BSRF test beam updates

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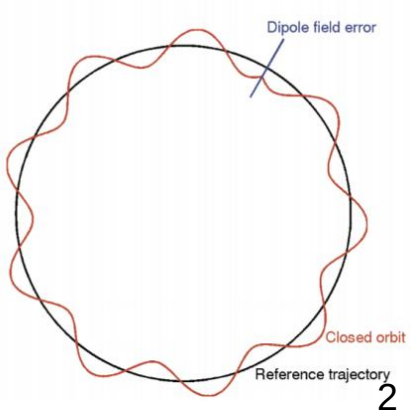
Introduction

- Test beam facility is desirable for detector R&D
- Major TB stations are built out of China
  - Not easy to use due to Covid-19
  - Limited available time slot for CEPC detectors
- Hall 10 test beam was used last year
  - Limited rate
  - Complicate beam setup
  - Can not be used for collision mode
- Potential BSRF test beam facility
  - High energy charged particle observed
  - reasonable rate measured
  - Compatible with BEPC collision mode

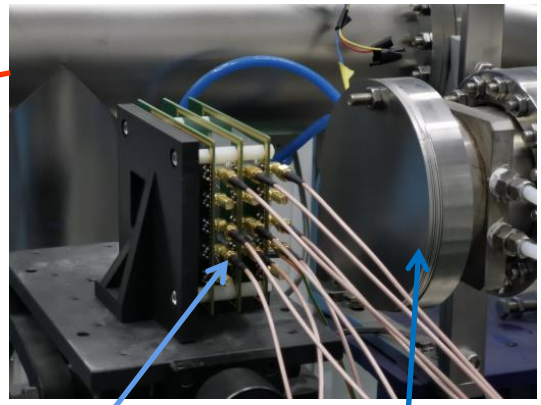
Presented on December 9 (for 4W1B results)
https://indico.ihep.ac.cn/event/13391/contribution/3/material/slides/0.pdf

Presented in CEPC day (December)
https://indico.ihep.ac.cn/event/13393/session/2/contribution/9/material/slides/1.pdf



Detection setup

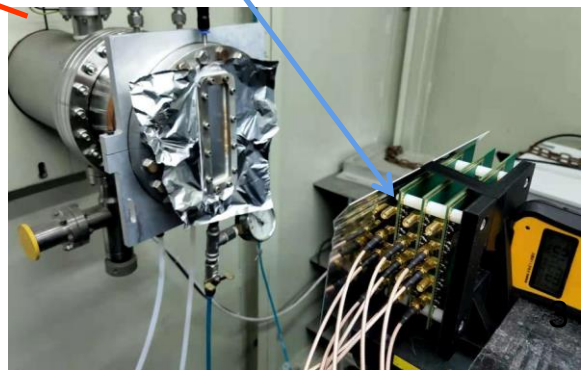
Setup in 1B3 station (**18m** away from BEPC ring)



LGAD detectors

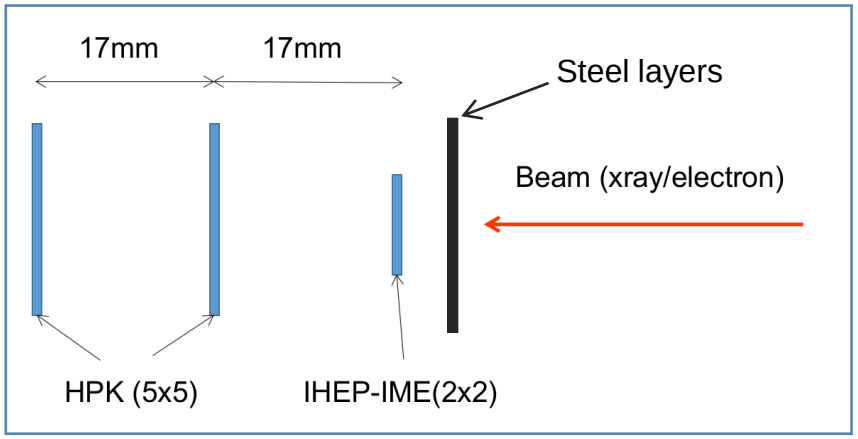
Various thickness steel layers

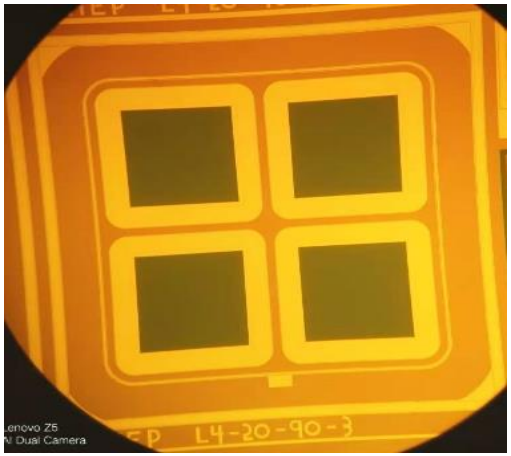
Setup in 4W1A station (40m away from BEPC ring)



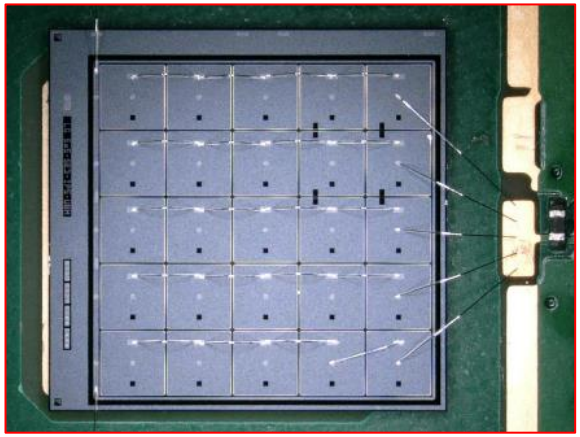
Detectors

- LGAD detector for quick signal test
  - sensive to charged particles
- Three layers LGAD to have coincident test
  - 1xIHEP-IME 2x2 (3x3mm^2), time resolution ~30ps
  - 2xHPK 5x5 (6.5mm^2), time resolution ~60-70ps

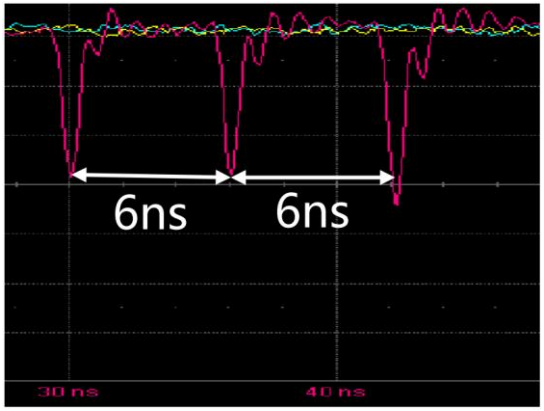




IHEP-IME 2x2



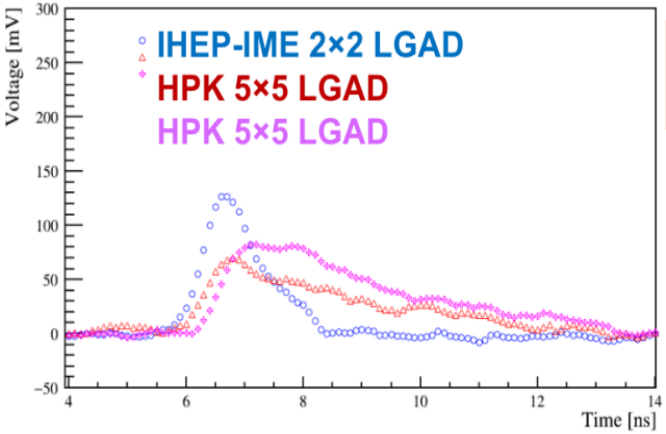
HPK 5x5



response for x-ray

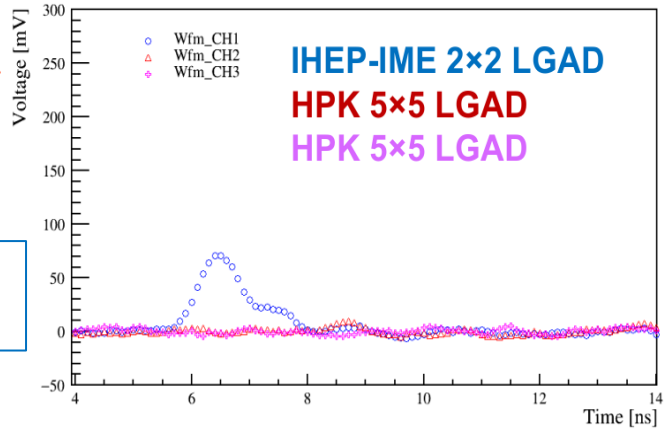
Detection results

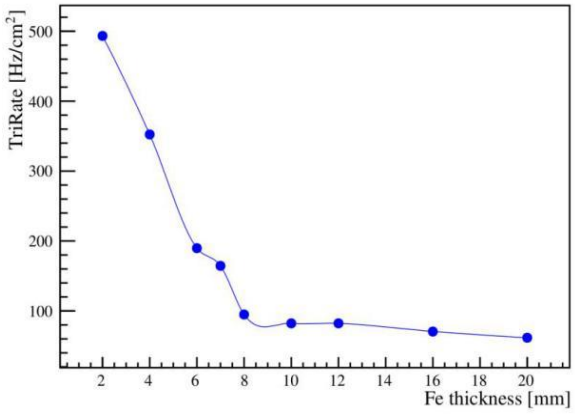
- Categorize events according to coincident requirement
  - Non-coincident events: only one LGAD fired, extremely high rate
  - Coincident events: >=2 LGAD observed events
- Measure Coincident rate and fraction with different thickness of steel layer

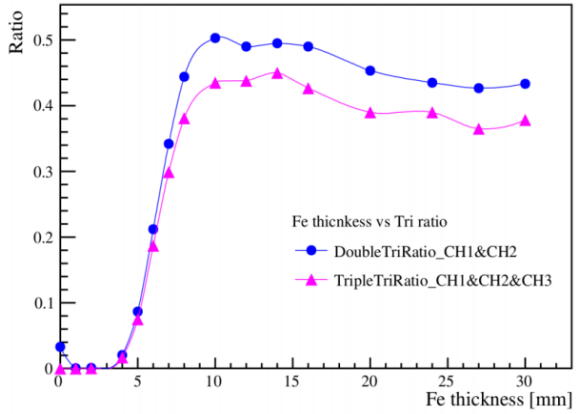


Typical non-coincident events, one LGAD fired

Typical coincident events, multiple LGAD fired



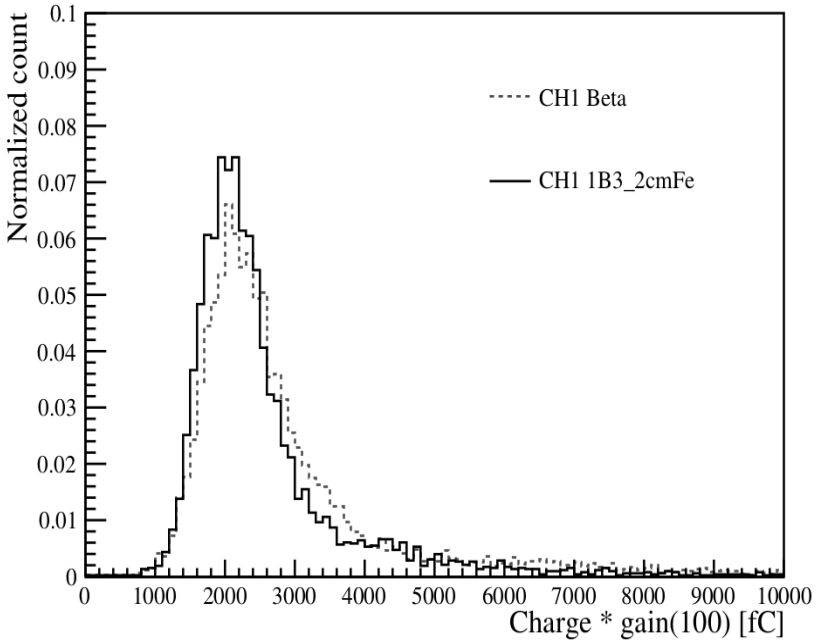




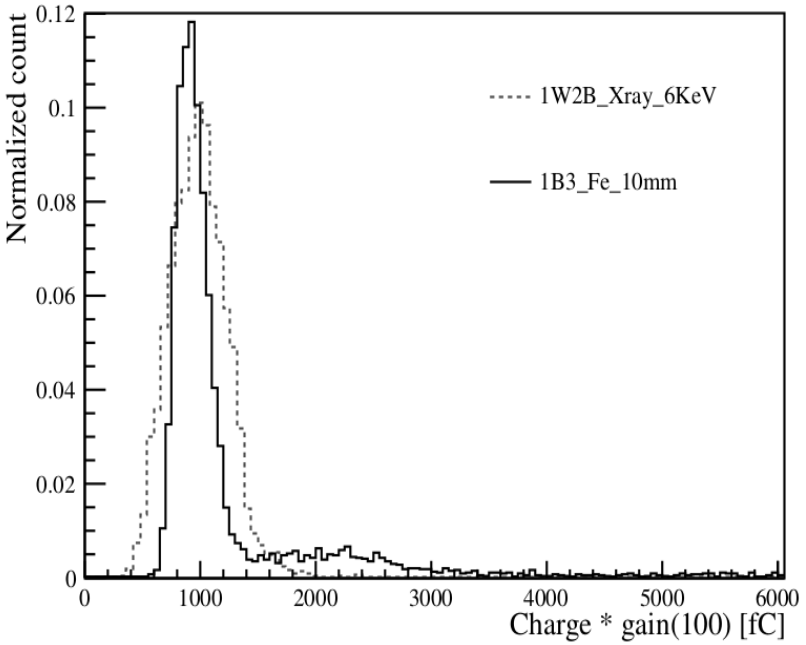
- Trigger on IHEP-IME sensor
- Rate decreases dramatically with increase of steel layers thickness
  - After 8mm, rate become stable ~50 Hz/cm^2
  - Fraction of double fired events is about 50% as maximum

Compared with β-source test results

- Test LGAD sensor response for 6 KeV x-ray in 1W2B station.
- Compared with to β-source test result in Lab



Coincident events show good agreement of sensor charge collection between β-source and 1B3 tests



Non-coincident events show good agreement of sensor charge collection with x-ray 6keV test results

Comparison

	DESY	IHEP Hall 10 E3 Line	BSRF (1B3)
Energy	1-6 GeV	< 1GeV (secondary beam)	~2.5 GeV (depend on BEPC beam energy,TBC)
Particle Type	electrons	Protons/Pions/Electrons	Electrons (TBC)
Trigger rate	250Hz/cm^2-4kHz/cm^2	0.6 Hz/cm^2 (designed)/<0.1 Hz/cm^2(detected)	~50 Hz/cm^2
Operation time	~10months/Y	~2 month/Y	~10 months/Y
Beam spot	4cm^2	~ 80 cm^2	~12 cm^2(mask size)

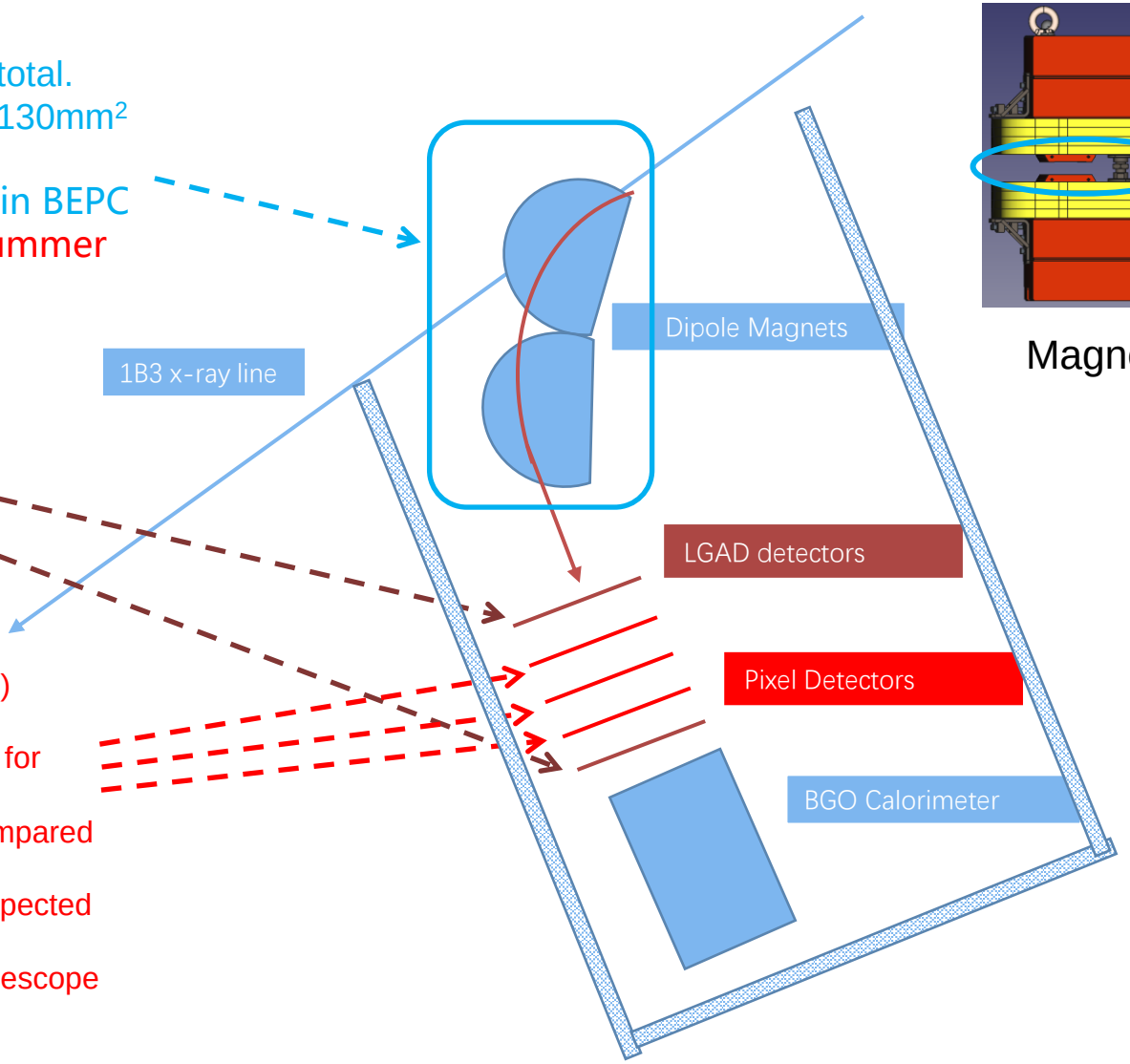
- We observed MIP-like particle in BSRF stations, and potentially the electrons
- Reasonable trigger rate ~50/cm^2 , much larger than Hall 10 facility
- The high priority is to confirm the type and energy

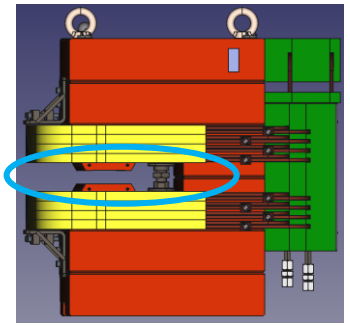
1B3 station electron detection proposal

Magnets, ~1.5 T, 4m long in total.
Uniform field area about 37x130mm^2
Turn around 22°.
Currently these Magnet is in BEPC tunnal. Need to wait for summer break

2Layers of LGAD (300μm thickness)
For event coincident test and trigger for Pix detector/BGO detector
LGAD sensor can be 20x20mm

3 Layers ATLAS Pix3 (20x20mm^2) detector
(700μm later 150μm thickness) for precise position measurement.
Caveat: large material budget compared to MIMOSA (50μm).
Need to perform simulation for expected spatial resolution. ~1-2months.
Later can be used to construct telescope for test beam





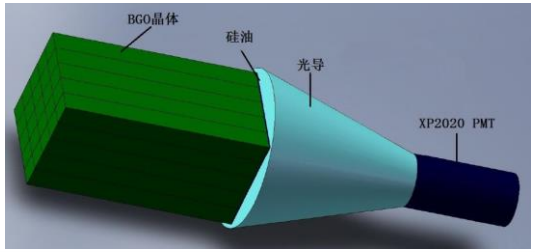
Magnet (B1)

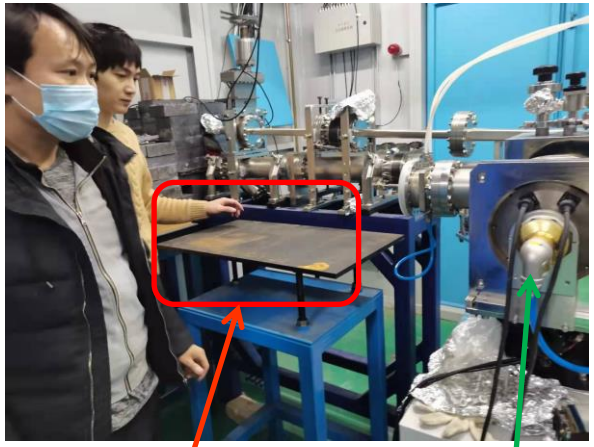
The whole construction and setup will be after summer break (long schedule)

1B3 station electron detection(short schedule)

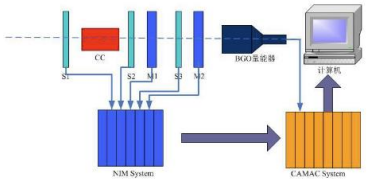
- Currently 1B3b line is used by accelerator colleague for vacuum ionization study with x-ray about 1-2 months.
  - Stop x-ray, no big impact for high energy particles
- Potentially use BGO calorimeter to test with a setup right after accelerator colleague facility timescale estimated ~1-2months

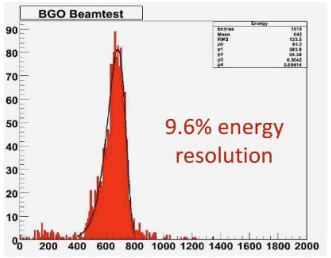
BGO contains 25 pieces 2x2x20mm^3 crystal bars. Total length is about 40-50 cm



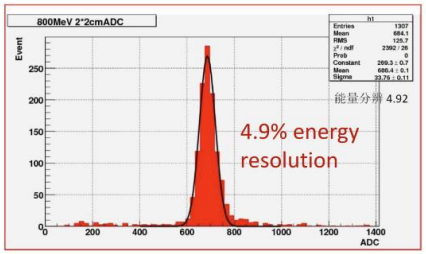


- Performance studies: response linearity and energy resolution
  - Combined tests at the IHEP BEPCII-TBF with
    - A Cherenkov Counter (CC), Multi-wire Chambers (M1,M2), Scintillator Counters (S1,S2,S3)

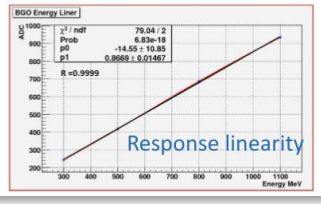




800 MeV electrons within 6x6 cm^2 around the calorimeter center



800 MeV electrons within 1x1 cm^2 around the calorimeter center



Energy resolution: suffered from the lateral shower leakage

Reference:
俞伯祥, "BESⅢ量能器建造及试验束多粒子位置探测器研制", 中国科学院研究生院 博士学位论文, 2010

Results in dissertation from Boxiang yu

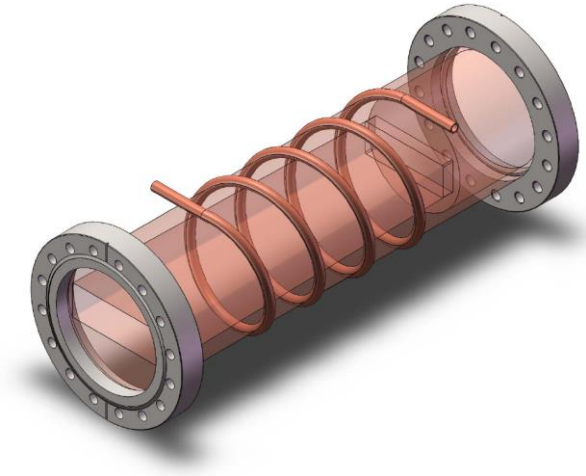
BGO detector is under recalibration with cosmic ray before using for 1B3 station test

Summary

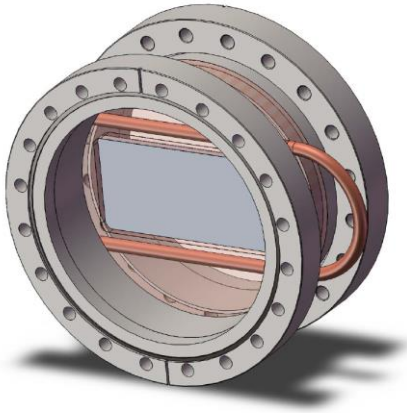
- Test MIP-like particles in BSRF station and its type is suspected to be electrons with relative high energy leaked from BEPC ring
- Brief test with LGAD sensors show a reasonale trigger rate about 50/cm^2 .
- Potentially a test beam facility based on those MIP particles for long term
  - Magnets to separate x-ray and charged particles
  - Pixel detectors used for telescope construction
  - BGO calorimeter to measure energy
- Performing first step to determine the type and energy of such particles
  - Two schedules planned based on BEPC running status

List of facilities

Fixed Mask
62.4x23.4mm^2



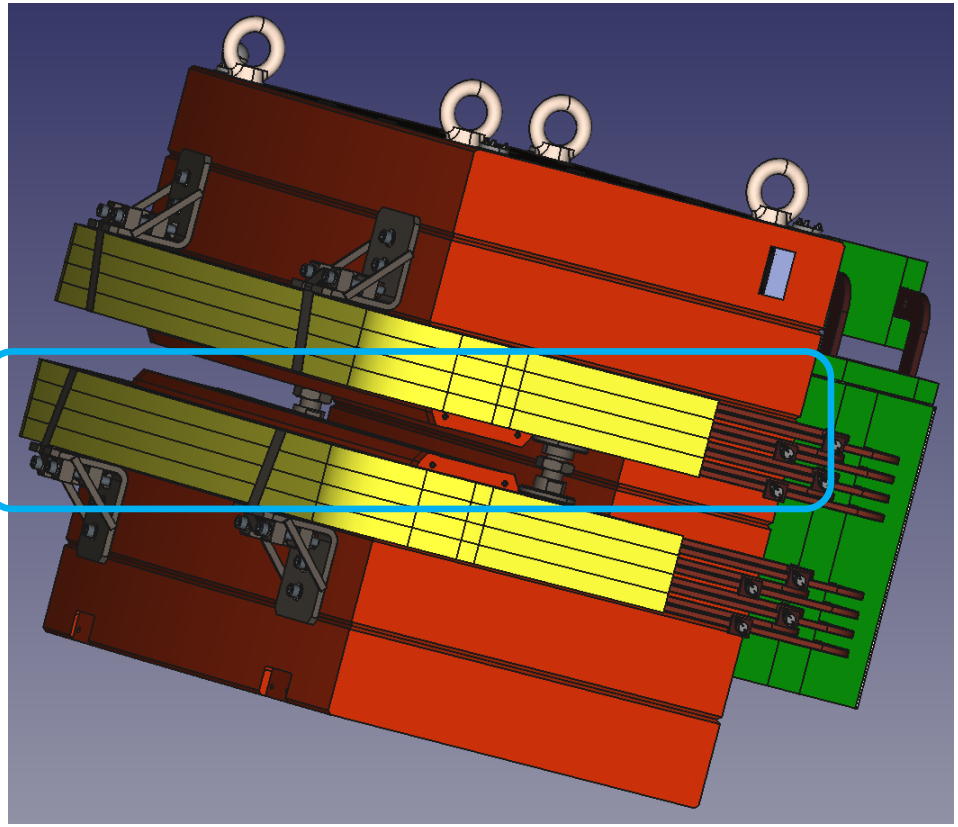
Be window
130x60mm^2



1B3 station electron detection and test beam

3D Model for Magnets

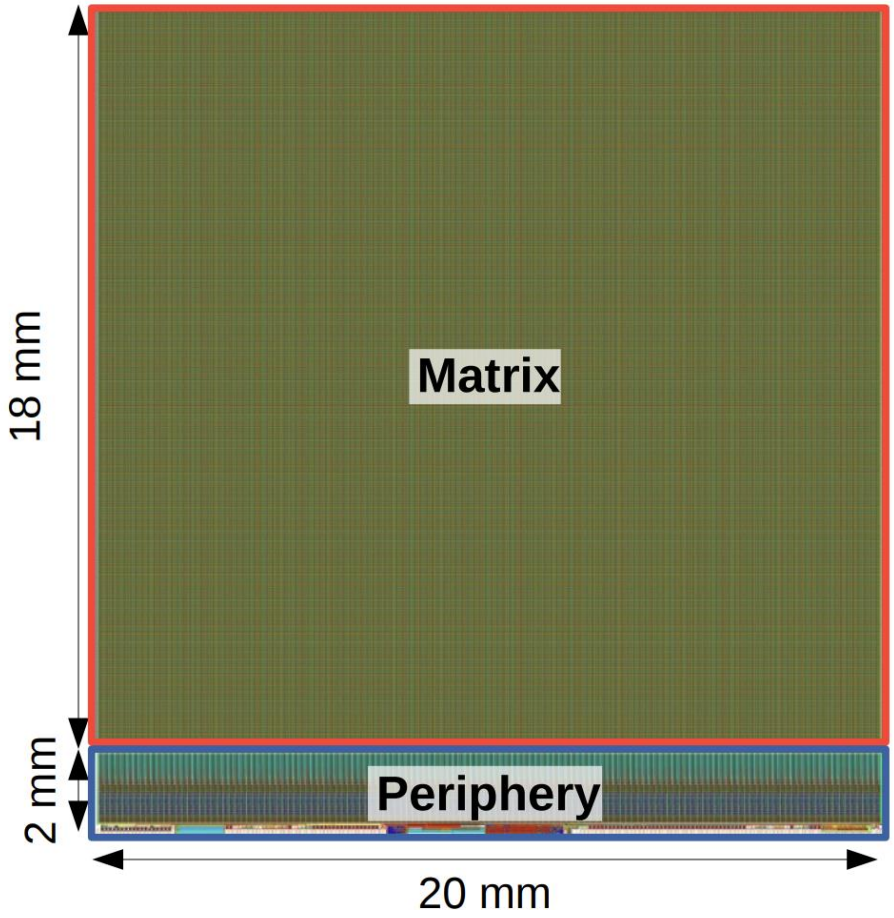
Small space for beam vacuum chamber



Need to have a design of vacuum chamber (Any idea?)

ATLASPix3

- Small material budget
- Pixel size not limited by bump bonds
- Part of the electronics directly inside the pixels (amplifier, comparator)
- Two regions:
  - Pixel matrix (sensitive)
    - Amplifier, comparator, tuning structures
  - Periphery (not sensitive):
    - readout logic, buffers, configuration registers



Need to understand the spatial resolution, material budget etc