



TPC Readout R&D in Canada



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TPC Readout R&D in Canada



★ Past work on GEM based readout:

- test cell for space point resolution studies with collimated x-ray source
- 15 cm drift length TPC for tracking resolution studies

★ New developments (since Chicago):

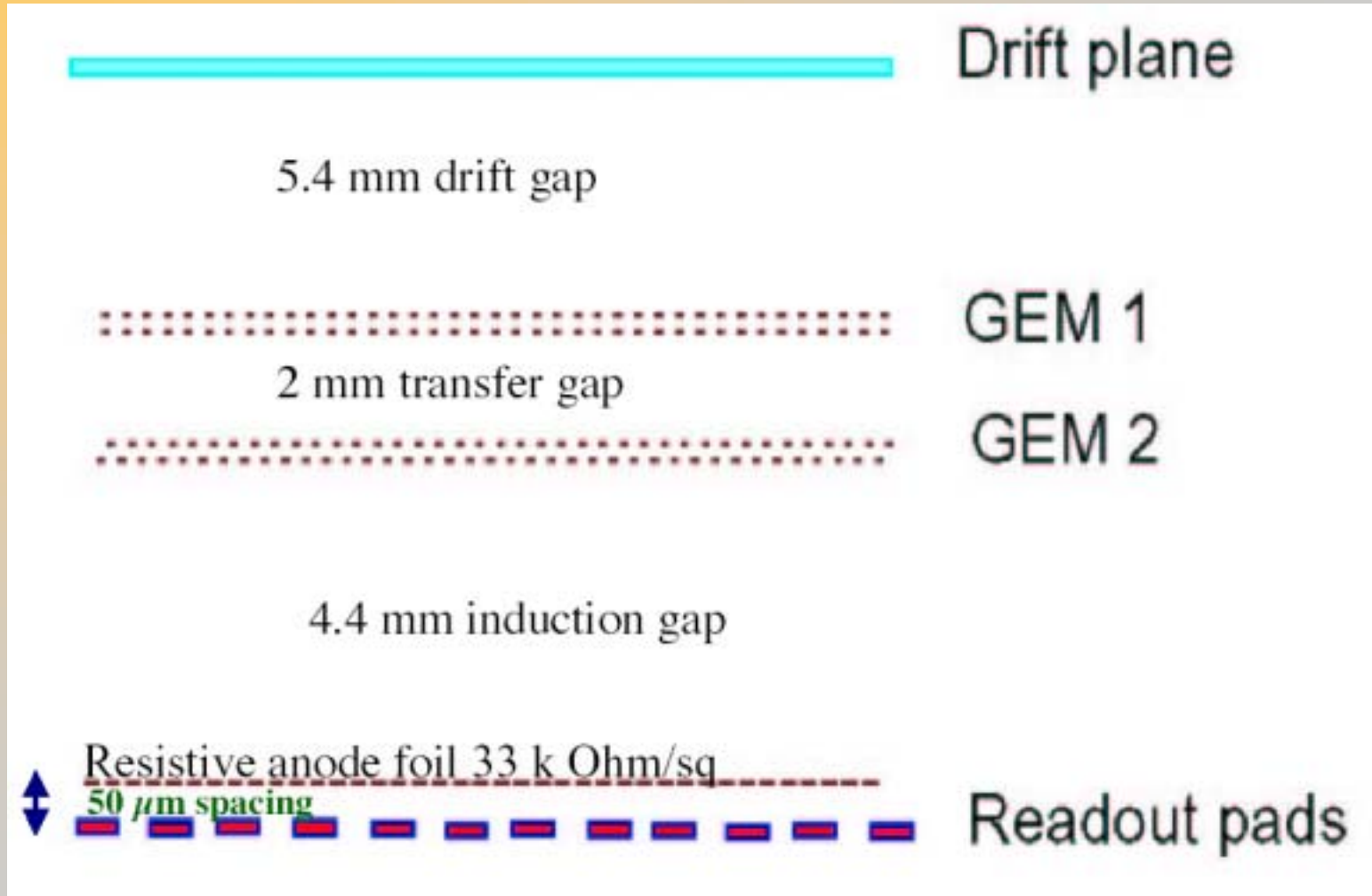
- charge dispersion
- TPC simulation package
- new multiplexed TPC readout structure
- new TPC under construction for magnetic field tests



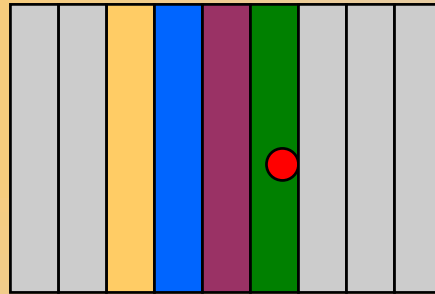
Charge dispersion with resistive anodes

- ★ For some TPC readout designs, the transverse size of charge clouds can be significantly smaller than the pad size
 - would result in degraded resolution
- ★ One possible solution is to spread out the signals over wider area using a resistive anode
 - measurements are underway to determine if this is a viable solution

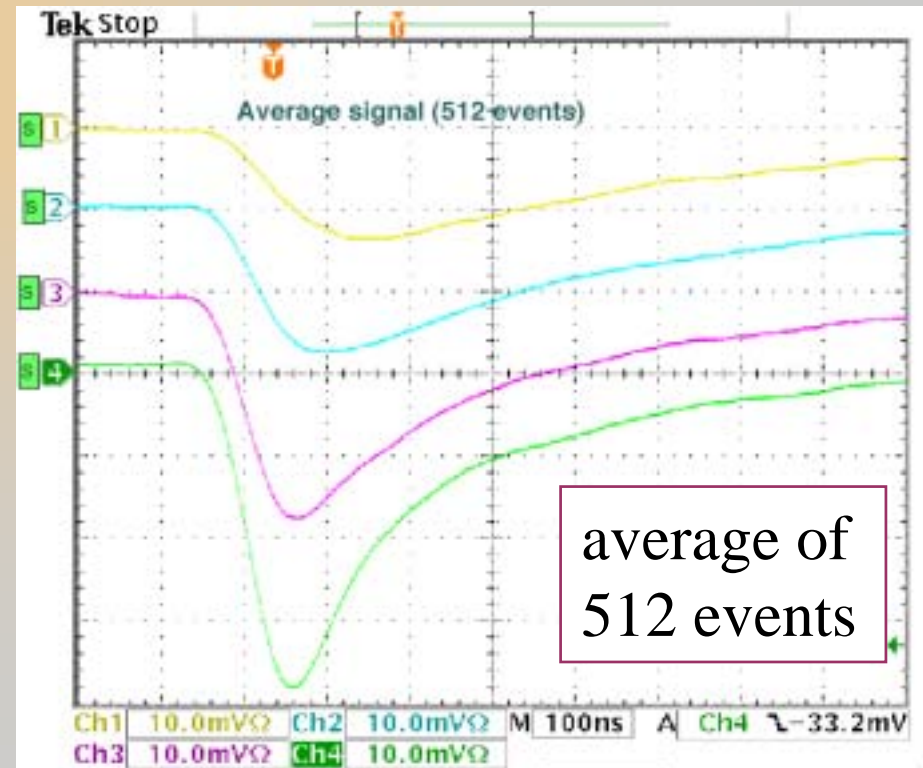
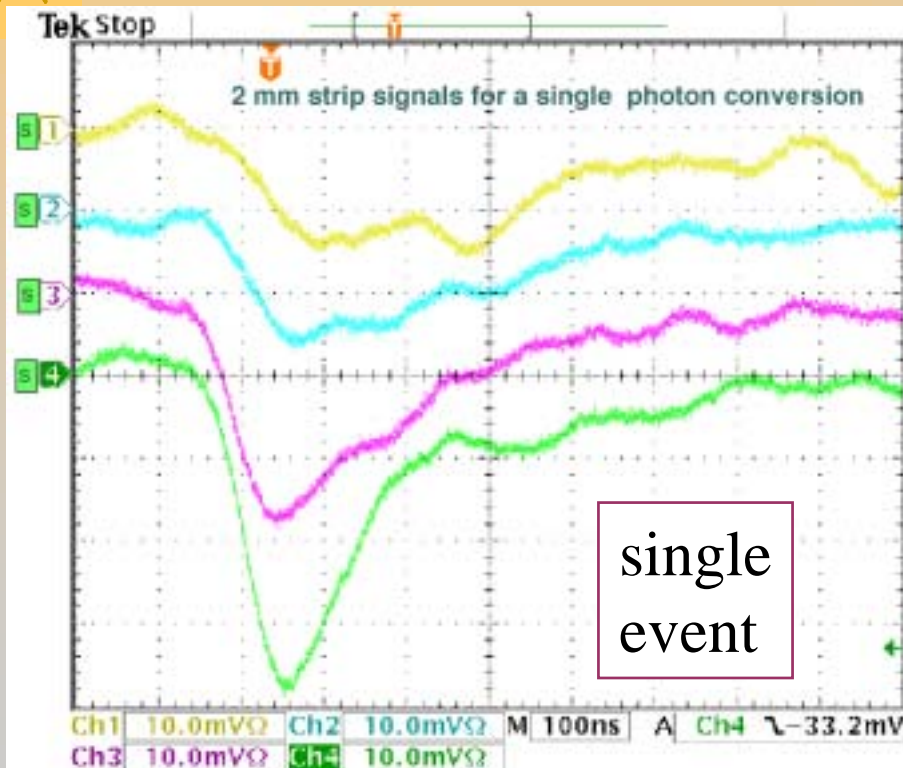
Resistive anode test setup



Observed signals



2.5 mm pitch strips



Theory...

2D analog of telegraph equation

Consider a GEM with a resistive anode. Anode collects avalanche charge. Any localized charge signal will spread radially with time. The 2-D Telegraph equation:

$$\frac{\partial Q}{\partial t} = \frac{1}{RC} \left[\frac{\partial^2 Q}{\partial r^2} + \frac{1}{r} \frac{\partial Q}{\partial r} \right] \quad 0 < r < a \text{ (anode sheet radius)}$$

$$= k^2 \left[\frac{\partial^2 Q}{\partial r^2} + \frac{1}{r} \frac{\partial Q}{\partial r} \right] \quad C = \text{capacitance per unit area}$$

$$\quad \quad \quad \quad \quad \quad \quad R = \text{surface resistivity (Ohms/}\square\text{)}$$

$$\quad \quad \quad \quad \quad \quad \quad L \sim 0$$

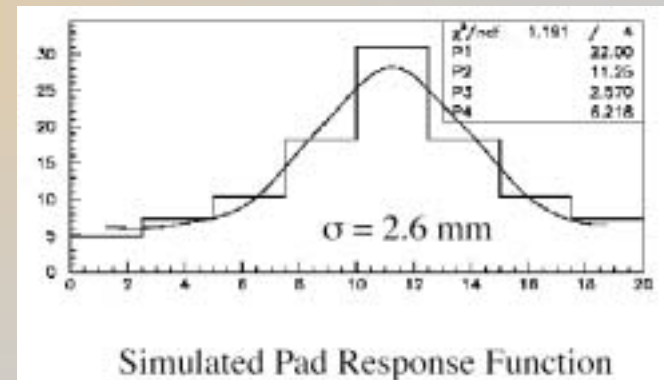
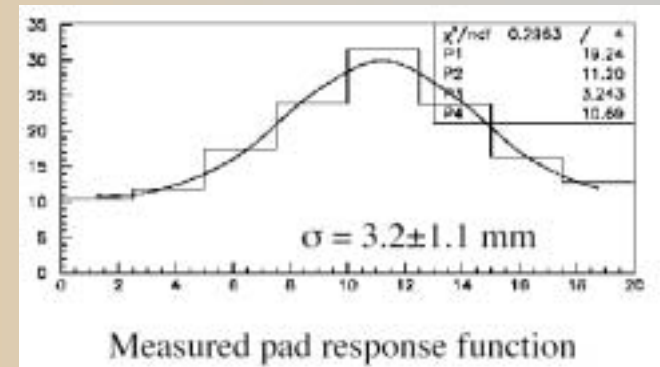
$$\quad \quad \quad \quad \quad \quad \quad k^2 = 1/RC$$

- Boundary conditions: $Q = f(r)$ at $t = 0$
 $Q = 0$ for $r = a$; $0 \leq t \leq \infty$

- Solution for initial point charge: Take limit $a \Rightarrow \infty$ for $Q = \delta(r)$ at $t = 0$ with $\int \delta(r) dr = 1$ is given by:

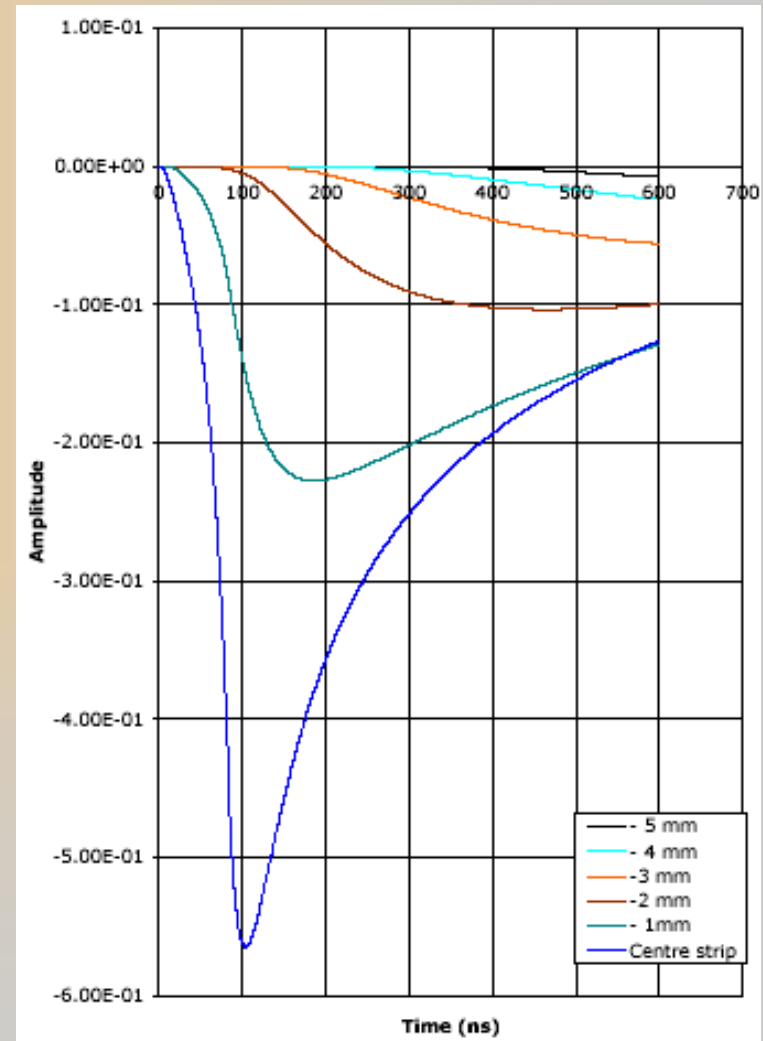
$$Q(r,t) = \frac{1}{2k^2 t} e^{-[r^2/(4k^2 t)]}$$

Incorporate finite size of initial charge cluster & amplifier rise & fall time effects to compare to measurement.



Optimization of pad response function

- ★ For $2 \text{ M}\Omega$ / and $100 \text{ }\mu\text{m}$ gap, the PRF is calculated to have a standard deviation of $700 \text{ }\mu\text{m}$
 - measurements are underway to verify this



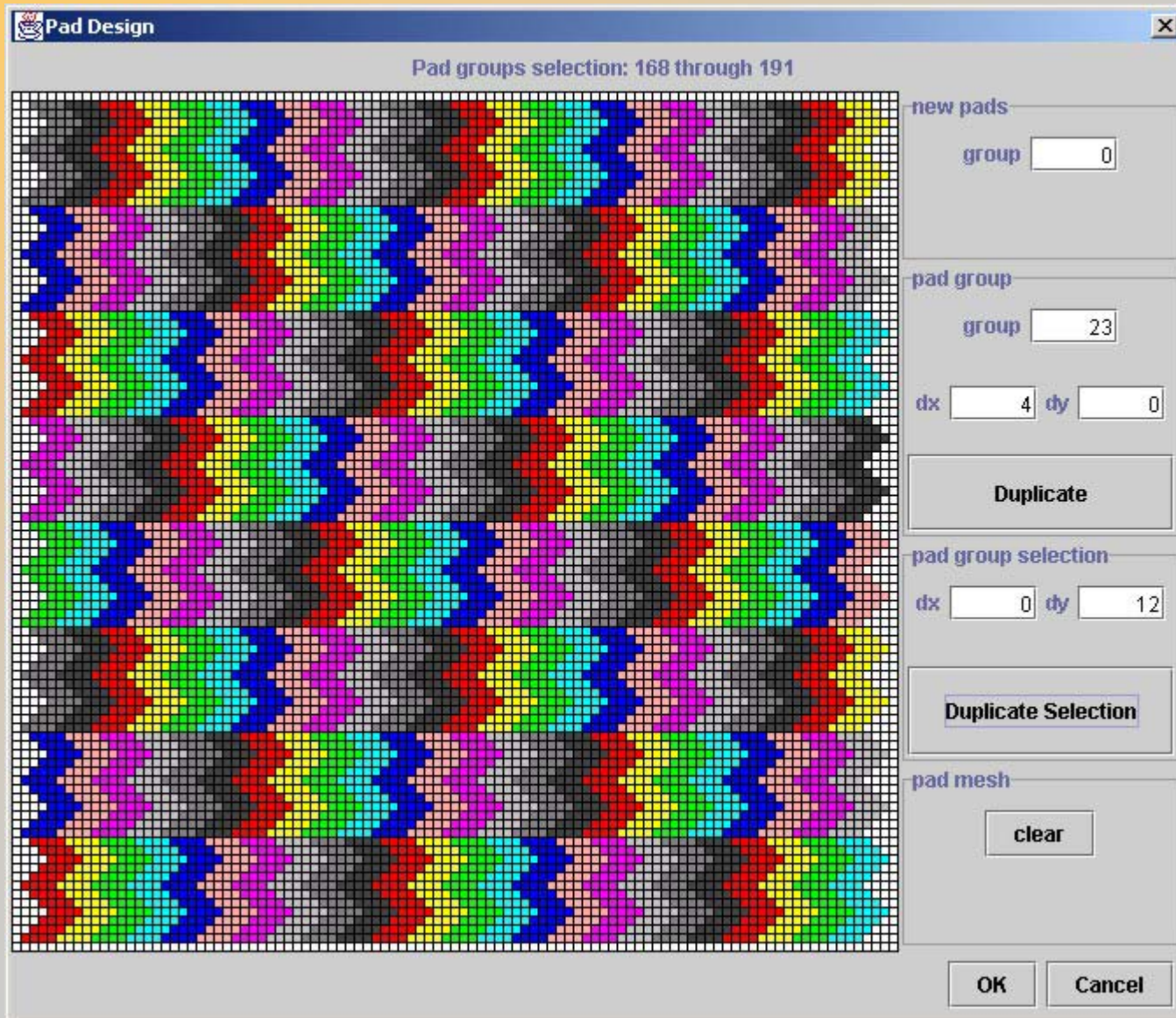


TPC simulation package

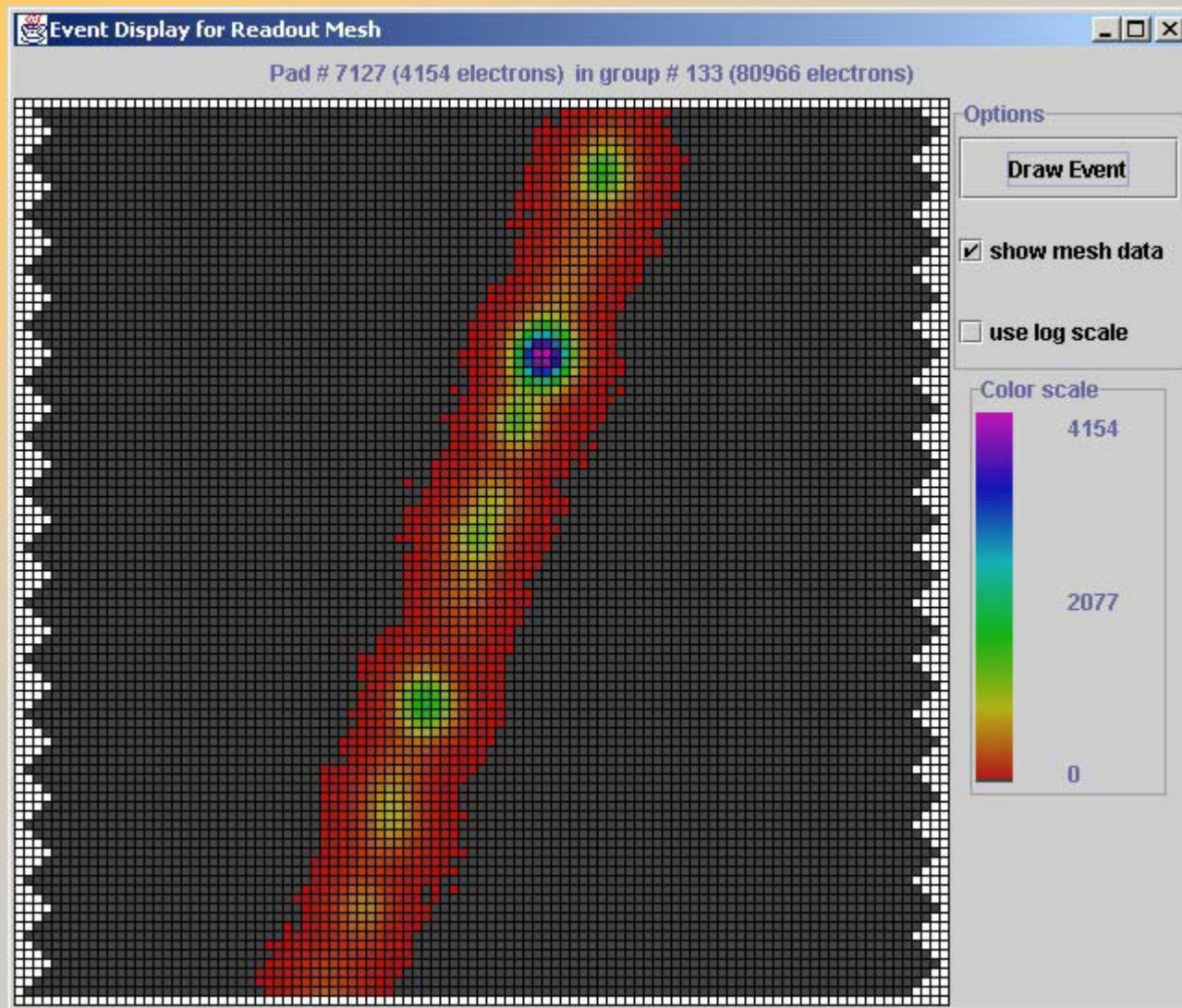
- ★ written in Java
- ★ easy to use
- ★ can build arbitrary TPC with GEM readout
- ★ any readout pad structure can be defined
- ★ sophisticated tracking algorithm

- ★ only simulates direct charge signals
 - does not simulate induced signals

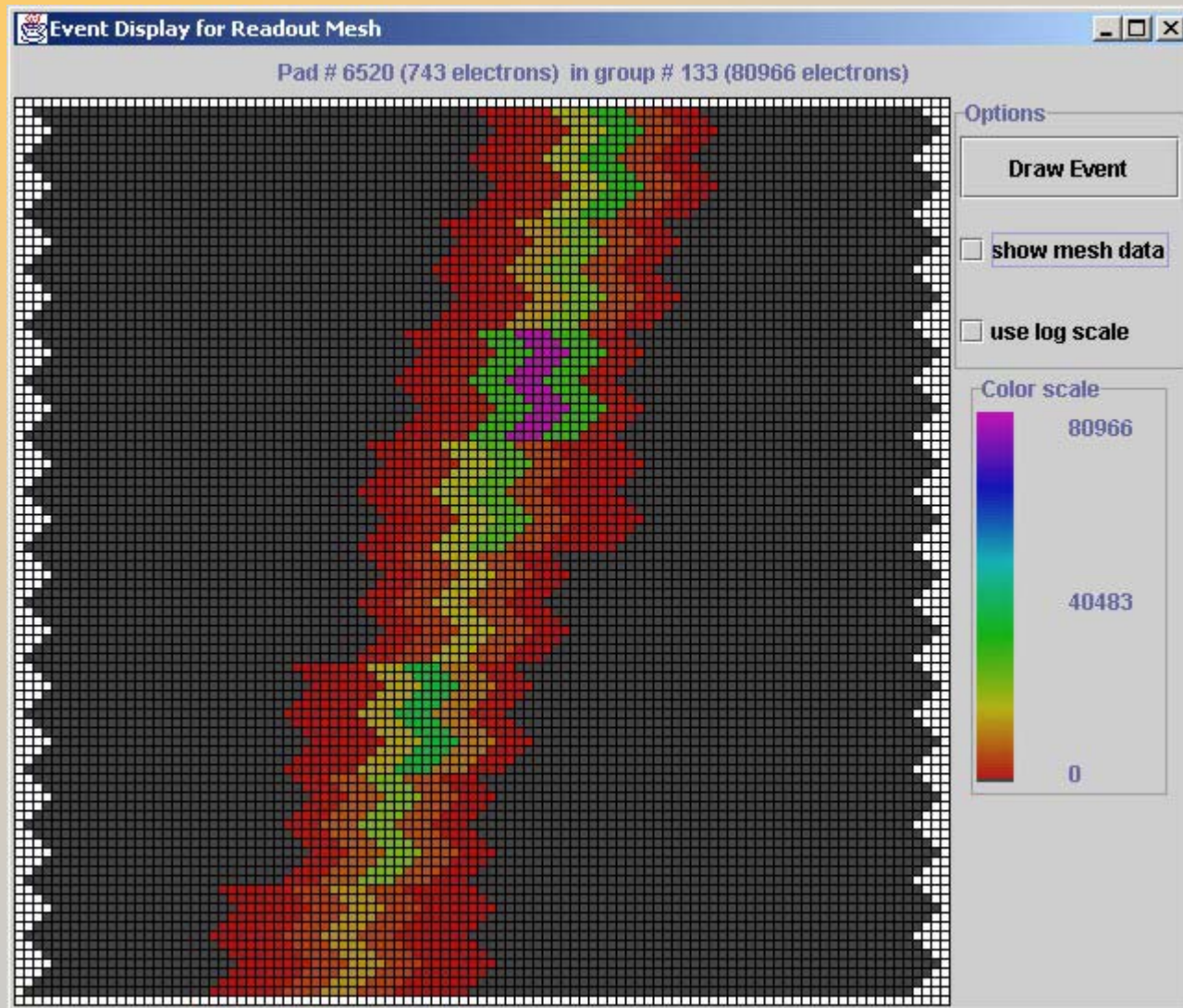
Designing readout pads



Adding an ionization track



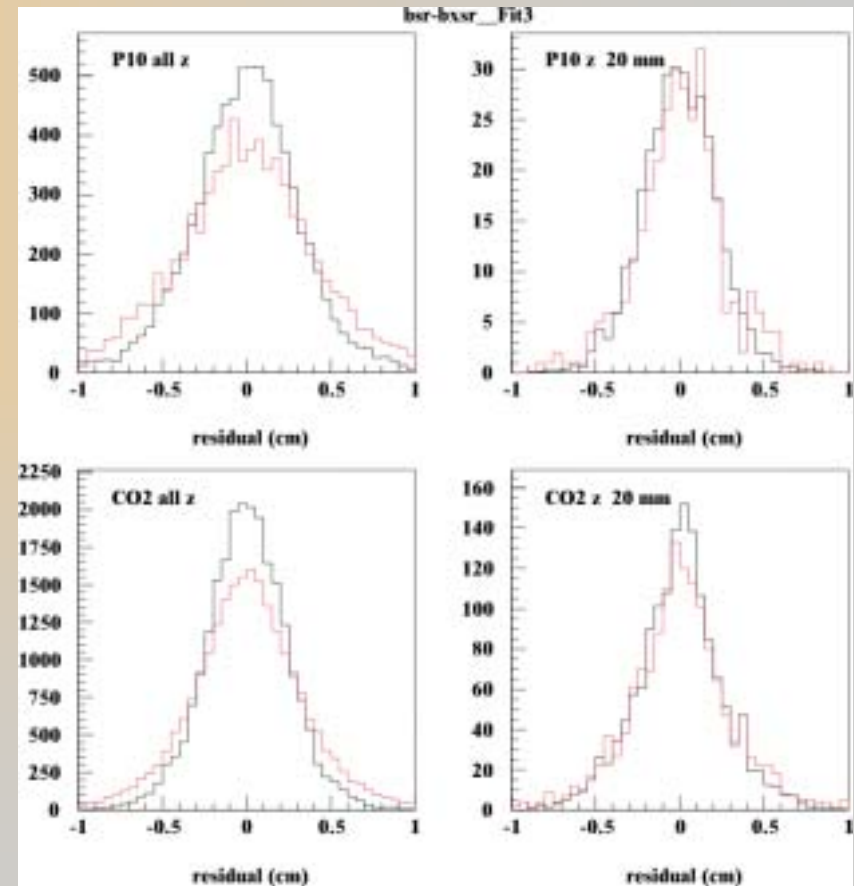
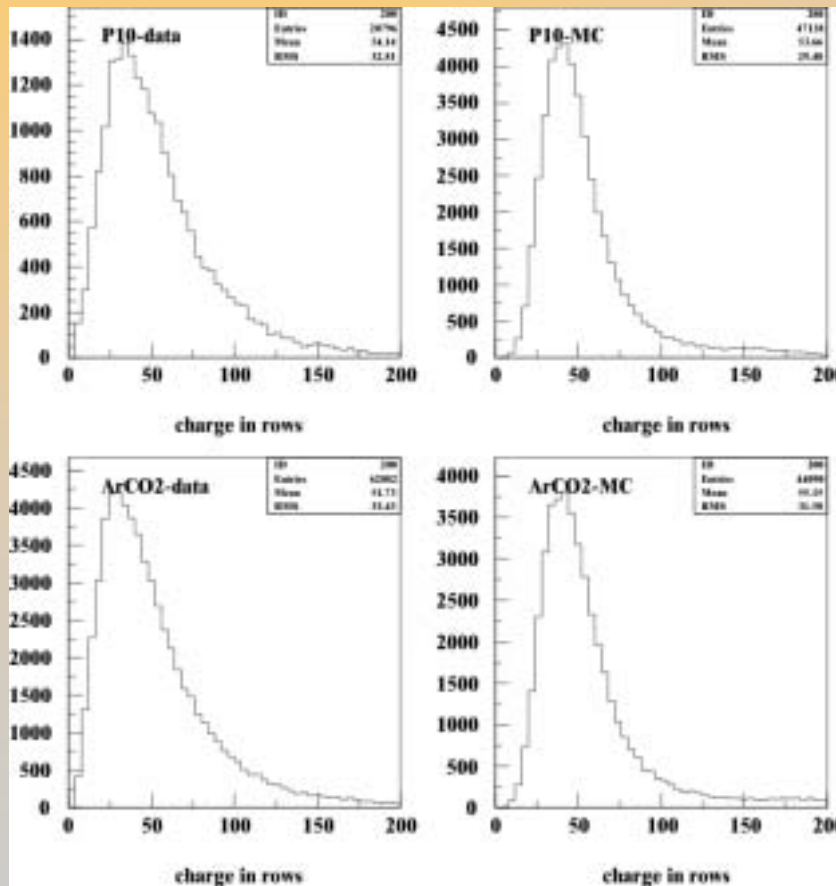
Signals on pads



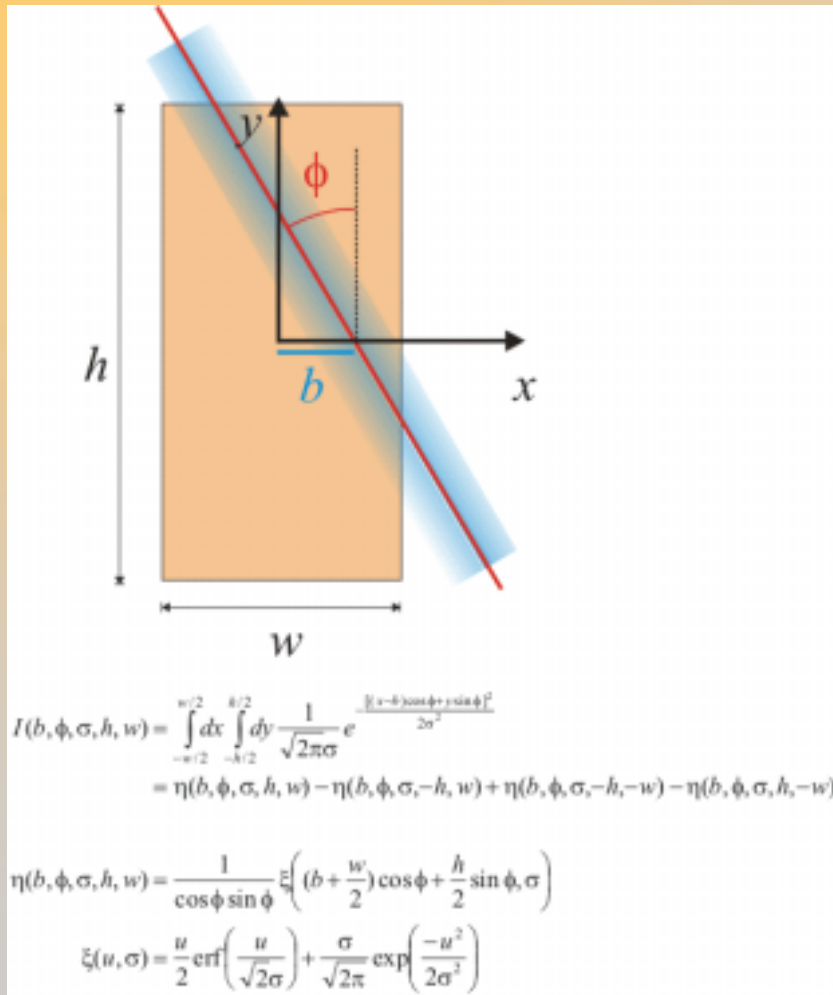
Comparison with prototype TPC data

Row charge

Track residuals



Track fitting



Fitter Control for Readout Mesh

XY Fitter

Set up XY fitter # of rows: 8

Parameter	Value	fixed
x0 (mm)	0.02734	<input type="checkbox"/>
phi (rad)	-0.31483	<input type="checkbox"/>
sigma (mm)	0.39565	<input type="checkbox"/>
gain	3.0E3	<input checked="" type="checkbox"/>
noise prob	0.0E0	<input checked="" type="checkbox"/>

Calculate Likelihood -Log(Likelihood) 146.40452

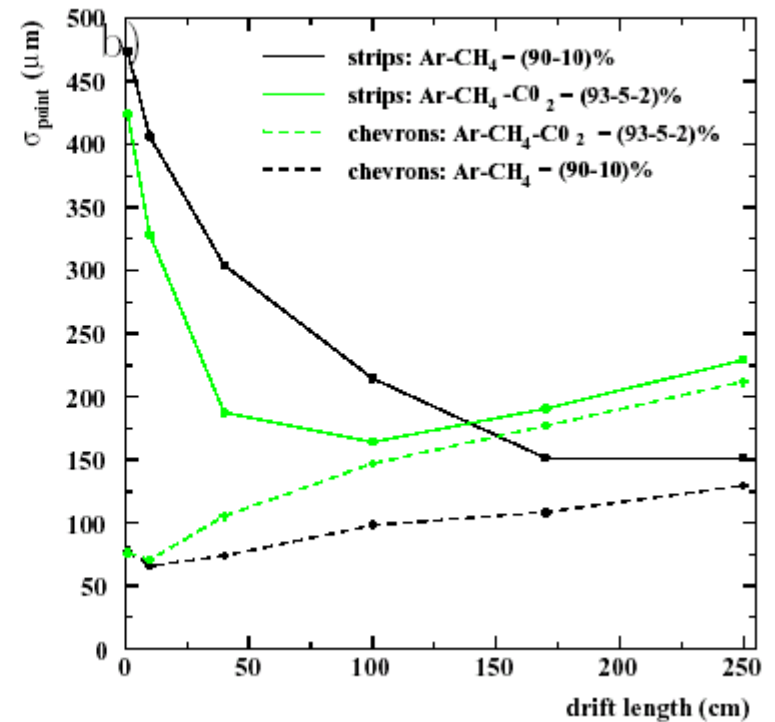
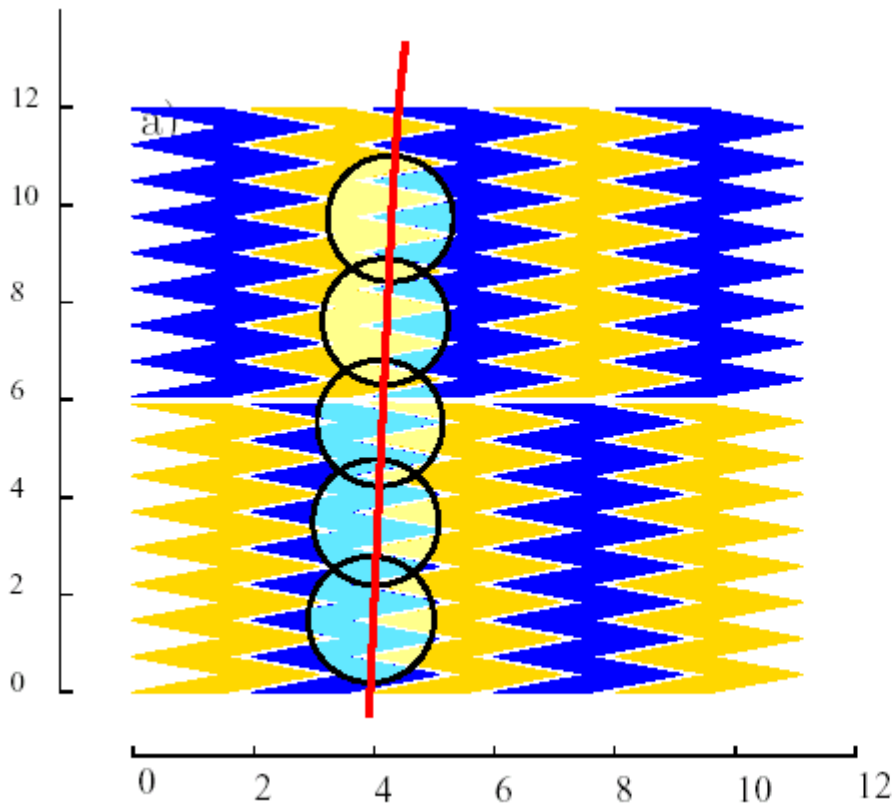
Do XY track fit 2 status: success

Parameter	Estimated Error	correlations
x0 (mm)	0.04752	0.22166 0.02369
phi (rad)	8.68606E-3	0.09799
sigma (mm)	0.0403	

uses the [Nonlinear Optimization Java Package](#) (uncmin) translated to java by Steve Verrill

Comparison of pad geometries for GEM

From TESLA TDR: advocates chevrons



Comparison of pad geometries for GEM

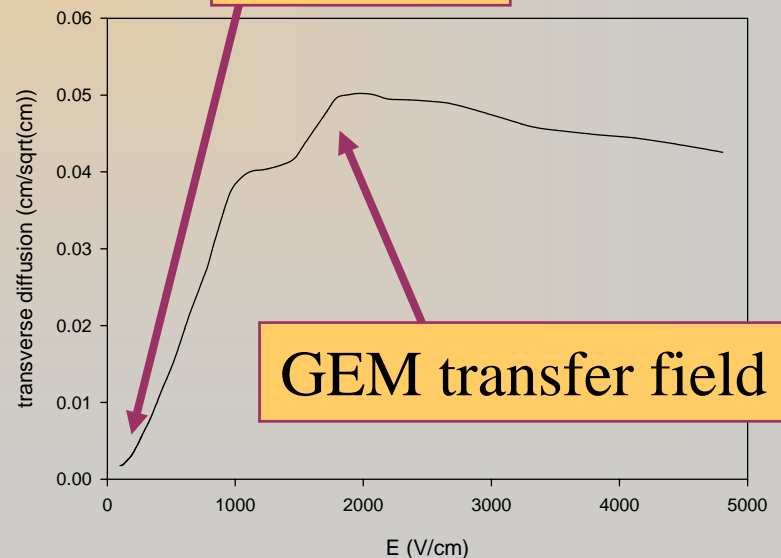
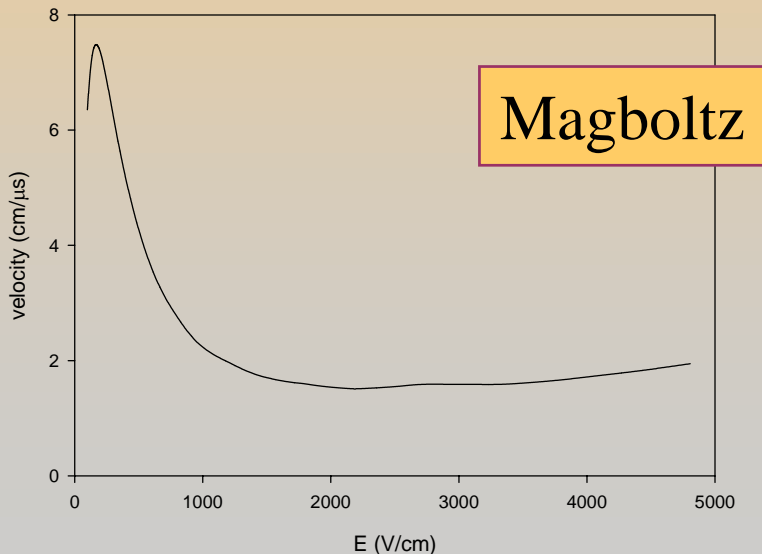
★ Current favourite gas mix: Ar CF₄

– fast at low fields

- low transverse diffusion in magnetic fields

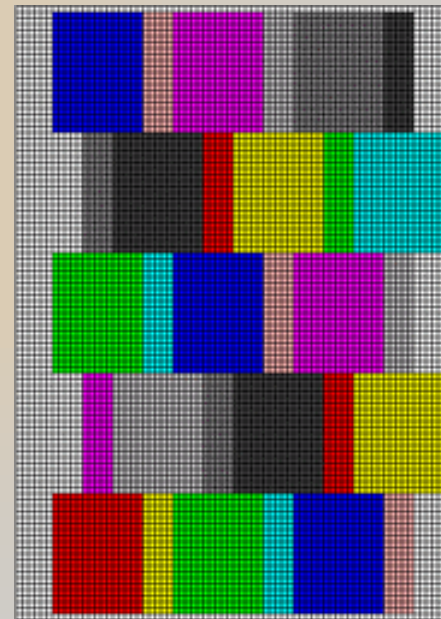
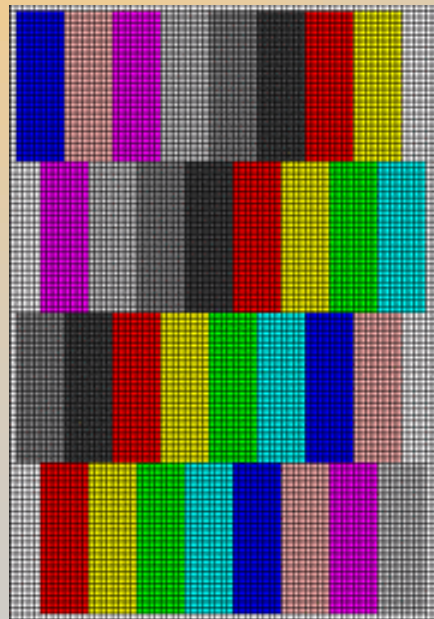
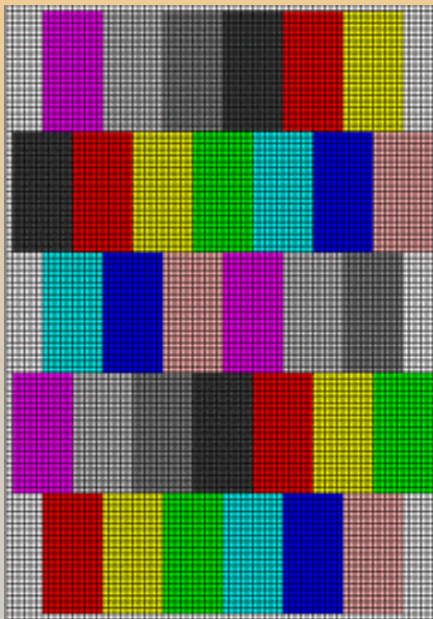
– larger diffusion at higher fields

– Example: Ar CF₄ (98:2)



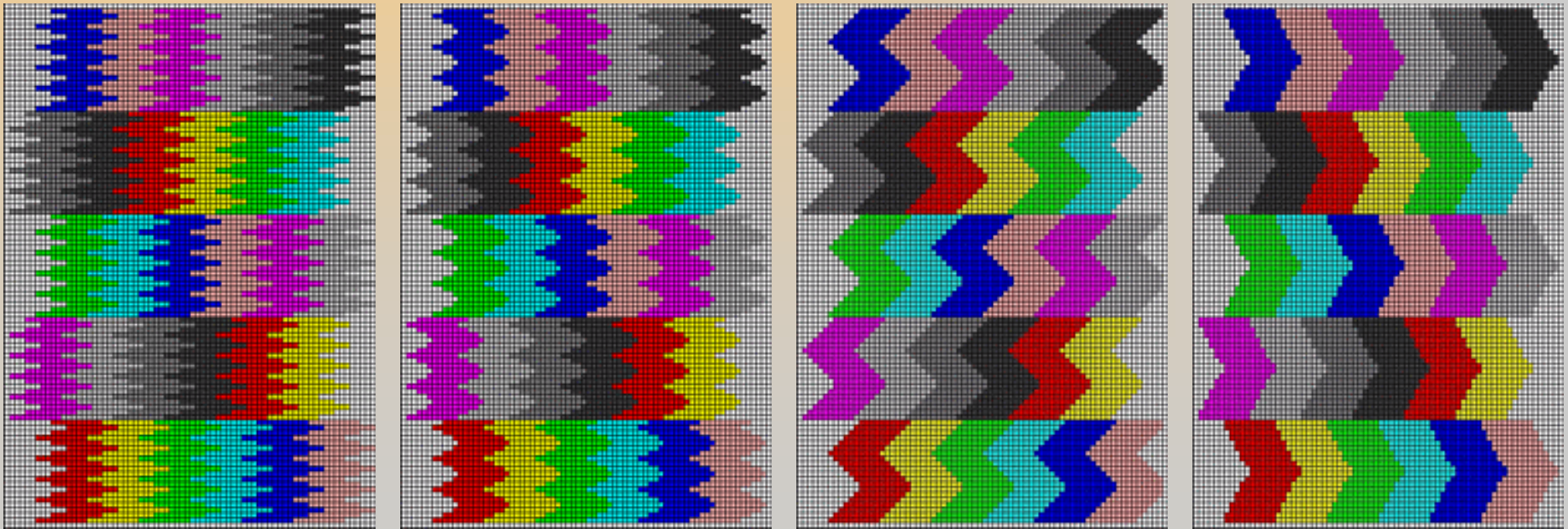
Comparison of pad geometries for GEM

- ★ Single tracks with $-0.1 < \phi, \psi < 0.1$
- ★ Seven pad geometries sample same ionization



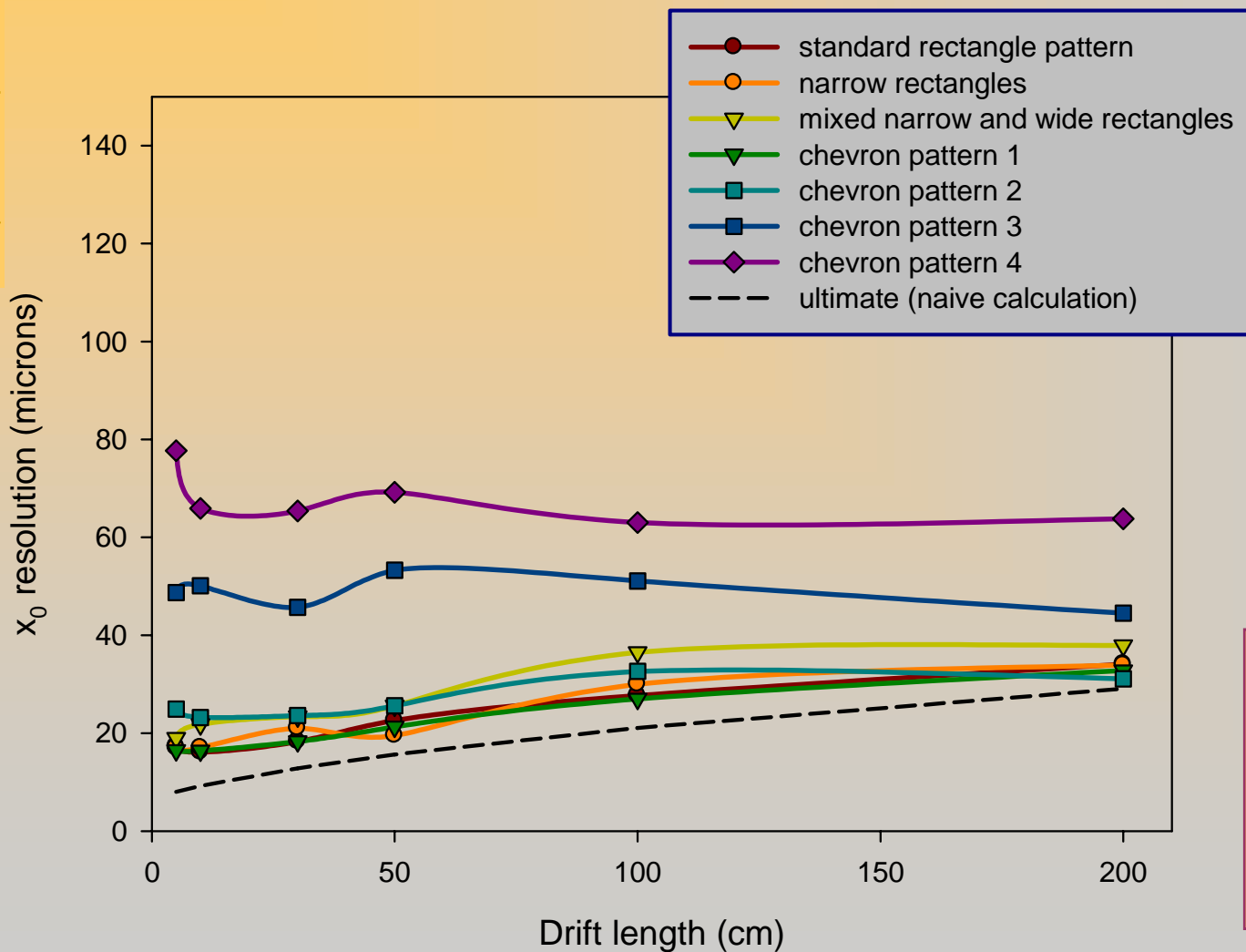
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Comparison of pad geometries for GEM

Ar CF₄ (98:2): 5 rows of 2.5 mm x 5 mm pads

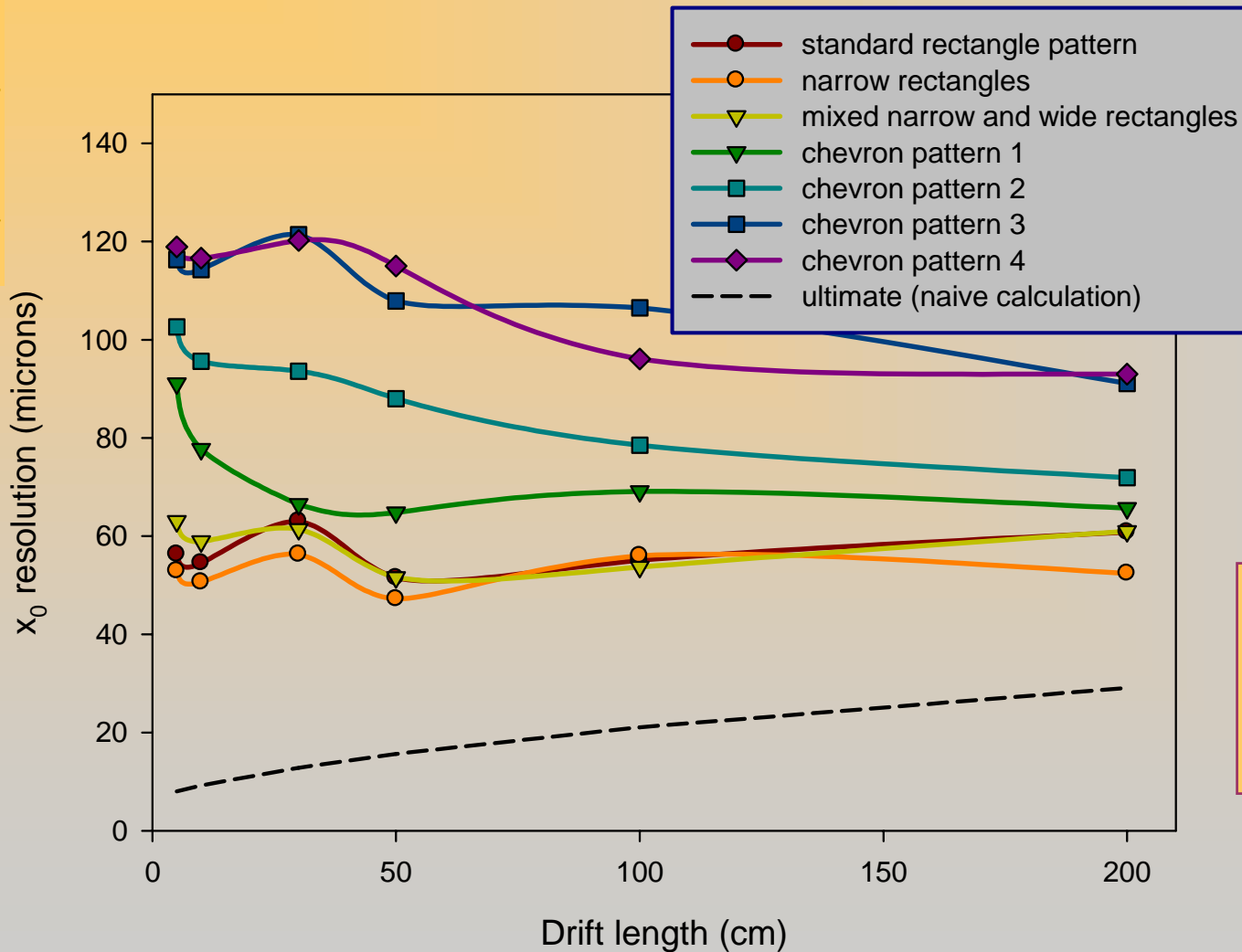


Defocussing
in 1 cm
GEM gap

Chevrons
unnecessary
in Ar CF₄
GEM TPC

Comparison of pads for Micromegas

Ar CF4 (98:2): 5 rows of 2.5 mm x 5 mm pads

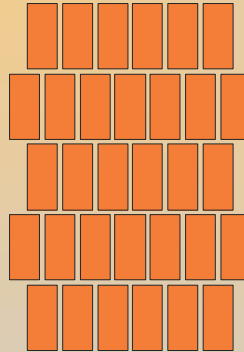


Defocussing required for micromegas

New multiplexed readout structure

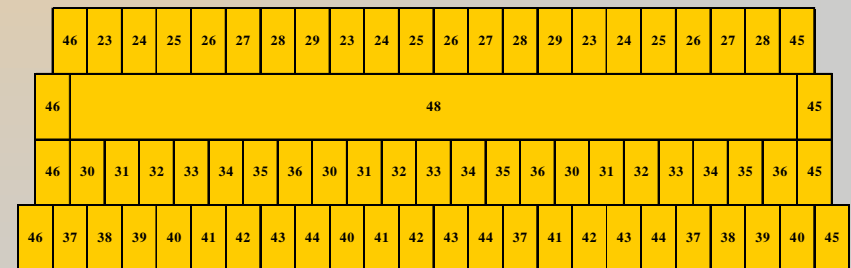
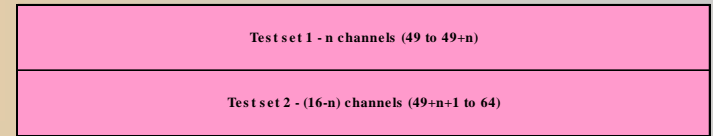
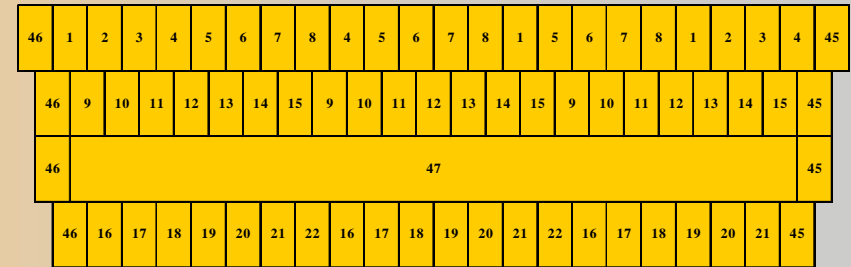
★ 3x multiplexing to readout 192 pads with 64 FADC channels

- easy for cosmics, multiplicity is low!
- should we consider multiplexing for the real TPC?
- use long pads for triggering



old

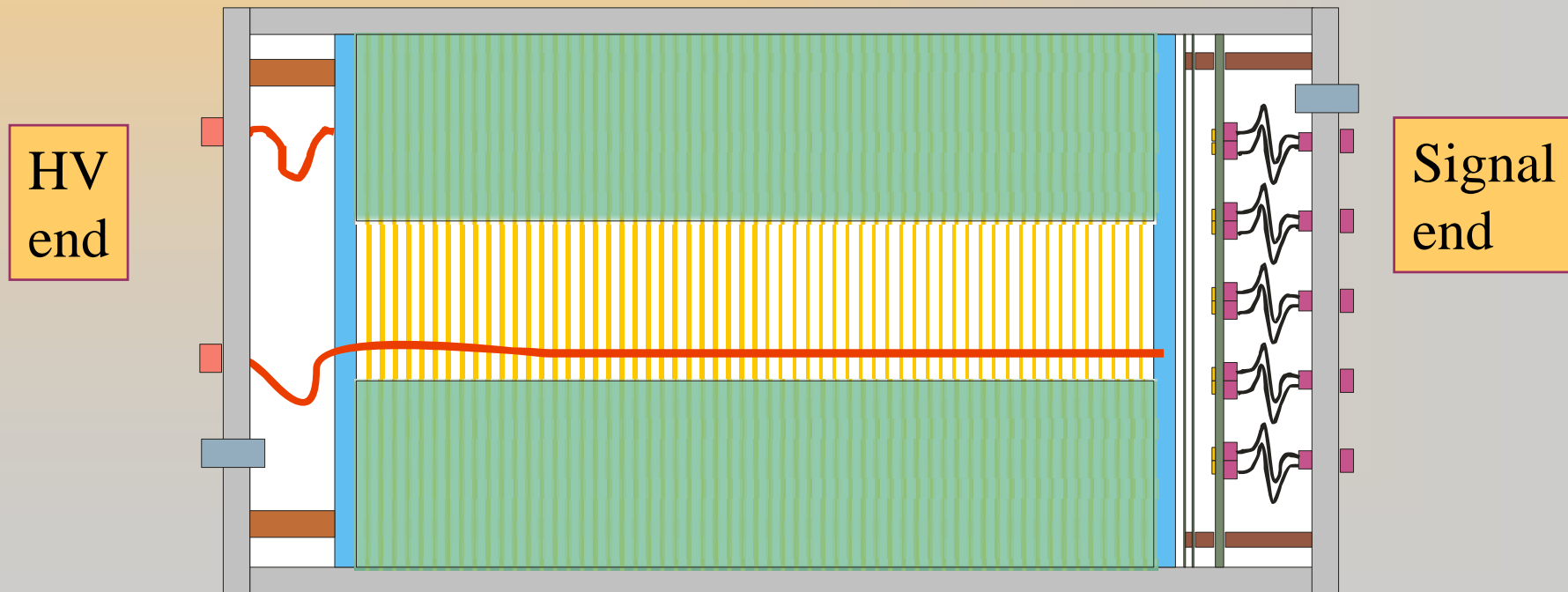
installed, taking data



new

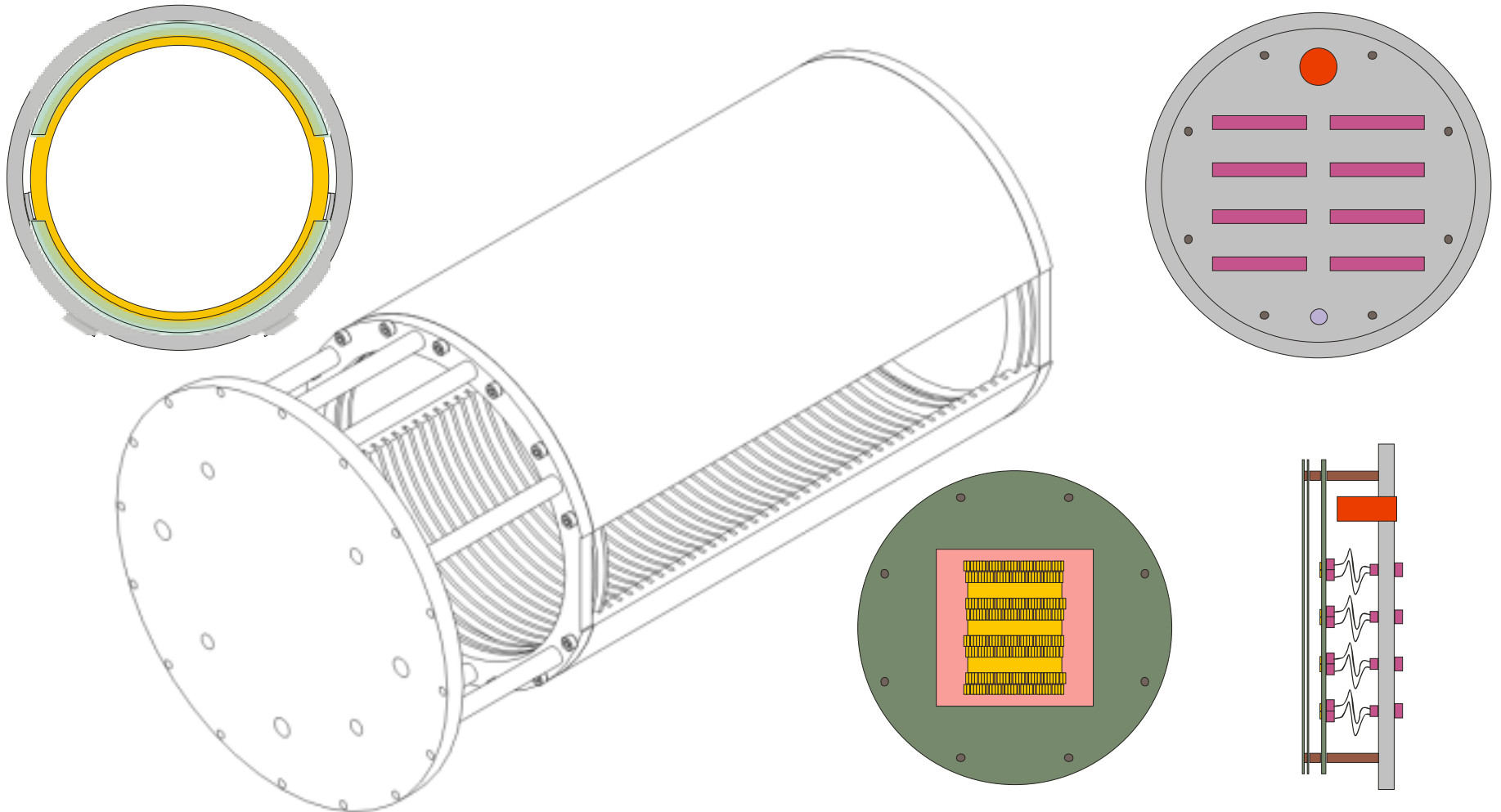
Construction of new TPC (TPC #2)

- ★ Cylindrical: fits TRIUMF (1T) and DESY (5T) magnets
 - acrylic tubes, outer diameter 22.2 cm
 - Use STAR-TPC electronics (256 channels)



Construction of new TPC (TPC #2)

★ 3D view of drift cage:





Summary

- ★ Continuing to make progress on many fronts:
 - resistive sheets to disperse charge (induction signals)
 - cosmic tracking with direct charge signals
 - simulation package development
 - preparations for magnetic field tests
- ★ Interested in test beam studies mid/late 2003:
 - test beam facilities?