

# LArFCS Cryogenic System Progress

Yichen, Sergey

11/23/21



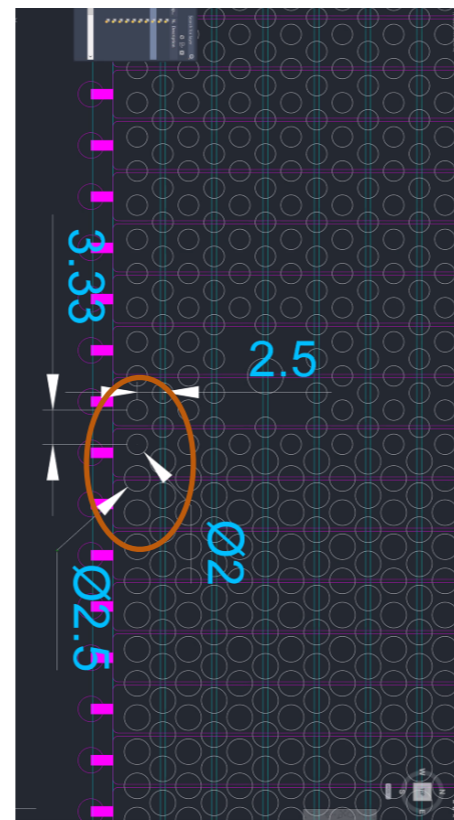
# Safety Related Issue

- ▶ **6000-gallon LN2 tank commissioning**
  - New safety pressure relief devices are expected next year
  - Going to start with the current pressure relief valve and burst disk for initial purge
  - Still waiting for the Work Order from Airgas for initial purge and cool-down
  - Response to lab buyer about the delivery contract, going to give it directly to Airgas due to low annual usage
  - Trailer delivery will be subjected to the COVID related temporary shortage, but the ePro direct order is all available
  
- ▶ **No any safety incident in the lab last week**

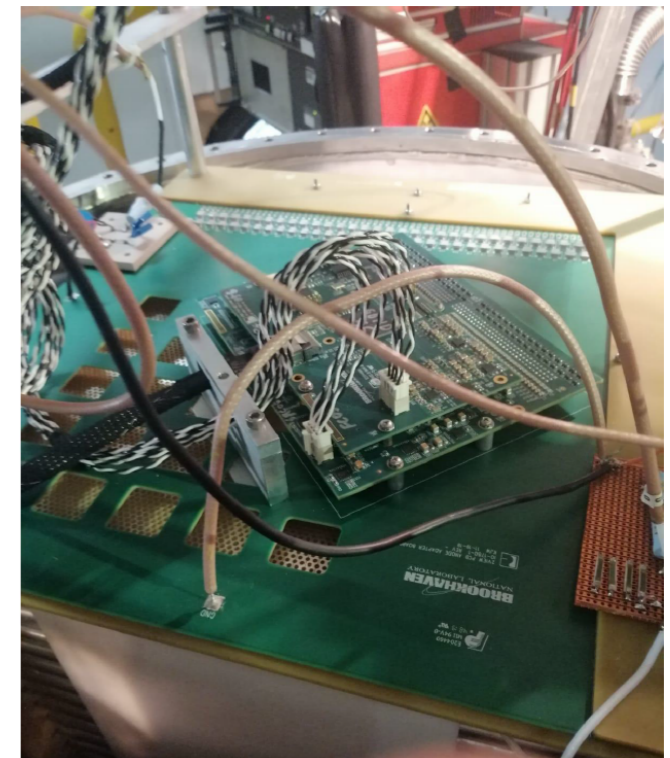
# Pad Readout Response COMSOL Simulation in 3D

## ► Pad readout testboard dimensions

- Two orthogonal sets of strips
  - Induction layer on one side, biased at ground potential
  - Collection layer on the other side, biased at positive voltage
  - Strip width 5 mm
  - Layer distance 3.2 mm, determined by the PCB thickness
- 320mm x 320mm active area, 64+64 strips with different hole
- pitch/diameter to optimize configuration:
- 2 mm hole and 2.5mm hole with hexagonal arrangement, distance of 3.33mm(vertical) 2.5 mm(horizontal)
- SBND FEMB readout



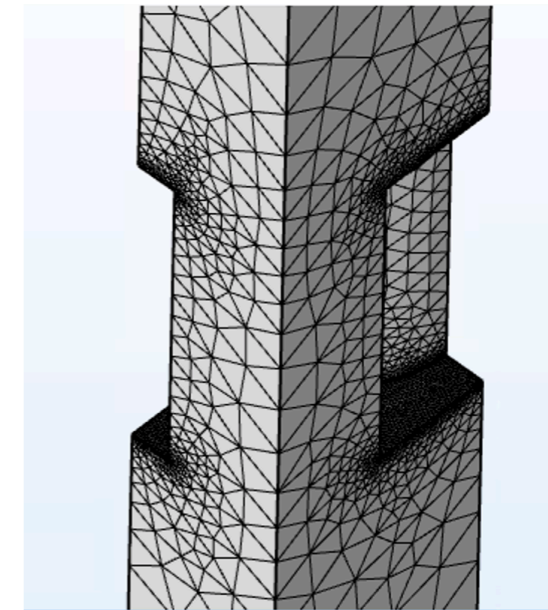
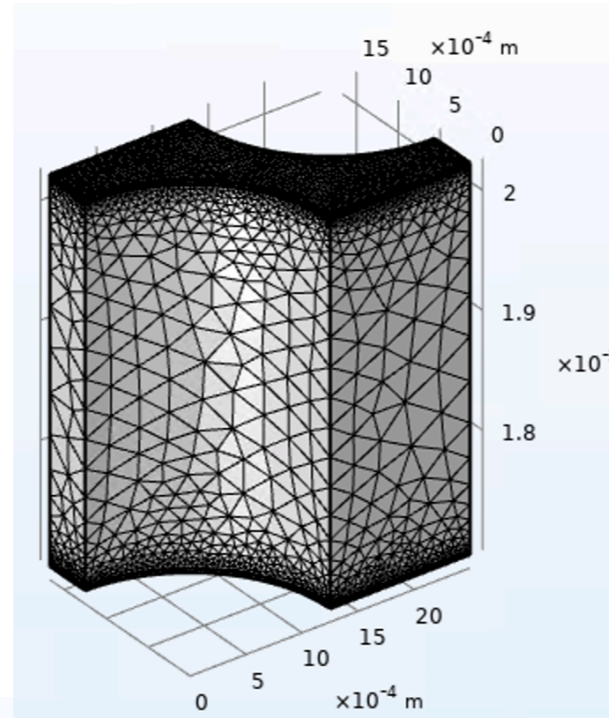
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# Pad Readout Response COMSOL Simulation in 3D

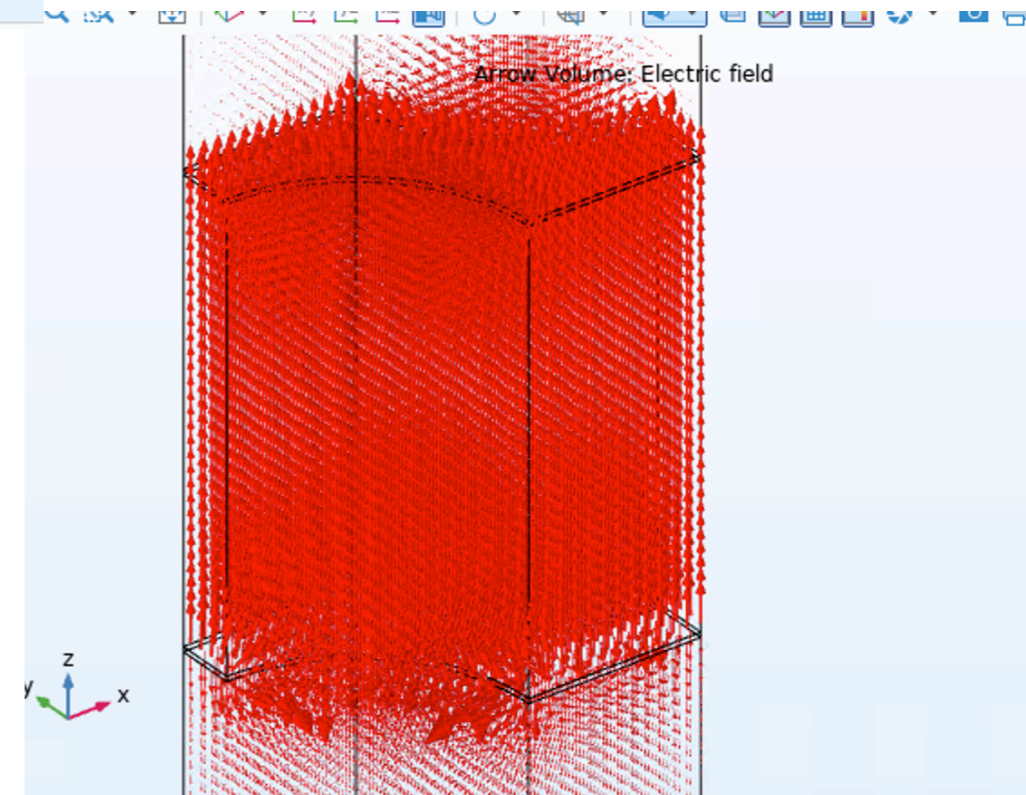
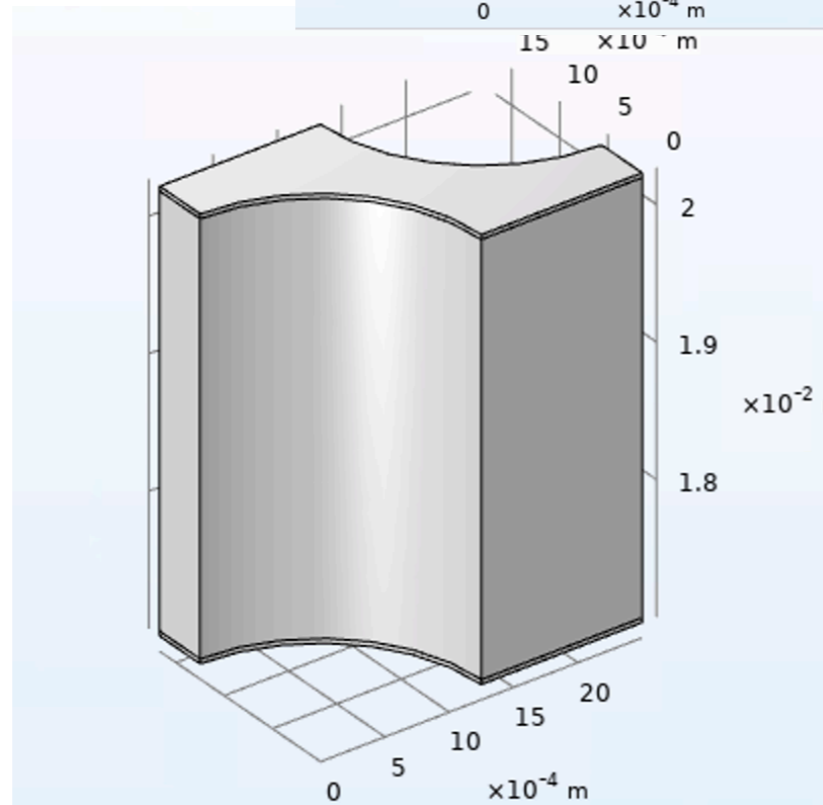
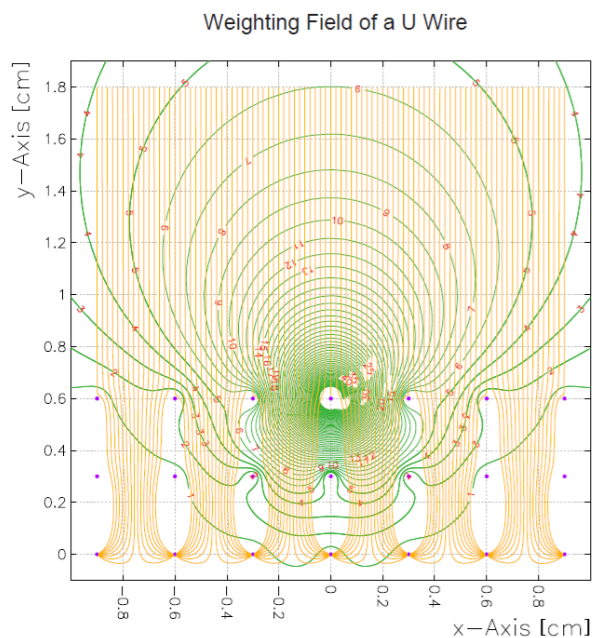
## ► Start from a minimum cell

- Total Dimension: 200mm x 1.67 mm x 2.5 mm
- 2.5 mm hole size
- 3.2 mm thickness
- Bias:
  - Top: 0V, Bottom: 2kV
  - Main drift field 500 V/cm



$$i = -qE_w v$$

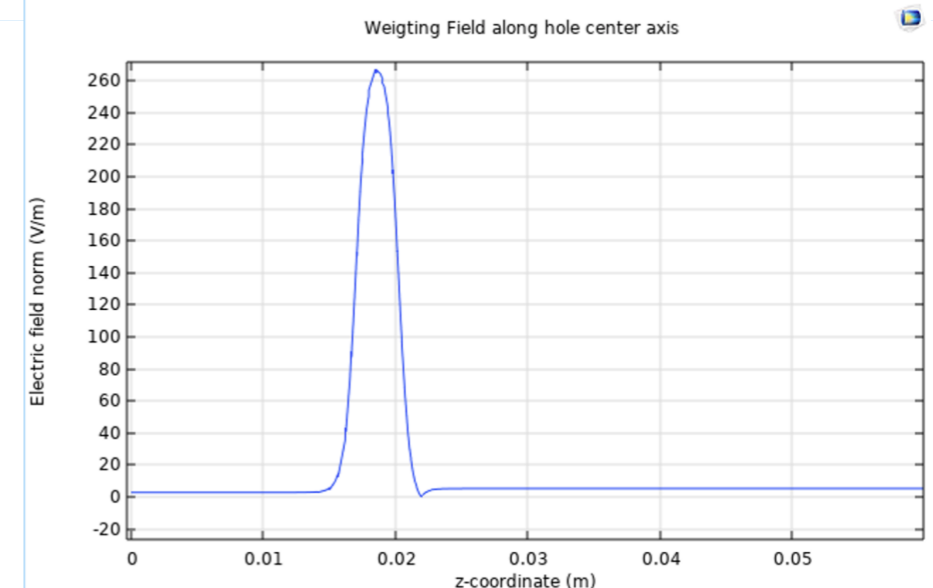
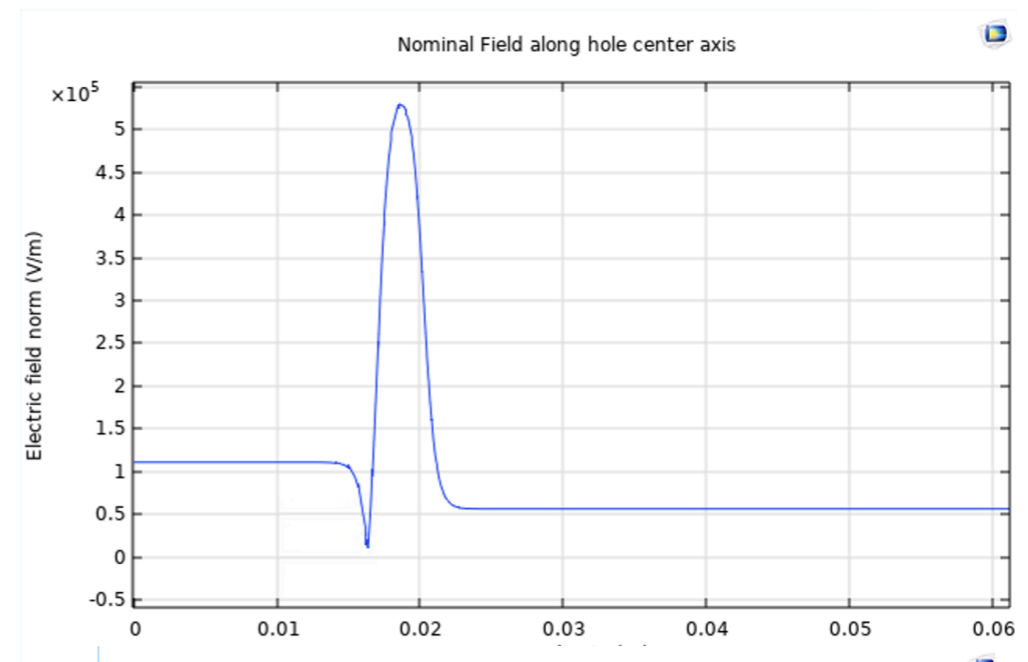
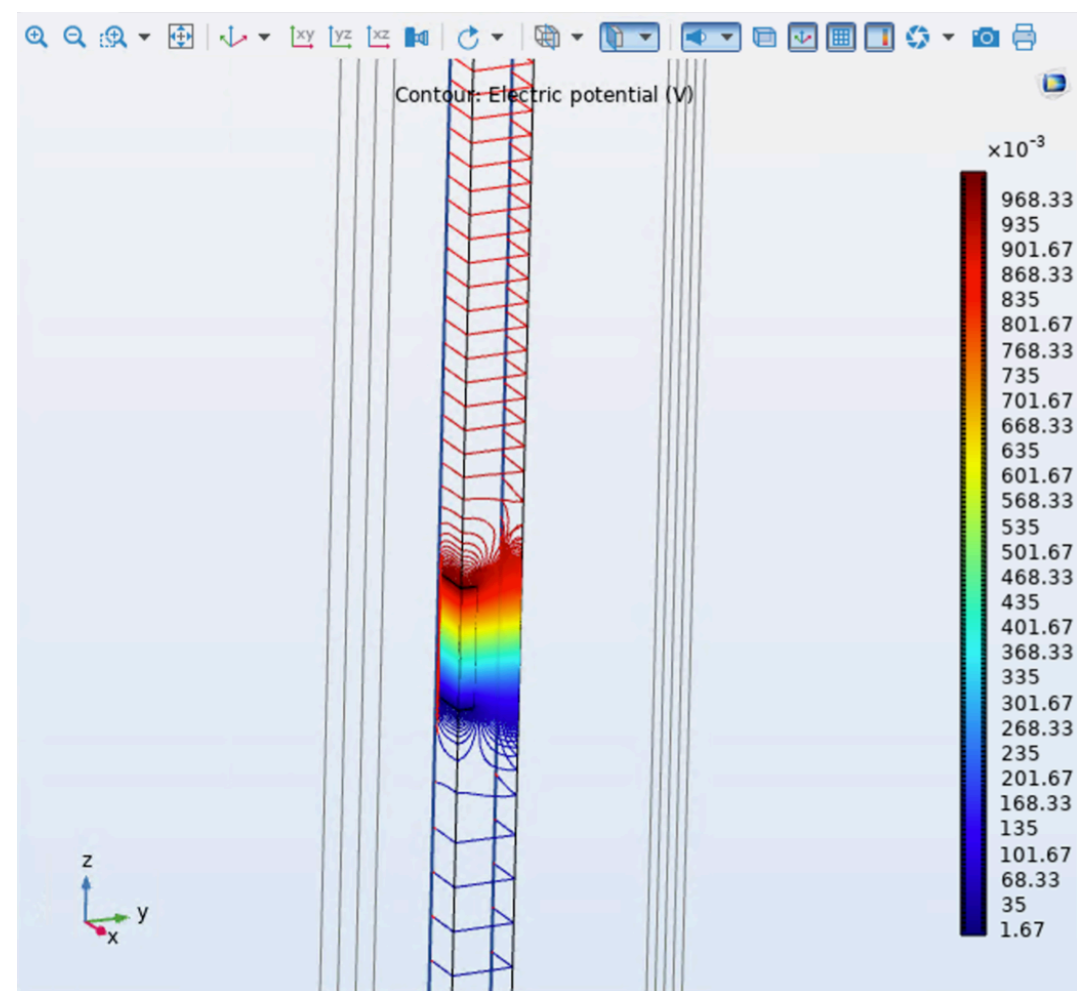
$q$ -charge;  $E_w$ -weighting field;  $v$ -velocity



# Pad Readout Response COMSOL Simulation in 3D

## ► Weighting Field

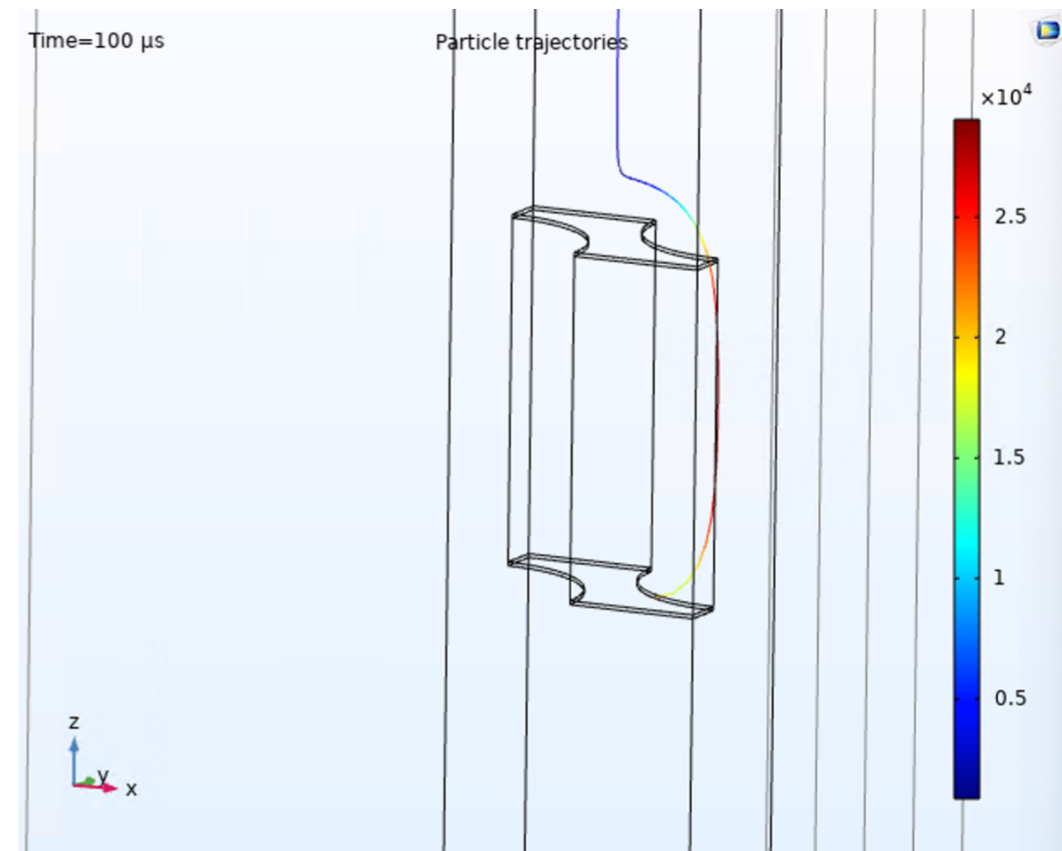
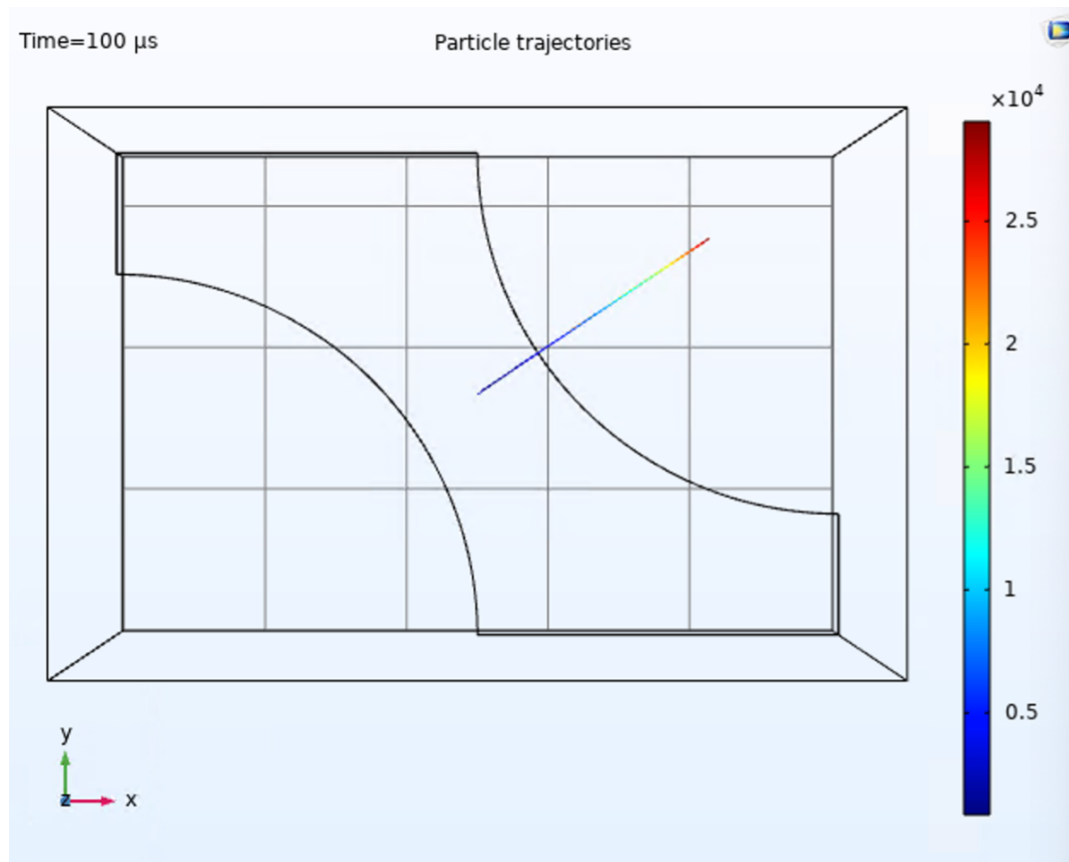
- Set electrode of interest at 1V, All the rest at ground
- Calculated by solving Laplace's Equation
- Weighting Field of Top layer shown



# Pad Readout Response COMSOL Simulation in 3D

## ► **Electron drifting**

- Calculated by the Charged Particle Tracing module of COMSOL
- Single electron released  $\sim 17$  cm away from the cell



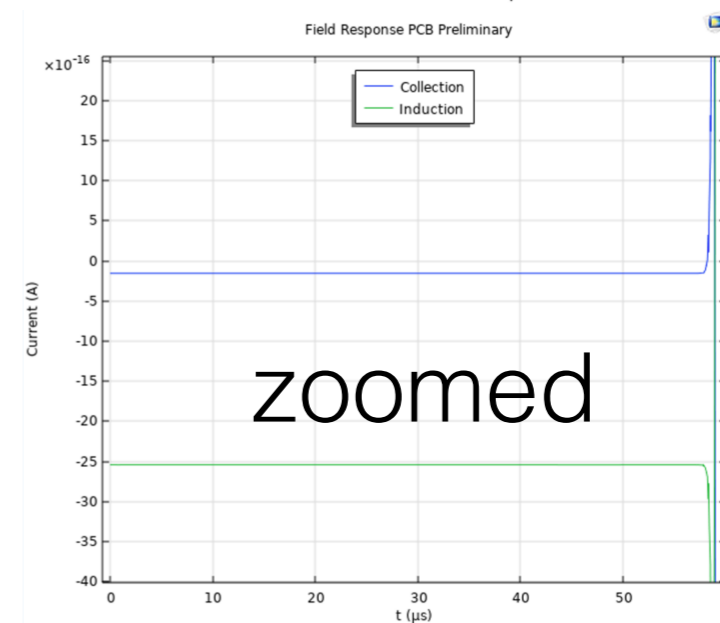
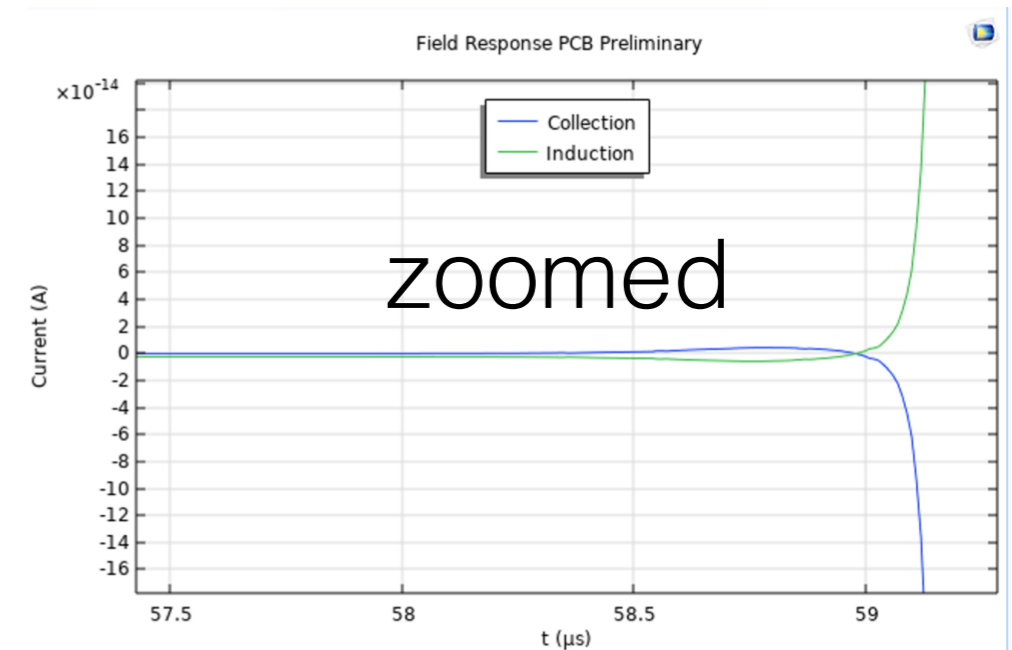
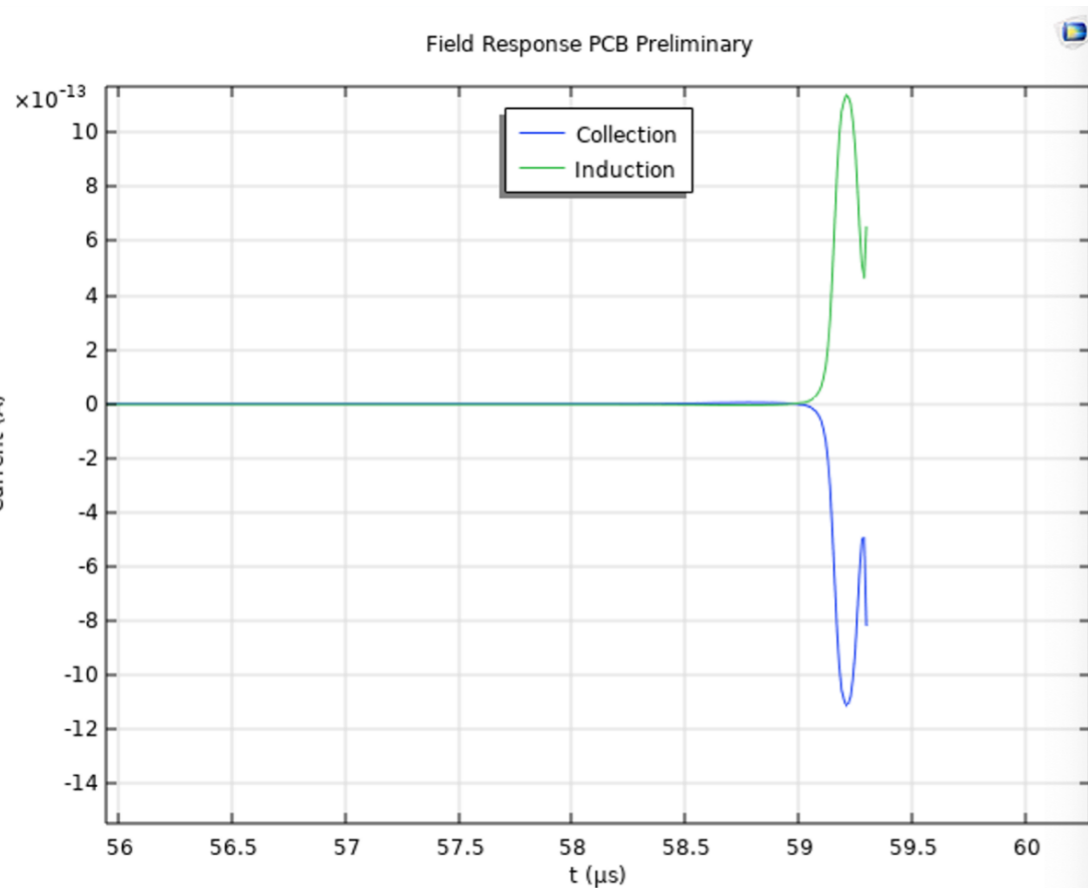
# Pad Readout Response COMSOL Simulation in 3D

## ► Field Response for Single Electron

- Field Response can be calculated by Shockley Ramo theorem

$$i = -qE_w v$$

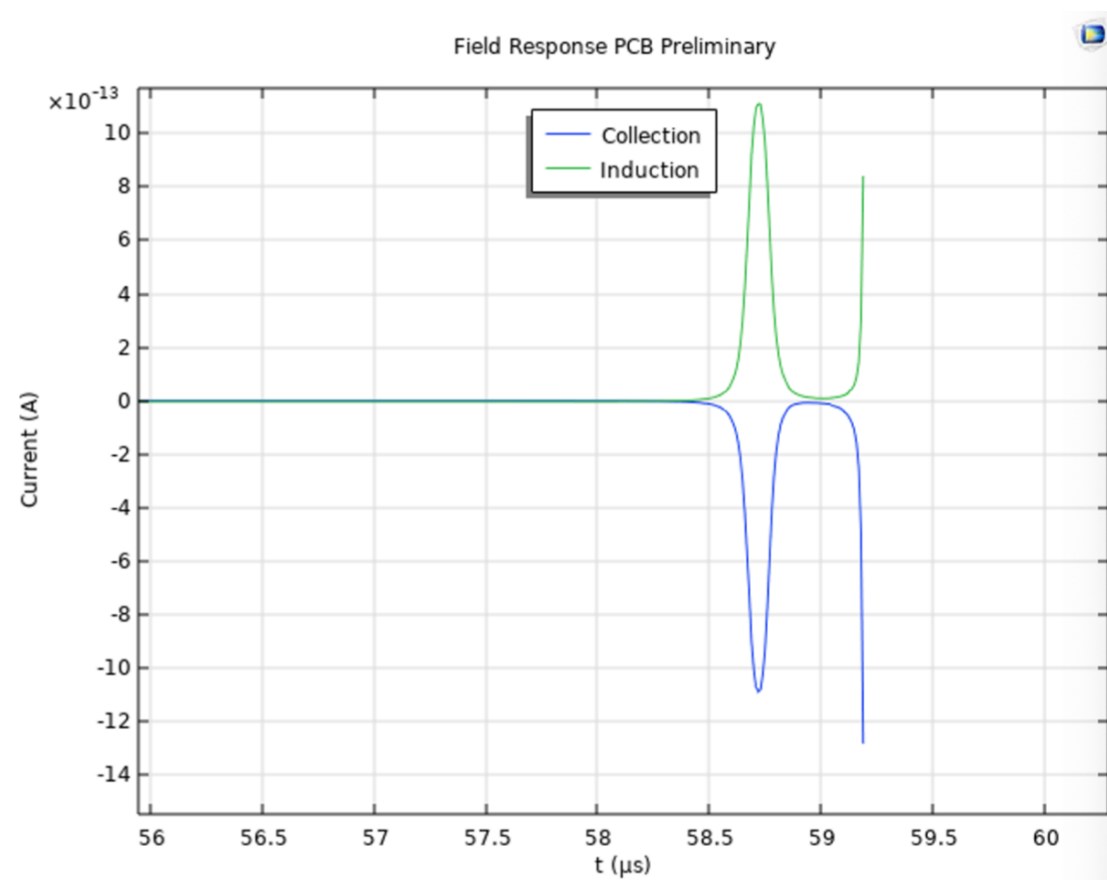
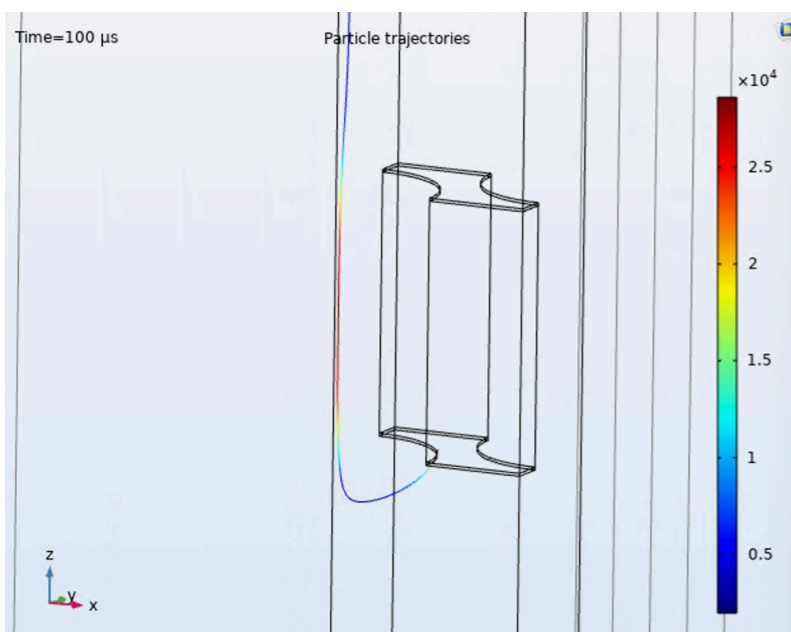
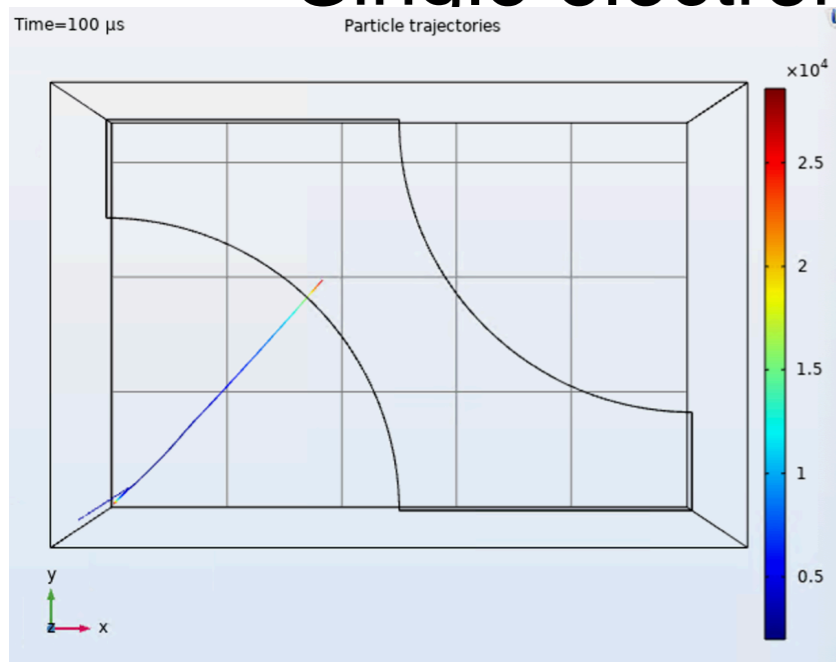
$q$ -charge;  $E_w$ -weighting field;  $v$ -velocity



# Pad Readout Response COMSOL Simulation in 3D

## ► Electron drifting

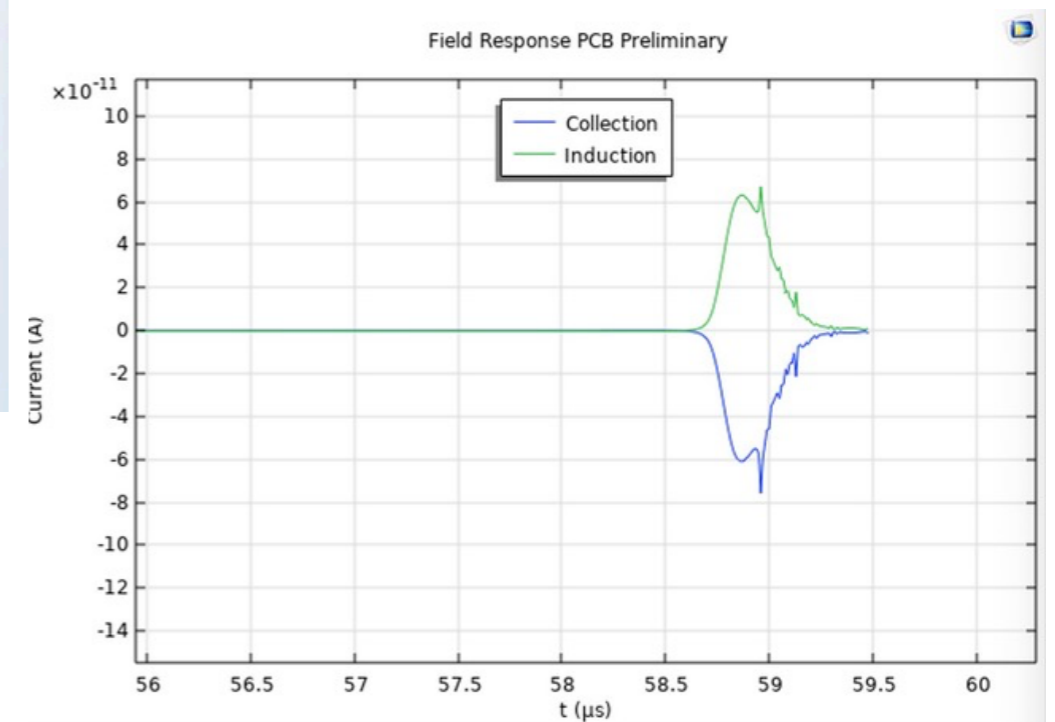
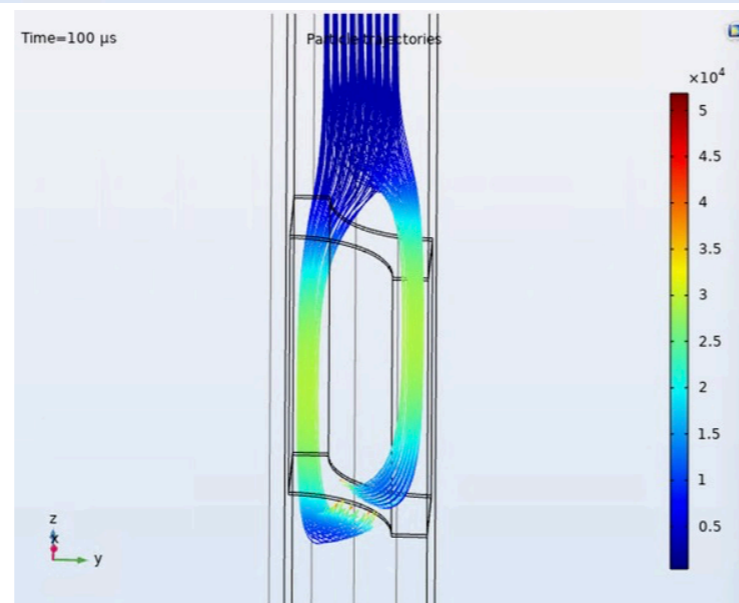
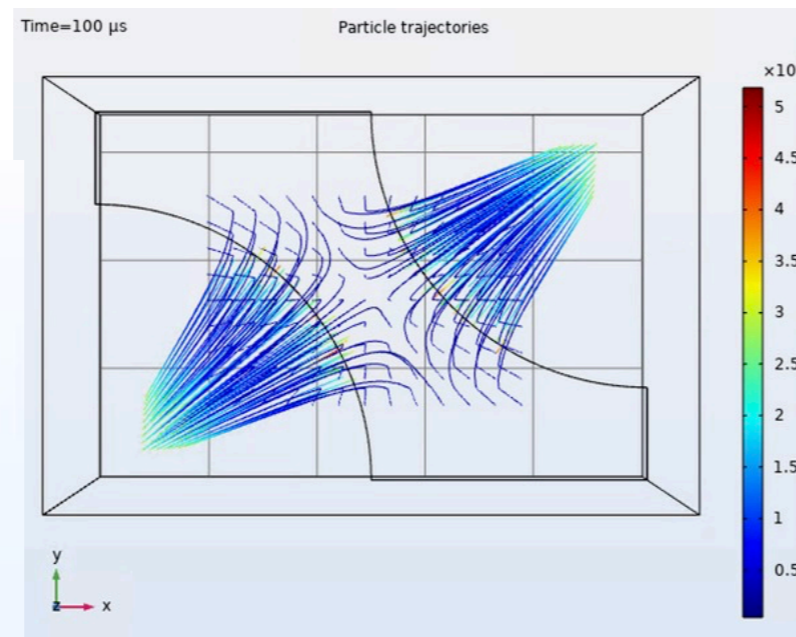
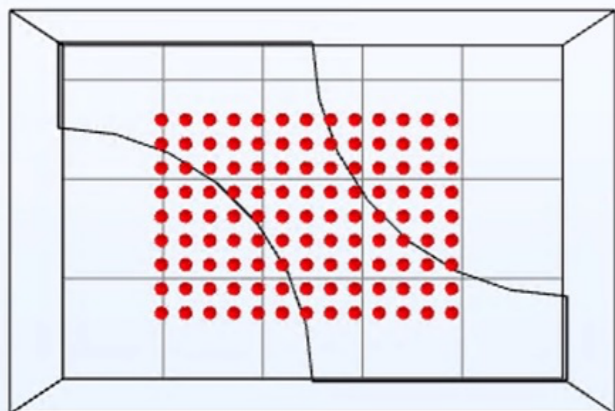
- Calculated by the Charged Particle Tracing module of COMSOL
- Single electron released  $\sim 17$  cm away from the cell



# Pad Readout Response COMSOL Simulation in 3D

## ► Electron drifting

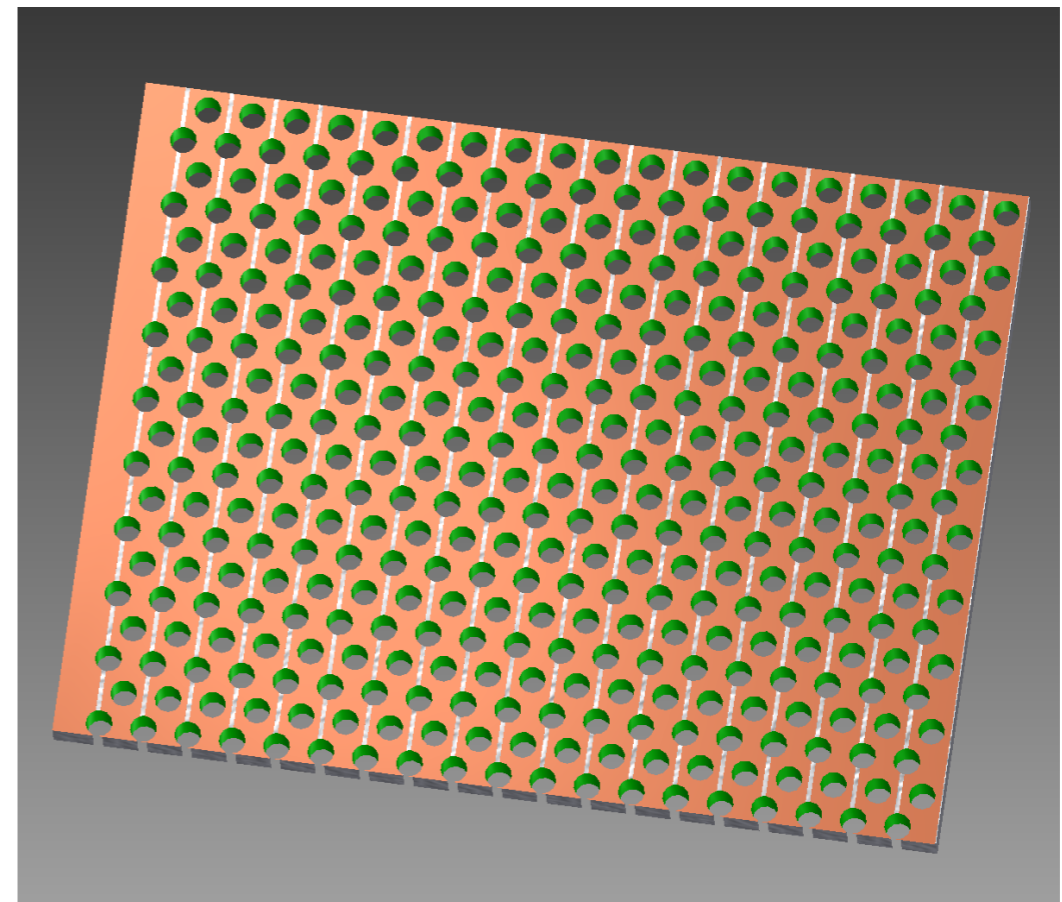
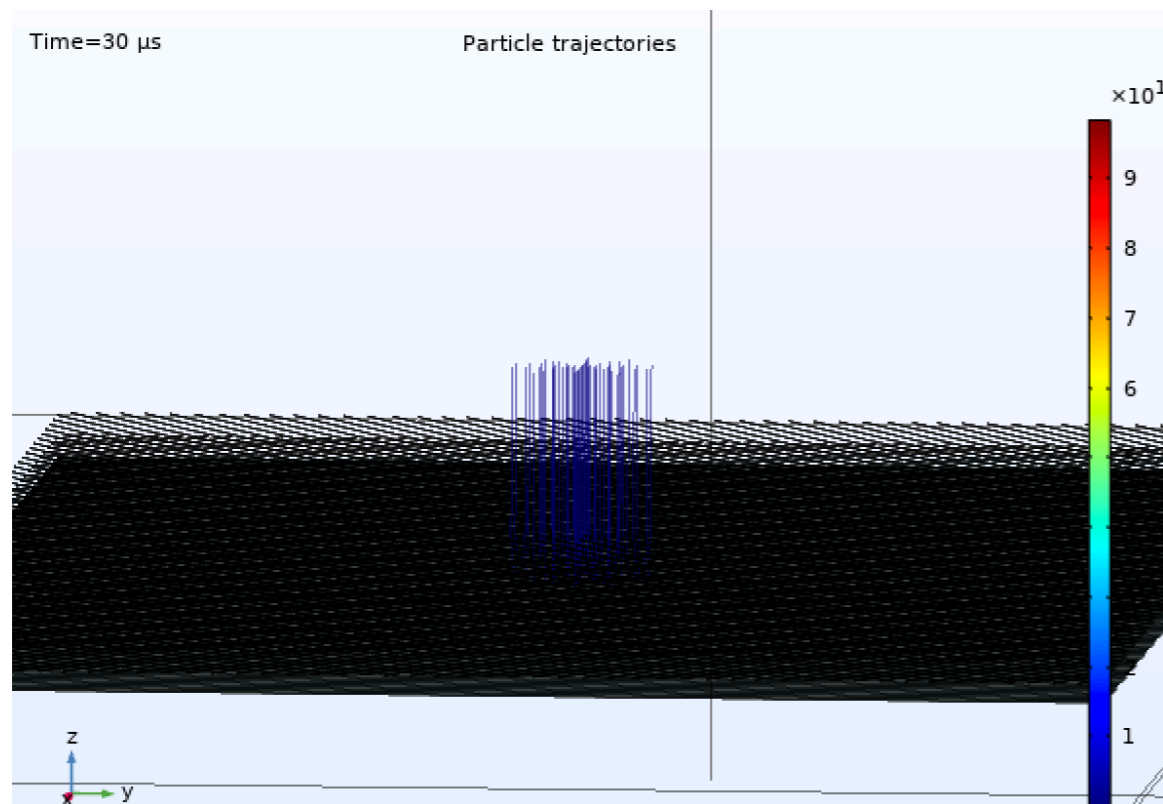
- Calculated by the Charged Particle Tracing module of COMSOL
- 117 electrons released  $\sim 17$  cm away from the cell



# Pad Readout Response COMSOL Simulation in 3D

## ▸ Next Steps

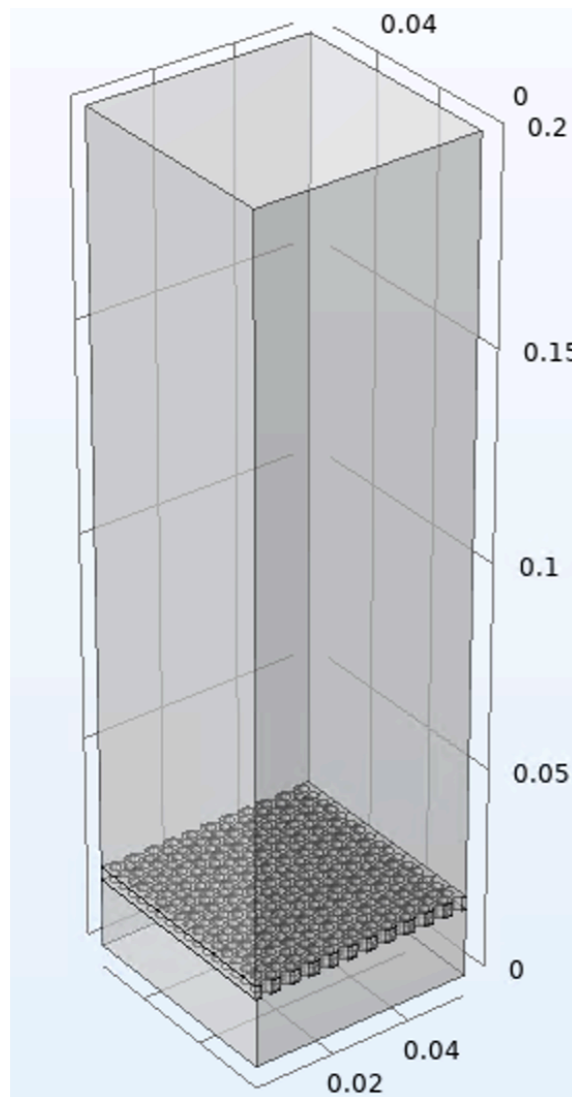
- Expand to a broad range with multiple strips
- Tried with wire in 3D for  $\sim 200$  wires,  $51 \times U$ ,  $51 \times Y$ , 100 V
- Field calculation is very time consuming, taking +24V
- Electron tracing takes much less time once field calculated
- Going to start with a brute-force way first
- Constructing the 3D geometry in COMSOL



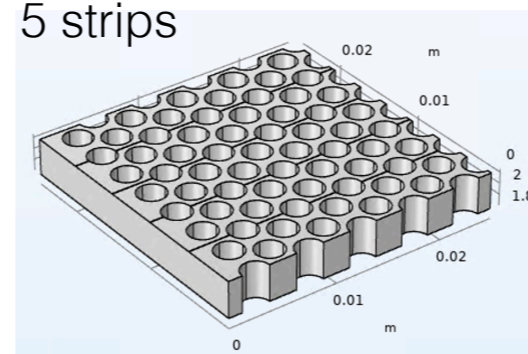
# Pad Readout Response COMSOL Simulation in 3D

## ► 3D Pad Readout in COMSOL – Multiple Strips

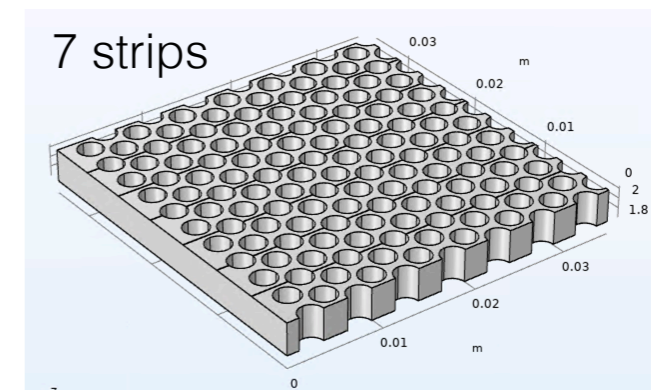
- Pad readout geometry implemented in COMSOL Induction layer on one side, biased at ground potential
  - Collection layer on the other side, biased at positive voltage +2000
  - Strip width 5 mm
  - Hole size 2.5 mm
  - PCB thickness 3.2 mm, determined by the PCB thickness
  - Programmable feature of geometry implemented( 20 cm total cell height)
  - Currently trying 11 strips (Current module contains 320mm x 320mm active area, 64+64 strips)



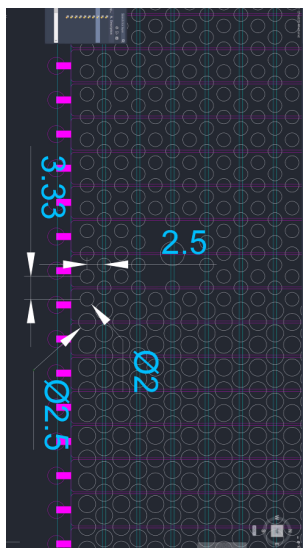
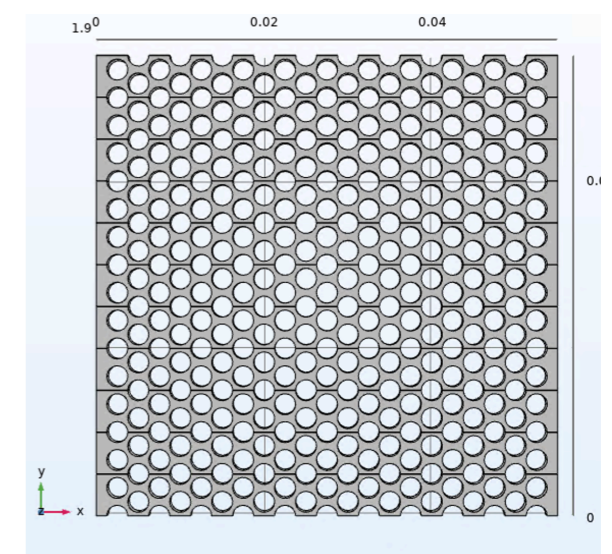
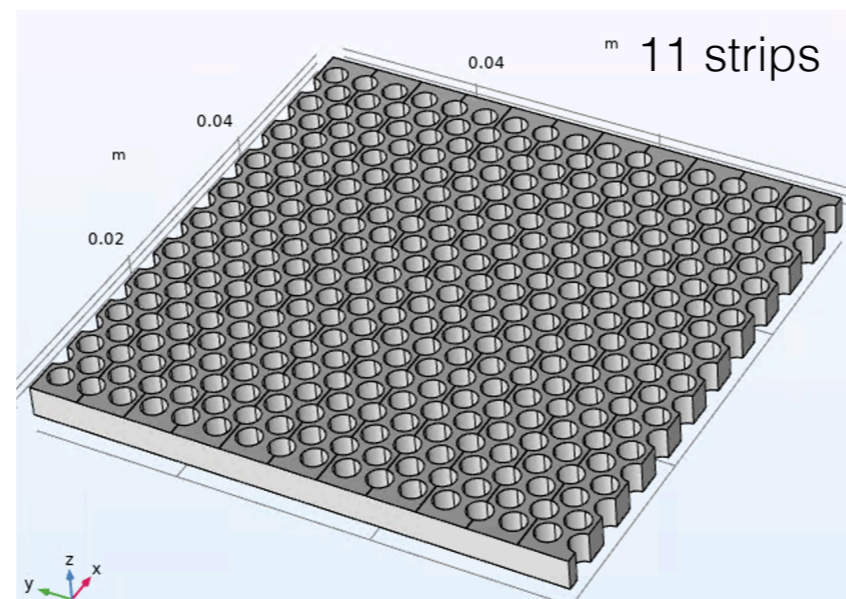
5 strips



7 strips



11 strips

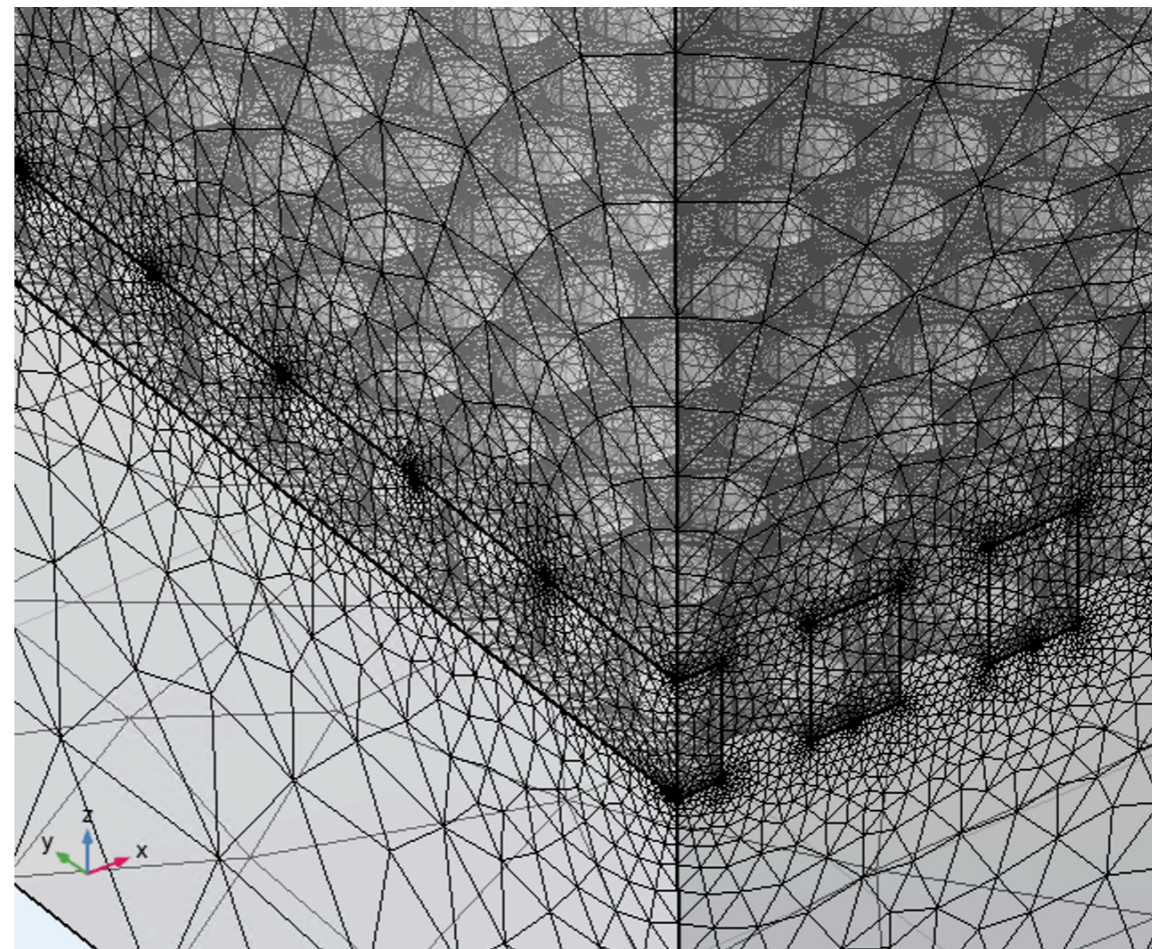
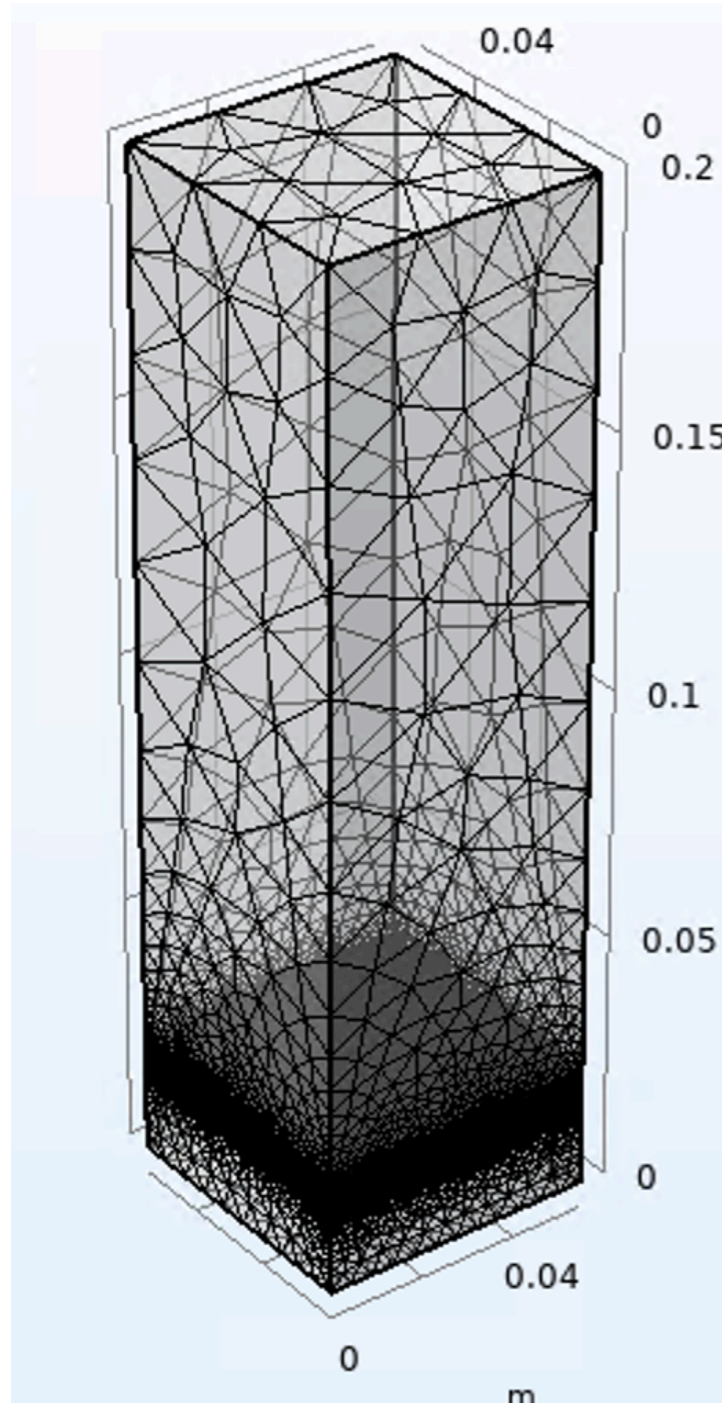


# Pad Readout Response COMSOL Simulation in 3D

## ► 3D Pad Readout in COMSOL—Multiple Strips

- Meshing

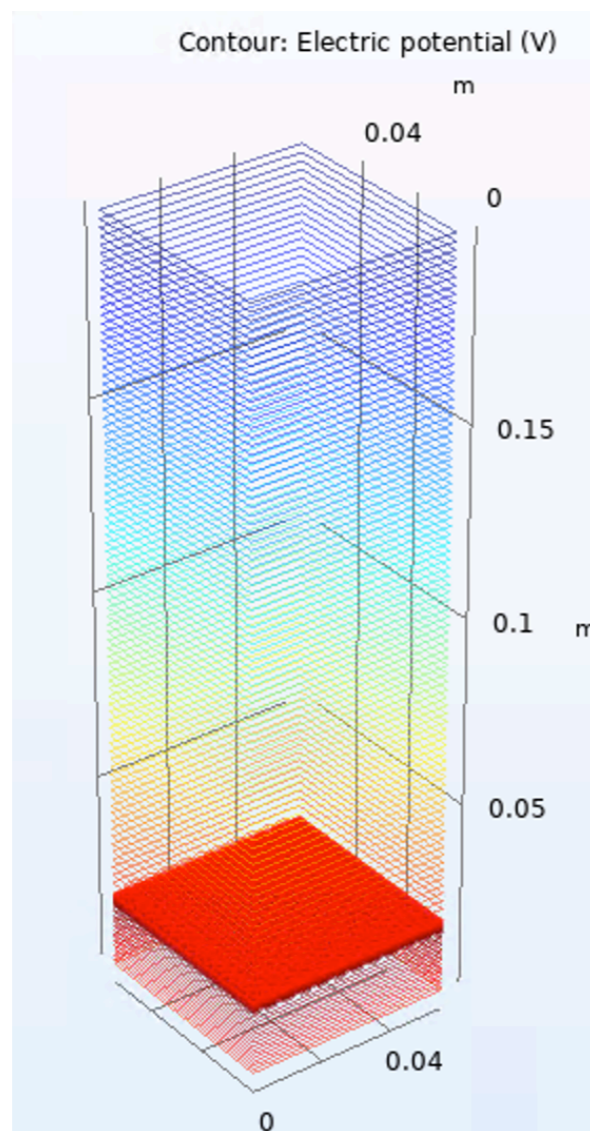
- With FEA method, Normal meshing take ~7 mins
- I can try with BEM method later



# Pad Readout Response COMSOL Simulation in 3D

## ► 3D Pad Readout in COMSOL—Multiple Strips

- Nominal Field
  - Field solution take ~3 mins
  - Induction Layer: 0 V, Collection layer:2000V, drift field: 0.5 kV/cm
  - Electric field line drawing takes too long, only equal potential is shown here

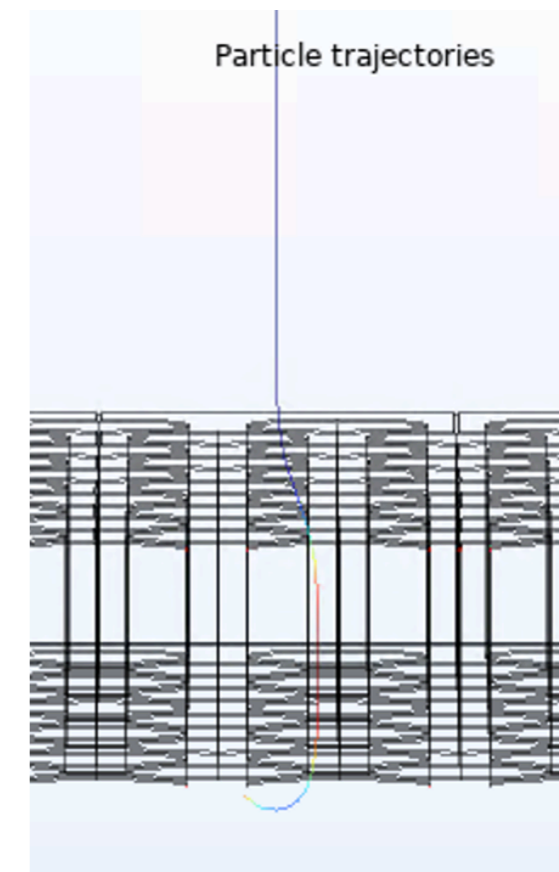
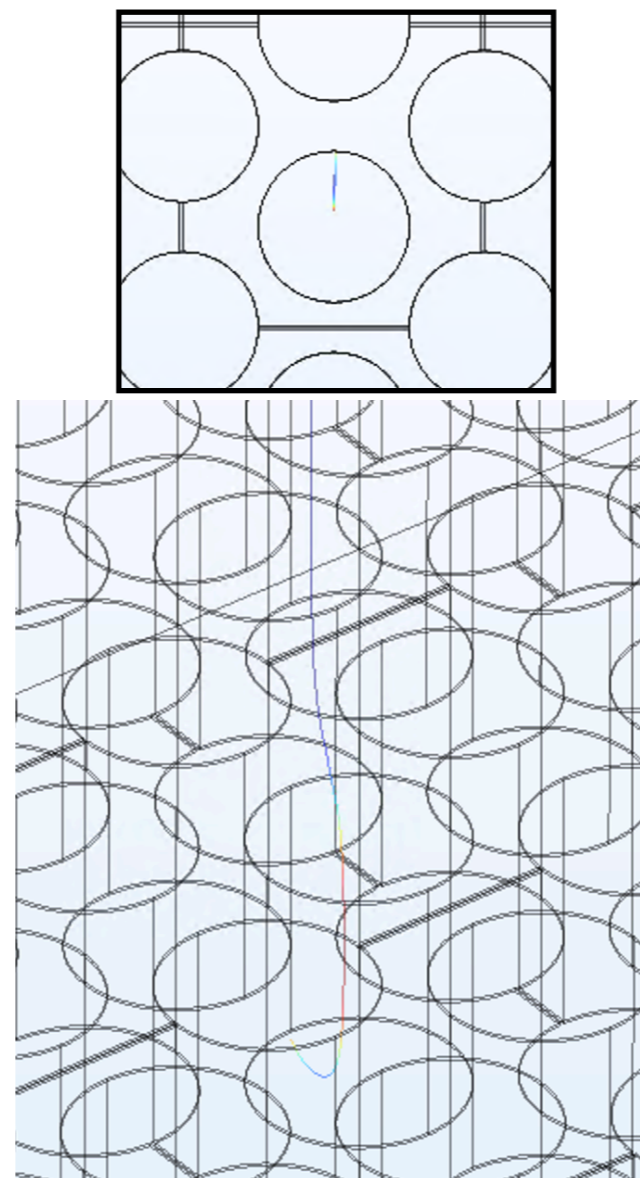
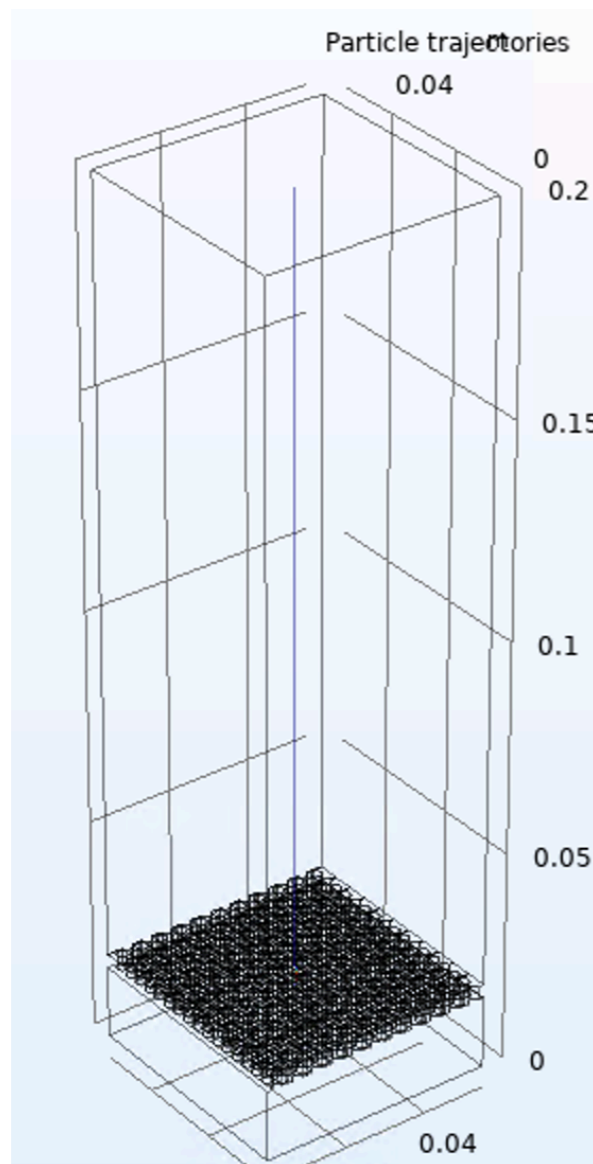


Placeholder

# Pad Readout Response COMSOL Simulation in 3D

## ► 3D Pad Readout in COMSOL – Multiple Strips

- Electron drift
  - Single electron starting at the center, 17 cm from the pad
  - Goes through the center of a hole
  - Charge particle tracking ~5 mins for single electron

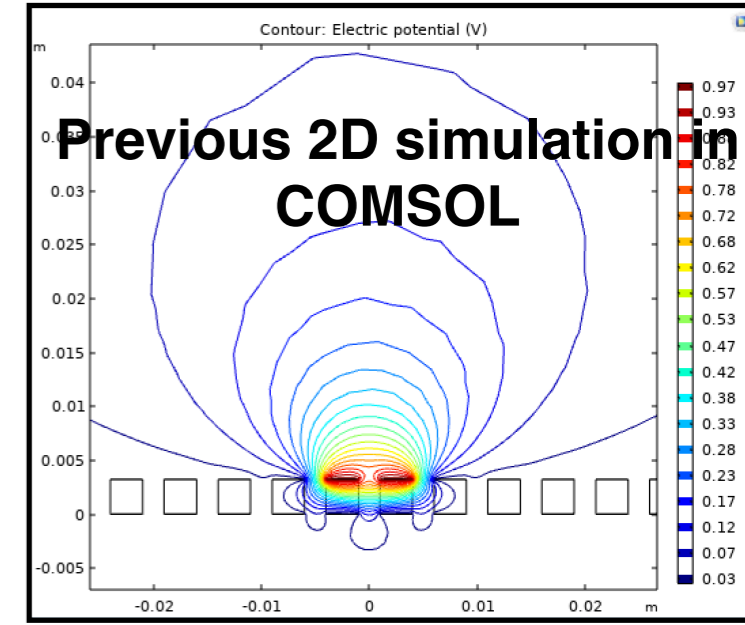


# Pad Readout Response COMSOL Simulation in 3D

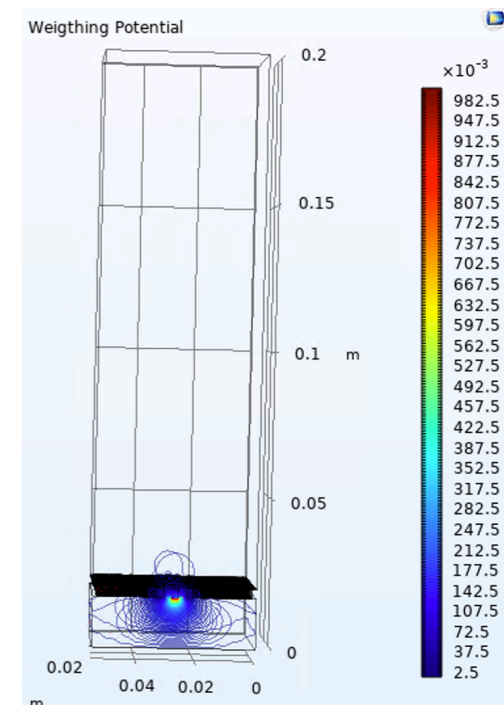
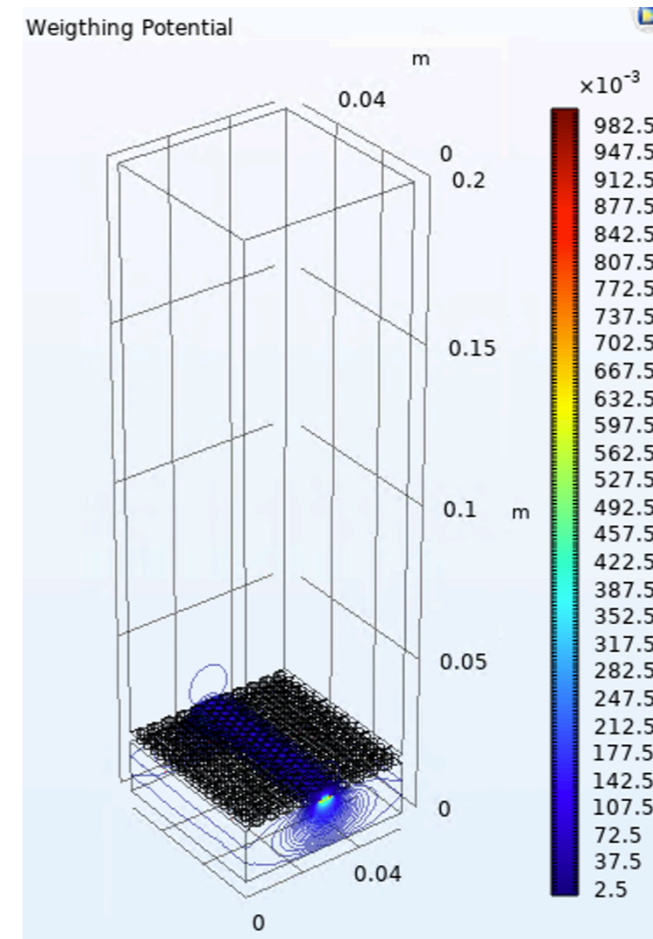
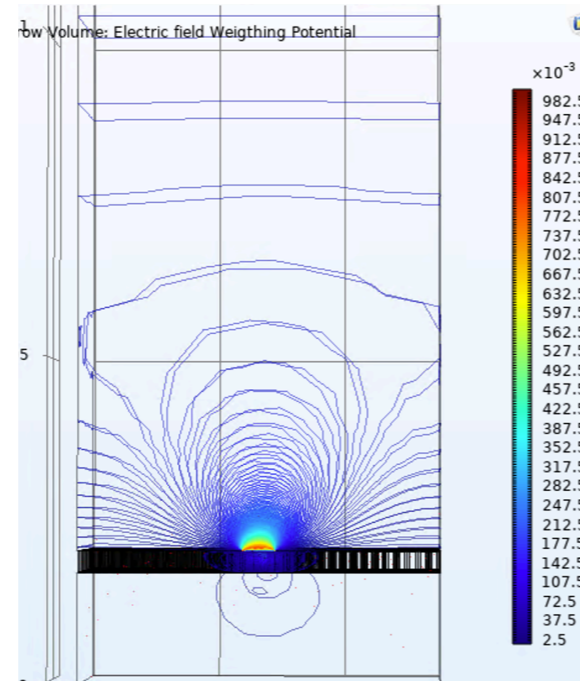
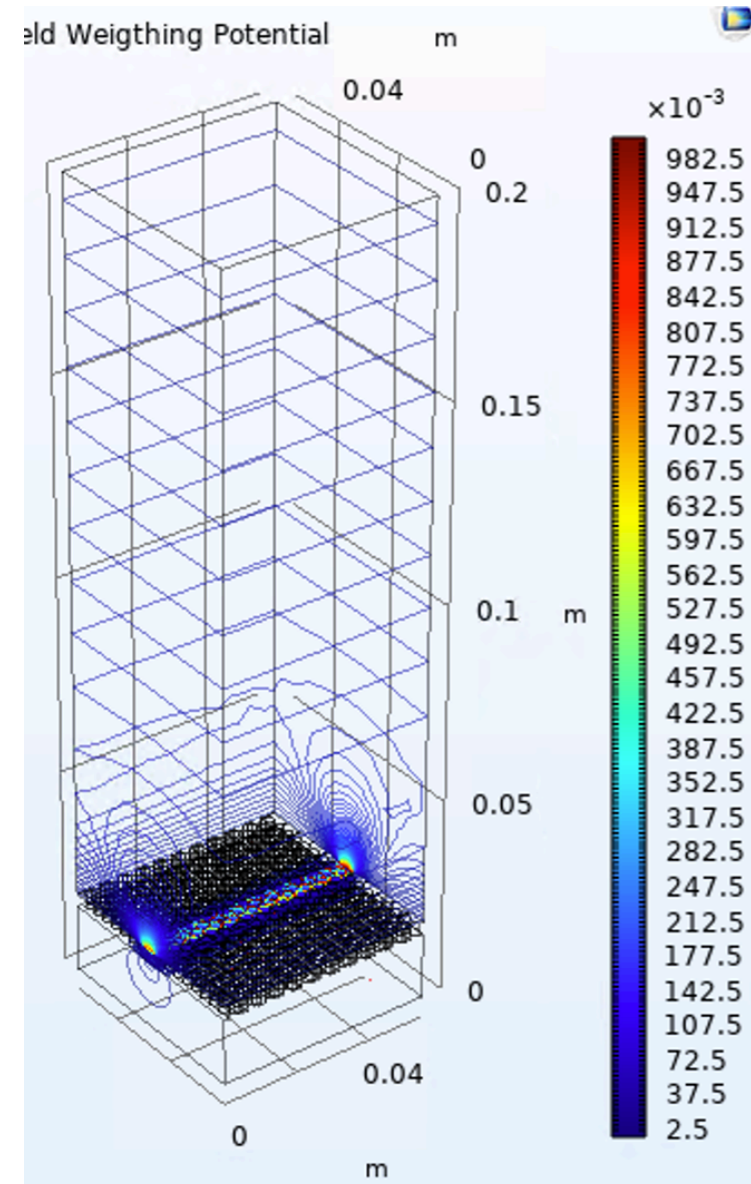
## ► 3D Pad Readout in COMSOL – Multiple Strips

- Weighting Field

- Solution of Laplace's equation
- MUMPS solver stalled at 80% over night with large out-of-core memory consumption
- Just tried with PARDISO solver, ~15 mins for the top induction layer
- Weighting potential similar to 2D by visual, need to check more carefully



## Latest 3D simulation in COMSOL

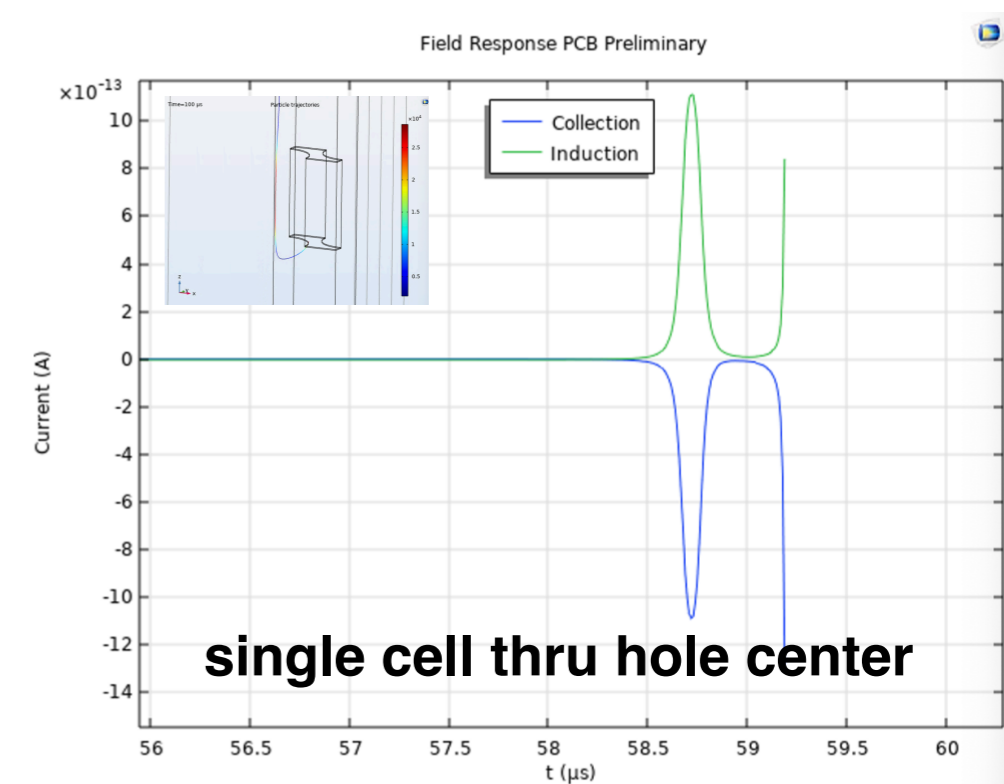
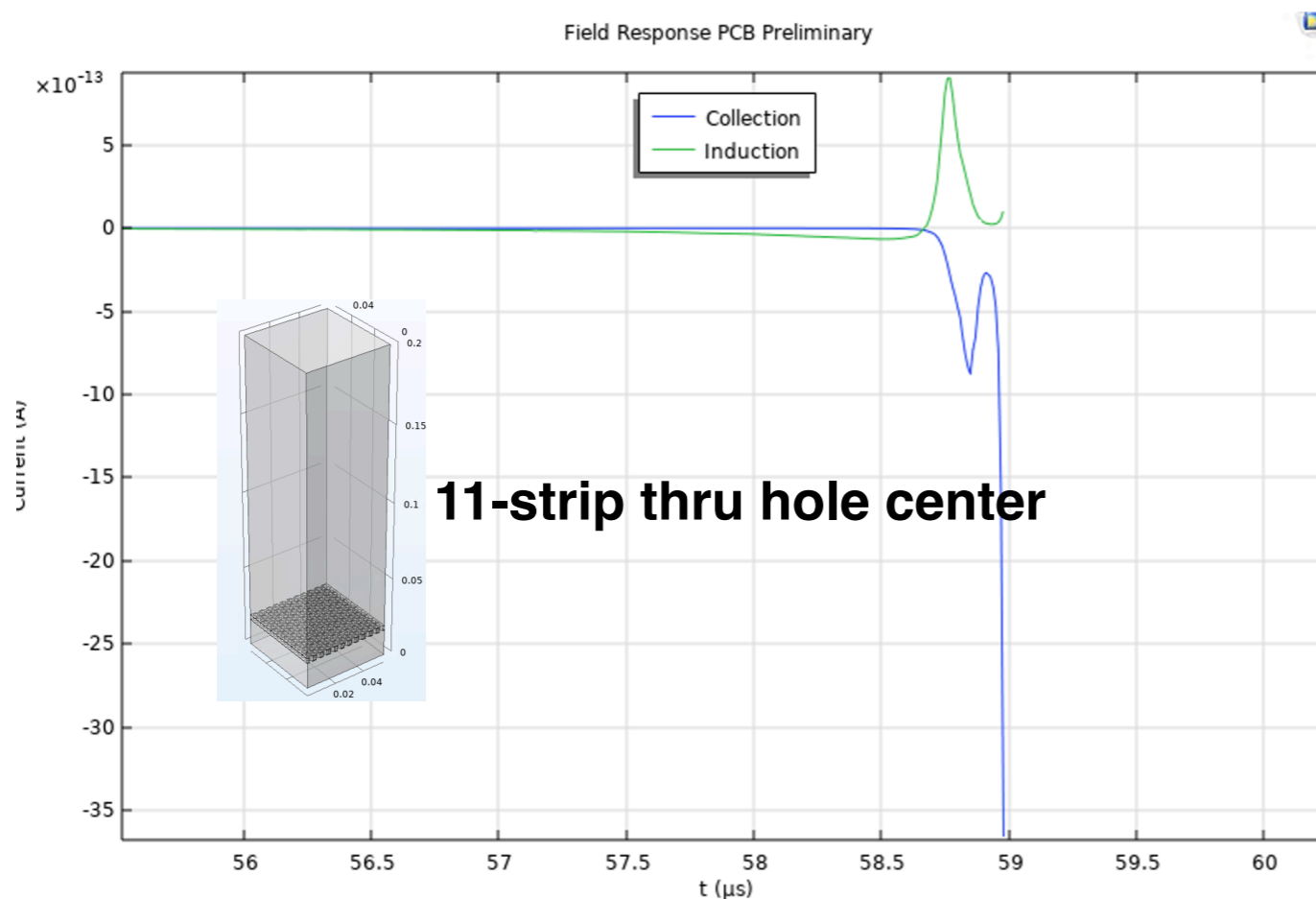


# Pad Readout Response COMSOL Simulation in 3D

## ► 3D Pad Readout in COMSOL—Multiple Strips

- Field Response Preliminary

- Single electron response on central strip calculated
- Significantly different from previous single-cell calculation
- Shape looks like 2D with bipolar shape on induction



# Pad Readout Response COMSOL Simulation in 3D

## ► **Summary of current 3D pad readout simulation in COMSOL**

- Field Response calculation done for a reduced pad readout module with 11 strips
  - Shape is significantly different from single-cell
- Multiple-strip module simulation is computationally heavy than single cell
  - For 11 strip, the time consumption for field calculation is 1 order higher
  - Can try large area later
- Fortunately, field calculation only needs to be done once
- Still affordable assuming going with similar configurations like uBooNE settings
- With try BEM method for comparison

### COMSOL runtime summary

	Time(s)
<b>Meshing</b>	~500
<b>Nominal Field</b>	144
<b>Weighting Field(Single strip)</b>	957
<b>Single Electron Drift</b>	298

# LArFCS schedule

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## ▸ PrM test at UCI

### • Day 1: Lab tour, Overview of system

- Familiar with the facility
- Practice with long PrM measurement
- Our PrM stack + electronics bench test
- Equipment and Operation procedure drafting
- Our PrM assembly and moving to the test dewar
- Pump down overnight

### • Day 2:

- Vacuum PrM test: Our Xe light source+Hamamatsu Xe Lamp
- Test with full PrM system: HV, electronics, DAQ etc.
- Our PrM Baseline measurement in vacuum
- UCI local purification system assembly (TBD)

### • Day3:

- GAr PrM test
- Additional Vac. test for QC
- Break vacuum and swap in long PrM
- Contingency for troubleshoot and repeat test
- UCI local purification system assembly (TBD)

### • Day4:

- Additional Bench test to our PrM
- Measurement with Long PrM in chamber
- Packing for shipping
- UCI local purification system assembly (TBD)

## November

S	M	T	W	T	F	S
31	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	1	2	3	4
5	6	7	8	9	10	11



# LArFCS schedule

## ▸ LArFCS Assembly

- Assembled the top flange
- Moved the top flange back to the main dewar
- Plumbing the system
- Pumping down

## ▸ Leak check, full system purge and Activation

- Ensure the leak tightness of the system
- Pump-purge system
- Troubleshooting
- Contingency in case of additional pump down cycle needed

## ▸ Activation of the on system purifier

- Gas analyzer readout test

## ▸ PrM local Assembly

- PrM bench test

## ▸ Purity Demo fill with gas analyzer reading only

- Cool down and fill with inline filter
- Purity measurement with gas analyzer only

December

S	M	T	W	T	F	S
28	29	30	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8