Recent advancements in alpha counting technology

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XIA LLC

Outline

- Review issues with background & two counter technologies
- Take a closer look at XIA's technology
- Review preliminary findings from a series of measurements last summer
- Summary/Conclusion

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Introduction

- Pressing need to measure α-particle emissions in today's materials
- SEMATECH
  - alpha detection limit ≥ 0.0001 α/cm^2/hr,
  - measurement times ≤1 week
- Instrument *background* is currently limiting our ability to achieve these goals

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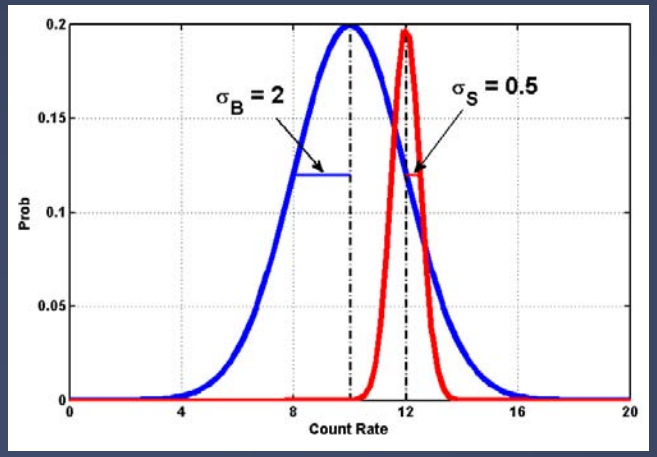
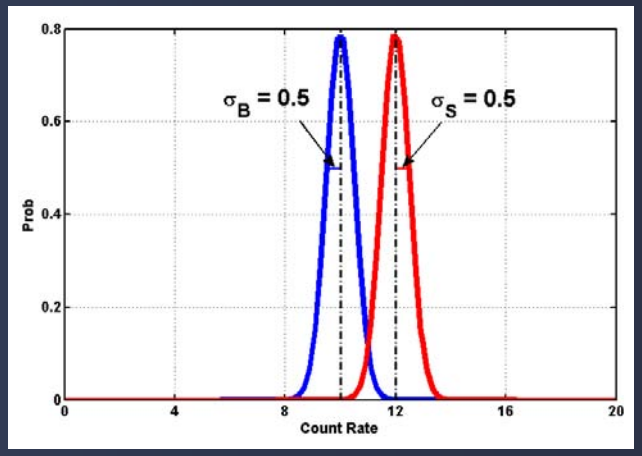
Why background is important

back·ground \'bak-,(g)raůnd\ *n* :

The count rate observed while measuring a sample which produces zero counts.





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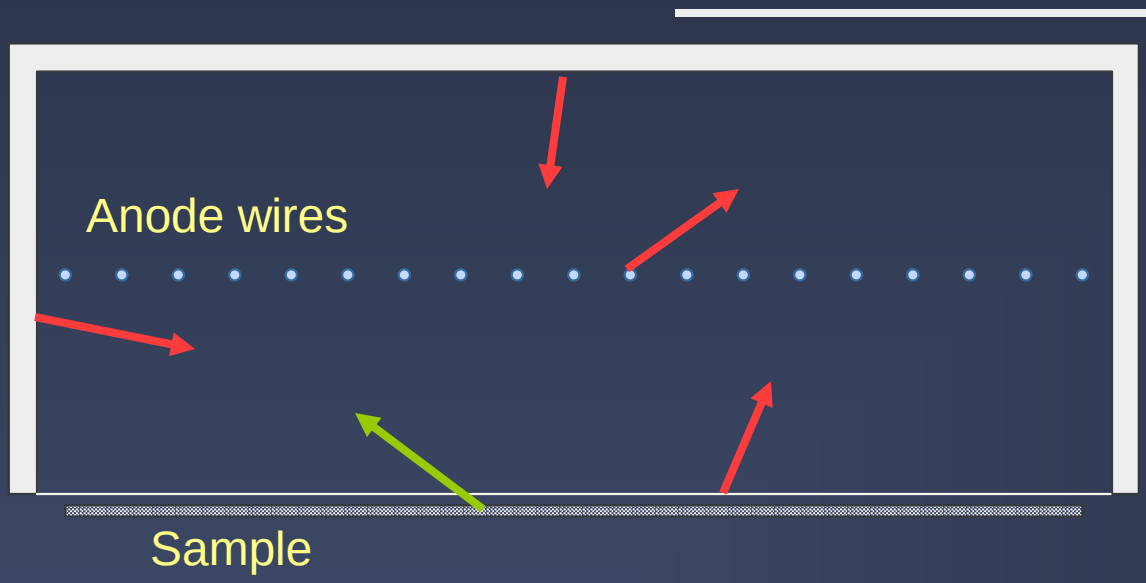
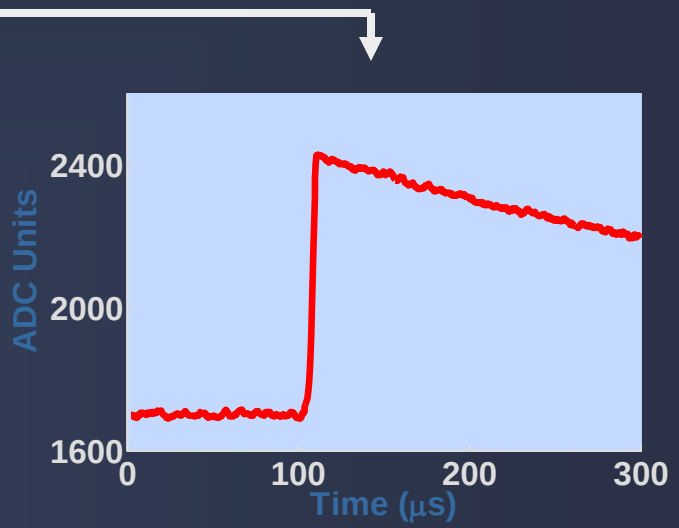
Gas flow proportional counter





Pulse Characteristics:
Good Signal/Noise
Risetime < 5 μs

- All pulses look the same!
- Intrinsic sources lead to a background of ~ 5 cts/hr

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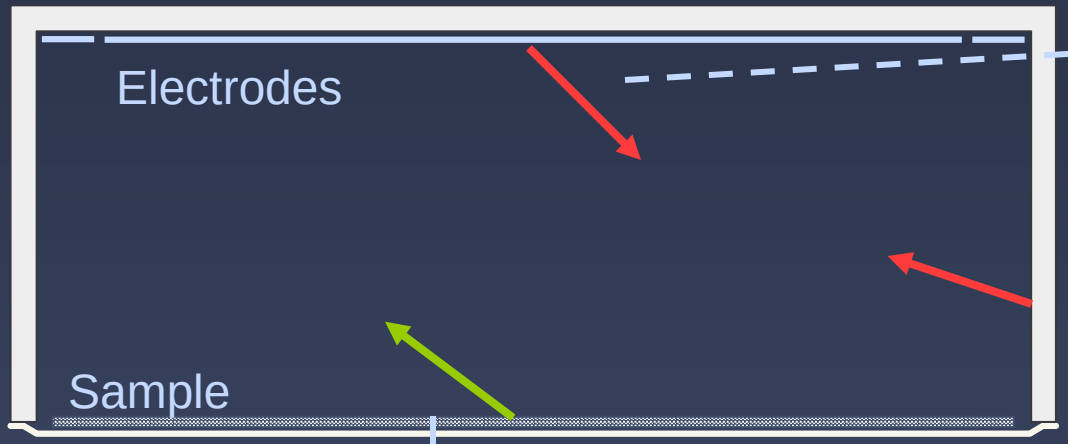
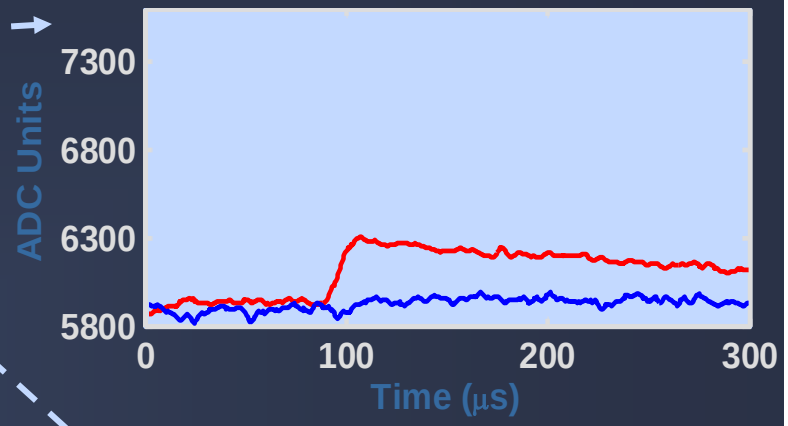
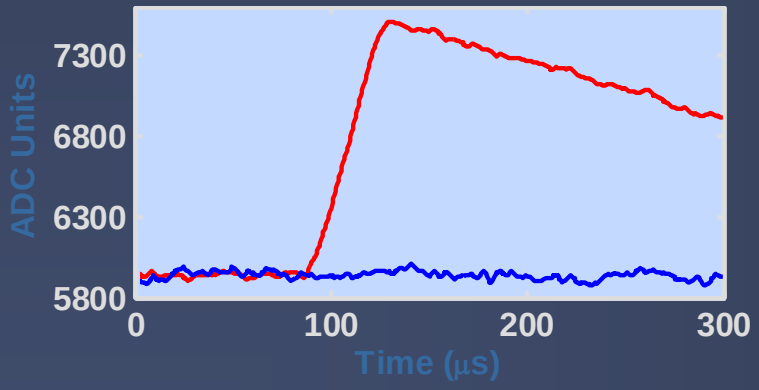
XIA's Dual Channel Ion Chamber



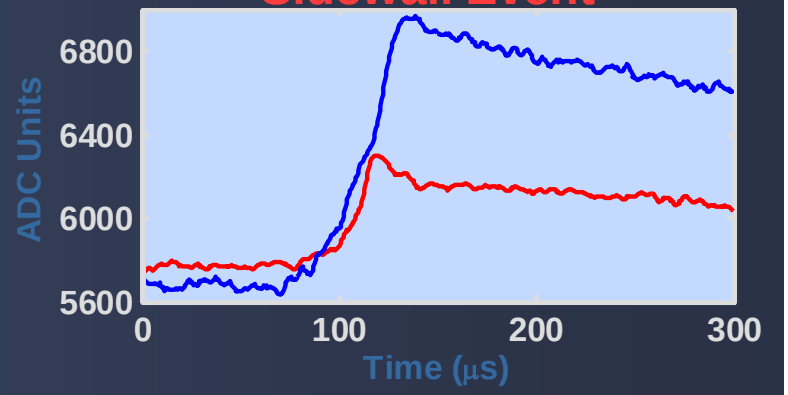
- Anode Event -



- Sample Event -



- Sidewall Event -



Pulse Shape Analysis reveals origin

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Comparative Measurements

Sample	*Count Time (hrs) ASI**	*Activity (α/hr/cm^2) ASI*	*Count Time (hrs) XIA*	*Activity (α/hr/cm^2) XIA*
1	656 (4 x 164)	0.0040 (4)	10	0.0044 (6)
2	273	0.0018 (2)	24	0.0019 (3)
3	756 (4 x 189)	0.0001 (2)	116	0.0006 (1)

*Model 1950 – Count time doesn't include background measurement time

- Full paper *An Evaluation of An Ultra-Low Background Alpha-Particle Detector* presented at NSREC 2009, and published in IEEE Trans. Nucl. Sci. Dec 2009

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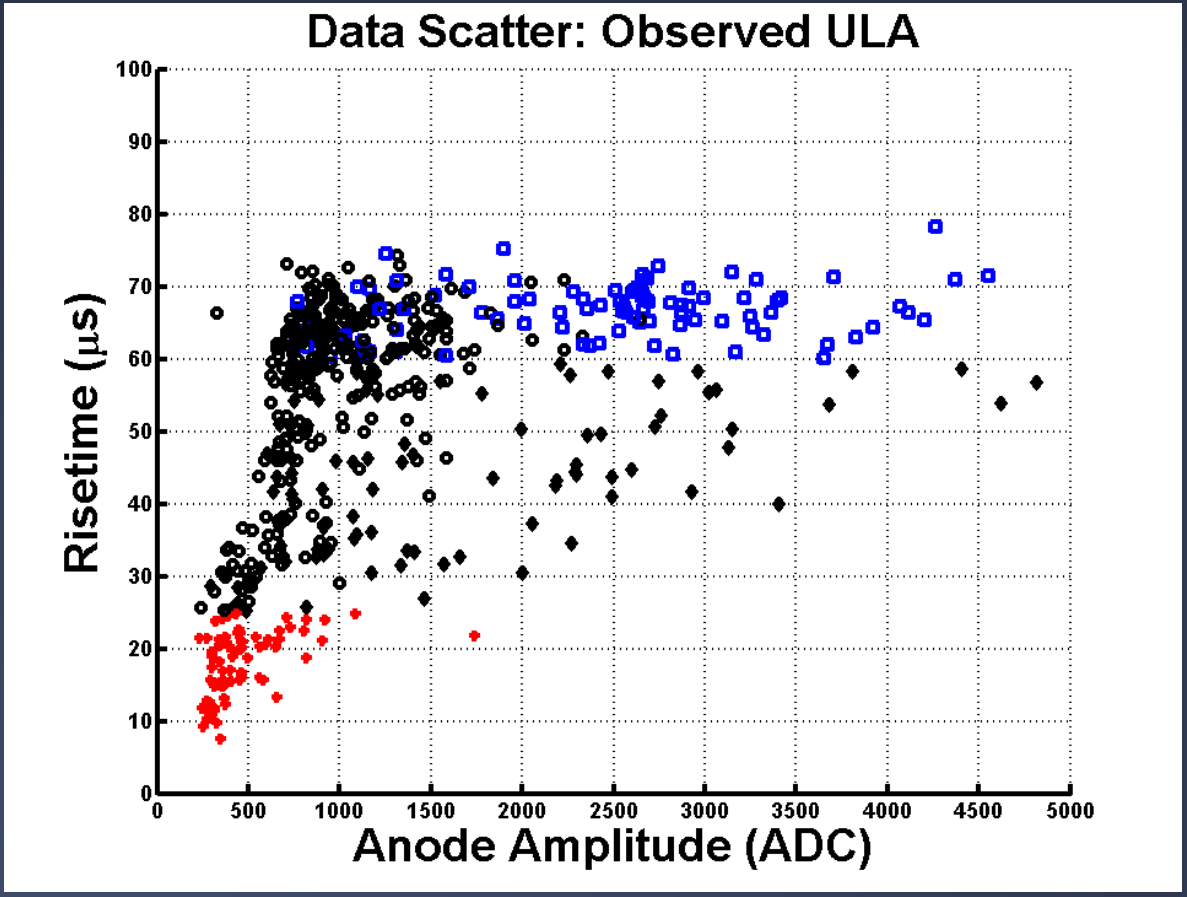
Theory is great, but…



– Events/pulses where we aren't expecting any!

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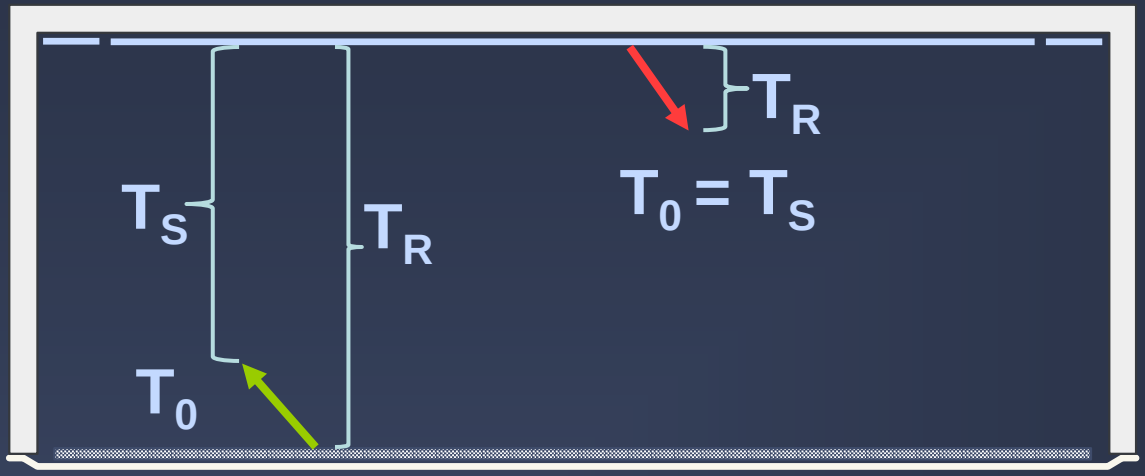
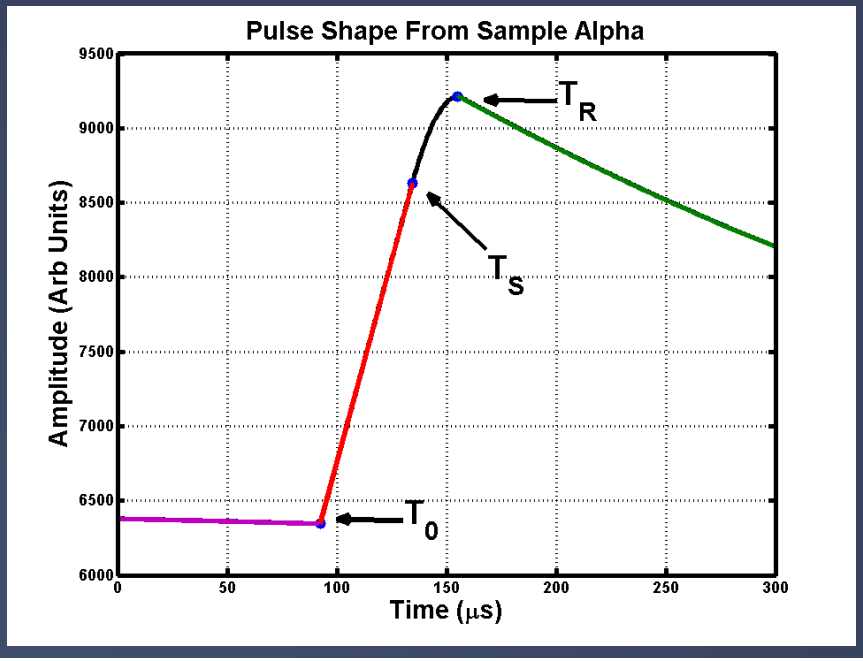
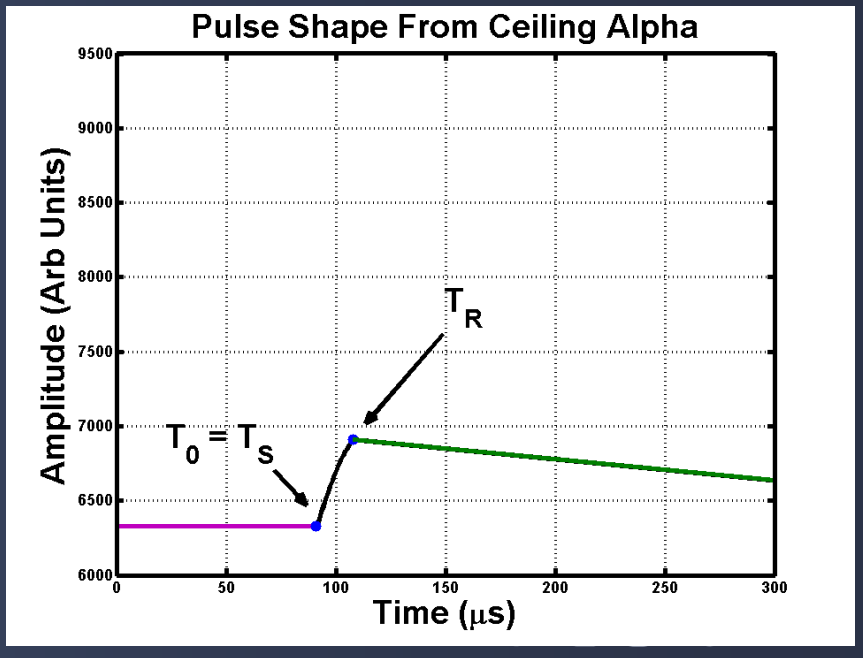
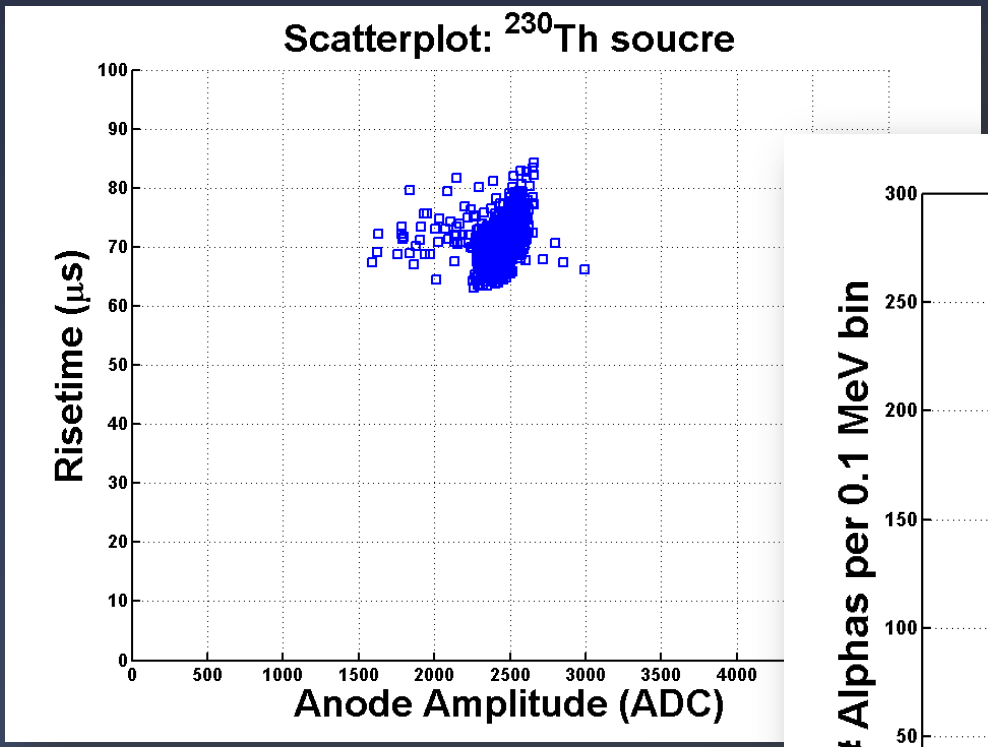
Pulse shape analysis

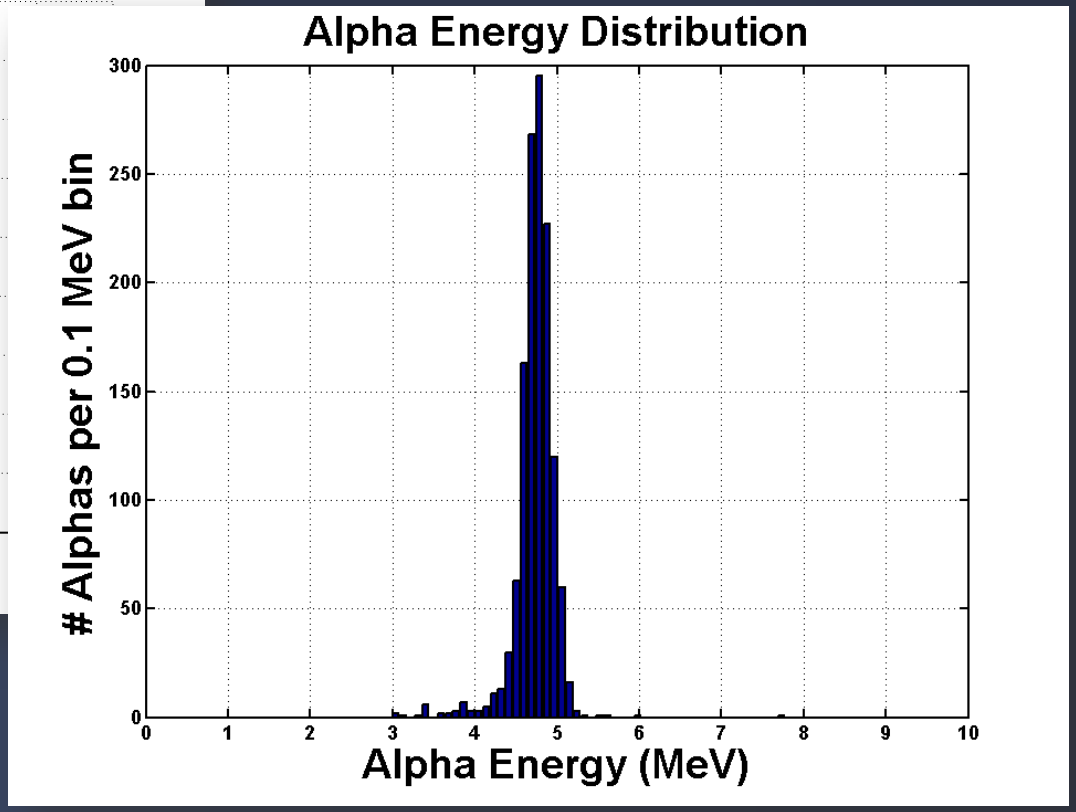






Energy Information





– Pulse amplitude is proportional to amt of charge deposited in gas (energy of alpha)

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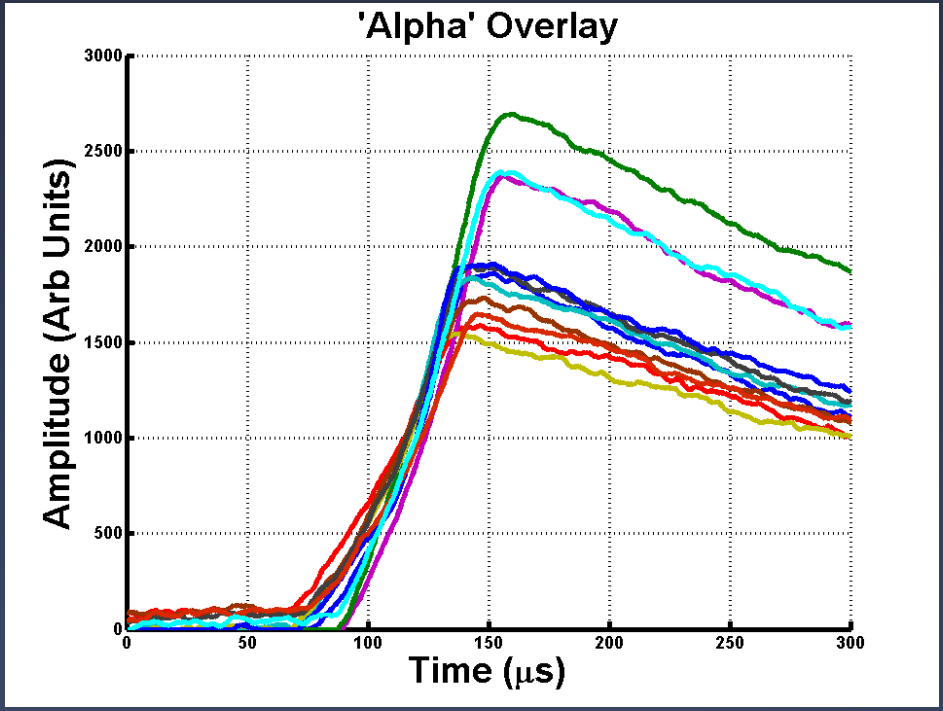
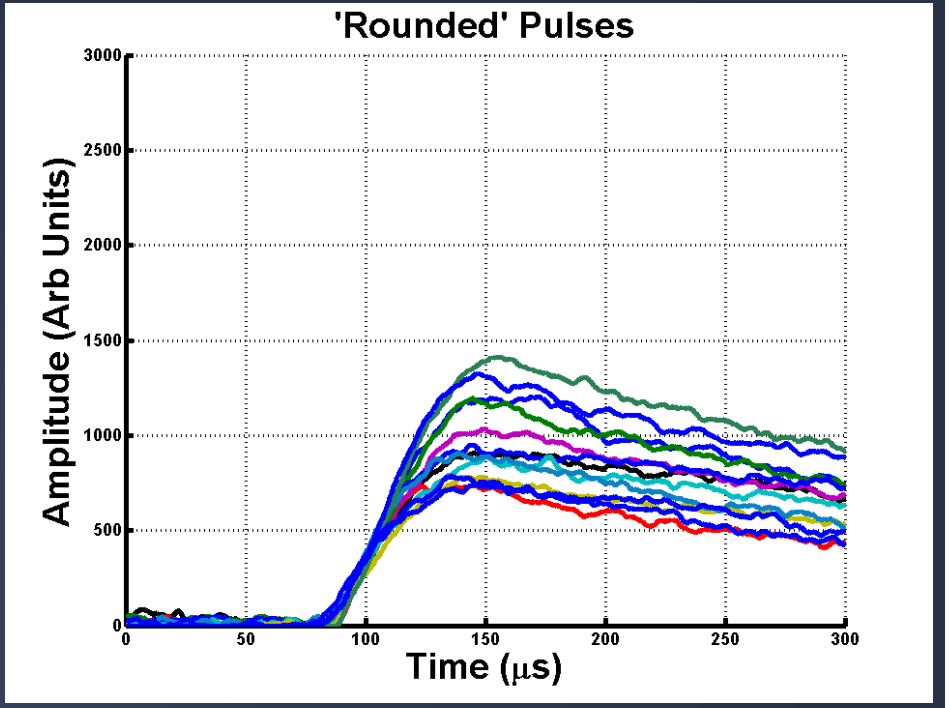
Unexpected shapes in detail





- Some look OK, just too fast → ‘mid airs’
- Some look too curved → ‘rounds’
- Implications

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Road Trip!

- Same counter, measuring same sample
- Remaining variables: location
- Selected locations:
  - XIA
  - Stanford
  - Soudan Underground Laboratory
  - LSM
  - ASTEP

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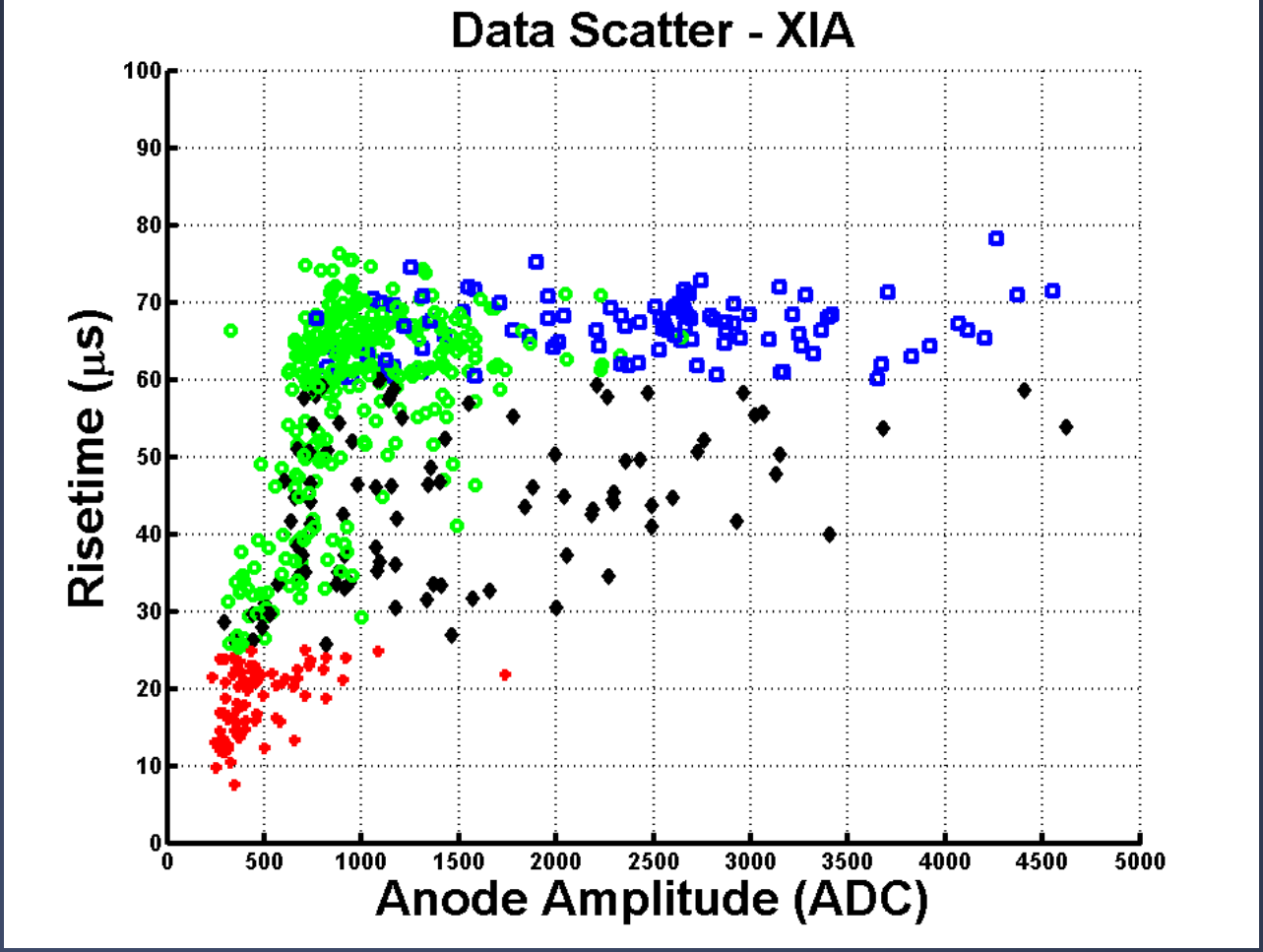
Measurement at XIA



Class	#
Alphas	93
Ceilings	71
Mids	92
Rounds	286

- Location: Hayward, CA
- Sea Level, No shielding

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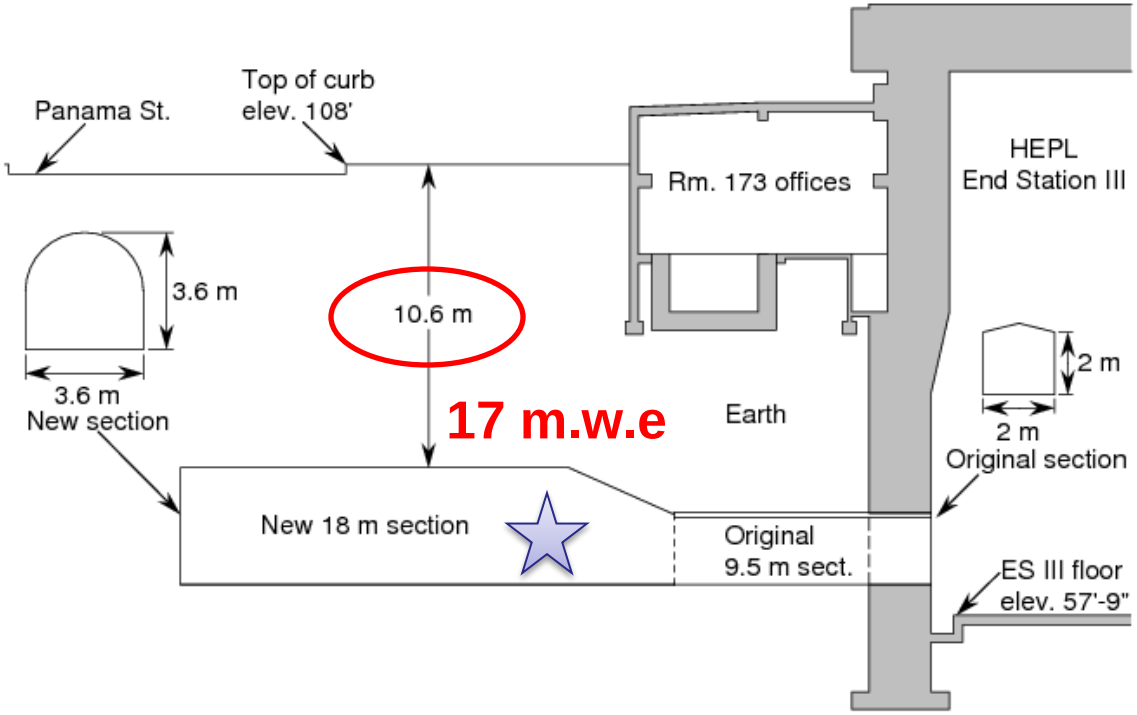
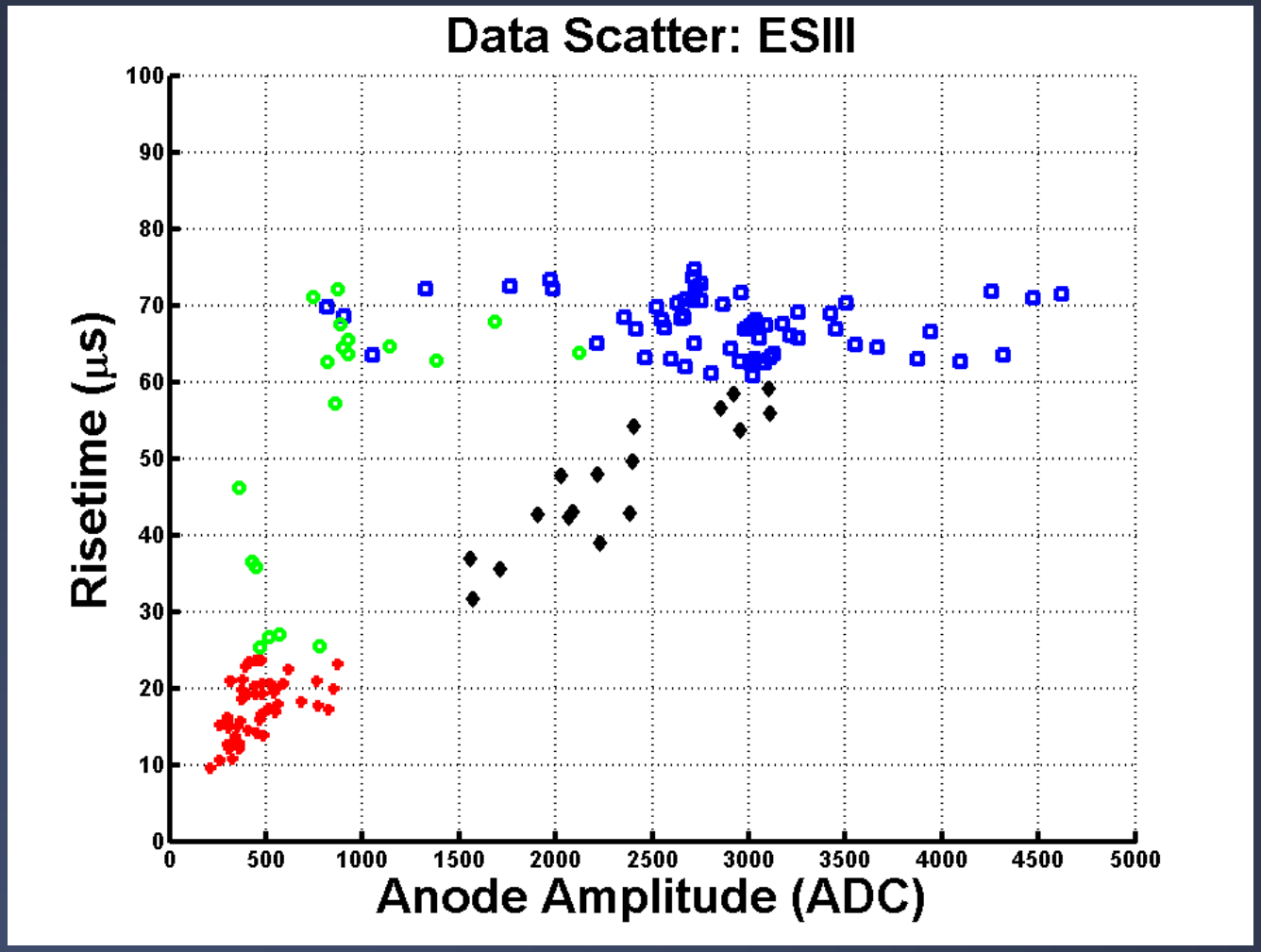
Location 1: HEPL ESIII

- Location: Stanford University
- 10.6 meters below surface
- 17 m.w.e



Location 1: Results



Class	#
Alphas	62
Ceilings	49
Mids	17
Rounds	19

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Location 2: Soudan UL (MN)

- Location: Northern Minnesota
- 2341 feet below surface
- 2030 m.w.e

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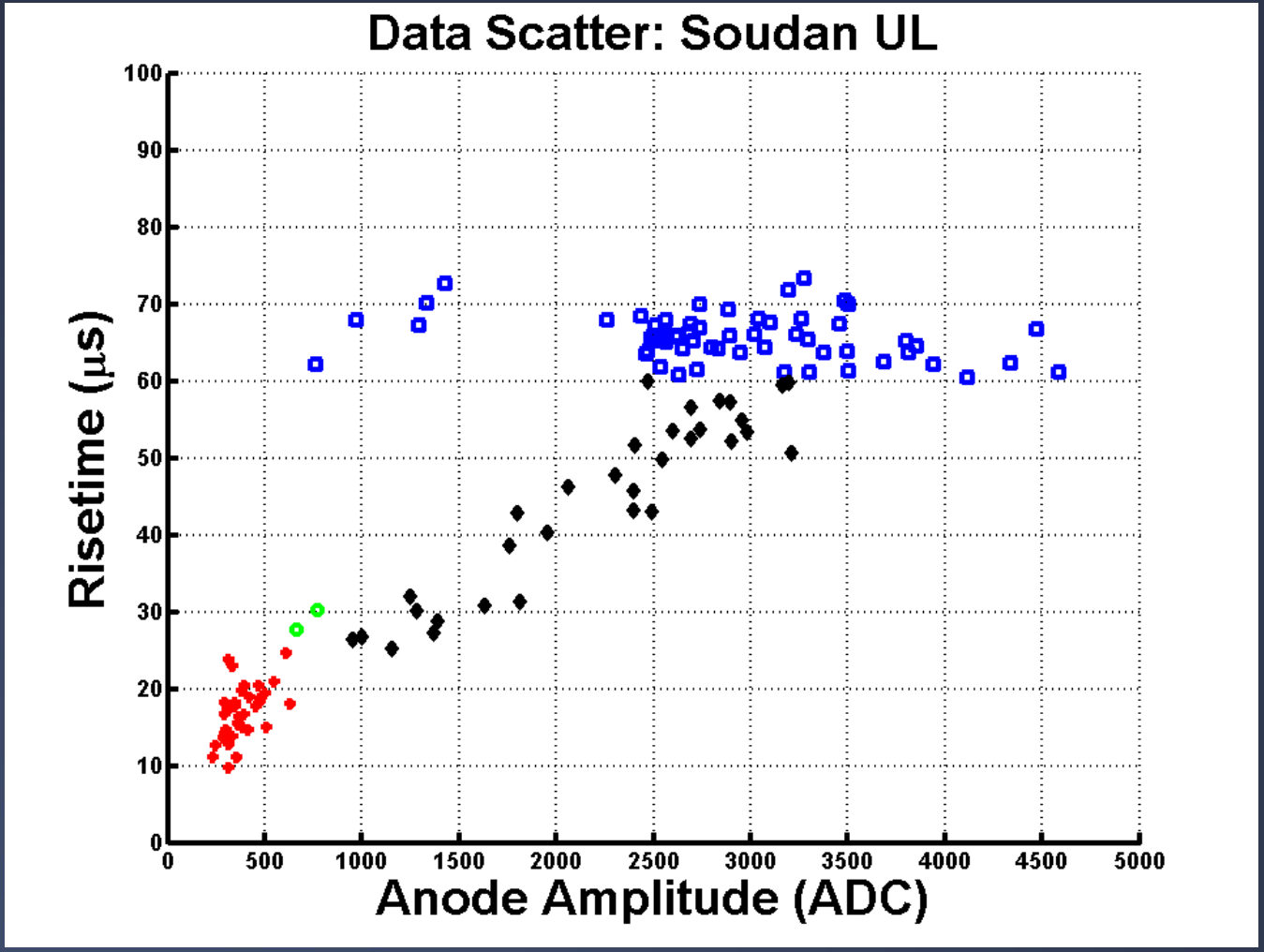
Location 2: Results



Class	#
Alphas	58
Ceilings	37
Mids	35
Rounds	2

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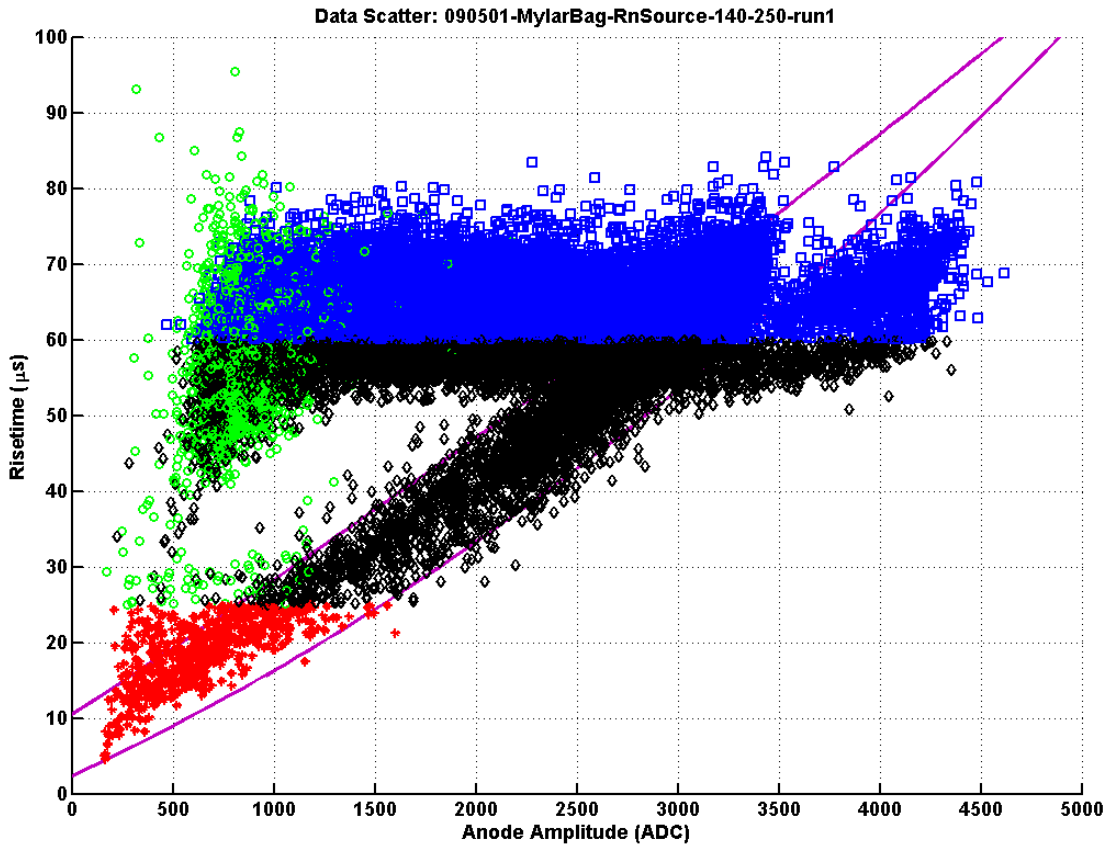
Quick aside: Radon



Rn-222 source placed in counting chamber

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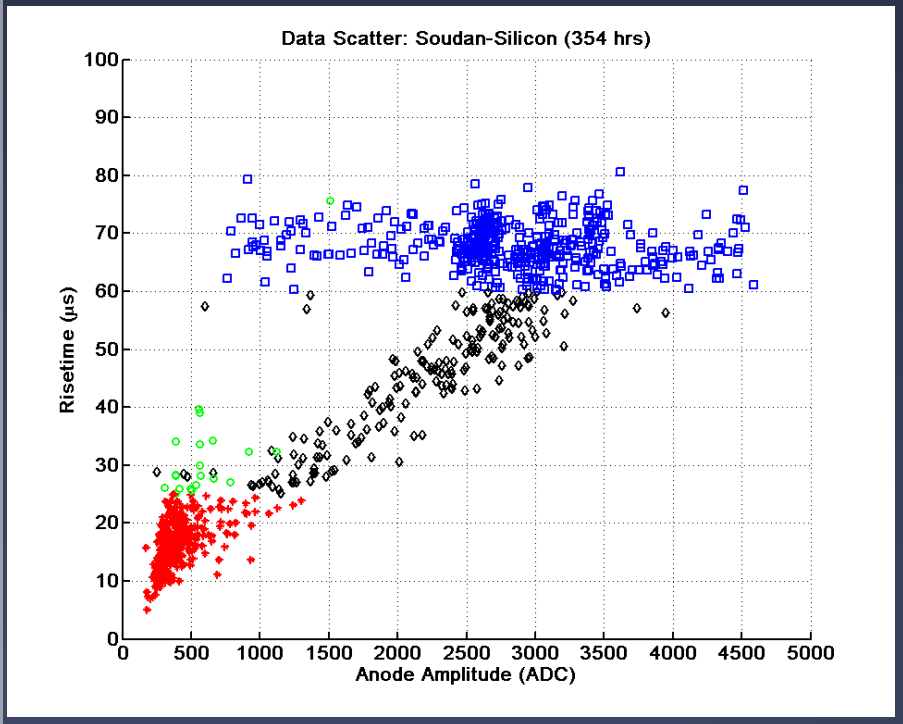
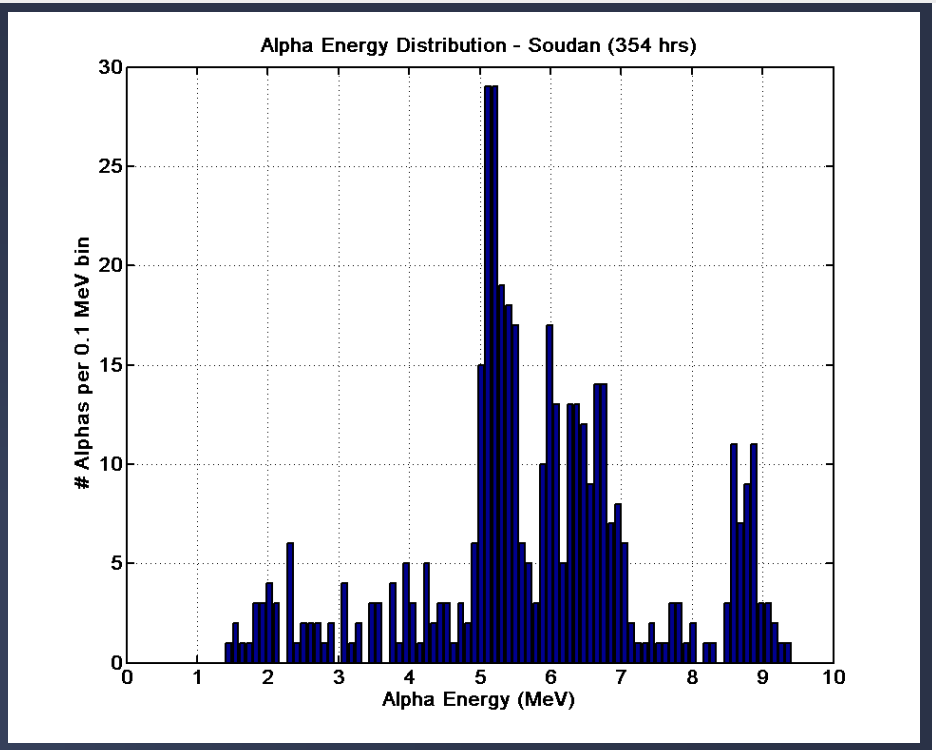
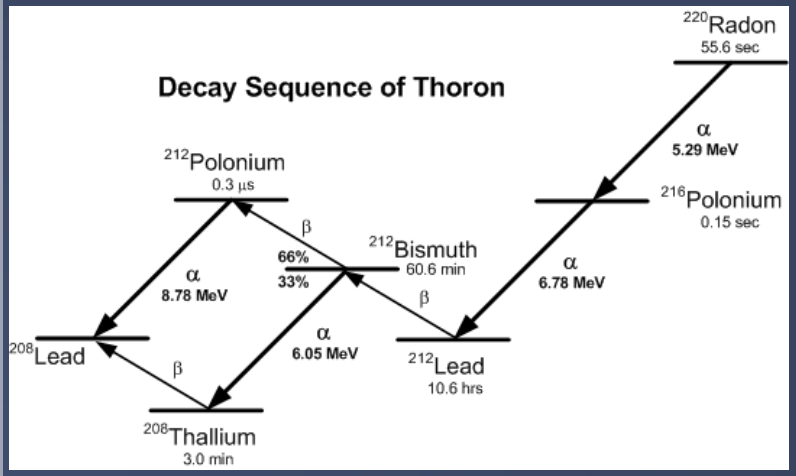
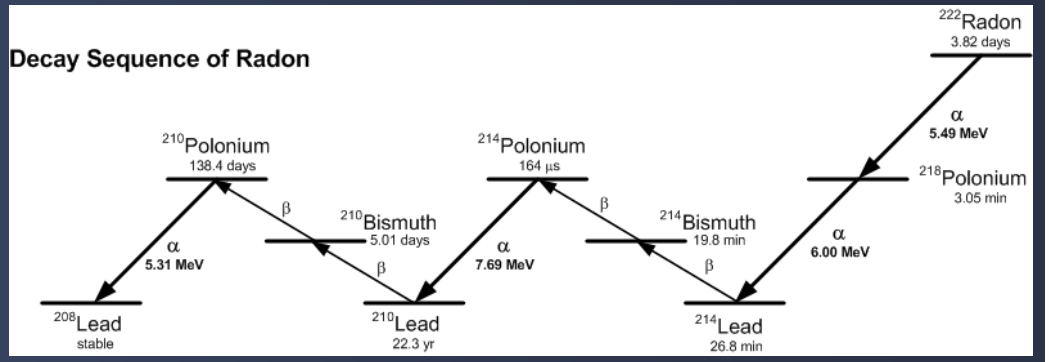
Long run in the mine









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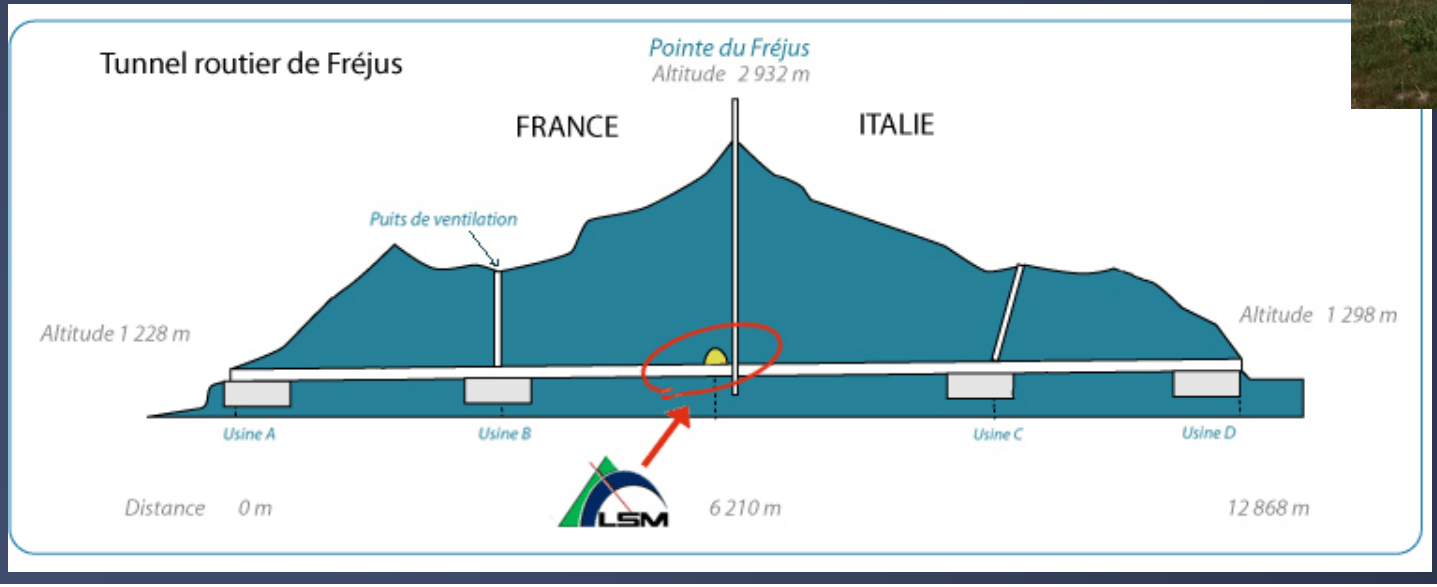
Location 3: LSM (France)

- Location: Modane, France
- ~1780 meters beneath an alp
- 4800 m.w.e



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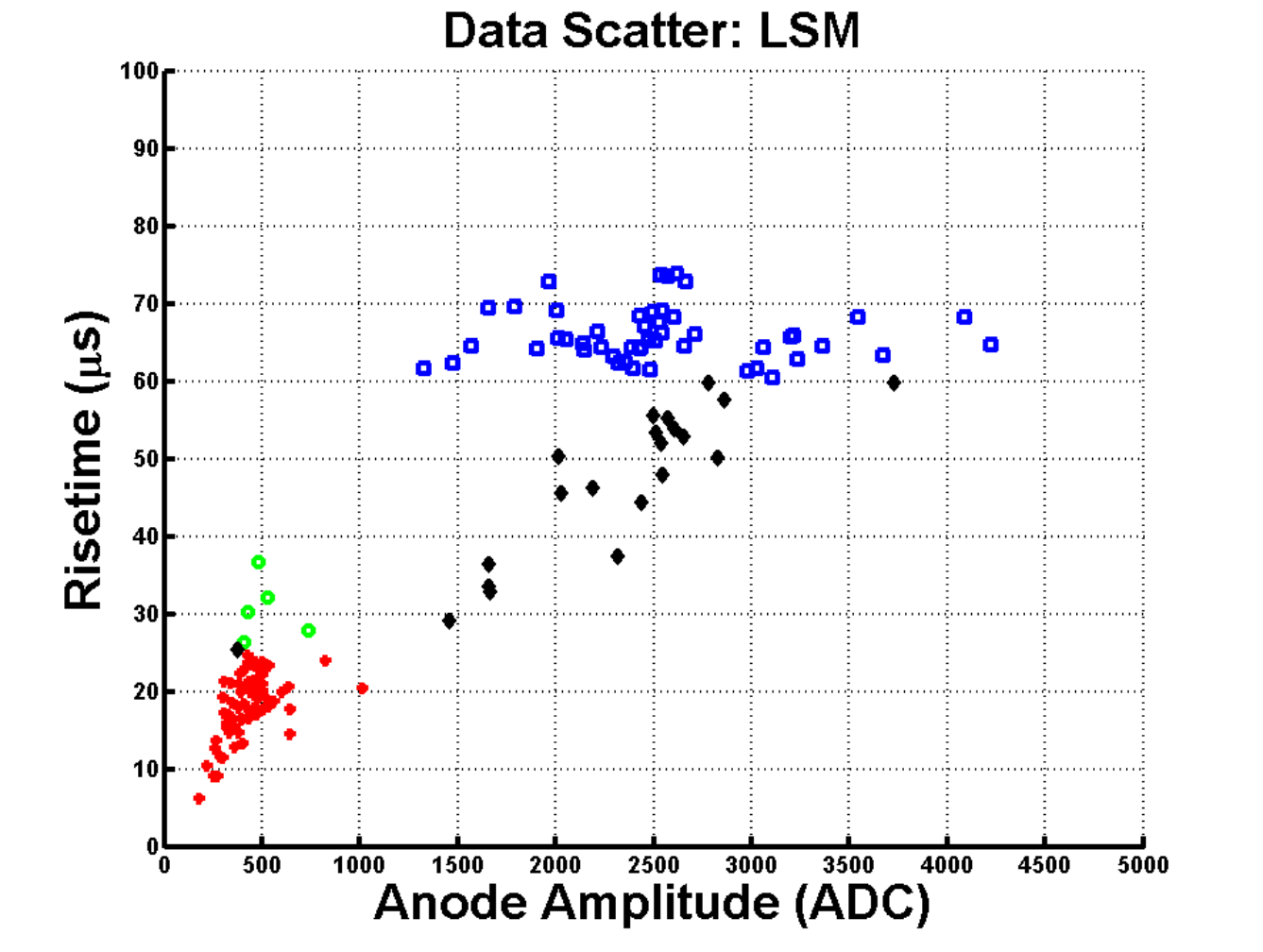
LSM: Results



Class	#
Alphas	50
Ceilings	65
Mids	22
Rounds	7

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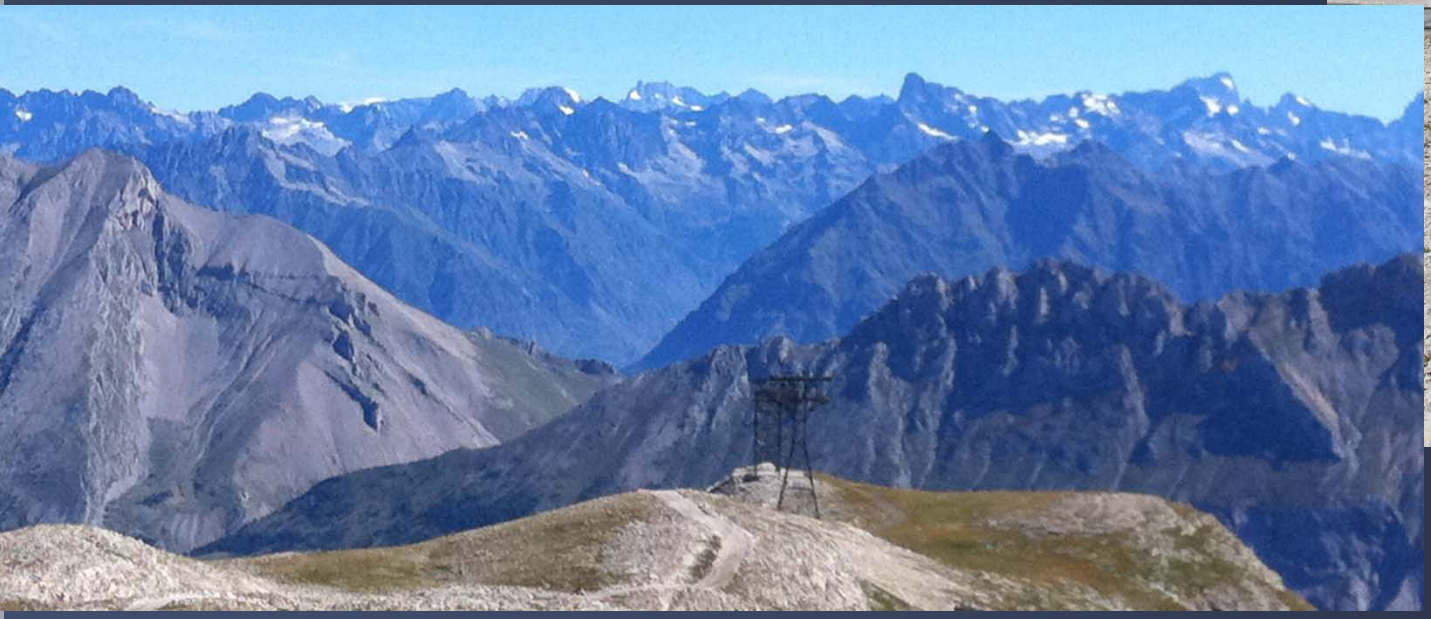
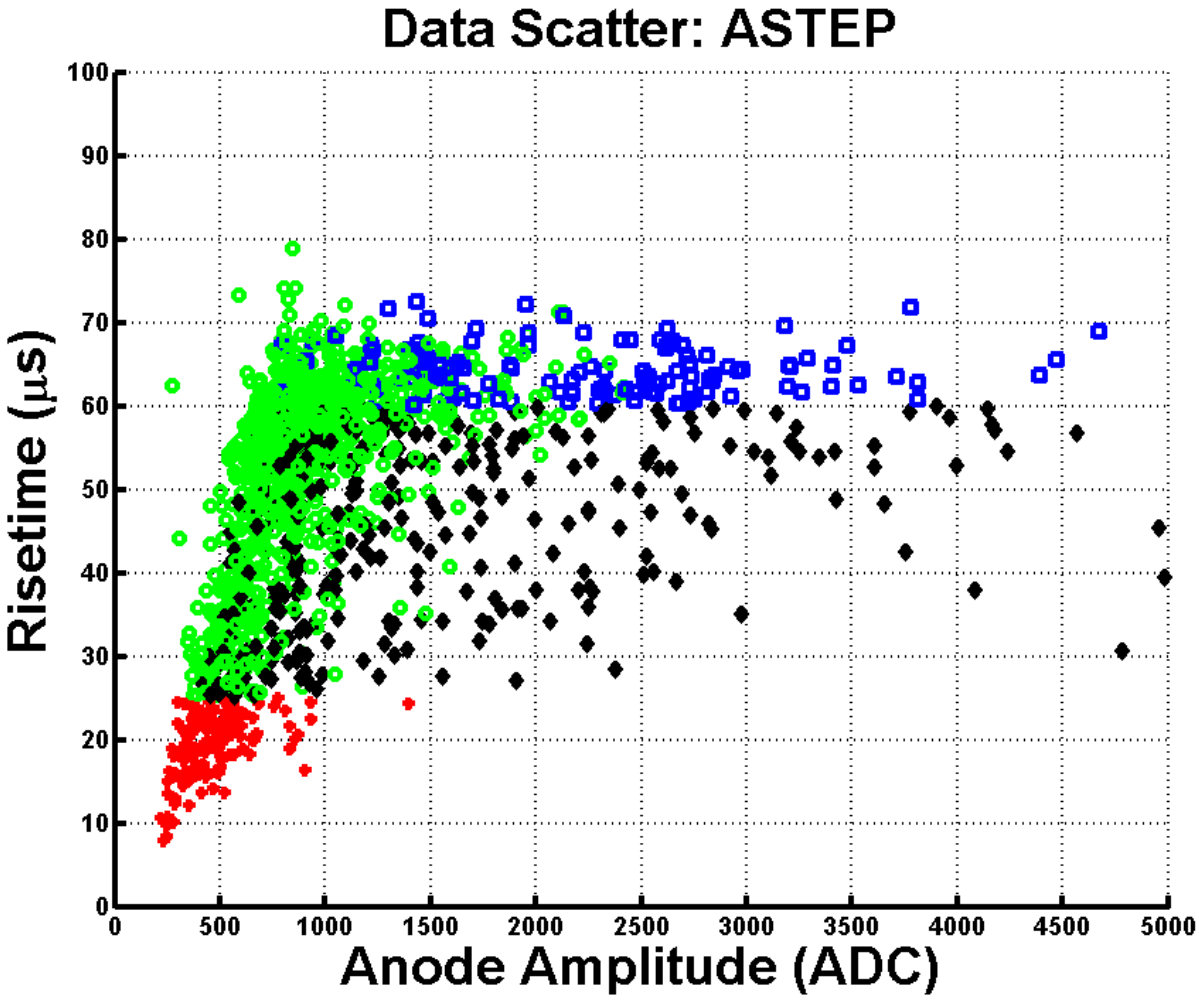
Location 4: ASTEP (France)

- Location: Plat. de Bure, France
- 2552 meters altitude
- Neutron acceleration factor (compared to NYC) = 6.45



ASTEP: Results



Class	#
Alphas	126
Ceilings	139
Mids	347
Rounds	882

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Road Trip: Summary

Location	Depth	Alphas	Ceilings	MidAirs	Rounds
XIA	0 m	93	71	92	286
Stanford	- 17 mwe	62	49	17	19
Soudan UL	- 2060 mwe	58	37	35	2
LSM	- 4800 mwe	50	65	22	7
ASTEP	+ 2552 m	126	139	347	882

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Road Trip: Conclusions

- Clear cosmogenic component
  - Many can be identified
  - Those which can't have estimated contrib. level of ~ 0.2 α/khr/cm2 (@ sea level), below 3MeV
- Counter well sealed from external environment
- Internal components of counter generating ^{220}Rn (~0.005 Bq/m3, 1000x below amb.)
  - Estimated contrib. level of ~ 0.3 α/khr/cm2

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Next steps

- Cosmics – not much we can do
  - *Don't run your counter on a mountain top!*
- Radon – In new counter (coming soon), strict component material analysis & construction techniques

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Summary

- Instrument background is critical when measuring low activity samples
- XIA's approach drives down background
  - Shortening required counting times
  - Reducing sources of measurement error
- We have identified two additional sources (which affect *all gas-type* ionization counter technologies)

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Thank you

- CDMS group – Stanford University
- Bill Miller & Univ Minnesota – Soudan UL
- Jean-Luc Autran & IM2NP – ASTEP and LSM

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