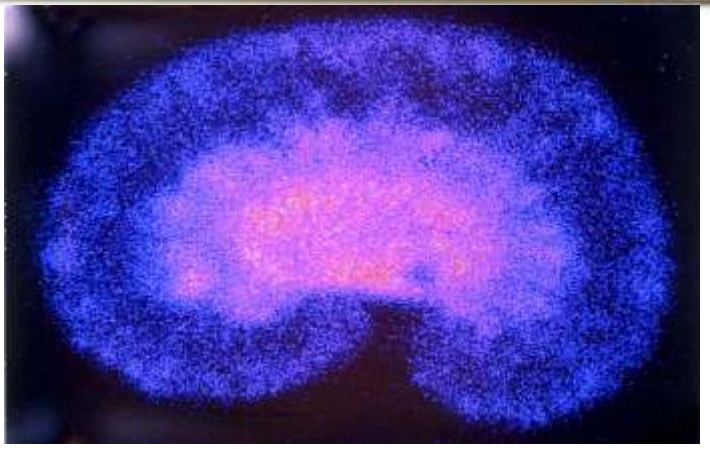
Georges Charpak, Physicien, prix nobel et encore

Ioannis Giomataris, CEA - Saclay



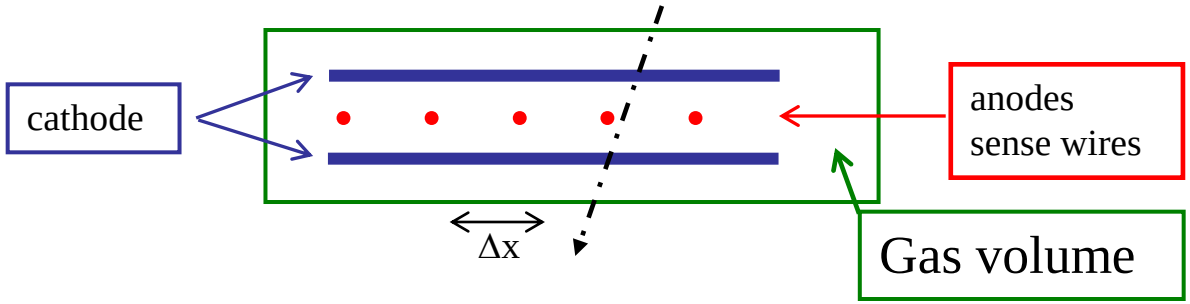
- Born in Dabrowica, Poland in 1924
- Moved from Poland to Paris in 1931
- During 2nd war served in resistance and emprisoned
- In 1944 he was deported to the Nazi concentration camp at Dachau
- In 1955, Phd from the College de France, Paris, under Frederic Joliot-Curie
- In 1985 member of the French Academy of Science
- Nobel Prize for Physics in 1992

His first particle physics experiment
The muon anomalous magnetic moment: g-2

Multiwire Proportional Chamber (MWPC)

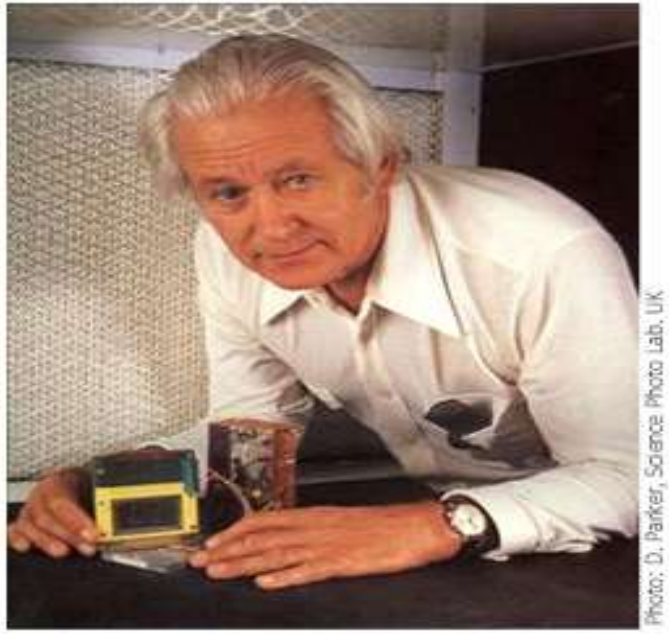
G. Charpak et al., Nucl.Instrum.Meth.62:262-268,1968
G. Charpak, D. Rahm, H. Steiner, NIM80:13-34,1970
G. Charpak, Ann.Rev.Nucl.Part.Sci.20:195-254,1970

His previous experience at College de France with a cylindrical counter 'was of paramount importance'

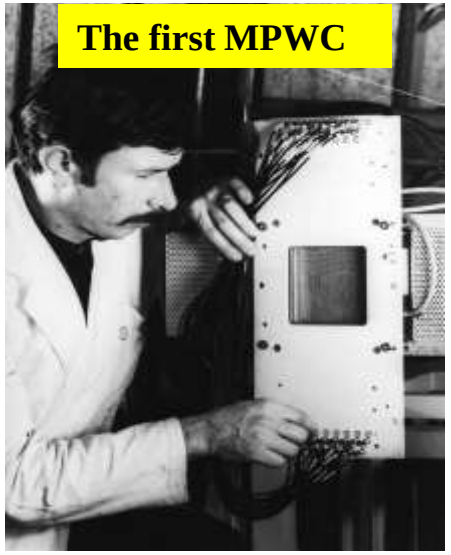


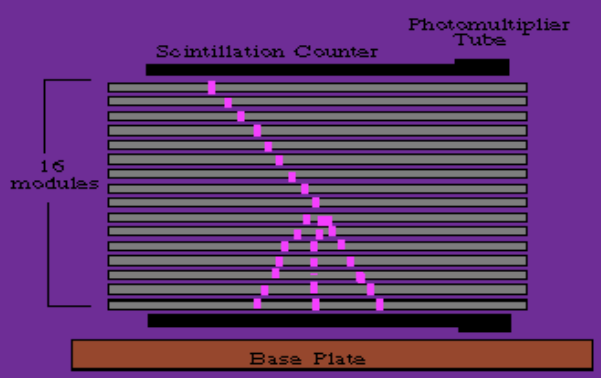
The Nobel Prize in Physics 1992

The Royal Swedish Academy of Sciences awards the 1992 Nobel Prize in Physics to **Georges Charpak** for his invention and development of particle detectors, in particular the multiwire proportional chamber.



Georges Charpak
CERN, Geneva, Switzerland



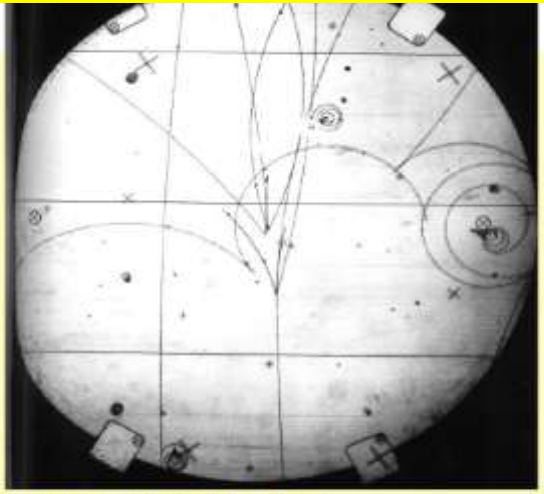


Spark chamber

1962 Neutrino muon discovery

G. Danby, J.M. Gaillard, K. Goulianos, L.M. Lederman, N. Mistry, M. Schwartz, J. Steinberger

Bubble chamber
Invented by Glaser in 1952



- pbar p → p nbar K^0 K^- π^+ π^- π^0
- nbar + p → 3 pions
- $\pi^0 \rightarrow \gamma\gamma$, $\gamma \rightarrow e^+ e^-$
- $K^0 \rightarrow \pi^+ \pi^-$

Gargamelle: Neutral current discovery

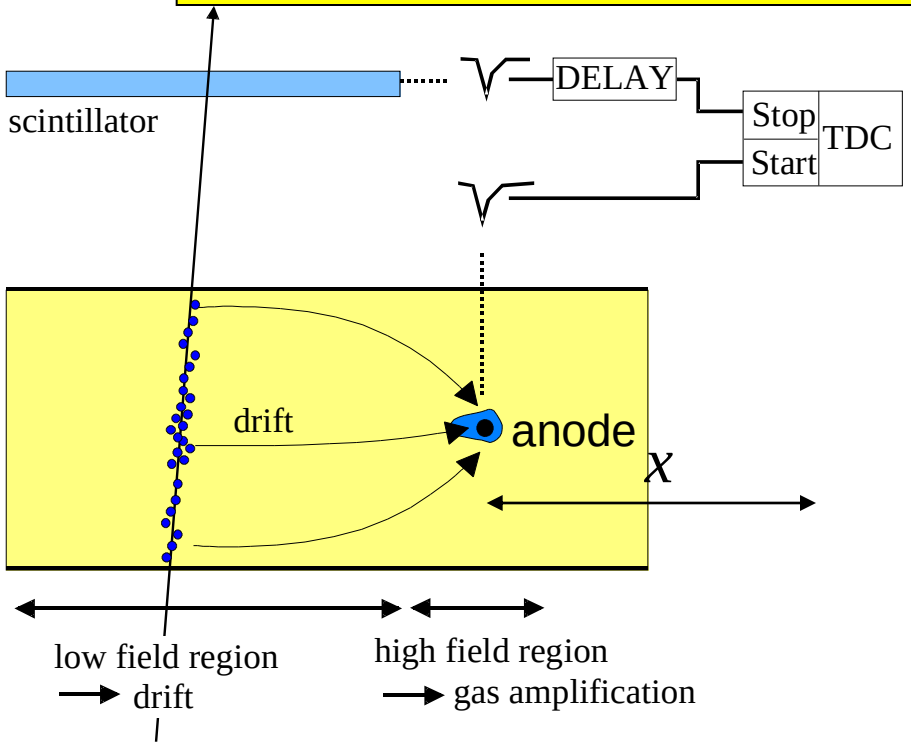
A.Lagarrigue, A. Rousset, P. Musset et al. in 1973

Compared to Spark chamber and bubble chamber
MWPC was much faster, improving spatial and time accuracy
Non significant dead time, radiation hard
No memory effect as in the bubble chamber

LARGE SIZE MWPC 1972

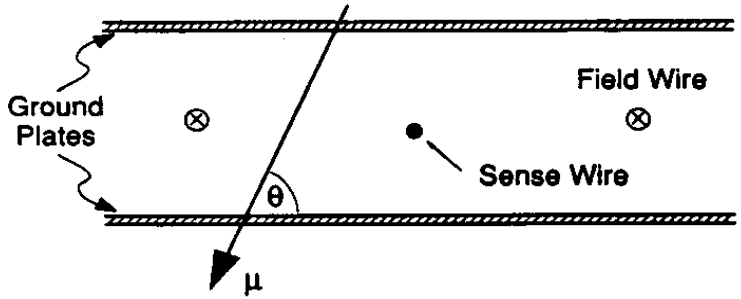
Drift chambers

T. Bressani, G. Charpak, D. Rahm, C. Zupancic, 1969
A.H. Walenta, J. Heintze, B. Schürlein, NIM 92 (1971) 373)
A. Breskin, Georges Charpak, B. Gabioud, F. Sauli, N. Trautner, W. Duinker, G. Schultz, NIM.119:9,1974.
Georges Charpak, F. Sauli , W. Duinker. NIM.108:413-426,1973.

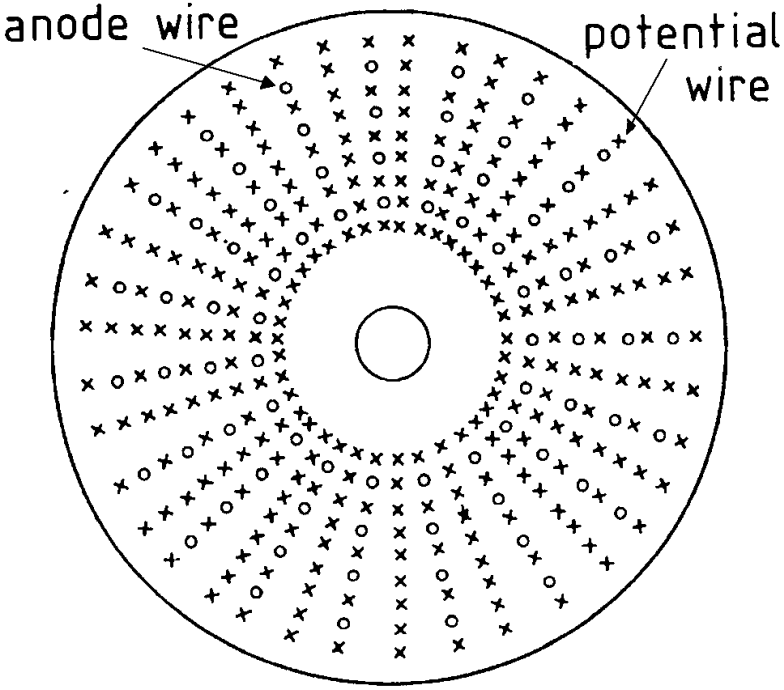


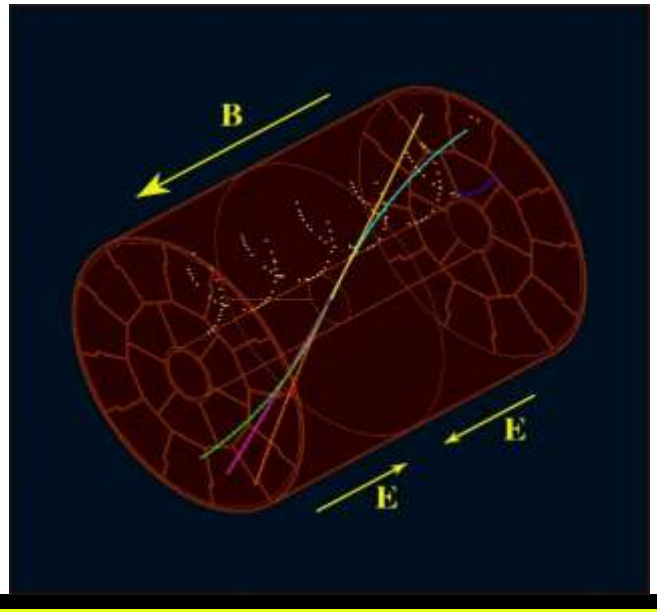
Measuring arrival time of electrons at sense wire relative to a time t_0 has opened many applications

Planar design



Cylindrical design



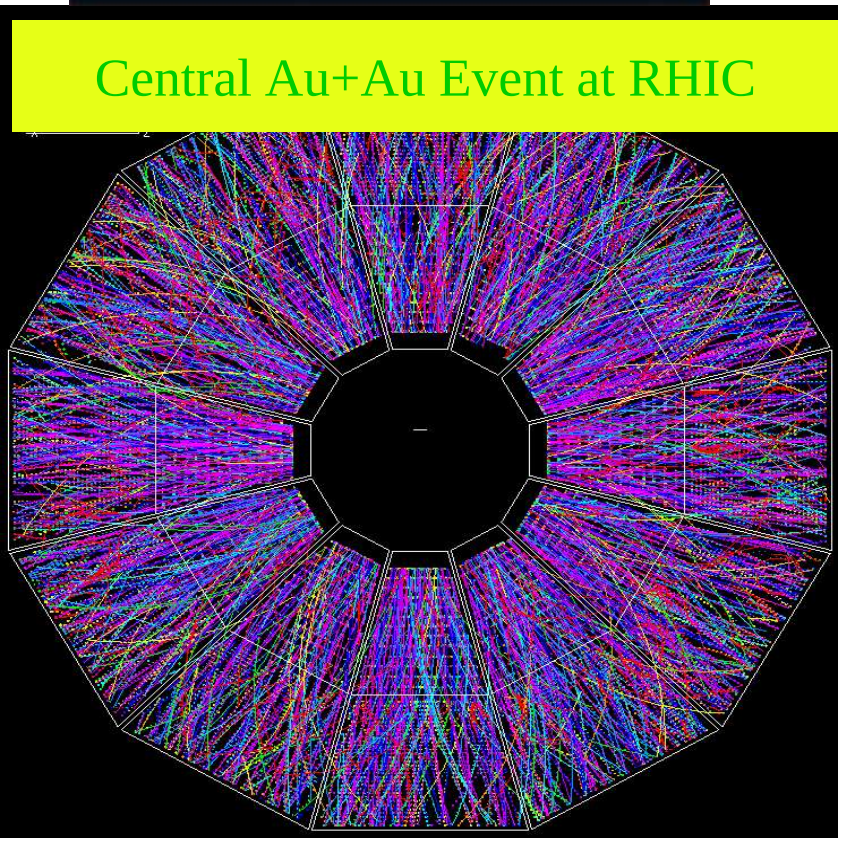


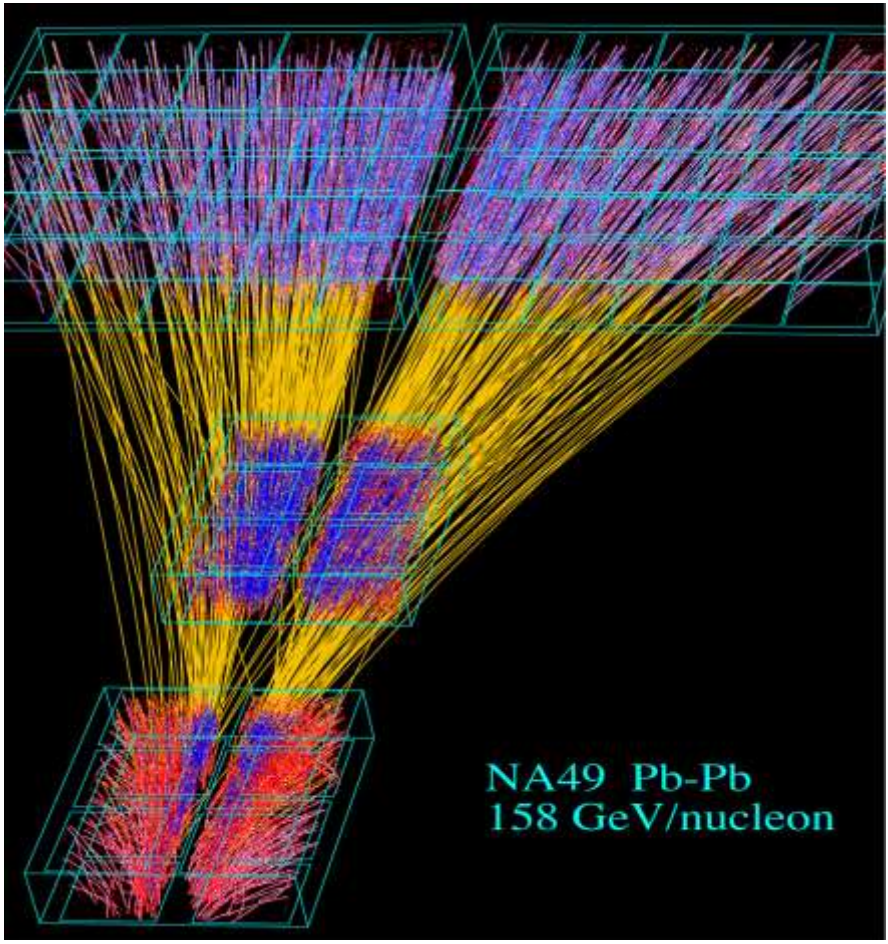
TPC DETECTOR, invented by D. R. Nygren in 1974

- high precision 3D information
- high density track capability
- Excellent momentum measurement

Drawback: space charge effect

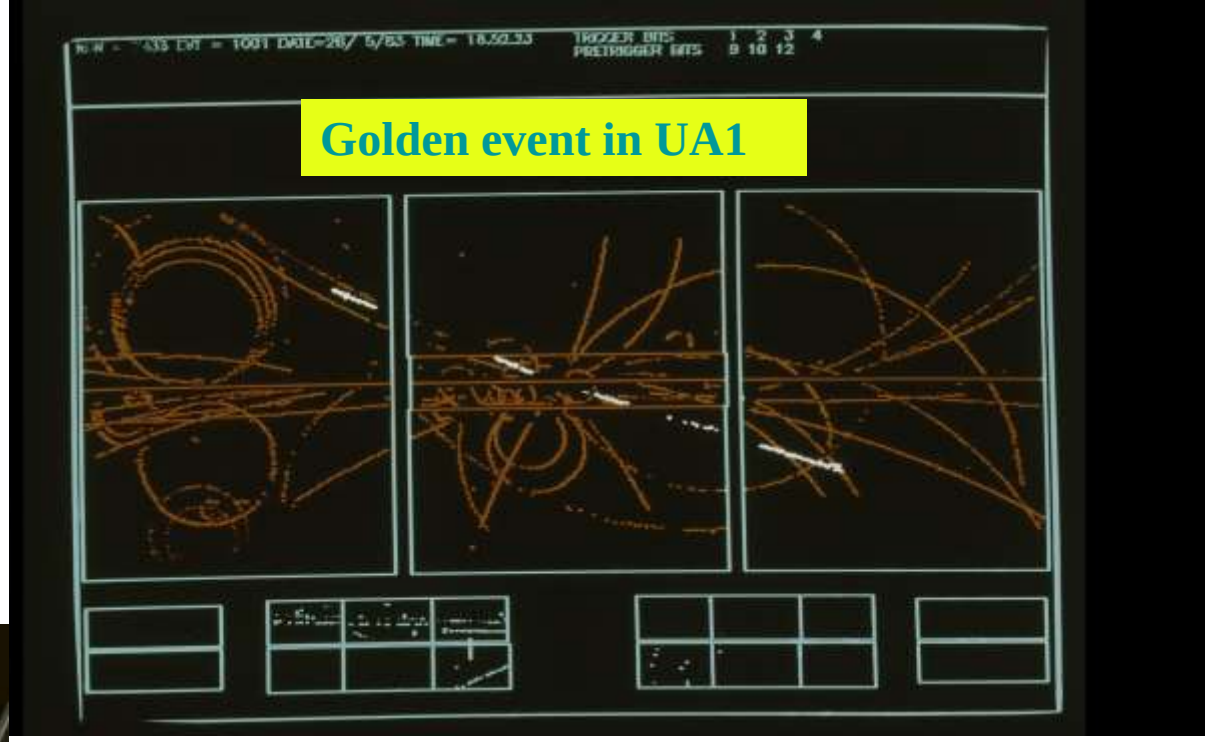
Central Au+Au Event at RHIC



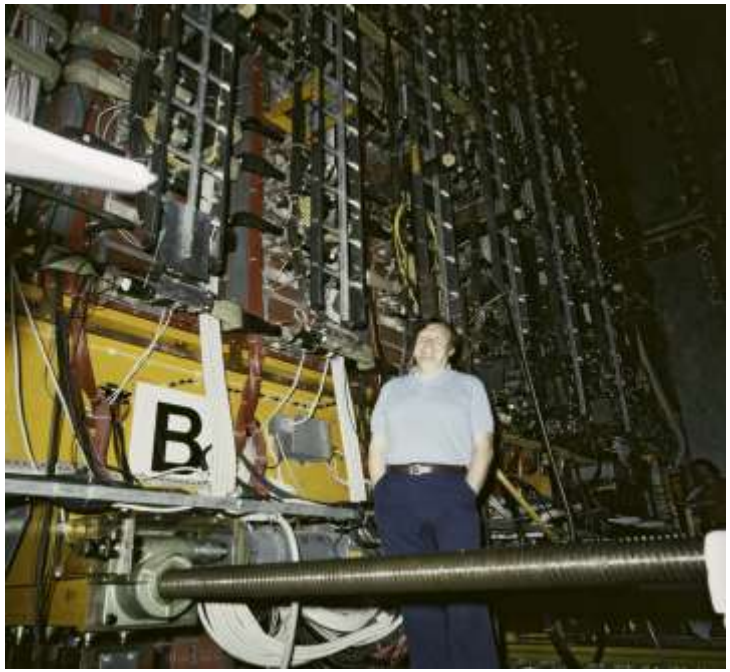


UA1

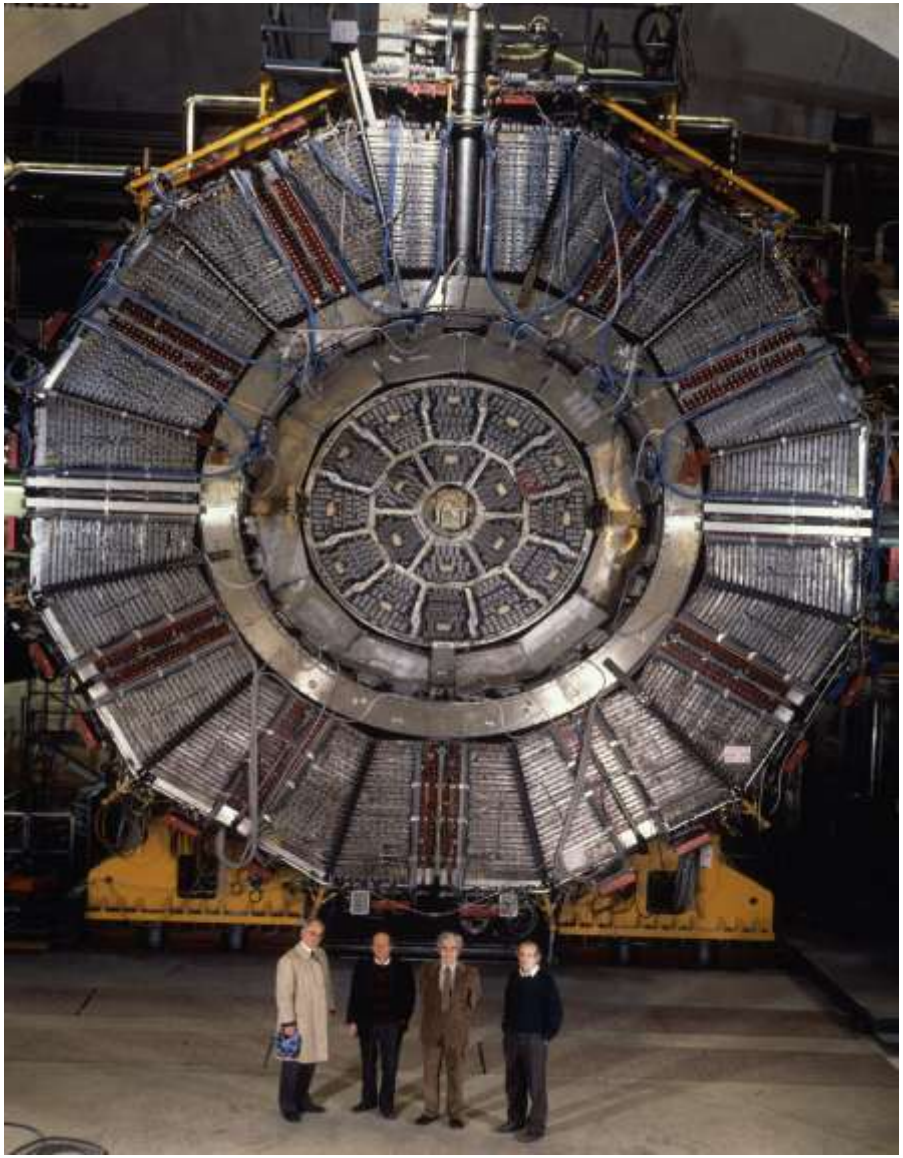
Discovery of W and Z

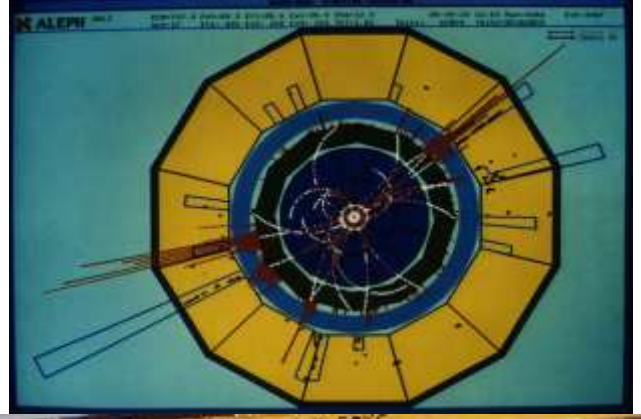


UA1 CENTRAL DETECTOR

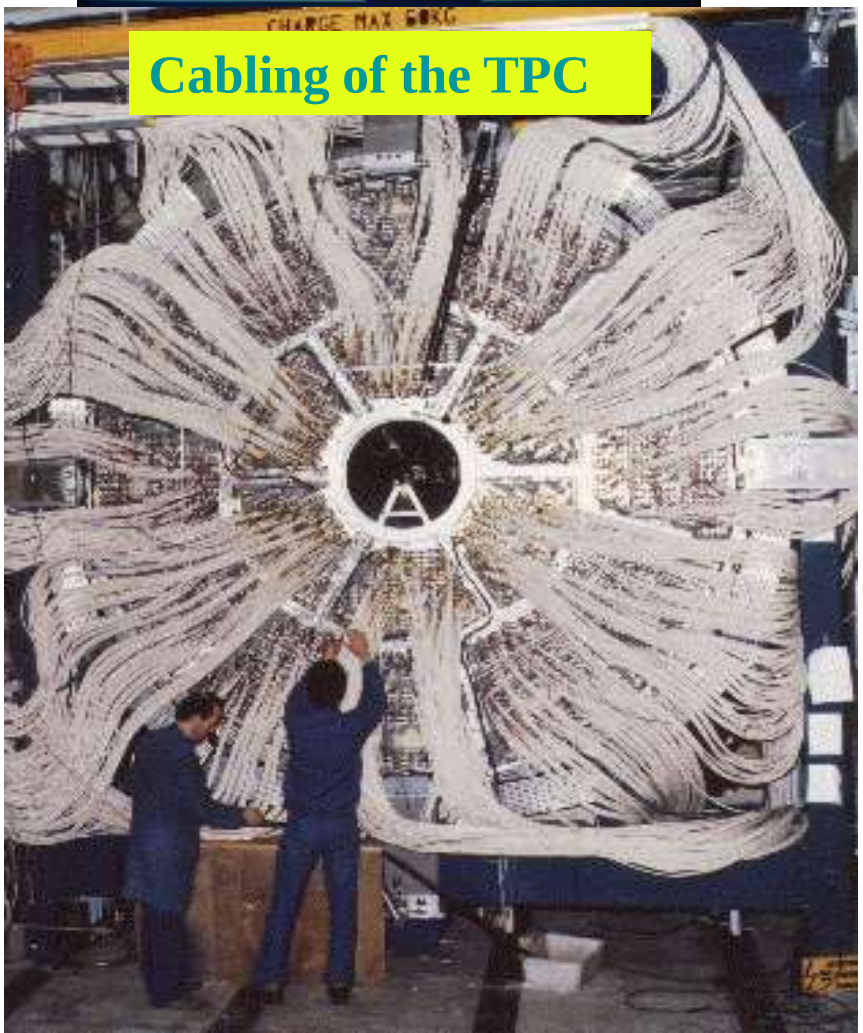


ALEPH

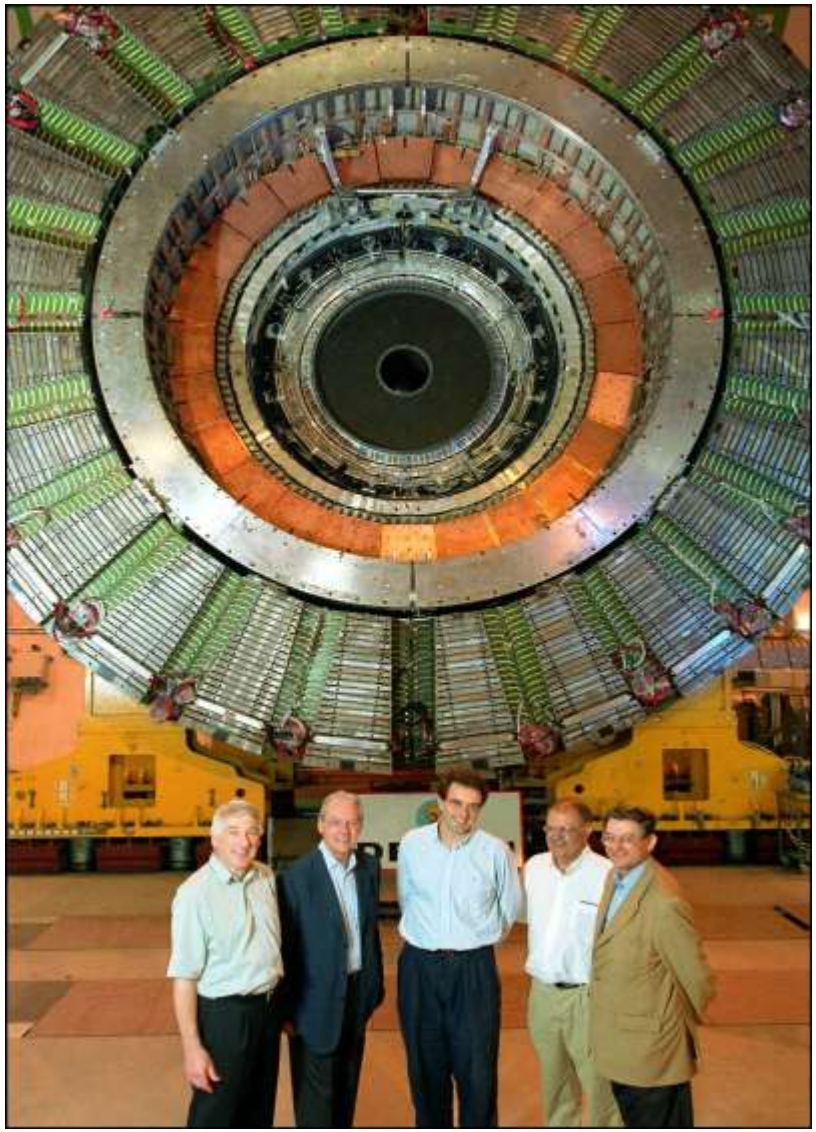




Cabling of the TPC

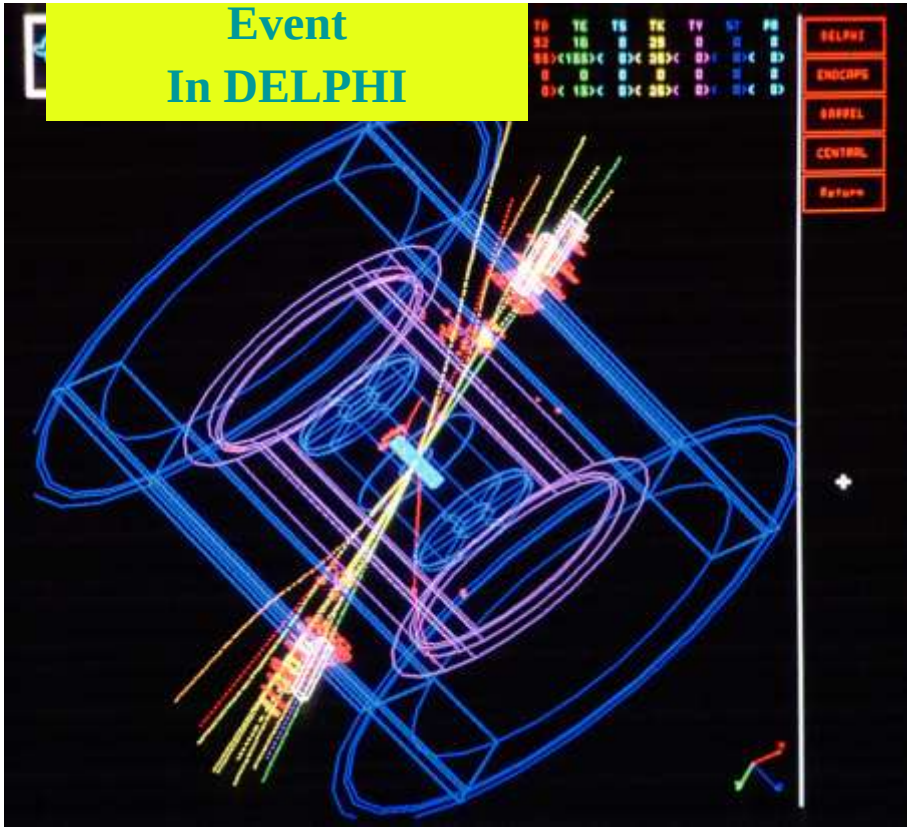


DELPHI



Barrel RICH module

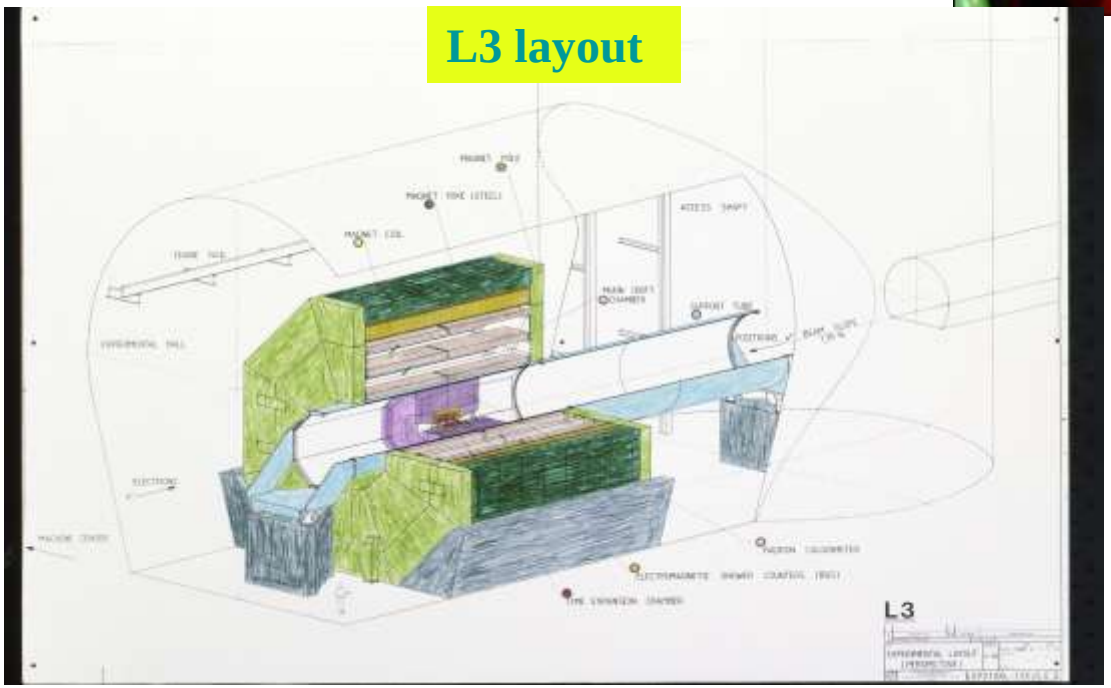
Event
In DELPHI



L3

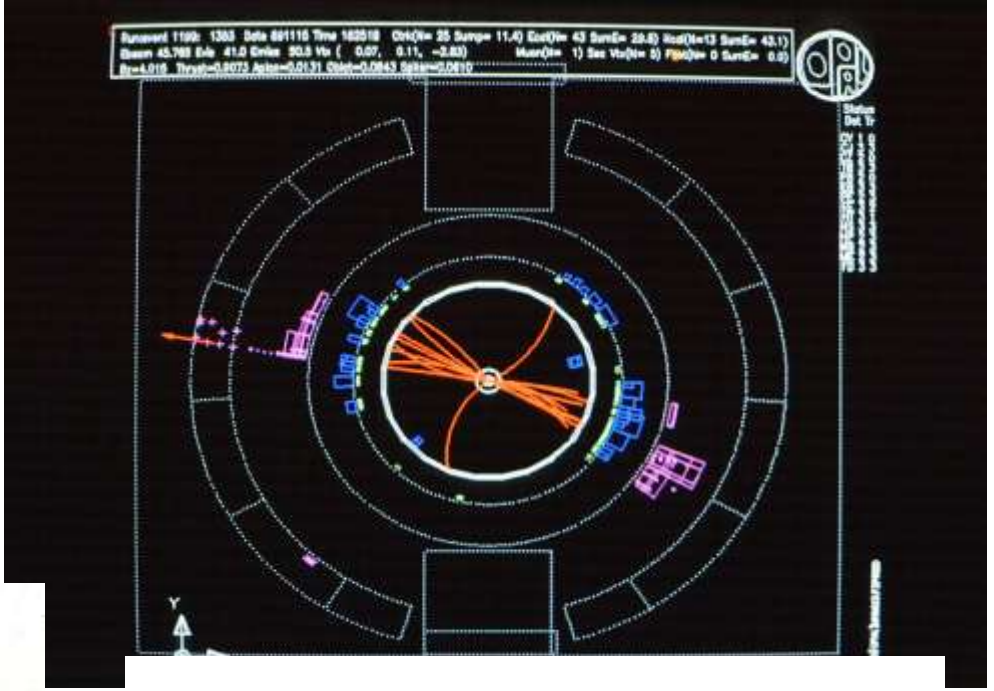
Muon chamber

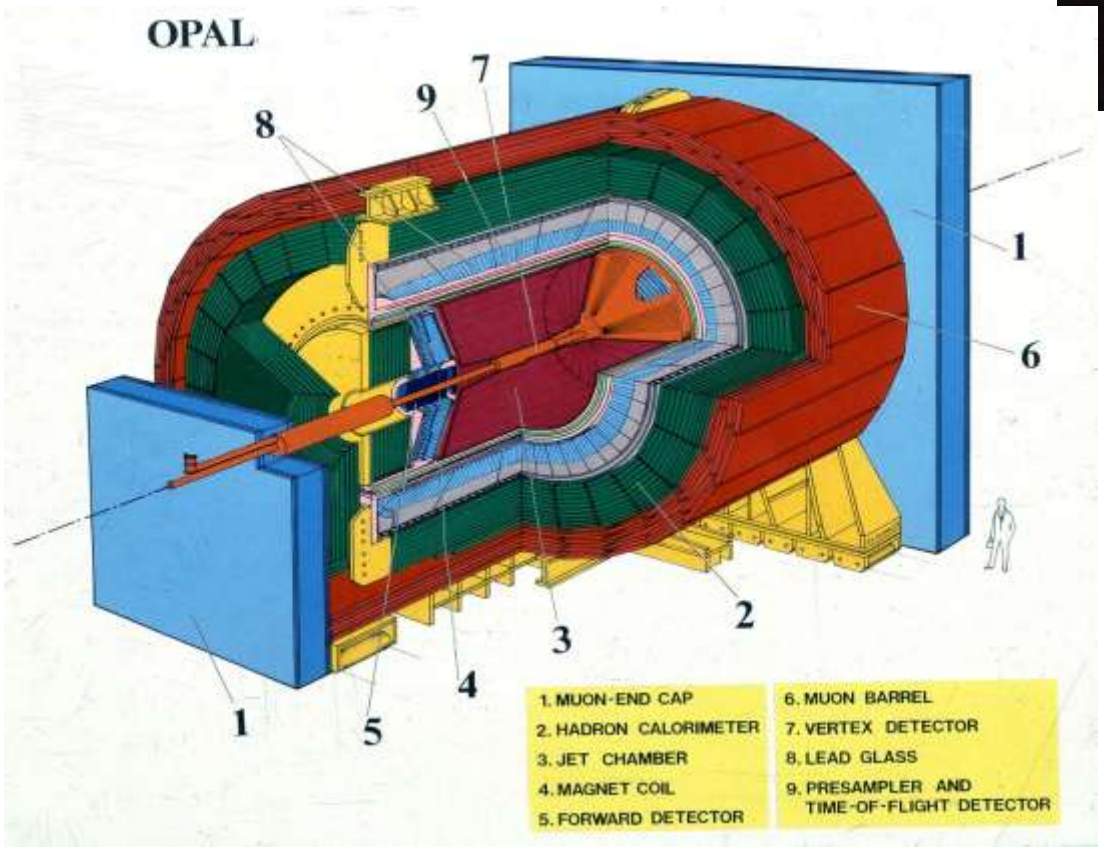
L3 layout

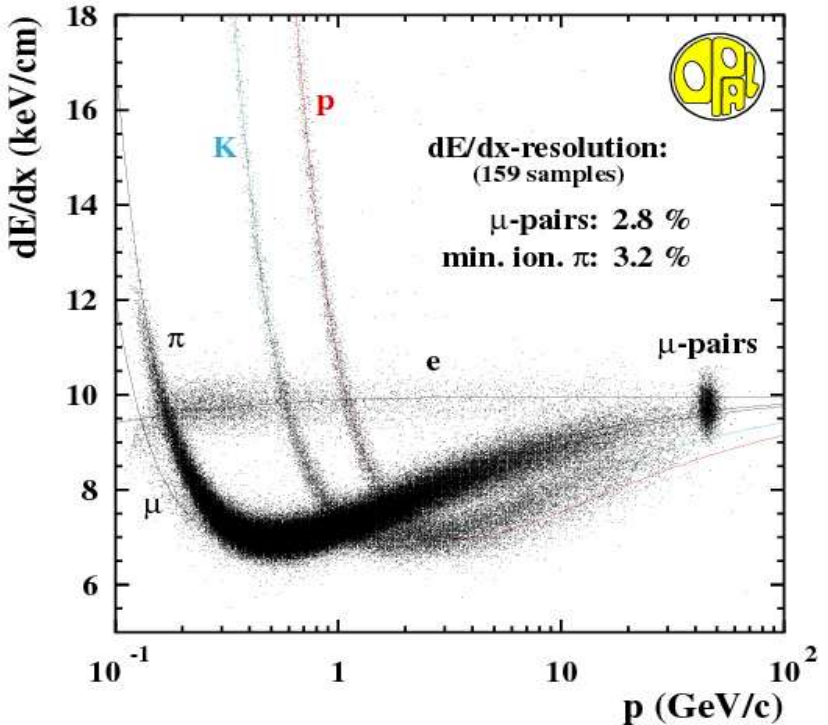


Three jet event

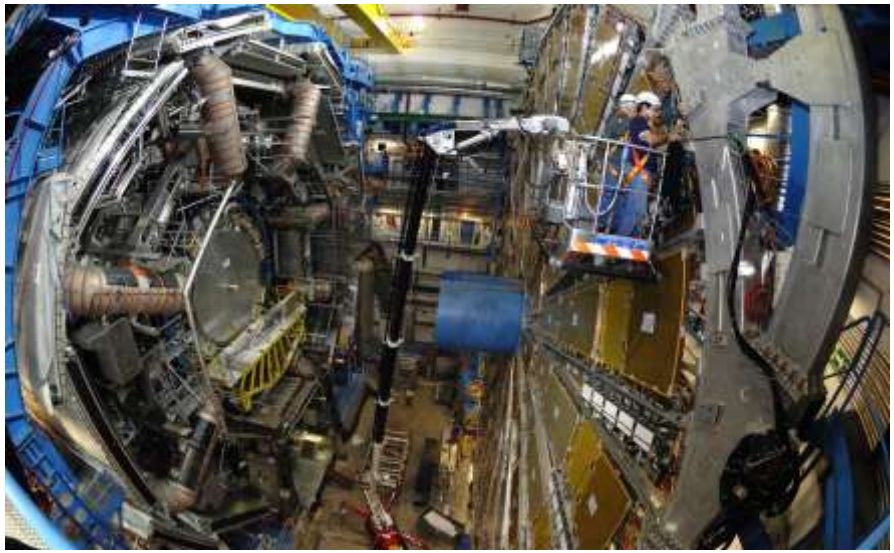
OPAL



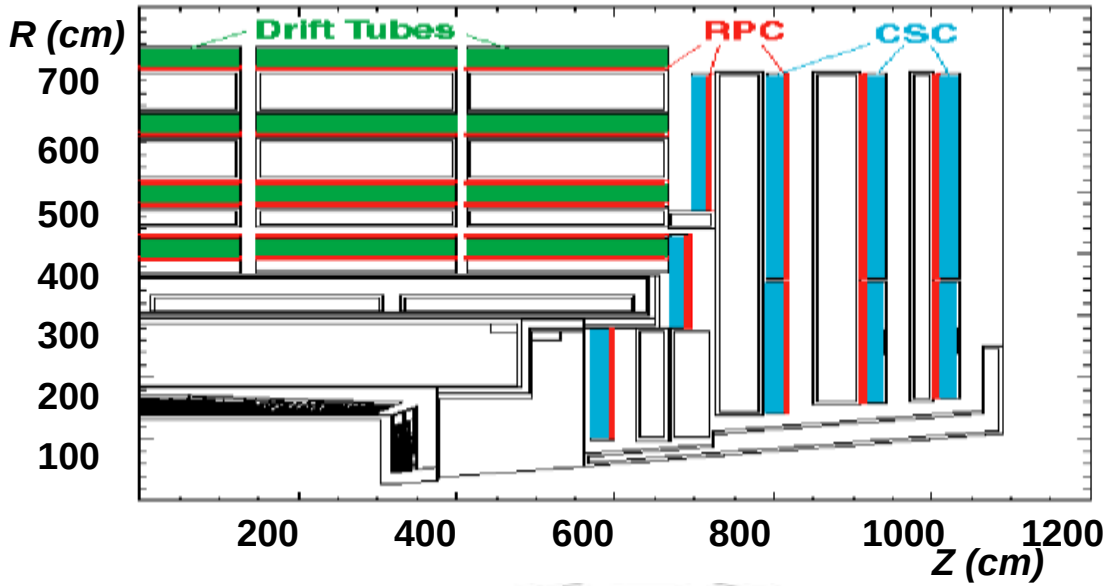

OPAL
1
2
3
4
5
6
7
8
9
1. MUON-END CAP
2. HADRON CALORIMETER
3. JET CHAMBER
4. MAGNET COIL
5. FORWARD DETECTOR
6. MUON BARREL
7. VERTEX DETECTOR
8. LEAD GLASS
9. PRESAMPLER AND TIME-OF-FLIGHT DETECTOR


dE/dx (keV/cm)
p (GeV/c)
dE/dx-resolution:
(159 samples)
μ-pairs: 2.8 %
min. ion. π: 3.2 %
K
p
π
e
μ-pairs
μ

ATLAS

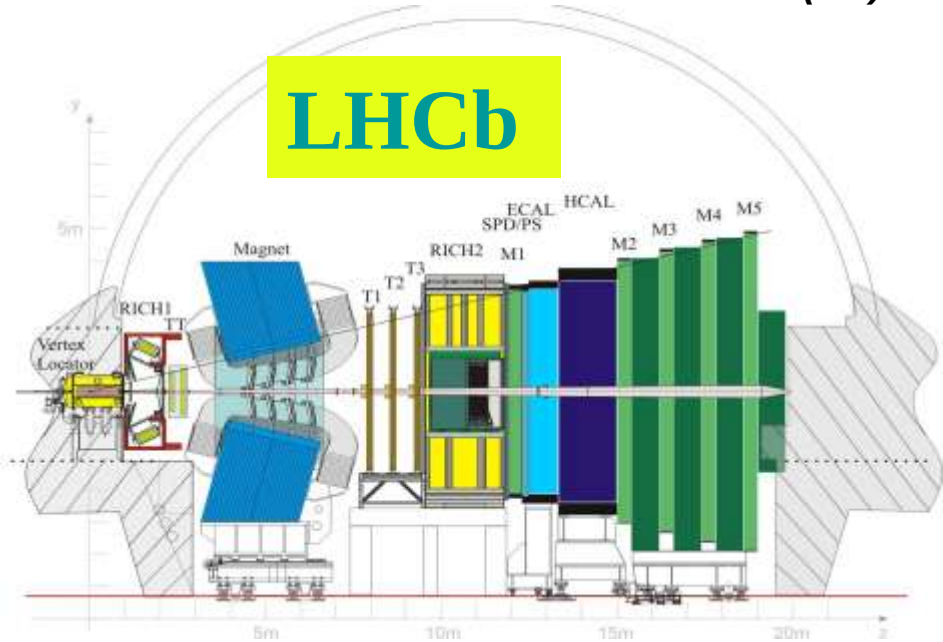


CMS



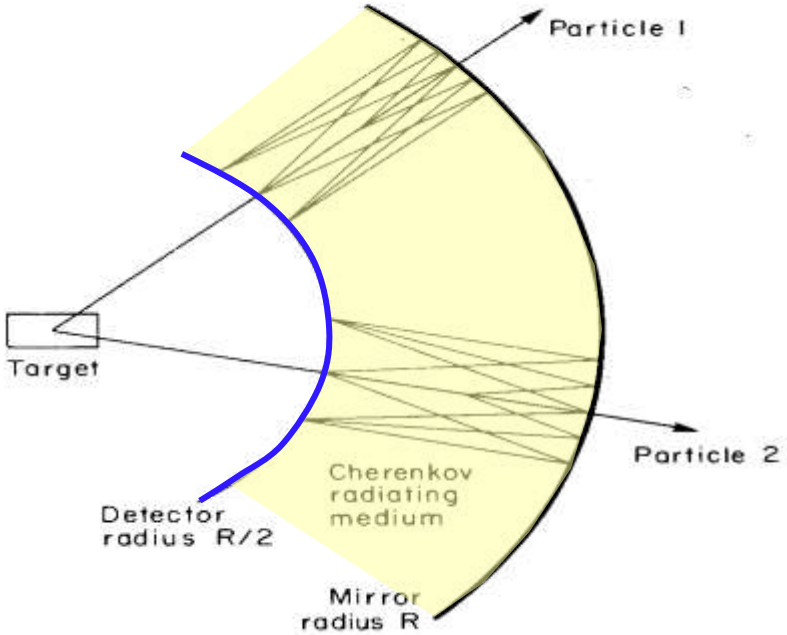
ALICE

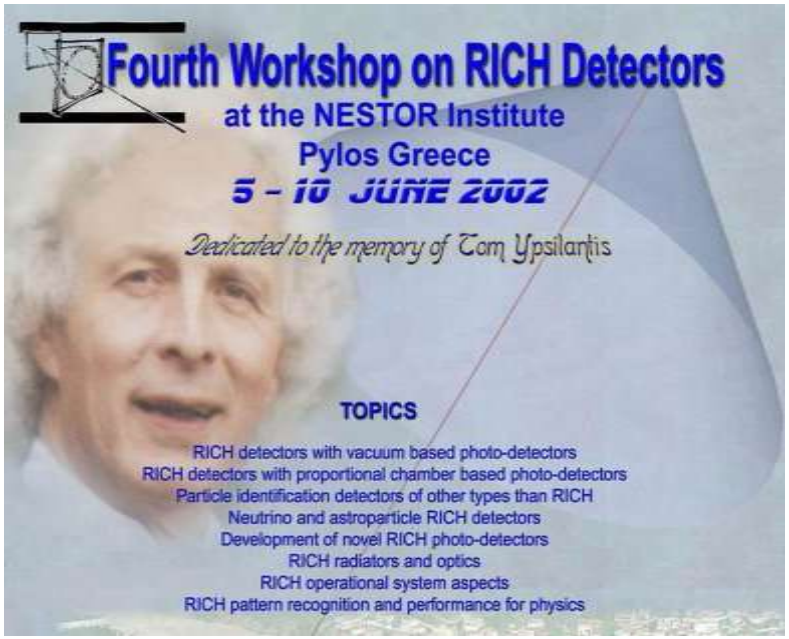
LHCb



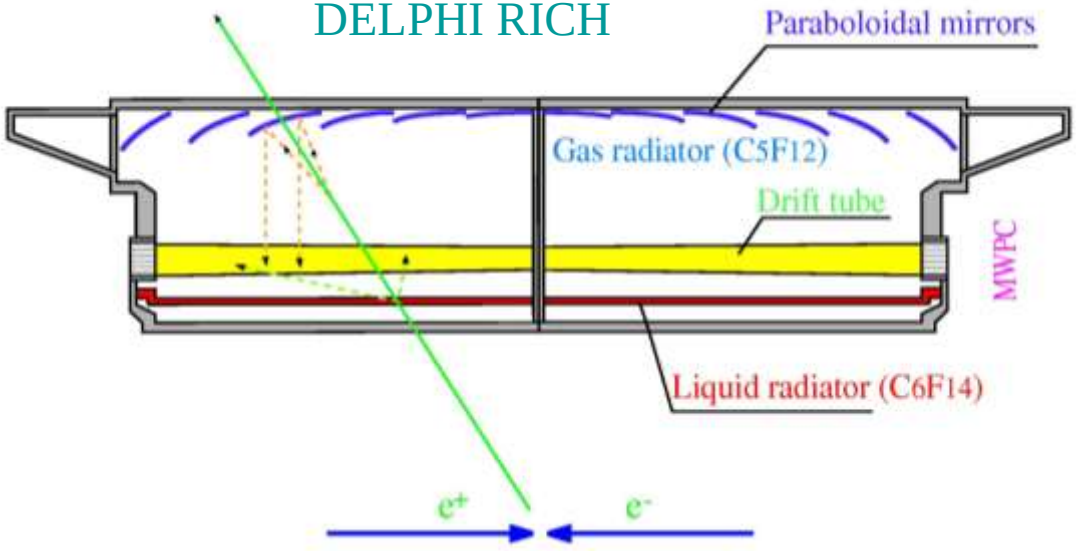
The Ring Imaging Cherenkov Counter (RICH)

J. Seguinot and T. Ypsilantis, Nucl. Instr. and Meth.142 (1977) 377

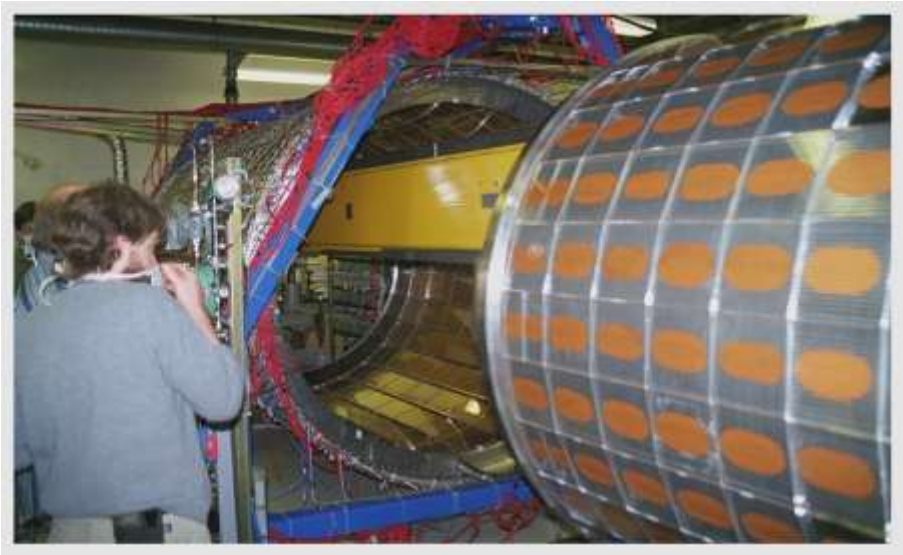




DELPHI RICH

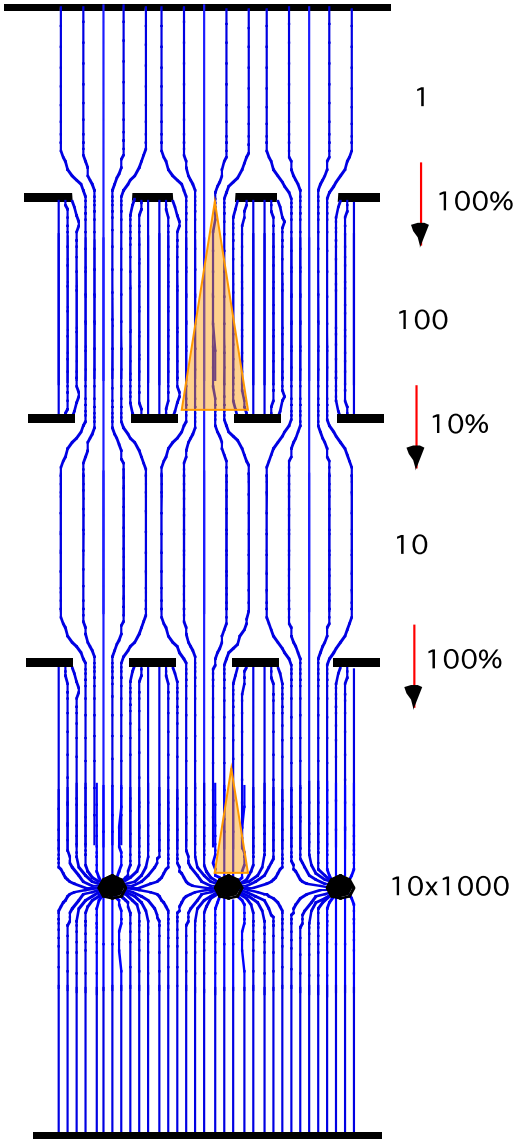


CLEO fast RICH

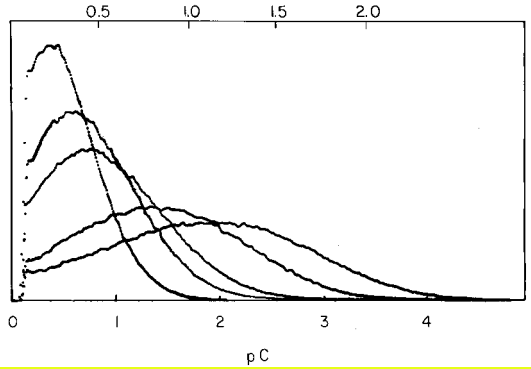


The multistep Chamber

G. Charpak and F. Sauli, Physics Letters 78B(1978)523
A. Breskin, G. Charpak, S. Majewski, G. Melchart, F. Sauli, NIMA161(1979)19



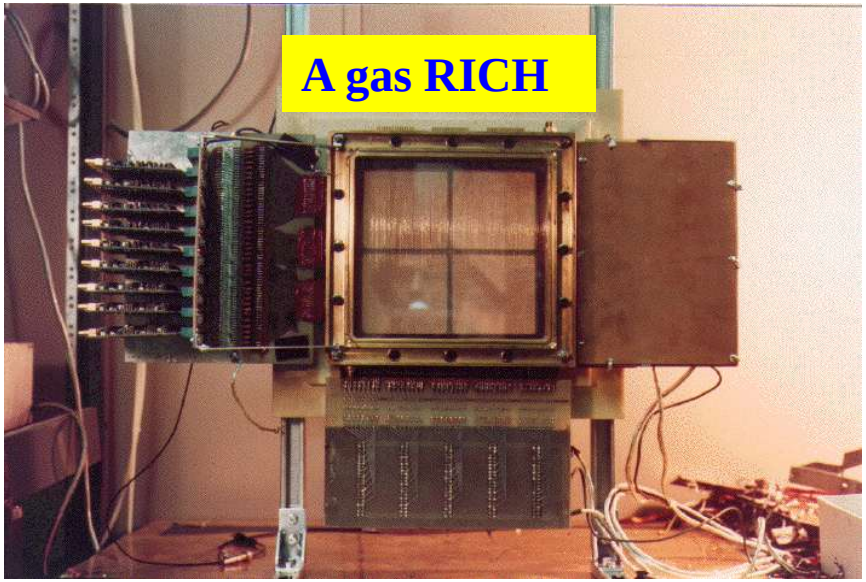
SINGLE ELECTRON
PULSE HEIGHT SPECTRA

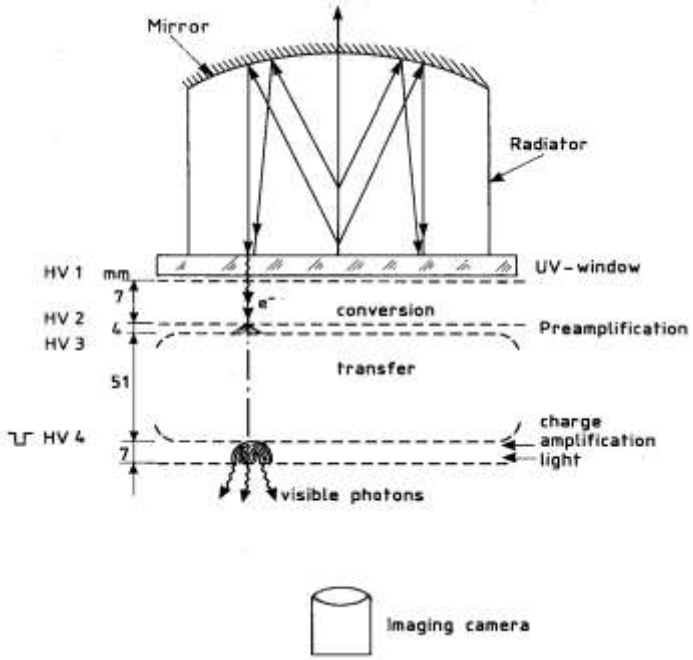


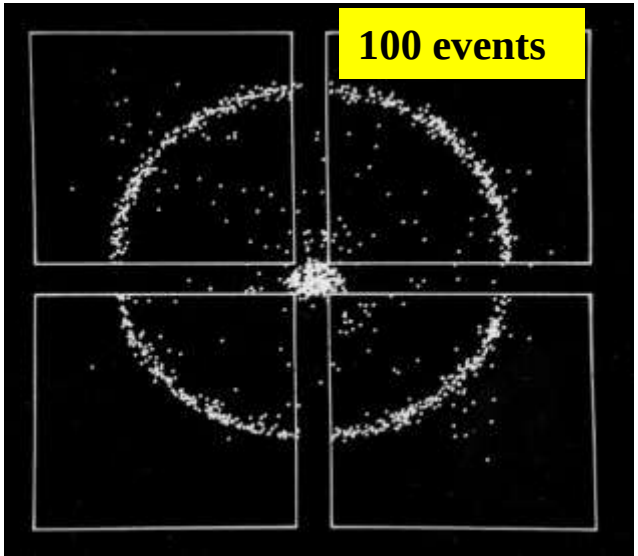
LARGE RICH: E605 EXPERIMENT AT FERMILAB (1985-95)
CERN-Columbia Univ.-FNAL-KEK- Saclay-SUNY -Washington.

The imaging chamber

Georges Charpak, W. Dominik, J.P. Fabre, J. Gaudaen, V. Peskov, F. Sauli, M. Suzuki ,
A. Breskin, R. Chechik, D. Sauvage, IEEE Trans.Nucl.Sci.35:483-486,1988.
Y. Giomataris, A. Gougas, W. Dominik, Georges Charpak, F. SaulI, N. Zaganidis, NIMA279(1989)322

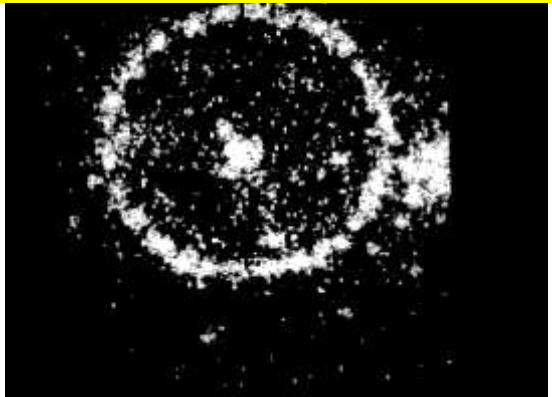


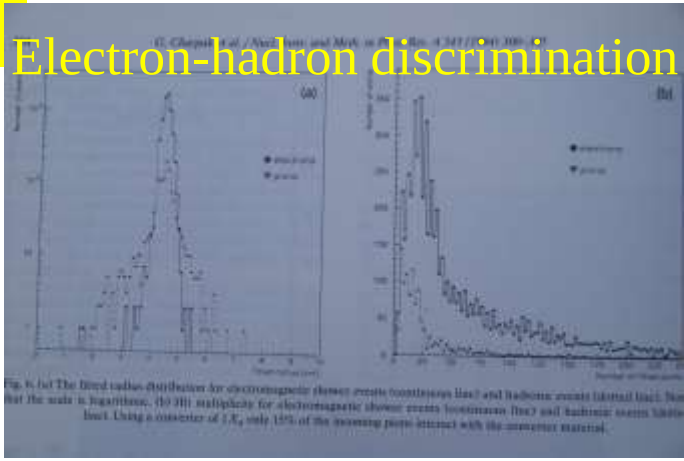




A single electron shower

G. Charpak, Y. Giomataris,, A. Gougas,NIM.A343:300,1994.

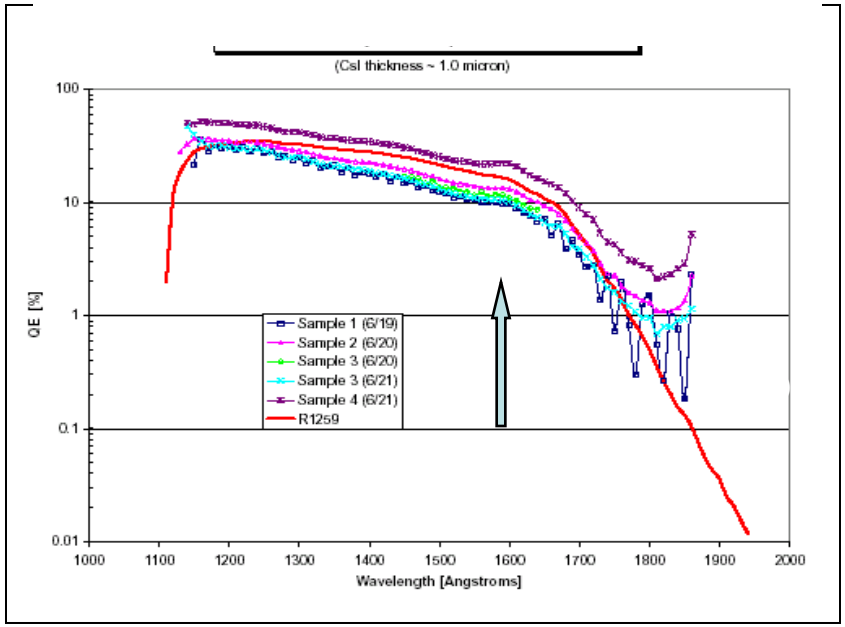


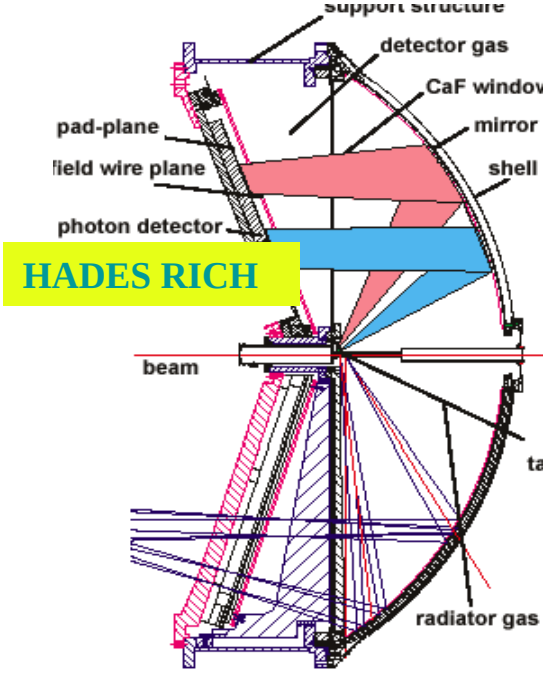


Solid photocathodes: CsI + gaseous detector

J. Seguinot, Georges Charpak, Y. Giomataris, V. Peskov, J. Tischhauser, T. Ypsilantis, NIM.A297:133-147,1990

A. Breskin, Nucl.Instrum.Meth.A371:116-136,1996.
F. Piuz et al.,Nucl.Instrum.Meth.A433:178-189,1999
D. Anderson, S. Kwan, V. Peskov, B. Hoeneisen,
Nucl.Instrum.Meth.A323:626-634,1992





A Hadron Blind Detector (HBD)

I. Giomataris,G. Charpak, NIM A310(1991)589

No windows ⟹ Large bandwidth

CF_4 provides the largest bandwidth

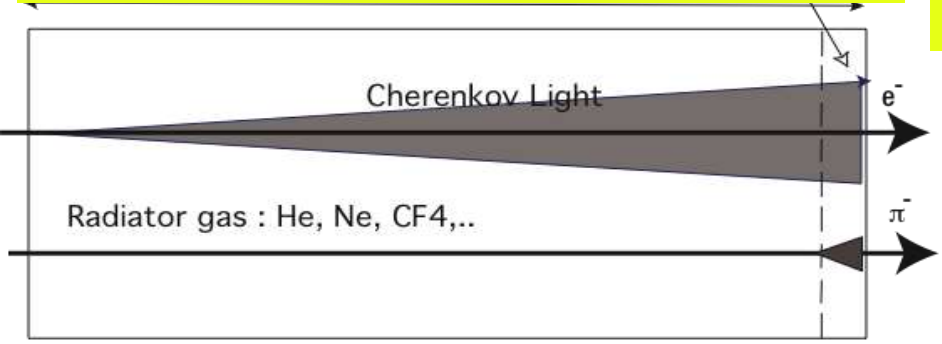
Y. Giomataris, G. Charpak, V. Peskov and F. Sauli, Nucl.Instrum.Meth.A323:431,1992

1992 First succesfull test at the SPS - CERN beam

MIT, CERN, Lausanne, ITEP,

M. Chen et al., NIM A346(1994)120

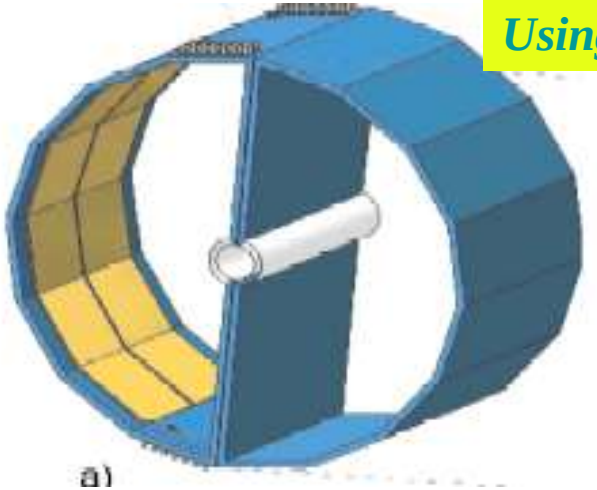
N_0 =500 measured, good electron efficiency with a hadron rejection factor of > 30

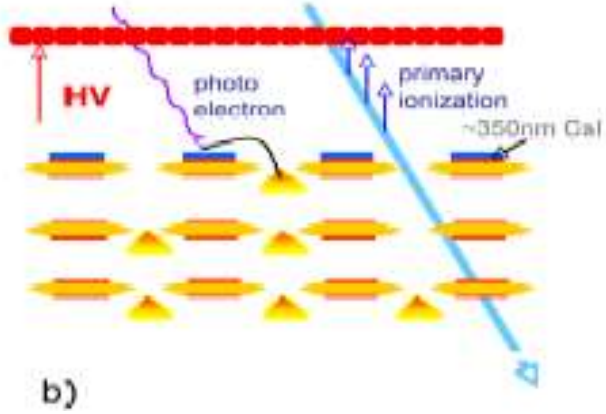


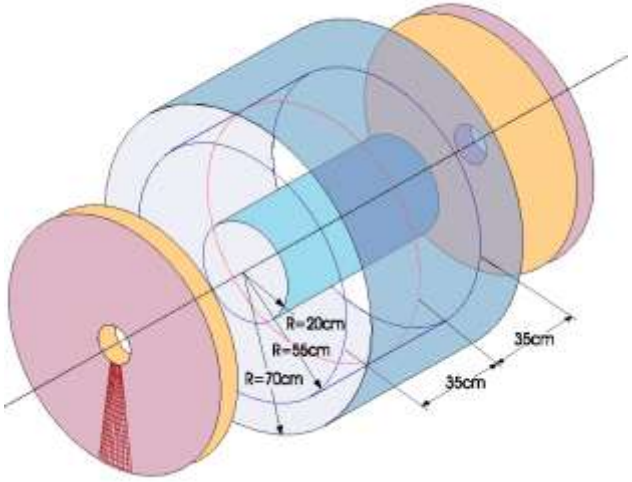
HBD concept verified by R.P. Pisani et al., Nucl.Instrum.Meth.A400:243-254,1997

HADRON BLIND DETECTOR in PHENIX

Using multiple GEM photodetectors



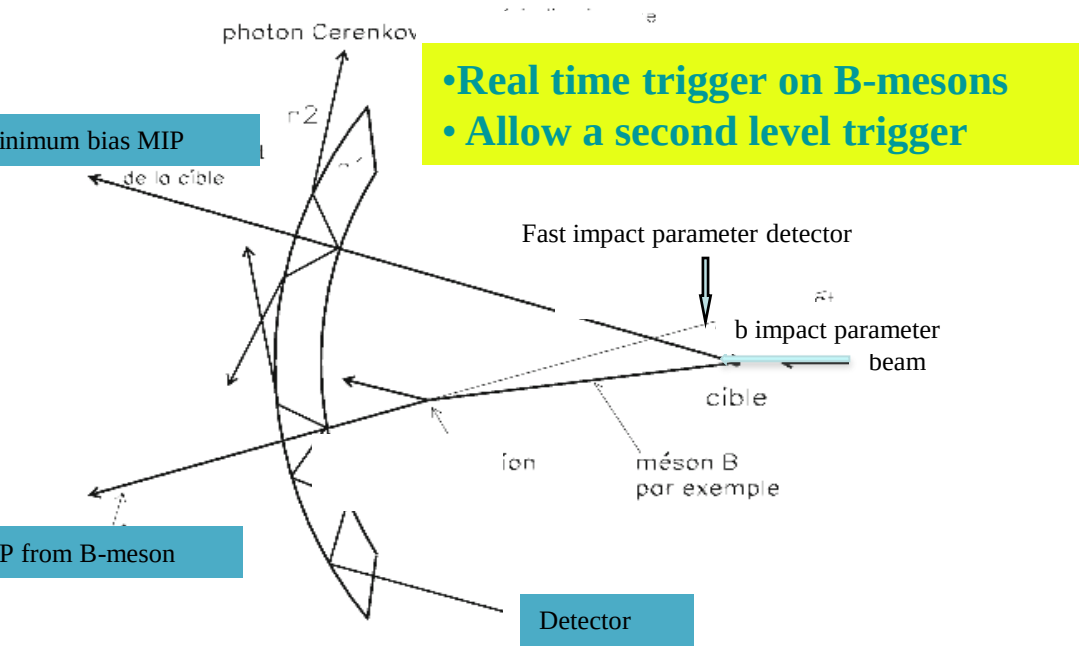




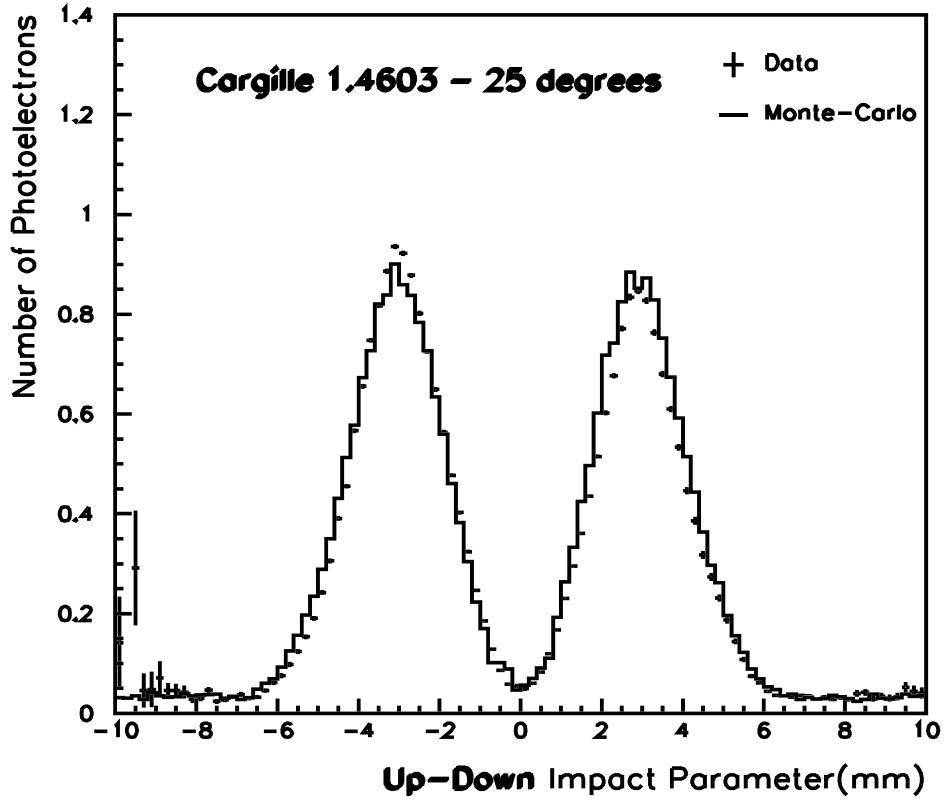
The trigger for Beauty *G. Charpak, I. Giomataris, L.Lederman, NIMA306(1991)439*

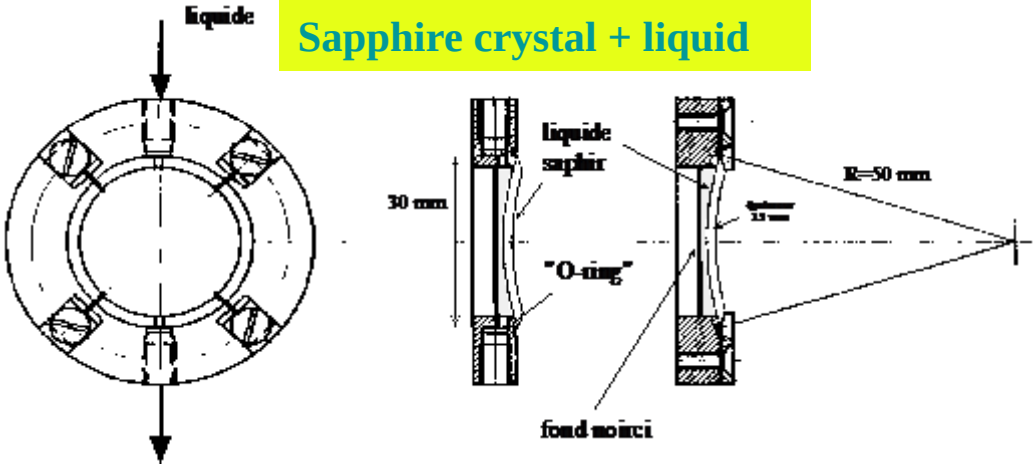
Developed by Lausanne Uni, Saclay,CERN

G. Charpak et al., NIMA332(1993)91-99
M. Atac et al., NIMA367(1995)372-376



•Real time trigger on B-mesons
• Allow a second level trigger



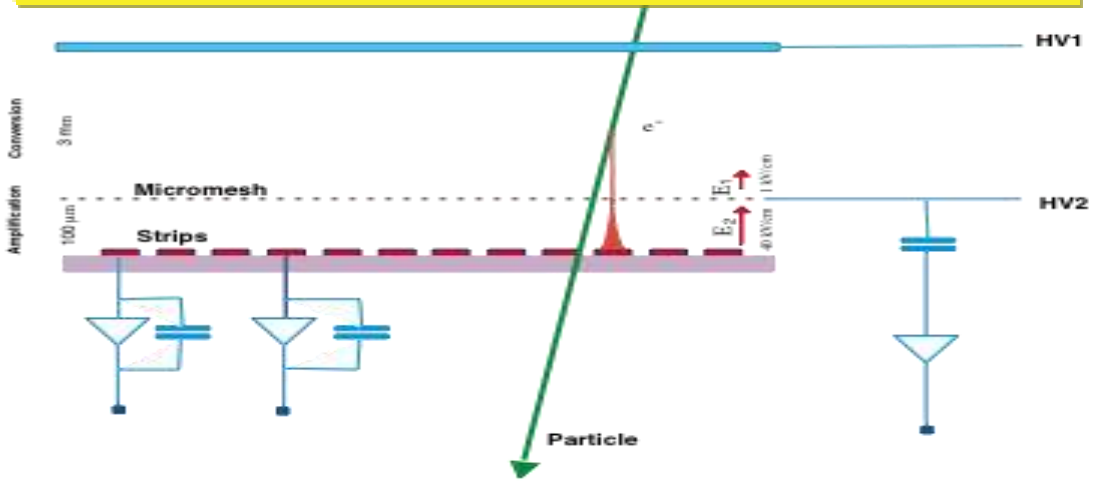


Sapphire crystal + liquid

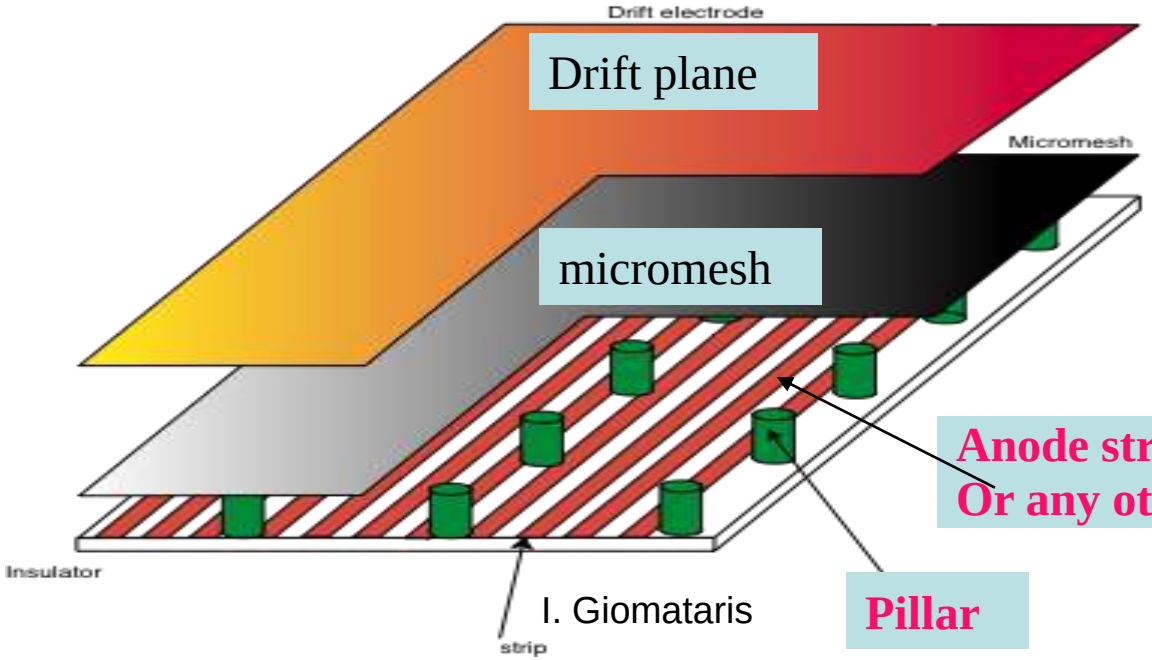
Designed for a fixed target experiment GAJET
Not approved

MICROMEGAS

Y. Giomataris, Ph. Rebourgeard, J.P. Robert, Charpak, NIMA376(1996)29



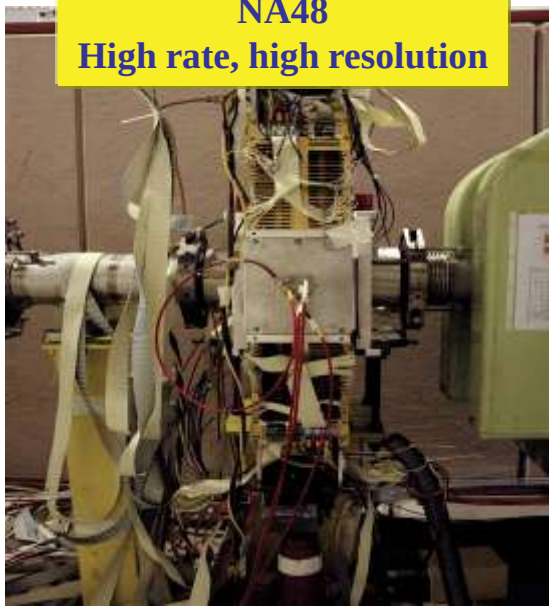
In 1st Micromegas
Fishing line spacers have been used



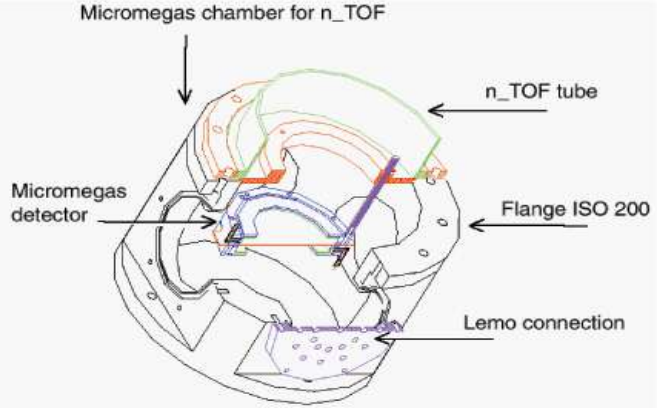
Micromegas detectors using conventional technology

COMPASS
40x40 cm^2 Micromegas

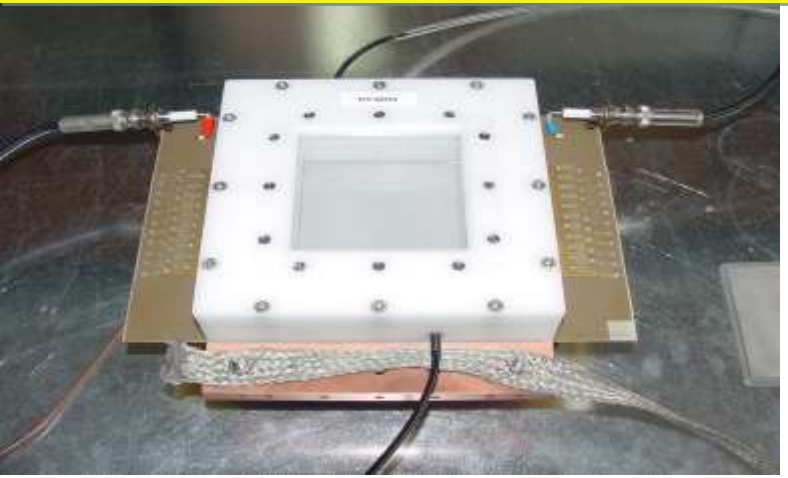
NA48
High rate, high resolution



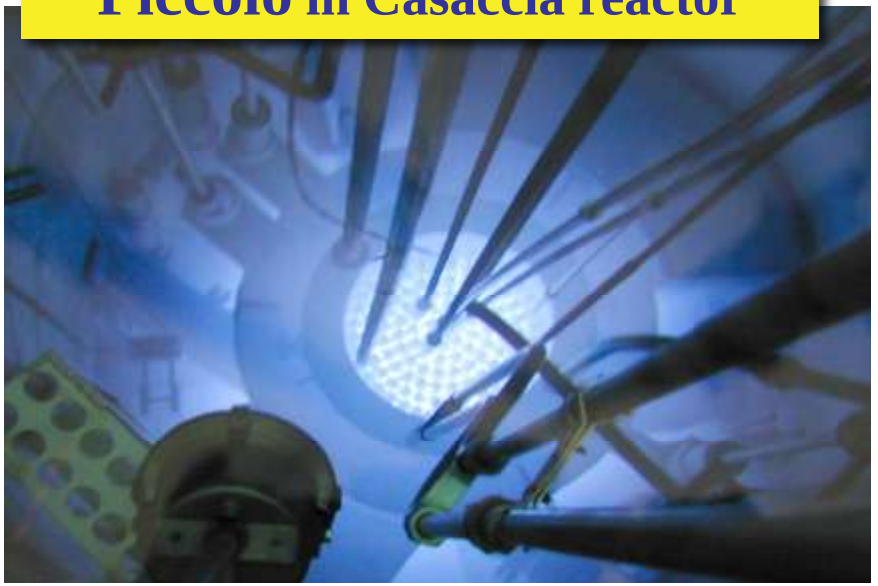
N-TOF



Micromégas Concept for Laser MégaJoule

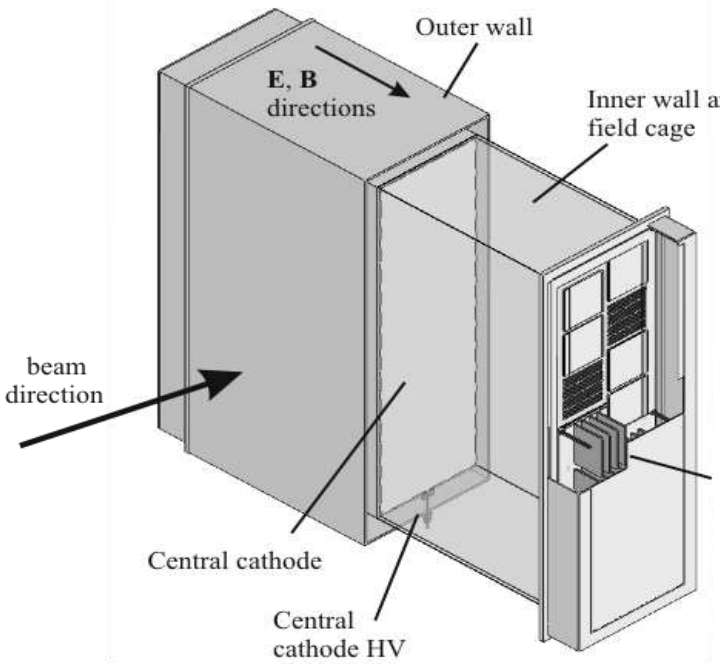


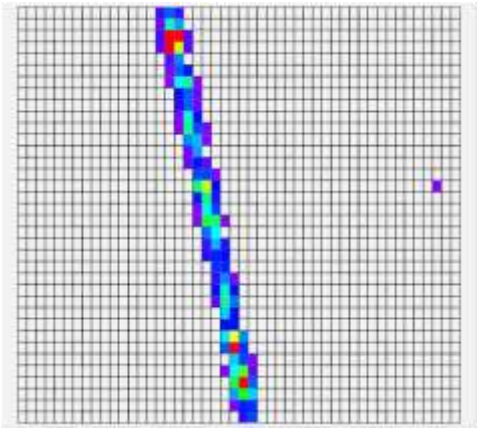
Piccolo in Casaccia reactor

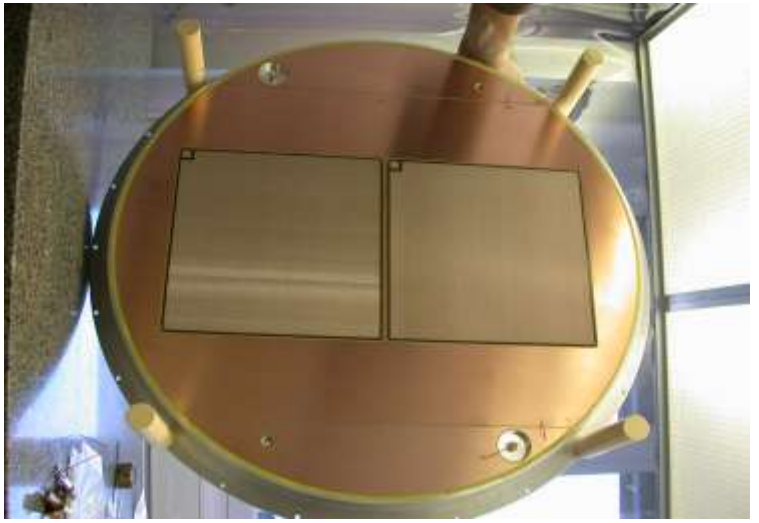


T2K Micromegas TPC project : about 10 m^2 detector surface

Goal: measure the ν_e and ν_μ fluxes and spectra and study ν cross-sections to predict the response at the SK detector .







Expected resolutions for a 70 cm track in the T2K TPC for B=0.2T:

s(p) / p < 8% @ 1GeV/c

s(dE/dx) < 9%

36 x 34 cm^2 « Bulk » MicroMegas

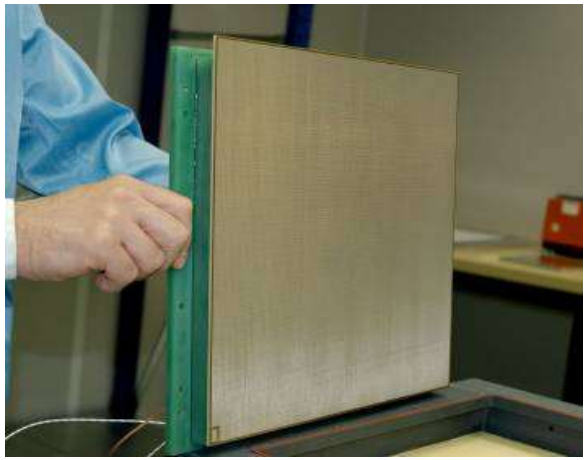
Total of 72 modules

The 3 TPCs will be ready and operational by the end of this year

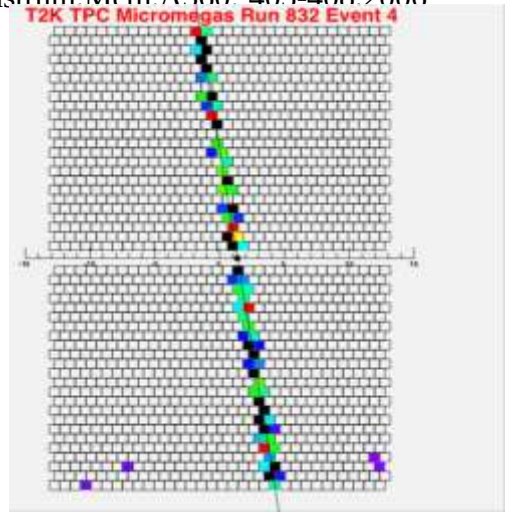
New technology
Bulk Micromegas

I. Giomataris et al., Nucl.Instrum.Meth.A560: 405-408,2006

J. Bouchez et al., Nucl.Instrum.Meth.A574:425-432,2007



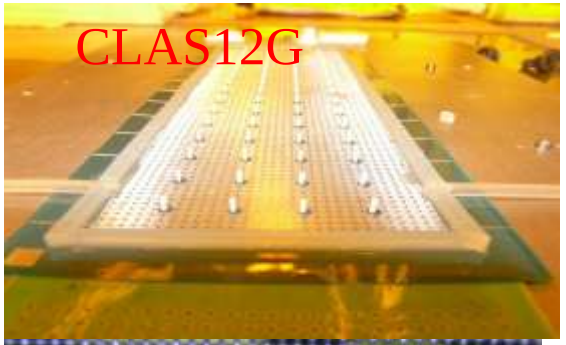
T2K



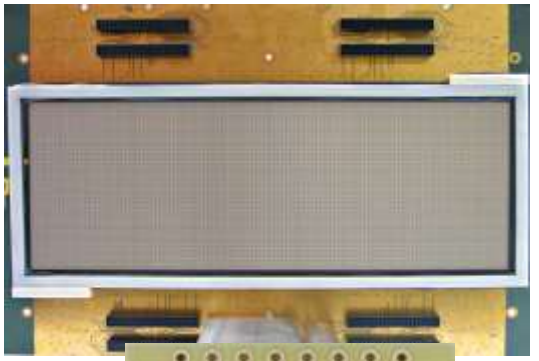
ATLAS-SLHC

Very-large

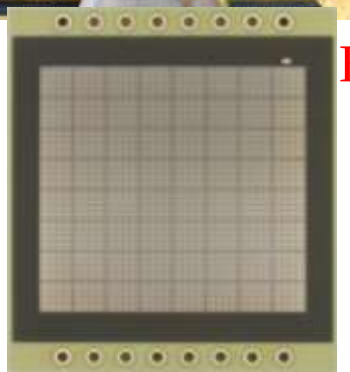
CLAS12G



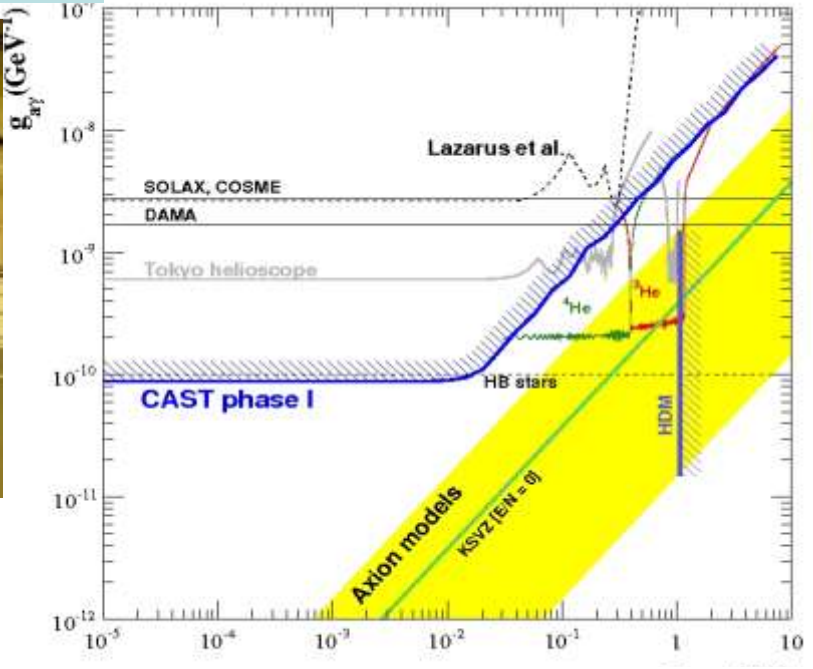
LLNB



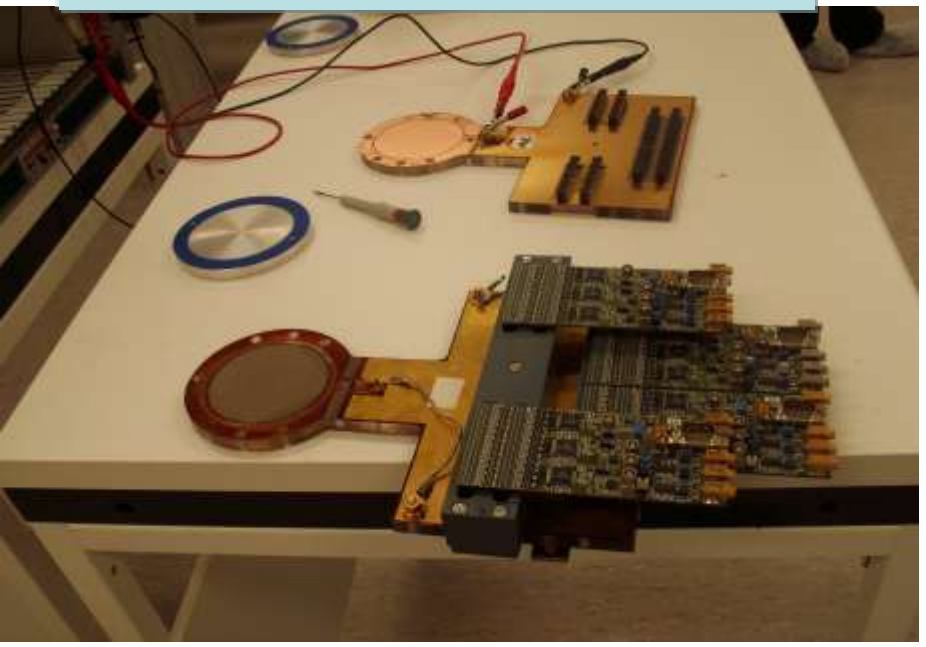
HCAL

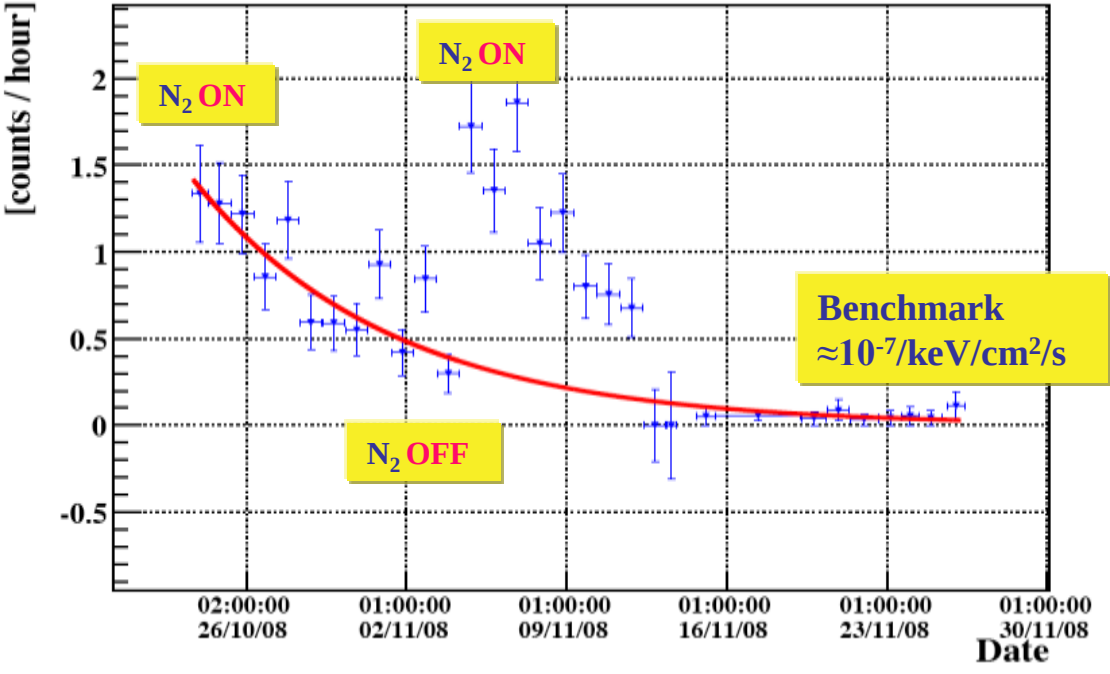


Micro-bulk in CAST - high performance

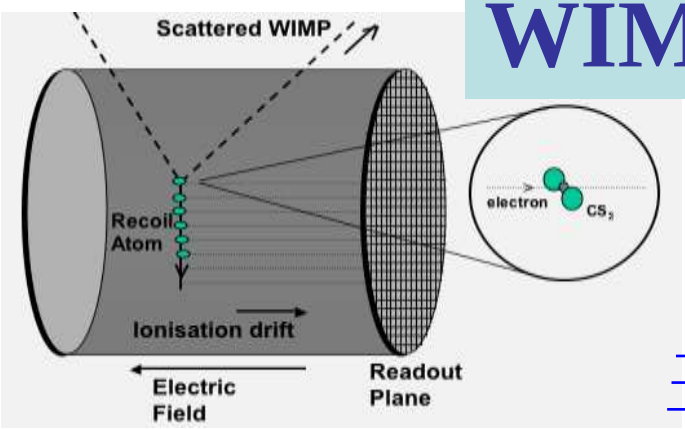


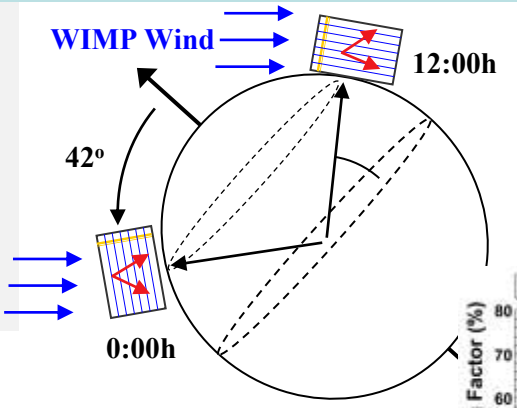
On low radioactivity support



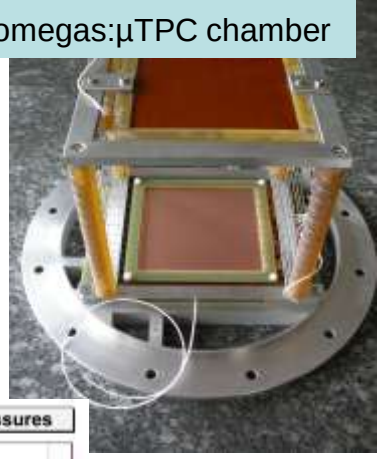


WIMP directional TPCs

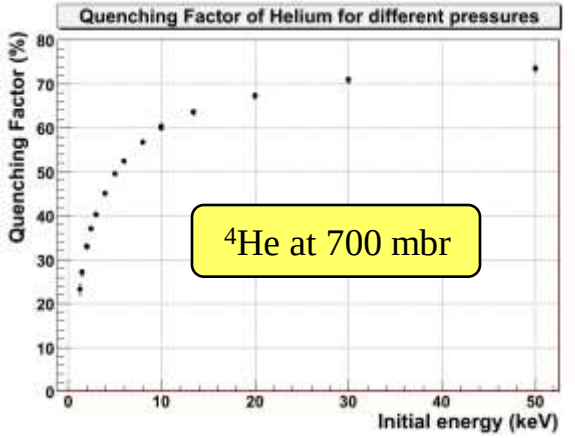




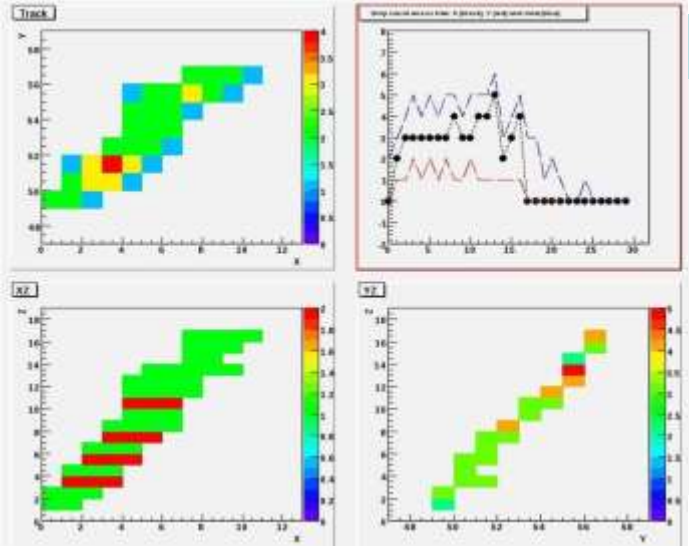
Micromegas:µTPC chamber



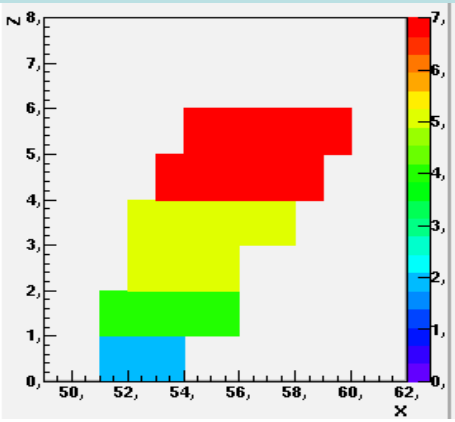
MIMAC-He3 MIcro-tpc Matrix of Chambers of He3
On-baryonic dark matter search, **Micromegas read-out**,
Grenoble – Saclay, Cadarache collaboration



Electrons by 5.9 keV ^{55}Fe

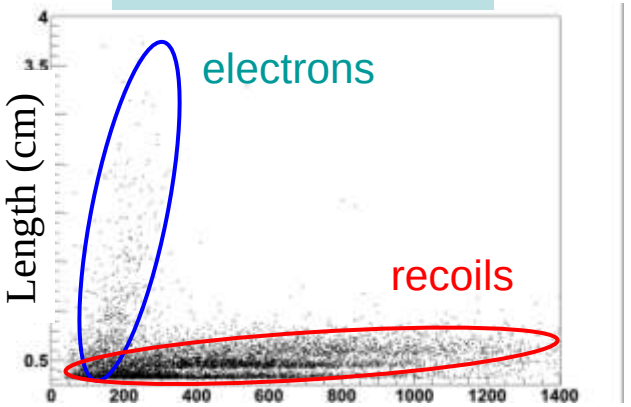


Recoil from 144 keV neutrons

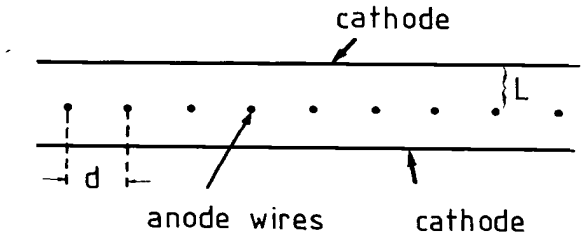


I. Giomataris

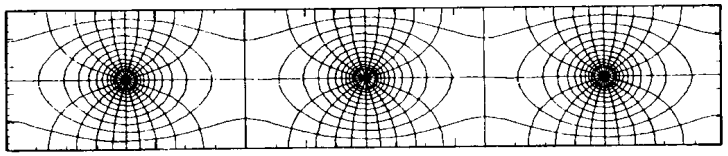
100 mbar Isobutane



MPWC

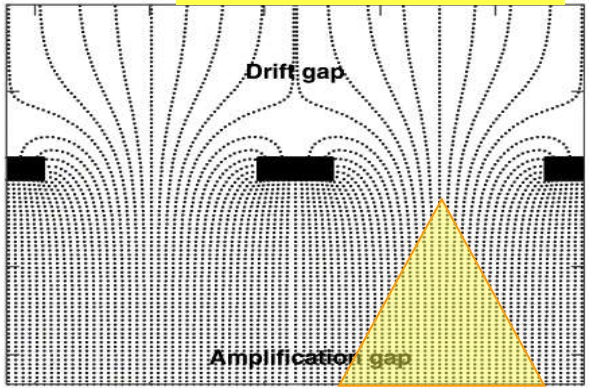


E=1/r
C ≈ **L>10 pF**



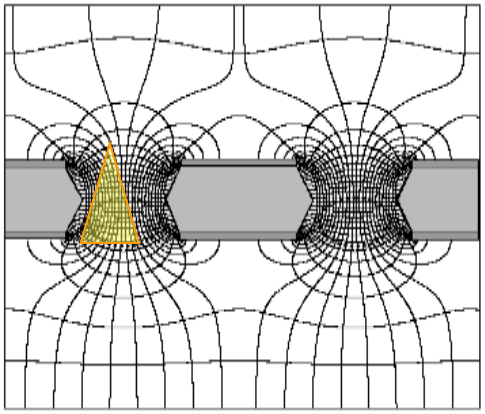
Parallel Plate Detector

Micromegas

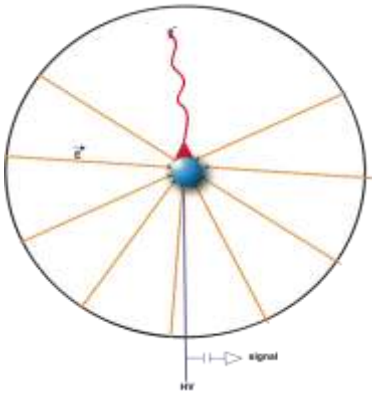


E= constant
C ≈ S > 1nF

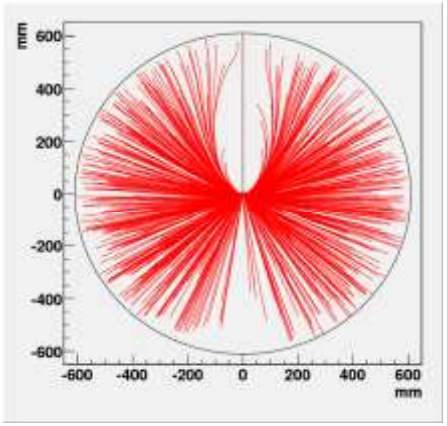
GEM



Spherical Proportional Counter



E=1/r²
C ≈ R_{in}< .1pF

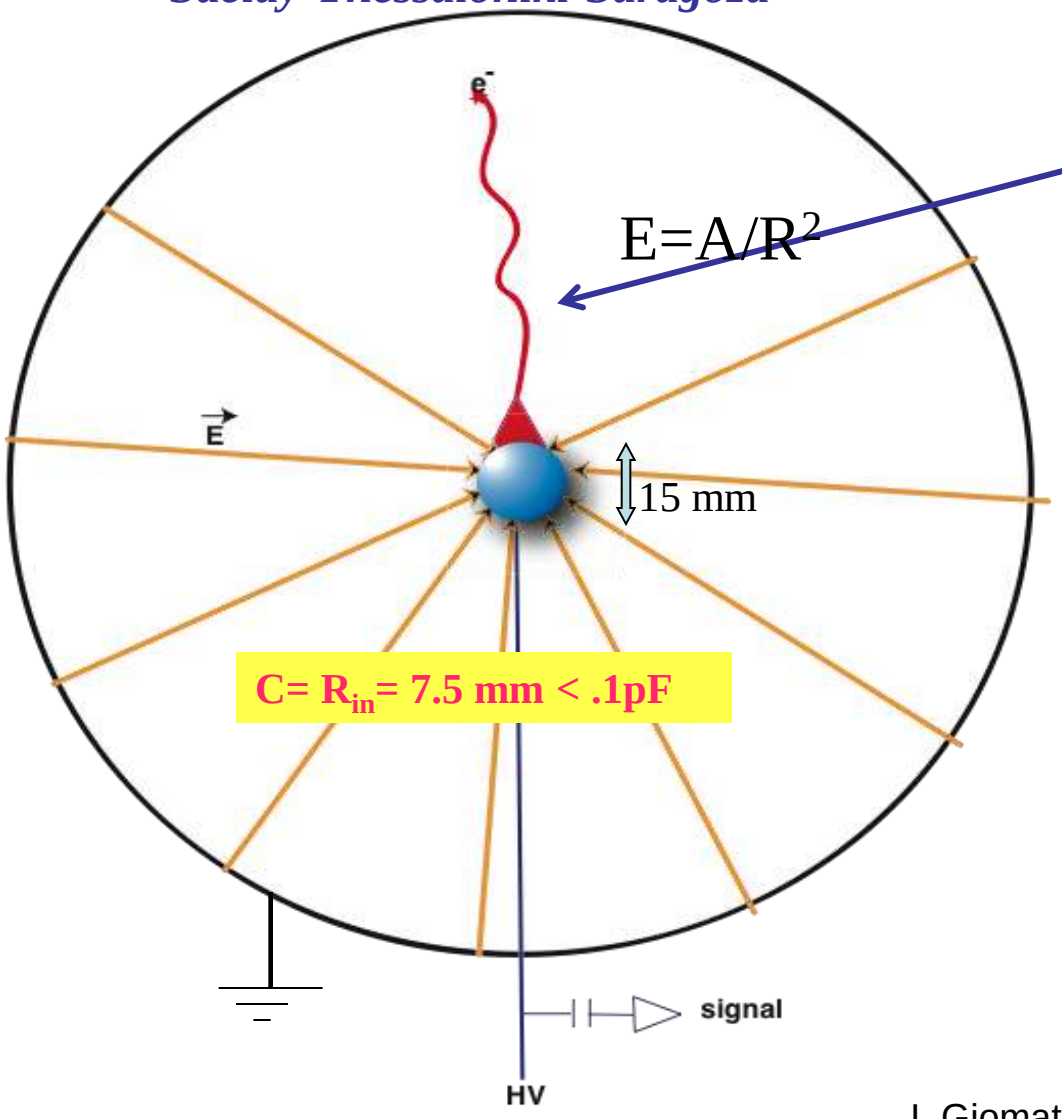


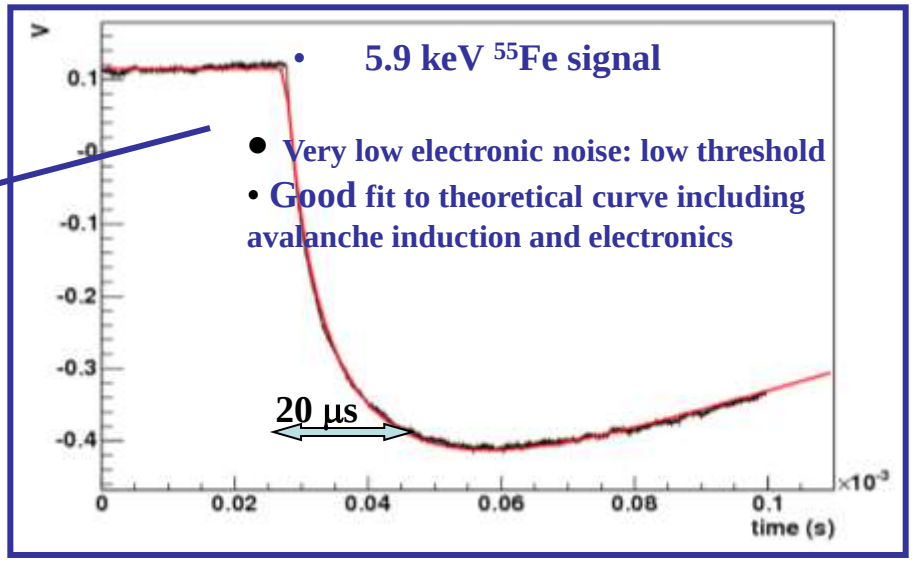
I. Giomataris

Radial TPC with spherical proportional counter read-out

Saclay-Thessaloniki-Saragoza

A Novel large-volume Spherical Detector with Proportional Amplification read-out, I. Giomataris *et al.*, JINST 3:P09007,2008





- 5.9 keV ^{55}Fe signal
- Very low electronic noise: low threshold
- Good fit to theoretical curve including avalanche induction and electronics

- **Simple and cheap**
- **single read-out**
- **Robustness**
- **Good energy resolution**
- **Low energy threshold**
- **Efficient fiducial cut**

His last visit in our laboratory - Saclay

‘Paris TPC Conference on rare event detection’
Active participation of Georges Charpak

1st Workshop on December 2002

3rd Symposium on December 2006

4th Symposium on December 2008

5th Symposium on December 2010

MUSIC AND EDUCATION

Education through science