ANTI-NEUTRON MEASUREMENT WITH THE TOP SUBDETECTOR AT BELLE II

- 2nd MANTRA Meeting
11:00 CET/20:30 ACDT 28/10/24

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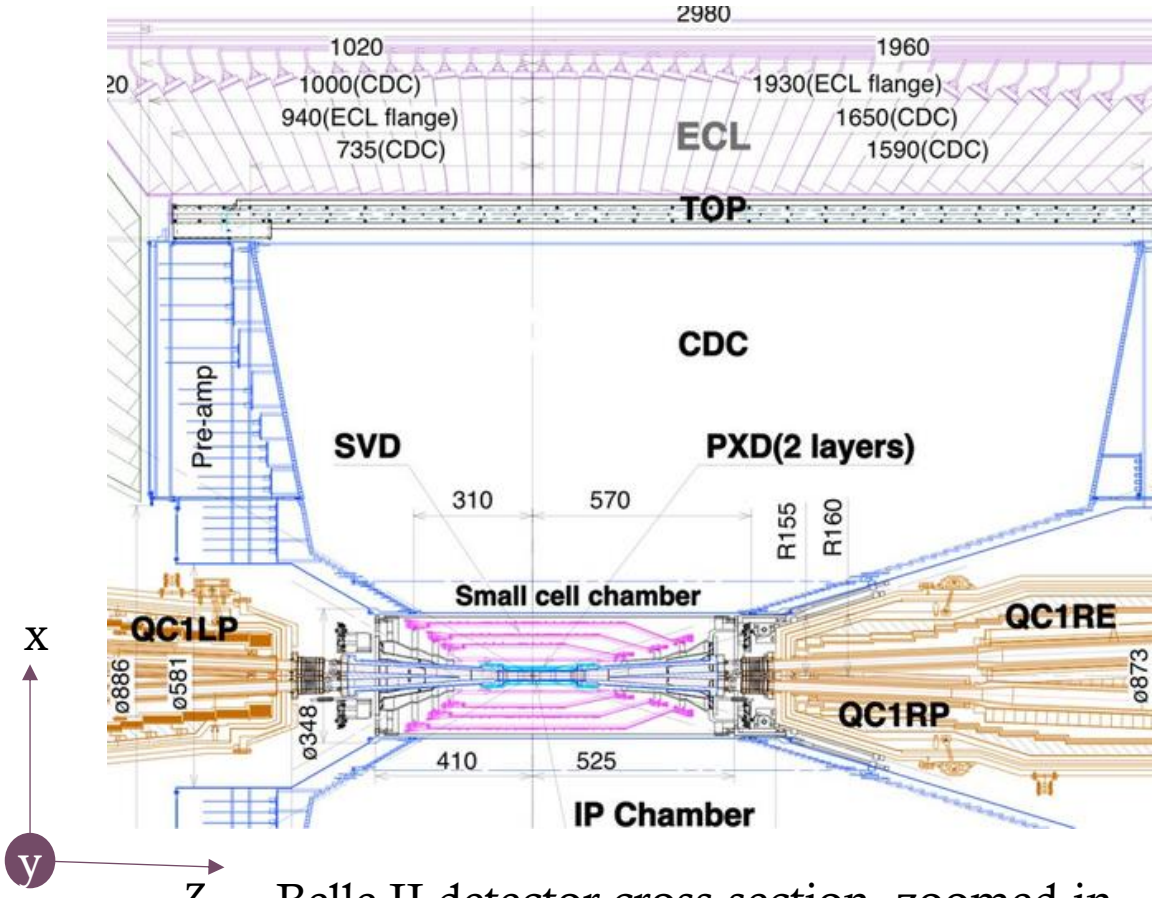
OUR GOAL



Belle II detector cross-section, zoomed-in

- **Determine a method of measuring the properties of anti-neutrons ($\bar{n}^0$ or "n-bar"), via the timing signatures of their annihilation in detector volumes.**
- Our case-study: the detector of the Belle II experiment.
- Traditionally, $\bar{n}^0$ are identified when they annihilate and induce hadronic showers that can be measured in the Electromagnetic Calorimeter (ECL) at Belle II. If annihilation products escape the ECL, measurements can be incomplete.
- Can improve $\bar{n}^0$ measurement by studying cases where annihilation products back-scatter into the Time-of-Propagation (TOP) subdetector, a timing-based Cherenkov radiation detector.
- Additionally, can look at cases where anti-neutron annihilation occurs slightly before or within the TOP, where products can be detected before further measurement when entering the ECL.

PROGRESS:

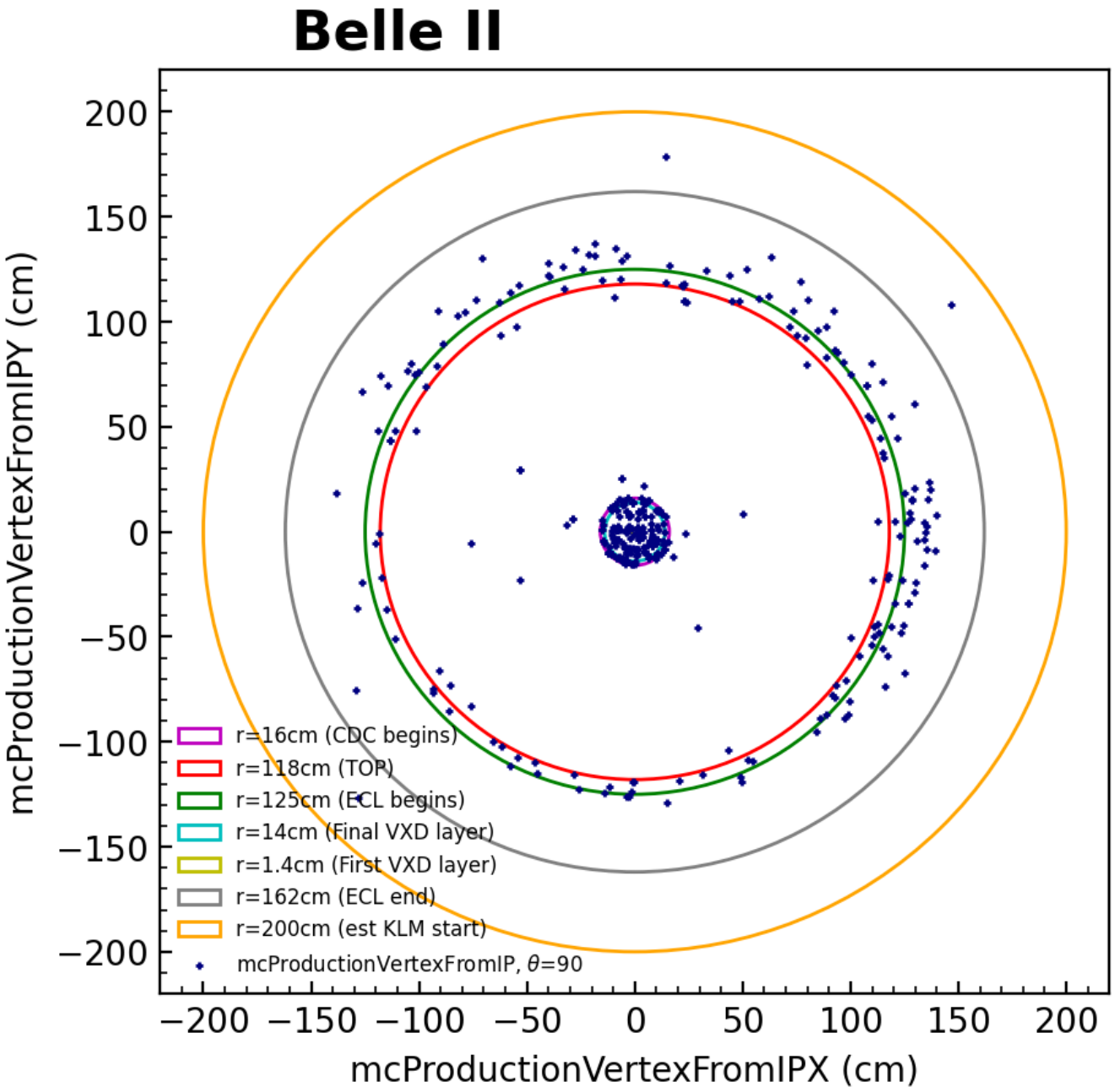
- Studying simulated TOP response to 10 000 MC generated (via Particle Gun/EvtGen packages) anti-neutron events, placed at the centre of the detector and travelling outwards; $|p|$=1 GeV, θ=90 and uniform $\phi \in [-\pi, \pi]$.
  - Also place p^+ at origin with same dynamics, to "tag" the event start time for the TOP.
- Restrict event consideration to when *charged pions* are created in the $\bar{n}^0$ annihilation, a common product that can leave signal in the TOP and escape the ECL.
  - Further restrictions are that the pions are created just before the TOP or radially beyond, and that there must be some tracking-based component (i.e. pions may curve back into the tracking chamber of the detector)

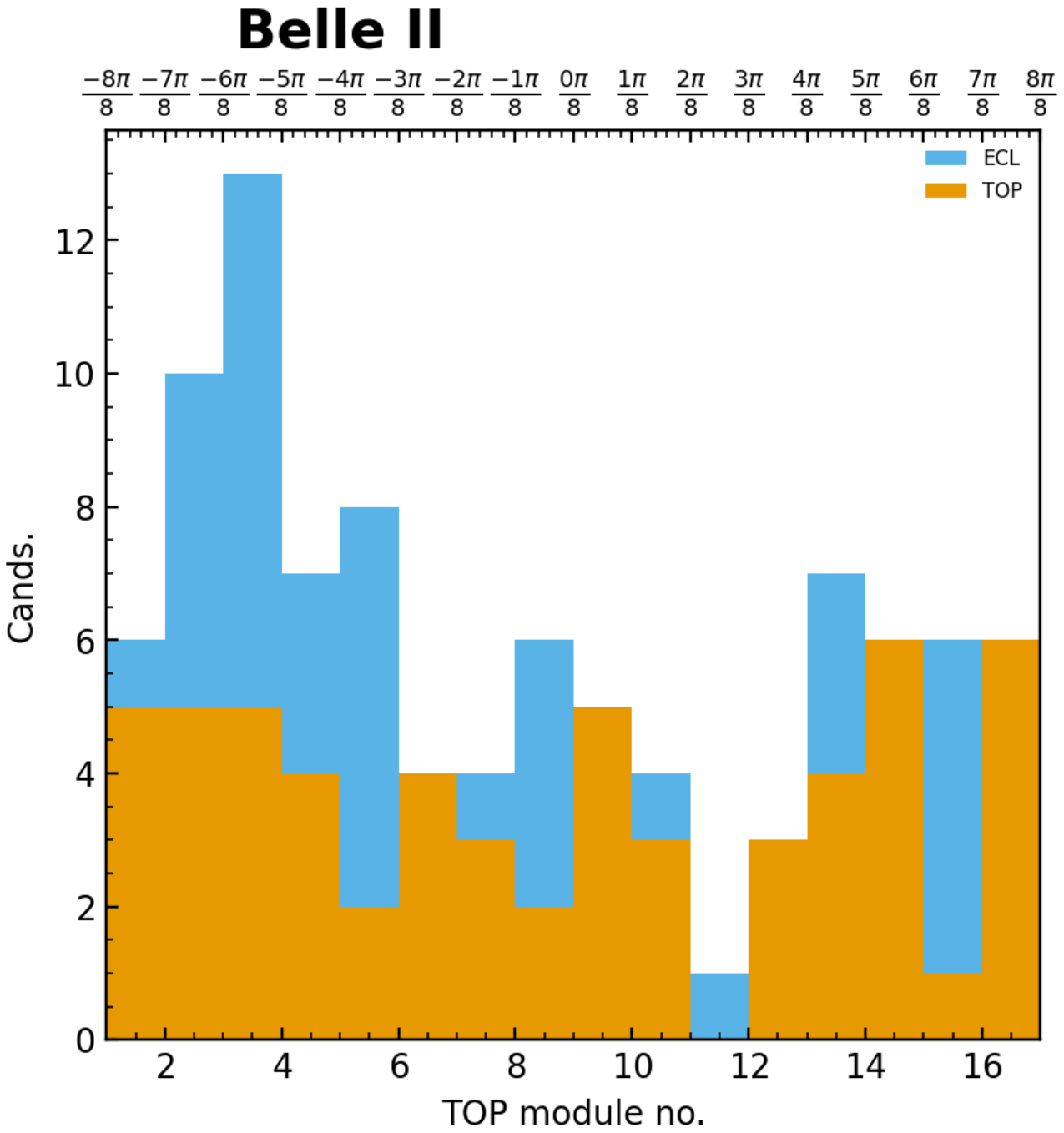
Statistics
10 000 events generated
8655 charged pcles found to cross the TOP, in **7963** events
165 are true pions that meet the criteria (*), in **162** events
Retention: ≈ 1.62 %

*abs(mcPDG==211) and mcPDG * charge >= 1 and mcProductionVertexFromIPRho >= 118cm and genMotherID==0

WHERE ARE $\bar{n}^0 \rightarrow \pi$ CONVERSIONS TAKING PLACE?

- Between 118cm and 125cm (*TOP to before ECL*): **62** pions across **61** events
- Between 125cm and 162cm (*in ECL*): **100** pions across **102** events.

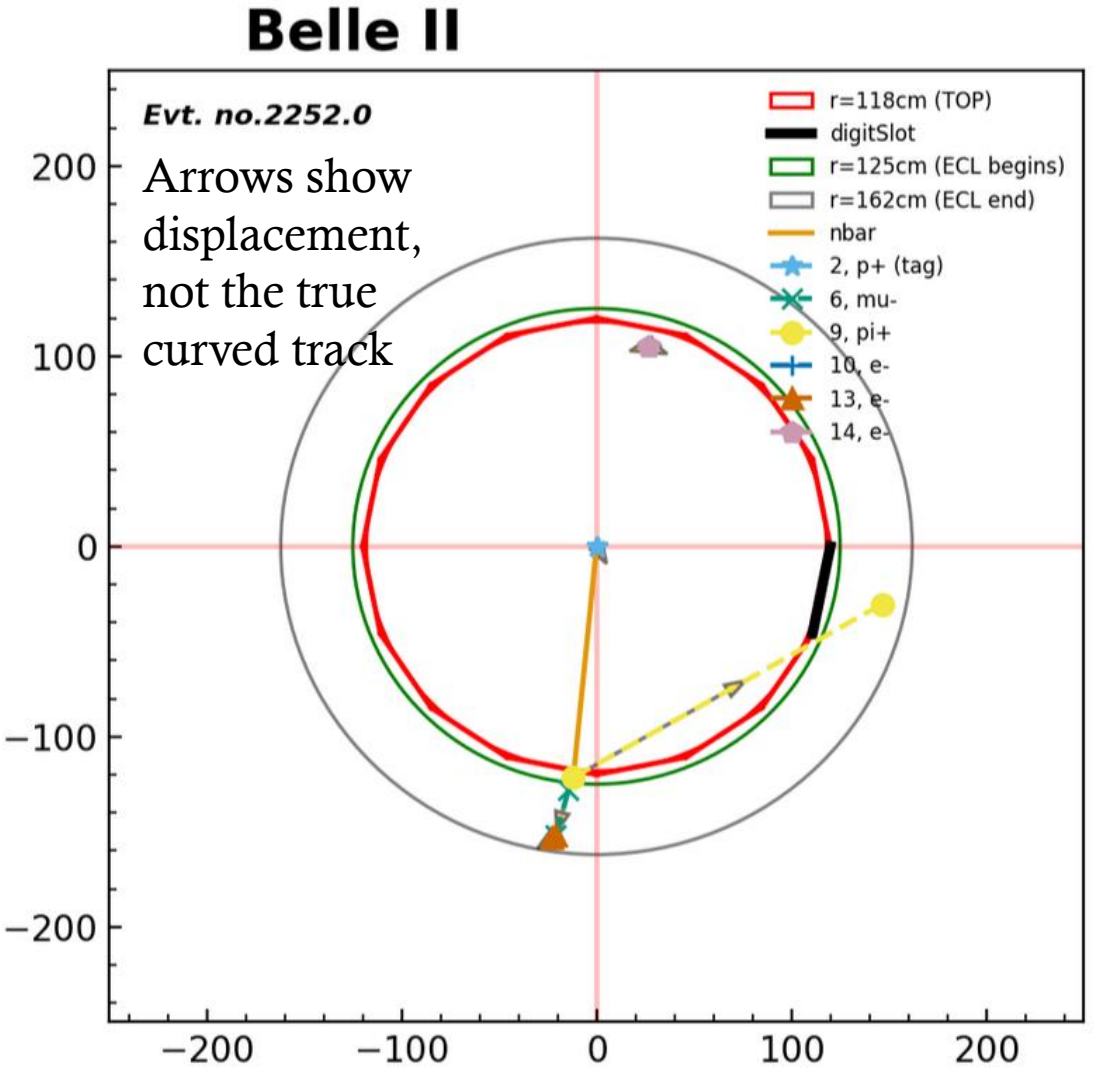


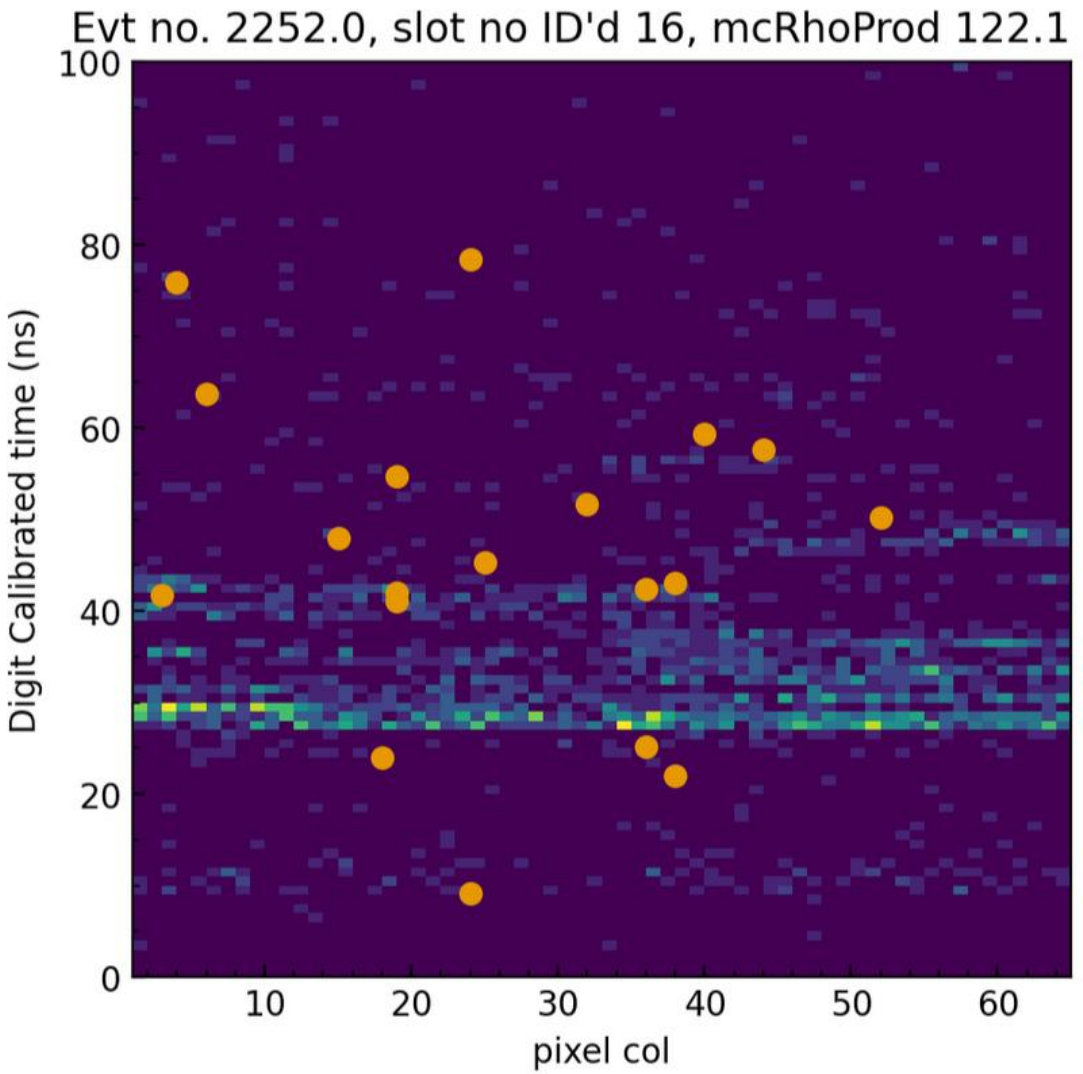


WHICH TOP MODULES ARE BEING STRUCK BY ANNIHILATION PIONS?

- The TOP subdetector consists of 16 modules placed cylindrically around the barrel of the detector, with axis parallel to the IP and beamline.
- Thus, each covers $2\pi/16$ azimuthally, with slot 1 beginning at $\phi = 0$
- Asymmetry??

WHAT ARE THE CHARACTERISTICS OF THE TOP SIGNAL IN THE INCIDENT MODULE FROM $\bar{n}^0$ ANNIHILATION EVENTS?





*Charged pion travelling through multiple slots?
Maybe need to look into signal in multiple slots?

Bullets: TOP signal

2D histogram: Implemented PDF of TOP signal of pion (*from IP)

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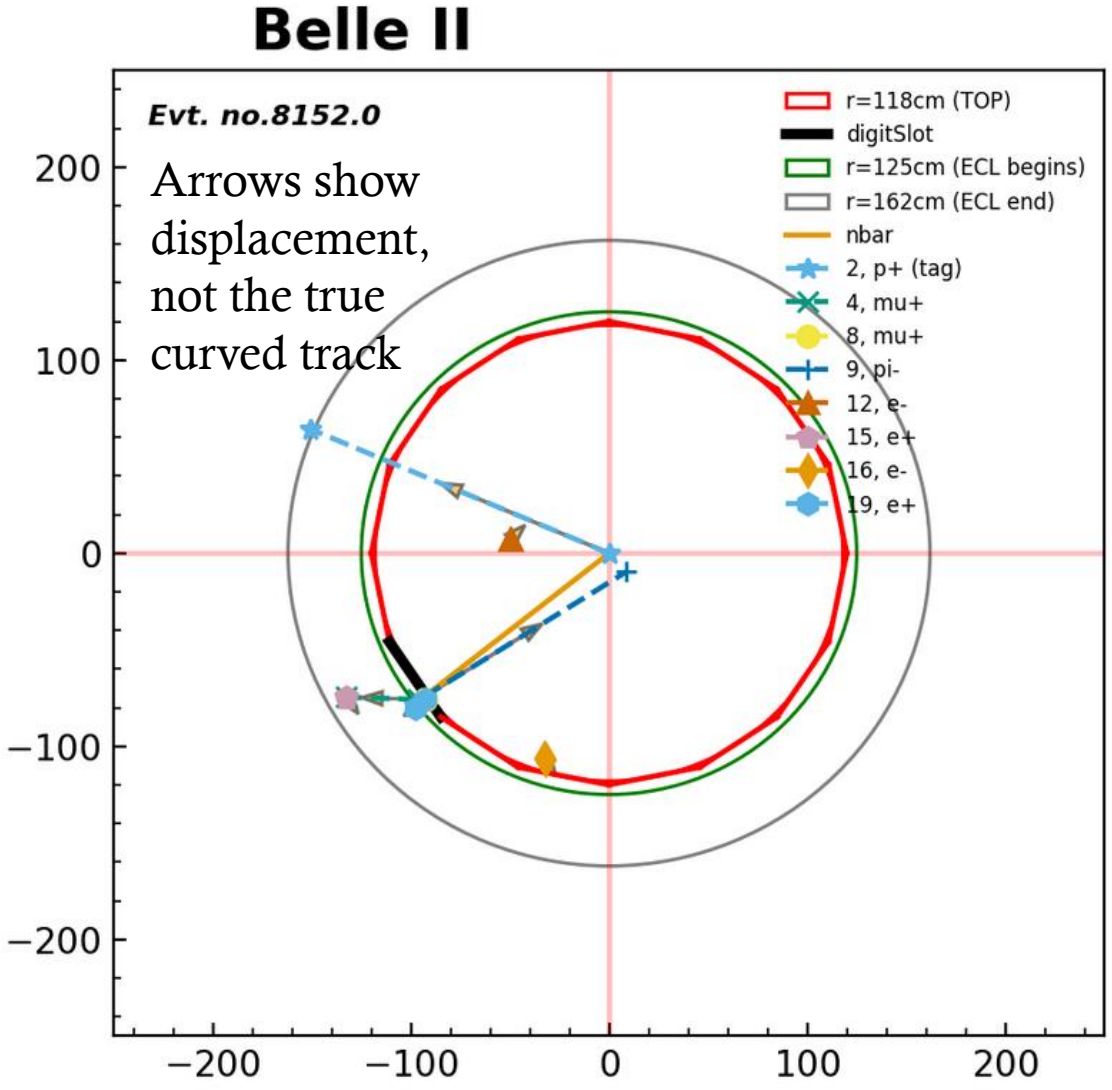

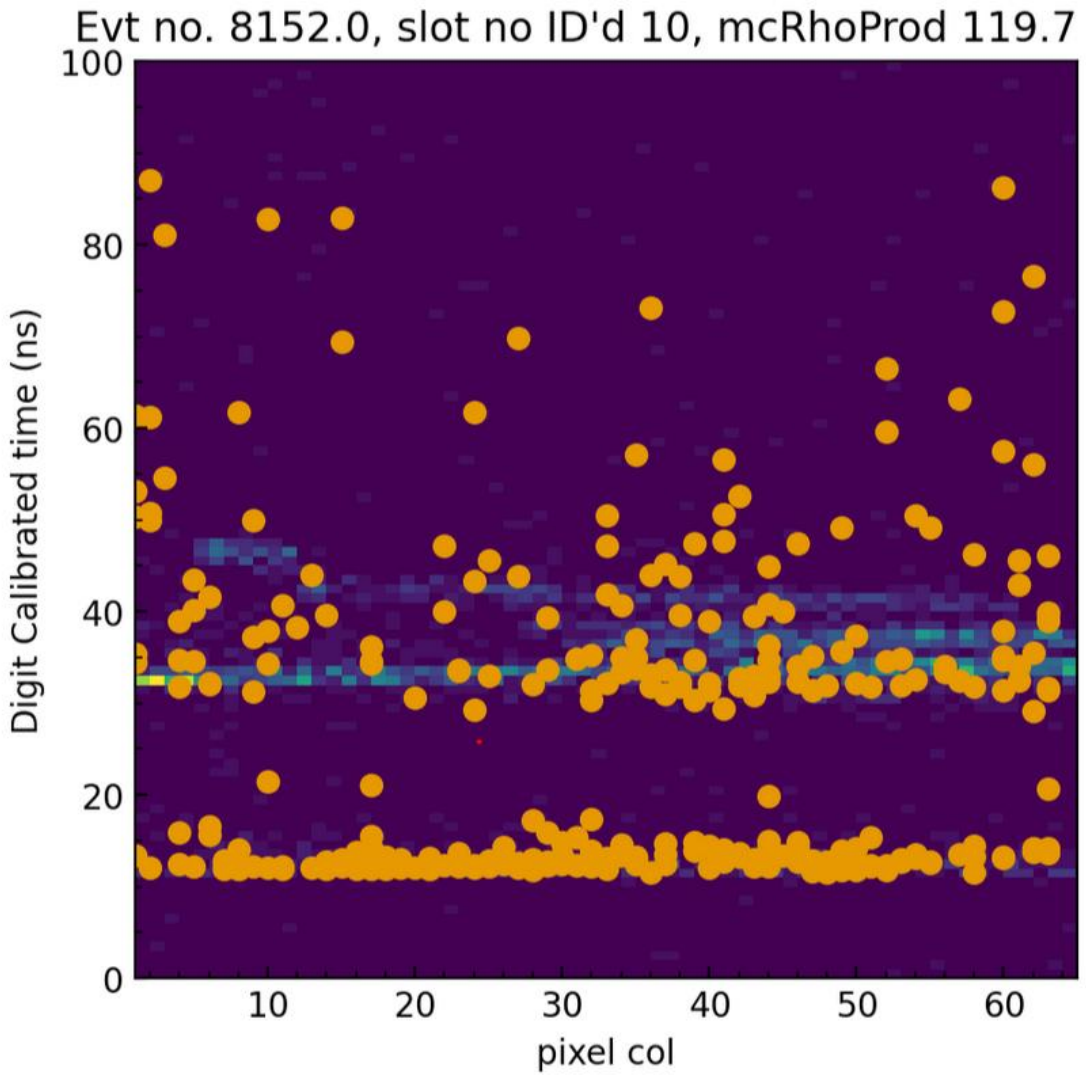

A much more common occurrence!

Bullets: TOP signal

2D histogram: Implemented PDF of TOP signal of pion (*from IP)

Jacarandas in bloom outside my office! Adelaide, 2024

NEXT STEPS

- Extend TOP analysis framework packages to be able to look at the global TOP response, to characterise annihilation pions that pass through multiple TOP modules.
- Generate and examine a larger MC sample
- Continue to investigate potential differences in $\bar{n}^0$ annihilations in the TOP, versus those in the ECL and back-scatter.