

The CoGeNT Dark Matter experiment

Michael G. Marino

23 May 2012

Outline

- Physics
- CoGeNT - Experiment + Technology
- Analysis, recent results

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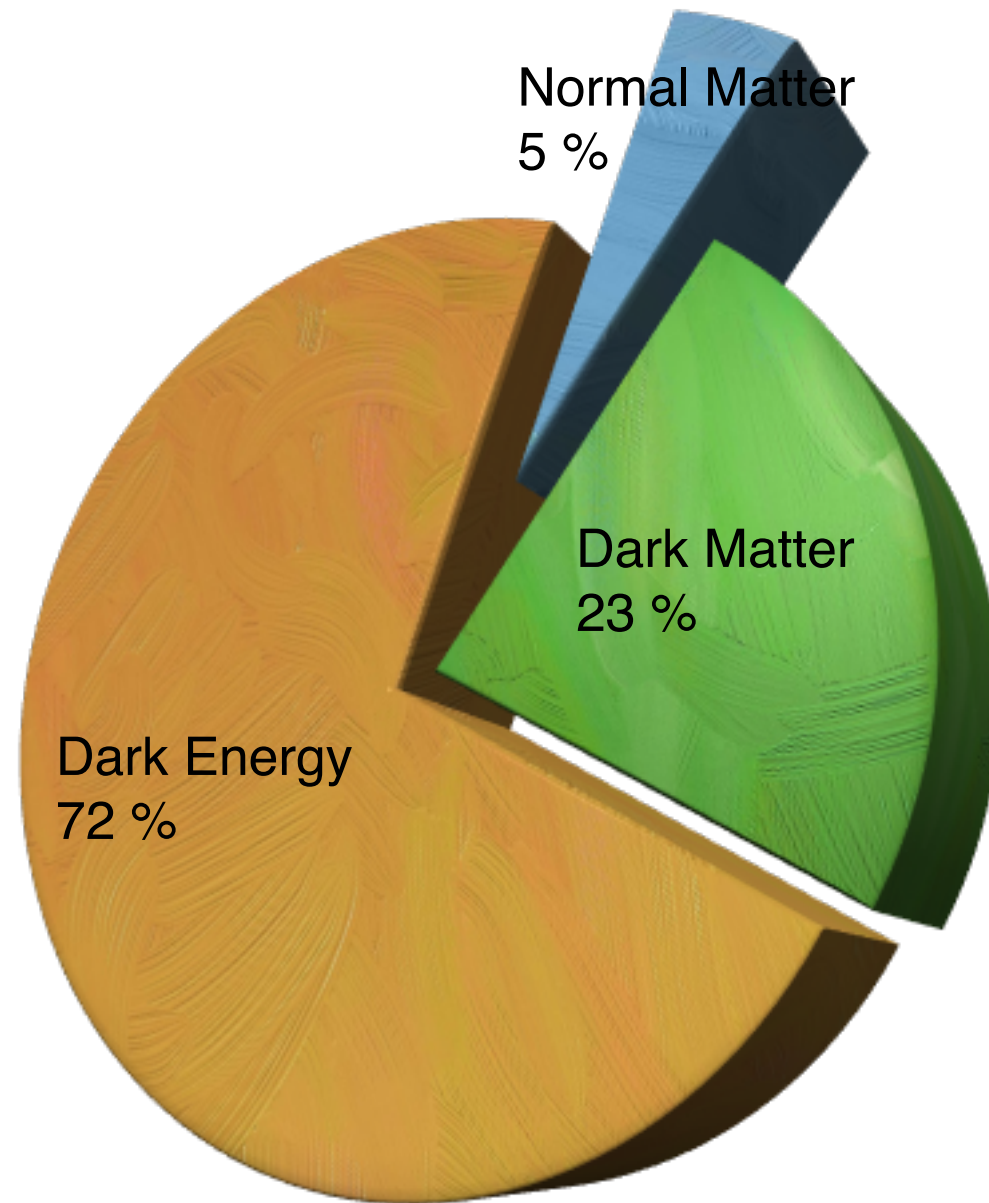
- Physics
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Dark matter

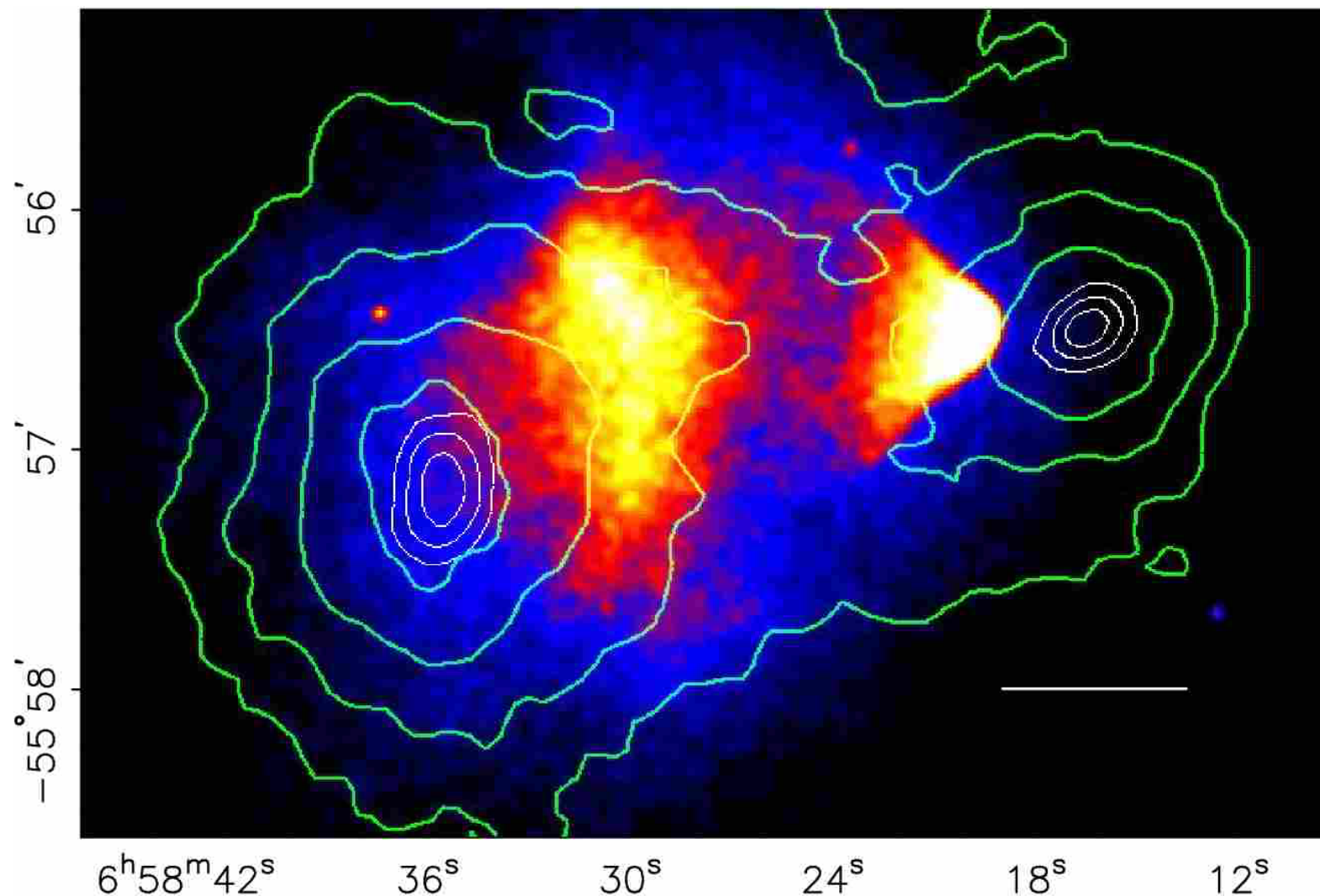
- What we know...

Dark matter

- What we know...



Dark matter: 'direct observation'



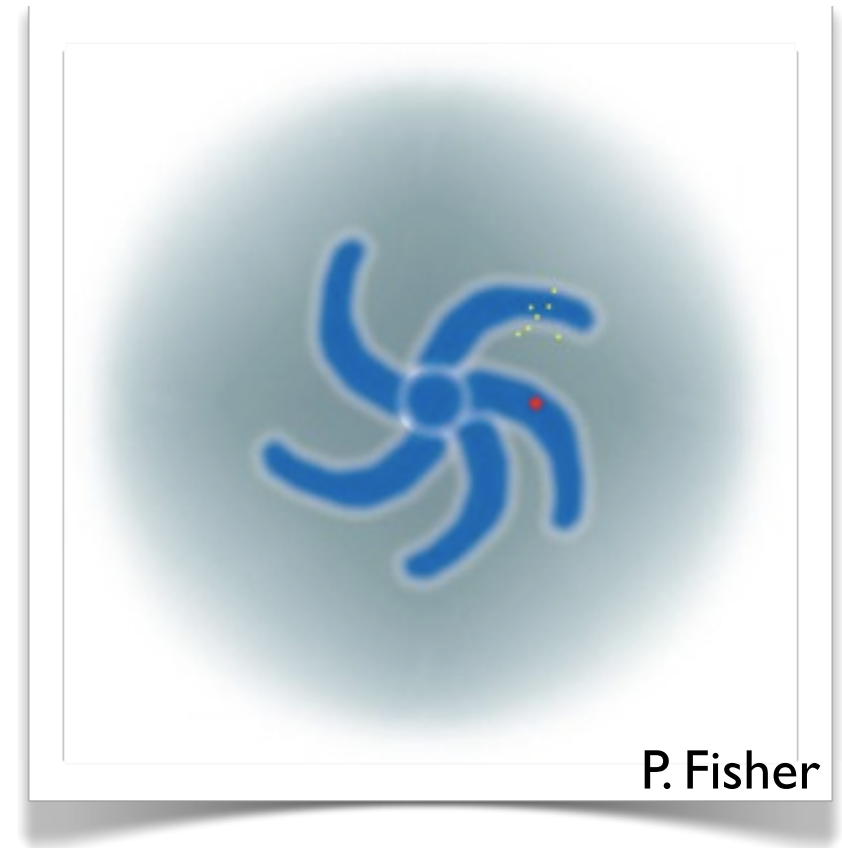
Green - mass
contours from
gravitational
lensing
Colors - X-rays
from hot gas

Picture of two colliding galaxy **clusters**

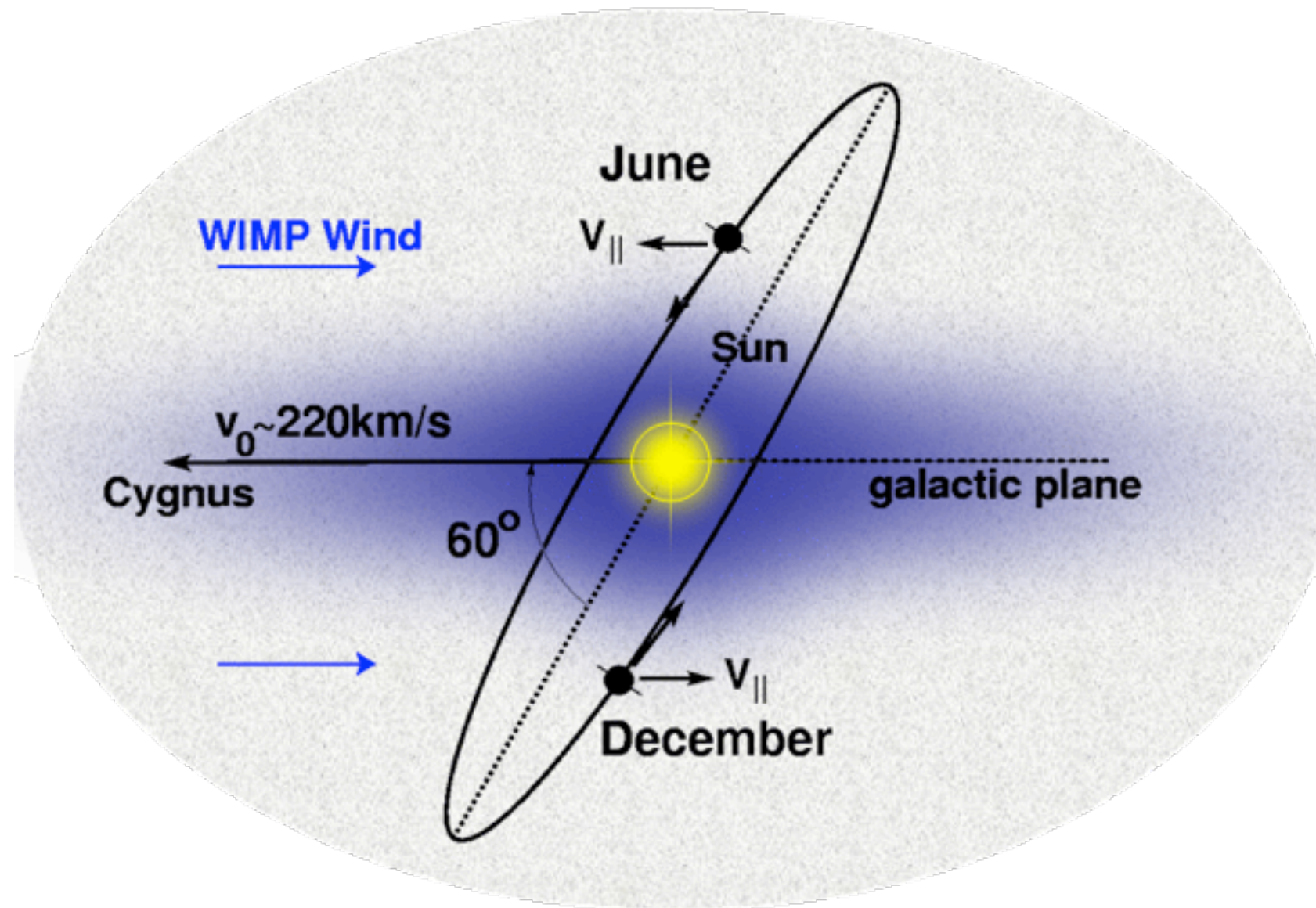
Fig from Clowe et al.,
Astrophys J. Letters **648**
(2006) L109

What about signals?

- Convincing signatures could include:
 - Preferred scattering direction
 - mass peak (non-WIMP)
 - Annual rate modulation
- } sensitivity with PPC/CoGeNT



Annual Rate modulation



Interaction rate dependent on relative velocity between detector and DM

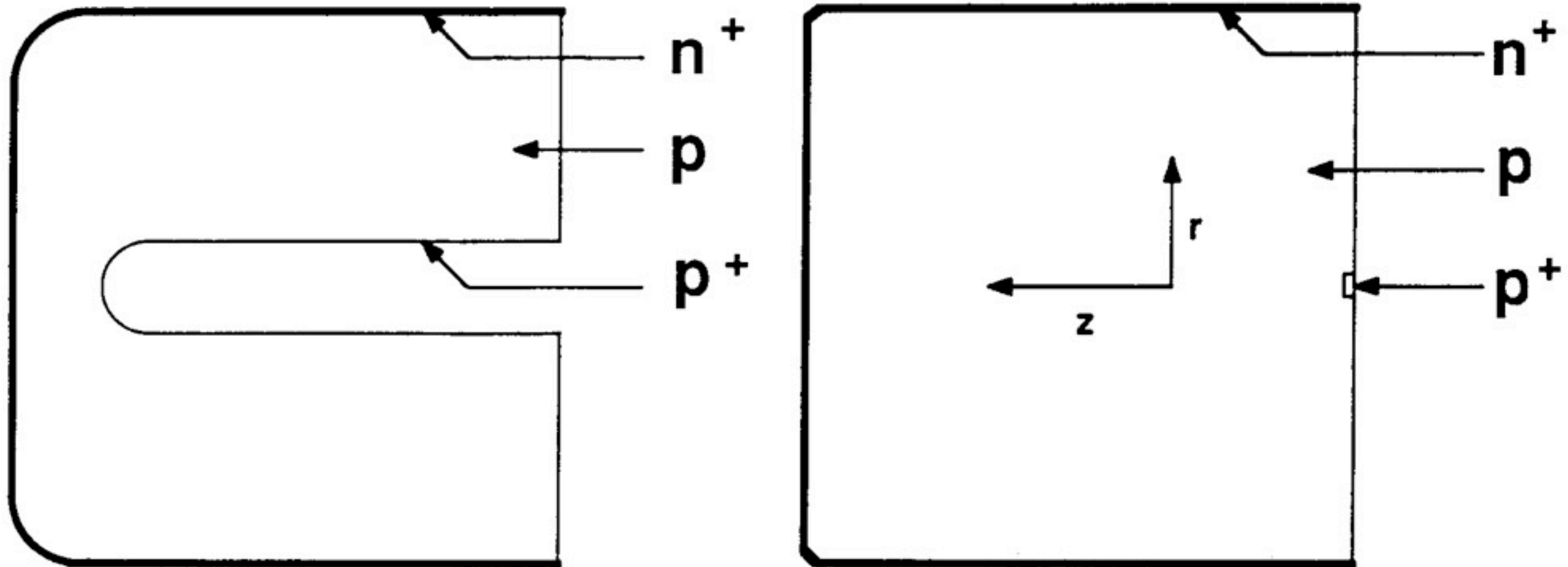
Figure: <http://www.hep.shef.ac.uk/research/dm/intro.php>

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Point-Contact Detectors

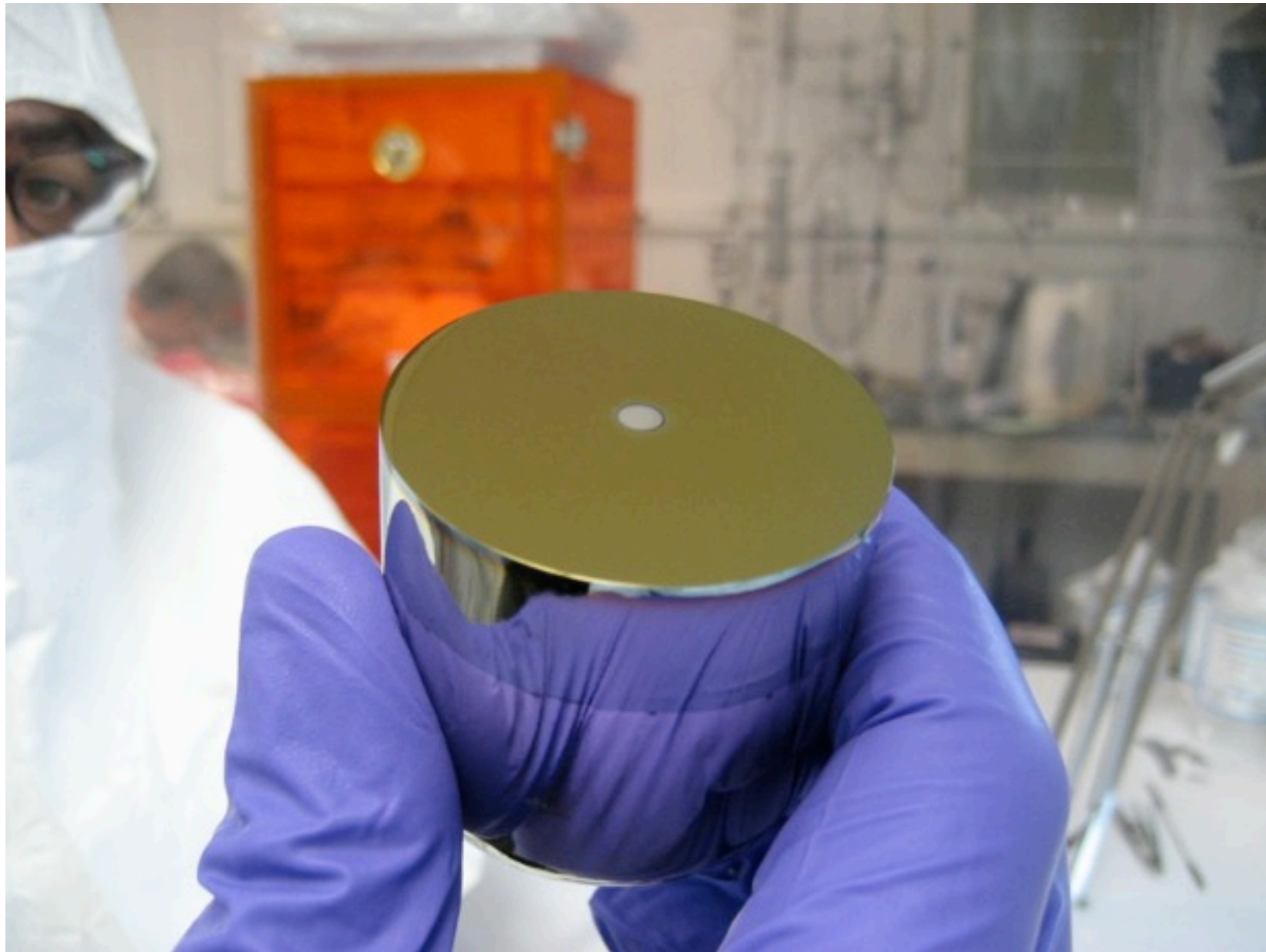
- P-type Point-Contact (P-PC) Germanium
- Geometry: low-capacitance, noise; long charge drift times



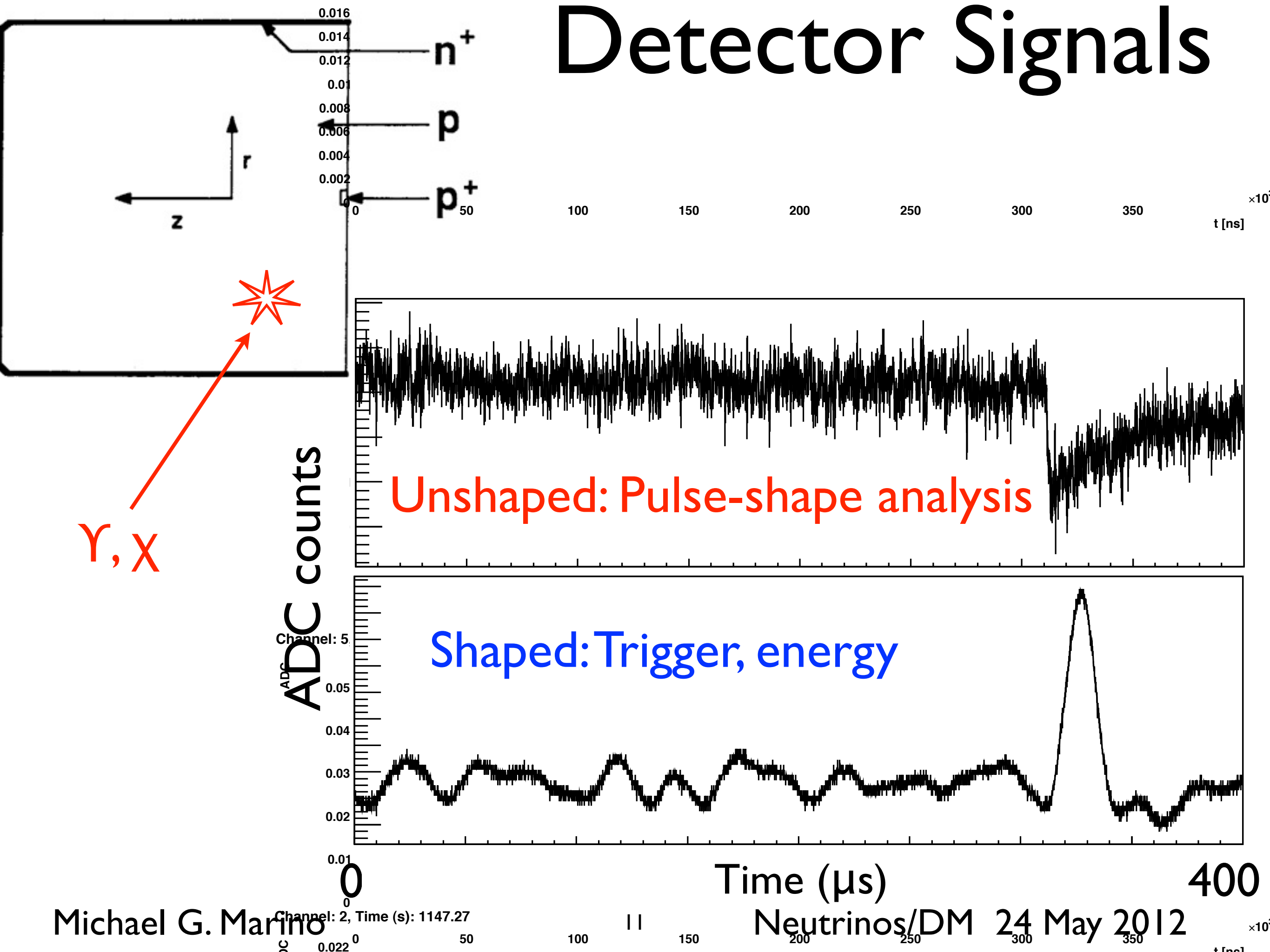
Luke et al., IEEE trans. Nucl. Sci. 36 , 926(1989).

Point-Contact Detectors

- P-type Point-Contact (P-PC)
- Geometry: low-capacitance, noise; long charge drift times



Detector Signals

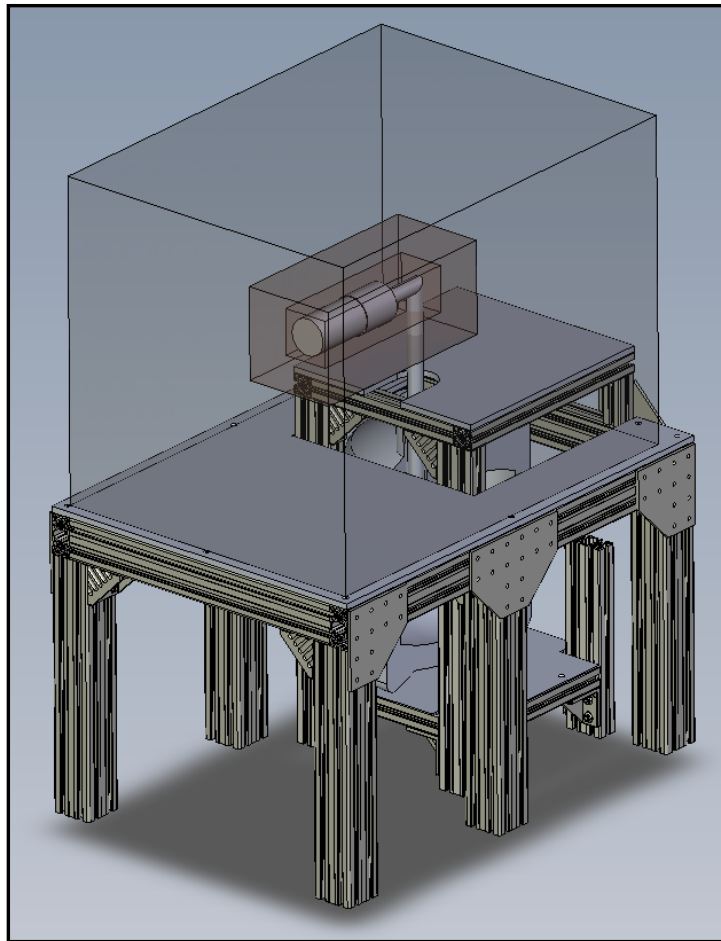


CoGeNT

Coherent **G**ermanium **N**eutrino **T**echnology
(and then Dark Matter)

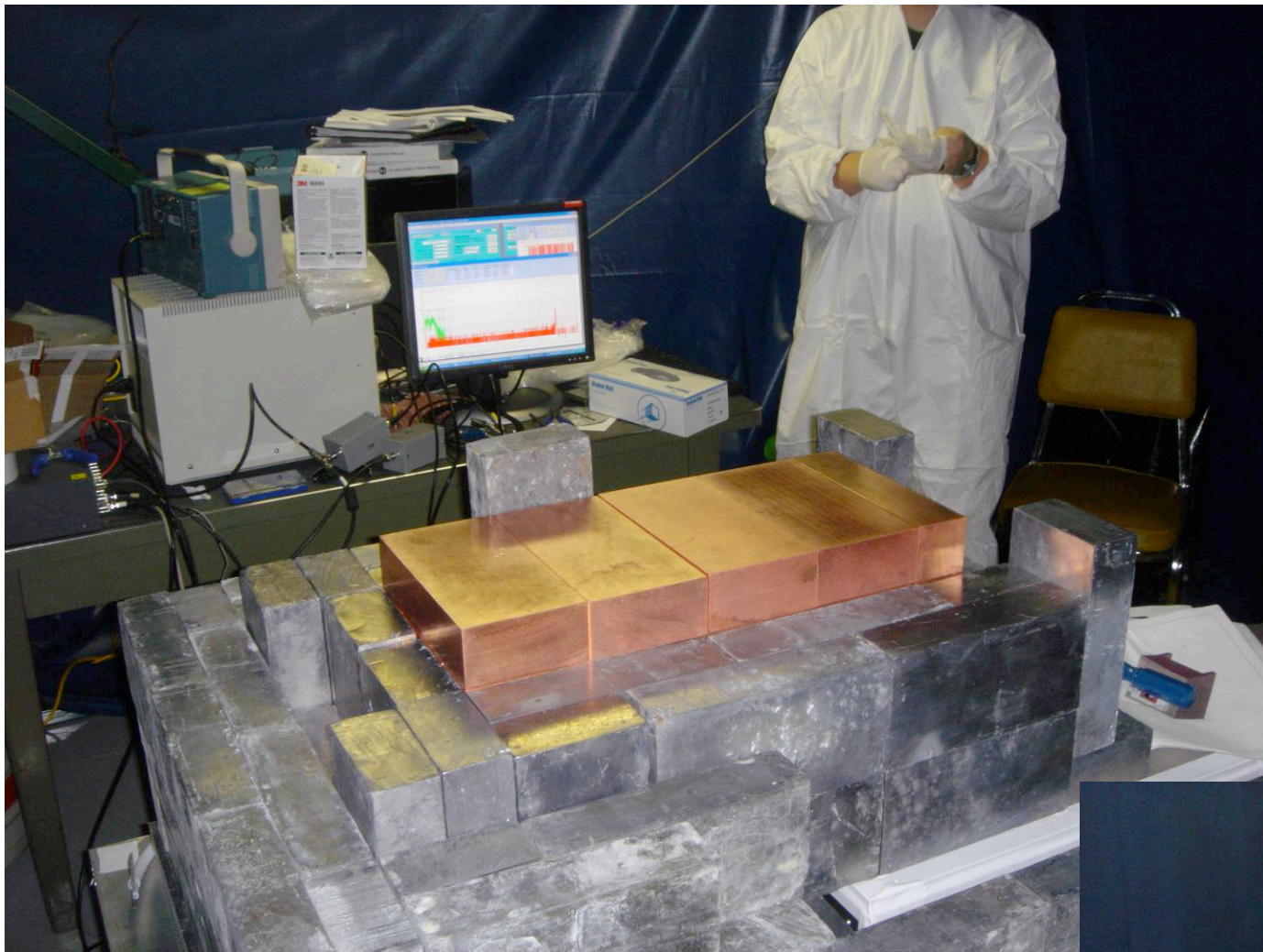
Located
underground (2100
meters water
equivalent) to
reduce background
from cosmic ray
muons





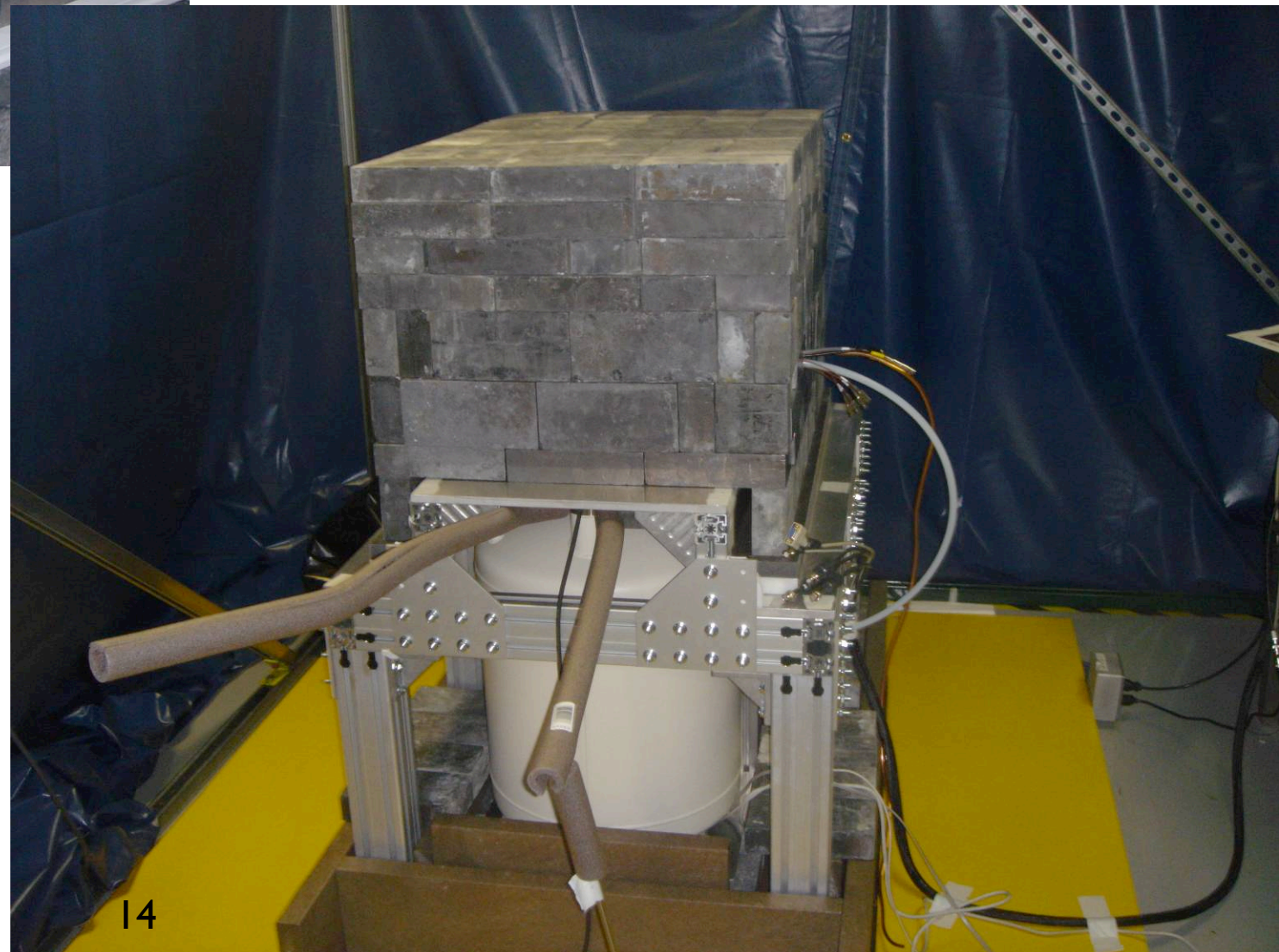
grey vertical wall

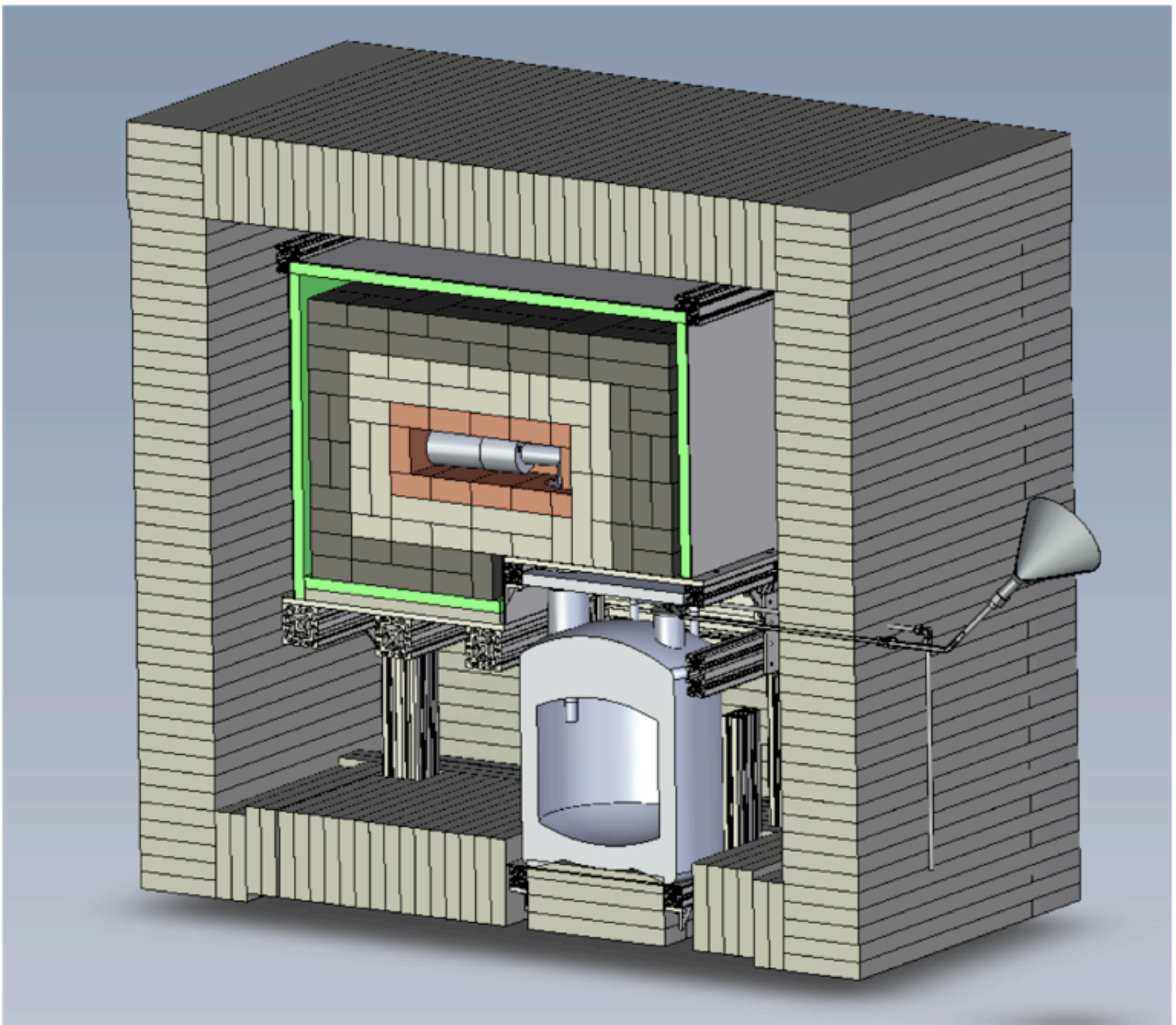
Initial deployment (previous detector)



Pictures:
J. Orrell,
E. Fuller

Michael G. Marino





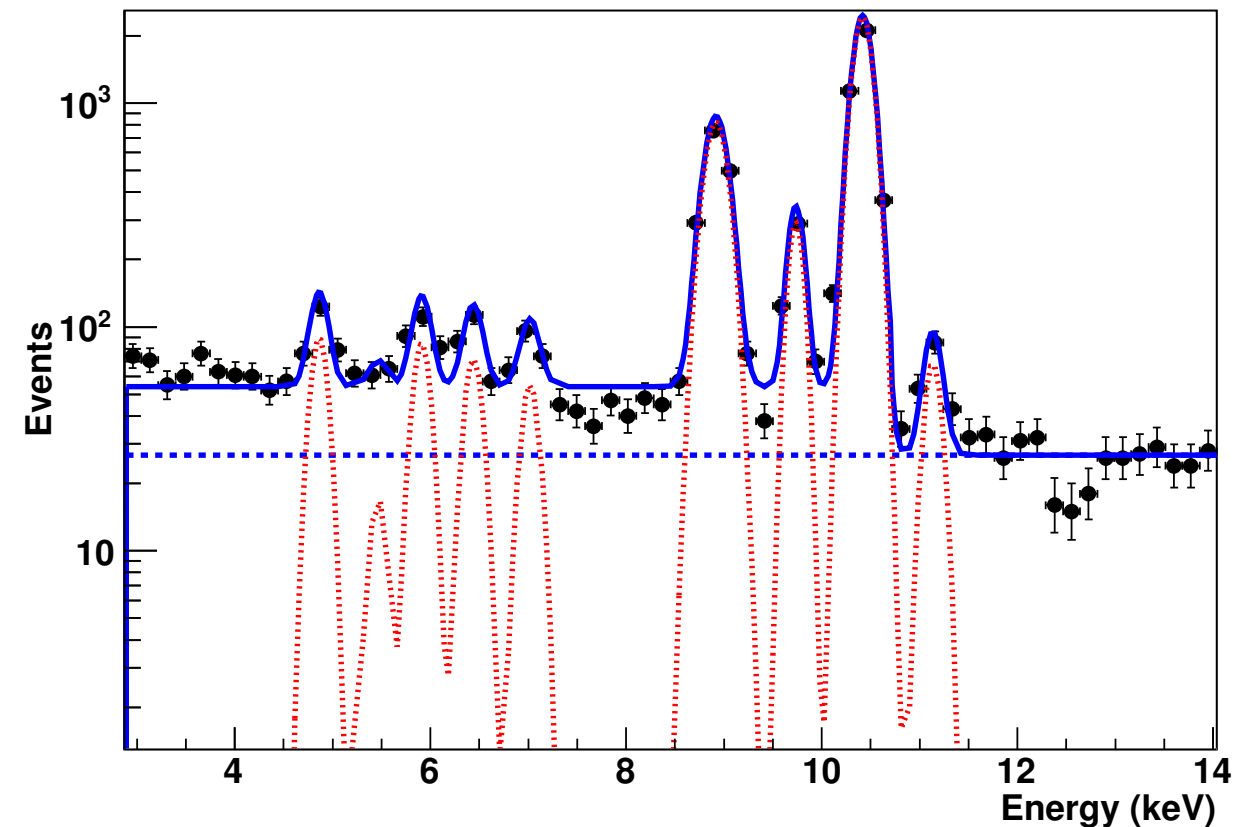
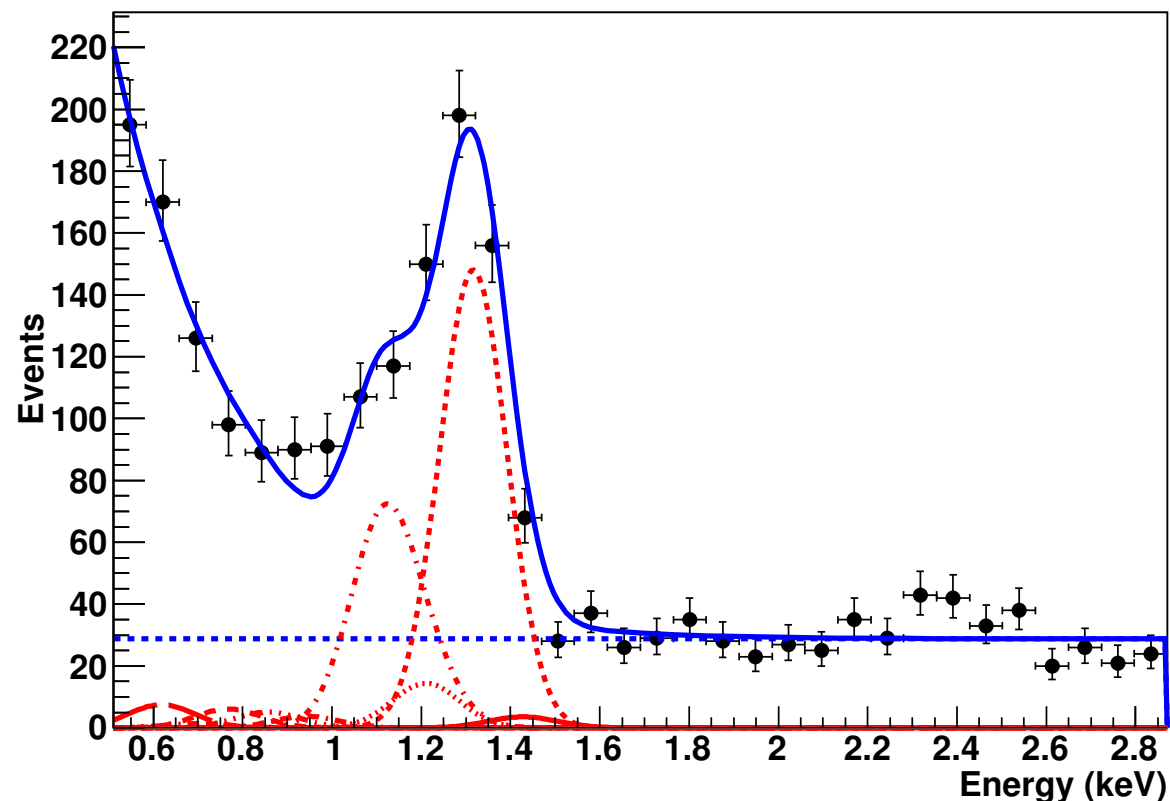
E. Fuller, J. Orrell

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Extracting Physics

- What we have:
- Energy, Time data over two channels:
 - $0.4 \rightarrow 3$ keV
 - $0.4 \rightarrow 14$ keV



- 4 Dec 2009 - 6 Mar 2011
- 442 live days, 458 days span

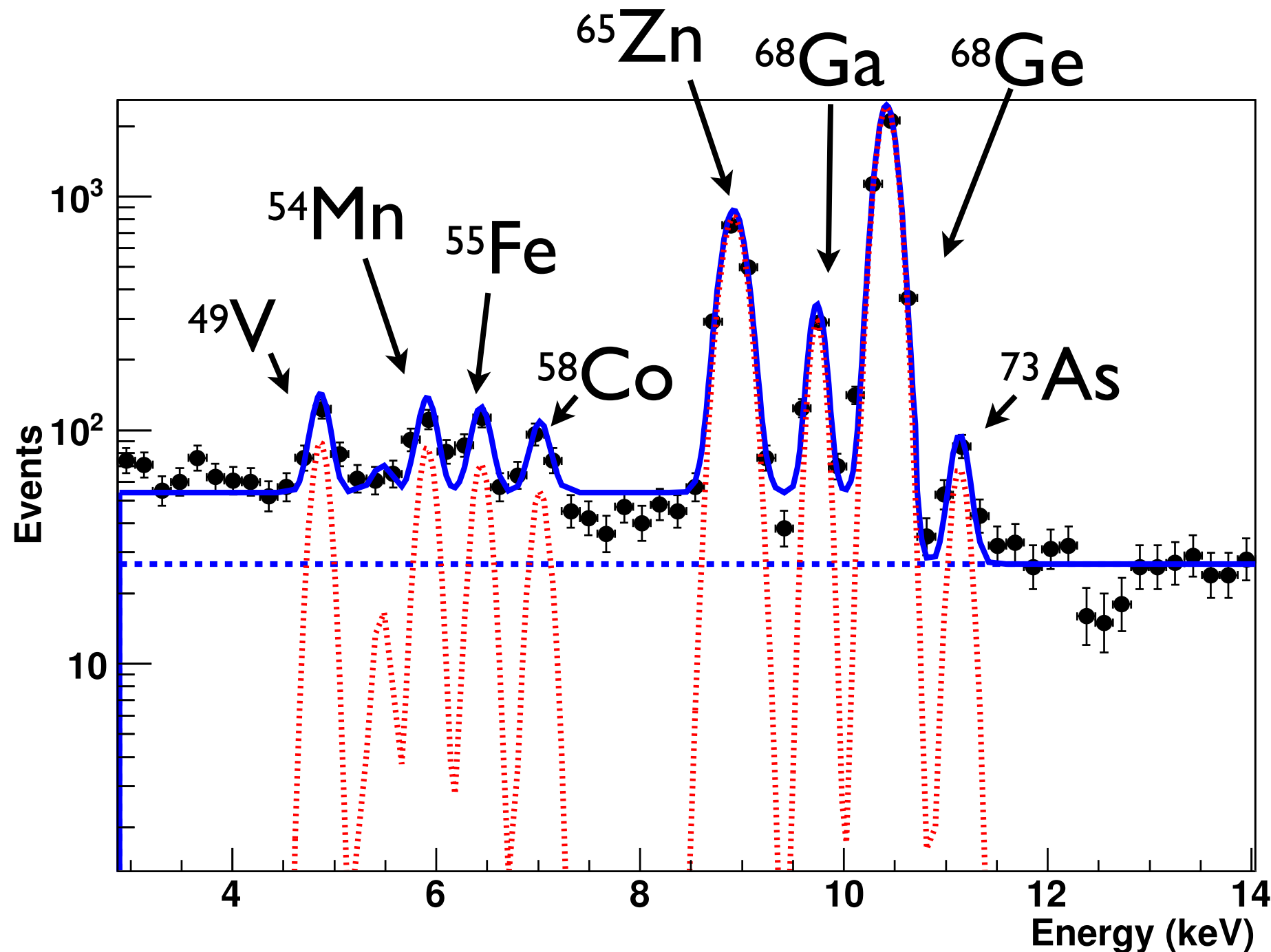
Extracting Physics

- Energy spectrum (e.g. WIMP exclusion)
 - *PRL* **106**, (2011) 131301.
- Time (+ energy) spectrum (modulation)
 - Subtraction analysis (U Chicago)
 - 2-D ML fit analysis (U Washington)

'High' Energy

Peaks are from electron-capture of cosmogenic isotopes in the detector.

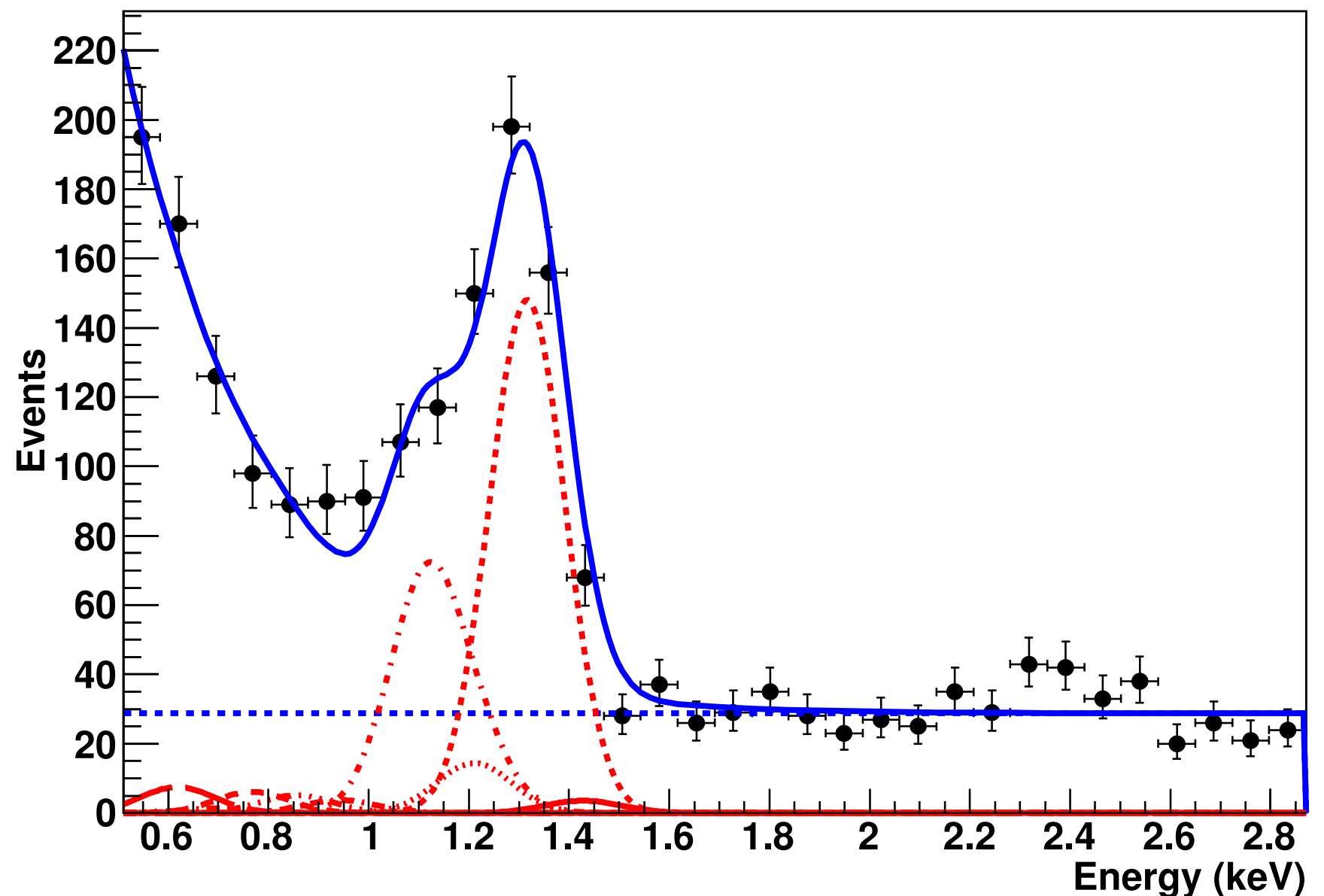
Each have K-capture lines (higher energy)...



‘Low’ Energy

Peaks are from
electron-capture
of cosmogenic
isotopes in the
detector.

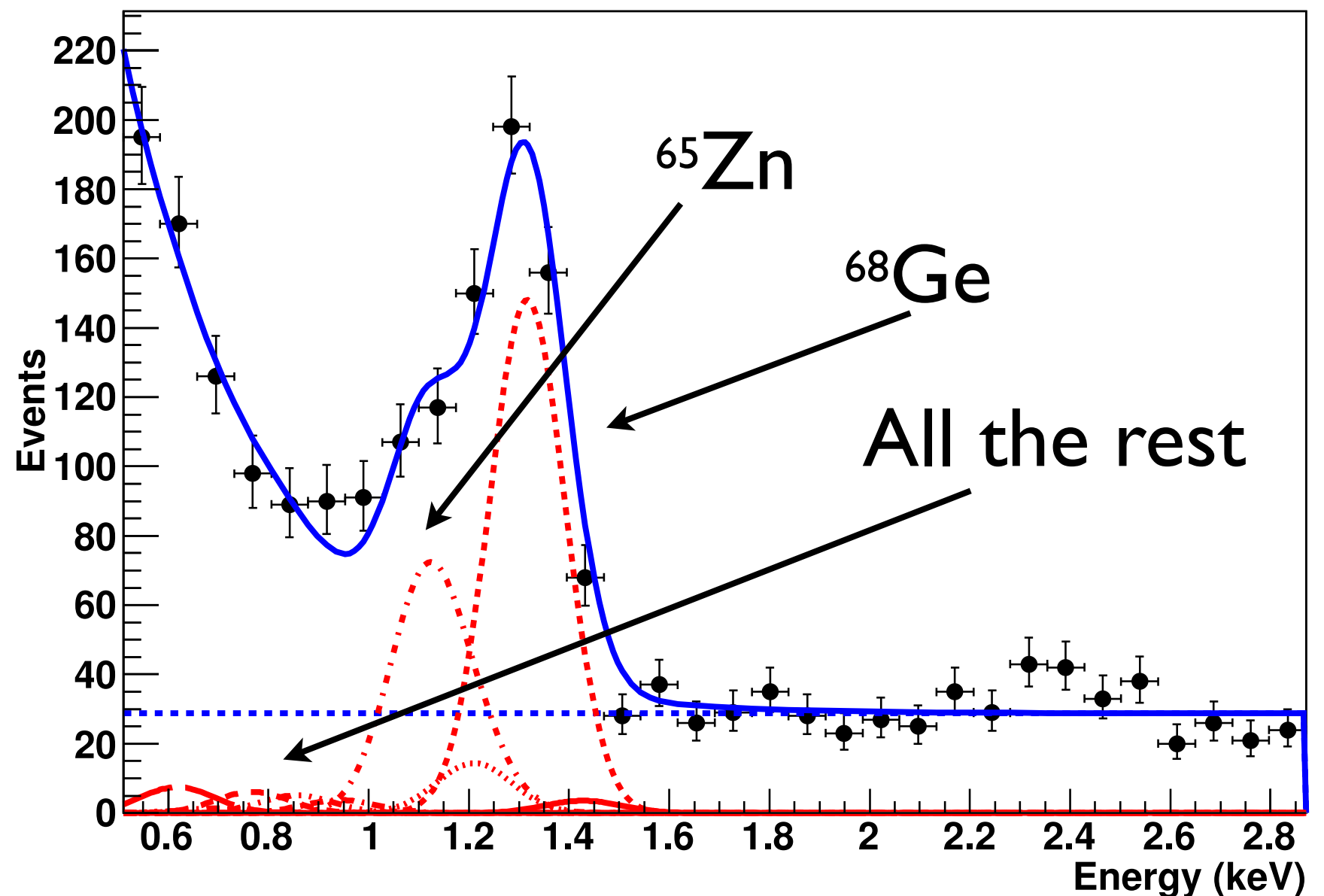
... and associated
L-capture lines
(low energy)



‘Low’ Energy

Peaks are from
electron-capture
of cosmogenic
isotopes in the
detector.

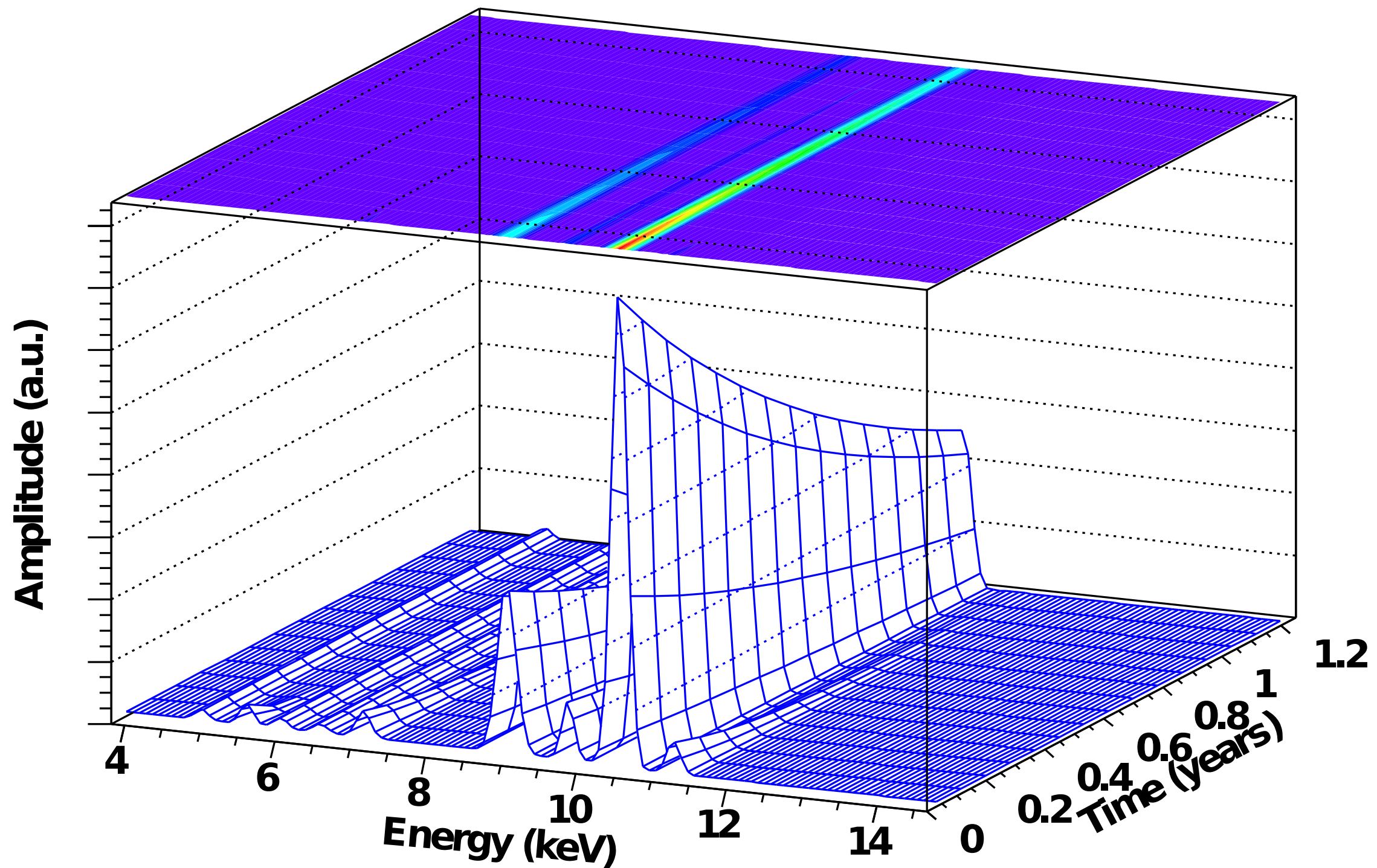
... and associated
L-capture lines
(low energy)



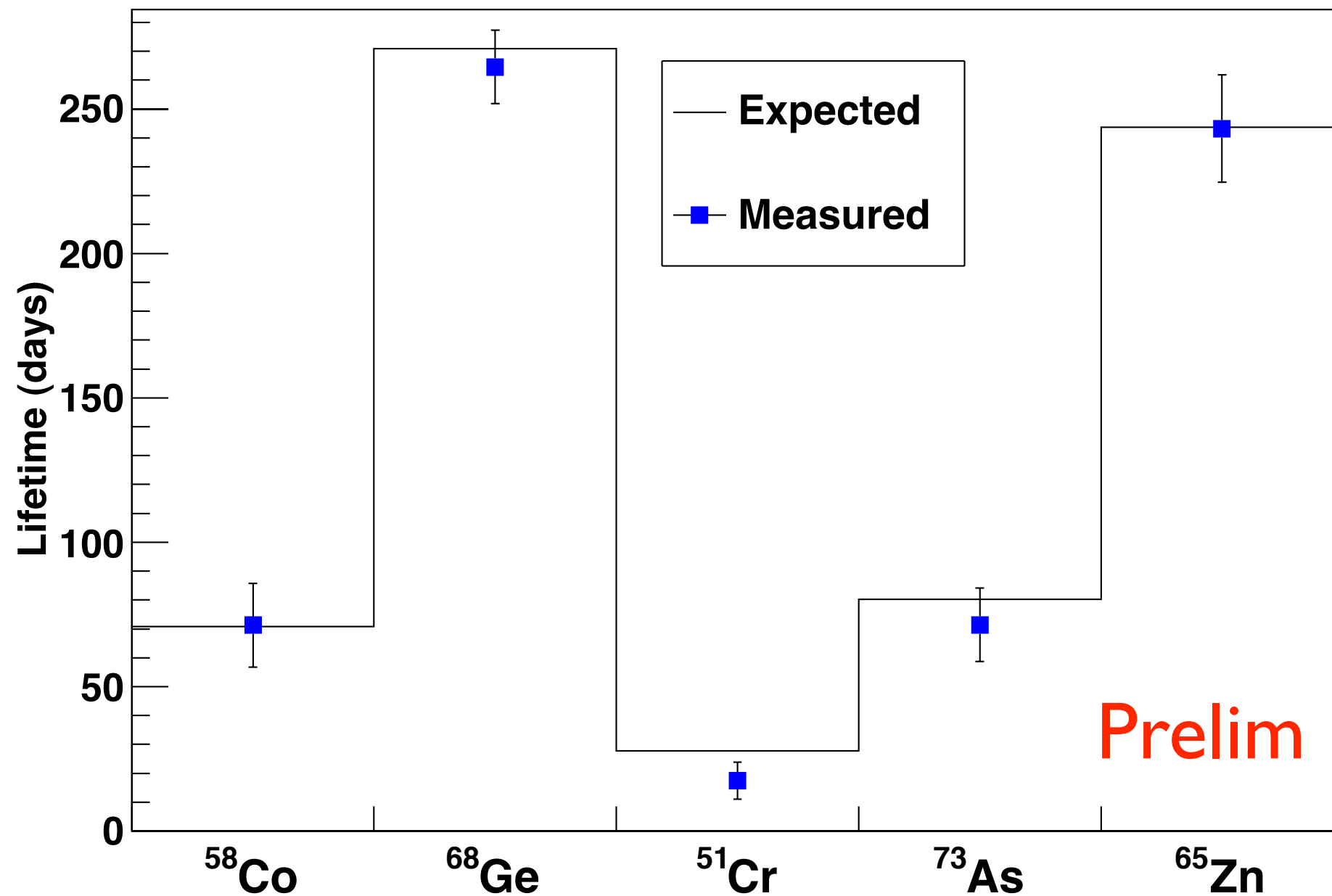
Time analysis

- 2-D time vs. energy analysis
- Simultaneous Max-likelihood fit over 2 channels
- Constrain L/K electron-capture peaks by their well-measured ratios
- Add oscillation PDF in low-energy channel

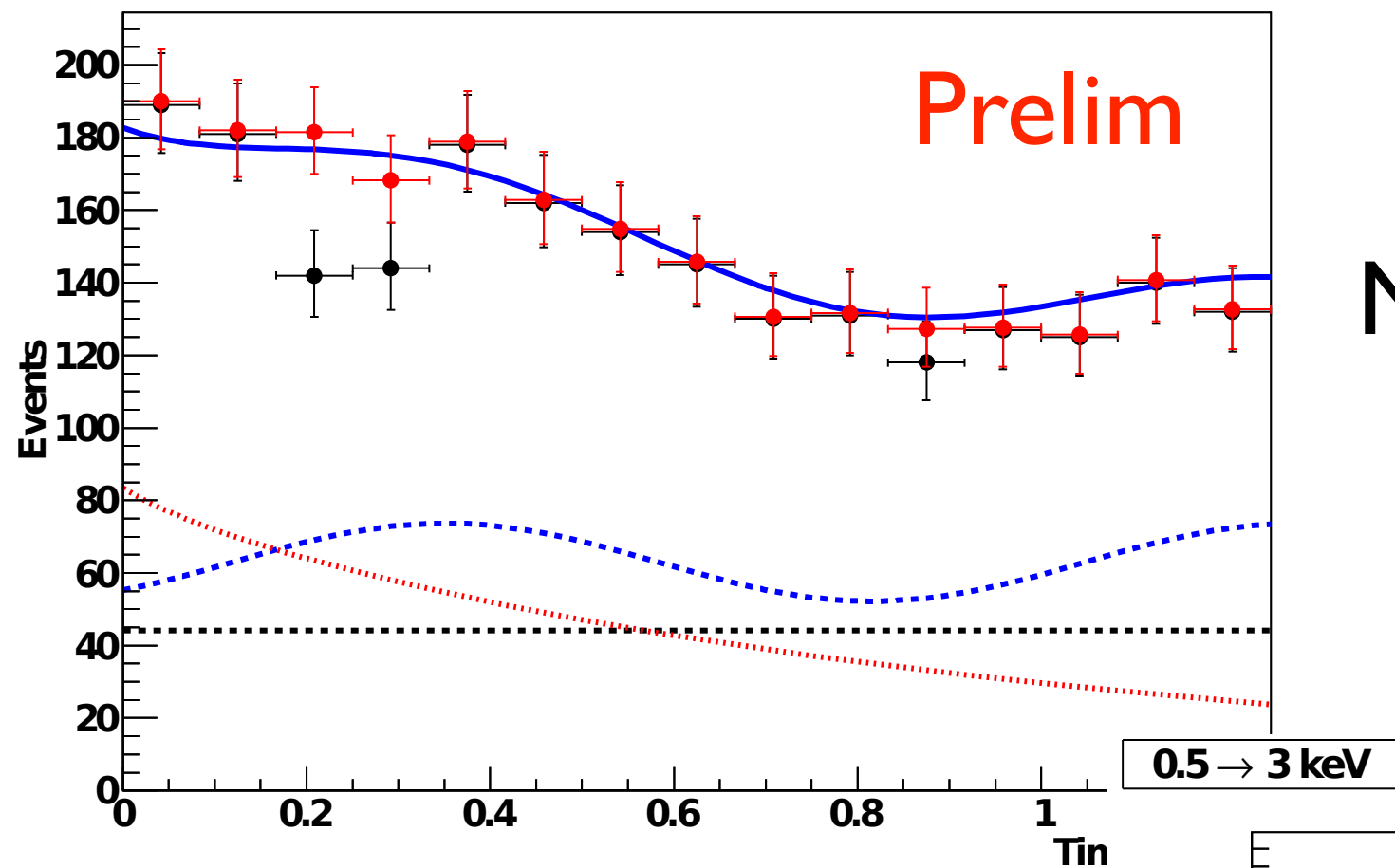
2-D Model Visualization



Crosscheck: Lifetimes



0.5 → 3 keV

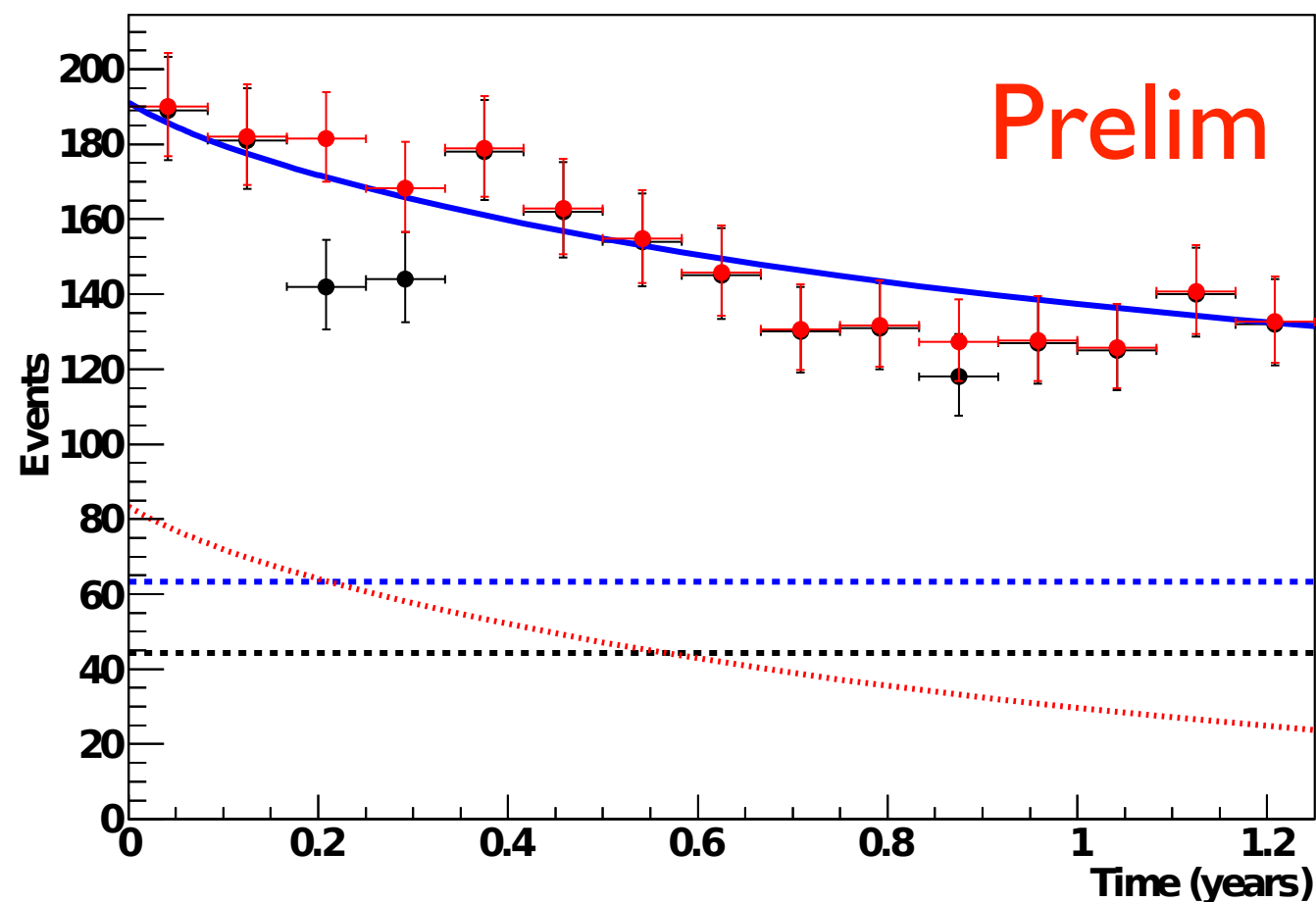


Model with Oscillation

Raw data

Livetime corrected

NULL Model

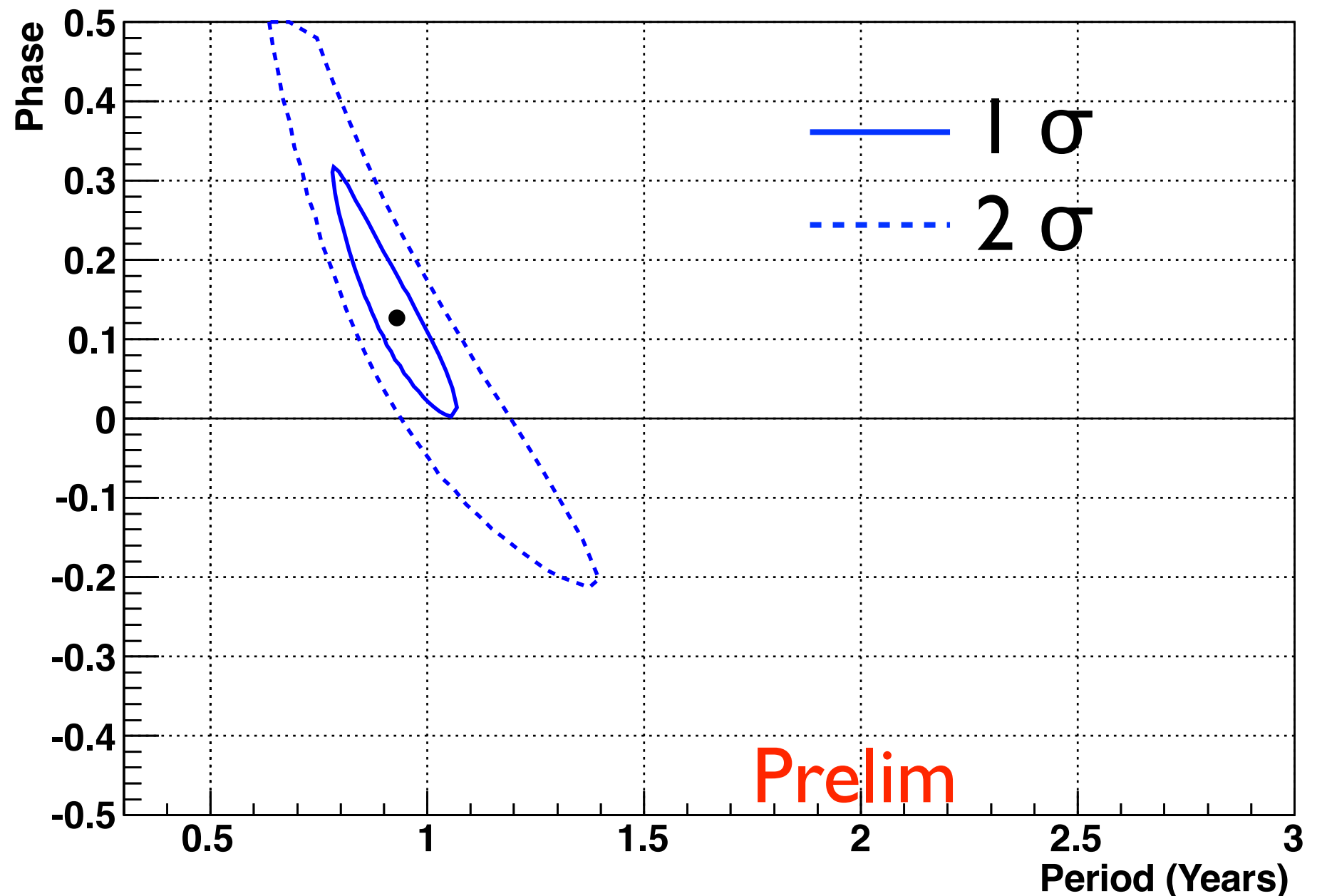


Phase vs. Period

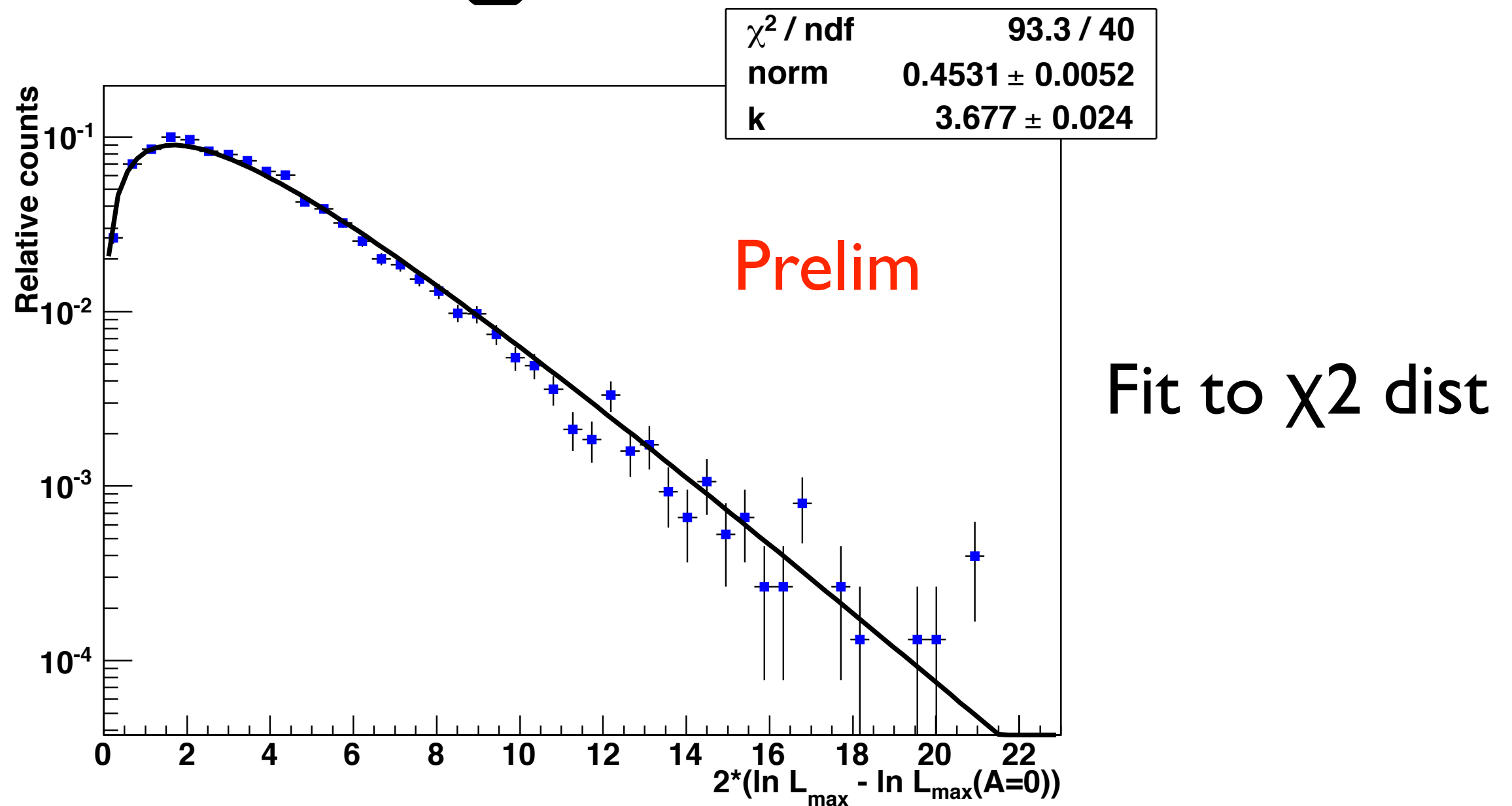
Best fit point:

Phase: 49.9 d
(Min ~23 Oct)

Period: 339.5 d



Significance



- Generate many toy models of NULL hypothesis, fit to signal + background, calc: $2 (\log L(B)_{\text{max}} - \log L(B = 0))$

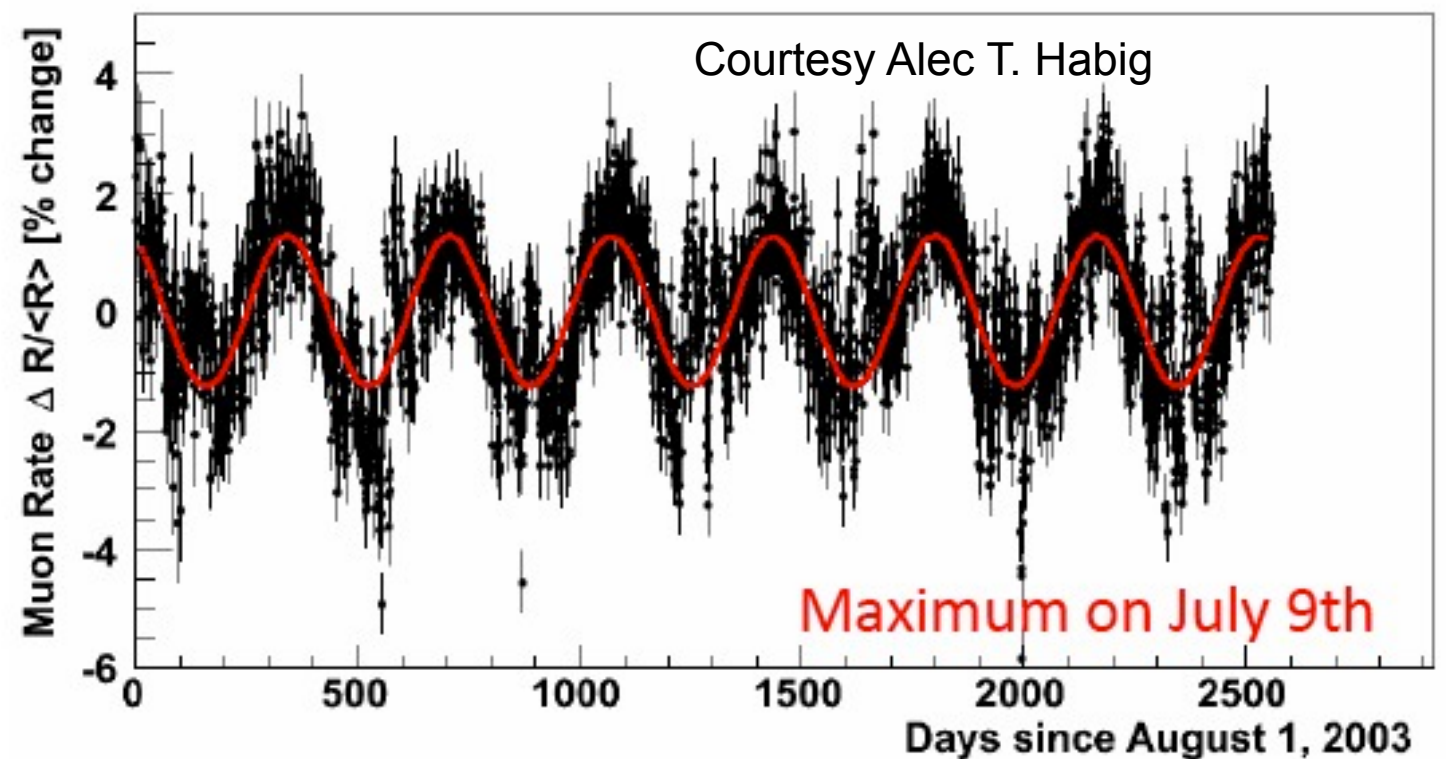
Fit summary

- ML fit (**Prelim**)
 - Min 23 Oct, Period: 339.5 d,
Ampl: $17.7 \pm 6.5\%$, significance 94.6%
- Subtraction (U Chicago, arXiv:1106.0650)
 - Min 16 Oct ± 12 d, period 347 ± 29 d,
Ampl: $16.6 \pm 3.8\%$, significance 99.4%

But what is it?

Muon modulation

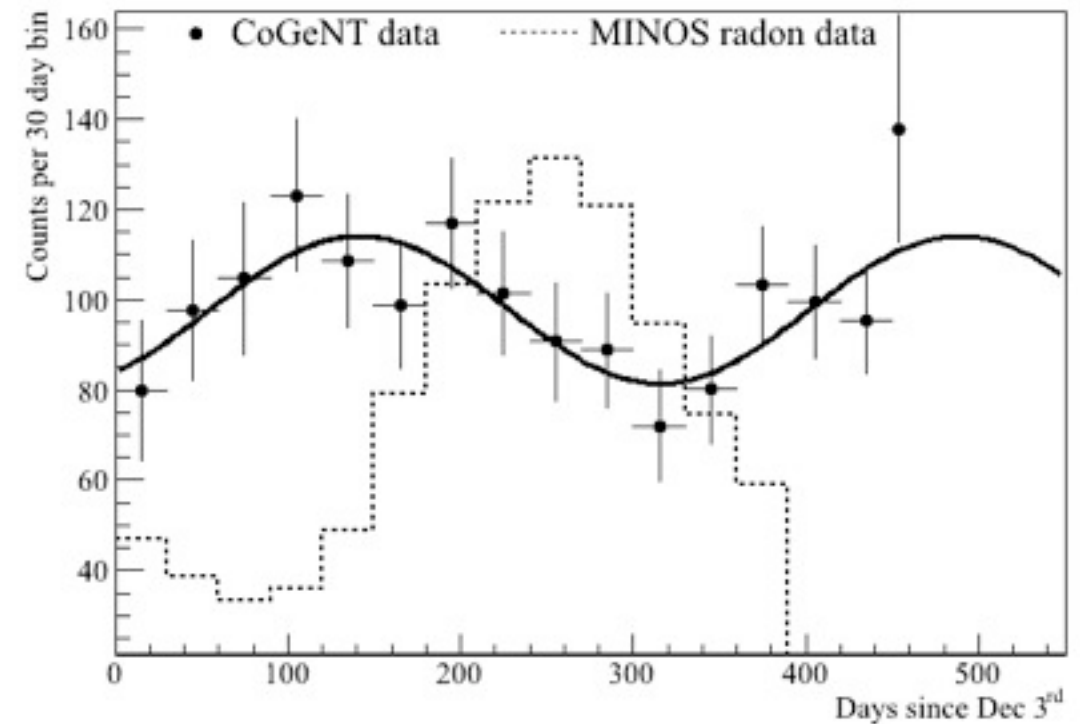
- MINOS muon flux modulation measured in Soudan
- Approximately $\pm 1.5\%$
- Peaks three months after best fit to present CoGeNT data.
- A 1.5% modulation of the estimated 339 ± 68 muon-induced events in shielding predicts a modulation of 5 events in the 0.5-3 keVee energy range
- The CoGeNT data set contains 2124 events in the 0.5-3 keVee energy range. **A 5 event modulation of muon induced events could only produce a 0.2% modulation effect in the CoGeNT data set.**



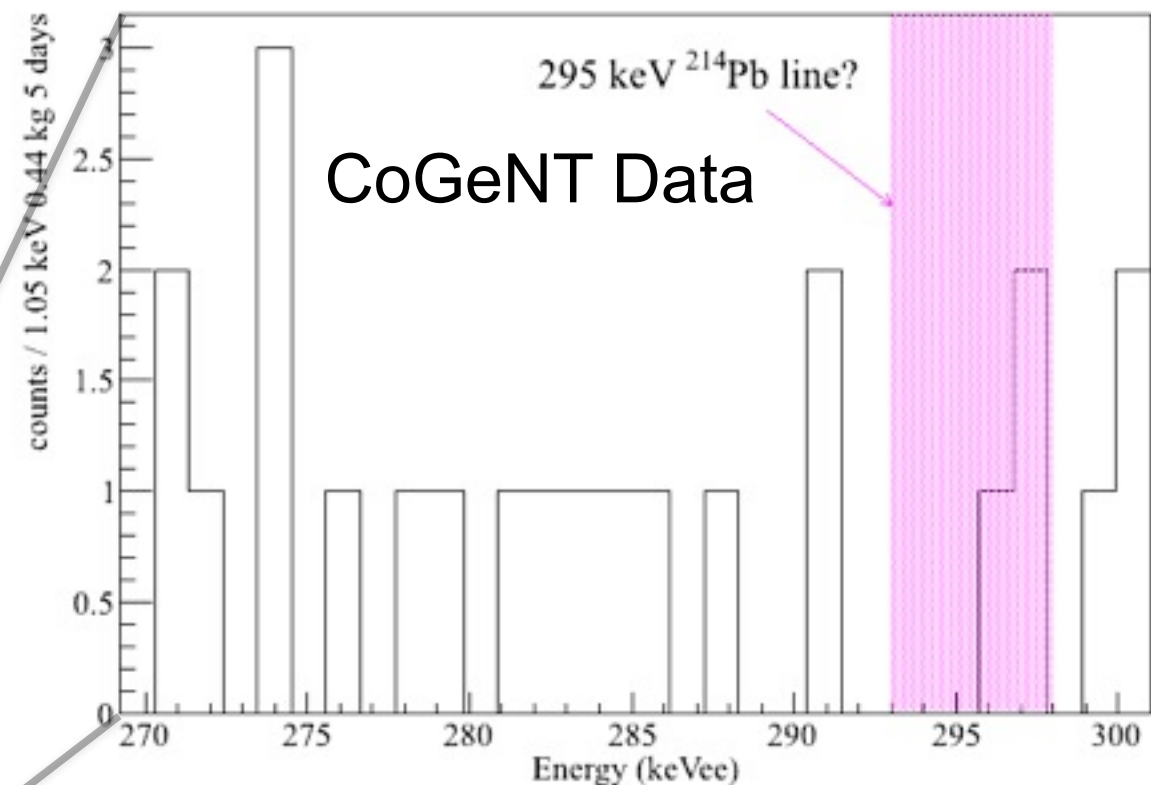
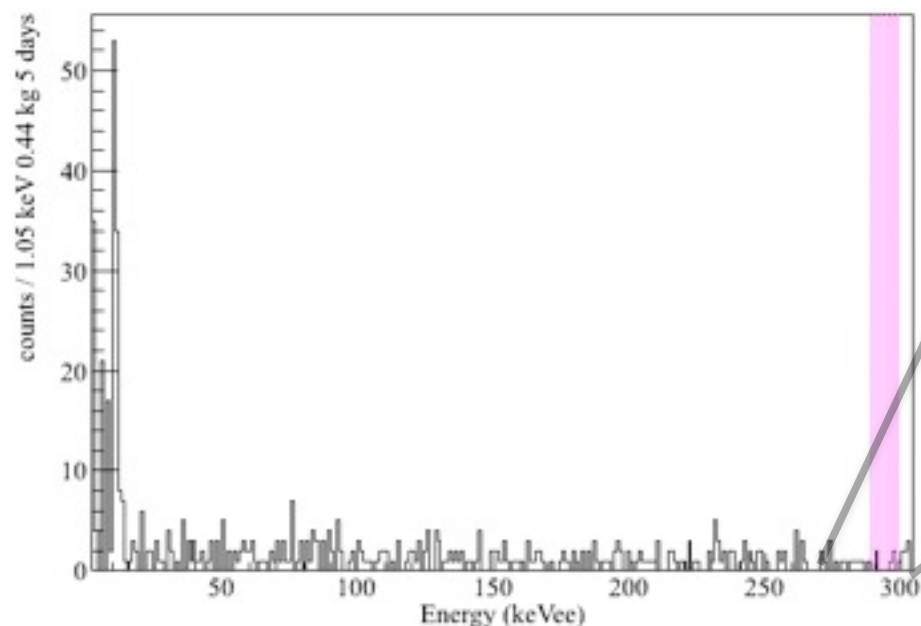
Slide: M. Kos, PNNL

Radon Modulation

- Radon levels modulate underground – Measured by MINOS
- Modulation out of phase!
- Also: Look at data out to 300 keV
- Infer the maximum number of events due to Rn in the data
- **2.8 events in 0.5 – 3.0 keV**



Prelim



Slide: M. Kos, PNNL

Summary

- Recent CoGeNT data consistent with an annual modulation at low energies, PRL 107 (2011) 141301, this is confirmed by two fully independent analyses
- Background analyses suggest muons and Rn can **not** account for this modulation, still investigating other possibilities
- Longer paper in preparation detailing analysis
- Detector **is** back up and running, data not yet analyzed, planned to open **June 2012**

CoGeNT collaboration

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