Update on Cryostat Instrumentation and Calibration Feed-through Needs

Sowjanya Gollapinni (UTK)
Calibration TF meeting
September 26, 2017

Instrumentation & Calibration devices

- Thermometers
- Purity Monitors
- Radioactive source calibration
- Field Calibration
- Cameras
- Laser system (Kendall's talk)
- Photon system calibration (Ranjan's talk today)
- Gas analyzers and Liquid level monitoring (currently put under LBNF's plate, talk at next Slow Controls and Cryo Consortium meeting, Oct. 6th; DUNE might have additional requirements, still need to understand this.)

Things are starting to converge for the Sep. 29th Technical Board meeting which is when the FT penetration proposals will be discussed/reviewed.

Where do we stand in terms of understanding the FT needs for all these devices?
In parallel, we are also trying to make the physics case for some devices...

Cryostat Penetrations

(Except for manholes, all ports are 250 mm OD)

Detector penetrations

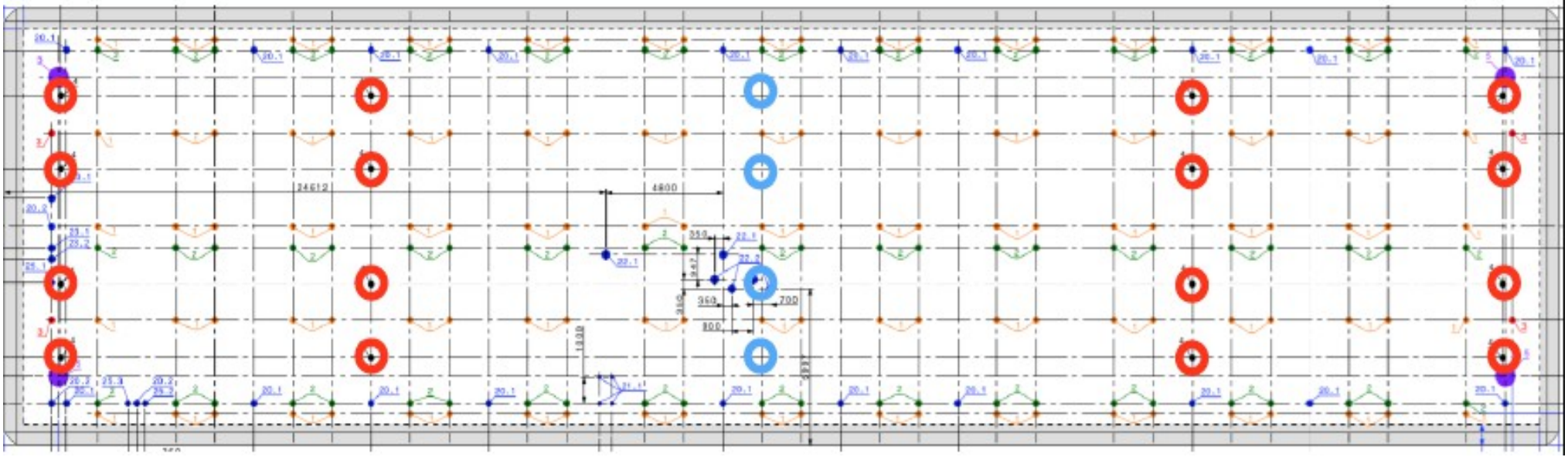
Pos.	Diameter [mm]	Quantity	Description
1	Ø250	120	Support
2	Ø250	72	Cable
3	Ø250	4	High voltage
4	Ø250	16	Instrumentation
5	Ø800	4	Manholes

Cryogenic penetrations

Pos.	Diameter [mm]	Quantity	Description
20.1	Ø250	20	L+G Ar cool down
20.2		3	Spare
21.1	Ø152	4	G Ar Controled vent
22.1	Ø324	2	G Ar Boil off
22.2		4	G Ar Relief/Safety
23.1	Ø273	2	L Ar Return
23.2		1	L Ar Emergency return
24.1	Ø350	4	L Ar Pump
25.1	Ø219	1	G Ar Purge
25.2		1	G Ar Make up
25.3		1	G Ar Momentum

Instrumentation ports

Proposed Additional Instrumentation Ports
(mainly motivated by radioactive source calibration)



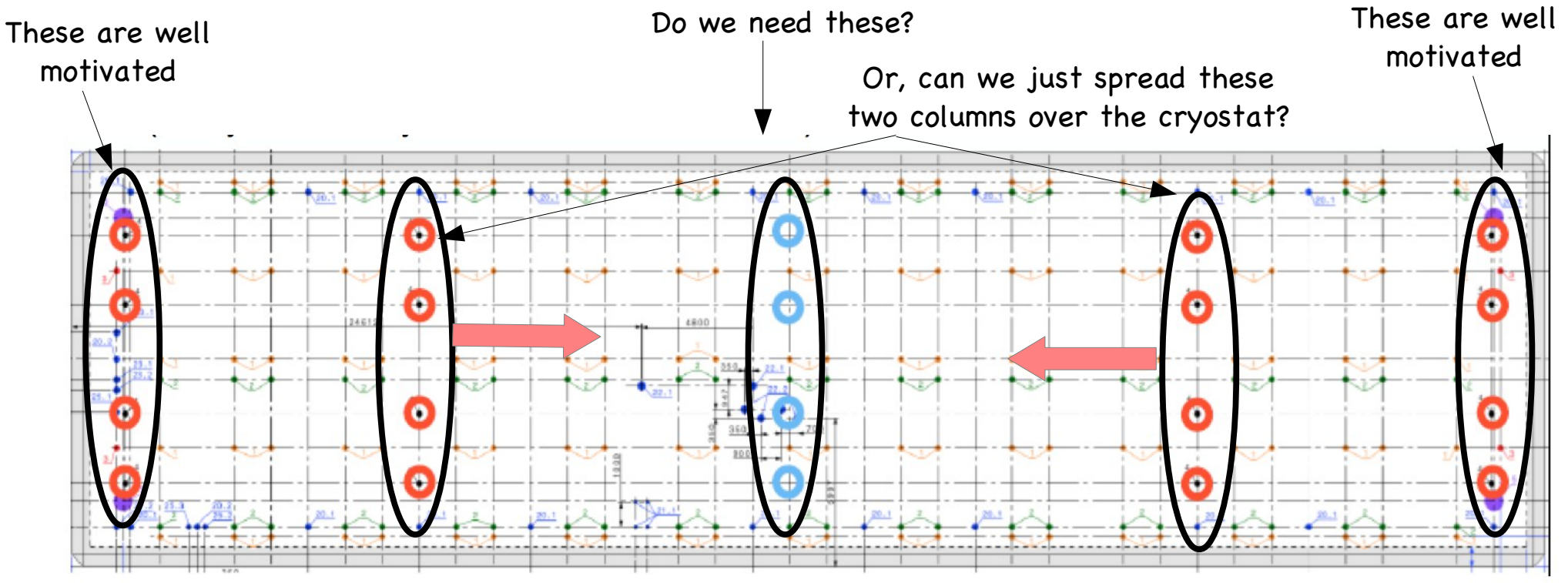
Radioactive source calibration -1

- **Desired source:**
  - 58Ni-252Cf source will emit 8-9 MeV gammas which are in the right range for calibration of the energy response in the SN region
- **FT width requirements:**
  - 20 cm diameter for any high energetic gamma source, already challenging.
  - Going thinner is possible, but will require extensive MCNP simulations and gamma yield measurements to answer – not doable on the Oct. 3 timescale.
  - The default 250mm OD (or 234mm ID) instrumentation will just be enough for ONLY radioactive source. If we want the FT to share e.g. a T-gradient monitor, the FT needs to be bigger.
- **How far should the source sit w.r.t. the field cage in the far right/left locations?**
  - Studies from Bo: Can sit as close as 15 cm but should not be far away by 50 cm. More precise estimate on the safest distance is possible but not before the Oct. 3 timescale.
  - Action item: Find out how far away the current FTs on the far right/left sit w.r.t. the field cage and w.r.t. the cryostat wall? **(from Jack)**

Radioactive Source Calibration - 2

8 vs 12 FTs question? The central column of FTs in Z are mainly motivated for position resolution needs for SN Physics. We need to how an uncertainty in position affects the energy scale to make a decision? How should the FTs be distributed along Z?

- If we expect 5 cm warping of CPA or APA (worst assumption) which translates to 0.3% change in E-field over 15 m in Z. Having 3 FT columns along full 60 m Z length would be good. Then, together with photon system and knowing the physical position of the source and its physical energy deposit, we could disentangle the cause of a visible energy shift.
- Additional simulation studies are possible for understanding position resolution requirements in detail for low energy events, but will need more time to converge. (Kate, Juergen)



Radioactive Source Calibration - 3

8 vs 12 FTs question? **G**et some realistic estimates of the tolerances in x-coordinate due to APA/CPA misalignment caused by e.g. support structures or thermal contraction

From Vic:

- +/-3mm variation in x-coordinate (drift direction) all along Z is expected, before and after cool down.
- During cool down, spacing will shrink by a uniform 7 mm. The CPA will bow 4 mm at its center (half height) due to the pressure differential caused by fluid circulation.
- Given this, there is not a strong motivation to have the central FT column. **Instead it would be good to move the inner columns more towards the center.**
- What are the tolerances in Z (in the plane of APAs) due to mis-alignment in APAs? – still investigating. In the Far Detector, the Field Cage encloses rows of 25 APAs. If the constraints are on the ends of the beam where it meets the FC, how well can we constrain the 24 gaps between the APAs?

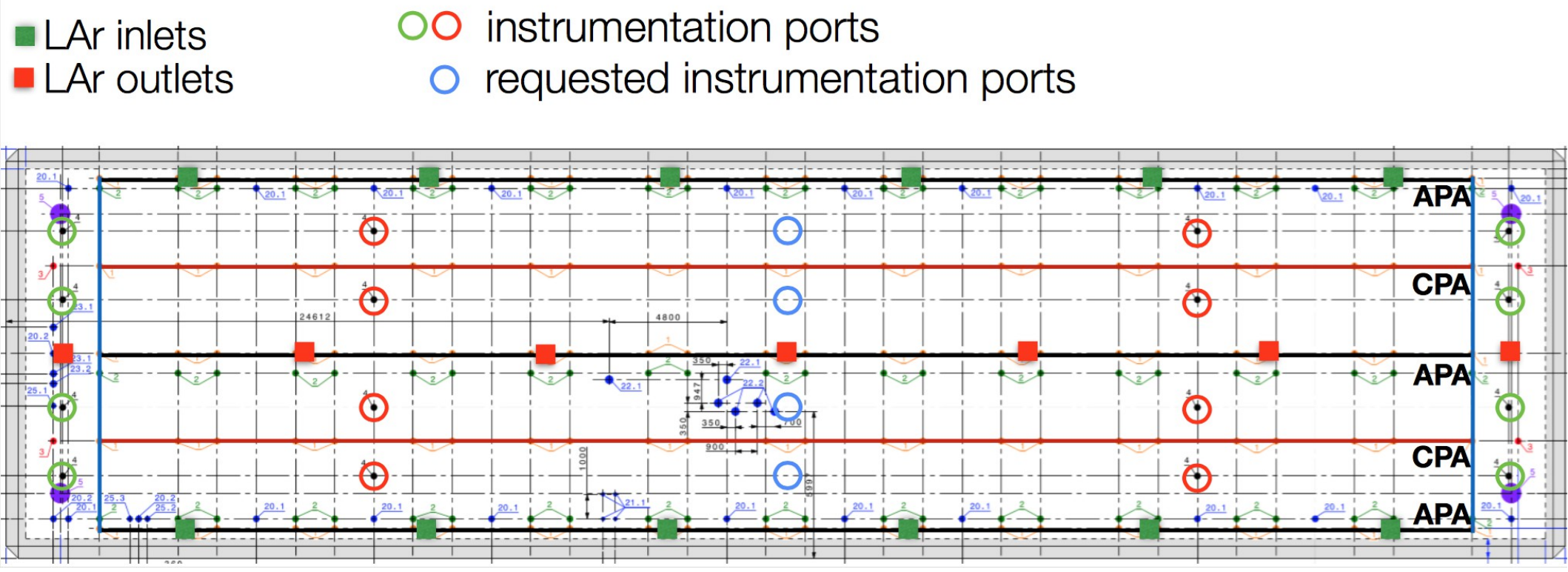
Action item: How much towards the center we want to move the inner two columns? Any constraints on this?

On a related note, From the Thermometer side, there is a strong motivation for the central FT column. In this case, it makes sense to ask for the central column with 275 mm ports so both Radioactive source and (Static) Thermometer array folks can share it.

- Need more details to finalize this. E.g. What are the FT width requirements for static thermometer arrays (ProtoDUNE-SP style)

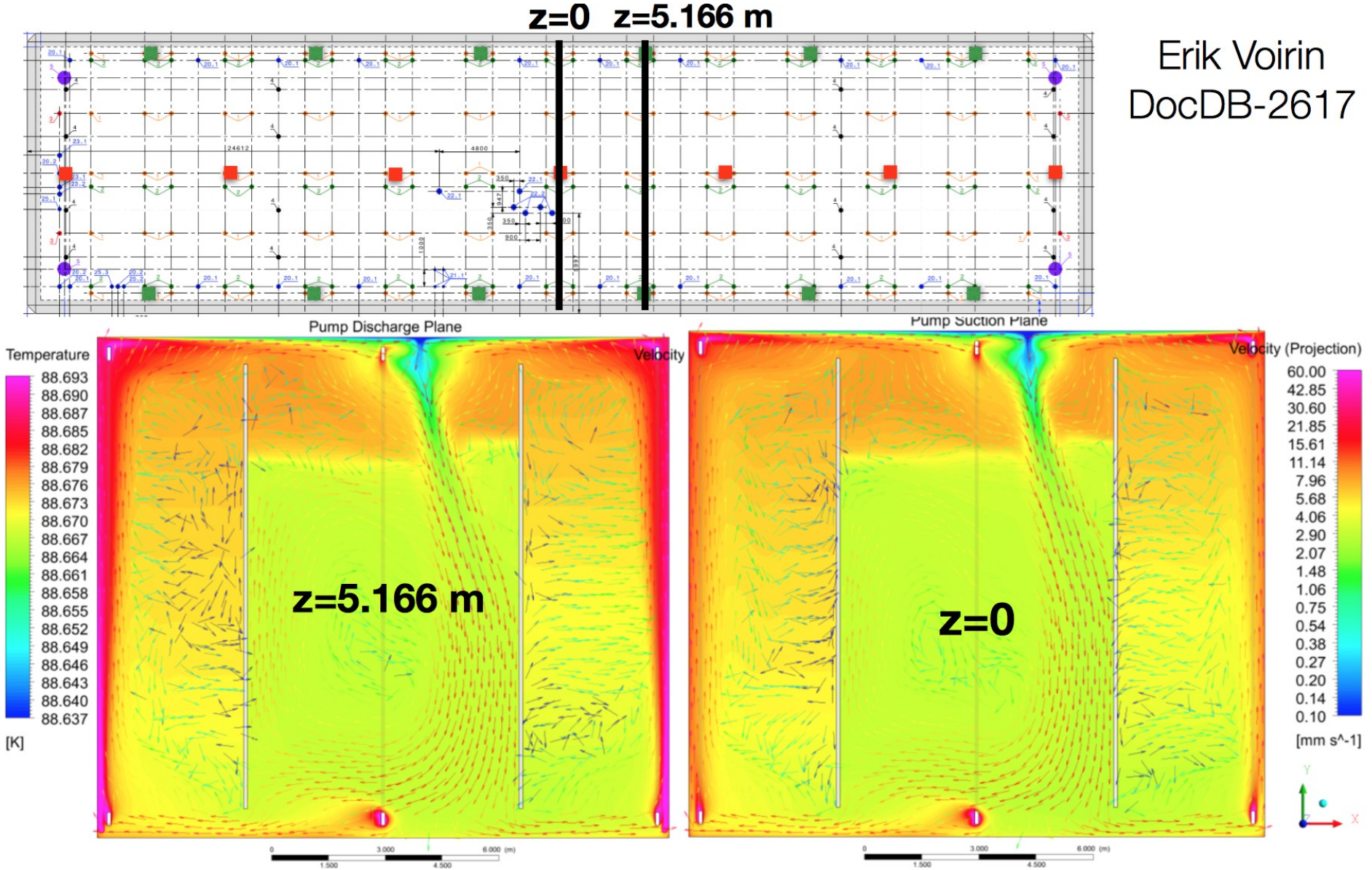
Thermometers -1 (based on Anselmo's slides)

- Very nice talk by Anselmo/Jelena on this at the last Slow Controls and Cryo. Inst. Consortium: https://indico.fnal.gov/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=15340
- Three types of monitors (following ProtoDUNE-SP style):
  - Static Thermometer stick with several temp. sensors
  - Dynamic T-Gradient Thermometers that can move vertically (allows self/cross calibration)
  - Several individual sensors at various locations of the cryostat.
- Fluid flow Simulations showing Temperature gradients are critical before we finalize thermometer locations.

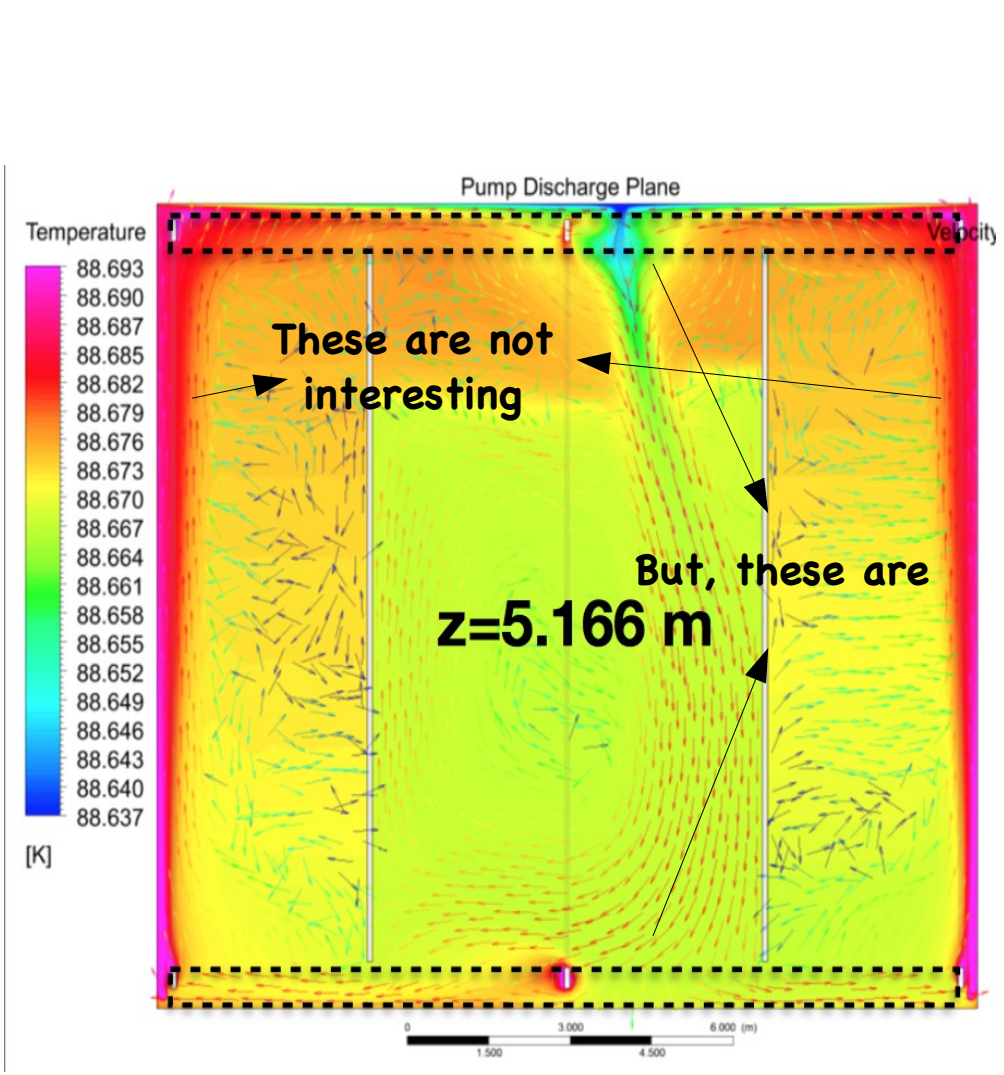


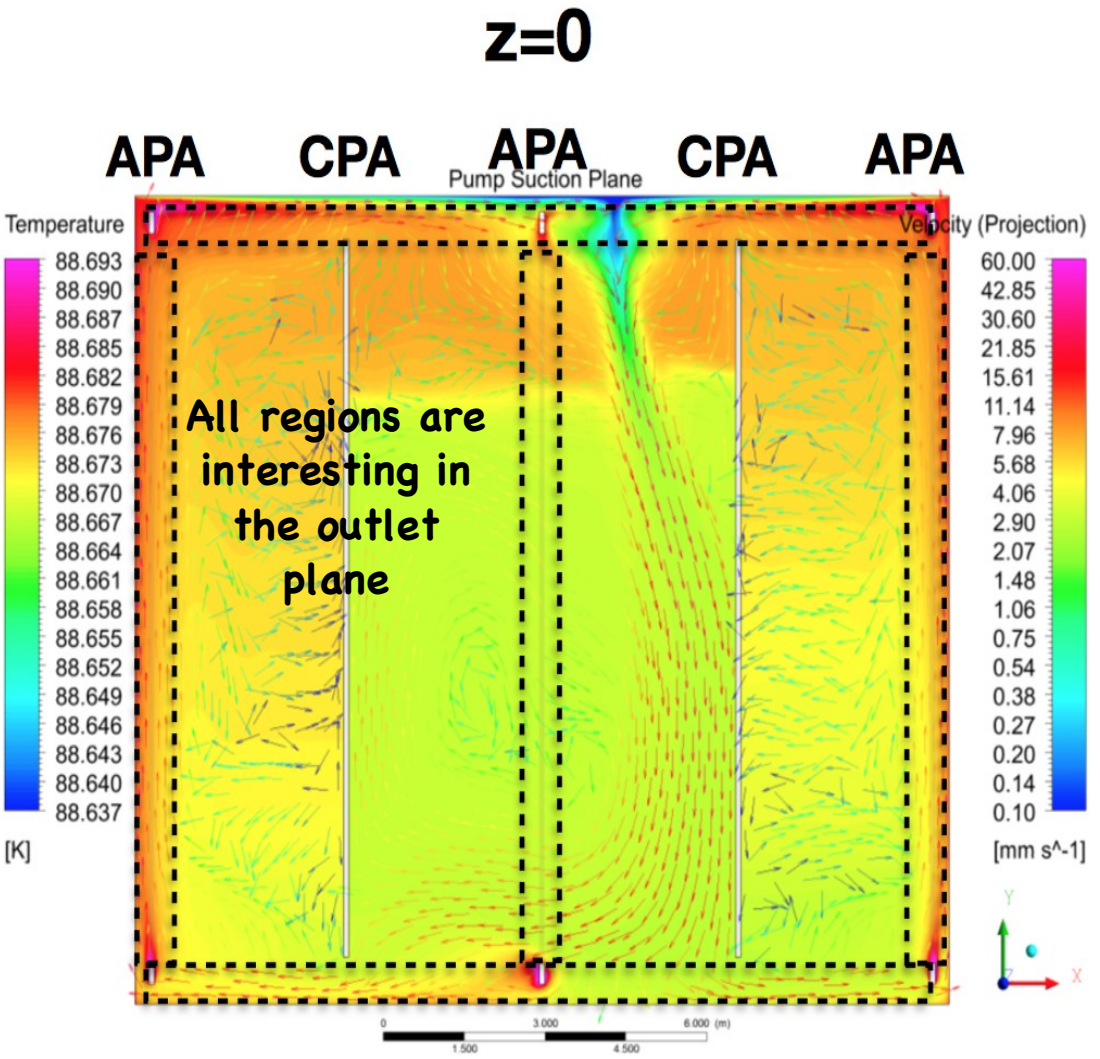
Fluid Flow Simulations

- These simulations are old, but still very informative. **South Dakota folks will provide us the most up to date temperature and impurity variation plots by today and this will be revisited. But, expect no big changes to what is proposed here.**



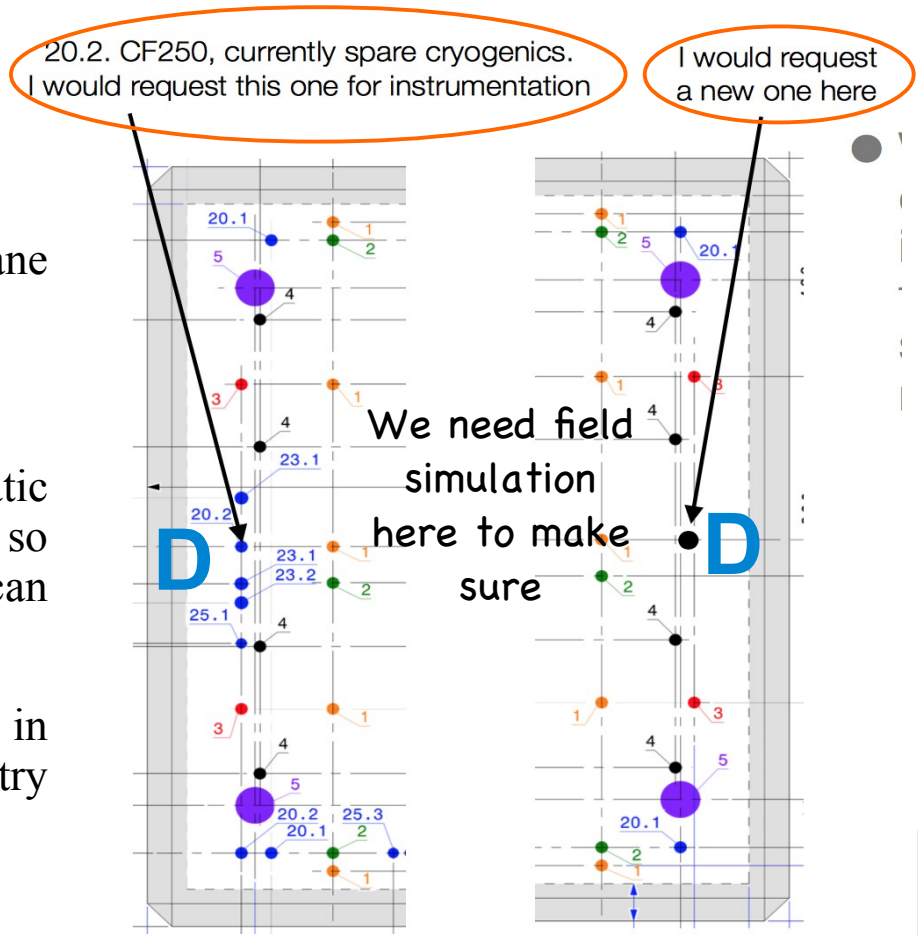
Pump Suction vs Pump discharge regions

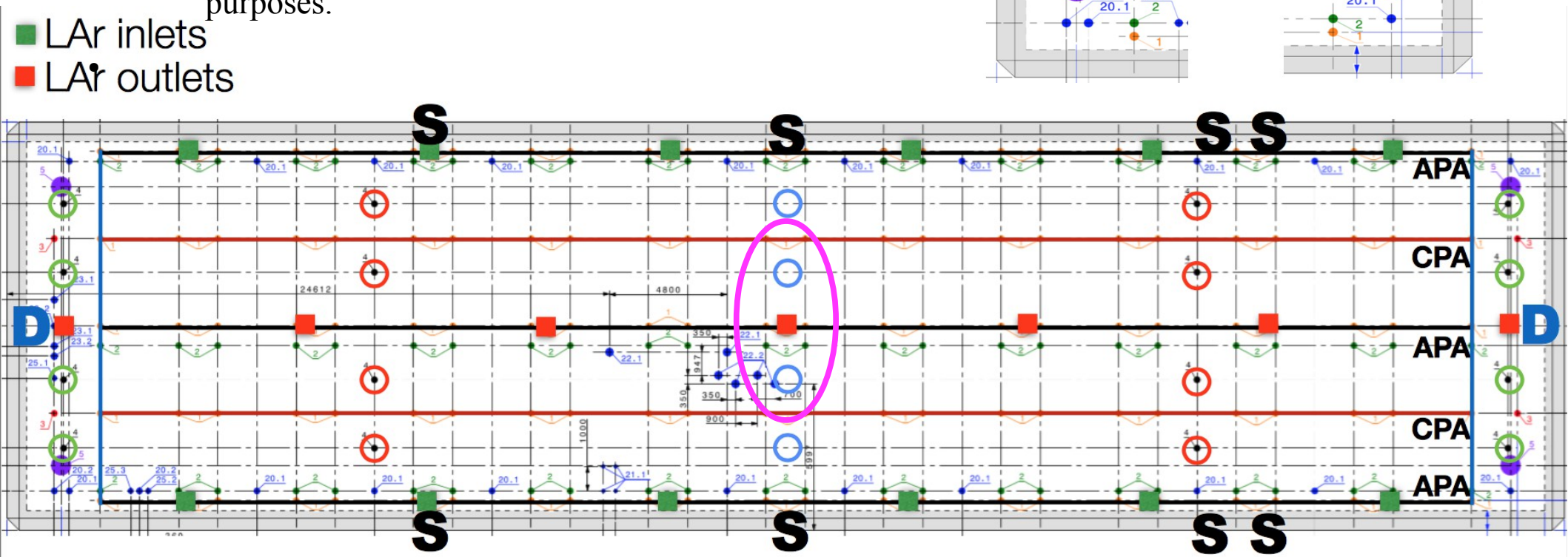




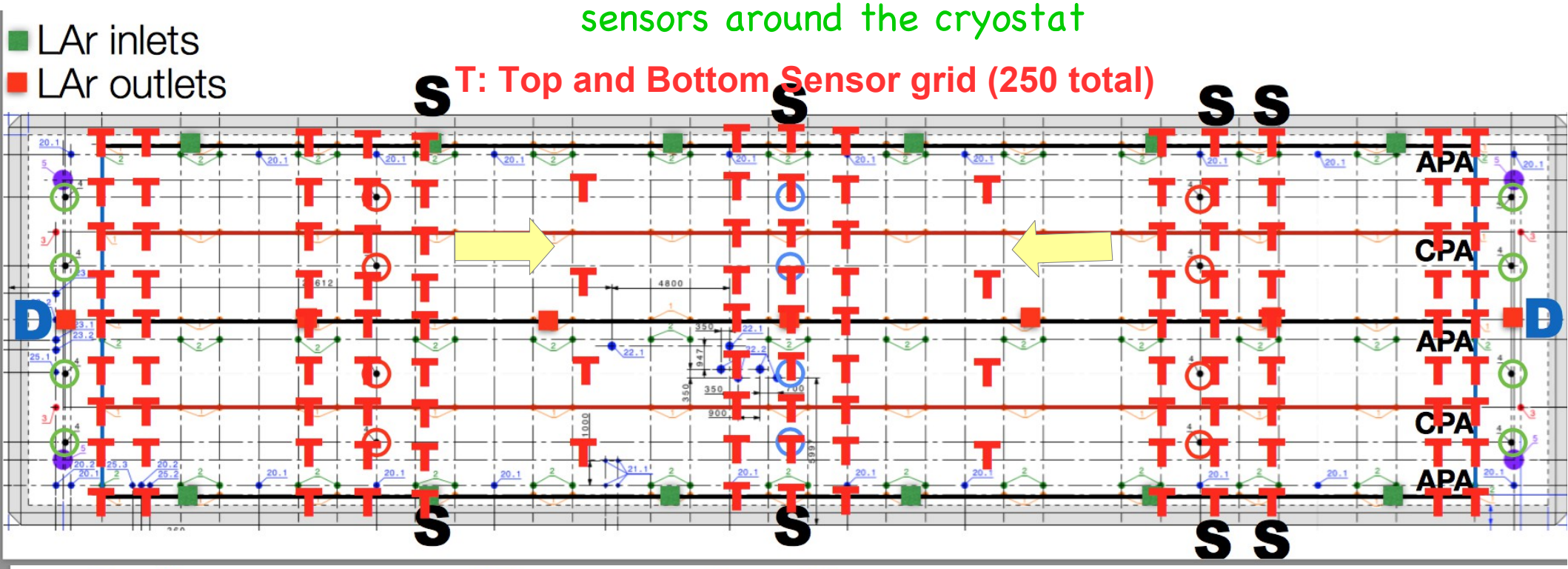
Proposal for Static (S) and T-Gradient (D) monitors

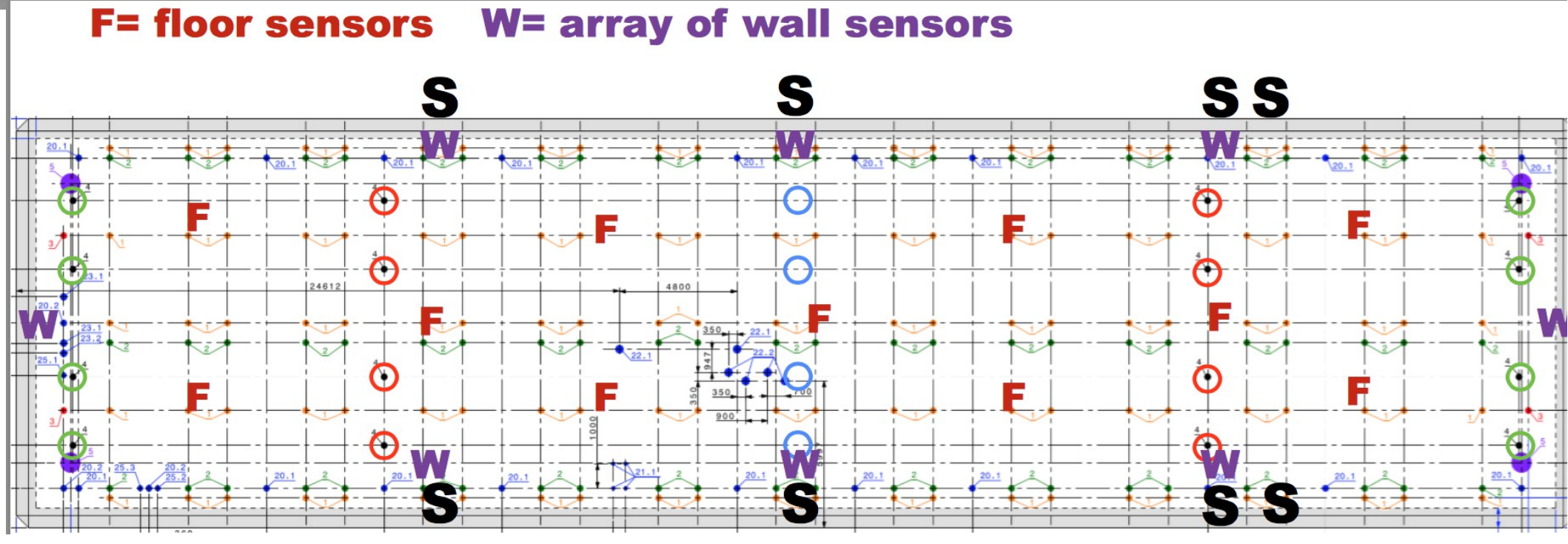
- Strongly requests the central FT column as it is Z=0 plane where most variations are shown by CFD.
  - This will also serve the radioactive source folks
  - Action item: Get the FT width estimate for static monitors. we might have to increase the port size so both thermometer and radioactive source folks can share the feed-through.
  - If not all 4, the two ports in the middle (magenta) in the central FT column are requested for thermometry purposes.





Moving the inner FT columns towards the center can skew the distribution of sensors around the cryostat



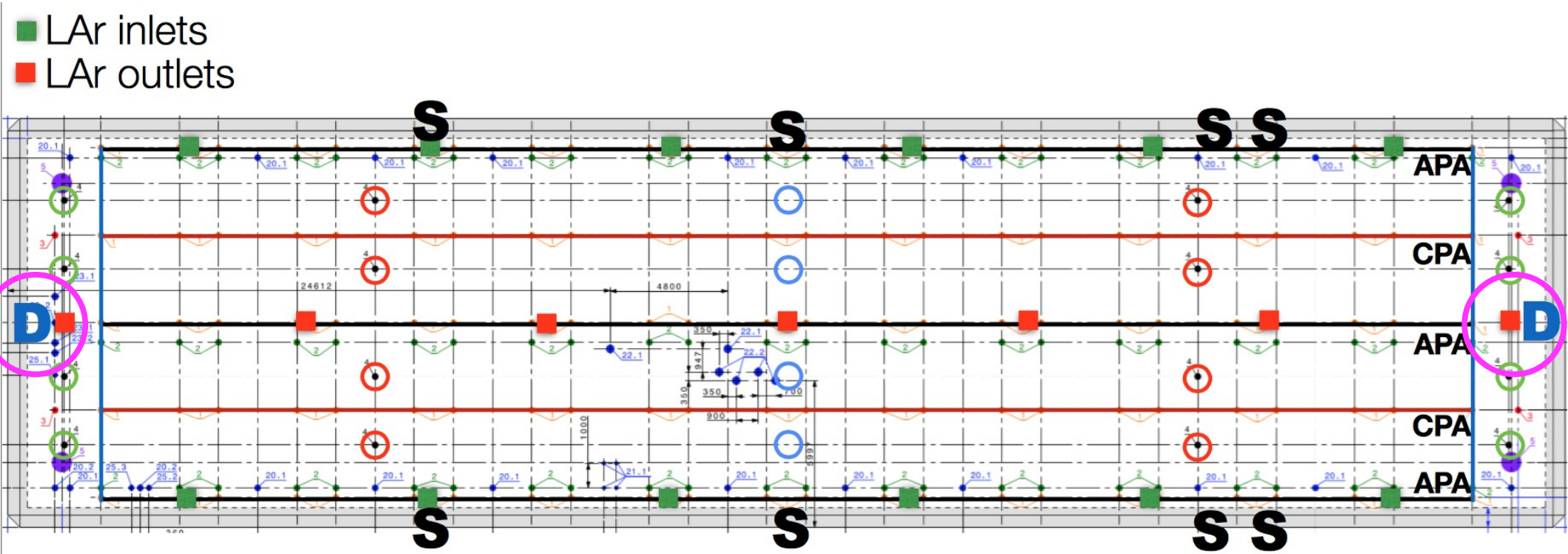


Summary and action items for Thermometers

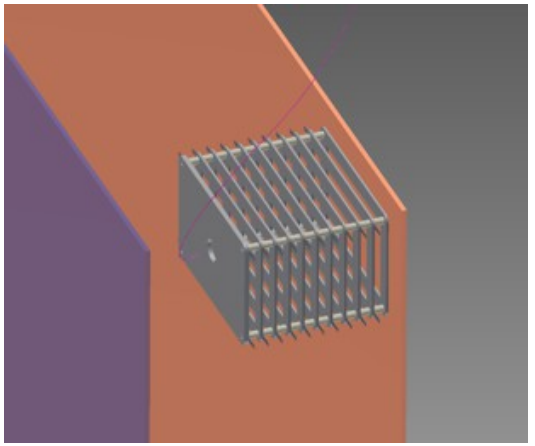
- The 4 FT central column is strongly requested. Will also serve the radioactive source folks.
  - Action item: get the FT width for Static thermometer to see if the ports need to be made bigger for both systems to share. For static thermometers all you need is to route cables. **(Anselmo)**
- Request the 20.2 spare Cryogenic port to be instrumentation port. David Montanari agrees.
- Request a new 250 mm port on the right side of the cryostat aligning with the APA, same location as the 20.2 port that is on the left.
  - Action item: For both Dynamic thermometer port locations, need E-field simulations to make sure field id okay. **(Anselmo)**
  - Action item: Get the distance of the Dynamic thermometer port locations from the field cage and from the cryo wall? **(from Jack)**
- Static Temp. ports can be shared with other devices, but ports for Dynamic Temp. monitor (on left and right) will be difficult to share (e.g. with purity monitors) due to the structure outside the cryostat and mechanical operation.
  - Action item: Get FT width requirement for the Dynamic T-gradient thermometer **(Jelena)**

Purity Monitors

- The best location for PMs also seem to be where Anselmo/Jelena proposed the T-gradient Thermometers (D) (in magenta below)
  - The field is expected to be low although will confirm this by simulation **(Anselmo)**
  - The updated impurity map from South Dakota folks will be very helpful in understanding it
- Since sharing a single FT maybe a problem, we can **consider requesting two additional ports right behind the "D" ports for instrumentation**
  - It is in general nice to have ports aligned with APA since the field is expected to be small in that region.



Field Calibration



- Nice talk by Chao (and Yichen) last week.
- The device will sit on the side wall of the cryostat behind APA
- FT width requirement: 10 inches (254 mm OD)
- One device at one location (minimal); Two devices with the second one in the middle (ideal); Devices need some support structure engineered.
- Action item: **What are the exact desired locations for FTs on the cryo roof penetration map?**
- The FT(s) doesn't even need to be right above. Near by ports will work. Optical fibre with length ~10m is okay for routing.
- Conclusion: **Two 250 mm (or slightly larger?) FTs close to the Cryostat side wall is needed to preserve this option**. We can also request these two locations as spare ports if there are issues.
- Other questions/concerns raised at the last meeting are all well taken.
  - Quantifying/benchmarking the performance of the device at the BNL test stand is a critical step before we finalize implementing this device for DUNE.
- **Chao is preparing a summary document to detail the proposal and future studies/plans**

Cameras

Cold/Cryogenic Cameras:

- Main motivation: HV system monitoring
- Needs and requirements come from HV consortium but the instrumentation itself can sit in the Slow Controls and Cryo. Inst. Consortium – still understanding the scope.
- Current proposal: 4 cameras looking at the 4 HV FTs; 1 camera near the top and 1 near the bottom ground planes looking at APAs.
- The FT width requirements depend very much on the design and cannot be quantified now.
- Need to define FT locations (would the 4 cameras sit right behind the HV ports? In that case do we need to ask for 4 additional ports for HV?)
- Currently HV consortium is working on it

Inspection/Warm Cameras:

- If the main goal is to inspect things during commissioning and other downtimes, existing instrumentation ports or spare ports or manholes can be used as needed for diagnostics.
- If there is plan for long term monitoring both from HV side and other systems, then more thought need to be put as to the purposes of cameras.
- Probably a combined design for both warm and cold cameras can be achieved.

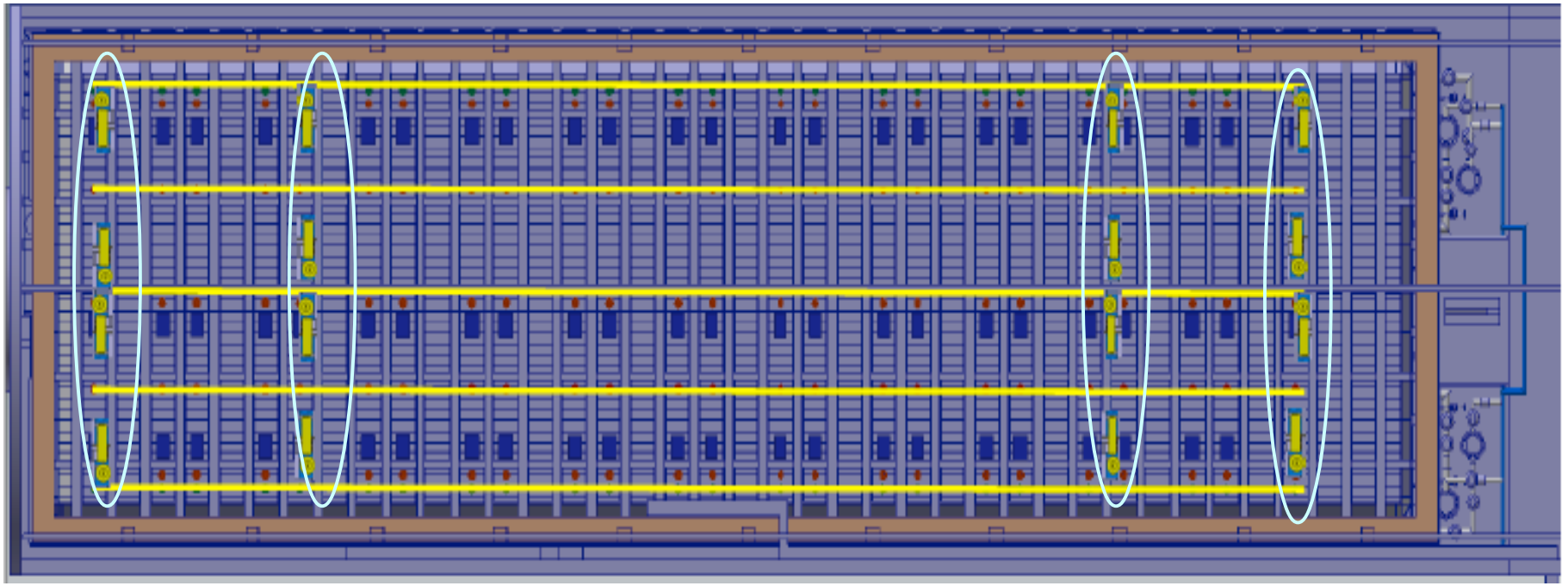
Laser System (Kendall's talk)

Developing a case for Laser:

- Alignment, timing, thermal contractions (or shifts) of support structures, debugging HV issues, disentangling noise/electronics failure/wire issues, stability monitoring, E-field map, energy calibration studies as feasible.

In parallel, understanding the FT needs if we go with this system:

- (Minimal) 16 FTs
- Working on even more minimal scoping and take advantage of spares/manholes etc.



Thanks to all those who have and are continuing to respond to our queries/concerns and are helping us move this forward!

Your input and effort is much appreciated.