

# Camera System

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Edgar Valencia

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**WILLIAM & MARY**

CHARTERED 1693

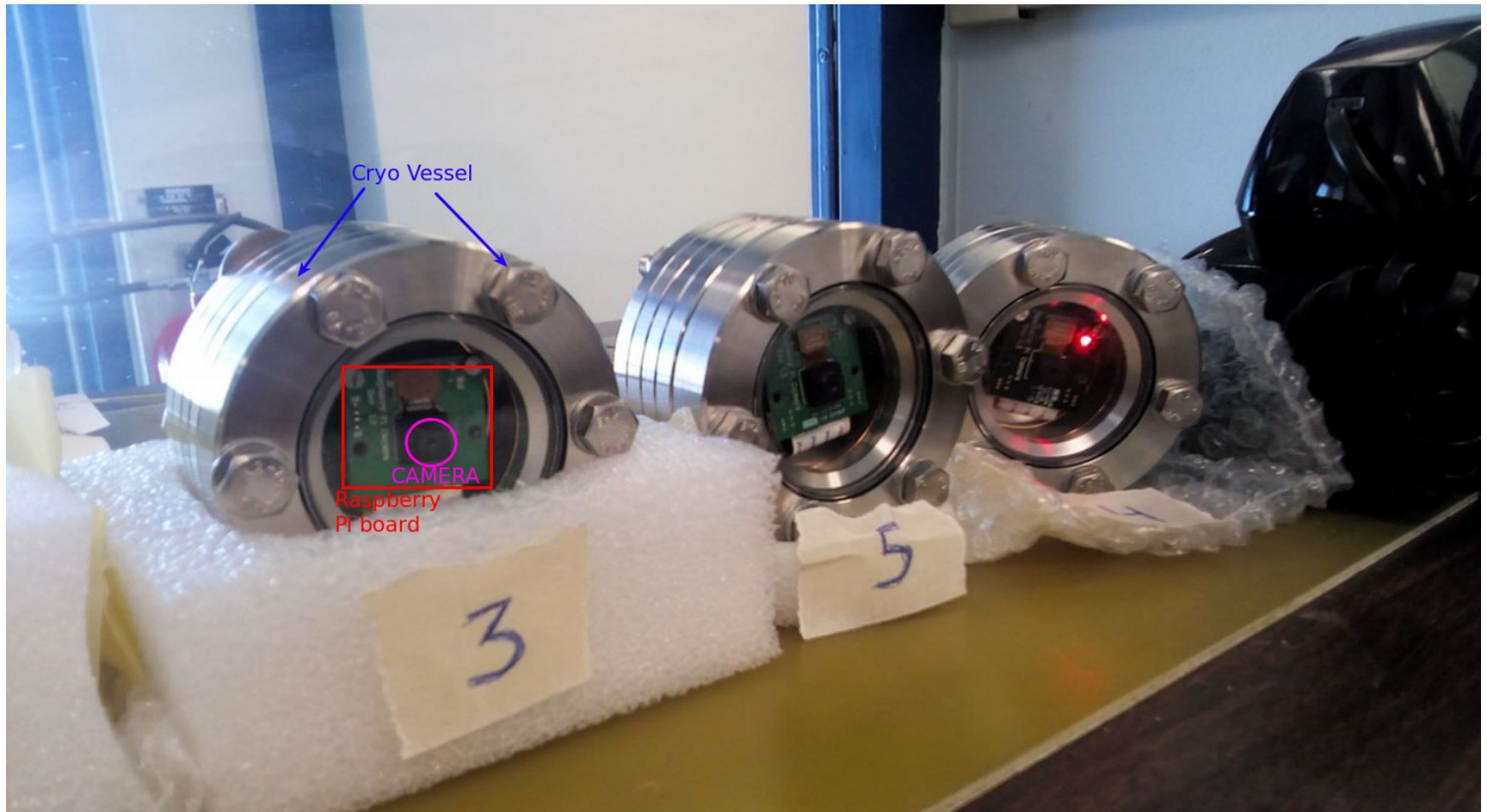
# Purpose of the system

- Monitor filling and verify status in collaboration with other devices.
- Monitor and identify location of HV breakdowns
- Visually inspect the interior of the cryostat after sealing and filling. General purpose.

# Cameras used in HV@PC4

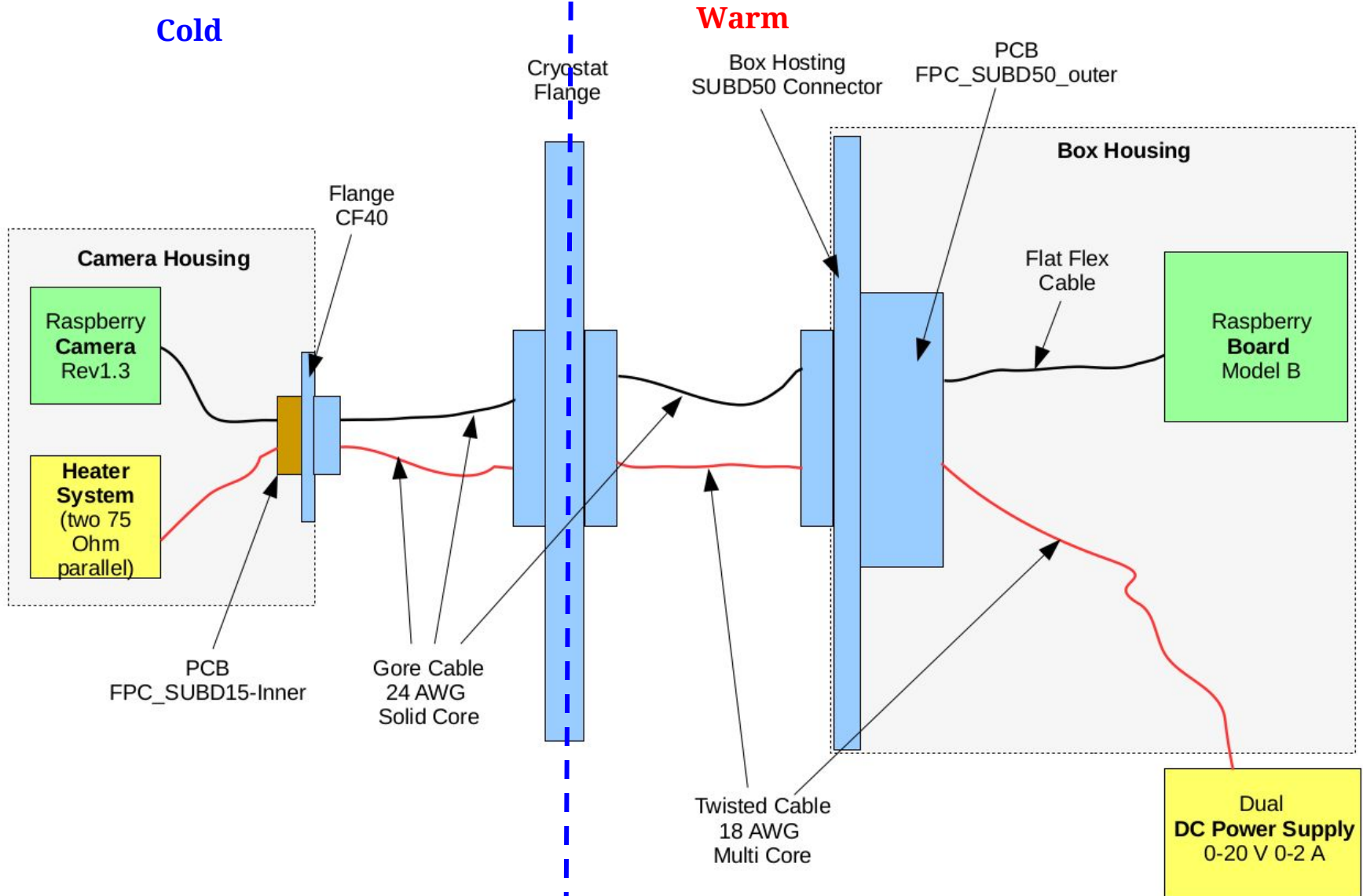
- Raspberry PI based system from CERN/Zurich provided PC4 HV test
- Adapted for operations at FNAL, cable lengths & heaters by Edgar, Cheng-Ju, and others. → **Thank you.**
  - Details and suggested improvements from Edgar.
- Successful data acquisition and operations.
- Current performance suggests a similar system can work for protoDUNE
  - Per my stock broker: *“Past performance does not guarantee future results”*
  - Purpose of PC4 test is to find problems.
  - But, proceed assuming status quo.

# Camera Assemblies

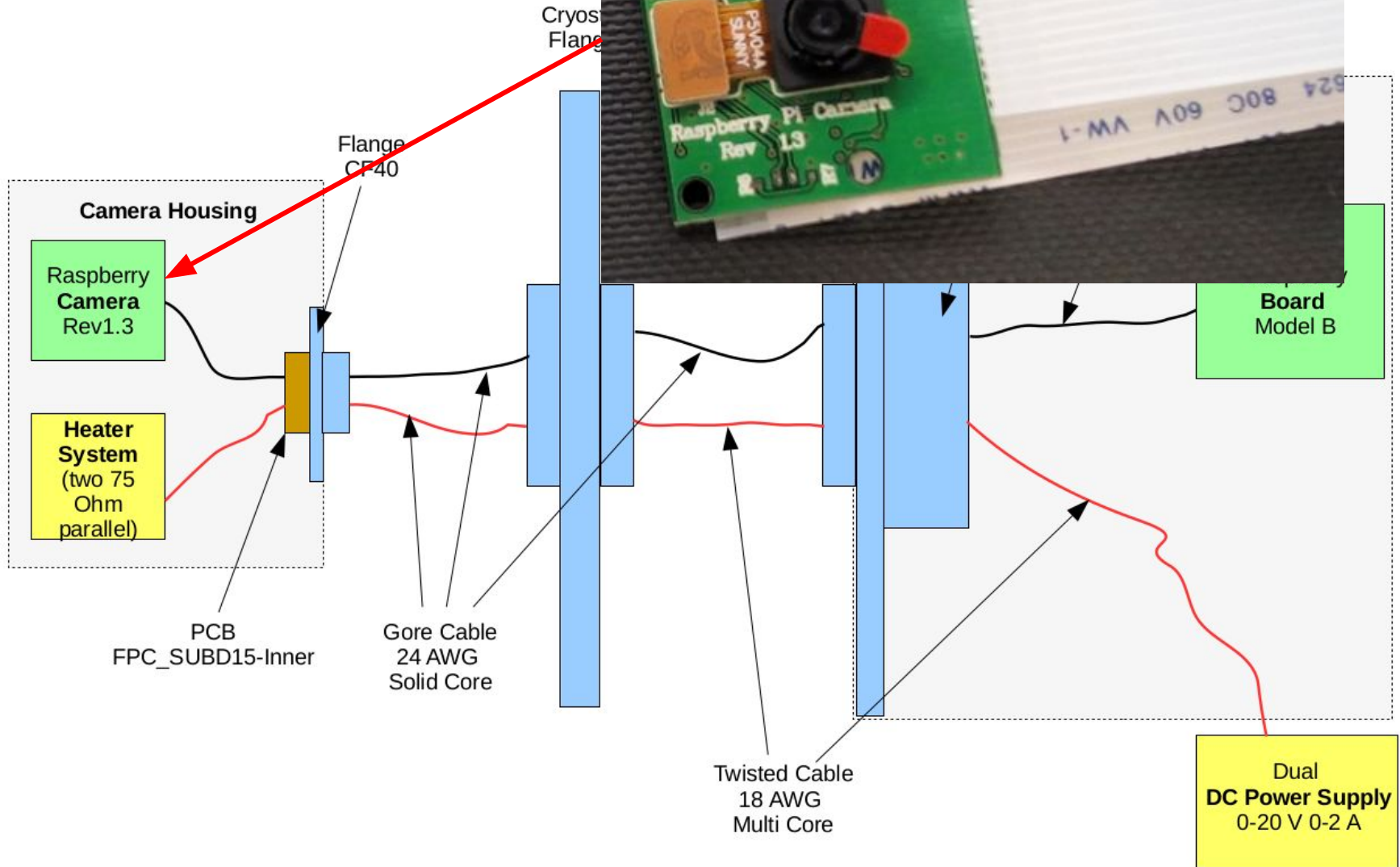


Thanks to ETH Zurich/ CERN.

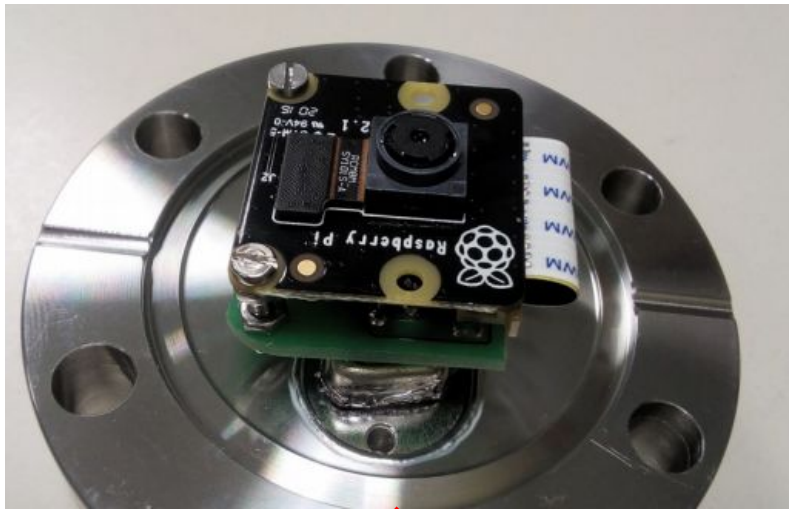
# System overview



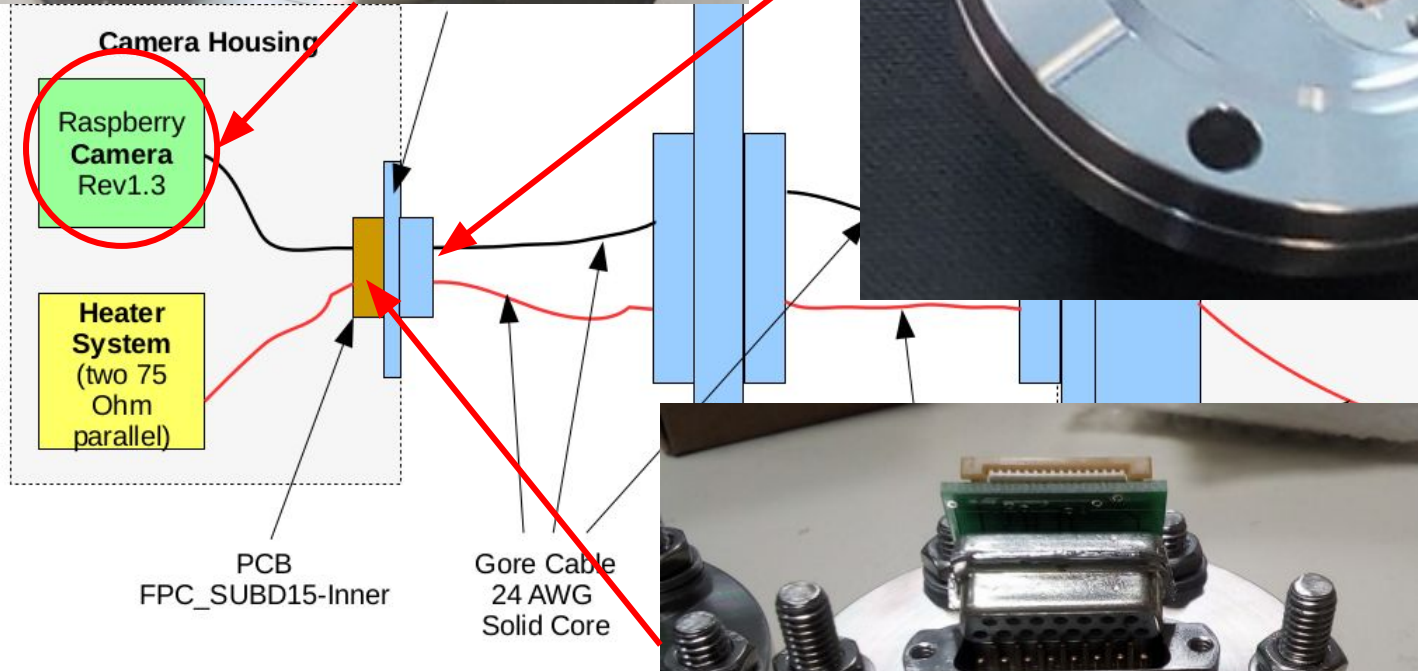
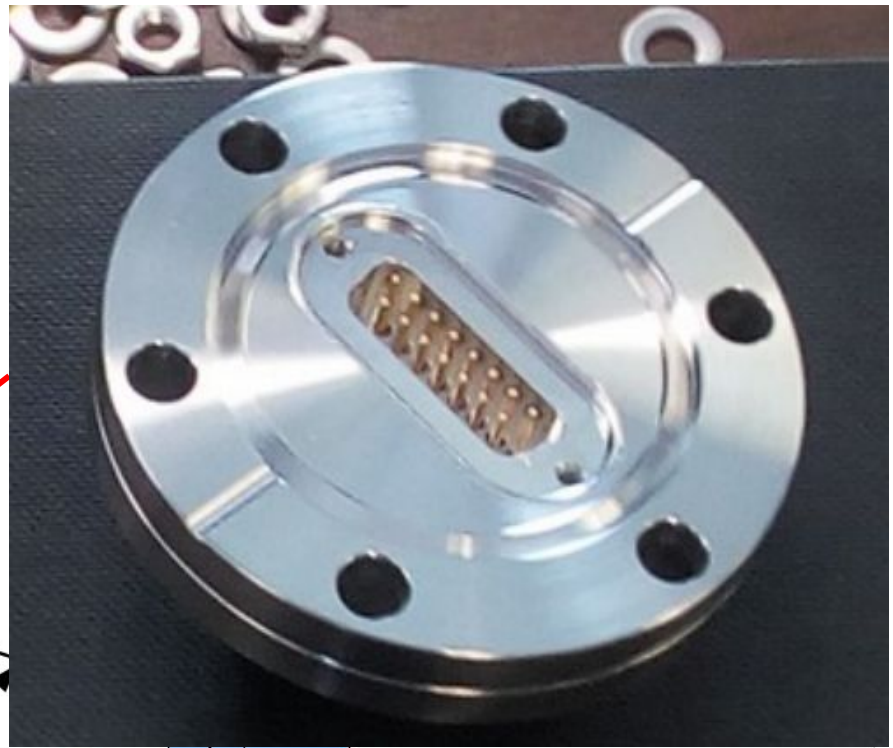
# System overview







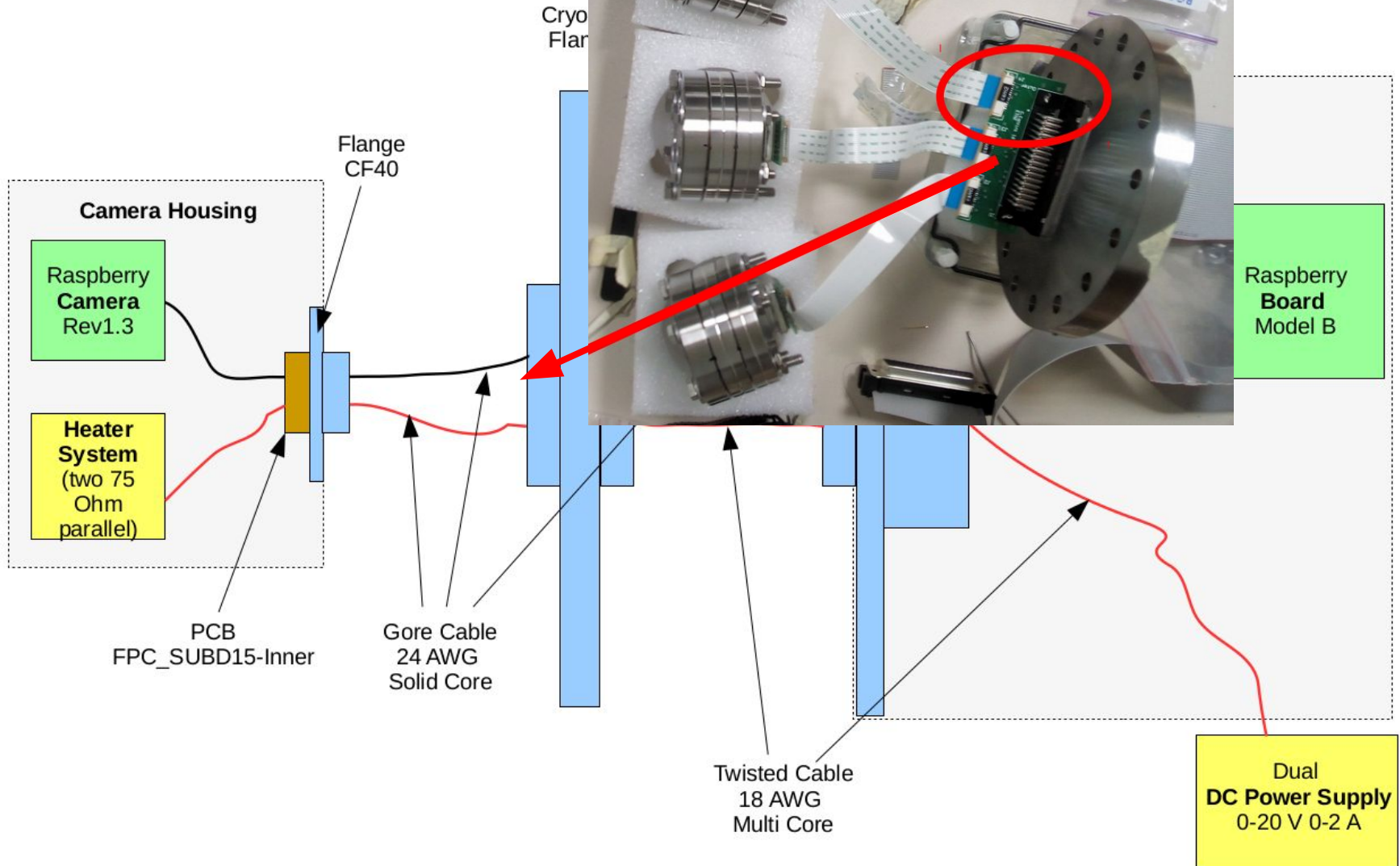
at  
e



Dual  
DC Power Supply  
0-20 V 0-2 A

# System overview

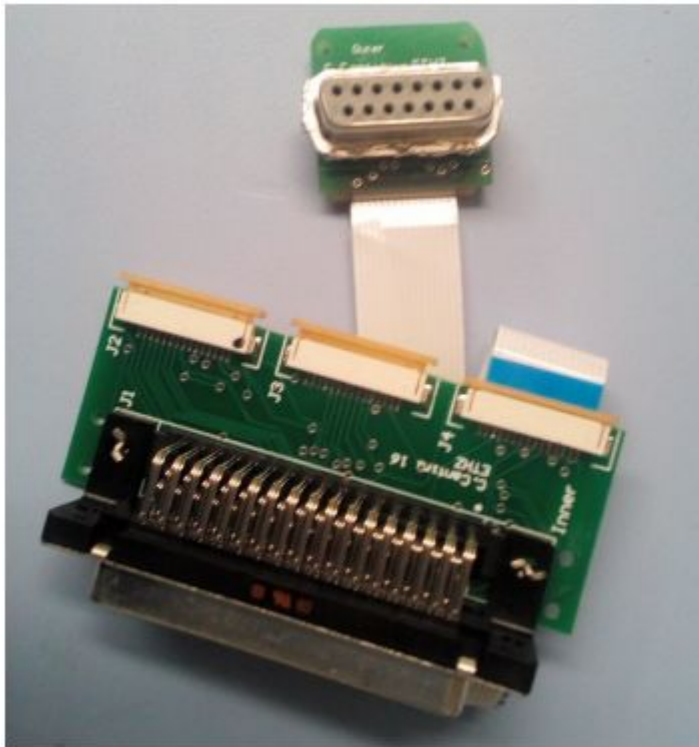
Original Setup





# Cable replacement

- Original flat flex cables gave poor images for  $L > 6\text{m}$
- Changed to multi-wire, solid core, 24 AWG cables from Gore inside cryostat
- Changed to 18 AWG multi-wire, multi-core cables outside cryostat



# Cable replacement

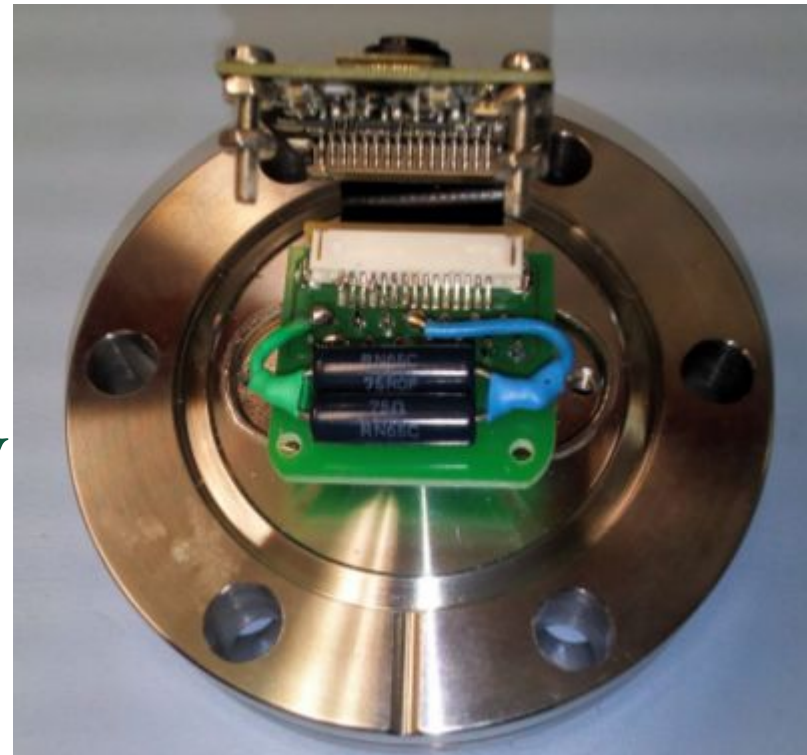


Camera	Length of Cable (m)	Plane / face
C0	4.8	Est
C1	3.6	Cup/South
C2	3.5	Top
C3	7.8	West
C4	6.0	North
C5	5.0	Cup/South

- Camera 5 stopped working 1 week after installation
- Camera 2 apparently has a bad connection and was disabled after 3 weeks.
- Need for autopsy and repairs. Consider installing redundant cameras.

# Heaters

- The cameras do not work reliably in LAr without heaters
- Repurposed spare ground lines to run 0.2ADC through a pair of 75 Ohm resistors coupled to the board
- Have warm  $\leftrightarrow$  cold cycled cameras multiple times
- Would like one power supply for each camera, or a resistive “power box”.

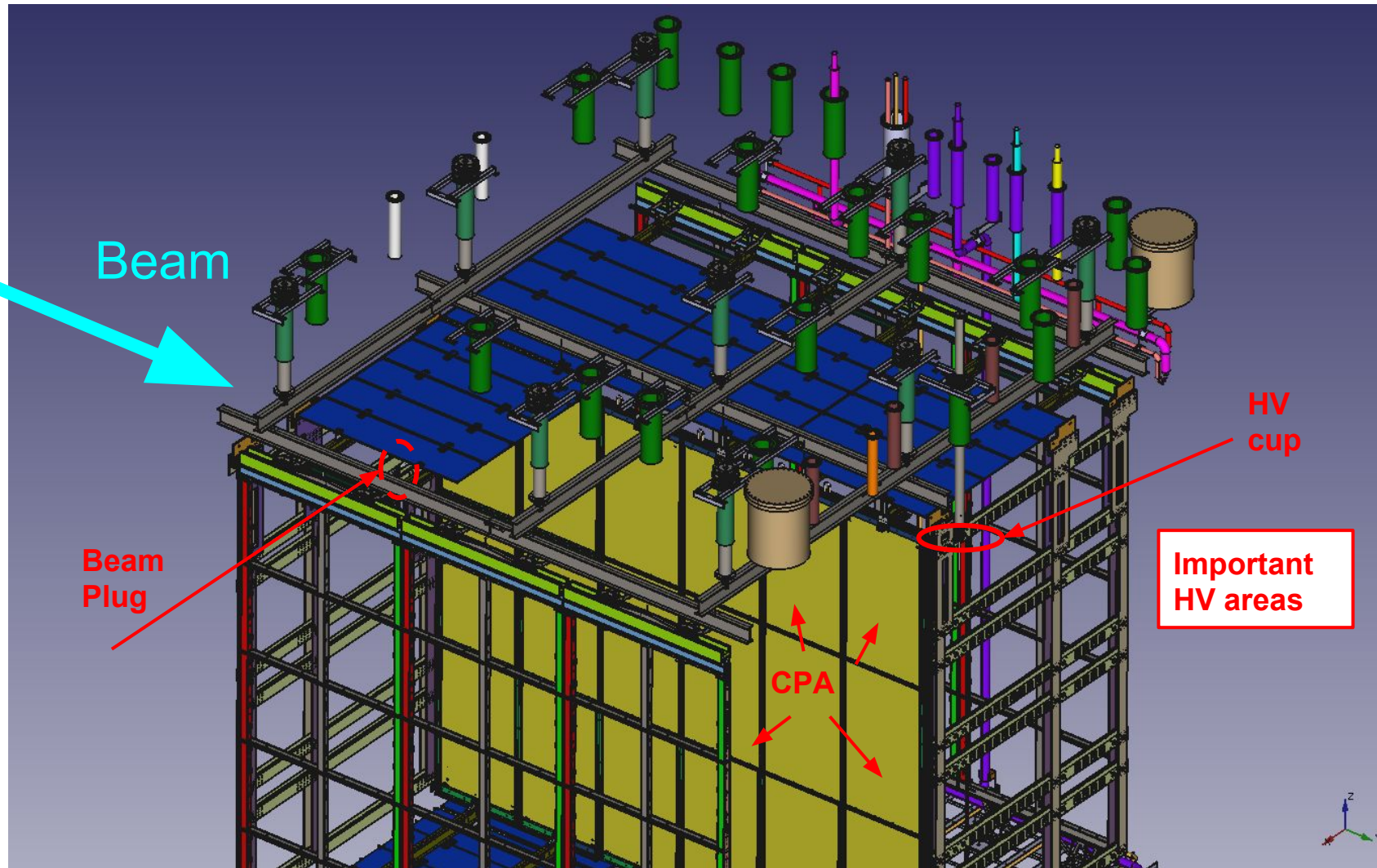


# Cables and connectors

- Experience connecting three 15 line cables to one 50 line Dsub connector wasn't positive.
- We prefer to have 15 pin connectors on cryostat flanges and dedicated cables for each camera.
- This makes each camera independent of the others and simplifies installation, operation and debugging.



# protoDUNE SP overview

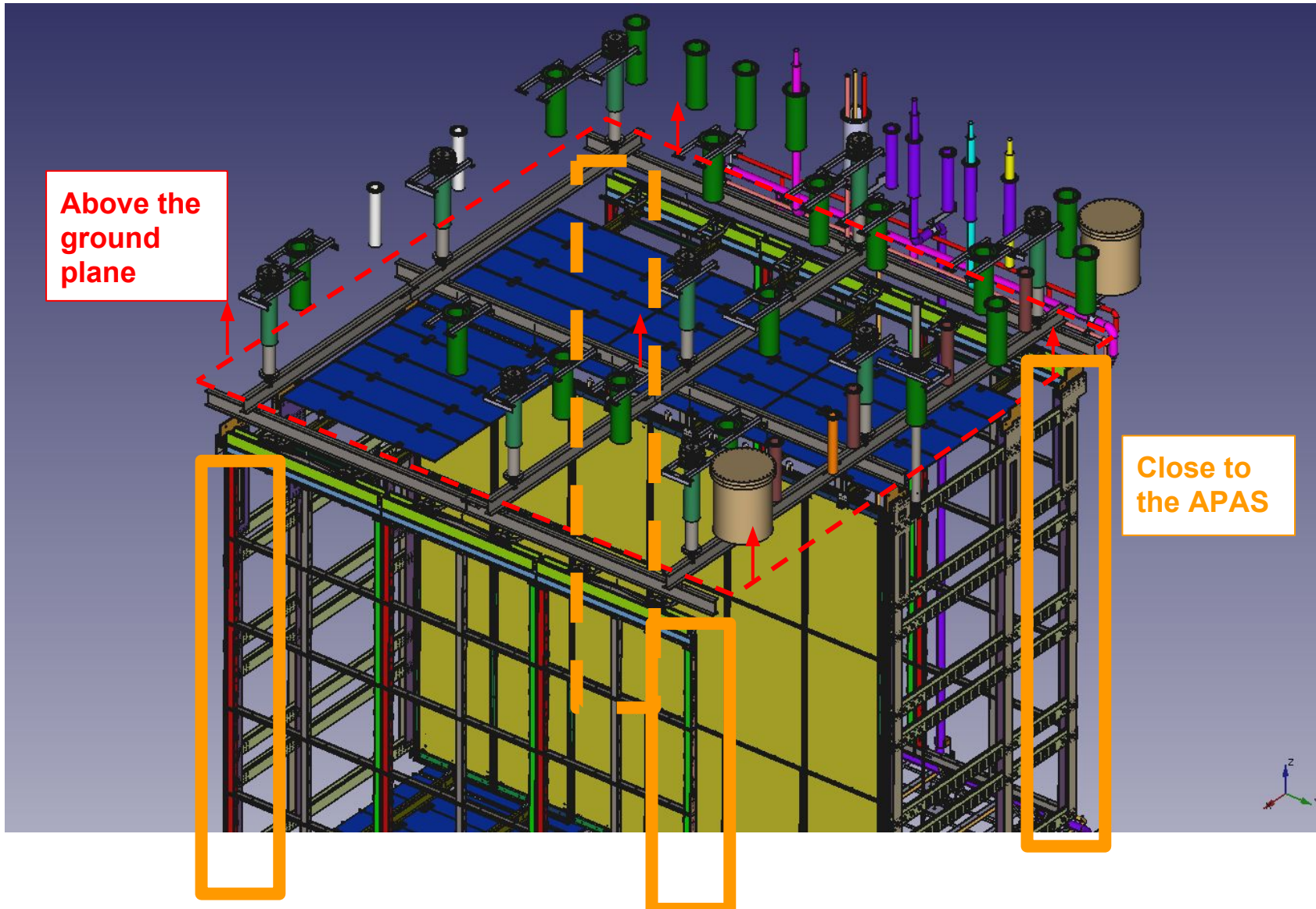




# Concerns for placing cameras

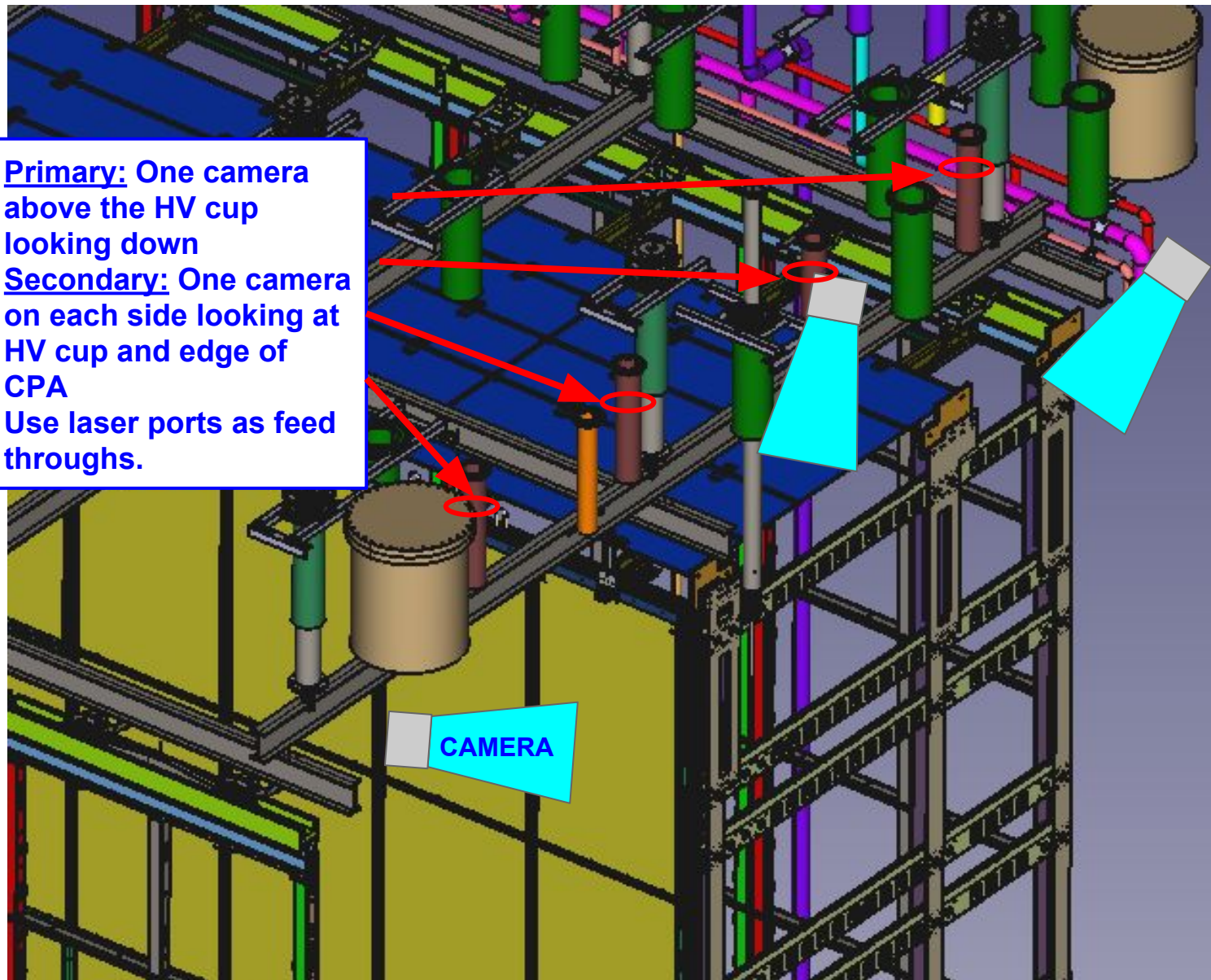
- Based on phone call with Bo Yu → **Thank you.**
- Avoid high field regions → discharge to walls
  - Cryostat walls at 0V
  - HV cup & CPA at -180KV
  - ...linear decrease to...
  - APA area at O(1kV)
- Cable runs should be kept as short as possible
  - An issue under study
  - 8m is the longest functional cable at the HV test
  - ... 3.5m the shortest
  - Some difficulty with middle length cables?
  - We should consider a warm repeater circuit.
- Should try to optimize focal length with lens inserts.

# Where can we place cameras?



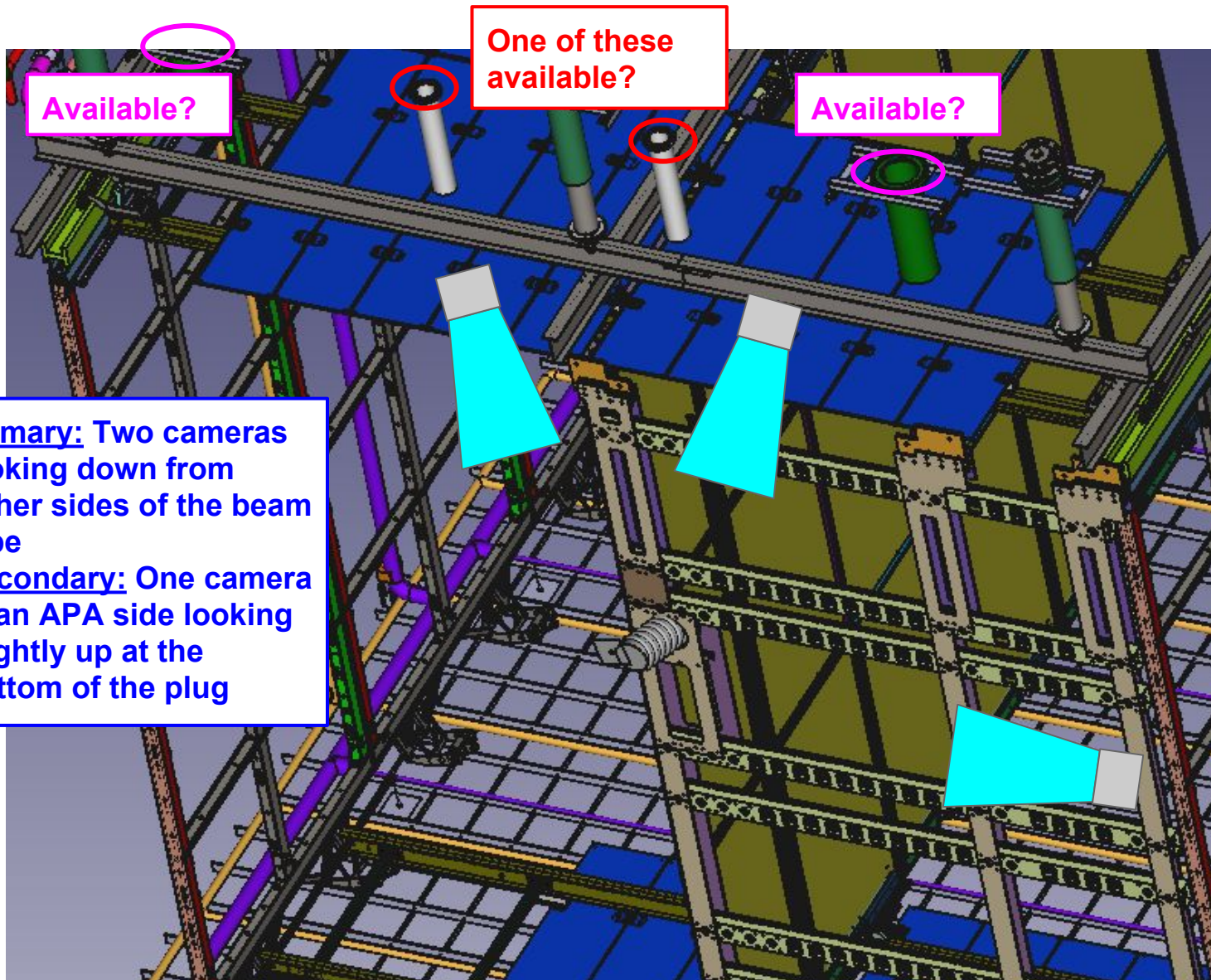
# Proposal - HV cup area

- Primary: One camera above the HV cup looking down
- Secondary: One camera on each side looking at HV cup and edge of CPA
- Use laser ports as feed throughs.





# Proposal - Beam plug area



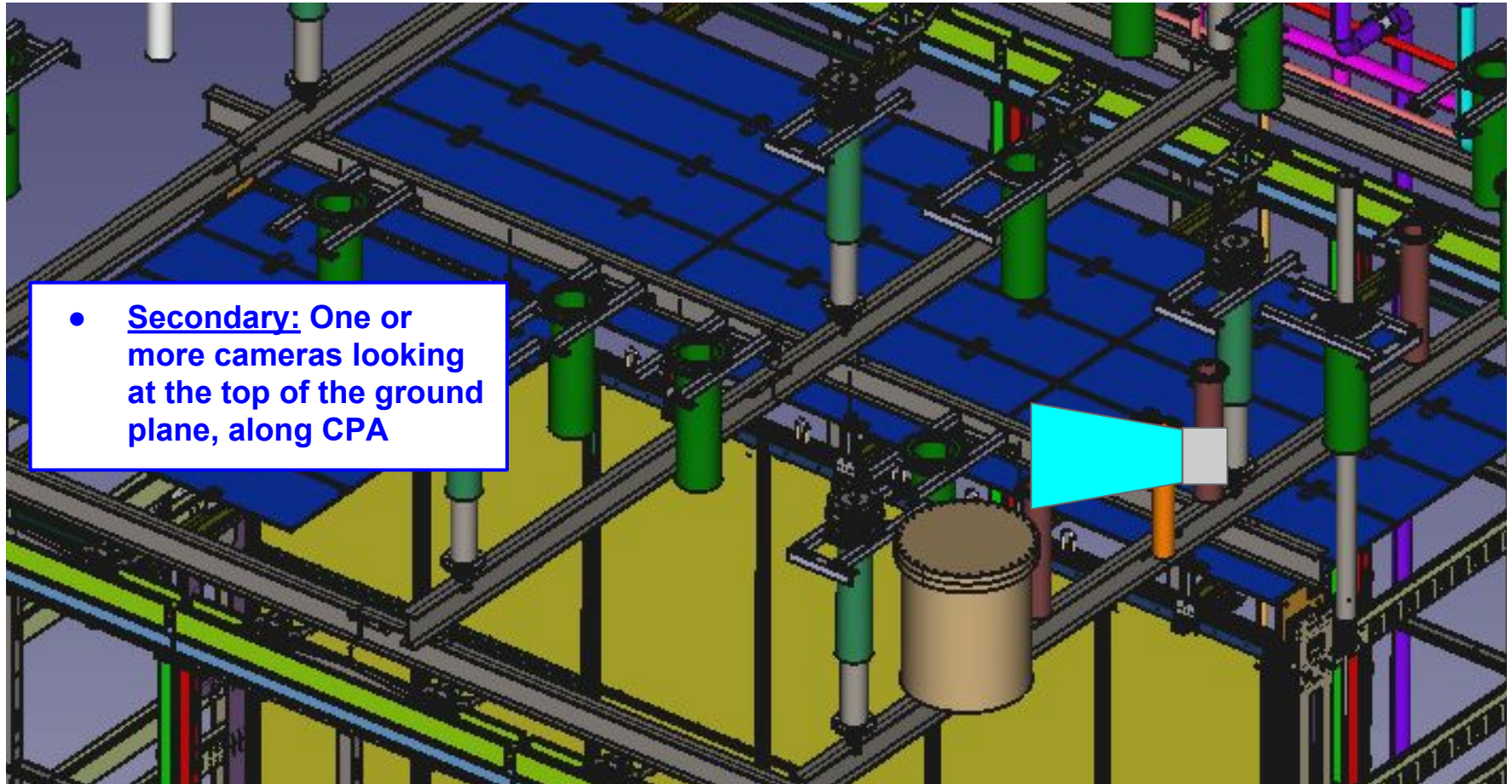
Available?

One of these available?

Available?

- **Primary:** Two cameras looking down from either sides of the beam pipe
- **Secondary:** One camera at an APA side looking slightly up at the bottom of the plug

# Proposal - ground plane



**Not clear that this is needed.**



# Notes on placement

- Possible to monitor the cryogenic piping region and/or the APA electronics
  - May require longer cable runs
- Should consider developing a signal repeater if we'd like cable runs longer than about 8 meters
  - Would sit outside cryostat
  - Might be worth putting some thought into this regardless

# Other Notes

- Preference for single camera D15 connectors on flanges based on HV test experience.
- Considering the addition of a thermometer using remaining spare ground line.
- Raspberry Pi SBCs
  - Need 5.25V @ 2A → will need to have this provided
  - Run UNIX OS. Ethernet connection.
  - Propose to place in housings atop the cryostat feedthroughs.
- Adapting camera focal lengths is possible but will require some R&D → <http://www.truetex.com/raspberrypi>