Final performances of the NA62 RICH detector

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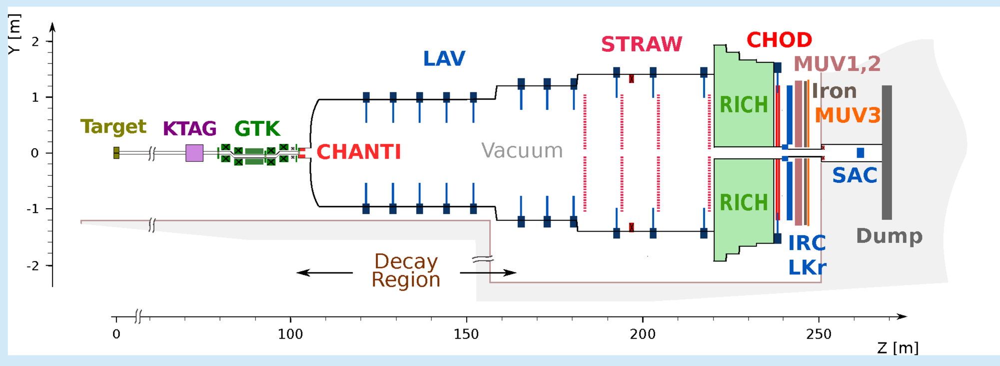
The NA62 experiment

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

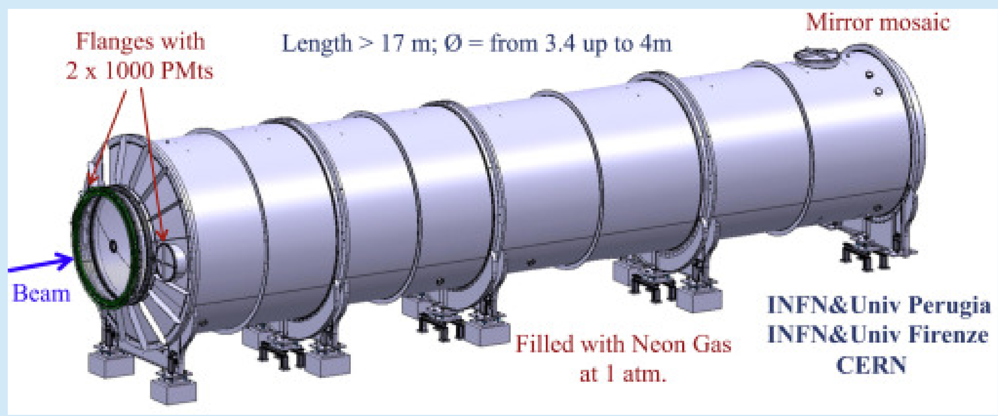
- $BR_{th}(K^+ \to \pi^+\nu\bar{\nu}) = (0.84 \pm 0.10) \times 10^{-10}$
- $BR_{\text{NA62}}(K^+ \to \pi^+\nu\bar{\nu}) < 1.85\ (2.44) \times 10^{-10}$ @ 90 (95)% C.L.
- $BR_{\text{NA62}}(K^+ \to \pi^+\nu\bar{\nu}) = (0.47^{+0.72}_{-0.47}) \times 10^{-10}$
- A 400 GeV/c proton beam from SPS impinges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

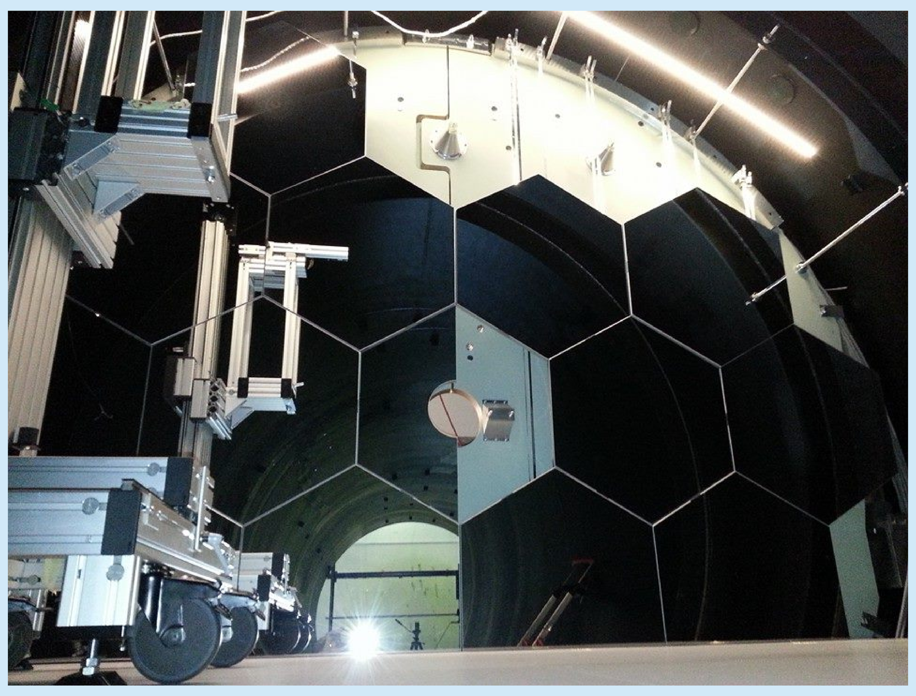


- **μ^+ contamination** in π^+ sample **∼ 1%** for 15 GeV/c $< p <$ 35 GeV/c
- measure track crossing time at **100 ps** resolution
- provide **L0 trigger** for charged particles

Vessel and radiator gas

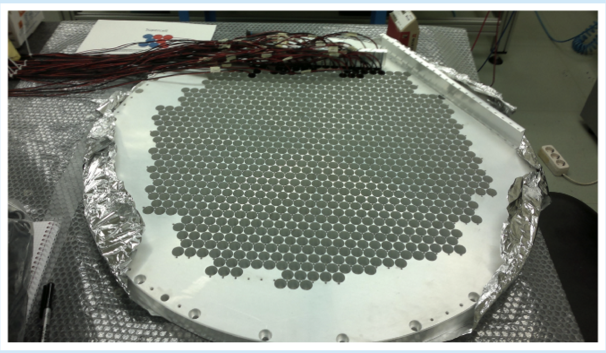
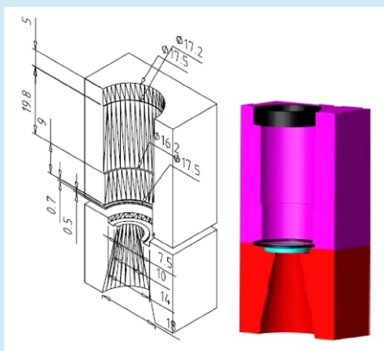
- 4 cylindrical sections of decreasing diameter (4 ÷ 3 m)
- beam pipe (⌀ 168 mm) at the center
- 200 m^3 of Neon at pressure slightly above 1 atm
- refractive index $(n-1) = 62.8 \times 10^{-6}$ at $\lambda = 300$ nm
- transparent in visible and near-UV and low chromatic dispersion
- low atomic number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

Mirror system



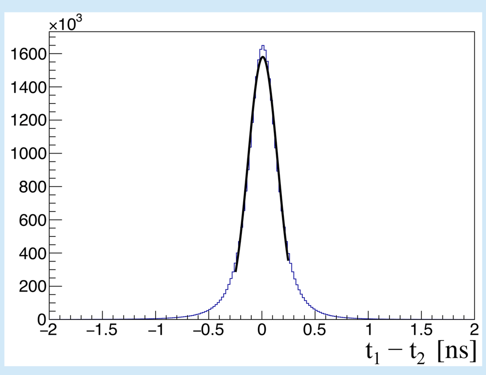
- mosaic of 20 spherical mirrors with curvature radius of 34 m
- 18 hexagonal mirrors 35 cm side and 2 semi-hexagonal mirrors with hole for beam pipe
- 2.5 cm thick glass, aluminium coat and MgF_2 protective layer
- average reflectivity ∼ 90% for λ in 195-650 nm
- D_0 ∼ 4 mm
- support structure: aluminium 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 ≃ 1 mm precision

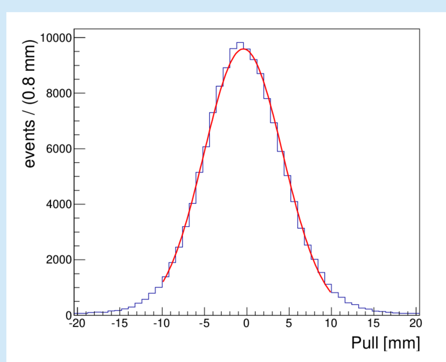
Light collection

- 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 ÷ 690 nm
- Q.E. = 20% @ λ_{peak} ∼ 420 nm
- PMs located in air and separated by neon by a quartz window
- Winston cone to increase the geometrical coverage

Time and space resolution

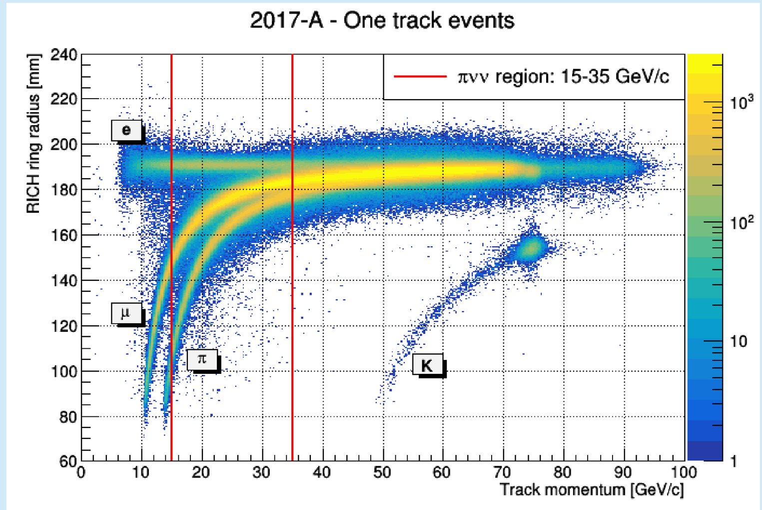




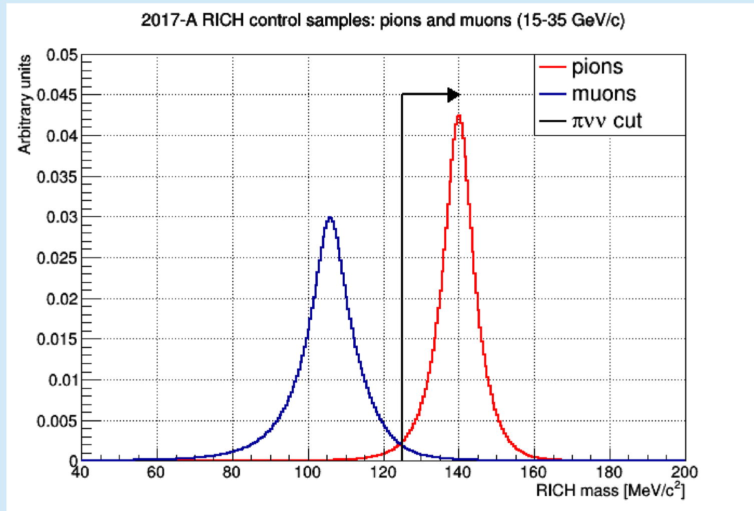
- Time difference between 2 groups of photons in the same ring: $\sigma_{t_1-t_2}$ is measured.
- Time resolution: $\sigma_t = 0.5 \cdot \sigma_{t_1-t_2} \simeq$ **70** ps.
- $Pull = (R - R^{exp})\sqrt{(N_{hits}-3)}$
- Single hit resolution: $\sigma_{Hit} = \sigma_{Pull} \simeq$ **4.7** mm

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

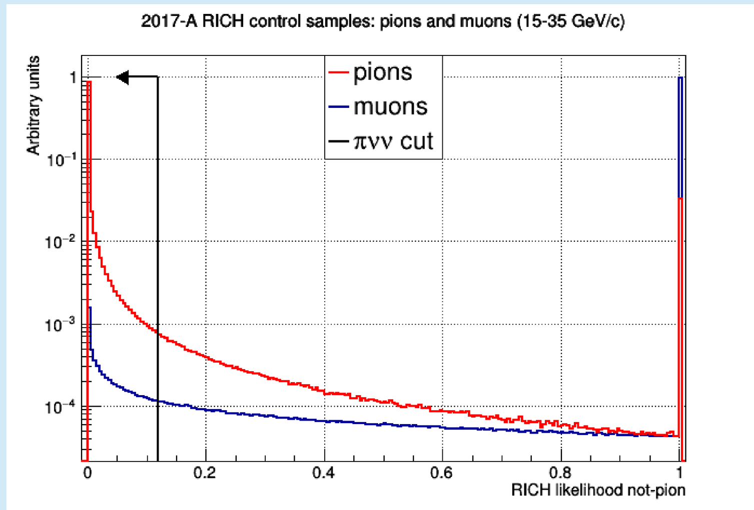
- Cherenkov ring radius (R) as a function of track momentum (P):



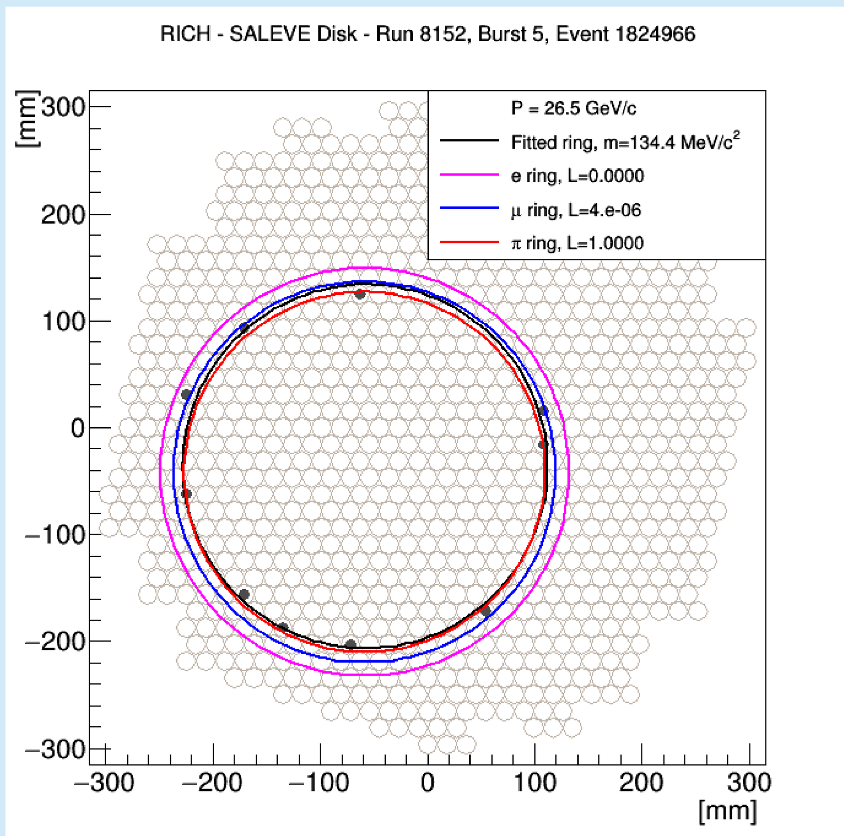
- Particle mass, $m(R,P)$, reconstructed with RICH, for muons and pions in the momentum range 15-35 GeV/c:

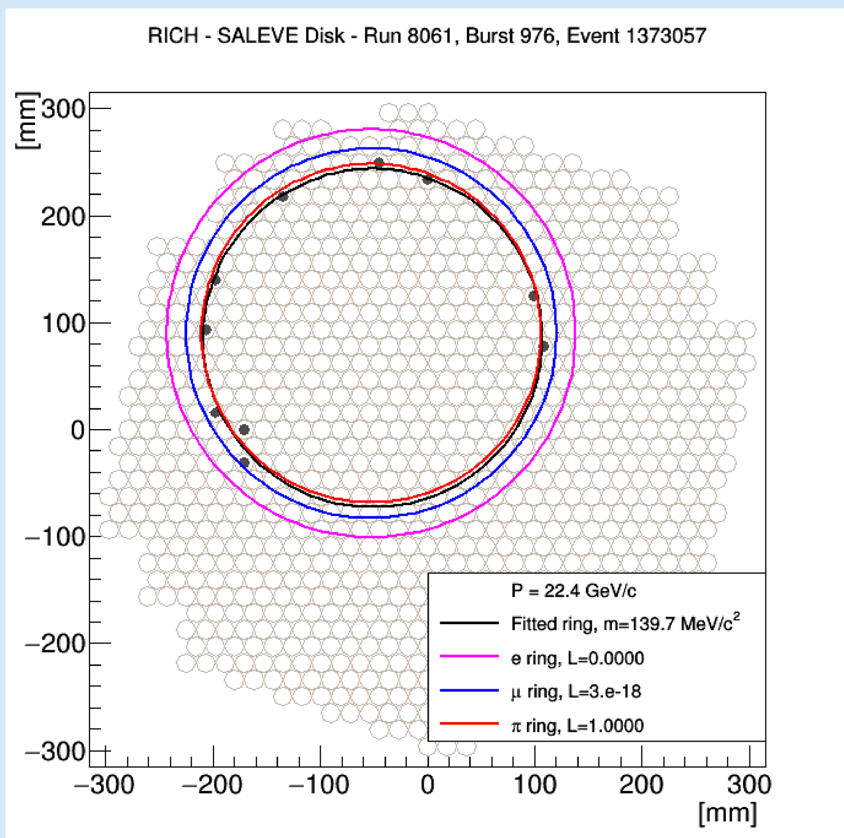


- RICH highest likelihood of the not-pion hypotheses, $L(not\ \pi)$, for muons and pions in the momentum range 15-35 GeV/c:



- Pion PID in $\pi\nu\nu$ selection: $m(R,P) > 125\ MeV/c^2$, $L(not\ \pi) < 0.12$
- 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)

M. Lenti, *on behalf of the NA62 Collaboration* - IPRD19, Siena (Italy) 14-17 October 2019