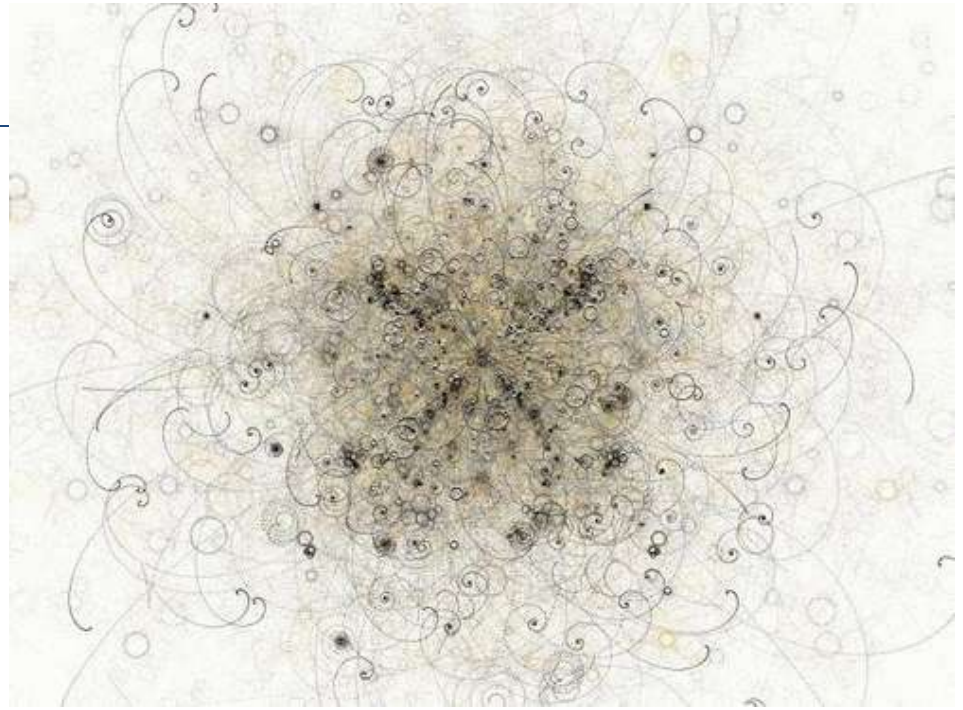
Announcements



Quiz:
- Assorted quizzes from earlier weeks. Pick up after class.
- Next quiz today

Homework:
Fourth HW posted. Due date **March 24 at 3pm** on gradescope

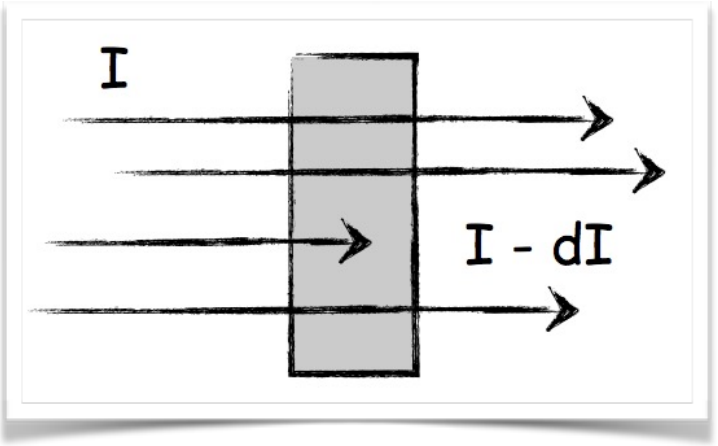
Paper:
-Outlines returned on gradescope – please take a look; reach out if you have questions
-Draft deadlines:
- **Optional**, 3/28 in class: bring a paper copy to me by this date if you want feedback
- For credit, 4/11 at 3pm, on gradescope

Midterm:
-Pick up graded midterms after class
-Will be curved to add 10 points to the score at the top of the page
- Note: your grade is the sum of your best four questions on the exam, the fifth question is not extra credit. in P803 it is the sum of question 5 and your best other three questions

Photon Interactions with Matter

Characteristic for interactions of photons with matter:

A single interaction removes a photon from the beam!



$$dI = -\mu\, I\, dx$$

[μ : absorption coefficient]

Beer-Lambert law:

$$I(x) = I_0 e^{-\mu x}$$

with $\lambda = 1/\mu = 1/n\sigma$

[mean free path]

Possible Interactions:

- Photoelectric Effect
- Compton Scattering
- Pair Production

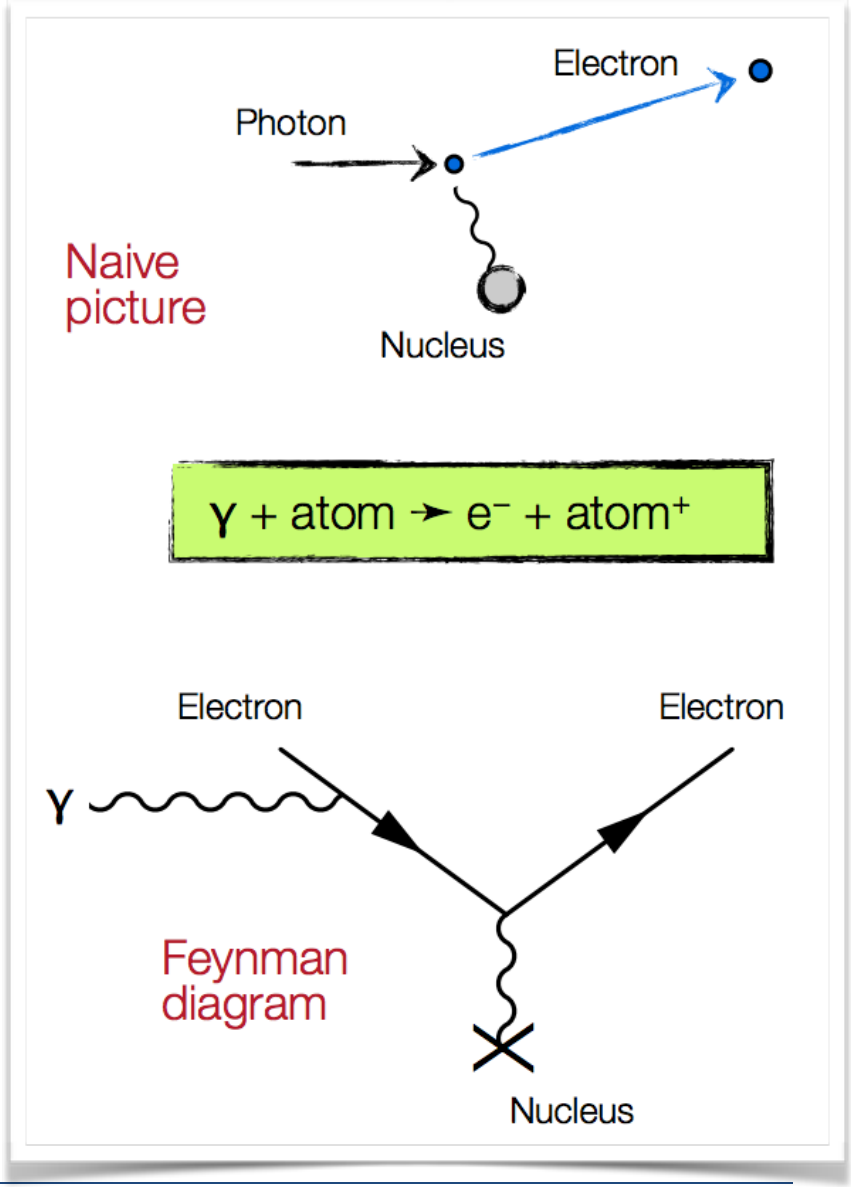
Photon Interactions - Photo-Electric Effect

Energy of outgoing electron:

$$E_e = h\nu - I_b$$

Photon energy

Binding energy [strongly Z dependent]



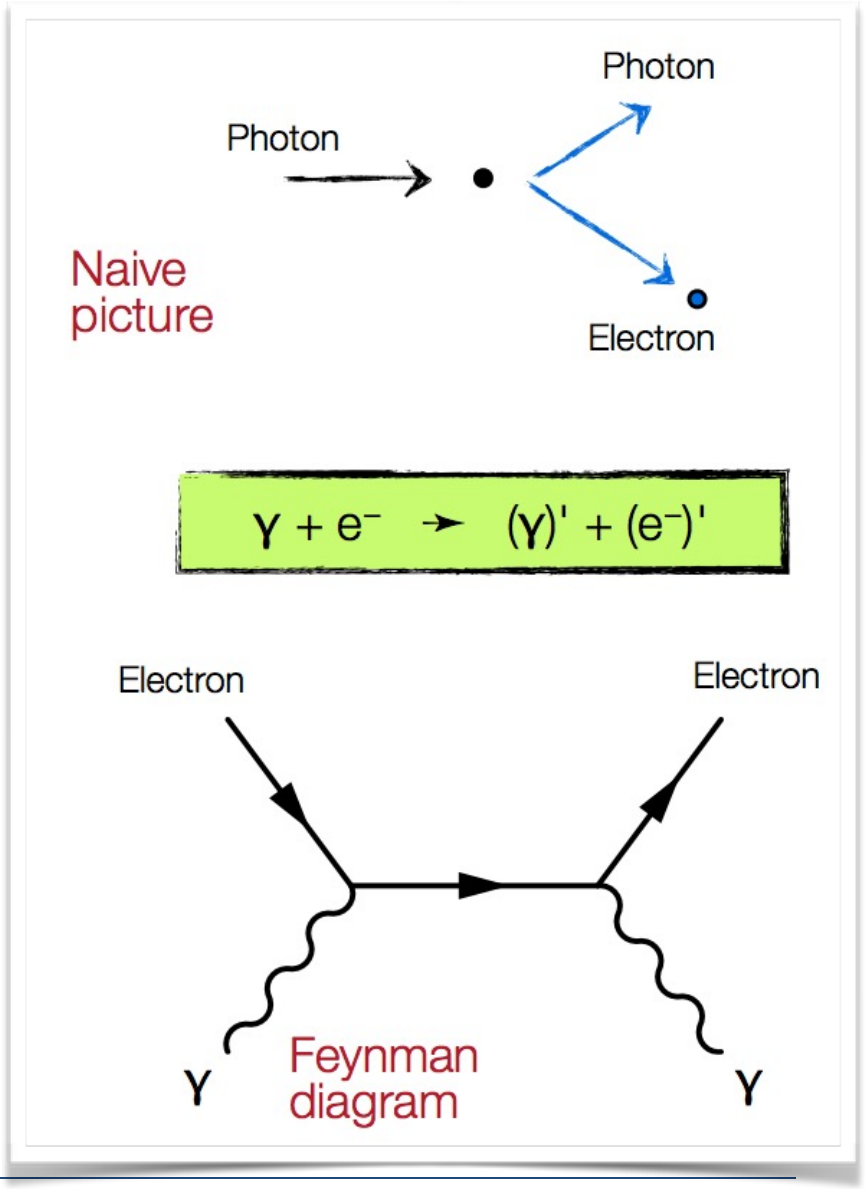
Photon Interactions - Compton Scattering

Energy of outgoing photon:

γ-Angle w.r.t. direction of incoming photon

$$E'_\gamma = \frac{E_\gamma}{1 + \frac{E_\gamma}{m_e c^2}(1 - \cos\theta)}$$

4-vector algebra;
[Ansatz: $p_4^2 = (p_1^2 + p_2^2 - p_3^2)$]



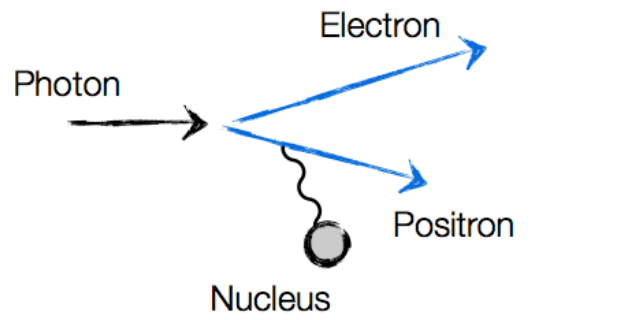
Photon Interactions - Pair Production

Energy threshold:

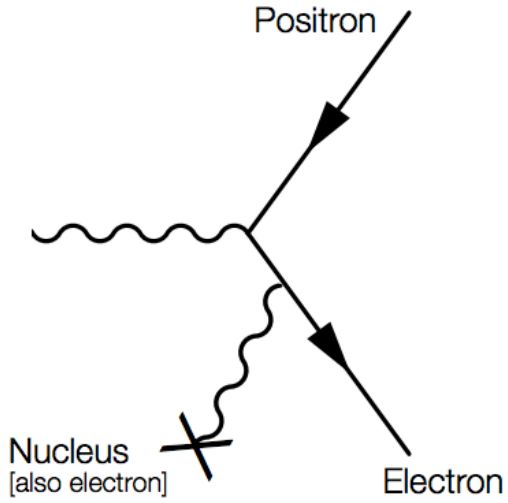
$$E_\gamma \geq 2m_e c^2(1+m_e/m_n)$$

2 x electron mass

Kinetic energy transferred to nucleus

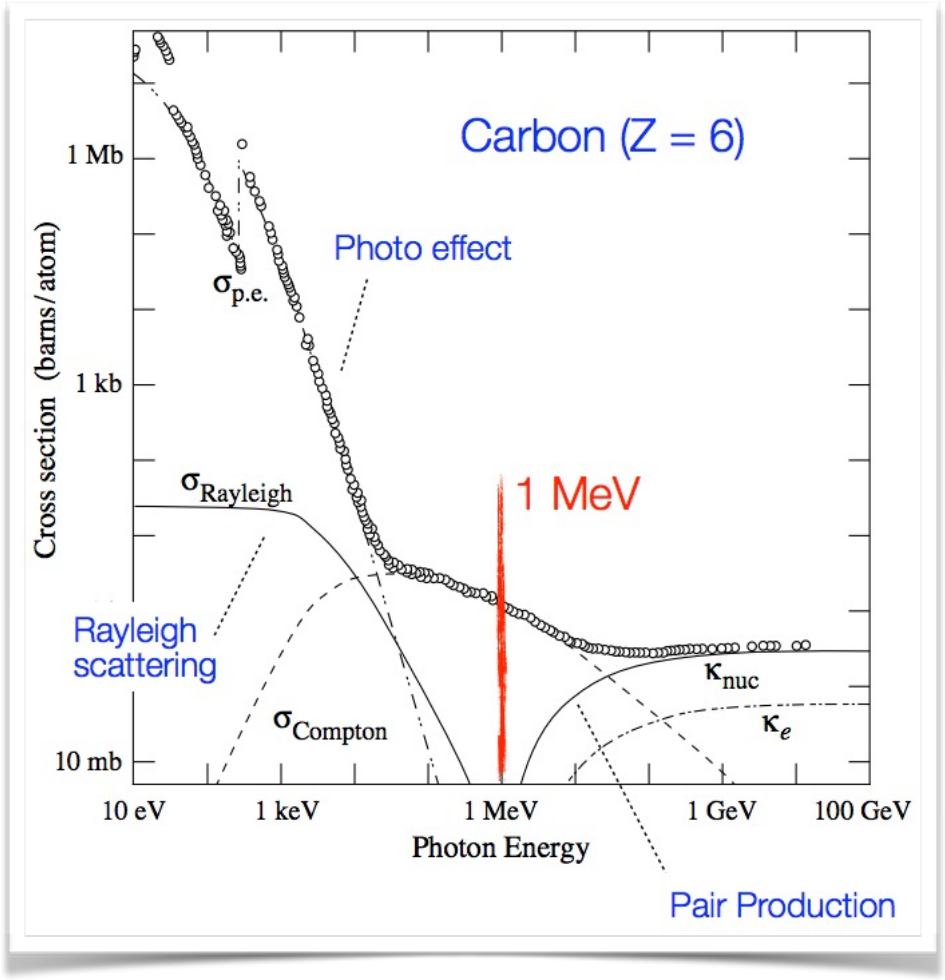


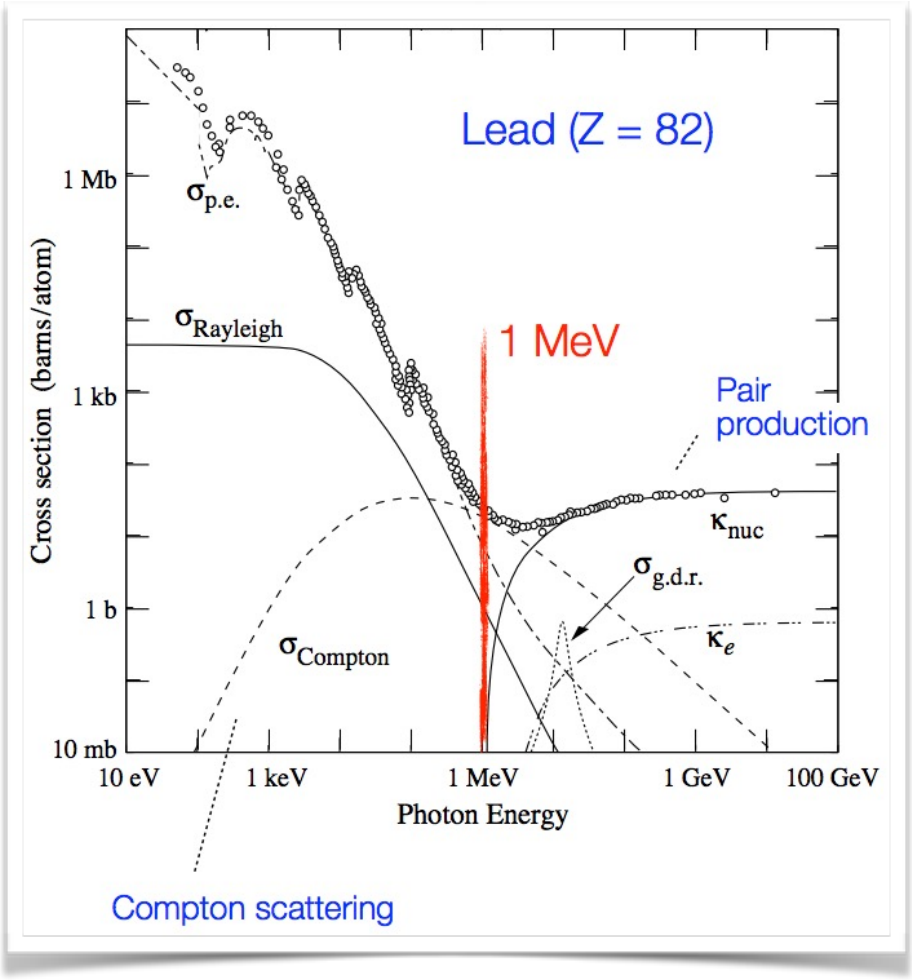
γ + atom → $e^+ + e^-$



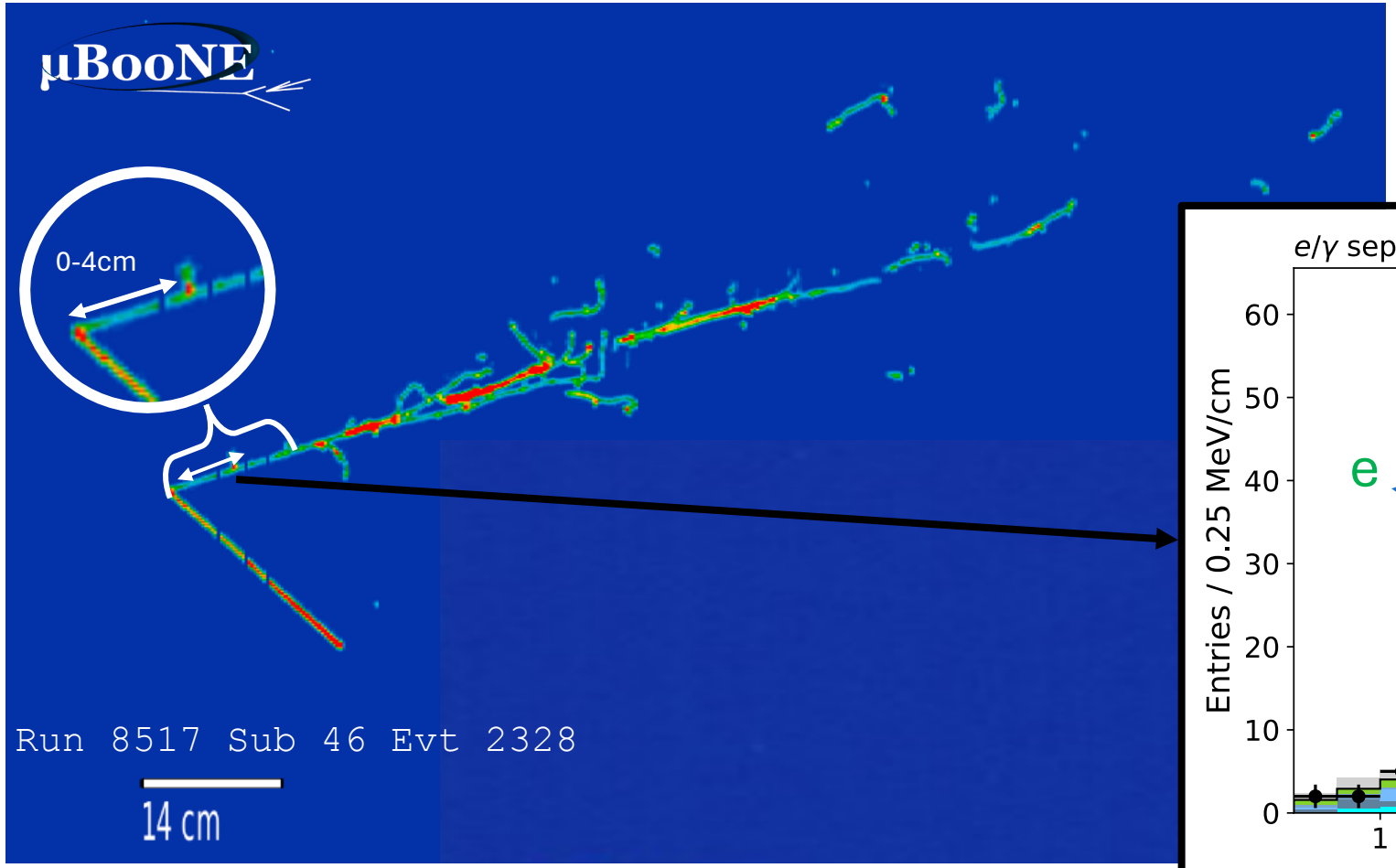
Interactions of Photons with Matter

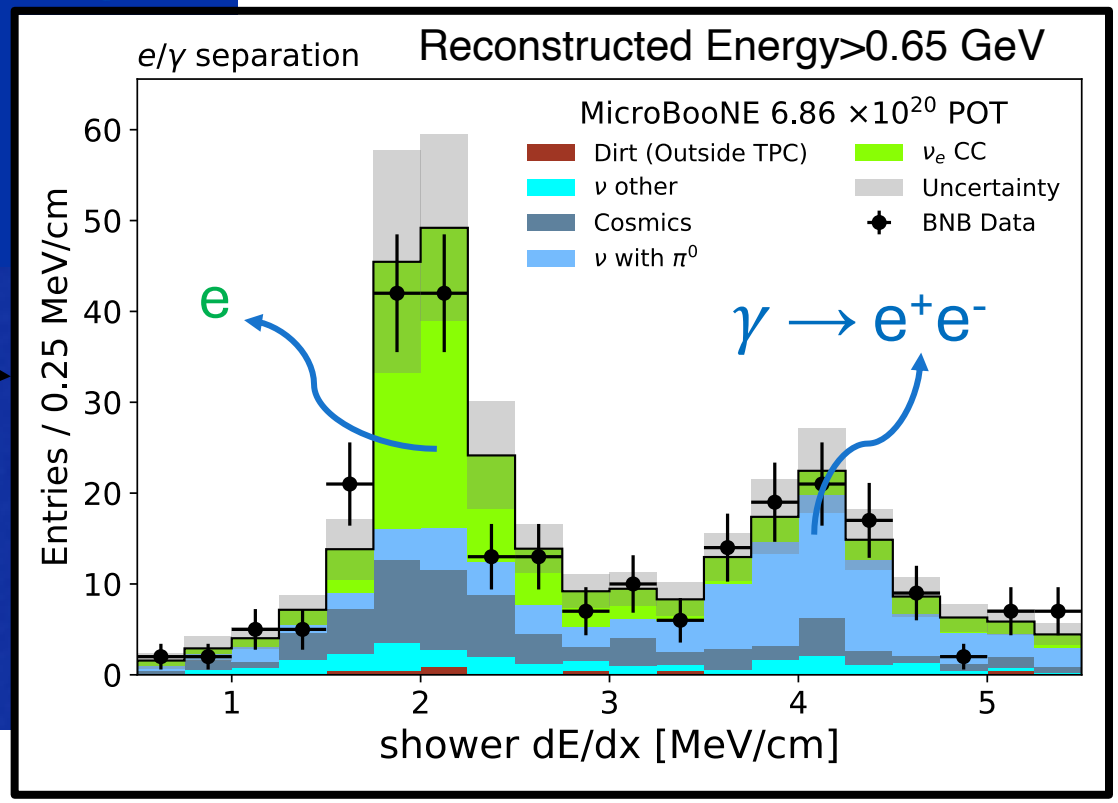
Photon Total Cross Sections





An Example: MicroBooNE Experiment





Recap / Up Next

Last time:

Particle Interactions with Matter

- Ionization
- Radiation
- High/low energy losses

This time:

Particle Detectors

- Detector strategies
- Particle Identification
- Detector Systems