Detection elements for DHCAL, based on THGEMs

report on the test beam results

H. Natal da Luz[1] J.F.C.A. Veloso[1] C. Azeved[1] D. Covita[1] A. Breskin[2] R. Chechik[2] M. Cortesi[2] L. Arazi[2] M. Pitt[2] A. White[3] S. Park[3] J. Yu[3] M. Breidenbach[3] D. Freytag[4] G. Haller[4] R. Herbst[4]

[1]Aveiro & Coimbra Univ. – Portugal (RD51)

[2]Weizmann Institute of Science – Israel (RD51)

[3]UTA – USA (RD51)

[4]SLAC - USA

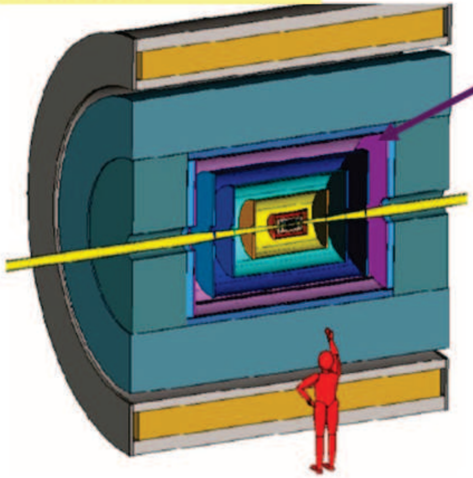
April, 14 2011

Summary

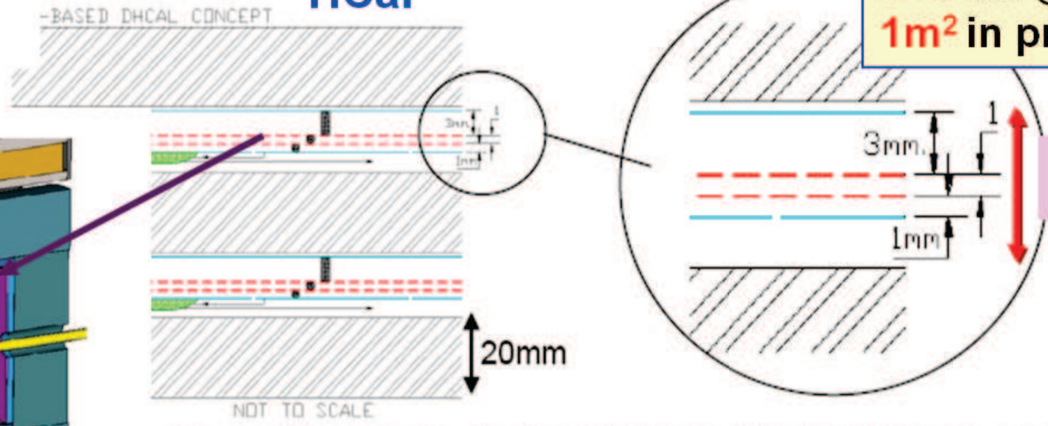
New concept for DHCAL: THGEM

A. White et al UTA

General detector scheme



HCal



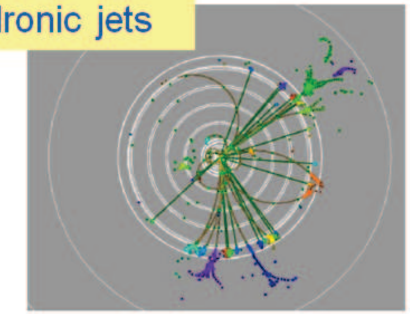
D-GEMs @ UTA:
$1m^2$ in process

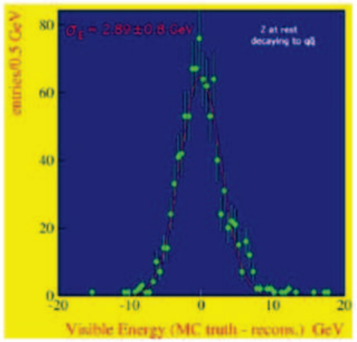
~6.5mm

2 sampling layers (**out of 40**) with THGEM-based elements

Sampling jets + advanced pattern recognition algorithms
➔ Very **high-precision jet energy** measurement.

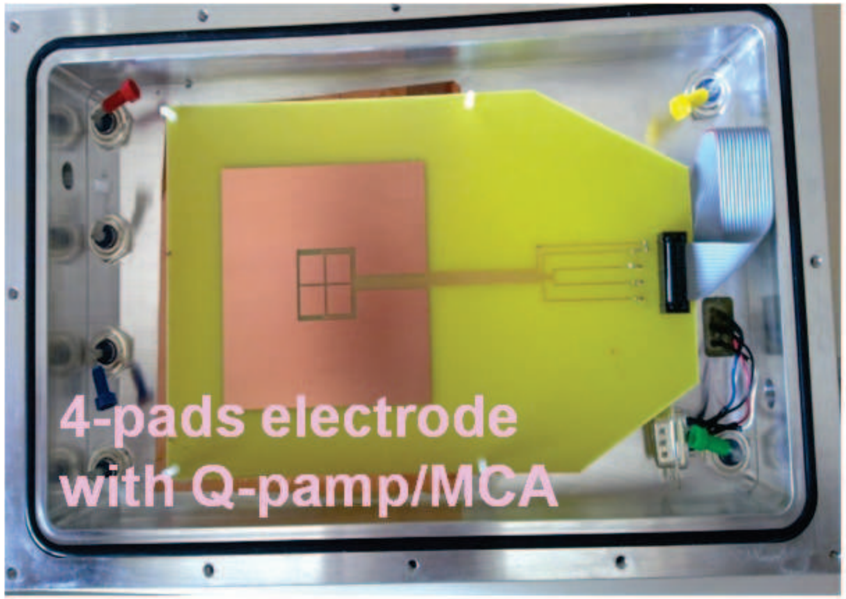
Simulated event w 2 hadronic jets

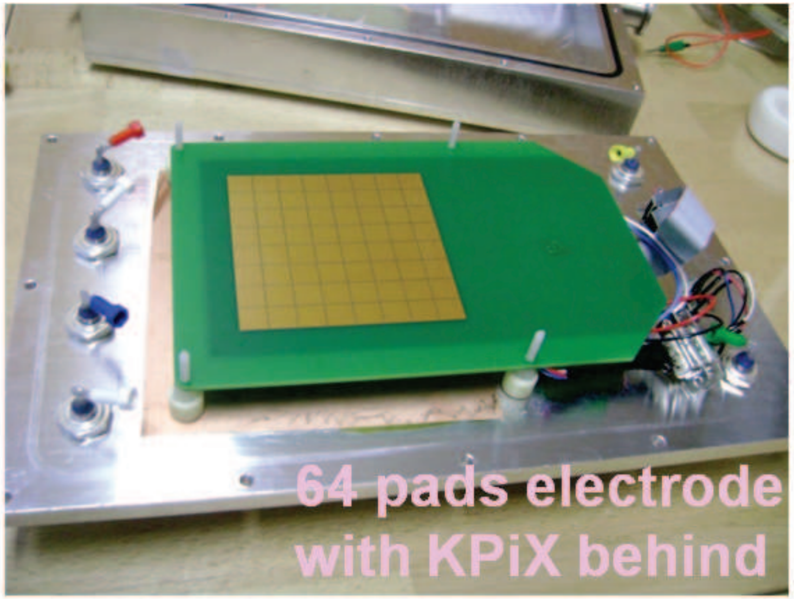




Reconstructed jet:
Simulated energy resolution
$\sigma/E_{jet} \sim 3\%$
(CALICE)

Two diferent readouts

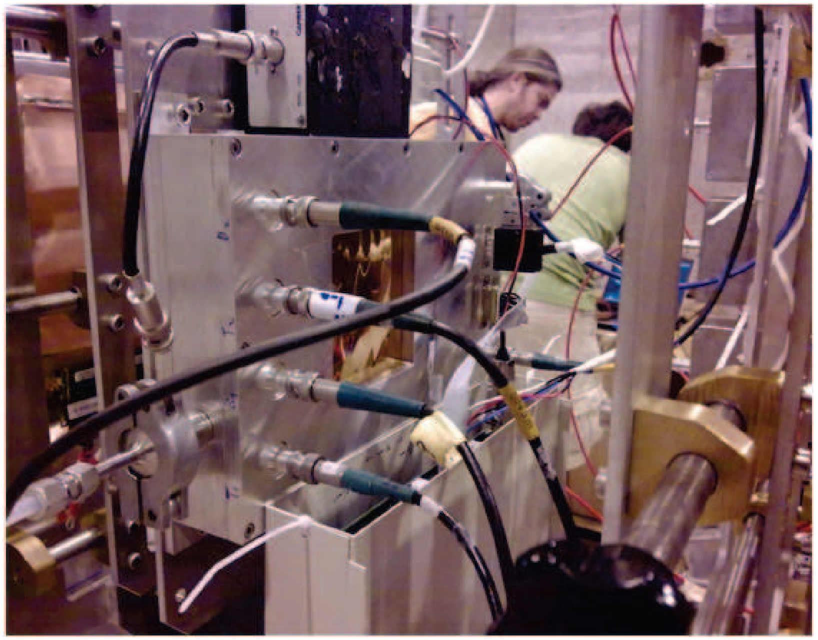




Two diferent types of readout

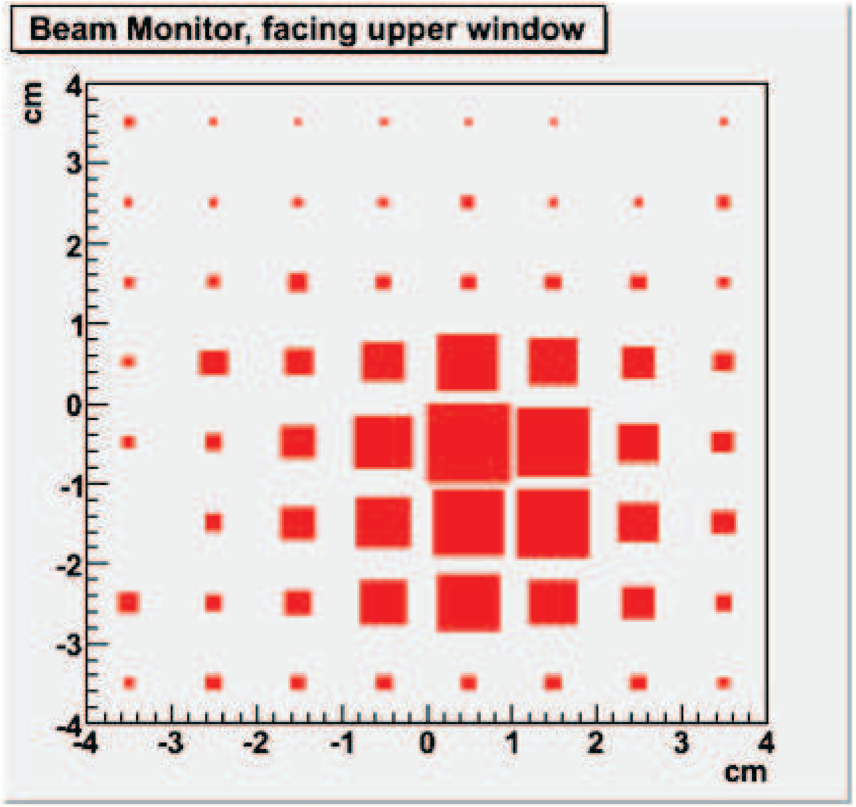
- Standard analog readout from 4 pads to charge preamp, shaping and MCA
- KPiX chip: 64 pads/channels, active area: $8 \times 8\,\mathrm{cm}^2$
  - ILC standard
  - 13-bit ADC in each pad
  - external triggering synched with ILC clock
  - plans exist for larger (up to 1024-pad) version

Installation at SPS/H4 beam line



- Two similar chambers used, one at a time in the RD51 tracker telescope,
- It was possible to swicth the chambers in few minutes.
- System triggered with 3 $10 \times 10\,\mathrm{cm}^2$ scintillators, plus one small $1\,\mathrm{cm}^2$ to isolate pads.

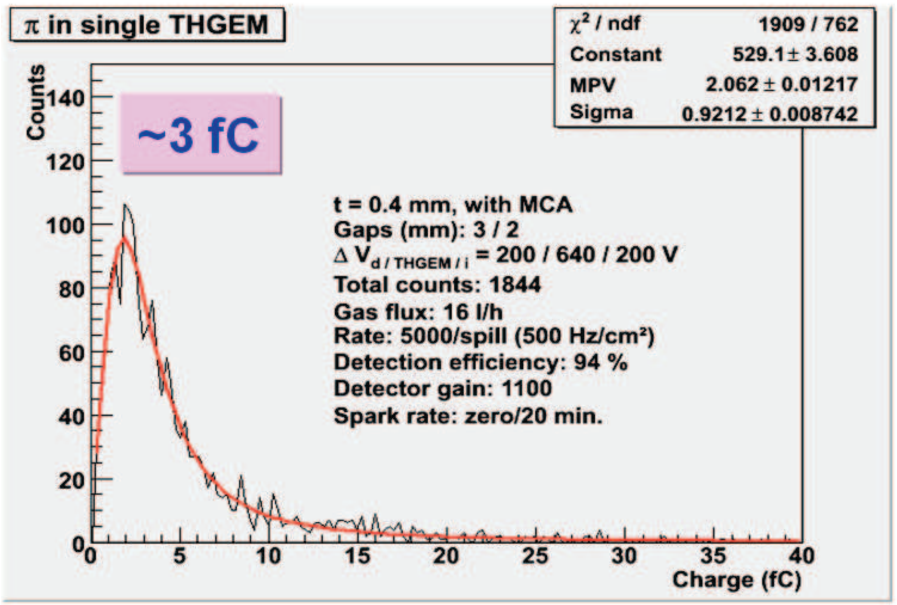
August Results



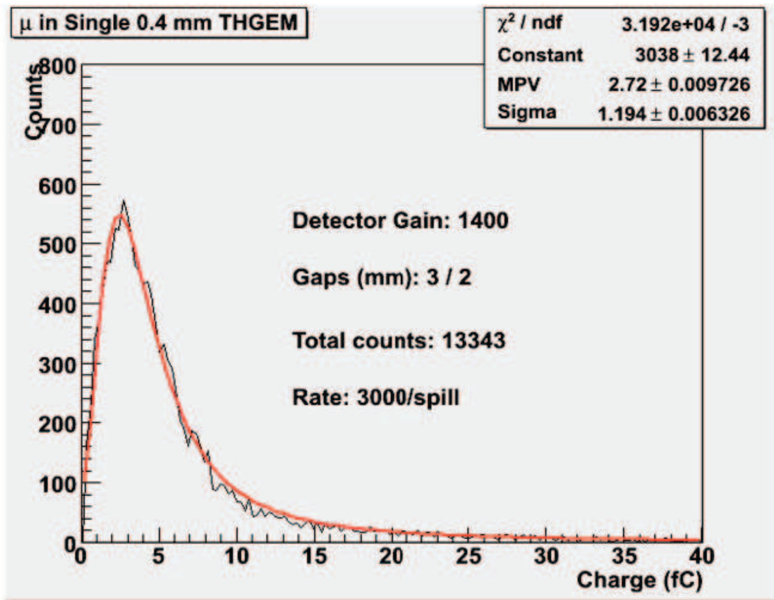
- KPiX worked fine during the first days, but was damaged short after,
- Most of the measurements were made using the standard electronic chain: 4-pads, pream, shaping and MCA,
- The same happened in the October period.

August Results - μ vs π

PIONS



MUONS



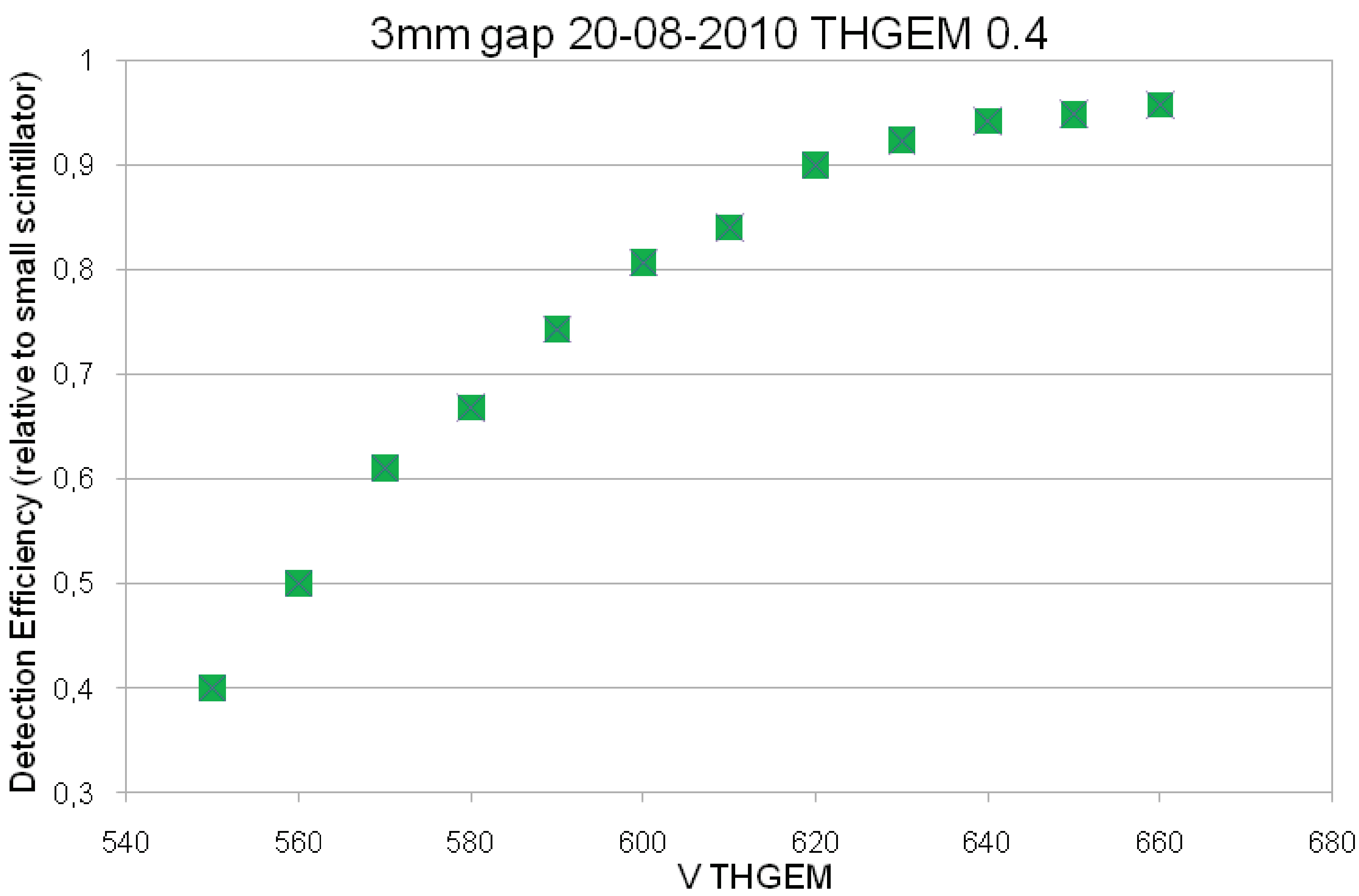
Measured very low discharge rates even with pions @ rates >>ILC

THGEM: 0.4mm

Gain: 1200-1400

- Muons ans pions easily measured, but charge signals very low,
- Spark rate was fine, but KPiX needed higher signals (> 15 fC).

August Results - efficiency



Maximum detection efficiency ($\epsilon = 96\,\%$) was reached very early, even with a small drift gap.

October period

Prospects

- Measurements with KPiX (single and double THGEM);
- Operate at higher gains;
- New multiplier geometries and operation modes (well, gain in induction gap, resistive film. . .);
- Differences when operating with muons and pions.

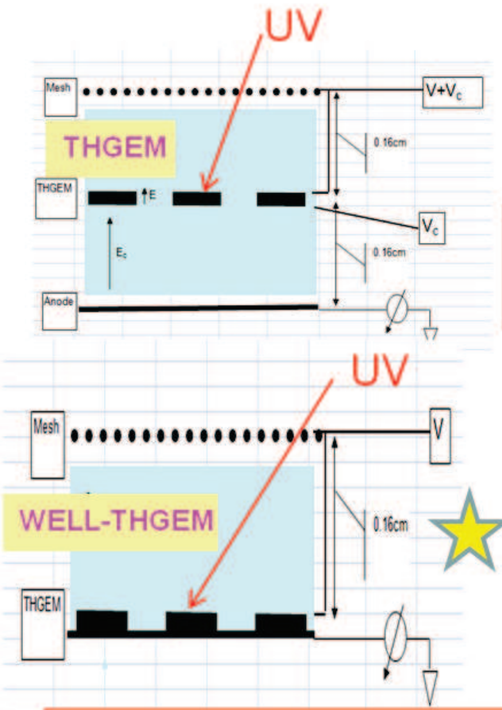
Some drawbacks

- Long MD after 10 hours of beam;
- Two KPiX boards, none worked;
- Long time with a misconfigured beam.

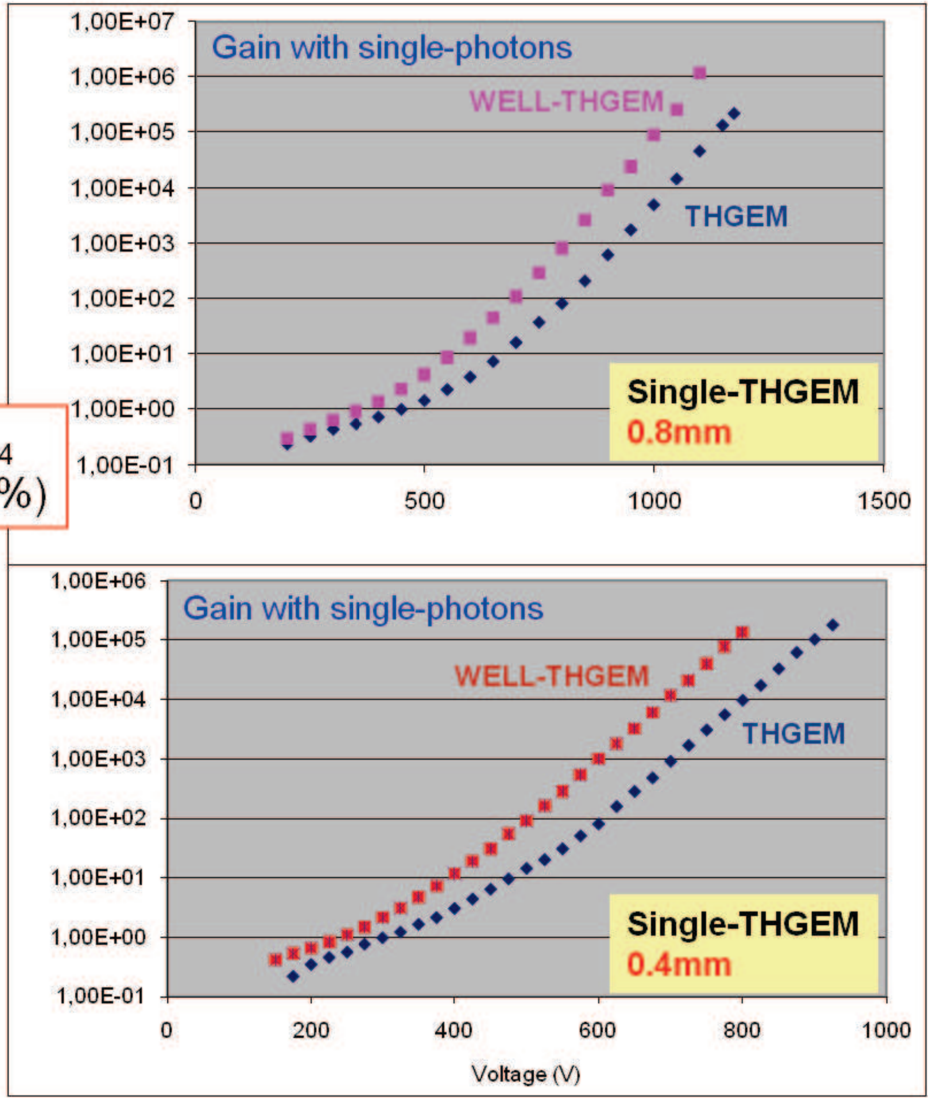
Compact Well-THGEM

(similar to:
Well-Counter of Bellazzini &
of Alfonsi et al. CRETE 09)

Present goal:
Reduce to minimum multiplier thickness



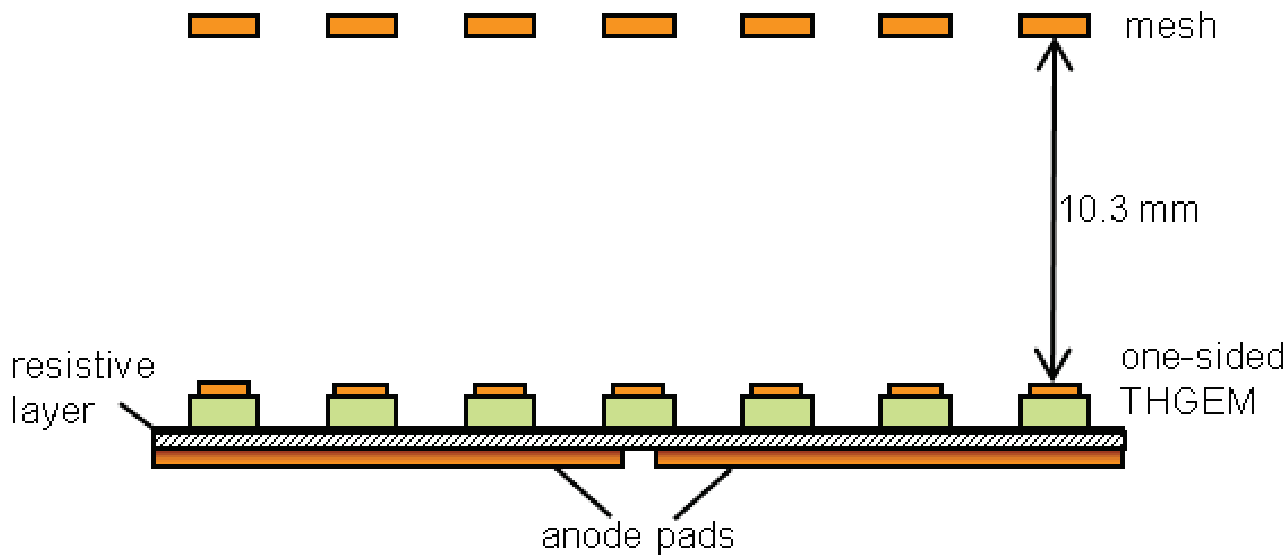
Gas: Ne/CH_4
(%CH_4 ~ 10%)



WELL: lower HV
0.8mm → higher gain

Without induction gap, it is possible to increase the size of the drift gap and the ionization.

Resistive Well-THGEM

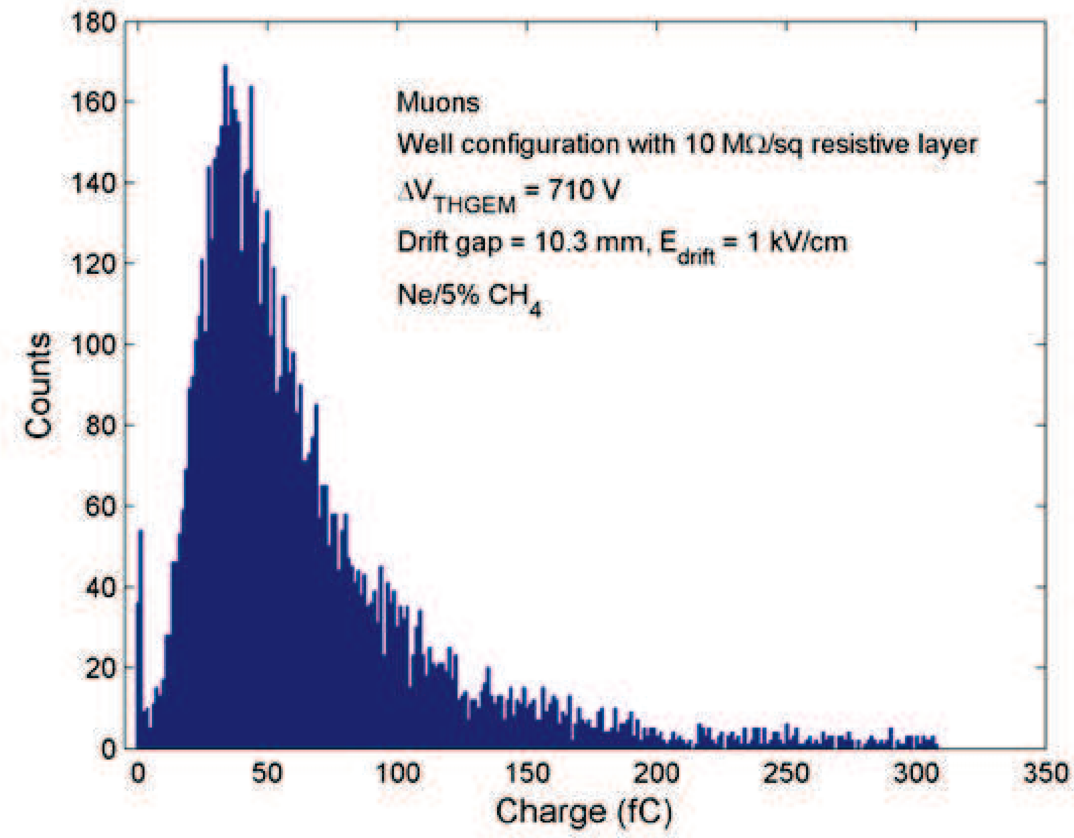


Advantages

- No induction gap
- Ground on both external electrodes
- Spark-protection of electronics

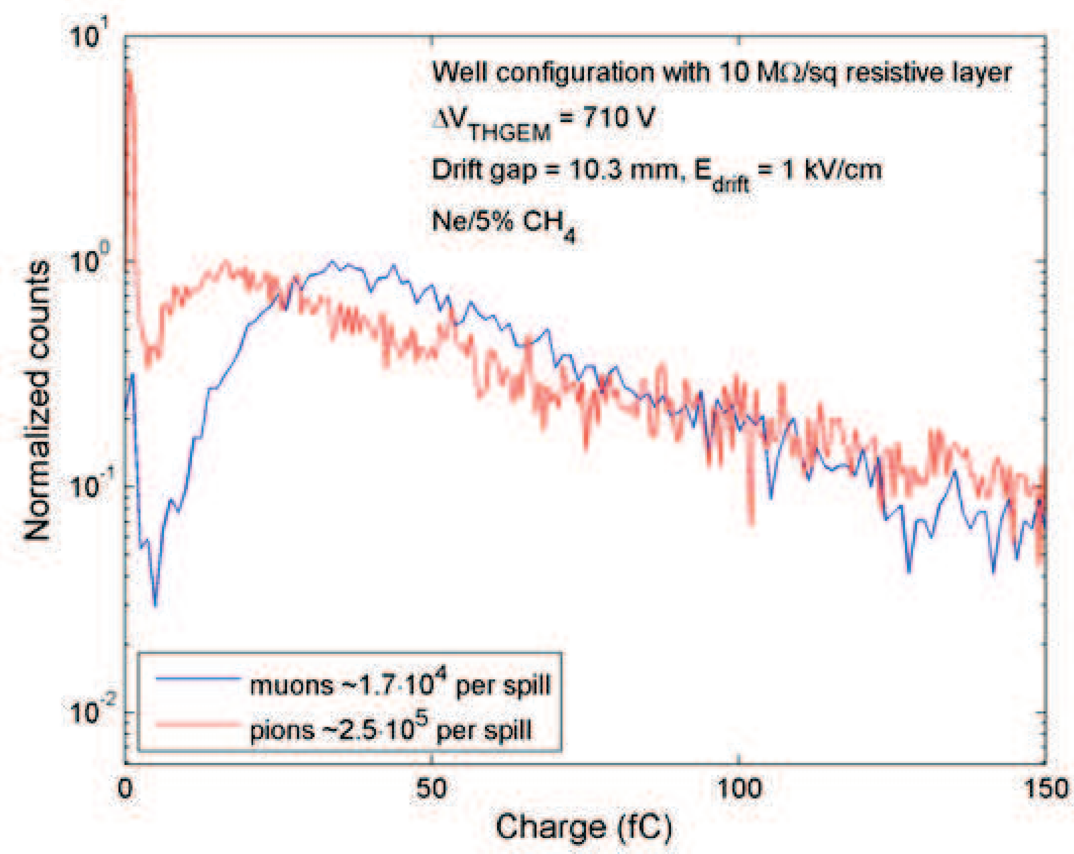
Under investigations at Weizmann

Resistive Well-THGEM



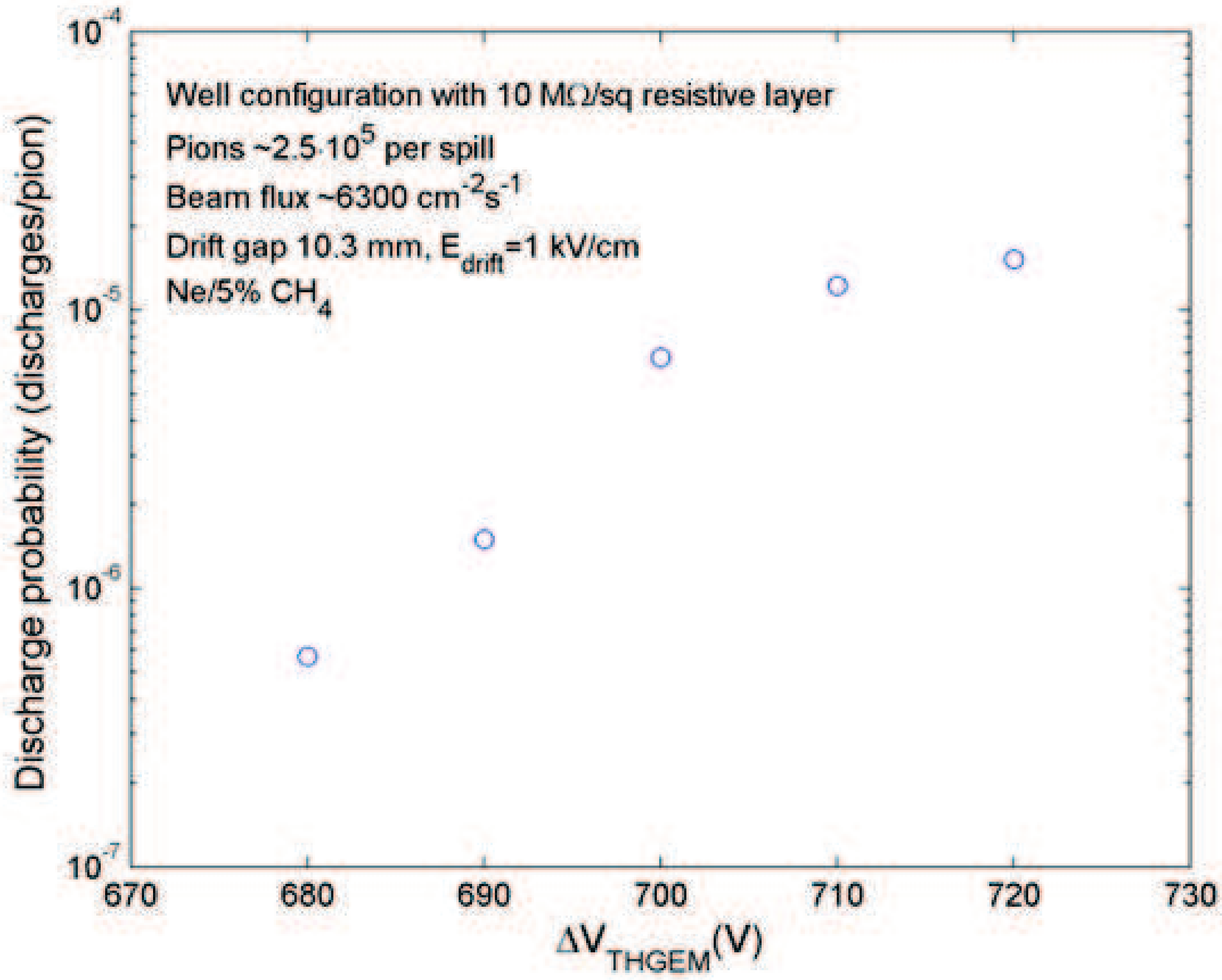
- Acquisition with standard electronics chain (KPiX was not working);
- Very high gain with no sparks ($\sim$ 5600);
- Charge pulses more than enough for KPiX.

Muons vs Pions



- Spectra are slighly different;
- Discharge rate increased with Pions (next slide);

Discharge rate - Pions



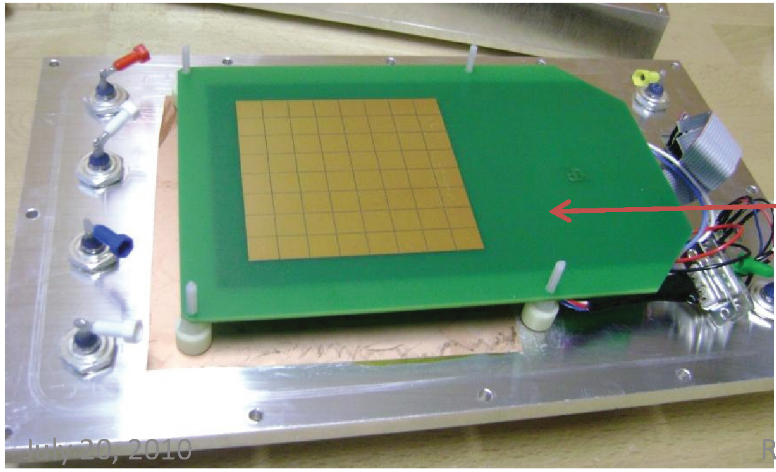
Measurements made at very high rates;

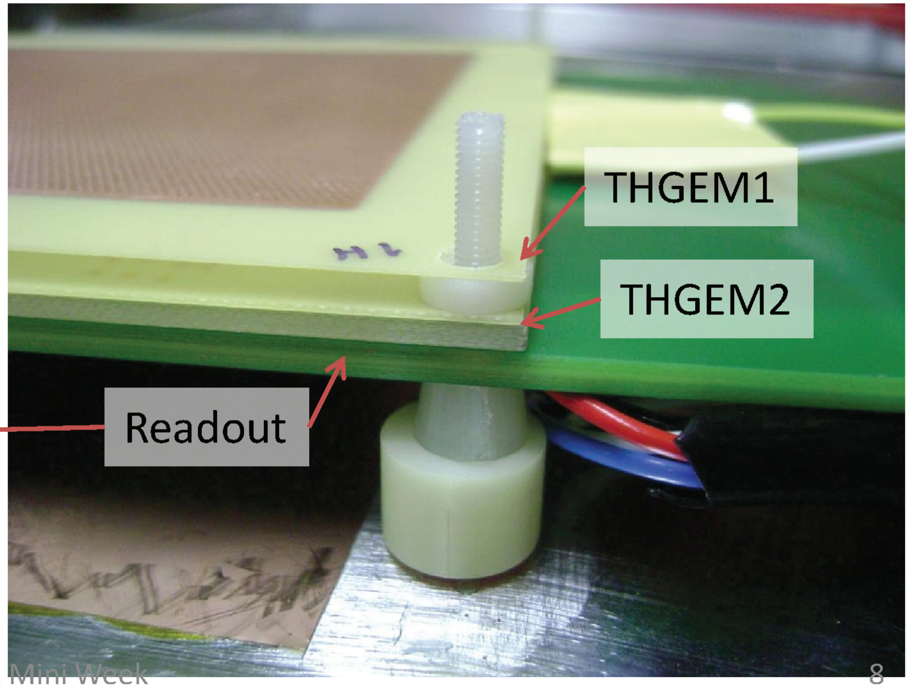
Conclusions

- The well configuration with a resistive layer appears promising: During sparks the voltage drops across the THGEM were of the order of a fraction of a volt, compared to dozen of volts in 'normal' configuration (with no resistive layer and with an induction gap).
- The very sensitive modern electronics SRS/KPIX permits operation at low gains (few fC), leading to stable operation also with hadronic showers.
- THGEMs seem to keep the performance for rates much higher than those expected in ILC environment.

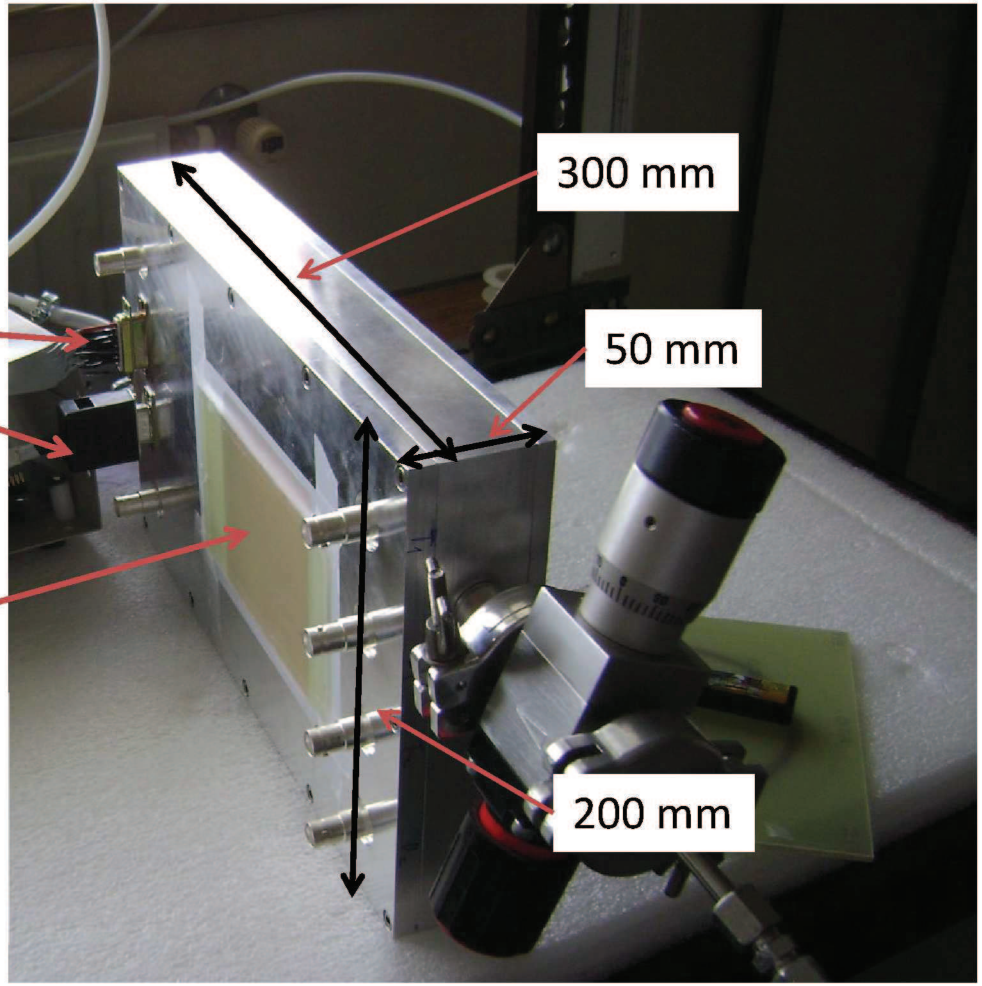
THGEM chamber

- THGEM area: 10x10 cm^2;
- Gas volume: ~280x180x32 mm^3;
- Ne:CH4 (95:5) mixture (non-flammable)
- Gaps: 3/2/2 mm (d/t/i) (might change).





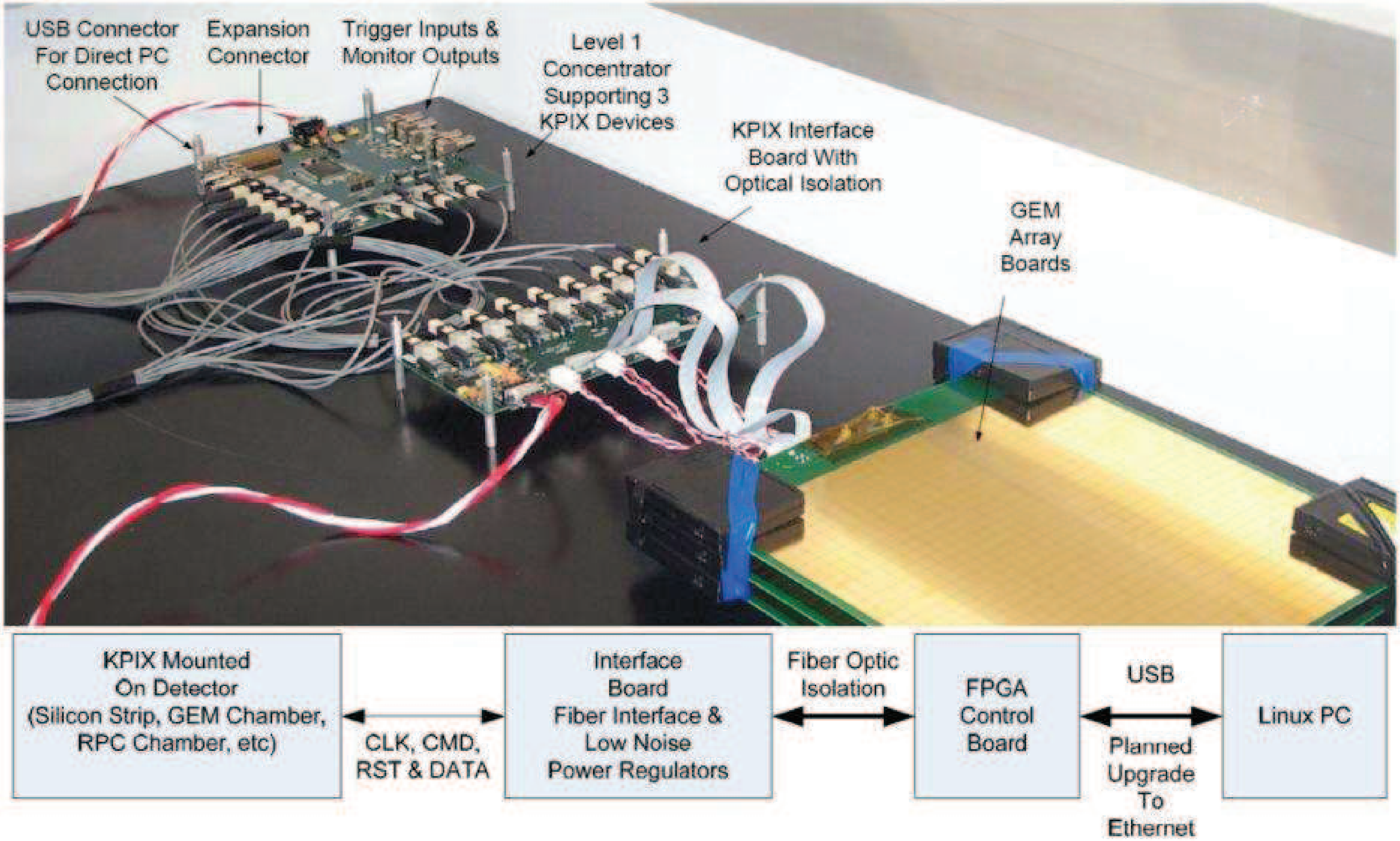
THGEM chamber



Data and power input/output

80*80 mm^2 window on both sides (only the G10 readout & THEMs are crossed by the beam)

GEM-DHCAL/KPiX boards with Interface and FPGA boards



DHCAL studies for THGEM chambers + Kpix9:

- Establish working Kpix9 readout, check data against previous results.

- Establish MIP signals, noise distributions for low rate beam in a number of pads.

- Measure the variation of MPV of Landau distributions with HV for a series of chamber positions/pads - move the chamber to hit different pad areas.

- Take combined data with THGEM and tracker system to establish tracks/pads correlations.

- Take series of runs with the chamber moving the chamber across beam to measure efficiency for each pad, sharing of signals between pads.

- Rate/time resolution studies.

Some needs

- KPiX linux computer remotely controlled from control room through ethernet;
- HV and LV also remotely controlled (CAEN SY2527);

No.Channels	Vmax	Ityp	purpose
5	-3000 V	300 nA	THGEM
3	+2000V	1mA	PMT
1	+7V	3A	Electronics, remote controll

We have used the CAEN main frame, together with boards A1821H (negative) and A1833 (positive) and everything was fine.

-NIM crate and coincidence logic for trigger and for analogic signals.

-KPiX electronics must communicate with tracker to allow event correlation;

-Mechanics to hold THGEM chamber: the same as used beforer