

MIT Bates for ultra-light silicon pixel detectors

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MIT Heavy-ion Group

DOE review of Bates Laboratory

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<https://pixelphilab.mit.edu>



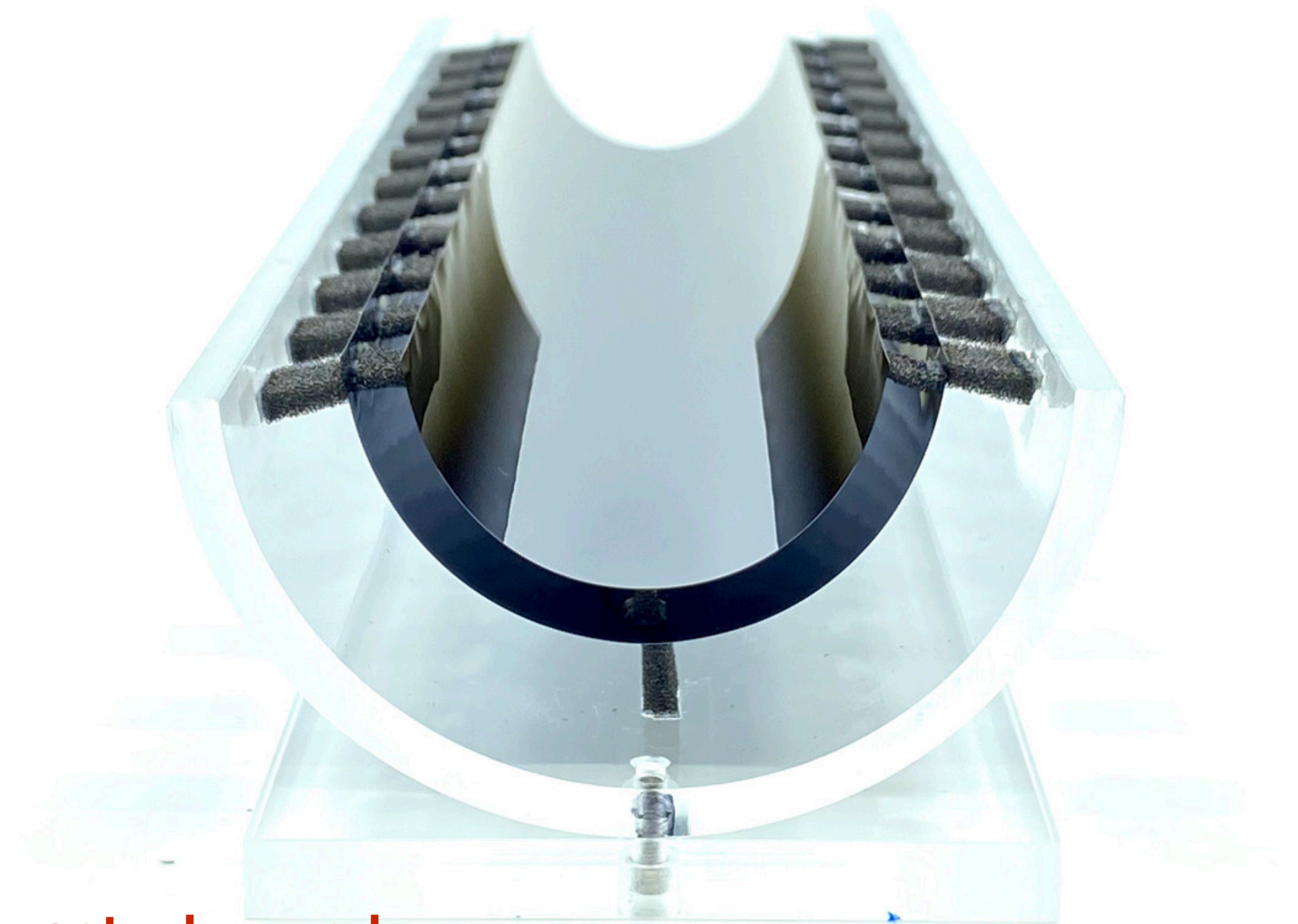
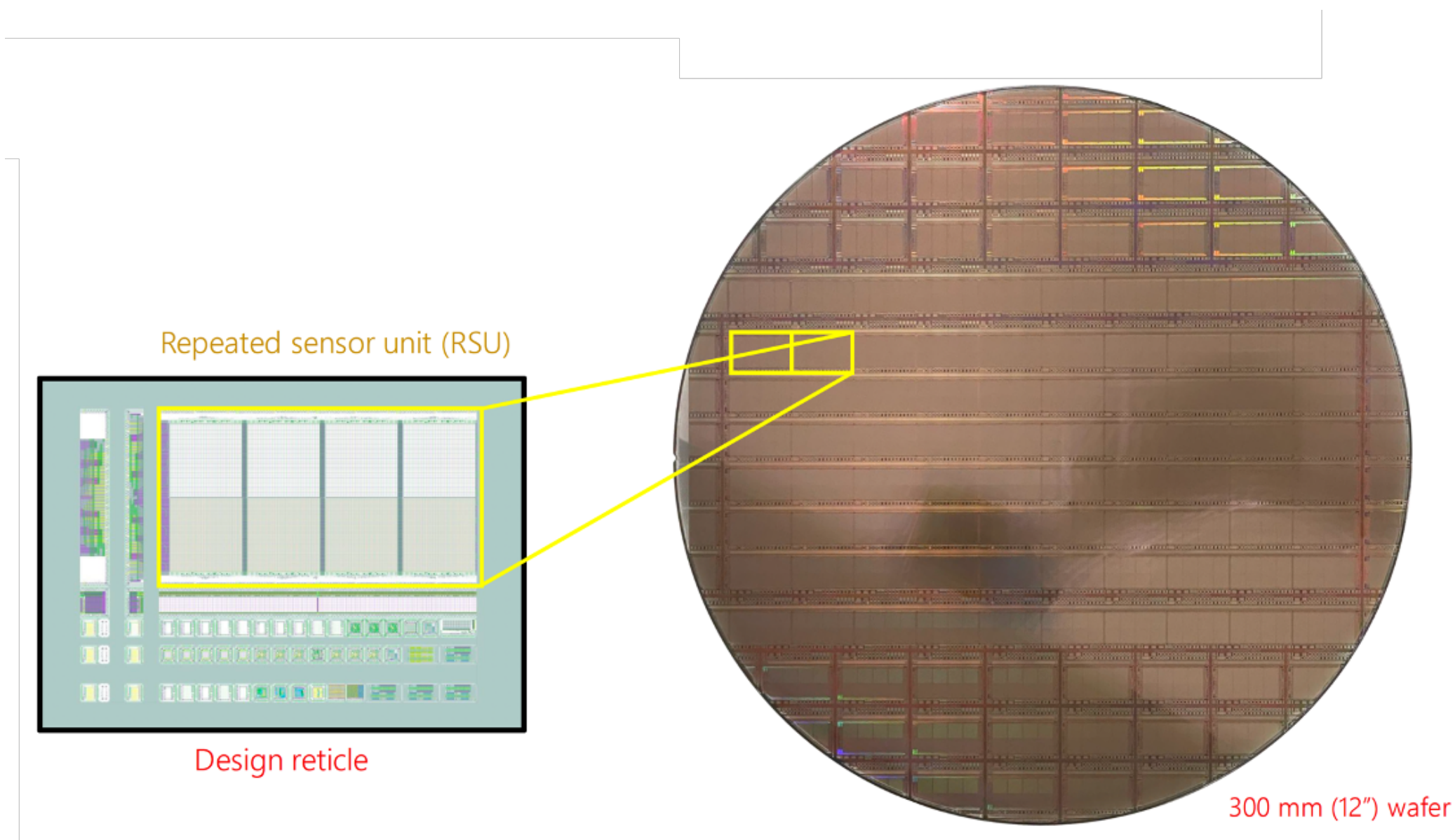
Next generation silicon detectors

MIT PixEL ϕ : a new laboratory to exploit a new cutting-edge silicon pixel technology:

→ Ultra-light (“massless”) Bendable Monolithic Active Pixels

- large sensors with “stitching” techniques

- “bendable” when thinned below $\sim 20\text{-}40\ \mu\text{m}$

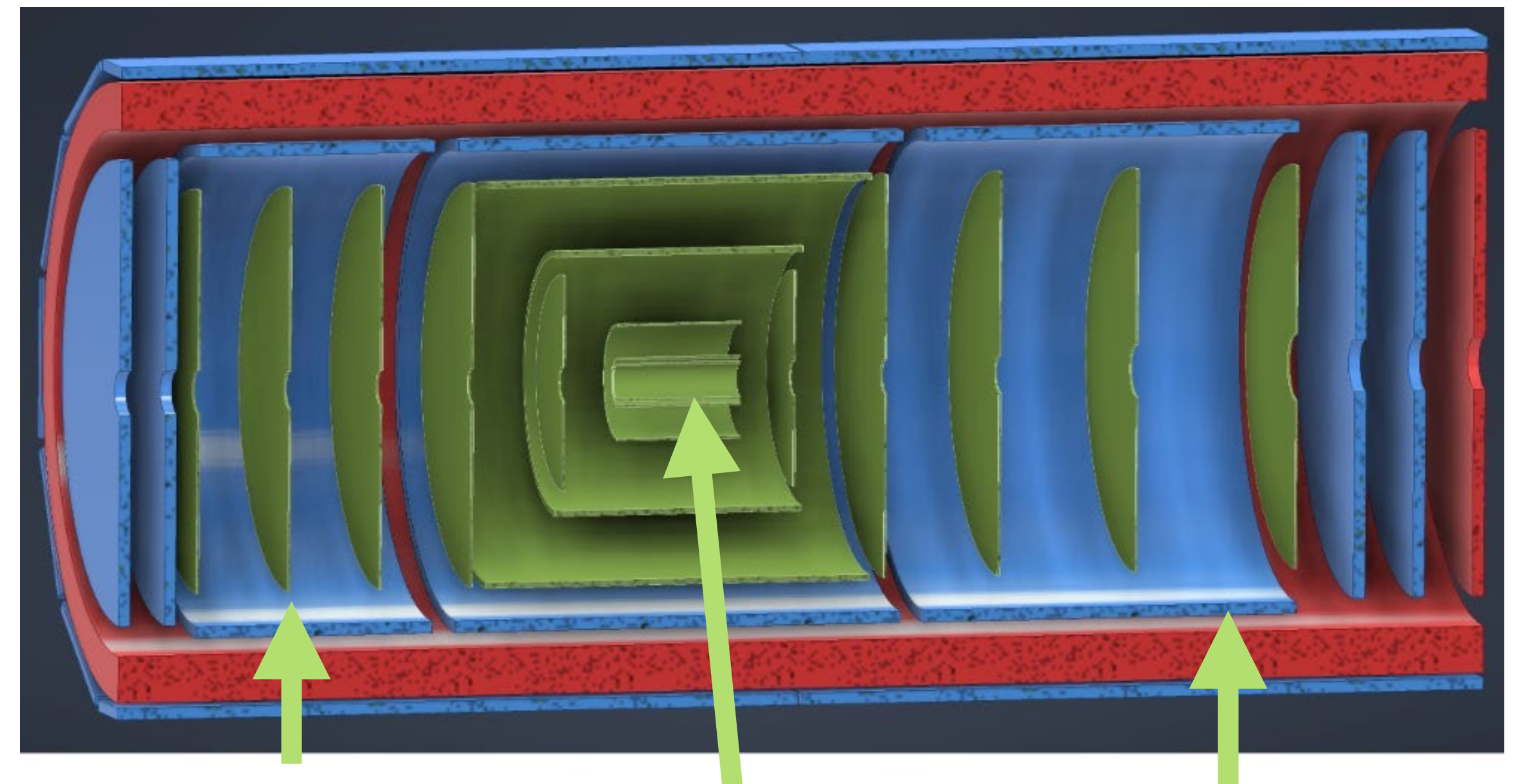
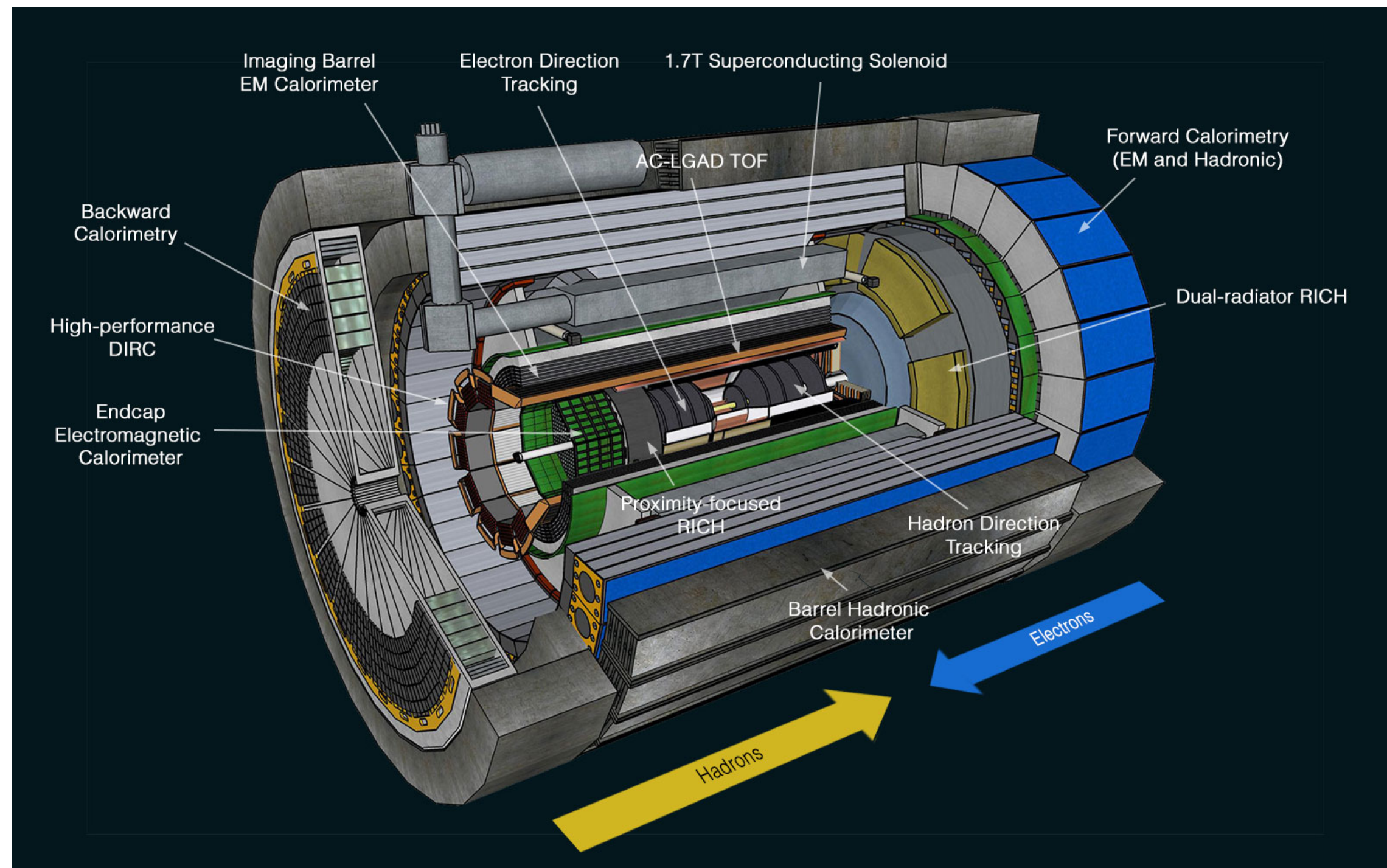


The Silicon Vertex Tracker (SVT) for ePIC@EIC is the most advanced application of stitched MAPS sensors for large-area wide-acceptance detectors

SVT for ePIC@EIC

SVT is paving the way for future large-area application of this new technology

→ unique technological challenges in terms of sensor R&D, cooling, mechanical design and integration



SVT disks SVT inner barrel SVT disks (IB)

Large-area stitched-MAPS sensors

PixEL ϕ at Bates: prospects beyond SVT

On-sensor AI for MAPS with hls4ml:

- noise-tagging and data reduction on MAPS for future HEP experiments (focus on e^+e^- for FCC and eA for EIC)

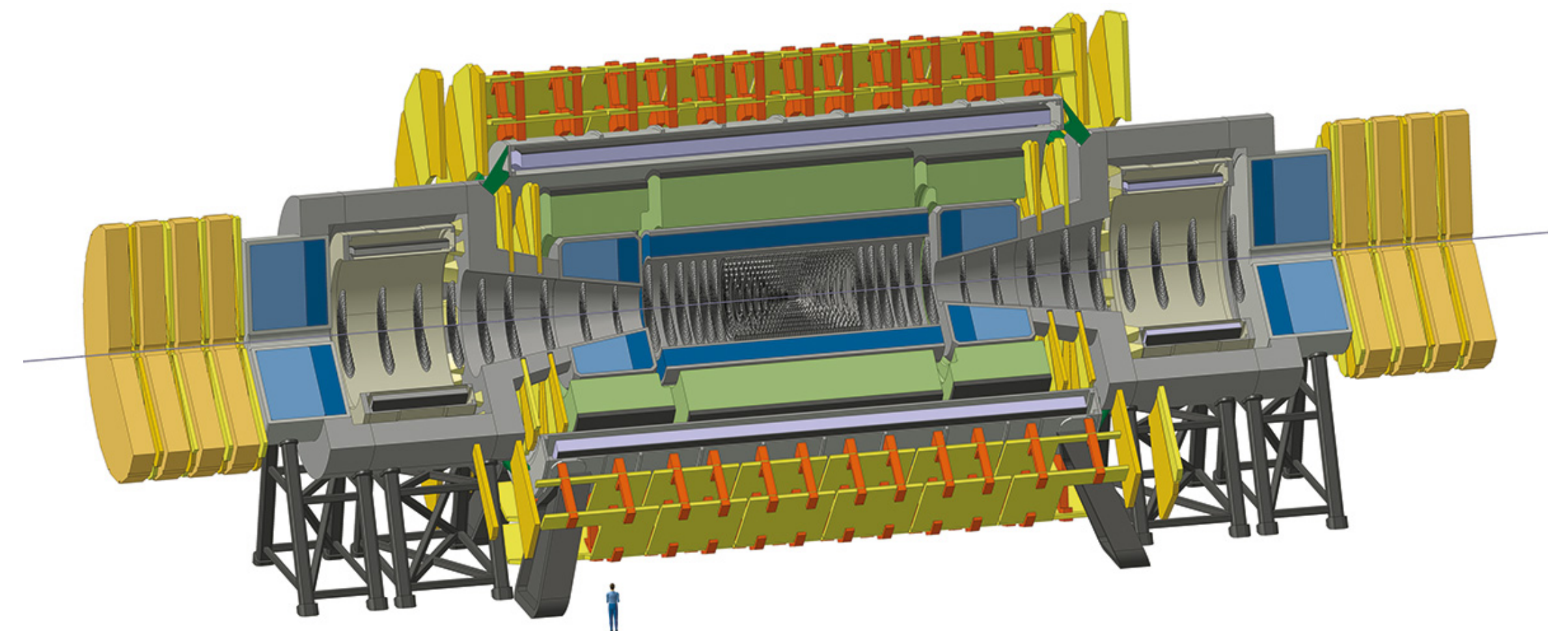
Applications in atomic physics:

e.g. detection of low-energy electrons for cold-atom physics

Medical imaging:

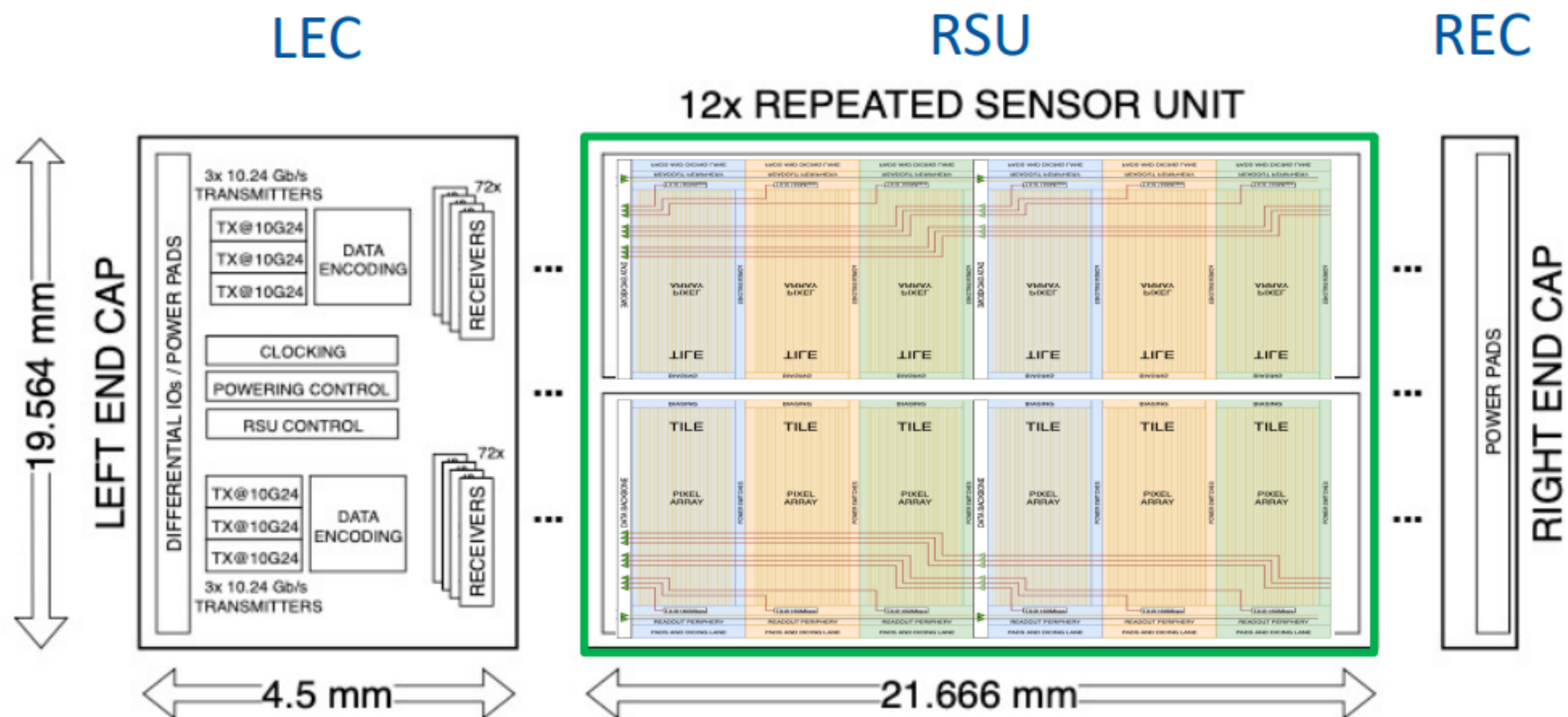
online calibration of proton/ion beams for ion therapy

MAPS-based tracker for the FCC at CERN



MIT PixEL φ : SVT contributions

- Major contributions to the sensor design and testing



- **Developing a brand new high-frequency testing strategy for large-area sensors**
→ MIT is leading the testing, characterization working group of the SVT collaboration
- **Design and optimize the SVT readout strategy for service reduction**

The sensor and testing activities are currently carried out at CERN to maximize the synergies with CERN MAPS experts:
→ **Our plan is to move and expand the testing lab to Bates over the course of the next 2-3 years**

PixEL ϕ at Bates: **planned** contributions to SVT mechanics

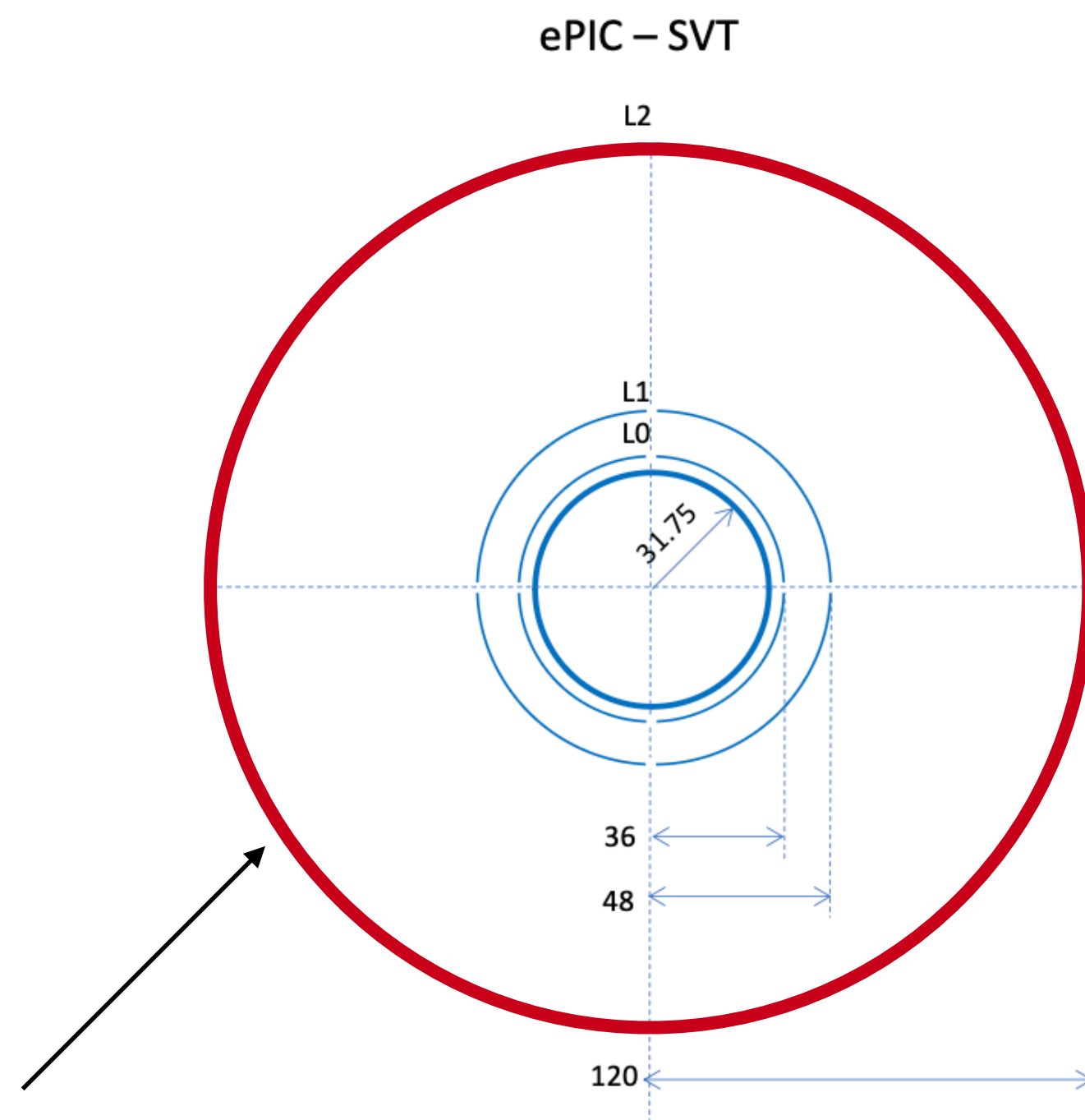
- **Simulation studies to characterize the mechanical properties of the SVT IB layers (ongoing)**

- implement SVT geometry in ANSYS, heat-dissipation studies
- test the impact of vibrations in the presence of air flows at different speeds
- define the specifications of a wind tunnel to test the IB mechanical design, cooling, ..

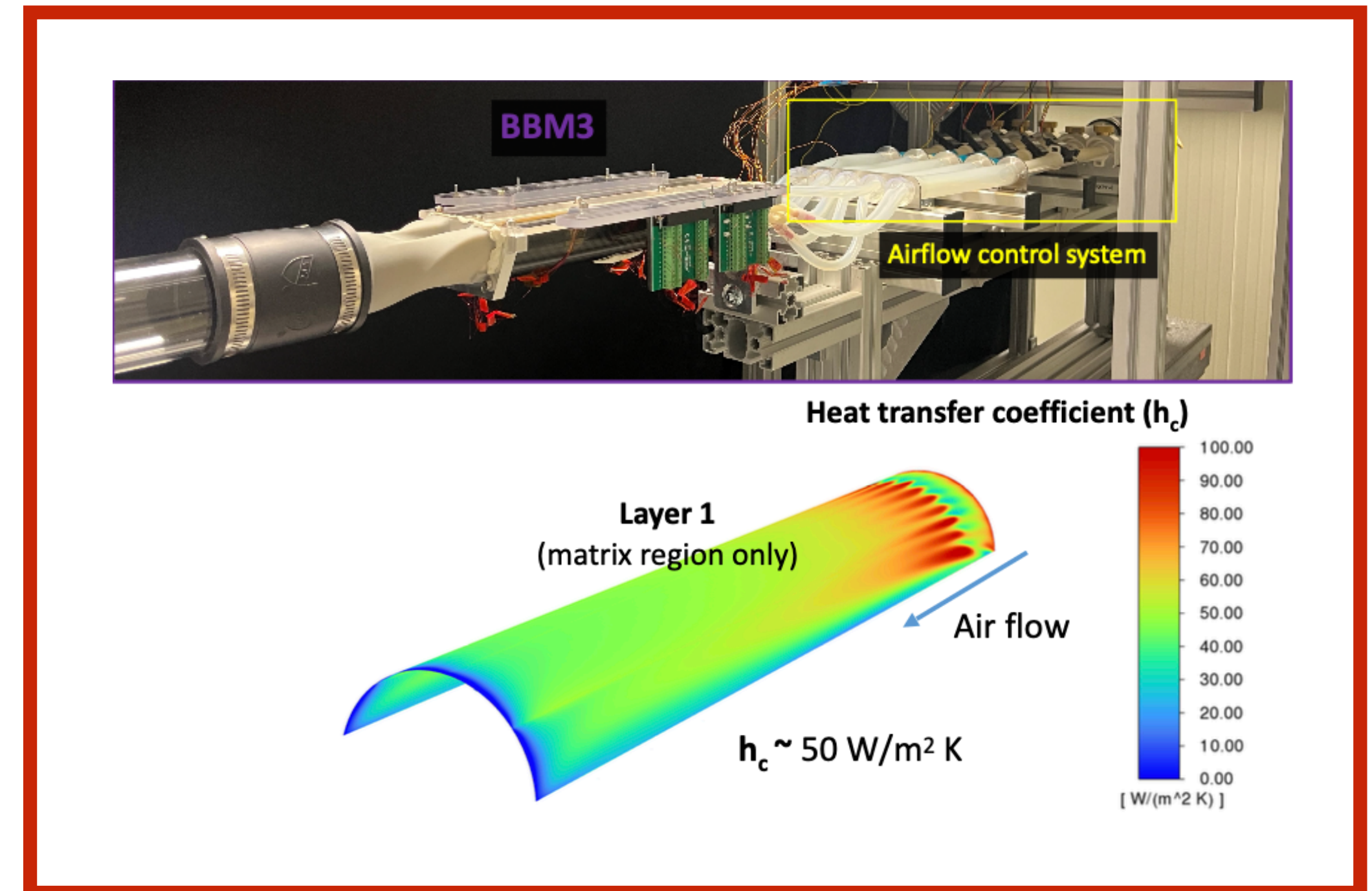
- **Design of the inner-barrel geometry, support structure, and cooling**

- MIT is in charge of the design and construction of the **Layer2**

C. Gargiulo, ITS3 Plenary 30 June 2023

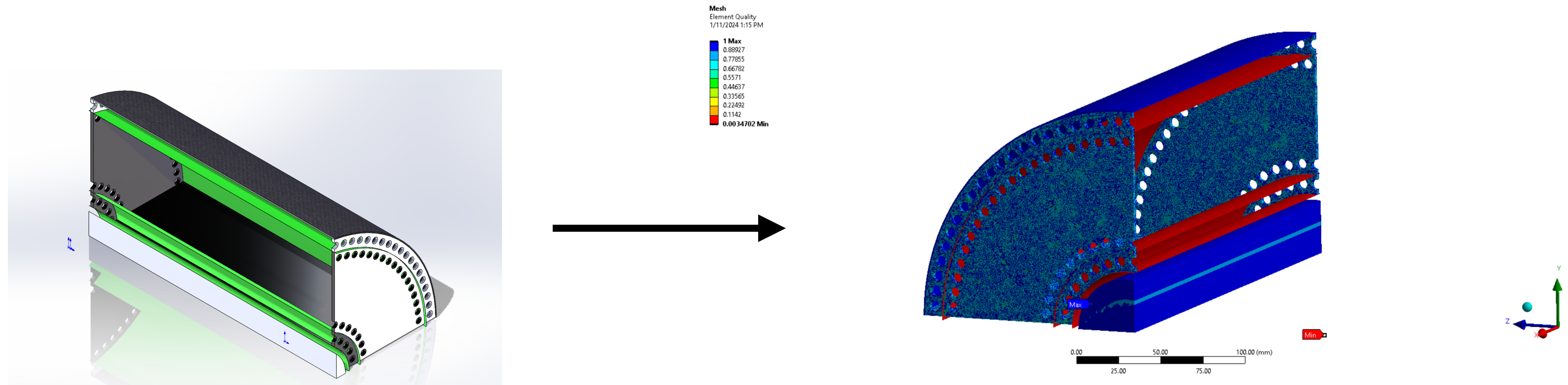


Layer2: the largest-R layer of bent MAPS sensor ever designed and constructed

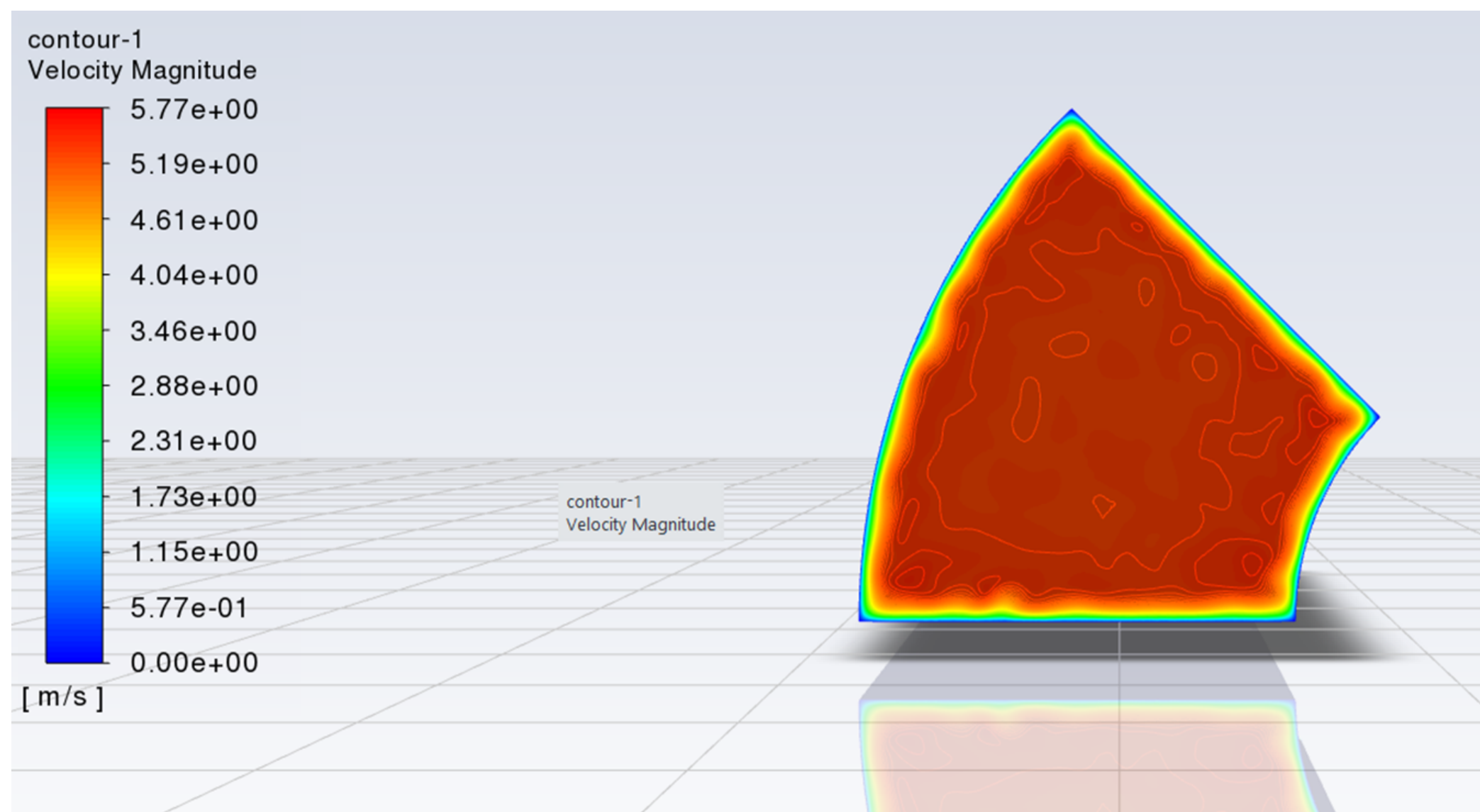


- **Design and construction of a wind-tunnel setup** to test the cooling, dissipation and mechanical properties of the SVT

PixEL ϕ at Bates: **status** of R&D activities to SVT mechanics



- Implemented the current mechanical design for the SVT in SolidWorks



- Develop a fluido-dynamic simulation to model the air-based cooling of the SVT
- Currently performing a thermal study to characterize the cooling performance in presence of a realistic heat dissipation

- preliminary studies are currently supported with in-kind Bates resources (Tricia Smith, Jim Kelsey)
- **SVT relies on Bates for the design and construction of the SVT L2!**

PixEL ϕ at Bates: our vision

- **Bates as a centre of excellence for the R&D, design, construction and assembly of large-area sensor detectors:**

- **Short/middle term plan:** leading role in the design and construction of the SVT third layer
- **Longer term:** future large-area detectors, medical applications, ..

- **Requirements:**

- Cutting-edge equipments for mechanics and electronics (bending, assembly, gluing..)
- Wind tunnels for large-area sensors
- Electronic equipment for testing (wafer probe machines, DAQ setups), bonding machine
- Spaces (clean room with vacuum systems)

- **Timescale**

- **Next 6 months:**

- clean room to be refurnished
- purchase of the bending tools

- **Next year**

- development of a wind tunnel
- purchase of mechanical equipment (e.g. Mitutoyo machine w/ alignment vacuum tools)

- **Next two/three years:**

- **Move the now CERN-based test laboratory to MIT/Bates**
- **Equip the Bates-based lab for the assembly of the SVT inner tracking layers**



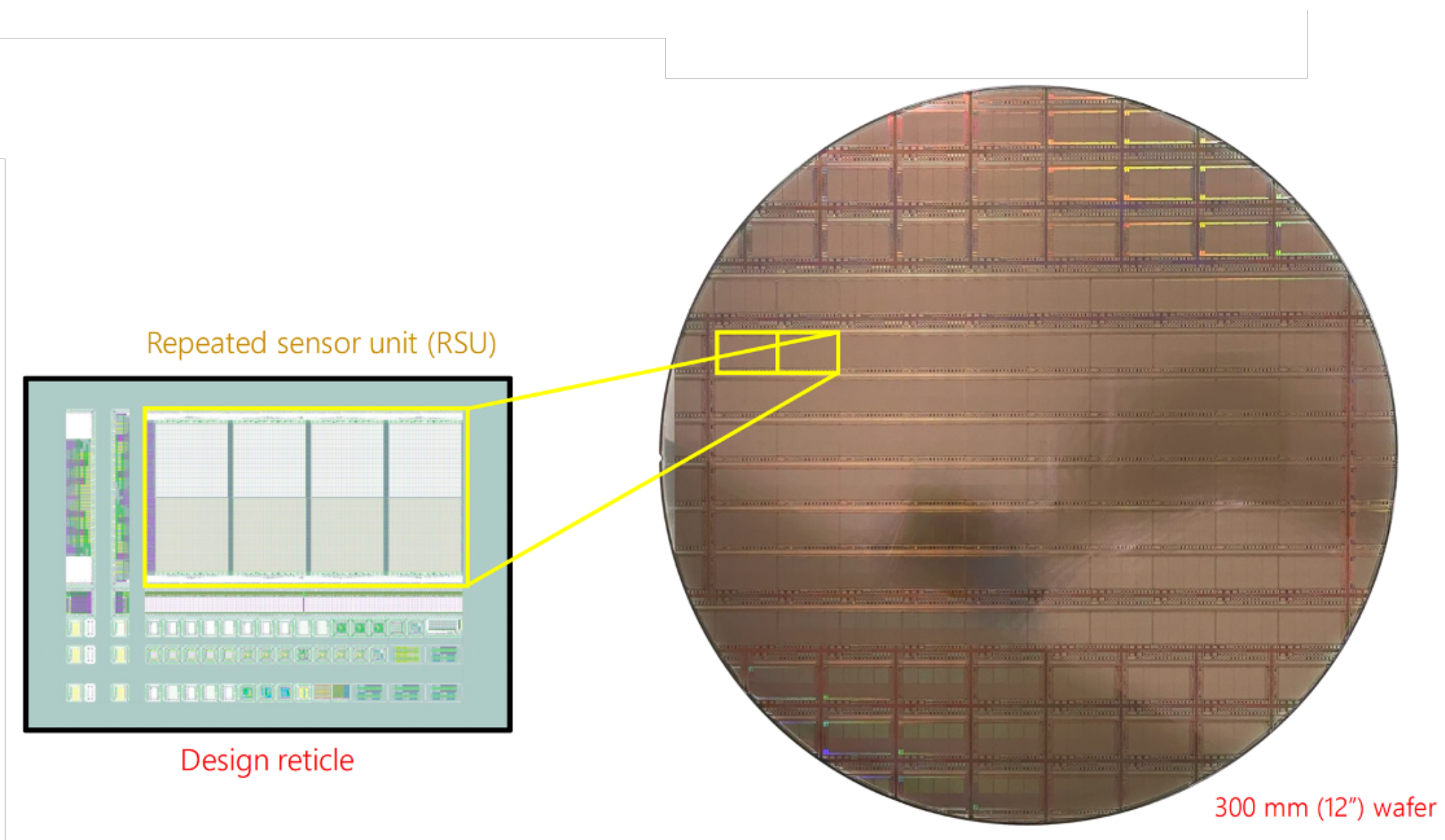
BACKUP

MIT PixEL ϕ : a Silicon Pixel Lab for ELeментарy physics at MIT

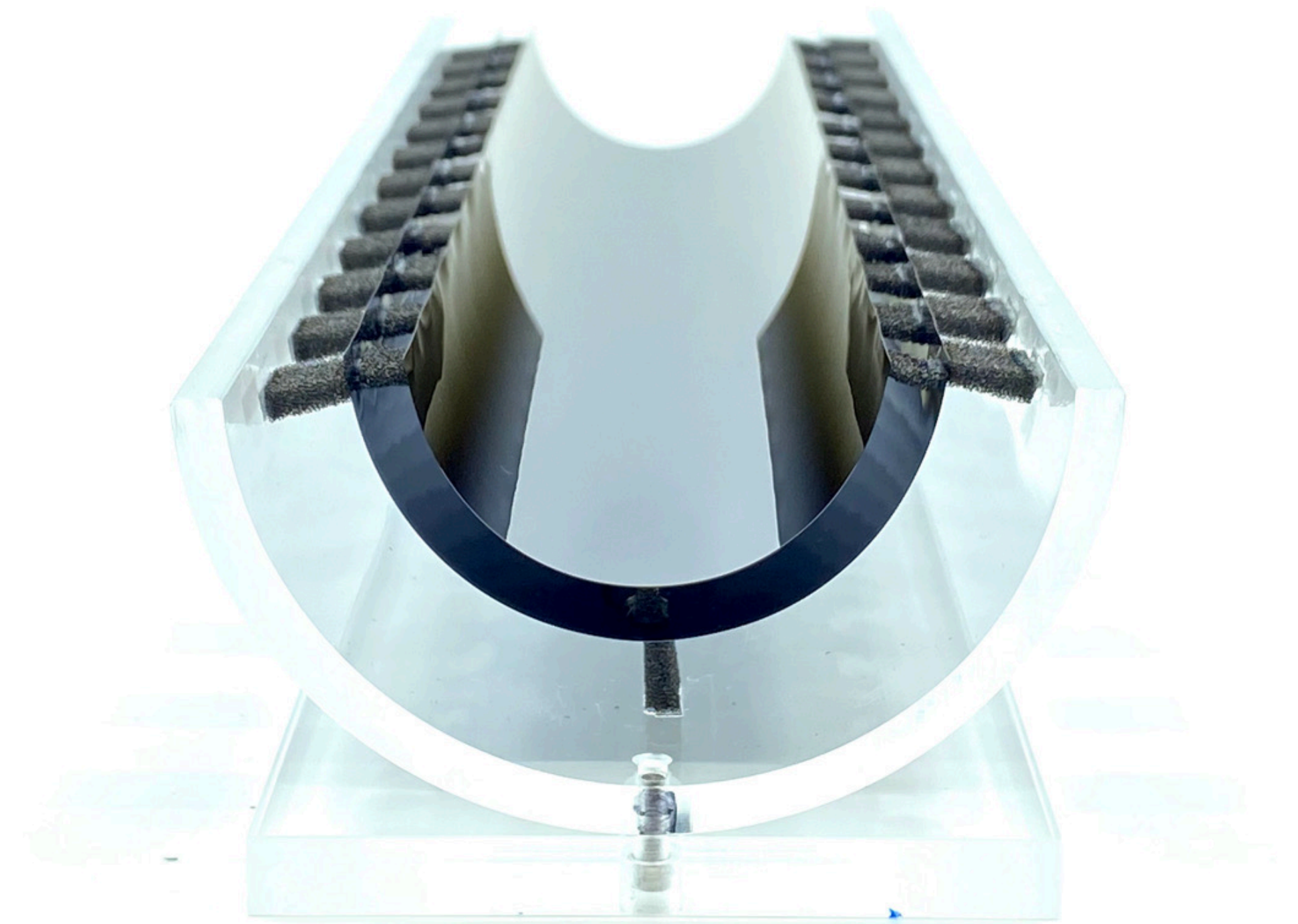
A new laboratory built at MIT to exploit a new cutting-edge silicon pixel technology:

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- large sensors with “stitching” techniques



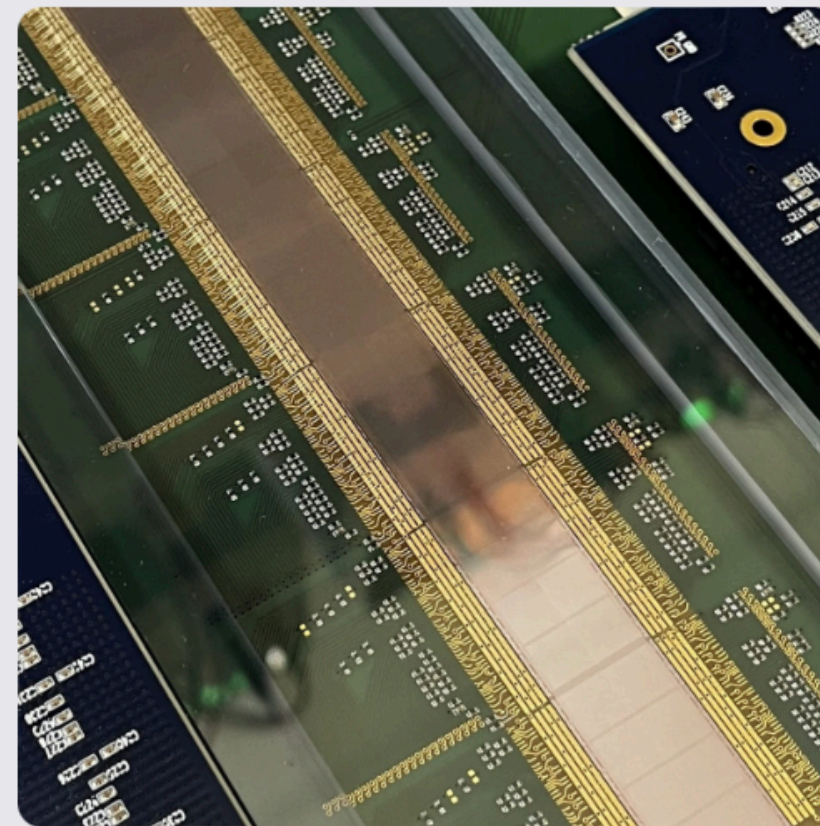
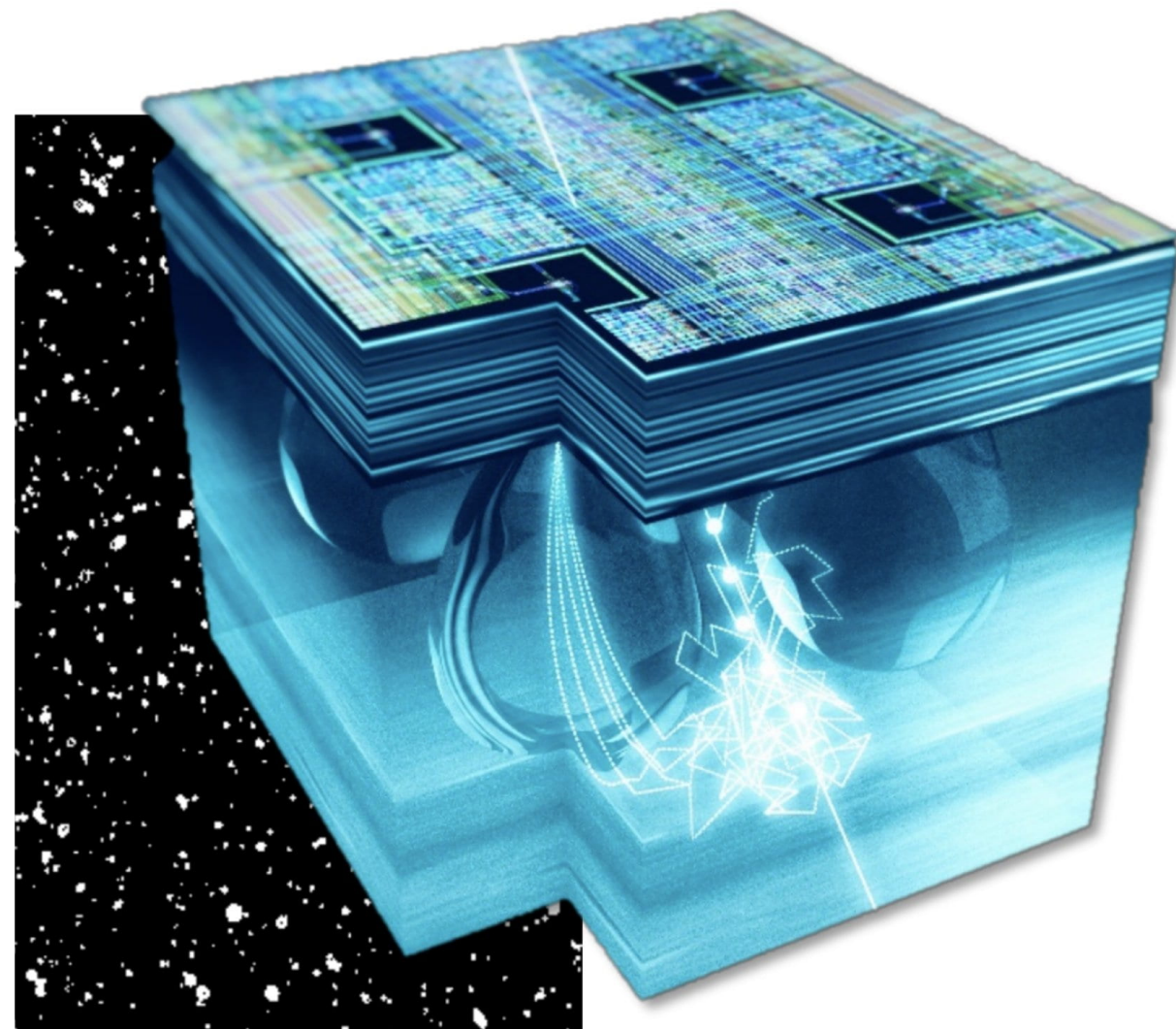
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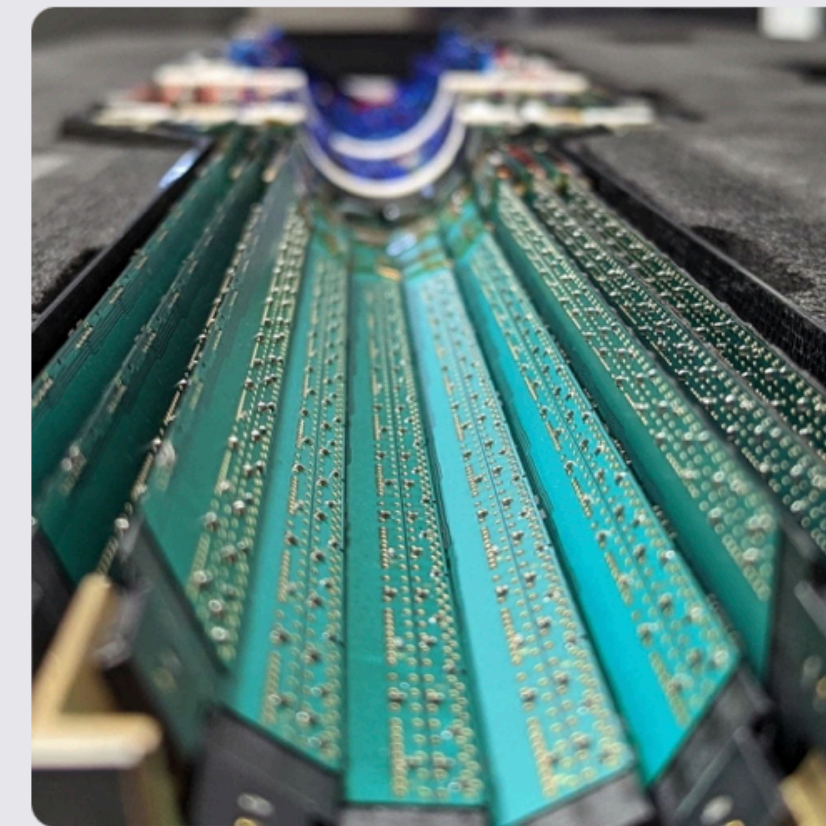
MIT PixEL ϕ : a Silicon Pixel Lab for ELeментарy physics at MIT

→ Next generation “stitched” MAPS technology for high-accuracy detectors for high-energy and nuclear physics

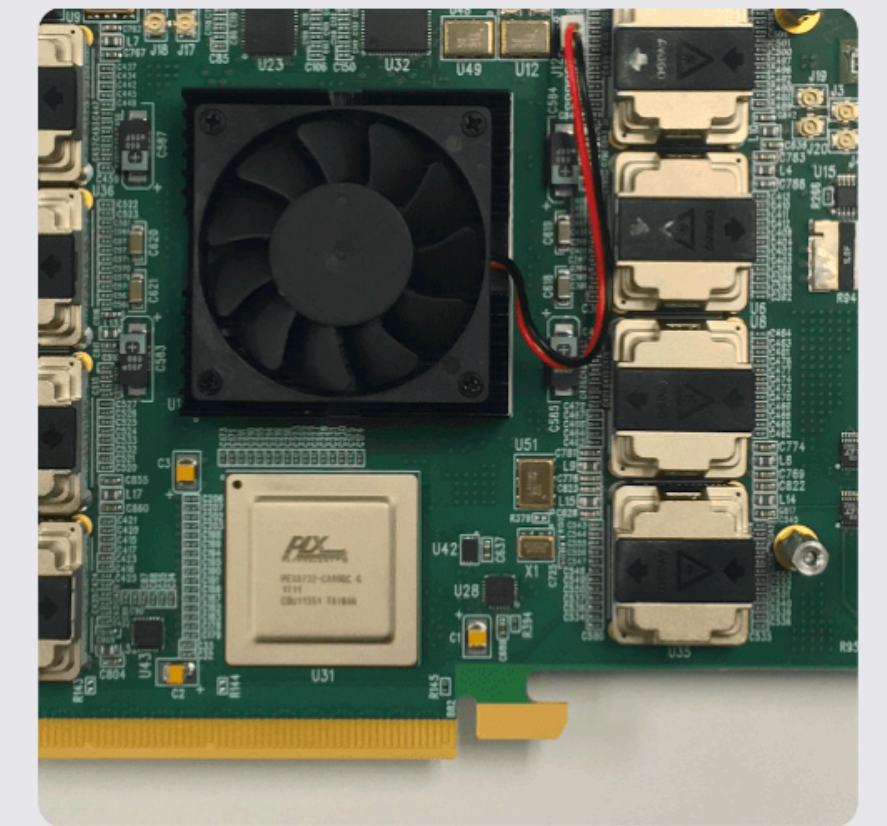
Ongoing projects



Silicon Vertex Tracker (SVT) for the ePIC experiment at the Electron-Ion Collider



MVTX for the sPHENIX experiment



Artificial intelligence with FPGA for MAPS detectors

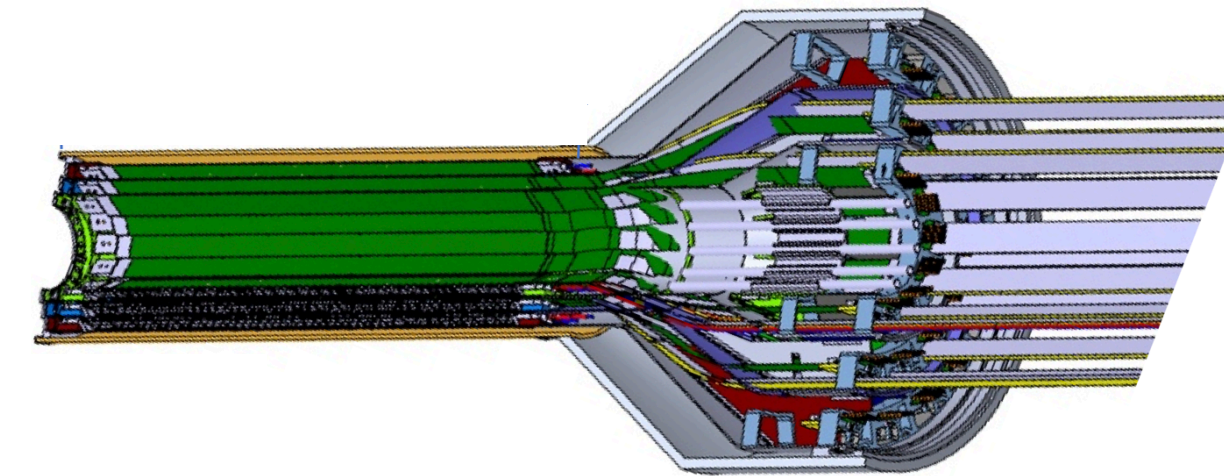
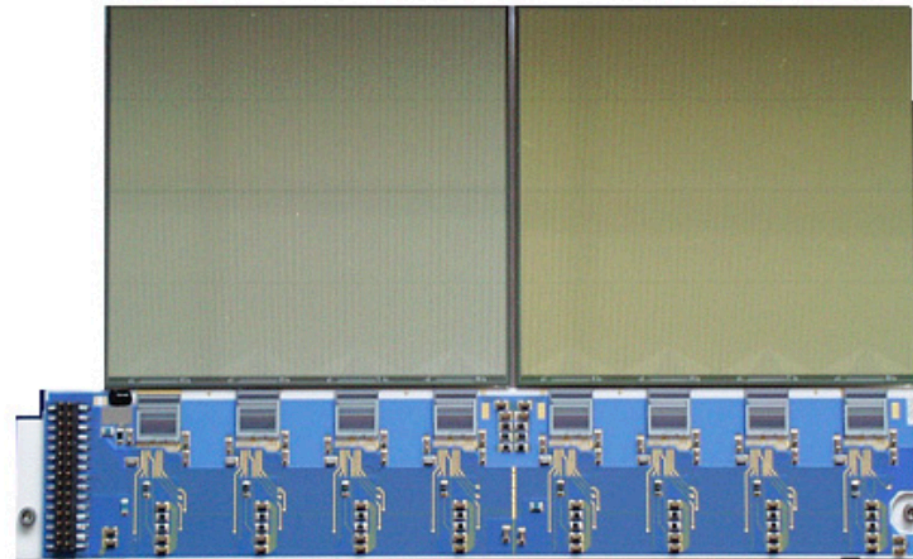
→ CERN-based MIT laboratory

Silicon detectors in the MIT heavy-ion group

→ Almost 30 years of experience in pixels detector design, construction, commissioning

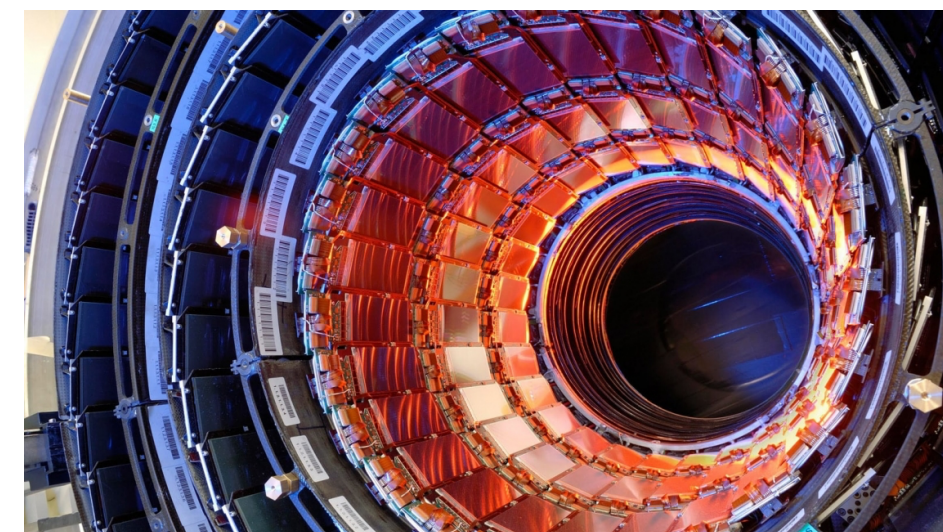
PHOBOS experiment at RHIC

AC-coupled, single-sided, silicon pad for tracking, vertexing, and multiplicity

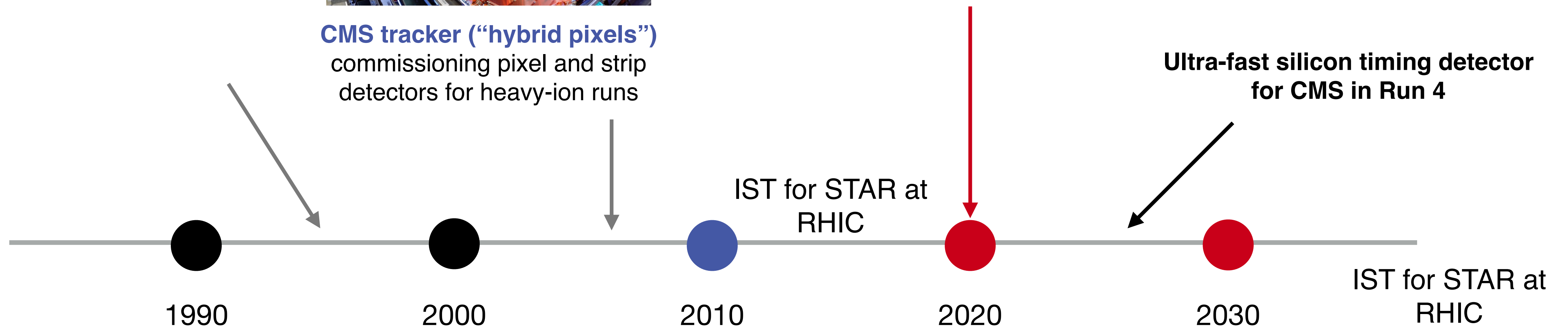


Monolithic Active Vertex Tracker (MVTX) for sPHENIX with ALICE ITS2 technology

- mechanical design, cooling, and integration
- module characterization
- DCS design, installation and commissioning



CMS tracker (“hybrid pixels”)
commissioning pixel and strip detectors for heavy-ion runs



SVT at the ePIC: timescale and synergies with the ITS3 project

Stronger synergy with ITS3 R&D

ePIC/EIC specific

