Camera Electronics Systems

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Large Synoptic Survey Telescope

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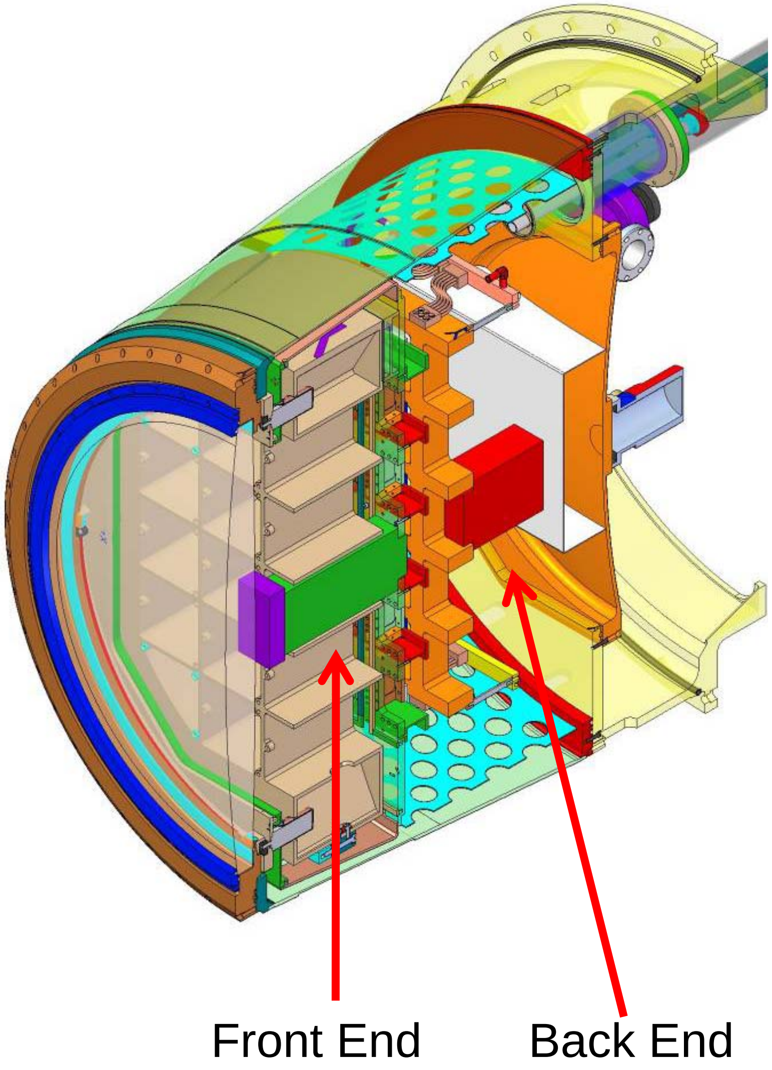
Penn

Outline

- Camera Electronic Systems
  - Science Electronics (including corner rafts)
  - Power regulation and distribution
  - Cabling
  - Controllers / sensors
  - Safety / Alarm system

- In-Cryostat Electronics
  - Quick overview
- Utility Trunk Electronics
  - Location(s)
  - Cabling challenges
  - Box utilization
  - Repair scenarios
  - Installation scenarios
- Cabling from camera to elsewhere
- Off Camera Electronics

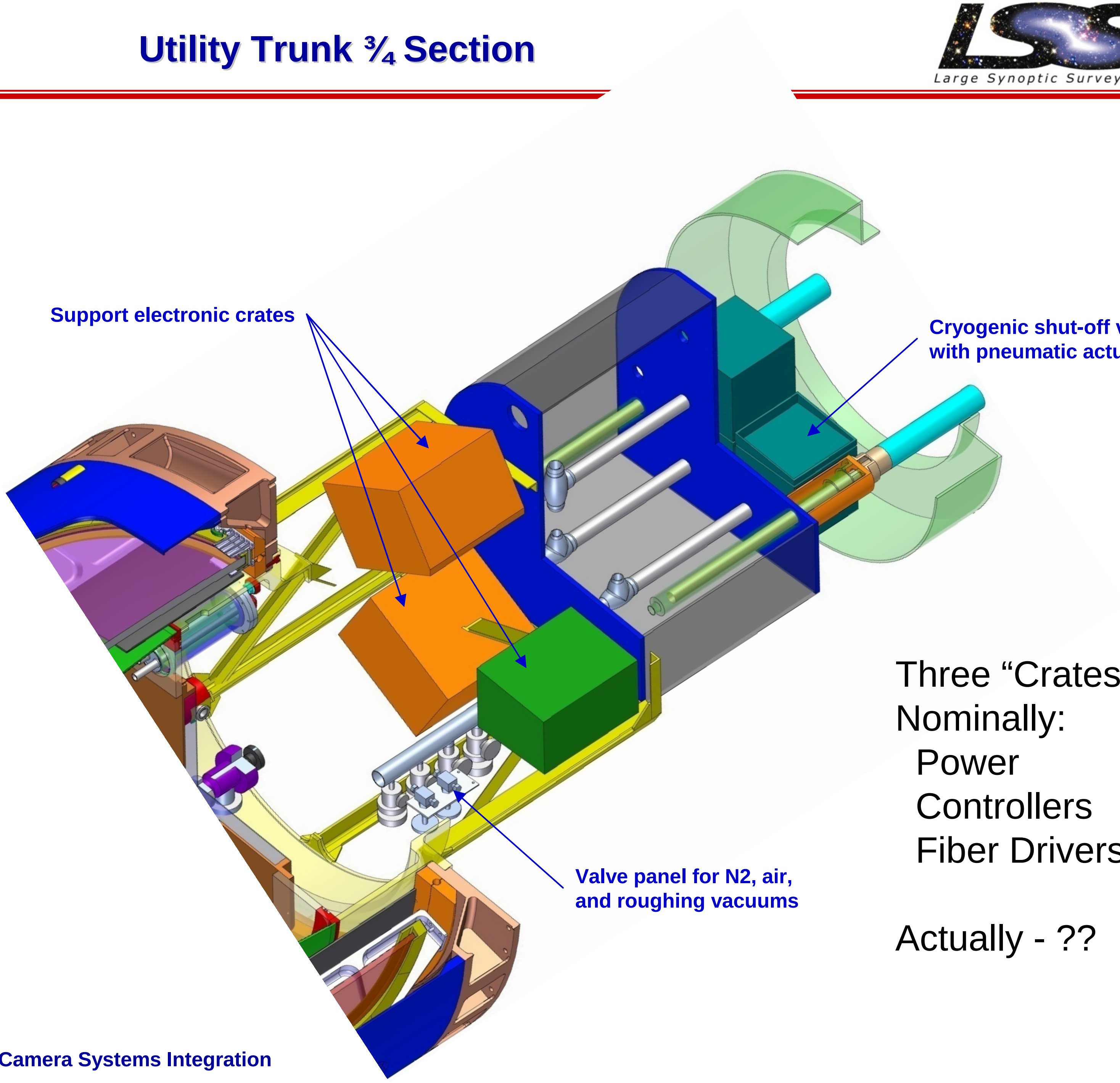
Science Electronics



- 21 Science rafts
- 4 Corner rafts
- Each with
  - Front End Electronics
  - Back End Electronics
  - Cables from sensors to FE
  - Cables from FE to BE
  - Cables from BE to Flange
- Each needing
  - DC power
  - Cooling
  - Control
- Each a source of
  - Data

- Input AC Power from Observatory
  - 1 or 3 Phase?
  - Input filter
  - AC→DC conversion
- DC-DC conversion for science loads
  - +7; +5; +18; +35; -70; …..
- DC-DC conversion for UT loads
  - +5; +12; +24; ….
- DC-DC conversion for other loads
  - ????
- Any AC loads in camera?
- Power supplies generally less reliable than most other electronics – therefore place active components in the "Electronics Boxes" in the UT where access is at least possible.
- Implies wiring from power input to those boxes and more complex wiring from that box or boxes to the various loads.

Utility Trunk ¾ Section



Three “Crates”
Nominally:
- Power
- Controllers
- Fiber Drivers

Actually - ??

- **Cabling to Boxes From:**
  - **Cryostat**
    - Power – about 10 wires per raft
    - Controls – about 10 wires per raft
    - Data – 4 coax per raft
    - In cryostat temp measuring
    - In cryostat other stuff
  - **Filter Changer**
    - 20 (?) wires
  - **Shutter**
    - 10 (?) wires
  - **Body temperature sensors / heaters**
    - Many wires
  - **Vacuum System(s)**
    - ???
  - **Cryo System(s)**
    - ???
- **Cabling from Boxes to Outside World:**
  - **AC Power from Observatory**
    - 1 quad
  - **Data Fibers to SDS**
    - 29+ pairs
  - **Ethernet (fiber?) to/from CCS**
    - A few pairs
  - **Safety System?**
    - ????

Controllers

- Controller Logic
  - TCM – Brandeis
  - Fiber Interface – Ohio State
  - Shutter - ?
  - Filter Changer - ?
  - X-Ray Calibration - ?
  - Vacuum - ?
  - Temperature (Cryostat) - ?
  - Temperature (Body) - ?
- Sensors
  - TCM – Temp + ?
  - Fiber Interface – Temp + ?
  - Shutter – limit switches, encoders, other?
  - Filter changer - limit switches, encoders, other?
  - X-Ray Calibration - limit switches, encoders, other?
  - Temperature (both) – RTD, NTC?
- Actuators
  - TCM – none
  - Fiber Interface – none
  - Shutter – motors, solenoids
  - Filter Changer – motors, solenoids
  - X-Ray Calibration – motors, solenoids
  - Vacuum – pump(s), valves?
  - Temperature (Cryostat) - heaters
  - Temperature (Body) – heaters, valves?, other?

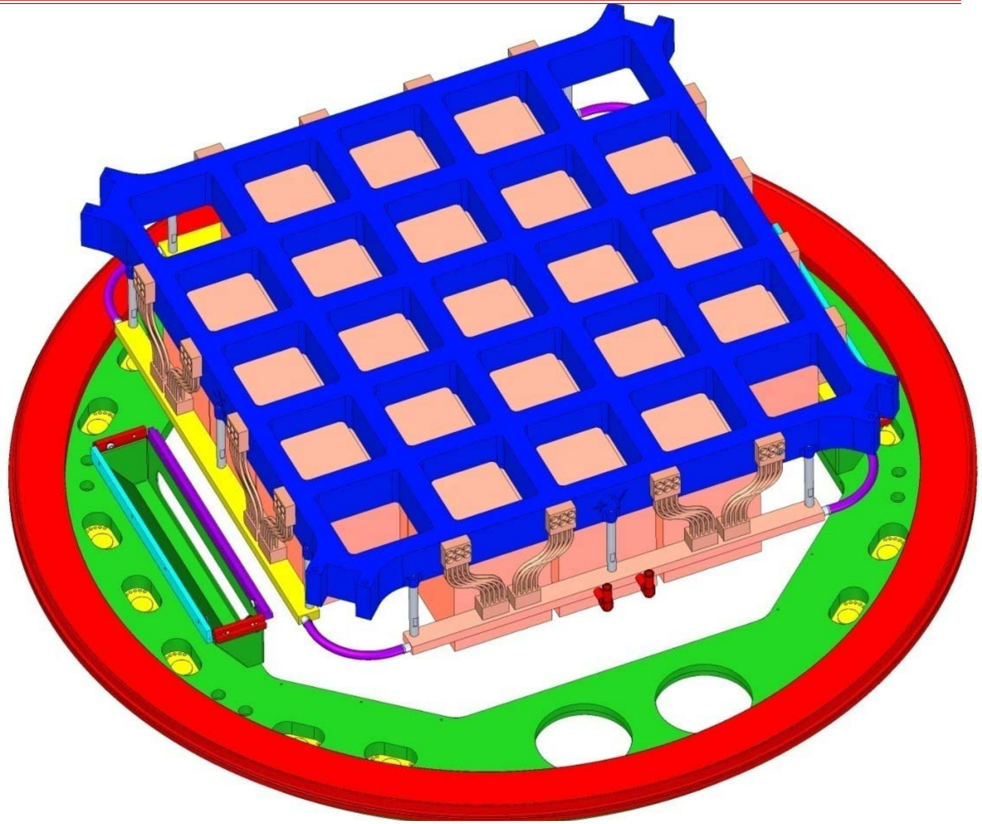
(Custom construction)

Safety and Alarm System

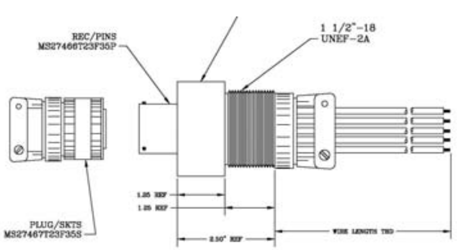
- Undefined except that "software does not protect hardware"
- Need to protect:
  - Sensors
    - Overvoltage
    - Deposition
    - Heat
    - Warping
    - ???
  - Grid & mechanics
    - Heat
    - Warping
    - ???
  - Cryostat
    - Loss of vacuum
    - Loss of coolant
    - ???
- Simple hardware based protection
  - Discrete logic
  - PLC
  - Other??
- Need to monitor:
  - Temps
  - Pressures
  - Flows
  - Voltages
  - Other??
- Need to control:
  - Power supplies
  - Coolers
  - Pumps
  - Other??

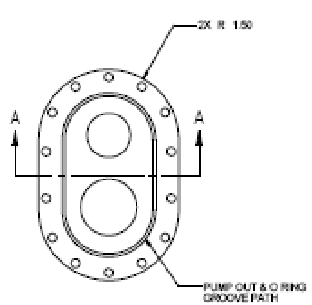
Data, Control, & Power Feedthroughs

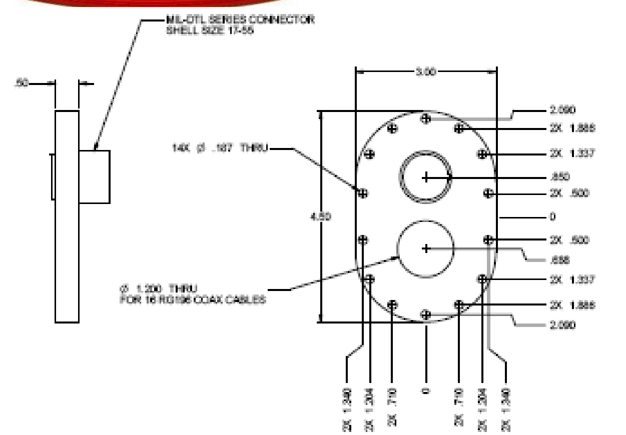
Large Synoptic Survey Telescope



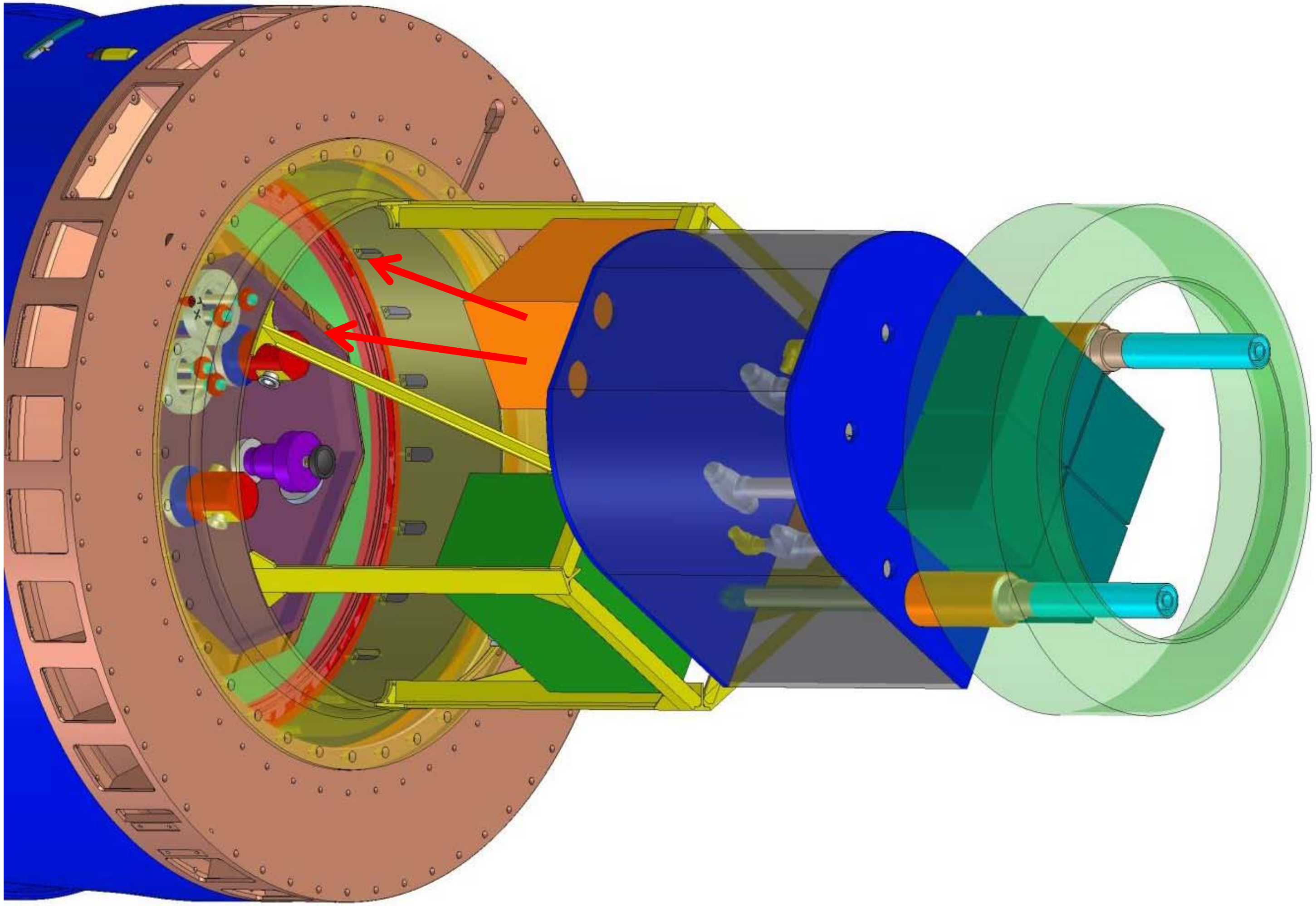
- **Two types of connection:**
  - **Coax for high speed data (4 coax per raft) – straight through coax, SMA connectors on Raft and Fiber ends.**
  - **Wire for power and control – wires to connector on Raft side, MS connector on UT side.**
- **Three rafts per feedthrough plate (corner rafts a bit special)**
  - **Need ~9 for science + corners**
  - **Need others (all wire??) for other cryostat functions plus calibration fiber feed throughs – cost not a strong function of volume at this level so specials are ok**







Harness Routing - Boxes to Cryostat and Shutter

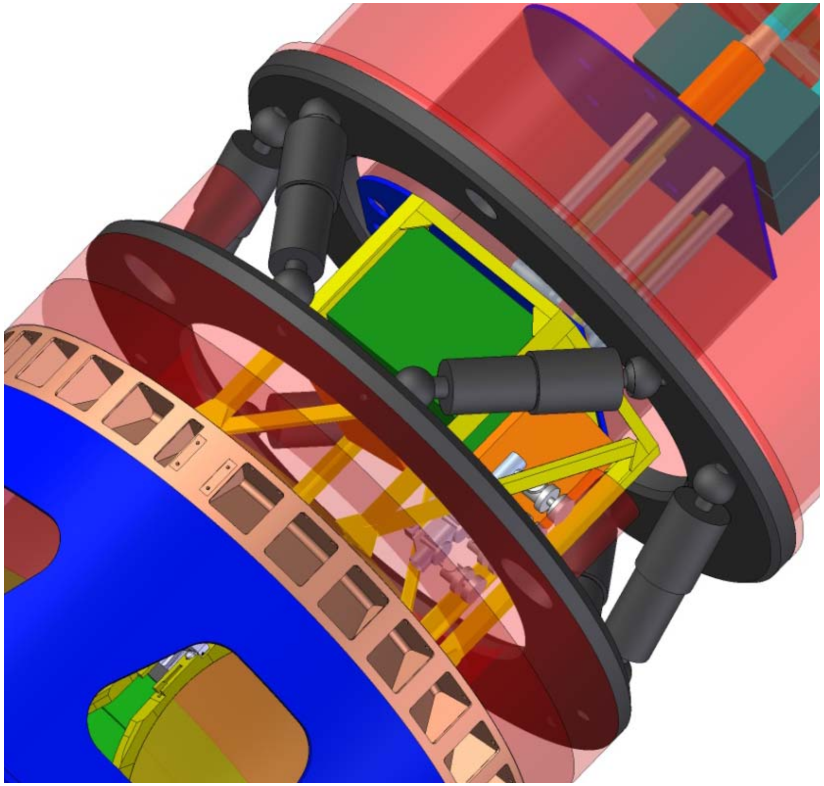


Box Design Considerations

- Total Volume
  - Guess 3 cubic feet total
  - Need to itemize objects to get better estimate
  - That needs designs for power, fiber, TCM, controllers – some time to go
- Shape / Design
  - Objects natural size / shape
  - Cabling
  - Cooling
  - Access through hexapod
  - No obvious standards to use but for regular parallelepiped can use Eurocard parts with custom side plates
- Cabling
  - Better for servicing of object to have no permanent cabling out front (large r)
  - Implies rear connectors that have object inputs and outputs – e.g. bulk power in, power to rafts out
  - May not be so easy for Fiber Interface??
  - May imply some “backplanes” to mount connectors, not to bus data (but maybe to bus power?)
  - Easy connect/disconnect of box harness would ease installation and servicing (or do we swing boxes out of UT volume using final harnesses?)
- Cooling
  - Conduction or do we have a fan or fans in the UT??

Installation, Access, Repair

- Installation on tooling fixture, relatively unconstrained.
- Fast repair scenarios imply reaching through hexapod, removing a cover, removing a board or sub-box and then replacing with a spare
- How much real access space is there?
- How wide / large can we make a removable panel (a card or sub-box is, presumably much smaller)?



To the Outside…..

- **Cabling plant (electro-optic only) is pretty small**
  - **AC Quad ~ 1cm dia.**
  - **100 Fibers ~ 1-2 cm dia.**
  - **Safety / Alarm ??**
- **Plumbing is much larger**

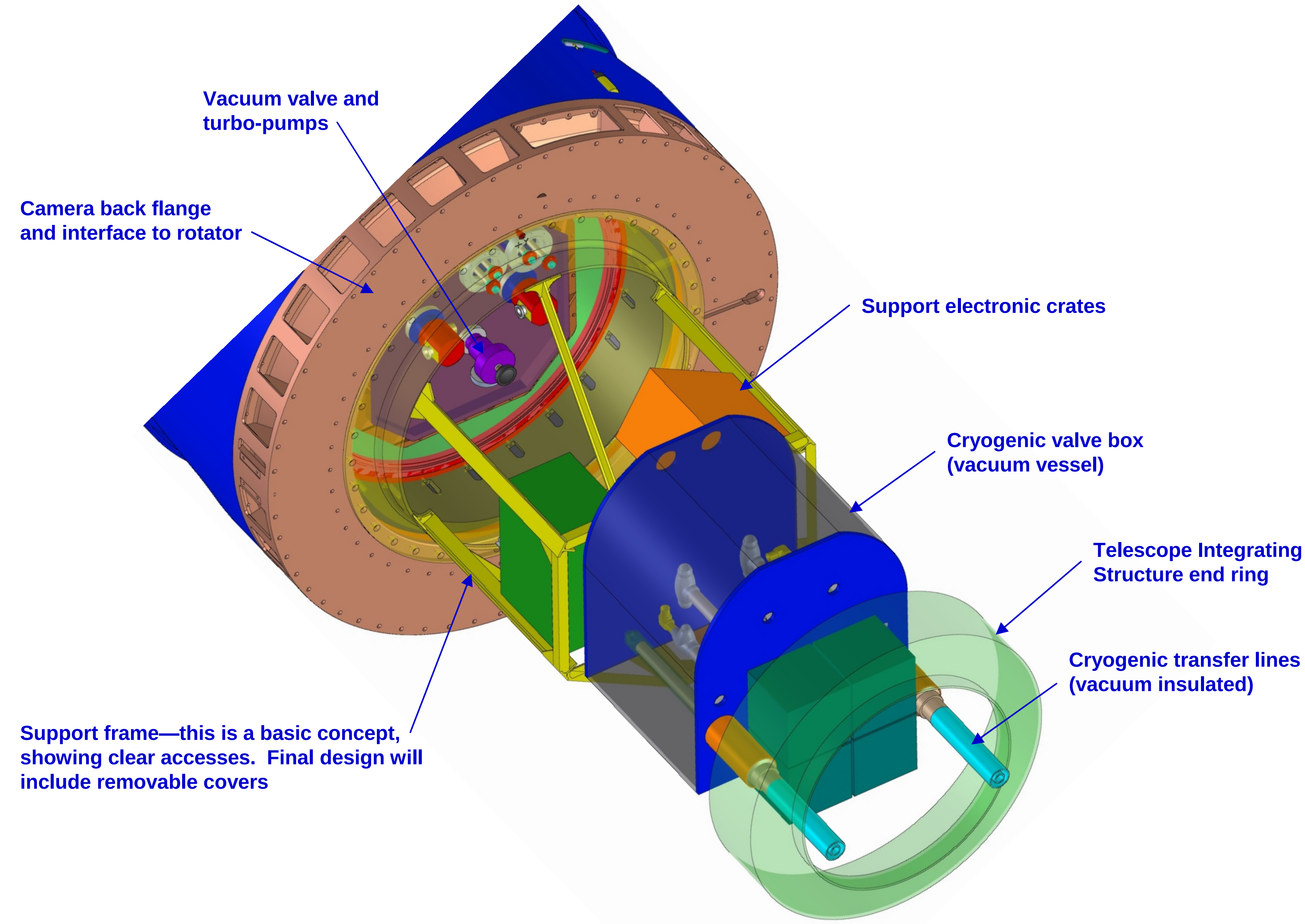
- **Off-Camera “Electronics” –**
  - **Safety / Alarm System**
  - **AC power conditioning (filtering, UPS, ??)**
  - **Parts of cooling and vacuum systems but not really part of “Electronics”**

Utility Trunk Contents

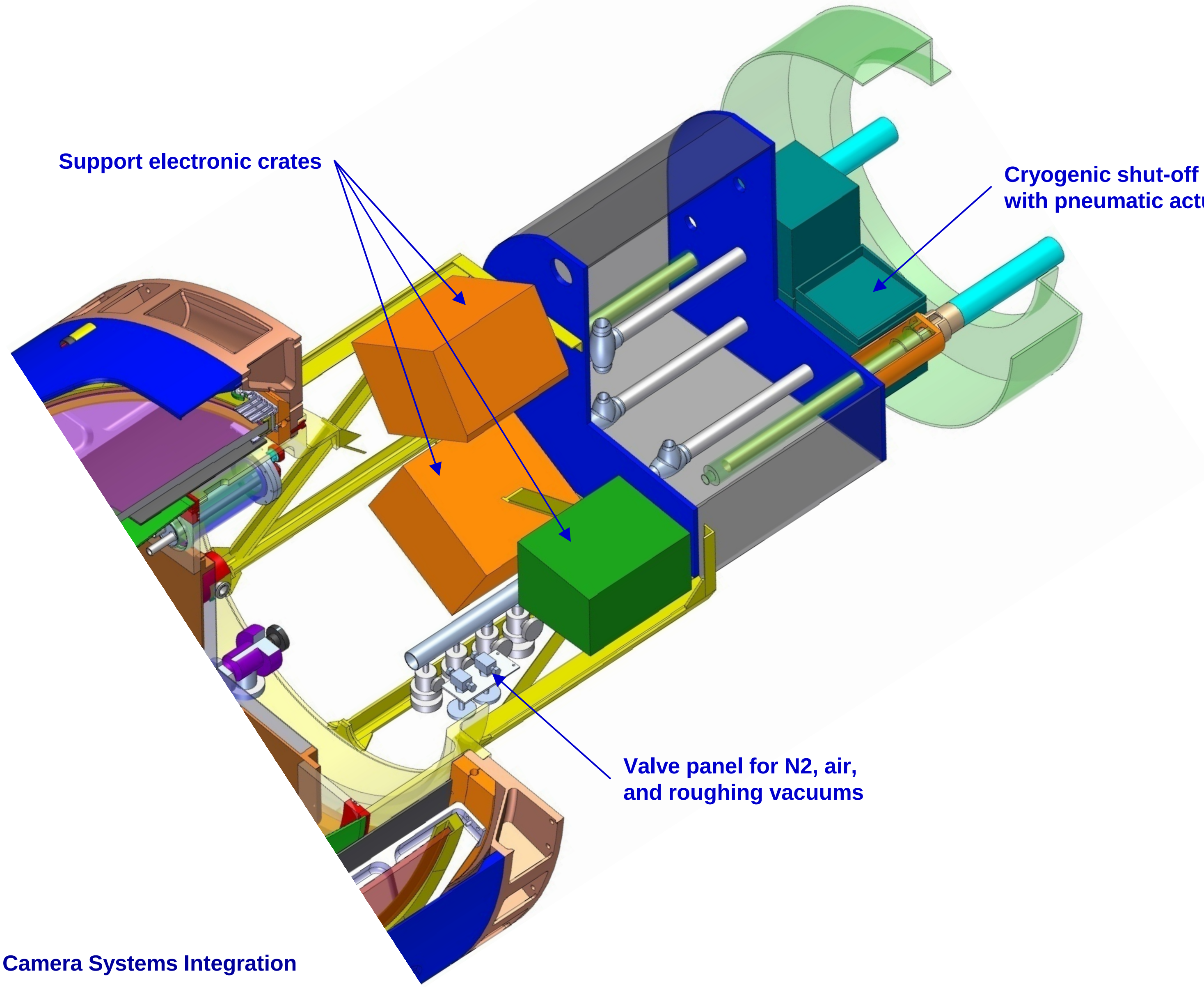
- **Until recently, we have just been holding the utility trunk volume open, knowing that we would have some camera hardware to put there**

- **We now have the start of a real design**
  - **Support electronics requirements**
    - 3 crates, each about 1 ft^3 (per Rick Van Berg e-mail)
    - Try to make the crates accessible through the support hexapod, so boards can be replaced on the telescope
    - Crates need provision for cooling
  - **Valve box requirements**
    - Valves must remain roughly vertical during normal operations
    - Valves should be remotely actuated, both for system safety and to speed up cooldown/warm-up cycles
    - Remote actuation means that valves do NOT need to be accessible for hand operation while on the telescope
    - Large, heavy, bulky cryogenic transfer lines must be accessible so they can be disconnected when the camera is being removed from the integrating structure (ground operation only)
  - **Interface with telescope**
    - Telescope rotator inside diameter is not negotiable, which means our Utility Trunk max diameter must get smaller → 940 mm is the max diameter allowed (CoDR trunk diameter is 1005 mm)
    - Access is essentially not possible while on the telescope EXCEPT by reaching through the hexapod support structure → this access is limited, but is the only way to get into the electronics crates

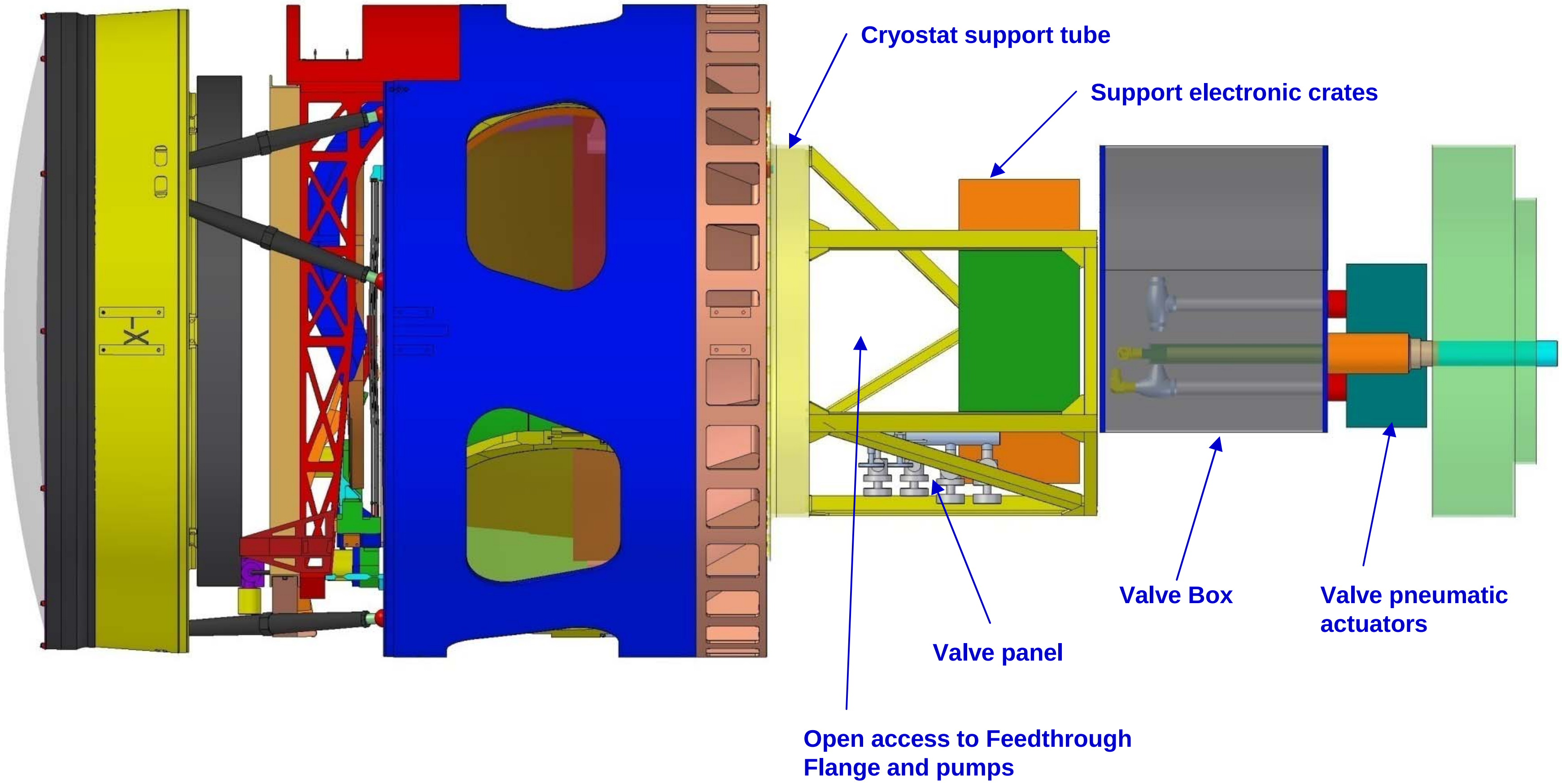
Utility Trunk Re-Design



Utility Trunk ¾ Section



Utility Trunk Side Elevation



Utility Trunk Inside the Telescope Structure

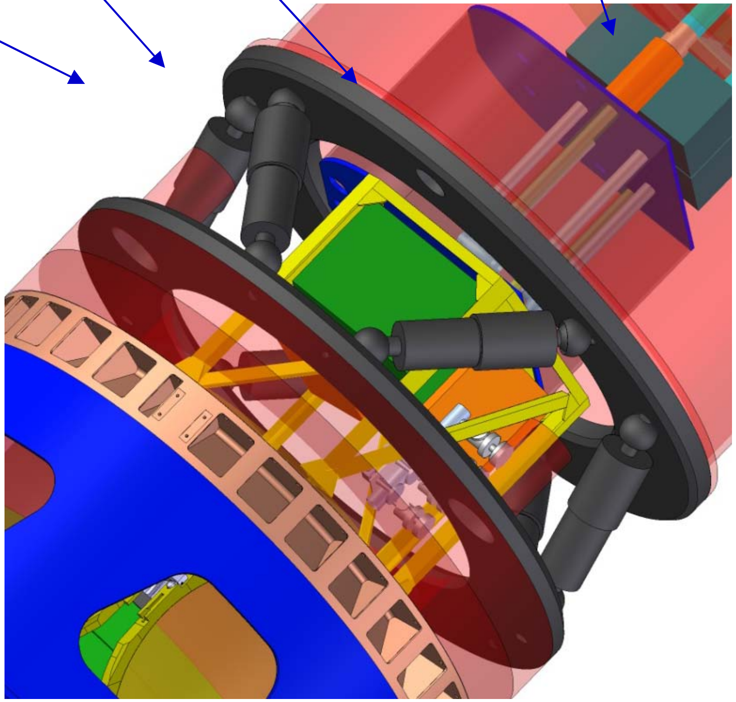
Support tube—this runs through the bore of M2 and its stiffening structure

Front end of telescope Integrating Structure

Hexapod—this is just a notional concept with much hardware missing

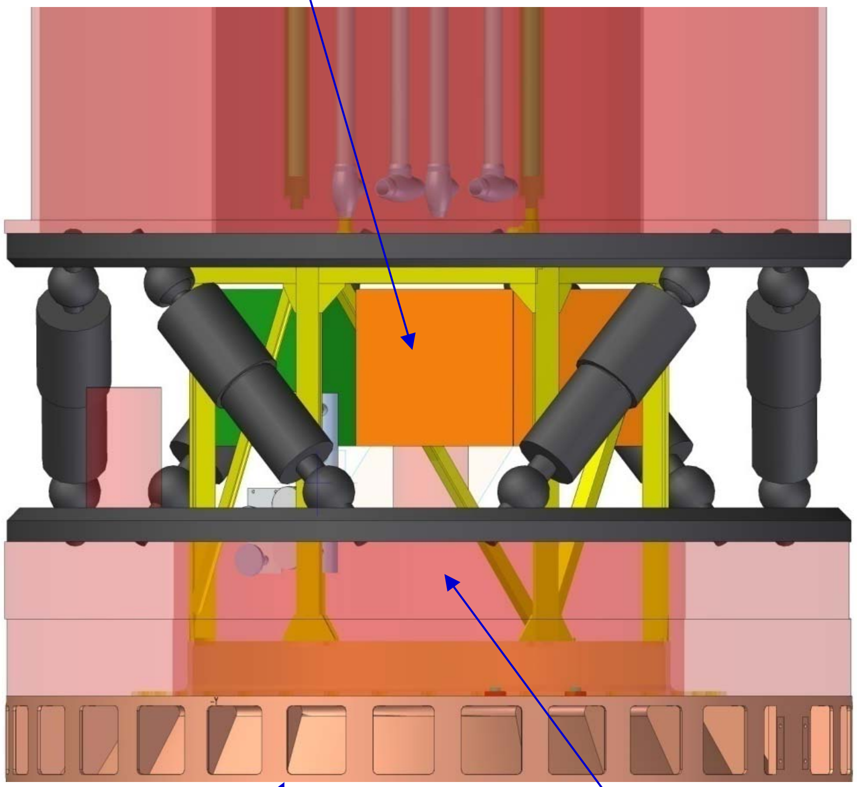
Rotator

Camera back flange mounted to Rotator



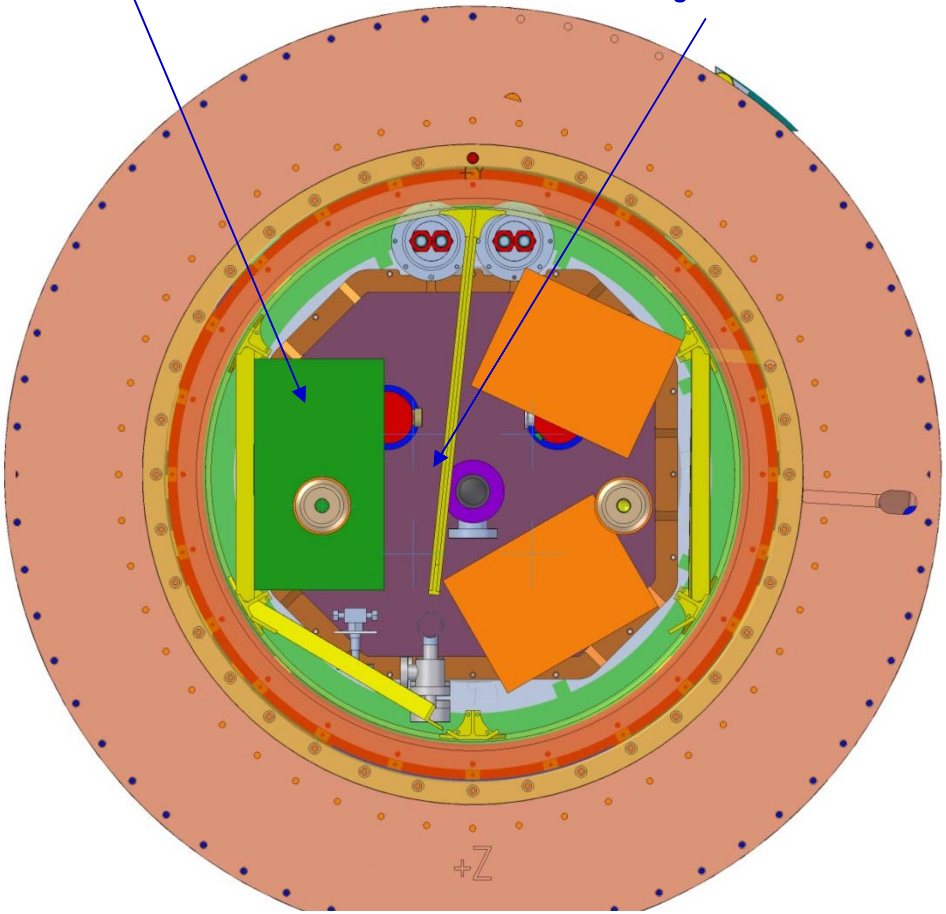
Access to Support Electronics Crates

Access to front of crates through the hexapod legs



Crates arrayed with front facing radially outward

Center volume clear for cable/fiber routing and cooling for crates



The camera rotates with respect to the hexapod, so if needed we can rotate the camera to align a crate with an opening in the hexapod

Additional volume is available, but the access is much more limited

Questions

- What is the preferred crate type?
  - It looks like we have a comfortable amount of room, so we don't need to miniaturize these crates
  - What standard crate type do you want to use? What are the standard shapes and sizes?
  - Once we have a crate type, we can lay out real crates and give you a much better idea of the total number of boards that will fit
- How do cables and fibers connect to crates?
  - The layout assumes that connections would be on the back side → these would be relatively inaccessible, but allow free access to the boards
  - Cables and fibers would likely be routed up cable ways mounted to the support structure
- Test crates
  - One problem with this (or any other) design is that the support electronics block direct access to the back end of the cryostat
  - This means that the crates cannot be there while we are integrating, but test crates will be needed
  - The test crates will need to be off to one side, meaning that all of our custom cable and fiber lengths won't reach the test crates
  - We could use pigtails or test cables → any timing issues?
- Other issues to work
  - We are also starting to firm up our N2, air, and vacuum plumbing needs → these can take up quite a bit of room, so we will be laying out volume for those systems, as well