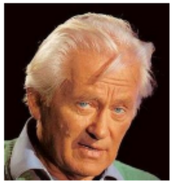
= Georges Charpak = 90th anniversary
(Ukraine, Lviv, Monday, July 21 – 14.00-19.00)

Bringing Nations Together Through Science: "CERN 60 Years of Science for Peace"



Final Program
Location : Lviv Polytechnic University (auditorium); *Stepan Bandera str. 12 – Lviv, Ukraine*

14.00	Opening words	*Maxim Titov* - Co-Spokesperson of the RD51/CERN Collaboration, CEA-Saclay, France
14:10	Welcome	*Borys Grynyov* - First Deputy Chairman, State Agency on Science, Innovation and Informatization of Ukraine
14.15	Welcome	*Yuriy Bobalo* - Rector of National University Lviv Polytechnic
14.20	Welcome	*Zinoviy Nazarchuk* - Head of Western Scientific Centre of NASU and of Ministry of Education and Science of Ukraine
14.25	Welcome	*Yuriy Pidlisnyy* - Deputy Head of Lviv Regional State Administration on humanitarian issues
14.30	Georges Charpak – a symbol for scientific cooperation	*Gilles Mametz* – French Embassy in Ukraine
14:50	CERN: Bringing nations together through science	*Agnieszka Zalewska* – President of the CERN Council, Poland
15:20	France – Ukraine cooperation: TESHEP and Other Joint Projects	*Achille Stocchi* – Head of Linear Accelerator Laboratory, IN2P3/CNRS, France
15:50	CEA Saclay Irfu: Technology Domains, Georges Charpak and future cooperation with Ukraine	*Nicolas Alamanos* – Deputy Head of IRFU, CEA-Saclay, France
16:10	Coffee Break	
16:30	Polish strategy for science in Ukraine and European perspectives	*Henry Sobczuk* – Polish Academy of Sciences, Poland
16:50	Greece strategy for science; Georges Charpak and four seas conferences	*Evangelos Gazis* – National Technical University, Athens, Greece
17:10	Video content – documentary film about Georges Charpak "The price of a nobel"	
17:40	Cooperation between CERN and Young Academy of Sciences of Ukraine. Presentation of the Ukrainian version of Georges Charpak's autobiography "Memoirs of an uprooted, physicist, citizen of the world"	*Ivan Riabchyj* - Young Academy of Sciences of Ukraine
18:00	Physicist who transformed the measurement of high-energy particles; from multi-wire proportional chamber to the novel gaseous detectors	*Maxim Titov* – Co-Spokesperson of the RD51/CERN Collaboration, CEA Saclay, France
18:20	Future projects in High Energy Physics: knowledge frontier / innovation / education / outreach	*Achille Stocchi* – Head of Linear Accelerator Laboratory, IN2P3/CNRS, France
19:00	End of the event	

Georges Charpak – 90th Anniversary

Physicist who transformed the measurement of high-energy particles

From Multi-Wire Proportional Chamber to Novel MPGD Gaseous Detectors

Ukraine, Lviv
July 21, 2014

The History of Instrumentation is VERY Entertaining

- A look at the history of instrumentation in particle physics

  → complementary view on the history of particle physics, which is traditionally told from a theoretical point of view

- The importance and recognition of inventions in the field of instrumentation is proven by the fact that

  → several Nobel Prices in physics were awarded mainly or exclusively for the development of detection technologies

Nobel Prizes in instrumentation ("tracking concepts"):

- 1927: C.T.R. Wilson, Cloud Chamber
- 1960: Donald Glaser, Bubble Chamber
- 1992: Georges Charpak, Multi-Wire Proportional Chamber

History of Particle Detection

Image Detectors

Bubble chamber photograph

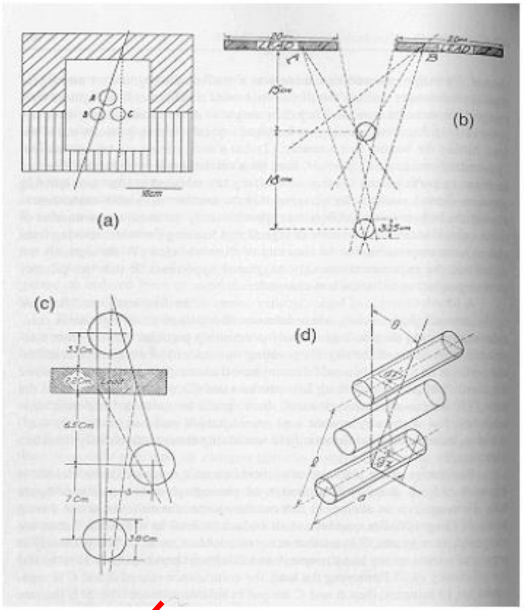
History of 'Particle Detection'

Image Tradition: Cloud Chamber
Emulsion
Bubble Chamber

Logic Tradition: Scintillator
Geiger Counter
Tip Counter
Spark Counter

Electronics Image: Wire Chambers
Silicon Detectors
…

'Logic (electronics) Detectors '

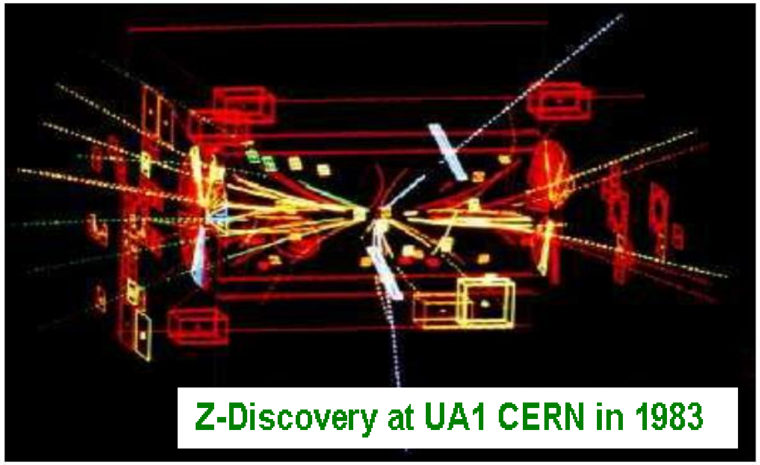


Early coincidence counting experiment

- 1906: Geiger Counter, H. Geiger, E. Rutherford
- 1910: Cloud Chamber, C.T.R. Wilson
- 1912: Tip Counter, H. Geiger
- 1928: Geiger-Müller Counter, W. Müller
- 1929: Coincidence Method, W. Bothe
- 1930: Emulsion, M. Blau
- 1940-1950: Scintillator, Photomultiplier
- 1952: Bubble Chamber, D. Glaser
- 1962: Spark Chamber
- 1968: Multi Wire Proportional Chamber, C. Charpak

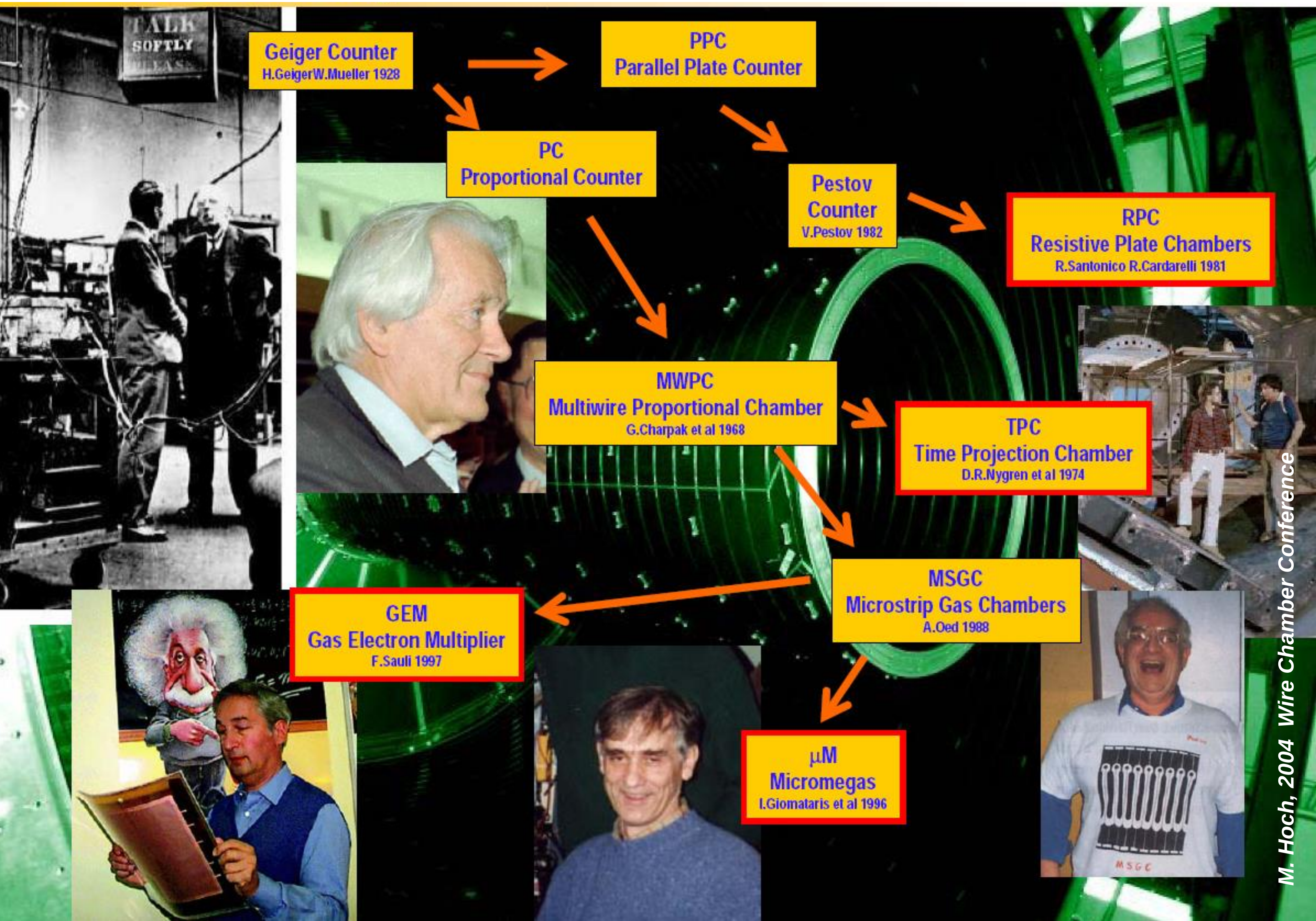
Etc. etc. etc.

Both traditions combine into the 'Electronics Image' during the 1970ies



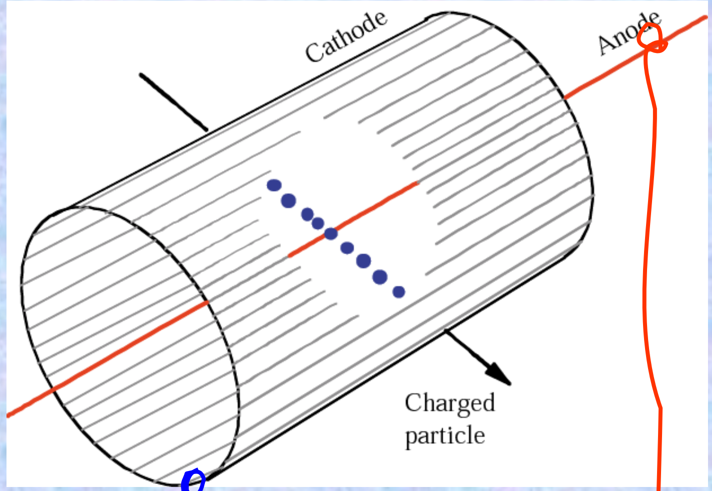
Z-Discovery at UA1 CERN in 1983

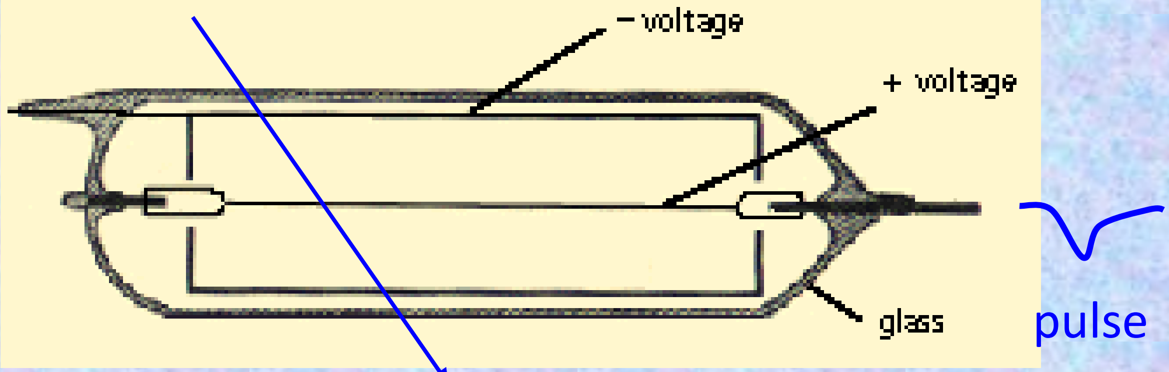
History of Gaseous Detectors

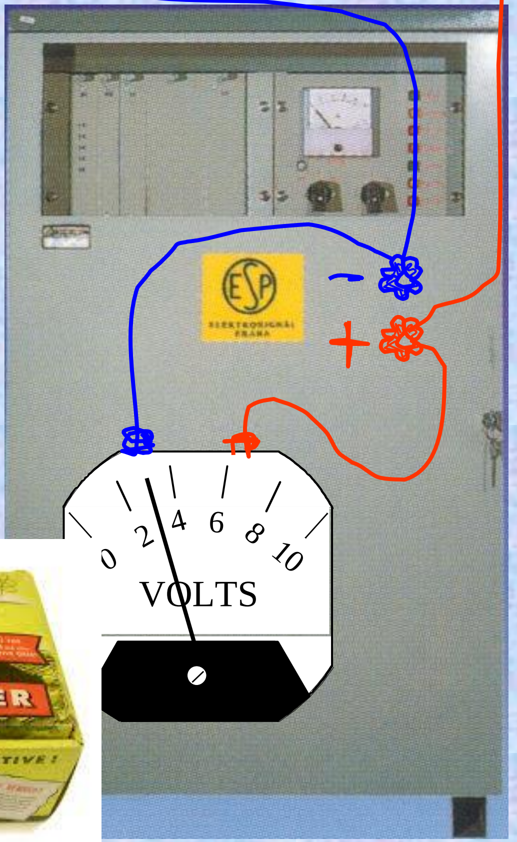


Geiger Counter

E. Rutherford ***1909*** ***H. Geiger*** ***1927***







The Geiger counter, later further developed and then called Geiger-Müller counter

First electrical signal from a particle !!!

E. Rutherford and H. Geiger, Proc. Royall Soc. A81 (1908) 141
H. Geiiger and W. Müllller, Phys. Zeiits. 29 (1928) 839

Georges Charpak Research: CV @ CERN

SCHOLARPEDIA: http://www.scholarpedia.org/article/Georges_Charpak

- *1960 Participated in the first exact measurement of the* ***magnetic momentum of the muon***
- *1961-1967 Development of various types of* ***non-photographic scintillation chambers***
- *1962-1967* ***Nuclear structure*** *studied by reactions (p$^+$2p) ;* ***Spark chambers****;*
- *1968 Introduction of* ***proportional multiwire chambers*** *and later* ***Drift Chambers;***
- *1971-1973* ***Discharge projection chambers;***
- *1974* ***Spherical drift chambers*** *for studies of proteins by X-ray diffraction ;*
- *1979-1989* ***Multistage avalanche chambers ;***

  -Application to ***photon counters for Cherenkov detectors****;*

  -Introduction of chambers based on ***luminescent avalanches****.*

  -Development of ***instrumentation for biological research*** *using* ***β-ray imaging;***

  -Development of ***Micromegas****.*

High-tech: *Founded* ***"Biospace"*** *for biomedical imaging.*

Educational activities: *1995* ***"La Main a la Patte"*** *- Science education to the French little ones*

Literature: *Author of numerous* ***books*** *on his life as scientist and science popularization*

Slides and/or photos are taken from presentations of his colleagues and friends:
Amos Breskin, Fabio Sauli, Yannis Giomataris

First Georges Work on Particle-Imaging: Direction Sensitive Spark Chambers

1957: CHARPAK'S EARLY WORKS ON GAS DISCHARGES

Journal de Physique et le Radium
Lettres a la Rédaction (1957)

OPTICAL SPARK CHAMBERS:

S. Fukui and S. Myamoto, A new type of particle detector: the discharge chamber, Nuovo Cimento 11 (1959) 113.

PRINCIPE ET ESSAIS PRÉLIMINAIRES D'UN NOUVEAU DÉTECTEUR PERMETTANT DE PHOTOGRAPHIER LA TRAJECTOIRE DE PARTICULES IONISANTES DANS UN GAZ

Par G. Charpak,
Laboratoire de Physique et Chimie Nucléaires,
Collège de France.

Considérons une particule ionisante qui traverse un gaz à la pression p, soumis à un champ électrique uniforme E, de durée T.

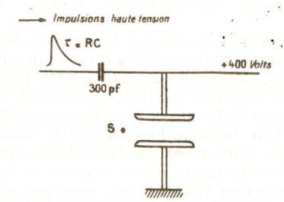


Fig. 1.

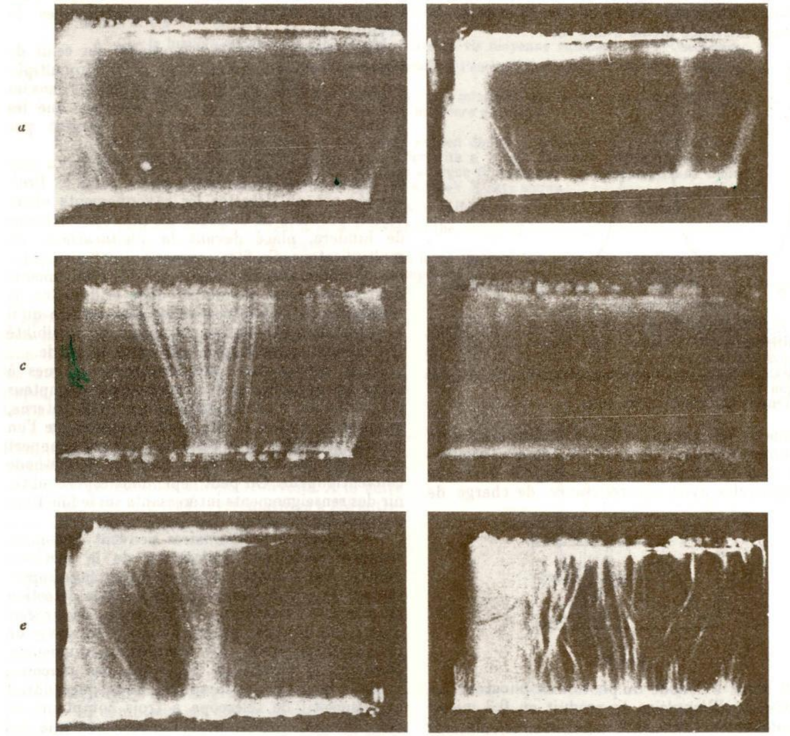
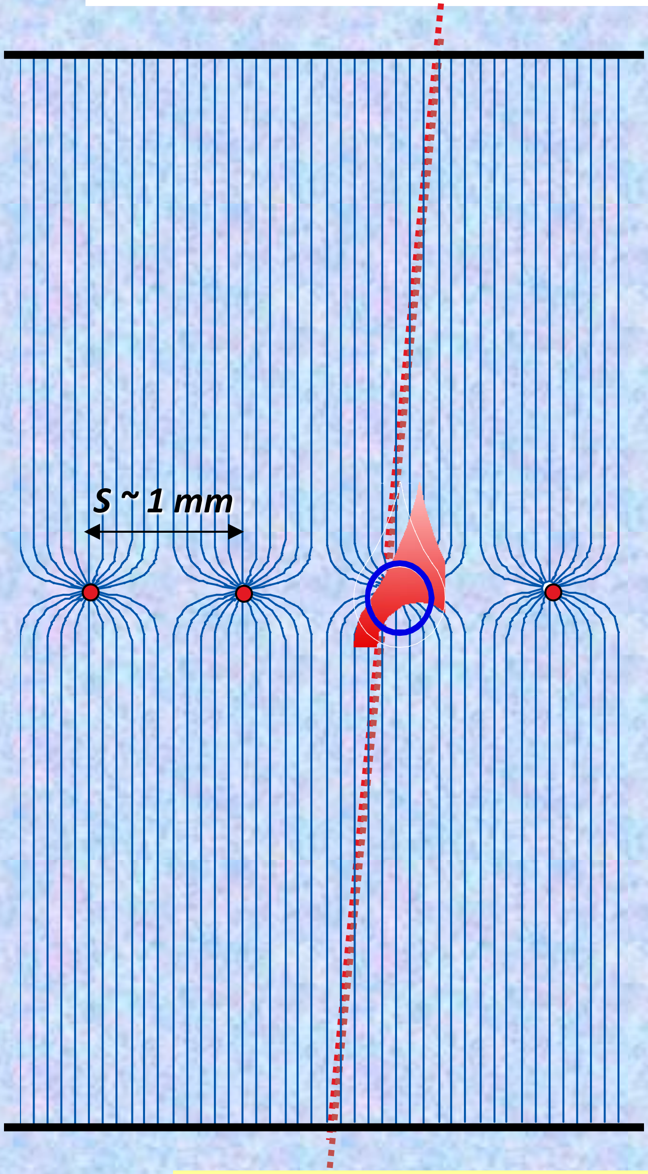


Fig. 2.

a) $V = 83\,000$ volts, $\tau = 1.25 \times 10^{-9}$ s, 18 000 impulsions, source latérale.
b) $V = 83\,000$ volts, $\tau = 1,25 \times 10^{-9}$ s, 6 000 impulsions, source latérale.
c) $V = 66\,000$ volts, $\tau = 6,25 \times 10^{-9}$ s, 9 000 impulsions, source sur électrode inférieure.
d) $V = 66\,000$ volts, $\tau = 6,25 \times 10^{-9}$ s, 6 000 impulsions, source sur électrode supérieure.
e) $V = 66\,000$ volts, $\tau = 6,25 \times 10^{-9}$ s, 1 800 impulsions, source latérale et source sur électrode inférieure, simultanément.
f) $V = 66\,000$ volts, $\tau = 6.25 \times 10^{-9}$ s. La pellicule de nickel, support de la source α, est retournée sur l'électrode inférieure.

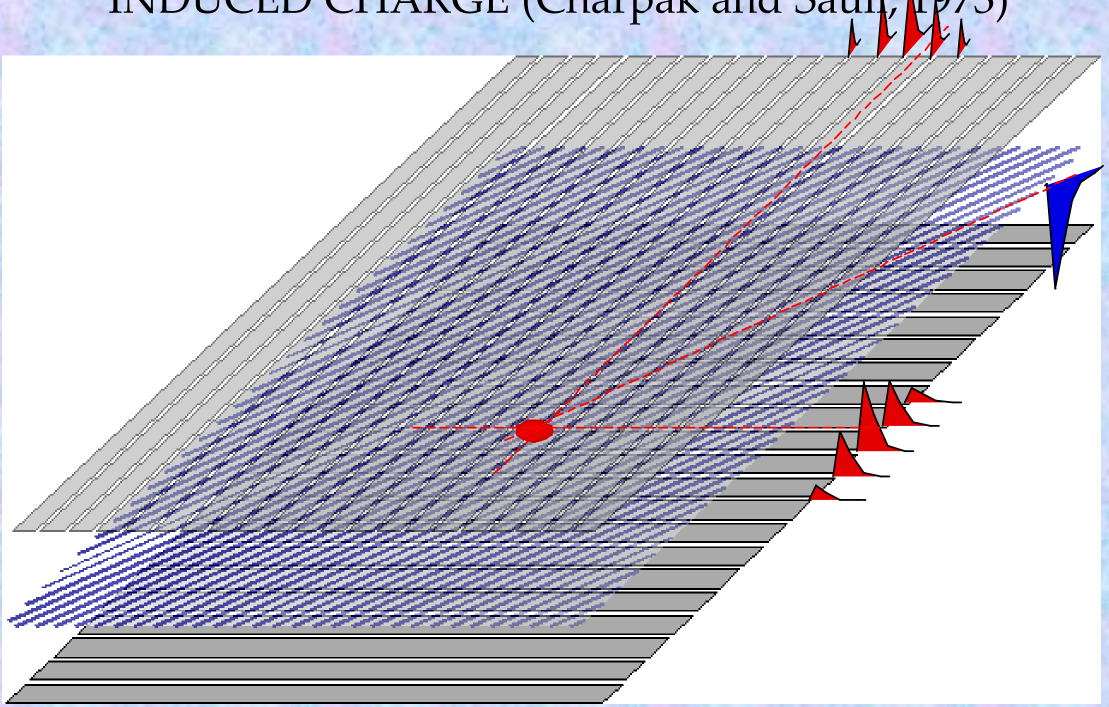
Multi-Wire Proportional Chamber (MWPC)



High-rate MWPC with digital readout:

Spatial resolution is limited to $\sigma_x \sim s/\mathrm{sqrt}(12) \sim 300\ \mu m$

TWO-DIMENSIONAL MWPC READOUT CATHODE INDUCED CHARGE (Charpak and Sauli, 1973)



Spatial resolution determined by: Signal / Noise Ratio

Typical (i.e. 'very good') values: S ~ 20000 e: noise ~ 1000e

Space resolution < 100 μm

Resolution of MWPCs limited by wire spacing

better resolution → shorter wire spacing → more (and more) wires...

1968: Multi-Wire Proportional Chamber (MWPC)

NUCLEAR INSTRUMENTS AND METHODS 62 (1968) 262–268; © NORTH-HOLLAND PUBLISHING CO.

THE USE OF MULTIWIRE PROPORTIONAL COUNTERS TO SELECT AND LOCALIZE CHARGED PARTICLES

G. CHARPAK, R. BOUCLIER, T. BRESSANI, J. FAVIER and Č. ZUPANČIČ

CERN, Geneva, Switzerland

Received 27 February 1968

Properties of chambers made of planes of independent wires placed between two plane electrodes have been investigated. A direct voltage is applied to the wires. It has been checked that each wire works as an independent proportional counter down to separations of 0.1 cm between wires.

Counting rates of 10^5/wire are easily reached; time resolutions of the order of 100 nsec have been obtained in some gases; it is possible to measure the position of the tracks between the wires using the time delay of the pulses; energy resolution comparable to the one obtained with the best cylindrical chambers is observed; the chambers operate in strong magnetic fields.

1. Introduction

Proportional counters with electrodes consisting of many parallel wires connected in parallel have been used for some years, for special applications. We have investigated the properties of chambers made up of a plane of independent wires placed between two plane electrodes. Our observations show that such chambers offer properties that can make them more advantageous than wire chambers or scintillation hodoscopes for many applications.

2. Construction

Wires of stainless steel, 4×10^{-3} cm in diameter, are stretched between two planes of stainless-steel mesh, made from wires of 5×10^{-3} cm diameter, 5×10^{-2} cm apart. The distance between the mesh and the wires is 0.75 cm. We studied the properties of chambers with wire separation $a = 0.1$, 0.2, 0.3 and 1.0 cm. A strip of metal placed at 0.1 cm from the wires, at the same potential (fig. 1), plays the same role as the guard rings in cylindrical proportional chambers. It protects the wires against breakdown along the dielectrics. It is

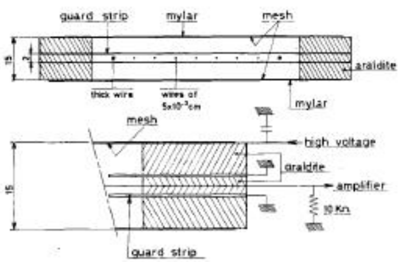


Fig. 1. Some details of the construction of the multiwire chambers.
A copper shield protects the wires at their output from the chamber and contains the solid state amplifiers.

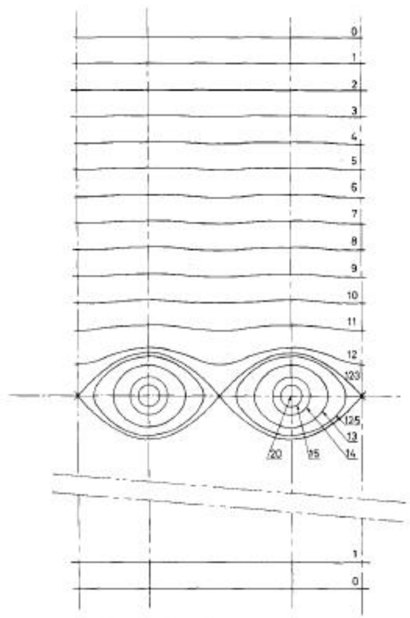
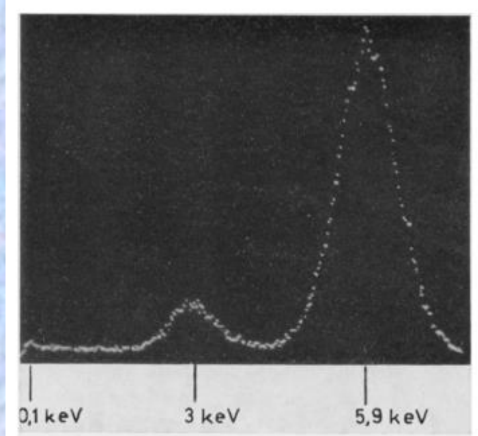
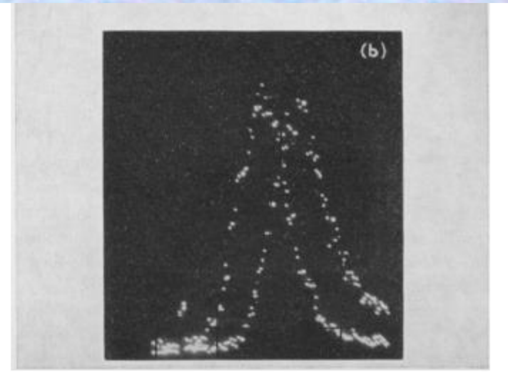


Fig. 2. Equipotentials in a chamber.
Wires of 4×10^{-3} cm diameter, 0.3 cm separation, and 1.5 cm total thickness. 20 V applied between the wires and the external mesh. Results from an analogic method.

ENERGY RESOLUTION ON 5.9 KeV:



DEPENDENCE OF COLLECTION TIME FROM TRACK'S DISTANCE:



→ DRIFT CHAMBERS

G. Charpak,R. Bouclier, T. Bressan,J. Favier and C. Zupancic: The use of Multiwire Proportional Counters to select and localize Charged Particles, Nuc. Instr. and Meth. 62(1968)262

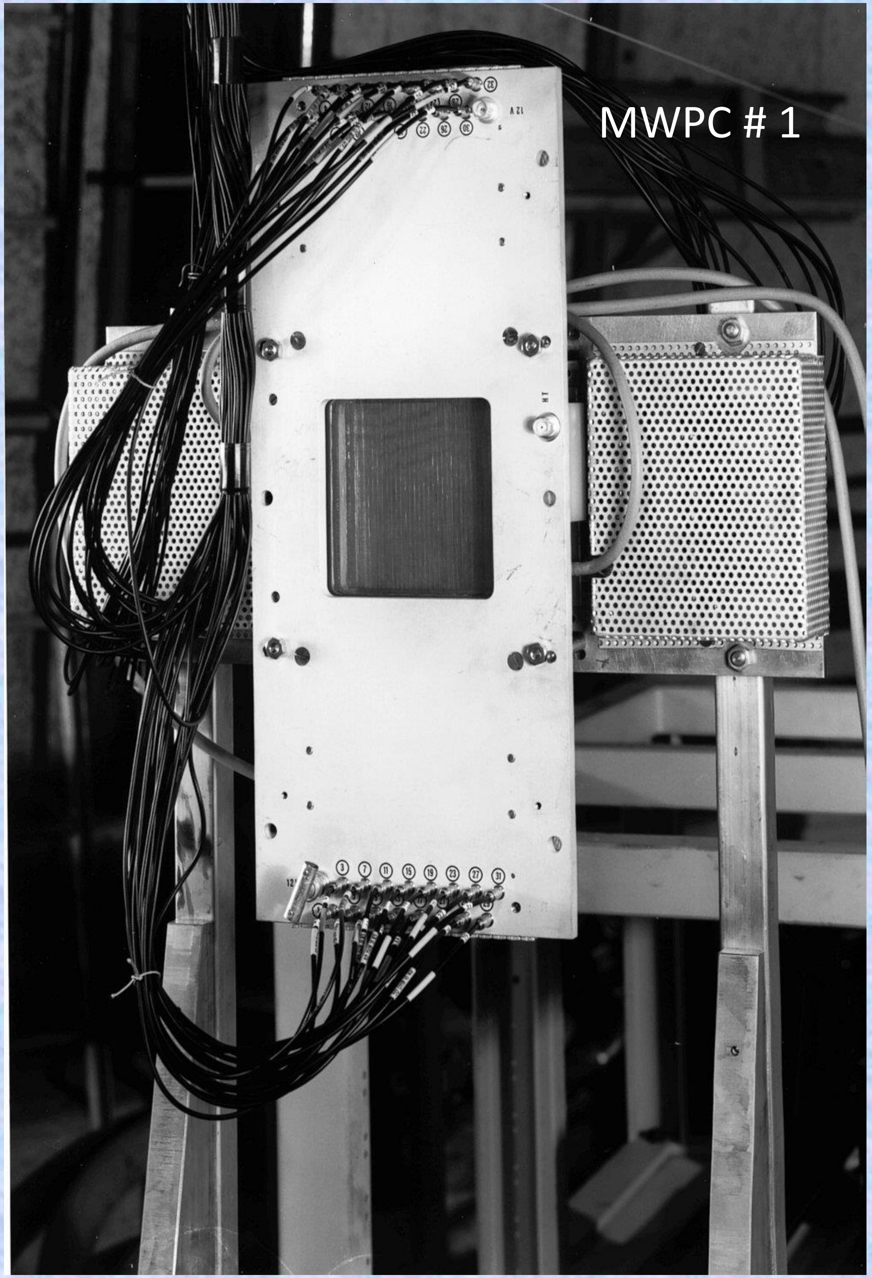
First Public Presentation of the Multi-Wire Proportional Chamber

colloque
international
sur
l'électronique
nucléaire
*
international
symposium
on
nuclear
electronics

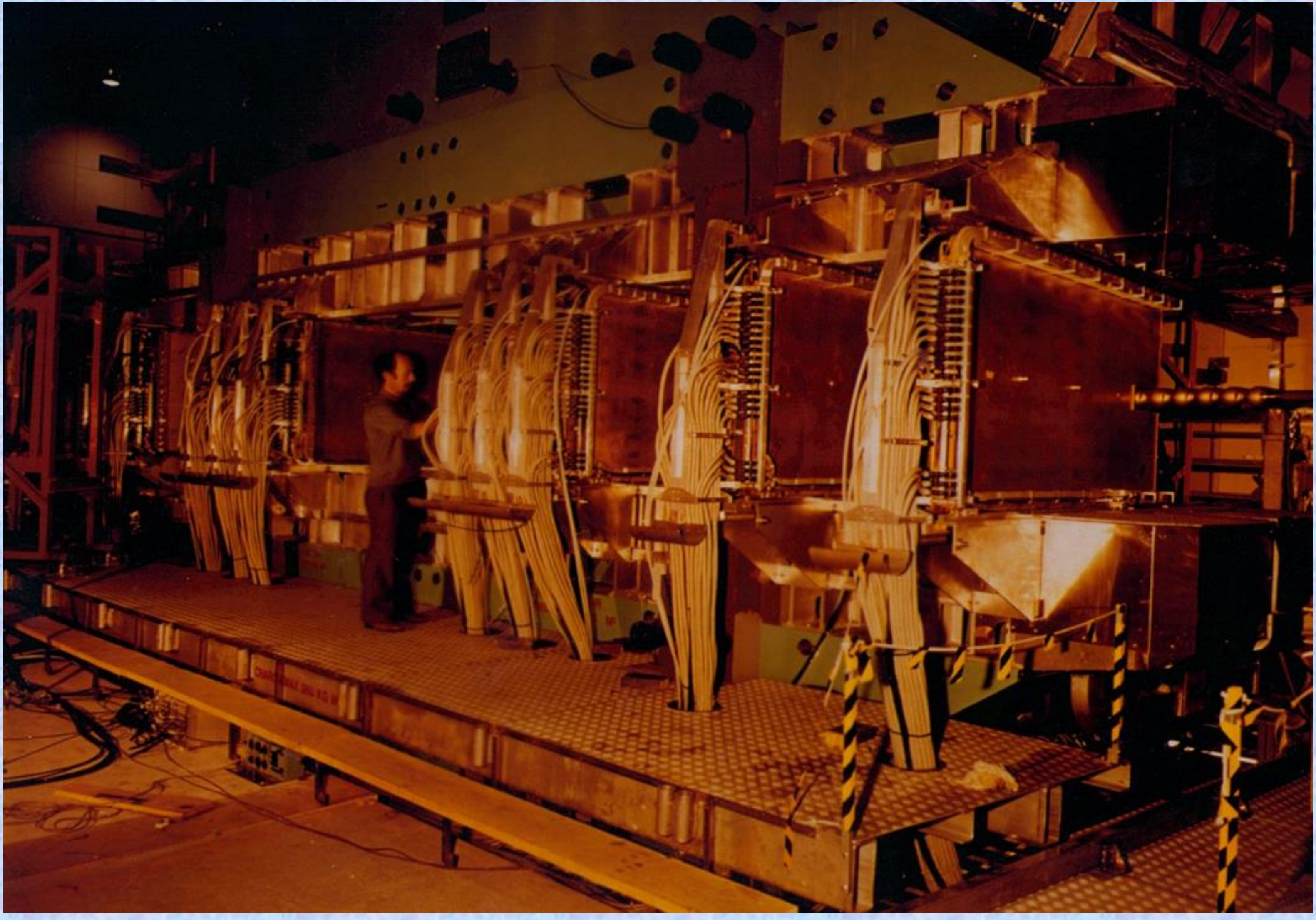
VERSAILLES,
10-13 September 1968

Chambres à Etincelles
Spark chambers

Rapporteur Reporter	**M. CHARPAK** CERN - GENEVE (Suisse)
Secrétaire scientifique Scientific Secretary	**M. FEUVRAIS** Faculté des Sciences - Lyon (France)

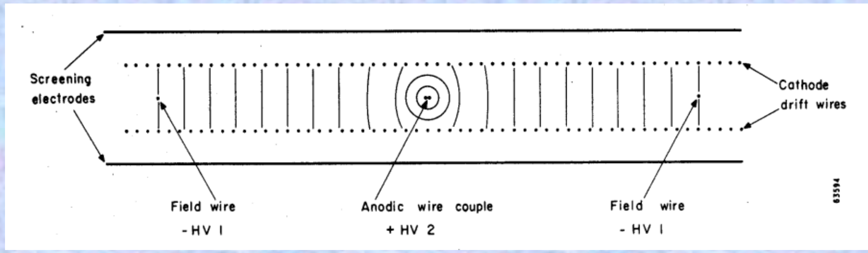


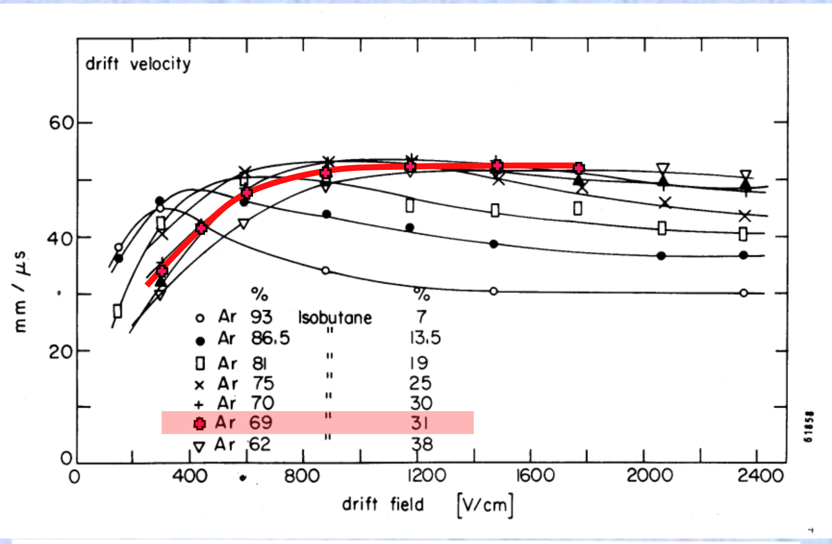
First Large Experiment with MWPCs

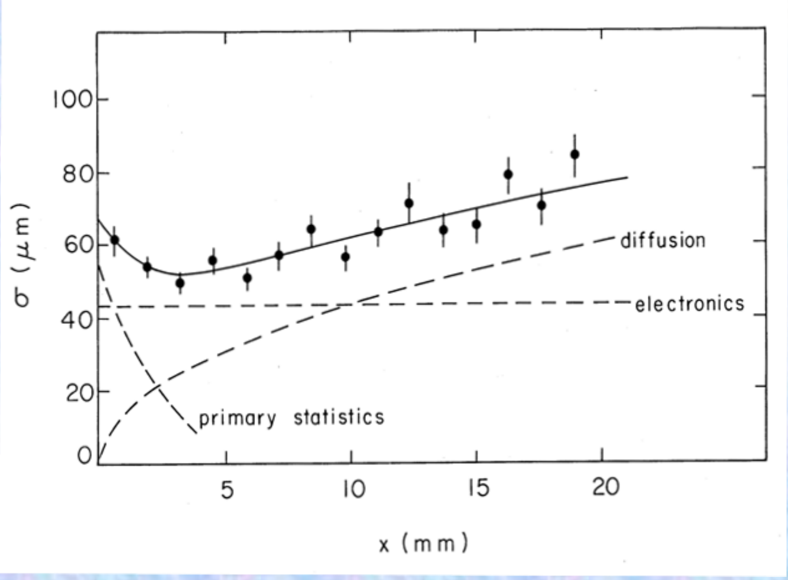


1972-1983: SPLIT FIELD MAGNET DETECTOR
40 LARGE AREA MWPCs AT CERN ISR:

High Accuracy Drift Chambers







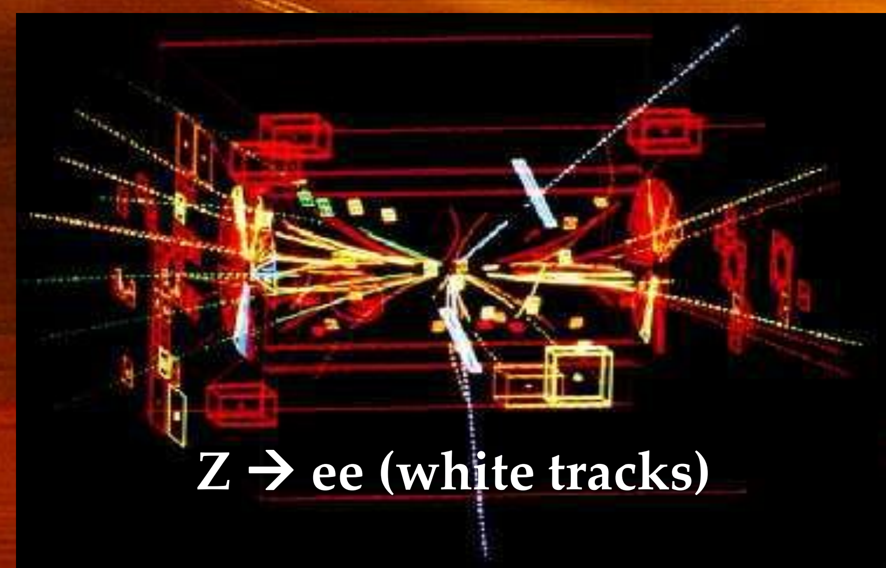
1973-75 Gases/conditions for Saturated drift velocity, magnetic fields….

Nobel Prize: W, Z - Discovery at UA1/UA2 (1983)

UA1 used the largest imaging drift chamber of its day
(5.8 m long, 2.3 m in diameter)

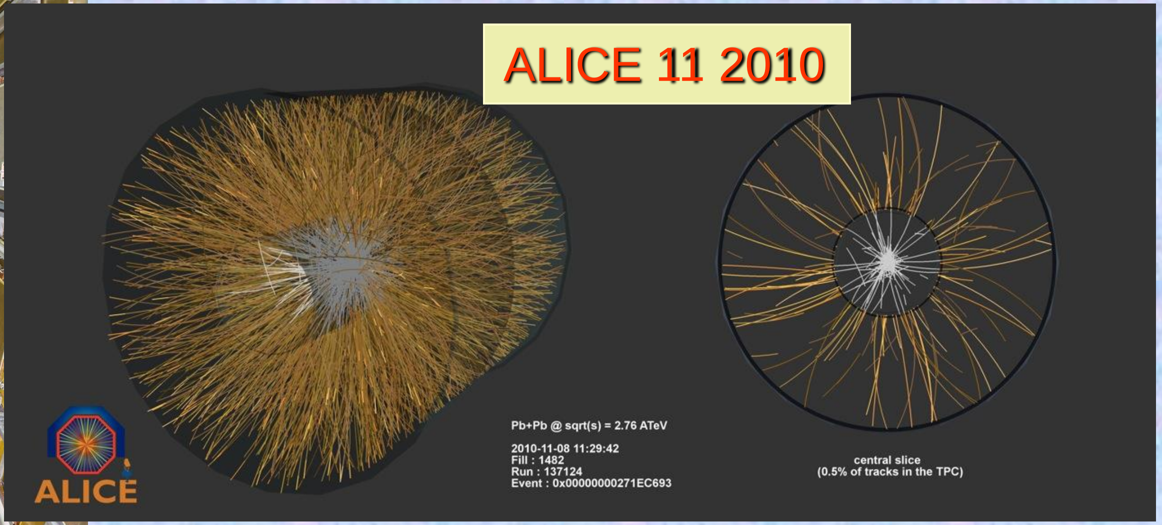
It can now be seen in the CERN Microcosm Exhibition

Particle trajectories in the CERN-UA1
3D Wire Chamber TPC
Discovery of W and Z bosons
C. Rubbia & S. Van der Meer Nobel 1984



CERN-LHC: Enormous Wire Chambers

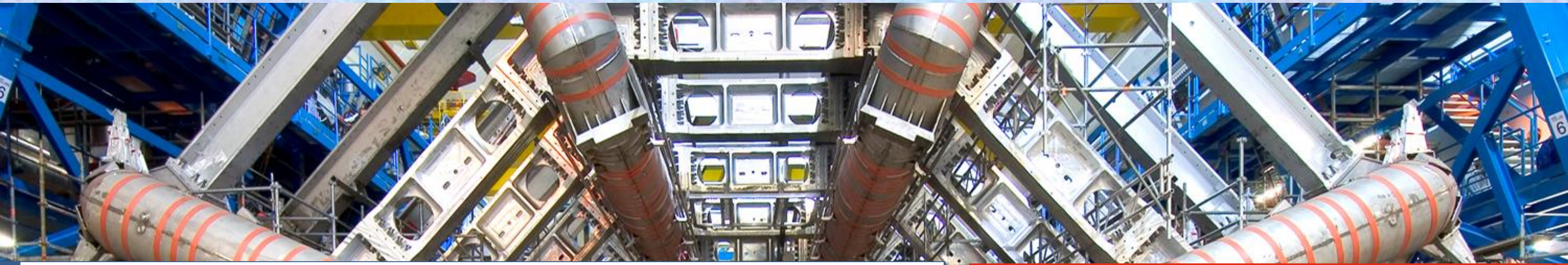
40 years later…



The Time Projection Chamber (TPC)

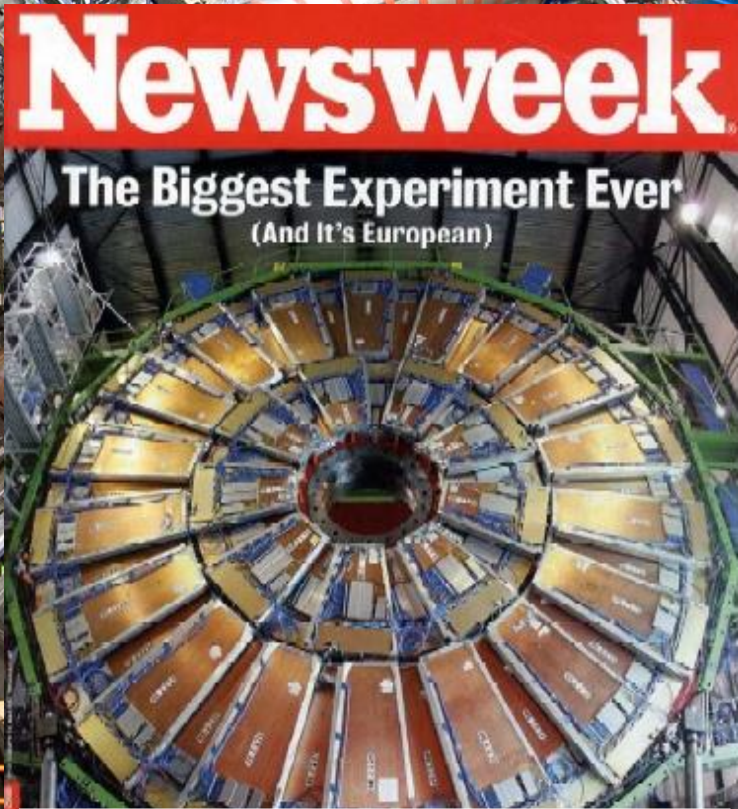
Thin-Gap Wire Chambers (TGC) of Weizmann Institute

The LHC Spectrometers: Triumph of Instrumentation



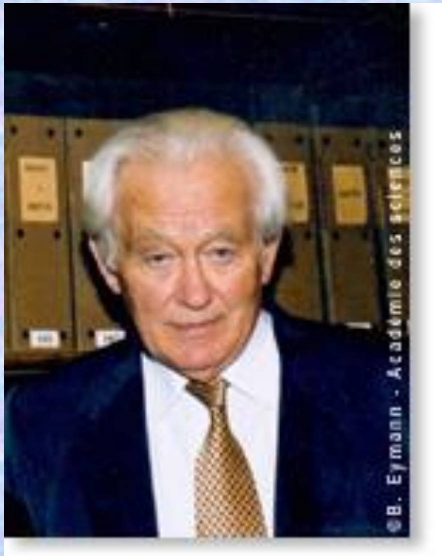
IMPACTS CAN BE UNEXPECTED:

The opera Les Troyens by Berlioz, as shown in Valencia, St. Peterburg and Warsaw (2011) used a set design based on ATLAS Detector



The "Gothic Cathedrals" of the 21st Century

French Academy of Sciences

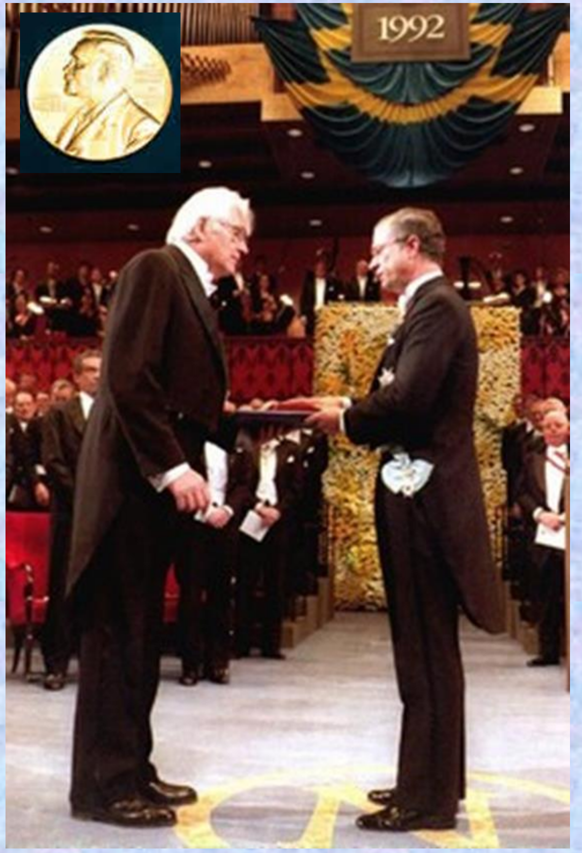


Elected to the Academy in ***1985***

Chevalier de la Legion d'Honneur

With Prof. Robert Dautray

Glory Halleluiah!



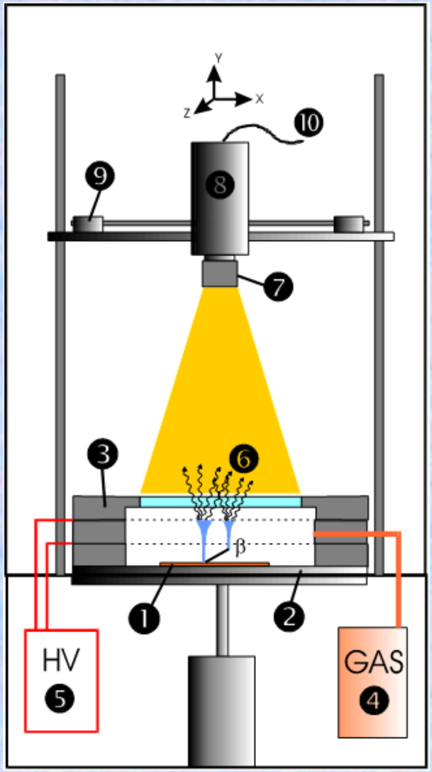
Nobel banquet in 1992: Charpak claimed that these advances offered *"the best solution for the radiography of such fragile objects as women's breasts"* and

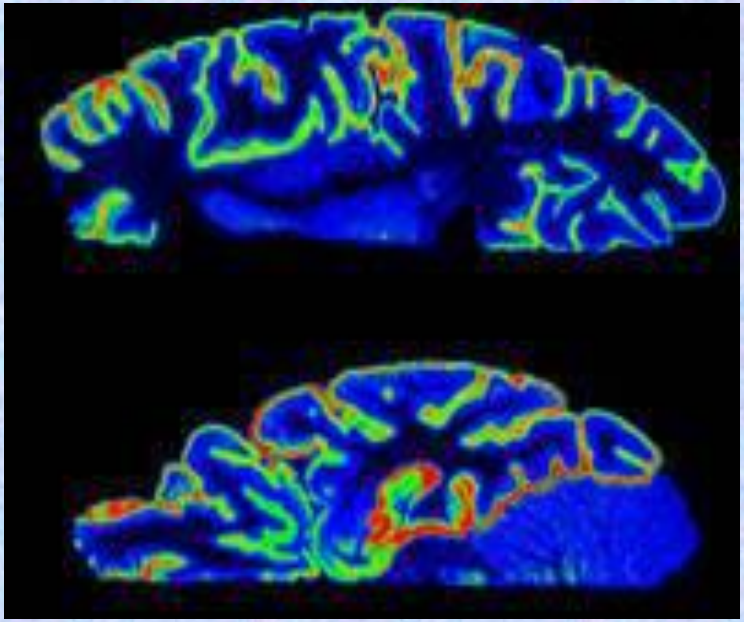
"**as fallout**, you will learn everything you want to know about the Higgs field, the hidden matter of the Universe, and marvelous new particles which are haunting the dreams of physicists"

Biospace: Company Founded in 1989 by Georges Charpak

~ 2000: LOW-DOSE 3D IMAGING

COMMERCIAL AUTORADIOGRAPHY SYSTEMS WITH GASEOUS DETECTORS

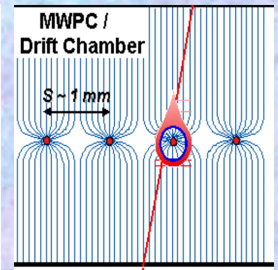


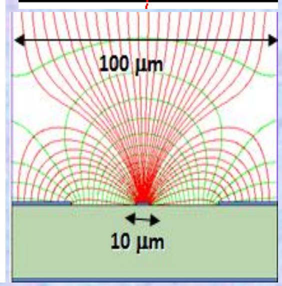


http://www.biospacelab.com

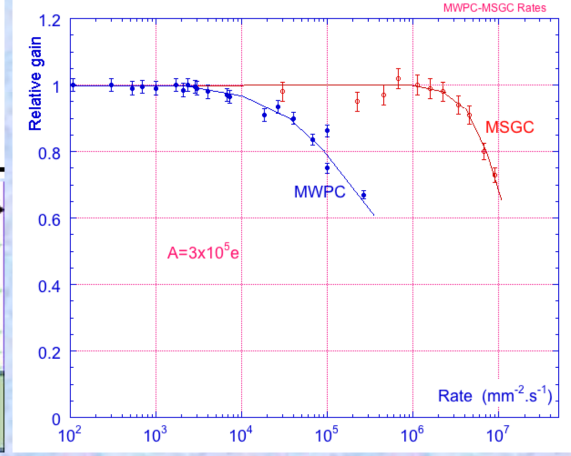
Micro-Pattern Gaseous Detector Technologies for Future Physics Projects

- Micromegas
- GEM
- Thick-GEM, Hole-Type and RETGEM
- MPDG with CMOS pixel ASICs (“InGrid”)
- Micro-Pixel Chamber (µPIC)

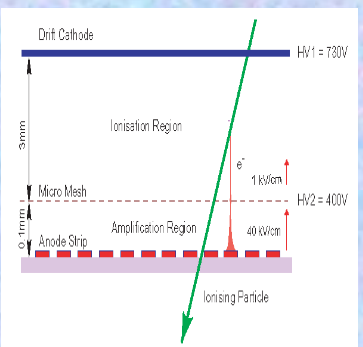


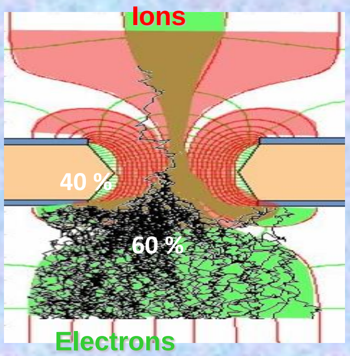


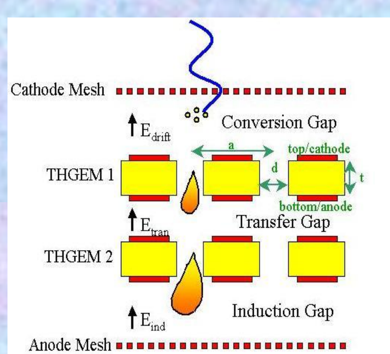
Rate Capability:
MWPC vs MSGC

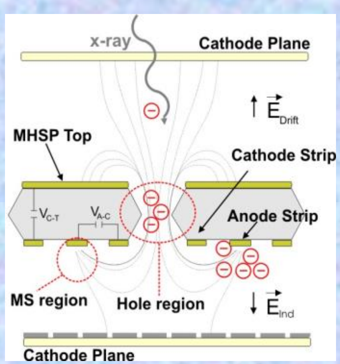


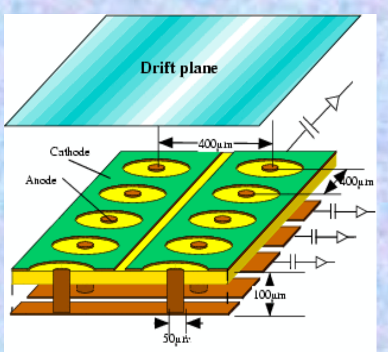
Micromegas | GEM | THGEM | MHSP | µPIC

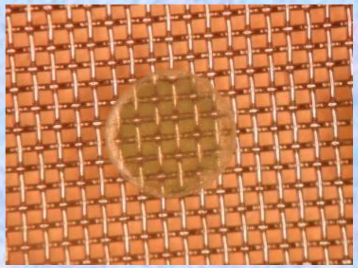


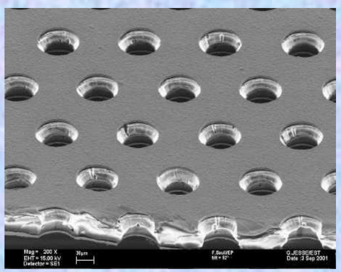


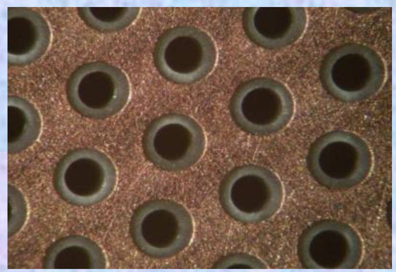


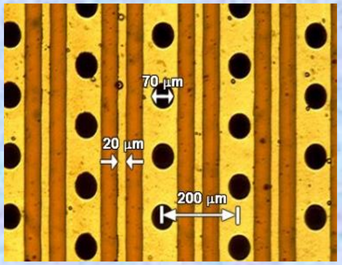


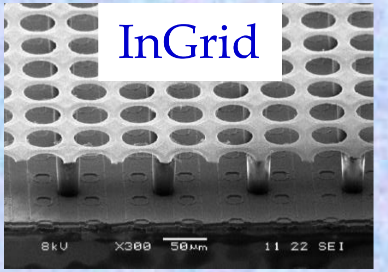




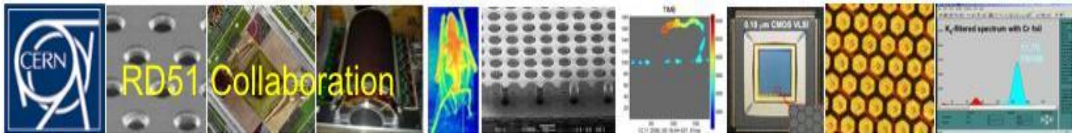


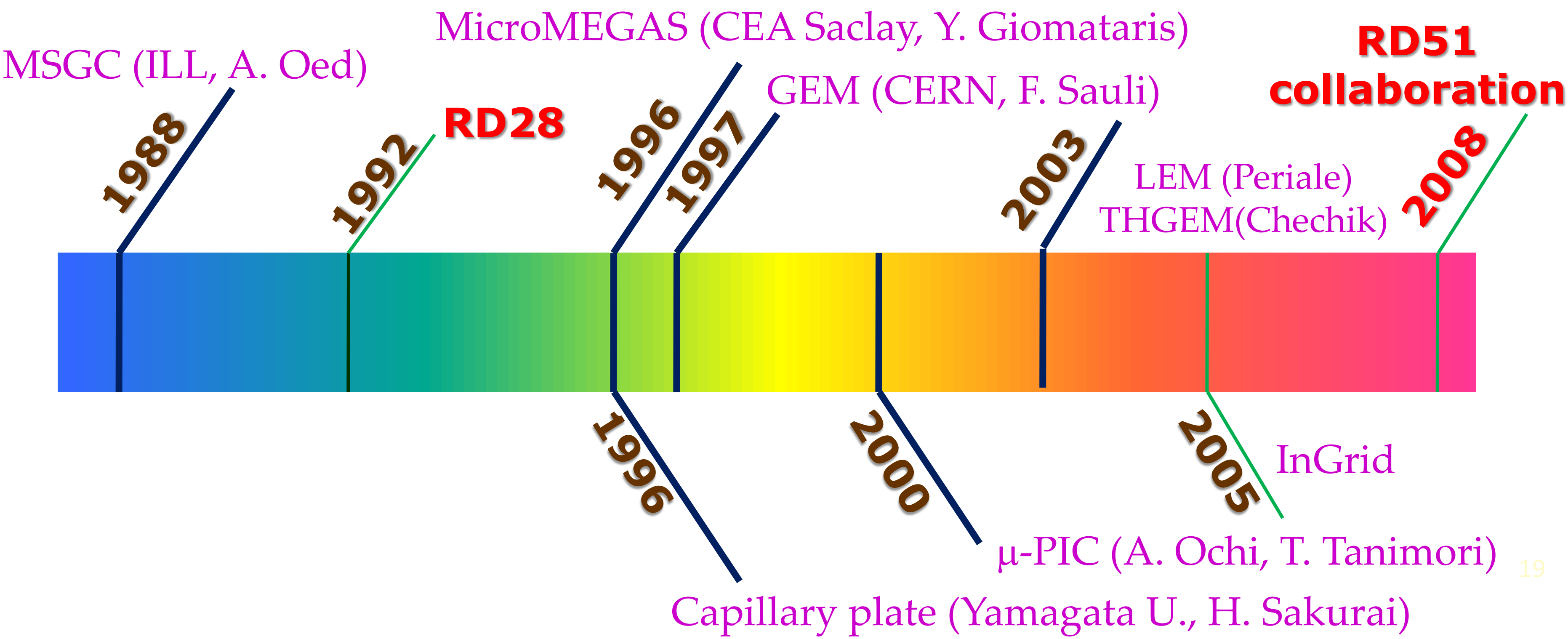






Historical Roadmap of the MPGD Technologies and RD51 Collaboration



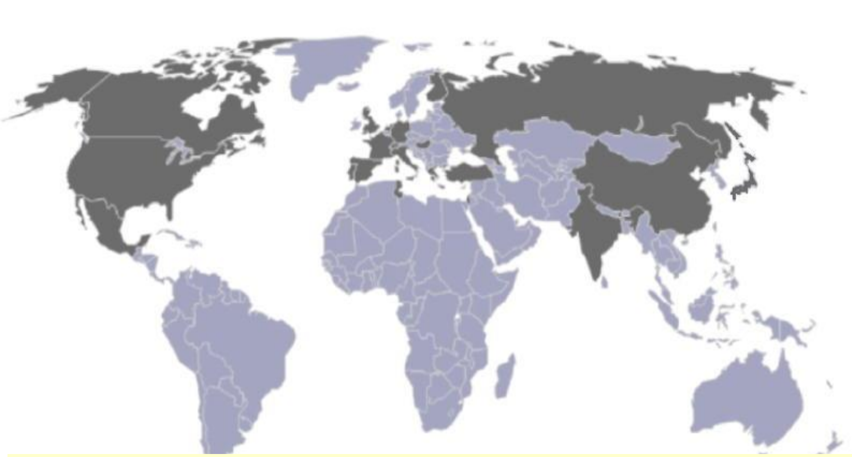


- Many of the Micro-Pattern Gaseous Detector Technologies were introduced before the RD51 Collaboration was founded

- With more techniques becoming available (or affordable), new detection concepts are being introduced and the existing ones are substantially improved

RD51 – Development of Micro-Pattern Gaseous Detector Technologies

The main objective is to advance MPGD technological development and associated electronic-readout systems, for applications in basic and applied research"



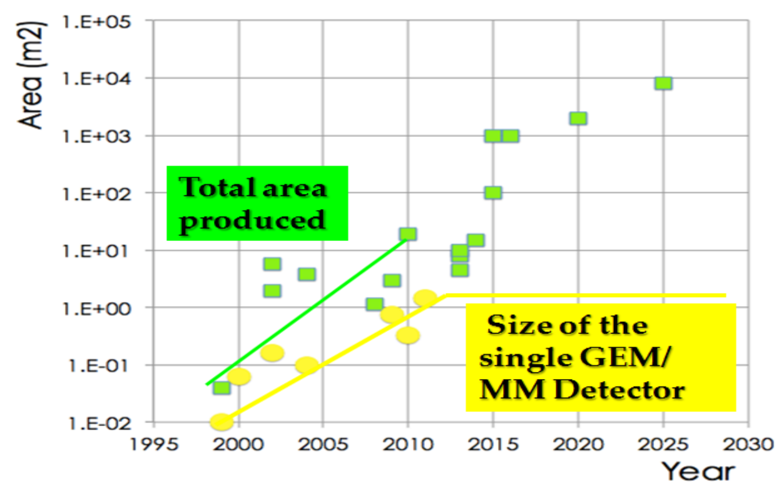
http://rd51-public.web.cern.ch/rd51-public

A fundamental boost is offered by RD51: from isolate MPGD developers to a world-wide net

World-wide Collaboration for the MPGD Developments → RD51 (91 institute, > 500 people):

- Large Scale R&D program to ***advance MPGD Technologies***
- Access to ***the MPGD "know- how"***
- Foster ***Industrial Production***

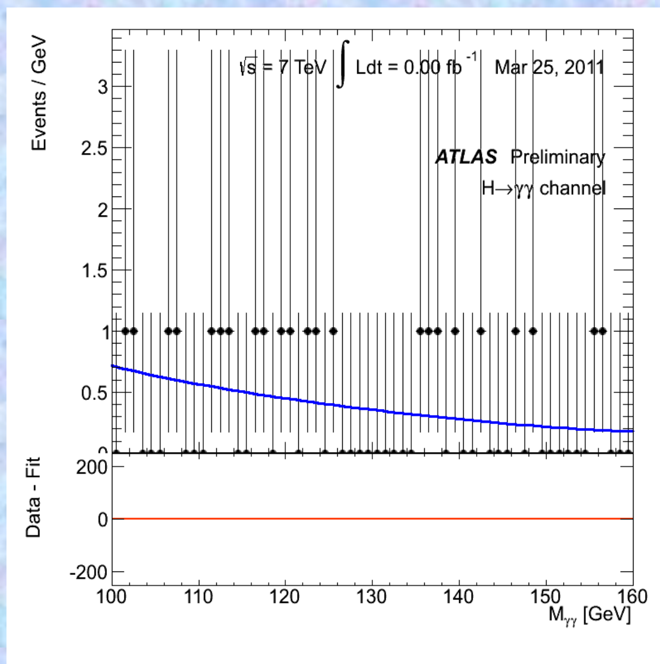
Advances in photolithography → Large Area MPGDs (~ m^2 unit size)

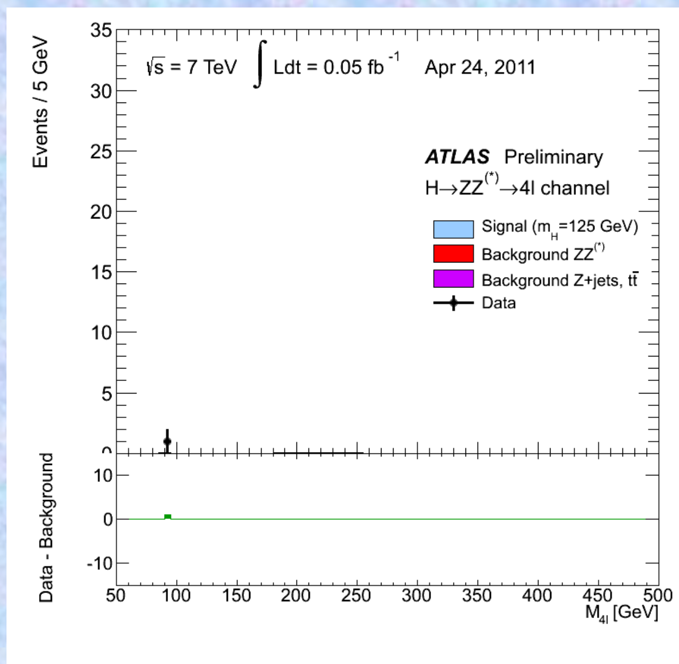


Higgs Boson and the Nobel Prize

The birth of the Particle – Evolution in time

H → γγ **H → ZZ**





The Nobel Prize in Physics 2013 : **François Englert, Peter Higgs:**

HIGGS DISCOVERY AT CERN, which validates the Brout-Englert-Higgs mechanism, marks the culmination of decades of INTELLECTUAL EFFORT by many people around the world

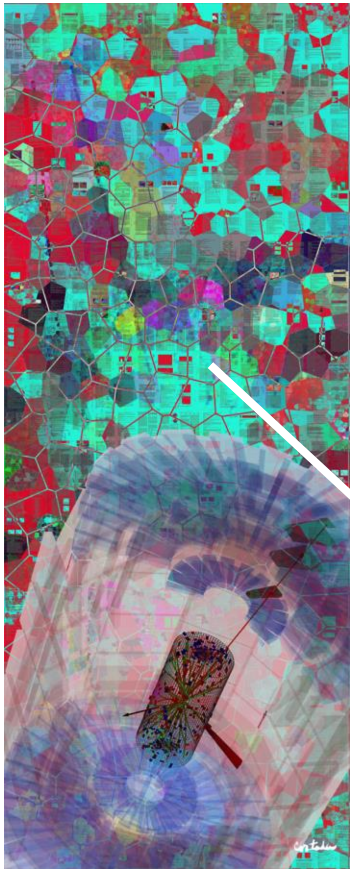
Art @ CMS Project: In Search of the Higgs Boson

M. Hoch (CMS)

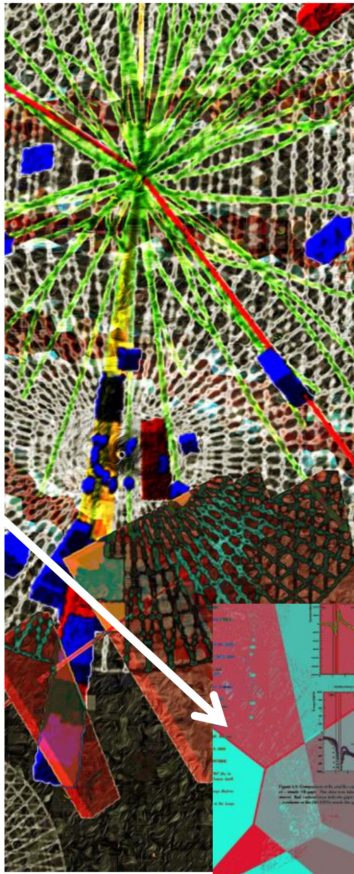
Inspire 'non scientific world' with science instruments & physics topics:

http://cern.ch/scienceartschool

Xavier Cortada (with the participation of physicist Pete Markowitz), digital art, 2013

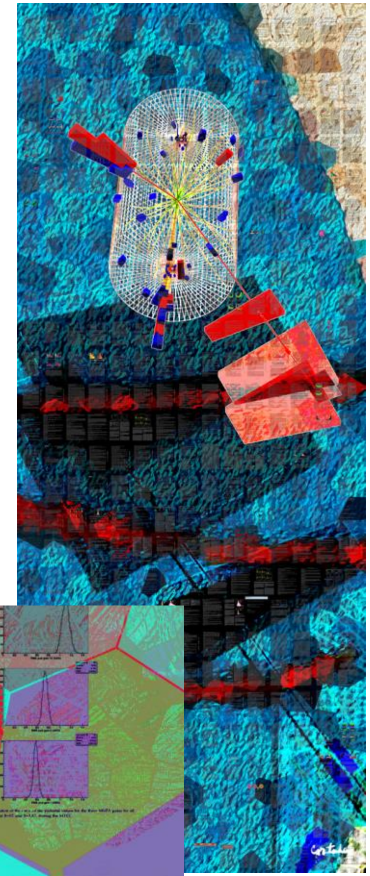


$H \rightarrow WW$

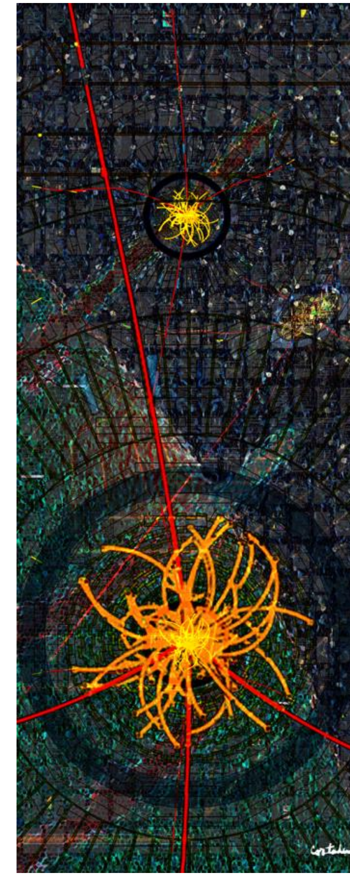


$H \rightarrow \gamma\gamma$

$H \rightarrow bb$



$H \rightarrow \tau\tau$



$H \rightarrow ZZ$

CMS Papers in Art Design:

Real CMS Event Displays: