Photon and Meson reconstruction with PCM

Marvin Hemmer

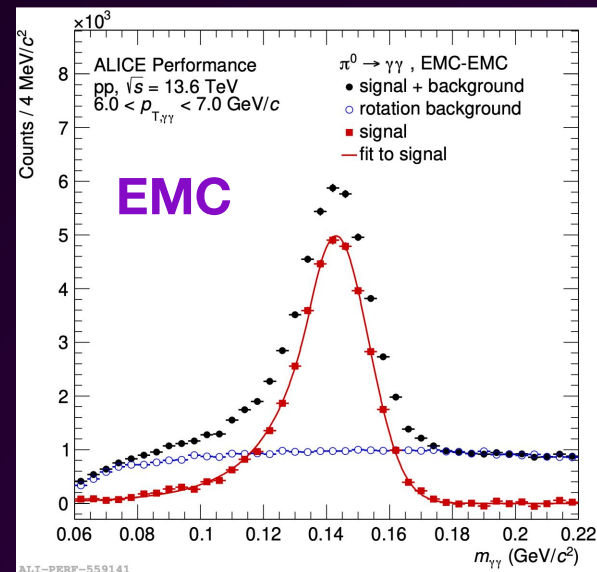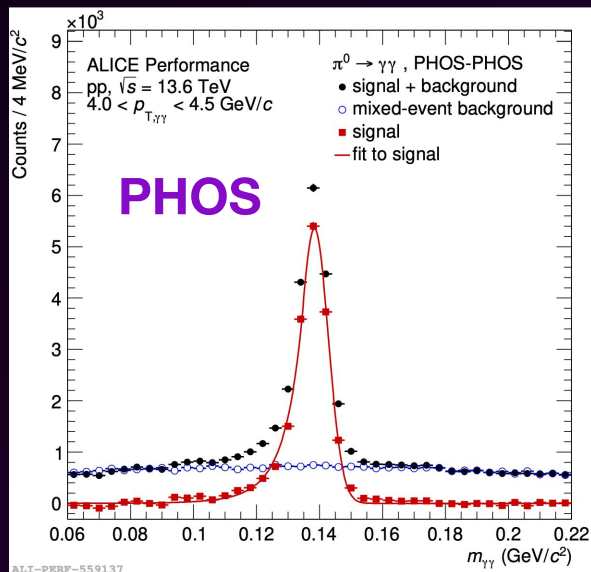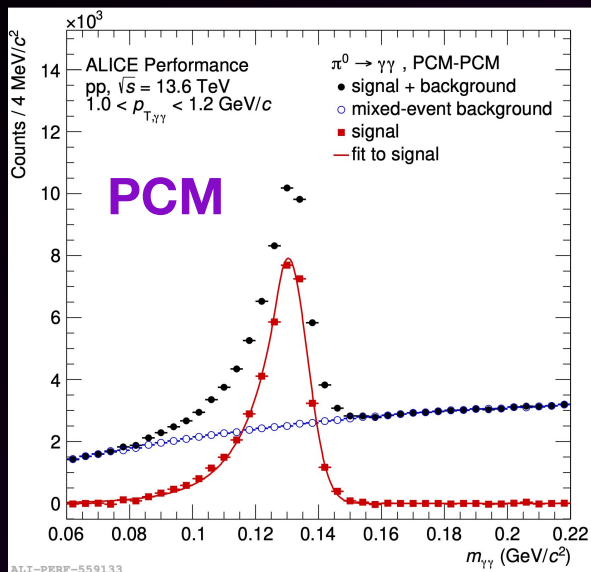O2 Analysis Tutorial- 10.11.2023

ALICE

Defining the Goal

- First results on neutral meson reconstruction using all three photon rec. methods
- **Focus on PCM in this talk**

PCM: A short introduction (Run 2)
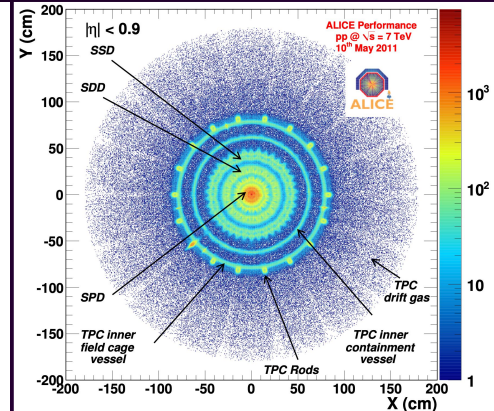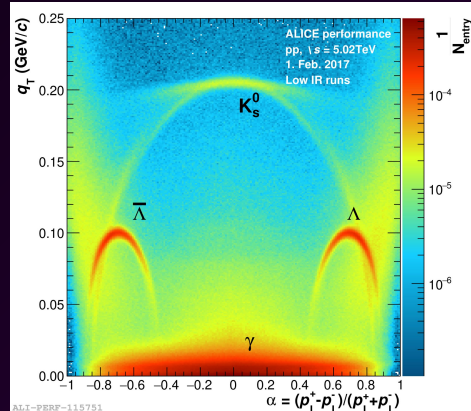
- Select electron candidates via dE/dx
- Build V0 candidates
- Select photons via qT cut
  - **Excellent purity of photons!**
- Conversion point shows detectors (ITS + TPC) and support structures

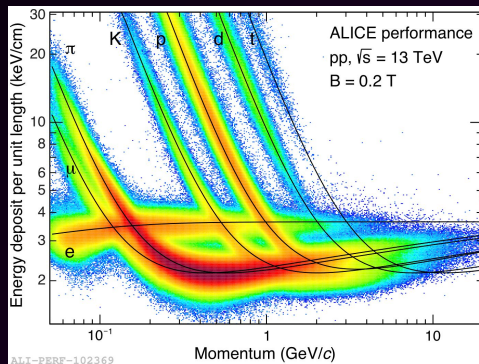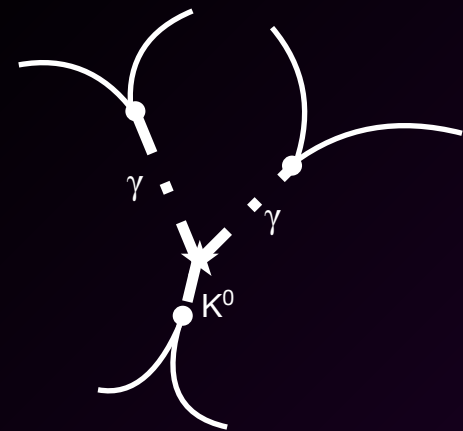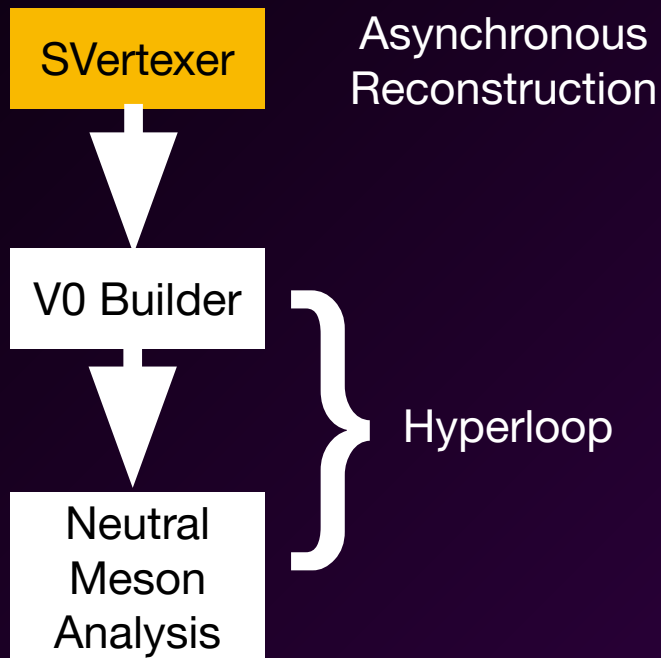# Standard Workflow in Run 3
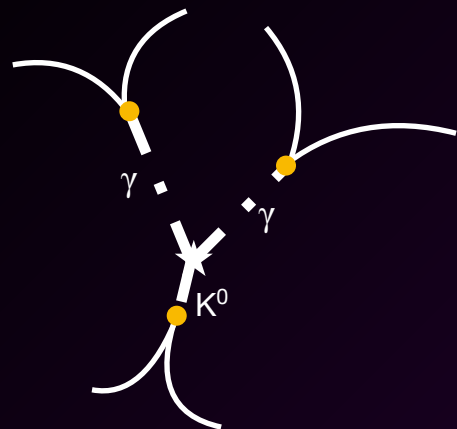
SVertexer

Asynchronous Reconstruction

V0 Builder

Neutral Meson Analysis

Hyperloop

- SVertexer
  - Secondary vertex finding
  - Input tracks: ITS + TPC

- V0 Builder
  - Selecting V0 candidates
  ➡ Conversion photons

- Neutral Meson Analysis
  - Pairwise combination of photon candidates

Standard Workflow in Run 3

SVertexer → V0 Builder → Neutral Meson Analysis

Asynchronous Reconstruction

Hyperloop

• SVertexer
  • Secondary vertex finding
  • Input tracks: ITS + TPC

• V0 Builder
  • Selecting V0 candidates
  ➡ Conversion photons

• Neutral Meson Analysis
  • Pairwise combination of photon candidates

Standard Workflow in Run 3
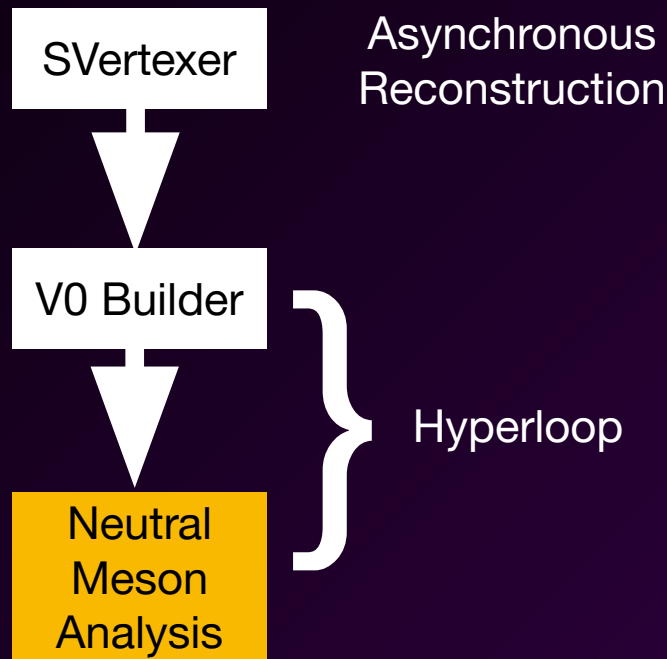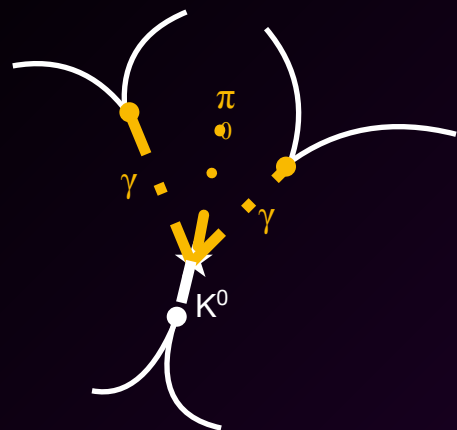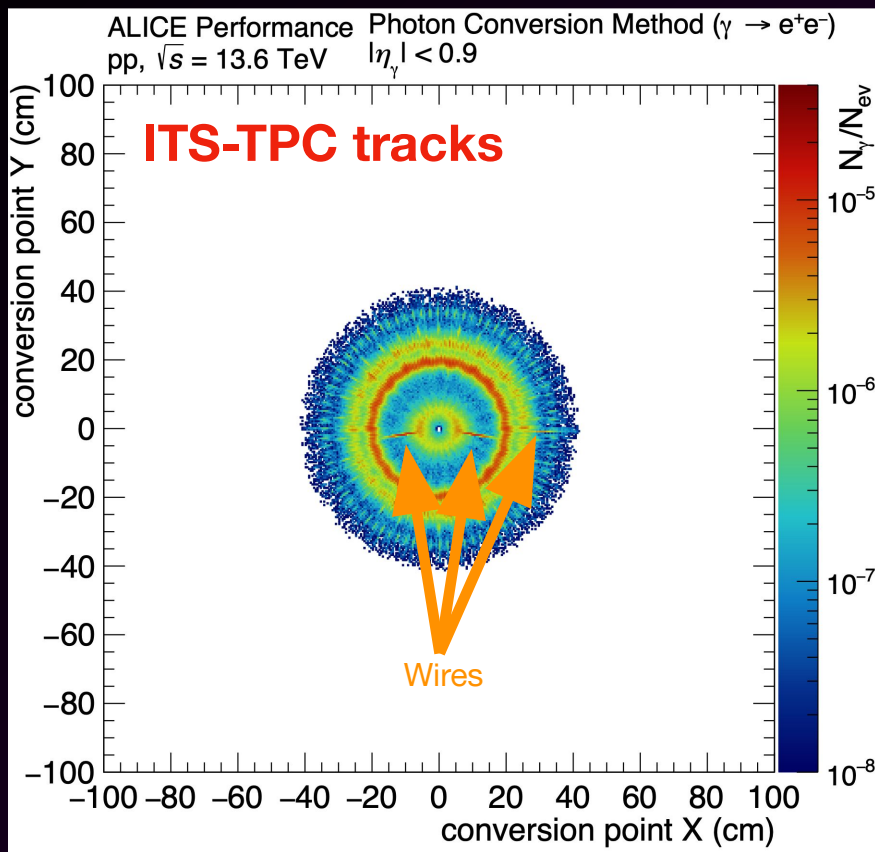

Asynchronous
Reconstruction

Hyperloop

- SVertexer
  - Secondary vertex finding
  - Input tracks: ITS + TPC

- V0 Builder
  - Selecting V0 candidates
  ➡ Conversion photons

- Neutral Meson Analysis
  - Pairwise combination of photon candidates

PCM Photons with SVertexer and V0 Builder

- SVertexer → conversion point
- V0 builder → conversion photon selection

- Three tungsten wires for conversions:
  - Two wires between ITS Inner Barrel and ITS Outer Barrel
  - One wire inside of ITS Outer Barrel between Middle and Outer Layer

PCM Photons with SVertexer and V0 Builder

Modified Workflow in Run 3

SVertexer

Asynchronous
Reconstruction

V0 Builder

Modified V0
Builder

Neutral
Meson
Analysis

Hyperloop
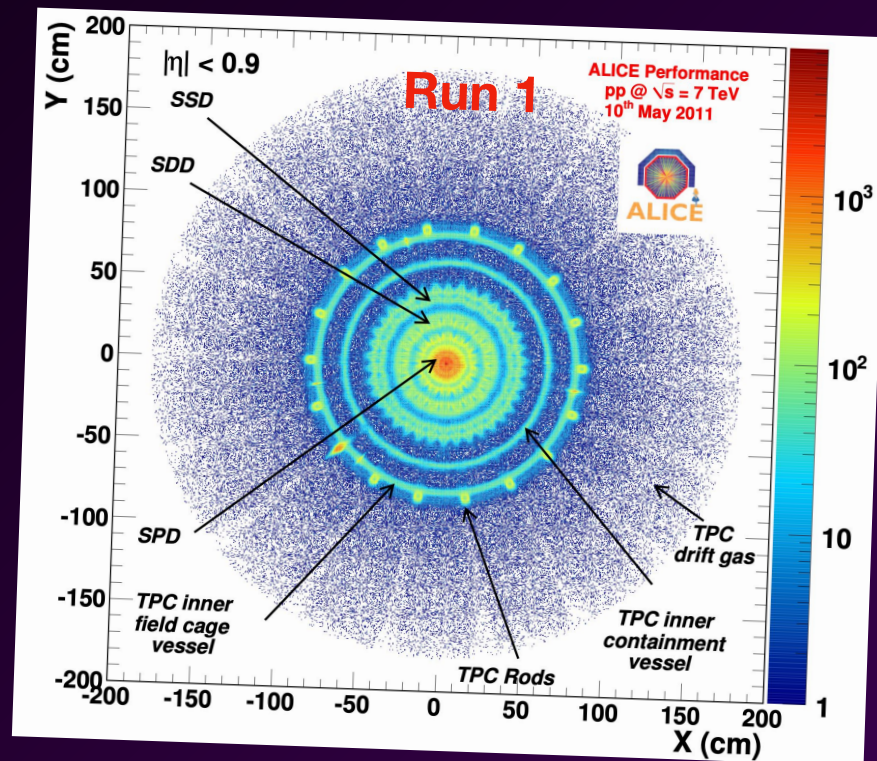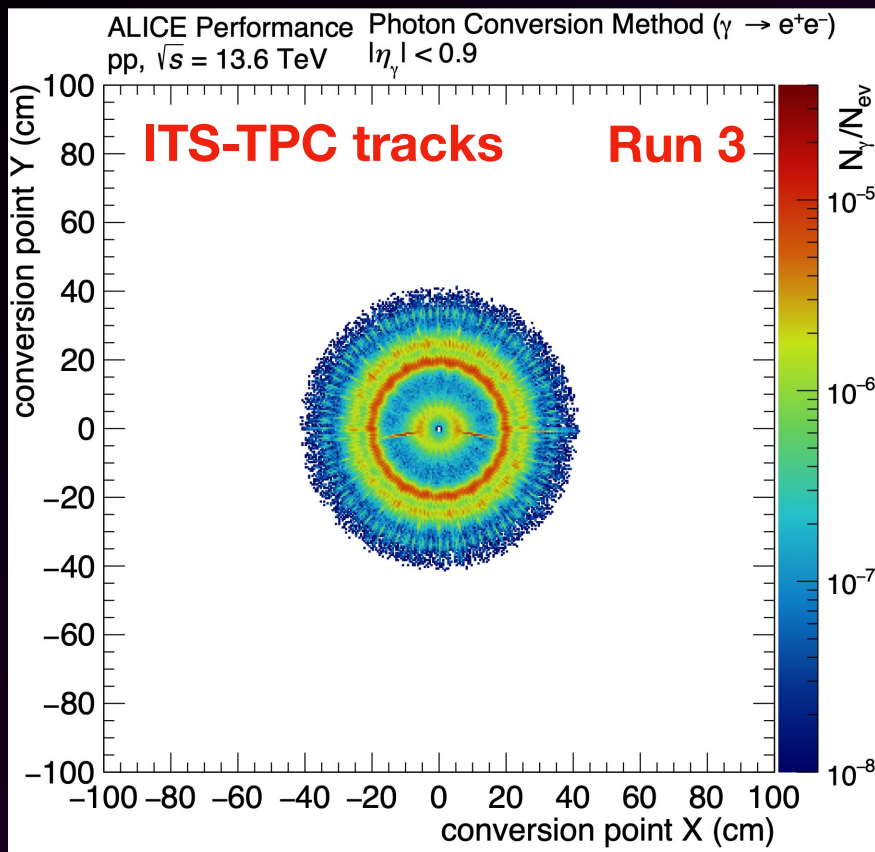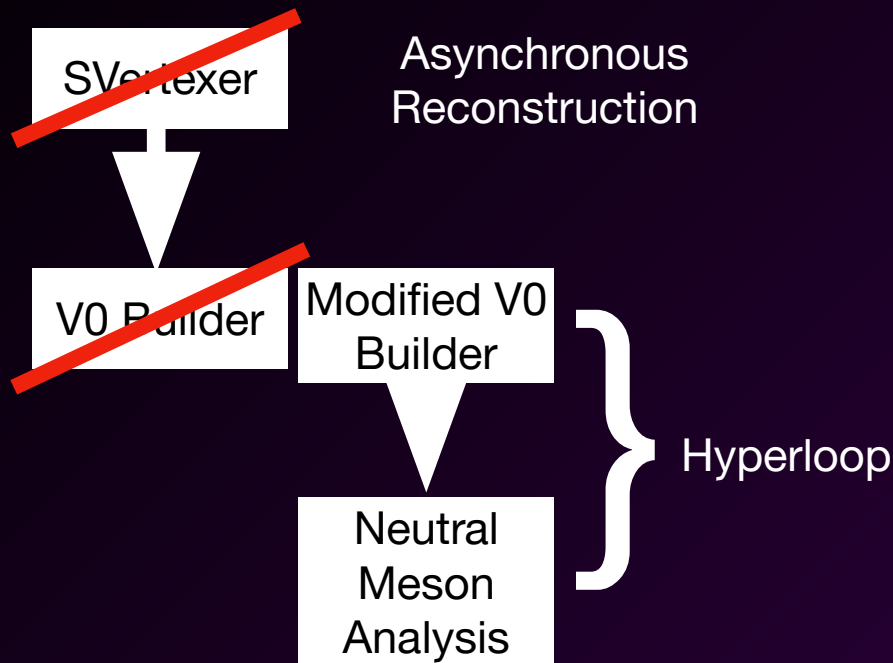
- Modified V0 Builder:
  - No dependence on SVertexer
  - TPC only tracks included
  - CPU intensive
- Tool to study V0 reconstruction

PCM Photons with Modified V0 Builder
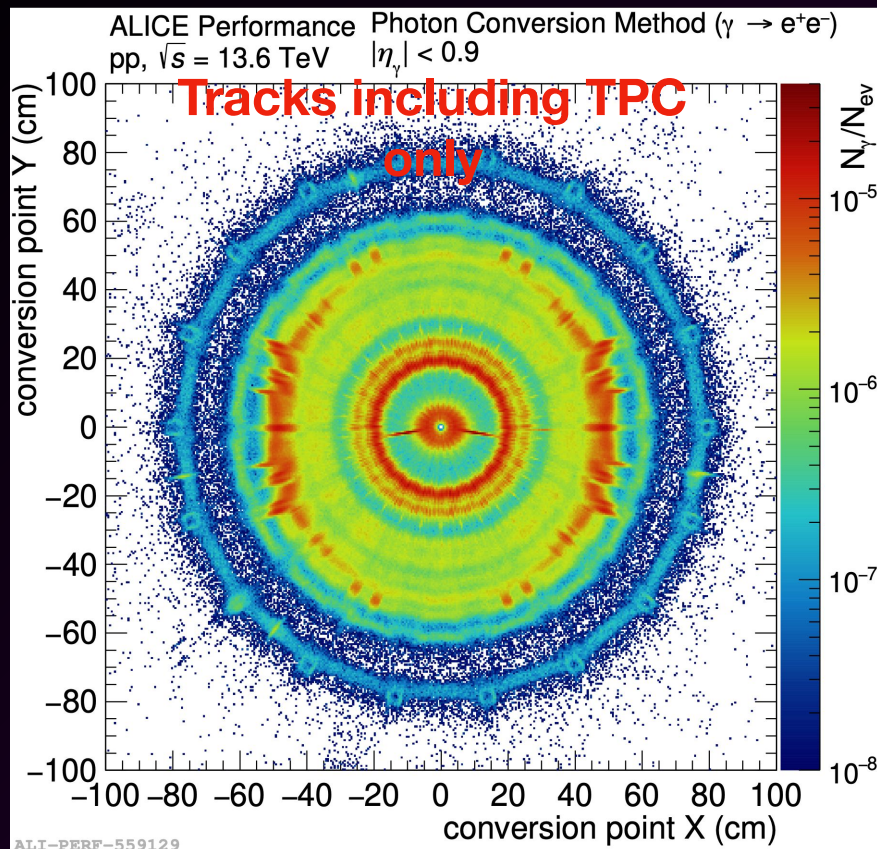
- Modified V0 builder
  → finds and selects conversion photons

- ITS-TPC and TPC only tracks
  - Enables reconstruction of conversions between ITS and TPC
  - Increased **maximum $R_{xy} \approx 83$ cm**

Modified Workflow in Run 3

SVertexer

Asynchronous Reconstruction

V0 Builder

Modified V0 Builder

Neutral Meson Analysis

} Hyperloop
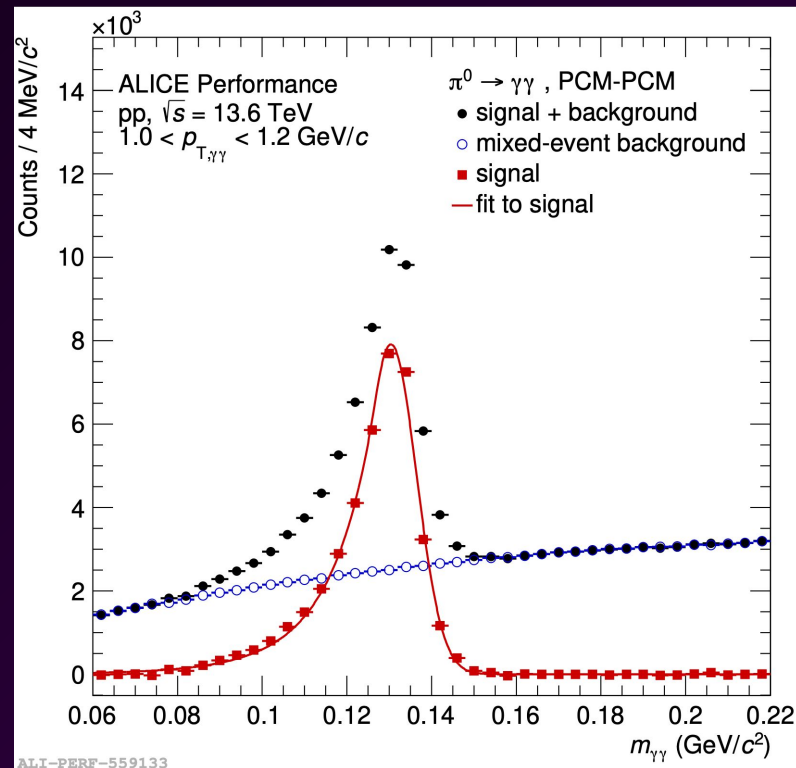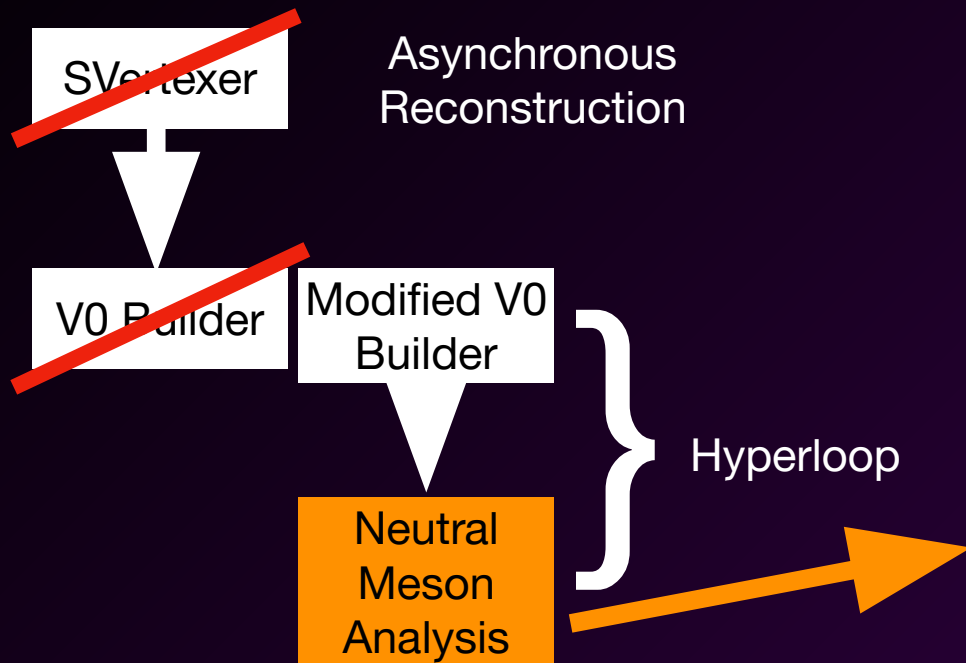
Caveats and things you should know

- The PCM method heavily relies on the correct description of the material budget in MC. Ongoing studies (O2-4062)

- The "create-pcm" task, should ideally be surpassed by the SVertexer
  → Depends on developments of SVertexer

- **You can contribute** to the effort!

Material studies

Tutorial: Try it yourself

- Code located at:
  https://github.com/AliceO2Group/O2Physics/tree/master/Tutorials/PWGEM/pcm (Updated on Wednesday!)
  https://github.com/AliceO2Group/analysis-tutorials/tree/master/o2at-3/PWGEM
  The analysis-tutorial folder contains a bash script allowing you to download the data and run the code!

- Step 0: Download the input data and try to run the code. Get Familiar with the task and try to understand the structure
- Step 1: Obtain a histogram with a photon pT spectrum
- Step 2: Obtain the Armenteros-Podolanski Plot
  and think of why it looks the way it looks.
  Are any more cuts required?
- Step 3: Compute pi0 candidates and see if you can find a peak
  Hint: Use the following:

  for (auto &[g1, g2] : combinations(CombinationsStrictlyUpperIndexPolicy(v0s_per_coll, v0s_per_coll))))
  And for example: ROOT::Math::PtEtaPhiMVector v1(g1.pt(), g1.eta(), g1.phi(), 0.);
- Step 4: Compare the SVerexer and the create-pcm task

Backup

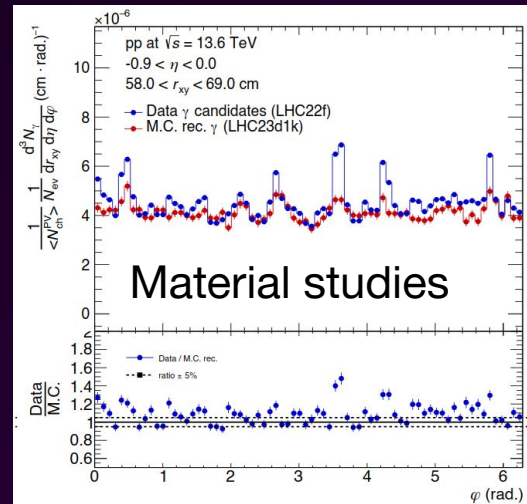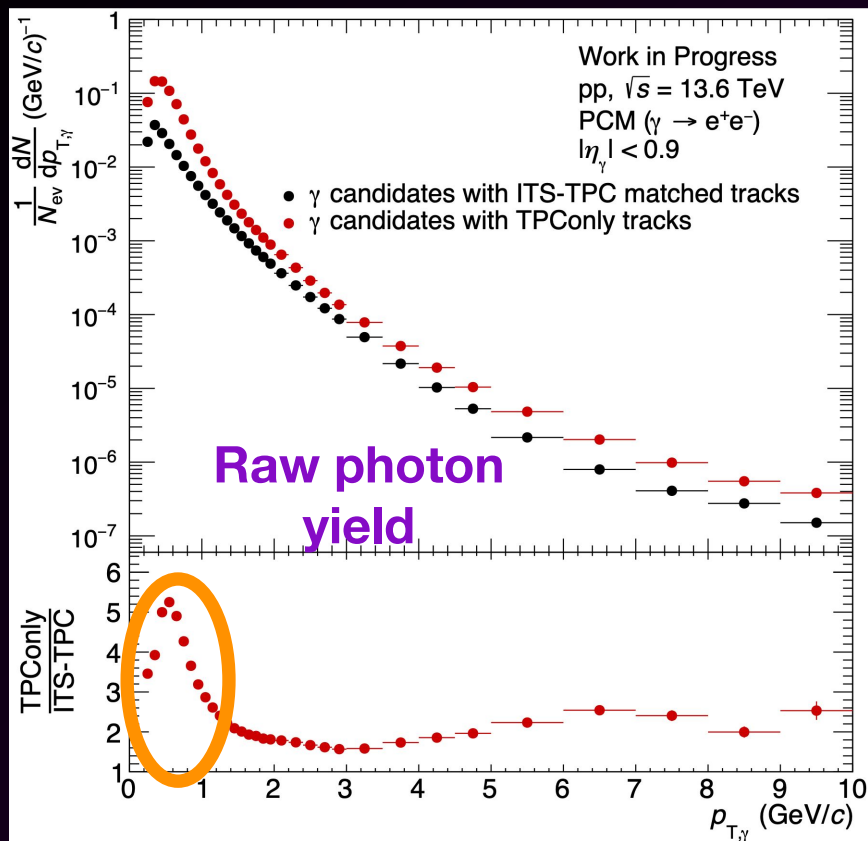# PCM Photons with Modified V0 Builder

- Modified V0 builder
  → finds and selects conversion photons

- ITS-TPC and TPC only tracks
  - Enables reconstruction of conversions between ITS and TPC
  - Increased **maximum R_{xy} ≈ 83 cm**
  - Largest increase in statistics at low p_T
- Challenge:
  - Heavy CPU usage on Hyperloop
- Possible solution:
  - Modify SVertexer to include TPC only tracks (F. Schlepper)

Photon Yield in low and high IR
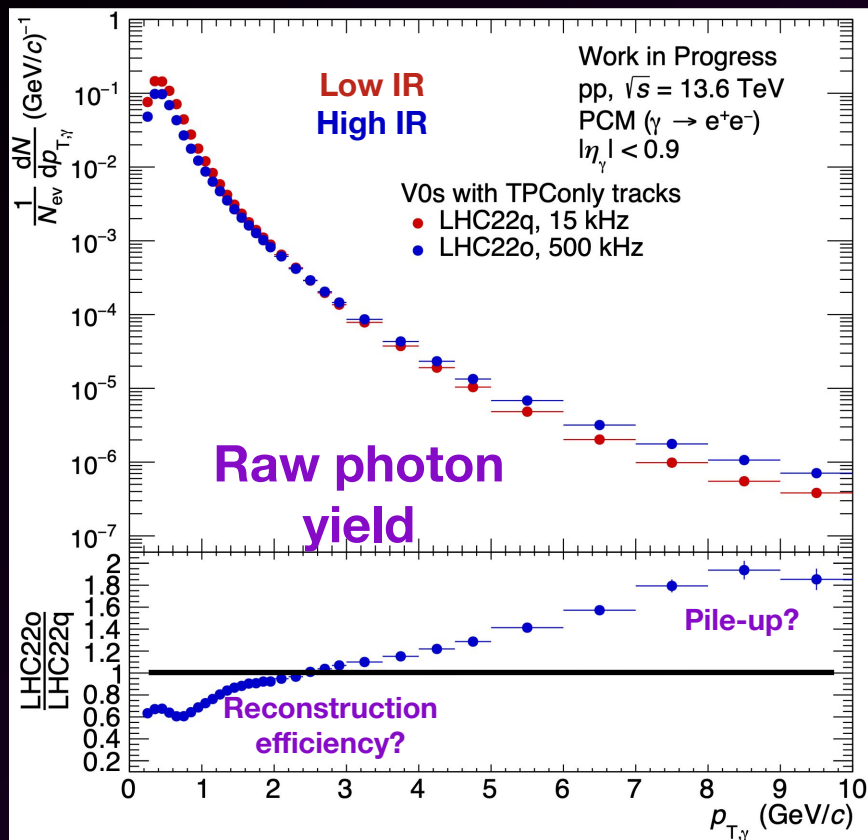
- Low interaction rate (IR 15 kHz): 1.1B Events
- High interaction rate (IR 500 kHz): 3.3B Events

- Challenge: Data taking in pp mostly at 500 kHz → Pile-up, distortions …?

- Larger p_T coverage in low IR
  - Higher V0 reconstruction efficiency at low p_T
- Pile-up at high p_T for high IR
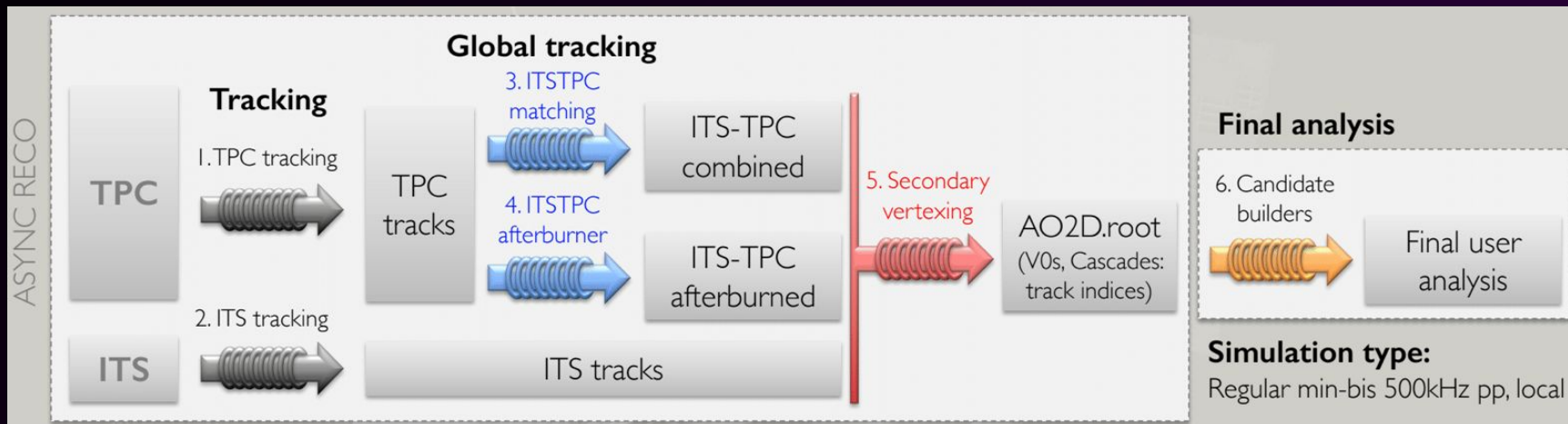
Comparison between low and high IR
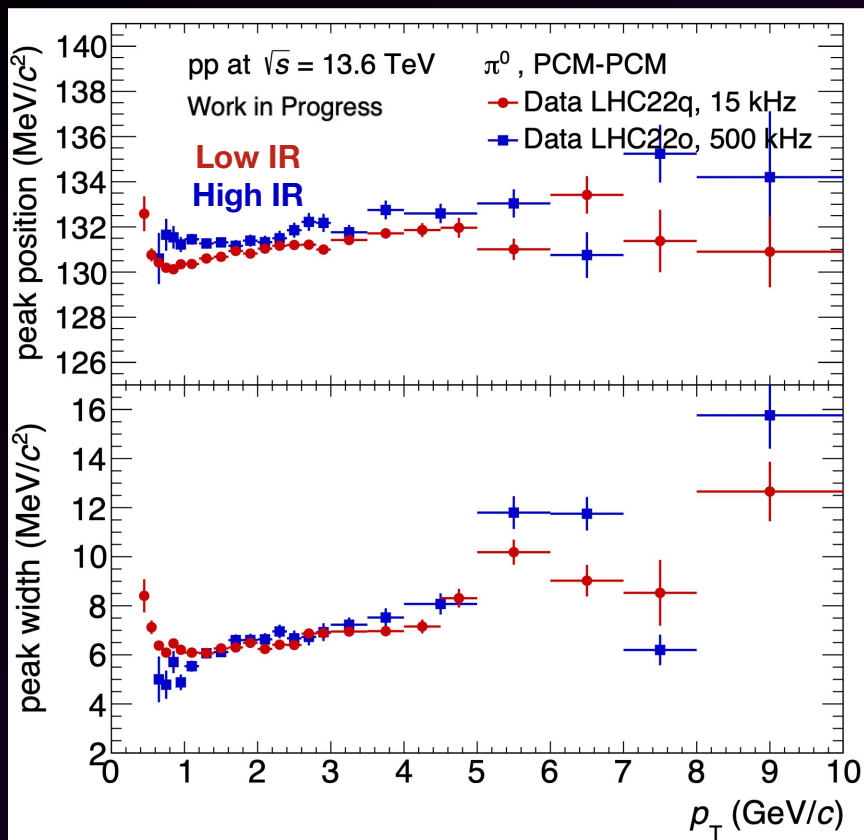
- Low interaction rate (IR 15 kHz): 1.1B Events
- High interaction rate (IR 500 kHz): 3.3B Events

- Peak position depends on IR
- Peak width independent of IR

Comparison between Data and MC
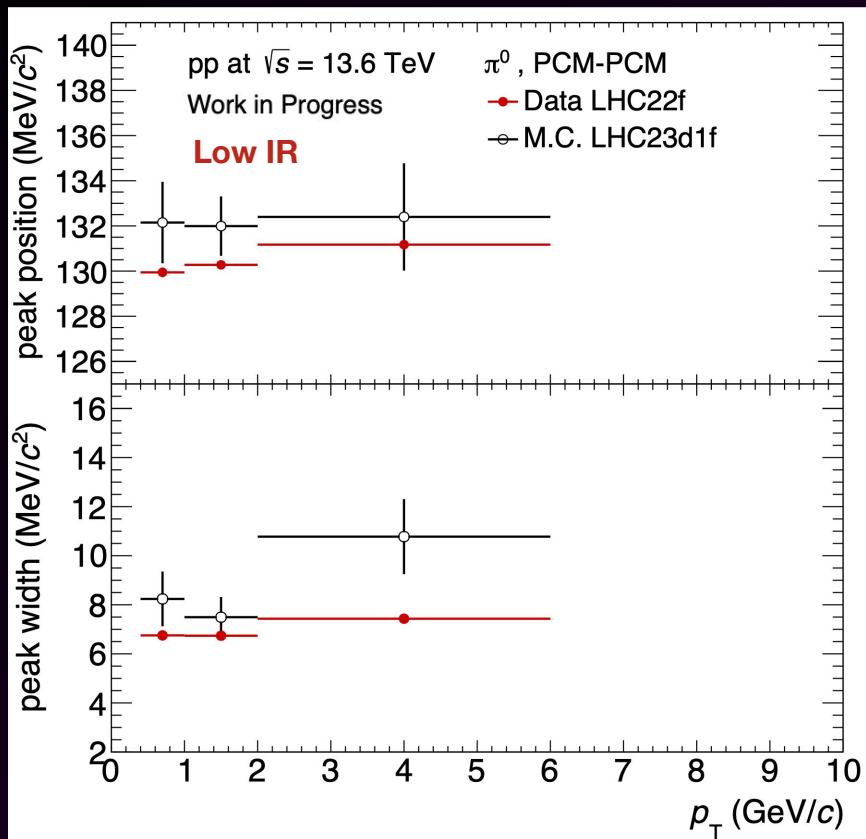
- Peak position and width higher in MC compared to data

- Currently only 0.6M events in anchored MC
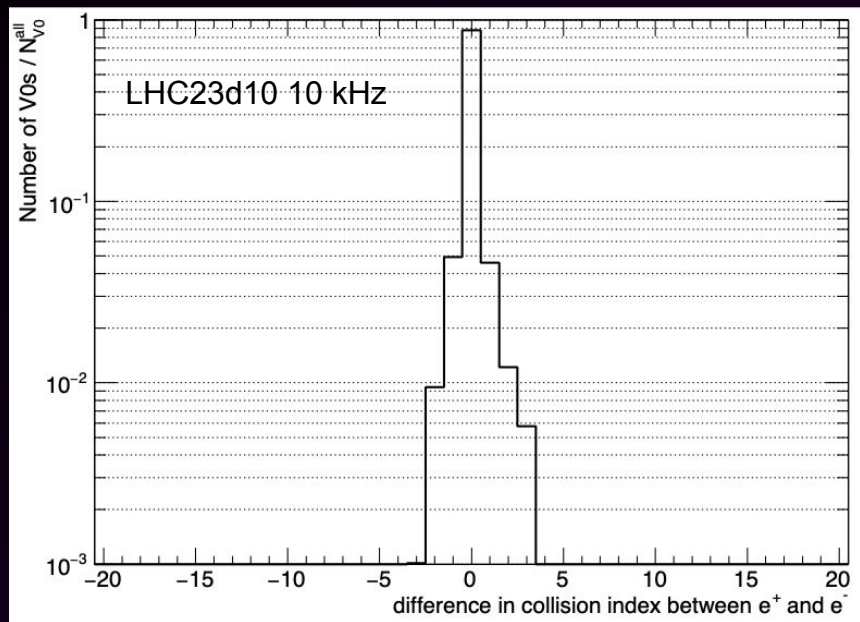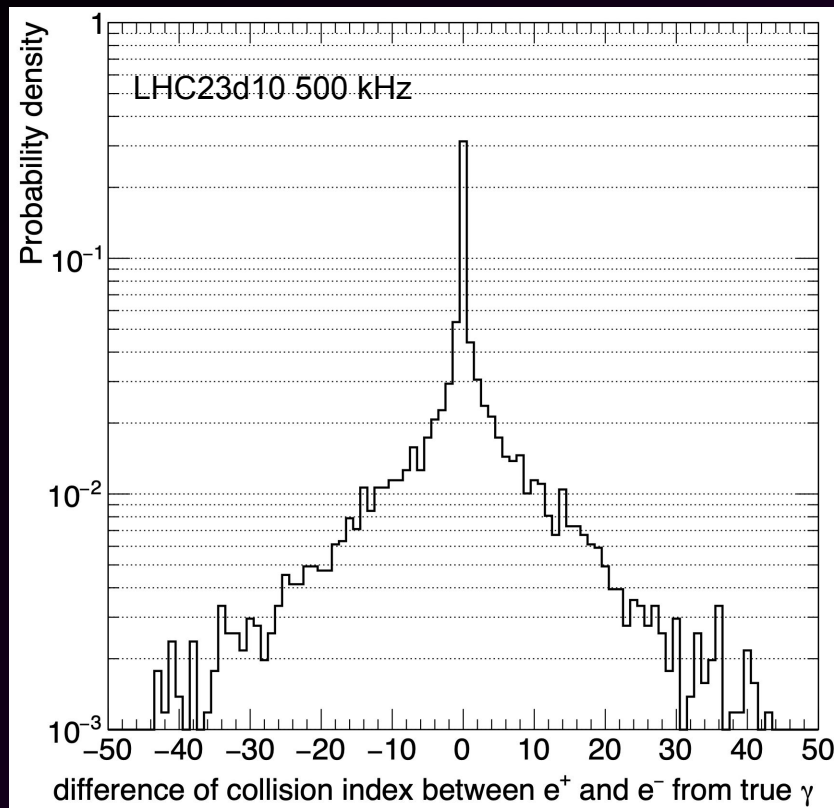- Ongoing study of material budget (A. Enderich)

Tracks

- ITS needs at least 4 hits for ITS track
- ITS needs at least 2 hits for afterburner matching to TPC tracks

Searching Window for V0 builder

- Tracks can be assigned to wrong collision
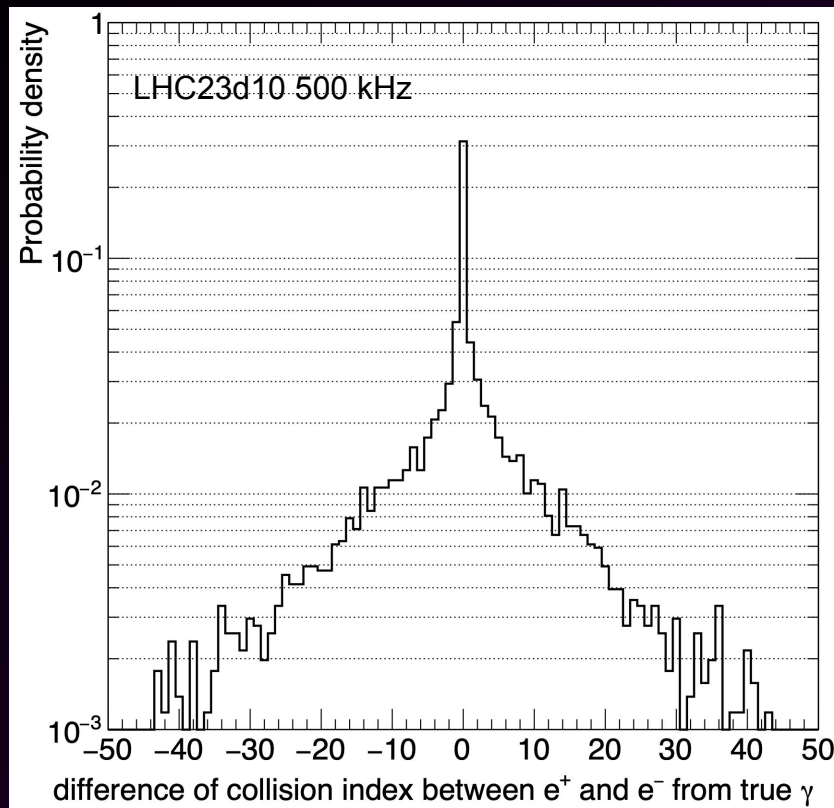 - Results in lower reconstruction efficiency for V0s
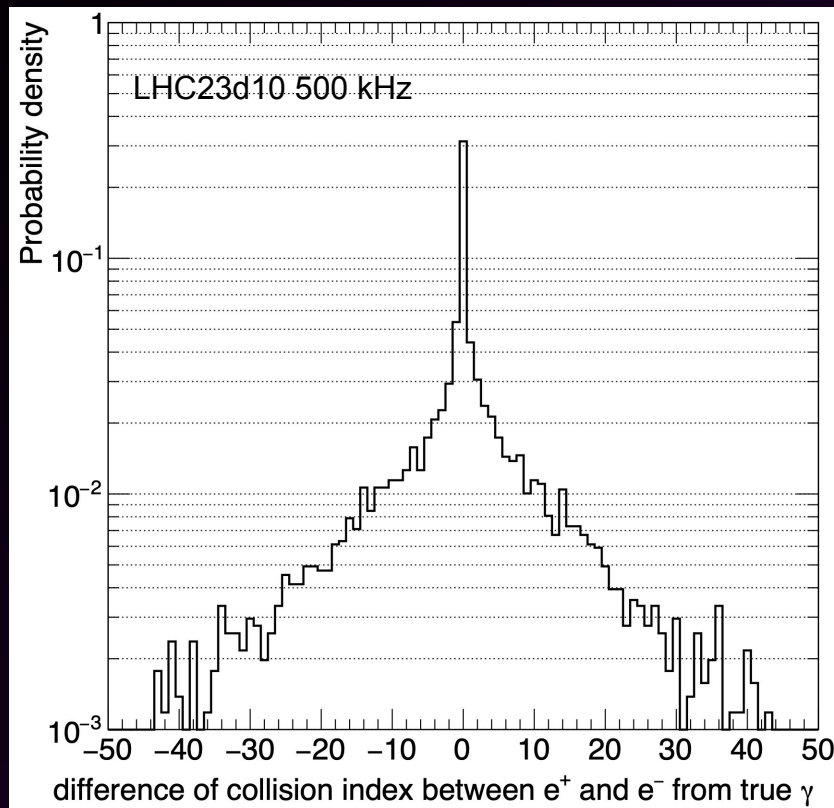
Searching Window for V0 builder

- Tracks can be assigned to wrong collision
  - Results in lower reconstruction efficiency for V0s
- Number of mismatches strongly IR dependent

Searching Window for V0 builder

LHC23d10 500 kHz

- Tracks can be assigned to wrong collision
  - Results in lower reconstruction efficiency for V0s
- Number of mismatches strongly IR dependent
- Implement searching window to increase efficiency
  1. Combine tracks from N consecutive collisions to construct V0s
  2. Assign V0 to collision with maximum cosine of pointing angle

Searching Window for V0 builder

- Tracks can be assigned to wrong collision
  - Results in lower reconstruction efficiency for V0s
- Number of mismatches strongly IR dependent
- Implement searching window to increase efficiency
  1. Combine tracks from N consecutive collisions to construct V0s
  2. Assign V0 to collision with maximum cosine of pointing angle
- In 500 kHz efficiency increases from 31% to 70% with searching window with N = 10
- Searching window size limited because of CPU time cost
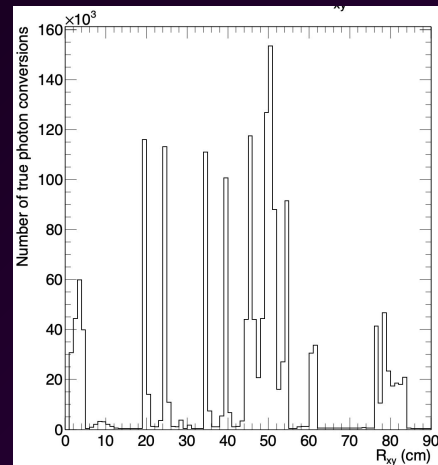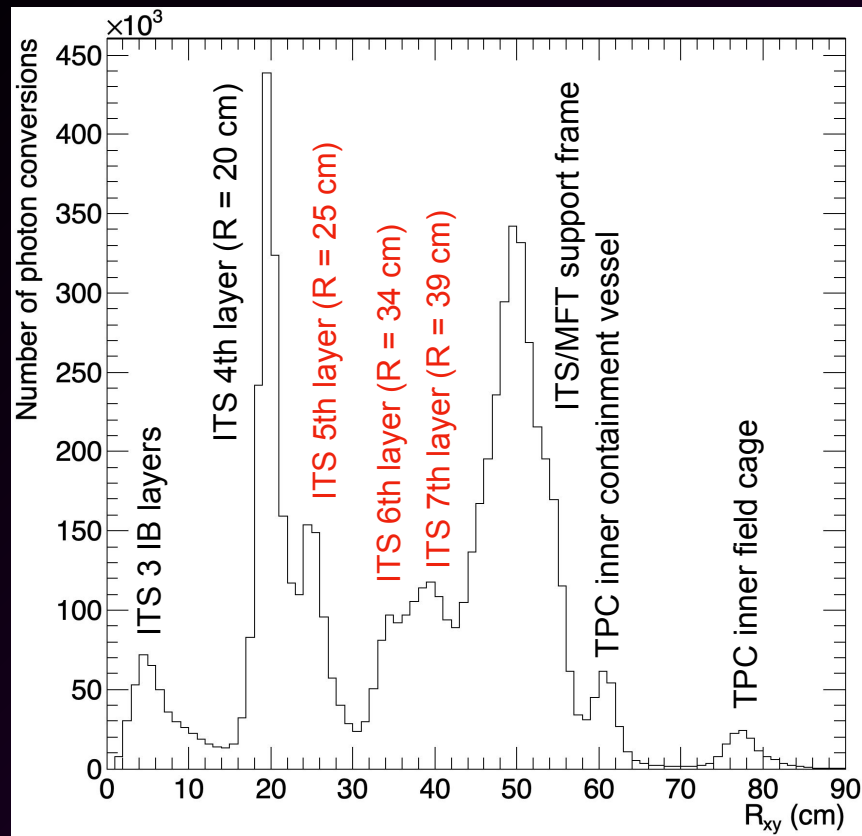
Conversion Point of TPC only Tracks
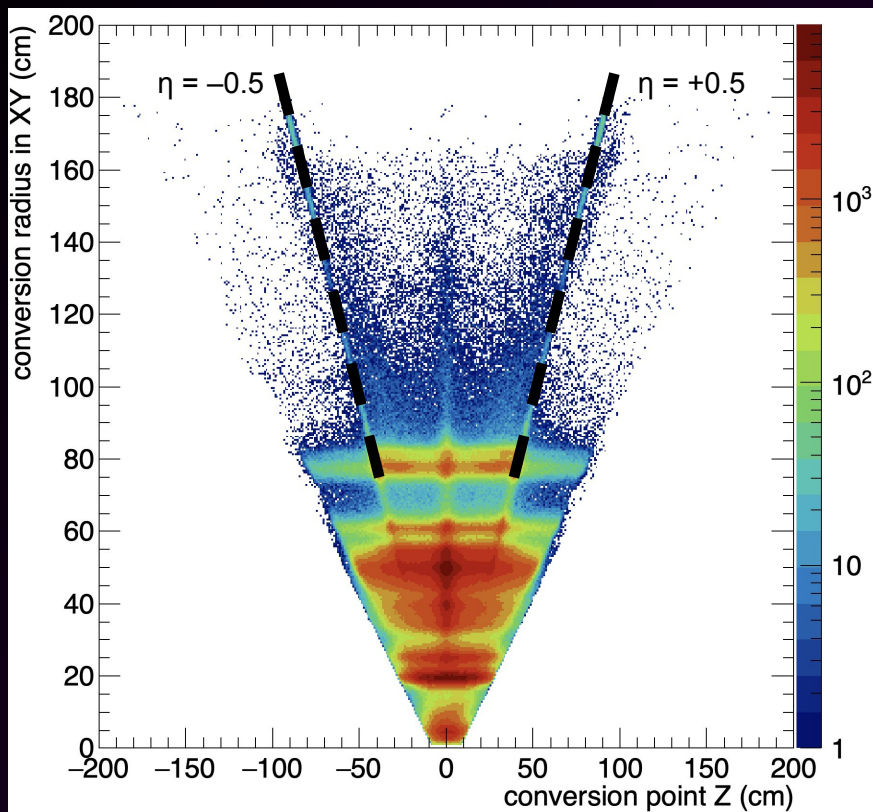
- Large number of TPC only tracks with = 0.5
➡ Wrong conversion point

Conversion Point of TPC only Tracks
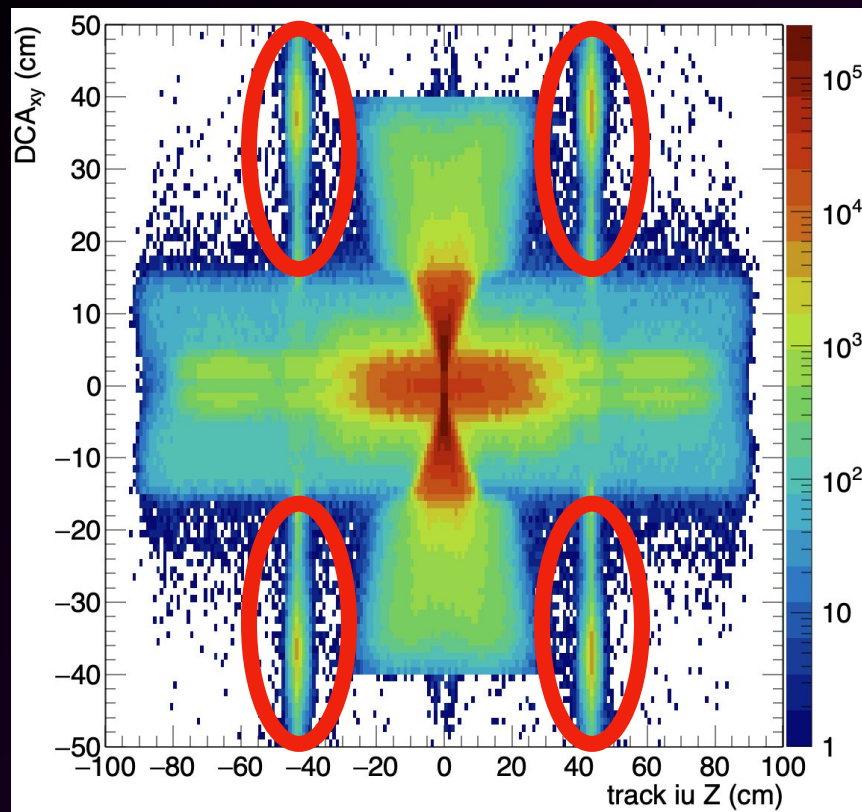
- Large number of TPC only tracks with
  = 0.5
➡ Wrong conversion point
- Removal of those photons via cut
  - Loss of roughly 50% of photons from TPC only tracks

Photon Conversions on late ITS layers

- Number of photon conversions decreases after 4th layer
- Due to criteria for ITS-TPC track:
  - N_{cl} ITS ≥ 2
- In MC number of conversions does not decrease