M. Chefdeville
4th RD51 collaboration meeting
Nov. 2009, CERN

SUMMARY OF WG2 SESSION

Outline

- Review on gaseous photo-multipliers
- Photoelectron extraction/collection efficiency of CsI coated TGEMs
- Recent measurements of TGEM
- Spark study with Bulk Micromegas
- Status of GEM tracker for SBS spectrometer
- GridPix
  - GOSSIP test beam results
  - Application for X-ray polarimetry and Dark Matter search experiment

Review on gaseous PMs by Peskov

Development of large- area gaseous photomultipliers

- Is it realistic to make them?
- The aim of "Peskov" talk is to review what was done in this direction in order to answer this question

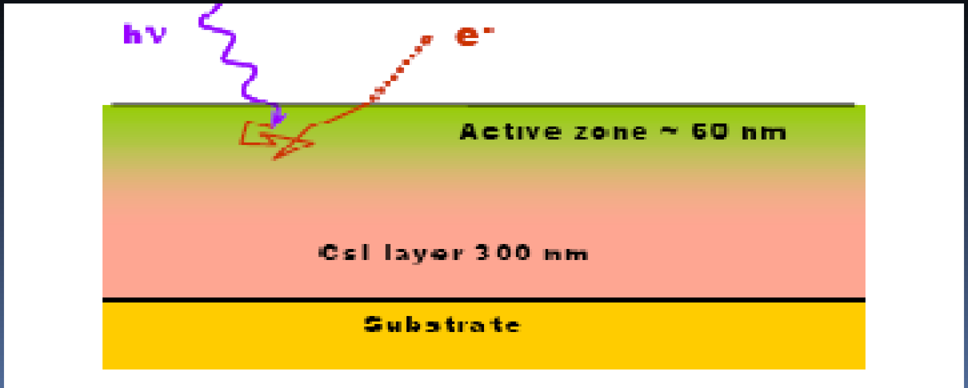
Short historical review

- First photo-sensitive MWPC in 1977
  - Photosensitive MWPC for **RICH applications** (benzene vapors, λ<135nm) and **plasma applications** (toluene vapors , λ<146nm)
  - Solid photocathodes (CuI, Cs-based photocathodes) with sensitivity to UV and visible light

- The greatest success was achieved with **CsI** photocathodes
  - **high quantum efficiency, tolerate a short contact with air, have potential for high time resolution**

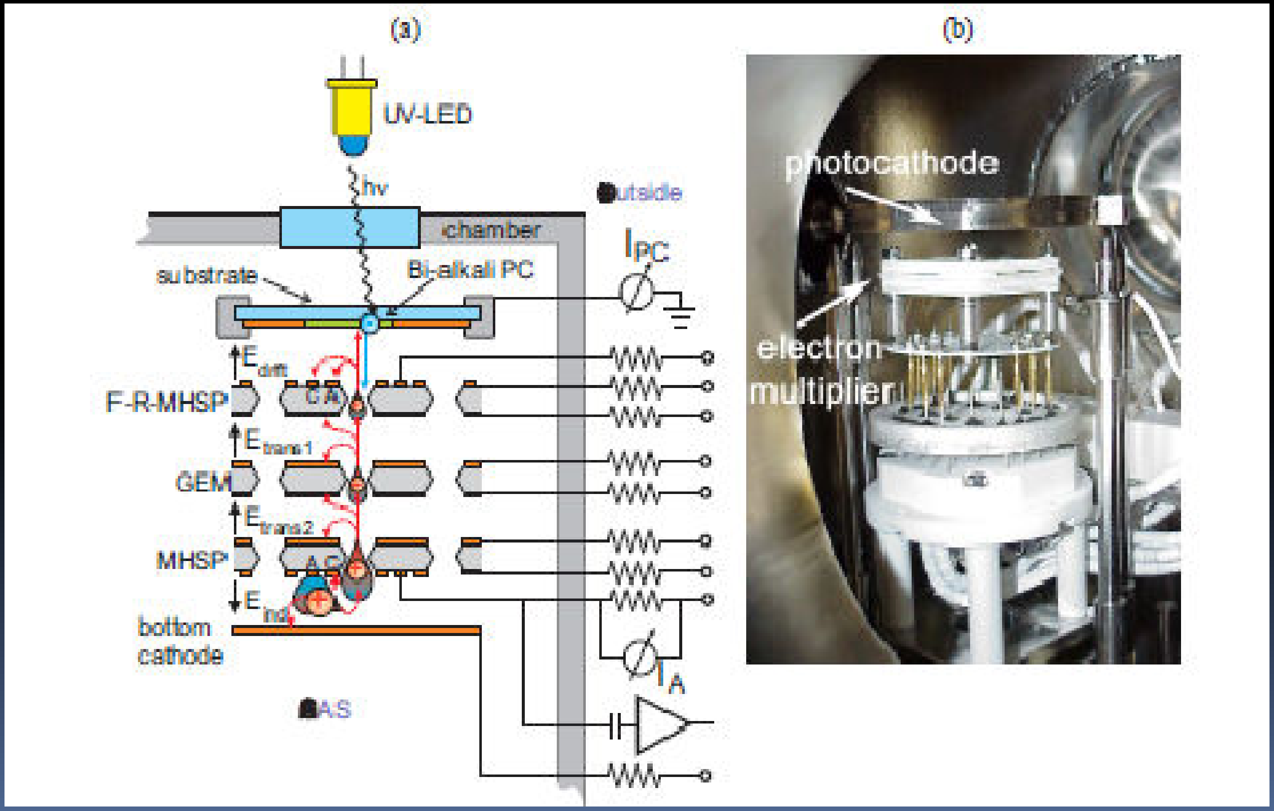
- **Now several experiments have CsI RICH: ALICE, HADES, COMPASS, STAR and others**

- Latest tendency : MPGD with CsI photocathode (photon/ion feedback suppression)



MPGD with photocathode

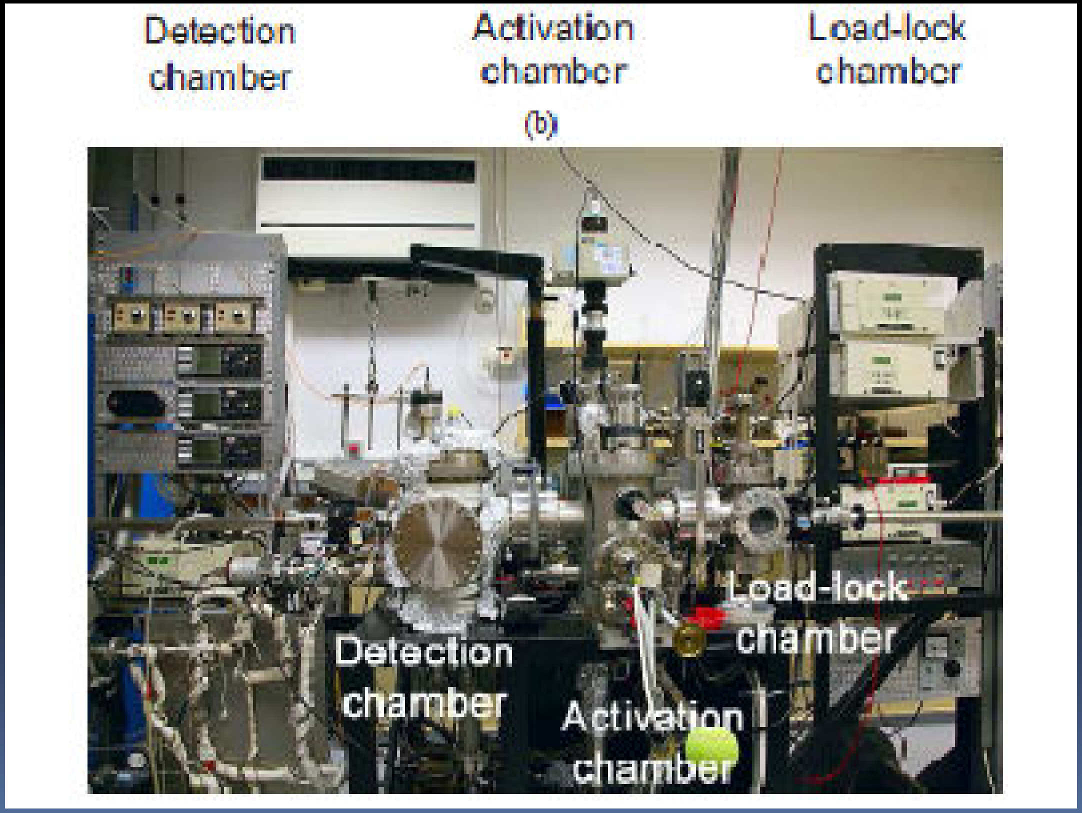
- Several detectors developed
  - Triple GEM, TGEM, MCP, double Micromegas, MHSP…



A. Lyashenko et al., JINST 4 P07005, 2009

MPGD with photocathode

- Fabrication setup complicated and expensive
  - *e.g. setup in Weizmann Institute of Science*

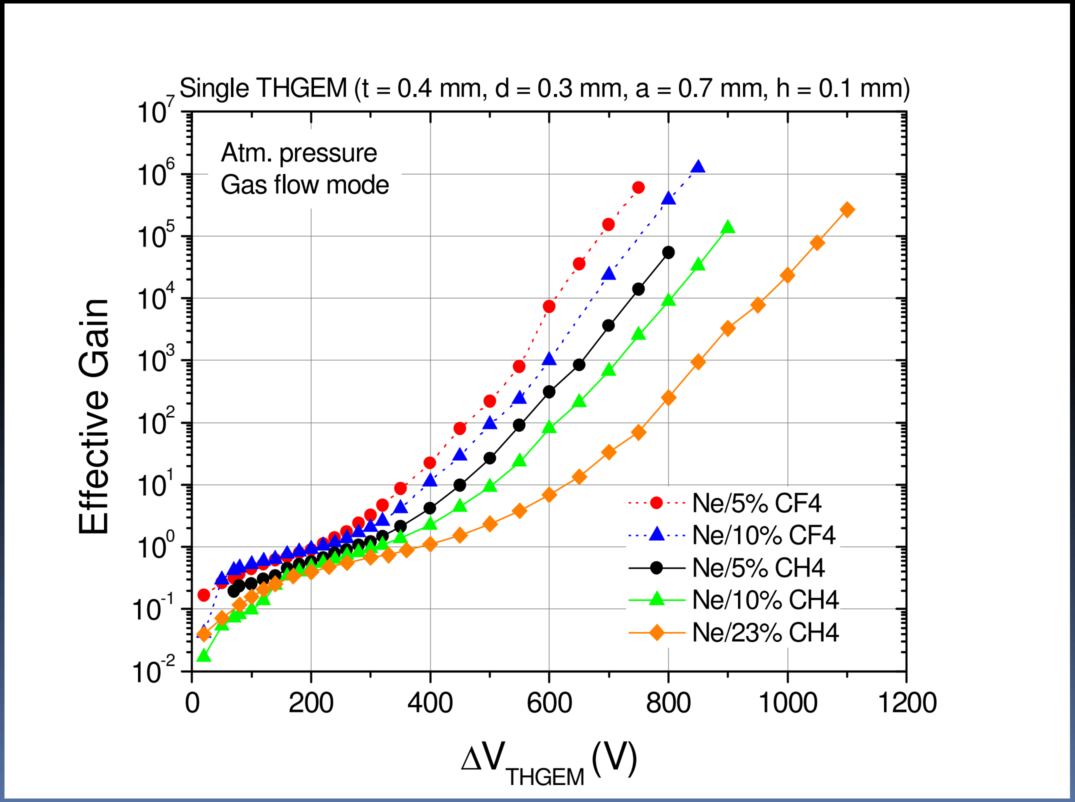


Conclusions

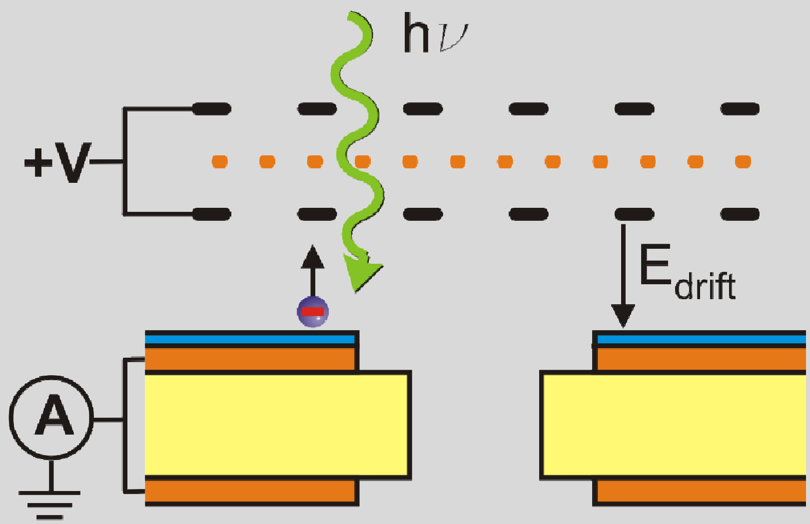
- Fabrication setup complicated and expensive
  - *e.g. setup in Weizmann Institute*
- Experience of several groups show that gaseous PMs based on MPGDs and sensitive to visible light can be done, although it is not an easy task
- Development PMs based on MPGD could be an excellent RD51 scientific and technological project
- A. Braem Lab has all know-how and all necessary equipment, so CERN could be the best place to implement this project
- What is needed to implement this project: some more funds and a few enthusiasts ready to work full time on this project

Characterization of TGEM with CsI photocathode

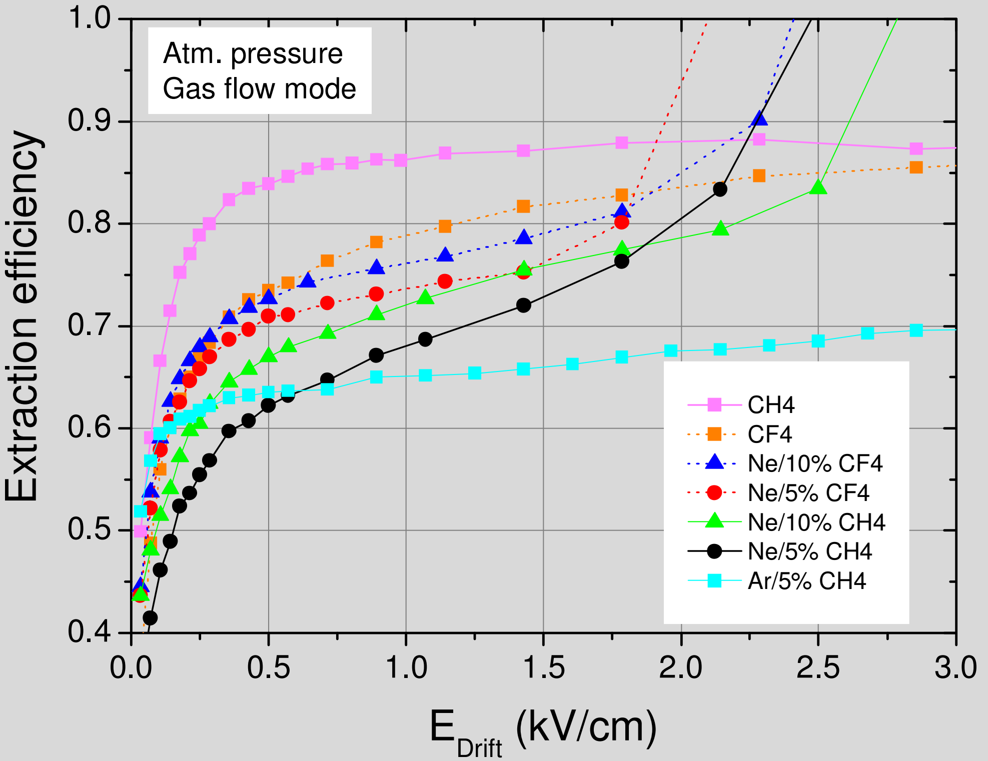
- University of Aveiro, Coimbra, Weizmann Institute
- Measurements of gas gain, photoelectron extraction and collection efficiency in Ne based mixtures



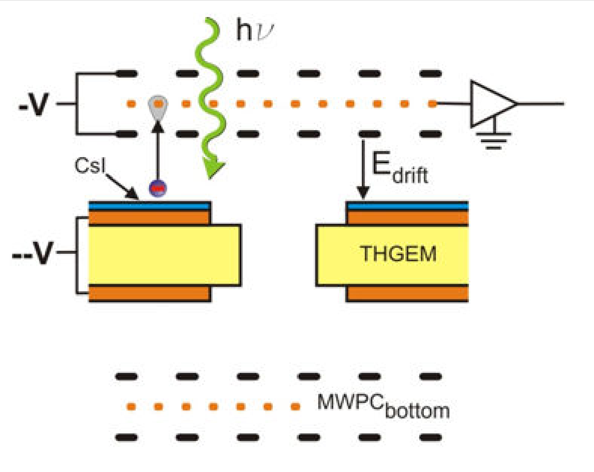
Extraction efficiency

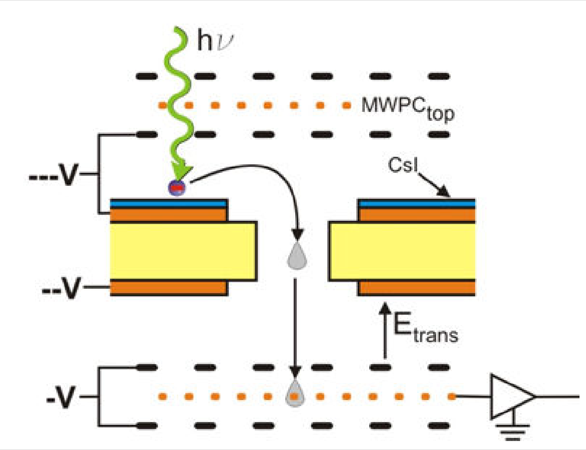


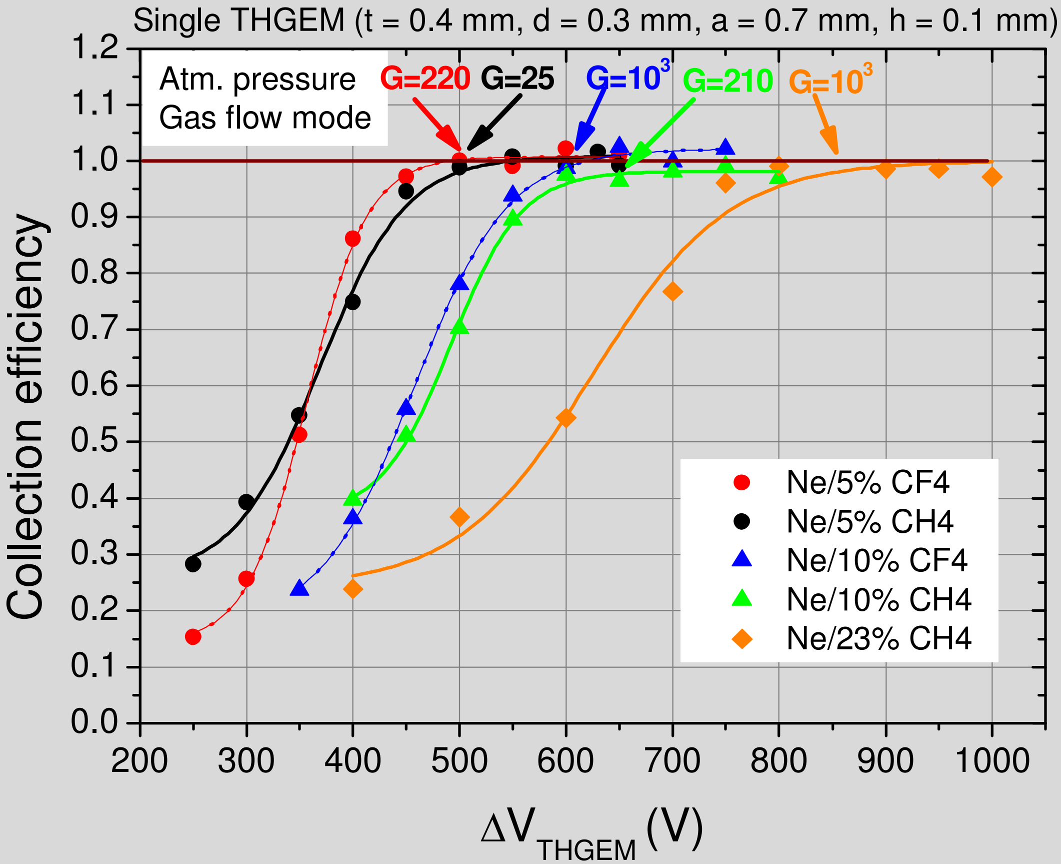
$$\varepsilon_{extr} = \frac{I_{gas}}{I_{vac}}$$



Collection efficiency

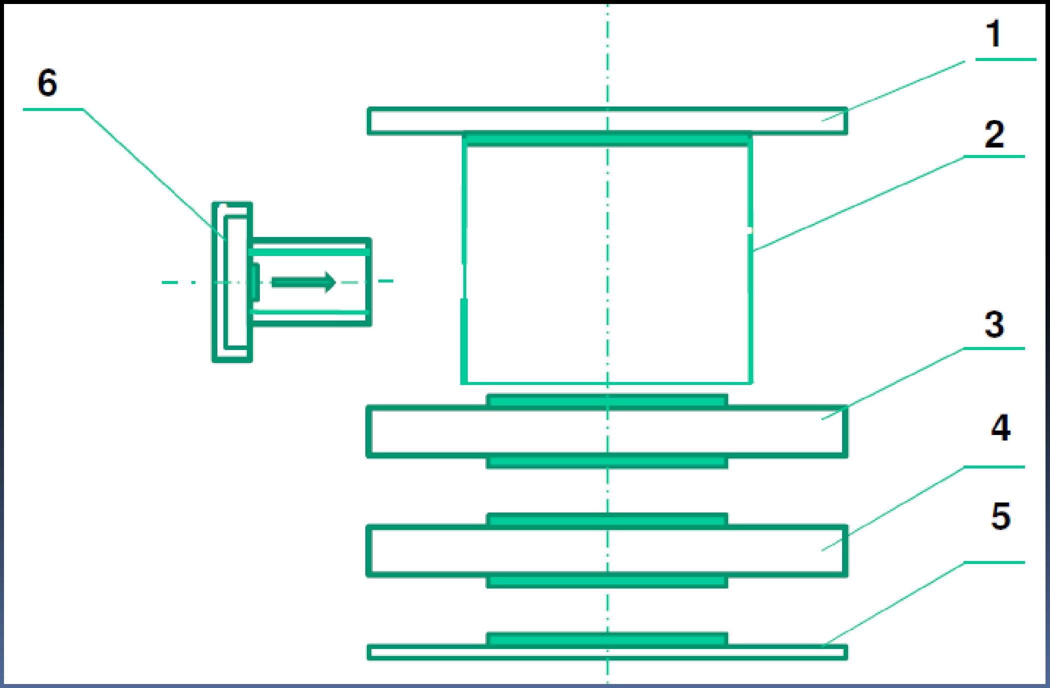






Test of TGEM in INR, Moscow

- Development of single, double TGEM, RETGEM, Wire GEM
  - Application for the ALICE RICH upgrade (FARICH)
- Gain measurements, electric field simulation
  - Alpha and beta sources



1. Drift electrode
2. Field masking cylinder
3. TGEM1
4. TGEM2
5. Collector
6. β-source

Studies with double TGEMs

Efield/e- drift simulation

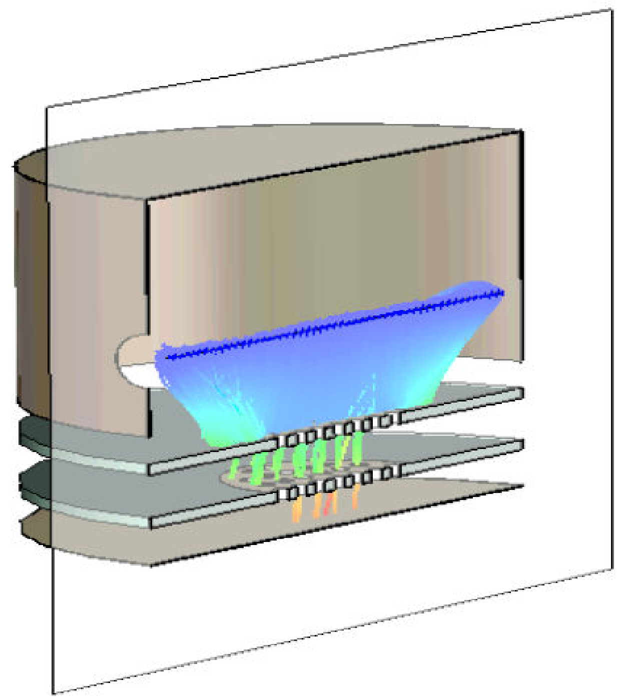
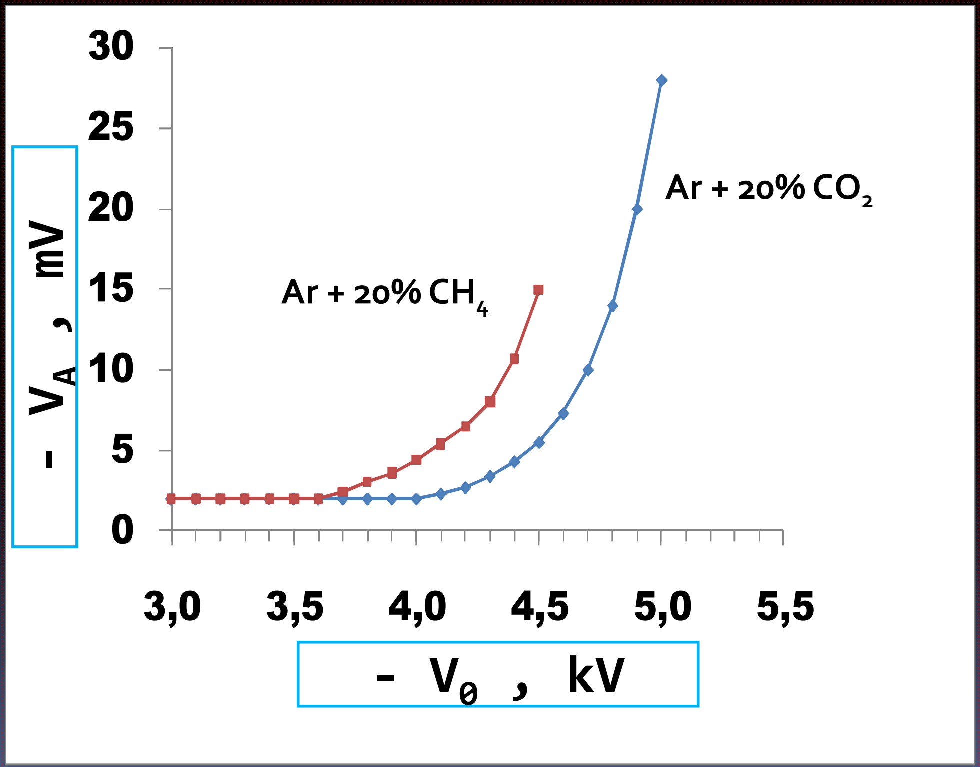


Fig.6 Charged avalanche with “field-masking cylinder”

Gas gain measurements



RETGEM and WireGEM

RETGEM with a graphite coating and PVC electrodes

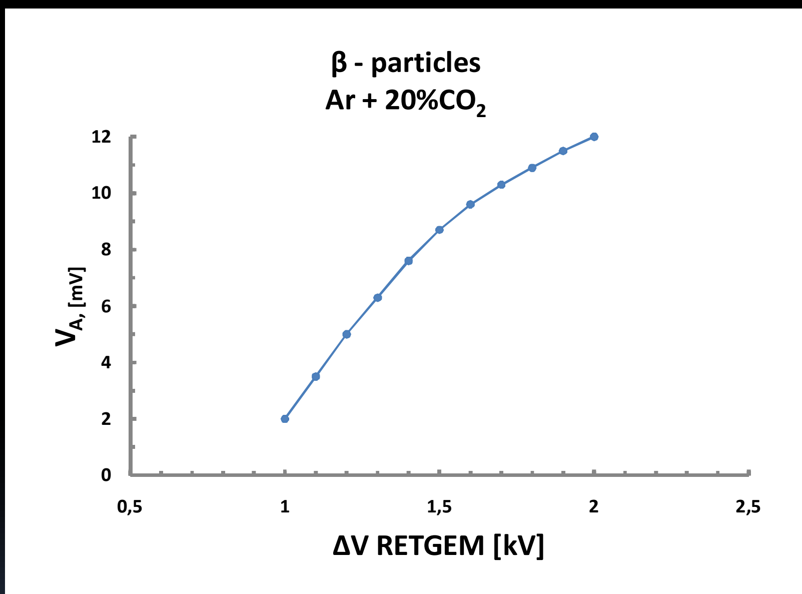
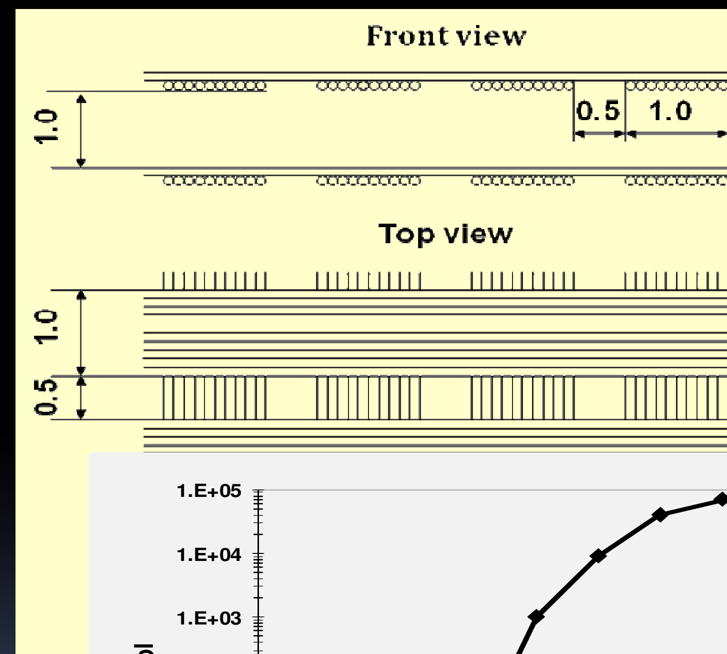
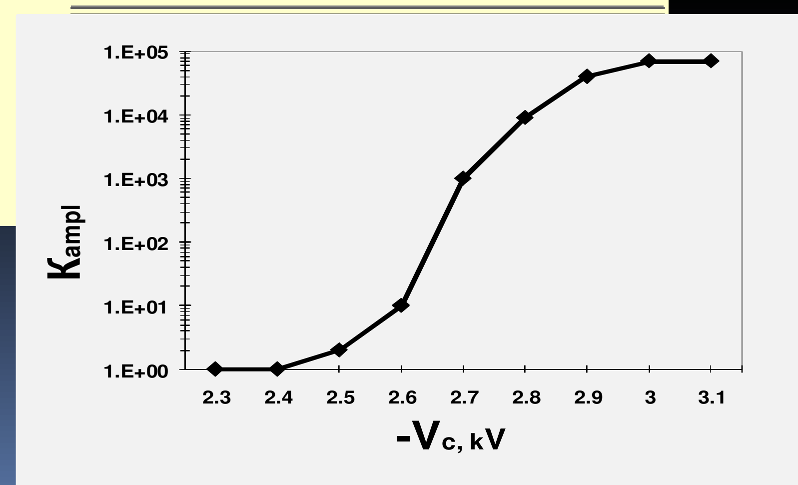


Fig.10 The amplitude of the signal v.s. voltage as a Fig.5 using β-source with I = 10^3 particles/s.

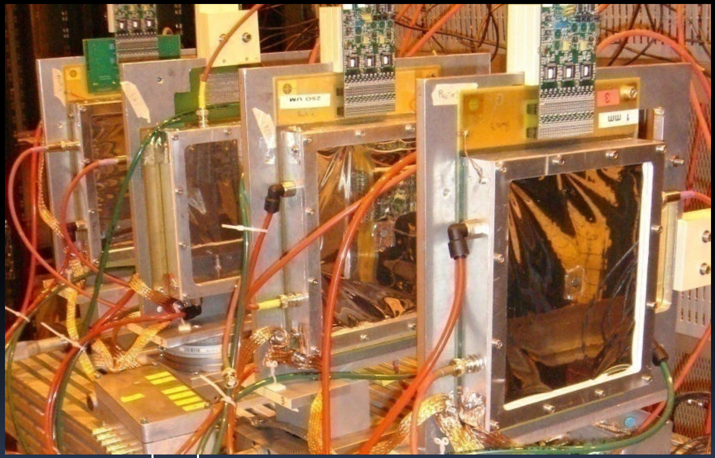
Wire GEM

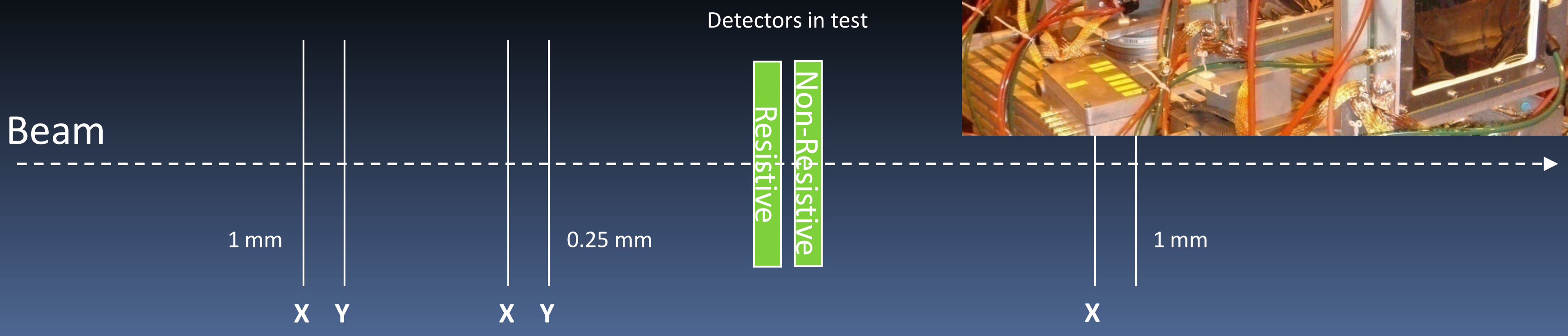




High intensity beam studies of sparks in resistively-coated and standard Micromegas detectors

- Saclay/Irfu group within MAMMA collaboration,
  13-19 Nov 2009 , 120 GeV/c pion beam at CERN/SPS
- Test different resistive films detectors manufactured by Rui De Oliveira at CERN and compare behaviour to non-resistive detectors
- Gas: 95%Ar + 3% CF_4 + 2% isobutane





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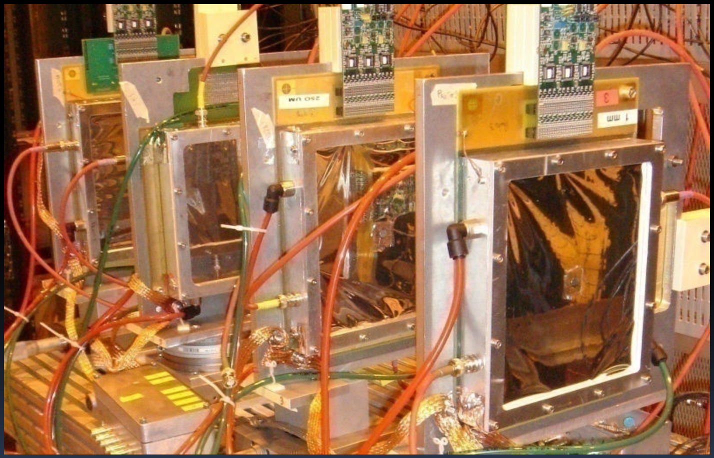


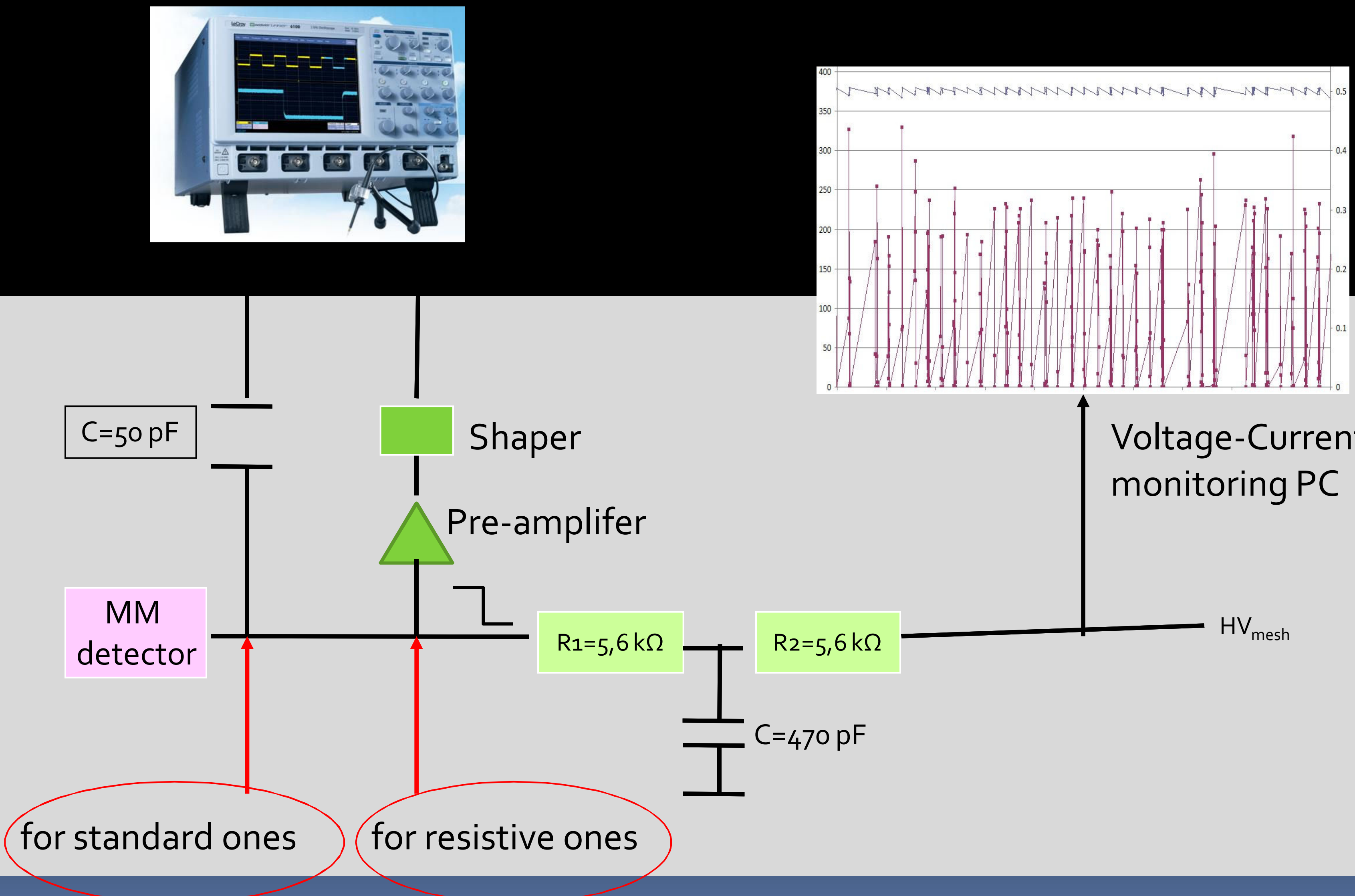
Tested detectors:

Standard bulk detectors

2 M Ω/sq.	Resistive kapton: R3&R4
250 M Ω/sq.	Resistive paste: R5
400K Ω/SQ.	Resistive strips: R6
Few tens of k Ω/sq.	Resistive pads: R7

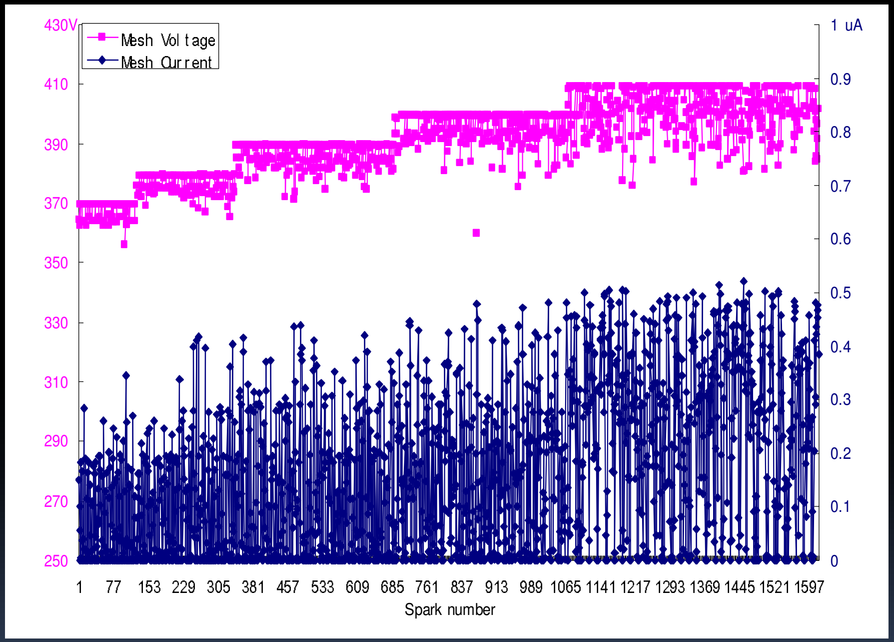
Segmented one: S1.

Spark counting device:

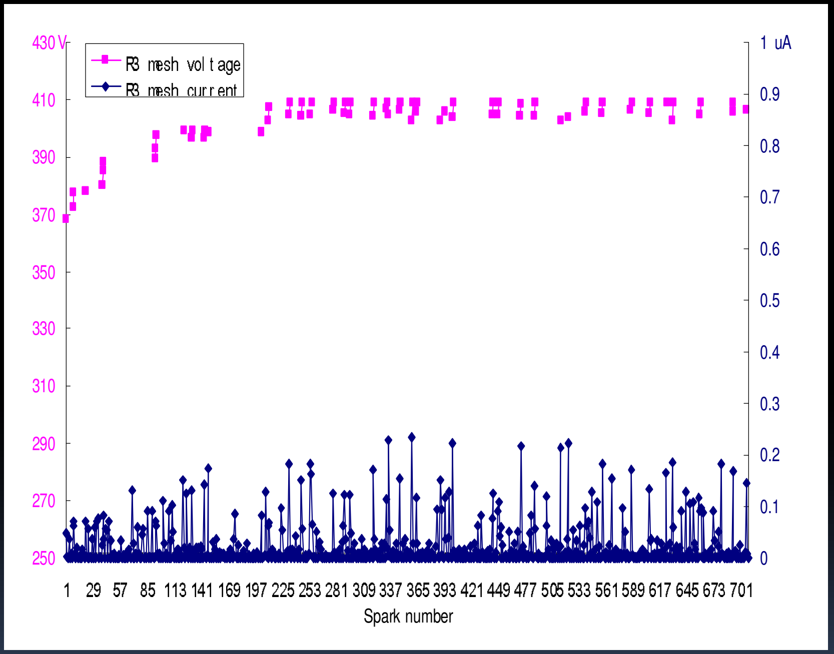


Different sparking behaviours of standard and resistive detectors

Standard SLHC2 @10KHz



Resistive R3, wide beam,15KHz 2 MΩ/ resistivity



SLHC2: HV=400 V (Gain ~3000): current when sparking < 0.5 μA
voltage drop< 5%

R3: HV=410 V (Gain ~3000): current when sparking < 0.2 μA
voltage drop< 2%

Spark study conclusion & outlook

- Resistive detectors R3 and R6 (2 MΩ/sq. & 400 kΩ/sq.) can reduce the spark rate by one order of magnitude w.r.t. uncoated ones R5 and R7 (250 MΩ/sq. & a few tens of kΩ) increase the spark rate

- All the resistive detectors can reduce the spark current and voltage drop by a factor of 2-10
thus provide a better working performance for high luminosity SLHC period.

- Performance such as efficiency and spatial resolution need to be done later to compare between the resistive one and standard one

Status of the Front Tracker development for the new SBS spectrometer at JLab

- Evaristo Cisbani from INFN-Rome Sanità Group
- CEBAF e- accelerator for study of Perturbative QCD, DIS Scattering, Parton models, Strong QCD, Spectroscopy
- Application of GEMs in front tracker

Requirements	Tracking Technology		
	Drift	**MPGD**	Silicon
High Rate (up to): **0.50 MHz/cm^2**	NO	**MHz/mm^2**	**MHz/mm^2**
High Resolution (down to): **<100 μm**	Achievable	**50 μm**	30 μm
Large Area: 40x150 and 50 x 200 cm^2 (+ minimize dead area)	YES	**Doable**	Very Expensive

New SBS Spectrometer @ JLab 12 GeV

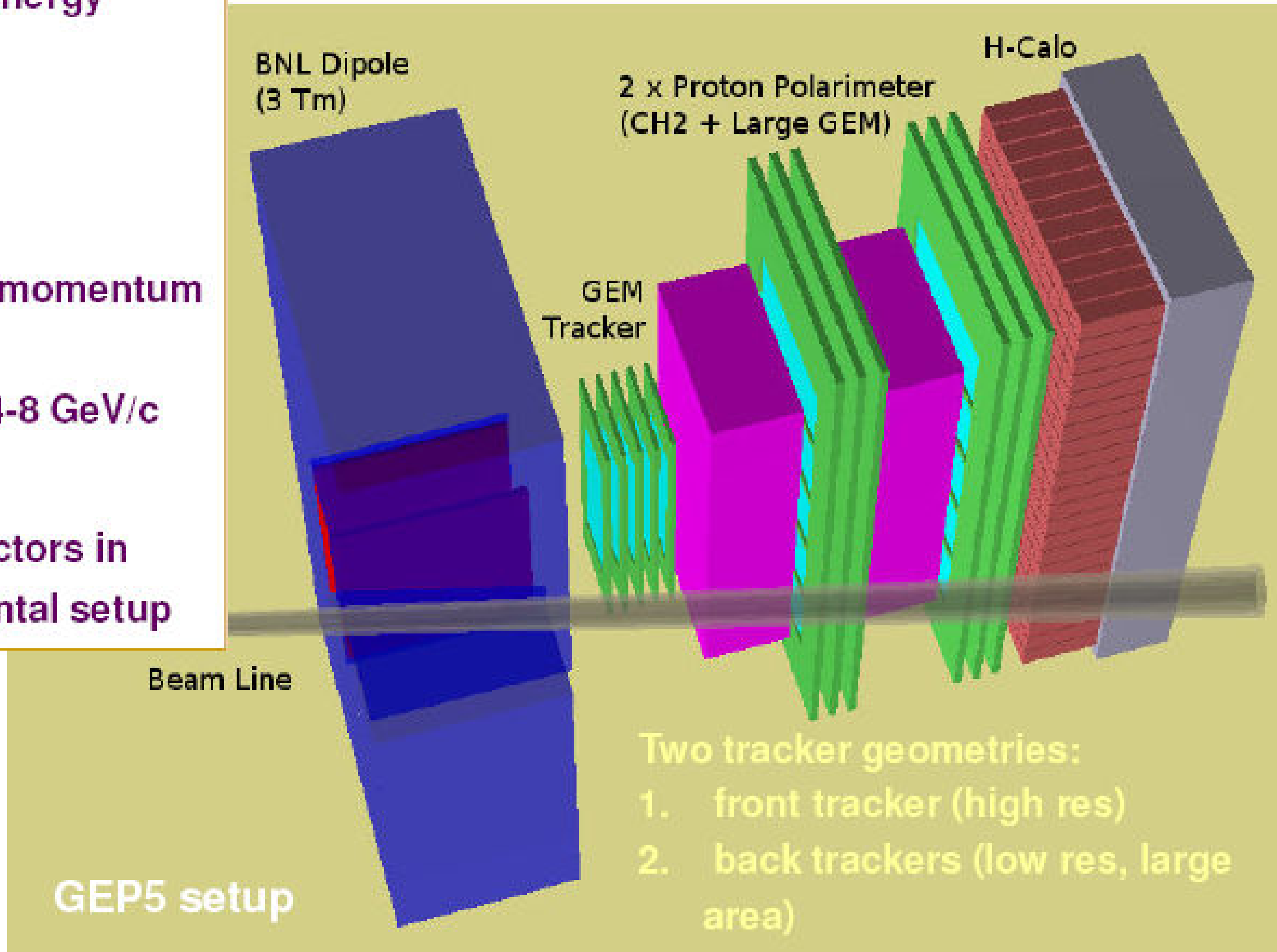
- **High Luminosity: 10^{38} /cm^2/s**
- **Support high background: 400 kHz/cm^2 (low energy photons mainly)**
- **Forward angle**
- **Large acceptance**
- **Good angular and momentum resolutions: 0.2 mrad, 0.5% @ 4-8 GeV/c**
- **Flexibility: use the same detectors in different experimental setup**

Ready in 2013

⇓

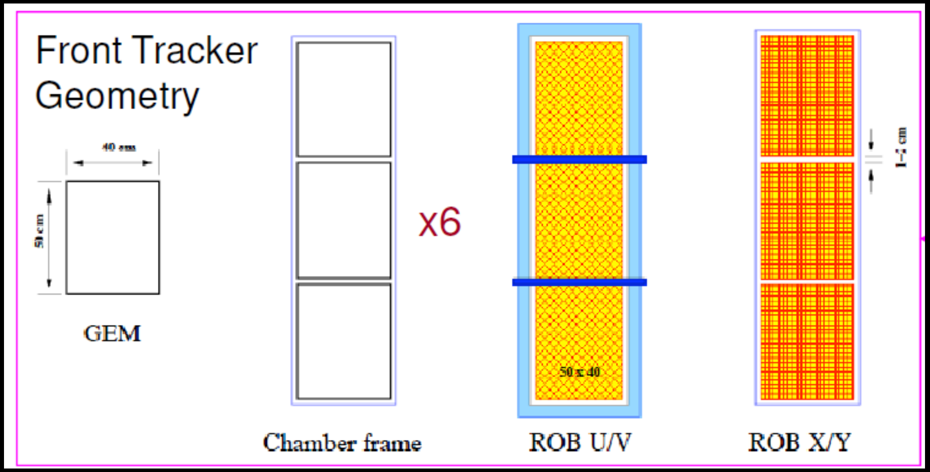
minimize development

hallaweb.jlab.org/12GeV/SuperBigBite/



Status

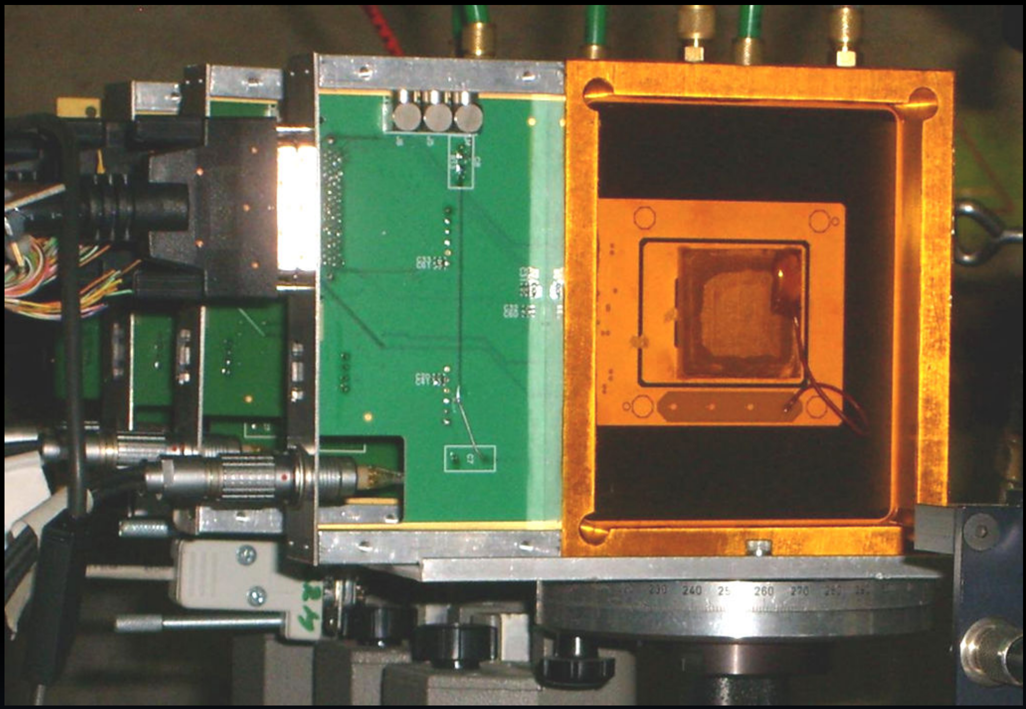
- Design of the first x/y full scale 40x50 cm2 prototype done (tanks to Rui) and ready for production
- Assembling tools almost completed (GEM stretcher similar to Bencivenni design, HV testing box, protocol …)
- First electronics prototypes available
- Expected to start testing module late February/March
- Next step (while testing prototype): design the u/v readout foil and produce the corresponding module

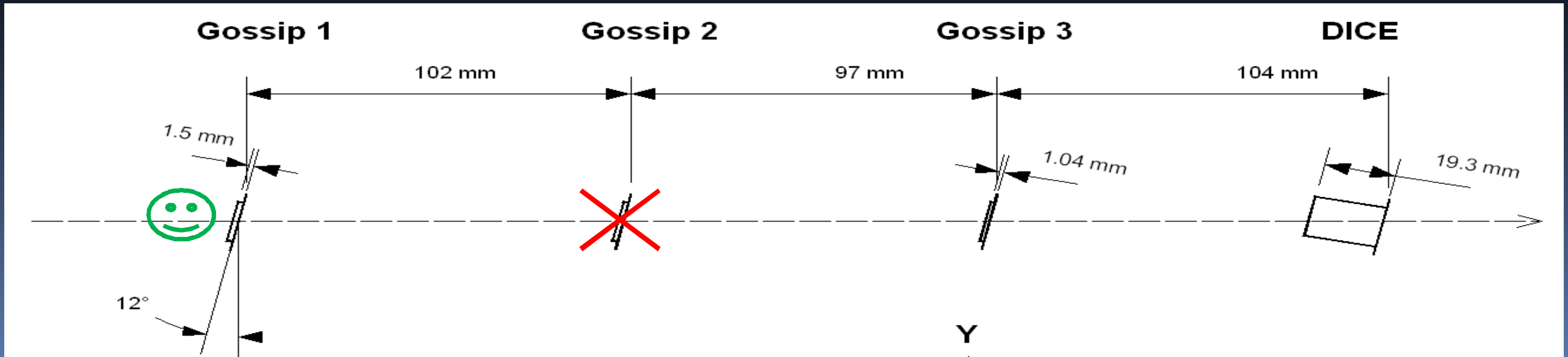


- ✓ **Single Module: 40x50 cm^2 "standard" 3-GEM foil**
- ✓ **Chamber combination of 3 or 5 adjacent modules**
- ✓ **Both x/y and u/v 2D (a la COMPASS) readout strips**
- ✓ **Electronics on the side (cyan) or beyond the dead areas (blue) at 90° degree**
- ✓ **About 50000 channels**

Operation of Gossip using DME/CO_2

- Analysis September 2009 test beam at CERN/PS
- Based on TimePix chip
  - TDC per pixel: 12.5 ns period
  - Threshold ~ 700 e^-
- Two Gossip detectors
  - Gossip 1: drift gap **1.5** mm high
  - Gossip 3: drift gap **1.0** mm high
- One GridPix detector
  - Drift gap **19.3 mm** high
  - Used as a reference to define tracks

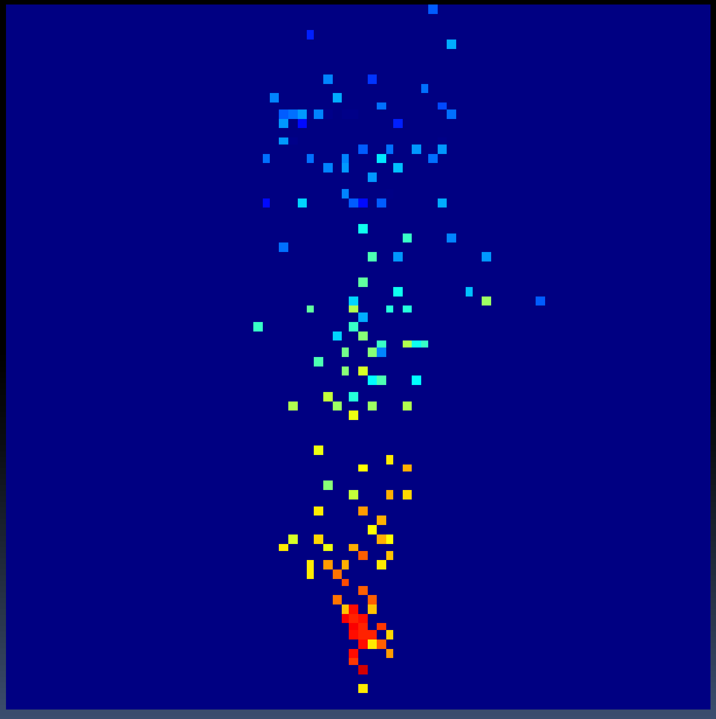




Comparing DME/CO_2 with Ar/iC_4H_{10}

- Measured in DICE detector: drift distance 19.3 mm
- Very low diffusion for CO_2/DME

Ar/iC_4H_{10} 80/20
(June 2009 testbeam)



80 pixels (440 µm)

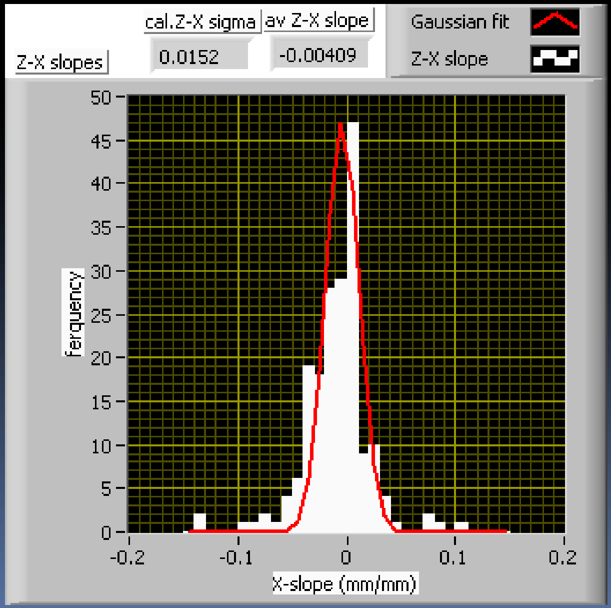
CO_2/DME 50/50

80 pixels (440 µm)

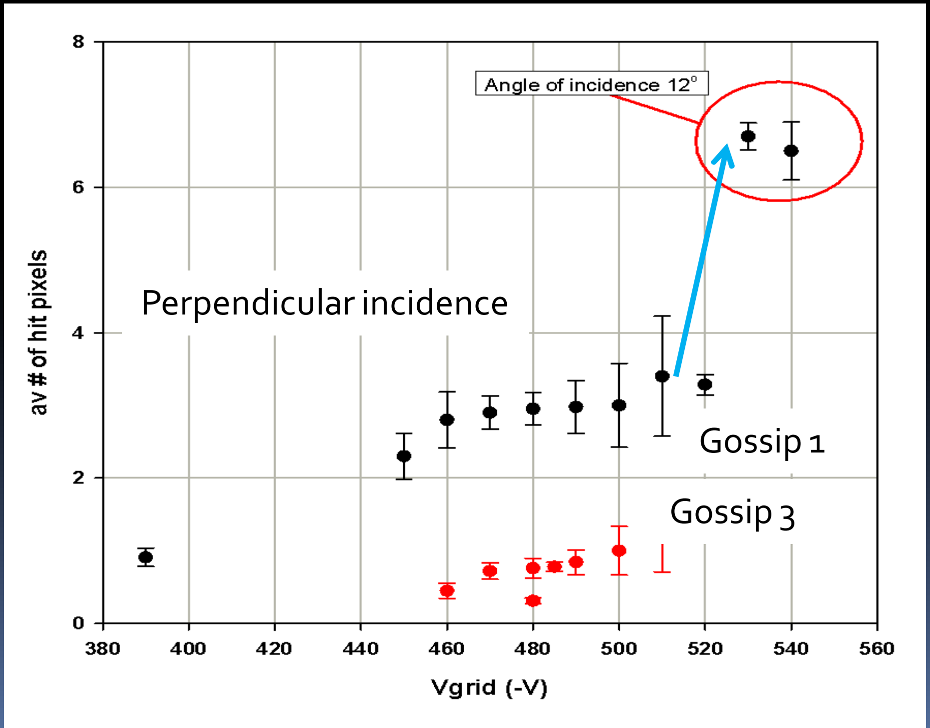
Summary of measurements

Track angle in GOSSIP 1

- Resolution
  - Resolution 15 mrad (0.9^0) in X
  - Resolution 70 mrad (4^0) in Y (poorer due to time slewing)



Number of hit and grid voltage

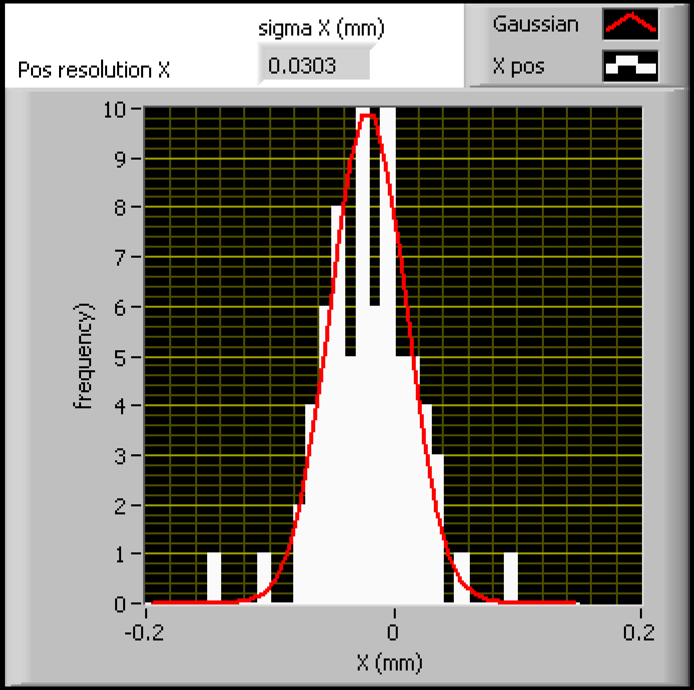


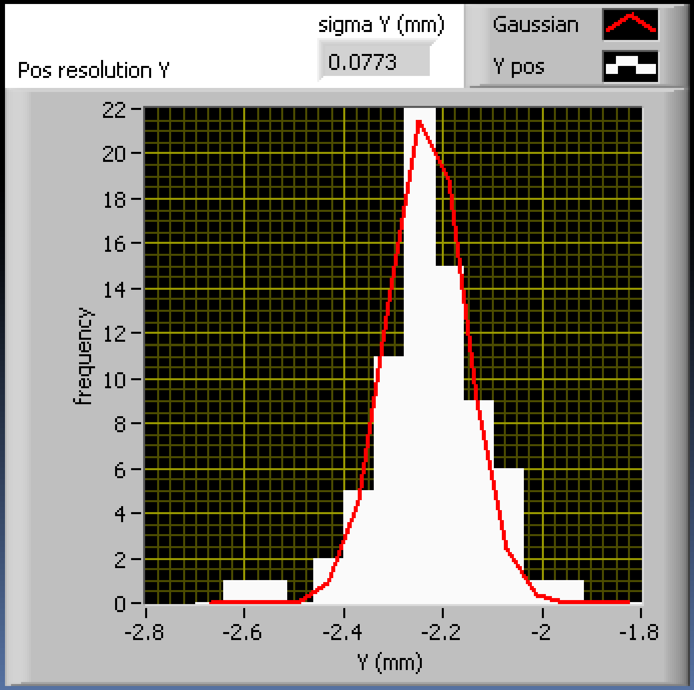
Position resolution of GOSSIP 3

- 75 events
  - 40% track efficiency in Gossip 3

- Residuals in X: **σ = 30 - 35 μm**
- This number includes
  - Accuracy of the fitted track (10 μm?)
  - Multiple scattering in 6 GeV beam (10 – 30 μm)
  - Poor hit statistics
    - average **1.5** hit pixels instead of **4.5** in Gossip 3
  - => **σ ≈ 15 μm** expected for well operating Gossip

- Residuals in Y: **σ = 70 - 80 μm**
  - => same correction: **σ ≈ 45 μm** expected for well operating Gossip



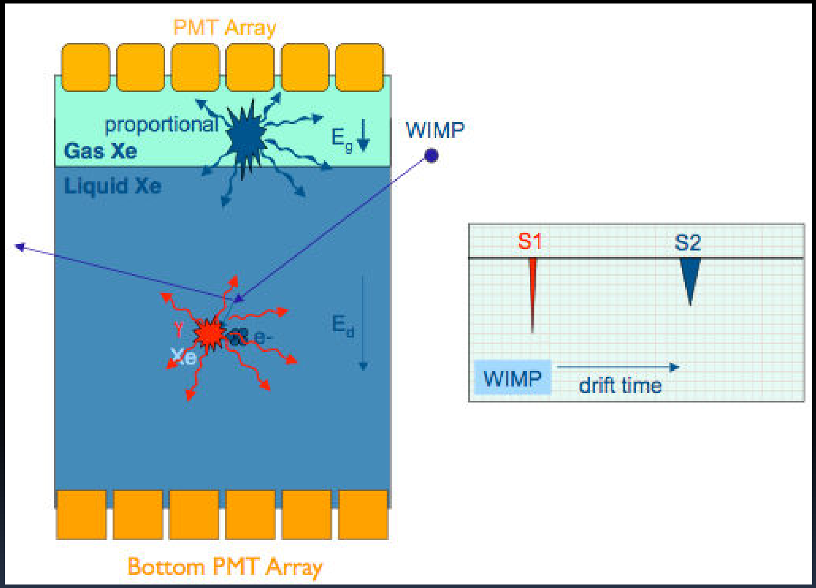


GridPix in cool Xe or Ar for DM search experiments

Noble Liquid WIMP Detectors

- DARWIN proposal
- Dark matter
  - Leading candidate: WIMPS
- Noble liquids
- Ongoing projects
  - WARP
  - Xenon10 / Xenon100 / Xenon1T

Measurement principle

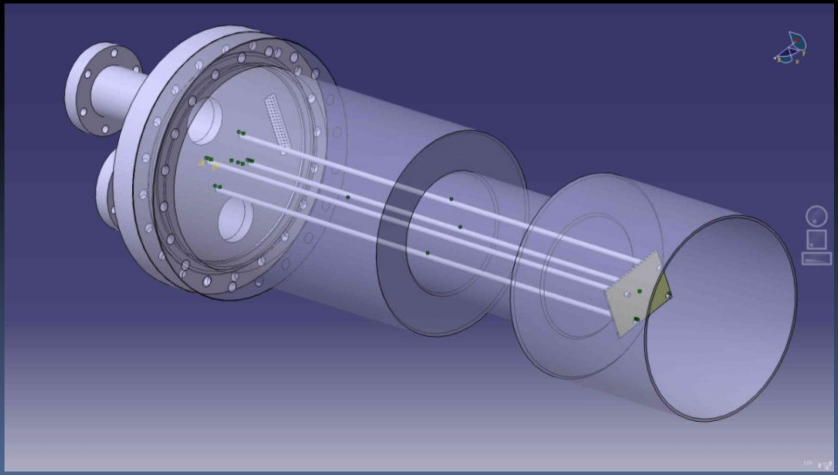


Replace top PMT layer with GridPix detectors

More and more precise information can be mined

Status

- Test setup being constructed
- Open questions to be answered
  - Operation in liquid Xe, Ar?
  - Multiplication in liquid?
  - Quenching?



Xray polarimetry with GridPix

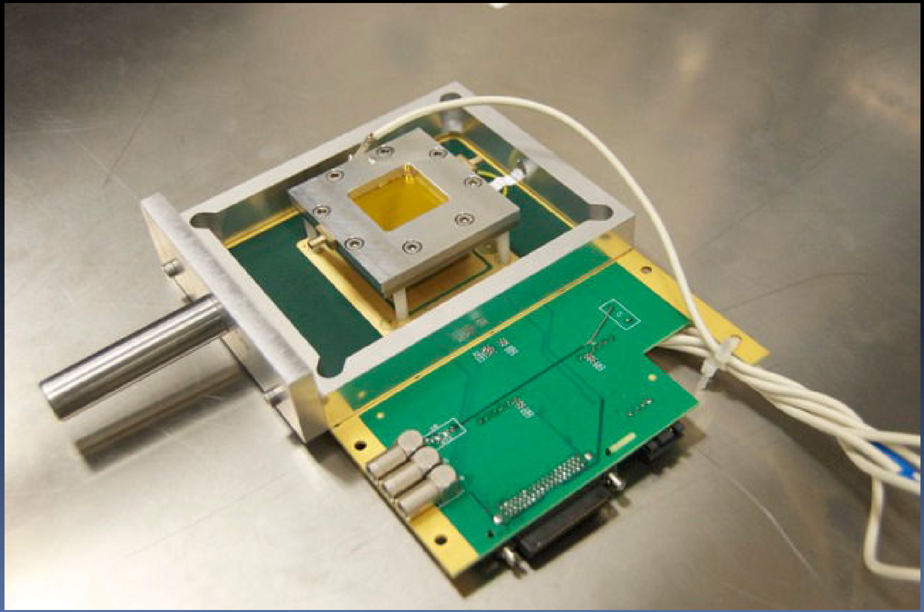
- Principle:
  - Photoelectron emission direction w.r.t. Xray propagation direction depends on its polarisation
  - Direction of polarization gives new information about radiation source

- Pixelated anode: reveal 3D ionisation pattern
  - Many effort in that direction from Belazzini group
  - Also possible with GridPix: PolaPix

GridPix detector design

Based on DICE design

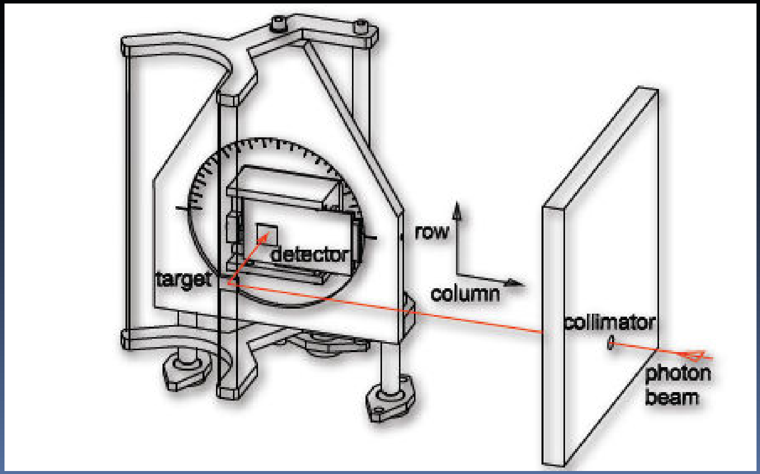
- 20 mm drift gap
- TimePix chip with InGrid
- Guard electrode for uniform field
- PolaPix: X-ray transparent kapton window



Gas choice

- He/iC_4H_{10}
- Ar/iC_4H_{10}
- Xe/iC_4H_{10}
- DME mixtures (DME/CO_2,Xe) (High voltages needed)
- High Z increases probability for detection but reduces range

Erlangen setup



Thanks for your attention