

Summary of the AC-LGAD workfest

Satoshi Yano

Hiroshima University SKCM²

AC-LGAD work fest

Jan.-09-2024 Morning

<div><div><</div><div>Tue 09/01</div><div>Wed 10/01</div><div>All days</div><div>></div></div>	
<div><div>Print</div><div>PDF</div><div>Full screen</div><div>Detailed view</div><div>Filter</div></div>	
08:00	<div><div><div>Introduction (10')</div><div>E1100/E1200, APS Conference Center</div><div>Zhenyu Ye</div><div>08:00 - 08:10</div><div></div></div><div><div>Barrel TOF (12'+3')</div><div>E1100/E1200, APS Conference Center</div><div>Satoshi Yano</div><div>08:10 - 08:25</div><div></div></div><div><div>Forward TOF (12'+3')</div><div>E1100/E1200, APS Conference Center</div><div>Wei Li</div><div>08:25 - 08:40</div><div></div></div><div><div>Far-forward AC-LGAD Detectors (20'+5')</div><div>E1100/E1200, APS Conference Center</div><div>Alexander Jentsch</div><div>08:40 - 09:05</div><div></div></div></div>
09:00	<div><div><div>Luminosity tracker (12'+3')</div><div>E1100/E1200, APS Conference Center</div><div>Dhevan Gangadharan</div><div>09:05 - 09:20</div><div></div></div><div><div>Discussion (20')</div><div>E1100/E1200, APS Conference Center</div><div></div><div>09:20 - 09:40</div><div></div></div></div>
10:00	
11:00	<div><div><div>Experience with LGAD sensor development for CMS ETL (20'+5')</div><div>E1100/E1200, APS Conference Center</div><div>Christopher Madrid</div><div>10:15 - 10:40</div><div></div></div><div><div>AC-LGAD sensor production at BNL (10'+5')</div><div>E1100/E1200, APS Conference Center</div><div>Gabriele Giacomini</div><div>10:40 - 10:55</div><div></div></div><div><div>AC-LGAD sensor lab test (10'+5')</div><div>E1100/E1200, APS Conference Center</div><div>Jennifer Ott</div><div>10:55 - 11:10</div><div></div></div><div><div>AC-LGAD sensor beam test (10'+5')</div><div>E1100/E1200, APS Conference Center</div><div>Shirsendu Nanda</div><div>11:10 - 11:25</div><div></div></div><div><div>AC-LGAD sensor irradiation test (10'+5')</div><div>E1100/E1200, APS Conference Center</div><div>Simone Mazza</div><div>11:25 - 11:40</div><div></div></div><div><div>Discussion</div><div>E1100/E1200, APS Conference Center</div><div></div><div>11:40 - 12:00</div><div></div></div></div>
12:00	

Jan.-09-2024 Afternoon

13:00	<div><div><div>Experience with ASIC Development for CMS ETL (20+5')</div><div>E1100/E1200, APS Conference Center</div><div>Dr Ted Liu</div><div>13:00 - 13:25</div><div></div></div><div><div>EICROC (17+3')</div><div>E1100/E1200, APS Conference Center</div><div>Christophe de la Taille</div><div>13:25 - 13:45</div><div></div></div><div><div>FCFD (17+3')</div><div>E1100/E1200, APS Conference Center</div><div>Artur Apresyan et al.</div><div>13:45 - 14:05</div><div></div></div></div>
14:00	<div><div><div>Sensor-ASIC Interconnection (17+3')</div><div>E1100/E1200, APS Conference Center</div><div>Mathieu Benoit</div><div>14:05 - 14:25</div><div></div></div><div><div>Discussion</div><div>E1100/E1200, APS Conference Center</div><div></div><div>14:25 - 14:45</div><div></div></div></div>
15:00	
16:00	<div><div><div>Introduction (15+5')</div><div>E1100/E1200, APS Conference Center</div><div>Tonko Ljubicic</div><div>15:15 - 15:35</div><div></div></div><div><div>Low-mass Kapton PCB (17+3')</div><div>E1100/E1200, APS Conference Center</div><div>Oskar Hartbrich</div><div>15:35 - 15:55</div><div></div></div><div><div>Service Hybrid (17+3')</div><div>E1100/E1200, APS Conference Center</div><div>Wei Li</div><div>15:55 - 16:15</div><div></div></div><div><div>Backend electronics (17+3')</div><div>E1100/E1200, APS Conference Center</div><div>Zhangbu Xu</div><div>16:15 - 16:35</div><div></div></div><div><div>Discussion (25')</div><div>E1100/E1200, APS Conference Center</div><div></div><div>16:35 - 17:00</div><div></div></div></div>
17:00	

Jan.-10-2024 Morning

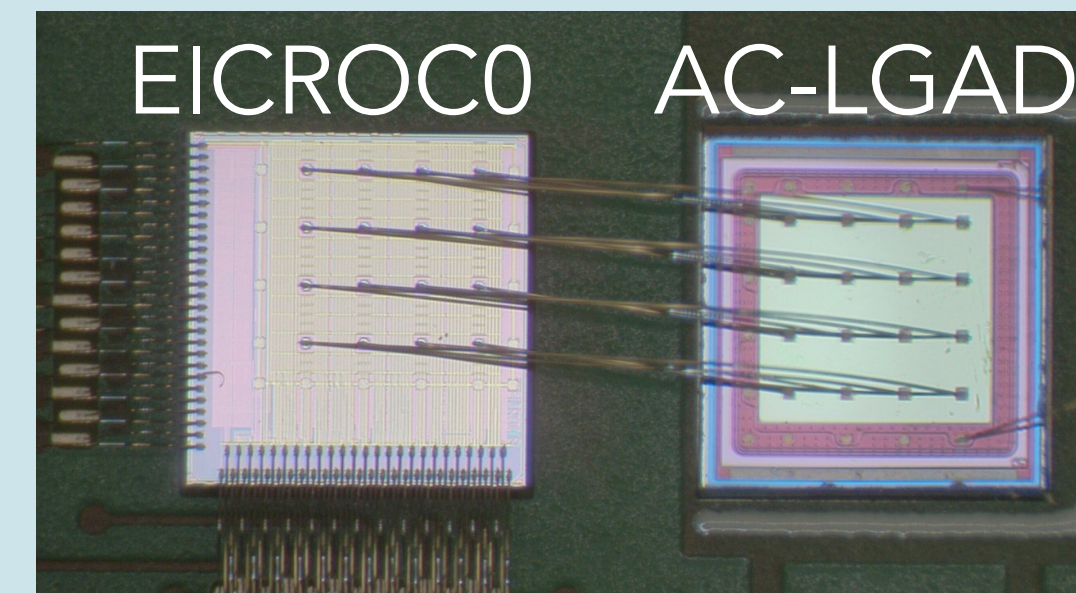
<div><div><</div><div>Tue 09/01</div><div>Wed 10/01</div><div>All days</div><div>></div></div>	
<div><div>Print</div><div>PDF</div><div>Full screen</div><div>Detailed view</div><div>Filter</div></div>	
08:00	<div><div><div>Demonstration</div><div>Clean Room</div><div>Prithwish Tribedy</div><div>08:00 - 08:20</div><div></div></div></div>

Jan.-10-2024 Afternoon

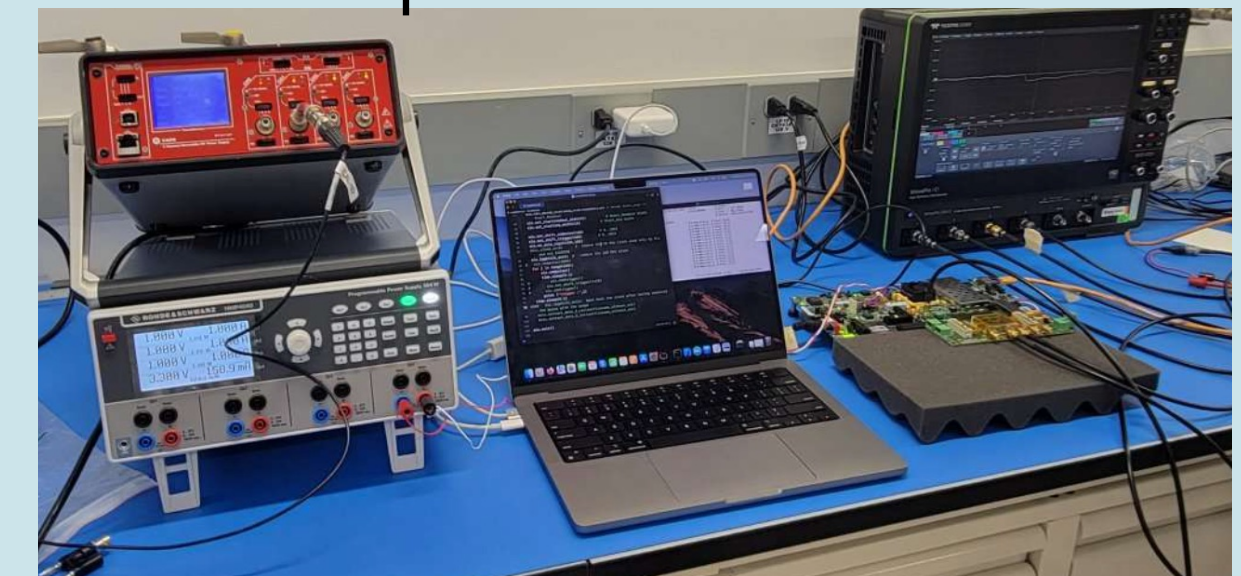
13:00	<div><div><div>BTOF Module assembly procedure and requirements</div><div>E1200, APS Conference Center</div><div>Matthew Gignac</div><div>13:00 - 13:25</div><div></div></div><div><div>FTOF Module assembly procedure and requirements</div><div>E1200, APS Conference Center</div><div>Mathieu Benoit</div><div>13:25 - 13:50</div><div></div></div></div>
14:00	<div><div><div>Discussion</div><div>E1200, APS Conference Center</div><div></div><div>13:50 - 14:15</div><div></div></div></div>
15:00	
16:00	<div><div><div>Status of barrel TOF plank / support design</div><div>E1200, APS Conference Center</div><div>Sushrut Kammarkar</div><div>14:45 - 15:00</div><div></div></div></div>
17:00	<div><div><div>TOF Staves Prototype Simulation and Testing</div><div>E1200, APS Conference Center</div><div>Yi Yang et al.</div><div>15:05 - 15:20</div><div></div></div><div><div>TOF Support Structure & Next steps</div><div>E1200, APS Conference Center</div><div>Andreas Werner Jung</div><div>15:25 - 15:45</div><div></div></div></div>

Successful demonstration of the EICROC

- The demonstration session of EICROC was held by the BNL and IJCLab teams



Setup @ clean room



Signal from ^{90}Sr



HGCROC capability for BTOF readout

- One comment about HGCROC compatibility with the strip AC-LGAD was gave

Strip-type AC-LGAD sensor

Size: $3.2 \times 4 \text{ cm}^2$

Geometry: $64 * 4$ strips

Readout: 1 cm and 500 μm pitch

Detector capacitance: **$O(10) \text{ pF}$**

Signal strength: **$1 - 30 \text{ fC}$**

EICROC

$32 \times 32 = 1024$ channels

Input capacitance: $C_d = \text{1-5 pF}$

Dynamic range: 1 - 50 fC

ToA and ADC

Jitter: 15 ps @ 10 fC

Power consumption: **1 mW/ch**

HGCROCv2/3

$36 \times 2 = 72$ channels

Input capacitance: $C_d = \text{5-50 pF}$

Dynamic range: 1 fC - 10 pC

ToA, ToT, and ADC

Jitter: **$> 100 \text{ ps @ } 15 \text{ fC (v3)}$**

Power consumption: **$5-10 \text{ mW/ch}$**

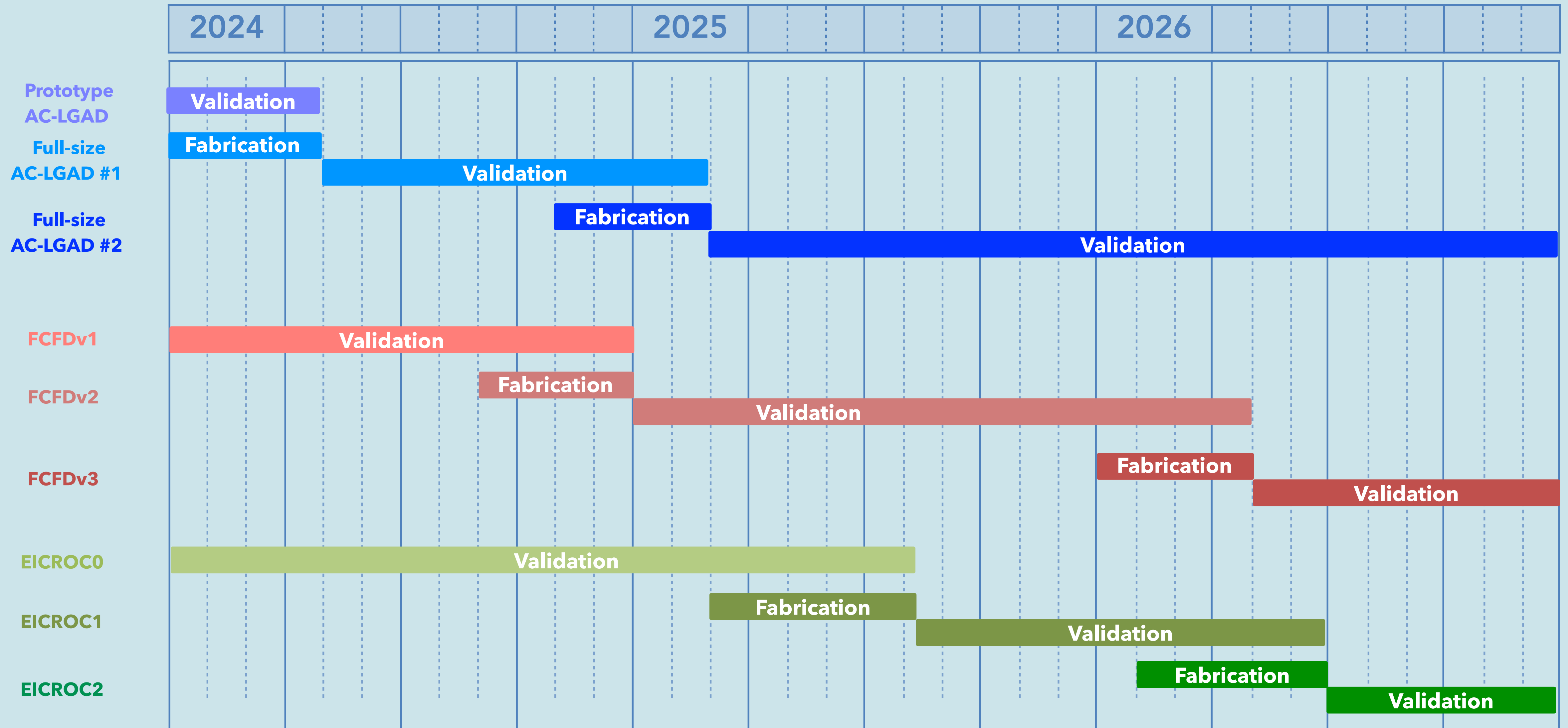
- HGCROC information is extracted [here](#)
- Input capacitance meets the requirement
- Is it fine from the jitter point of view?
- More cooling power is necessary

Kapton Flex Hybrid (PCB)

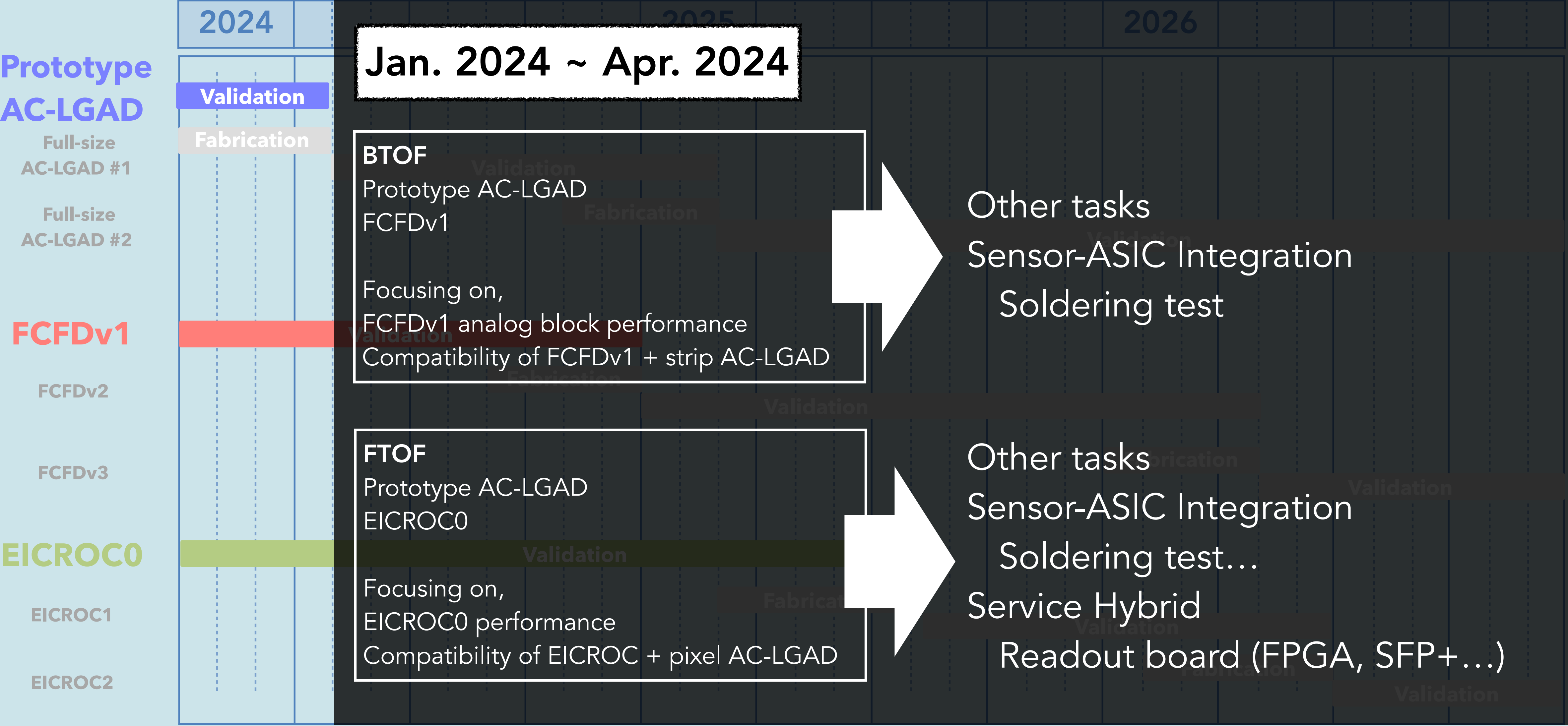
- After Oskar's presentation, a suggestion to contact the sPHENIX INTT team was given
- The INTT is the silicon strip tracker similar to the ePIC BTOF
 - It has been built by Japanese and Taiwan colleagues
- The long PCB (1.3m) has been established and already used in sPHENIX
- Note: they use the PCB for extending (like connecting module to service hybrid in our case), so it is not sure that we can use it as in BTOF
- The [paper](#) has been sent to Tonko and Oskar
- RIKEN and Nara Woman University is very interested in the cooperation with the PCB R&D

Backup

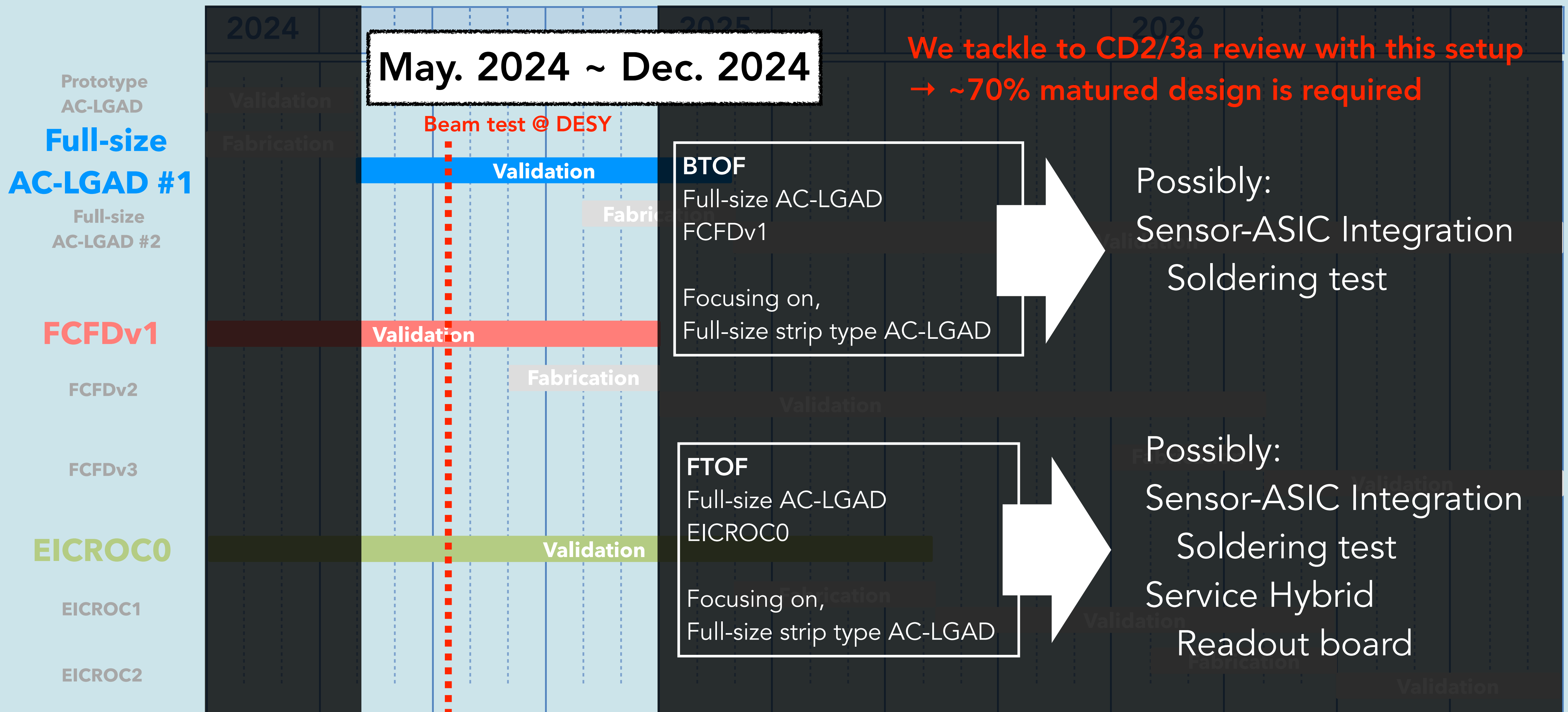
Rough schedule of sensors + ASICs



Rough schedule of sensors + ASICs

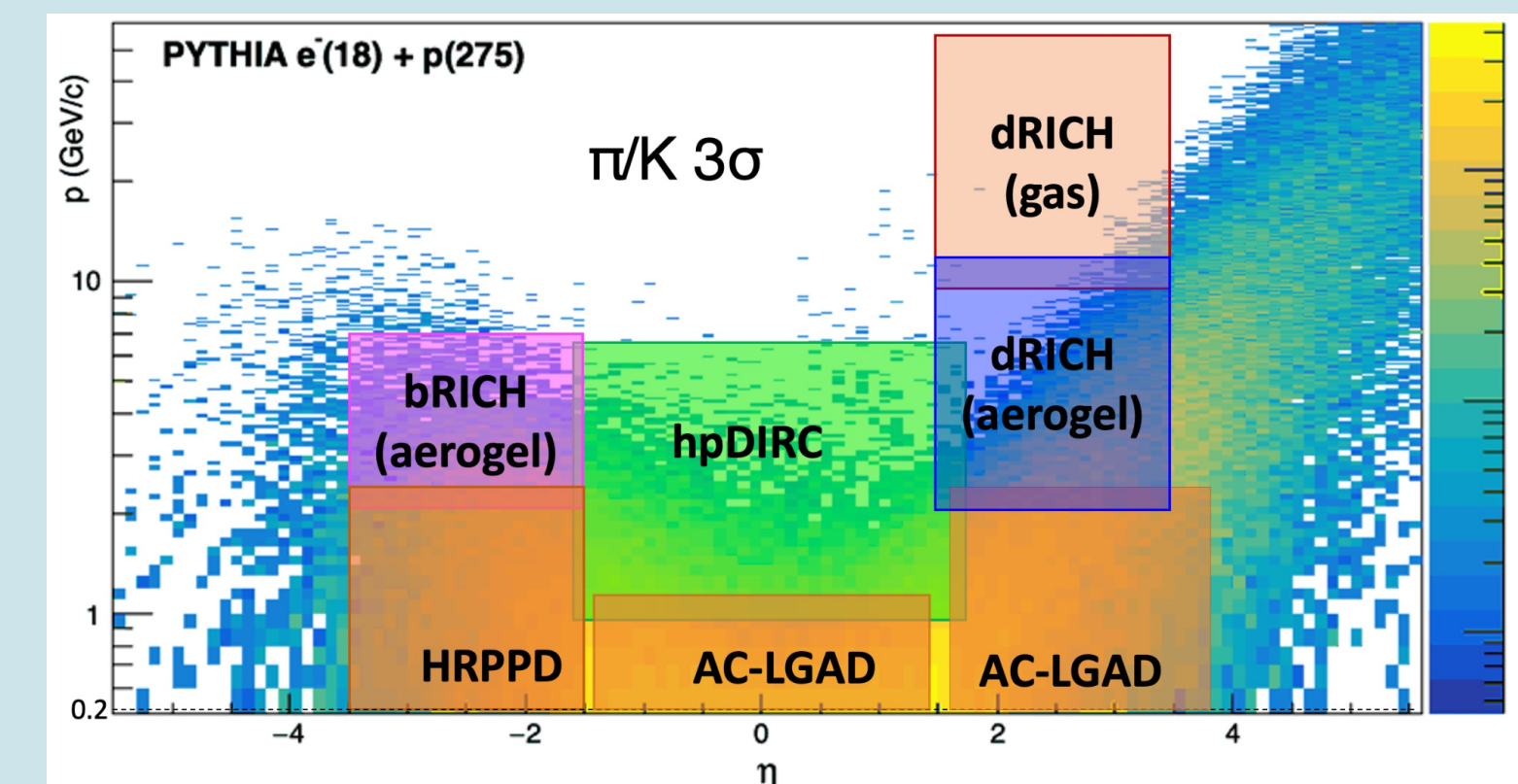


Rough schedule of sensors + ASICs

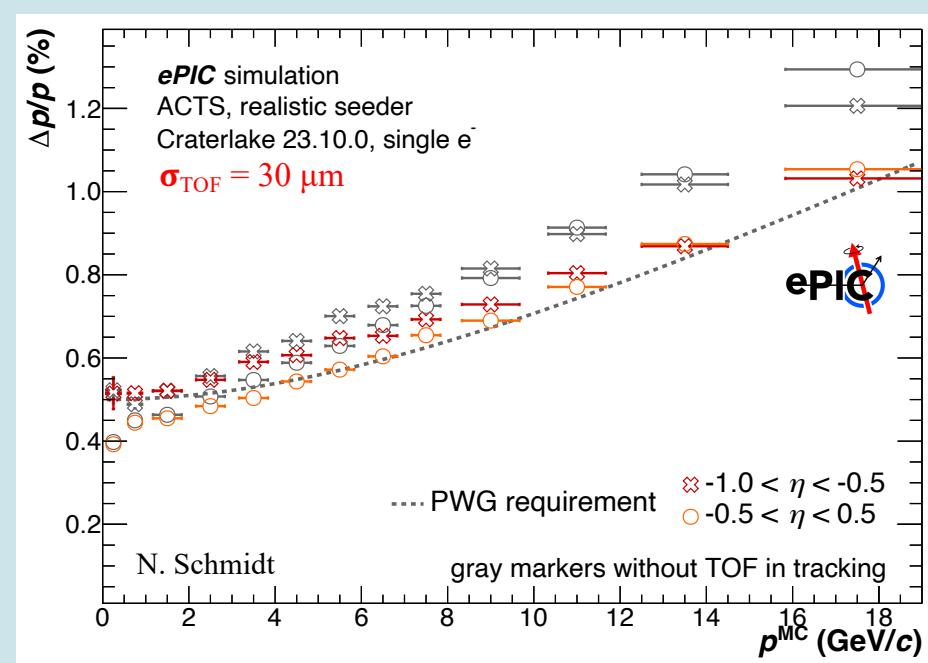
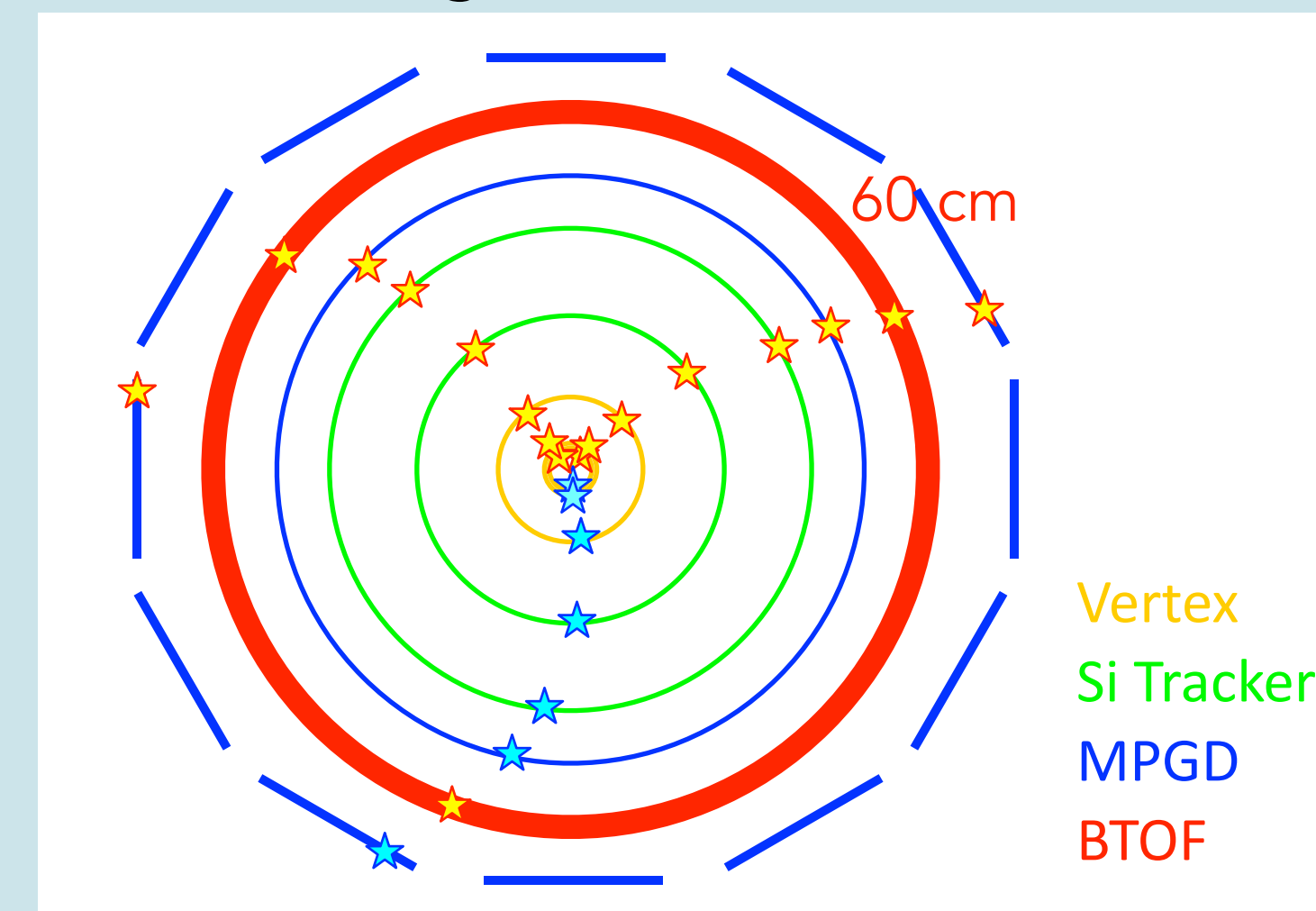


BTOF in the ePIC detector

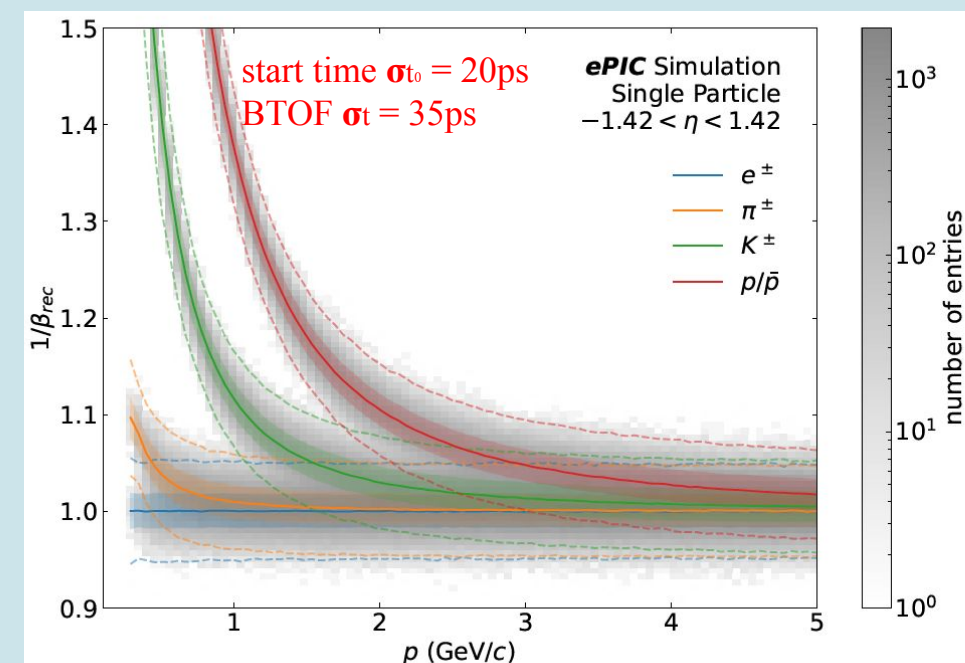
- BTOF is a main PID detector covering low- p_T at mid-rapidity
- High momentum particle momentum resolution is improved by BTOF
- Beam-induced background can be rejected by timing information
- Timing resolution of 35 ps and spatial resolution of 30 μm is required
 - 3 sigma π/K separation up to $\sim 1.2 \text{ GeV}/c$
- Strip AC-LGAD technology meets the requirements
 - To reduce total readout channels, strip AC-LGAD will be adopted ($\sim 12 \text{ m}^2$)



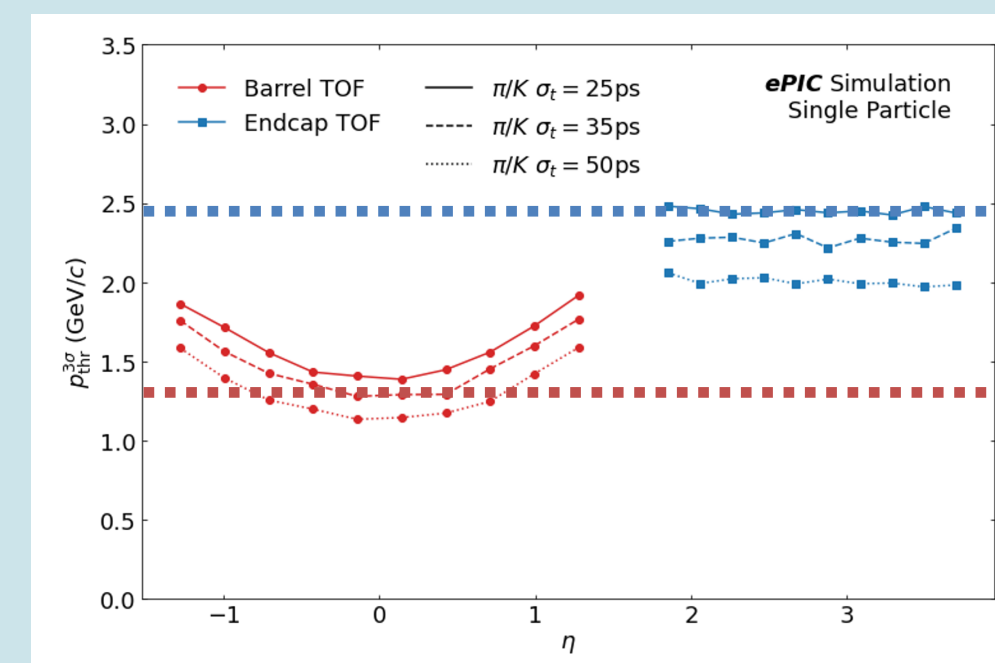
Tracking detectors in ePIC



By N. Schmidt



By O. Hartbrich

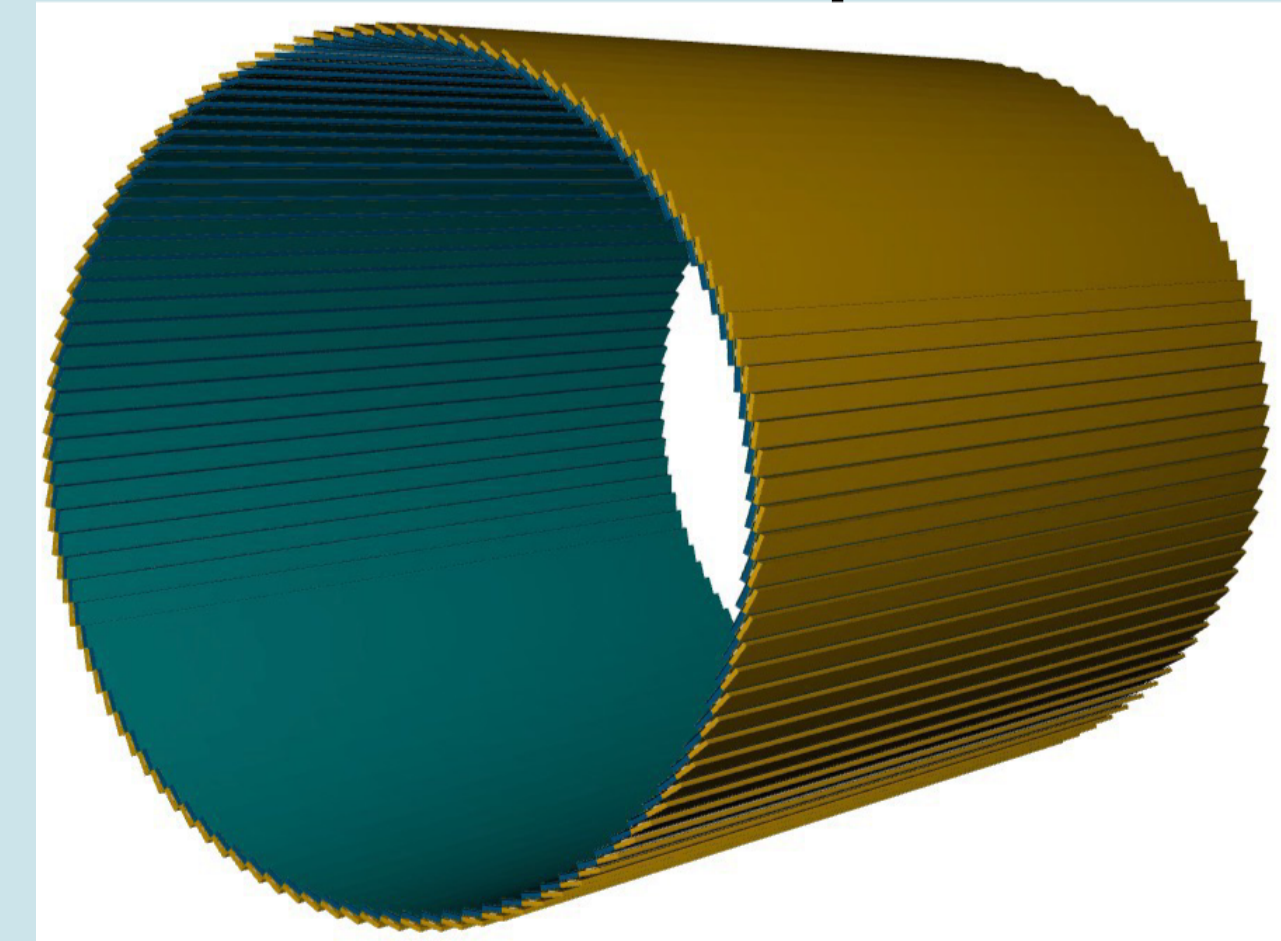


By O. Hartbrich

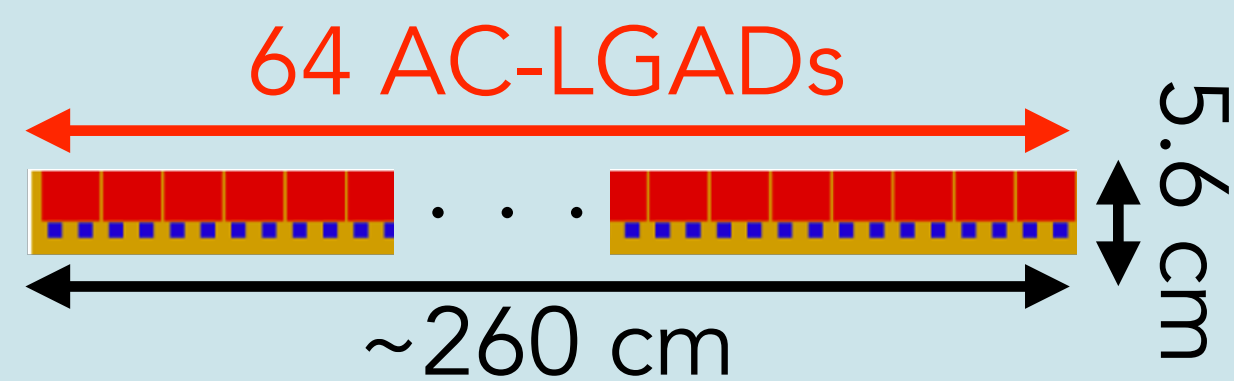
Detector Layout

- BTOF is composed of 144 modules to make a cylindric
- 64 AC-LGAD strip sensors are attached to one module
 - ASIC place is under discussion (depending on the ASIC pixel geometry)
- Radius is 60 - 63 cm from the beam pipe covering $-1.42 < \eta < 1.77$
- Total material budget in acceptance is $\sim 0.01 X/X_0$

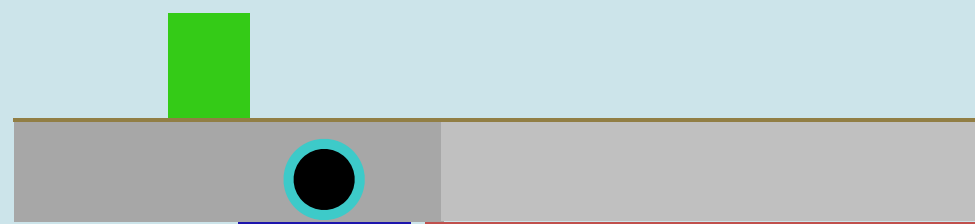
BTOF shape



Module top view

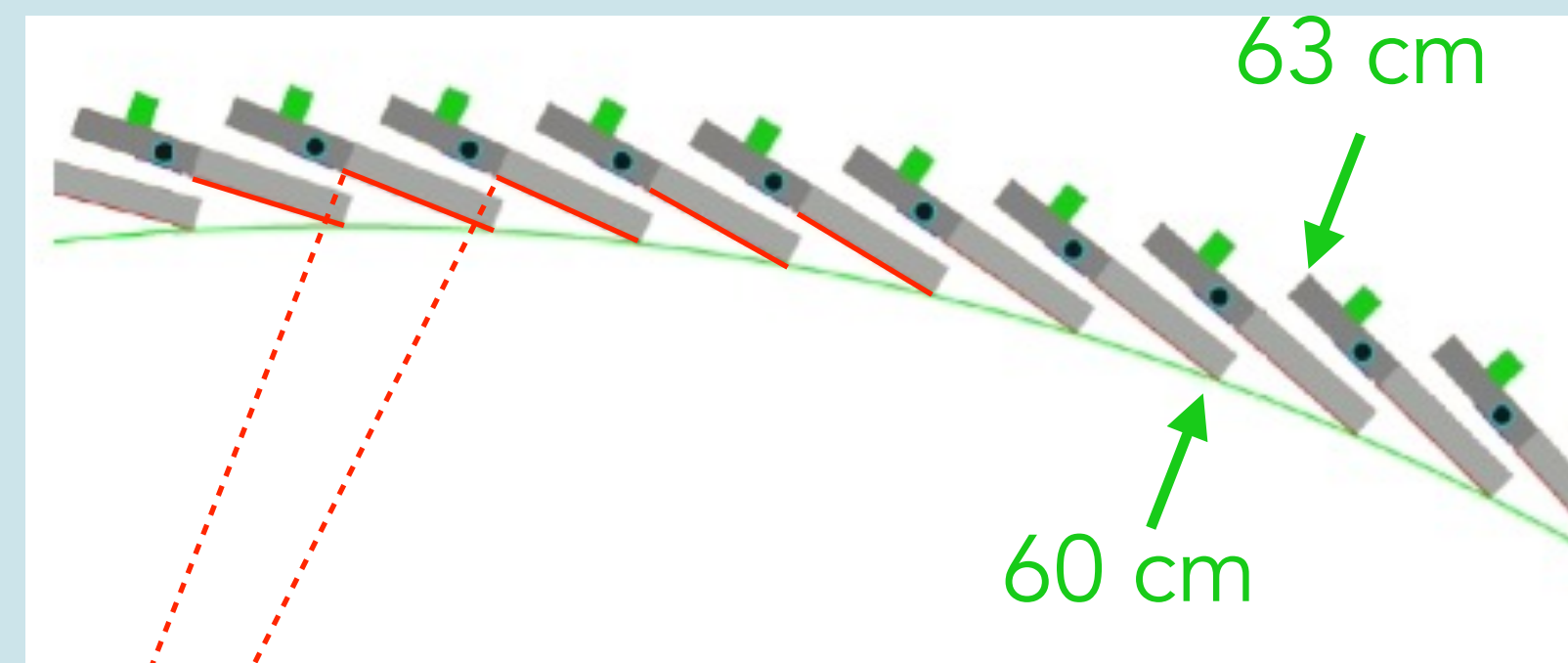


Module cross section

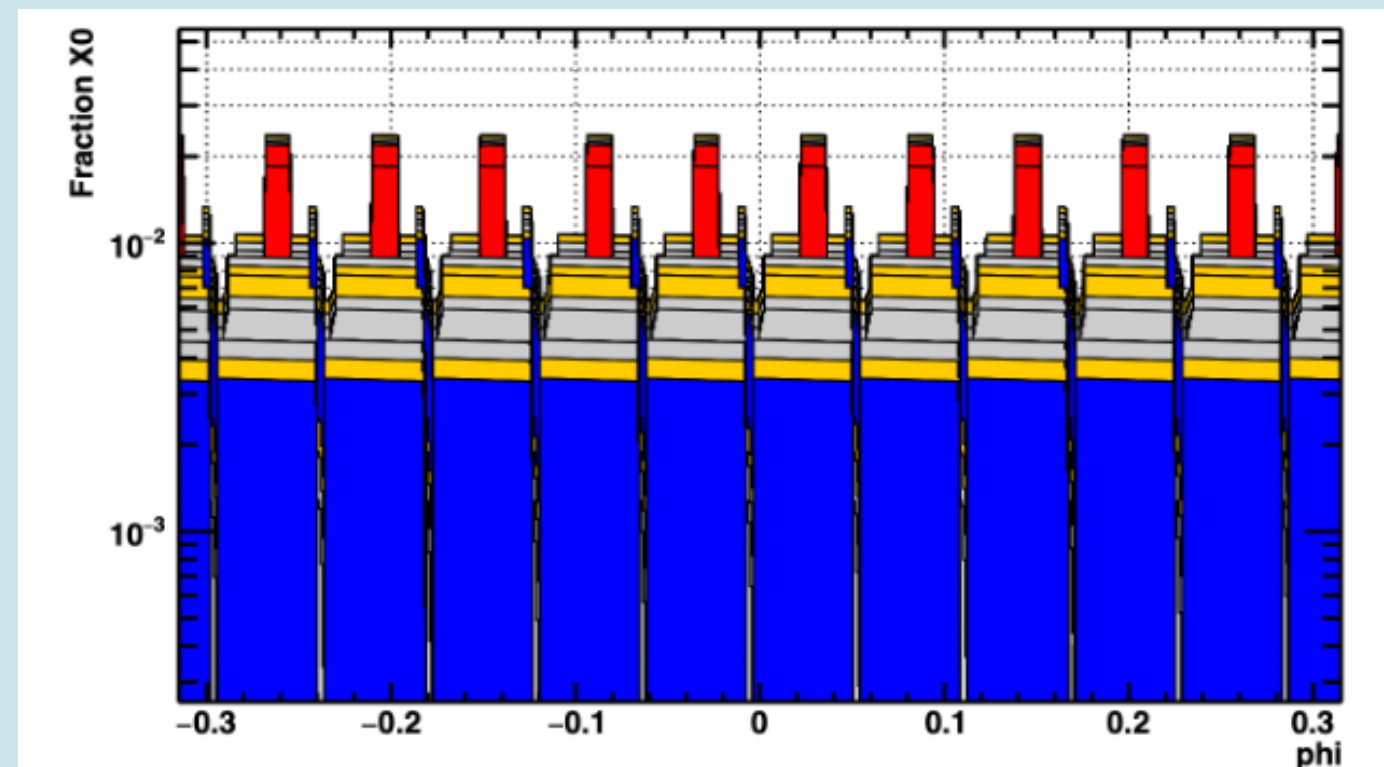


Cylindrical structure by modules

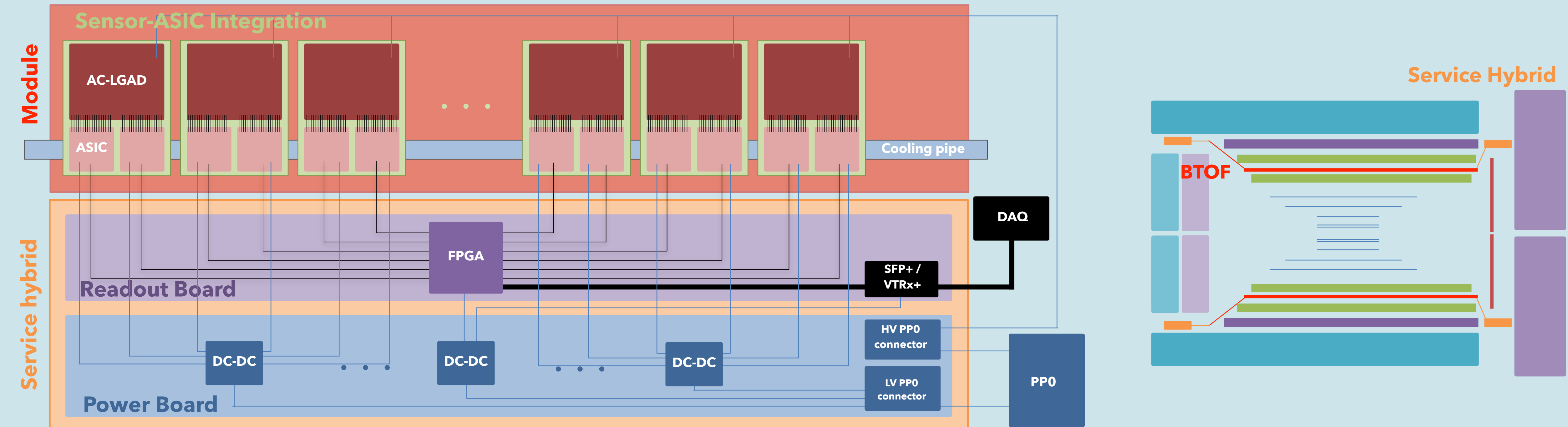
3 mm overlap in ϕ



Material budget



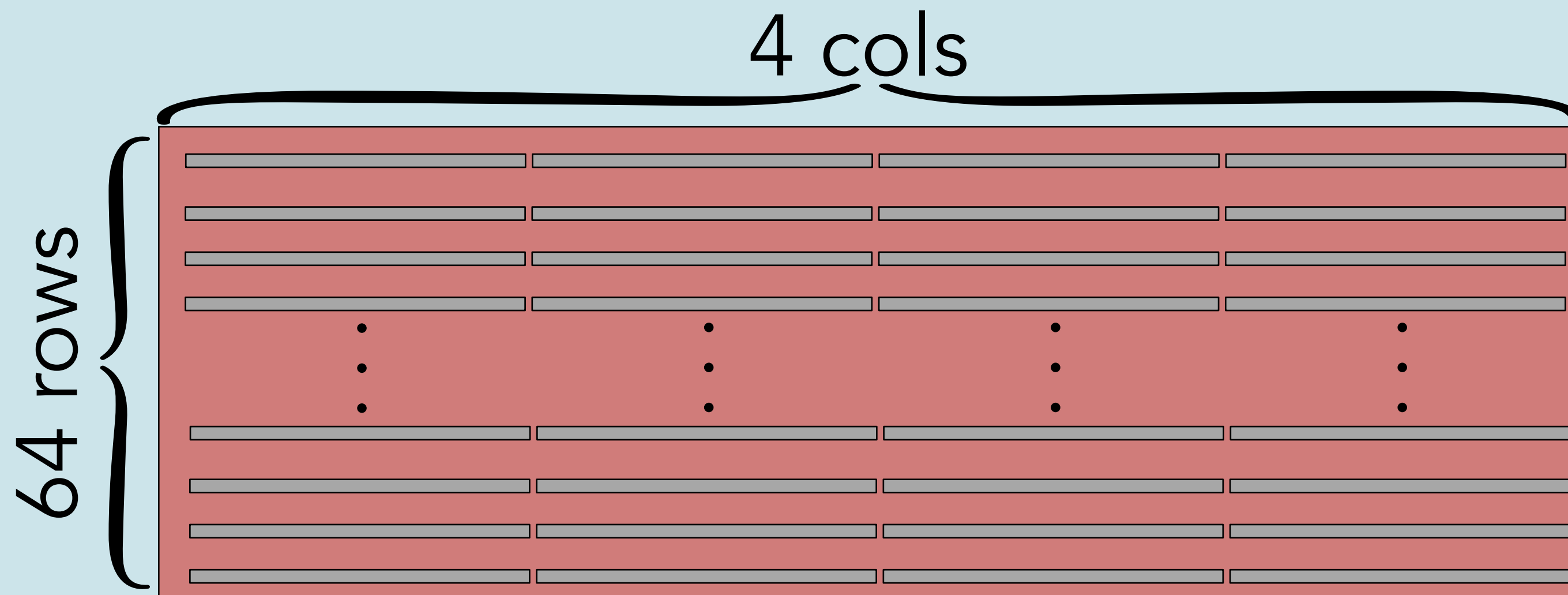
BTOF system structure



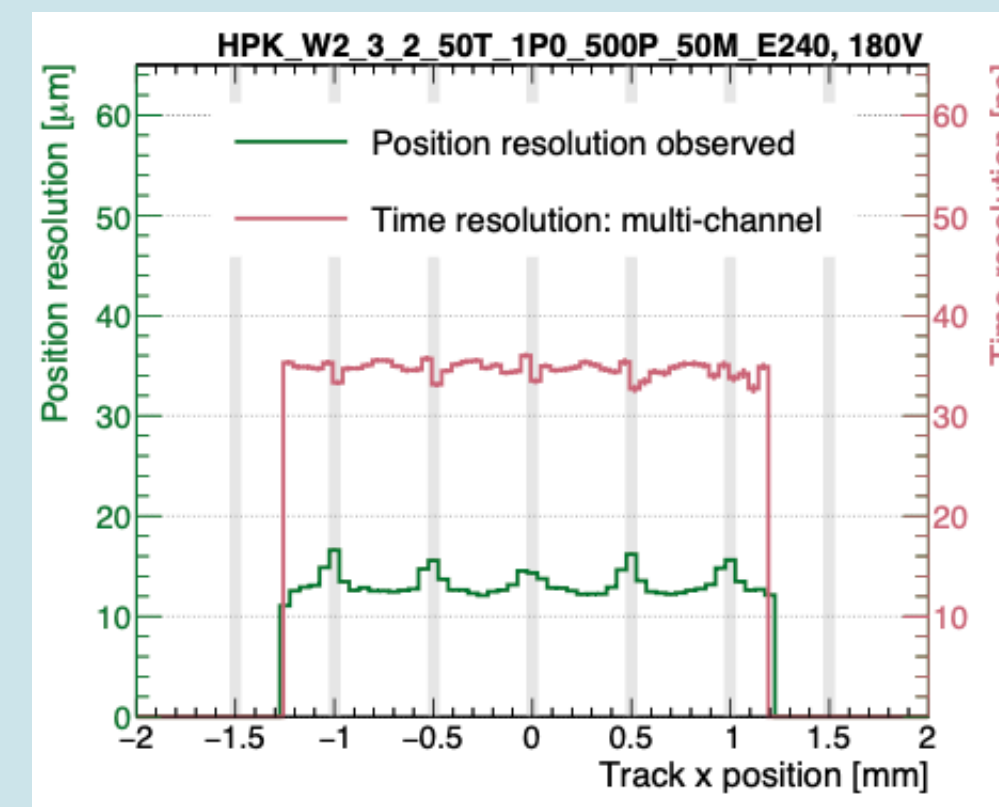
- Sensor signal is readout by 2 ASICs
- ASICs which is the main heat source are cooled by a water pipe embedded inside the module
 - Beam pipe geometry depends on the position of the ASIC
- Data I/O and power supply are controlled by the Service-hybrid
- The service-hybrid is placed outside of the acceptance

BTOF AC-LGAD sensor

- AC-LGAD technology meets the strict spatial and time resolution requirements
- Strip-type sensor, $3.2 \times 4 \text{ cm}^2$ sensor size with $0.05 \times 1 \text{ cm}^2$ metals, is used in BTOF
 - The readout metal geometry in a sensor is 64×4 and 256 channels each
- Due to charge sharing between multiple readout electrodes, $30\mu\text{m}$ spatial resolution can be achieved in φ direction



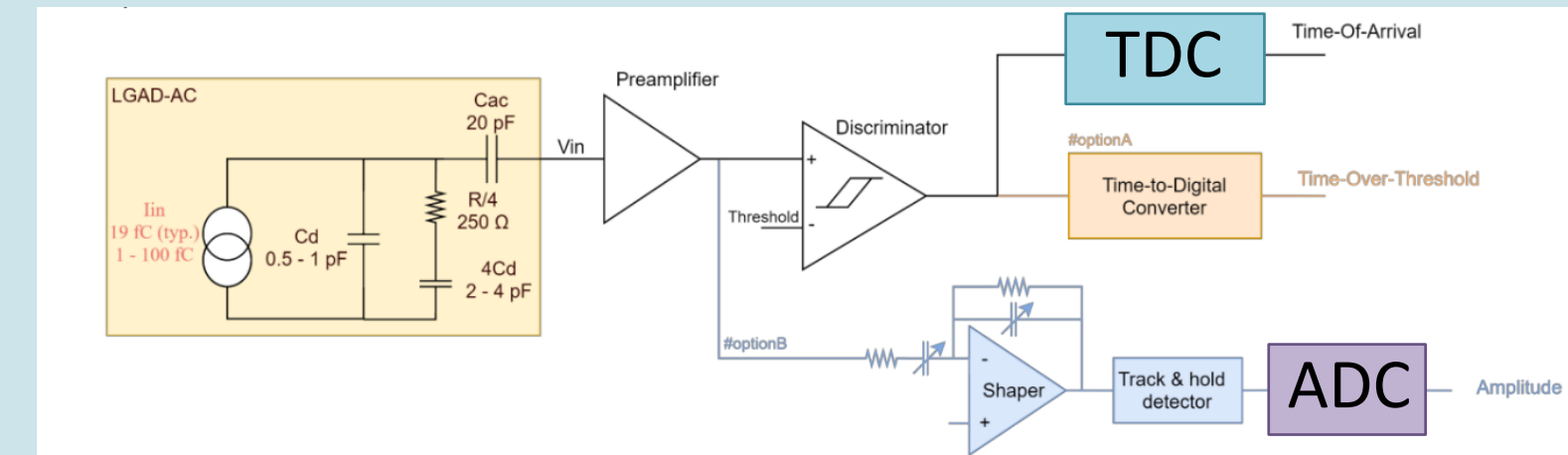
[eRD112 FY24 Proposal](#)



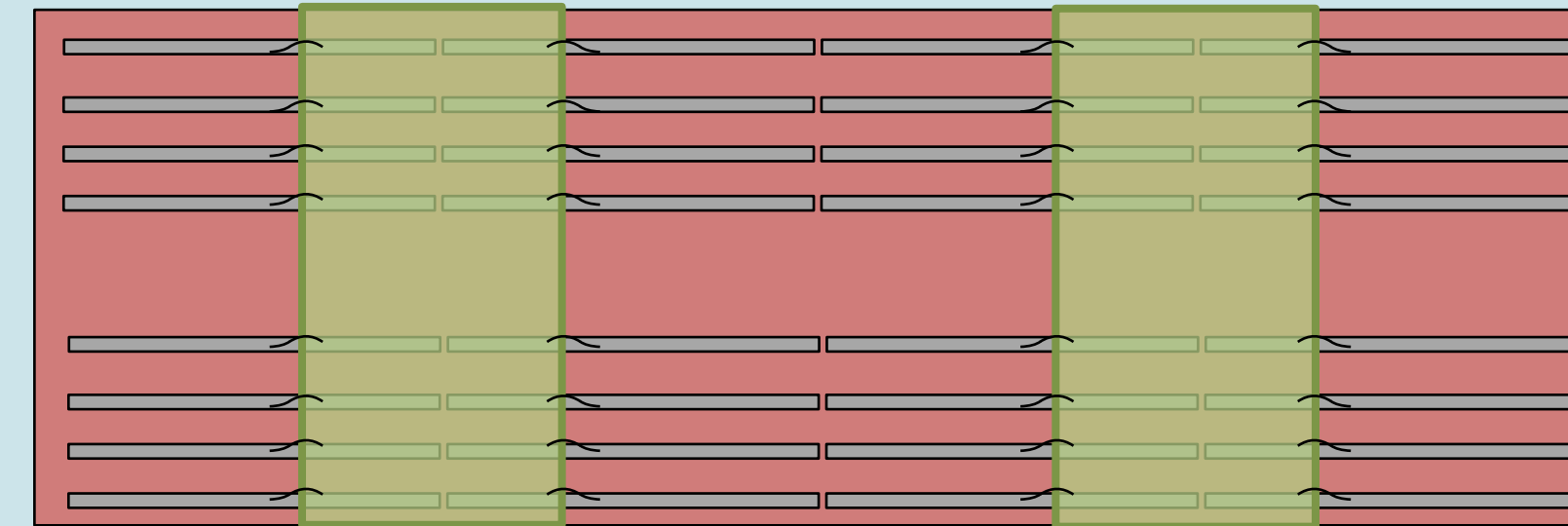
- Total information
 - **9216 sensors**
 - **11.8 m^2**
 - **2.4 M readout channels**

BTOF ASIC

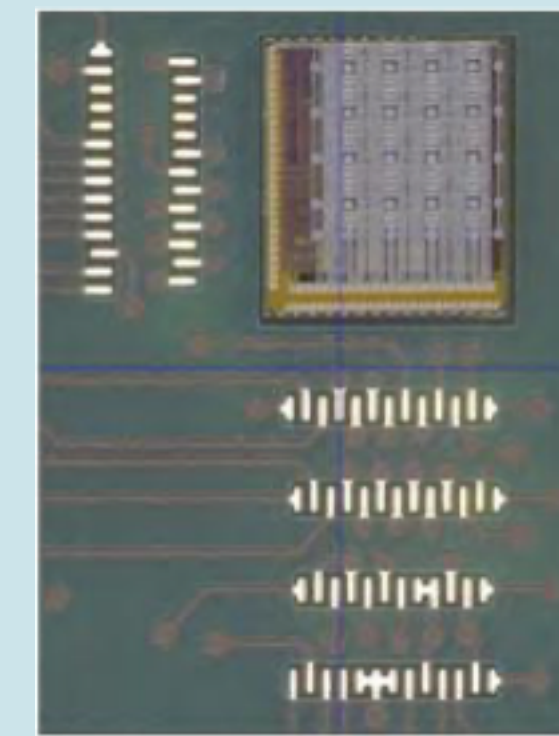
- Not only high-time resolution TDC but also ADC must be measured
- Due to the large capacitance and readout geometry characteristics caused by the strip type, care must be taken when selecting an ASIC
- EICROC (16x16) is one of the common ASICs used in ePIC
 - Design focuses on pixel AC-LGAD readout (tuned for low capacitance)
 - 10-bit TDC and 8-bit ADC is now available (EICROC0)
 - Modification is necessary to read higher capacitance sensor (strip AC-LGAD)
- FCFD is a new ASIC to use strip AC-LGAD readout
 - FCFD can read higher capacitance AC-LGAD sensor
 - Multiple-channel analog is available for FCFDv1
- A variety of third-party ASICs continue to be explored as back-up solutions



ASIC



EICROC0



FCFDv0

