CALCI consortium meeting
16/11/2023

DEEP UNDERGROUND NEUTRINO EXPERIMENT

Temperature Monitoring System installation in FD1 and FD2

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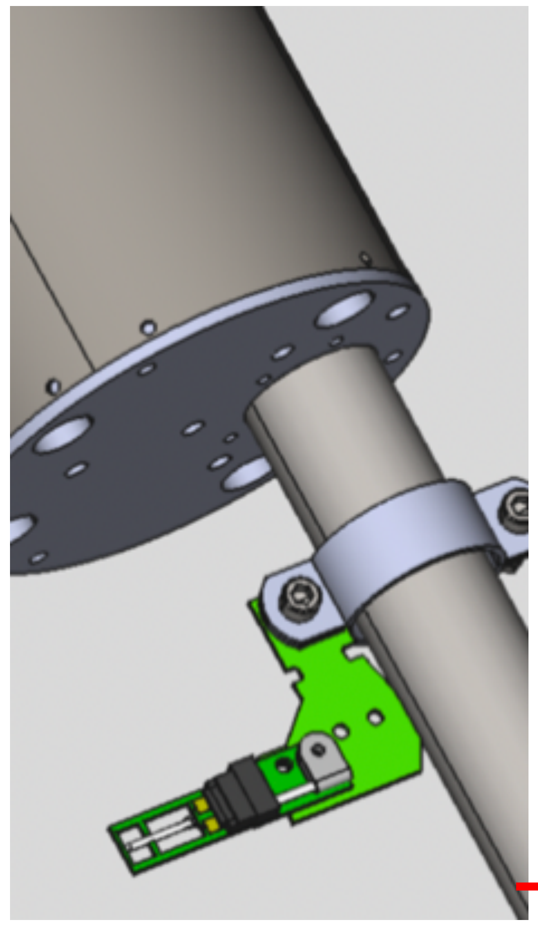
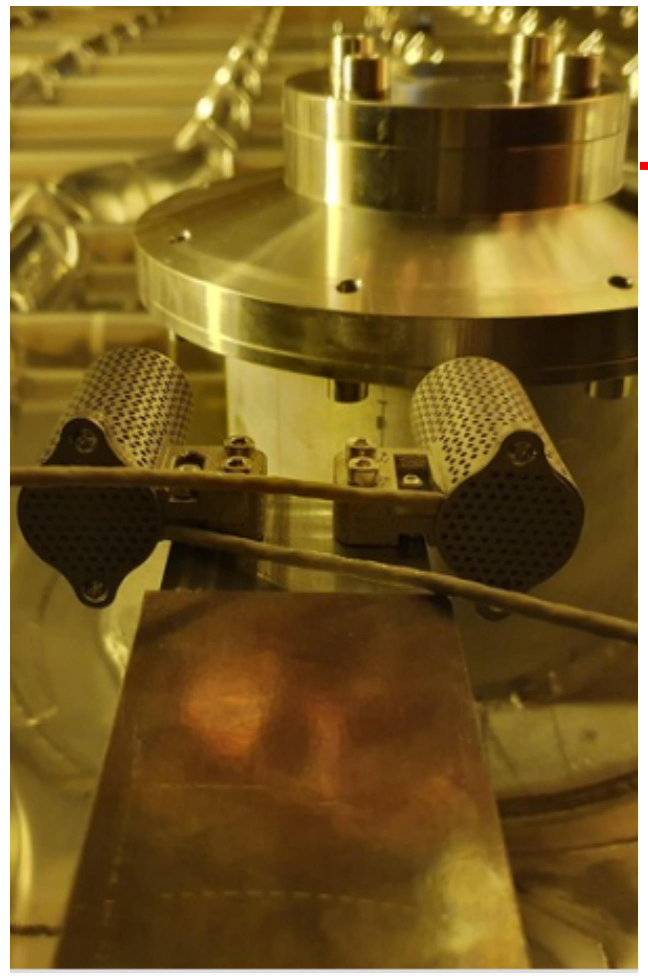
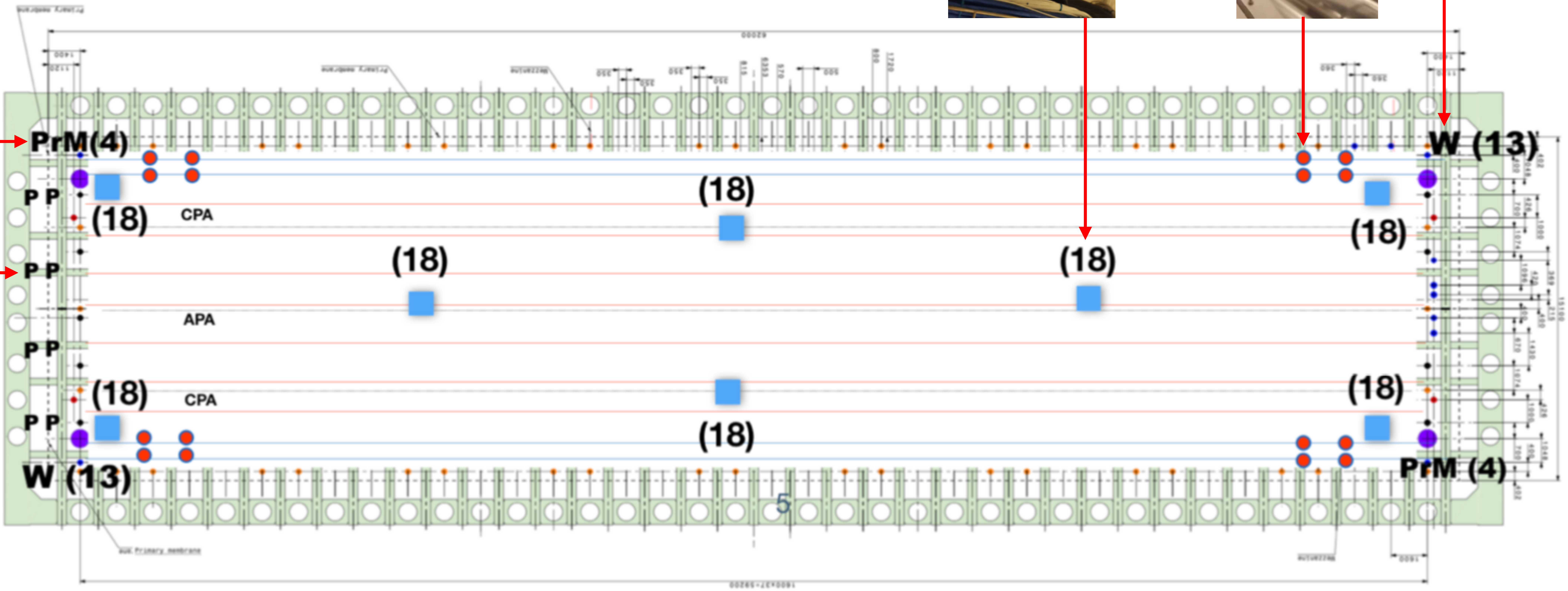
(IFIC-Valencia)

Thermometers for FD1& FD2 (except APA)

- Inlet sensor
- Gas array (18 sensors in each array)
- **P** pump sensor
- **W** Wall sensors (13 sensors in each array)
- **PrM** PrM sensors (4 units in each array)



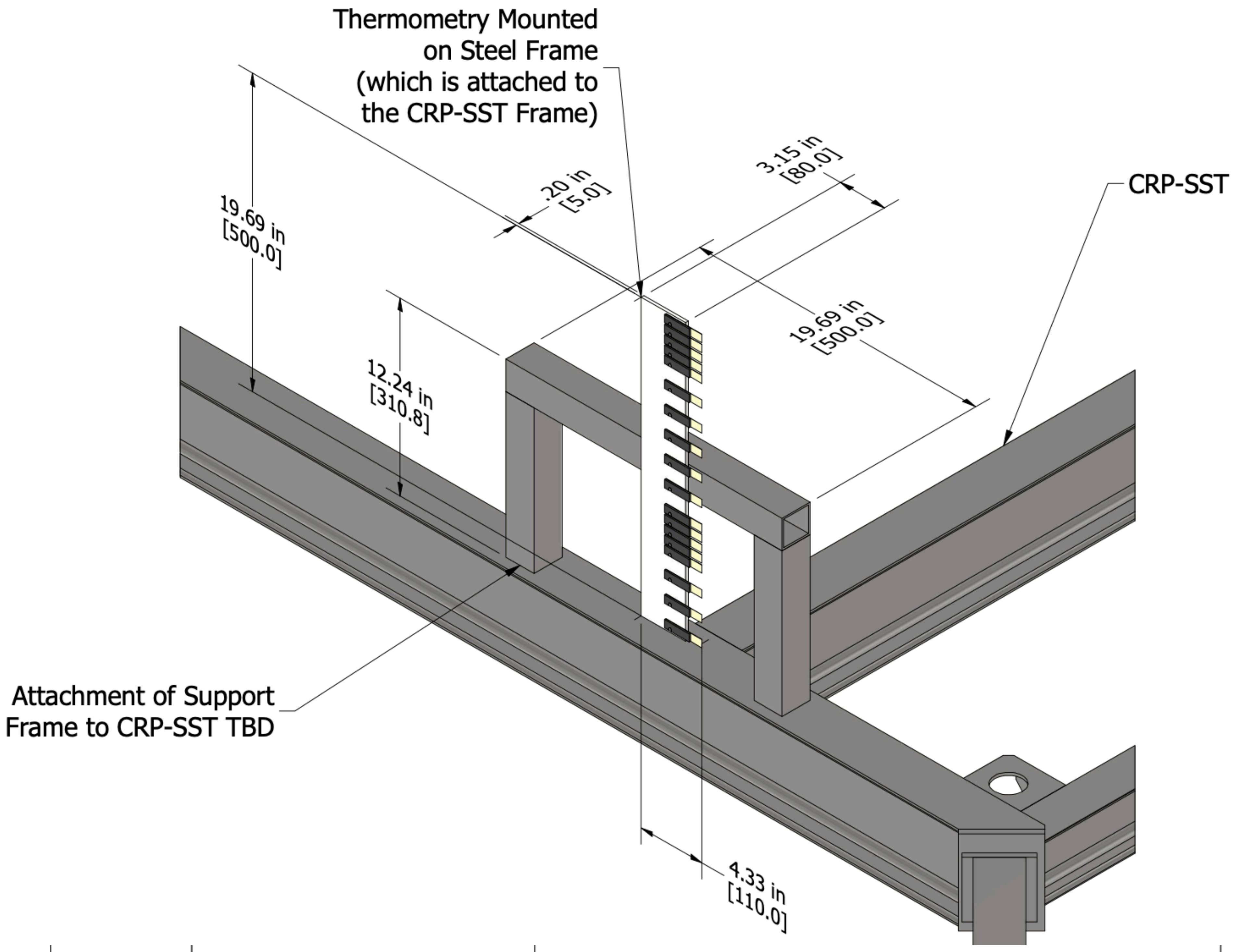


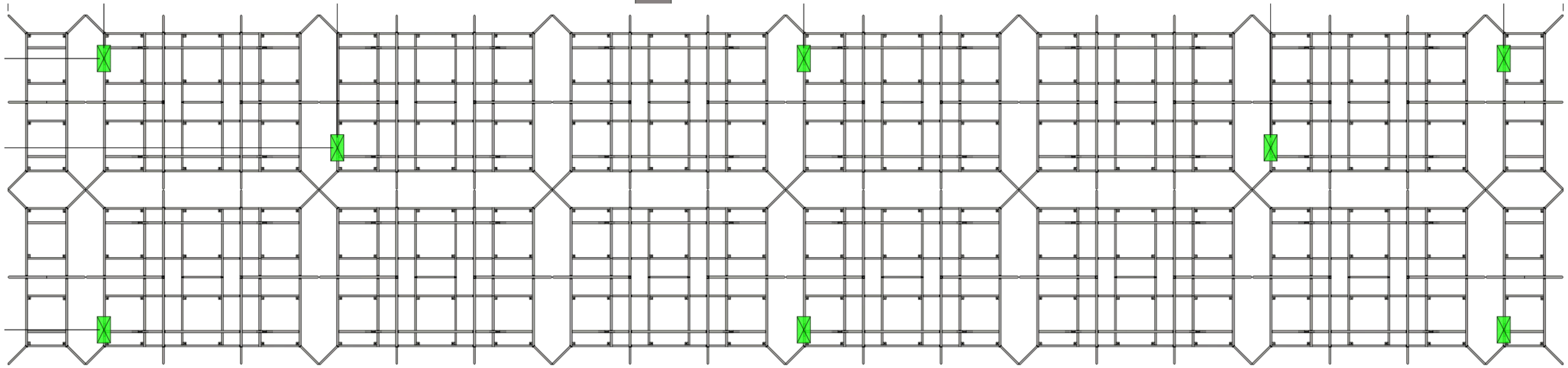


Gas array in FD2

Nick Joniak

https://edms.cern.ch/ui/file/2881719/1/2881719-02_FD2_Interfaces_Thermometry_230411.pdf

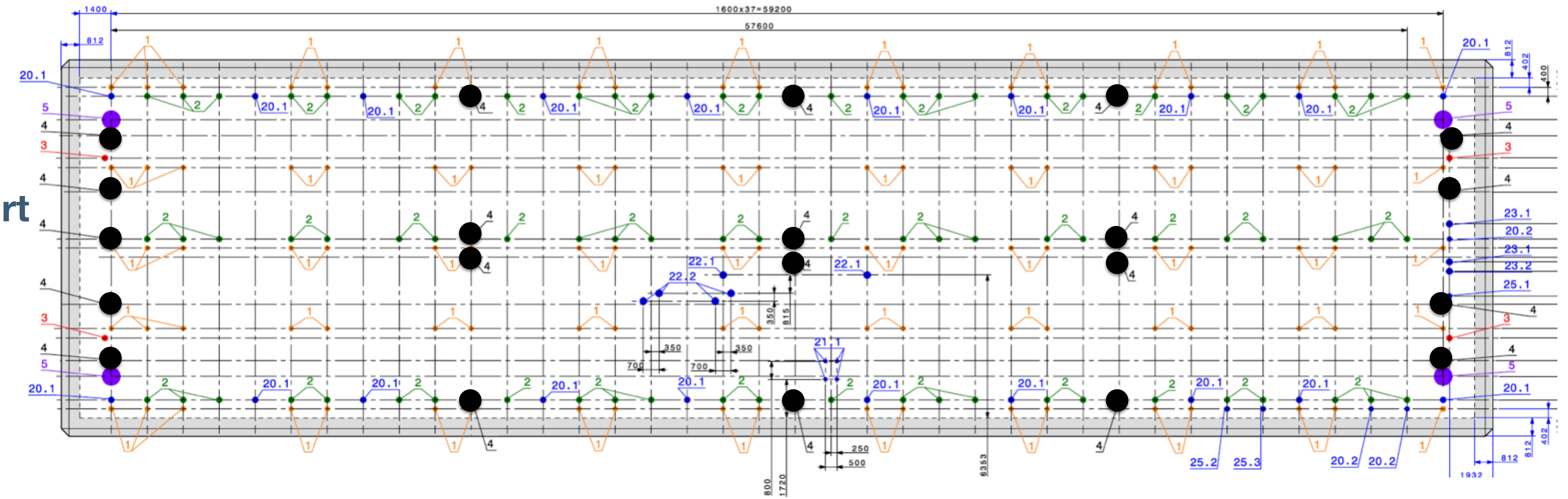




- Current proposal: use CRP SST

FD1 Cryostat ports

- **CALCI port**



Pos.	Diameter [mm]	Quantity	Description
1	Ø200	100	Support
2	Ø250	75	Cable
3	Ø250	4	High voltage
4	Ø250	21	Instrumentation
5	Ø800	4	Manholes
7	2680x13428	1	Temporary Construction Opening

FD1 Cryostat ports

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7	2680x13428	1	Temporary Construction Opening

- Need to understand which of those ports could be used. Ideally:
  - A port in each corner
  - 3 ports in the middle for gas arrays to avoid having many long cables (each GA has 18 cables)

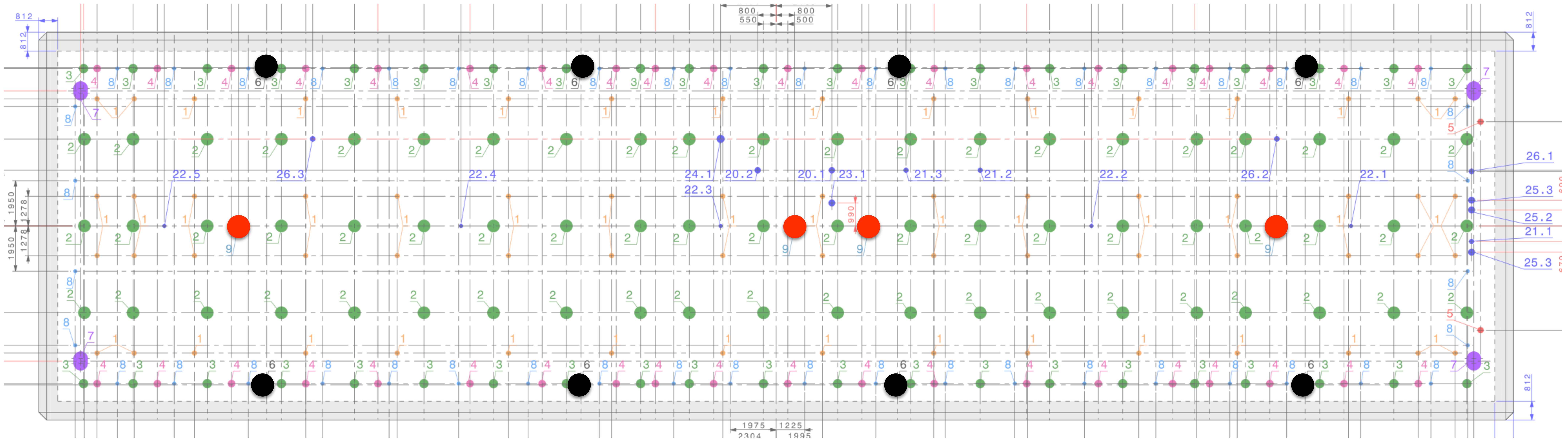
FD1 cabling

- Route bottom cables towards vertical corner and then go up
    - Cable tray, pigtails in M10 bolts?
- Central gas arrays: cable tray, DSS ?
- SUBD-25 connectors (6 cables). No problem for DN250 flanges

To be workout with I&I

FD2 Cryostat ports

- Laser and spare
- T-port



Detector penetrations

Pos.	Diameter [mm]	Quantity	Description
1	Ø200	64	CRP Supports
2	Ø526	63	Top Center CRP Cables
3	Ø381	42	Top Side CRP Cables
4	Ø304.8	40	Bottom CRP Cables + PDS
5	Ø250	2	High voltage
6	Ø250	8	Spare and Laser
7	Ø800	4	Manholes
8	Ø150	48	FC Supports
9	Ø250	4	CALCI NtS
10	7400 x 2680	1	Temporary Construction Opening

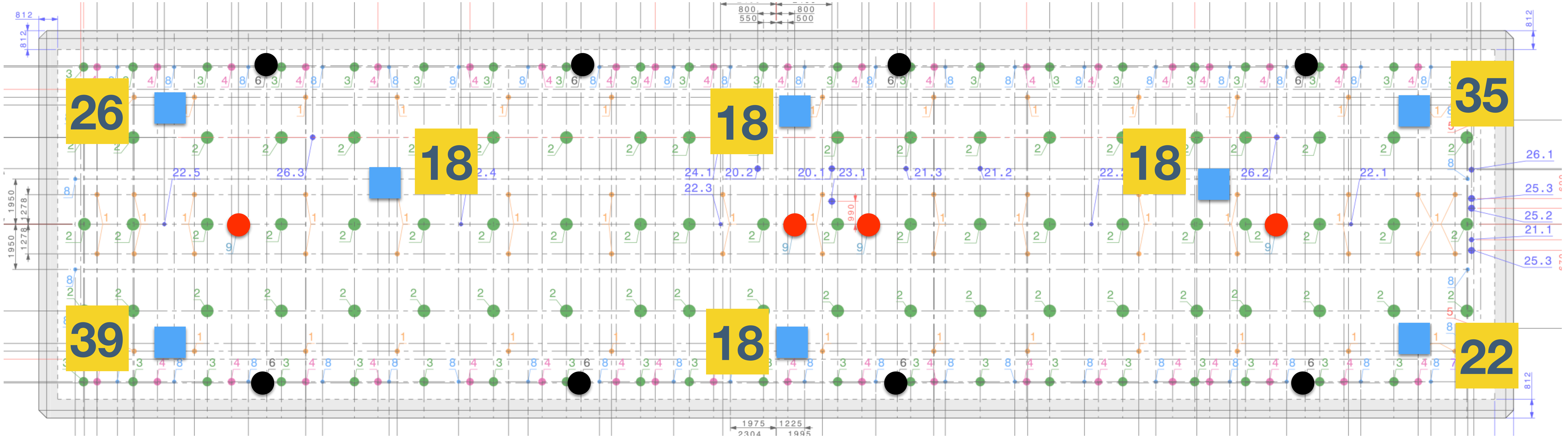
FD2 cabling

Laser and spare

T-port

Gas array

39 # cables



- T-Ports are far away from corners
- Can we use CRP cable trays ? To be understood

To be workout with I&I

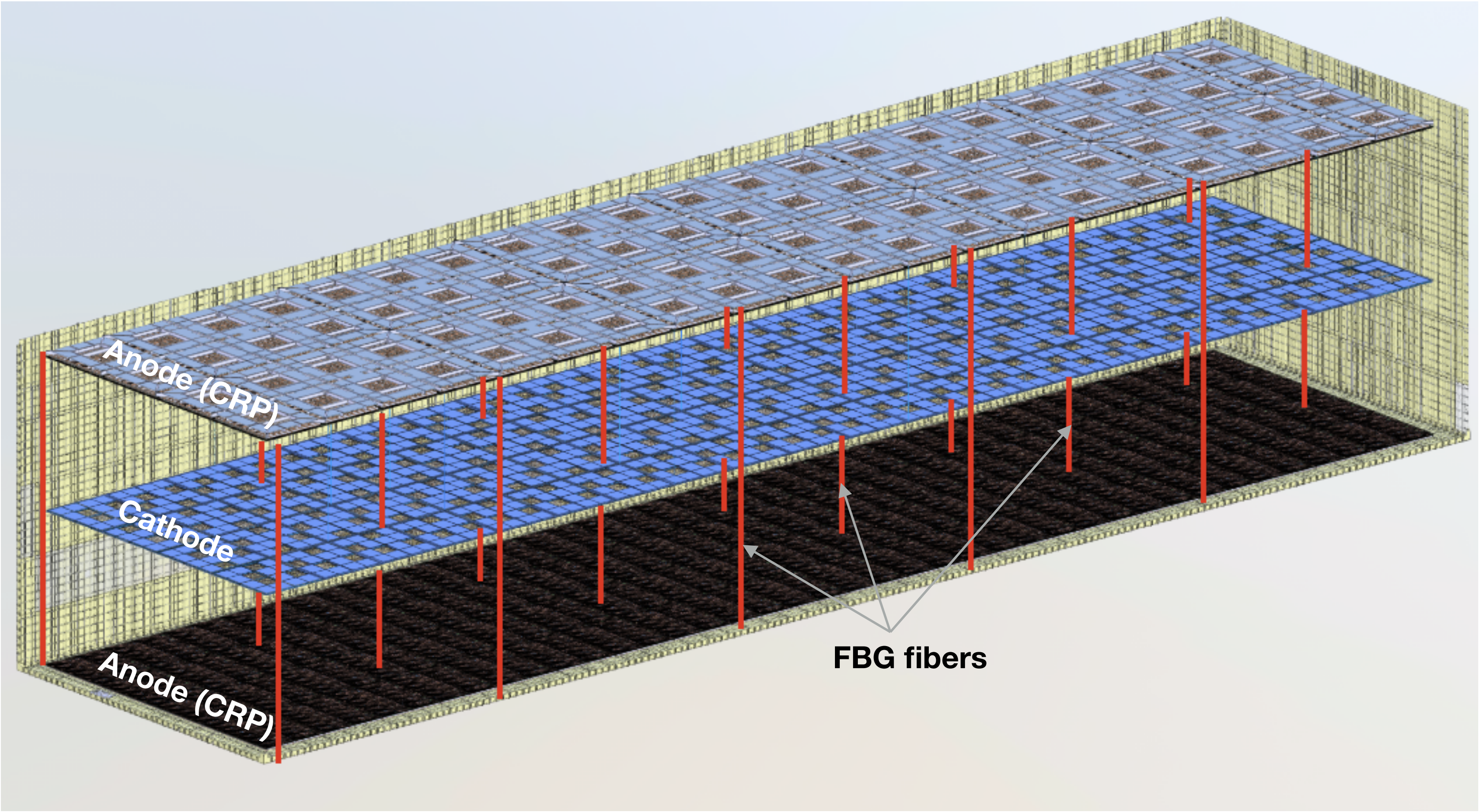
FD2 cabling

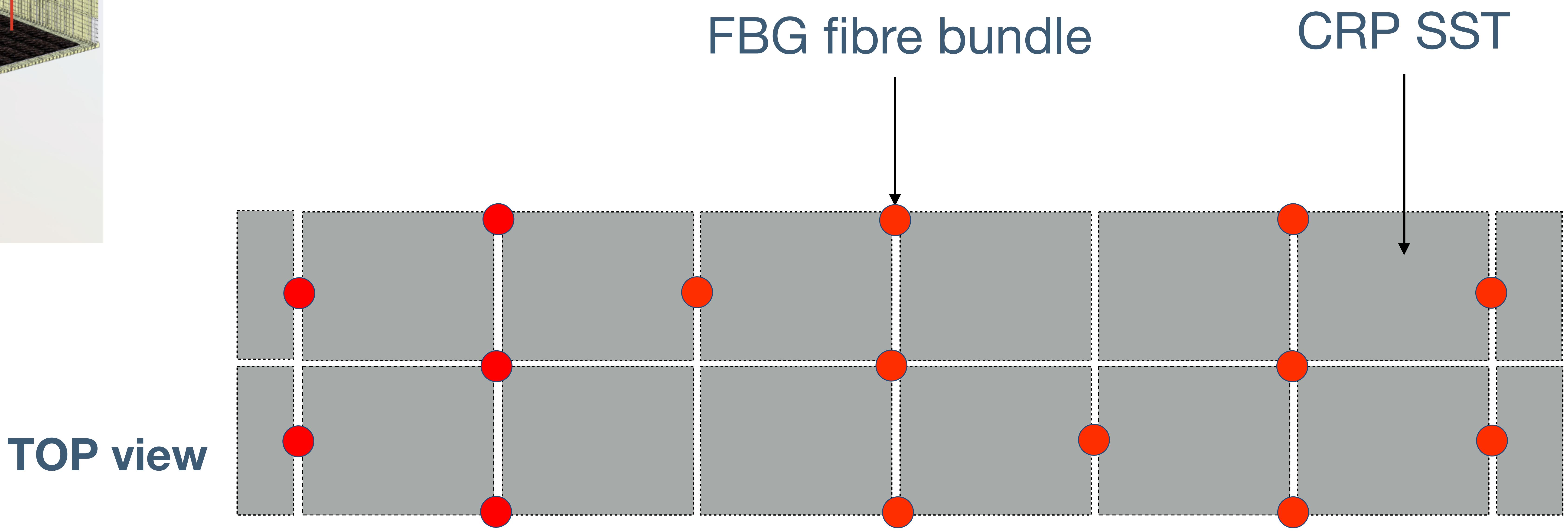
- T-Ports are far away from corners
- Can we use CRP cable trays ? To be understood
- Another option is tu use the CRP SST for gas arrays
- Still would need to understand how to extract bottom cables

To be workout with I&I

Fibre based thermometry for FD2

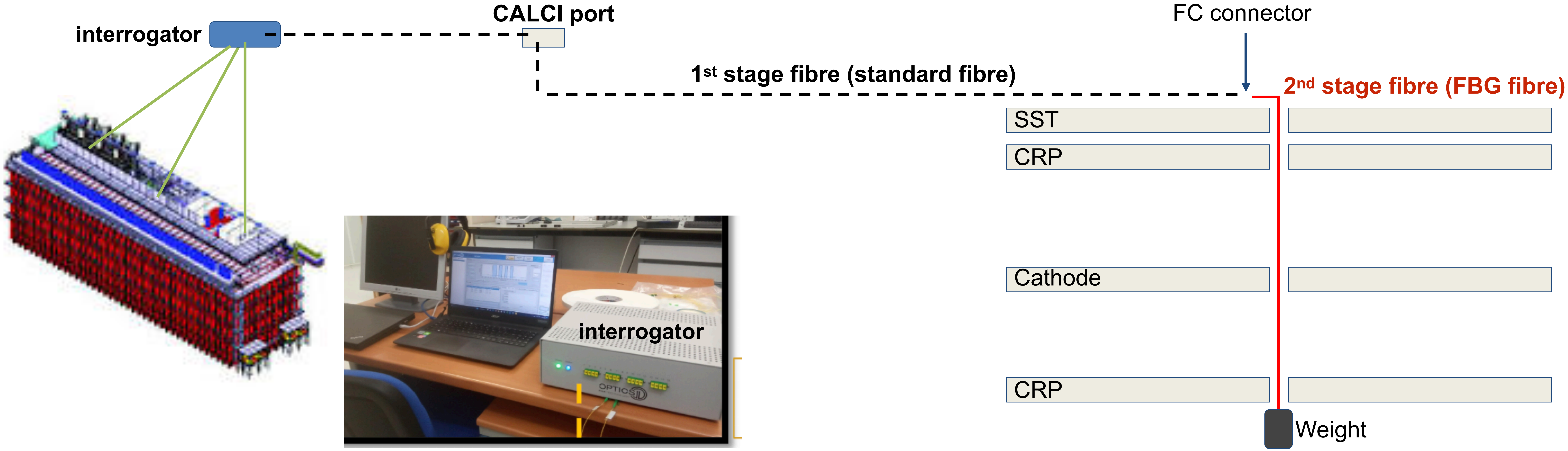
- 15 vertically aligned optical fibre bundles, with 3 fibres each, with ~30 FBG sensors per fibre. A total of 1350 sensors
- The readout is performed by 3 interrogators, outside the cryostat.





Fibre based thermometry for FD2

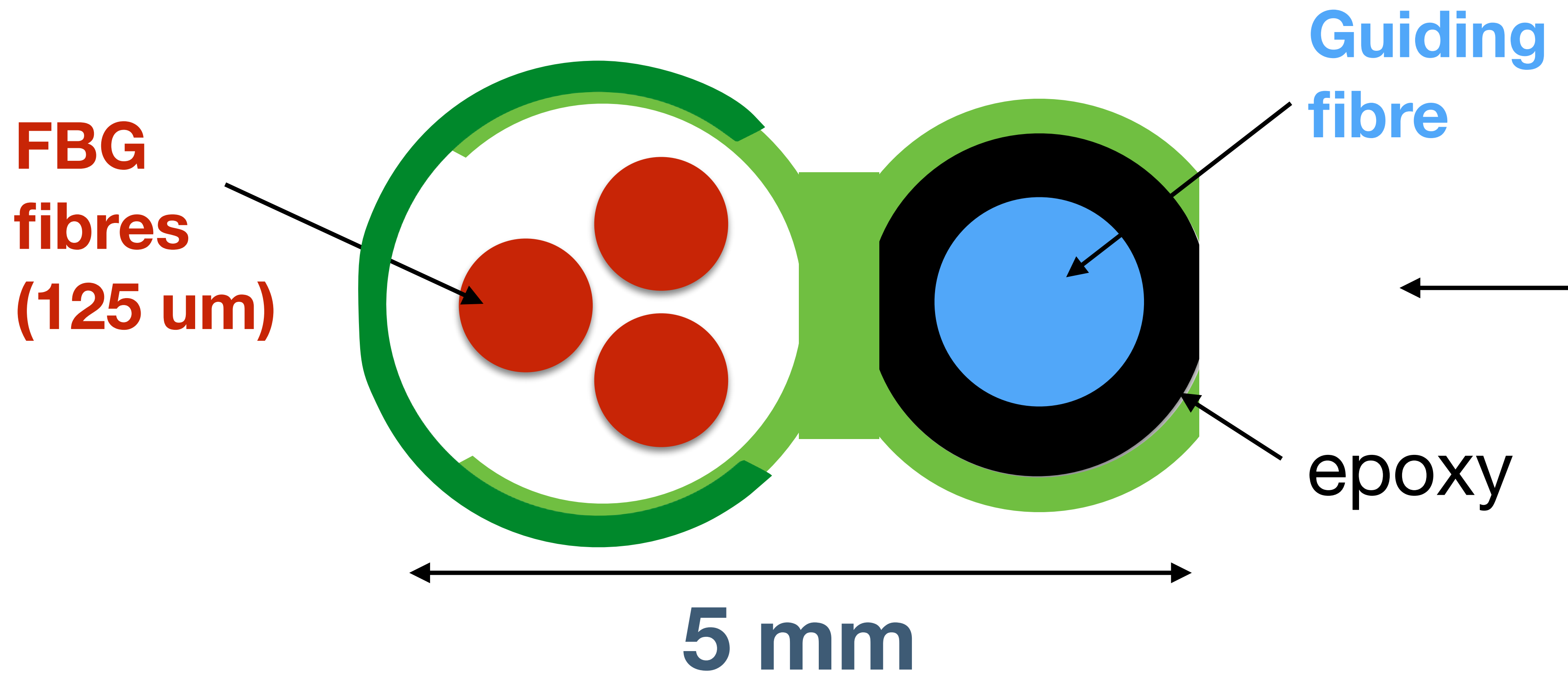
- The first stage starts at the interrogator placed outside the cryostat at room temperature, enters in the cryostat through a CALCI port, it is routed along a cable tray, and ends near the measurement point, on the CRP superstructure (SST), next to one of the dyneema ropes, where it is fixed. The termination is a FC connector. This first stage will be a standard fibre with a protection jacket.
- The second stage (FBG fibres) is connected to the first one through a FC connector. Then it descends vertically, crossing the cathode gap and the bottom CRPs to the floor. A plumb will give a constant tension to the fibre.

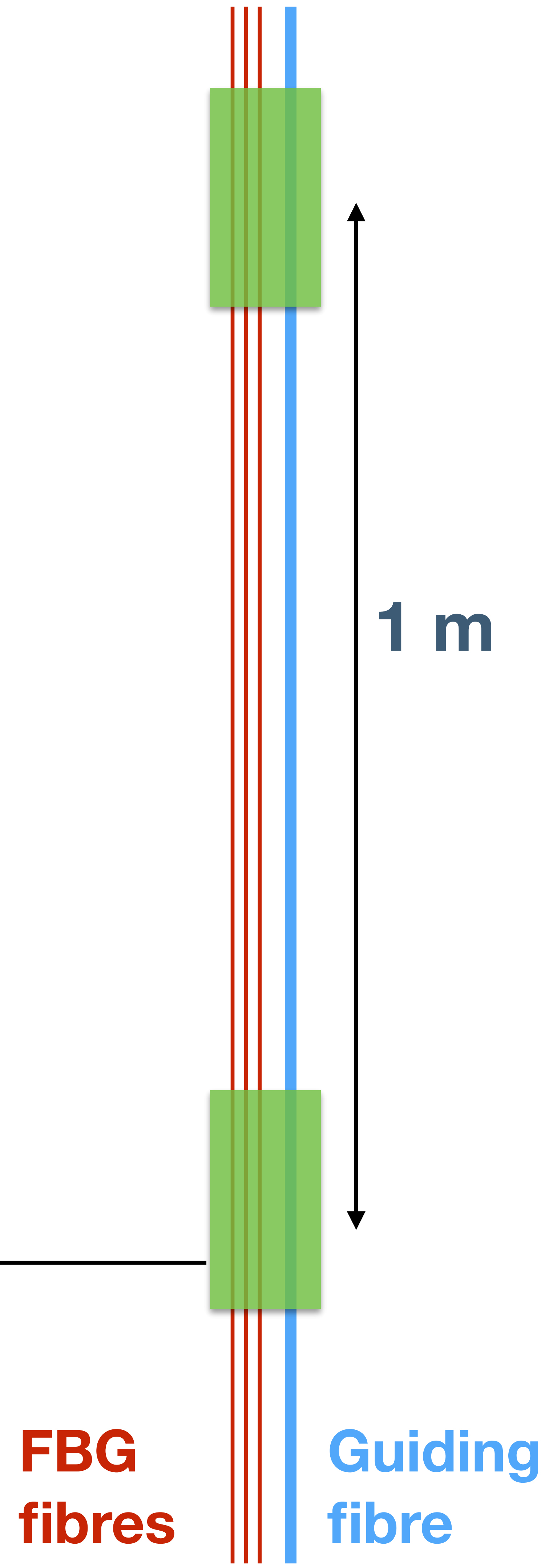


Interfaces with cathode

Fibre bundle

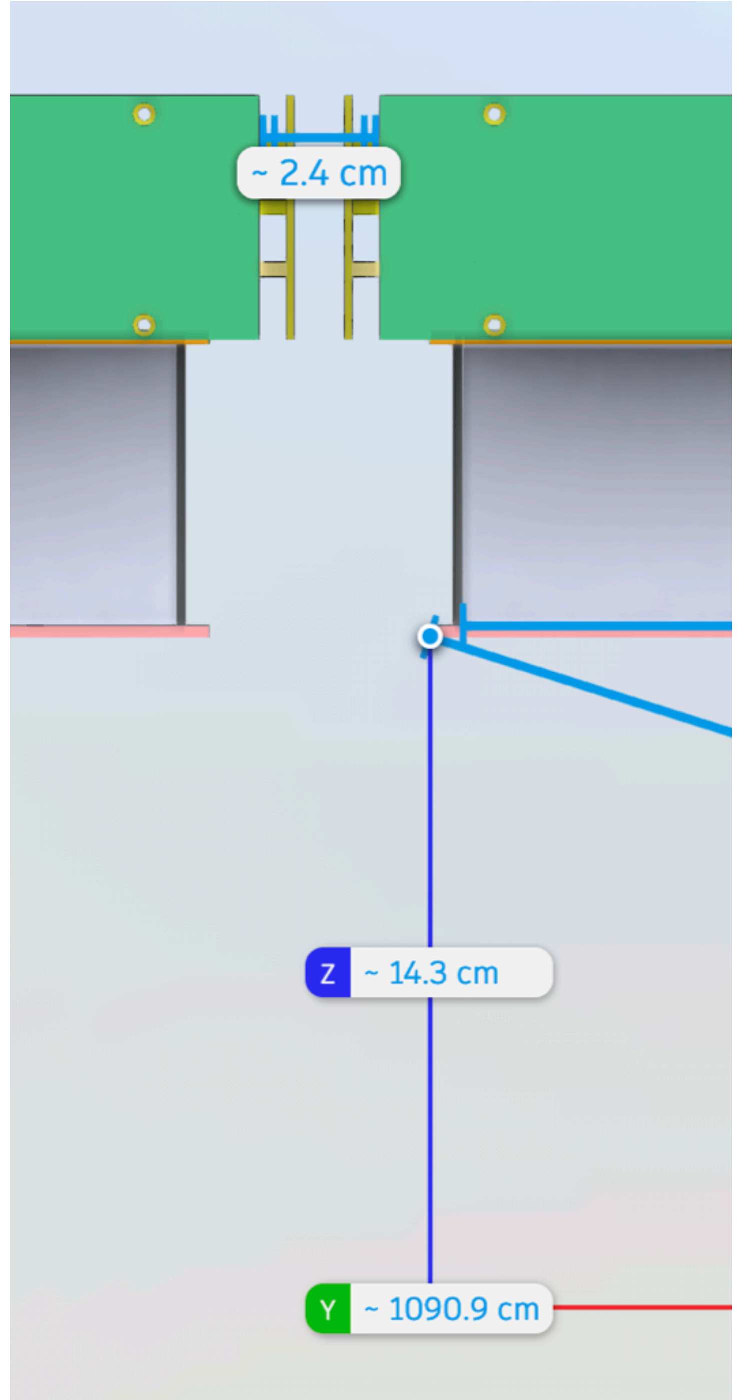
- Each bundle will have a guiding fibre and three FBG fibres
- Motivation is twofold:
  - Mitigate the risk in the case of fibre breaking
  - Increase precision with 3 independent measurements at the same location
- A very small piece (5 mm) attached to the guiding fibre will keep FBG fibres in place

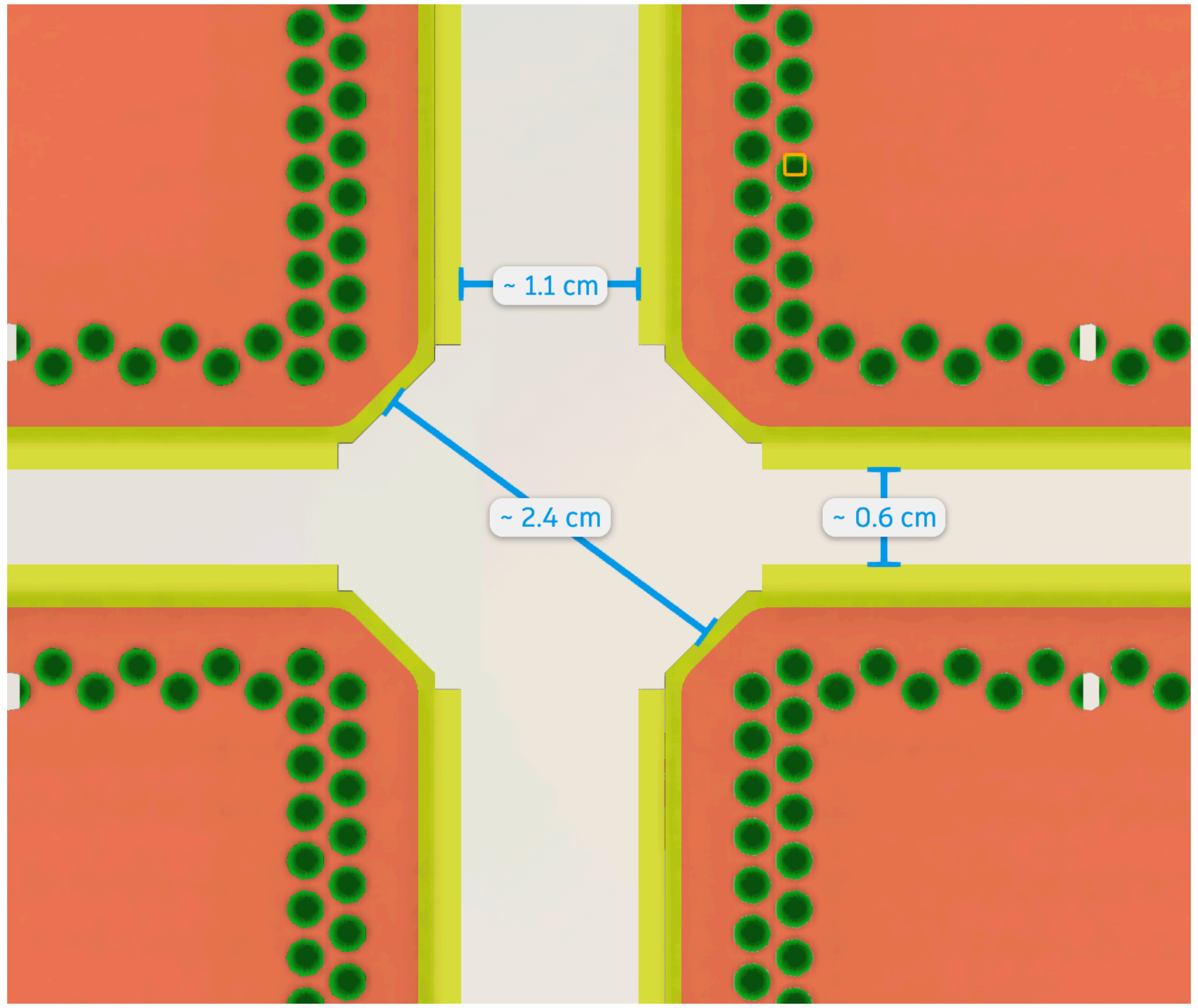


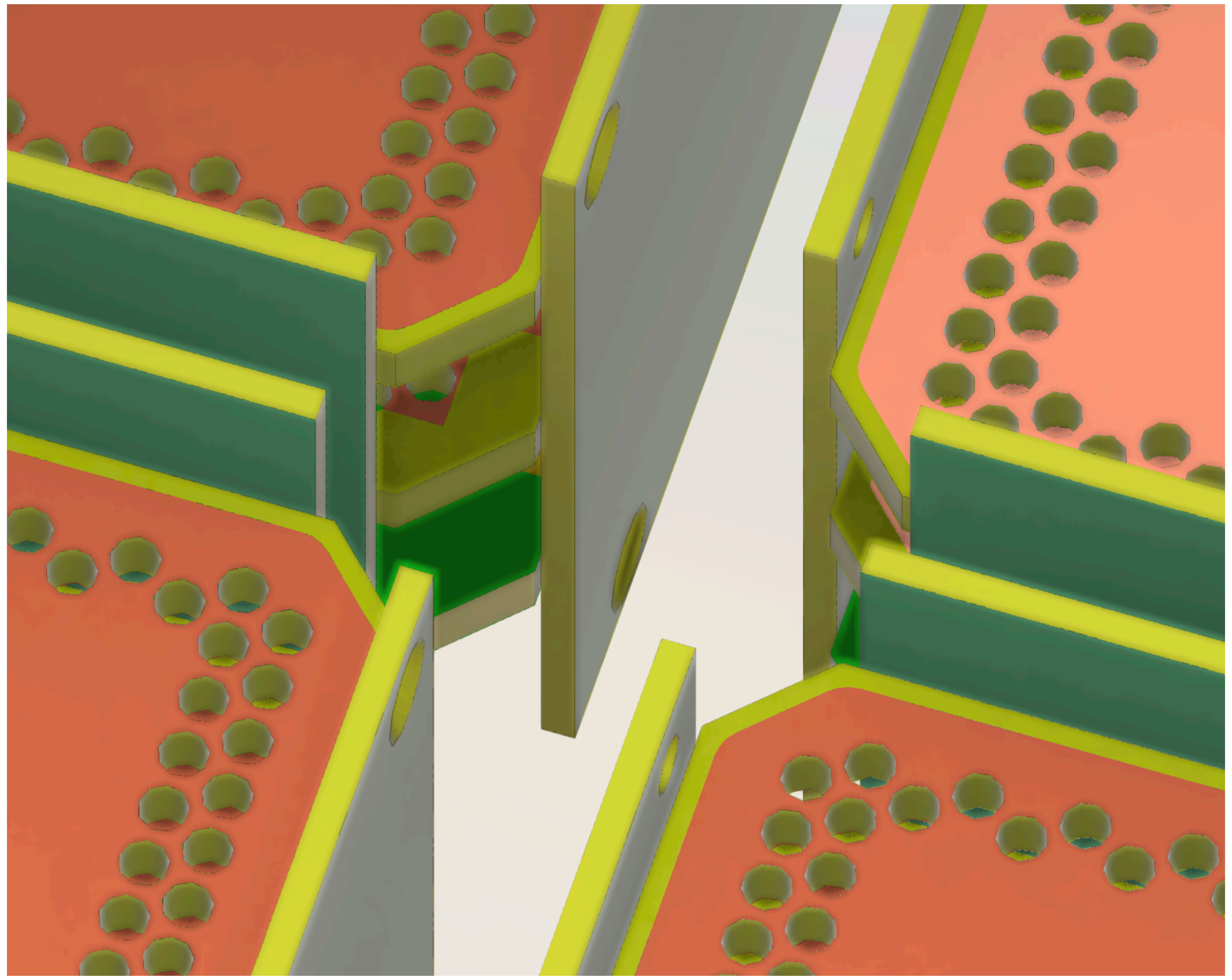


Interfaces with bottom CRP

- There are 1-2 cm space between CRPs
- In vertical we have 14 cm for the weight
- Weight currently under design

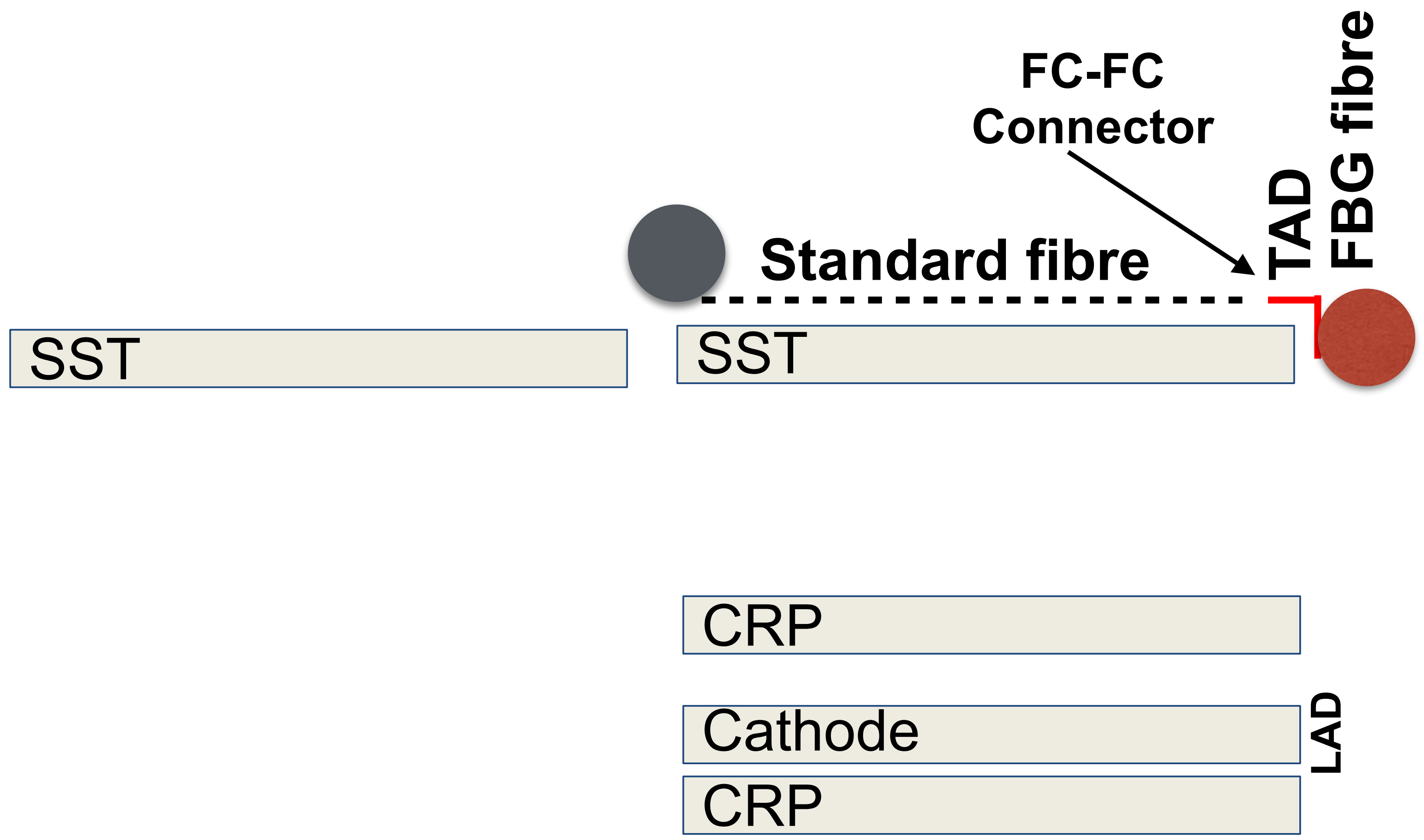


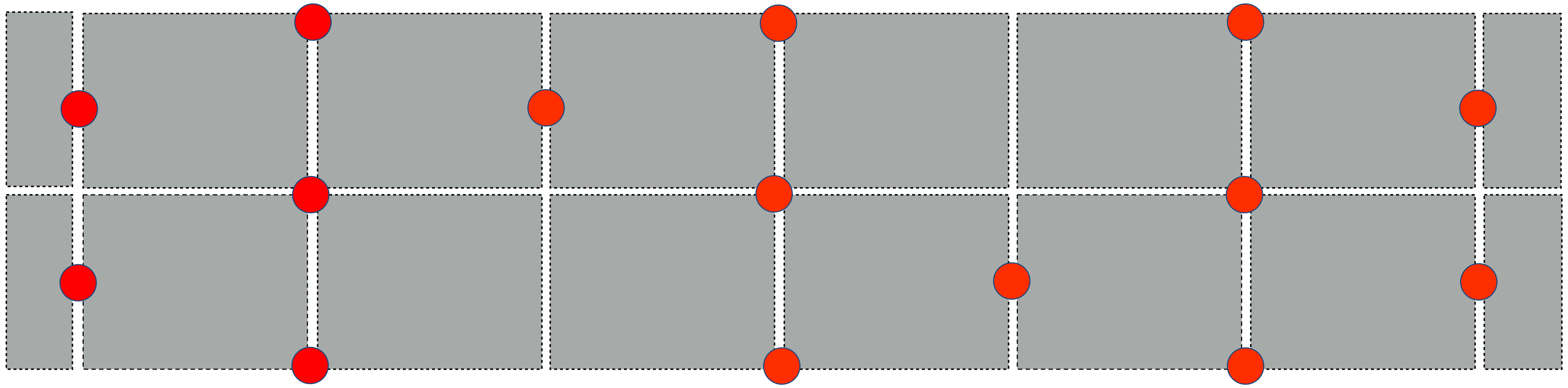




Installation sequence (conceptual)

1. The TAD with the winded FBG fibres is installed on the CRP SST. The standard fibres are connected to the FBG ones and routed on the CRP SST to one of its corners
2. The SST is elevated
3. When the neighbour SST is elevated standard fibres on the previous SST are routed on this SST to the CALCI TMS port, and pulled up
4. When the cathode is installed they are deployed vertically down to the cathode, passing through the LAD guiding piece. The remaining fibre length is kept winded on the coil below the cathode
5. Once the corresponding bottom CRP is installed the fibre bundle is unwinded down to the floor
6. The plumbs are attached to the fibres and introduced in the a cylinder to avoid swinging





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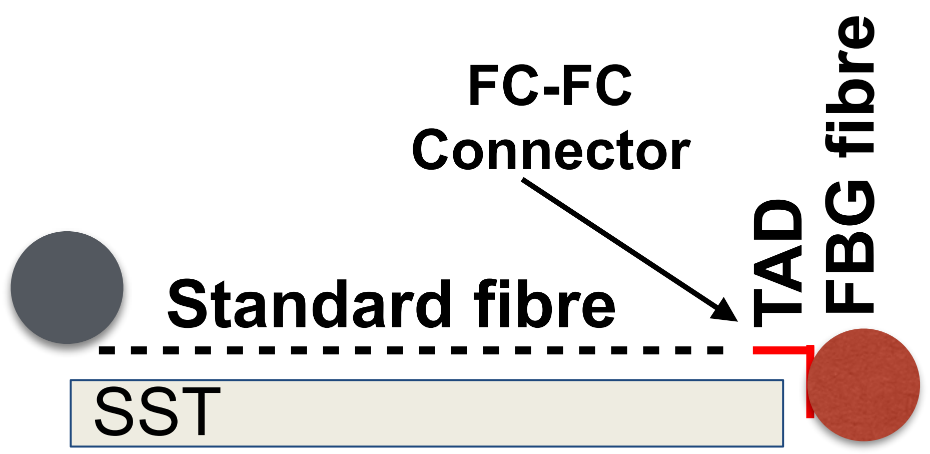

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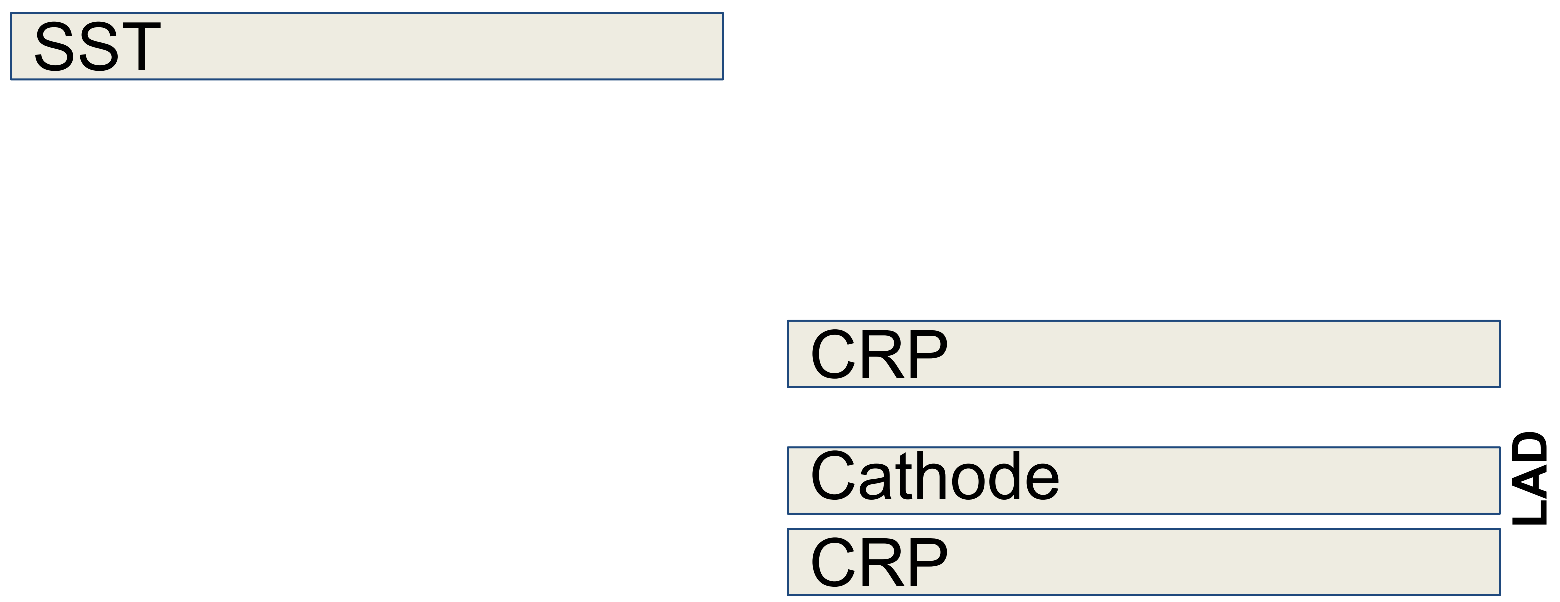

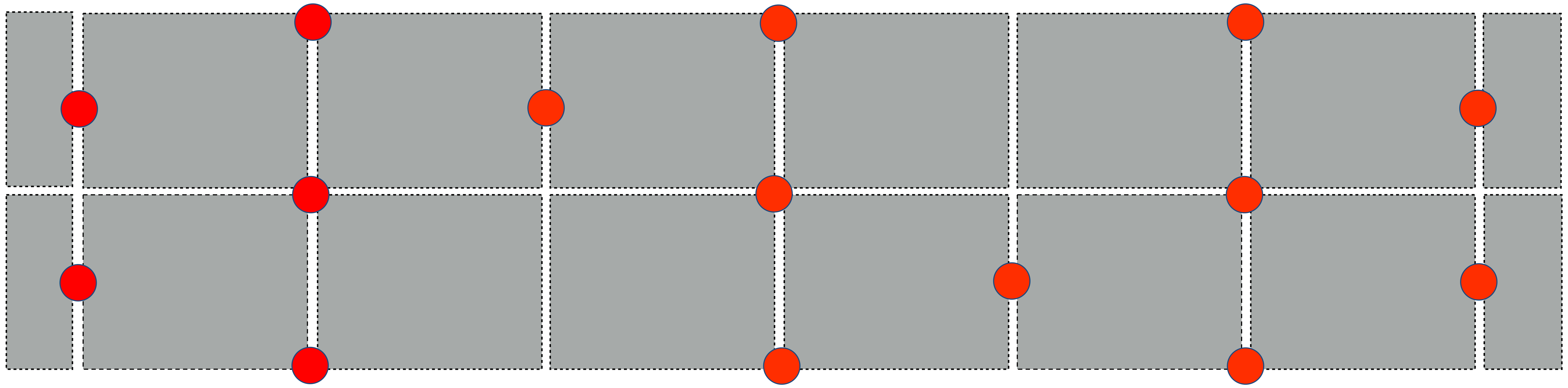

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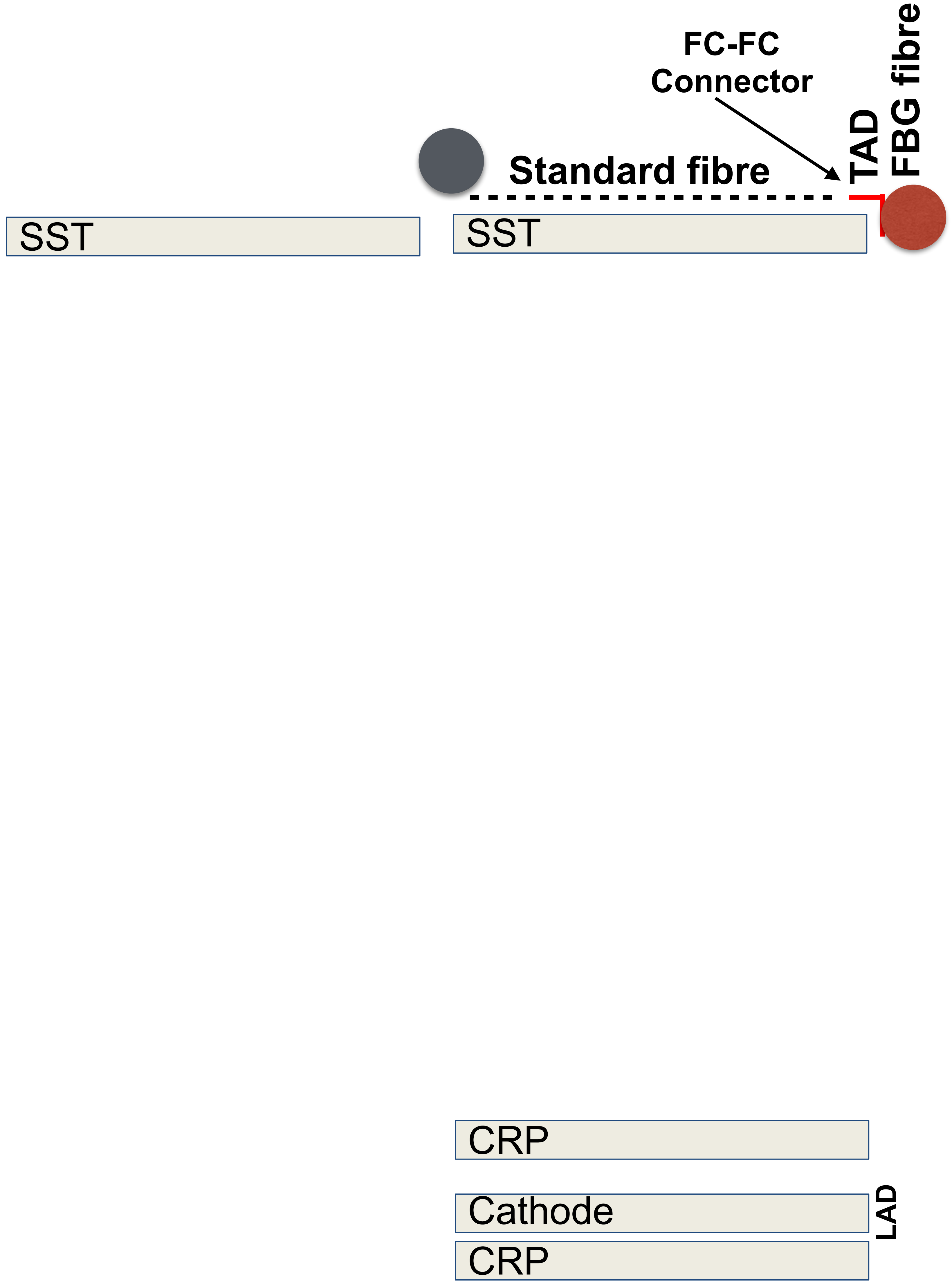

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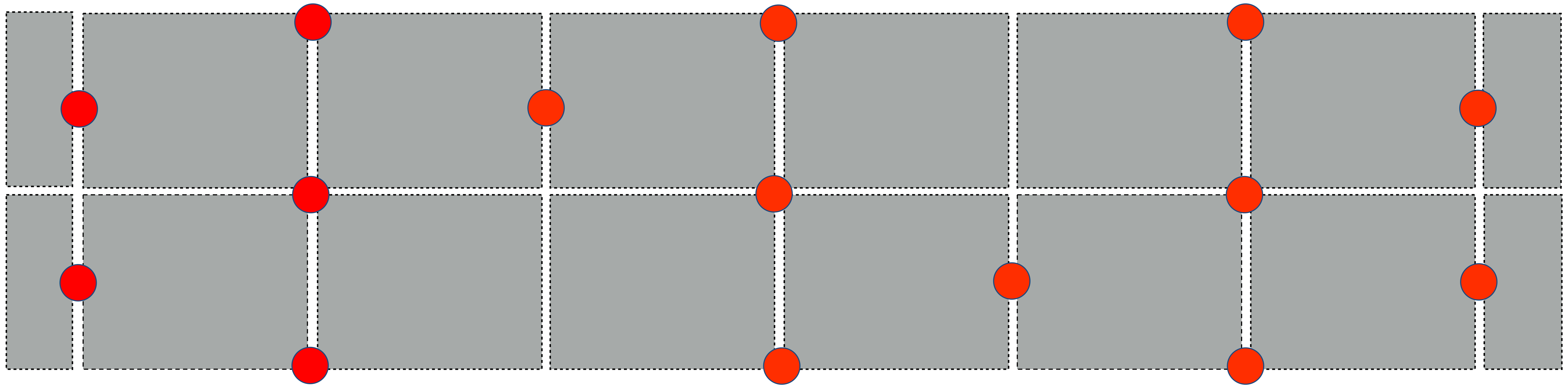

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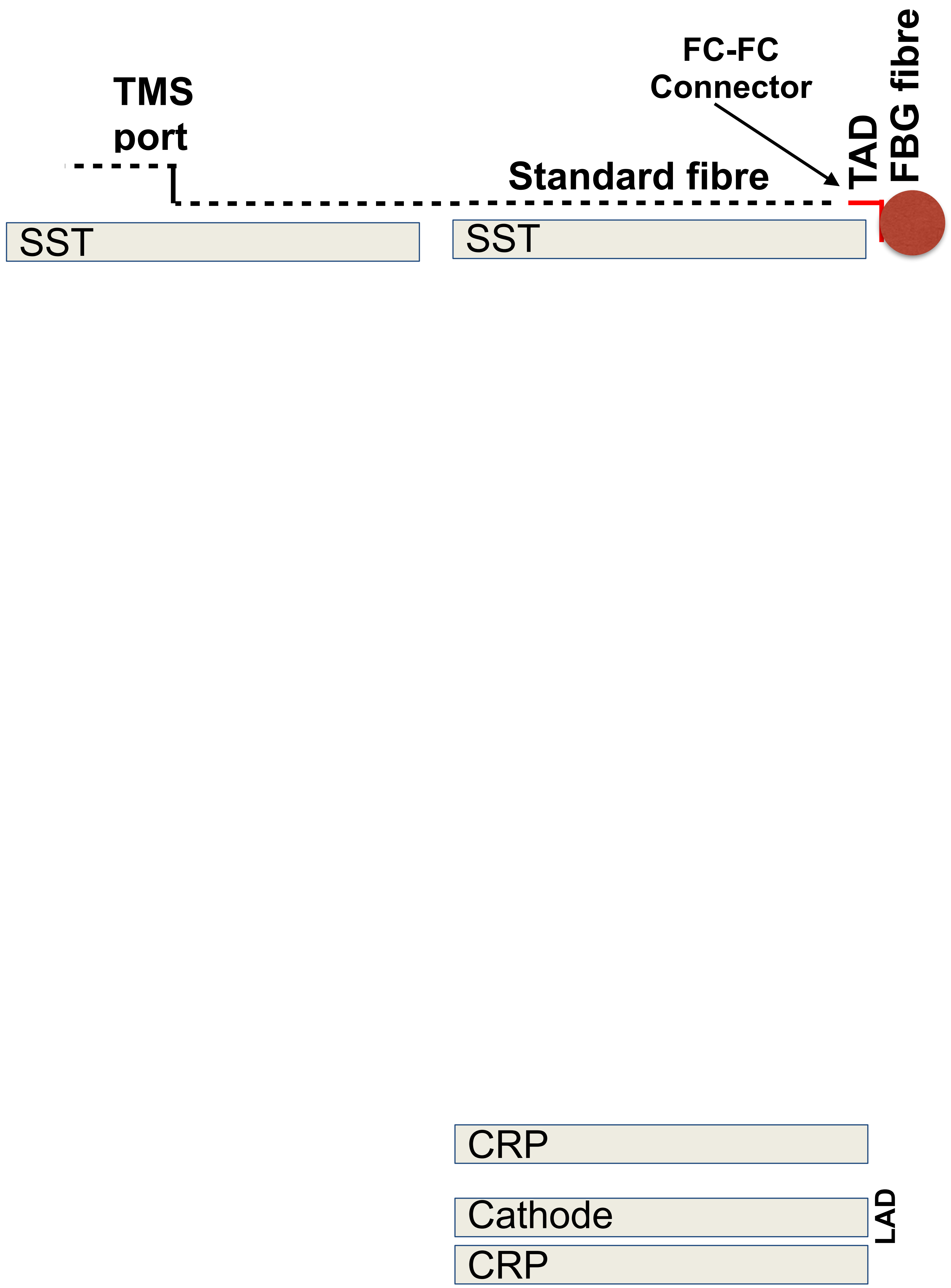

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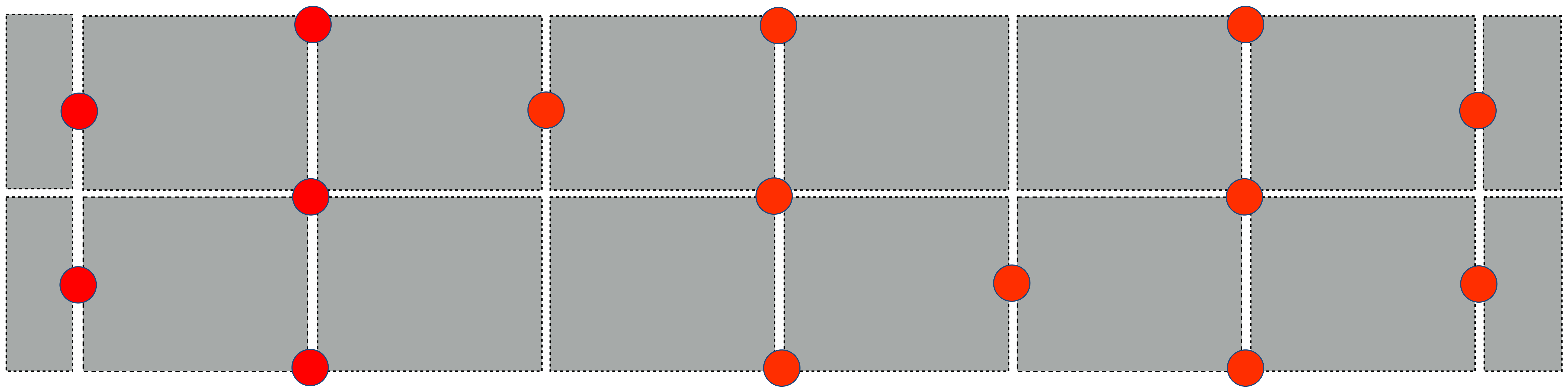

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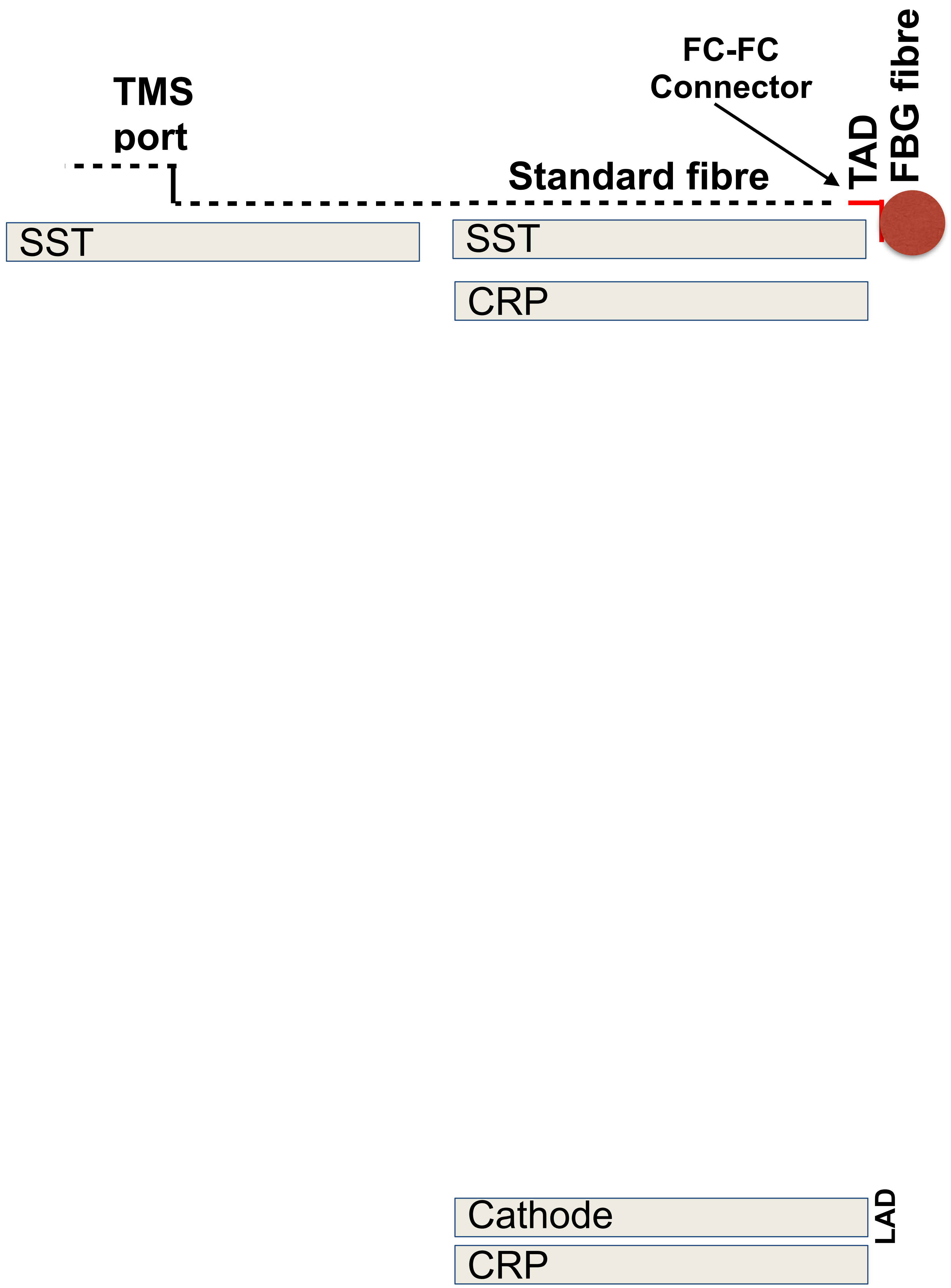

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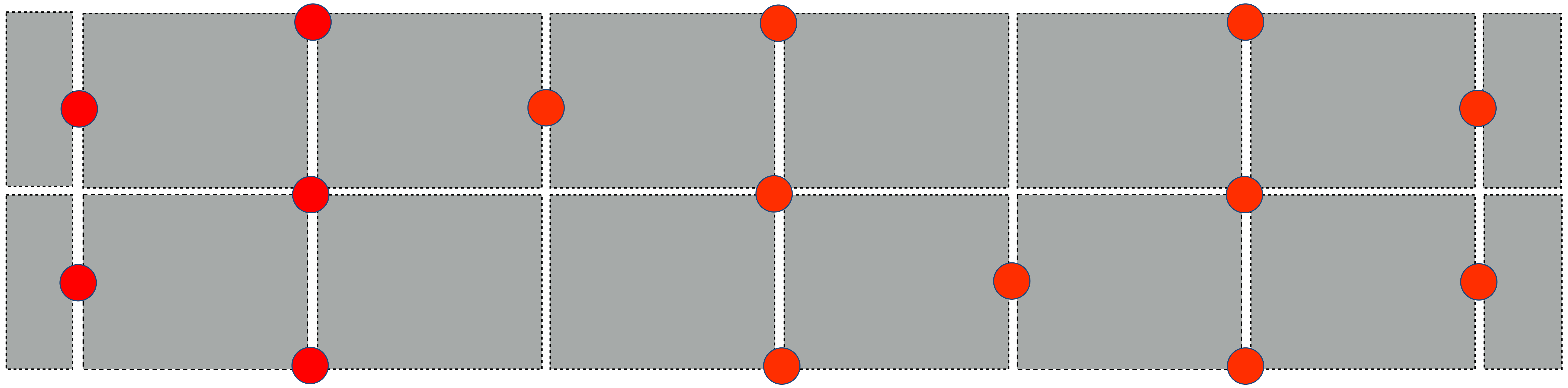

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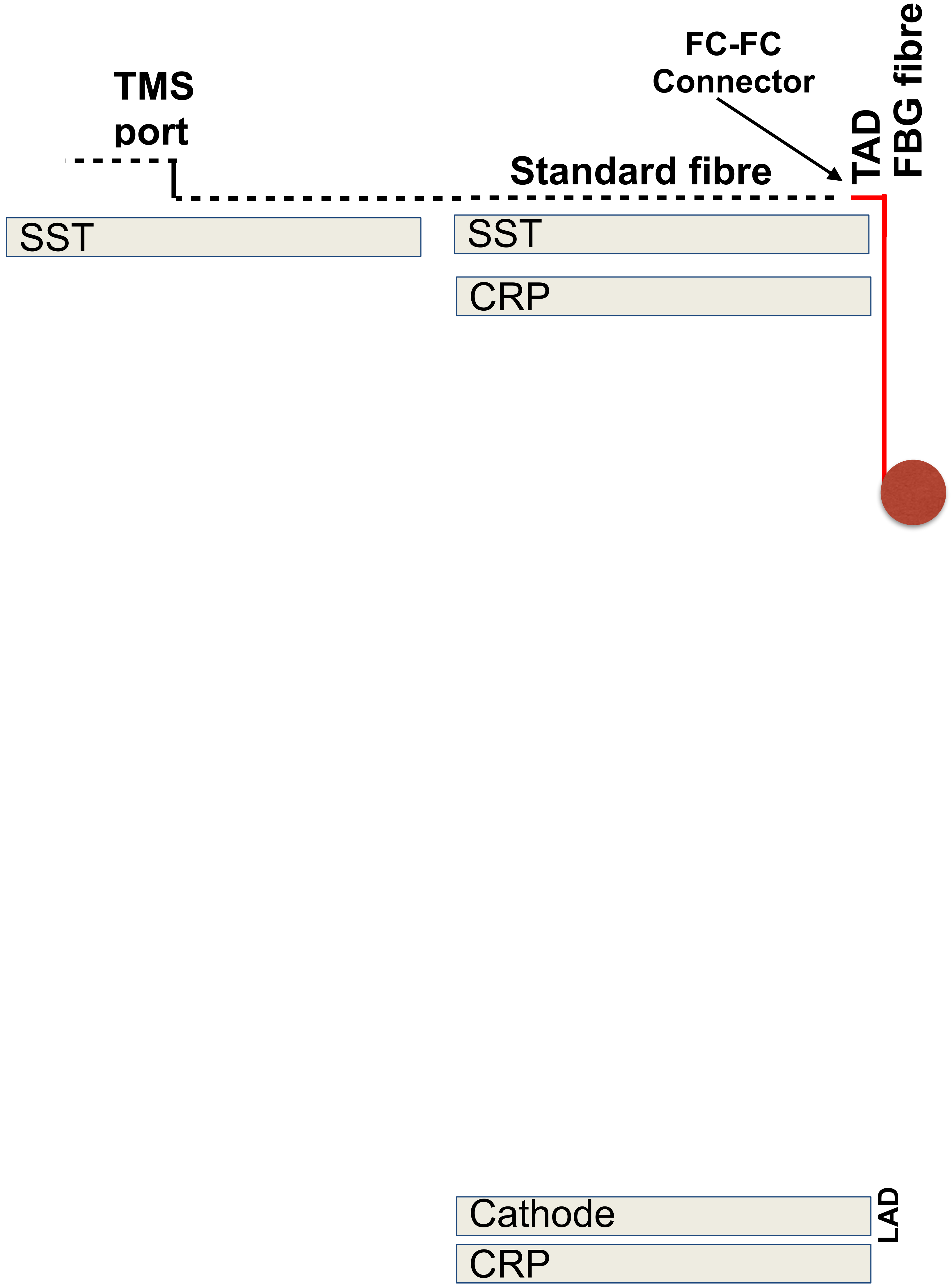

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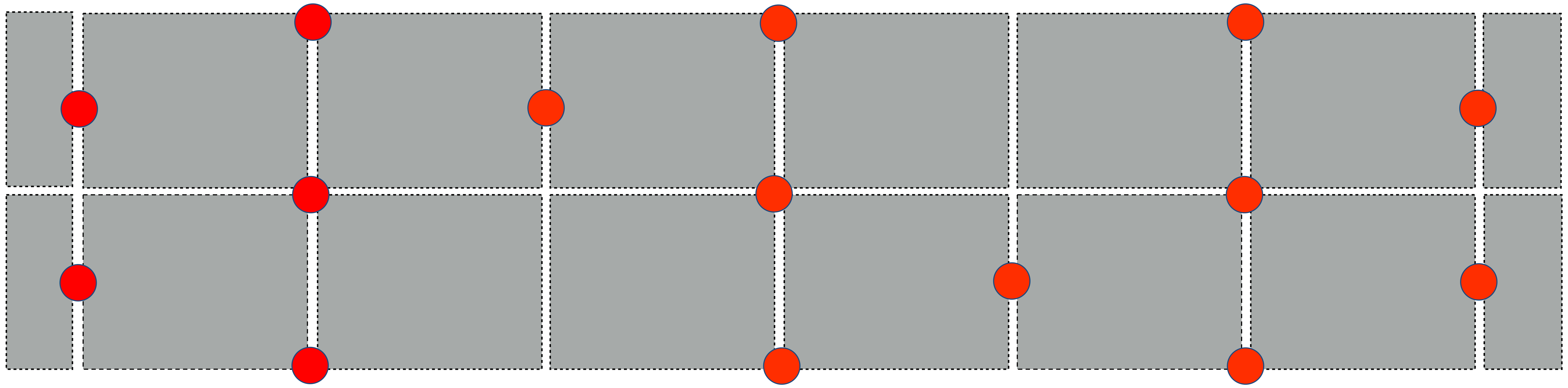

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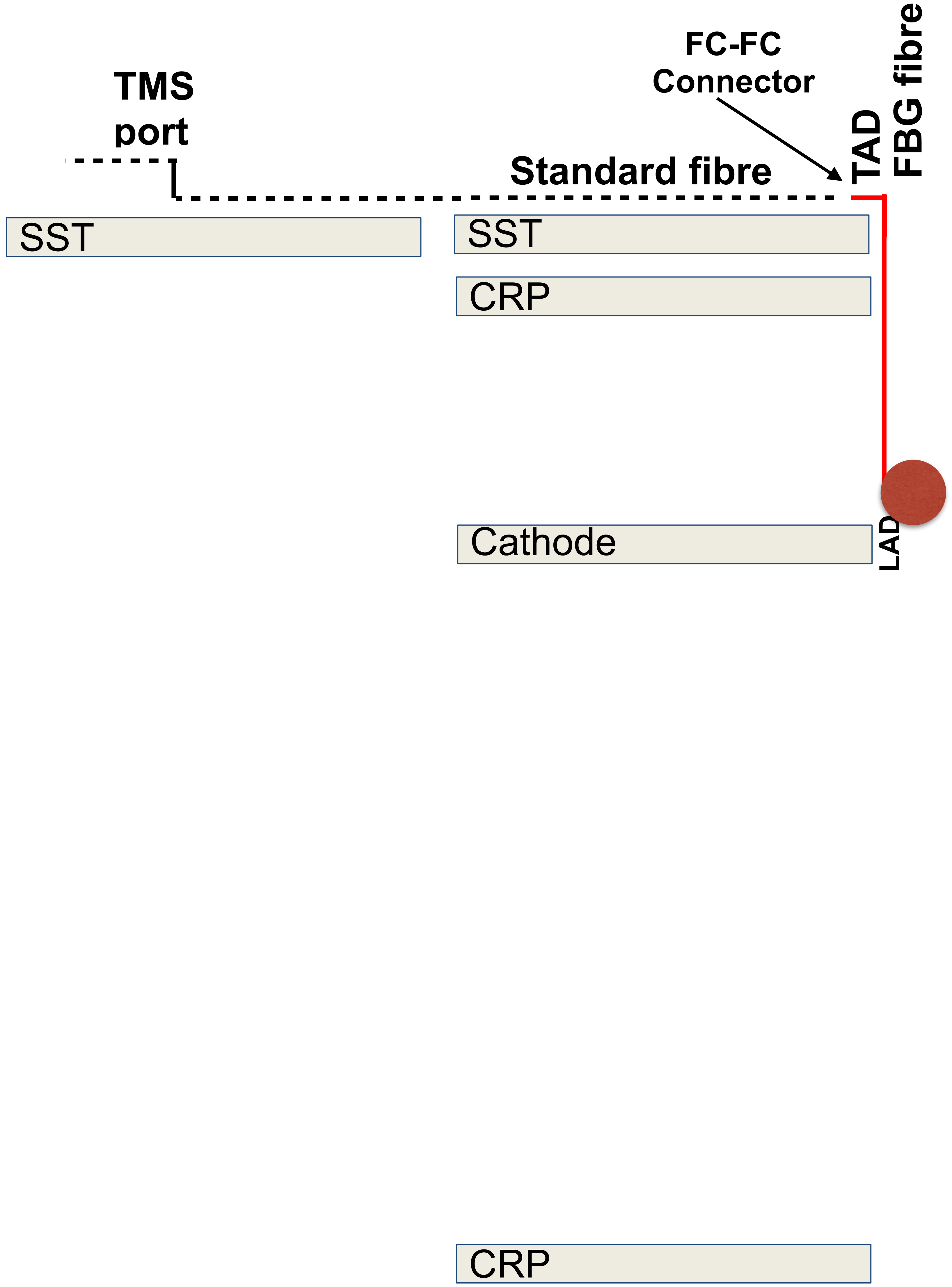

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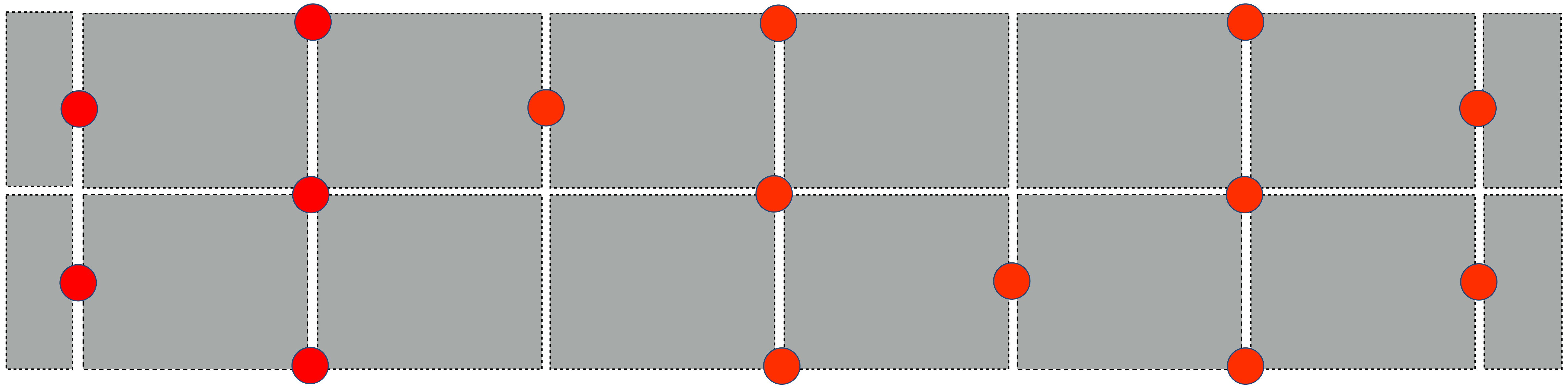

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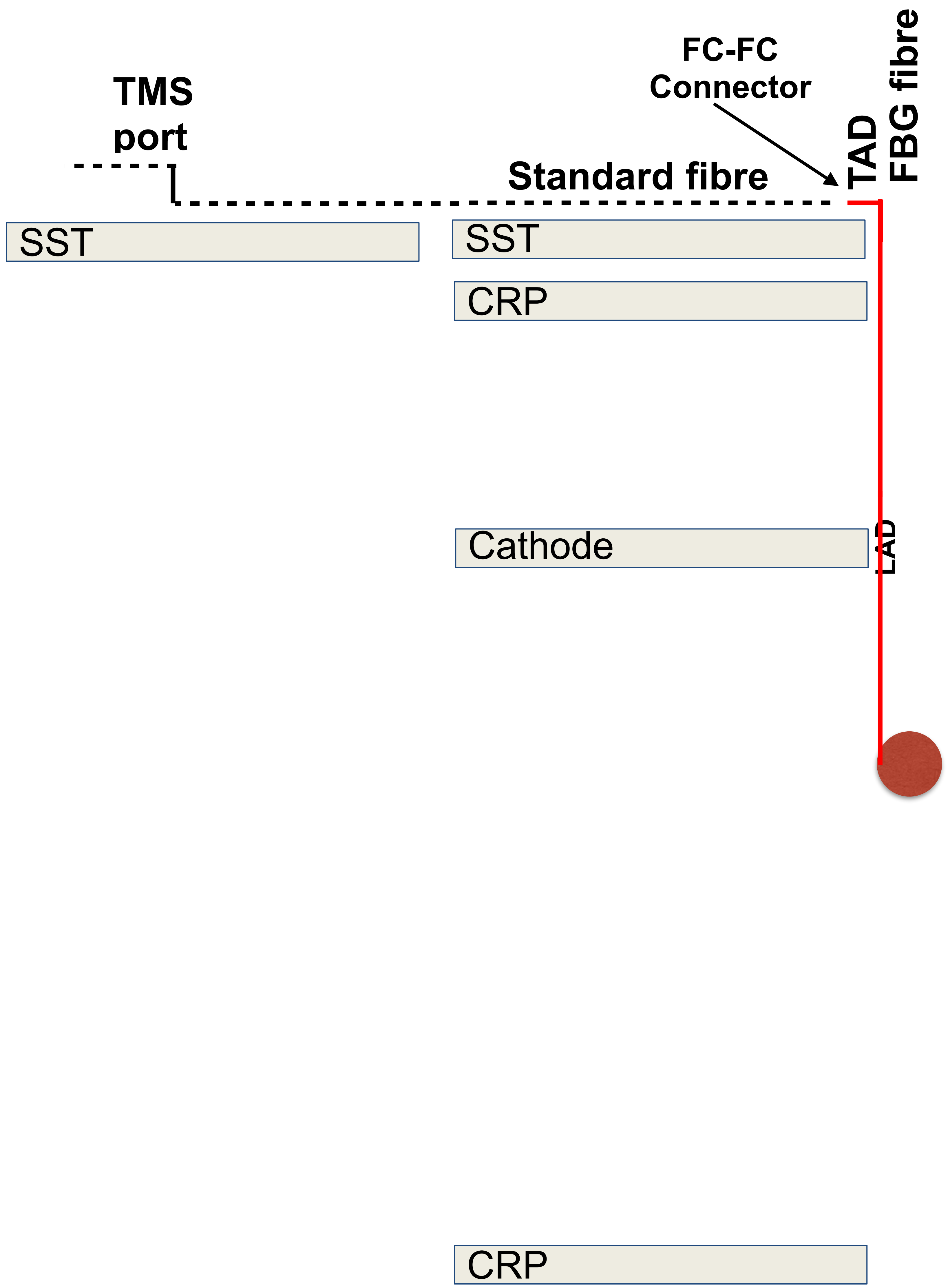

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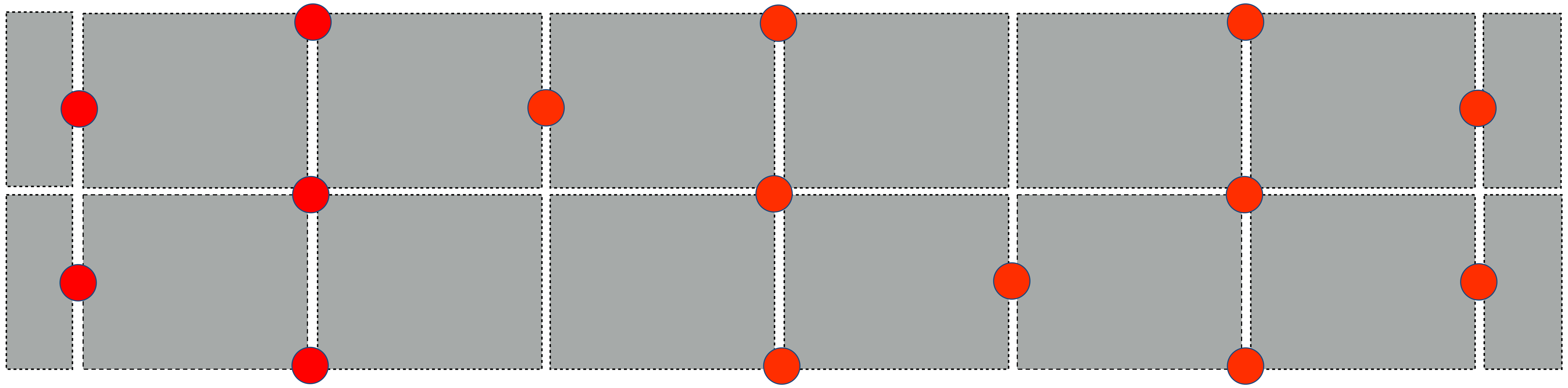

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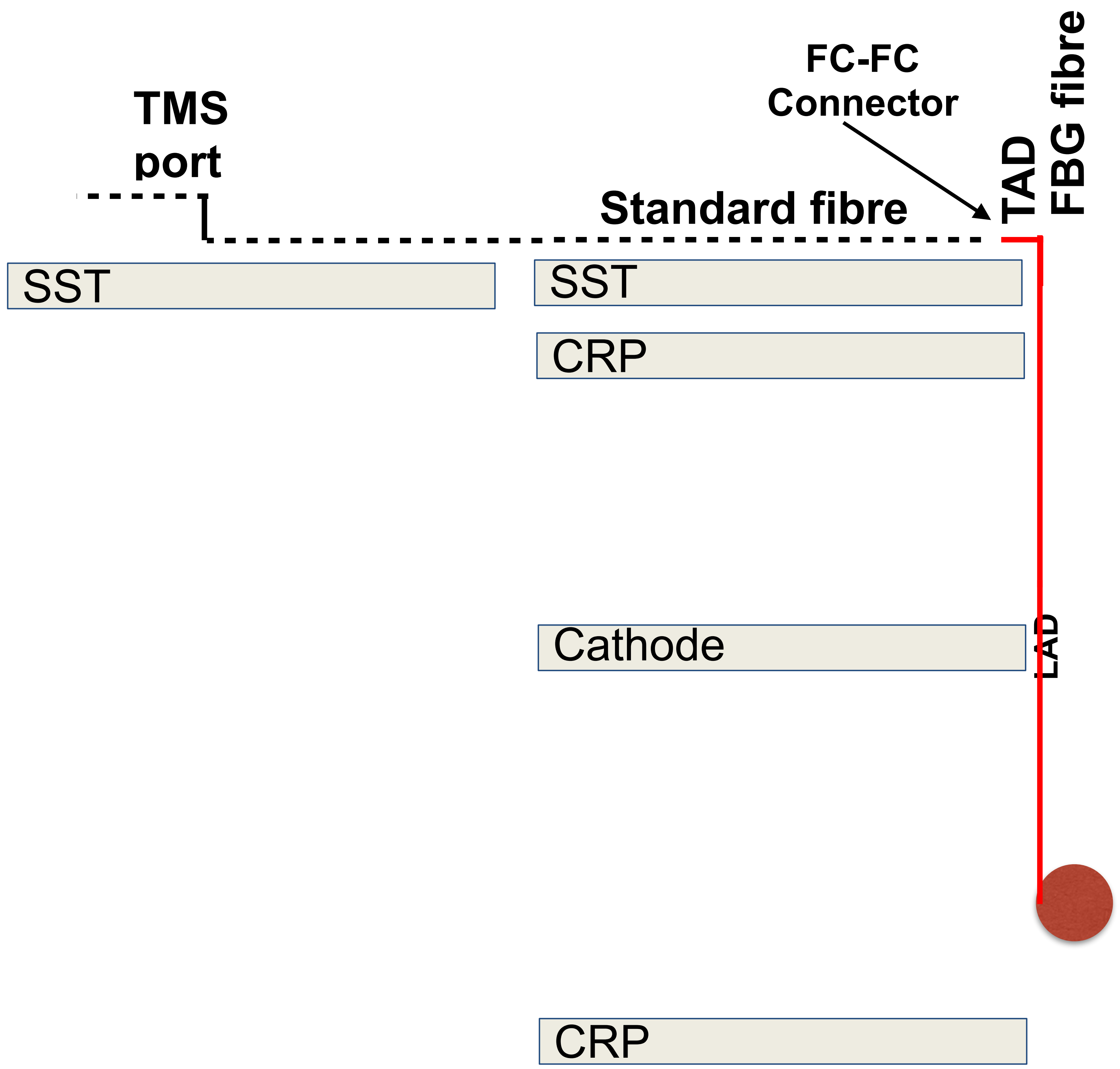

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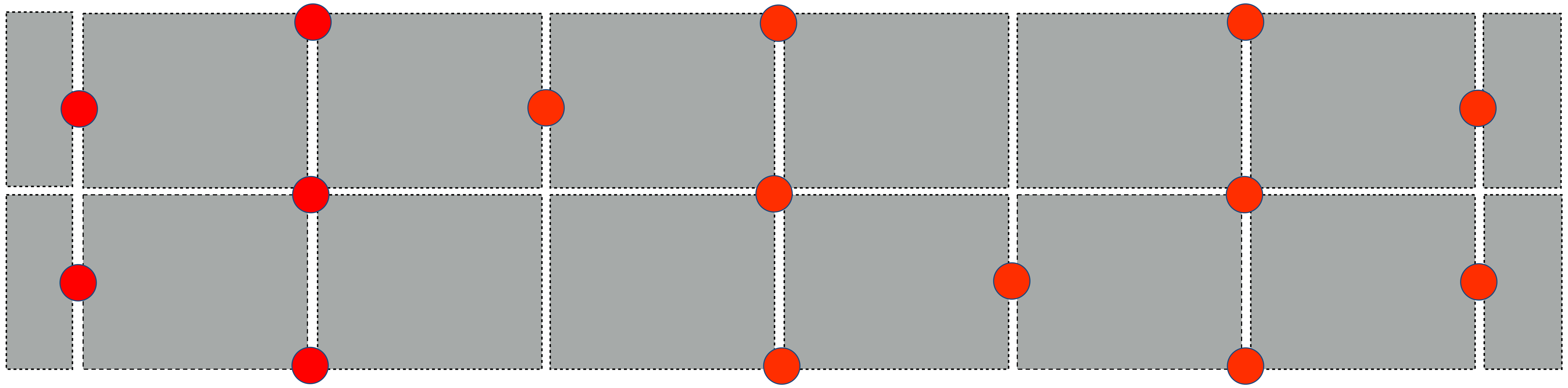

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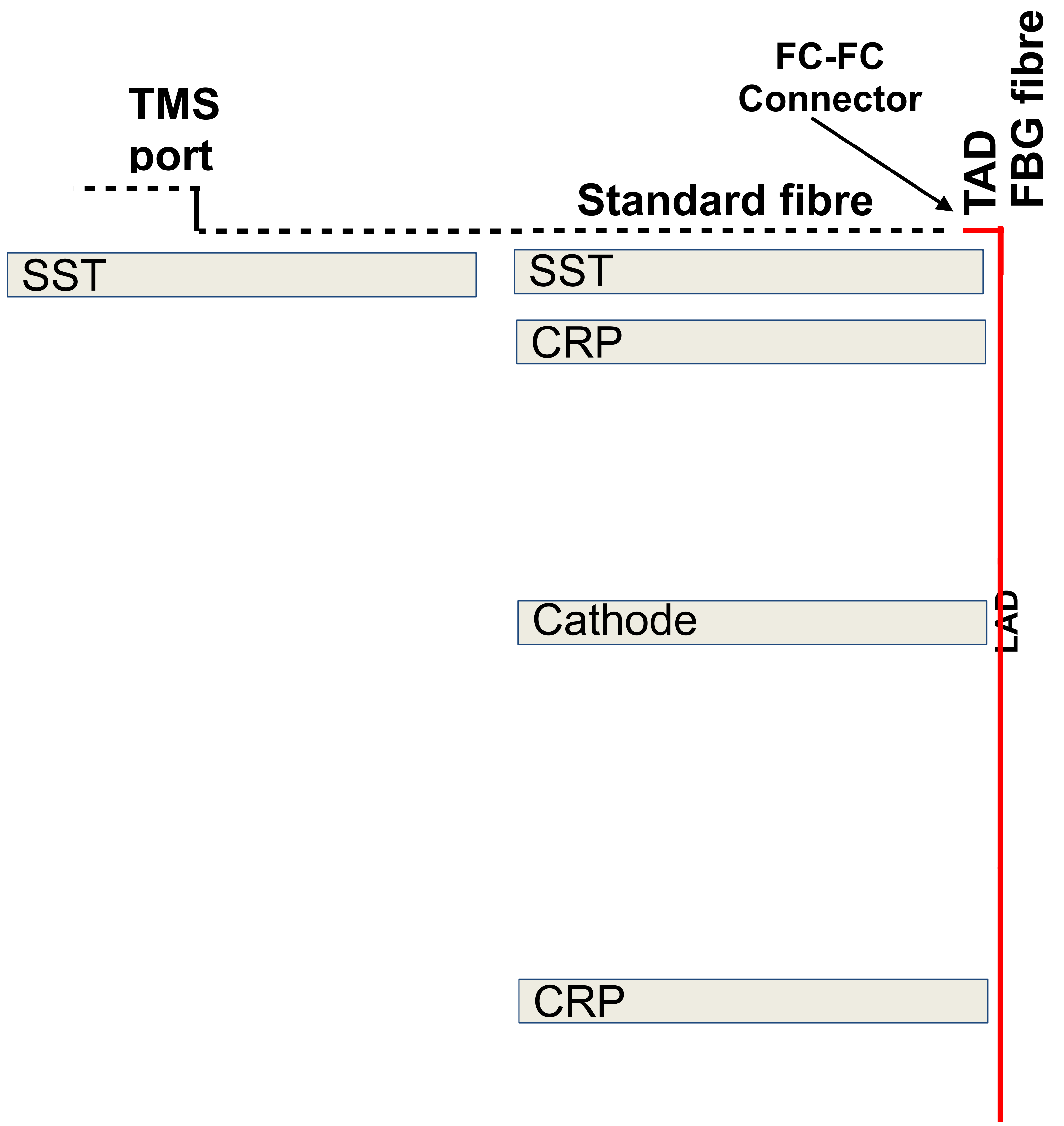

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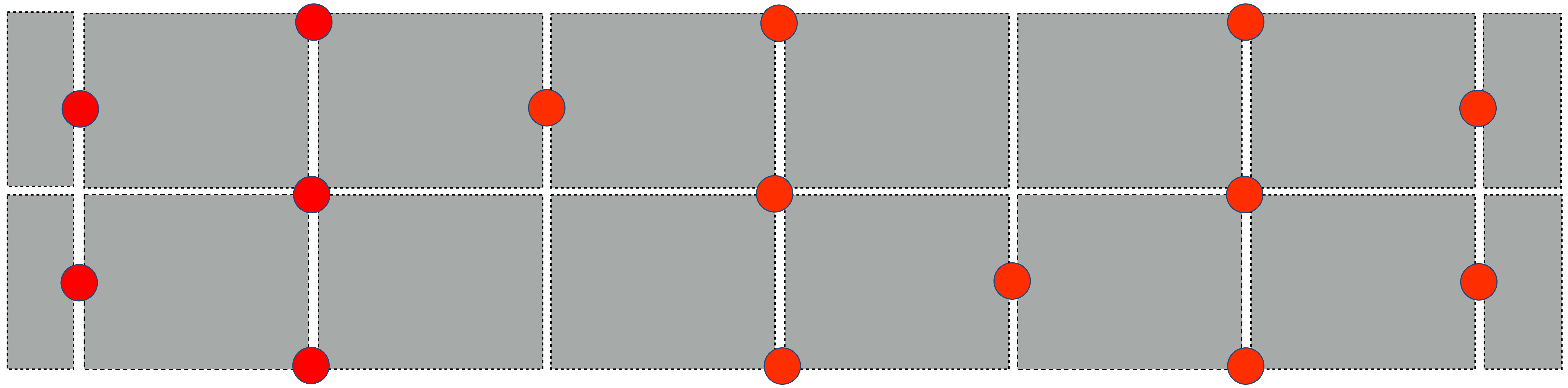

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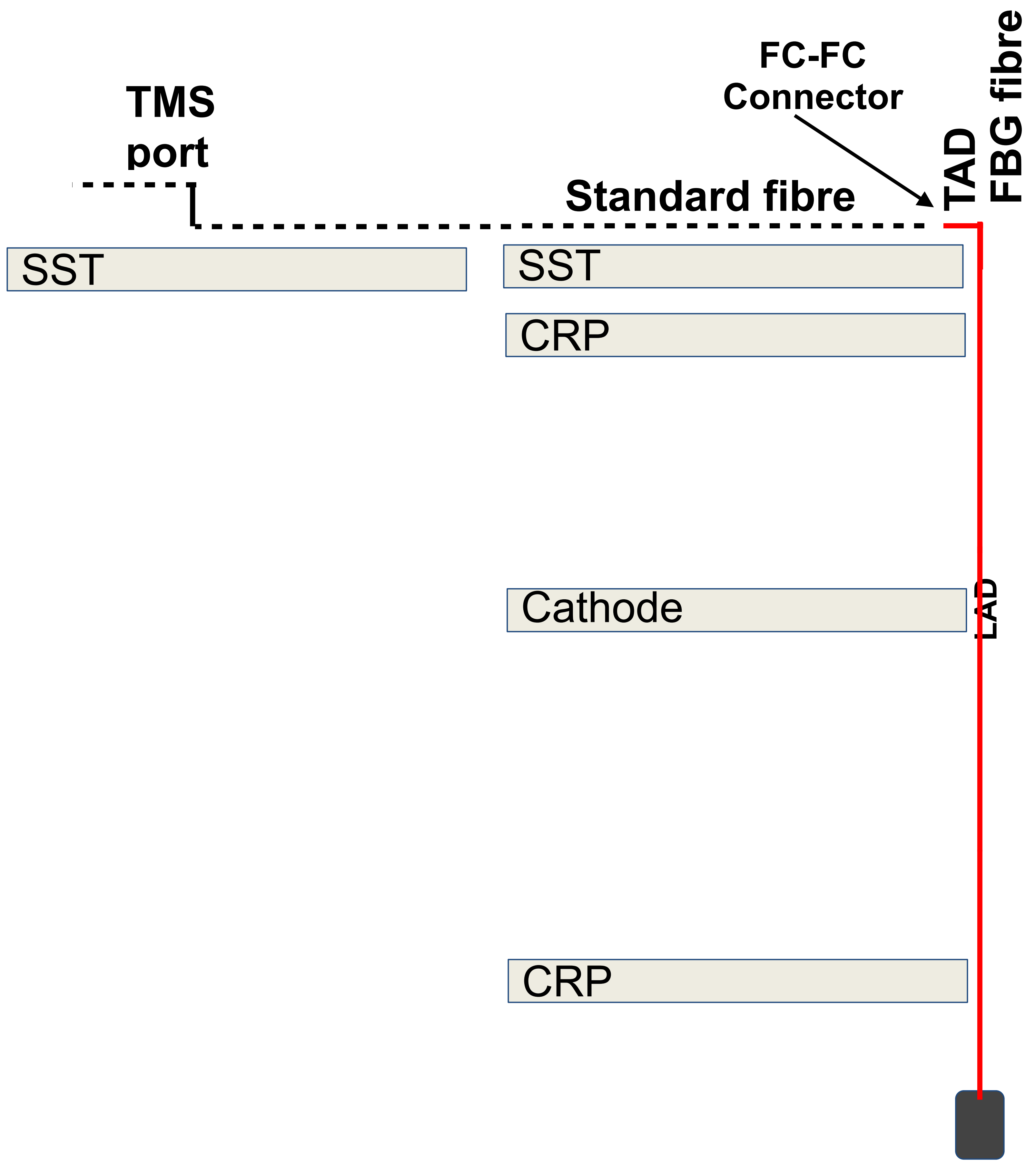

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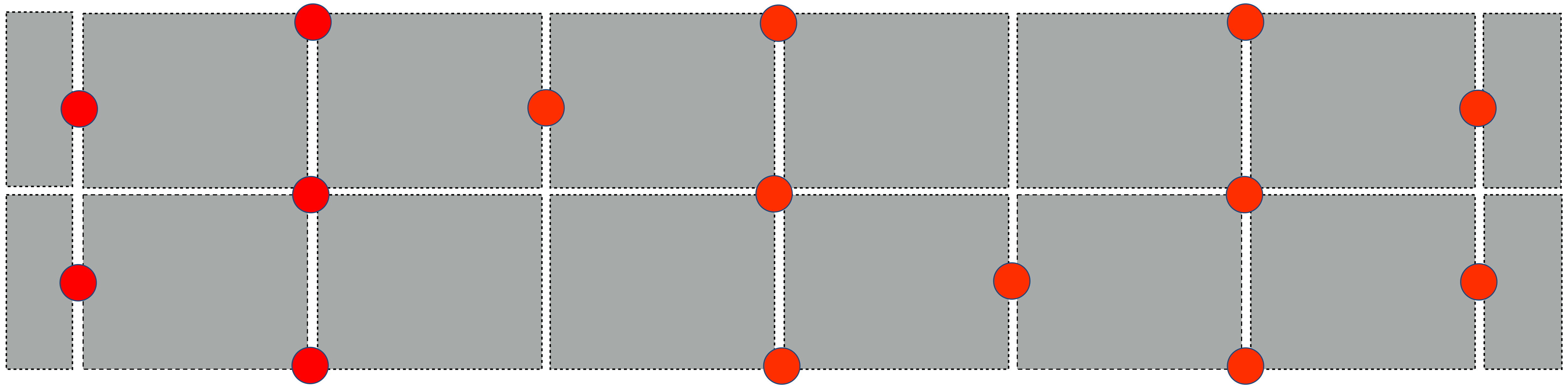


Routing on CRP SST

Current proposal

Gas array

▲ Gas array (GA)

● FBG measurement point (TAD & FC connector & vertical fibre)

Cable bundle pre-installed on SST

Cable bundle installed at height

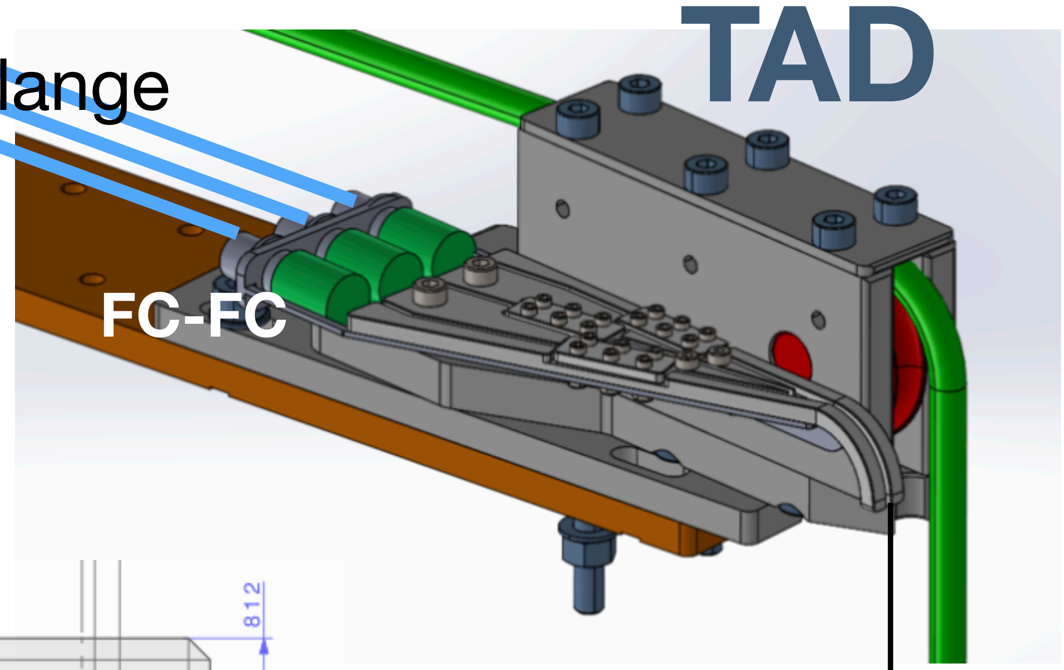
18 18 # RTD cables

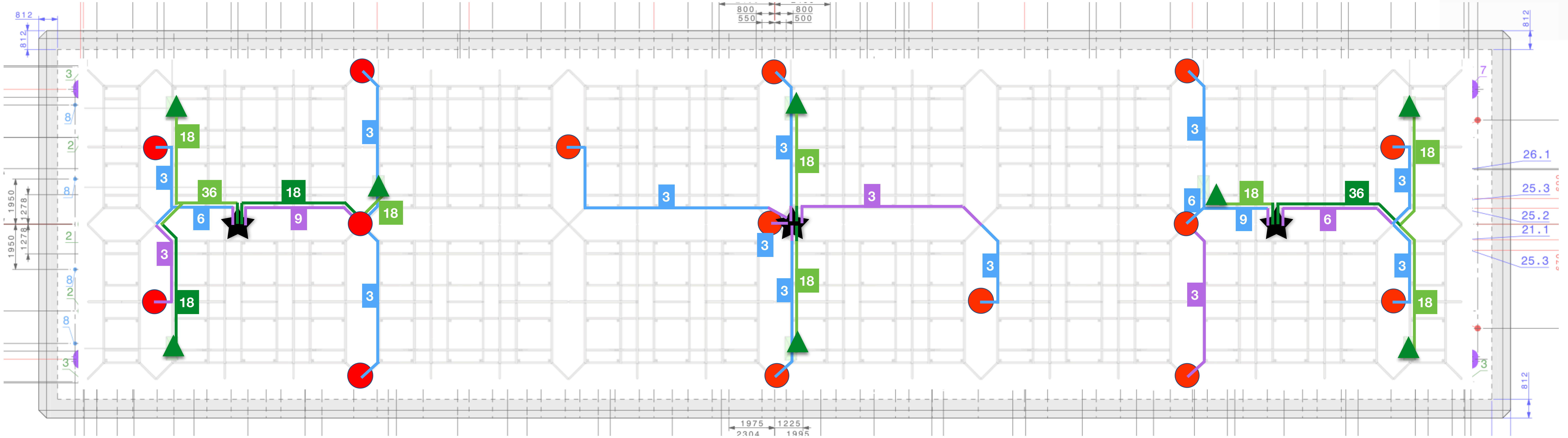
Fiber pre-installed on SST

Fiber installed at height

3 3 # fibers

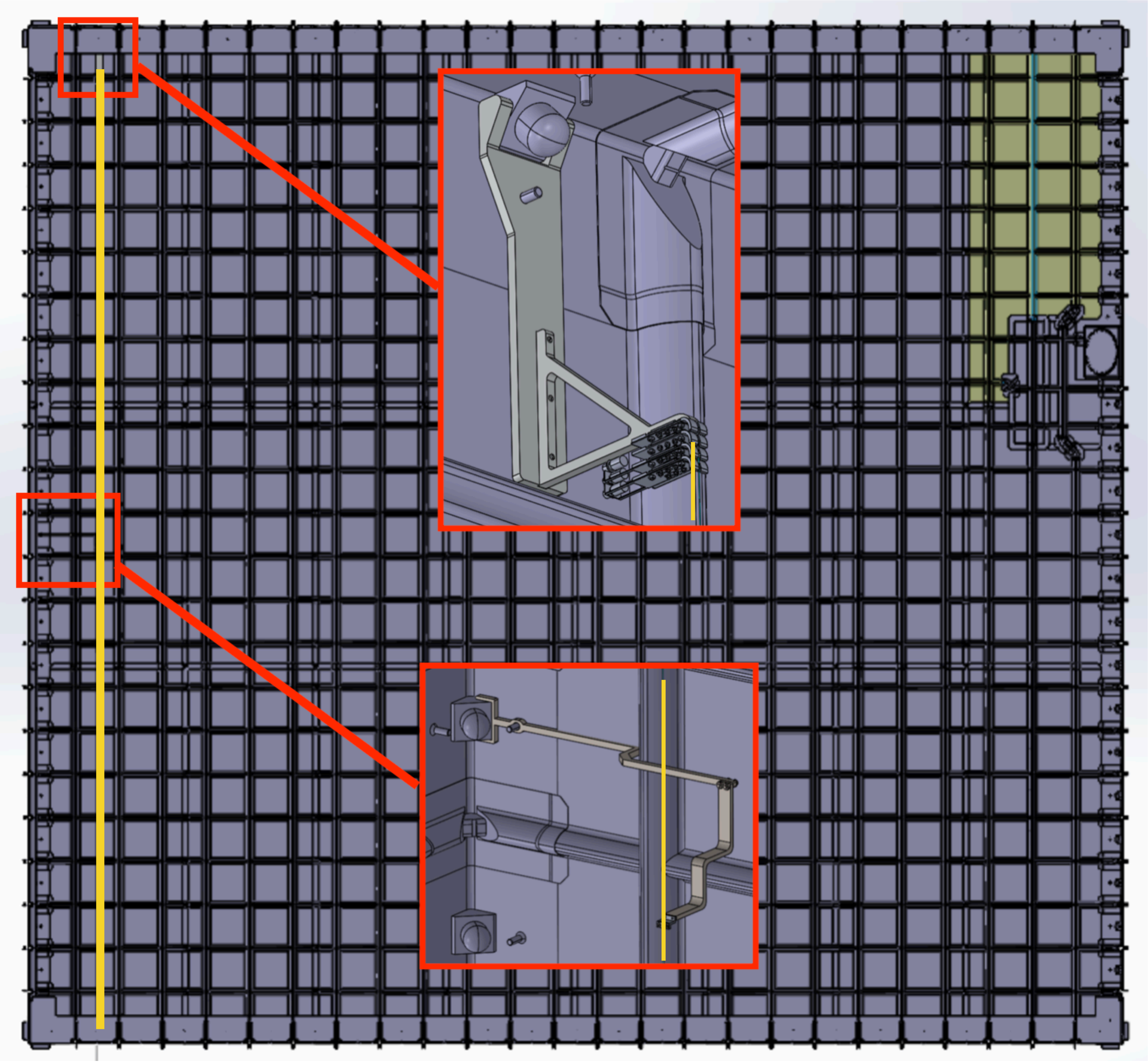
★ Cryostat port (3 units) and interrogator (3 units)



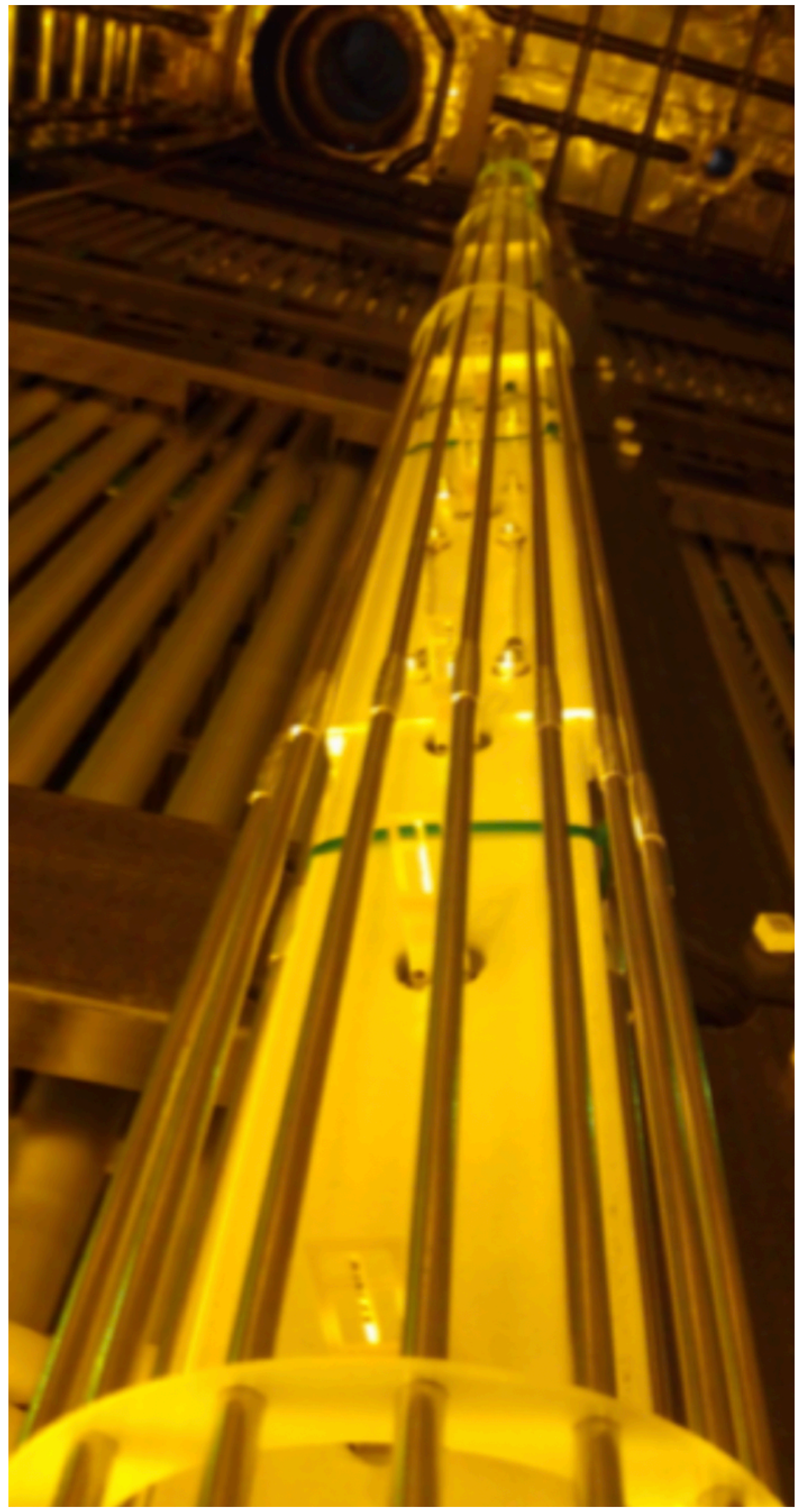


Test installation at CERN

- The system is being prototyped and will be installed in PD-VD in January



- A second, more advance prototype, with better fibres, could be installed later besides the T-Gradient monitor in PD-HD
- The 48 RTDs calibrated to 3 mK could be very useful to understand the FBG performance



Installation schedule

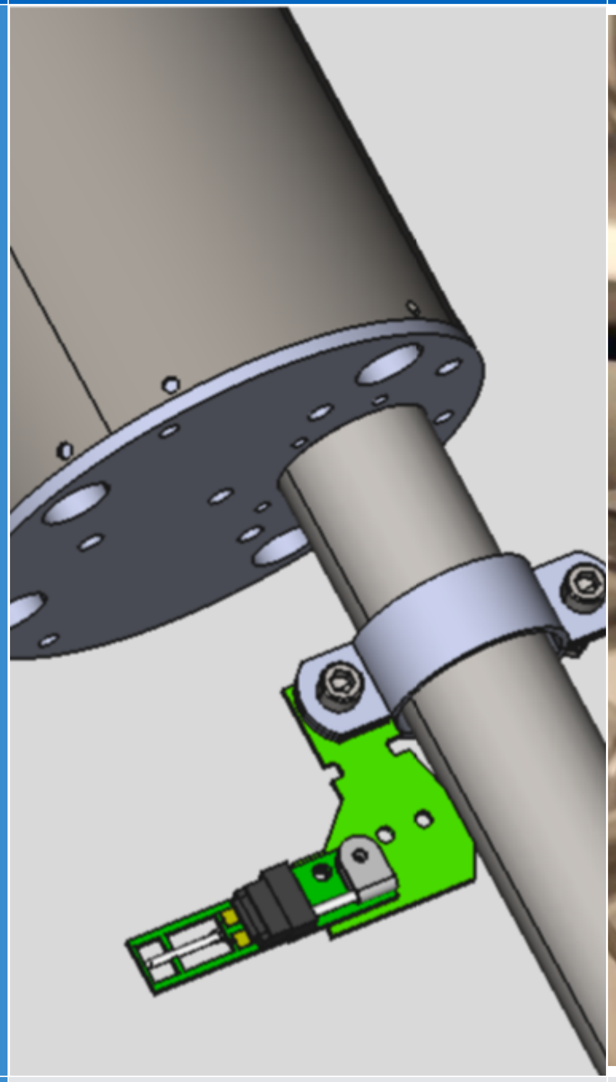
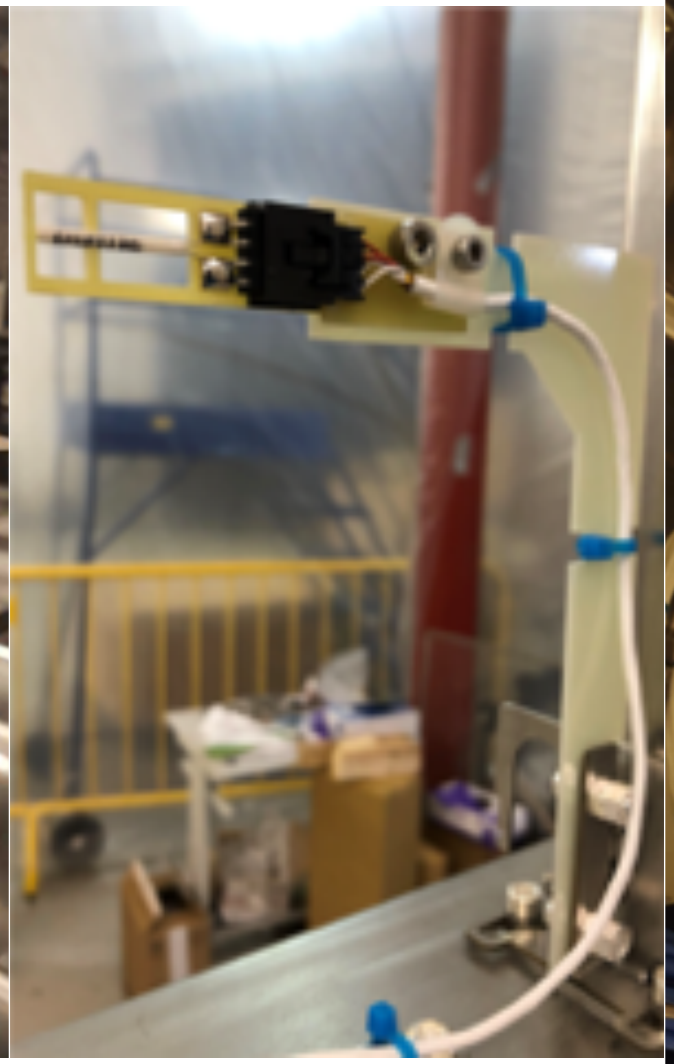
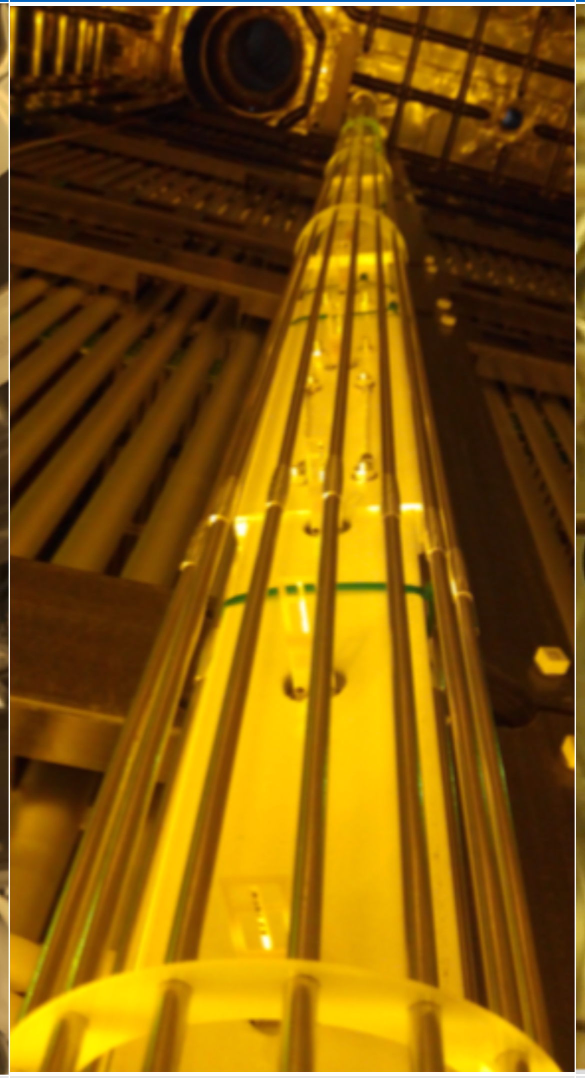
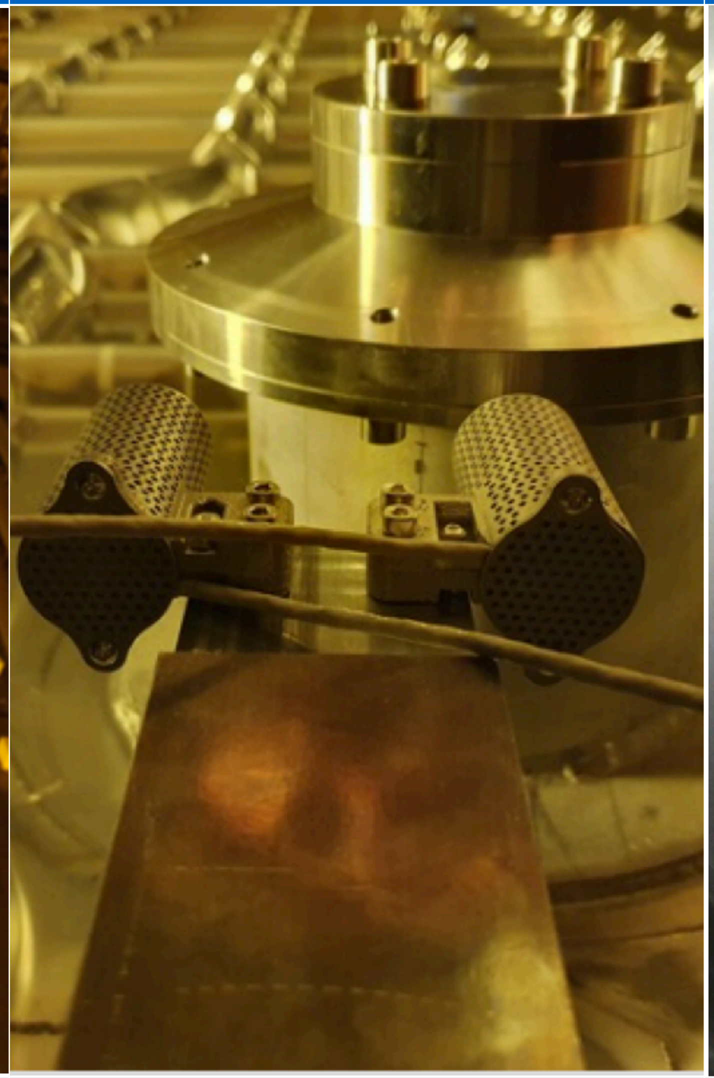
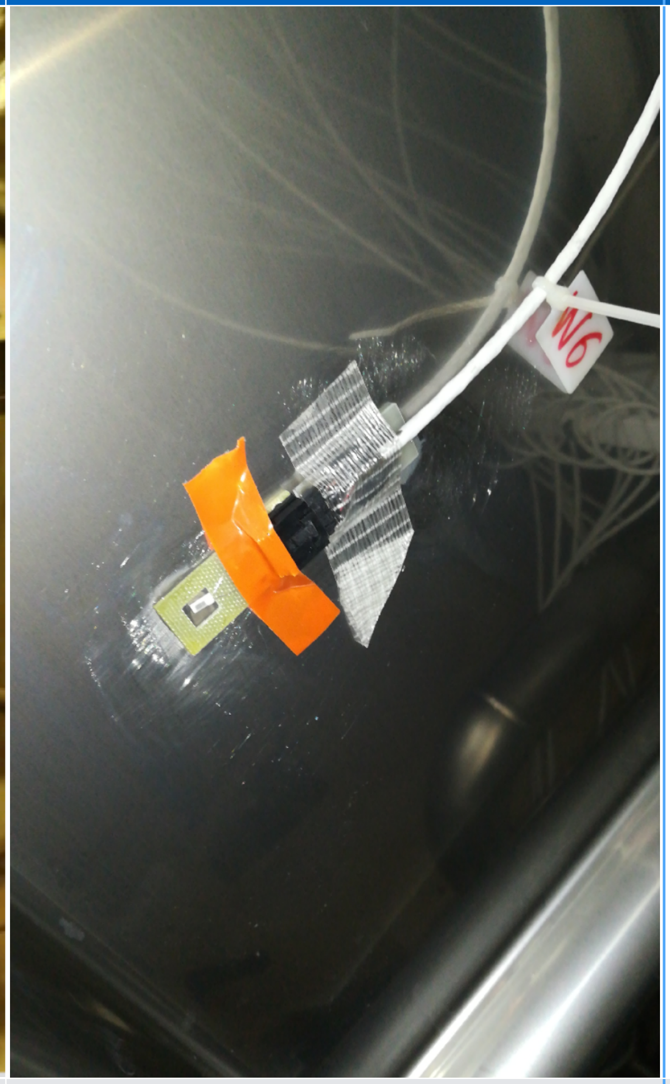
- **FD1 only**: APA sensors installed at APA factories following their schedule
  - Cabling from upper APA to flange is similar to the one of the PDS and will be done by I&I
- **FD2 only:** fibres would be installed during detector installation in coordination with CRP and cathode (about 7 months)
- Pump, Inlet, wall and gas sensors will be installed before the detector
  - We estimate 3 weeks for each FD module
- PrM sensors will be installed in coordination with PrMs after the detector

Action items

- RTDs:
  - Penetrations and cable routing
  - Gas array anchoring points
  - Rack space and warm cabling
- FBGs:
  - Ongoing R&D to achieve 5 mK precision
  - Penetrations and fibre routing from flange to CRP SST
  - Installation interfaces with CRP and cathode
  - Evaluate risks: fibre breaking, fibre charging up, …
- Flanges:
  - Who is responsible for closing unused CALCI ports ?

Backup

Thermometers for FD1& FD2

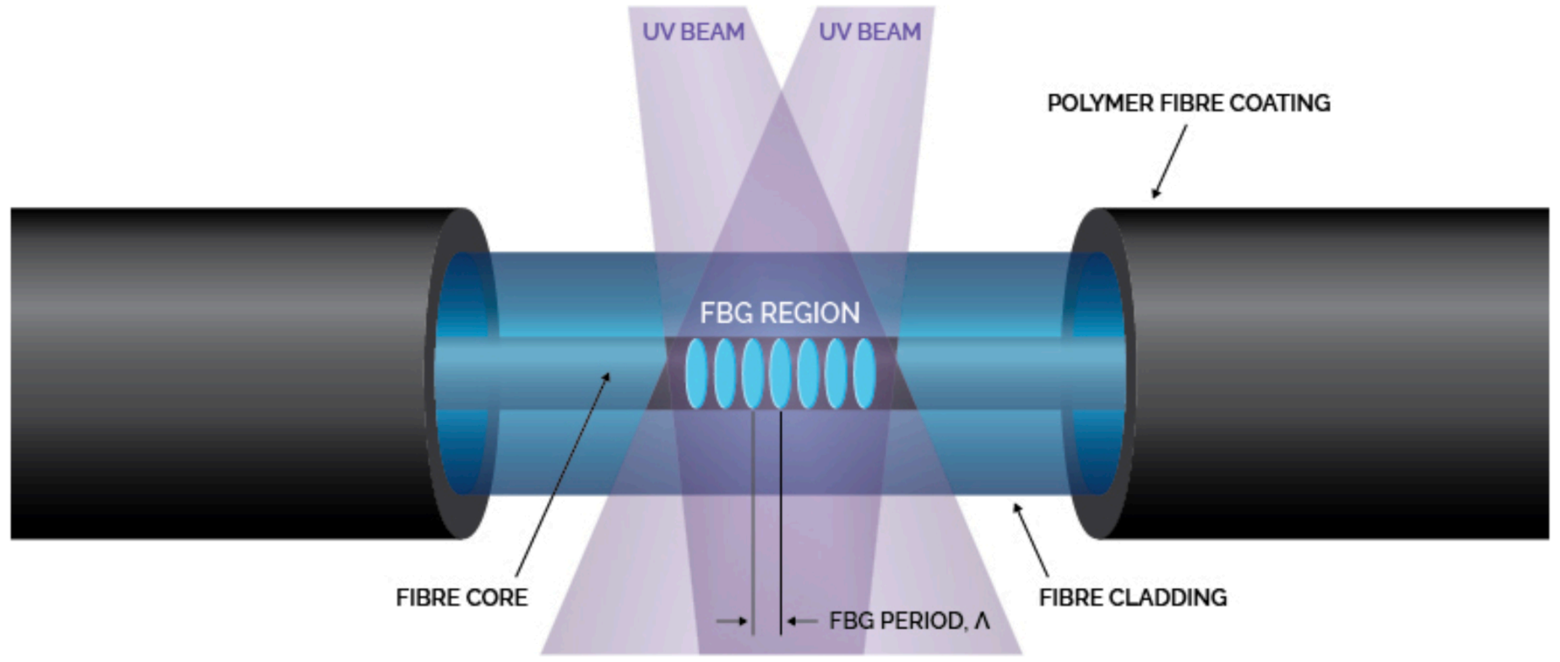
	Purity Monitors	LAr Inlets + Pipes	APAs	ullage	T-Gradients	pumps	wall	TOTAL
								
PD-HD	6	4+8	16	36	48+24*	2	5	149
PD-VD	mainly monitoring, minimal calibration with CFD							
FD1	8	16	600	144	0	8	26	802
FD2	8	16	1800 (fibers)	144	0	8	26	2002

Production schedule

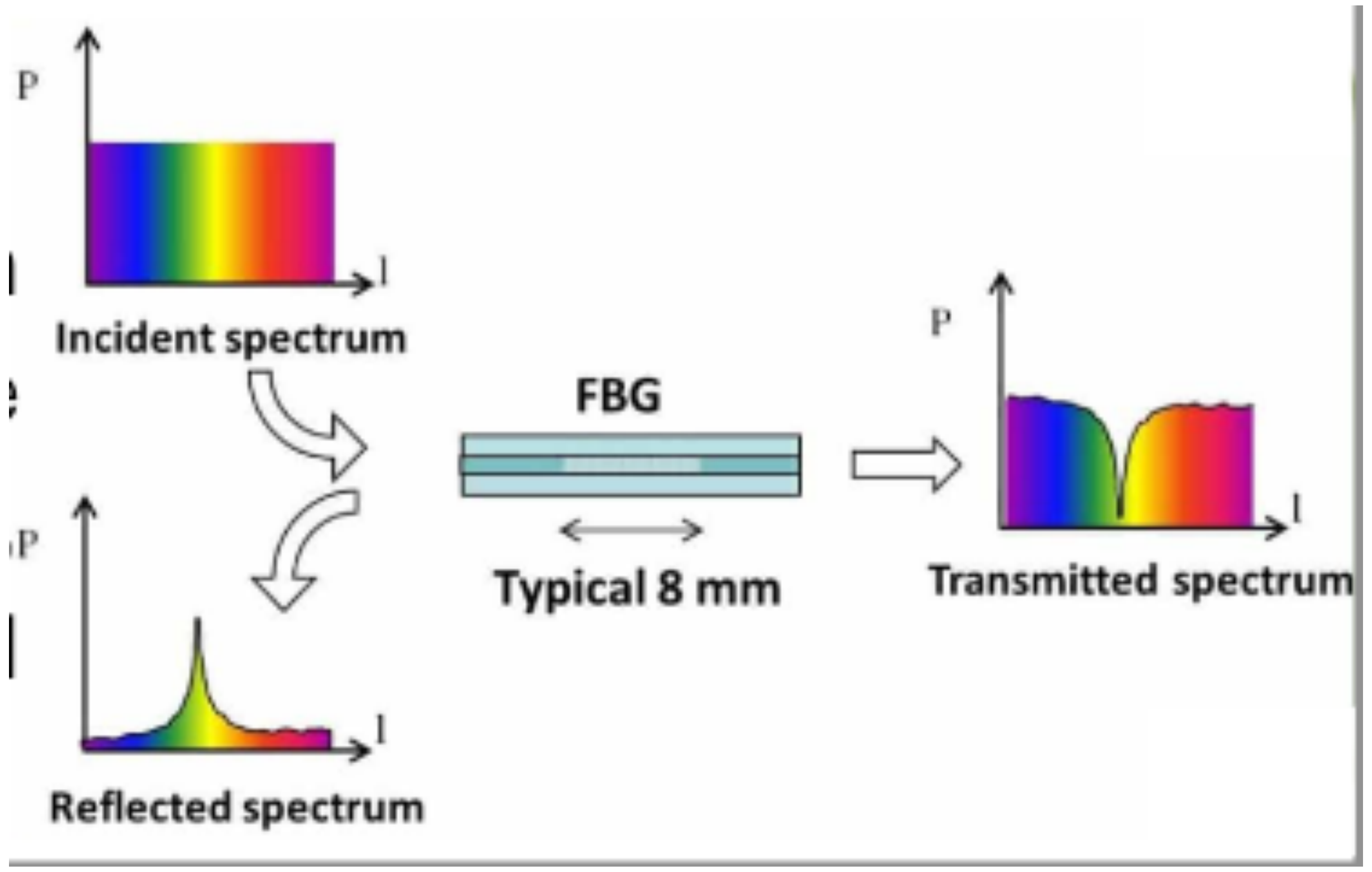
- FD1 APA sensors in production since early 2022
  - Most material procured except 30% of the cable & 50% of the sensors. Place order before Christmas
- Cryostat sensors (inlet, pump, wall, PrM and gas arrays):
  - Mature designs exist except for support of inlet sensors and gas arrays (differ from PD-HD). Both to be prototyped early 2024
  - PRR mid 2024
  - Procurement of components by end 2024
  - Fabrication and calibration in 2025:
    - 202 sensors for each module. Estimated time, 6 moths for each module
- Minimal changes to PD-HD readout. 6 months production in 2025

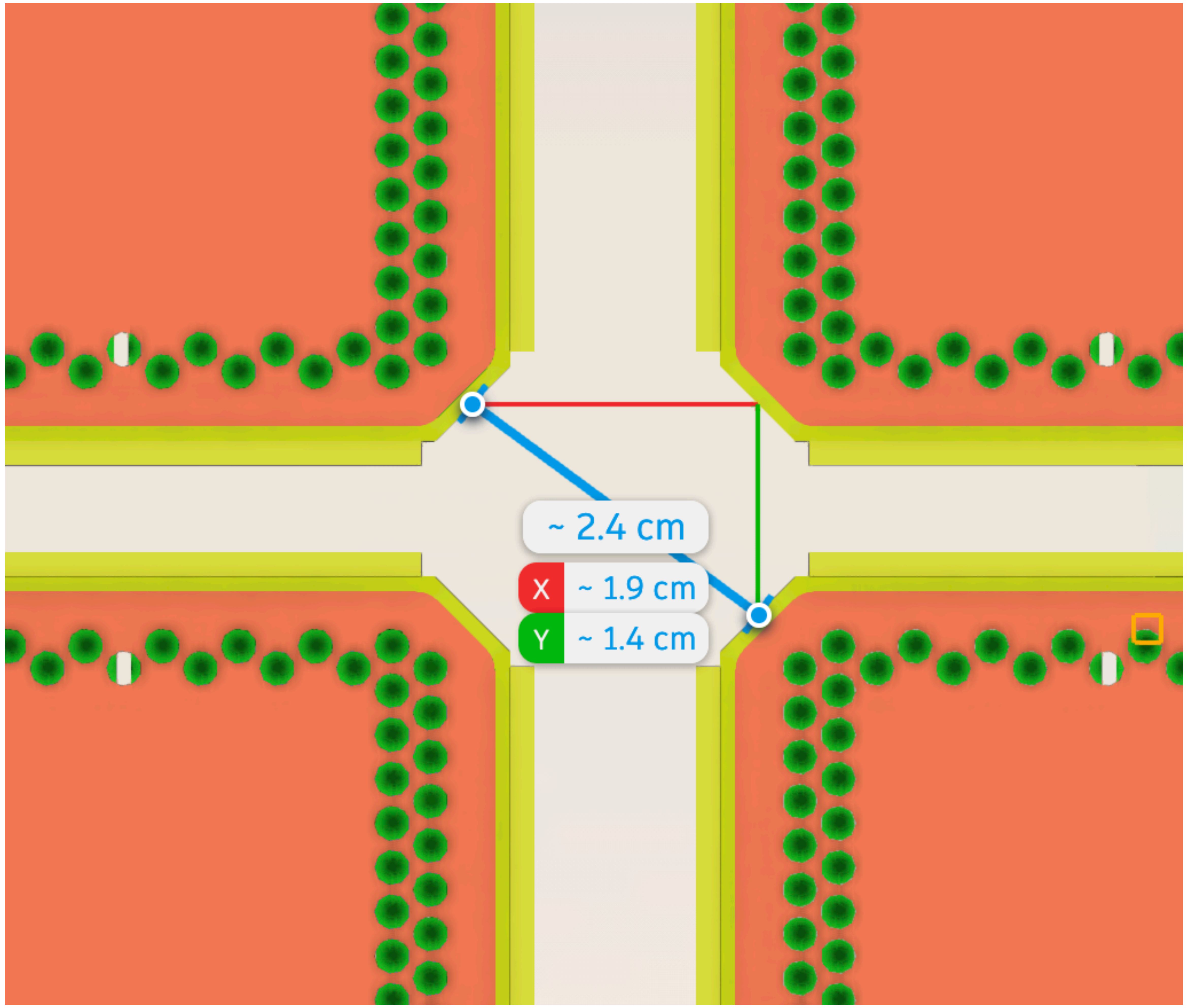
Fibre based thermometry for FD2

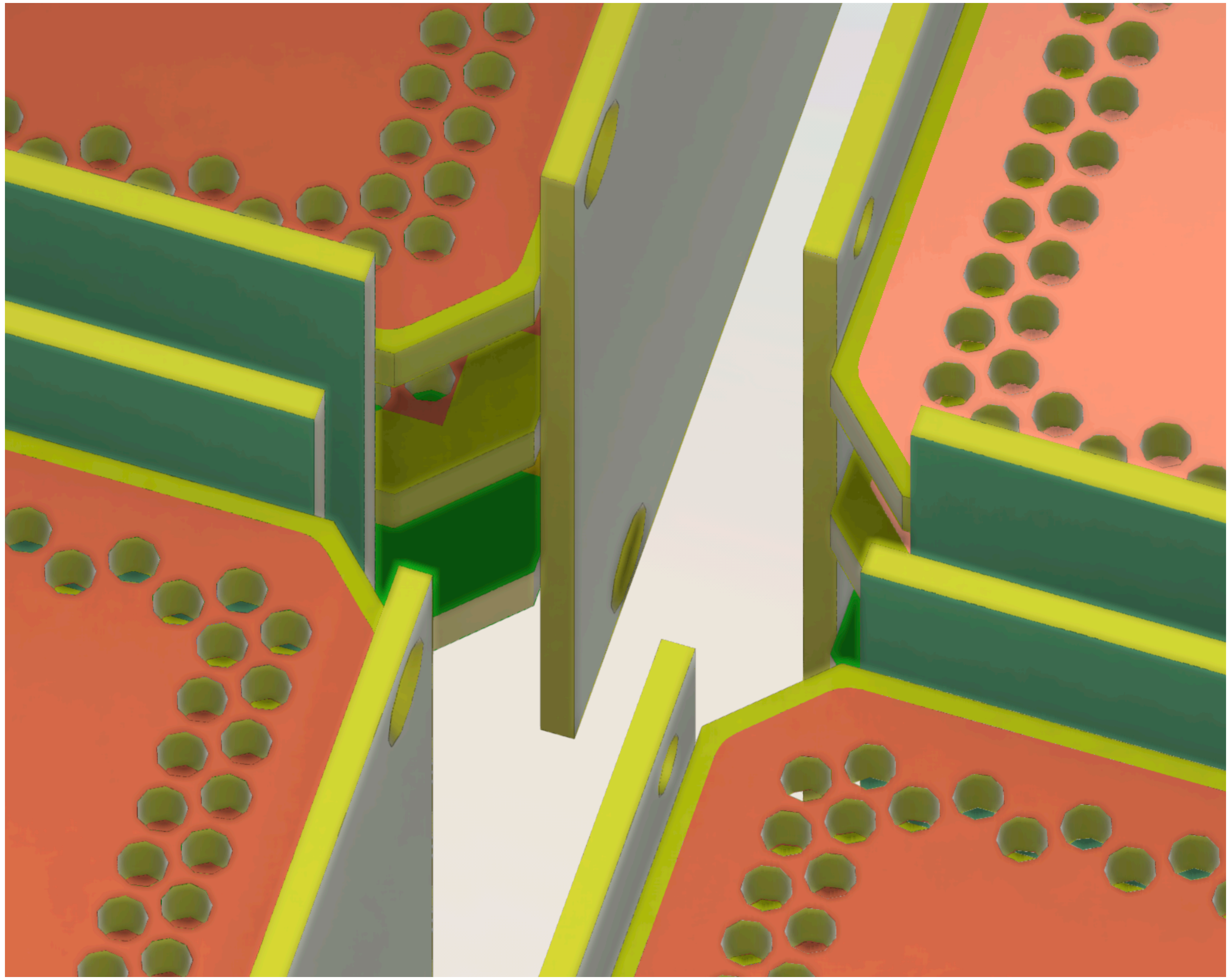
- FBG (Fiber Bragg Gratings) are localised modulations of the fibre refractive index

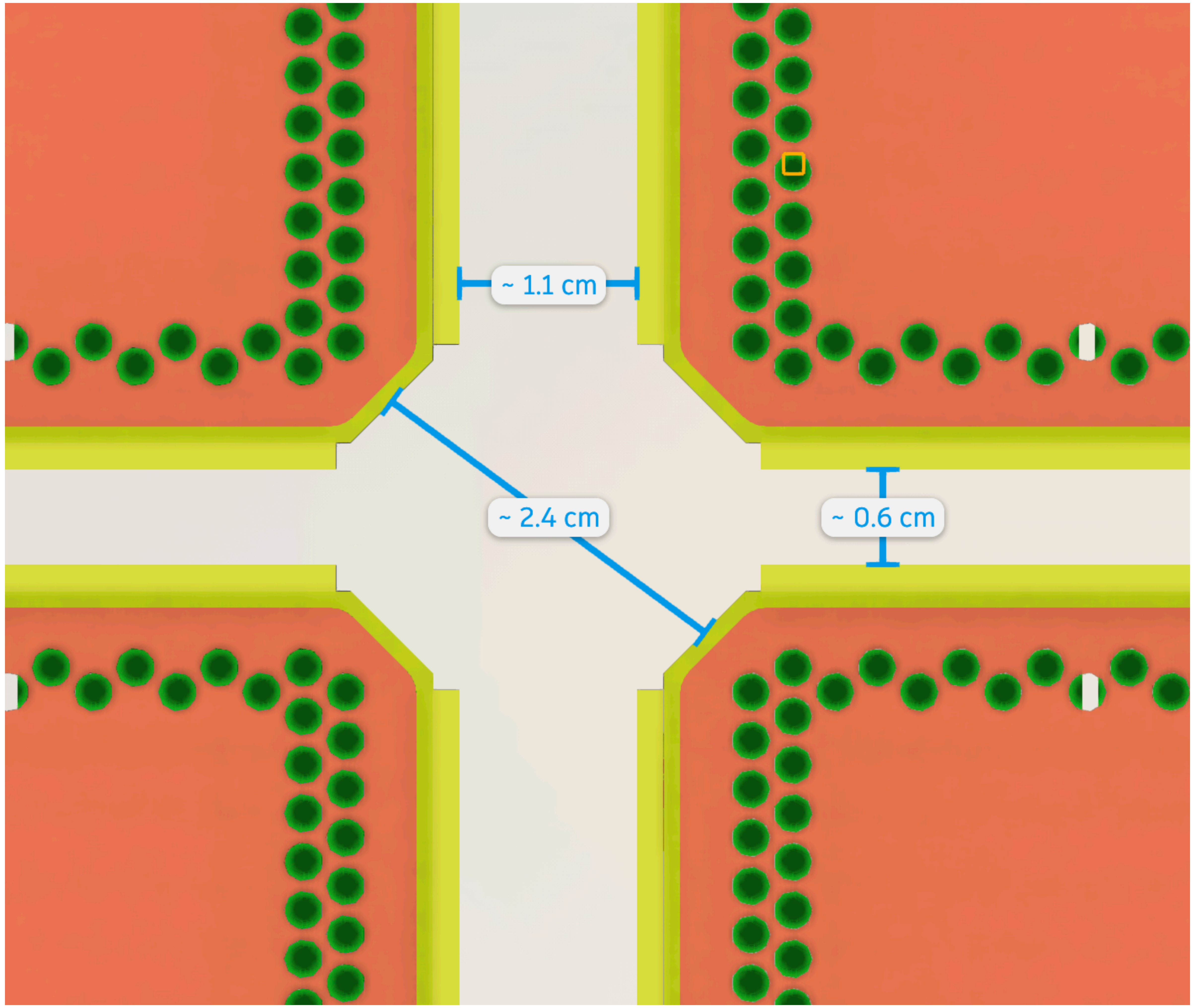


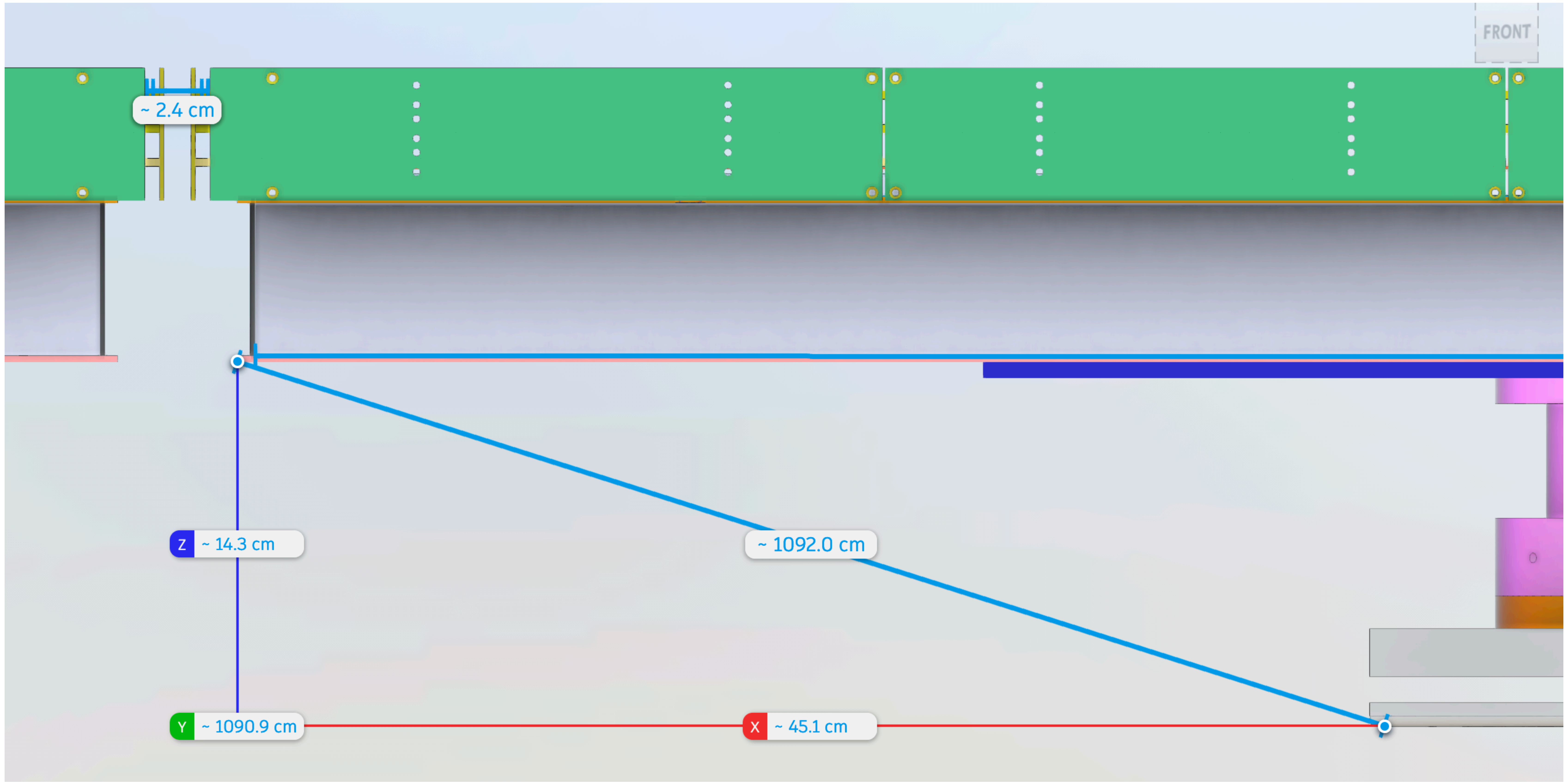
- An interrogator sends WL calibrated light which reflects only in one FBG and is analysed back by the interrogator
- The WL shift has information about temperature, humidity and strain at the FBG
- If strain and humidity are kept under control temperature can be inferred

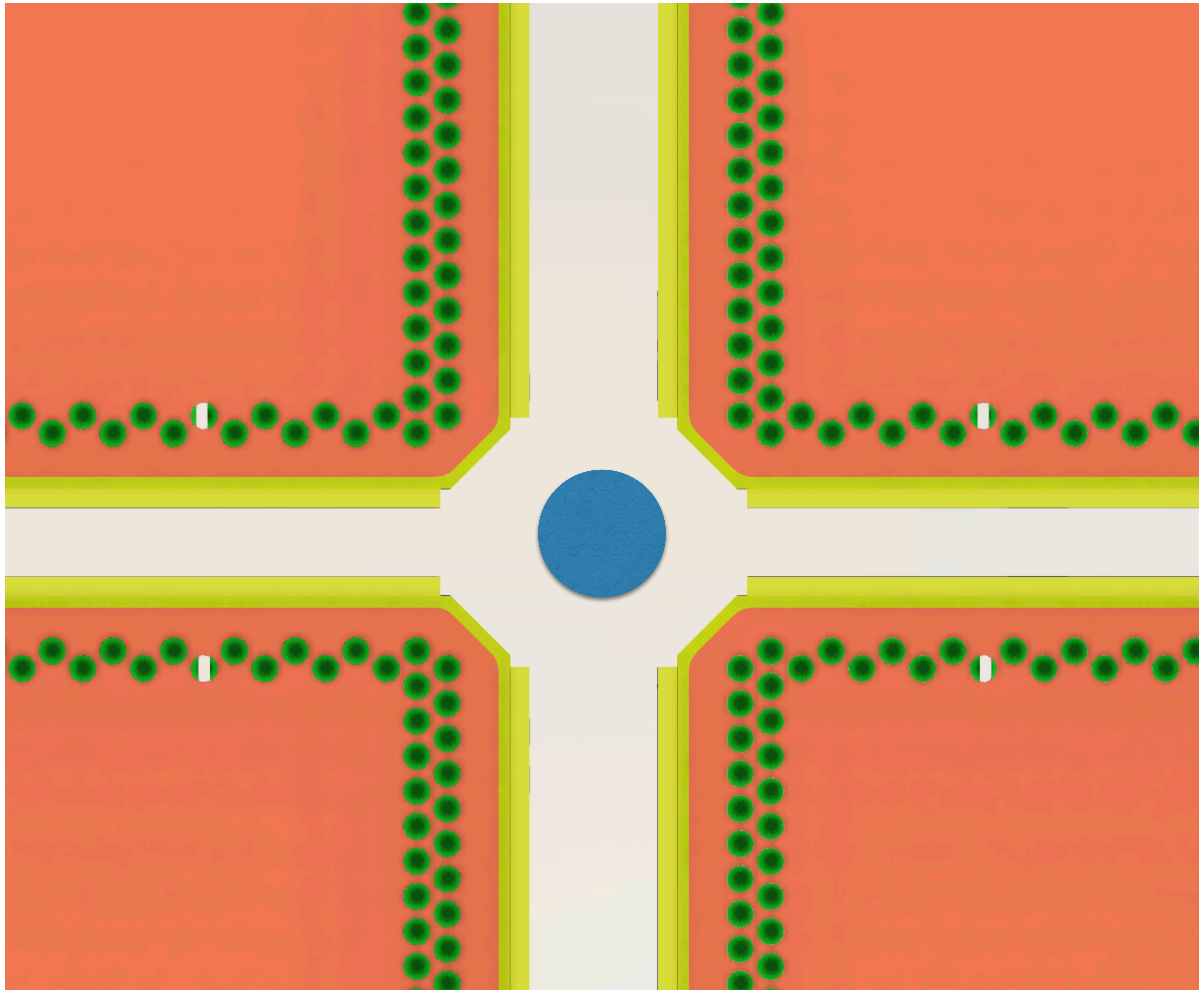



~ 2.4 cm
X ~ 1.9 cm
Y ~ 1.4 cm




~ 1.1 cm
~ 2.4 cm
~ 0.6 cm


FRONT
~ 2.4 cm
Z ~ 14.3 cm
~ 1092.0 cm
Y ~ 1090.9 cm
X ~ 45.1 cm



FD2 Detector Installation Summary New Proposed Schedule-V6

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Week 10	
Mechanical Tech - Total FTE per shifts	49	48	41	39	37	36	60	48	79	78	79	78	70	69	42	42	43	35	41	18
Sr Mechanical Tech - Total FTE per shifts	19	12	12	12	12	12	17	12	18	18	18	18	15	15	6	6	6	5	9	9
CRP Consortia - Total FTE per shifts	12	0	21	27	36	36	33	30	24	24	24	24	18	18	0	0	0	0	33	9
HV Consortia - Total FTE per shifts	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0
PD Consortia - Total FTE per shifts	24	0	12	4	12	0	16	4	40	28	40	28	40	28	28	28	24	24	18	0
TDE Consortia - Total FTE per shifts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	12
B_Elec Consortia - Total FTE per shifts	12	0	0	0	0	0	26	0	20	20	20	20	20	20	20	20	14	20	0	0

	Week 11		Week 12		Week 13		Week 14		Week 15		Week 16		Week 17		Week 18		Week 19		Week 20	
Mechanical Tech - Total FTE per shifts	41	35	71	41	72	42	71	41	87	57	72	42	72	42	72	42	103	49	102	72
Sr Mechanical Tech - Total FTE per shifts	11	17	17	11	18	12	17	11	15	9	12	6	12	6	12	6	42	12	18	10
CRP Consortia - Total FTE per shifts	27	15	27	15	30	18	27	15	21	9	10	0	0	0	0	0	24	0	18	18
HV Consortia - Total FTE per shifts	30	24	42	30	42	30	42	30	54	42	54	42	54	42	54	42	34	22	30	18
PD Consortia - Total FTE per shifts	12	0	12	18	12	18	12	18	24	30	24	30	24	30	24	30	24	30	24	30
TDE Consortia - Total FTE per shifts	26	24	36	24	36	24	36	24	28	16	12	0	12	0	0	0	0	0	0	0
B_Elec Consortia - Total FTE per shifts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	12	12

	Week 21		Week 22		Week 23		Week 24		Week 25		Week 26		Week 27		Week 28		Week 29		Week 30		Week 31	
Mechanical Tech - Total FTE per shifts	94	80	60	60	60	60	60	60	60	60	60	60	60	60	60	60	36	36	37	37	22	22
Sr Mechanical Tech - Total FTE per shifts	16	12	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4	5	4	6	6
CRP Consortia - Total FTE per shifts	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	9	9	0	0
HV Consortia - Total FTE per shifts	28	20	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	4	4	10	10
PD Consortia - Total FTE per shifts	30	24	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0	0	6	6
TDE Consortia - Total FTE per shifts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B_Elec Consortia - Total FTE per shifts	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	0	0

Link to file version 7 is [EDMS: 2957537](#) WORK IN PROGRESS! **HV Cathode needs to be 14 weeks**