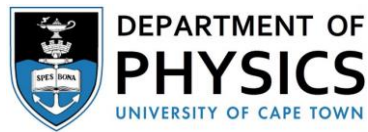


A COMPACT SCINTILLATION DETECTOR FOR MOBILE NEUTRON SPECTROSCOPY

Detecting neutrons in mixed fields over an energy range of 1 – 100 MeV

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3. INCAS³, Assen, NL

Overview

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- Neutron measurements
 - ▣ Dosimetry at high altitudes
 - ▣ Security and monitoring

Overview

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 - ▣ Dosimetry at high altitudes
 - ▣ Security and monitoring
- Detector
 - ▣ Requirements
 - Compact
 - Flexible acquisition
 - Low power

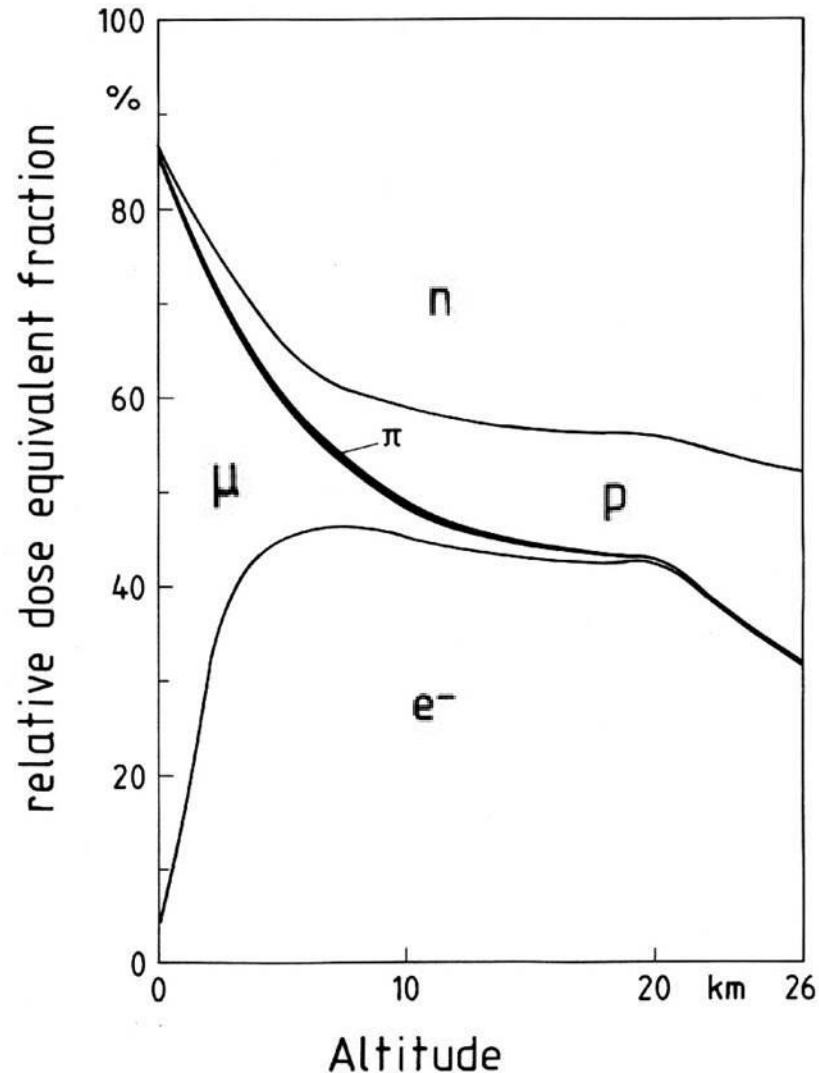
Overview

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- Neutron measurements
 - ▣ Dosimetry at high altitudes
 - ▣ Security and monitoring
- Detector
 - ▣ Requirements
 - Compact
 - Flexible acquisition
 - Low power
 - ▣ Solution
 - SiPMs + Plastic Scintillator
 - FPGA + ARM SoC

Neutrons at high altitudes

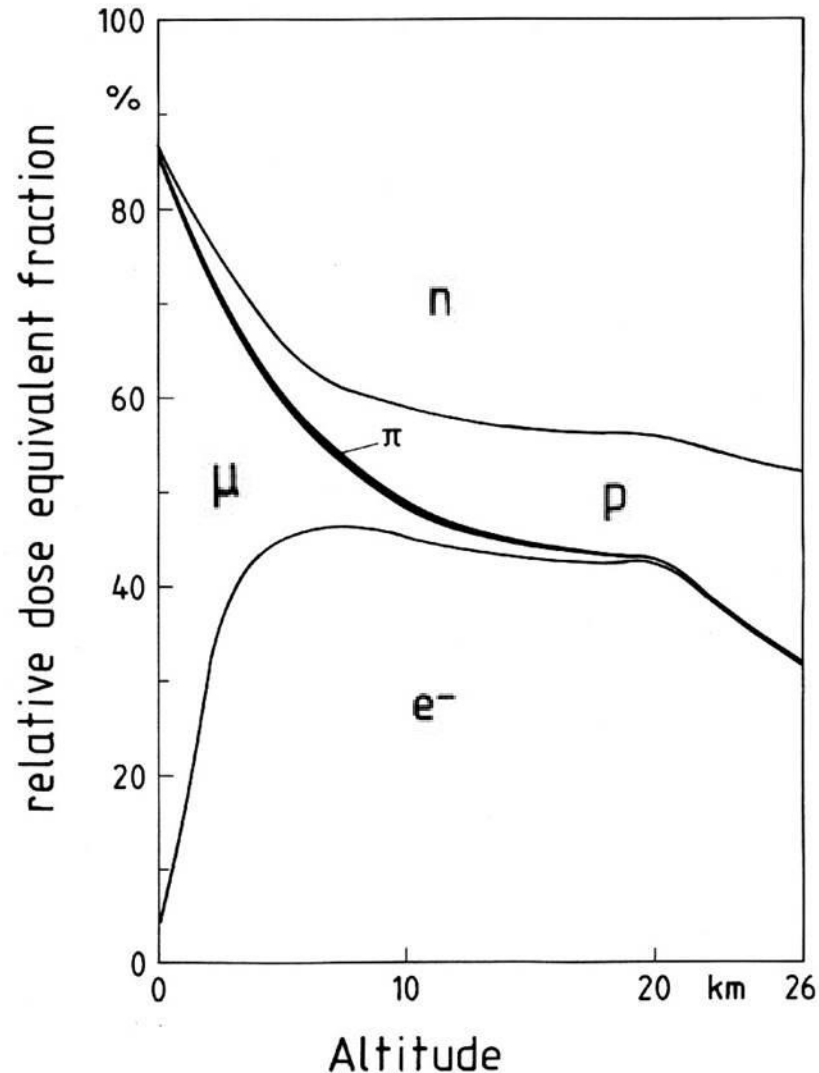
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□ Secondary radiation

Neutrons at high altitudes

3



- Secondary radiation
- >90% of neutron dose: $E > 1 \text{ MeV}$
- Peak at $\sim 100 \text{ MeV}$

Reactions in Organic Scintillators

4

- n-p scattering
 - ▣ Elastic
 - ▣ Dominant for $E < 20 \text{ MeV}$

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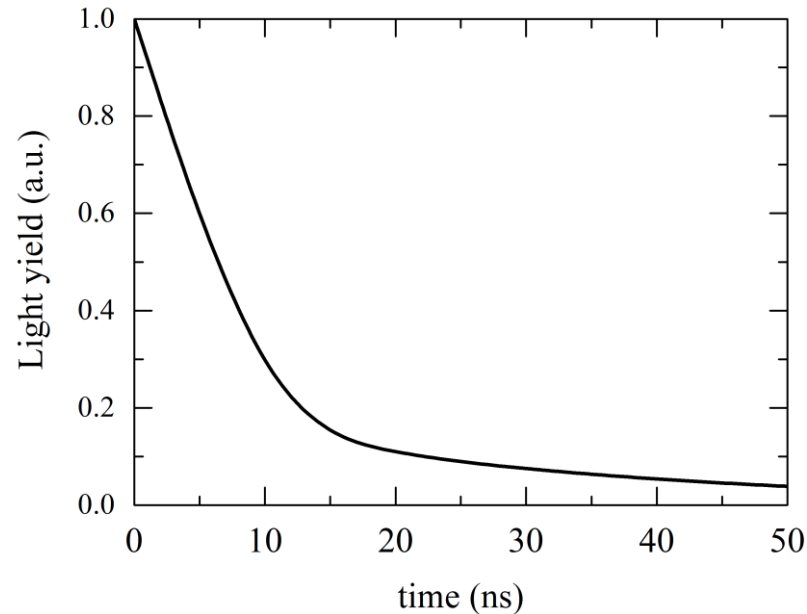
- Scintillation from charged particles

Pulse Shapes

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- Light output: Slow and fast decay components

$$L(t) \sim A \exp\left(-\frac{t}{\tau_F}\right) + \exp\left(-\frac{t}{\tau_S}\right)$$



Pulse Shapes (continued)

6

- A depends on charged particle dE/dx

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Pulse Shapes (continued)

6

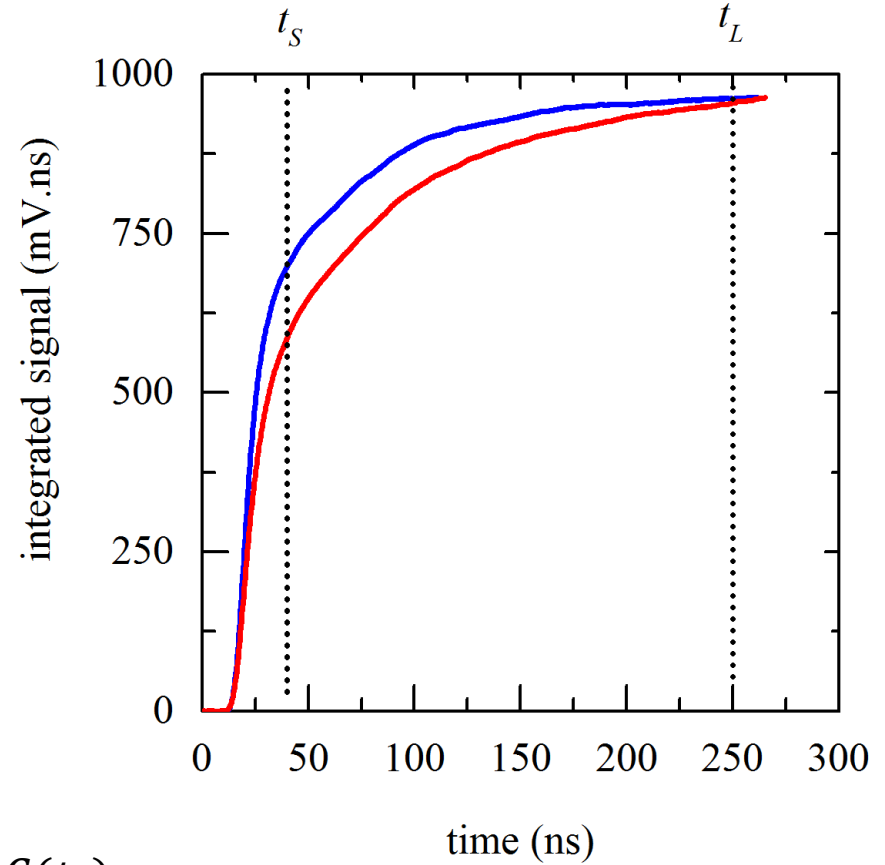
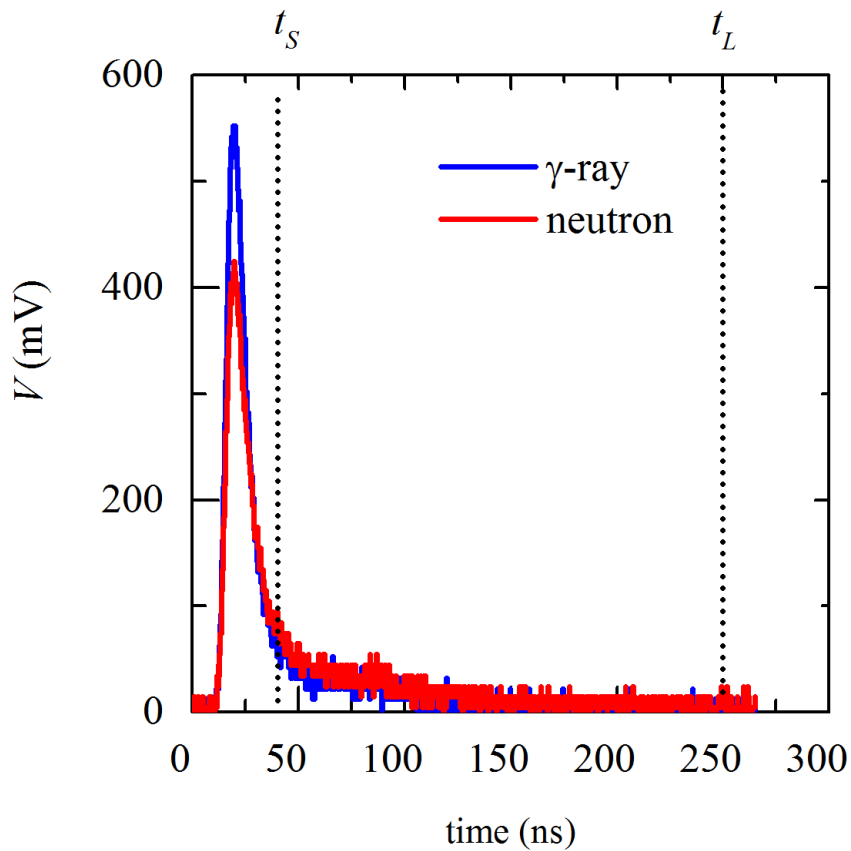
- A depends on charged particle dE/dx

$$L(t) \sim A \exp\left(-\frac{t}{\tau_F}\right) + \exp\left(-\frac{t}{\tau_S}\right)$$

- Pulse shape discrimination:
 - ▣ Pulse classification by particle type
 - ▣ Proton / electron \Rightarrow neutron / gamma
 - ▣ p / d, etc at higher energies

Charge Comparison PSD

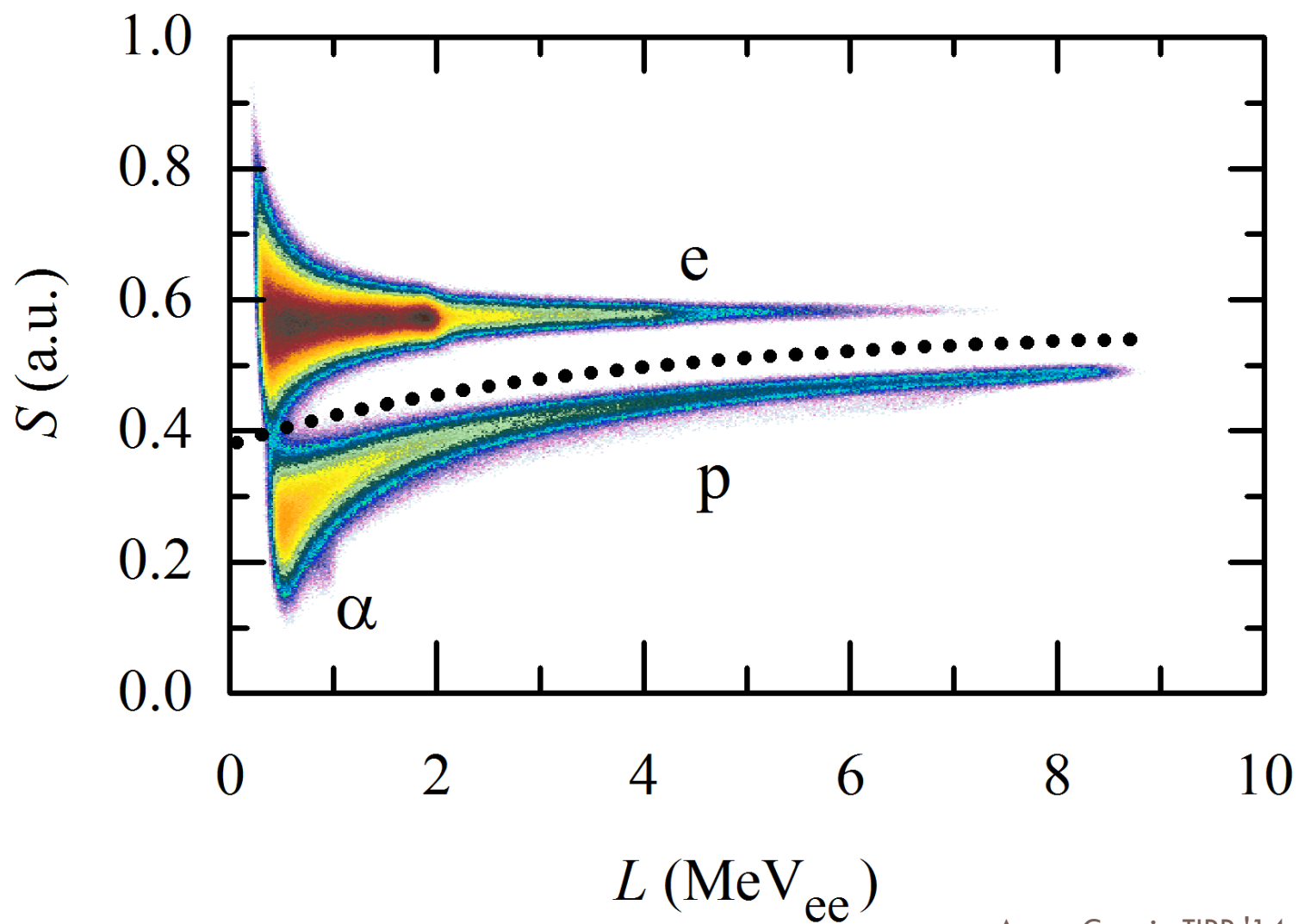
7



$$S = \frac{C(t_S)}{C(t_L)}$$

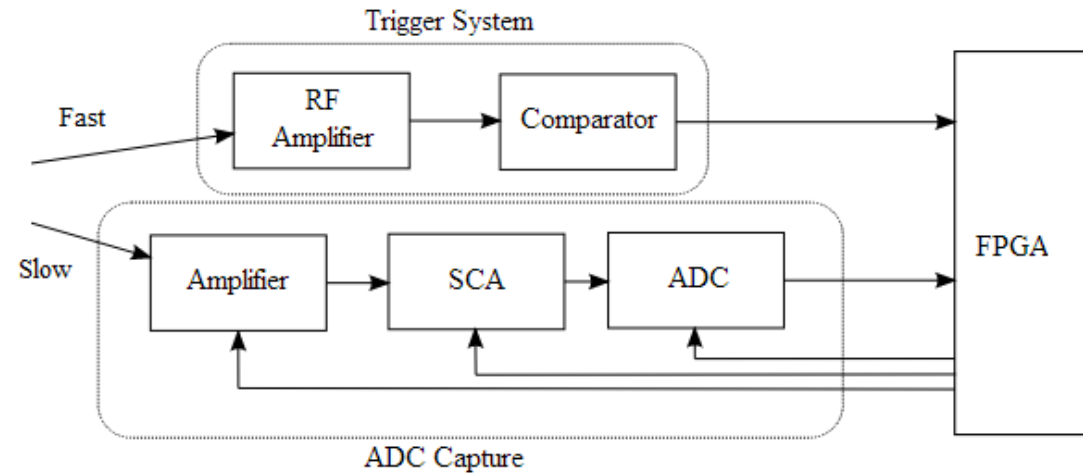
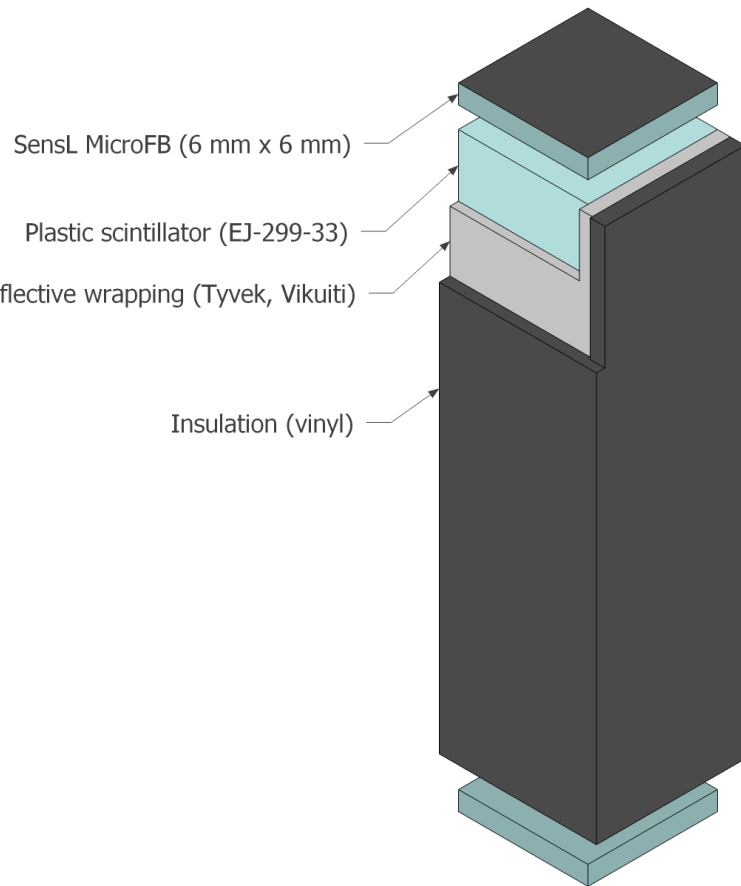
PSD: EJ-309 [liquid] & 14 MeV neutrons

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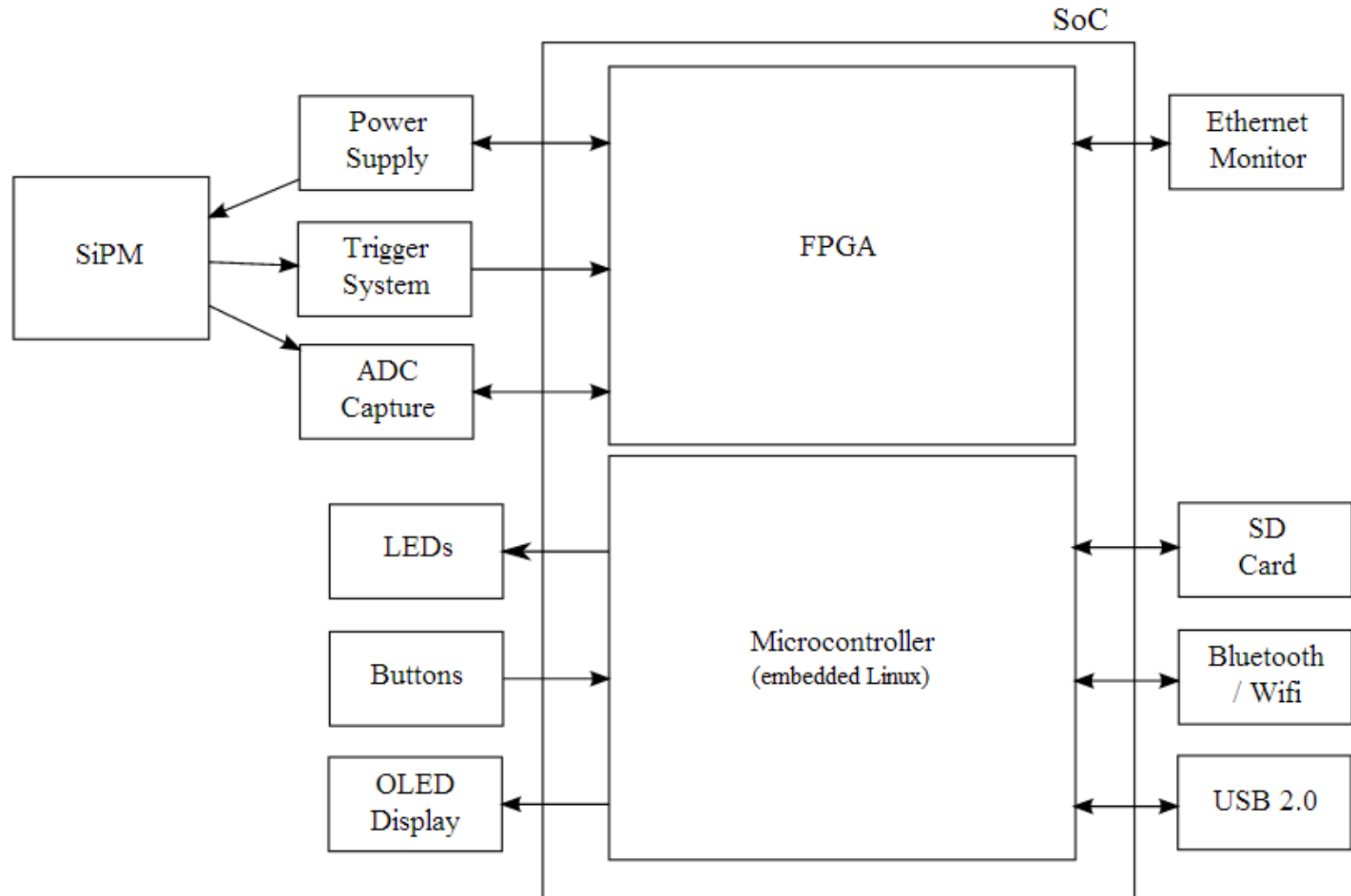
Detector Design

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Detector Design

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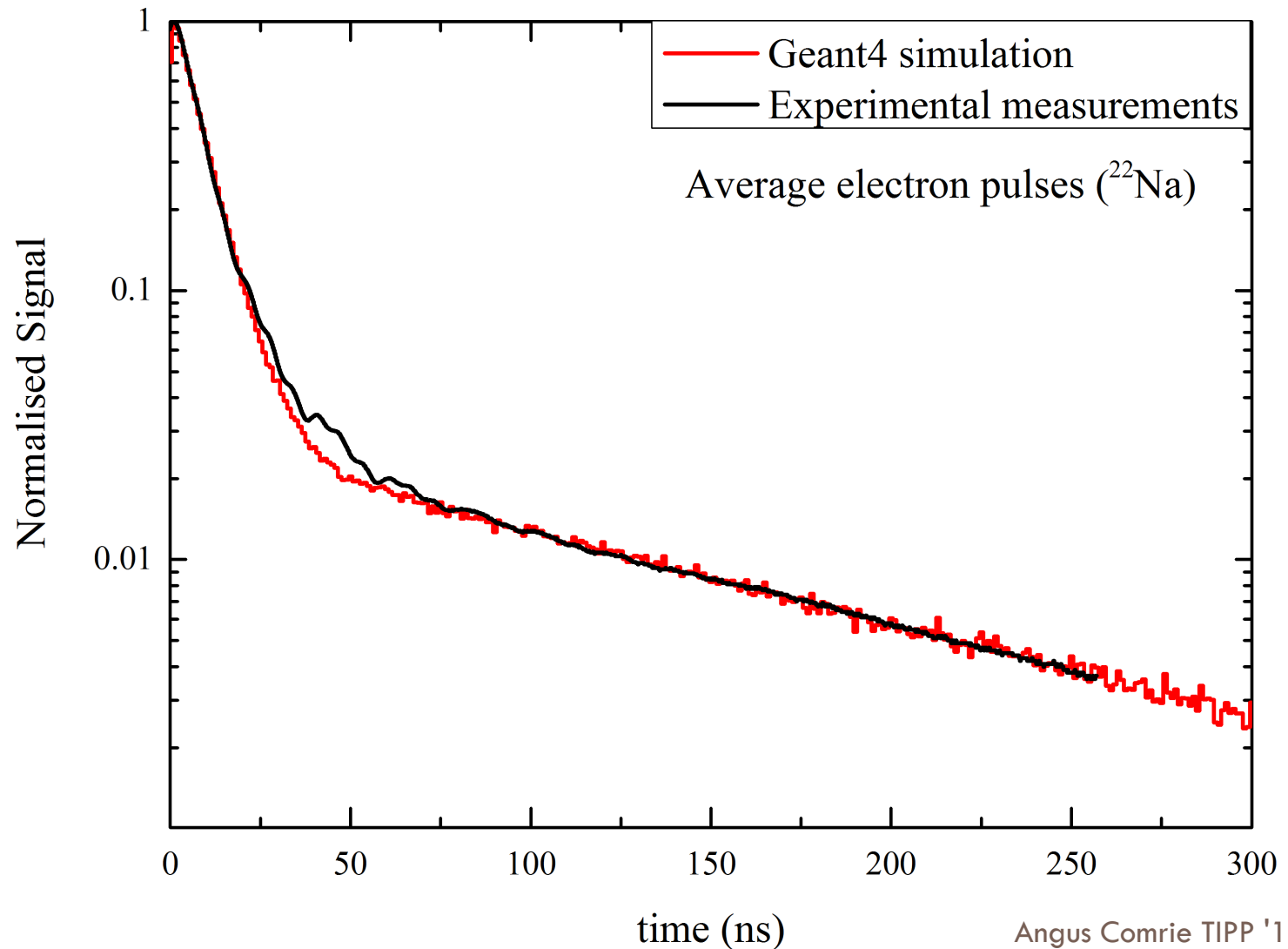
Detector Characterization

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- Geant4 simulation (n-p + optical, PMT)
- Low energy measurements
- High energy (cyclotron) measurements (to do)

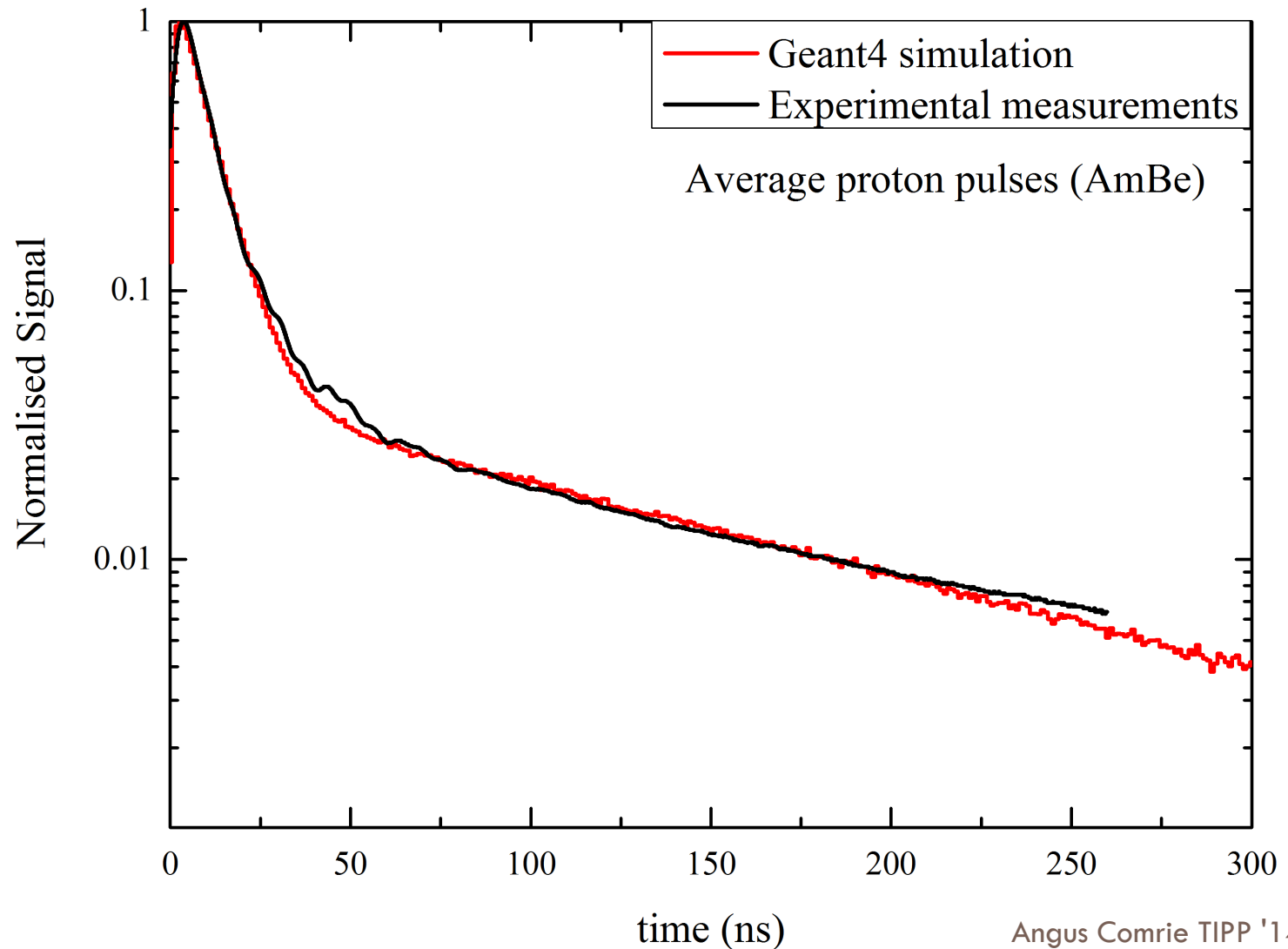
Simulation: Pulse shapes

12



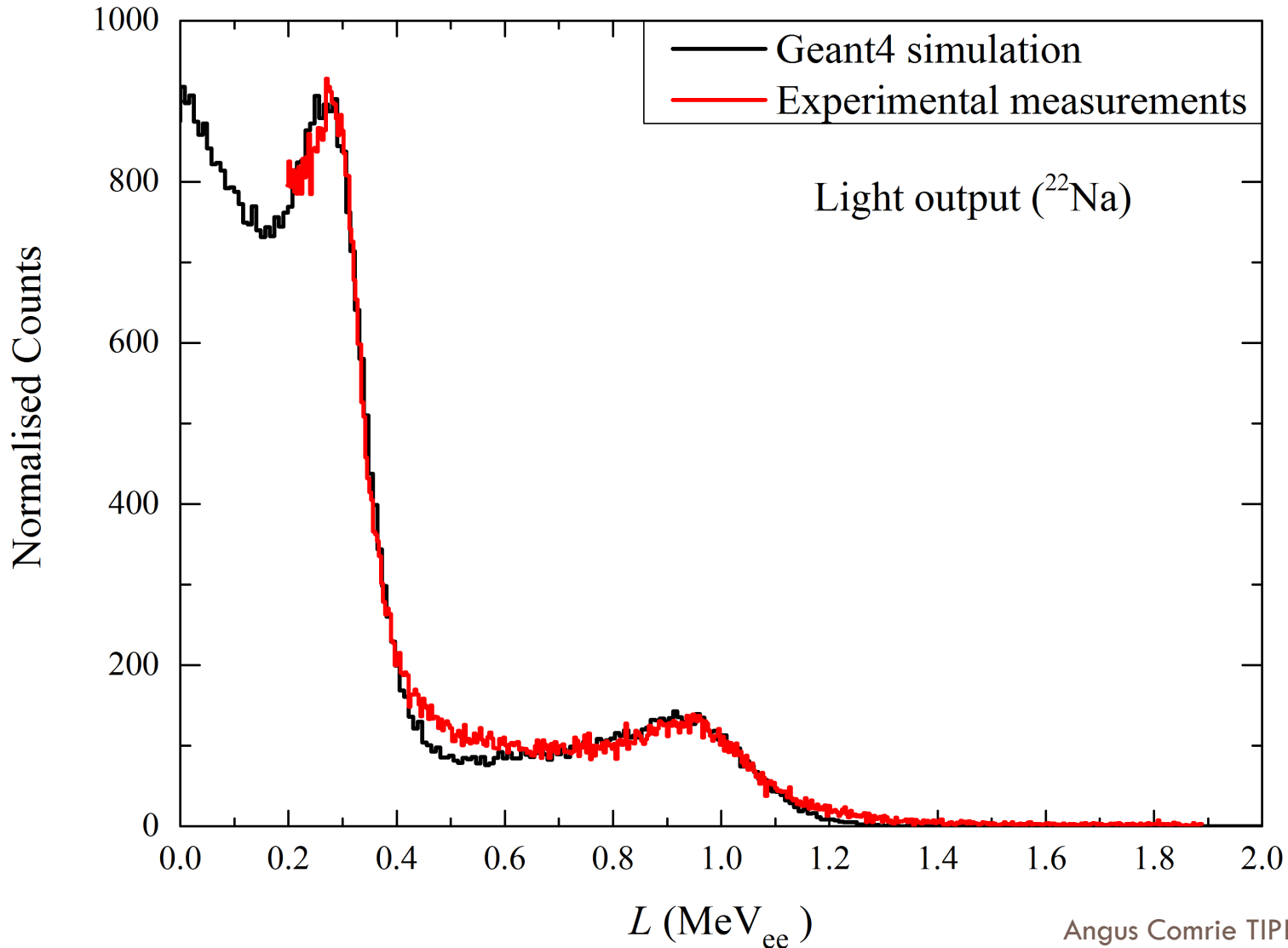
Simulation: Pulse shapes

13



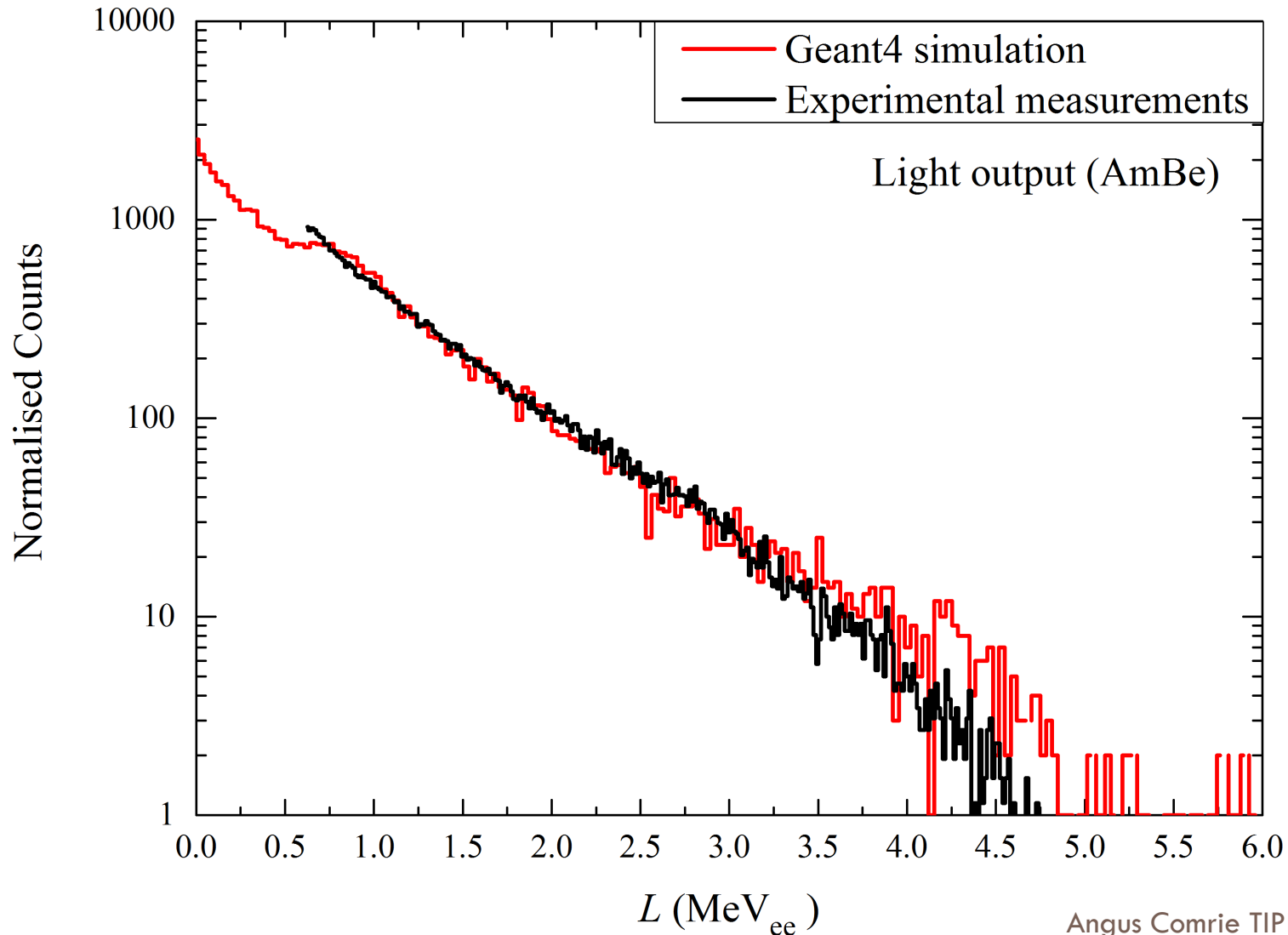
Simulation: Light output

14



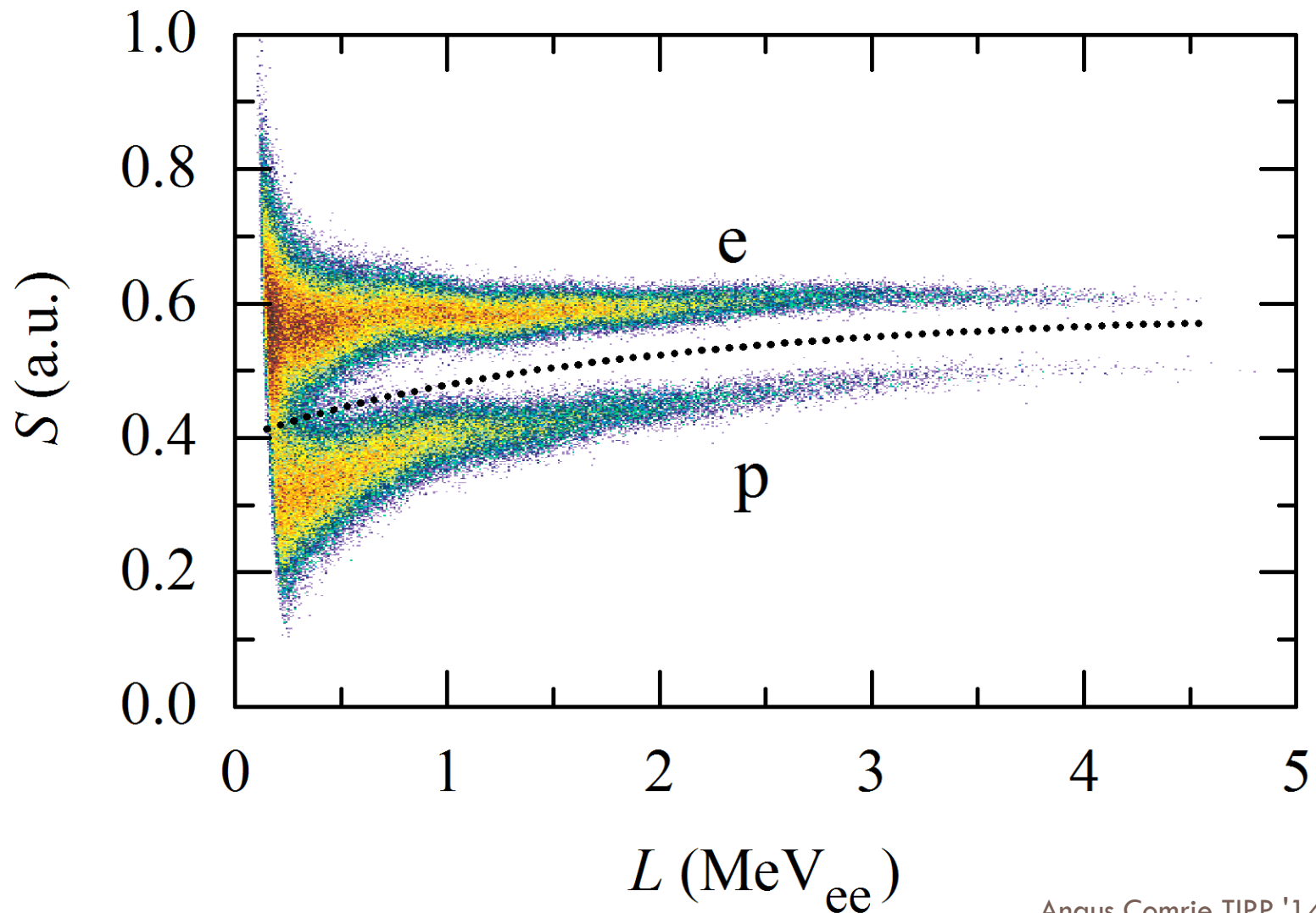
Simulation: Light output

15



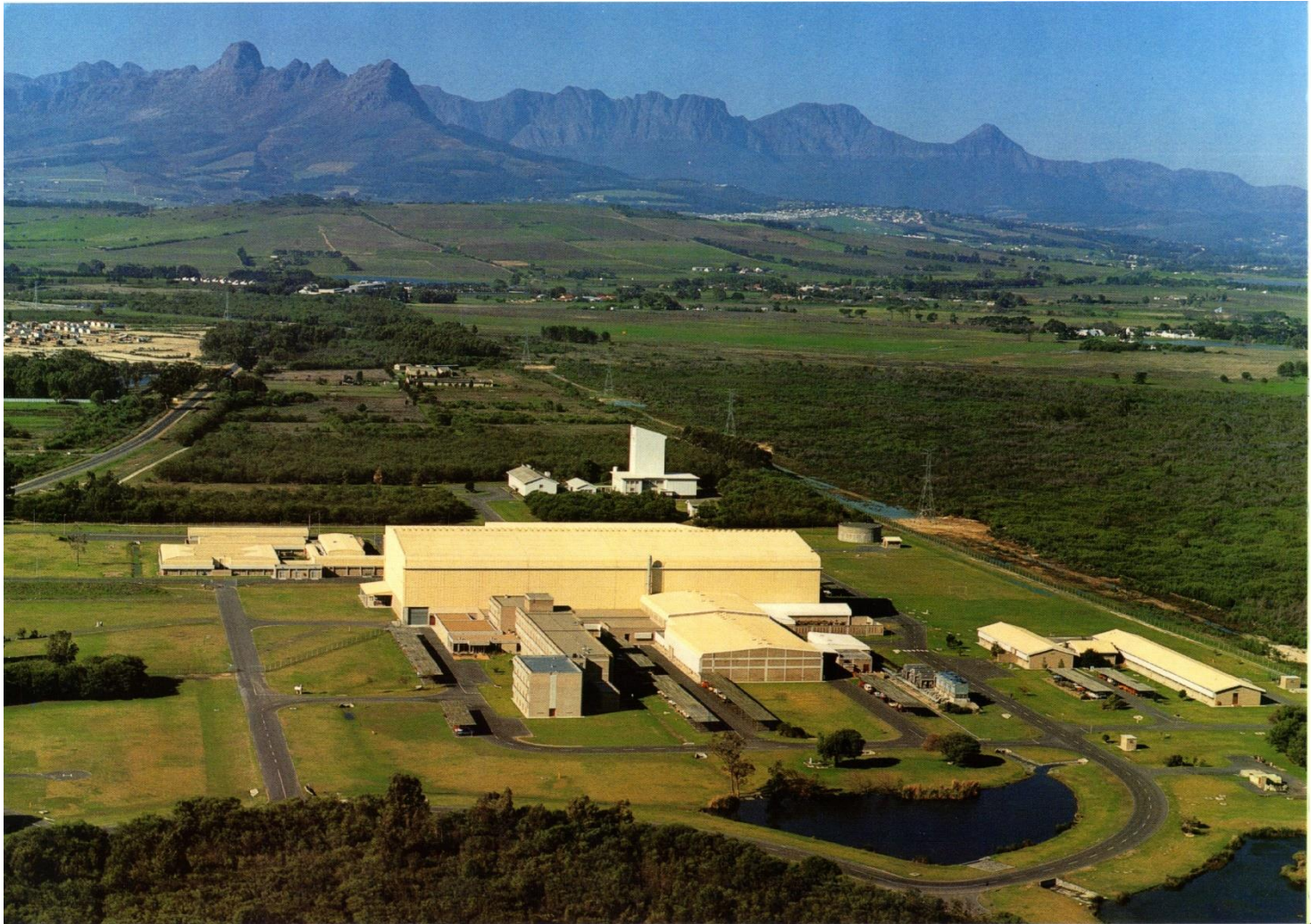
PSD: EJ-299-33 [plastic] & AmBe

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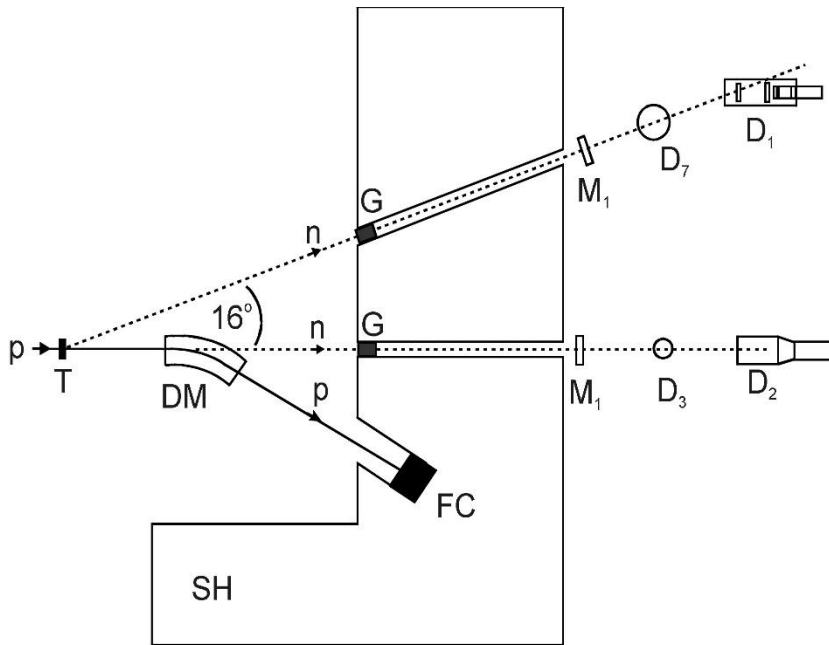
iThemba LABS Cyclotron

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Neutron production

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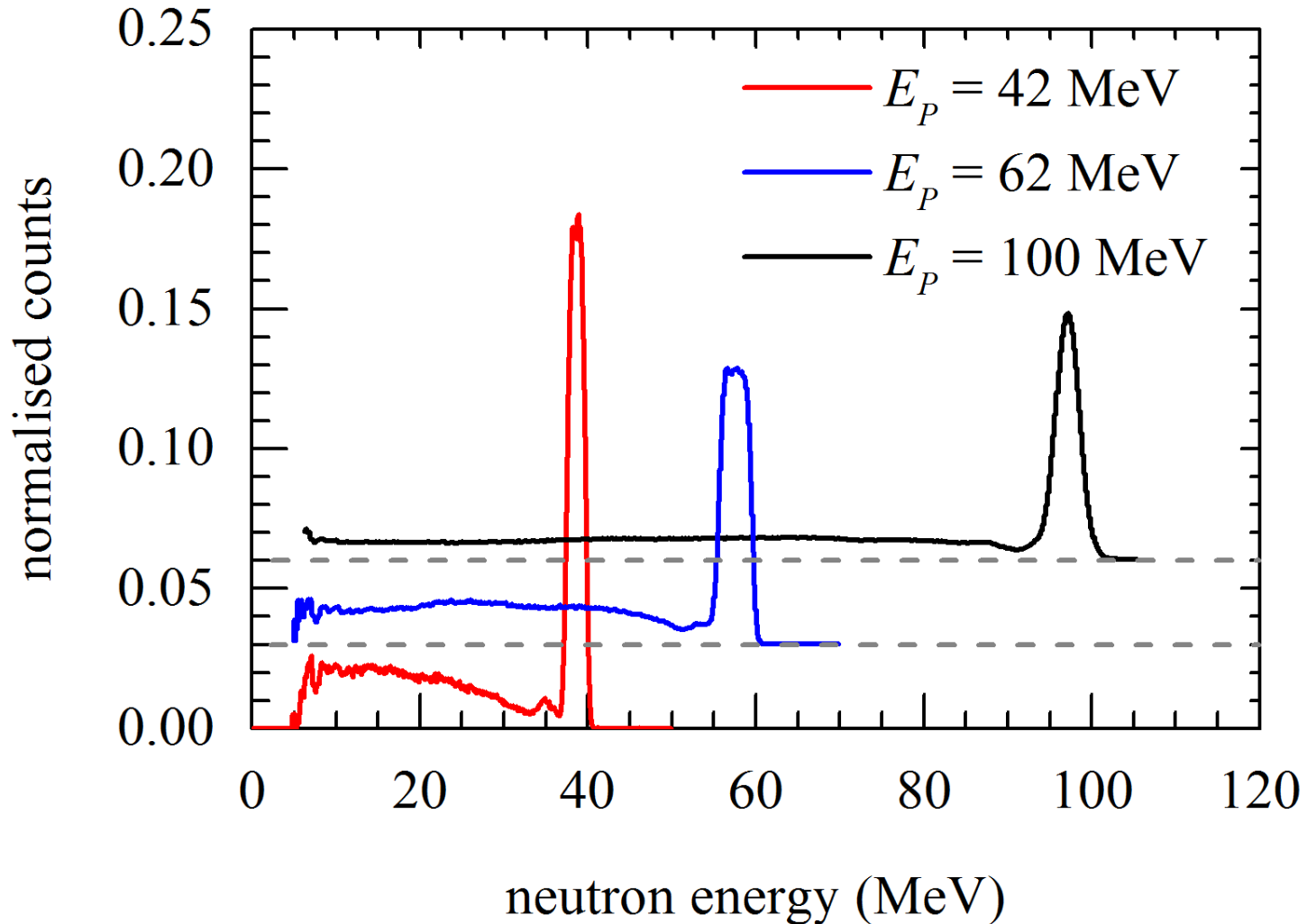


p	Pulsed proton beam
T	Lithium or beryllium target
n	Neutron beams (0° & 16° lab)
DM	Dipole magnet
FC	Faraday cup (beam dump)
SH	Iron & concrete shielding
G	Graphite filters
M ₁	Neutron monitors
D ₁ , D ₂ , ...	Neutron detectors

- Pulsed beam
 - Quasi-monoenergetic
 - 20 – 200 MeV
- Mixed field (n / gamma)

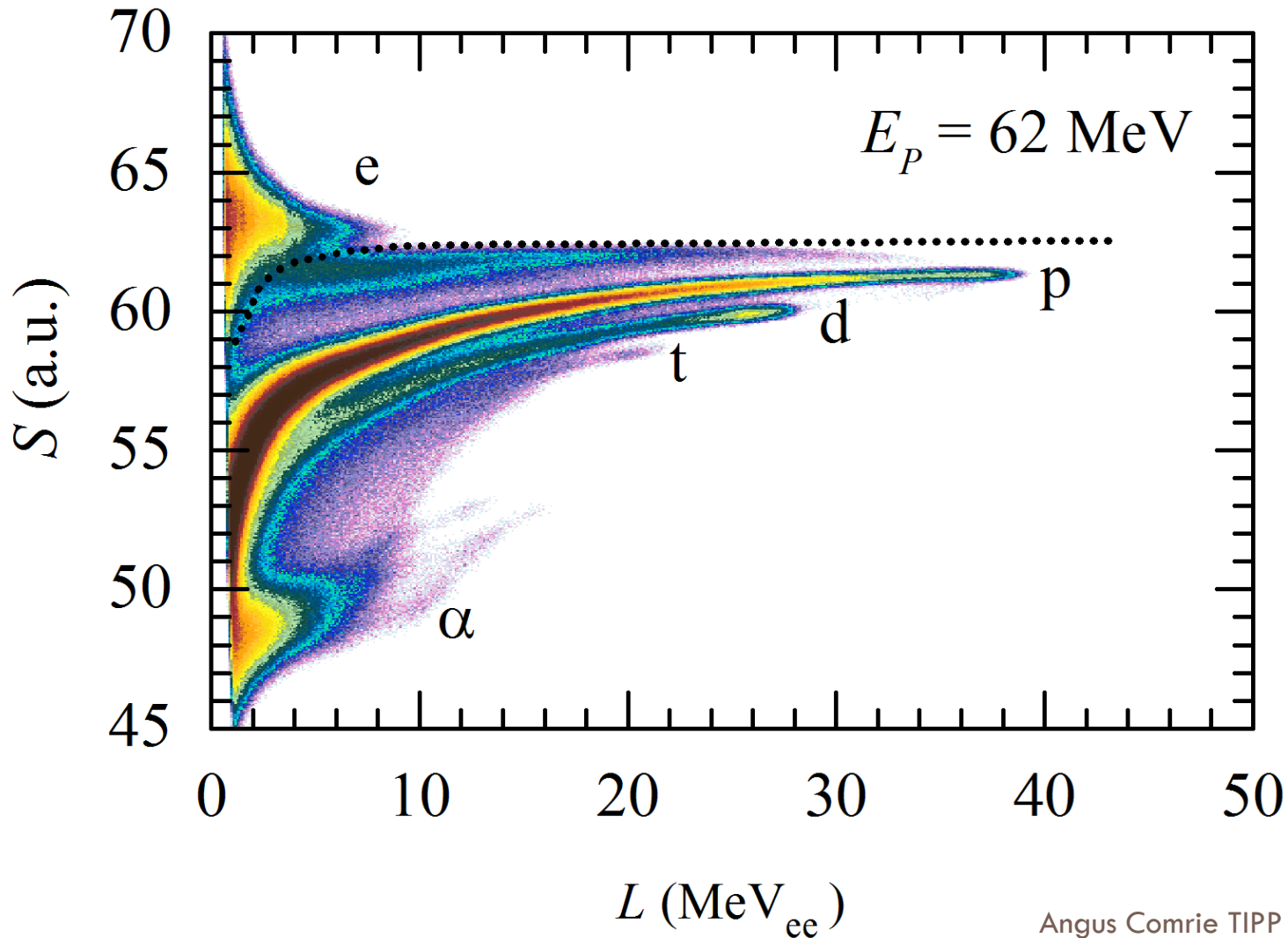
Neutron energy (EJ-309)

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PSD (EJ-309)

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Conclusion

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- Wide variety of applications for compact neutron detector
- Promising PSD results with EJ-299-33 Plastic
- Geant4 simulation matches experiment
- Future measurements will fully characterise our detector at cyclotron energies