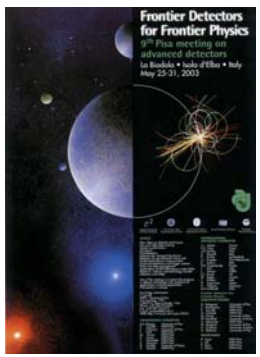
The COMPASS Spectrometer at CERN



G. Mallot/CERN

On Behalf of the Compass Collaboration

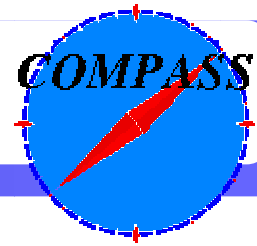
9th Pisa Meeting, ELBA, 25 – 31 May, 2003

COMPASS Collaboration

Bielefeld, Bochum, Bonn (ISKP, PI), Burdwan and Calcutta, CERN, Dubna, Erlangen, Freiburg, Heidelberg, Helsinki, *Lisbon*, Mainz, Moscow (INR, LPI, MSU), Munich (LMU, TU), Nagoya, *Prague*, Protvino, Saclay, Tel Aviv, Torino (Univ., INFN), Trieste (Univ.,INFN), Warsaw (SINS, TU)

- More than 200 physicists from 26+*2* Institutes

COMPASS Physics



Hadron structure and Spectroscopy

- Muon beam programme
  - Quarks and gluon polarisation in polarised nucleons
  - Polarisation transfer in fragmentation
  - Transverse spin distribution

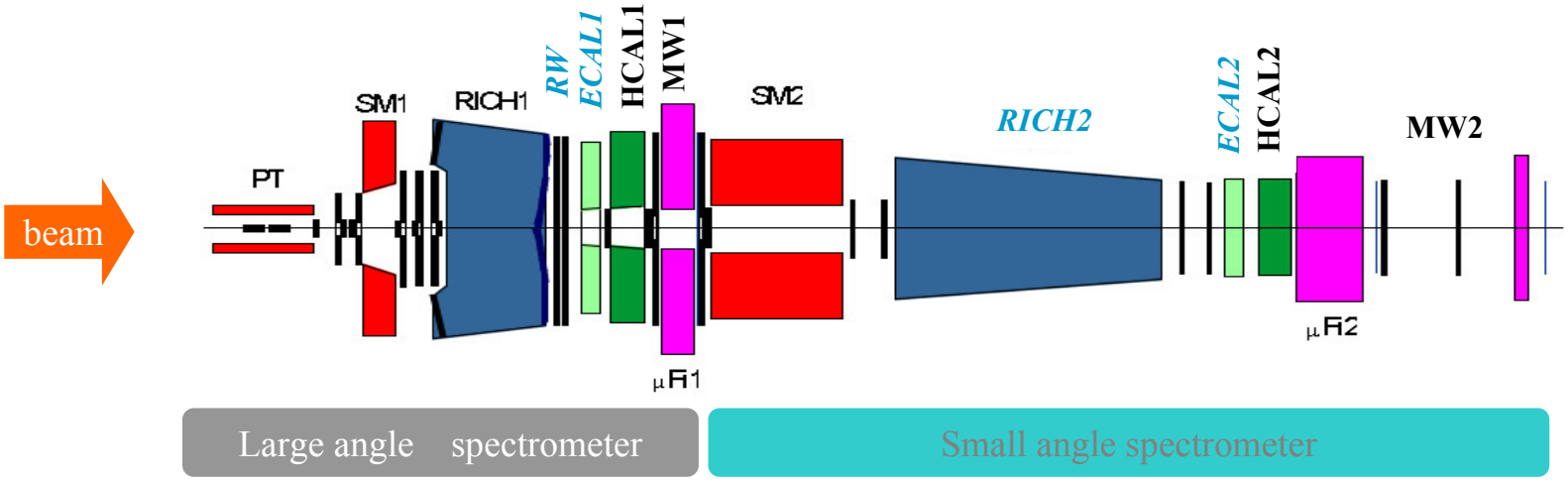
- Hadron beam programme
  - Polarisibility of kaons and pions
  - Glue balls
  - Semi-leptonic decays of charmed hadrons
  - Double charmed hadrons

Operate in quite different conditions with (μ, p, π) beams

Calendar

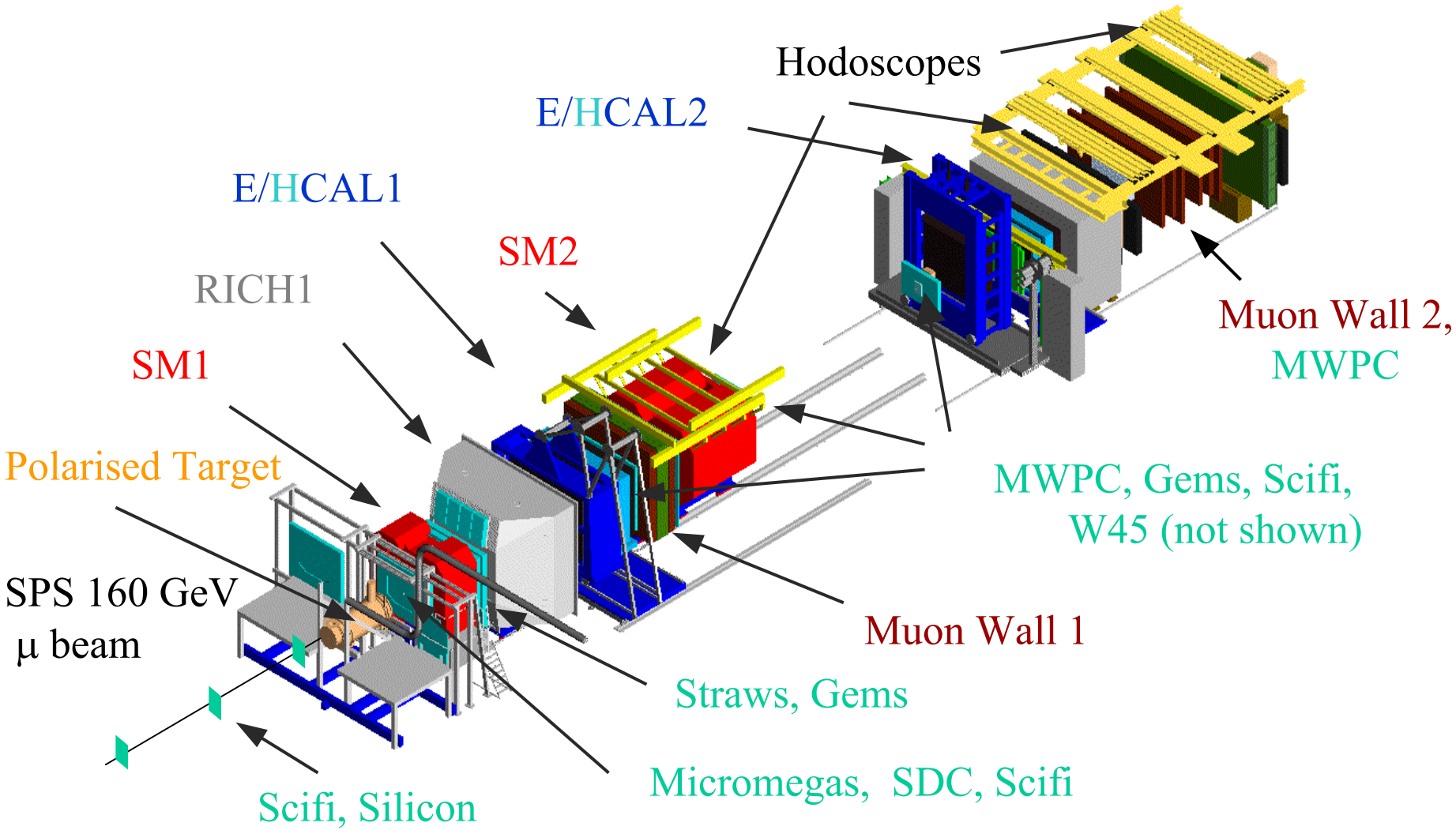
- **1996:** proposal
- **1997:** conditional approval
- **1998:** MoU, September
- **1999 – 2000:** construction and installation
- **2001:** commissioning run
- **2002:** full scale data taking (100 days)
- **2003 – 2004:** data taking
- **2005:** SPS shutdown
- **2006 – 2010:** planned data taking

Spectrometer layout



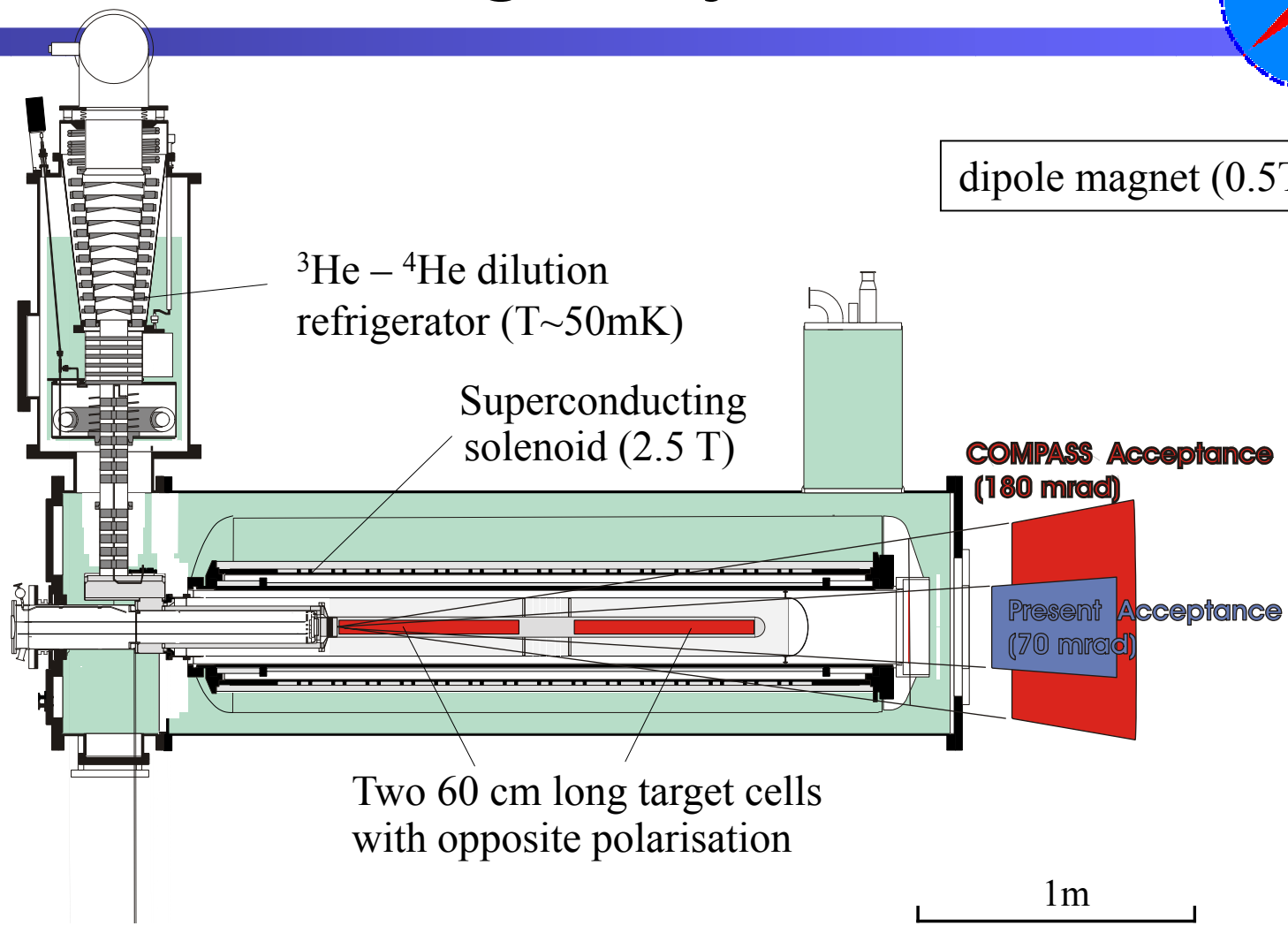
- two-stage spectrometer, each stage comprising
  - small and large area tracking
  - momentum measurement
  - particle ID
- *Blue*: detectors for next stage of experiment, to be constructed

The COMPASS Spectrometer

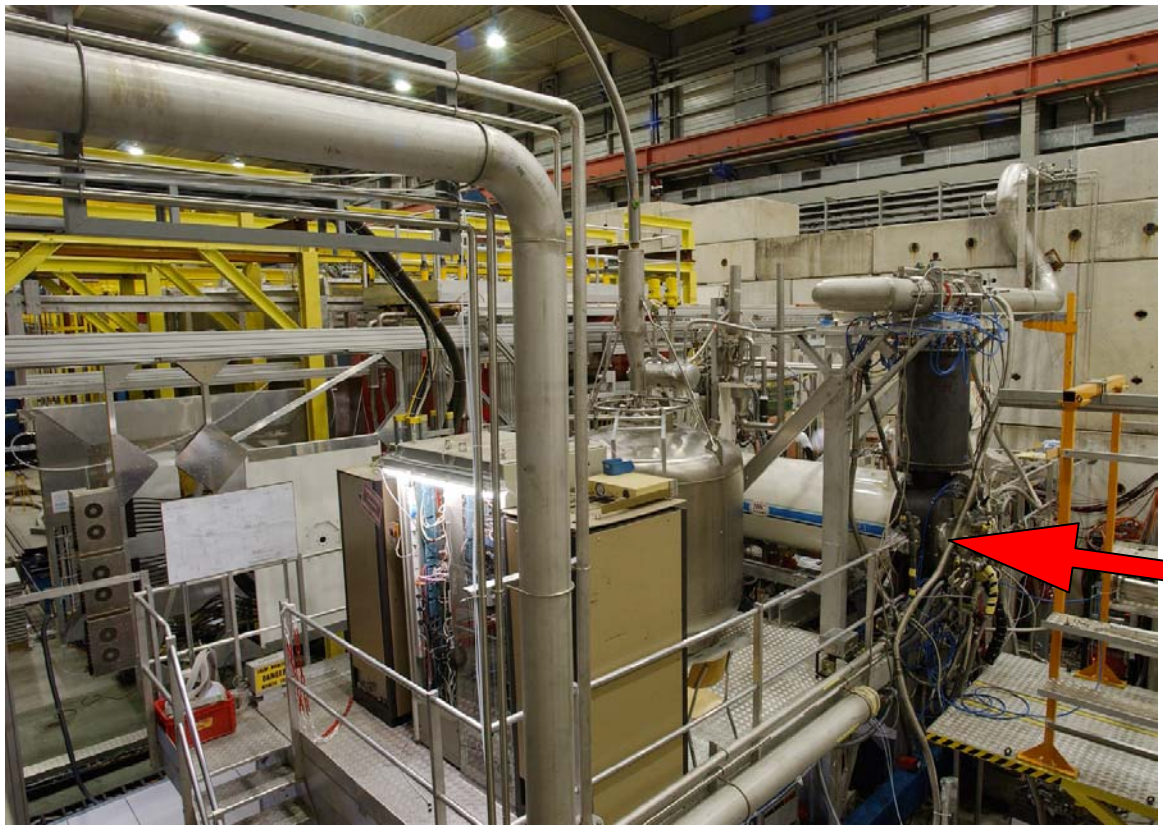


COMPASS Spectrometer

Target system



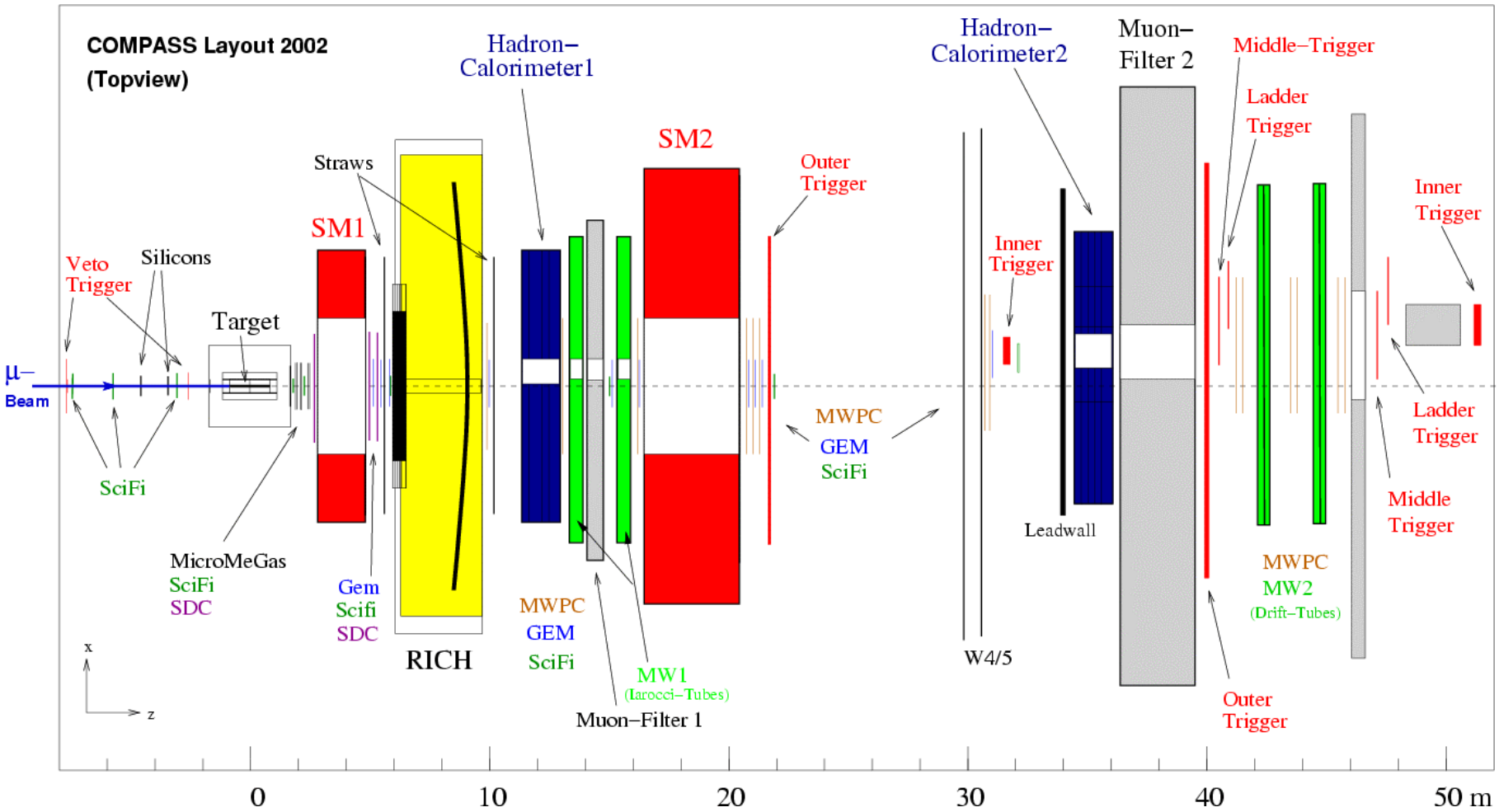
Polarised target



- ^{6}LiD
- ± 50 % polarisation
- 50 % dilution factor
- 2.5 T
- 50 mK

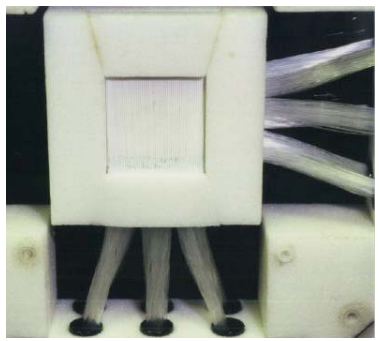
μ

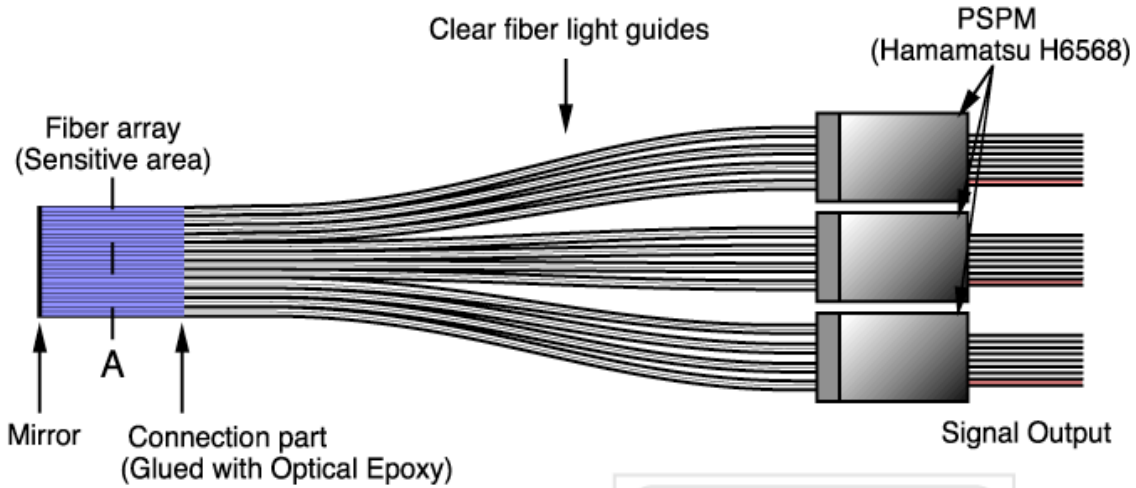
Spectrometer 2002



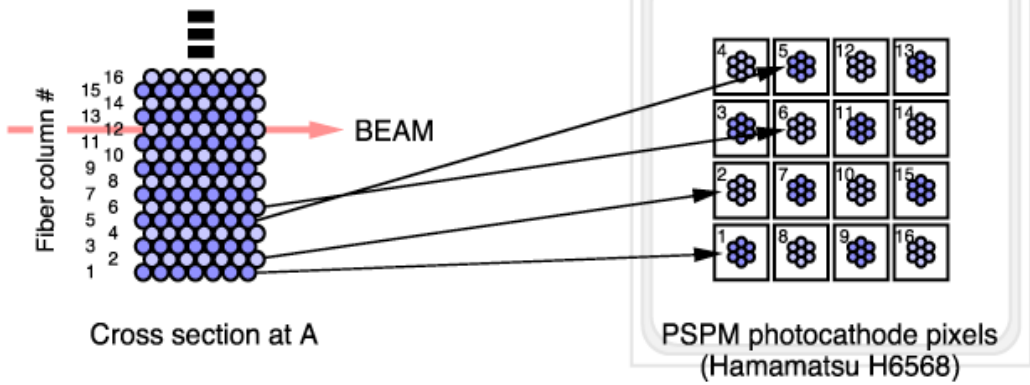
SciFi

Kuraray SCSF-78MJ



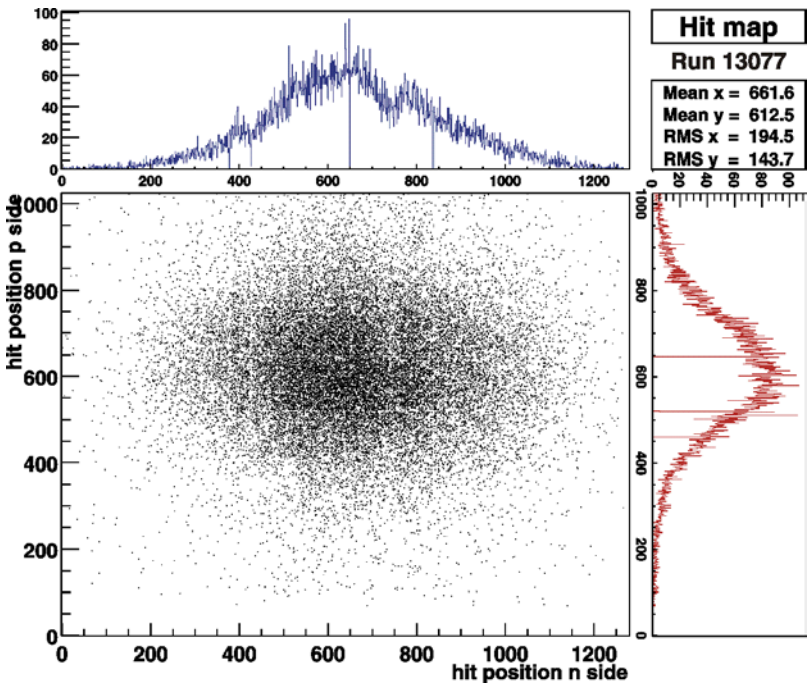


7 fibre layers with
0.5 – 1 mm diameter
up to 5 MHz/fibre
21 coordinates
4x4 – 12x12 cm^2
350 – 550 ps
130 – 250 µm
efficiency ~ 99 %



Silicon

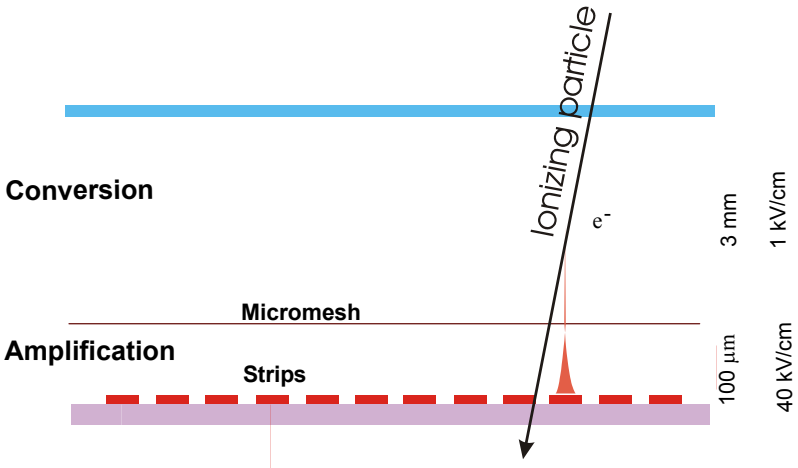
Beam profile

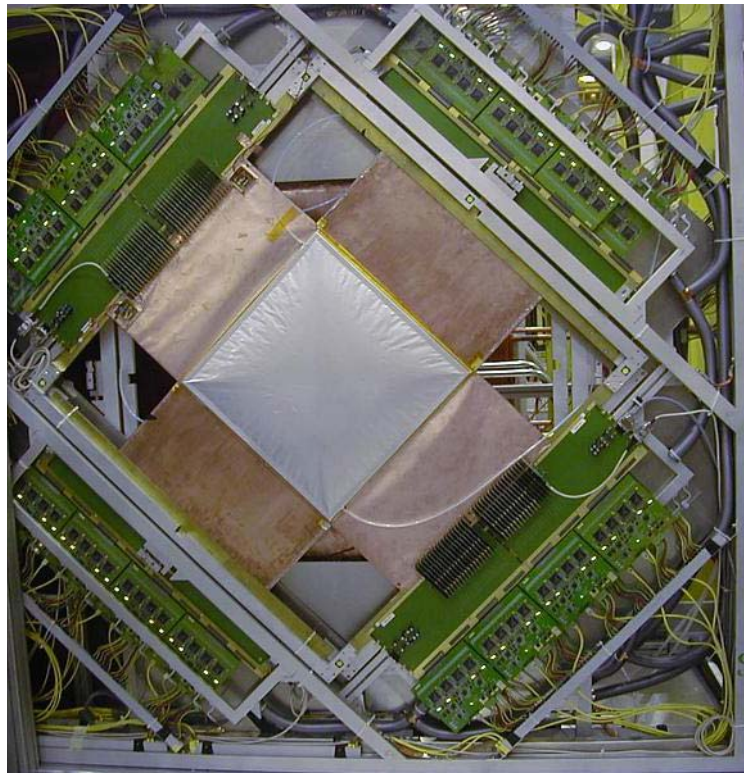


- 4 double-sided silicon detectors
- size 50 x 70 mm^2
- pitch 50 μm
- time resolution 3 ns
- efficiency ~ 99%
- additional cold silicon station in 2003

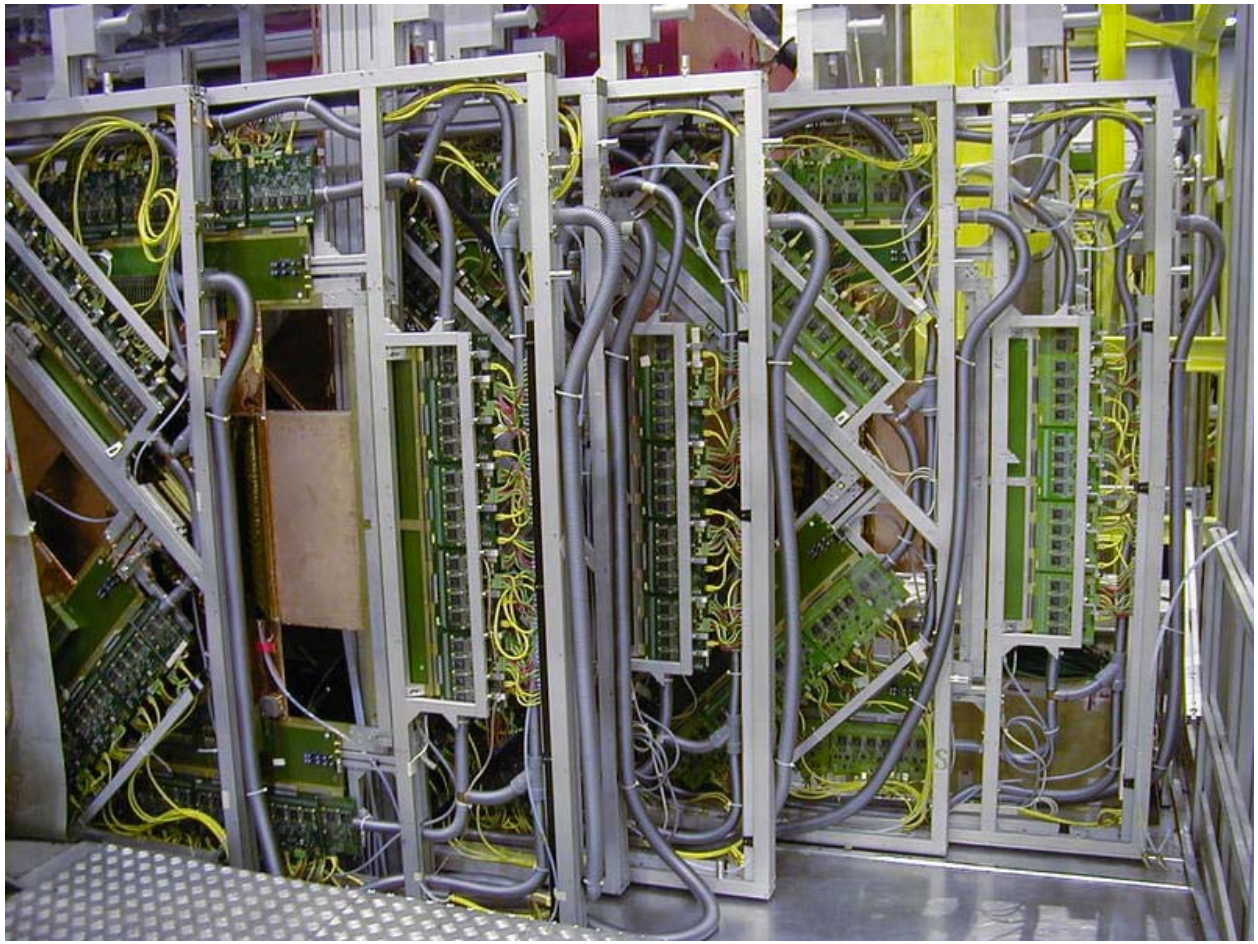
MicroMegas

3 stations, 12 coordinates
size 40x40 cm^2
pitch 360 – 420 μm
time res. < 10 ns
space res. 70 μm
efficiency > 97%
$Ne/C_2H_6/CF_4$ 80/10/10 %

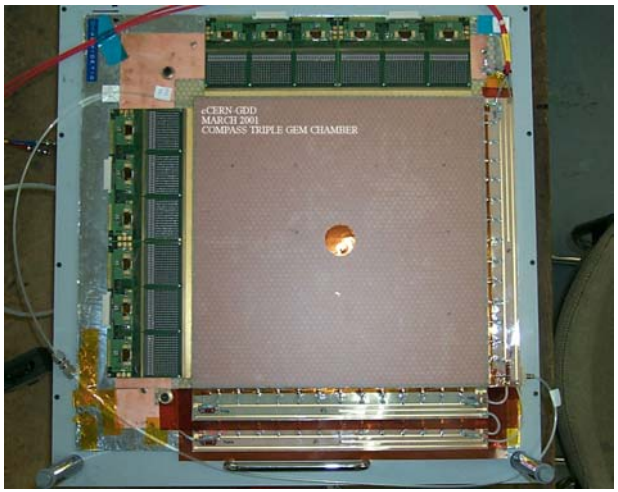


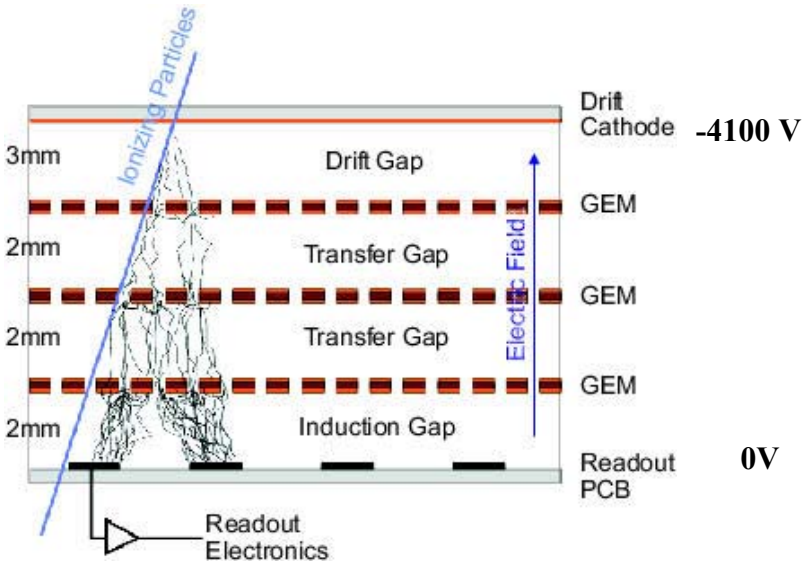


Six MicroMegas stations



Gems

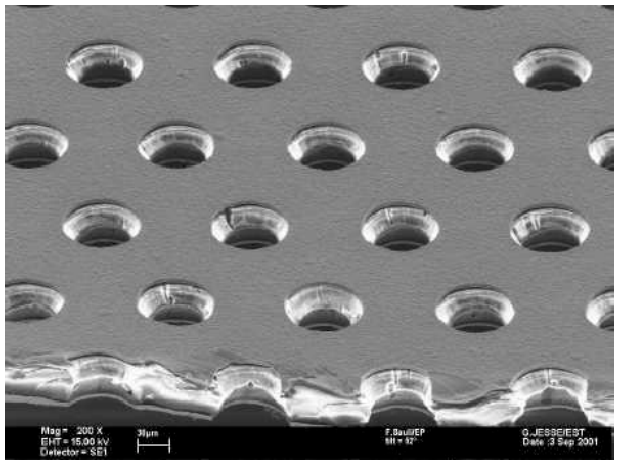


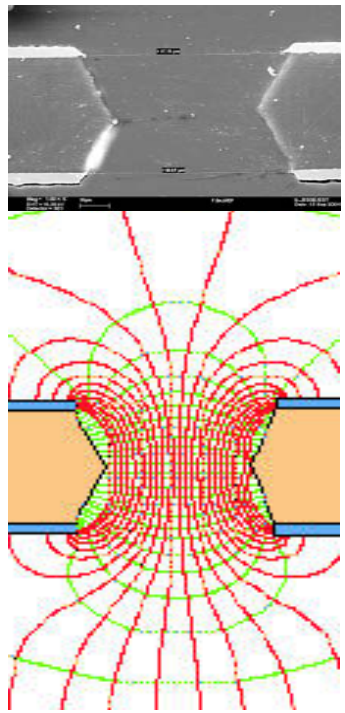


- 20 triple Gems detectors
- in 10 stations
- 40 coordinates
- size 30x30 cm^2
- 12 ns time resolution
- 50 μm space resolution
- efficiency ~ 97 %
- Ar/CO_2 70/30 %

Gems

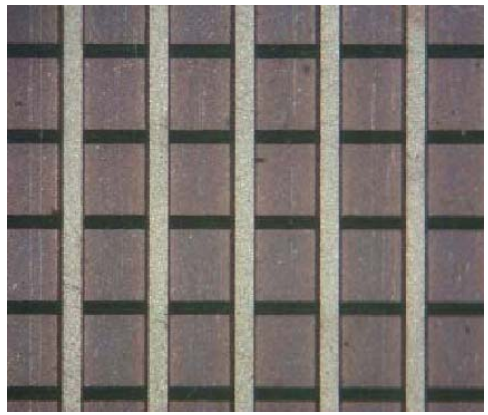
Gem foil

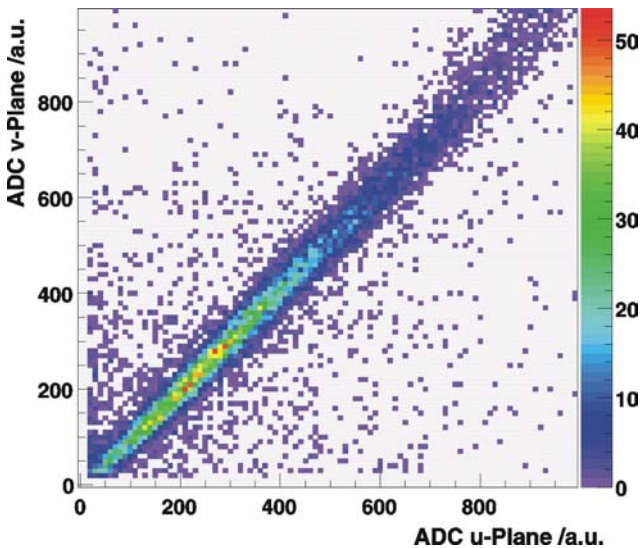




Gem readout plane

two dimensional read-out
crossed strips, 400 μm pitch
80 / 340 μm wide

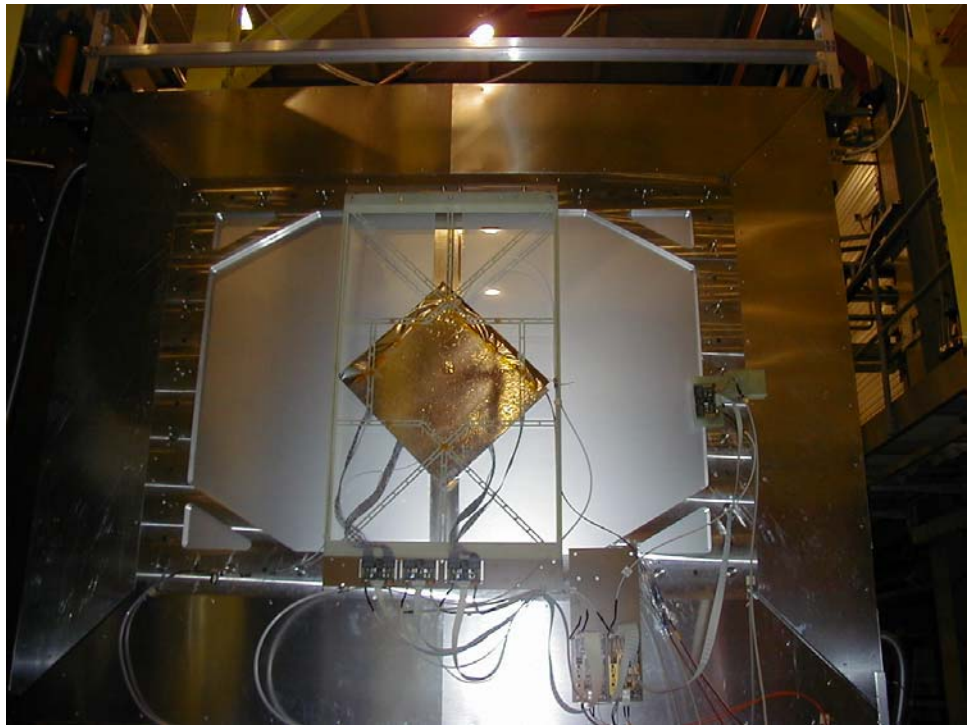




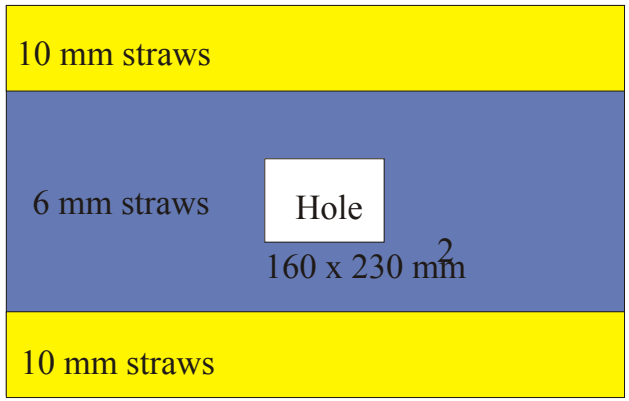
cluster charge correlation
charge ratio about unity

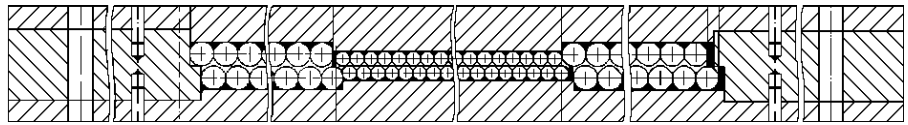
SDC

- 3 drift chambers
- 24 coordinates
- size 120x120 cm^2
- 7 mm drift cell
- 170 μm space resolution
- efficiency > 95 %
- $Ar/C_2H_6/CF_4$ 45/45/10 %



Straws

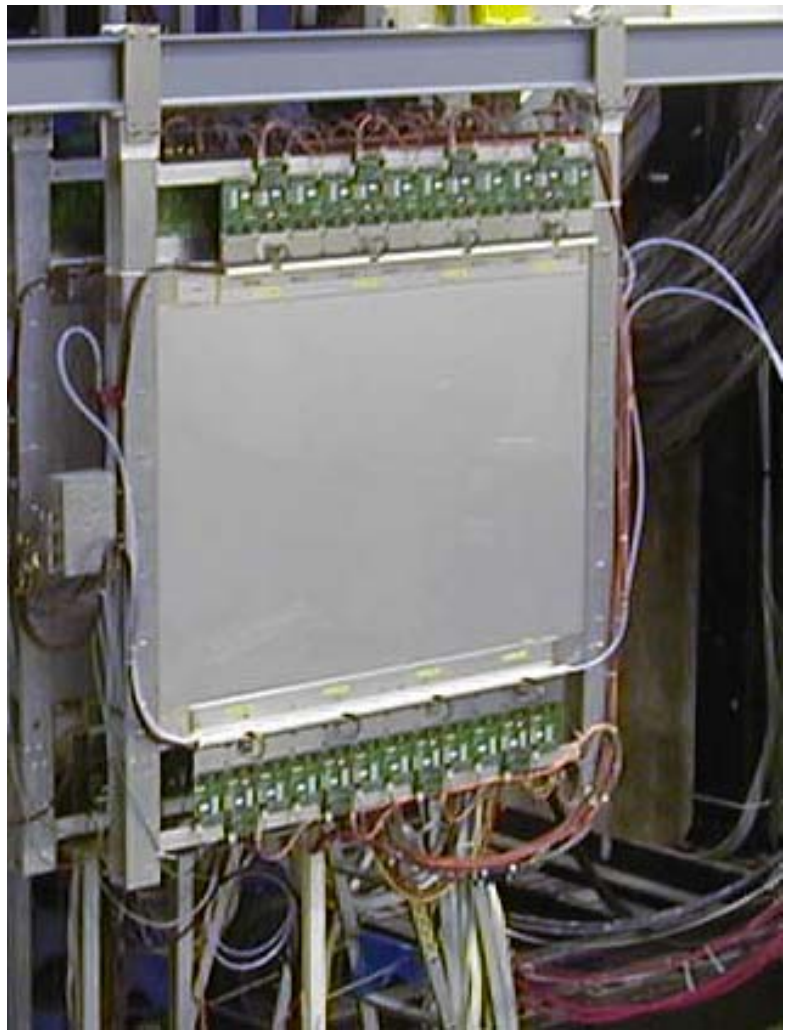




- 15 double layers of 6 and 10 mm straws
- size 325x242cm^2
- resolution 270 μm
- efficiency 85 – 98 %
- $Ar/CF_4/CO_2$ 74/20/6 %

MWPCs

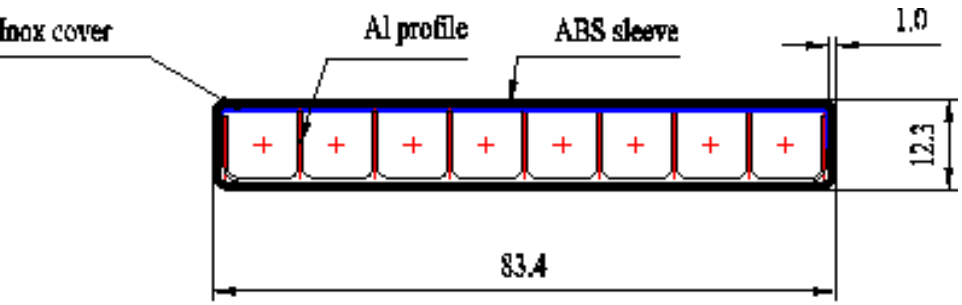
- 11 stations with 34 planes
- size 150x120 cm^2 (150x94 cm^2)
- 2 mm pitch
- efficiency 99 %
- $Ar/CF_4/CO_2$ 74/20/6 %



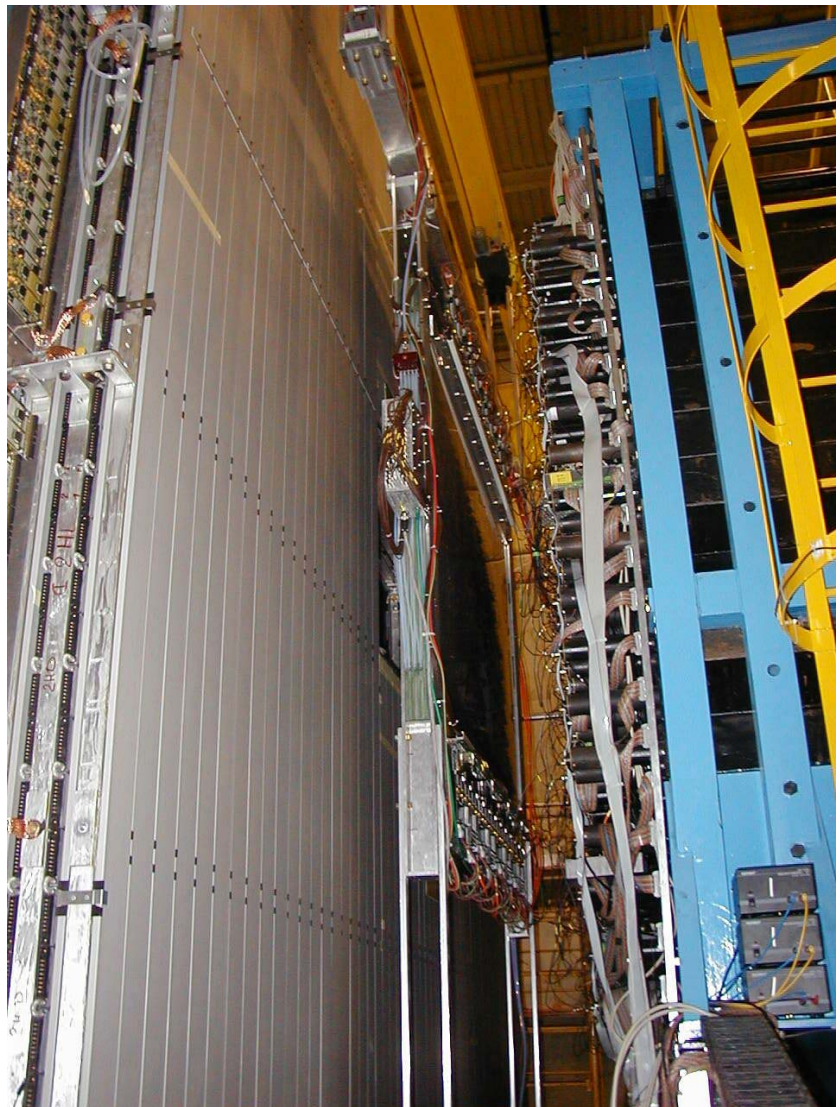
W45 drift chambers

- 3-4 chambers with 4 planes each
- 5.2 x 2.4 m^2
- 40 mm drift cell
- 50 – 100 cm diameter central dead zone
- $Ar/CF_4/CO_2$ 85/10/5%

Muon Wall 1

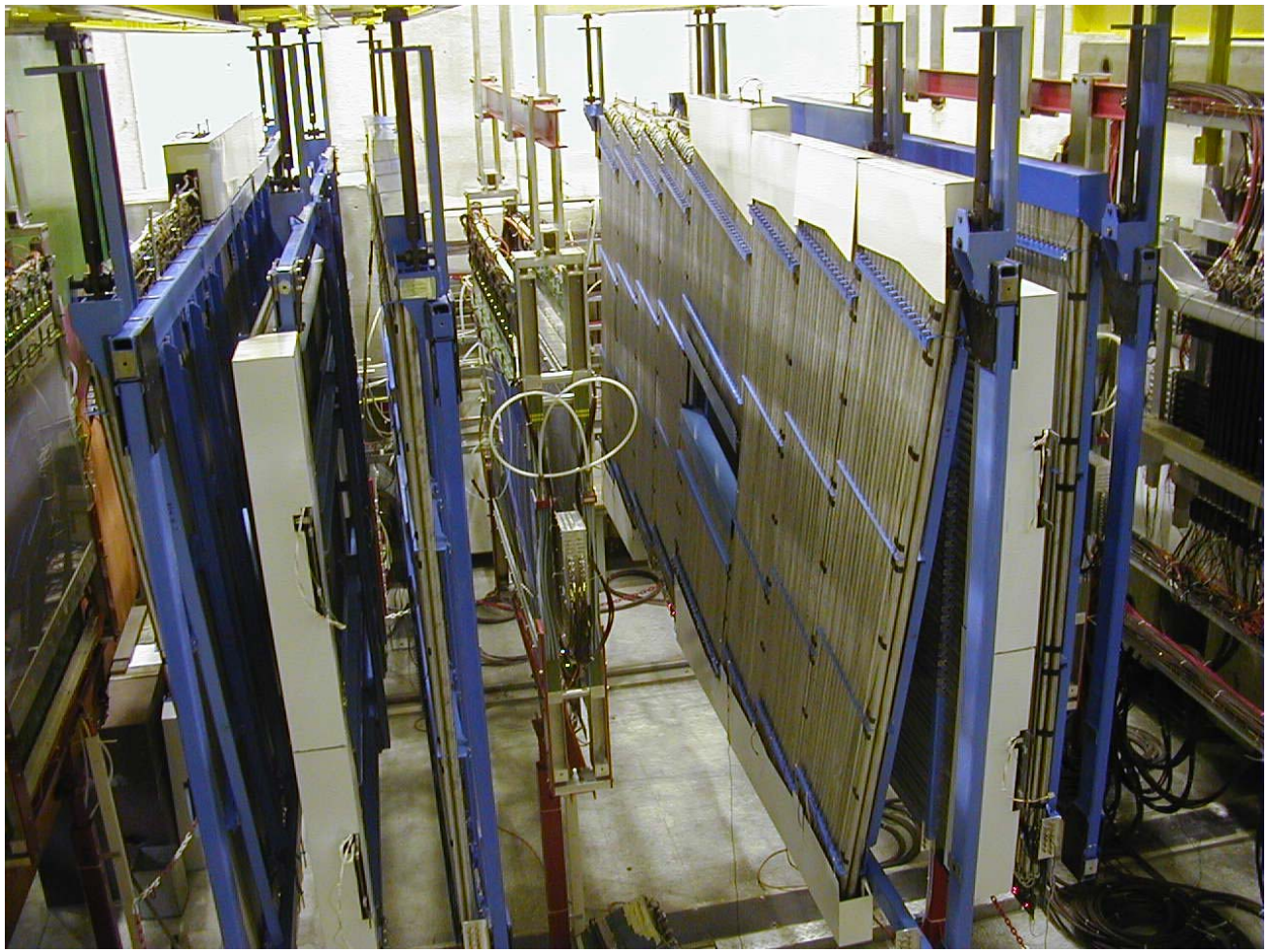


- size 4x2 m^2
- 2 stations sandwiching a 60 cm iron absorber
- 4 double layers per station
- 10 mm pitch



Muon Wall 2

- steel drift tubes
  3 cm diameter
- 6 double layers
- size 470x220 cm^2
- located downsteam
  240 cm thick concrete
  wall



Calorimetry

- HCAL 1 (500 ch)
- sandwich: Fe + scintillator
- planar WLS for read-out

$$\pi : \frac{\sigma}{E} = \frac{59.4\%}{\sqrt{E}} \oplus 7.6\%$$

- HCAL 2 (200 ch)
- sandwich: Fe + scintillator
- WLS fibres for read-out

$$\pi : \frac{\sigma}{E} = \frac{65\%}{\sqrt{E}} \oplus 4\%$$

- ECALs

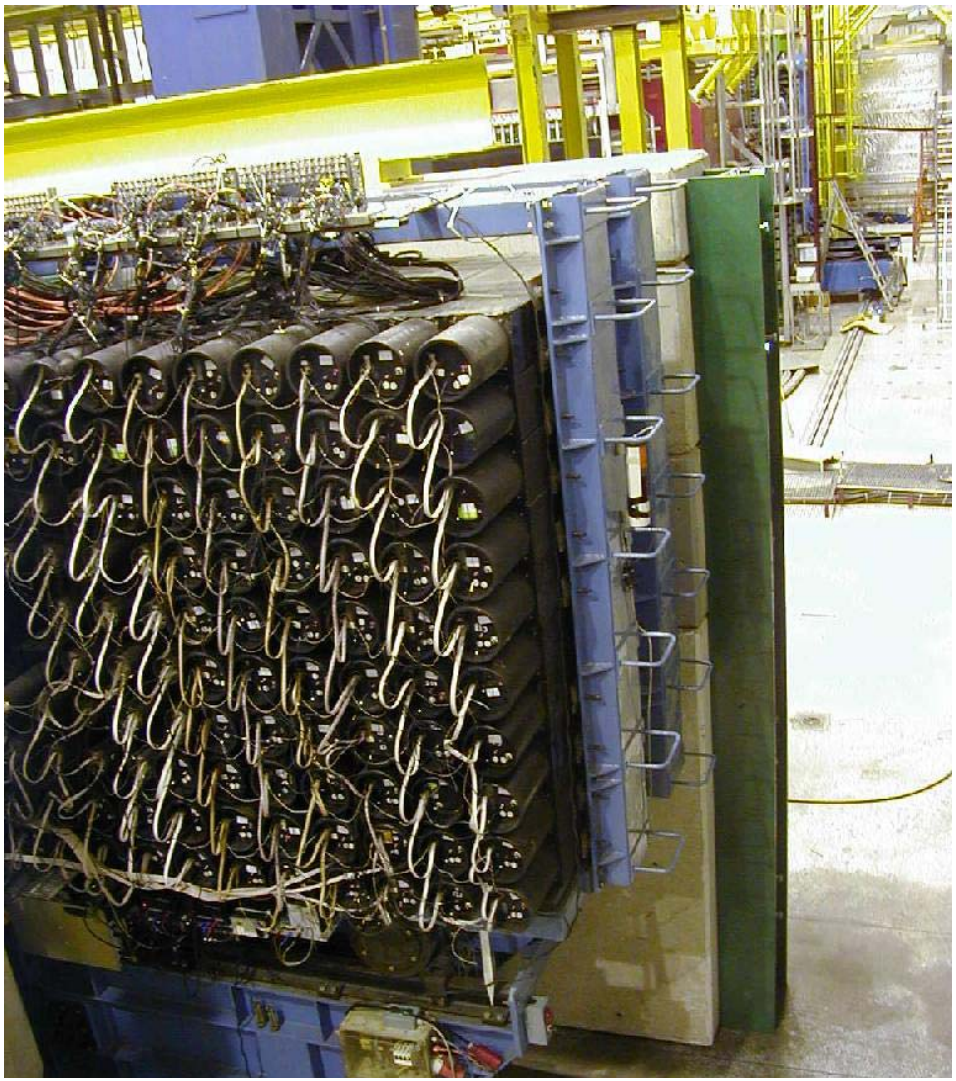
GAMS

$$\frac{\sigma}{E} = \frac{5.8\%}{\sqrt{E}} \oplus 2.3\%$$

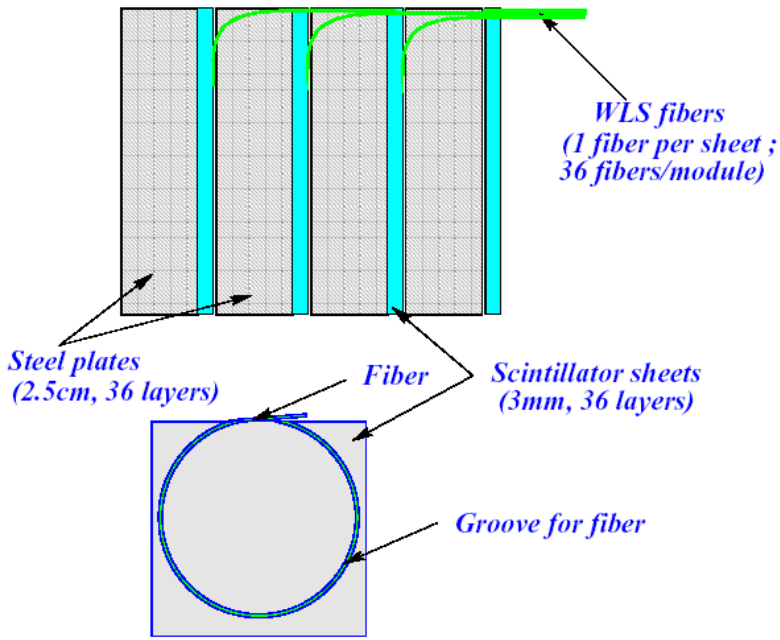
- lead glass (blocks from GAMS + OLGA)
- ECAL1 frames installed only
- ECAL2 presently GAMS

  2000 channels (50%)

HCAL2



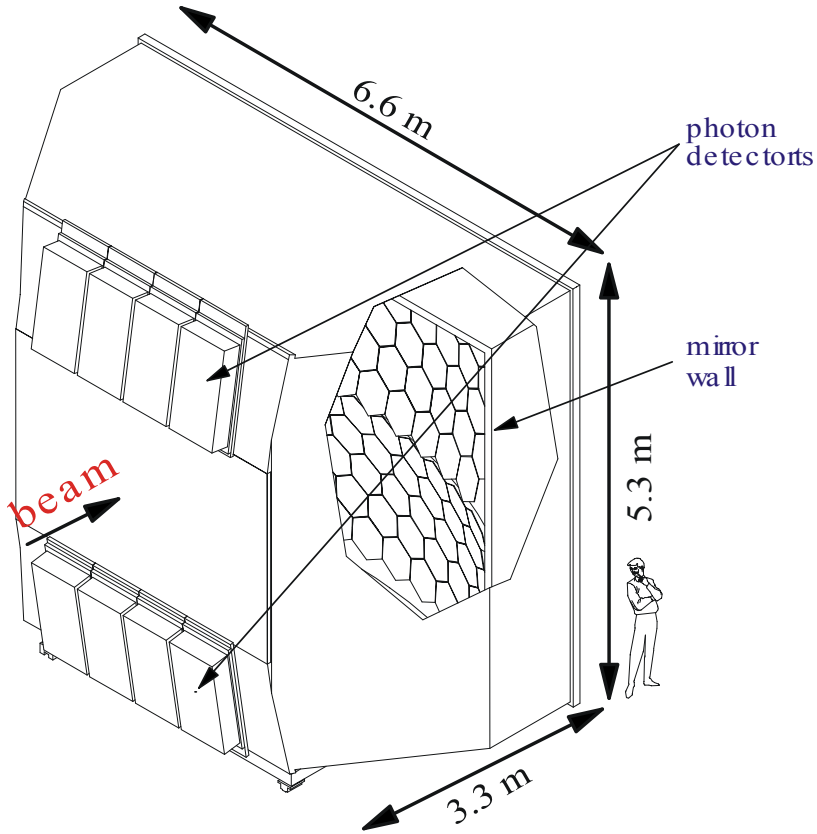
20x20 cm^2 module size



RICH-1

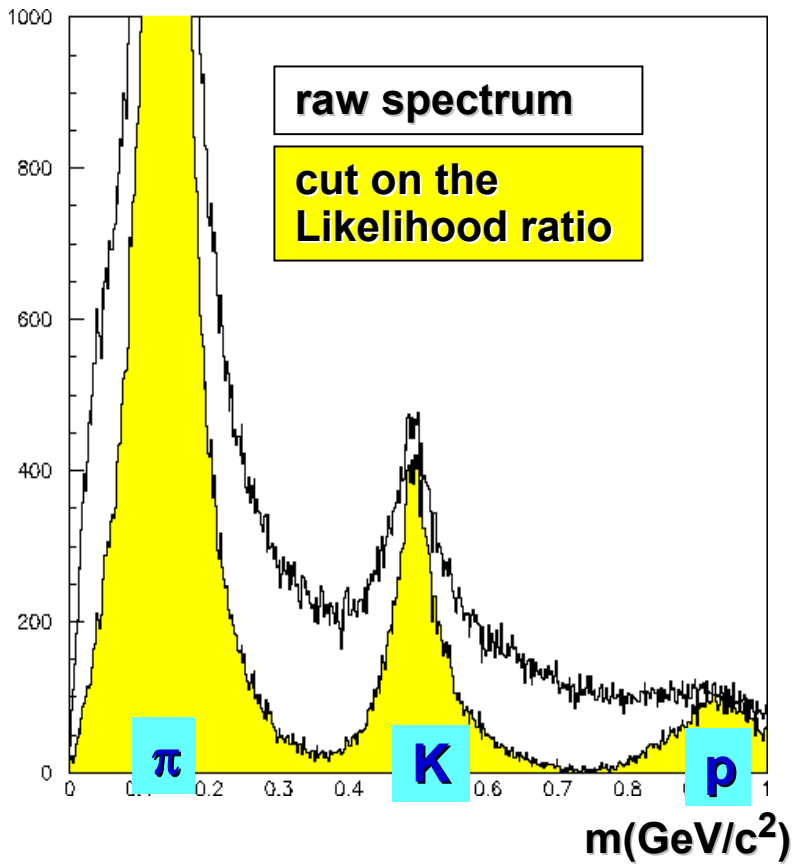
see talk by S. Dalla Torre

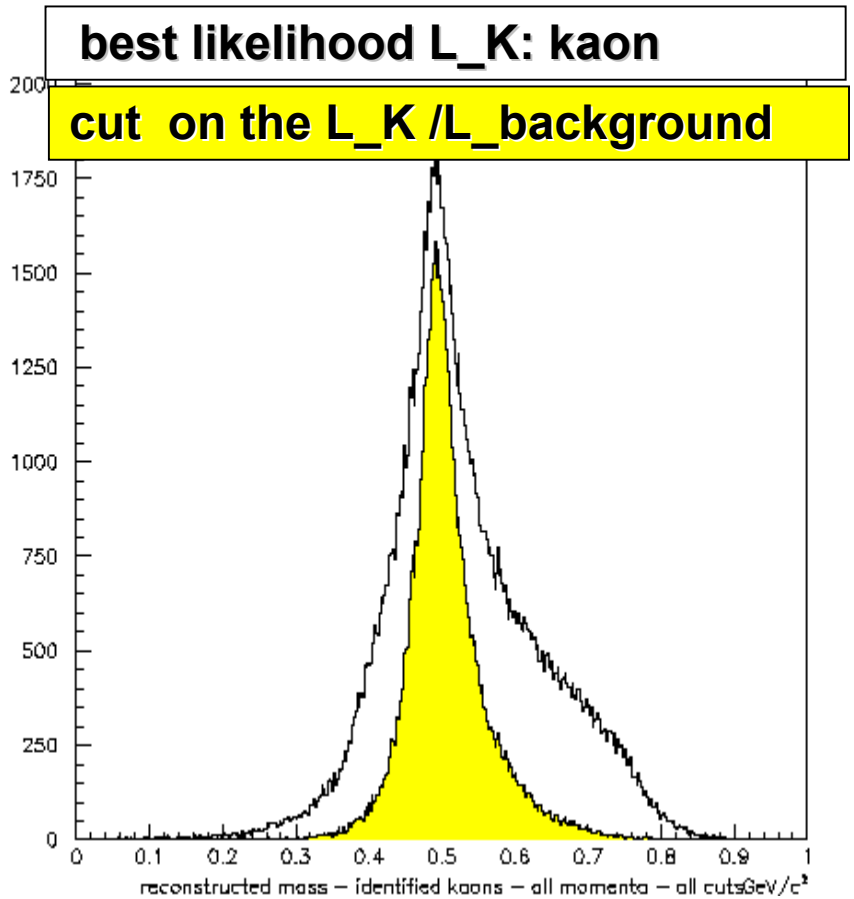
- 80 m^3 (3 m C_4F_{10} radiator)
- 116 VUV mirrors
- 5.3 m^2 VUV detectors
  - MWPC CsI photo-sensitive cathodes
  - 8x8 mm^2 pads
- 84k analog r/o channels



RICH-1 mass spectrum

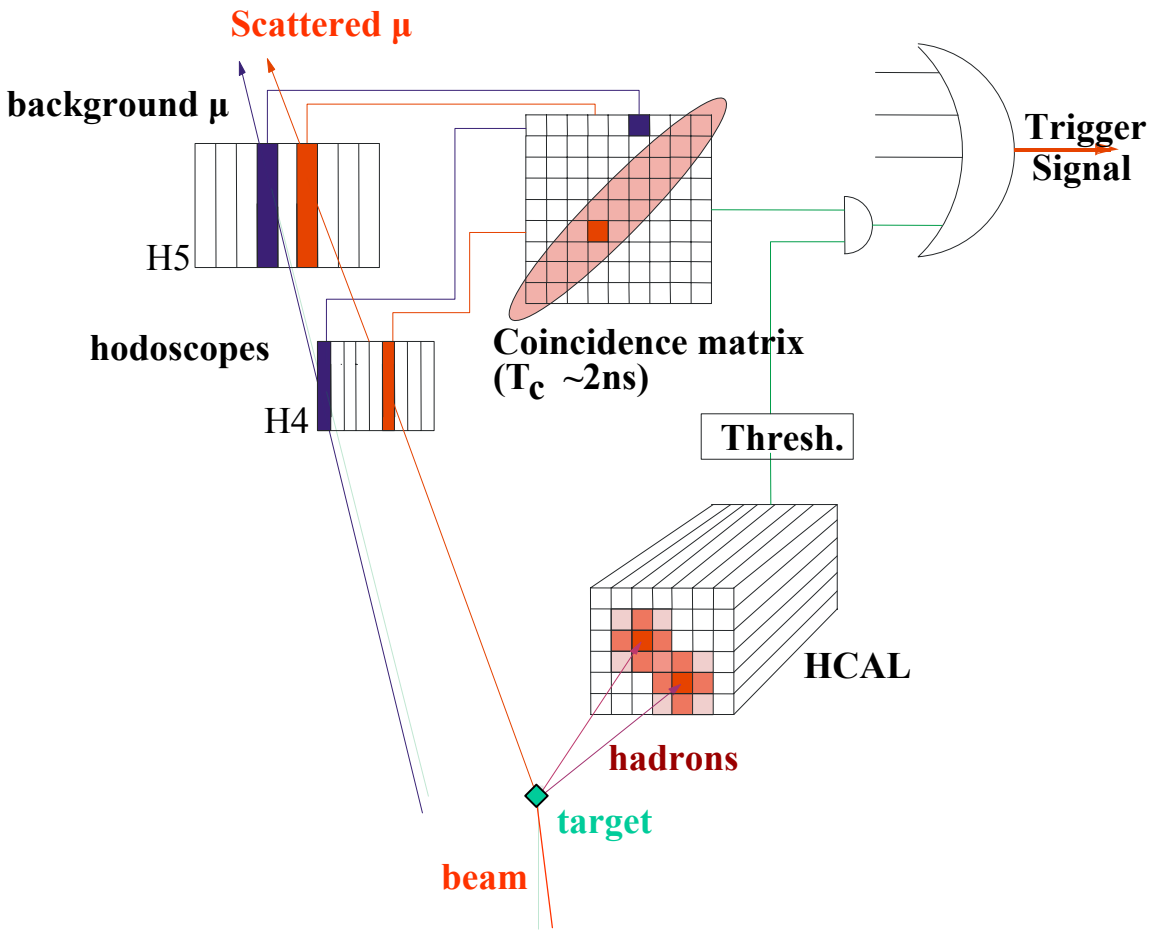
8 < *p* < 38 GeV/*c*





Trigger Principle

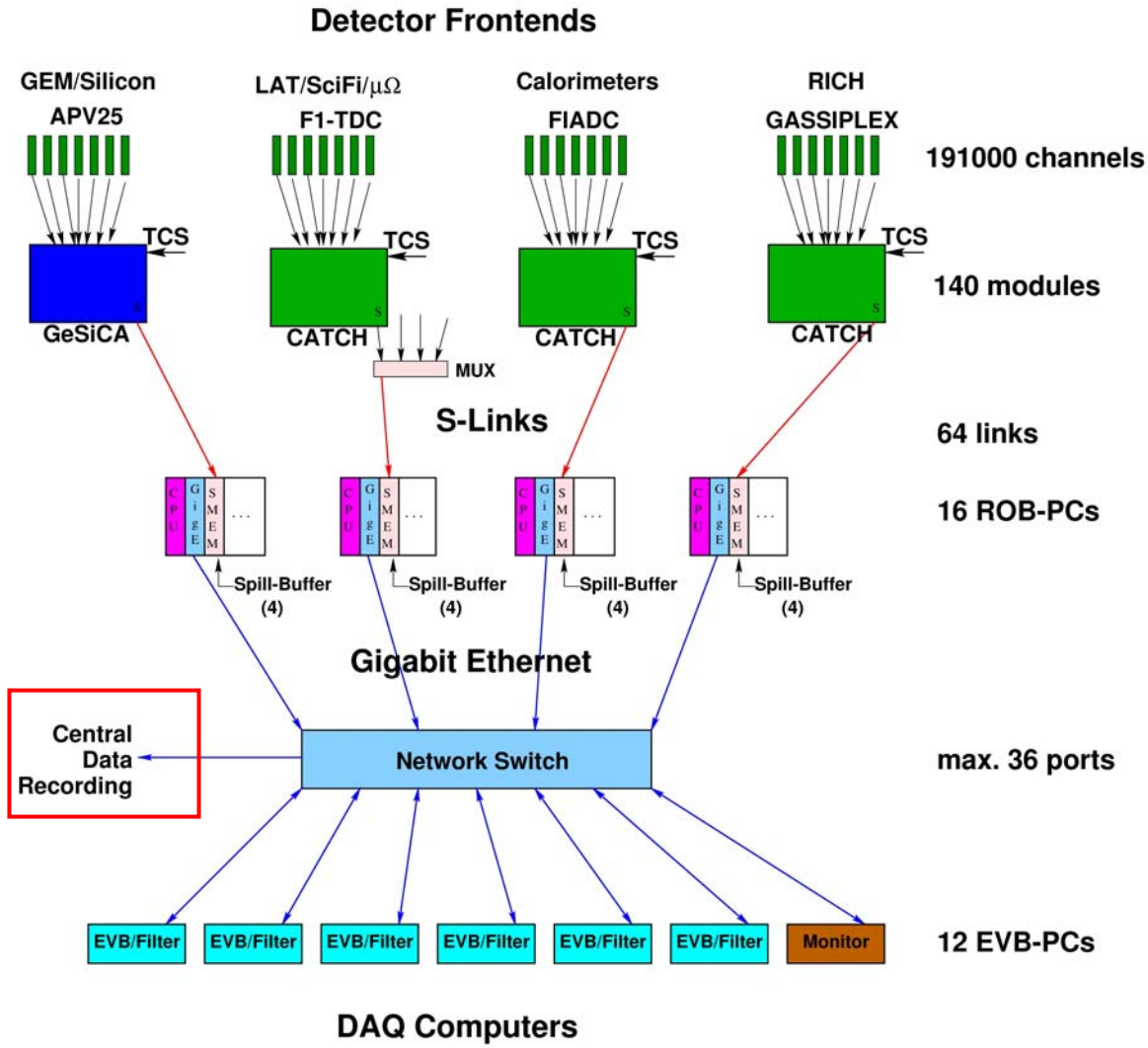
Trigger: (H4 * H5) * (HCAL1 v HCAL2)



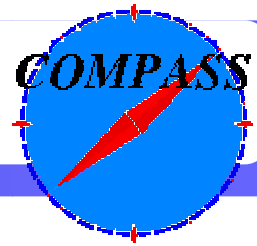
Trigger hodoscopes

FE & DAQ

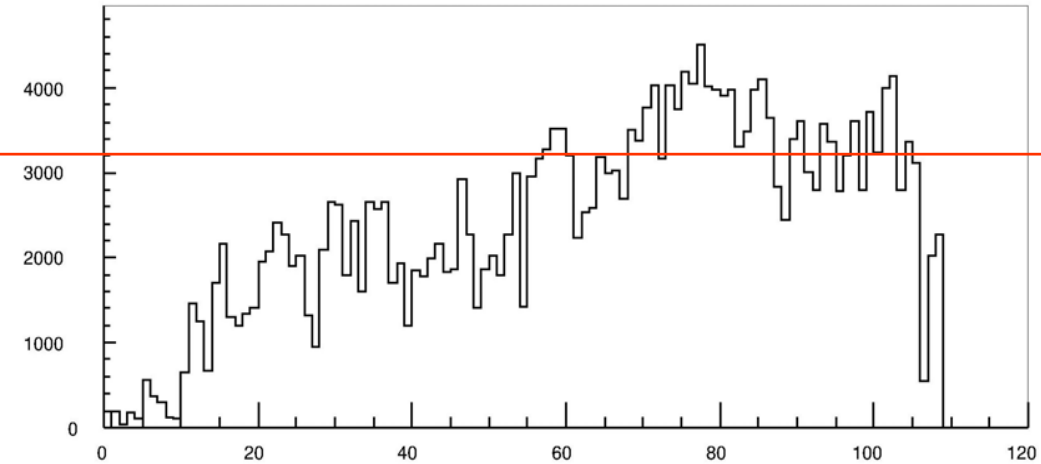
- pipelined readout architecture
- 200k channels
- event size ~ 40 kB
- used trigger rate:
  5 kHz
- data rates:
  - 220 MB/s in spill
  - 60 MB/s DC



Central data recording

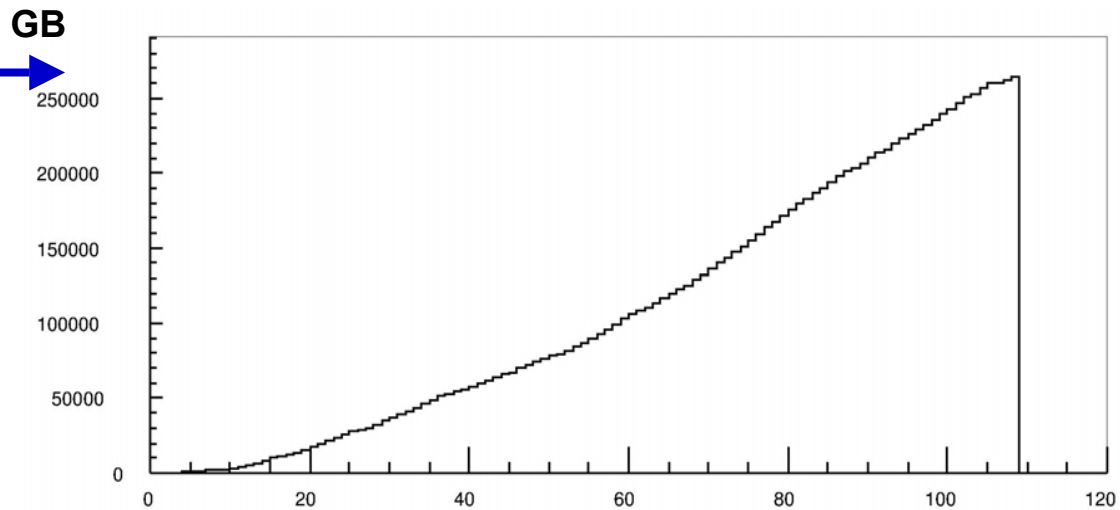


Design value (35MB/s)



260 TByte in ~100 days

5 billion events



Compare to BaBar:

1TByte/day

662 TByte in 1999-2002

Summary

- COMPASS spectrometer at CERN installed
- Successfully operated in 2002
- Novel detector techniques and DAQ used in large scale experiment
- Preparation for completion of spectrometer under way for the running period

  2006 – 2010