Development of a SiPM-based RICH detector for the future ALICE 3 experiment at LHC

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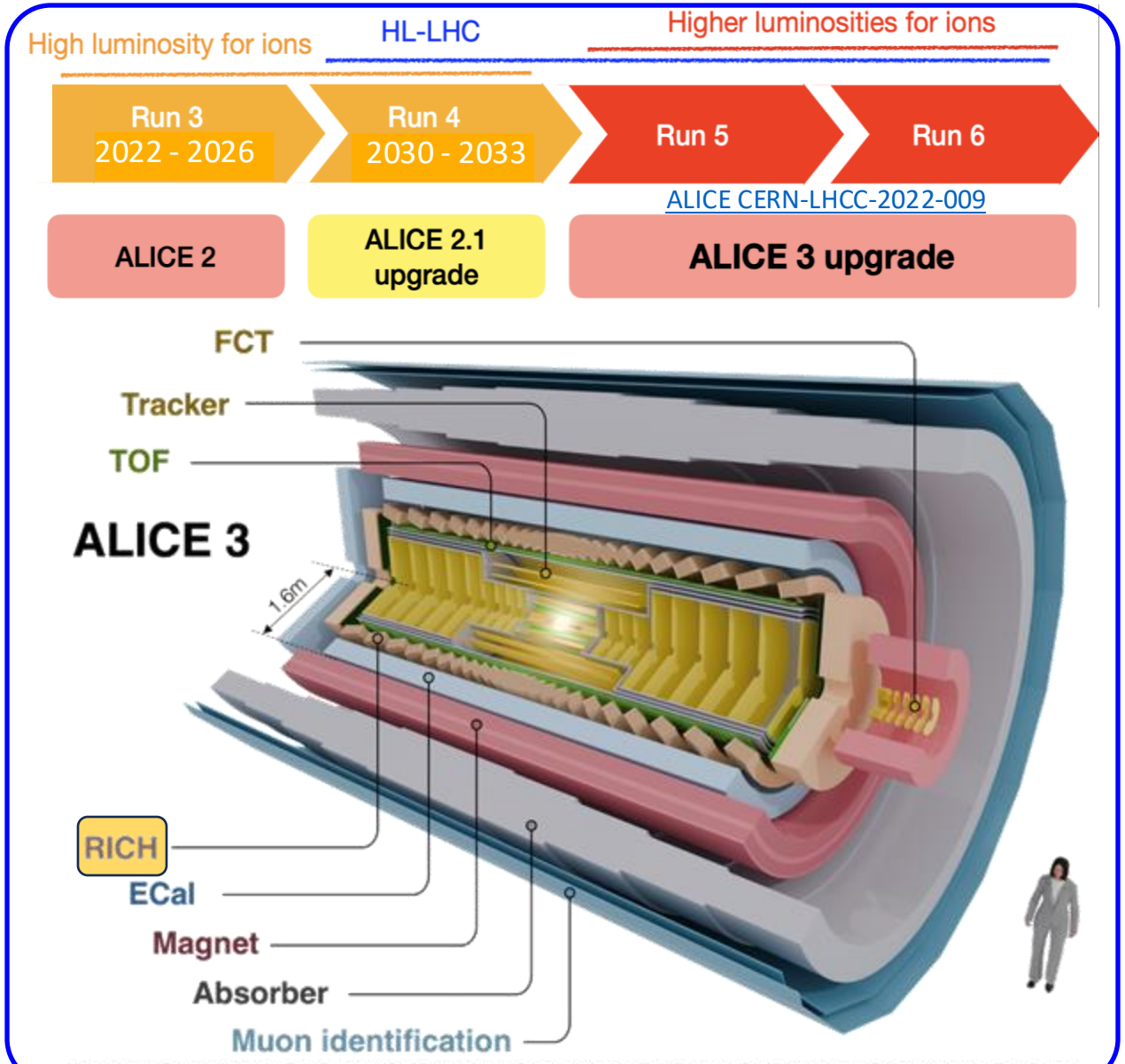
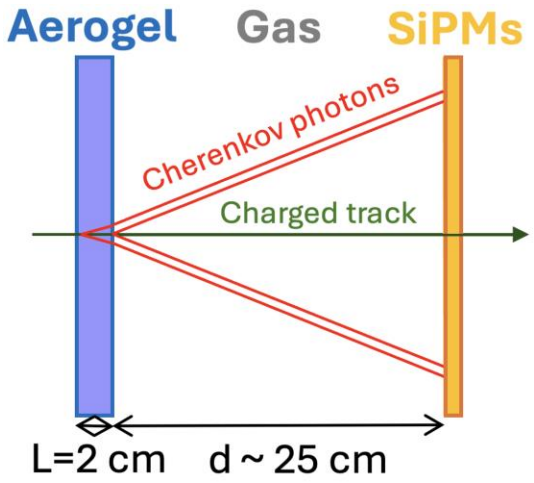
for the ALICE Collaboration

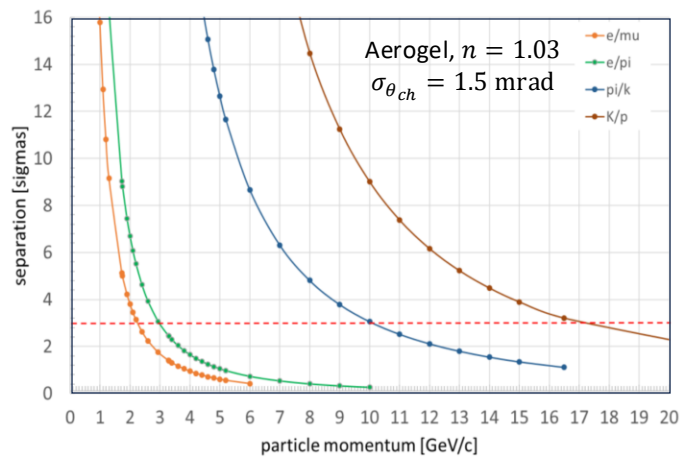
IFD 2025 – March 17-19, 2025

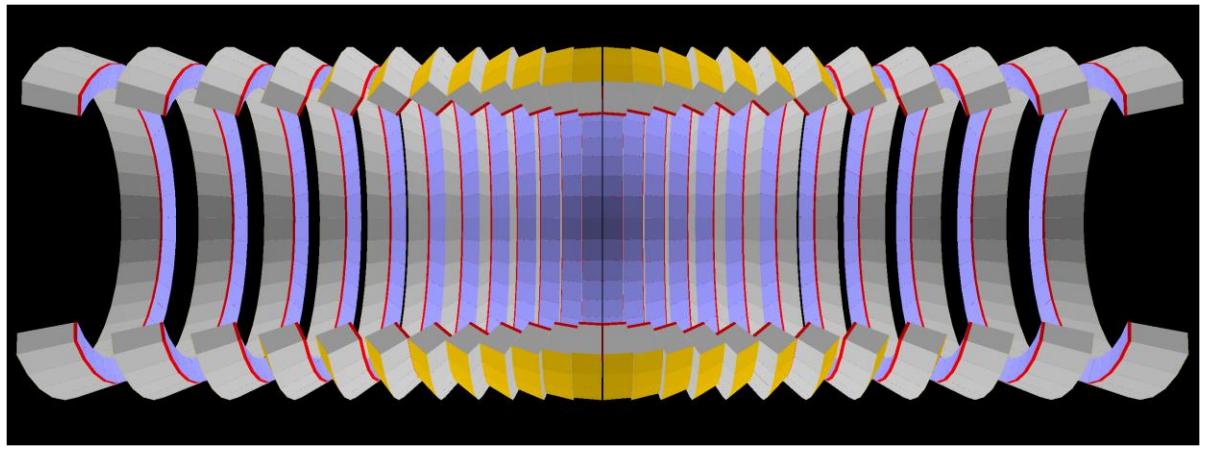
The ALICE 3 bRICH detector



bRICH: Proximity-focusing RICH based on aerogel+SiPMs in a projective geometry







2024 beam test set-up@PS-T10

Aerogel radiator: 2 cm thick tile with n=1.03, $\Lambda \approx 5.5$ cm @ 400 nm

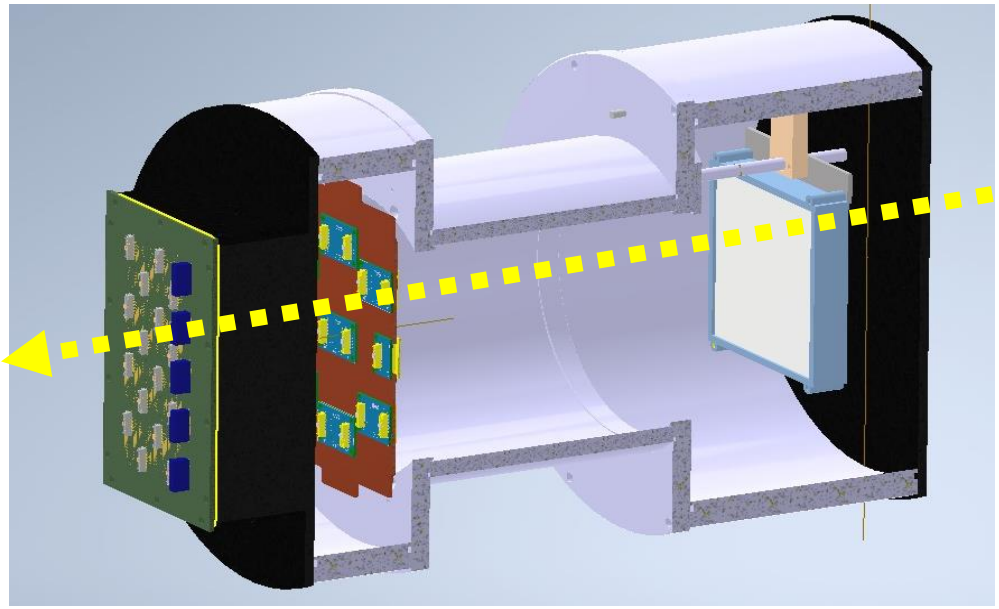
Central array: 1 HPK SiPM S13361-3050AE-08 (64 3x3 mm^2 SiPMs)

Ring arrays: 7 HPK SiPM S13361-2050AE-08 (64 2x2 mm^2 SiPMs)

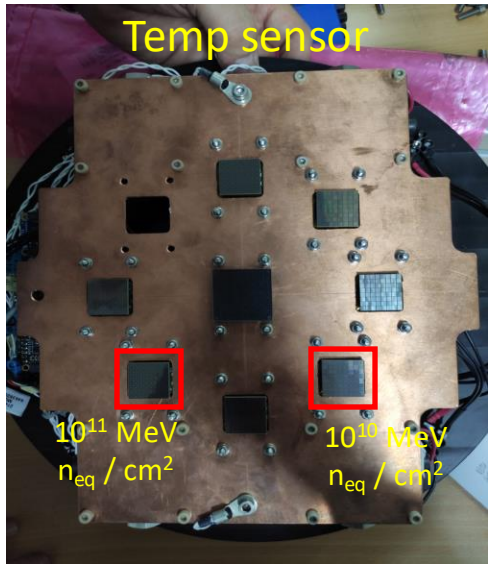
SiPM cooling: Down to -5 °C using water chiller + Peltier Cells

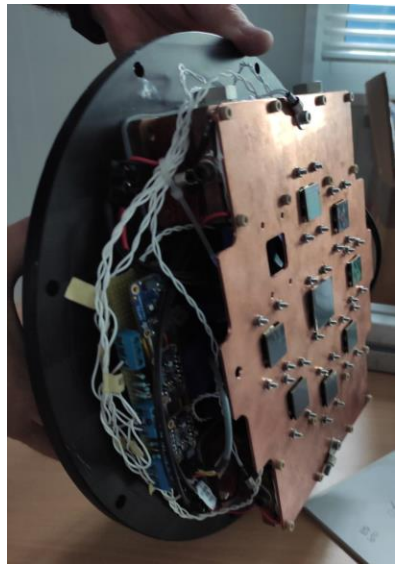
Proximity gap: 23.4 cm between aerogel and SiPMs flushed with Ar

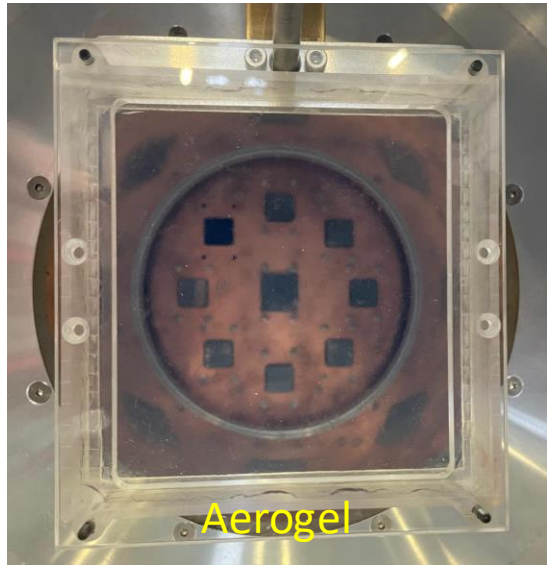
Front-end: Custom board based on Radioroc 2 FE ASIC and picoTDC

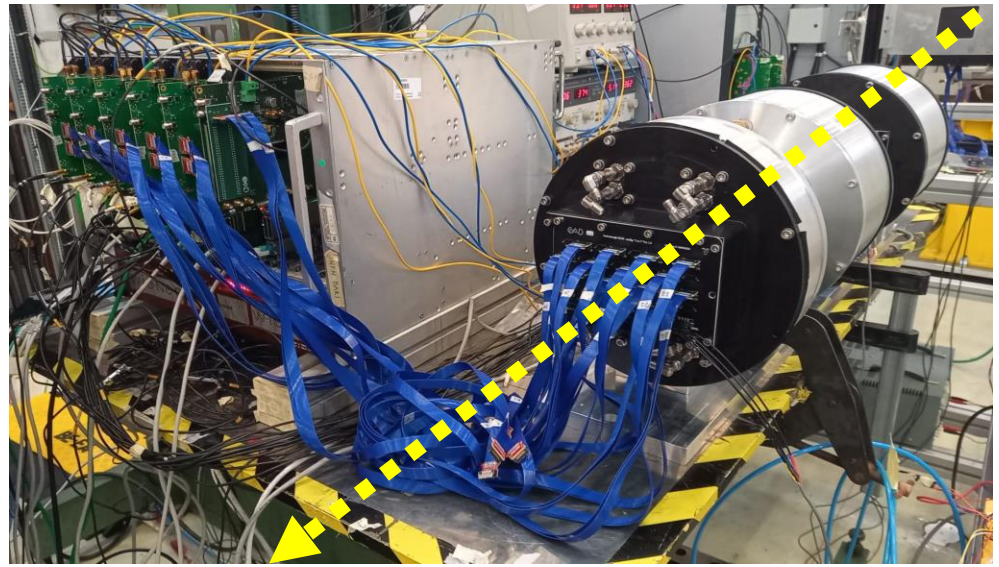


Additional vessel equipped with 2 extra HPK SiPM S13361-2050AE-08 for charged particle timing studies ⇒ See contribution by Bianca Sabiu



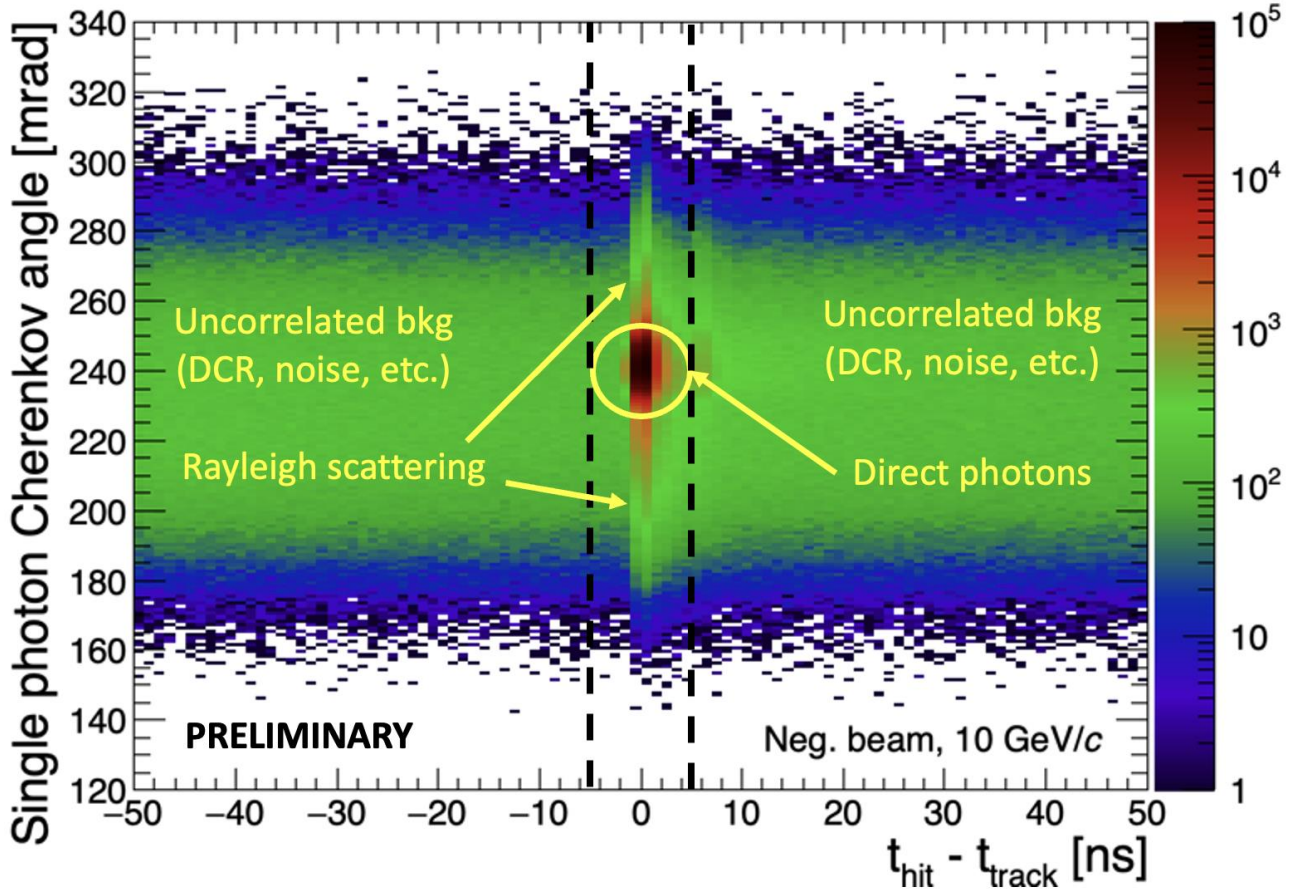


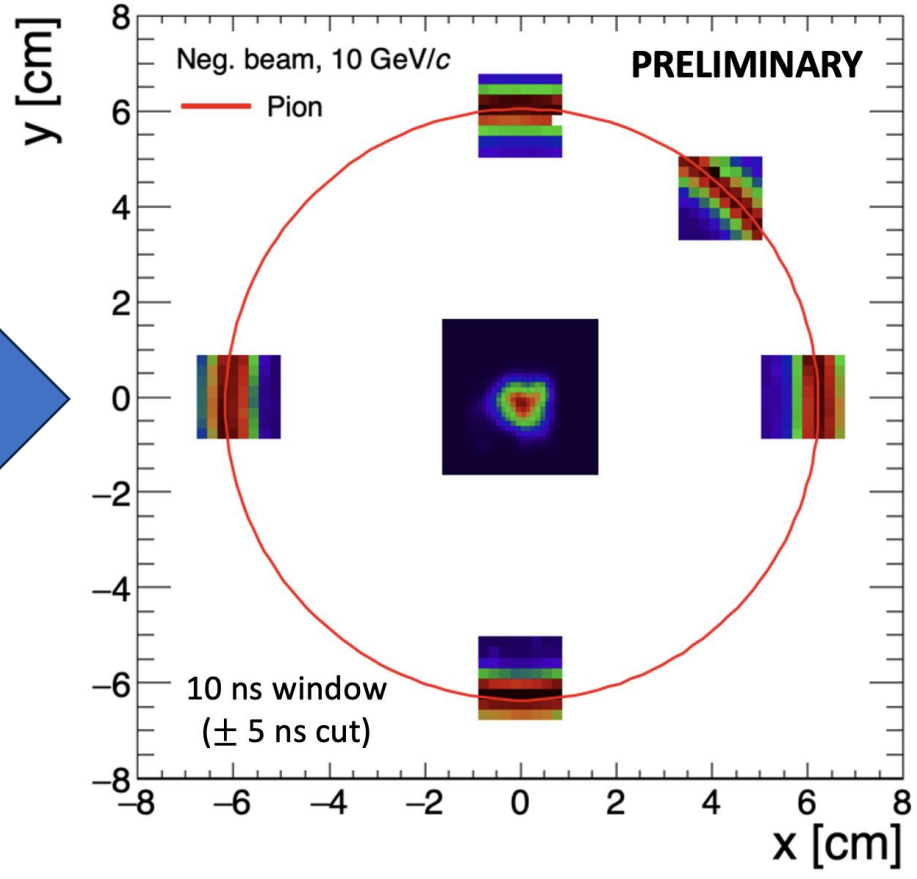




DCR bkg suppression using timing

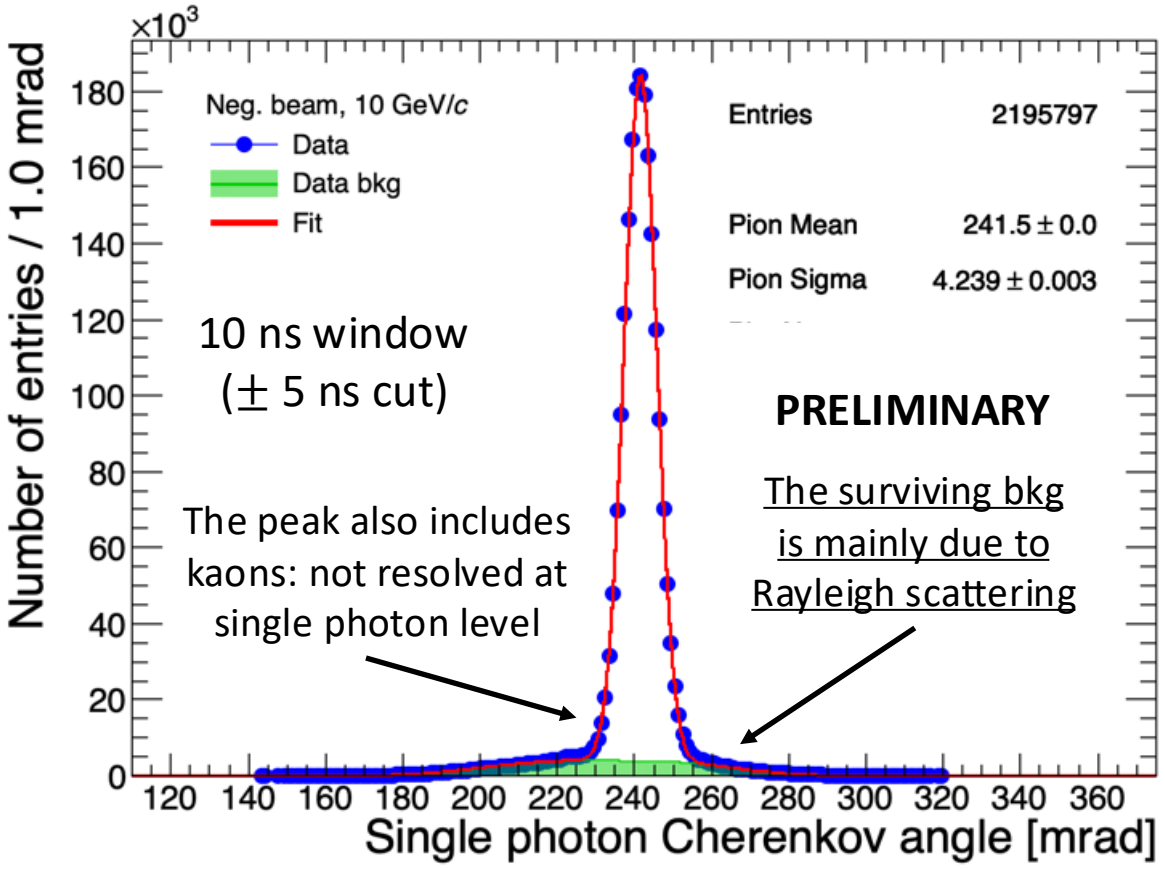
- Assuming all hits at candidate Cherenkov photon for ring reconstuction
- Signal hits fall in a few ns window wrt track on top of Rayleigh / DCR bkg
- Possibility to significantly suppress uncorrelated DCR bkg using timing

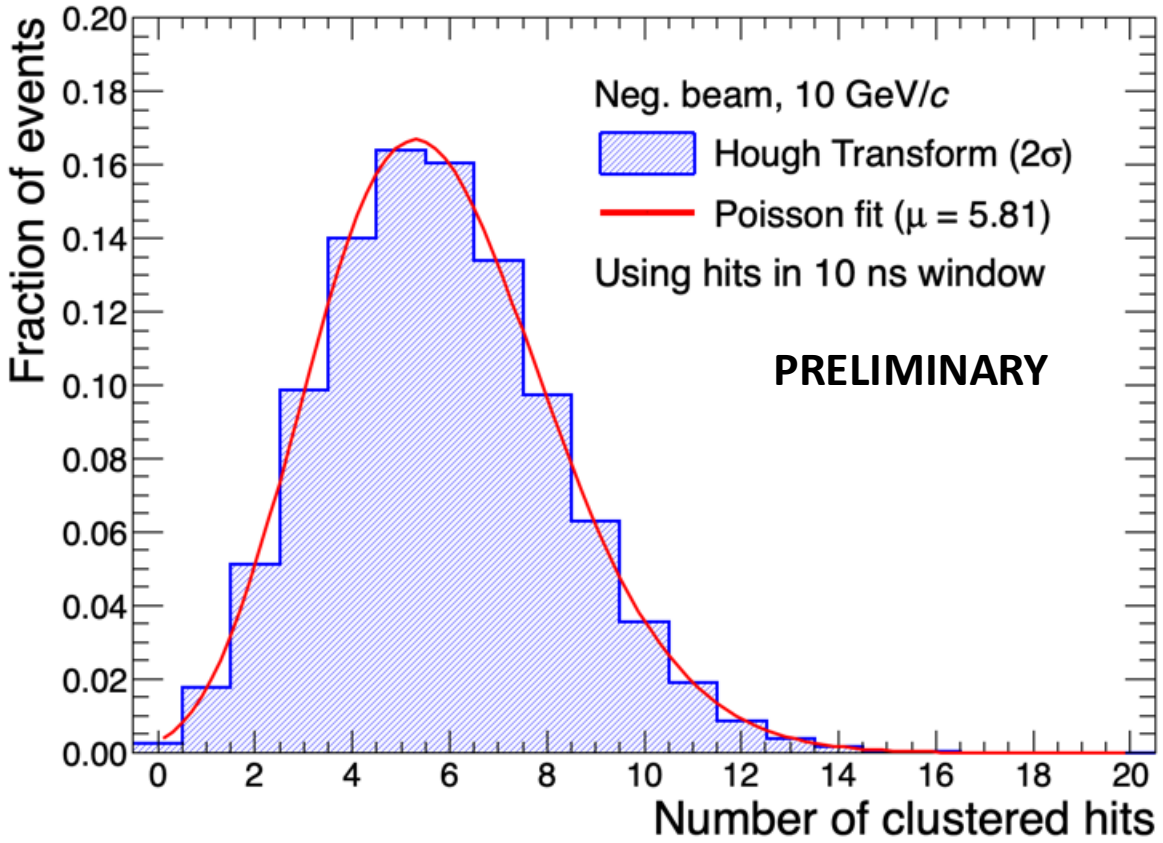




Cherenkov angle recostruction

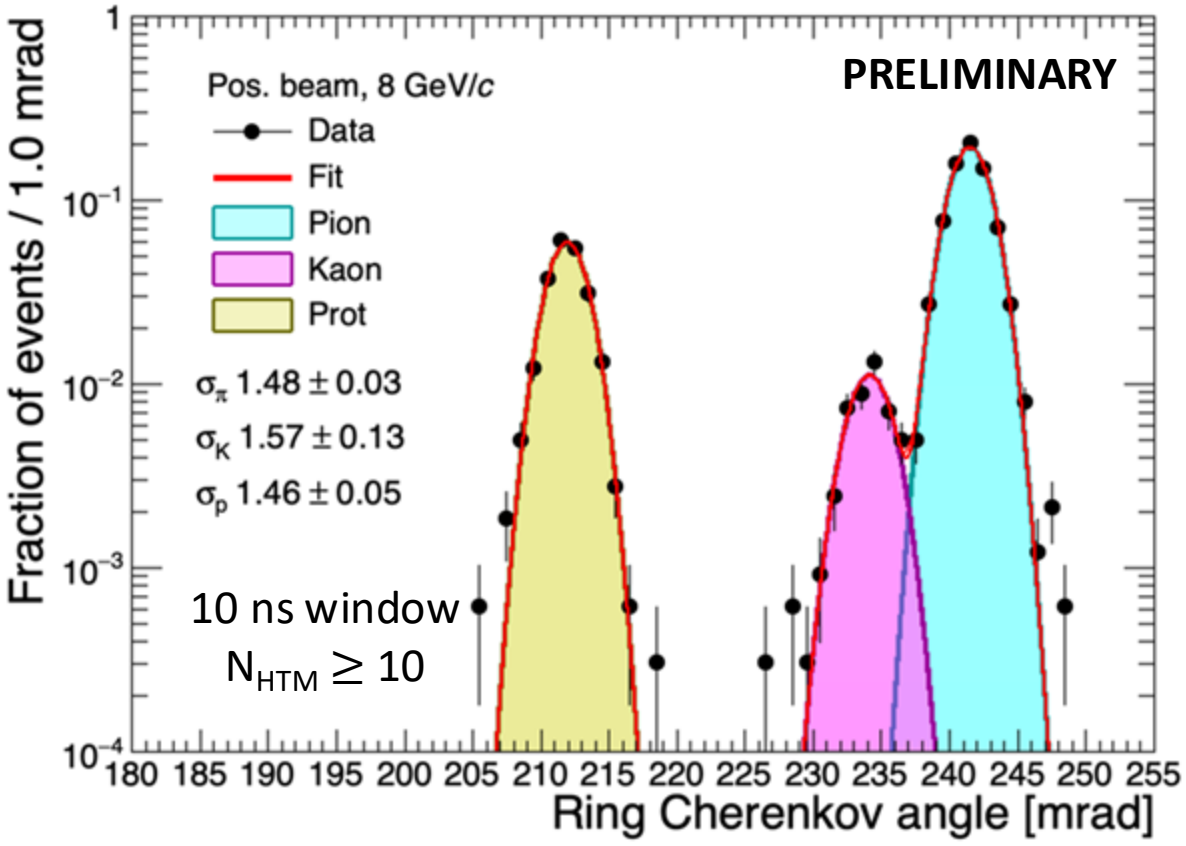
- **Single photon angular resolution at angle saturation of about 4.2 mrad**
- **Background level consistent with expectations @ operation T and V_{ov}**
- **Approximately 6 selected hits per track at saturation with 25% acceptance**

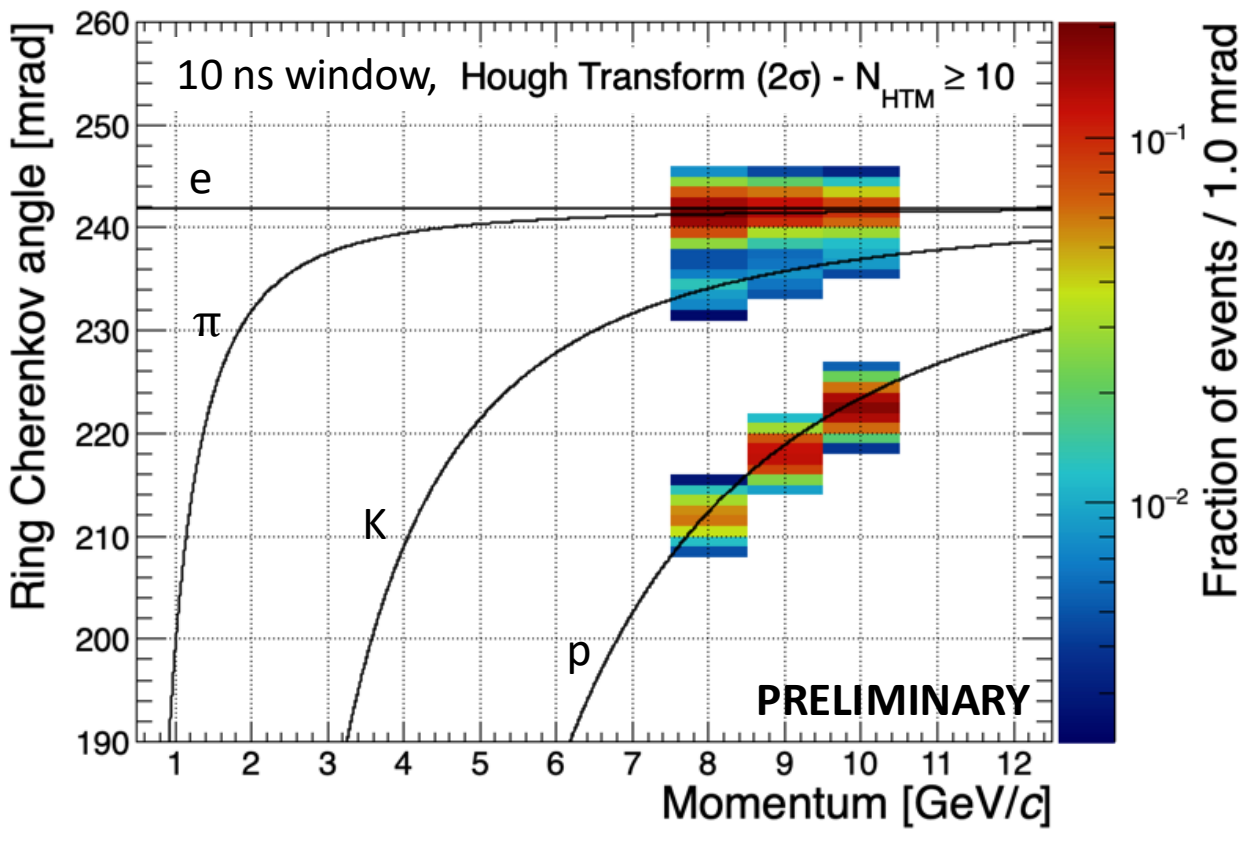




Separation power vs momentum

- Comparing results with positive beam @ 8,9,10 GeV/c with $N_{HTM} \geq 10$
- Reconstructed ring angles follow the expected scaling with momentum
- Separation of π, K and p beyond 3σ, with π/K limit at 10 GeV/*c* as required





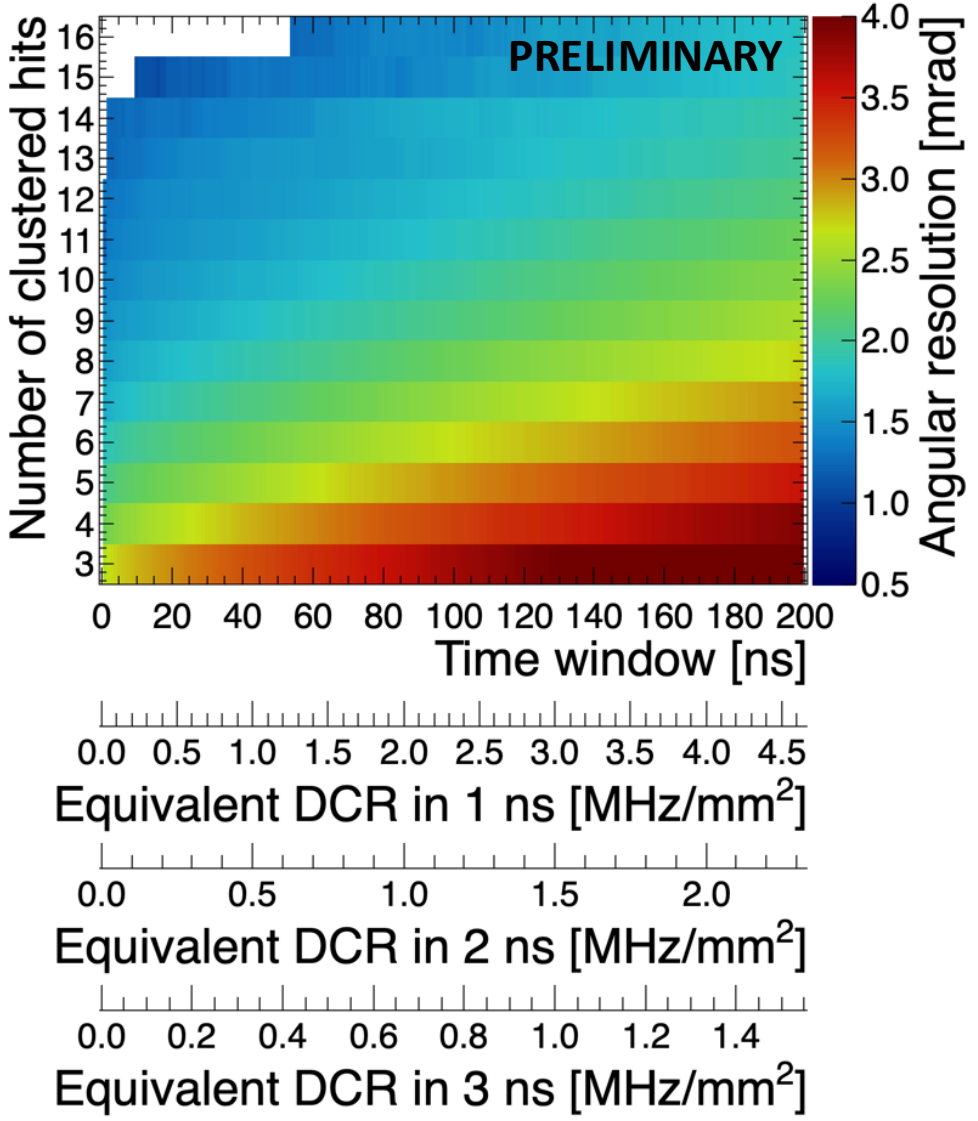
Stability with increasing background

Performance vs time window and DCR

- We studied the pattern recognition stability considering wider and wider windows with the nominal 23.3 kHz/mm^2
- We scaled the resulting mean number of background hits in terms of the **equivalent DCR bkg** we would have in the target **1-2-3 ns acquisition window** for the ALICE 3 RICH

Results

- ≈ **0.5 mrad worsening** up up to **1 - 4 MHz/mm^2 equivalent** depending on the considered acquisition time window
- **This study proves the stability of the reconstruction and physics performance up to the considered DCR levels**



Conclusions

Measured RICH performance

- Measured photon yield, single photon angular resolution and ring angular resolution consistent with ALICE 3 target
- Excellent signal efficiency signal-to-background ratio achieved in time matching windows shorter than 5 ns
- Performance scaling vs momentum in agreement with expectations (e.g. > 3σ π/K separation up to ≈ 10 GeV/c)
- Stable reconstruction performance beyond MHz/mm^2 DCR values considering proper DAQ / time matching windows

Thank you for your attention

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