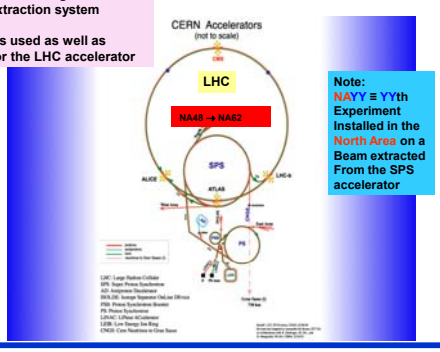
The RICH detector of the NA62 experiment at CERN

INFN Firenze, INFN Perugia, INFN Pisa, CERN

The CERN Accelerator Complex

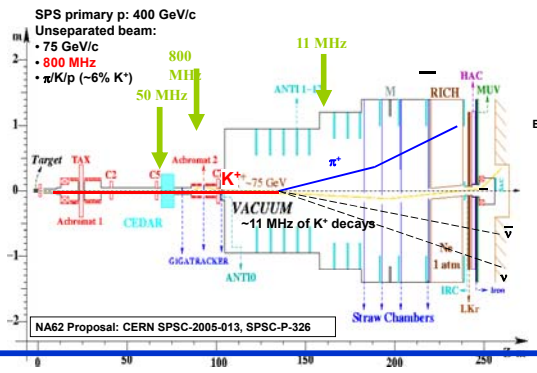
The SPS at CERN produces 400 GeV/c protons using either a fast or slow extraction system

The SPS is used as well as injector for the LHC accelerator

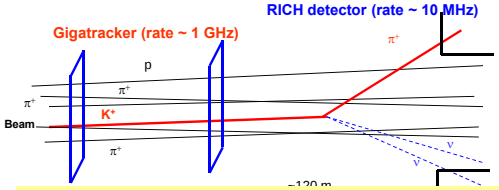


Note:
NAYY ≡ YYth Experiment Installed in the North Area on a Beam extracted From the SPS accelerator

NA62: a new experiment to measure the ultra-rare decay $K^+ \to \pi^+ \nu\bar{\nu}$



NA62 Principle of Measurement



Unseparated charged beam with Kaon decay in flight technique

- A CEDAR detector is used to tag the K^+ in the unseparated beam
- The particle ID system consists of a Si pixel detector to track the K^+ and a RICH to separate the decay products.
- Need to associate the decay pion to the charged kaon in the beam in a very high particle rate environment (beam ~1 GHz)

K^+ : Gigatracker Si pixel detector with excellent time resolution (~ 100 ps)
π^+ : RICH (Neon, 1 atm) read by fast Photomultipliers

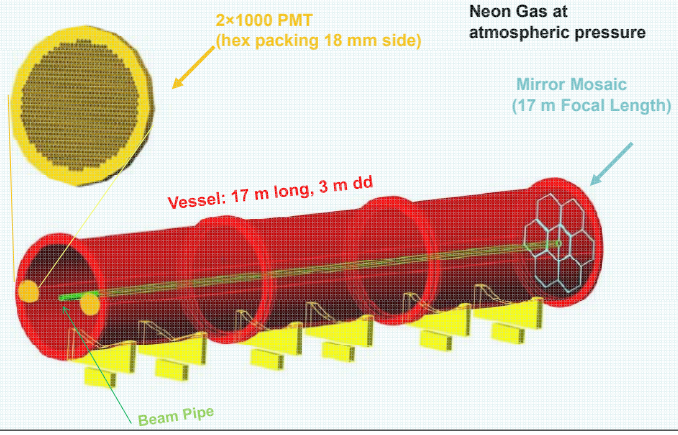
THE NA62 DETECTORS

- **CEDAR:** differential Cherenkov counter to tag the K^+ in the beam (50MHz)
- **GIGATRACKER:** Beam spectrometer consisting of 3 Si micropixel stations upstream the decay region (800 MHz) for K^+ tracking
- **STRAW:** magnetic spectrometer consisting of 4 chambers of straw tubes to measure direction and momentum of charged decay products (~10 MHz)
- **RICH:** Ring Image Cherenkov, providing muon/pion separation, measuring the pion crossing time and acting as fast trigger for charged tracks
- **LAV:** ANTI-counters (Lead glass) surrounding the vacuum tank providing full coverage for photons at large angles
- **LKR:** The high-performance electromagnetic calorimeter built for the NA48 experiment acting as photon veto in the forward region
- **IRC/SAC:** Photon veto at small and intermediate angles
- **CH-ANTI:** a set of ring anticounters located after the last Gigatracker station to form a "guard ring" and a large ring around the beginning of the decay volume to veto charged particles coming from the collimator
- **MUD:** hadron calorimeter and muon detector

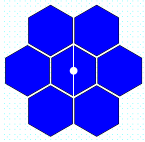
The RICH detector

Requirements

- Separate π–μ at 5×10^{-3} for 15 GeV < p < 35 GeV
- Measure track time at 100 ps (to avoid pile-up with the Gigatracker)
- Main charged Trigger



The Mirrors



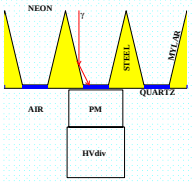
- Hexagonal Mirrors
- 17 m focal length
- 1 m diameter
- 2.5 cm thick glass
- D_0 < 4 mm
- Aluminum deposit with MgF_2 coat
- MARCON company
- piezo actuators for alignment

The light collection

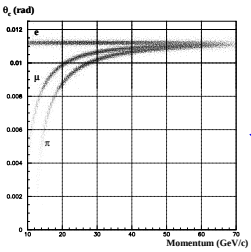
Winston Cones covered with Mylar:

- 22 mm high
- 18 mm wide (max)
- 7.5 mm wide (min)

1 mm thick quartz window



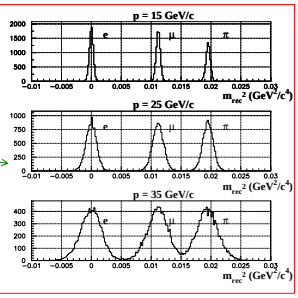
Simulation



$$m_{rec}^2 = p^2\left(\vartheta_{\max}^2 - \vartheta_c^2\right)$$

$$n-1 = 63\times10^{-6} \quad \text{[Neon]}$$

$$r_c(\max) = \vartheta_c(\max)\times f \approx 19 \text{ cm}$$

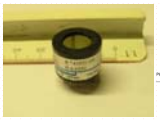


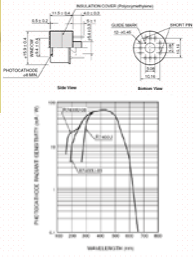
The Photomultipliers

Hamamatsu R7400 U03

- Metal package tube
- 16 mm dd
- 8 mm active dd
- 185 nm – 650 nm
- 420 nm peak sensitivity
- UV glass window
- Bialkali cathode
- Gain: 7 x 10^5
- Transit time 5.4 ns
- Transit time spread: 0.28 ns
- Number of dynodes: 8
- Applied Voltage: 800 V (1000 V max)

Hamamatsu R7400 U06: quartz window (165-650 nm)

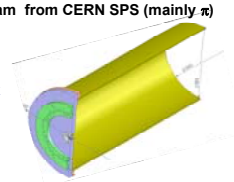


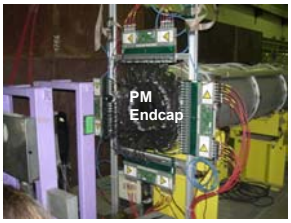


RICH-100 prototype: the 2007 Test Beam

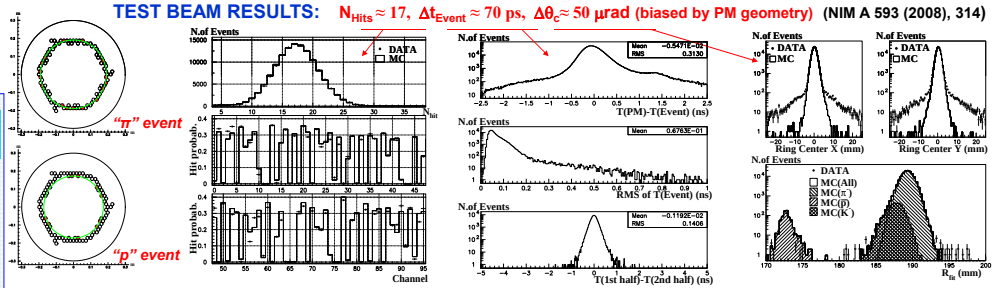
200 GeV/c negative hadron beam from CERN SPS (mainly π)

- 17 m long, 60 cm wide vessel
- Mirror by MARCON:
  f = 17m, d = 50 cm, 2.5 cm thick
- 96 PMT Hamamatsu R7400
- Neon at atmosferic .pressure





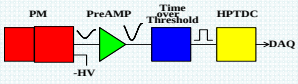
TEST BEAM RESULTS: $N_{Hits} \approx 17$, $\Delta t_{Event} \approx 70$ ps, $\Delta\theta_c \approx 50$ μrad (biased by PM geometry) (NIM A 593 (2008), 314)



PM Hit Maps

Electronics and DAQ

Integrated Data Acquisition and Trigger with time resolution ~100 ps



- NINO ASIC as fast Time Over Threshold discriminator
- HPTDC with 100 ps LSB
  - TELL1 board (LHCb) final
  - CAEN V1190 (128ch) for test beam

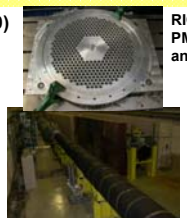
Electronic board:
- 128 TDC channels, 100 ps resolution (HPTDC, CERN) control FPGA and static memory on-board.
- 10 layers PCB (16xLVDS connectors, individual shielding)

Full Motherboard (512 channels) with PC on-board and 4 x1 Gb/s links

RICH-400 prototype: the 2009 Test Beam

Going on (may-june 2009) at CERN: soon results

- PM endcap changed
- 414 PM (20% of total)
- New TDC (TELL1)
- Validate π–μ separation in 15<p<35 GeV/c
- Improve PM cooling



RICH-400 prototype:
PM holder, PM Endcap and cooling system

P. Cenci and M. Pepe, INFN Perugia – KAON09, Tsukuba , Japan - June 9 - 12 2009