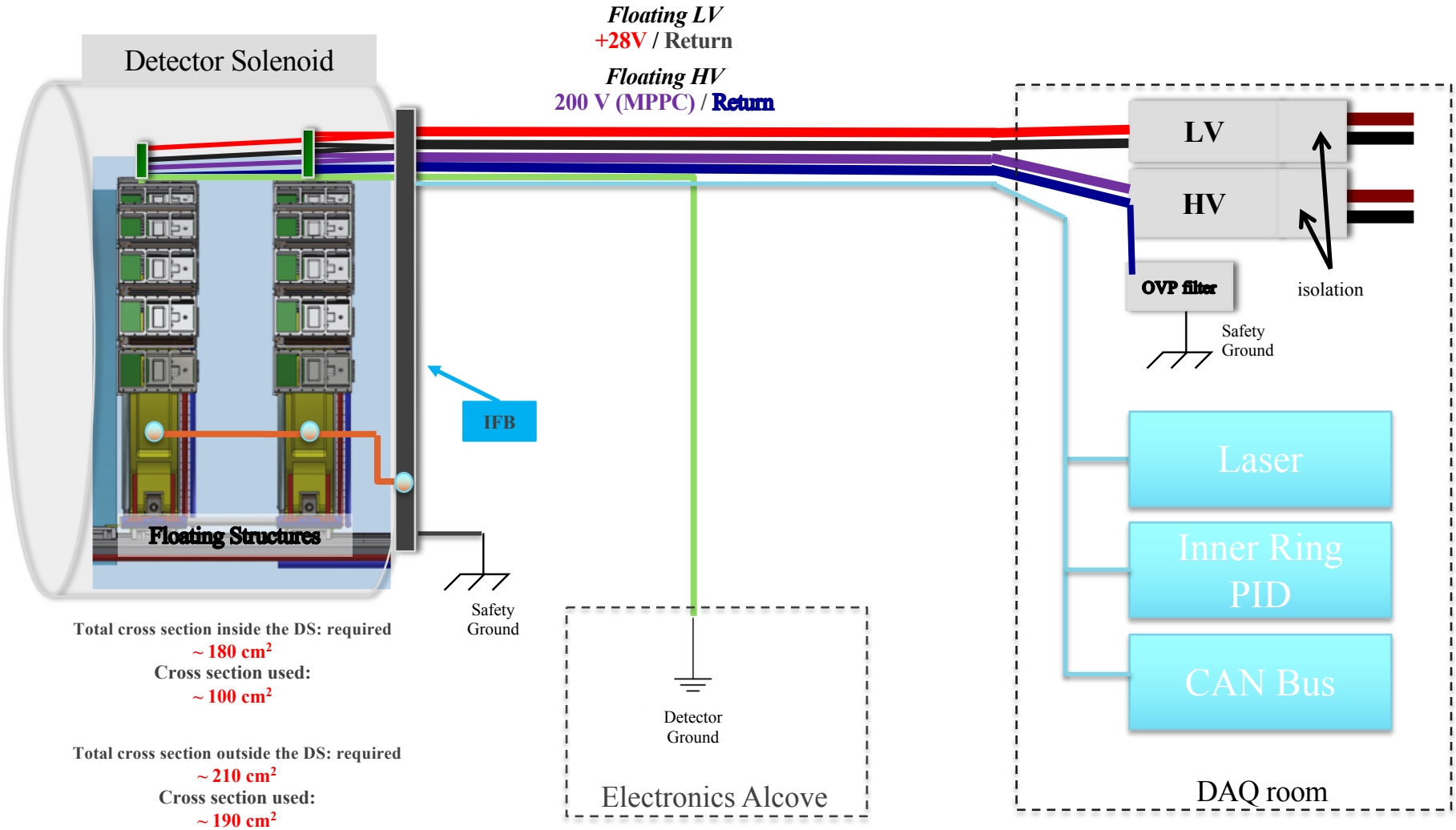
Calorimeter Services Distribution

A. Saputi and I. Sarra, on behalf of the Calorimeter Team

Integration Meeting

14 October 2020

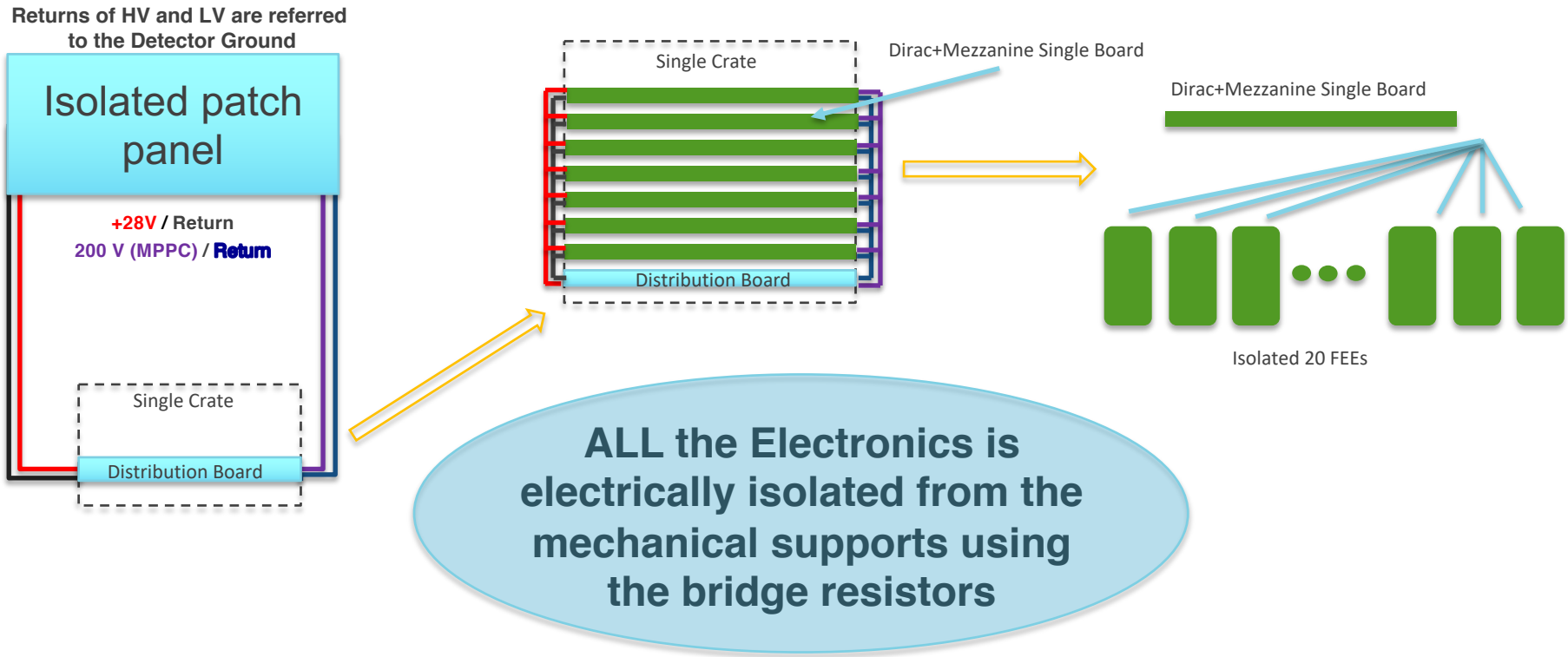
Routing Scheme



Total cross section inside the DS: required
~ 180 cm²
Cross section used:
~ 100 cm²

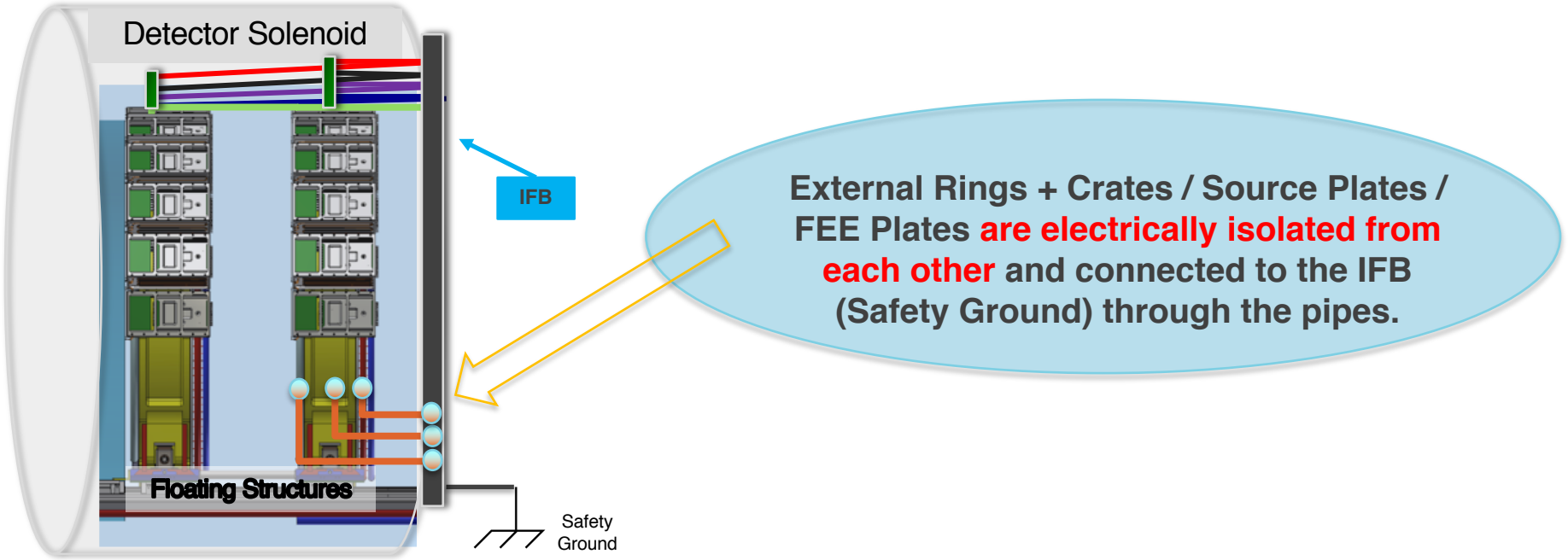
Total cross section outside the DS: required
~ 210 cm²
Cross section used:
~ 190 cm²

Inside the DS: per half disk



Safety Ground

- **Safety Ground:** Mechanical parts of the calorimeter are connected to the safety ground (the IFB) using the pipes (source pipes, cooling pipes).



Electrical Services

Outside the Detector Solenoid

Calorimeter Power Supplies

- Two racks 48 U size in the DAQ room
- Two lines per crate for LV/HV: Pos and Neg SiPMs

Power dissipation at the rack level per disk

- 20 HV module —> 20 x 500 mA x 200 V x 1.4 (taking for safety into account a 70% power supply efficiency) = 3 kW
- 20 LV module —> 20 x 10 A x 28 V x 1.4 (taking for safety into account a 70% power supply efficiency) = 8 kW

Total ~ 11 kW per disk

Calorimeter Power Supply: RACKs

Network Rack	U-count
RPS	48
Slow Controls	47
AC Switch Box	45 - 46

		44
		43
LV-d0-p0-c0-s0	TTi CPX400SP	40 - 41 - 42
HV-d0-p0-c0-s0	TTi PLH250-P	
LV-d0-p0-c0-s1	TTi CPX400SP	
HV-d0-p0-c0-s1	TTi PLH250-P	
		39
LV-d0-p0-c1-s0	TTi CPX400SP	36- 37 - 38
HV-d0-p0-c1-s0	TTi PLH250-P	
LV-d0-p0-c1-s1	TTi CPX400SP	
HV-d0-p0-c1-s1	TTi PLH250-P	
		35
LV-d0-p0-c2-s0	TTi CPX400SP	32 - 33 - 34
HV-d0-p0-c2-s0	TTi PLH250-P	
LV-d0-p0-c2-s1	TTi CPX400SP	
HV-d0-p0-c2-s1	TTi PLH250-P	
		31
		30
LV-d0-p0-c3-s0	TTi CPX400SP	27 - 28 - 29
HV-d0-p0-c3-s0	TTi PLH250-P	
LV-d0-p0-c3-s1	TTi CPX400SP	
HV-d0-p0-c3-s1	TTi PLH250-P	

		26
LV-d0-p0-c4-s0	TTi CPX400SP	23 - 24 -25
HV-d0-p0-c4-s0	TTi PLH250-P	
LV-d0-p0-c4-s1	TTi CPX400SP	
HV-d0-p0-c4-s1	TTi PLH250-P	
		22
		21
LV-d0-p1-c0-s0	TTi CPX400SP	18 - 19 - 20
HV-d0-p1-c0-s0	TTi PLH250-P	
LV-d0-p1-c0-s1	TTi CPX400SP	
HV-d0-p1-c0-s1	TTi PLH250-P	
		17
LV-d0-p1-c1-s0	TTi CPX400SP	14 -15- 16
HV-d0-p1-c1-s0	TTi PLH250-P	
LV-d0-p1-c1-s1	TTi CPX400SP	
HV-d0-p1-c1-s1	TTi PLH250-P	
		13
LV-d0-p1-c2-s0	TTi CPX400SP	10 - 11 - 12
HV-d0-p1-c2-s0	TTi PLH250-P	
LV-d0-p1-c2-s1	TTi CPX400SP	
HV-d0-p1-c2-s1	TTi PLH250-P	
		9
		8
LV-d0-p1-c3-s0	TTi CPX400SP	5 - 6 - 7
HV-d0-p1-c3-s0	TTi PLH250-P	
LV-d0-p1-c3-s1	TTi CPX400SP	
HV-d0-p1-c3-s1	TTi PLH250-P	
		4
LV-d0-p1-c4-s0	TTi CPX400SP	1 - 2 - 3
HV-d0-p1-c4-s0	TTi PLH250-P	
LV-d0-p1-c4-s1	TTi CPX400SP	
HV-d0-p1-c4-s1	TTi PLH250-P	

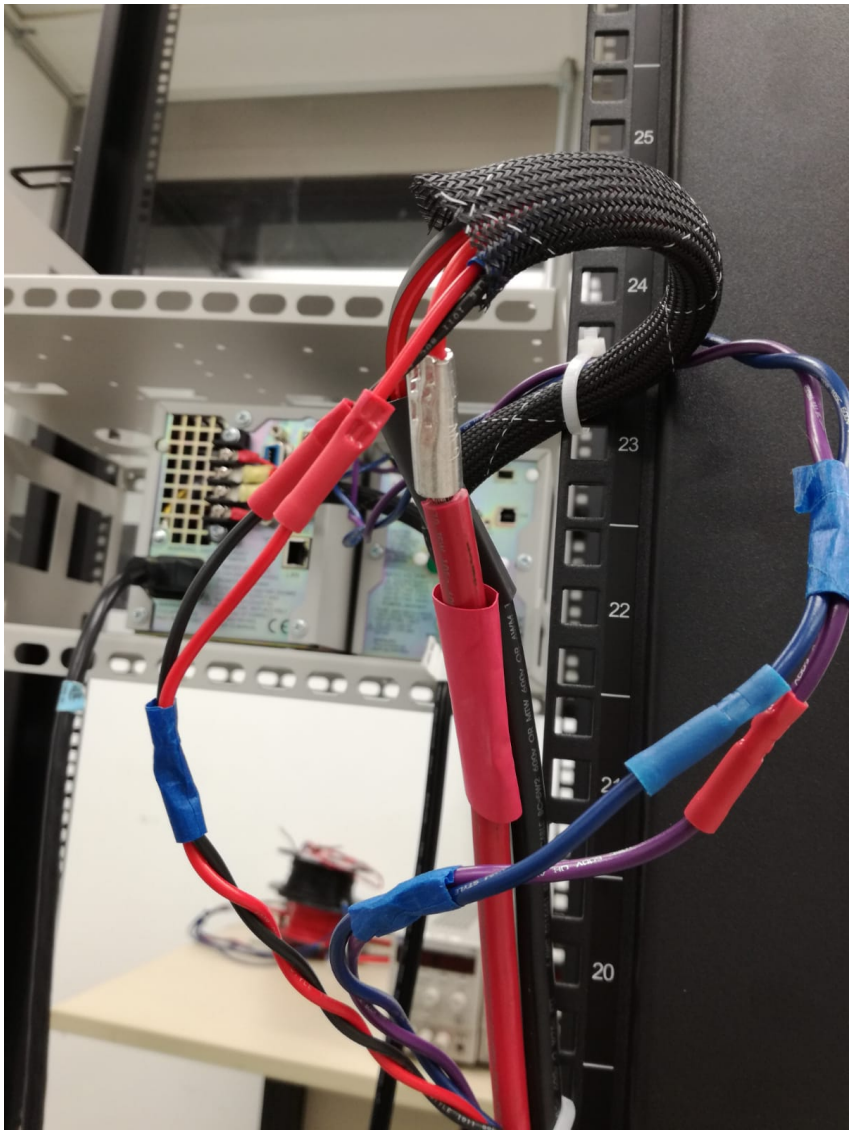
power supplies distribution: DISK0 (same for Disk1)

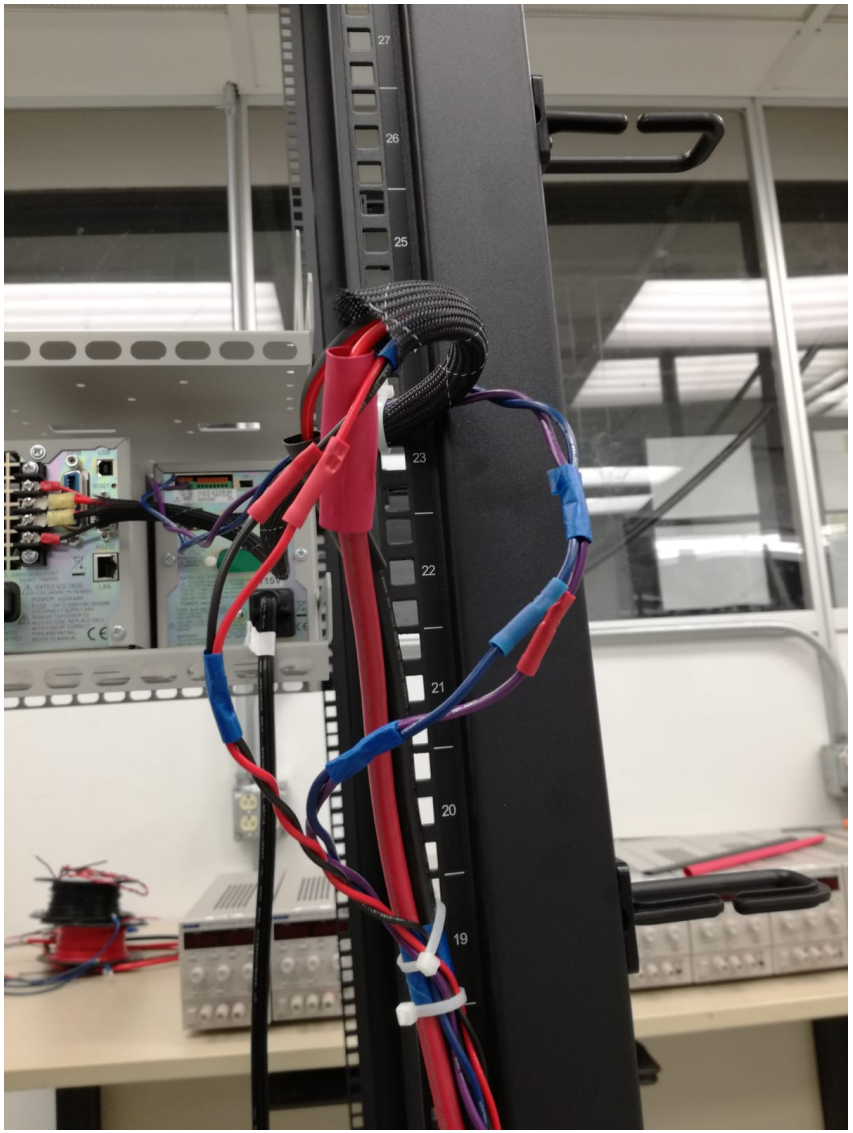
	Open space beetwen rack modules to increase the air flow
	Open space in the rack module

HV and LV - Cables – Connection at the Racks

The size of the cable, where necessary, will be adapted to the connectors diameter: ***example for the LV from 6AWG --> 2 x 16 AWG per line***

HV and LV - Cables – Connection at the Racks





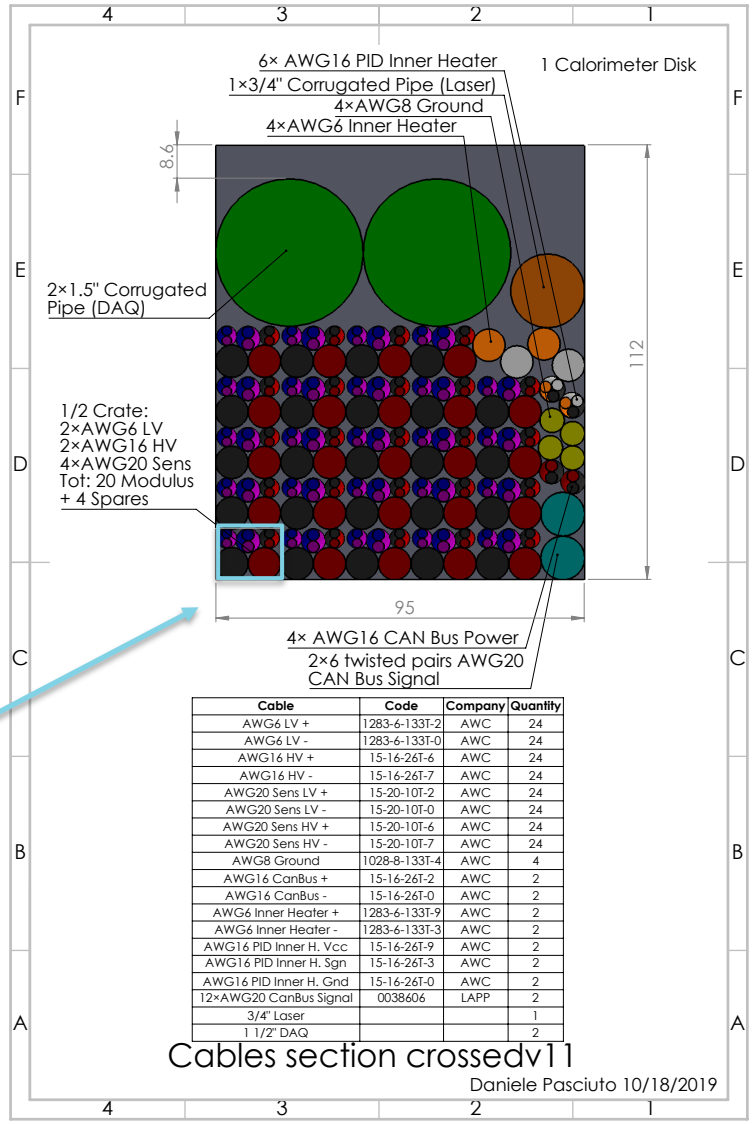
HV and LV - Cables - Outside the DS

Possible configurations per one DISK:

- We are in the requirement with an overall cross section of 9.5 x 11.2 cm^2 ~ 105 cm^2

- 2 x 1.5” Corrugated for the TDaq fibers
- 1 x ¾” Corrucated for the Laser fibers

Single module
½ crate for LV/HV



Cable	Code	Company	Quantity
AWG6 LV +	1283-6-133T-2	AWC	24
AWG6 LV -	1283-6-133T-0	AWC	24
AWG16 HV +	15-16-26T-6	AWC	24
AWG16 HV -	15-16-26T-7	AWC	24
AWG20 Sens LV +	15-20-10T-2	AWC	24
AWG20 Sens LV -	15-20-10T-0	AWC	24
AWG20 Sens HV +	15-20-10T-6	AWC	24
AWG20 Sens HV -	15-20-10T-7	AWC	24
AWG8 Ground	1028-8-133T-4	AWC	4
AWG16 CanBus +	15-16-26T-2	AWC	2
AWG16 CanBus -	15-16-26T-0	AWC	2
AWG6 Inner Heater +	1283-6-133T-9	AWC	2
AWG6 Inner Heater -	1283-6-133T-3	AWC	2
AWG16 PID Inner H. Vcc	15-16-26T-9	AWC	2
AWG16 PID Inner H. Sgn	15-16-26T-3	AWC	2
AWG16 PID Inner H. Gnd	15-16-26T-0	AWC	2
12×AWG20 CanBus Signal	0038606	LAPP	2
3/4" Laser			1
1 1/2" DAQ			2

Procurement and Mock-Up

- Procurement of one disk (30 ft length) cables concluded.
- All the cables are in Sidet…

→ We are ready to try the real mock-up

Line	Ordered	Unit	Item Number / Description	Site
1	720	FT	BONDED 6 AWG BLACK-RED 1283 133T BLACK AND RED BONDED	PA SITE 01
	1 X 720' -0/+10% TOLERANCE - 3-4 WEEK LEAD TIME ARO			
2	720	FT	16 AWG BLUE-VIOLET TWISTED UL 1015 16 AWG 26T BLUE & VIOLET TWISTED	PA SITE 01
	1 X 720' -0/+10% TOLERANCE - *STANDARD LAY 3-5 DAY LEAD TIME ARO			
3	720	FT	20 AWG BLACK-RED TWISTED UL 1015 20 AWG 10T BLACK & RED TWISTED	PA SITE 01
	1 X 720' -0/+10% TOLERANCE - *STANDARD LAY 3-5 DAY LEAD TIME ARO			
4	720	FT	20 AWG BLUE-VIOLET TWISTED UL 1015 20 AWG 10T BLUE & VIOLET TWISTED	PA SITE 01
	1 X 720' -0/+10% TOLERANCE - *STANDARD LAY 3-5 DAY LEAD TIME ARO			
5	120	FT	1028-8-133T-4 MTW 8 1C 1028 133ST MTW YELLOW *1	PA SITE 01
	JUST YELLOW STOCK PA			

LV

HV

LV Sens

HV Sens

Ground

	-0/+10%			
6	250	FT	12 AWG BLACK-RED TWISTED UL 1015 12 AWG 65T BLACK & RED TWISTED	PA SITE 01
	1 X 250' (250' MOQ) -0/+10% TOLERANCE - *STANDARD LAY 3-5 DAY LEAD TIME ARO			
9	60	FT	1283-6-133T-9 6 1C 1283 6AWG 133ST WHITE	WI SITE 04
	STOCK WI			
10	60	FT	1283-6-133T-9 6 1C 1283 6AWG 133ST ORANGE	WI SITE 04
	3-5 DAY LEAD TIME ARO (SHIP FROM WI) WHITE DYED ORANGE			
11	60	FT	LAPP UNITRONIC® LIHCH (TP) DATA,] SIGNAL & CONTROL CABLE - 20 AWG/6 PAIR -	

Can Bus +5V and GND

Temp Inner Ring -

Temp Inner Ring +

Can Bus Data

Instrumentation Feed-through Bulkhead

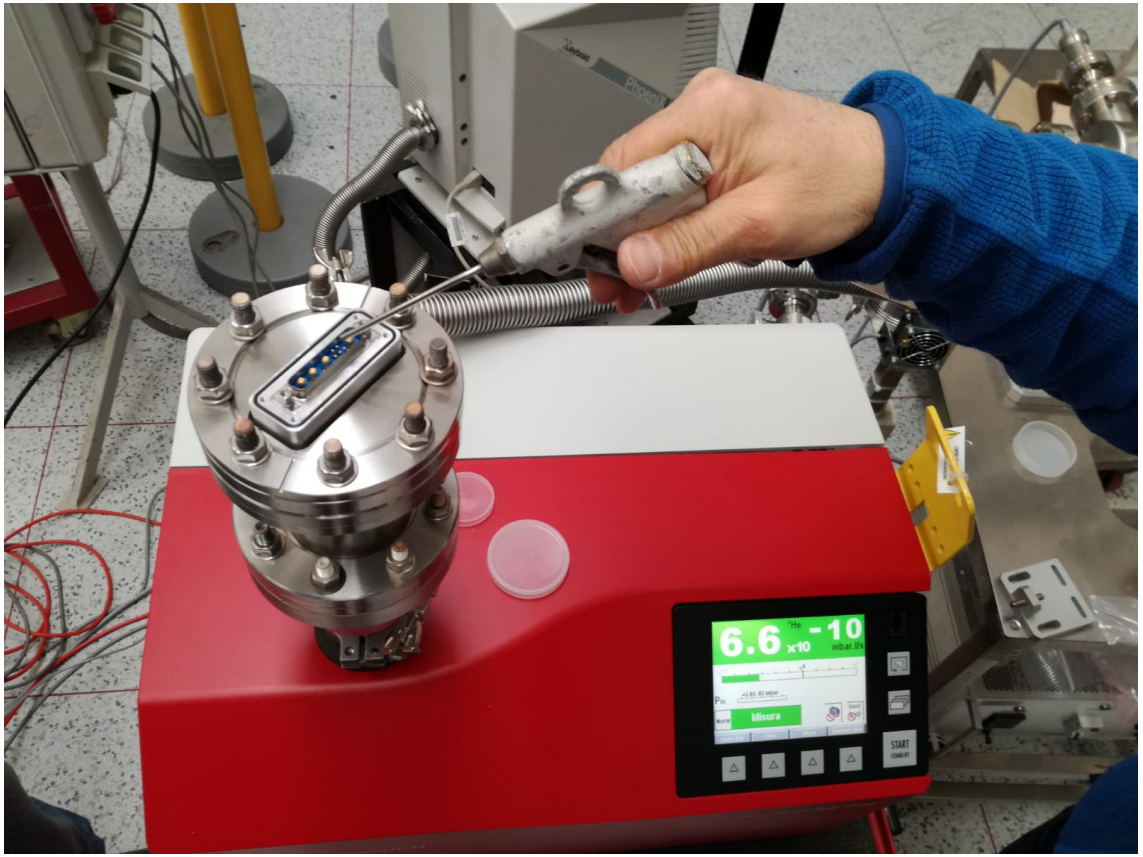
At IFB

IFB-CONNECTORS	Flange #	Num. Connectors per Flange #	Spares Per Flange #	KIND
Laser Fiber	0-1	2		FIBM3−IR00−02−S−3
TDAQ Fiber	0-1	4		Pavetech VS-18
LV	0-1	10	2	XAVAC9W4M/SI.2/AA
HV	0-1	10	2	XAVAC9W4M/SI.2/AA
GND	0-1	1		XAVAC9W4M/SI.2/AA
CAN	0-1	2		XAVAC15M/SI.0/AA
Inner ring	0-1	1		XAVAC9W4M/SI.2/AA

Connectors: milled Aluminum inside and outside the DS

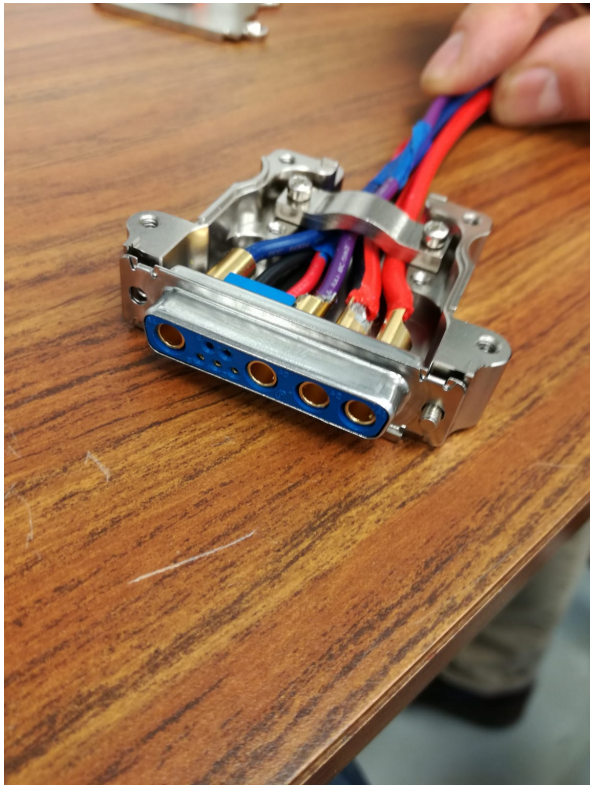
IFB - Connectors Leak test -

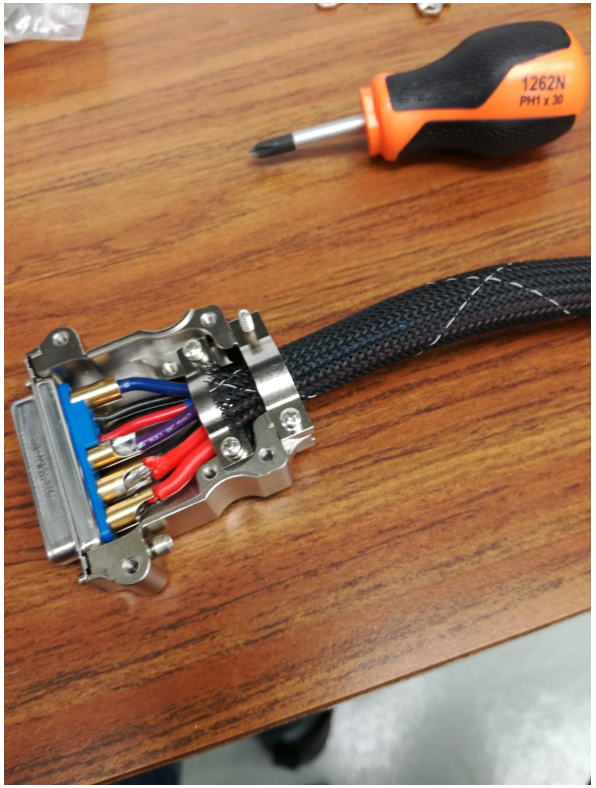
IFB connectors leak test better than 10^{-9} Torr

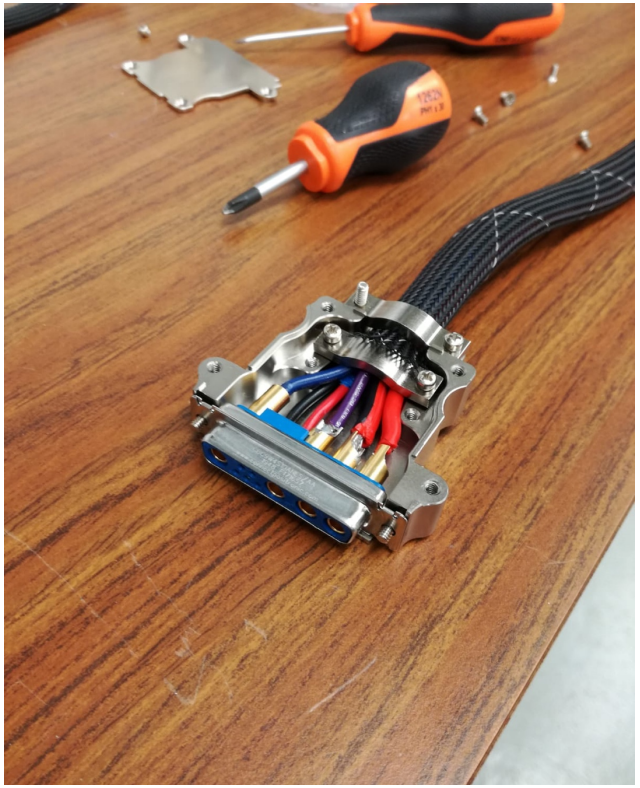


Fermilab

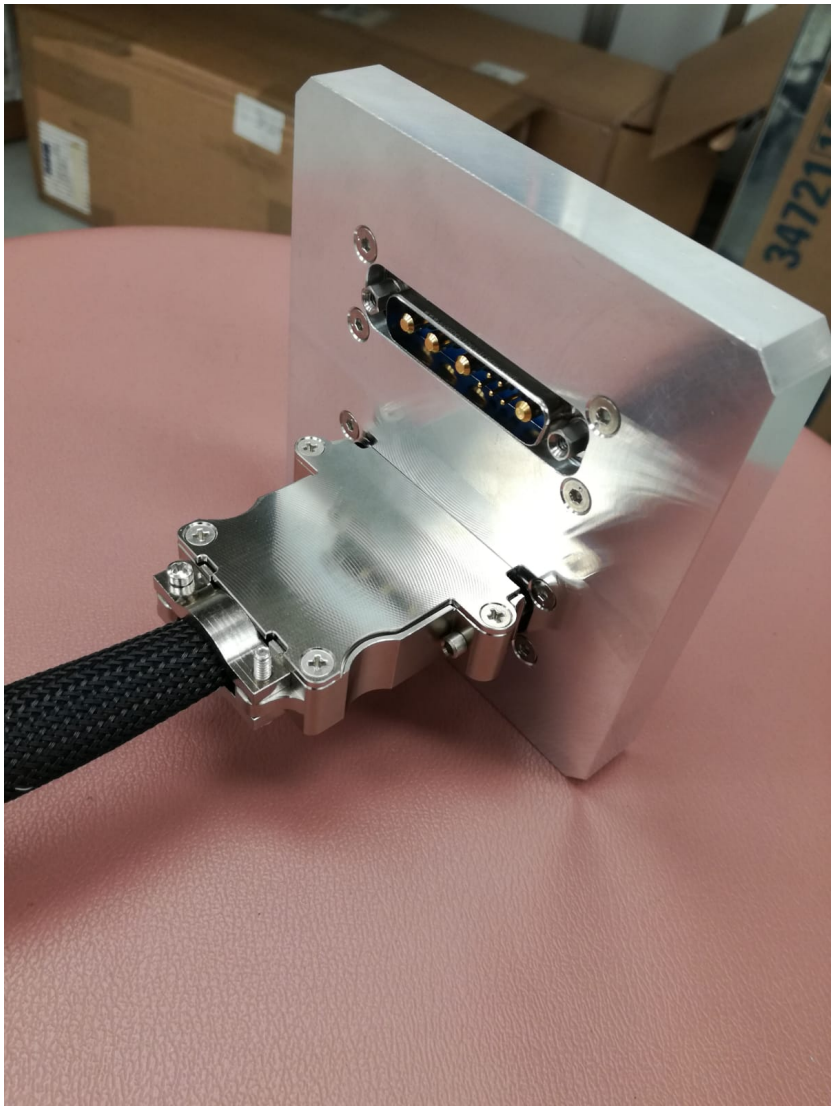
IFB - Cables Connection HV/LV-

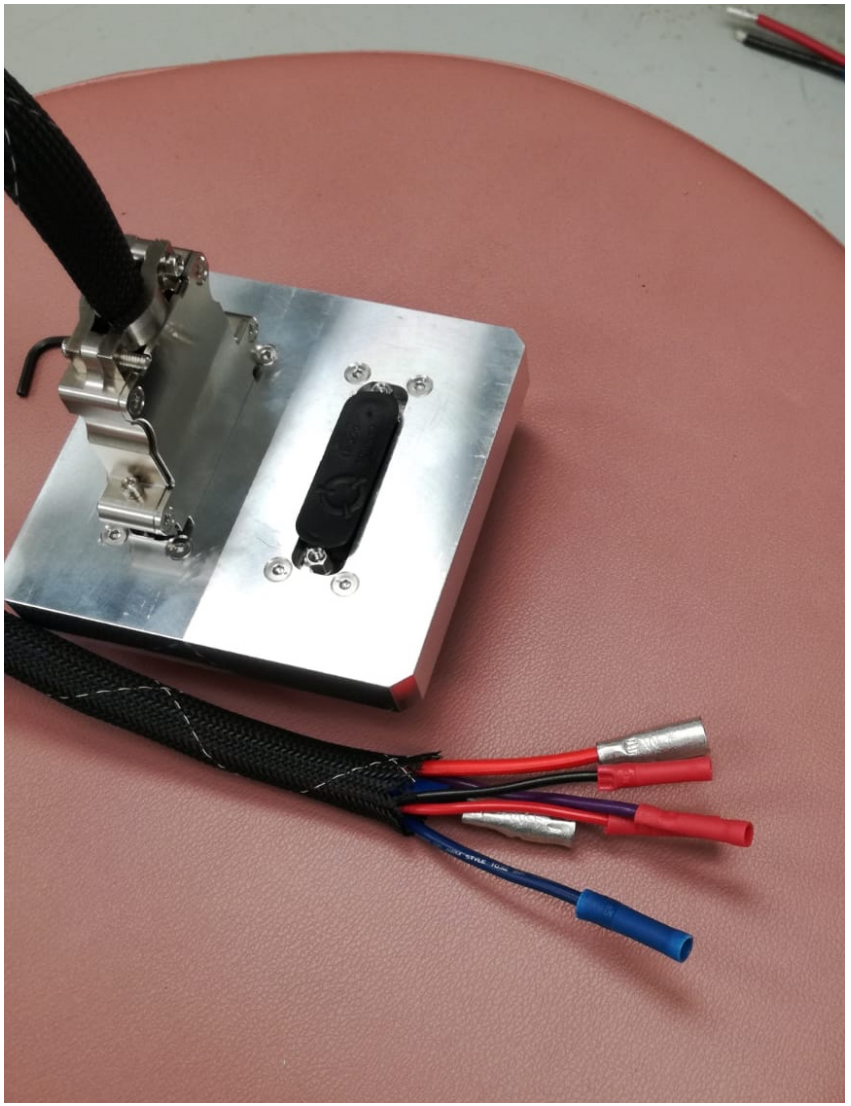






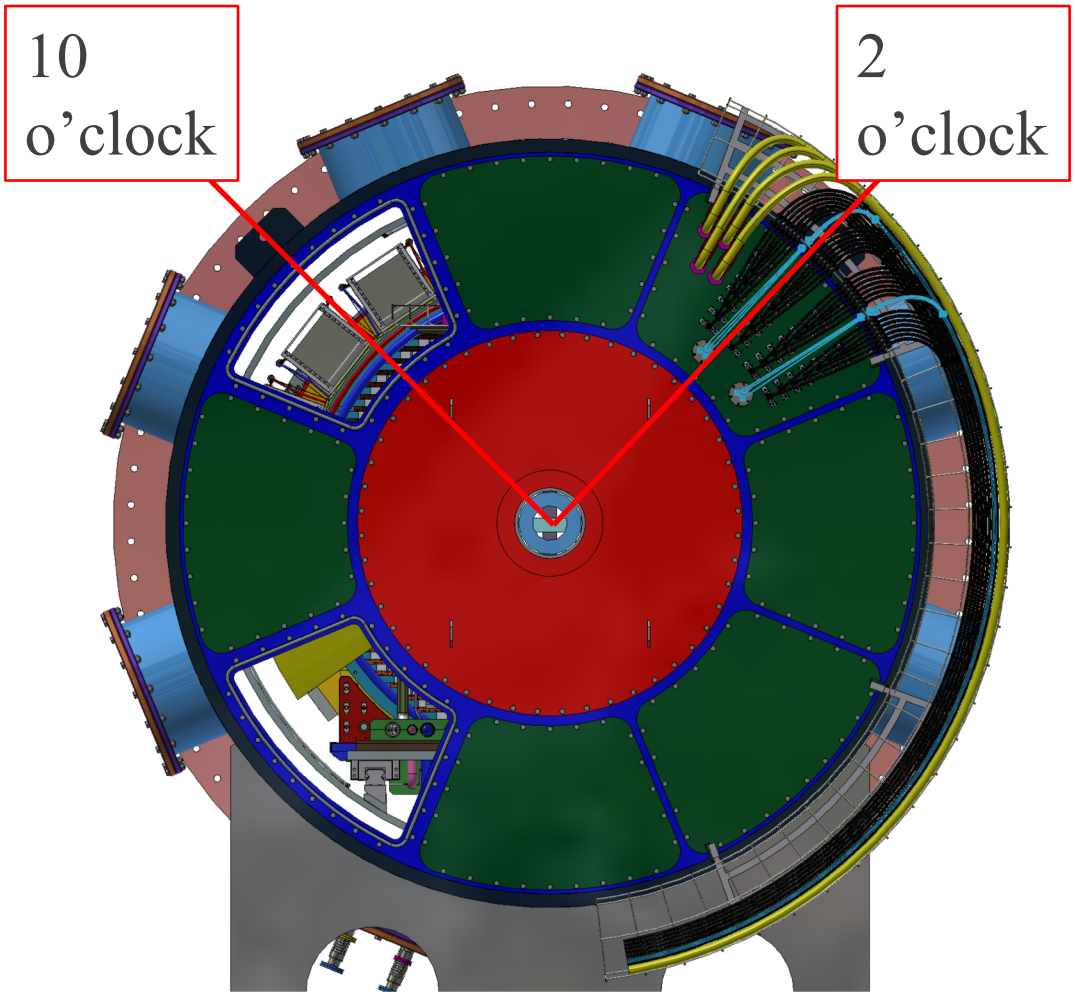
IFB - Connector Connection -



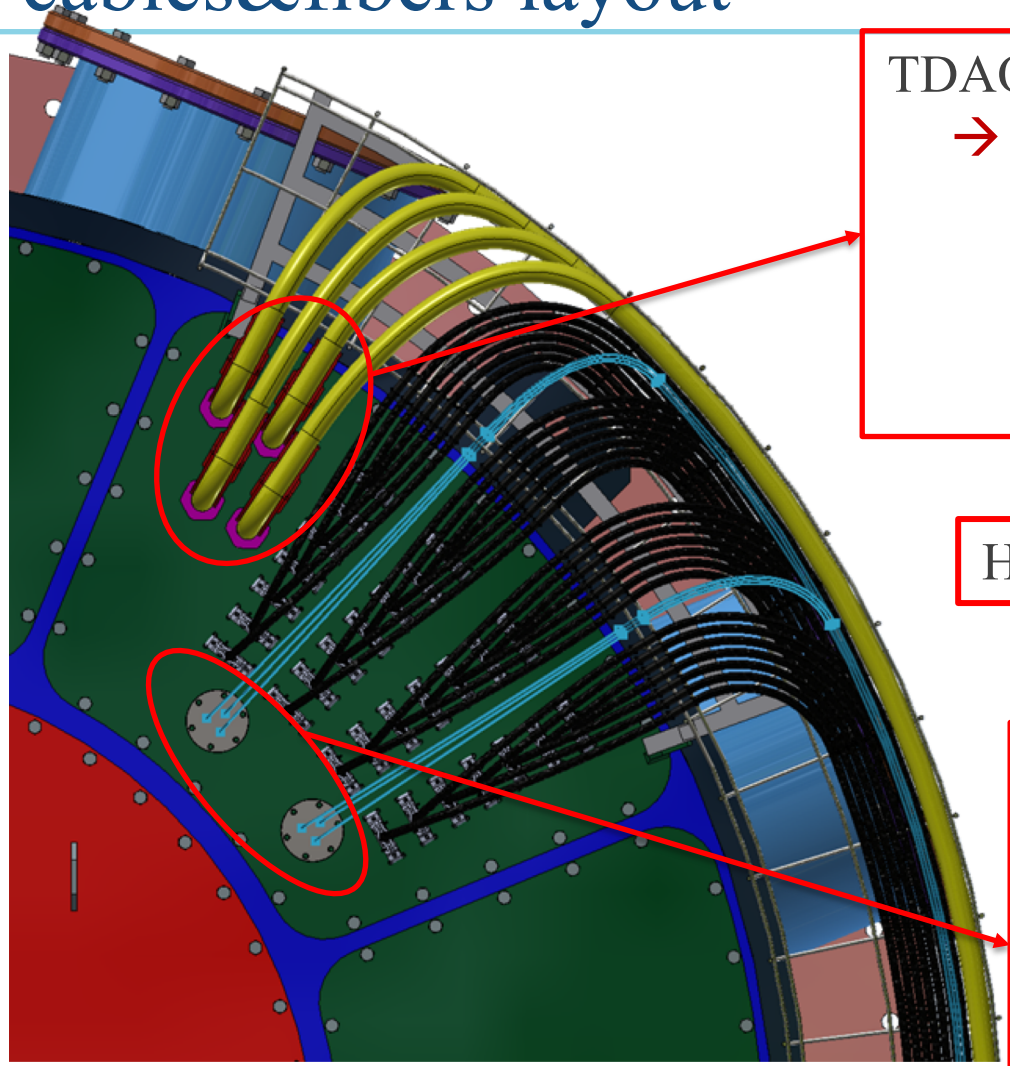


IFB flanges reserved for EMC

Our design uses 2 sectors of the IFB for the optical fibers and cables

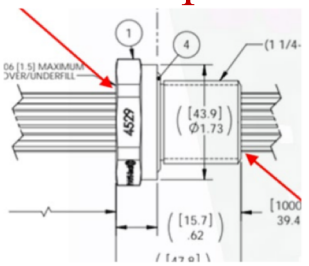


IFB cables&fibers layout



TDAQ: 48 fibers per connector

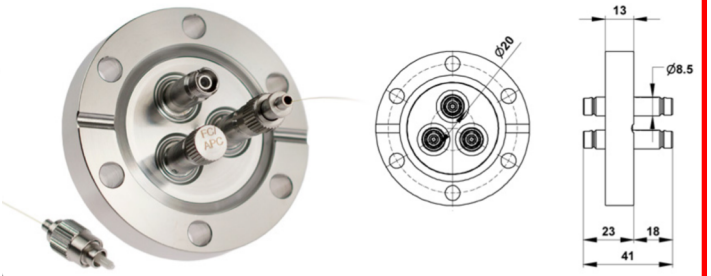
→ 4 connector per flange



HV/LV: 28 connectors

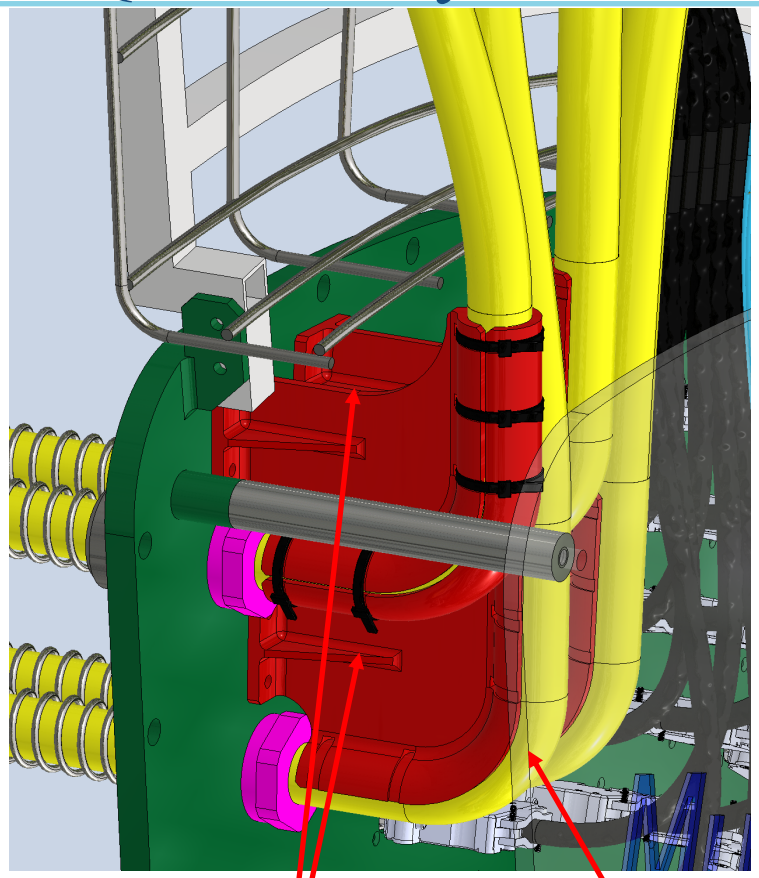
Laser: 3 fibers per connector

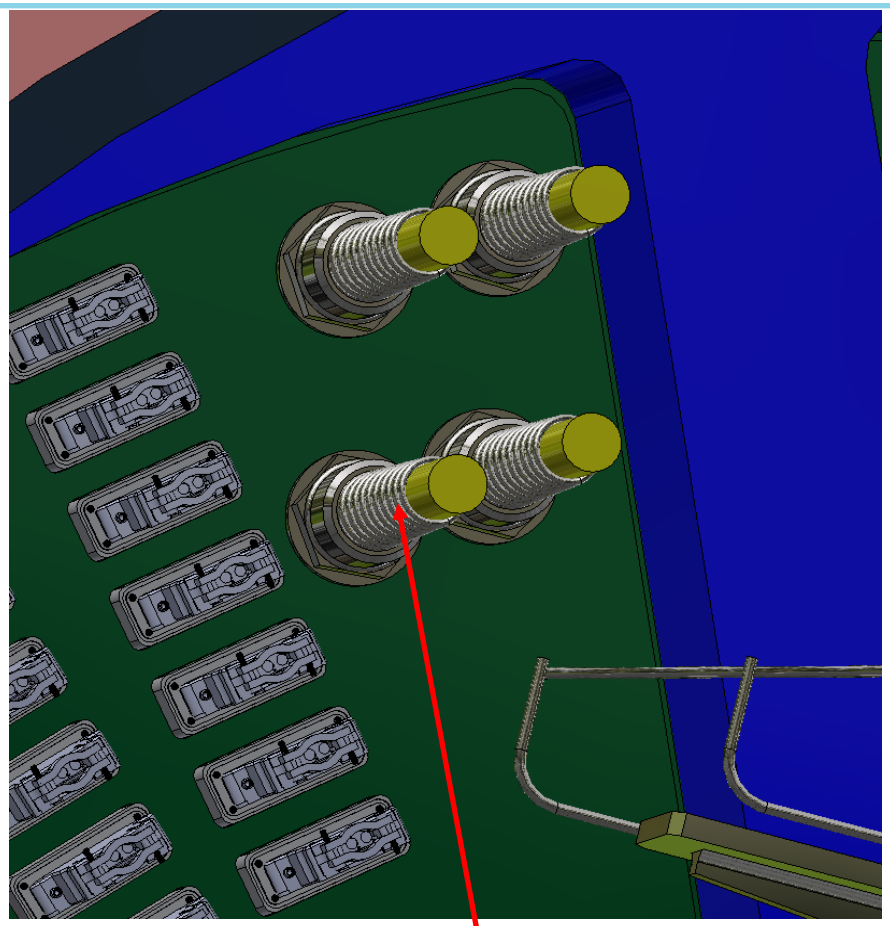
→ 2 connector per flange



Fermilab

TDAQ fibers layout





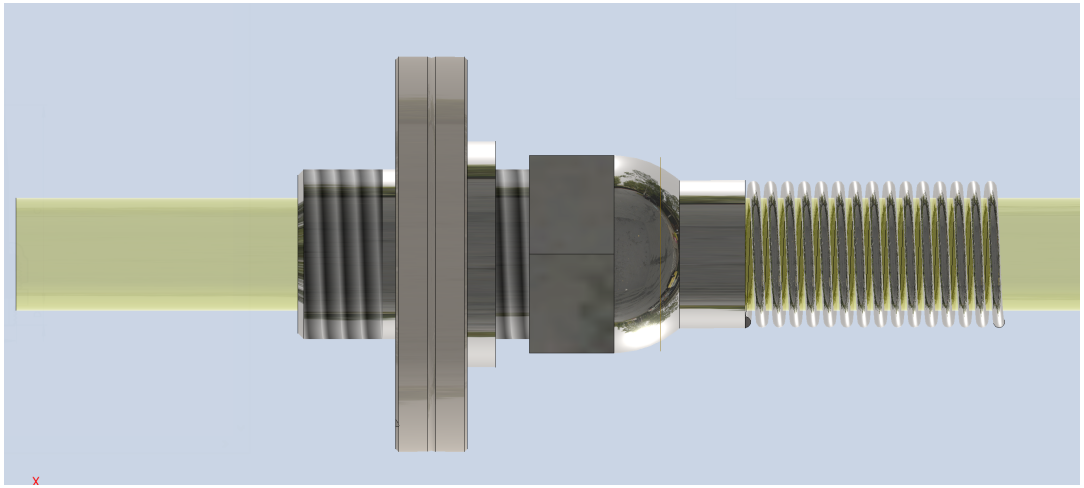
TDAQ fiber supports (front side)

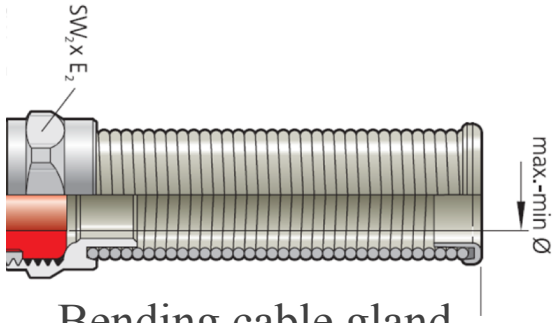
Bending radius = 50 mm

Bending cable gland (back side)

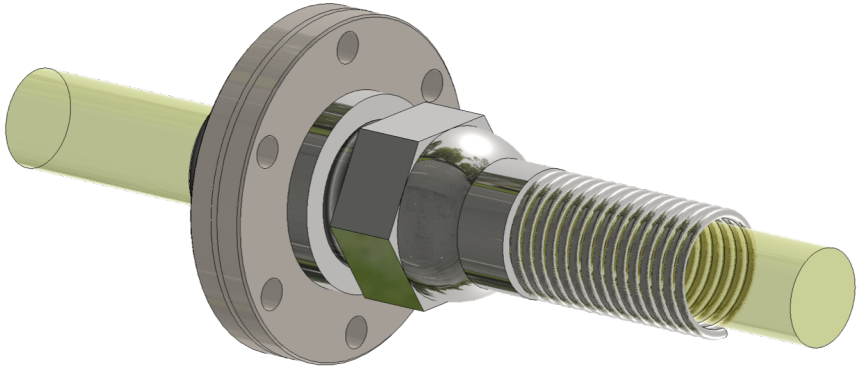
Fermilab

Bending Cable Gland



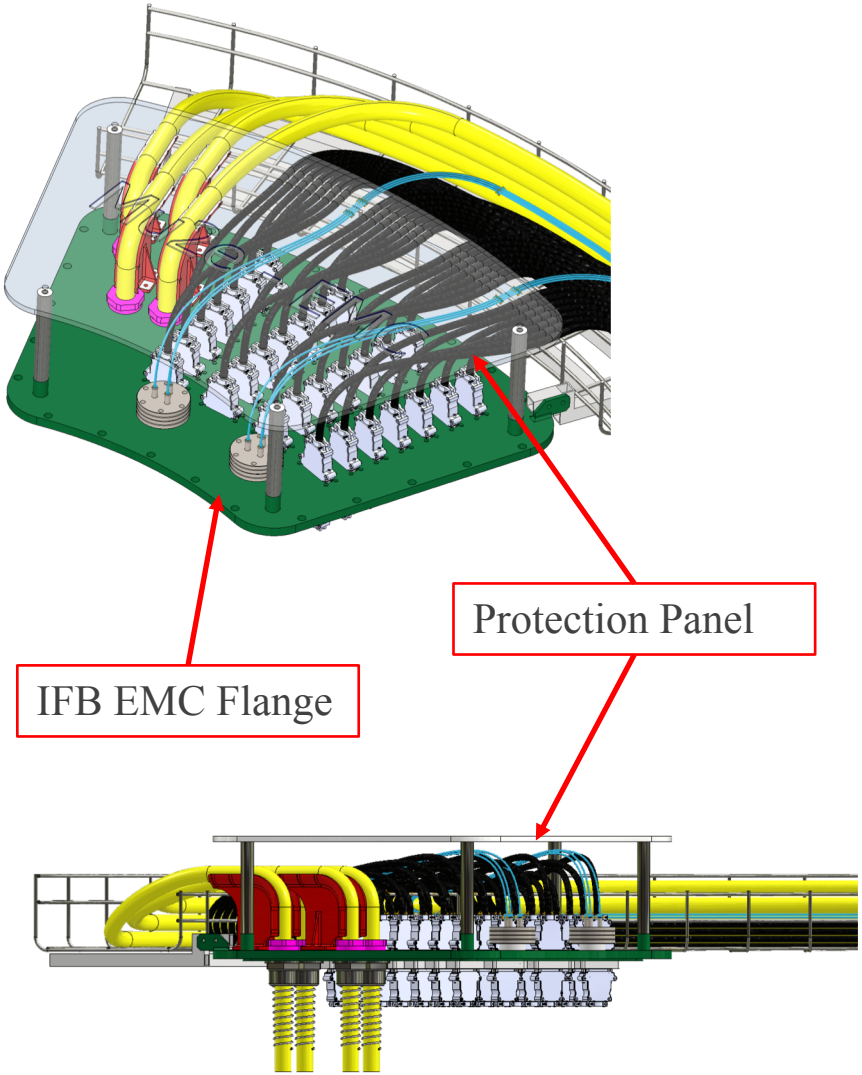


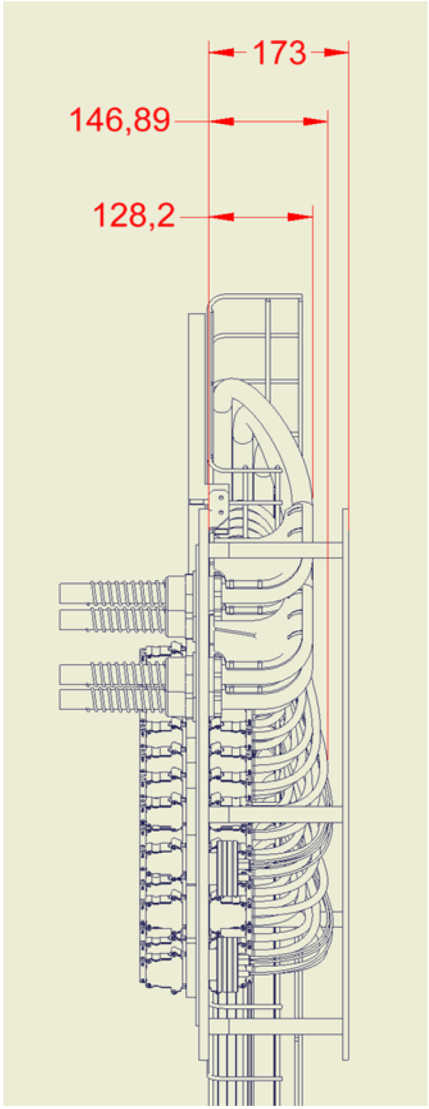
Bending cable gland



Bending cable gland

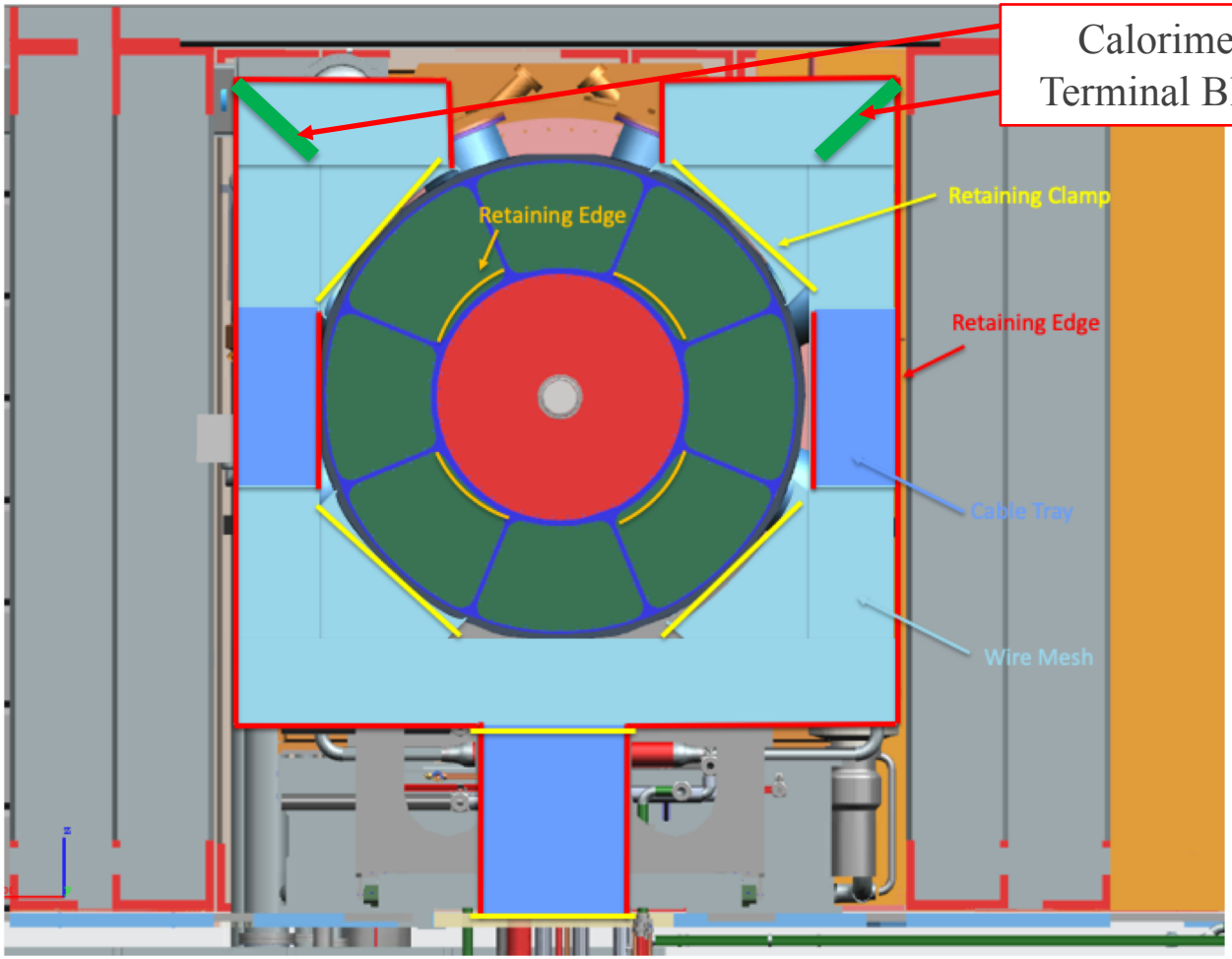
IFB layout





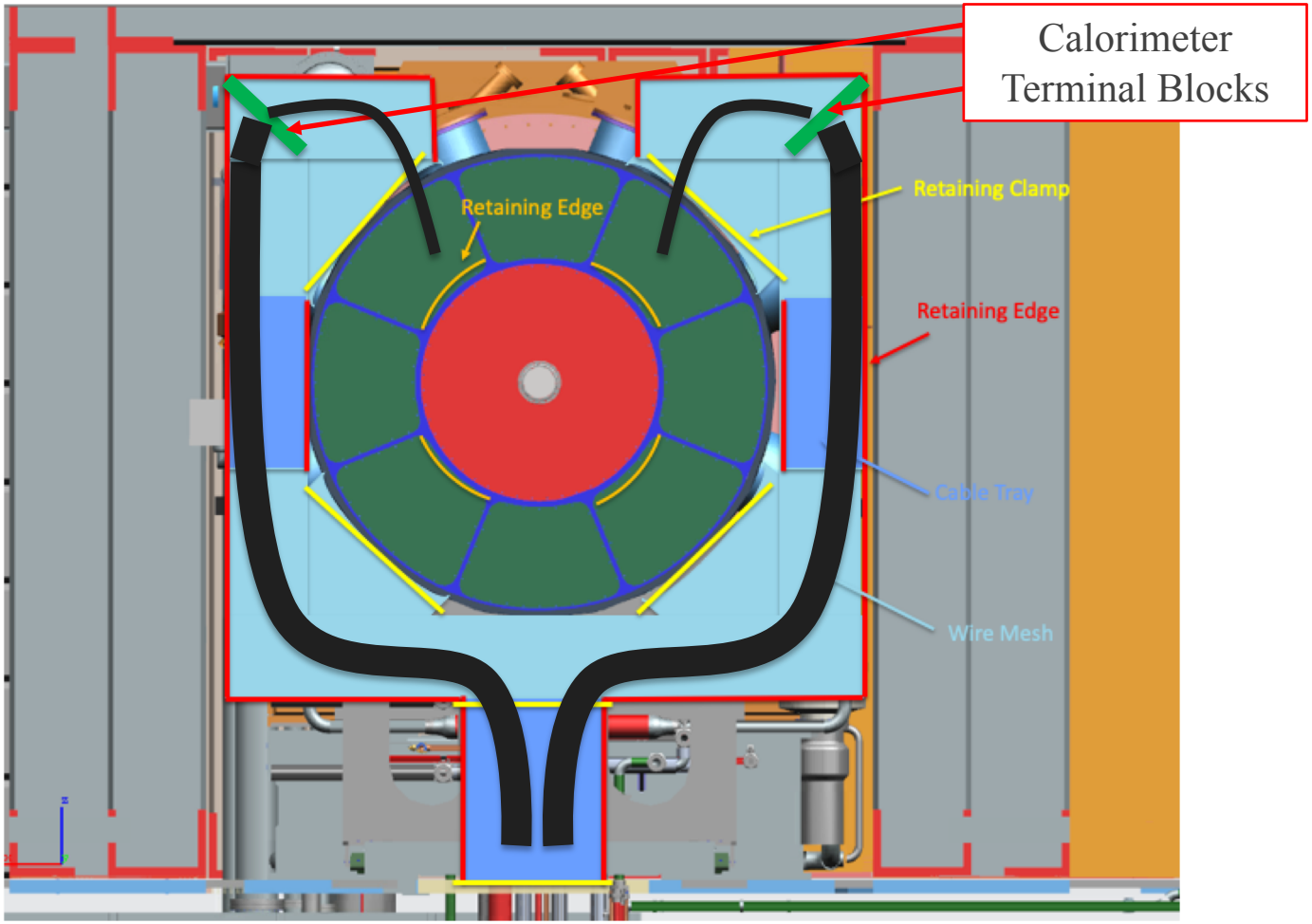
IFB flanges: new Scheme -1-

George has increased our available space → terminal blocks can be lodged at the two high corners of the IFB



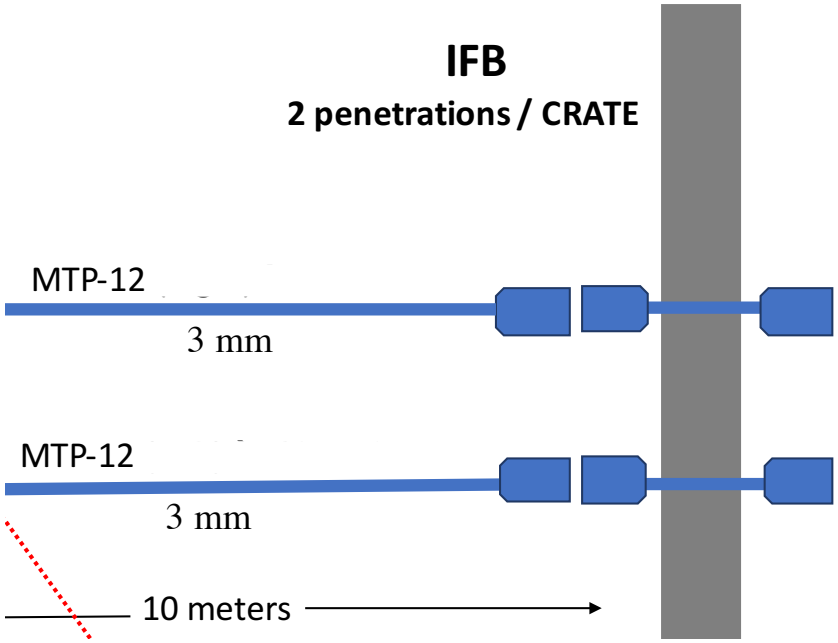
IFB flanges: new Scheme -2-

George has increased our available space → terminal blocks can be lodged at the two high corners of the IFB

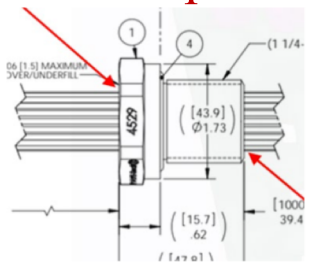


TDAQ and Laser

Electrical Services: TDAQ fibers at IFB



TDAQ: 48 fibers per connector
→ 4 connector per flange

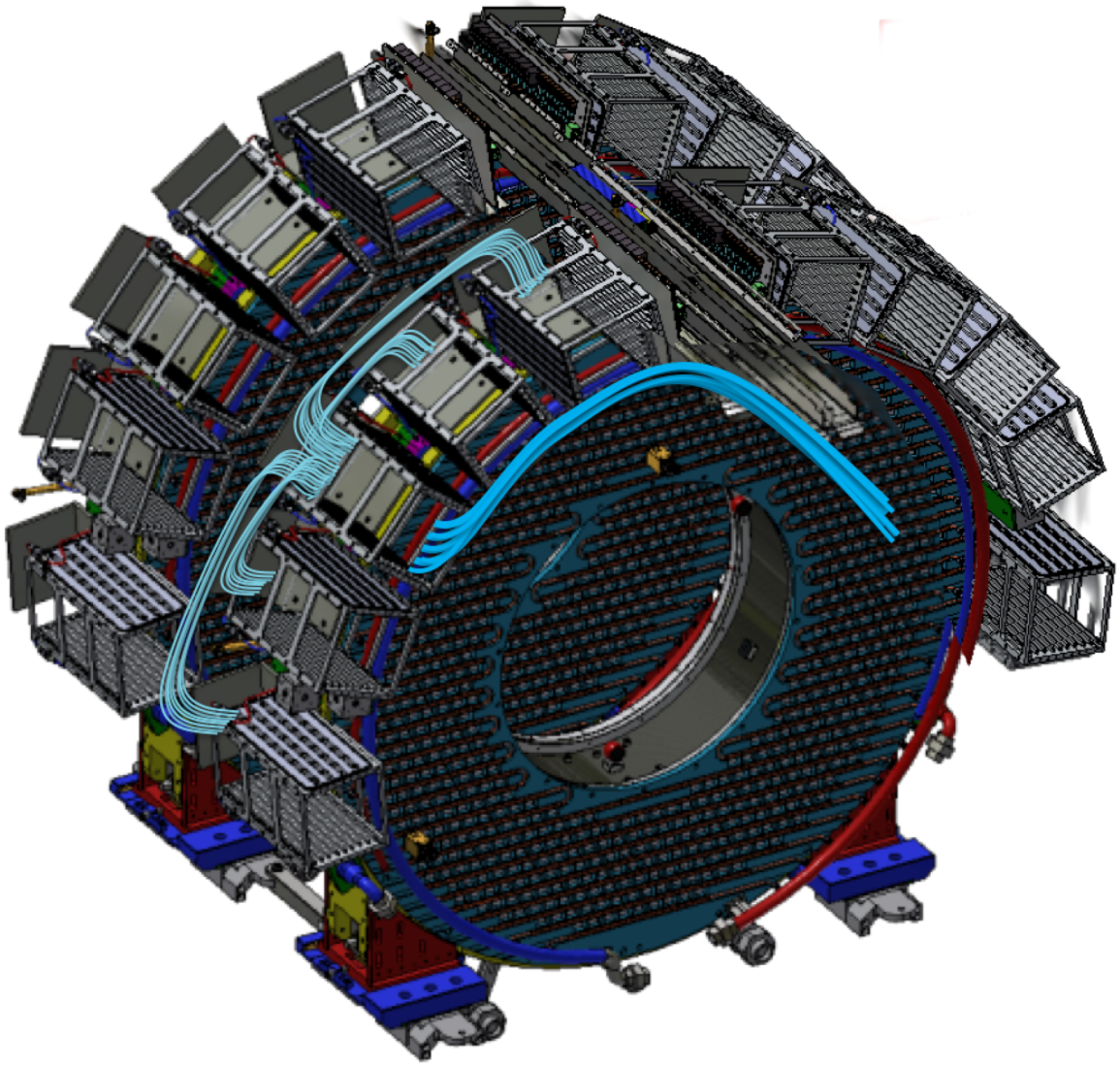


- ***Fibers glued in the flange***

- ***Connectors at the end of both part***

→ 8 IFB penetrations for 28 MTP-12
for serving all calorimeter + 4 spares

Example of TDAQ fibers distribution: ½ DISK

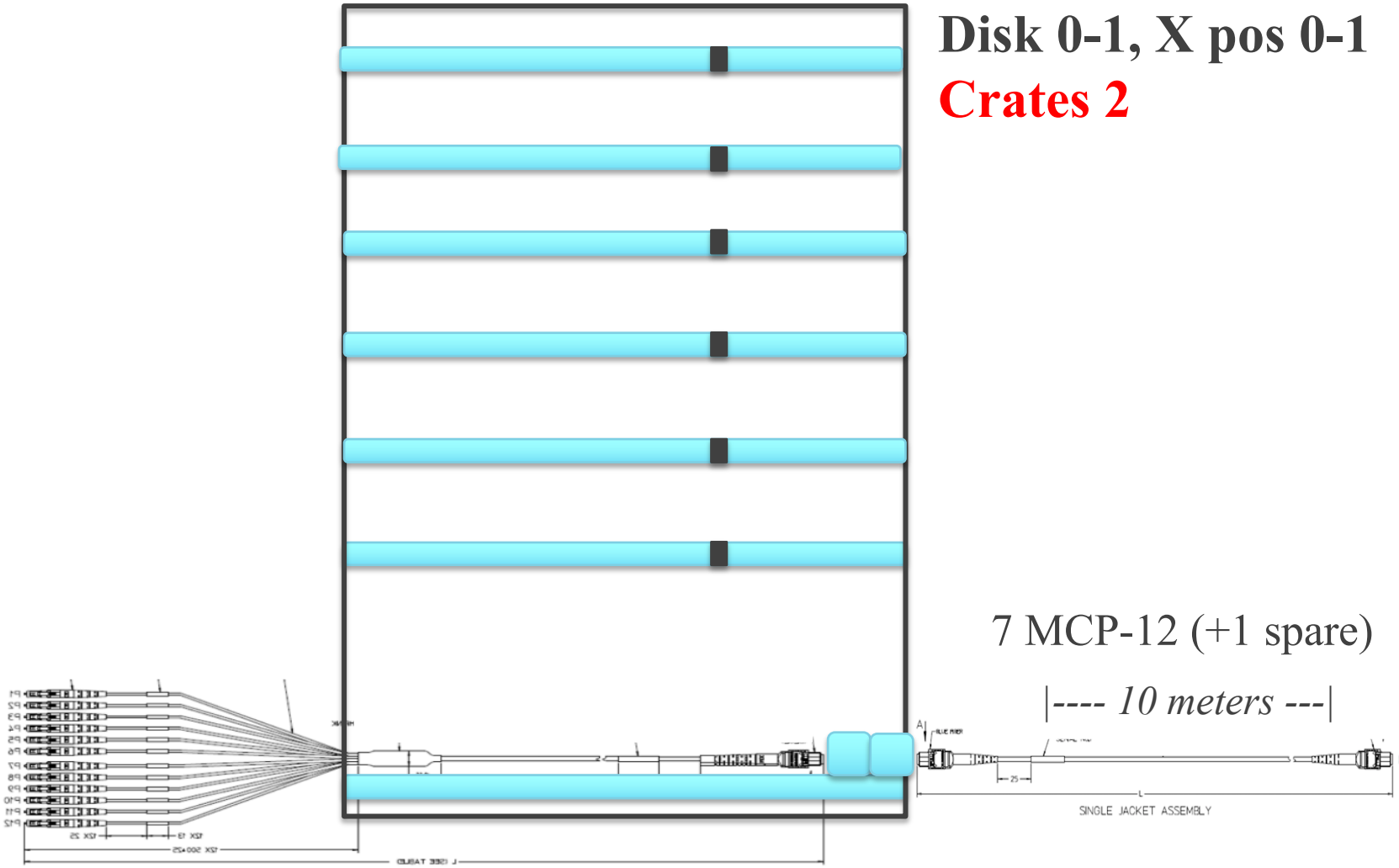


Input for ½ DISK
Crates 2: **7xMTP-12 = 42 boards**
+ (1 spare MCP-12)

Needed
Crates 0: **8 boards** → 16 fibers + 2 spares = 18 fibers
Crates 1: **8 boards** → 16 fibers + 2 spares = 18 fibers
Crates 2: **6 boards** → 12 fibers + 2 spares = 14 fibers
Crates 3: **7 boards** → 14 fibers + 2 spares = 16 fibers
Crates 4: **7 boards** → 14 fibers + 2 spares = 16 fibers

Tot 82

TDAQ fibers: from MTP to final fibers in Crate2



TDAQ – DB-Margin

All considerations about the optical fibers scheme from Ryan's talk ➔ docDB 17943

- Versatile Link App. Note v2.7 lists "Radiation Penalty" for the VTRx at 2.5dB @ 5E14n/cm^2. If Radiation Penalty for VTRx is added, upstream margin is reduced to: 1.37 dBm.

- Projection to the calorimeter: ~ 5E^{12}n/cm^2 ➔
- With one connection more (loss of ~ 0.25 dB) we stay largely in the margin.

Electrical Services: Laser

- Eight 70 m fibers (1 mm diameter Fused Silica), routed from the DAQ room to the IFB to bring the light to **8** 2" **diffusing spheres** located on the calorimeter structure;

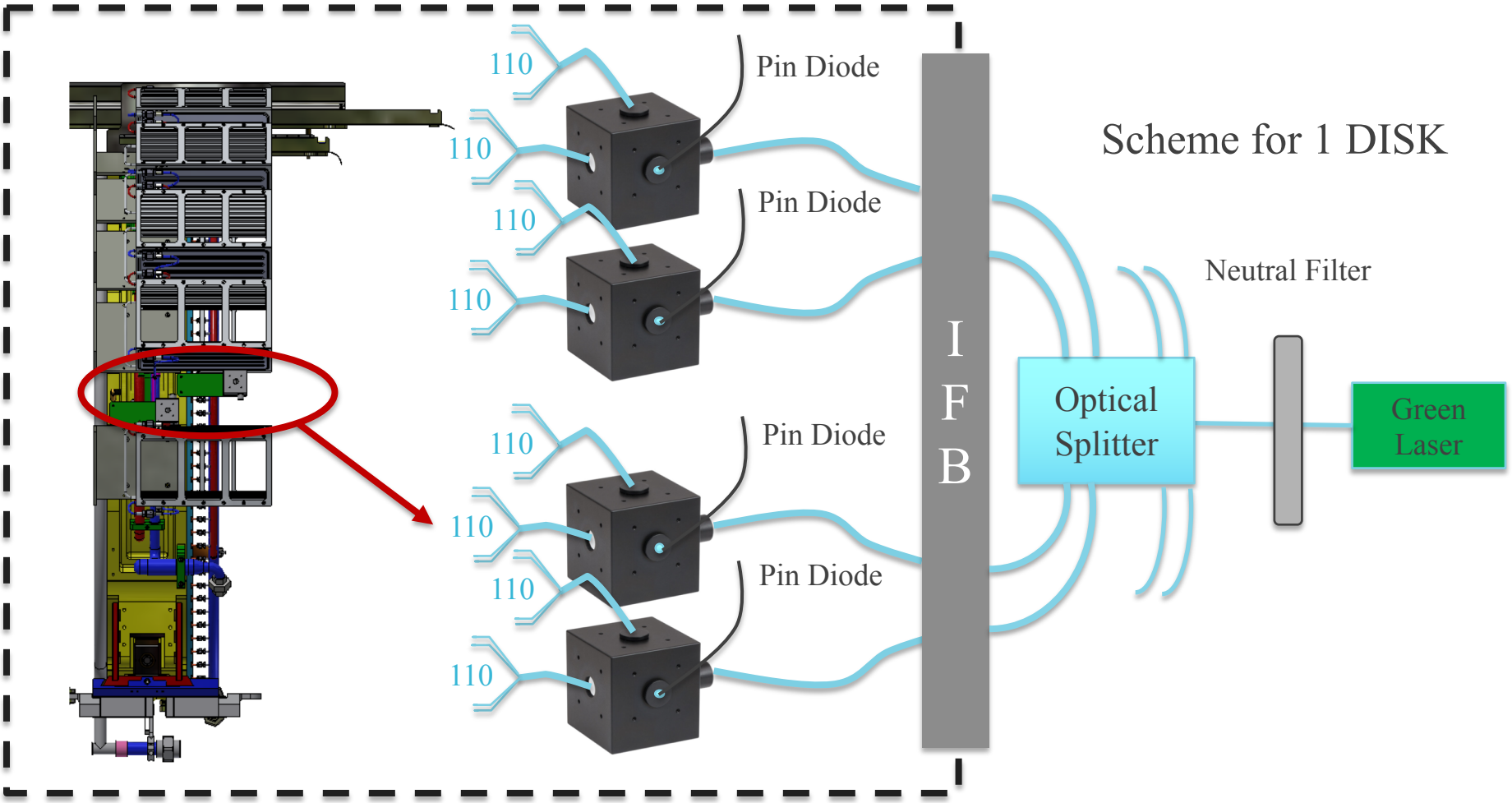
- Each disk will house four diffusing spheres;

- **Each sphere has 2 pin diodes for monitor and 2 bundles** (1 bundle→ 110 fibers each of 200 μm diameter) of silica fibers.
- Each fiber will be inserted into a lodging in the back of the crystals close to the SIPM holders;

- The pin diode signals will be acquired using 8 channels in the DIRAC boards

→ 8 IFB penetrations for the fibers + 4 spares

Electrical Services: Laser

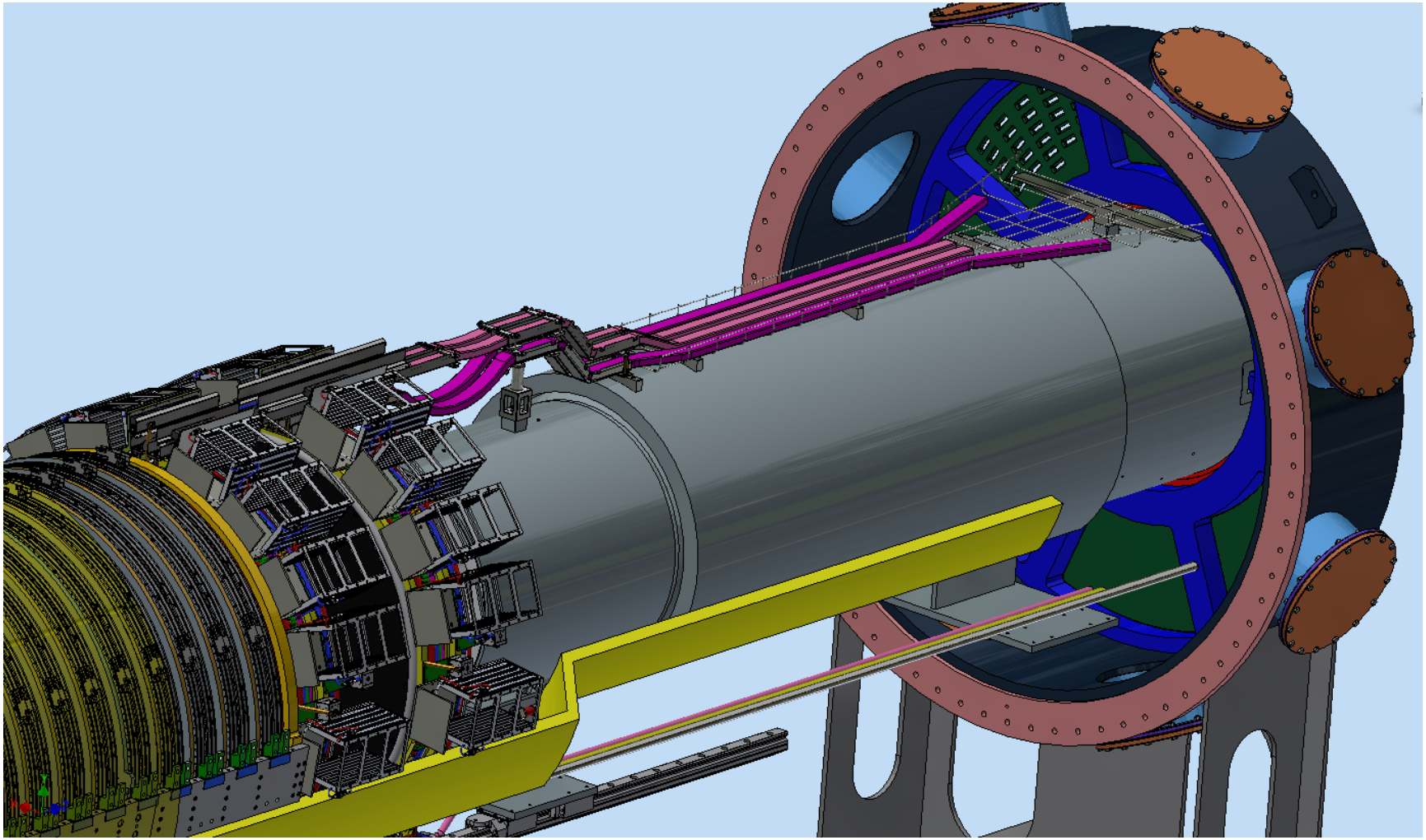


Electrical Services: Fibers summary

		Cable/disk	Type	Nominal Diameter	Measured Diameter	Weight
Laser Fibers	**Front** (source side)	2 DX Side + 2 SX Side		2 mm		
	spare	1 DX Side + 1 SX Side		2 mm		
TDAQ Fibers	**Main Fibers**	7 DX Side + 7 SX Side	multi-fibers (12 fibers)	3 mm		
	spare	1 DX Side + 1 SX Side		3 mm		

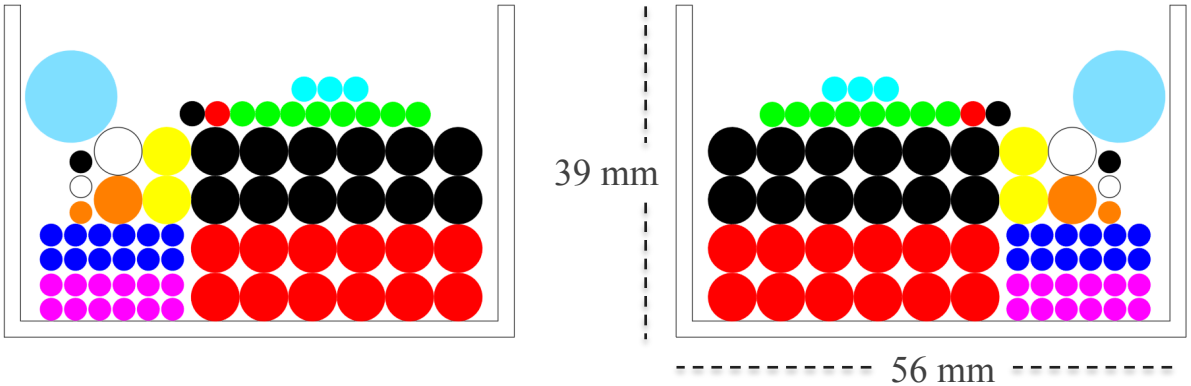
Inside the Detector Solenoid

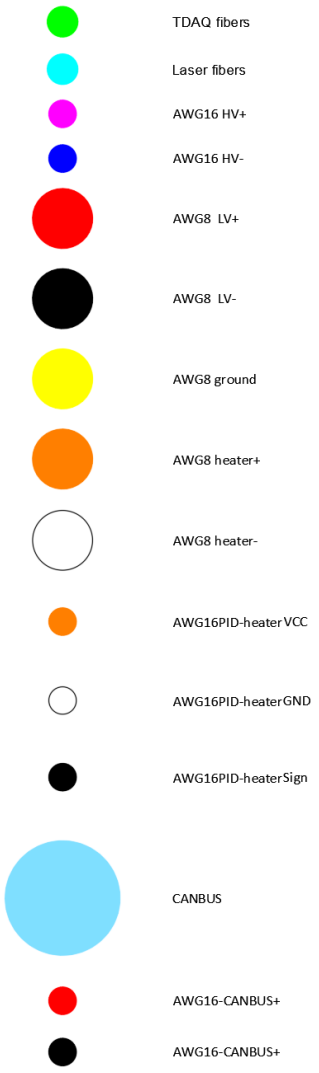
Routing inside the DS



HV and LV - Cables - Inside the DS

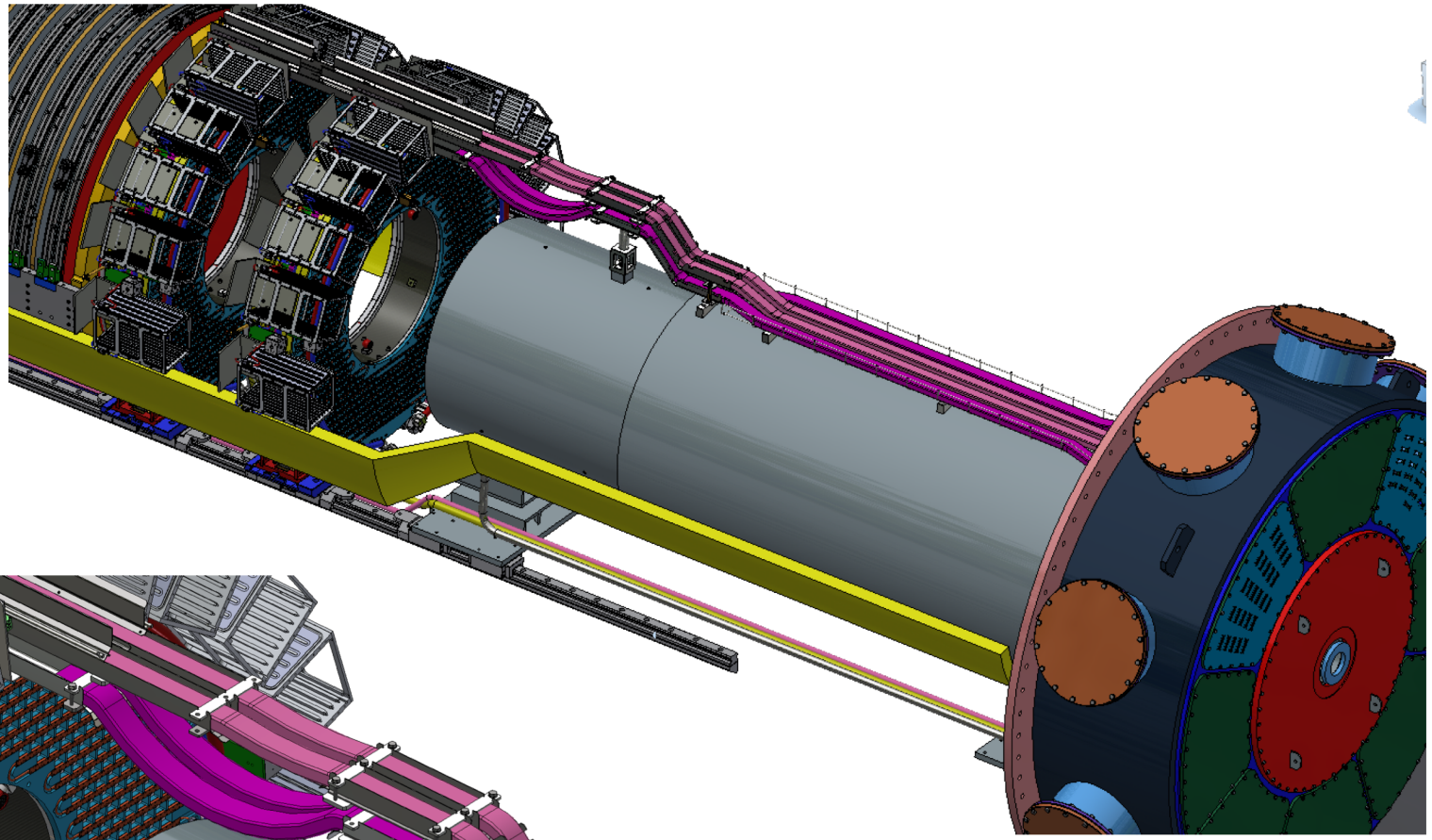
Possible configurations per one DISK (2 slices):

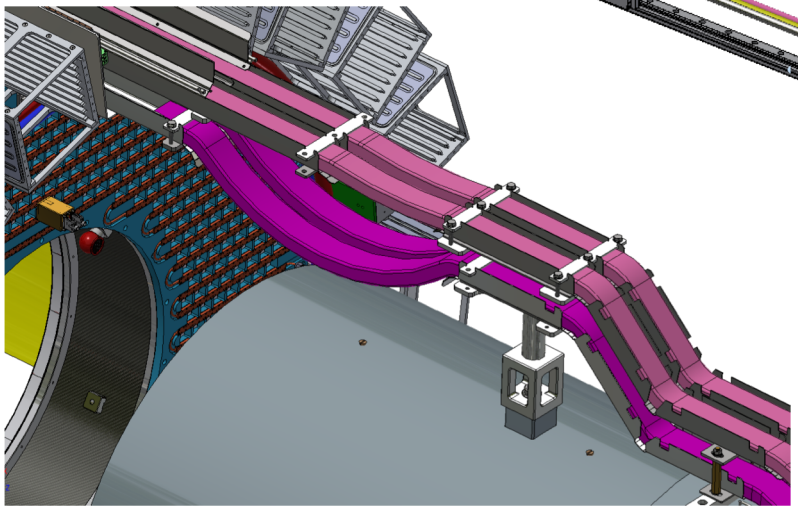




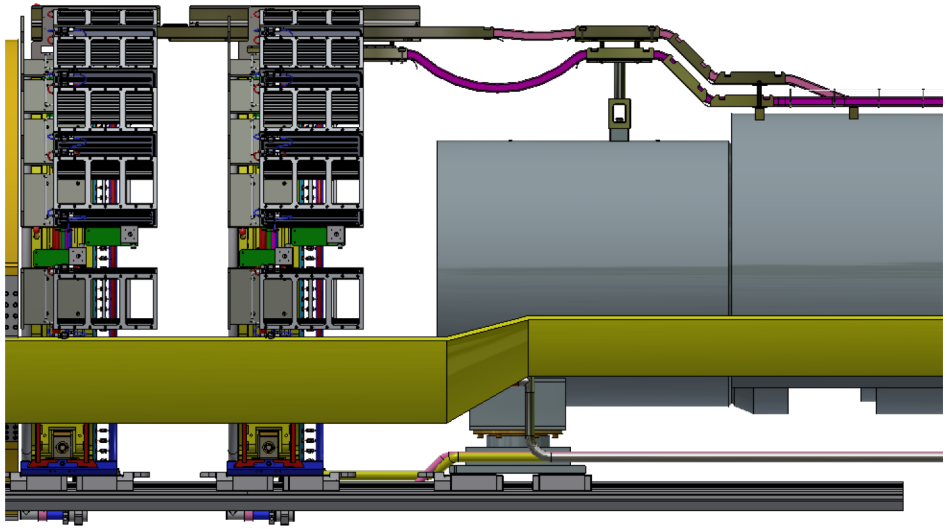
Cables/Fibers per disk						
Pos.	Q.ty	Cables	Code	Company	Diameter [mm]	Color
1	24	AWG16 HV+	M16878/5BJE-6	AWC	2.7	violet
2	24	AWG16 HV-	M16878/5BJE-7	AWC	2.7	blue
3	24	AWG8 LV+	M16878/5BNL-2	AWC	5.9	red
4	24	AWG8 LV-	M16878/5BNL-0	AWC	5.9	black
5	4	AWG8 ground	M16878/5BNL-5	AWC	5.9	yellow
6	2	AWG8 heater+	M16878/5BNL-9	AWC	5.9	orange
7	2	AWG8 heater-	M16878/5BNL-3	AWC	5.9	white
8	2	AWG16 PID heater VCC	M16878/5BJE-9	AWC	2.7	orange
9	2	AWG16 PID heater GND	M16878/5BJE-3	AWC	2.7	white
10	2	AWG16 PID heater Sign	M16878/5BJE-0	AWC	2.7	black
11	6	Laser fibers			2	(cyan)
12	16	TDAQ bundles			3	(green)
13	2	CANBUS			11.3	sky blue
14	2	AWG16 CAN BUS+	M16878/5BJE-2		2.7	red
15	2	AWG16 CAN BUS+	M16878/5BJE-0		2.7	black

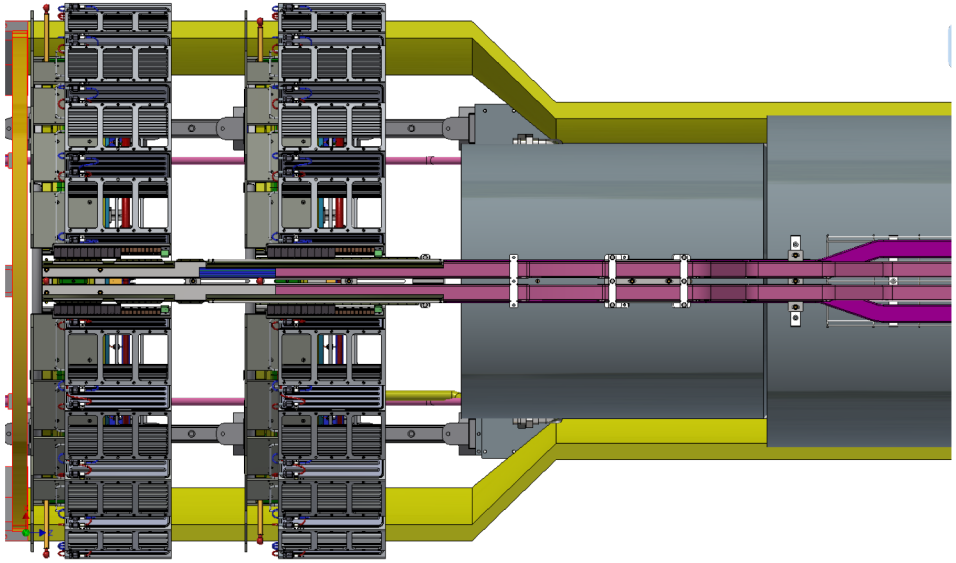
Routing inside the DS





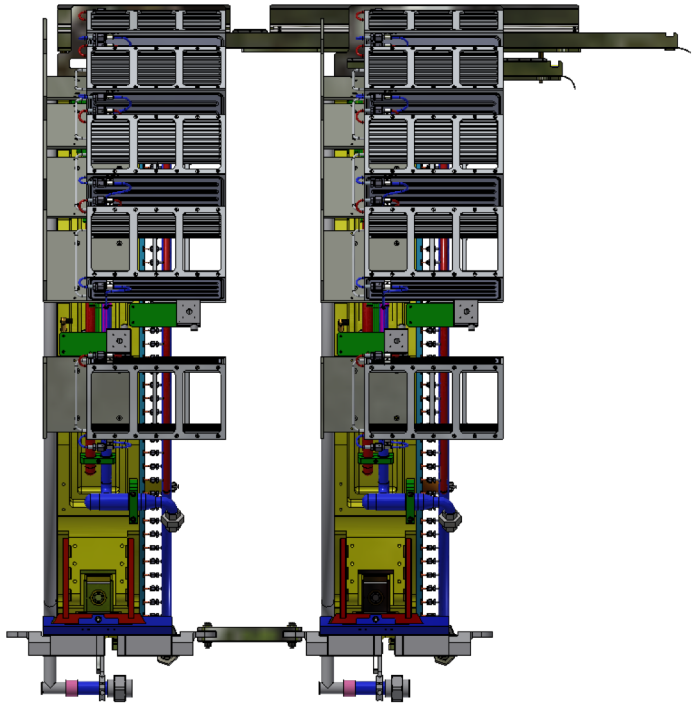
Routing inside the DS

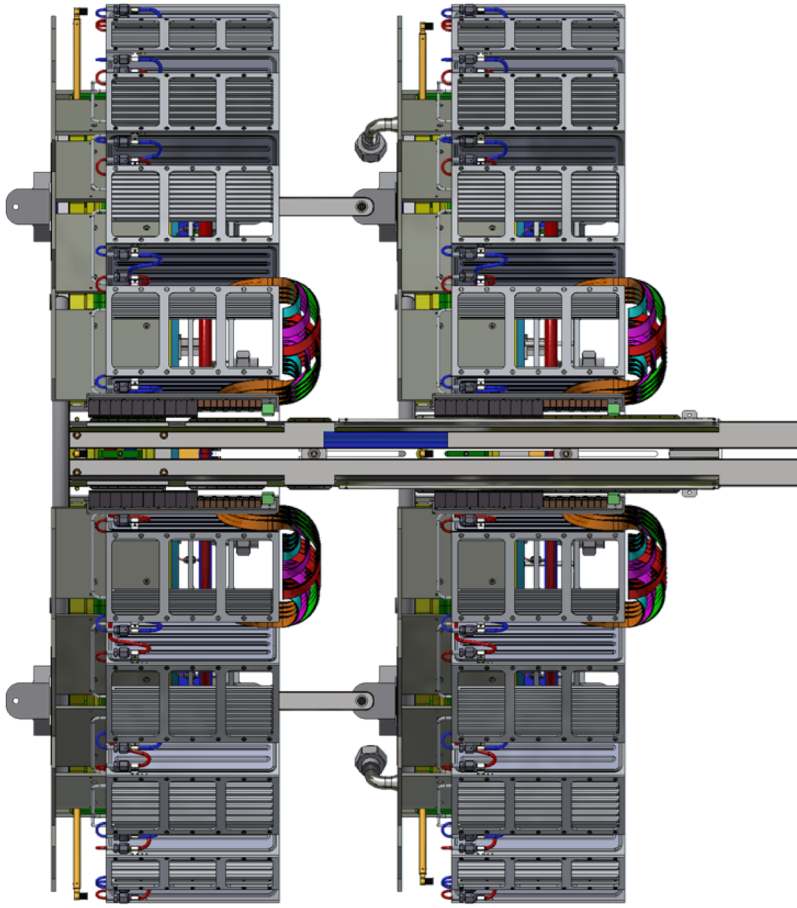




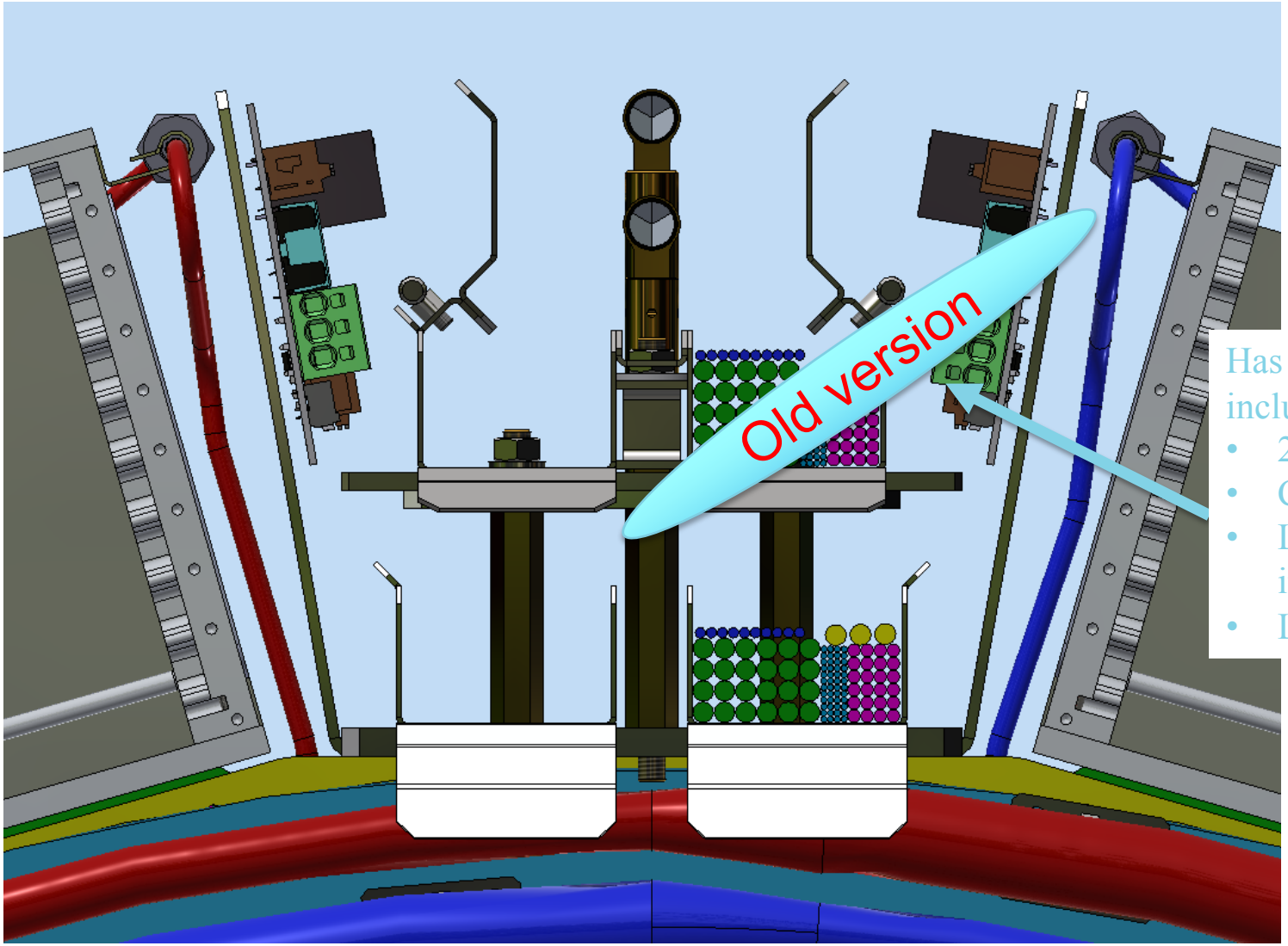
Cable Trays

- The trays can slide one on top of the other to allow the “downstream disk” to move.
- The trays can be locked together to stiffen the structure during the translation.





Four Primary Patch Panels

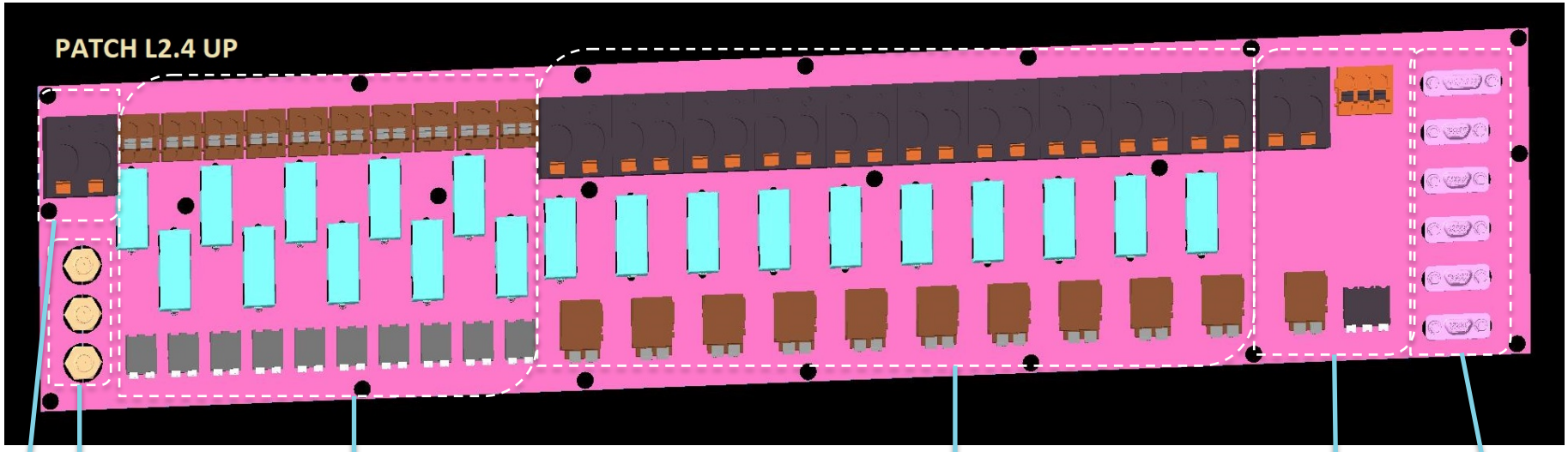


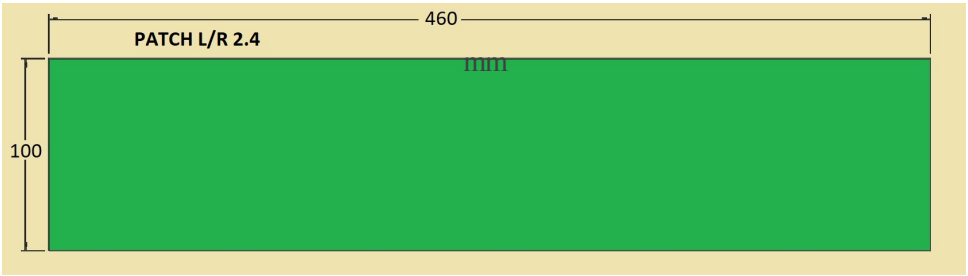
- Optical fibers
- LV – 8 AWG
- HV – 12 AWG
- Sens – 22 AWG
- Ground – 8 AWG

Has been modified including:

- 2 ground cables
- CAN bus
- LV TEMP for the inner ring
- Laser Fibers

Primary Patch Panel Scheme – New Version





Electrical Services

From Patch Panel to Crates

STILL ONGOING

Calorimenter Internal Distribution

- Calorimeter services distribution will be done along of the external disk:

  → from the patch panel to the distribution board in the crate

From PatchPanel to Crates	Disk #	Xpos #	Ncable #		N.Cables	N.Spare	I-Max(A)	Logical Name	System	LOCATION	AWG	L(m)	Diam. (mm)	Material	KIND
LV+	0-1	0-1	0-4	0-1	40	8	10	LVP-d0-p0-c0-s0	CAL	CALPP-CRATES	12	1.5	3,6	TEFLON/SILVER-COPPER	M16878/5BLE-2
LV-	0-1	0-1	0-4	0-1	40	8	10	LVN-d0-p0-c0-s0	CAL	CALPP-CRATES	12	1.5	3,6	TEFLON/SILVER-COPPER	M16878/5BLE-0
HV+	0-1	0-1	0-4	0-1	40	8	0,5	HVP-d0-p0-c0-s0	CAL	CALPP-CRATES	16	1.5	2,7	TEFLON/SILVER-COPPER	M16878/5BJE-7
HV-	0-1	0-1	0-4	0-1	40	8	0,5	HVN-d0-p0-c0-s0	CAL	CALPP-CRATES	16	1.5	2,7	TEFLON/SILVER-COPPER	M16878/5BJE-6
Can+	0-1	0-1	0-4		20			CANP-d0-p0-c0-s0	CAL	IFB-CALPP	26	10	1,8	TEFLON/SILVER-COPPER	M16878/4BDE-3
Can-	0-1	0-1	0-4		20			CANN-d0-p0-c0-s0	CAL	IFB-CALPP	26	10	1,8	TEFLON/SILVER-COPPER	M16878/4BDE-4
5V	0-1	0-1	0-4		20		0,1	CANLVP-d0-p0-c0	CAL	IFB-CALPP	26	1.5	2,7	TEFLON/SILVER-COPPER	M16878/4BDE-2
ground_can	0-1	0-1	0-4		20		0,1	CANLVN-d0-p0-c0	CAL	IFB-CALPP	26	1.5	2,7	TEFLON/SILVER-COPPER	M16878/4BDE-0
LVTempInner+	0-1	0-1			4		10	innerP-d0-p0-c0-s0	CAL	CALPP-CRATES	12	1.5	3,6	TEFLON/SILVER-COPPER	M16878/5BLE-2
LVTempInner-	0-1	0-1			4		10	innerN-d0-p0-c0-s0	CAL	CALPP-CRATES	12	1.5	3,6	TEFLON/SILVER-COPPER	M16878/5BLE-0

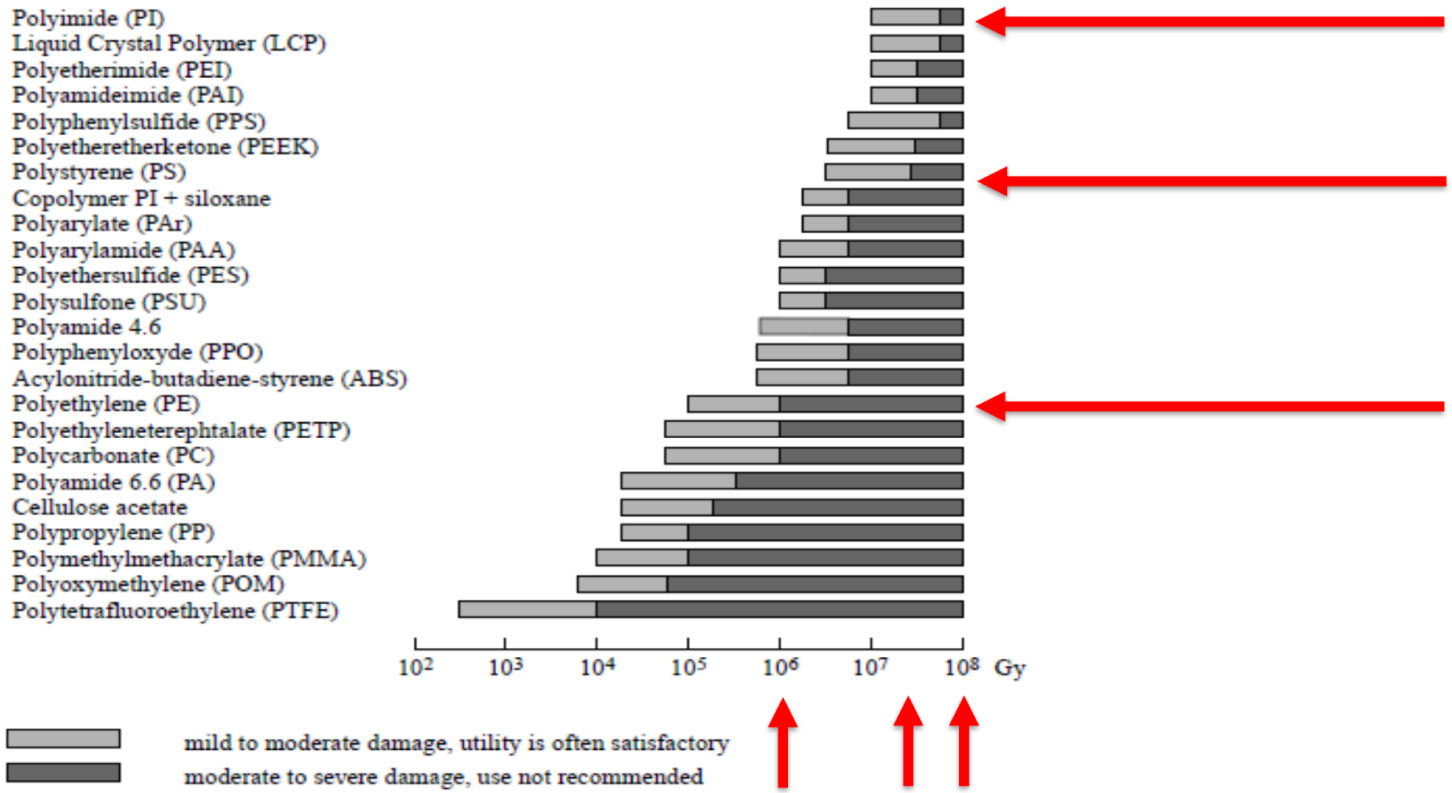
All the cables have been already acquired and are in Sidet

SPARES

Legend

Table 2a

General classification of rigid thermoplastics with respect to their radiation resistance



These appreciations can only serve as a general guideline; environmental conditions such as temperature, humidity and dose rate, as well as additives influence the radiation behaviour of materials.

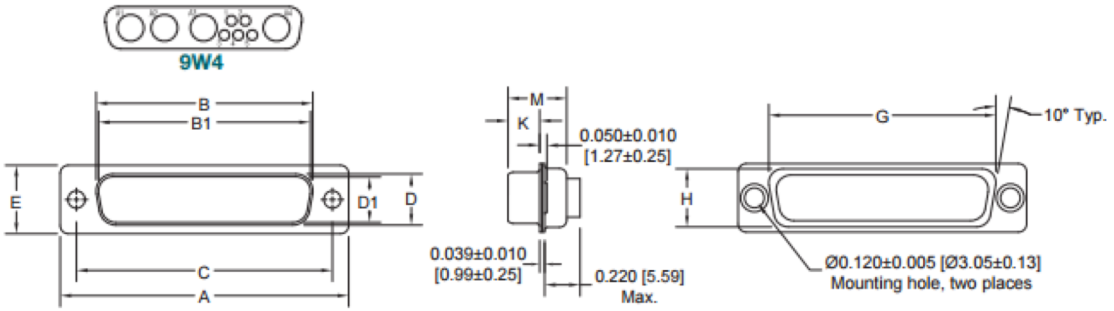
Fibre reinforced composites based on these resins can be at least one order of magnitude better.

M. Tavlet, A. Fontaine, and Schonbacher, Compilation of radiation damage test data, Part II, 2nd ed: Thermoset and thermoplastic resins, composite materials, CERN-Report 98-01 (1998)

Electrical Services: HV and LV - Connectors

We will use 2 kind of connectors of the same size per crate (example for a Xavac connector):

- 1 High Power (LV);
- 1 High Voltage.



SHELL SIZE 3 MALE	2.088 [53.04]		1.534 [38.96]	1.852 [47.04]		0.329 [8.36]	0.494 [12.55]	1.625 [41.28]	0.422 [10.72]	0.230 [5.84]	0.426 [10.82]
SHELL SIZE 3 FEMALE	2.088 [53.04]	1.511 [38.38]		1.852 [47.04]	0.311 [7.90]		0.494 [12.55]	1.625 [41.28]	0.422 [10.72]	0.243 [6.17]	0.429 [10.90]

ELECTRICAL CHARACTERISTICS:

SIZE 20 CONTACTS

Contact Current Rating:	7.5 amperes nominal.
Initial Contact Resistance:	0.008 ohms maximum.
Proof Voltage:	1000 V r.m.s.

SIZE 8 CONTACTS

POWER CONTACTS

Contact Current Rating - Tested per UL 1977:

Standard Contact Material:

0.078 inches diameter / 12 AWG terminations:	39 amperes.
0.094 inches diameter / 10 AWG terminations:	50 amperes.
0.125 inches diameter / 8 AWG terminations:	70 amperes.

See Temperature Rise Curves on page 1 for details.

High Conductivity Contact Material:

8 AWG terminations:	80 amperes.

See Temperature Rise Curves on page 2 for details.

Initial Contact Resistance:

Standard Contact Material:	0.0005 ohms max. per IEC 60512-2, Test 2b.
High Conductivity Contact Material:	0.00035 ohms max. per IEC 60512-2, Test 2b.
Proof Voltage:	1000 V r.m.s.

SHIELDED CONTACTS

For electrical characteristics, see page 69.

HIGH VOLTAGE CONTACTS

For electrical characteristics, see page 69.

CONNECTOR

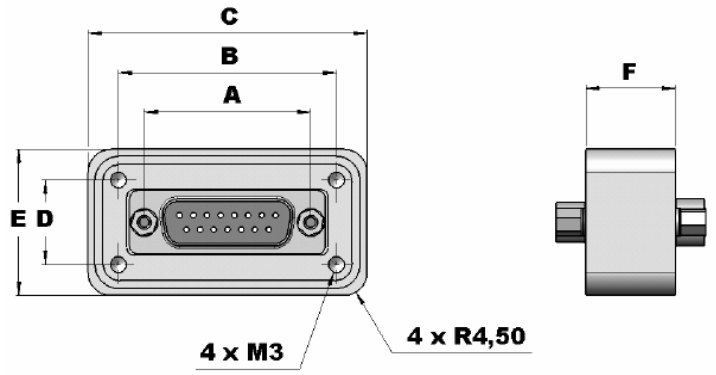
Insulation Resistance:	5 G ohms.
Clearance and Creepage Distance:	0.039 [1.0mm] minimum.
Working Voltage:	300 V r.m.s.

CLIMATIC CHARACTERISTICS:

Temperature Range:	-55°C to +125°C.
Damp Heat, Steady State:	10 days.

At IFB

XAVAC® DIMENSIONS



	A	B	C	D	E	F	
						Type 0-1-5*	Type 2-3-4*
SHELL SIZE 1	24,99	34,29	46,37	16,00	28,08	18	24
SHELL SIZE 2	33,32	43,64	55,79	16,76	28,92	18	24
SHELL SIZE 3	47,04	56,36	67,42	16,02	27,08	18	24
SHELL SIZE 4	63,50	73,46	85,38	16,90	28,82	18	24
SHELL SIZE 5	61,11	71,28	82,99	19,68	31,40	18	24
SHELL SIZE 6	63,50	73,26	84,38	20,88	32,00	18	24

** See ordering information: STEP 5 – Type of contacts*

STEP	1	2	3	4	5		6
EXAMPLE	XAVAC	15	M/S	G	.0	-	S****

STEP 1 – BASIC SERIES
XAVAC series

STEP 2 – CONNECTOR VARIANTS
Normal density
9-15-25-37-50
High density
15-26-44-62-78-104
Mixed combinations (Consult Combo-D catalog)
2WK2 up to 46W4

STEP 3 – CONNECTOR GENDER
M/S : Male/Female Posiband
M/M : Male/Male
Marking inverted on the two insulators front side
Not available for high density / mixed combinations
S/S : Female Posiband/Female Posiband
Marking inverted on the two insulators front side
Not available for high density / mixed combinations

STEP 4 – TYPE OF APPLICATIONS
G : Gold for Space version
D : Gold and Dimpled for Space version
S : Stainless-steel for Space version
Residual magnetism, consult factory
I : Stainless-steel for Industrial version

STEP 5 – TYPE OF CONTACTS
0 : Normal density
1 : High density
2 : Power and/or mixed combinations
3 : Coax and/or mixed combinations
4 : High voltage
5* : *Thermocouple contact (only normal density)*

STEP 6 – SPECIAL OPTIONS
Consult Sales Department

STEP 4 – TYPE OF APPLICATIONS
G : Gold for Space version
D : Gold and Dimpled for Space version
S : Stainless-steel for Space version
Residual magnetism, consult factory
I : Stainless-steel for Industrial version

One last slide..