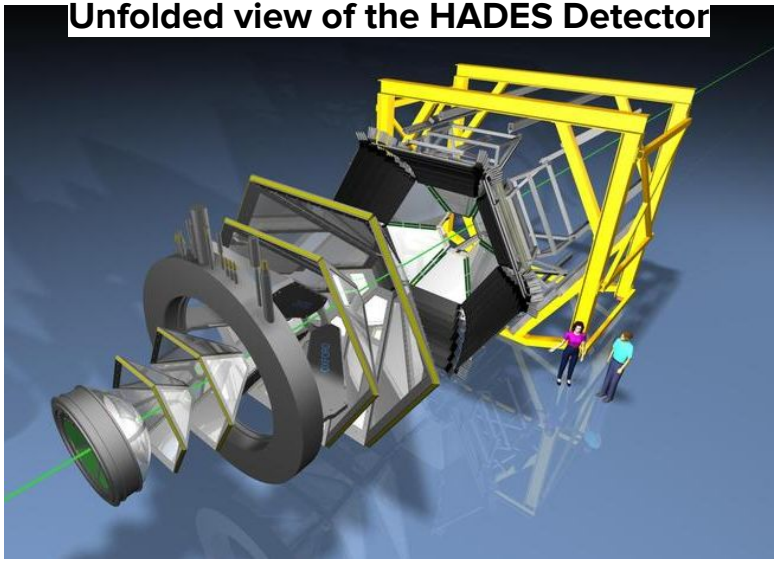
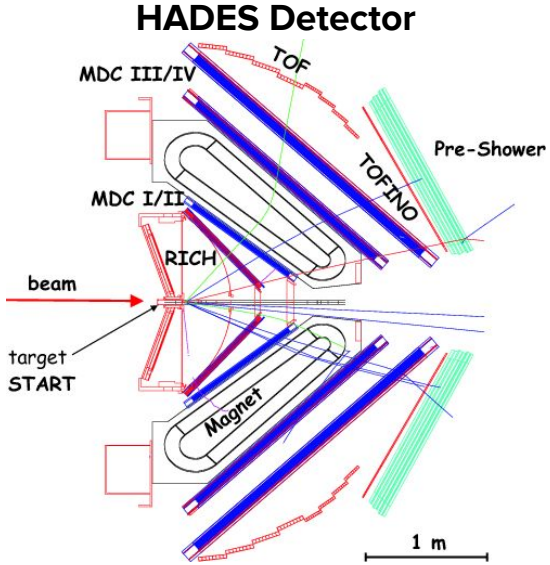
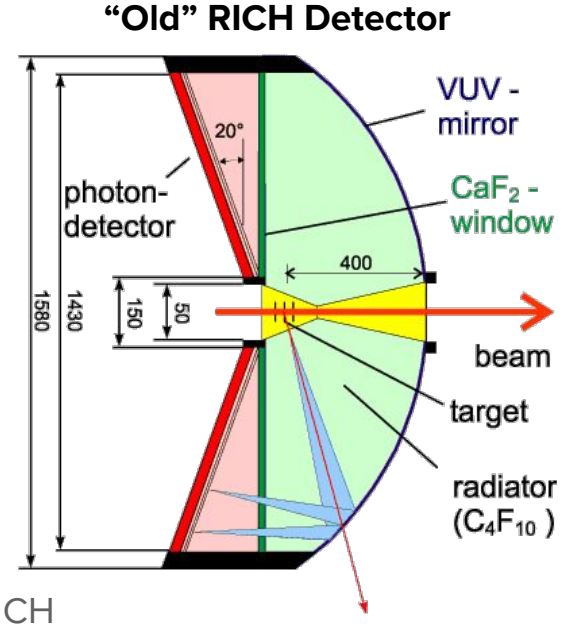
Fast Readout and Performance of the upgraded HADES RICH in Heavy Ion collisions

2019-09-12 | Jörg Förtsch for the HADES RICH working group

The HADES detector





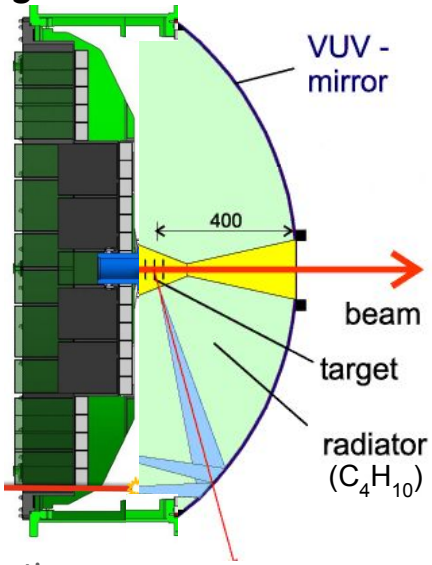


- HADES : High Acceptance DiElectron Spectrometer
  - Installed at GSI SIS 18, in operation since 2001
  - Studying baryonic matter in light and heavy systems
  - Part of FAIR – phase 0 program

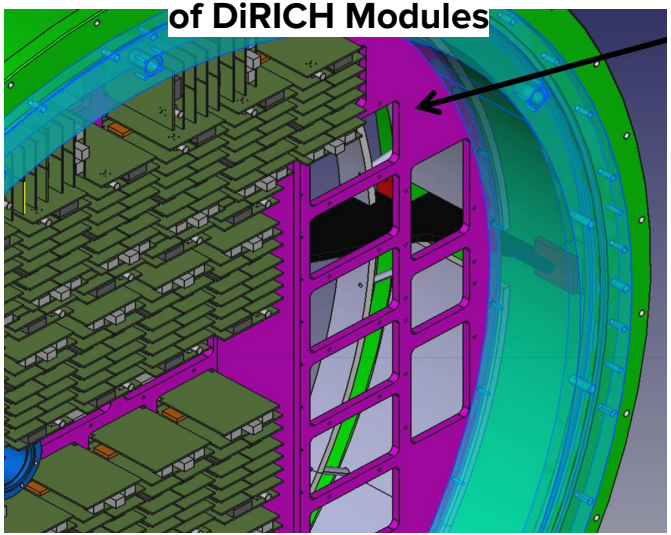
- "Old" HADES RICH
  - C_4F_{10} radiator
  - Low material budget, carbon mirror
  - Hadron blind detector
  - Electron id 15 MeV/c < p_e < 1.5 GeV/c
  - CsI cathode, MWPC readout

The upgraded RICH

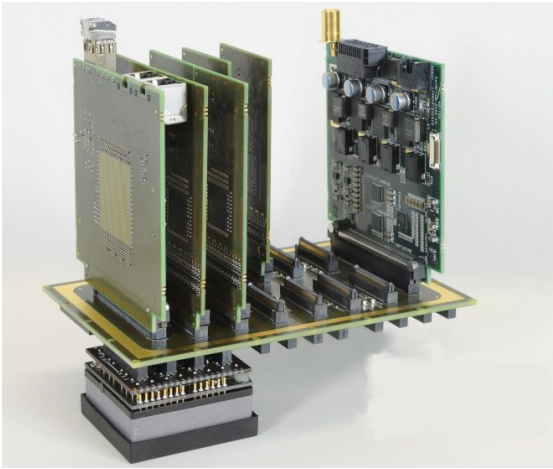
Upgraded RICH Detector



RICH Backside with Blocks of DiRICH Modules



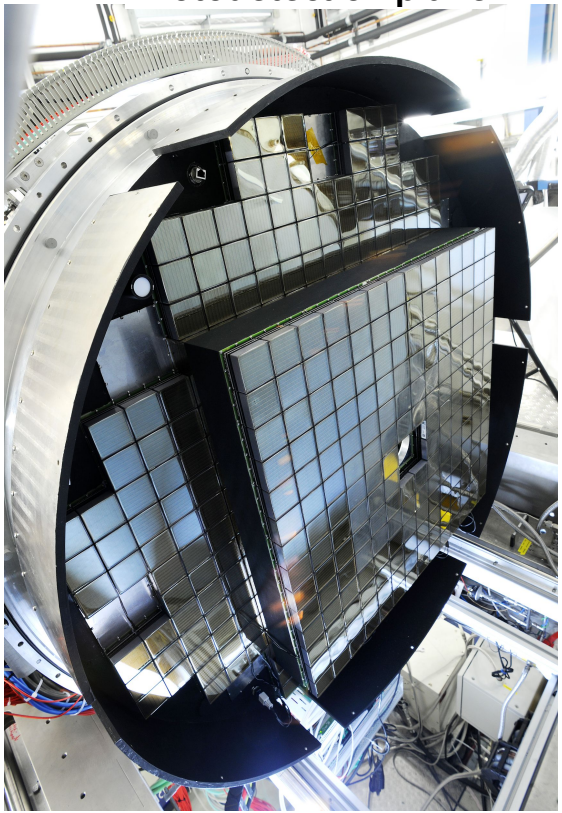
One DiRICH Backplane-Module



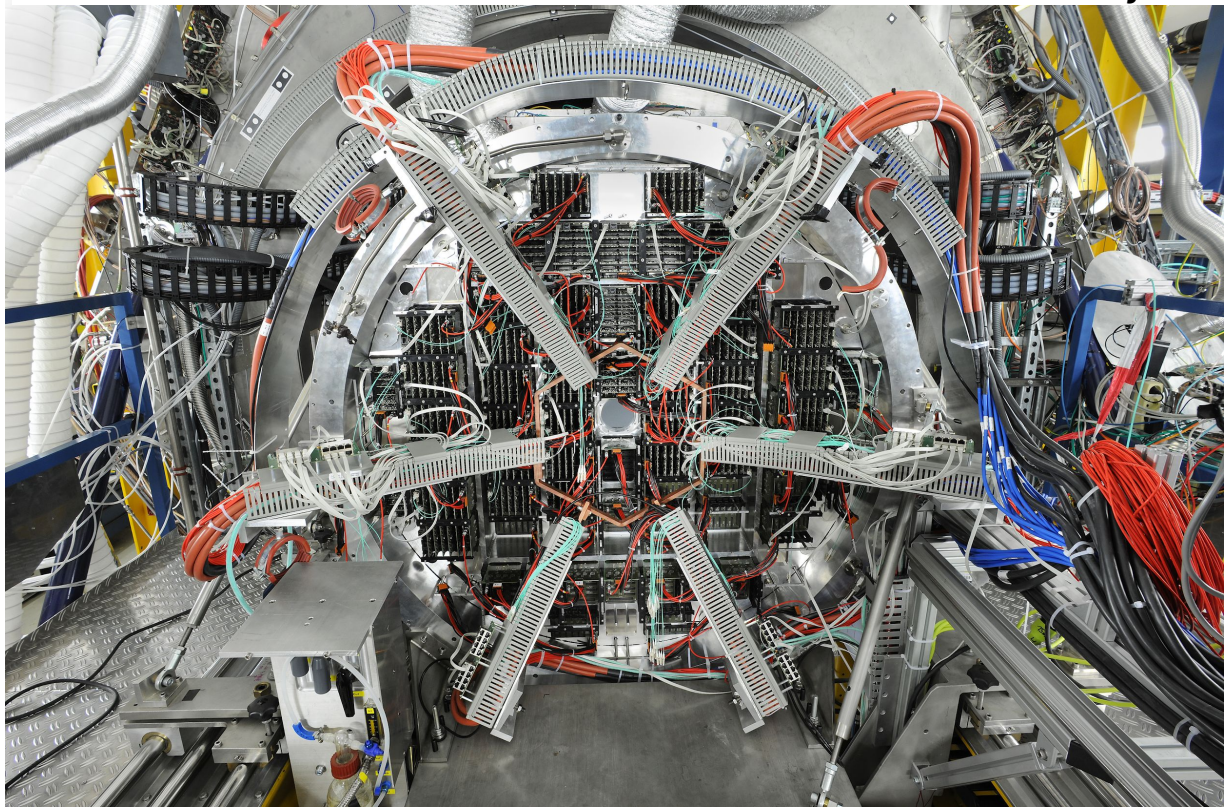
- Motivation:
  - Ensure stable RICH operation for future FAIR program - 2025 and beyond
  - Improve close-pair dielectron reconstruction
    (essential for future physics program)
- Concept:
  - Share MAPMTs and readout chain development with CBM RICH
  - Photodetection plane equipped with 428 64ch H12700 MAPMTs - Measure (arrival) time (LE) and Time over Threshold (ToT) of each channel with the DiRICH-FEB
  - Modular backplanes serve as gas- and light tight seal
  - Use C_4H_{10} as radiator gas

The upgraded RICH - The real thing

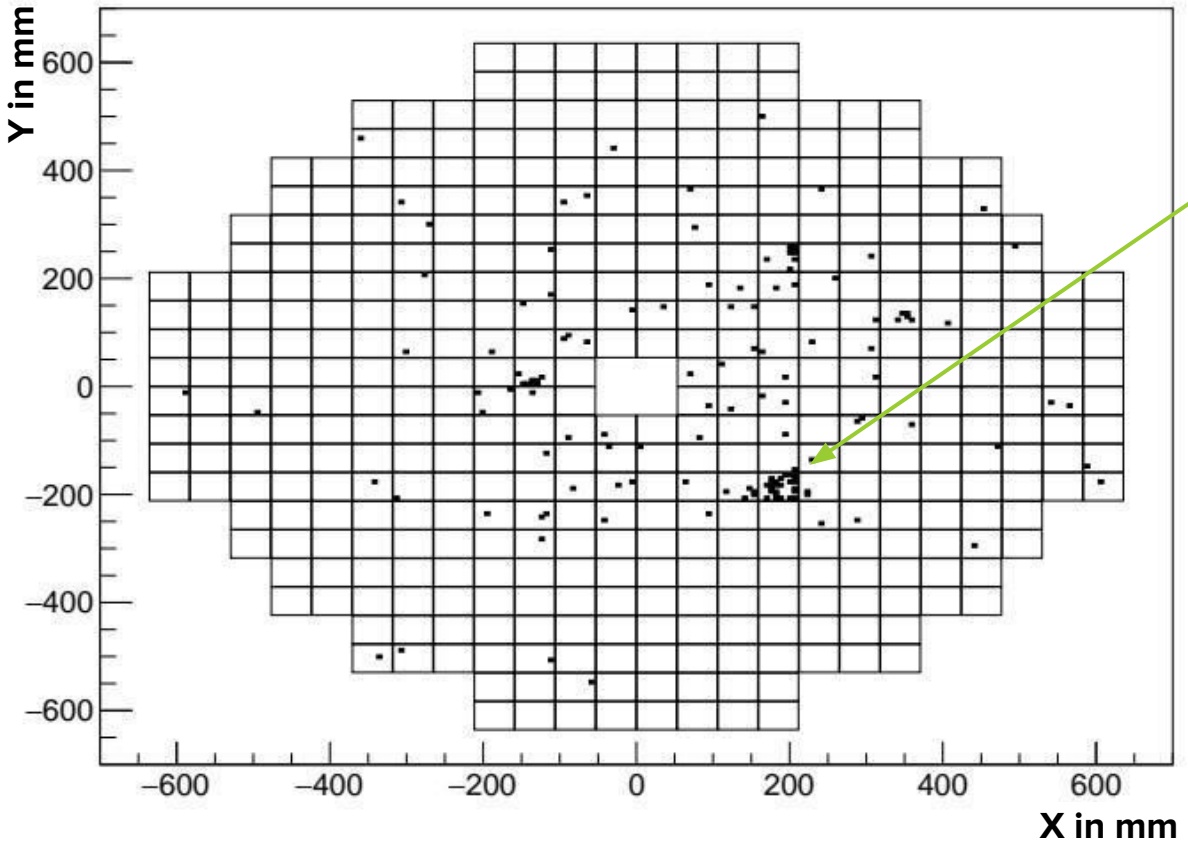
Photodetection plane



Backside of the HADES RICH with view onto the DiRICH readout system

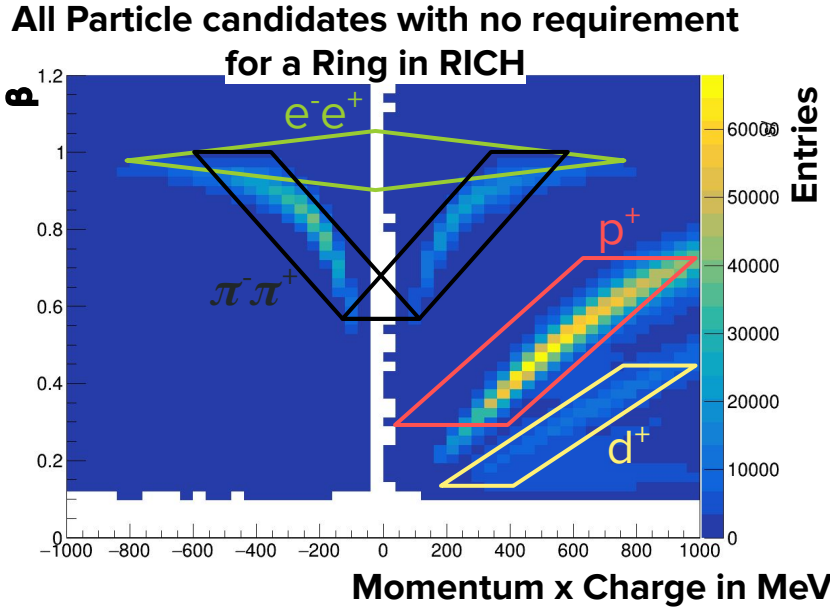


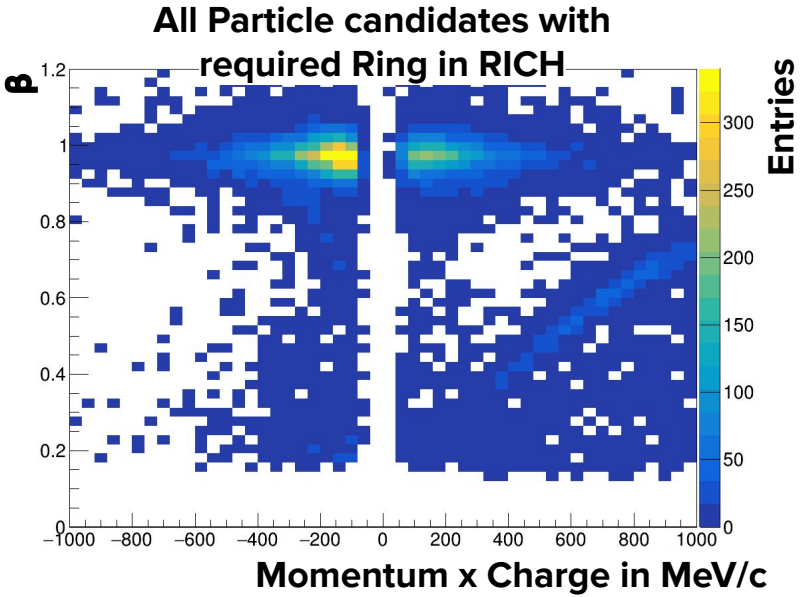
Single Event Display of one of the first Rings (no cuts appl.)



- Full HADES Detector during one of the first events
- Ring clearly visible
- Ring still surrounded by additional hits (charge sharing between channels or capacitive crosstalk)
- Ring still accompanied by coincident noise in the full detector
- Here no hit (arrival) time (LE) and Time over Threshold (ToT) cuts are applied

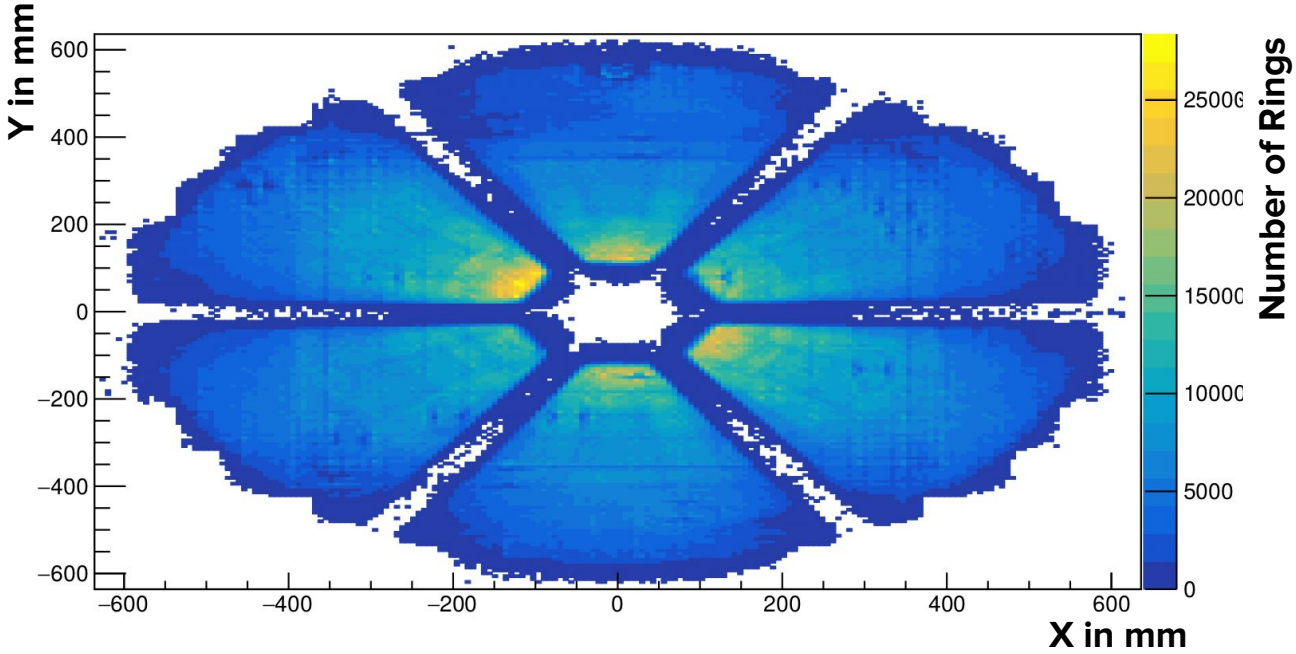
Impact of RICH on Particle ID





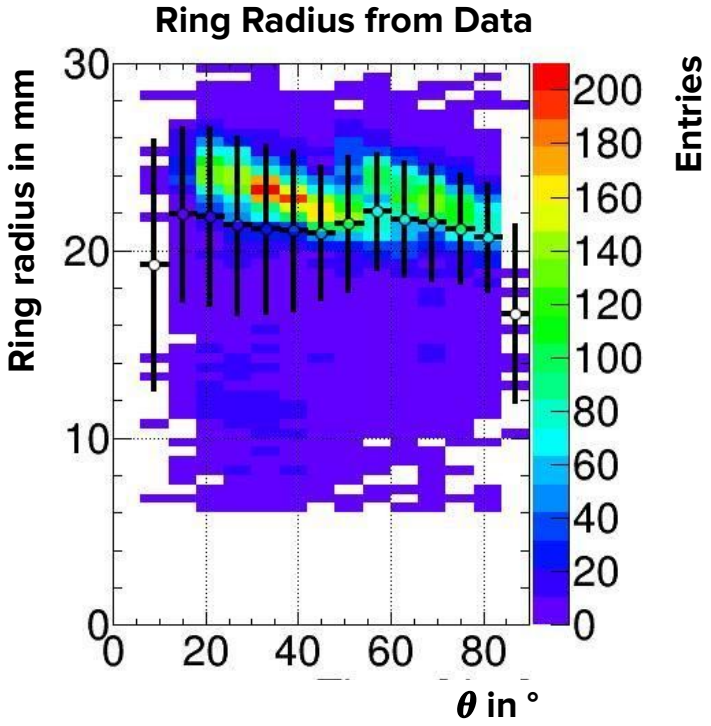
- Channel individually cut on:
  - Hit arrival time w.r.t trigger (Δt=60ns)
  - Time over Threshold: (meanToT-4σ to 15ns)
- Requiring a RICH-Ring matched to the individual track (angular difference < 1°)
  - The radius of the RICH-Ring needs to be between 17 mm and 30 mm

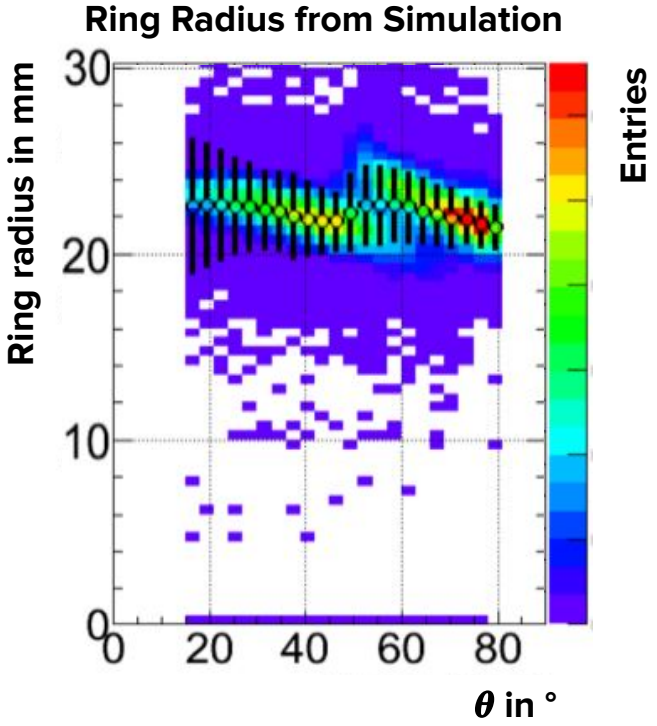
Ring Center Positions of Electron Rings



- Ring center positions for rings matched to an electron reconstructed in TOF/RPC
- **Homogeneously spaced over full detector**
- Clearly visible are the spokes of MDC each 60° in ϕ

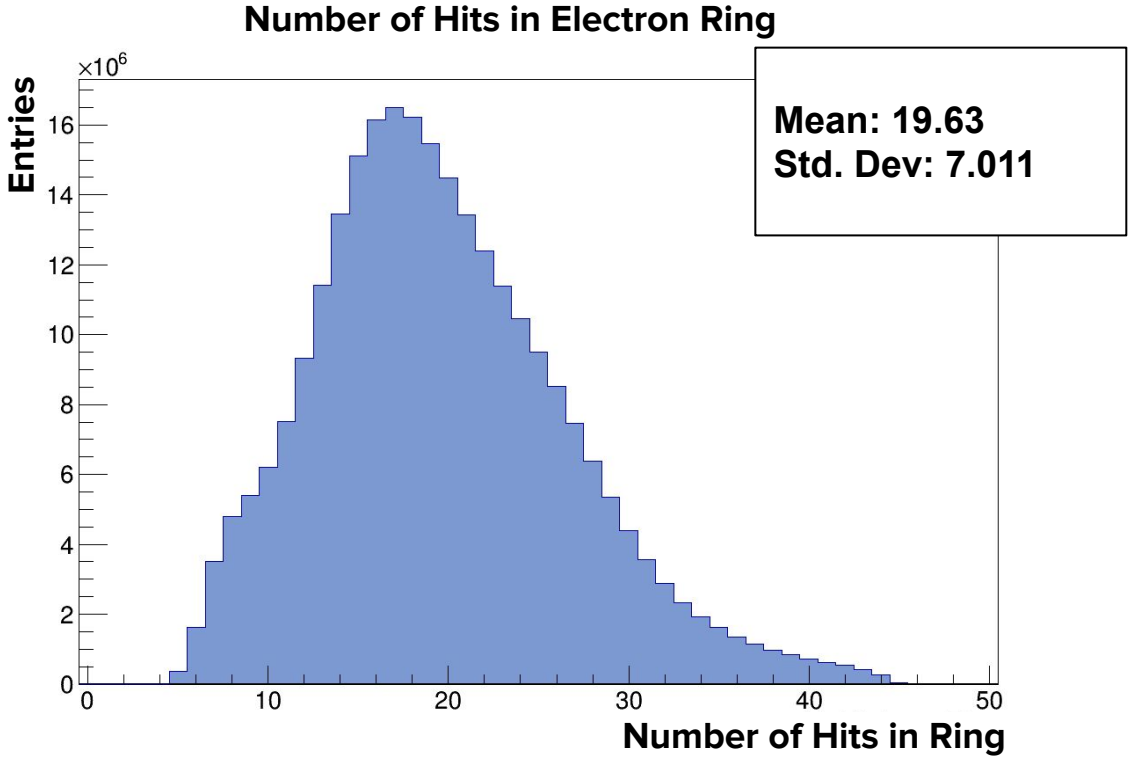
Radius Distribution for Electron Rings





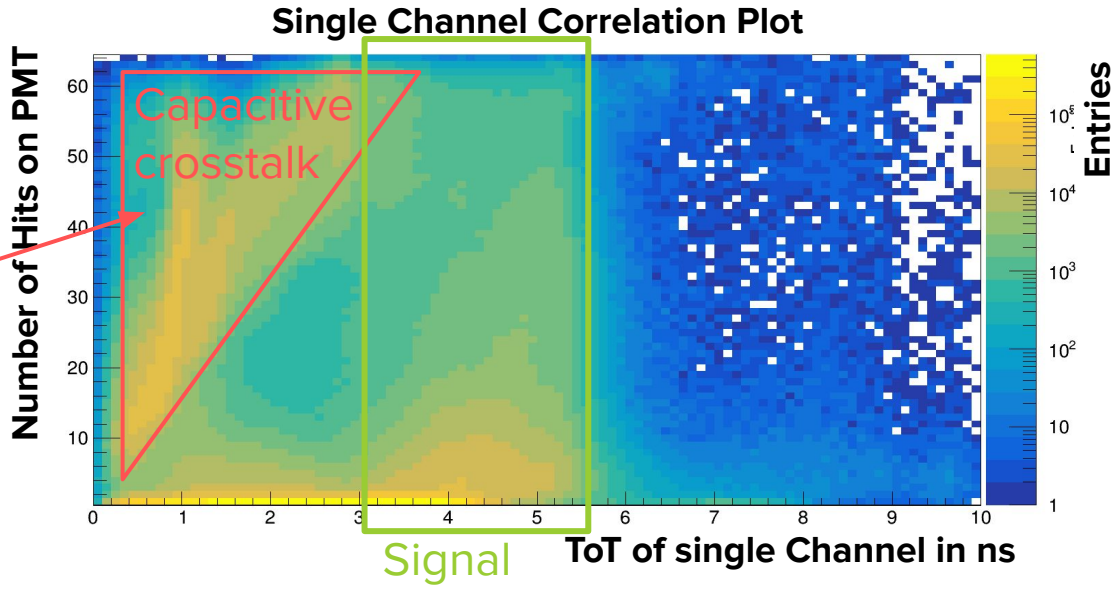
Hit multiplicity per Ring without ToT-based Hit selection

- From simulation an average of 15 hits per ring expected
- Bump at low number of hits indicates underlying contribution
- Still significant contribution from capacitive crosstalk due to relaxed ToT cut

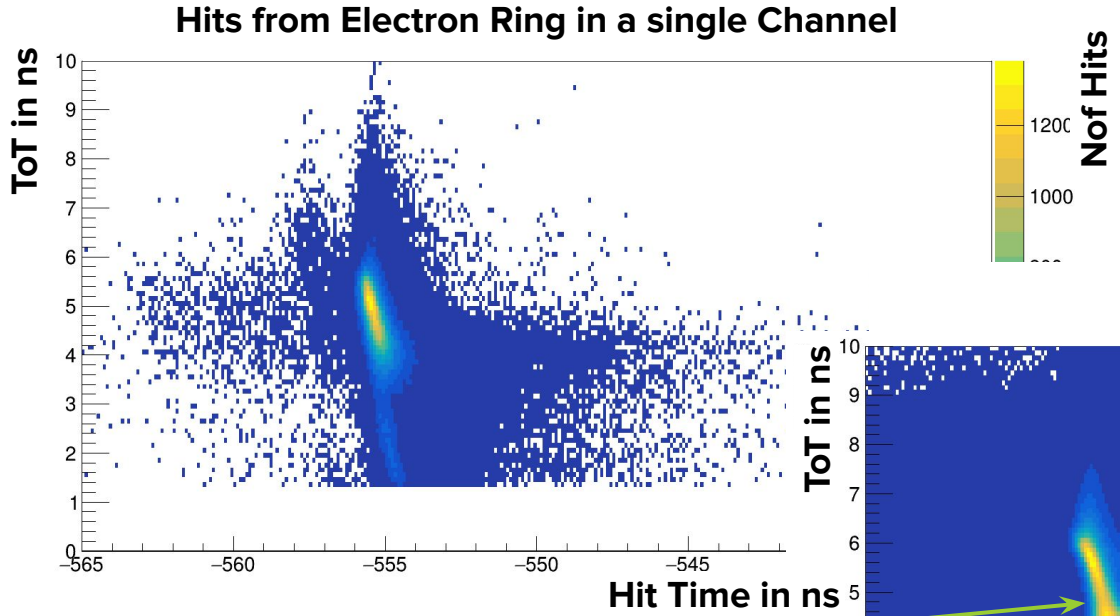


Correlation between ToT and Number of Hits per PMT

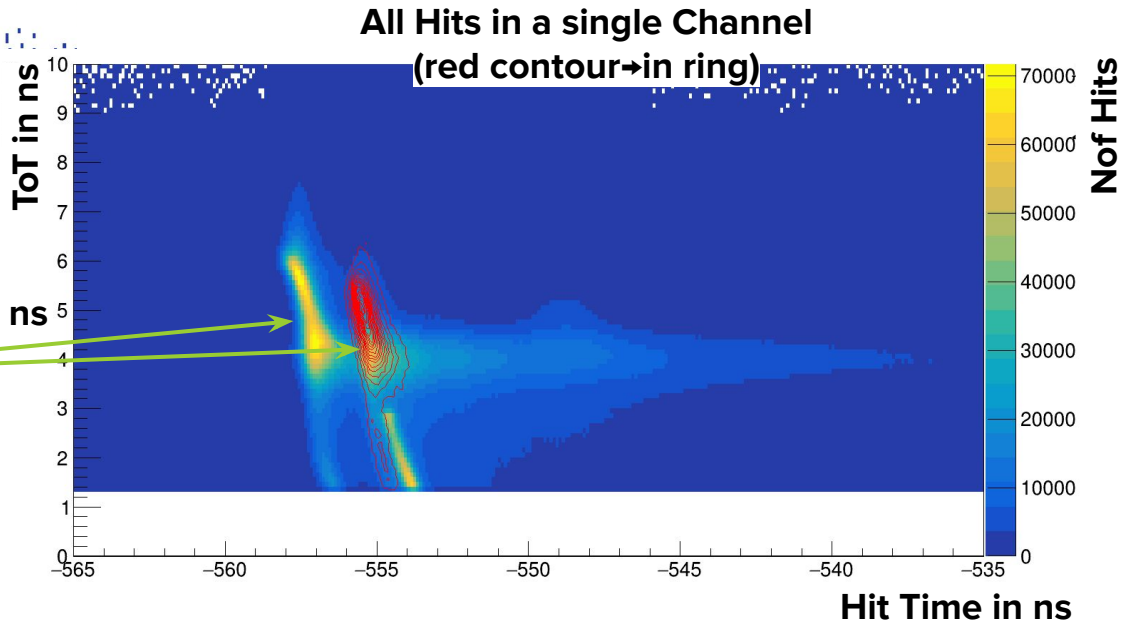
- Capacitive crosstalk visible in distribution of single channel ToT against number of hits on same MAPMT
- ToT for crosstalk hits increases with MAPMT occupancy - indication of capacitive crosstalk
- **Capacitive crosstalk still separable from single photon peak via ToT-Cut**



Time vs. ToT Spectra of Individual Channels

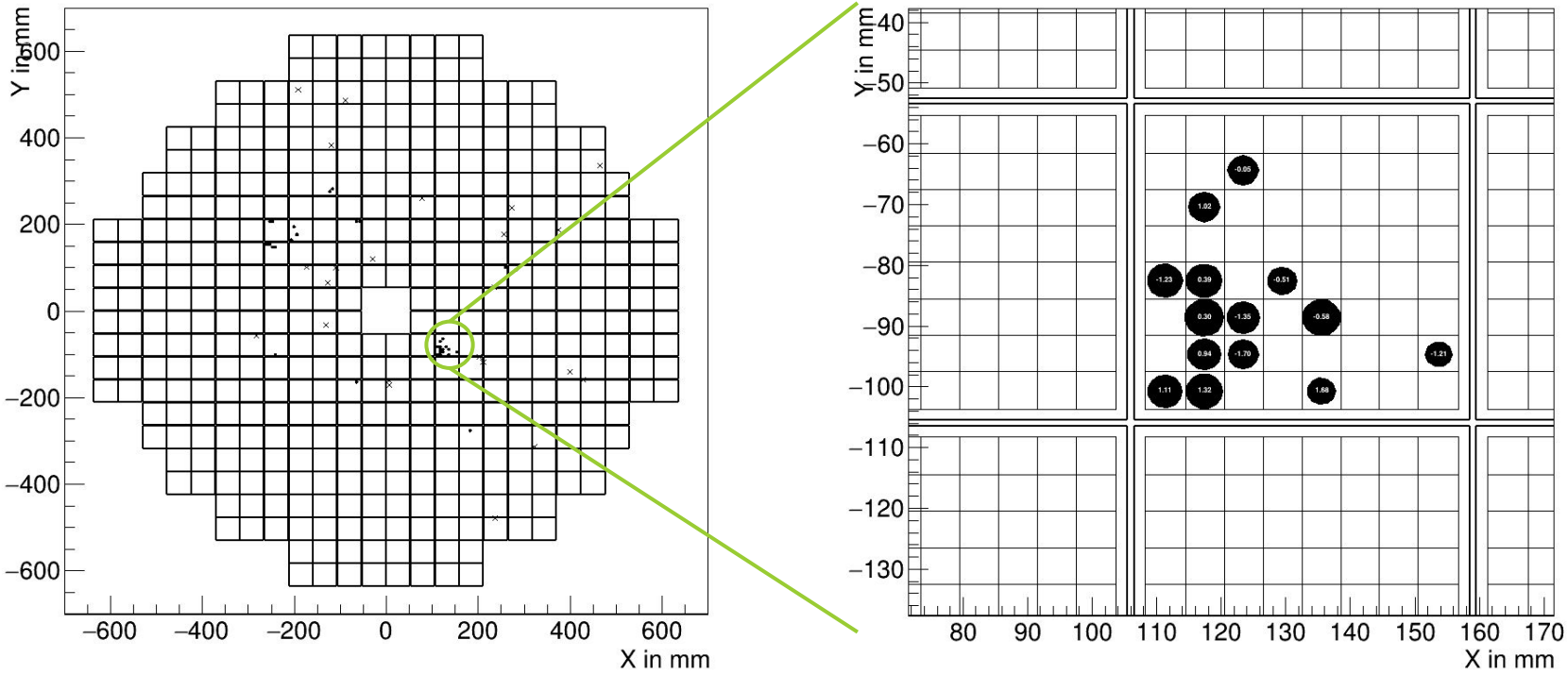


- For each individual channel
  - Fill time and ToT of its hits that contribute to an electron ring



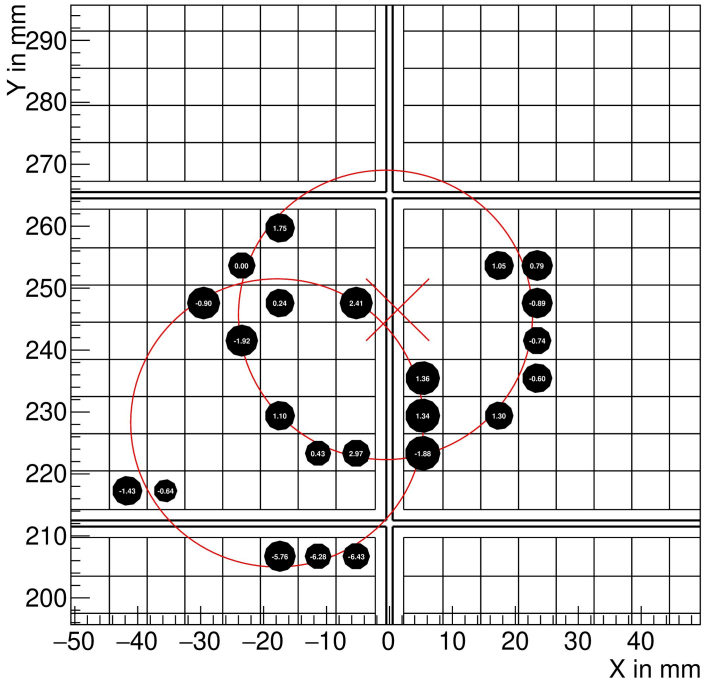
- Visible two peak structure
  - First peak definitely not correlated to electron rings

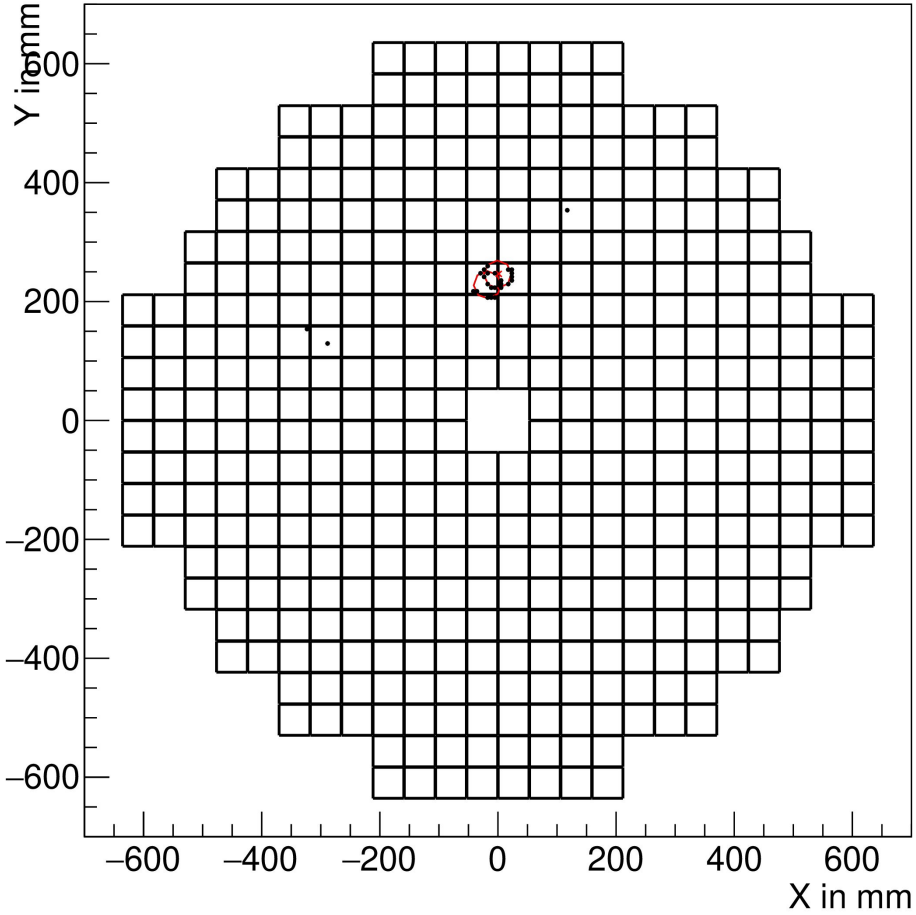
Single Event Plot for first Peak in Time vs. ToT Spectra



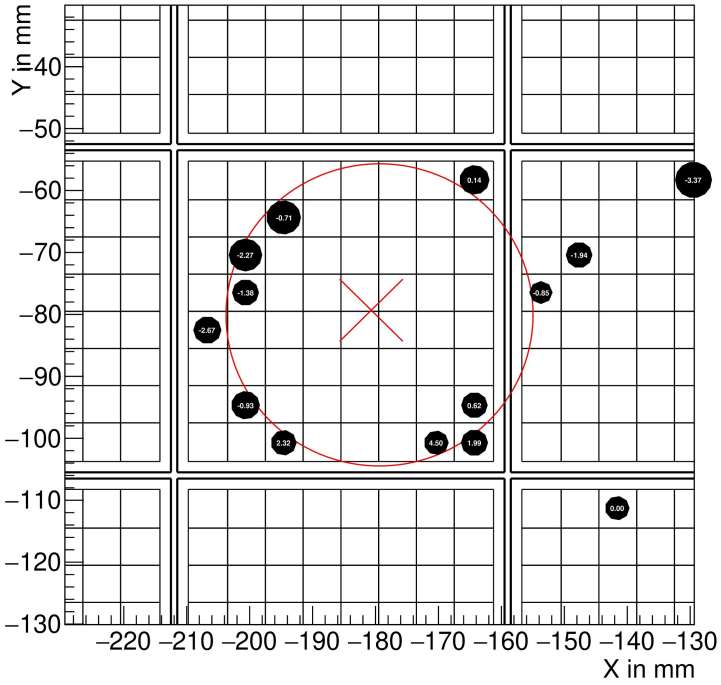
- Simulation indicates “backwards” flying electrons skimming directly over the MAPMTs
  - Those would cast a highly elliptical ring

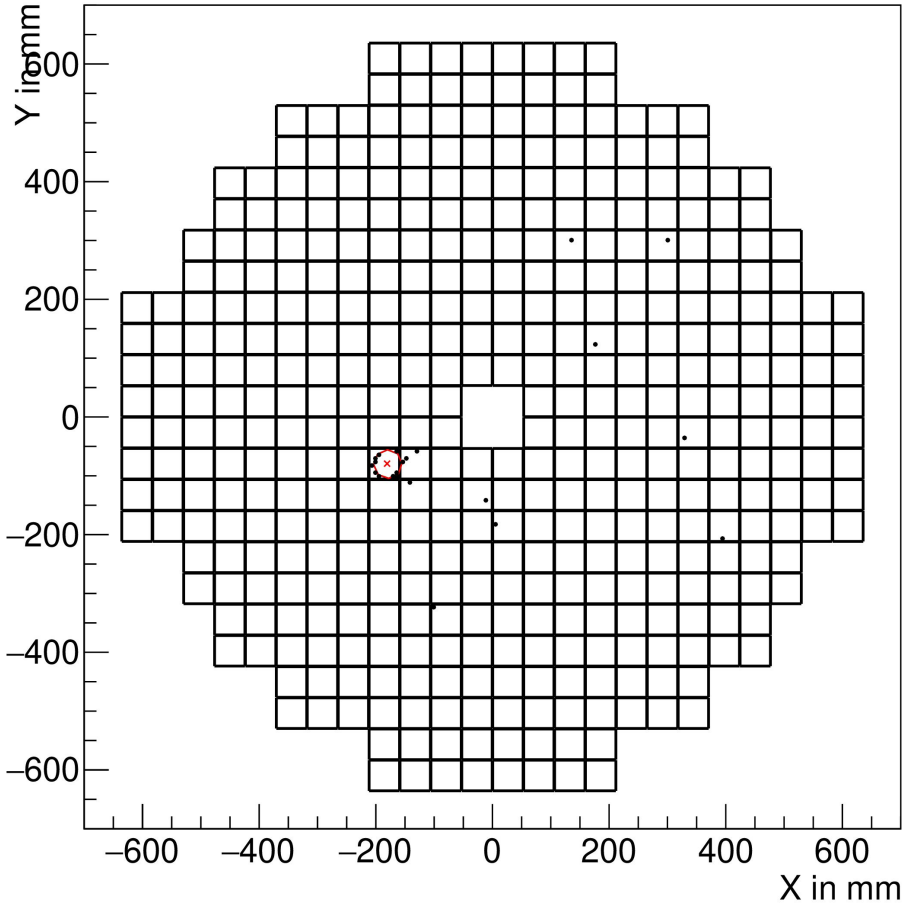
Single Event Plot with Cut on Signal Peak





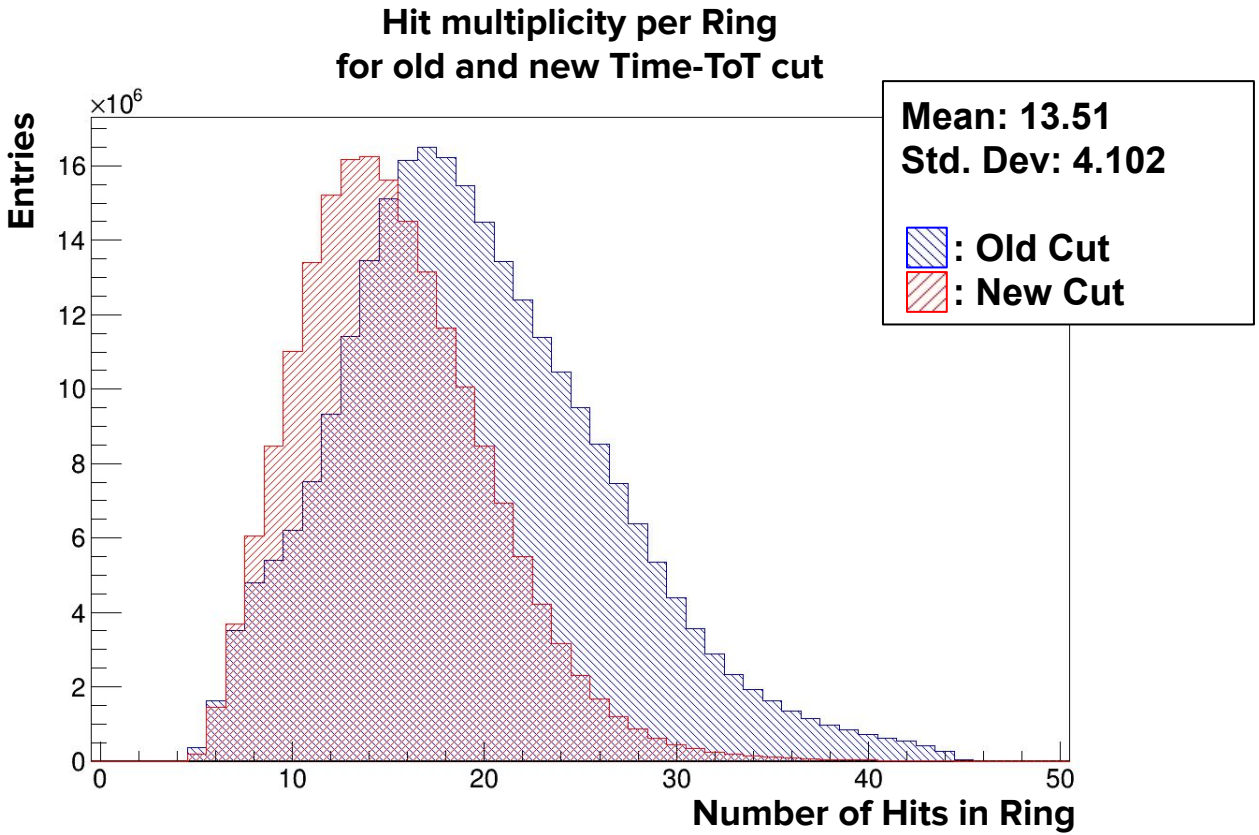
Single Event Plot with Cut on Signal Peak





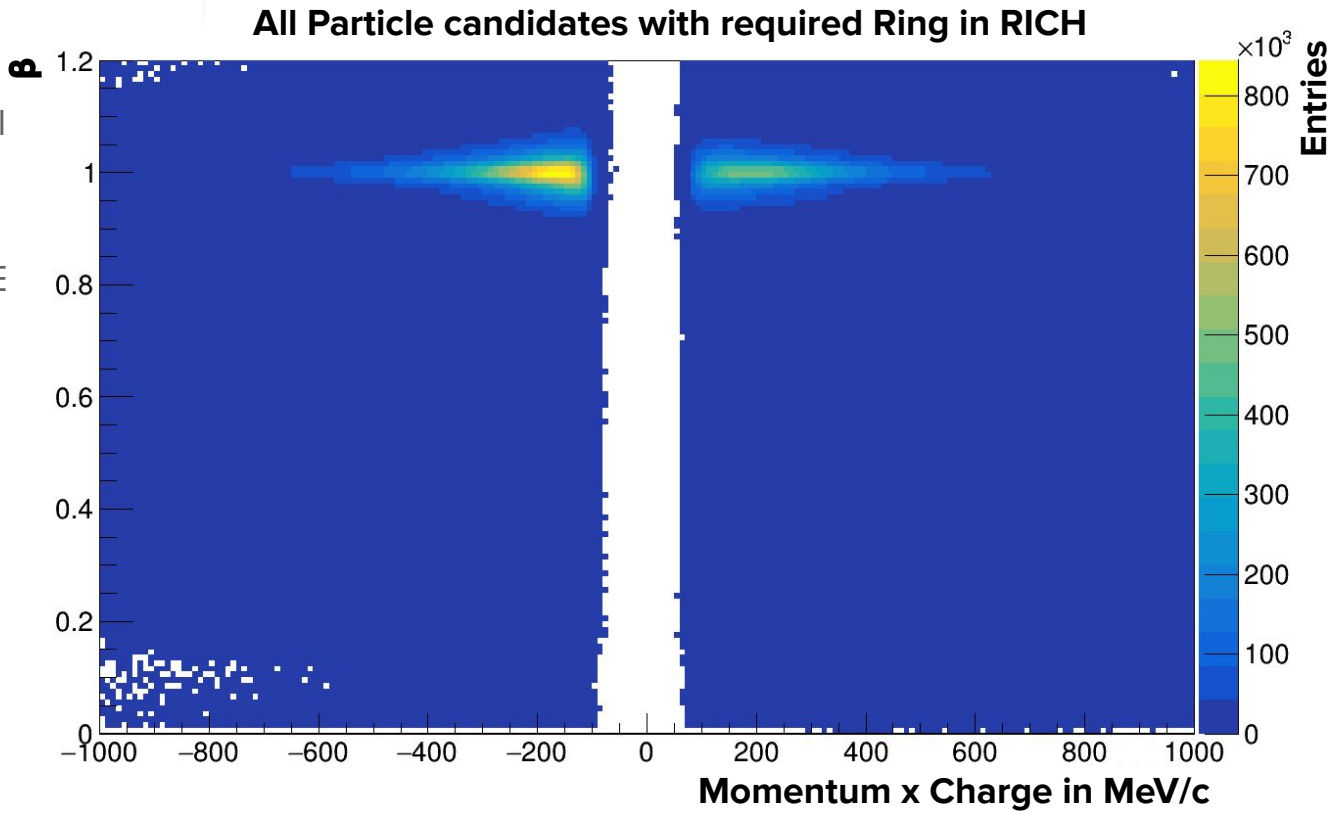
Hit multiplicity per Ring with strict Time and ToT cuts

- Number of measured photons in ring for rings matched to an electron track with strict cut on hit time and ToT
- Average number of hits per ring are close to the simulated 15
- Bump to lower number of hits per ring not visible anymore



Beta Momentum Distribution with strict Time and ToT cuts

- Requiring a RICH-ring matched to the individual track
- Stricter cut on ToT and LE
- **Only e^- e^+ "visible" in spectrum**
- **Proton and Pion heavily suppressed**

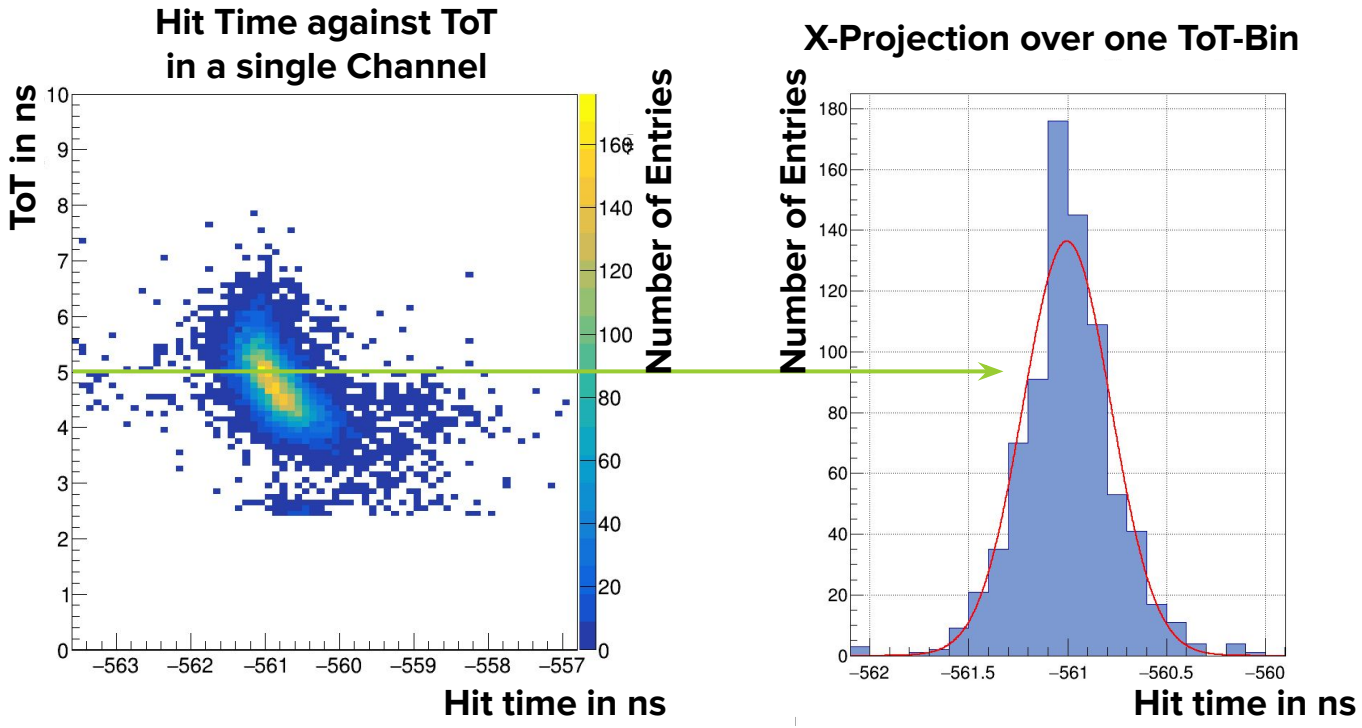


Single Channel Timing relative to Trigger

- For each channel fill an individual histogram with hit time and ToT if the hit belongs to an electron ring

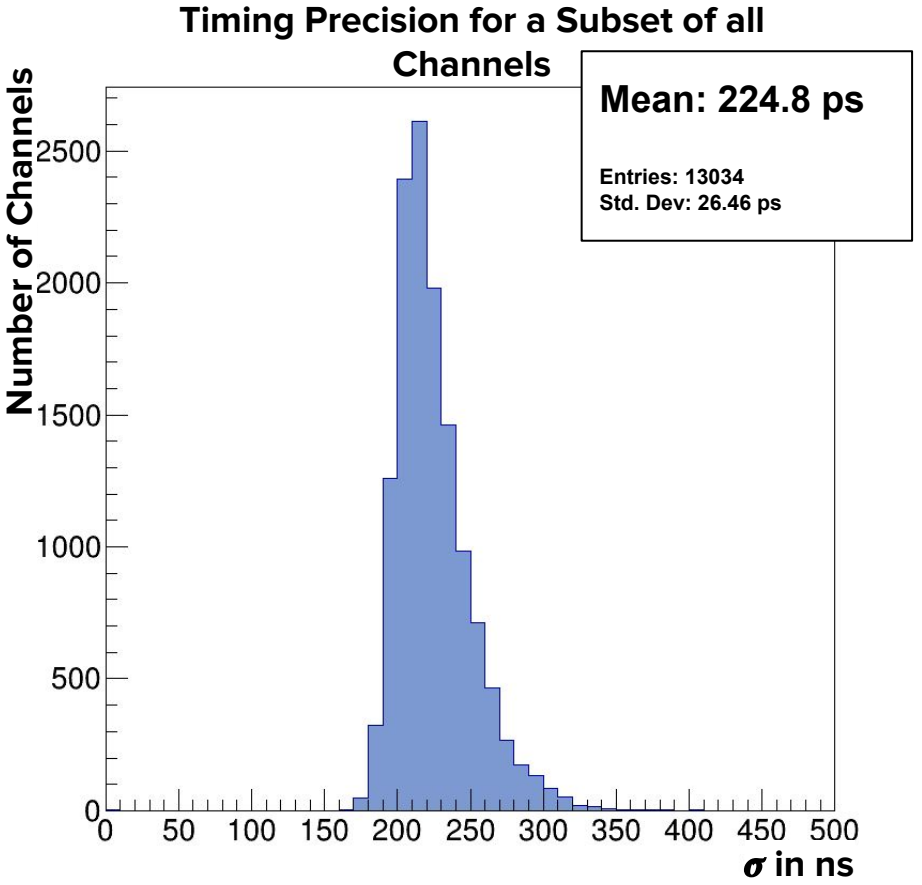
- Take each channel's 2D-distribution and make a X-projection through the largest bin

- Fit the resulting 1D "single" ToT distribution with a Gaussian distribution



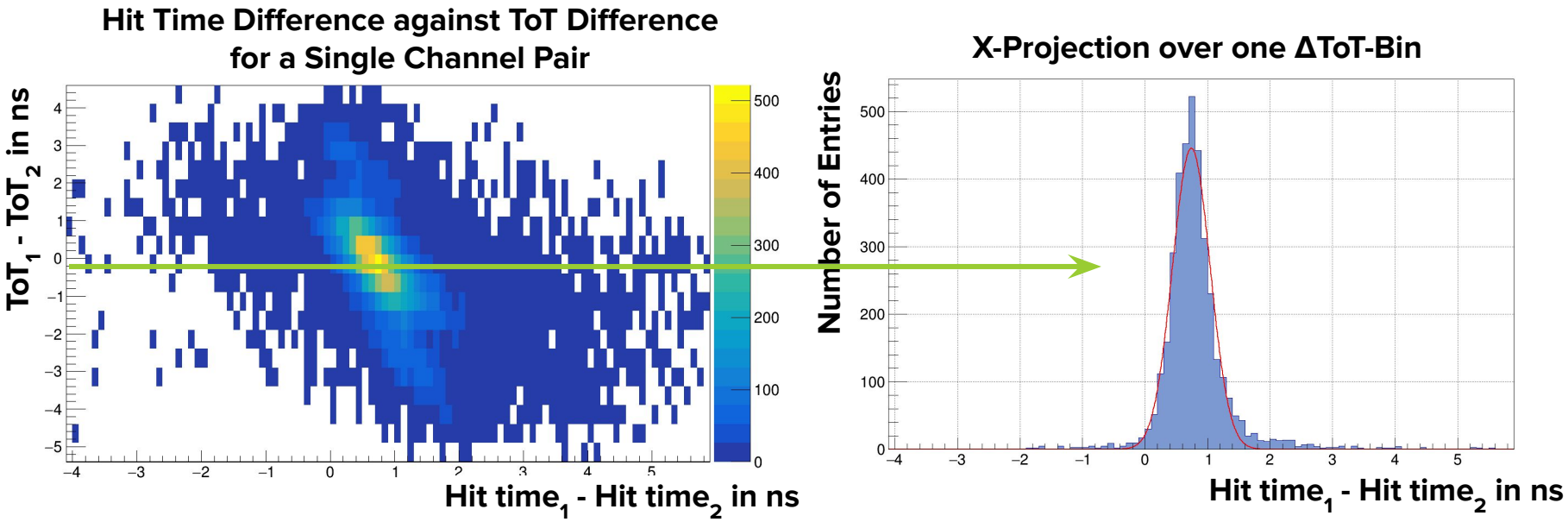
Single Channel Timing Precision relative to Trigger

- **Average timing precision of σ = 225 ps** can be achieved for a single ToT-Bin (0.1 ns) in the “full” detector (work in progress)
- HAMAMATSU claim typical transit time spread (FWHM) 350 ps for H12700 MAPMTs
  - roughly equals σ = 150 ps
- Contribution of trigger jitter leading to a worse timing precision



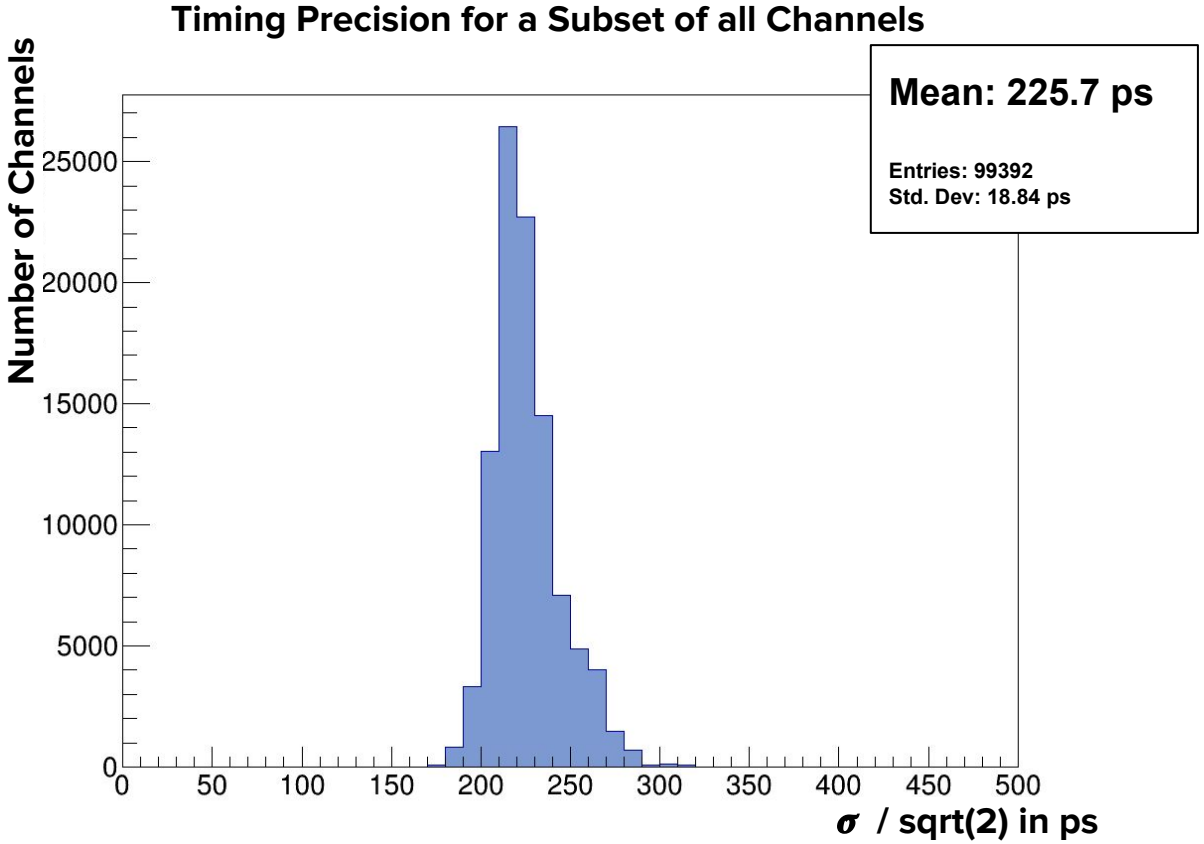
Channel to Channel Timing Precision

- For each pair of channels fill an individual histogram with hit time differences and ToT differences if both channels did see a photon from the same electron ring



Channel to Channel Timing Precision

- **Average timing precision around σ = 226 ps** for a single bin in ΔToT (0.5 ns) (work in progress)
- Still influenced by walk since here the walk of two channels contribute to a broadened time distribution
- Walk correction needs to be made before final timing precision can be stated



Summary

- HADES RICH upgrade with new MAPMT readout and DiRICH readout chain finalized this year
- In time for very successful 4-week production beamtime March 2019
- Use of RICH provides strong suppression of non-electron background
- RICH performance in good agreement with simulations
- Structures in the hit time distribution are nearly fully understood
- Precise Time Over Threshold measurement vital for suppression of background
  - In particular capacitive crosstalk
- First studies indicate a full detector timing precision better than σ = 225 ps in average (work in progress)

Backup

Beamtime Webpage

GSI

HADES: FAIR Phase-0 Experiment

HADES FAIR

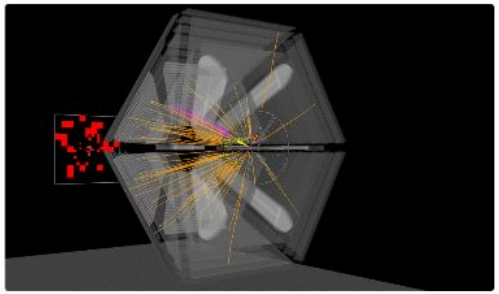
Impressum Datenschutz

HADES monitoring LIVE

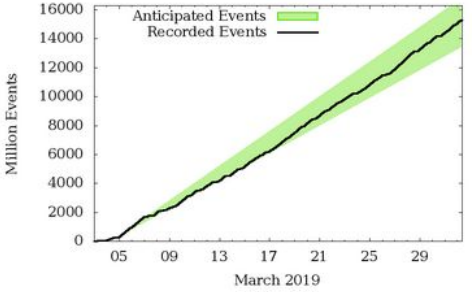
Ag+Ag 1.58A GeV

Date:	10 April 2019
Event rate:	16-18 kHz
Collected events:	15268.68 × 10^6
Collected data:	359.23 TB
Last update:	22:30

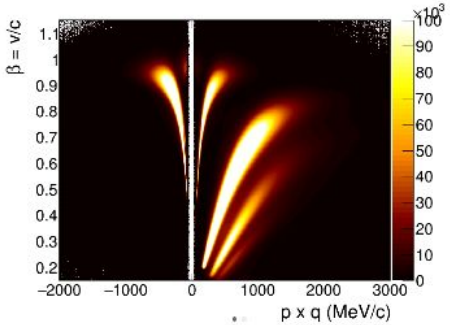
Event Display



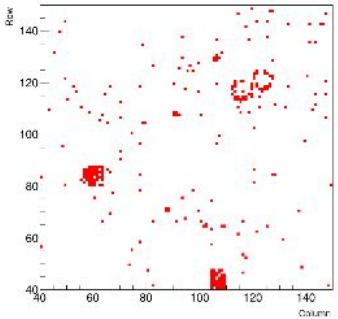
Run statistics



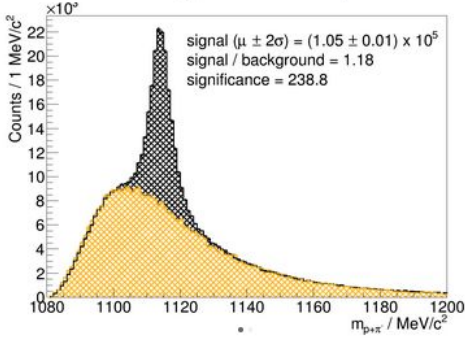
PID: Velocity vs Momentum - TOF



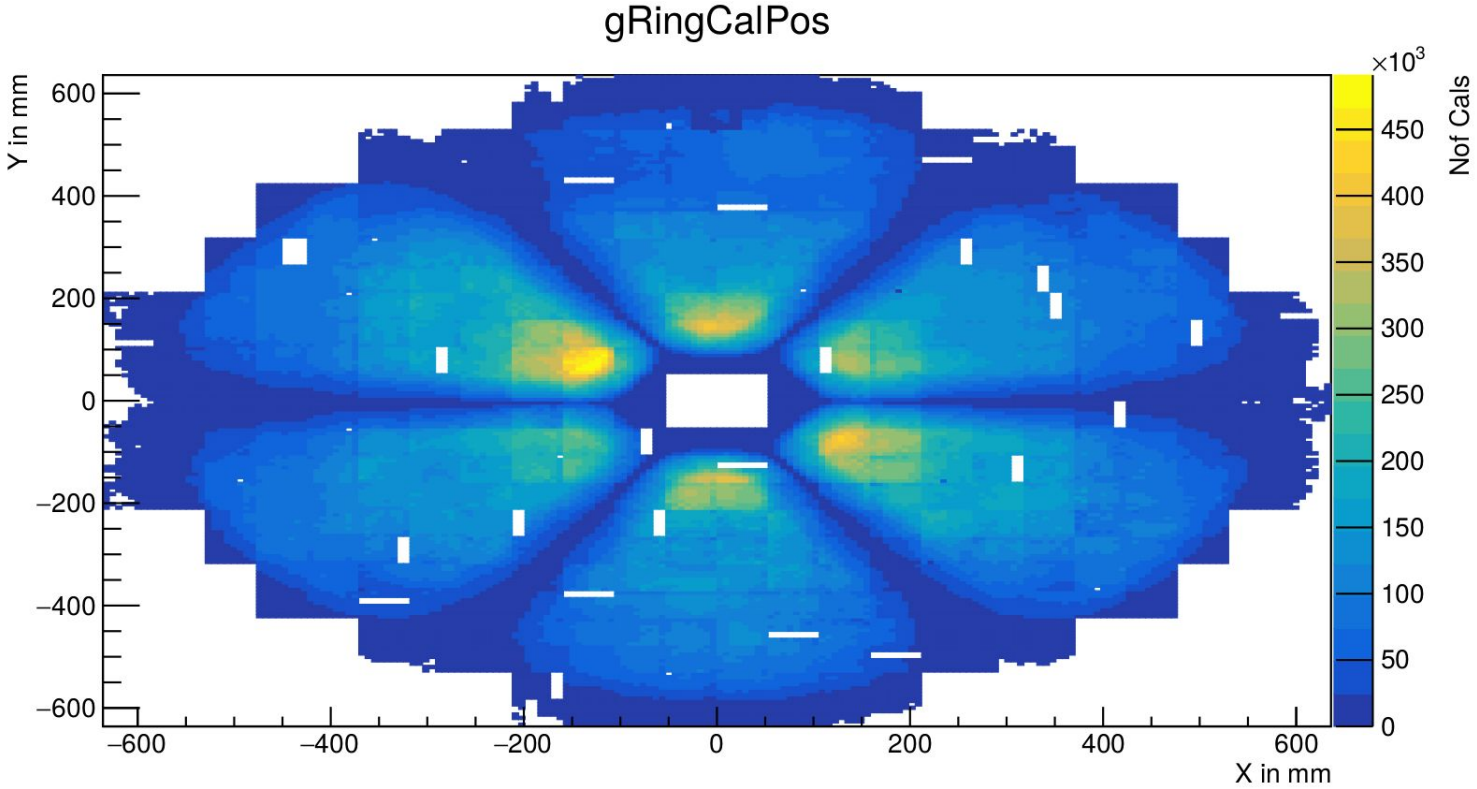
e^+/e^- Cherenkov Rings



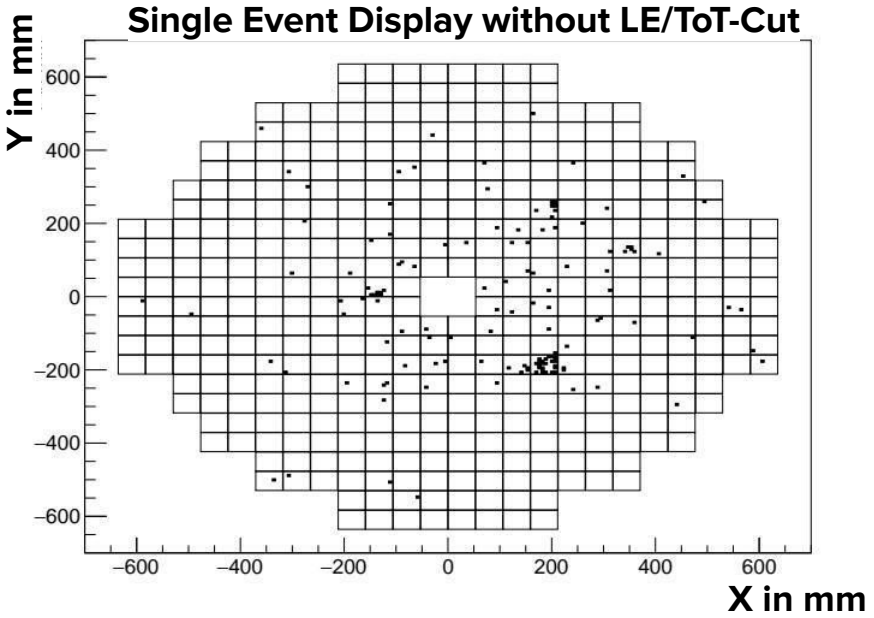
Online Hyperons: $\Lambda \rightarrow p + \pi^-$

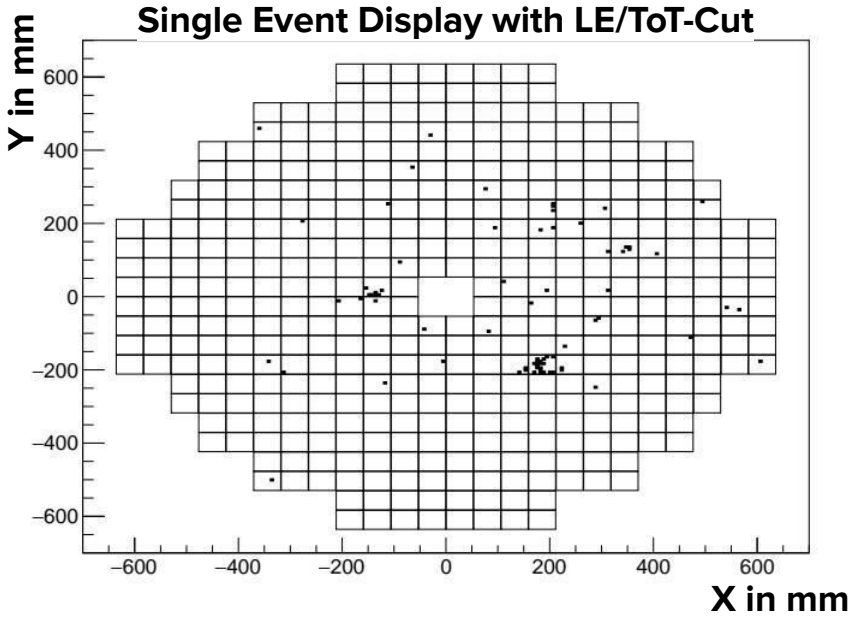


Ring Hit Positions of Rings matched to an Electron



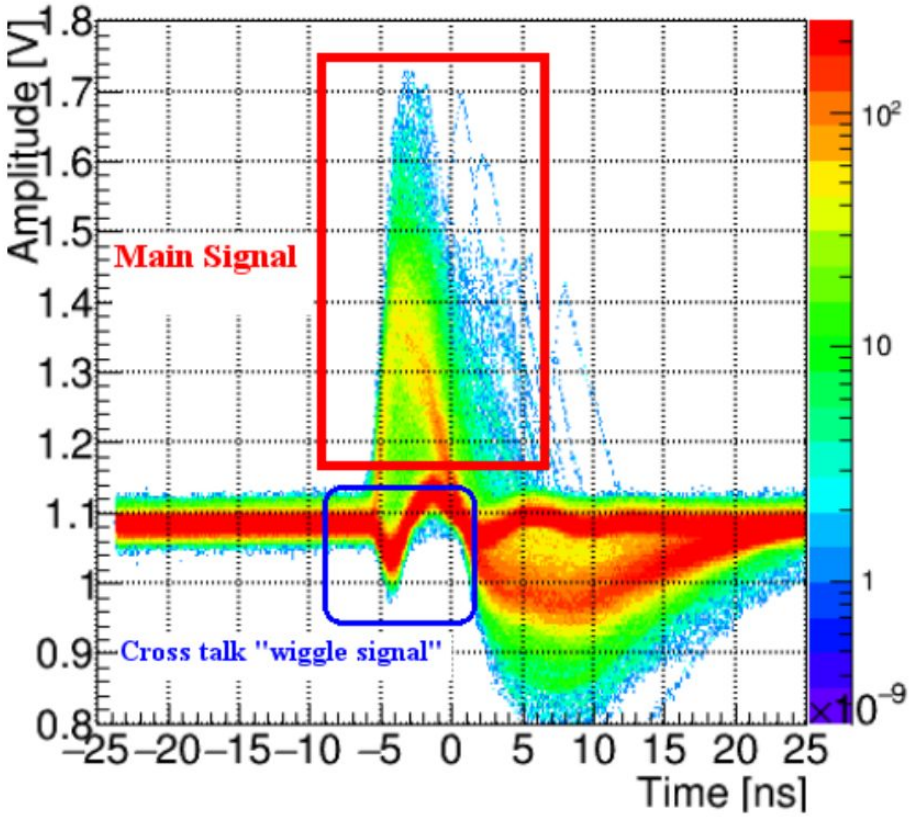
Improvement of Single Events with Time and ToT-Cut



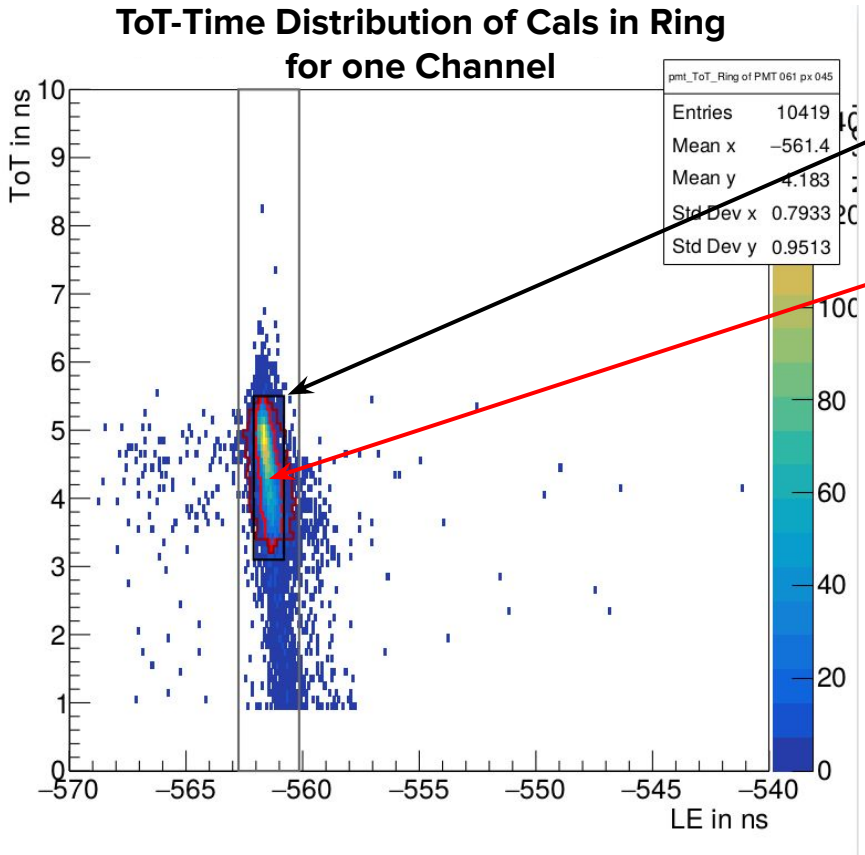


- Channel individually cut on:
  - Leading edge (Δt=60ns)
  - ToT (-4σ -- 15ns w.r.t. SPP)

Wiggle Signal



Cut definition



- Different Cuts are:
  - “Coarse”-Cut
    Rectangular area around “Fine”-Cut
  - “Fine”-Cut
    Region with **0.1*Maximum_Value**
  - For channels where no cut-values could be retrieved (less than 3 Bins with >100 Cals), the further analysis is subdivided into
    - “useempty”
      meaning **channels** with too few hits are **included without cut**
    - “normal”
      meaning **channels** with too few hits are **excluded** from further analysis

Single Event Plot for signal Peak in Time-vs-ToT