Test beam preparation for ITS upgrade at SLRI Beam Test Facility

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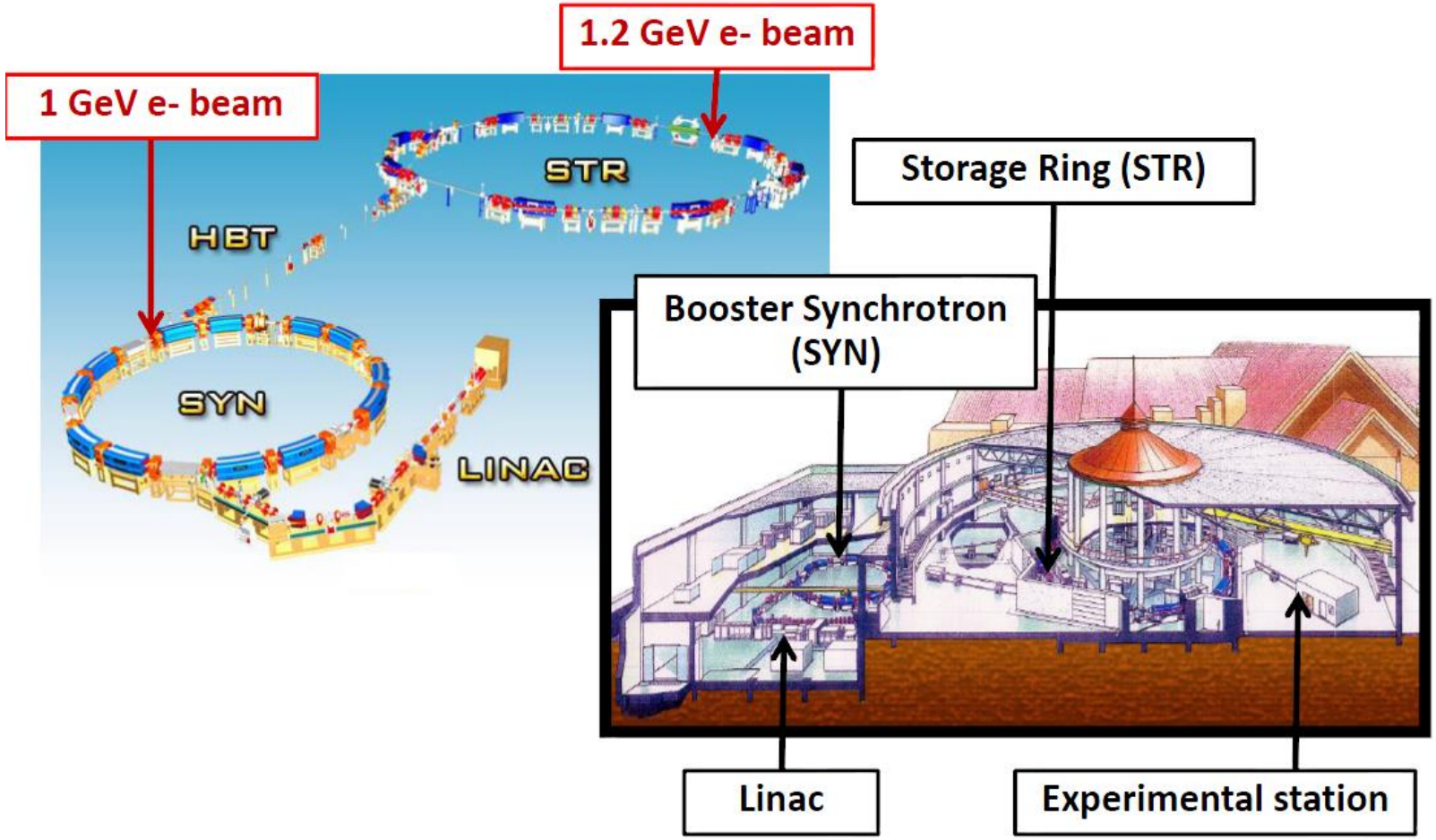
Synchrotron Light Research Institute (SLRI)

Outline:

- Motivation of SLRI Beam Test Facility (SLRI BTF)
- Preparation for electron test beam and results
- Future plans of SLRI BTF

Siam Photon Source

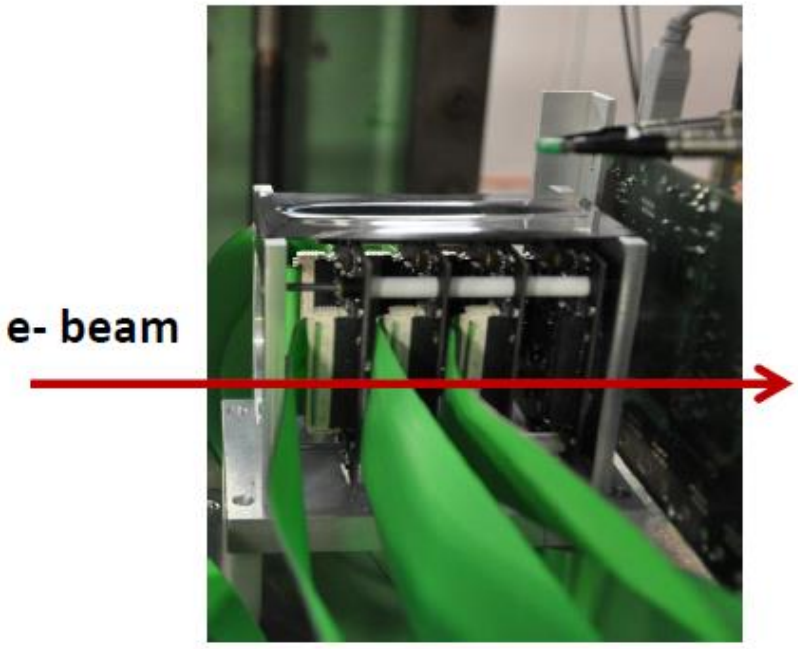


- 24 hours of synchrotron light service
- 10 experimental stations:
  - Small Angle X-rays Scattering (SAXS)
  - Photoelectron emission spectroscopy (PES)
  - Infrared Spectroscopy (IR)
  - X-ray Absorption Spectroscopy (XAS)
  - etc.
- Linac, SYN, HBT used during injection process twice daily
  - In operation for 2 hours
  - Available more than 20 hours

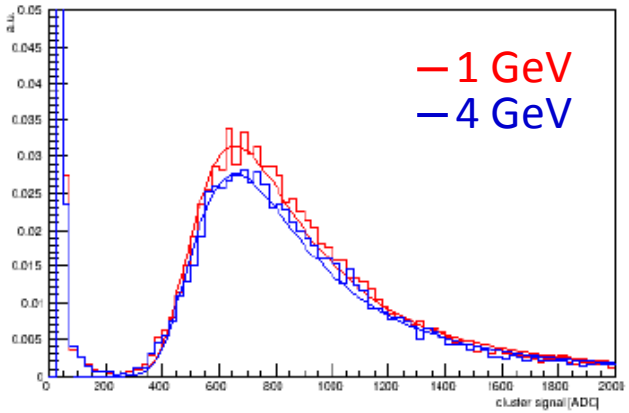
Plenty of electron beam beamtimes at SLRI : sensor chip test for ITS upgrade

Feasibility of 1 GeV electron beam test

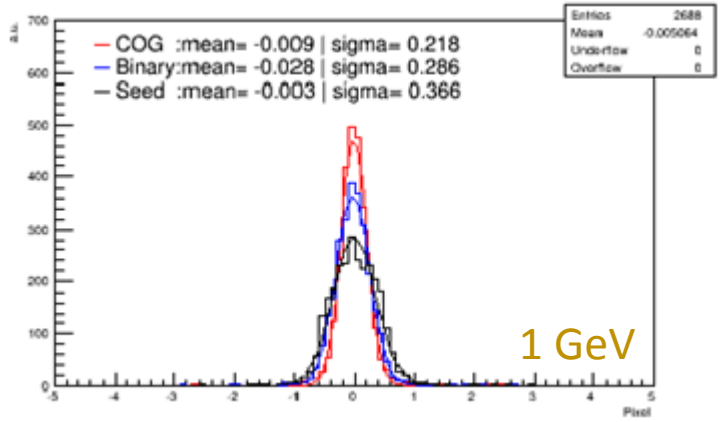
Explorer chip tests with 1 and 4 GeV beam energy at DESY



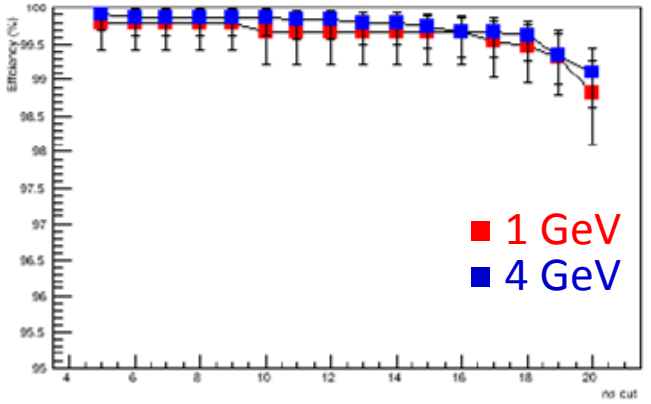
Cluster signal of 1 and 4 GeV beam test



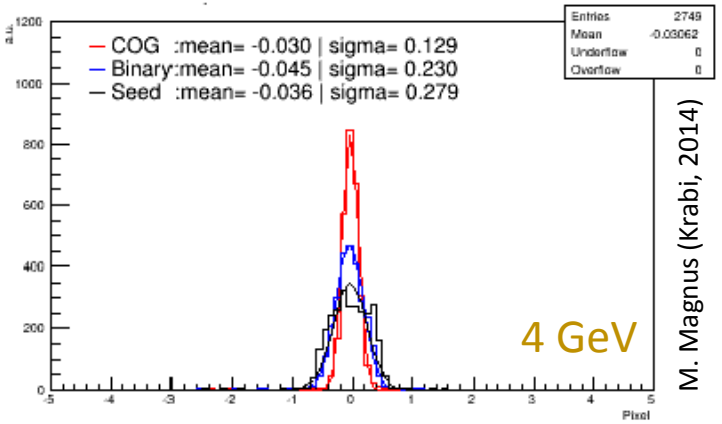
Position resolution of 20 μm Explorer pixels



Detection efficiency of 1 and 4 GeV beam test



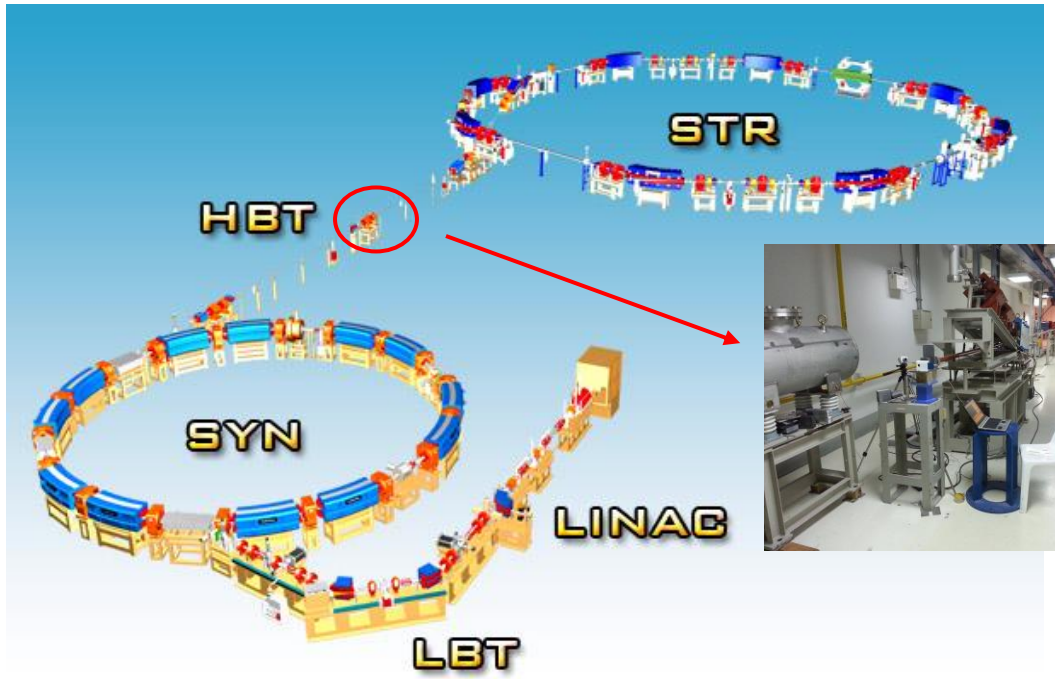
L. Musa (ALICE week 2014)

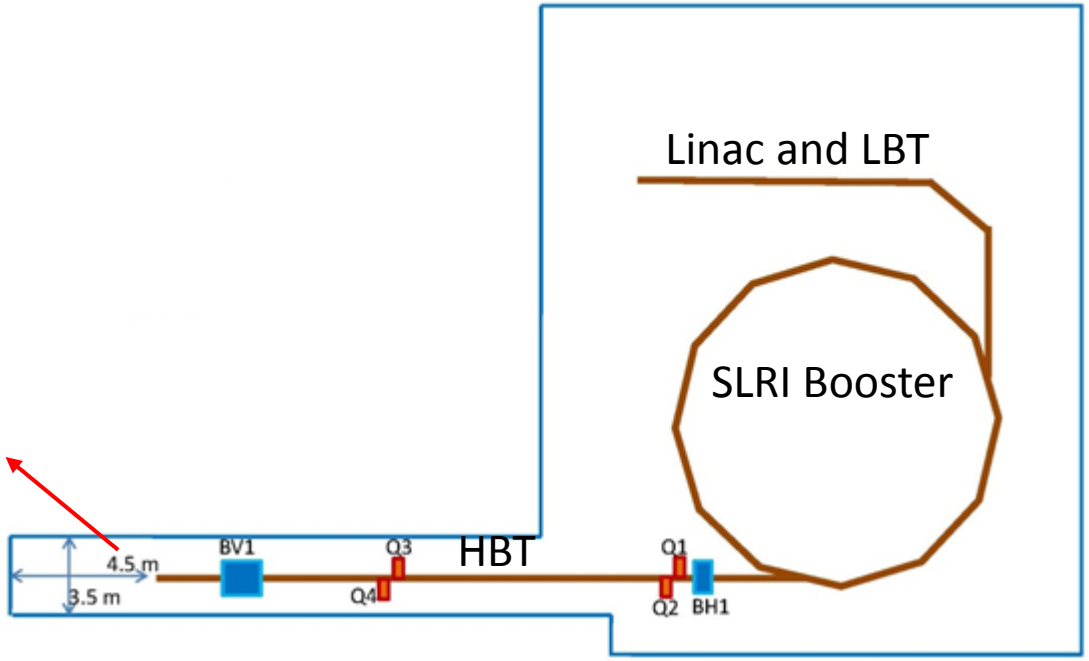


M. Magnus (Krabi, 2014)

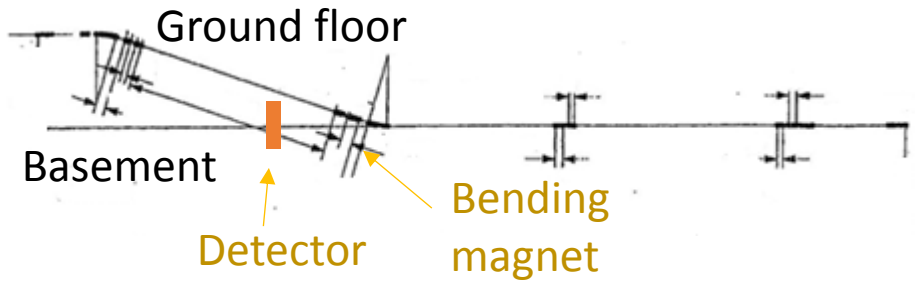
1 GeV electron beam is good enough

Current beamline: short term setup



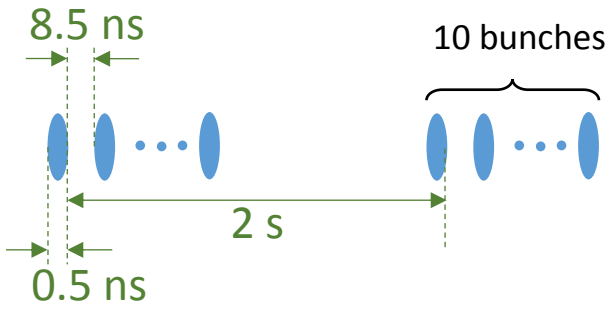


- No beamline modifications 👍
- Quickest way to prepare electron beam for testing detectors 👍
- Not monoenergetic test electron beam 👎



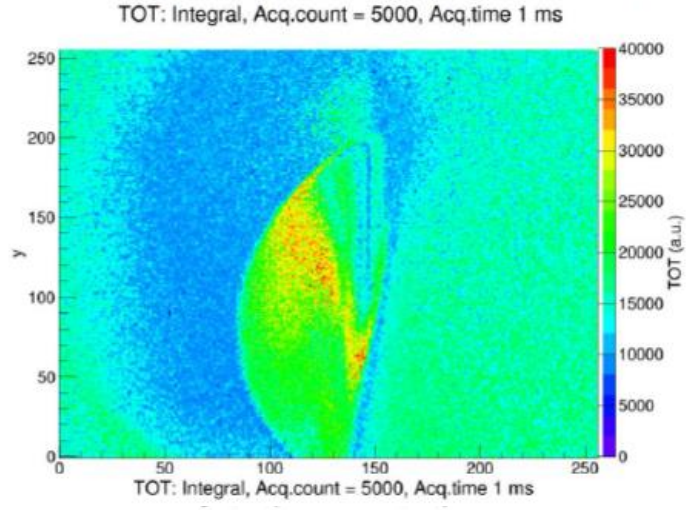
Electron beam parameters at SLRI BTF

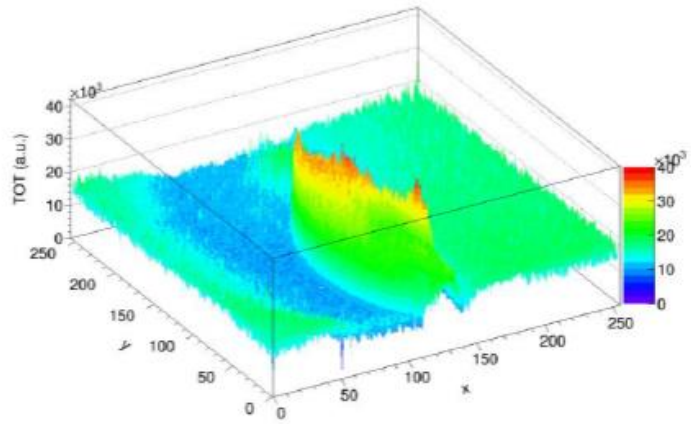
Particle	electron
Energy	1 GeV
Energy Spread	~0.05% at 1GeV
Max. Current	~10 mA
Pulse duration (bunch duration)	~8.5 ns
Bunch length	~0.5 ns
Repetition rate	0.5 Hz



Beam intensity ~ 3×10^8 e/repetition rate

- **Time over threshold mode measurement**

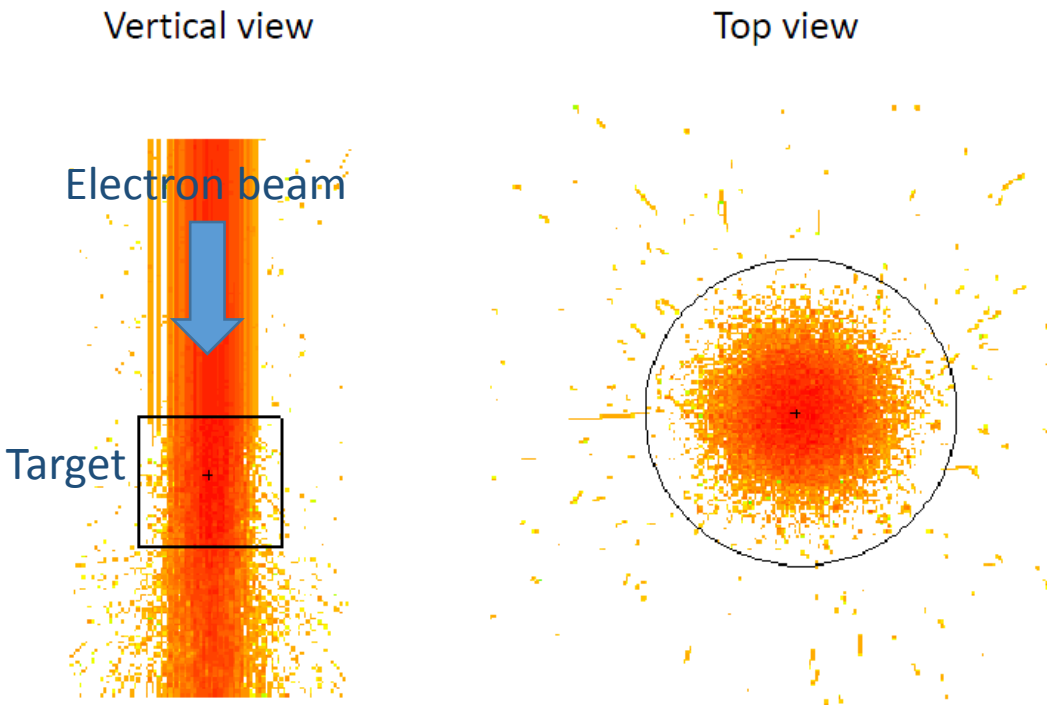


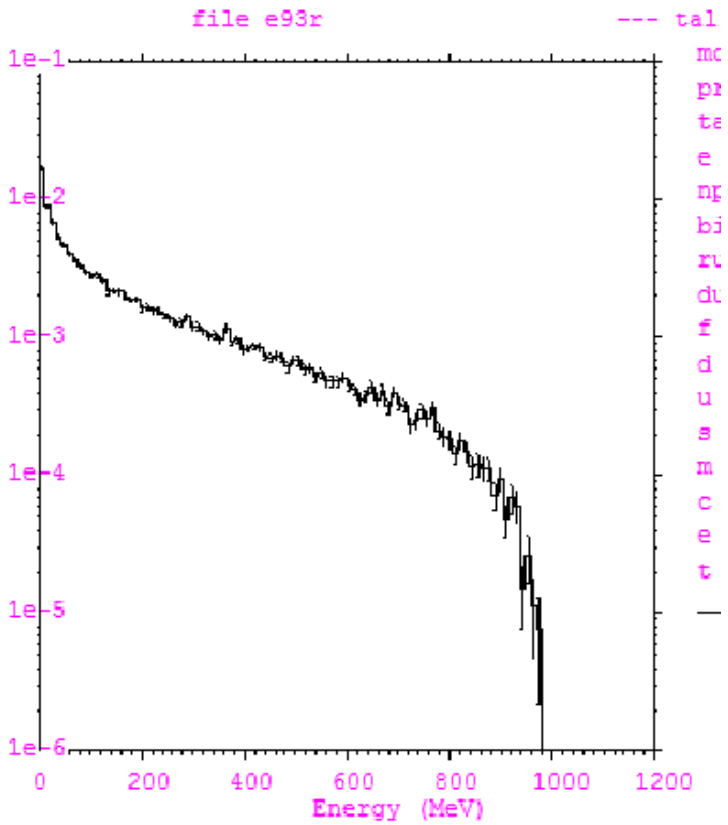


Electron beam reduction required!!

Target simulation by MCNP

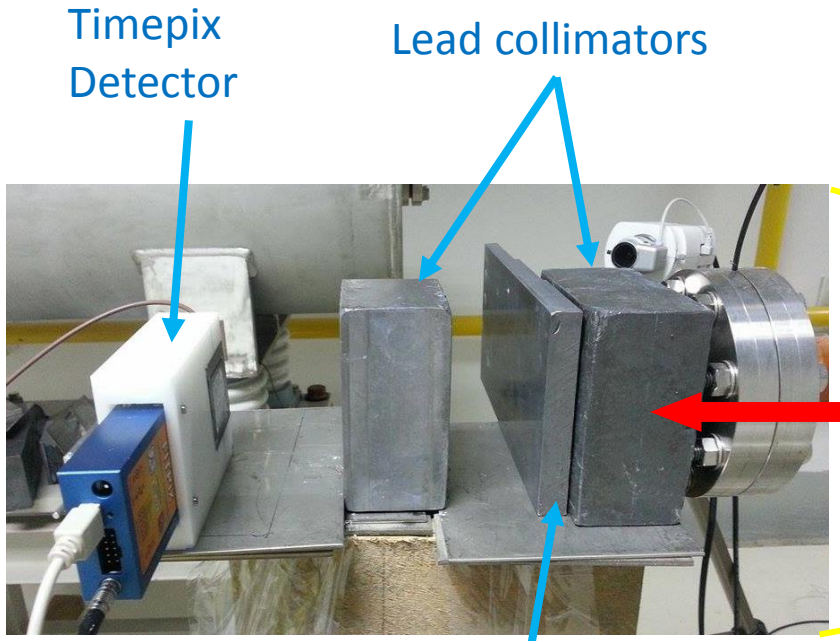
Lead target thickness 9.3 mm ~ $1.7X_0$
Electron beam -> 1 GeV, Gaussian distribution with σ = 0.3 mm

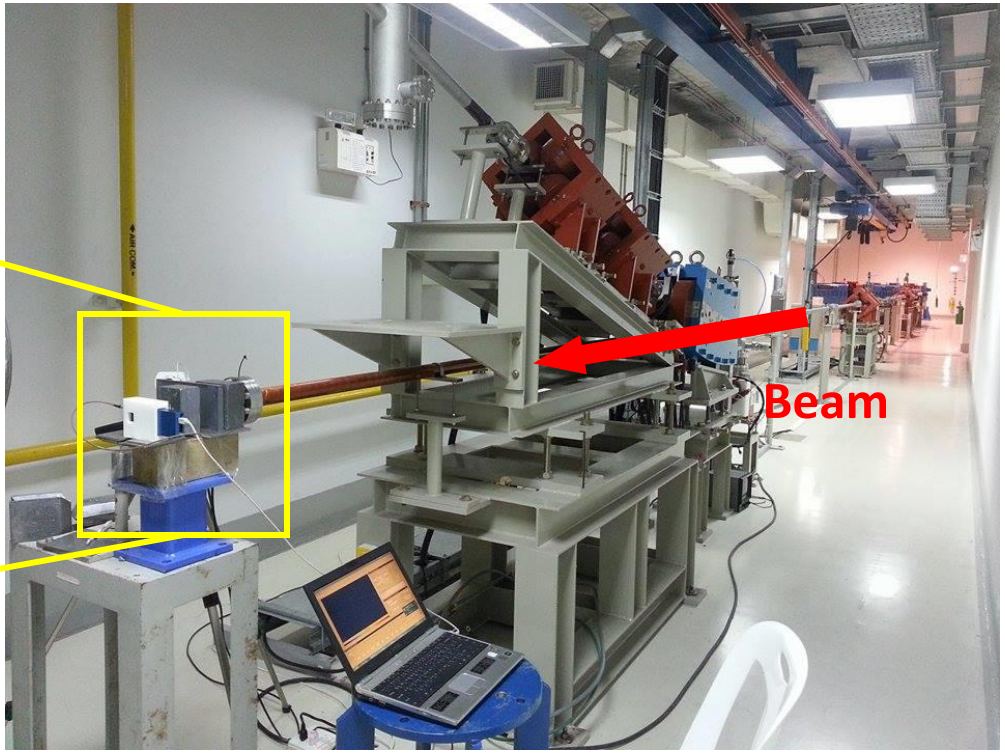




Zero 1 GeV electrons traverse the target!
Beam energy slightly > 1 GeV needed

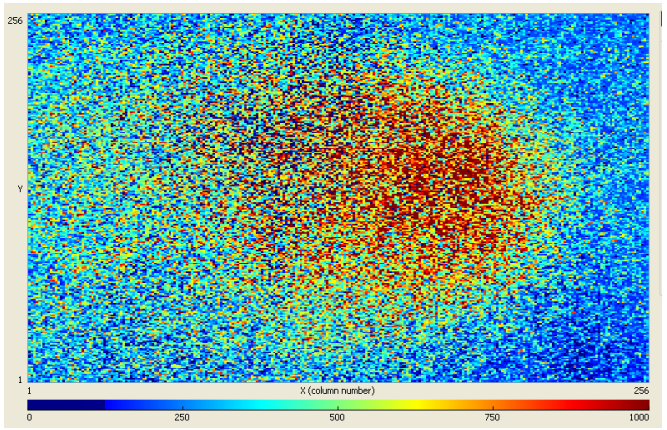
Beam intensity reduction setup

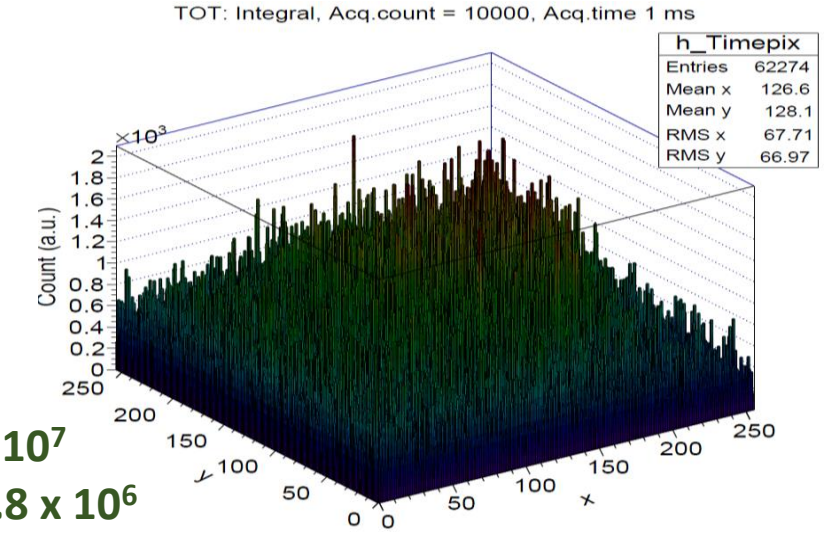




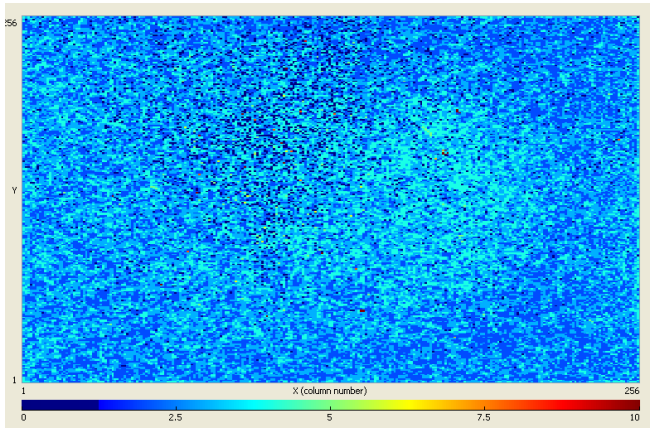
Result of 5 mm lead target

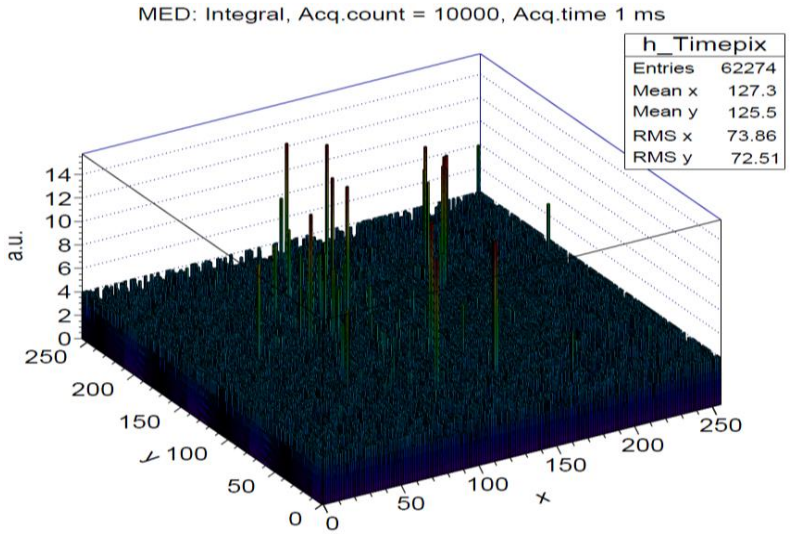
Time over Threshold mode





Medipix mode

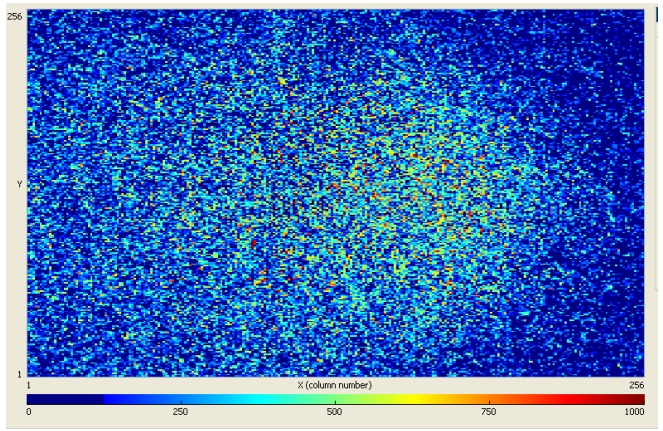


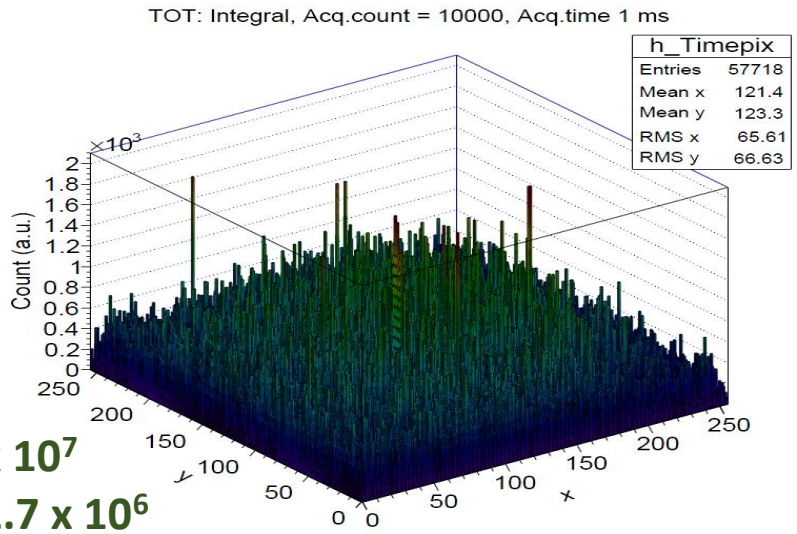


Acquisition time : 1 ms
Acquisition count : 10^4
Total count on sensor = 2.9 x 10^7
Count per repetition rate = 5.8 x 10^6

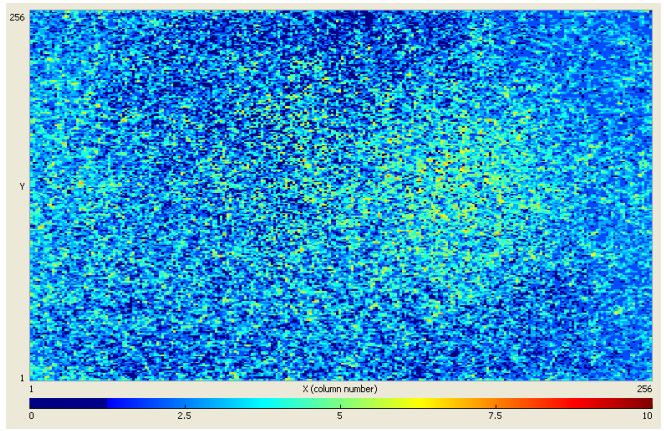
Result of 9 mm lead target

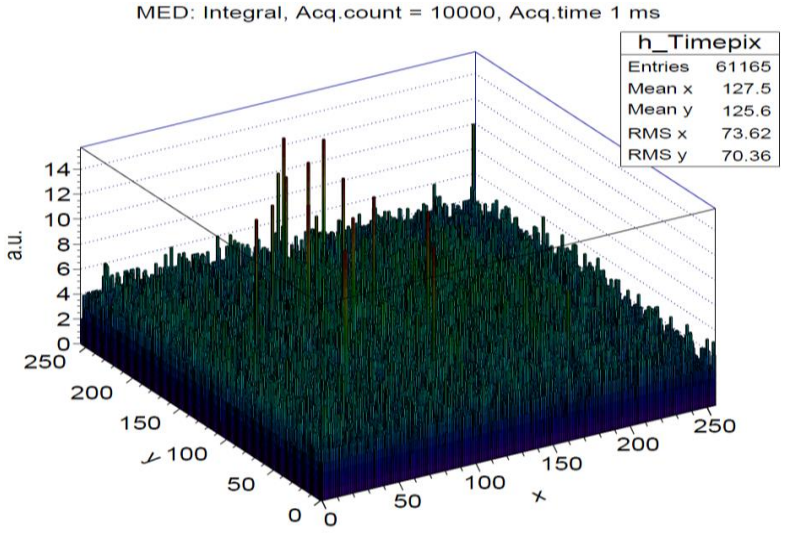
Time over Threshold mode





Medipix mode

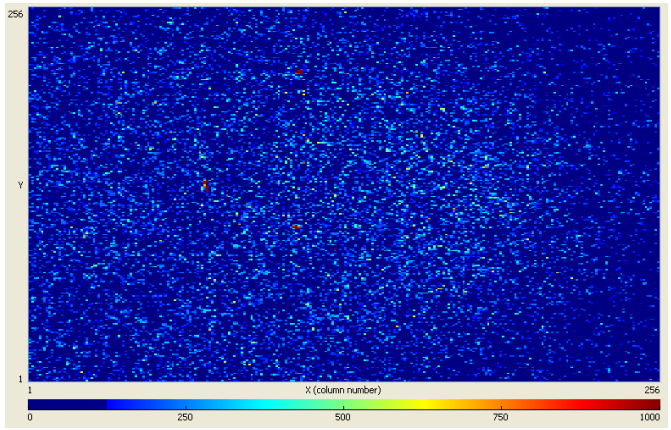


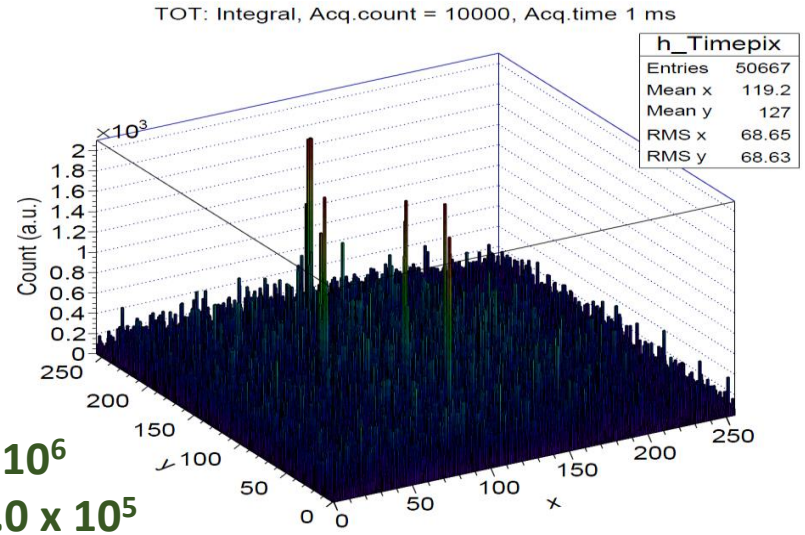


Acquisition time : 1 ms
Acquisition count : 10^4
Total count on sensor = 1.3 x 10^7
Count per repetition rate = 2.7 x 10^6

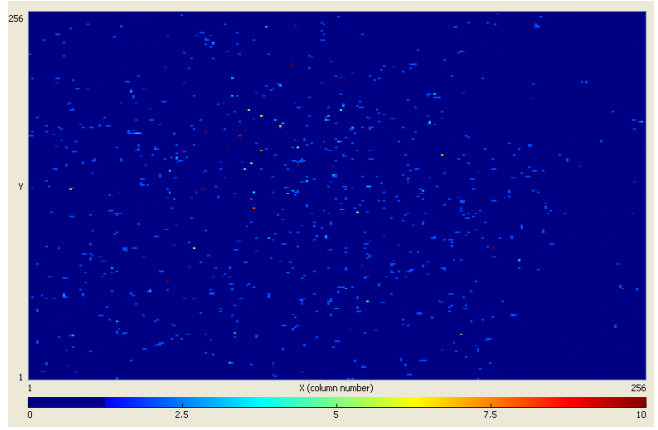
Result of 13.5 mm lead target

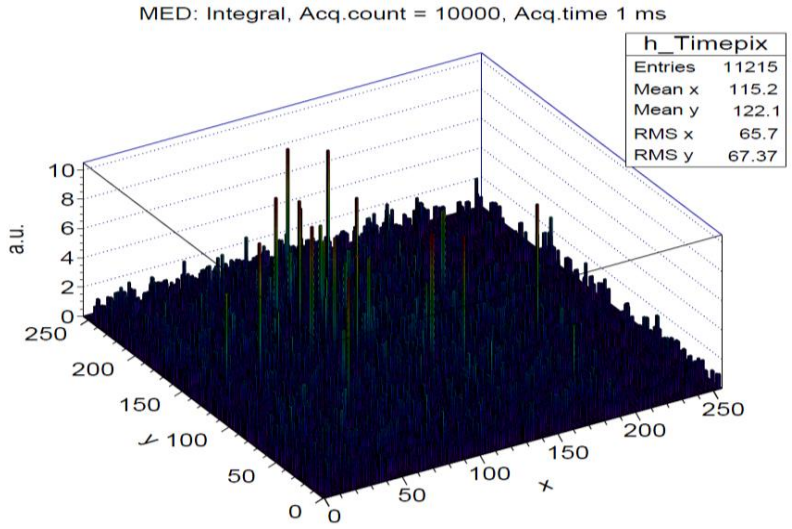
Time over Threshold mode





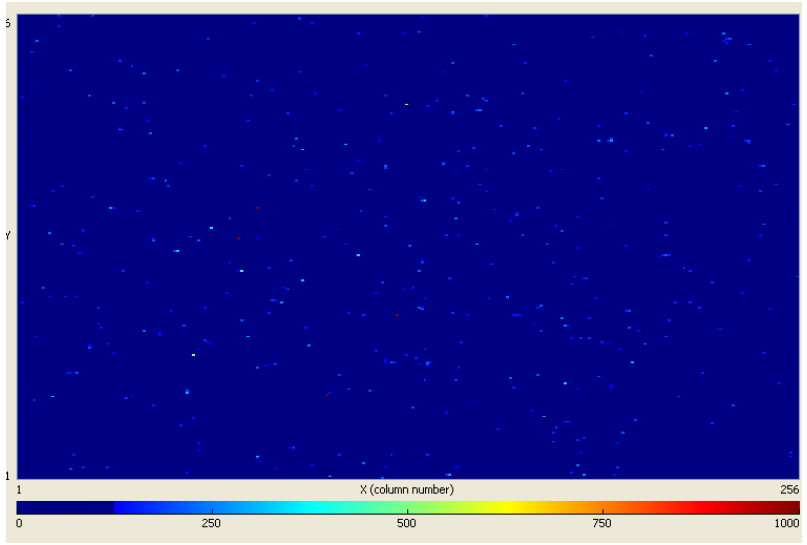
Medipix mode





Acquisition time : 1 ms
Acquisition count : 10^4
Total count on sensor = 4.6 x 10^6
Count per repetition rate = 9.0 x 10^5

Results of excessively thick target



target thickness (mm)	# electrons on sensor for 10 s	# electrons on sensor
5	2.9E+07	5.8E+06
9	1.3E+07	2.7E+06
13.5	4.6E+06	9.0E+05
26	1.6E+06	3.1E+05
~ 60 ($10.7X_0$)	1.7E+05	3.5E+04
Background	2.3E+04	4.6E+03

Lead shield

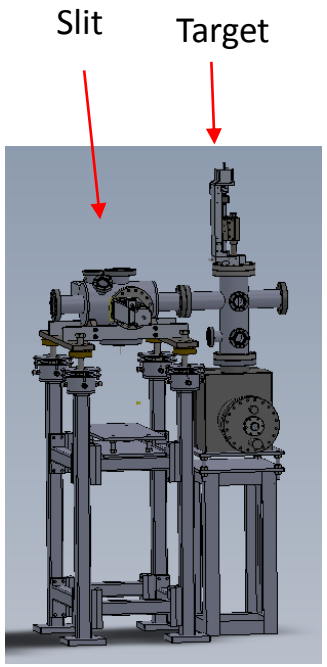
secondary particles detected on the sensor.

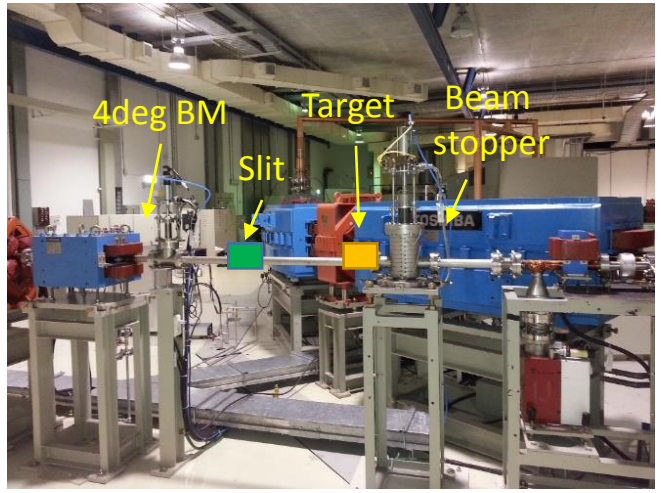
Total count on sensor = 1.7 x 10^5
Count per repetition rate = 3.5 x 10^4

Background
Total count on sensor = 2.3 x 10^4
Count per repetition rate = 4.6 x 10^3

Different setup required to avoid detecting 2nd particles!

Planned beamline: temporarily setup



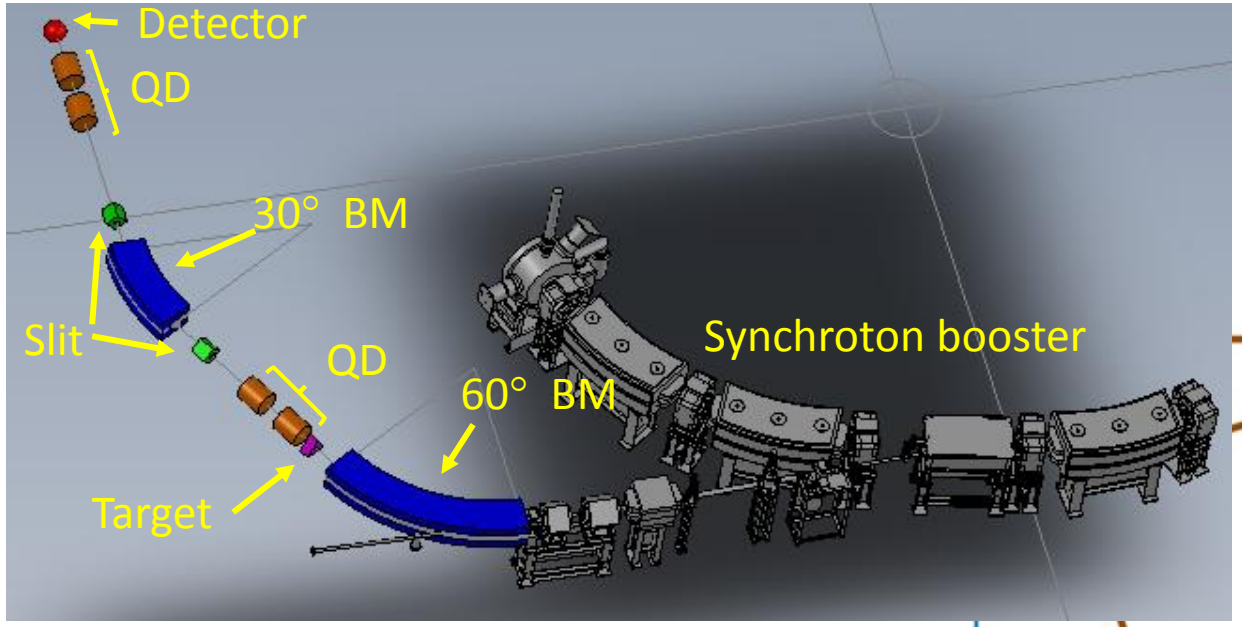


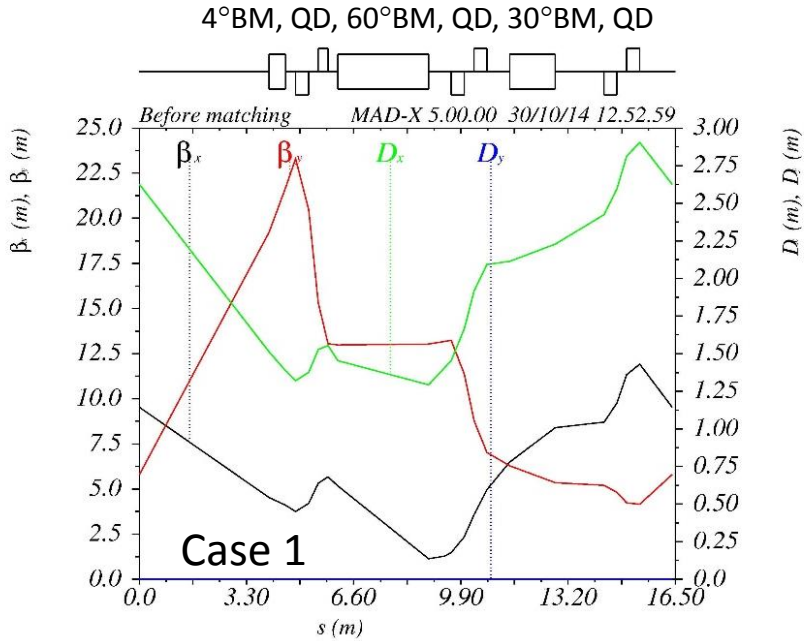
- Motivated by BTF at DAFNE facility
- Use 4 degree magnet as energy selector (possible by calculation)

Energy resolution 4° bending magnet with ρ = 7.2m:
$|dE/E|$ = 2% with upstream slit of 1 mm wide, σ_x = 5mm

Planned beamline: long term setup

Dedicated to provide test beams with various number of electrons in a long term
(Won't be ready for ITS upgrade schedule)





Locations	Beam size (mm) of 1 GeV beam	
	Case 1	Case 2
Target	σx = 0.9112 σy = 0.1616	σx = 0.6302 σy = 0.3075
Detector	σx = 1.3399 σy = 0.2281	σx = 1.5429 σy = 0.1984

Conclusion

- Number of electrons reduced from 10^8 to 10^4 e^-/repetition rate
- 1-100 e^-/repetition rate possible with improved experimental station
- Different detectors/setup required to confirm results
- Plans to build temporary and permanent beam test stations for ITS upgrade project and test beam services started

Thanks to …
SLRI-BTF team: K. Kittimanapun, N. Chanlek, P. Klysubun, S. Suppajiarapun, K. Sittisard, S. Cheedket, N. Chantong, S. Boonsuya, S. Krainara, S. Sangaroon (MSU)
DAFNE-BTF team: P. Valente, B. Buonomo, L. Foggetta
WG5 and ITS upgrade team

Backup slide

Initial value - Beam parameter at the front of HBT

2 System design

2.1 Design concept

High energy beam transport transports the beam from synchrotron ring to storage ring. The high energy beam transport is confirmed to satisfy the system requirements of this project by old-magnets, old-magnet power supplies and monitors.

The Beam condition of outlet of synchrotron ring is as follows.

$\beta x = 6.75m$ $\beta y = 3.46m$

$\alpha x = 0.10$ $\alpha y = 0.19$

$\eta x = 1.85m$ $\eta y = 0m$

$\eta' x = 0.0$ $\eta' y = 0.0$

Beam condition of inlet of storage ring is as follows.

$\beta x = 7.49m$ $\beta y = 5.73m$

$\alpha x = 0$ $\alpha y = 0$

$\eta x = 0m$ $\eta y = 0m$

$\eta' x = 0.0$ $\eta' y = 0.62$

1.2 GeV

```
horiz.beam emittance ................ =   440.293 nm
vert.beam emittance ................. =     4.403 nm
coupling ............................ =     1.00000 %
rel.energy spread ................... =     0.05905 %
momentum compaction factor, alpha_c . =     0.194190
```

1.0 GeV

```
horiz.beam emittance ................ =   305.759 nm
vert.beam emittance ................. =     3.058 nm
coupling ............................ =     1.00000 %
rel.energy spread ................... =     0.04921 %
momentum compaction factor, alpha_c . =     0.194190
```

Bending magnet

- Based on magnetic rigidity : Bρ = 3.3E [GeV] then an e-beam of 1.2 GeV -> Bρ = 4 T.m

B (T)	rho (m)	Path (m) for each angle (deg)		
		30	45	60
0.5	8.00	4.19	6.28	8.37
1	4.00	2.09	3.14	4.19
1.5	2.67	1.40	2.09	2.79
2	2.00	1.05	1.57	2.09

→ Best option: proper size and field

- BTF Frascati : distance from target to 1st magnet ~ 1.9 m
  (target, 2 x quads, slit)
- Energy acceptance or resolution of bending magnet (energy selector):
  |dE/E| = 4% with σ_x = 5mm, H = 55 mm, h = 62 mm, l = 1.5, ρ = 2.67 m

$$\left|\frac{\Delta E}{E}\right| = \frac{h}{2L_2} + \sqrt{2}\left(\frac{\sigma_x}{L_1} + \frac{H}{2L_1}\right)$$