



The RICH detector of the NA62 experiment

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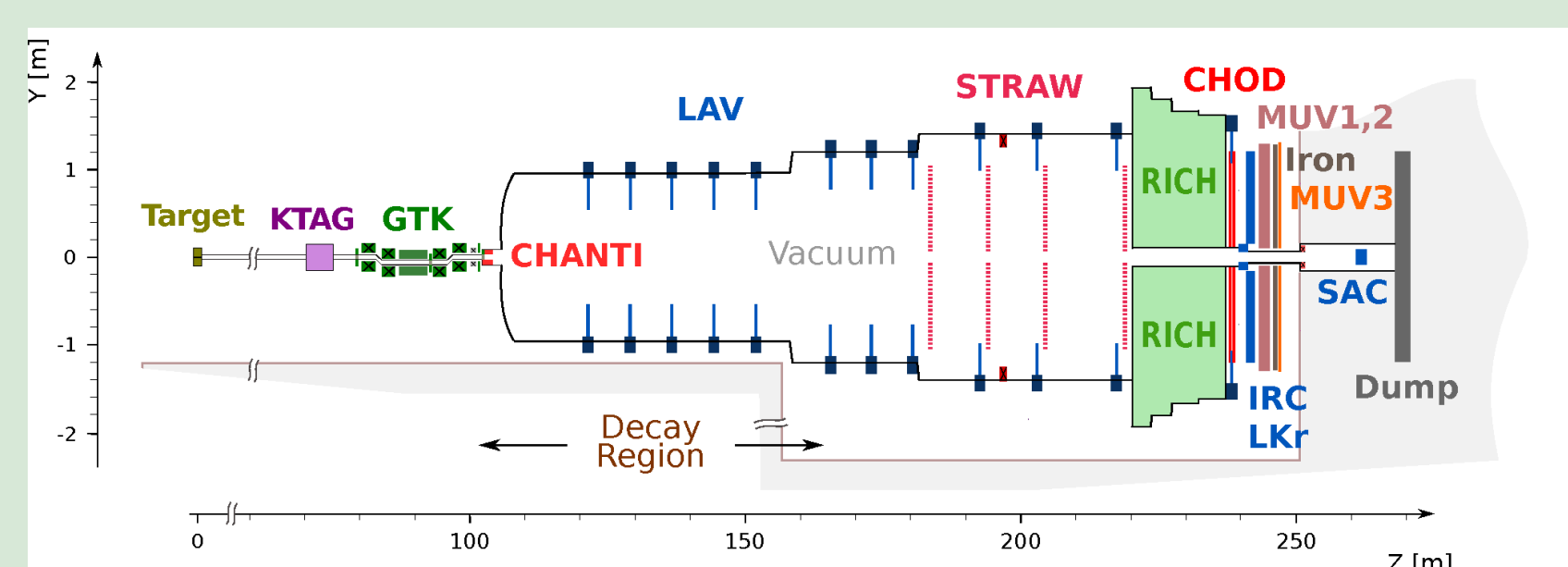
The NA62 experiment

NA62 main goal: $BR(K^+ \rightarrow \pi^+ \nu \bar{\nu})$ measurement, a theoretically clean process, extremely sensitive to new physics.



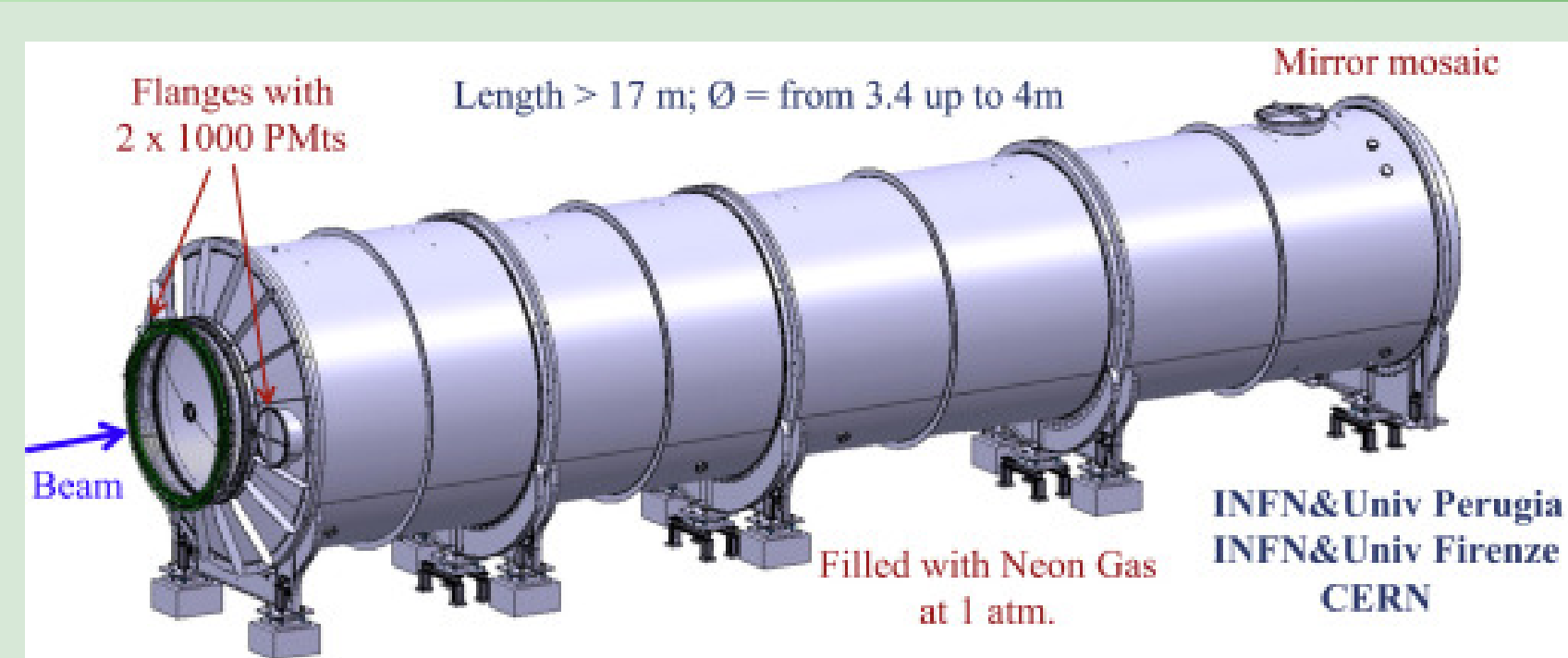
- $BR_{th}(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (0.84 \pm 0.10) \times 10^{-10}$
- $BR_{NA62}(K^+ \rightarrow \pi^+ \nu \bar{\nu}) < 1.85 (2.44) \times 10^{-10}$ @ 90 (95)% C.L.
- $BR_{NA62}(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (0.47^{+0.72}_{-0.47}) \times 10^{-10}$
- A 400 GeV/c proton beam from SPS impinges on a fixed target producing a 75 GeV/c hadron beam ($\sim 6\% K^+$) with a nominal rate of 750 MHz.

Experimental strategy



- High timing resolution to support a high-rate environment
- Kinematic event reconstruction (of both initial and final state)
- Charged Particle IDentification: π, μ, e
- Hermetic vetoing of photons

RICH requirements

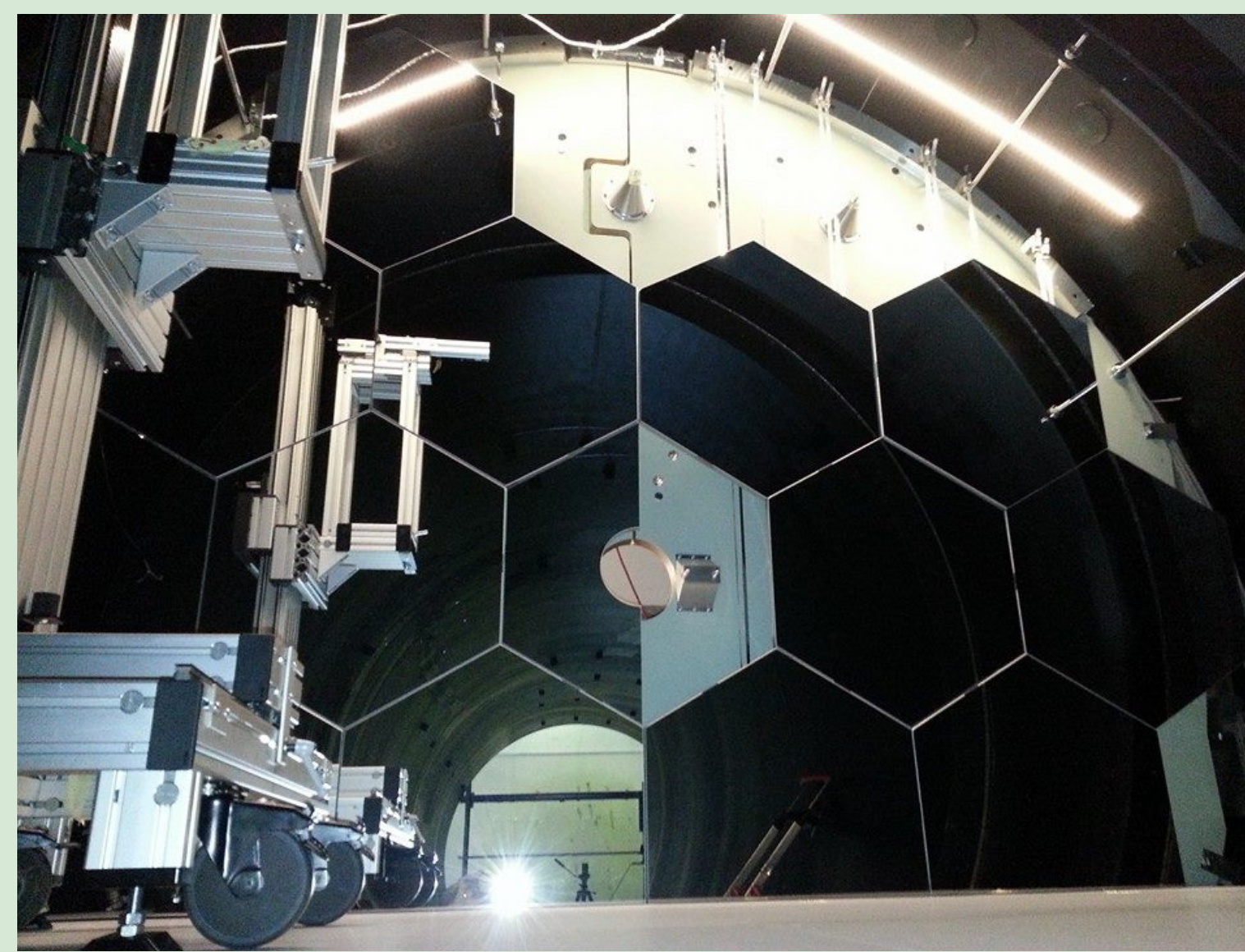


- μ^+ contamination in π^+ sample $\sim 1\%$ for $15 \text{ GeV}/c < p < 35 \text{ GeV}/c$
- measure track crossing time at 100 ps resolution
- provide L0 trigger for charged particles

Vessel and radiator gas

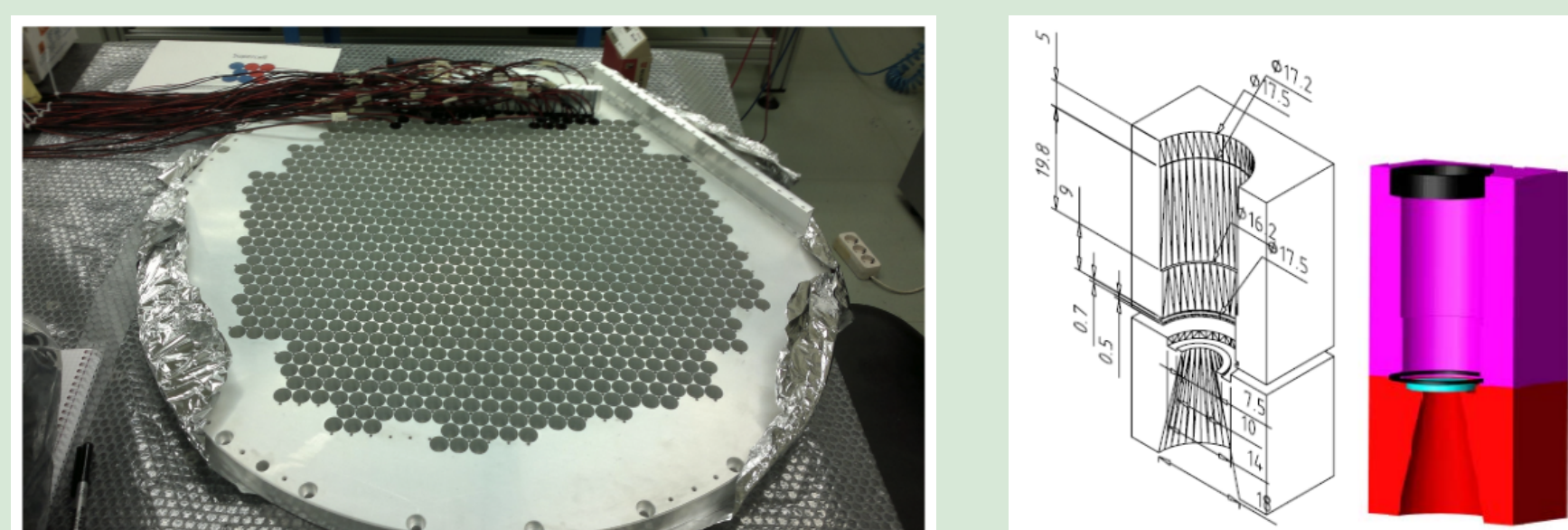
- 4 cylindrical sections of decreasing diameter ($4 \div 3 \text{ m}$)
- beam pipe ($\varnothing 168 \text{ mm}$) at the center
- 200 m^3 of Neon at pressure slightly above 1 atm
- refractive index $(n - 1) = 62.8 \times 10^{-6}$ at $\lambda = 300 \text{ nm}$
- transparent in visible and near-UV and low chromatic dispersion
- low atomic number to minimize X_0
- Cherenkov threshold for π :
 $p_{thres} = m/\sqrt{n^2 - 1} = 12.5 \text{ GeV}/c$

Mirror system



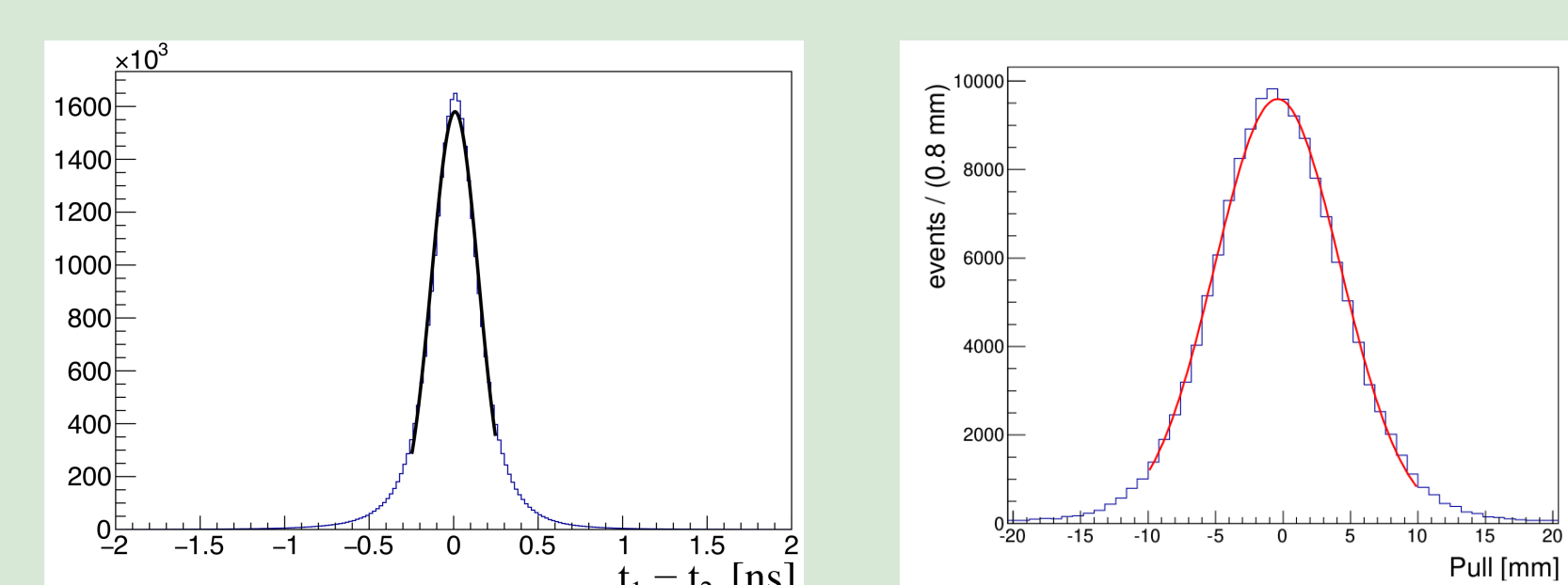
- mosaic of 20 spherical mirrors with curvature radius of 34 m
- 18 hexagonal mirrors 35 cm side and 2 semi-hexagonal mirrors with hole for beam pipe
- 2.5 cm thick glass, aluminium coat and MgF_2 protective layer
- average reflectivity $\sim 90\%$ for λ in 195-650 nm
- $D_0 \sim 4 \text{ mm}$
- support structure: aluminium honeycomb panel
- mirrors supported by a back dowel, two Al ribbons keep the mirror in equilibrium and allow its orientation while a third ribbon prevents rotations
- alignment through piezo-motors out of acceptance with $\simeq 1 \text{ mm}$ precision

Light collection



- 1952 PMs Hamamatsu R7400U-03 located in two spots (976 each spot)
- 16 mm wide face, 8 mm active region, packed in hexagonal structure with 18 mm cell size
- UV glass window and bialkali cathode
- 8 dynodes, gain = 1.5×10^6 at 900 V
- sensitive between 185 \div 690 nm
- Q.E. = 20% @ $\lambda_{peak} \sim 420 \text{ nm}$
- PMs located in air and separated by neon by a quartz window
- Winston cone to increase the geometrical coverage

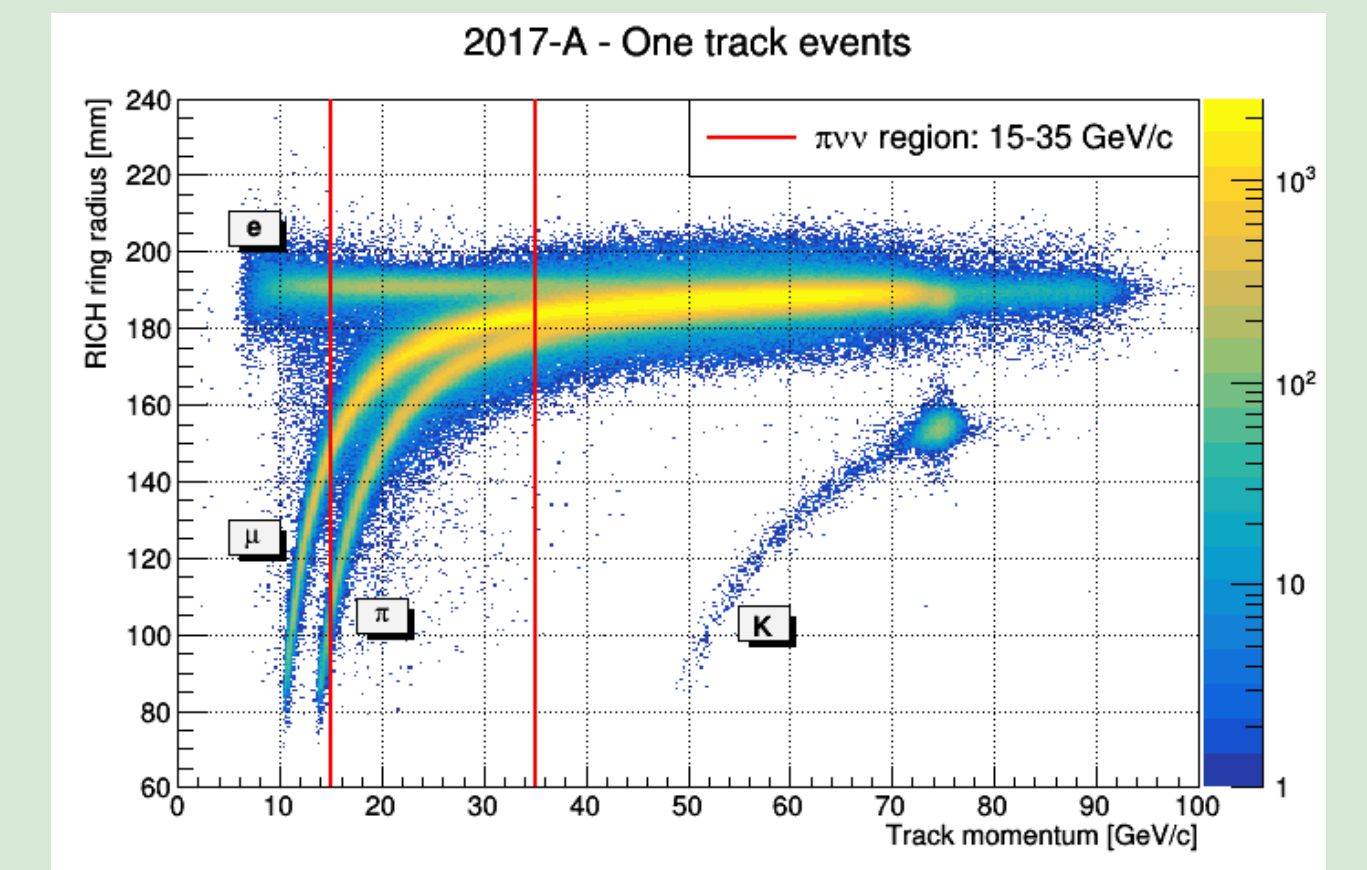
Time and space resolution



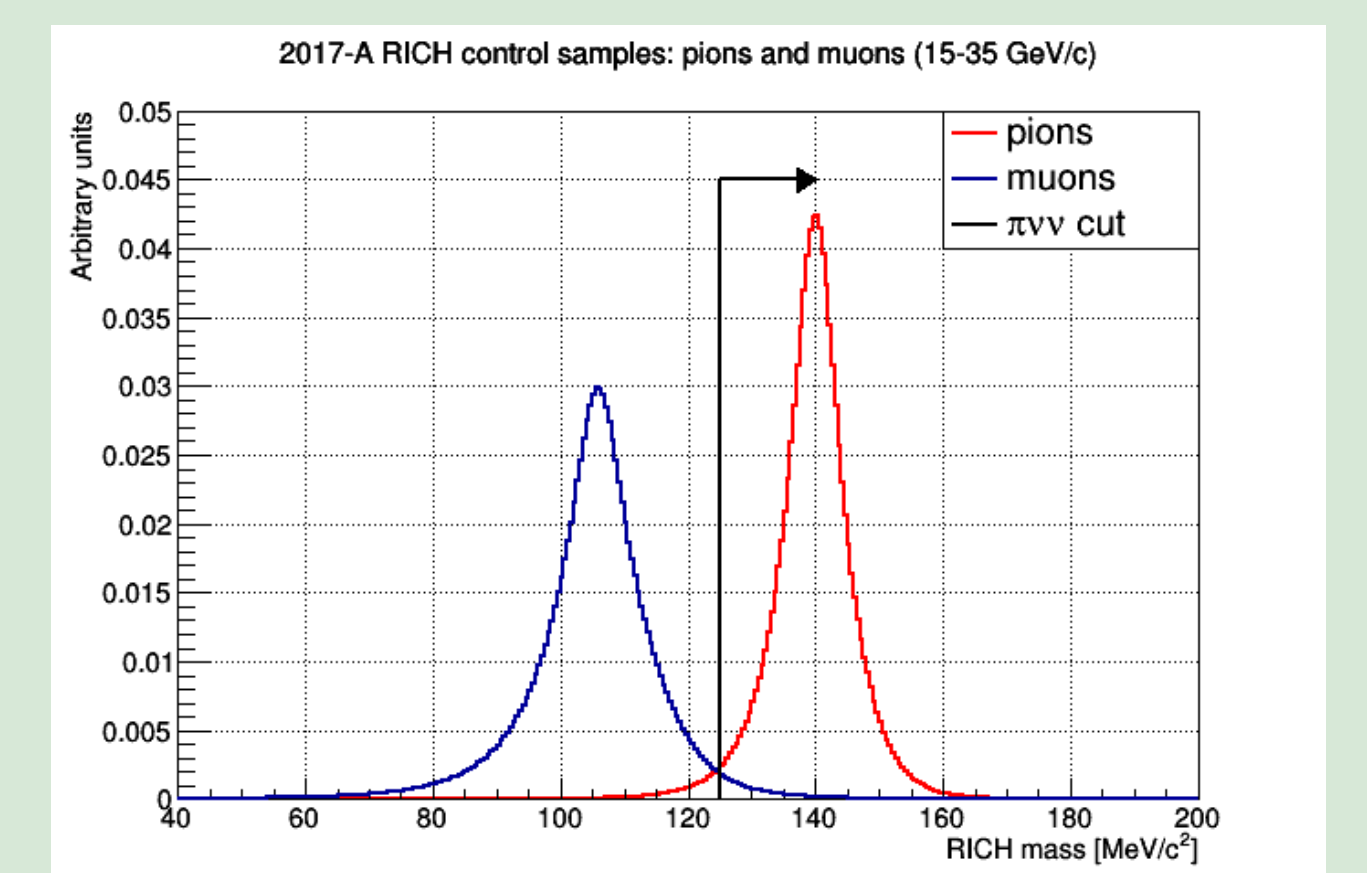
- Time difference between 2 groups of photons in the same ring: $\sigma_{t_1-t_2}$ is measured.
- Time resolution: $\sigma_t = 0.5 \cdot \sigma_{t_1-t_2} \simeq 70 \text{ ps}$.
- $Pull = (R - R^{exp})\sqrt{(N_{hits} - 3)}$
- Single hit resolution: $\sigma_{Hit} = \sigma_{Pull} \simeq 4.7 \text{ mm}$

RICH for $\pi\nu\nu$ study (2017 data)

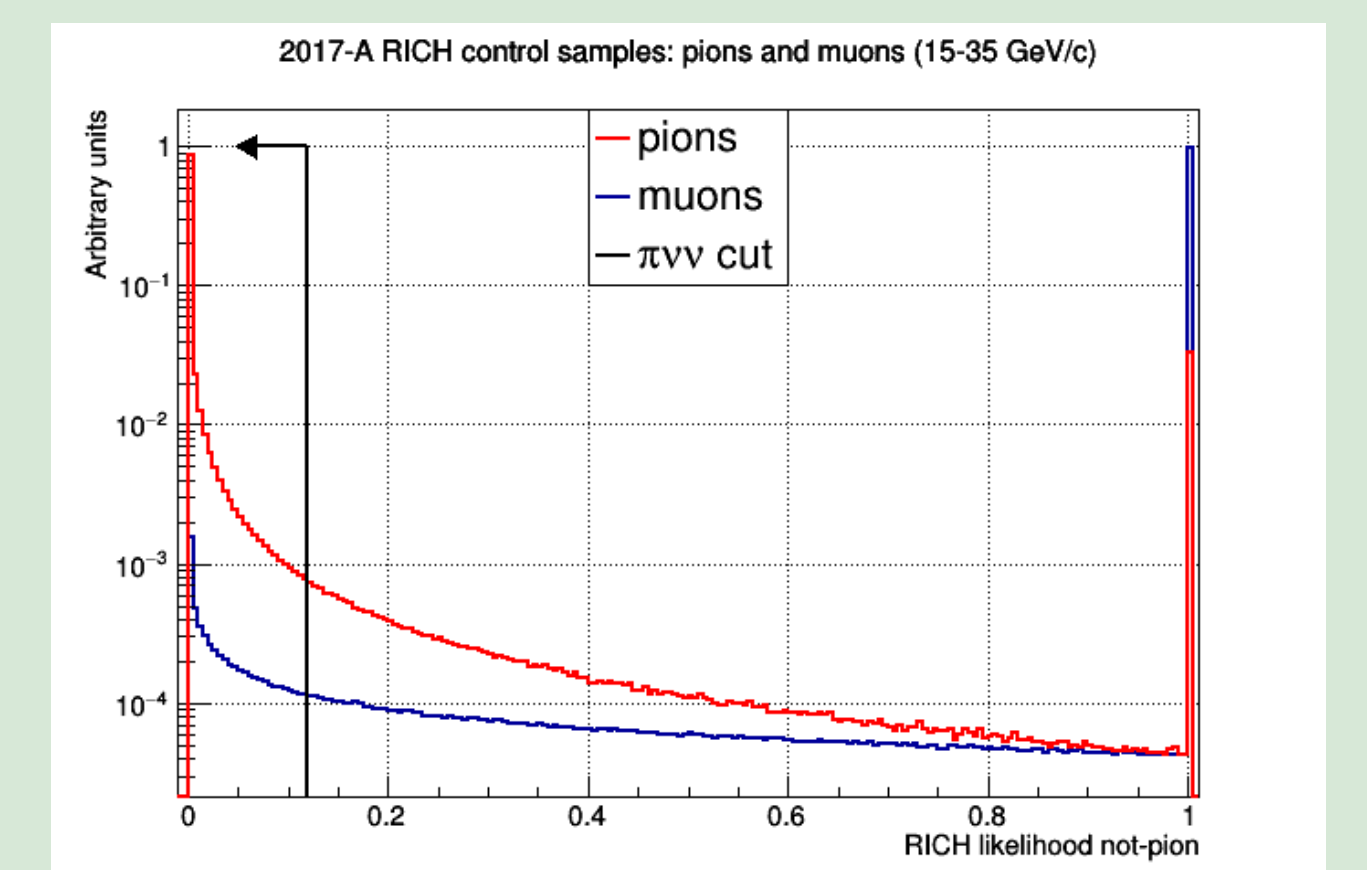
- Cherenkov ring radius (R) as a function of track momentum (P):



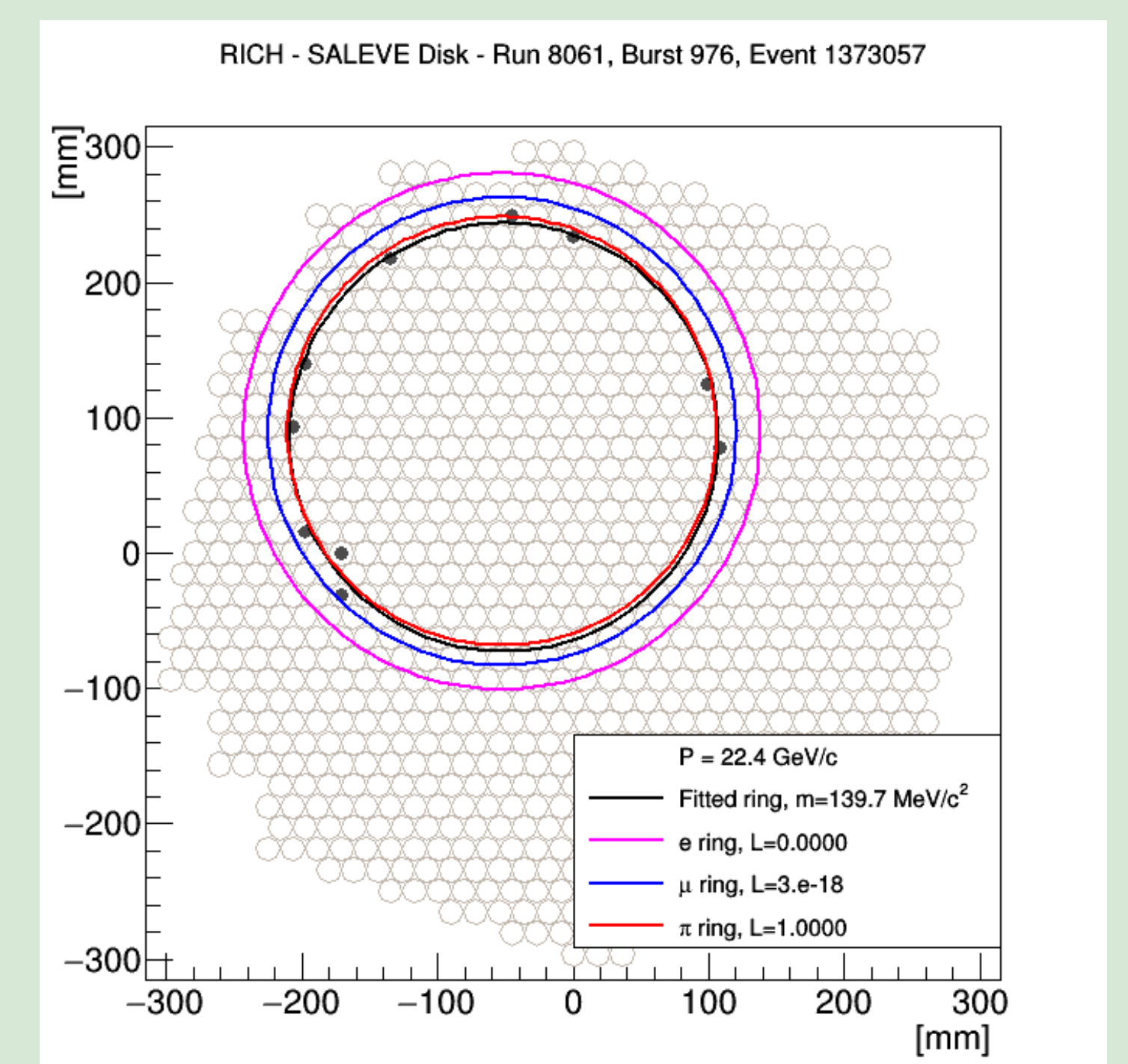
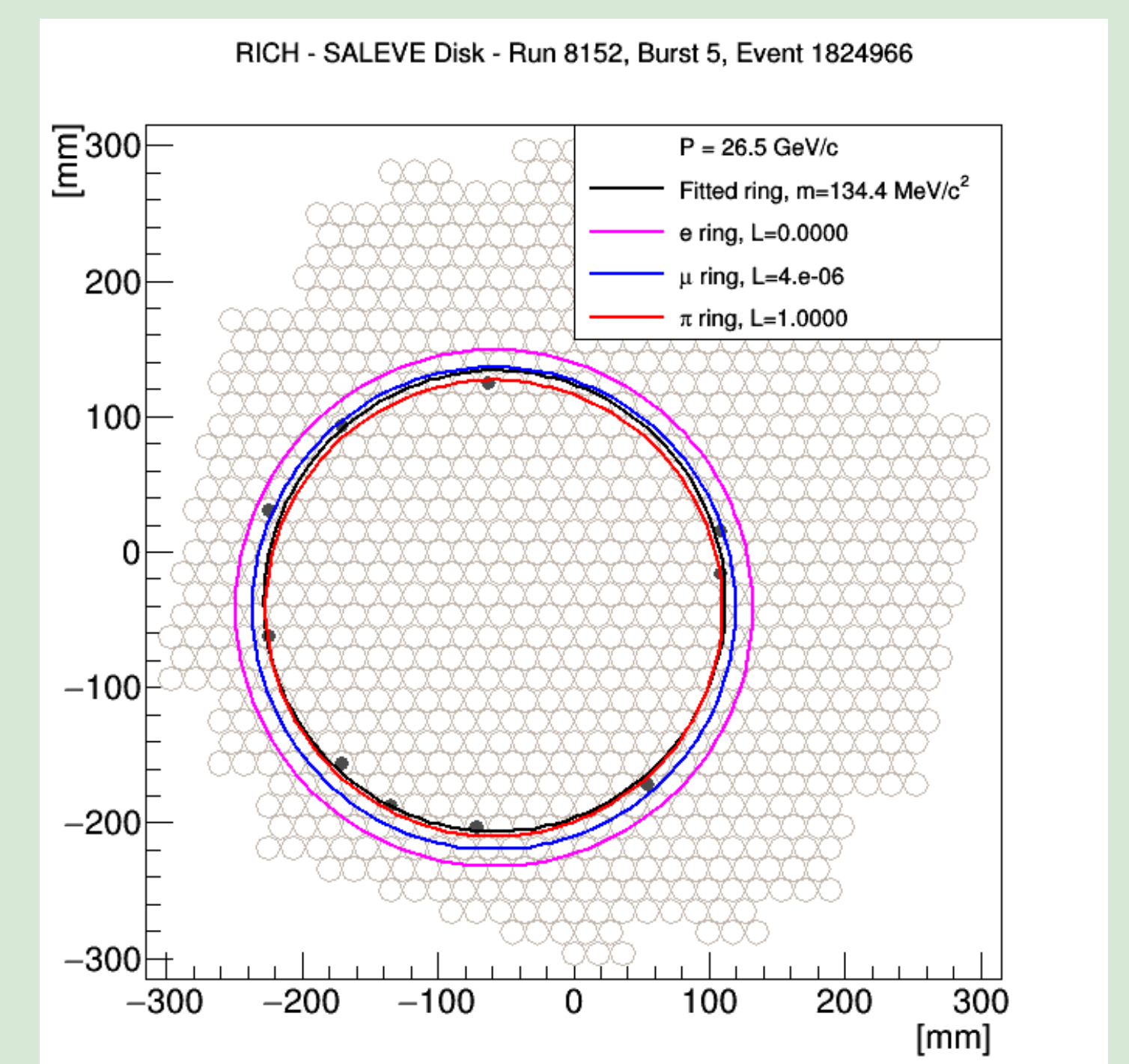
- Particle mass, $m(R, P)$, reconstructed with RICH, for muons and pions in the momentum range 15-35 GeV/c:



- RICH highest likelihood of the not-pion hypotheses, $L(not \pi)$, for muons and pions in the momentum range 15-35 GeV/c:



- Pion PID in $\pi\nu\nu$ selection:
 $m(R, P) > 125 \text{ MeV}/c^2, L(not \pi) < 0.12$
- The two $\pi\nu\nu$ candidates in RICH:



- RICH performance in $\pi\nu\nu$ analysis:
 $\epsilon(\pi) \simeq 83\% @ \epsilon(\mu) \simeq 0.2\%$ (in 15-35 GeV/c)