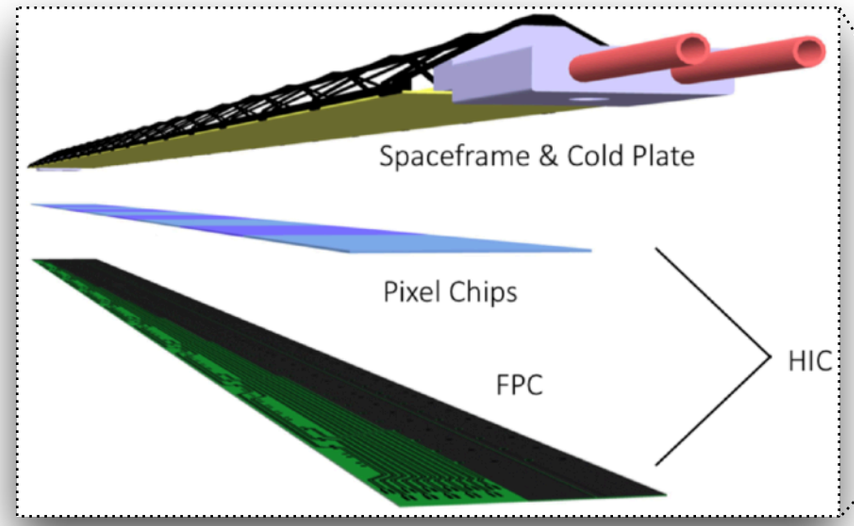
ALPIDE @ LUXE update

Noam Tal Hod

Jul 23 2019

Reminder



LUXE photon-induced setup (Not in scale)

- based on ALICE's ITS barrel staves
- one layer could be 1 or 2 staves in a row

News

- Met with ALICE ITS people in early July
  - got a tour in the ITS assembly clean room (pics in next slides)
- Got the CAD drawings of all barrel stave elements
- Confirmed the overall layout of the tracker system*
  - minor issues to complete the list (cables, crates, etc.)
- Confirmed the layout of the power supply system*
  - getting quotes from CAEN now
- Will get soon the formal template docs (MoUs etc.)
- Got another (lighter) version of the simulation software
  - detector response and reconstruction (to be tested soon)
- Bottom line: no need to change the LoI text in terms of costs

System layout

PCI express boards embedded in a PC

~20k CHF/board

FELIX/CRU

GBT optical fibre

~???k CHF

LV power supply (3V)

~30-40 m copper conductors

~6k CHF/chiller

Cooling plant

~2k CHF/board

Power board (up to 2 units)

~?k CHF/crate

custom 6U VME crate (up to 2 units)

I2C link (conf & mon)

Power unit1

Power unit2

~4k CHF/unit

Readout unit1

Readout unit2

Up to 3 staves per RU

TwinAx

???

~13k CHF/stave

stave1

stave2

Copper pipes with plastic tube ends. (water kept at 18º)

Power layout

Control PC

SY4527 Mainframe

A3486 power converter
3 phase 220/400 Vac ⟶ 48 V DC
(2 channels, 40 A, 2 kW each)

A1676A×1?
Branch
Controller

A2518×2?
-5V reverse
bias supply:
8 channels

Power board
(up to 2 units)

Power unit1

Power unit2

regulates
substrate's
biasing

I2C link
(conf & mon)

EASY3000 crate

custom 6U VME
crate (up to 2 units)

A3009B×4?
12 Channel
(8V/9A/45W)

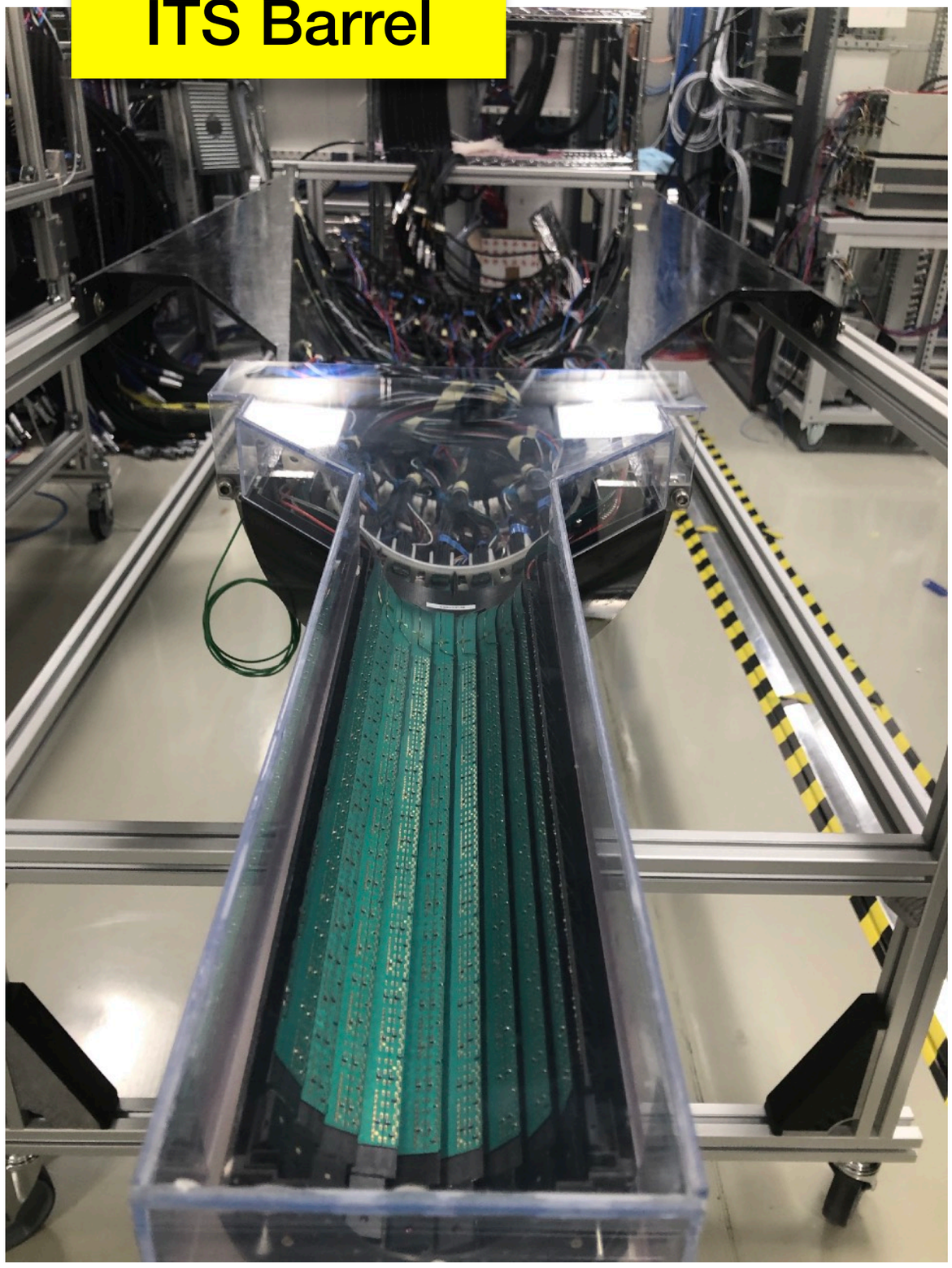
Readout unit1

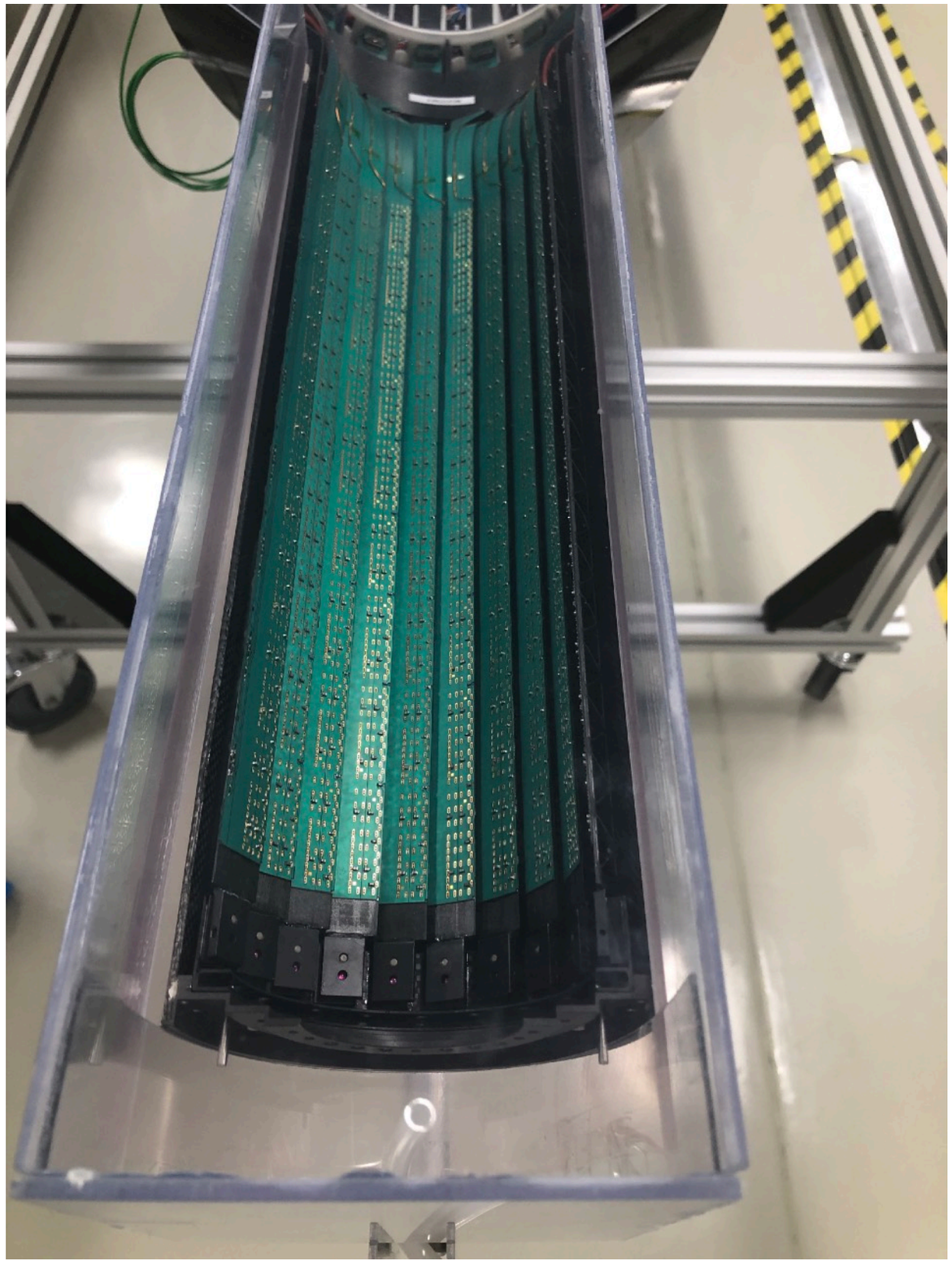
Readout unit2

operation
in B-field
and low
radiation

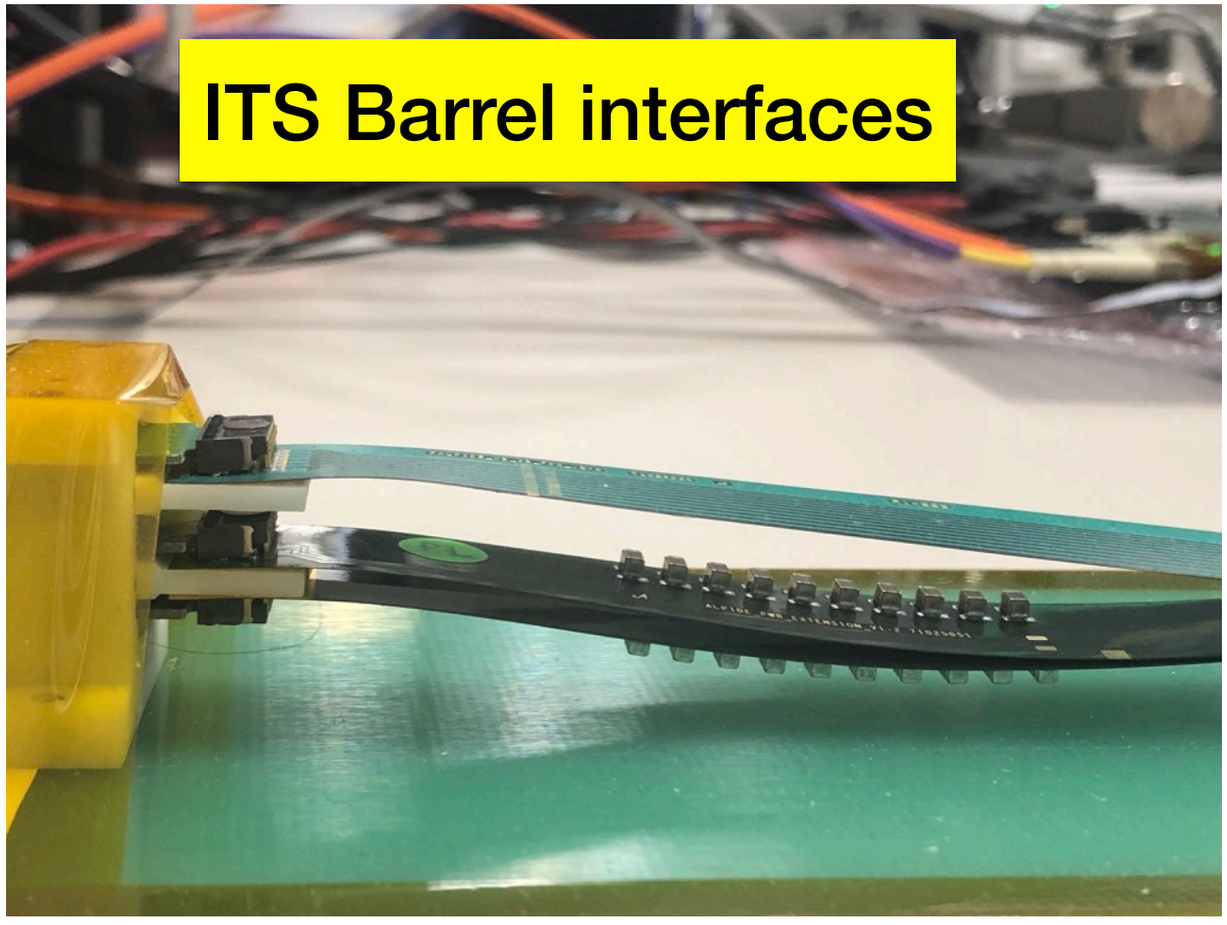
~30 m
copper
conductors

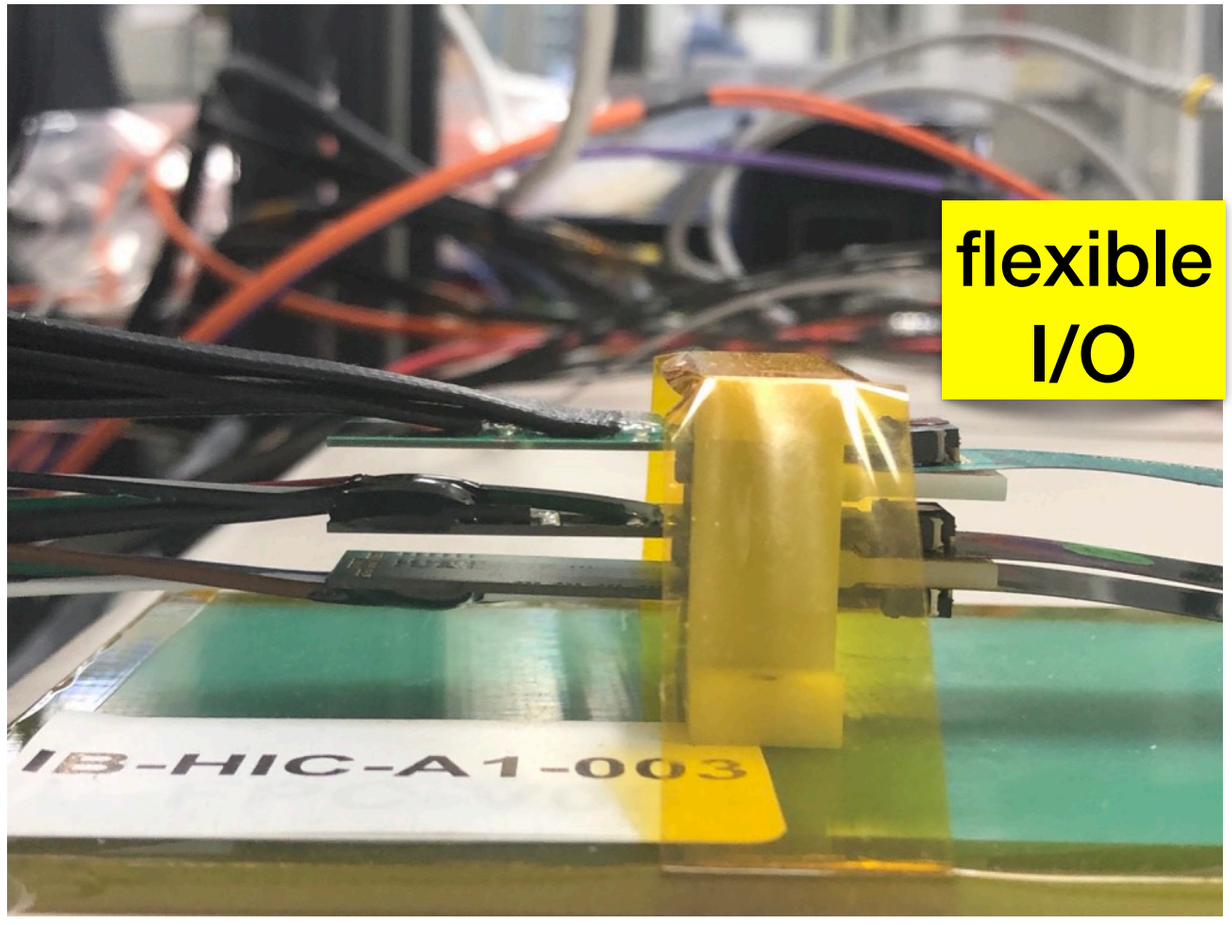
ITS Barrel

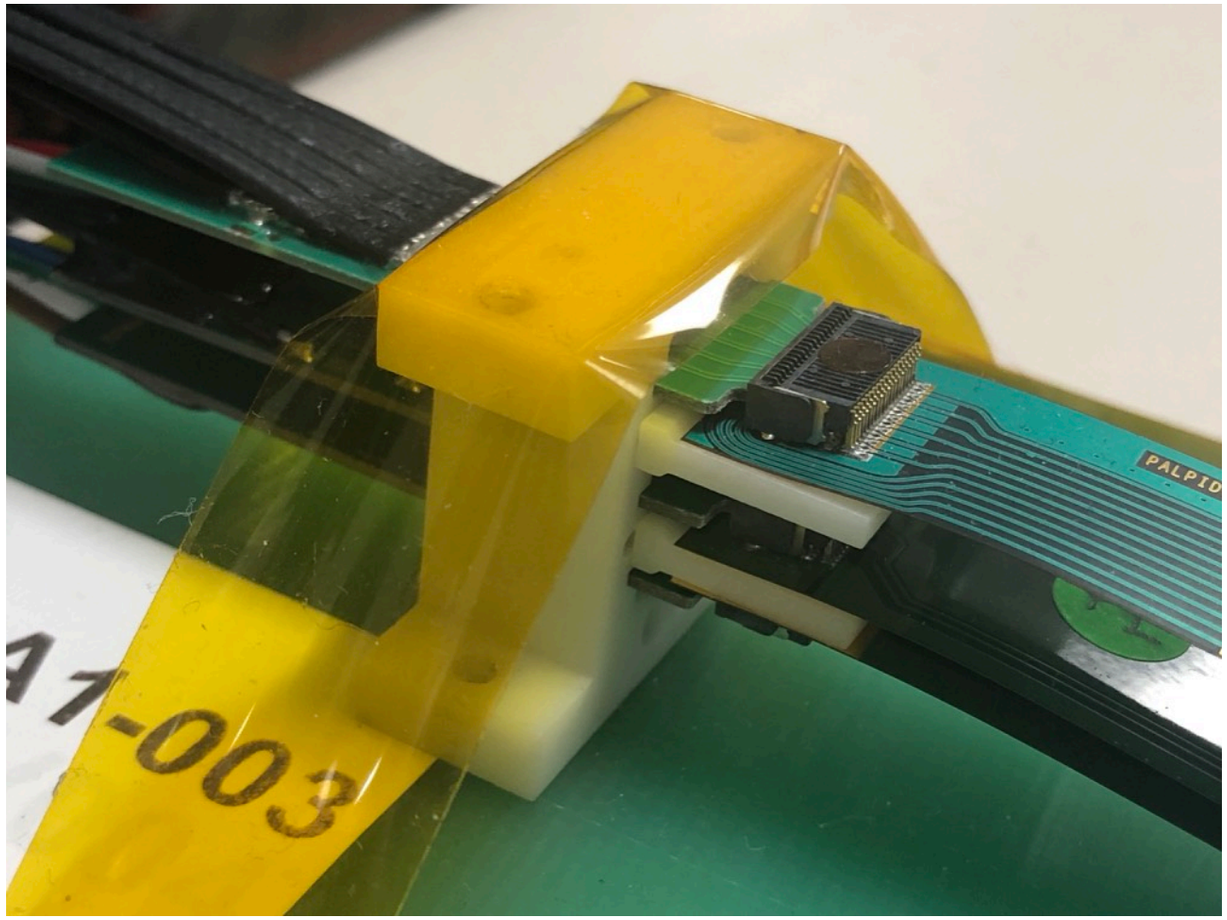


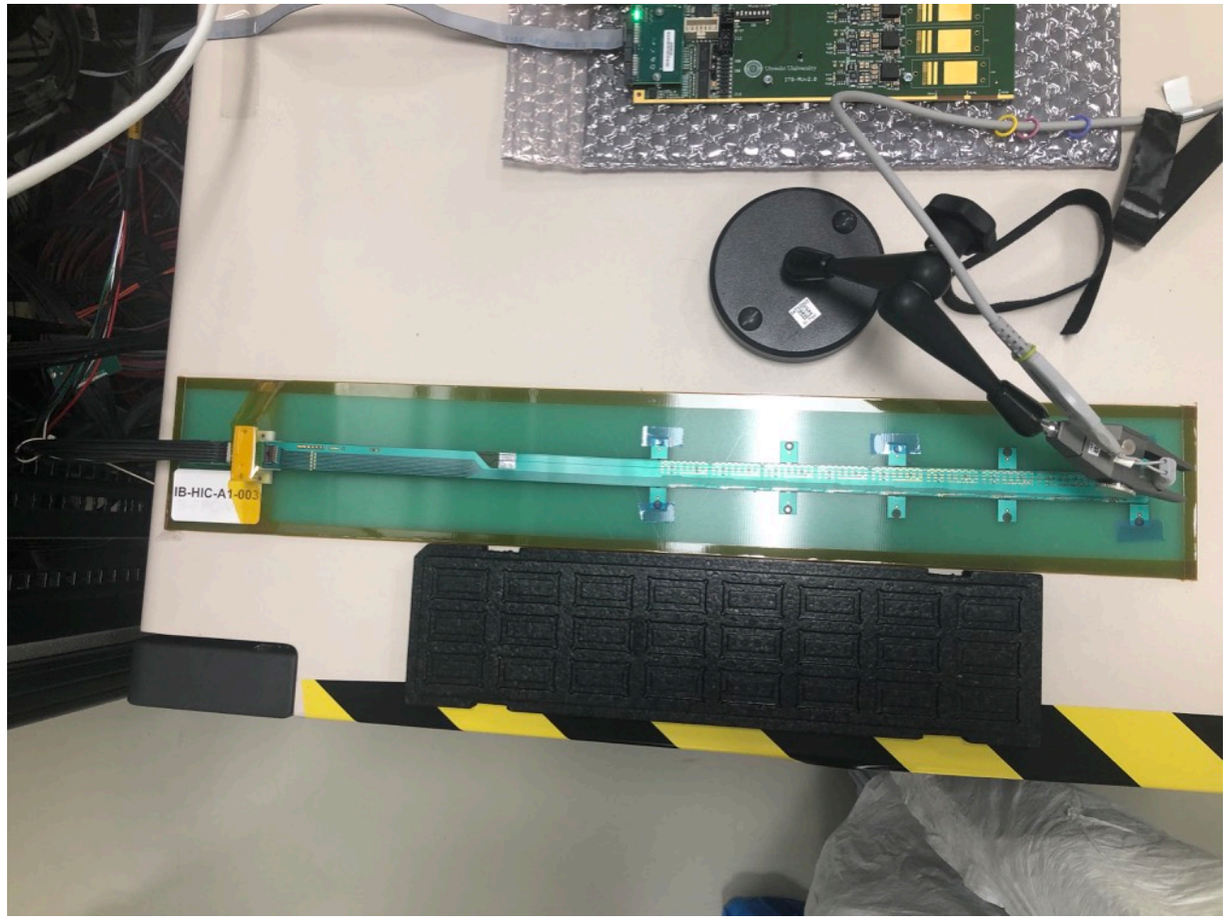


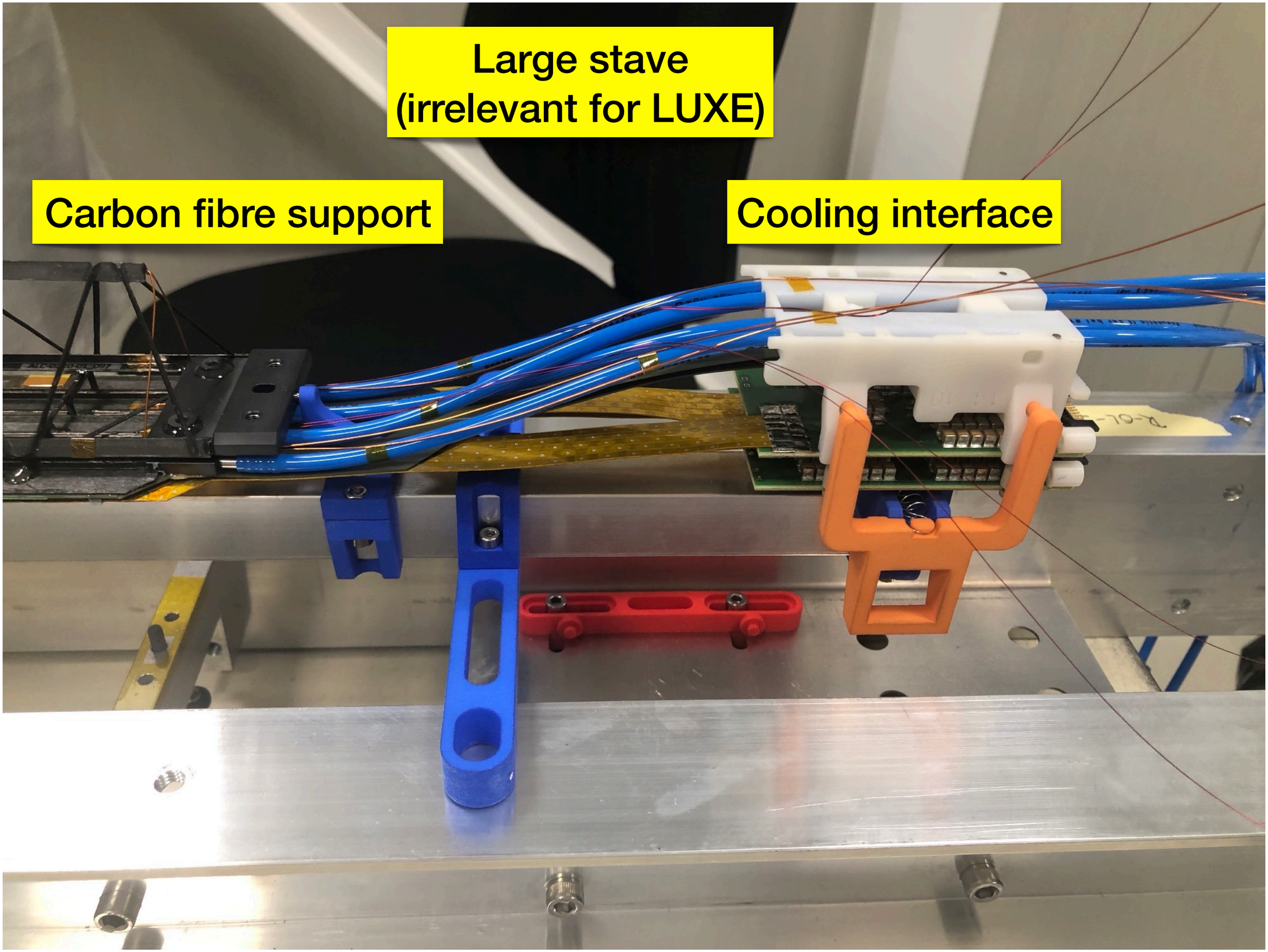
ITS Barrel interfaces



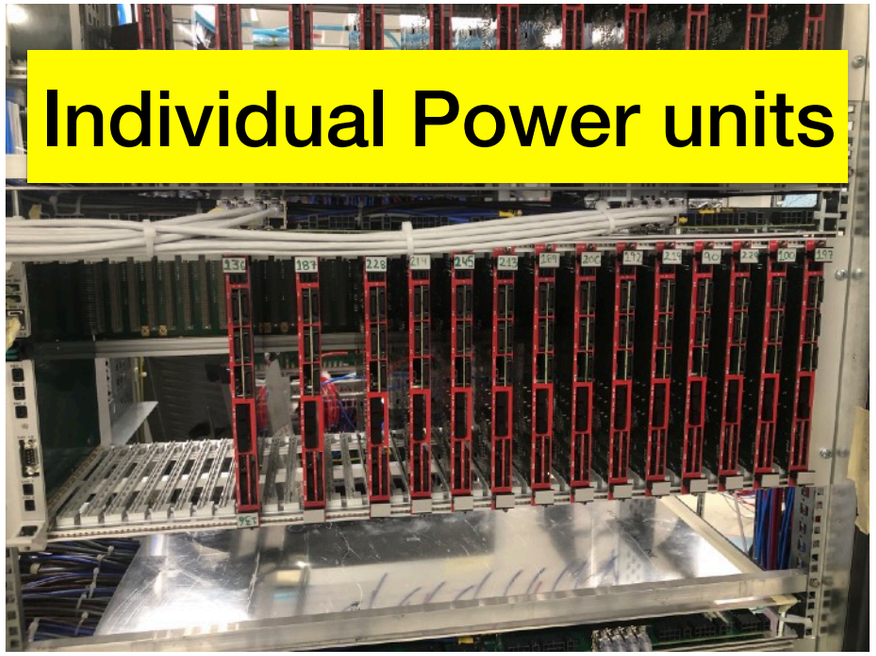


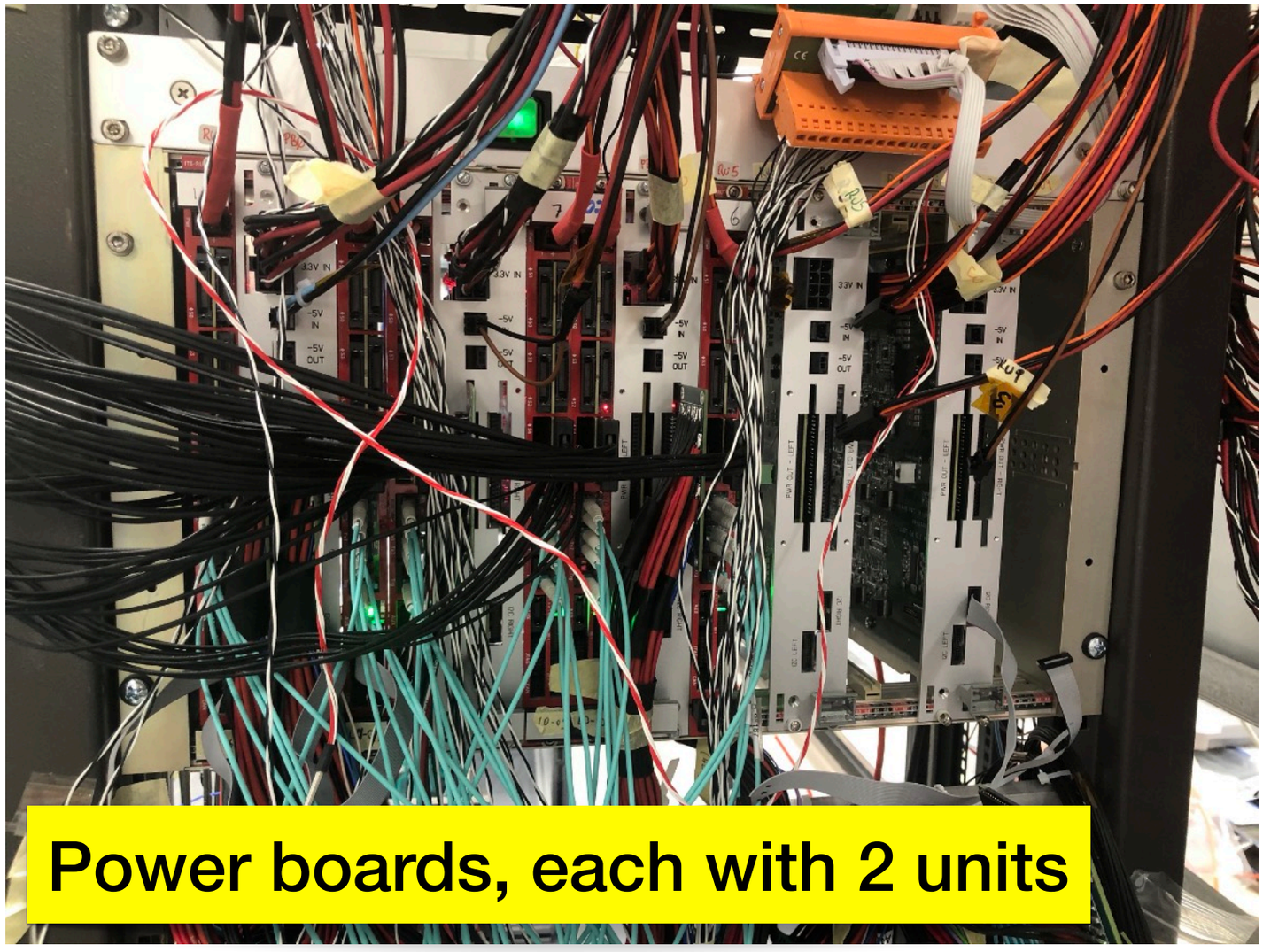





Large stave
(irrelevant for LUXE)
Carbon fibre support
Cooling interface

Individual Power units

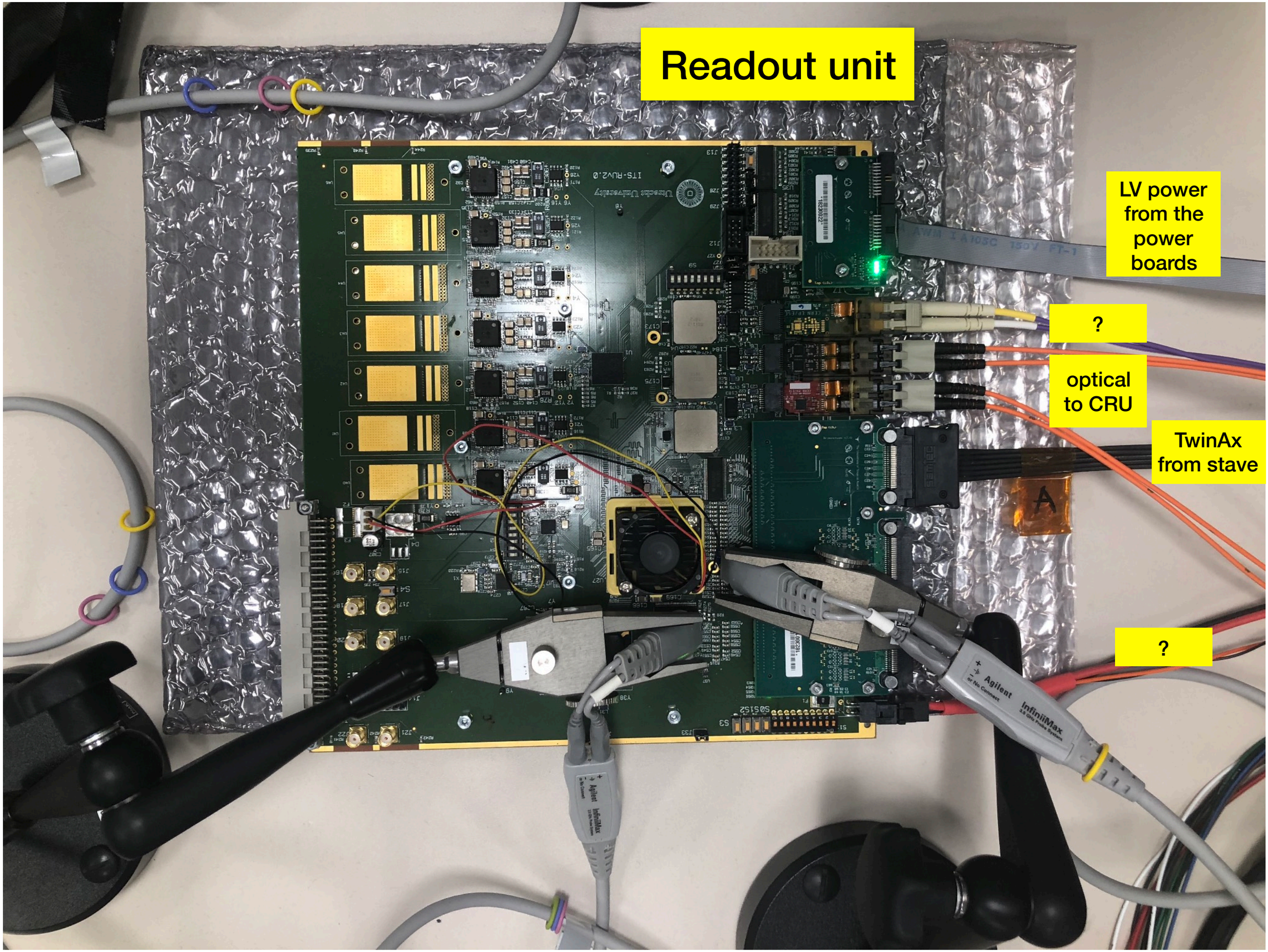




Power boards, each with 2 units

LV power supply

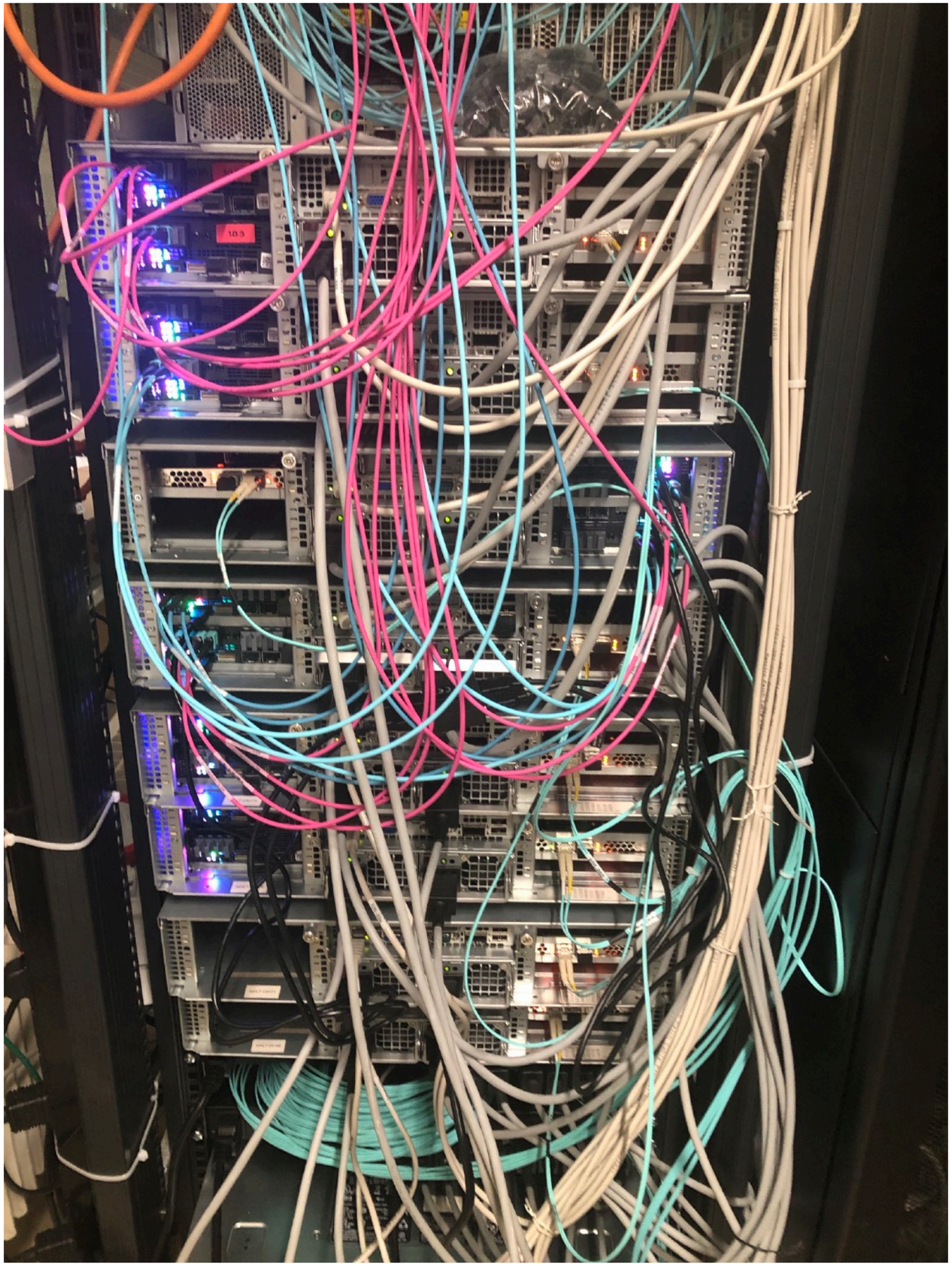
Readout unit



Cooling plant (will move to ALICE cavern)

Chiller for small operations

CRU's (LHCb) could be FELIX



Costs [CHF]

quantities are shown only for one “tracker” and spares assuming ~50 cm long layers

		Item cost	2-stave system cost	quantity	detector cost	comments
ALICE ITS specific	Stave	13000	26000	9	234000	16 + 2 spares ⟶ could be 2 detectors!
	Readout unit	4000	8000	9	72000	8+1 spare (2 staves per unit case)
	Readout unit crate				0	custom 6U VME crate (up to 2 units) crate
	Power board	2000	2000	9	18000	8+1 (up to 2 power units)
	Power board crate			3	0	probably not to costly, TBC
CAEN LV power supply	Mainframe SY4527			1	0	quote requested in Germany
	Branch controller A1676A			1	0	quote requested in Germany
	Reverse bias supply A2518			2	0	quote requested in Germany, quantity TBC
	EASY3000 crate			1	0	quote requested in Germany
	LV power supply card A3009B			4	0	quote requested in Germany, quantity TBC
	Power converter A3486			1	0	quote requested in Germany
	Control PC	2000	2000	1	2000	quote requested in Germany
	LV cables				0	could be 30-40 m long, TBC
DAQ and cabling	FELIX/CRU PCI cards	20000	20000	1	20000	FELIX: can connect up to 16 RUs
	Computer(s)	4000	4000	2	8000	Wait for ALICE tender campaign
	TwinAx cables				0	up to 3-4 m long, TBC
	GBT Optical fibres				0	can be very long, PCs can stay “upstairs”
Cooling	Chillers	6000	6000	2	12000	based on experience from CERN
	Distribution system			1	0	to be designed, should be below 10k
	Copper pipes (cooling)				0	TBC
	Plastic tubes (cooling)				0	TBC
Mechanichs	Motorised stages	13000	26000	1	26000	not clear yet if needed
	Anti-vibration table/stand	5000	5000	1	5000	not clear yet if needed
	Total				397000	

Summary

- For a 16 stave configuration: 1 / 2 “systems” if we need to cover ~50 cm / ~25 cm
  - 16 RUs (1/RU) or 8 RUs (2/RU) or 6 RUs (3/RU). Costs: ~64k, ~32k, ~24k
  - FELIX: in all cases all 16 / 8 or 6 RUs could be connected to one FELIX card
- Power supply
  - quotes underway, probably >50k CHF, still below ~500k CHF (one “system”)
- Locations (care about radiation and magnetic field):
  - power supply modules in ALICE ITS are about 30-40 m from the detector
    - readout units and power boards are ~3-4 m from the detector
      - connected with cables that have a maximum length of 8 m (closer is better…)
- Decide between LHCb CRU and FELIX
  - CRUs are used by ALICE
  - FELIX is used by sPHENIX and I have in-house experts at WIS
- Testbeam with Luciano’s people at DESY
  - proposal to run with a stave object
  - they will provide all the necessary hardware and experts while we can learn a lot

BACKUP

Random comments

- Cooling
  - water: 0.3L/h, input ~18º, while the sensor would be at ~21º
  - air: depending on the humidity and conditions in the tunnel

- Power boards: one PB (mounted on a custom crate) has 2 power units supplying 2 staves. Managed by Berkley

- Readout units (one per stave), managed by CERN/NIKHEF/Austin
  - each RU can in principle support up to 3 IB staves as input
  - in ALICE: only 1 IB stave per RU due to bandwidth considerations
  - each RU has up to 3 uplinks, and 1 downlink
    - CRU supports up to 8 RU if all 3 uplinks are used
    - FELIX would in principle be able to support up to 16 RUs

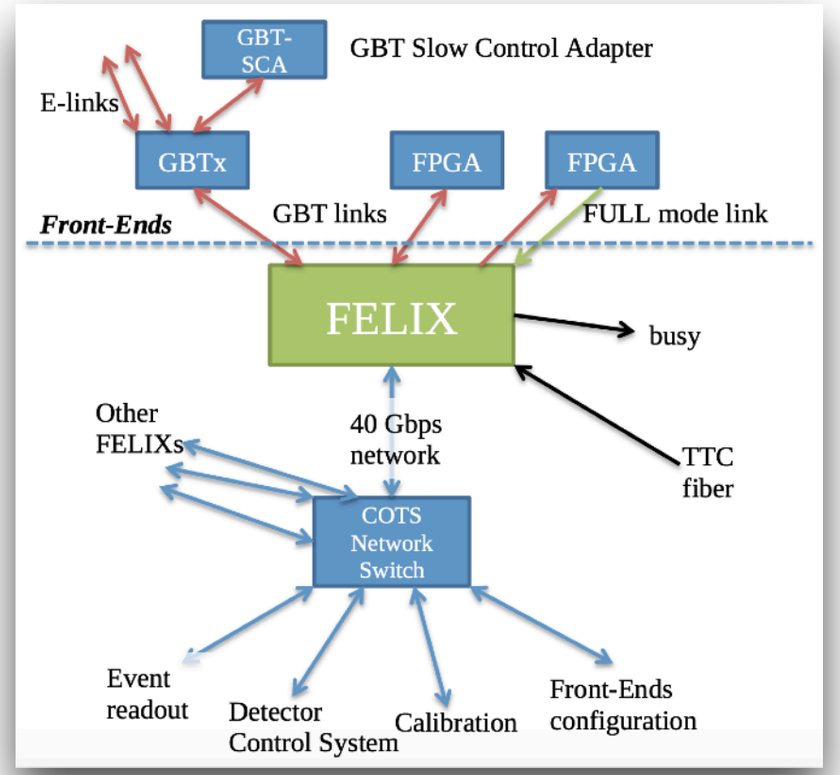
- TwinAx cables
  - CERN version: more rigid, not very easy to handle
  - commercial: not approved by CERN safety (not halogen free)

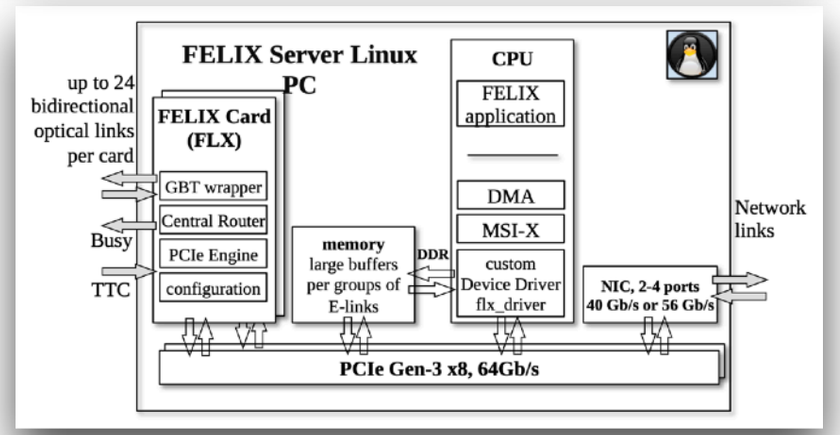
- Recommend to use 2 CRUs/FELIXs installed in a single PC, with each managing 10 staves (could also have 2 PCs)

- The foreseen ALICE ITS server configuration: 2 x Intel Cascade Lake Xeon Silver 4210 CPU and 12x8 GB RAM (to equip all memory channels)

FELIX (Front-End LInk eXchange)

- A new detector independent readout architecture
  - FPGA based PCIe card providing access to FE systems
  - scalable, detector agnostic and easily upgradeable
- <u>On one direction:</u>
  - the GigaBit Transceiver (GBT) architecture provides a high-speed (4.8 Gb/s) radiation-hard optical link for data transmission from the on-detector FE elx
  - the GBT provides up to 42 independent data links, however sharing the same fibre
  - the GBT link data is funnelled to the host PC memory
  - data packets are routed onwards via a commercial switched network
- <u>On the other direction:</u>
  - receives packets from the network and forwards them to specific on-detector electronic modules (slow control etc)
  - handles the input from the Time, Trigger and Control (TTC) system and distributes to on-detector electronics over low-and-fixed-latency GBT link
- Can in principle be able to support 16 readout units (RUs)
  - FELIX supports up to 48 bi-directional GBT links, while the CRU is configured with only 24 bi-directional links





J. Anderson et al 2016 JINST 11 C12023

ITS Power scheme

The power to the ITS Readout Units and ITS Power Boards is supplied by a power system by CAEN of the EASY3000 type. It is composed by the following modules:

- CAEN A3009B
  - These are the modules directly supplying to the Readout Units and Power Units via ~30 m copper conductors.
  - They are 12 Channel (8V/9A/45W) modules for operation in magnetic field and (low) radiation environment.
  - ITS use 61 of these.

- EASY3000 Crates
  - These are crates hosting up to 5 CAEN A3009B each. ITS use 13 of these.

- CAEN A3486 power converters.
  - These are modules converting from 3 phase 220/400 Vac to 48 V DC (2 channels, 40 A, 2 kW each).
  - The 48 V DC is the required supply to the A3009B modules. ITS need 12 of these.

- CAEN A2518 modules
  - These are used to generate negative supply voltage (-5V) for the Power Board reverse bias channels that regulates the biasing for the substrate of the ALPIDE chip.
  - Each one has 8 channels. ITS use 4 of these.

- CAEN A1676A Branch Controller modules
  - These are control and communication boards that expand the capabilities of the mainframe.
  - They implement the hardware control layer for all the A3009 and the A3486 units. ITS use 3 of these.

- CAEN SY4527 multichannel power supply system.
  - This is a configurable modular unit, consisting of a CPU, Power Supply section, Front panel modules, board crate.
  - The CAEN A1676A branch controllers and the CAEN A2518 modules are installed directly on the board crate of the SY4527.
  - Typically there is one as master element of a full CAEN EASY3000 system.

ITS readout scheme

The best configuration of readout units and FELIX cards would depend on the expected data rates from the staves

- The FELIX card is indeed very similar to the ALICE CRU card, it supports up to 48 bi-directional GBT links (the CRU card is configured with only 24 bi-directional links), but features a different FPGA than the CRU card
- Both cards are PCIe cards with 16-lane Gen-3 PCIe interfaces
- In both the CRU and the FELIX card, the performance over the PCIe bus has been measured in the order of 100Gbps, so that is the main limitation
- Each Readout Unit (RU) can in principle support up to 3 IB staves as input
- In ALICE: 1 IB stave per RU due to bandwidth considerations
- Each RU has up to 3 uplinks, and 1 downlink
- So a ALICE CRU supports up to 8 RU if all 3 uplinks are used, while FELIX would in principle be able to support 16 RUs
- Again, these are maximum numbers, and one would have to consider the expected data bandwidth in order to determine the best configuration
- So for a 20 IB stave configuration, one can in principle attach those to 7 RUs, if one uses the 3 IB staves per RU configuration
- In that case all 7 RUs could be connected to one CRU or one FELIX card