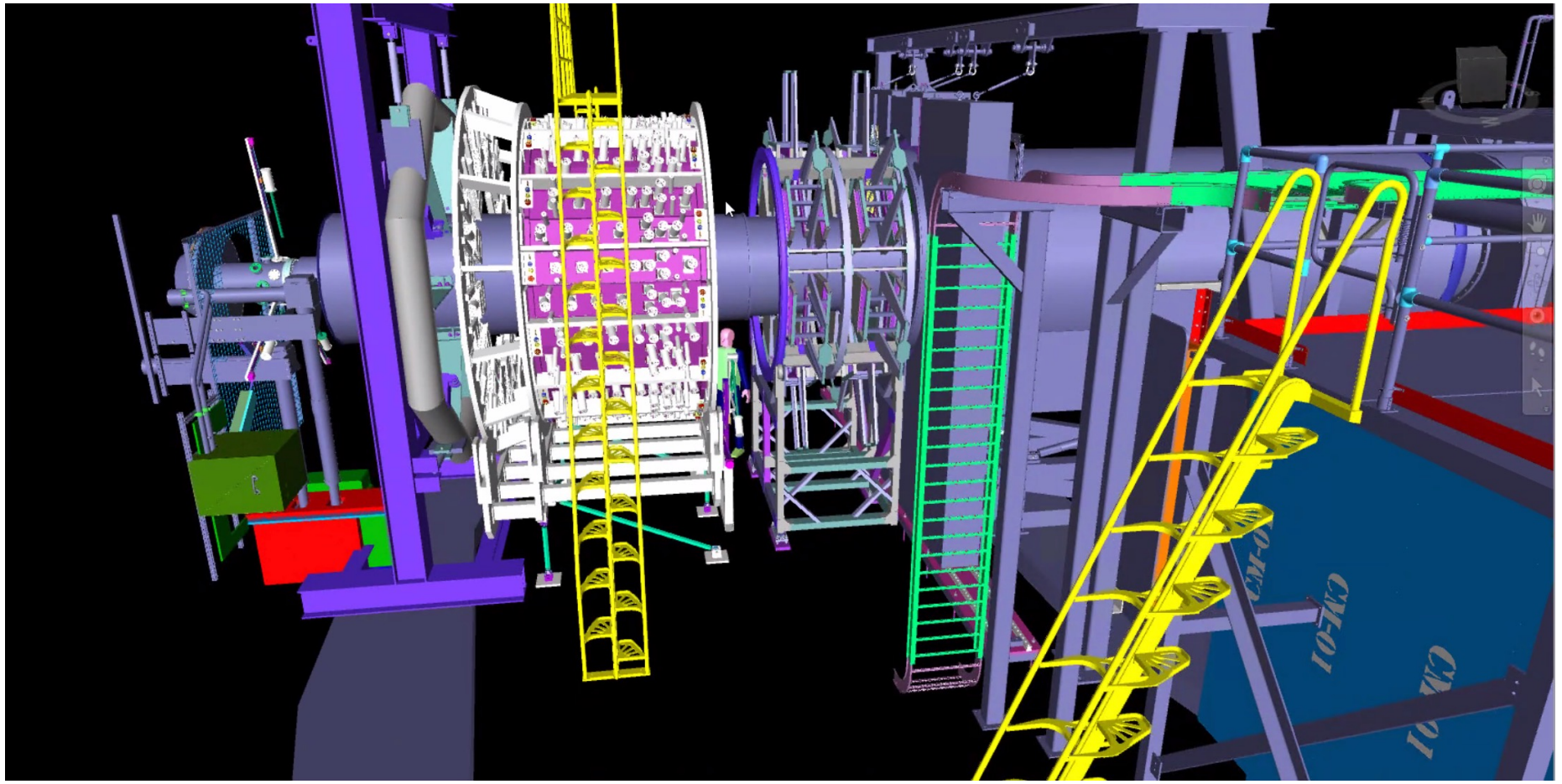
MOLLER Detector Cables and Connectors

April 13, 2023

Dustin McNulty – Idaho State University



Detector channel accounting

- Both integrate- and event-mode: (needs HV, twinax, coax, and base LV)

Main Detectors: 224	8 detectors per segment, 28 segments
Auxiliary Detectors: 112	LAMs (7x2), US scanner (2), beam halo monitors (2x14), Shower-max (28), Pion detector (28), DS scanners (4), and SAMs (8)

- Event-mode only: (needs HV, coax, fiber RO, and power)

GEM Detectors: 28	7 GEMs per wheel, all 4 wheels (only HV and fiber RO)
Trigger Scintillators: 14	7 paddles per wheel on 2 wheels (HV and coax)
HVMaps Detectors: 84	3 arrays per Main det. Segment (power, fiber RO)

❖ All cables except HVMaps' power route to the SBS bunker

Detector channel accounting

- Both integrate- and event-mode: (needs HV, twinax, coax, and base LV)

  Main Detectors: 224 + 16 spares

  Auxiliary Detectors: 112 + 8 spares

  Total: 335 + 25 spares = 360 channels

- Event-mode only: (needs HV, coax, fiber RO, and power)

  GEM Detectors: 28 + 3 spares (HV and fiber RO)

  Trigger Scintillators: 14 + 2 spares (HV and coax)

  HVMaps Detectors: 84 + 6 spares (power and fiber RO)

  --This leads to additional 47 HV and 16 coax channels

  ❖ Note there are no GEM HDMI or LV cables accounted for here

Cable size assessments (Main and Aux Dets)

- For ease of bulk size assessments, I have grouped all Auxiliary detector cables into the same bundle sizes as the main detector (that is, bundles of 8 cables)
- Bundles 1 – 7 are for Main detector, bundles 8 – 11 are for Auxiliary detectors

							70% packing frac	
Bundle No.	purpose	cable type	dia (in)	area (sq.in)	cables/ bundle	total area (sq.in)	total area (sq. in)	bundle dia (in)
1 & 8	PMT HV	RG59	0.25	0.049	8	0.39	0.51	0.81
2 & 9	PMT twinax	RG108	0.25	0.049	8	0.39	0.51	0.81
3 & 10	PMT coax	RG58	0.2	0.031	8	0.25	0.33	0.64
4 & 11	pmt base power	AWG18	0.08	0.006	8	0.04	0.06	0.27
5	HVmaps fiber RO	TBD	0.13	0.012	3	0.04	0.05	0.25
6	Hvmaps power	AWG15	0.1	0.008	48*	0.38	0.49	0.79
7	Hvmaps pow sigs	AWG15	0.1	0.008	8*	0.06	0.08	0.32

*These HVMaps numbers are only for patch panel to floor routing (because of splicing)

Cable size assessments (GEMs and Scintillators)

- Bundle #12 for GEM and trigger scintillator HV and bundle #13 for trigger scintillator coax
- These go from detector to SBS bunker
- Bundle #14 for GEM fiber RO goes from GEM racks to SBS bunker

							70% packing frac	
Bundle No.	purpose	cable type	dia (in)	area (sq.in)	cables/ bundle	total area (sq.in)	total area (sq. in)	bundle dia (in)
12	PMT HV	RG59	0.25	0.049	8	0.39	0.51	0.81
13	PMT coax	RG58	0.2	0.031	8	0.25	0.33	0.64
14	GEM fiber RO	TBD	0.13	0.012	7	0.09	0.11	0.38

Cable group footprint (Main Detectors)

- Bundles 1 - 5 route from segment patch panel to the SBS bunker
- Bundles 5 and 6 route from segment patch panel to GEM racks. There is a spice at the patch panel and splice a few meters before the electronics racks.

These numbers are for all 28 segments plus 2 spare segments

Main Detectors		70% packing fraction: 30 bundles			
Bundle No.	purpose	group area (sq.in) 70%	group diam (in) 70%	group width (in) 70%	
1	PMT HV	19.90	5.03	24.19	
2	PMT twinax	19.90	5.03	24.19	
3	PMT Coax	12.74	4.03	19.35	
4	pmt base power	2.25	1.69	8.13	
5	HVmaps fiber RO	1.87	1.54	7.41	
6	Hvmaps power	19.10	4.93	23.70	
7	Hvmaps pow sigs	3.18	2.01	9.67	
Groups 1 - 5 sum		56.65	17.33	83.26	
				6.94	in feet
Groups 6 - 7 sum		22.29	6.95	33.37	
				2.78	in feet

Cable group footprint (Aux. and GEM Detectors)

- Bundles 8 - 11 route from detectors to the SBS bunker

These numbers are for all 112 detectors plus 8 spares (15 bundles)

Auxiliary Detectors		70% packing fraction: 15 bundles/grp		
Bundle No.	purpose	group area (sq.in) 70%	group diam (in) 70%	group width (in) 70%
8	PMT HV	9.95	3.56	12.09
9	PMT twinax	9.95	3.56	12.09
10	PMT Coax	6.37	2.85	9.67
11	pmt base power	1.12	1.20	4.06
Groups 8 - 11 sum		27.39	11.16	37.92
				3.16 in feet

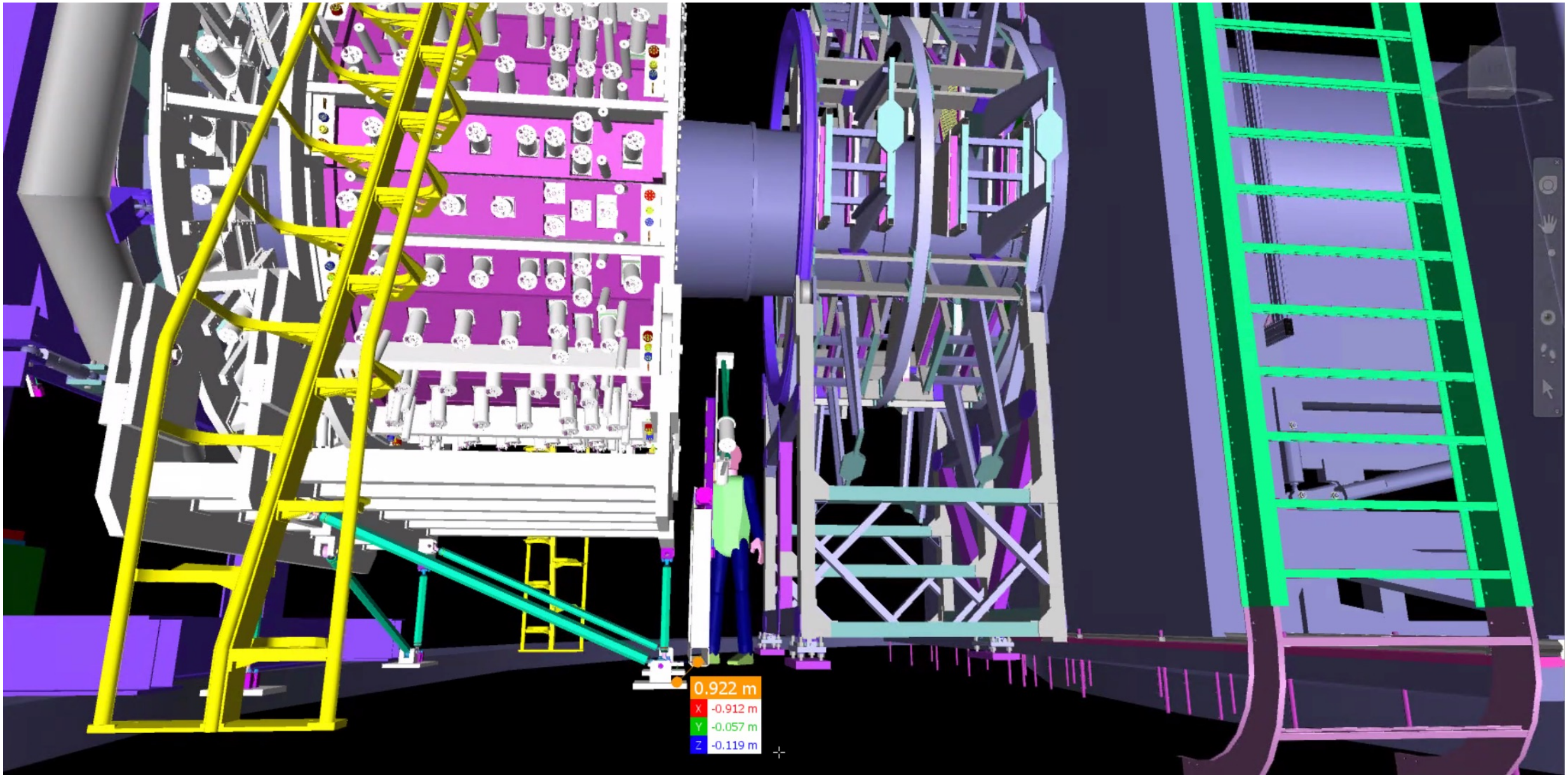
- Bundles 12 -13 route from detectors to the SBS bunker
- Bundle 14 routes from GEM racks to the SBS bunker

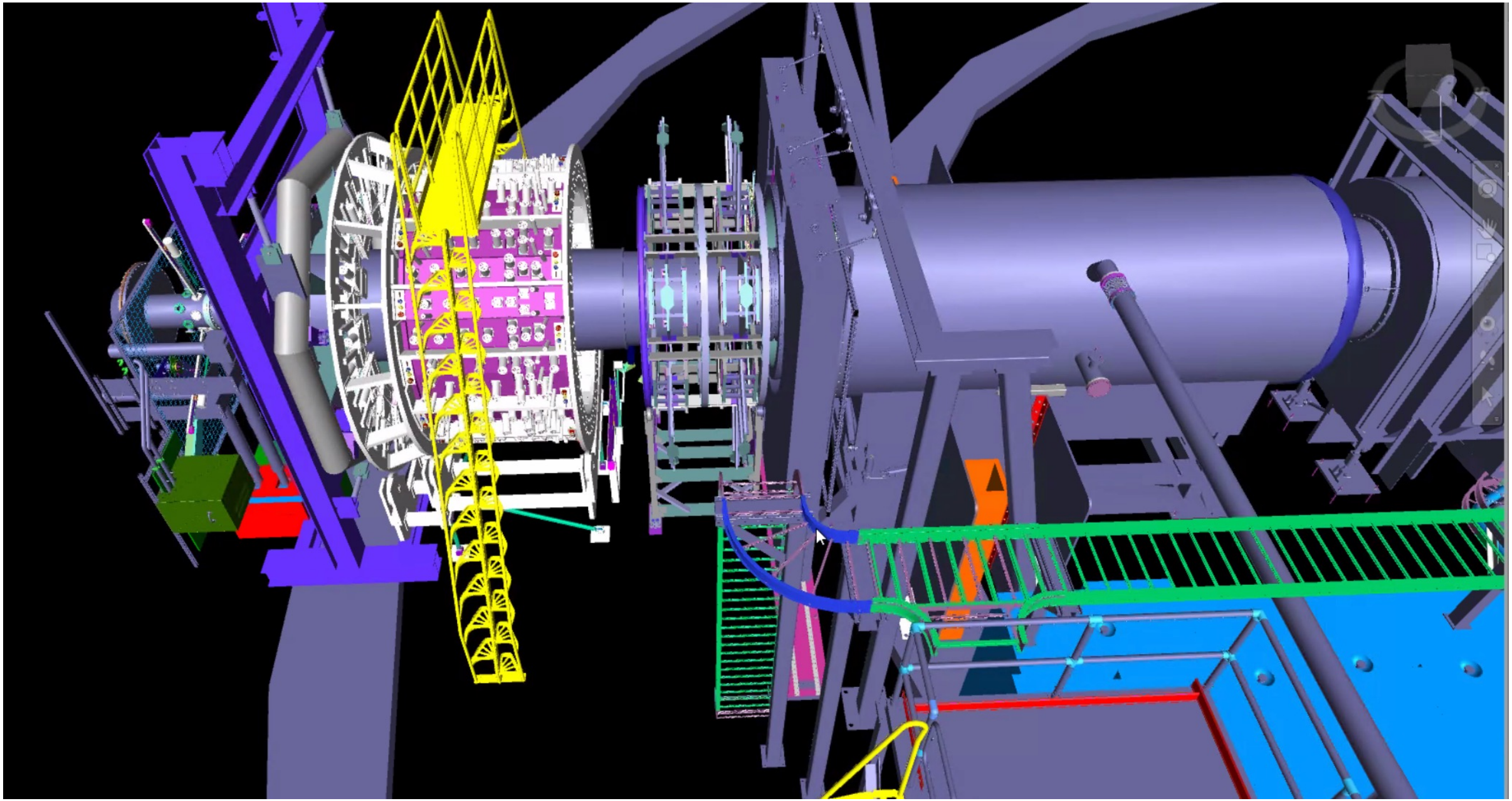
These numbers are for 6 HV bundles, 2 coax bundles, and 10 fiber bundles

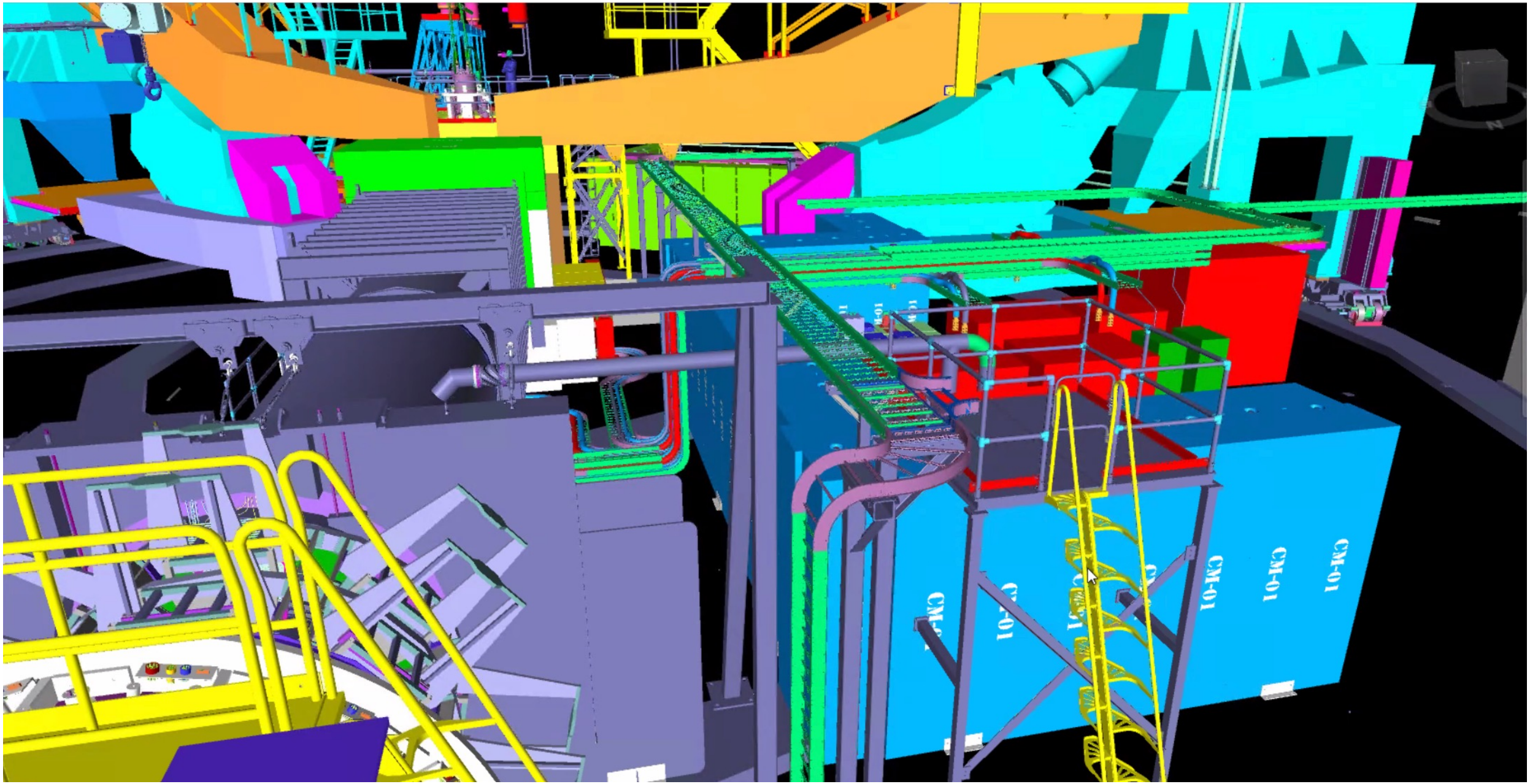
GEM Detectors		70% packing fraction:		
Bundle No.	purpose	group area (sq.in) 70%	group diam (in) 70%	group width (in) 70%
12	PMT HV	3.98	2.25	4.84
13	PMT Coax	0.85	1.04	1.29
14	GEM fiber RO	1.45	1.36	3.77
Groups 12 - 14 sum		6.28	4.65	9.90
				0.82 in feet

Cable group footprint Summary

	All Detectors		70% packing fraction: 30 bundles				
	Bundle No.	purpose	group area (sq.in) 70%	group diam (in) 70%	group width (in) 70%		
Main detectors	1	PMT HV	19.90	5.03	24.19		
	2	PMT twinax	19.90	5.03	24.19		
	3	PMT Coax	12.74	4.03	19.35		
	4	pmt base power	2.25	1.69	8.13		
	5	HVmaps fiber RO	1.87	1.54	7.41		
	6	Hvmaps power	19.10	4.93	23.70		
	7	Hvmaps pow sigs	3.18	2.01	9.67	in feet	
	Groups 1 - 5 sum		56.65	17.33	83.26	6.94	
	Groups 6 - 7 sum		22.29	6.95	33.37	2.78	Not included in cable tray sum
Aux detectors	8	PMT HV	9.95	3.56	12.09		
	9	PMT twinax	9.95	3.56	12.09		
	10	PMT Coax	6.37	2.85	9.67		
	11	pmt base power	1.12	1.20	4.06	in feet	
	Groups 8 - 11 sum		27.39	11.16	37.92	3.16	
GEM detectors	12	PMT HV	3.98	2.25	4.84		
	13	PMT Coax	0.85	1.04	1.29		
	14	GEM fiber RO	1.45	1.36	3.77	in feet	
	Groups 12 - 14 sum		6.28	4.65	9.90	0.82	
	Total sum in cable tray		**90.32**	**33.15**	**131.08**	**10.92**	

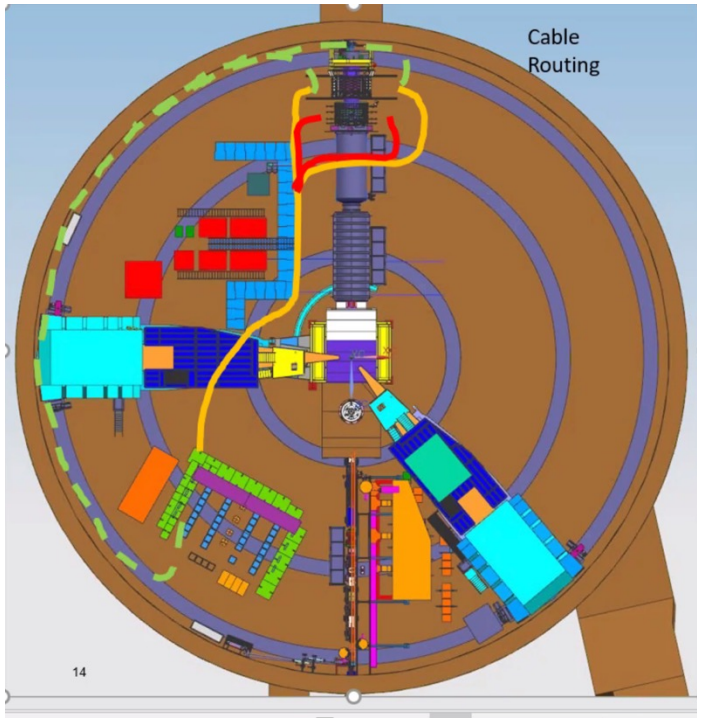

0.922 m
X -0.912 m
Y -0.057 m
Z -0.119 m

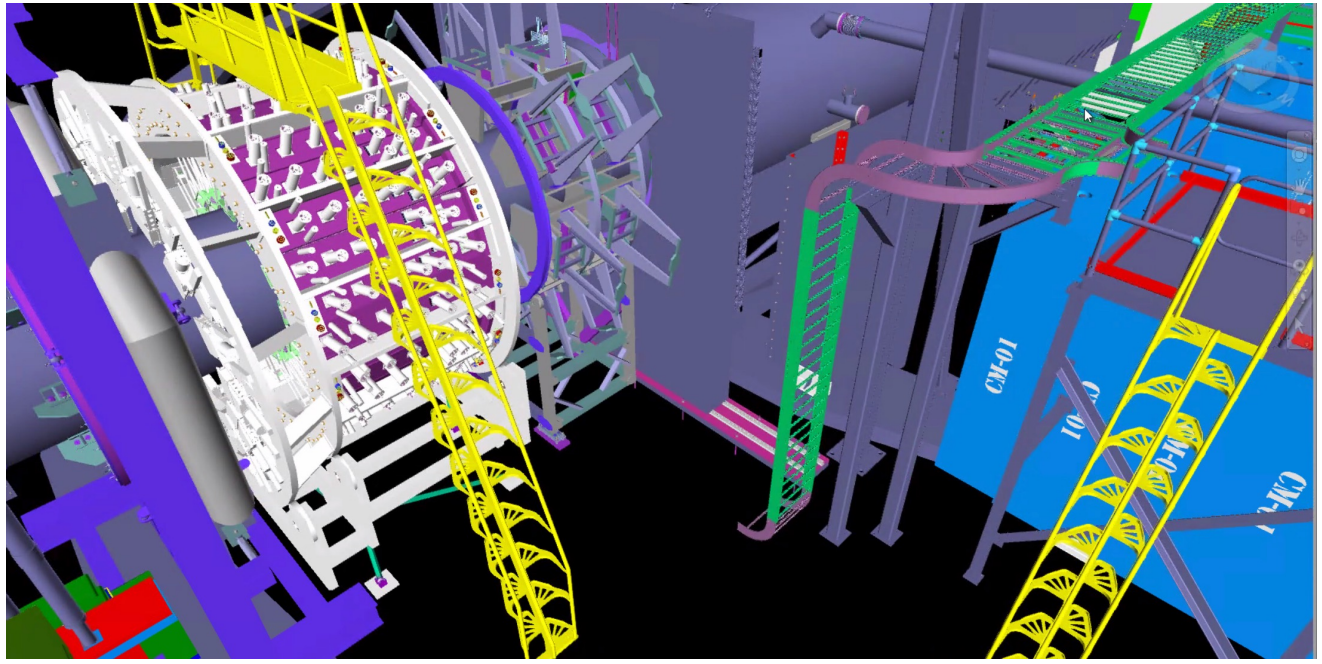



CM-01
CM-01
CM-01

Cable lengths needed

Bundle #	purpose	Bundle destination	Indiv. Cable Length (ft)	Total needed Length (ft)	Grand Total Length (ft)
1	PMT HV	SBS bunker	250	60000	101750
2	PMT twinax	SBS bunker	250	60000	90000
3	PMT coax	SBS bunker	250	60000	94000
4	pmt base power	SBS bunker	250	60000	90000
5	HVmaps fiber RO	SBS bunker	250	22500	
6	Hvmaps power	SBS bunker	spliced	TBD	
7	Hvmaps pow sigs	SBS bunker	spliced	TBD	
8	Aux. PMT HV	SBS bunker	250	30000	
9	Aux. PMT twinax	SBS bunker	250	30000	
10	Aux. PMT coax	SBS bunker	250	30000	
11	Aux PMT base power	SBS bunker	250	30000	
12	GEM /Scint PMT HV	SBS bunker	250	11750	
13	Scint PMT coax	SBS bunker	250	4000	
14	GEM fiber RO	SBS bunker	250	7750	

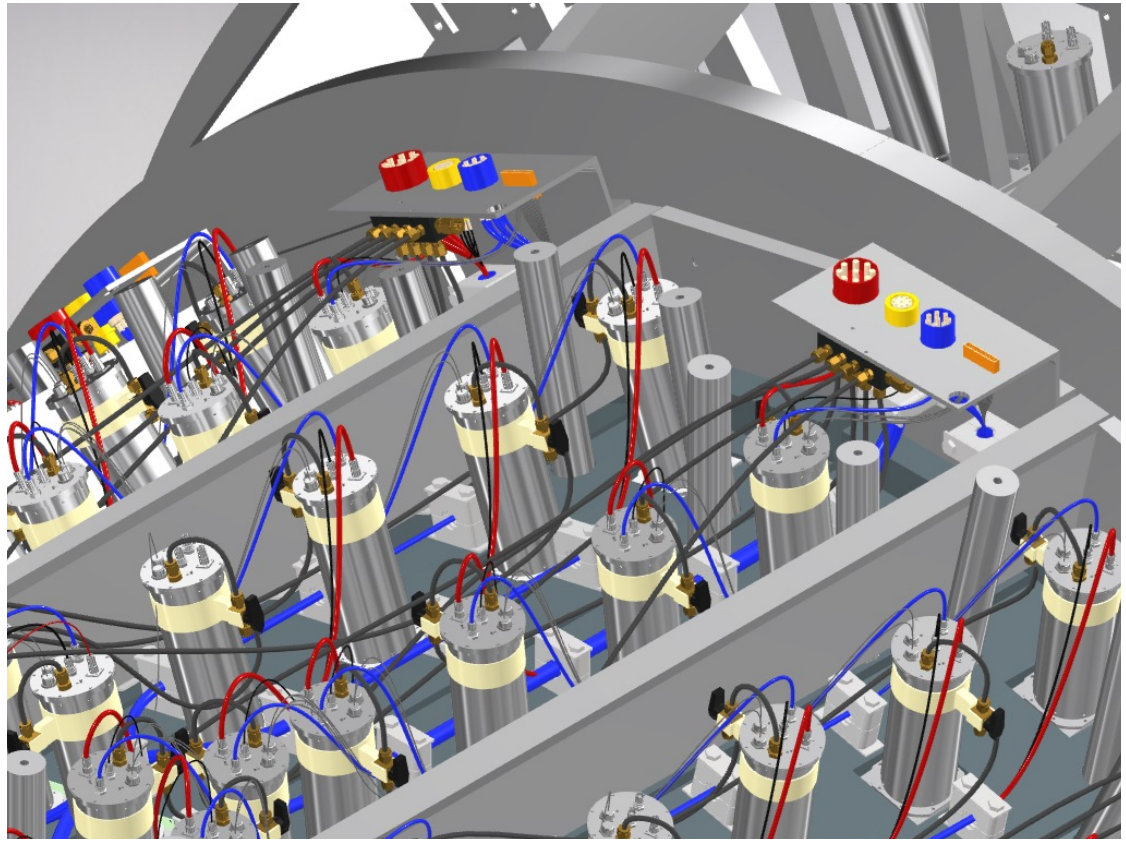




- These are cable lengths from patch panel or Aux detector to SBS bunker, including spares
- There are also cable lengths needed for routing internal to segment patch panels (see next slide)

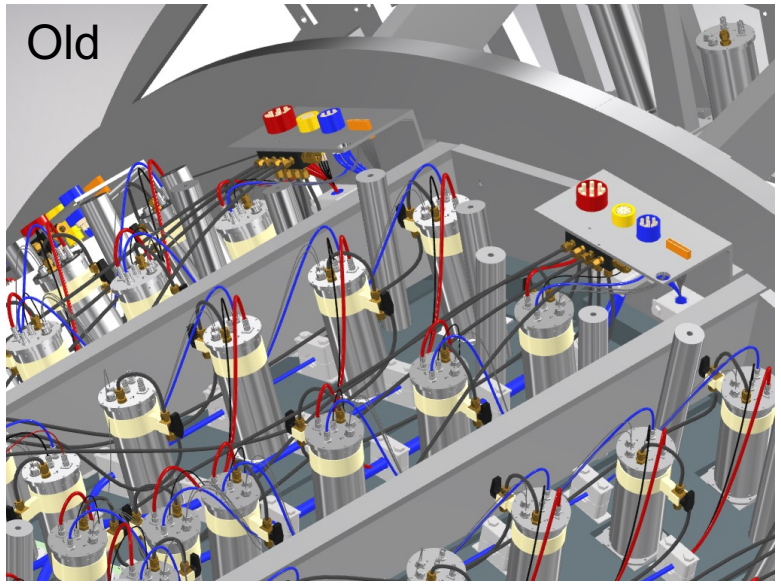
Cable lengths internal to Main Det. Segments

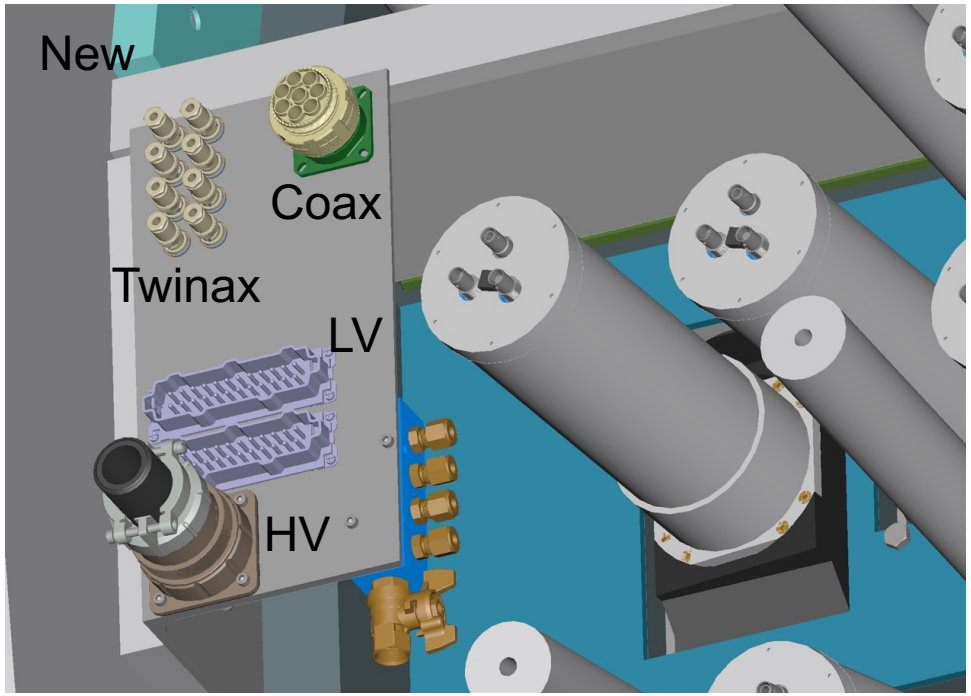
Front-flush Segment	Indiv. Cable Length (in)	Total needed Length (ft)
ring 1	15	35
ring 2	28	65
ring 3	53	124
ring 4	62	145
ring 5	73	170
ring 5	73	170
ring 5	75	175
ring 6	87	203
Total	466	1087

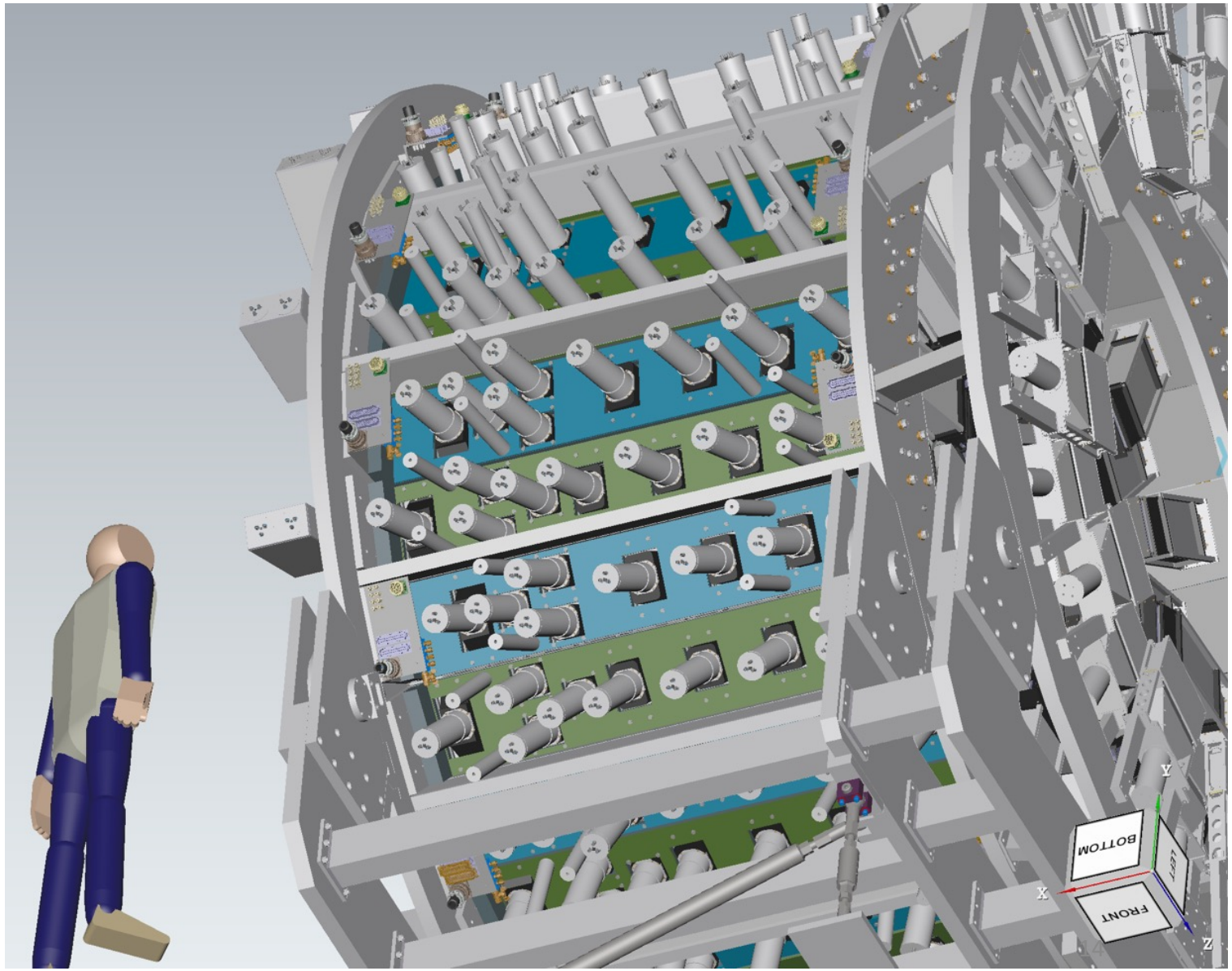


- Total column is for 28 segments. Need to examine back-flush lengths to get more accurate numbers here
- This total length is needed for each of HV, twinax, coax, and base power. There are also HVMaps wires that still need accounting here

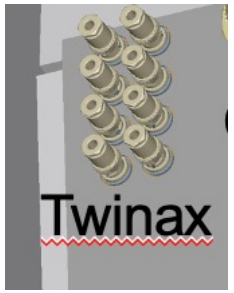
Main Detector Patch Panel





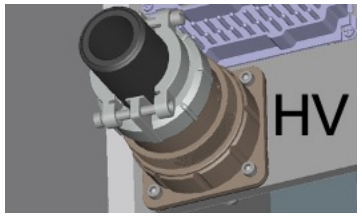


Main Detector Patch Panel: Integrate mode signals



- 8 twinax bulkhead, jam-nut feedthroughs (female to female)
  - Company: L-com.com
  - Brand: generic 78 Ohm
  - https://www.l-com.com/Coaxial-Adapter-78-Ohm-BNC-Twinax-Jack-Jack-Bulkhead
  - Price: $24 each (qty: 1 - 9), $21.20 each (qty: 25 - 99). [363 in stock, 224 needed]
  - Prototype Cost: $24*8 = $192
  - Production Cost (for 224): ($21*8)*28 = $168*28 = $4704
- 16 twinax male cable connectors (internal to patch panel – these are connectors on either end of short cables internal to detector segments)
  - Company: L-com.com
  - Brand: generic 78 Ohm
  - https://www.l-com.com/coaxial-twin-bnc-cable-plug-solder-type
  - Price: $15 each each (qty: 1 - 9), $12.50 each (qty: 99+). [5021 in stock, 448 needed]
  - Prototype Cost: $15*16 = $240
  - Production Cost (for 448): ($12.50*16)*28 = $200*28 = $5600
- 16 twinax male cable connectors (external to patch panel—these are on either end of the long (250 ft) runs from patch panel to US bunker)
  - Company: L-com.com
  - Brand: generic 78 Ohm
  - https://www.l-com.com/coaxial-twin-bnc-cable-plug-solder-type
  - Price: $15 each (qty: 1 - 9), $12.50 each (qty: 99+). [5021 in stock, 448 needed]
  - Prototype Cost: $15*16 = $240
  - Production Cost (for 448): ($12.50*16)*28 = $200*28 = $5600

Main Detector Patch Panel: High Voltage



- 1 HD HV connector (8 conductor)
  - Company: GES High Voltage Inc.
  - Brand: GES
  - Quote from 2/6/2023:
    - Part#: 7749011 GB 915/1E PTFE
      - receptacle, panel mount, 9-pole, 8x HV pins, female contacts 2.7mm silver plated 1x earthing pin, female contact 2.5mm silver plated
      - Price: $341.03 each (qty: 1), $298.06 (qty:28)
    - Part#: 7790417 KS 915/1E PTFE Sym KmV
      - plug, cable mount, 9-pole, symmetric cable gland 8x HV pins, male contacts 2.7mm silver plated
      - Price: $435.13 each (qty: 1), $380.30 (qty:28) (includes strain relief backing)
  - Prototype Cost: $341 + $435 = $776
  - Production Cost (for 28): ($298 + $380)*28 = $678 *28 = $18984

Main Detector Patch Panel: High Voltage

- 8 SHV male cable connectors (internal to patch panel – these are connectors on the pmt side of the short cables internal to detector segments)
  - Company: Federal Custom Cable
  - Brand: generic SHV crimp for RG59
  - https://www.fccable.com/SHV-Plug-Connector-CRIMP-For-RG59-RG62-RG140-RG210/2414/C1102/
  - Price: $40 each (qty: 1 - 9), $37 each (qty: 224). [stock seems available]
  - Prototype Cost: $40*8 = $320
  - Production Cost (for 224): ($37*8)*28 = $296*28 = $8288

- 8 SHV male cable connectors (external to patch panel—these are at the US bunker end of the long (250 ft) runs from patch panel to US bunker)
  - Company: Federal Custom Cable
  - Brand: generic SHV crimp for RG59
  - https://www.fccable.com/SHV-Plug-Connector-CRIMP-For-RG59-RG62-RG140-RG210/2414/C1102/
  - Price: $40 each (qty: 1 - 9), $37 each (qty: 224). [stock seems available]
  - Prototype Cost: $40*8 = $320
  - Production Cost (for 224): ($37*8)*28 = $296*28 = $8288

Main Detector Patch Panel: Event-mode signals

- 1 HD Coax connector (8 conductor)
  - Company: Arrow.com
  - Brand: Amphenol (50 Ohm)
    - Receptacle (not including contacts): Part#: TVP00RW-25-8S-LC (sockets)
      - https://www.ebay.com/itm/313445903623?
      - https://www.arrow.com/en/products/tvp00rw-25-8s-lc/amphenol
      - Price: $165.11 each (qty: 1 - 9), $150 each (qty: 25 - 49). [158 in stock, 28 needed]
    - Plug (not including contacts): TV06RW-25-8P-LC (pins)
      - https://www.mouser.com/ProductDetail/Amphenol-Aerospace/TV06RW-25-8P-LC?qs=VJiCFk877q7wiAwI%252BudX3g%3D%3D
      - Price: $121.77 each (qty: 10 min) [none in stock, 28 needed]
      - Strain relief: https://www.peigenesis.com/en/shop/part-information/M8504938S25W/PCD/EACH/911140.html#specs
      - Price: $11.28 each [312 in stock 28 needed]; not 100% sure this part fits
  - Prototype Cost: $165+ $122 + $11 = $298
  - Production Cost (for 28): ($150 + $121 + 11)*28 = $282*28 = $7896

Main Detector Patch Panel: Event-mode signals

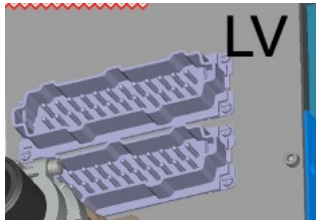
- Contacts: need 8 pins and 8 sockets for RG58 cables internal and external to patch panel
  - Part#: 21-033101-29 (socket for RG58)
    - https://www.mouser.com/ProductDetail/Amphenol-Aerospace/21-033101-029?qs=ht%2F6rtrL%252BHGqPwhLKlnbbQ%3D%3D
    - Price: $143.55 each (qty: 1), $115.68 each (qty: 100)... [none in stock; 13 week lead time]
    - Prototype Cost: $143*8 = $1144
    - Production Cost (for 224): $115*224 = $25760
  - Part#: 21-033102-29 (pin for RG58)
    - https://www.mouser.com/ProductDetail/Amphenol-Aerospace/21-033102-029?qs=vFIbPToLYxJ9ugdd9gbErQ%3D%3D
    - Price: $95.02 each (qty: 1), $54.64 each (qty: 100). [none in stock; 13 week lead time, 224 needed]
    - Prototype Cost: $95*8 = $760
    - Production Cost (for 224): $55*224 = $12320

Main Detector Patch Panel: Event-mode signals

- 8 BNC coax male cable connectors (internal to patch panel – these are connectors on the pmt side of the short cables internal to detector segments)
  - Company: Federal Custom Cable
  - Brand: generic BNC crimp for RG58
  - https://www.fccable.com/BNC-Male-Connector-CRIMP-For-RG58-RG141-RG303-LMR195-B7806A/2317/C1017/
  - Price: $7 each (qty: 1 - 9), $6.50 each (qty: 224). [stock seems available]
  - Prototype Cost: $7*8 = $56
  - Production Cost (for 224): ($6.50*8)*28 = $52*28 = $1456

- 8 BNC coax male cable connectors (external to patch panel—these are at the US bunker end of the long (250 ft) runs from patch panel to US bunker)
  - Company: Federal Custom Cable
  - Brand: generic BNC crimp for RG58
  - https://www.fccable.com/BNC-Male-Connector-CRIMP-For-RG58-RG141-RG303-LMR195-B7806A/2317/C1017/
  - Price: $7 each (qty: 1 - 9), $6.50 each (qty: 224). [stock seems available]
  - Production Cost (for 224): ($6.50*8)*28 = $52*28 = $1456

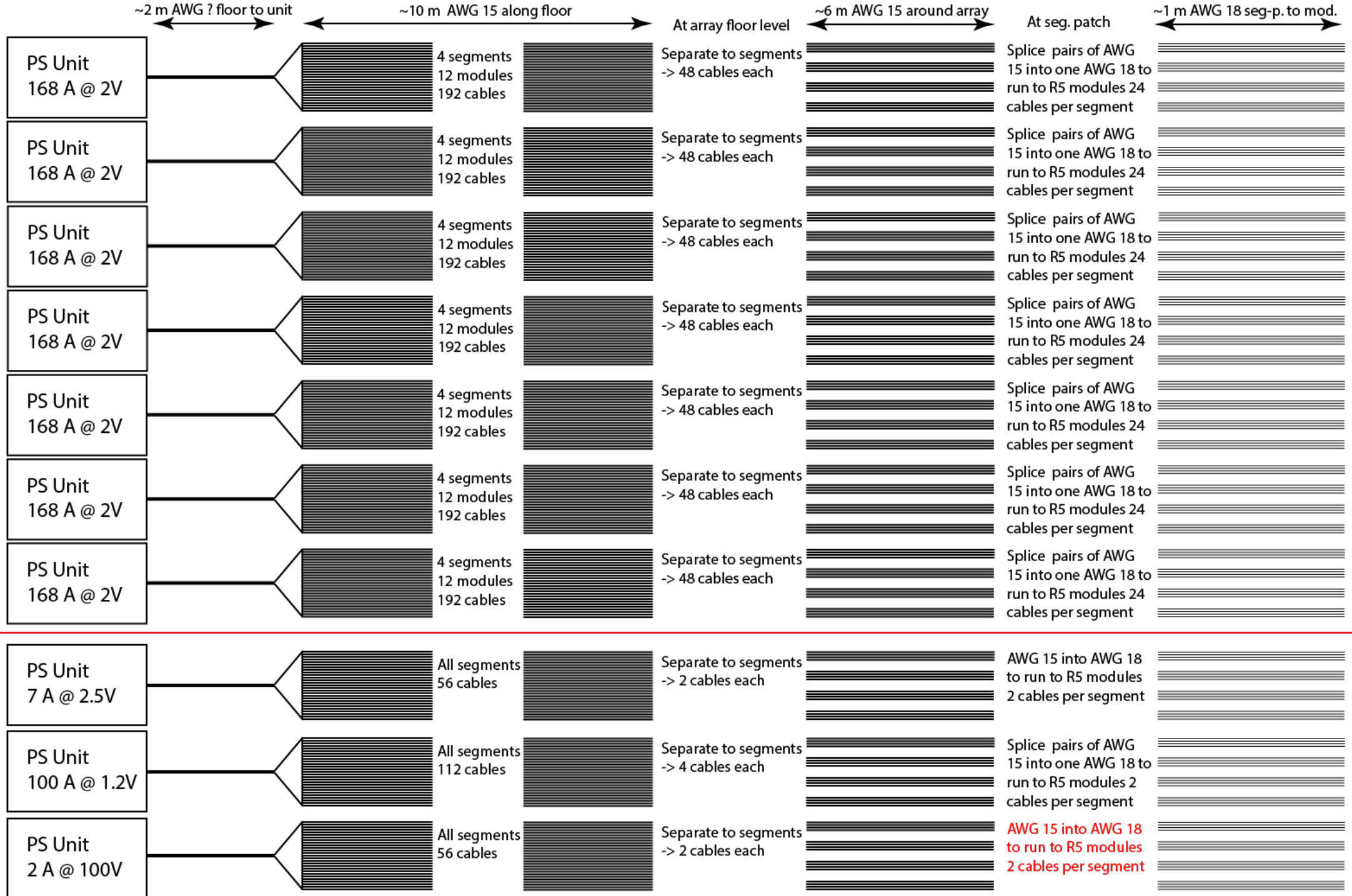
Main Detector Patch Panel: HVMaps power



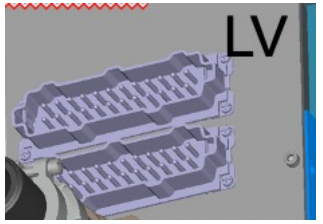
- HVMAPS power: external to patch panel requires 56 AWG15 wires; internal to patch panel requires 30 AWG18 wires (note this requires splicing at the connector and splicing at the floor)
  - 2 Weidmüller HDC HE 24 connector assemblies (24 conductor each). **We only need 30 of the 48 total channels and so this can also be used for the base power and switch (8 of them—one for each pmt per segment)**
    - Receptacle (including contacts): Part#: HDC HE 24 MS. Supports up to AWG12
      - https://www.mouser.com/ProductDetail/Weidmuller/1211100000?qs=juCpvWVDeytj2wHKpb4qaw%3D%3D
      - Price: $20 each (qty: 1 - 9), $16 each (qty: 50 - 100). [80 in stock, 56 needed]
    - Plug (including contacts): Part#: HDC HE 24 FS (sockets). Supports up to AWG12
      - https://www.mouser.com/ProductDetail/Weidmuller/1211300000?qs=juCpvWVDeyvRw%2FT1VF%2FVIQ%3D%3D
      - Price: $20 each (qty: 1 - 9), $16 each (qty: 50 - 100). [89 in stock, 56 needed]

    - Other potential parts we may want or need for these:
      - Receptacle bulkhead housing: (not sure if we need) https://www.mouser.com/ProductDetail/Weidmuller/1212400000?qs=CQWry4MfcR%2FHHaXbU1nOtQ%3D%3D
        - Price: $20 each (qty: 1 - 9), $16 each (qty: 50 - 100). [101 in stock, 56 needed]
      - Plug housing: (I think we want these) https://www.mouser.com/ProductDetail/Weidmuller/1787820000?qs=juCpvWVDeyvrBaNm7snOiw%3D%3D
        - Price: $20 each for 1, $16 each for 50 [0 in stock, 56 needed]; 3 week lead time
      - Plug housing cover: (not sure if we need this) https://www.mouser.com/ProductDetail/Weidmuller/1665640000?qs=juCpvWVDeys4ve5Br%2FW%2Fdg%3D%3D
        - Price: $32 each for 1, $26 each for 50 [5 in stock, 56 needed]; 15 week lead time
      - Cable gland: (I think we want these) https://www.mouser.com/ProductDetail/Weidmuller/1193600000?qs=OQh%252BYpNShStymmM%252BNd8mWA%3D%3D
        - Price: $11 each for 1, $9 each for 50 [0 in stock, 56 needed]; 5 week lead time
    - Prototype Cost: ($20+$20+$20+$11)*2 = $142
    - Production Cost (for 56 assemblies): (($16+$16+$16+$9)*2)*28 = $114*28 = $3192

HVMaps power cabling



Main Detector Patch Panel: PMT base power



- Will be routed through one of the Weidmüller connectors. There is no splicing for these. These will use AWG18 wire from SBS bunker to patch panel

- 8 lemo male cable connectors (internal to patch panel – these are connectors on the pmt side of the short cables internal to detector segments); cable type will be RG-174
  - Company: Digikey
  - Brand: Lemo
  - https://www.digikey.com/en/products/detail/lemo/FFA-0S-250-CTAC32/2786345
  - Price: $24 each (qty: 1 - 9), $18 each (qty: 224). [stock seems available]
  - Prototype Cost: $24*8 = $192
  - Production Cost (for 224): ($18*8)*28 = $144*28 = $4032

Main Detector Connector costs

Connectors needed per Main detector segment	Location	Prototype Cost (for 1)	Production Cost for 30	
8 twinax female bulkhead conn.	at P. Panel	$192	$5040	
16 twinax male cable conn.	Internal	$240	$6000	
16 twinax male cable conn.	external	$240	$6000	
HD HV connector (plg & rec)	at P. Panel	$776	$20340	
8 SHV male cable conn.	internal	$320	$8880	
8 SHV male cable conn.	external	$320	$8880	
1 HD Coax connector (plg & rec)	at P. Panel	$298	$8460	
8 Contacts: sockets	at P. Panel	$1144	$27600	
8 Contacts: pins	at P. Panel	$760	$13200	
8 BNC coax male cable conn.	internal	$56	$1560	
8 BNC coax male cable conn.	external	$56	$1560	
2 HDC HE 24 conn. (plg & rec; acc.)	at P. Panel	$142	$3420	CFI
8 Lemo male cable conn.	internal	$192	$4320	
Total Cost:		$4.7k	$115.3k	

This does not include the cost of HVMaps fiber readout cables/connectors or connectors needed at the HVMaps

Auxiliary Detector Connector costs

Cable connectors needed for Auxiliary detectors	Location	Production Cost for 30
120 twinax male cable conn.	at detector	$1500
120 twinax male cable conn.	at electronics	$1500
151 SHV male cable conn.	at detector	$5587
151 SHV male cable conn.	at electronics	$5587
136 BNC coax male cable conn.	at detector	$884
136 BNC coax male cable conn.	at electronics	$884
120 Lemo male cable conn.	at detector	$2160
Total Cost:		$18.1k

This does not include GEM HDMI cables/connectors or GEM fiber readout cables/connectors

Cable costs (still in progress)

Integrate mode

- We need a total of 224 + 16 + 111 + 9 = 335 + 25 = 360 cables that are each 250 ft (~75 m) long
- And we need a total of ~1100 ft of twinax cable internal to the Main detector segments
- Twinax cable (including Aux dets and everything): I need to contact vendors, but I can purchase 1000 ft for $2050 online here: https://www.milestek.com/p-16950-78-ohm-twinaxial-cable-0242-od
  - This is UL2 (fire-rated), 78 Ohm twinax cable. I bought 200 ft of it for use in my lab recently.
  - It is $2.05 per ft which is cheaper than Pasternack or Newark, but need to contact vendors since we need 84,850 ft. At $2050/1000ft, this cable would cost $2050*(56+27.75+1.1) = $174k. We'll need to reach out to vendors here to discuss supply capability and potential volume discount.

HVMaps power

- I couldn't find AWG15 cable but found AWG14 cable for $0.174/ft or $435 for 2500 feet. https://www.wireandcableyourway.com/14-awg-type-mtw-wire-41-strand-250-or-500-spool
  - Still need work on this, but roughly need 15 – 20 m (or 50 – 65 ft) times 192*7 = 67200 – 87360 ft
  - Also need additional 15 – 30 m (or 50 – 65 ft) times 224 = 11200 to 14560 ft (for power readout)
  - So 102000 ft of AWG14 cable costs ~$17.7k (this is budgeted through CFI)
- Still need to look into cost of AWG18 wire internal to segment patch panel for HVMaps
- There are also low gauge wires that run from the power-supplies and splice into the AWG15 cables at the floor

Cable costs (still in progress)

HVMaps fiber RO

- TBD. We need a total of 84 + 6 = 90 fibers that are 250 ft (~75 m) long (this is budgeted through CFI)

GEM fiber RO

- TBD. We need a total of 28 + 3 = 31 fibers that are 250 ft (~75 m) long (Is this NSF or DOE?)

PMT base power

- TBD. I think we should just reuse SBS coax for this. We need at least AWG18; need 335+25=360 cables plus ~1100 ft internal to detector segments

Event mode

- RG-58 cable. **Plan to recycle coax cables from SBS for this**
- We need a total of 224 + 16 + 111 + 9 + 14 + 2 = 349 + 27 = 376 cables that are 250 ft (~75 m) long
  (Main, Aux, Scint)
- For Main detector, have HD coax connector on one end and BNCs on the SBS bunker end
- We also need a total of ~1100 ft of coax cable internal to the Main detector segments: one end is at the HD coax connector and other end has BNCs that connect to pmts

High Voltage

- RG-59 cable. **Plan to recycle HV cables from SBS for this**
- We need a total of 224 + 16 + 111 + 9 + 14 + 2 + 28 + 3 = 377 + 30 = 407 cables that are 250 ft (~75 m)
  (Main, Aux, Scint, GEM)
- For Main detector, have HD HV connector on one end and SHV or other? on the SBS bunker end
- We also need a total of ~1100 ft of HV cable internal to the Main detector segments: one end is at the HD HV connector and other end has SHV connectors that connect to pmts

SBS cables (to use possibly)

- MOLLER is planning to reuse about 400 coax and HV cables from SBS (100 m long was the original plan)
- Paul K. reached out to SBS for information about their cables. Here's the Q & A:

Q1: We had understood that both sets of cables were about 100m long. Is that correct? Or are there different numbers of cables of various lengths in use by SBS?

A1: "Since we recently decided to go with an FADC-based DAQ, we no longer need the 100m delay cable. So we will be using a mix of cables. We are making about 800 75m cables and the remainder will be existing 100m cables." wrote Don Jones

Q2: Are the HV cables terminated with SHV connectors on both sides, or do they have some other connectors?

A2: We are currently using 24 channel cables that go to break out HV boxes with SHV or plastic connectors. The 24 pin cables are 75 m long and connect between HV boxes on either end. We have 92 SHV boxes (24 ch) and since you a box on both ends of a cable that is enough to provide 46*24=1104 HV channels. Short SHV cables are then used to connect from the boxes to the PMTs and HV supply modules.

SBS cables (Q & A continued)

Q3: Are the coax cables terminated with BNC connectors, or Lemo, or some other connectors?

A3: The 75 and 100m cables are all BNC-BNC. They go from front end patch panel to DAQ patch panel

Q4: If the long cables are BNC on both ends, how does SBS handle converting to Lemo to input to the FADCs? Do you use a patch panel, or free-hanging patch cables, or something else?

A4: We then use a combination of BNC-LEMO patch panels to LEMO-LEMO cables and BNC-BNC patch panels to BNC-LEMO cables to go to the FADCs.

Q5: Does SBS have any sort of support system at the DAQ crate end to provide strain-relief of the cables? If SBS doesn't use that, have other Hall A experiments considered that (I have to admit I don't recall having any in the past).

A5: I have purchased some magnetic base loops for cable tying bundles to the rack and some cable trays for going horizontally across the top of crates. Time will tell if these work well. (see photo)

Other Considerations

- The cost of the aluminum angle for the patch panel
  - Here is a part from McMaster Carr for ¼ inch thick, 1 foot long 6” x 6” aluminum 6061 angle bracket ($40 each) https://www.mcmaster.com/catalog/129/4169/8982K46
  - We’ll also need to machine it for mounting holes. I’m not sure yet what the cost would be but could be $200+ each I estimate

- Cable braid for bundles. These are for organization and protection purposes; If we use them for the entire length from detector to US bunker, then they would increase the calculated cable bundle areas by 10 – 20%. I was thinking to at least have them at the detector end where they’ll need to run along the floor. We may also want them at the US bunker end. The sleeves could be a heavy duty plastic but this type doesn’t provide any RF noise shielding. I’m not sure if we want or need that anywhere. Here’s the product I found
  - https://www.cableorganizer.com/categories/cable-management/cable-sleeving/braided/abrasion-resistant/clean-cut-heavy-duty/#features
  - A 500 ft spool of ½” diameter nominal (it can expand to 2x that) cost $400
  - There are a lot of products out there and we could perhaps purchase some small samples to test. The minimum length order for the above item is 100 ft for $79. I’m not sure we need to deal with this aspect now, but it could be in the budget.

Other Considerations

- There will also be cable support hardware needed for the Main detector. This is currently being designed and will consist of aluminum bars or rods sticking out radially from the Main detector barrel at each patch panel location. There will also be cable clamp mechanisms needed to attach cables to the support bars. The supports are needed for strain relief at the patch panel as well as to support the weight of the cables as they route around the barrel to the floor. This will add machined parts and other off-the-shelf hardware costs to the budget.

- We will also need cable strain relief system at the electronics end. Can we reuse SBS parts here or are there other stockpiles?

- What else?

Summary

- Cable and connector accounting and costing is getting mature. The cross sectional area of all cables in the cable tray is 112.6 sq. in. which is equivalent to an area 2 ft x 4.7 inches
- We need to decide on HV connector at the electronics end: SHV or other?
- We need approval from Jlab for the splicing scheme and need to make sure HVMaps cable runs are long enough
- We need to model the Main detector external cabling (external to patch panel), cabling support and strain relief system, and floor routing (ISU is working on this)
- Each individual detector group: GEMs, pion, LAMs, SAMs, scanners, DBMs, and Shower-max needs to consider how cables will be routed and supported for their detector system(s)
- I am in touch with vendors for full-service builds of our HD connectors and cables (it's taking some time with Amphenol—they want specifics and told me they usually are sent a drawing)
- We will look into having a vendor make all the twinax long cables for us
- I feel we will or could lose the benefit of free SBS cables if we go with a full-service build of the HD connectors
- There are still cable costing details to nail down
- We plan to prototype one complete patch panel, including all connectors and HD connector cable assemblies