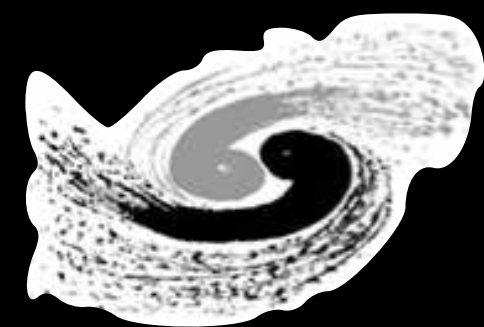


# Test Beam opportunity on Beijing Synchrotron Radiation Facility (BSRF)

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IHEP, Chinese Academy of Sciences

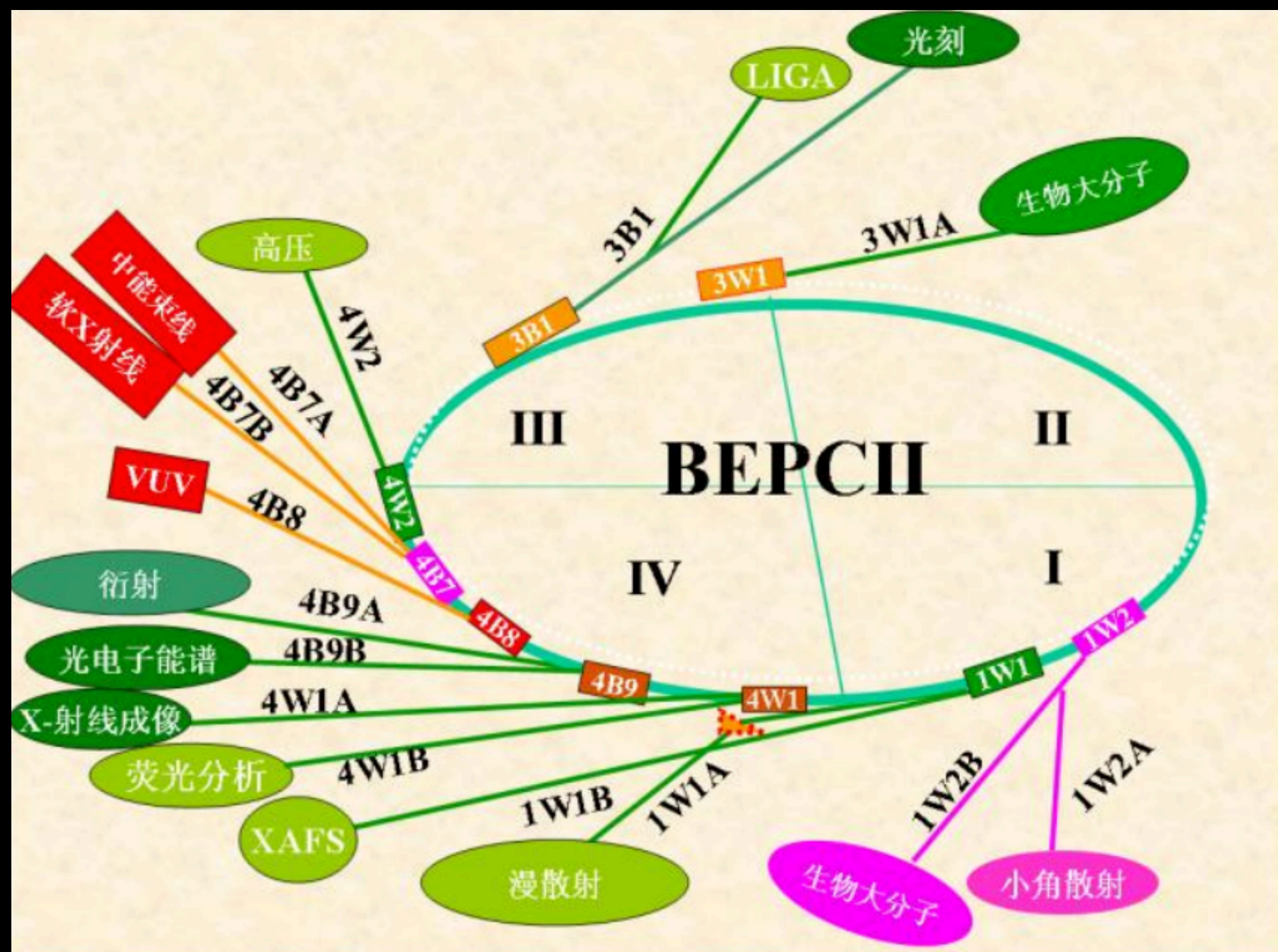


中国科学院高能物理研究所

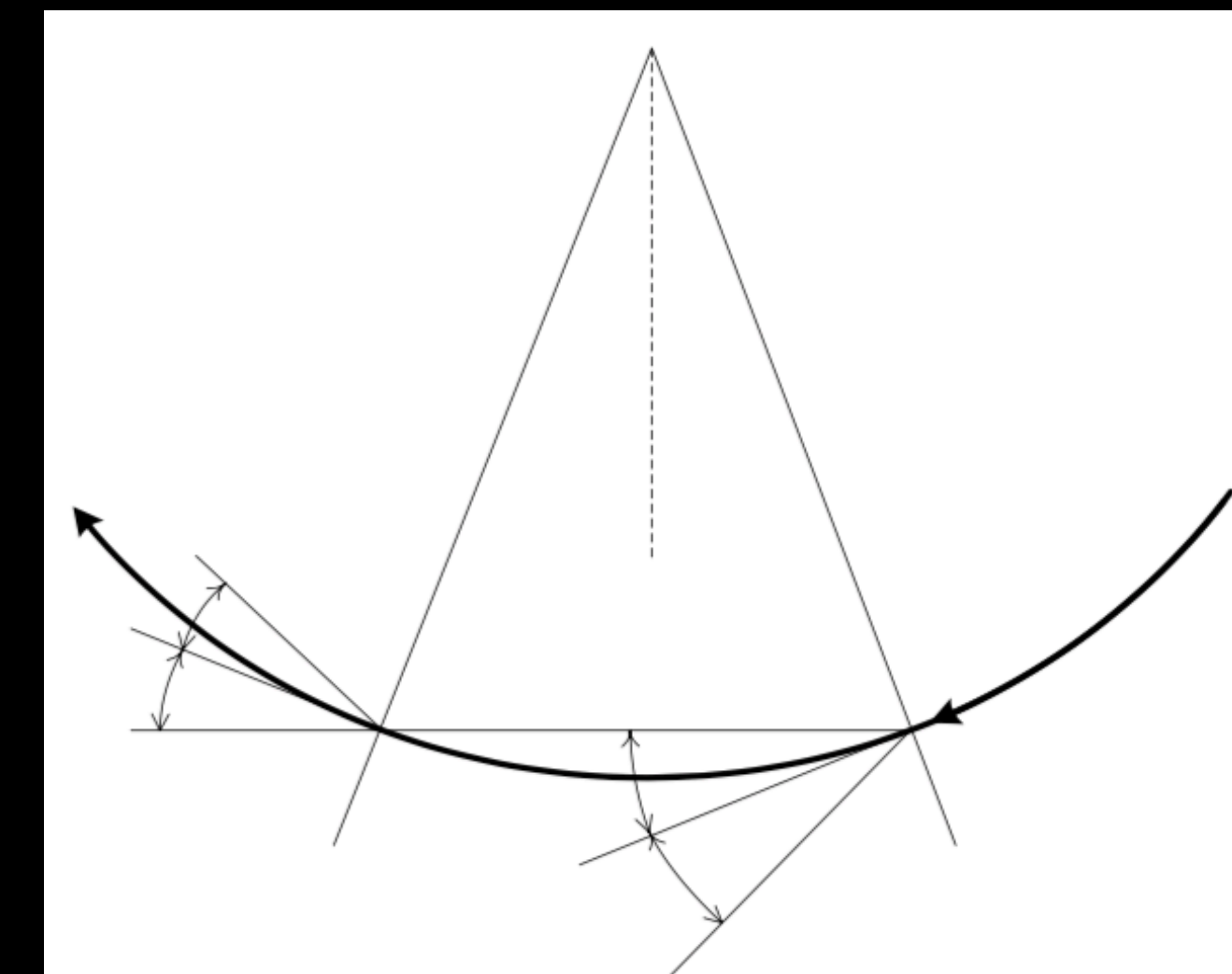
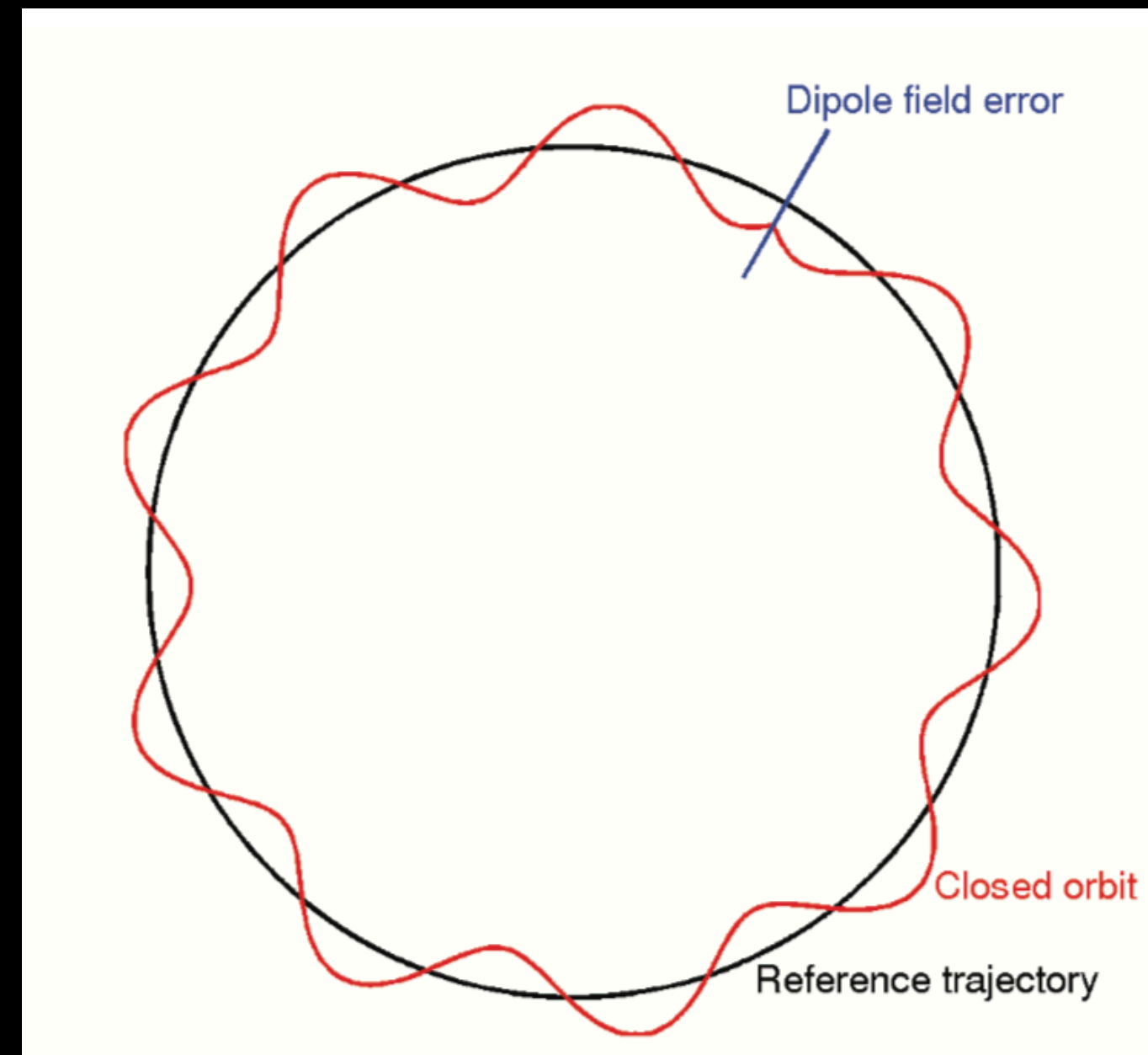
*Institute of High Energy Physics  
Chinese Academy of Sciences*

# Motivation

- Due to pandemic, many CEPC testbeams scheduled at DESY were cancelled
- Test beam facility in IHEP Hall 10 can be alternative option
- ❑ However Limited by event rate, and operation time (~2 months per year)
- Beijing Synchrotron Radiation Facility (BSRF) stations can be alternative
- Out-of-phase electrons may go through BSRF station
- Advantage of BSRF:
  - ❑ Long operation period (~10 months per year)
  - ❑ Potential to have high event rate and high energy electrons



## Electron orbit

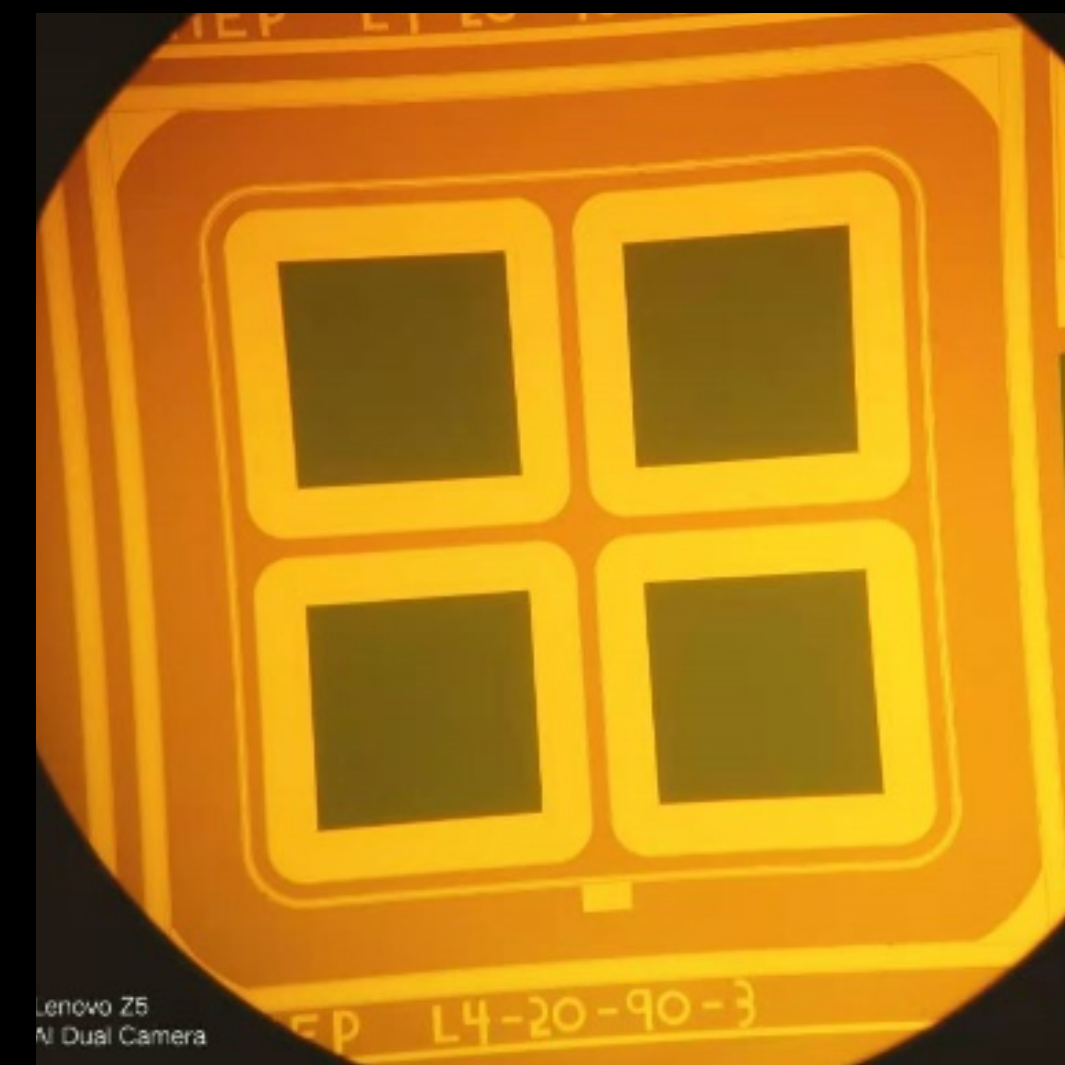




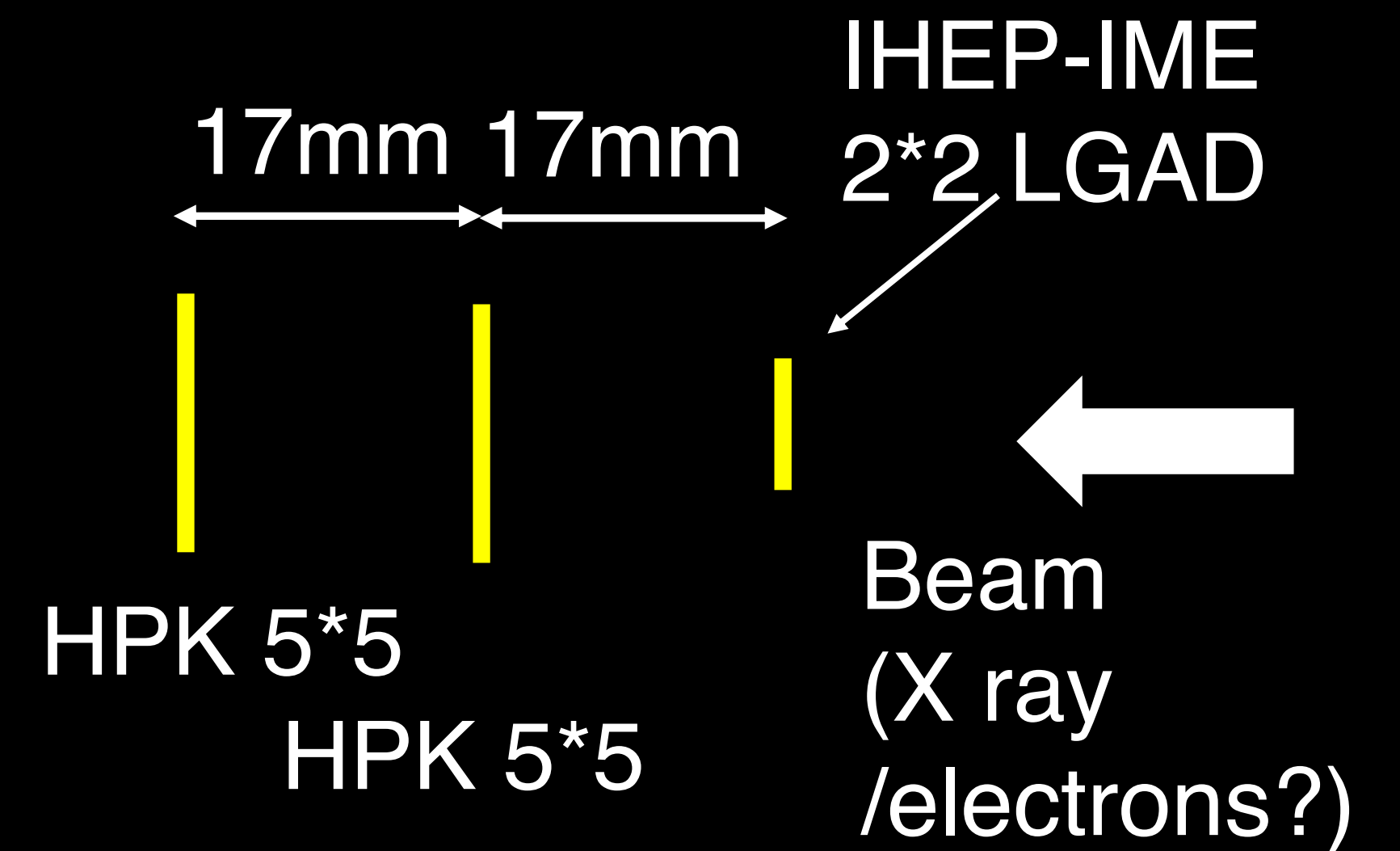
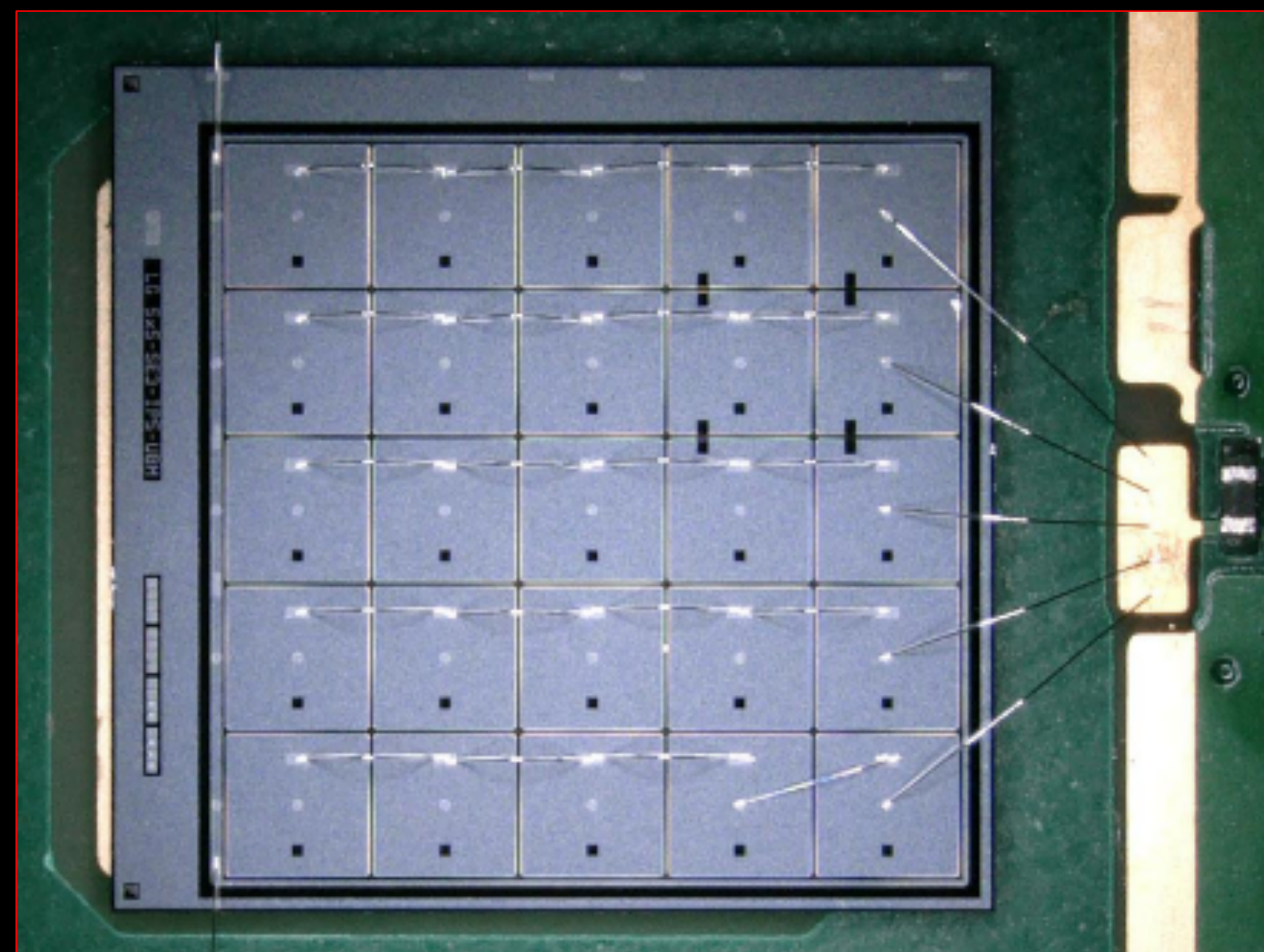
# Detector at BSFC testbeam

- Three detectors are used, data taking with Oscilloscope
- One IHEP-IME 2×2 LGAD. Area: **3mm×3mm**, time resolution: **39ps**
- Two HPK 5×5 LGAD. Area: **6.5mm×6.5mm**, time resolution: **60-70ps**
- One HPK 15×15 LGAD. Area: 20 mm ×20 mm, low signal level

**IHEP-IME  
2×2 LGAD**



**HPK 5×5 LGAD  
Single channel readout**



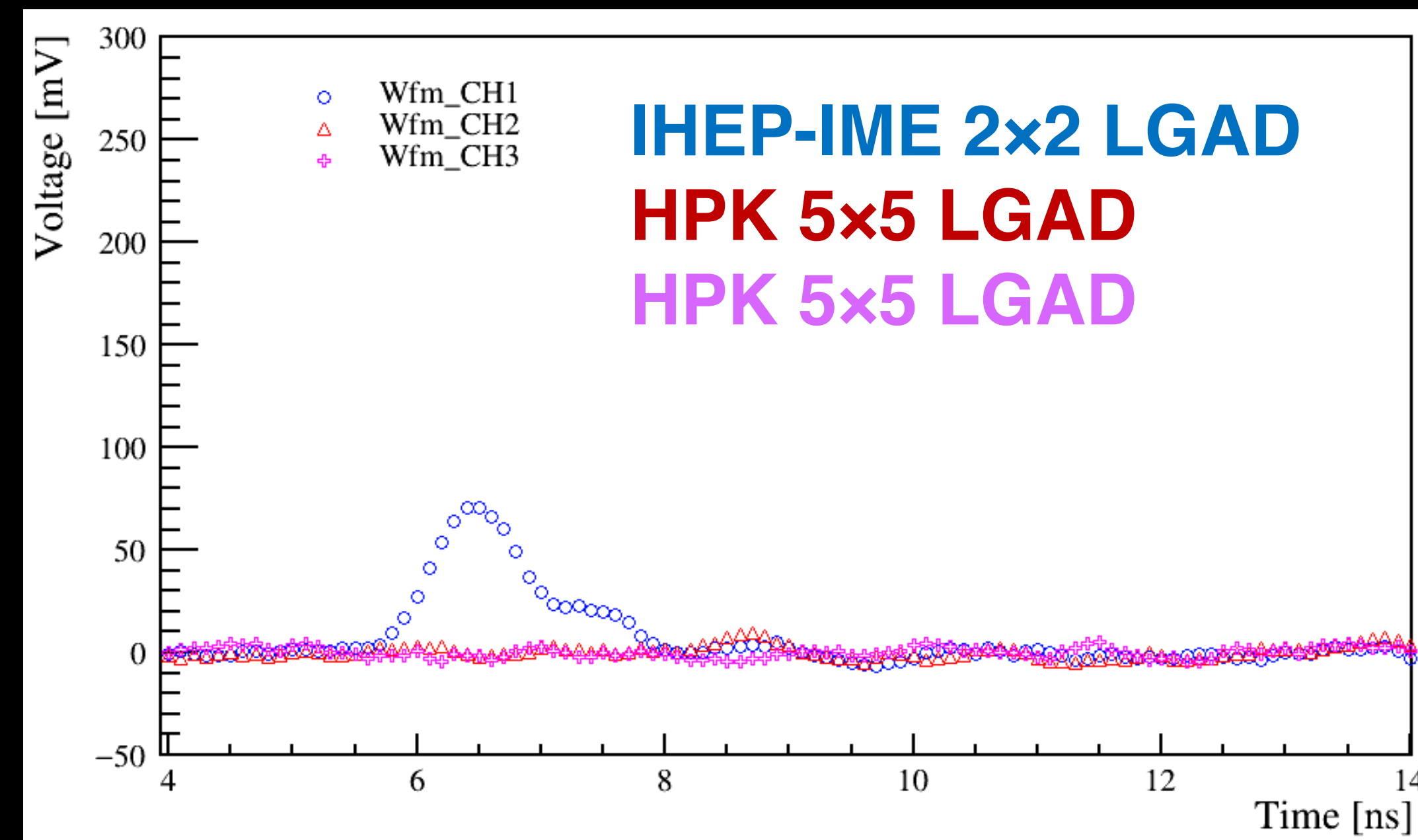
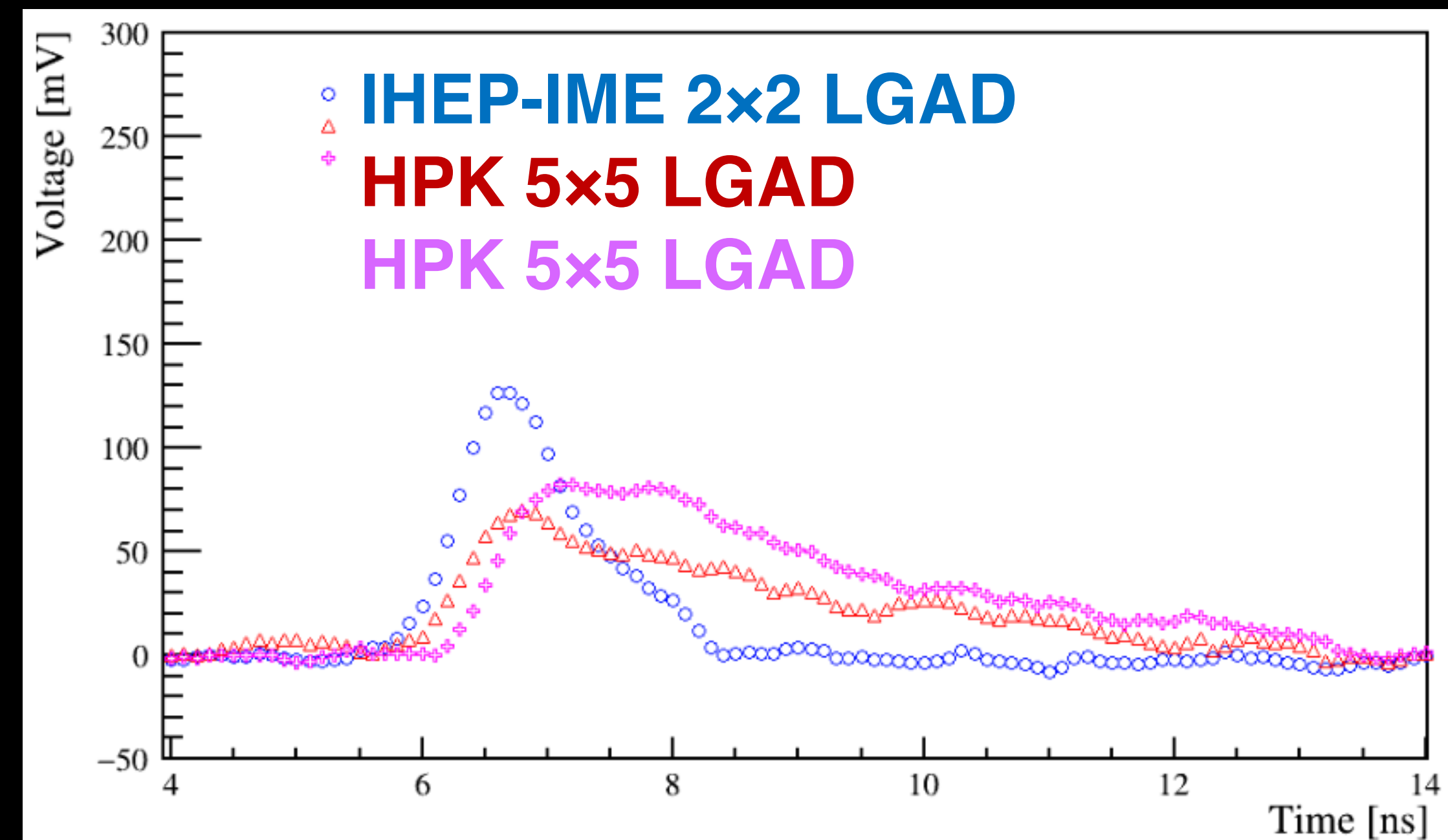
# Detector signal at BSFC testbeam

- Two type of signal: **Coincidence and non-coincidence events**

**Typical Coincidence events**  
(Coincidence signal  
in 2~3 LGAD detectors)

**Typical non-coincidence events**  
(signal only in 1 LGAD  
no signals for others LGADs )

- high rate , Period: ~6ns
- Consistent with BEPC cycle



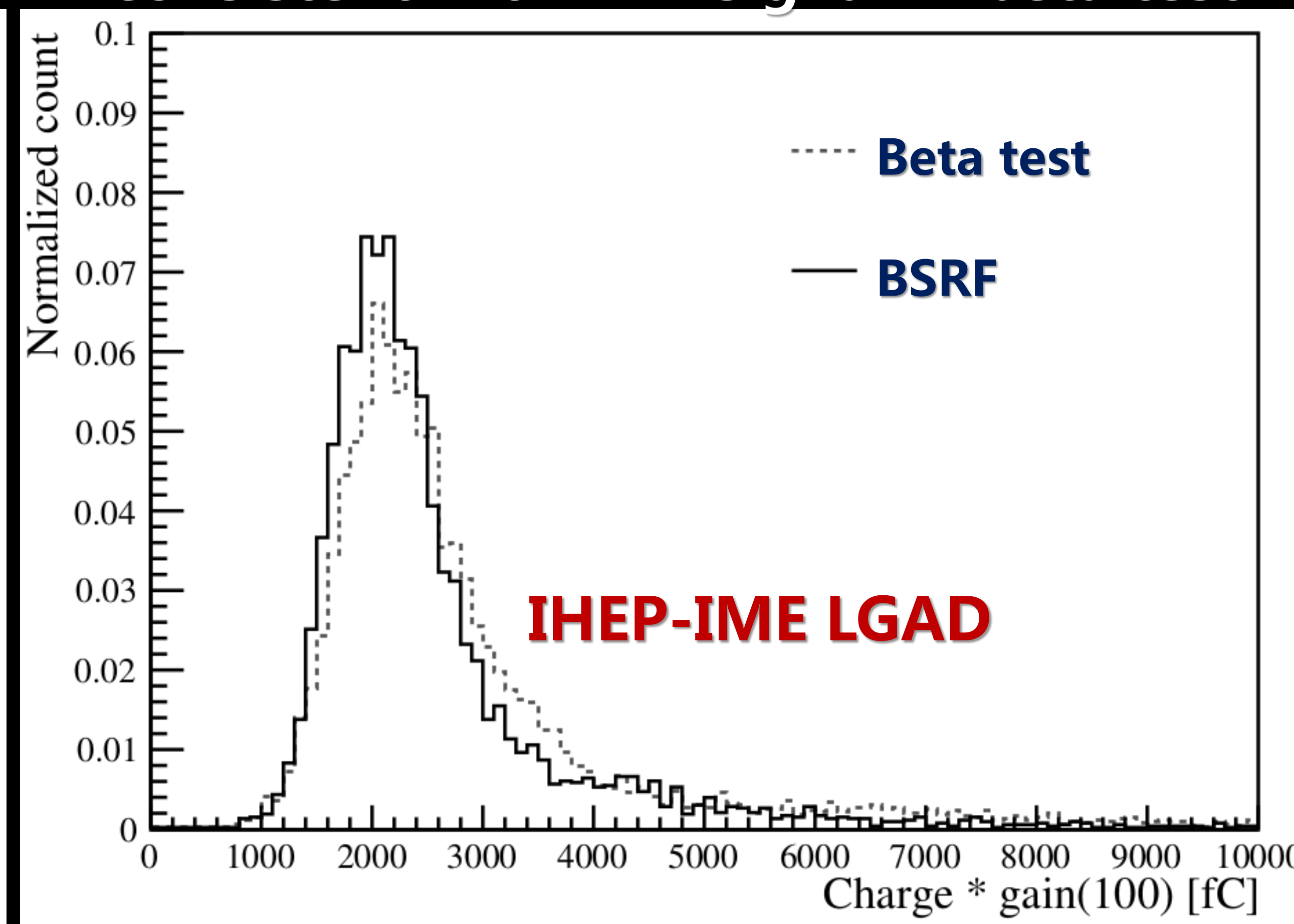
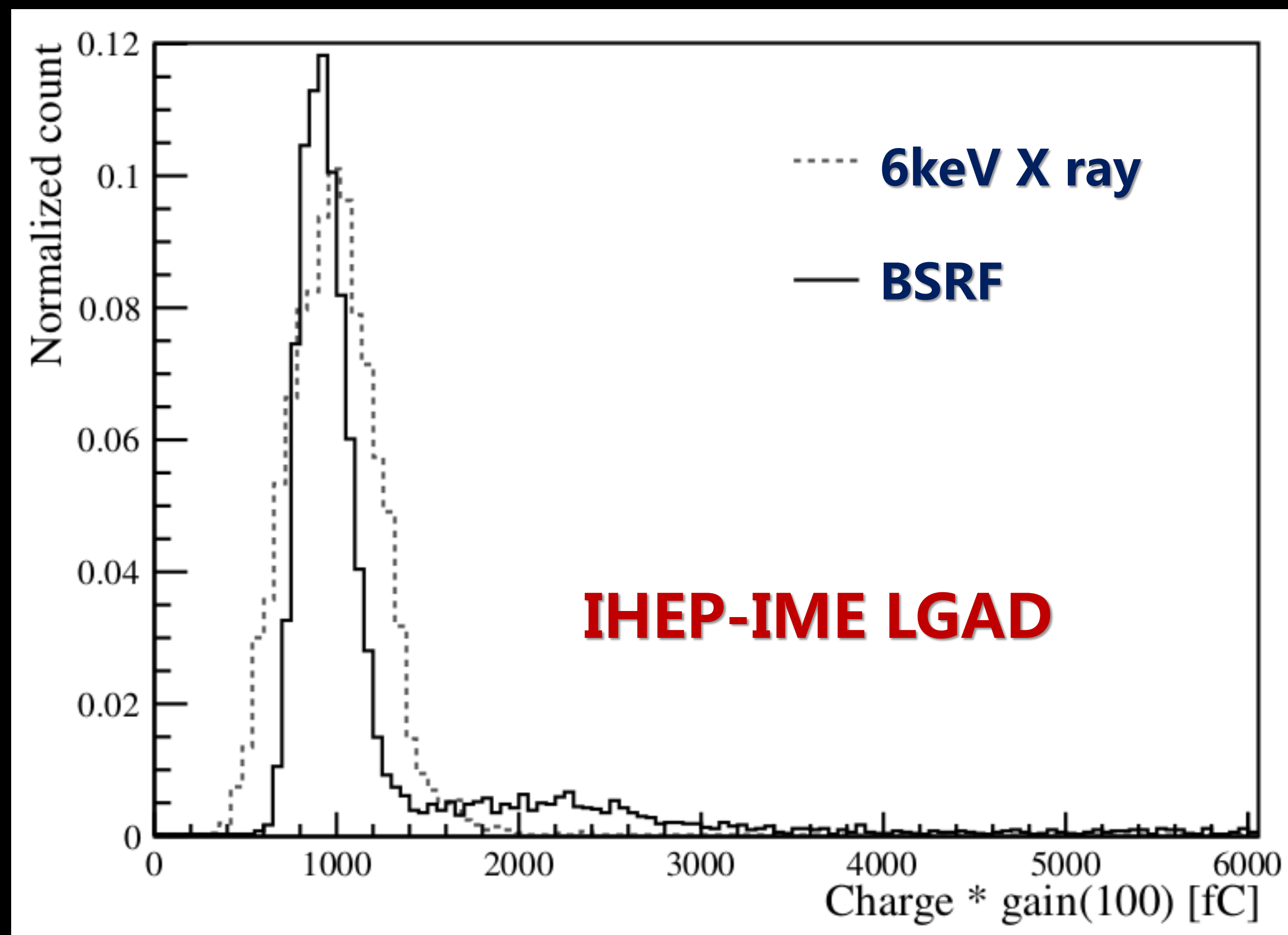
# Detector signal at BSFC testbeam

## Collected charge of non-Coincidence

➤ Similar to 6keV X ray

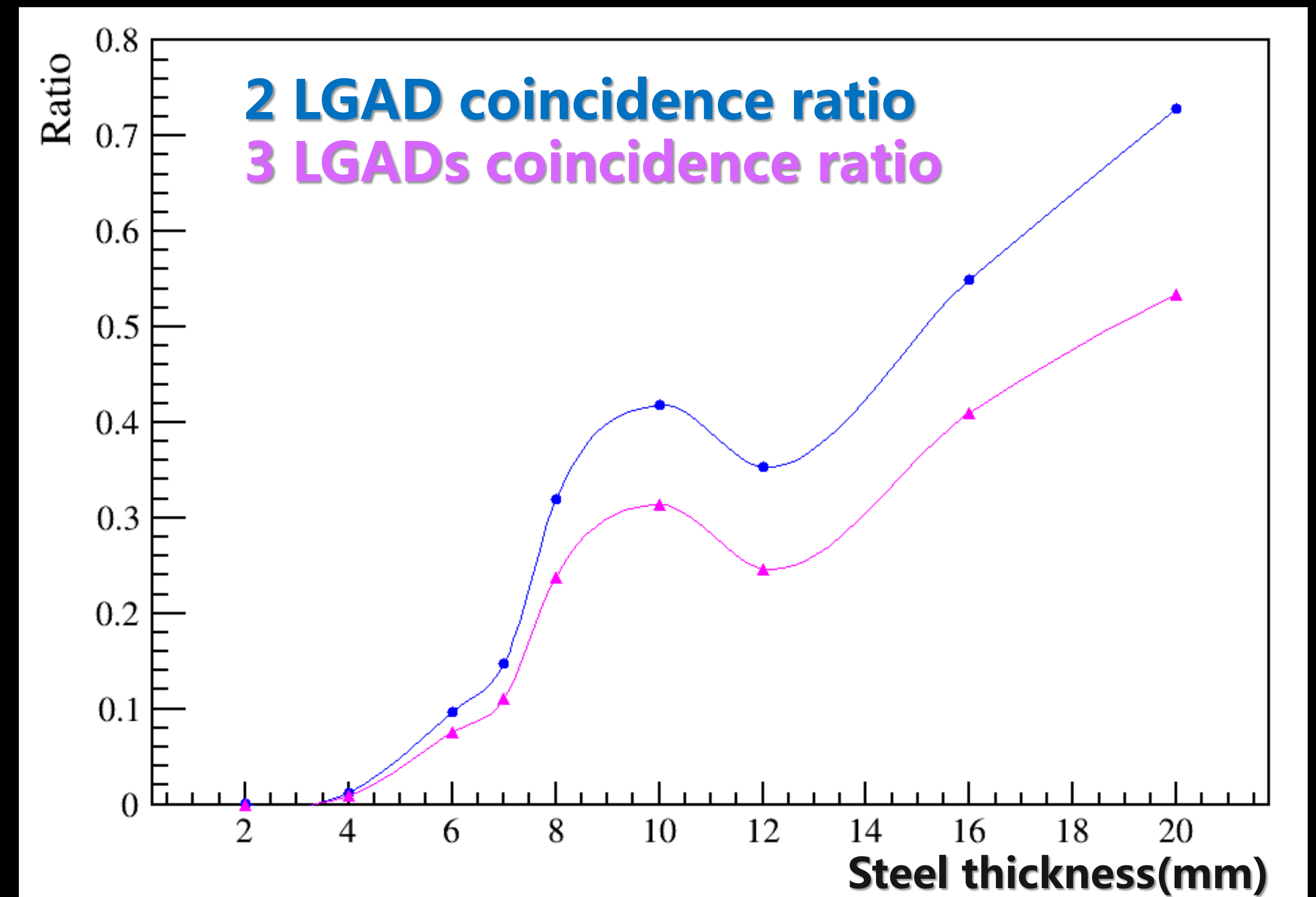
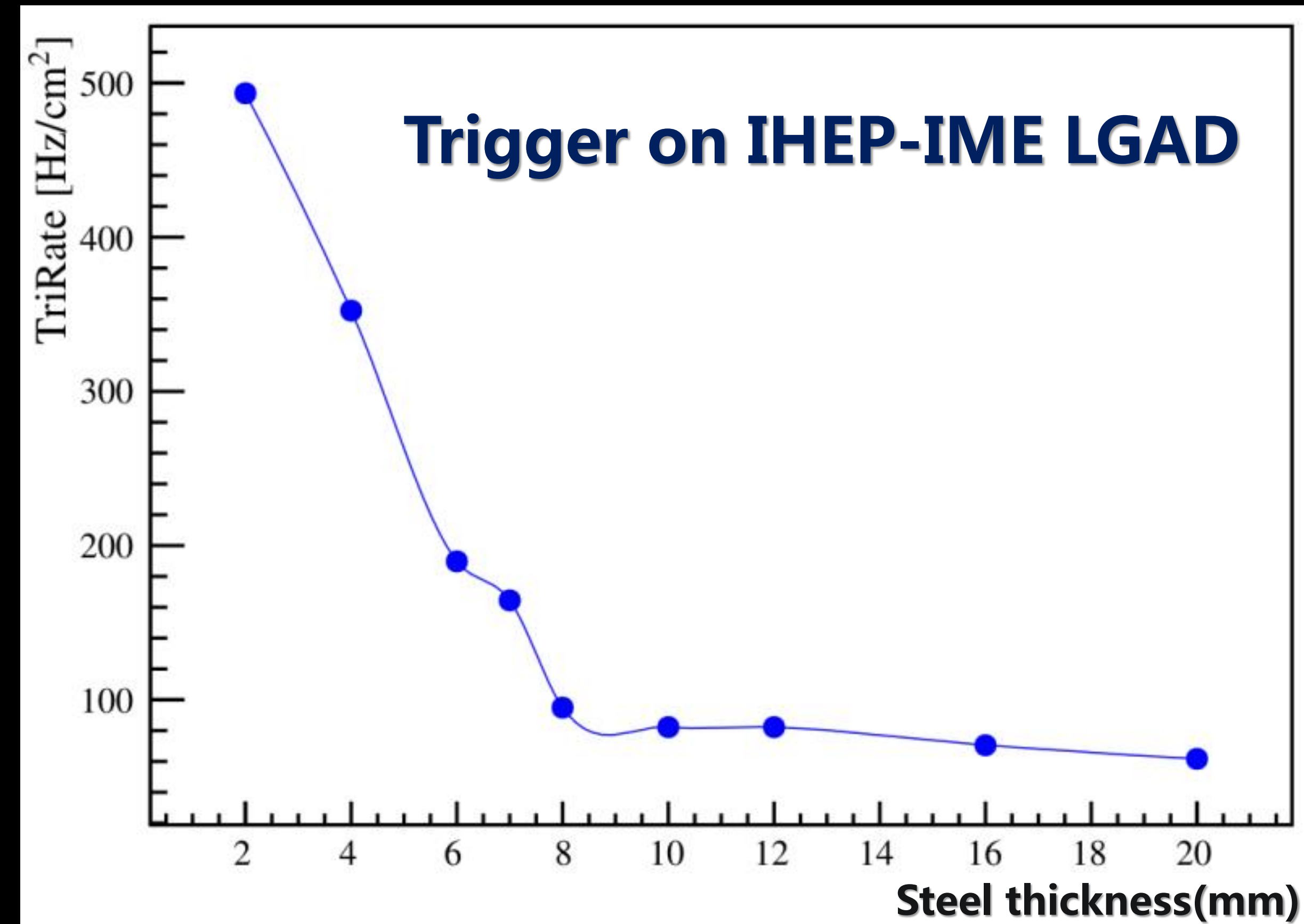
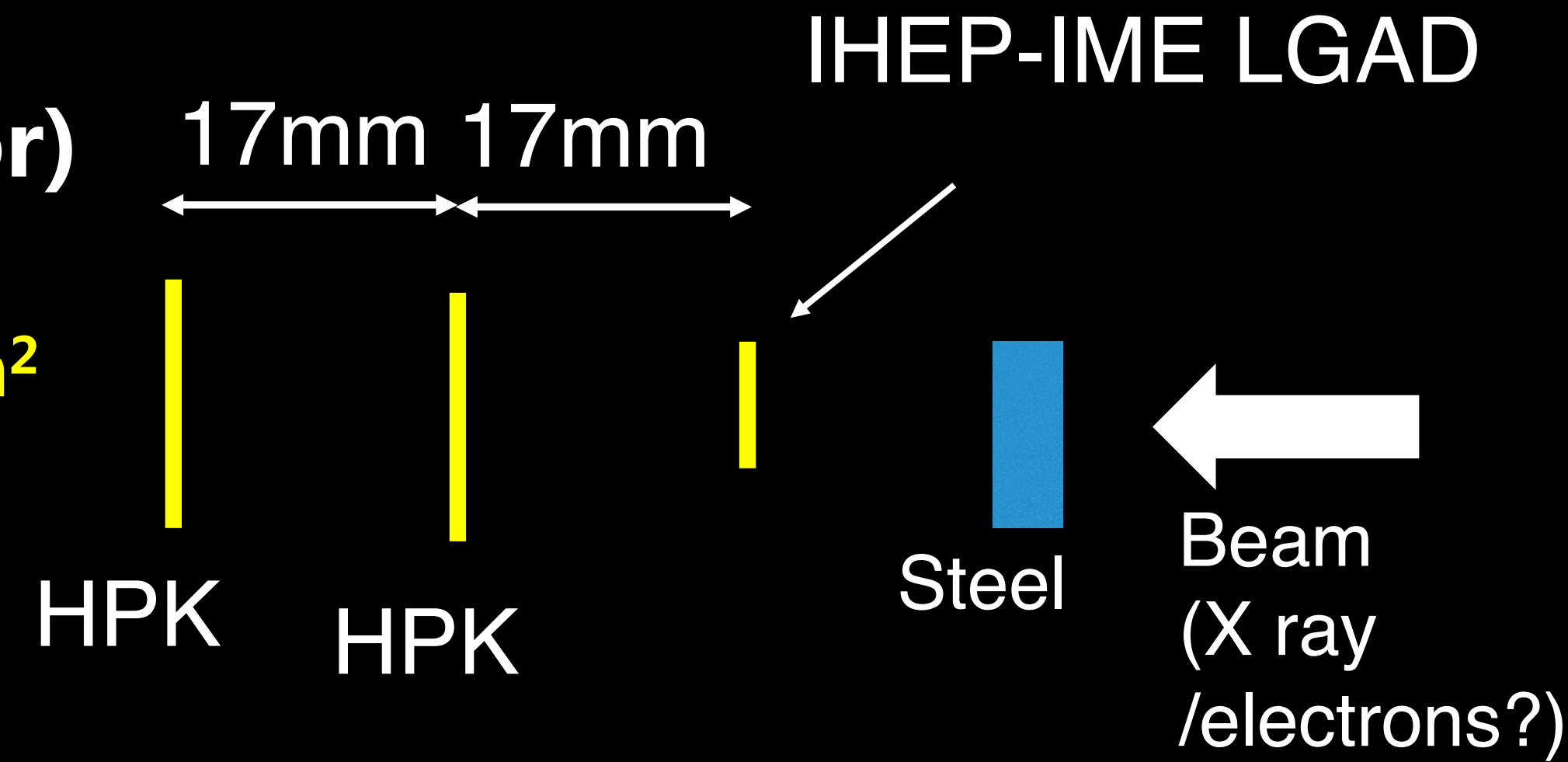
## Collected charge of Coincidence signal

➤ consistent with MIP signal in beta test



# Trigger rate

- Triggering on IHEP-IME LGAD (upstream detector)
- Adding more layers of steel to absorb X ray
- **Trigger rate decrease, and then became stable at  $\sim 50\text{Hz}/\text{cm}^2$**
- **Coincidence events ratio increased**



# Event rates

➤ Coincidence events rate (MIP-like event rate) is higher in station closer to BEPC ring

BSRF Station	1B3	4W1A
Coincidence events rate (Hz/cm <sup>2</sup> )	~50	~1.5 Hz/cm <sup>2</sup>
Distance to BEPC ring (meter)	18	~43

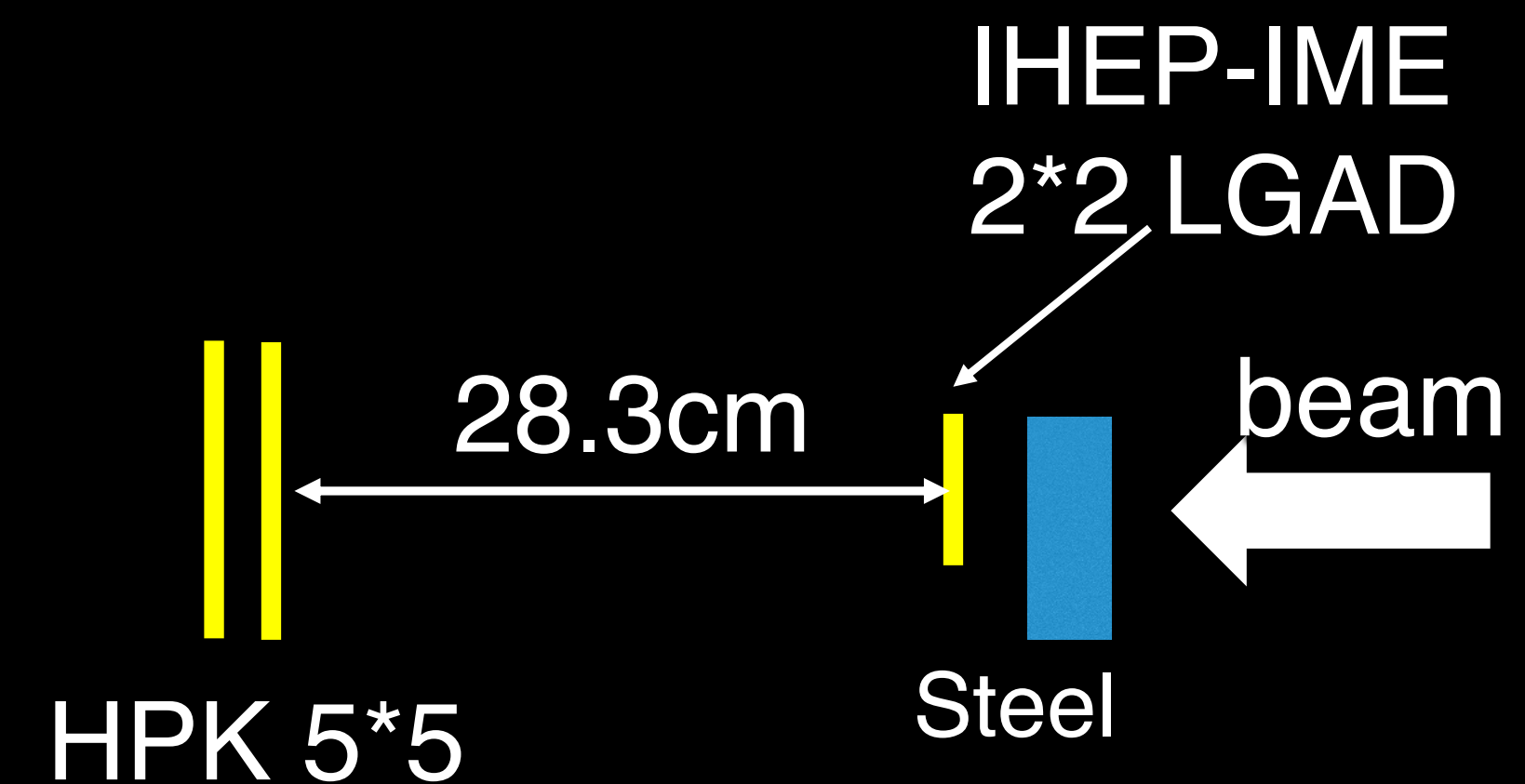
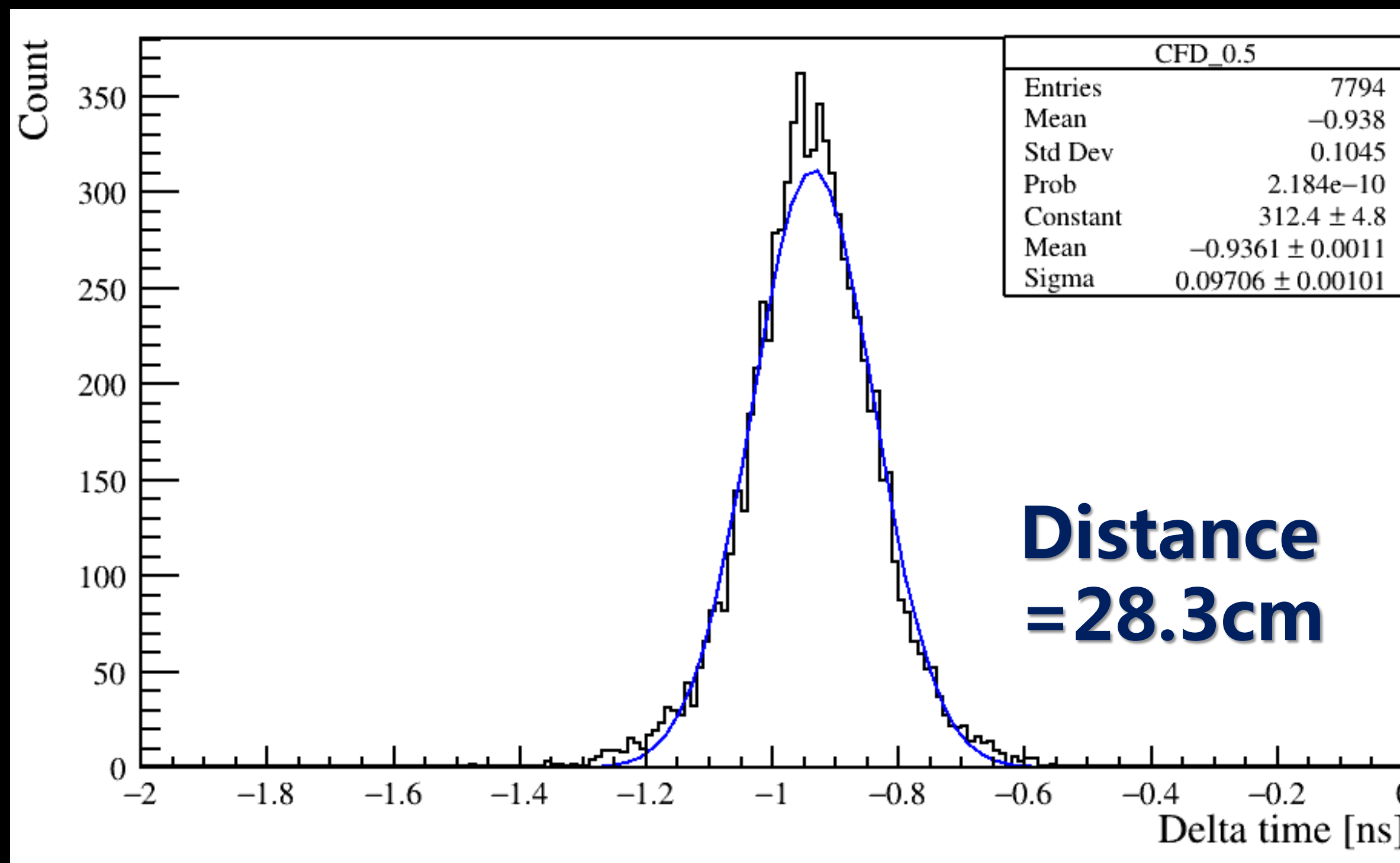
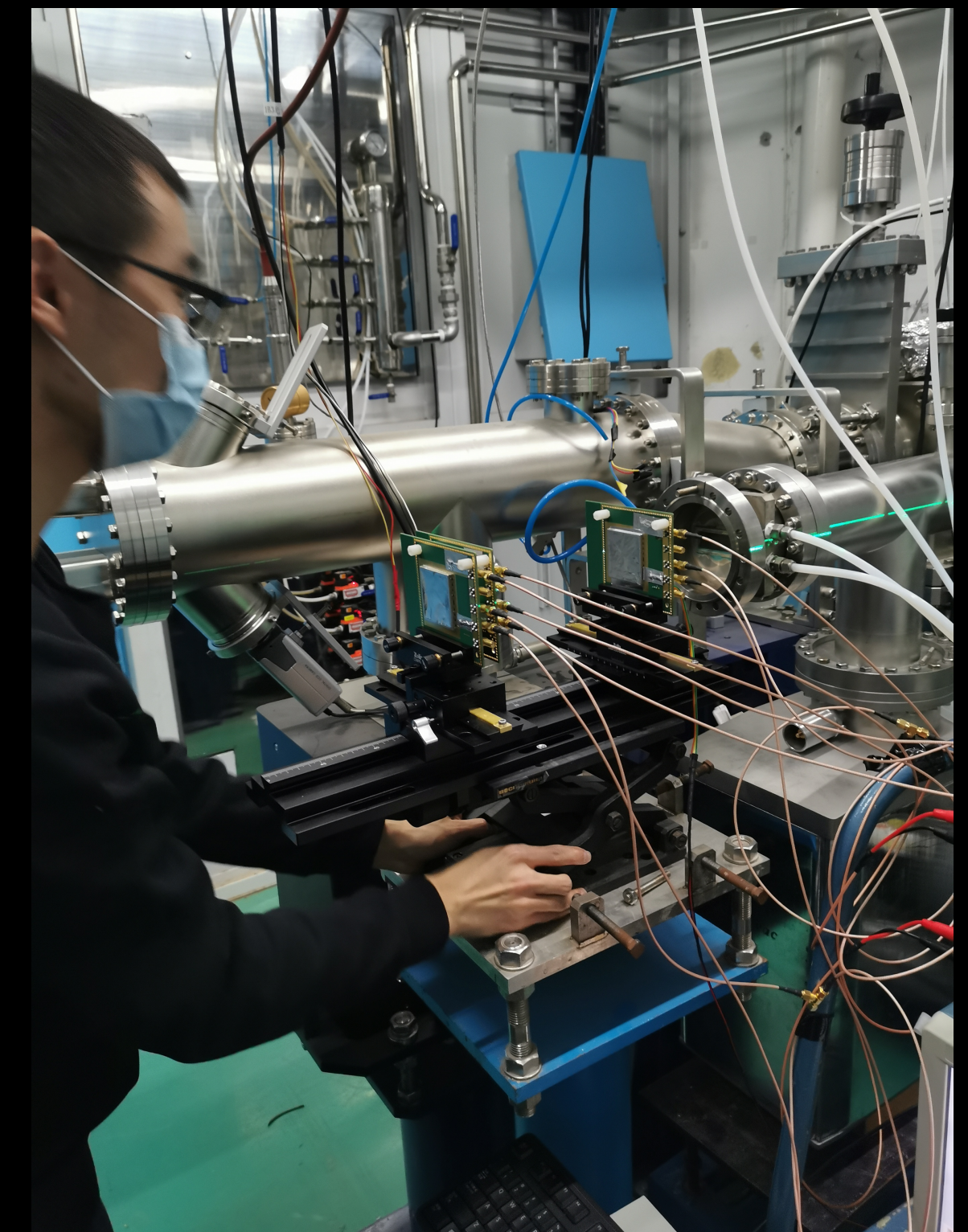




# Time of flight– identifying MIP-like particle

- In coincidence events, what is MIP-like particle ?
- Is that low momentum proton or pion (secondary particles) ?
- Or high energy electrons ?

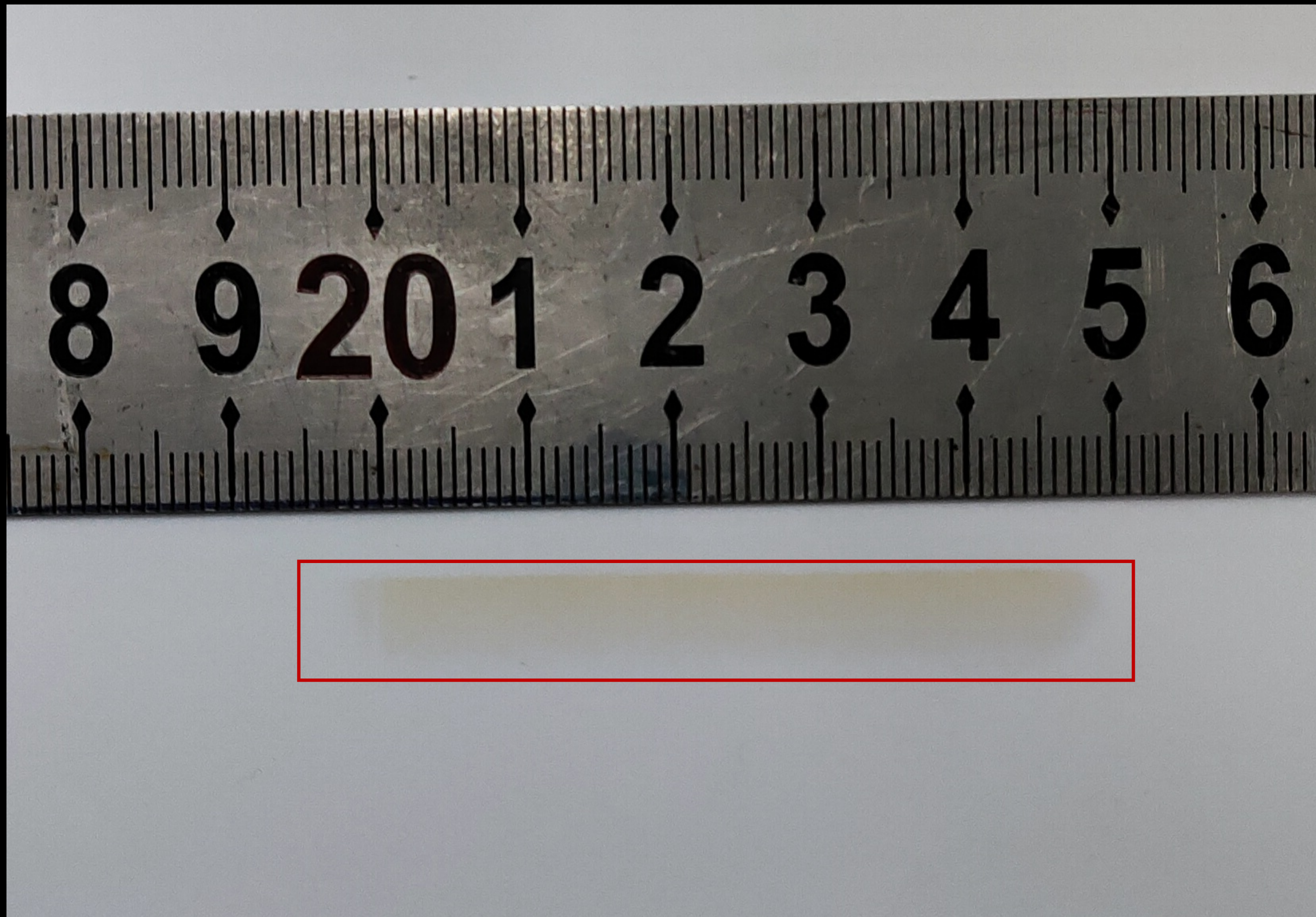
- Measured flight time=936 ps,  $\sigma_t=97$ ps
- Expected flight time = 943 ps
- Consistence with speed of light ( electron like)
- Exclude proton below 1GeV
- Exclude pion below 0.2 GeV



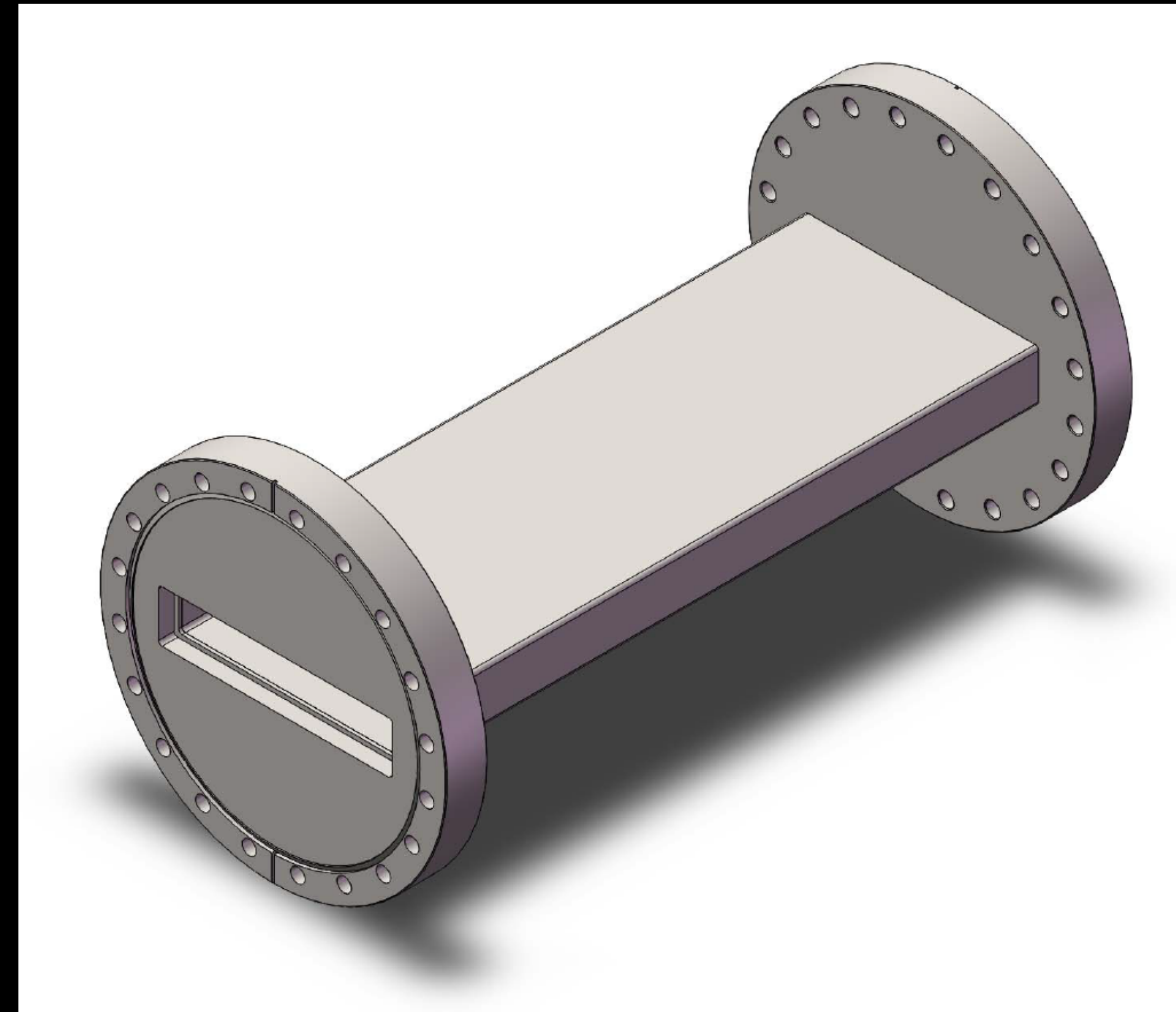
# Beam profile

- Beam spot size: ~0.5cm \* 5cm (estimated from burn mark)
- Beam spot size is consistent with of the shutter shape

Burn mark in 1B3 station

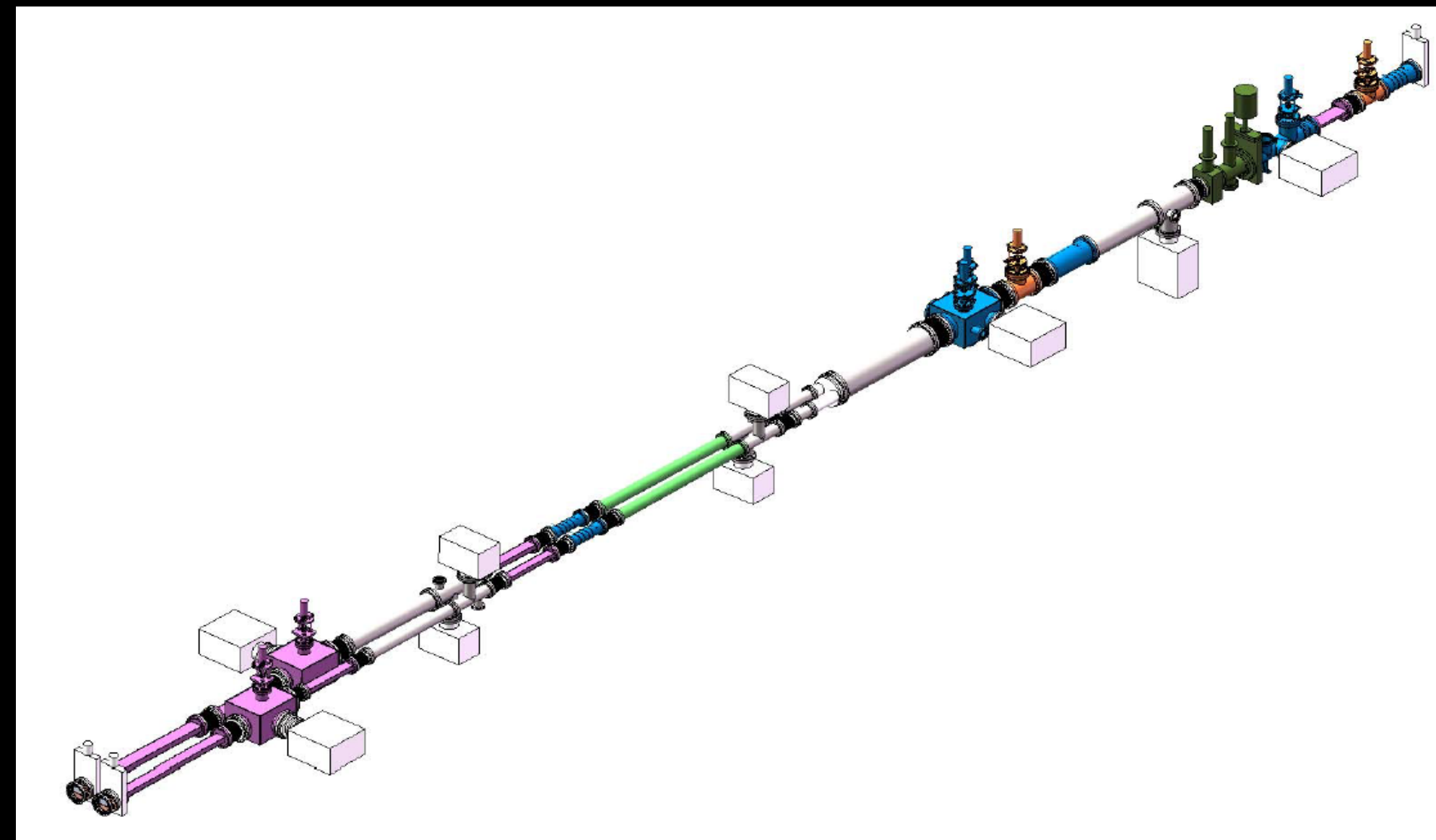


Shutter in 1B3 station



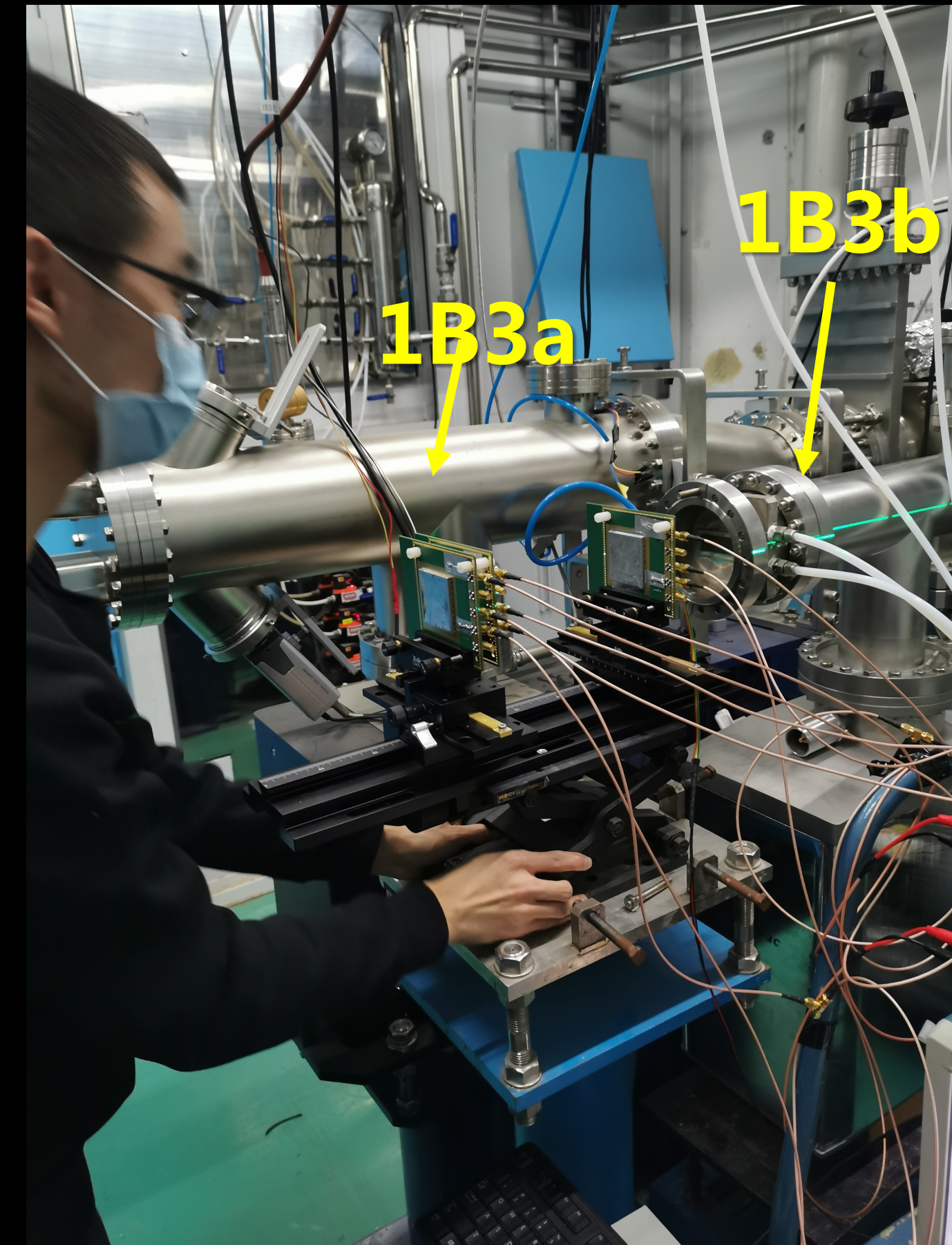
# Potential of using 1B3b station for detector test beam

- 1B3a was used for XRD spectrum (material structure study)
- 1B3b is now borrowed temporarily
- Test beam potential study (last week)
- Accelerator colleague will use 1B3b for next 1~2 months for vacuum study (插入件在X辐照下放气实验)
- Has potential to build test beam facility for longer term at 1B3b
- Use CEPC vertex detector chips to build beam telescope
- Build a magnetic to sperate X ray from electron beams, also measure the momentum of electrons



1B3a

1B3b



# Summary

- Found MIP-like particles in three BSRF stations (likely to be high energy electrons)
- The largest MIP-like event rate is about 50Hz/cm<sup>2</sup>
- BSRF stations has potential to become a good test beam facility

# Comparisons

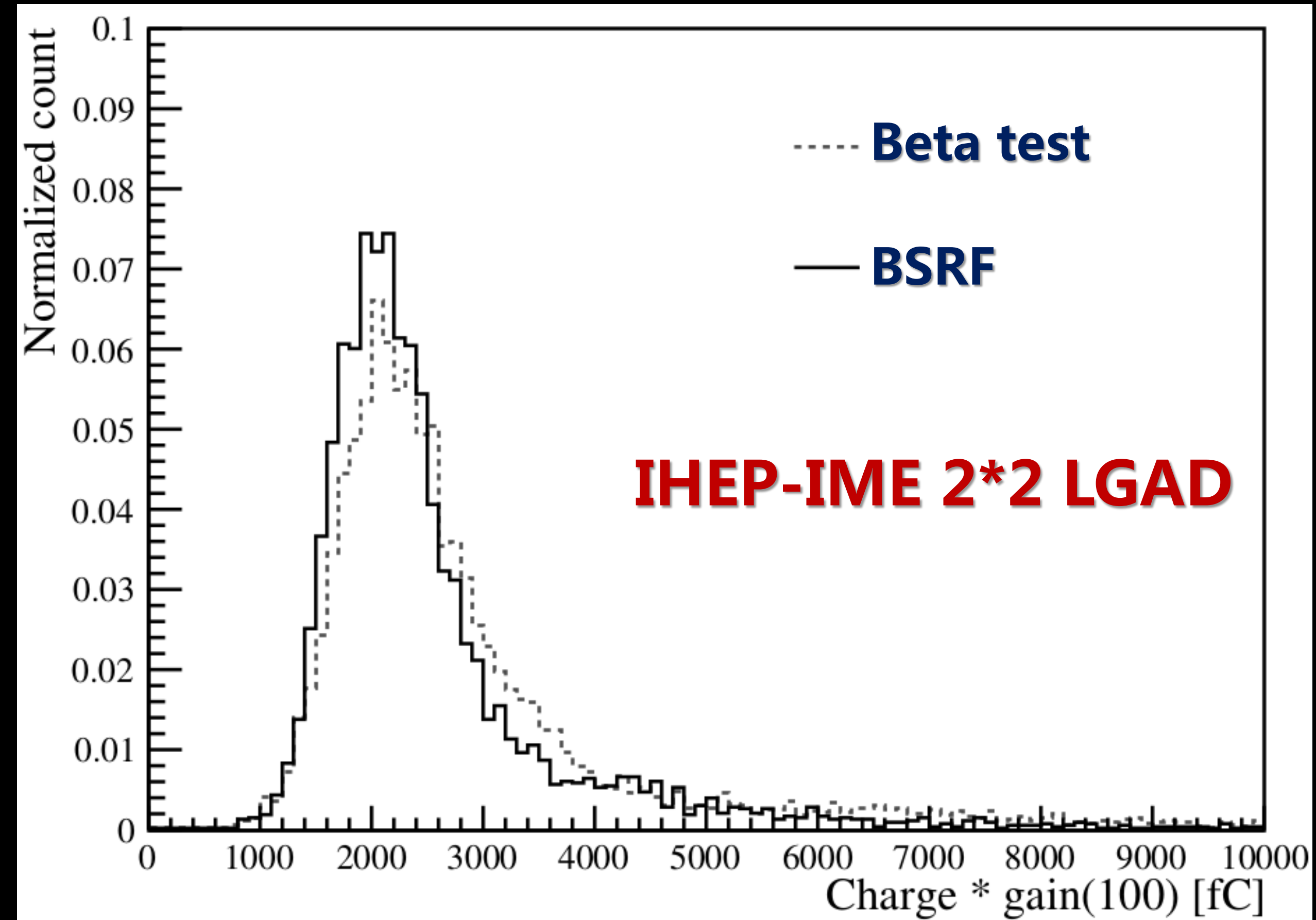
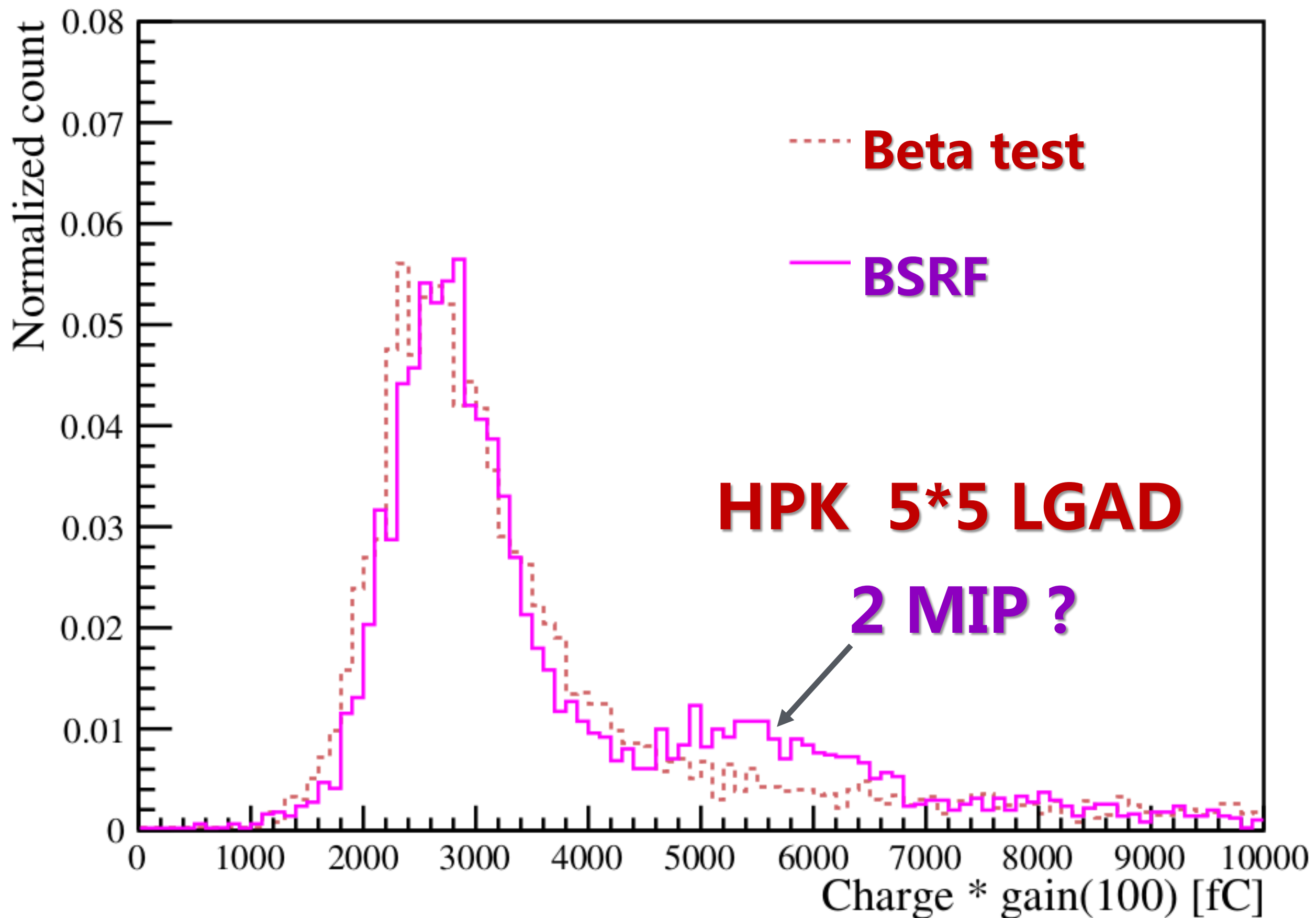
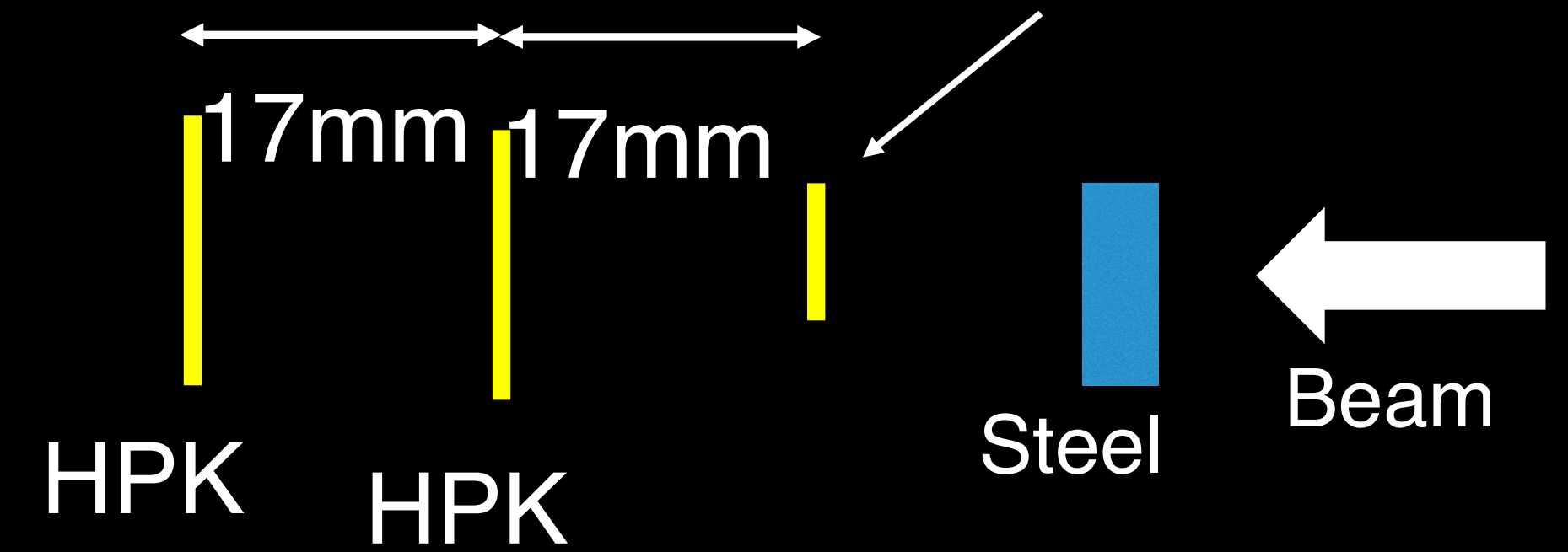
	<b>DESY</b>	<b>IHEP</b> Hall 10 E3 beam line	<b>BSRF</b>
<b>Momentum</b>	<b>1-6 GeV</b>	<b>&lt;1 GeV secondary beam</b>	<b>1~2.5 GeV (to be measured)</b>
<b>Particles</b>	<b>electrons</b>	<b>Protons/ Pions/ /Electrons</b>	<b>Electrons ? (to be confirmed)</b>
<b>Trigger rate</b>	<b>250Hz/cm<sup>2</sup> ~4000 Hz/cm<sup>2</sup></b>	<b>0.6 Hz/cm<sup>2</sup> (design) &lt;0.1 Hz/cm<sup>2</sup> (measured)</b>	<b>~50 Hz/cm<sup>2</sup></b>
<b>Operation period</b>	<b>~10 months/ year</b>	<b>~2 months/ year</b>	<b>~10 months/ year</b>
<b>Beam spot Size</b>	<b>4cm<sup>2</sup></b>	<b>~80cm<sup>2</sup></b>	<b>~2.5cm<sup>2</sup> Depending on shutter shape</b>

# Coincidence signal at BSFC test beam

IHEP-IME LGAD

## Collected charge of Coincidence signal

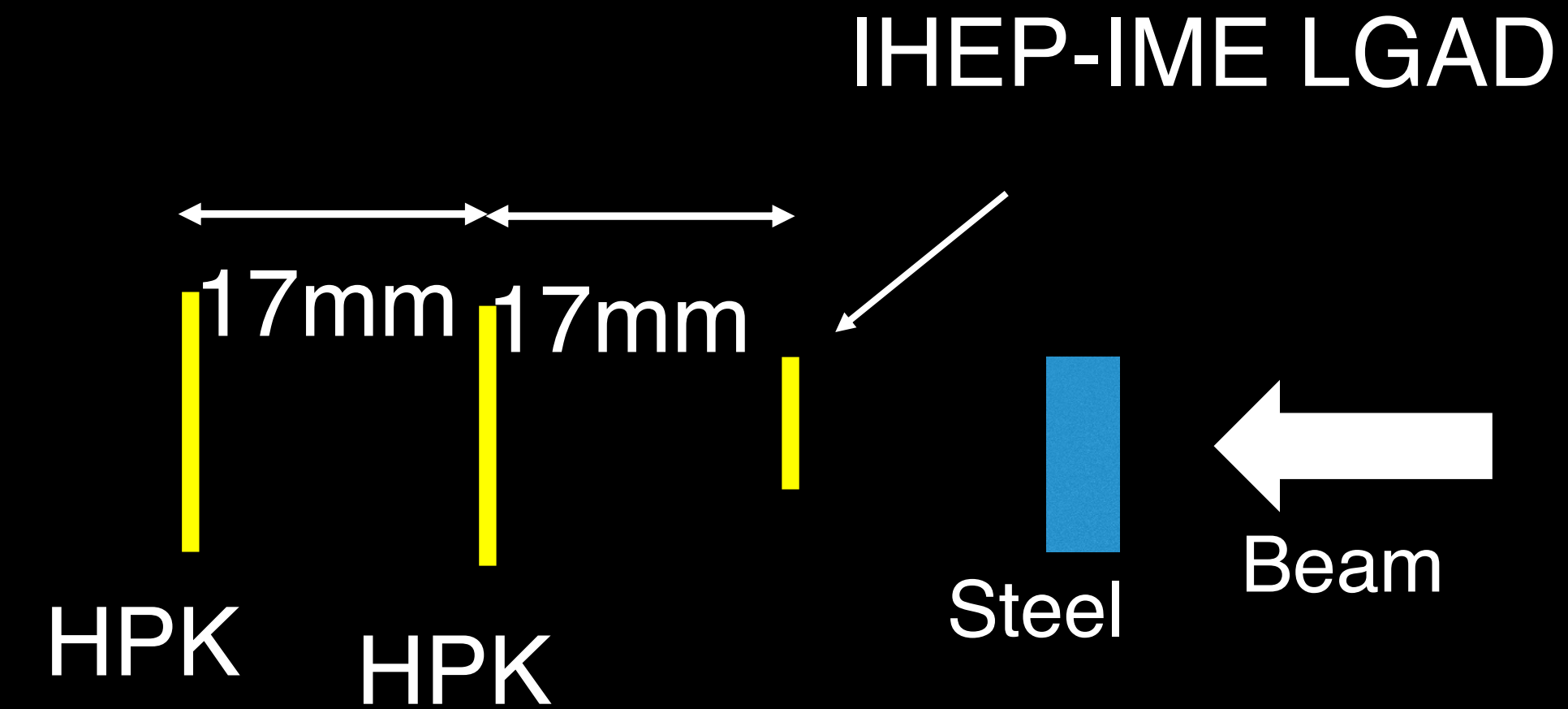
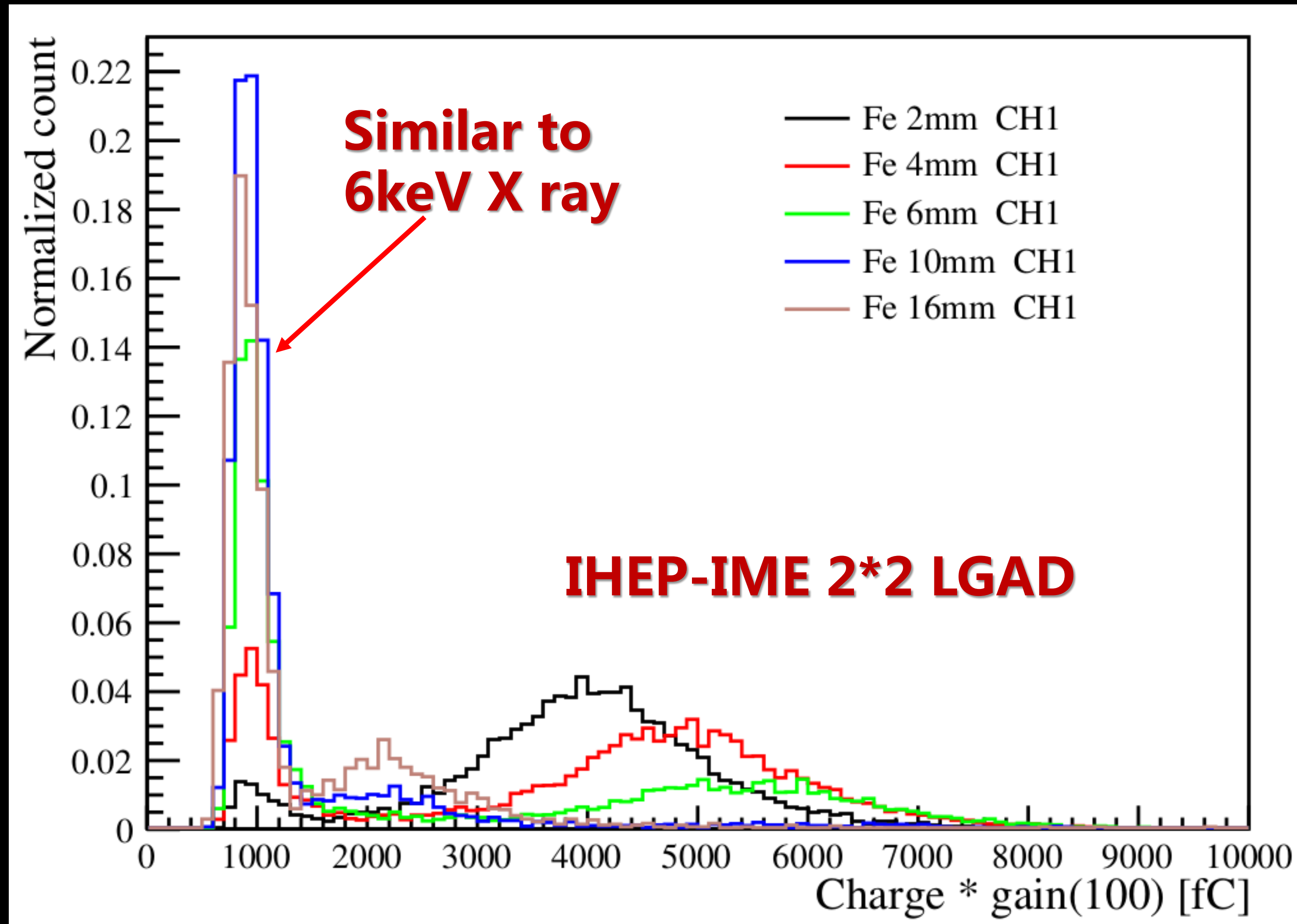
- consistent with MIP signal in beta test
- 2MIP like signal in large area LGAD



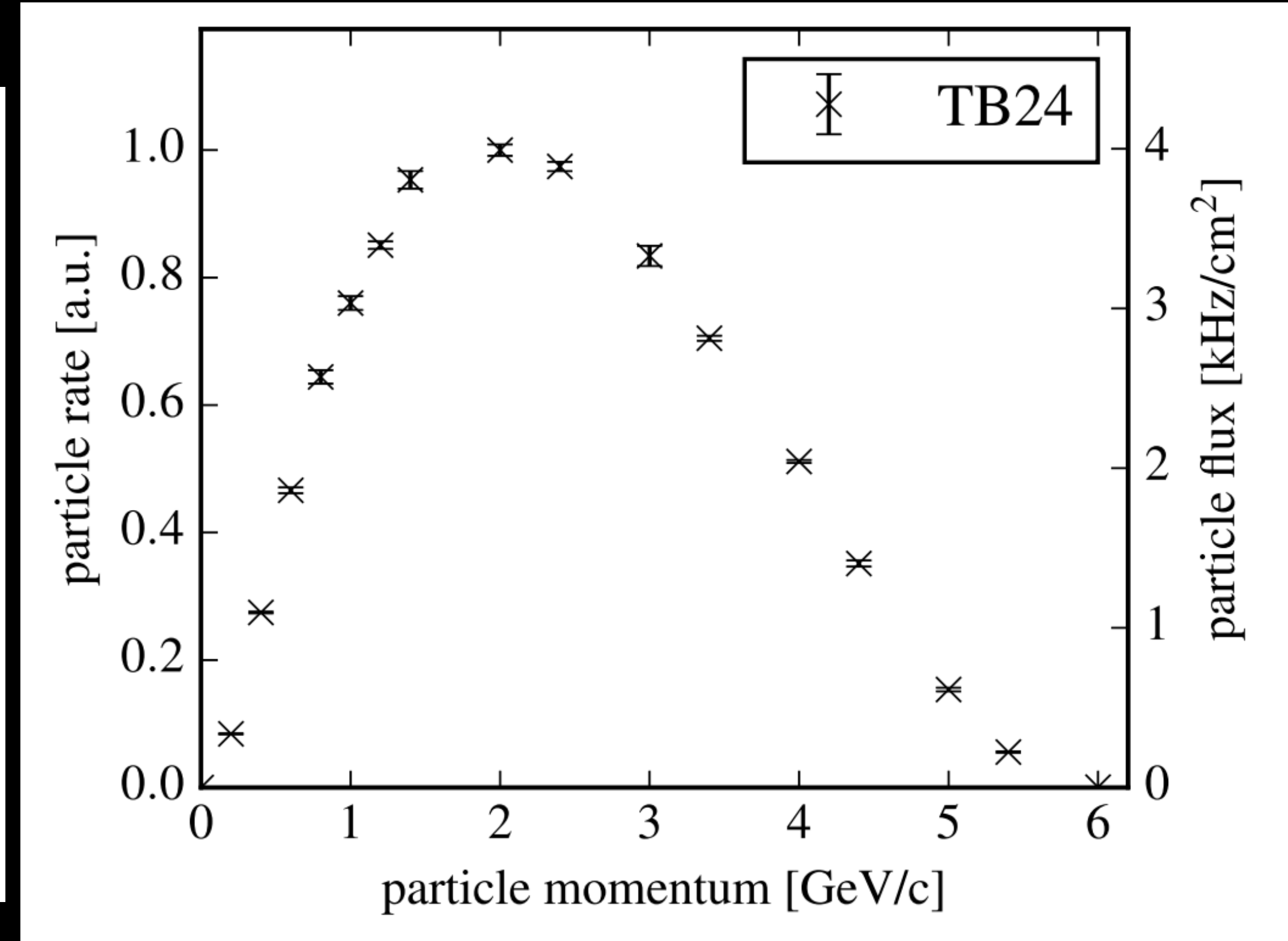
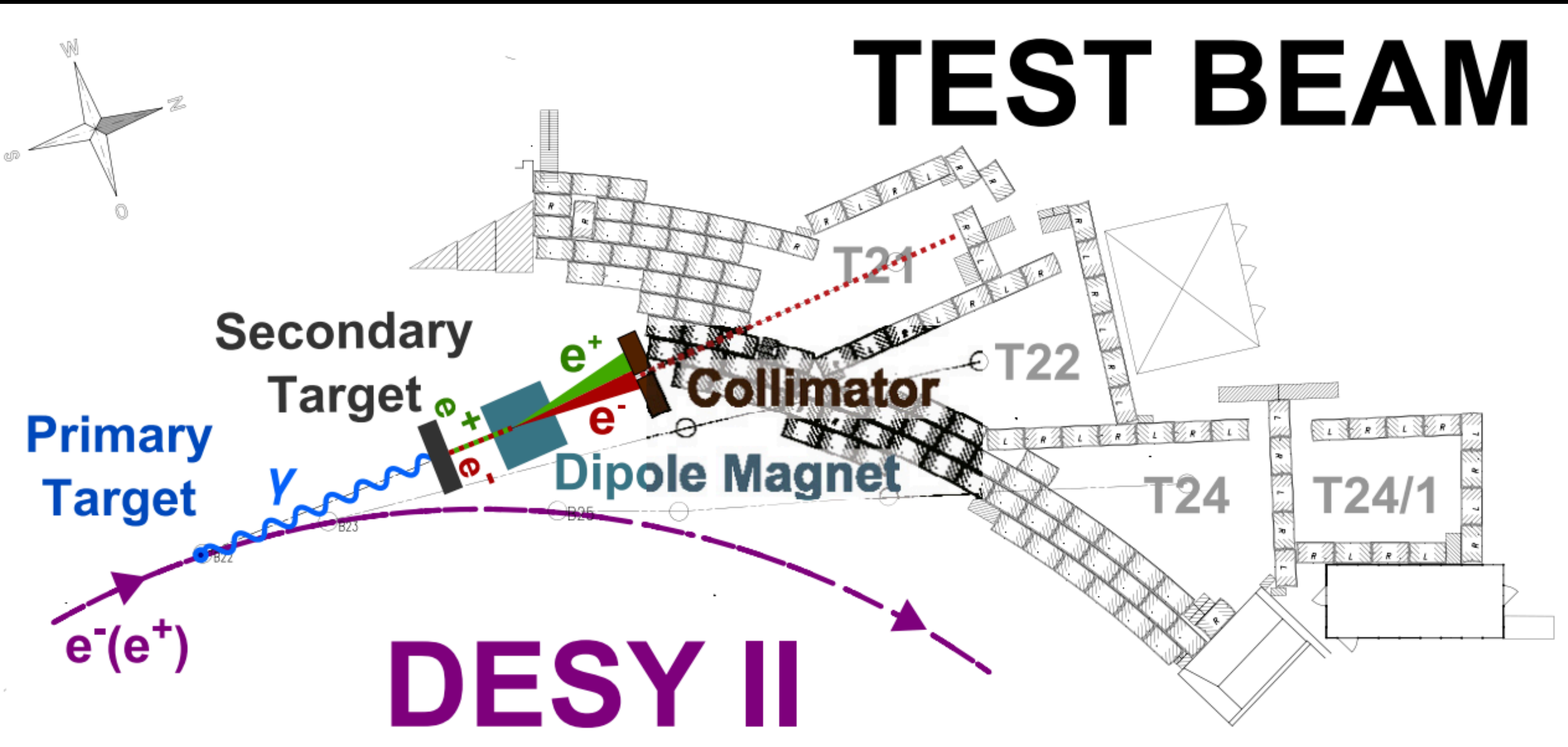
# Non-Coincidence signal at BSFC test beam

## Collected charge of non-Coincidence

- First peak is similar to 6keV X ray
- The origin of the second peak is unknown, it disappeared after putting more Steel

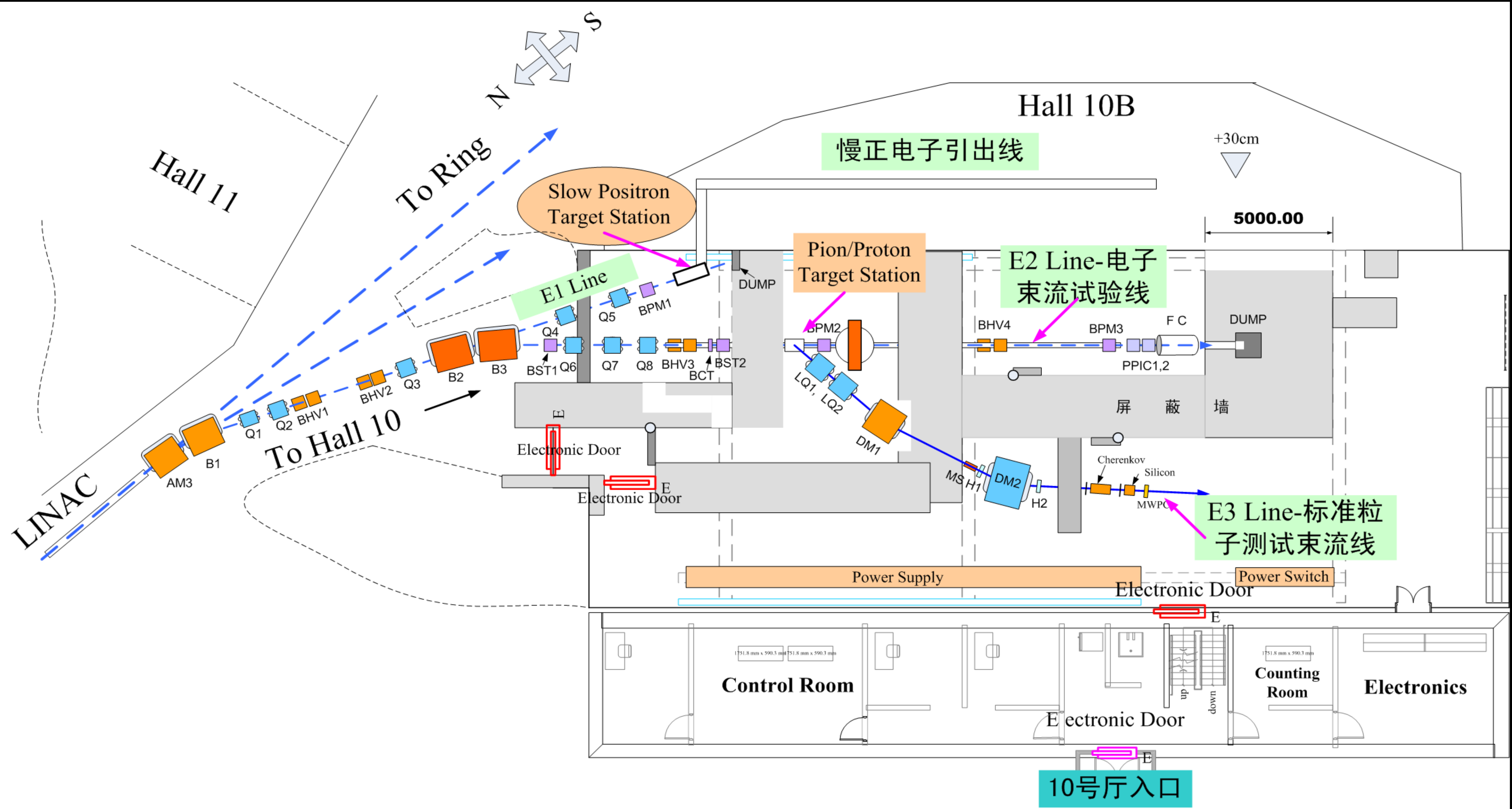


# DESY test beam facility





# IHEP Hall 10

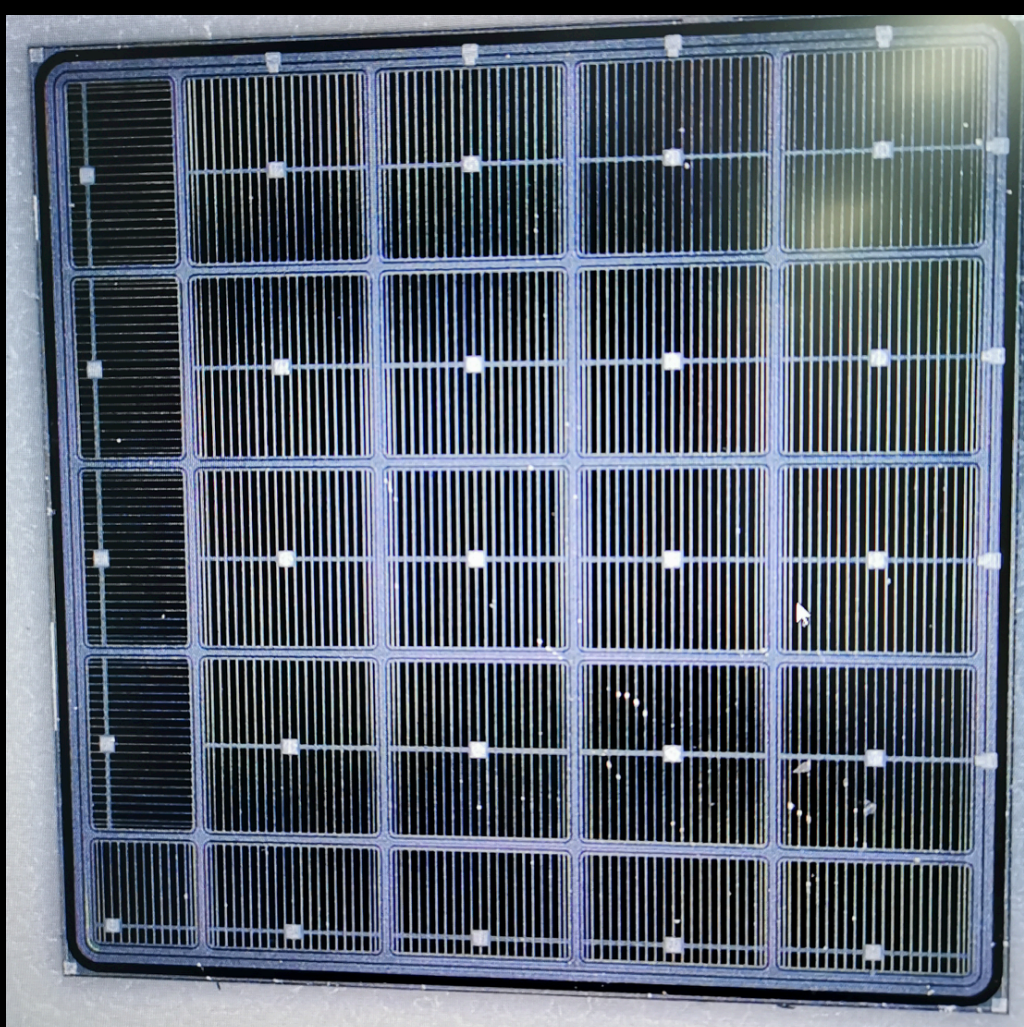


The Configuration of Beijing-BTF Upgrade at Hall 10

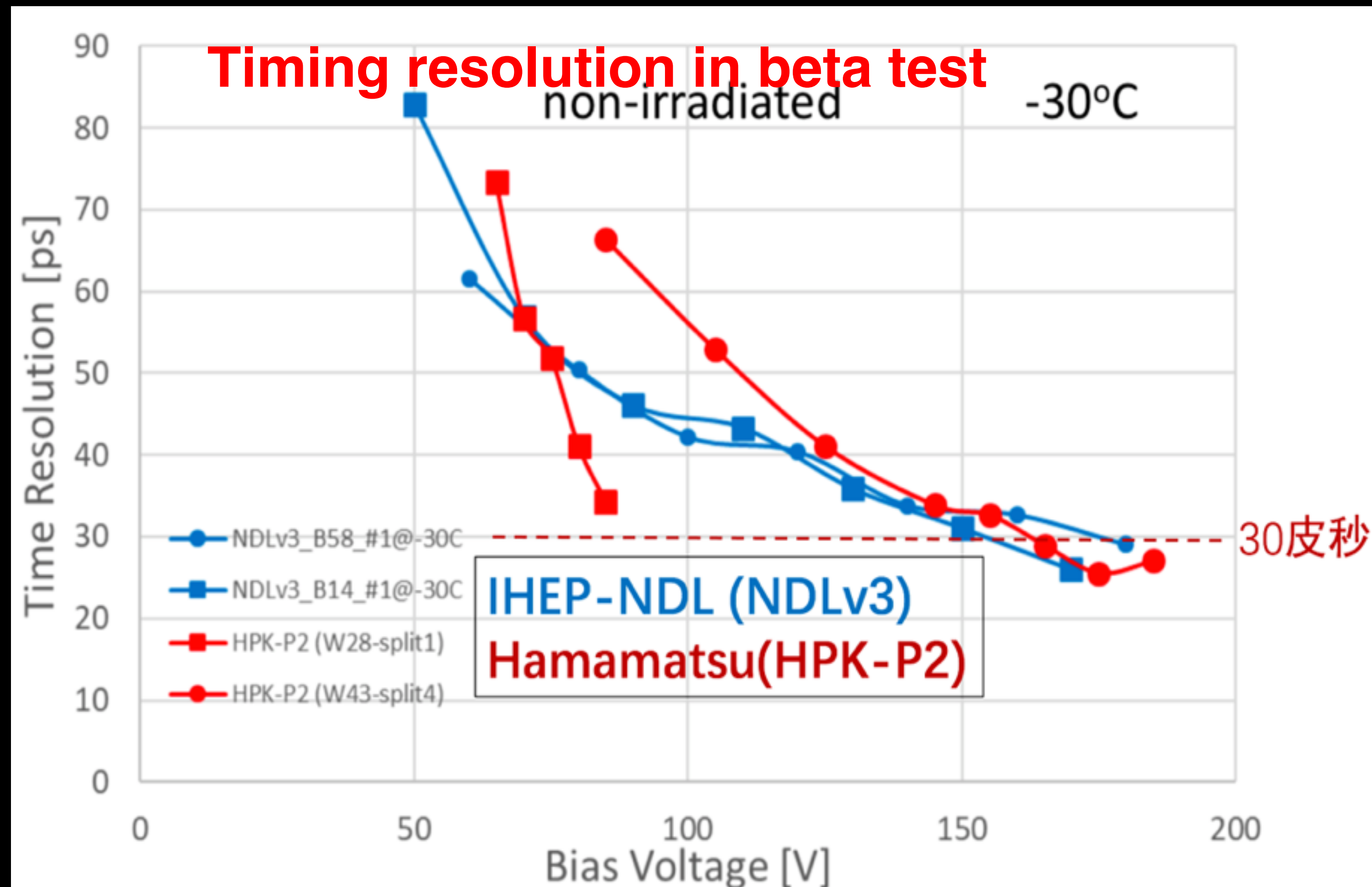
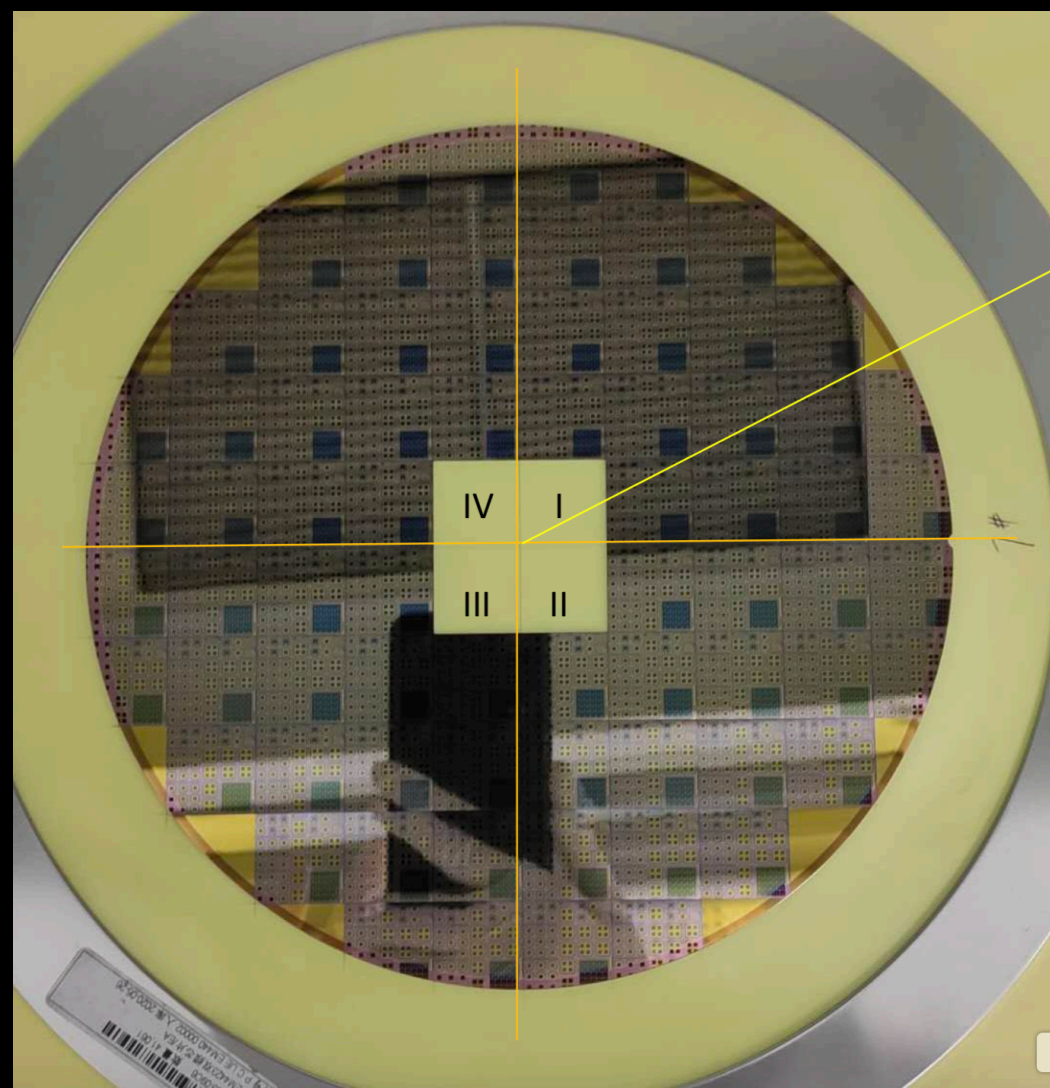
# CEPC timing detector : R & D status

- IHEP and Beijing Normal U. developed IHEP-NDL LGAD sensors
  - Can reach 25 pico-second(ps) , similar performance compared to HPK sensors
- IHEP and Institute of micro-electronics (IME) developed IHEP-IME sensors
  - IHEP team (Mei Zhao ...) designed, IME fabricated

IHEP-NDL sensor

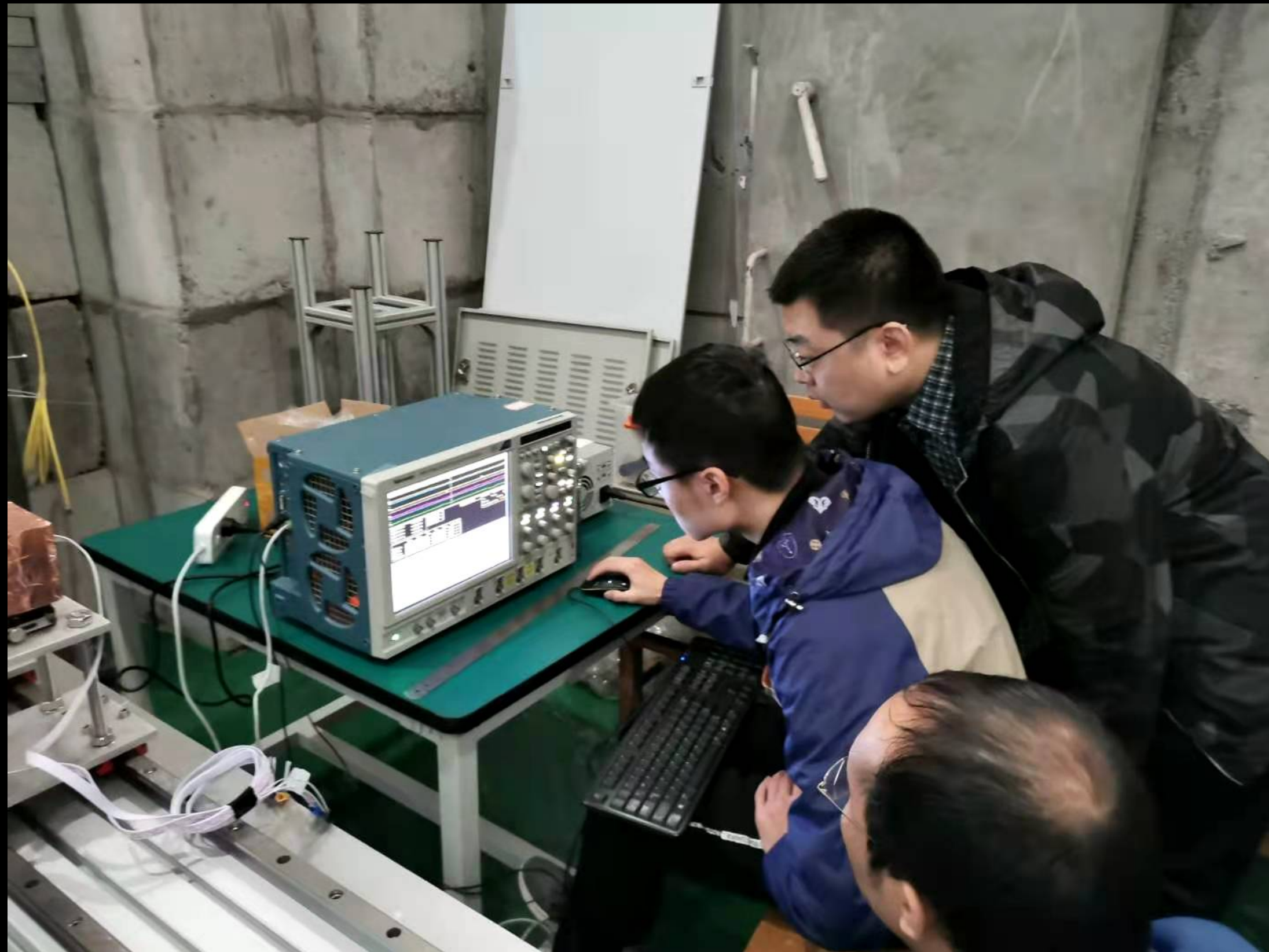


IHEP-IME sensors  
8 inch wafer



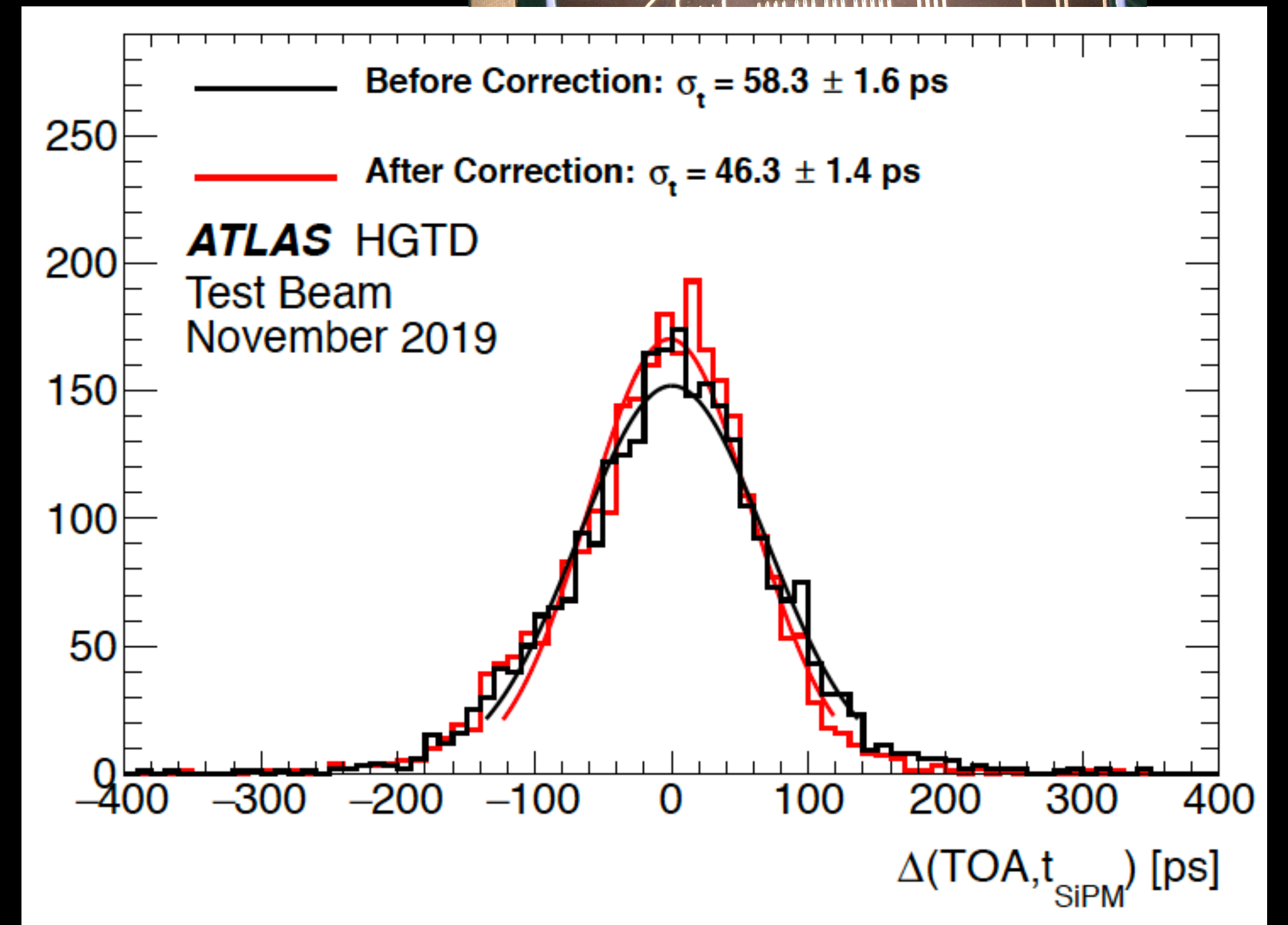
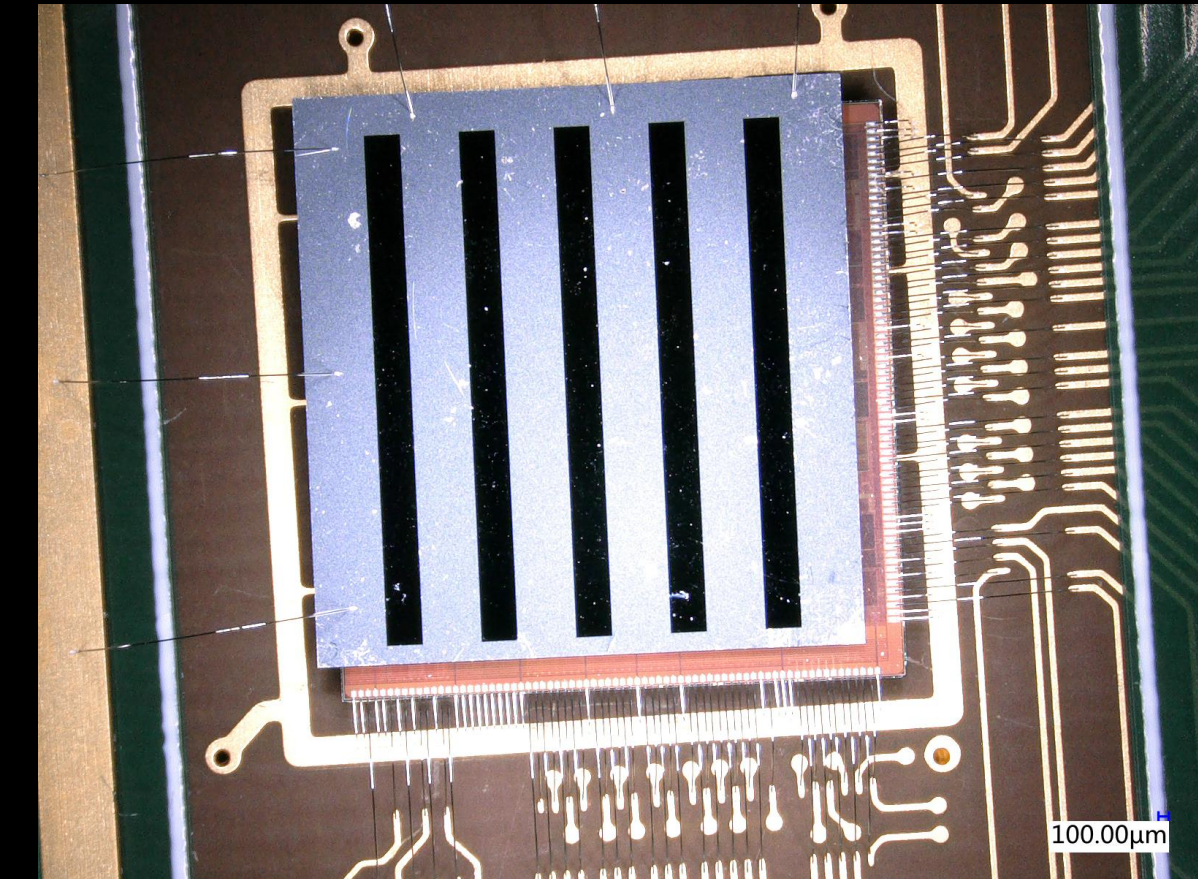
# CEPC timing detector :IHEP Test beam 2020

- Timing detector team (3 postdocs and 4 students) participate IHEP test beam
- ➔ **Tuning the beam, taking shifts, commissioning the detectors**
- Postdoc: Bo Liu, Yunyun Fan, Xuan Yang
- Students: Mengzhao Li, Shuqi Li, Han Cui, Chengjun Yu



# Outlook: Testbeam with ATLAS HGTD module

- Time resolution: 45ps
- Position resolution: ~1mm
- Area : 6.5mm\*6.5mm --> (2cm\*4cm)



# Detector signal at BSFC testbeam

- Collected charge in **non-coincidence signal** is consistent with **~10keV X ray signals**
- Collected charge in **coincidence signal events** is consistent with **MIP signal in beta test**
- Found two-MIP like signal in HPK LGAD in BSRF beam tests
- **Two MIP particles hitting one LGAD detector at the same time ?**

