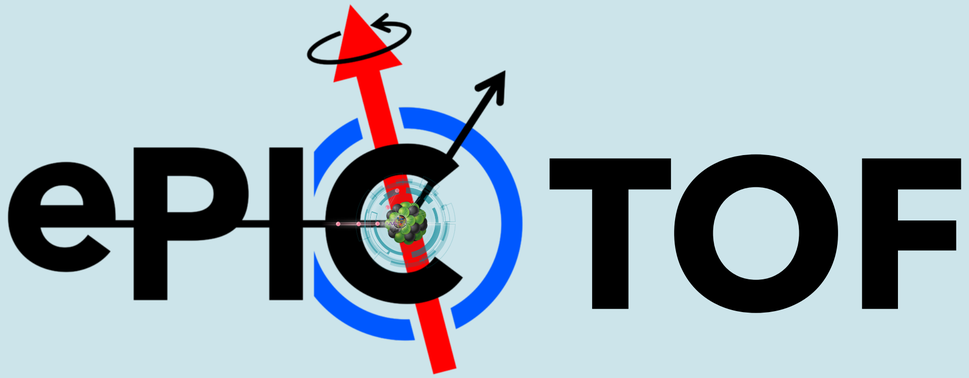


Load map of AC-LGAD development in Japan

Satoshi Yano

Hiroshima University SKCM²

EIC-Asia meeting

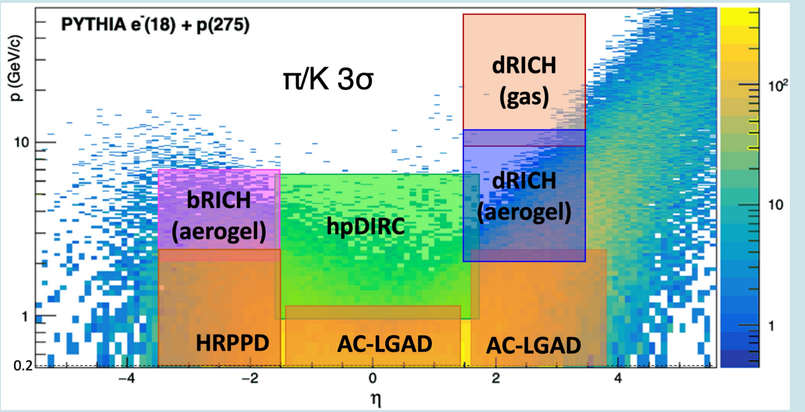
07/13/2023

TOF in the ePIC detector

- TOF (bTOF+fTOF) is a main PID detector covering low-p_T region in ePIC

Detector	r (cm)	z (cm)	Rapidity coverage	Momentum range for 3σ π/K separation
Barrel TOF	63<r<66	-120<z<120	-1.40<η<1.40	0.2 < p_T < ~1.2 GeV/c
Forward TOF	8<r<67	180<z<190	1.74<η<3.83	0.2 < p < ~2.3 GeV/c

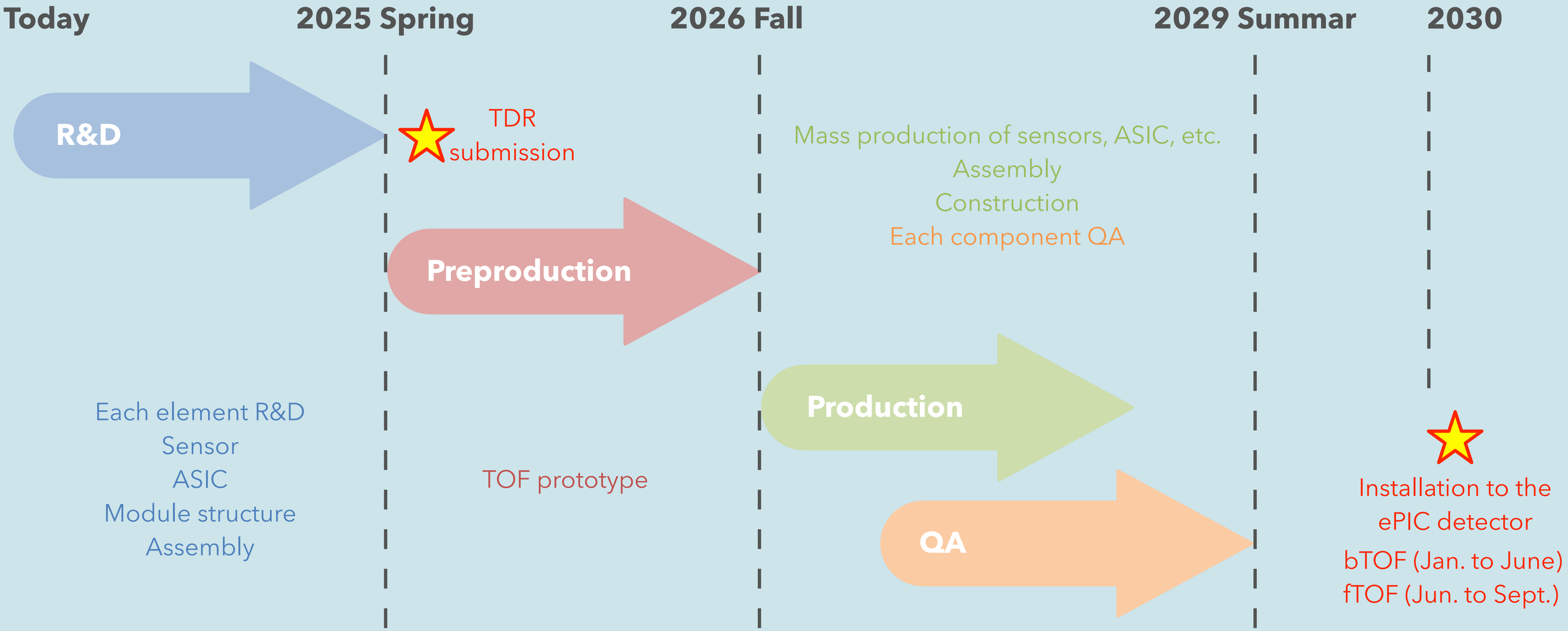
- Required performance is the timing resolution of 35ps (25ps) and spatial resolution of 30um (30um) for bTOF and (fTOF)
  - 3 sigma π/K separation up to ~1.2 GeV/c and ~2.3 GeV/c for bTOF and fTOF, respectively



- AC-LGAD technology meets the requirements
  - bTOF and fTOF use the strip and pixel type, respectively

Detector	Area	Channel size	Channel number	Time resolution	Spatial resolution	Material budget
bTOF	~10 m²	0.5mm x 10mm	~2.2 M	35 ps	30 μm in r·φ	0.01 X0
fTOF	~1.4 m²	0.5mm x 0.5mm	~5.6 M	25 ps	30 μm in x and y	0.025 X0

Schedule of TOF in ePIC

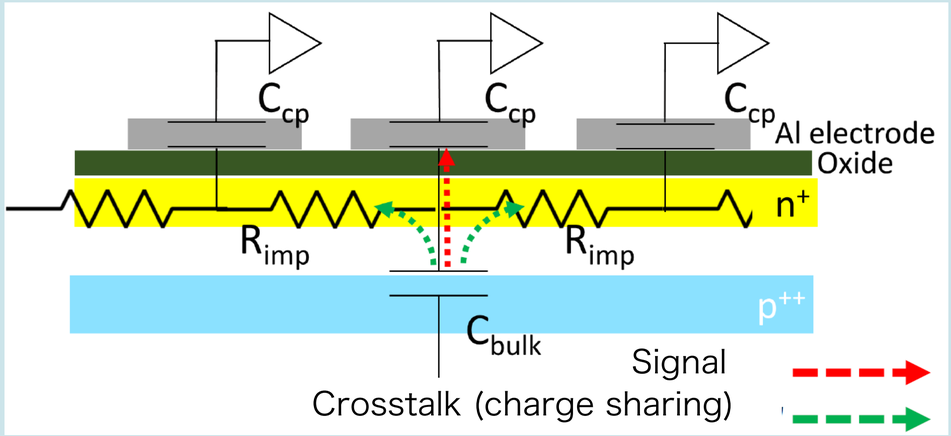


AC-LGAD R&D elements

- Signal strength per electrode and charge spread in the sensor are the tuning points
  - Signal strength is relevant to the timing resolution
  - Charge spread is relevant to spatial resolution

- Example (1): Large electrode sizes can collect large amounts of charge (=better timing resolution), but small charge sharing between vicinity electrodes (=worse spatial resolution)
- Example (2): Thick sensor can generate larger charges than a thin one (better timing resolution), but the arrival time is uneven (worse timing resolution)

- Key tuning parameters
  - Electrode size
  - Sensor thickness
  - n+ dose concentration (n+ layer resistivity)
  - p+ gain layer dose concentration (gain)
  - gain uniformity



K. Nakamura et al., JPS Conf. Proc. 34, 010016 (2021)

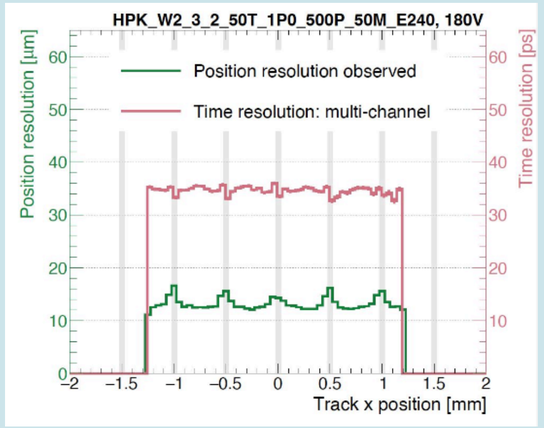
R&D status

- Timing and spatial resolution have achieved the required performance with the R&D sensors
  - 35 ps timing resolution and 15 um spatial resolution with strip geometry (50um thickness)
  - ~20ps timing resolution (20um thickness)

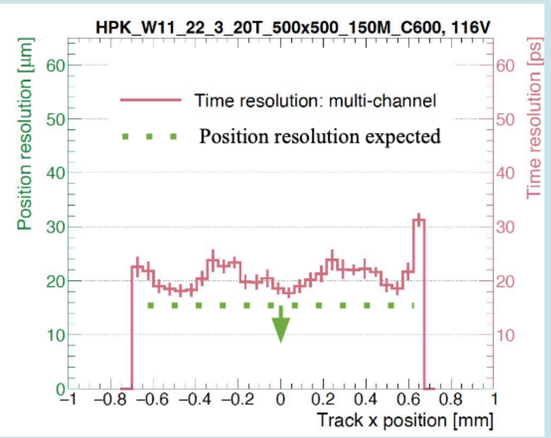
- The larger scale strip sensor (1cm x 500um electrode) test has been started
  - Aiming the final design is 3.2x4 cm^2 (1cm x 500um electrode x 4 x 64) with 2 ASIC (EICROC has 128 channels)

- Each parameter is being finalized
  - Next batch is for finalizing the parameters
  - Next next batch is for the real scale + real readout design

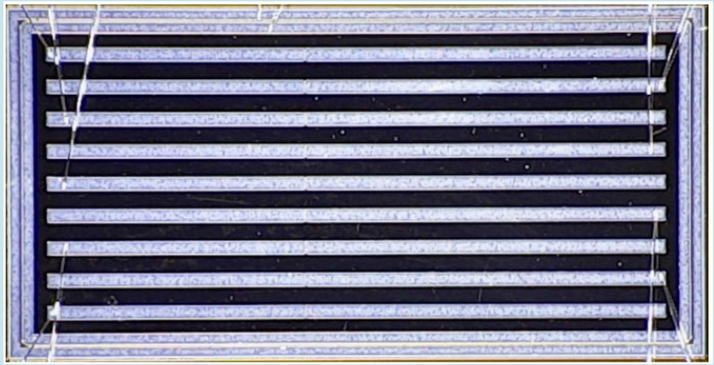
Strip



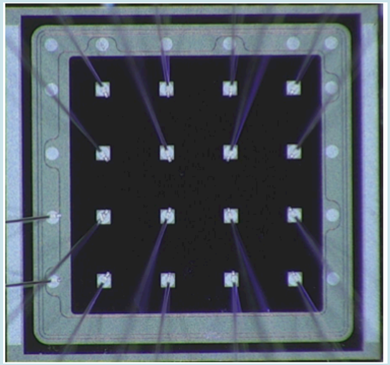
Pixel



Strip



Pixel

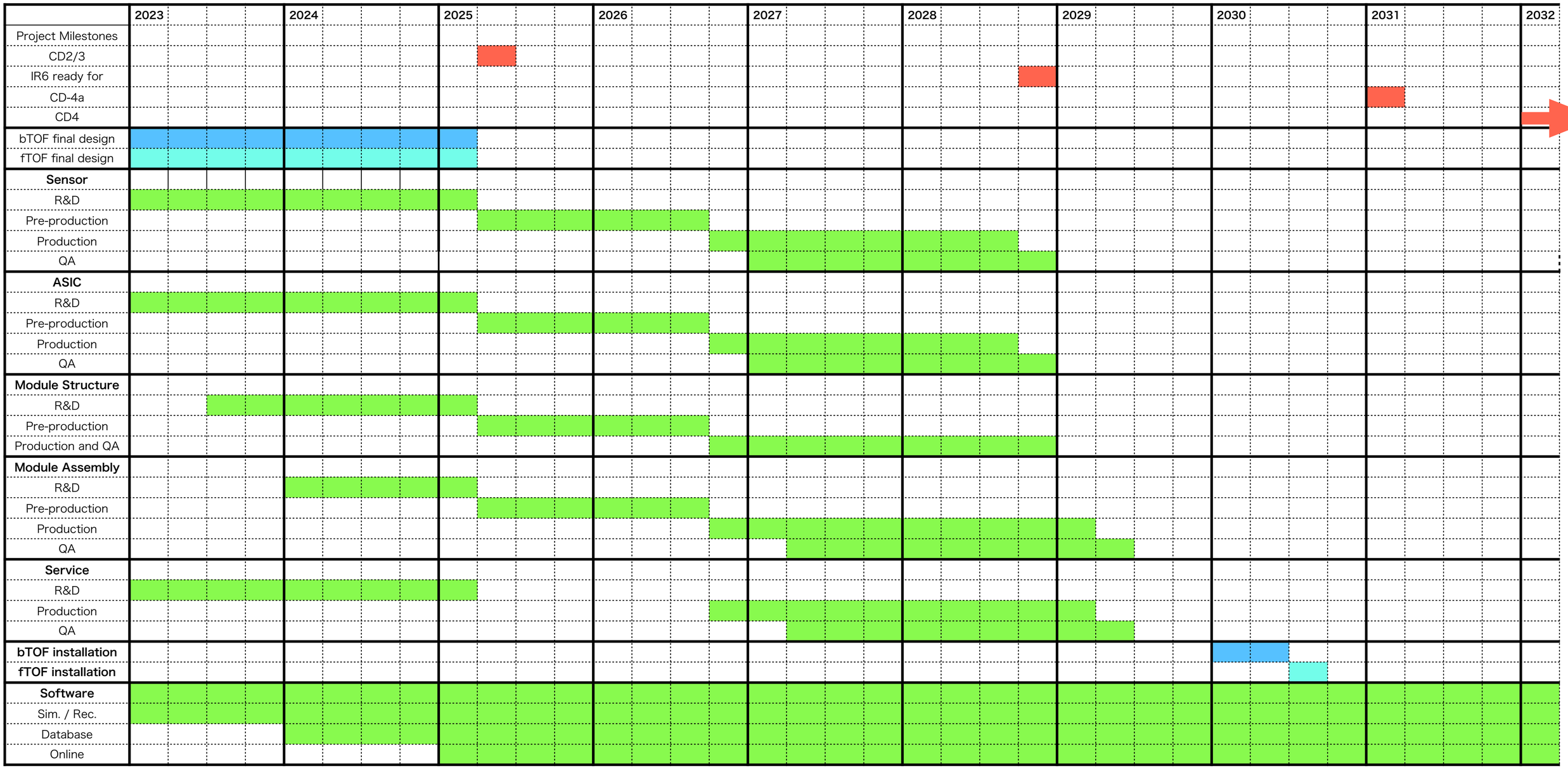


Road map of the AC-LGAD R&D in Japan (To be update)

2023 August	2023 Fall	2024	2025
Preparation phase	**Sensor R&D starting phase**	**Sensor R&D phase**	**Prototype testing phase**
Visit KEK (Koji Nakamura) Learn how to proceed with AC-LGAD R&D Visit BNL (Alessandro Tricoli) Learn how to proceed with AC-LGAD + EICROC R&D	AC-LGAD + EICROC R&D: Checking the performance of the latest HPK and BNL sensors @ HU with ^{90}Sr Comparison with the other institute results to prove our R&D system is going well If possible, give some feedback to the next batch	AC-LGAD + EICROC R&D: Checking the performance of the sensors @ HU (^{90}Sr), KEK (Laser), Tohoku Univ. (e beam) Full-scale sensors + EICROC: Checking the performance of the sensors @ HU (^{90}Sr), KEK (Laser), Tohoku Univ. (e beam)	Module R&D: Checking the performance of the module @ HU (^{90}Sr), KEK (Laser), Tohoku Univ. (e beam)

Summary

- EIC-Japan is almost ready to join the AC-LGAD sensor R&D
- Training at KEK and BNL is being planned
- The specific idea of the R&D in Japan is under preparation
- We need to discuss collaboration with the other institutes involving the R&D


2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
Project Milestones
CD2/3
IR6 ready for
CD-4a
CD4
bTOF final design
fTOF final design
Sensor
R&D
Pre-production
Production
QA
ASIC
R&D
Pre-production
Production
QA
Module Structure
R&D
Pre-production
Production and QA
Module Assembly
R&D
Pre-production
Production
QA
Service
R&D
Production
QA
bTOF installation
fTOF installation
Software
Sim. / Rec.
Database
Online