



The ePIC Silicon Vertex Tracker

Overview and workshop goals

Ernst Sichtermann (LBNL)

SVT Working Meeting

LBNL – October 8–9, 2026

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Why we are here – for discussion

1

Open information exchange on SVT

Status, plans, and challenges from sensors and ASICs through layers, disks and integration to readout and system tests

2

Institutions new to SVT

Capabilities, people and interests — and where there are ‘win-win’ opportunities to integrate within SVT

3

Advance deliverables, owners and dates

Collected through both days and closed out Friday 15:30; input to SVT institutional board, project, collaboration.

The two days at a glance

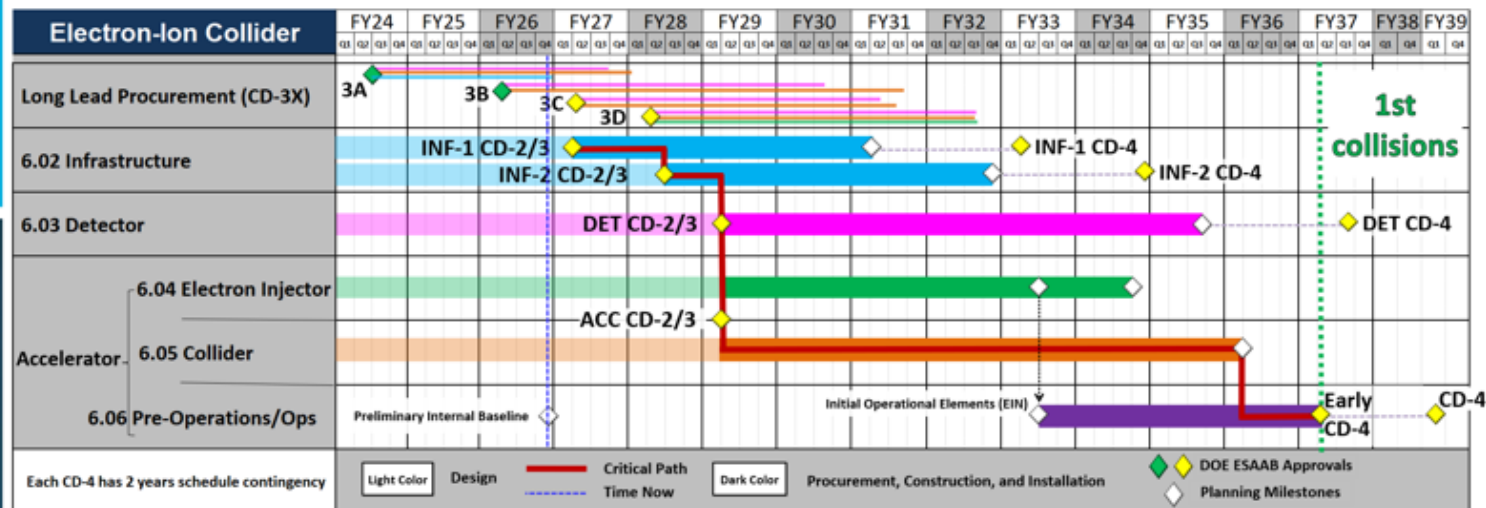
Thursday

- Institutional capabilities and interests
- Simulation · Outer Barrel · Inner Barrel
- Disk modules, assembly and test article
- Integration and installation · automated assembly

Friday

- Wafer probing, sensor QA, bench tests
- Ancillary ASIC, disk FPCs, beam tests
- DAQ, slow controls, streaming readout
- Chain and system tests · close-out

High Level Project Schedules



Strategic Schedule

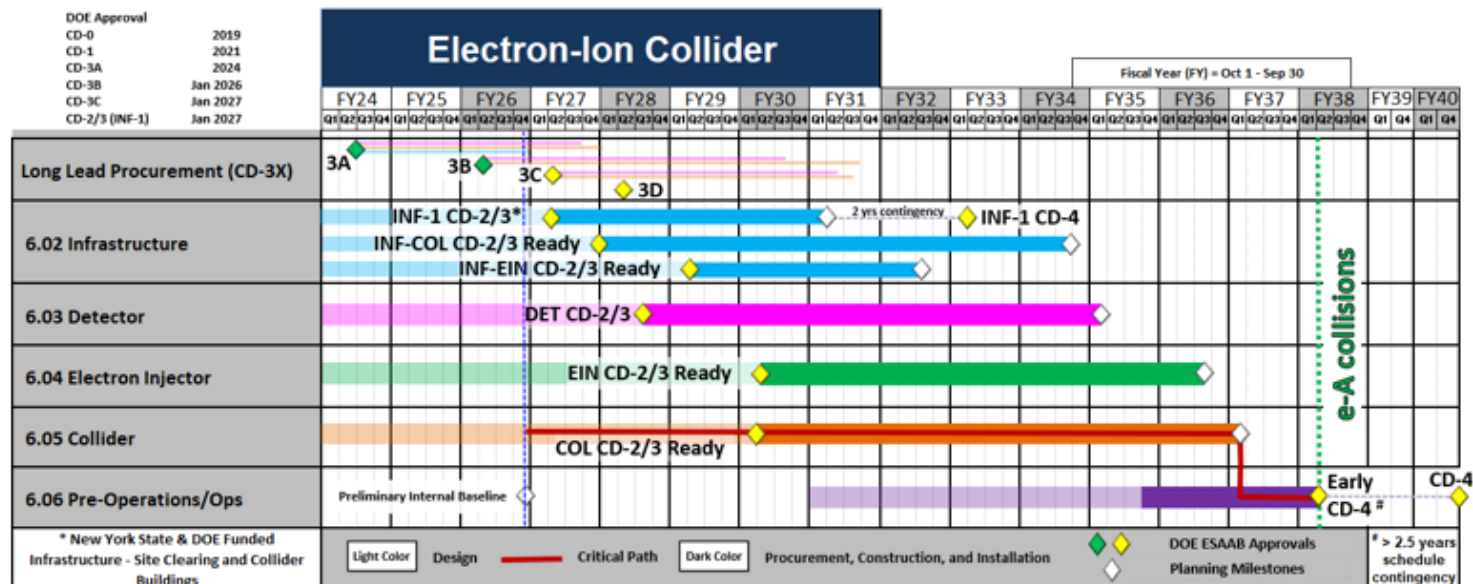
The strategic schedule integrates subproject sequencing, key approvals, and the path to early operations (as shown at DOE Review)

- Management tool that guides project planning efforts and is not currently supported by the P6 schedule.

PIB Schedule – Path to CD-4

Schedule shown contains no funding limitations beyond FY26 and no resource leveling

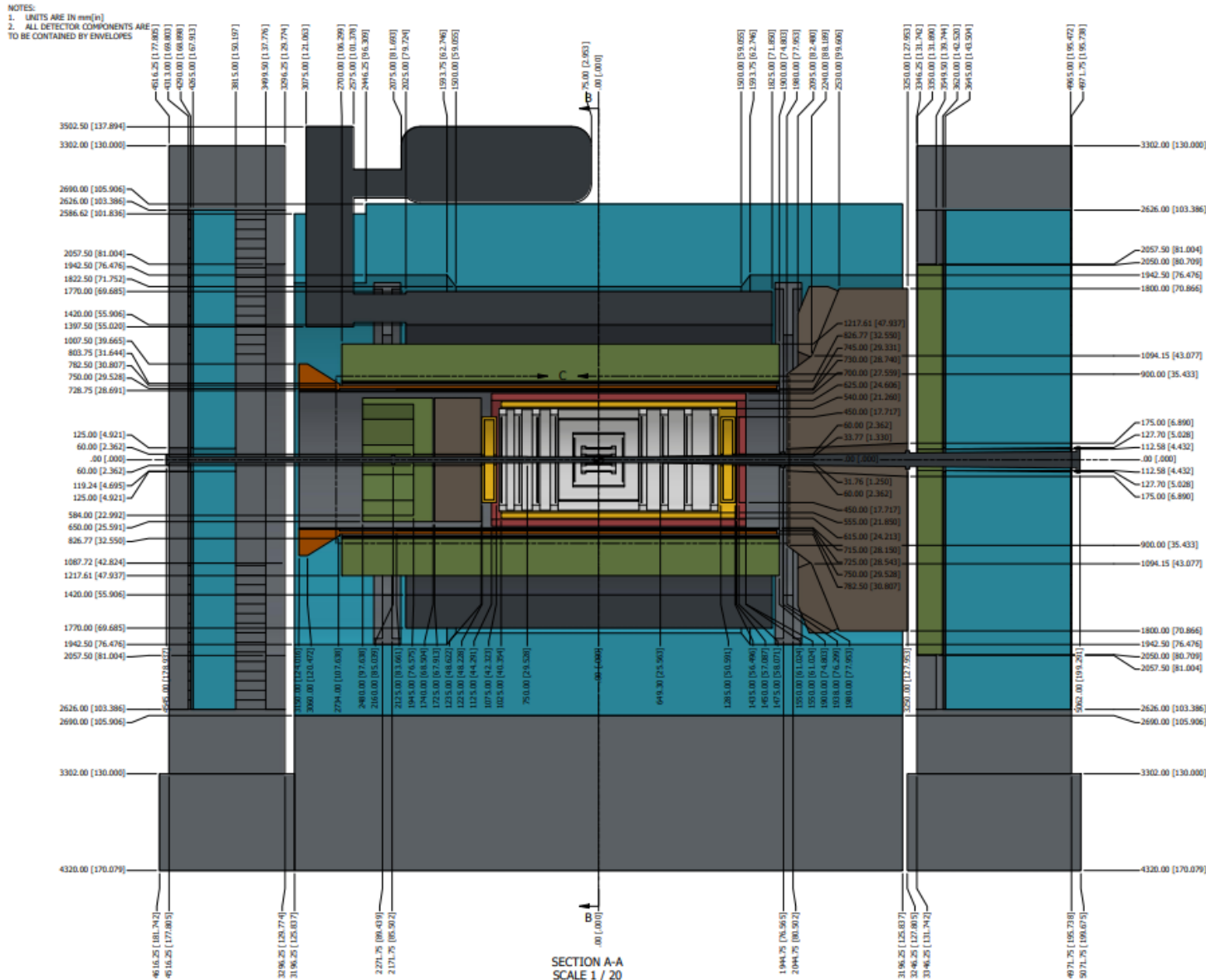
- Detector ready for (CD-2 in Q1/FY27 and CD-3 in Q3/FY28)
- CD-2 and CD-3 dates fully constrained by activities in PIB
- PIB schedule stretched out due incomplete accelerator installation schedule.



Electron-Ion Collider

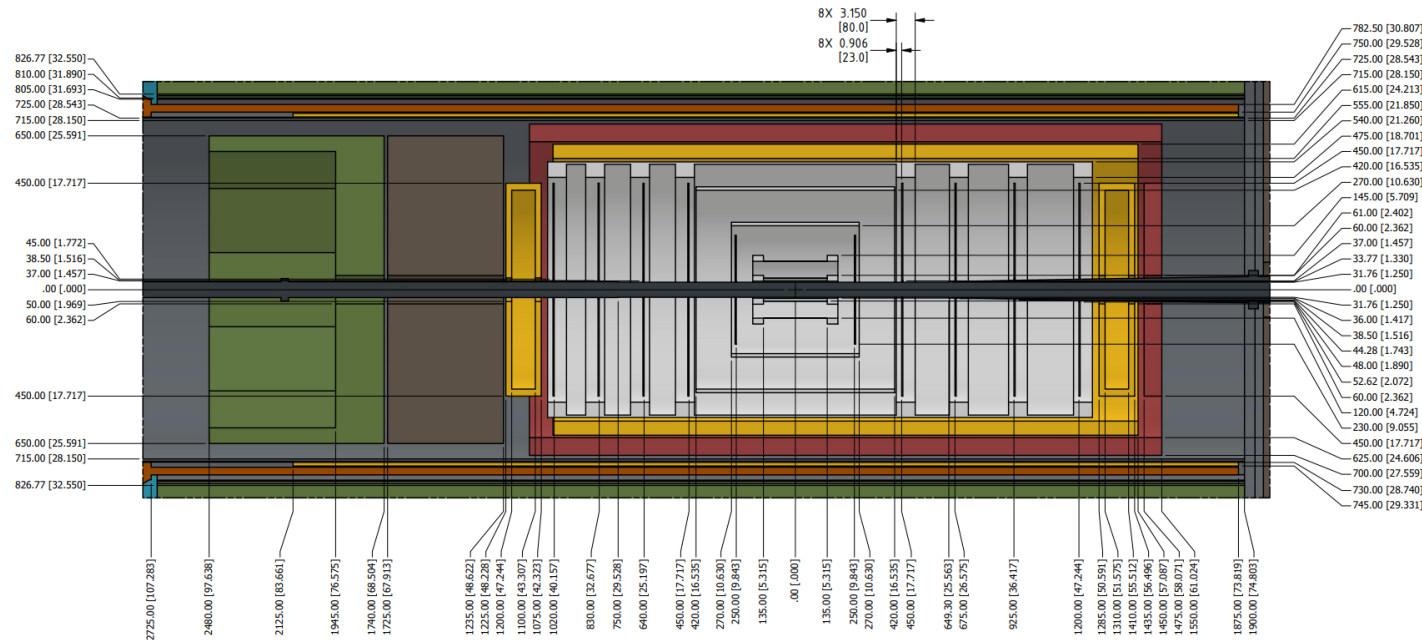
ePIC biweekly meeting September 25th, 2026

Where the SVT sits in ePIC



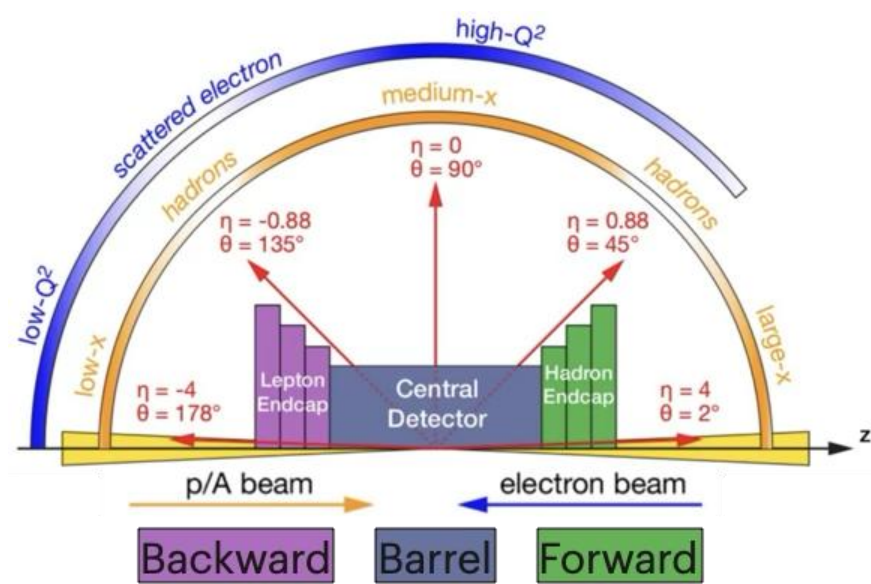
- Innermost subsystem of the ePIC central detector, inside the 1.7 T MARCO solenoid
- Silicon provides the precision space points and the vertex; MPGD layers (CyMBaL, μ RWELL) and AC-LGAD time-of-flight around it add points and timing
- Active volume $-105 < z < 120$ cm, $r \lesssim 42$ cm
- One of 26 subsystems, all with streaming readout

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What the physics asks of the SVT



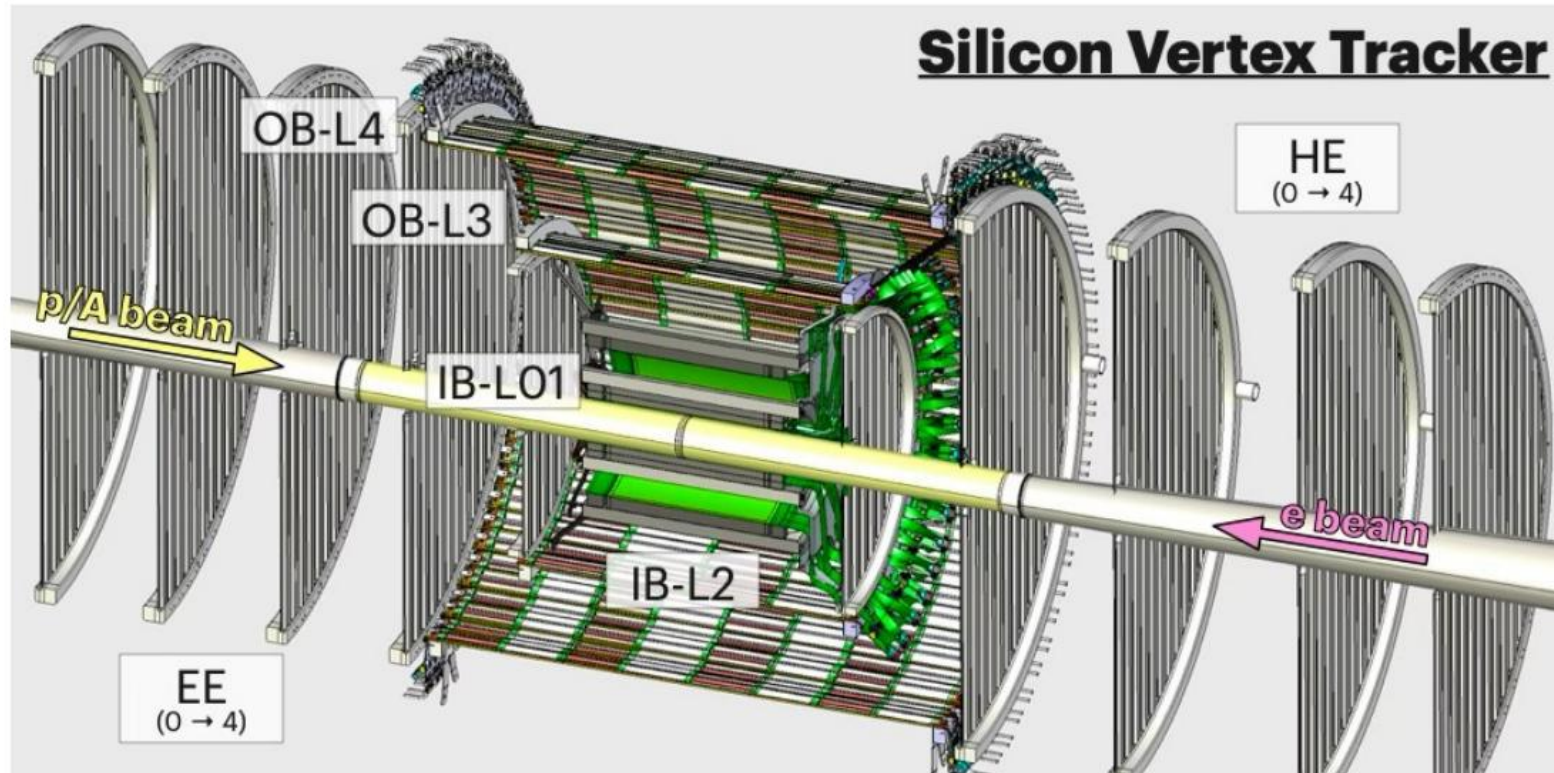
Pseudorapidity regions of the central detector (L. Gonella, VERTEX 2026)

η range	Δp/p [%]	DCA _r [μm]
-3.5 to -2.5	0.10·p ⊕ 2.0	30/pT ⊕ 40
-2.5 to -1.0	0.05·p ⊕ 1.0	30/pT ⊕ 20
-1.0 to 1.0	0.05·p ⊕ 0.5	20/pT ⊕ 5
1.0 to 2.5	0.05·p ⊕ 1.0	30/pT ⊕ 20
2.5 to 3.5	0.10·p ⊕ 2.0	30/pT ⊕ 40

Momentum in GeV; requirements at the event vertex

- **Precision:** single-point resolution better than 10 μm and minimal material in a 1.7 T field and ≈42 cm radius; charm and beauty decay lengths of ~100 μm set the pointing scale
- **Radiation:** mostly below 10¹¹ n_{eq}/cm²; up to a few hundred krad close to the beam pipe — modest by LHC standards
- **Rates:** physics below 0.5 MHz; 2 μs integration window; backgrounds dominate the hit load

Four regions, about 8.5 m² of silicon



Inner Barrel (IB)

- Three layers: L0, L1, L2
- Radii: 38, 50, 126 mm; length 27 cm
- $X/X_0 \approx 0.07\%$ per layer
- Bent, thin, wafer-scale ITS3 sensor

Outer Barrel (OB)

- Two layers: L3, L4
- Radii: 270 and 420 mm
- $X/X_0 \approx 0.25\%$ (L3) and 0.55% (L4)
- Hollow stave structure; EIC-LAS sensor

Endcaps (EE, HE)

- Two arrays of five disks: EE0–4, HE0–4
- Radii: 240 and 420 mm
- $X/X_0 \approx 0.25\%$ per disk
- Corrugated disk structure; EIC-LAS sensor

Overall dimensions

- $-1.05 \text{ m} < z < 1.2 \text{ m}$
- $r \lesssim 0.43 \text{ m}$ (active)

Sensors

- Monolithic active pixel sensors, TPSCo 65 nm
- Pixel pitch $O(20 \times 22.5) \mu\text{m}^2$
- Integration time $\leq 2 \mu\text{s}$
- Power density $\sim 40 \text{ mW/cm}^2$

Mechanics, services and cooling

- Aluminium-based flexible printed circuits
- Room-temperature operation, air cooling
- Carbon foam and carbon-fiber composite supports
- DAQ boards based on IpGBT, VTRX+, FELIX
- Serial powering for OB, EE and HE

The scale of what has to be built

16

MOSAIX sensors - IB

Inner Barrel: 3 layers, 6 half-layers, 68 stitched segments

1472

EIC-LAS sensors - OB

Outer Barrel: 736 dual EIC-LAS modules on 114 staves

~2200

EIC-LAS sensors - disks

10 disks; one EIC-LAS and one ancillary ASIC per module

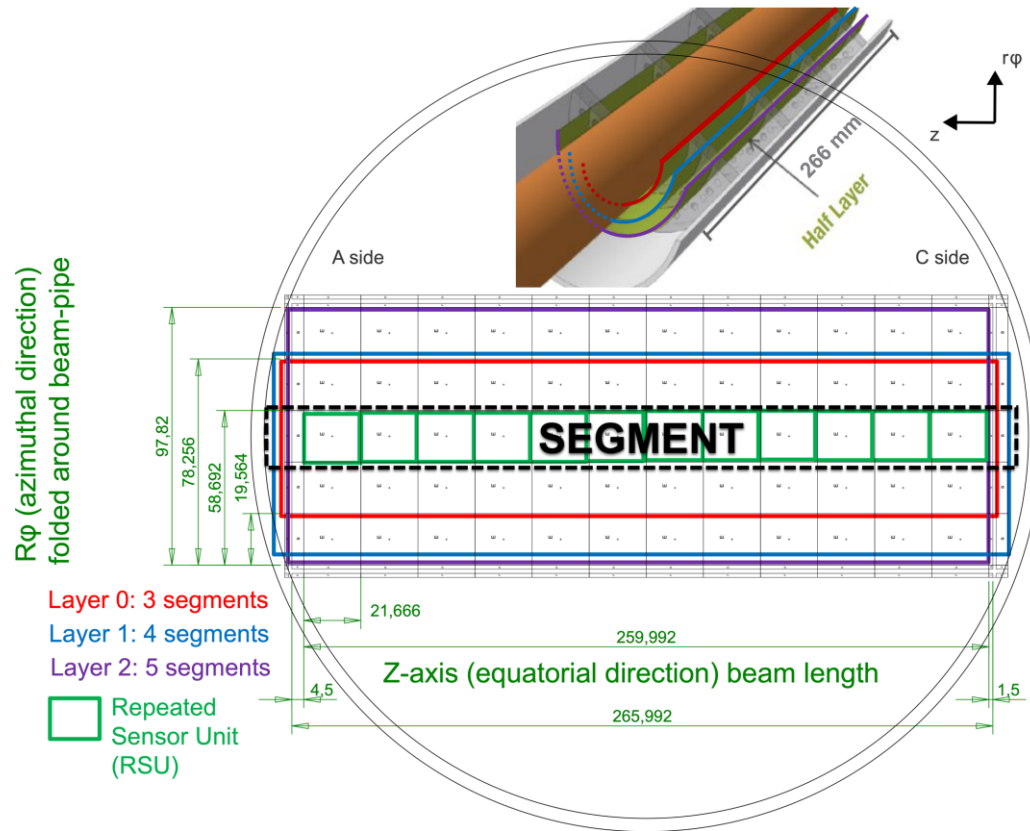
~8.5 m²

active silicon

of which ~8 m² in the Outer Barrel and disks

- The Inner Barrel is a small number of very delicate objects,
- The outer barrel and disks present a scaling challenge: several thousand modules to assemble, test, track and ship — sensor and module QA, assembly throughput (including automation) and system tests are where added capacity counts most

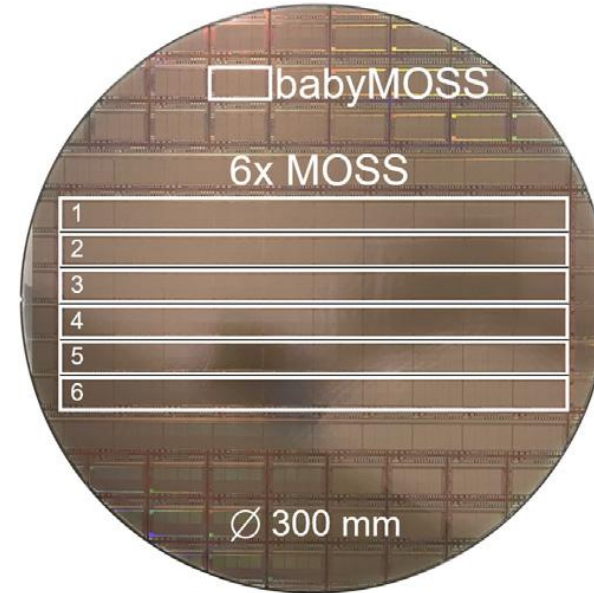
Two sensors from one design: MOSAIX and EIC-LAS



ALICE ITS3 Technical Design Report, CERN-LHCC-2024-003 / ALICE-TDR-021

- SVT Inner barrel uses MOSAIX, the ALICE ITS3 wafer-scale stitched sensor, in TPSCo 65 nm
- SVT Outer barrel and disks use EIC-LAS, to be modified from MOSAIX by reducing the repeated sensor units from 12 to 5–6, the high-speed data links from 8 to 1, the voltage of one power-domain, and the clock frequency

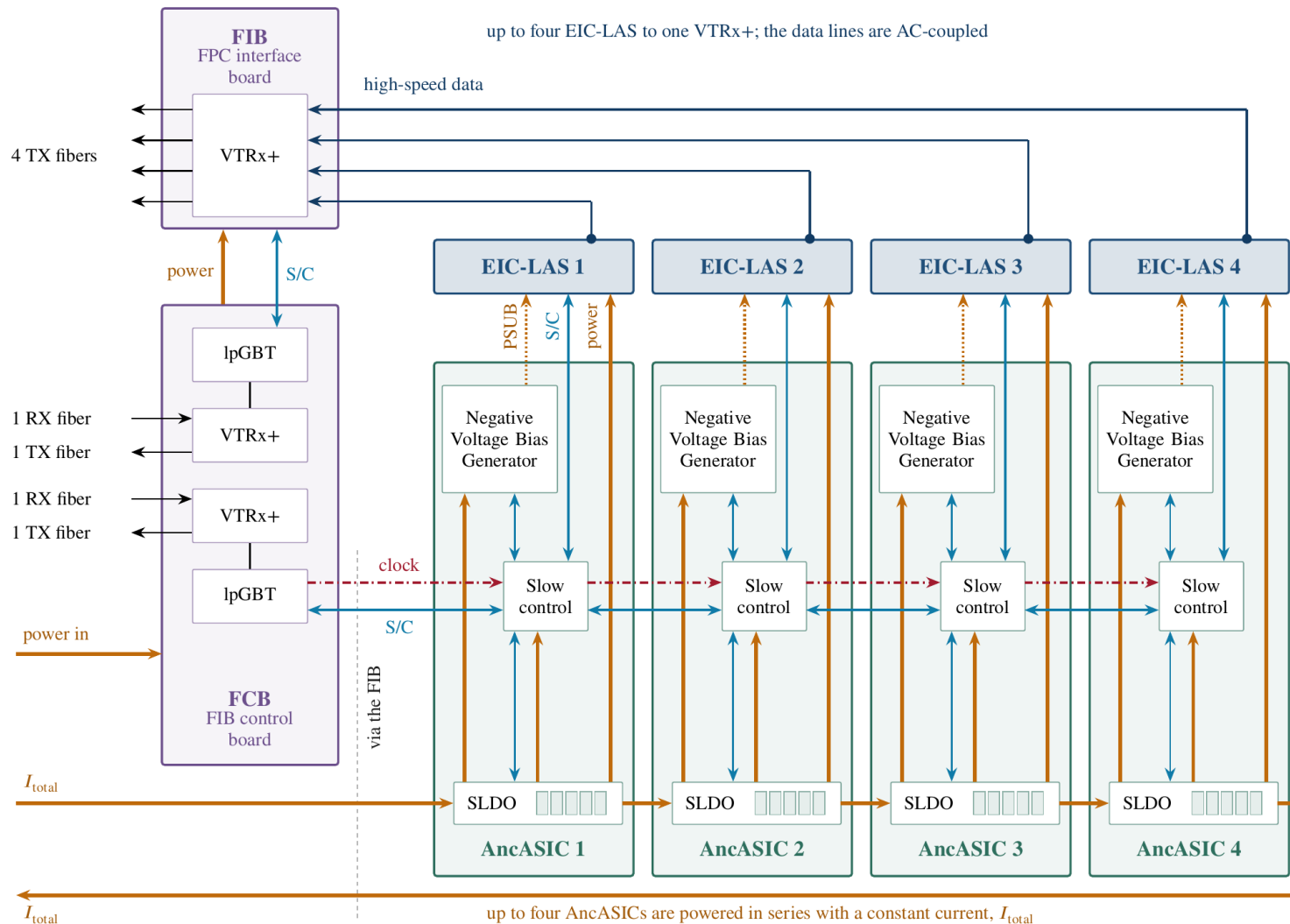
- ER1 is fully characterized:



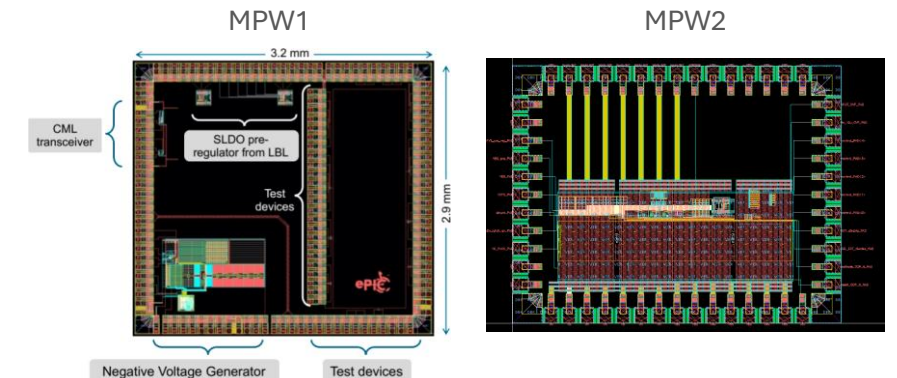
O. Abdelrahman et al., Nucl. Instrum. Meth. A 1086 (2026) 171297

- ER2 MOSAIX received February 2026; wafer probing at CERN, then thinning, dicing and distribution
- ER3 submission targeted for January 2027

Keeping the services light: the ancillary ASIC



- An ancillary ASIC minimizes the modifications that would otherwise need to be made to MOSAIX → EIC-LAS
- Reduces the services that would otherwise dominate the material budget
- Shunt-LDOs power the four sensor voltage domains — up to four AncASICs run in series on one current
- A programmable charge pump generates the negative sensor bias
- Slow control (AncBrain) is daisy-chained across AncASICs to cut traces and cables
- Up to four EIC-LAS to one VTRx+; data lines AC-coupled
- XFAB 110 nm BCD-on-SOI; MPW1, MPW2 tested; MPW3: full V1
- (Multiple EIC-LAS chains and FIBs per FCB)



How the three regions are built: test articles in hand

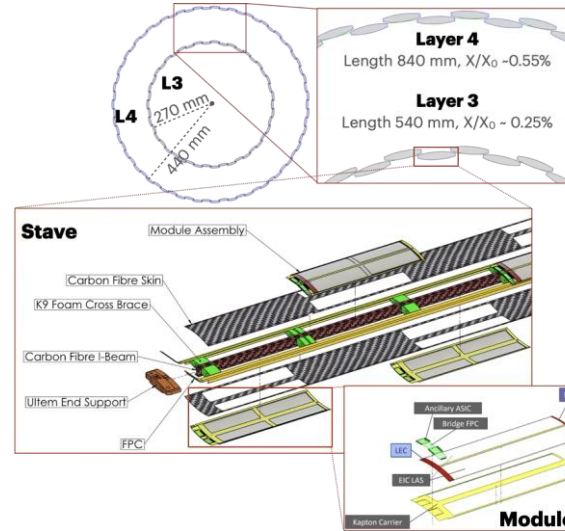
Inner Barrel



- Sensors $\leq 50 \mu\text{m}$ thick, bent to radius on carbon-foam supports; air cooling between layers
- L0–L1 half-barrel test articles validate tooling, thermal behavior and wire bonds under airflow

Today 13:00 — D. Elia

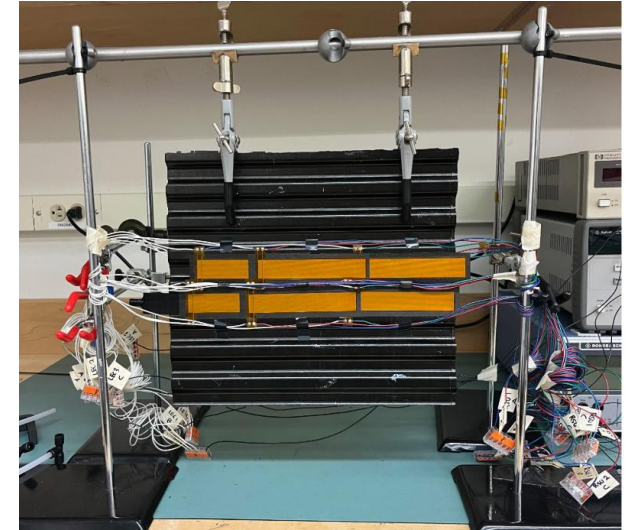
Outer Barrel



- Hollow carbon-fiber staves; two-sensor modules on both faces; air flows through the stave
- L4 test article: temperatures within specification, airflow-induced vibration below $1 \mu\text{m}$ RMS

Today 11:15 — J. Glover

Disks



- Corrugated carbon core, single-sensor modules tiled on both faces; air through the channels
- Heated core prototype shows clear forced-convection cooling; first mode above 100 Hz

Today 13:35 — N. Apadula, E. Buron

Expected tracking performance against the requirements

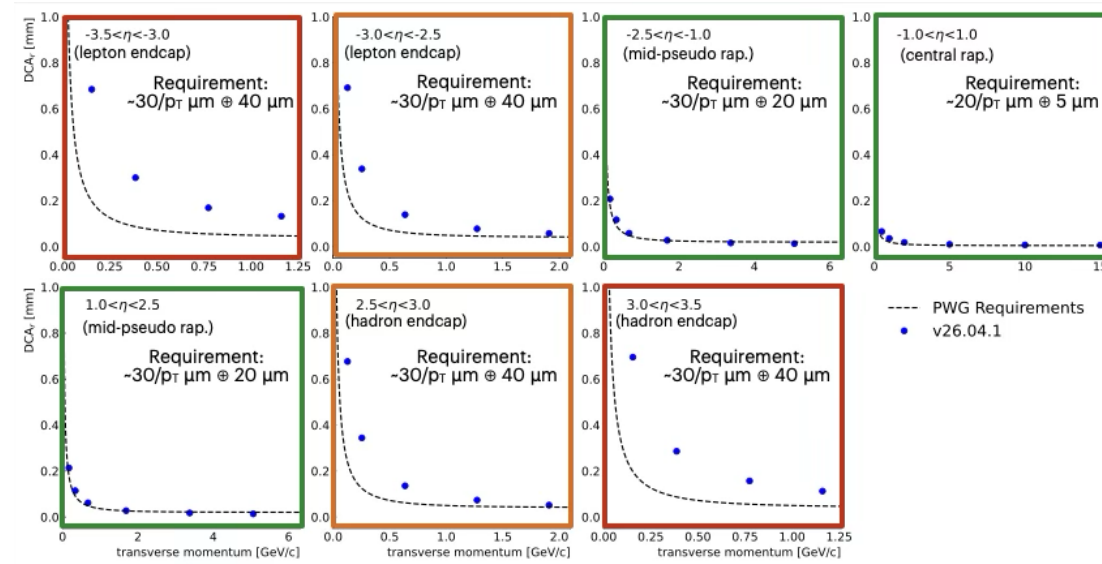
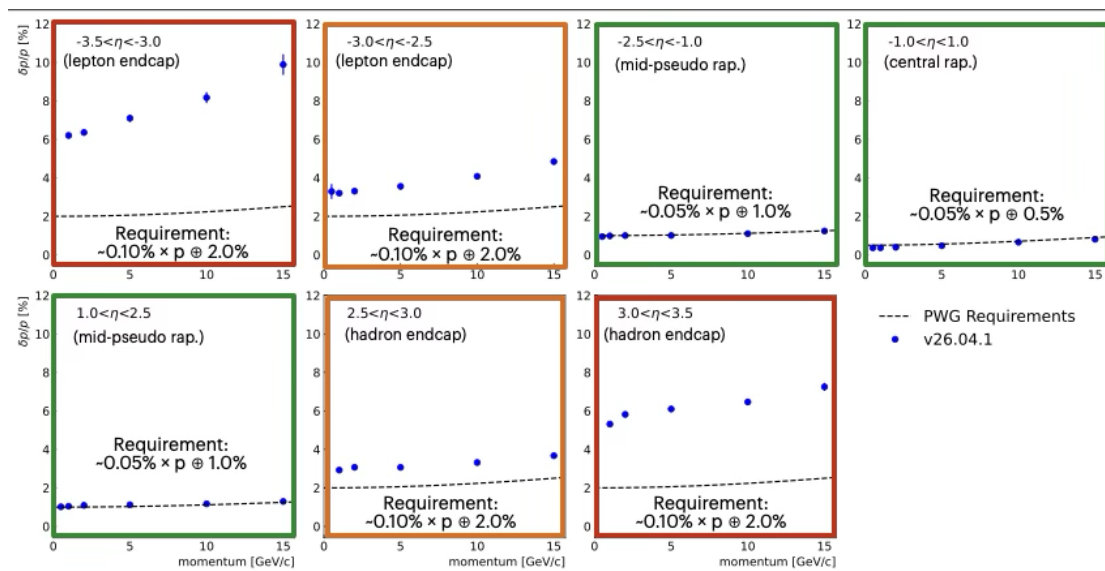
Relative momentum resolution

- Requirements met in the central region and at mid-pseudorapidity
- Fair agreement at large η
- Challenging at very large η , especially the lepton endcap

Pointing resolution

- Requirements met in the central region and at mid-pseudorapidity
- Good agreement at large η
- Fair agreement at very large η

Full-framework simulation: requirements met over $-2.5 < \eta < 2.5$, limited at the extremes by the lever arm; track-finding efficiency 88% on average, 98% above 5 GeV; purity 95%



Single pions, 0.5–15 GeV, generated at the nominal collision vertex and propagated through a preliminary detector design (geometry, material and point resolutions); recorded hits processed with the ACTS combinatorial Kalman filter.

Where we stand, and what drives the schedule

When	Milestone
Mar 2024	First incremental Preliminary Design Review
Jun 2024	Final Design Review for VTRx+ and lpGBT (early procurement)
Jan 2026	Second Preliminary Design Review: 60% design maturity; CD-3B approved
Feb 2026	MOSAIX ER2 sensors and pad wafers received
Autumn 2026	ER2 thinning, dicing and distribution; AncASIC MPW3 (complete V1)
Jan 2027	MOSAIX ER3 submission
2027	EIC-LAS V1 — timing depends on the CERN–DOE agreement
2028	Pre-production, then production; AncASIC V2
from 2032	SVT installation
2034+	Start of data taking

- MOSAIX and EIC-LAS design and production are on the critical path
- EIC-LAS needs access to the MOSAIX design database; the CERN–DOE agreement is not yet signed or in effect; this is among the biggest overall SVT risks
- The Inner Barrel remains MOSAIX-based in either case; ER2 purchase complete
- UK situation presents an intricate challenge
- MPGDs are the worst-case fallback at degraded performance

How the work is organized, and where it is designed and will be built

Work package	Leads
WP1 Sensor design	I. Sedgwick (RAL), J. de Melo (BNL)
WP2 Sensor testing	I. A. Cali (MIT), L. Tomasek (CTU)
WP3 Electrical interfaces	Z. Ye (LBNL), vacant
WP4 Layers and disks	D. Elia (INFN), G. Viehhauser (Oxford), N. Apadula (LBNL)
WP5 Readout and powering	J. Glover (Birmingham), J. Schambach (ORNL)
WP6 Global mechanics and integration	A. Jung (Purdue), B. Denos (Purdue)
WP7 Interlocks, slow control, monitoring	with the DAQ working group
WP8 Database	collaboration
WP9 Software and simulation	S. Li (LBNL), vacant -- collaboration

Detector subsystem collaboration: E. Sichtermann (LBNL, subsystem lead); R. Turrisi (INFN) and G. Viehhauser (Oxford), co-technical coordinators; V. Bhopatkar (JLab), project control account manager. About twenty institutions — and growing.

Where it is designed and will be built

Inner Barrel

Design, assembly and test in Italy

Outer Barrel

Design, assembly and test in the UK*

Disks

Design, assembly and test in the US *and Japan (goal)*

Integration

integration and installation at BNL

* UKRI defunded UK EIC effort, see also <https://indico.bnl.gov/event/33679/> This will inevitably need to change design-completion and assembly

The next two days: what each session should settle

When	Session	WP	To settle — and where help is needed
Thu 10:45	Simulations — S. Li	9	Geometry and material updates; who joins (not project-funded)
Thu 11:15	Outer Barrel — J. Glover	4, 5	Stave and module plans; test-article program
Thu 13:00	Inner Barrel — D. Elia	4	L2 tooling and test articles toward pre-production
Thu 13:35	Disks — N. Apadula, E. Buron	4	~2200 modules: assembly sites, throughput, test article
Thu 15:30	Integration, installation — J. Silber, B. Denos	6	Interfaces, services, installation sequence
Thu 17:00	Automated module assembly — B.-H. Lim	4	Where automation pays off in module production
Fri 9:00	Wafer probing, sensor QA, bench and AncASIC tests, FPCs, beam tests	1–3	QA flow and capacity; beam-test plan
Fri 13:00	DAQ, slow controls, streaming readout — J. Schambach, T. Gunji	5, 7	Readout chain and streaming interface
Fri 14:00	Chain and system tests — Z. Ye, J. Schambach	all	Test setups, sites and schedule
Fri 15:30	Close-out	—	Deliverables, owners, dates

Further pointers

Previous SVT working meetings

- July 2025 at CFNS Stony Brook, <https://indico.bnl.gov/event/28216/>
- December 2025 in Oxford, <https://indico.bnl.gov/event/30334/>

Recent overview talks by SVT colleagues

- L. Gonella, [Design and status of the ePIC SVT](#), VERTEX 2026, Stoos, 23 July 2026
- Z. Ye, [A MAPS Silicon Vertex Tracker for the ePIC experiment](#), PIXEL 2026, September 2026

Indico and mailing list(s)

- Indico: <https://indico.bnl.gov/category/496/>
- SVT general mailing list: <https://lists.bnl.gov/sympa/info/epic-svt-l>

Publications

- ePIC SVT Collaboration, *The Silicon Vertex Tracker for the ePIC experiment at the EIC*, NIM A, in preparation
- R. Turrisi (2026); S. Ciarlantini & C. Bonini (2026); M.T. Camerlingo (2026) — conference proceedings

Backup

Backup — operating environment and sensor specifications

Radiation (10 years, top luminosity, conservative)

- Most of the SVT below 10^{11} n_eq/cm²; innermost layers and hadron-going disks 10^{11} – 10^{12} n_eq/cm²
- TID 10 krad to a few hundred krad near the beam pipe; below 10 krad elsewhere

Rates

- Physics below 0.5 MHz; vertex region $|z| < 80$ – 100 mm; no in-crossing pileup
- 2 μ s integration window; hit probability $\sim 10^{-7}$ per pixel per frame
- Total data rate ~ 200 Gb/s (NIM-A draft; to be reconciled with design reports)

MOSAIX specification	Value
Pixel	$22.8 \times 20.8 \mu\text{m}^2$
Fill factor	93%; 144 independent tiles
Efficiency / fake-hit rate	$> 99\%$ / $< 0.1 \text{ pixel}^{-1} \text{ s}^{-1}$
Particle rate	4.4 MHz/cm^2
Off-chip data	30.72 Gb/s
Integration time	$\geq 2 \mu\text{s}$
Radiation tolerance	$10^{13} \text{ n_eq/cm}^2$; 10 kGy
Power	40 mW/cm^2

Backup — close-out template

Area	Deliverable	Owner (institution)	Needed by	Depends on
Sensor QA and wafer probing				
AncASIC and FPC tests				
Disk modules and assembly				
Outer Barrel staves and modules				
Inner Barrel layers				
Integration and installation				
DAQ, slow controls, streaming				
Chain and system tests				
Simulation				
NIM-A article				