SVT Workfest Summary

Ernst Sichtermann (LBNL)

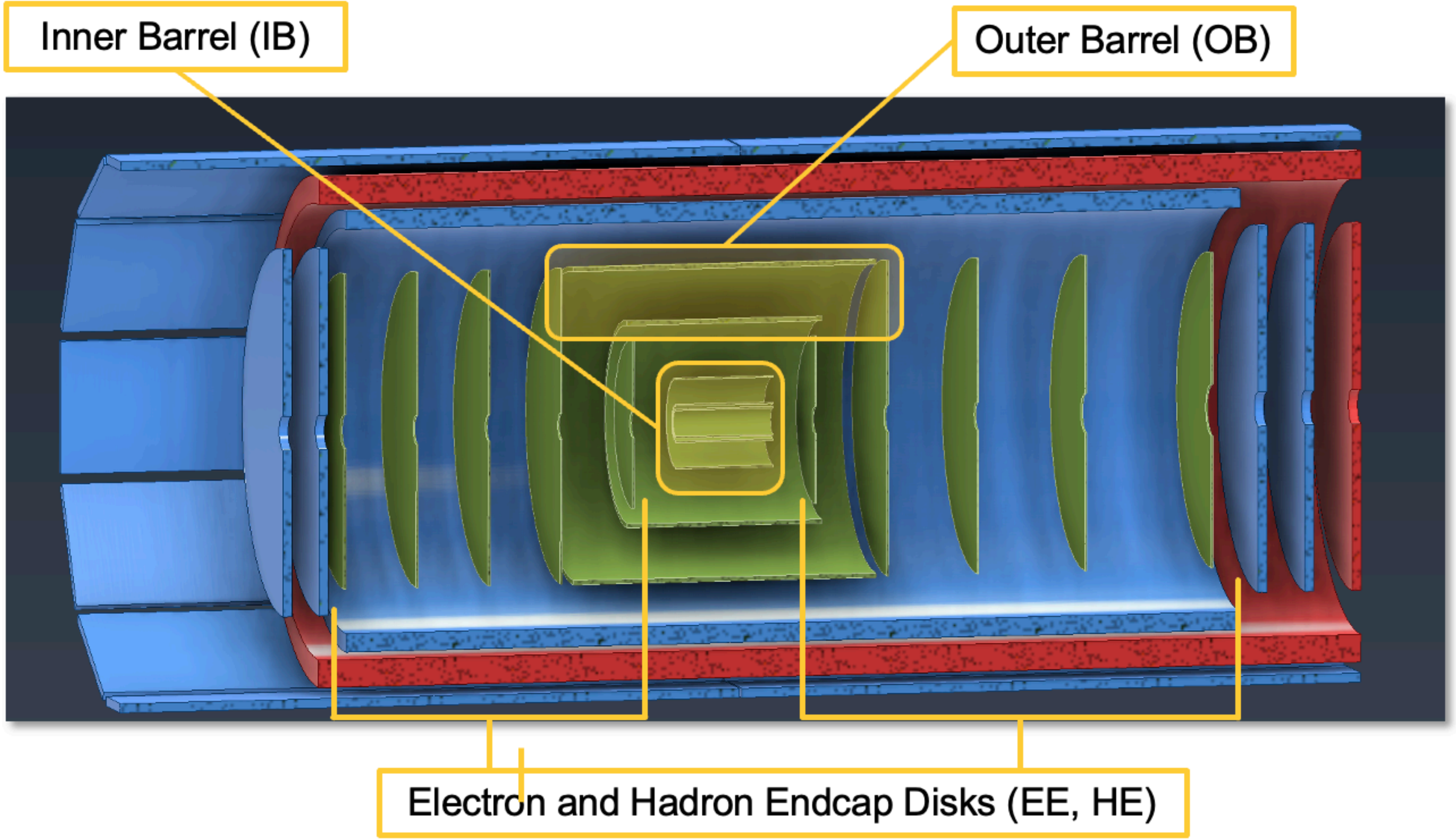
ePIC Collaboration Meeting,
Lehigh University — July 27, 2024

SVT - for reference

- **Inner Barrel (IB)**
  - Three layers, L0, L1, L2,
  - Radii of 36, 41, 120 mm
  - Length of 27 cm
  - X/X_0 ~ 0.05% per layer
  - Curved, thinned, wafer-scale sensor

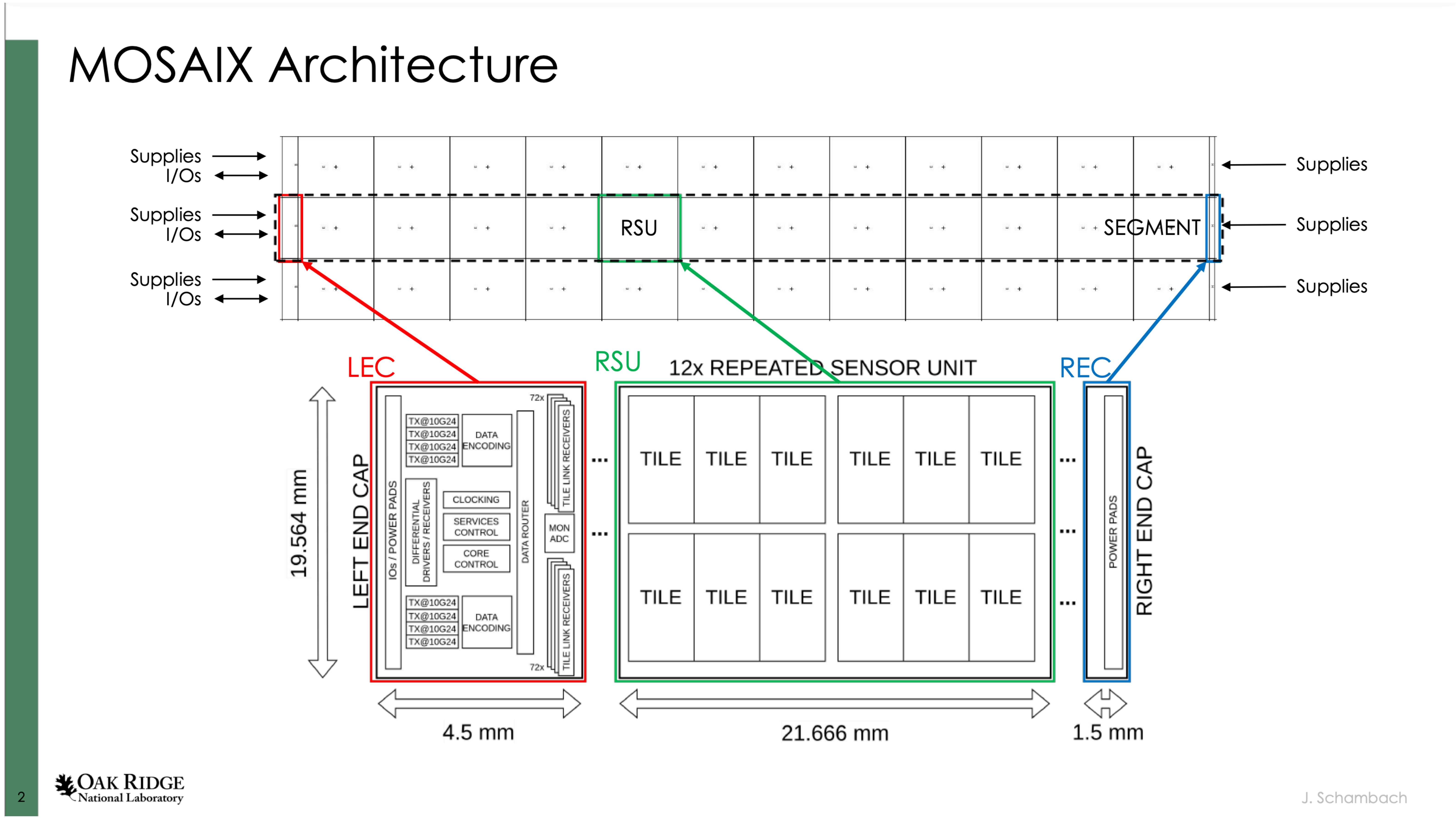
- **Outer Barrel (OB)**
  - Two layers, L3, L4
  - Radii of 27 and 42 cm
  - X/X_0 ~0.25% and ~0.55%
  - More conventional structure w. staves

- **Electron/Hadron Endcaps (EE, HE)**
  - Two arrays with five disks
  - X/X_0 ~0.25% per disk
  - More conventional structure



- **Lengths for L2—L4 increase so as to project back to z = 0; disk radii adjust accordingly**

SVT - for reference



SVT heavily relies on MOSAIX development for ALICE-ITS3 at CERN,

- Inner Barrel: same sensor,
- Outer Barrel and Disks: EIC large-area sensor — identical pixel matrix, changes to endcap (and number of RSUs)
- Ancillary IC to provide (serial) powering of all domains, bias voltage, and service reduction for slow control.

SVT Workfest — 2024 ePIC Summer Mtg.

Half-day workfest:

- Thursday morning so as to facilitate remote participation
- Featured inner barrel, readout, beam-tests and irradiation, services
- Indico: https://indico.bnl.gov/event/20727/sessions/7434/#20240725

Smaller scale Workfest was productive — as intended

Success Factors:

- everyone who actively participated — in person and remote
- in-person interactions — workfest and throughout the meeting,
- well-prepared parallel-session style talks with a wealth of information,

Thanks to all who participated and local organization!

SVT Workfest: Thursday July 25, 2024

Thu 25/07

Print | PDF | Full screen | Detailed view | Filter

08:00

Inner Barrel - Overview and Plans *Domenico Elia et al.*
Rm 512, Lewis Lab 08:35 - 08:55

09:00

Bending and Assembly of the L0 and L1 layers *Domenico Colella*
Rm 512, Lewis Lab 09:00 - 09:20

Progress on Inner Barrel mechanics design *Rosario Turisi*
Rm 512, Lewis Lab 09:25 - 09:45

Update on Readout *Dr Joachim Schambach*
Rm 512, Lewis Lab 09:50 - 10:20

10:00

11:00

Update on Irradiation and Beam Tests *Zhenyu Ye*
Rm 512, Lewis Lab 11:05 - 11:25

Update on Services *Ernst Sichtermann*
Rm 512, Lewis Lab 11:30 - 11:50

Domenico Elia

Istituto Nazionale di Fisica Nucleare
SEZIONE DI BARI

SVT IB interests & contributions

Latest figure @ April 2024 SVT general meeting:

- integrated design of the 3 innermost layers including mechanics, cooling, readout and powering, up to the electrical/optical interface:
  - ✓ develop bending procedure, eg L0 (similar for L1) — INFN
  - ✓ extend to L2 considering additional issues — INFN, MIT Physics, Berkeley Lab
  - ✓ design L0/L1 and L2 support structures — Berkeley Lab
  - ✓ integration of the cooling needs — UKRI Science and Technology Facilities Council, INFN
  - ✓ development of the edge FPC(s)
- choice of the cooling:
  - ✓ simulation studies with ANSYS — MIT Physics, Berkeley Lab
- thermo-mechanical prototypes:
  - ✓ build prototypes for both L0/L1 and L2 — INFN, MIT Physics, Berkeley Lab
  - ✓ perform dedicated tests of prototypes in wind tunnel — MIT Physics, Berkeley Lab
  - ✓ test of embedded silicon thermal properties in a thermal chamber — INFN
- support structure within the subsystem to keep everything together
  - ✓ connection of L0/L1 to L2
  - ✓ explore needs for a (light) supporting external shell (to L2) — INFN, MIT Physics, Berkeley Lab

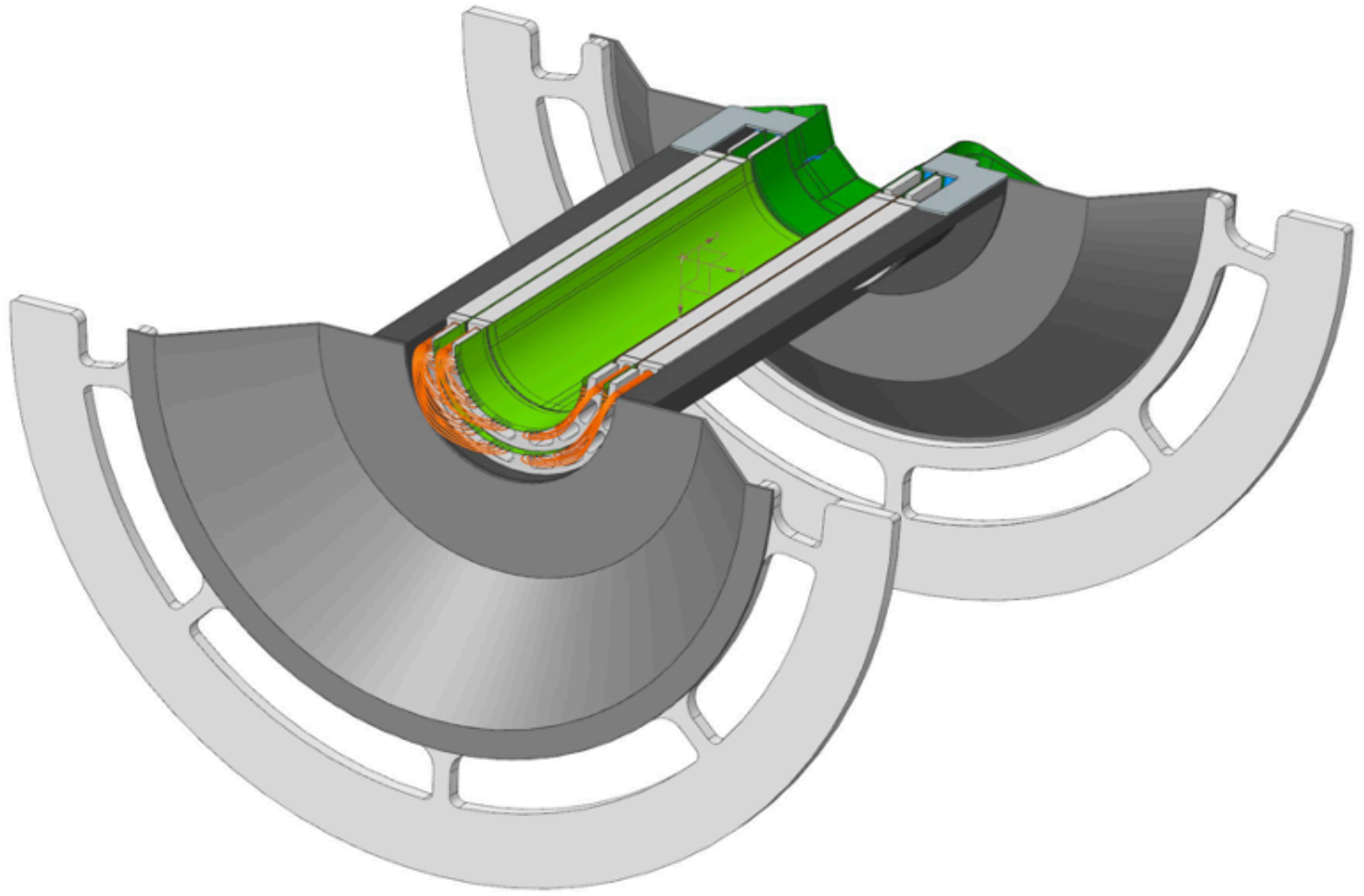
SVT Workfest — Inner Barrel

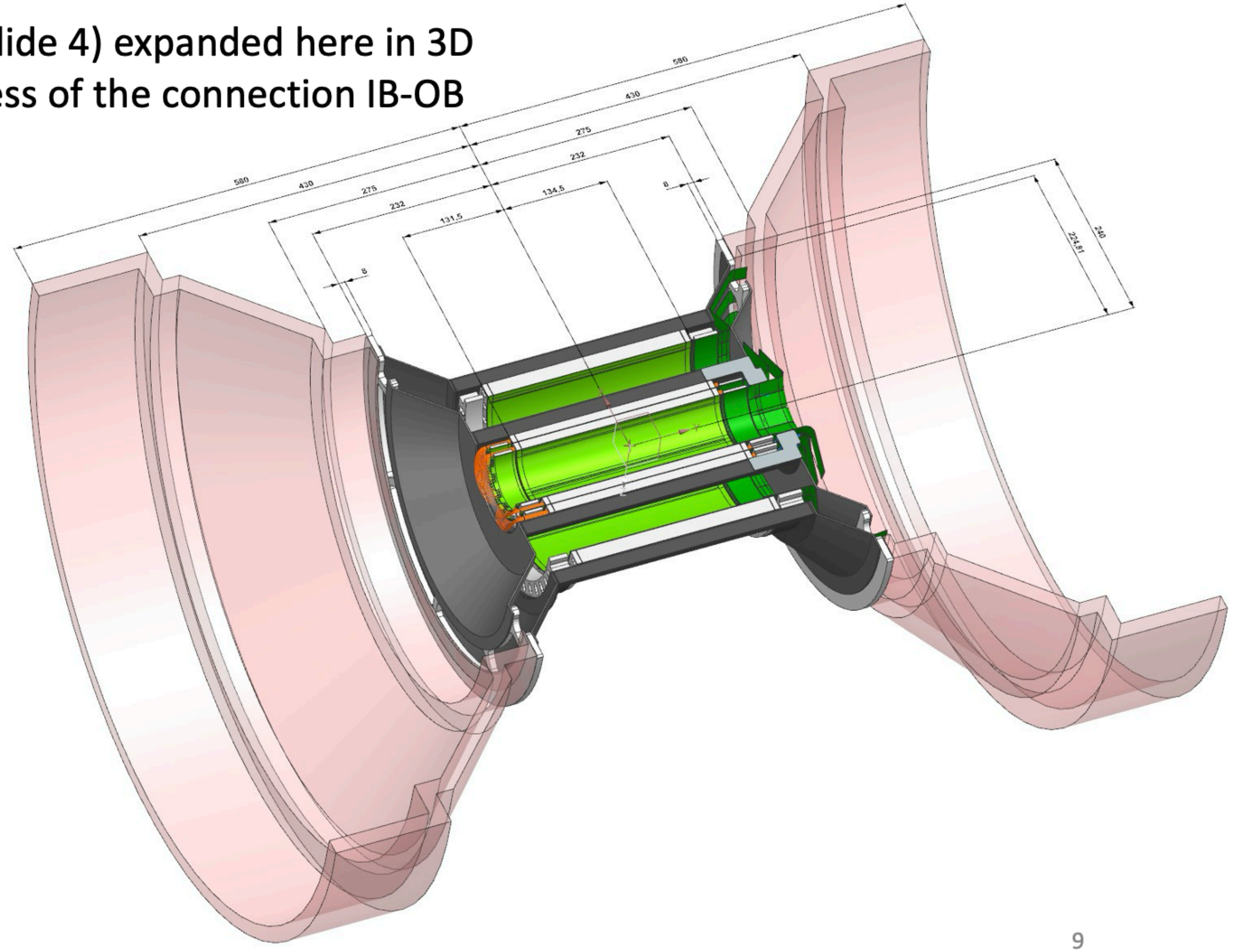
Rosario Turrisi

SVT IB connection to OB

The "first" sketch (slide 4) expanded here in 3D
→ just for a first guess of the connection IB-OB

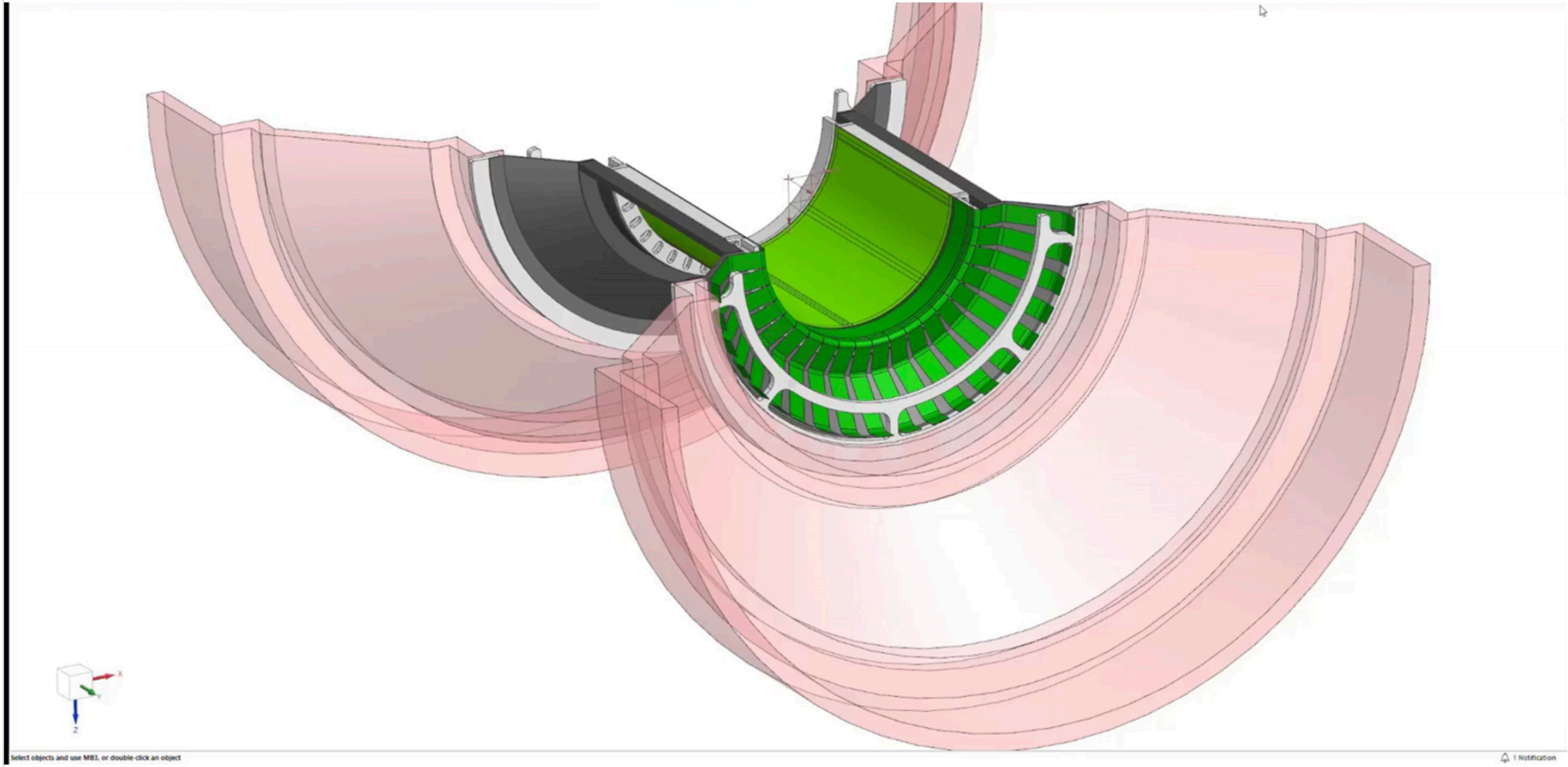
L0+L1 on the global support with the flange for L2 support and OB connection





SVT Workfest — Inner Barrel

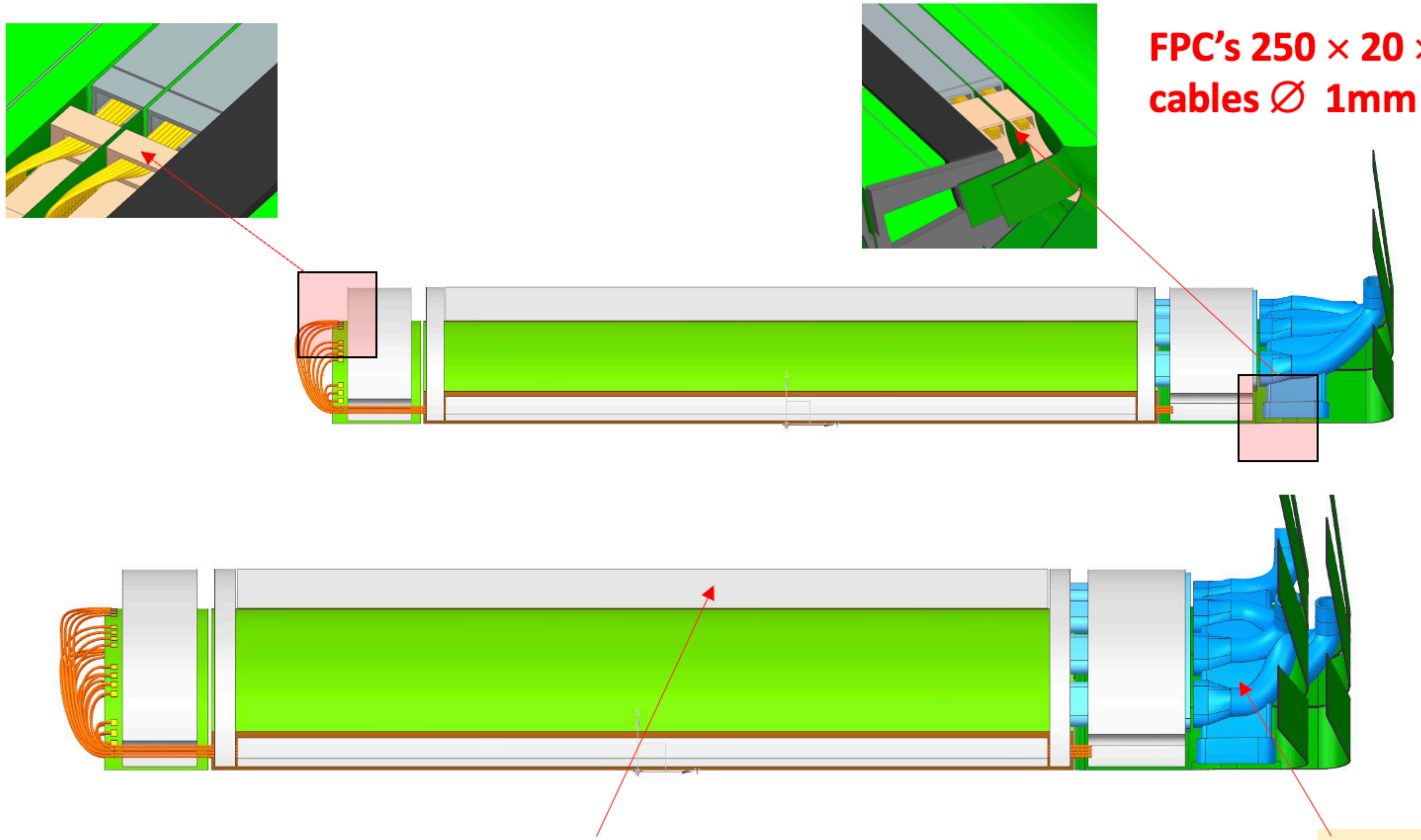
Rosario Turrisi



SVT Workfest — Inner Barrel

Rosario Turrisi

L0-L1 local mechanics



L0+L1 with local support structures

WARNING: here cable trays are supposed in CFC instead of carbon foam → to be defined!

Carbon foam "rib", positioned on the facing borders of the two sensors

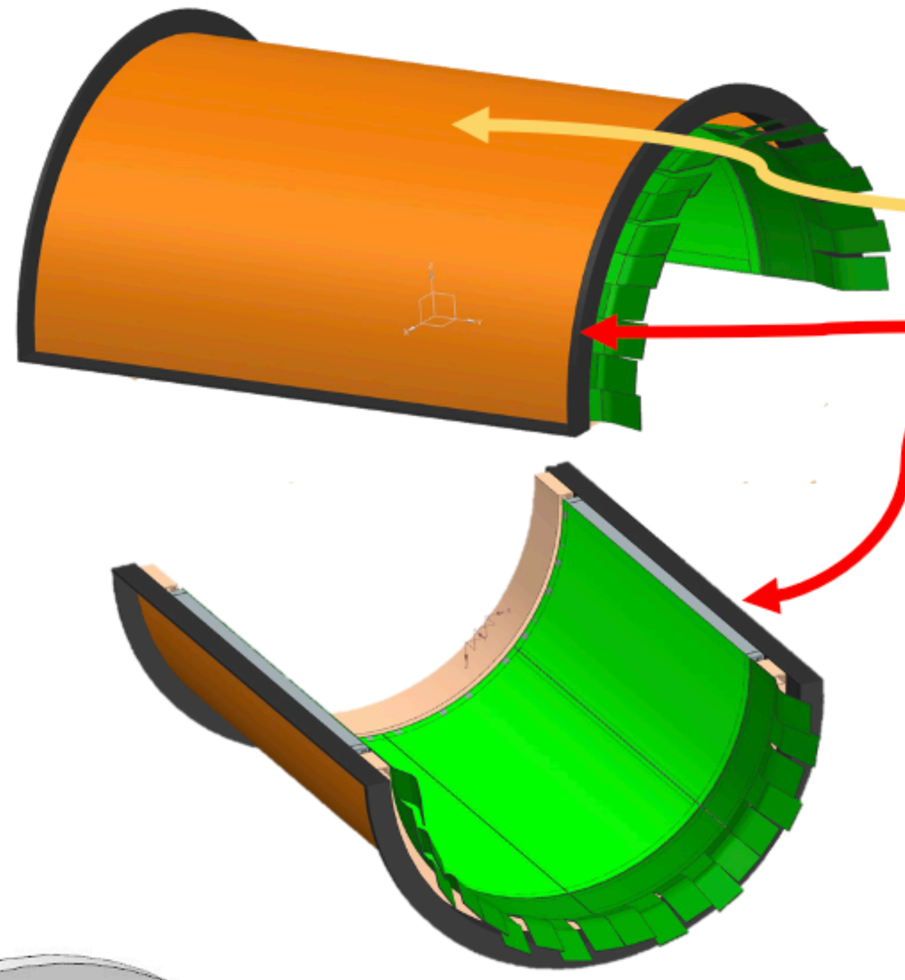
Air collectors are "manyfold": one input 3-4 outlets L0-L1 resp.

SVT Workfest — Inner Barrel

Rosario Turrisi

SVT IB mechanical support L0+L1, L2

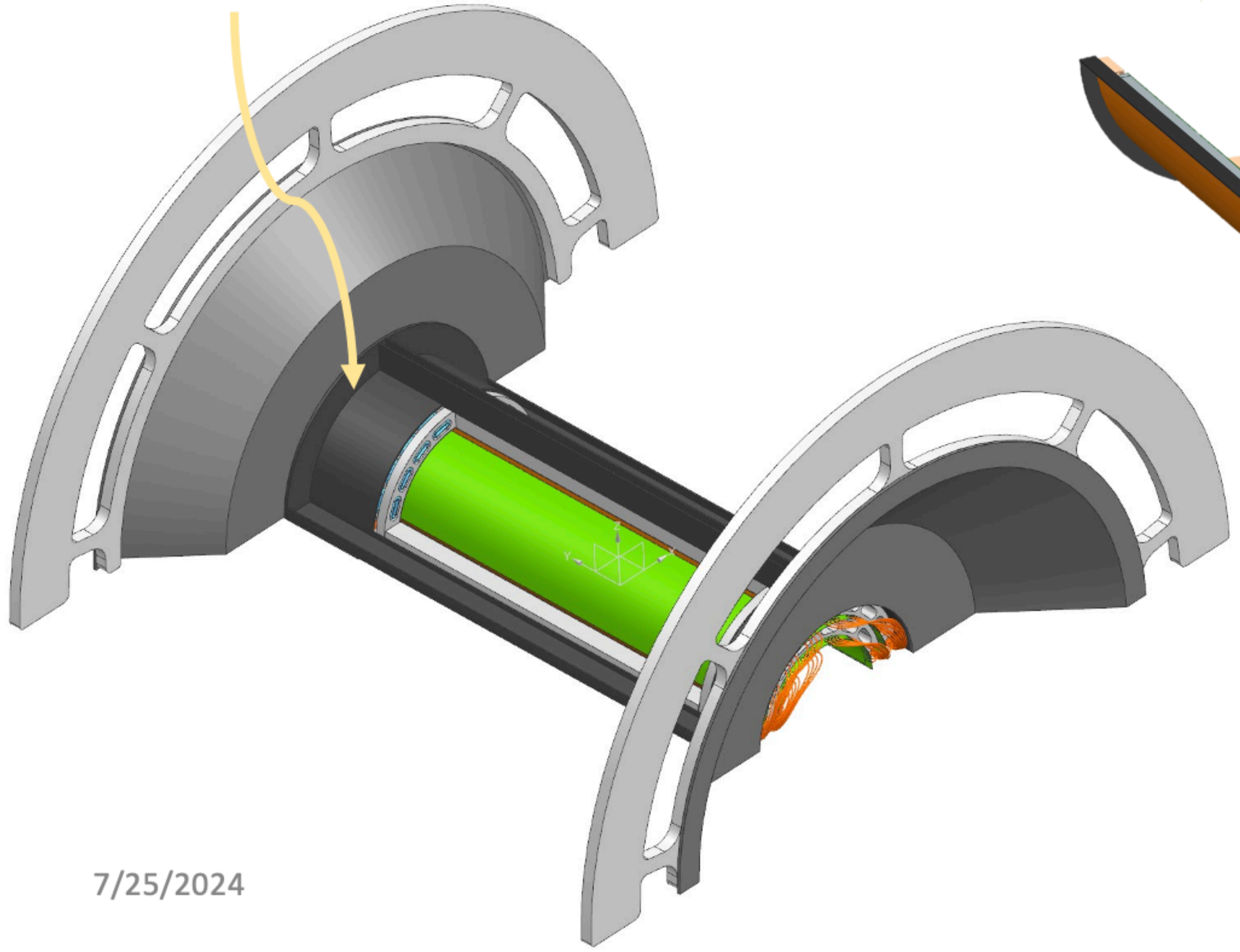
L2 on its frame (current guess - details to be discussed with MIT)



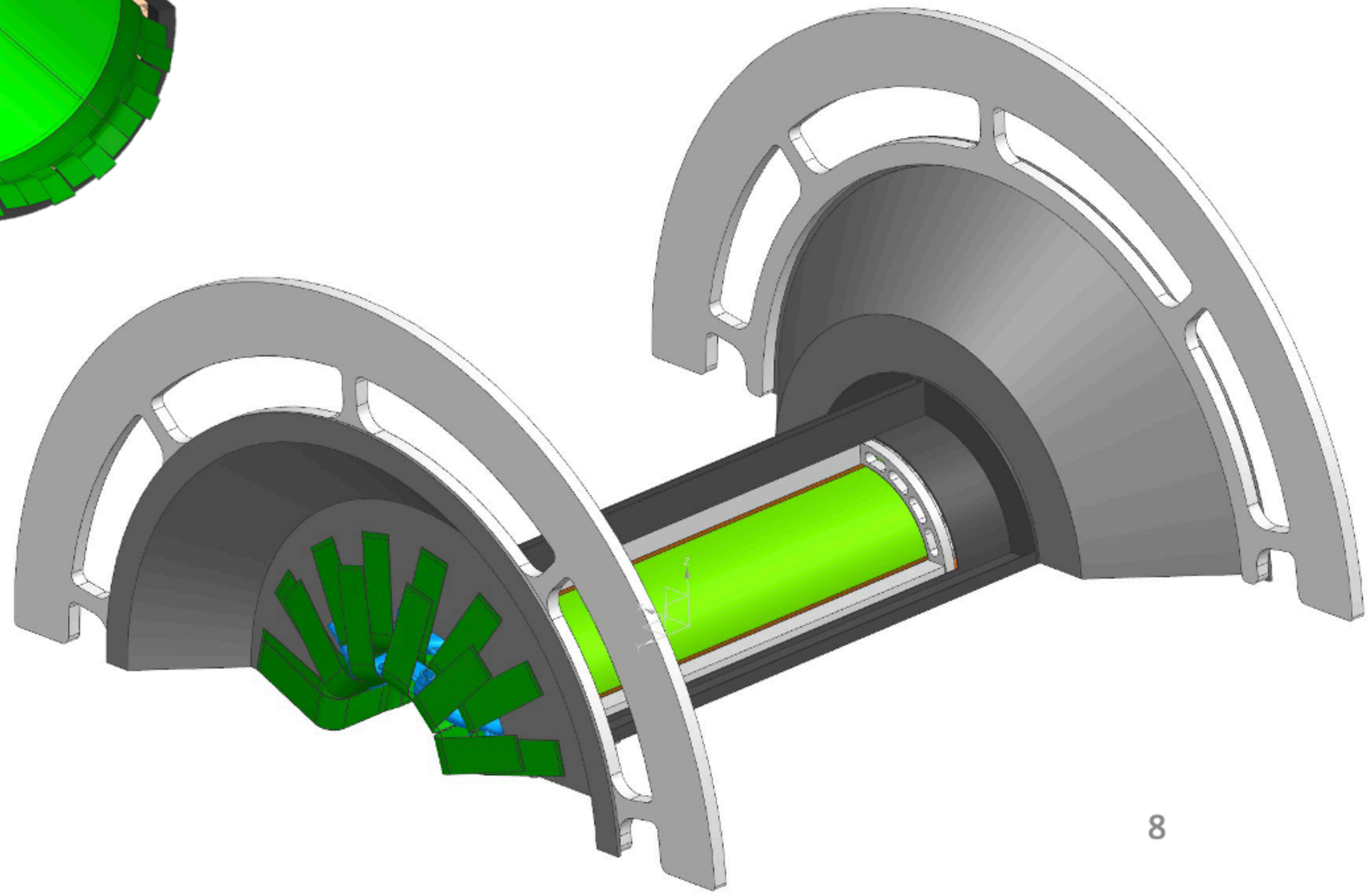
- Kapton
- Frame (CFC) to support the sensors

L0+L1 on global support

Frame to hold the half-rings and longerons supporting the sensors



L0+L1 on global support



SVT Workfest — Inner Barrel

Domenico Colella

3. Prototyping campaign plan

Prototype assembly general goals
- single layer assembly
- L0 and L1 layers connection
- air-cooling mechanism verification

Prototype	Components	Goal
IBL01_P1 (half-layer)	• 2 naked silicon L1 sensors • L1 local support structure (3-D printed) • outer support shell (machined in PEEK)	• finalize half-layer assembly procedure
IBL01_P2 (half-barrel)	• IBL01_P1 + • 2 naked silicon L0 sensors • L0 local support structure (3-D printed)	• finalize half-barrel assembly procedure
IBL01_P3 (half-layer)	• 2 naked silicon L1 sensors • L1 local support structure (carbon foam) • outer support shell (carbon fiber, to be defined)	• thermal chamber test
IBL01_P4 (half-barrel)	• IBL01_P3 + • 2 naked silicon L0 sensors • L0 local support structure (carbon foam)	• thermal chamber test
IBL01_P5 (half-barrel)	• 2+2 silicon L0+L1 **sensors with heaters from CERN** • L0+L1 local support structures (carbon foam) • outer support shell (carbon fiber, to be defined) • **air distribution inlet et outlet** (to be designed) • PT1000 sensors (to be glued on heater surface)	• wind tunnel test

Summer/Fall prototyping campaign:

- Thermo-mechanical,
- Campaign for entire SVT — Inner Barrel, Outer Barrel, and Disks
- Focus in next slides on Inner Barrel,
- Dummy silicon with actual SVT dimensions in hand, thinned and diced, distributed to Italy/CERN, UK, and US.

SVT Workfest — Inner Barrel

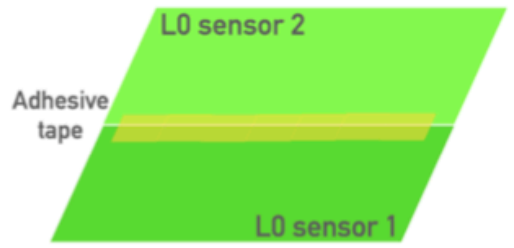
Domenico Colella

1. Silicon sensor bending technique

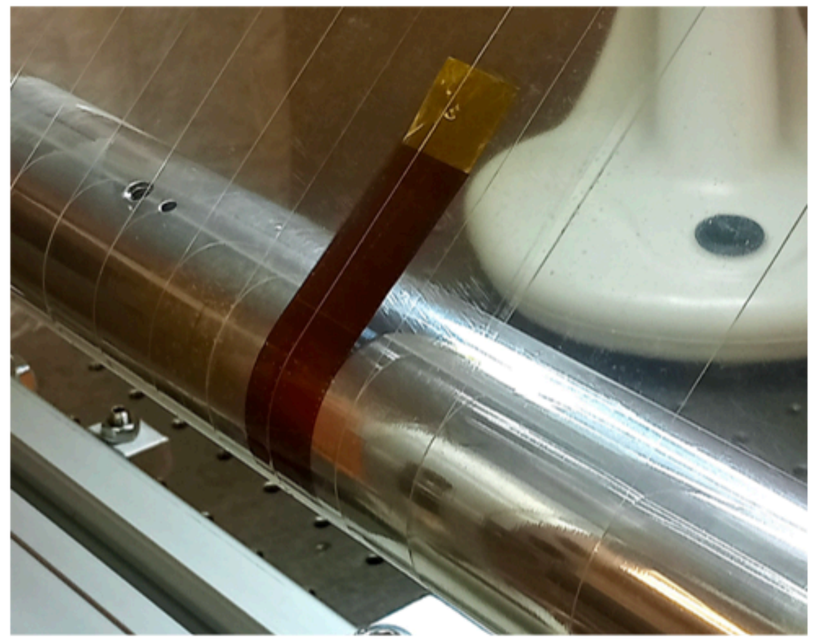
Single object bending

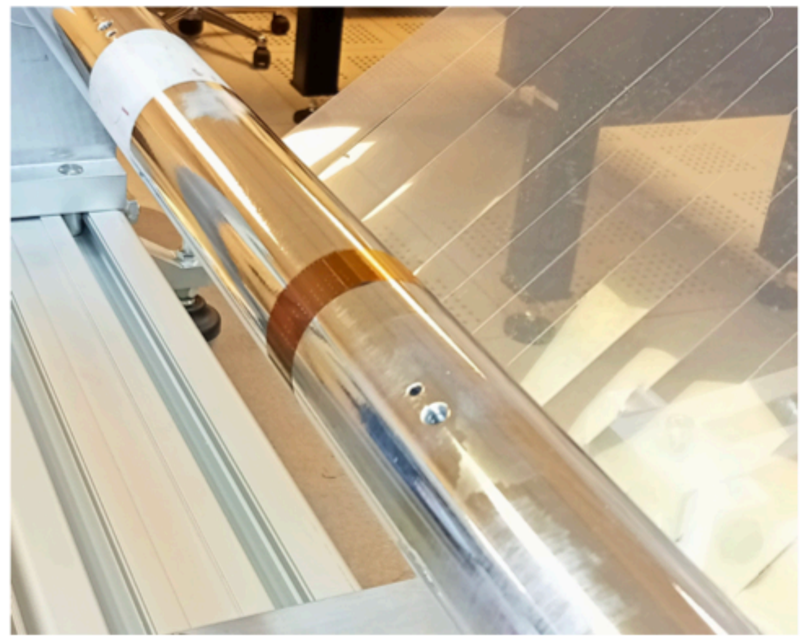
Test conditions:
- 50 μm ALPIDE sensors (30 mm x 15 mm)
- bending radius 18 mm
- adhesive tape thickness: from 12 μm to ~60 μm

Bare+tape strategy



- Reduced amount of kapton
- Feasibility to be verified





Attempt	Adhesive tape thickness	Result	Note
#1	12 μm	breakage	Close to tape-to-mandrel edge
#2	12 μm	success	Cusp at sensors junction
#3	40 μm	success	Reduced cusp
#4	60 μm	breakage	Cusp not reduced wrt 40 μm Breakage (probably) due to already stressed silicon

SVT Workfest — Inner Barrel

Domenico Colella

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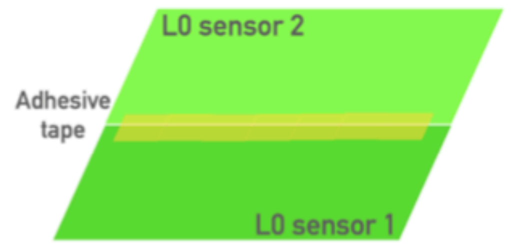


- Reduced amount of kapton
- Feasibility to be verified

Next tests:
- material: 2 ALPIDE (50 µm) + large size silicon pieces (not regular shape)
- parameter to be explored:
  - adhesive tape thickness: increase to verify reduction of cusp height
  - tape width: present 18 mm (half on each sensor)
- verify effect of support structure in cusp height reduction

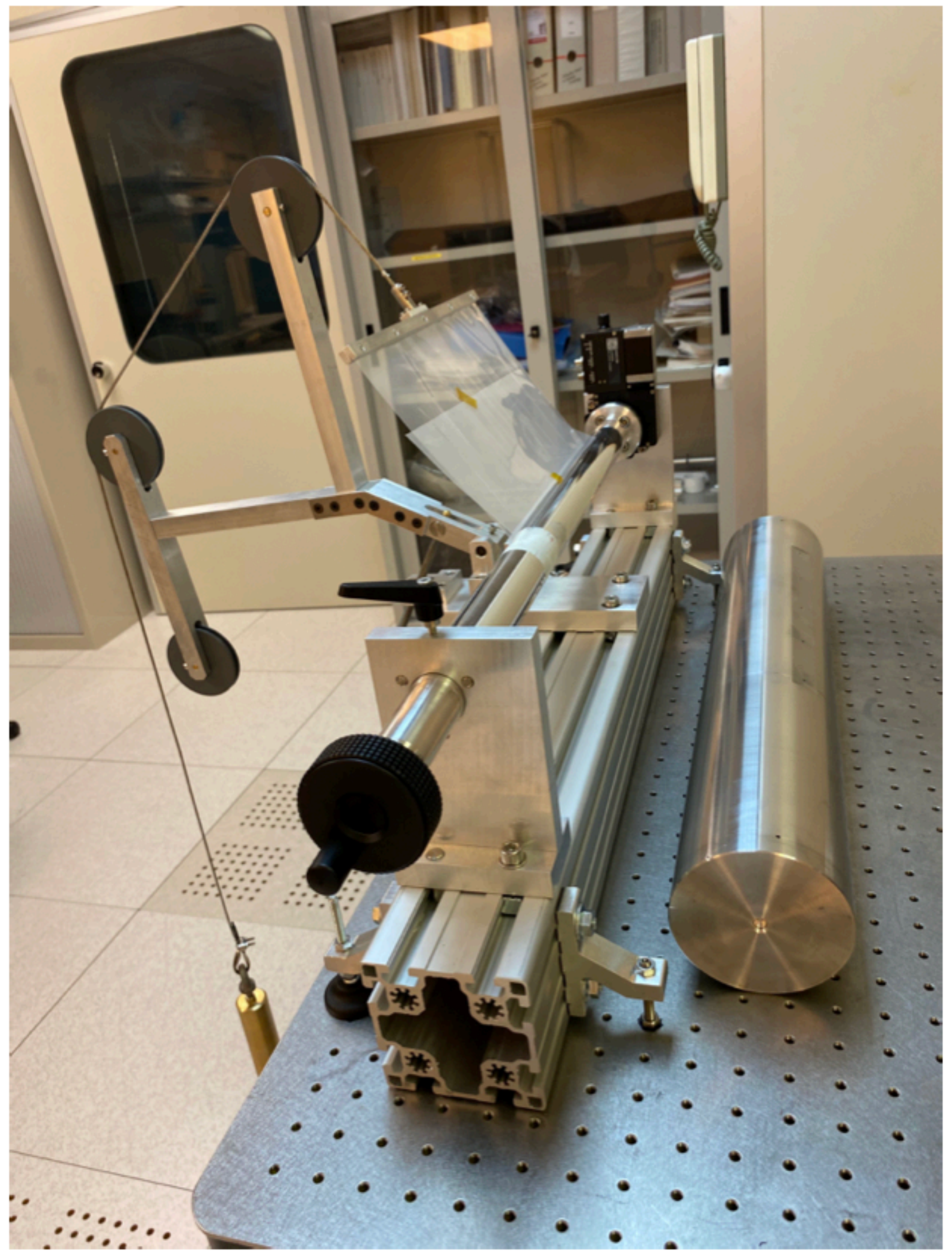
SVT Workfest — Inner Barrel

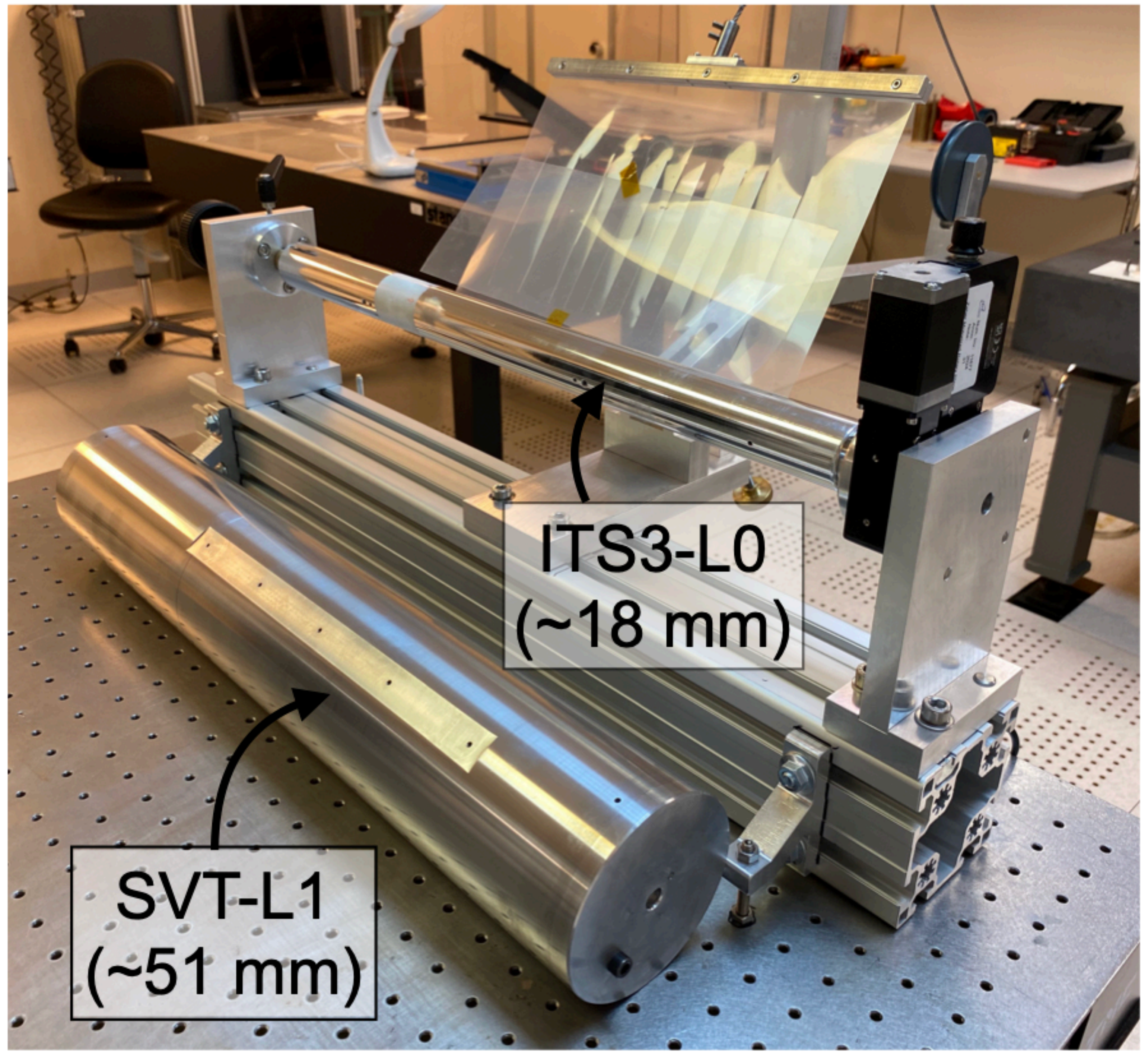
Domenico Colella

3. Prototyping campaign plan

Setup and tools update:

- Dedicated bending setup available
- First version of L1 mandrel available
    - Producer for high quality mandrels identified

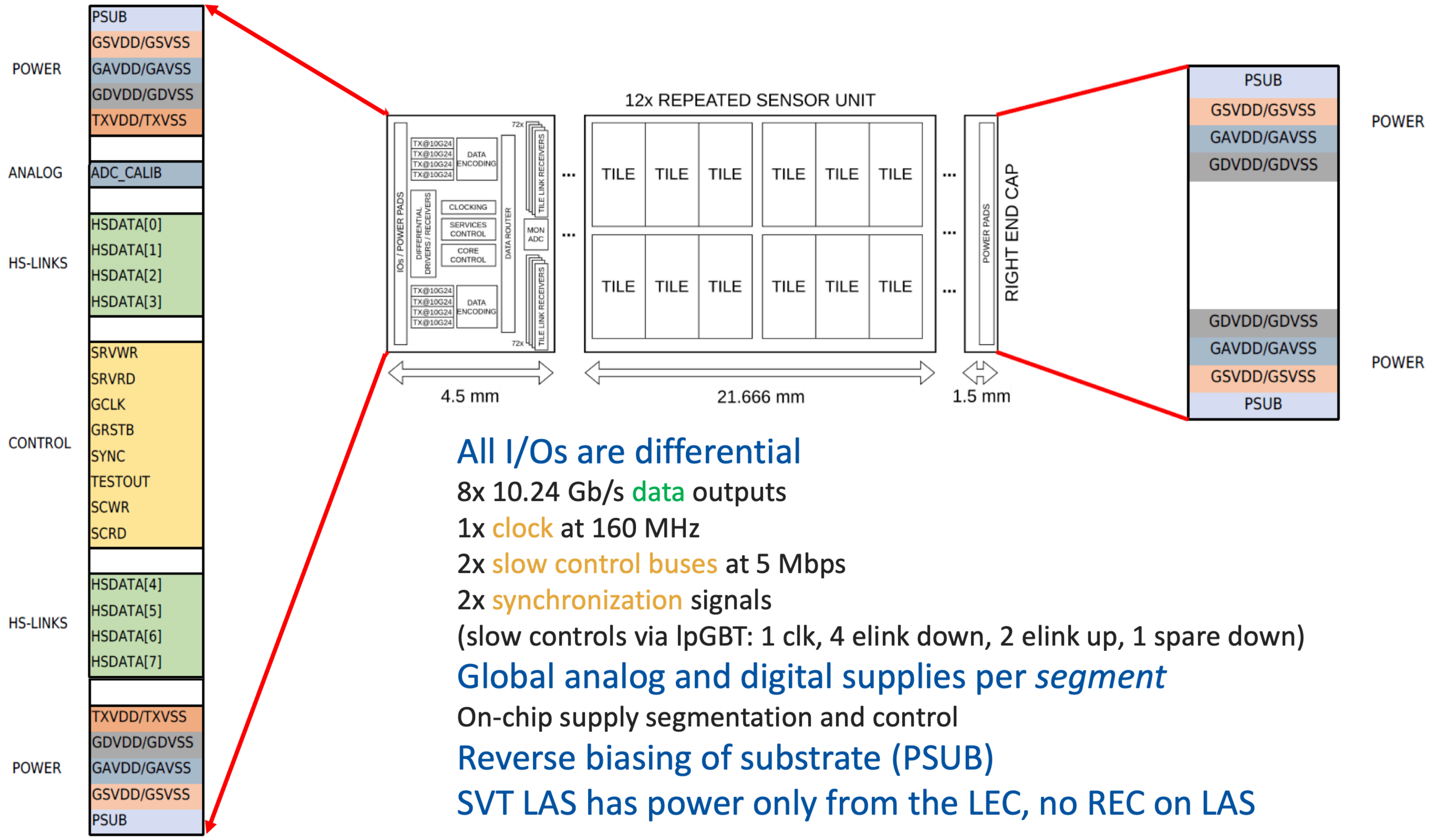




SVT Workfest — Readout

Jo Schambach

Supplies and I/Os



All I/Os are differential

8x 10.24 Gb/s data outputs

1x clock at 160 MHz

2x slow control buses at 5 Mbps

2x synchronization signals

(slow controls via lpGBT: 1 clk, 4 elink down, 2 elink up, 1 spare down)

Global analog and digital supplies per *segment*

On-chip supply segmentation and control

Reverse biasing of substrate (PSUB)

SVT LAS has power only from the LEC, no REC on LAS

13 OAK RIDGE National Laboratory

J. Schambach

Recall, SVT relies on MOSAIX:

- Inner Barrel: same sensor,
- Outer Barrel and Disks: EIC large-area sensor — identical pixel matrix, changes to endcap,
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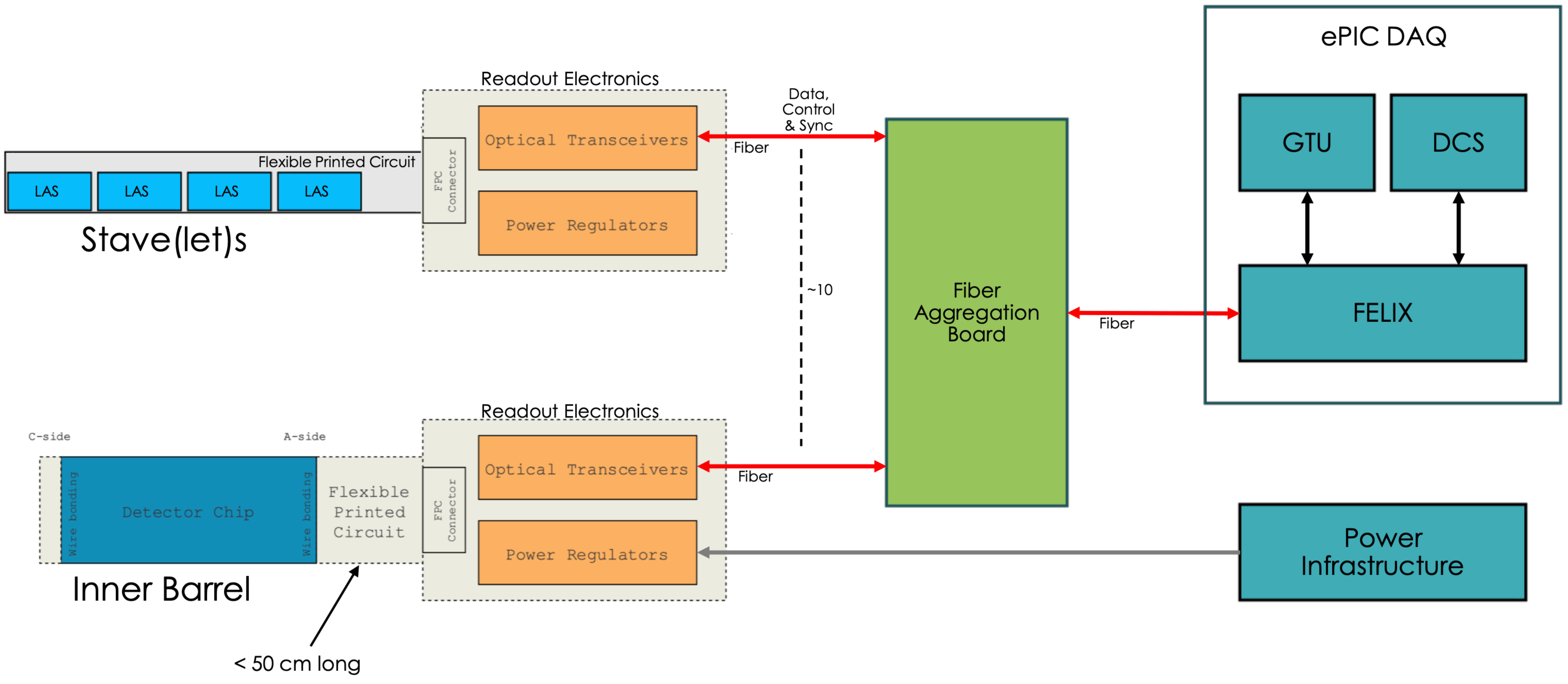
SVT Workfest — Readout

Jo Schambach

SVT Electronics – Simplified Overview

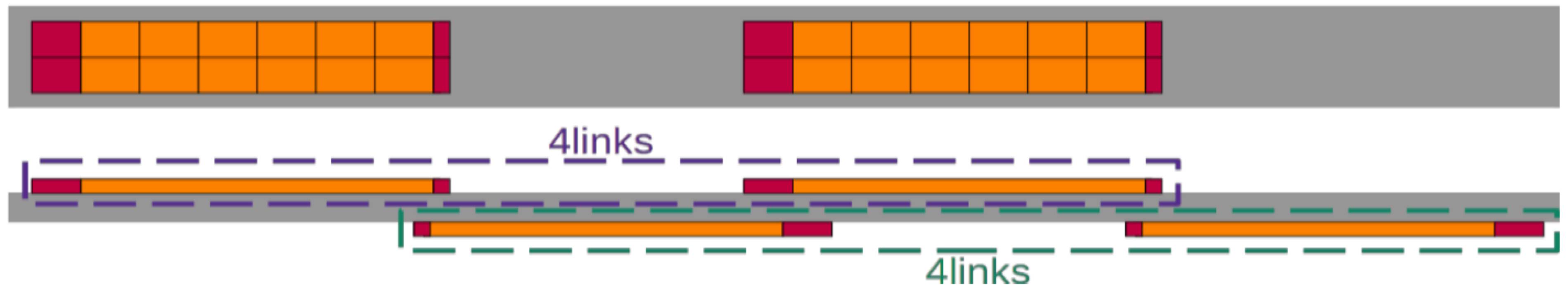


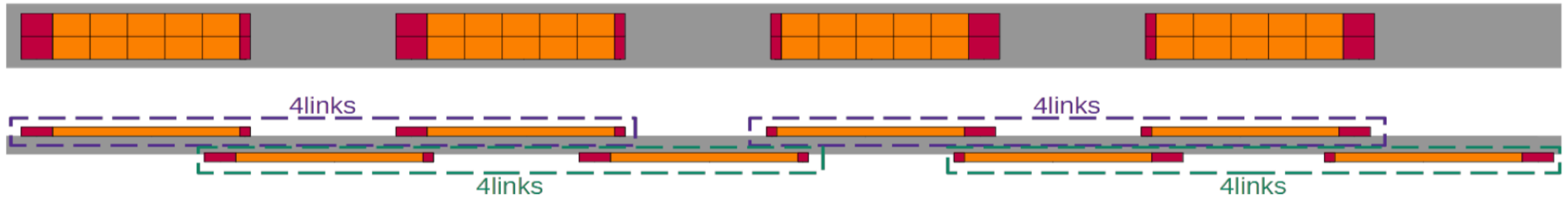
SVT Workfest — Readout

Jo Schambach

Disk/Outer Barrel Readout Configuration

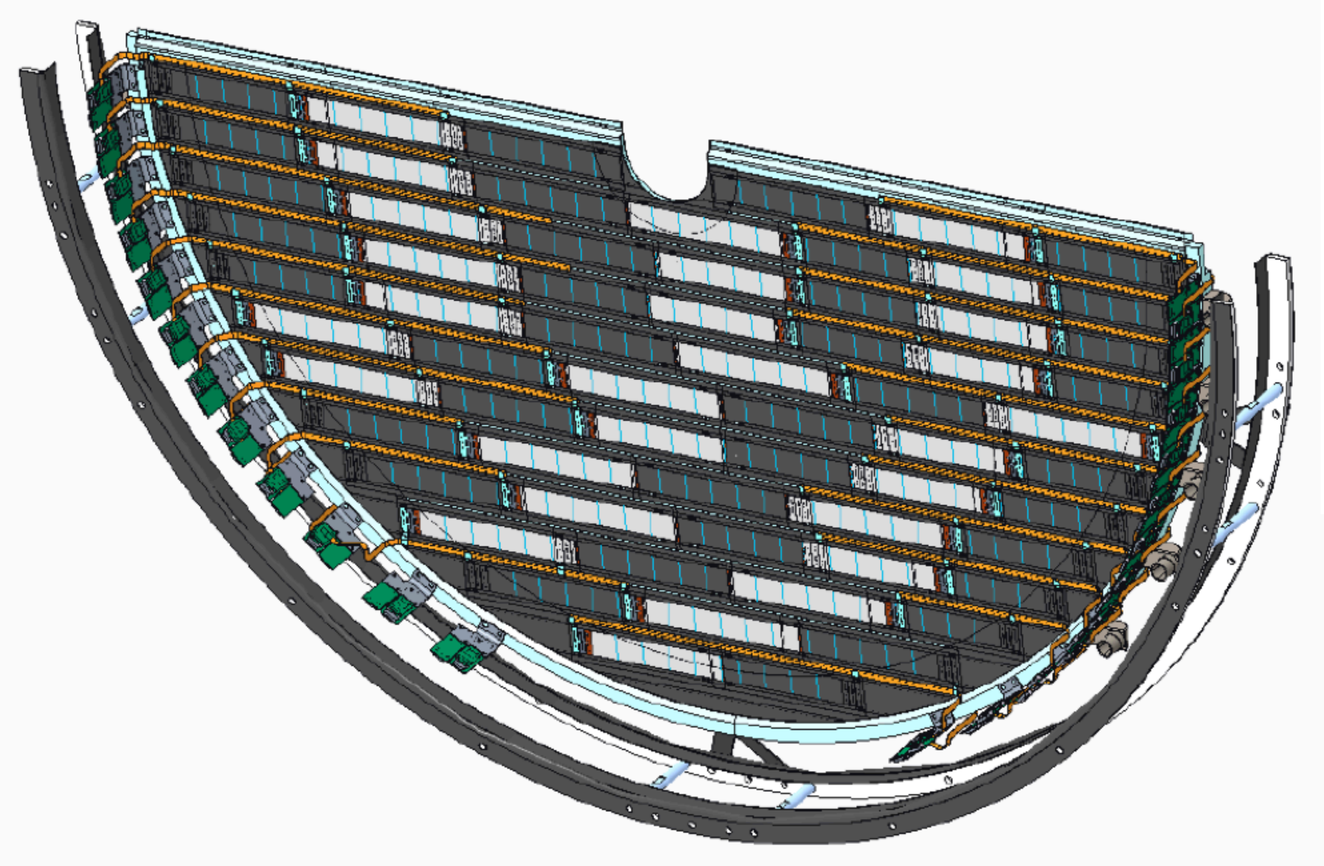
Outer Barrel Layer 3



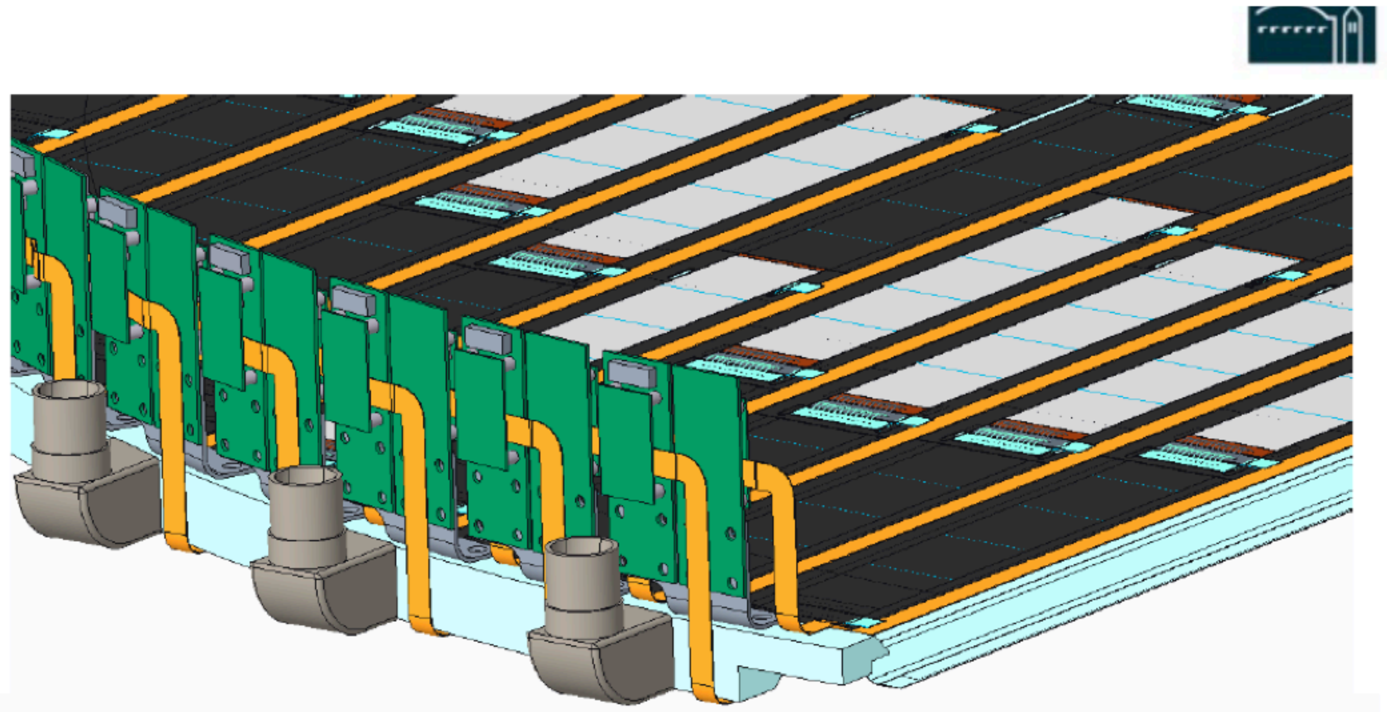


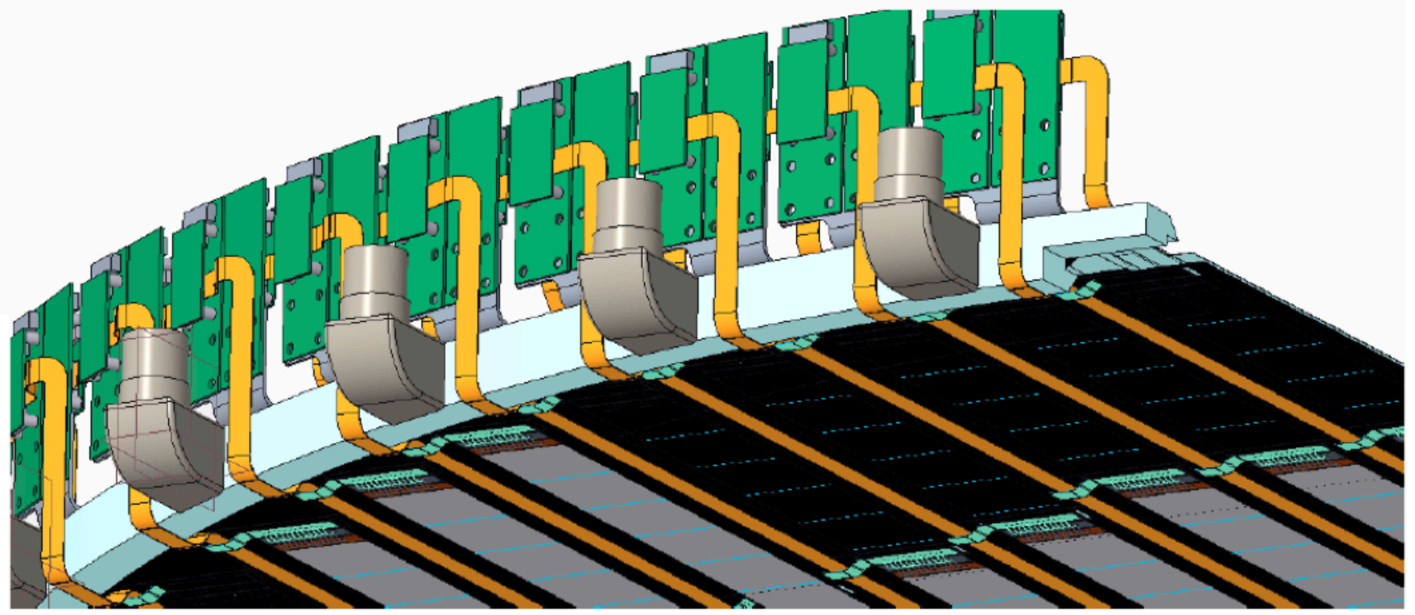
Outer Barrel Layer 4

Readout boards



Disks

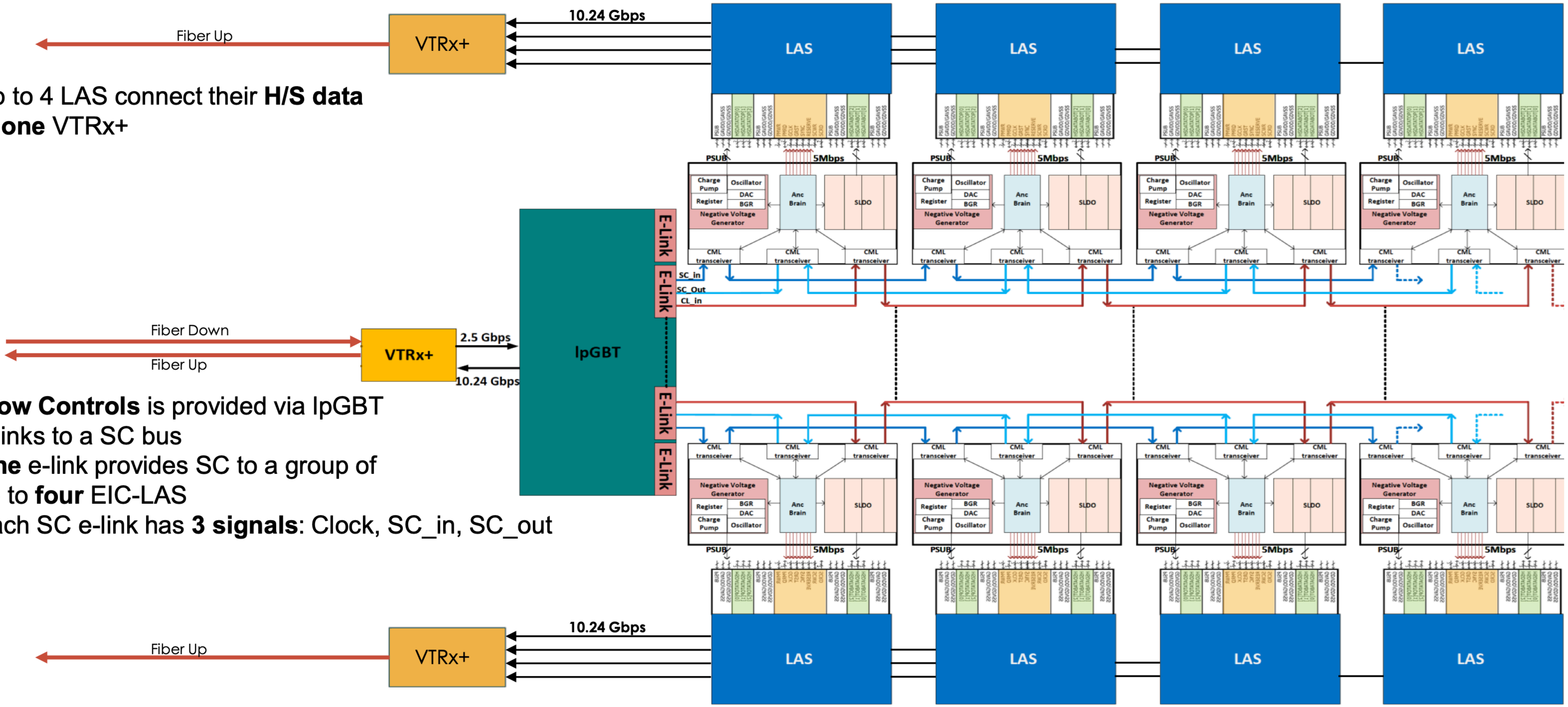




SVT Workfest — Readout

Jo Schambach

Outer Barrel and Disk Readout Electronics



Up to 4 LAS connect their **H/S data** to **one** VTRx+

Slow Controls is provided via lpGBT e-links to a SC bus

One e-link provides SC to a group of up to **four** EIC-LAS

Each SC e-link has **3 signals**: Clock, SC_in, SC_out

SVT Workfest — Readout

Jo Schambach

Jo’s talk is a treasure trove of information and (follow-up) questions:

How long does it take to run calibration scans?

- Duration largely depend on parallelism
- In final readout system, full parallel scans possible
- Sequential scans probably required for v

	Powering (s)	Matrix configuration (s)	In
Parallel	0.5	121	56
Sequential	72	9212	81

Assumptions:
Threshold scan
DAC resolution: 256
Pulses per settings: 50
Integration window: 100 us
Gap between rows: 1000 us
Readout polling: 500 us

How long does it take to configure the pixel matrix?

- Pixels configuration via periphery slow control endpoint
- Configuration accomplished by 4 actior
  - Set configuration value
  - Select rows
  - Select columns
  - Commit
- Assuming the need to mask 1% of pixels:
- **Time to configure 1 tile: 0.028 seconds**
- **Time to configure a segment: 4 seconds**

Configuration Scrubbing & Monitoring

- To ensure that all pixels keep their configuration during a run, the configuration should be updated with regular intervals.
- For scrubbing, individual pixels must be addresses, to avoid overwriting any non-default configuration
- Time to execute scrub cycle 1 tile: 2.8 seconds
- **Time to execute scrub cycle segment: 7 minutes**
- Tile readout monitoring:
  - Assuming less than 50 registers to monitor per tile
  - **< 200 ms** per segment

SVT Workfest — Beam and Irradiation Tests

Zhenyu Ye

BERKELEY LAB

Summary and Outlook

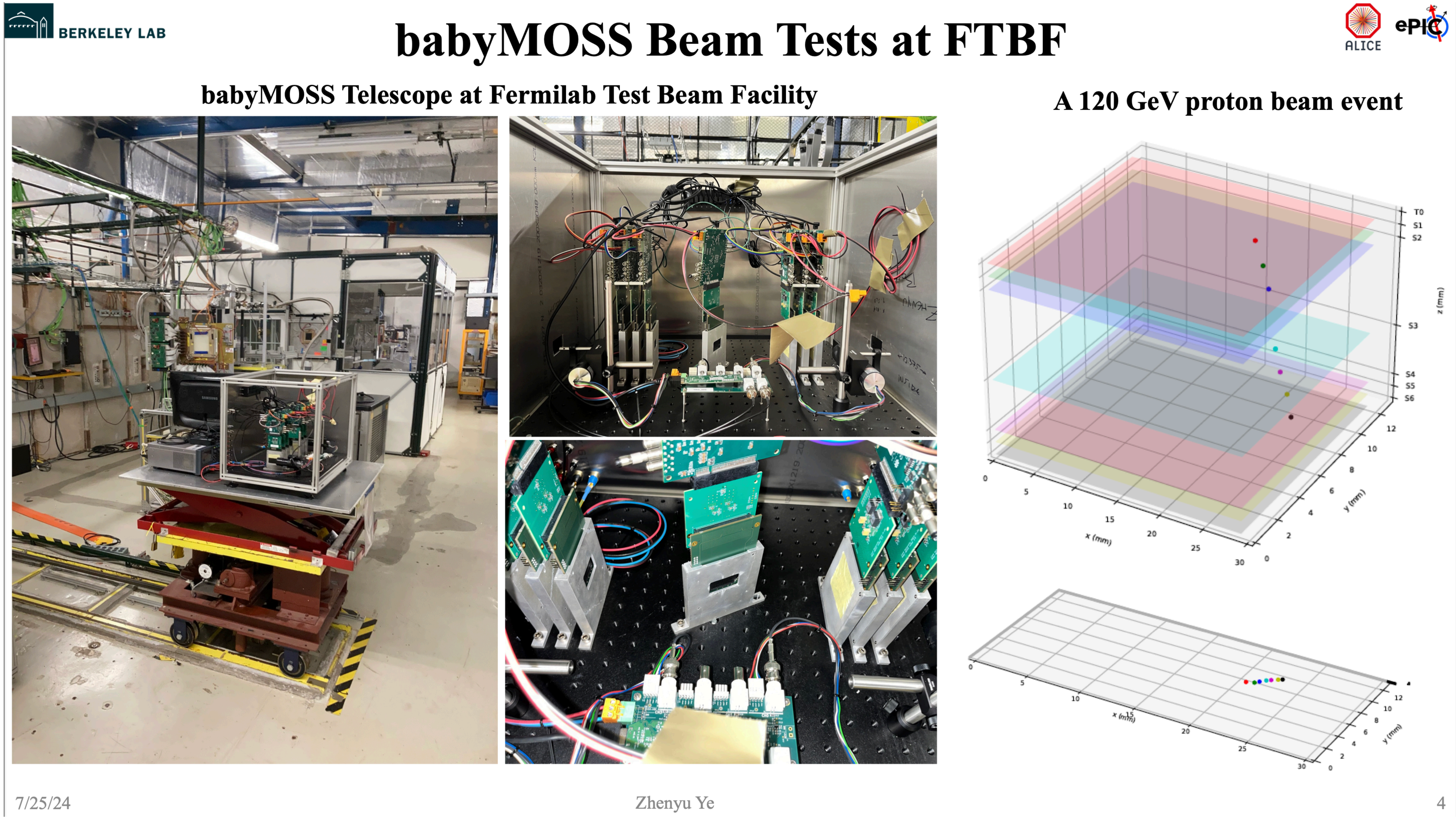
ALICE ePIC

- **Beam Tests at Fermilab Test Beam Facility on May22-June 4 and June 26- July12, 2024**
  - Assembled and commissioned a 7-plane babyMOSS telescope with 120 GeV protons
  - Studied the dependence of sensor performance on incident angle
  - Data analysis is nearly completed to extract efficiency, resolution, cluster size
- **SEE Tests at Berkeley Accelerator Space Effects Facility on May 22-23 and July 1, 2024**
  - Measured babyMOSS SEL and DAC register SEU cross-sections as a function of LET
  - Searched for SEL-sensitive circuits on babyMOSS with motion-controlled collimators
  - Data analysis is nearly completed to extract cross-sections and locations of sensitive circuits
- **Plan for Winter 2024/Spring 2025:** irradiate babyMOSS sensors and study the temperature dependence of pre- and irradiated sensor performance in the lab and with beam

Note: babyMOSS is a single RSU product from the Engineering Run 1 submission in the development sequence towards MOSAIX.
ER2 design in progress, with contributions from EIC designers — submission products are beyond pre-TDR/PDR timeline.
ER3 is the production sensor.

SVT Workfest — Beam and Irradiation Tests

Zhenyu Ye



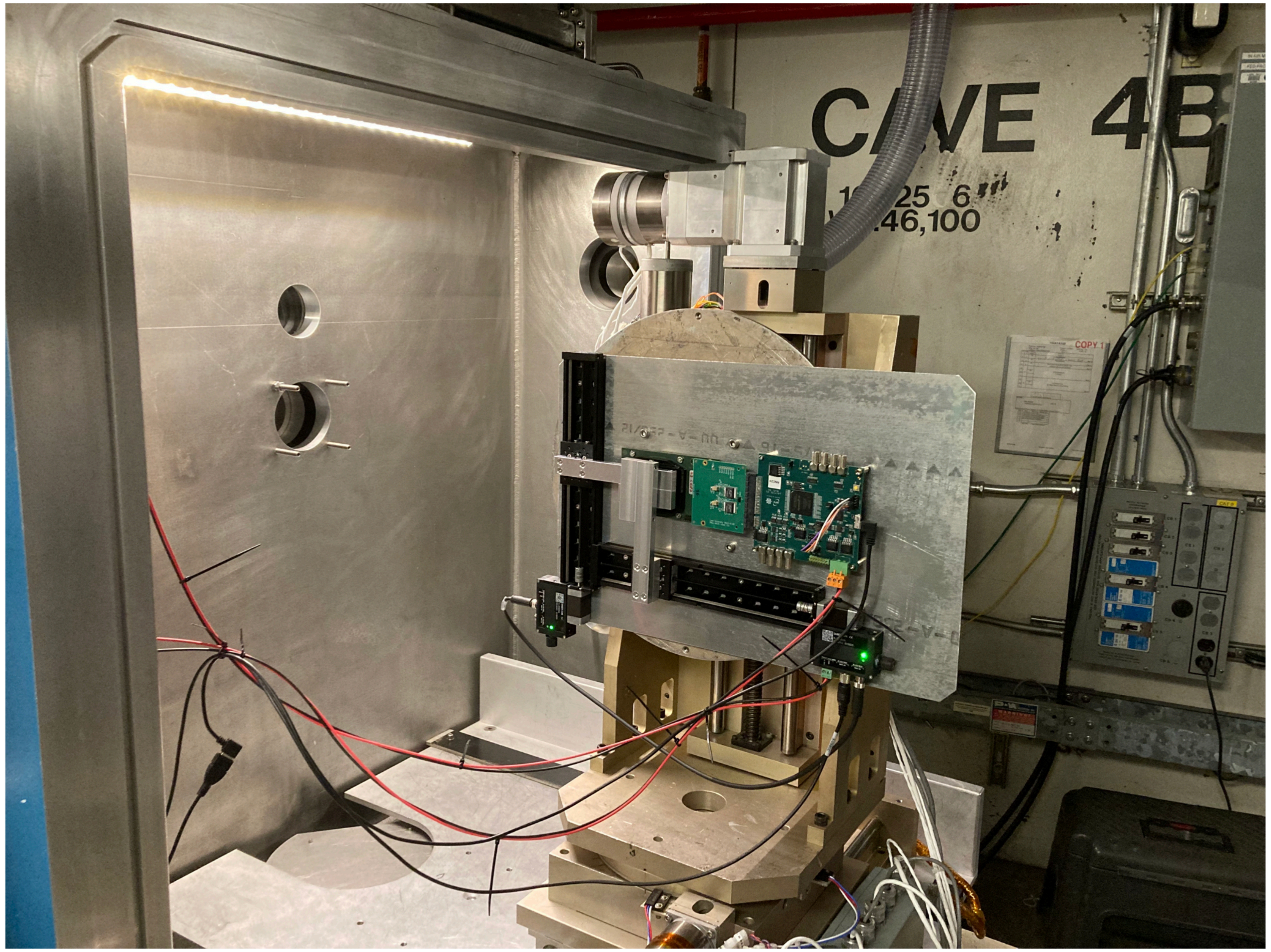
Zhenyu Ye

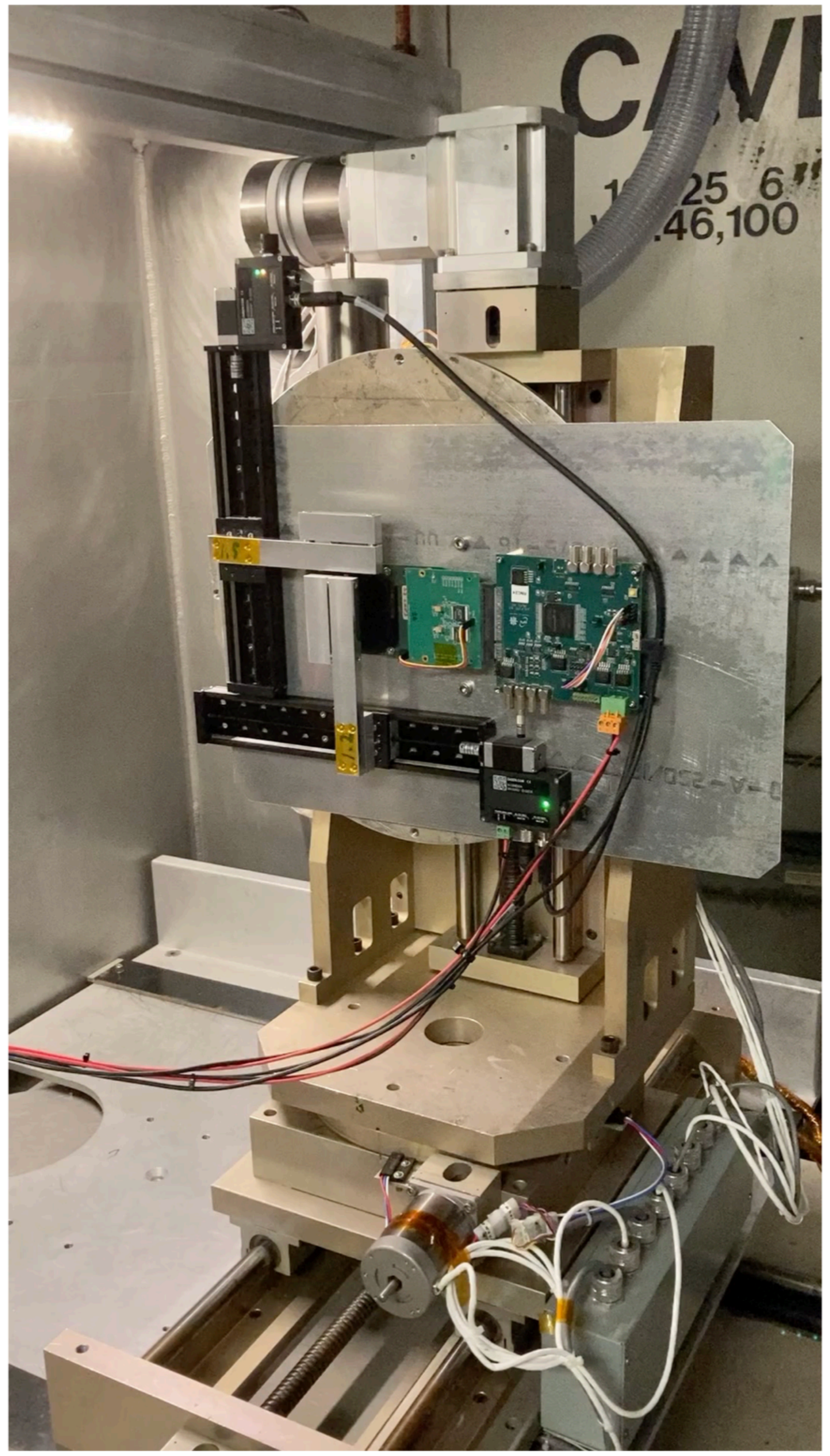
SVT Workfest — Beam and Irradiation Tests

BERKELEY LAB

babyMOSS SEE Tests at BASE

ALICE ePIC





Thank you to all who participated,

and in particular also the local organization