Calibration / HV interfaces

Bo Yu, José Maneira, Sowjanya Gollapinni, Kendall Mahn

DUNE Installation Meeting

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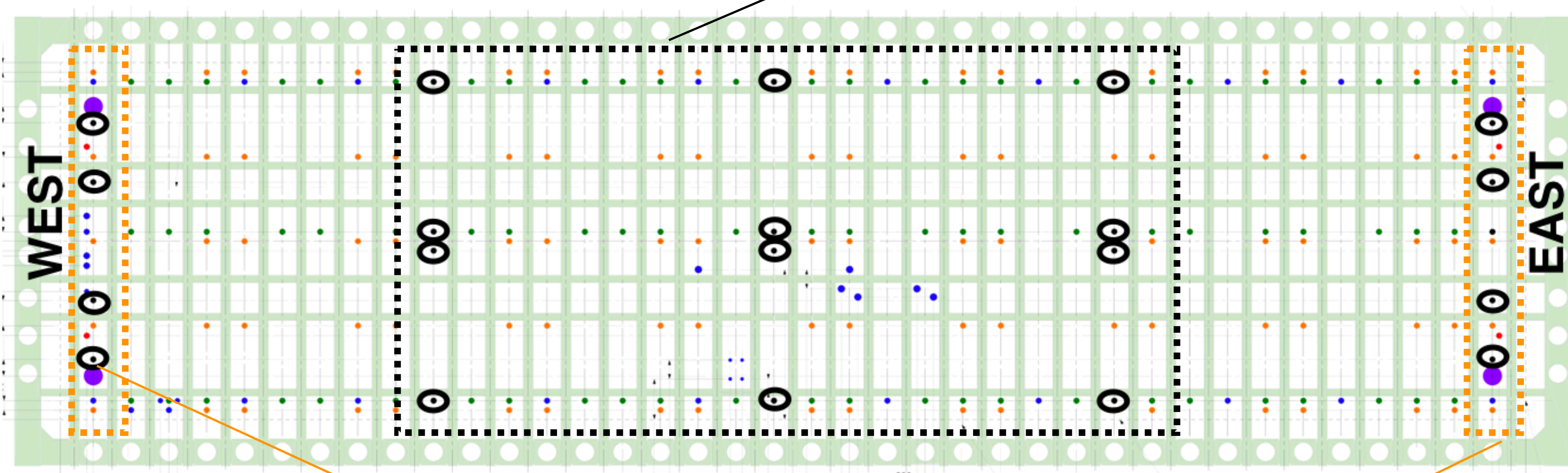
LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS

Summary

- Main reference: interface documents
  - DocDB 7066
  - EDMS: https://edms.cern.ch/document/2145142
- Calibration systems with HV interfaces:
  - ionization laser periscopes (holes in FC)
  - laser beam location system (attached to FC)
  - photoelectron laser system (targets on CPA)
  - radioactive source deployment system (moving close to FC)
- Calibration systems with **no** HV interfaces
  - pulsed neutron source

Laser Ionization System

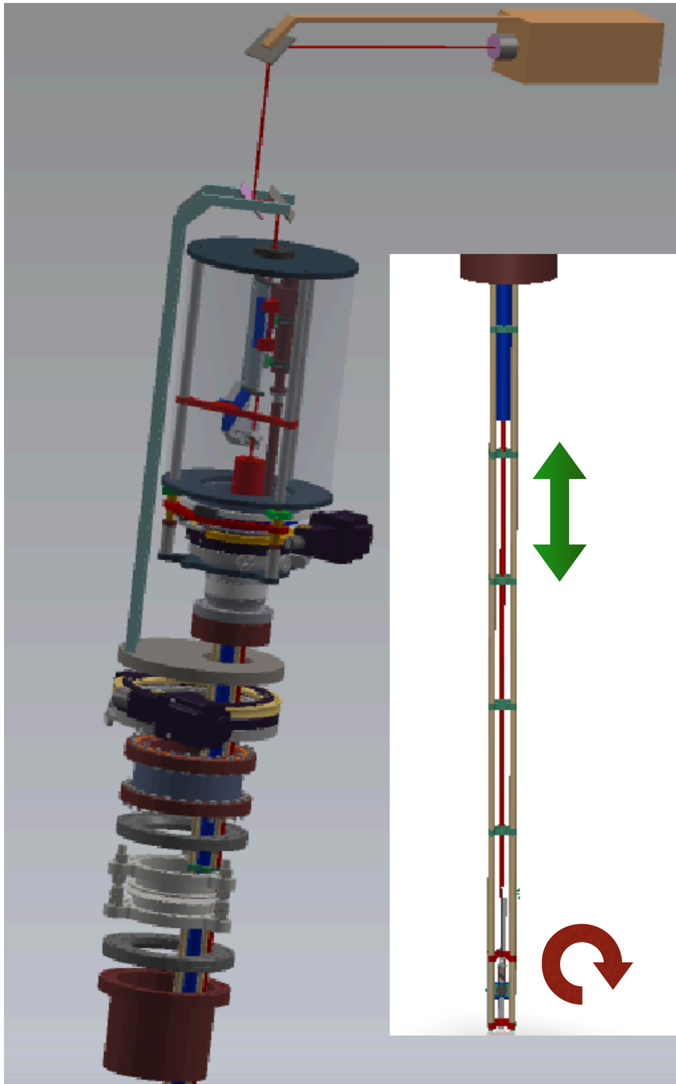
Baseline
Design 1 (SBND design)
FC penetration

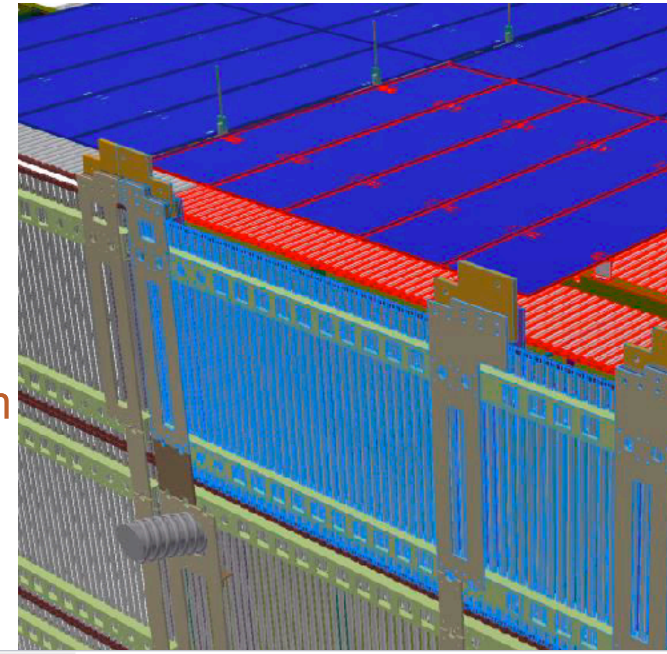


Alternative
Design 2 (eccentric dual-rotary system,
developed from the SBND design);
No FC penetration

Alternative for end-walls

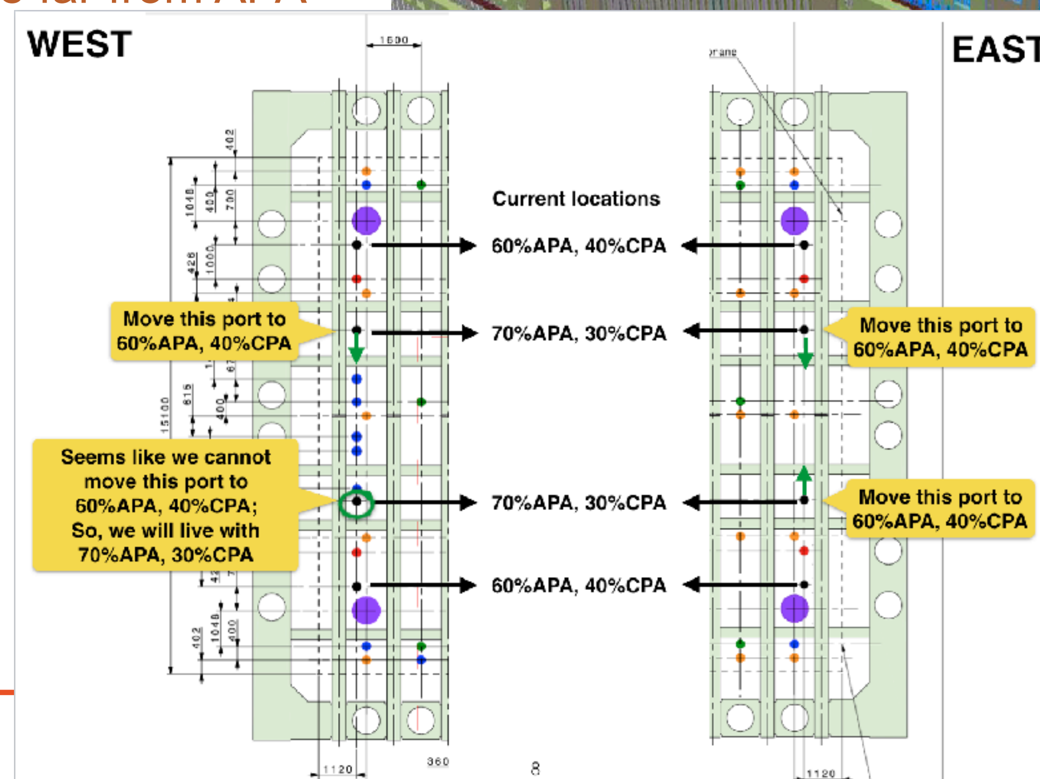
Dual rotary system adds a degree of freedom and solves low coverage due to FC shadows.





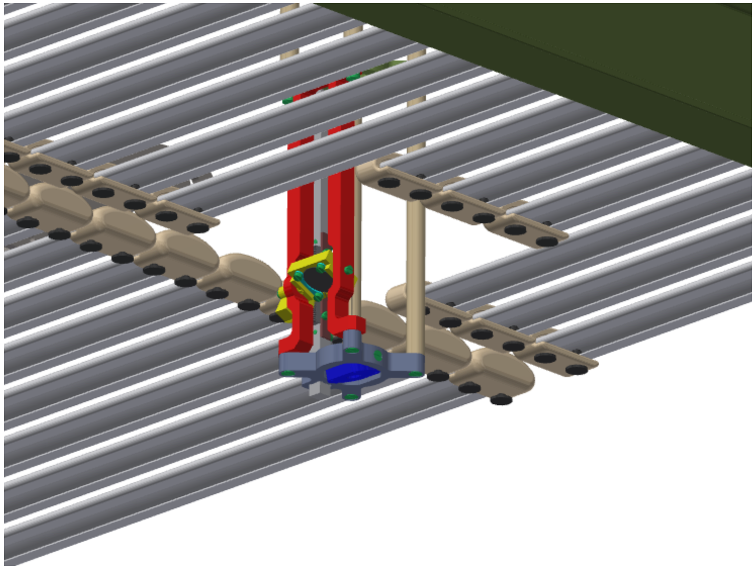
Outside FC, about 40 cm away in z

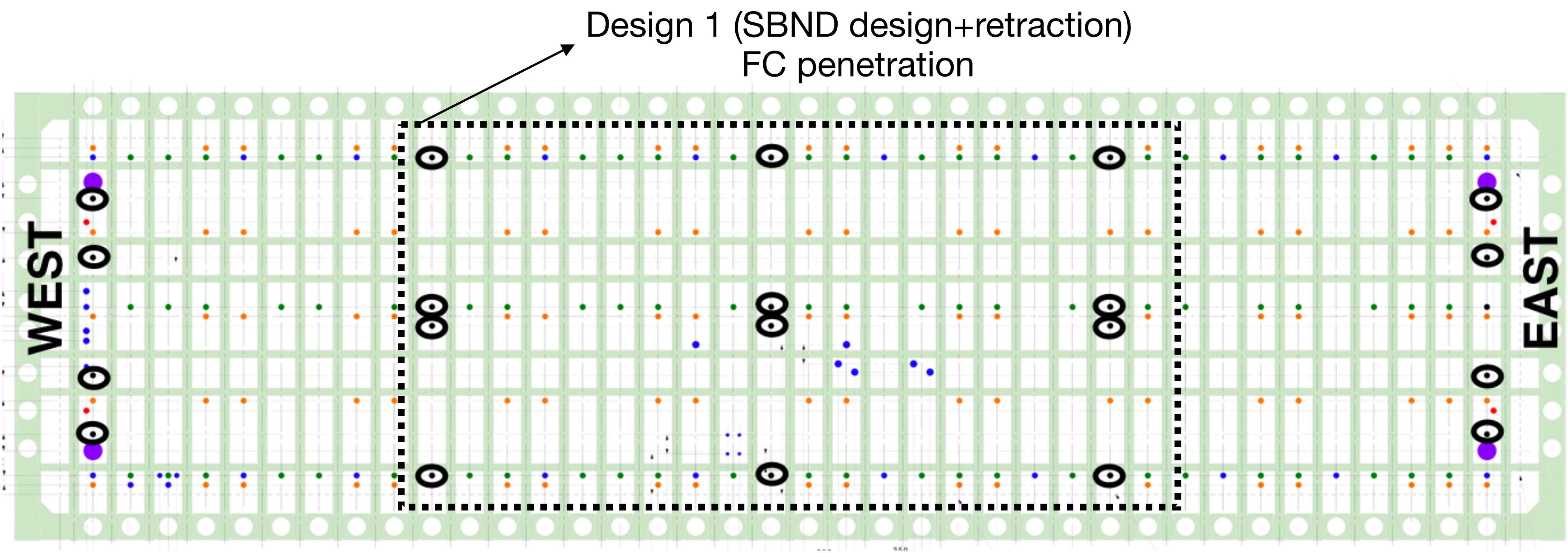
HV less of an issue, but need to check, because they are far from APA



Laser Ionization System

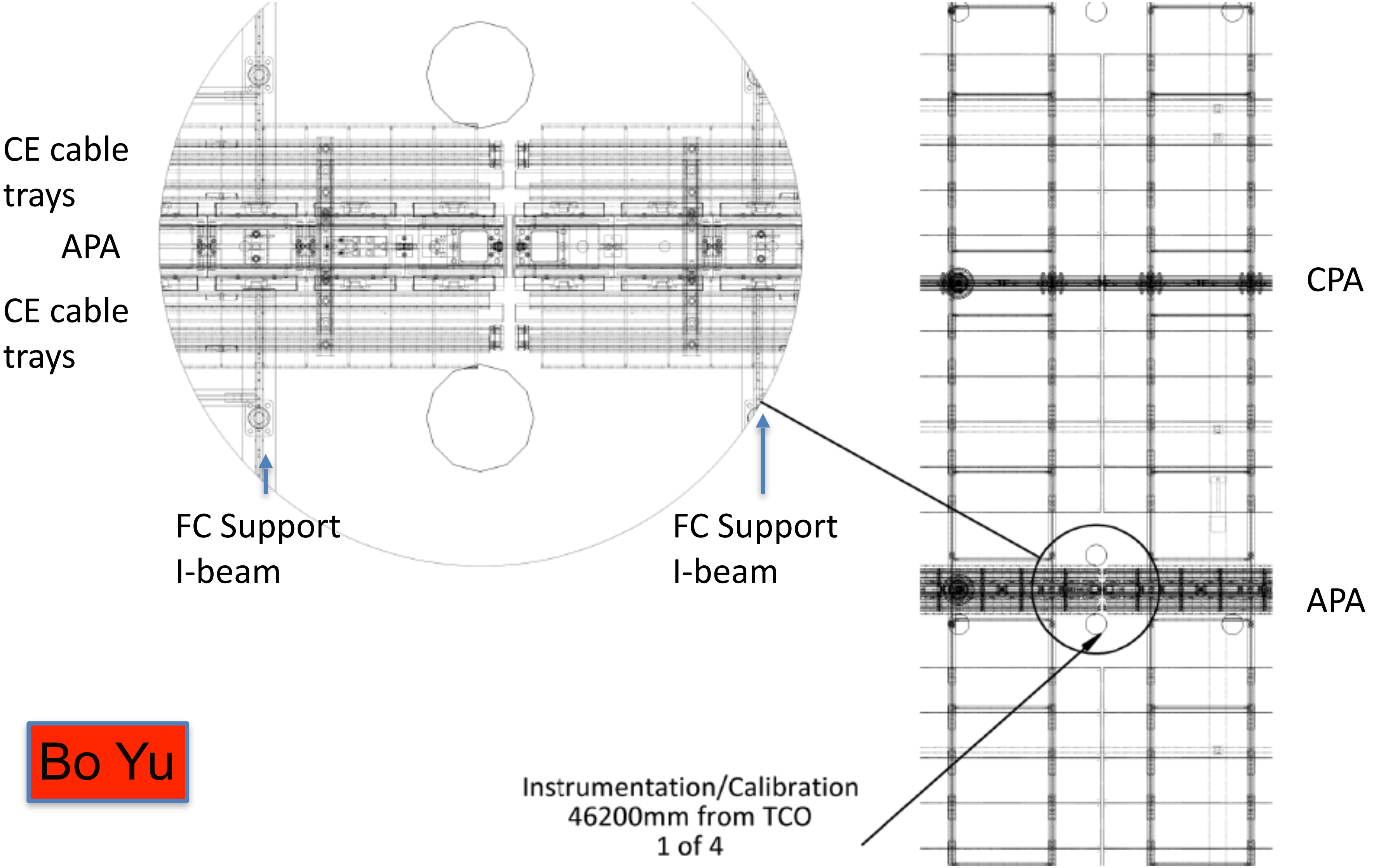
- 12 periscopes, entering field cage
- non-conducting material: PAI plastic, quartz mirrors





LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS many slides from Bo Yu following

Laser Point Position 1



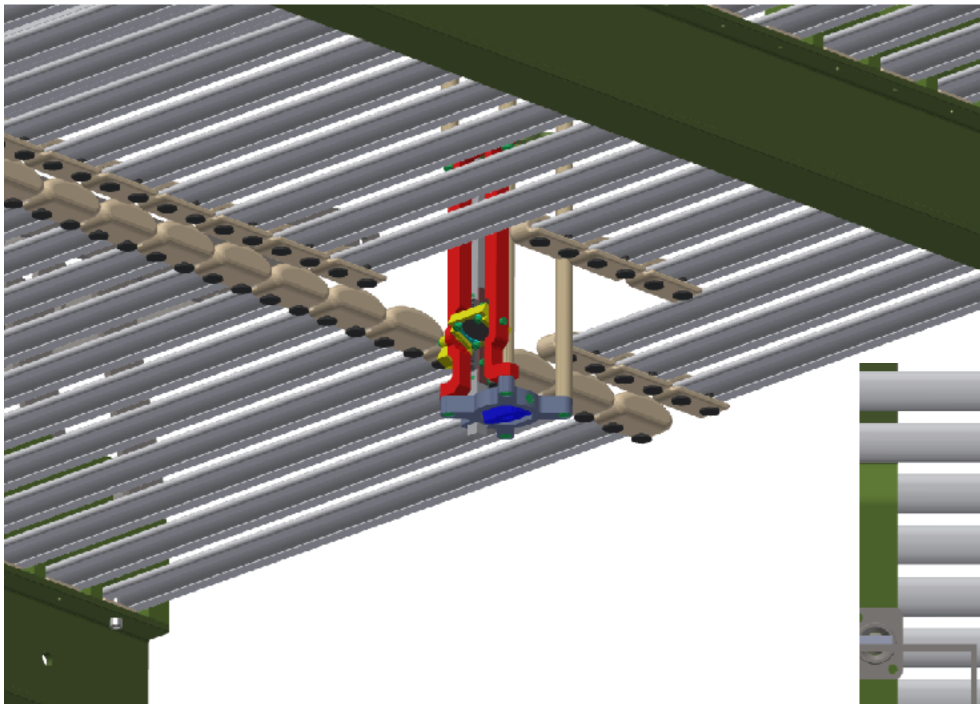
Bo Yu

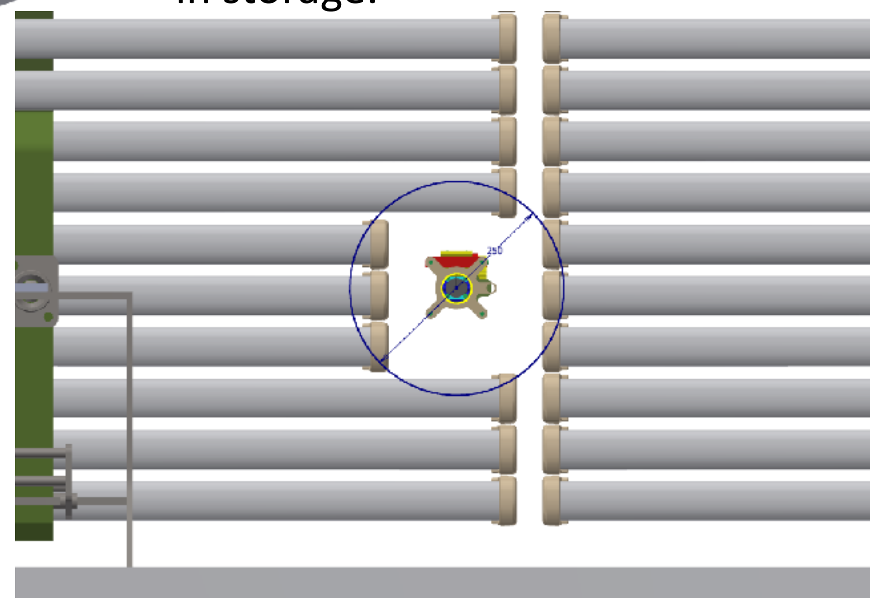
https://edms.cern.ch/file/2060543/1/Detector_Views_Center_2060543.pdf

Laser Point Position 1

This is the easiest location to create an opening in the FC: simple shortening a few profiles on one side of the field cage module. No other changes are needed.

We are planning to assemble all FC modules underground. A special set of FC profiles with non-standard lengths will fabricated by the "factory" and shipped to SURF. These special modules will be clearly marked in storage.





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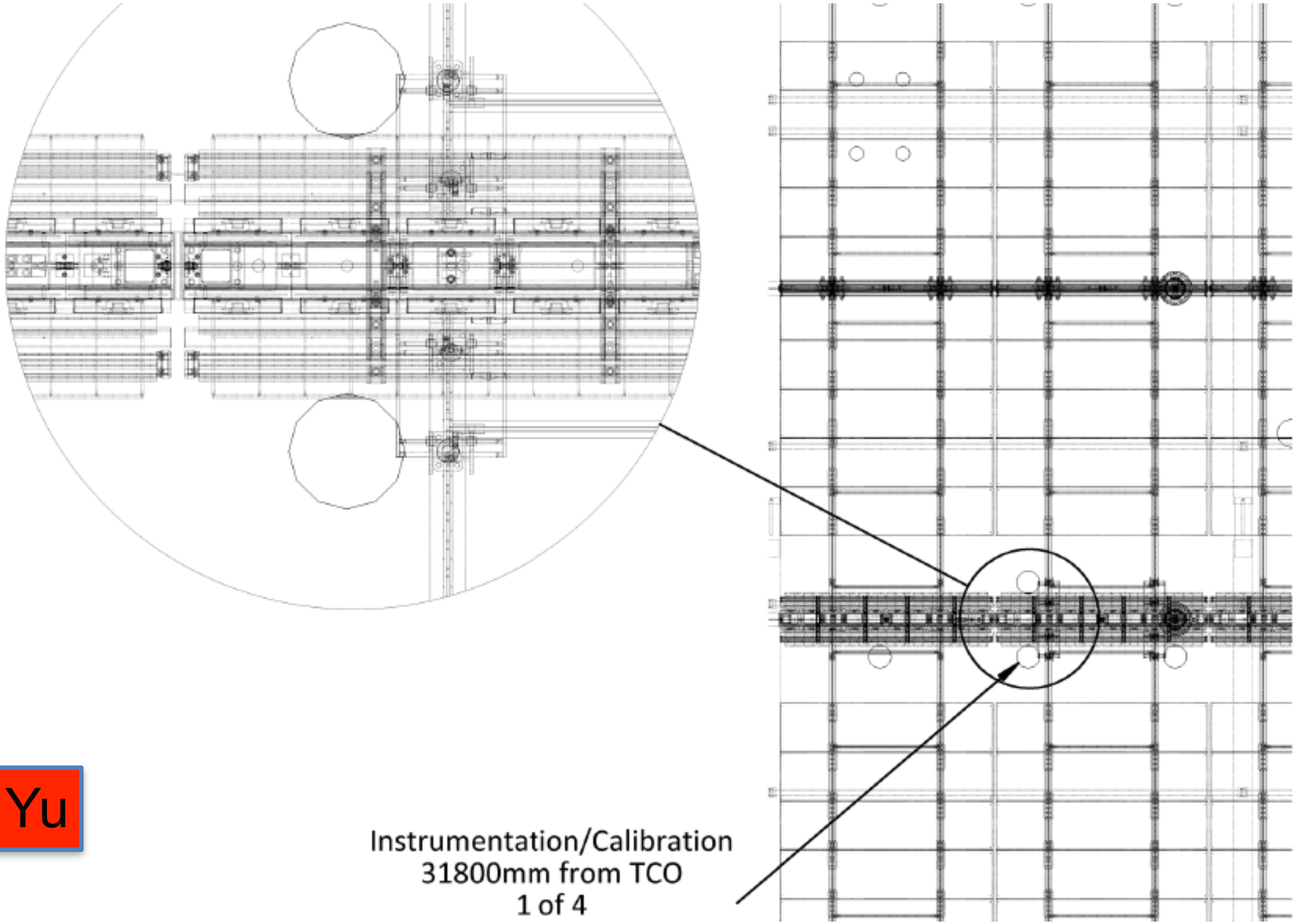
Laser Point Position 2



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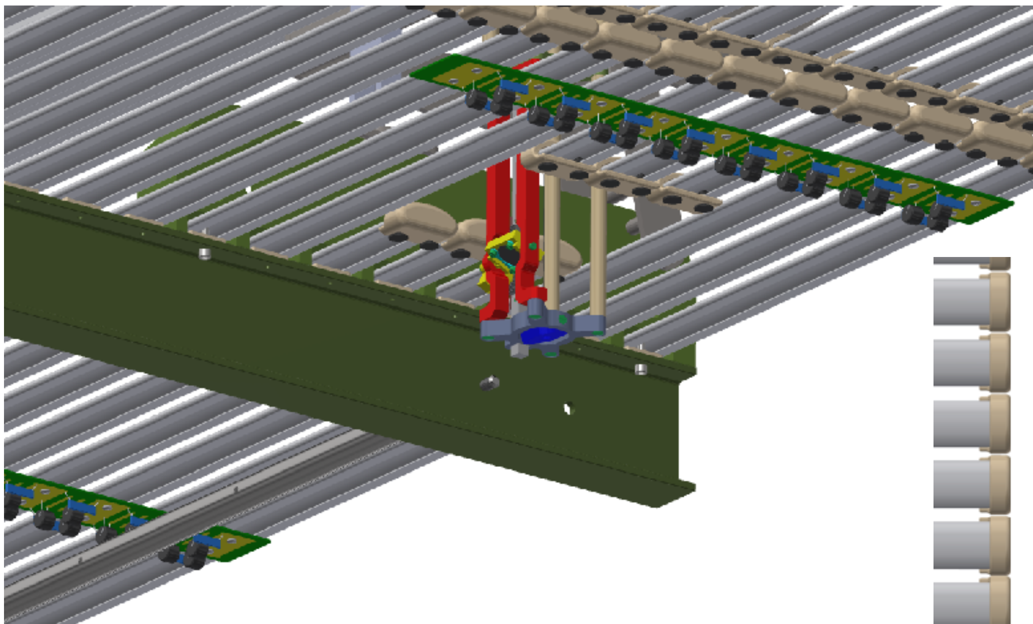
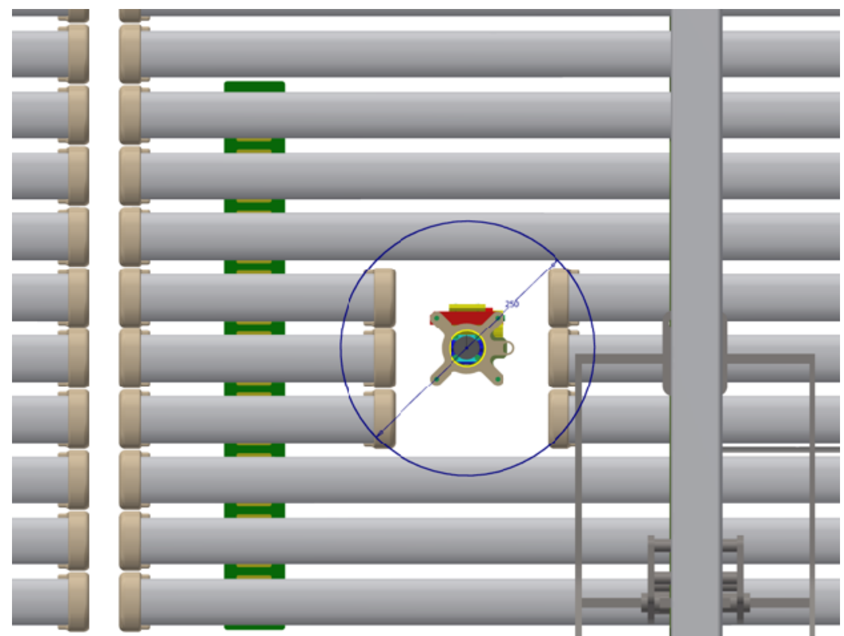
https://edms.cern.ch/file/2060543/1/Detector_Views_Center_2060543.pdf

Laser Point Position 2

Cut the profiles on FC module into a long, and a short sections. The long pieces are mounted on the I-beams as usually. The short pieces are supported locally by the uncut profiles. In fact, a special R divider board could be used for both the mechanical support and electrical connections. This divider, and the one it is connected to in parallel must have double per tap resistance. No change to the neighboring module.



Compared to a standard module, this type will have a slight cost increase in M&S and labor.



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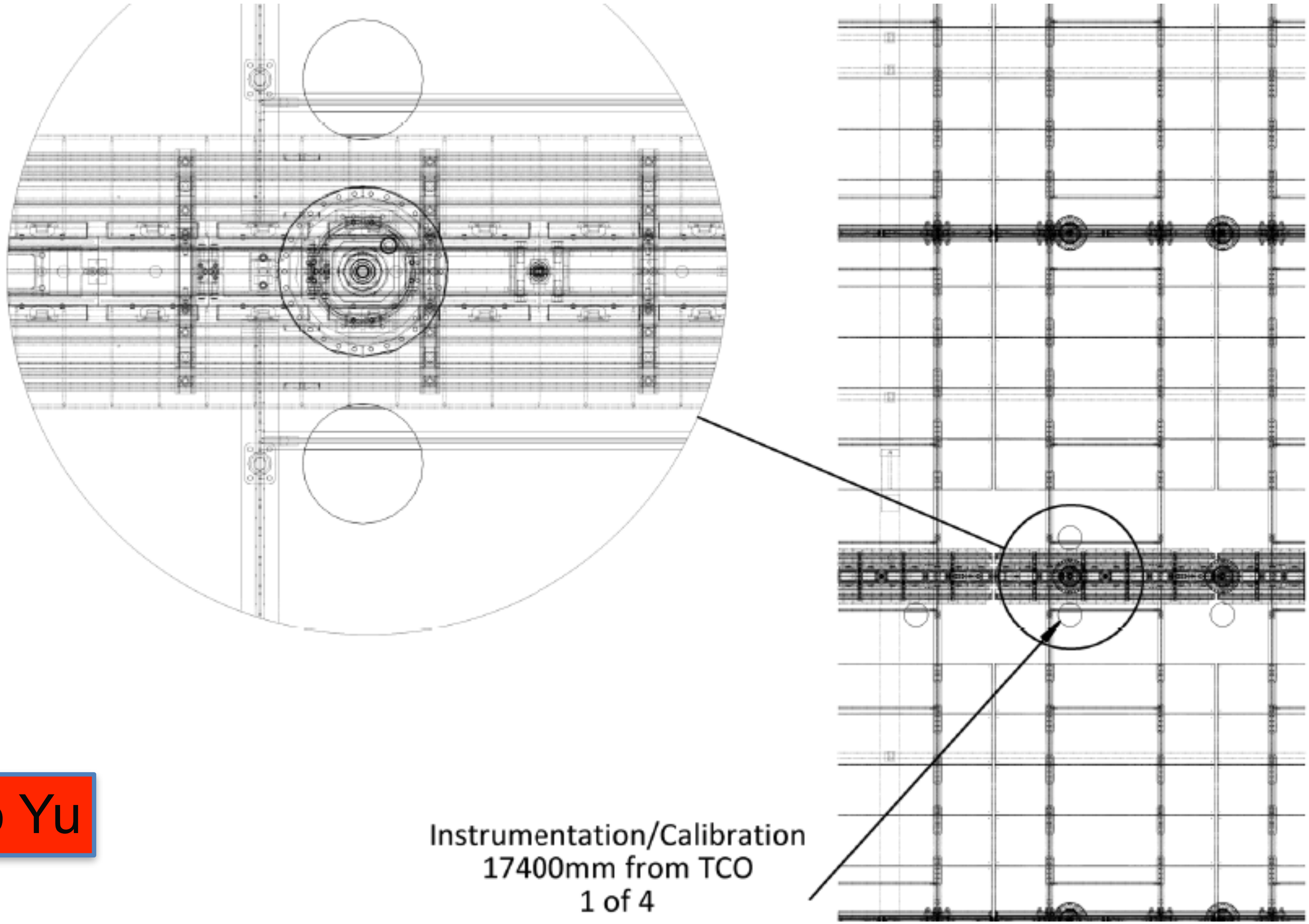
Laser Point Position 3



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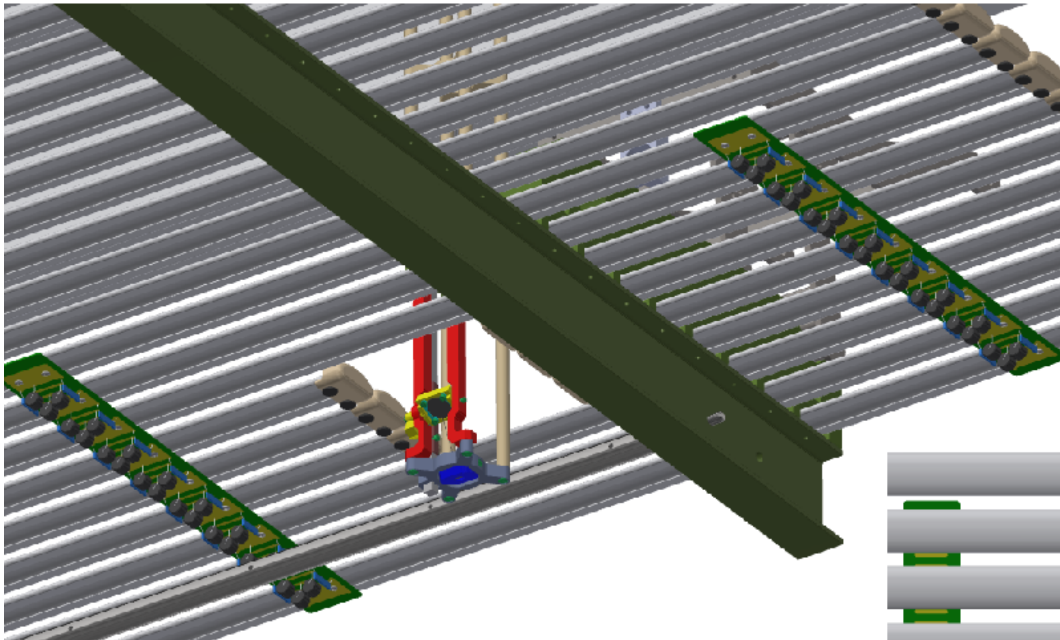
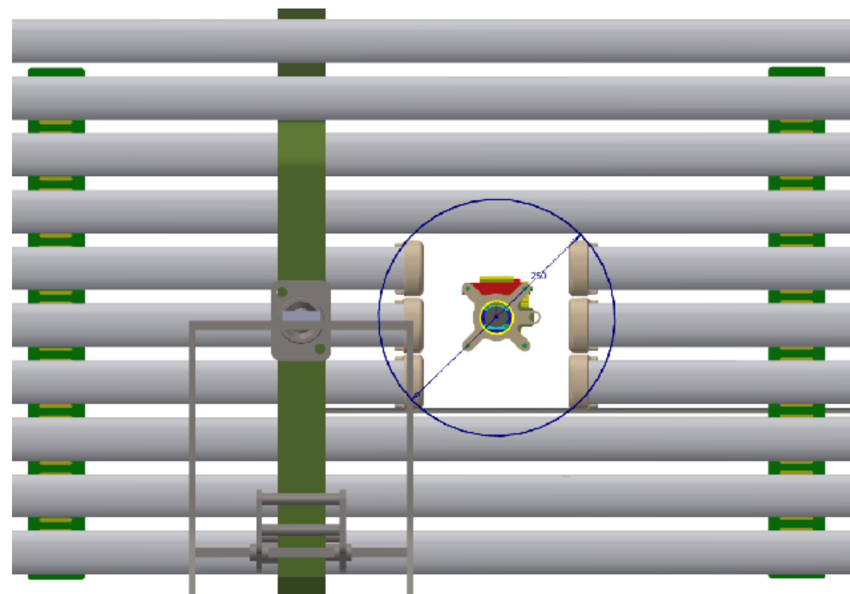
https://edms.cern.ch/file/2060543/1/Detector_Views_Center_2060543.pdf

Laser Point Position 3

Cut the profiles on FC module into two sections. Both sections are mounted on one I-beam, and stabilized by special double value R divider boards.



A small cost increase similar to the previous design is expected.



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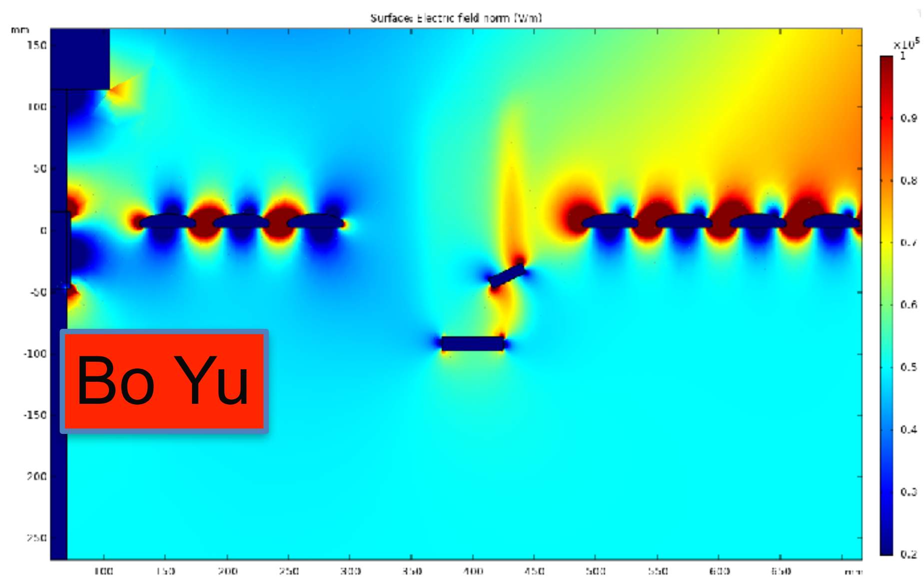
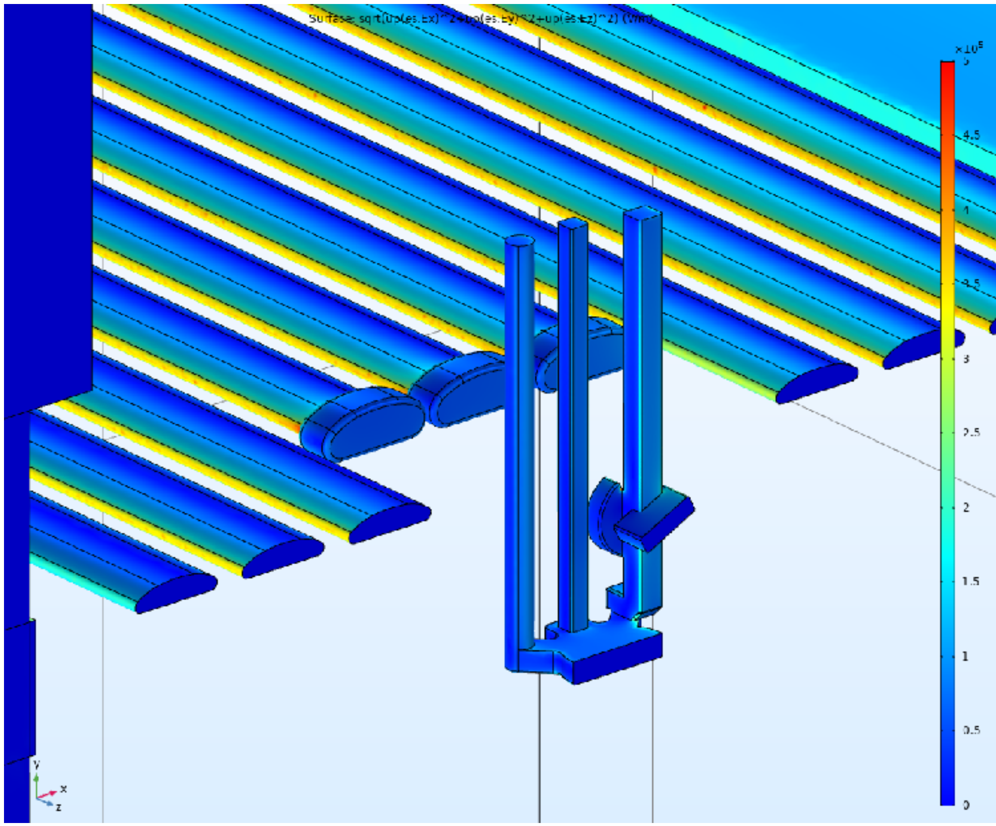
E Field Around the FC Opening

The bias voltages around the FC opening is about -15kV, 10% of the cathode voltage.
There is no indication of high surface E field on the FC or on the laser head.
There is some change of E field in the active volume in the vicinity (within 1-2 cm) of the laser head structure.

E field map on the symmetry plane through the opening



Surface E field plot. All insulating surfaces charged up.

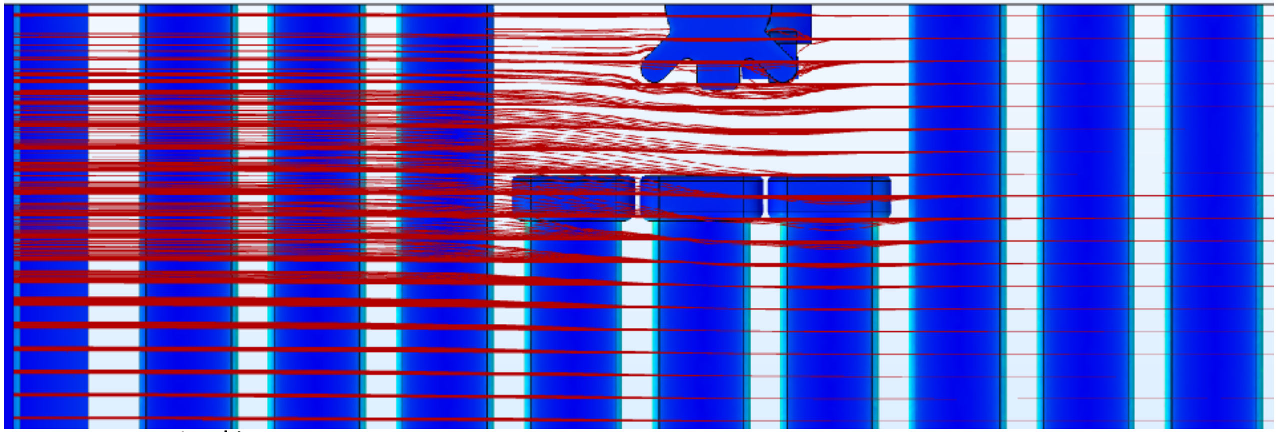


Impact on Electron Drift

The opening in the FC does introduce some distortion to the drift field nearby.

The max. distortion in drift lines is about 1.5cm.

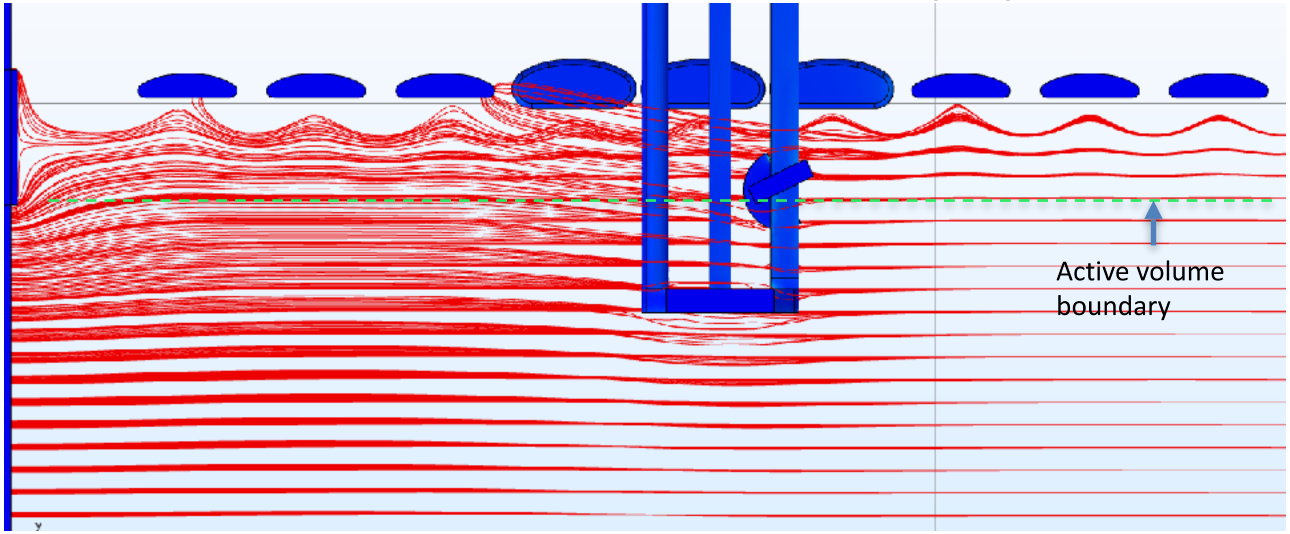
Although the distortion is local, all upstream events must pass through this region and therefore their arrival positions are affected.



APA

CPA ->

Looking along beam



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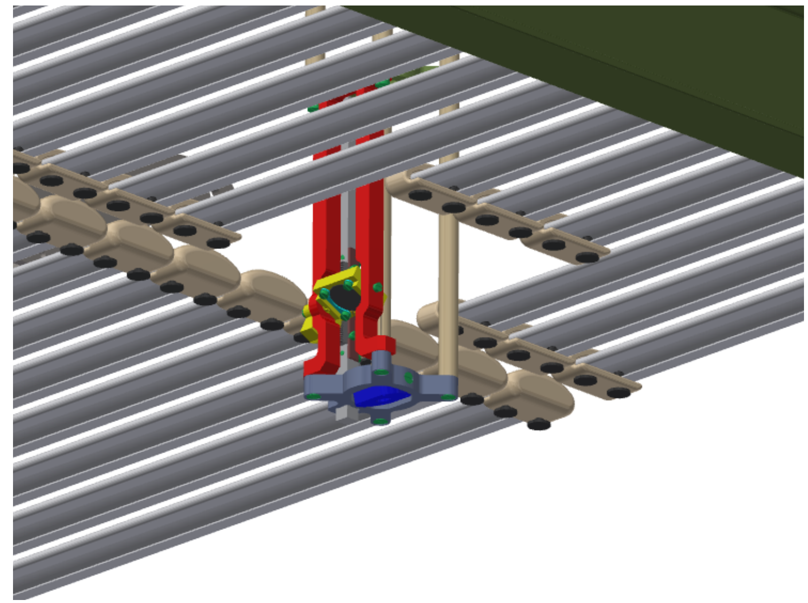
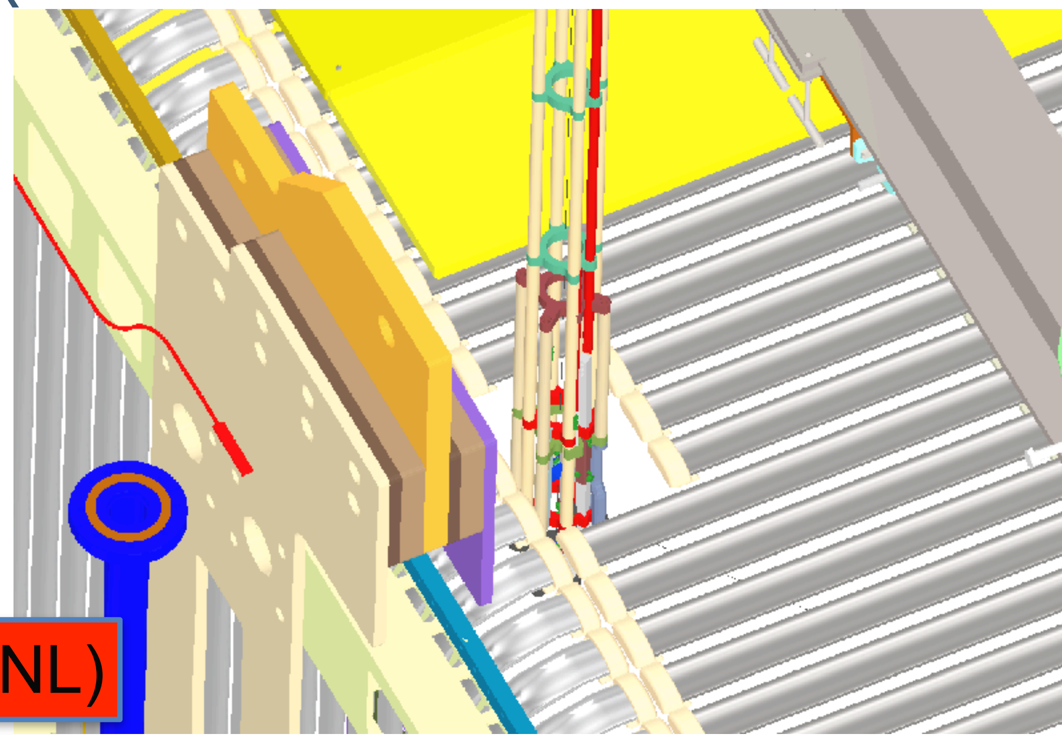
Laser Ionization System
Open issues



- **How much can we enter into the FC ? 10, 20 cm ?**
  - **this is possibly just a matter of how much fiducial volume we are willing to sacrifice**
- **We are studying a retraction option. How much clearance above the FC is deemed safe ?**

ProtoDUNE-II SP plans

- All must be tested in ProtoDUNE, so aiming to install baseline and alternative systems
- The distance from the FC opening to APA will be larger that DUNE, FD, so it's a more conservative test
- Many interferences to check
  - ground plane
  - curved profiles
  - DSS supports
  - new TPC position…



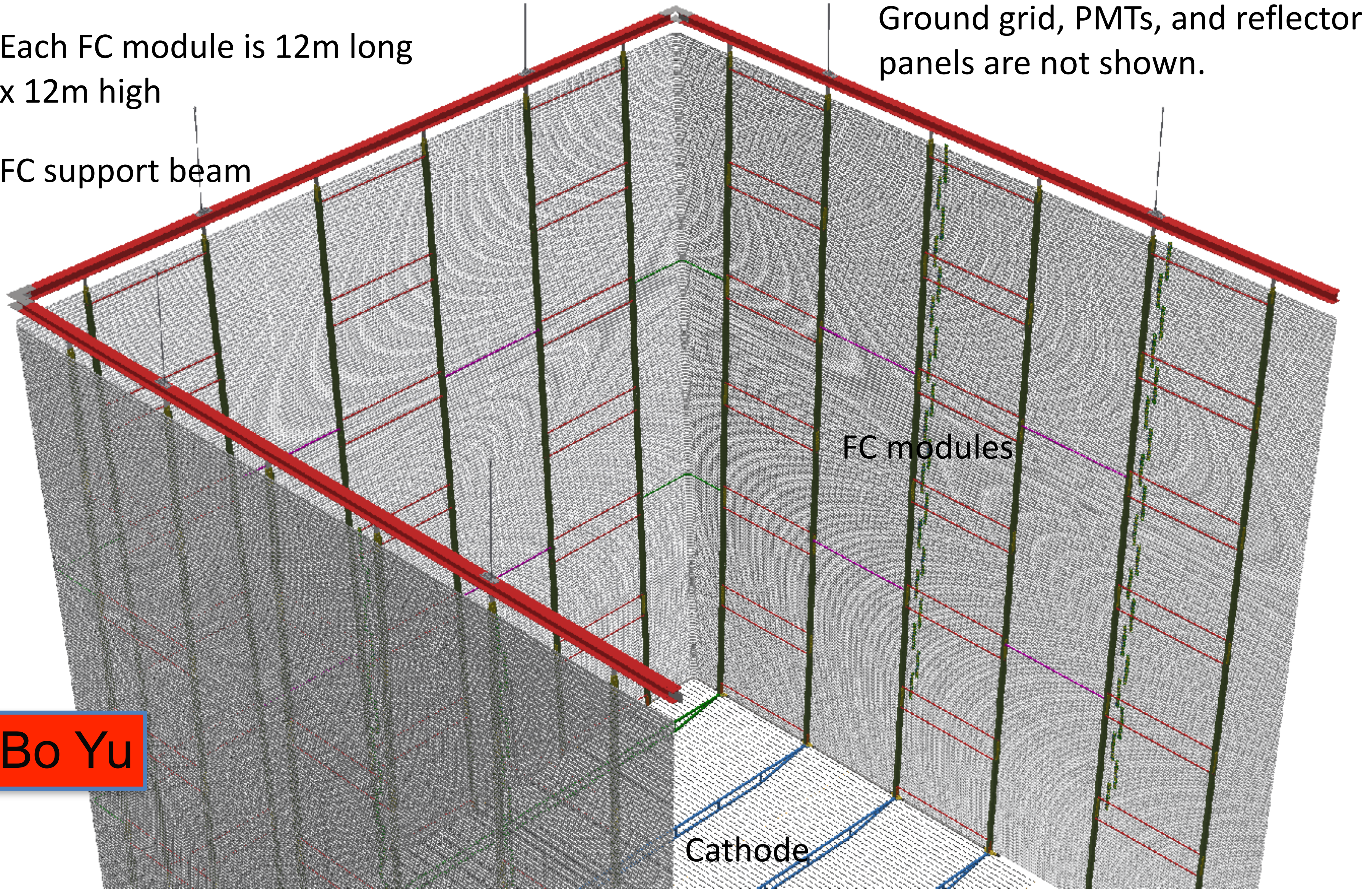
Jan Boissevain (LANL)

DUNE DP

- Unlike the SP FD, the DP FD is expected to have significant space charge effect from the ionizations of Ar39, accumulated by the 12m drift, and the electron multiplication in the LEMs
- Calibration lasers are more important in the DP FD to map out the E field in the entire active volume.
- It is easier to introduce laser heads inside the TPC in the DP: the top of the TPC is at low voltage, and we have designed a large clearance ~15cm from the inside of the FC profiles to the CRP's active aperture along the two long walls of the TPC.
- However, the PMTs and WLS panels are facing the laser beams.

Bo Yu

The HVS at One End of a DP Module

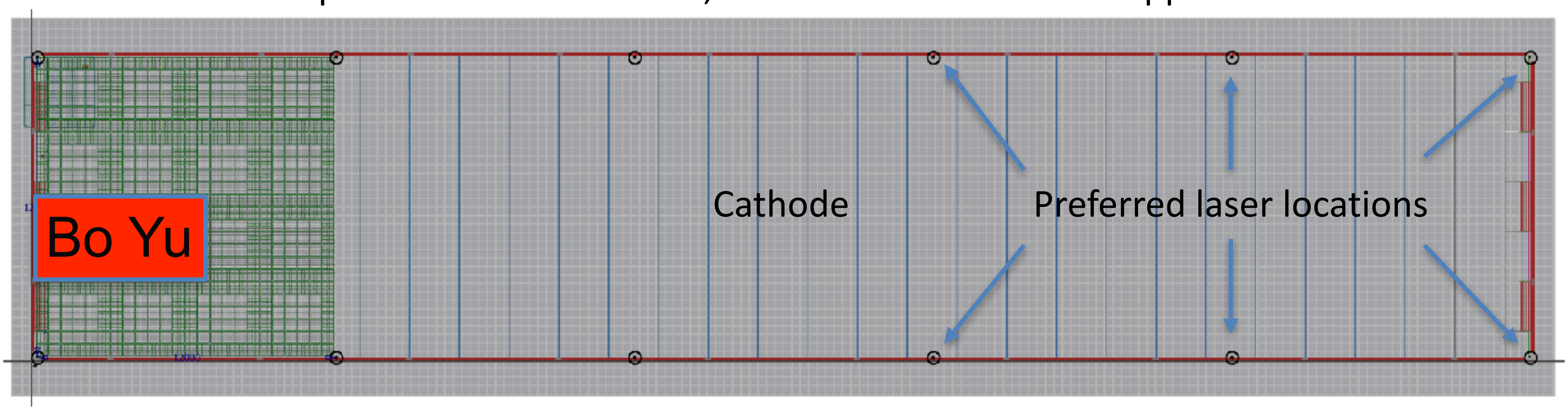


Bo Yu

Preferred Locations for Laser Heads

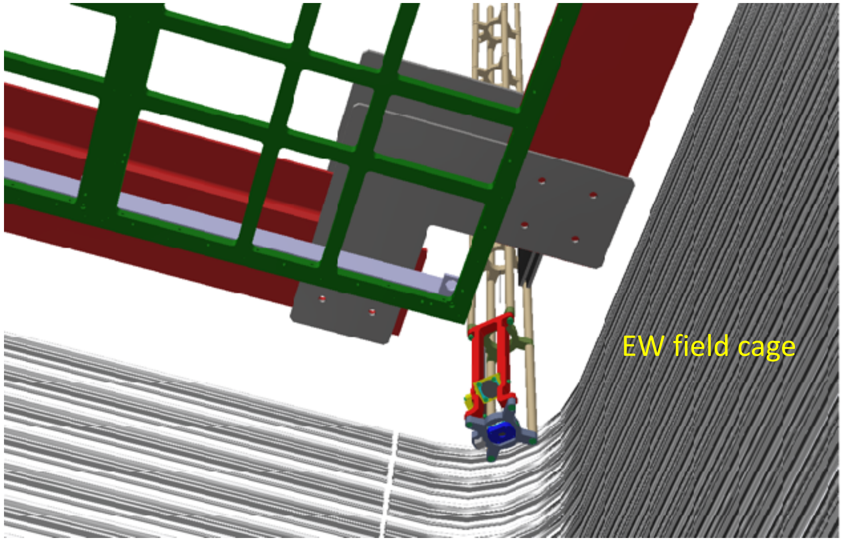
- We have a 15cm nominal gap between the inner FC profile surface and the CRP outer edges when cold. Lasers in this gap will not interfere with FC profiles and CRPs. But the top FC beams need to be modified for this: best at beam joints.
- Preferred locations for the laser ports: ~12m apart forming a rectangle. Position the port at the joints of two 12m long FC support beams.
- Since the FC and its support beam shrink about 0.3% in the cold, the opening through the beams must account for the shrinkage.

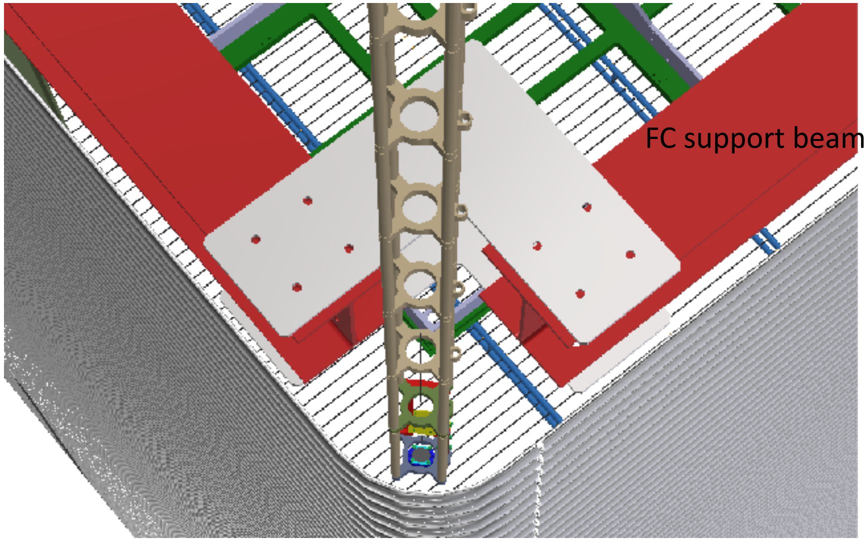
A plan view of the DP TPC, the red lines are the FC support beams



Possible Location Example: Corner

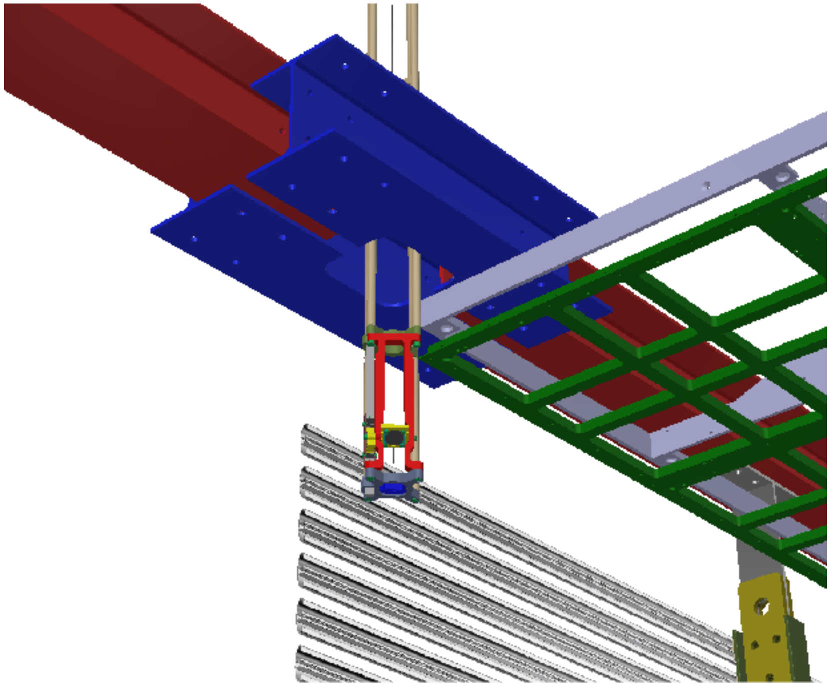
- In a FC corner, the FC support beams have no load, therefore it is easy to make a hole for the laser head.
- However, a laser head in the corner will see the most movement between warm and cold relative to the other TPC structures: CRPs have invar frames so their shrinkage is minimal. FC will shrink ~ 9cm in the long direction and 2cm in the other. This relative movement must be considered in locating the laser ports.

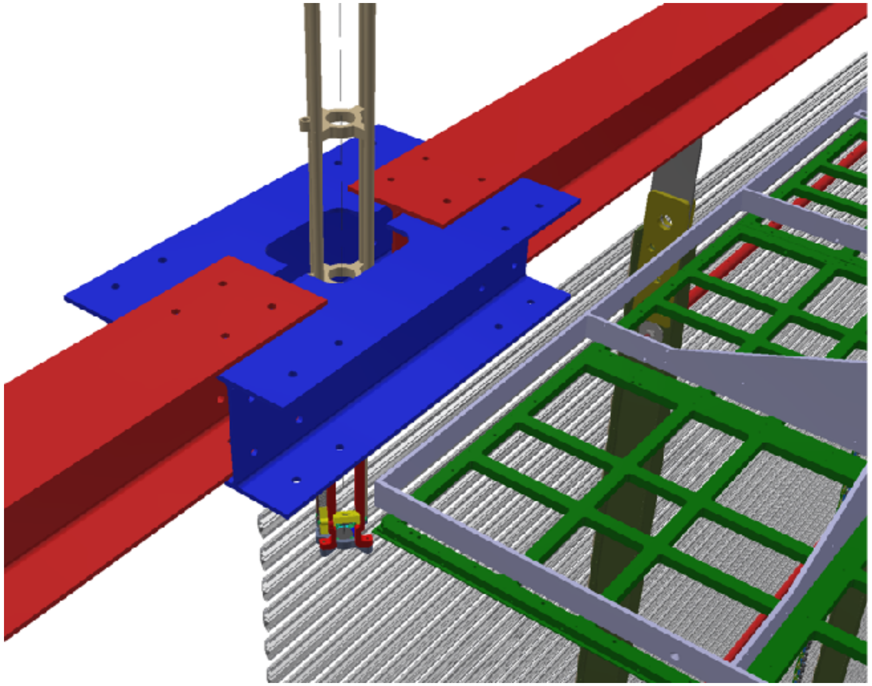




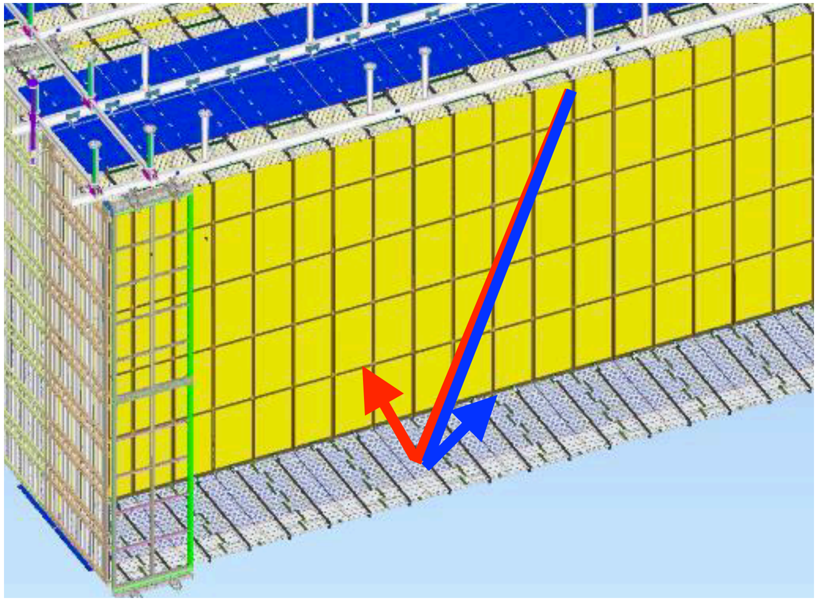
Possible Location Example: Long Side

- Along the two long walls of the TPC, there are 4 breaks in the FC super module suspension beams. They are the natural locations for laser heads to pass through.
- The FC suspension beams are 12m long. The 4 locations are @ ±6m, ±18m from the middle of the long FC array. The expected shrinkages of the FC at these 4 locations are ±16mm, and ±49mm along the wall, and 16mm toward the CRP. These shifts need to be accommodated in the laser openings on the beams.





Location with mirrors



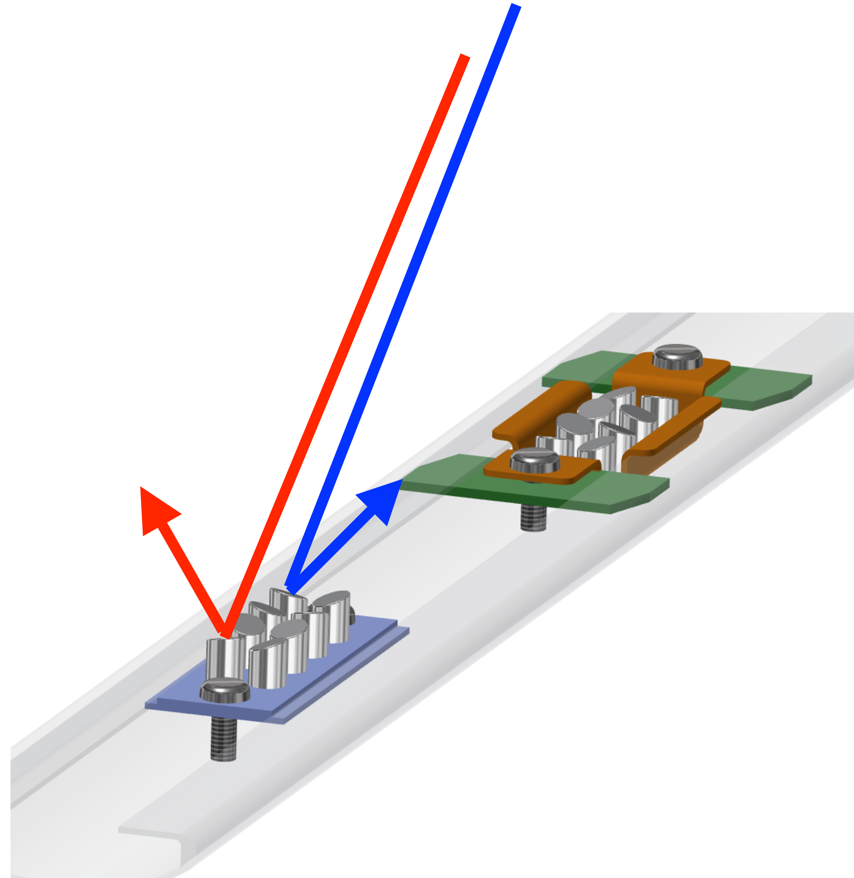


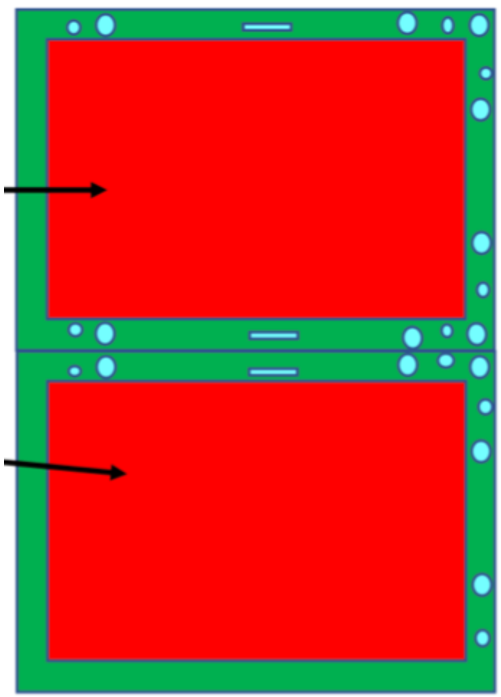
Photo-electron (PE) Laser

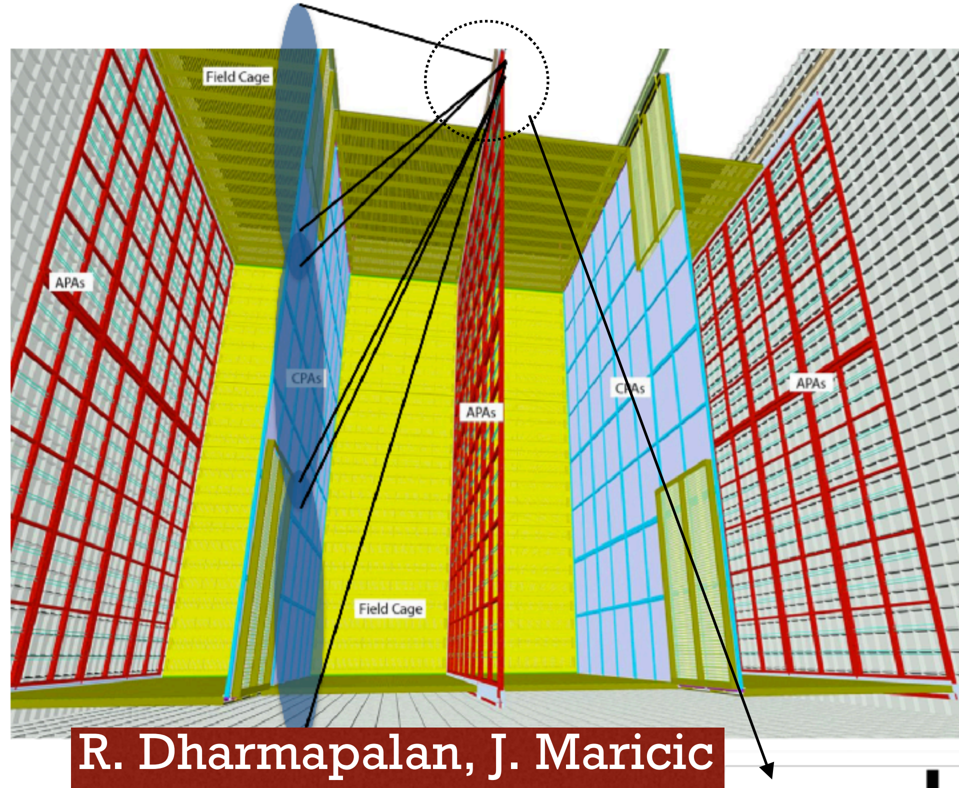
Concept:

- Illuminate metal targets (e.g. Al) on CPA using 266 nm light from laser via fiber optics
- Ejected electrons drift back with known "t0"

Current Plan:

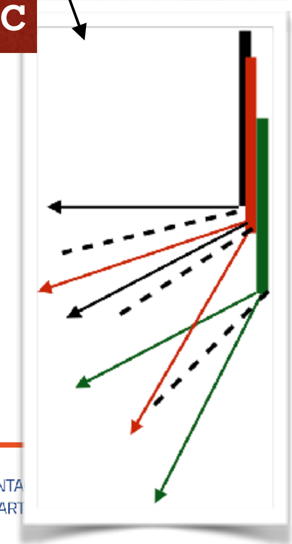
- The fibers terminate to a diffuser on the APA
- Fibers on top, angled illumination on the CPA surface
- Fibers routed along the cold electronics cable trays





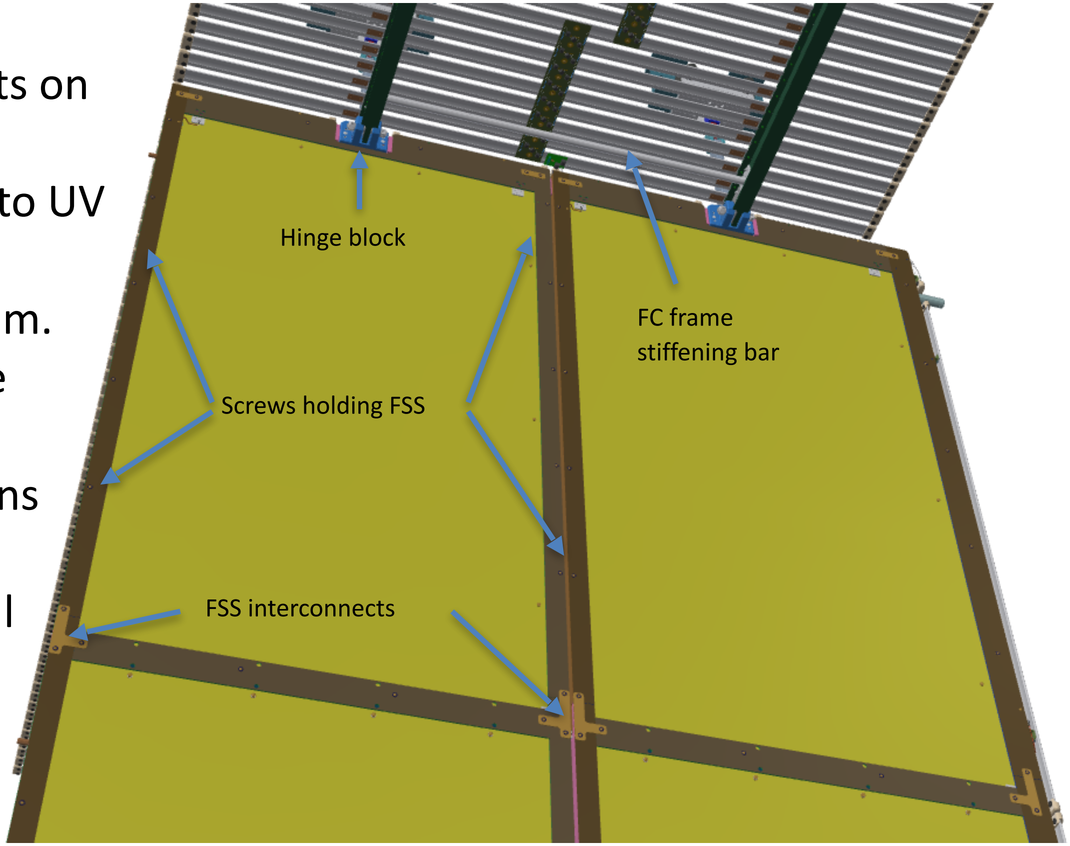
Open issues:

- PE ejection from Kapton?
- How to attach the Al targets?



Photoelectric Effect

- A photoelectron laser system is described in the TDR. It shines diffused UV light over a large area on the cathode with some predefined metallic target pattern, and aims to generate bursts of electrons drifting toward the wire planes.
- We don't see problem of having small metallic targets securely mounted on the cathode surfaces. Large targets (long metal strips) weakens the resistive nature of the cathode and should be avoided.
- There are a number of metal objects on cathode/FC that would contribute.
- The resistive Kapton does respond to UV light. Its QE is about 2 orders of magnitudes lower than Ag in vacuum. This means if one knocks off a large number of electrons from a small target, a greater number of electrons will also be emitted on the Kapton surface being illuminated. They will arrive simultaneously with those from the targets, on a large number of wires.



Radioactive Source

J. Reichenbach

Source center about 40 cm away from FC
But source is 20 cm wide, so will pass close to FC support structure

Mechanical Source Deployment Scheme