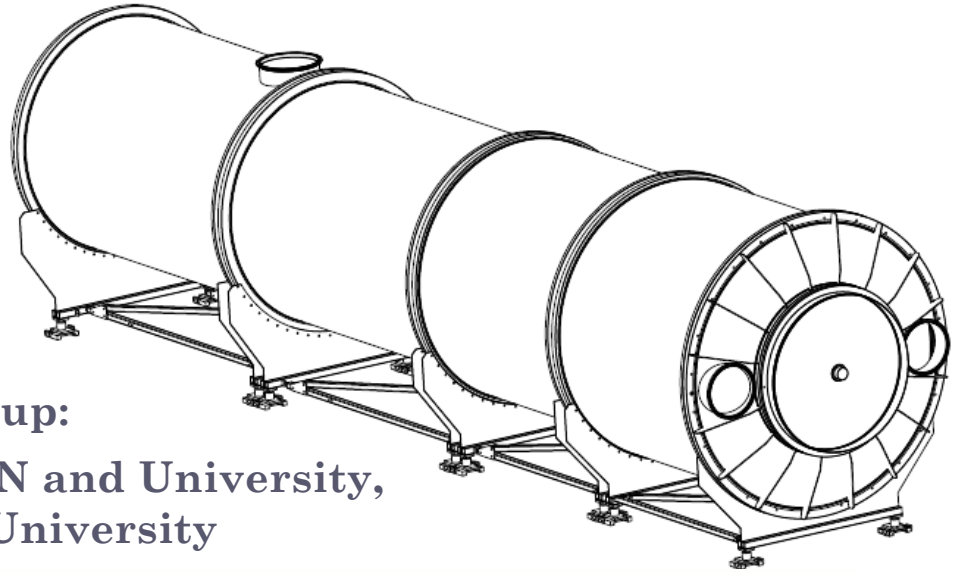
PERFORMANCES OF THE NA62 RICH DETECTOR

Francesca Bucci
INFN, Sezione di Firenze
on behalf of the NA62 collaboration



RICH Working Group:
CERN, Firenze INFN and University,
Perugia INFN and University

FRONTIER DETECTORS FOR FRONTIER PHYSICS
13th Pisa Meeting on Advanced Detectors

24-30 May 2015 - *La Biodola, Isola d'Elba (Italy)*
Europe/Rome timezone

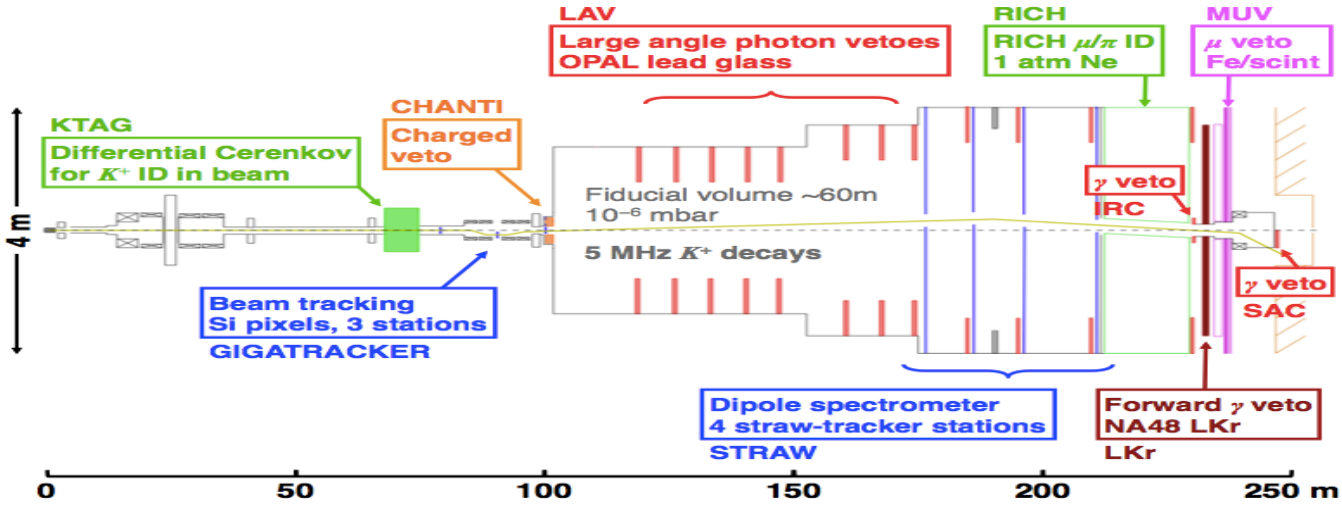
THE NA62 EXPERIMENT

Fixed target experiment at the CERN Super Proton Synchrotron

NA62 primary goal: Measure BR($K^+ \to \pi^+ \nu\bar{\nu}$) with 10% accuracy by collecting O(100) SM events in 3 years of data taking

One of the theoretically cleanest channel in flavor physics

BR($K^+ \to \pi^+ \nu\bar{\nu}$) = $(7.81 \pm 0.75 \pm 0.29) \times 10^{-11}$ [Phys. Rev. D83 (2011) 034030]



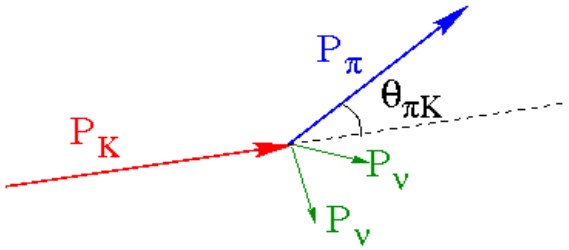
2012-2014: Detector Installation
October 2014: NA62 Pilot Run

2015-2016-2017: Physics Runs

The NA62 Challenge

Suppression of decay channels with BR ≥ 10^{10} BR($K^+ \to \pi^+ \nu\bar{\nu}$)
and similar experimental signature: BR($K^+ \to \mu^+ \nu$)=63.4%

- Need good kinematic rejection: 10^{-5} (GTK+STRAW)



$$m^2_{miss} = (p_K - p_\pi)^2$$

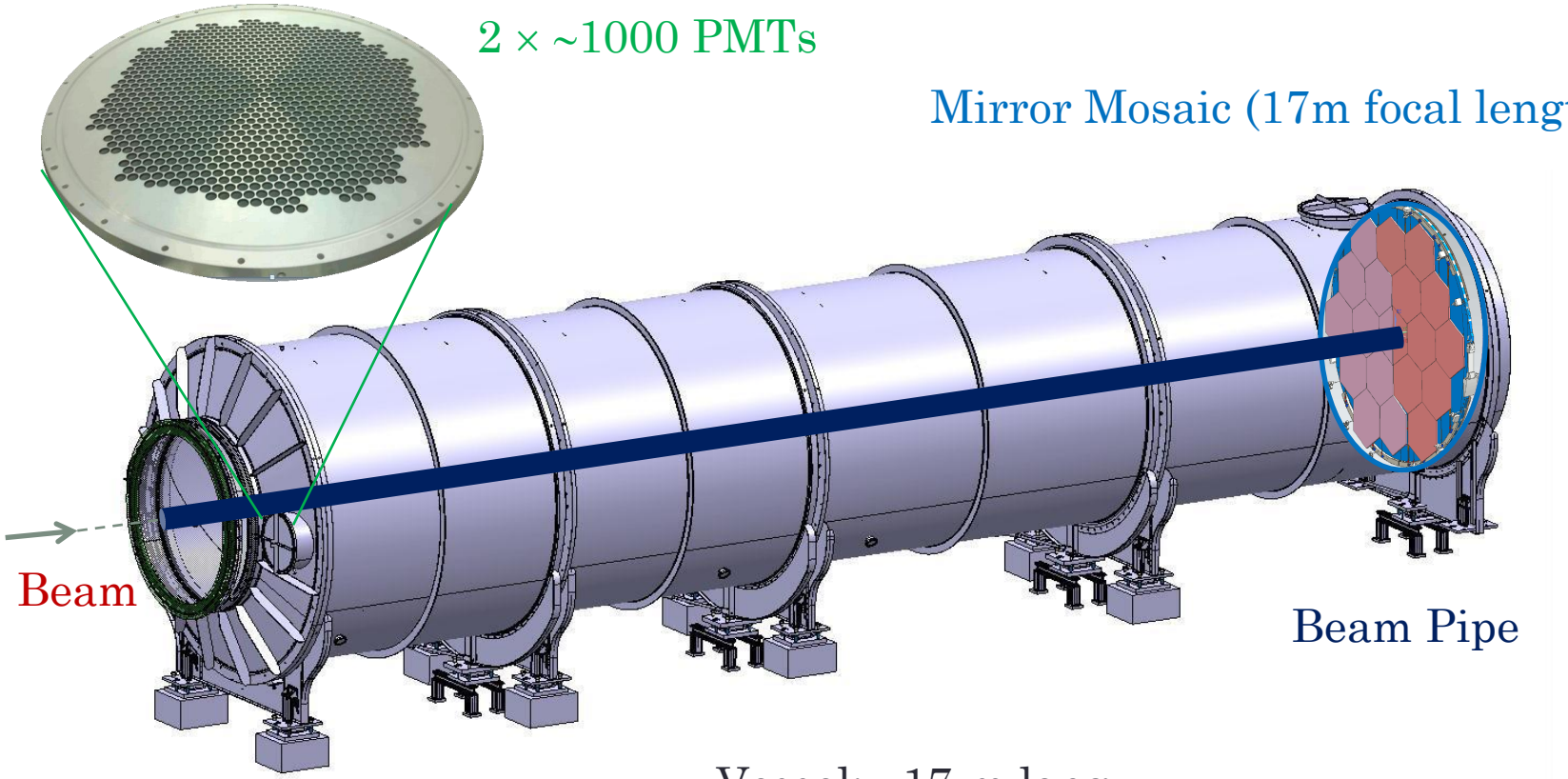
- Need good PID: muon veto 10^{-5} (MUV), pion identification with muon contamination <10^{-2} (RICH)

- Need precise timing: 100 ps both upstream (GTK) and downstream (RICH) the decay region

RICH Requirements

- Suppress the μ contamination in the π sample by a factor of at least 100 between 15 and 35 GeV/c momentum
- Measure the pion crossing time with a resolution of about 100 ps
- Produce the L0 trigger for a charged track

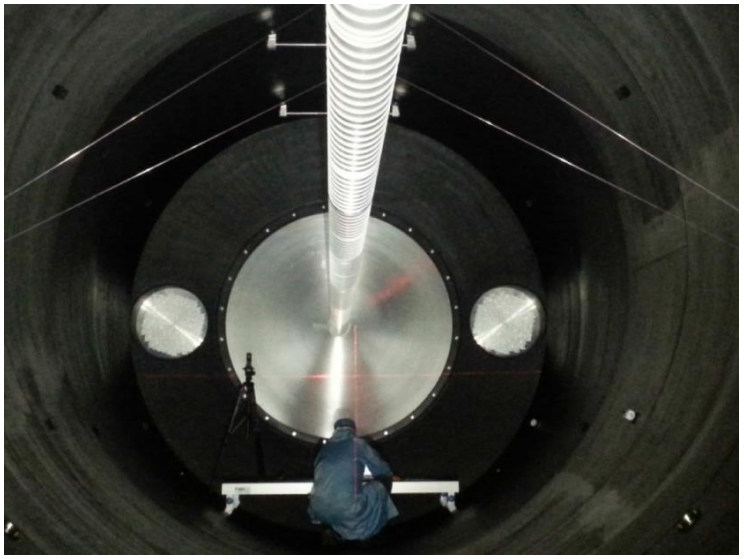
The RICH Layout



Vessel: ~17 m long

RICH Vessel

- Vacuum proof tank
- 17 m long made of structural steel
- subdivided into 4 cylindrical sections of decreasing diameter (4→3.4 m) and different lenghts
- beam pipe (∅ 168 mm) going through
- thin Al entrance and exit windows



RICH Radiator

RICH vessel has an overall volume of 200 m^3

- Neon slightly above atmospheric pressure at room temperature
- $(n-1) = 62.8 \times 10^{-6}$ at $\lambda = 300$ nm
- $p_{threshold} = m/\sqrt{(n^2 - 1)} = 12.5$ GeV/c for π
- Good light trasparency in visible and near UV, low chromatic dispersion

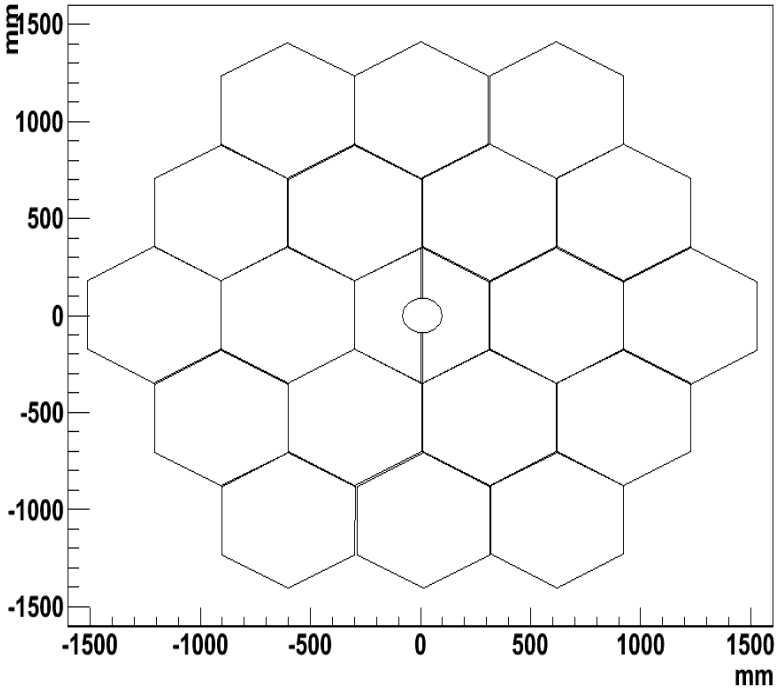
RICH performances rather immune to impurities ⇒
operated with a sealed gas volume without gas renewal

During the pilot run the leak rate was much smaller than 0.1 mbar l/s

RICH Mirror

A mosaic of 20 spherical mirrors used to reflect the Cherenkov light

- 18 hexagonal mirrors (35 cm side)
- 2 semi-hex with pipe hole



2.5 cm thick glass coated with Al

Thin dielectric film added

Optical parameters

- R=(34.0±0.2) m
- Average reflectivity > 90% (195-650 nm)
- $D_0 \leq 4$ mm

Mirrors Support

Al honeycomb structure, 5 cm thick, chosen as mirror support panel

- Mirrors are supported by a dowel inserted in the back and connected to the panel
- Two thin aluminium ribbons keep the mirror in equilibrium and allow its orientation
- A third vertical ribbon is used to avoid mirror rotations
- The semi-hexagonal mirrors have two holes and a single ribbon

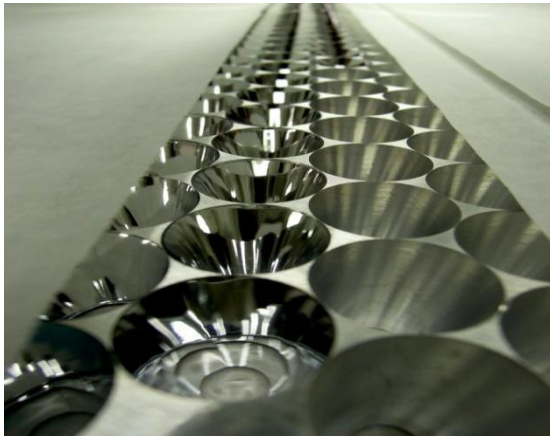
Piezo motors, out of the acceptance, allow a remotely controlled orientation

Preliminary mirrors alignment by using laser

RICH Photo-Detection System

The reflected light is collected by 1952 PMTs with 18 mm pixel size

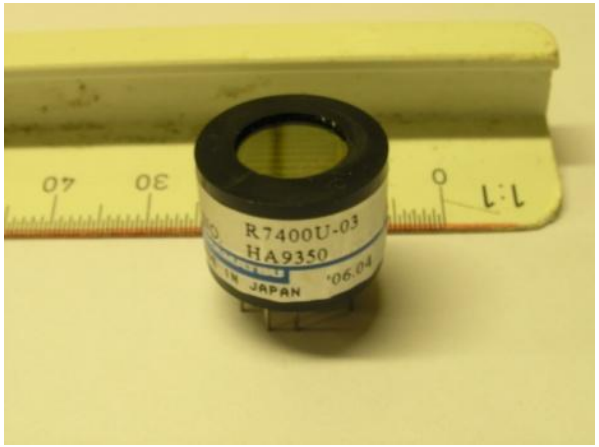
The PMTs are assembled in a compact hexagonal packing into 2 aluminium disks placed at the upstream endcap



Light is collected by means of Winston cones with aluminized mylar foil
Quartz windows to separate neon from air

RICH PMTs

- Hamamatsu R7400U-03
- UV glass window, 16 mm ∅ (8 mm active ∅)
- Custom made HV divider

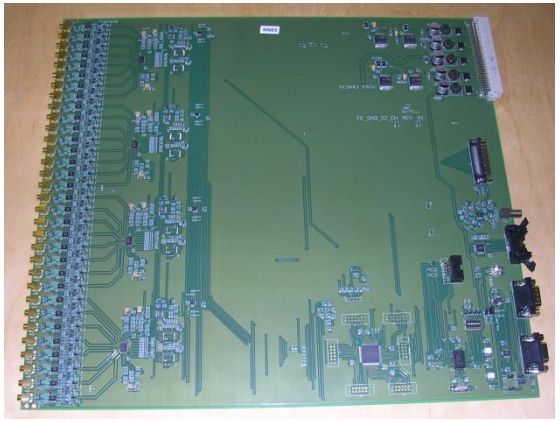


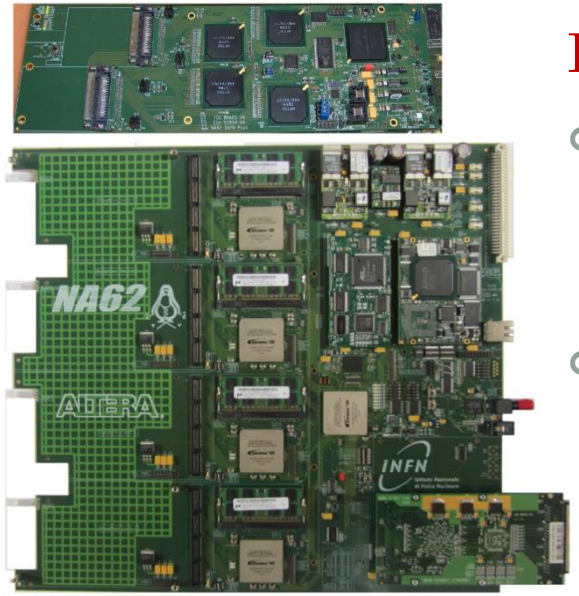
- Sensitivity range 185-650 nm (420 nm peak)
- Gain 1.5×10^6 at 900 V
- Q.E. ~ 20% at peak
- 280 ps time jitter (FWHM)

RICH Front-End and Read-Out System

RICH front-end

- Custom-made current amplifiers with differential output
- NINO chips used as discriminators
- 64 boards
- Each boards has 32 channels





RICH read-out:

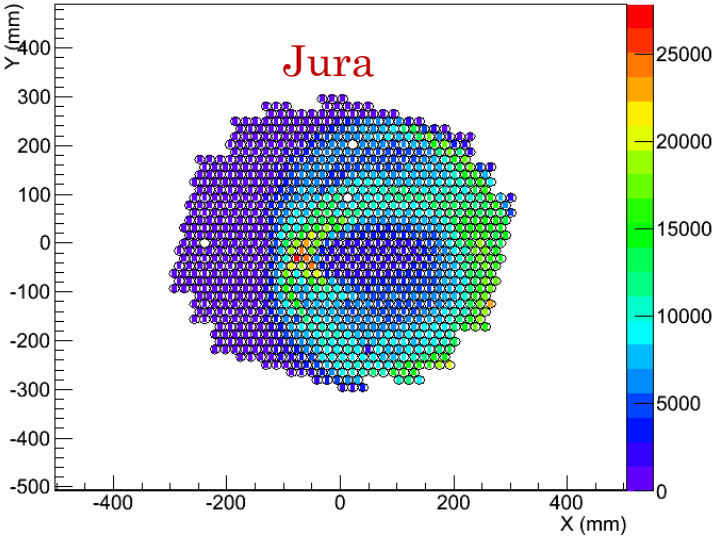
- 128 channels TDC daughter Boards (TDCB), each one housing 4 CERN HPTDC (High Performance TDC)
- 5 TEL62 mother boards (4 for the 2000 PMTs, 1 for the multiplicity read-out used to produce the L0 trigger), each one housing 4 TDCBs

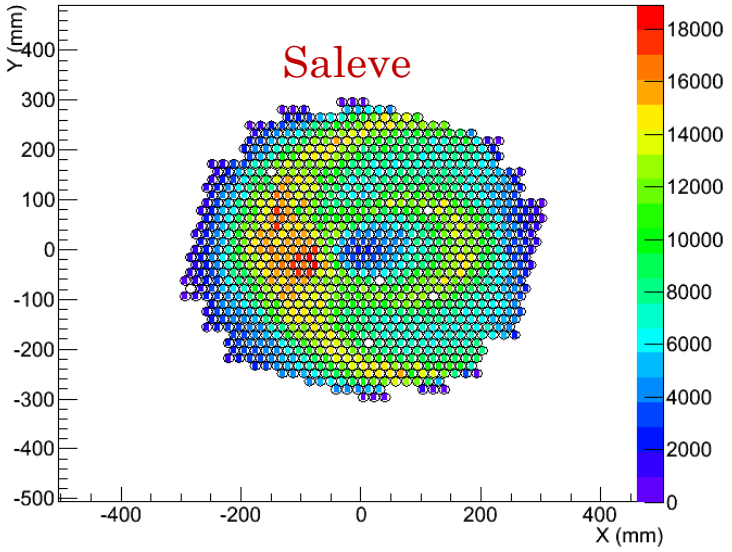
RICH Commissioning

RICH installation completed at the beginning of NA62 Pilot Run in 2014:

- Two-months first physics data taking with (almost) full setup(*)
- Commissioning of hardware and readout with particles at 5% of beam intensity

Select π^+sample from $K^+ \rightarrow \pi^+\pi^0$decays reconstructing the π^0 from LKr information





(*) GTK, STRAW and MUV detectors partially equipped

Tests and Results

In 2014 Pilot Run STRAW detector partially equipped
(STRAW data not available during the RUN) ⟹
The RICH remote alignment plan could not be fulfilled

- Select $K^+ \to \pi^+\pi^0$ decay using only LKr information
- Extrapolate the selected charged tracks to the RICH mirror
- Compare the predicted position of the ring center with the one from the fit

Try and raise one mirror in Y with piezomotors

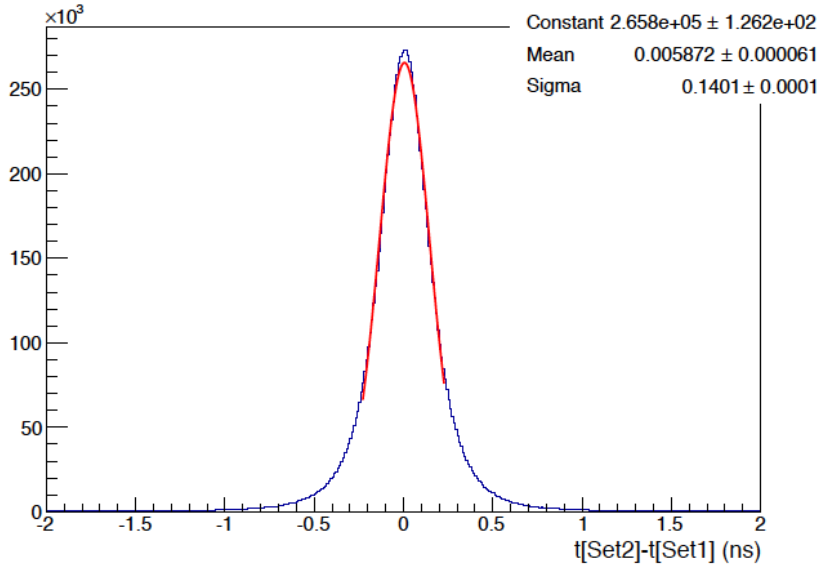
Mirror	Δx (cm) (before)	Δx (cm) (after)	Δy (cm) (before)	Δy (cm) (after)
20	-0.8±0.2	-1.0±0.1	-0.7±0.1	1.4±0.1

Movement of mirror 20 in y : 2.1±0.1 cm as expected

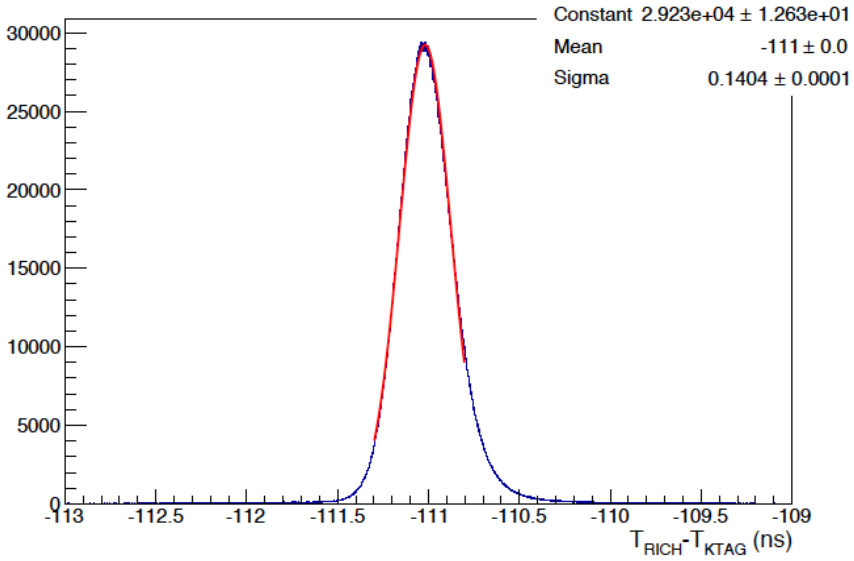
Tests and Results

The RICH event time resolution is about 70 ps

σ = 140 ps = 2 * event time resolution



Event time resolution measured by splitting the hits of a Cherenkov ring in two halves and computing the difference of the average times

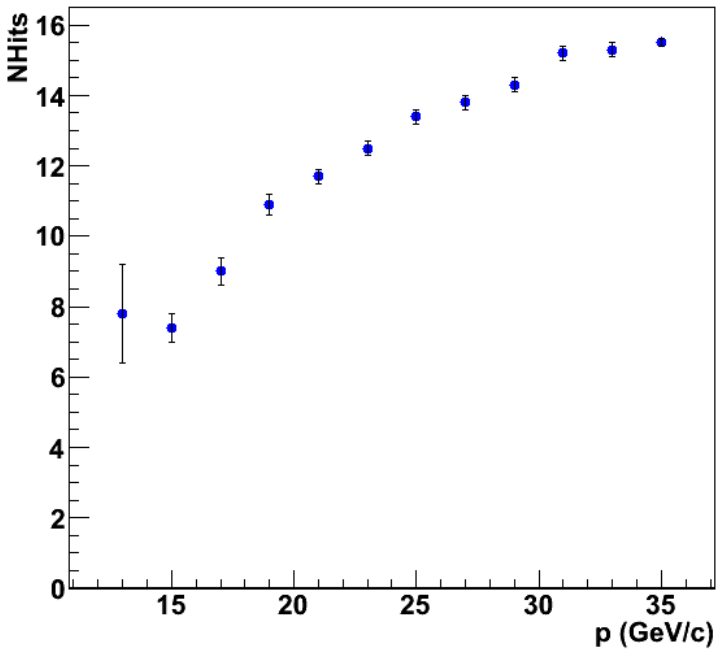


Difference between the average time of a Cherenkov ring and the KTAG time

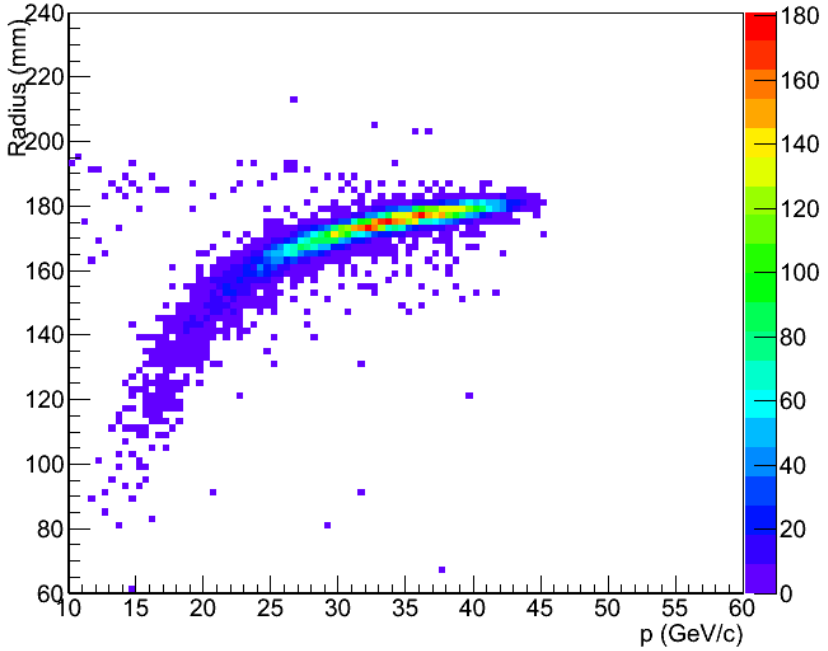
Tests and Results

π^+ sample from $K^+ \rightarrow \pi^+\pi^0$ decays selected without spectrometer information

Nhits vs Momentum

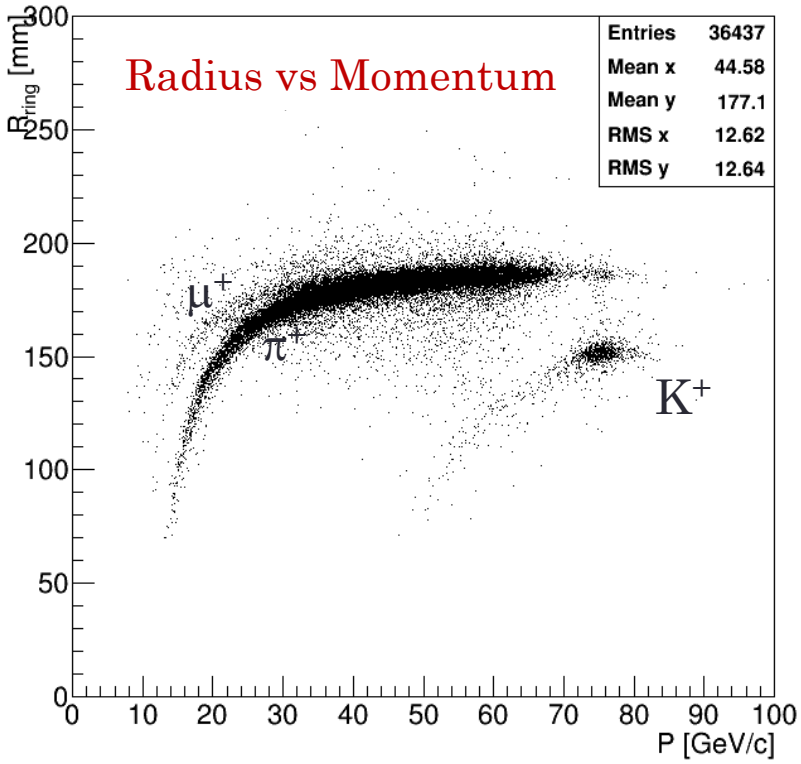


Radius vs Momentum



Tests and Results

Only recently we had access to the spectrometer information



A small fraction of the beam entered the detector during the 2014 run

Conclusions

NA62 beam line ready

Detector installation completed

2014 Pilot Physics Run

- RICH fully commissioned
- Preliminary results show that RICH is performing as expected

The 2015 Run will allow to understand better the RICH performances

RICH will provide the necessary information for the 2015 physics analysis