Preliminary Results from the AlCap Experiment

John R Quirk on behalf of AlCap
DPF: Particle Detectors
2 Aug 2017

TOC

- Motivation for AlCap (COMET/Mu2e)
- Setup of AlCap
- Work packages and runs
- Analysis Update

COMET/Mu2e

- Search for neutrinoless muon-electron conversion in the presence of a nucleus

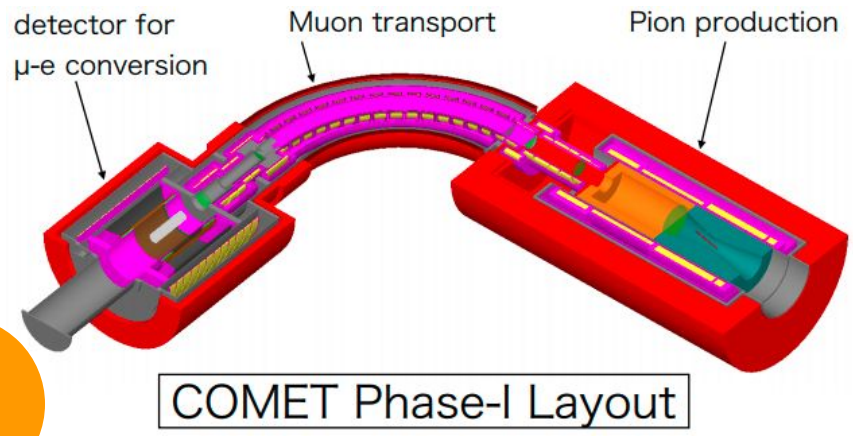
$$\mu + N \rightarrow e + N$$

- An example of charged lepton flavor violation (CLFV), indicative of BSM physics

$$\mathrm{SES}(\mu \rightarrow e) = 3.0 \times 10^{-17}$$

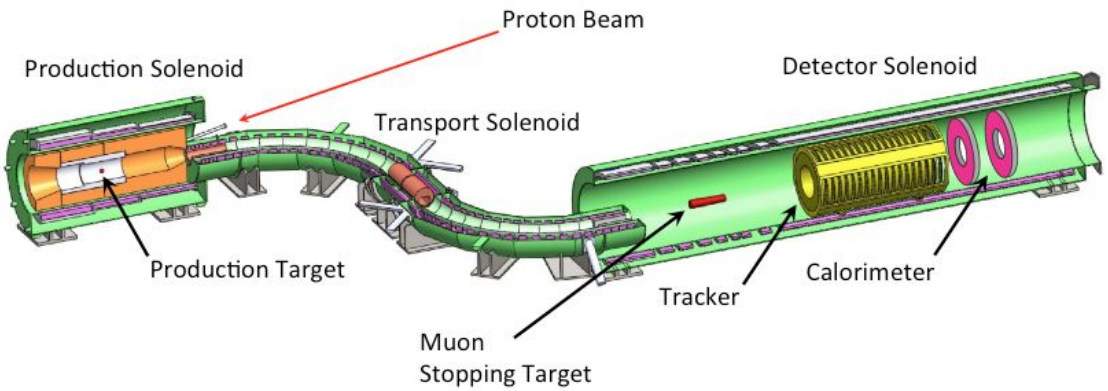
COMET/Mu2e Layout

COMET



STM

Mu2e



STM

Muonic Aluminum

- Atomic capture

$$\mu + \mathrm{Al} \to \mu\mathrm{Al}$$

- Decay-in-orbit

$$\mu\mathrm{Al} \to \mathrm{Al} + e + \bar{\nu}_e + \nu_\mu$$

- Nuclear capture

$$\mu\mathrm{Al} \to N + \nu_\mu + p + n + \ldots$$

AlCap Motivation

- Damage
  - Memory corruption of electronics
- Noise
  - Heavy charged particle hits on tracker (*p, d, t, α*)
  - Neutron captures near detectors
- Normalization
  - Muonic X-rays
  - Muon nuclear capture γ-rays
  - Activation γ-rays

AlCap

Collaborative effort measuring the charged and neutral particle backgrounds impacting the COMET and Mu2e experiments, as well as evaluating normalization schemes under consideration.

AICap Institutions

COMET

Mu2e

Imperial College London

BERKELEY LAB

BROOKHAVEN NATIONAL LABORATORY

大阪大学 OSAKA UNIVERSITY

UCL

W

Institute of High Energy Physics
Chinese Academy of Sciences

Fermilab

Argonne NATIONAL LABORATORY

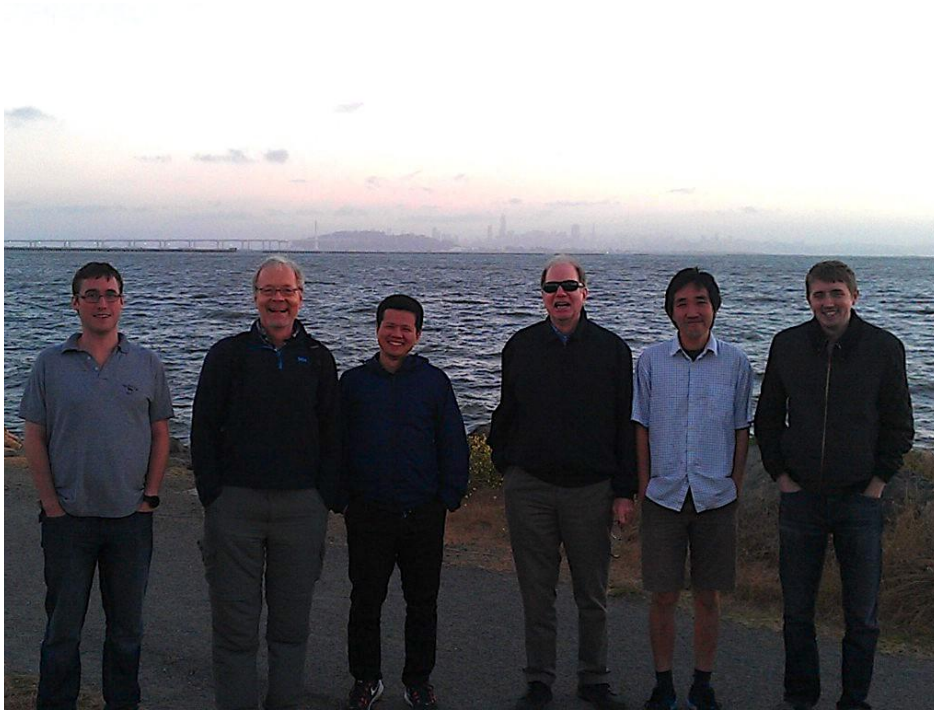
INFN

BOSTON UNIVERSITY

(Some of the) AlCap Collaboration

Third run @ PSI

Col. Meet. @ LBNL



Experiment Organization

Work Packages

- WP1: Charged Particle Spectra
  - *p*, *d*, *t* noise
- WP2: *X*/γ-rays
  - Normalization
- WP3: Neutrons
  - Backgrounds, damage

Run Schedule

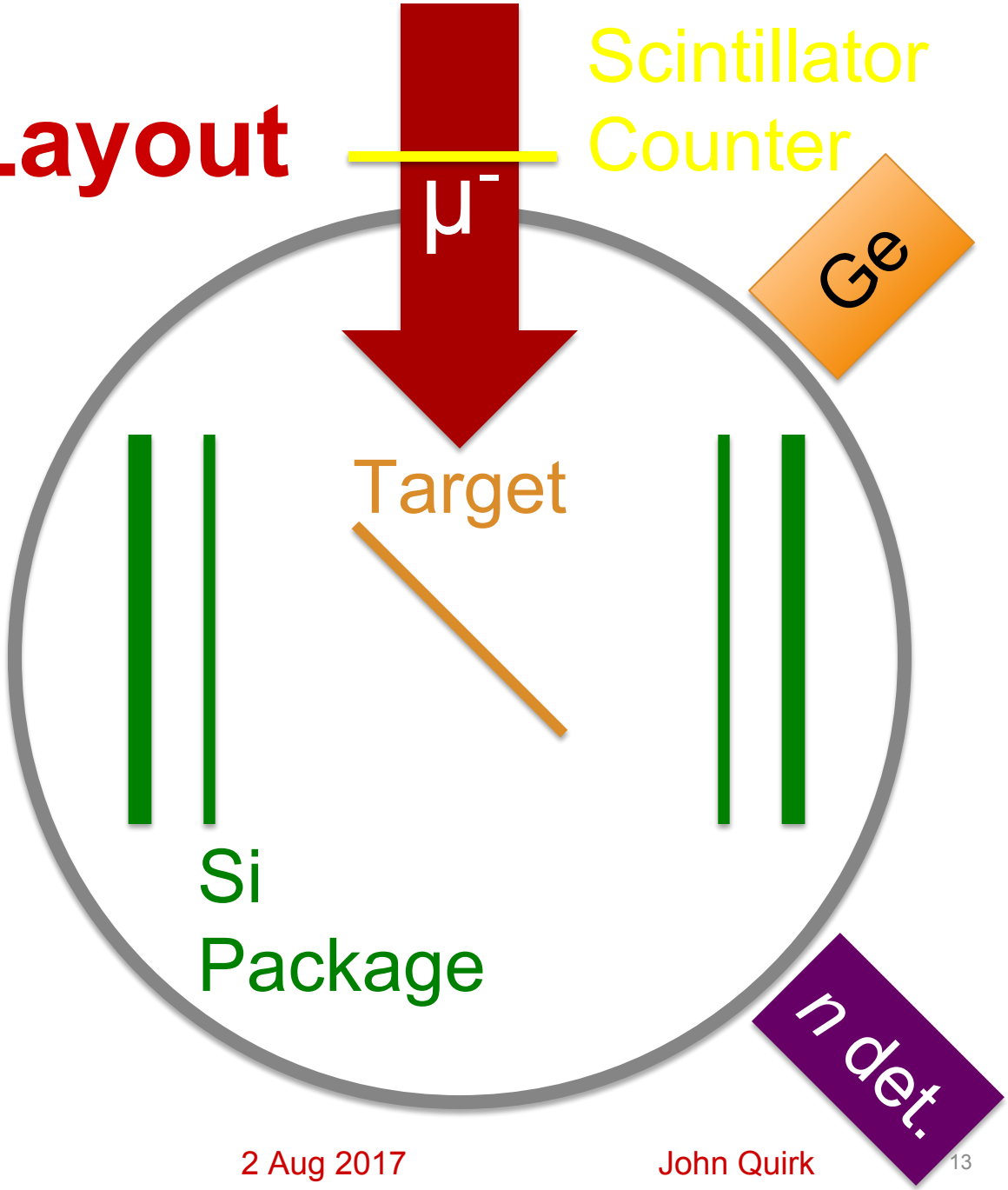
- R2013: Completed
  - Dec 2013
  - WP 1, 2, 3
- R2015a: Completed
  - Jun 2015
  - WP 2, 3
- R2015b: Preparation
  - Nov 2015
  - WP 1, 2

Target Materials

R2013	R2015a	R2015b
• Al	• Al	• Al
• Si (passive)	• Ti	• Ti
	• Pb	• Si (active)
	• SS	
	• H20	
	• Mylar	

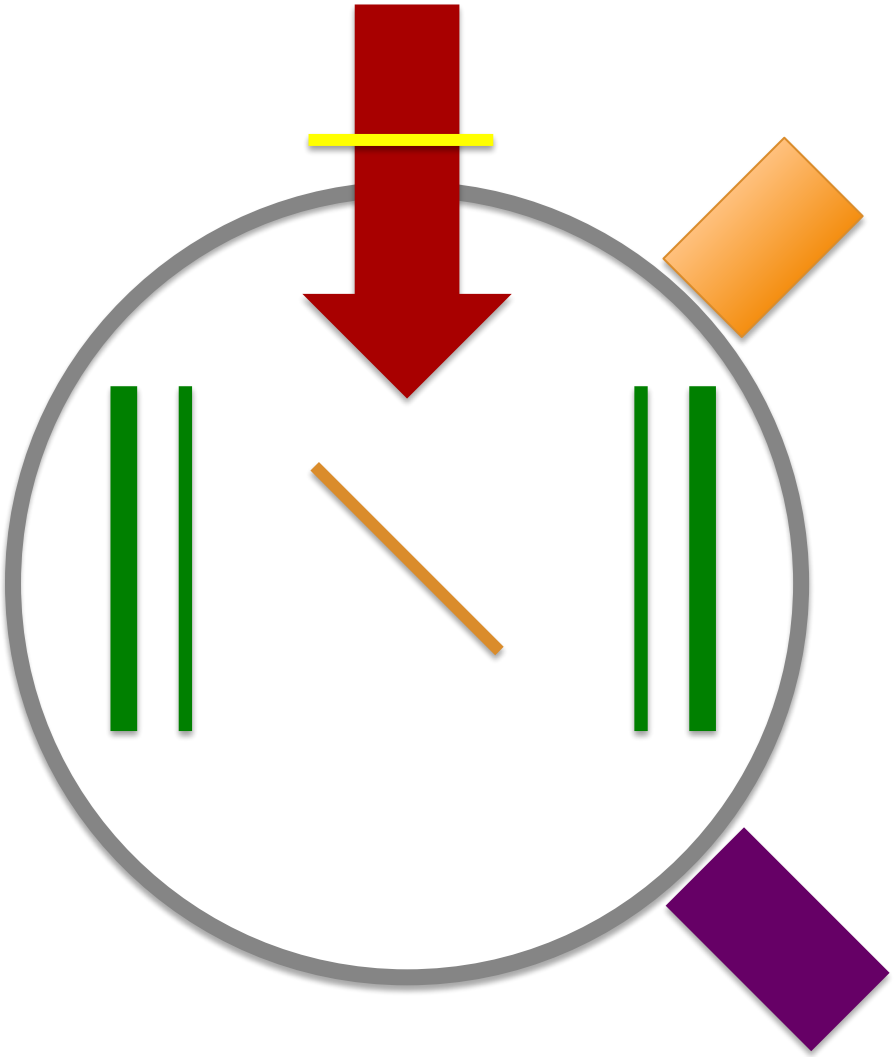
Multiple target thicknesses and beam momenta

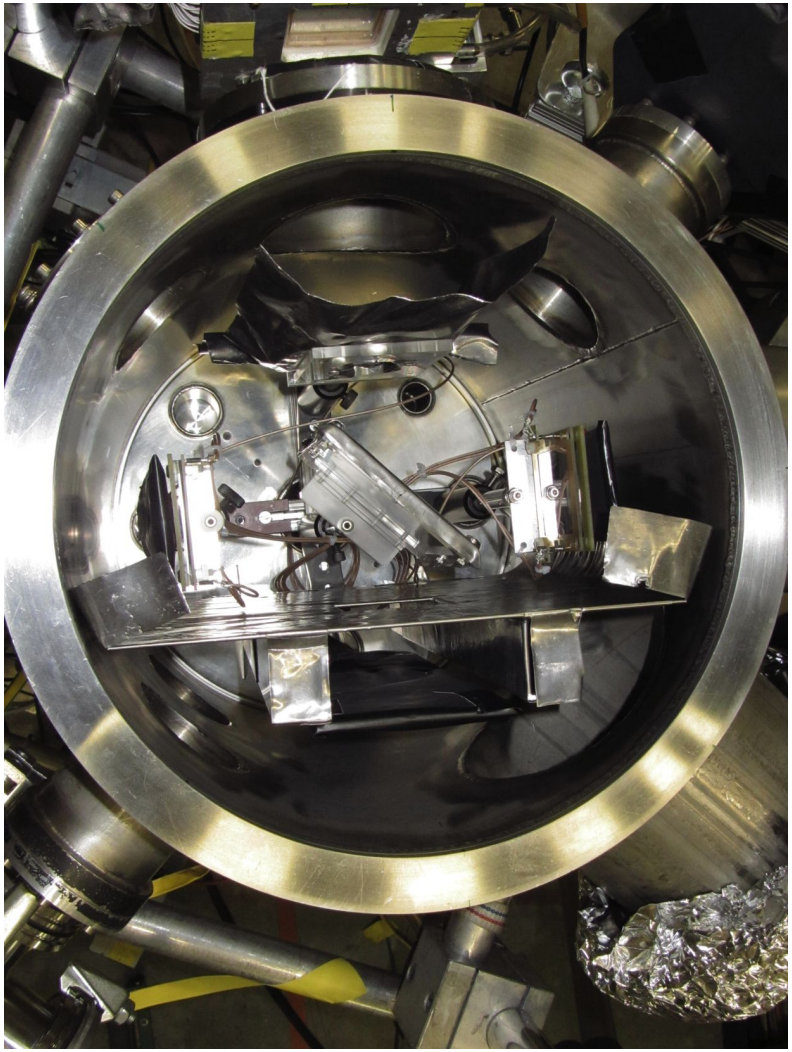
R2013 Layout



SS Vacuum
Chamber
Ø = 30 cm
h = 60 cm

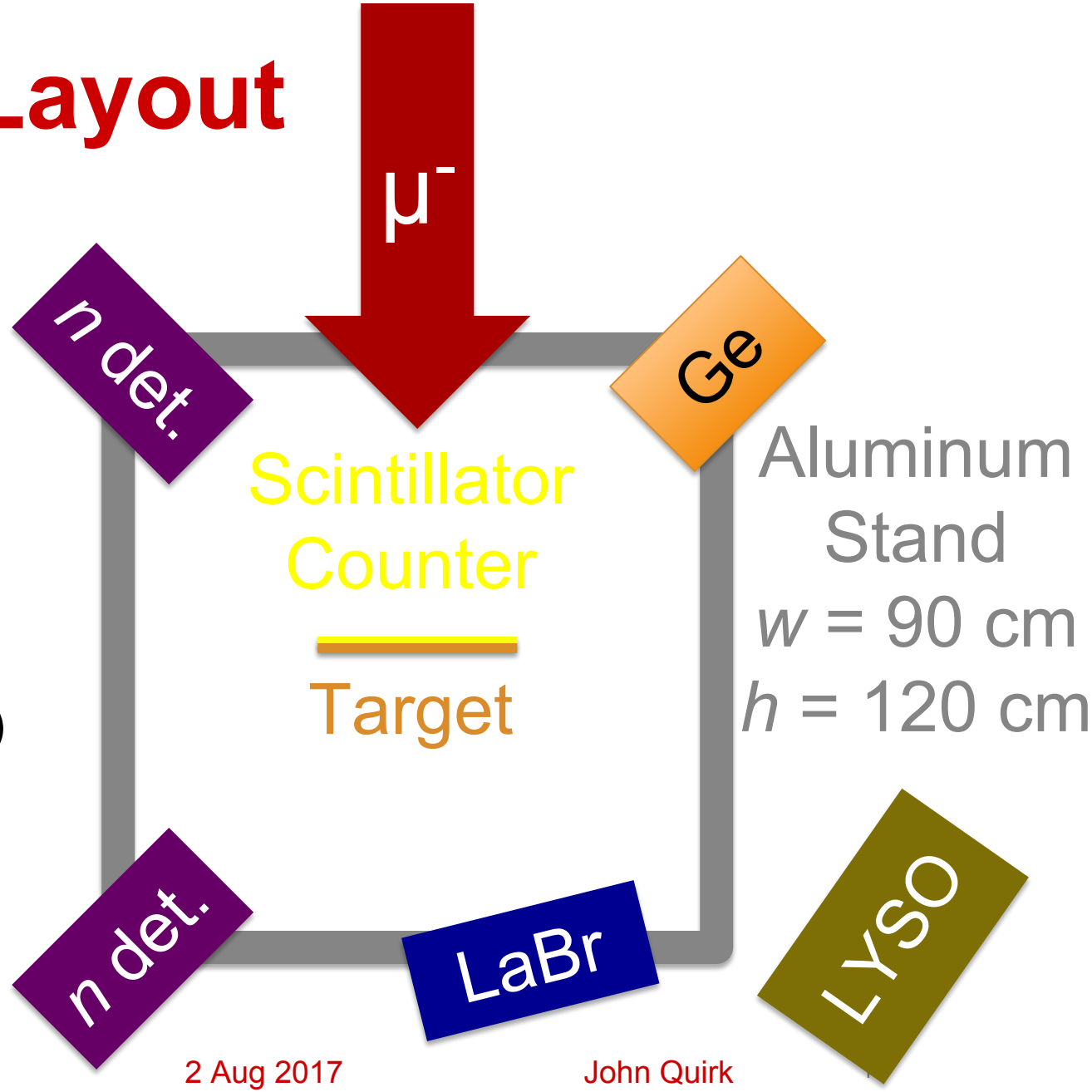
R2013 Setup



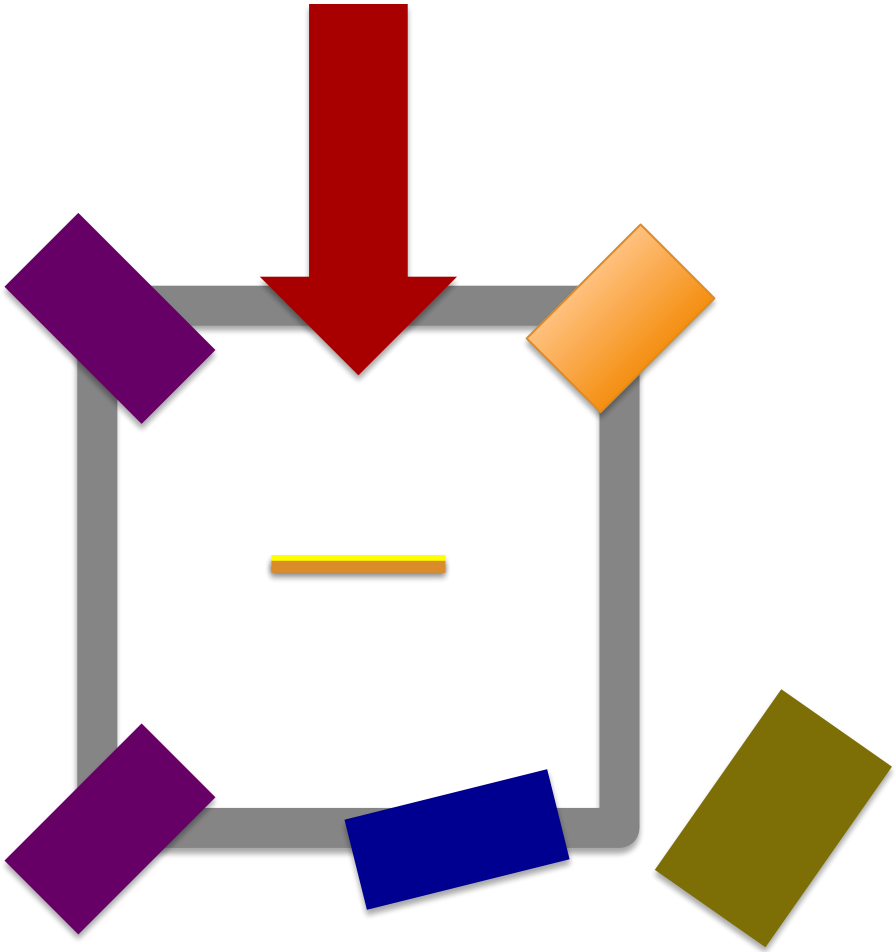


R2015a Layout

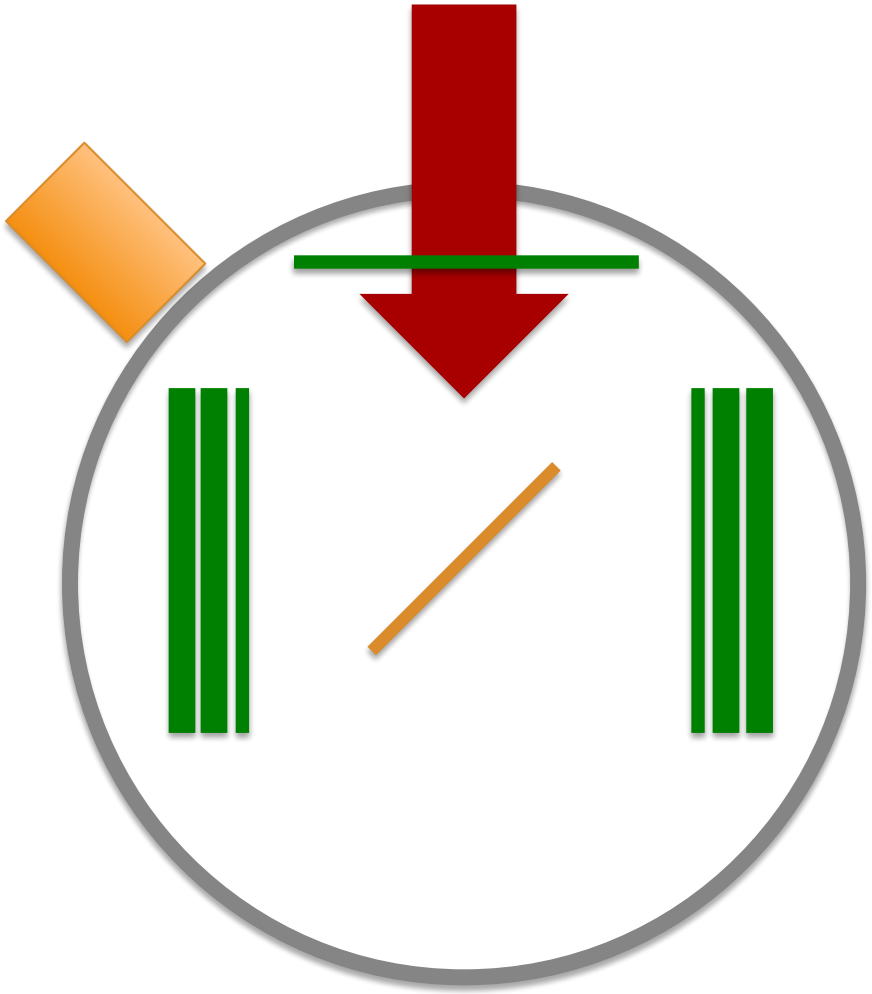
- No vacuum chamber (neutrals only)
- No Si detectors
- Extra *n* detector
- New Ge detector
- Added LaBr(Ce) and LYSO detectors

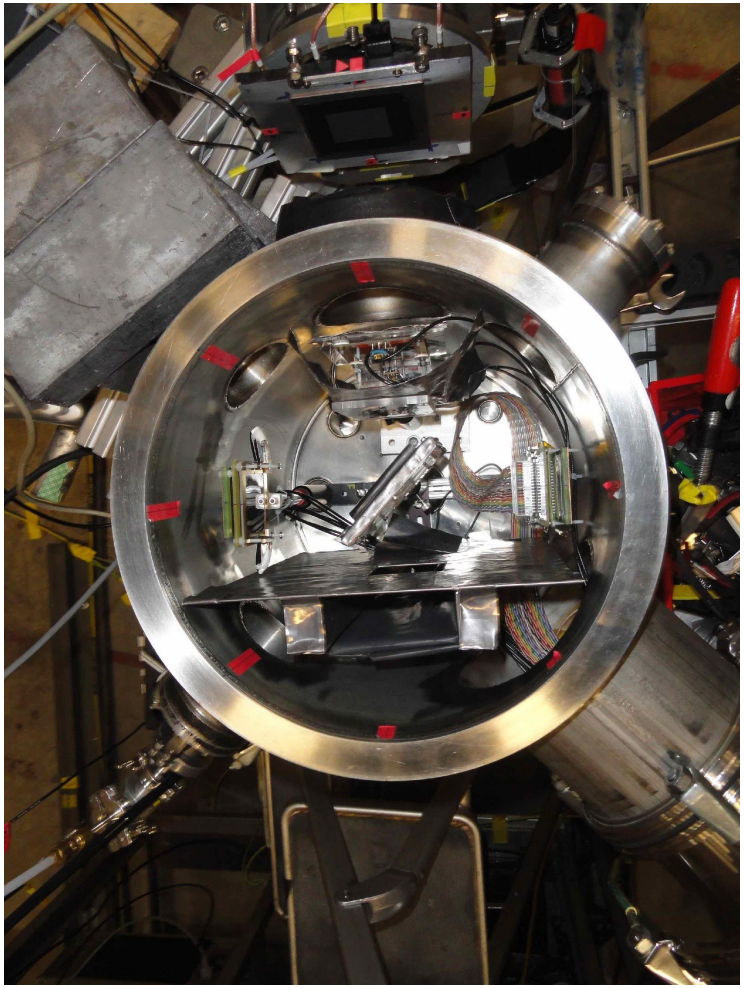


R2015a Setup

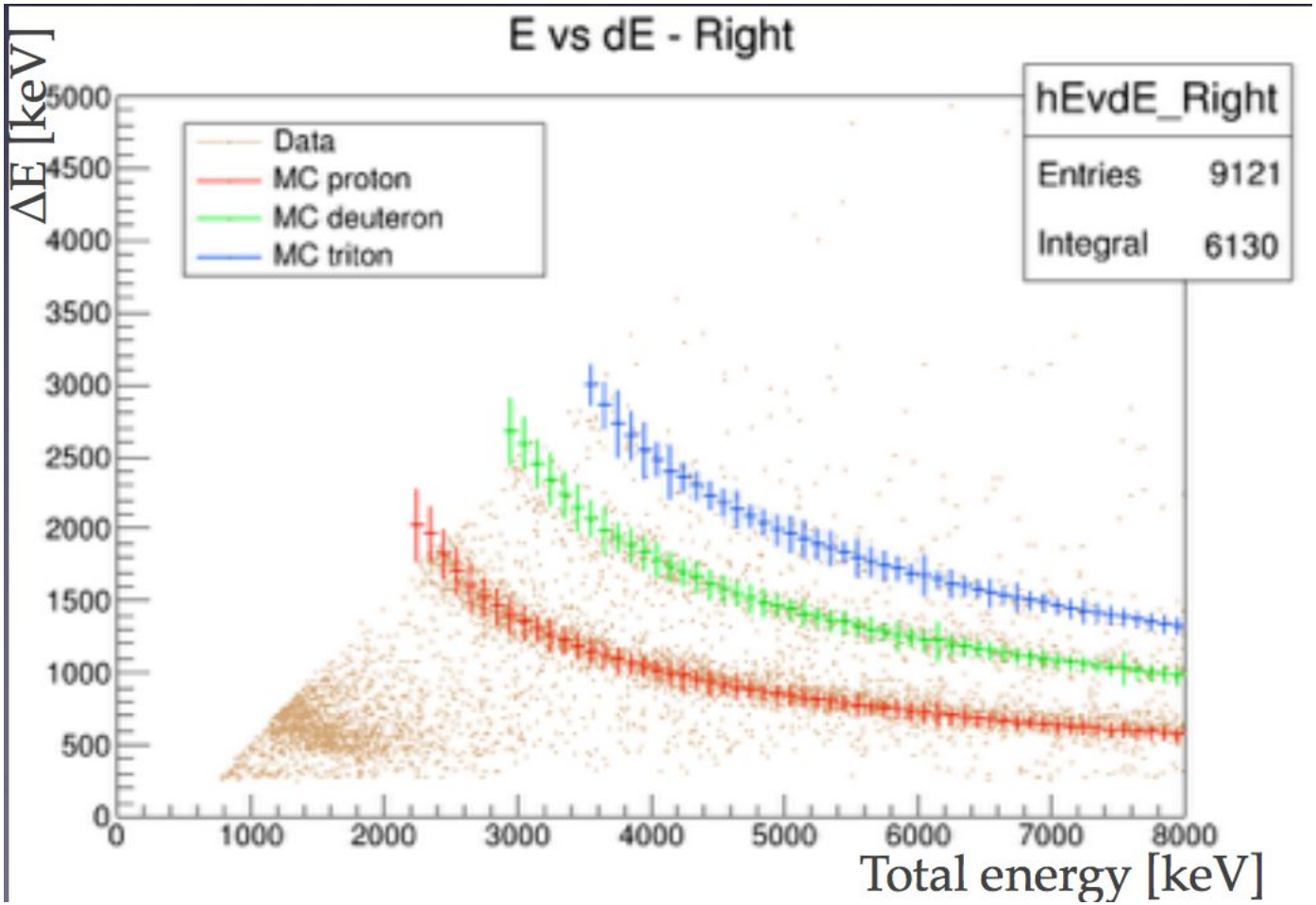


R2015b Setup



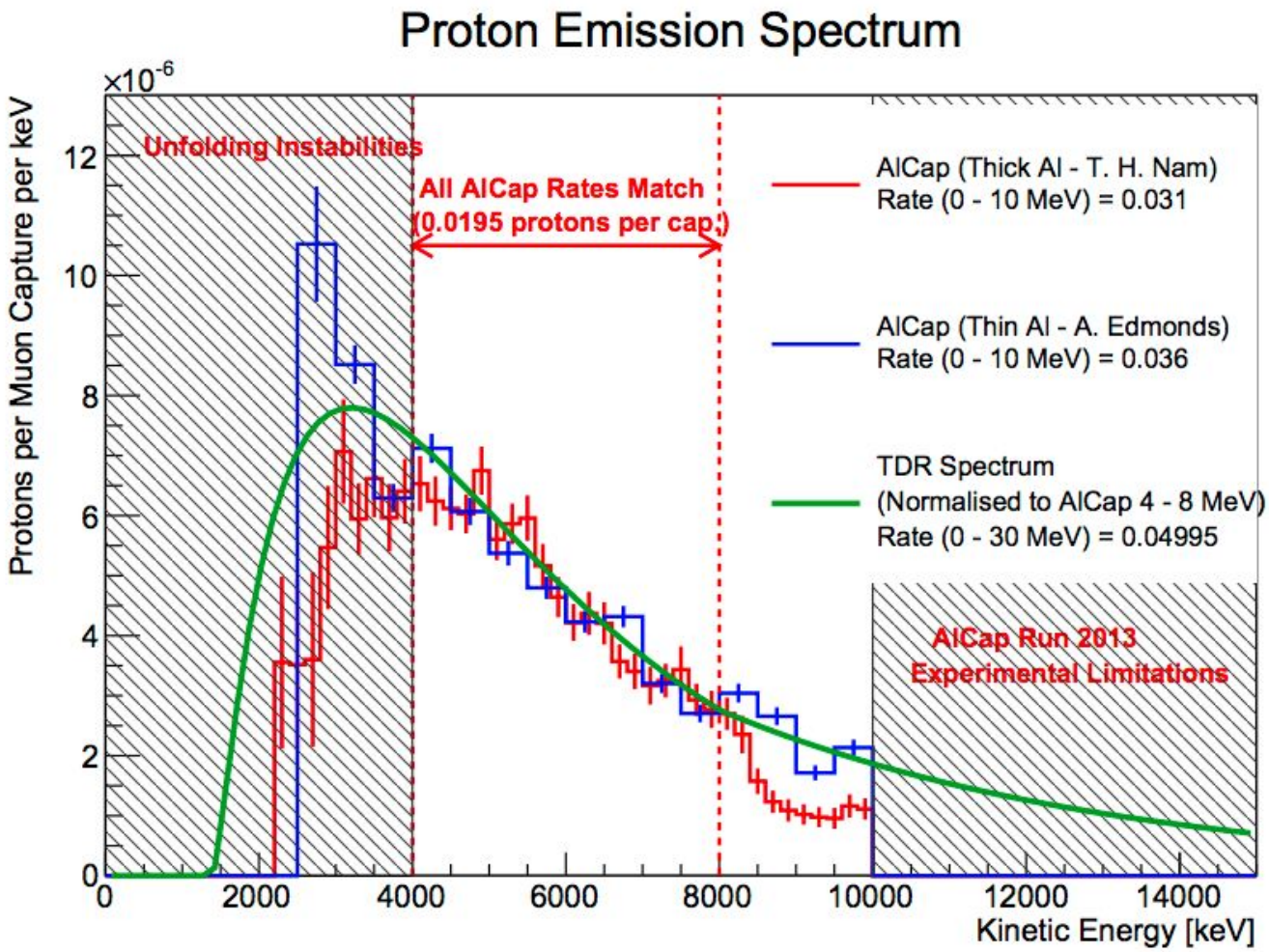


Charged Particle Status (R2013)



N. Tran
Thesis
2014

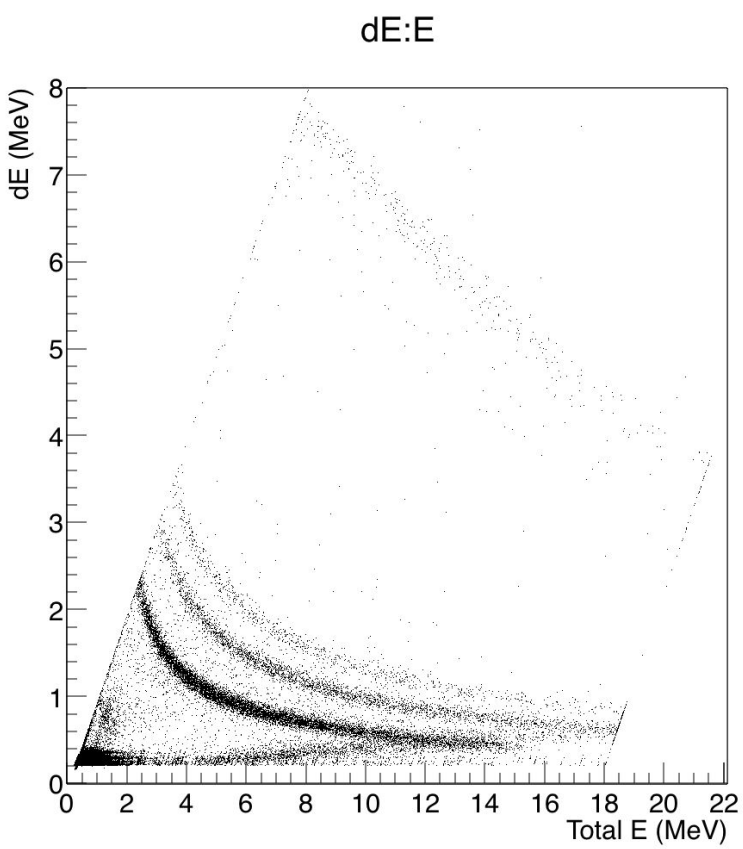
Charged Particle Status (R2013)



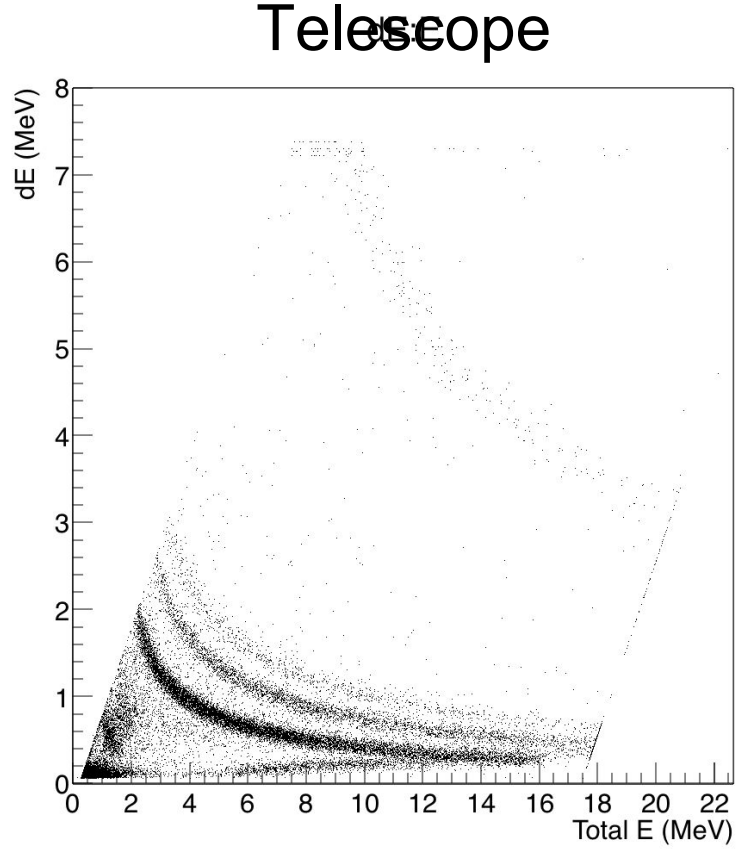
A. Edmonds
Preliminary
internal

Charged Particle (R2015b)

Left Si Telescope

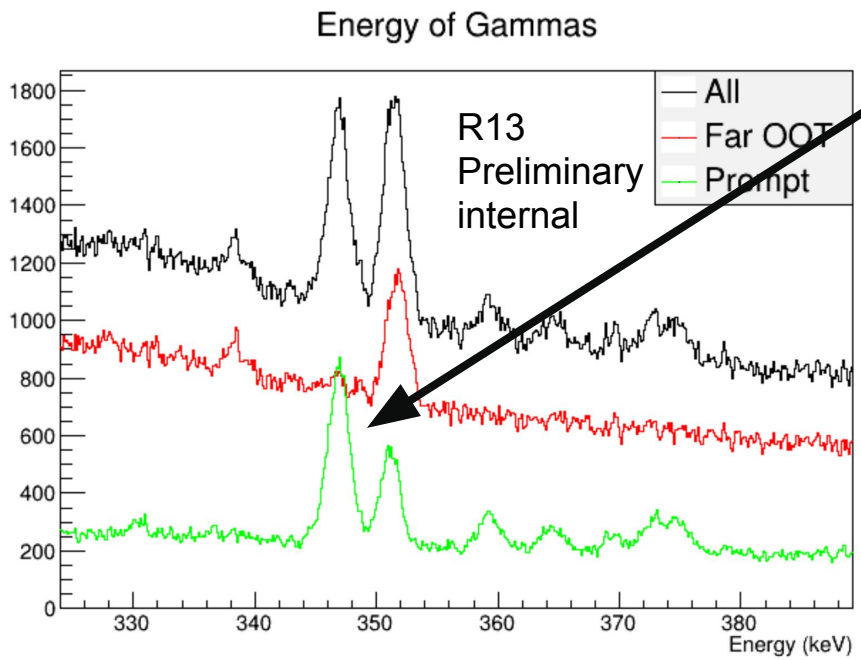


Right Si Telescope



M. Wong, Preliminary internal

Photon Status



- **X-ray** 347 keV muonic 2*p*-1*s* used for AlCap normalization
- **Capture Gamma** 1.8 MeV so far agrees with literature
- **Activation** 844 keV poor S/N, tough...

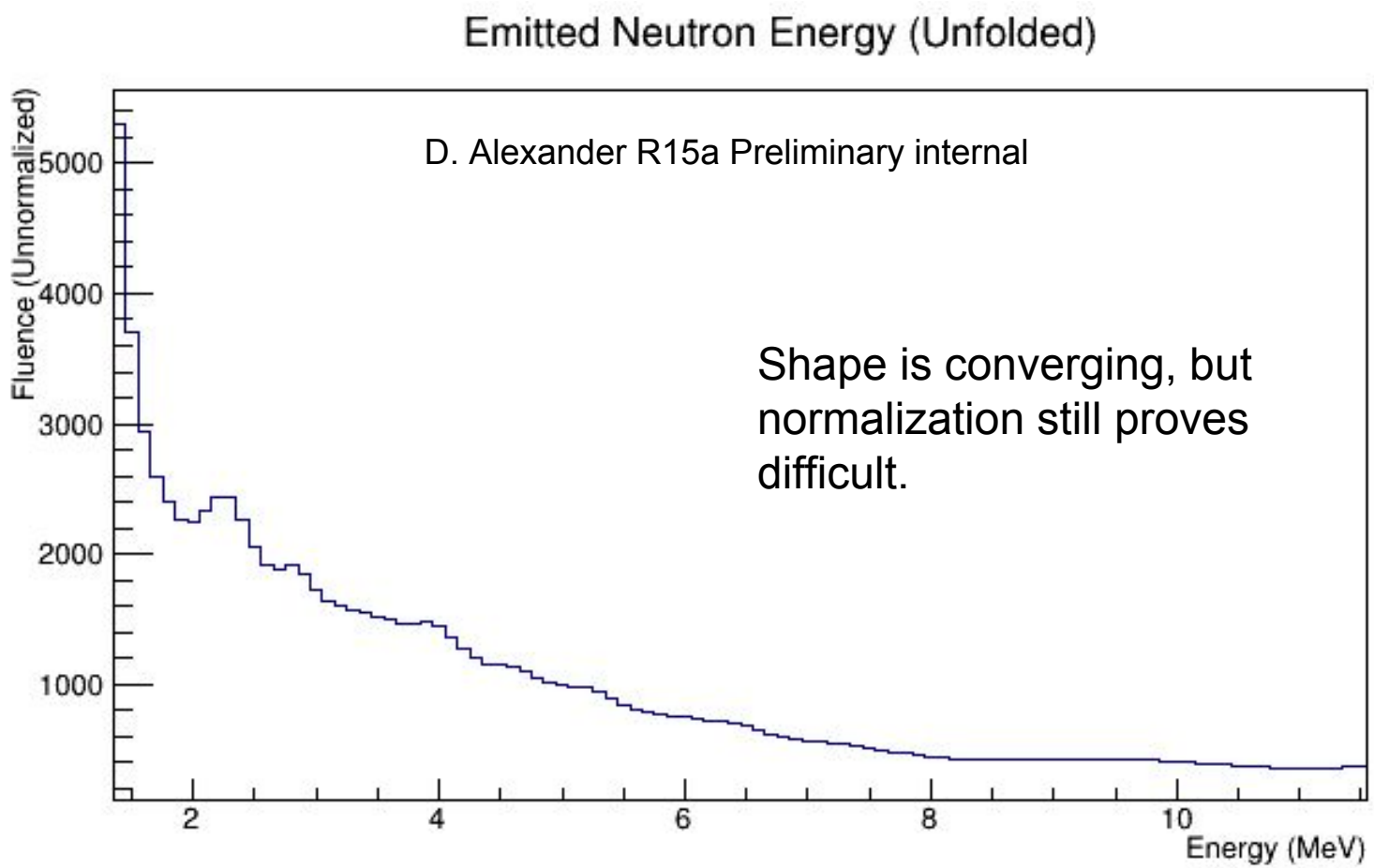
$$R_{1809} = \frac{16032.54}{1.57 \times 10^{-4} \times 3.30 \times 10^{8} \times 0.609} = 0.51 \pm 0.05$$

Detector acceptance

Al capture rate

N. Tran
R15a Preliminary
internal

Neutron Status (R2015a)



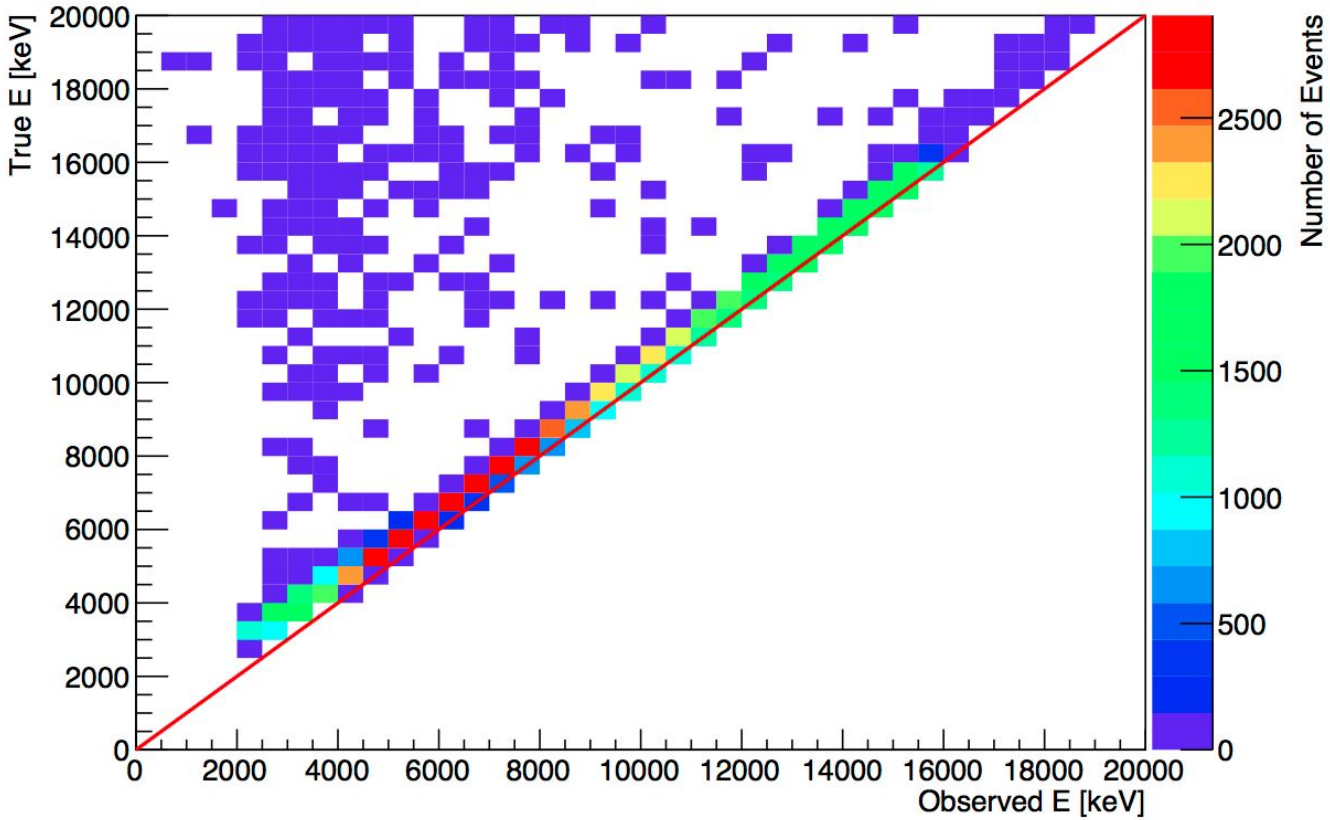
Shape is converging, but normalization still proves difficult.

Conclusion

1. Charged particle spectra for muonic Al, Ti, and Si
2. Neutron spectra for muonic Al, Ti
3. Gamma spectra for Al, Ti, Si, and more

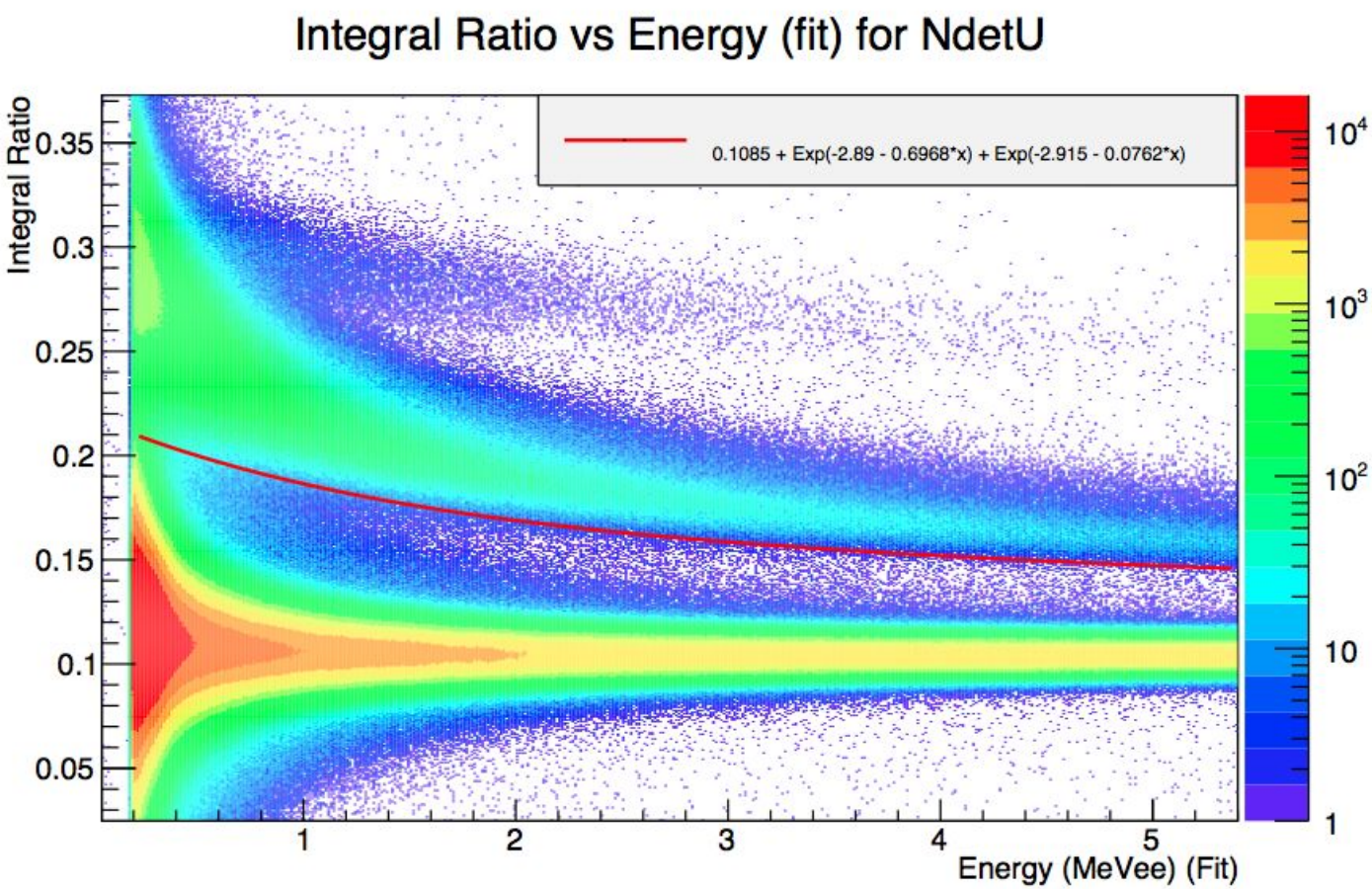
Halfway to publishable results, but preliminary results have already been impactful for COMET/Mu2e

Charged Particle Status (R2013)

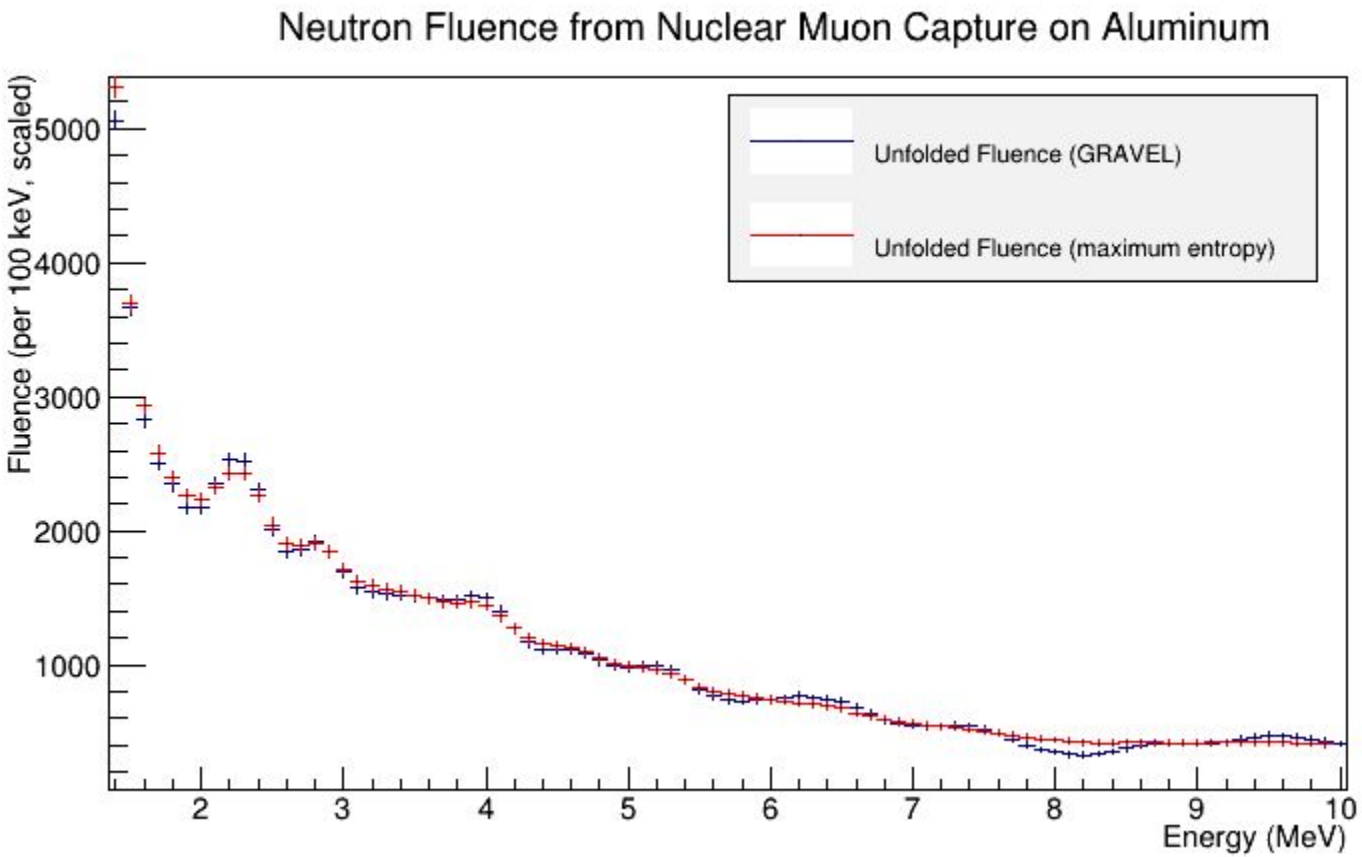


A. Edmonds
Thesis
2015

Neutron Status (R2015a)



Neutron Status (R2015a)



Neutron Status (R2015a)