Pixel Cables

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Pixel General

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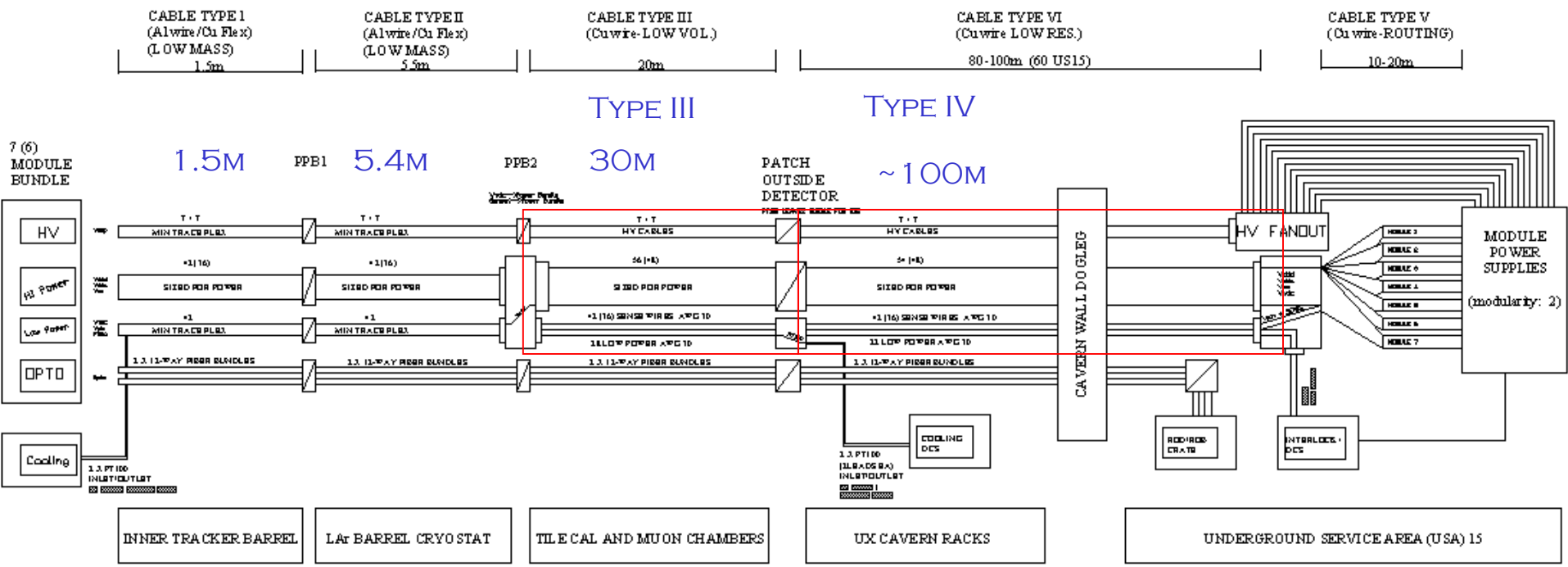
Cable Plant Overview

- Reminder of what we're talking about
- Cable plant consists of Cable types 1-5 but not pigtail
- Cables sized based on local optimizations (e.g. mass, space, voltage drop) for each region
- Cost estimates focus on Type III and Type IV



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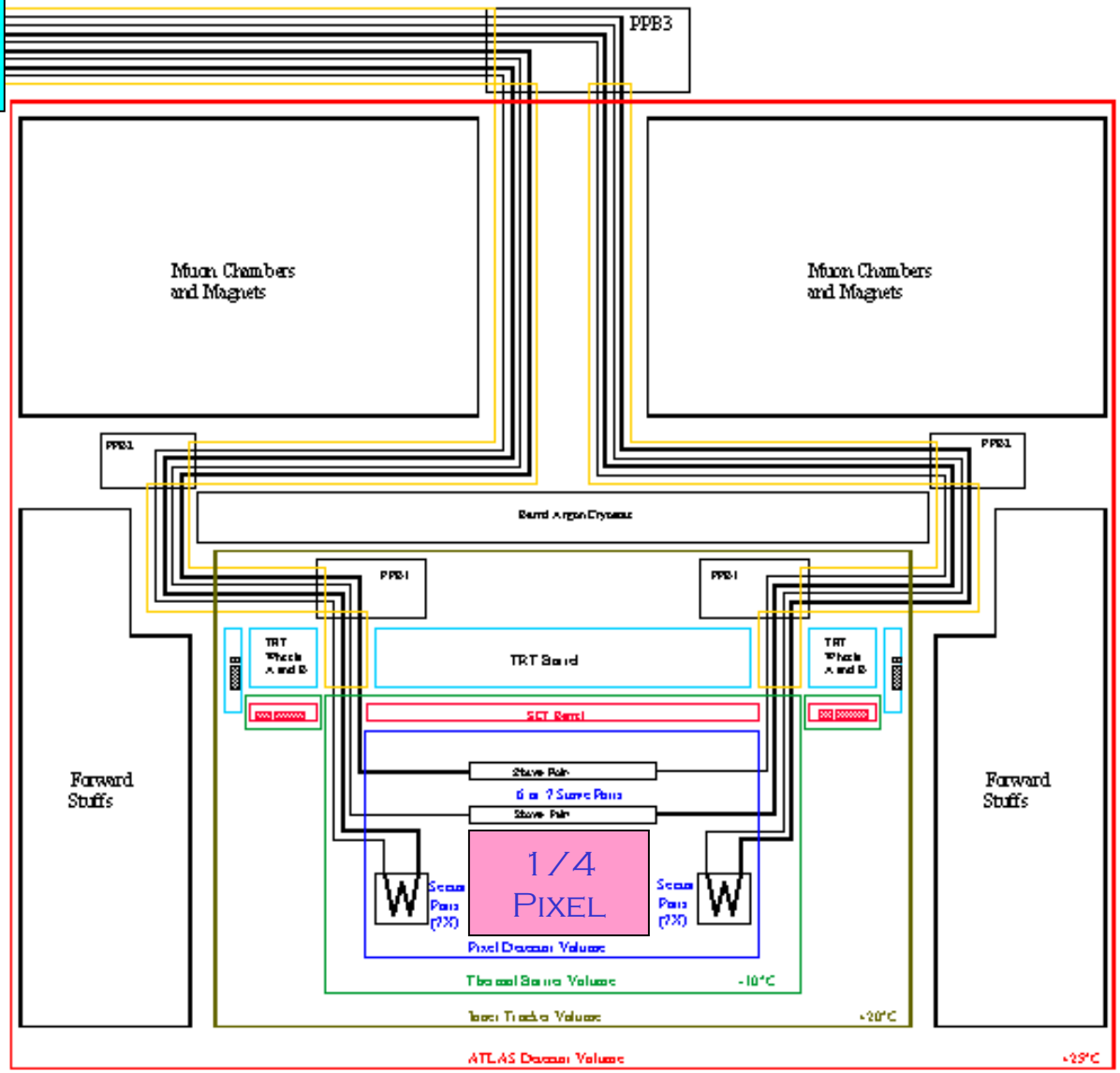
Tubing Layout

Pixel Cooling Rack



Tubes also jump up in size at every patch panel, can be typed similarly by region
type I to PPB1,
type II to PPB2,
etc

Staves and Sectors are cooled in pairs, currently in series

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Cooling Tubes

- **Diameters are defined by Cooling group in conjunction with M Olcese**
- **Connectors preliminarily selected, but not optimal nor meeting all requirements**
- **Auxiliary elements of tubing plant not well understood**
  - Tube insulation
  - Heat Exchanger(s)
  - Heaters
  - Temperature sensors
  - Fluid Sensors

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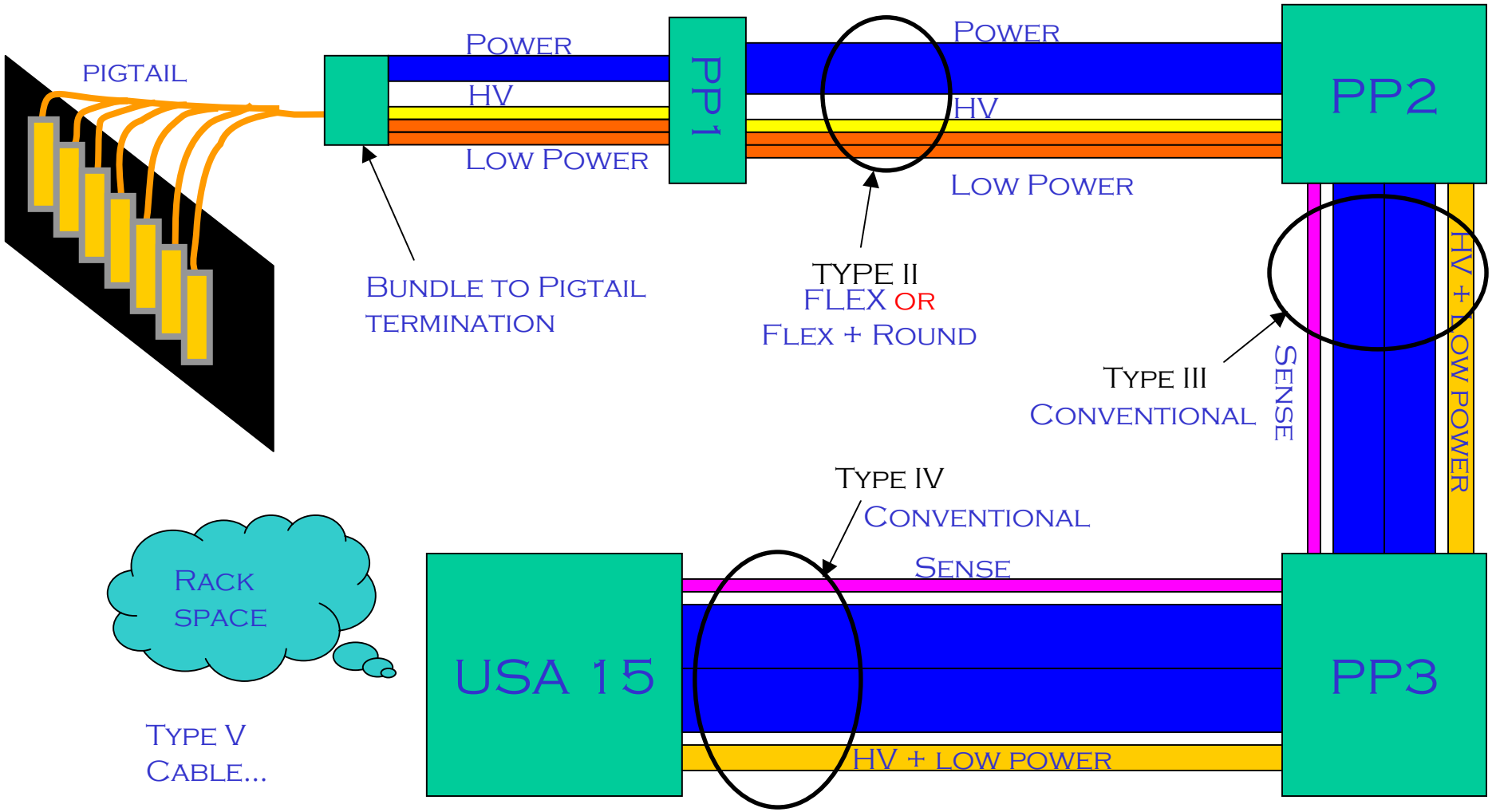
Cable Bundles Schematic



Definition of Bundles

- **A bundle powers 1/2 sector or 1/2 stave (6 or 7 modules)**
- **Cables within bundle can be divided into two categories--High and low power**
- **These can use different technologies to meet requirements**
- **A bundle is made of**
  - Power Cables for 6/7 modules
    - Vdd, Vdda, Vcc, Vvdc**
    - Flex or Round wire with conductor thickness and pitch sized for current
  - Control Cables for 6/7 modules
    - PT1000 (NTC), Iset0, Iset1, Reset, Vpin, Vvdc**
    - Minimum technological thickness and pitch conductor flex cable
  - High Voltage Cables for 6/7 modules
    - Vdet
    - nominally same flex technology as control, but meets HV requirements
- ****Special traces not so easily split into the above categories:**
    - Vvdc starts with control cables (I&II) and moves to power cables at PP2
    - Sense wires do not run all the way into the detector-start at PP2 (III&IV only)

Low Mass Cables (Types I & II)

- **Cable technology split functionally**
  - Low current voltages **Control** and **HV** on minimum thickness conductor **flex**–SAME ART FOR BOTH TYPE I & II
  - High Current (Power) on either thick conductor **flex** or twisted pair **round** conductor
- **Definitions of components**
  - **Power** Cables for 6/7 modules
    - **Vdd, Vdda, Vcc, Vvdc****
    - Flex or Round wire with conductor thickness and pitch sized for current
    - Flex-Types I and II are each different art
    - Twisted pair option jumps in conductor size at PP1
  - **Control** Cables for 6/7 modules
    - **PT1000** (NTC), **Iset0**, **Iset1**, **Reset**, **Vpin**, **Vvdc****
    - Minimum technological thickness and pitch conductor flex cable
  - **High Voltage** Cables for 6/7 modules
    - **Vdet**
    - nominally same flex technology as control, but meets HV requirements

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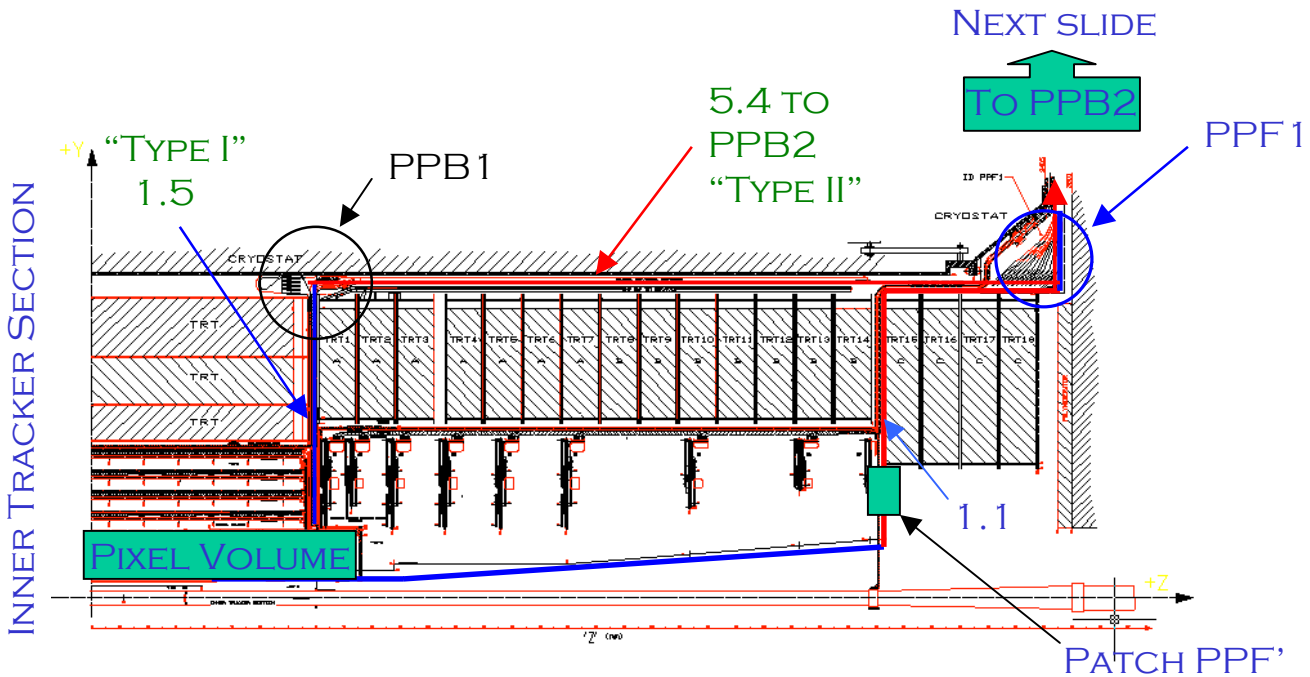
Cable Types I & II (low mass cables)



Type II cables are shown in Red, type I in Blue

B-Layer services are run along a different path than the rest of Pixel Services--change at PPF1

- Power cables change size at PPB1 and PPF1 from "Type 1" to "Type 2"
- Nominally both have a 0.4V drop, sized based on respective lengths
- Undecided whether all flex or combination of flex and twisted pair--wait for prototype cable sets and test results
- ROM Cost Estimate
  - Flex Material Cost and Labor
  - Conventional Cable Cost
  - Termination Parts and Labor

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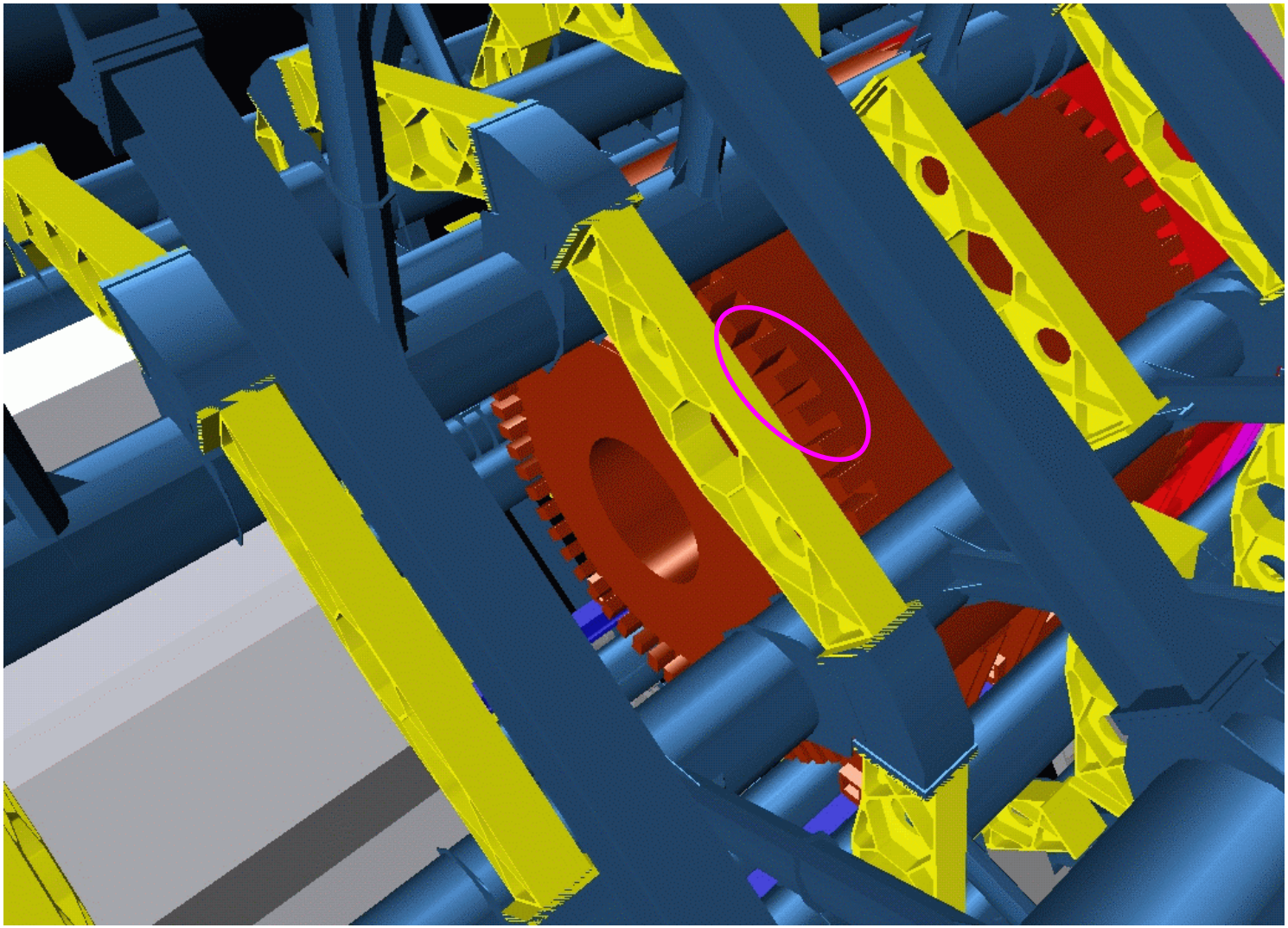
End of Cryostat-PPB2



Patch panel 2 is in the region of the "Fingers"
there is one PP2 per bundle

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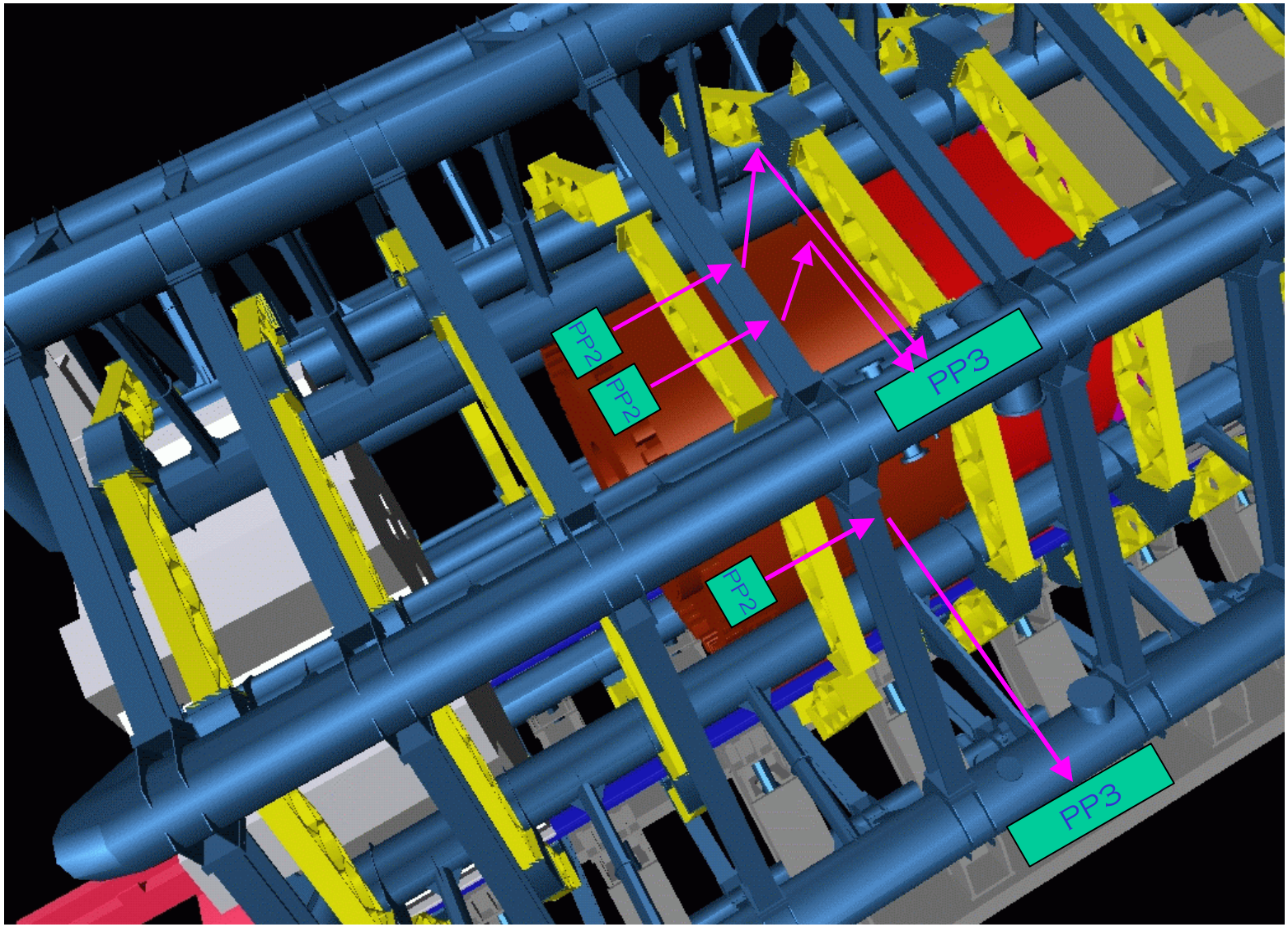
Type III cable route



PP3 will be a focus of several PP2's worth of bundles

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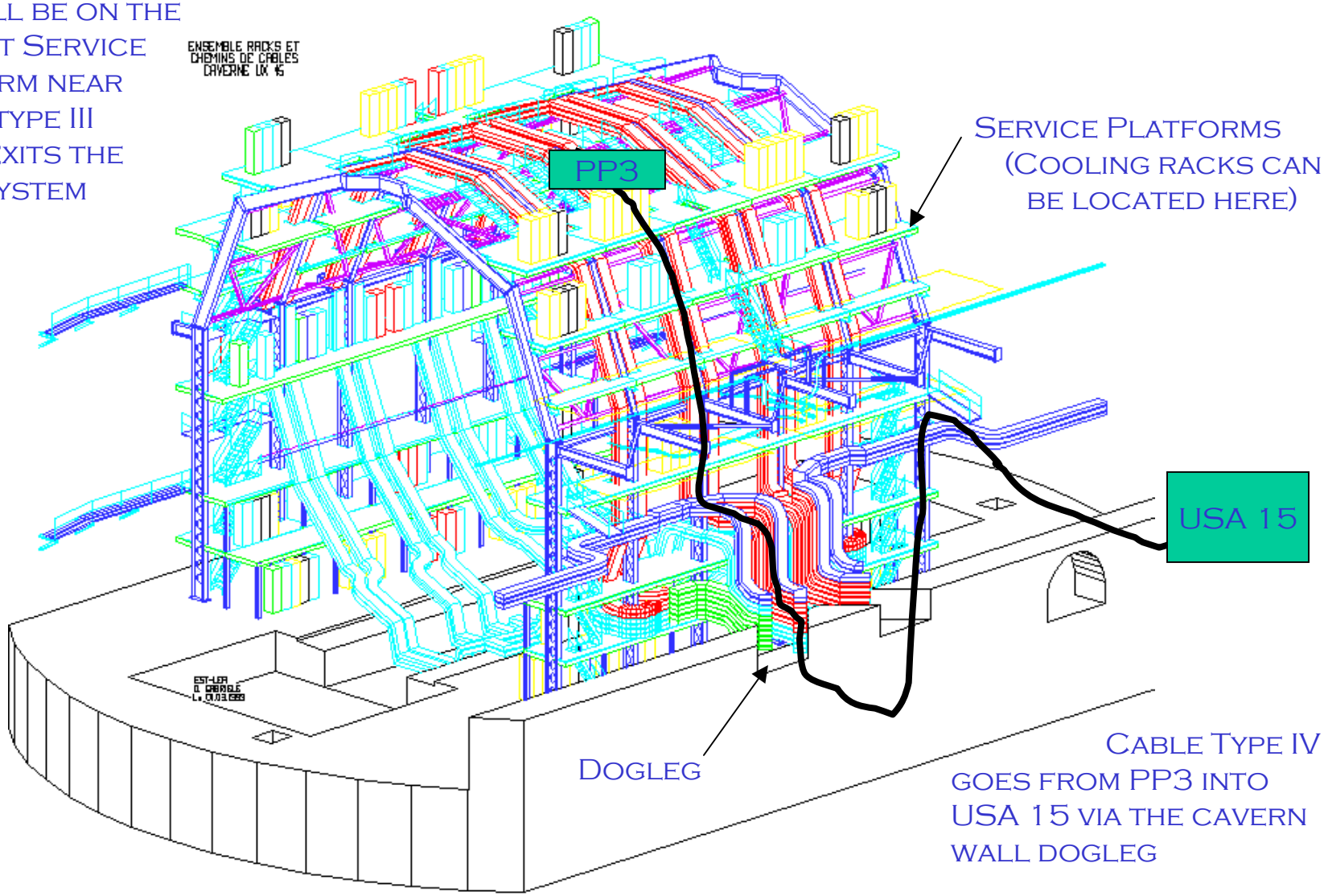
Cable Type IV Cable route

PP3 will be on the closest Service Platform near where type III cable exits the muon system



Several PP3's are distributed around the Circumference of ATLAS

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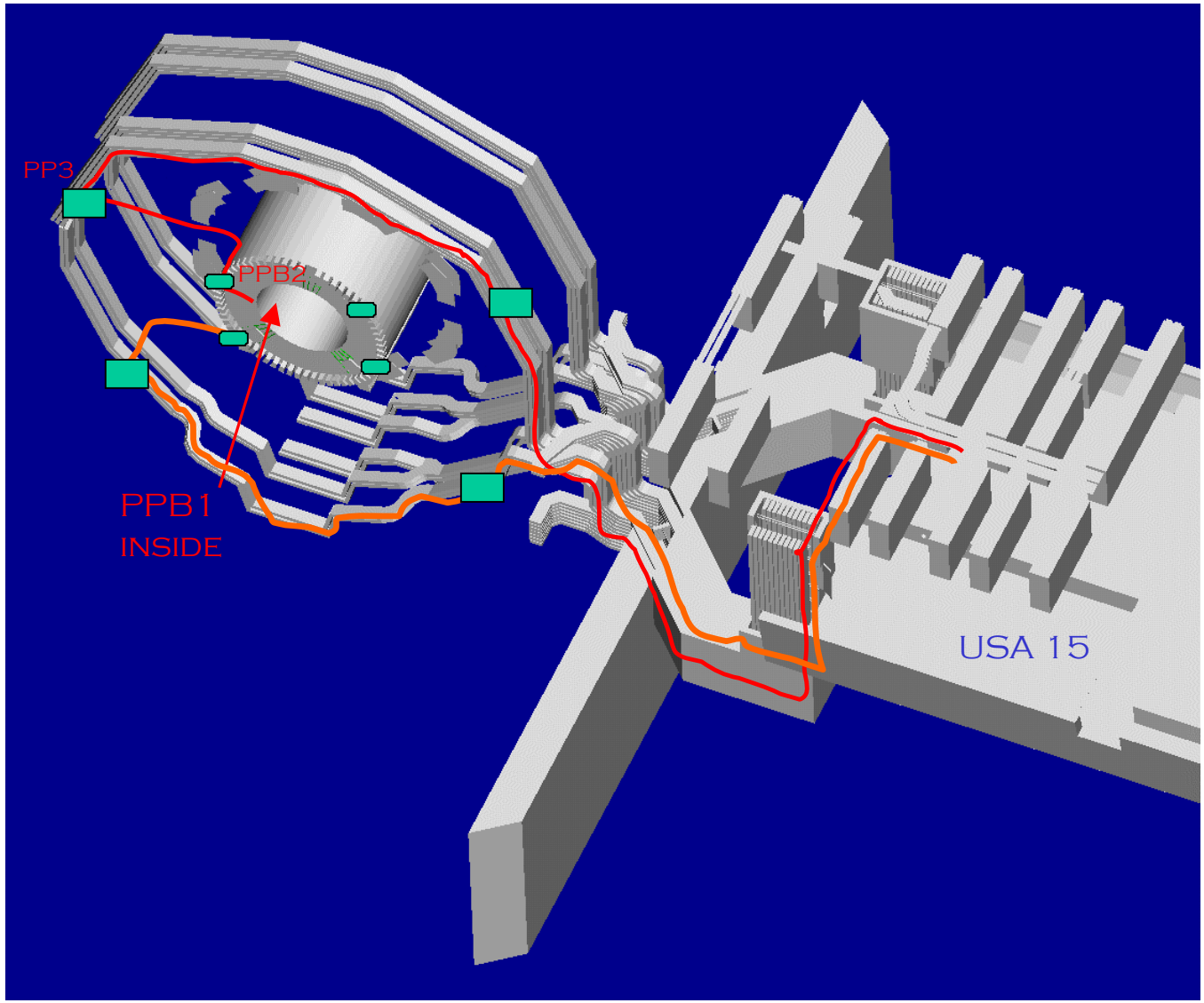
Service Plant Physical Layout



Worst case route is shown

Conventional Cables (III & IV)

- **ROM cost estimate**
  - Vendor quote
  - Composite comparison from catalogs
  - Comparison with SCT
- **Clearly most expensive portion of service plant**
- **Cables sized for voltage drop not to exceed 6V at chip**
  - Leads to very large conductors
- **Every voltage has separate return for EMI purposes**
  - vastly increases the number of conductors
- **Sense wires run from power supplies up to PP2 only**
  - Power supply currently does not use sense wires
- **Must meet CERN fire safety regulations**
  - Leads to exotic insulator materials
  - Or: Requires testing of smoke qualities to verify acceptance

Comparison with SCT

Type IV Cable Comparison

Description	Pixel	SCT	Difference
Power	2-#10 NTP	1-~#11TP	extra #10 pair
Power	2-#12 NTP	1-#14 TP	extra #12 pair, #12vs#14
Sense/Cont.	11-#26 TP	7->#26 TP	60% more
High Voltage	1-#22HV TP	1->#26HV TP	~equal
(lump with S/C)		3->#26 (single)	(lumped with Sense/Cont.)

- **Results of Comparison**
  - Power
    - SCT uses smaller gauge wire (higher voltage drop)
    - SCT has one less significant voltage
  - Small Gauge Conductor
    - We have 60% more small gauge wire
    - They have many more single ended voltages than we do
  - High Voltage
    - Roughly equivalent, but 1000V spec is more expensive
- **Depending on factors accounted for, our cable costs at least twice as much as theirs**
  - We have 1 more large guage wire, but are in otherways similar
  - delta should be on order +10%/module-not 100%

Cost Estimate Preliminary Observations

- **Cost of cables, as designed, is more than an order of magnitude larger than what is in budget**
- **SCT have estimates which are ~70% lower than ours--need to get more estimates**
  - Accounting for this only gets us to within an order of magnitude
- **Most changes in the design (e.g. lower conductor size, remove sense wires, reduce return line count) produce ~10% change in cost (each)**
  - Can see how to reduce by factor 2, but not 10, but only by change of scope and requirements of cables
- **Observed that price per meter changes significantly for conductors larger than #14**
  - Cost goes roughly with conductor count up to ~#14, then size matters
- **IS41 is not standard outside of CERN (maybe Europe)**
  - Some companies have bid for SCT with less exotic materials than posted on IS41 appendix 2
  - Materials in most of my estimate(s) are very expensive-guess that this contributes for the 70% differential

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Conclusions

- **Cost is higher than anticipated**
  - Types III & IV are primary cost drivers
- **Will investigate specific cost saving avenues to be applied to design before seeking new quotes**
  - Higher voltage drop cables
  - No Sense Wires
  - Less return wires for low-current lines
- **Certain options have cost implications making it unclear where the optimal cost is**
  - Higher voltage drop makes more expensive supplies or voltage regulation
- **Propose to make prototype cables as designed to determine module sensitivity to cable cost saving options**