

# Megatile Prototype in 2021 Beam Test

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On behalf of the JGU team:

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Including the PRISMA detector lab team:

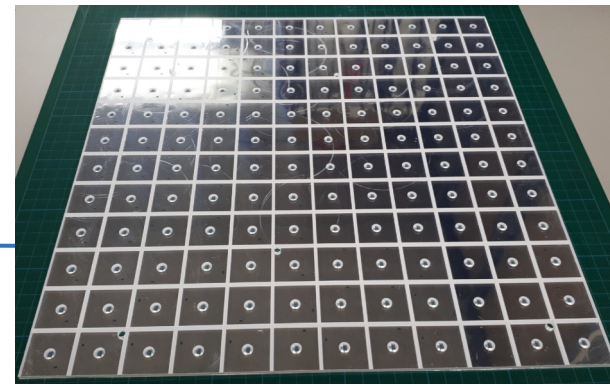
Anastasia Mpoukouvalas, Steffen Schönfelder, Quirin Weitzel

Calice Collaboration Meeting

28.09.2023

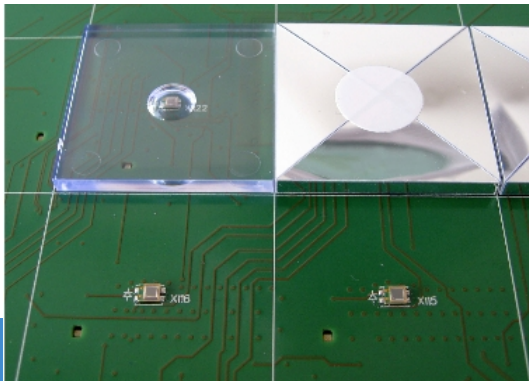


# Reminder: AHCAL Designs



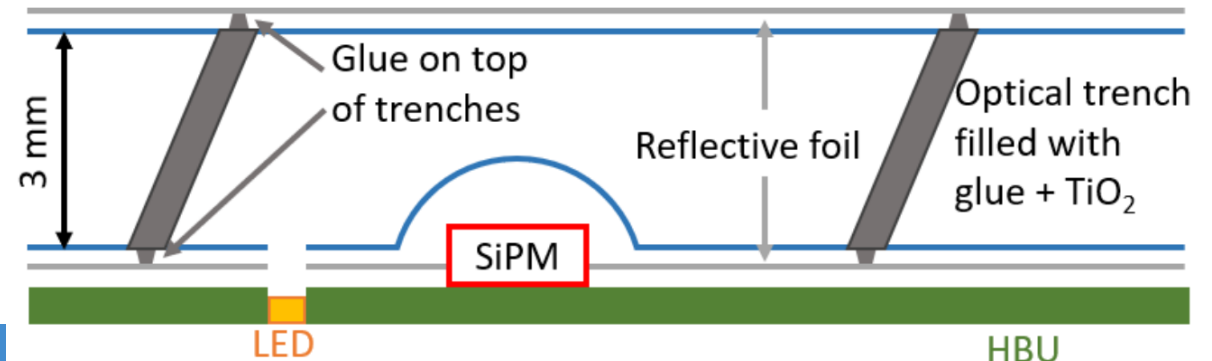
## Single Tile Design

- Scintillator tiles individually wrapped in reflective foil
- Glued to board one by one
- Pro: Light tightness
- Con: High object count; dead area between tiles



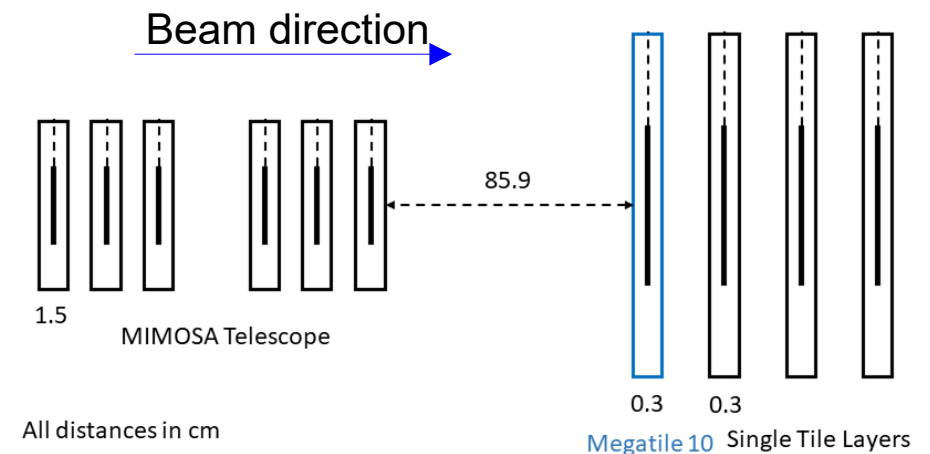
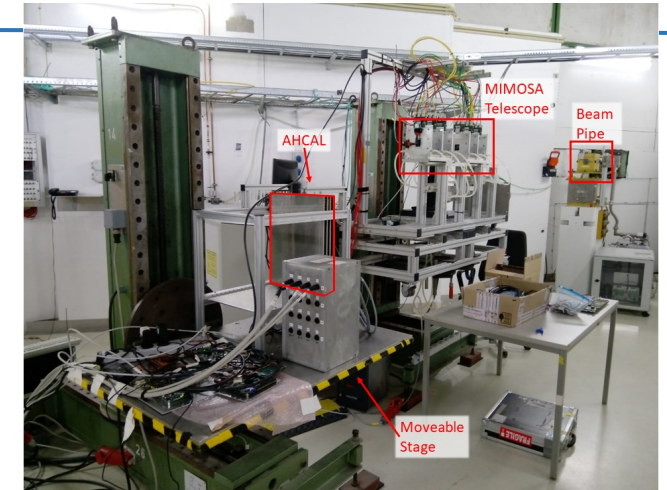
## Megatile Design

- Large scintillator plate with optically separated trenches filled with reflective TiO<sub>2</sub>
- Plate wrapped in reflective foil
- Pro: Easier assembly; no dead areas
- Con: Not fully light tight



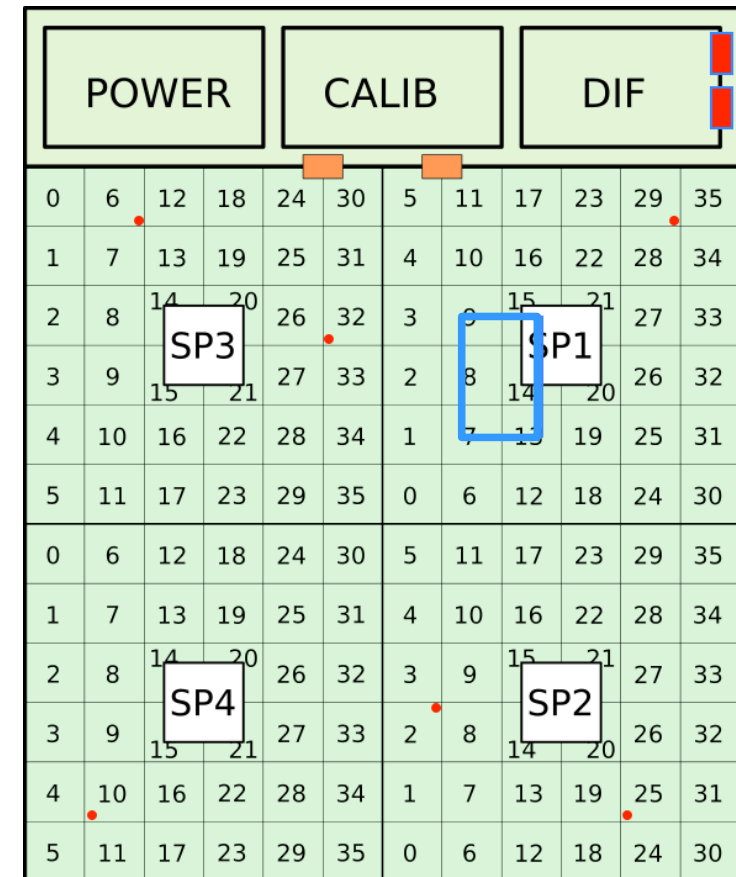
# Megatile in Test Beam

- Latest beam test at DESY in 2021
- Electron beam with 3 GeV and 5 GeV
- MIMOSA beam telescope with 6 planes
  - Size of sensor:  $10.6 \times 21.1 \text{ mm}^2$
  - 578 x 1152 pixels
- 1 Megatile layer (latest prototype) right after telescope, 3 single tile layers behind



# Megatile in Test Beam

- Latest beam test at DESY in 2021
- Electron beam with 3 GeV and 5 GeV
- MIMOSA beam telescope with 6 planes
  - Size of sensor: 10.6 x 21.1 mm<sup>2</sup>
  - 578 x 1152 pixels
- 1 Megatile layer (latest prototype) right after telescope, 3 single tile layers behind
- Fine scan with step size of 4 mm over 6 channels



# Beam Telescope Reconstruction

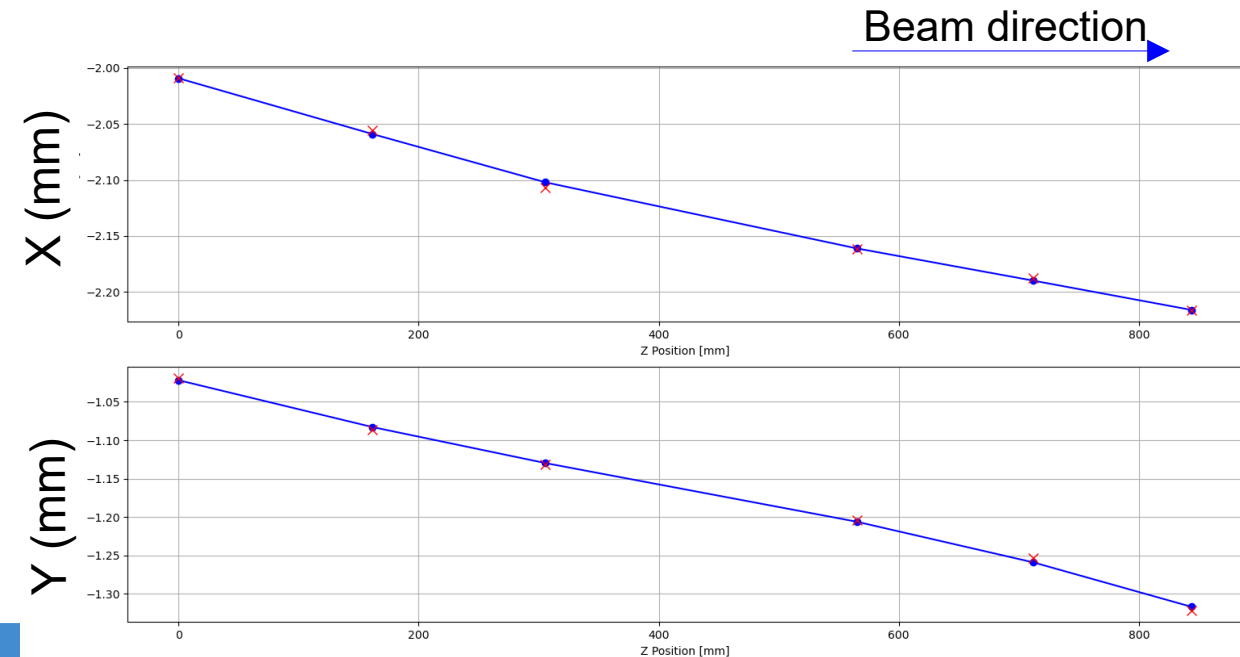
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- Done with Corryvreckan
- Hit:
  - Pixel column and row position, time-stamp, charge, raw information
- Cluster:
  - Collection of neighbouring hits in space and time
  - Center used in tracking to reconstruct trajectory
- Track:
  - Fit over clusters (here: one cluster per telescope layer)
  - Track position in x and y for each telescope layer

# Beam Telescope Reconstruction

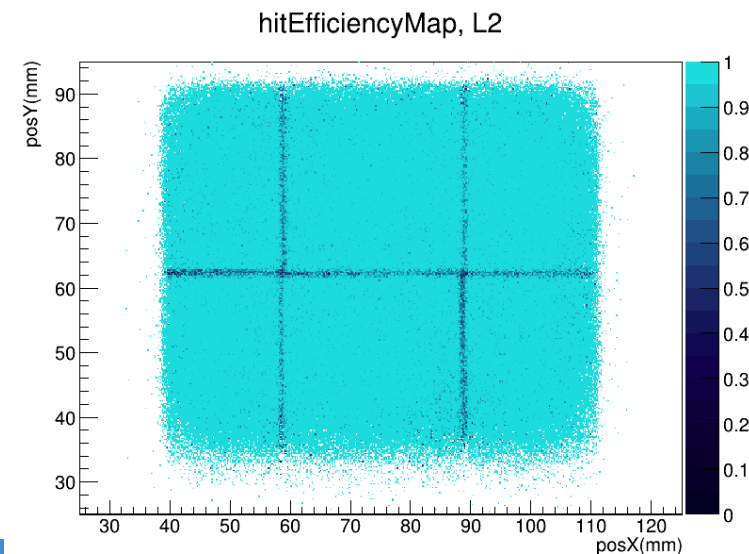
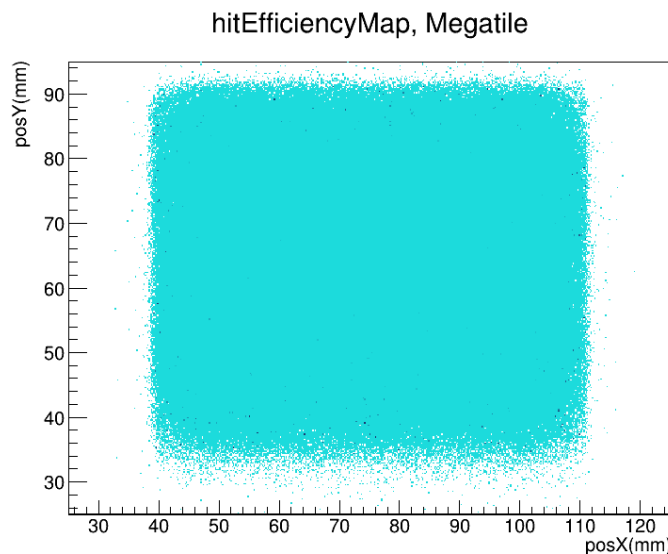
- Fitting model: General Broken Lines
  - Done with Corryvreckan
  - Combines uncertainties from position of cluster center and scattering
  - Reconstruct trajectory as set of lines with kinks at sensor planes
  - Minimise residuals for each plane

✕ Cluster  
— Track



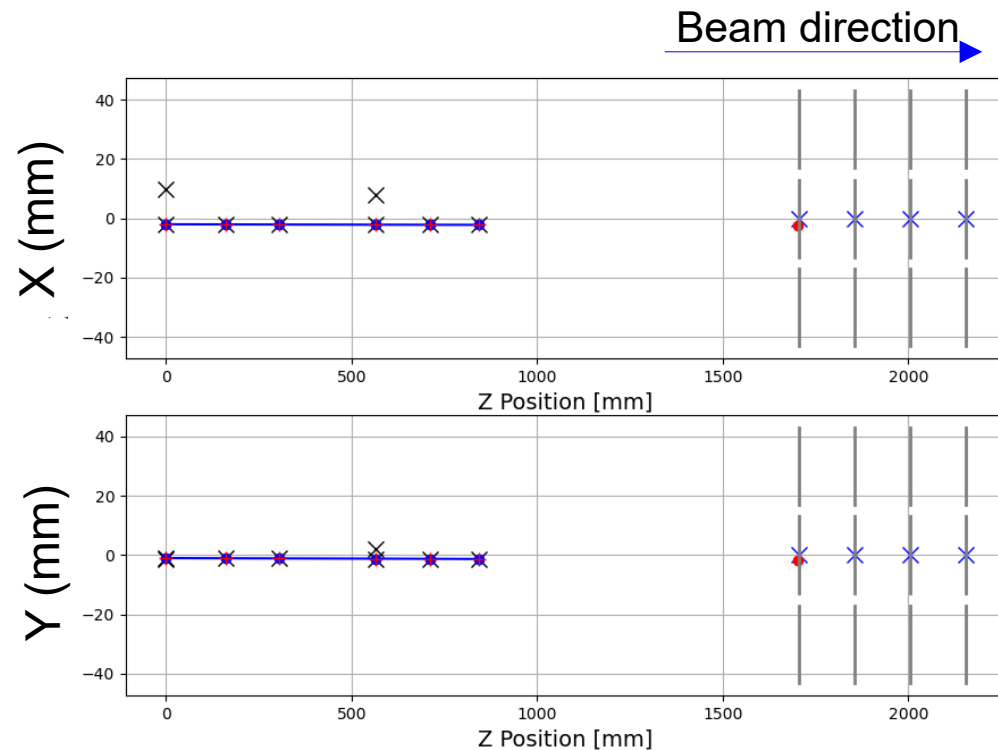
# First Look at Efficiency

- Efficiency definition using telescope:
  - $\frac{\text{\# telescope tracks with hit in layer}}{\text{\#telescope tracks}}$  at each X and Y bin in considered AHCAL layer
  - Similar efficiency over whole surface of Megatile (no drops due to trenches)
  - In single tiles: gaps are visible
- Software by Jiri Kvasnicka (FZU Prague)



# Examples of events: Good Tracks

- Combine with hit information from AHCAL
- Extrapolate track onto AHCAL layer to find where track is hitting
- One track in telescope, one hit per layer in expected AHCAL channel

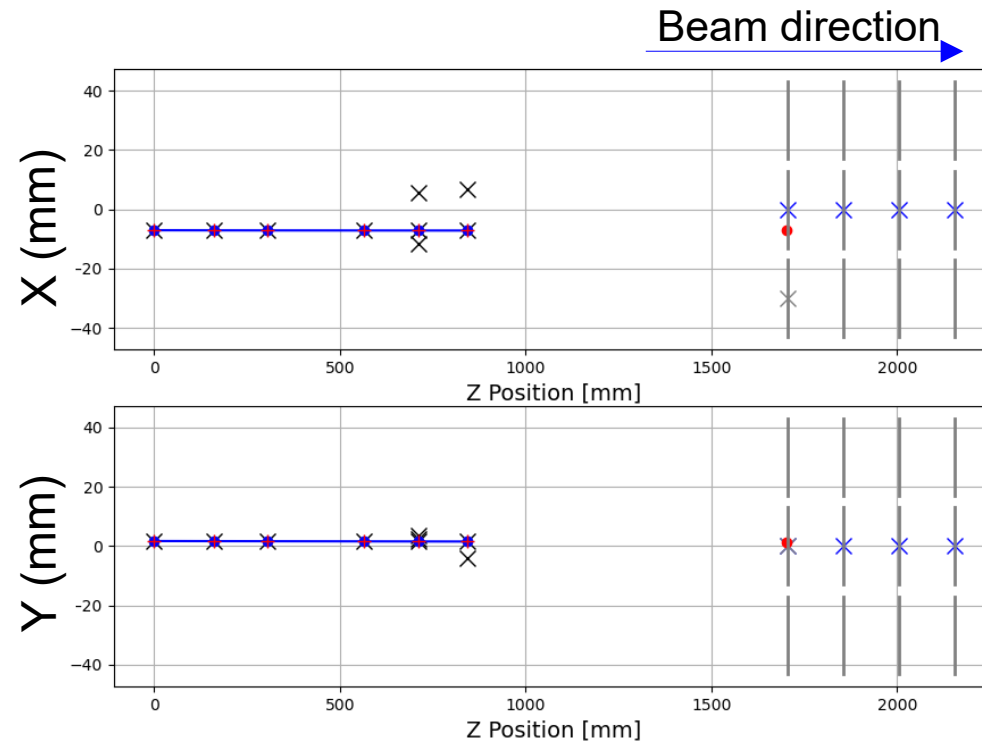


- × Cluster
  - + Cluster associated to track
  - Extrapolated track position
  - Track
- Hits in AHCAL:
- × -0.5 MIP to 0.5 MIP
  - × 0.5 MIP to 1.5 MIP
  - × 1.5 MIP to 2.5 MIP
  - × >2.5 MIP



# Examples of events: Potential Cross Talk

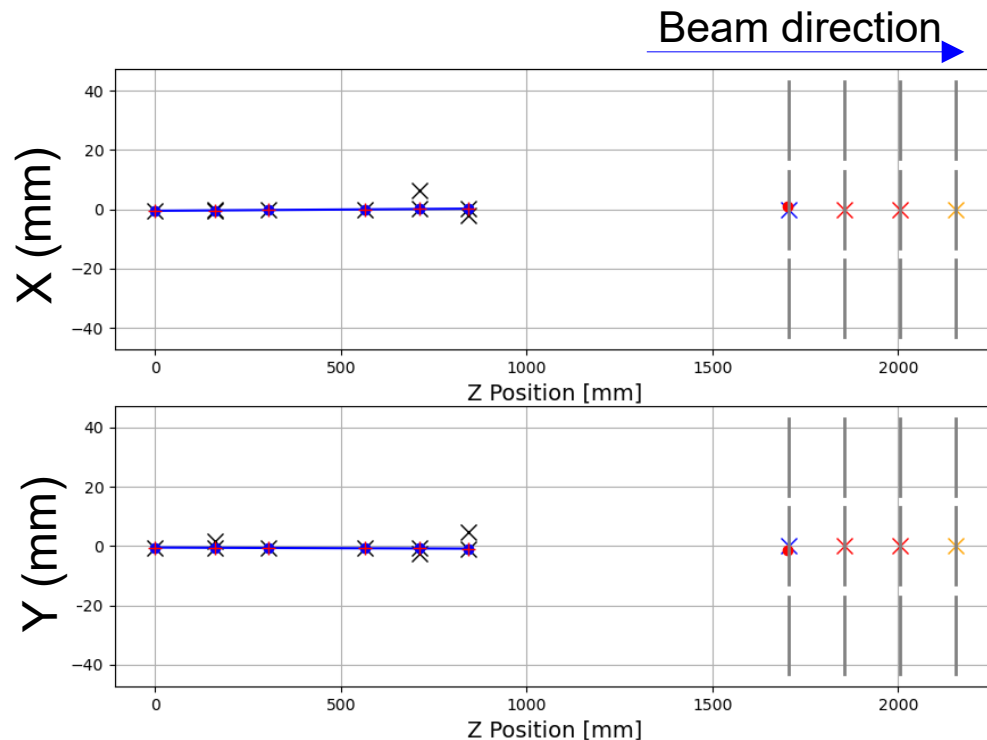
- Hits at  $\sim 1$  MIP in expected AHCAL channel, lower energy in neighbouring channel



- × Cluster
  - + Cluster associated to track
  - Extrapolated track position
  - Track
- Hits in AHCAL:
- × -0.5 MIP to 0.5 MIP
  - × 0.5 MIP to 1.5 MIP
  - × 1.5 MIP to 2.5 MIP
  - × >2.5 MIP

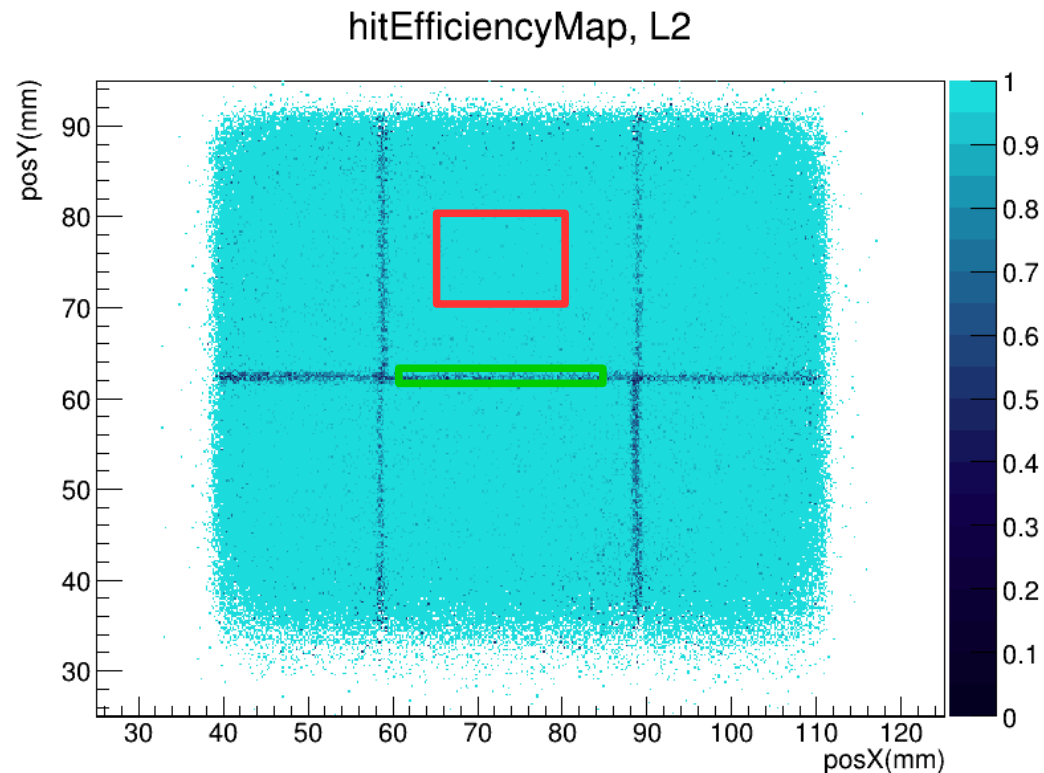
# With AHCAL events: Potential Shower

- Hits in expected AHCAL channel, but energy  $>1.5$  MIP in at least one layer
- Potentially shower or missed second particle
  - See “Intrinsic Time Resolution of Plastic Scintillator Tiles with SiPM Readout for Highly Granular Calorimeters” (Master Thesis, Fabian Hummer)



- × Cluster
  - + Cluster associated to track
  - Extrapolated track position
  - Track
- Hits in AHCAL:
- × -0.5 MIP to 0.5 MIP
  - × 0.5 MIP to 1.5 MIP
  - × 1.5 MIP to 2.5 MIP
  - ×  $>2.5$  MIP

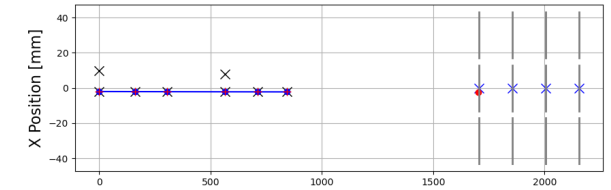
# Investigate Behaviour in Middle of Tile vs Trench Region



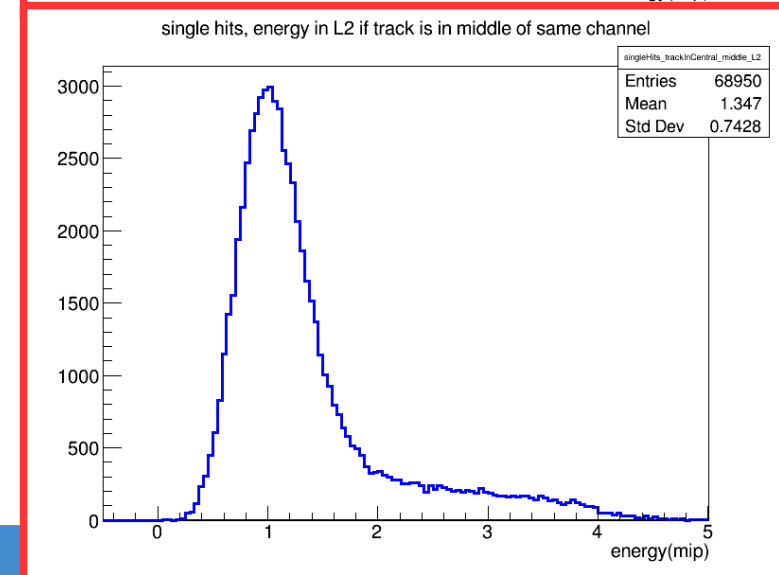
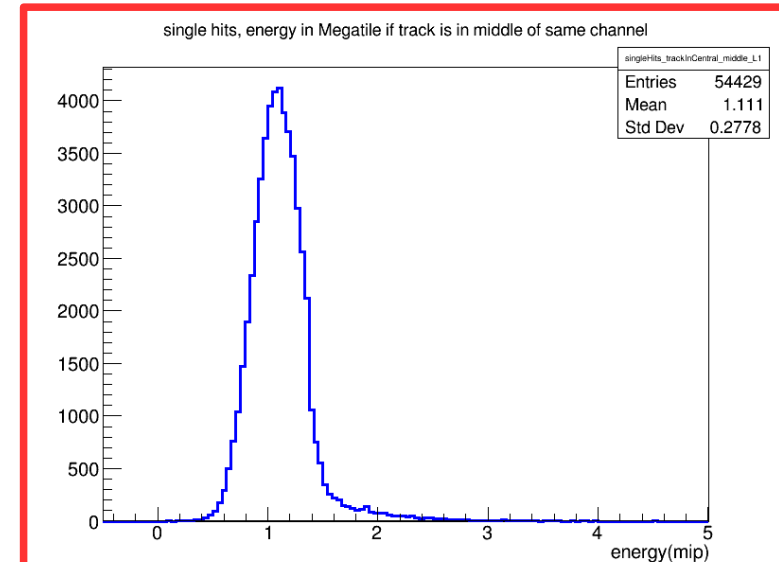
Middle Area  
X: 65-80 mm  
Y: 70-80 mm

Trench / Gap Area  
X: 60-85 mm  
Y: 62-63 mm

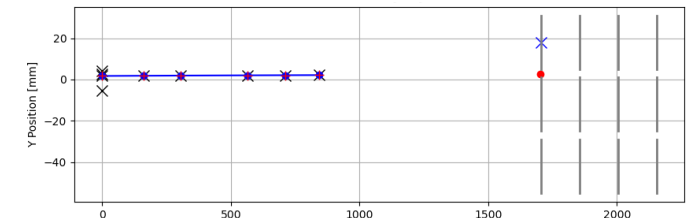
# Single Hits in Middle Area



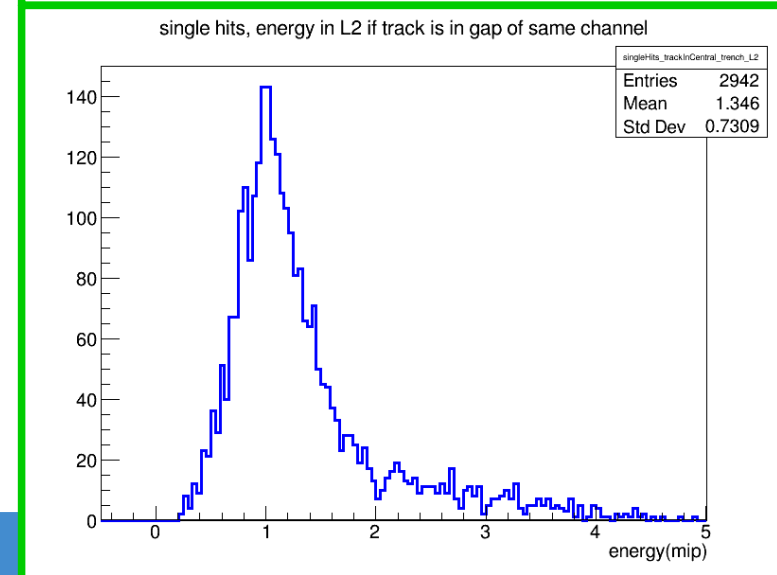
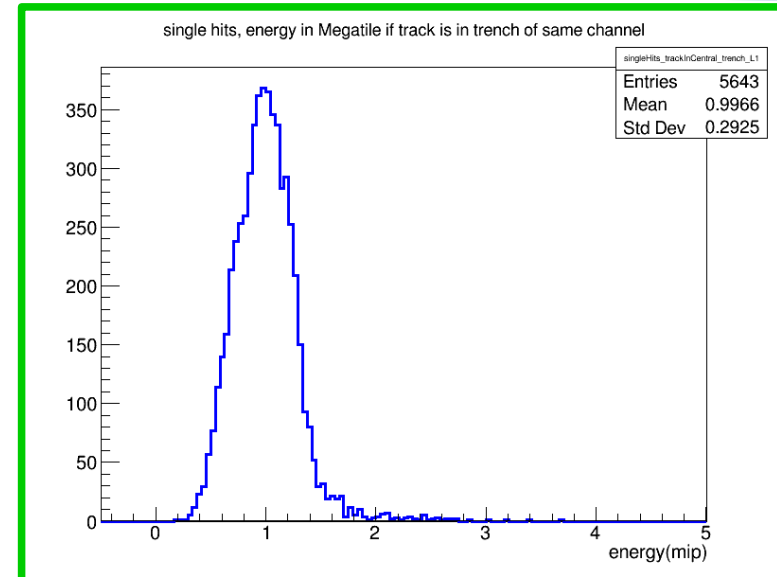
- Track in middle area and exactly one hit in same channel with HitBit=1 and energy > 0.07 MIP
- Hit is in expected tile
- MIP-like signal in Megatile and single tiles
- Different shapes possibly explained by cross talk
- To be checked by correlating energies in different layers for same event



# Single Hits in Trench / Gap Area



- Track in trench / gap area and exactly one hit in channel adjacent to trench with HitBit=1 and energy > 0.07 MIP
- More hits with less energy in Megatile
- MIP-like signal in single tile, but less events, as signal is in gap

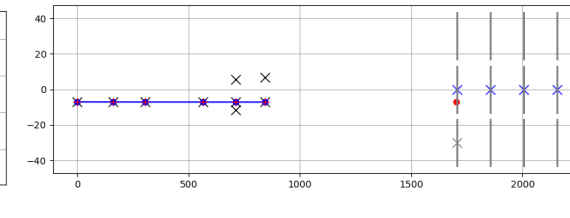
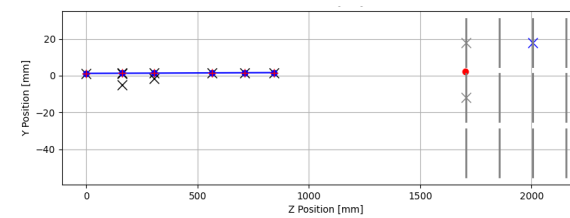


# Double Hits Using Track Position

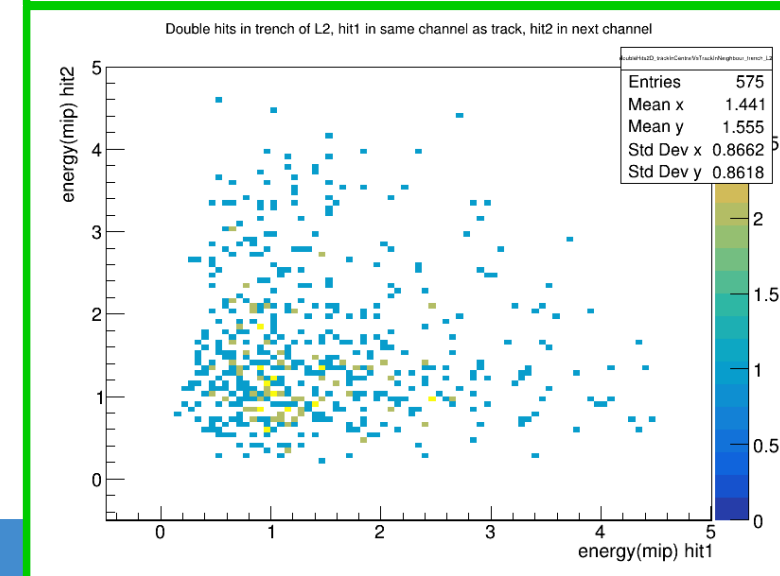
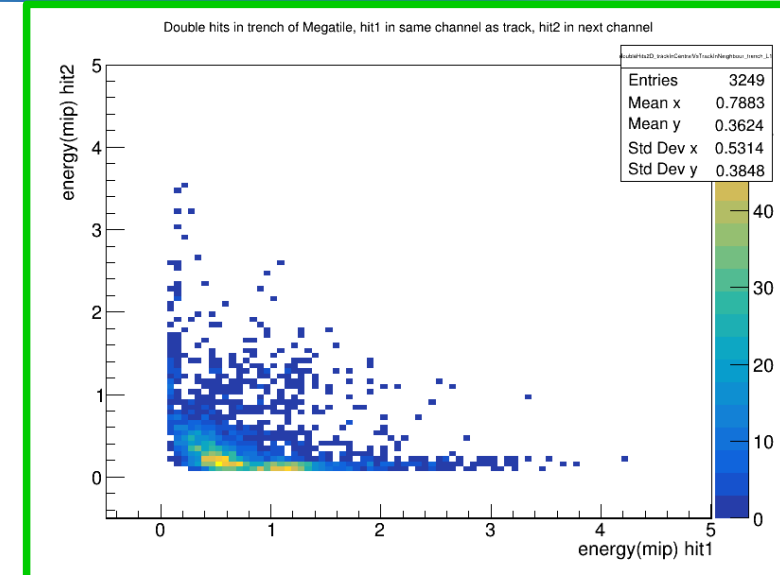
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- Exactly two hits in at least one AHCAL layer
- One track in telescope
- If track is in **middle**:
  - If hit is in expected tile: Hit 1
  - If hit is in neighbouring tile: Hit 2
- If track is in **trench**:
  - If hit is in one of the tiles adjacent to trench: Hit 1
  - If hit is in neighbouring tile: Hit 2

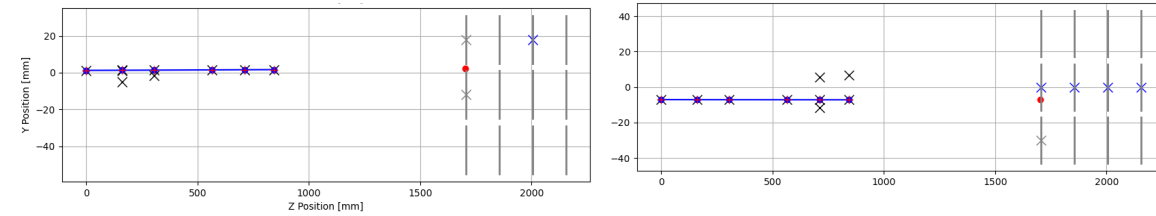
# Double Hits in Trench / Gap Area



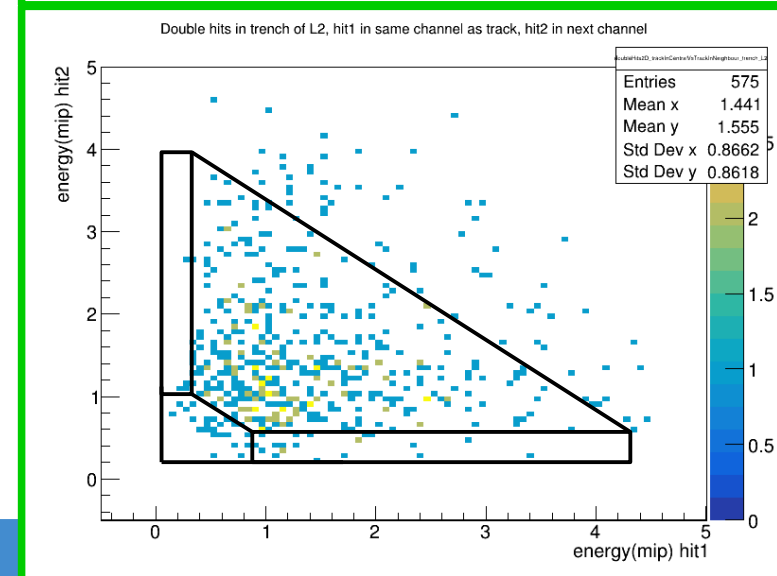
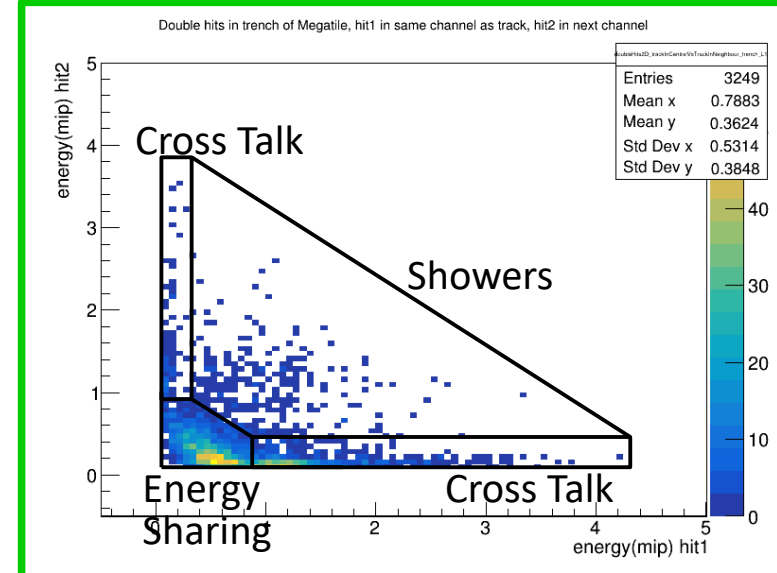
- Track in trench area
- Hit 1 in one of the tiles adjacent to trench
- Hit 2 in neighbouring tile



# Double Hits in Trench / Gap Area

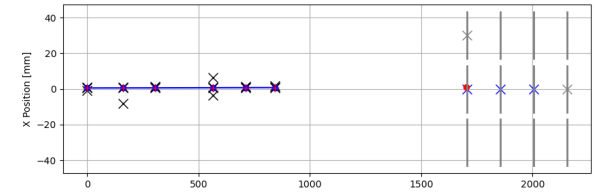


- Track in trench area
- Hit 1 in one of the tiles adjacent to trench
- Hit 2 in neighbouring tile
- In Megatile:
  - Energy sharing
  - Cross talk
  - Showers
- In single tile: mostly showers

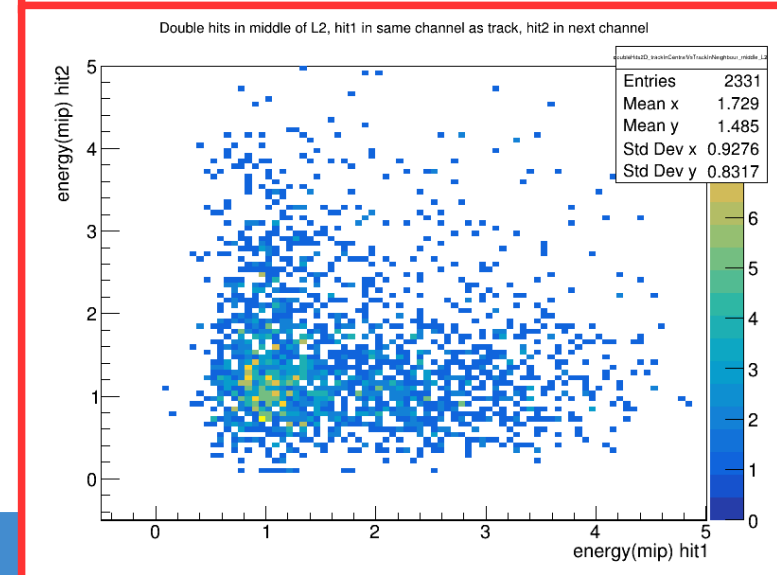
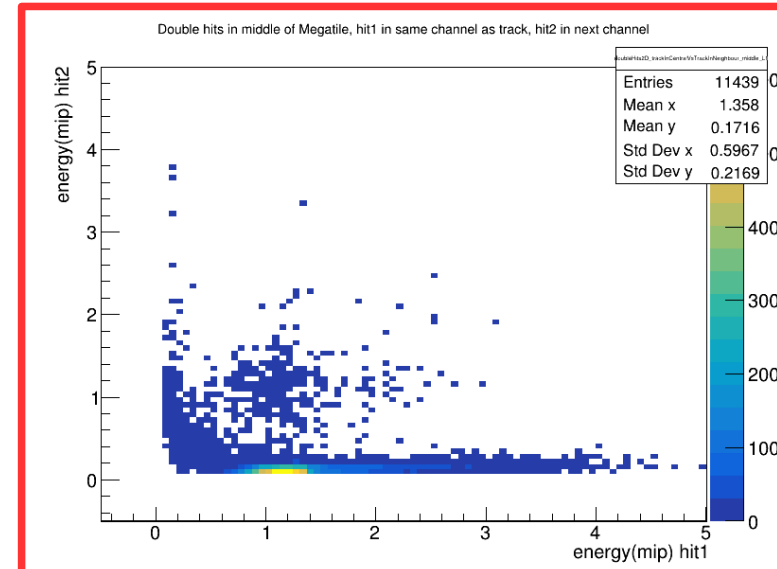




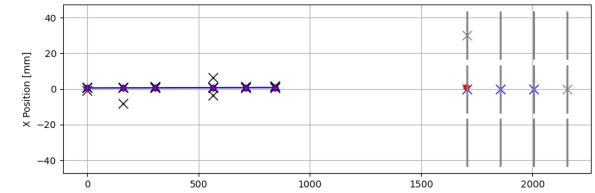
# Double Hits in Middle Area



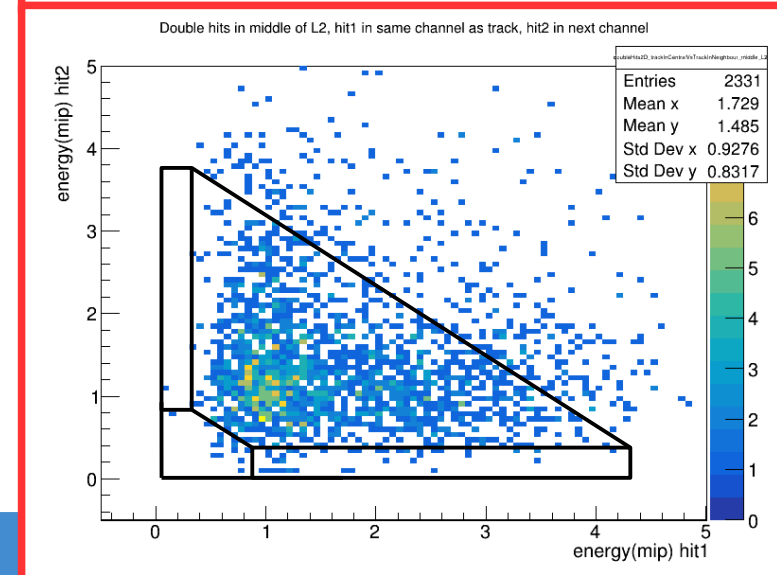
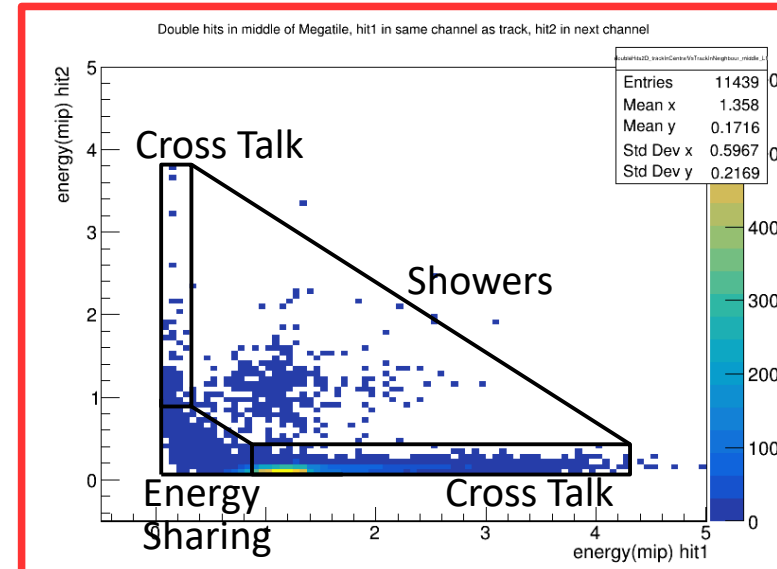
- Track in **middle** area
- Hit 1 in expected tile
- Hit 2 in neighbouring tile



# Double Hits in Middle Area



- Track in **middle** area
- Hit 1 in expected tile
- Hit 2 in neighbouring tile
- In Megatile:
  - Less energy sharing than in trench
  - Cross talk
  - Showers
- In single tile: mostly showers



# Conclusion and Outlook

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- Use of telescope together with AHCAL to select and understand different event cases
- Some event topologies in middle of tile and trench / gap area are qualitatively understood
  - In Megatile:
    - Mostly MIP-like signal in middle area
    - More energy sharing and cross talk in trench area
- To do:
  - Select clean sample of events for quantitative characterisation of e.g. efficiency and cross talk

Thank you for your attention!