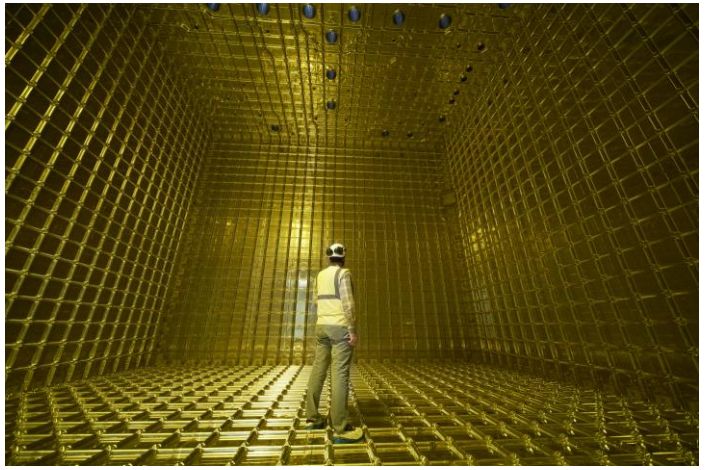
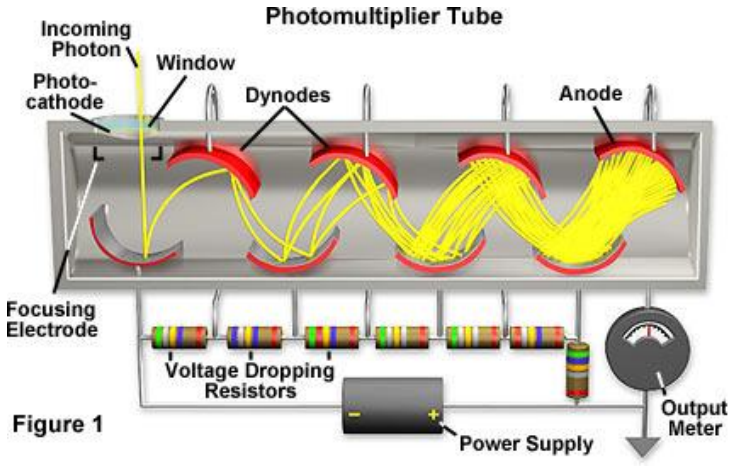
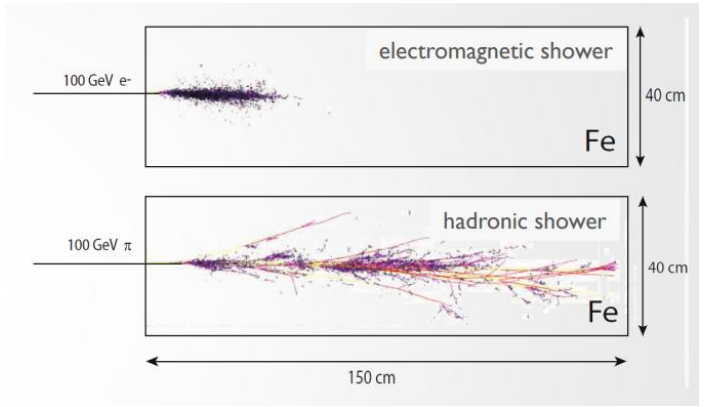
Particle Detection

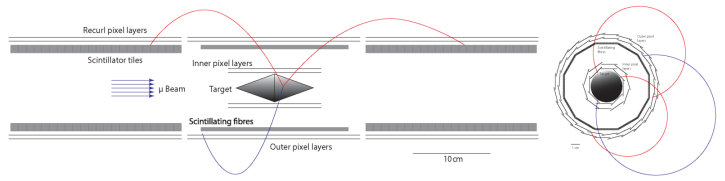
Liverpool@CERN Particle Physics School 2025

Ned Howarth









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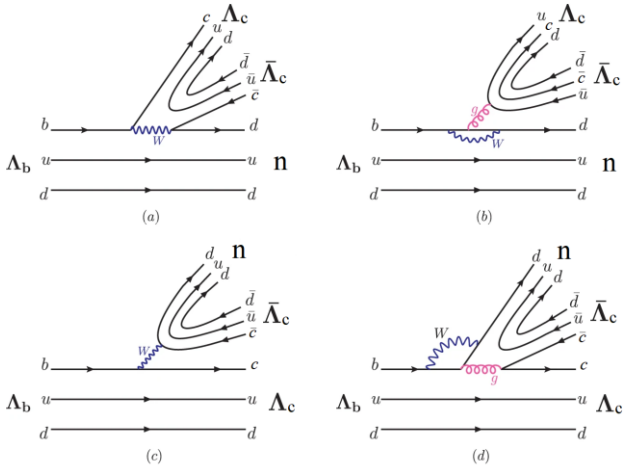
- Researcher on LHCb Looking at purely baryonic decays and neutrons.



Testing The SM

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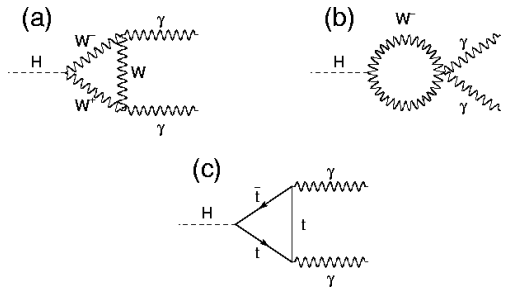

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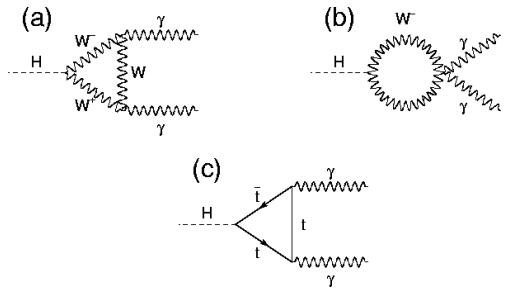

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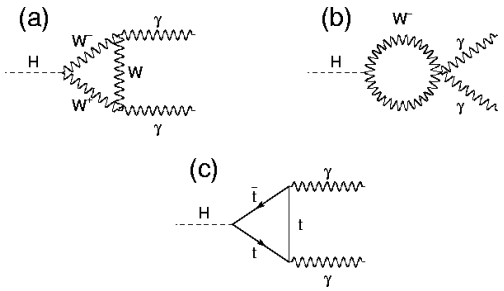

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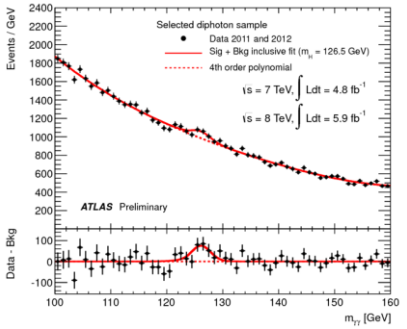

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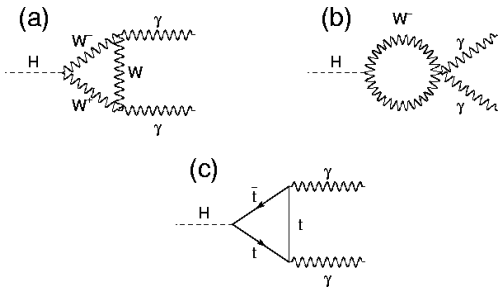

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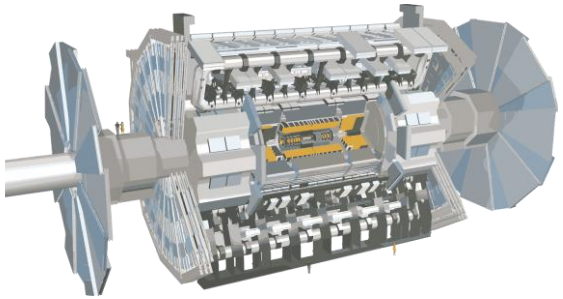

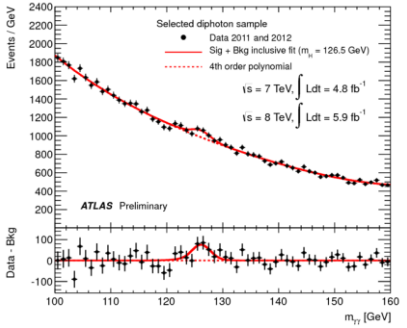

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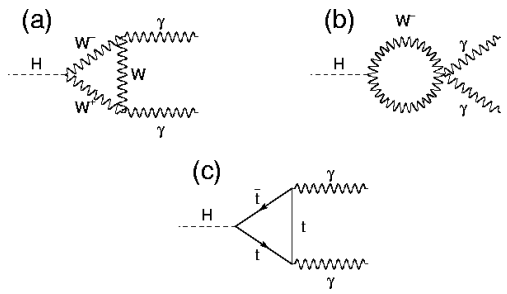

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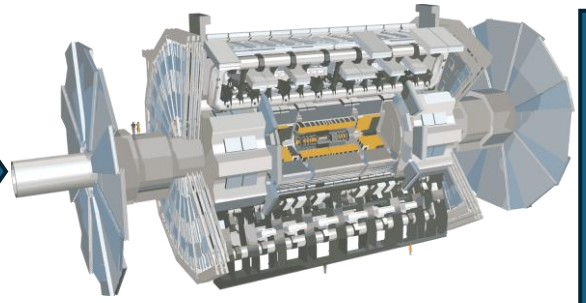
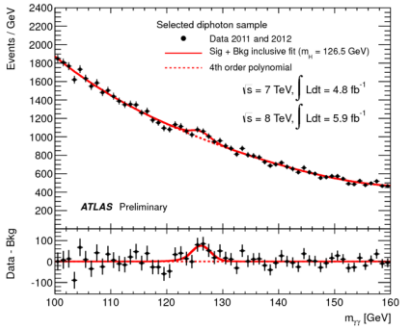
- Physics Processes
- Interaction with matter.



- Digitisation
- Particle Signatures
- Data Analysis



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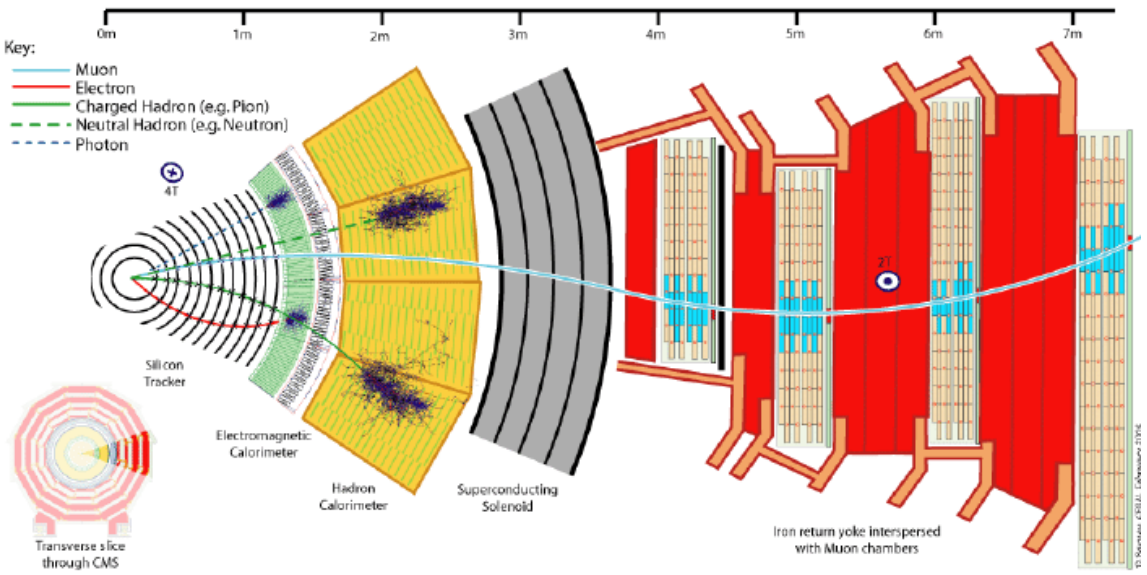

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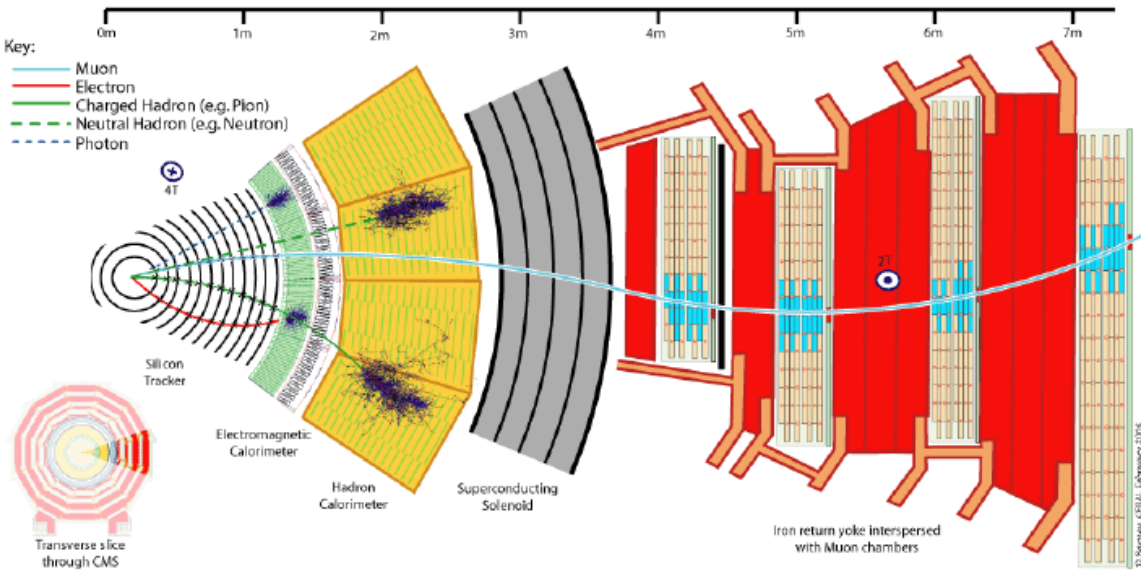


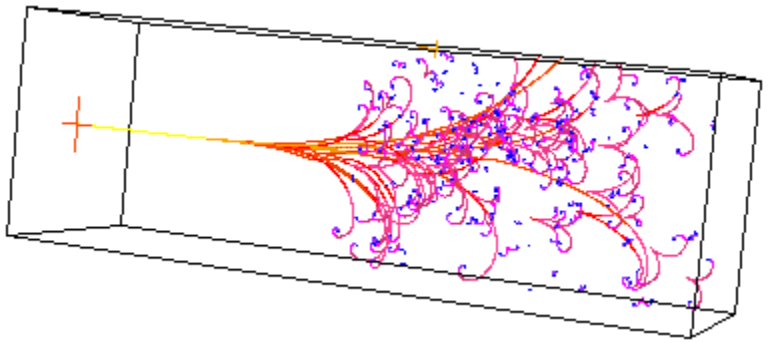
Detector

Physicist

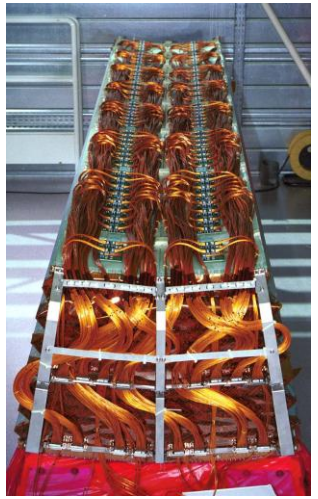
Interactions with Matter; Our Toolkit.

- Particle enters some material.
- What happens?
- How can we utilise that to build a detector.
- Can we optimise to look for certain physics.
- Let's build up a toolkit.

Interaction



Build a Detector



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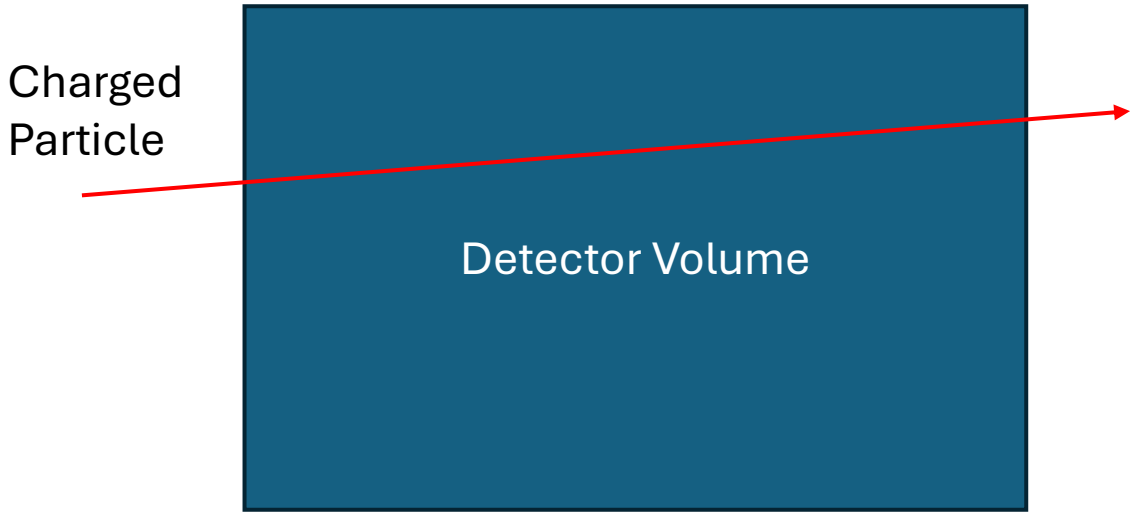

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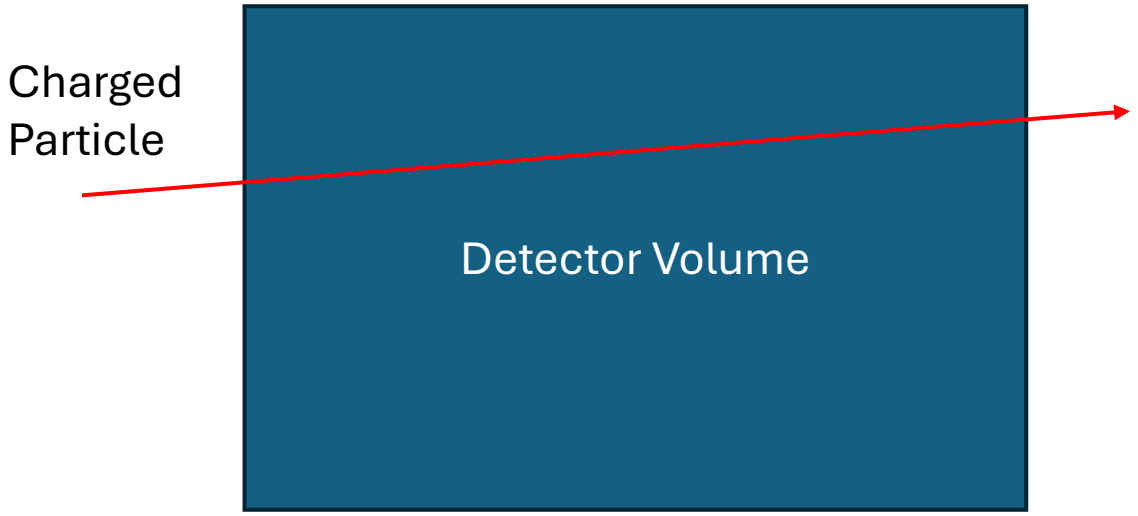

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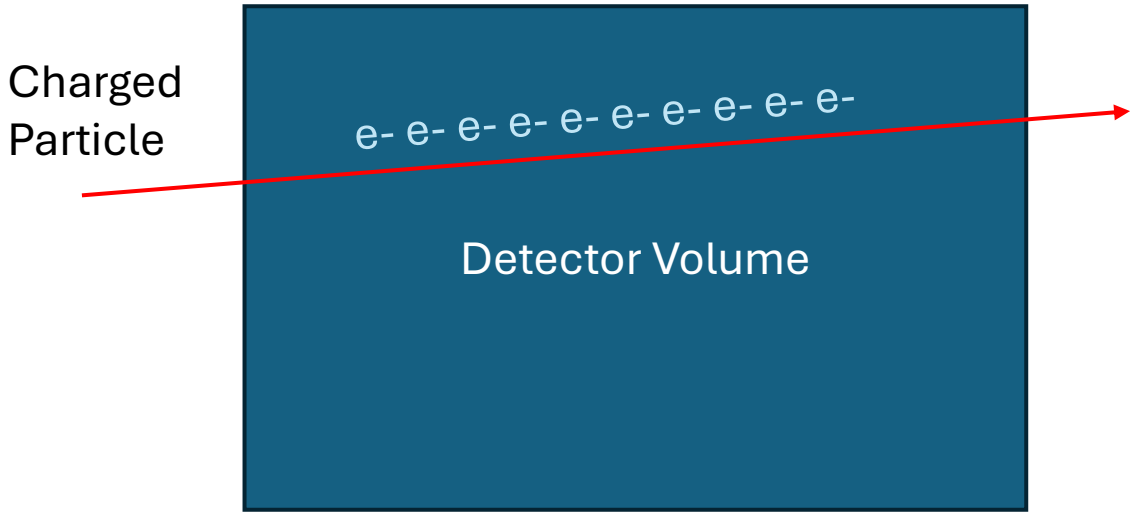

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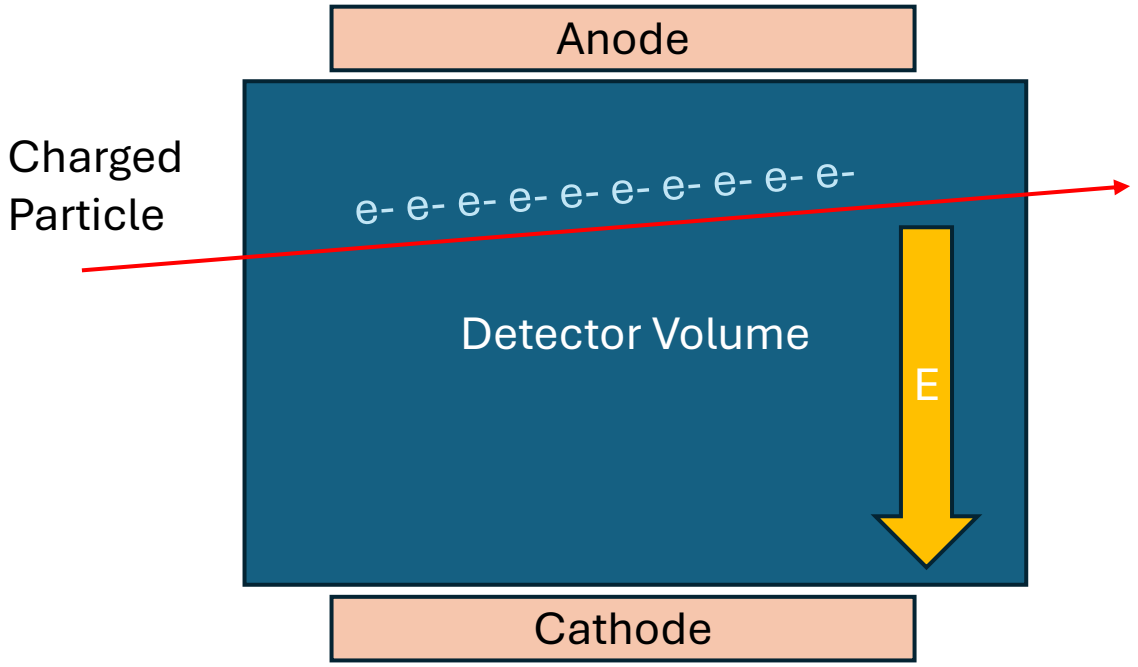

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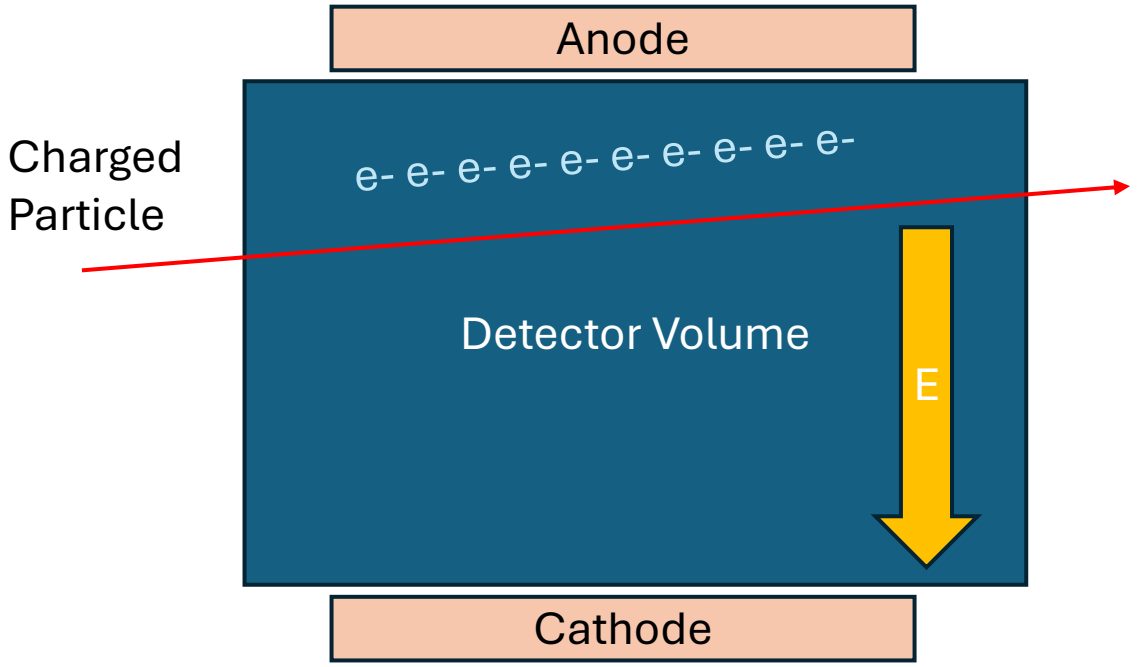

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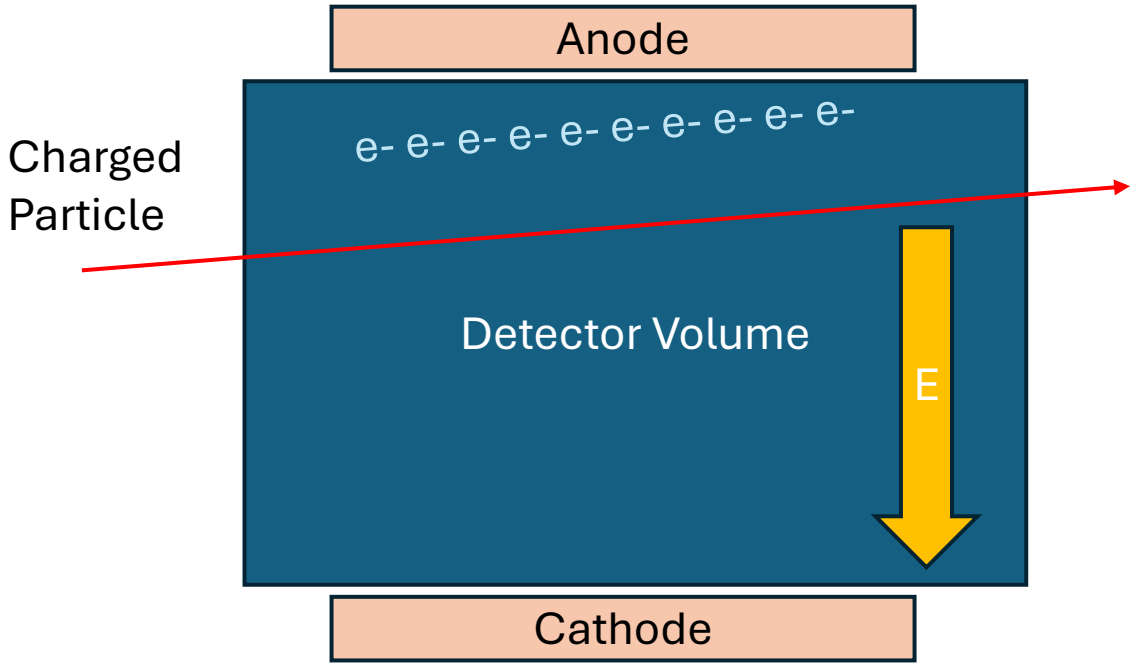

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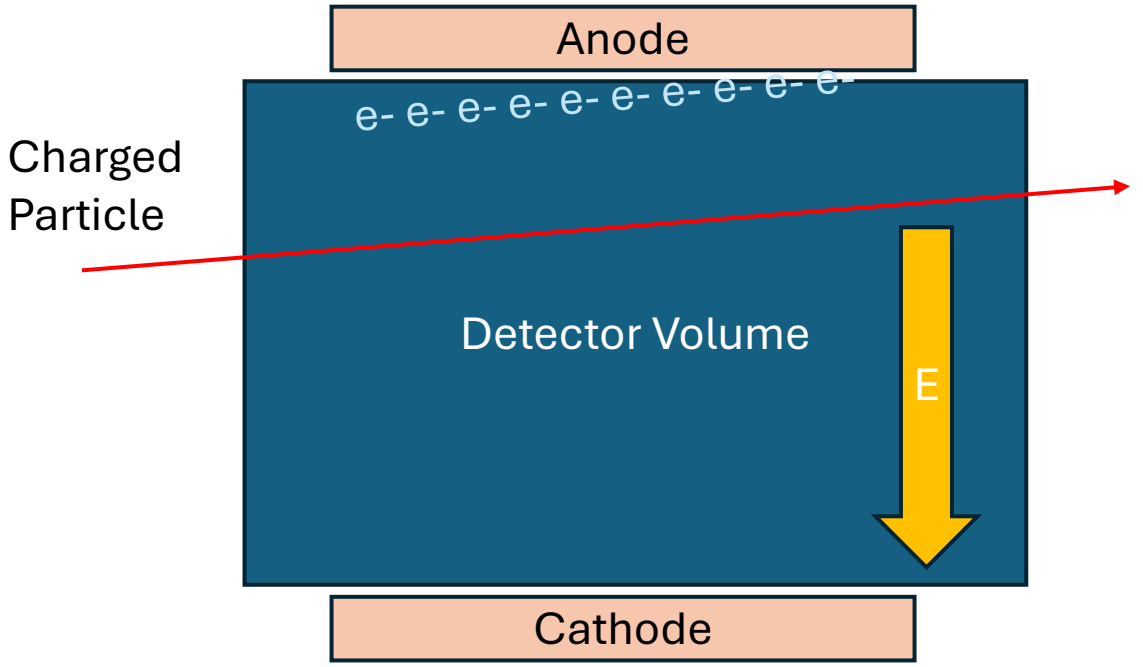

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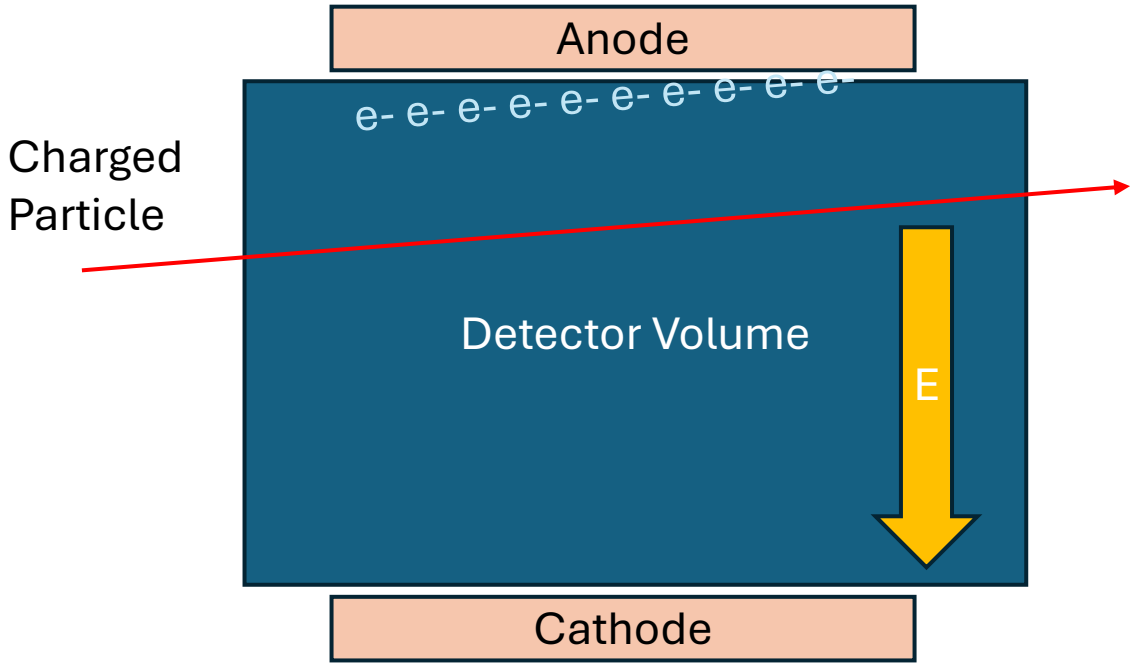
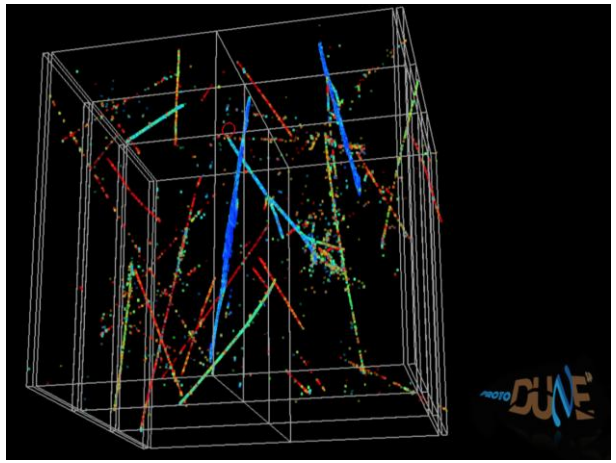
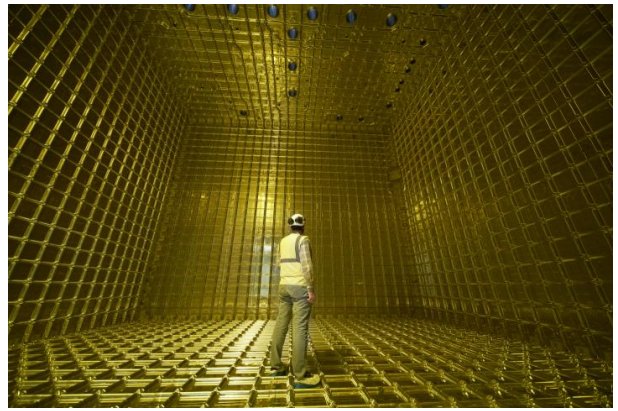
- If our volume is big enough and has timing information, collecting charge allows us to reconstruct the particle track.
- We have a time projection chamber.

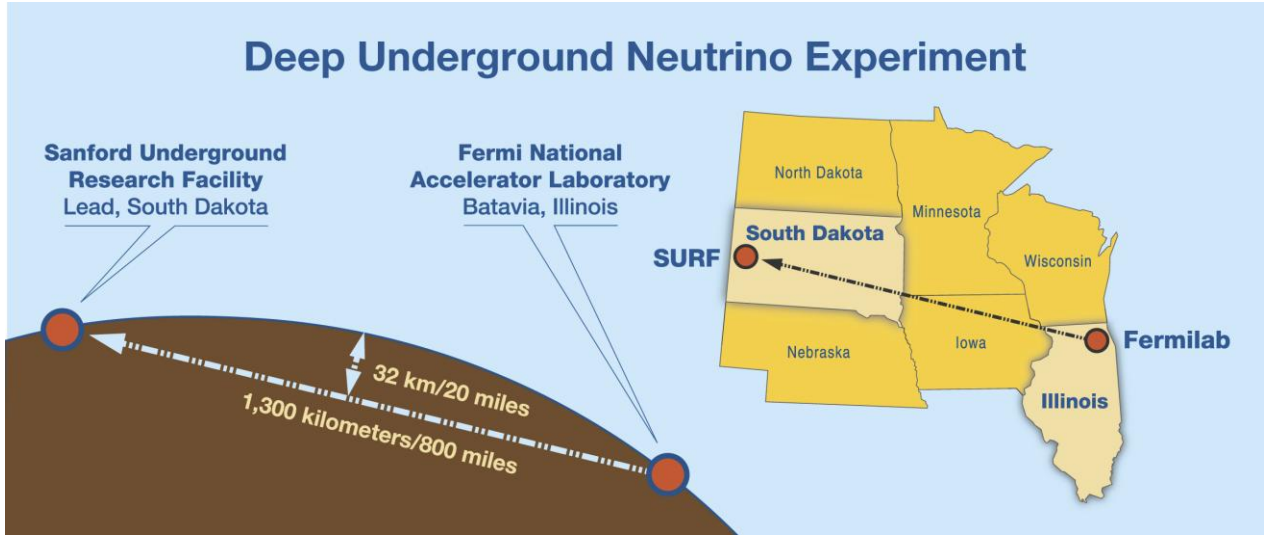


Time Projection Chambers - Dune

- There are now many different TPCs that use different material interactions to create free charge that they can measure.
- Dune is a large-scale neutrino experiment that is currently being built in South Dakota.
- It will be filled with a huge(!) volume of liquid argon.
- When a neutrino bumps into an argon atom's core, it produces particles that knock loose electrons in the liquid argon.
- Proto-Dune is based at CERN.

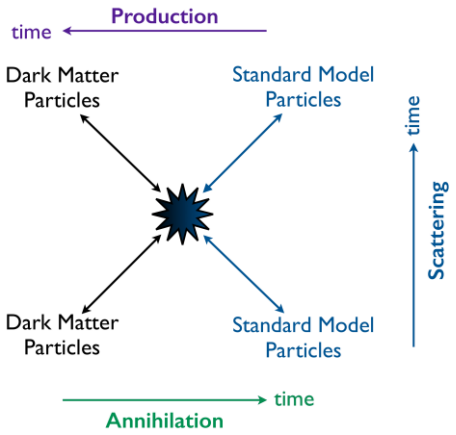


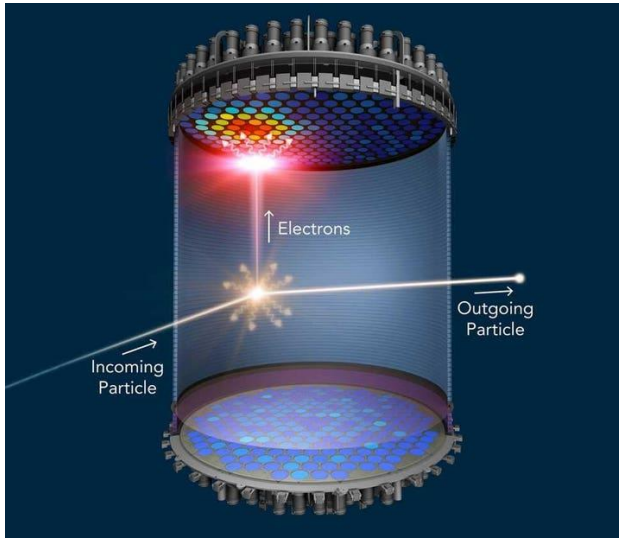




Time Projection Chambers – Dark Matter

- Dark Matter Physicists are looking for dark matter particle candidates called WIMPs, weakly interacting massive particles.
- This through ionisation by nuclear recoil.
- One DM TPC Experiment is Lux Zeppelin.
- Detector medium is liquid xenon.
- Also in a mine in south Dakota…





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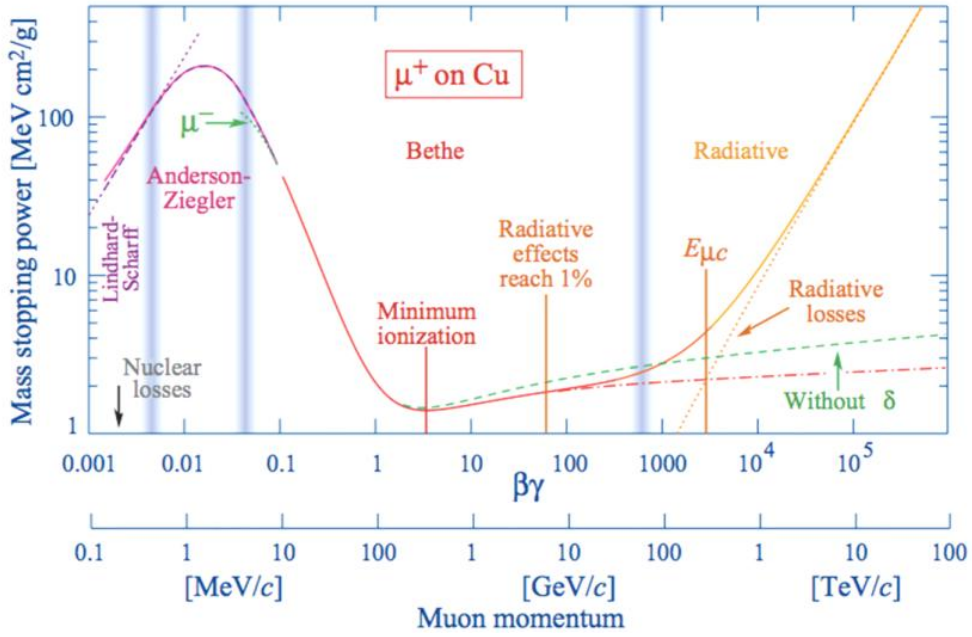

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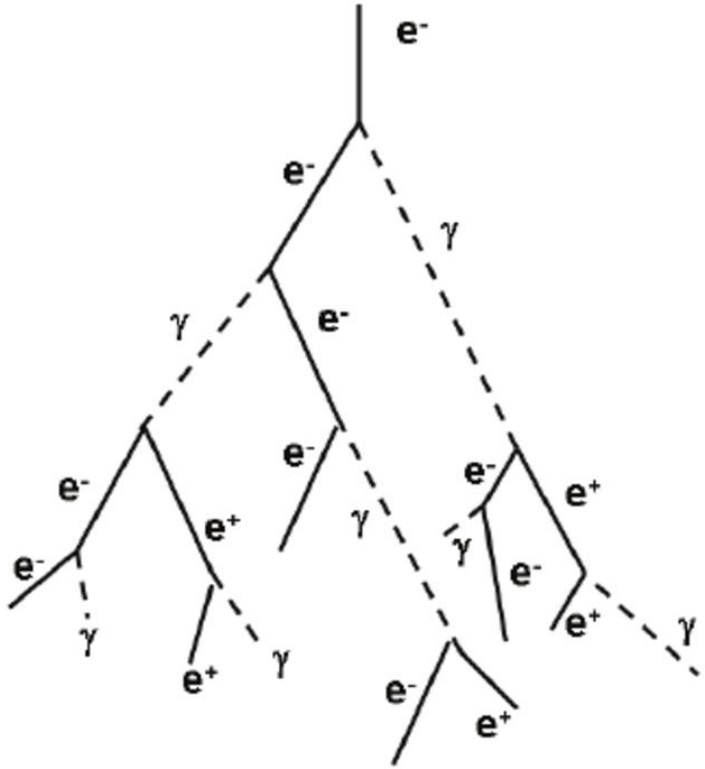

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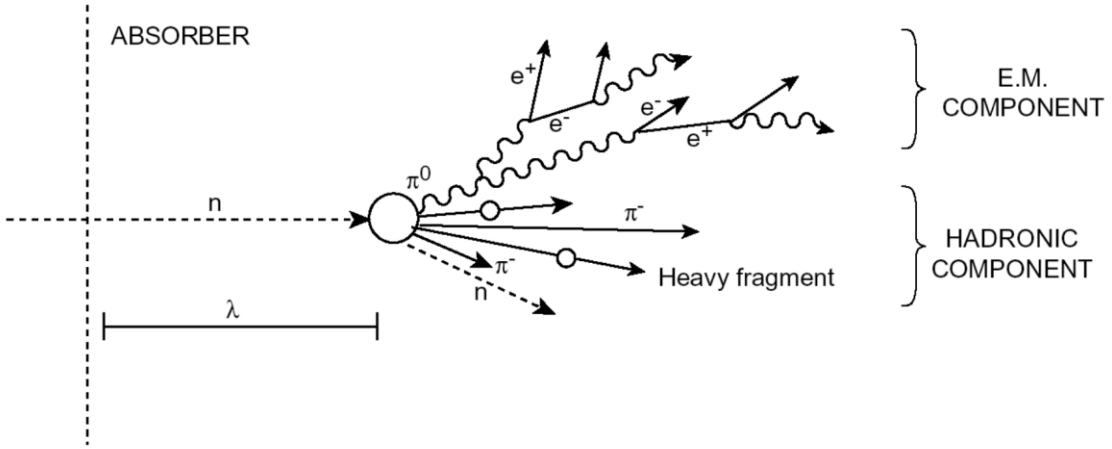

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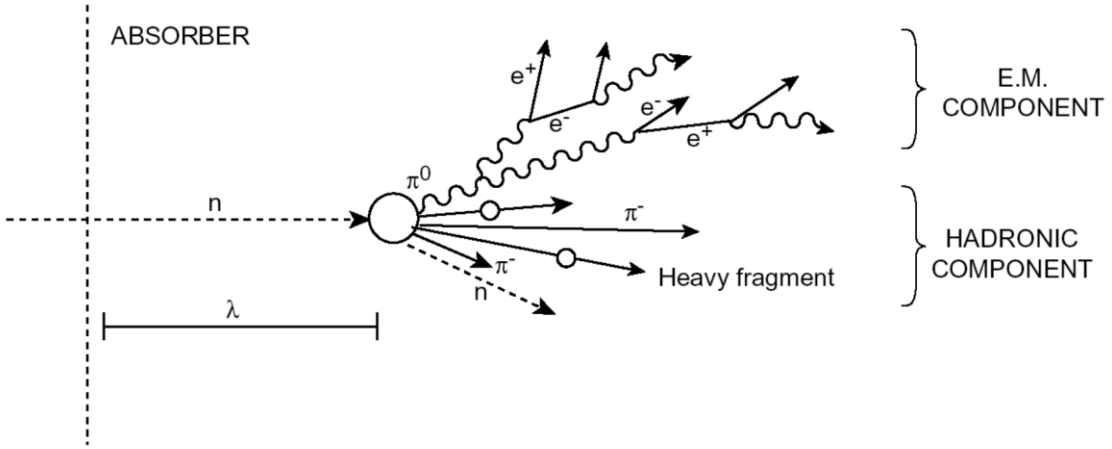

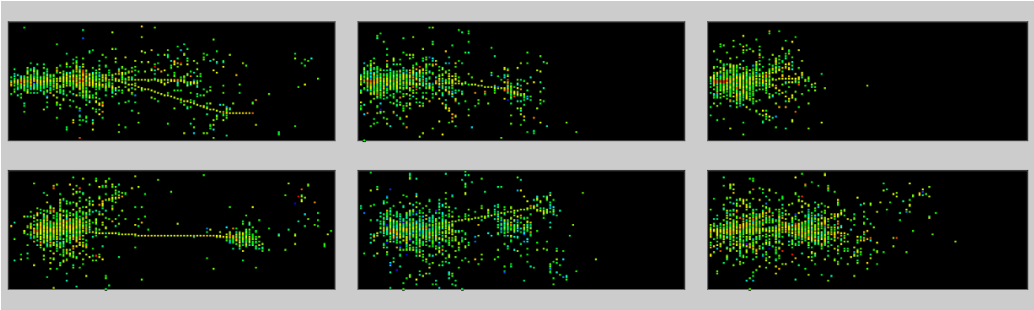

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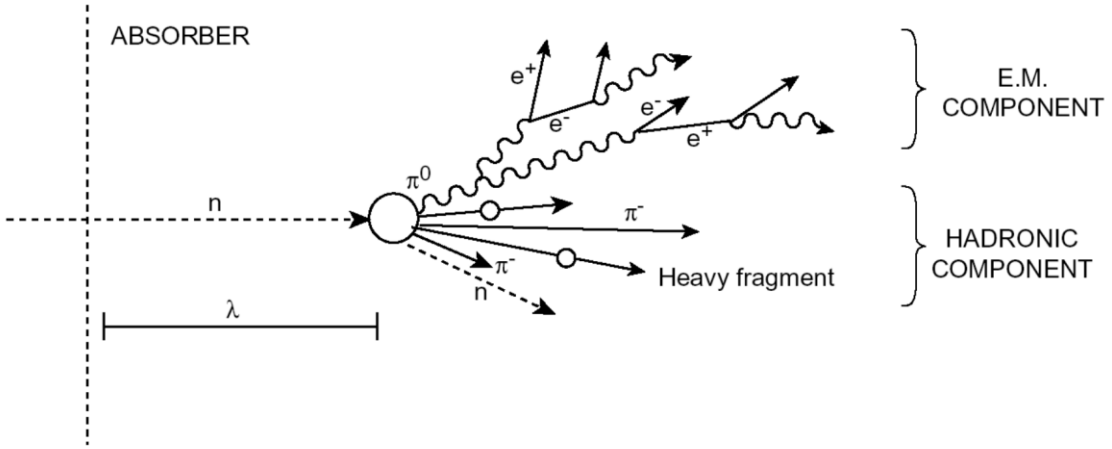

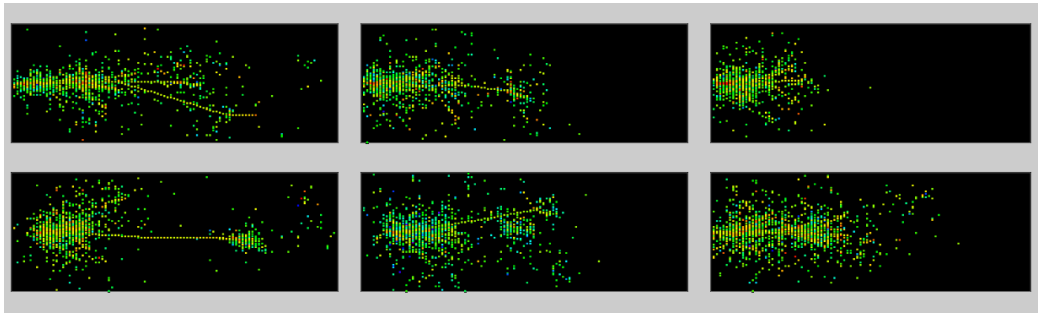

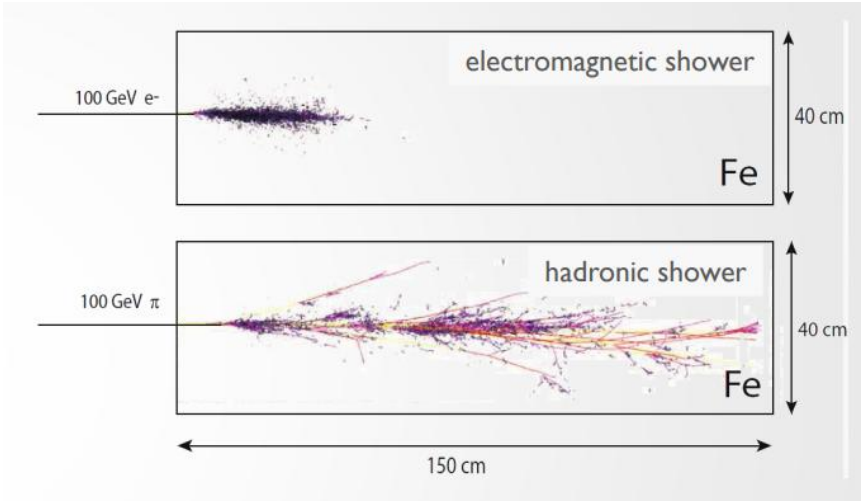

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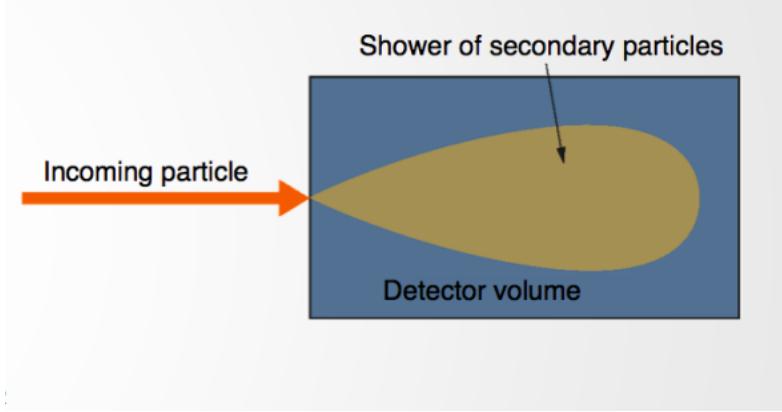

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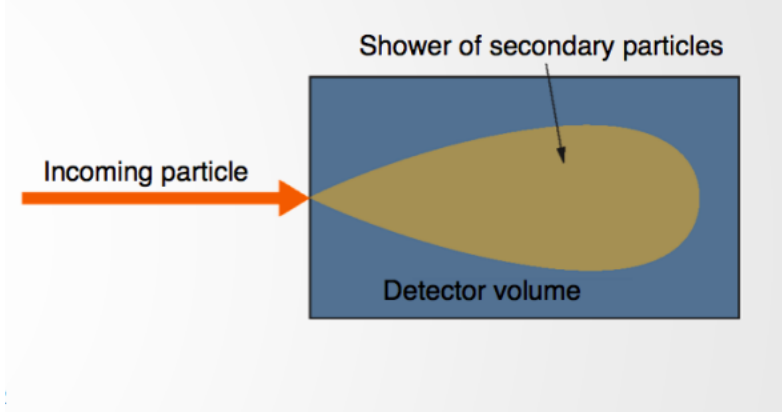

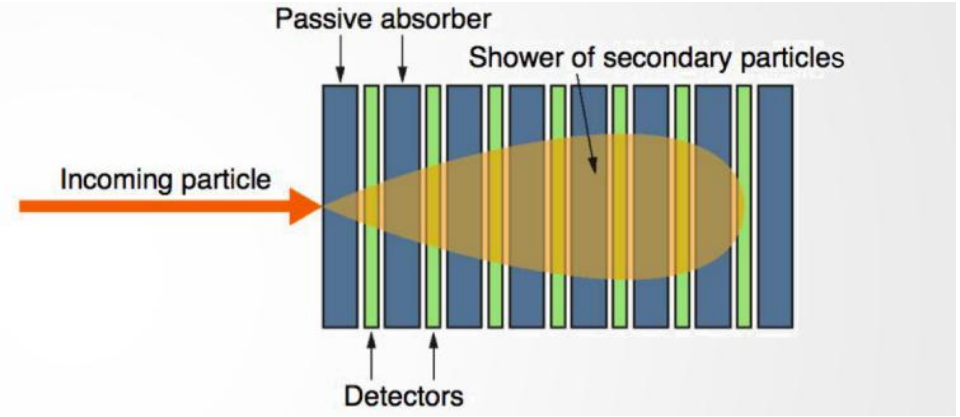

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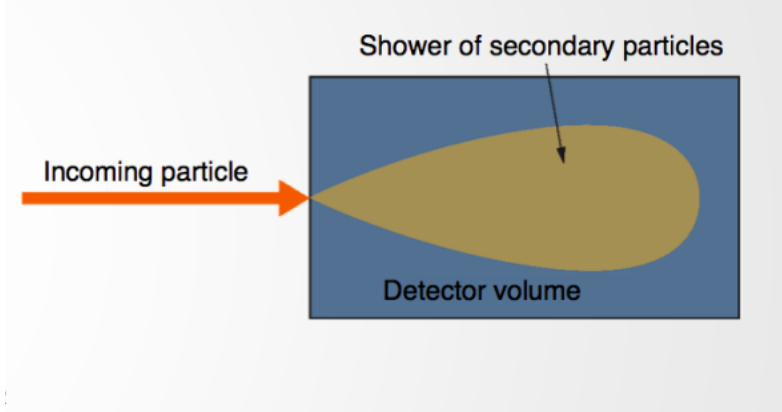

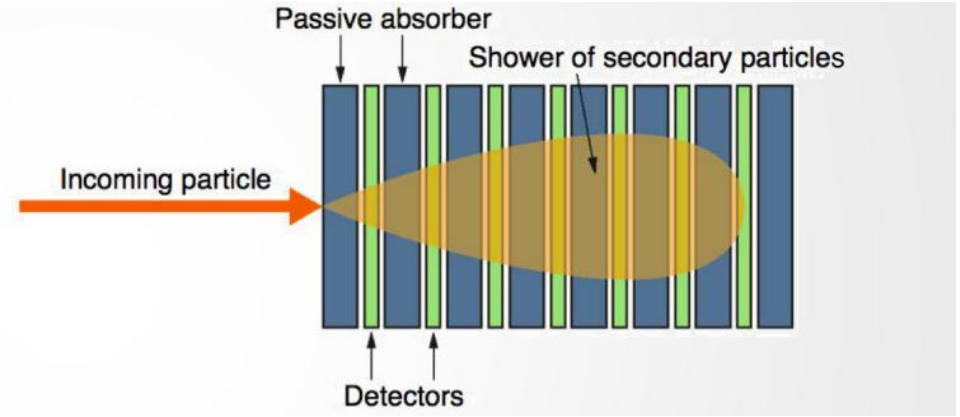

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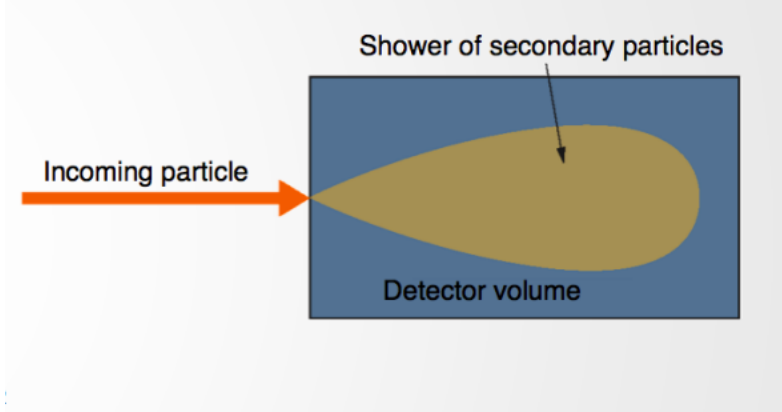

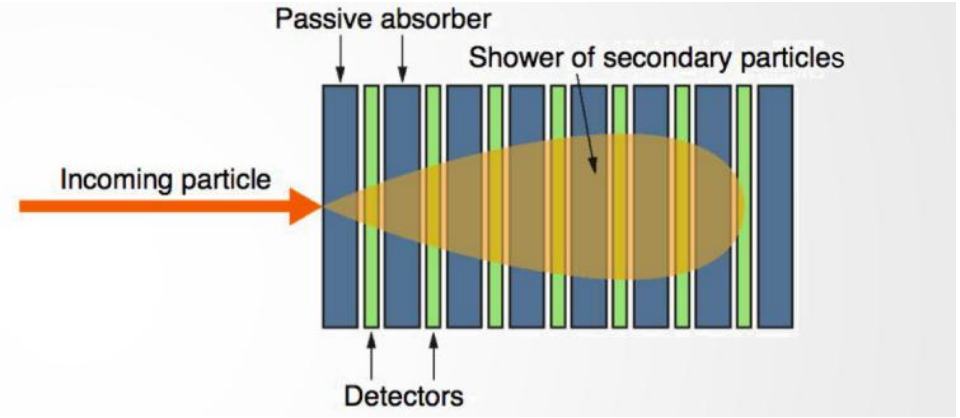

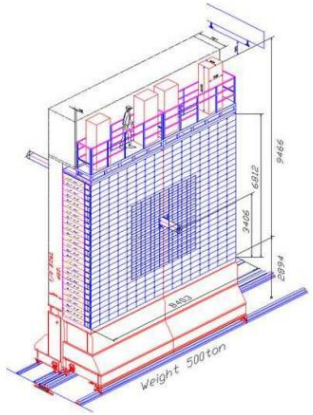

LHCb HCAL

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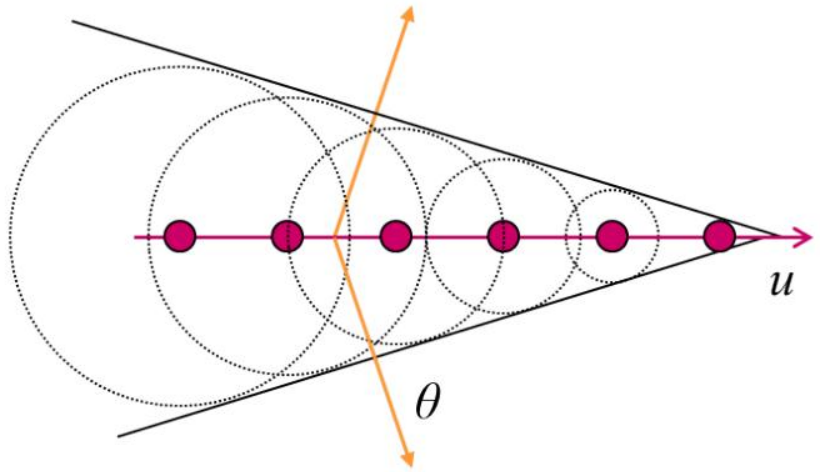

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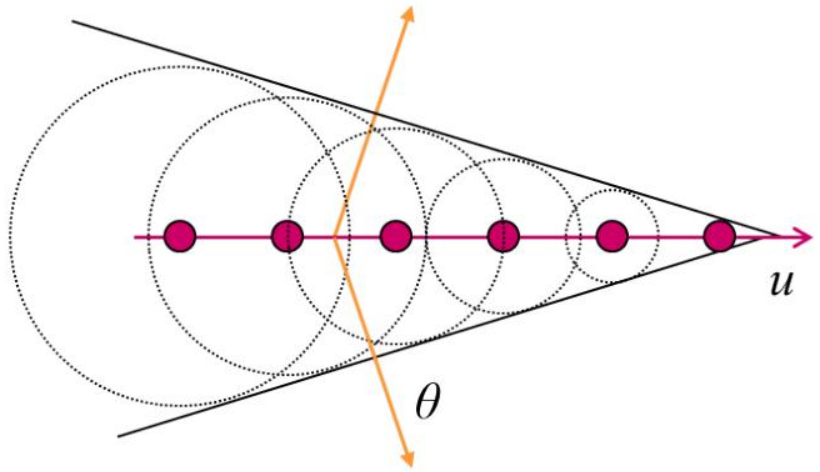

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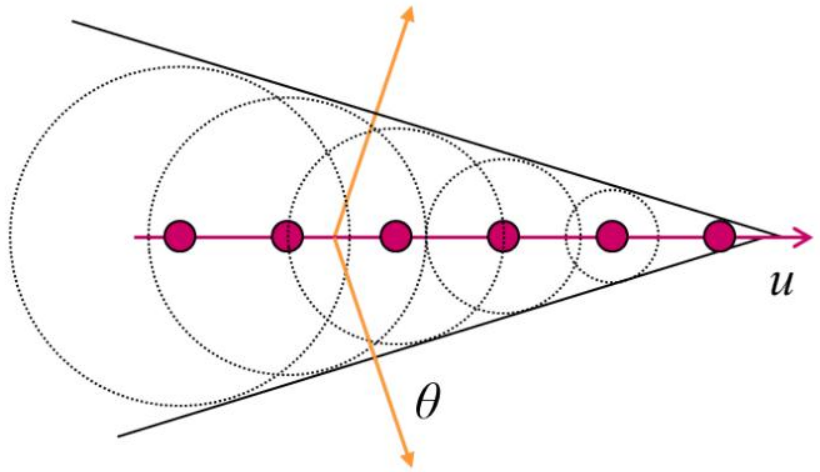

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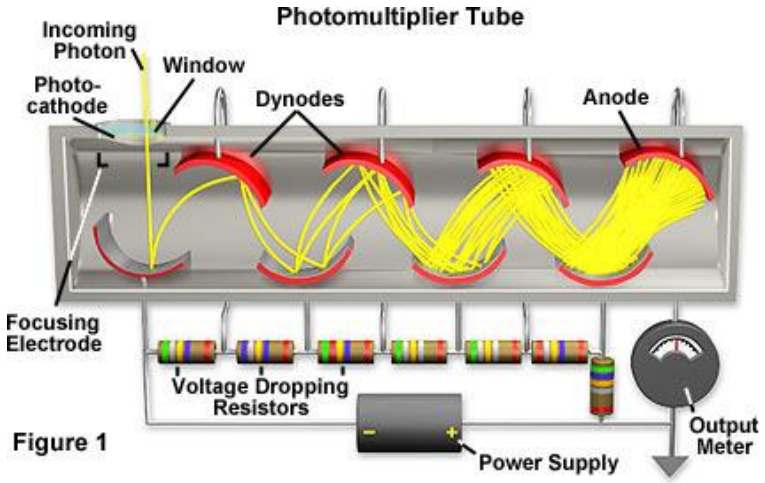

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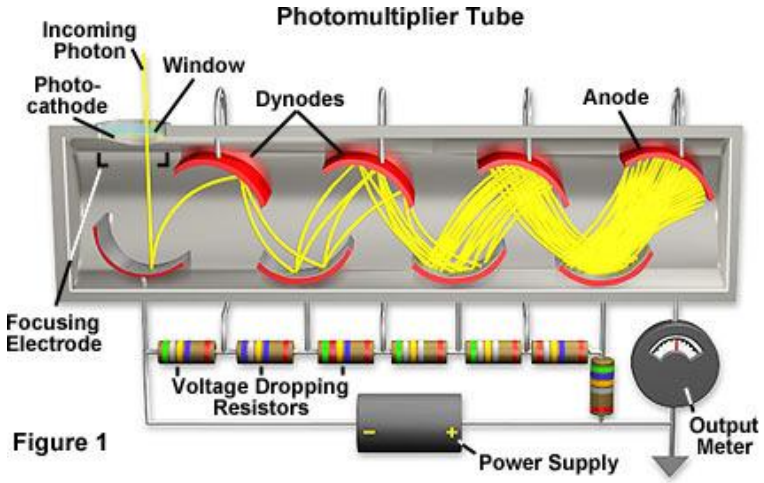

Figure 1

The Cherenkov Effect

- Can we measure it?
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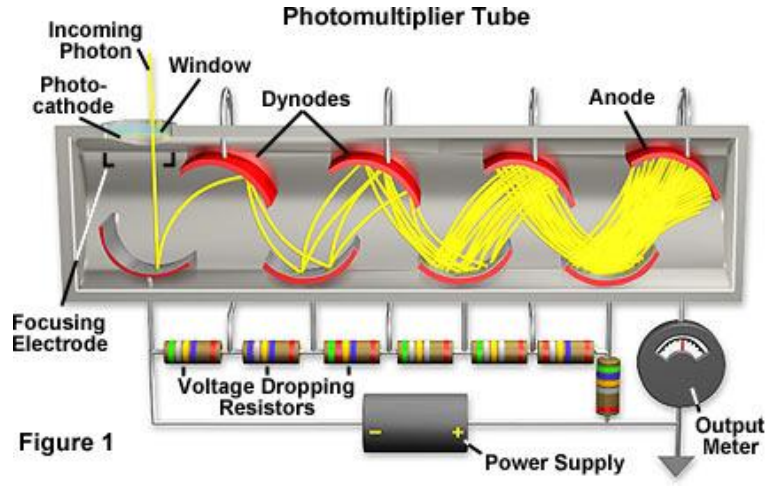
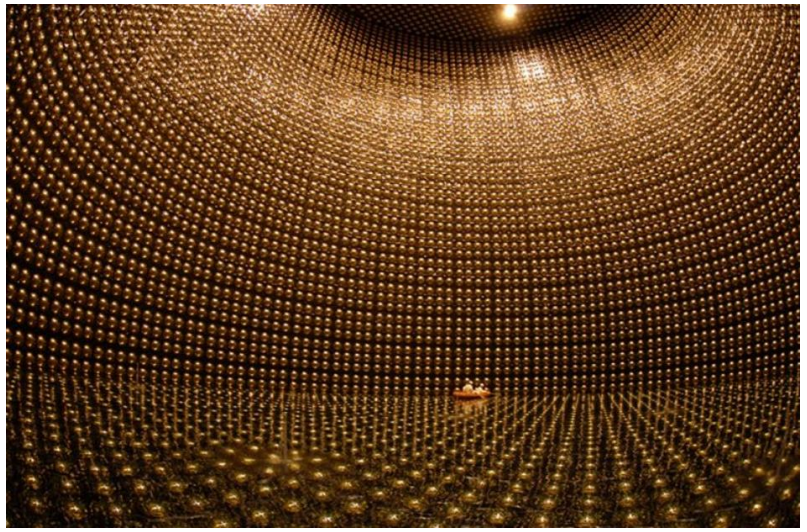
- Sometimes LOTs like at Super Kamiokande in Japan.





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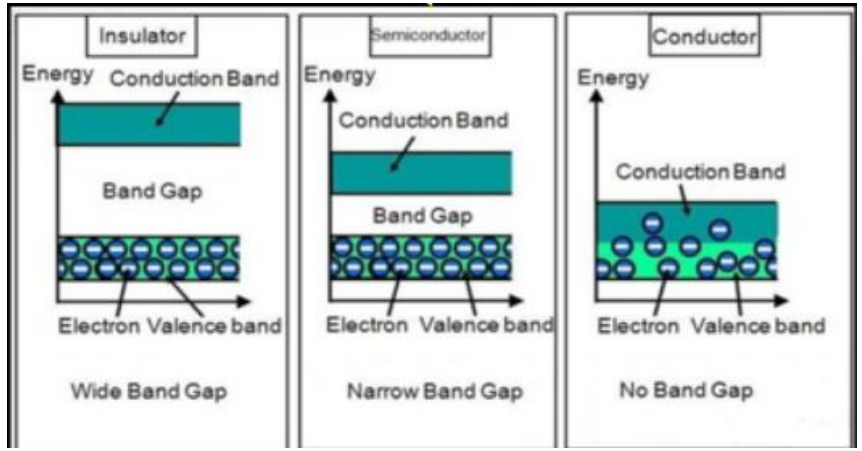

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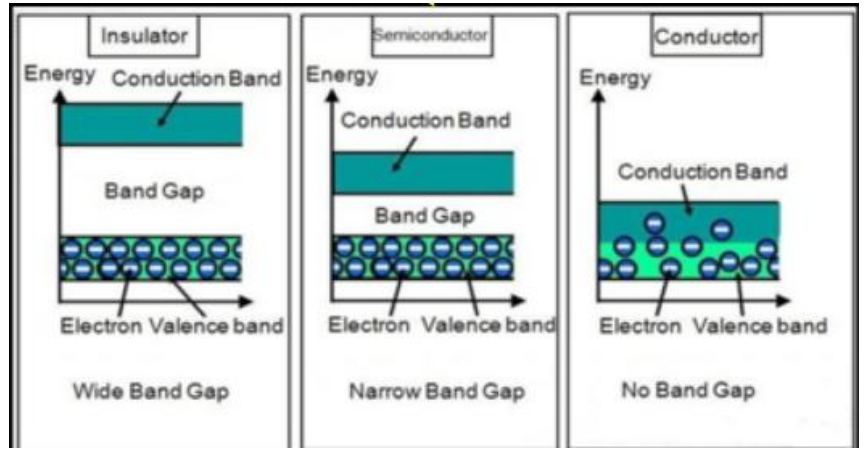

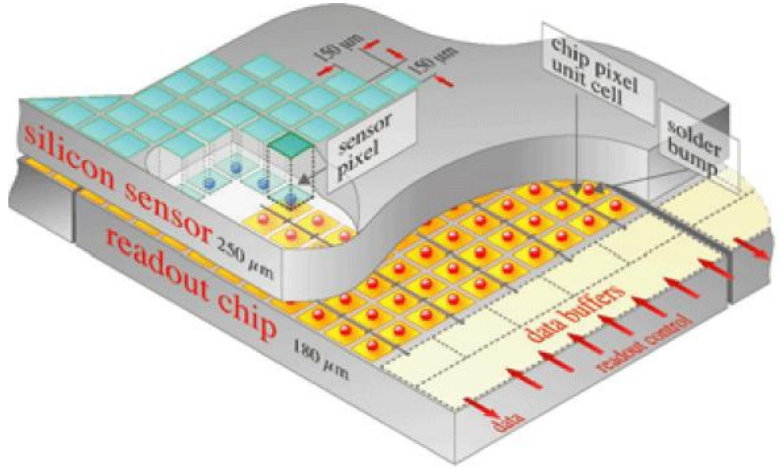

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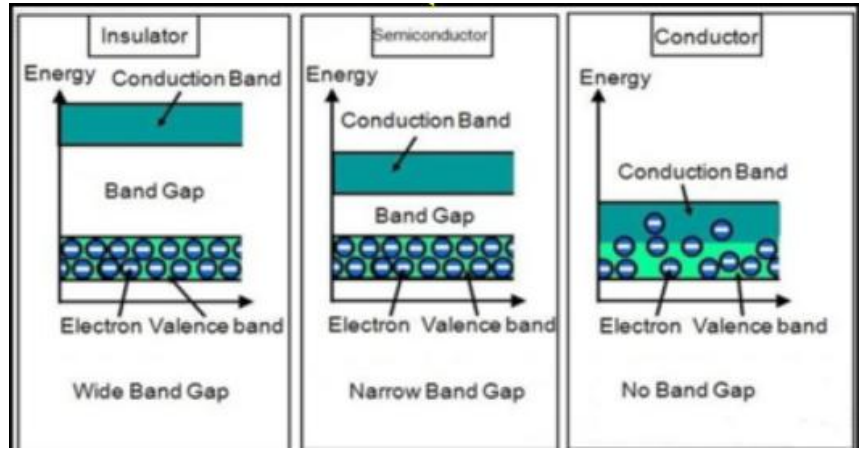

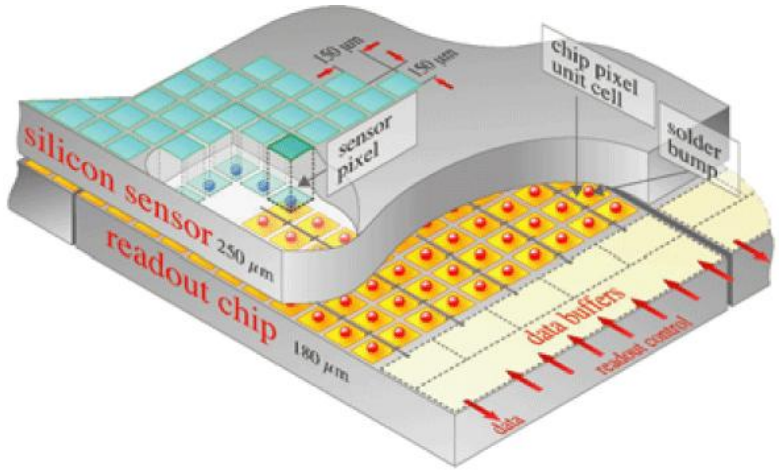

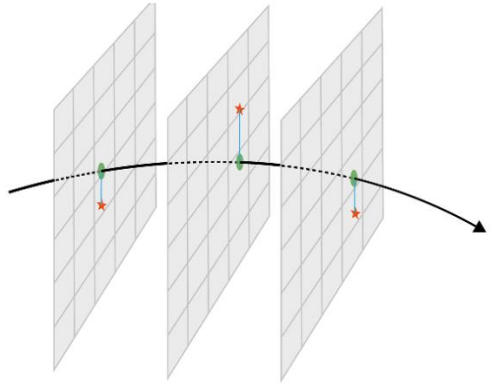

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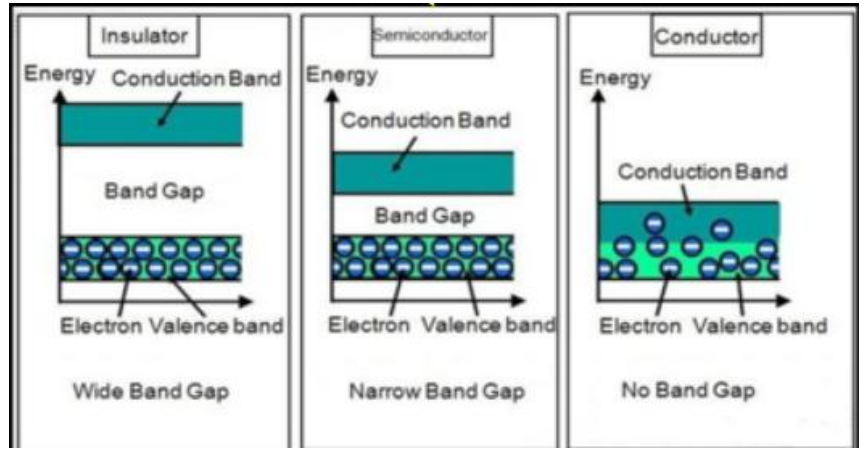

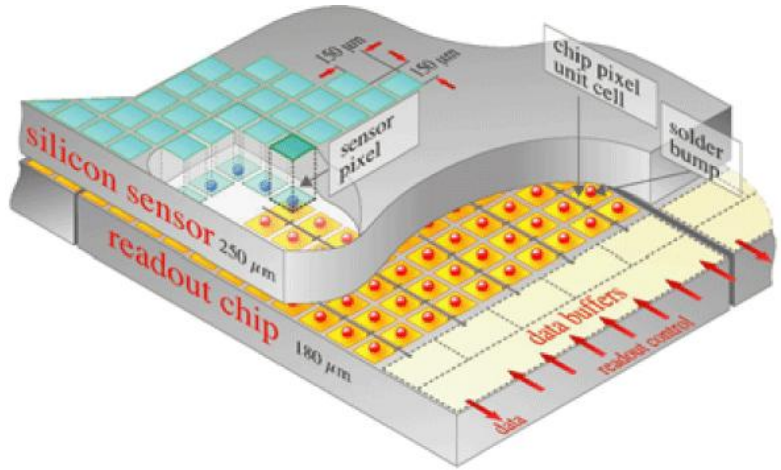

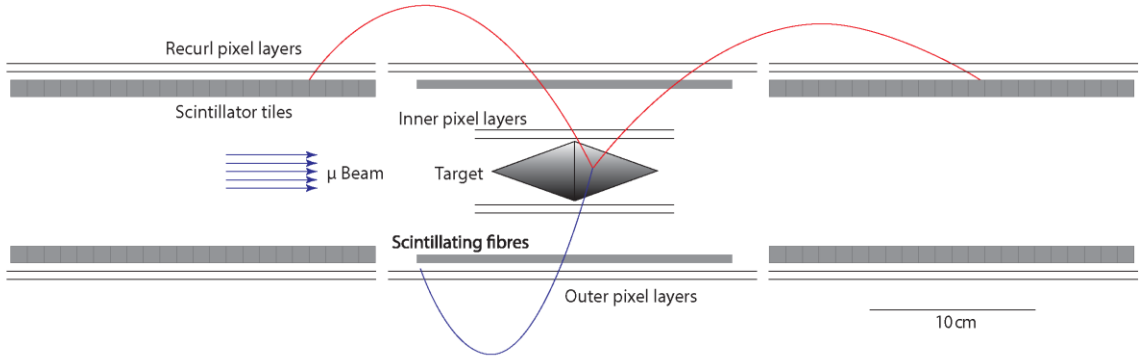

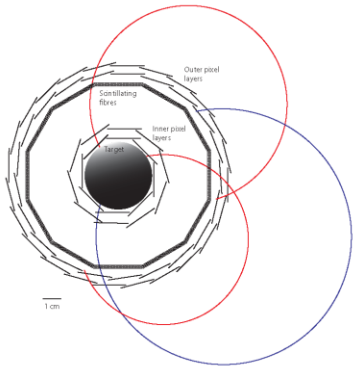

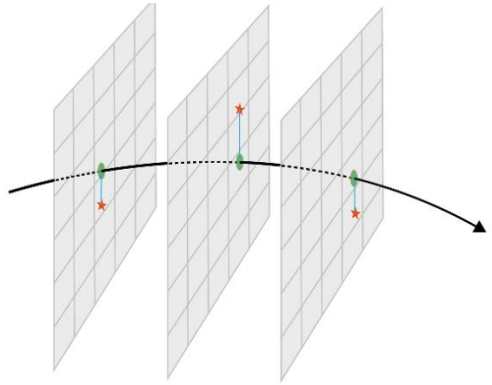

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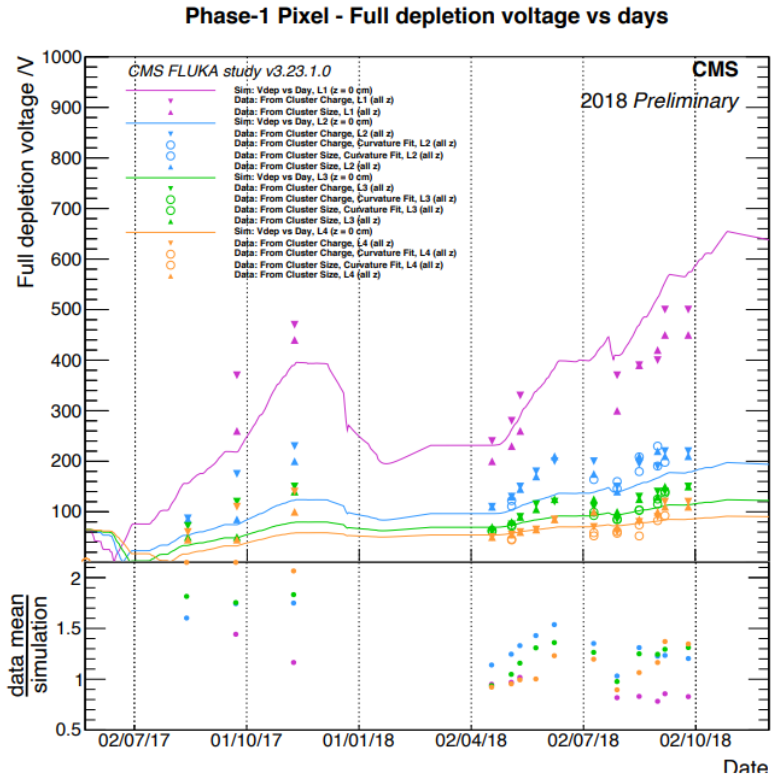

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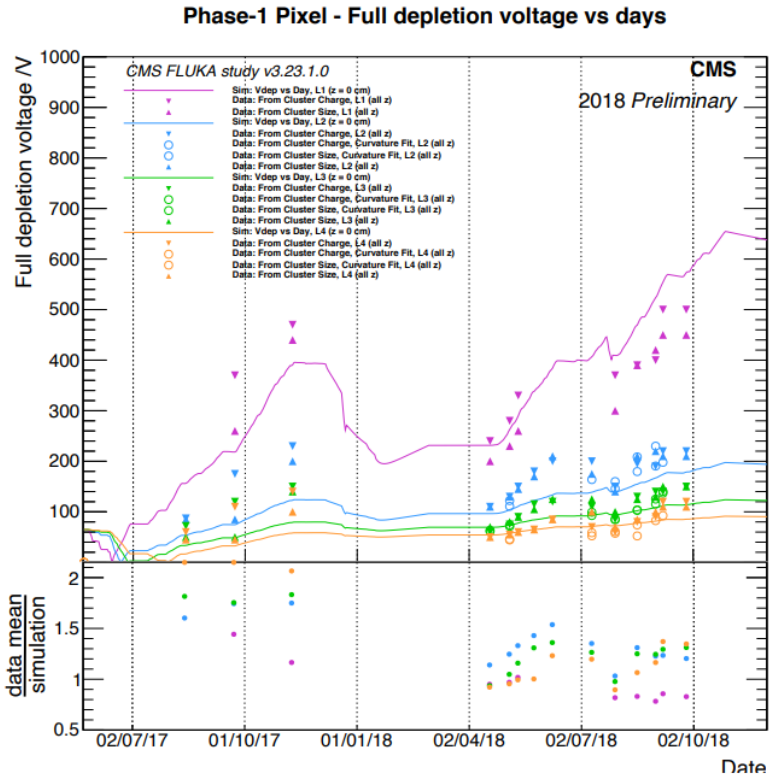

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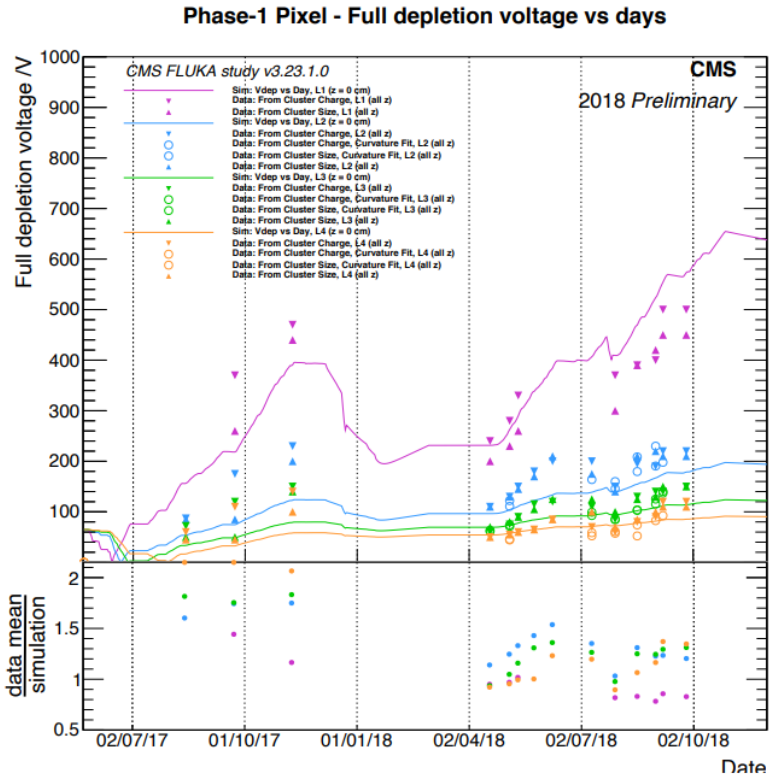

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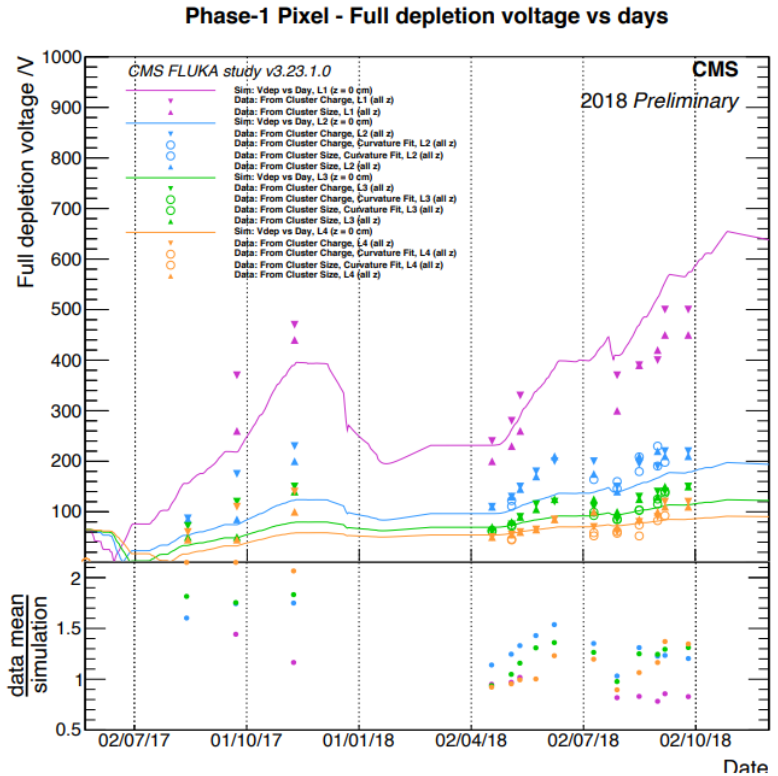

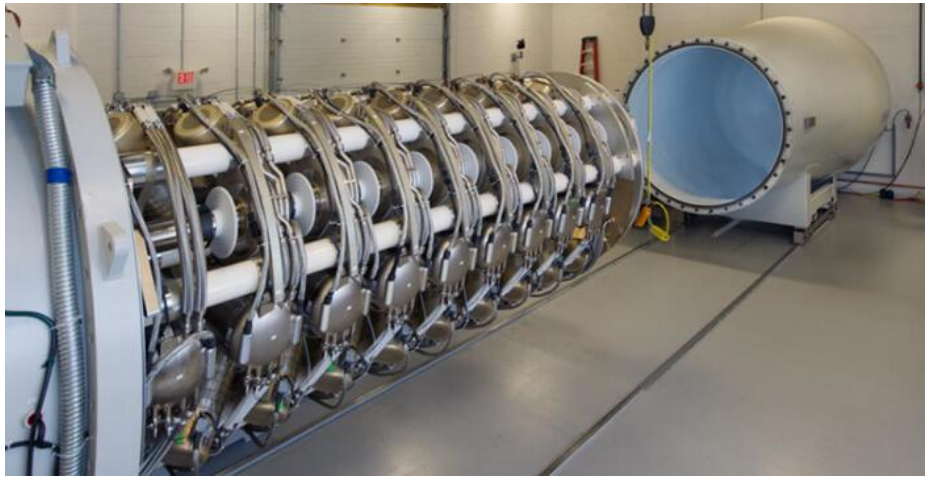

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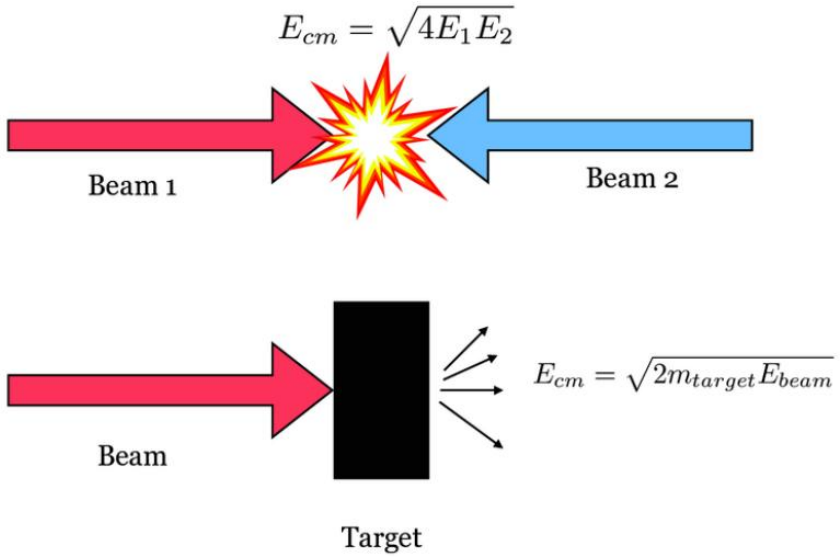

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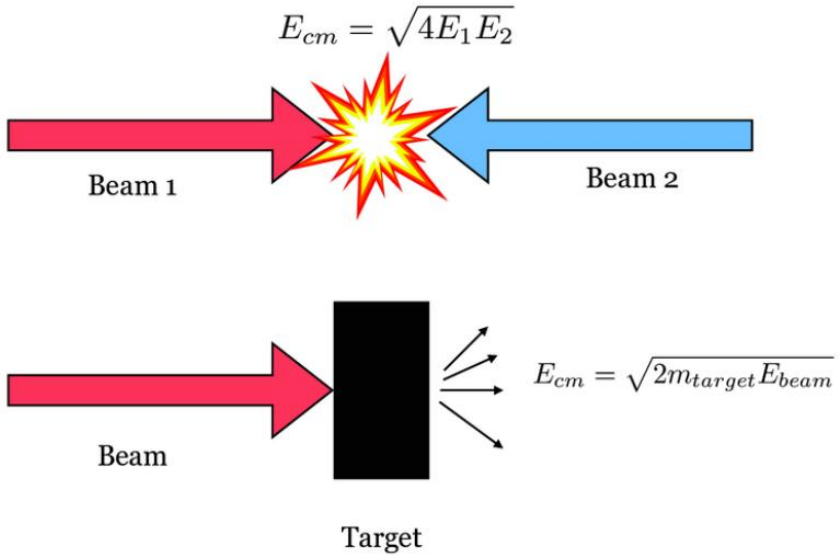

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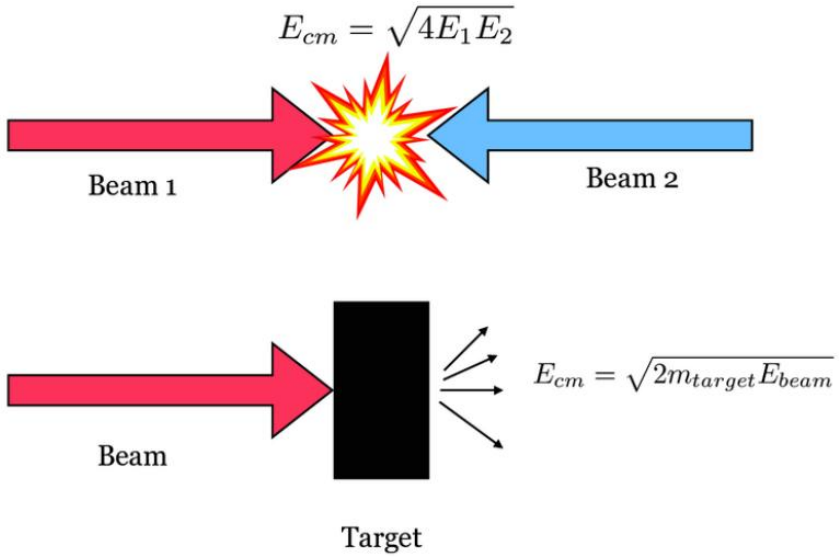
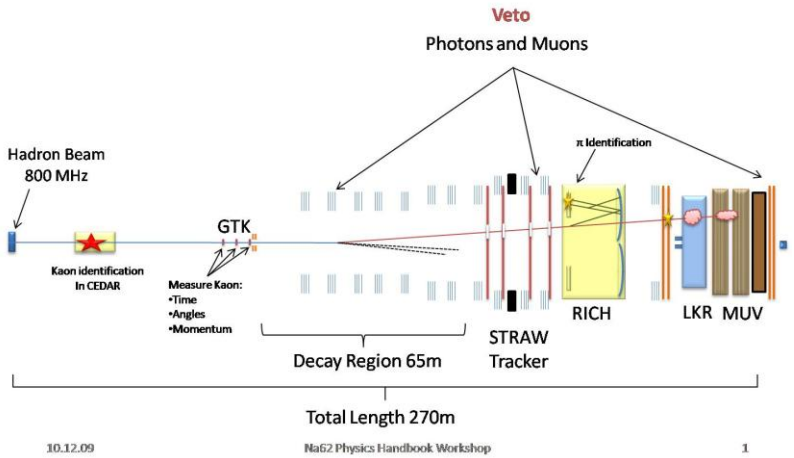
- E.g Na62 an ultra-rare kaon decay experiment looking for decays of order 10e-12.





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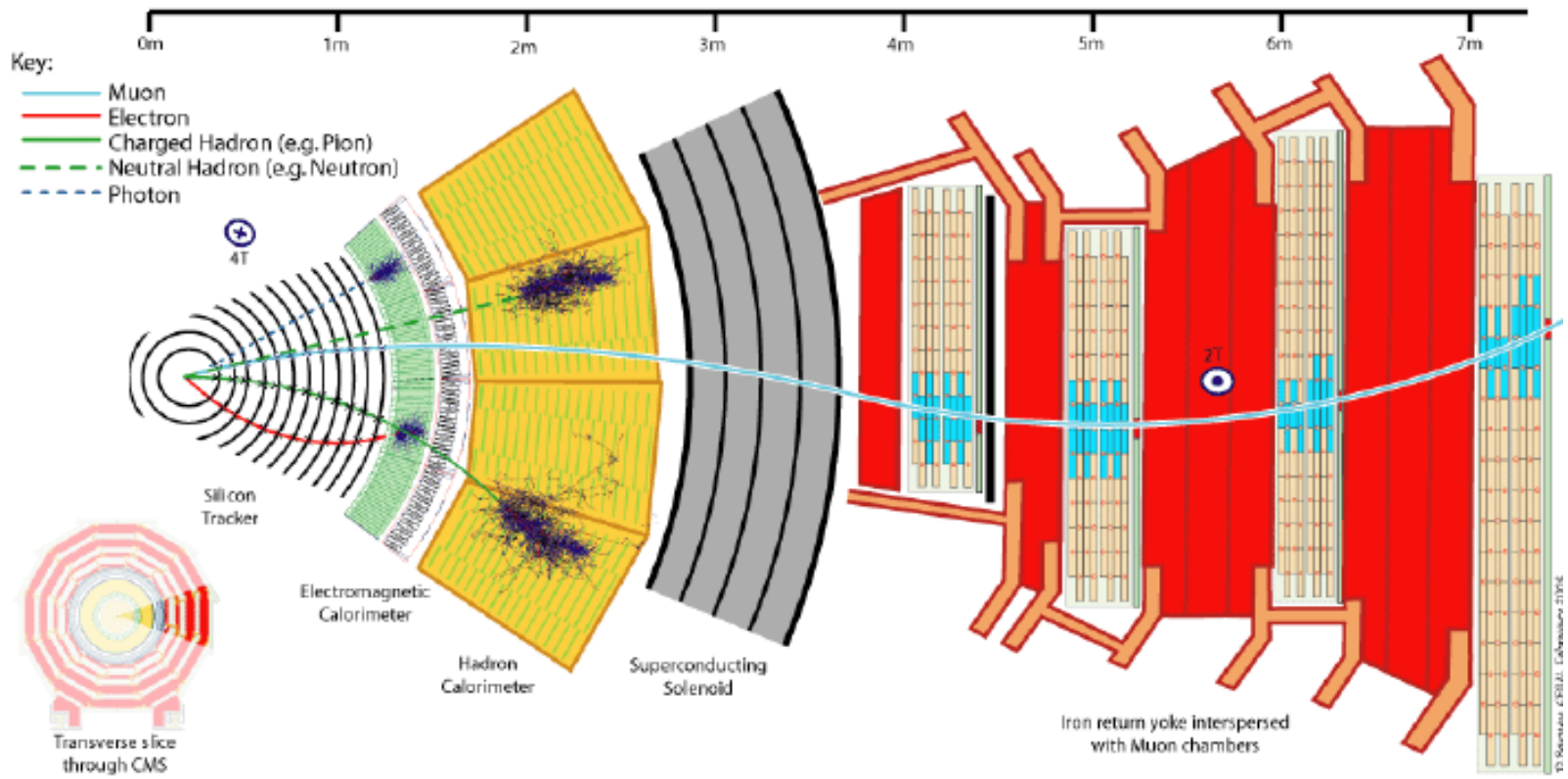

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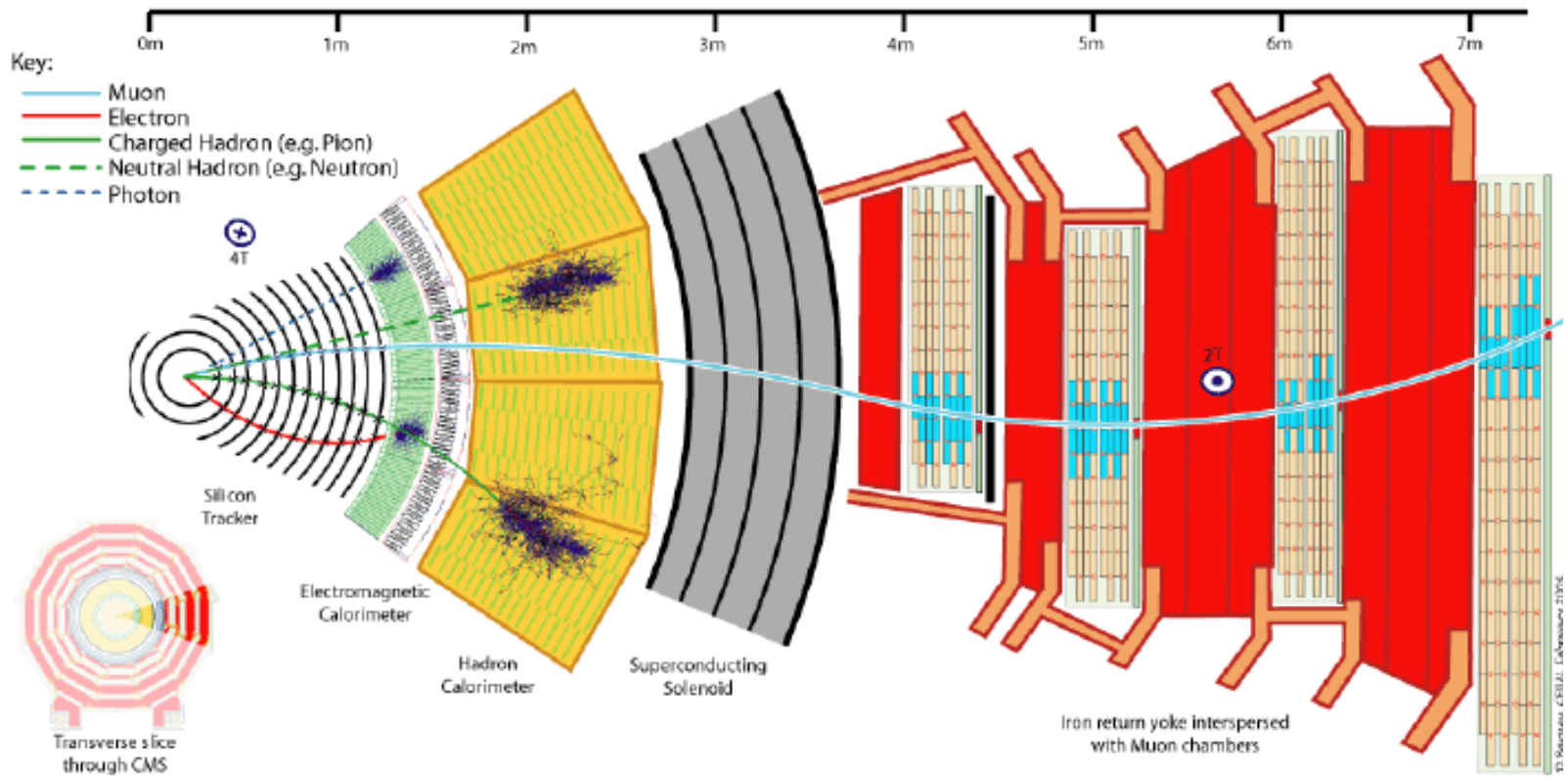

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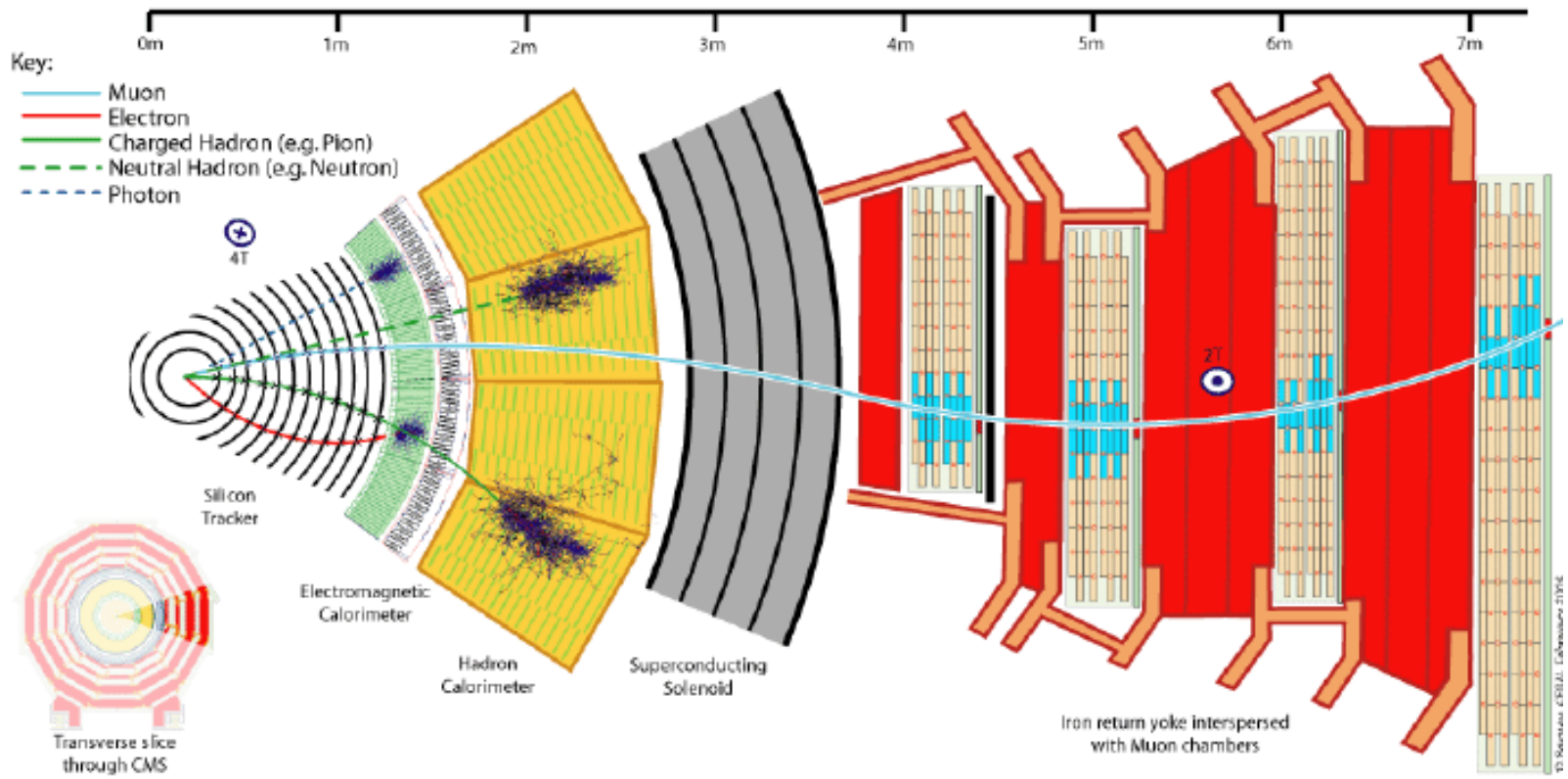

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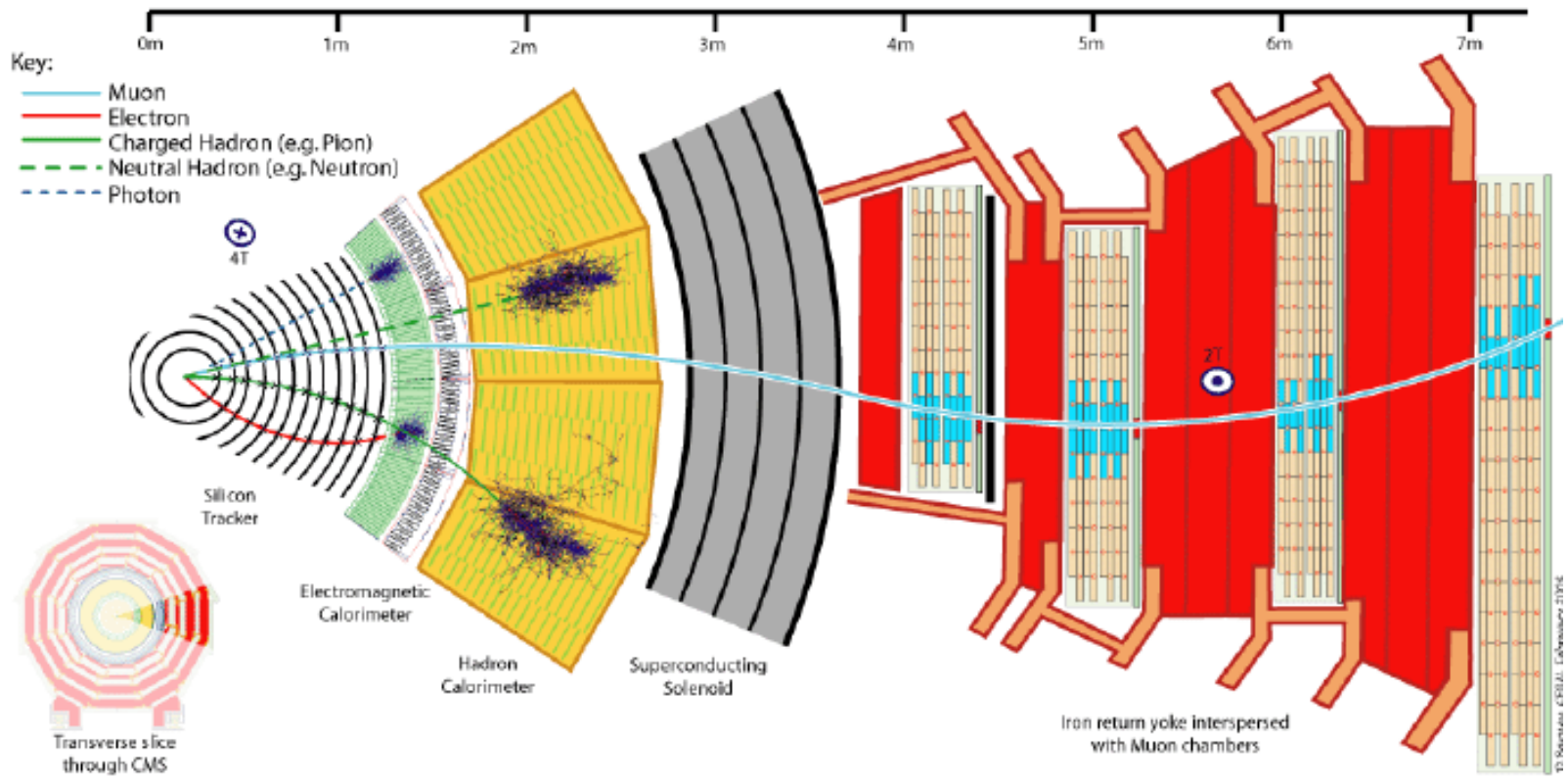

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