



中国散裂中子源
China Spallation Neutron Source



高能质子束实验终端
High-energy Proton Experiment Station



Progress of China's First Proton Test Beam HPES



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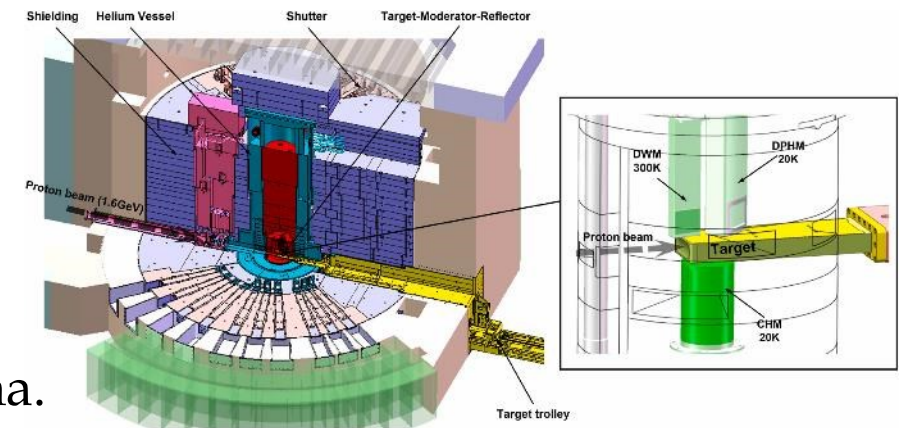
Recent tests to HPES



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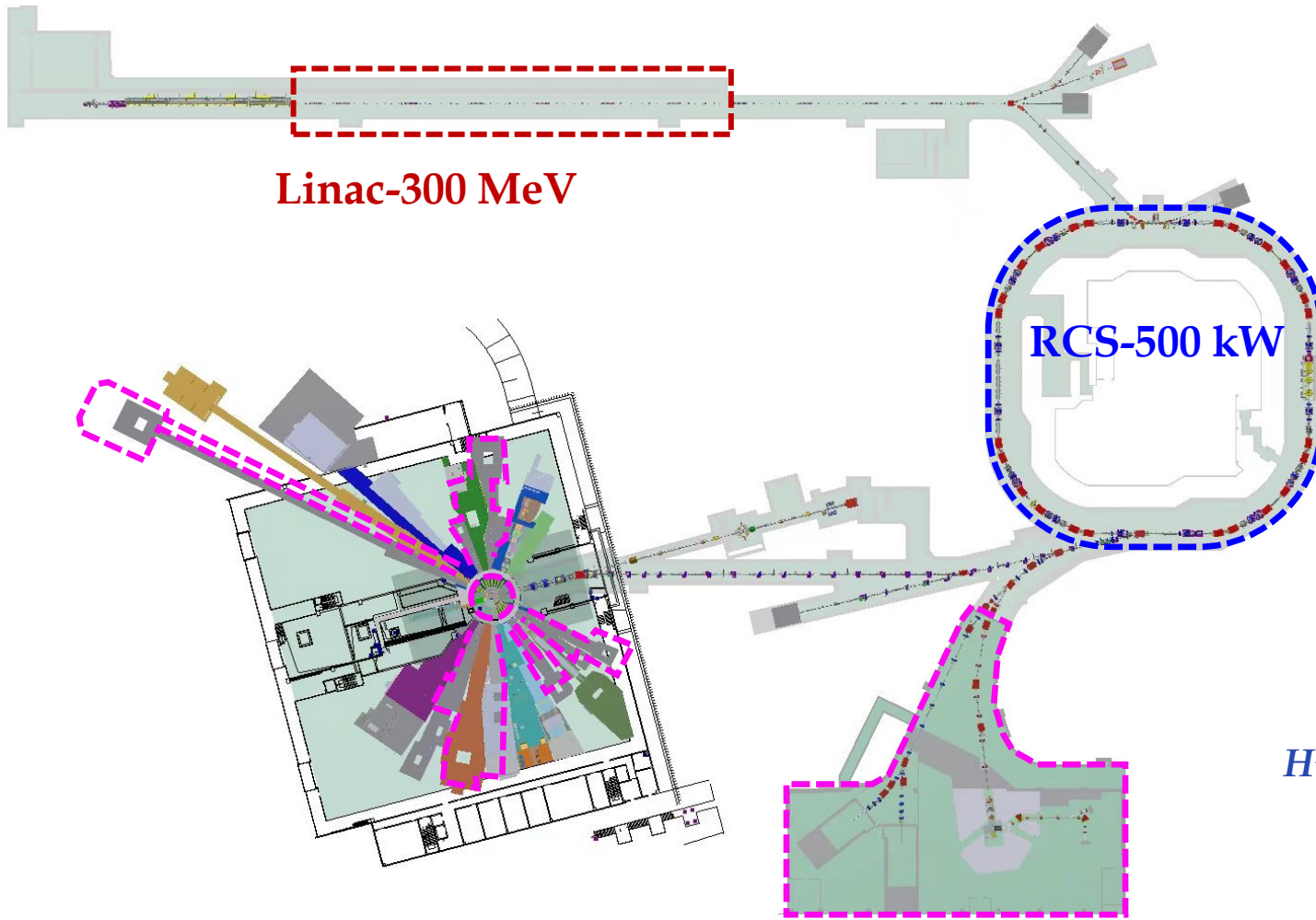
Milestone and Summaries

1.1 CSNS



- China Spallation Neutron Source (CSNS) @ Dongguan, China.
- Run since 2018, power: 185 kW.
- We are pushing the second phase of CSNS

[DOI:10.1016/j.nima.2025.170431](https://doi.org/10.1016/j.nima.2025.170431)



➤ Improvement to CSNS:

- Linac energy 80 MeV → 300 MeV
- Beam power 185 kW → 300 kW
- 11 new neutron beam lines
- One Surface muon source
- One 1.6 GeV proton test beam

High-energy Proton-beam Experiment Station (HPES)

First beam delivery: 2029

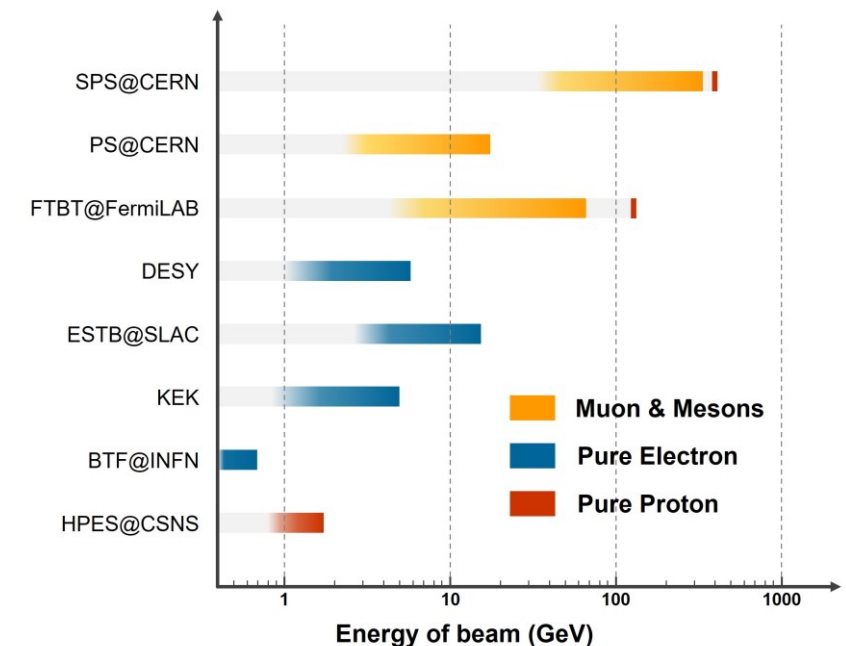
Neutron spectrometers and terminals-11 to be build

High-energy Proton-beam Experiment Station (HPES)

Bird view of HPES beam parameters

| Parameters | Designed Values |
|---------------------------------|--|
| Primary beam energy | 1.6 GeV |
| Energy spread | <2% @ 1.6 GeV |
| Tunable energy range | 0.8 – 1.6 GeV |
| Proton flux | 10^3-10^8 p/s |
| General Macro-pulse frequency | 25 Hz |
| Effective macro-pulse frequency | 24 Hz |
| Macro-pulse length | 1 ms |
| Interval of micro-pulse | 410 ns |

- ▣ **First** GeV-proton test beam in China.
- ▣ Flexible proton beam with flux tunable.
- ▣ Fill the absence of test beam resources in 1 GeV energy region.



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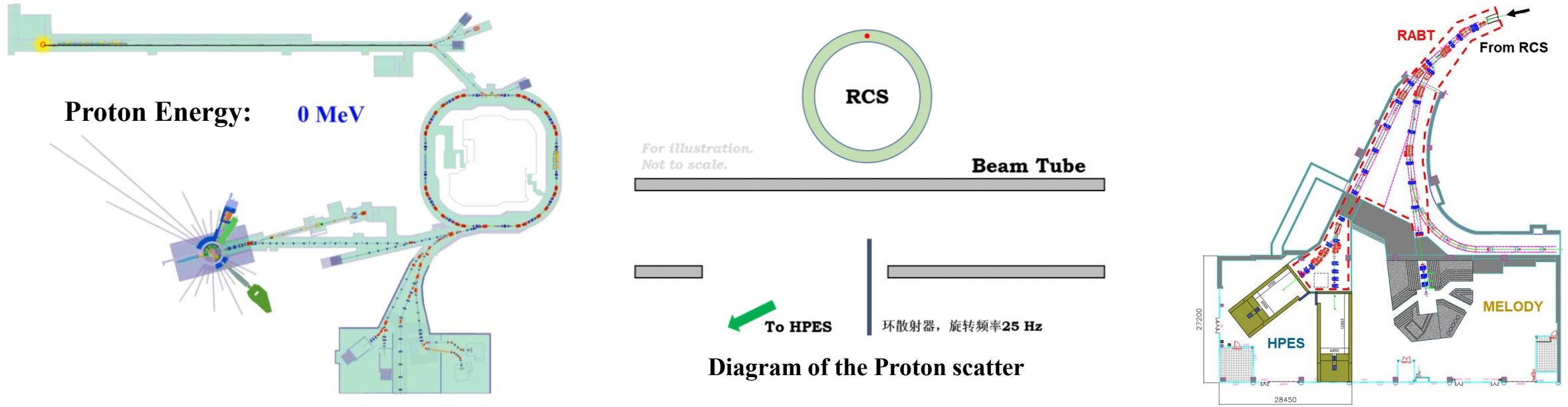
Recent tests to HPES



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Milestone and Summaries

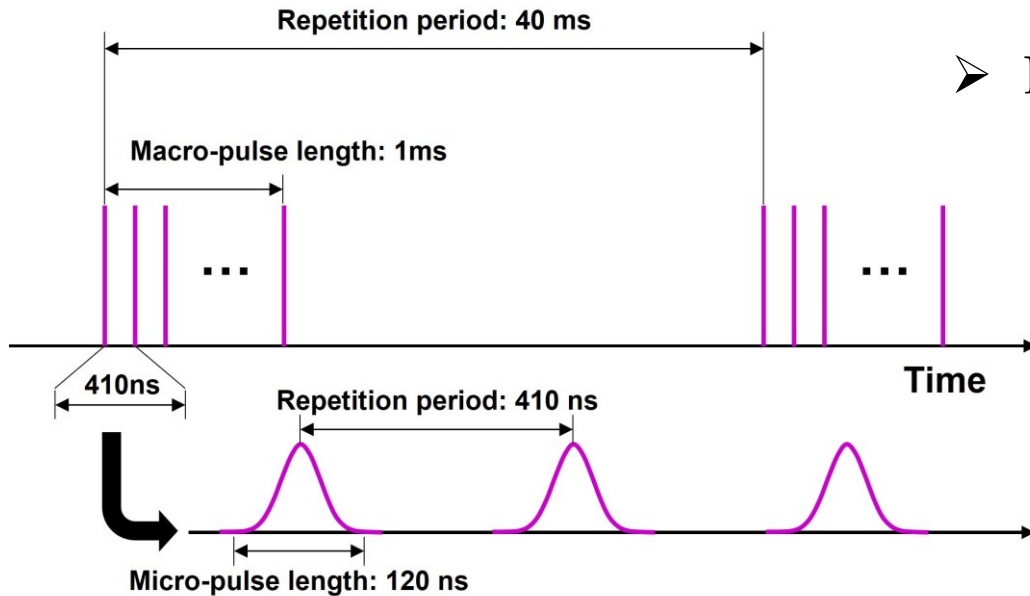
2.1 proton extraction



- The proton scatter foil rotates in 25 Hz, synchronous with beam in RCS.
- Foil will interact with beam halo when it arrives.
- Small fraction of protons elastic scattering at 20 – 25 mrad and extracted by a Lamberson Magnet.
- Extracted protons delivered by RABT to the terminals of HPES.

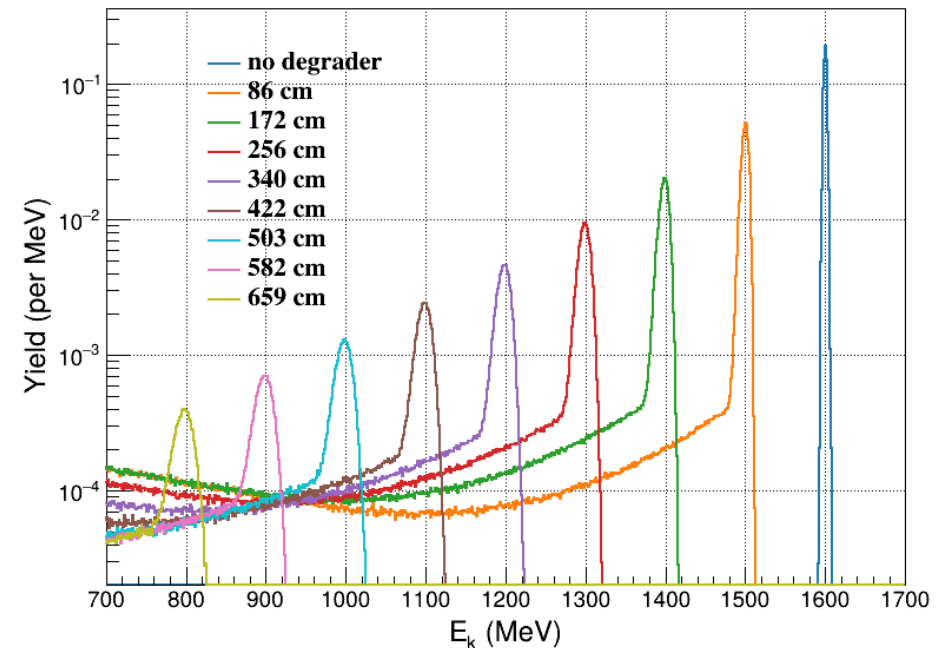
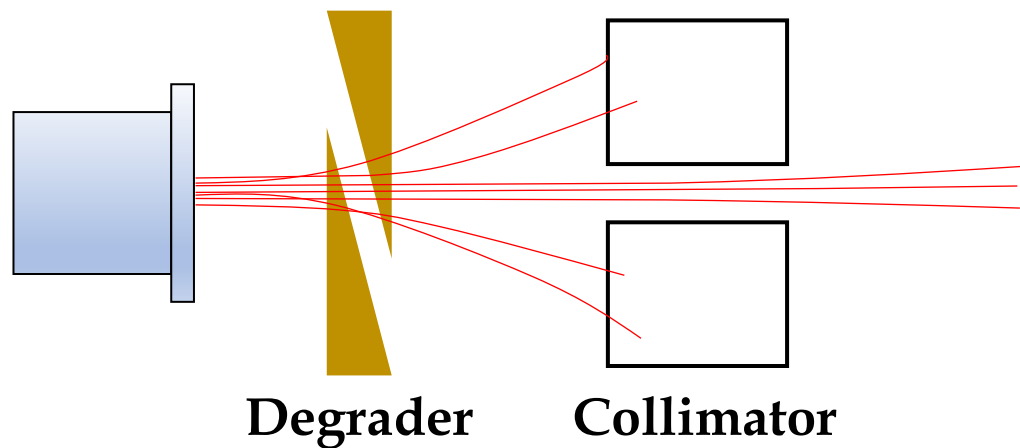
DOI: [10.1103/PhysRevAccelBeams.27.070401](https://doi.org/10.1103/PhysRevAccelBeams.27.070401)

- Dual-hierarchy structure of HPES proton beam:
 - Macro pulse frequency 25 Hz (24 Hz effective)
 - Macro-pulse length 1 ms, with 39 ms interval.
 - Micro-pulse distributed in the macro-pulse.
 - Each micro-pulse width is 120 ns cycled by 410 ns.



2.3 Proton energy

- Energy of primary proton beam: 1.6 GeV.
- HPES uses a degrader to tuned the energy of proton beam.
- Continuous proton energy range: 0.8 – 1.6 GeV.

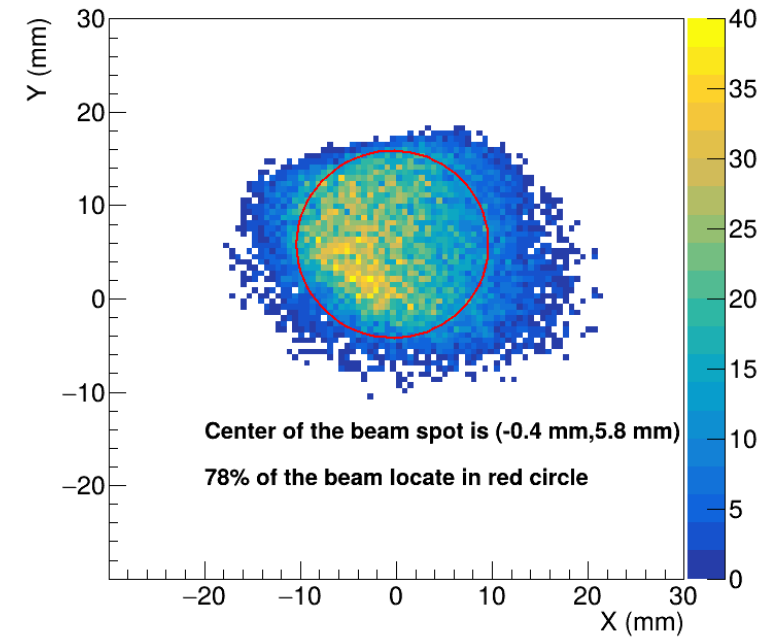
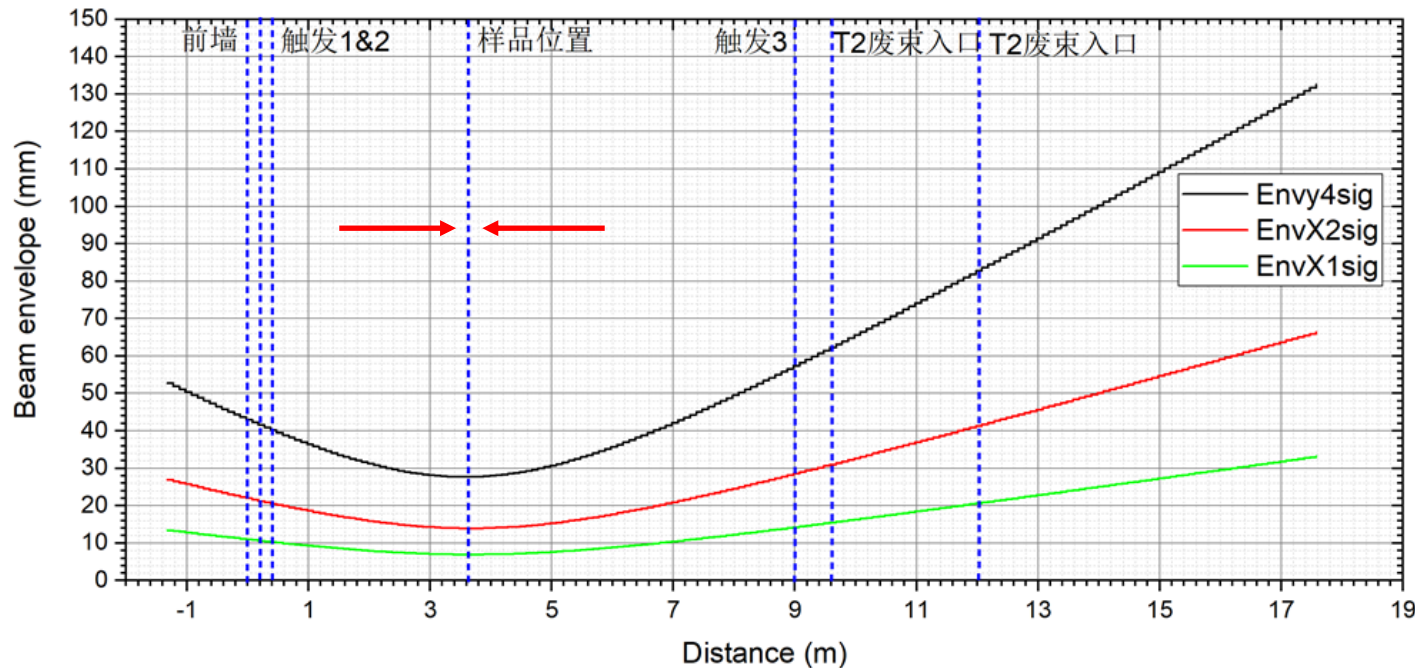


Simulated via Geant4

2.4 Proton flux and beam spot



- Proton flux and profile of HPES is tunable by collimator and scattering foil.
- Flux adjustable in 10^3 - 10^8 p/s.
- The beam spot adjustable in $10 \times 10\text{mm}^2 \sim 100 \times 100\text{mm}^2$.



3. Devices in HPES Terminal



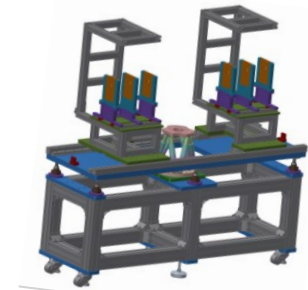
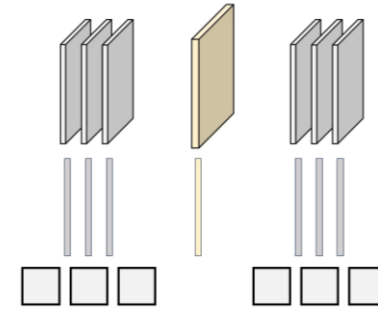
- HPES is equipped with 7 Detector In Terminal (DIT):
 - Reference DIT: providing reference information of the protons.
 - Statistic DIT: providing statistic information of the beam.

| Devices | | Usage |
|---------------|--------|---|
| Reference DIT | HEPTel | Provide reference track of protons for tracker test, < 10 μ m |
| | LEMS | Provide reference energy of protons calorimeter test, 1% @ 1.6 GeV. |
| | FLASH | Provide reference to the time gate to the DUT, < 1ns. |
| Statistic DIT | PALET | Measure the profile of the extracted beam. |
| | PROUD | Measure the time structure of the extracted beam. |
| | BMOS | Monitor the flux of the extracted beam without interception. |
| | SEEM | |

3.1 Reference DIT

TRACK

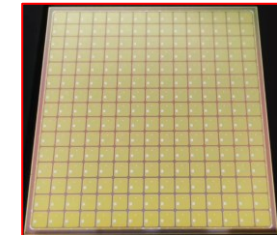
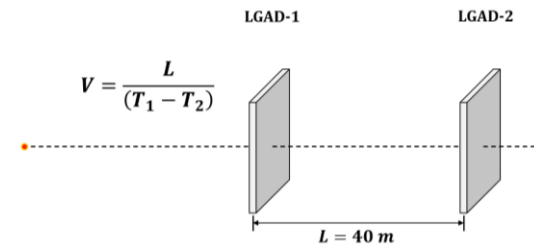
- A EUDET-type proton telescope equipped in HPES.
- 6 MIMOSA-28, DUT resolution reach $< 10 \mu\text{m}$.
- Telescope resolution is expected reach $< 5 \mu\text{m}$.
- We are also developing a telescope based on Jadepix. Prototype will be tested at CERN East Area.



DOI:10.1007/s41365-024-01447-9

ENERGY

- A TOF spectrometer developed to measure energy.
- 2 LGAD, 40 m distance, E res. $\sim 1\%$ @1.6 GeV.
- LGAD pixels are bonded in parallel to reduce readout channels.
- Timing resolution of each $\sim 100 \text{ ps}$.

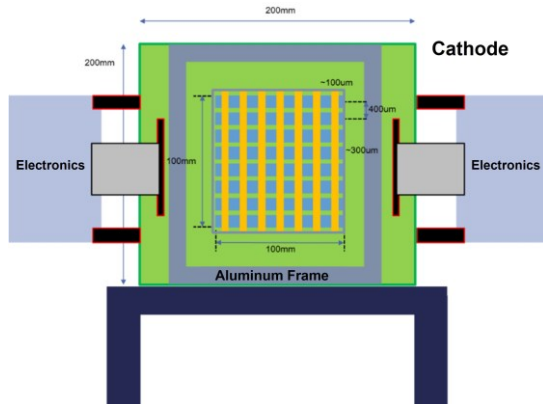


TIME

- A trigger device designed to provide time gate reference.
- Scintillator fiber coupled with PMT.
- Trigger time spread $< 1 \text{ ns}$.
- Prototype have been tested at CERN North Area.



3.2 Statistic DIT

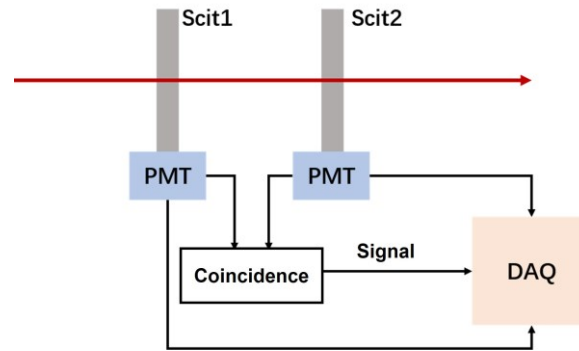


PALET

Profile Detector

Micromegas

Positioning Res. 0.3 mm

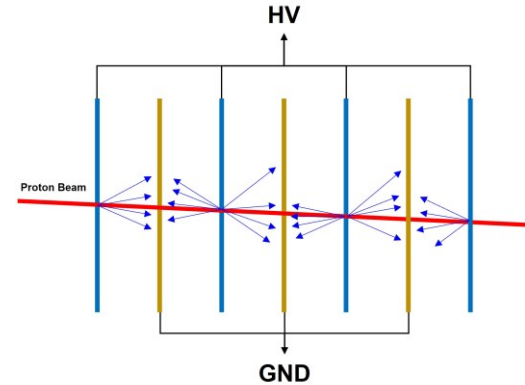


PROUD

Beam Tuning Detector

Plastic Scintillator

Dynamic range 1-10⁴ p/pulse

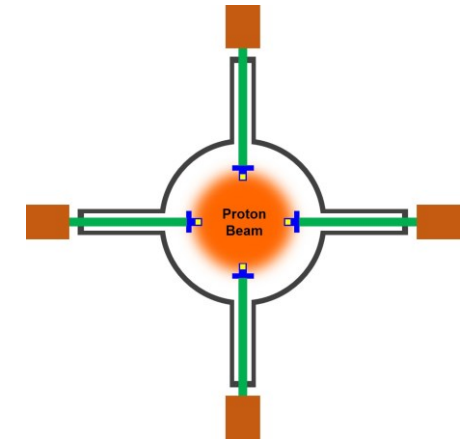


SEEM

Flux Monitor

Aluminum Multiplier

Intensity > 1E4 p/s



BMOS

Flux Monitor

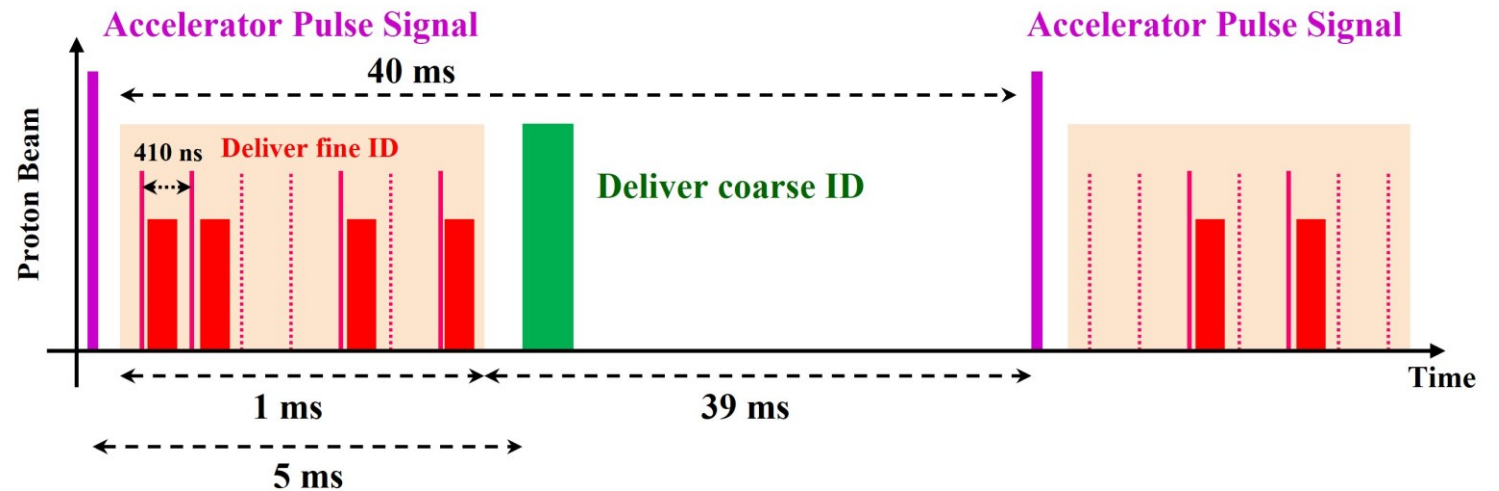
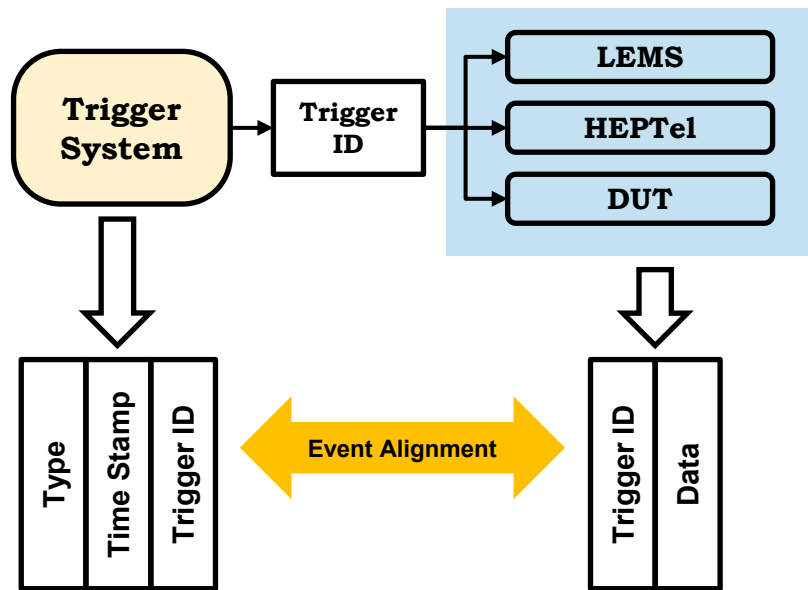
Silicon Carbide

Intensity < 1E5 p/s

3.3 Trigger Logic Unit



- Rigorous alignment proton by proton is required by tracker and calorimeter tests.
- A trigger logic unit has been designed in HPES **based on AIDA-2020 architecture**.
- Trigger ID will be fan out to DUT and DIT and packed in data as label of data alignment.
- Primary tests have been carried out in SPS.



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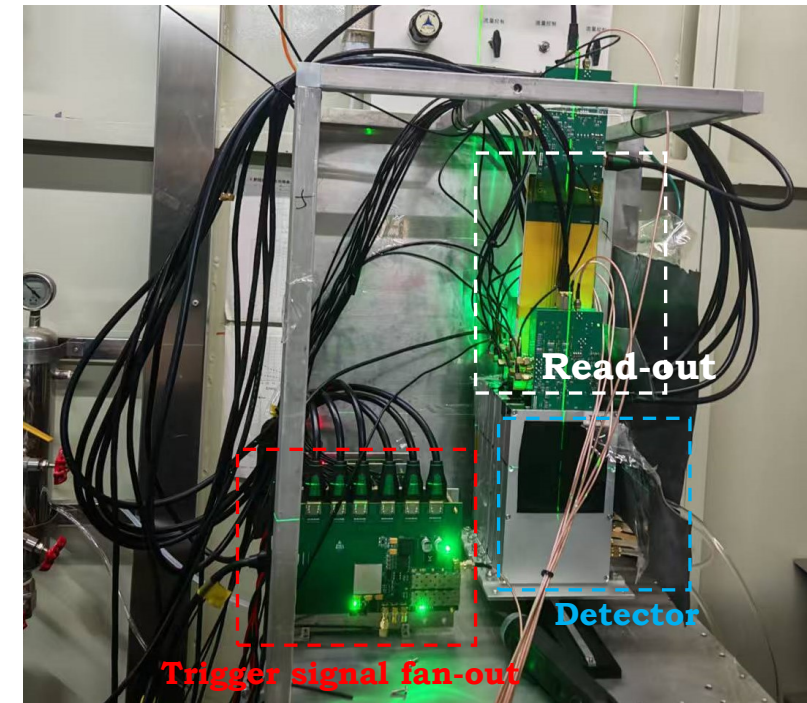
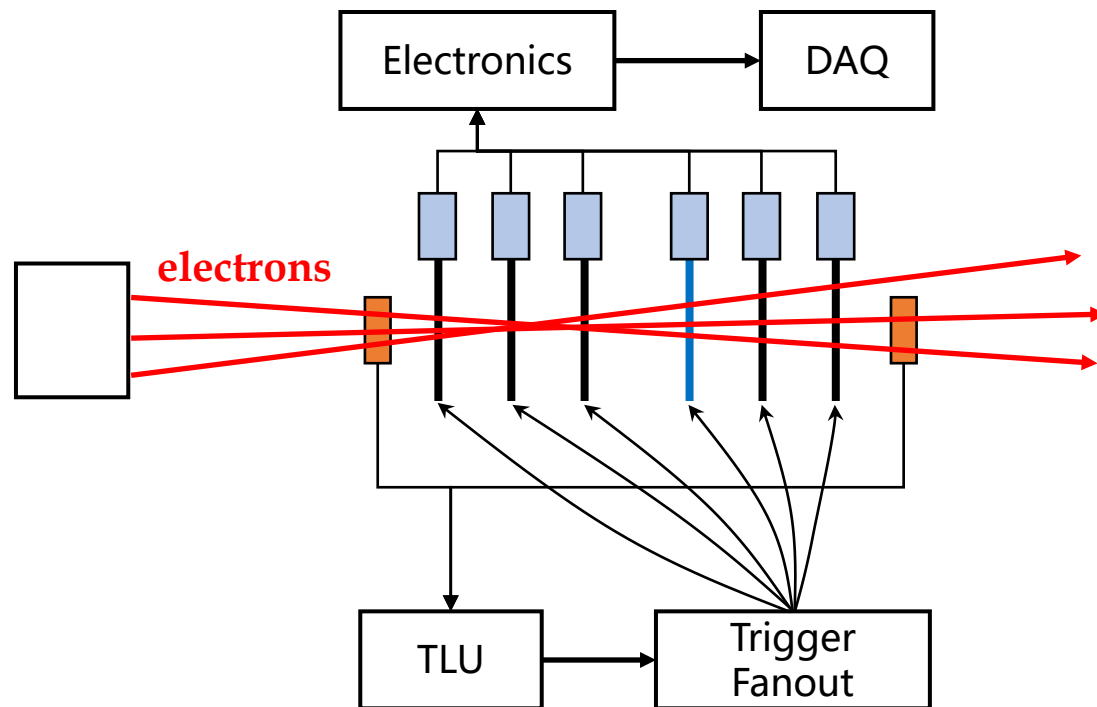


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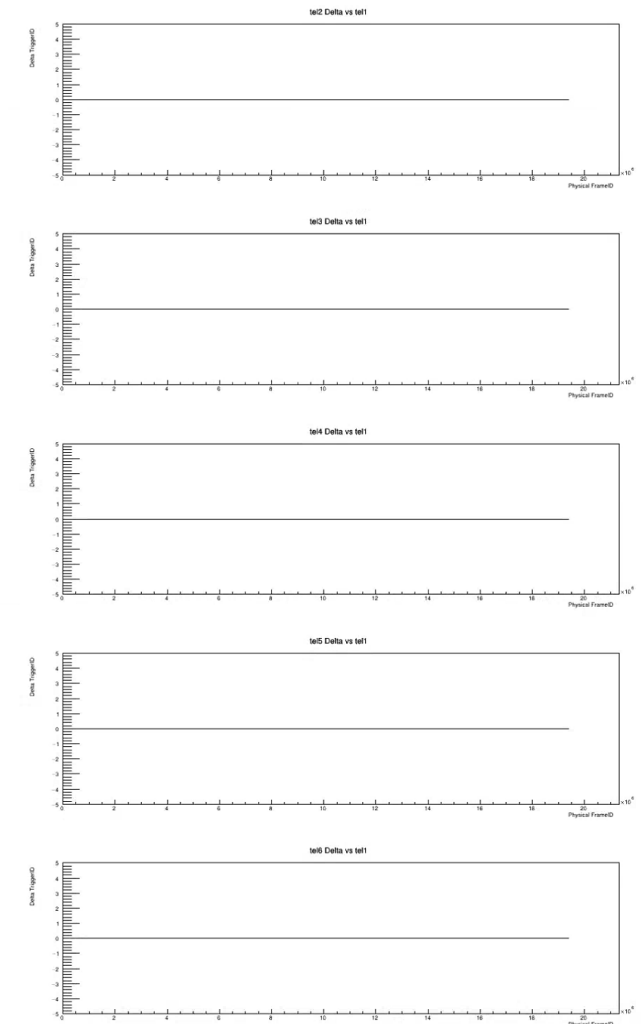
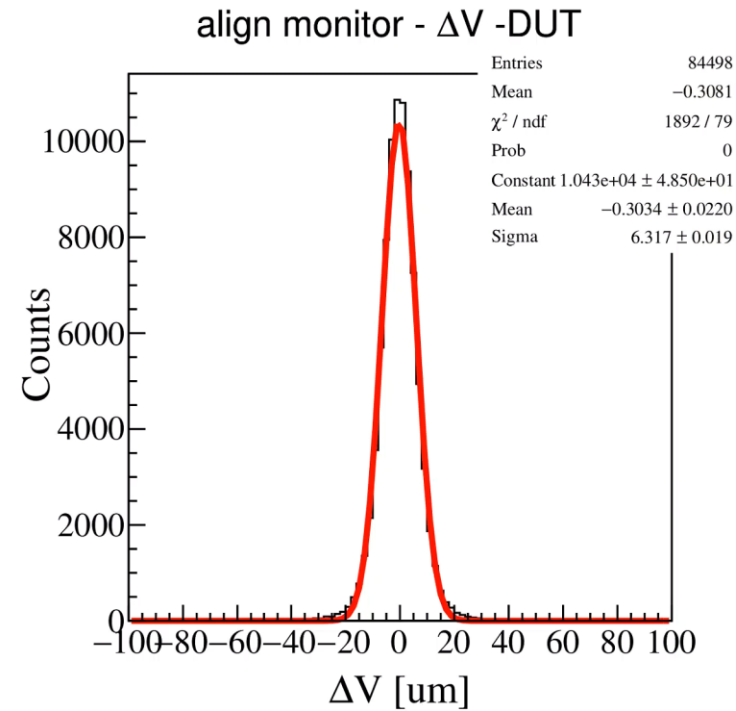
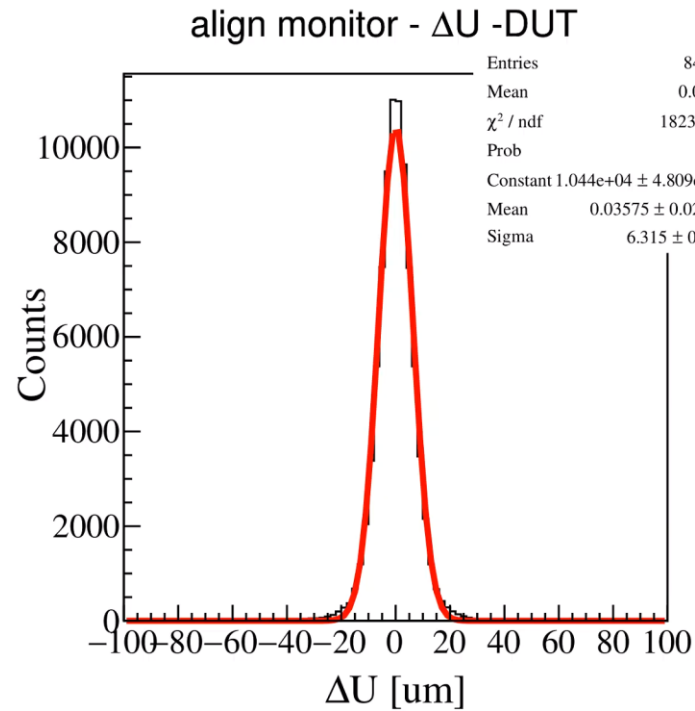
Milestone and Summaries

4.1 Test to Telescope

- Utilize electrons specially produced by BSRF (Beijing Synchrotron Radiation Facility).
- Energy of electrons: widely spreaded, most in 1.37 GeV.
- Coordination with TLU and DAQ are tested.



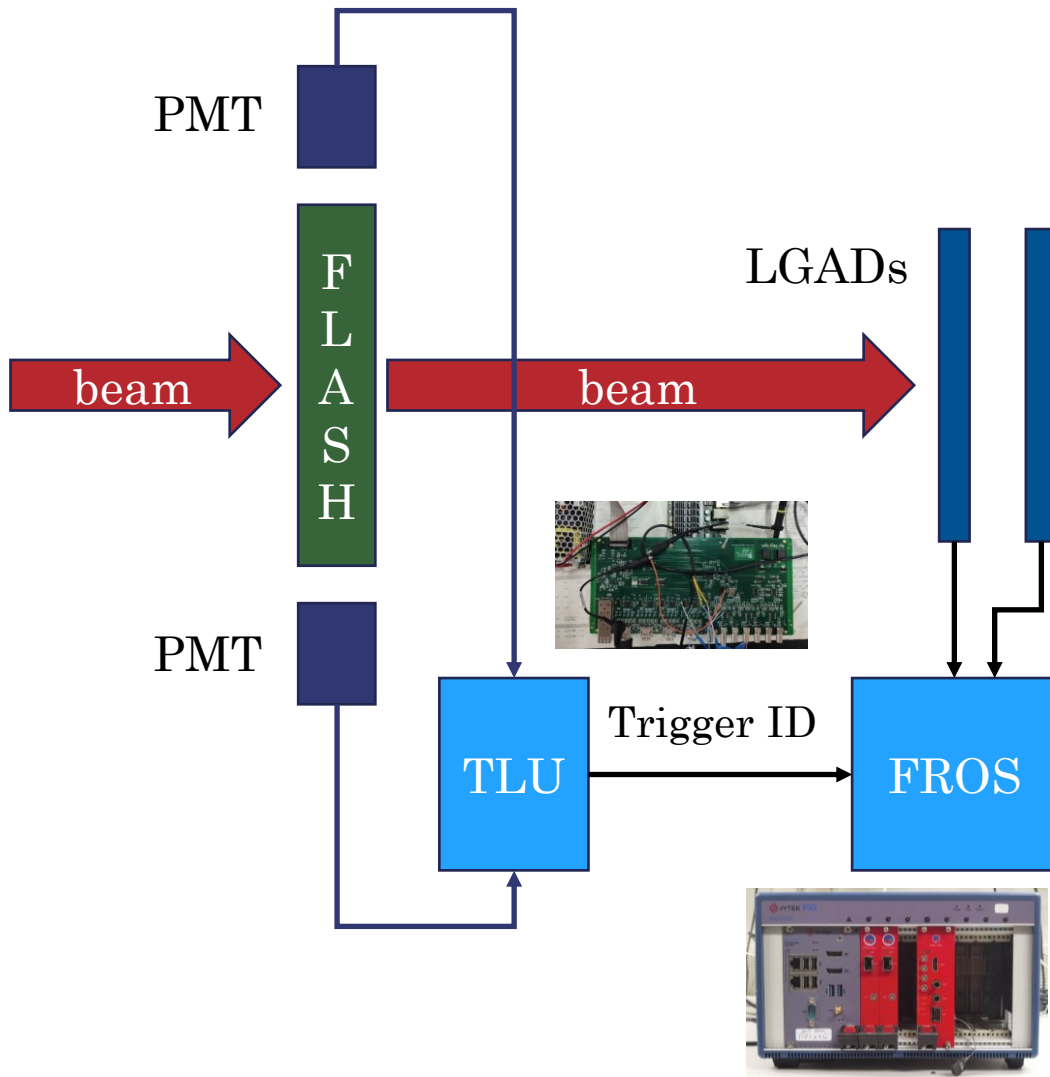
4.1 Test to Telescope



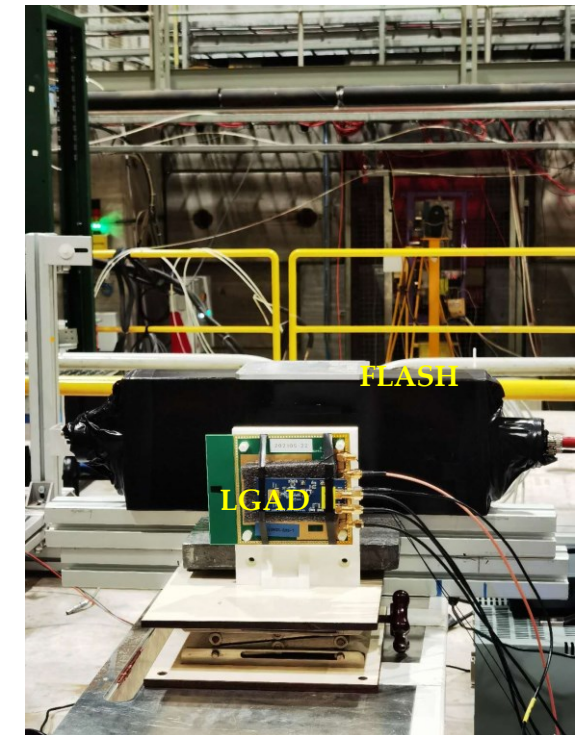
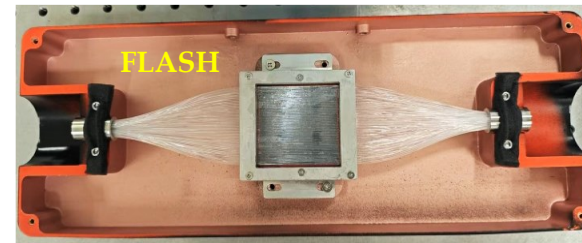
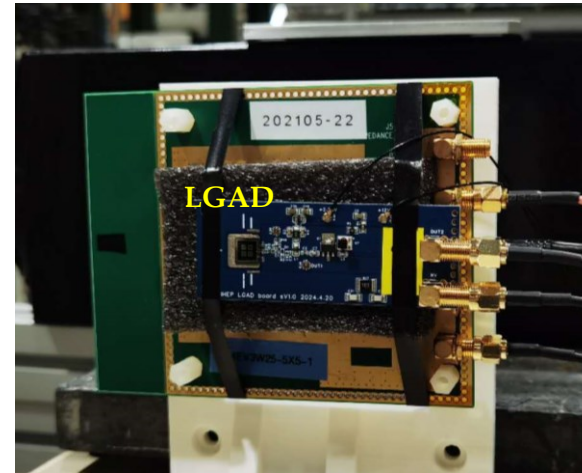
Consistency of ID

- Trigger ID can be correctly packed into the data package.
- DUT resolution reaches $6.3 \mu\text{m}$.
- It proves the HEPTel possesses preliminary test capabilities.

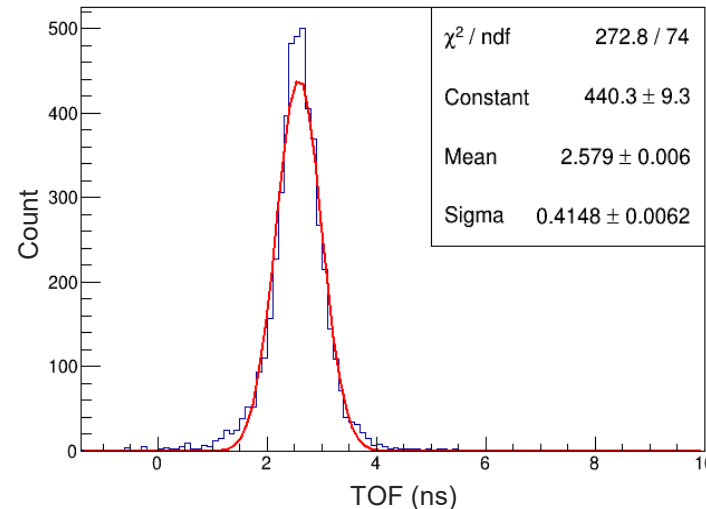
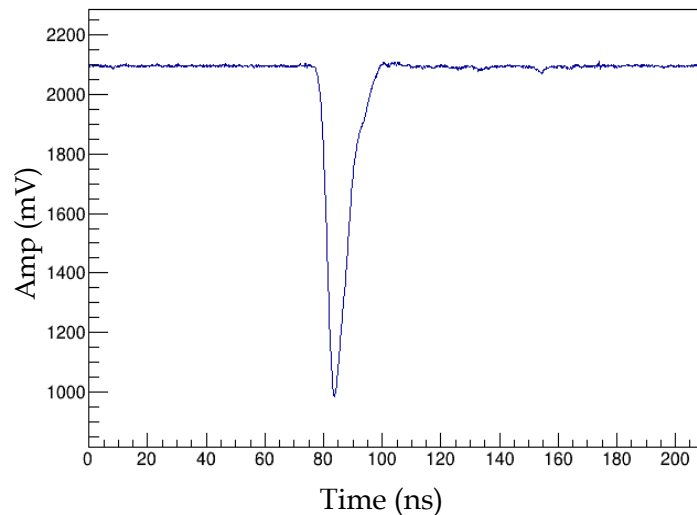
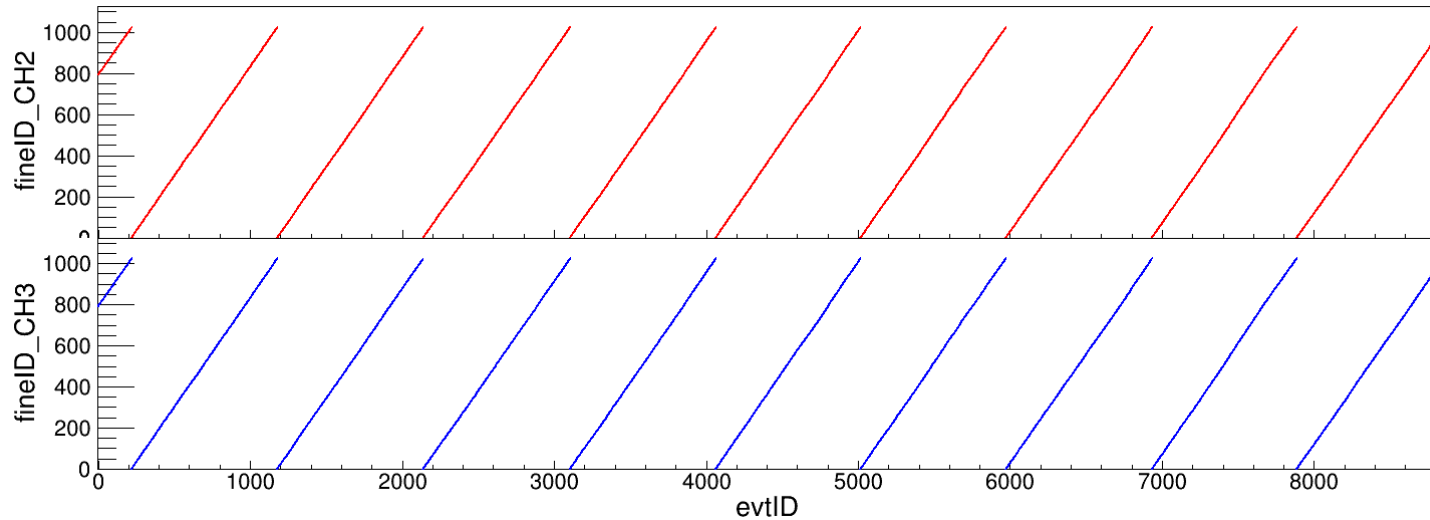
4.2 Test to TLU



- In PPE168 of H8 at SPS.
- FLASH triggers TLU. LGAD performs as DUT.
- FROS records waveform of LGAD and trigger signal from TLU.



4.2 Test to TLU



- Two LGADs have been tested.
- The trigger ID of two channels matches with each other very well.
- Resolution of both LGAD is ~ 300 ps, which worse than our expectation.
- This test has preliminarily validated the function of the TLU in HPES.
- The TLU will be improved this year with more designed functions.

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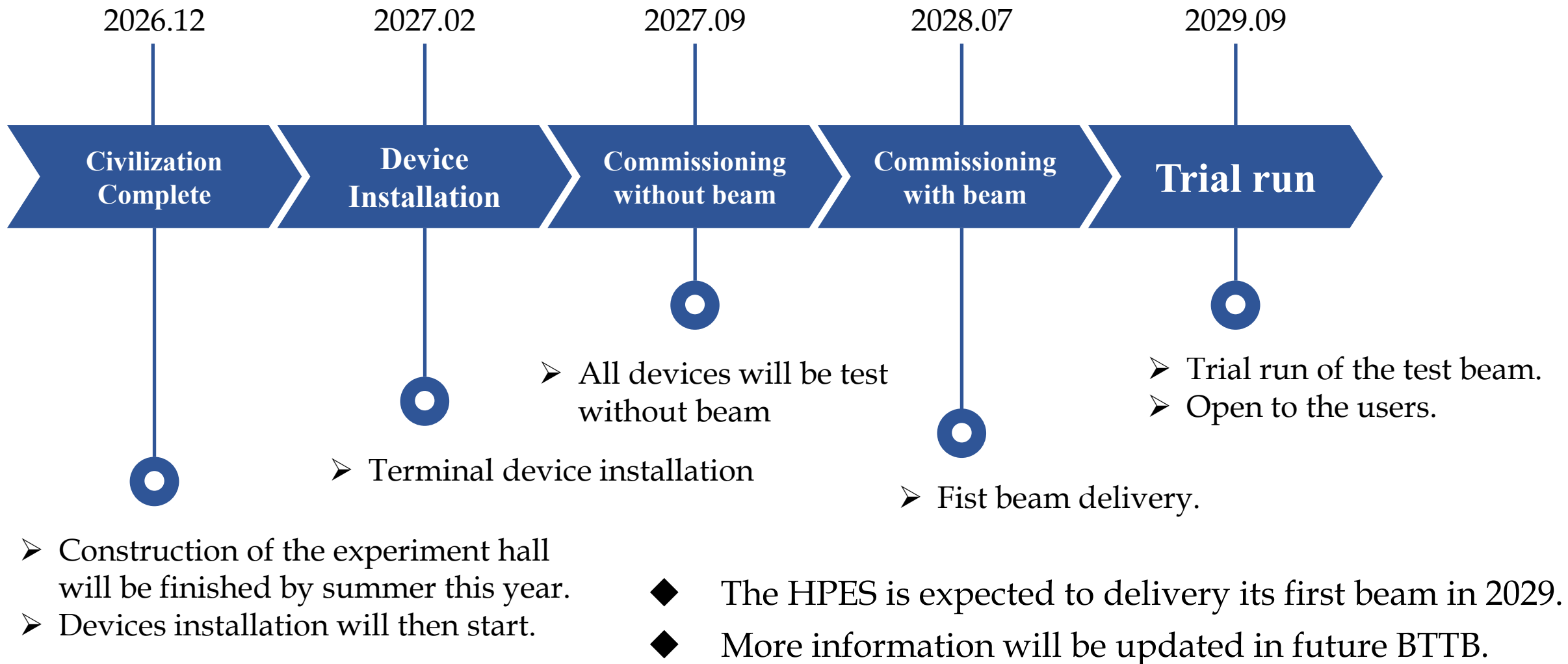
Recent tests to HPES



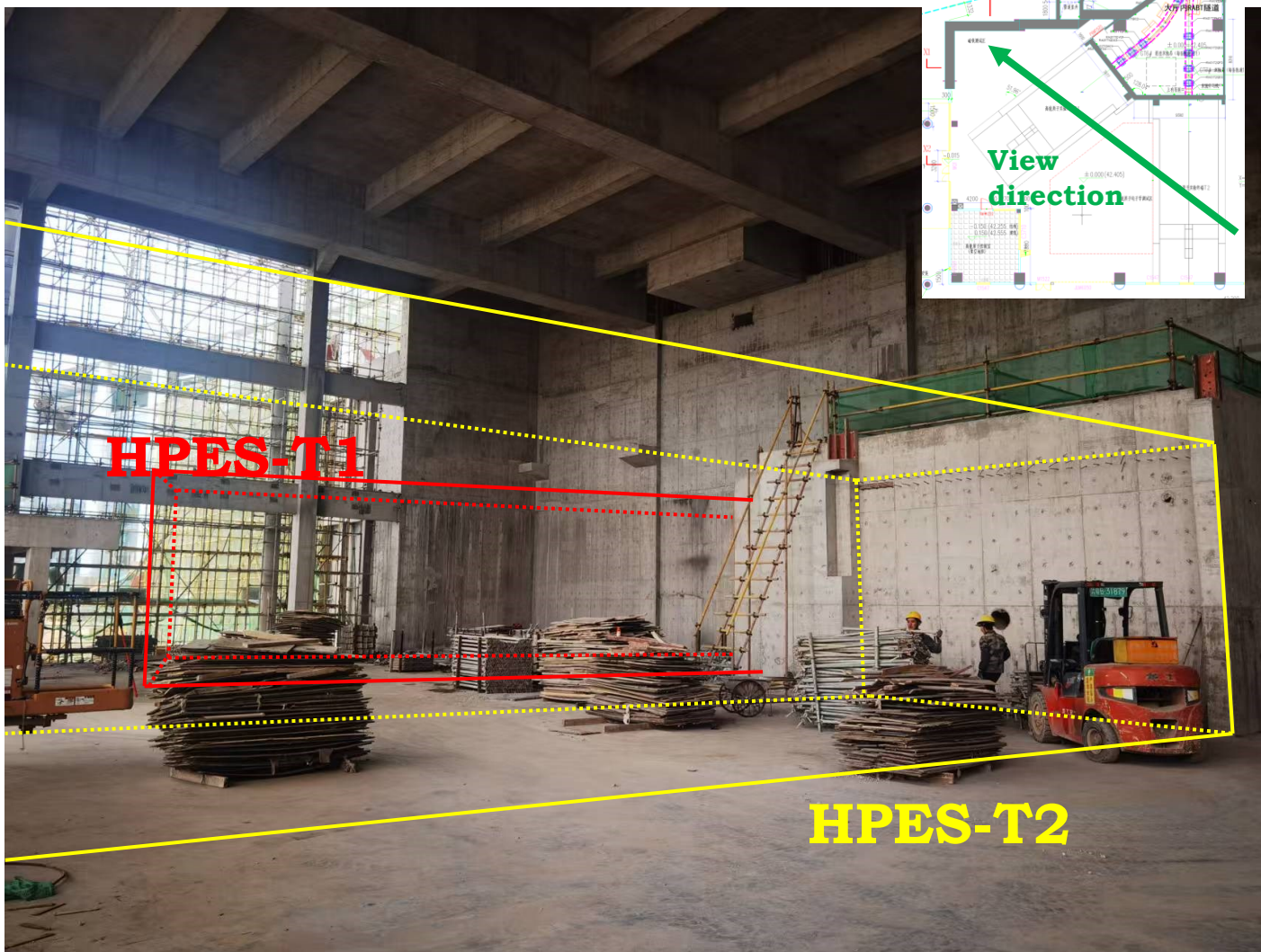
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Milestone and Summaries

5.1 Milestone of HPES construction



5.2 Recent progress of HPES



5.3 Summaries



- China's first proton test beam will be completed in 2029.
- 1.6 GeV proton beam can be provided with flexible flux and beam spot size as requirement of users.
- Multiple DIT have been equipped with HPES in supporting the users:
 - EUDET-type telescope with resolution $< 10 \mu\text{m}$.
 - TOF proton energy spectrometer with res. 1% @ 1.6 GeV.
 - Trigger device with TLU for data alignment proton by proton.
- HPES will open to everyone. Welcome to contact with us if you are interested.



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- The application process for the **2026 International Young Talent Exchange Program to China** is now open.
- **3 types of funding are provided.**
 - **Visits and Exchanges:** Funding is provided for groups of young foreigners to participate in exchange activities in China for a duration of no more than **30** days.
 - **International Internships:** Funding is provided for currently enrolled young foreigners to conduct internships in their field of study or research in China for a duration of no more than **60** days.
 - **Short-term Employment:** Funding is provided for graduated young foreigners to engage in short-term work in their field of study or research in China for a duration of no more than **90** days.
- **Criteria:**
 - **Must not be** a citizen of the People's Republic of China.
 - **Must be** between 18 and 35 years old (born between April 1, 1991 and April 1, 2008).
 - **Education:** Must be currently enrolled in or have graduated within the last three years from an overseas higher education institution (including vocational and technical colleges), holding a relevant degree (Bachelor's, Master's, or Doctorate).
- **International travel and insurance fares will be covered.**
- **Please contact with me if you are interested.**
- **Deadline of application 17. Apr. 2026, so as soon as possible!**

<https://www.citef.org.cn/CITEF/LEAP/citefenglish/html/index.html>

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致谢



承蒙厚爱
感谢倾听
Thanks!