Welcome !

Q&A and Tutorial session

Interaction of particles/radiation with matter

Lucia Di Ciaccio

About me

Lucia Di Ciaccio

Professor of Physics at University of Savoie

Member of the ATLAS Collaboration @ LHC

Mobility:

University of Rome I (study)
CEA-DPh Saclay (postdoc)
University of Rome II (university researcher)
University of Savoie (professor)

Experiments:

Fixed target beauty search (NA19)
Neutron-antineutron oscillation (NADIR)
Proton decay (TAUP)
e^+e^- physics (DELPHI @ LEP)
pp physics (ATLAS @ LHC)

Work on:

MWPC
RPC and Flash Chamber
Monte Carlo
Electromagnetic calorimeter (HPC, LAr)
Data reconstruction
Data analysis (SM @ LHC,
Higgs&beauty @ LEP)

Organisation of the course: IPM

- 4 videos (~ 2 h):
  * Generalities
  * Neutral particle interactions,
  * Charged particles interactions 1 and 2
- Q&A (30', now)
- Tutorials (3 h)

  Questions (today, discussions + assignments)

  Exercises (2 sets) to do them 'together':

  1st set of exercises (today):

  I'll ask you to do them (you can ask questions)

  → correction by you & by me

  (share screen: files or ZOOM whiteboard)

  2nd set of exercises (tomorrow):

  → to do for tomorrow (assignments)

  → correction by you & by me (as above)

Further considerations about the IPM course

This course has large unavoidable overlaps with course of 'Experimental Particle Physics of Marco Delmastro' (it is difficult to speak of experimental particle physics without explaining what happens when a particle crosses matter)

Some of you have already followed IPM courses since this may be included in university courses.

➔ Please take it It will be as a review,
a test of what you know

Questions about NEUTRAL Particle/Radiation

Q1. photons signature in detectors in high energy physics detectors?

Q2. What is a π^0 (~ mass, quantum numbers, proper time)?
How to detect a π^0 ? Which are the challenges @ LHC to detect a pi0?

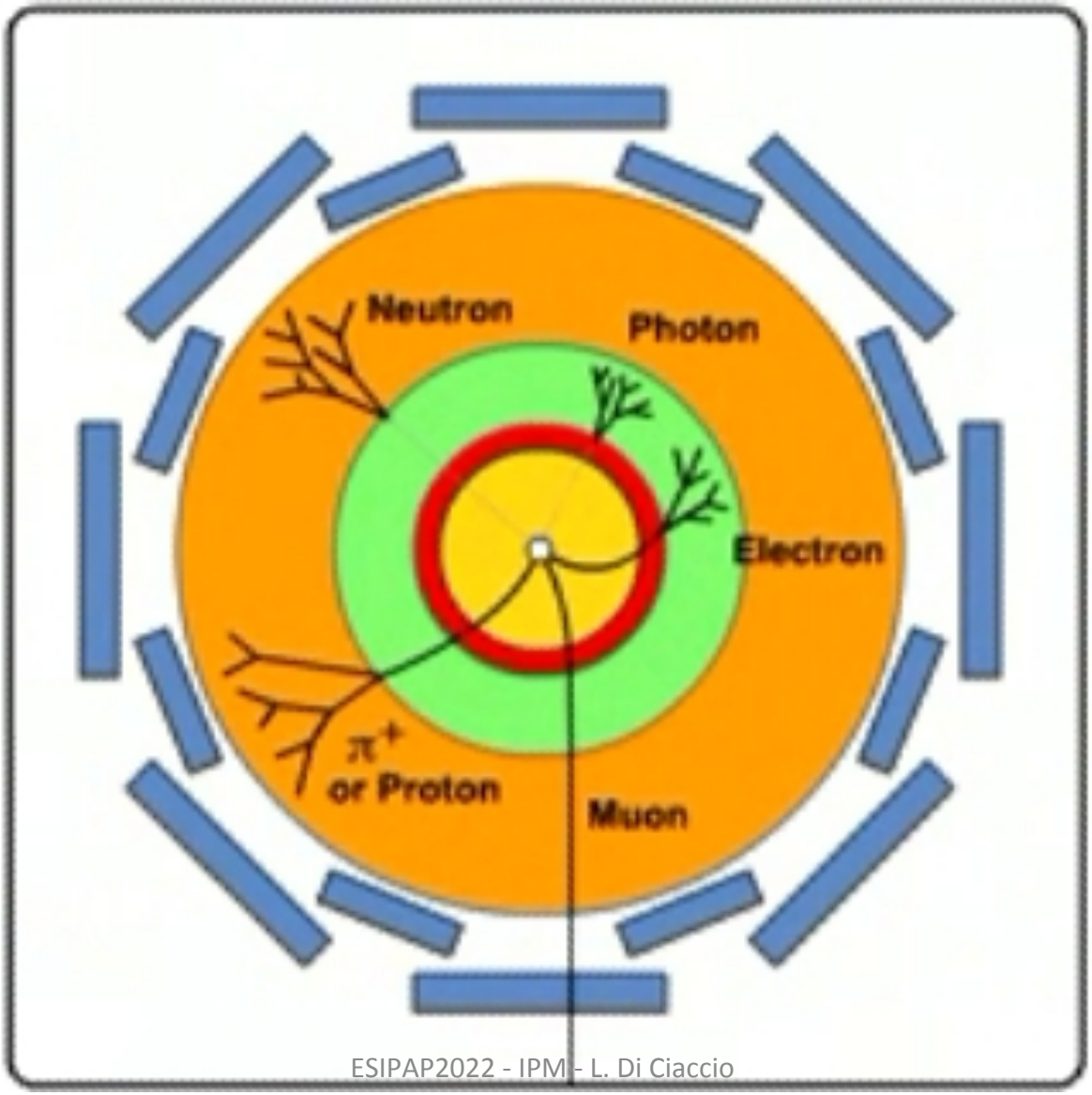
Q3. What is a neutral kaon (mass, quantum numbers, proper time) ?
How to detect/identify a low/medium energy K^0 ?

Q4 What is a B^0 (mass, quantum numbers, proper time) ?
How to detect a B^0 in the ATLAS/CMS detectors ? Assignment

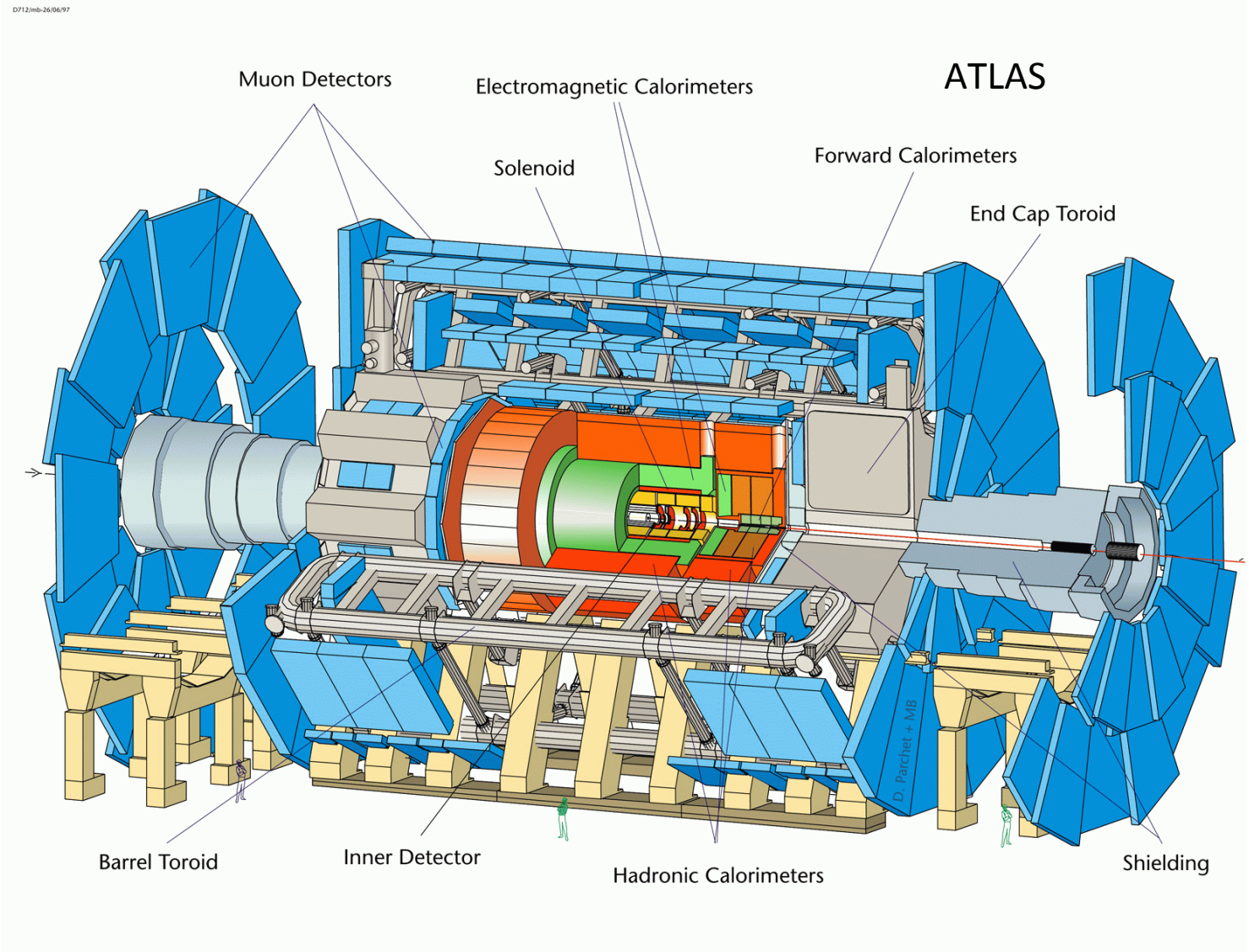
Q5 What is a thermal neutron?
How to build a collimated beam of thermal neutrons ?
How to detect a neutron ? Assignment

Q6 Neutrons for imaging ("radiography").
Advantage? Disadvantages? Assignment

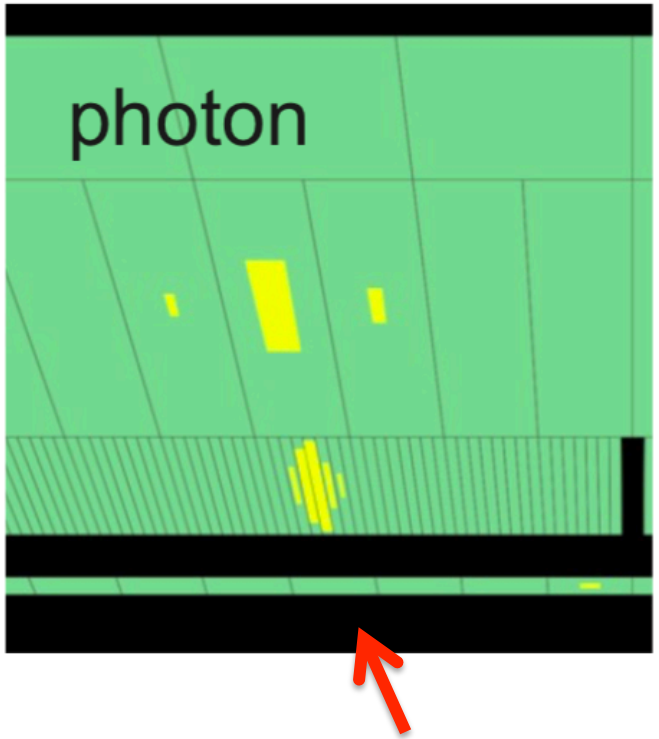
Q: Photons signature in high energy physics detectors?



Q: Photons signature in high energy physics detectors?

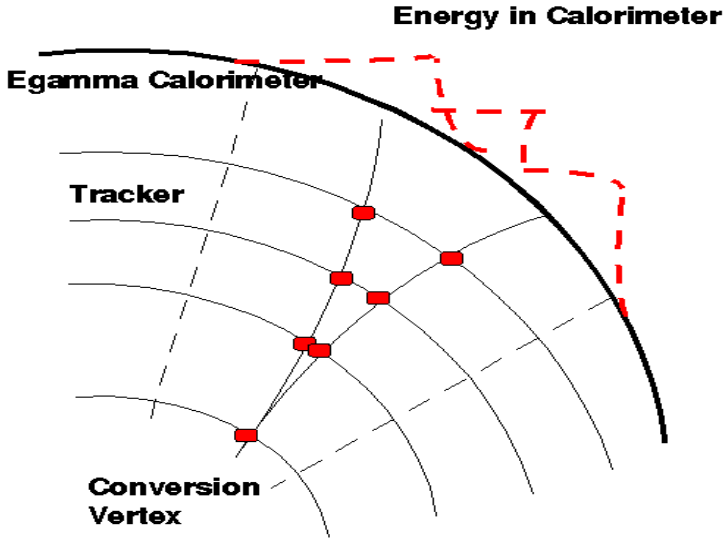


Q: Photons signature in high energy physics detectors?

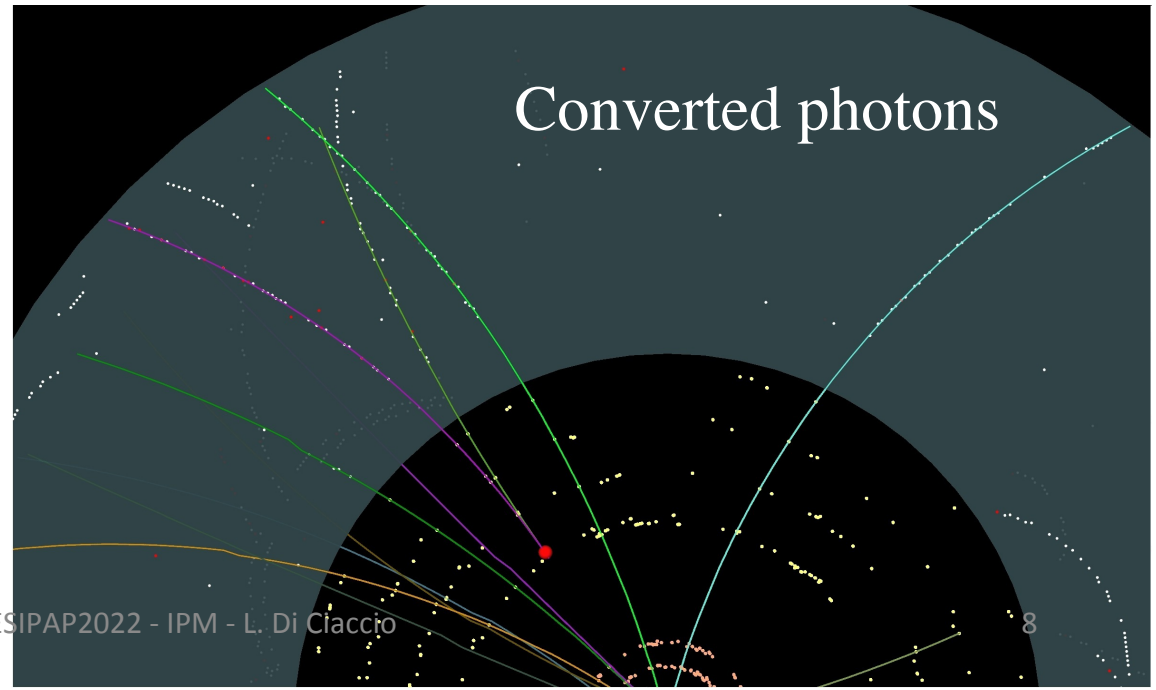


Unconverted photons

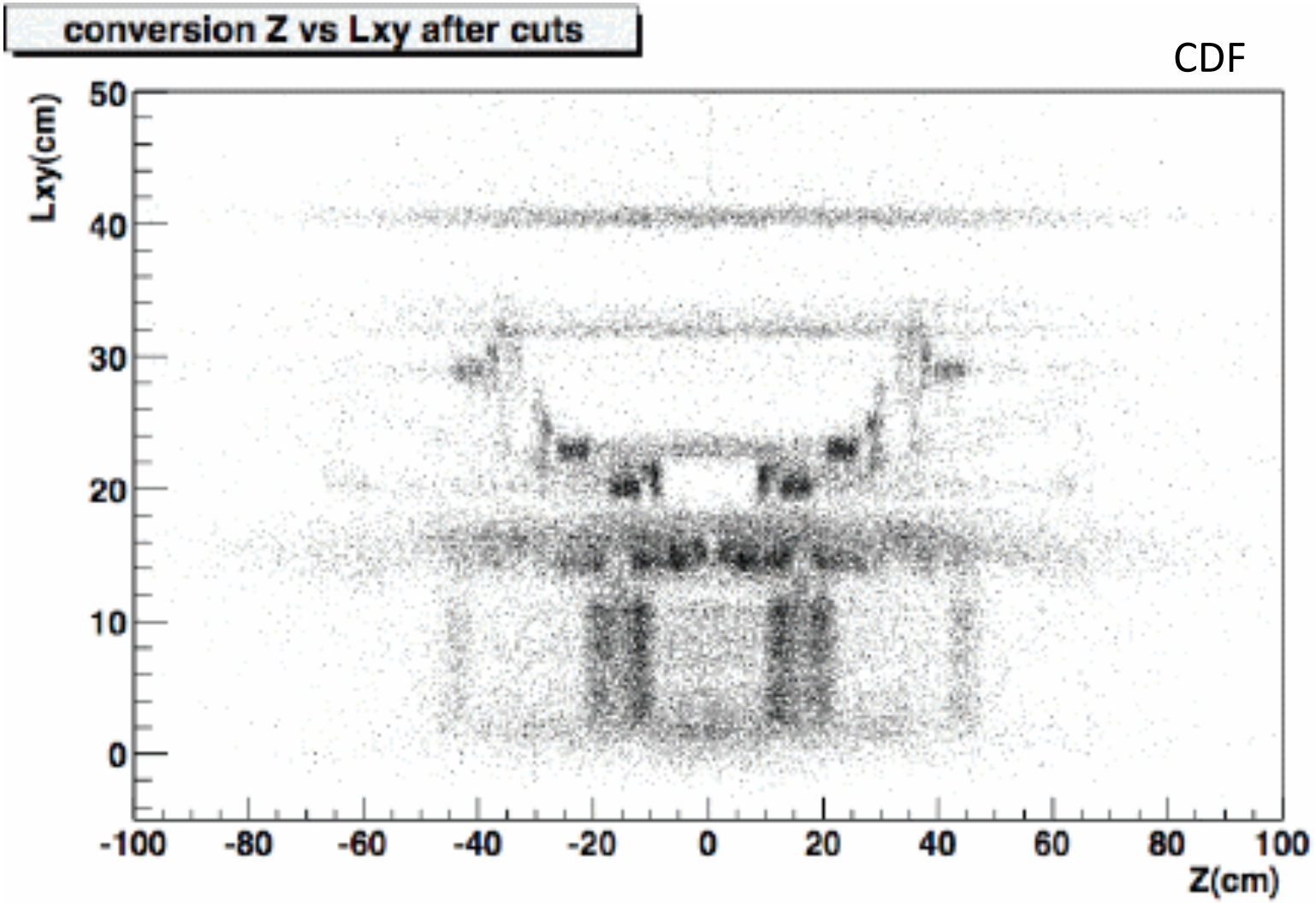
Converted photons



Sometimes only 1 prong is reconstructed



Thanks to photon conversion it is possible to make a radiography of the detector : compare data & MC ← important !



Q: What is a π^0 (~ mass, quantum numbers, proper time)?

π^0

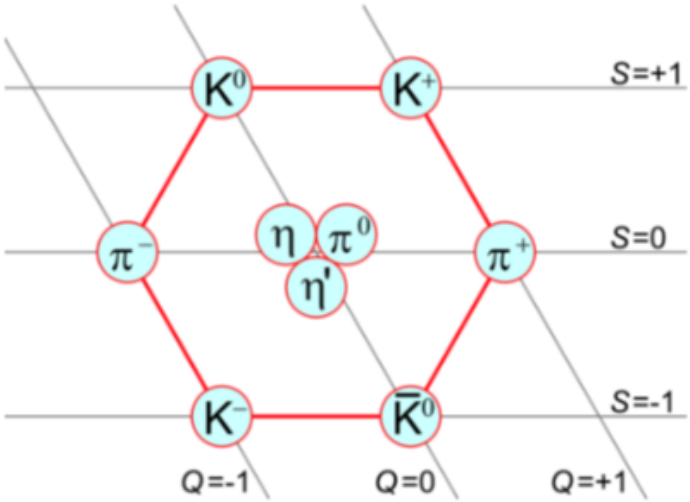
Mass: 134.9768(5) MeV/c^2

Spin: 0

Parity: -1

→ pseudoscalar meson

$$\frac{1}{\sqrt{2}}\left(u\bar{u} - d\bar{d}\right)$$



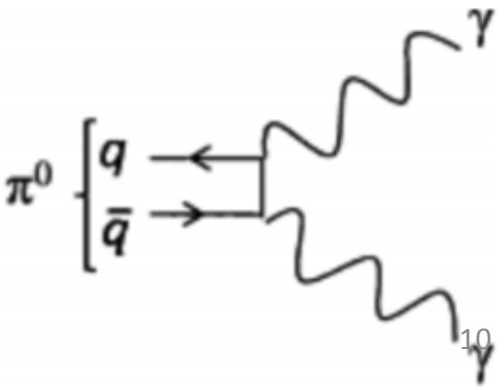
Charge conjugate of himself $J^{PC} = 0^{-+}$

Interactions: strong, weak, electromagne

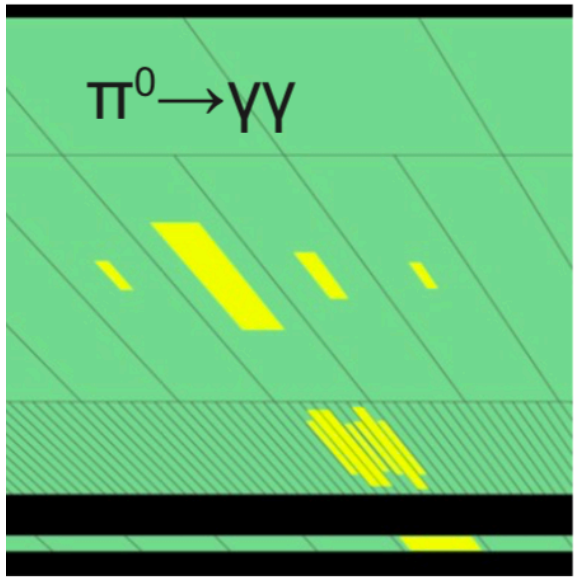
Decay via electromagnetic interaction

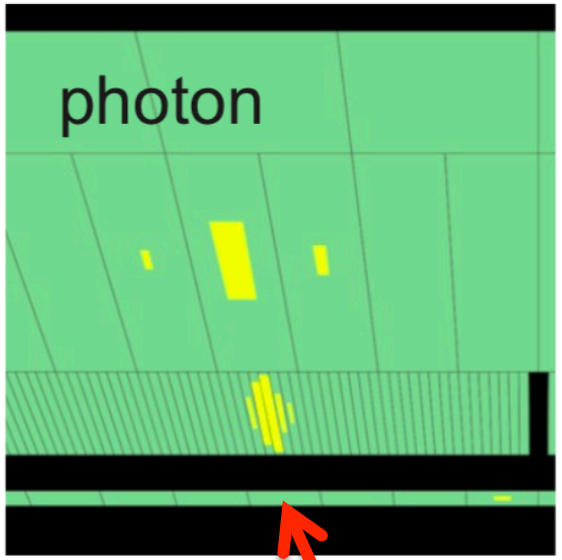
$\pi^0 \rightarrow 2\gamma$ Br = 0.988

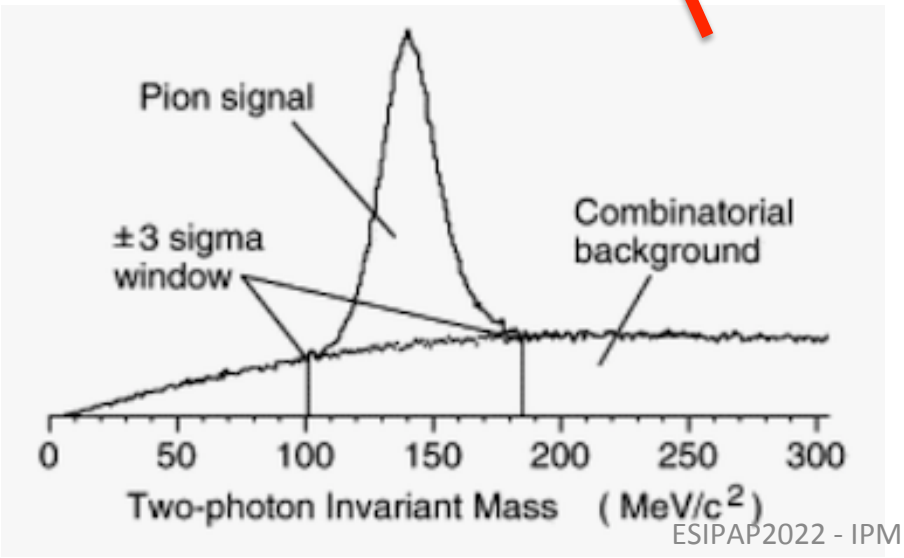
$\tau = 0.85\times10^{-16}$ s



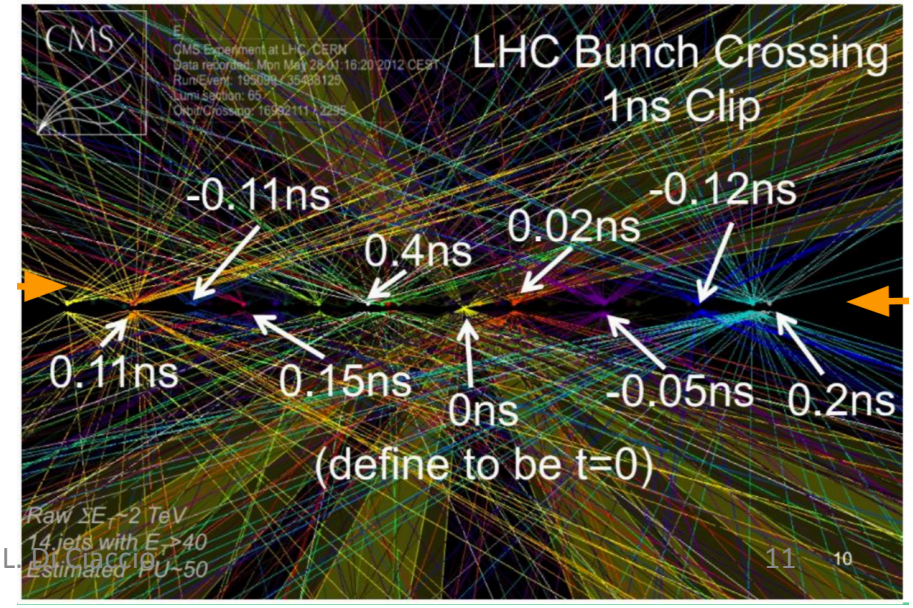
How to detect a π^0 ? Which are the challenges@ LHC to detect a π^0?
Challenges @ LHC to detect a π^0 ? Discriminate :







In a very dense environment



Q: What is a K^0 (~ mass, quantum numbers, proper time)?

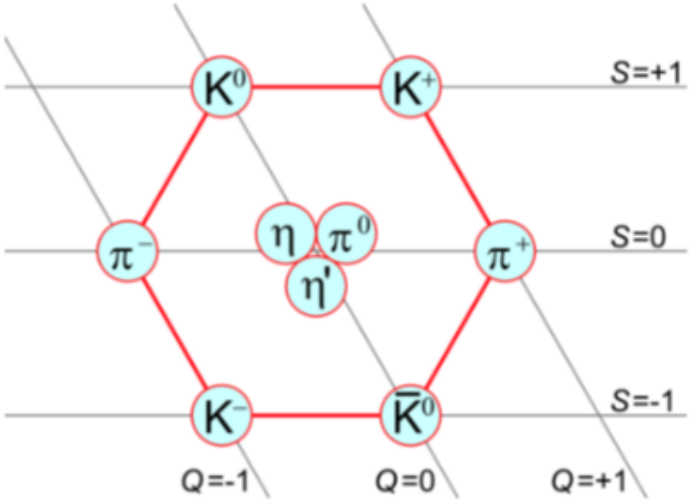
K^0 $d\bar{s}$

Mass: 497.611 MeV/c^2

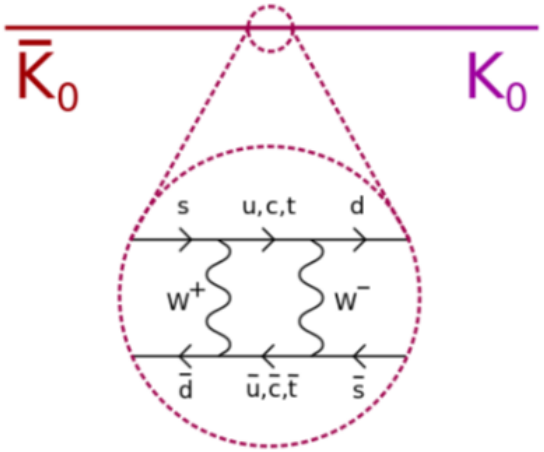
Spin: 0

Parity: -1

→ pseudoscalar meson



The mass eigenstates are not the weak interaction eigenstates



→ K^0_S and K^0_L

Mean lifetime: $\tau = 8.954\ 10^{-11}$ s (K^0_S)

$\tau = 5.116\ 10^{-8}$ s (K^0_L)

Main decays:

$K^0_S \rightarrow 2\pi$ CP (K^0_S) ~ +1

$K^0_S \rightarrow 3\pi$ CP (K^0_L) ~ -1

How to detect/identify a low/medium energy K^0 ?

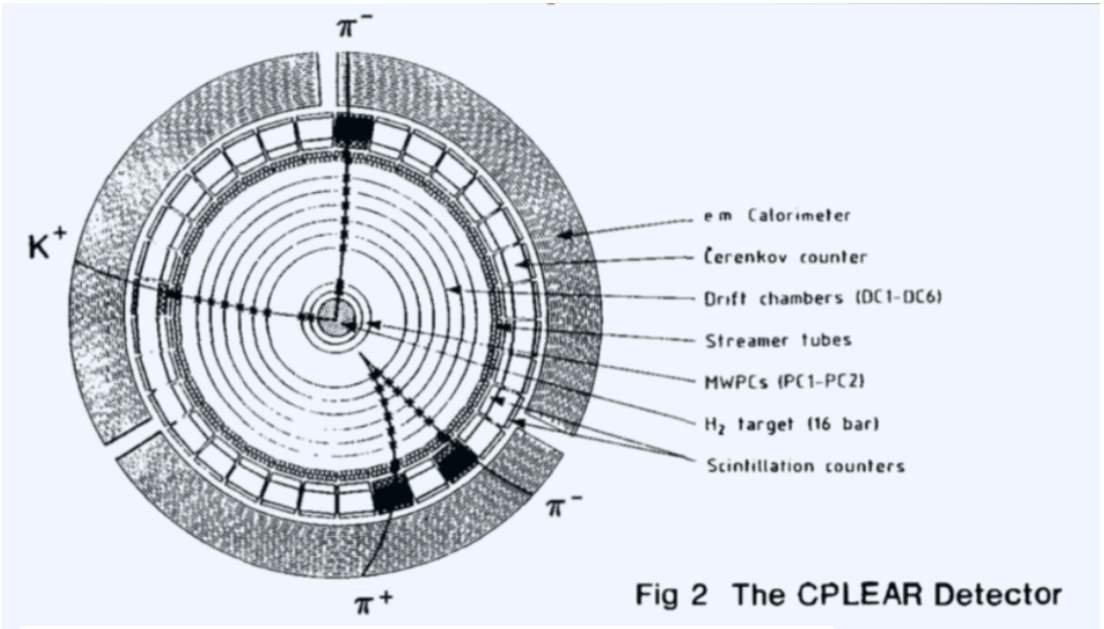
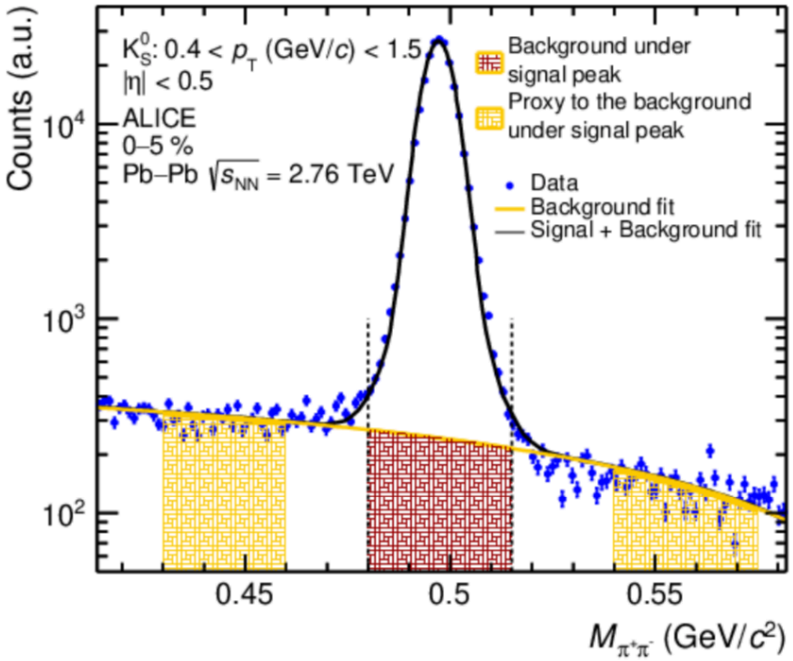


Fig 2 The CPLEAR Detector



→ K^0_S and K^0_L

$c\tau$: 2.7 cm (K^0_S)

15 m (K^0_L)

Main decays:

$K^0_S \rightarrow 2\pi$ $K^0_S \rightarrow 3\pi$

V0 signature

Similar as $\Lambda \rightarrow p\,\pi$

Λ (uds)

$m_\Lambda \sim 1.1$ GeV/c2

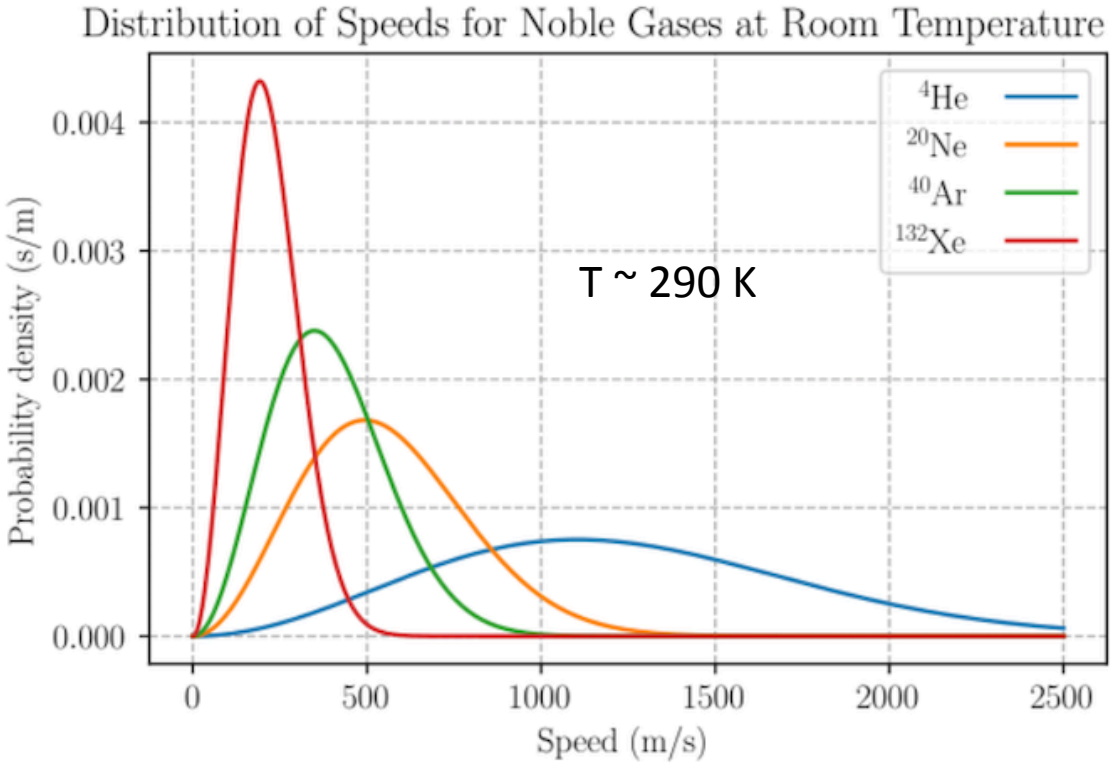
$\tau \sim 2.6\ 10^{-10}$

What is a thermal neutron?

'Free' neutron

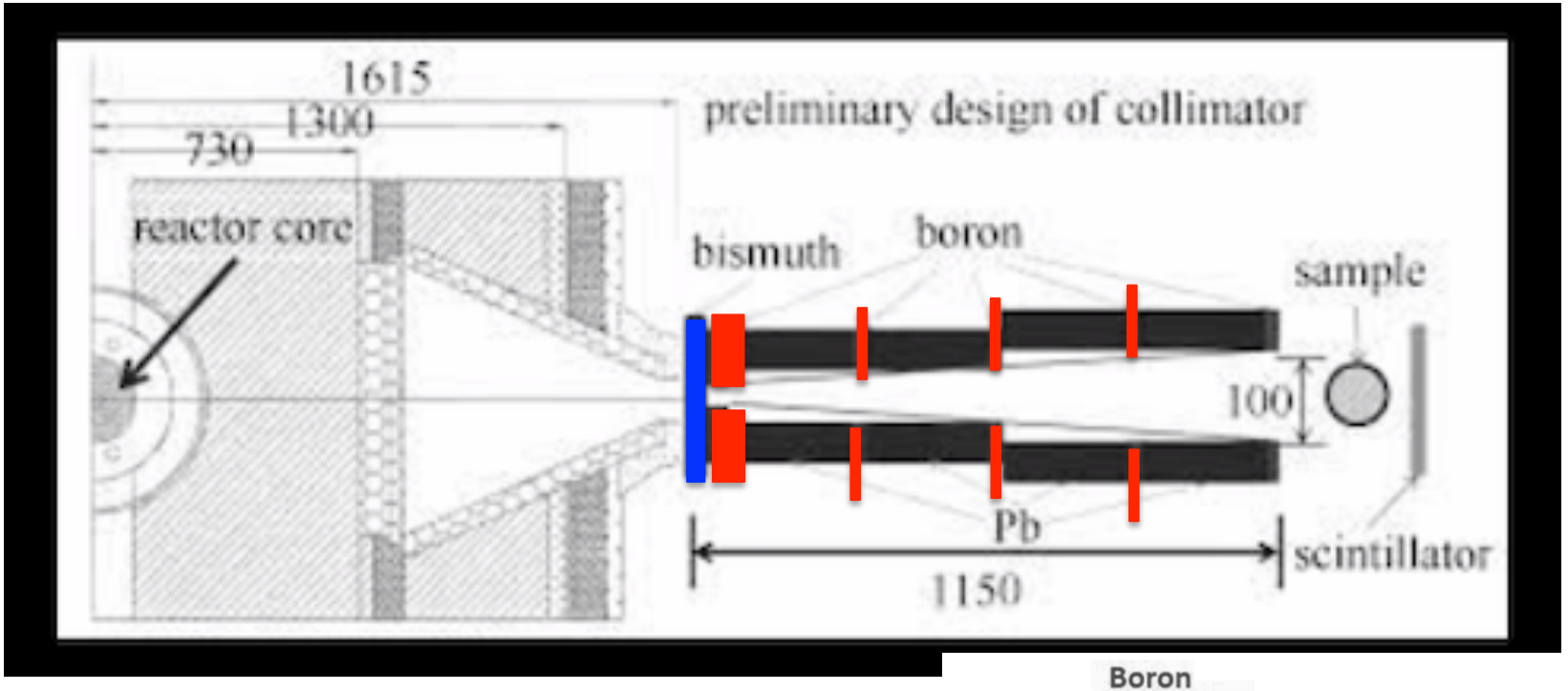
$E_{kin}^{n} \sim 0.025$ eV (speed ~ 2.19 km/s)

E_{kin}^{n} corresponding to the most probable speed @ T = 290 K

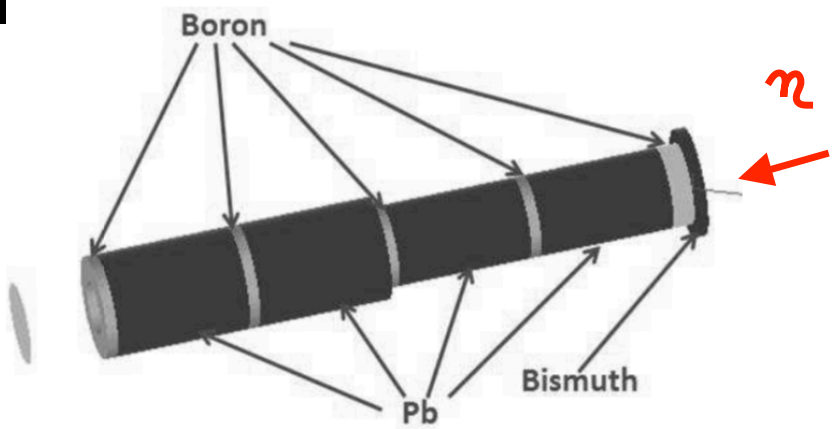


Maxwell–Boltzmann distribution of T

How to build a collimated beam of thermal neutrons ?



https://arxiv.org/abs/1305.0672v1
(neutrons for radiography)



Bi scatter off some fast neutrons, minimise the gamma rays background
B high neutron radiative capture cross section