Light Collection Efficiency Map of XENON100 detector

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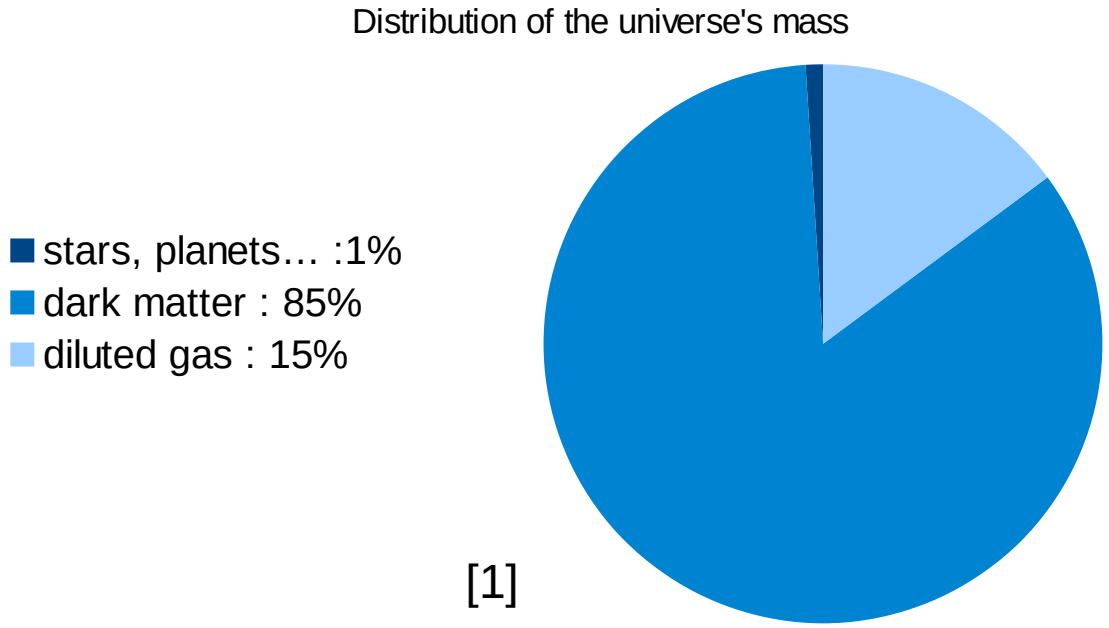
Outline

- Introduction
- The XENON100 experiment
- Cesium source and selection of events in the photopeak
- Conclusion

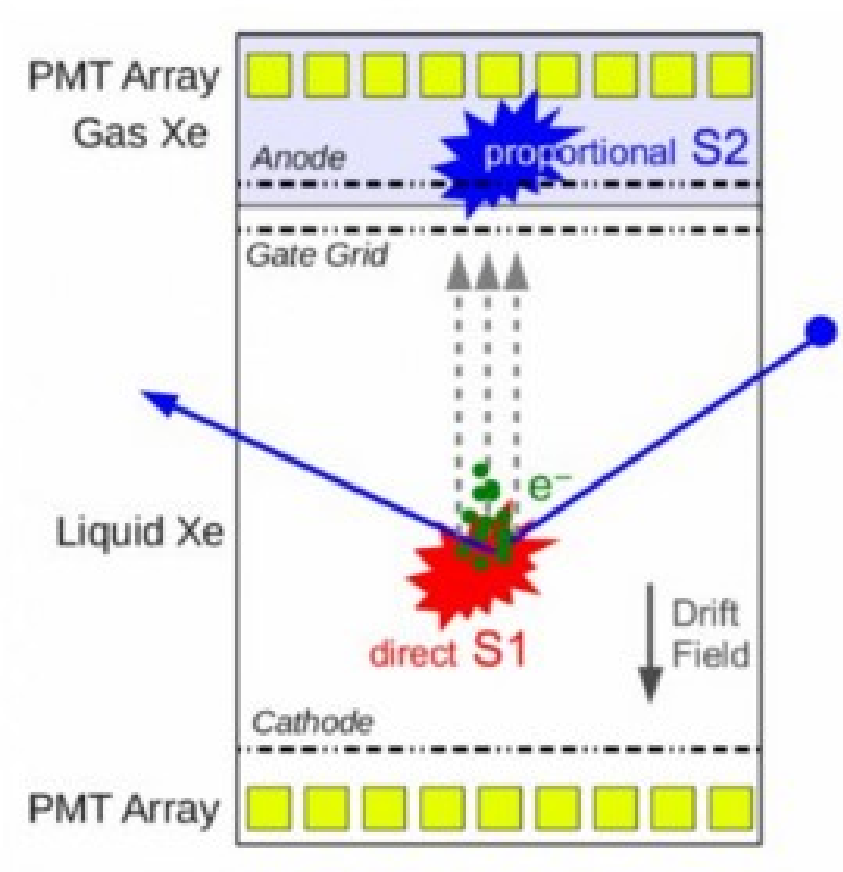
Introduction

- What is Dark Matter ?
  - Missing mass in the universe
  - Weakly interacting particles



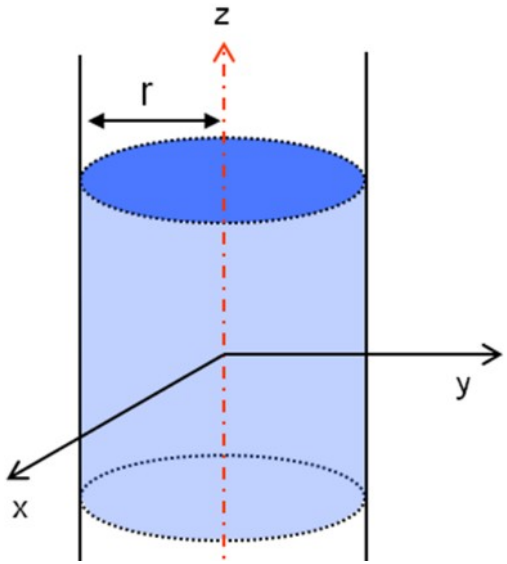
[1]

The XENON100 experiment



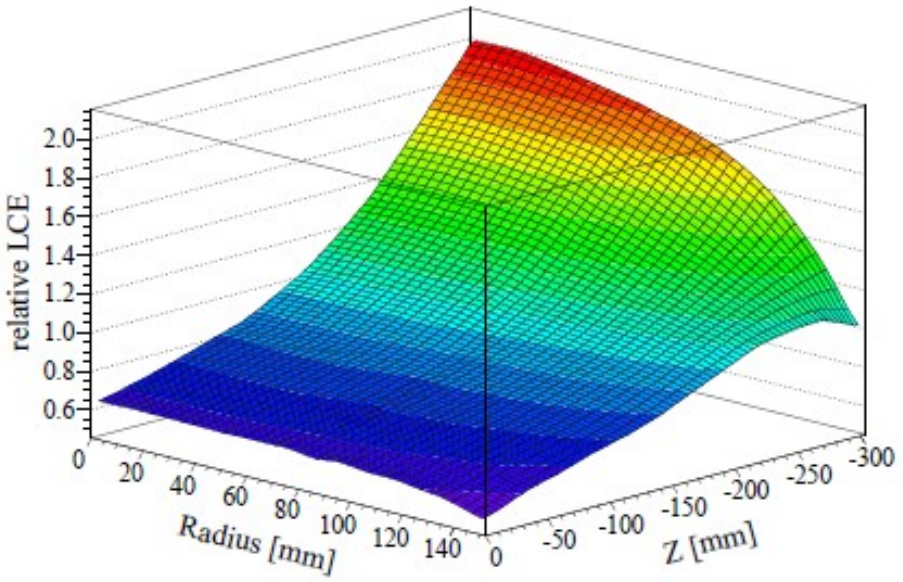
[3]

- TPC filled with liquid xenon
- Two signals: S1 and S2
- Reconstruction of the interaction position



Cesium source

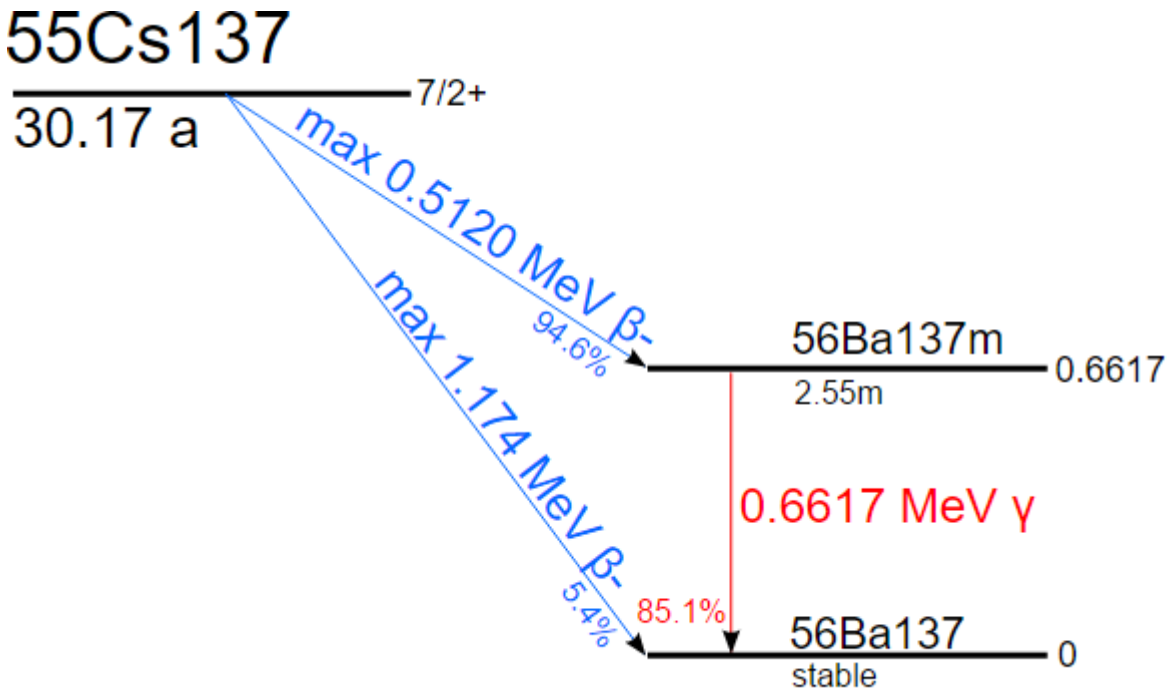
- Light Collection Efficiency Map
  - For given energy, the quantity of measured light depends on the position of the interaction
  - Several effects :
    - Reflectivity
    - Impurities
    - Solid angle effect
    - Rayleigh scattering



[3]

Cesium source

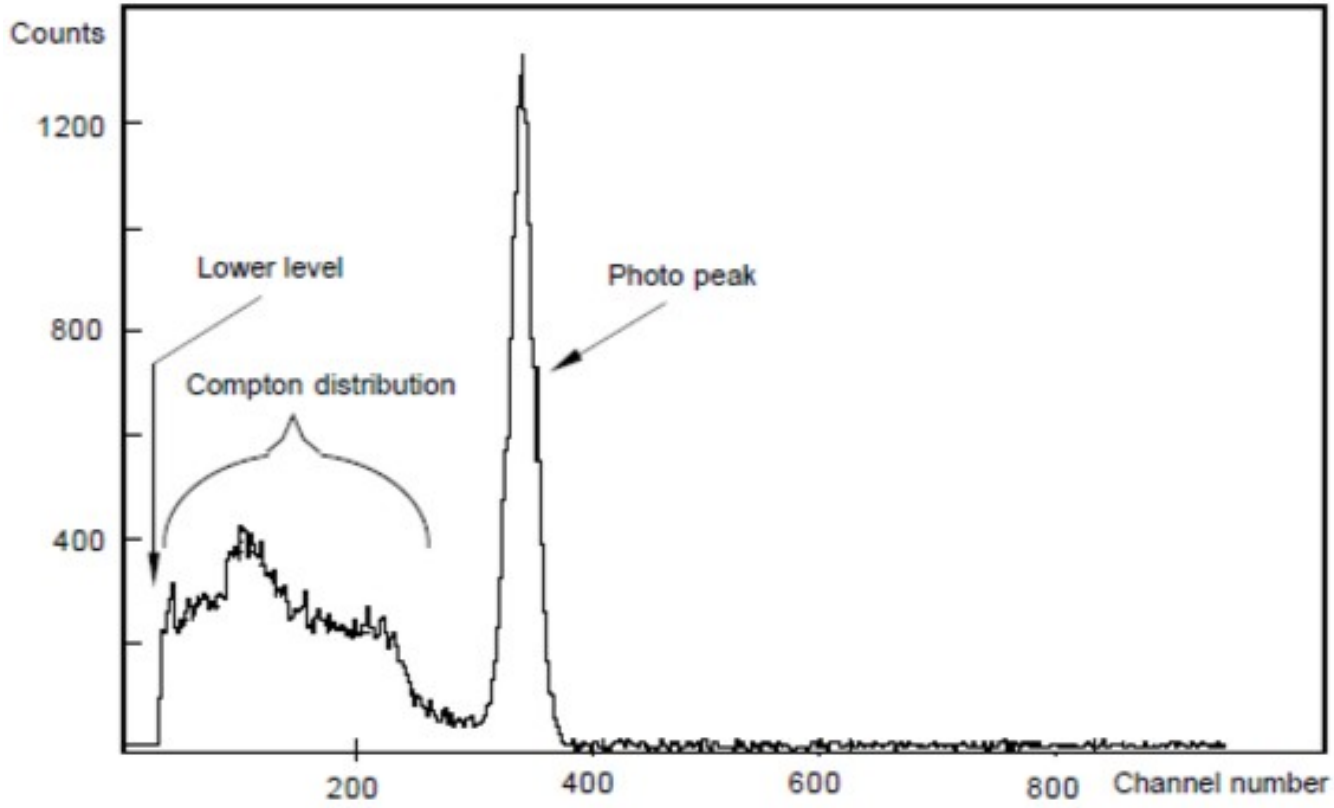
- Cesium source



[4]

Cesium source

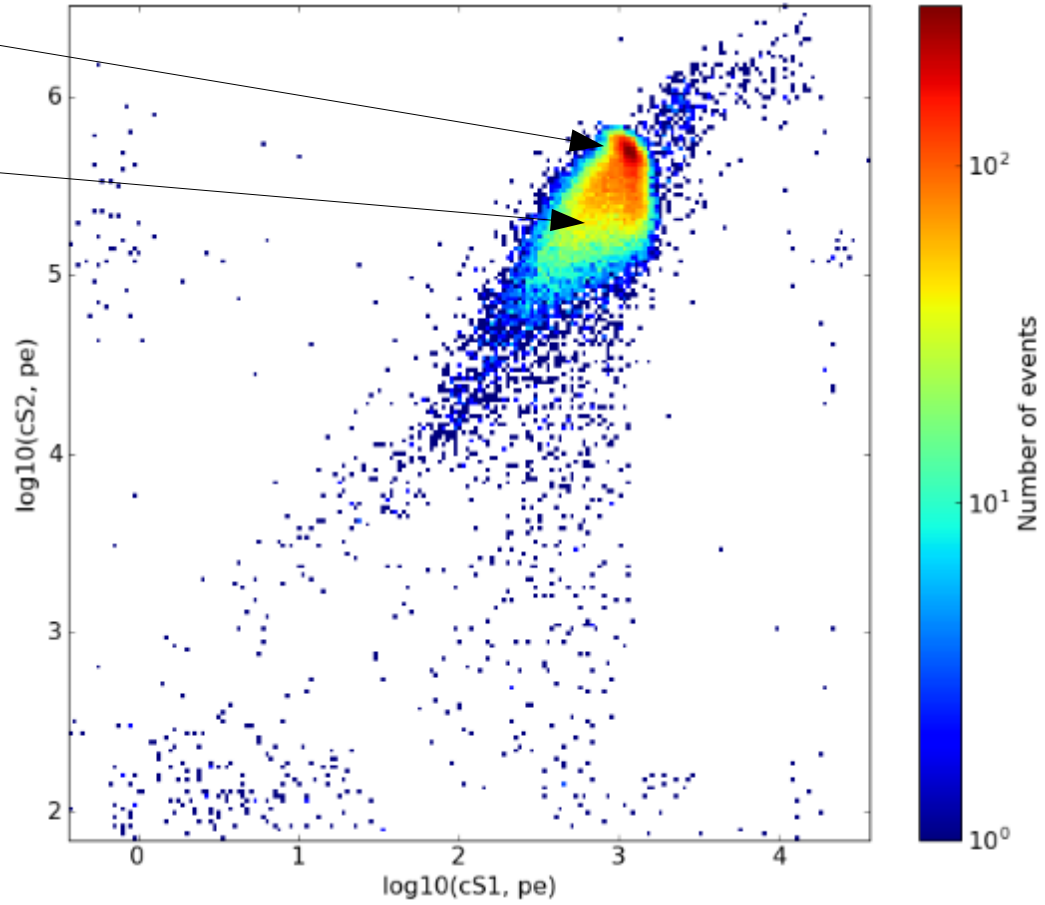
- Photoelectric effect
- Compton scattering



Selection of events in the photopeak

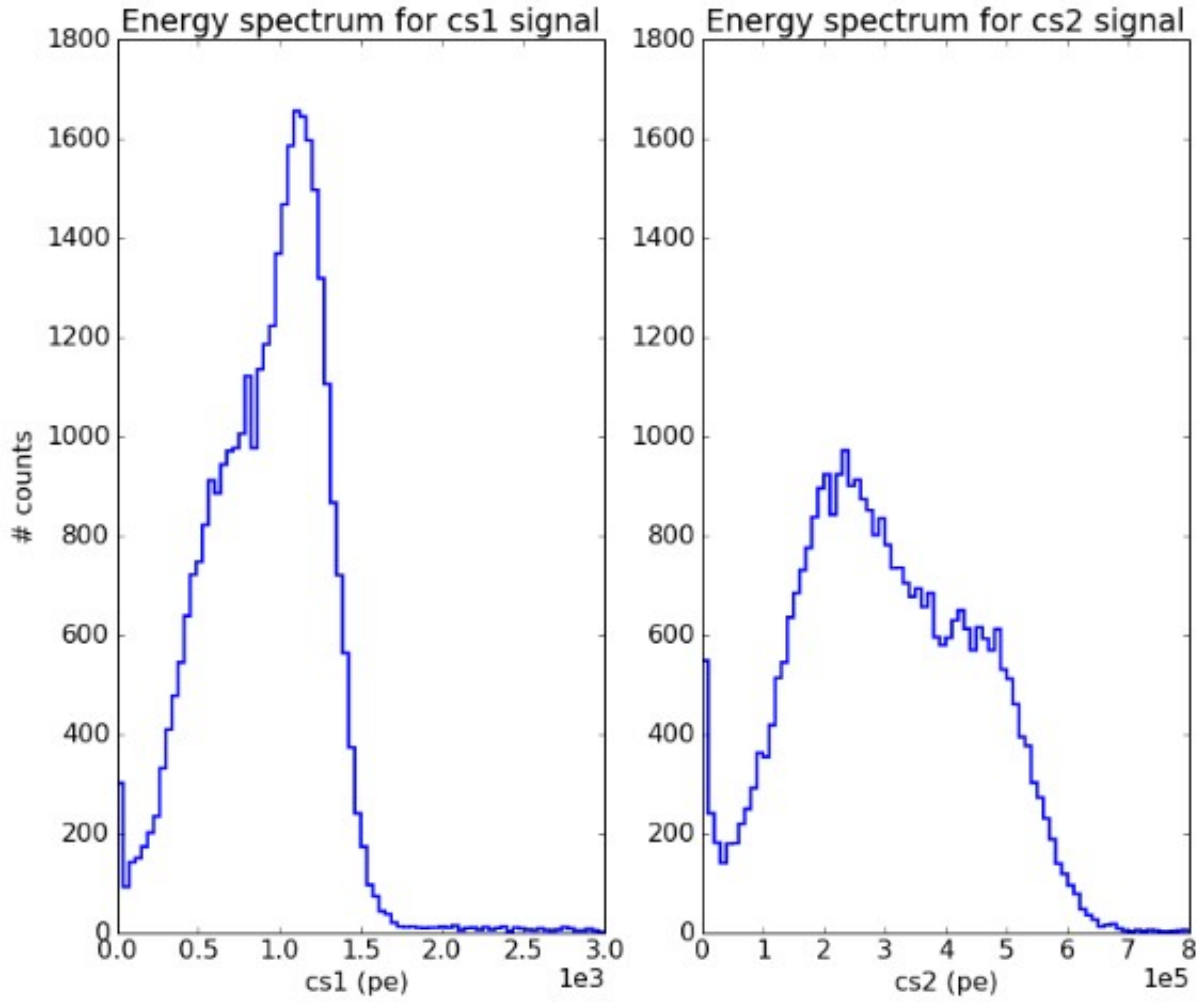
Photopeak

Compton distribution



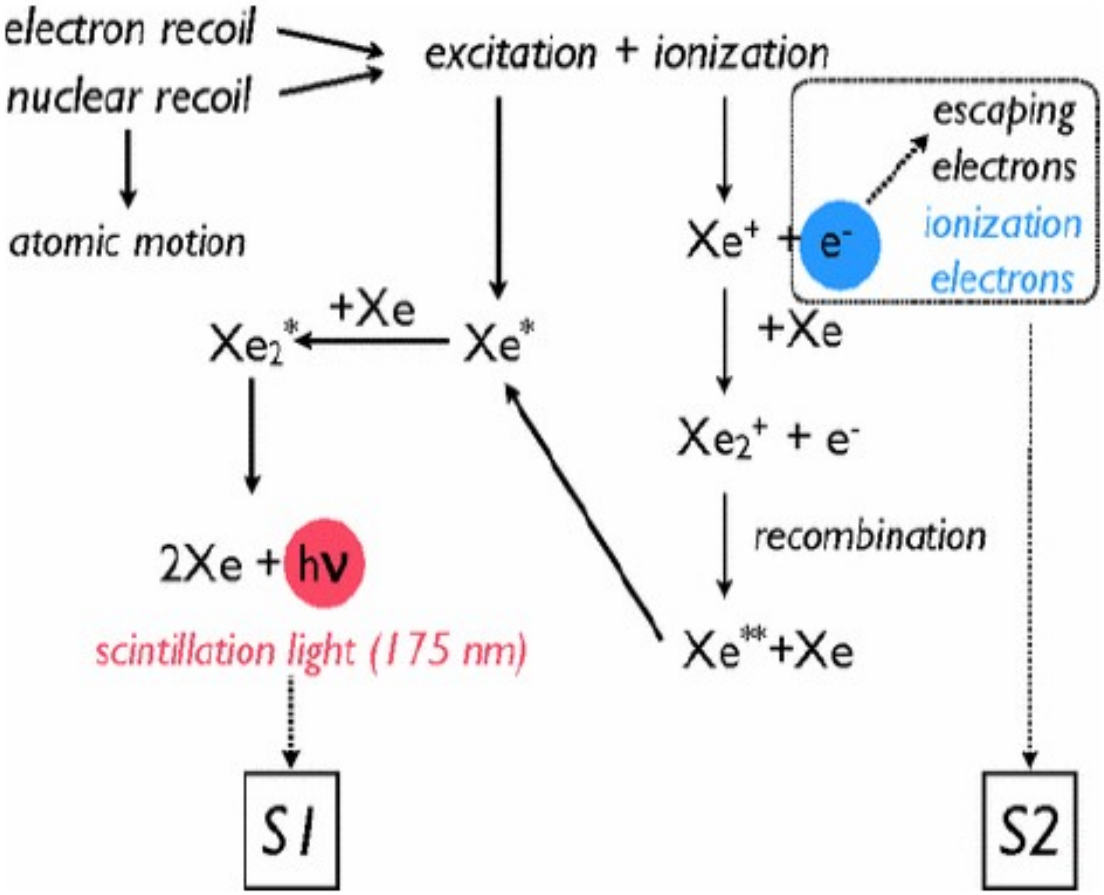
Selection of events in the photopeak

- CS1 and CS2 energy spectrum



Anti-correlation

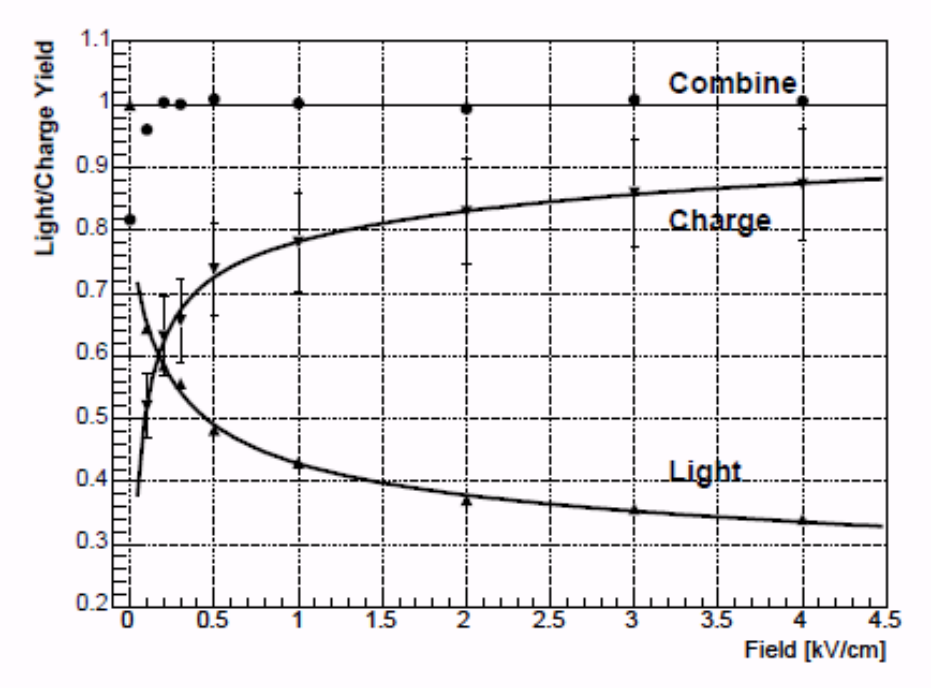
Anti-correlation between scintillation signal (S1) and ionization signal (S2)



[5]

Anti-correlation

- S1 is proportional to the light yield, S2 to the charge yield.
- Combine S1 and S2 to improve the energy resolution



[6]

Combined Energy Scale

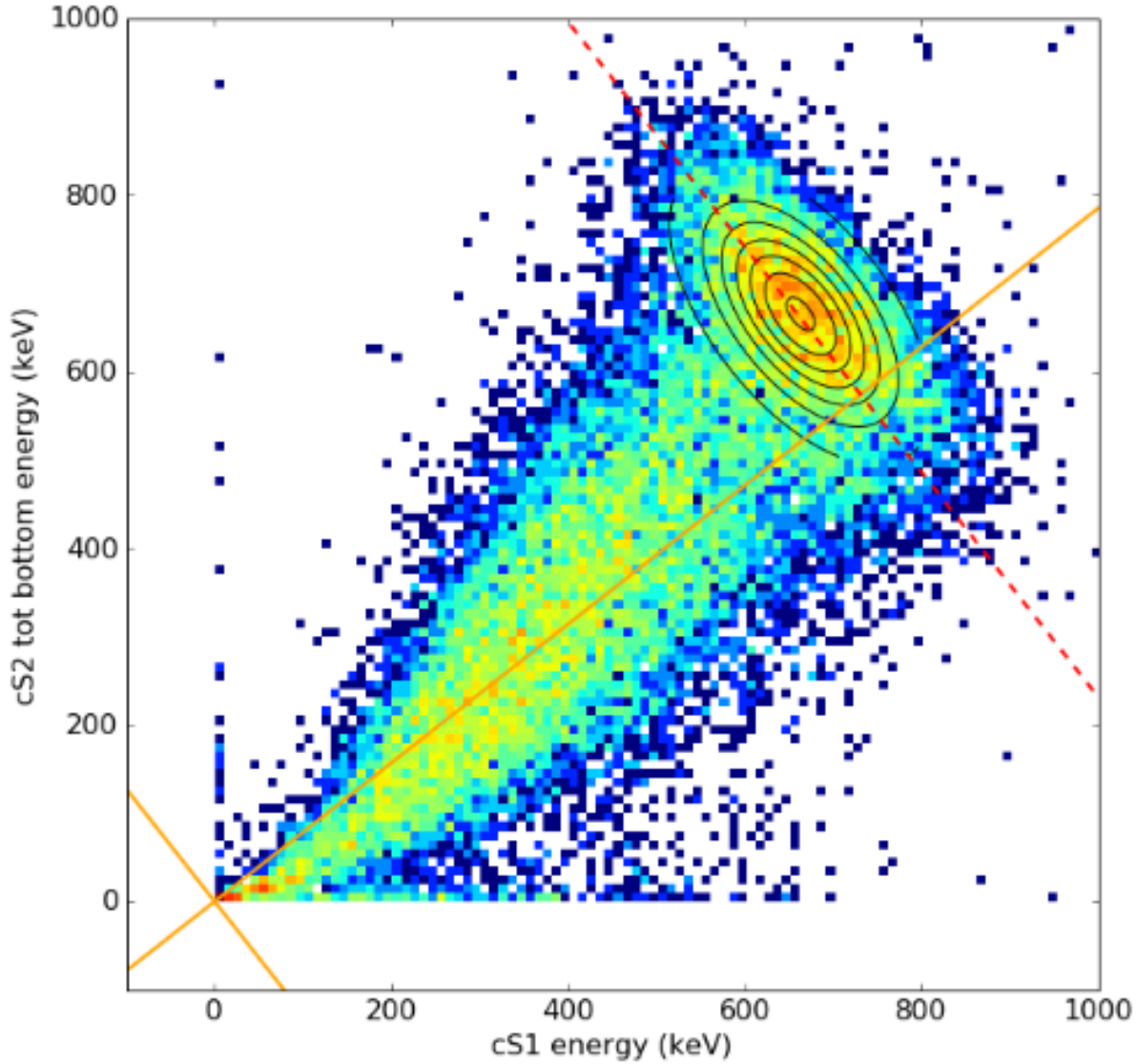
- Combined Energy Scale

$$CES = a * cS1 + b * cS2 \quad tot \quad bottom$$

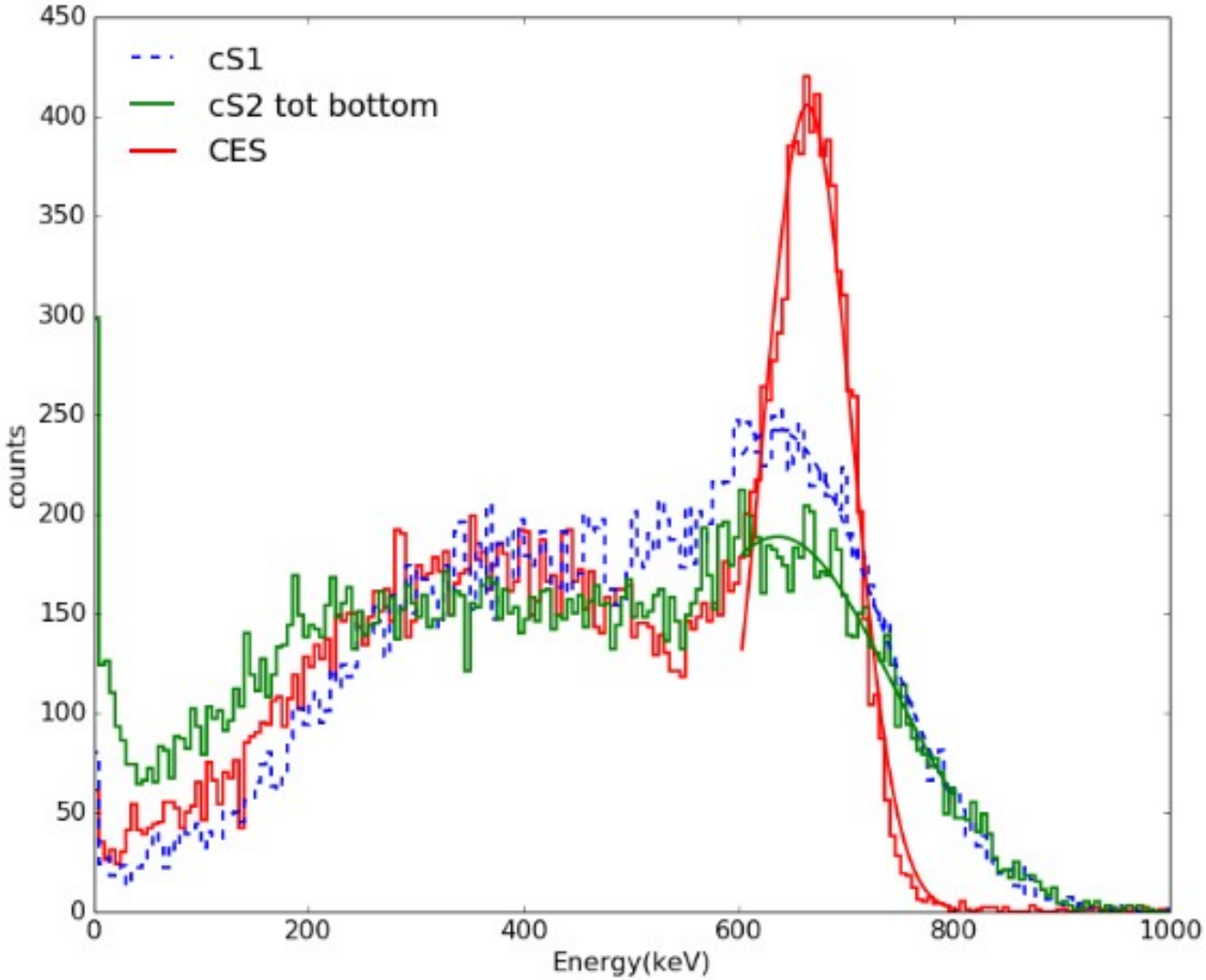
  - CS2 tot bottom is the corrected S2 signal measured by the bottom PMTs array

[6]

Combined Energy Scale



Selection of events in the photopeak



Conclusion

- Improvement of the energy resolution for the selection of events
- Next step of my project
  - Select events in the photopeak
  - Divide the TPC in r,z slices
  - Correct S1 with a overall LCE map
  - Build a per PMT LCE map

Thank you for listening

Do you have any questions?

Bibliography

[1] BERTONE, Gianfranco, 2014, Le mystère de la matière noire, dans les coulisses de l'univers, Dunod, Quai des Sciences.

[2] Penn State: The rotation curve of the Milky Way: https://www.e-education.psu.edu/astro801/content/l8_p8.html

[3] XENON100 Collaboration, astro-ph.IM (2012), arXiv:1107.2155, The XENON100 Dark Matter Experiment, http://arxiv.org/pdf/1107.2155.pdf

[4] Wikipedia: Caesium 137, https://en.wikipedia.org/wiki/Caesium-137

[5] Le Calloch M., these (2014), Study of the single electron charge signal in the XENON100 direct Dark Matter search experiment

[6] XENON Collaboration, Astro-ph (2007), arXiv:0704.1118v1, Observation of Anti-correlation between Scintillation and Ionization for MeV Gamma-Rays in Liquid Xenon, http://arxiv.org/pdf/0704.1118v1.pdf

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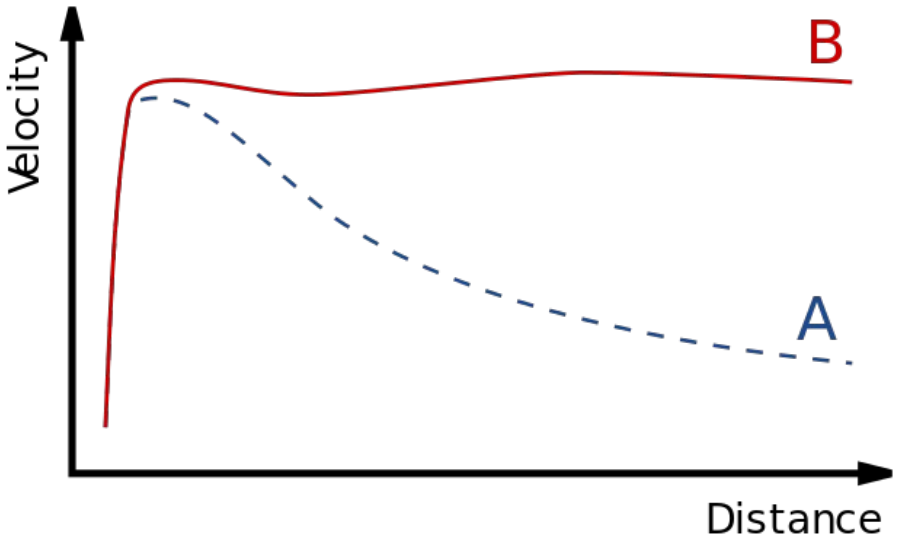
Introduction

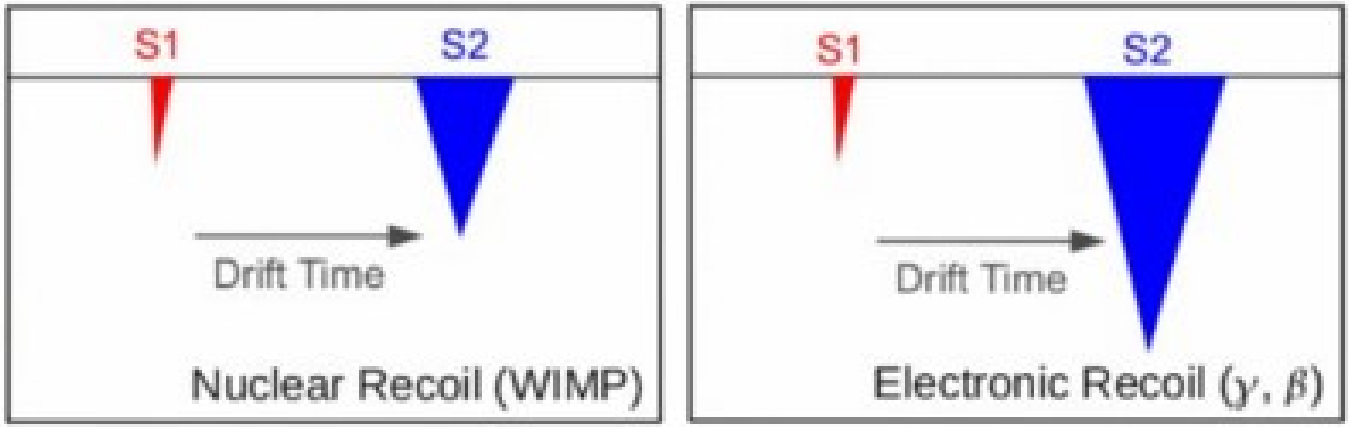
- Rotational curve of Galaxies
  - A : Theoretical curve based on visible mass of galaxies
  - B : Curve based on observation
- Gravitational lens
  - Bending of light by a massive object
  - Galaxies mass can be directly measured



[2]

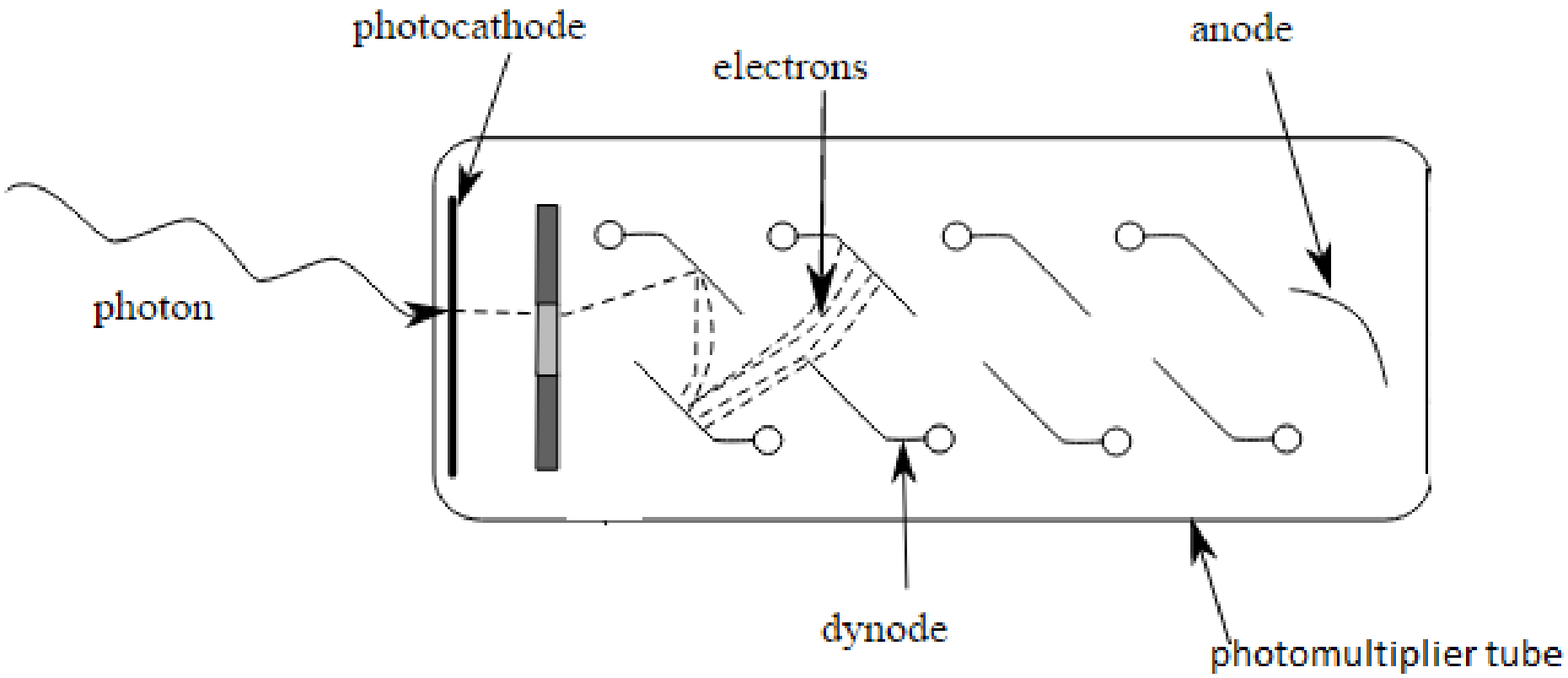
The XENON100 experiment

- Discrimination of interactions



[3]

Photomultiplier Tubes



Combined Energy Scale

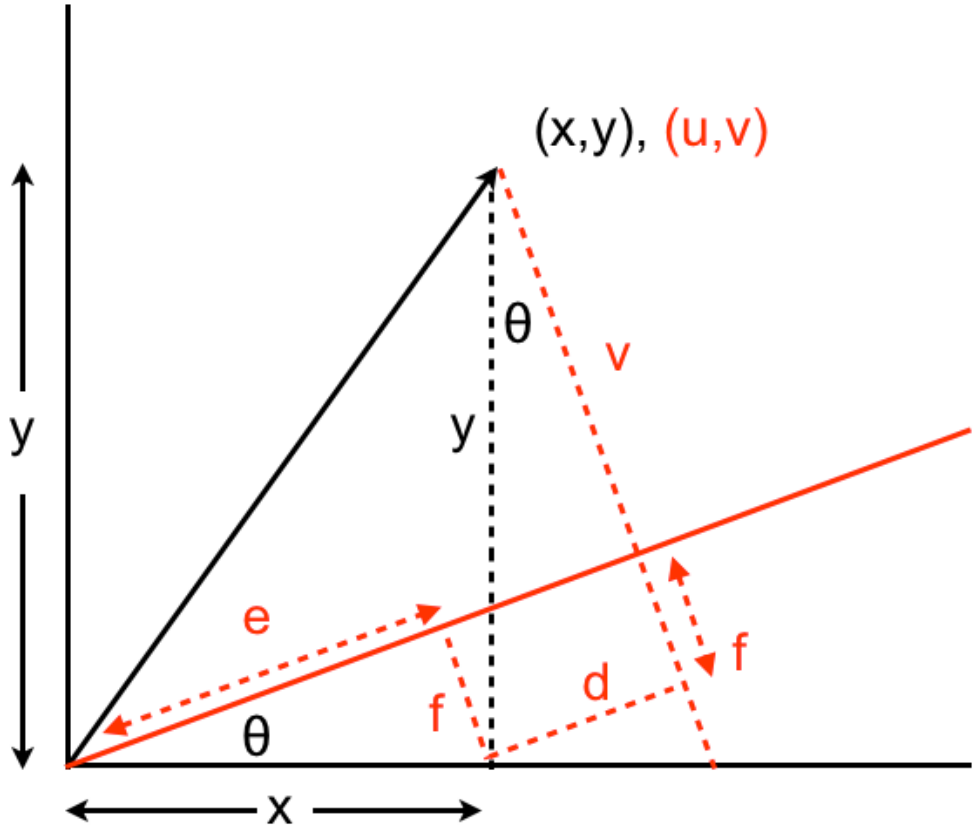
$$CES(keV) = a * CS1(keV) + b * CS2 \quad tot \quad bottom/200(keV)$$

$$\theta = 0{,}5 * \arctan\left(\frac{(2\rho\sigma_{CS1}\sigma_{CS2})}{(\sigma_{CS1}{}^2 + \sigma_{CS2}{}^2)}\right)$$

$$a = \frac{-662}{(\cos(\theta) - \sin(\theta))} * \sin(\theta) = 0{,}56$$

$$b = \frac{662}{(\cos(\theta) - \sin(\theta))} * \cos(\theta) = 0{,}44$$

Combined Energy Scale



d = y sin θ	v + f = y cos θ
e = x cos θ	f = x sin θ
u = x cos θ + y sin θ	v = y cos θ - x sin θ