



TPC GEM readout R&D

Snowmass workshop

July 14, 2001

Carleton GEM group:

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Hans Mes, Jean-Pierre Martin, Ernie Neuheimer

<http://www.physics.carleton.ca/~karlen/gem>

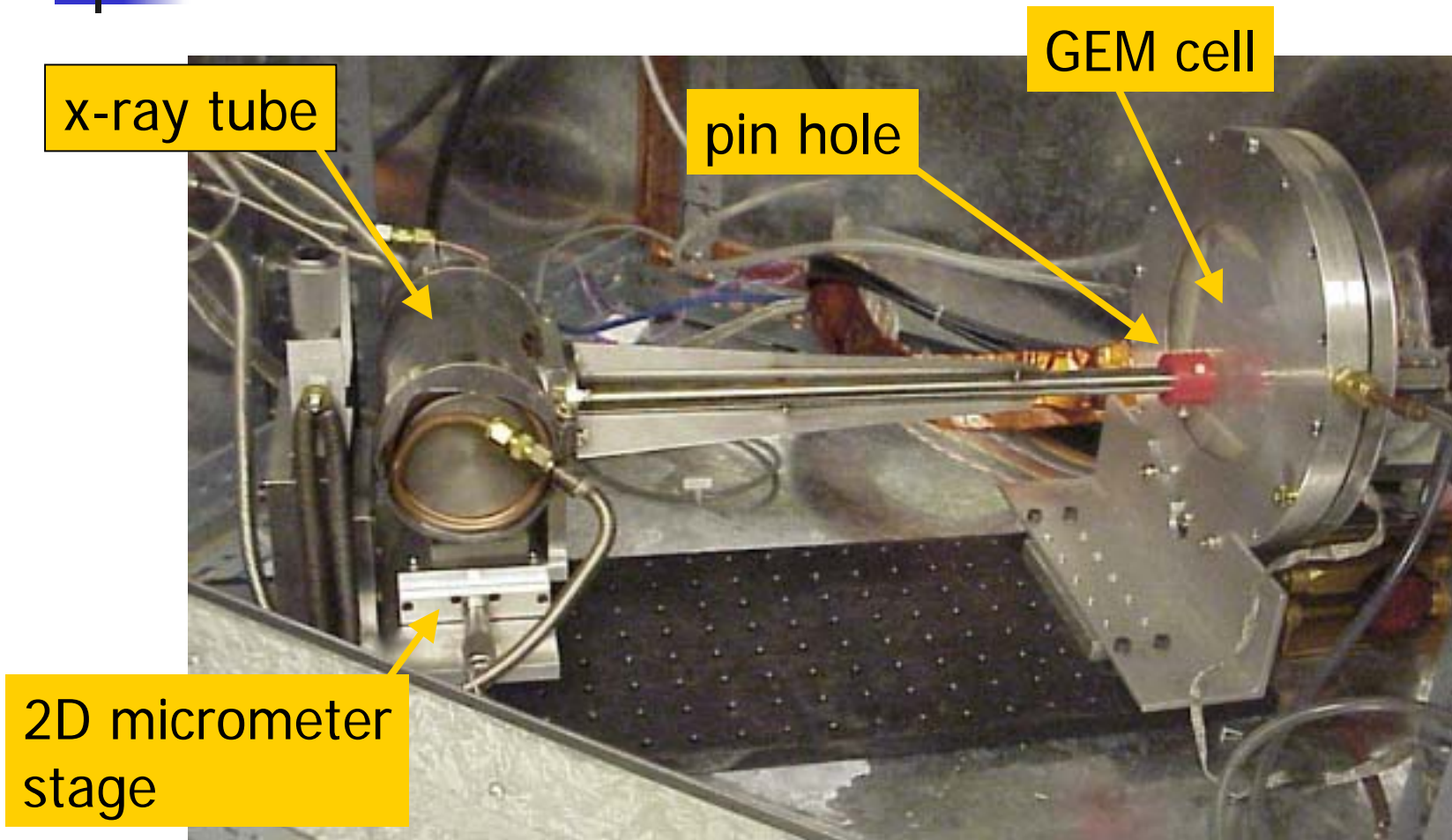


Goals

- To demonstrate that the potential advantages for GEM readout can be realized:
 - Improved space point resolution
 - $E \times B$ and track angle systematics suppressed
 - Improved two particle separation power
 - $r - \phi$: signals distributed over smaller area
 - z : faster induction pulses ($v_e > v_{ion}$)
 - Natural ion feedback suppression
 - no gating required (non-triggered expt.)
 - Less mass in the TPC endcap
 - no wires held under tension

present
focus:

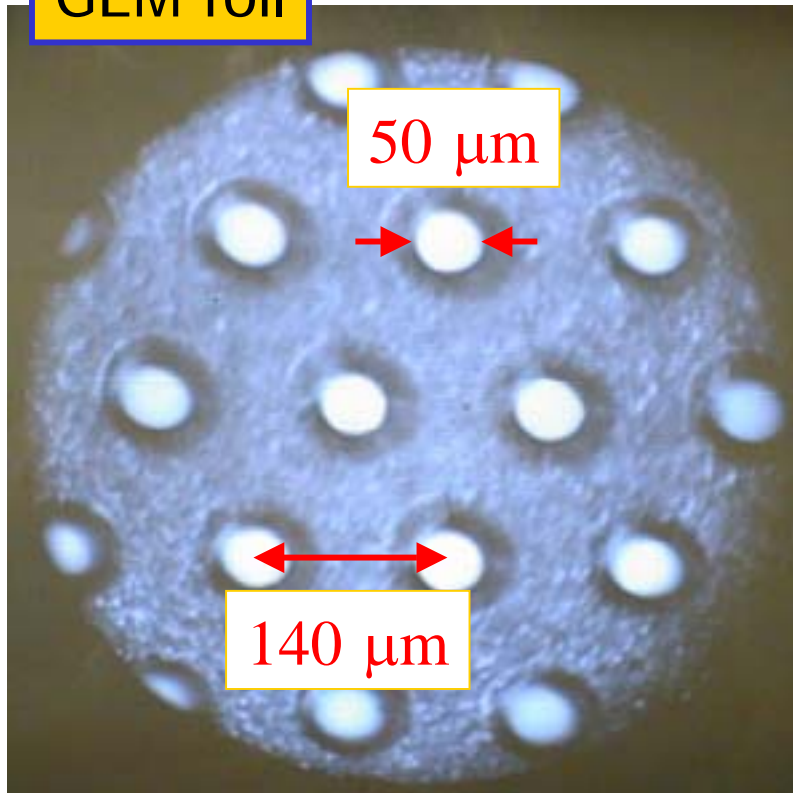
Point resolution studies at Carleton



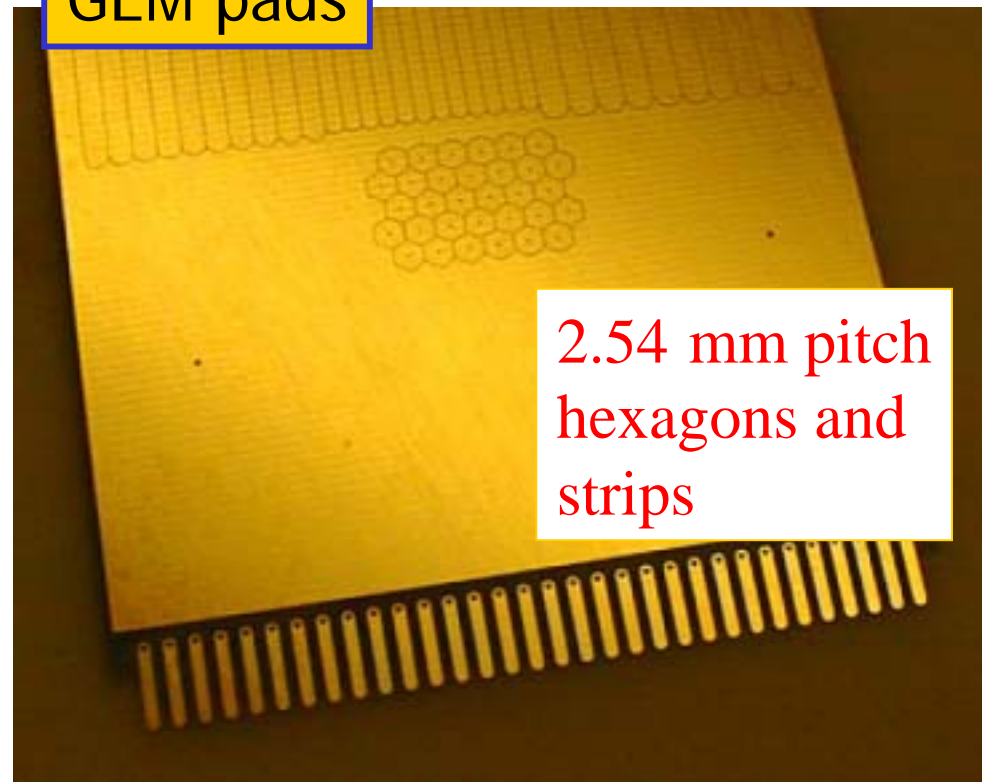
GEM foils and pads

fabricated at the CERN PCB workshop

GEM foil

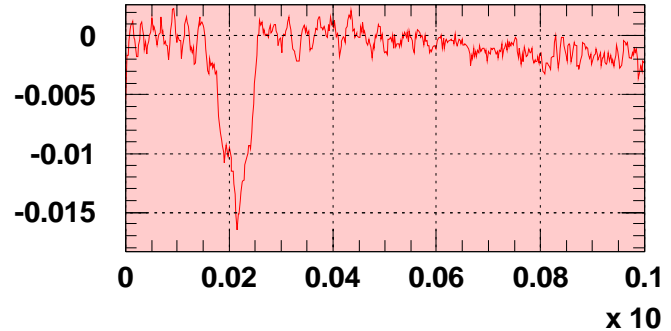
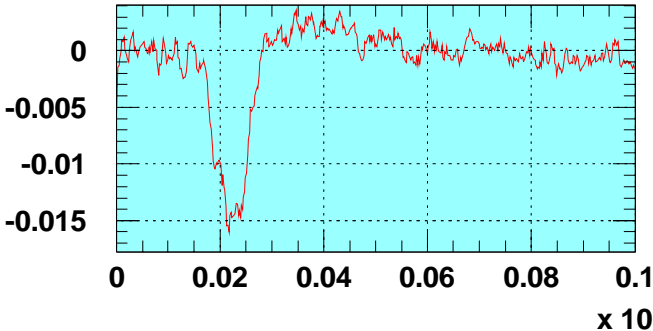
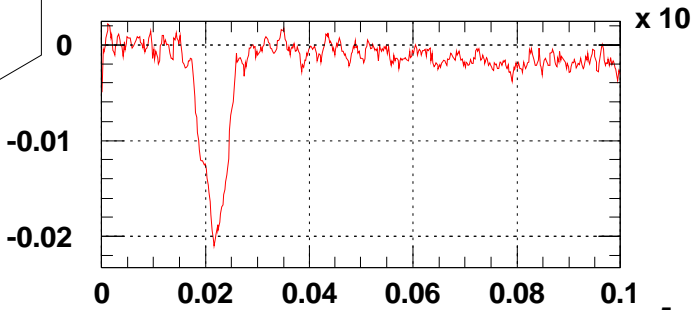
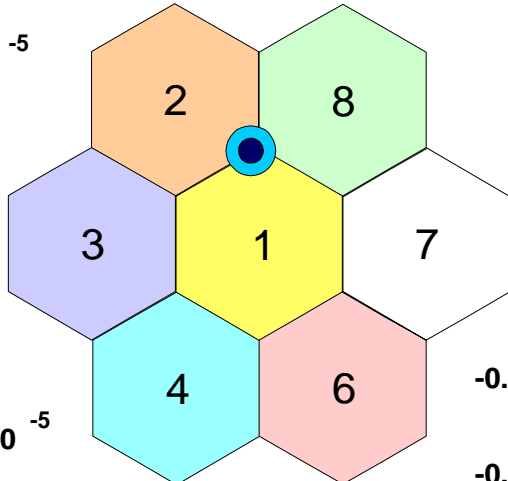
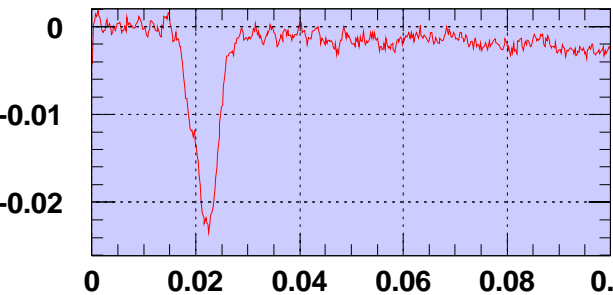
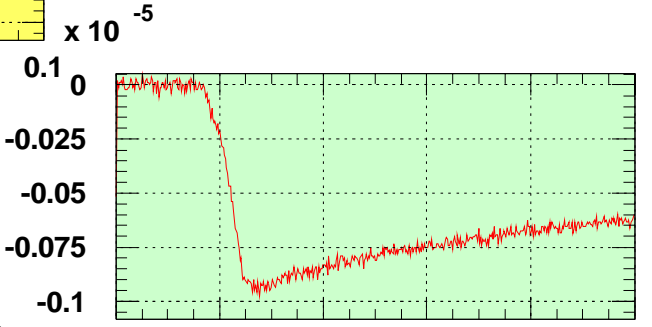
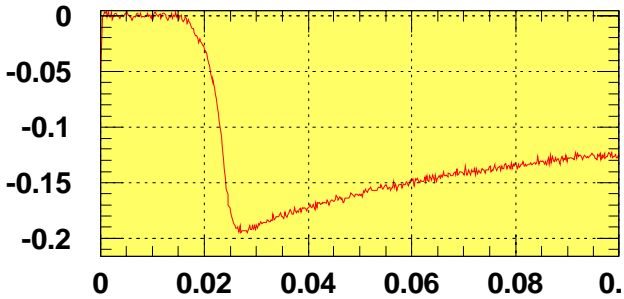
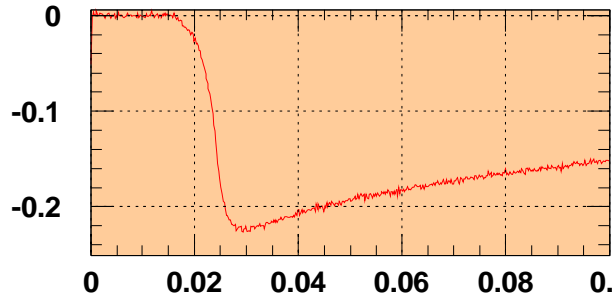


GEM pads

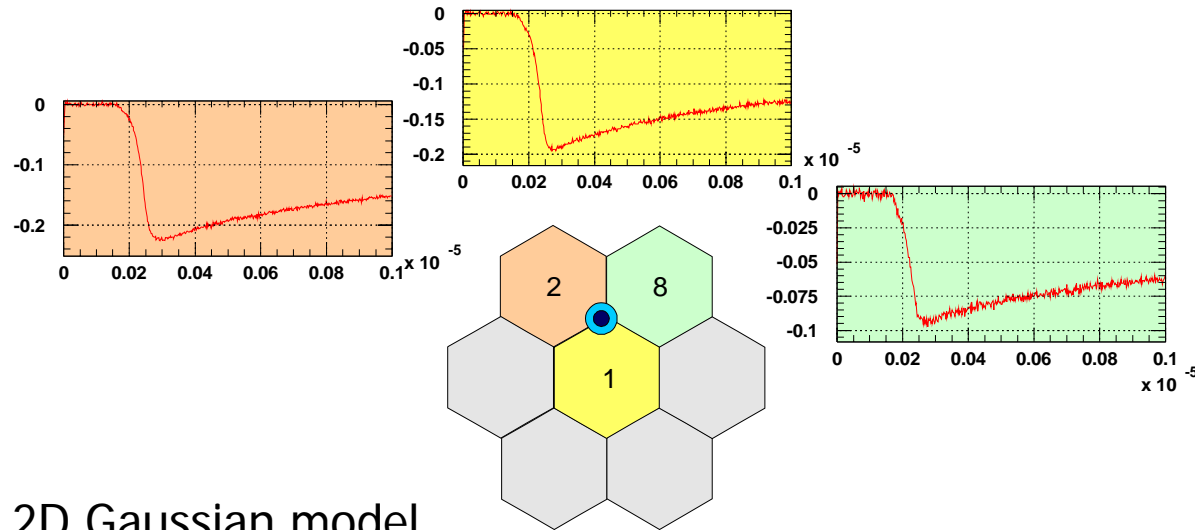


An event

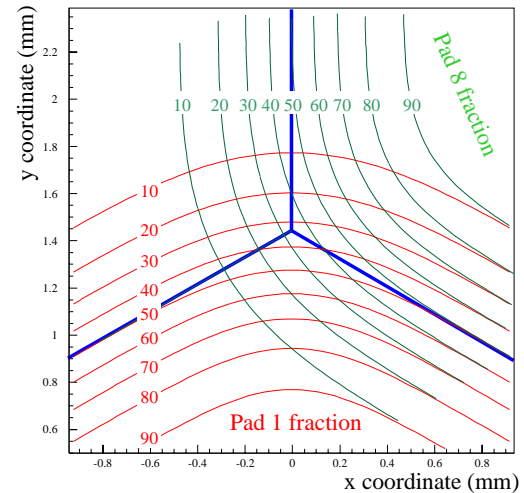
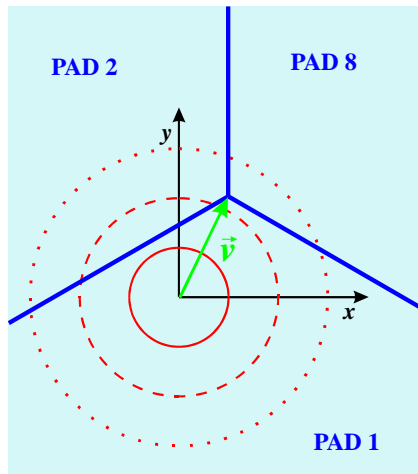
Ar CO₂ (90:10)
HQV810 preamps



Position estimate from charge sharing



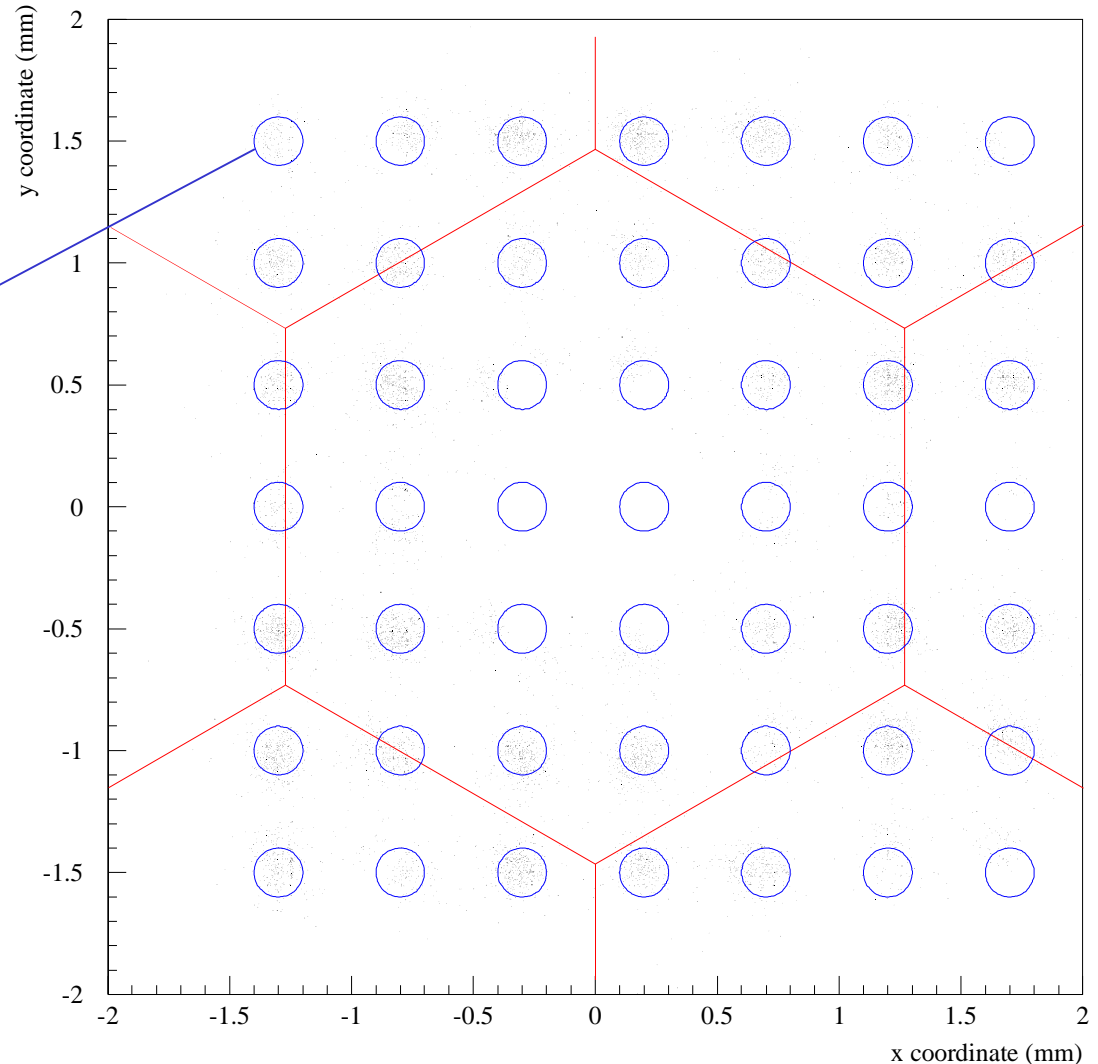
2D Gaussian model



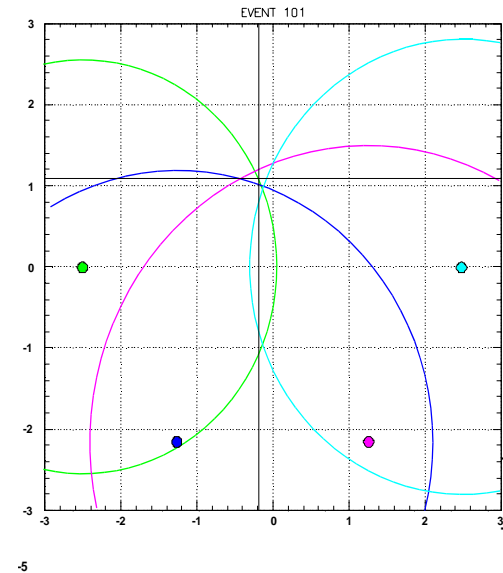
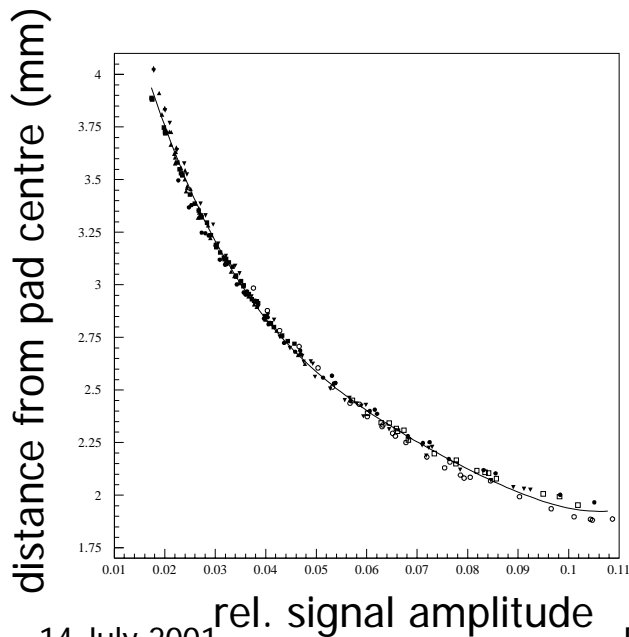
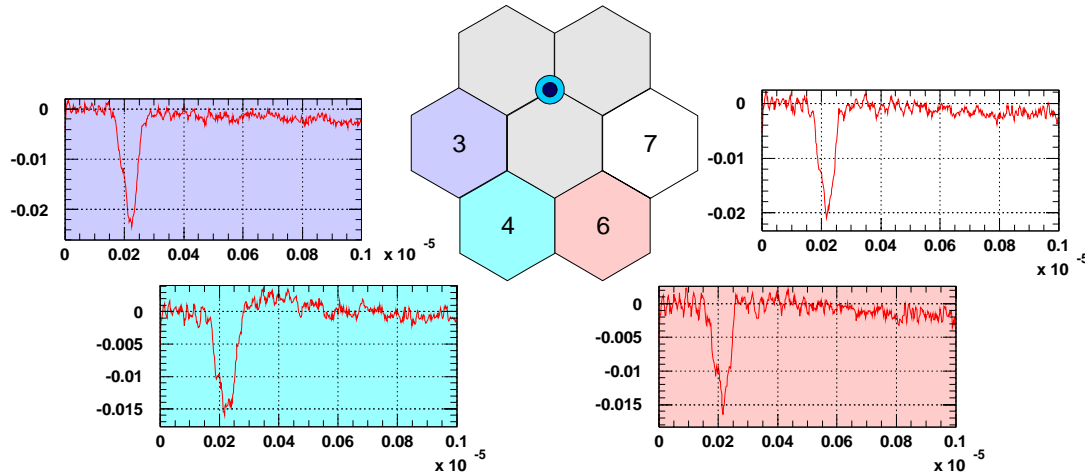
Scan over entire pad – charge sharing

100 μm circles centred at pin hole locations during scan

- With P10 gas:
 - cloud size 550 μm
 - x,y standard deviations: ~70 μm

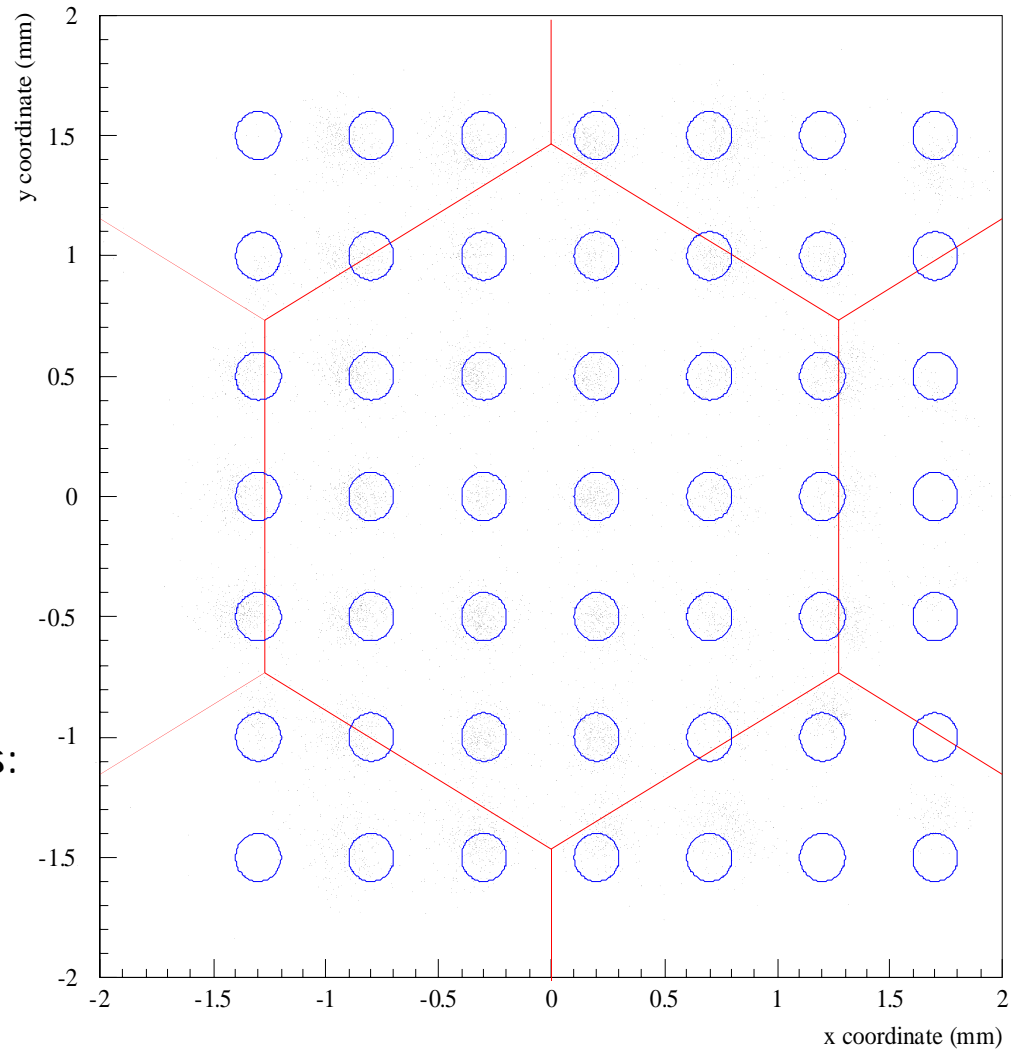


Position estimate from induced signals

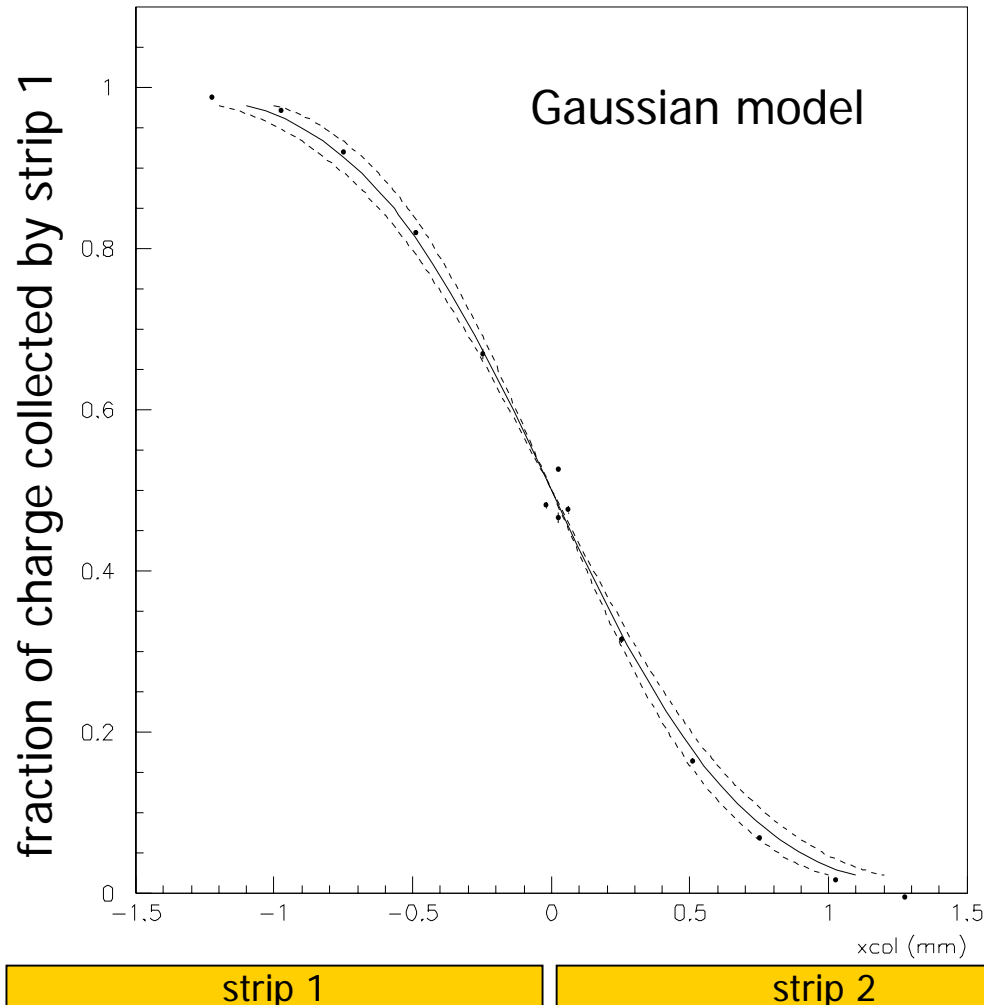
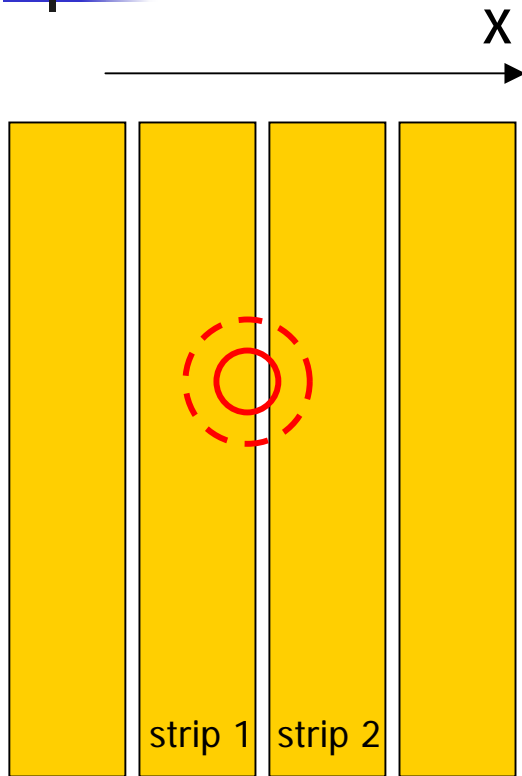


Scan over entire pad – induced signals

- With P10 gas:
 - x,y standard deviations:
~80 μm
 - note: systematics in x
clearly seen

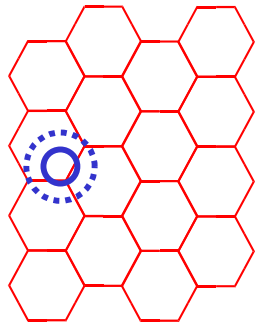
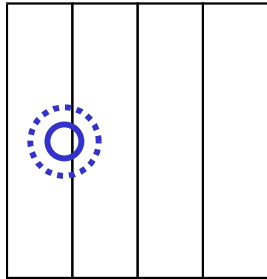


Strip geometry – charge sharing

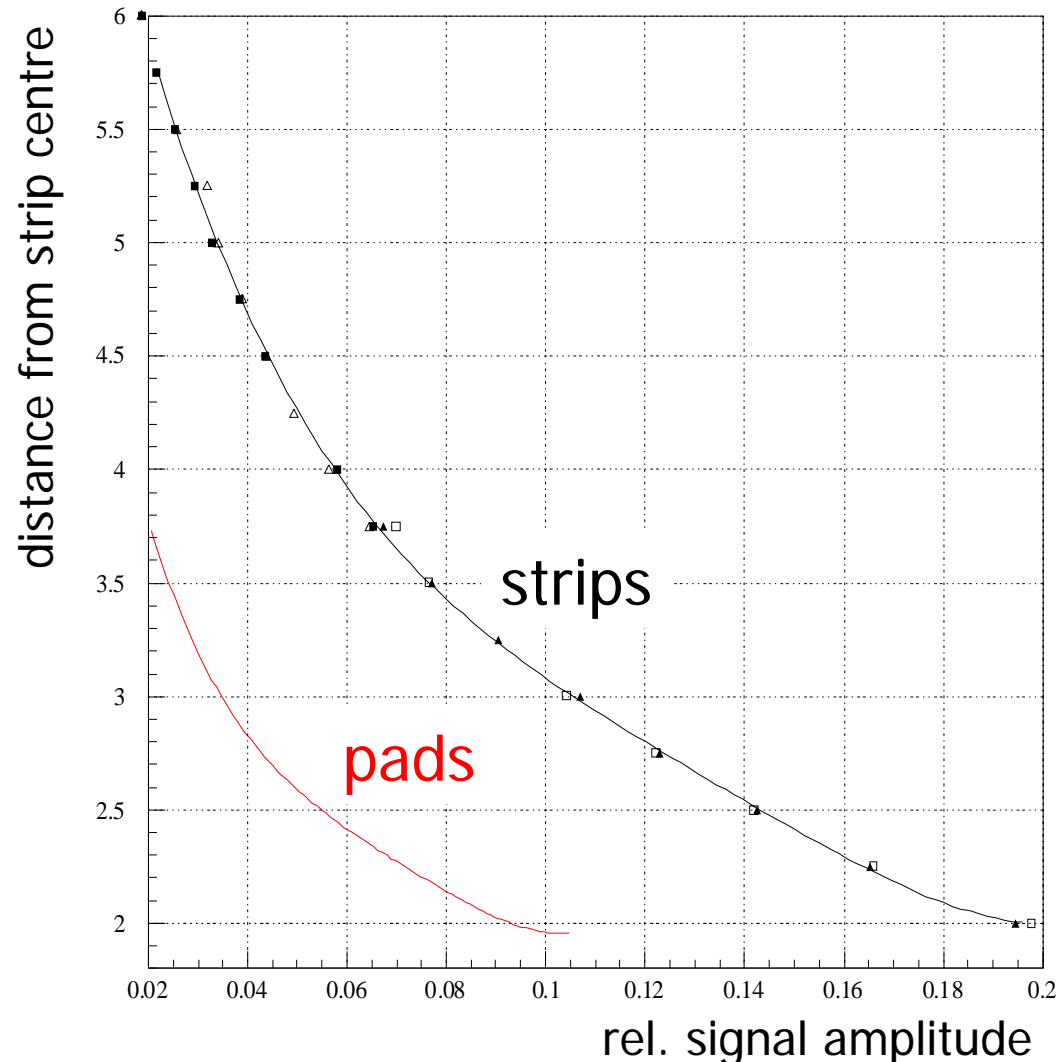


- With P10 gas:
 - x standard deviation:
~70 μm

Strip geometry – induced signals

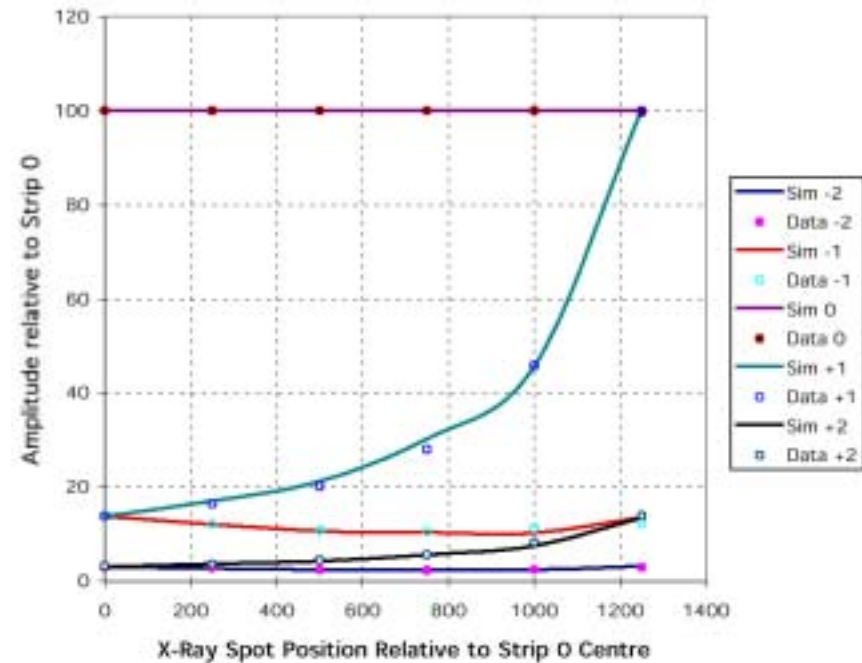
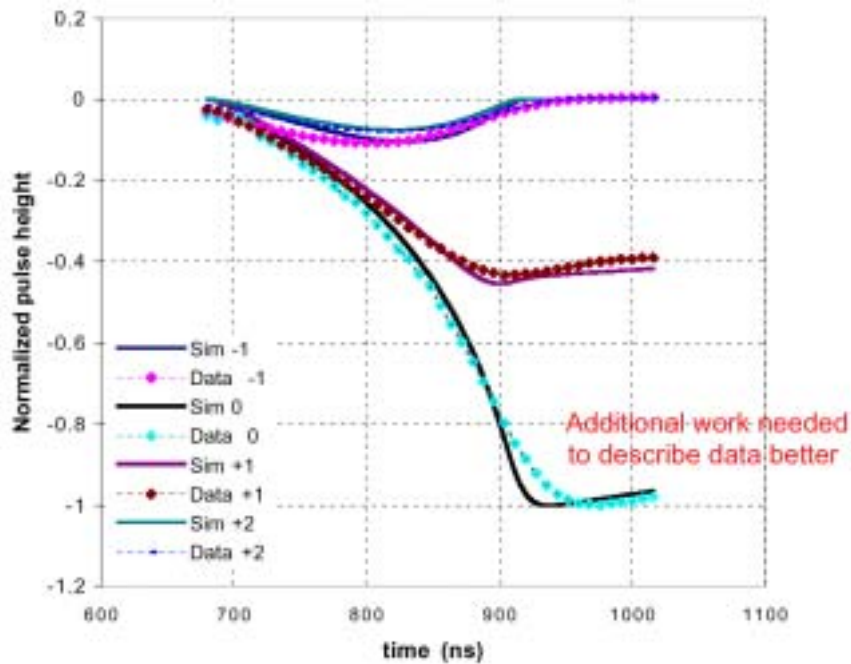


- Strip geometry has larger induced signals by factor of 2 – 3
 - x standard deviation: $\sim 70 \mu\text{m}$



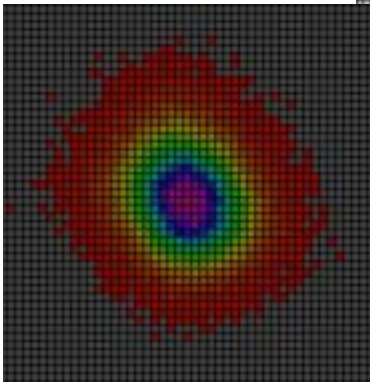
Simulation studies

- Simulation using 1st principles confirms understanding of signals



Simulation studies (cont.)

- Java simulation of GEM under development
 - arbitrary GEM structure and pad geometry can be defined interactively
 - empirical simulation of pad signals



GEM Design

Gas Gap: Drift Gap

Thickness: 4.1 mm Trans. diff. coeff.: 945 sec/2mm
Drift velocity: 40 mm/ns Long. diff. coeff.: 192 sec/2mm

Full Pad 2

Gain: 100 Transparency: 1 Thickness: 8.1 mm

Full hole layout:

HexPack x-hole: 0.14 mm x-number: 215 x-origin: -15.67 mm
y-number: 215 y-origin: -15.67 mm

Full hole shape: Circle radius: 8.05 mm

Gas Gap: Transfer Gap

Thickness: 2 mm Trans. diff. coeff.: 200 sec/2mm
Drift velocity: 23 mm/ns Long. diff. coeff.: 45 sec/2mm

Full Pad 1

Gain: 100 Transparency: 1 Thickness: 8.1 mm

Full hole layout:

x-hole: 0.14 mm x-number: 215 x-origin: -15 mm
y-number: 215 y-origin: -15 mm

radius: 8.05 mm

Trans. diff. coeff.: 200 sec/2mm
Long. diff. coeff.: 45 sec/2mm

x-number: 21 x-origin: -20 mm
y-number: 11 y-origin: -20 mm

u-size: 2 mm v-size: 4 mm

Electronics for Readout Pad

Timing

rise time: 20 ns gain: 10 mV/KC
fall time: 40 ns

Scope

Trigger	1	2	3	4	5	6
	112	114	115	116	117	118
	0	8	325	319,334	182,171	1

70,000
60,000
50,000
40,000
30,000
20,000
10,000
0

320 340 360 380 400 420 440 460 480 500

■ Pad 113
■ Pad 114
■ Pad 115
■ Pad 116
■ Pad 117
■ Pad 118

Statistics for Readout Pad

u/width	0.7	0.05	0.05	mm
v/width	0	0.05	0.05	mm
u/height	11	0.05	0.1	mm
left	0	0		mm
right	50	1		mm
height	10			mm

Statistics for Readout Pad

Current Data

Charge distribution for: 501,888 electrons

Mean x: 0.903 mm 0.532 mm
Mean y: 0.002 mm 0.526 mm

Cumulative Data

Cumulative summary for: 10 events

Mean x mm: 0.712 mm 0.948 mm
Mean y mm: 0.000 mm 0.955 mm

Mean x rms: 0.521 mm
Mean y rms: 0.912 mm

Charge fractions in pads

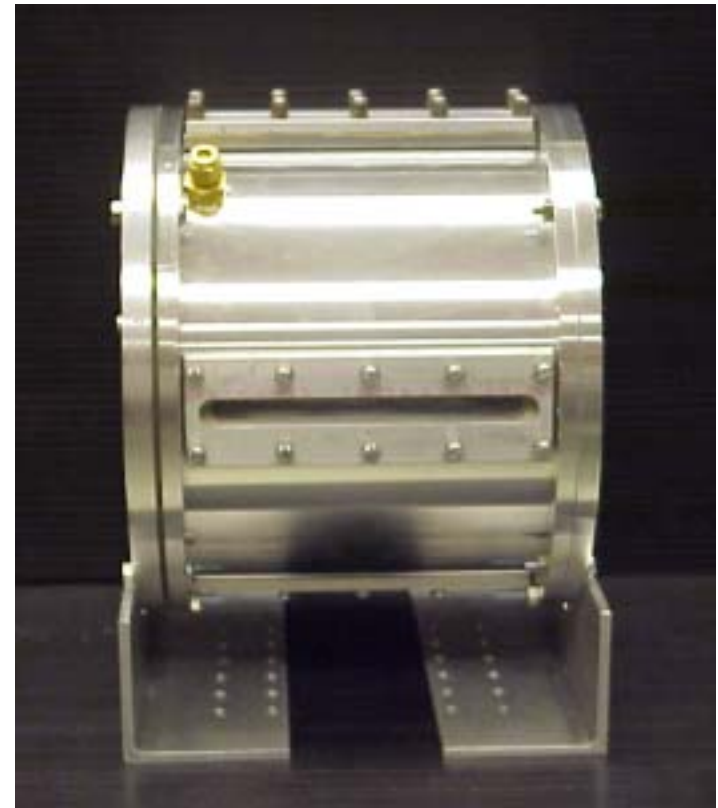
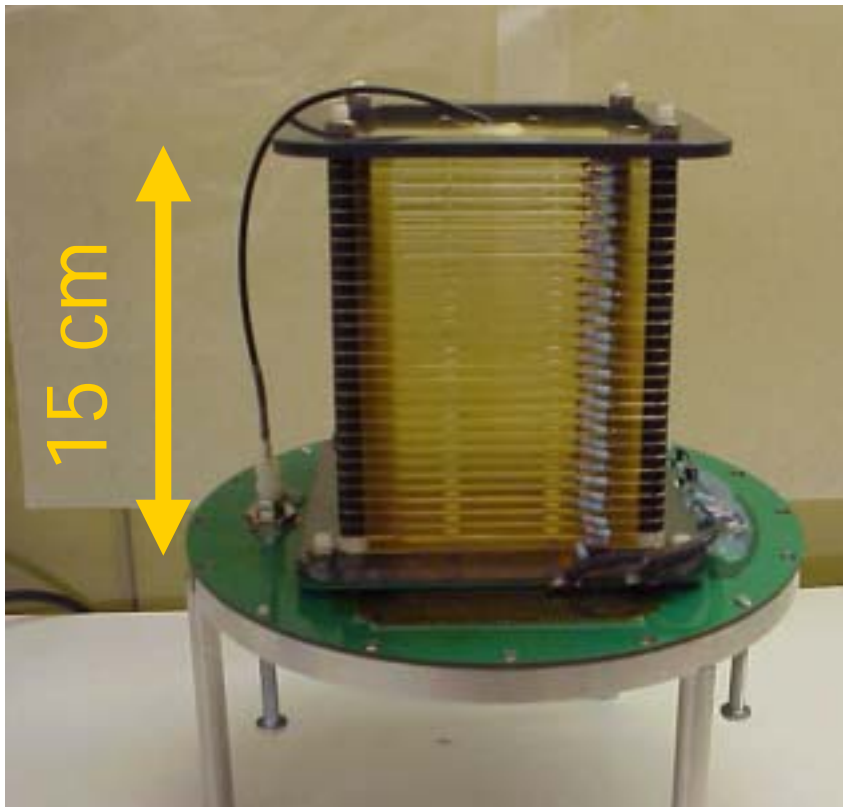
1	2	3	4	5	6
8	0	0.8837	0.6263	0.363	8

Charge fractions (real RMS) in pads

1	2	3	4	5	6
8	0	0.8837	0.7086	0.2224	8
8	0	0.8833	0.0318	0.032	8

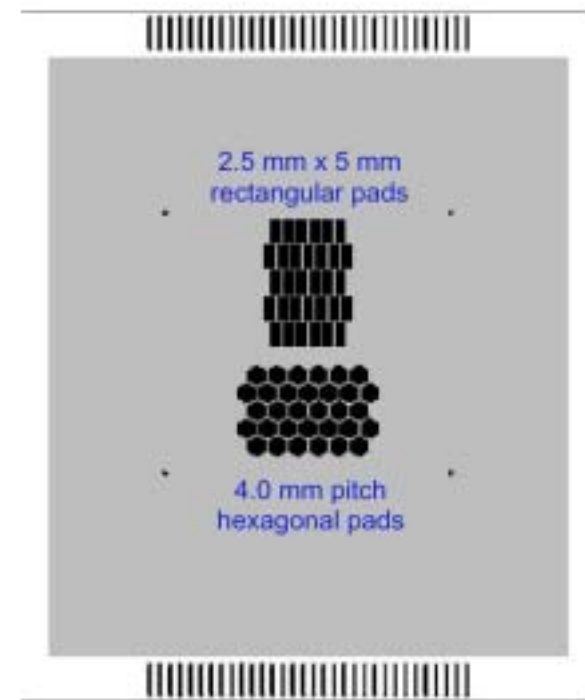
Plans for future studies

- Mini-TPC constructed and being commissioned



Plans for future studies (cont.)

- Mini-TPC readout with cosmic ray telescope
 - 32 channels of custom 200 MHz FADC
 - new readout structures
 - estimate tracking resolution with triplets
 - two track resolution?
 - test beam?



Issues

- Optimization of design

- gas choice
- GEM stages
- pad design

} all coupled
for example:



low gain ion gate



high gain stage(s)

high field
region - diffuser



few mm scale
pad structure

- optimize with simulation – check with data

- Long term stability of GEMs

- A lot of work to be done!