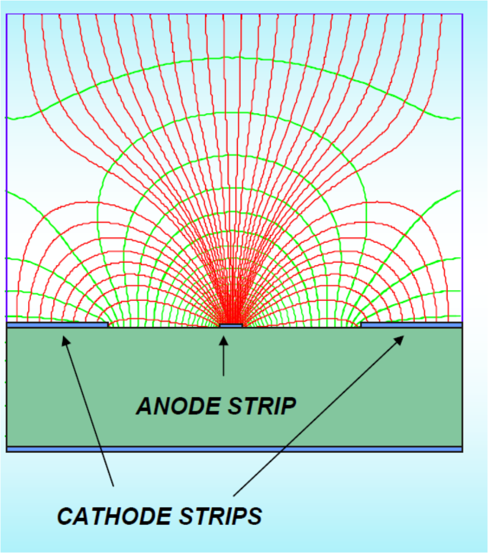
MSGCs and their descendants. Past, present and future

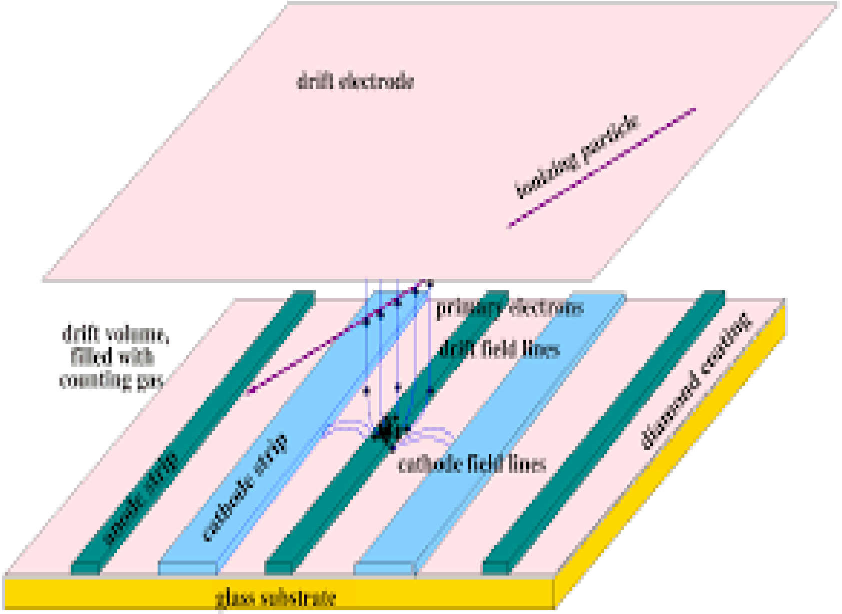
V. Peskov

CERN and Inst. of Chem. Phys., RAN



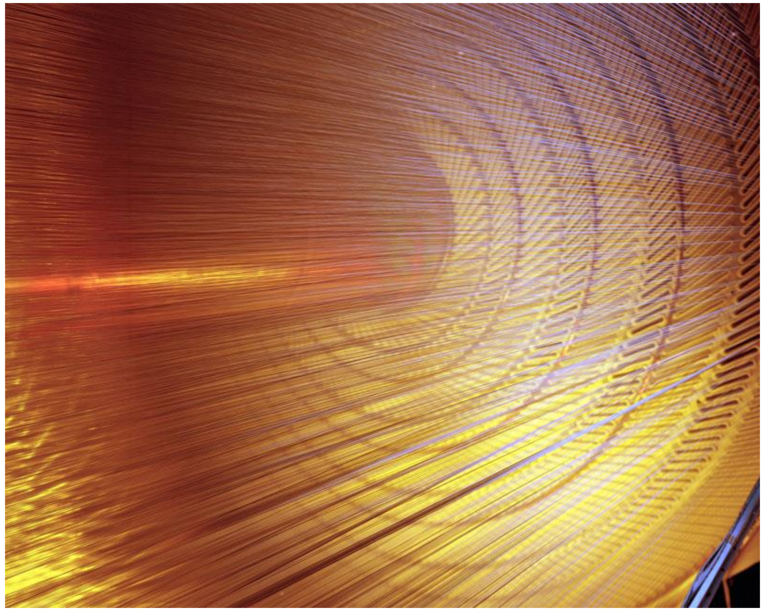
Today, at the A. Oed memory session, it will be relevant to highlight his contribution to the gaseous detectors development:

Microstrip detectors manufactured by
a <u>microelectronic technology</u>
and
the first tests of hole-type structures

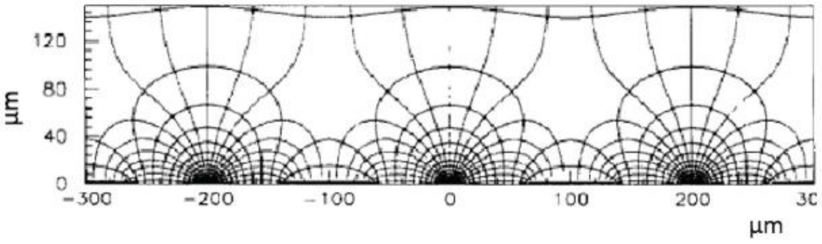


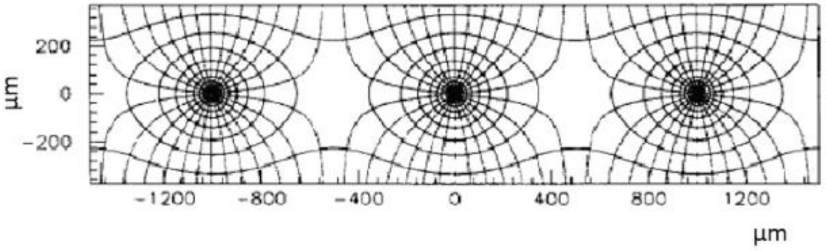
Technology
Pioneer
1988

This first idea opened a new direction in detector developments: wires were replaced by strips with a much smaller pitch



MSGC



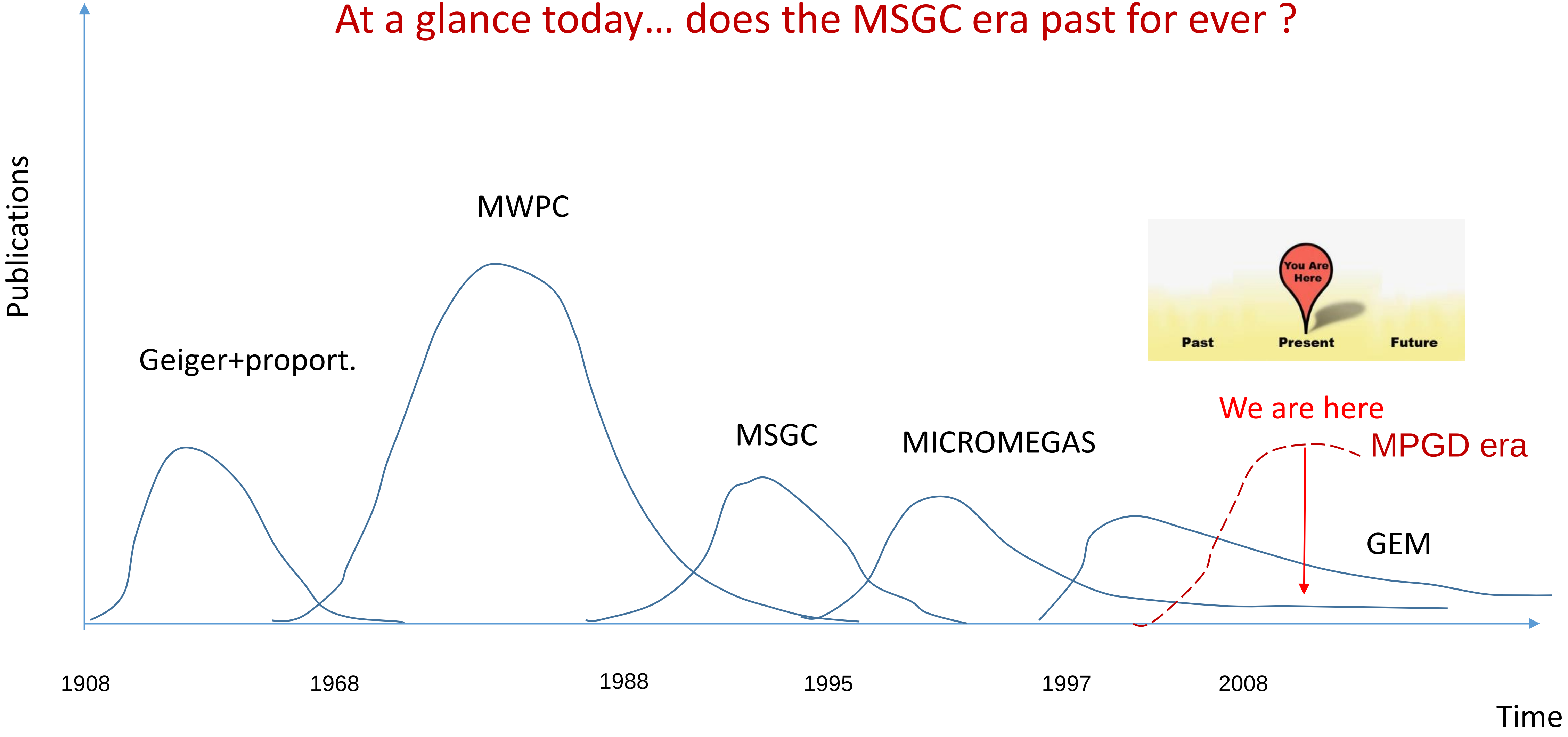


MWPC

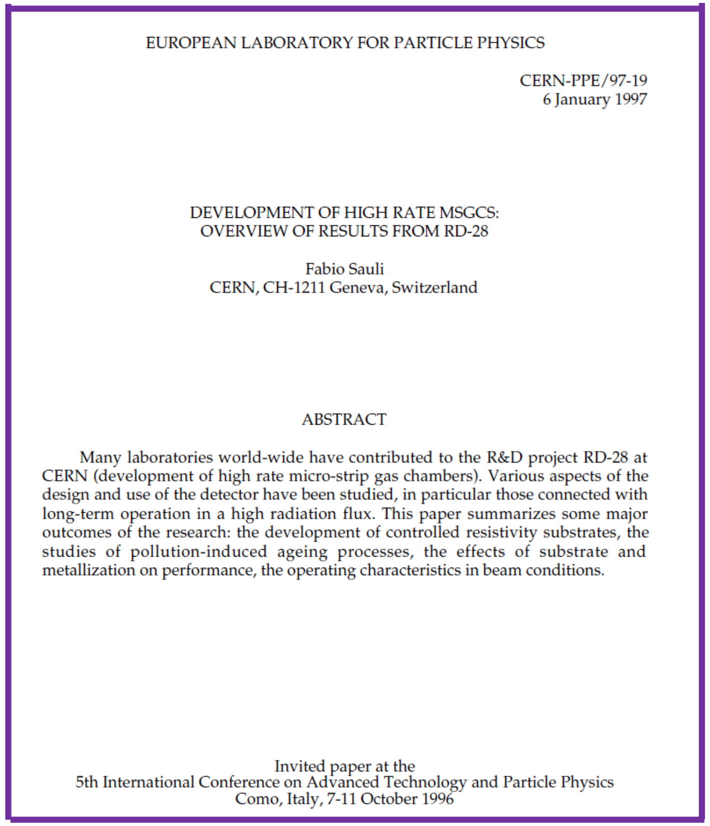
Field lines are similar, but **the scale is different!**

MSGC was invented more then 30 years ago

At a glance today… does the MSGC era past for ever ?



General trends in gaseous (and other) detectors developments: all had a pick and then decay in time



EUROPEAN LABORATORY FOR PARTICLE PHYSICS

CERN-PPE/97-19
6 January 1997

DEVELOPMENT OF HIGH RATE MSGCS:
OVERVIEW OF RESULTS FROM RD-28

Fabio Sauli
CERN, CH-1211 Geneva, Switzerland

ABSTRACT

Many laboratories world-wide have contributed to the R&D project RD-28 at CERN (development of high rate micro-strip gas chambers). Various aspects of the design and use of the detector have been studied, in particular those connected with long-term operation in a high radiation flux. This paper summarizes some major outcomes of the research: the development of controlled resistivity substrates, the studies of pollution-induced ageing processes, the effects of substrate and metallization on performance, the operating characteristics in beam conditions.

Invited paper at the
5th International Conference on Advanced Technology and Particle Physics
Como, Italy, 7-11 October 1996

MSGC was invented in 1988, it took then
5-6 years to get a momentum, so the peak of the developments
was in1992-1995. It was a fascinating time…

I.MSGCs. Past

(Remember the past glory. Peak of the MSGCs.)

Sauli CERN RD28 (40 laboratories worldwide)

Let's jus mention few exciting developments:

Neutron spectrometer (ILL)

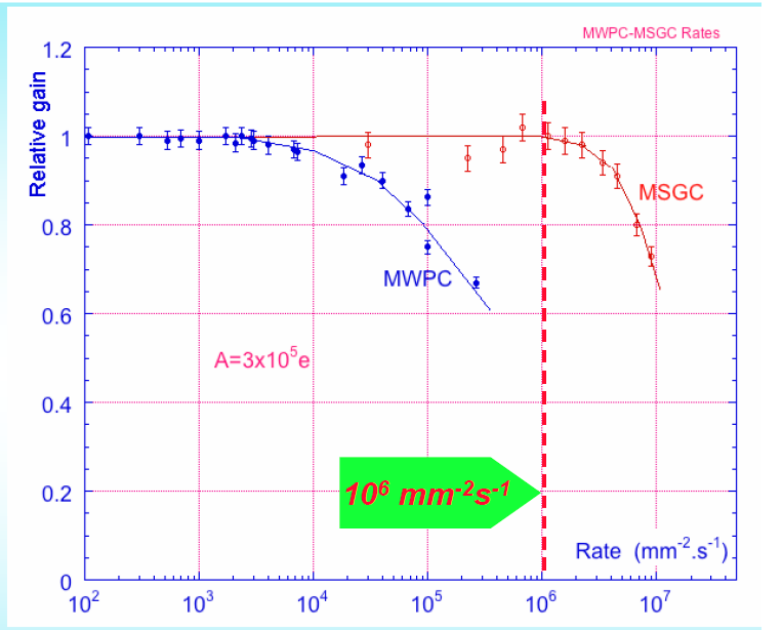
Large area 30x30 cm^2 MSGC for flight

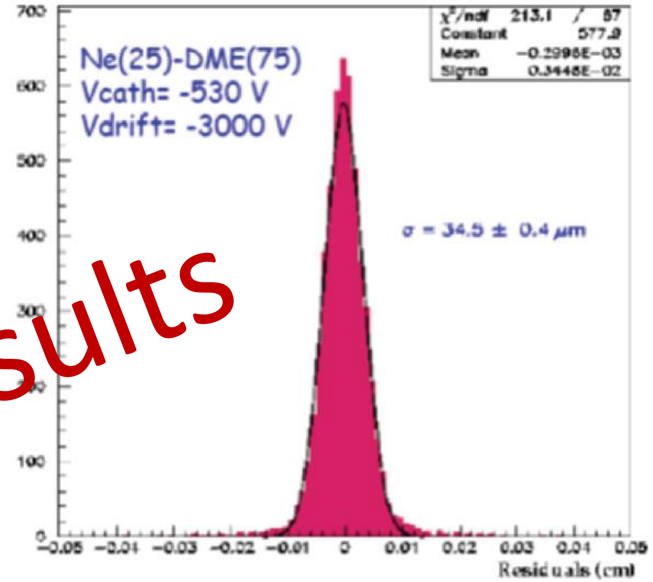
experiment (NASA)

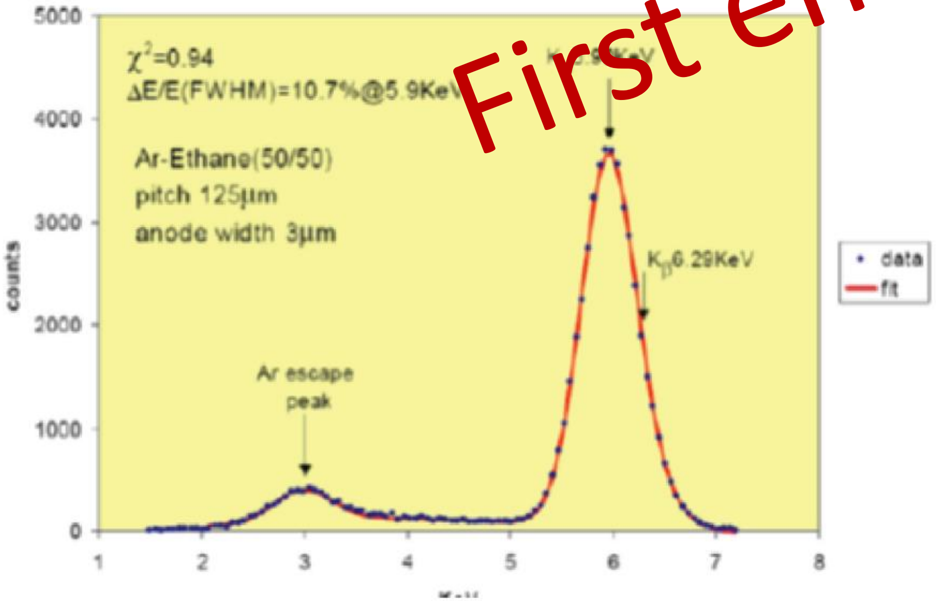
Multiplication in LXe (Coimbra group),

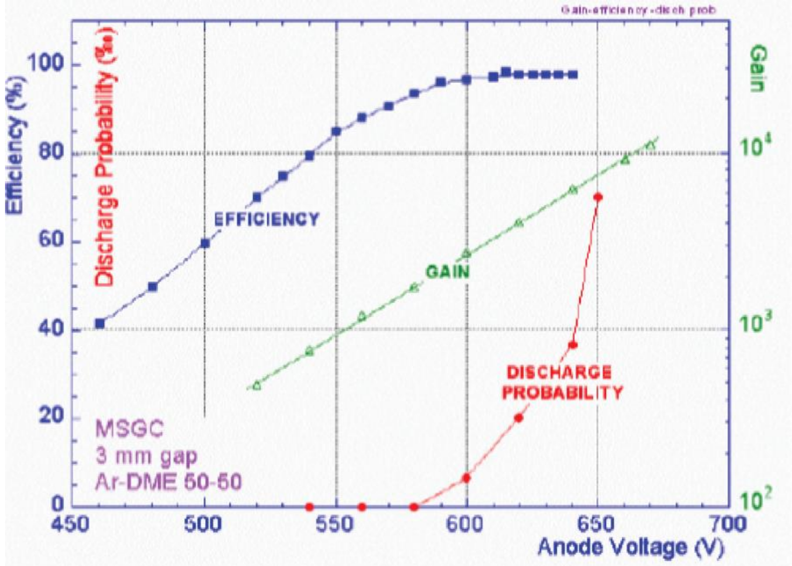
etc

First encouraging results



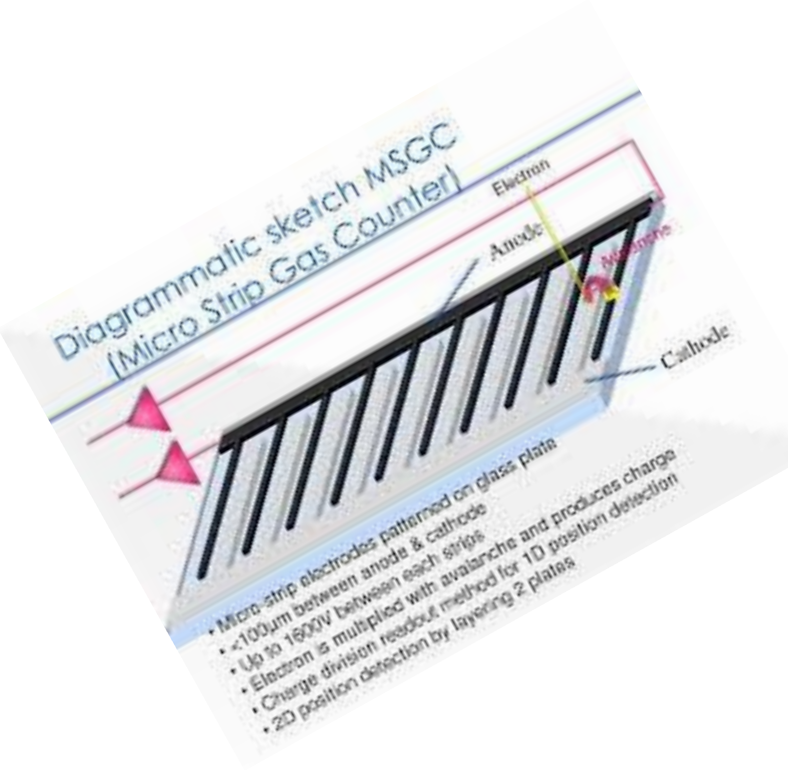


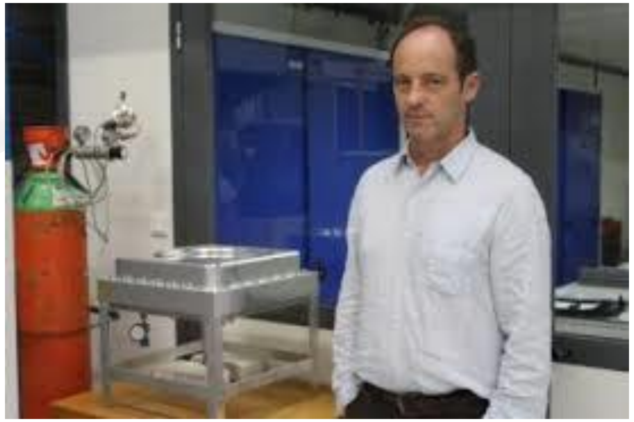




The key contributors to the initial MSGC success

A special role in dissemination this technology belongs Peter Geltenbort, who provided our community with MSGCs in most of cases free of charge.





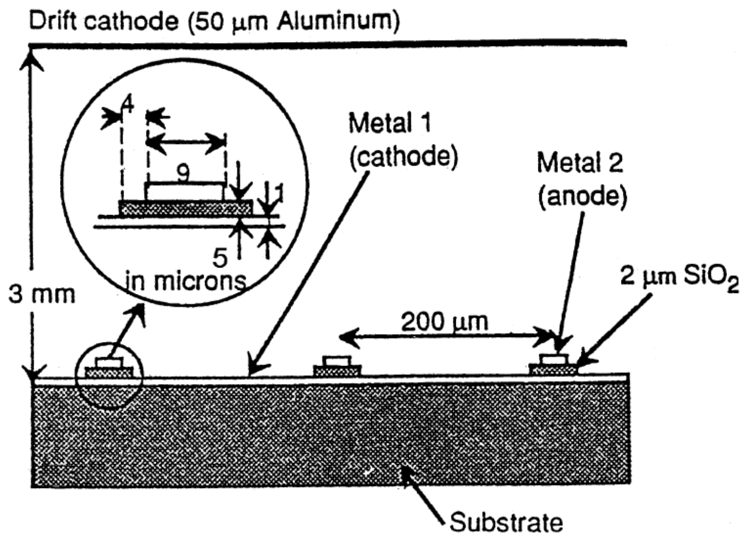
Bruno Guerard, who was a right hand of Anton and then his successor, made MSGCs operational and reliable in the big ILL D20 diffractometer, which is in continuous operation since 2000 !

Descendants

Besides the MSGC development it is equally important that

Oed's idea inspired other researches in exploring the potentials of microelectronics in gaseous detectors manufacturing

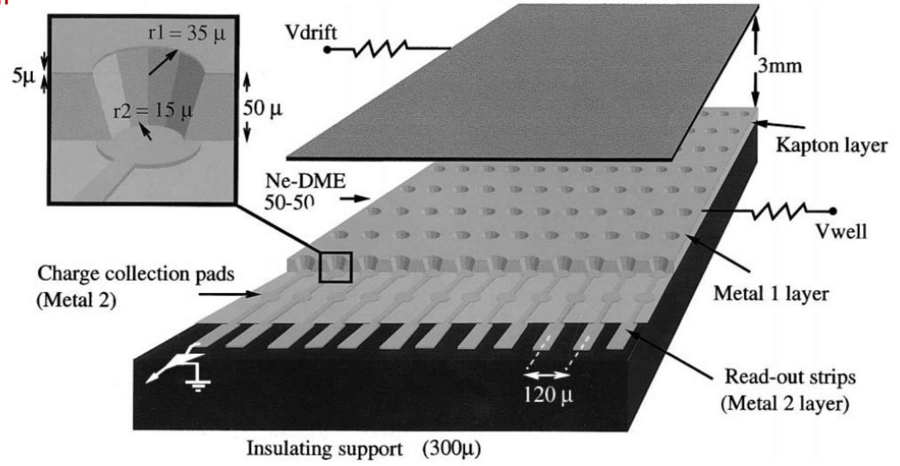
…few examples

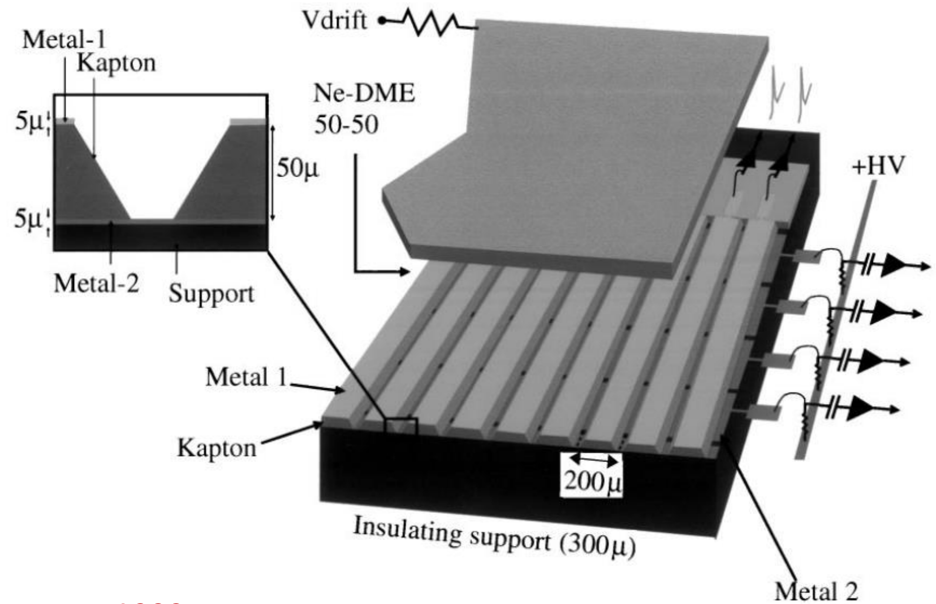


1993 Microgap (to improve rate characteristics)

1999,
Microwell

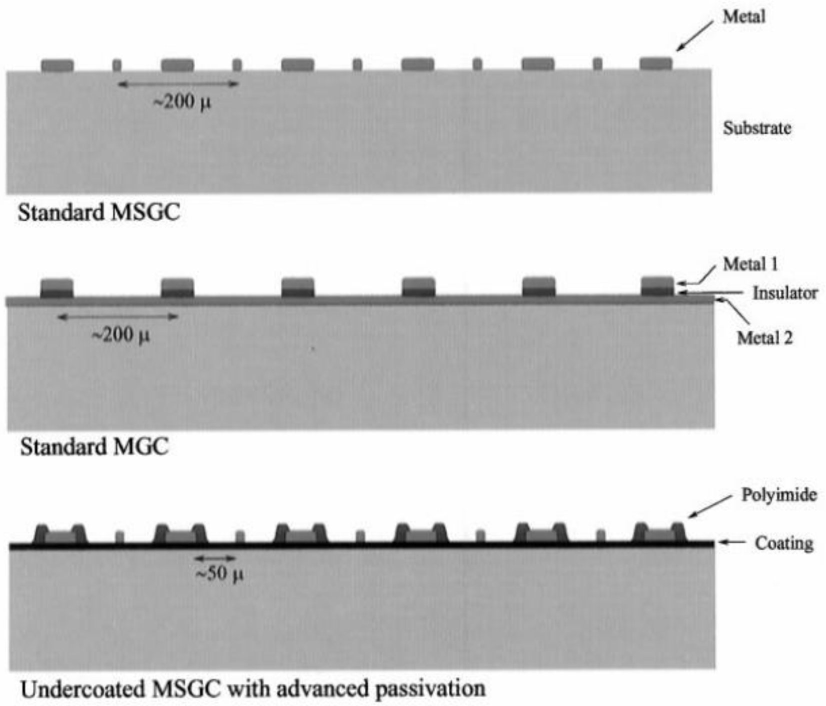
R. Bellazzini et al./Nucl. Instr. and Meth. in Phys. Res. A 423 (1999) 125–134



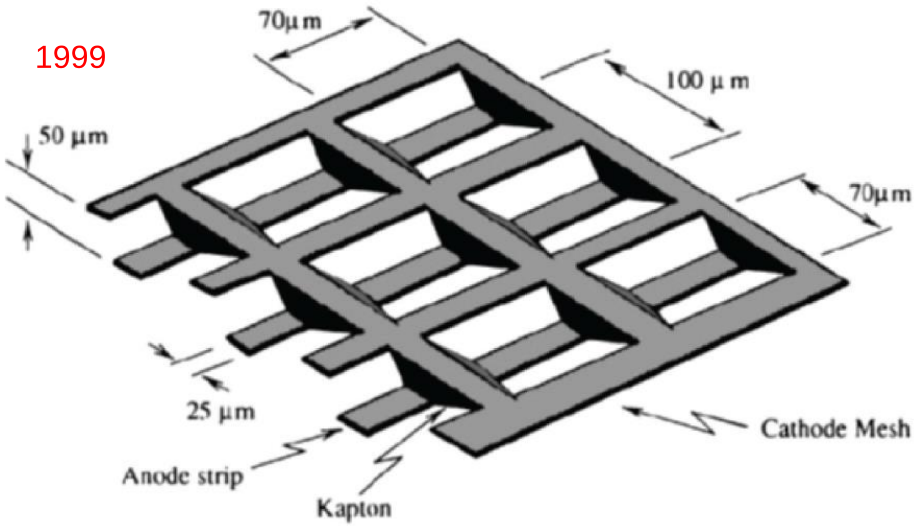


1999

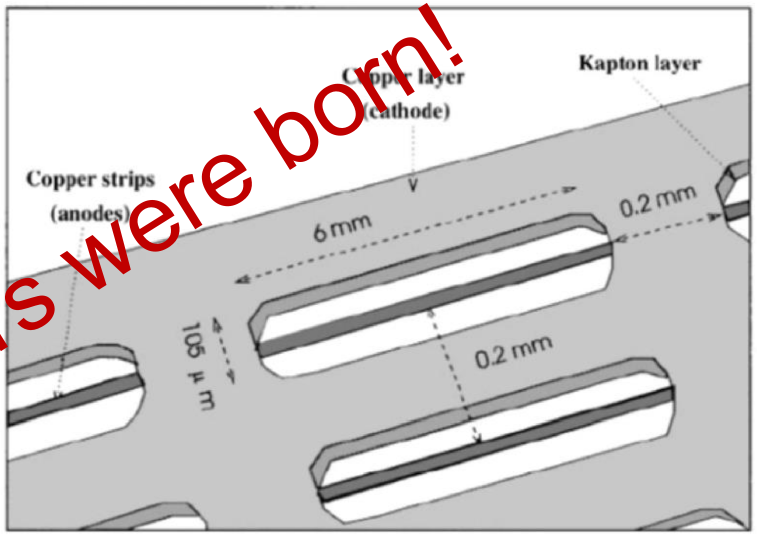
Fig. 1. Schematic diagram of a micro-groove detector with x, y read-out at 90°.



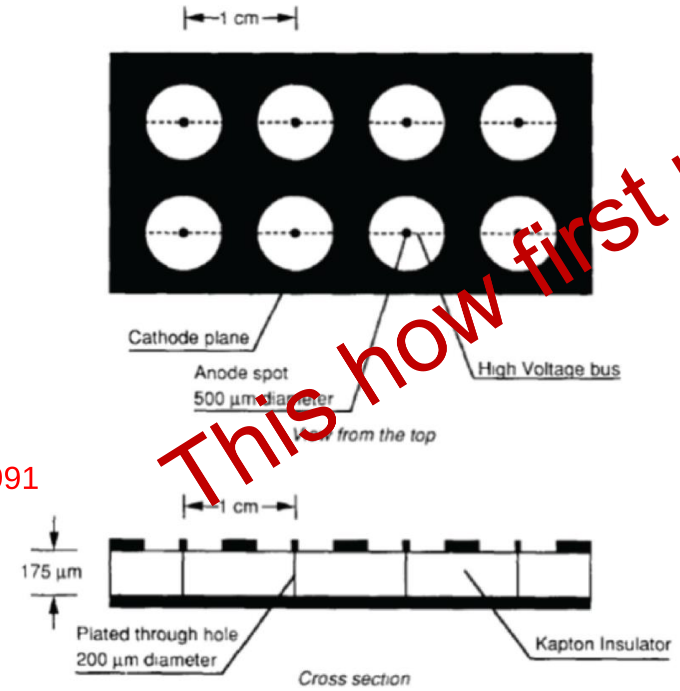
1999



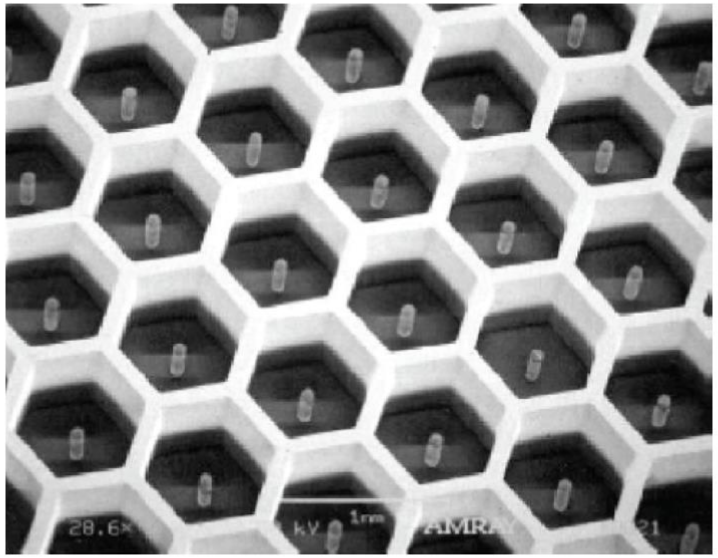
1999



1991

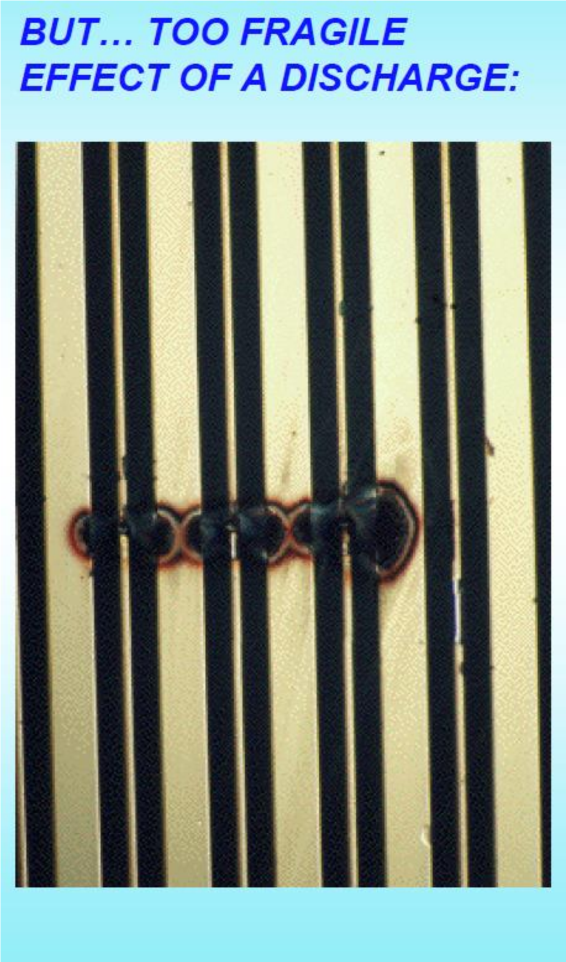


2000



This how first micropattern detectors were born!

Of course, there were some problems



For example:

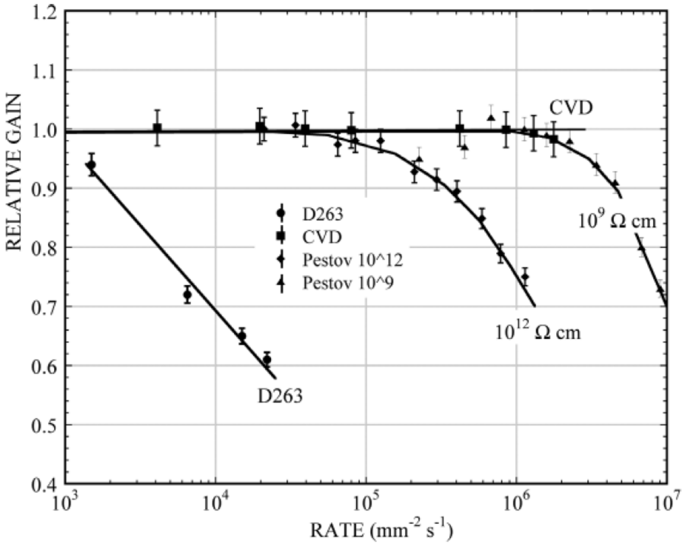
Aging,

Charging up effect,

Glass polarization,

Low spark resistance

Step-by step the RD28 community solved these problems



Charging up -Pestov glass

or other low resistivity materials

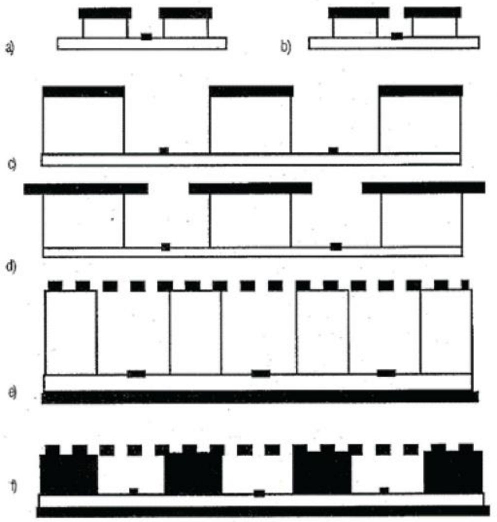
Aging- gas optimization

Sparking- preamlification in the drift

or 3D versions

<u>The greate success</u> : MSGC+GEM (empirical solution)

and application of this double-step device in Desy



Letter to the Editor

A MICROSTRIP AVALANCHE CHAMBER WITH TWO STAGES OF GAS AMPLIFICATION

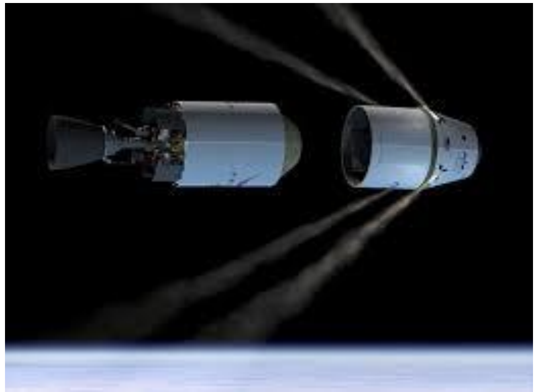
F. ANGELINI, R. BELLAZZINI, A. BREZ, M.M. MASSAI, G. SPANDRE and M.R. TORQUATI
Università degli Studi di Pisa and INFN Sezione di Pisa, Via Livornese 582/A, 56010 San Piero a Grado, Pisa, Italy

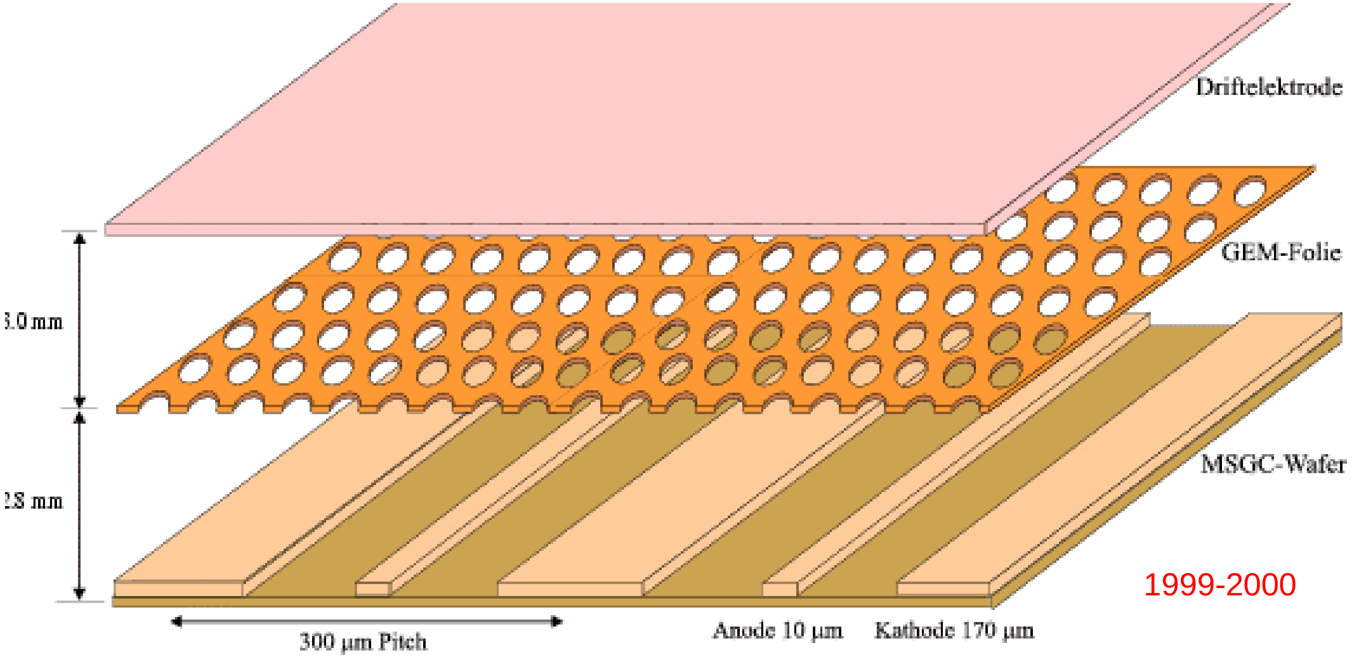
F. SAULI
CERN, Geneva, Switzerland

1990

Spark rate reduction with two stage devices

Herra-B detector layout:

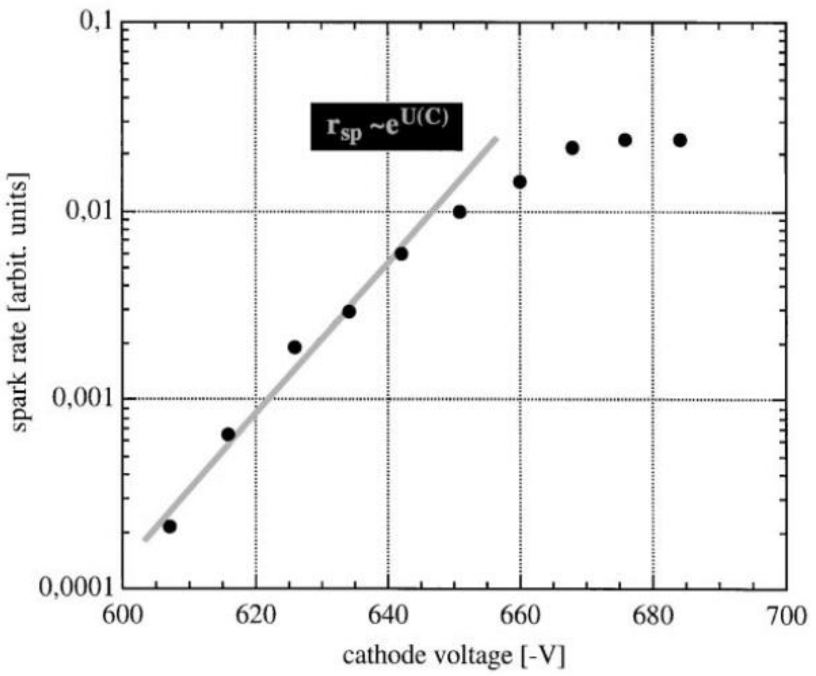




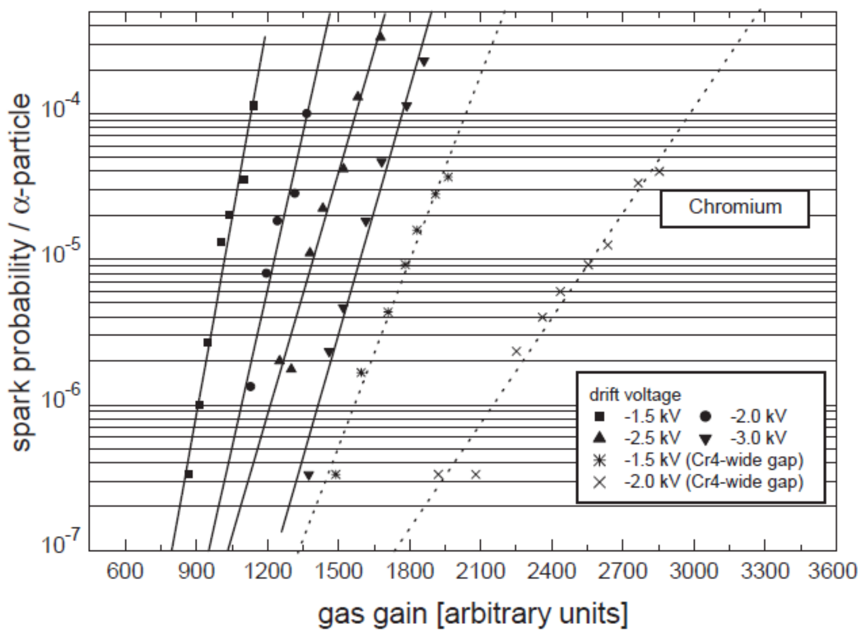
1999-2000

T. Zeuner , NIM A446,2000,324

Effect of a double step device on the spark probability reduction
(Herra-B results with **alpha particles**)



MSGC



MSGC+GEM

Other examples of two-stage devices

Letter to the Editor

A MICROSTRIP AVALANCHE CHAMBER WITH TWO STAGES OF GAS AMPLIFICATION

F. ANGELINI, R. BELLAZZINI, A. BREZ, M.M. MASSAI, G. SPANDRE and M.R. TORQUATI
Università degli Studi di Pisa and INFN Sezione di Pisa, Via Livornese 582/A, 56010 San Piero a Grado, Pisa, Italy

F. SAULI
CERN, Geneva, Switzerland

1990

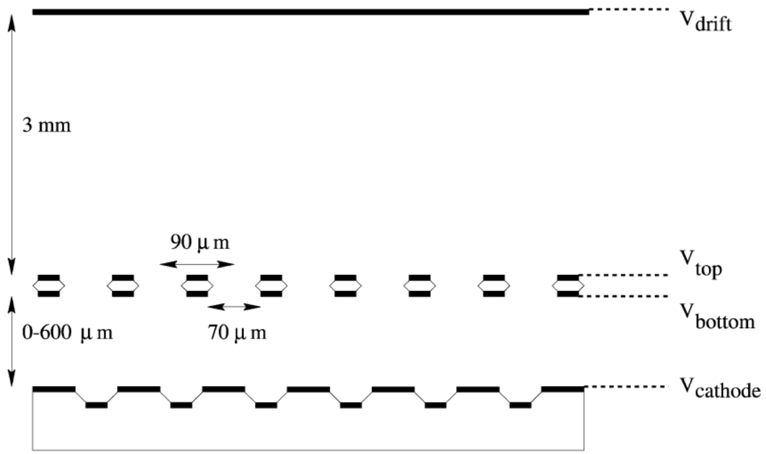


Fig. 1. Cross-section through an MGD tightly coupled to a pre-amplifying GEM.

ELSEVIER
Nuclear Instruments and Methods in Physics Research A 425 (1999) 218–227
IN PHYS
RESEAR
Section

A two-stage, high gain micro-strip detector

R. Bellazzini[a,c,*], M. Bozzo[b], A. Brez[a], G. Gariano[a], L. Latronico[b], N. Lu
M.M. Massai[a], A. Papanestis[a], R. Raffo[a], G. Spandre[a], M.A. Spezziga
[a]*INFN-Pisa and University of Pisa, Via Livornese 582/A, I-56010 S. Piero a Grado, Pisa, Italy*

Micro Strip Gas Chambers with Gas Electron Multipliers and their Application in the CMS Experiment

Von der Fakultät für Mathematik, Informatik und Naturwissenschaften der Rheinisch-Westfälischen Technischen Hochschule Aachen zur Erlangung des akademischen Grades eines Doktors der Naturwissenschaften genehmigte Dissertation

vorgelegt von

Diplom-Physiker Dirk Macke
aus Mönchengladbach

Berichter:

Universitätsprofessor Dr. rer. Nat. Günter Flügge
Privatdozent Dr. rer. Nat. Wolfgang Struczinski

Tag der mündlichen Prüfung: 16. Oktober 2000

Great disappointment: CMS rejected MSGCs due to the fear of sparks

Conclusion:… it tuned out that sparking is the main MSGC problem

However, if we analyse all data, it can be can conclude that :

sparking at a gain~ 10^4

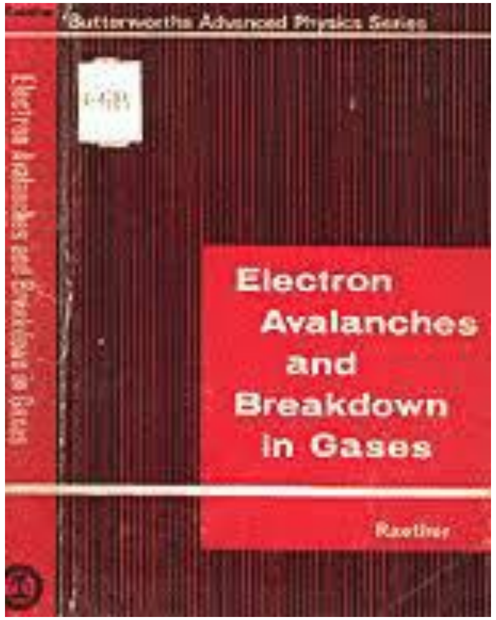
with ^{55}Fe was common for most of micropattern detector developed at that time

Why is it like this?

The puzzle was solved in:

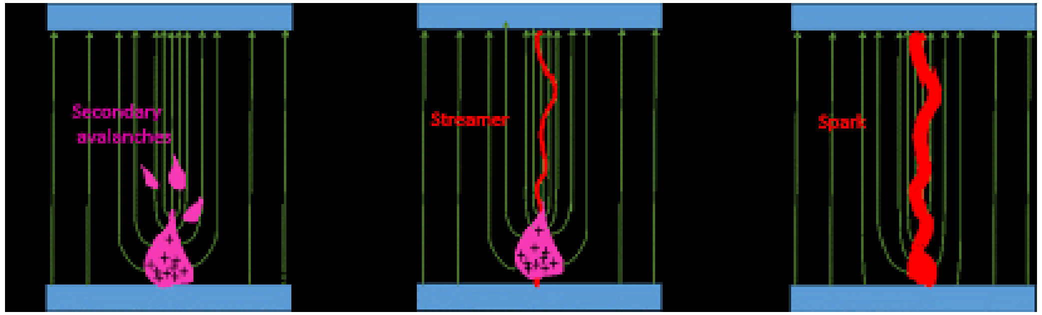
P. Fonte et al., IEEE Trans Nucl. Sci.

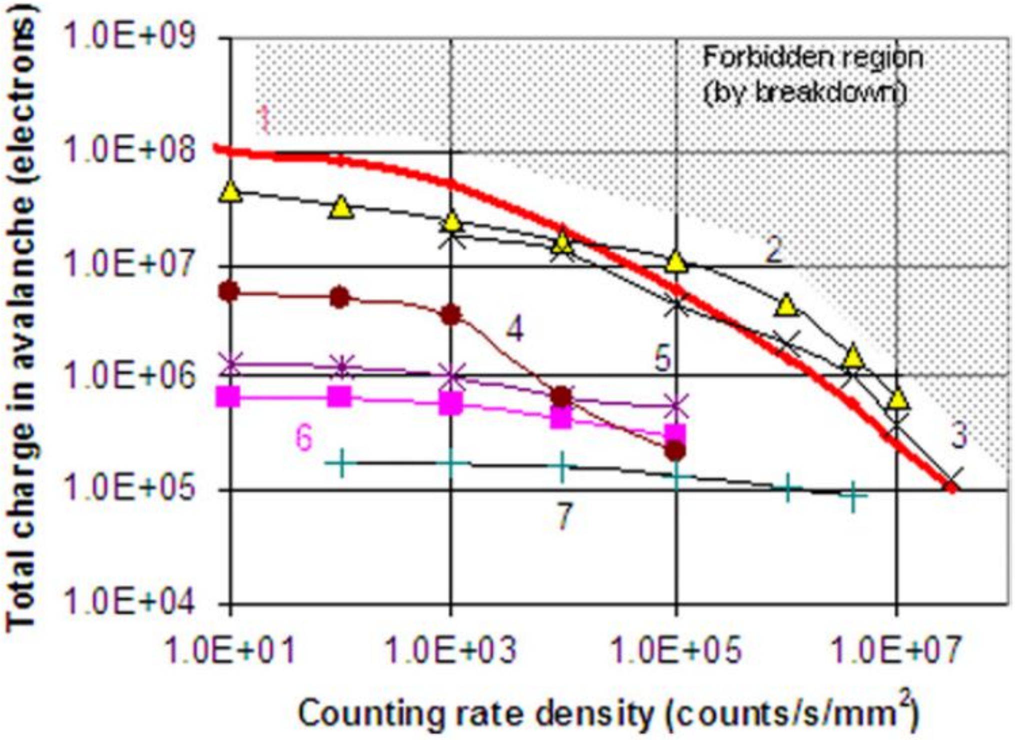
46,1999,321



The sparks appear when the Raether limit is reached $An_0=Q_{crit}$ (the value of which depends on several parameters such as gas, geometry etc., and typically is10^6-10^7 electrons)

As can be seen, the lowest gain can be achieved with alphas (n_0~10^5)





.. therefore, <u>sparking was not a specific problem of the MSGC,</u>
but rather a problem **common** for most of
micropattern detectors

Figure 4. The maximum achievable gain, limited by breakdown, as a function of the x-ray flux for various detectors: (1) PPAC with 3 mm gap; (2) MICROMEGAS; (3) PPAC with 0.6 mm gap; (4) microstrip gas chamber with 1 mm strip pitch; (5) microstrip gas chamber with 0.2 mm strip pitch; (6) GEM; (7) microgap detectors with 0.2 mm strip pitch. Large counting rate densities require a reduction in the gas gain to prevent breakdown. See [52–55] and references therein for the original data and details. All data were converted to total avalanche charge.

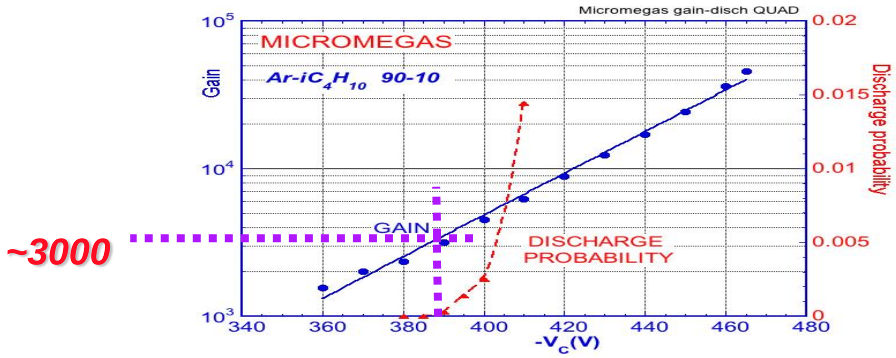
MEASURE GAIN WITH ^{55}Fe X-RAYS AND DISCHARGE PROBABILITY WITH INTERNAL ALPHA SOURCE FROM ^{220}Rn

MPGD CERTIFICATION

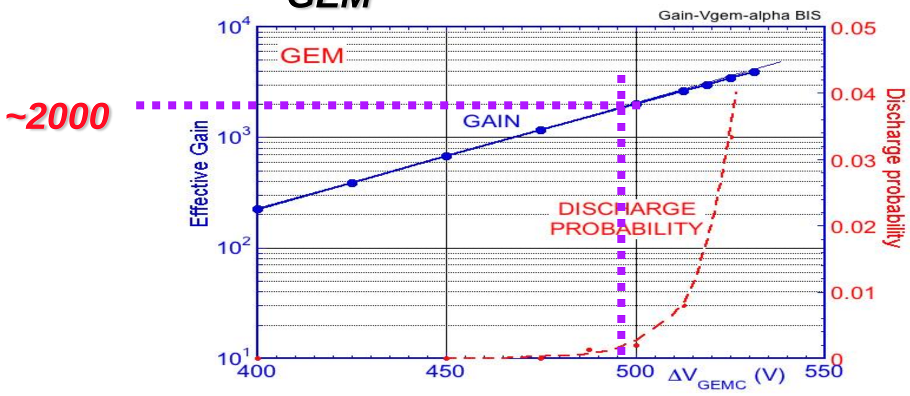
The maximum gain before discharge is almost the same for all MPGD tested:

DETECTOR	MAX GAIN	MAX CHARGE
MSGC	2000	4 10^7
ADV PASS MSGC	1000	2 10^7
MICROWELL	2200	4.4 10^7
MICROMEGAS	3000	6 10^7
GEM	2000	4 10^7

MICROMEGAS



GEM



S. Bachmann et al, Nucl. Instr. and Meth. A479(2002)294

F. Sauli, Report at the RD51 collaboration meeting in Amsterdam, 2008

To conclude this part (the “Past”):

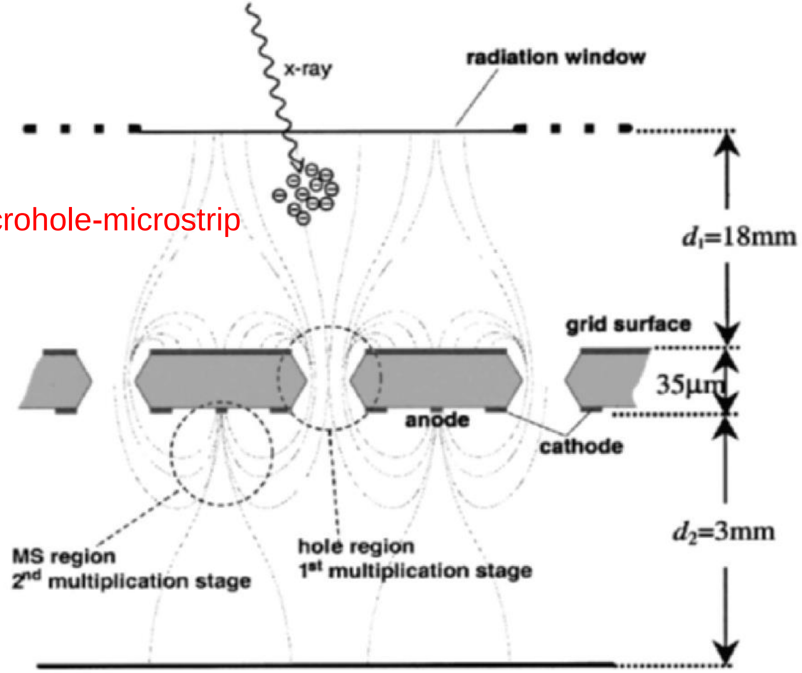
MSGCs in a multistep configuration could operate reliably,
However, new players came: GEM and MICROMEGAS -
and the interest to the MSGCs starts gradually diminishing

Where are we today?

II. Present

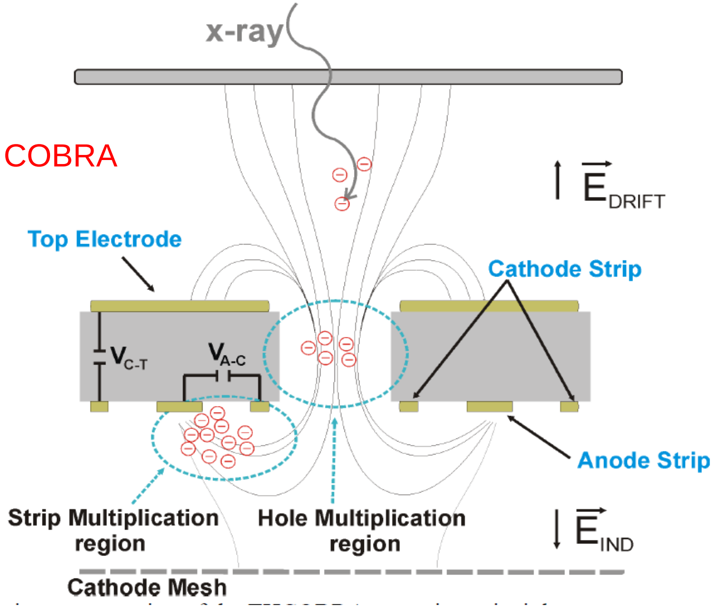
1. Hybrid detector: Strip and holes (applications: photodetectors, TPC, cryogenics)
2. Spark –protected resistive MSGC
3. Development MSGC for avalanche multiplication in noble liquids

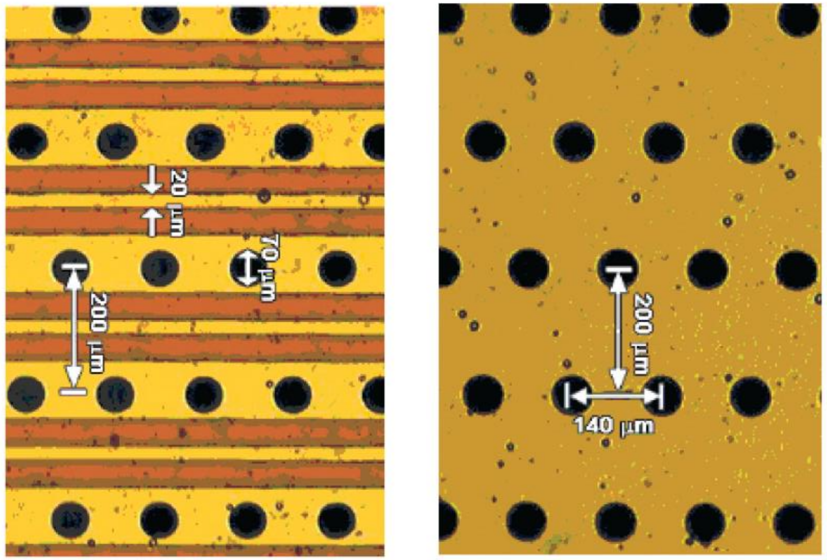
Microhole-microstrip

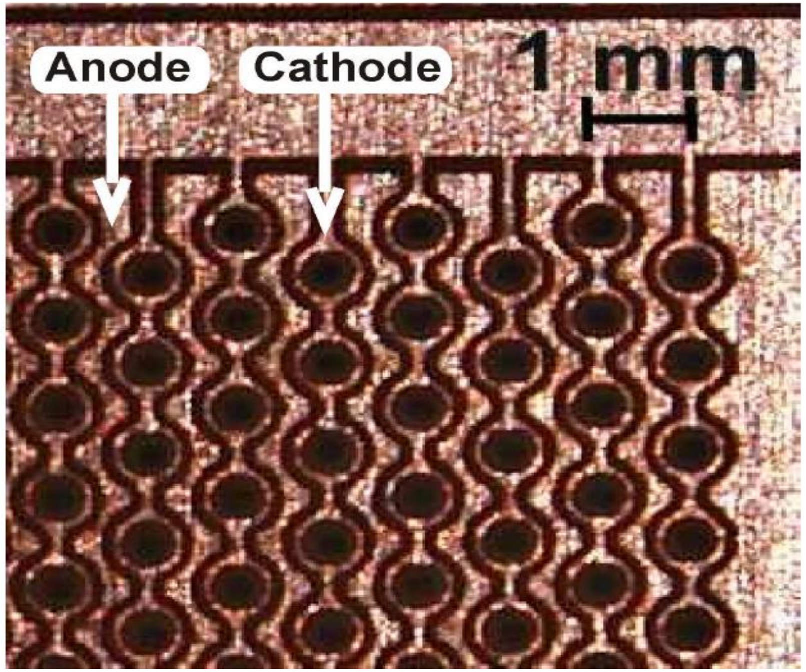


NIM A: 504:1-3 (2003) 364-368

COBRA

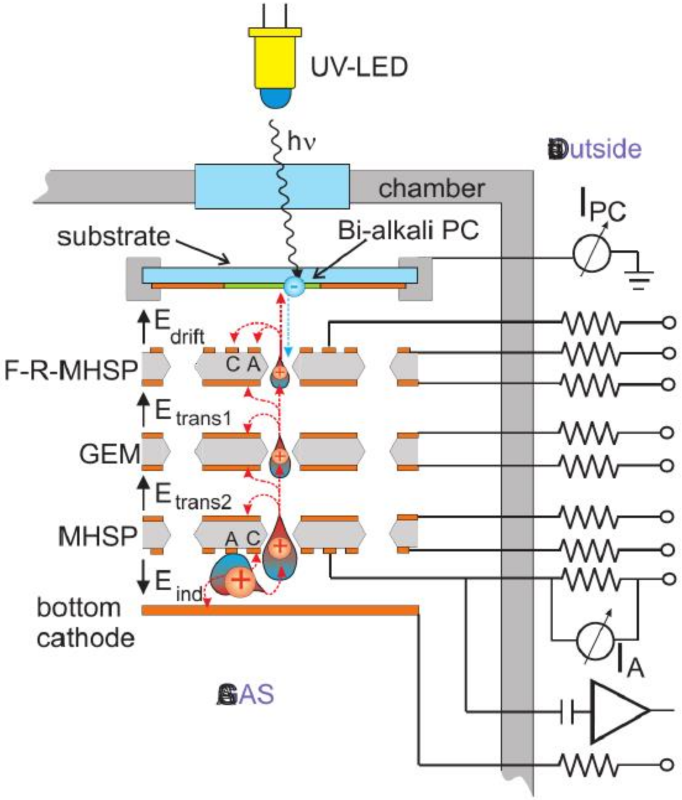


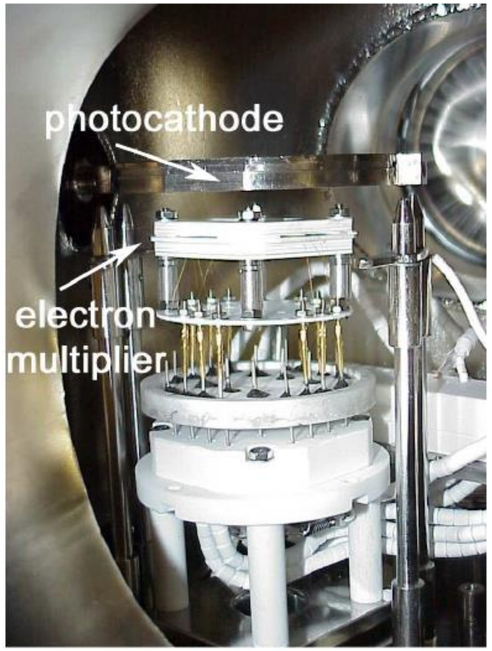


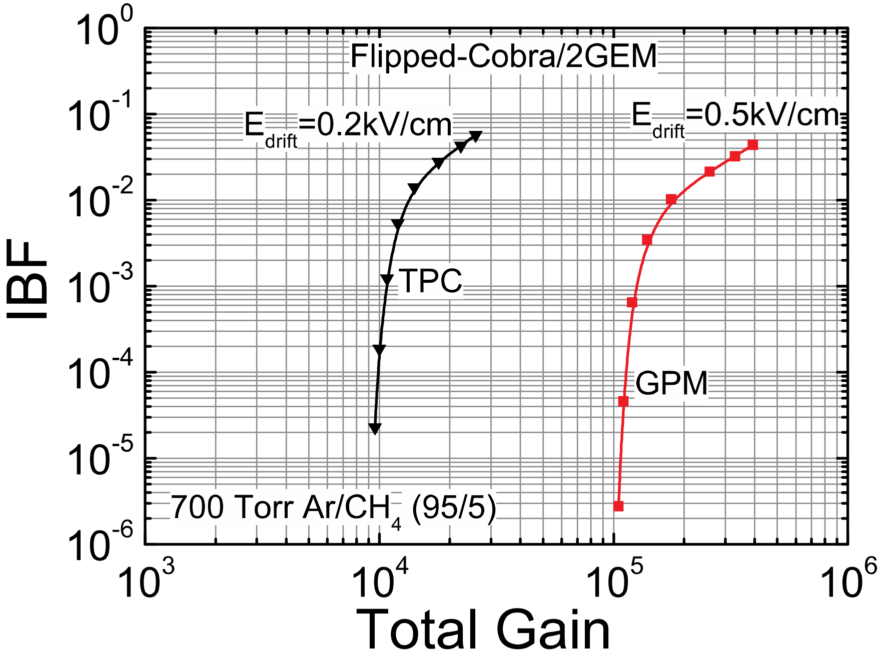


Visible sensitive GPMs

- First successful operation (no voltage gating)



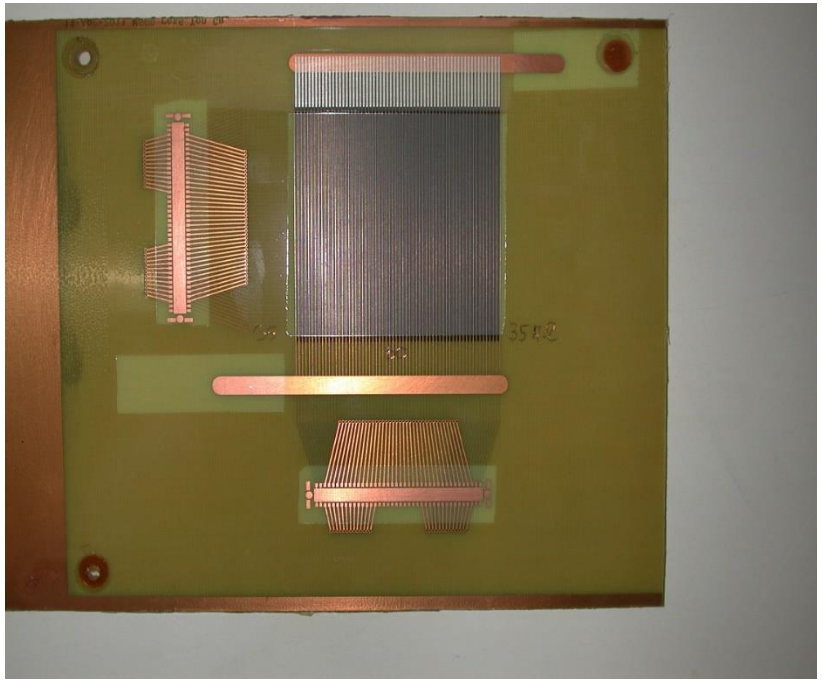


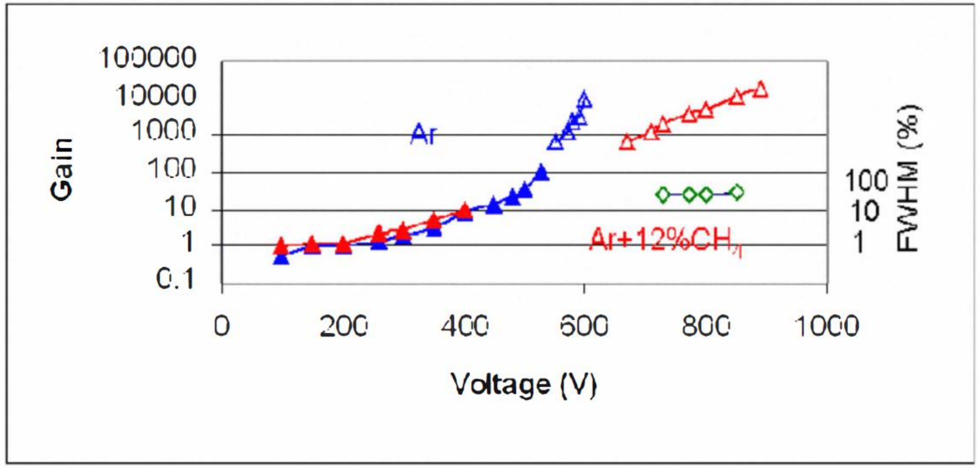


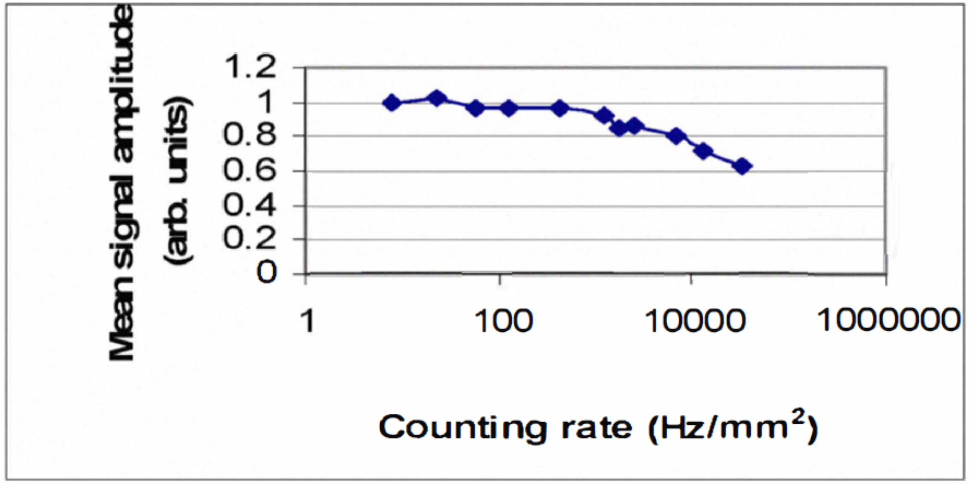
Lyashenko et al., JINTS 4(2009)P07005

Problem-to produce with a large area

MSGC with resistive electrodes

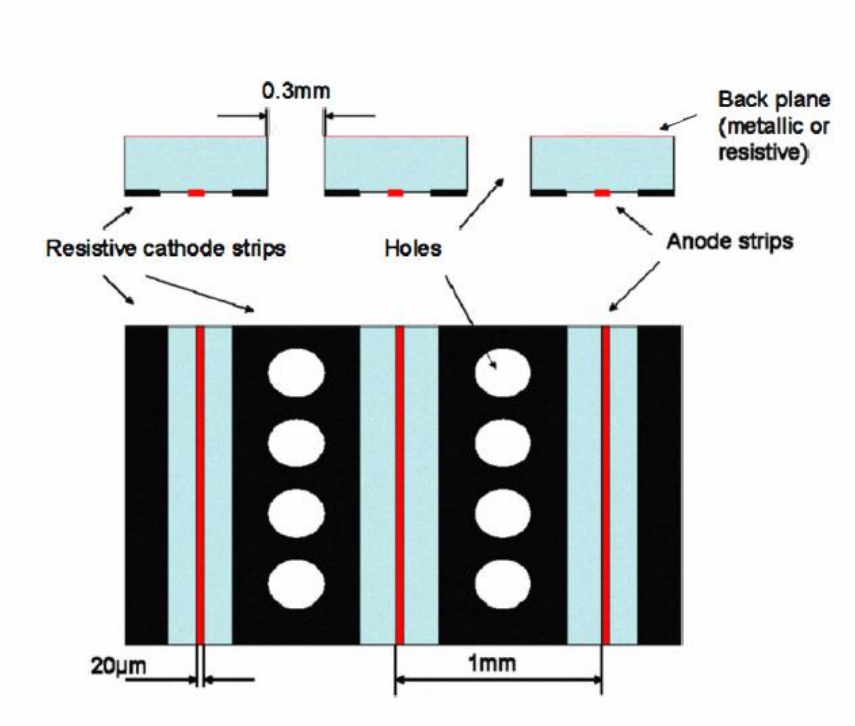


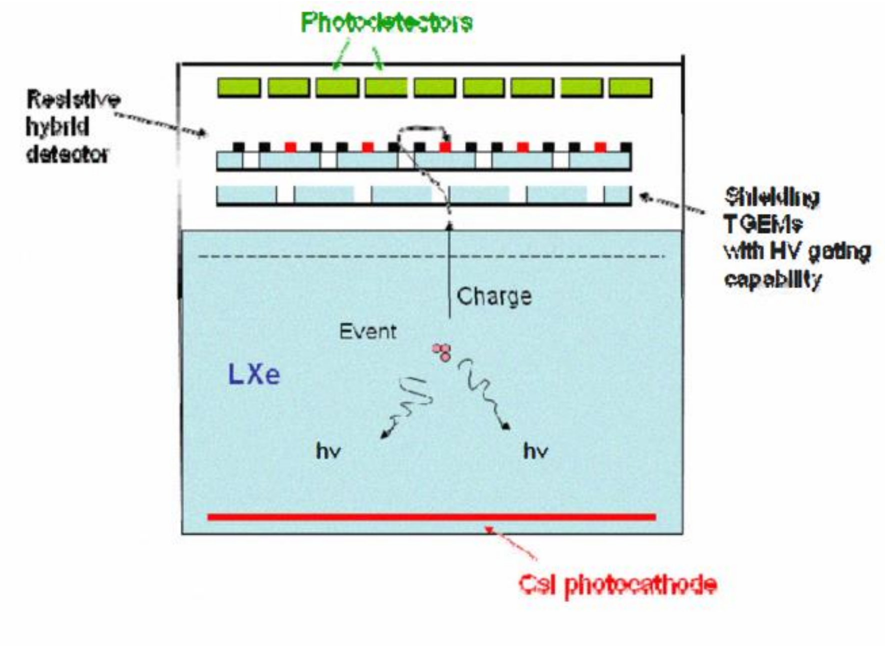




Withstands sparks, can be produced with a large effective area, easy to clean

Resistive "microstrip-microhole R-MSGC
(for a dual-phase cryogenic TPC)





In hybrid R-MSGC, the amplification region will be geometrically shielded from the CsI photocathode (or from the doped LXe) and accordingly the feedback will be reduced

Decendnce of decendnce:

kind of “Bellazini microwell” detector, but spark-protected:
with with resistive electrodes

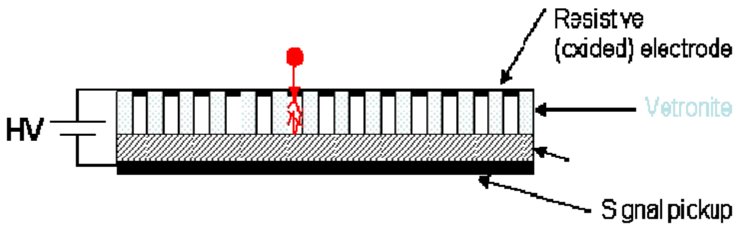
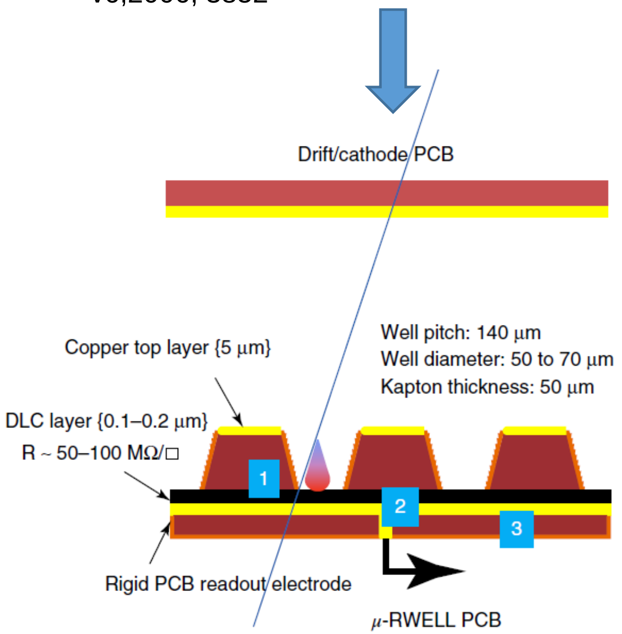
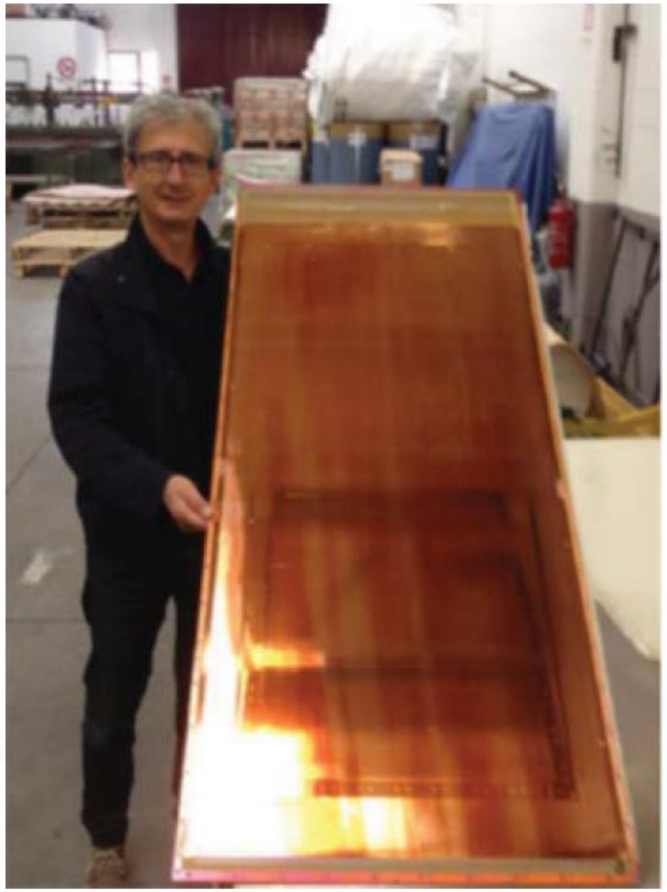


Fig. 21. A schematic drawing of the RETGEM the top electrode of which was coated by a CuO layer and the bottom electrode (the anode) was a thick high resistivity plate.

A.   Di Mauro et al, IEEE Nucl. Sci. Conf Rec. v6,2006, 3852



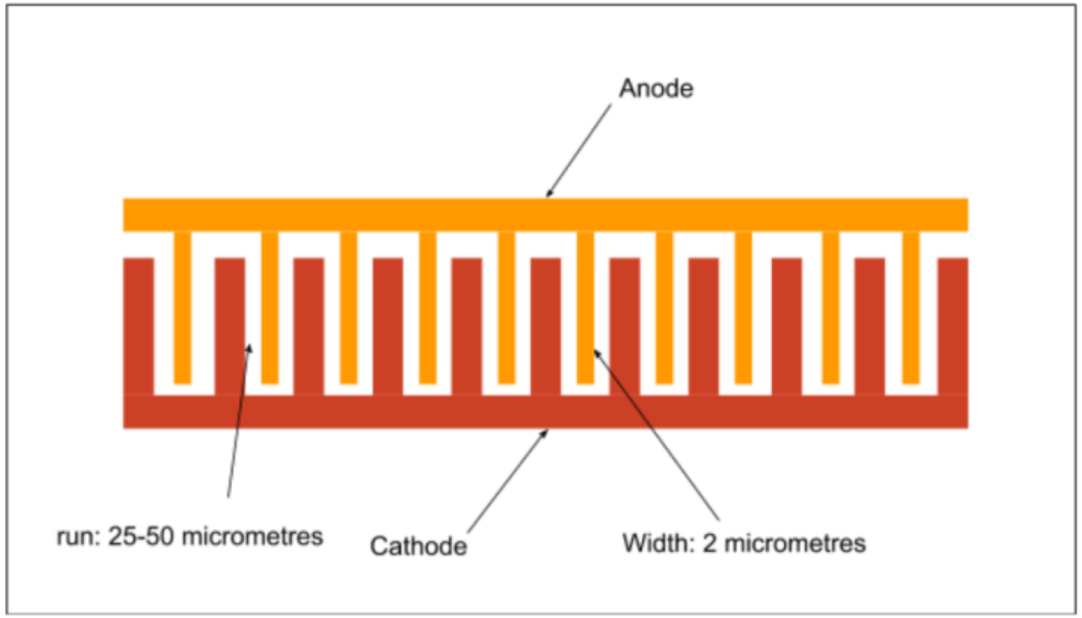


MSGC detectors for multiplication in noble liquids

New technological possibilities may give the second life to strip detectors, for example, as

a multiplication structure in noble liquids

(Current Neutrino Platform R&D)



III. Possible Nearest Future

⇓ ?

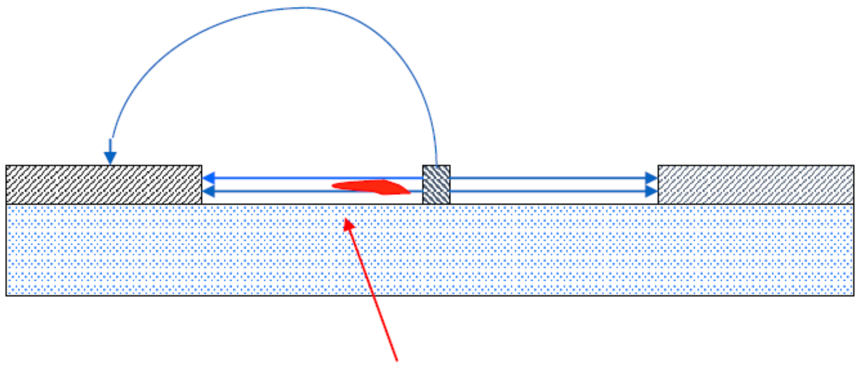
RD51 DISCO initiative

One of the problems in the past was that MSGC is almost a 2D amplification stricture

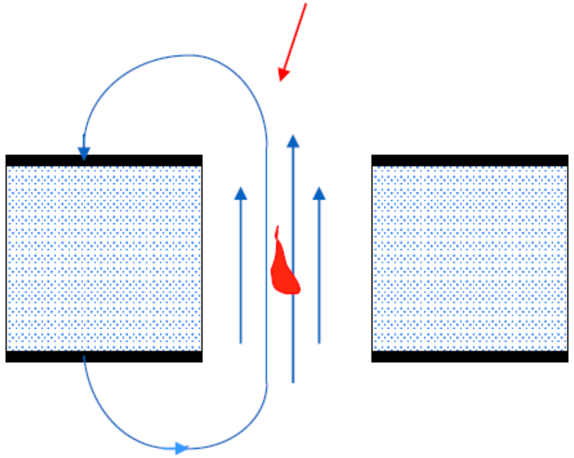
A new approach: to explore a 3D strip-type multiplication structure with a radial electric field

(with or even without resistive electrodes)

A feature of streamers:
if a streamer starts in an electric field with parallel field lines, it is difficult to stop it

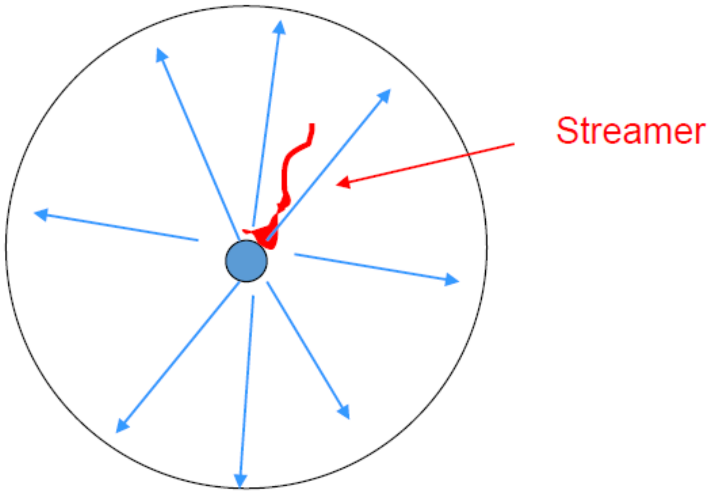


Regions with parallel fields lines where any streamer, if appear, is unquenched and may reach the cathode



In contrast:
in a radial field streamers could be self-quenched

Self-quenched streamer

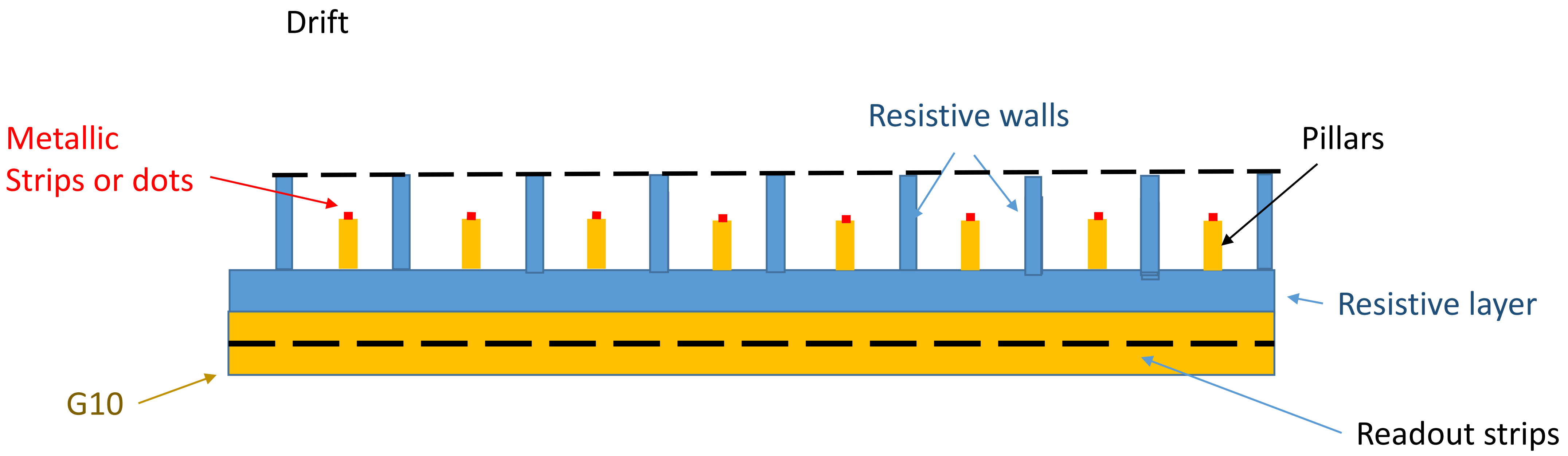


Streamers cannot propagate to the cathode because the electric field drops as 1/r

Spark-less hybrid MPGD strip or dots type

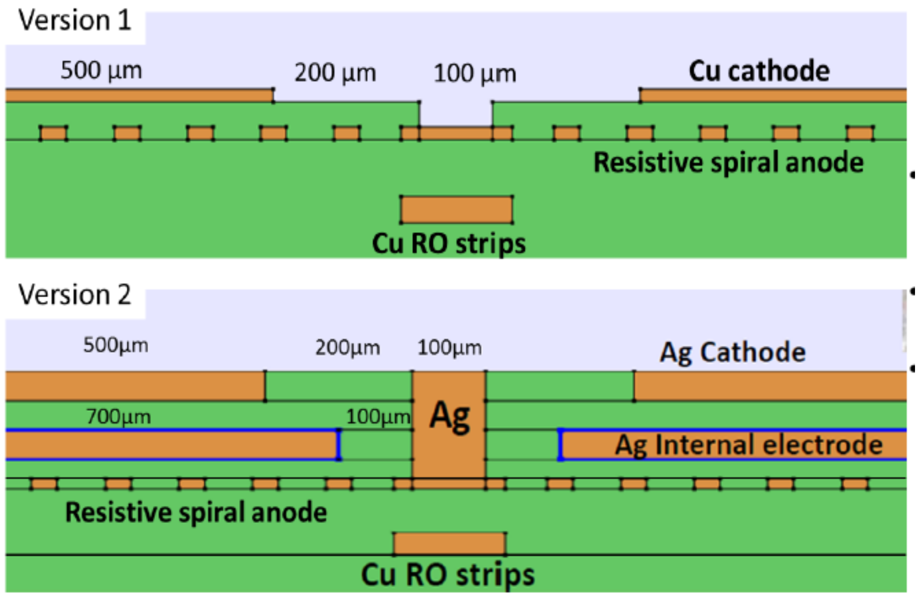
(could be easier to build)

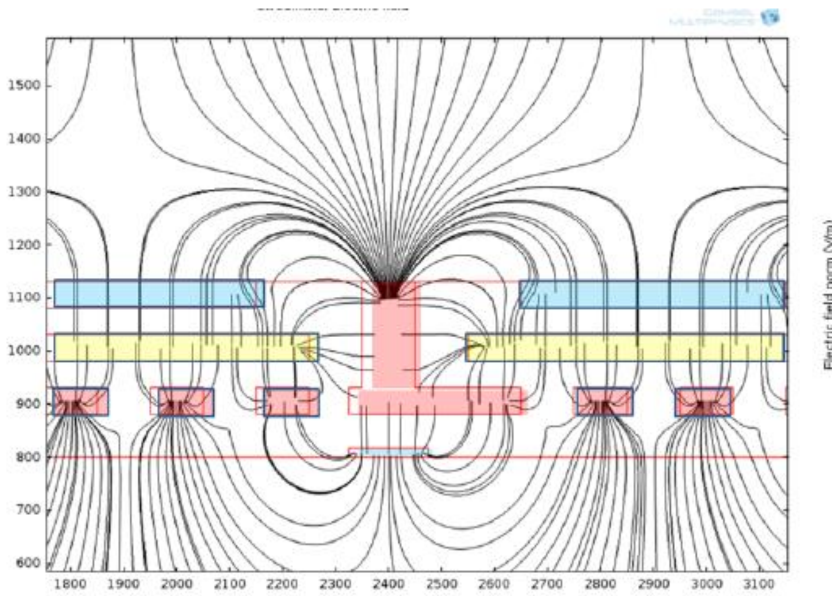
Side view



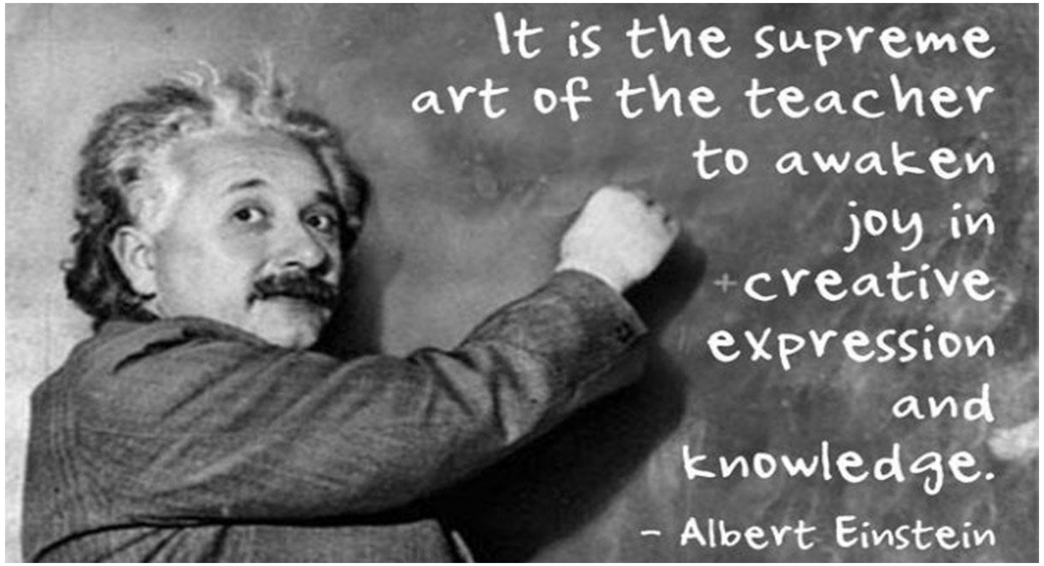
A large scale prototype was already tested: *V. Peskov et al., IEEE Nucl . Sci., 45,1998,244*

An interesting supporting approach: field shaping by inner strips





V. Cairo et al, JINST 9 C11022, 2014



Conclusions

A.Oed initiated a new direction in gaseous detectors developments-tiny amplification structures manufactured by a microelectronics technology

This is, in fact, how **micropattern detectors** were born, which are still in rapid progress, culminating with MICROMEGAS and GEM

However, the original strip–based designs, enriched with new ideas, continue to leave!

Thank you, Anton!

Backup