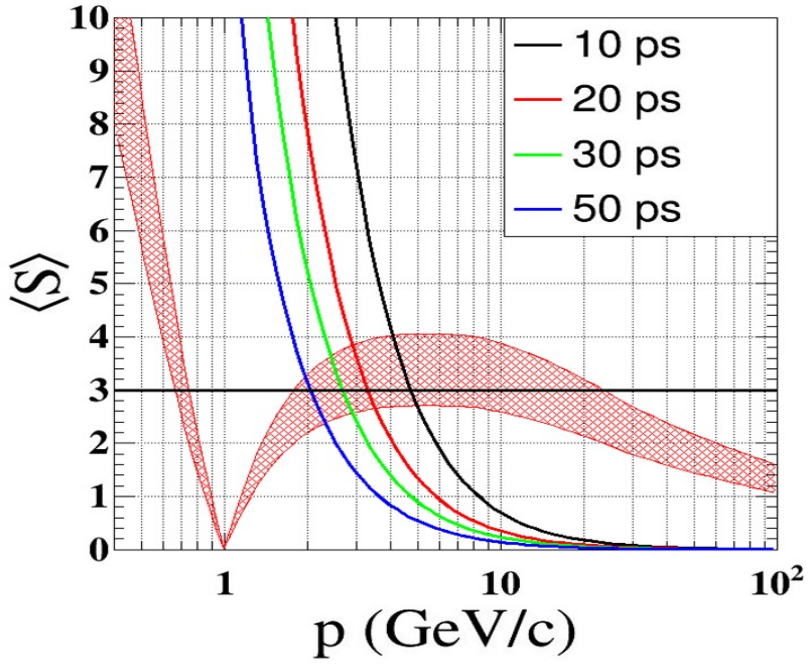
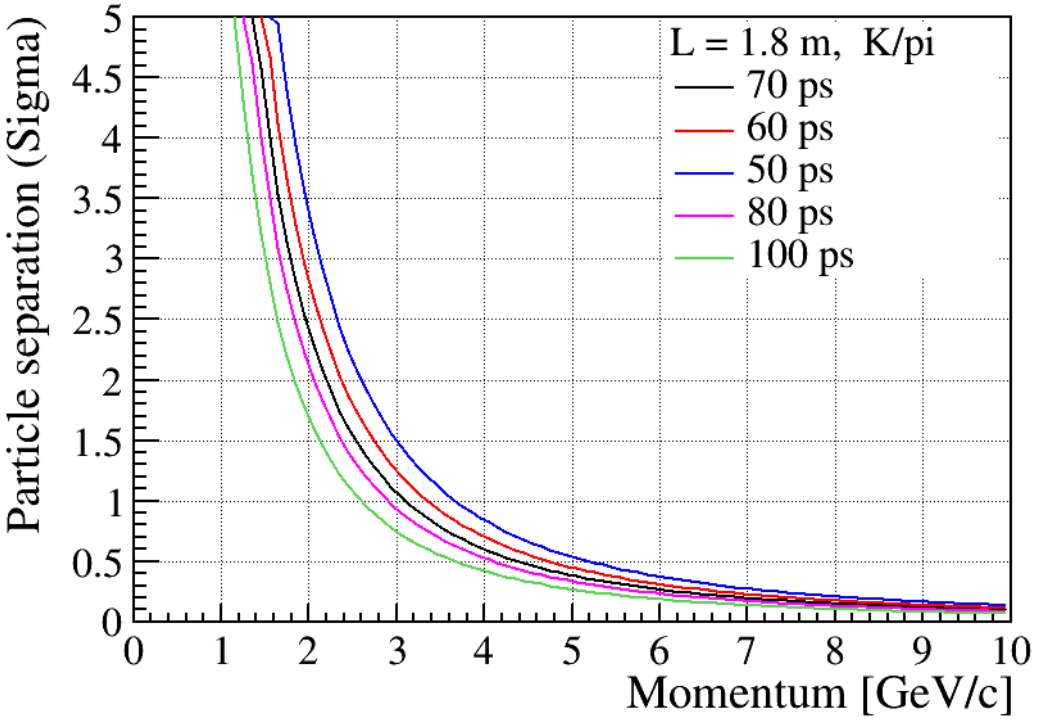
LGAD based time of flight and outer tracker

Physics requirement

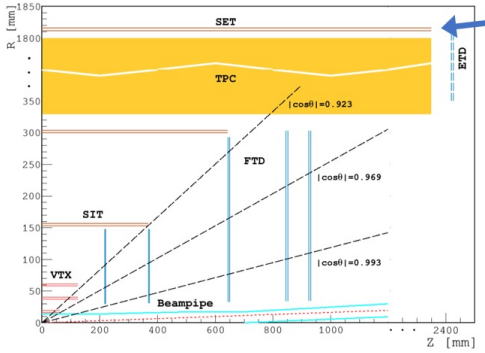
- 3 sigma K/pi seperation below 2GeV
  - 50 ps precision is the target



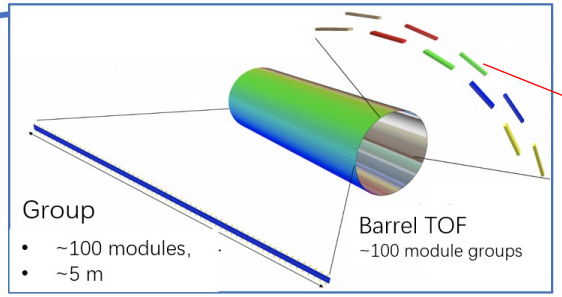


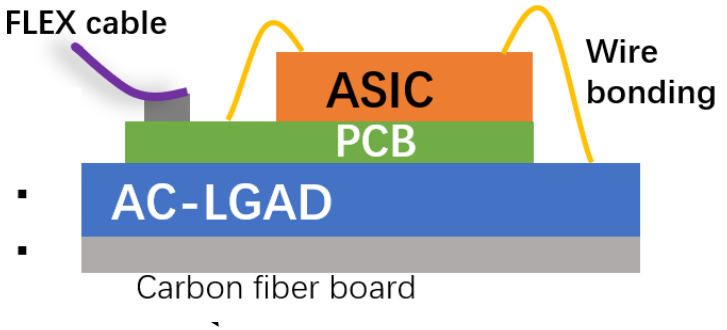
CEPC 4D outer tracker

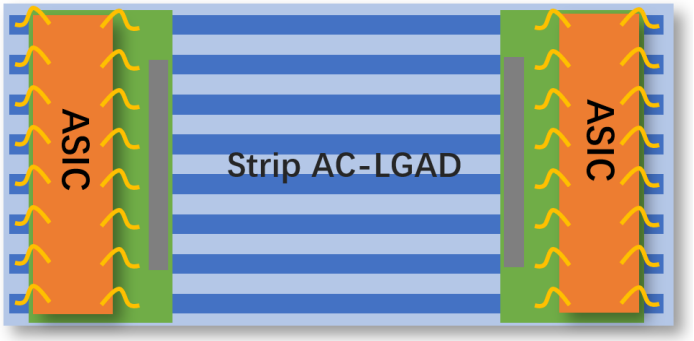
Baseline detector concept in CDR

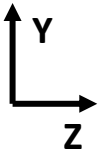


LGAD timing detector in Barrel region









CEPC 4D outer tracker concept design:

- Should be part of SET (silicon wrapper layer outside TPC o drift chamber)
- Serve as Timing detector and part of the tracker
- Barrel : 50 m^2 , Endcap 20 m^2 , **~ 10^6 channels**
- Strip AC-LGAD (each strip: **4 or 10 cm × 0.05cm**)
  - Timing resolution: 30-50 ps
  - Position resolution: ~ 10 μm @ R-phi direction
  - ~ 1mm @ z direction

Strip AC-LGAD + ASIC :

- TOT->amplitude->charge sharing->position
- TOA+TOT->timing (time–amplitude correction)

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Arrangement of the ToF with strip LGAD

- One layer:

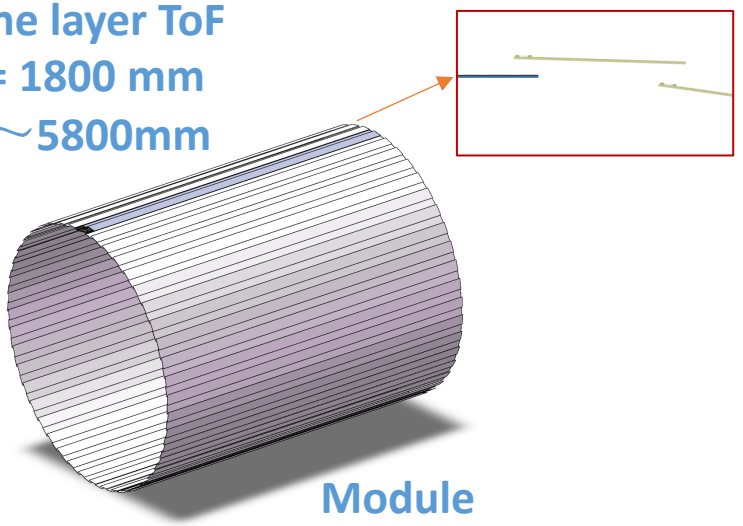
90 ladders，45 ladders each side,

42 modules/ladder，28 ASIC/module

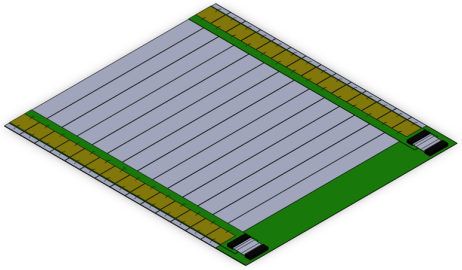
- Total modules needed：

  45 *2*42 = 3780 modules

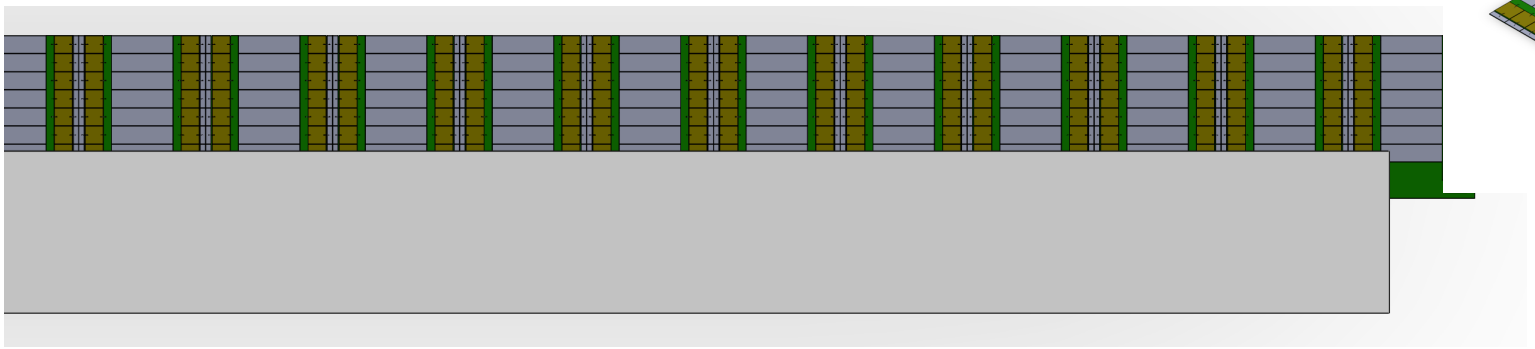
One layer ToF
R= 1800 mm
H～5800mm



Module
140mm x 160mm



Ladder



	ATLAS HGTD	CEPC TOF barrel
Area (m^2)	6.4	~ 70
Granularity	1.3 mm ×1.3mm	70mm × 0.1mm (10平方厘米，每个芯片128道）
Capacitance	4pF	~10 pF
Charge	>4fC	>15fC
Channel number	**~ 3.6 × 10^6**	**~ 1×10^7 (**10644480)
Module assembly	Bump bonding	Wire bonding at strip
MIP Time resolution	30-50 ps	~50 ps
Spatial resolution	~ 300 µm	~ 10 µm
Number of Module	8032	3780 (14cm*14cm)
Number of channels per module	255	2816 (22 芯片，128道）
Data size	16 bit (9 TOT, 7 TOA) 2.5ns →量程 25ns bunch	16 bit (9 TOT, 7 TOA) + channel(7bit, 128) +bunch ID(8bit) + chip ID (4-5 bit) ~40-48 bits
Data rate		5Hz/ cm2

Endcap design

- ITK strip endcap

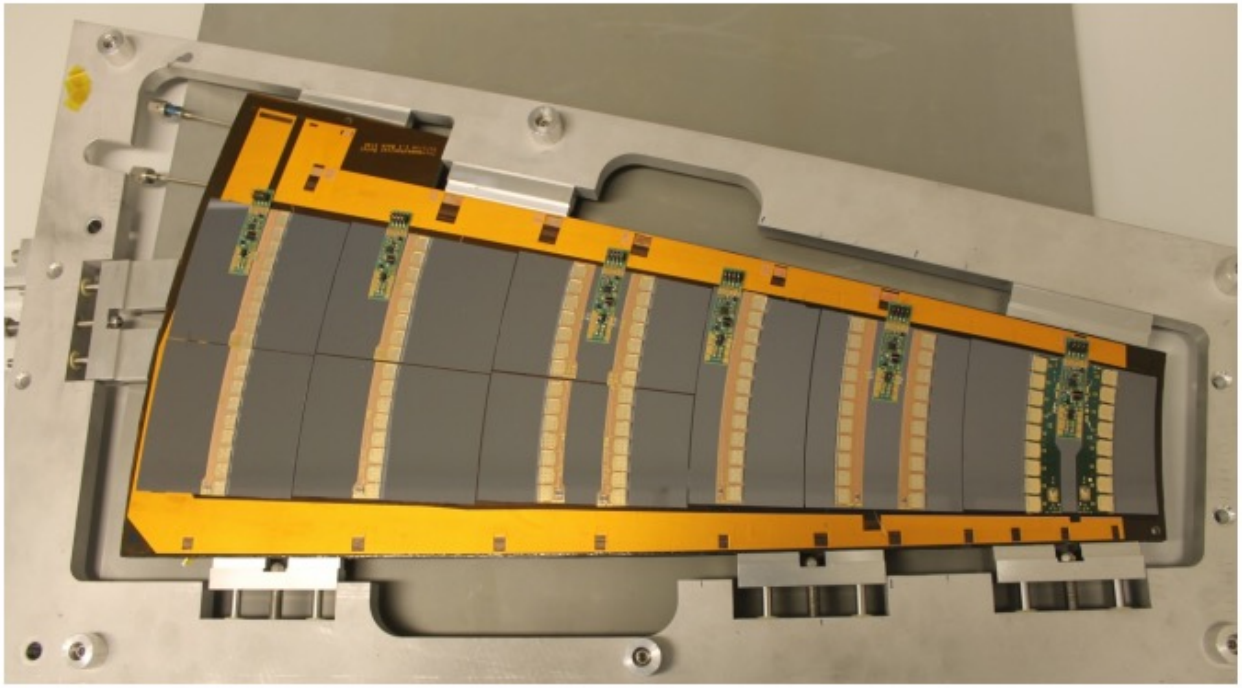
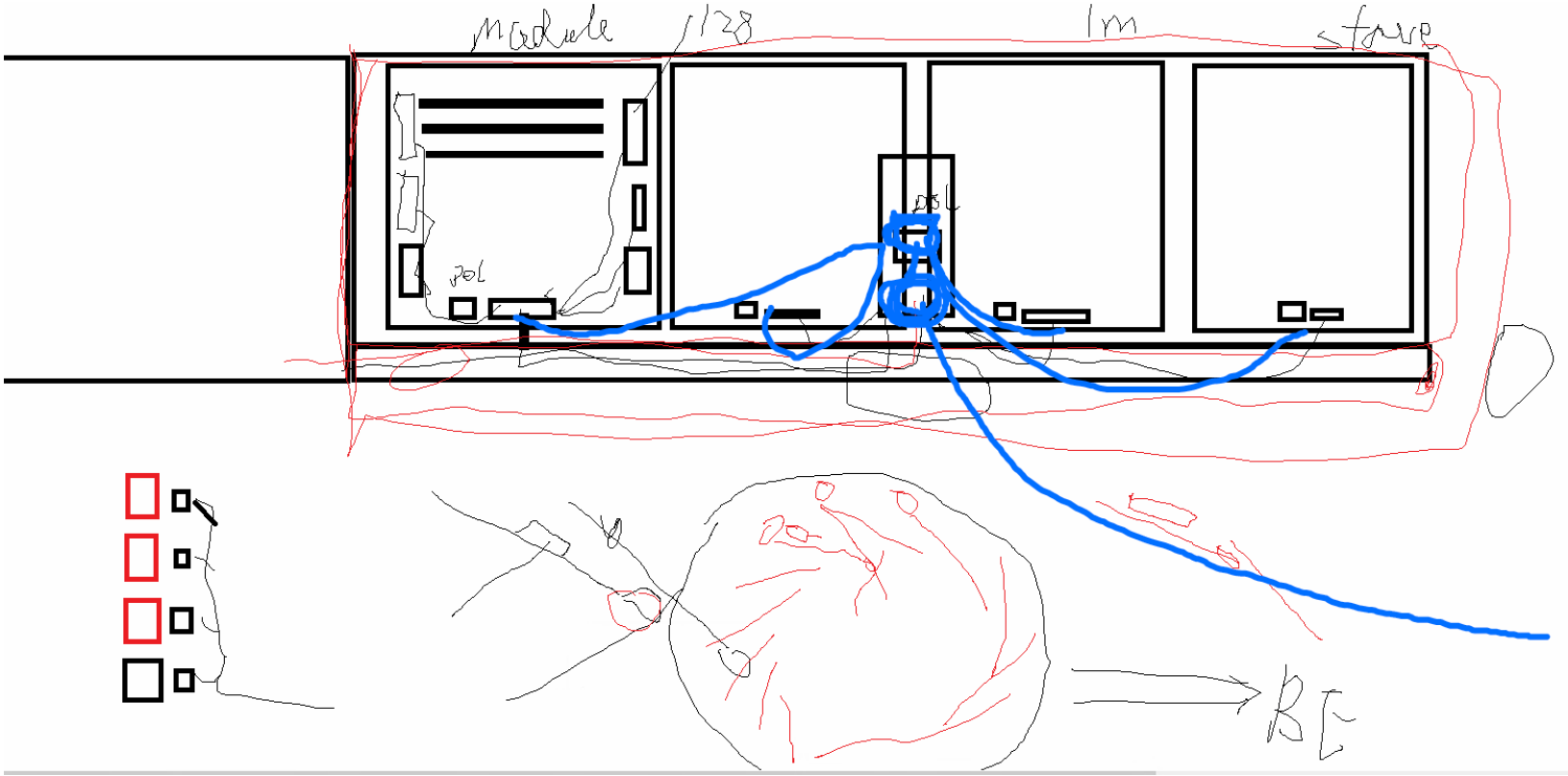


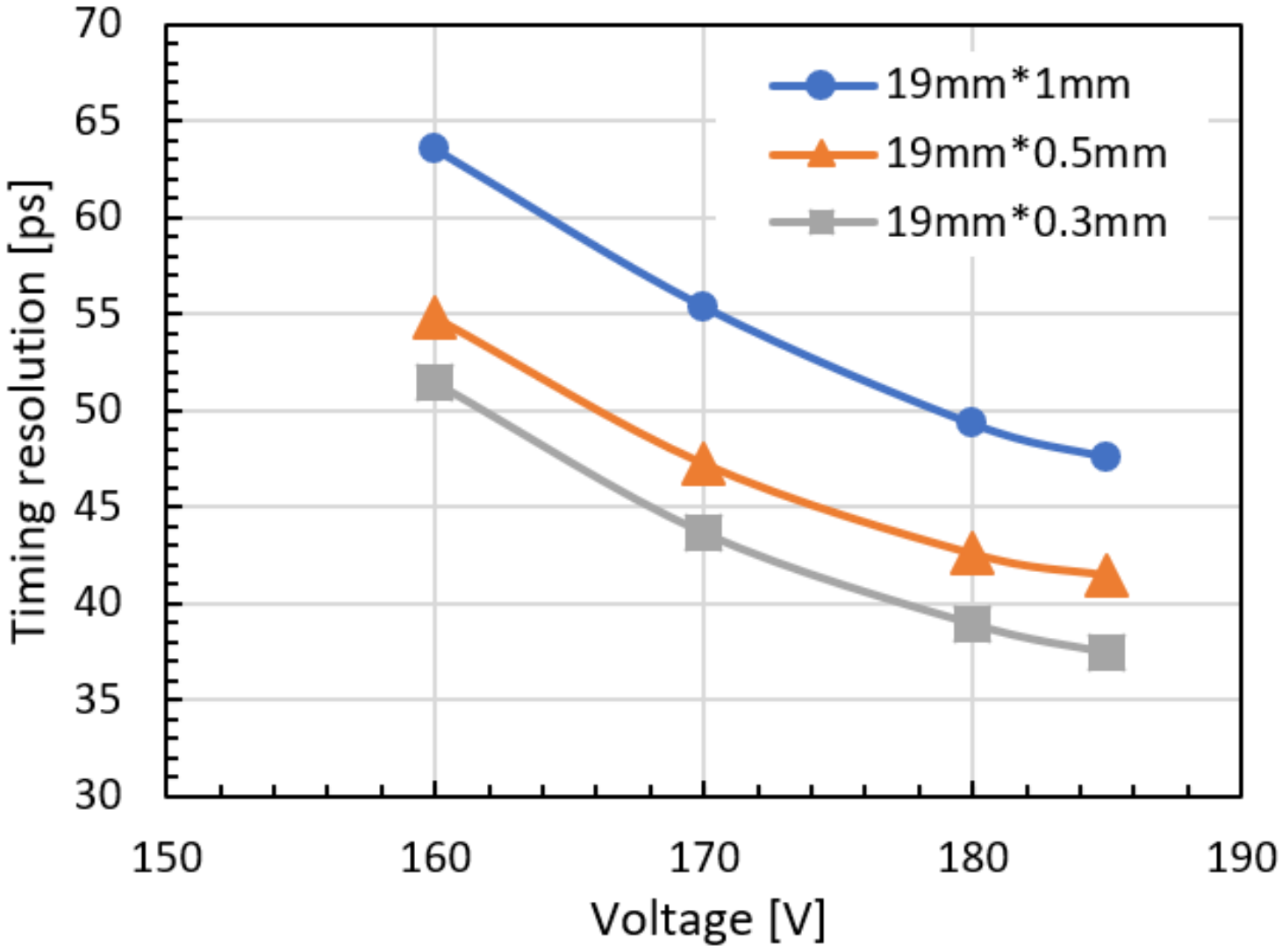
Figure 9.18: Photo of the thermo-mechanical petal prototype.

Backup

确定了电子学框架

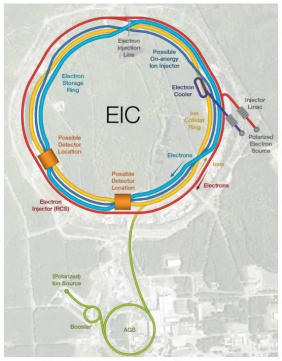


Timing resolution (different dimension of strip)

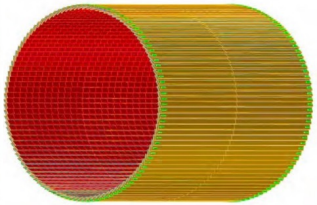


Application of AC-LGAD

Electron-Ion Collider (EIC): Timing-tracker

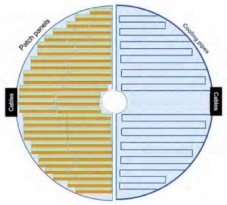


Barrel AC-LGAD detector



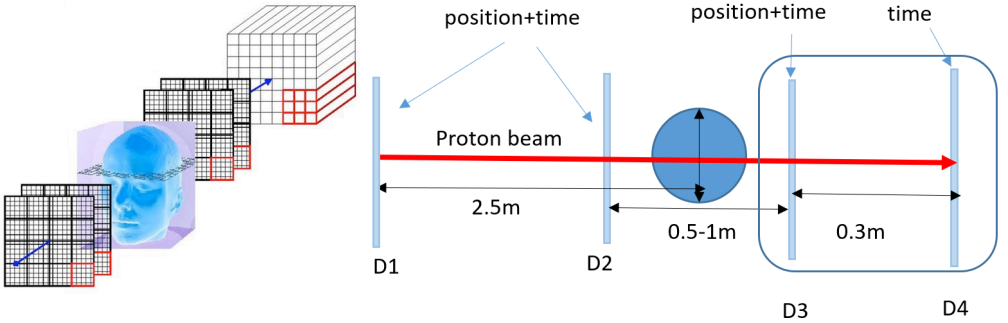
10.9 m^2

Hadron endcap AC-LGAD detector

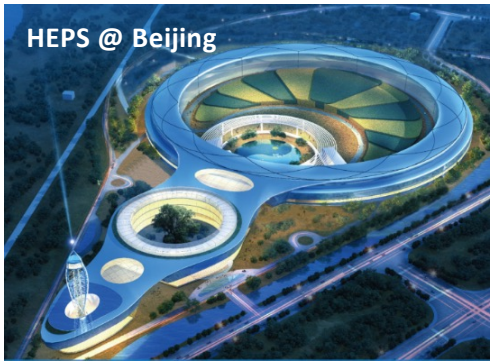


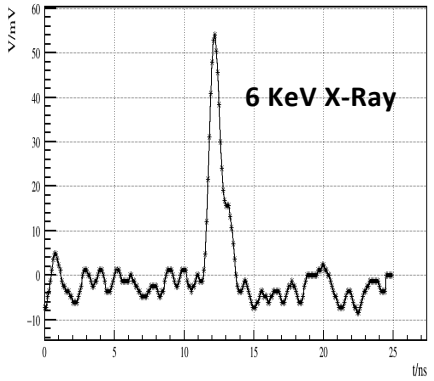
2.22 m^2

Nuclear Medicine Instruments:
Such as proton therapy and proton CT



X-ray detectors @ advanced light sources





other applications

- Beam Telescope for Beam Test Platform
- LiDAR: Positioning and Navigation
- Track and time detectors in other particle physics and nuclear physics experiments
- …

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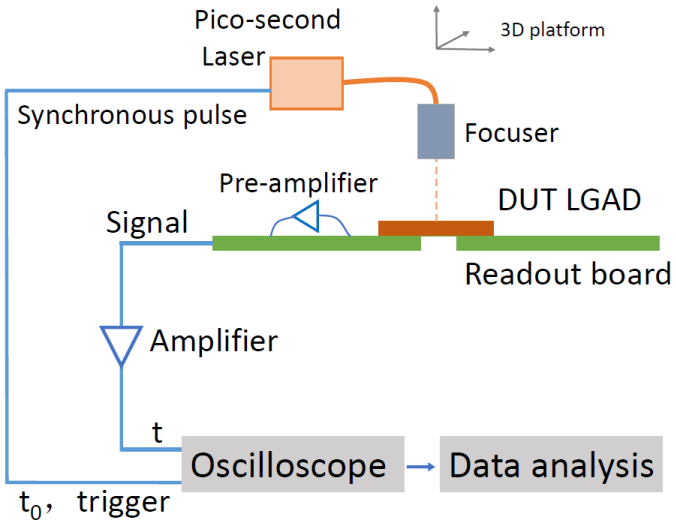
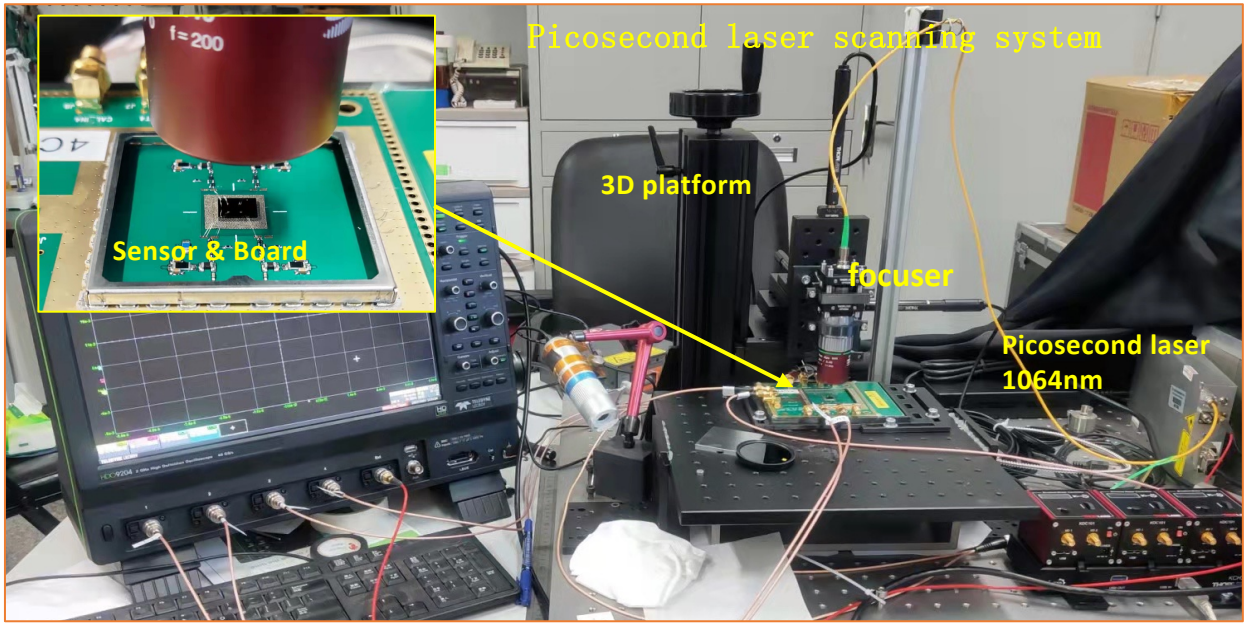
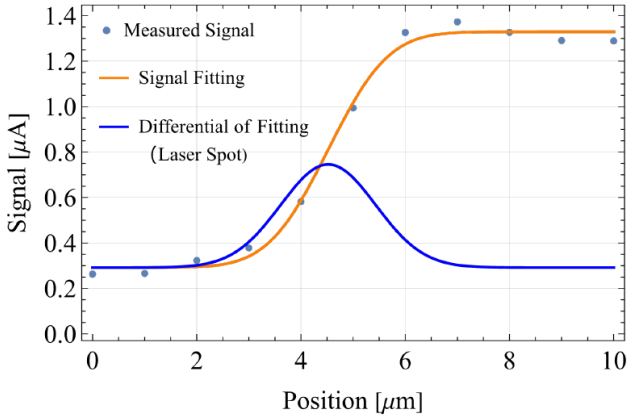
4.1 AC-LGAD sensor test： Picosecond laser test

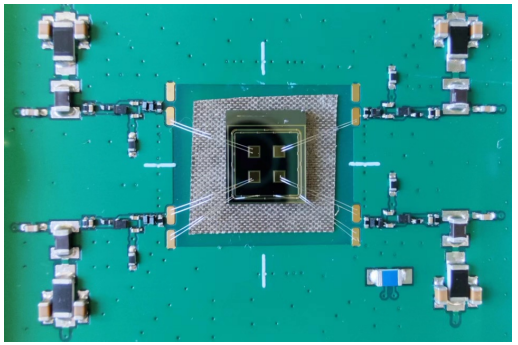






Picosecond laser scanning system

- Displacement accuracy 1 μm
- Automated scanning
- Picosecond laser 1064nm
- Spot size 2~5 μm



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