ProtoDUNE-SP CFD Update

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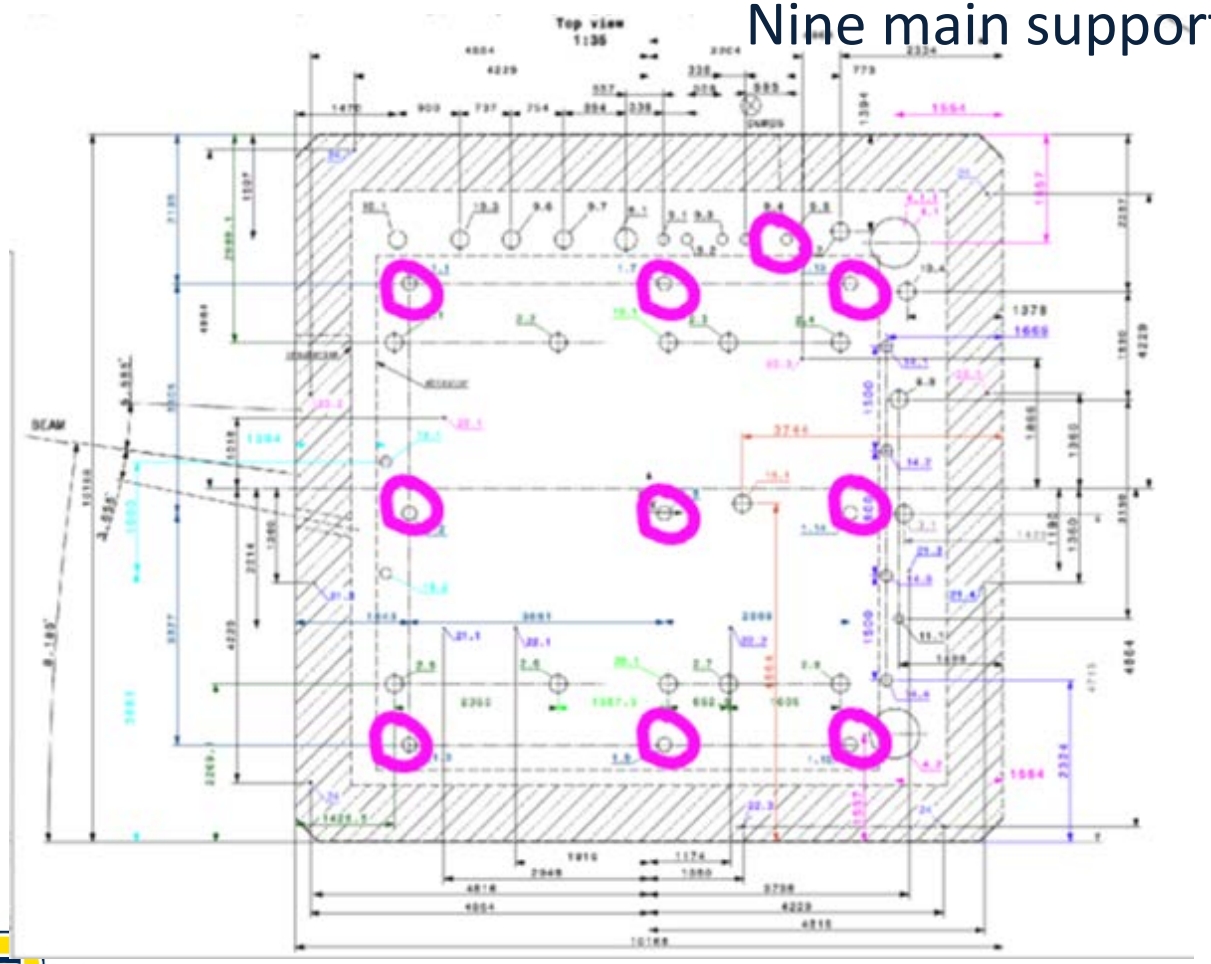
ProtoDUNE Modeling- Previous Work

Initial Model: Main Gaseous Argon Return
Nine main support feedthroughs



Main Gaseous Argon Return

ProtoDUNE Modeling – Previous Work

- Created an explicit model of the ullage:
  - Flow from liquid to ullage = 7.0 g/s
  - Nine feedthroughs plus main boil-off modeled
- Investigated mass inlet conditions:
  - Constant mass flux
  - Mapped mass flux (based on results of liquid simulation)
- Investigated multiple outgassing procedures
  - 99% through main boil-off, 1% split between other nine feedthroughs
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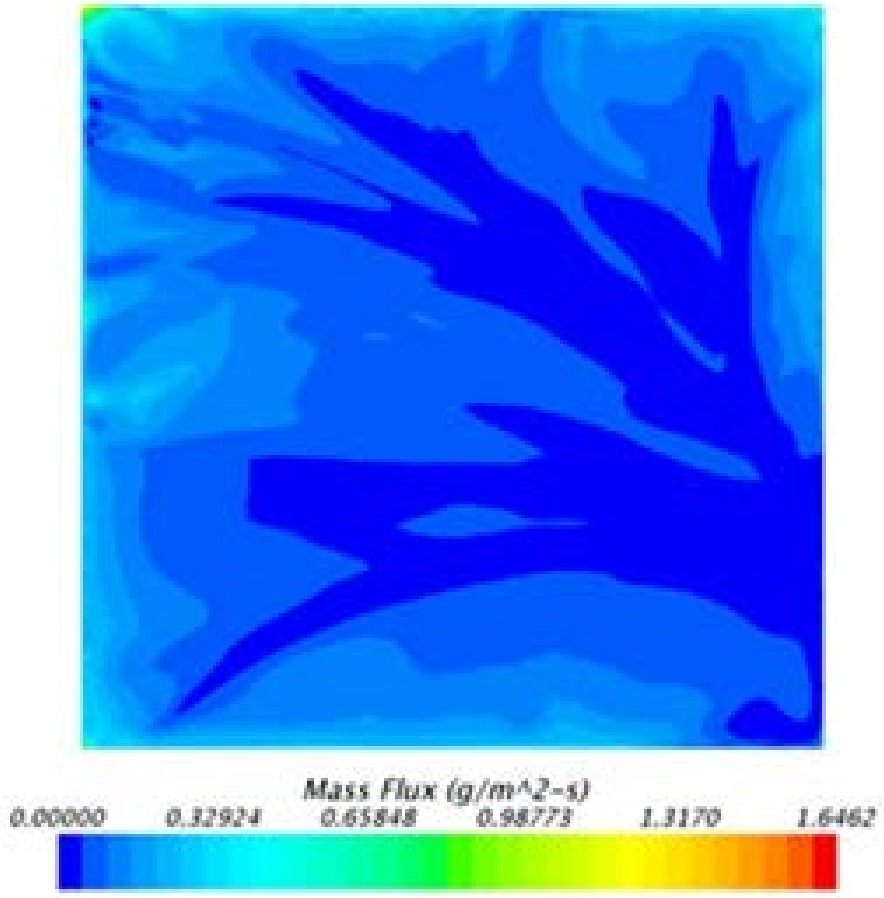
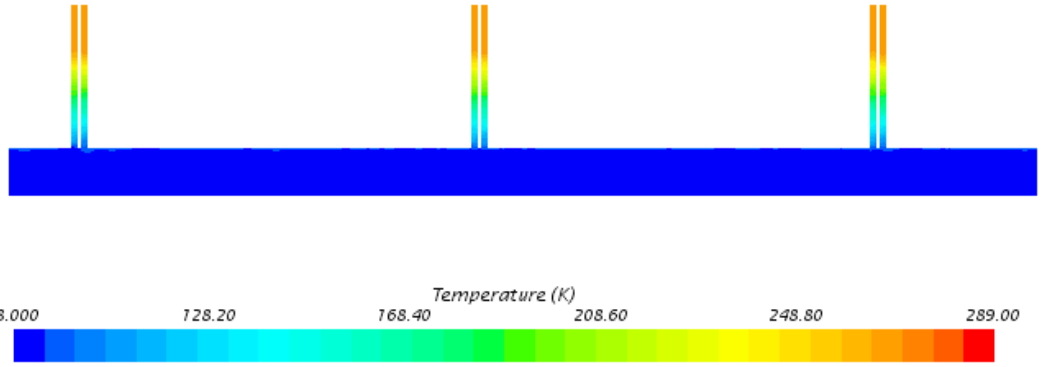
ProtoDUNE Modeling – Previous Work

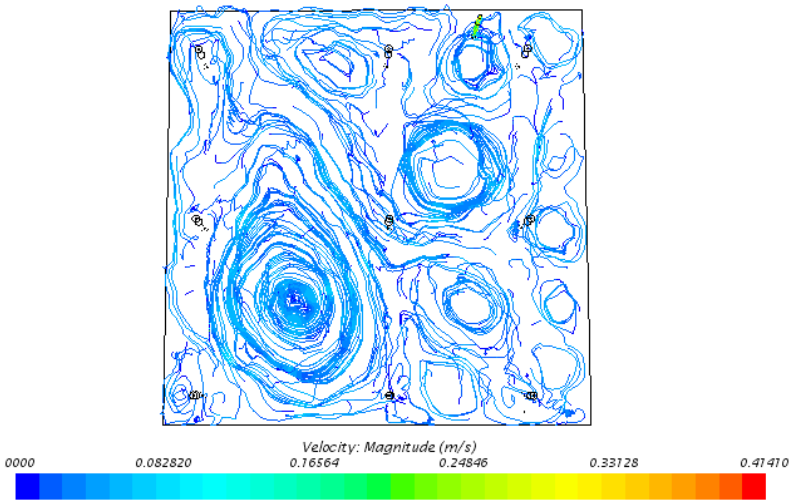
- Investigated mass flux condition
  - Constant mass flux
  - Mass flux from liquid simulation results

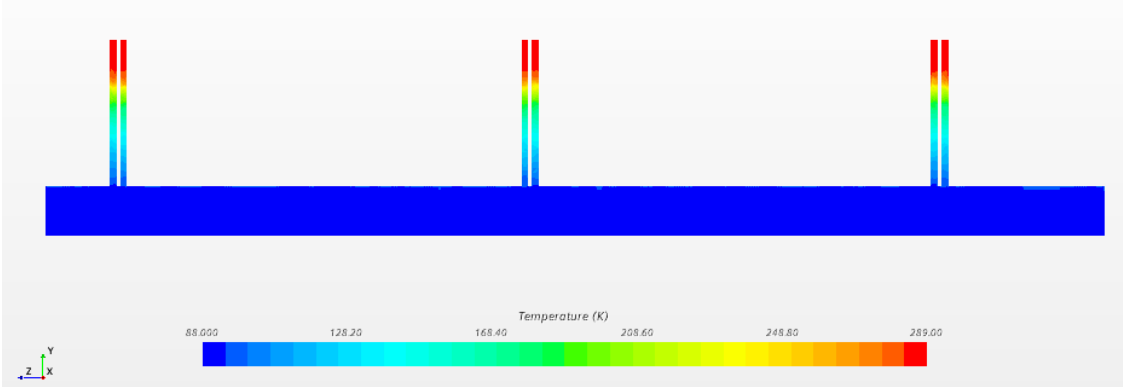


ProtoDUNE Modeling – Previous Work

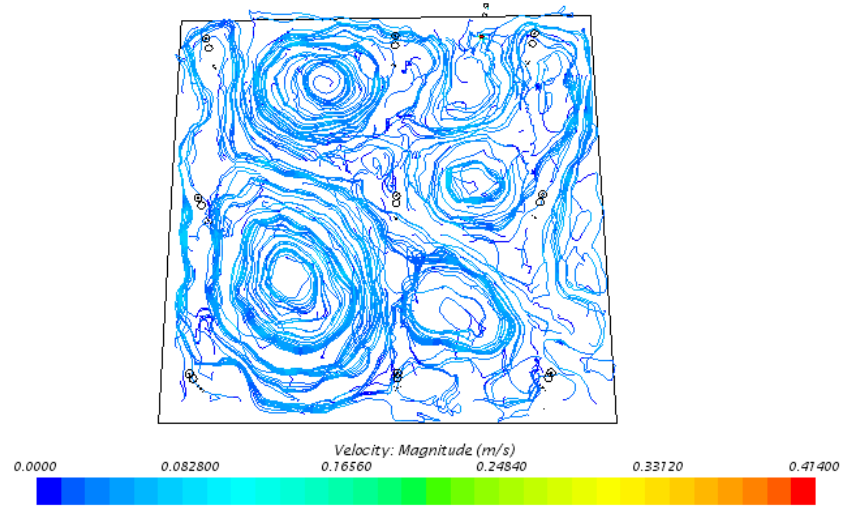


Uniform Mass Flux
Inlet Condition

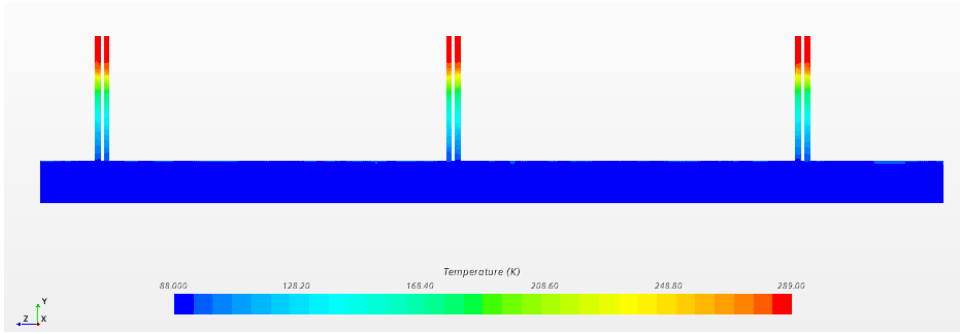




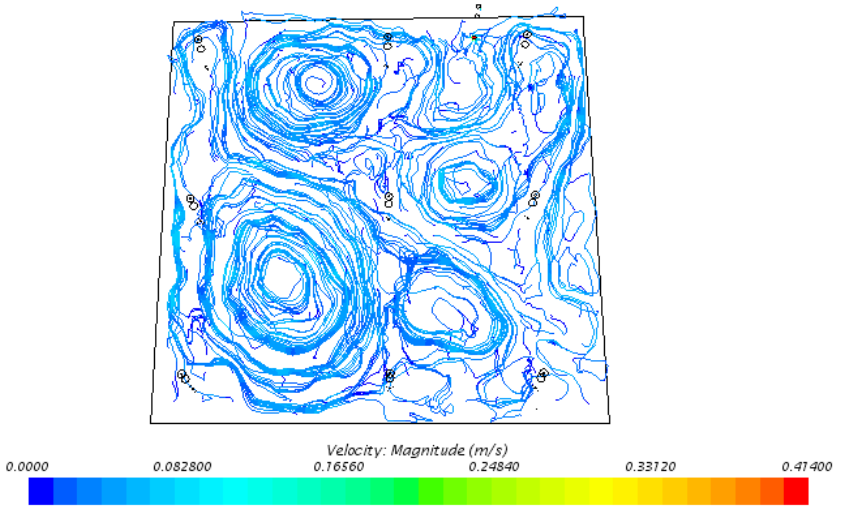
Mapped Mass Flux
Inlet Condition

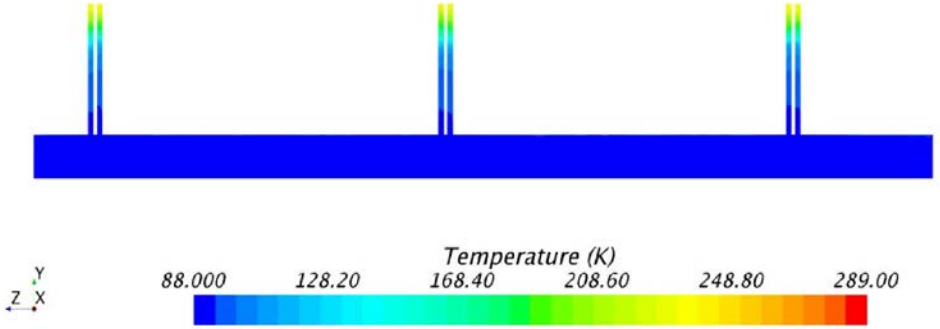


ProtoDUNE Modeling – Previous Work

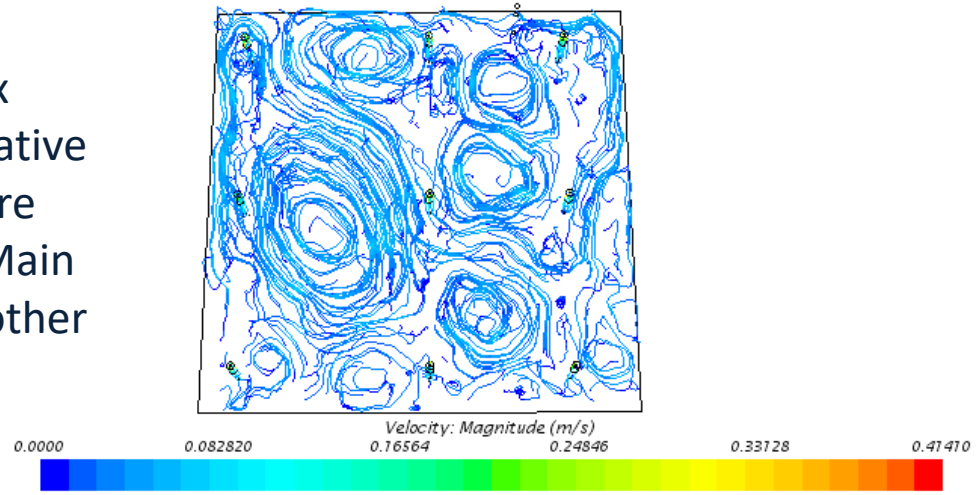


Mapped Mass Flux Inlet Condition, origin outgassing procedure (99% of flow through M Return, 1% through oth feedthroughs)



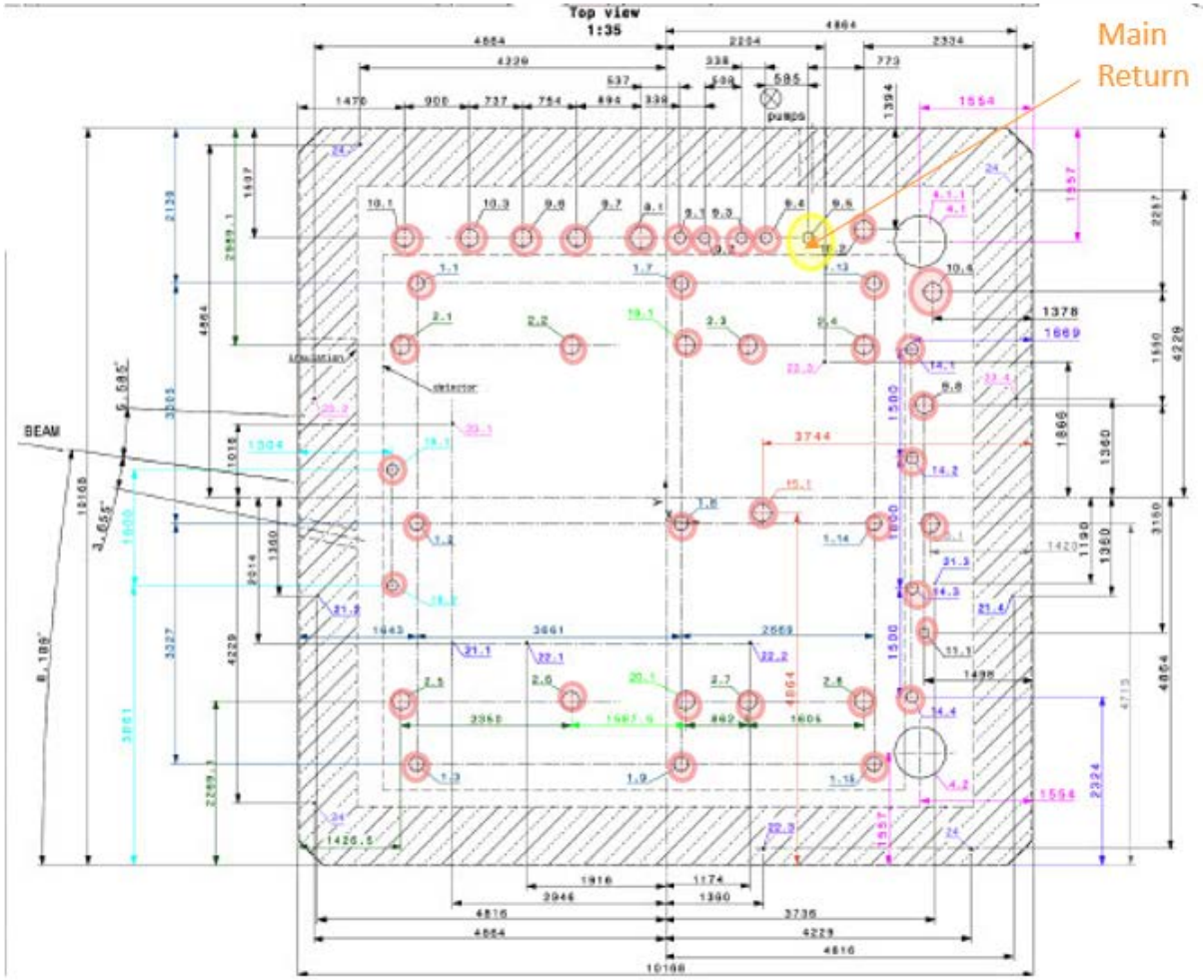


Mapped Mass Flux Inlet Condition, alternative outgassing procedure (1% of flow through Main Return, 99% through other feedthroughs)

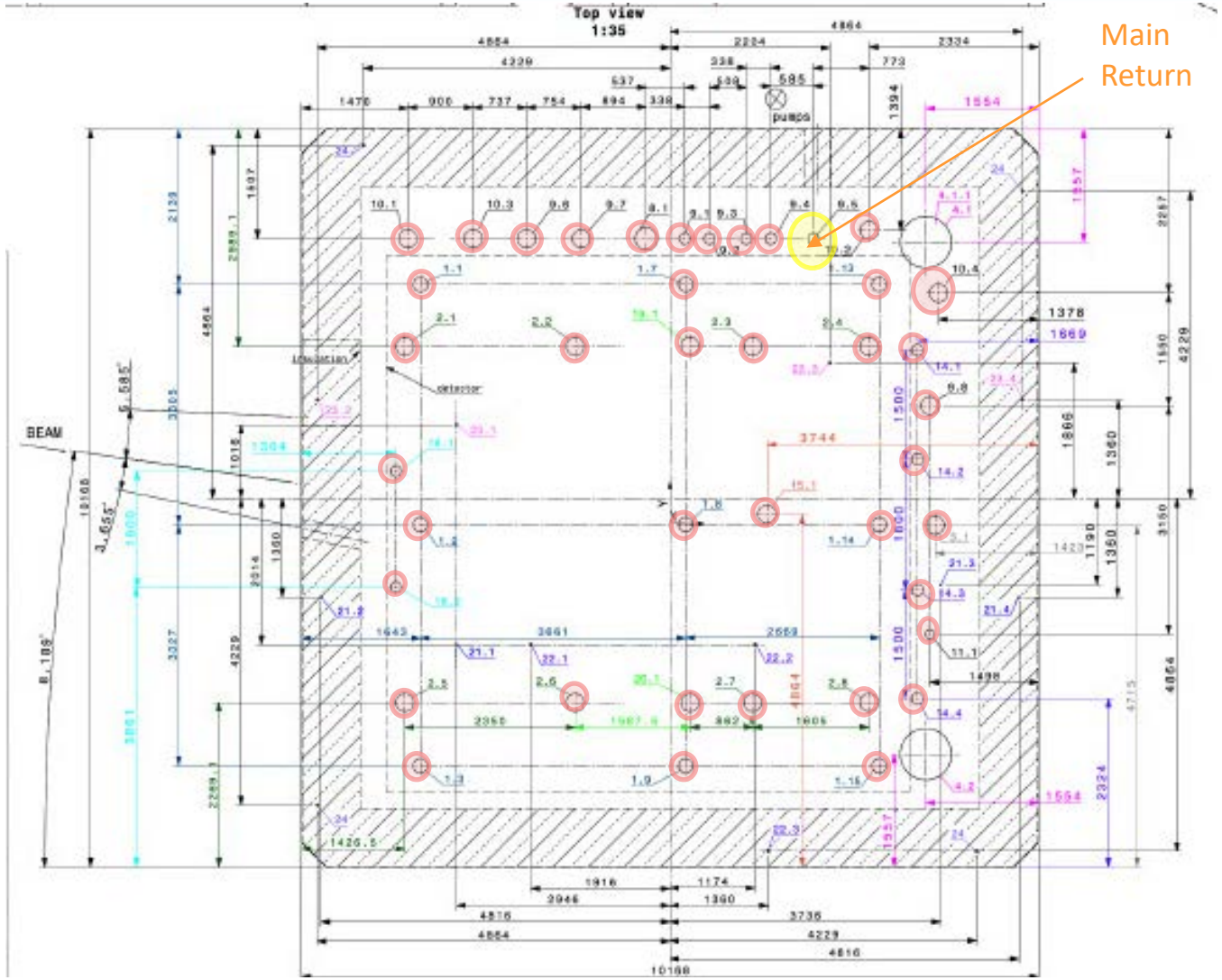


ProtoDUNE Modeling – New Information

- Alternative outgassing procedure significantly changed the flow:
  - Important to understand actual flow patterns to accurately model behavior
- Previous information:
  - Flow through nine feedthroughs plus main return
  - 1% of flow through main return, 99% split between nine feedthroughs
  - Total mass flow rate: 7 g/s
- New information:
  - Flows through all 41 feedthroughs
  - Total mass flow rate: 60 g/s
  - 50 g/s through Main Return, 10 g/s split between other 40 feedthroughs



Penetrations Drawing



Detector penetrations

Pos.	Diameter* [mm]	Description
1.1	Ø200	Support US-BL
1.2		Support US-Center
1.3		Support US-BR
1.7		Support MS-BL
1.8		Support MS-Center
1.9		Support MS-BR
1.13		Support DS-BL
1.14		Support DS-Center
1.15		Support DS-BR
2.1	Ø250	Spare US-BL
2.2		Cable US-BL
2.3		Cable MS-BL
2.4		Cable DS-BL
2.5		Spare US-BR
2.6		Cable US-BR
2.7		Cable MS-BR
2.8		Cable DS-BR
3.1	Ø250	Detector HV
4.1	Ø710	Manhole NE
4.2	Ø710	Manhole SE
6.1	1200x7300mm	Temporary Construction Opening
7.1	Ø250	Spare window 1
7.2		Spare window 2
7.3		Beam window
14.1	Ø160	Spare DS-BL 1
14.2		Camera
14.3		Temperature measurements
14.4		Static temperature profiler
15.1	Ø250	CPA Flasher Calibration Fibers
18.1	Ø150	Beam plug gas purge
18.2		Camera
19.1	Ø250	Spare MS-BL
20.1	Ø250	Spare

* Pipe outer diameter. Aperture is 20mm less.

Cryogenic penetrations

Pos.	Diameter* [mm]	Description
8.1	Ø304	GAr Combo
9.1	Ø152	Temperature measurements
9.2		LAr Distribution
9.3		Camera
9.4		LAr Cooldown to Condenser
9.5		GAr Boil Off
9.6	Ø250	Dynamic temperature profiler
9.7		LAr Cooldown
9.8		Spare
10.1	Ø250	Main PSV/VSV
10.2		Gmd plane mon + Mmeter + cameras
10.3		Purity monitors
10.4		Cryostat small vent
11.1	Ø125	Spare
13.1	Ø350 (See NB in Front view)	LAr Pump 1

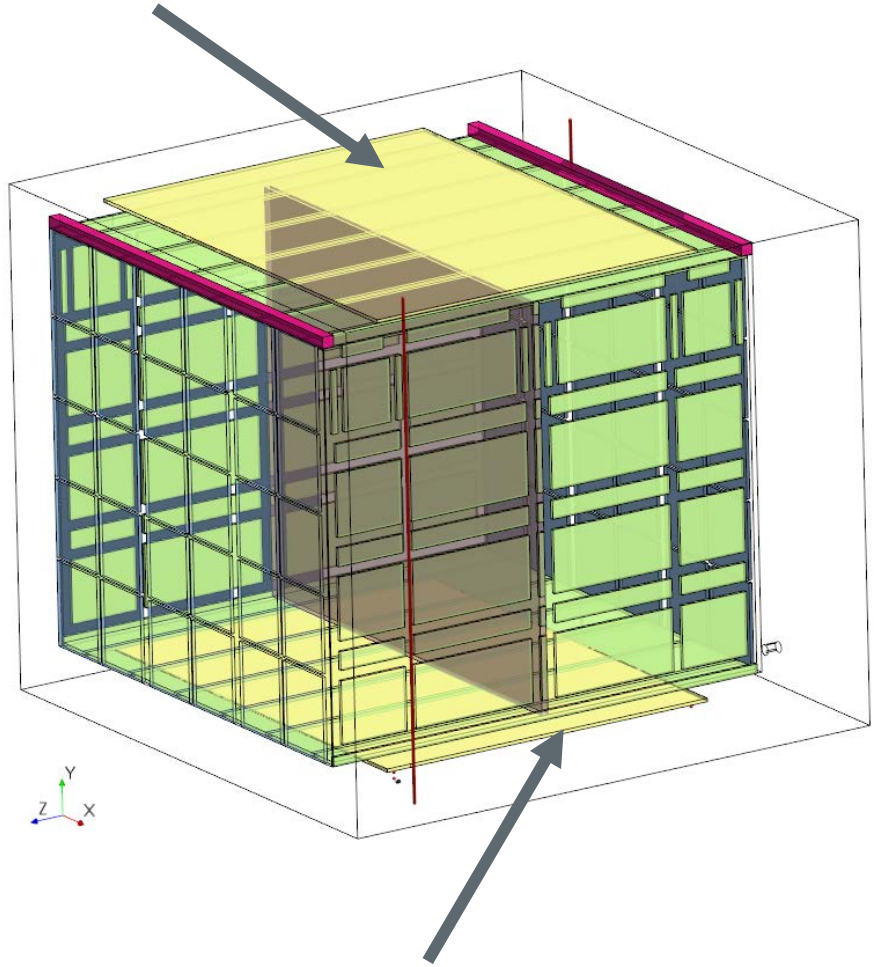
* Pipe outer diameter. Aperture is 20mm less.

ProtoDUNE Modeling – Updated Information

- Further understand port geometry
  - How many wires in each port?
    - Wire volume affects flow behavior
    - Wire insulation causes impurities
- Diameters in drawing- internal or external?
- Verify updated flow information
  - Equal flow between all ports
  - 50 g/s through Main Return
  - 10 g/s split between other feedthroughs

ProtoDUNE Modeling – GP Update

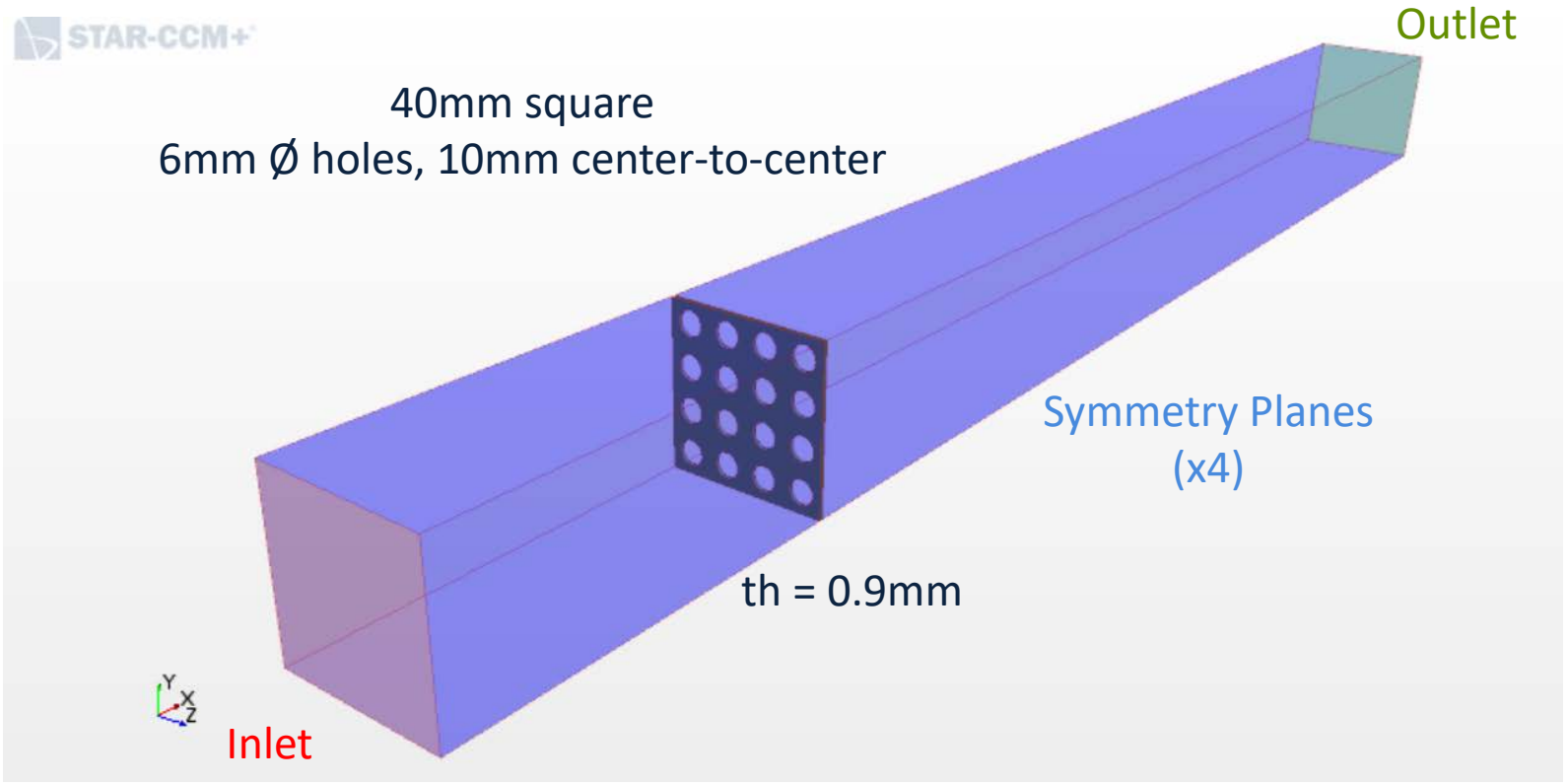
- Ground Planes (GP) modeled as porous region
  - Similarly as: FC, APA
- Values for viscous and inertial resistances and porosity revisited
  - Model flow through subsection of “actual” geometry



GP Porosity Study

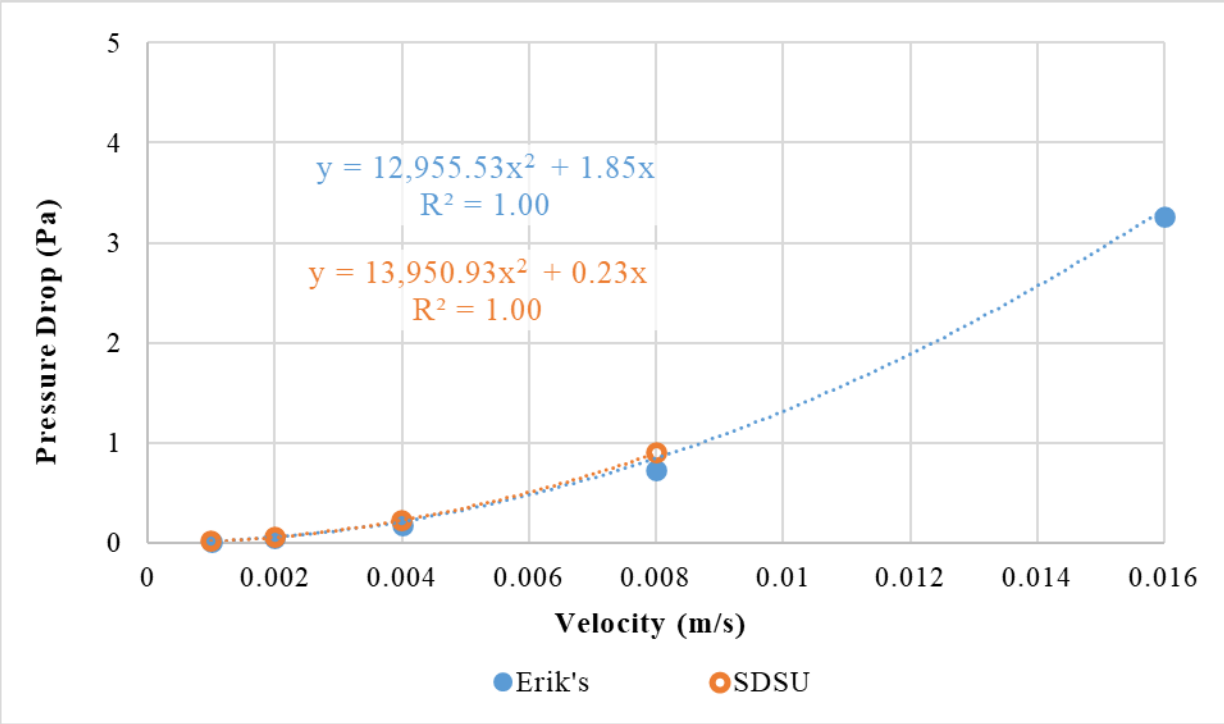
- Inlet Velocities = [0, 1, 2, 4, 8] mm/s
- Fluid Properties = same as in full LAr model

- FIND:
  Pressure Drop with Velocity



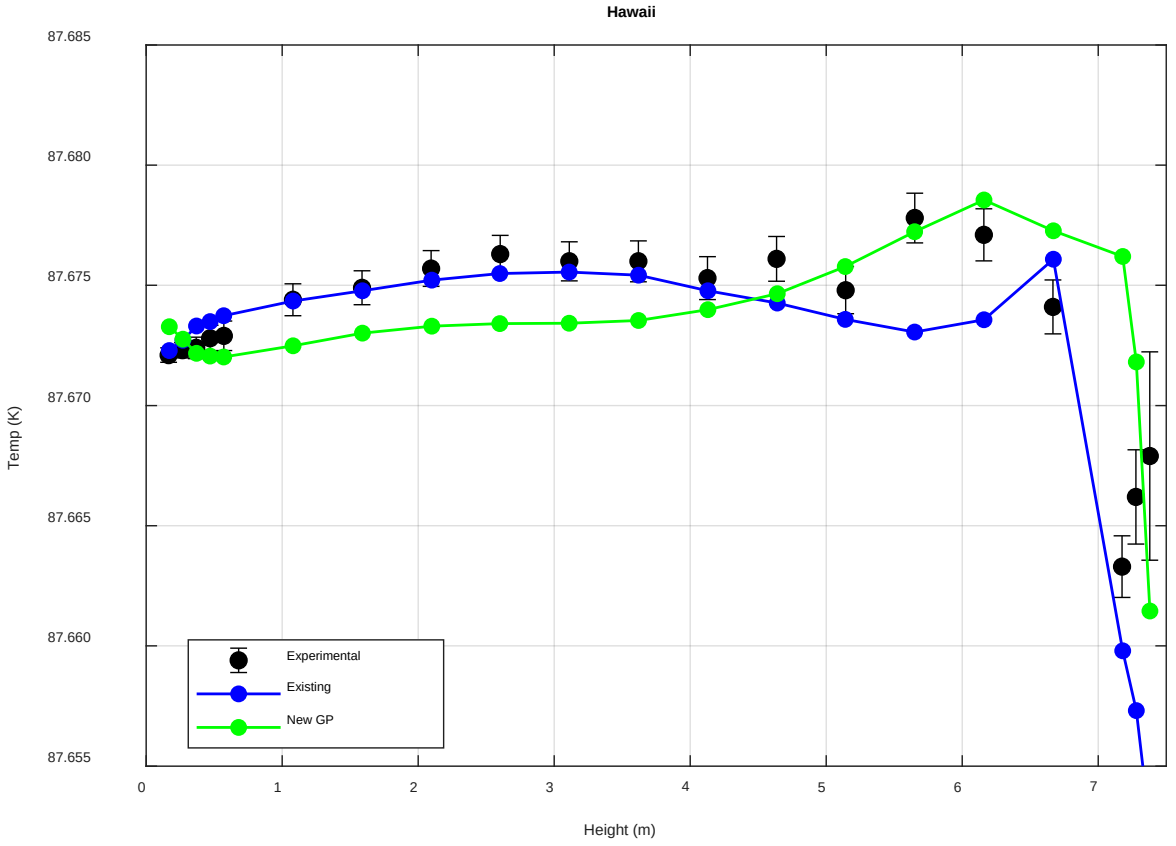
GP Porosity Study

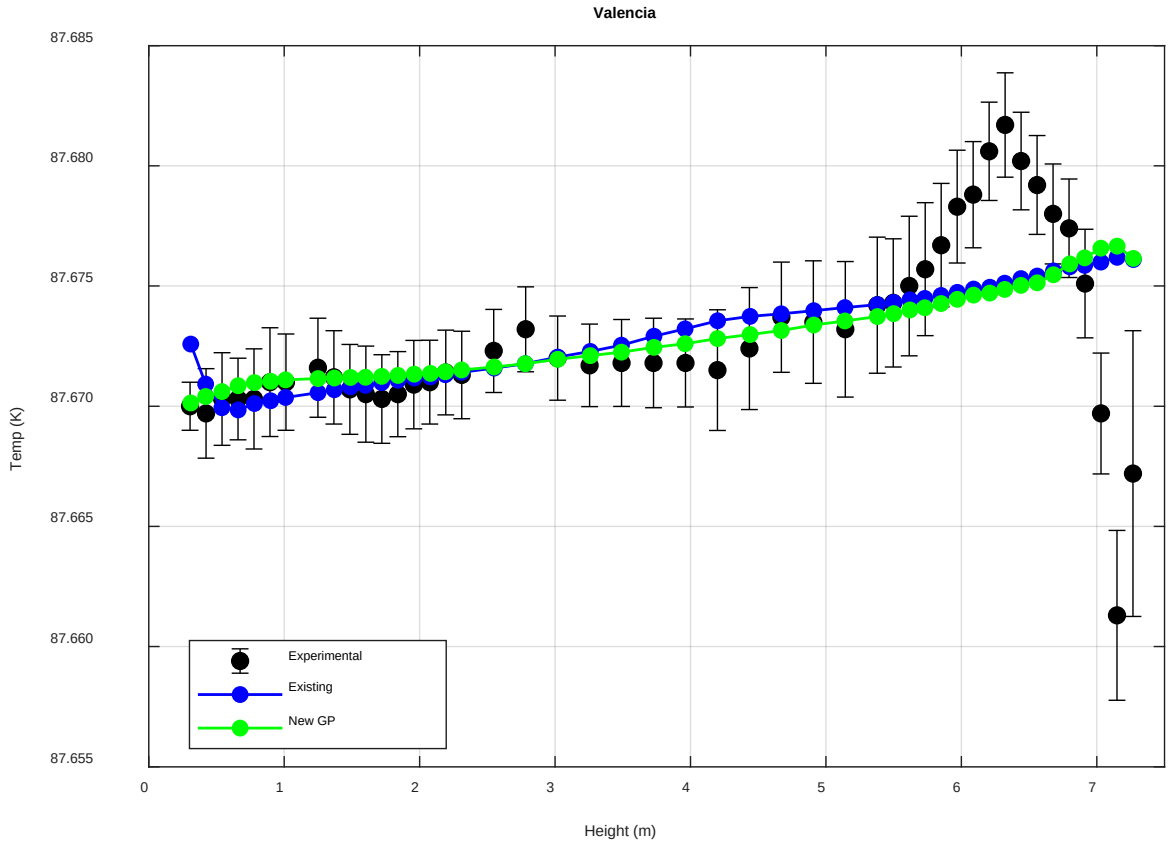
- Second Degree Polynomial Coefficients and plate thickness used to compute viscous and inertial loss parameters



	Converted From Erik's	Existing CFD	New CFD
Porosity (-)	0.28	0.1	0.28
Viscous Resistance (kg/m^3-s)	131	4007	4.67
Inertial Resistance (kg/m^4)	2.5 E5	2.4 E7	2.8E5

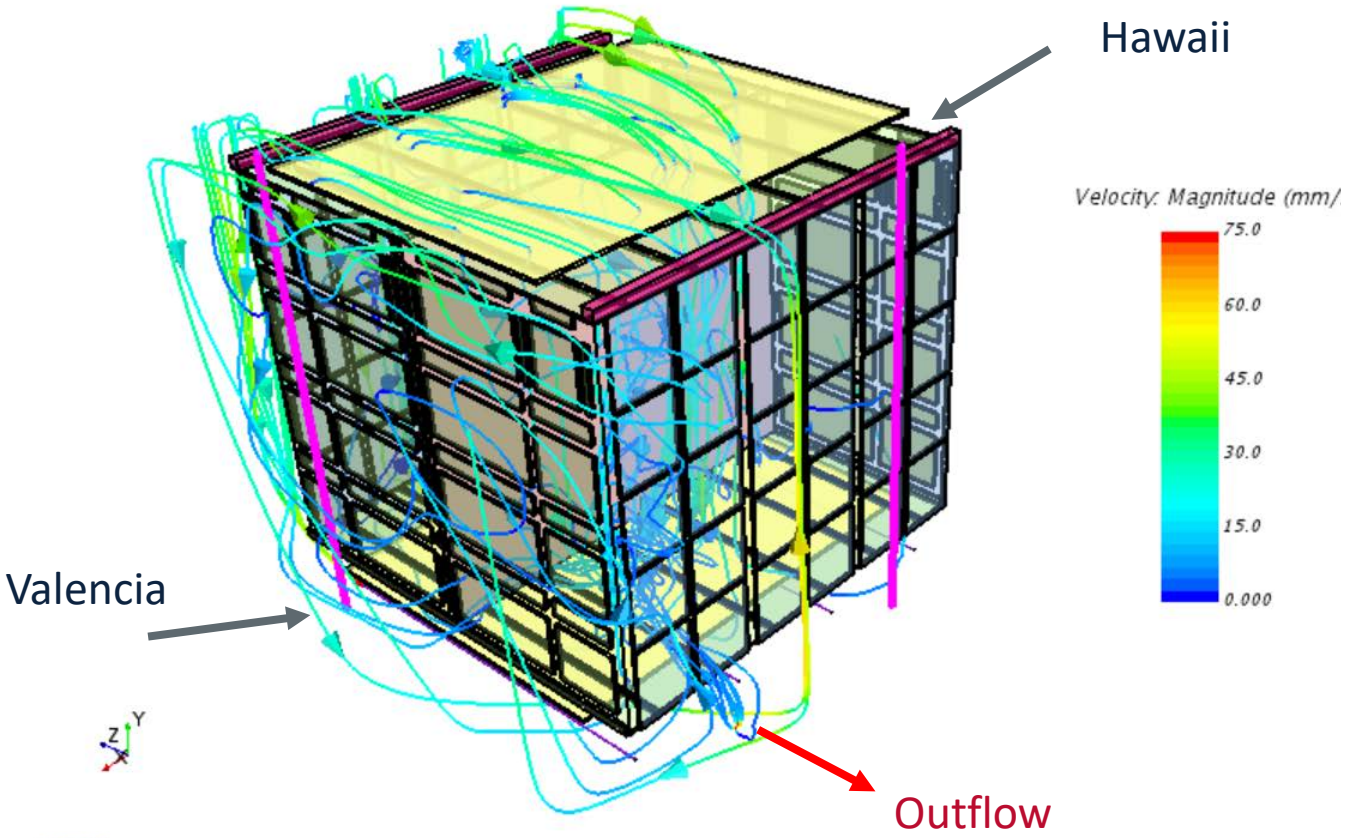
GP Porosity Study Implemented



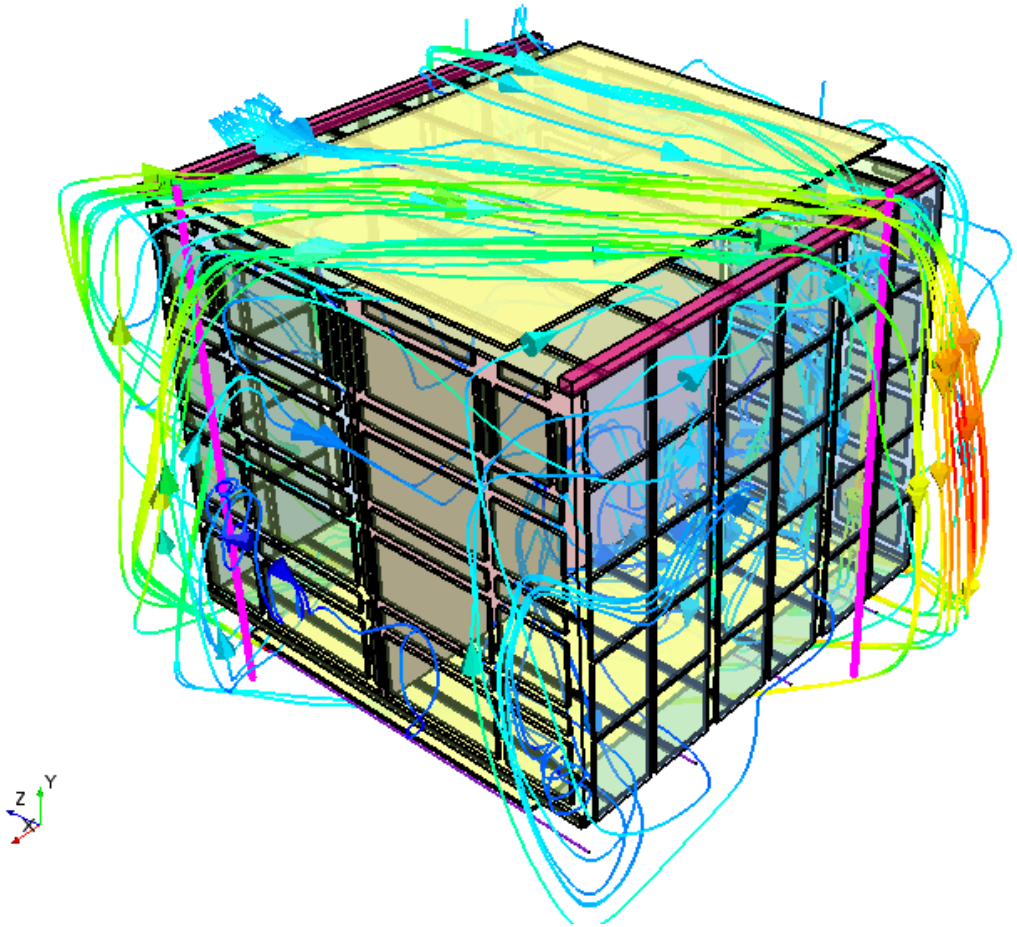


GP Porosity Study Implemented

New GP



Existing GP



Summary – GP Update

- Correctly defining geometry does have significant impact on flow profiles of LAr
- "Missing" geometry in model may be reason for Valencia temp. disagreement
  - Need to understand Cable Tray geometry (i.e. cable packing/ routing)
- **Are there recent CAD models or photos of this geometry?**