Joint EIUCG/ePIC Collaboration Meeting

ePIC Electronics Development - MPGD

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L3 CAM WBS 6.10.08

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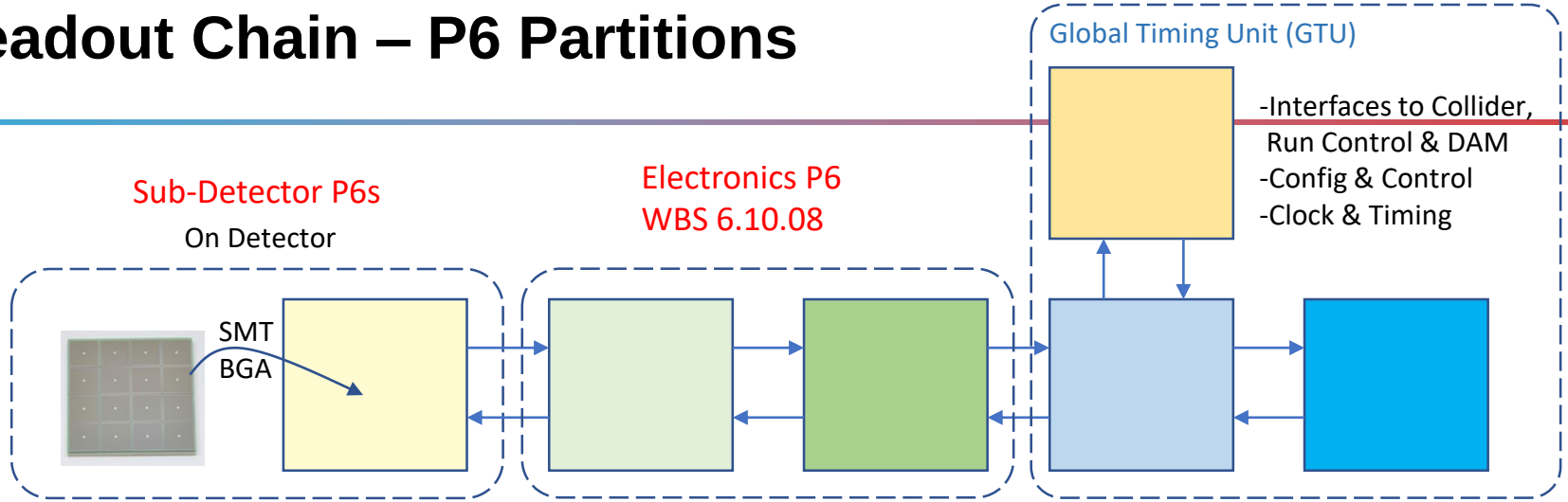
Electron-Ion Collider

Outline

- Streaming Readout
  - Chain, Interconnection Model
- eRD109 Initiatives
- SALSA
- Resources
- Timeline
- Outlook

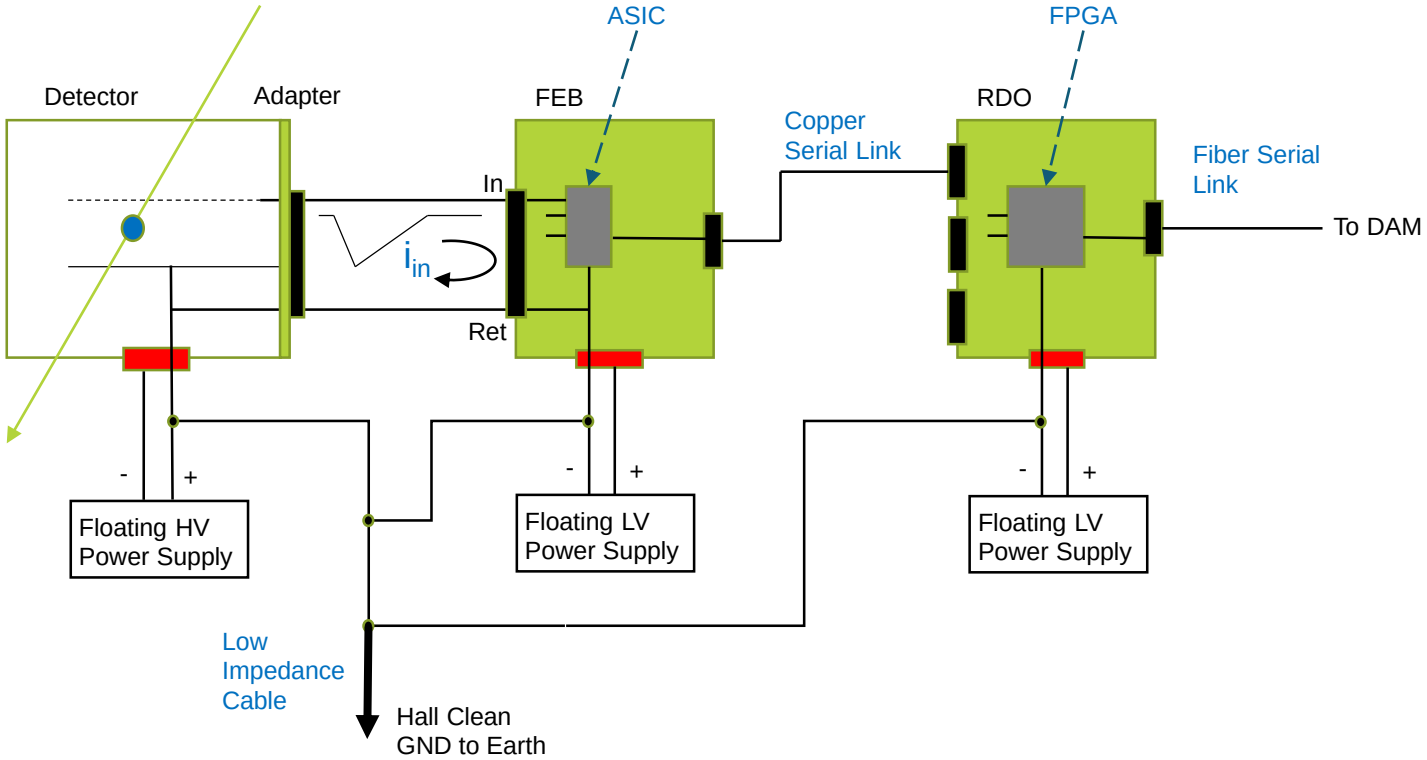
Streaming Readout Chain – P6 Partitions



Name	Sensor	Adapter	Front End Board (FEB)	Readout Board (RDO)	Data Aggregation Module (DAM)	Computing
Design	Detector Specific	Detector Specific	Detector Specific	Few Variants	Common	Common
Function	-Multi-Channel Sensor	-HV/Bias Distribution -HV divider -Interconnect Routing	-Amplification -Shaping -Digitization -Zero Suppression -Bias Control & Monitoring	-Communication -Aggregation -Formatting -Data Readout -Config & Control -Clock & Timing	-Computing Interface -Aggregation -Software Trigger -Config & Control -Clock & Timing	-Data Buffering and Sinking -Calibration Support -QA/Scalers -Collider Feedback -Event ID/Building -Software Trigger -Monitoring
Attributes	-MAPS -AC-LGAD -MPGD -MCP-PMT -SiPM -LAPPD	-Sensor Specific -Passive	-ASIC/ADC -Discrete -Serial Link	-FPGA -Fiber Link	-Large FPGA -PCIe -Ethernet	-COTS -Ethernet

❖ Nomenclature standardized after August 2022 Electronics & DAQ Review (PDR 1) .

Interconnection Model



- Consider low impedance and multiple connections for input signal return currents.
- Floating power supplies allow for GND reference at the detector to the hall clean GND column in IP6.
- Make provisions for GND connections on PCBs and detectors.
- Consider segregating sub-detector systems' grounding.
- Use low impedance cables.

eRD109 Initiatives

- Addresses ASIC and Electronics R&D needs.
- FY23 Proposals submitted in October 2022 (DAC R&D Review August 2022)
  - Contract awards took longer than expected.
- FY24 Proposals submitted in July 2023 (DAC R&D Review August 2023)
  - Contract awards should now be in synch with FY funding
  - Continuation of previous work.
- FY25 Proposals due 1 July 2024 (DAC R&D Review August 2024)

- R&D completion dates have been included in P6
  - Si-related R&D tends to have longest times to complete
  - ASIC completion is ~4 years, compatible with EIC detector schedule.
- ASIC & Electronics:
  - Discrete/COTS – Calorimeters, SiPMs, 12-14 bit
  - CALOROC – Calorimeters, SiPMs, 10 bit *
  - EICROC - AC-LGAD, pixel *
  - FCFD – AC-LGAD, strip
  - ALCOR – dRICH, SiPM, 1 p.e.
  - SALSA – MPGD.

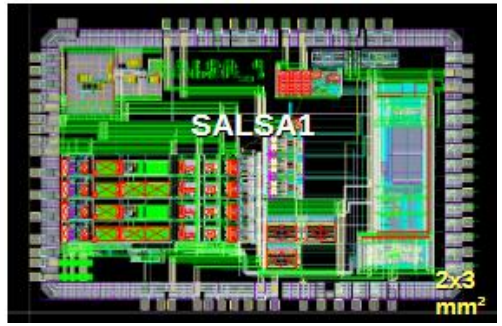
*Considerable commitment of resources by OMEGA/IN2P3.

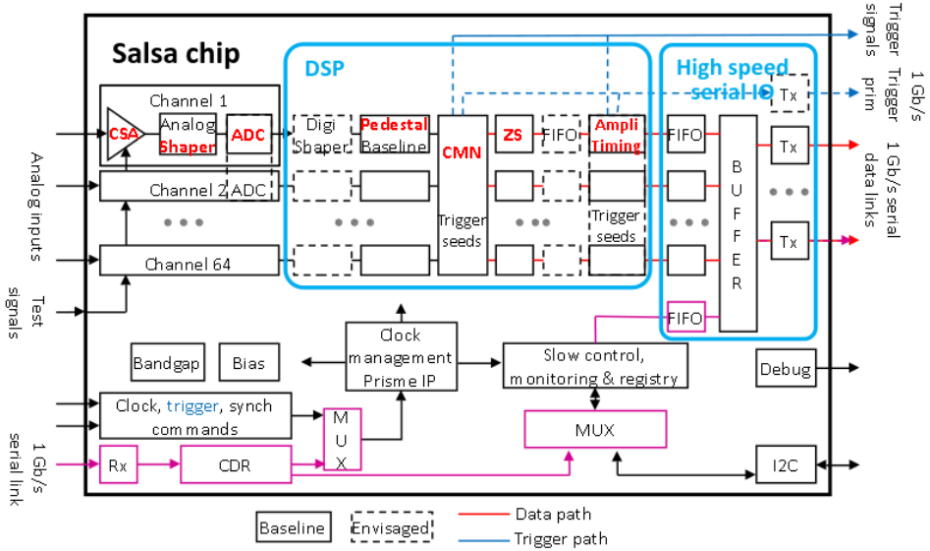
- Original plan: R&D until mid-FY27.
- But … No additional OPC funds for R&D.
- FY25 is the last year for eRD109 submissions.
- FY25 funds SALSA proposal to completion.
- FY26+ funds from activities in P6 for Engineering & Design (PED) and construction.

SALSA

MPGD – SALSA (CEA-Saclay, U. Sao Paulo)

- 64 Ch
- 65 nm CMOS
- Peaking time: 50 – 500 ns;
- Inputs: Cdin<200 pF; Dual polarity; Q: 3 – 250 fC
- ADC: 12 bits, 5 – 50 MSPS.
- Extensive data processing capabilities
- I2C configuration.
- Triggerless and triggered operation;
- Several 1 Gbps links.
- Power: 15 mW/Ch; Radiation Tolerant.





- Approximate quantities and costs.
- Costs include mask sets, fabrication and packaging, wrt quantities needed.

	#Ch	#Ch/Unit	#ASICs/ Wafer	#Wafers	Node (nm)	Packaging	Cost/ch ($)
SALSA	202 k	64	500	9	65	BGA	4.1

- Production
  - 65 nm: $750 k masks + $3.5 k per wafer
  - Packaging BGA: $3-$7.5 per chip.

- SALSA0 (IP blocks): FY23
- SALSA1: FY23 – FY24
- SALSA2: FY23 – FY25
- SALSA3: FY25 – FY26
- SALSA: FY27 – FY28

Resources – Design, Development, Construction

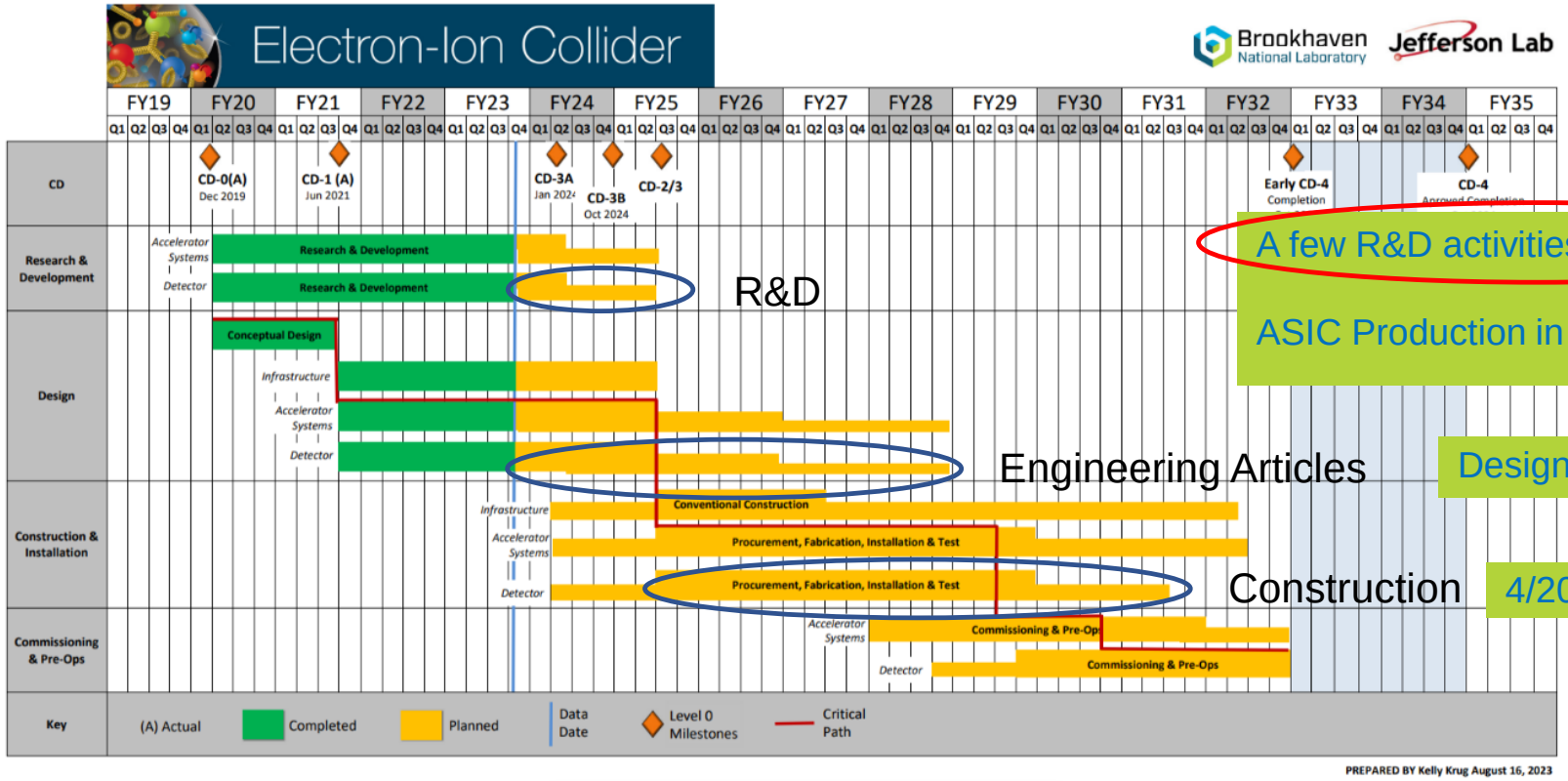
Detector System		Channels	SensorTechnology	Redout Technology	Institution
Si Tracking					
	3 vertex layers	7 m^2	MAPS	lpGBT, VTRX+	STFC, UK, ORNL
	2 sagitta layers	368 pixels	MAPS	lpGBT, VTRX+	STFC, UK, ORNL
	5 backward disks	5,200 MAPS sensors	MAPS	lpGBT, VTRX+	STFC, UK, ORNL
	5 forward disks		MAPS	lpGBT, VTRX+	STFC, UK, ORNL
MPGD Tracking					
	Barrel, e & H Endcaps	202 k	uRWELL, MicroMegas	SALSA	CEA, OMEGA, JLab
Forward Calorimeters					
	LFHCAL	63,280	SiPM	CALOROC	ORNL, Debrecen
	HCAL Insert	8 k	SiPM	CALOROC	ORNL, Debrecen
	pECAL W/SciFi	16,000	SiPM	Discrete	IU
Barrel Calorimeters					
	HCAL	7,680	SiPM	CALOROC	ORNL, Debrecen
	ECAL SciFi/Pb	5,760	SiPM	CALOROC	U Regina, ORNL
	ECAL Imaging Si ASTROPIX	500 M pixels	Astropix		KIT,NASA (GSFC), ANL
Backward Calorimeters					
	nHCAL	3,256	SiPM	CALOROC	ORNL
	ECAL (PWO)	2,852	SiPM	Discrete	IU, EEEMCAL Consortium
Far Forward					
	B0: 3 Crystal Calorimeter	135	SiPM/APD	Discrete	IU, JLab
	B0: 4 AC-LGAD layers	688,128	AC-LGAD Pixel	EICROC	IJCLab, OMEGA, BNL, ORNL, Rice
	2 Roman Pots (RP)	524,288	AC-LGAD Pixel	EICROC	IJCLab, OMEGA, BNL, ORNL, Rice
	2 Off Momentum (OMD)	294,912	AC-LGAD Pixel	EICROC	IJCLab, OMEGA, BNL, ORNL, Rice
	ZDC: Crystal Calorimeter	900	SiPM/APD	Discrete	IU, JLab
	ZDC: HCAL	9,216	SiPM	CALOROC	ORNL, Debrecen, JLab
Far Backward					
	Low Q Tagger 1	33,030,144	Timepix4		U. Glasgow
	Low Q Tagger 2	33,030,144	Timepix4		U. Glasgow
	Low Q Tagger 1+2 Cal	420 (2x210)	SiPM	CALOROC	U. York
	2 Lumi PS Calorimeter	3,360 (2x1680)	SiPM	Discrete	U. York
	2 Lumi PS Tracker	128,000 (2x64,000)	AC-LGAD Strip	FCFD/EICROCx	FNAL, OMEGA, Hiroshima, NTU, ORNL, UIC, UH, Rice, KSU, Tokyo
	Lumi Direct Photon Calorimeter	100	SiPM	Flash250	AGH Krakow, JLab
PID-TOF					
	Barrel bTOF	2,359,296	AC-LGAD Strip	FCFD/EICROCx	FNAL, OMEGA, Hiroshima, NTU, ORNL, UIC, Rice, BNL, KSU, Tokyo
	Hadron Endcap fTOF	3,719,168	AC-LGAD Pixel	EICROC	IJCLab, OMEGA, BNL, ORNL, Rice
PID-Cherenkov					
	dRICH	317,952	SiPM	ALCOR, VTRX+	INFN (BO, FE, TO)
	pfRICH	69,632	HRPPD	FCFD/EICROCx	BNL, FNAL, JLab
	hpDIRC	73,728	MCP-PMT or HRPPD	FCFD/EICROCx	BNL, FNAL, JLab

Responsibilities for development of the electronics needs to be well defined and assigned.

- Institutions – expressions of Interest.
- BNL, JLab – Support as needed.
- Covering Adapters, FEBs, RDOs, GTUs, DAMs.

Timeline - Project

- Construction and Installation includes procurements and deliveries and are initiated at different times of this phase.



Refer to slide 5

A few R&D activities until mid FY27

ASIC Production in FY25 – FY28

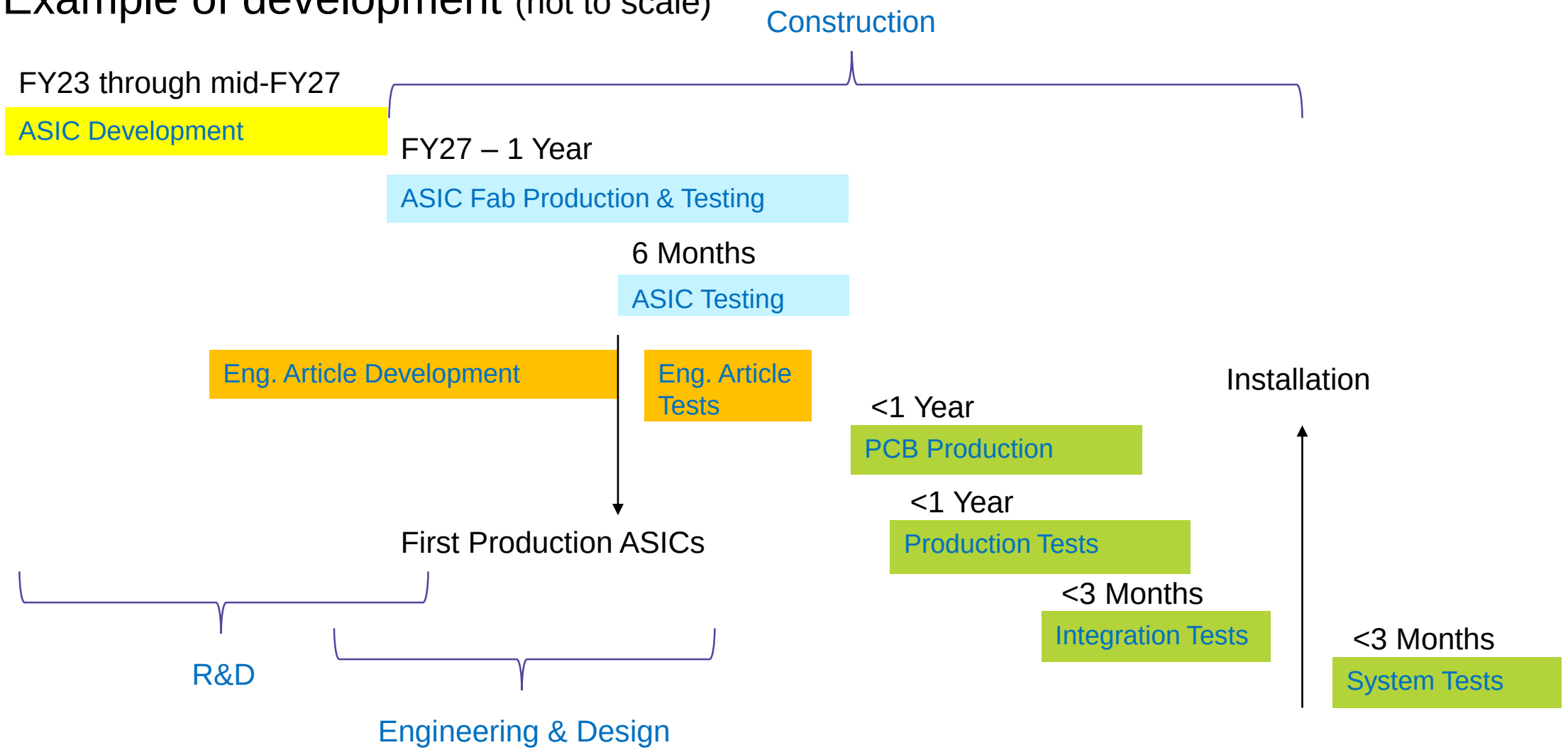
Design until 9/2028

4/2025 to 4/2031

- ❑ Bulk of Construction & Installation phase for Electronics: April 2025 – October 2029.
- ❑ Installation of some items may be extended to April 2031.

Timeline cont. – Development to Installation

- Example of development (not to scale)



Timeline cont. - Installation

Charge 3

eRD102	eRD109	R&D Milestones	FEB QC Complete
Calorimeters	Discrete, CALOROC	30 September 2025	Mar 2028 – Jan 2030
AC-LGAD	EICROC, FCFD	30 September 2025	Nov 2027 – Jan 2029
dRICH	ALCOR	2 January 2026	Nov 2028
MPGD	SALSA	31 March 2026	Sep 2028 – Jun 2029
LAPPD/MCPMT	FCFD/EICROCx	23 December 2026	Sep 2028 – Jan 2029

- eRD102 – Electronics for detectors R&D.
- eRD109 – Readout R&D.
- R&D Milestones – ASICs ready for production.
- ASIC Production FY25 – FY28.
- FEB QA/QC Complete – Ready for integration.

FY23 – FY26 FY25 – FY28

R&D (eRD109)

ASIC Production

FY26 – FY29

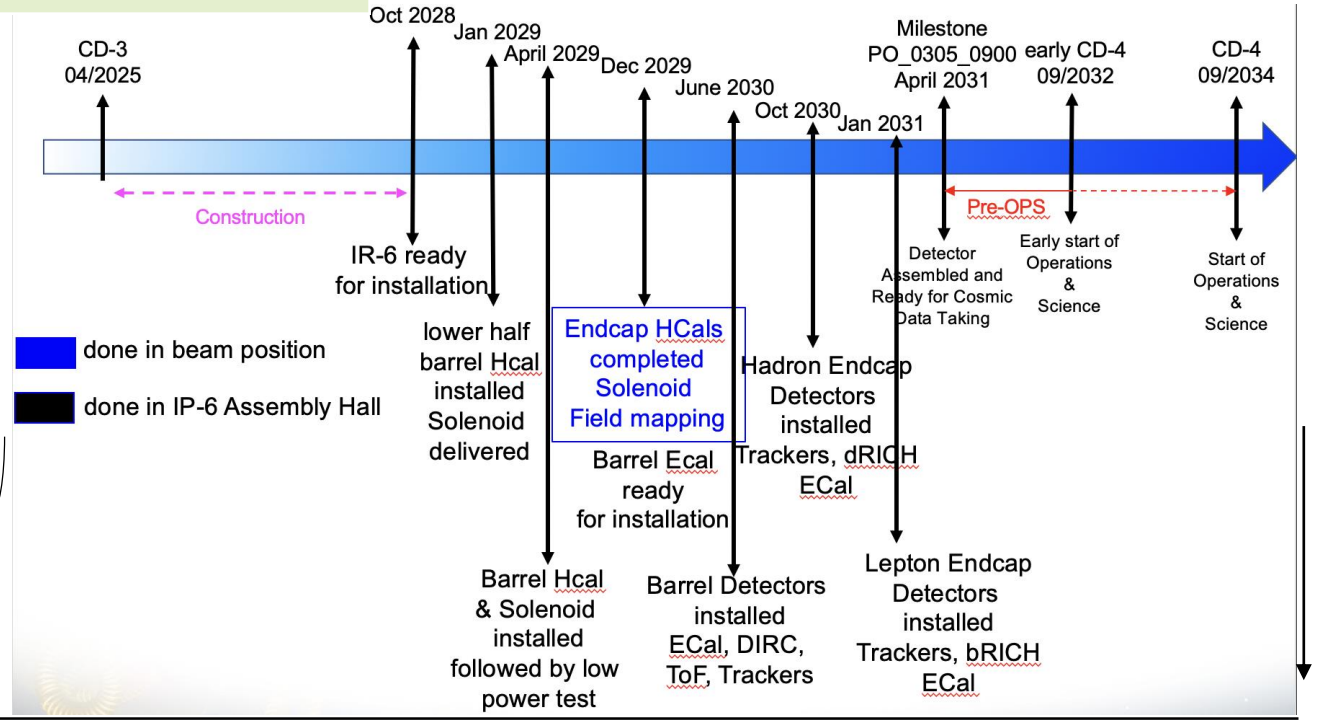
Readout Production & QC

11/2027 – 1/2030

QC Complete

Installation

Jan 2029 – Jan 2031



Outlook

- Commit resources (institutions, groups, personnel) to develop the readout electronics (engineering, design, construction).
- Adapter – define geometry, interconnects, power distribution.
- FEB – define geometry, interconnects, power needs: ← See talk by Tim C.
  - Schematics, PCB footprint/layout/stackup, power components – synergy with others.
  - In preparation for ASIC availability.
- RDO – define location, interconnects, power needs:
  - Schematics, PCB footprint/layout/stackup, power components – synergy with others.
  - Build upon current developments of ppRDO and dRICH RDO.
  - Select fiber transceiver.
- Testing – develop test requirements (PCBs and system).
- Production – develop strategy for fabrication, standards, QA/QC, including testing, towards installation.