



VISITS TO COMPASS / NA58

Seminar for guides
9 March 2005

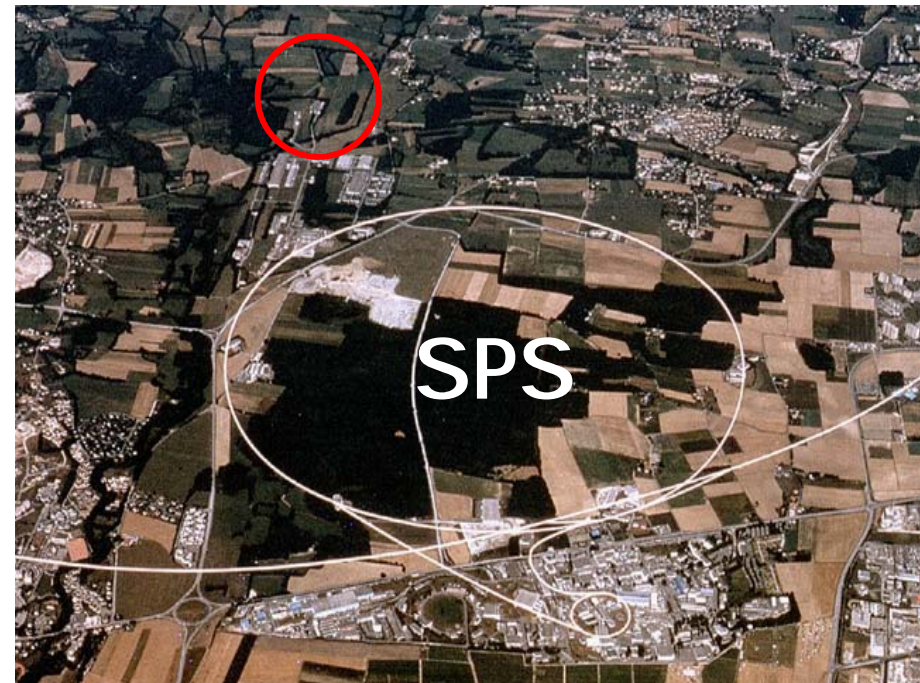
Susanne Koblitz
Gerhard Mallot



WHAT IS COMPASS ?

- ❑ Fixed-target experiment at SPS

in the North Area in Preveessin





COmmon Muon Proton Apparatus for SStructure and Spectroscopy

- 2 different physics goals:
 - hadron structure
 - hadron spectroscopy

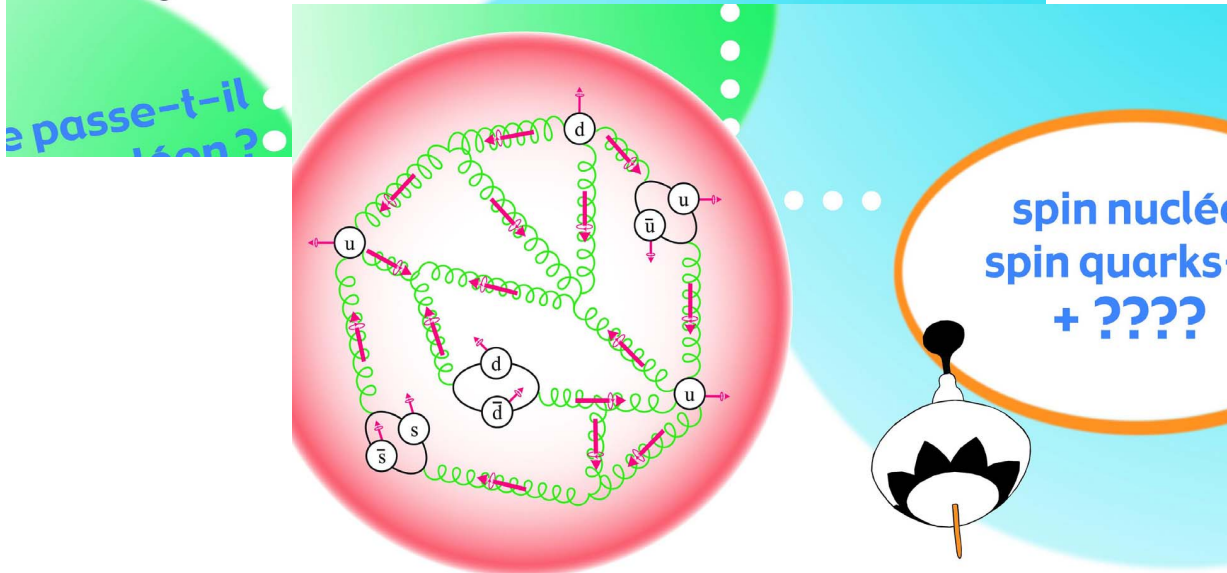
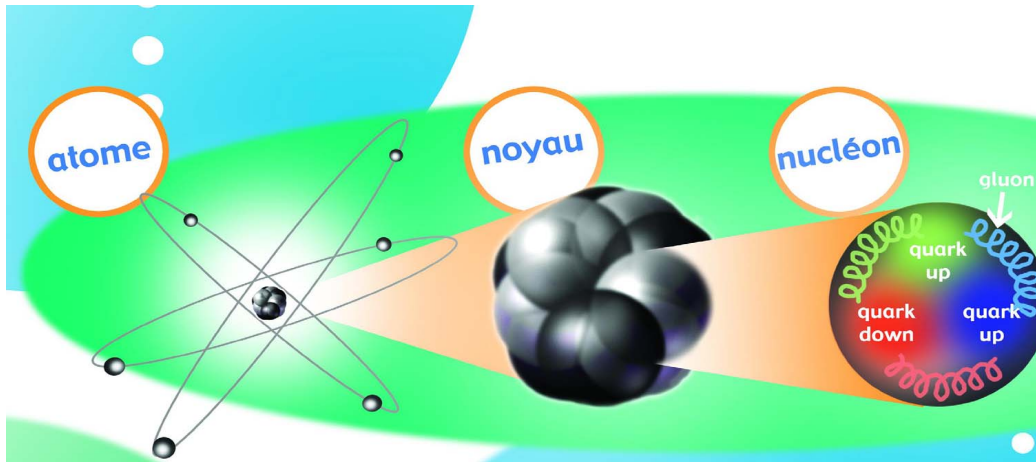
- 2 different set-ups:
 - muon beam
 - hadron beam



Spin Structure of Nucleons

Nucleon spin made up of:

- quark spins
- gluon spins
- orbital angular momentum



HOW?



Spin Experiments are puzzling !



Wolfgang Pauli and Niels Bohr, 1955

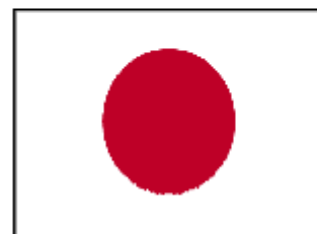
wondering about a tippe top toy





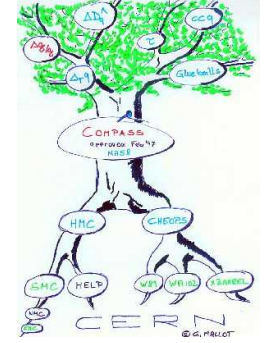
COMPASS COLLABORATION

- 230 physicists
- ca. 26 institutes
- 11 countries





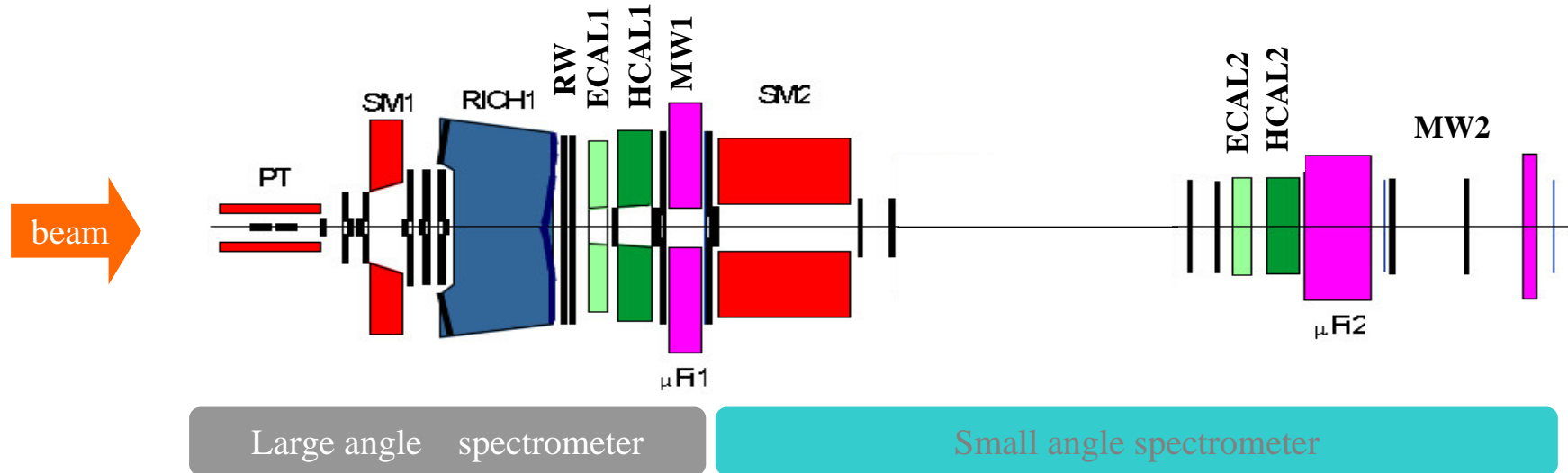
Calendar



- **1996:** proposal
- **1997:** conditional approval
- **1998:** MoU, September
- **1999 – 2000:** construction and installation
- **2001:** commissioning run
- **2002 – 2004:** data taking
- **2005:** SPS shutdown
- **2006 – 2010:** data taking
- **2011 –** interest in new physics programme



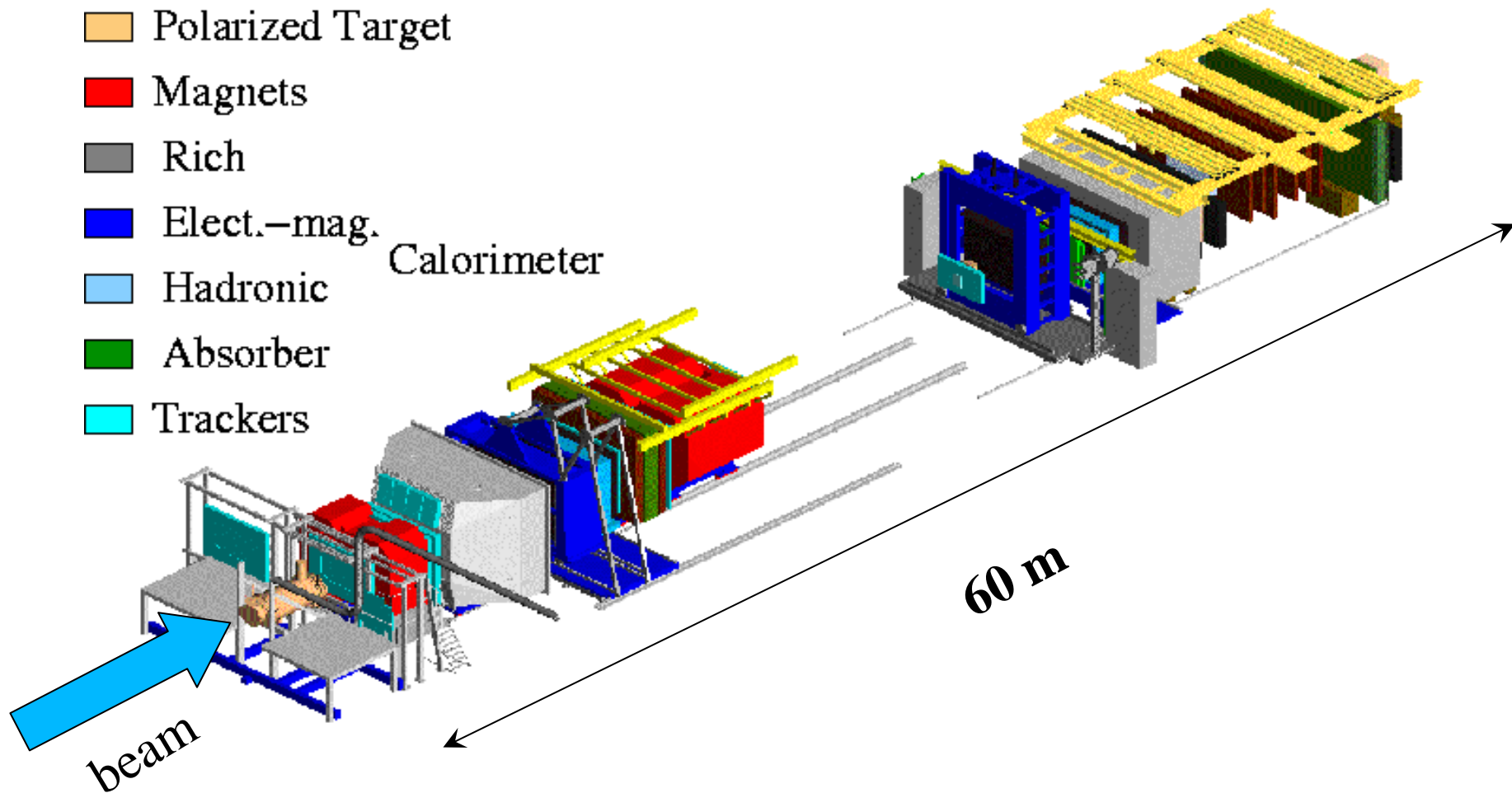
Spectrometer layout



- two-stage spectrometer, each stage comprising
 - small and large area tracking
 - momentum measurement
 - particle ID

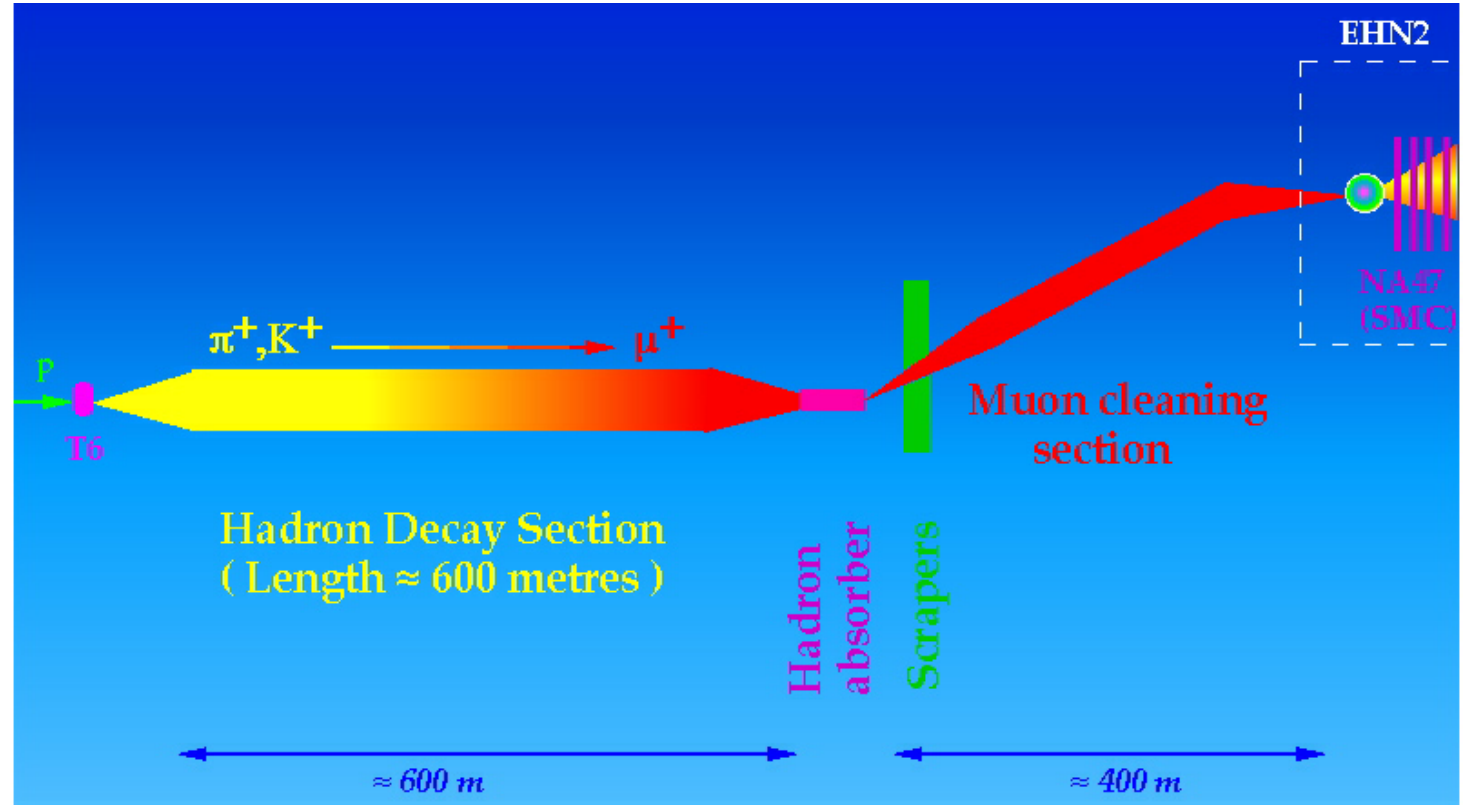
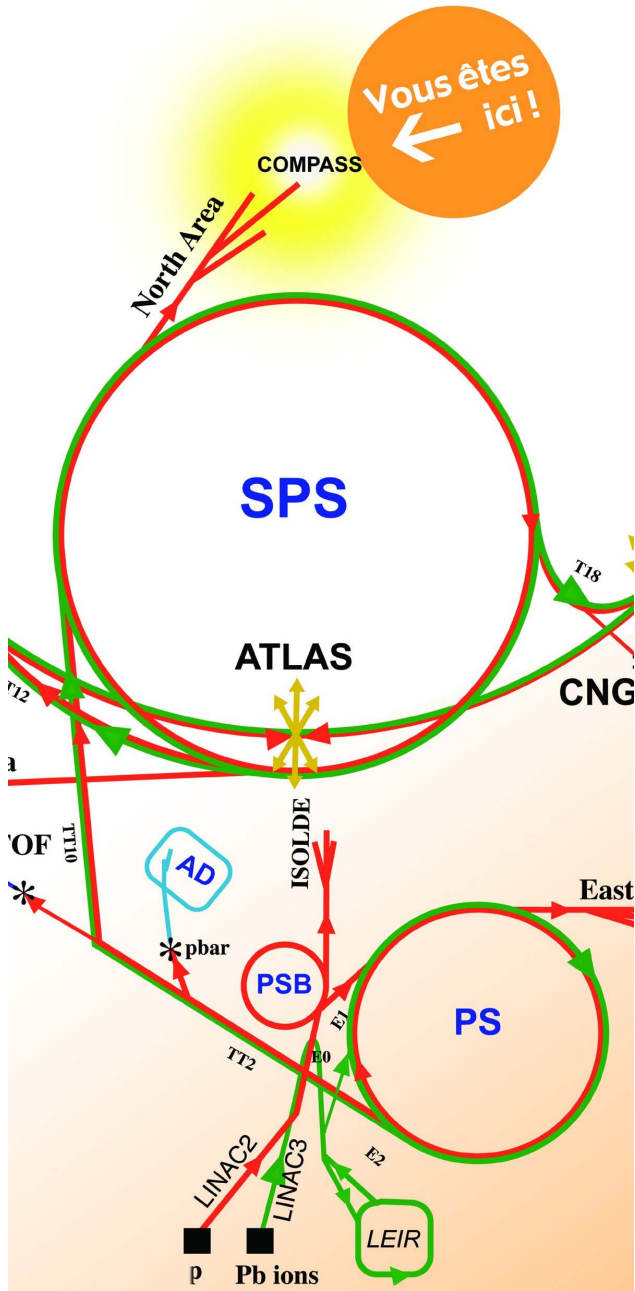


COMPASS Detector





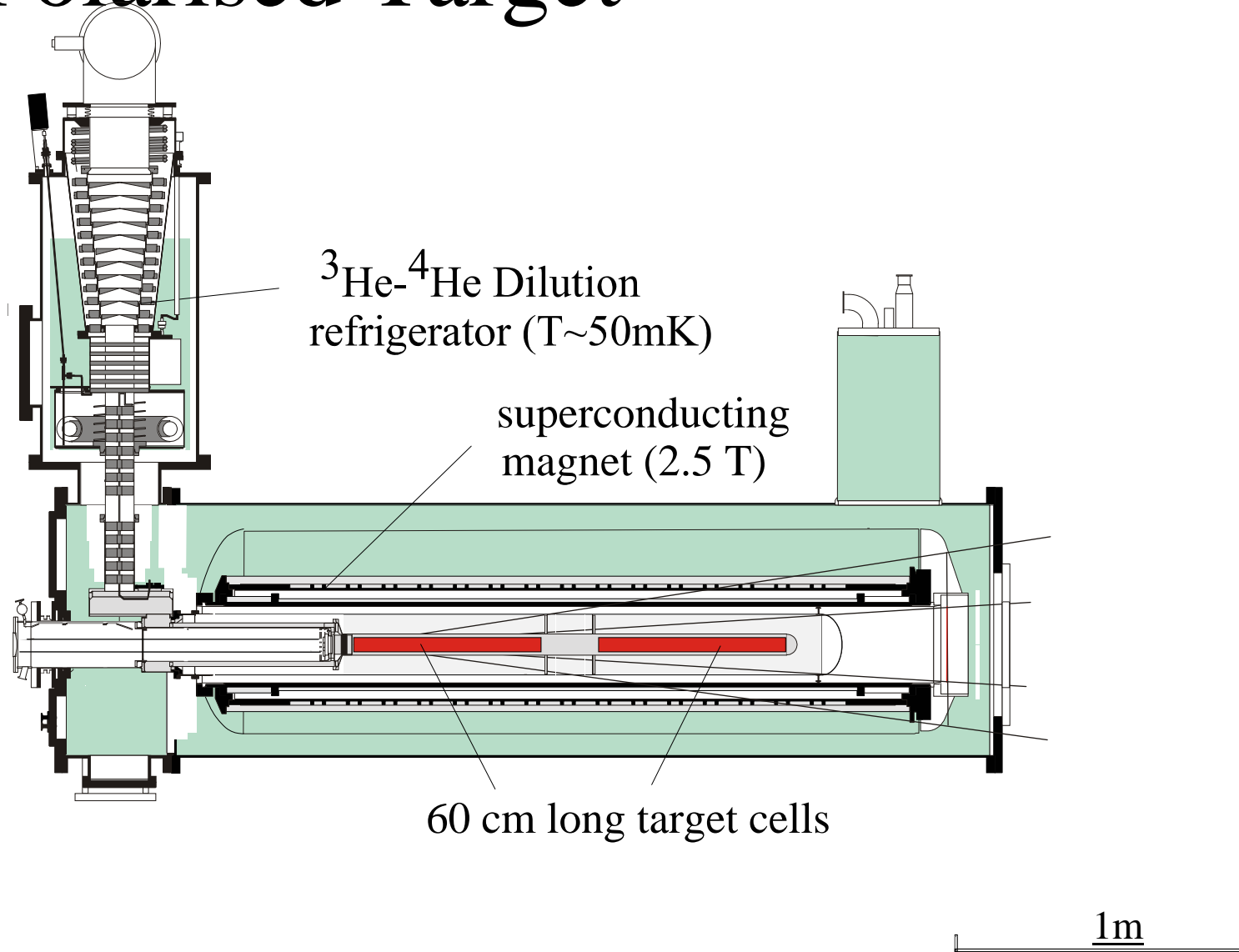
Beam Line



μ beam: 160 GeV/c, $5 \cdot 10^7$ /s, **80 % pol.**
 π, K beams: 300 GeV/c, $\sim 10^7$ /s



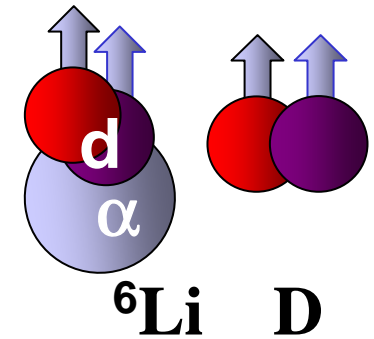
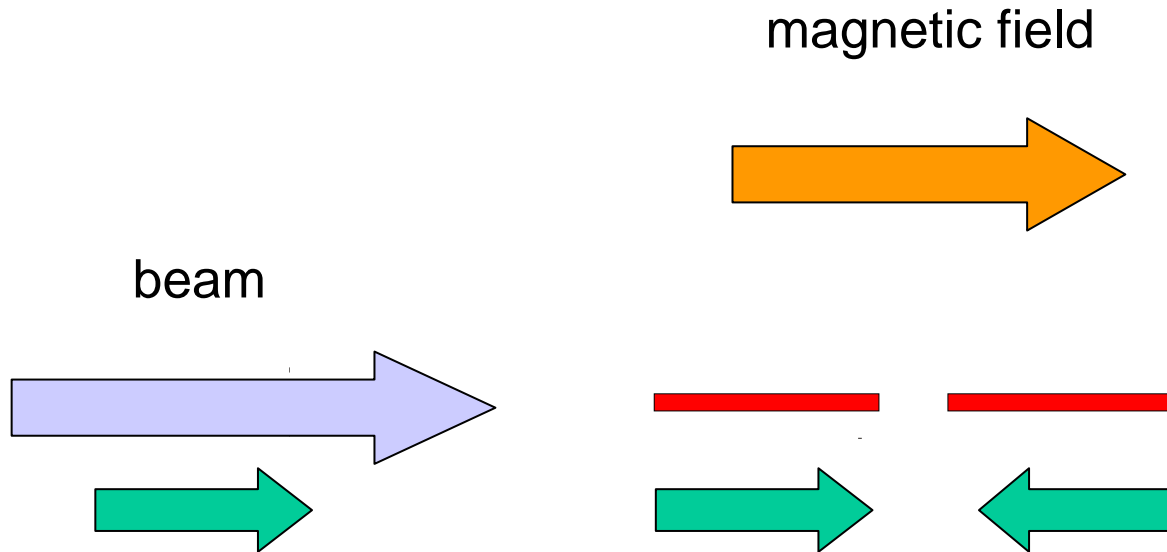
Polarised Target





Target Spin Reversal

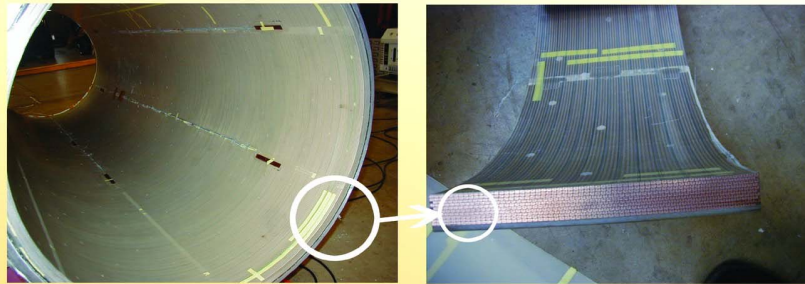
- need beam **and** target polarisation
- simultaneous measurement of both polarisations





Strong magnetic field

1 Solénoïde supraconducteur et champ magnétique fort



Intensité du courant circulant dans ce matériau supraconducteur :
 $1200 \text{ A} / \text{mm}^2$

+ champ magnétique fort :

100 GigaT magnétars répéteurs de rayons gamma

100 MegaT pulsars étoiles à neutrons

100 T étoiles naines blanches

2,5 T COMPASS

150 milliT taches solaires

10 milliT aimants courants pour coller au frigo

400 microT surface de Jupiter

100 nanoT dans les maisons sur Terre

0,5 nanoT espace interstellaire Voie Lactée

1 femtoT suite de neurones actifs
du cerveau humain !

plus froid



Low temperature



^3He – ^4He dilution refrigerator

2 Le point le plus froid du CERN

Ultra froid, le réfrigérateur à dilution....proche du zéro absolu !

Température ambiante	20°C	293,15°K
Equivalence degrés Celsius/Kelvin	1°C	274,15°K
Brrrr !!!!	0°C	273,15°K
Congélateur	-25°C	248,15°K
Record de froid (Antarctique)	-89°C	183,55°K
Cible COMPASS	-273°C	0,06°K



Dynamic Polarisation

- Transfer of electron polarisation to nucleons using **microwave irradiation**

3 Dynamic Polarisation Polarisation dynamique

a Au début, le sens du spin des nucléons a une infinité de possibilités...
Au début, le sens du spin des nucléons a une infinité de possibilités...

b Puis, dans le champs magnétique fort, il n'y a plus que deux états possibles du spin des nucléons : parallèle ou non parallèle à la direction du champ magnétique.
Puis, dans un champs magnétique fort, il n'y a plus que deux états possibles du spin des nucléons : parallèle ou non parallèle à la direction du champ magnétique

a Finally, by injecting microwaves, the spins of the nucleons are all in the same direction!
Et enfin, après l'injection de micro-ondes, les spins des nucléons se retrouvent tous dans le même sens !

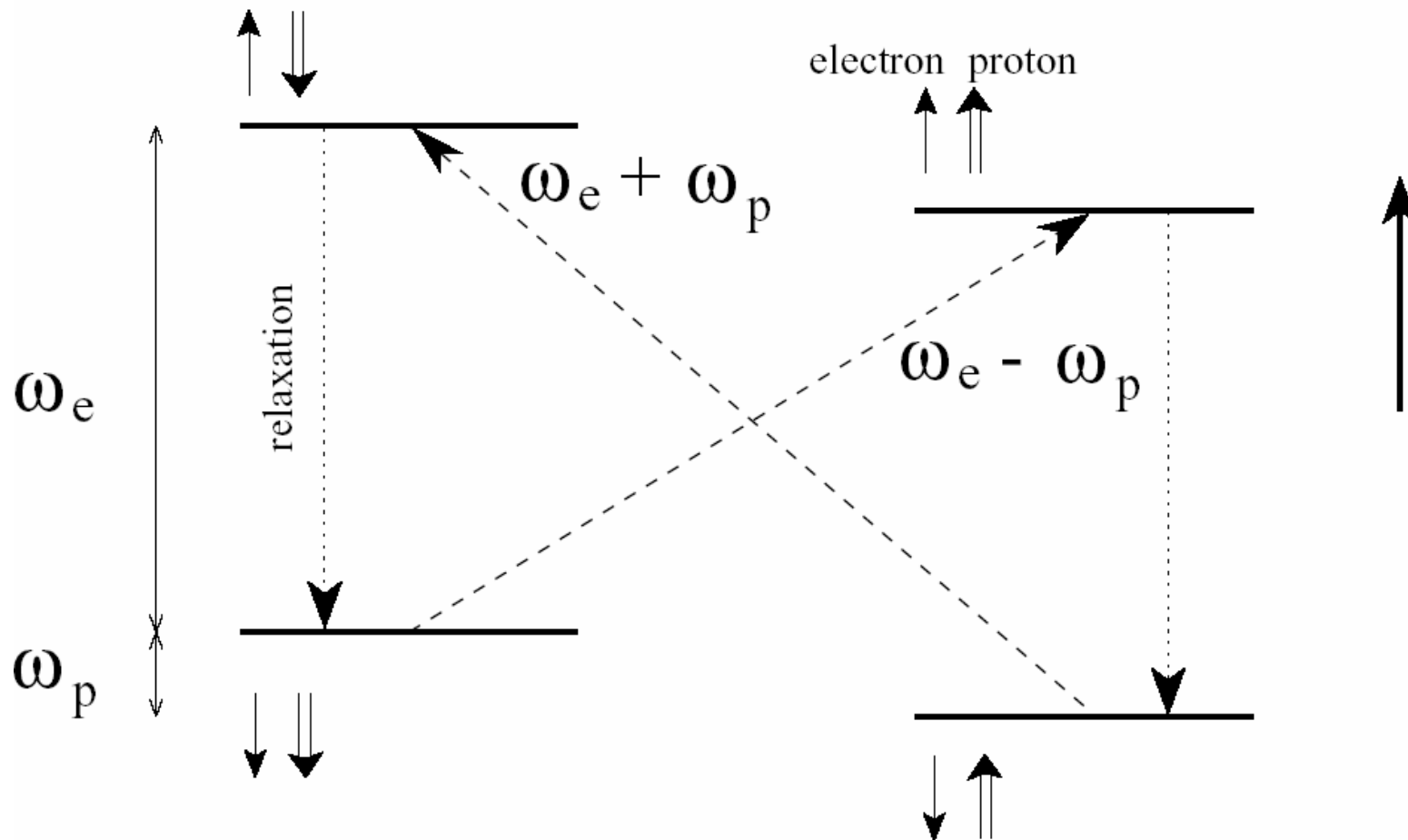
Direction du champ magnétique
Direction du champ magnétique

Loading of the target materials:
Chargement des matériaux de la cible:



Level scheme DNP

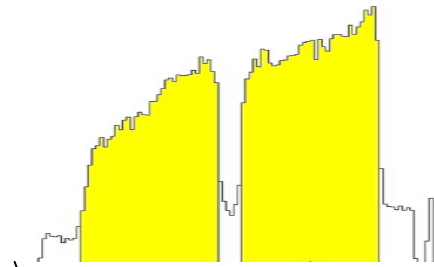
At the magnetic field and the temperature of the target 100% of (free) electrons are polarised but only 0.5% of protons and 0.1% of deuterons.





Tracking Chambers

- mainly wire chambers using gas ionisation
- silicon
- scintillating fibres



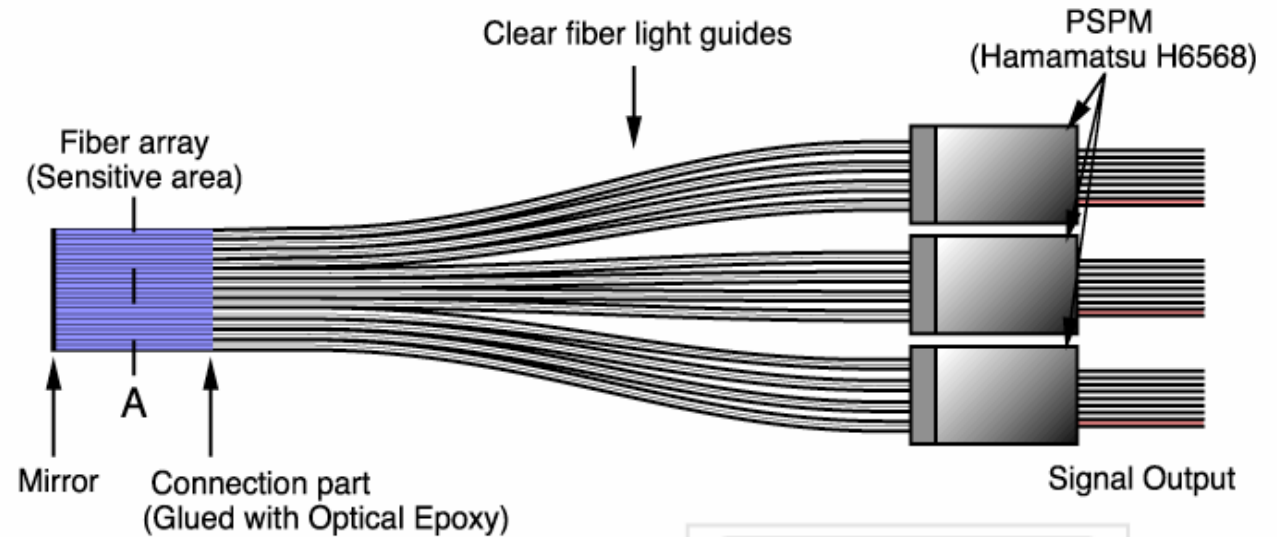
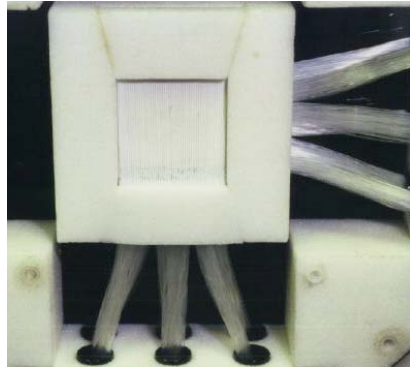
Ils enregistrent les points où ils ont été percutés par les particules avec une précision comprise entre quelques dixièmes de mm et 20 microns.

En reliant les points enregistrés par chacun des détecteurs, on peut reconstituer en 3D les trajectoires des particules et connaître ainsi leur origine et leur direction.

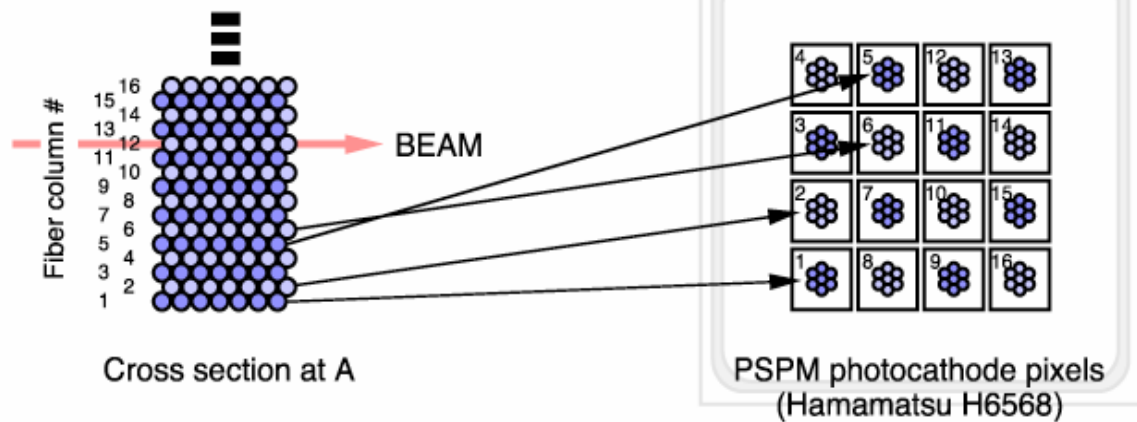


Scintillating fibres

Kuraray SCSF-78MJ



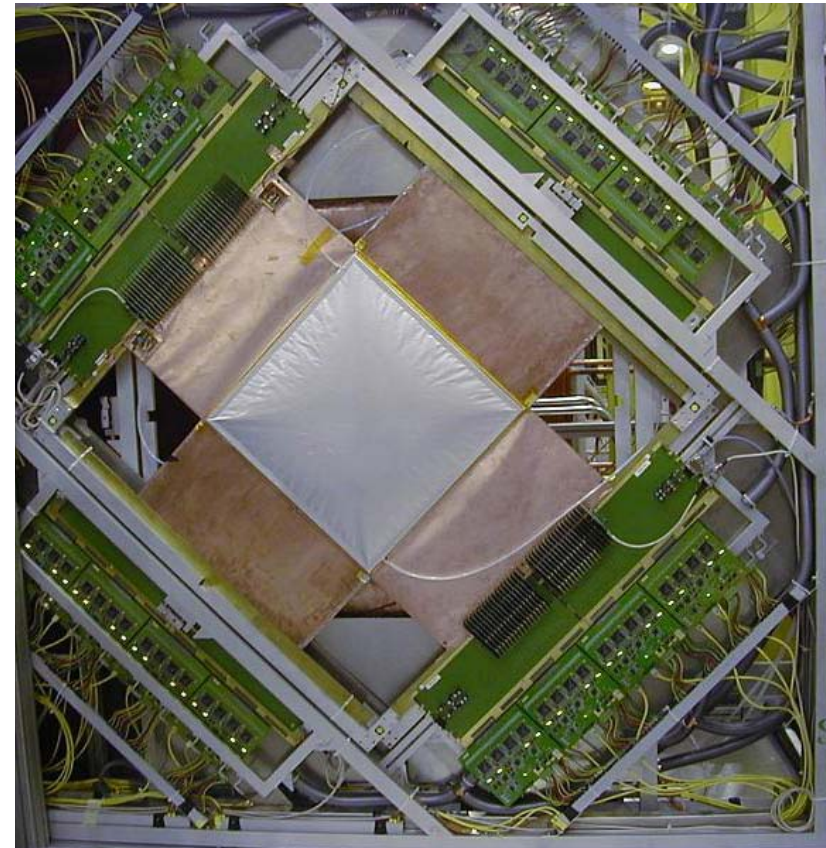
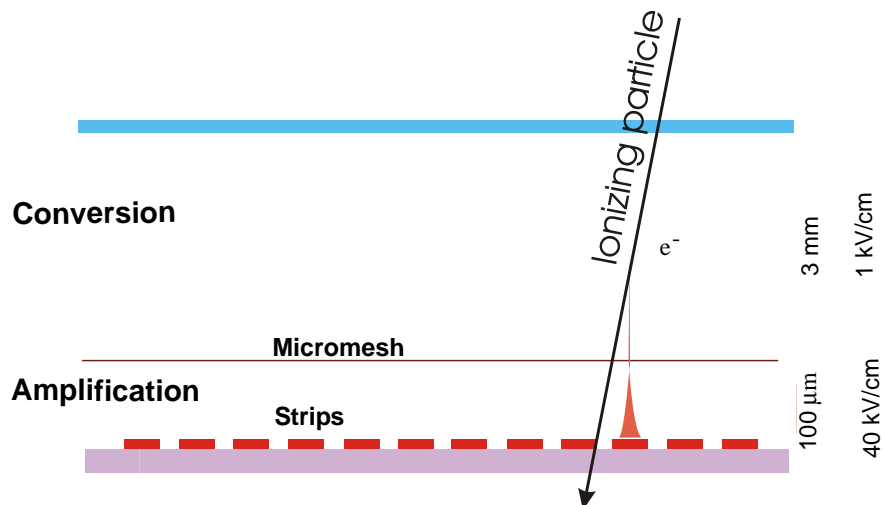
7 fibre layers with
0.5 – 1 mm diameter
up to 5 MHz/fibre
21 coordinates
4x4 – 12x12 cm²
350 – 550 ps
130 – 250 μm
efficiency ~ 99 %





MicroMegas

3 stations, 12 coordinates
size 40x40 cm²
pitch 360 – 420 μm
time res. < 10 ns
space res. 70 μm
efficiency > 97%
Ne/C₂H₆/CF₄ 80/10/10 %





Magnets for momentum measurement

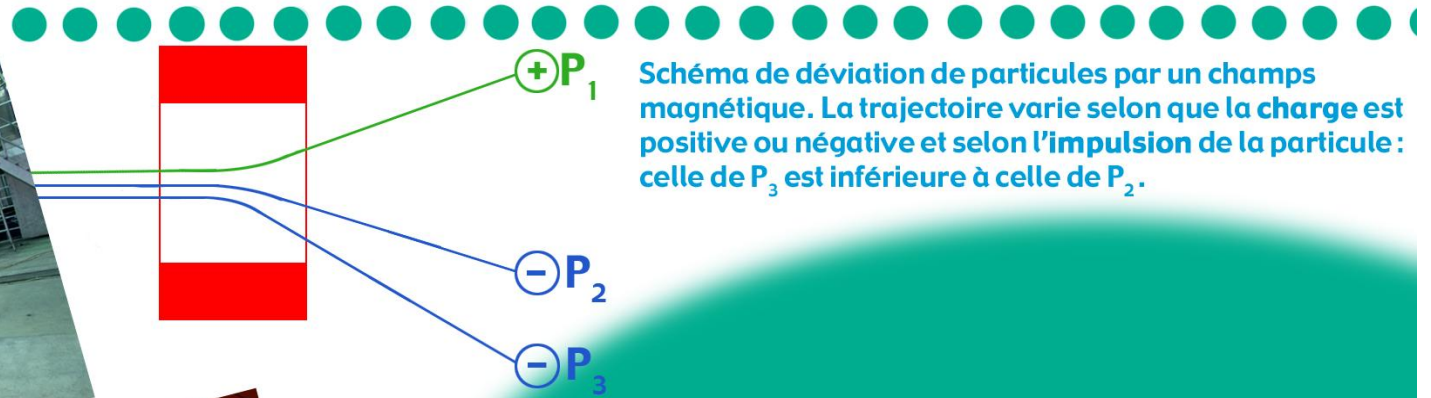
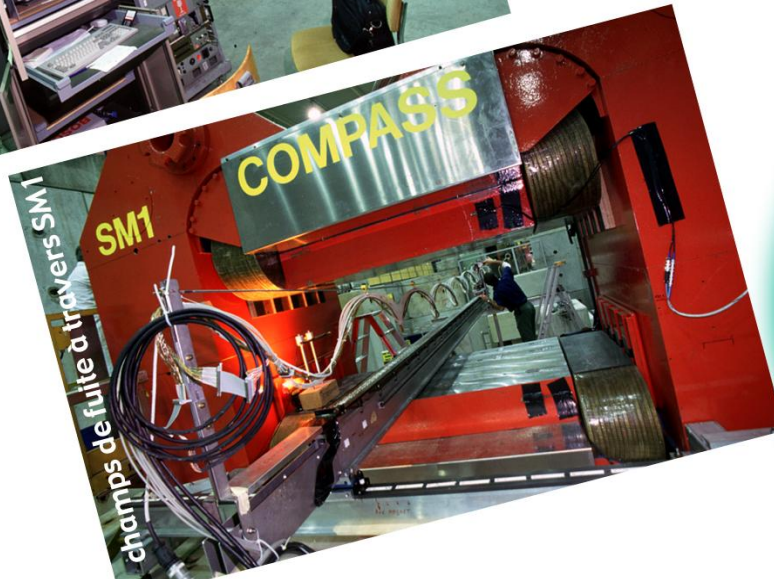


Schéma de déviation de particules par un champs magnétique. La trajectoire varie selon que la charge est positive ou négative et selon l'impulsion de la particule : celle de P_3 est inférieure à celle de P_2 .

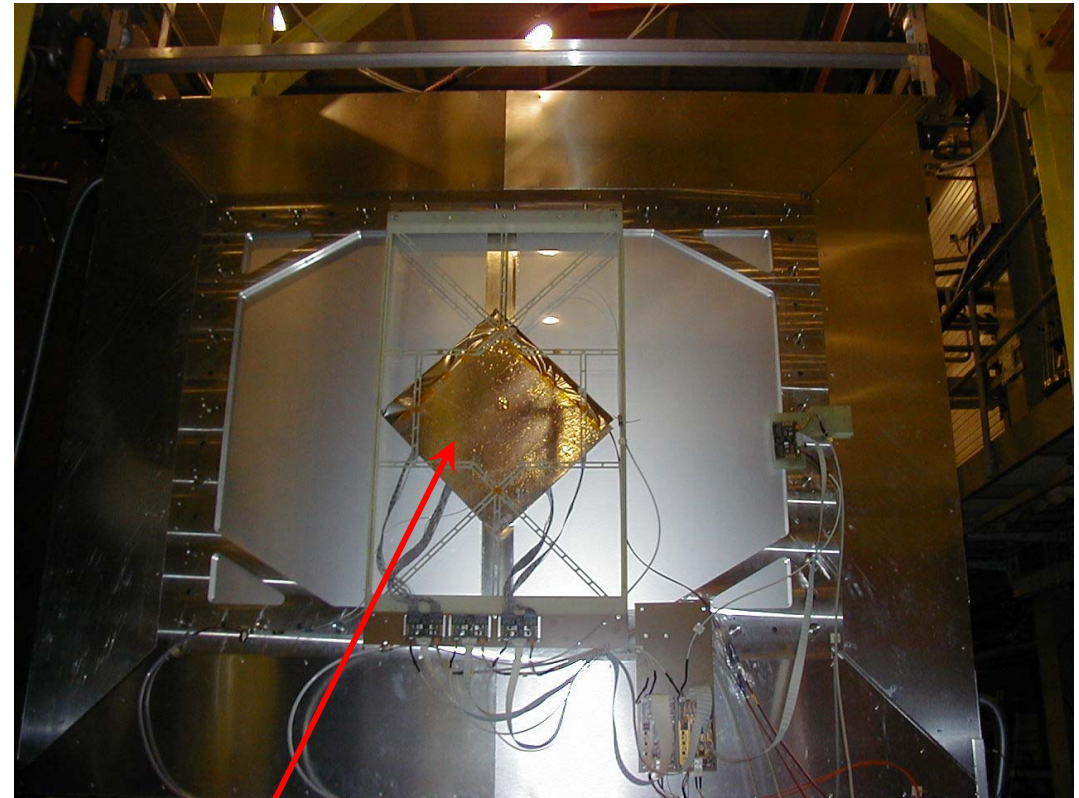
En effet, le champs magnétique des aimants fait dévier la trajectoire des particules,

et cette déviation dépend de leur charge mais aussi de leur impulsion.



Drift chamber with GEM

- 3 drift chambers
- 24 coordinates
- size 120x120 cm²
- 7 mm drift cell
- 170 μm space resolution
- efficiency > 95 %
- Ar/C₂H₆/CF₄ 45/45/10 %



GEM



Straws

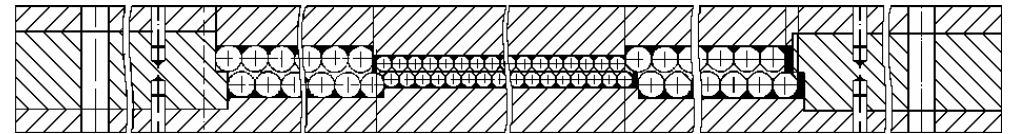
10 mm straws

6 mm straws

Hole

160 x 230 mm²

10 mm straws

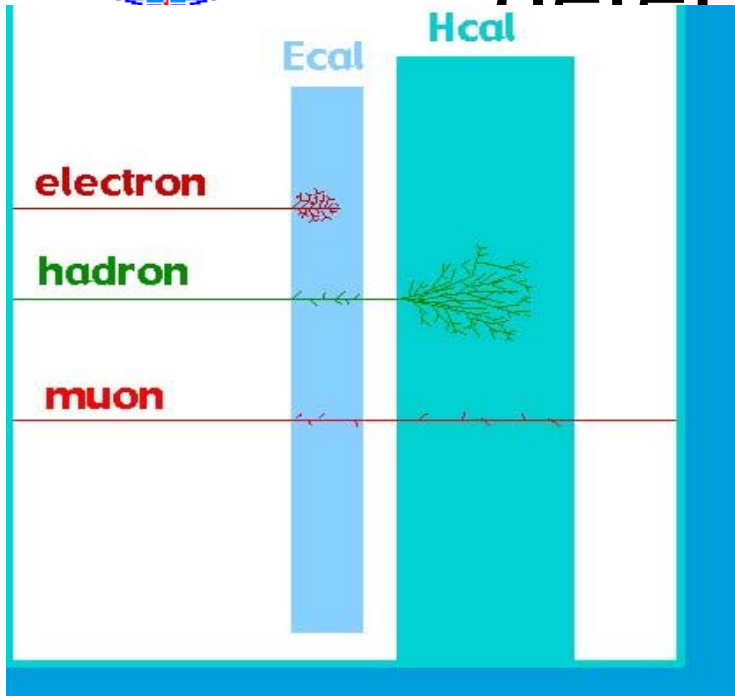
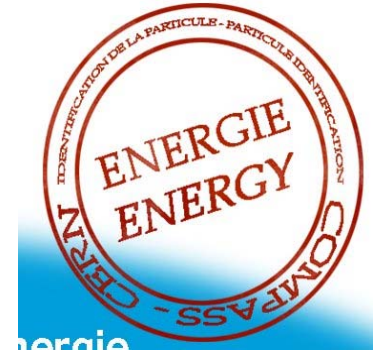


- ❑ 15 double layers of 6 and 10 mm straws
- ❑ size 325x242cm²
- ❑ resolution 270 μm
- ❑ efficiency 85 - 98 %
- ❑ Ar/CF₄/CO₂ 74/20/6 %

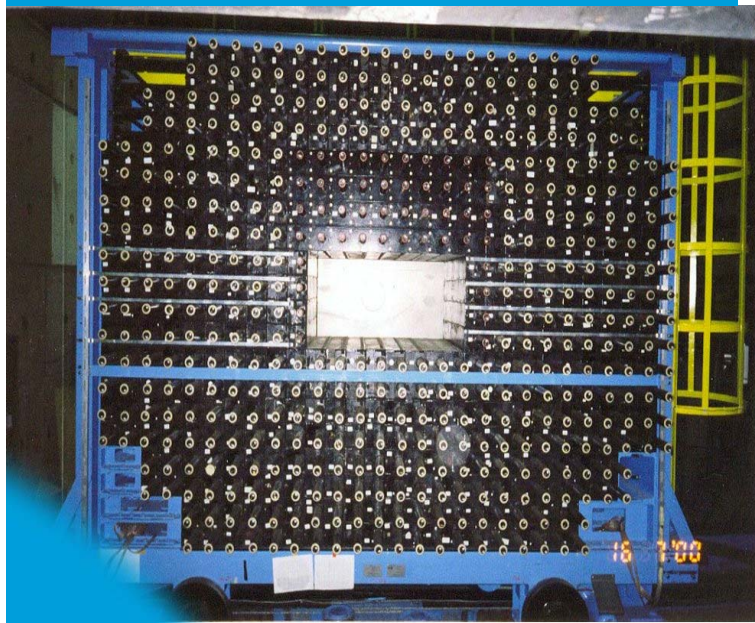
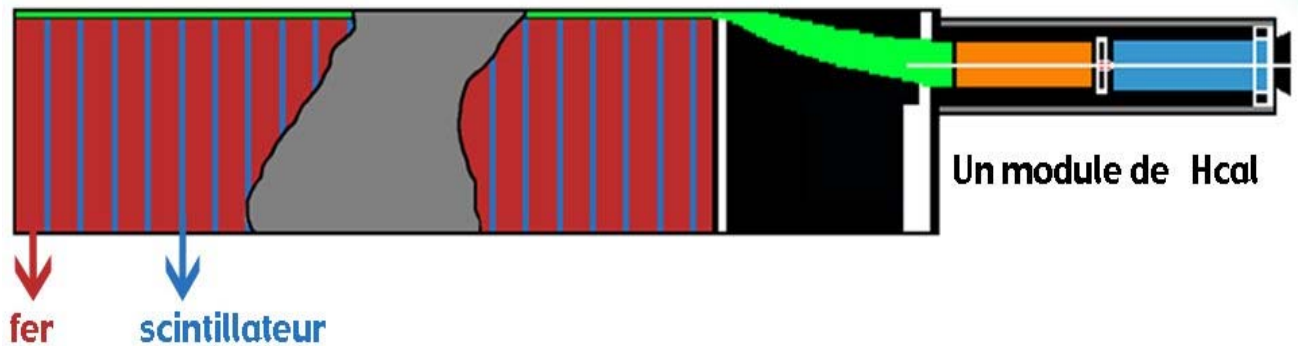




Calorimeters for Energy determination



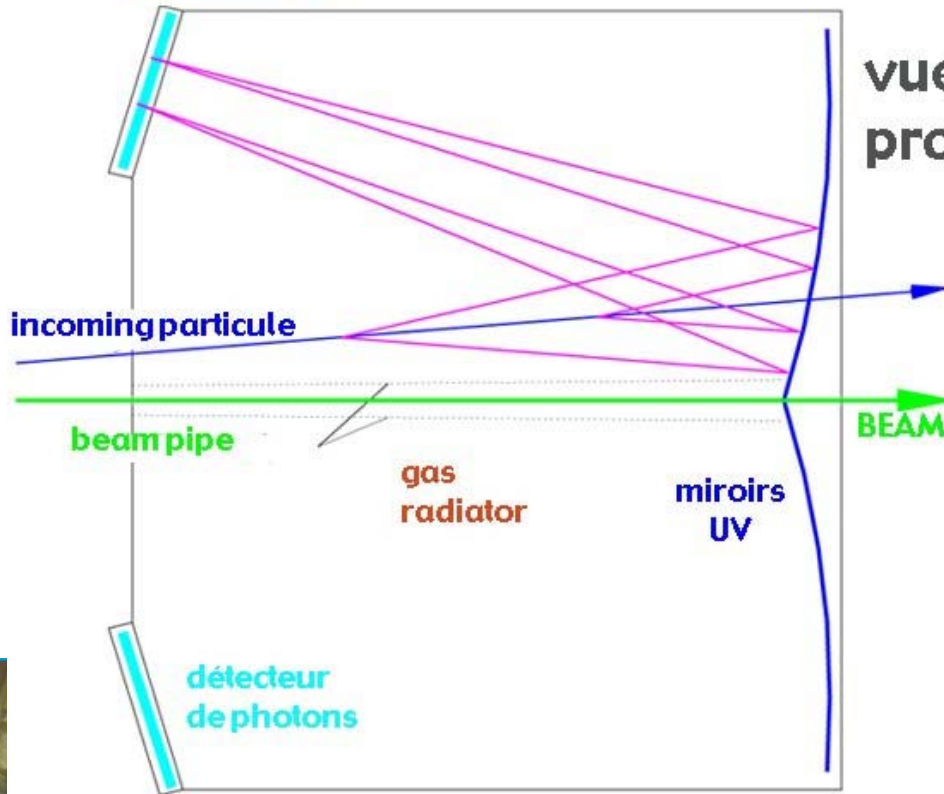
- Sampling calorimeter (HCAL):
'counts' particle in shower at certain locations along the shower



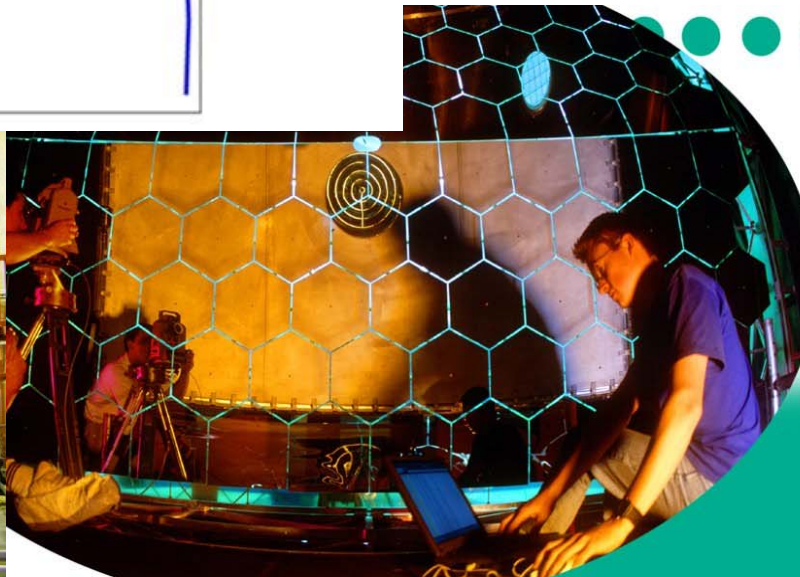
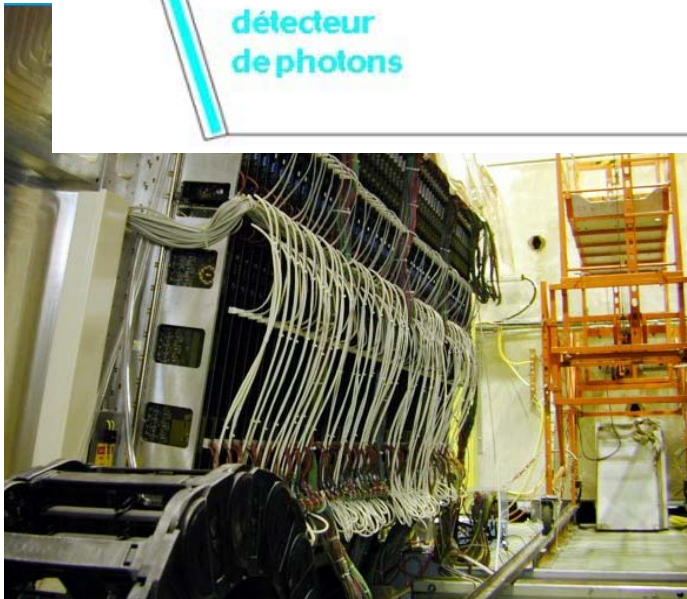
- Lead glass calorimeter (ECAL):
collects all light from Cherenkov effect



Ring Imaging Cerenkov Detector



- Opening angle of light cone measures velocity, if particle velocity $>$ velocity of light in medium (heavy gas)
- Analog to supersonic bang
- Energy + velocity \Rightarrow mass

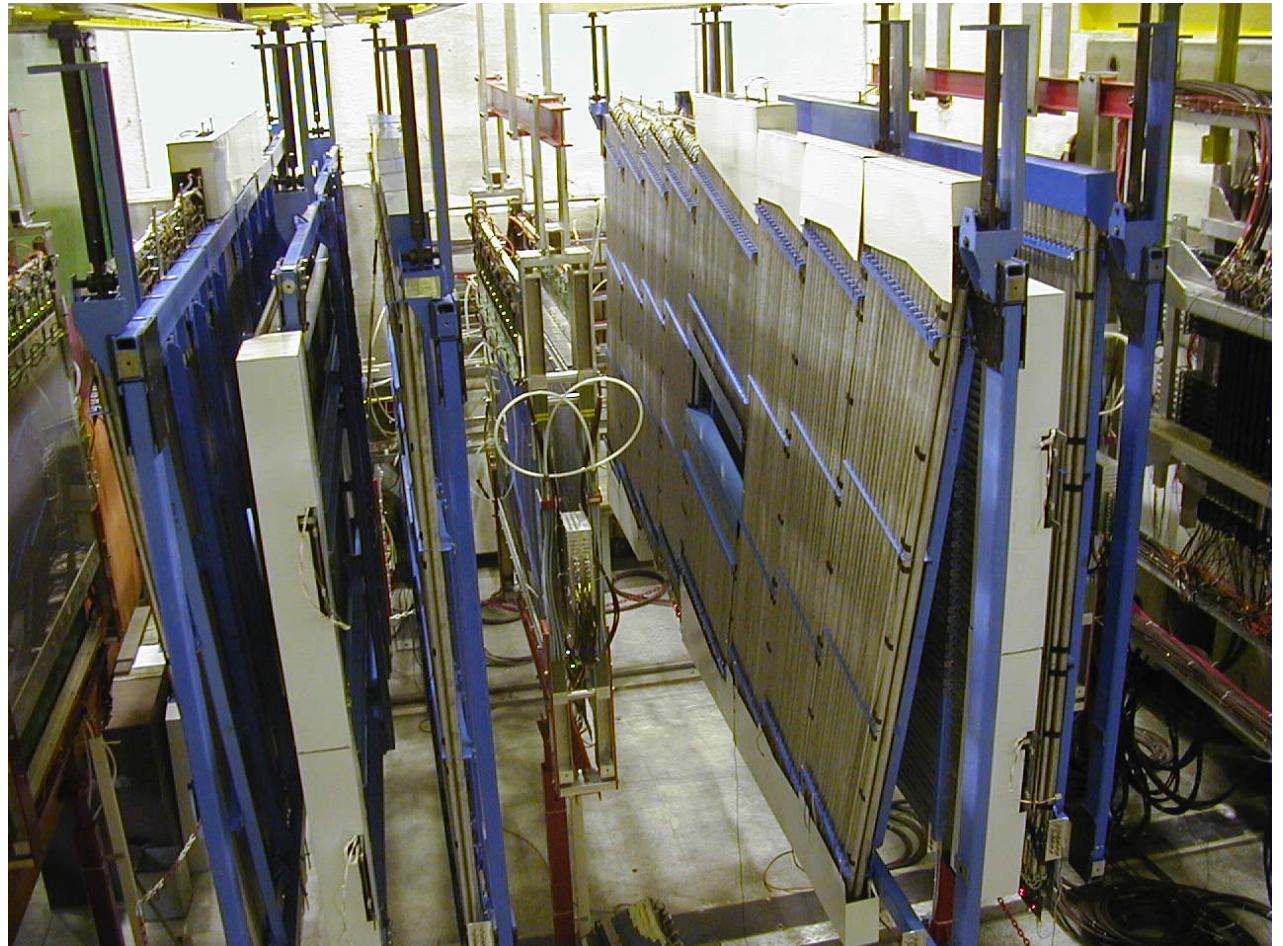




Muon Wall 2

Muon identification downstream of absorber wall (concrete)

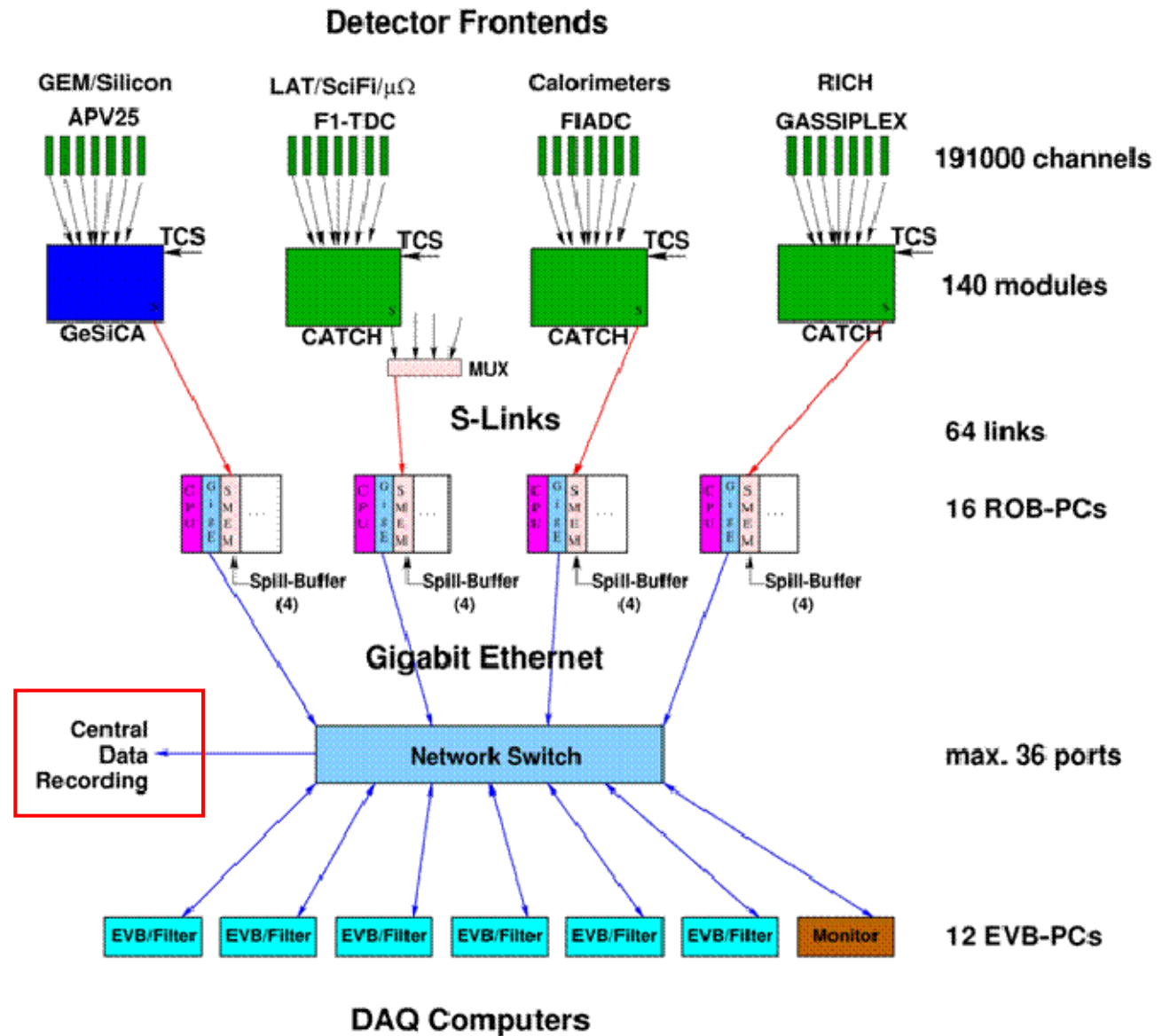
- steel drift tubes
3 cm diameter
- 6 double layers
- size 470x220 cm²
- located downstream
240 cm thick concrete
wall





FE & DAQ

- pipelined readout architecture
- 320k channels
- event size ~ 40 kB
- used trigger rate:
5 kHz-20 kHz
- central data recording
via optical fibres in
computing centre





COMPASS in Numbers

- Dimensions: 6m x 6m x 60m
- Data Taking: 1 spill every 14.8s
 - 1 spill: 5 seconds, 2×10^8 particles
 - 1 spill: ~ 2 CDROMS of recorded data
 - 4-5 TByte/day
 - 1 PByte in total (2002-2004)
- about 320'000 read out channels
- COMPASS setup costs: 25 MCHF
(without existing material and manpower)



INFOS and CONTACTS

- ❑ main COMPASS webpage:
<http://wwwcompass.cern.ch>
- ❑ COMPASS picture gallery:
<http://wwwcompass.cern.ch/compass/gallery/welcome.html>
- ❑ Muon Beam Line M2:
<http://sl.web.cern.ch/SL/eagroup/beams.html#m2>
- ❑ COMPASS infos for guides:
http://visits.web.cern.ch/visits/guides/tools/manual/english/new_itineraries.html
- ❑ CONTACTS:
- ❑ COMPASS: Susanne Koblitz - 76538