WG2 summary
RD51 Collaboration Metting
24th-27th May 2010, Freiburg

M. Chefdeville

LAPP, Annecy

TASK 1

Common test standards, performance evaluation:

1. Spatial resolution (Rϕ, Z) in TPC, W. Wang, A. Bellerive
2. MPGD behaviour in neutron beams (GEM, uM), G. Croci
3. Ion backflow in CsI coated THGEM, J. Veloso
4. Photo-e- extraction efficiency from CsI, D. Covita
5. GEM in a double phase liquid Xe detector, V. Solovo

TASK 2

Discharge studies and spark-protection development for MPGDs

1. Test of spark protections, R. Gaglione
2. Resistive uM for ATLAS upgrade, V. Polychronakos

TASK 3

Generic aging and material radiation hardness studies

TASK 4

Charging up and rate capability

1. Gain stability in uBulk, F.G. Iguaz
2. Resistive uM for ATLAS upgrade, V. Polychronakos

TASK 5

Study of avalanche statistics

1. Ionisation fluctuation studies with TimePix/InGrid, M. Lupberger

Common test standards, performance evaluation:

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TASK 1

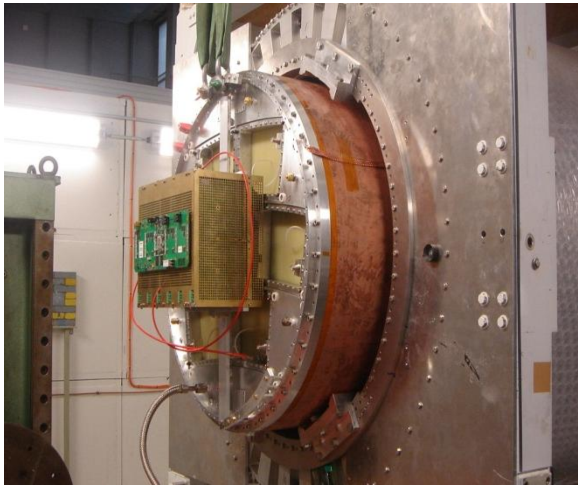
Recent results from a TPC with resistive Micromegas, *W. Wang*

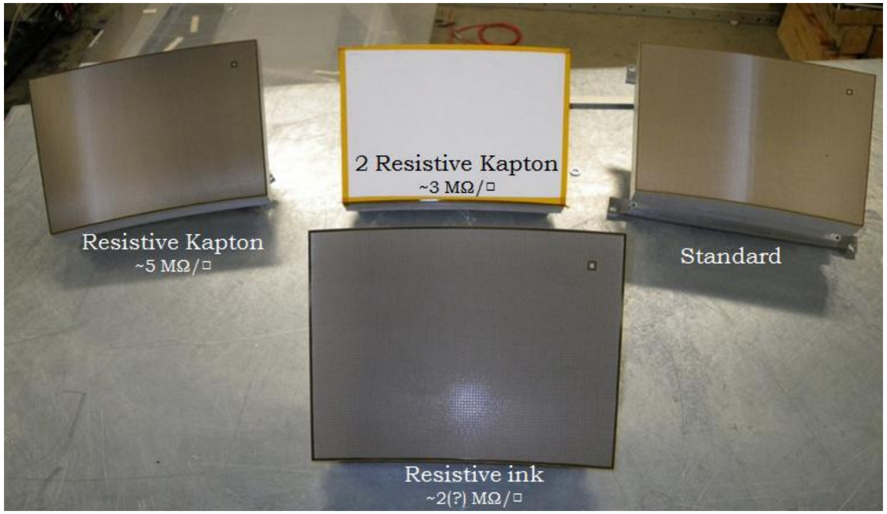
LP-TPC for ILC

- Beam test of four different modules: 1 standard & four with coatings of different resistivity
  - Resistive & Carbon loaded kapton (3-4, 5 MΩ/□)
  - Resistive Ink (2 MΩ/□)
- With/without B field (0/1 T)

Preliminary DESY/TB results

- Pad response function
- Mean residual per row
- Drift velocity
- Spatial resolution
- Effect of V_{mesh} and peaking time

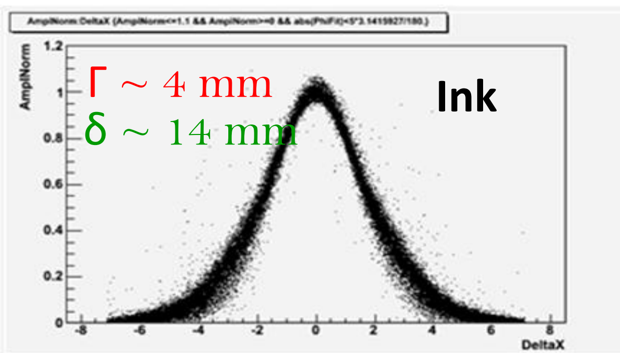


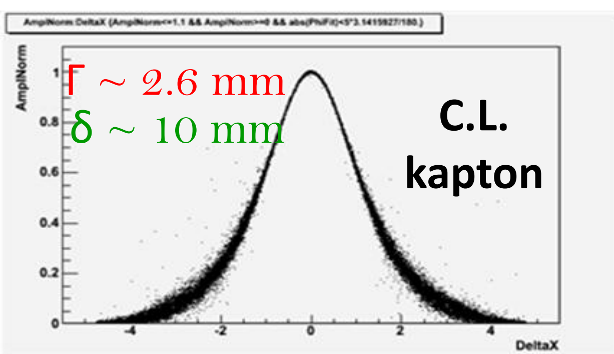


Recent results from a TPC with resistive Micromegas, *W. Wang*

Pad response function

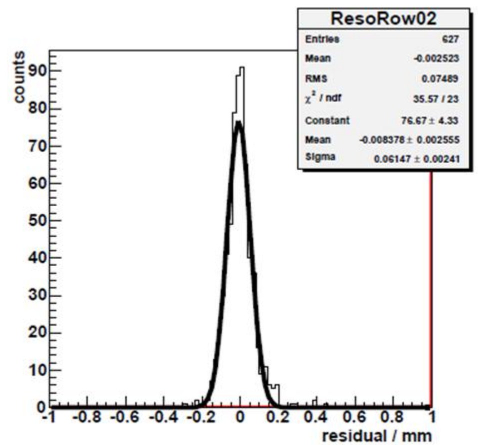
- T2K gas, 1 T, 5 cm drift



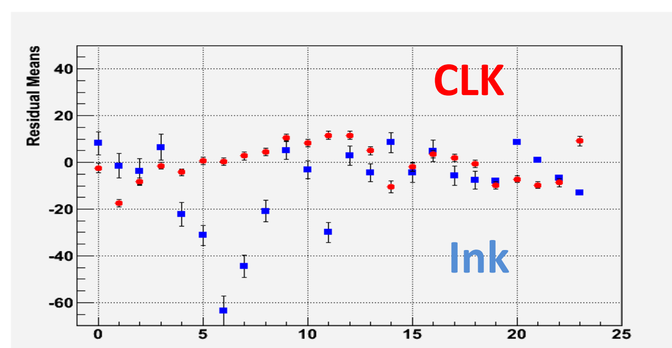


Position residuals x_{row}-x_{track}

- Better uniformity of CLK



Mean VS row @ Z=5cm

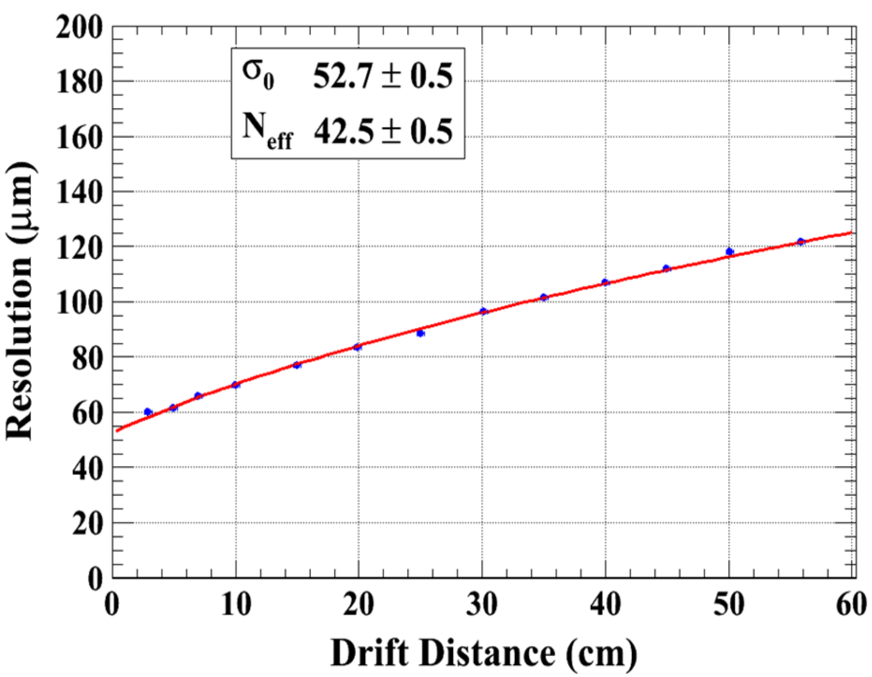


Recent results from a TPC with resistive Micromegas, *W. Wang*

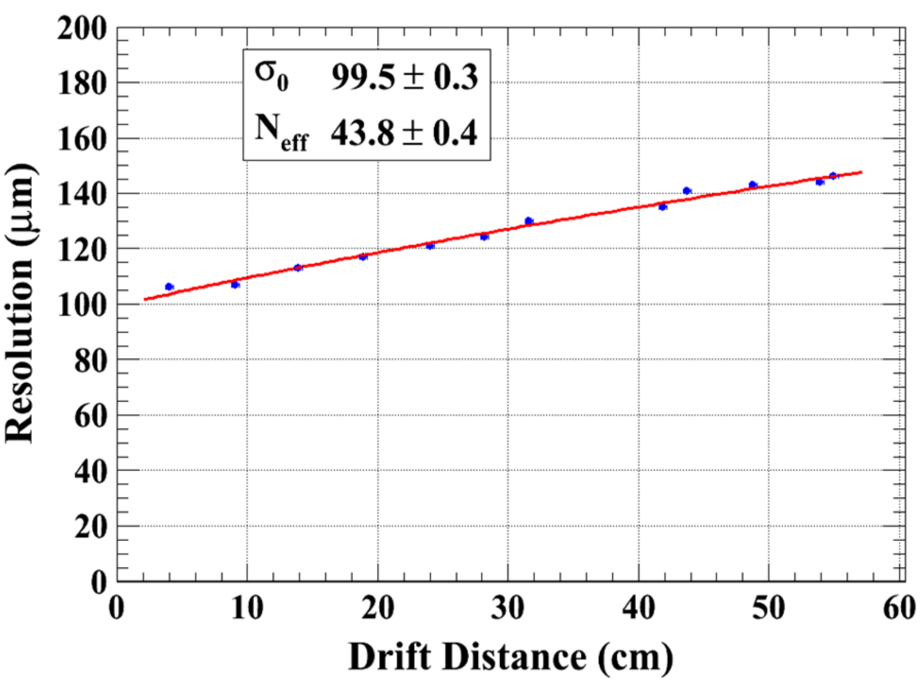
Resolution as a function of drift distance

Resolution at z=0: 50 times smaller than the pad size. Quantitative measurement of N_{eff} .

$$\sigma = \sqrt{\sigma_0^2 + \frac{C_d^2 \cdot z}{N_{eff}}}$$



Module_CLK



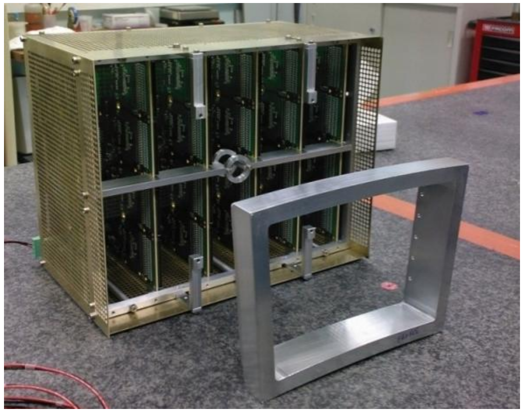
Module_INK

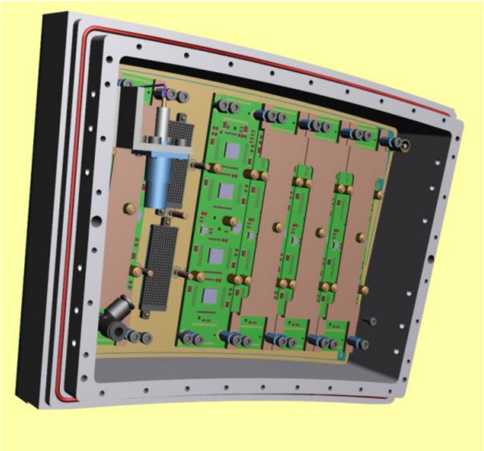
Recent results from a TPC with resistive Micromegas, *W. Wang*

Next step: New electronics

- Fully equip 7 modules with more integrated electronics, still based on the T2K AFTER chip: first proto. June 2010, test fall 2010

- Then production and characterization of 9 modules in 2011 at the CERN T2K clean room.



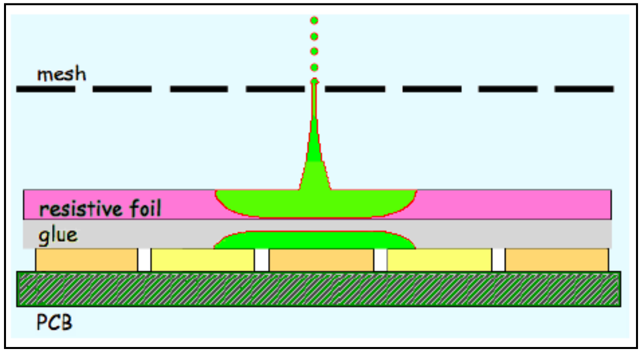


Time resolution of the Carleton prototype TPC,

A. Bellerive

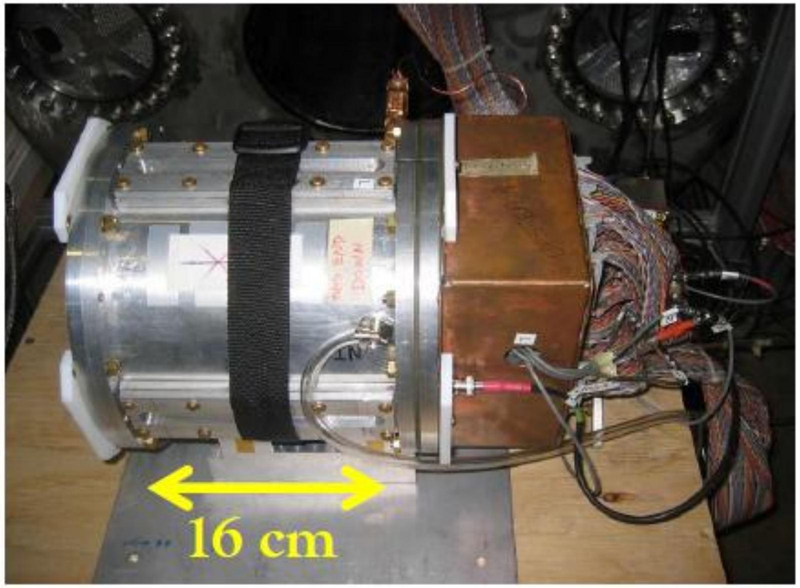
Motivations

- ILC TPC point resolution goals:
  - Transverse plane: 100 μm @ 2 m
  - z-direction: 500 μm @ zero drift
- Time resolution important:
  - Measure the total momentum
  - Associate track to bunch crossing
  - Connect track back to vertex in a high background environment



Carleton TPC

- 16 cm drift, 126 pads, 2x6 mm^2
- Charge dispersion on readout plane
- Data sets: 4 GeV/c pions 2005 & cosmics 2006 at ≠running conditions
- Improved PRF algorithm analysis

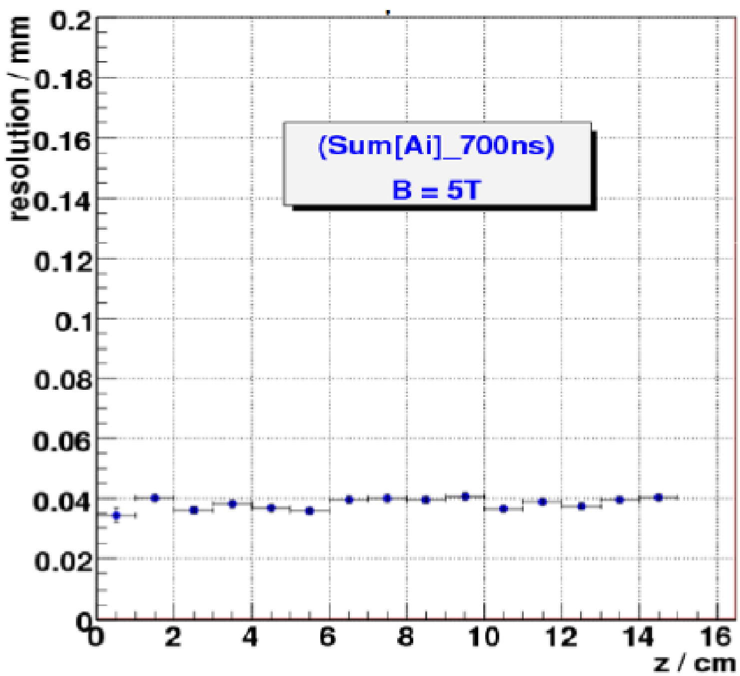


Time resolution of the Carleton prototype TPC,

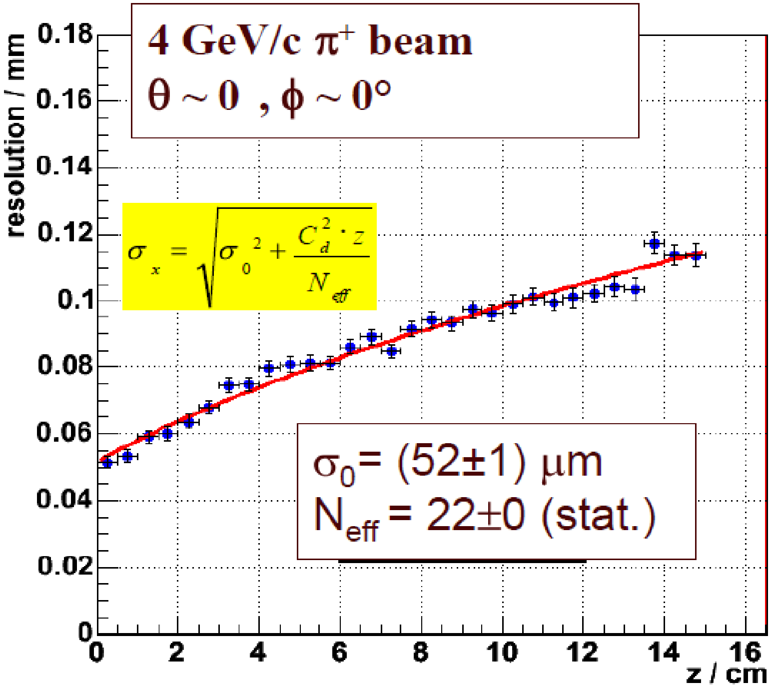
A. Bellerive

XY resolution (reminder)

- Comics @ DESY, 5 T, T2K gas



- 4 GeV/c π+ @ KEK, 1 T, Ar/iso 95/5

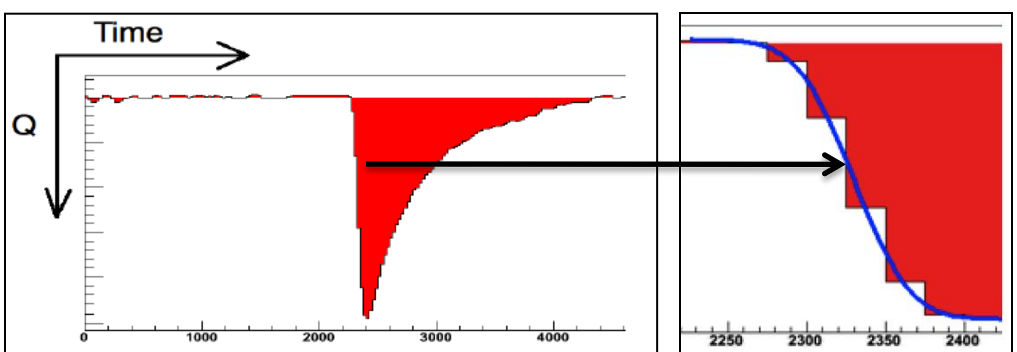


Extrapolation at ILC: 100 μm @ 2.5 m!
What about time resolution?

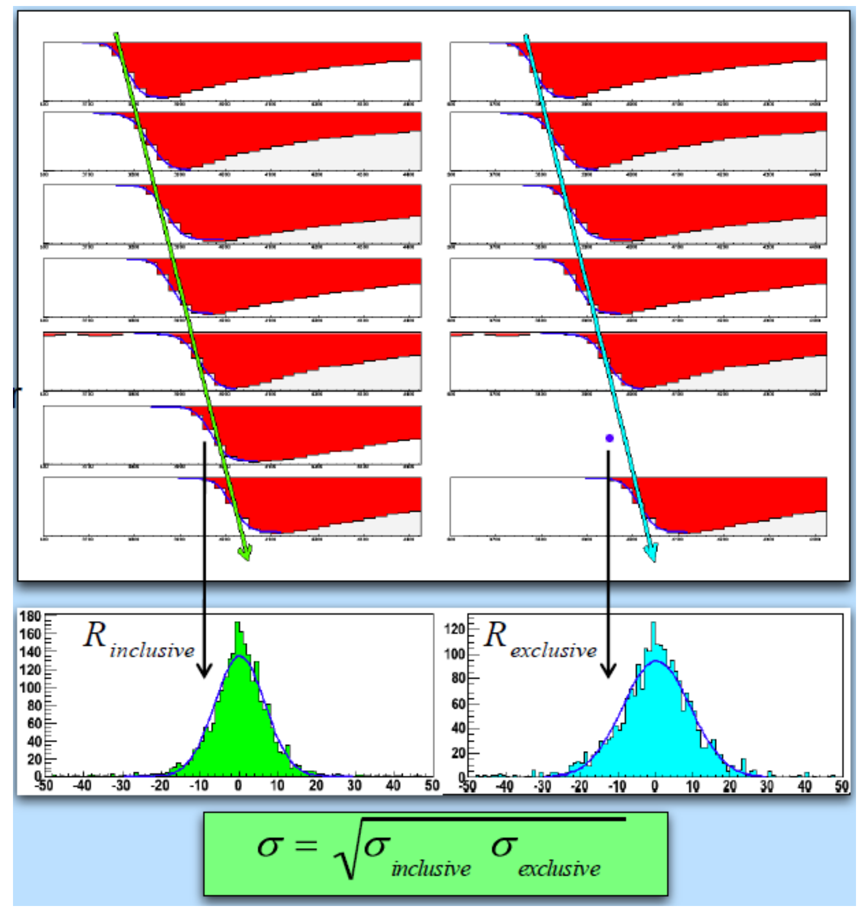
Time resolution of the Carleton prototype TPC,
A. Bellerive

Cluster arrival time

- Primary charge collecting pad signal shape is determined mainly by long. diffusion
- Timing determined by error function fit to the leading edge
- Arrival Time taken as the time of maximum induced current



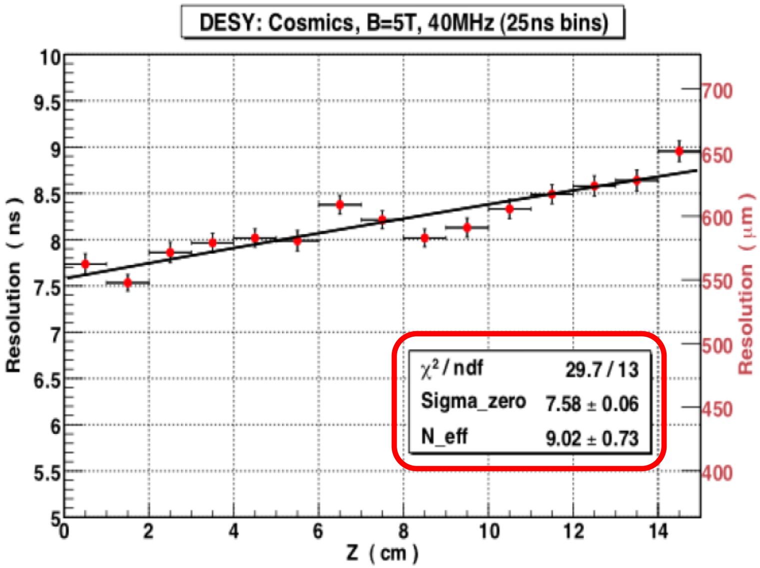
Time resolution



Time resolution of the Carleton prototype TPC,
A. Bellerive

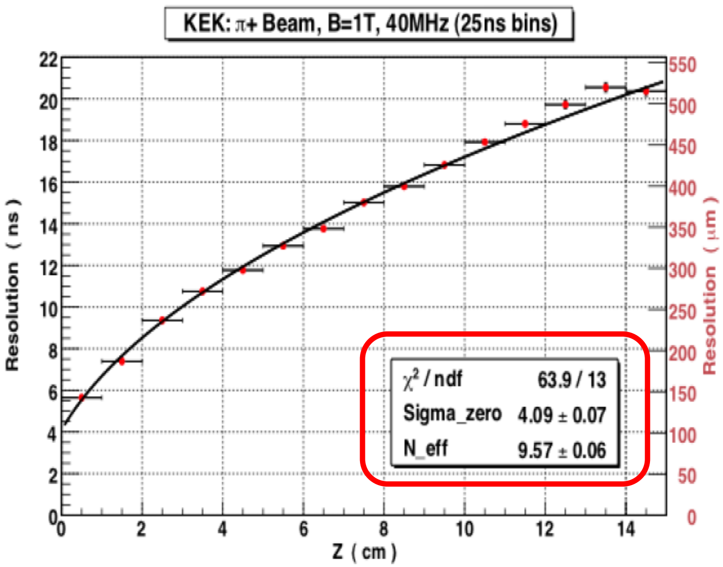
Comics @ DESY, fast gas

- Ar/iso/CF4 95/5/3: 7.27 cm/μs
- Long. diff. coef. 248 μm/√cm



Pions @ KEK, slow gas

- Ar/iso 95/5: 2.53 cm/μs
- Long. diff. coef. 479 μm/√cm



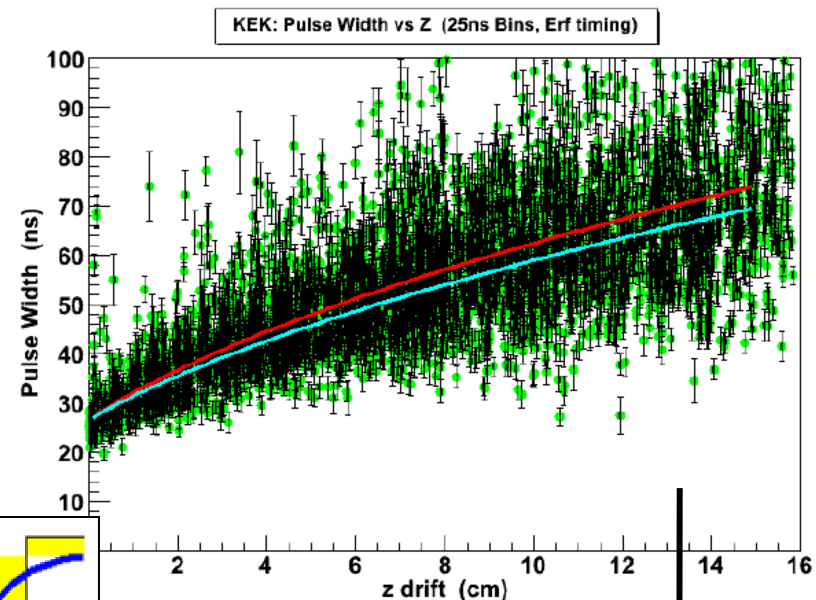
Extrapolation at ILC (zero drift): 100 μm (slow gas) & 550 μm (fast gas)

Time resolution of the Carleton prototype TPC,

A. Bellerive

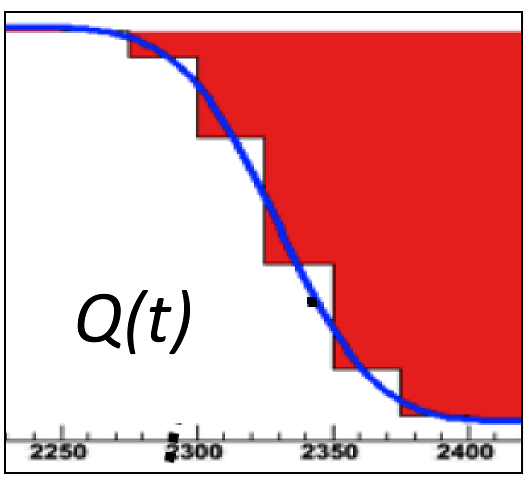
Diffusion measurement

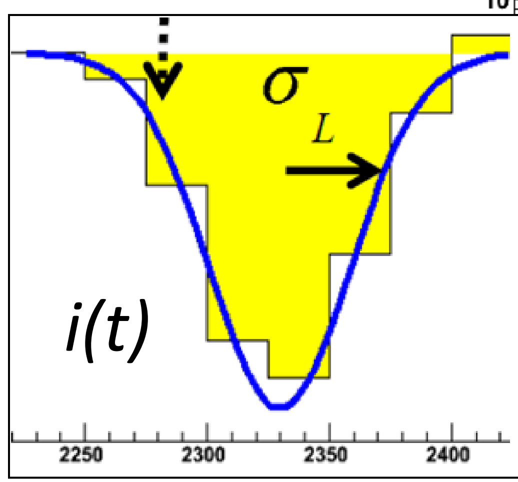
- Primary charge collecting pad signal shape is determined mainly by long. diffusion
- Extract « current width » VS drift distance and fit diffusion curve



$$D_L = 423 \frac{\mu m}{\sqrt{cm}} \quad (magboltz : 479)$$

$$D_L = 268 \frac{\mu m}{\sqrt{cm}} \quad (magboltz : 248)$$





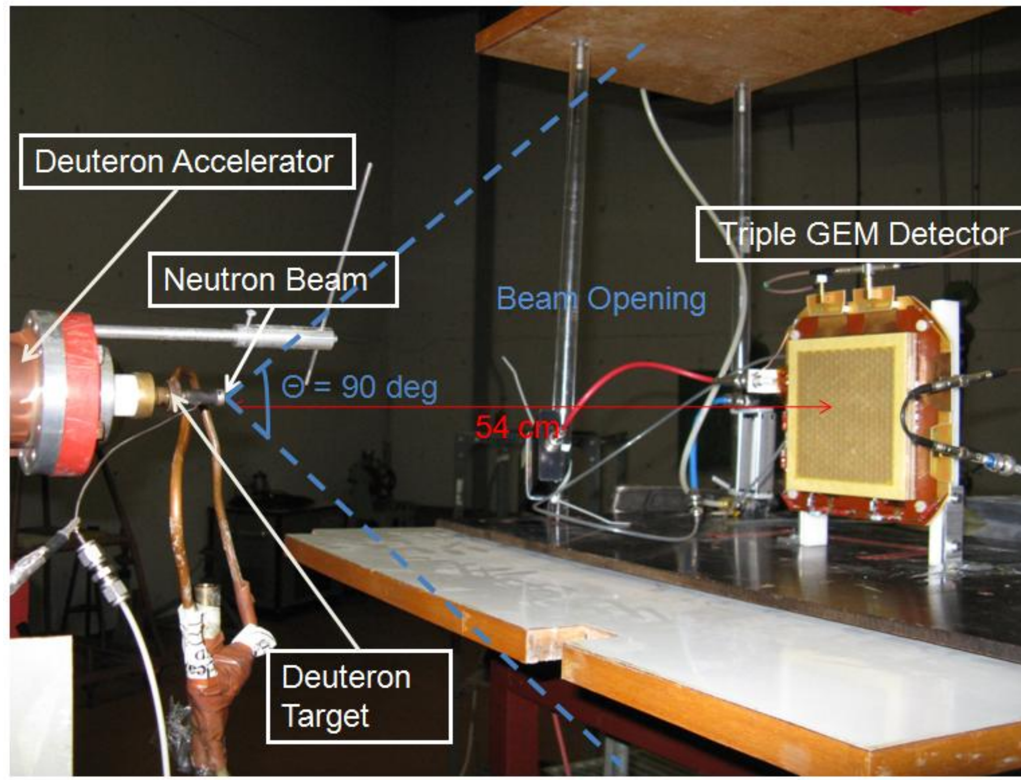
Geant4 Simulation of neutron interaction with GEM-foil and gas, *G. Croci*

Motivations

- Understand recent measurements performed in Athens with a triple GEM in a 5.5 MeV neutron beam

- Ar/CO_2 70%/30%
- 5.5 MeV neutrons from 2.8 MeV deuteron beam collision on a deuteron target
- Pulse Height measurement at the anode

Beam test setup

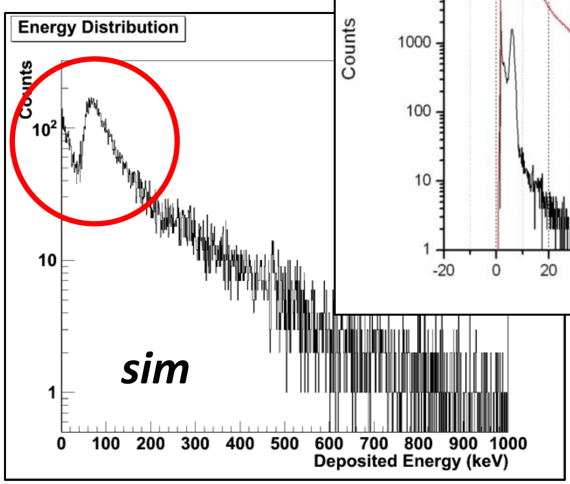


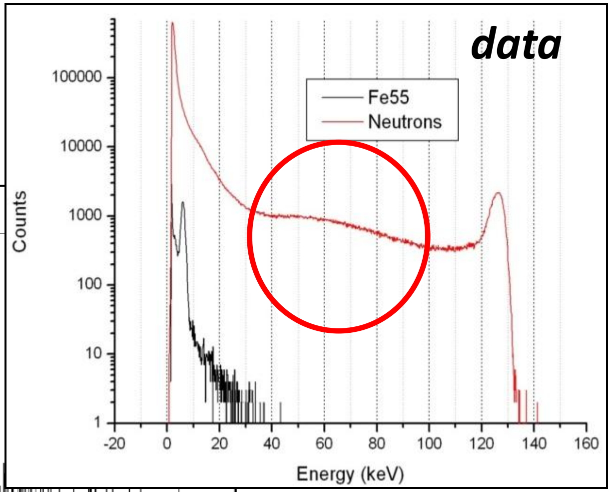
*Neutrons Flux = 2.2*10^5 Hz/cm^2*
Distance Source-Detector = 23 cm
Detector Gain = 5000

Geant4 Simulation of neutron interaction with GEM-foil and gas, *G. Croci*

Measured/simulated spectra

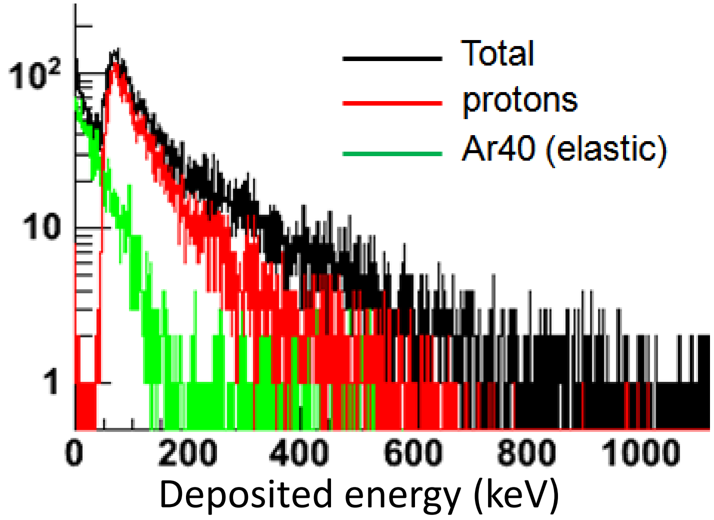
- Neutron conversions, photons from material activation, saturation peak
- Neutron peak reproduced





Main physics processes

- Neutron conversion result mainly in protons and Ar40 ions
- Where are they emitted from?



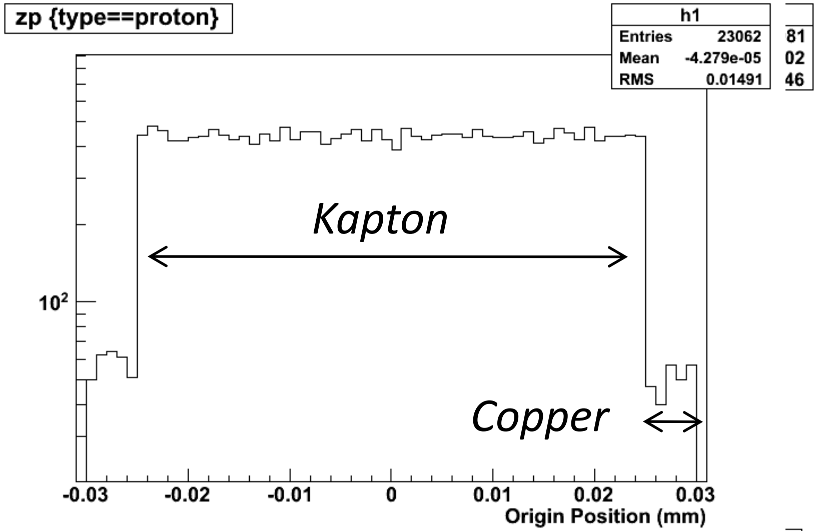
Geant4 Simulation of neutron interaction with GEM-foil and gas, *G. Croci*

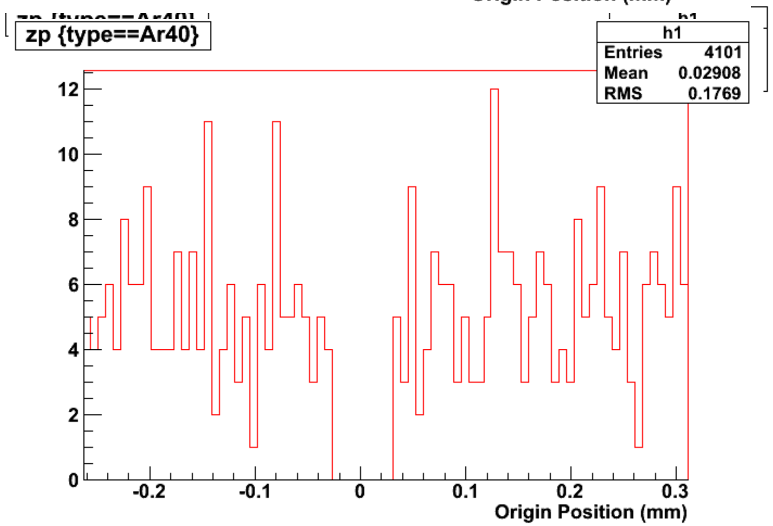
Origin positions

- Protons: Kapton >> Cu >> Gas
- Ar40 ions: from Gas

Outlook

- Simulation reproduces data
  - Spectrum contributions
  - Places where particles are produced
- Recent measurement on uM resistive chamber in neutron beam (MAMMA)
- Similar simulation work presented in Feb. 2010 Mini-week with an emphasis on sparks (S. Procureur talk)

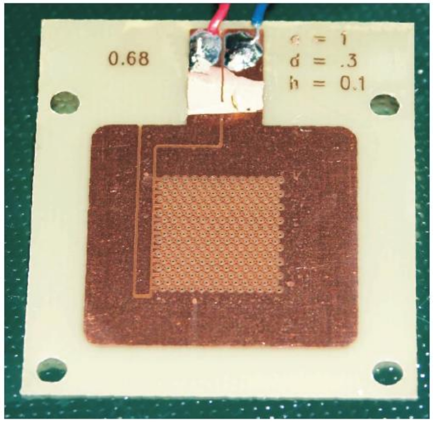


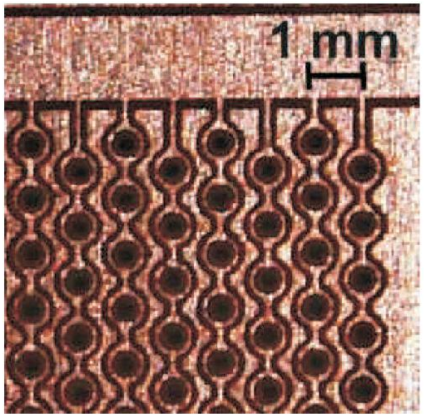


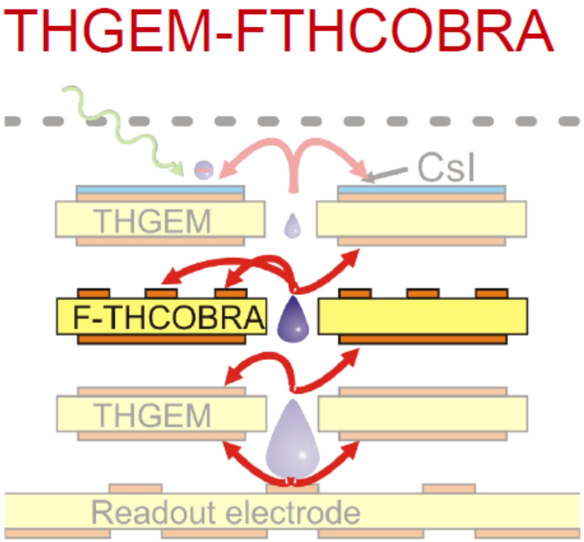
Ion backflow reduction in THGEM cascades using a THCOBRA, *J. Veloso*

Motivations

- Gaseous PM for RICH and visible photon detection
- Combine photocathode (PC) and MPGD
- High gain operation implies large number of BF ions and thus PC aging
- Trap ions in intermediate stage in THGEM cascades



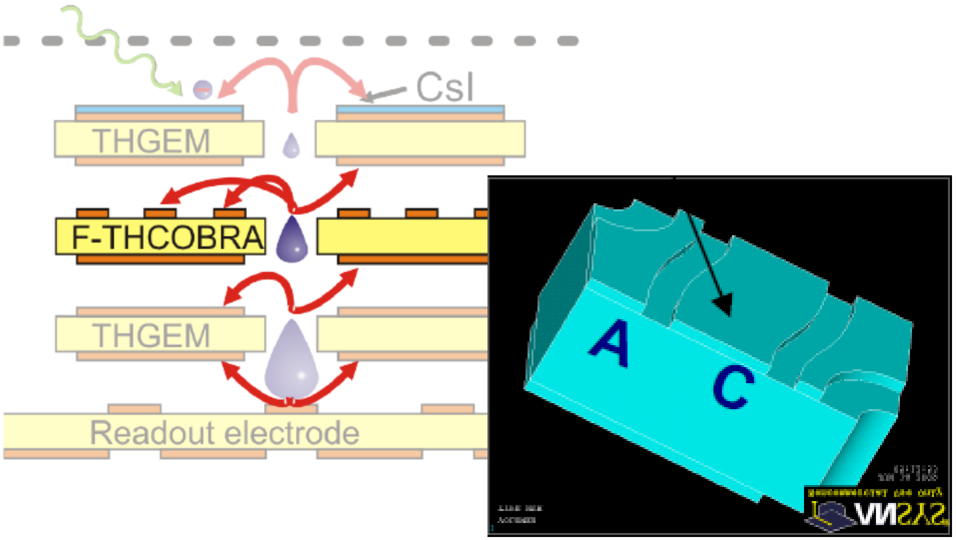


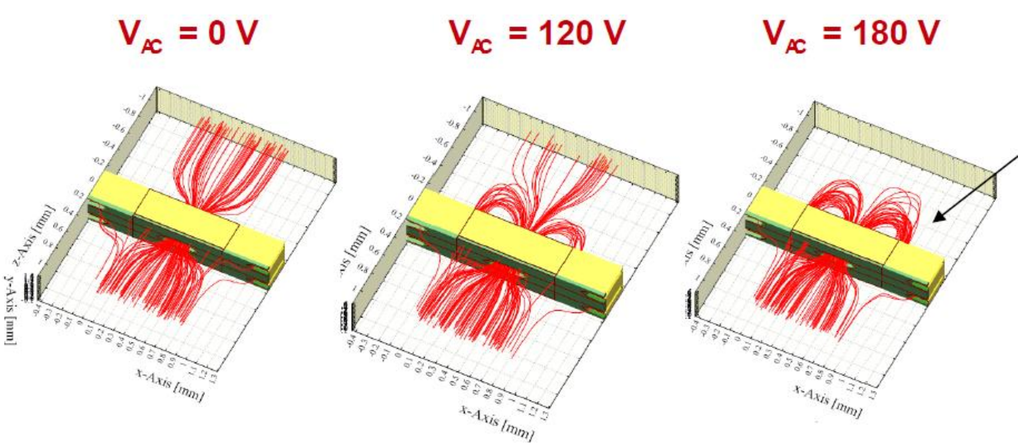


Ion backflow reduction in THGEM cascades using a THCOBRA, *J. Veloso*

Operating principle

- COBRA: 3 electrodes
  extra freedom in field shape
- V_{AC} controls ion collection and electron transparency (field inversion @ 180 V)
- Calculation shows IBF of 10^{-2} while collection eff. of e- close to 1



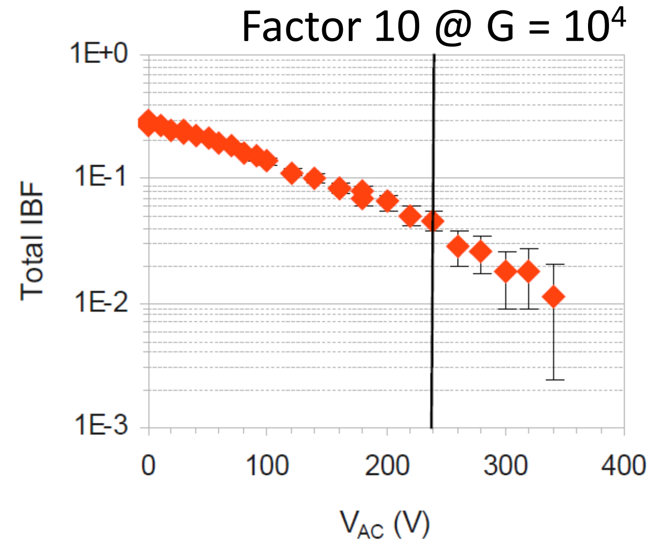


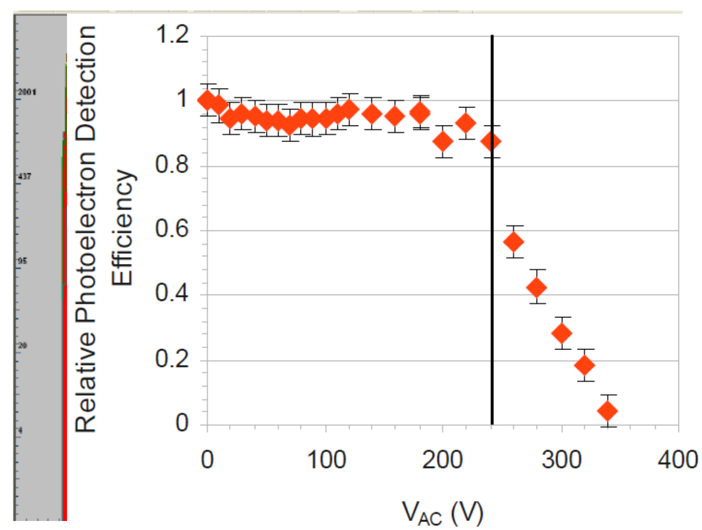
Ion backflow reduction in THGEM cascades using a THCOBRA, *J. Veloso*

Measurement in pure Ne

- Ion backflow fraction defined as **$(I_{CsI}+I_{grid})/I_{bottom}$**
- (Relative) detection efficiency from counting rate keeping same total gain

- Next: systematic studies (gas, field) and simulation to optimize geometry





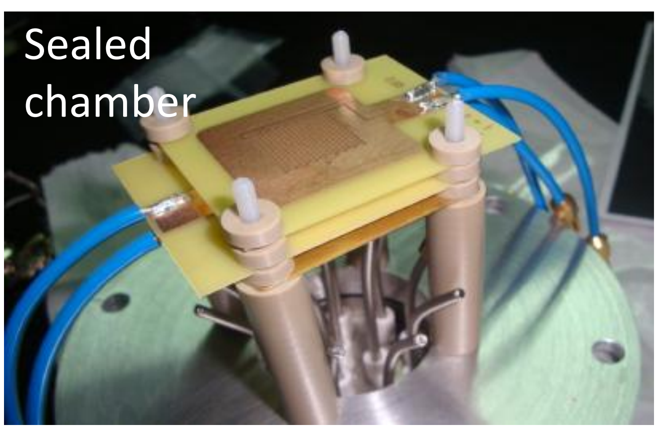
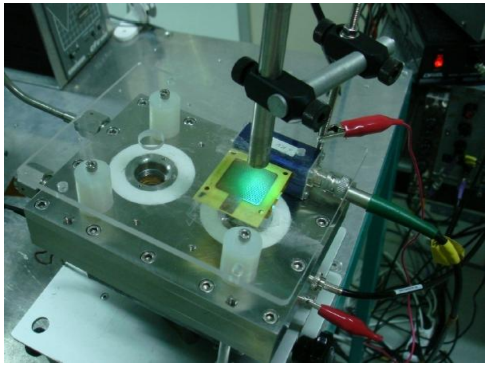


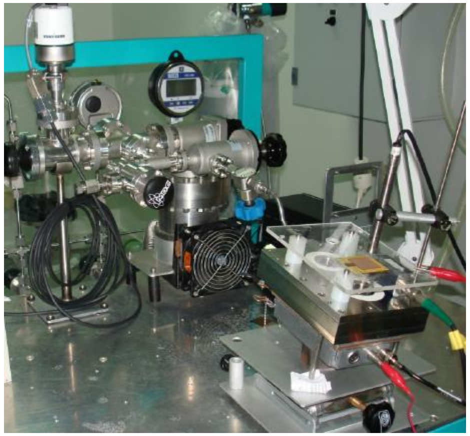
Photo-e- extraction efficiency from CsI PC in noble gases (Ar, Xe) up to 10 bars, *D. Covita*

Motivations

- Detection of hard X-rays in gas requires high pressures
- Can a CsI-based readout be applied for such an application?
- Measure photo-e- extraction efficiency @ different pressures

Experimental setup





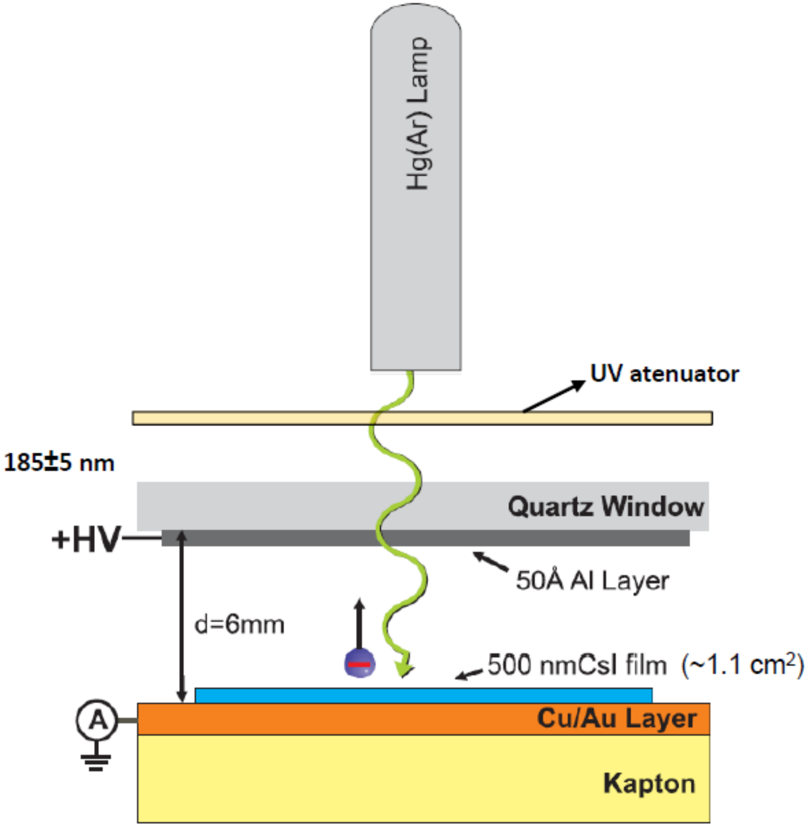


Photo-e- extraction efficiency from CsI PC in noble gases (Ar, Xe) up to 10 bars, *D. Covita*

Method

1. Pump the system < 10^{-5} mbar
2. Measure the current *VS E/p*
3. Fill the system
4. Re-measure the current *VS E/p*
5. Repeat at ≠ P, up to 10 bar
6. Complete 3 series of measurements
7. Take the average of I(E/p) to obtain the efficiency curve

Results

- About 17 % in Xenon with no significant effect of the pressure
- 30 % in Argon (2 % var. with P)

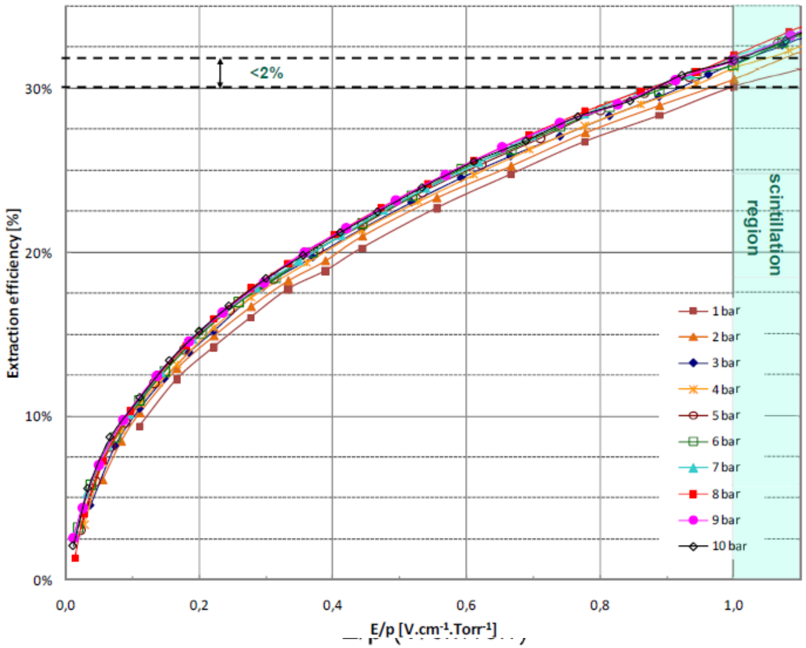


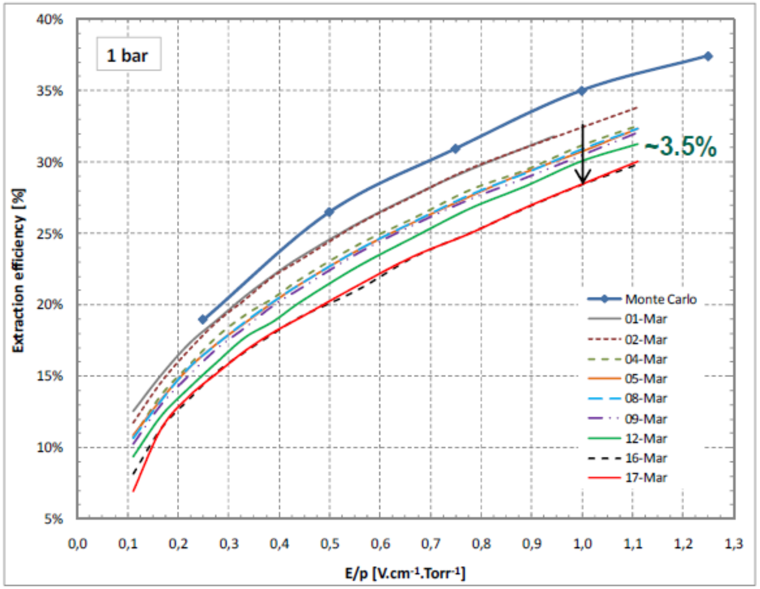
Photo-e- extraction efficiency from CsI PC in noble gases (Ar, Xe) up to 10 bars, *D. Covita*

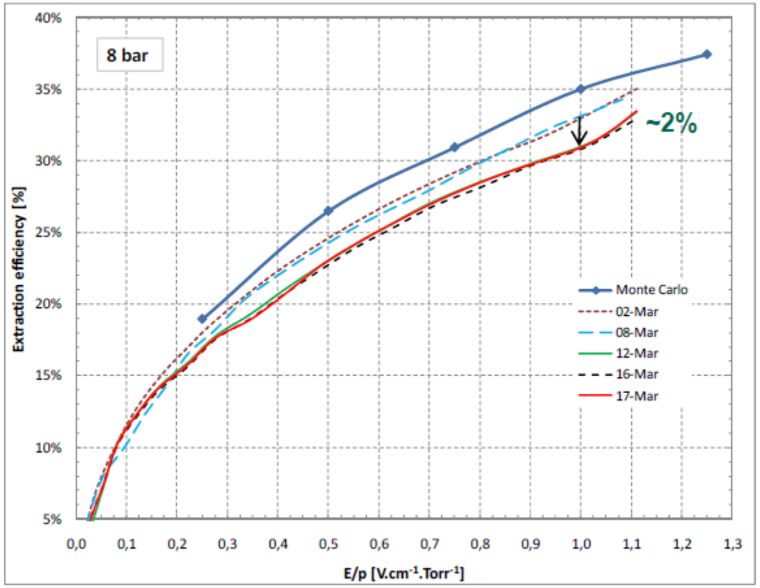
Extraction eff. and time

- Observed mild drop of efficiency with time in Ar
  - More pronounced at low P
  - Photo-cathode aging?

Future plans

- Extend the studies to Ne, Kr & mixtures with organics (CH4, CF4)
- Systematic studies of aging in Ar & Xe



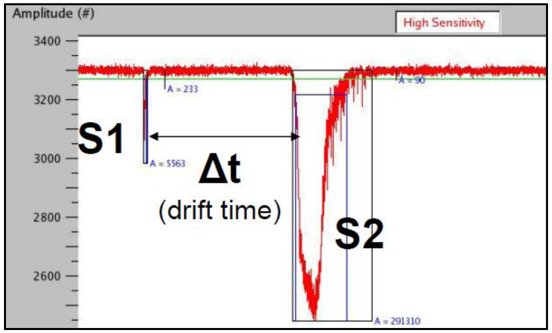


GEM in a double phase liquid Xe detector,
V. Solovov

Double phase detectors

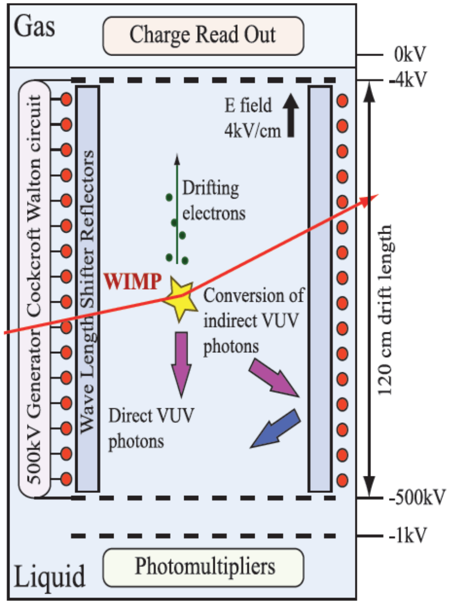
- Interaction of WIMP in liquid Xe results in a nuclear recoil:
  - Direct scintillation light (S1)
  - Ionisation e- (S2)
    - Gas amplification or
    - Secondary scintillation light

- Ratio S1/S2 useful to discriminate signal and background



Motivations

- PMT are the main source of intrinsic radioactivity
- Is it possible to have a cleaner readout and maintain performance?



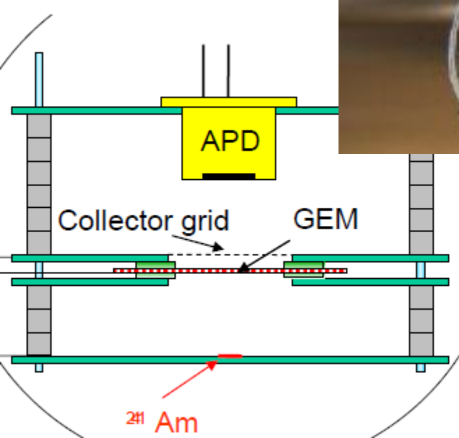
APD
SiPM
GEM + APD
CsI + GEM + APD

GEM in a double phase liquid Xe detector,

V. Solovov

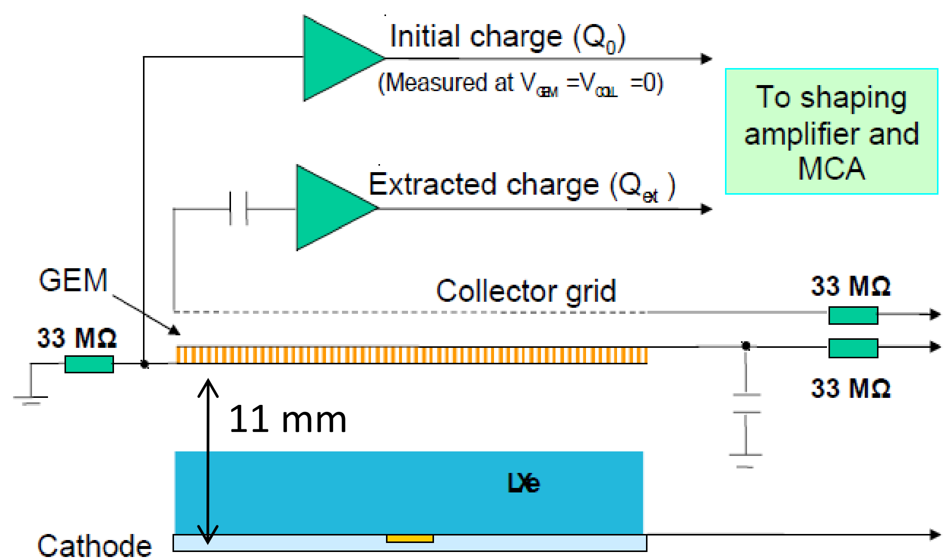
Experimental setup

- Automatic temperature control (slight T gradient)
- Americium alpha source



HV and electronics

- Cathode @ -6 kV
  Collector @ 2 kV
  ΔV(GEM) = (600-300) V
- Initial charge of 3 fC



GEM in a double phase liquid Xe detector,

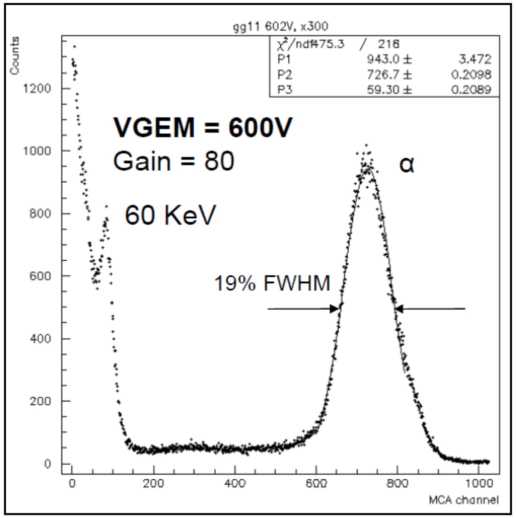
V. Solovov

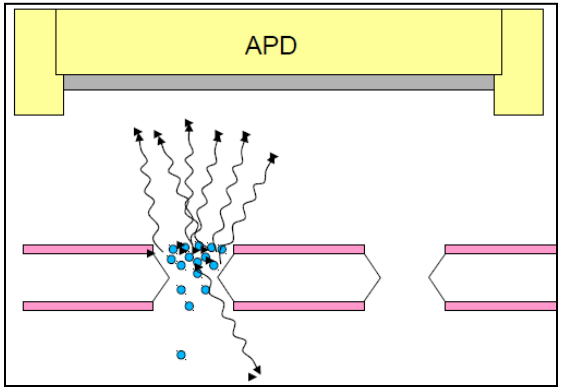
Charge spectra on collector

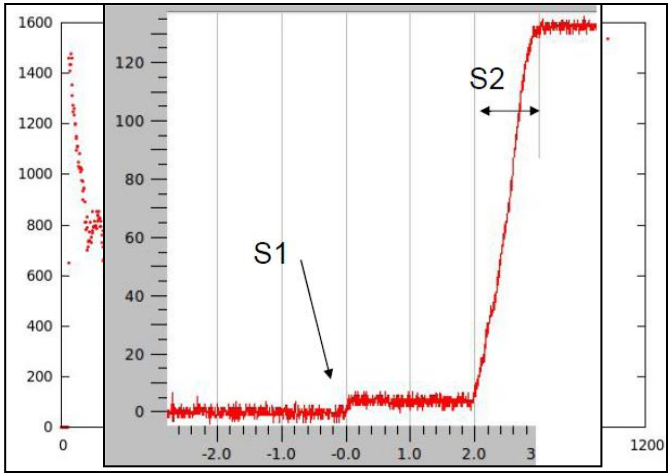
- Gain up to 150 @ 625 V
- Poor resolution (15-20 % FWHM) due to low GEM electron transparency

On-going work with GEM+APD

- Sensitive area of 0.2 cm^2
  Higher overall gain, better S/N
- But lower resolution
  off-axis events -> incomplete collection
- Analysis of primary & secondary signals







Discharge studies and spark-protection development for MPGDs

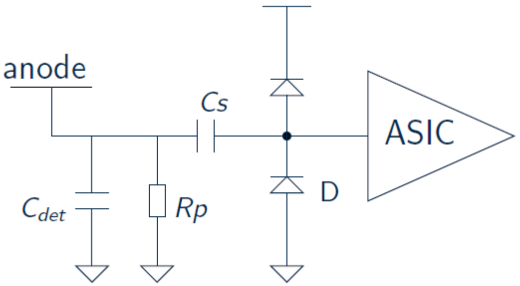
1. Test of spark protections, R. Gaglione
2. Resistive uM for ATLAS upgrade, V. Polychronakos

TASK 2

Test of spark protections, *R. Gaglione*

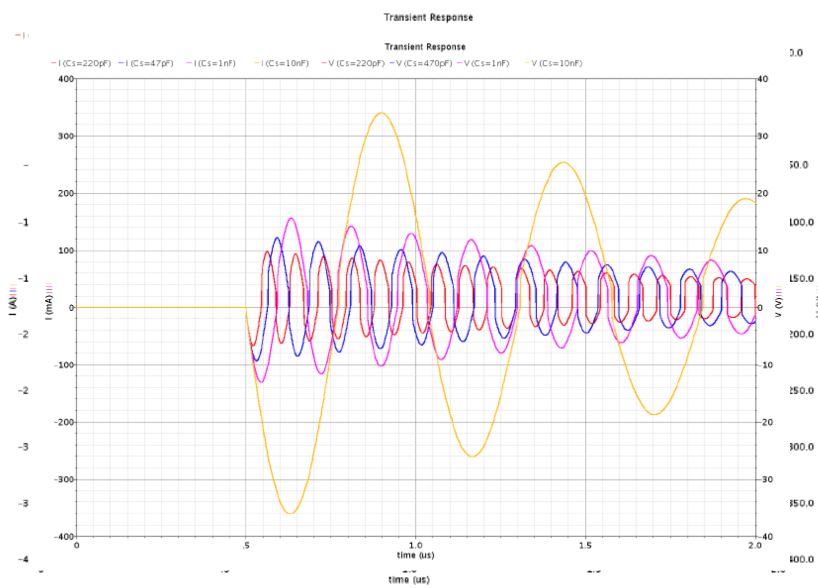
Motivations

- Make spark proof Micromegas chambers for a PFA/DHCAL
  - Low hit multiplicity desired -> No resistive coatings
  - Discrete R, C, diodes on PCB or inside PCB/ASICs
- First chambers (12x32 cm2) equipped with GASSIPLEX & COMPASS boards spark proof
- Problems began when using a new chip and when increasing the mesh size



Effect of the diodes (simulation)

- Look at spark current & voltage for ≠ coupling capacitors with/w.o. diodes
  - Ringing: need to protect from both polarities



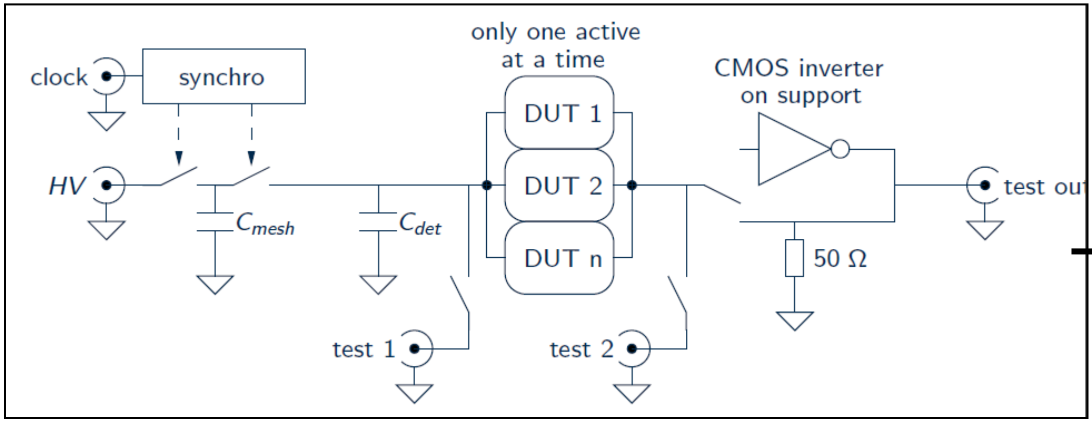
Test of spark protections, *R. Gaglione*

Protection test board

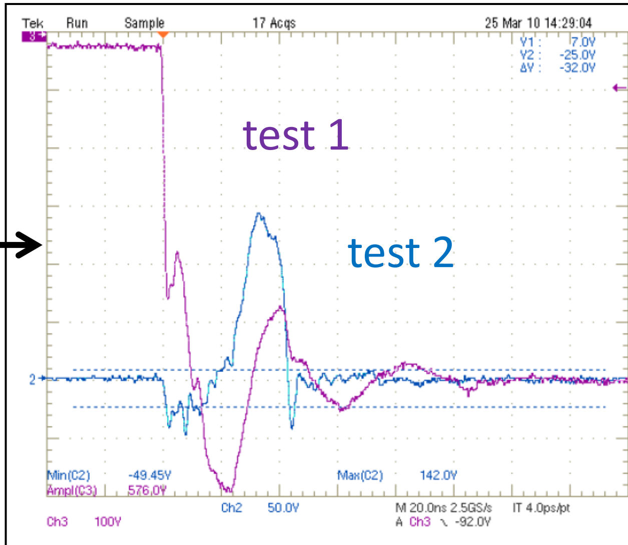
- Compare structures under same spark conditions
- Work just started
  first tested network is the one shown in previous slide

Analysis and future plans

- Look at pulse parameters (Amplitude, RMS)
- Large differences between diodes from different manufacturers
- Capacitor dielectric other than NPO are not reliable, even high voltage rated ones
- Test more structures + ones with embedded network



Inspired from one TOTEM publication



Test of spark protections, *R. Gaglione*

Protection test board

- Compare structures under same spark conditions
- Work just started
  first tested network is the one shown in previous slide

Analysis and future plans

- Look at pulse parameters (Amplitude, RMS)
- Large differences between diodes from different manufacturers
- Capacitor dielectric other than NPO are not reliable, even high voltage rated ones
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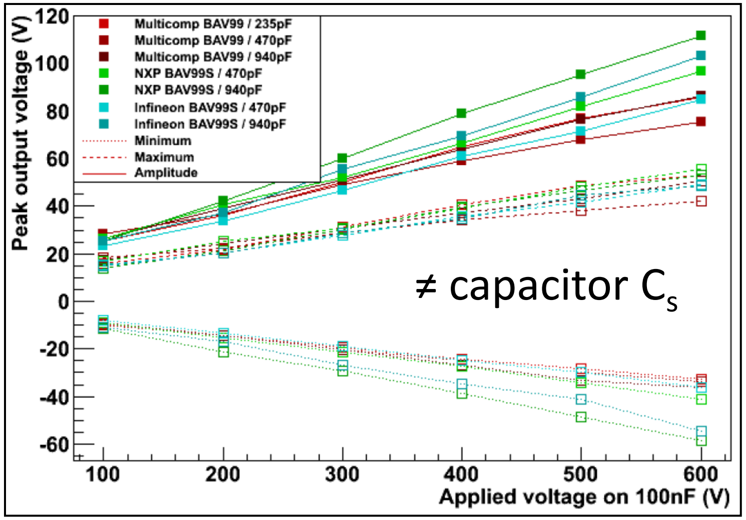
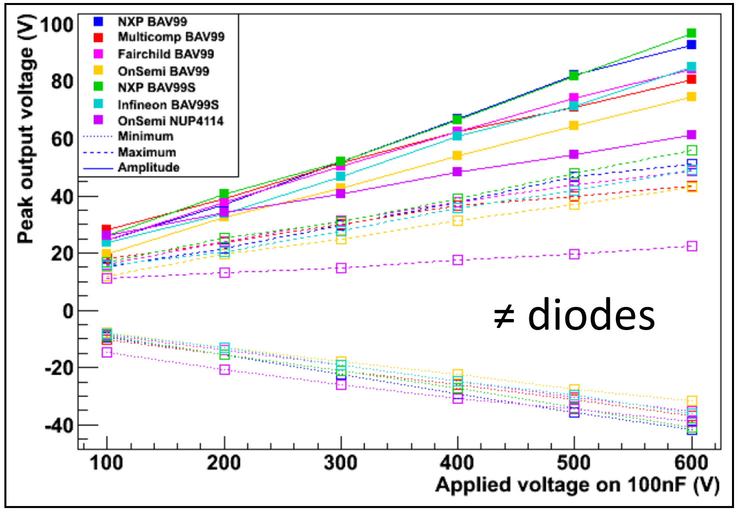
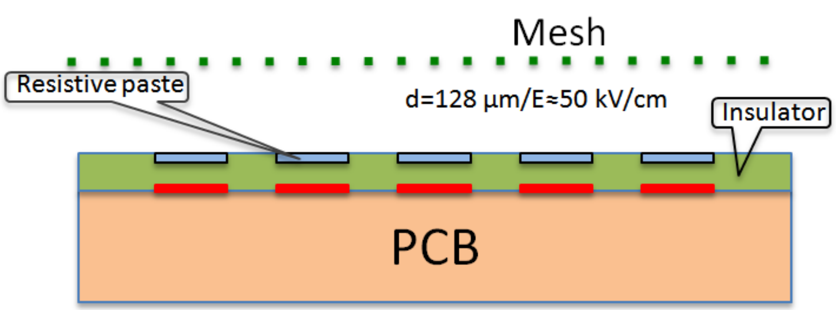




Micromegas for ATLAS progress report,
V. Polychronakos

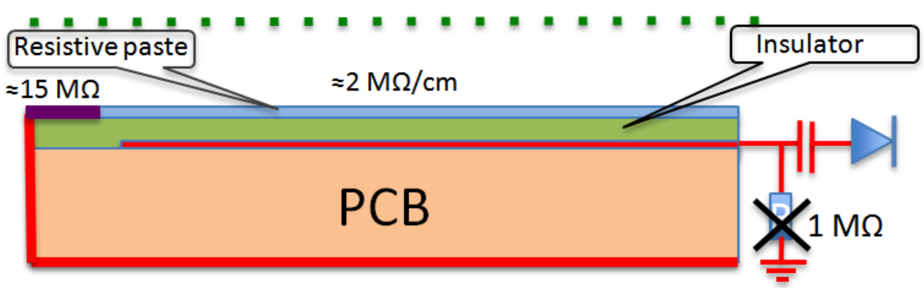
Work on sparks

- Make detector spark proof with adequate resistive coating
- Several coatings & config. tested in beam (R1…R10)
- Test chambers:
  10x10 cm2 with 10 cm long strips at 250 µm pitch



New chamber R11

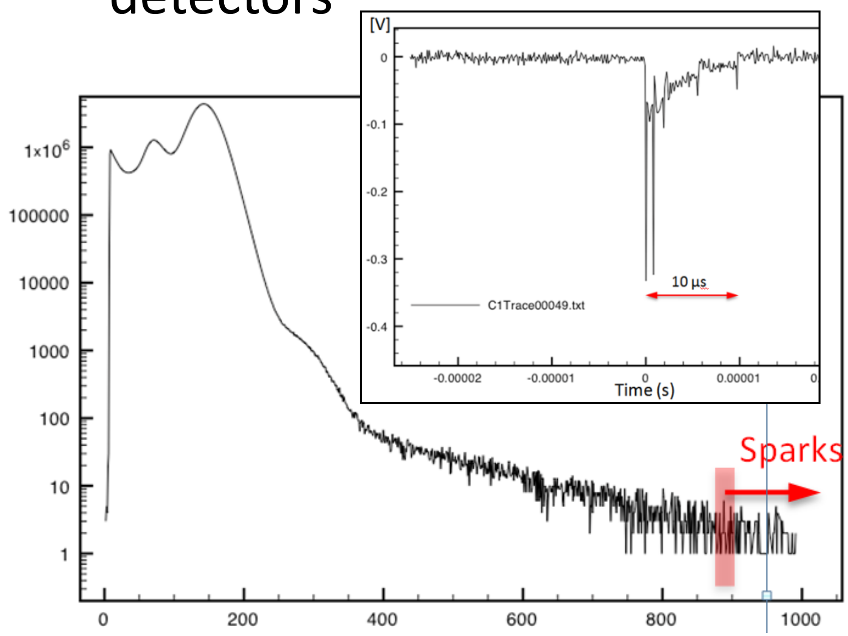
- Resistive strips (≈2 MΩ/cm)
  - are connected through 15 MΩ to ground
  - separated by a thin insulating layer from readout strips
- Readout strips are floating
  - capacitive coupling of signals
- Spark current flows to ground through 15 MΩ



Micromegas for ATLAS progress report,
V. Polychronakos

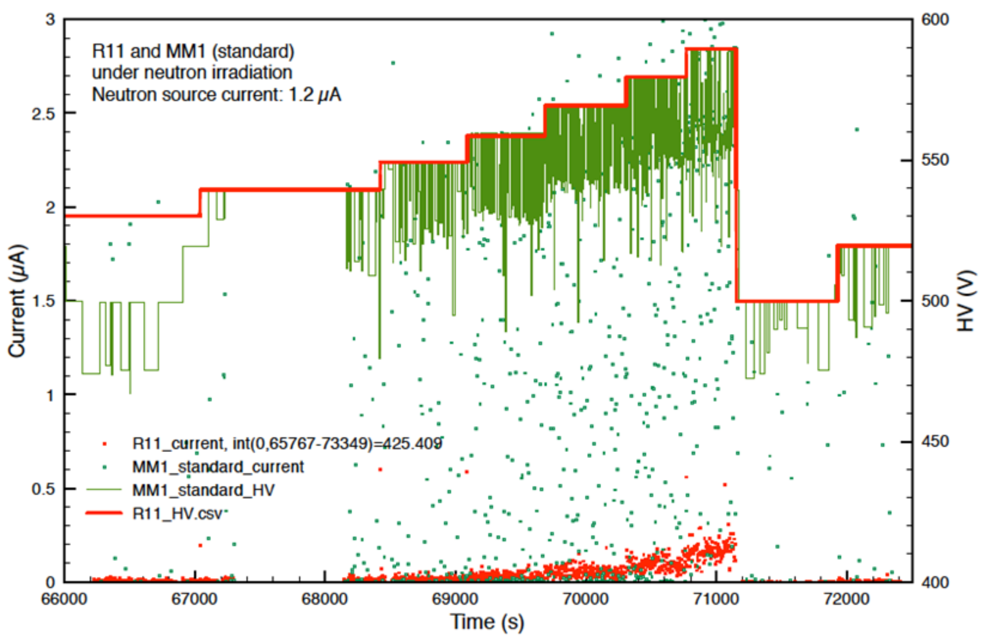
Characterisation with ^{55}Fe

- Gain: 1-2.10^4 max.
- Energy resolution: 25 % FWHM
- Spark signal current 1000 times smaller compared to standard detectors



Test in a neutron beam

- Standard chamber: spark current of several µA
- R11 chamber: 10-20 nA only



Micromegas for ATLAS progress report,

V. Polychronakos

Progress on electronics

- Chip designs for micro-pattern gas detectors are under development at BNL, CEA Saclay, LAPP Annecy…
- Good collaboration between different efforts
- Scalable Readout System is becoming available in summer 2010
- First implementation with APV25 chip to be tested with GEMs and our Micromegas
(maybe already in July test beam)

BNL chip features

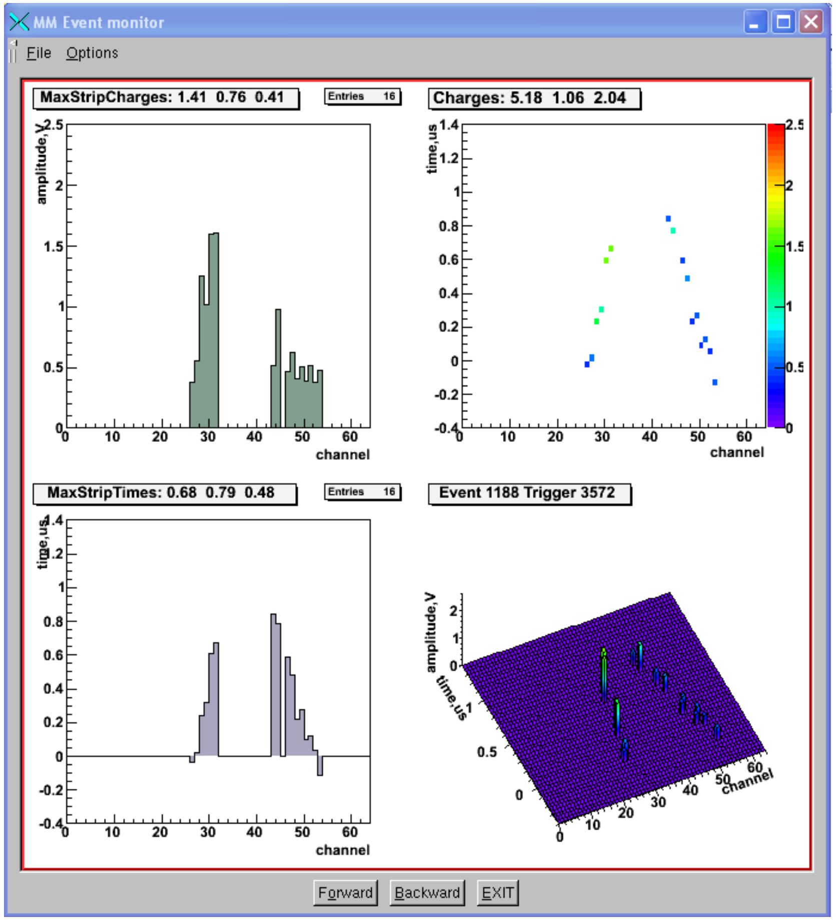
- Data Driven System with Peak Amplitude and Time Detection: on-detector zero suppression
- Neighbour-channel enabling circuitry: high thresholds without losing small amplitudes
- Able to provide Trigger Primitives for on-detector track finding logic
…

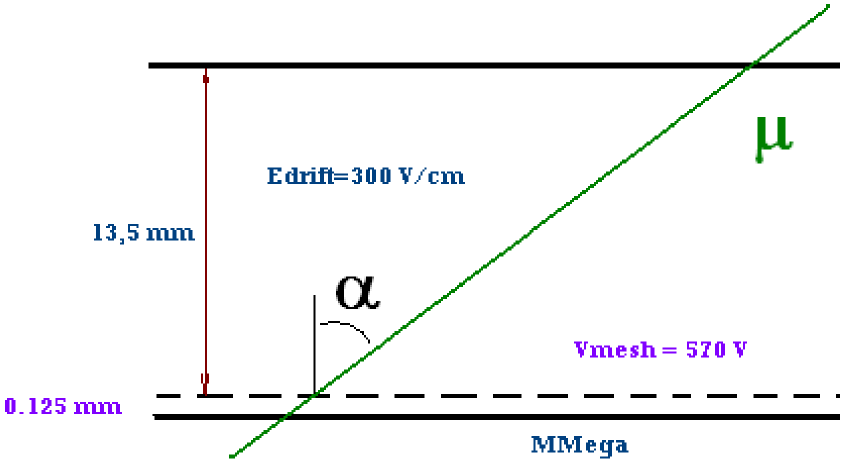
Micromegas for ATLAS progress report,
V. Polychronakos

Example of test of BNL chip with Micromegas

- On-chip zero suppression: only channels that exceed a predefined trigger threshold, plus the two neighbouring ones are analyzed and read out

Simulation

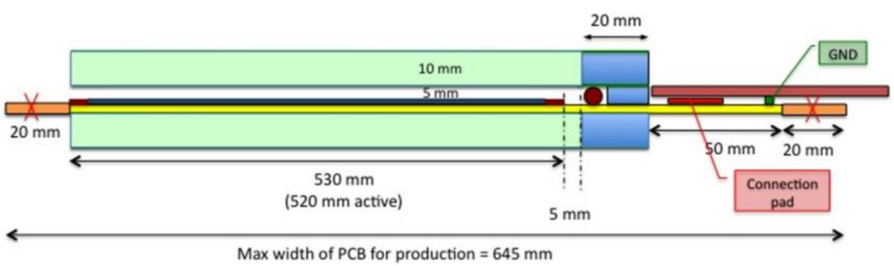


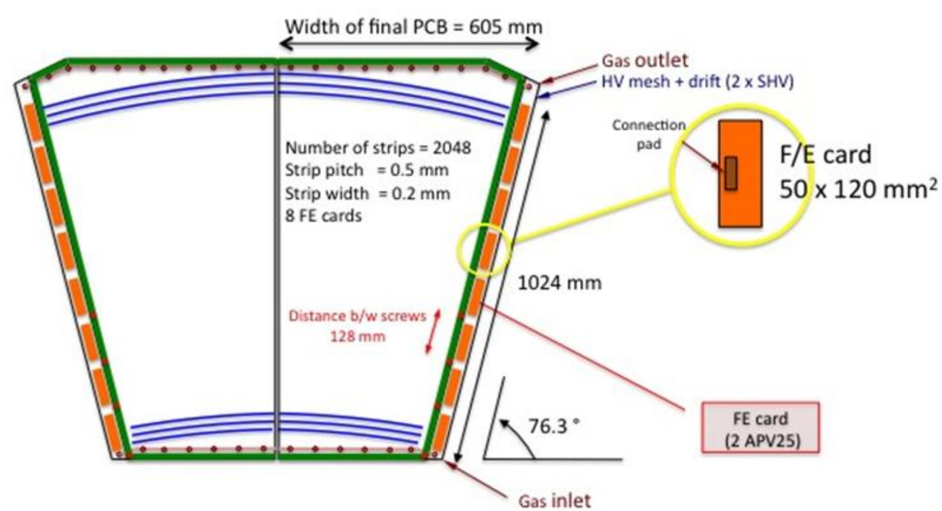


Micromegas progress report, *V. Polychronakos*

Next steps

- R11 chamber:
  - Optimization of R11 parameters
  - Test of R11 in neutron beam at Demokritos/Athens, 3-7 May (done, more studies later this year)
  - Test beam (π's) at CERN SPS/H6 in July and October
- Finalize specifications for readout electronics
- Proceed with full-size prototype
  - single active plane made of two halves is under design
  - probably half resistive strips, half bare
  - APV25 chip and RD51 readout system
- Multi-plane full-size prototype design will start this fall
  - BNL electronics should be available
  - could install a test chamber in ATLAS during 2012 shut down





Generic aging and material radiation hardness studies

TASK 3

Charging up and rate capability

1. Gain stability in uBulk, F.G. Iguaz
2. Resistive uM for ATLAS upgrade, V. Polychronakos

TASK 4

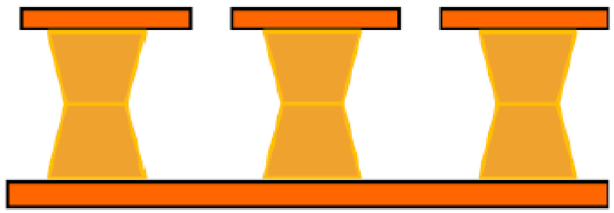
New results of MicroBulk detectors, *F.J. Iguaz*

Motivations

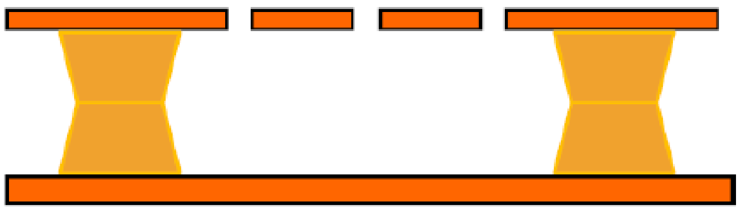
- Gain needs some time to stabilize when certain amount of insulating material are present in the foil
- Studied with GEMs reported hours long stabilization time for some particular geometry
- What about Micromegas(es)?

Different Micromegas

- Standard MicroBulk



- MicroBulk with pillars

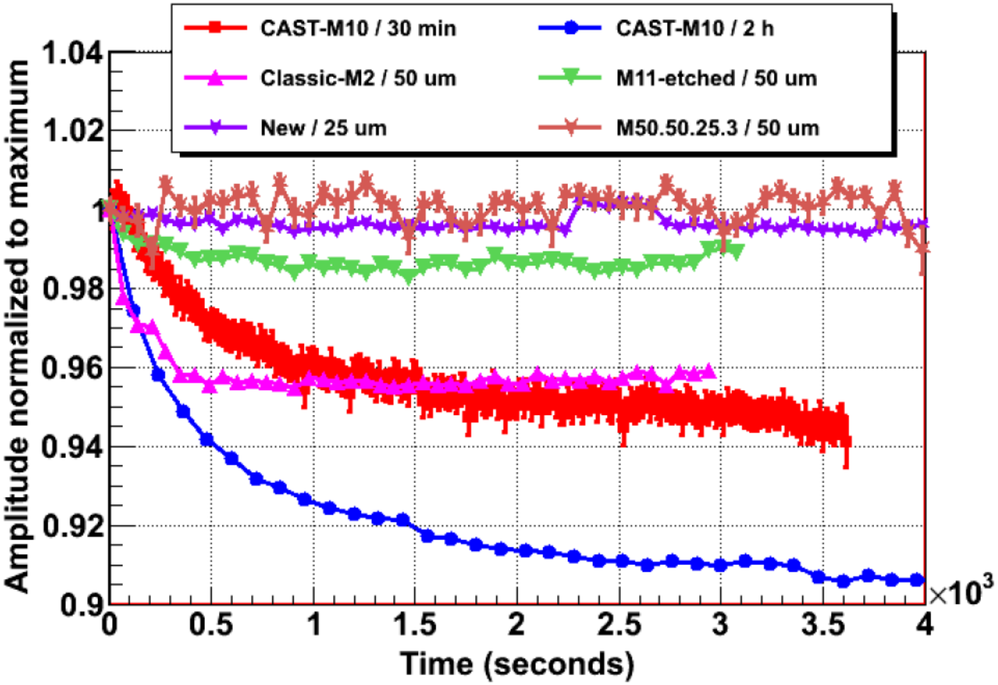


- MicroBulk after being etched
- CAST MicroBulk

New results of MicroBulk detectors, *F.J. Iguaz*

Results

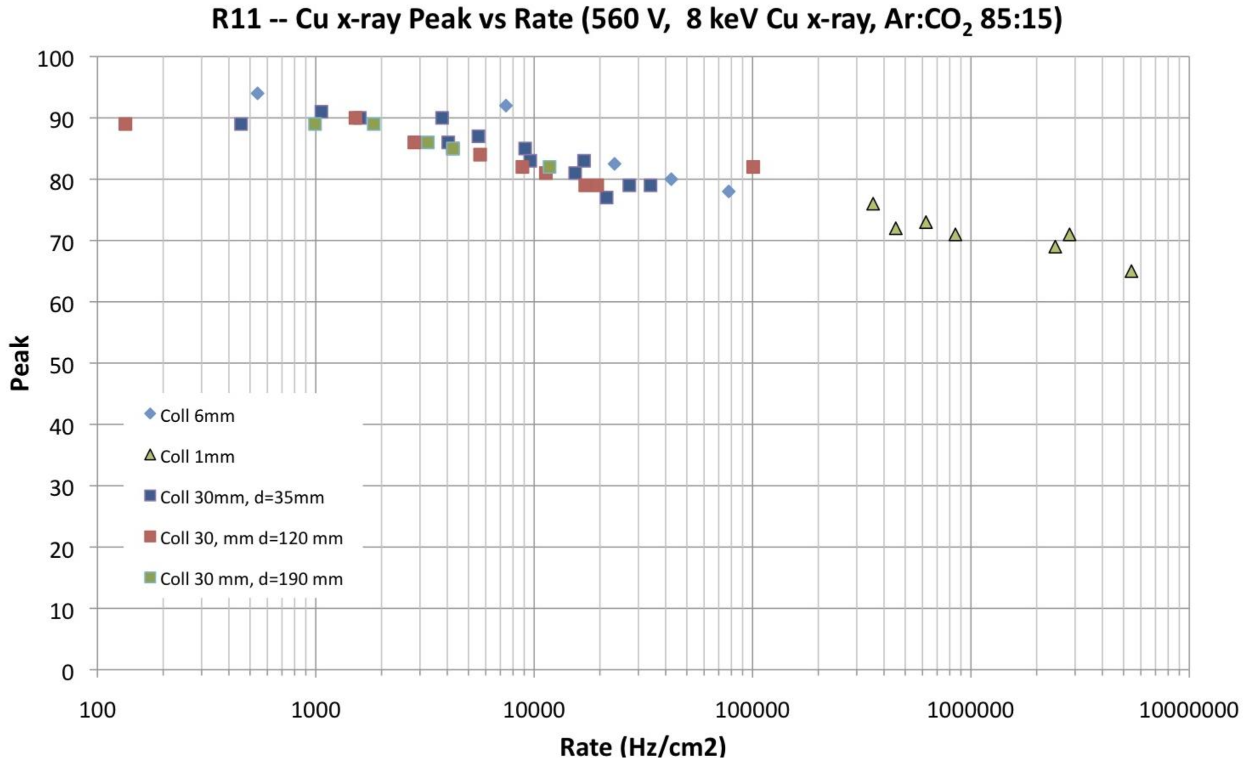
- Micromegas with pillars show no amplitude decrease
- Not the case of standard MicroBulk which show 10 to 40 minutes stabilization times



Micromegas progress report, *V. Polychronakos*

Rate performance of R11 chamber under X-ray irradiation

- Depends on several parameters
  - Gas, detector geometry, irradiation (kind of particles, collimation)



Study of avalanche statistics

1. Ionisation fluctuation studies with TimePix/InGrid, M. Lupberger

TASK 5

Study of gain fluctuations with InGrid and TimePix, *M. Lupberger*

Motivations

- TimePix/InGrid detector
  - Single e- sensitivity
  - New tool to study ionisation phenomena in gases
- Counting the number of primary e- from ^{55}Fe quantum conversions (Fano factors & Polya parameter)
- Measurement of single avalanche charge using chip Time Over Threshold mode (Polya parameter)

Saclay setup

Gas box, volume: 1,5 l

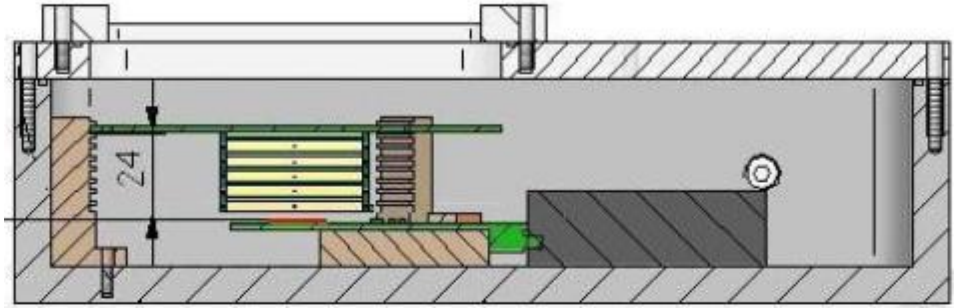
Source: Fe55, directly on cathode

Gas: ArIso 95/5 (ArIso 80/20, P10, CF4)

Readout: MUROS, 36MHz, Pixelman
Filter: > 10 Pixel per Frame

Drift distance: max. 2,4 cm
Amplification gap: 50µm
SiProt: 7µm

Field degrader
No anode plate around InGrid



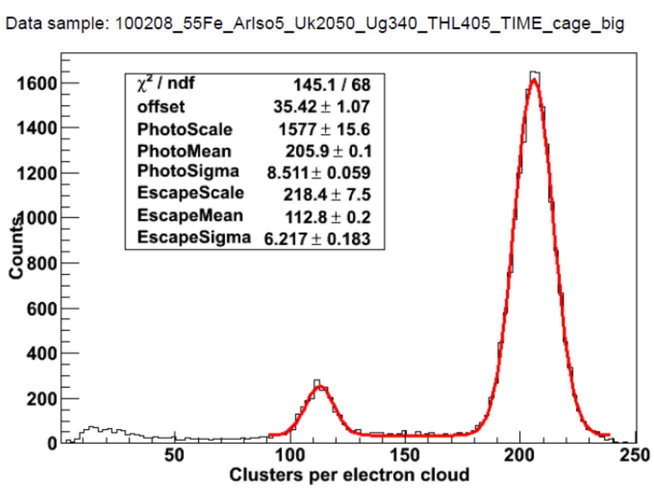
Study of gain fluctuations with InGrid and TimePix, *M. Lupberger*

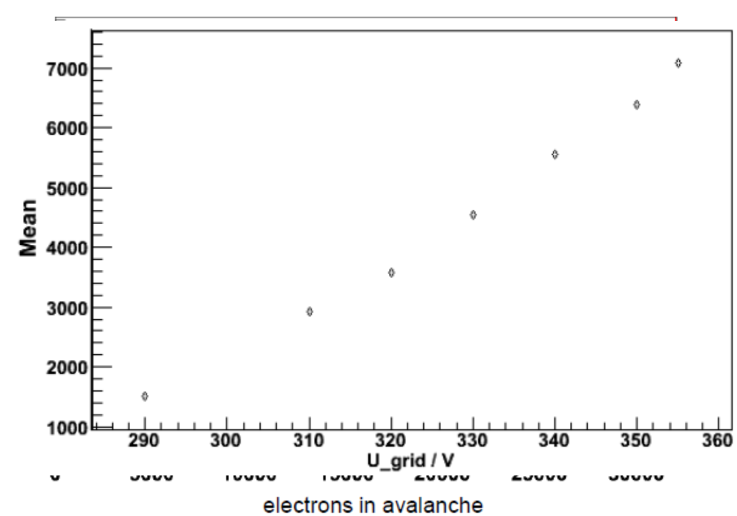
Counting primary electrons

- In Ar/iso 95/5
  - Fano factor of 0.21
  - Parameter θ between 1 and 1.5
- Other mixtures
  - Higher spark probability in P10
  - Too low diffusion in other mix. Enlarge drift up to 10 cm

Time Over Threshold

- Not linear at low charge
  - Fit charge spectra from 4000 e-
  - Just tail fit at low gains
- Trend of Polya mean with gain is not exponential at all!
  - Low gains: TOT calibration OK?
  - High gain: SiProt effect?

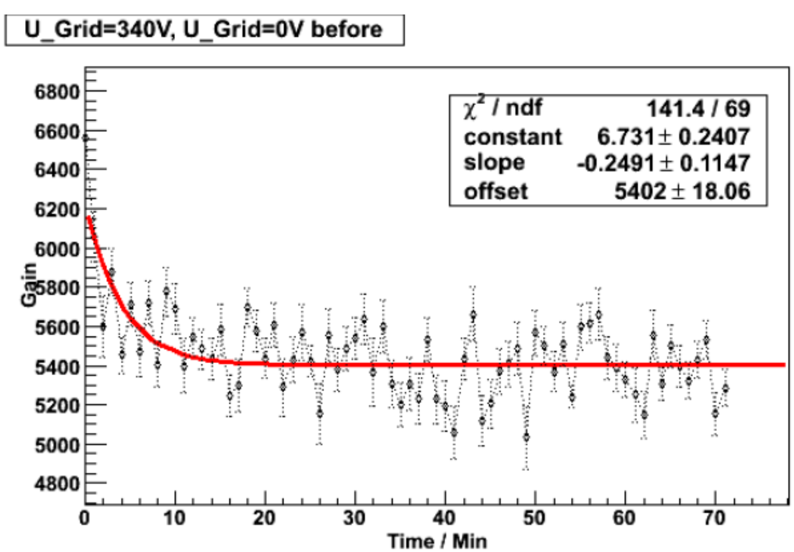




Study of gain fluctuations with InGrid and TimePix, *M. Lupberger*

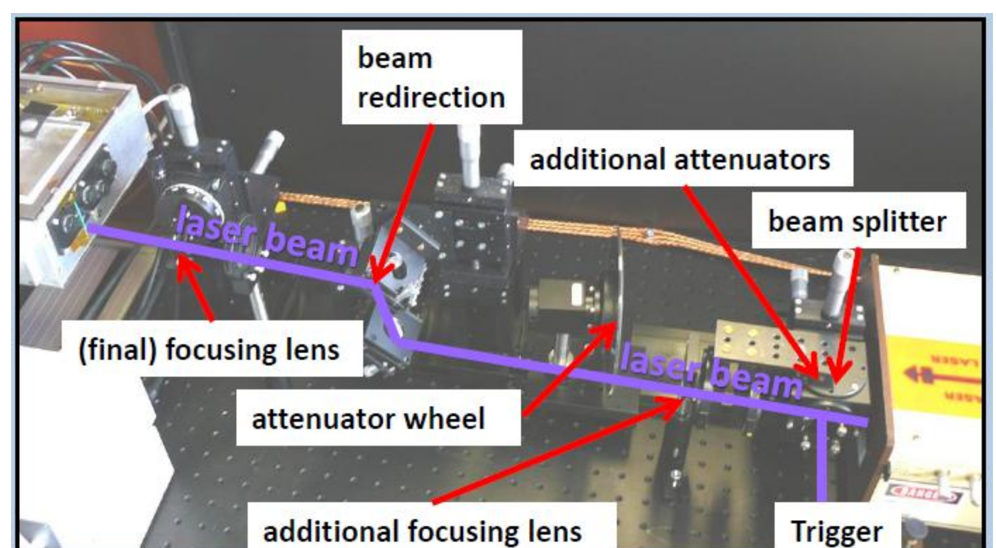
Influence of SiProt

- SiProt acts as capacitor that charges with avalanches and discharges over high resistance
  - Time variation of field and gas gain
  - Gain drop from 6240 to 5402 within 4+/-2 min



Future plans

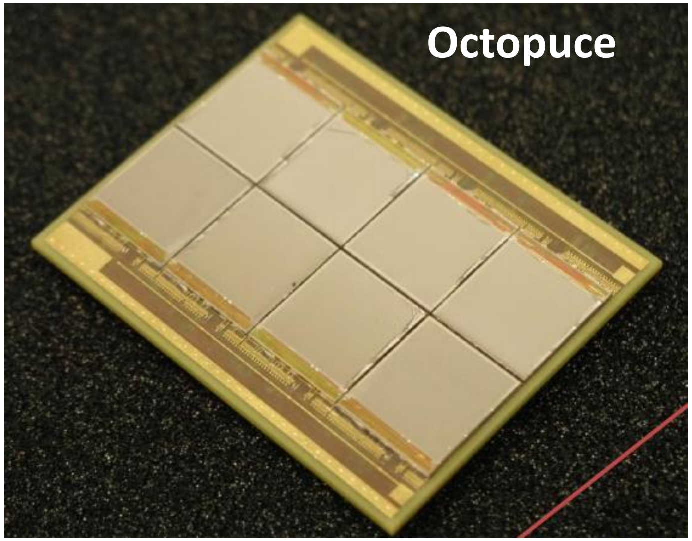
- Laser measurements in Freiburg
  - TIME mode: drift velocity
  - TOT mode: SiProt charging-up and surface scan



Study of gain fluctuations with InGrid and TimePix, *M. Lupberger*

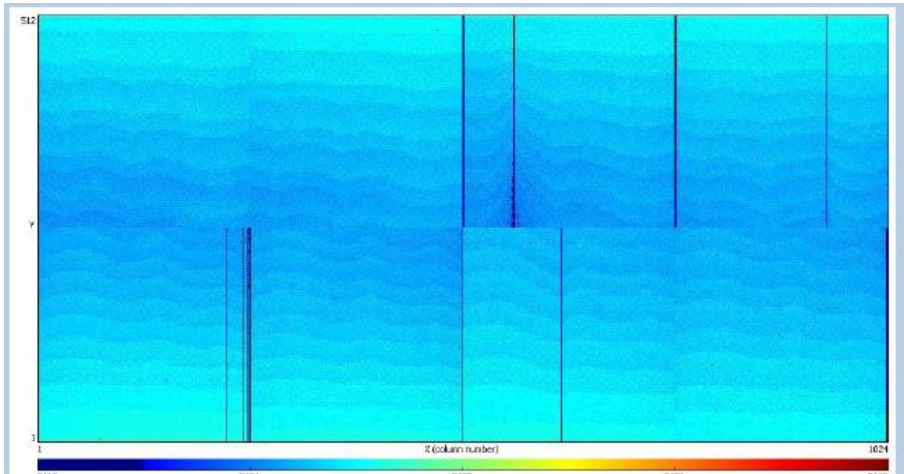
8 chip panel for the LP-TPC

- Board equipped first with bare 8 chips at NIKHEF
- End April: 8 post-processed TimePix on board



Next steps

- HV test of each chip
- Calibrate TOT (noise, threshold)
- Lab test with 55Fe & cosmics chamber is ready
- Beam test @ DESY in LP



Test pulses in TIME mode

Conclusion

- Lot of results presented at this meeting

  Ion backflow, spatial resolution, photo-e- extraction efficiency, spark protections, neutron irradiation, gas gain fluctuations…

  connected to several of the WG2 tasks

- Thanks to the speakers for their contributions

- Thanks you all for your attention