

# *A Framework for TPC Simulation*

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Dean Karlen  
Carleton University / University of Victoria



# *Motivation for this work*

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- ★ Explore the parameter space for TPC design:
  - dimensions, gas, B field, gas amplification technology, pad designs
- ★ Simulation must be anchored on reality:
  - compare with several prototype TPCs
  - understand signals
  - test out tracking ideas
- ★ Not intended for use inside a LC detector simulation package for physics studies



# Requirements/Design

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## ★ Requirements

- Easy to use (graphical interface)
- Flexible enough to allow any TPC design
- Easy to maintain / add additional features
- Portable

## ★ Design choices

- Object oriented (Java)
- Use JAS tools:
  - JAS Histogrammer
  - JAIDA

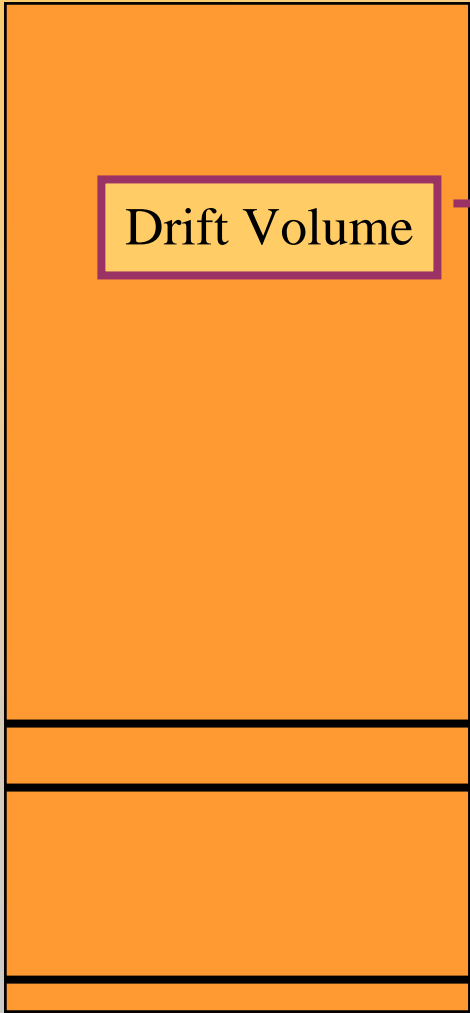


# *Building a TPC*

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- ★ The TPC is built from a set of TPC parts
  - gas volumes
  - GEM foil amplification stages
  - readout pad structures
- ★ TPC parts have methods to transport electron clouds through them
- ★ The parameters for each TPC part are accessible through a single design window

# TPC design window



Drift Volume

- GEM foil 2
- transfer gap
- GEM foil 1
- induct. gap
- readout

**TPC Design**

OK

Gas Gap: Drift Gap

Thickness	150 mm	Trans. diff.	190 $\mu\text{m}/\text{sqrt}(\text{cm})$
Drift velocity	9 $\mu\text{m}/\text{ns}$	Long. diff.	200 $\mu\text{m}/\text{sqrt}(\text{cm})$

GEM Foil: Foil 2

Gain	80	Collection eff.	1	Extraction eff.	0.7	Thickness	0.1 mm
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Foil hole layout:

Hex Pack	pitch:	0.14 mm	x number:	215	x origin:	-15.07 mm
			y number:	215	y origin:	-15.07 mm

Foil hole shape: Circle radius: 0.05 mm

Gas Gap: Transfer Gap

Thickness	2 mm	Trans. diff.	400 $\mu\text{m}/\text{sqrt}(\text{cm})$
Drift velocity	50 $\mu\text{m}/\text{ns}$	Long. diff.	250 $\mu\text{m}/\text{sqrt}(\text{cm})$

GEM Foil: Foil 1

Gain	80	Collection eff.	1	Extraction eff.	0.7	Thickness	0.1 mm
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Foil hole layout:

Hex Pack	pitch:	0.14 mm	x number:	215	x origin:	-15 mm
			y number:	215	y origin:	-15 mm

Foil hole shape: Circle radius: 0.05 mm

Gas Gap: Induction Gap

Thickness	5.7 mm	Trans. diff.	400 $\mu\text{m}/\text{sqrt}(\text{cm})$
Drift velocity	50 $\mu\text{m}/\text{ns}$	Long. diff.	250 $\mu\text{m}/\text{sqrt}(\text{cm})$

Pad Mesh: Readout Mesh

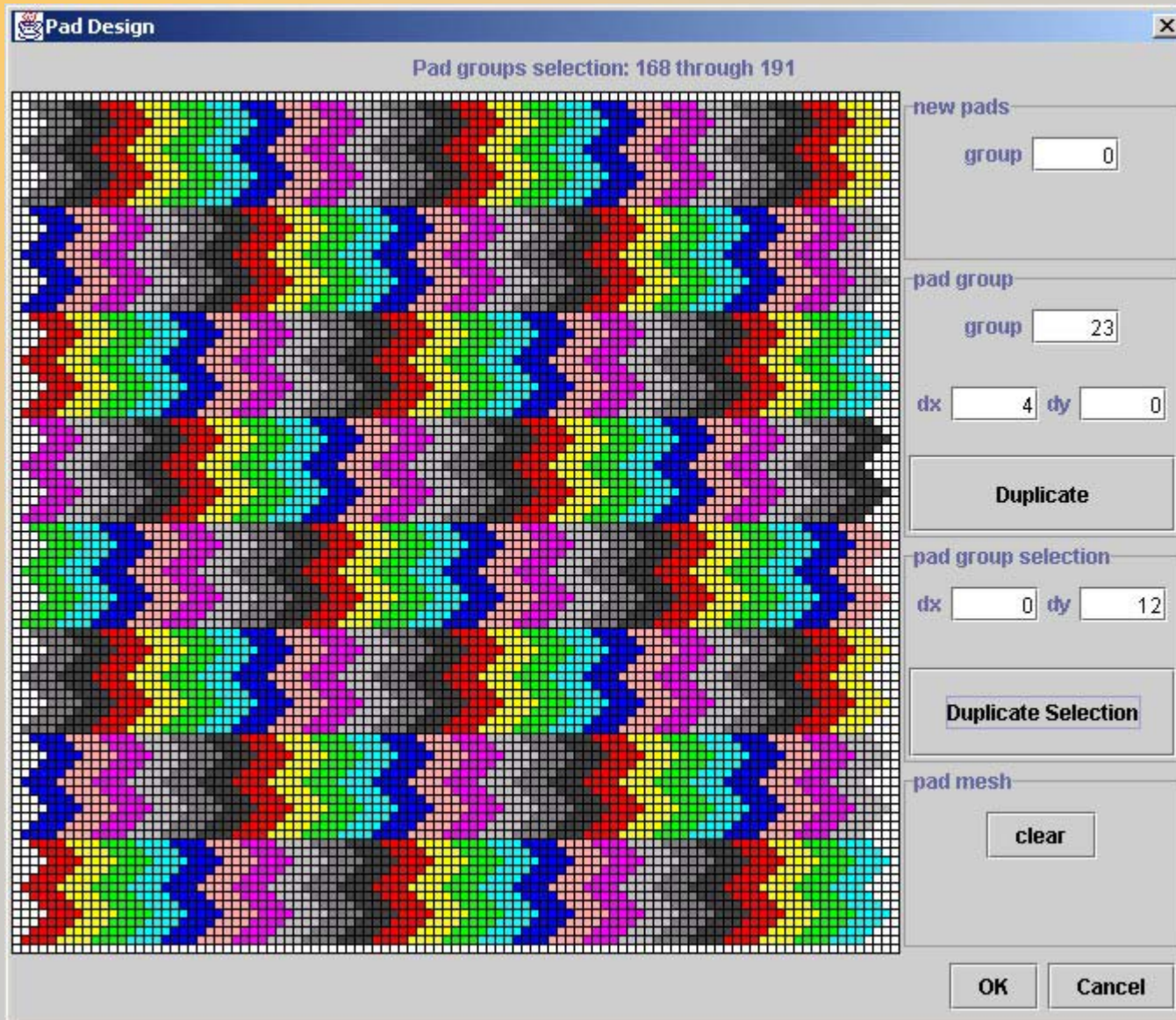
Pad Designer    Reset Mesh

Pad Mesh layout:

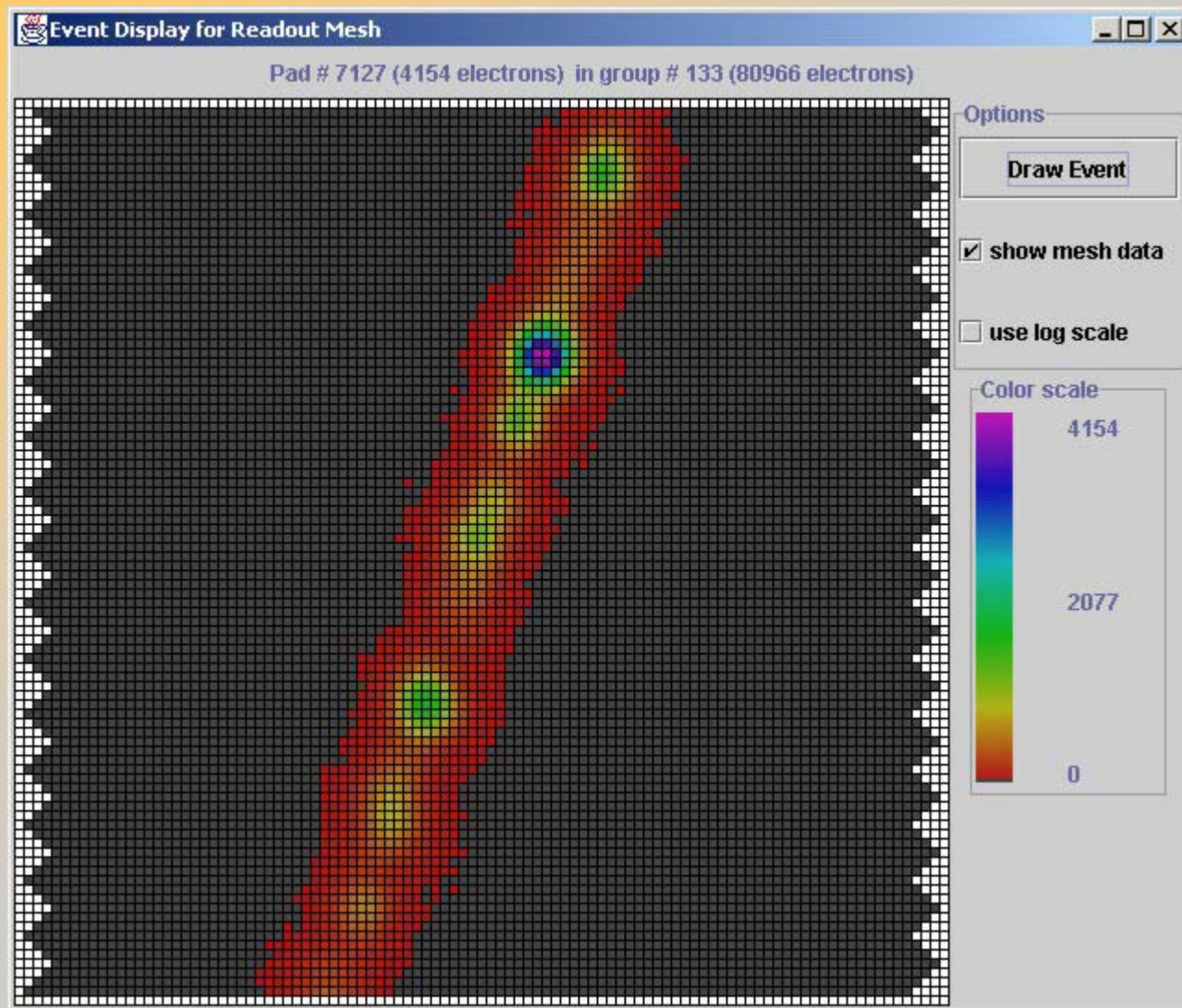
Mesh	pitch:	0.3 mm	x number:	100	x origin:	-10 mm
			y number:	100	y origin:	-10 mm

Pad shape: Square size: set to pitch size

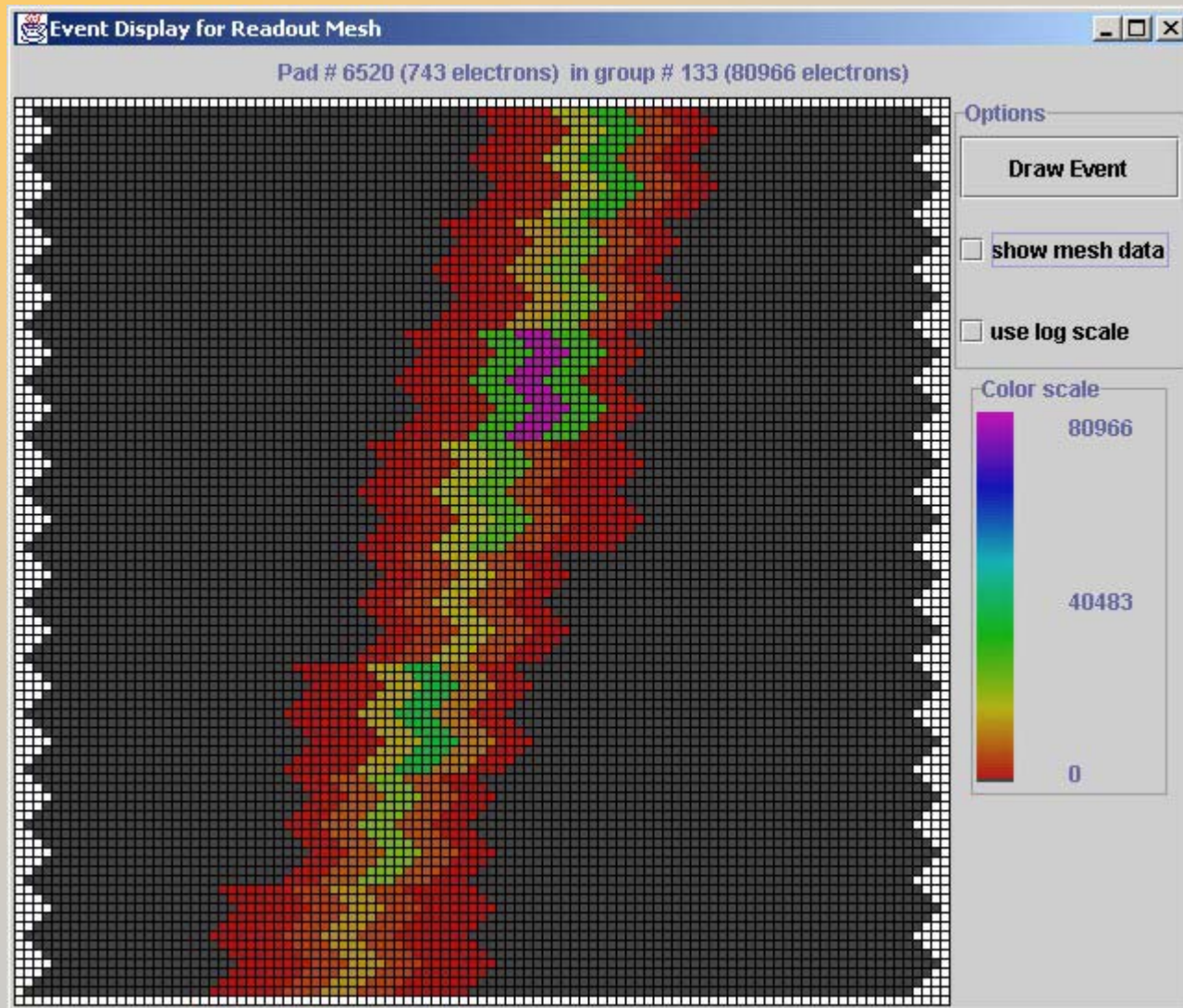
# Designing readout pads



# Adding an ionization track

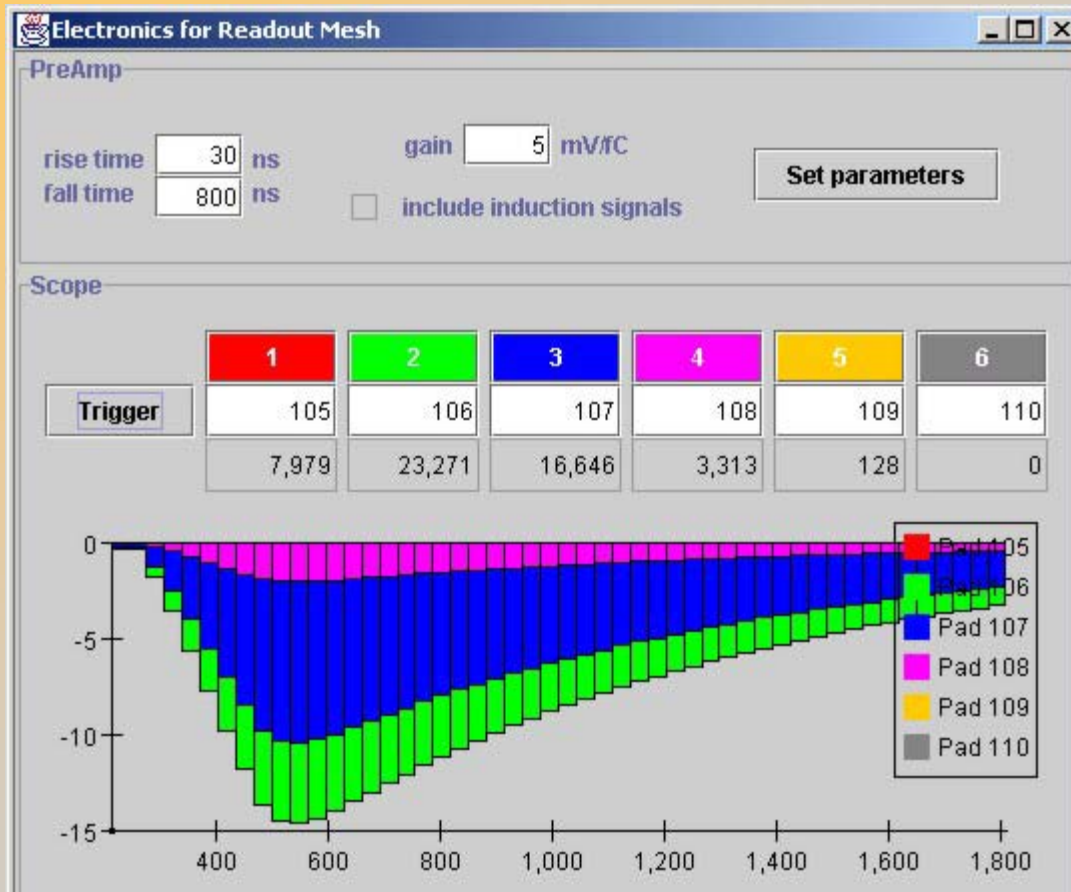


# Signals on pads



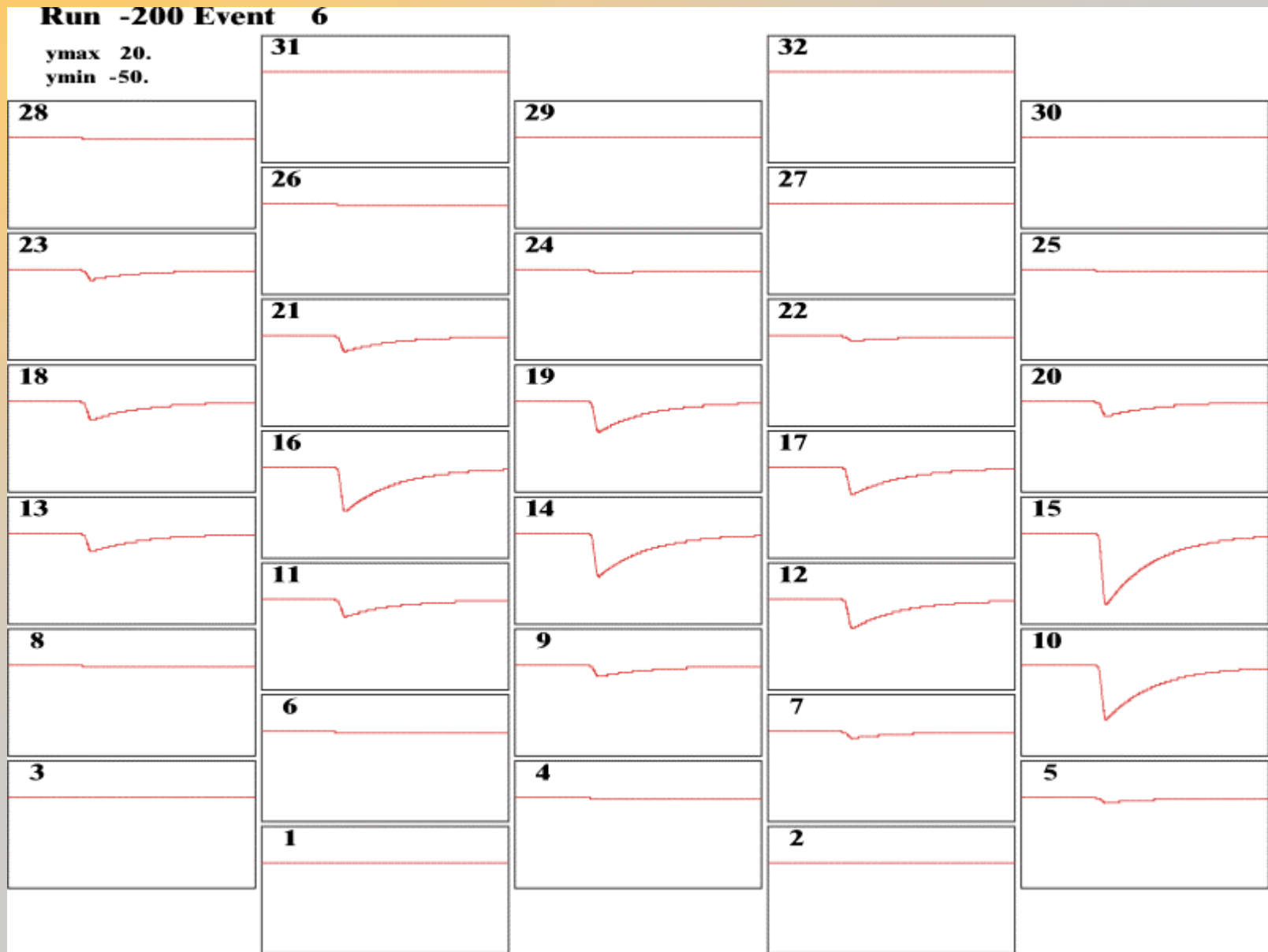


# Signals on pads



Data can be written to disk for “offline” analysis...

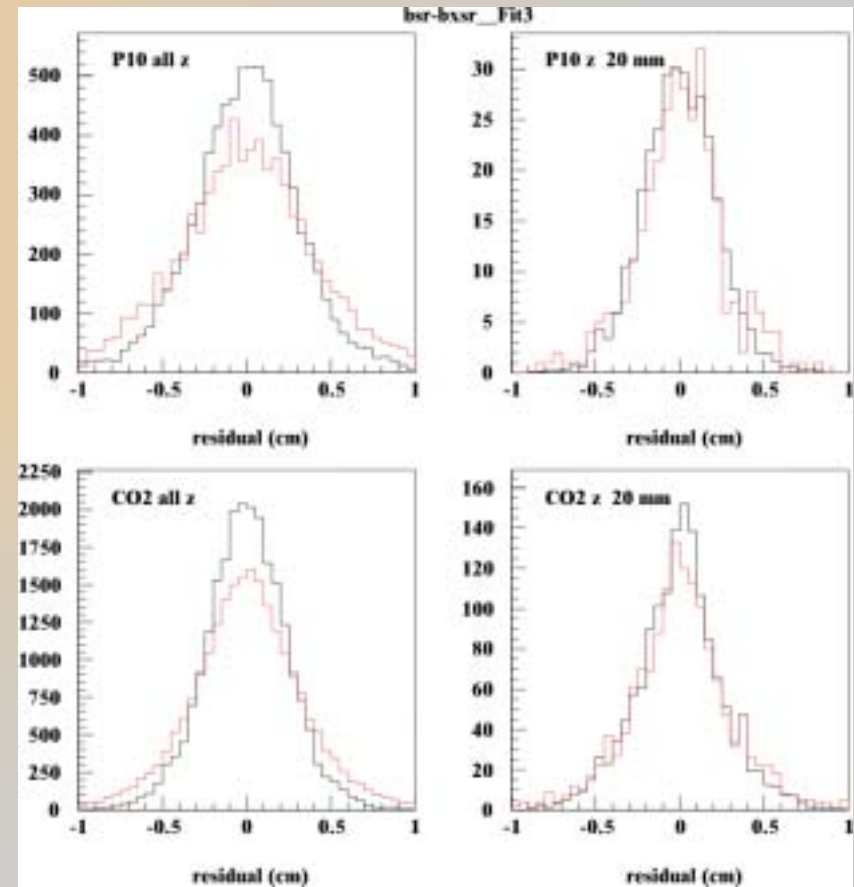
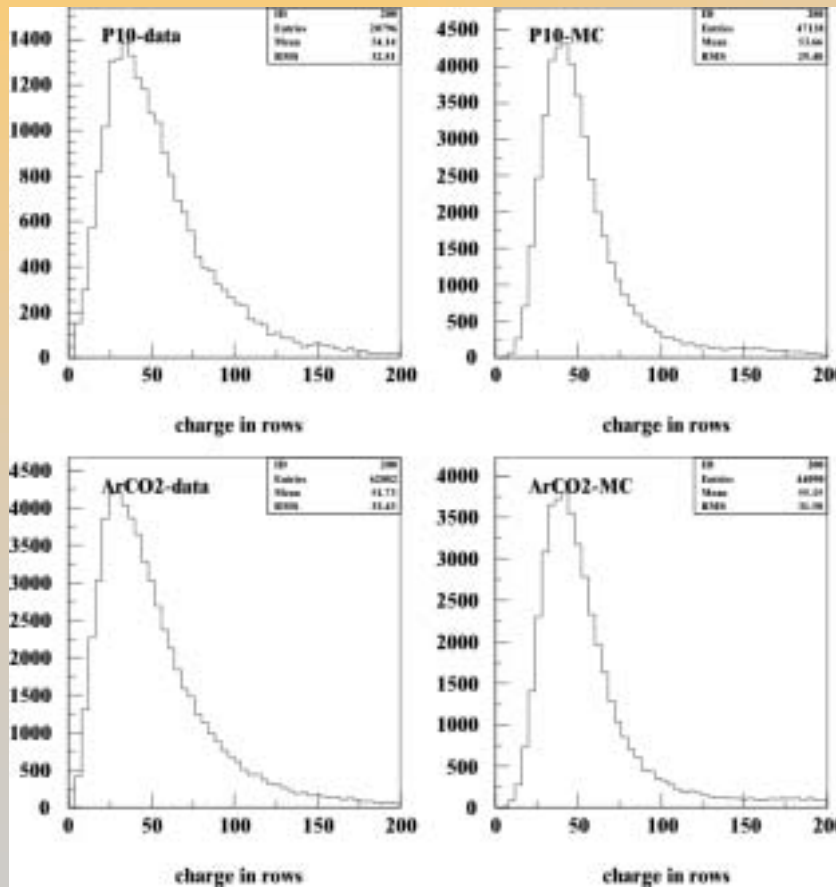
# Comparison with prototype TPC data



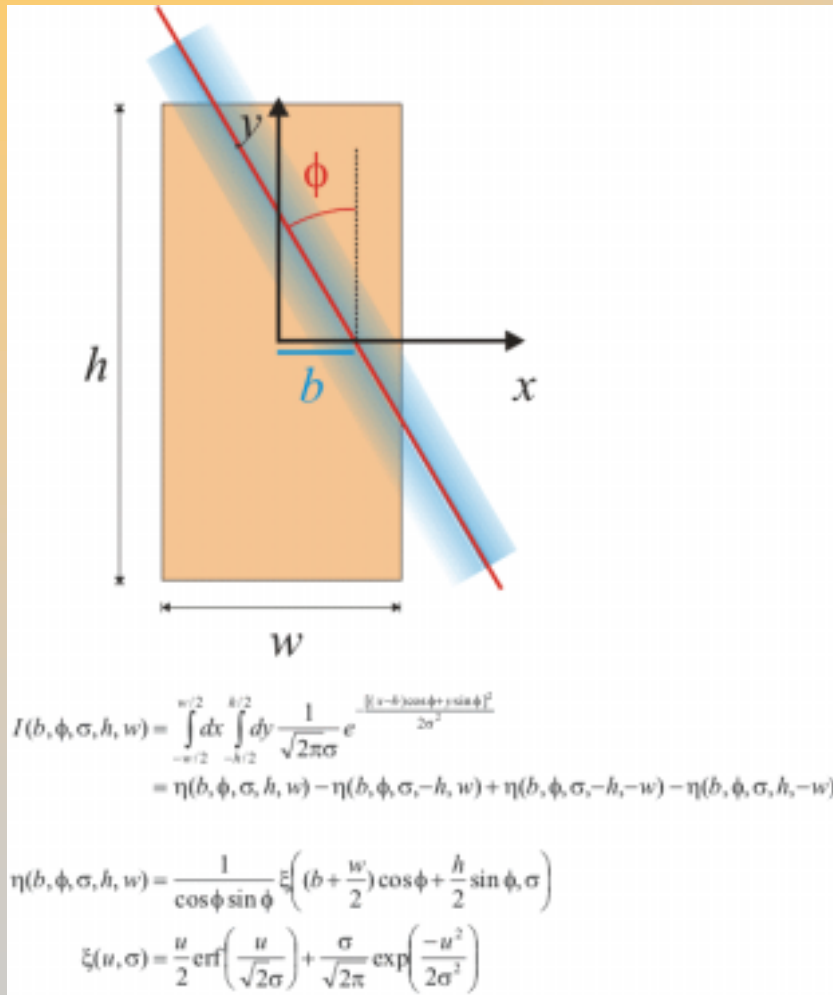
# Comparison with prototype TPC data

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

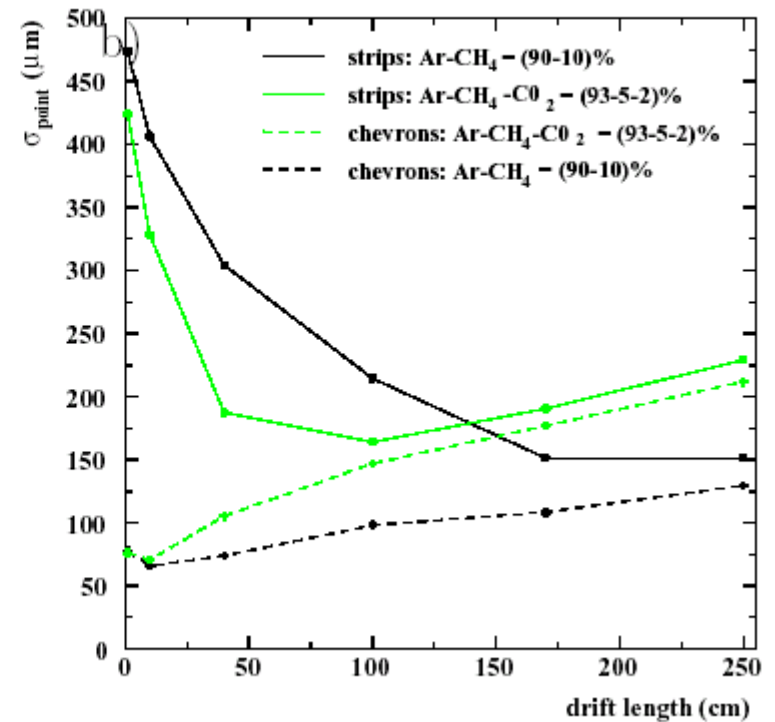
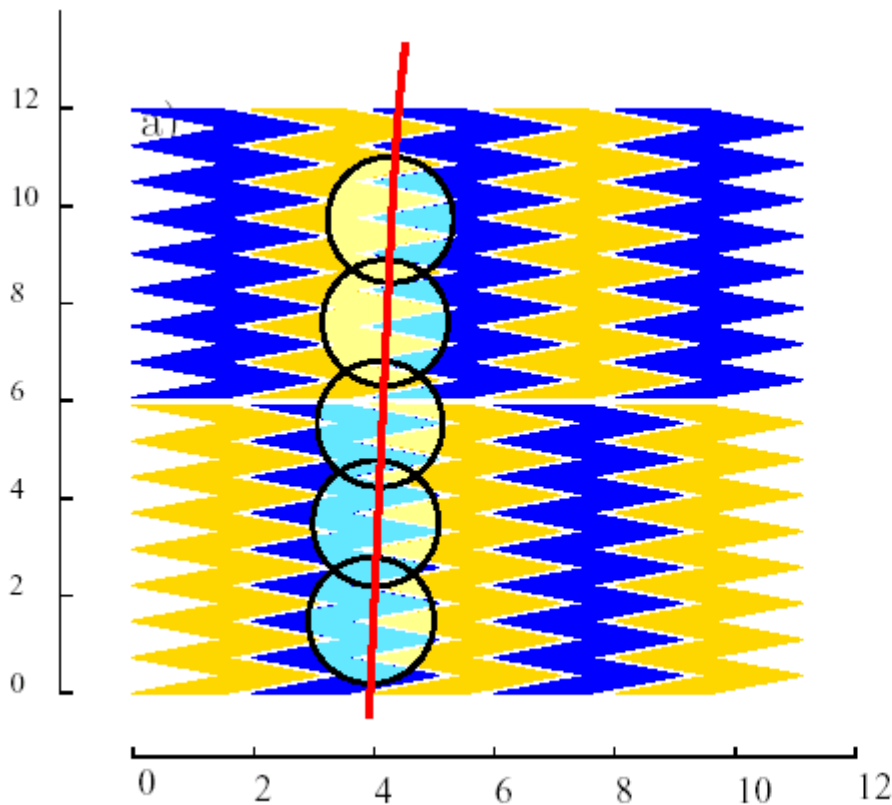
Do XY track fit 2 status: success

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

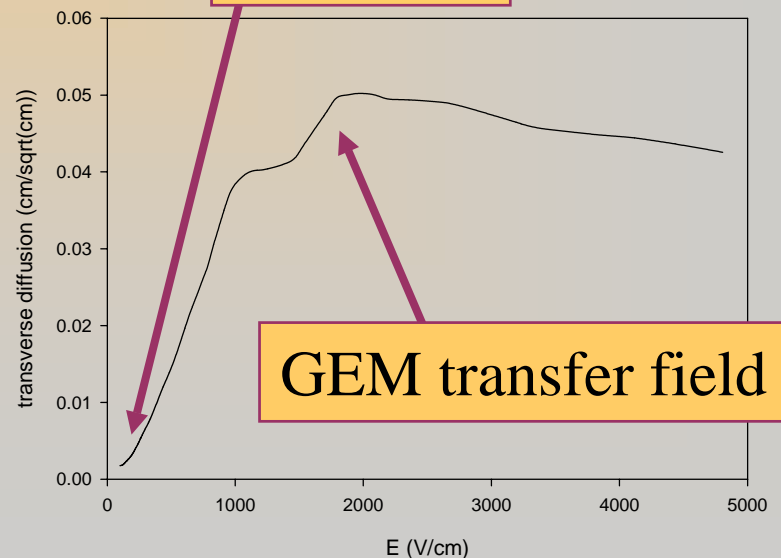
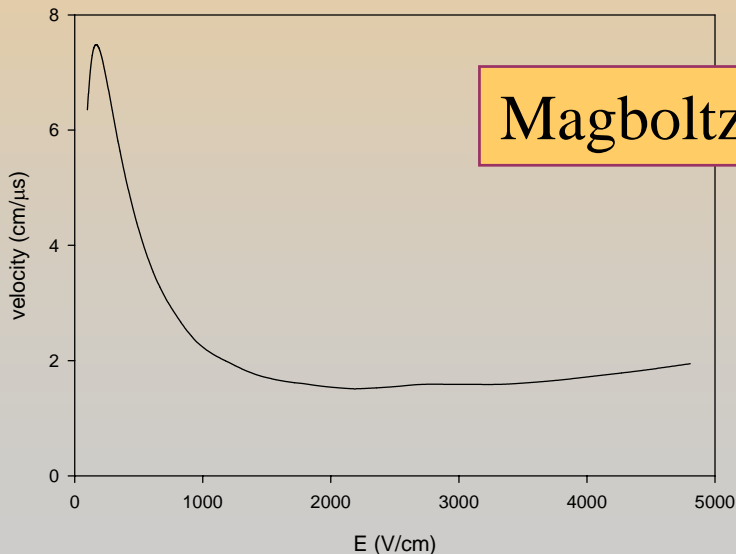
## ★ Current favourite gas mix: Ar CF<sub>4</sub>

– fast at low fields

- low transverse diffusion in magnetic fields

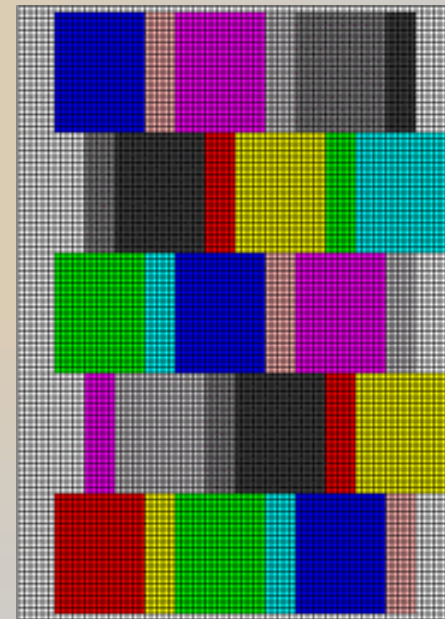
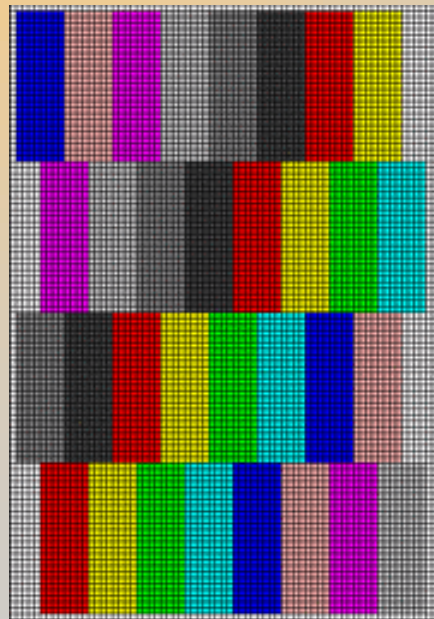
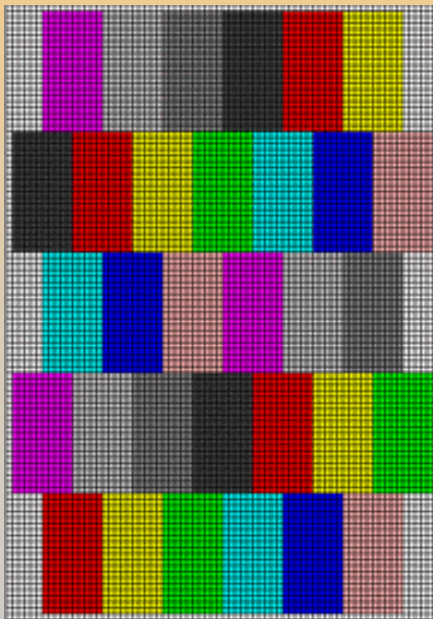
– larger diffusion at higher fields

– Example: Ar CF<sub>4</sub> (98:2)



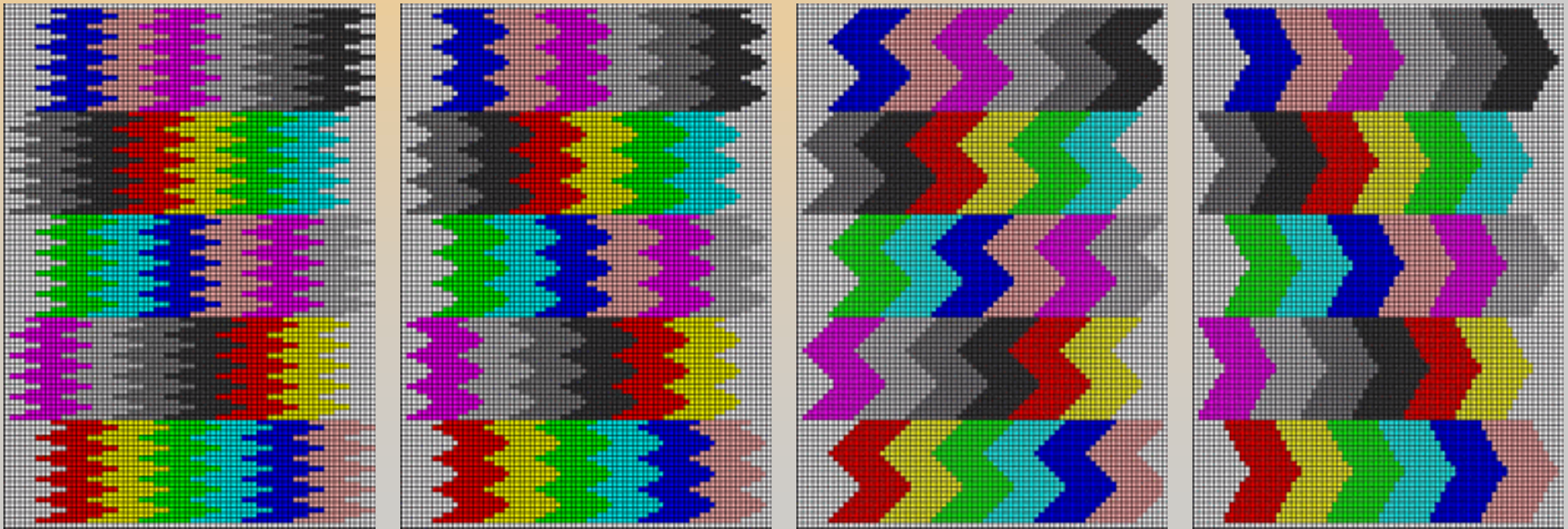
# Comparison of pad geometries for GEM

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



# Comparison of pad geometries for GEM

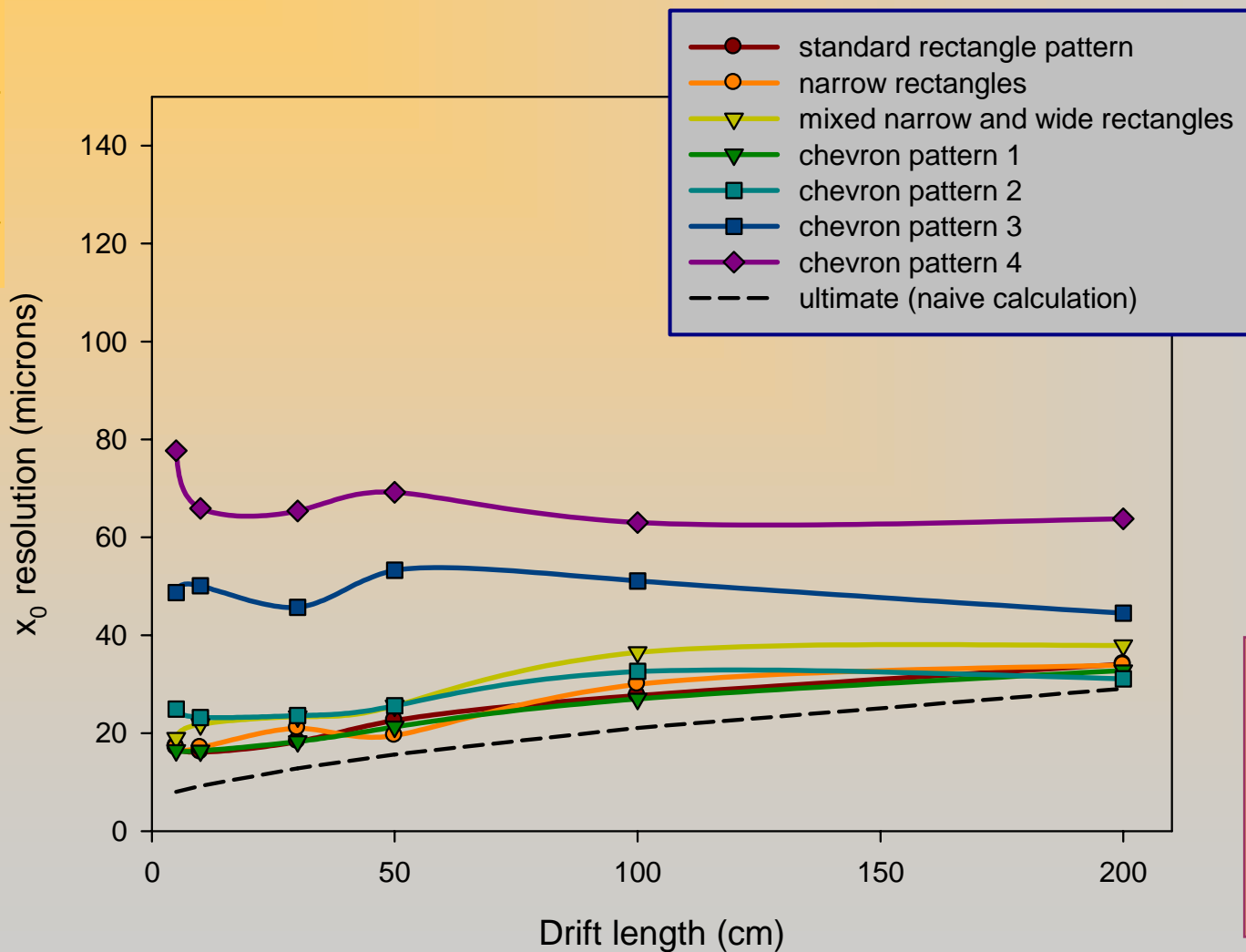
- ★ Single tracks with  $-0.1 < \phi, \psi < 0.1$
- ★ Seven pad geometries sample same ionization





# Comparison of pad geometries for GEM

Ar CF<sub>4</sub> (98:2): 5 rows of 2.5 mm x 5 mm pads

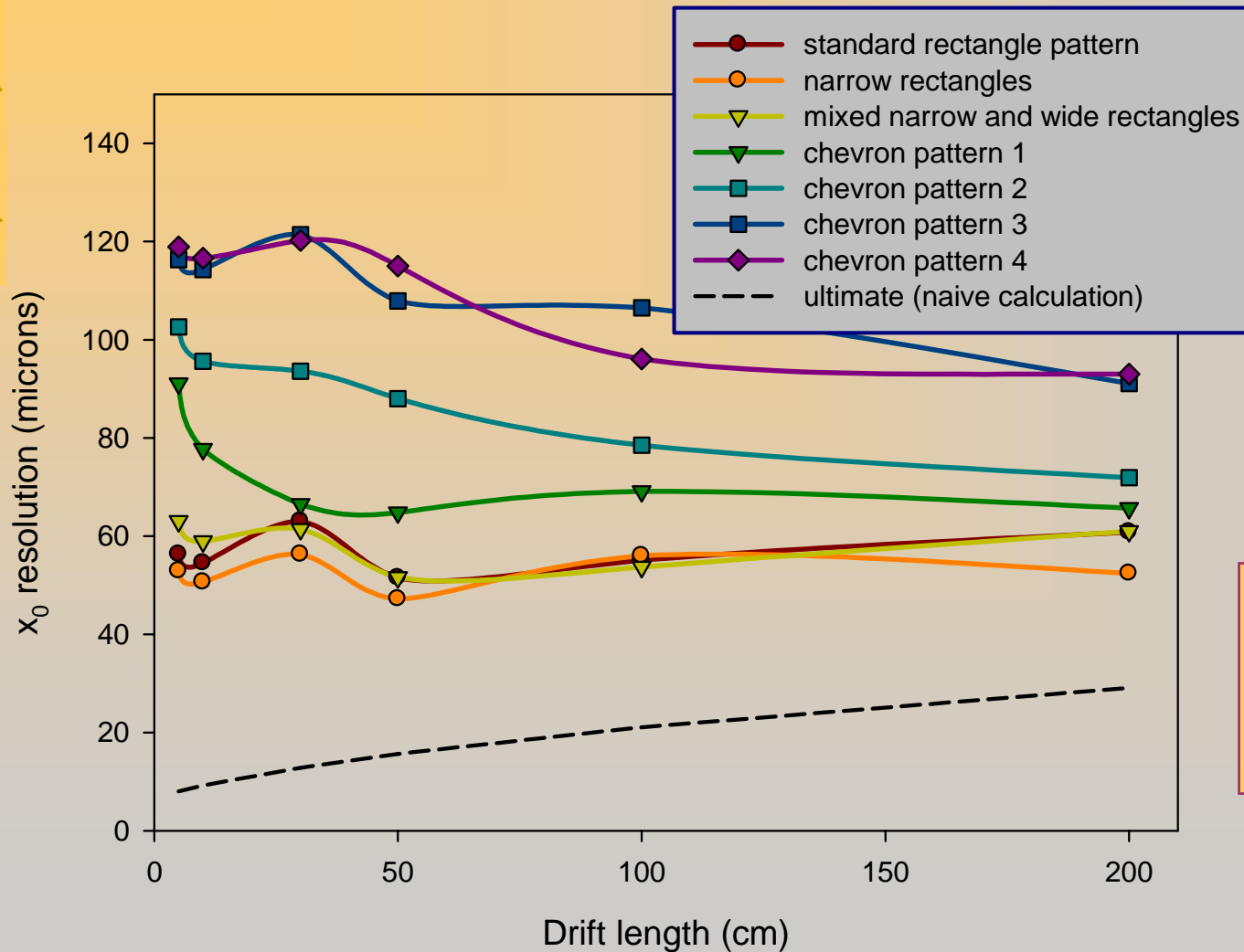


Defocussing  
in 1 cm  
GEM gap

Chevrons  
unnecessary  
in Ar CF<sub>4</sub>  
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



# *Future possible development*

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- ★ Include cluster size distributions calculated by HEED
- ★ Add noise: electronic & random SR conversions
- ★ Include “offline analysis”
  
- ★ Question: If other groups interested in the program, how best to allow for group development?
  
- ★ To download program, go to:  
<http://www.physics.carleton.ca/~karlen/gem/simulation>