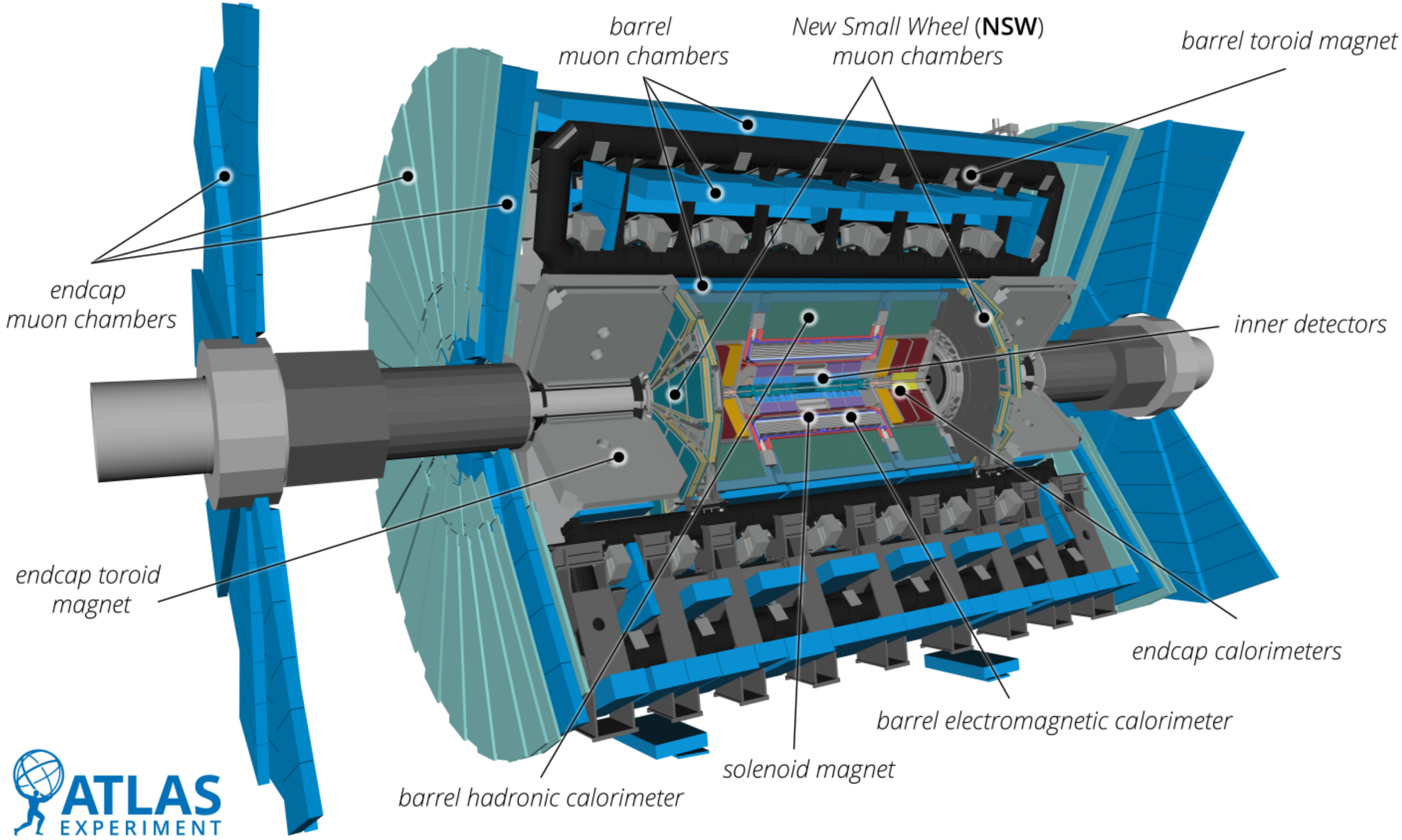
Displaced ALP decays to photon pairs at the LHC

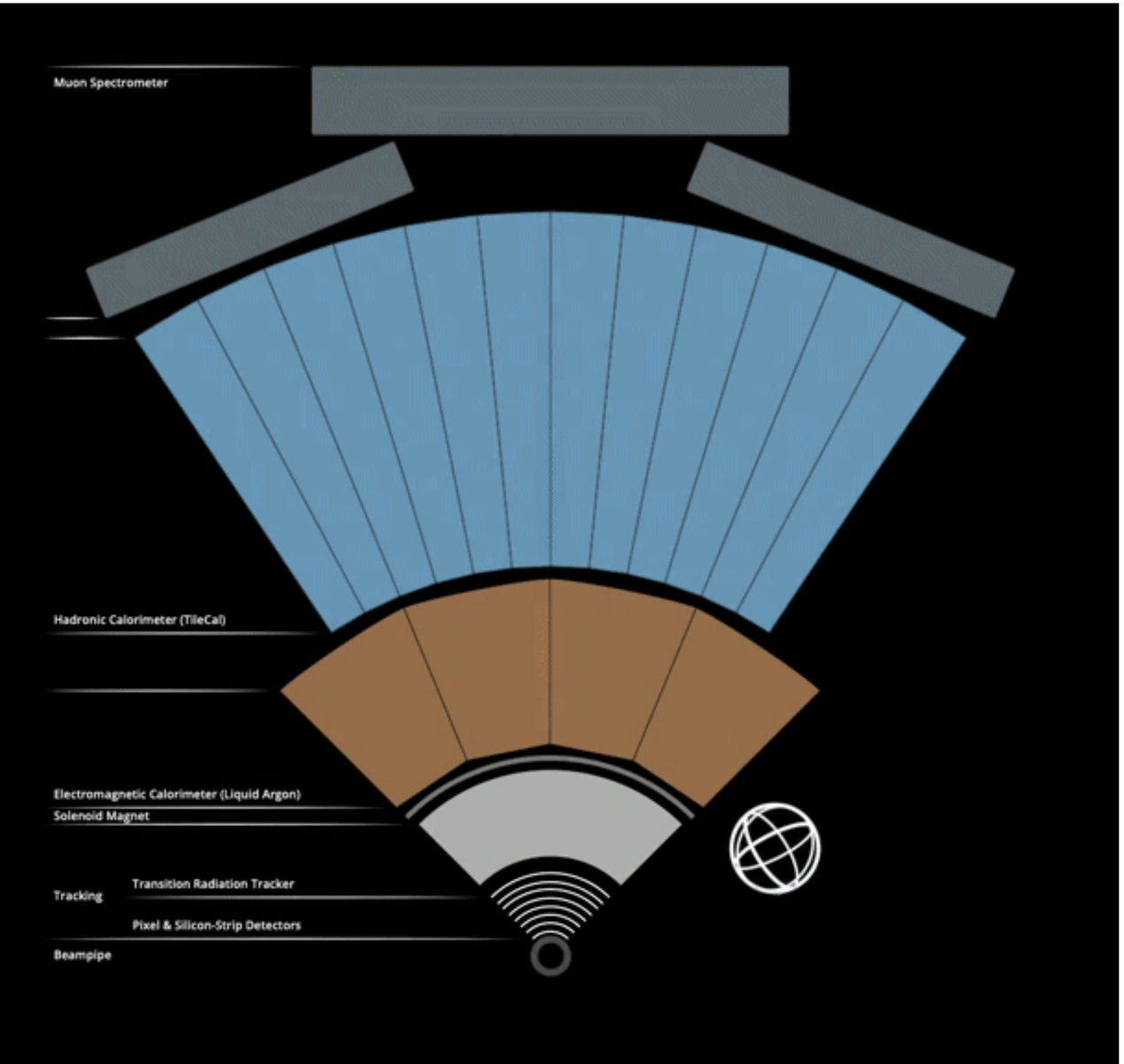
Christian Ohm (KTH)

OKC BSM meeting, March 30, 2023

ATLAS experiment



Particle identification



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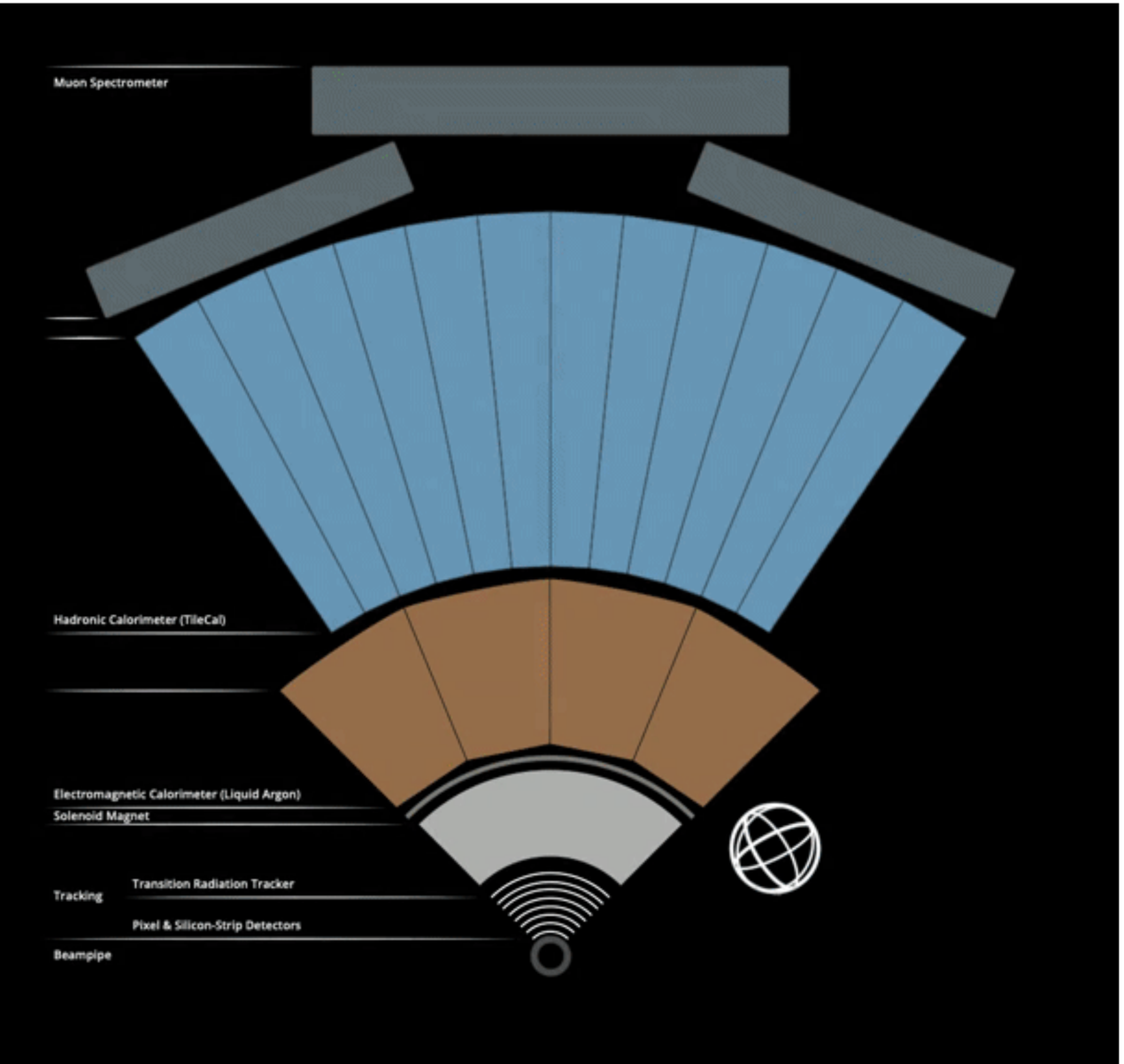

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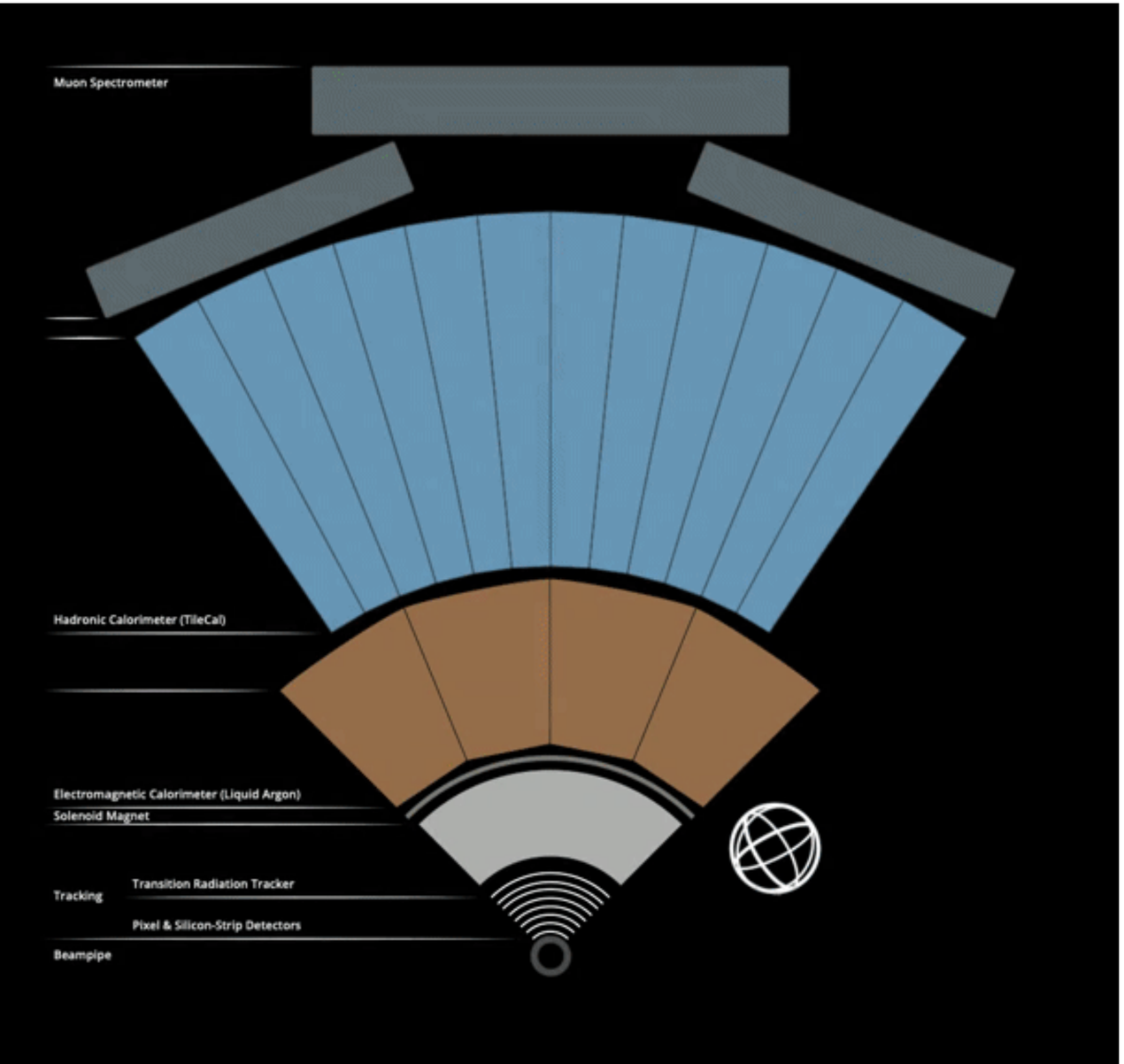

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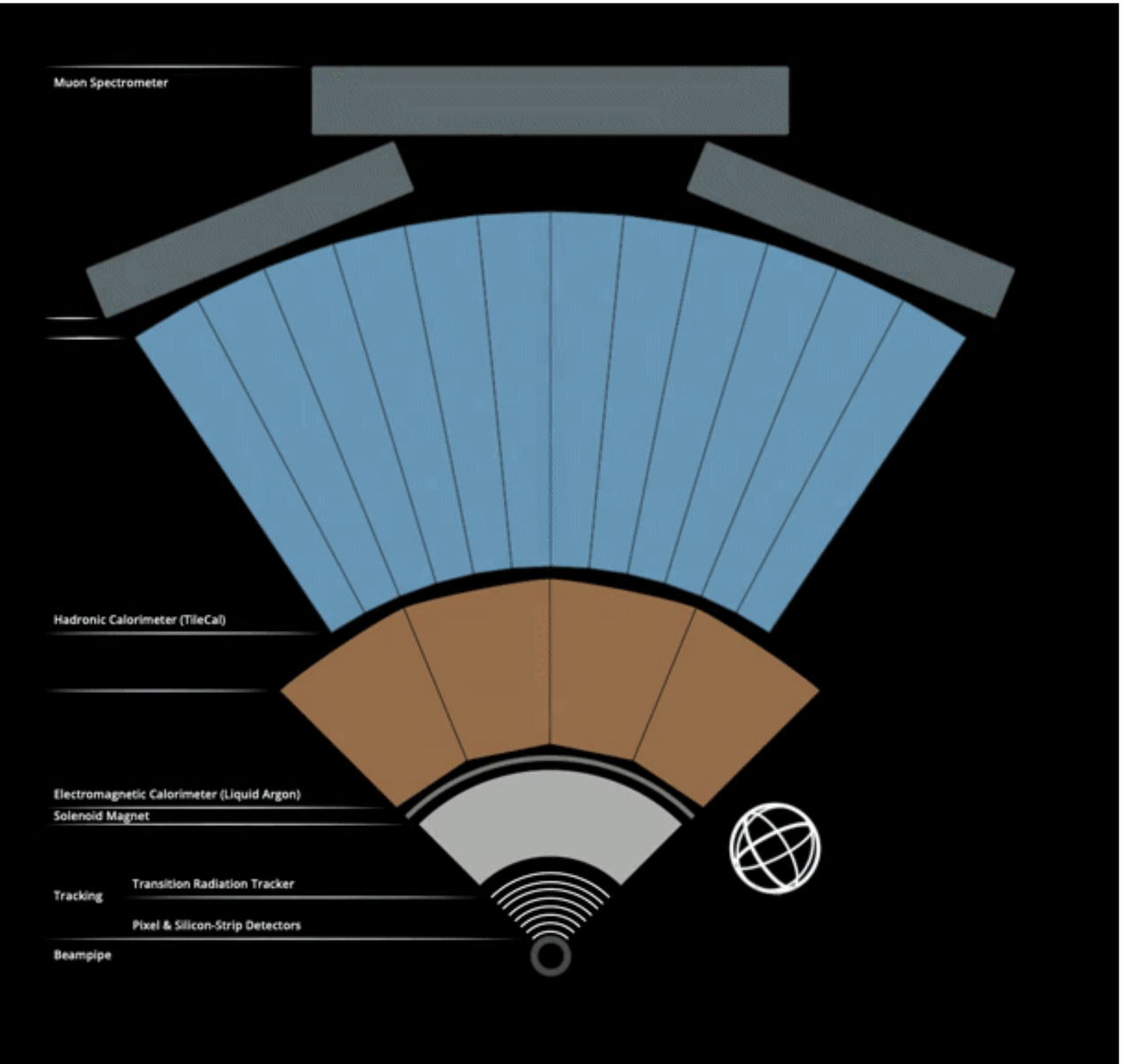

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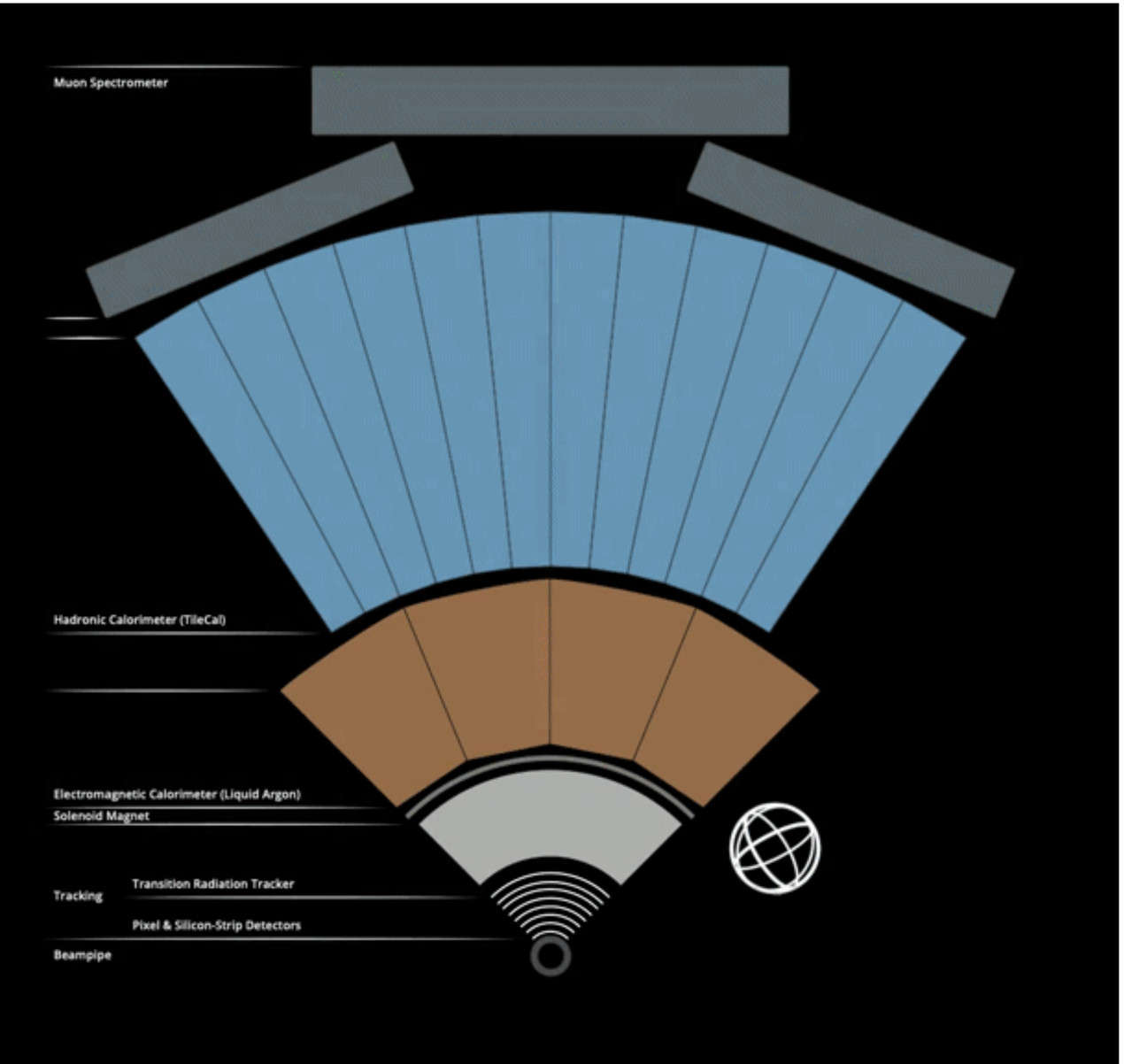

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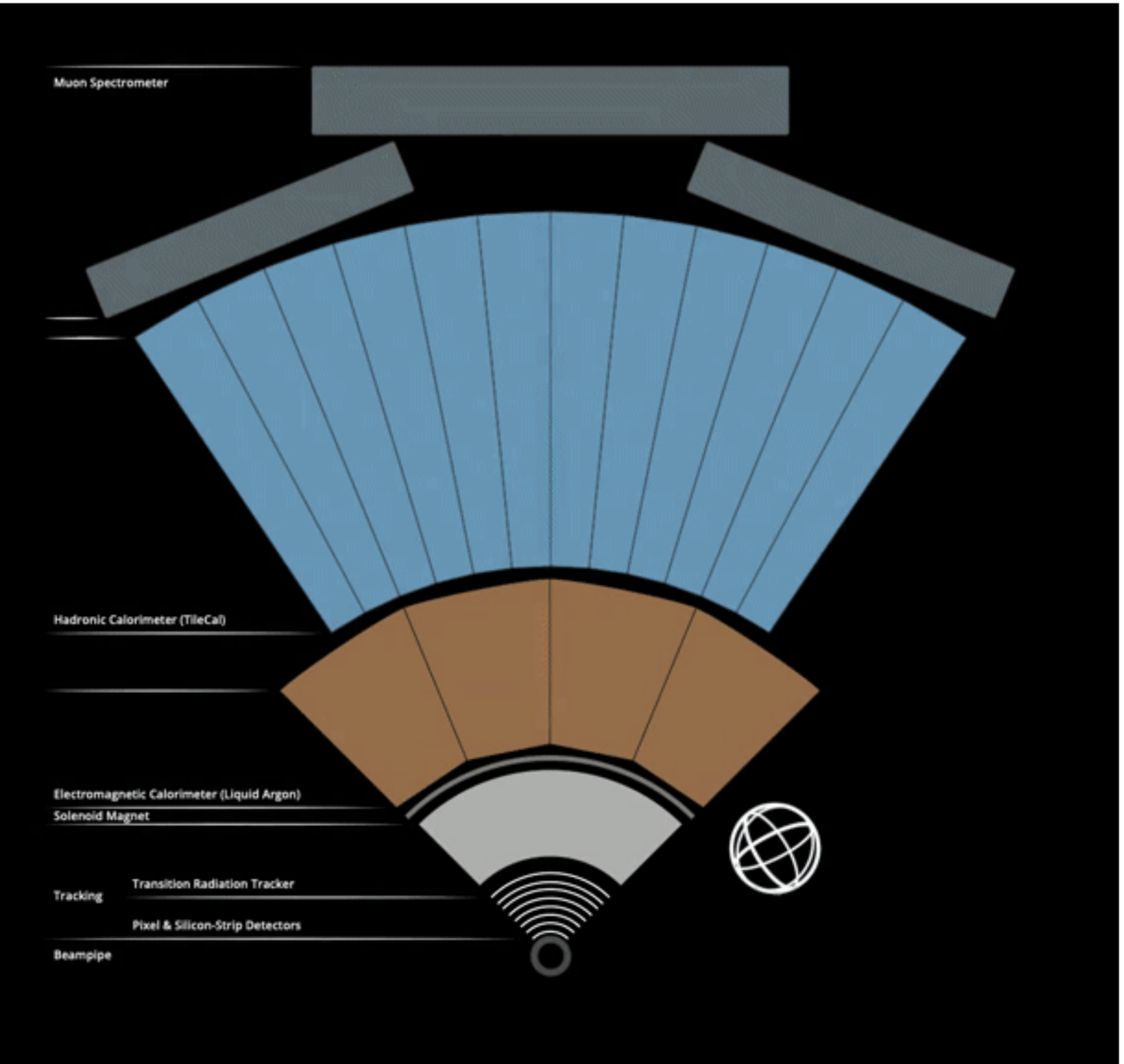

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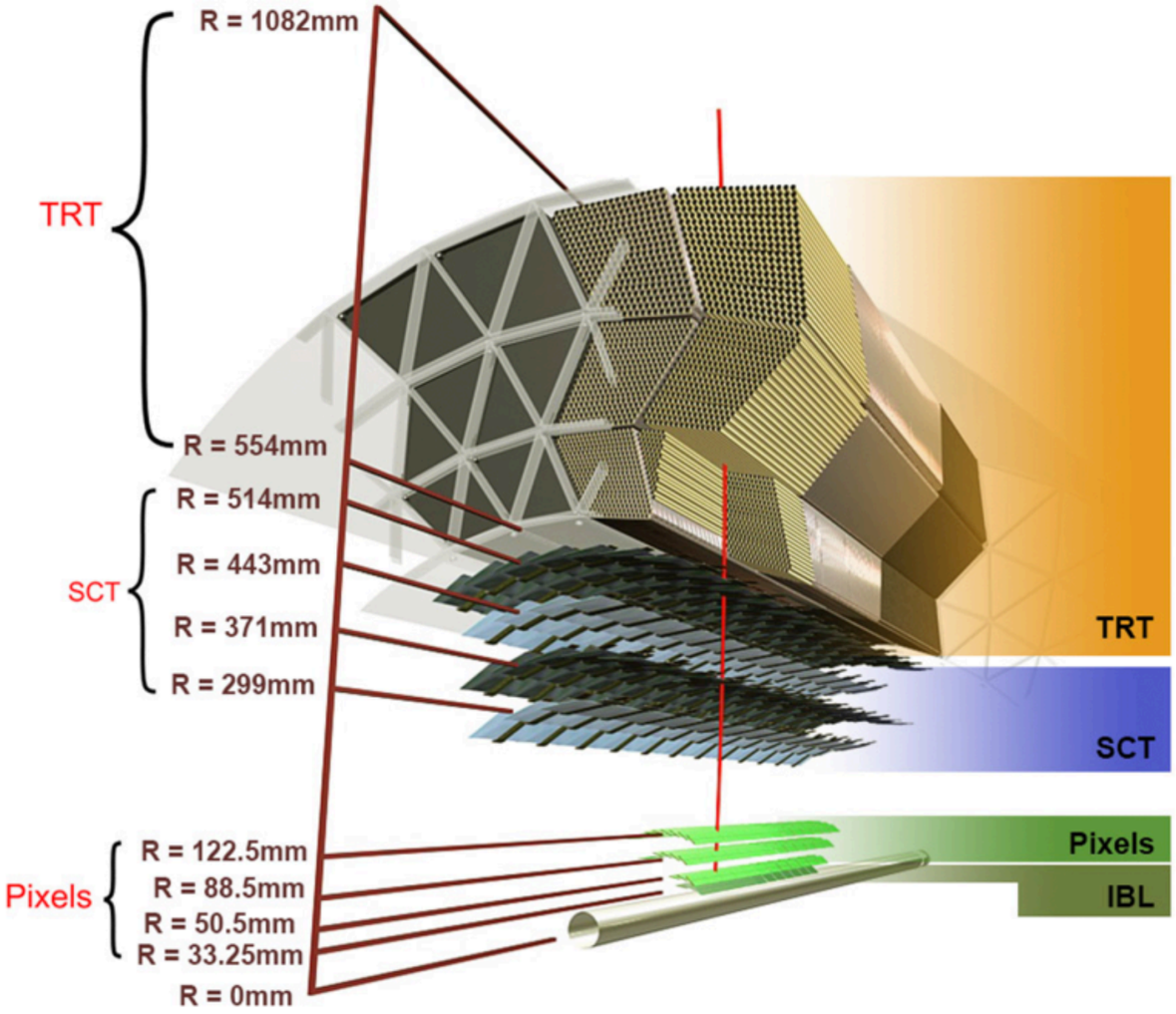
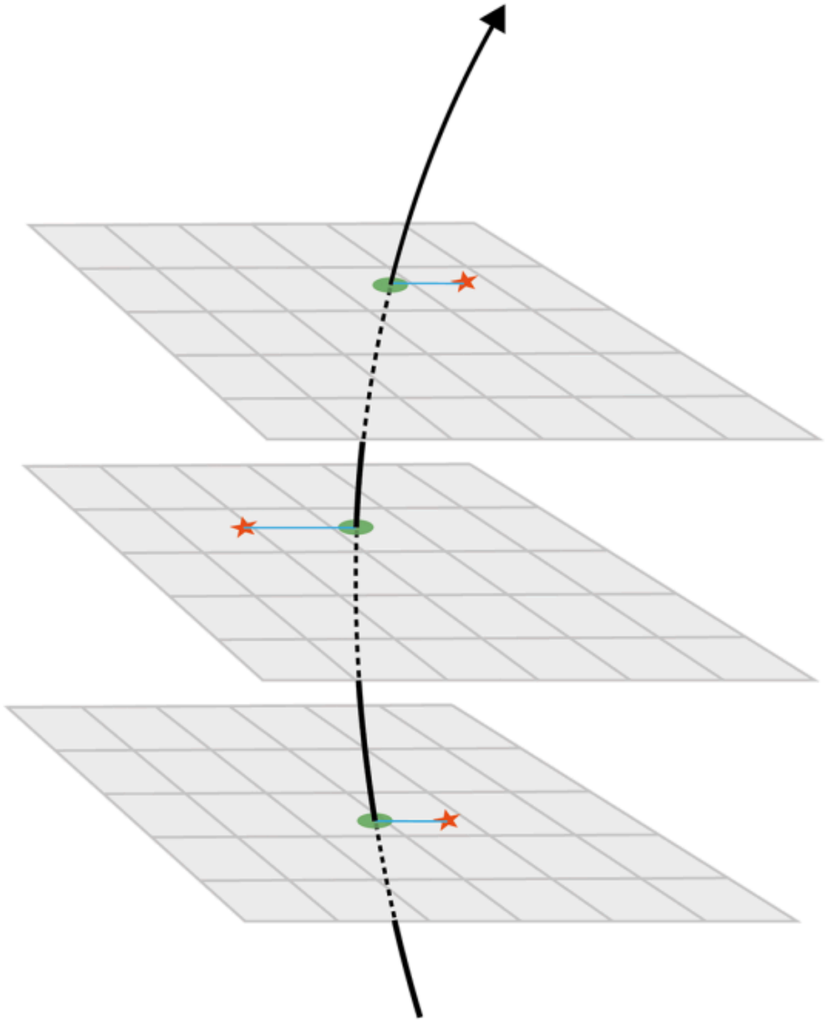
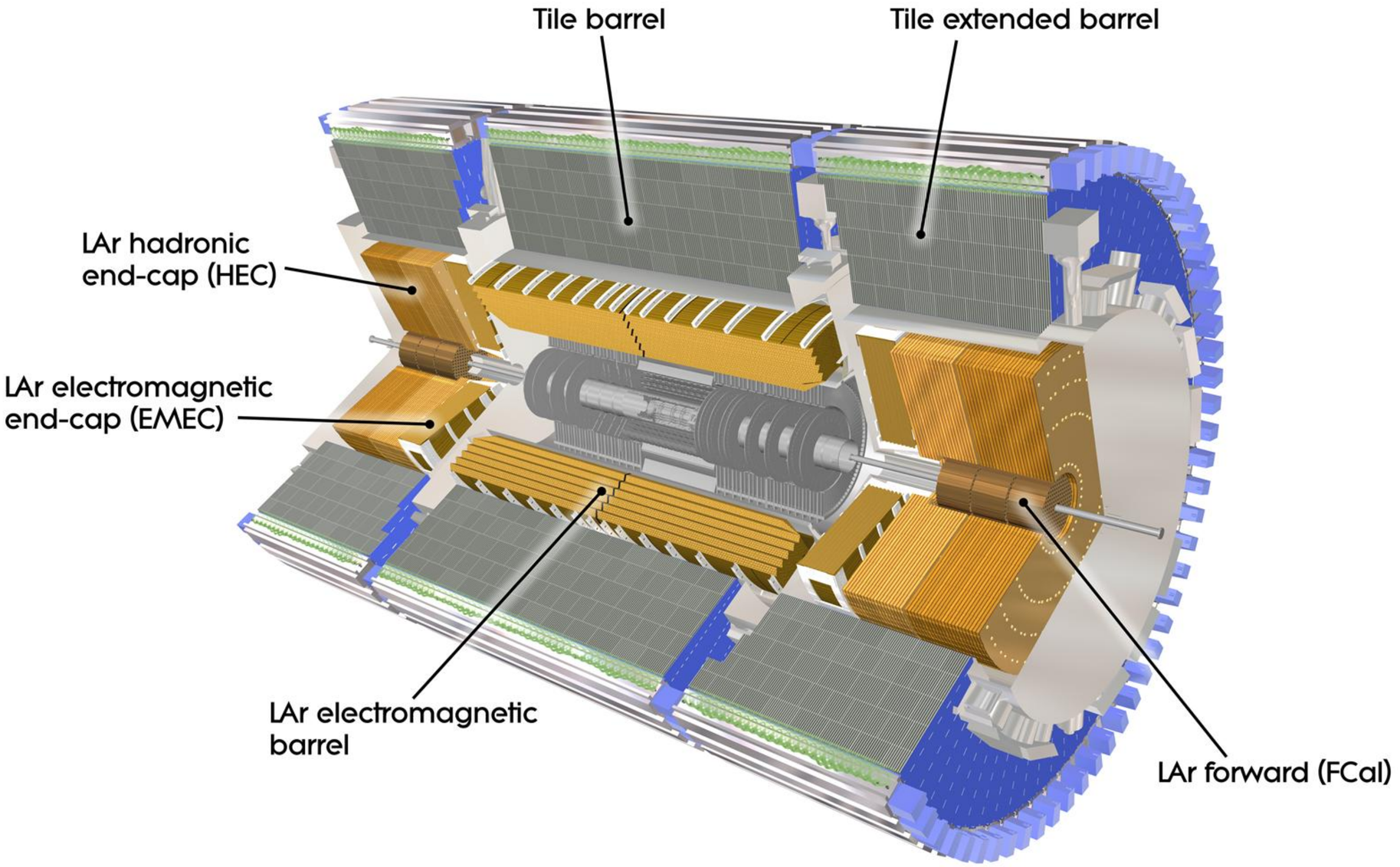
  - We'll come back to this!

Inner Detector and tracking





Calorimeters



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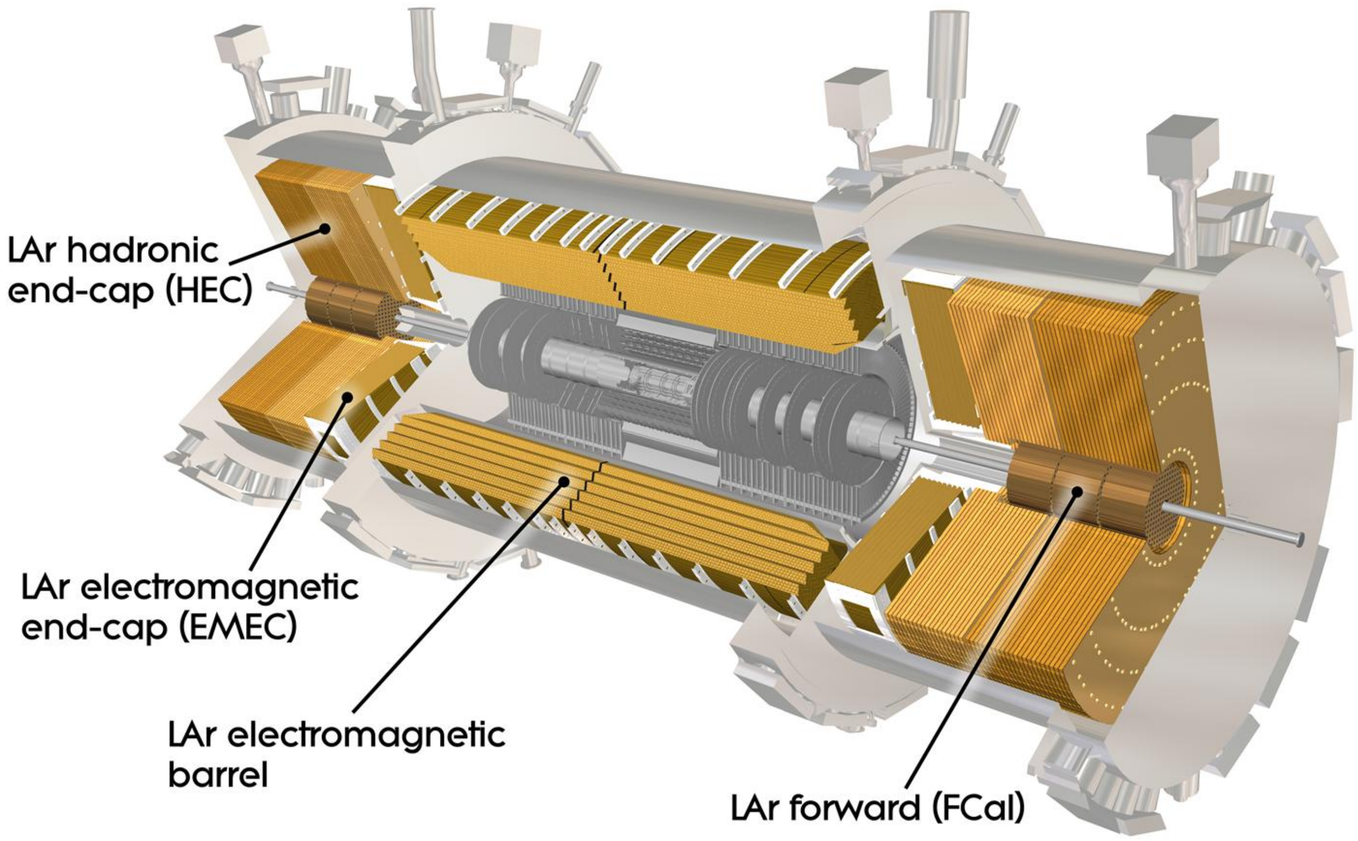

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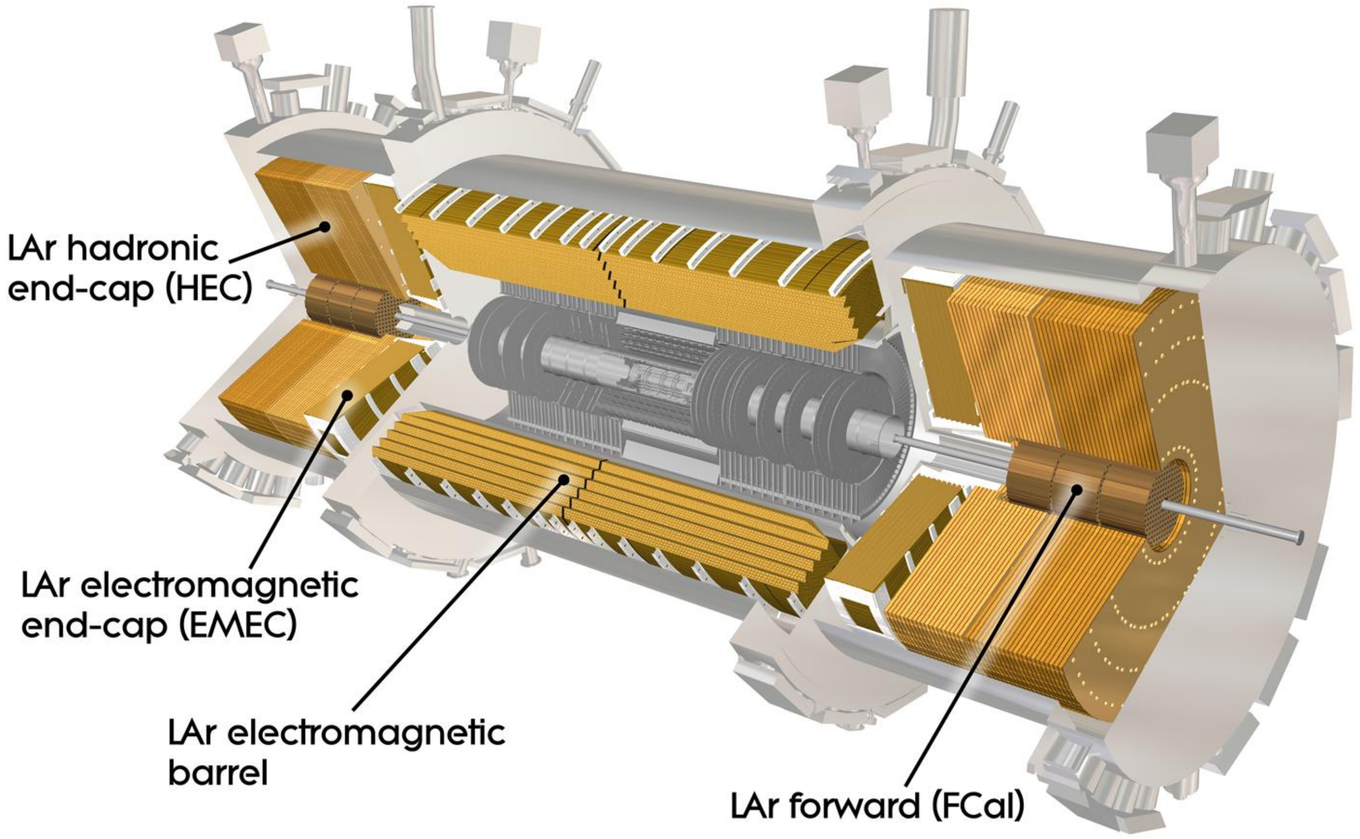
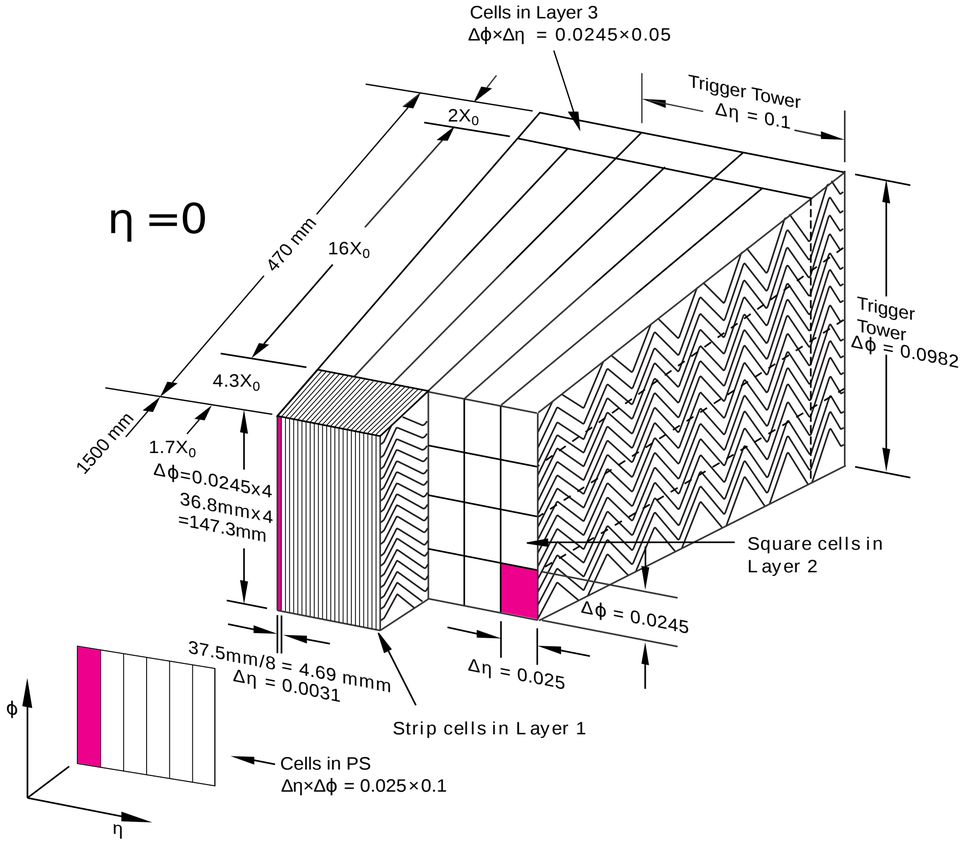
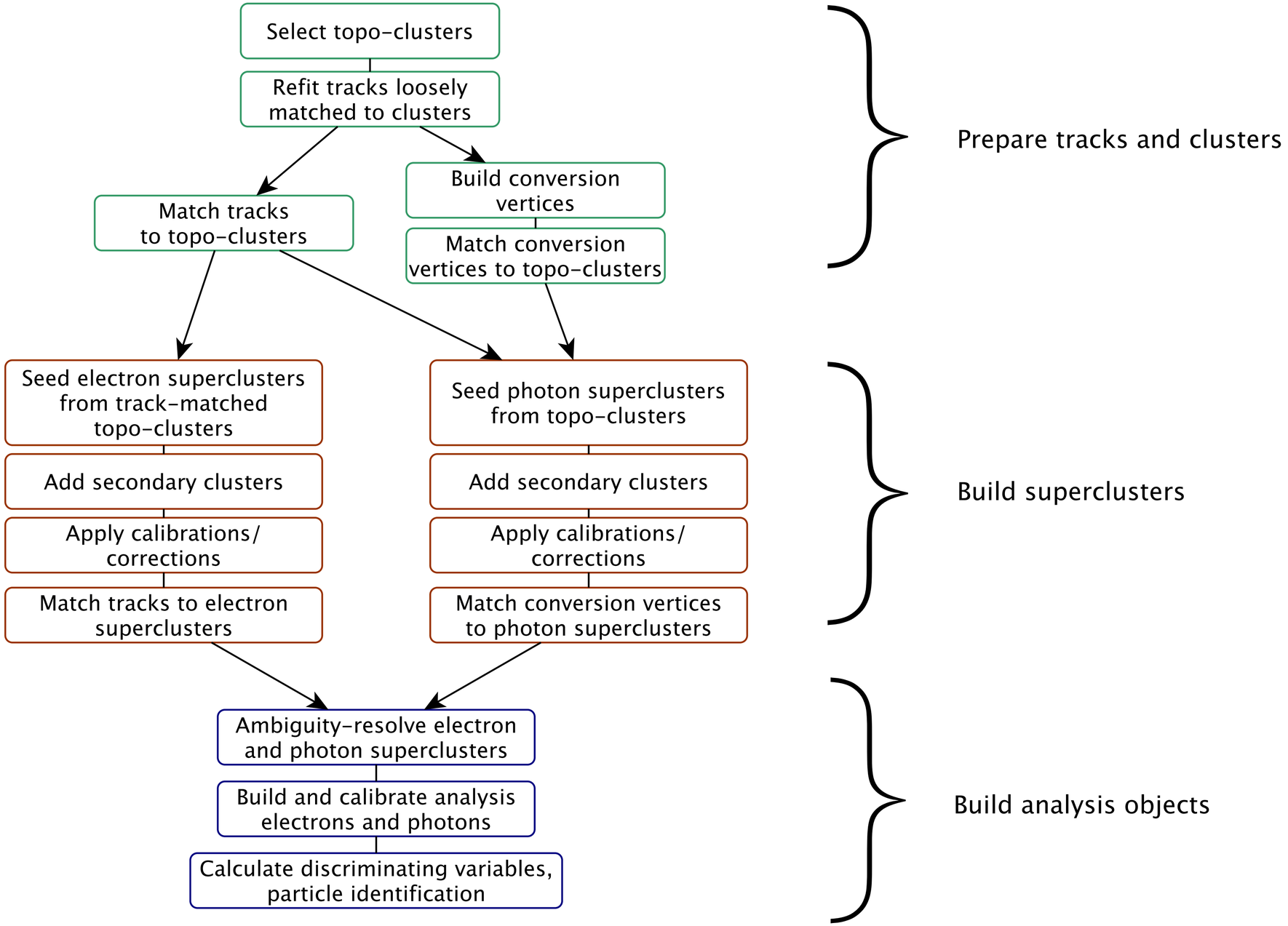
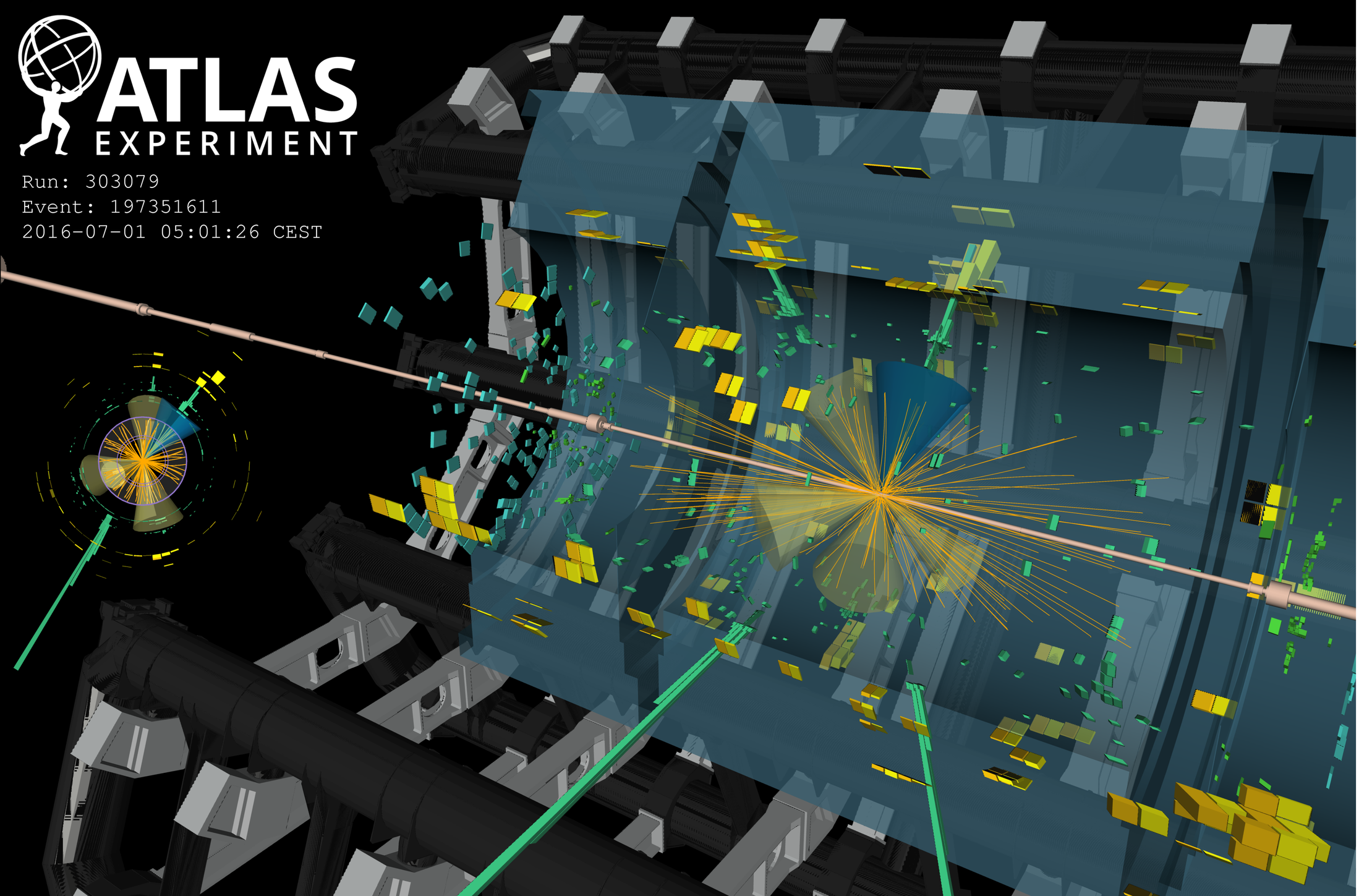




Photon (and electron) reconstruction





Candidate event:
$t\bar{t}H, H \rightarrow \gamma\gamma$

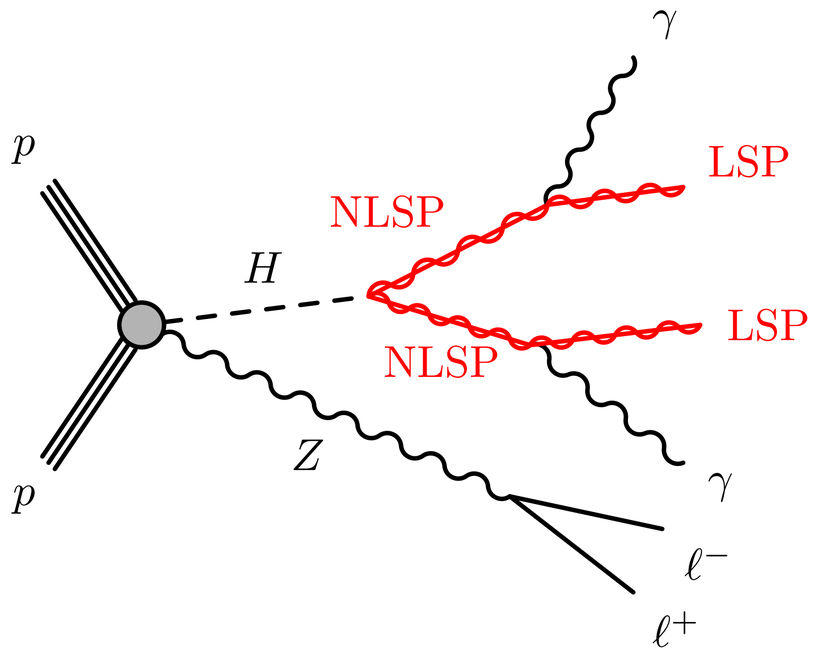
Photons: green

Jets: yellow cones (blue tagged as *b*-jet)

What about displaced photons?

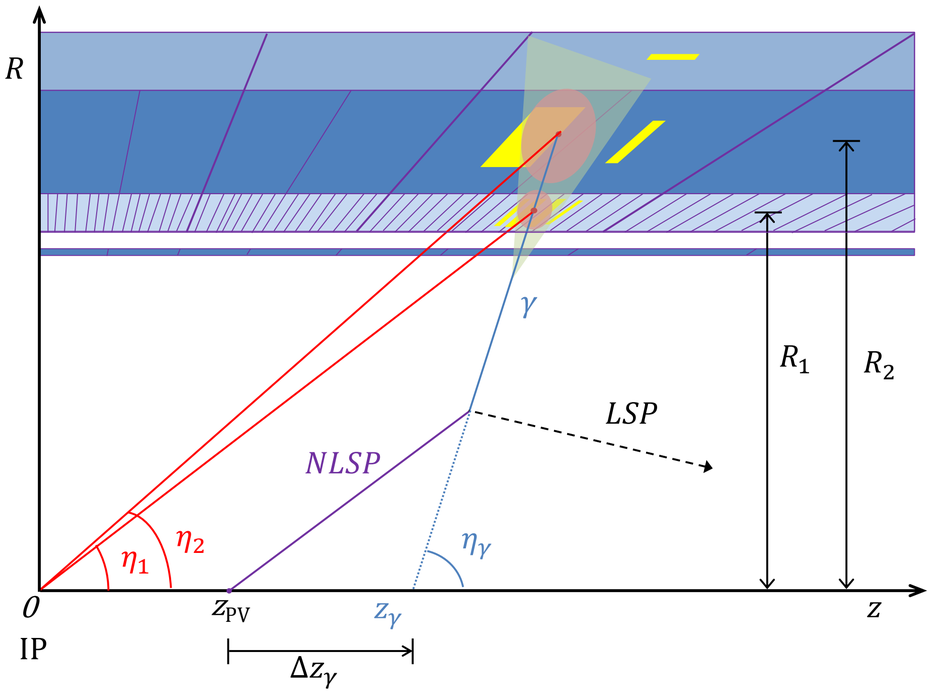
Recent search using displaced photons

Search for Higgs decaying to long-lived NLSPs, in turn each decaying to a photon and an LSP ($\rightarrow p_{\mathrm{T}}^{\mathrm{miss}}$)



Exploits two key photon characteristics:

- **"*Non-pointing*", i.e. does not point back to primary vertex**
- ***Delayed* due to massive NLSP + longer flight path**



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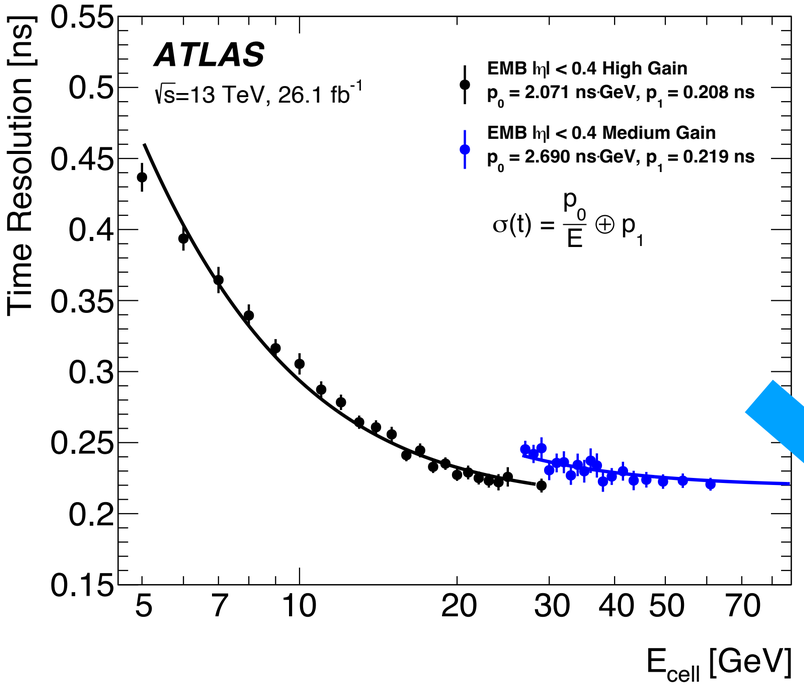

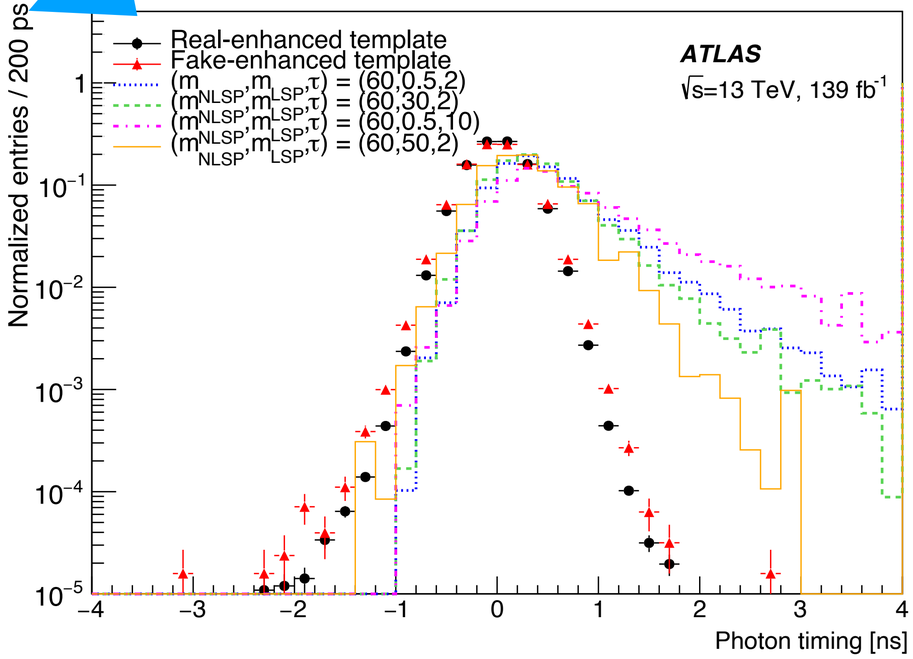

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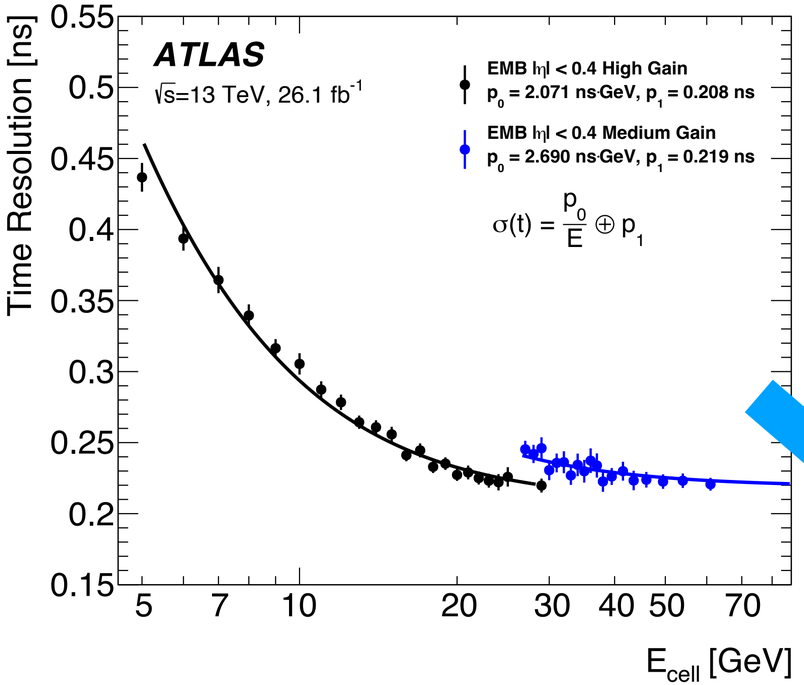
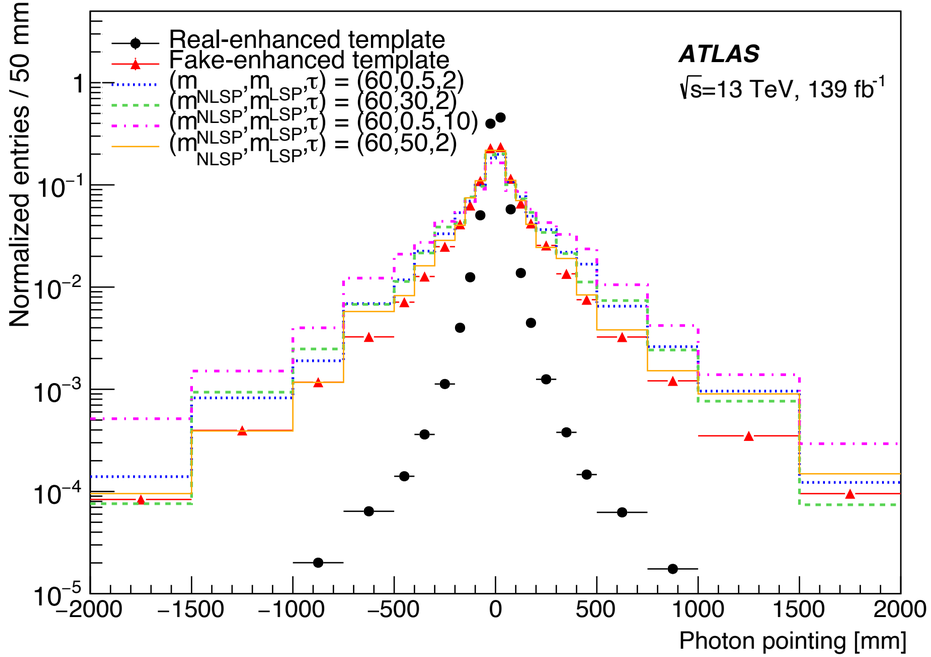
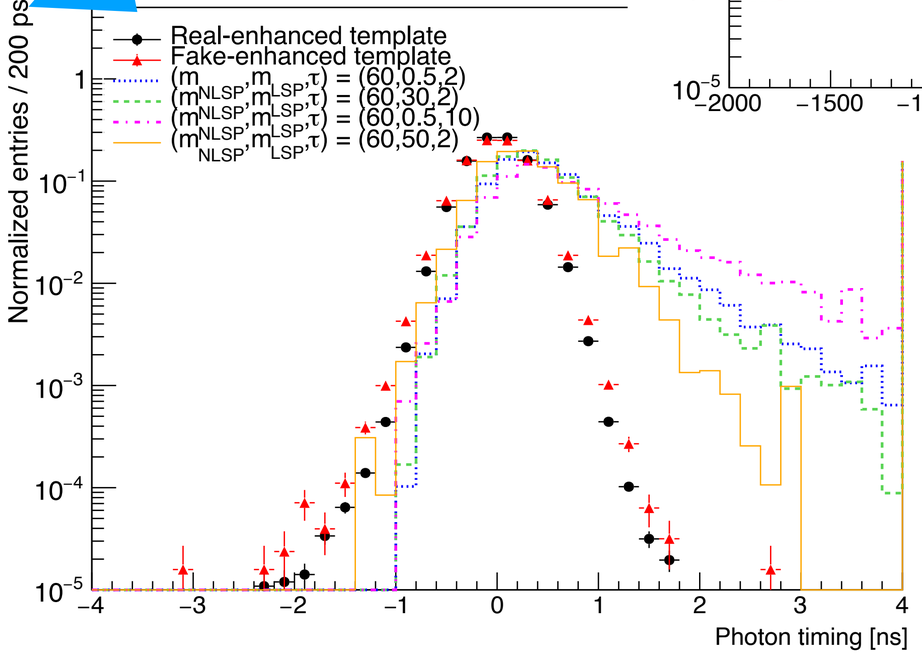


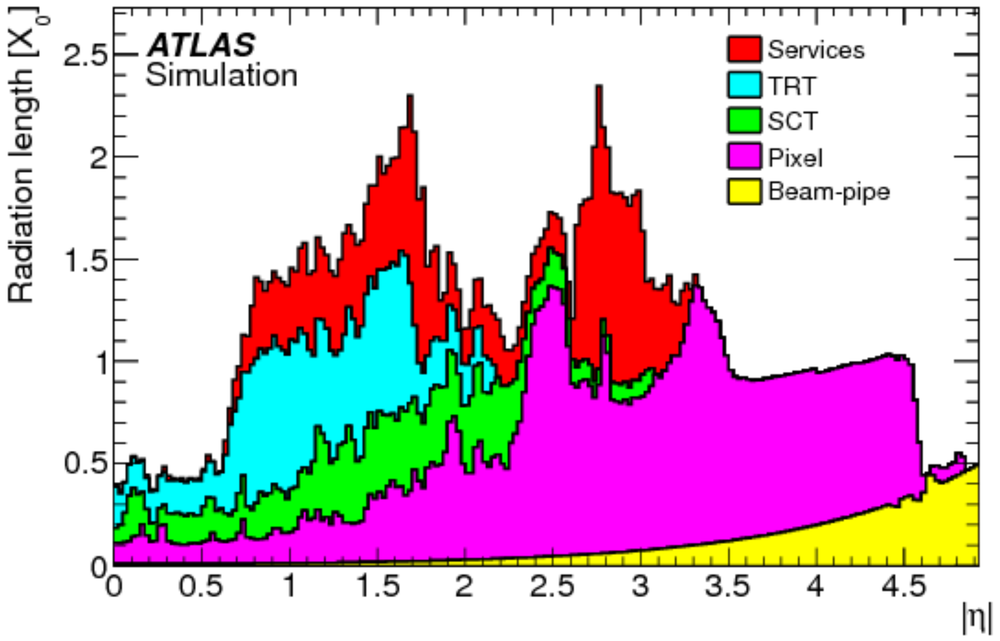




Challenges

- Kinematics in ALP case in paper quite different, with $m_{\mathrm{ALP}} \lesssim$ 1 GeV, produced with high $p_{\mathrm{T}} \Rightarrow$ significant boost
  - Small opening angle between photons
  - No significant delay in photon energy deposit

Challenges



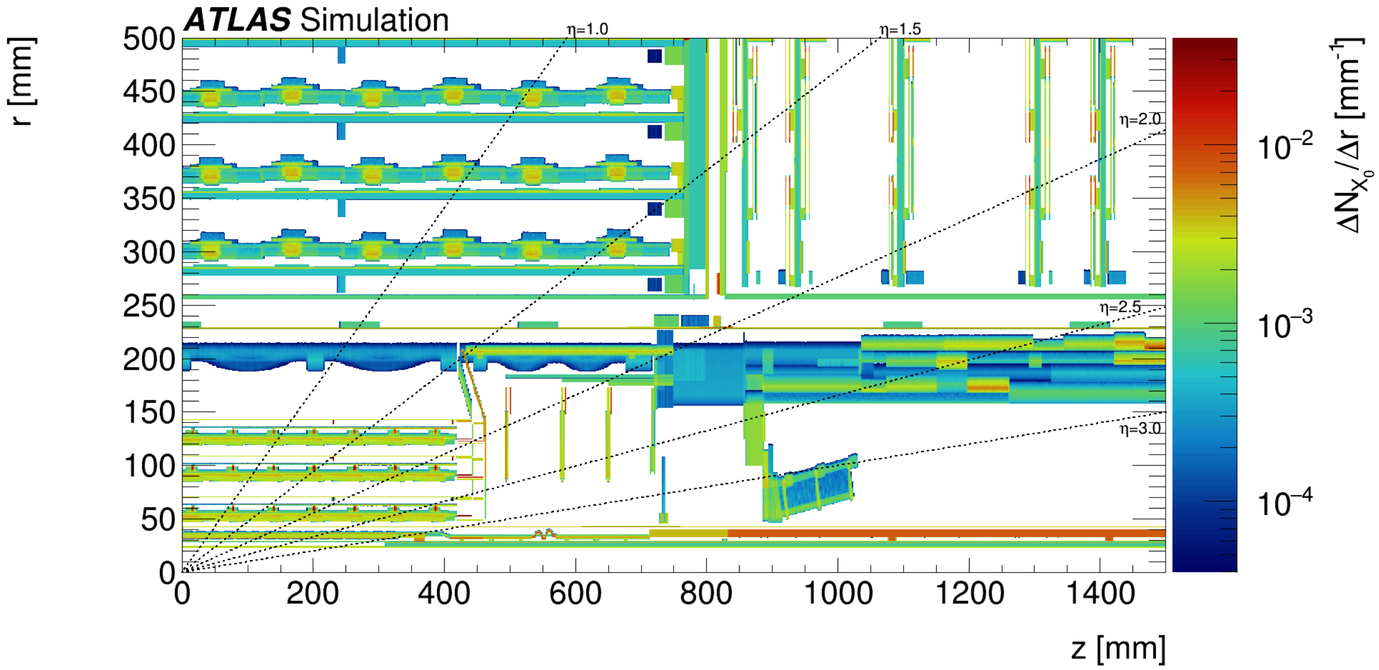
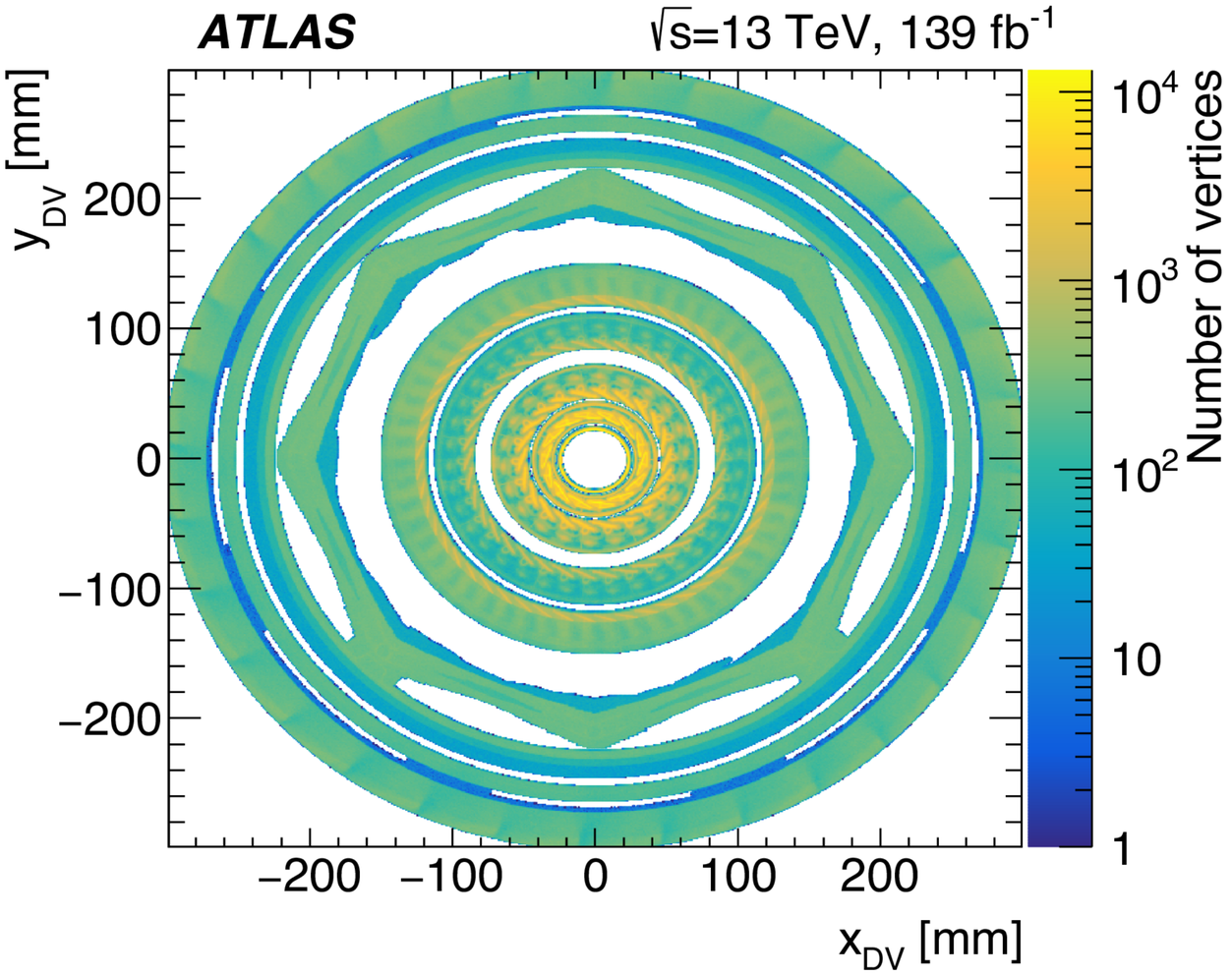
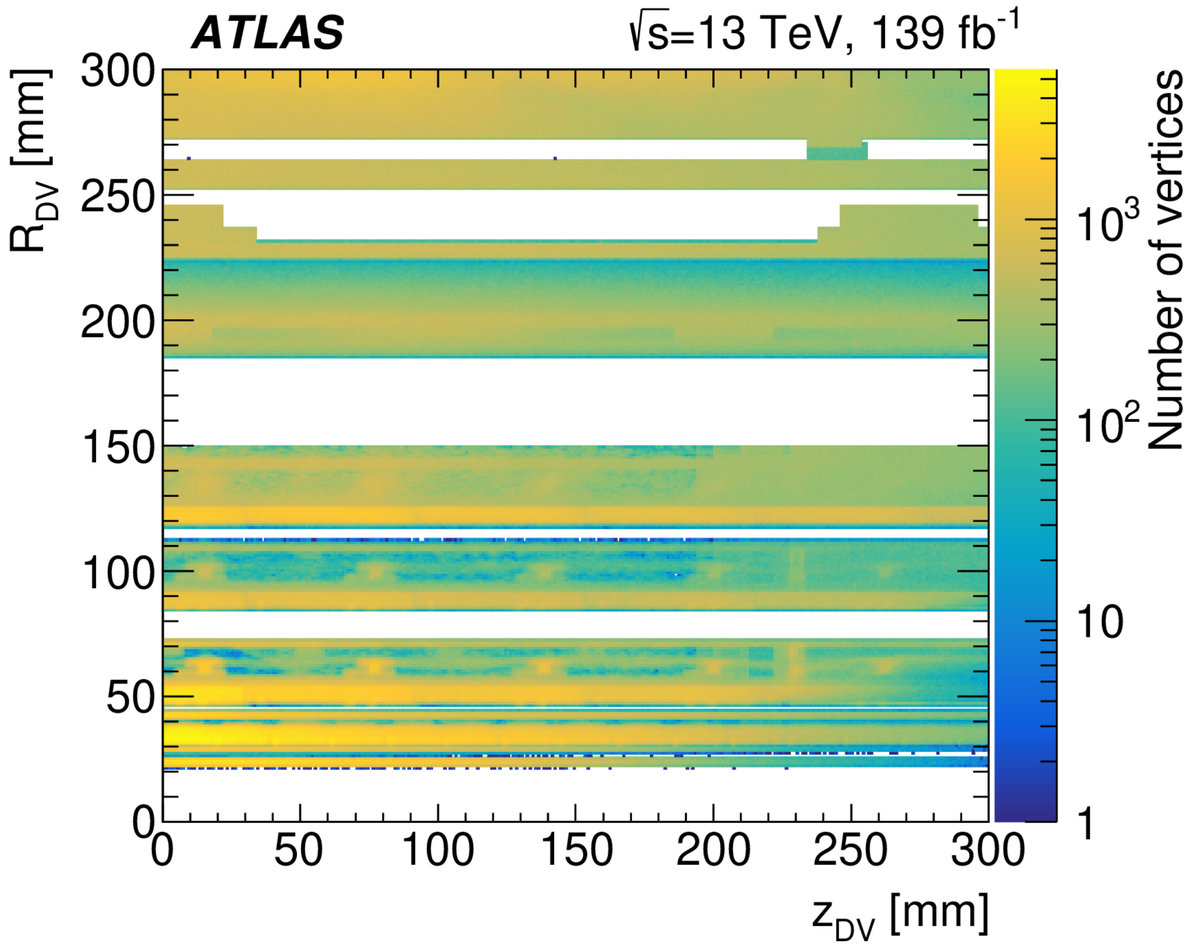


Figure 4: The r–z distribution of the differential number of radiation lengths, $\Delta N_{X_0}/\Delta r$, for the *updated* geometry model of a quadrant of the inner detector barrel region of the pixel detector and the SCT. The simulated material is sampled for each z-position along a straight radial path (perpendicular to the beam line).

What chance is there that both photons would convert early enough in the ID such that the DV of the ALP can be reconstructed?

Challenges





Huge number of high-pT hadrons created in collisions, and they also undergo hadronic interactions in the detector material

—> displaced vertices where there is material, just like the photons, with variable number of hadrons instead of e^+e^-

What about π^0? They would be produced here, and decay primarily to $\gamma\gamma$…