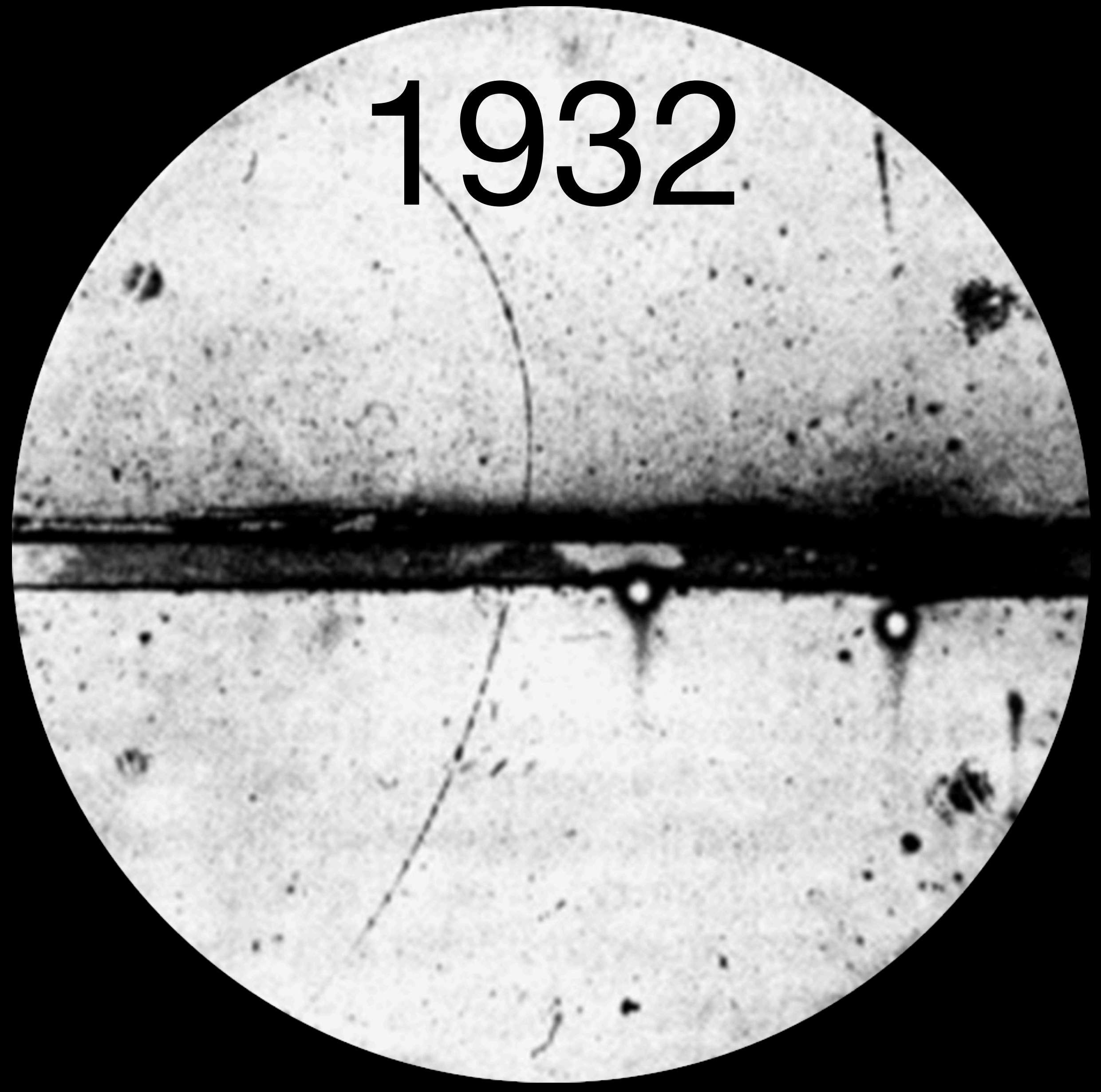
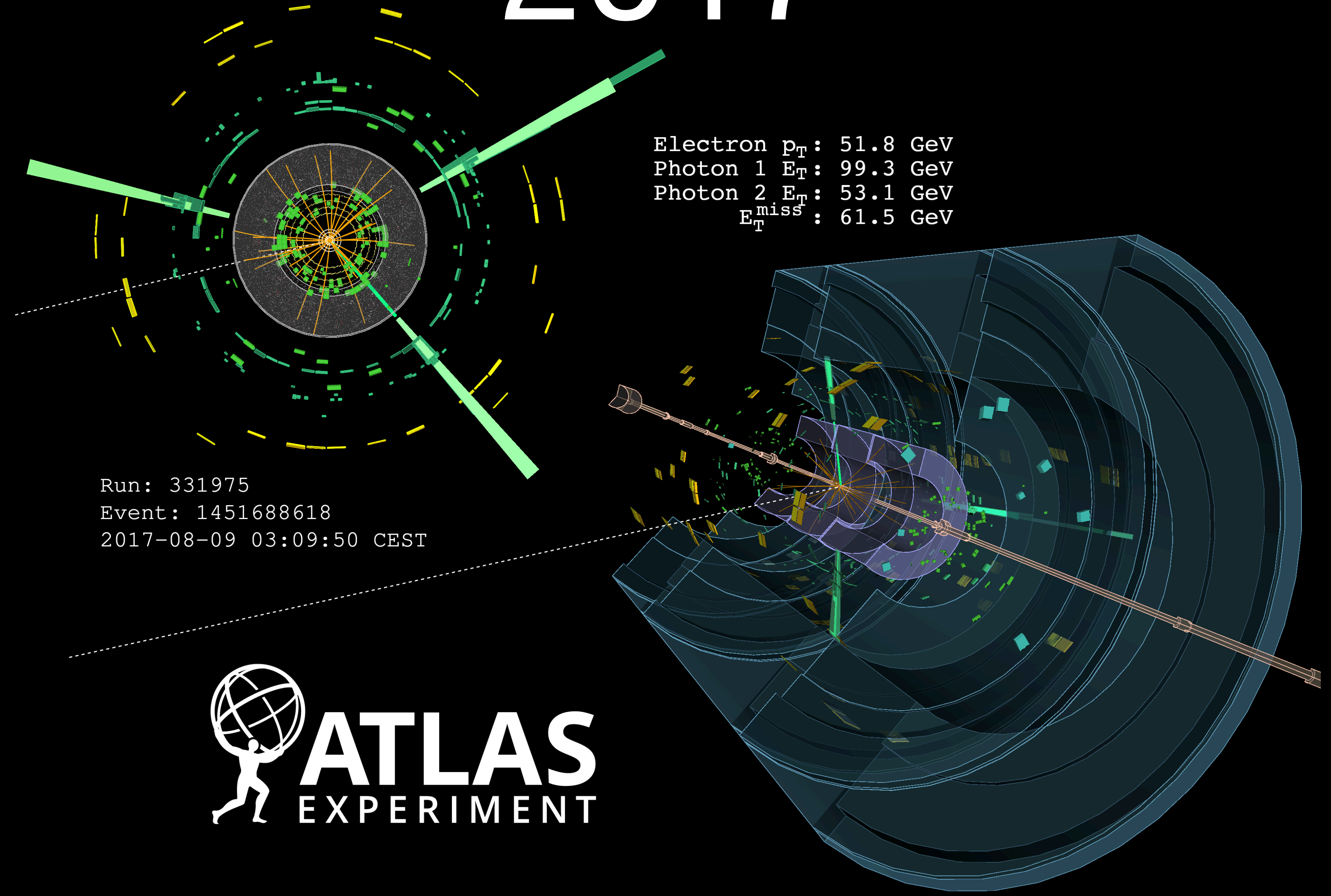
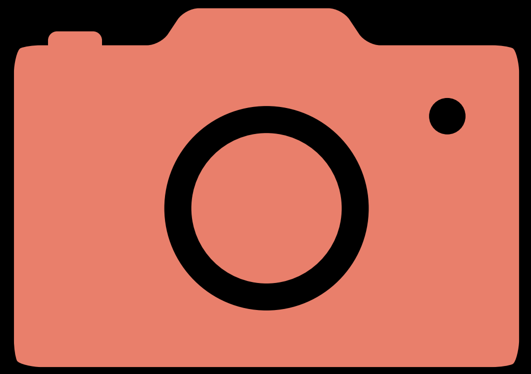
PHYS 7363 - Experimental Particle Detection and Detectors I



Particle detectors are the workhorses of experimental physics. In this course, we'll dive deep into their physics, exploring the incredible evolution of our experimental techniques over the past nine decades. You'll gain a solid understanding of *particle detection* and *identification*, examine the intricate designs of modern detectors, and learn how machine learning is being harnessed to push the boundaries of detector design. If you're intrigued by how we "see" subatomic particles, this course is for you!

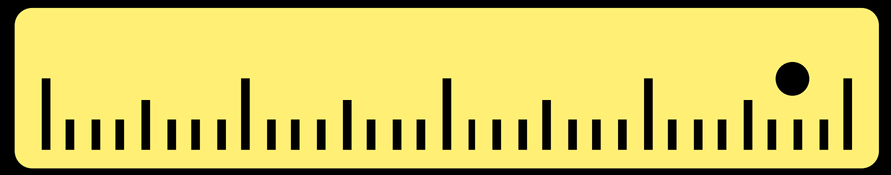
2017





Detect

Identify



Measure

To discuss prerequisites (and any questions on the content of the course), please contact me: saptaparnab@smu.edu

Schedule

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
August	18	19	20	21	22	23	24
	25 ✅	26	27	28	29 ✅	30	31
September	1	2	3 ✅	4	5 ✅	6	7
	8 ✅ 1.5 hours	9	10	11	12	13	14
	15 ✅ 1.5 hours	16	17 ✅ 1.5 hours	18	19 ✅ 1.5 hours	20	21
	22 ✅ 1.5 hours	23	24 ✅ 1.5 hours	25	26 ✅ 1.5 hours	27	28
October	29 ✅ 1.5 hours	30	1 ✅ 1.5 hours	2	3 1.5 hours	4	5

Schedule

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
October	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
	27	28	29	30	31	1	2
November	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
December	1	2	3	4	5	6	7
	8	9	10	11	12	13	14

Schedule

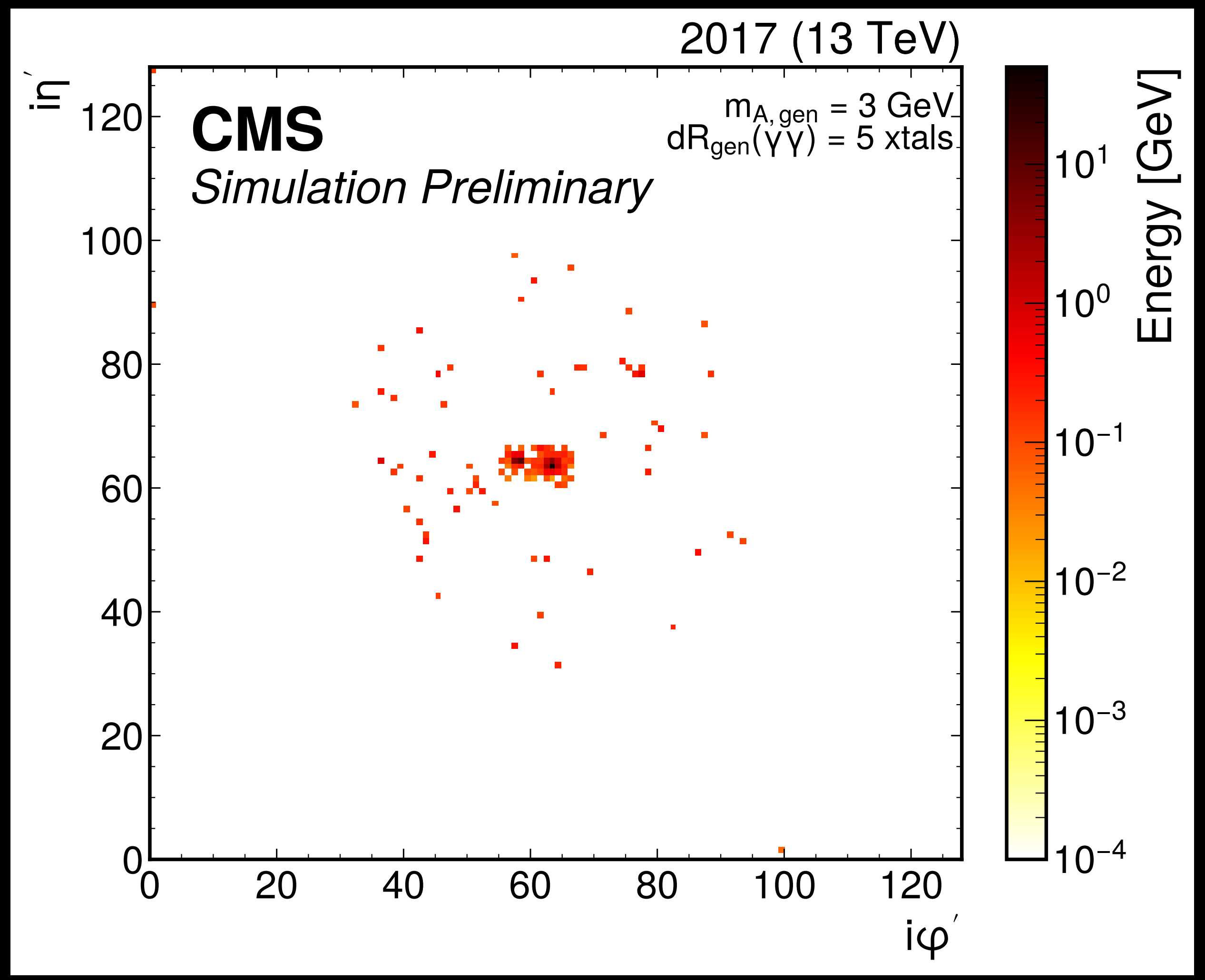
- Midterm on October 27th
- We decided on continue with this 80 min long lectures thrice a week
  - We will continue with this schedule unless I think that we don’t need to meet for that long a time frame
  - Next week, I am away at a conference, so we will meet on Monday as planned in person, Wednesday would be a zoom lecture and no lecture on Friday

Following up on fitting

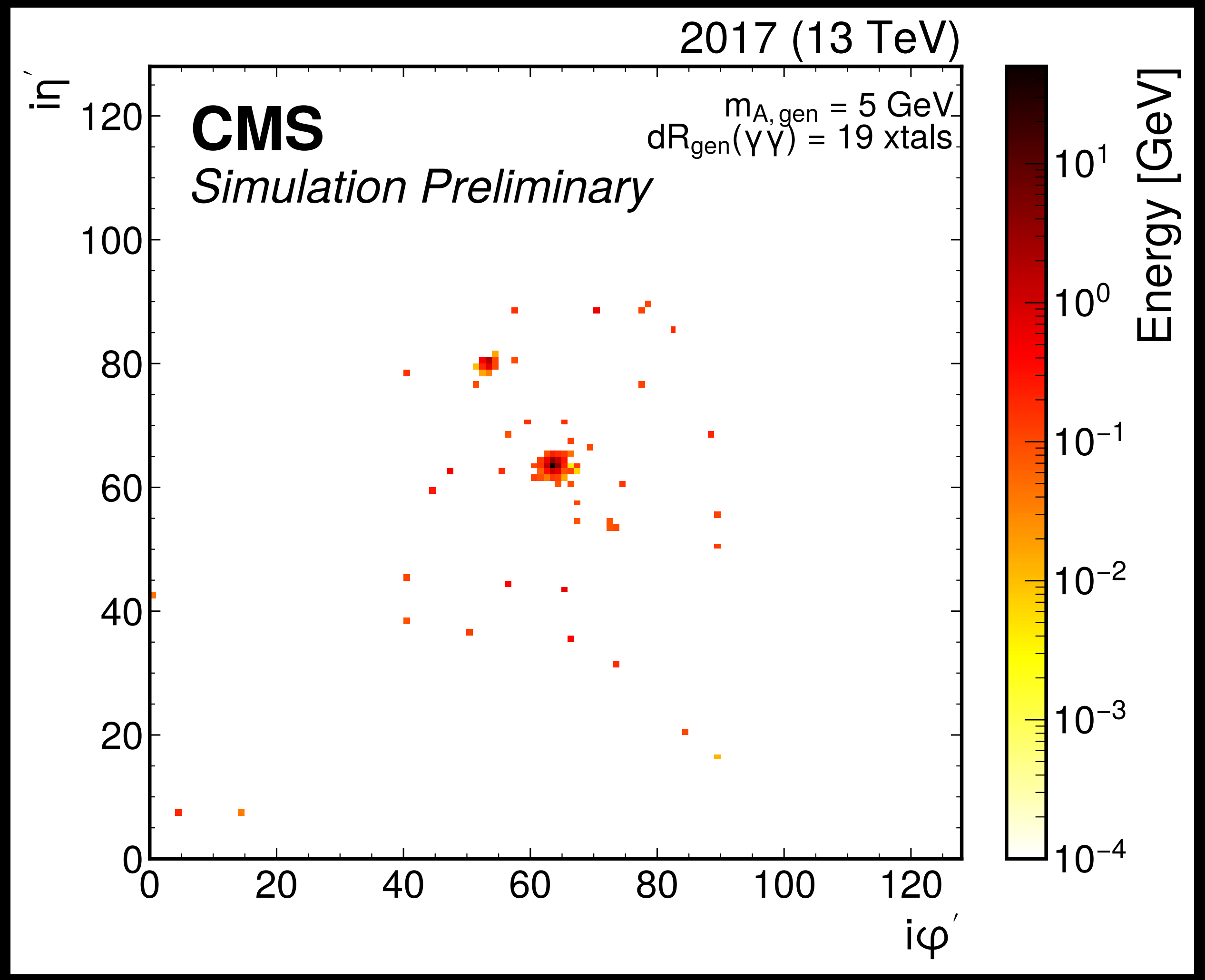
- Please produce the χ^2/number of degrees of freedom for the fits we have performed in class

How our detectors enable searches

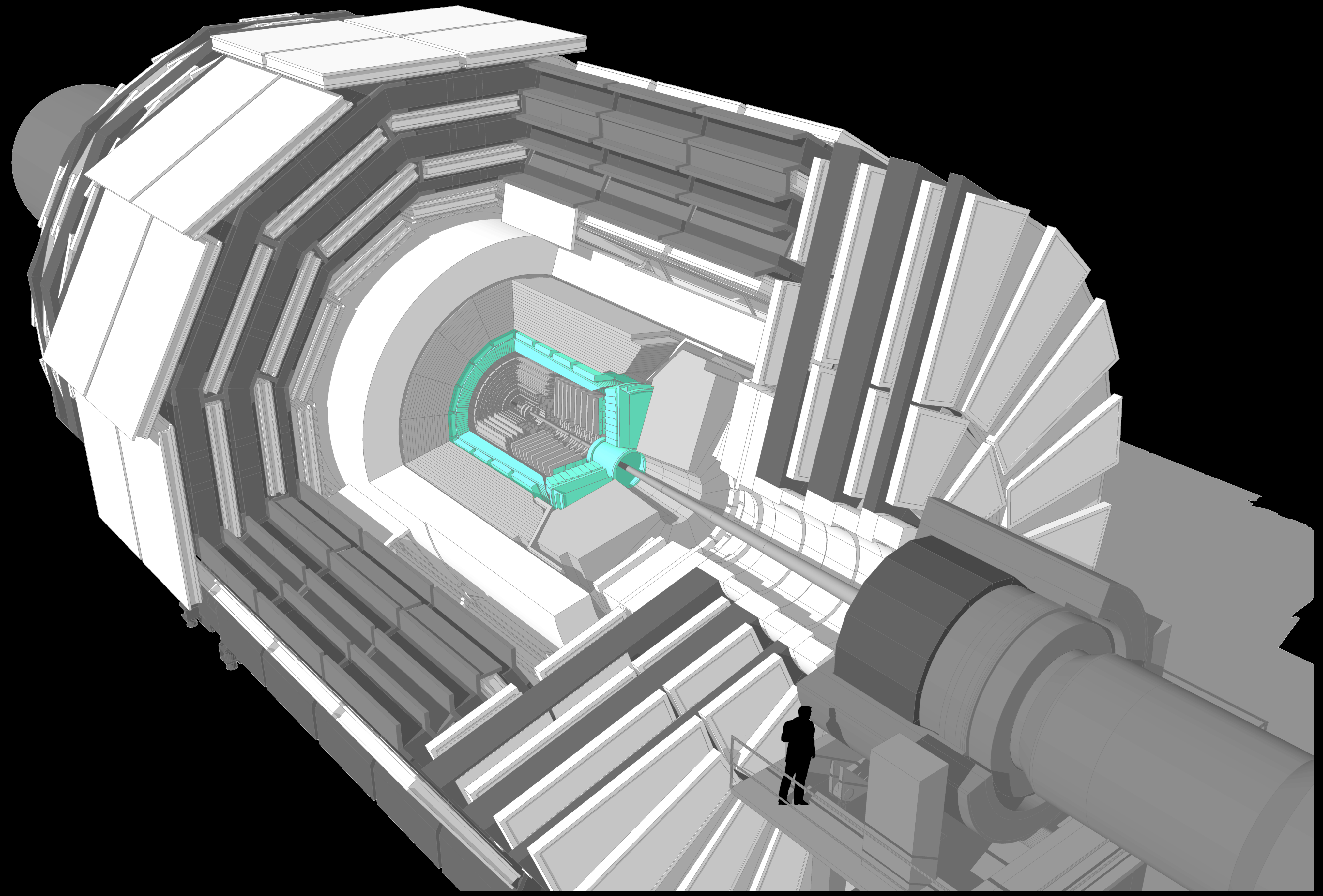
- Energy deposit maps in the ECAL from simulation and decay of $H \to AA, A \to \gamma\gamma$
- Categorize in terms of opening angles between two photons ($\Delta R_{\text{gen}}(\gamma\gamma)$)

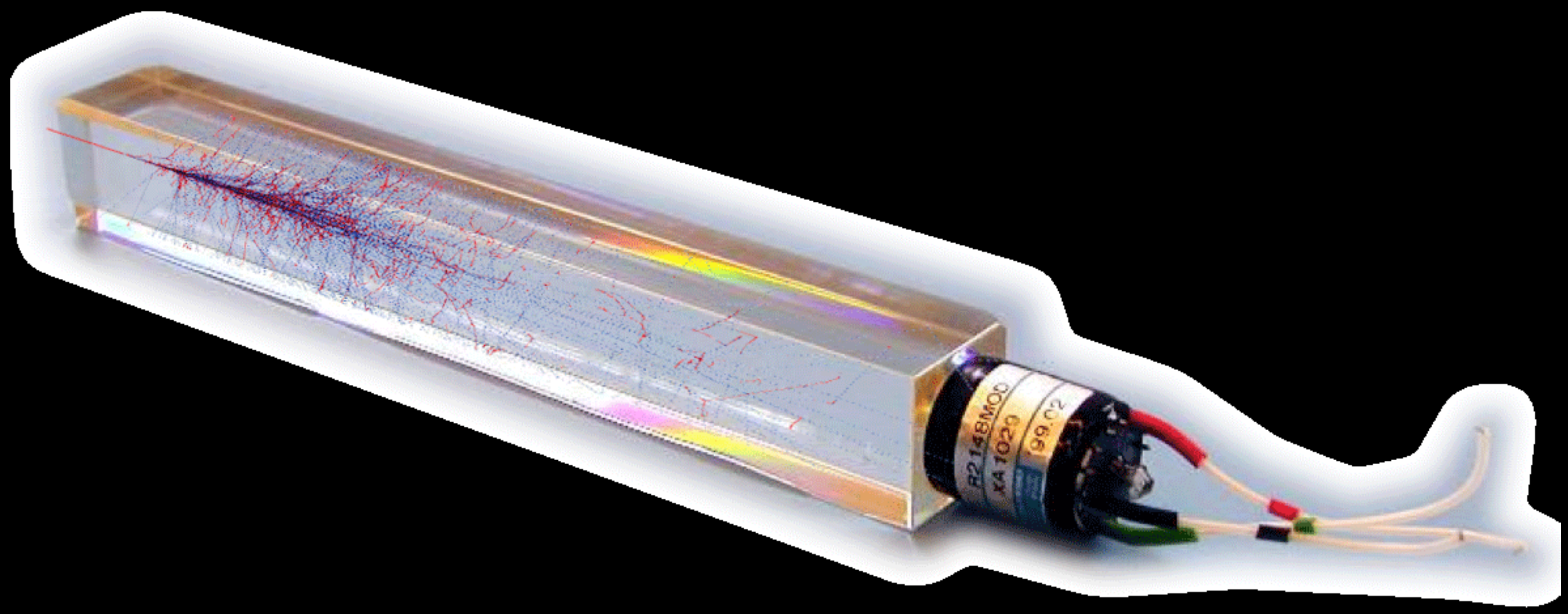


Overlapping clusters (m_A = 3 GeV) : reconstructed as a single photon ☝️



Higher energy (m_A = 5-15 GeV) but second cluster is softer ☝️





Calorimetry

- Based on chapter 15 of the book

Longitudinal shower profile

- The dimensions of showers determine the construction of calorimeters
- An empirical formula for the longitudinal energy distribution of a shower was derived by Longo and Sestili:
  - $\frac{dE}{dt} = E_0 \frac{b^a}{\Gamma(a)} t^{a-1} e^{-bt}$
  - Parameters a and b depend on the total energy deposited (E_0) and Z and Γ is the gamma function
  - Shower maximum $t_{max} = \frac{a-1}{b}$

Longitudinal shower profile

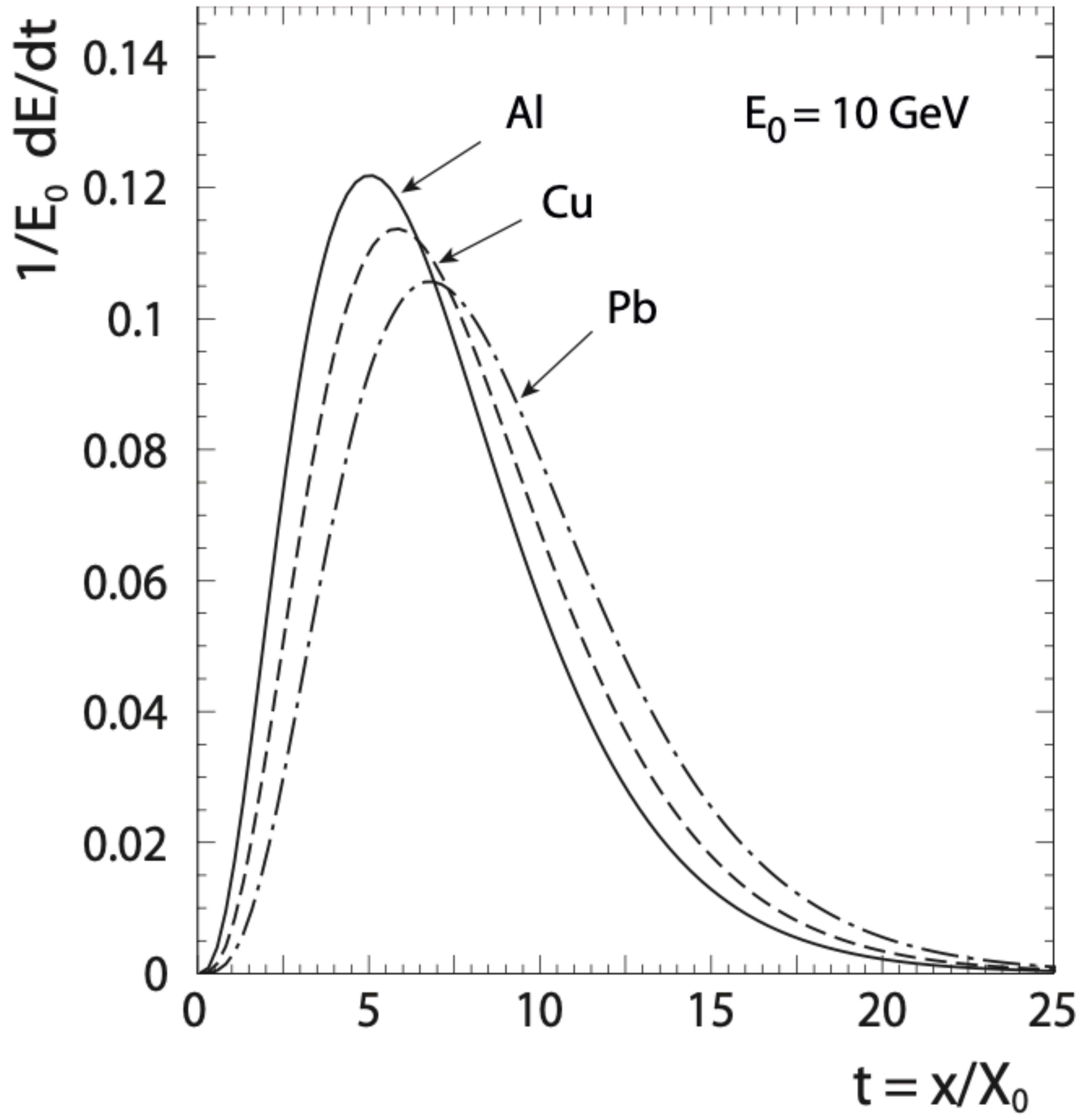
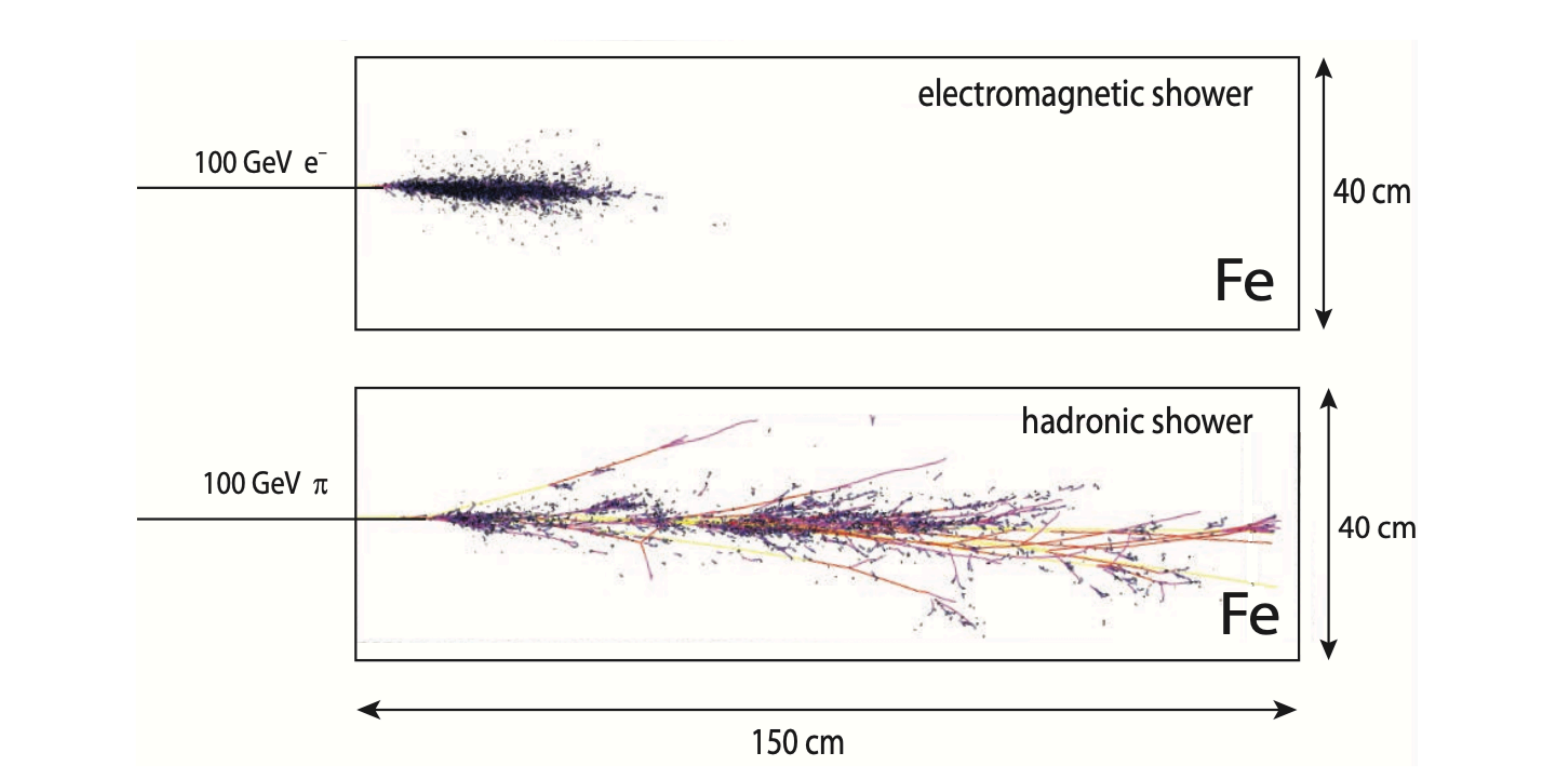


Fig. 15.4 Longitudinal profiles of 10-GeV electron showers calculated according to the Longo formula (15.17) for three different materials. The parameters are: $b = 0.5$, the same for all materials, and a calculated from (15.18) and (15.19). Due to the normalisation factor $1/E_0$ the area under each curve is the same. The differences in the shower development are due to the different critical energies of the three materials (see table 3.4).

Lateral shower profile

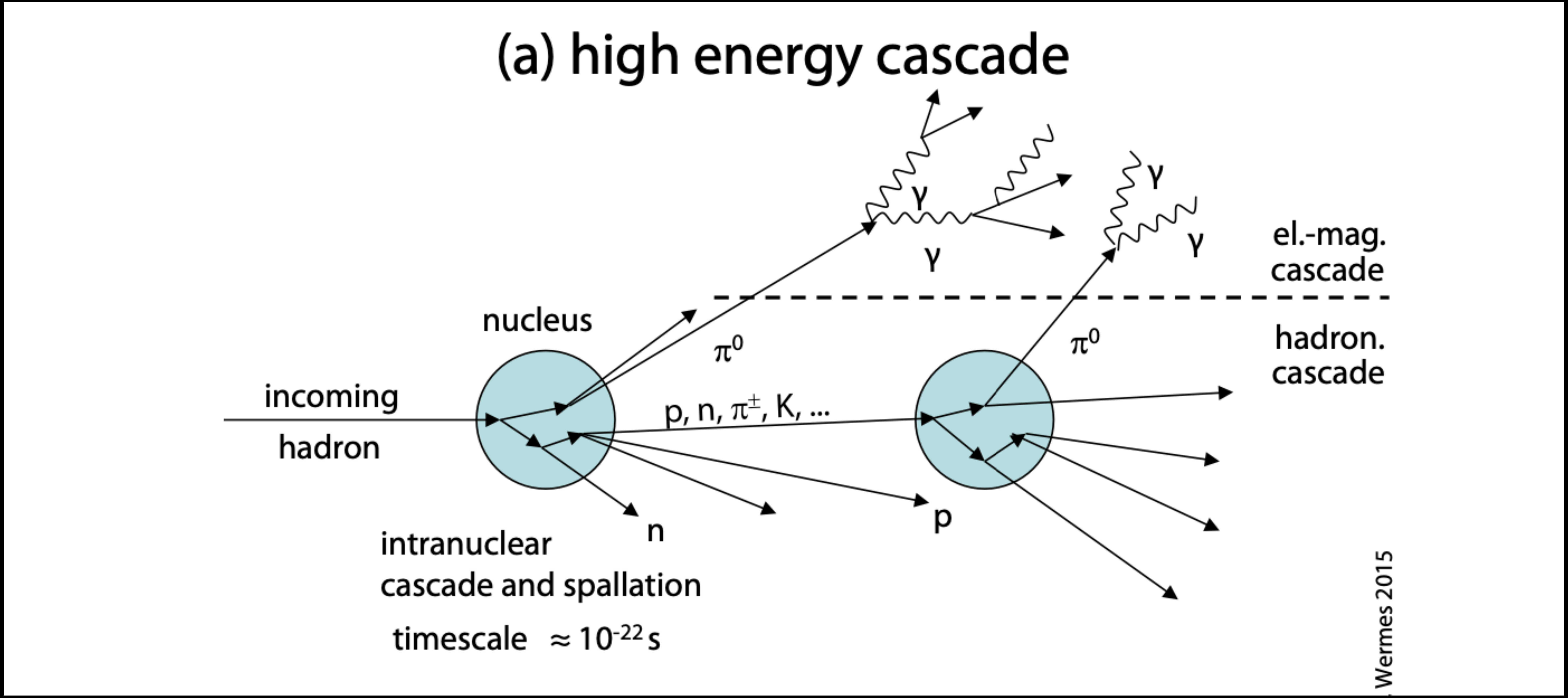
- At high energies, two shower processes scatter particles under a very small angle, naturally showers do not extend much laterally
- Lateral profile determined by other factors like multiple scattering of low energy charged particles
- Follow details of lateral shower profiles in Fig. 15.6 of the book and the accompanying section

Comparison of electromagnetic and hadronic showers



Hadron Showers

- High energy hadrons form particle showers when passing through dense material



Spallation: The excited nucleus releases its energy through emission of nucleons