

# SREFT (Spatially Resolved Fission Tracker)

Time Projection Chamber 2023

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Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

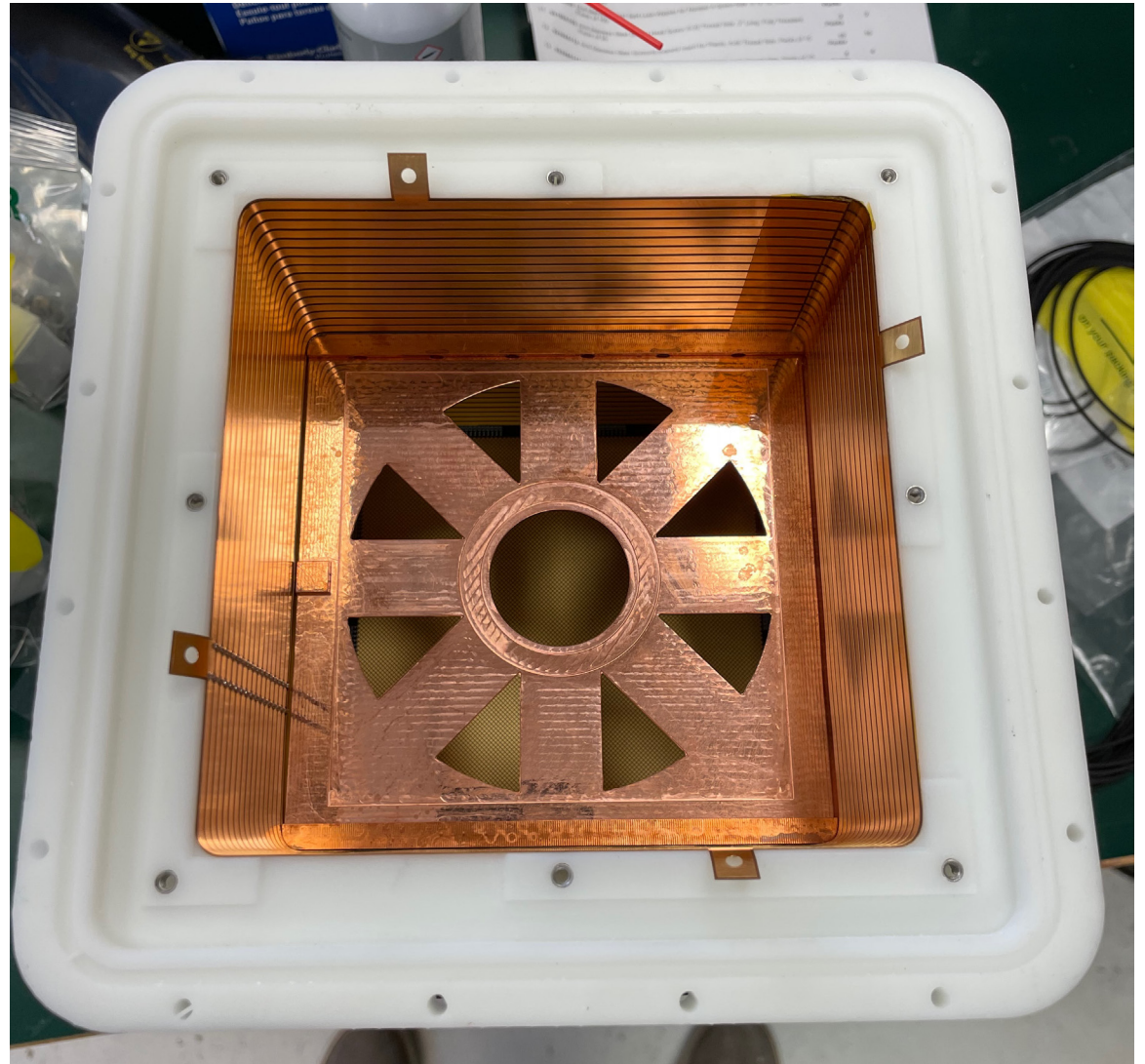
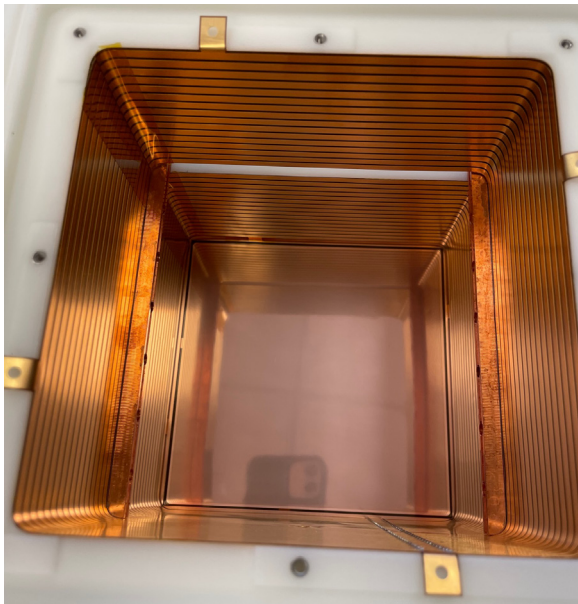
# SREFT is the Spatially Resolved Fission Tracker

- The SREFT TPC leverages lessons learned and operational experience from the larger NIFFTE TPC project
- Rapid prototyping achieved by in-house stereolithography 3D printing
- SREFT will address neutron-induced fission cross sections and we are investigating neutron-induced light charged particle ( $n,p$  and  $n,\alpha$ ) reactions as well
  - Will require higher pressures and/or a backing detector to range out less ionizing particles



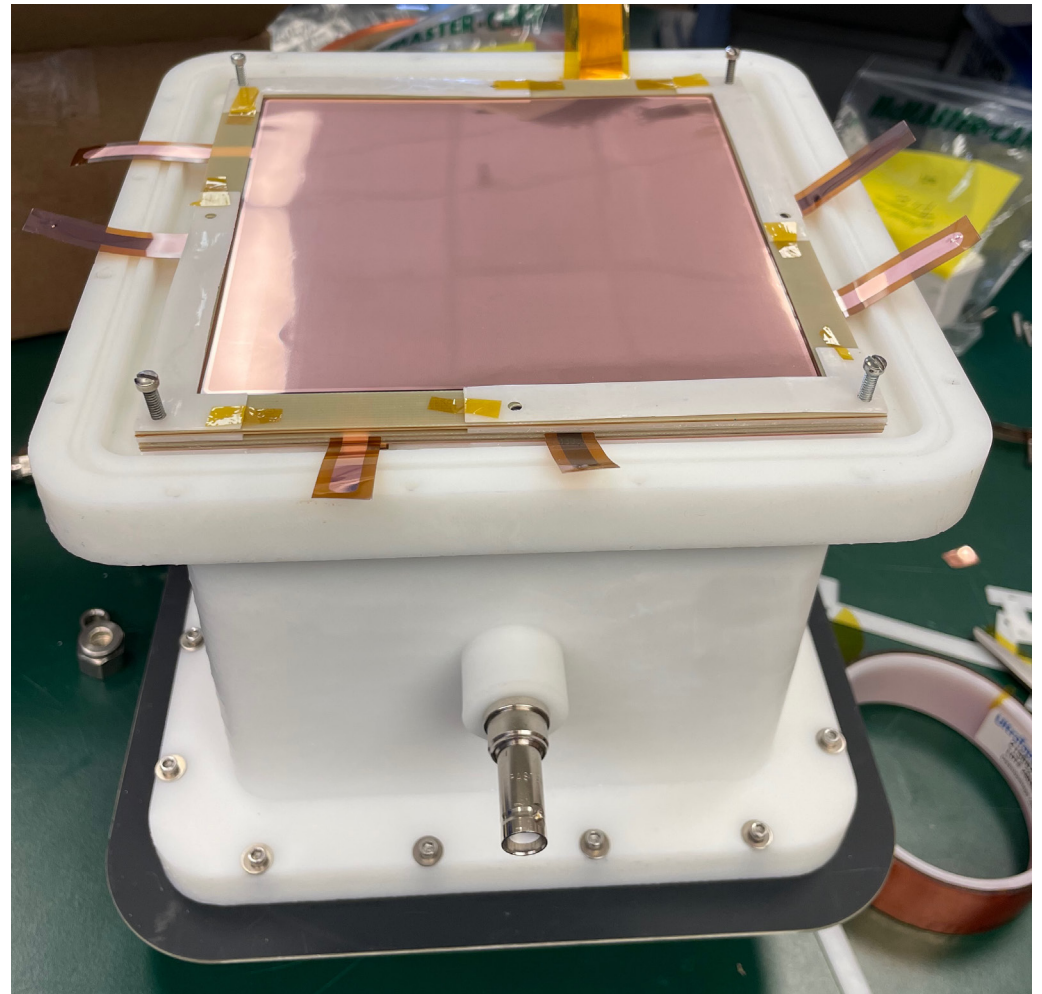
# Central Cathode Field Cage

- Central cathode made of copper slides in and out of the face of the detector on rails
- Field cage is a polyimide flex circuit field cage to degrade HV to establish uniform drift field



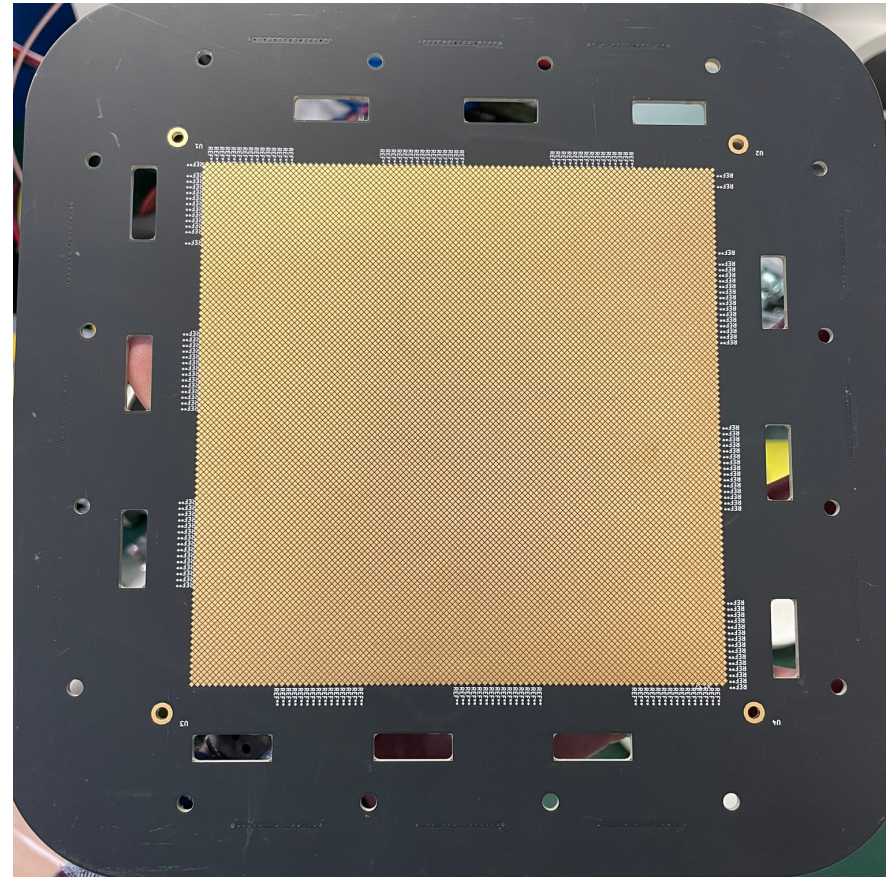
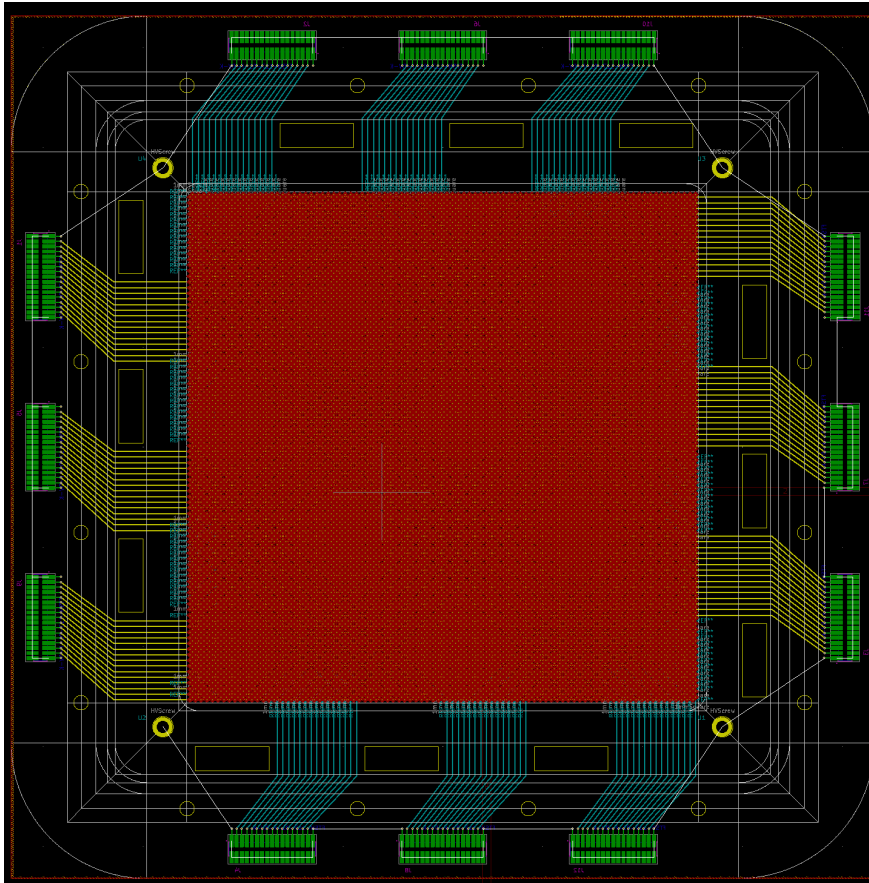
# Gas Electron Multiplier Gain Stage

- A stack of up to three Gas Electron Multipliers (GEMs) will provide a variable gain up to a factor of  $\sim 10^4$ 
  - Initial tests were completed but paused to work on some HV and gas handling control software
  - More precise spacers have been ordered to ensure uniform spacing between the GEMs to enhance gain stability



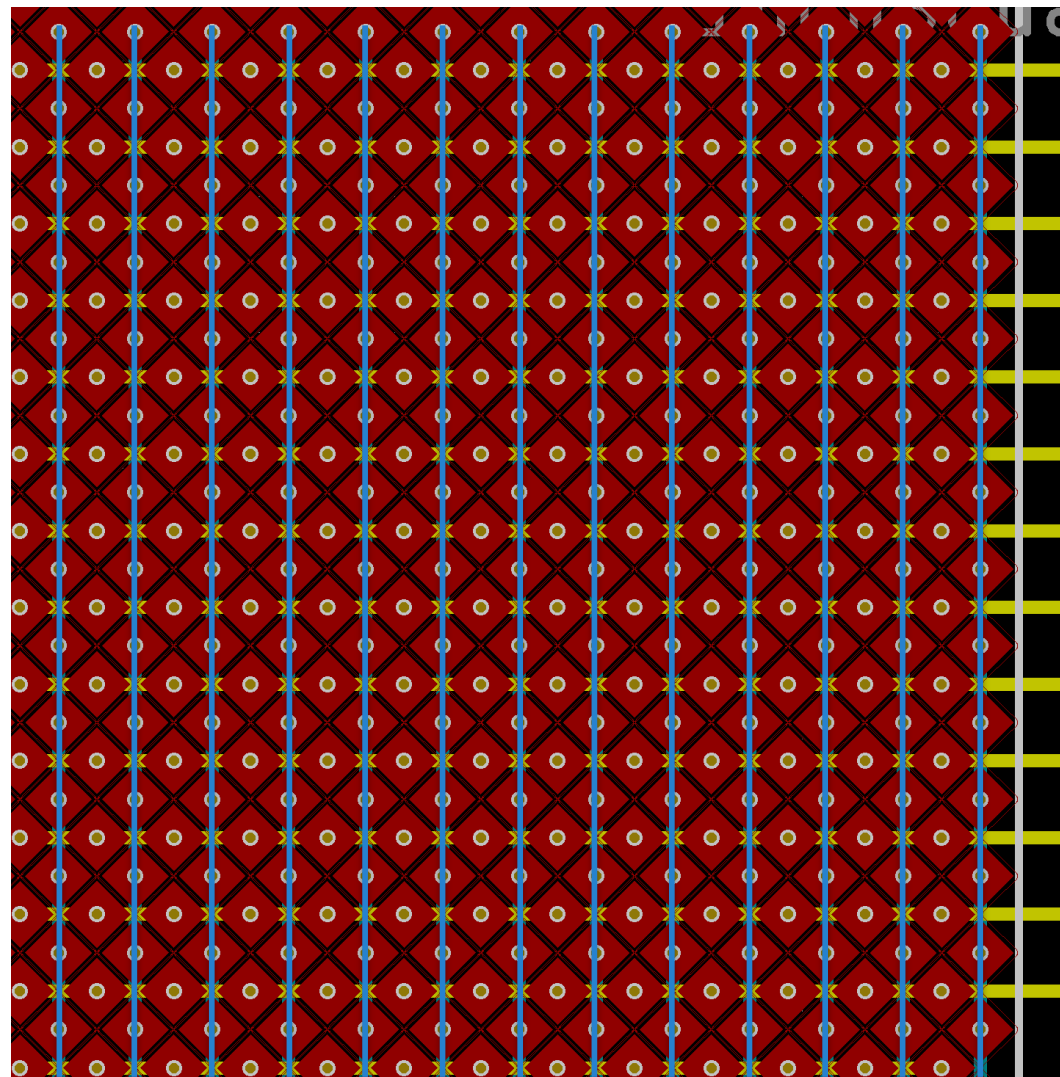
# Strip Anode Pad Plane Readout

- Readout is accomplished by a strip anode readout plane
  - 1-mm pitch diamond pattern connected in rows of 90 vertically and horizontally
  - X,Y,Z determined by arrival time of charge.
  - 180 channels of electronics compared to 16200 if each pad were to be read out

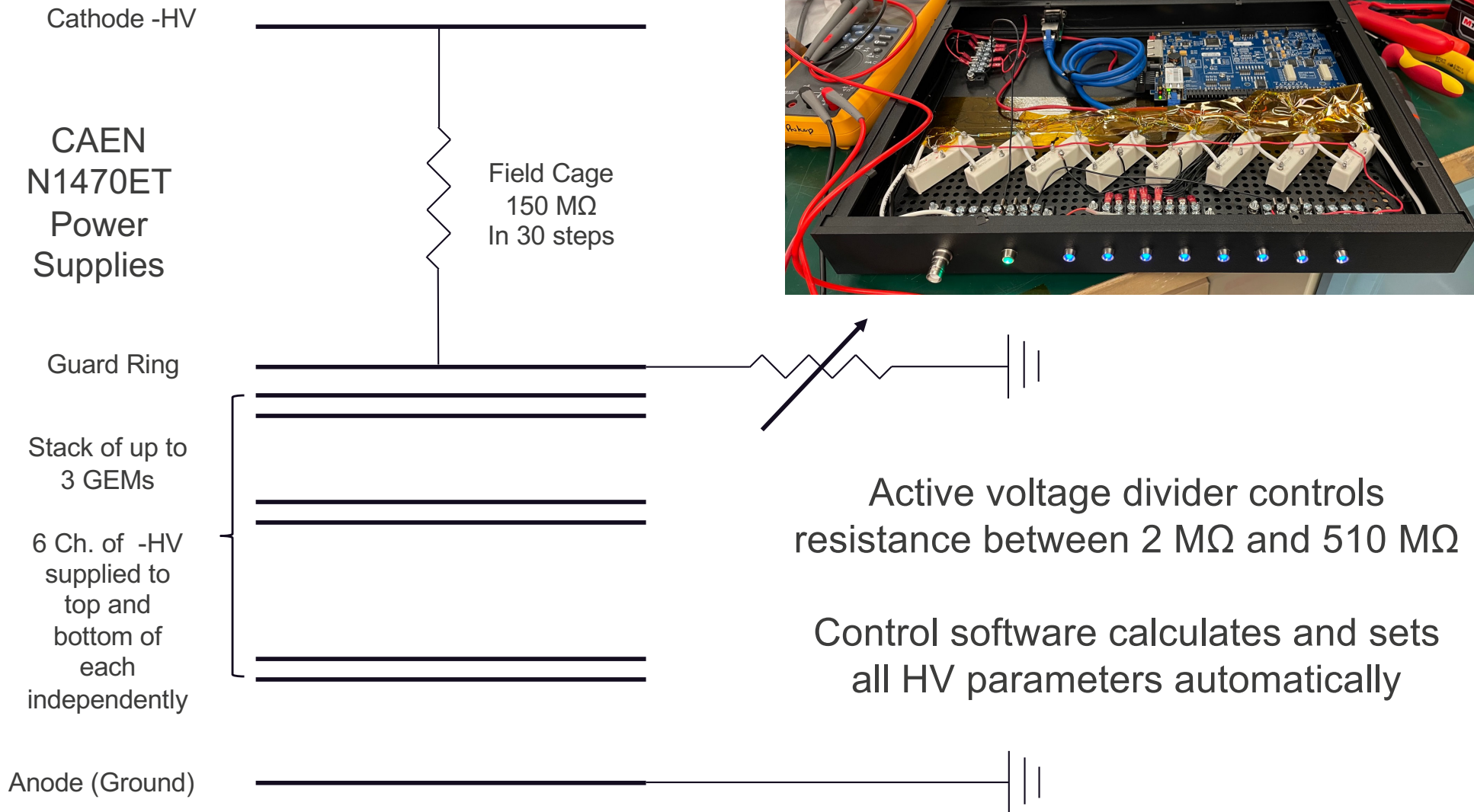


# Strip Anode Pad Plane Readout

- Collection of 16200 diamonds connected into an array of 90 horizontal and 90 vertical strips by traces inside the anode board
- Correlation between these orthogonal “strips” gives X and Y and the overall timing characteristics of charge collection give Z



# High Voltage Application and Control



# High Voltage Control

Low Voltage | High Voltage | Gas Handling | RGA

Calculate Voltages | Apply Bias | Remove Bias

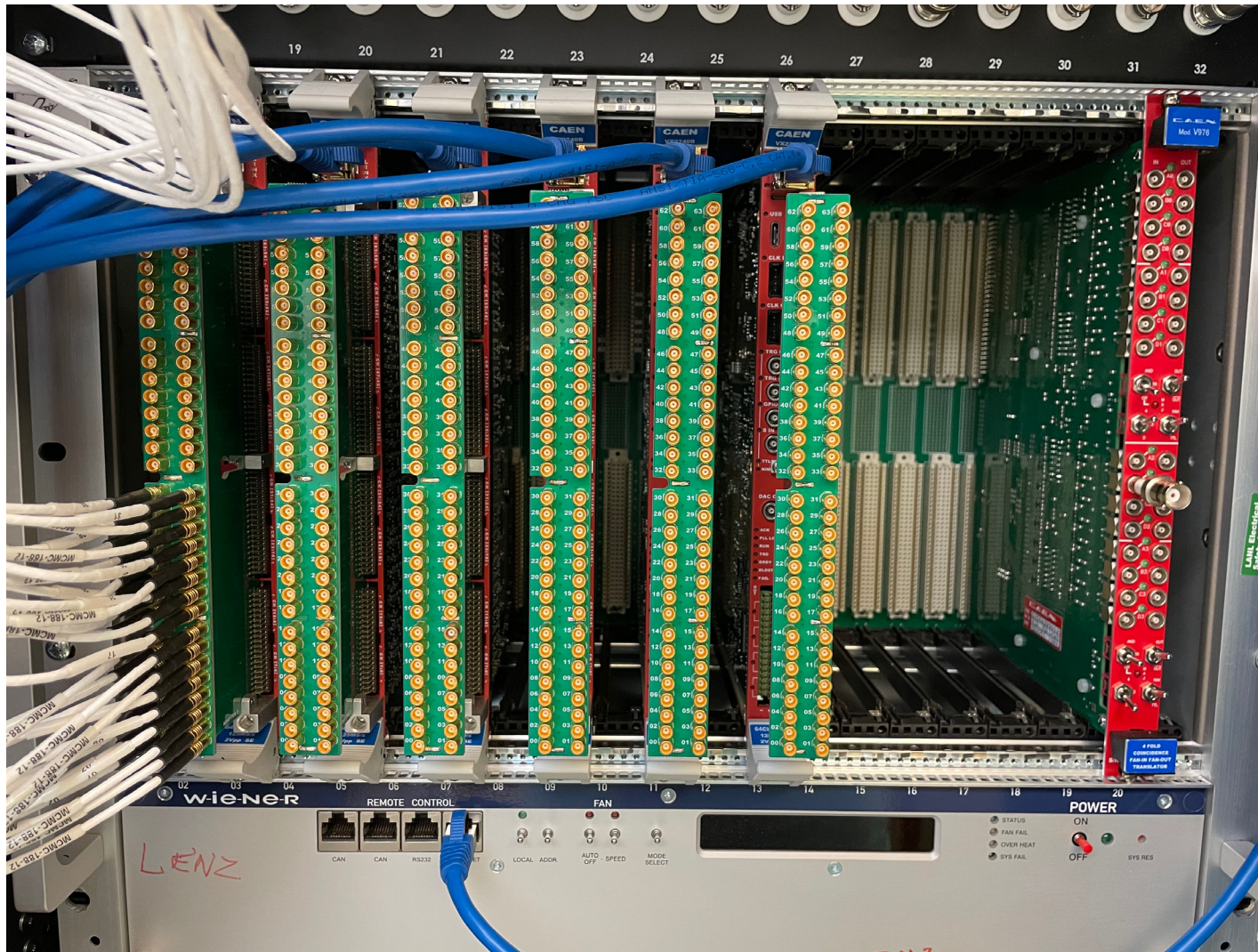
30 Ramp Time (s)  Permit Bias Changes  Permit Configuration Changes

Idle		Required Voltage (V)	Supply Number - Channel	Supply Voltage (V)	Supply Current (uA)	Ramp Rate Up (V/s)	Ramp Rate Down (V/s)
100.00	Requested Field Cage Gradient (V/cm)	0	1 2	0	0	0	0
	Estimated Field Cage Gradient (V/cm) Cathode Preamp (V)	0		0	0	0	0
	Estimated Cathode Voltage (V) Top of Top Gem	0	0 0	0	0	0	0
	Estimated Guard Ring Voltage (V) Bottom of Top Gem	0	0 1	0	0	0	0
250.00	dV on Top Gem (V)						
200.00	Transfer Gap 1 Gradient (V/mm) Top of Middle Gem	0	0 2	0	0	0	0
	Bottom of Middle Gem	0	0 3	0	0	0	0
250.00	dV on Middle Gem (V)						
200.00	Transfer Gap 2 Gradient (V/mm) Top of Bottom Gem	0	1 0	0	0	0	0
	Bottom of Bottom Gem	0	1 1	0	0	0	0
250.00	dV on Bottom Gem (V)						
200.00	Induction Gap Gradient (V/mm) Resistance Setting	0	(Mega Ohms) Required	0	(Mega Ohms) Applied		
1.00	Transfer Gap 1 Distance (mm)	68.125	Distance from Cathode to Guard Ring (mm)				
2.00	Transfer Gap 2 Distance (mm)	0.625	Distance From Guard Ring to Top Gem (mm)				
1.00	Induction Gap Distance (mm)	26.000	Resistance on Bias Tee (Mega Ohms)				
		150.000	Resistance on Field Cage (Mega Ohms)				

**Module Connection Status**

172.16.9.20	CAEN N1470 Supply Number 0 Status	ttyUSB1	MKS 946 Module 0 Status
172.16.9.21	CAEN N1470 Supply Number 1 Status	ttyUSB0	MKS 946 Module 1 Status
172.16.9.103	Sealevel 470E I/O Module Status	ttyUSB2	Agilent Turbo Controller
		172.16.9.100	Sealevel 470E I/O Module Status

# Commercial Preamplifiers and CAEN VX2745 DAQ



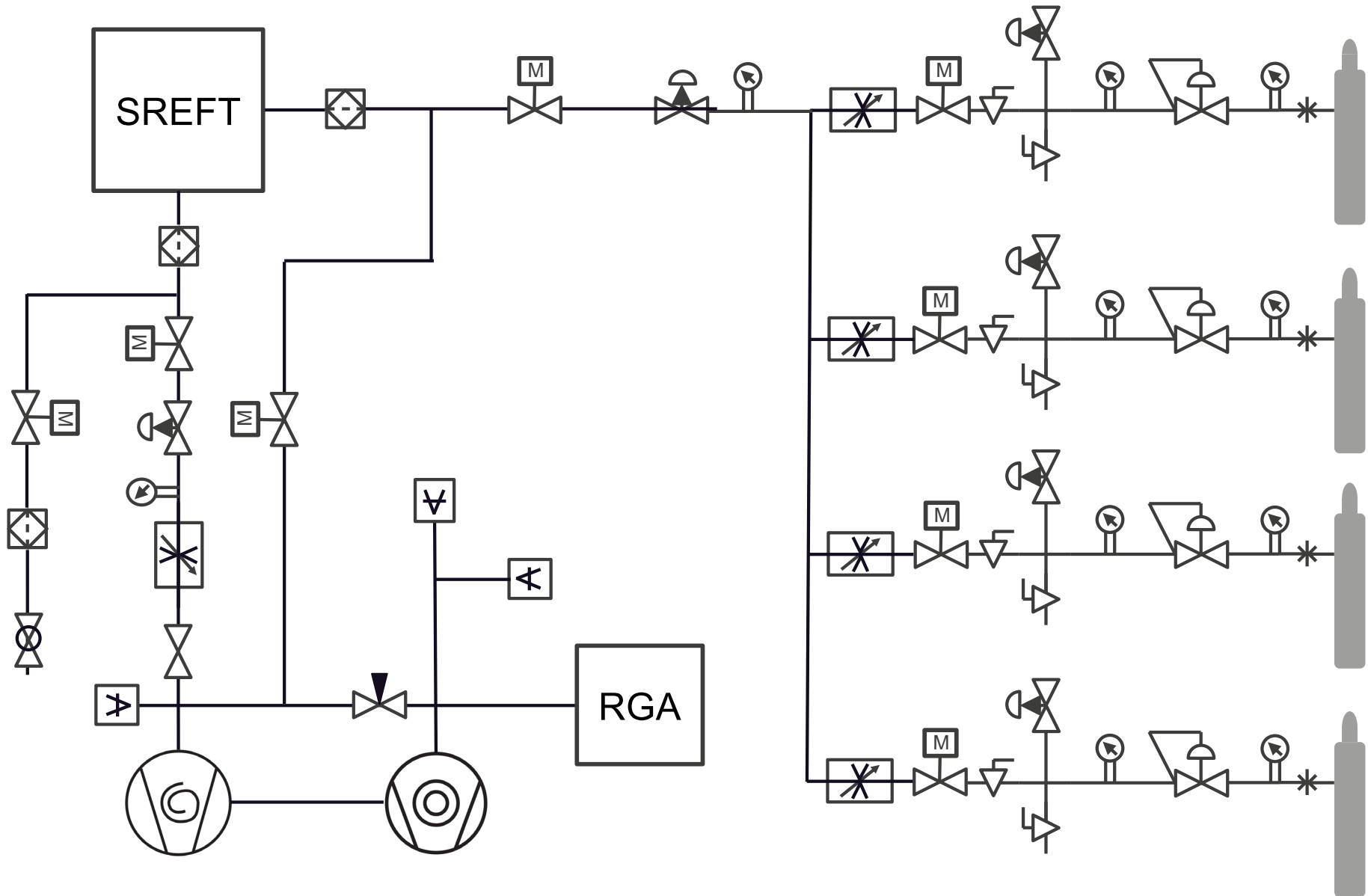
## Preamplifiers

- Commercial Kromek ev-5903

## CAEN VX2745

- 64 channels per board
  - 16-bit ADCs
  - 125 MSPS
  - Variable gain
- 
- MIDAS frontend

# Gas Handling System – Diagram



# Gas Handling System – Early Picture

- MKS mass flow controllers, baritrons, and 946 controllers allow ratios of up to 4 gasses at a user-defined pressure and flow rate
- Most valves have been fitted with electric actuators
- MKS RGA keeps track of the gas composition and purity
- Digital pressure gages monitor tank and inlet pressures
- Control interface in QT will integrate with MIDAS to record gas handling information into the data stream



# Gas Handling Control

Low Voltage
High Voltage
Gas Handling
RGA

### Pressure Control Setting Recipe

PID Number	1	P Ctrl Channel	Inlet
Pressure SP	0.00	PID Channel	MFC 0
Prop - Kp	0.00	Ctrl Start (s)	0.00
Integral - Ti	0.00	Start (%)	0.00
Derivative - Td	0.00	End (%)	0.00
Direction	Upstream	Ceiling (%)	0.00
SchedGainCoeff	0	Preset (%)	0.00
GainSchedBand	0	Base (%)	0.00

Read PID
Write PID

Start Gas Flow

Vent

### MFC Ratio Recipe

Ratio Number	1
MFC 0 (%)	0.00
MFC 1 (%)	0.00
MFC 2 (%)	0.00
MFC 3 (%)	0.00

Read Ratio
Write Ratio

### Active Settings

Change Active PID Number
1

Change Active Ratio Number
1

Vent Valve	Open	Closed
Inlet Valve	Open	Closed
Exhaust Valve	Open	Closed
RGA Valve	Open	Closed

### Pressure Readings (Torr)

Inlet Baritron	<input type="text"/>
Exhaust Baritron	<input type="text"/>
Foreline Convection	<input type="text"/>
High Vacuum Convection	<input type="text"/>
High Vacuum Cold Cathode	<input type="text"/>
Control Set Point (torr)	0.00
Protection Set Point (torr)	0.00

#### MFC 0

Gas Correction	<input type="text"/>
Flow Rate (sccm)	<input type="text"/>
Pressure (PSIG)	<input type="text"/>

#### MFC 1

Gas Correction	<input type="text"/>
Flow Rate (sccm)	<input type="text"/>
Pressure (PSIG)	<input type="text"/>

#### MFC 2

Gas Correction	<input type="text"/>
Flow Rate (sccm)	<input type="text"/>
Pressure (PSIG)	<input type="text"/>

#### MFC 3

Gas Correction	<input type="text"/>
Flow Rate (sccm)	<input type="text"/>
Pressure (PSIG)	<input type="text"/>

#### Exhaust MFC

Gas Correction	<input type="text"/>	MFC Mode	OPEN
Flow Rate (sccm)	<input type="text"/>	Set Point (sccm)	100.00

#### Inlet Valve 0 Status

Open
Closed

Pressure (PSIG)	<input type="text"/>
Gas Type	Argon

#### Inlet Valve 1 Status

Open
Closed

Pressure (PSIG)	<input type="text"/>
Gas Type	Argon

#### Inlet Valve 2 Status

Open
Closed

Pressure (PSIG)	<input type="text"/>
Gas Type	Argon

#### Inlet Valve 3 Status

Open
Closed

Pressure (PSIG)	<input type="text"/>
Gas Type	Argon

#### Turbo Pump Status

Start
Stopped

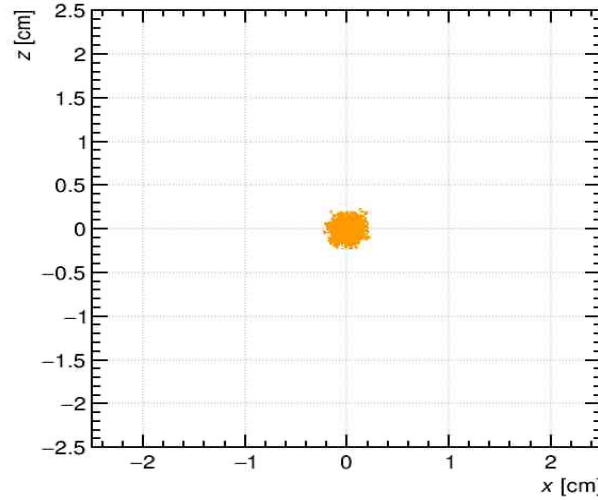
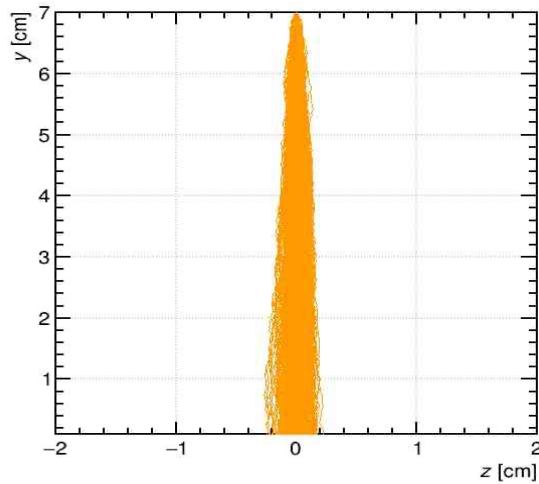
Power (W)	<input type="text"/>	Frequency (Hz)	<input type="text"/>
Controller Temp (C)	<input type="text"/>	Pump Temp (C)	<input type="text"/>

#### Module Connection Status

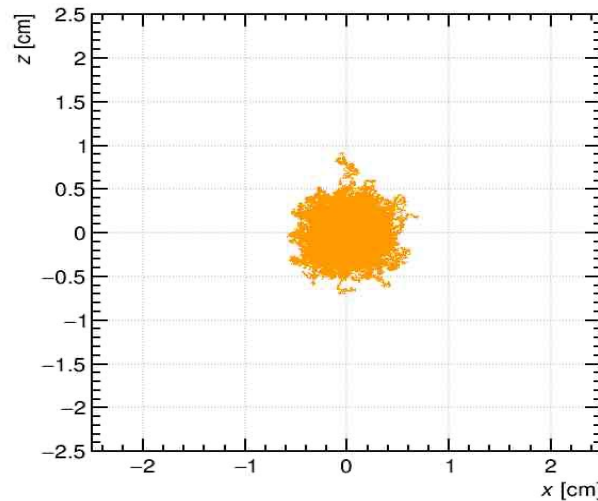
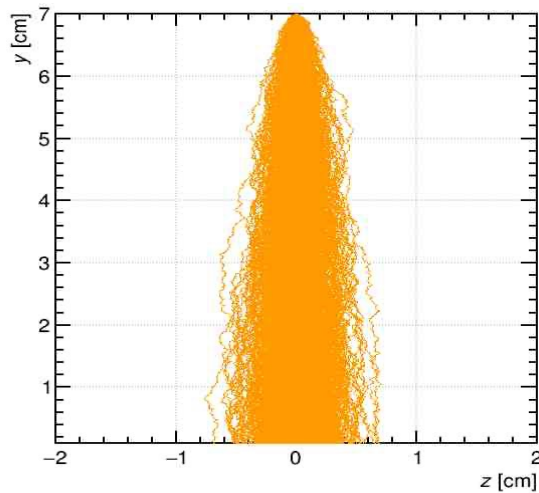
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<input type="text" value="172.16.9.21"/>	CAEN N1470 Supply Number 1 Status	<span style="background-color: green; color: white;">ttyUSB0</span>	MKS 946 Module 1 Status
<input type="text" value="172.16.9.103"/>	Sealevel 470E I/O Module Status	<span style="background-color: green; color: white;">ttyUSB2</span>	Agilent Turbo Controller
		<span style="background-color: red; color: white;">172.16.9.100</span>	Sealevel 470E I/O Module Status

# Simulation Efforts by Jaspreet – Electron Diffusion

- Looking at electron diffusion for different gas mixtures



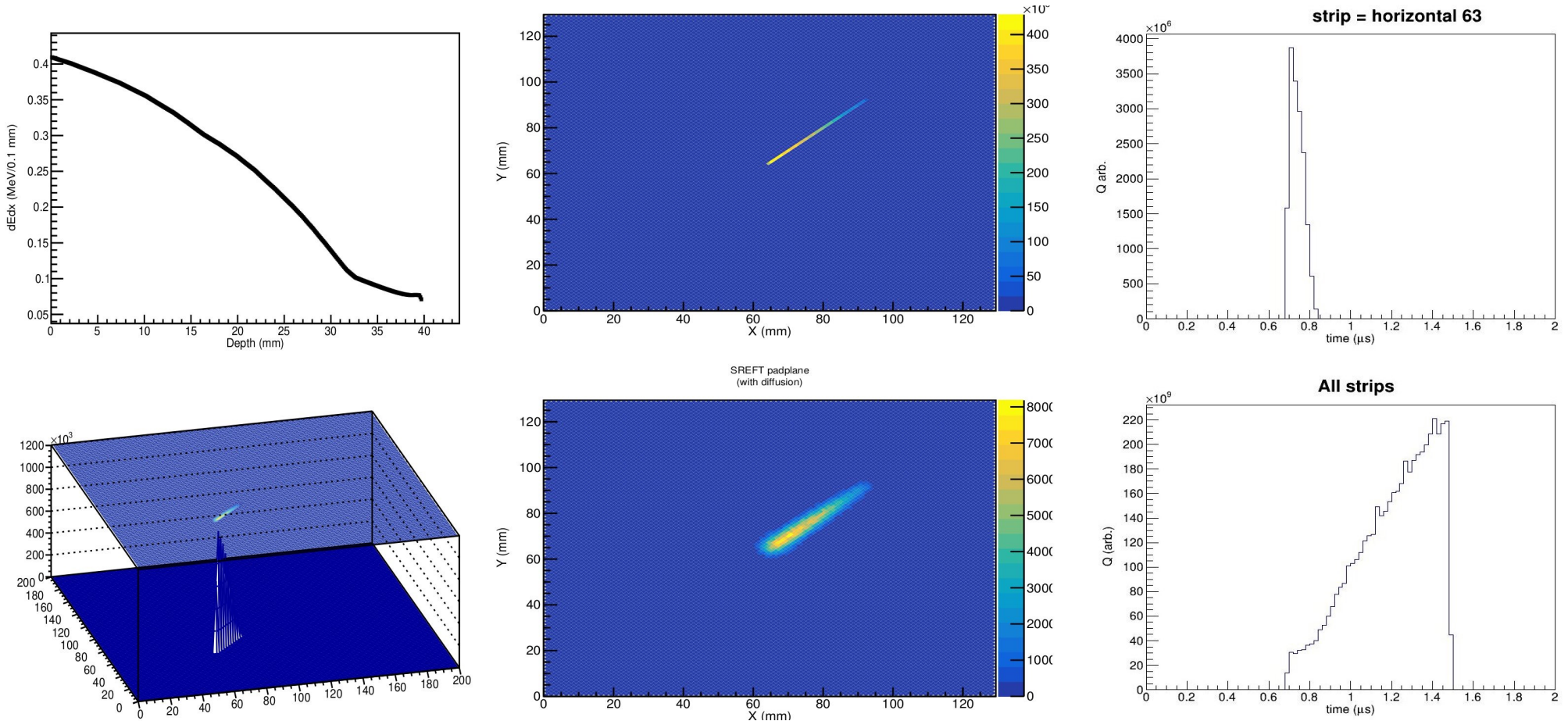
90% Ar  
10% CF<sub>4</sub>



90% Ar  
10% CH<sub>4</sub>

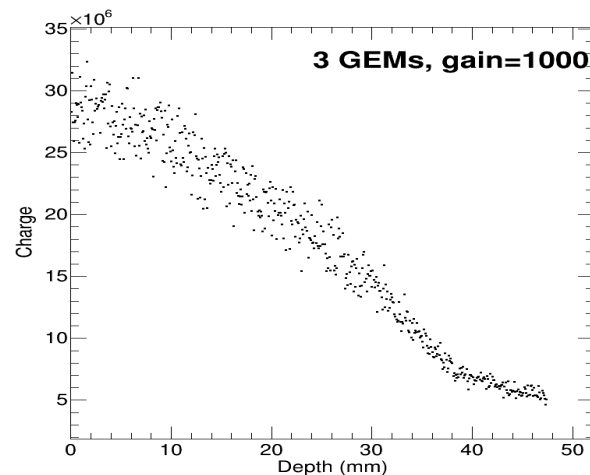
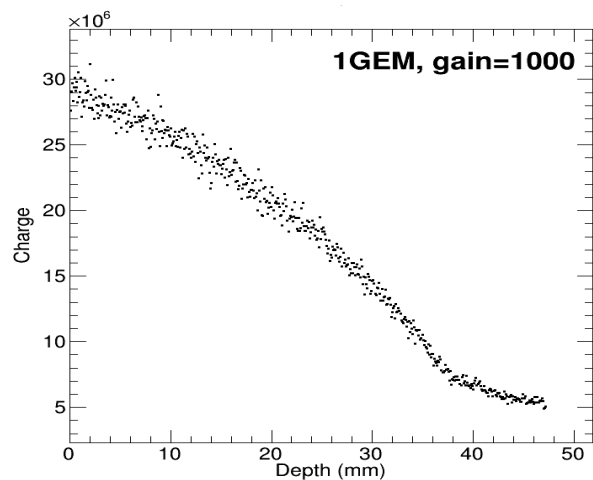
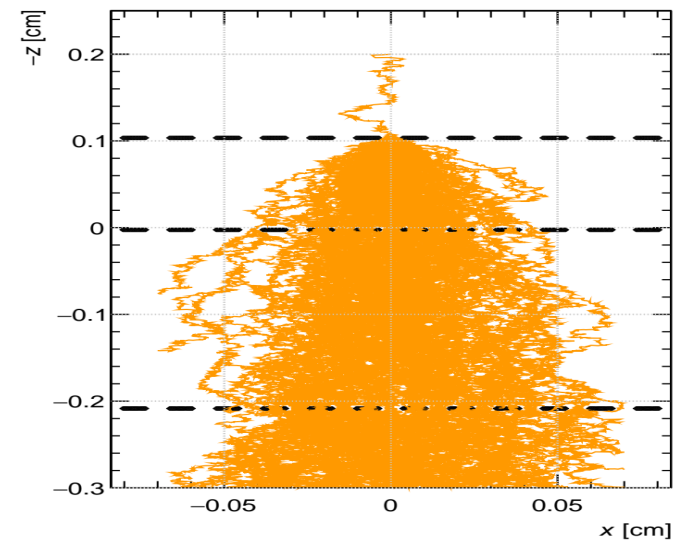
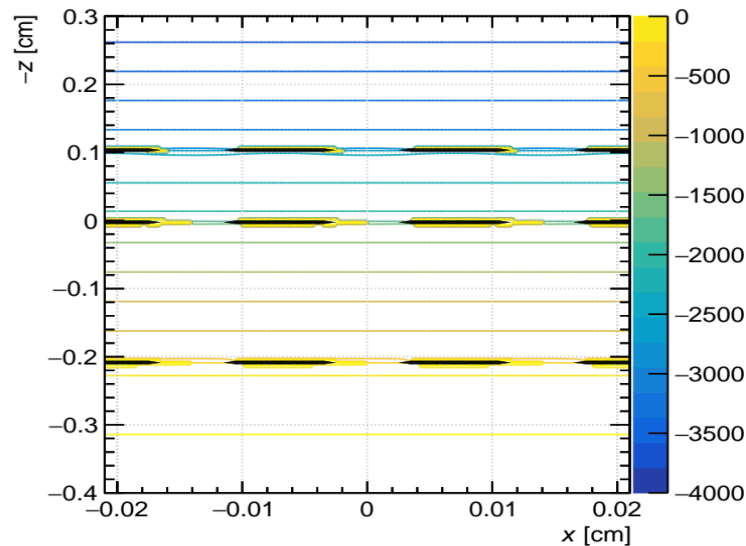
# Simulation Efforts by Jaspreet – Tracks and Timing

- Simulation of a fission fragment traversing the detector showing the charge collection as a function of time for an individual strip and all strips



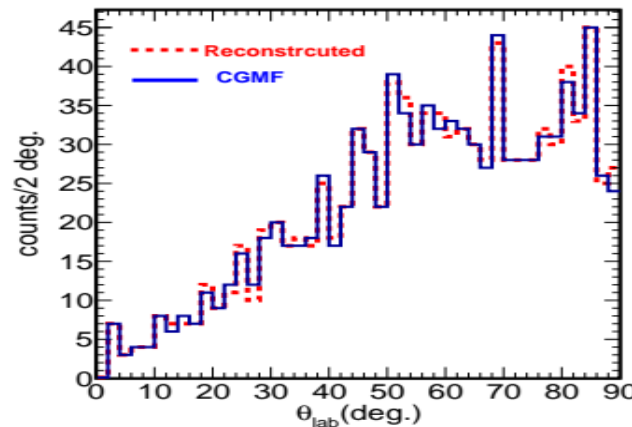
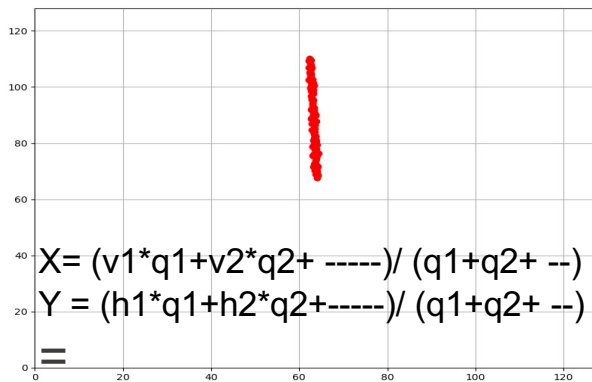
# Simulation Efforts by Jaspreet – GEM Gain

- Field mapping and simulation of electrons passing through a triple stack of GEMs

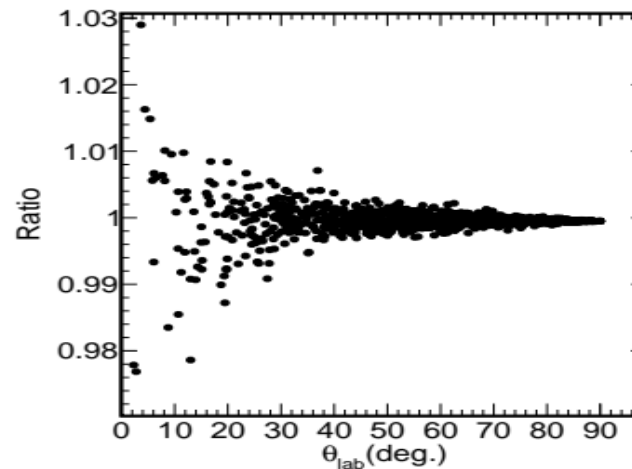
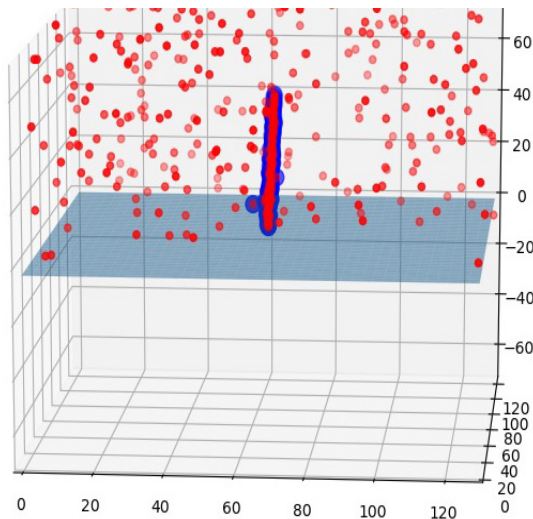


The gain variation is worse for a stack of three GEMs as compared to a single GEM.

# Simulated Tracks Using Fission Fragments from CGMF

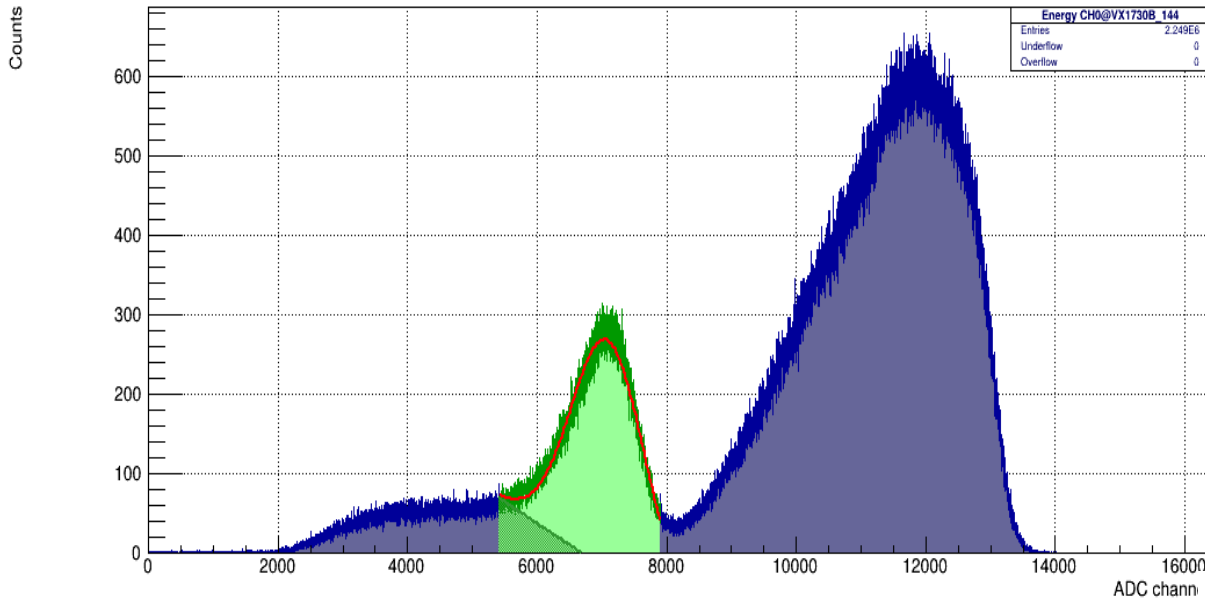


- **Track Reconstruction uses Random Sampling Consensus (RANSAC) to fit a line to a cluster of points in space deduced from the coincident arrival of charge on orthogonal X and Y strips.**



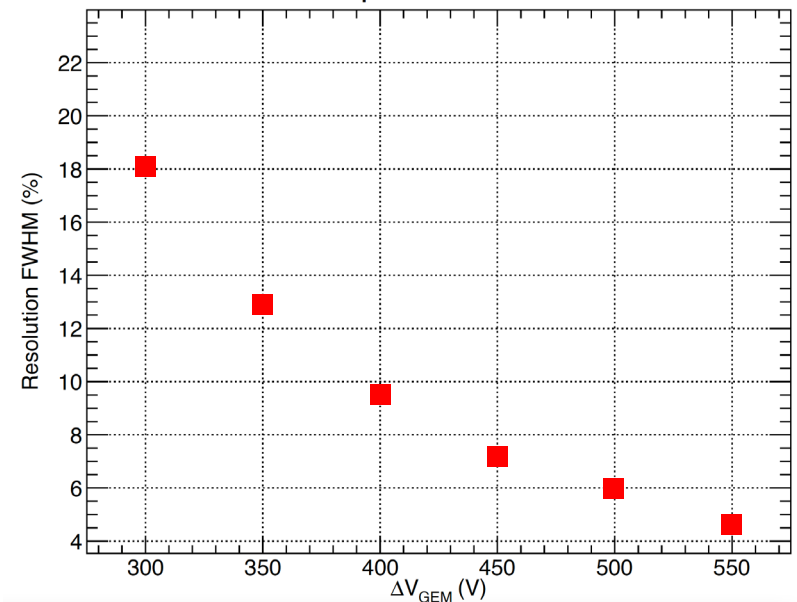
- Better than 0.2 degree agreement on simulated data
- Actual values for the angle and vertex reconstruction will be determined soon using source data

# First Measurements with GEMS



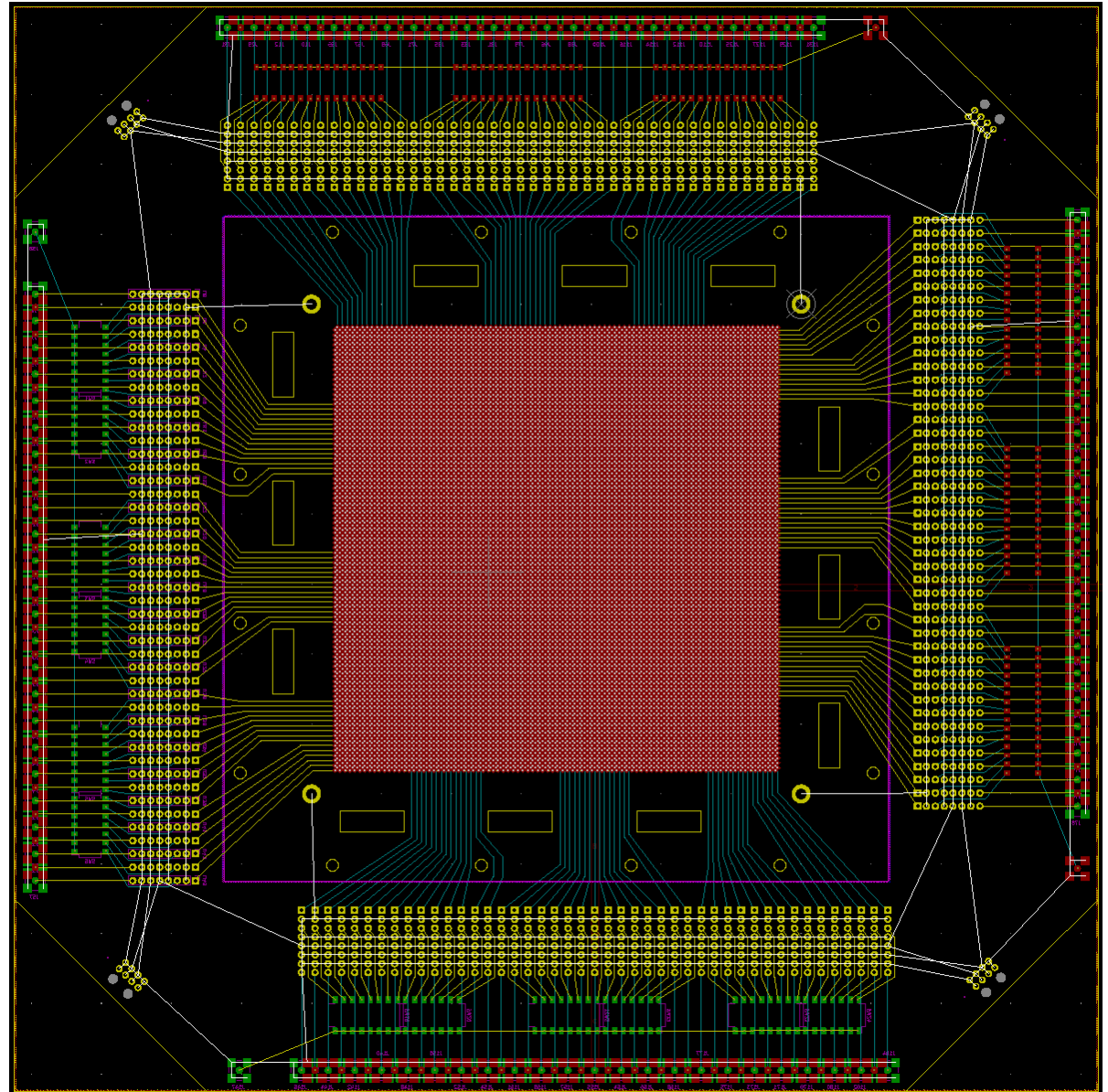
Ar:CH<sub>4</sub>(90:10) 1 atm.

- Four line alpha source test to see the resolution of the top GEM.
  - Achieved about 19% FWHM using COMPass with no real effort. Not great but there are reasons...
  - More data with vx2740s to be collected
  - Gain measurements to follow



# Anode Board Changes

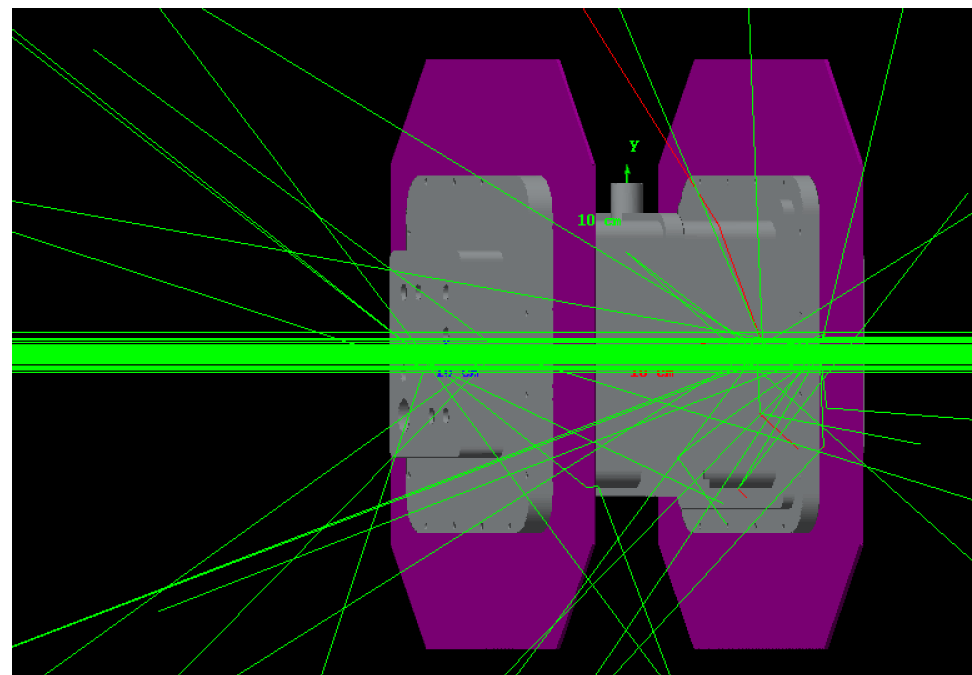
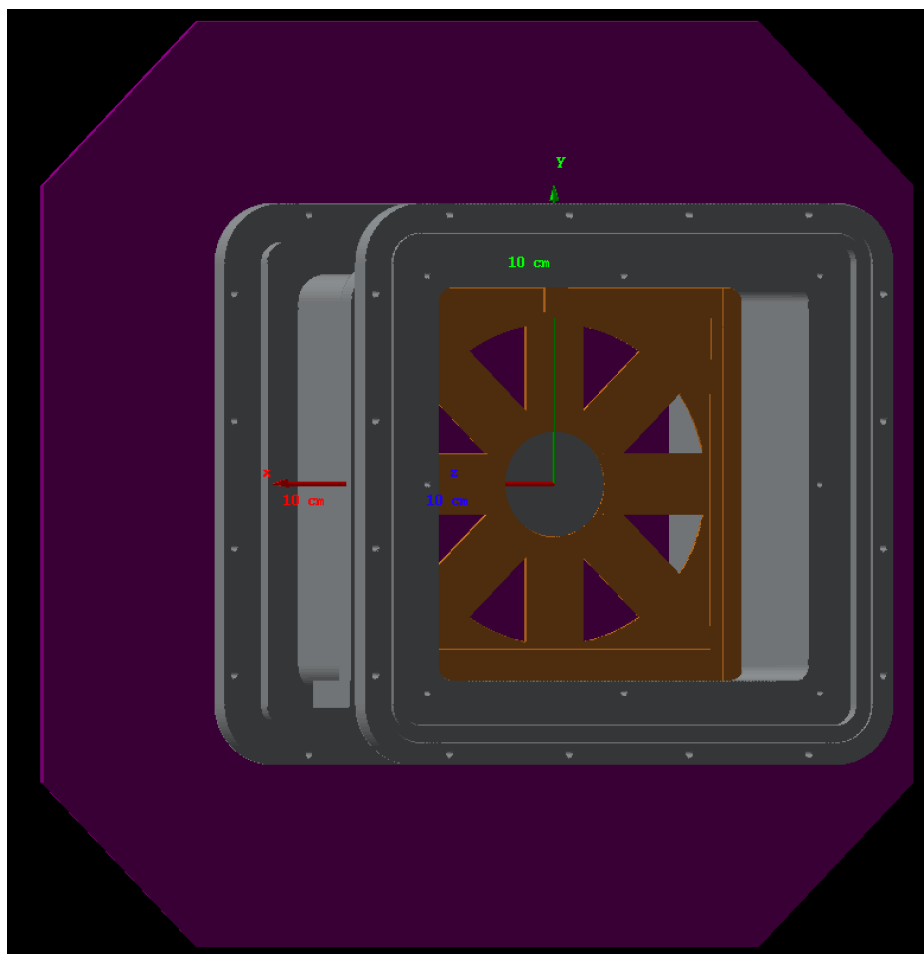
- So first lesson learned is that for single-ended signals ribbon cables are the devil. The anode channels showed nice signals, but the noise was horrible...
- The preamp mezzanines were supposed to be directly attached but design changes for 3D printing and feedthroughs made that not possible
- New anode with preamps directly attached should arrive today or tomorrow



# GEANT4 Simulations

(I just started yesterday so we have a ways to go)

- GEANT 4.11.01.p01
- CADMesh allows us to import all the .stl files to rapidly form the geometry



- We will integrate the codebase developed by Jaspreet to estimate the signals we expect to see on the anode
  - We will investigate backgrounds and pileup to see their impact on tracking

# Plan going forward

- Assemble aluminum components, new anode boards, and GEM spacers into the final version of this variant of the instrument
  - All parts should arrive within the next two weeks
- Perform gain measurements with a variety of gas mixtures to optimize detector performance
- Perform benchtop measurements with  $^{252}\text{Cf}$  to commission the instrument for in-beam use
- In-beam  $^{238}\text{U}/^{238}\text{U}$  ratio measurement to validate the instrument performance
  - If we can't get a ratio of unity we have no business measuring anything else
- In-beam  $^{16}\text{O}(n,\alpha)$  using the same  $^{238}\text{UO}_2$  target
  - FOR FREE! (Need to run at a second higher pressure to range out higher-energy  $\alpha$  particles)
- In-beam  $^{16}\text{O}(n,\alpha)$  using the LENZ  $\text{Ta}_2\text{O}_5$  target.
  - This is an interesting cross check on a long-running LENZ campaign

Thank you.  
Questions?



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