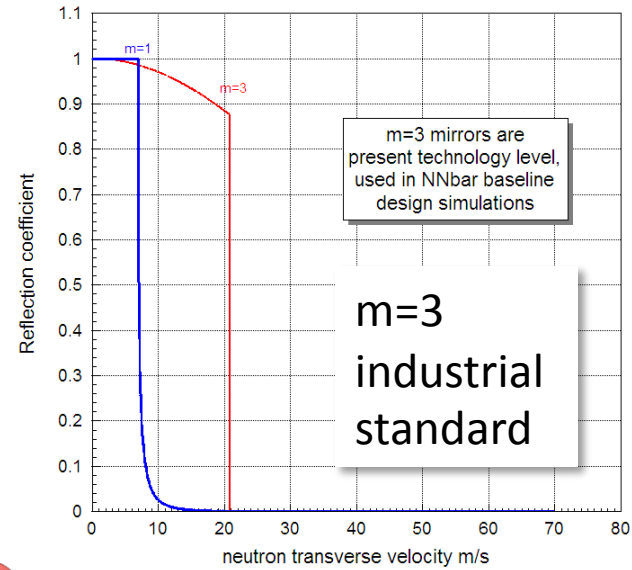
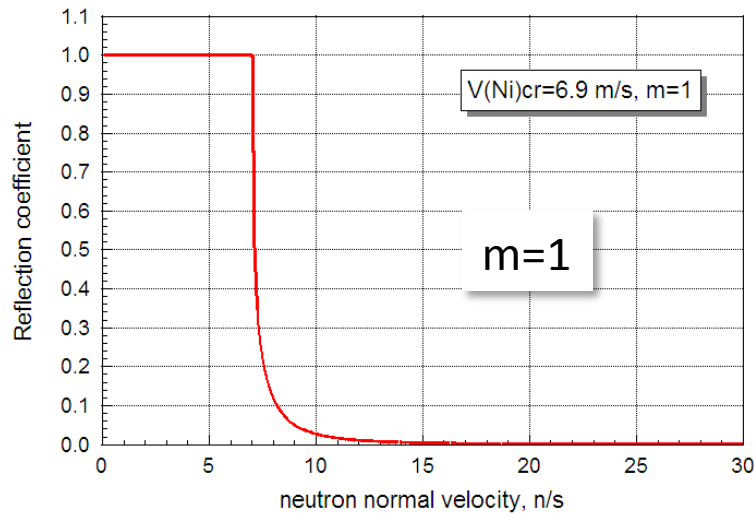
Development of colder neutron moderators 35K → 2K

MC simulation example: source dia 25 cm, target dia 2m, source-target distance 1150 m, $3\theta_C$ reflector starts at $z=2\text{m}$ with dia 1 m; ends at $z=33\text{m}$ with dia 4 m

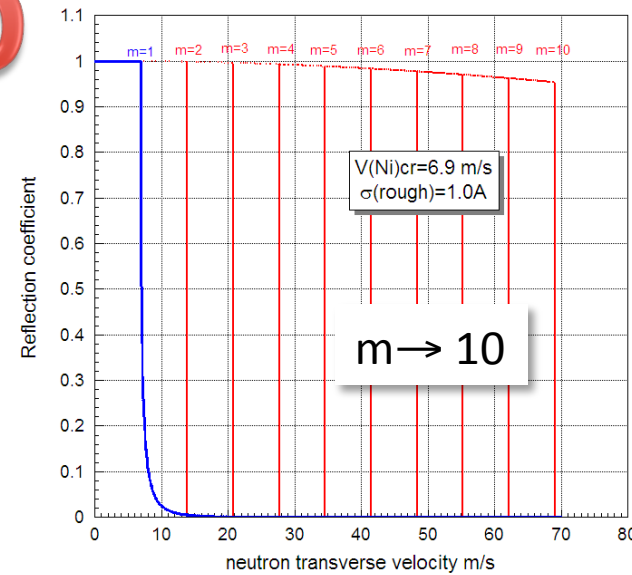


R&D

Development of high- m neutron reflectors



R&D

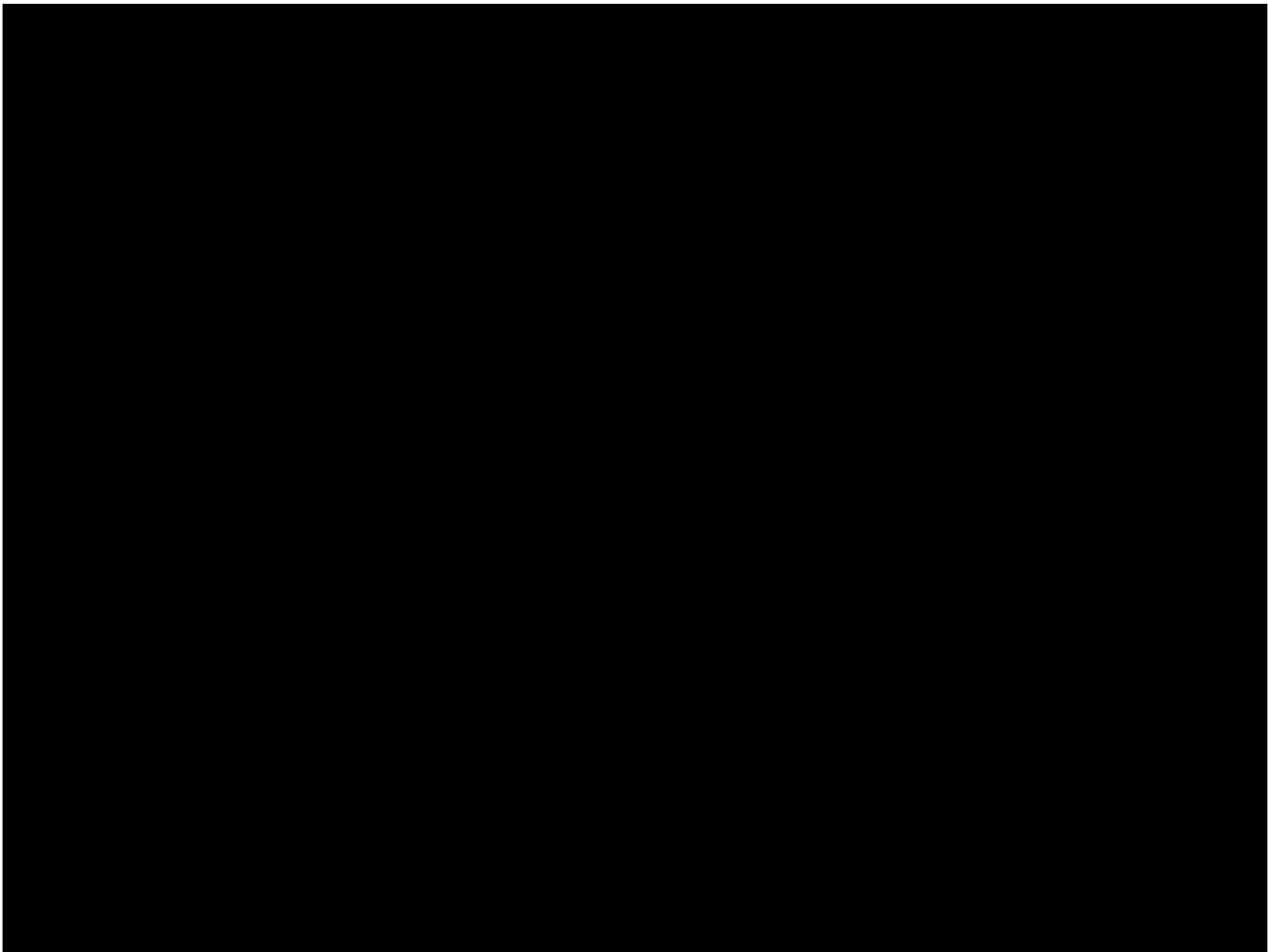


H. Shimizu, KEK/Japan

Economically possible in future

Conclusions

- ❖ NNbar proposal scope can be modified to match existing constraints
- ❖ Hope that DUSEL PAC will help us to define the scope leading to the “current” status
- ❖ Other Vertical experiments can do the same. Interaction with PAC is crucial here
- ❖ We can continue act as Vertical Facility Collaboration for generic common vertical construction and engineering issues
- ❖ Through PAC we need path to CD0 and CD1 reviews



Survey of Magnetic Field in the Ross and Yates Shafts at Sanford Lab July 2009

One of “Early Implementation Proposals” of Vertical Facility Collaboration

Goal: to check that there are no magnetic anomalies in Homestake vertical shafts

Measurement Team:

George Duffy (UT undergraduate summer project)

Mark Hanhardt (Measurement Team - magnetometer, tablet, cage speed)

Dana Byram (Measurement Team - magnetometer positioning, cage speed)

Connie Giroux (Measurement Team - cage speed)

Jim Hanhardt (Shaft Safety Supervisor, Measurement Team - cage speed)

Jared Thompson (Measurement Team - cage speed and data recording)

Kara Keeter (Measurement Team - cage speed)

Brian Lowery, Chad Ronish (High-school teachers)

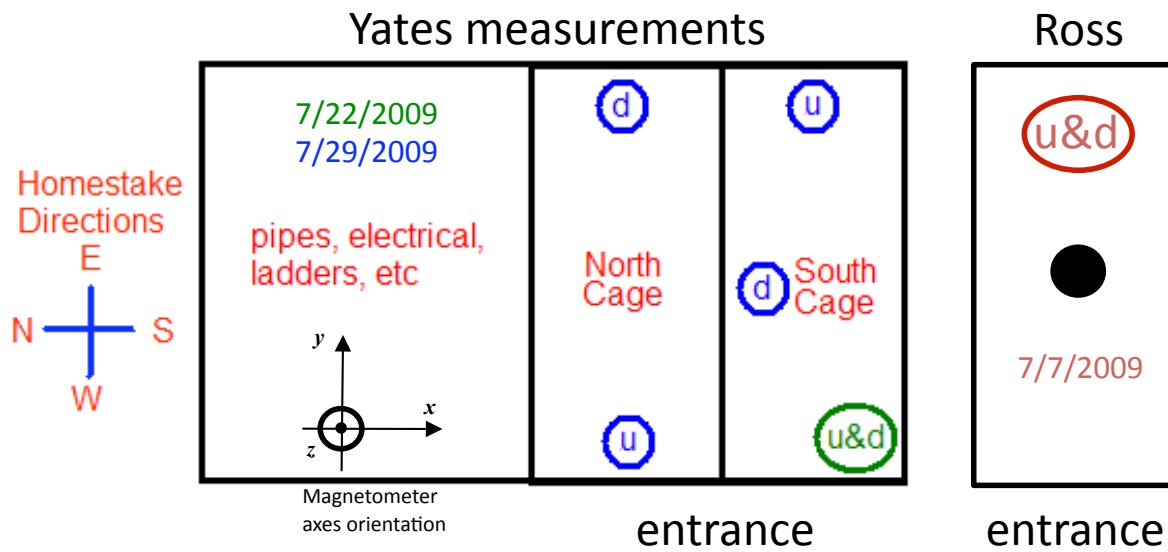
Jaret Heise, Reggie (Observers)



Honeywell 3-axes Magnetometer
HMR2300 with range ± 2 Gauss,
accuracy 1%, rate 20 Hz

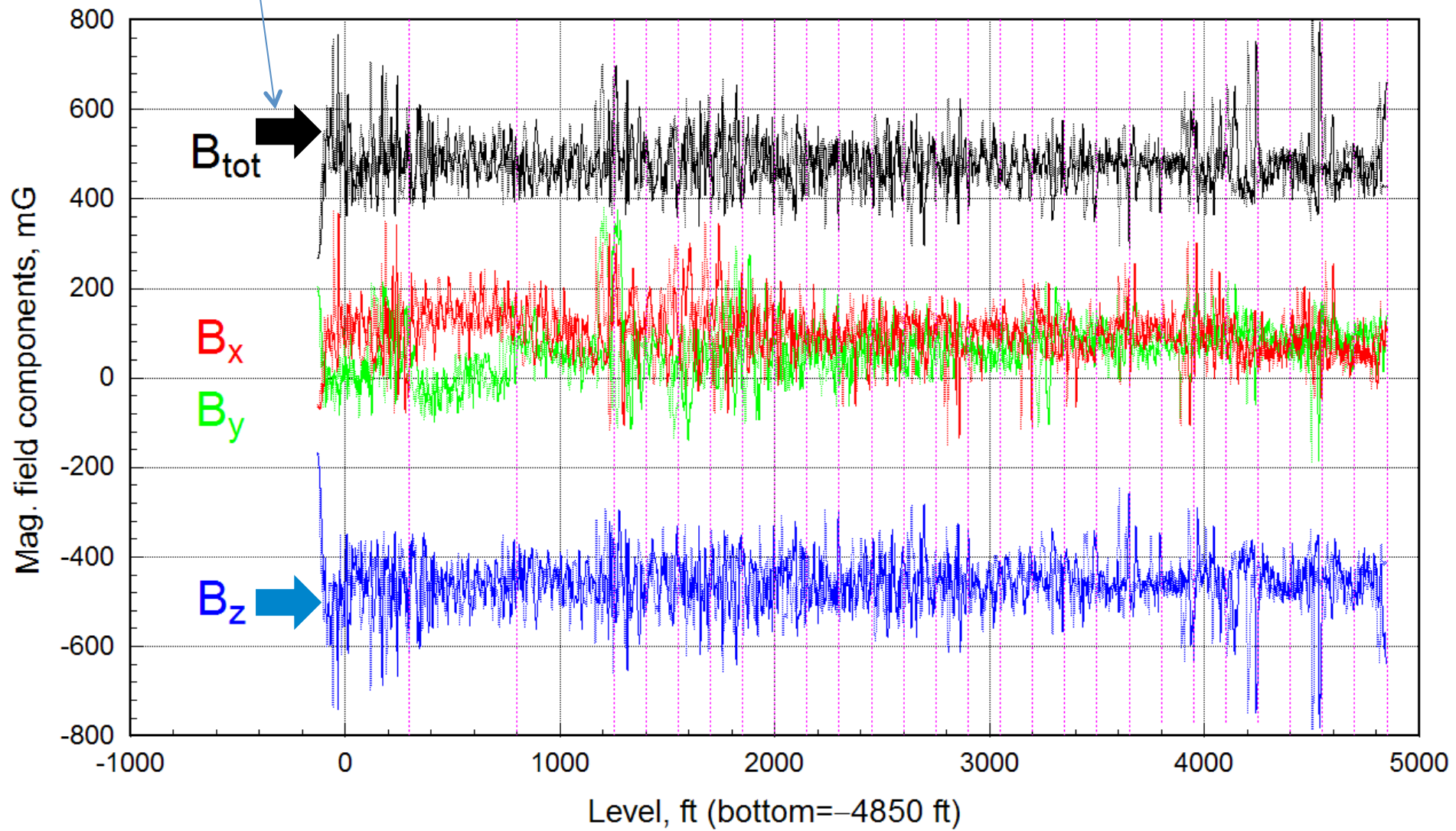


Outside measurements



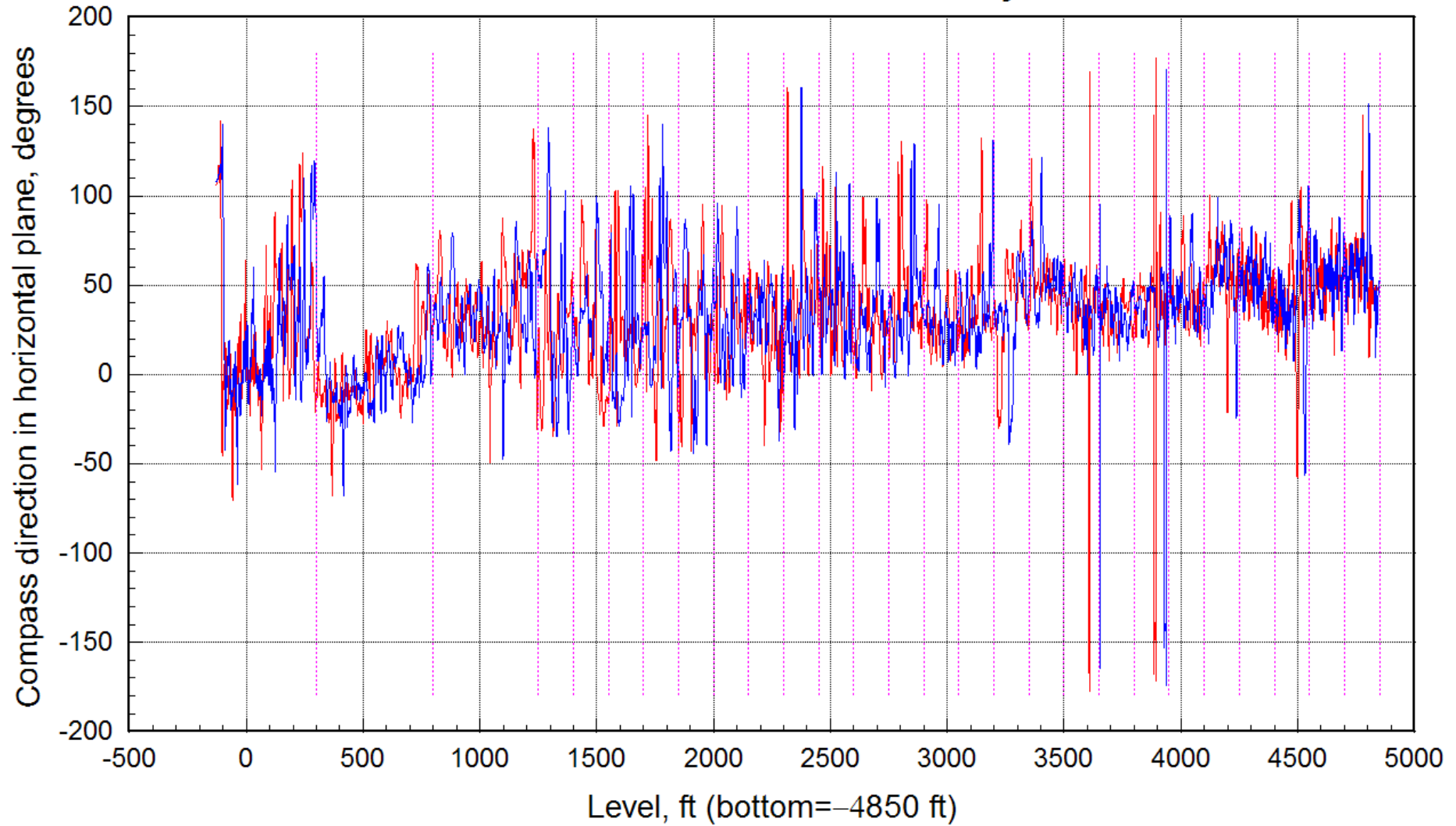
Geomagnetic
models

ROSS DOWN/UP Overlay

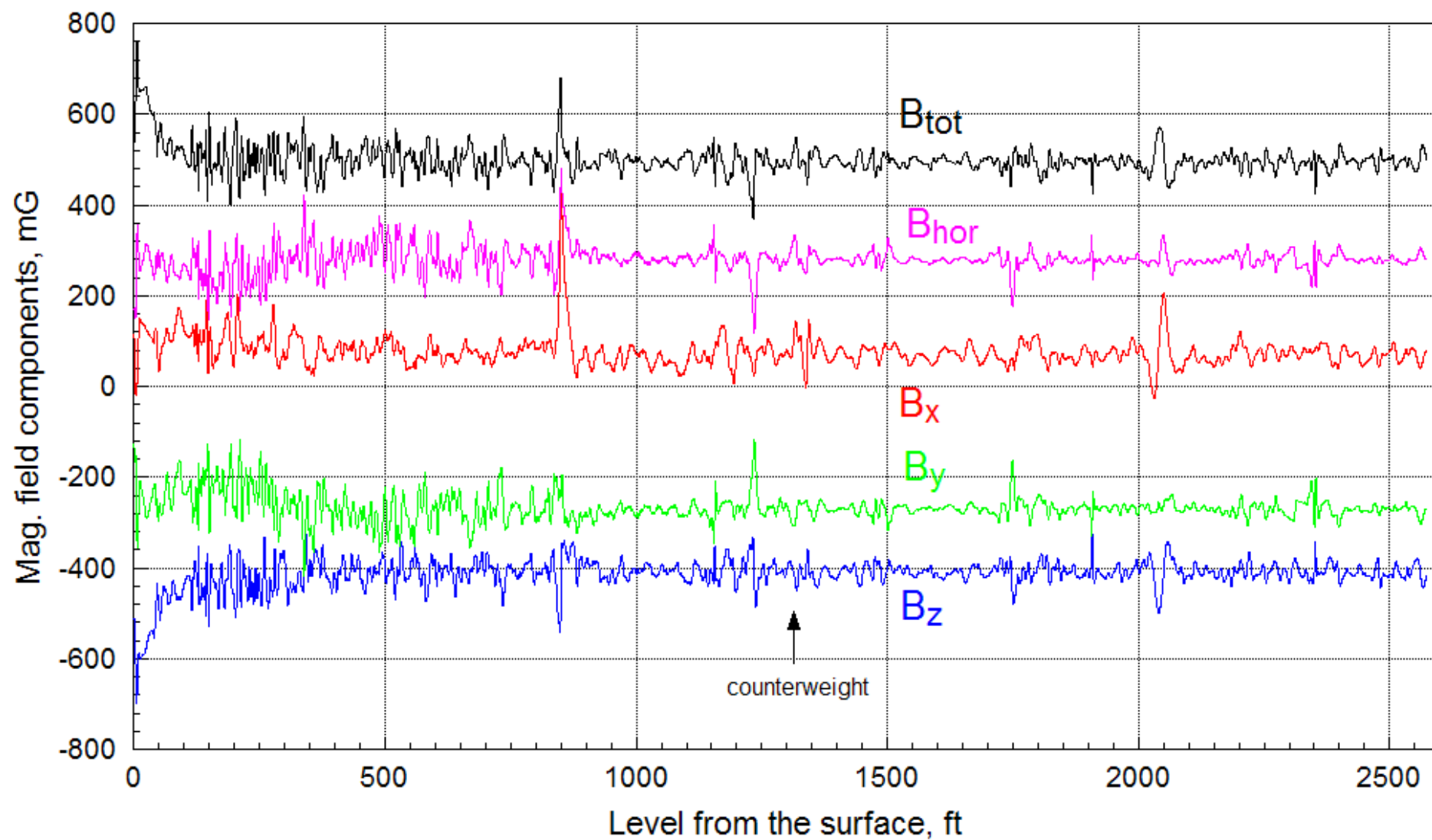




ROSS DOWN/UP Overlay

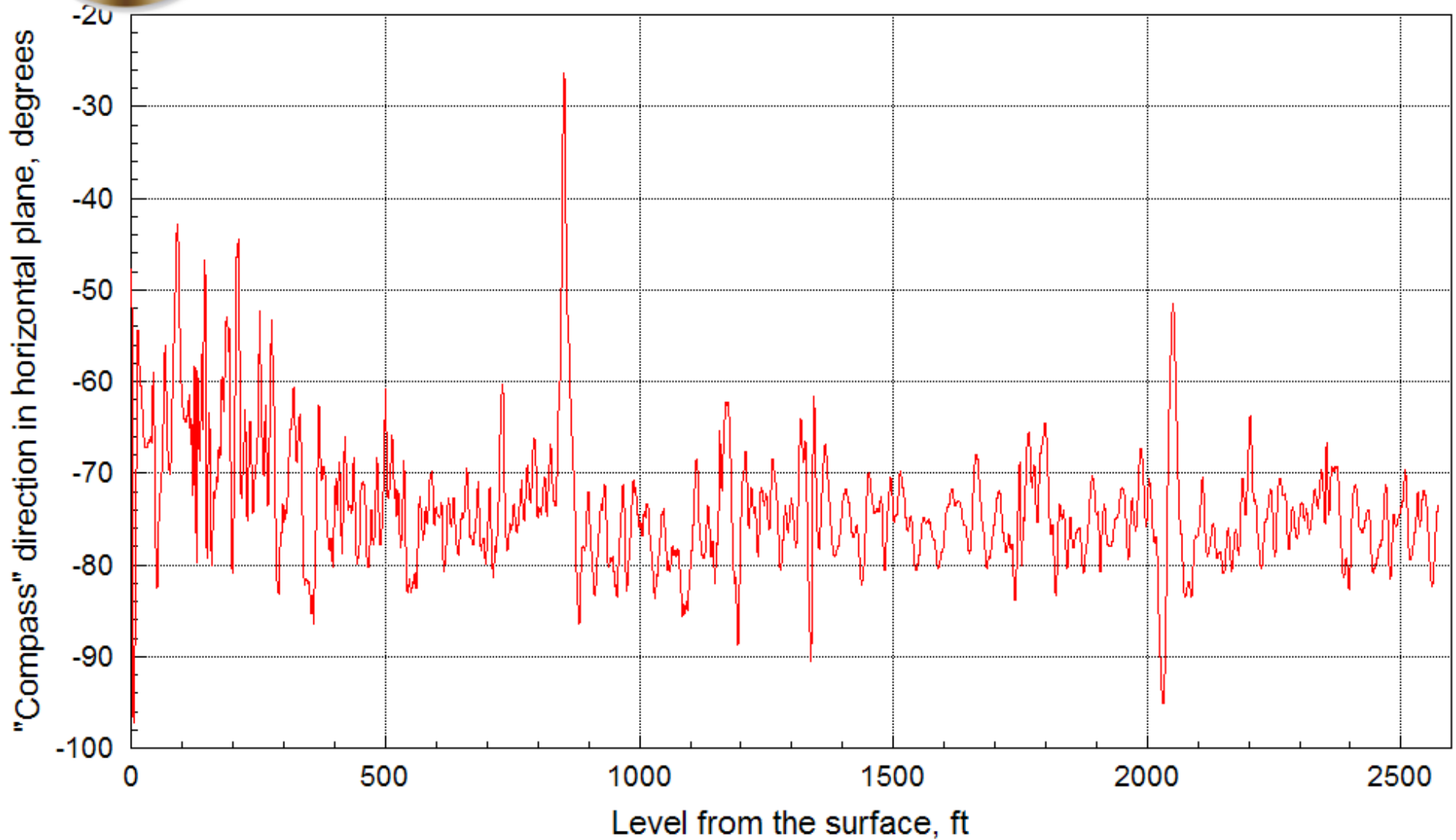


Yates July 29 Down North Cage





Yates July 29 Down North Cage



Conclusions

- ❖ Expected average mag. field was found
- ❖ No large magnetic anomalies
- ❖ Seen peaks are likely due to some equipment located at different levels (not all identified)
- ❖ Shafts for vertical experiments should have no magnetic constructions
- ❖ Now we have input to verify with prototypes that such fields are shieldable to nT levels