The NA62 experiment

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

- $\text{BR}(K^+ \to \pi^+\nu\bar{\nu}) = (0.84 \pm 0.10) \times 10^{-10}$
- $\text{BR}_{\text{NA62}}(K^+ \to \pi^+\nu\bar{\nu}) < 1.85(2.44) \times 10^{-10}$
  @ 90 (95)% C.L.
- $\text{BR}_{\text{NA62}}(K^+ \to \pi^+\nu\bar{\nu}) = (0.47 \pm 0.72) \times 10^{-10}$
- 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.

RICH requirements

- $\mu^+$ contamination in $\pi^+$ sample ~ 1% for 15 GeV/c < $p$ < 35 GeV/c
- measure track crossing time at 100 ps resolution
- provide L0 trigger for charged particles

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 $\lambda$ in 195-650 nm
- $D_0 \sim 4$ 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 $\sim 1$ 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 = $1.5 \times 10^6$ at 900 V
- sensitive between 185 - 690 nm
- Q.E. = 20% @ $\lambda_{\text{peak}} \sim 420$ nm
- PMs located in air and separated by neon by a quartz window
- Winston cone to increase the geometrical coverage

Vessel and radiator gas

- 4 cylindrical sections of decreasing diameter (4 ÷ 3 m)
- beam pipe (~ 168 mm) at the center
- 209 m$^3$ of Neon at pressure slightly above 1 atm
- refractive index ($n - 1$) = 62.8 × 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 $\pi$: $p_{\text{thr}} = m/\sqrt{n^2 - 1} = 12.5$ GeV/c

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.
- $P_{\text{full}} = (R - \text{CPR}) \sqrt{\text{L}_{\text{comb}} - 3}$
- Single hit resolution: $\sigma_{H\text{it}} = \sigma_{\text{Pfull}} \simeq 4.7$ mm

Experimental strategy

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

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

- Particle mass, $m(R, P)$, reconstructed with RICH, for muons and pions in the momentum range 15-35 GeV/c.
- $L(\text{not } \pi) \sim 0.12$
- The two $\pi\nu\nu$ candidates in RICH:

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