



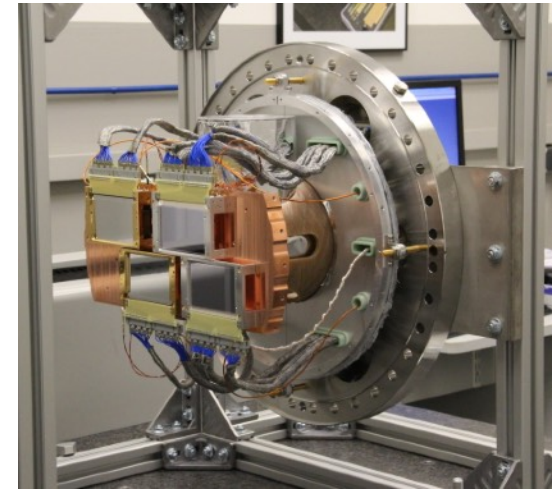
KOALA Beam Test @ COSY

25.06.2019 | YONG ZHOU | IKP-FZJ

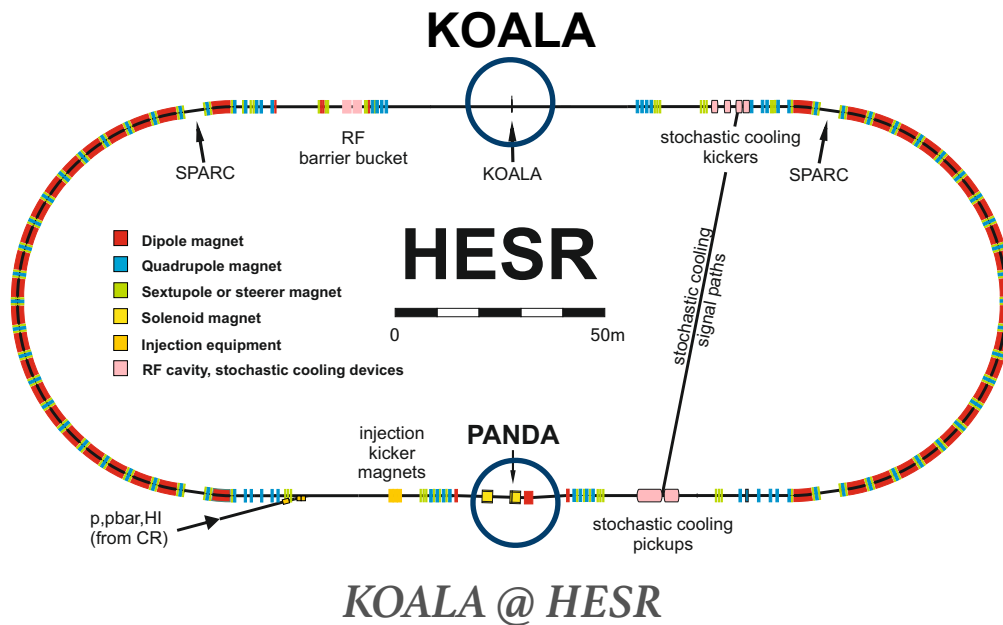
KOALA Experiment

- Parameter input for absolute luminosity determination of PANDA-LMD
- $|t|$: **0.0008 ~ 0.1 (GeV/c)²** by measuring recoil protons
- Independent location at HESR
- Recoil detector built & tested

Recoil Detector:



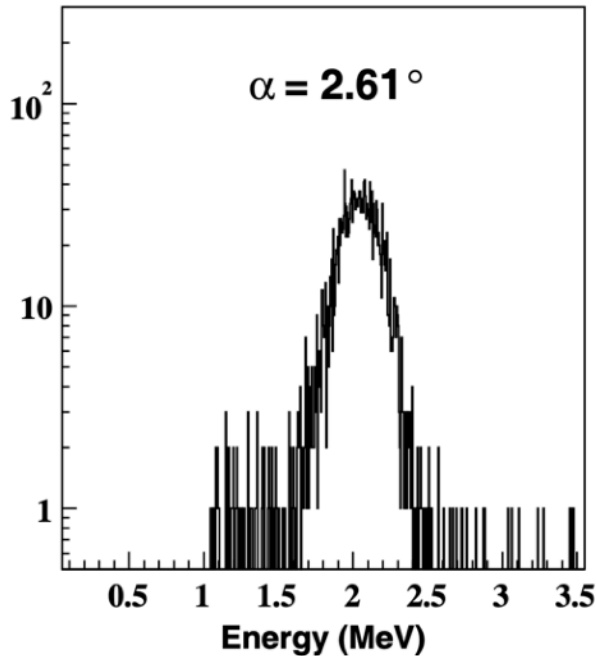
- 2 Si + 2 Ge
- Strip width: 1.2 mm
- ΔE_{FWHM} : < 20 keV (Si)
< 30 keV (Ge)



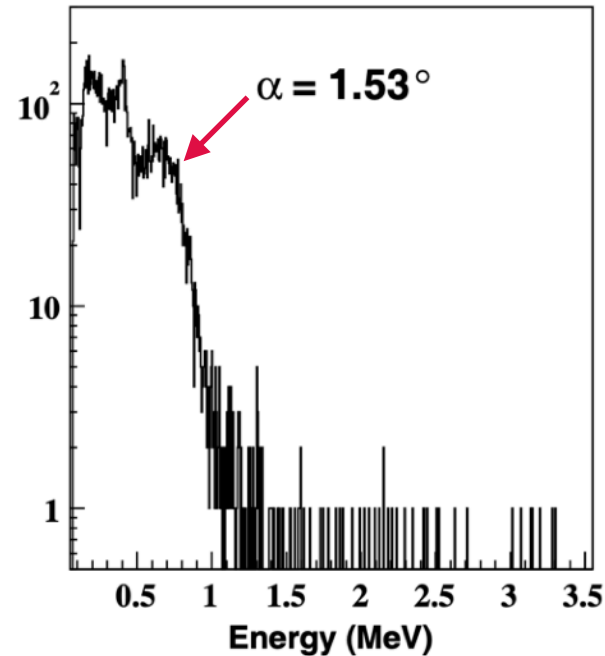
Recoil Detector Commission @ COSY

- Two beam tests (p-p elastic scattering) : 2013 & 2015
- $|t|$ range achieved: $0.001 < |t| < 0.1$ (GeV/c)²
- **Limitation: large background at small recoil angle ($\alpha = 90^\circ - \theta$)**

Strip#44 @ Si1



Strip#28 @ Si1

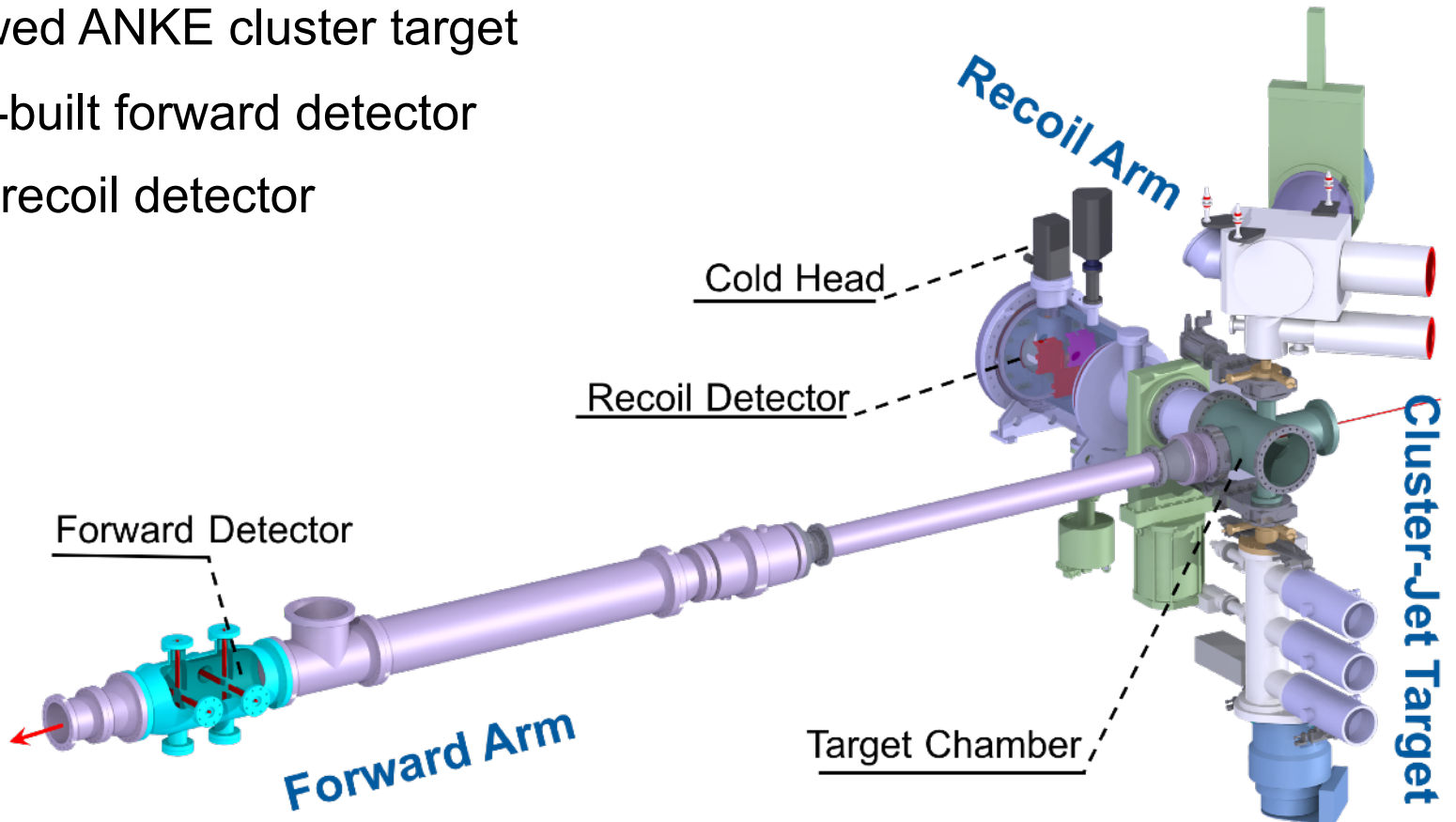


A coincidence with the forward scattered proton is needed for background suppression (mainly from pions close to $\alpha=0^\circ$)

New Setup @ COSY

Forward detector is added to measure the scattered proton/anti-proton.

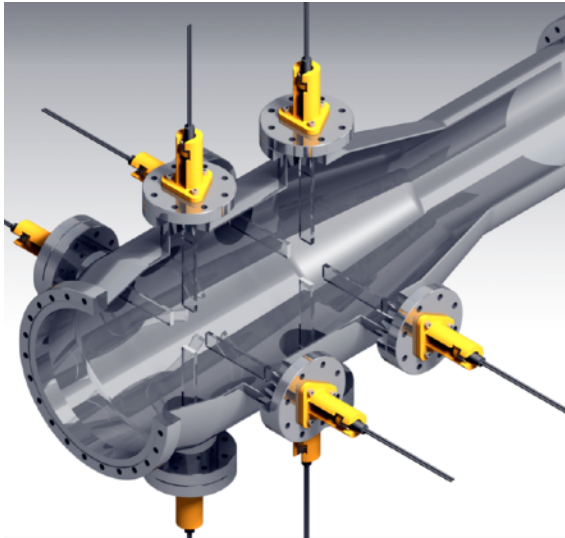
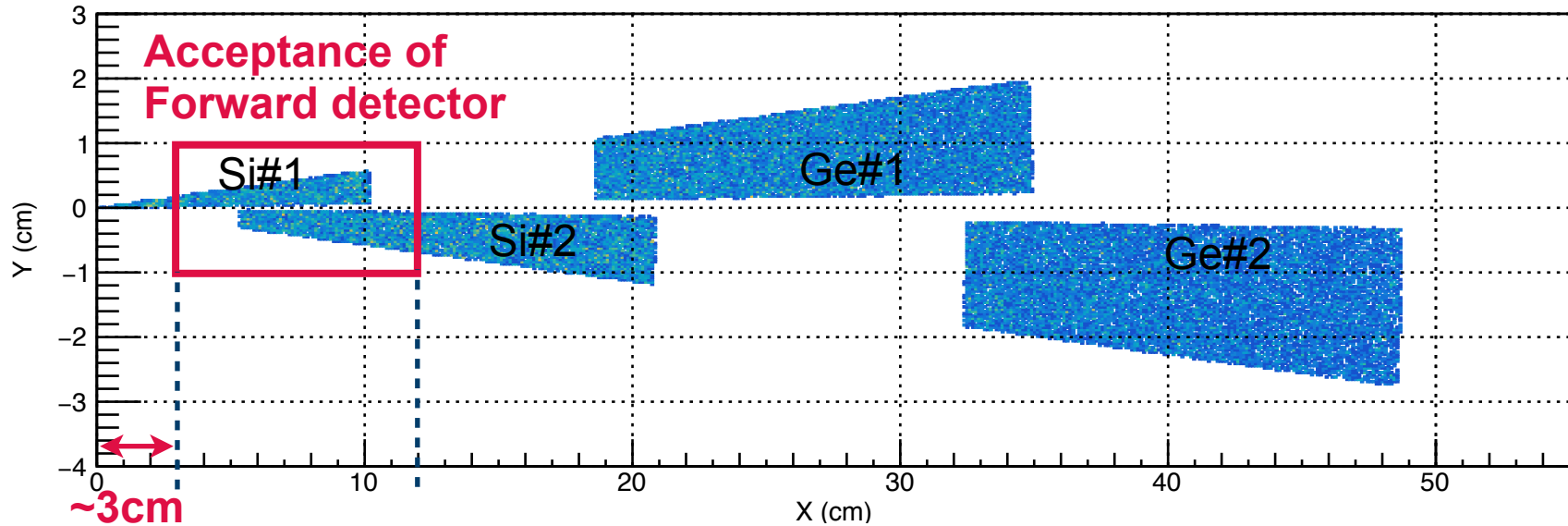
- Renewed ANKE cluster target
- Newly-built forward detector
- Same recoil detector



KOALA Setup Model @ COSY

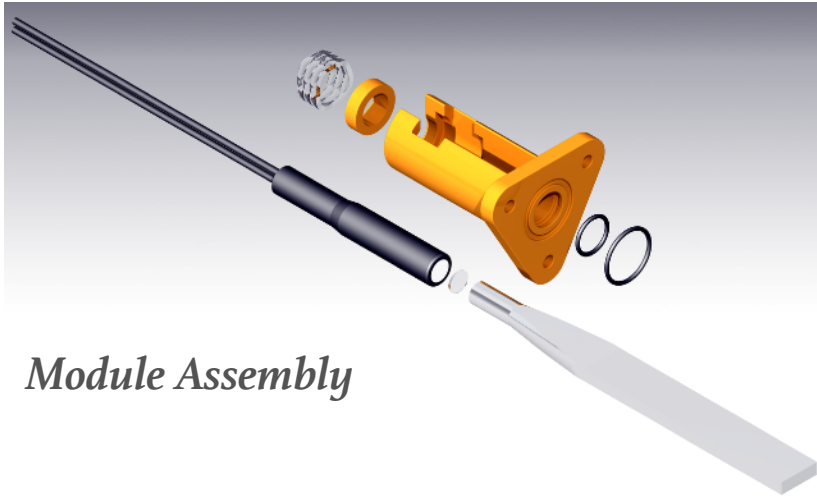
Forward Detector: Design

Distribution of the Correlated Scattering Proton in Fwd Detector Position @ 4.6m



- Scintillator: 90 x 20 x 6 mm³
- Position: z= +4.6 m and +4.8 m
- Polar angle (@4.6 m) : $0.4^\circ < \theta < 1.5^\circ$
- 8 modules in 4 symmetric pairs:
 - Beam position monitoring
 - Reduce random coincidence

Forward Detector: Assembly & Test



Module Assembly

- Scintillator: **BC-408**
- PMT: **Hamamatsu H6900**
- Light-shielding:
 - **Al-tube (100 μ m)**

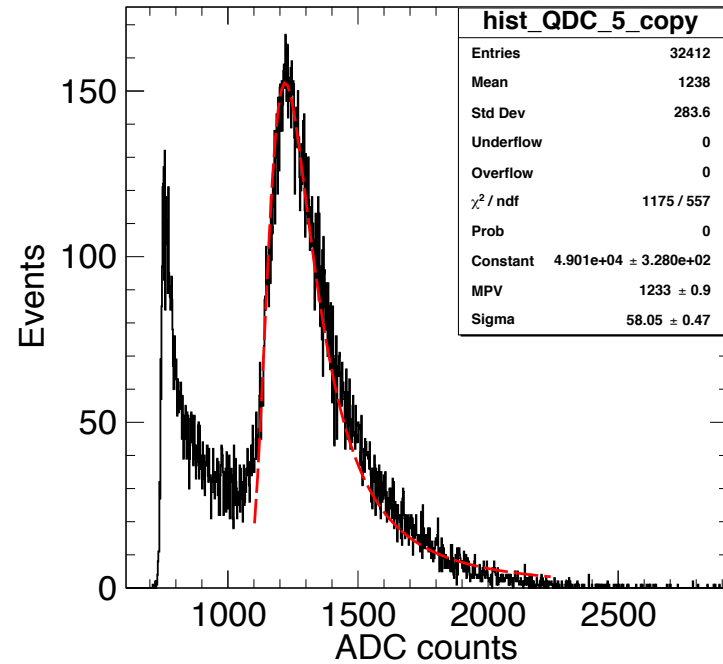
Aluminium Tube:



Assembled Module:

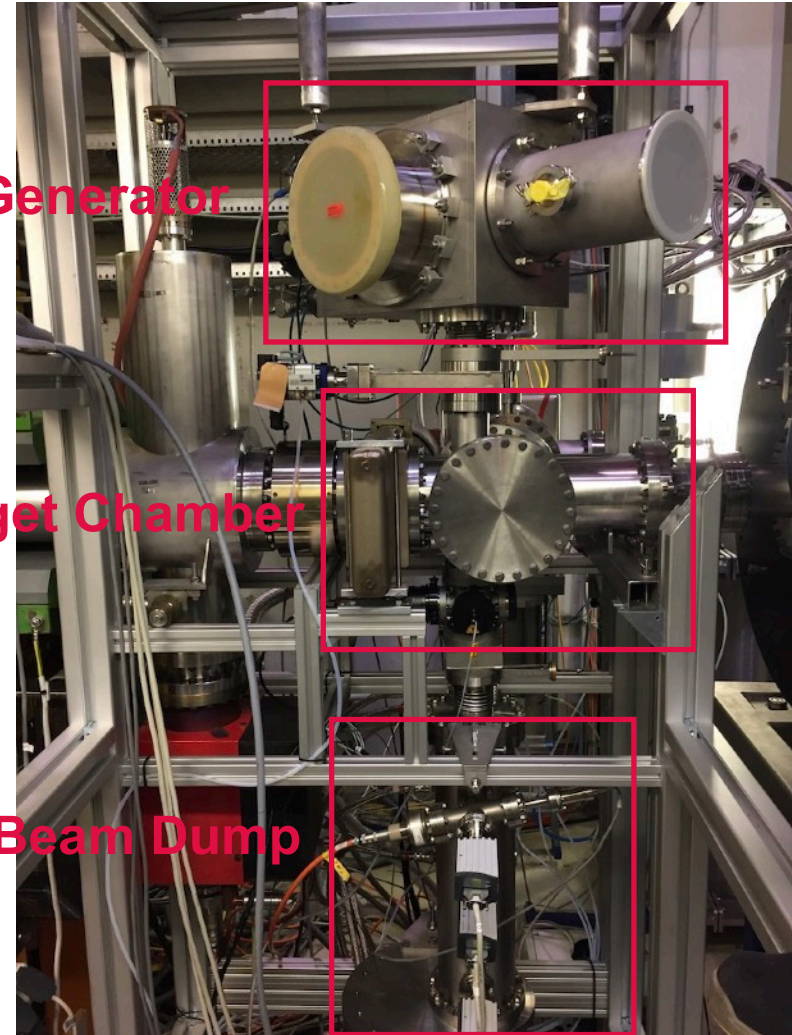


Cosmic MIPs Spectrum:

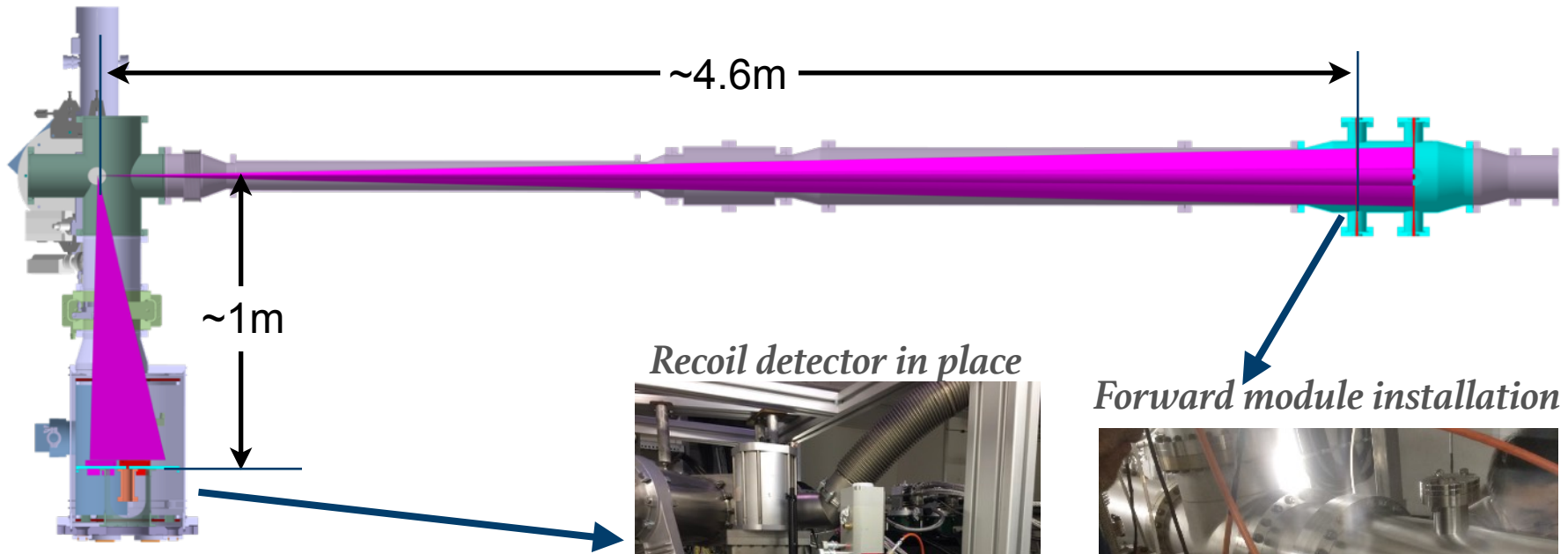


Cluster-Target

- Thickness (along beam): 1~2 mm
- Intensity: $\sim 10^{14}$
- Position measurement using rod

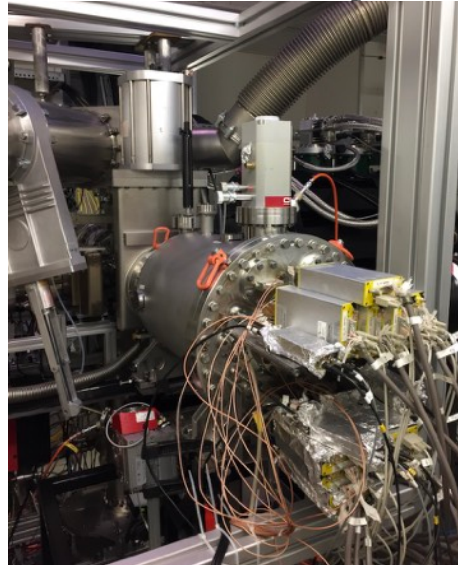


Beam Test: Configuration



- Location: ANKE @ COSY
- $P_{\text{beam}} : 3.2 \text{ GeV}/c$
- Self-triggering: (Rec || Fwd)
- Beam cooling: unstable
- Timestamp: Si1(16-48), Si2(1-22)

Recoil detector in place



Forward module installation

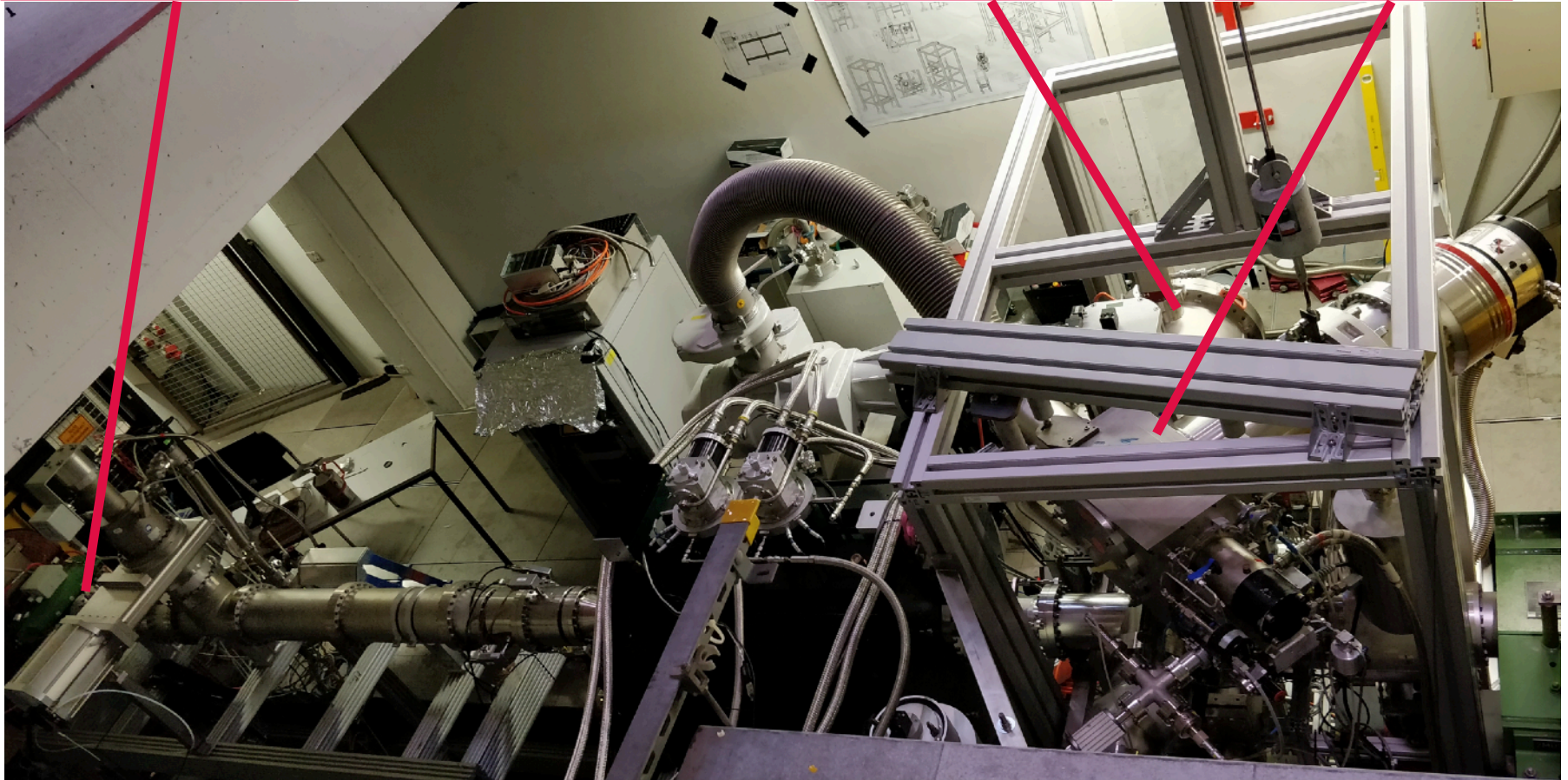


Beam Test: Layout Picture

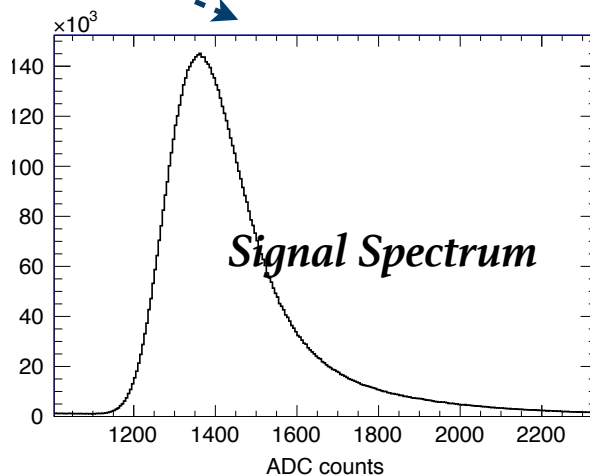
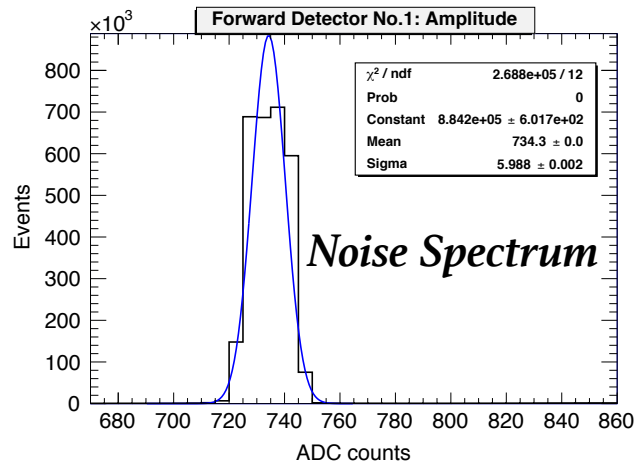
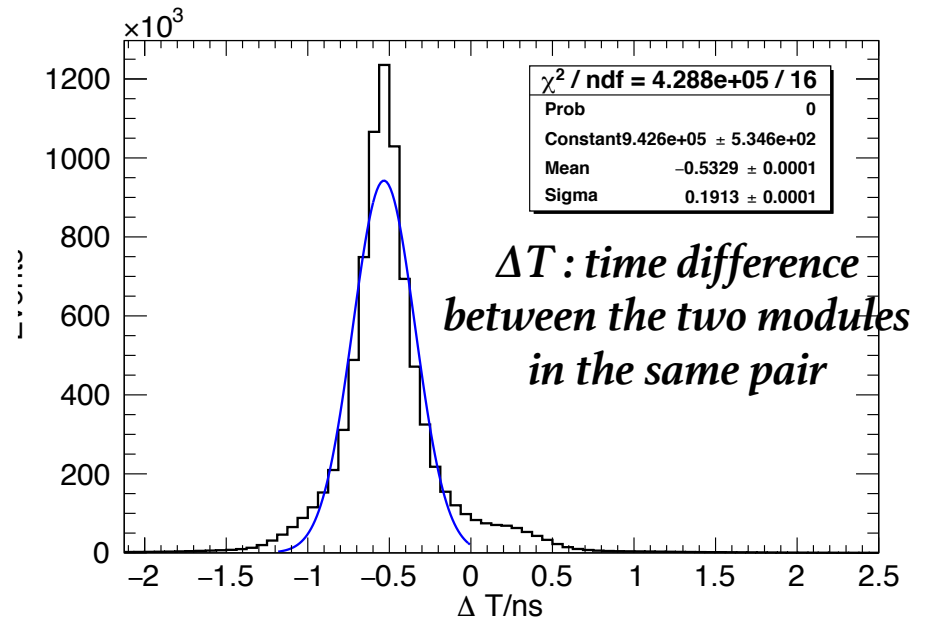
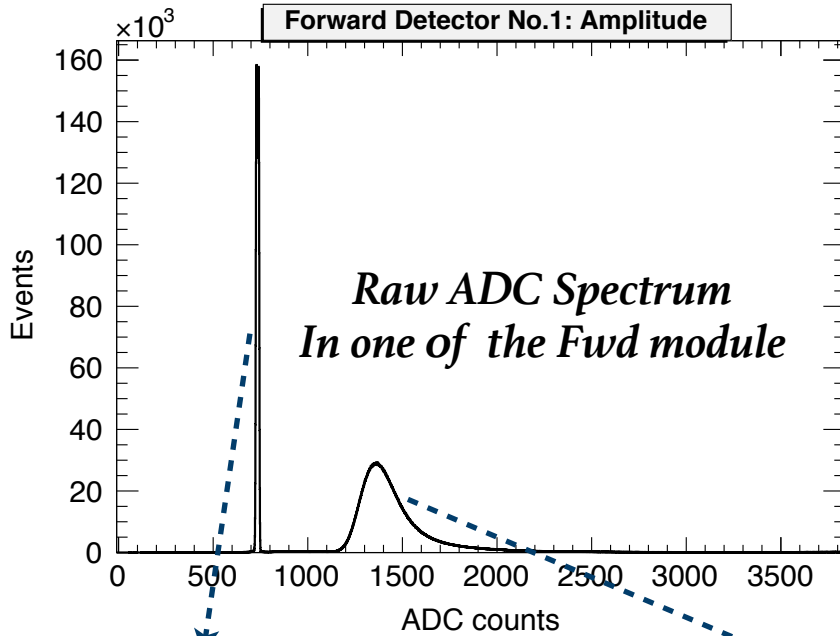
Forward chamber

Recoil chamber

Target Generator



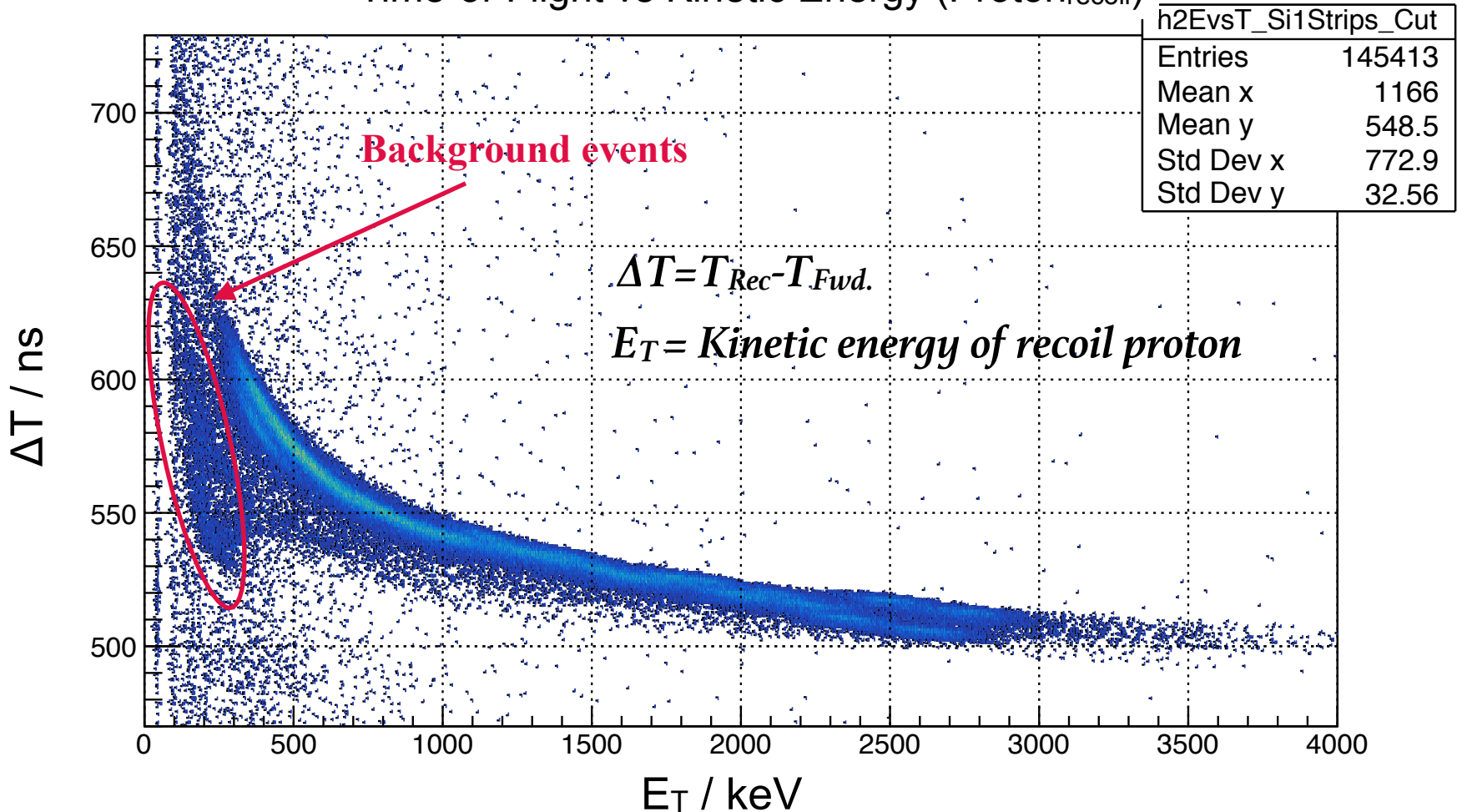
Results: Forward Detector Performance



- **Signal/Noise:**
 $\sim 10^2$
- **Time resolution:**
 ~ 140 ps

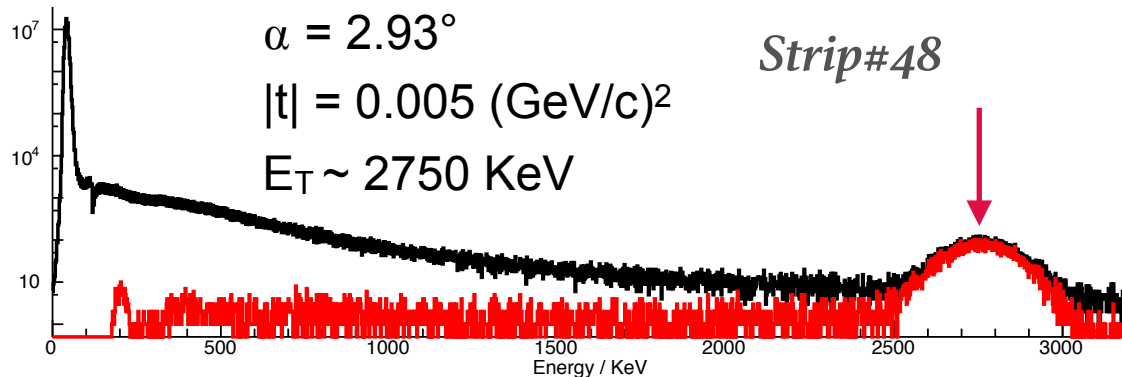
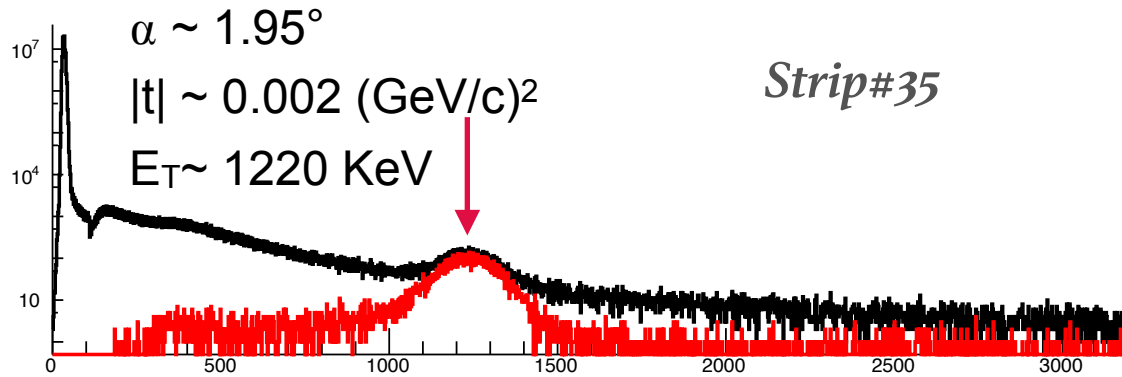
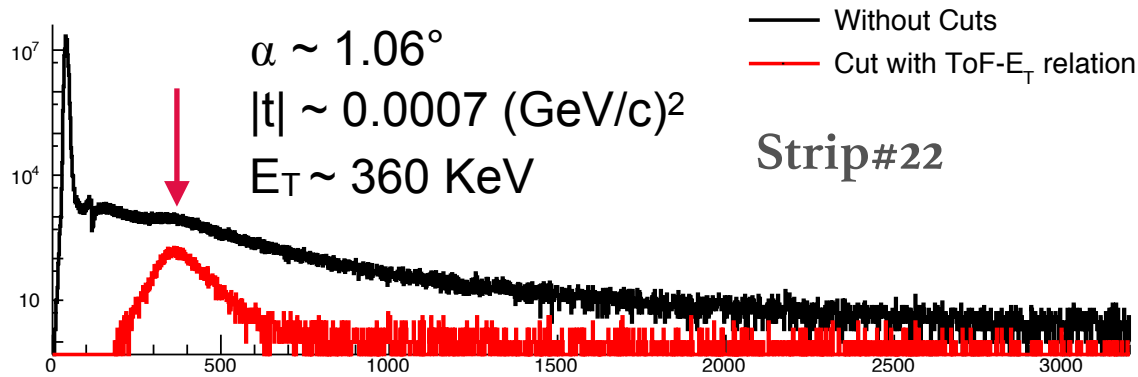
Results: Forward and Recoil Correlation

Time-of-Flight vs Kinetic Energy (Proton_{recoil})



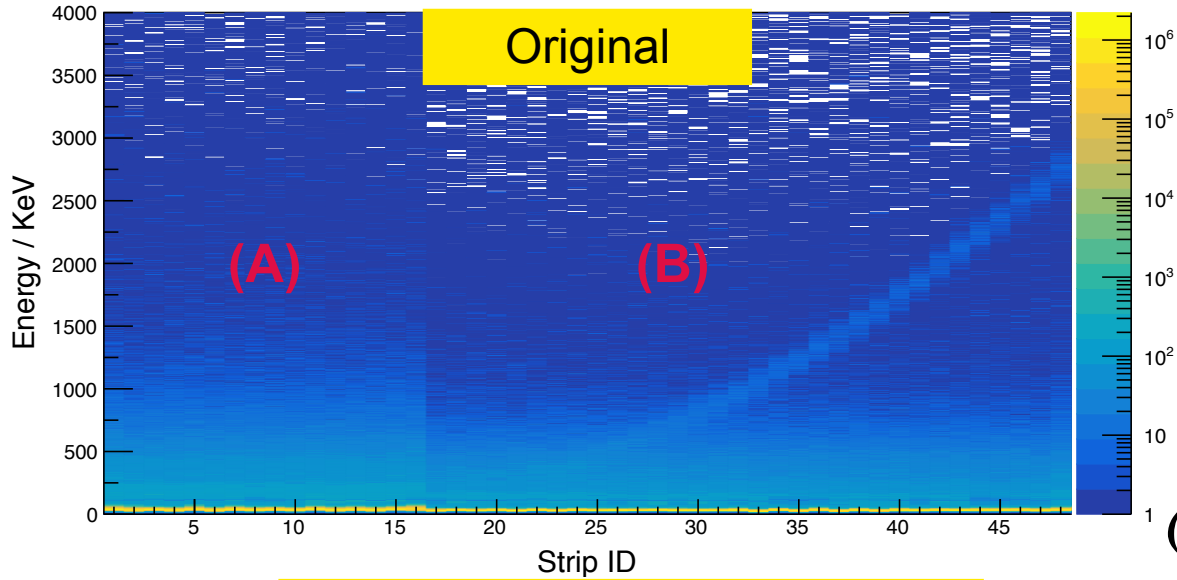
! Electronic time delay not calibrated in the graph

Results: Example Strips @ Si1



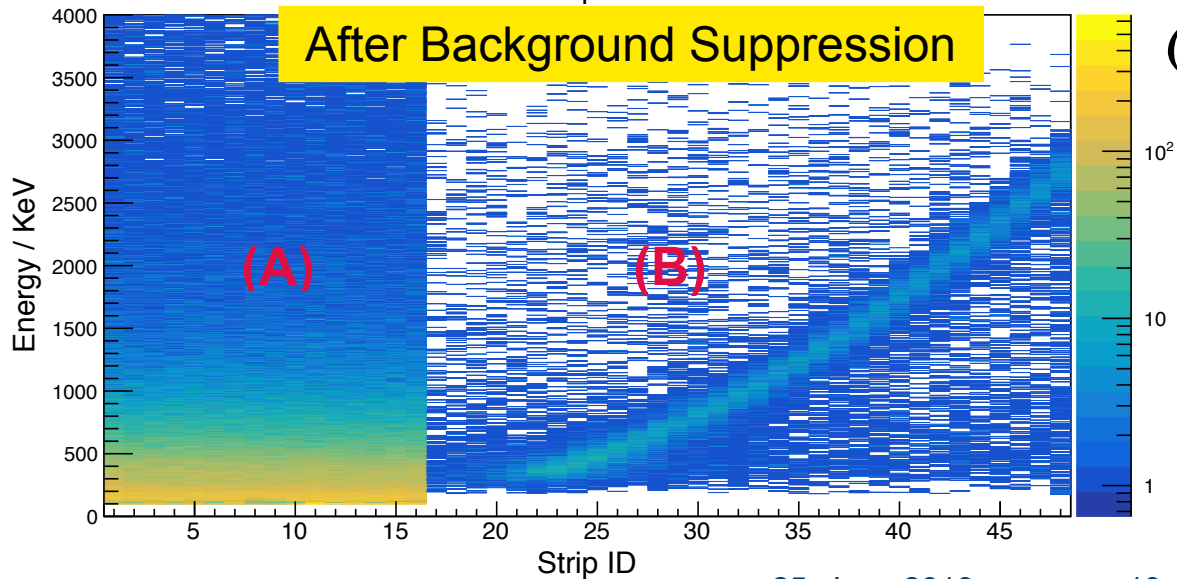
- Minimum E_T :
 $\sim 320 \text{ keV}$
- $|t|_{\text{min}}$ extended to:
 $\sim 0.0006 \text{ (GeV/c)}^2$

Results: Si1 Hits Spectrum



(A): strips not covered by Fwd

(B): strips covered by Fwd



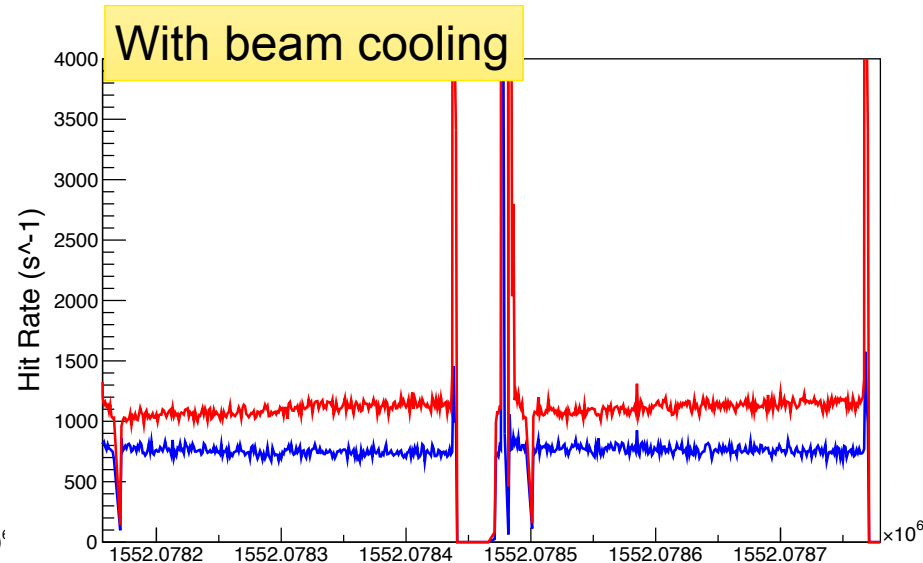
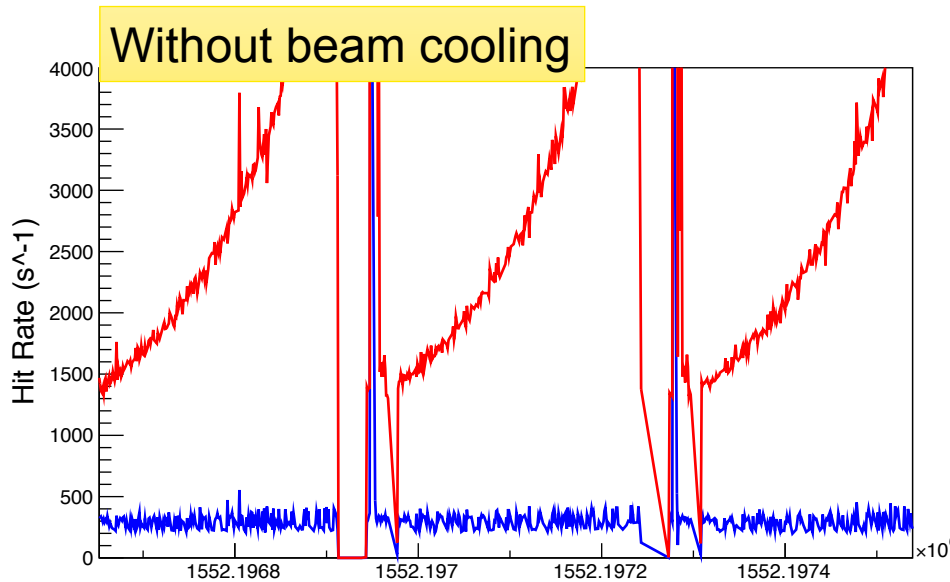
Issues: Poor Vacuum in Target Chamber

- **Poor vacuum in target chamber:**
 - Expected: $\sim 10^{-8}$, reality: $\sim 10^{-6}$
 - Ge#1 and Ge#2 not working due to large leakage current
- **Decrease the target intensity to get better vacuum**
 - Lower interaction rate \rightarrow Lower statistics
- **Possible Causes:**
 - Cluster not in liquid phase
 - Temperature of nozzle is higher than before
 - **Solution:** adding one more cryo pump in the target generator

Issues: Beam Cooling

Beam profile expands without cooling: **With beam cooling:**

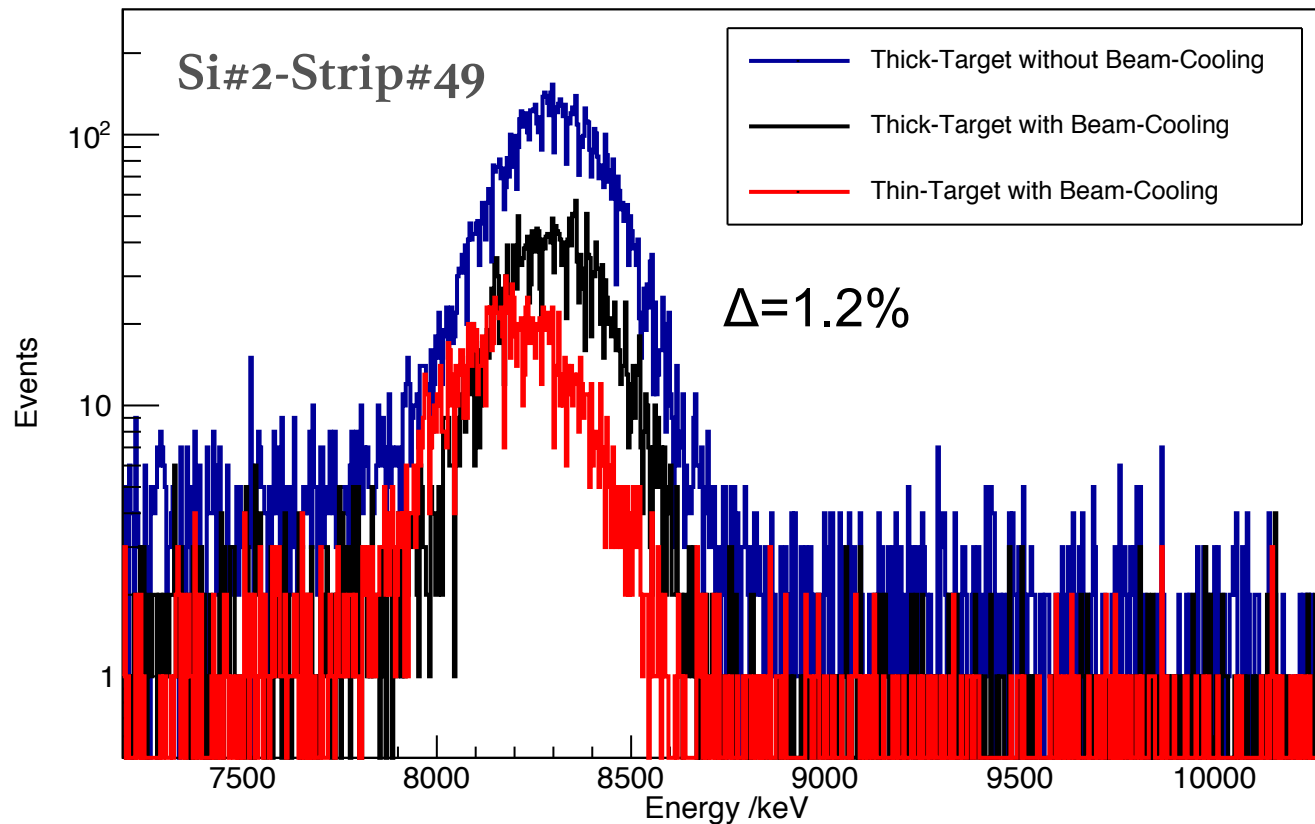
- Huge hit rate in the forward detector
 - Varying dead time in DAQ
 - Interesting events not recorded
- Stable hit rate and dead time
 - Better estimation of systematic error



Hit rates of recoil detector (blue) and forward detector (red)

Issues: Target Thickness Effect

- Energy peak displacement with the change of target intensity/thickness
- **Center of Interaction Point is affected by target intensity/thickness**



Summary & Outlook

Summary:

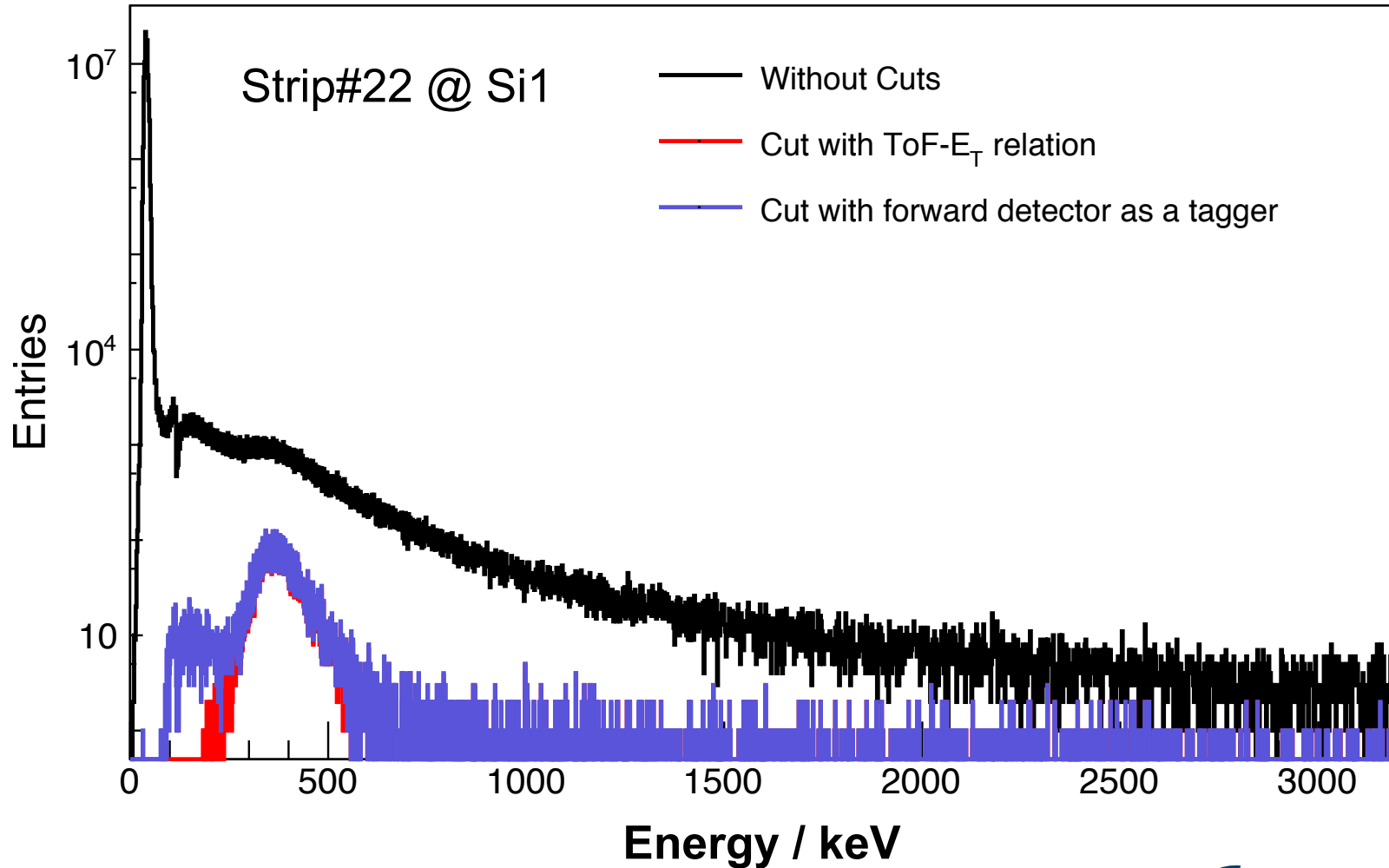
- The forward detector has been built, tested and commissioned successfully
- P-P elastic scattering measured by recoil detector and forward detector with coincidence has been achieved
- High background can be effectively suppressed, and then $|t|$ could be extended down to 0.0006 (GeV/c)^2

Outlook:

- Improvement of cluster-target: adding one more cryo-pump
- Estimation of systematic error contributed by background suppression
- Full system running in August beam test (≥ 3 beam energies)

THANK YOU !!

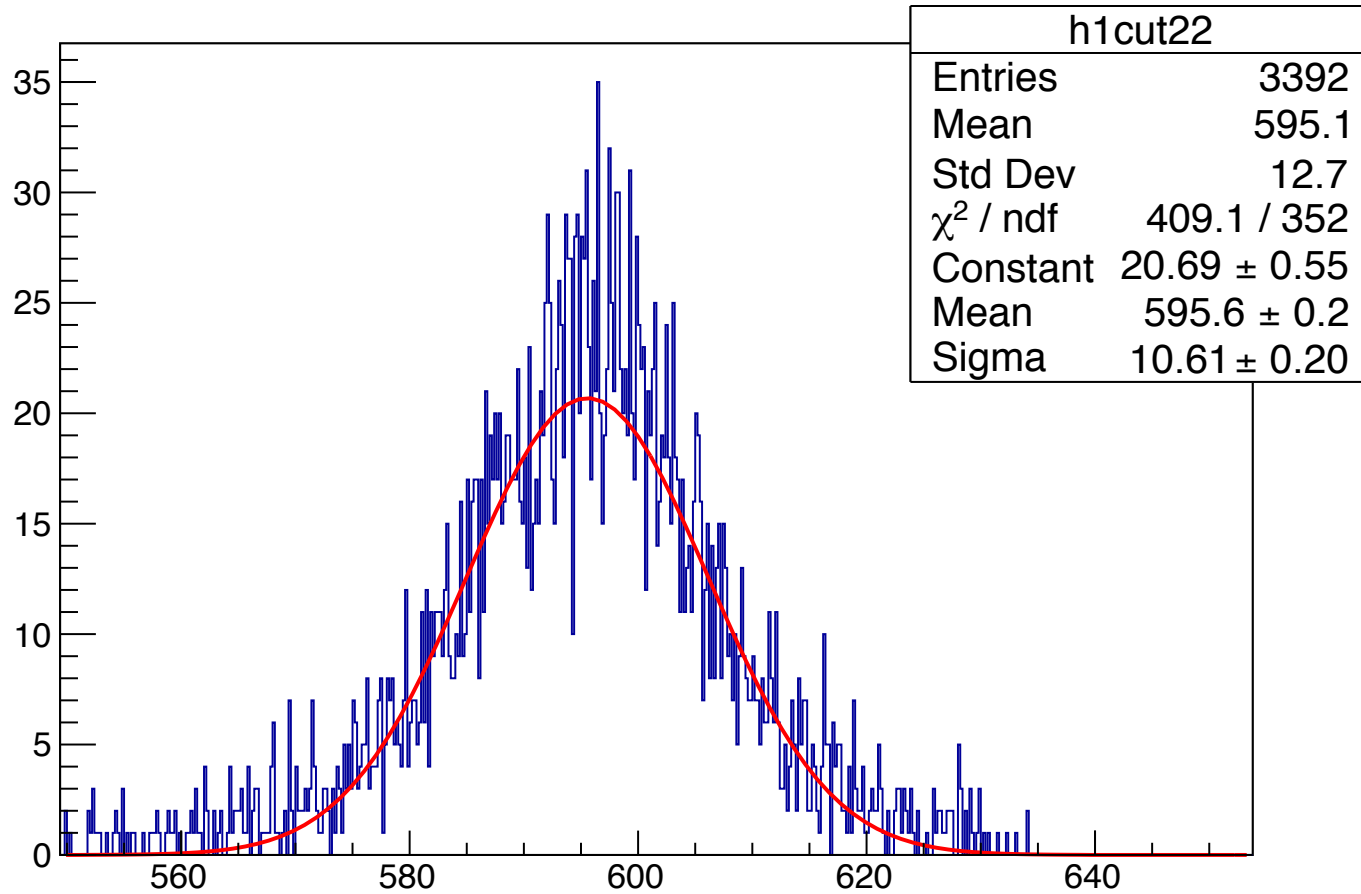
Cut Effects:



Time Resolution of Recoil Detector

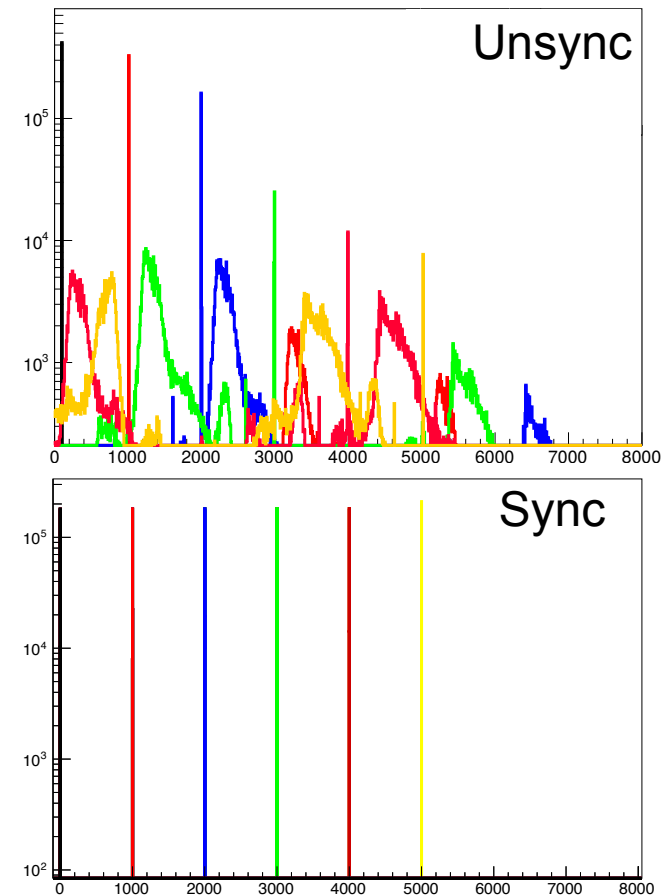
Strip#22 @ Si1

h1cut22





Timestamp difference between modules



- VME bus
- TDC, ADC, QDC from Mesytec
- Synchronization clock: VME internal clock (16 MHz)
- Or external clock (<75 MHz)