Calibration Task Force (TF) Activities

Sowjanya Gollapinni (UTK)
Kendall Mahn (MSU)

DUNE Monthly Collaboration Call
October 6, 2017

Calibration TF meetings

- Calibration TF was formed around the time of the August Collaboration meeting
  - Conveners: Sowjanya (sgollapi@utk.edu) & Kendall (mahn@pa.msu.edu)
- We have started regular meetings, alternating weekly b/n
  - Thursdays 3 to 4 pm EDT
  - Tuesdays 9 to 10 am EDT
- Indico Page: https://indico.fnal.gov/category/703/
  - Indico: Under DUNE → Task Force Meetings → SP/DP Calibration
- A lot of productive discussions on a range of calibration topics happening, if you are a calibration enthusiast, you should attend!

TF charge: Long-term

- What are our calibration-driven physics requirements? What is the associated impact on Oscillation Physics?
  - a big first step here is understanding the physics requirements
  - No detailed ties (yet) exist between high-level physics requirements and knowledge of calibration parameters
- A calibration strategy and needed studies for the TDR timeline
  - Define sources of uncertainty and how to measure them?
  - Demonstrate a strategy to achieve necessary precision

Our Physics requirements are stringent and calibration is not the only source of uncertainty!

TF charge: Short-term

- Recommendations on Calibration hardware
  - Cryostat interfaces (only interfaces, not the actual designs) are being finalized, need to make decisions about cryostat interfaces for calibration
- Current focus of the TF
  - Understand needed calibration hardware from various sources
  - Goals of calibration devices: physics motivations, risk mitigation, stability monitoring, commissioning,…
  - Understand Feedthrough (FT) needs: No. of FTs, location and width of each FT

Lot of progress over the past few weeks: Converging on an amended proposal for FTs, iterating with TB and cryostat team

Cryostat Penetrations

- Calibration Task Force working closely with Slow Controls and Cryogenic Instrumentation Consortium to understand the overall design for the FTs
- We are also working closely with APA and HV consortia as needed

Instrumentation side

- Thermometers
- Purity Monitors
- Cameras

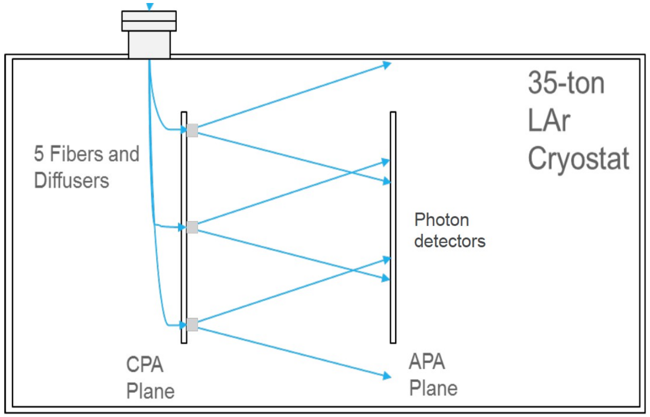
Calibration side

- Radioactive source
- Photon System
- Laser System
- Field Response

- Focused discussions held at TF meetings on all the above calibration devices (check out our meeting pages)

Calibration devices

- Radioactive Source calibration (Juergen, Kate, Bob, ...)
  - Energy scale calibration for low energy events
  - 58Ni-252Cf source (desirable) will emit 8-9 MeV gammas, in the right range
  - Source sits outside the Field cage and the produced gammas enter the active volume
  - More studies underway to better understand energy and position resolution needs
- Photon System Calibration (Ranjan, Zelimir, ...)
  - Verify photon gain monitoring and timing resolution; Monitor stability; Useful during commissioning and testing photon system
  - Light Diffusers on one side of first CPA and on two sides of the second CPA
  - Highly insulated optic fibers for HV signal
  - Each CPA side is split into 45 cells with optical fiber feeding into each cell.
  - Fiber is grouped together to reduce the number of overall FTs required



Laser System

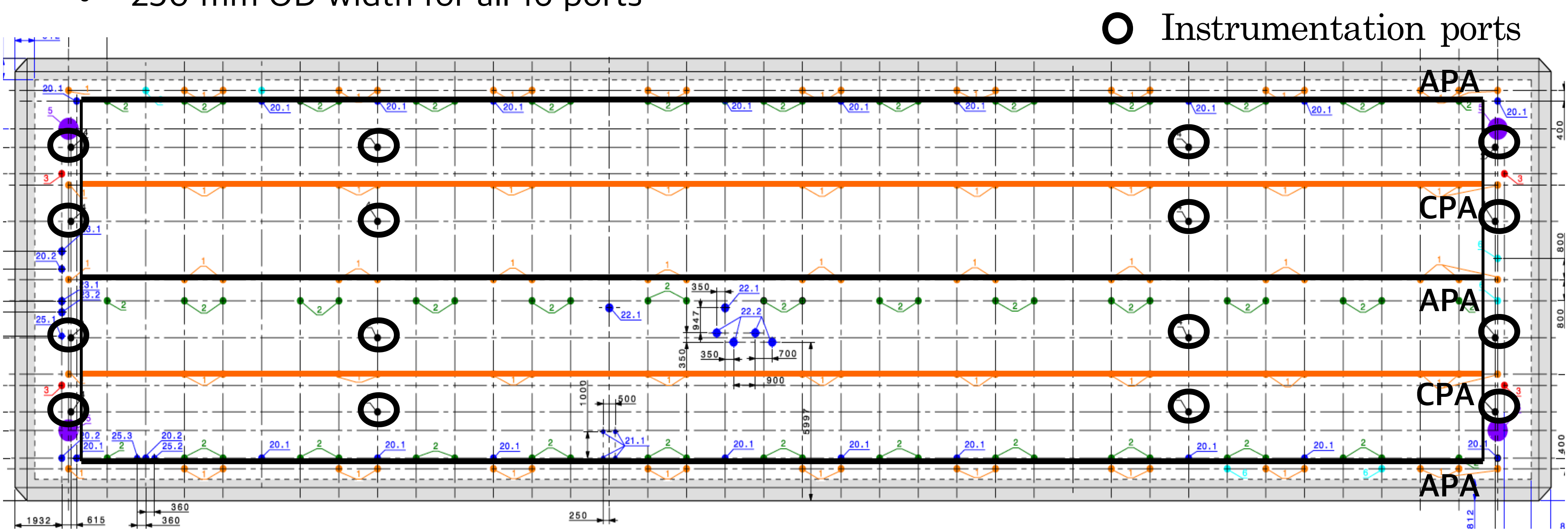
- Collating arguments and specific motivations for the Laser system relative to what will be feasible from other information (e.g. cosmics)
- Laser is motivated as a stability monitor, system for diagnosis (e.g. field cage resistor failure), & E-field map along with many other possible measurements
  - **Current analysis:** cosmics are an important tool, but cannot provide rapid measurements or sufficient spatial information given their rates
  - We currently have no system in the detector that can provide an independent probe for calibration. A laser system provides this with reduced or removed interdependencies thus mitigating risks.
  - Discussions ongoing, would like to launch short-term and long-term studies for this as soon as possible
- In parallel, defining FT scenarios/needs for Laser with uB/SBND reference design in mind

What do we have in our current FT design?
Confirm or request amendment to existing design

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
6	Ø250	6	Spare
7	2680x12110	1	Temporary Construction Opening

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	Ø304	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

- 16 instrumentation ports (see black circles in the image below)
- 250 mm OD width for all 16 ports



Optimizing FT needs

- If we require dedicated ports for all of our instrumentation and calibration, we will need about 3 times more ports than what we have in our current design (16 FTs)! – see backup
- After a discussion at the special TB meeting and cryostat team, iterating on the possibility of using other available ports: detector support (DSS), signal cable or cryogenic ports

The goal is to minimize the no. of penetrations on the cryostat as a general principle (to reduce heat leaks and such) and optimize FT needs from calibration and instrumentation side.

Input from Oct. 3rd meeting from Cryostat Team (from Technical Coordinator)

Status as of yesterday

System	New ports	From Oct. 3 meeting
Purity Monitors	-	Mount using cable tray (explore)
Thermometers (Dynamic T-Gradient)	-	Mount using cable tray (explore)
Static Thermometers	-	Cryogenic, DSS ports (mount using cable tray?)
Photon gain monitoring	-	DSS ports on top of CPAs
Field response calibration	-	DSS or Cryogenic ports
Radio active source	18 to 20 ports (need to understand how to spread/share)	Multi-purpose, share
Cameras		Multi-purpose, share
Laser system		Multi-purpose, share

See backup for an illustration of the proposed 18 (Option A) and 20 (Option B) FT scenarios. The discussions on this have just started.

Next Steps

- Finalizing FT needs remains a priority over the next month
- In parallel, would like to
  - Start discussions/studies to better understand physics requirements
  - Define short and long-term studies for each calibration source (cosmics, laser, space charge,...) – we want to start quantifying things!
- DUNE Physics Week in November, a great venue to do this
  - Will define a specific set of tasks and identify contact points to lead the studies. Agenda coming up soon...
  - Will join hands with reco/sim conveners to prepare the needed samples and find people power to do the studies

There is a lot that needs to be done, we can use all the help we can get, so, please join our effort and contribute!

Subscribe to the Calibration Task Force:

DUNE-CALIBRATION-TF

Backup

Cosmics and other sources of muons

- ***Overall cosmic rate:*** 4000 per day per 10 kt module
  - https://indico.fnal.gov/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=14909 (Vitaly)
  - Stopping muons: 30/d/10kt, APA-CPA crossing tracks 200-500/d/10kt
  - Limited angular coverage: No muons at zenith angles >75 degrees
  - Roughly, each collection plane wire is hit only every 2-3 days **at best** (assuming 100% efficiency and no geometry considerations)
- ***Beam induced rock muons:*** 1 - 3/d/10kt
- ***Atmospheric neutrinos:*** ICARUS saw 0.3 ν per day (476 ton active volume), implies 7/d/10kt for DUNE. Also muons from atm ν - rock interactions.
  - typically lower energy, multiple Coulomb scattering effects dominate

Local Setup @BNL

Illuminate Au-photocathode with precise scan of electron locations

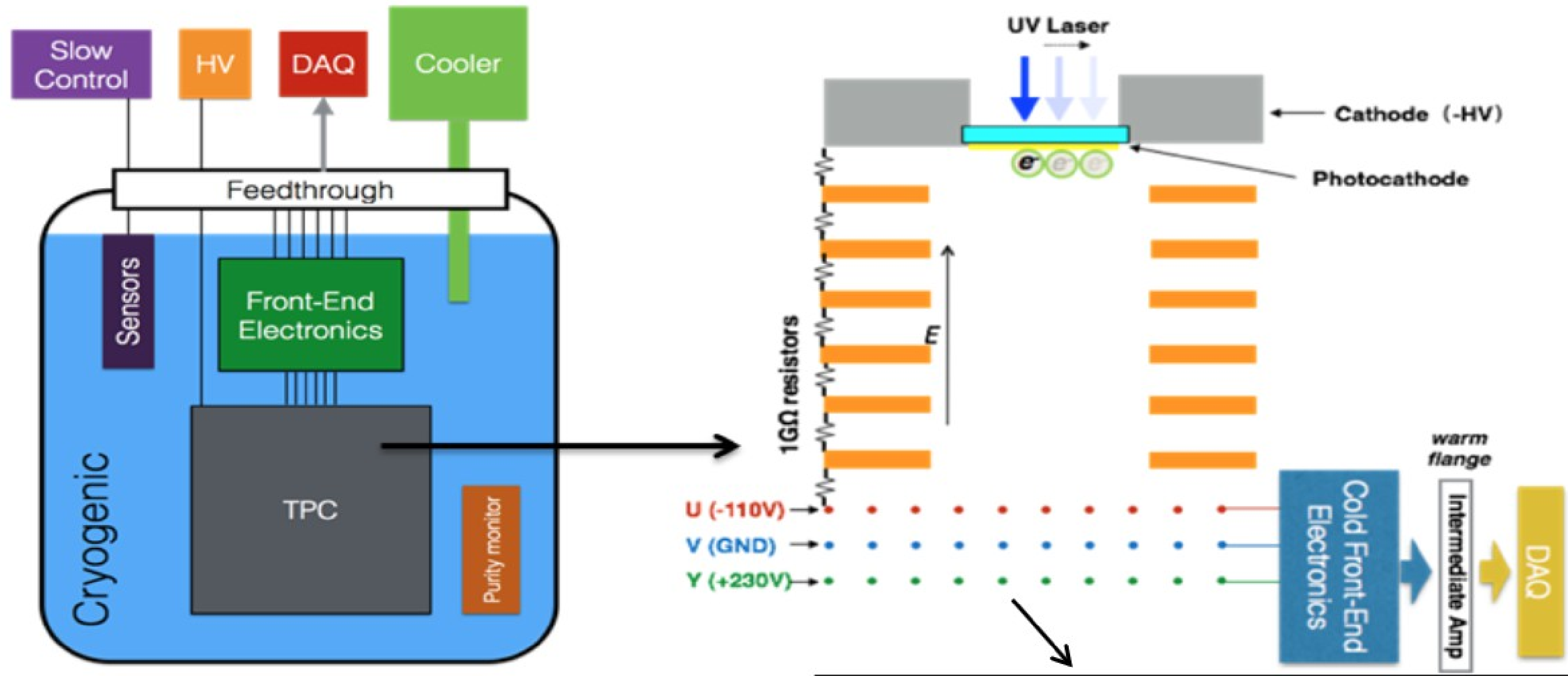


Figure 6. Schematic of the liquid argon field calibration system (LArFCS).

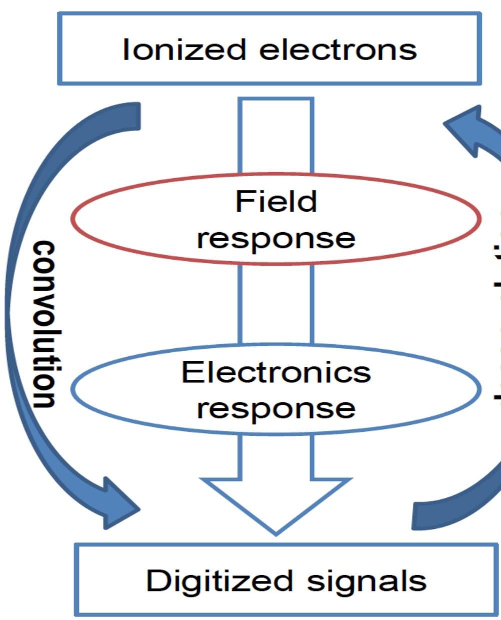
Reproduce MicroBooNE and DUNE wire patterns and configurations

- Sub systems: Cryogenic, TPC, Laser, Front-end electronics, DAQ, etc.
- Goal: precisely measure field response function versus position, compare with 2D and 3D simulations such as Garfield and BEM

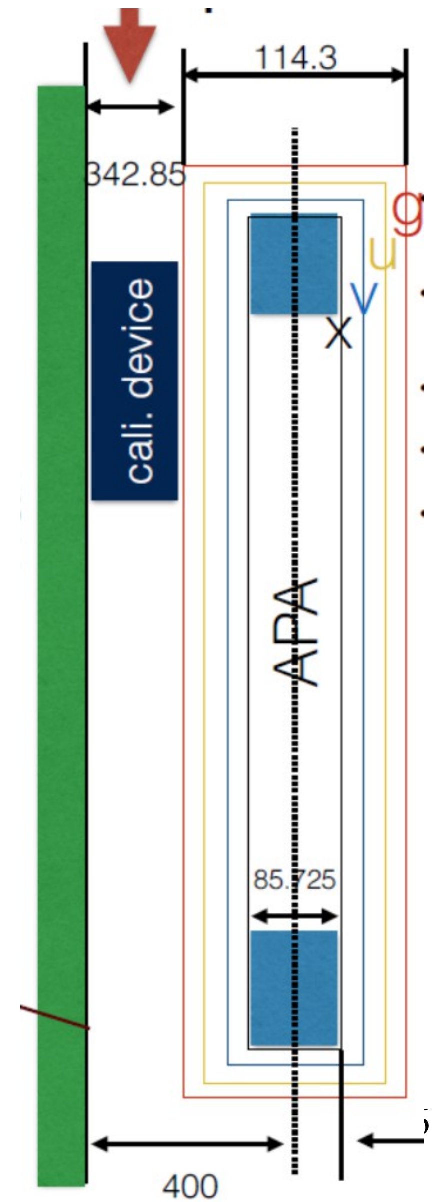
Field Response Calibration

(contact points: Chao, Yichen)

- https://indico.fnal.gov/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=15234
- Motivation
  - Induction plane signals significantly depend on field response due to their bipolar nature of the signal
  - Current field response based on simulation; proposal to directly measure field response at BNL test stand
  - With DUNE, want to preserve the option to do in-situ field response calibration



- The device will sit in the space b/n outer APA and the cryostat side wall
- Would like FT as close as possible but limited by the GTT membrane feature of the cryostat
- Also limited by the clearance on top of the proposed location of the device



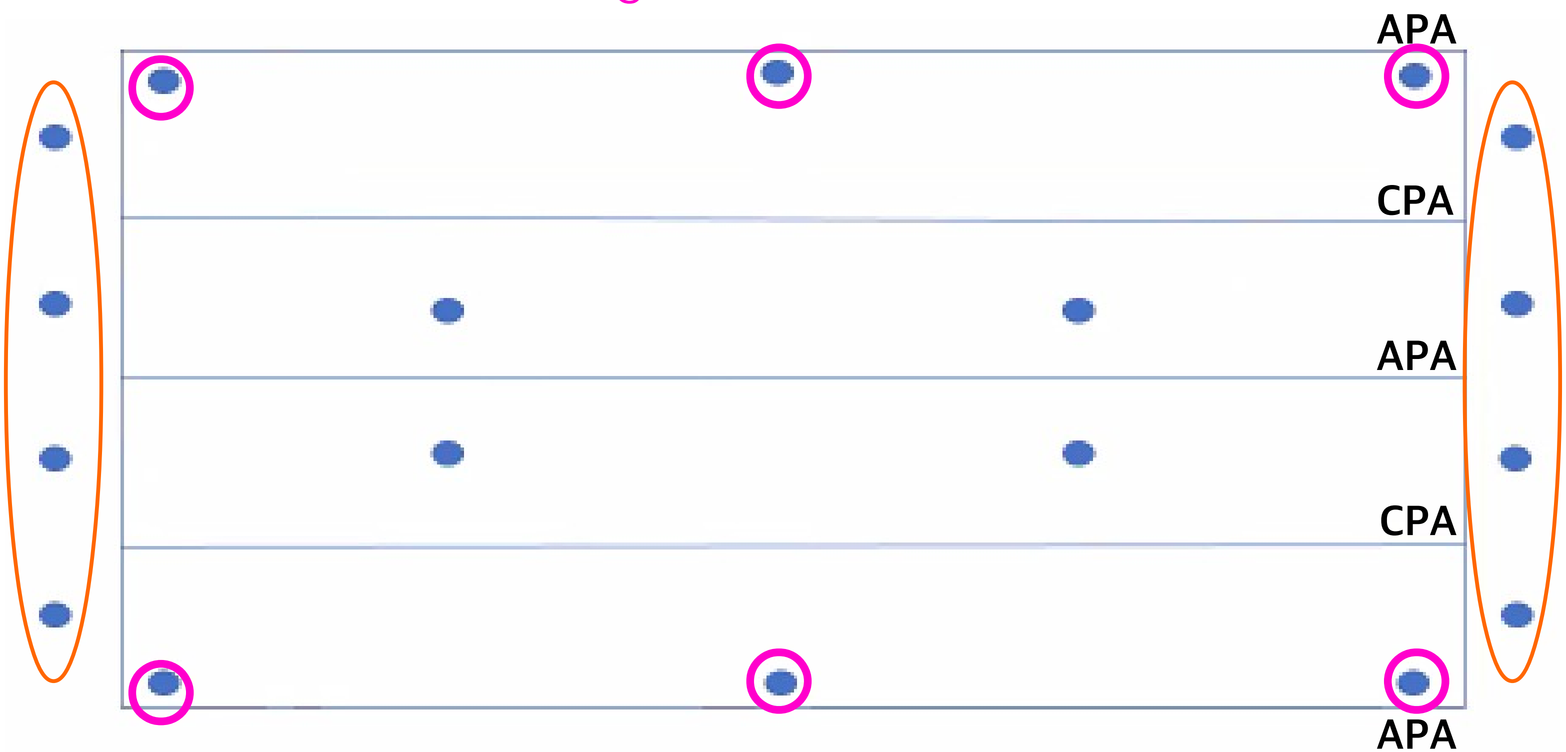
FT request summary

System	Required FT width (minimum)	No. of ports requested
Purity Monitors	160 mm ID	2
Thermometers (Dynamic T-Gradient)	150 mm ID	2
Radio active source and Static Thermometers (Shared)	280 mm ID	4
Cameras	180 mm ID	12
Photon gain monitoring	154 mm ID (5 FTs) 254 mm ID (5 FTs)	10
Field response calibration	200 mm ID	2
Laser system	200 mm ID	20
	Total new requests	**52**
Existing ports Radioactive source Calibration (increase size for 4 inner FTs)	200 mm ID (4 outer FTs) 280 mm ID (4 inner FTs)	16
	Total ports (existing+new)	**68**

Scenario 1: 18 port arrangement for Radioactive, Cameras & Laser

The ones circled in pink – less flexibility to move due to constraints in those regions

Outside the Field Cage (Radioactive source & Cameras)

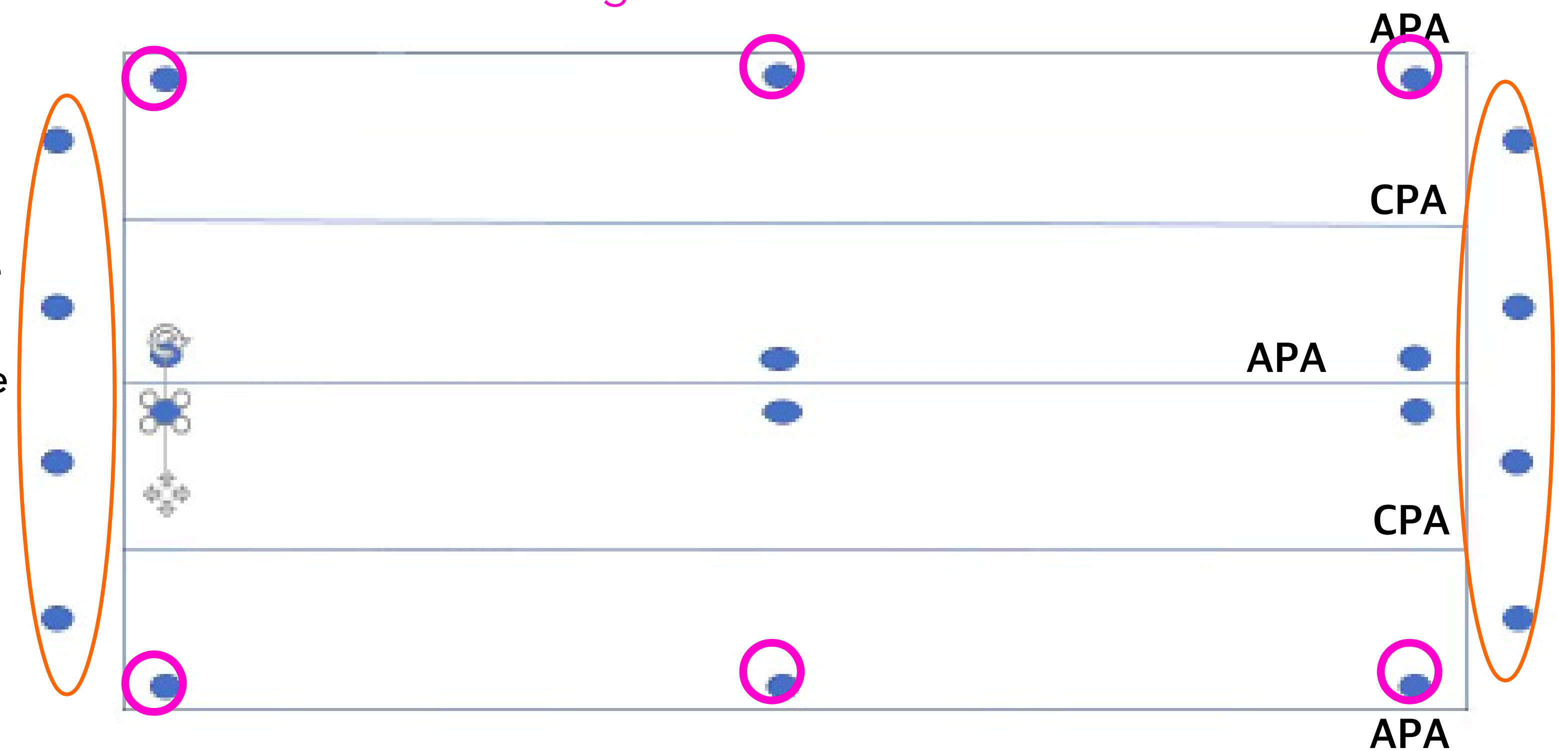


Outside the Field Cage (Radioactive source & Cameras)

- Four ports in the central region, not close to APA
  - – is that an issue for laser being at 60% of drift close to CPA?

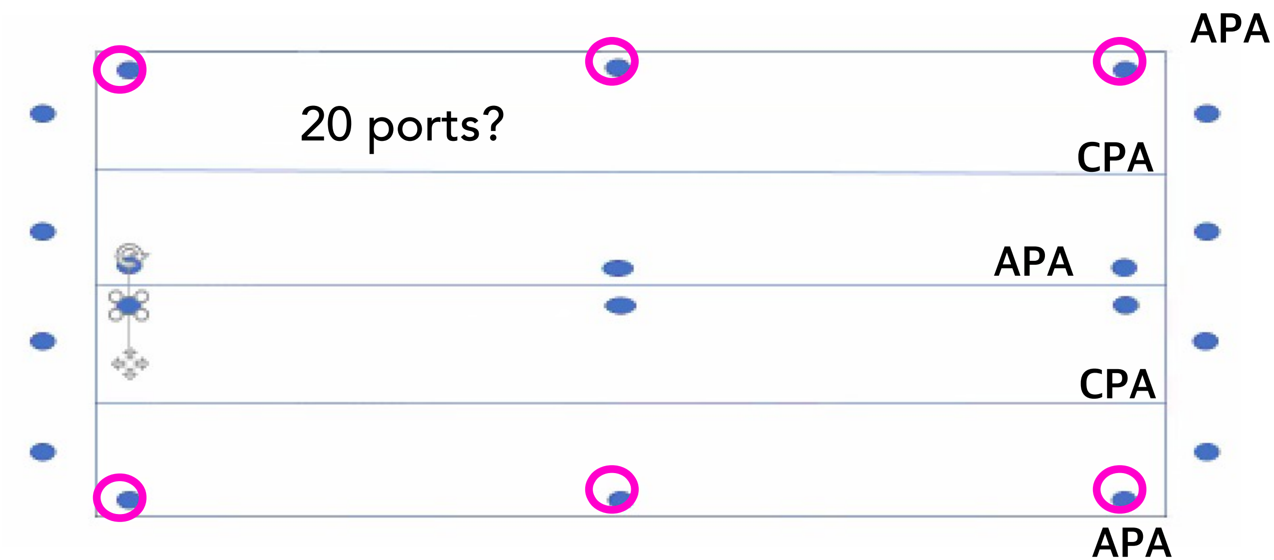
Scenario 2: 20 port arrangement for Radioactive, Cameras & Laser

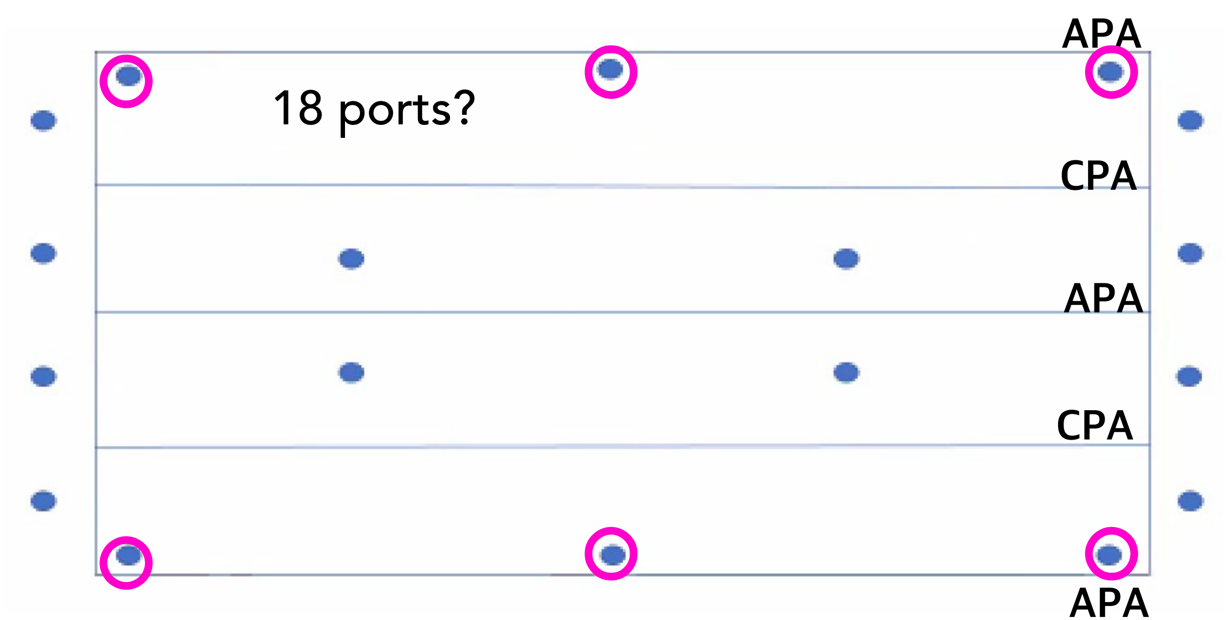
The ones circled in pink – less flexibility to move due to constraints in those regions



- This arrangement moves the ports very close to APAs as needed for laser
  - Radioactive source wanted mid-drift. Is that an issue?
- Sampling reduced in Z – one data point for radioactive source

Main question: How to arrange the 4 or 6 ports in the central region?





Laser has a lot on the flange, so this could mean

- So, we maybe looking at using cameras/radioactive source during commissioning as needed
- Then Laser takes over these shared ports after that? (except for the ones outside the FC)

Is this reasonable?