DEEP UNDERGROUND NEUTRINO EXPERIMENT

17/10/2019

temperature sensors on APAs

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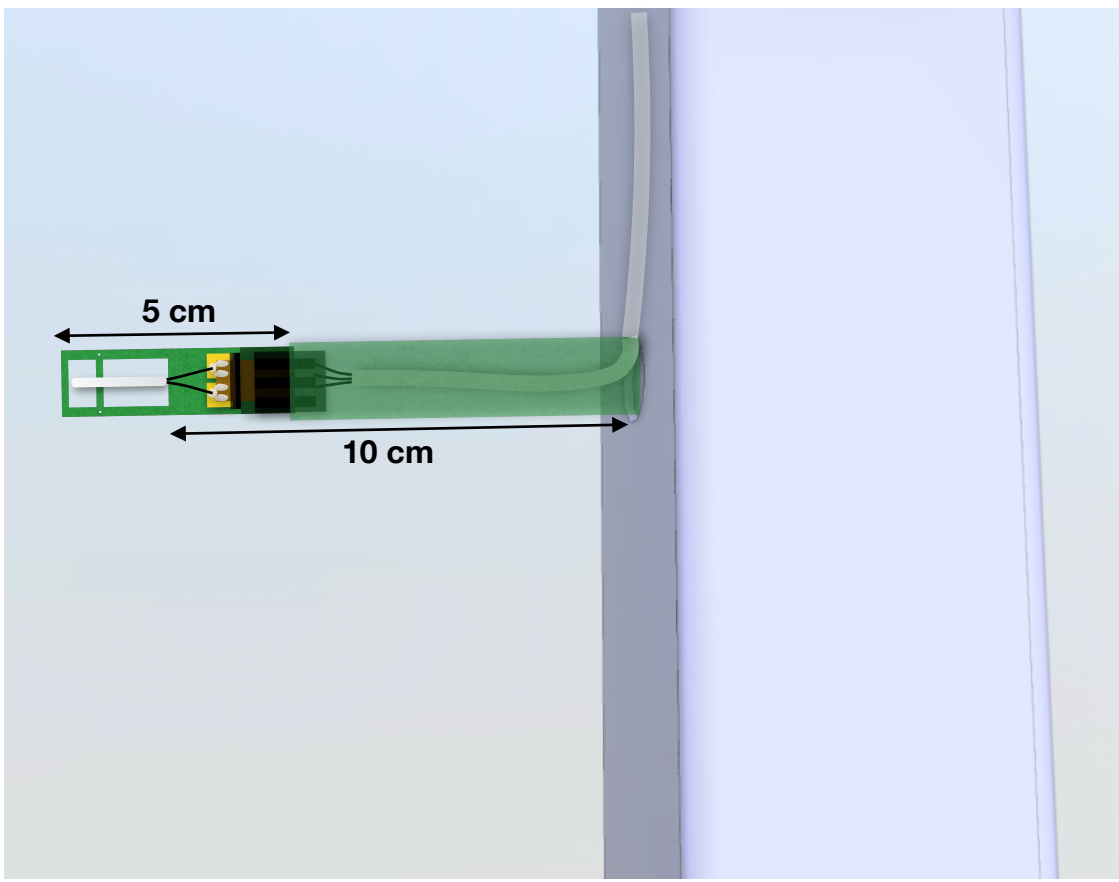
Introduction

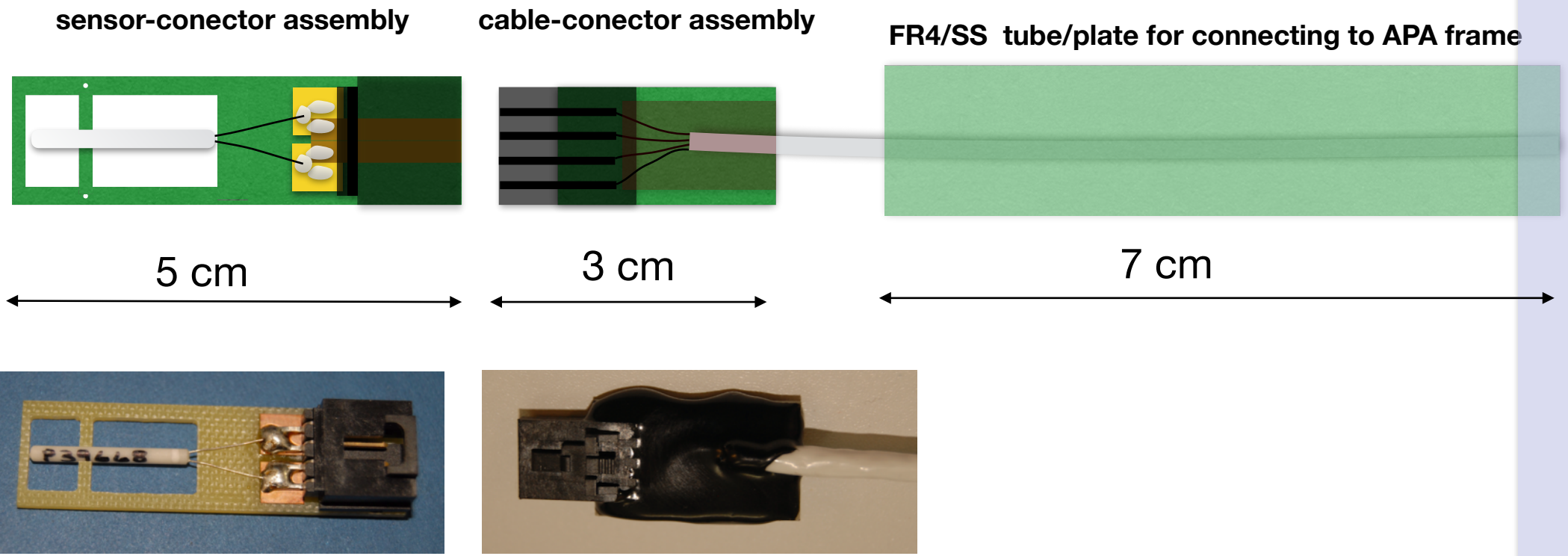
- The possibility of adding sensors on the APAs was discussed at the CISC session in the CM meeting with representative from APA and PDS consortia in the audience
- The initiative was positively received and there is consensus in moving forward. There are however some concerns:
  - interfere with APA production and installation schedule
  - x-talk with PDs
  - Noise on wires
  - Cable routing

Sensor positioning

- Sensor should be kept at some distance from the APA frame to minimize the effect of the frame in the LAr flow and temperature



The different pieces



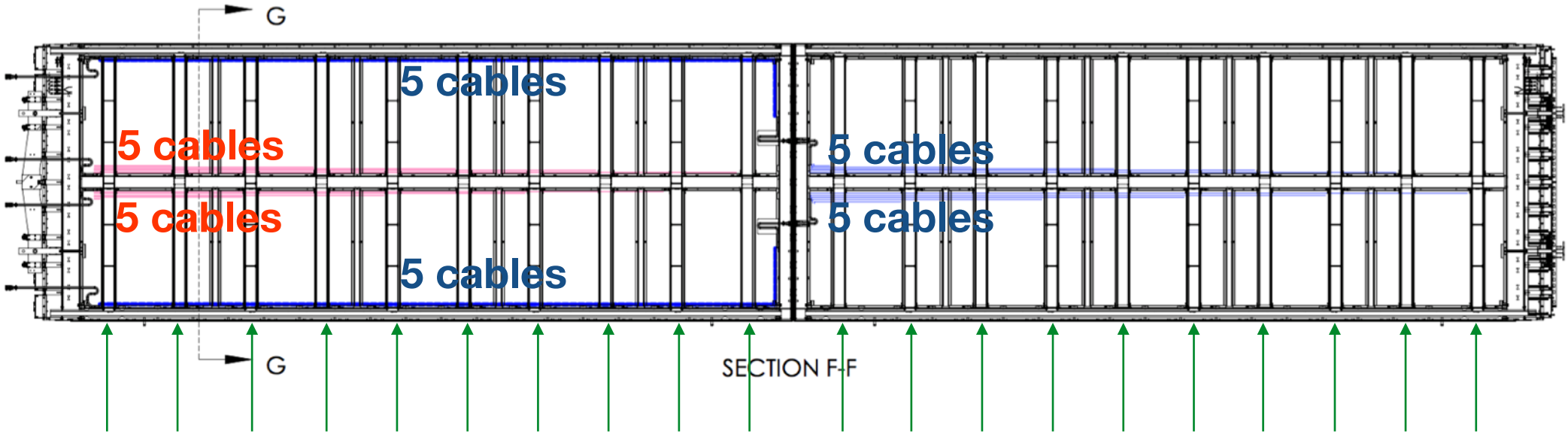
- All this could be modified to simplify installation and mitigate risks. Each unit is very light so it should be easy to anchor it to APA frame
- We could for example use a thin SS plate (1 mm) such that no space is taken from the PD cables

Cable routing

- Cable routing is one of the main issues
- The baseline is to use PD cables and connectors for RTDs
  - Each cable has 6 individually shielded twisted pairs.

~8 mm diameter

Cable routing

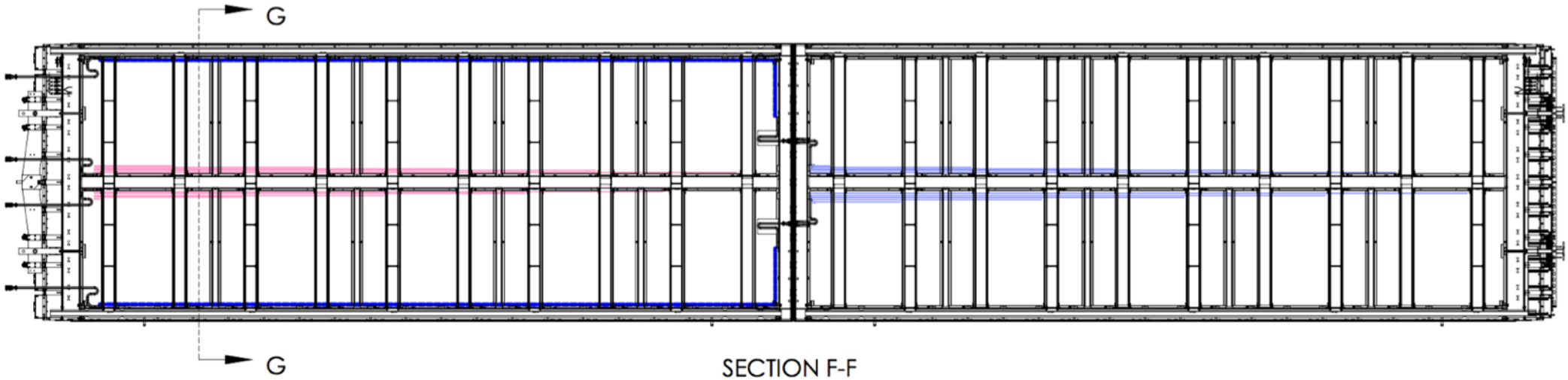


10 PDs per APA, 20 in a doublet

- In blue, 10 cables from bottom PDs
- In red, 10 cables from top PDs

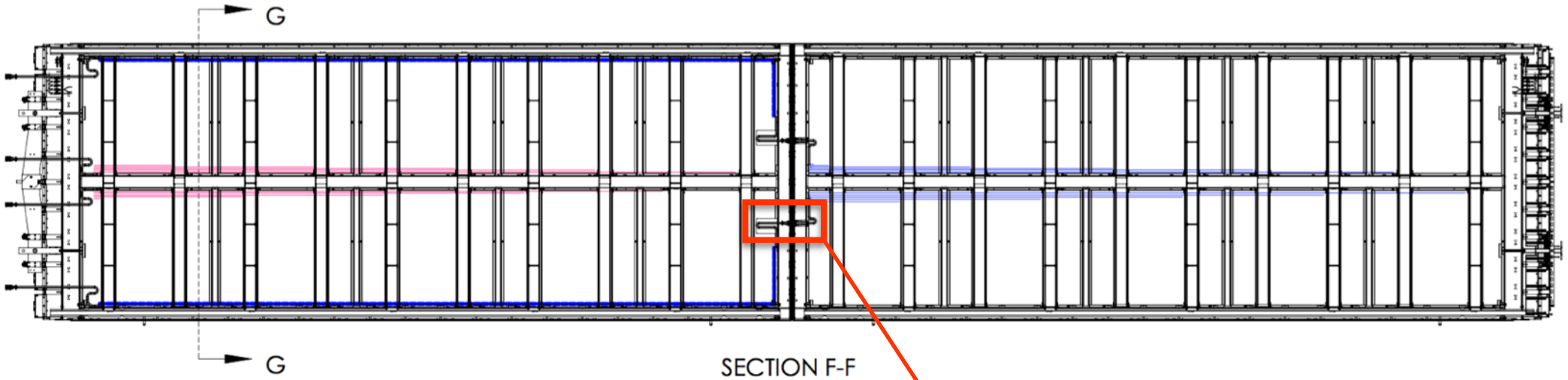
The idea is to add a sixth cable to each group

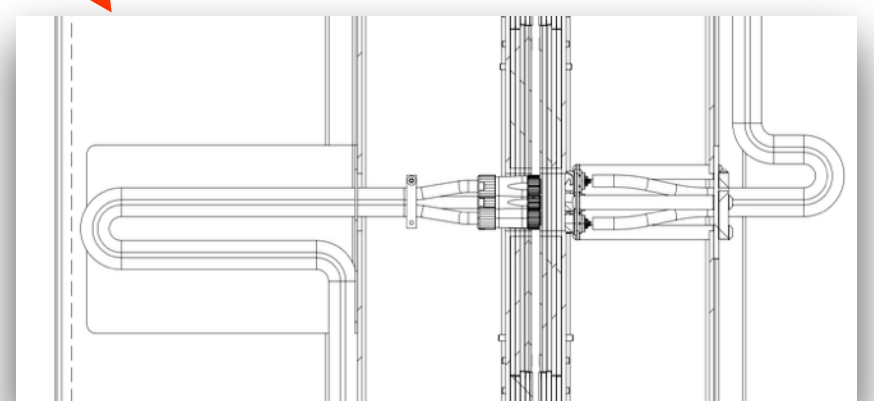
Problem: APA connection



SECTION F-F

Problem: APA connection





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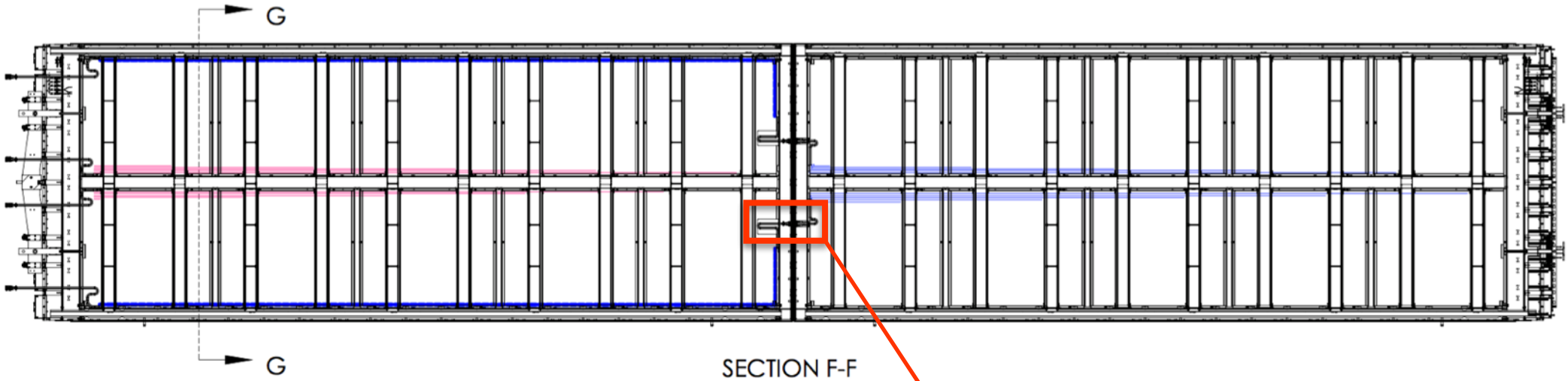
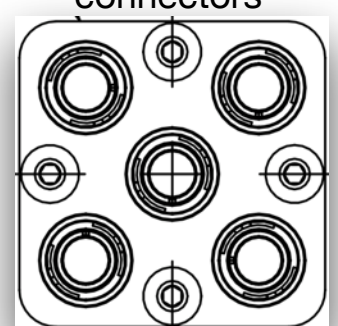
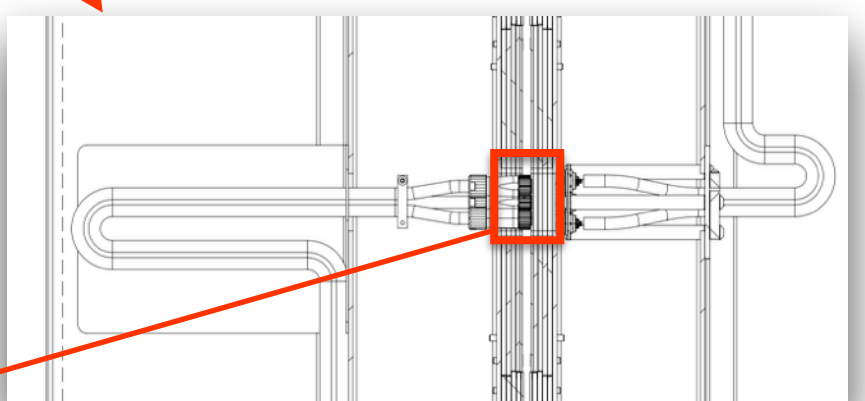


five 12-pins connectors





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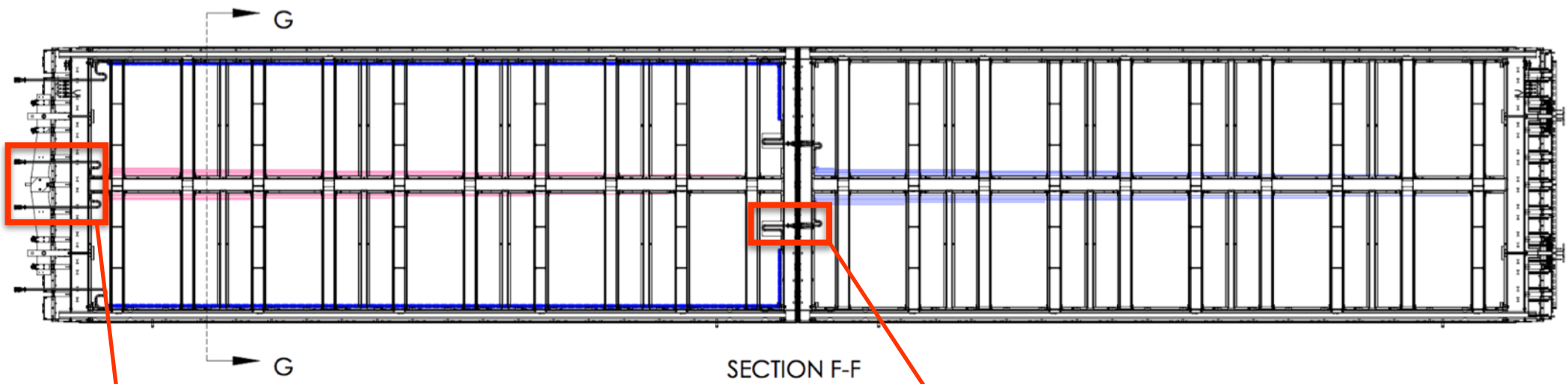

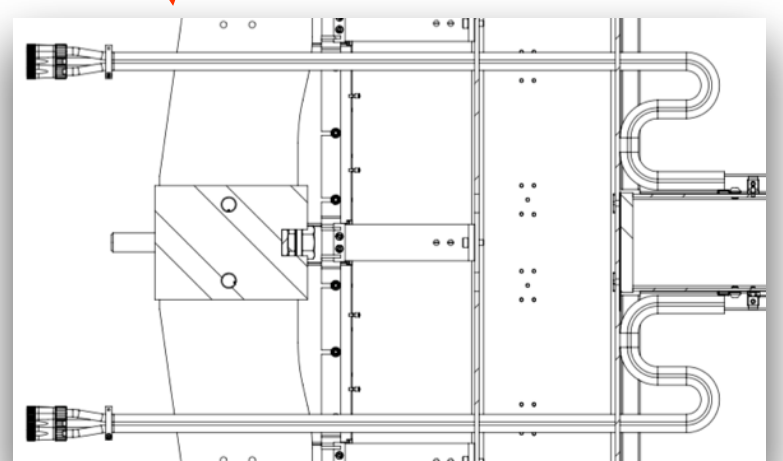

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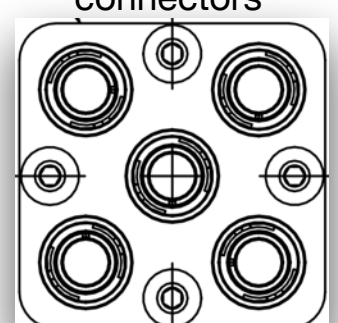

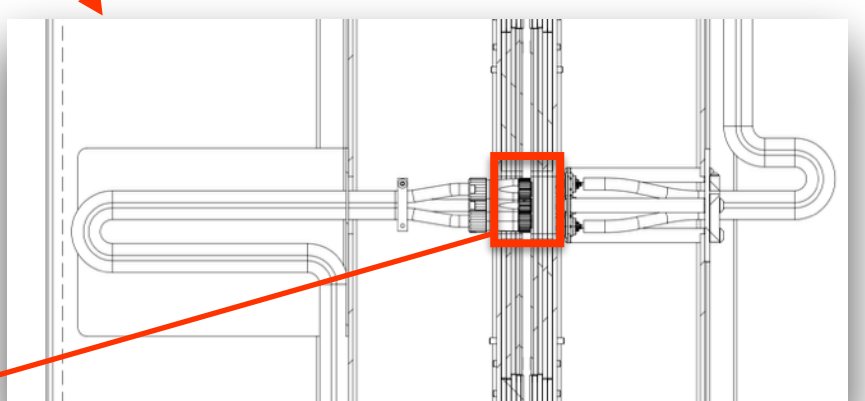

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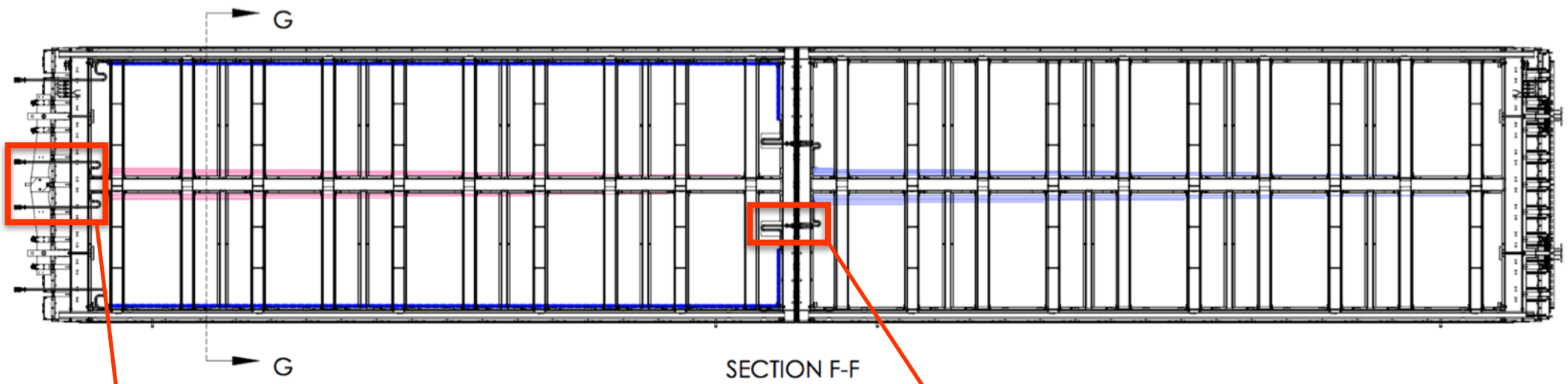

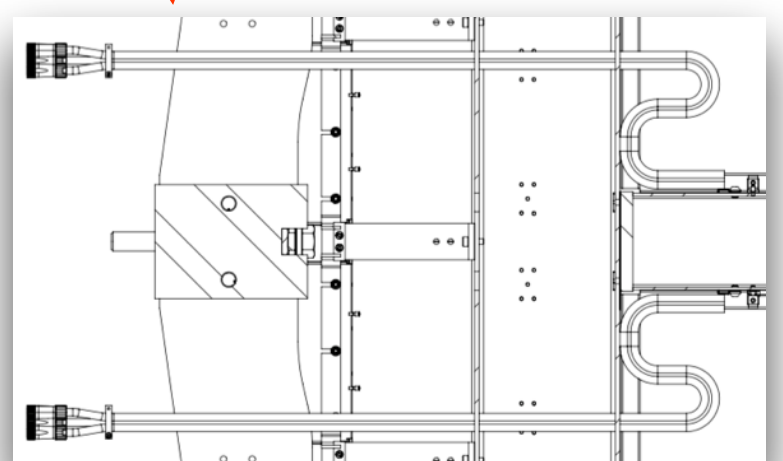

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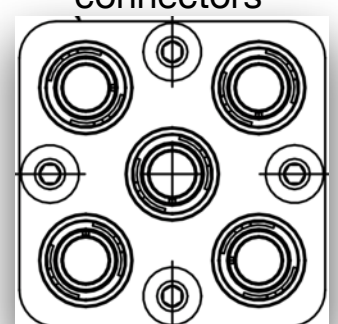
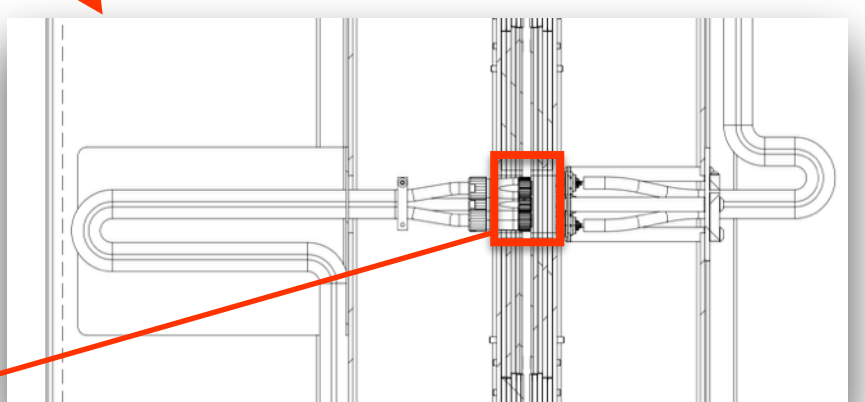
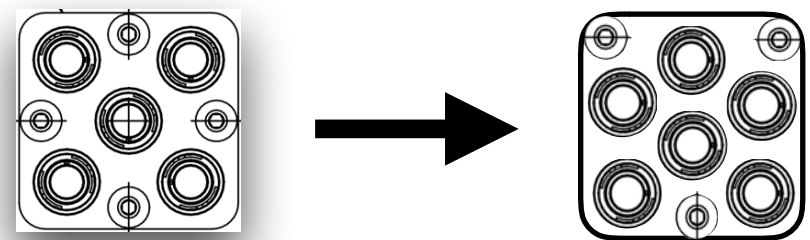




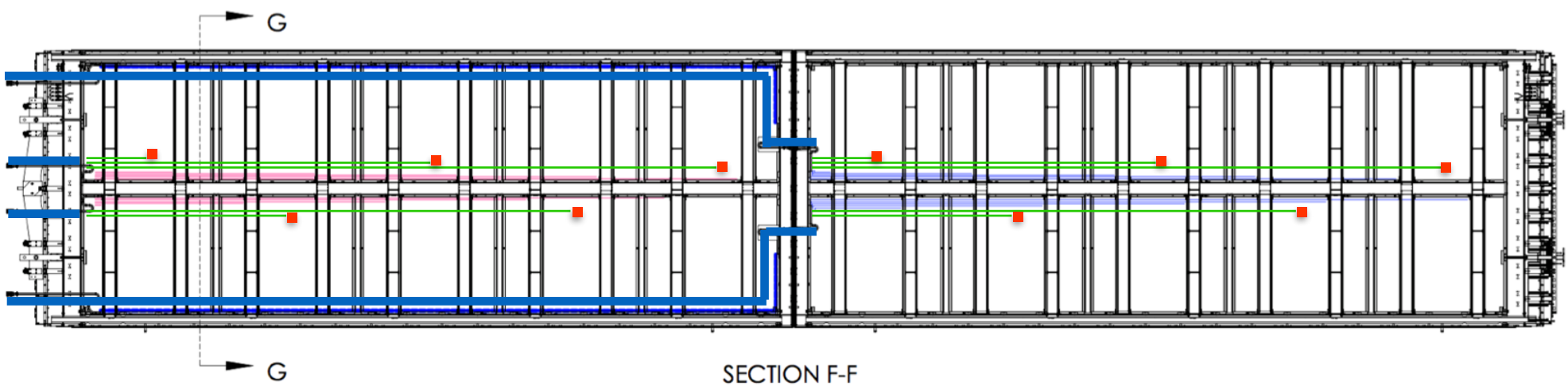
Add a new connector

Baseline option

- Add a new PD cable to each group of 5 cables
- Add a new connector to the feedthrough

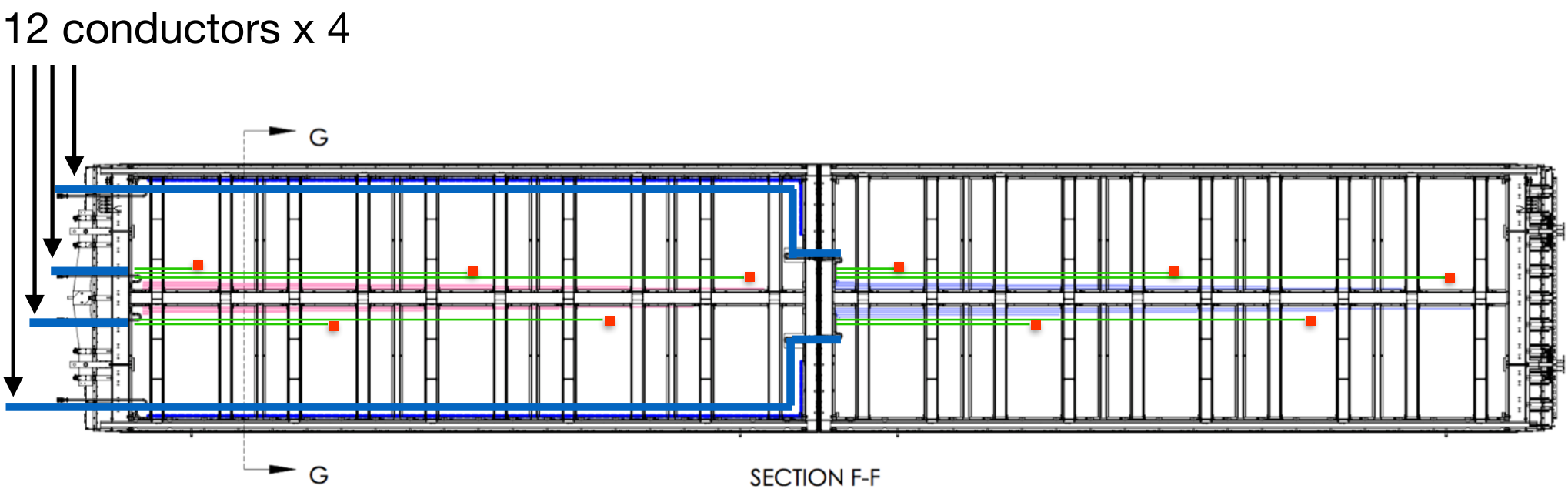


- Bring additional PD cable (blue) to top of APA, and from there use dedicated cables (green)



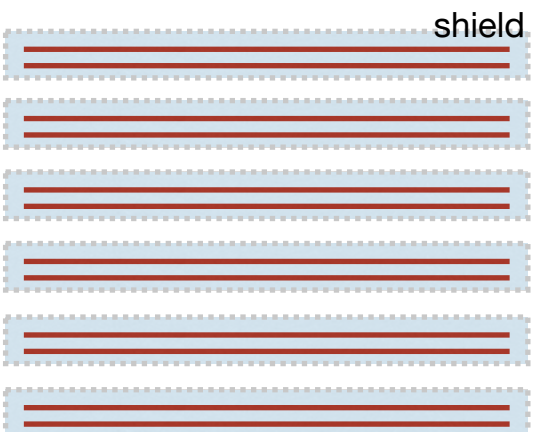
Number of sensors per cable

- Each PD cable has 12 conductors
- In principle we could read 3 sensors per cable
- Since we have 4 of those cables we could read up to 12 sensors per APA doublet

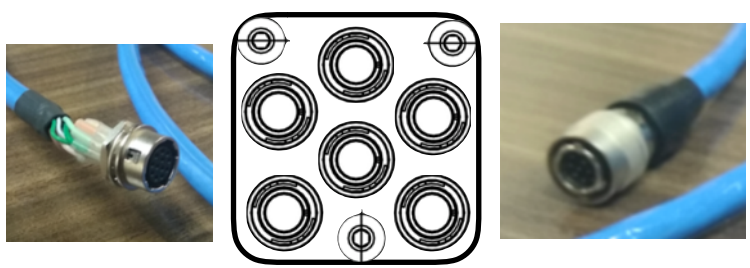


Grounding

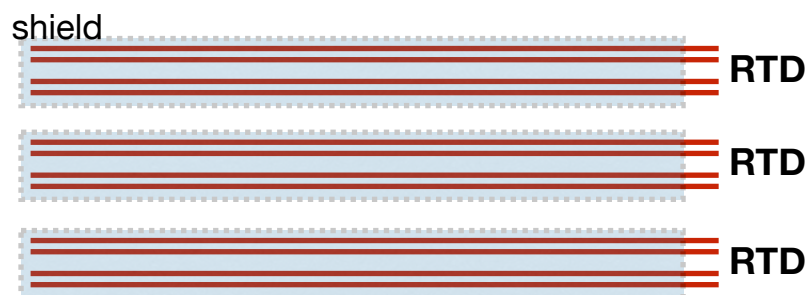
- The main problem is grounding
- We need to pass the ground from top to bottom through the feedthrough



6 twisted pairs with individual shield ending in a 12-pin connector

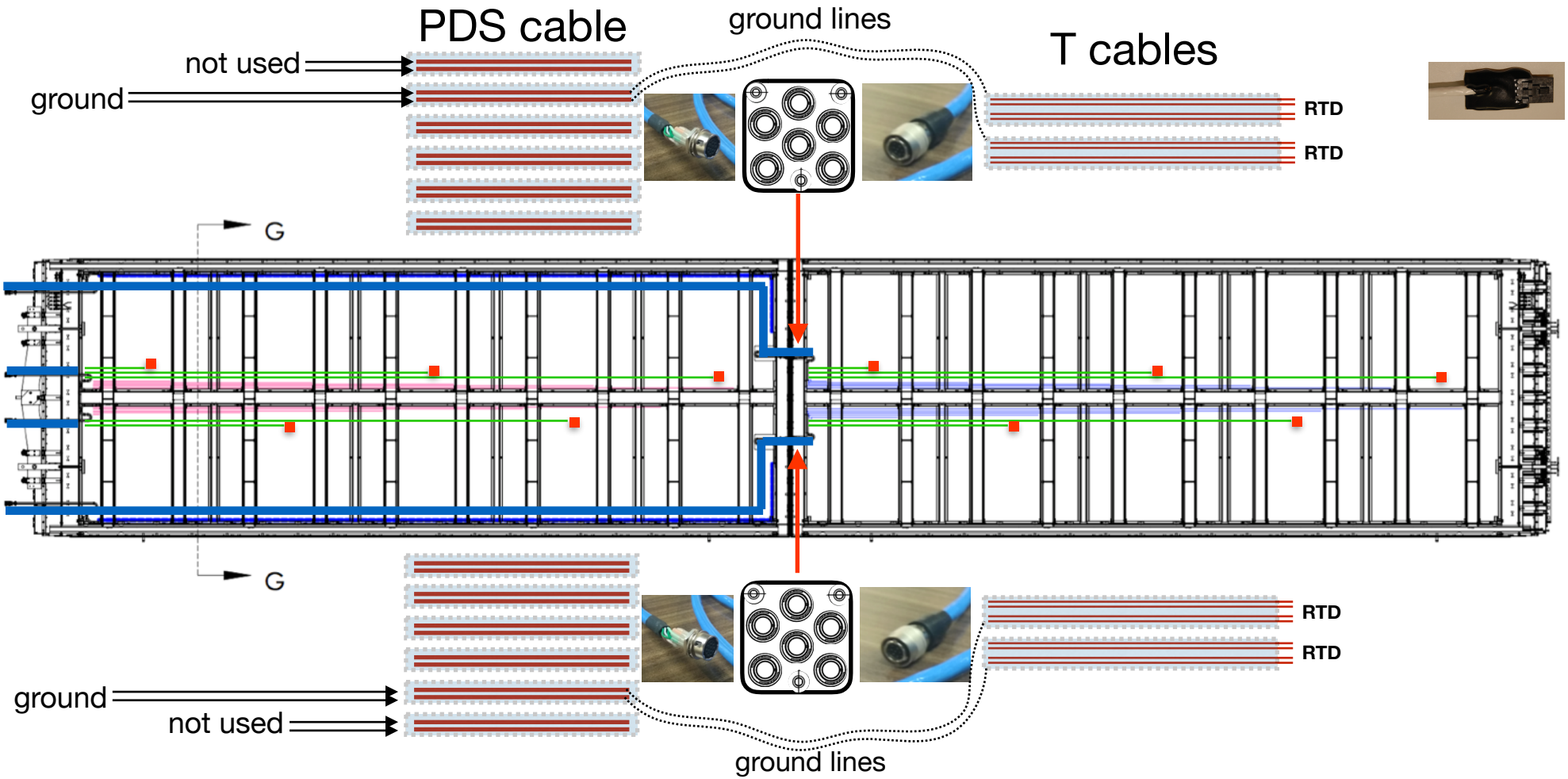


feedthrough with 6 connectors. One of them for RTDs



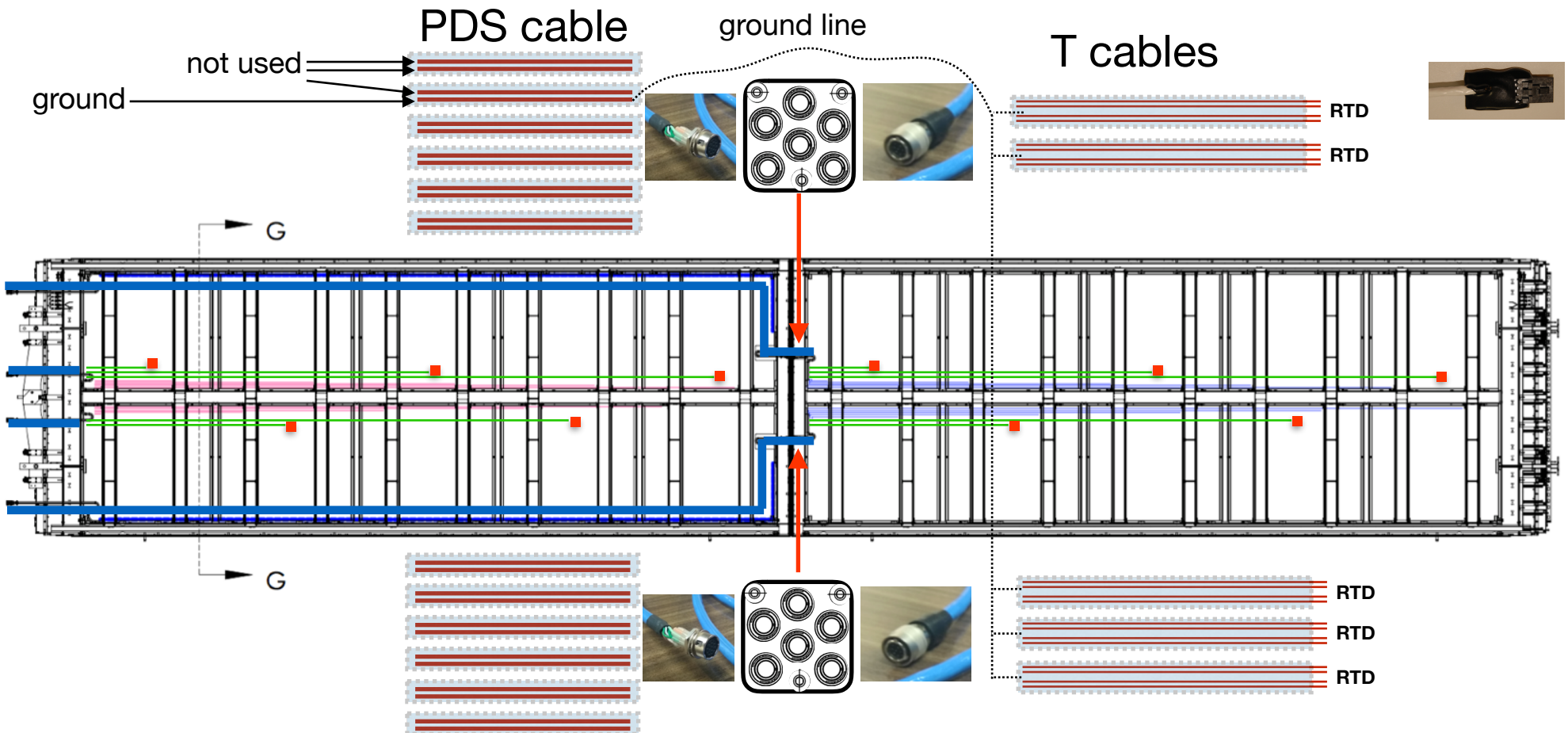
3 cables with two twisted pairs each ending in a 12-pin connector

Option I



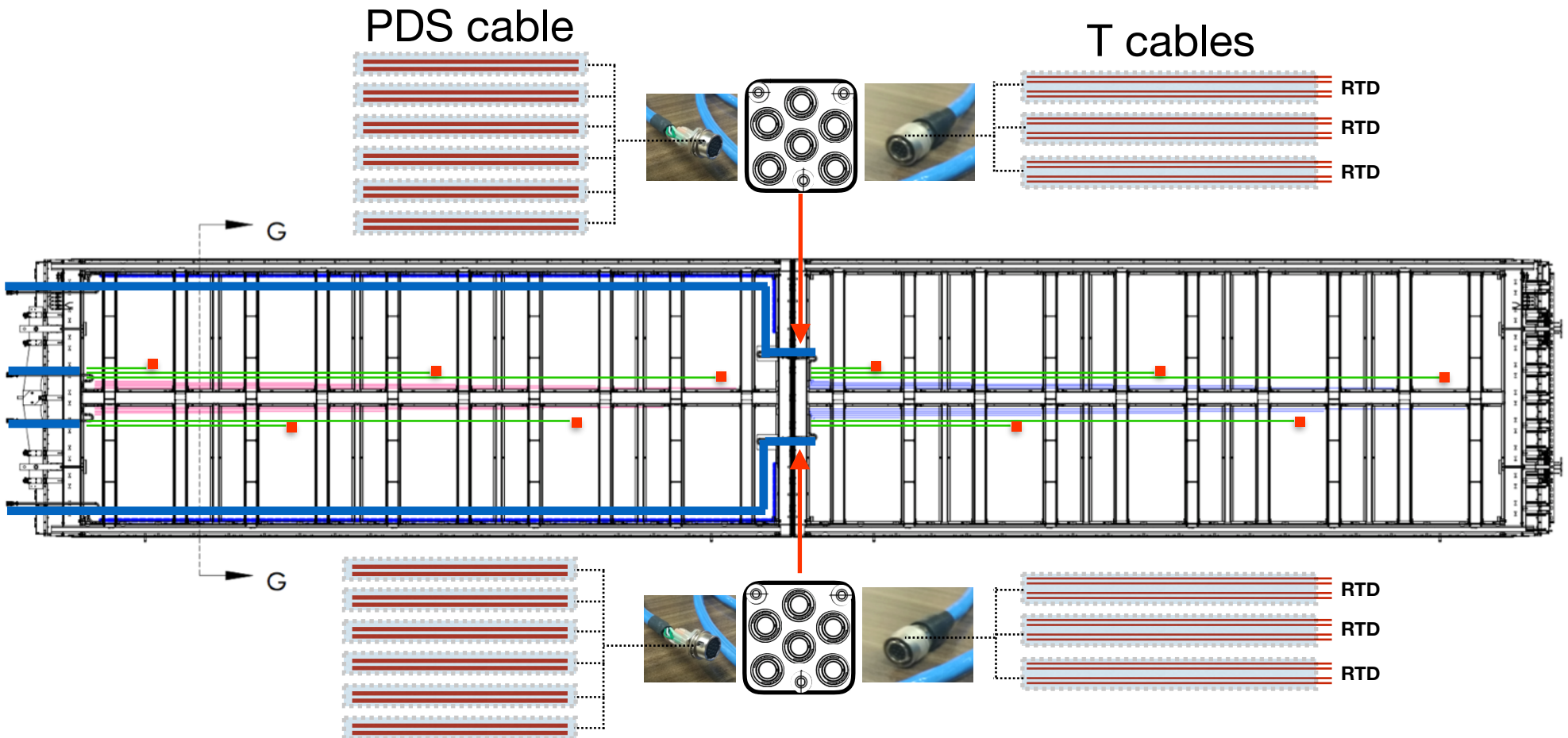
- D. Warner suggested to use two of the conductors in each PDS cable to pass the ground individually to the shield of each RTD cable. But then we loose one sensor in each PDS cable. Maximum would be 4 sensors in the bottom APA

Option II



- Can't we use just one conductor in one of the two cables to bring the ground to 5 RTD cables ?
- In this case we could have 5 sensors per APA

Option III



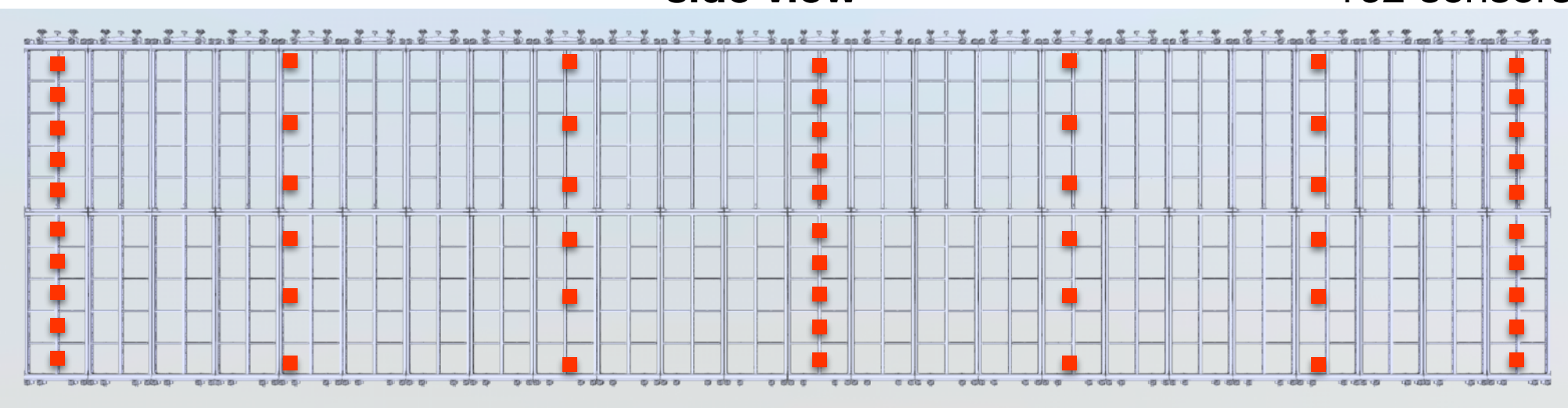
- Or even better, can't we use the connector shield to bring the same ground to 3 sensors ?
- In this case we could have 6 sensors per APA

Sensor distribution

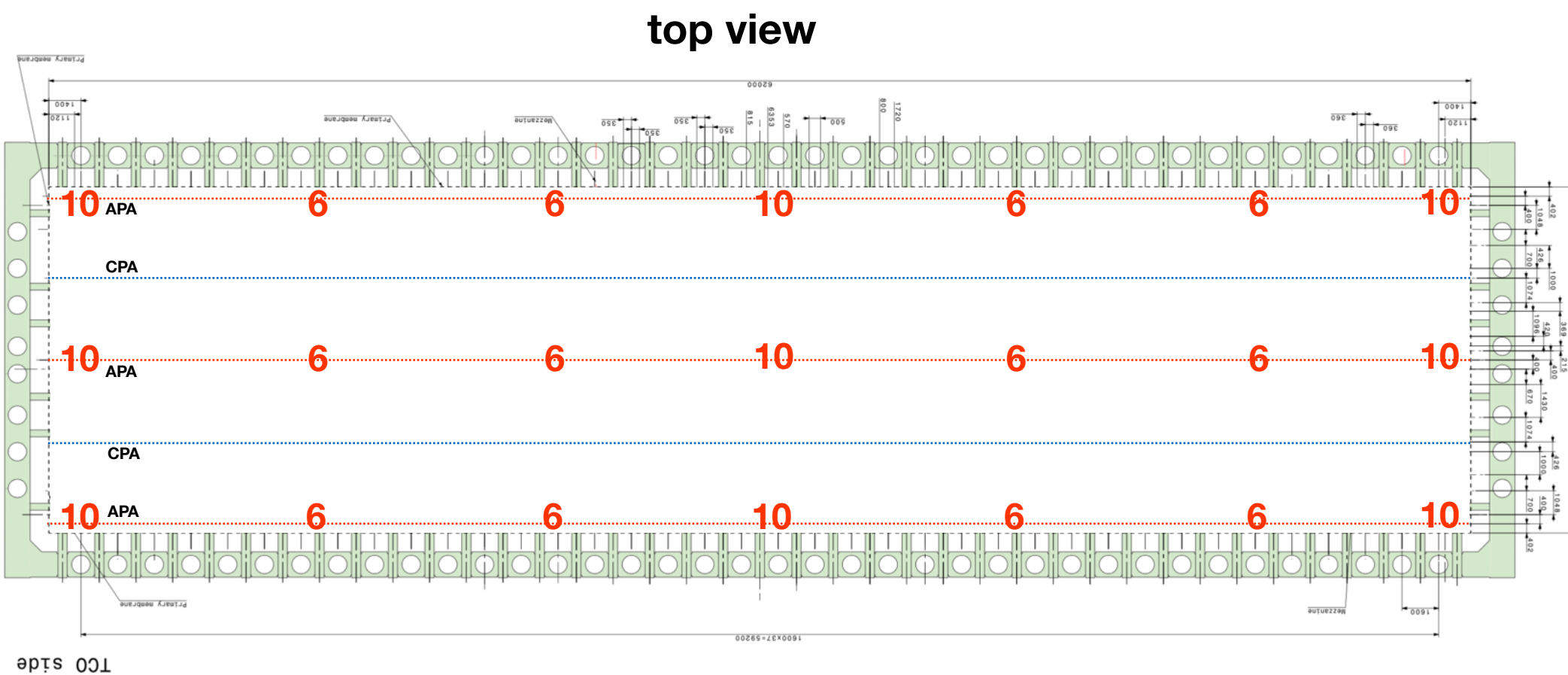
Option I

- First thoughts
  - Sensors every 4 APA doublets
    - 4 doublets with 6 sensors and 3 with 10 sensors. Total 54 sensors
  - Repeated for each of the 3 APA rows: 162 sensors
- It would be better to have more sensors in some of the doublets (we had 48 in ProtoDUNE-SP) but this is probably not feasible

side view 162 sensors



- Number of sensors in each APA doublet are indicated

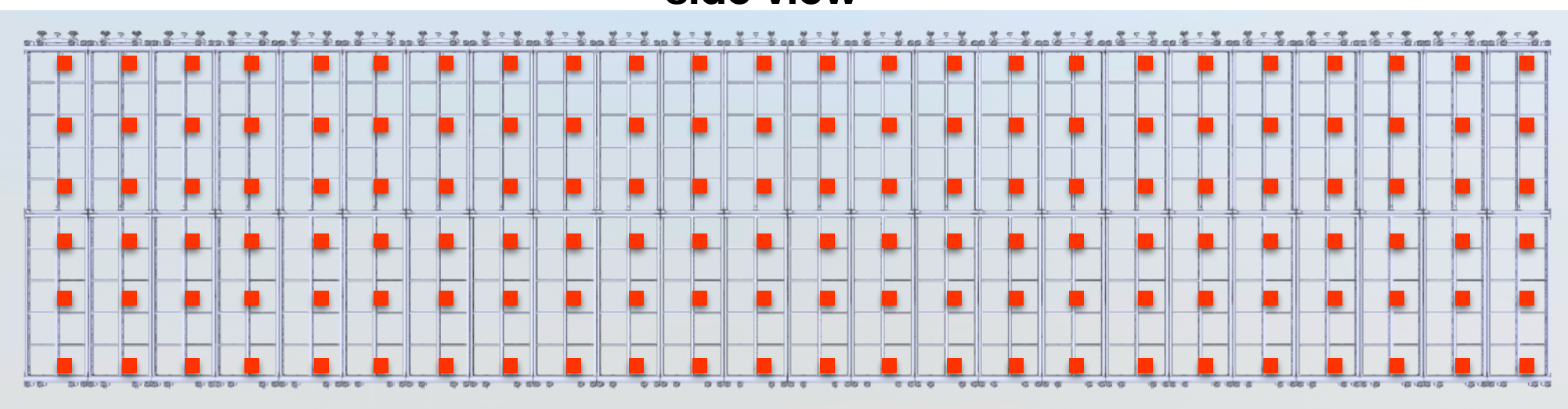


Option II: identical APAs

- If we don't want to condition APA installation sequence all APAs should be identical
- But this is a problem since to have sufficient vertical density the number of sensors would be too large (> 2000)
- The configuration below has 450 sensors and vertical density is poor

side view

450 sensors

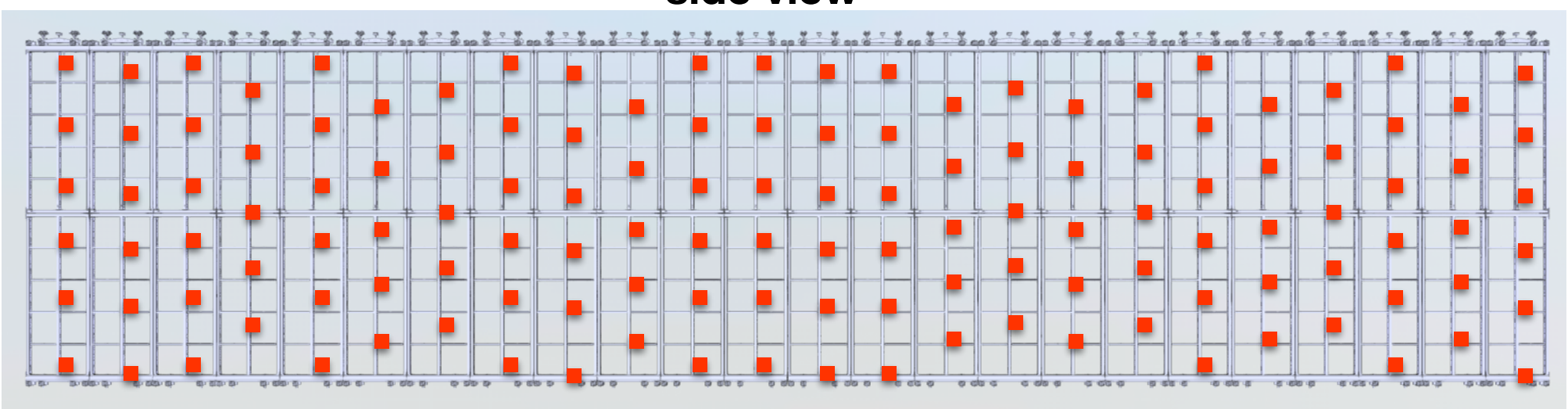


Option III: randomizing

- A solution to this could be te one below, covering ~30 different heigts
- We could have different configurations (5 ?) with 5/6 sensors at different heights such that about 30 different heights are covered
- Installation sequence would ignore the T-sensor configuration
- The resulting distribution would be something like this:

400 sensors

side view

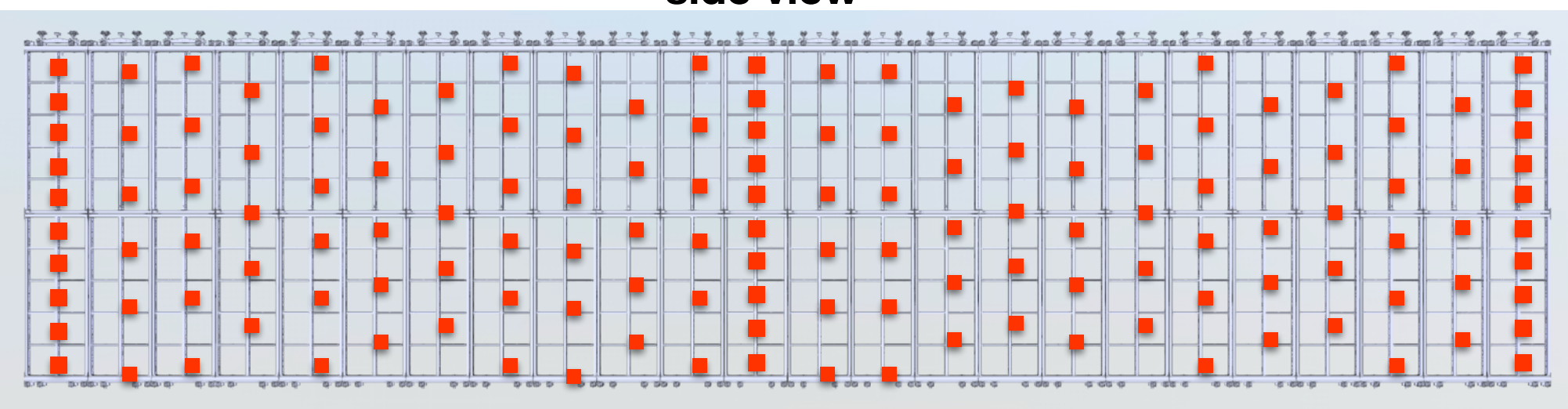


Option IV: randomizing

- More density at the borders and in the center

side view

486 sensors

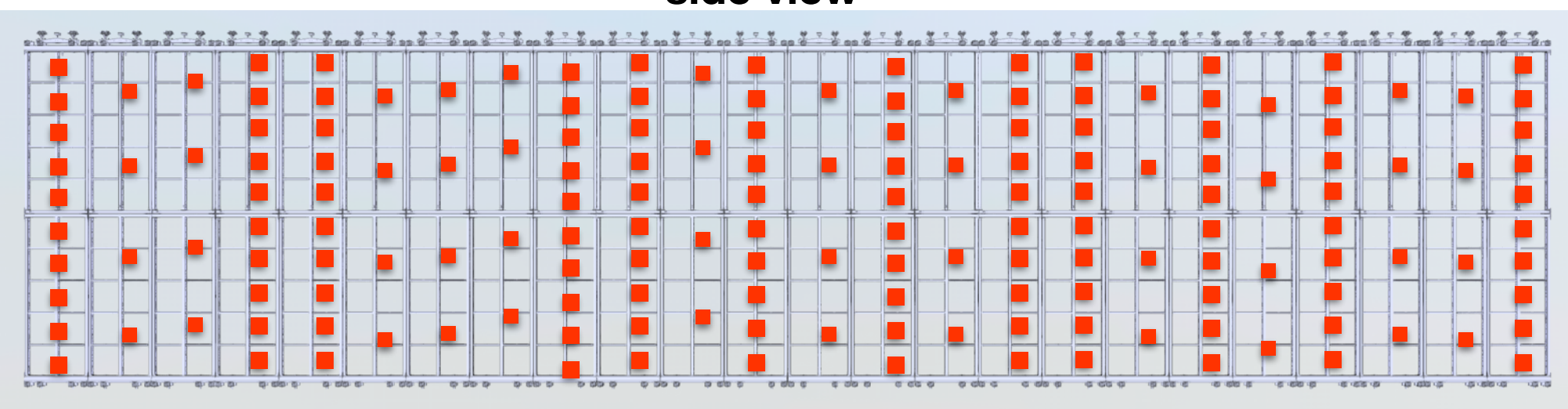


Option V: randomizing

- Also randomizing the high density arrays

side view

516 sensors



Optimization

- Miguel is working on a toy simulation to optimize the sensor map
  - Assume a temperature map T=f(x)*g(y)*h(z)
  - Assume a given sensor distribution
  - Simulate measurement errors and LAr fluctuations
  - Fit the simulated data to the functions above to extract parameters
  - Vary sensor distribution to minimize error on those parameters
  - Sensor distribution driven by:
    - A maximum of 500 sensors
    - Number of arrays with 10 sensors
    - Number of sensors in low density arrays (4,5,6 ?)
    - Any arrays at predefined positions ?

Conclusions

- Working with D. Warner on PDS cable option
- ~10 sensors per APA doublet is the maximum
- “randomization” option is the baseline
- working in optimazing sensor distribution