励起原子核ガンマ線を用いた MEG液体キセノン検出器の較正とモニター

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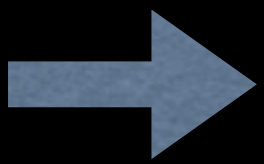
Motivation

- Requirement for calibration using gamma-ray
  - Near 52.8 MeV
  - Constant energy
- $\pi^- + p \rightarrow \pi^0 + n$, $\pi^0 \rightarrow 2\gamma$ is powerful way, but
  - We should change beam setting and prepare liq. H_2 target
  - Cannot do frequently



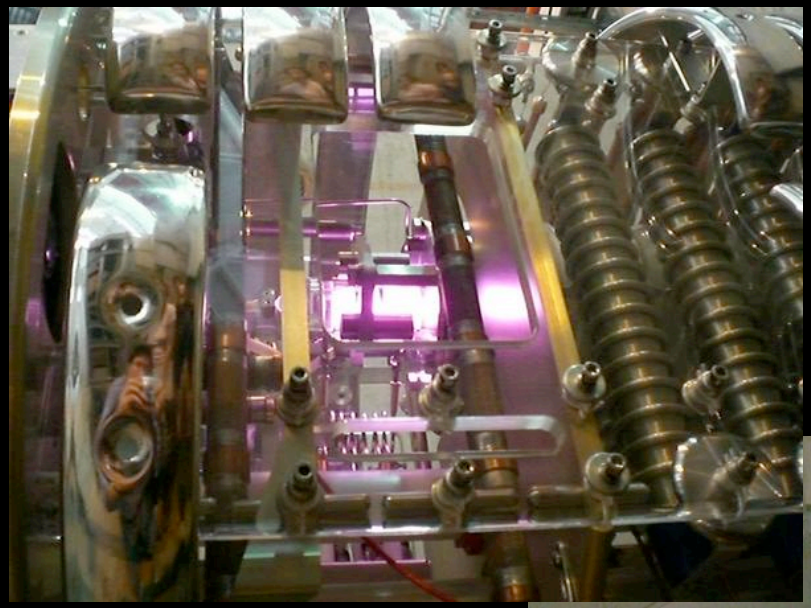
γ from nucleus reaction is helpful

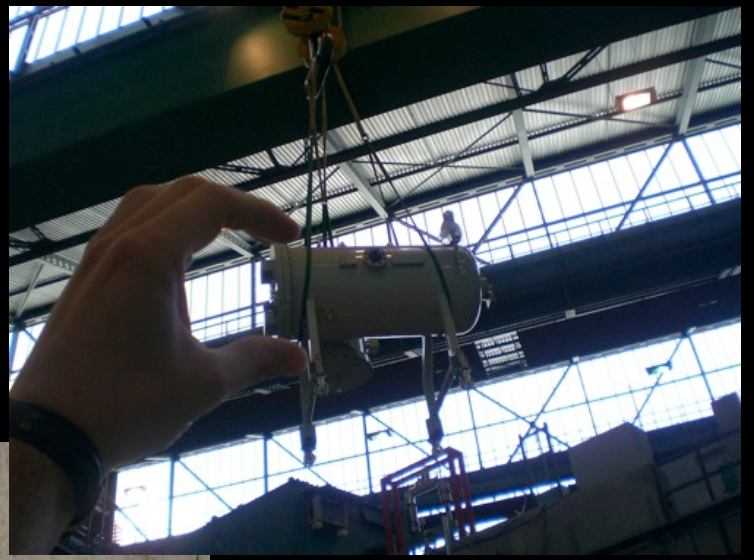
γ-ray production using proton beam

Reaction	Resonance energy	σ peak	γ lines
Li(p,γ)Be	440 keV	5 mb	17.6 MeV, 14.6 MeV
B(p,γ)C	163 keV	$2\ 10^{-1}$ mb	4.4 MeV, 11.7 MeV, 16.1 MeV

- Li : Sharp line 17.6MeV , broad line 14.6MeV
  - Can be used to monitor the energy scale and resolution of the liquid Xe detector
- B : 4.4 MeV and 11.7 MeV time coincident γ
  - Can be used to adjust timing of Liq. Xe detector and timing counter

Cockcroft-Walton accelerator



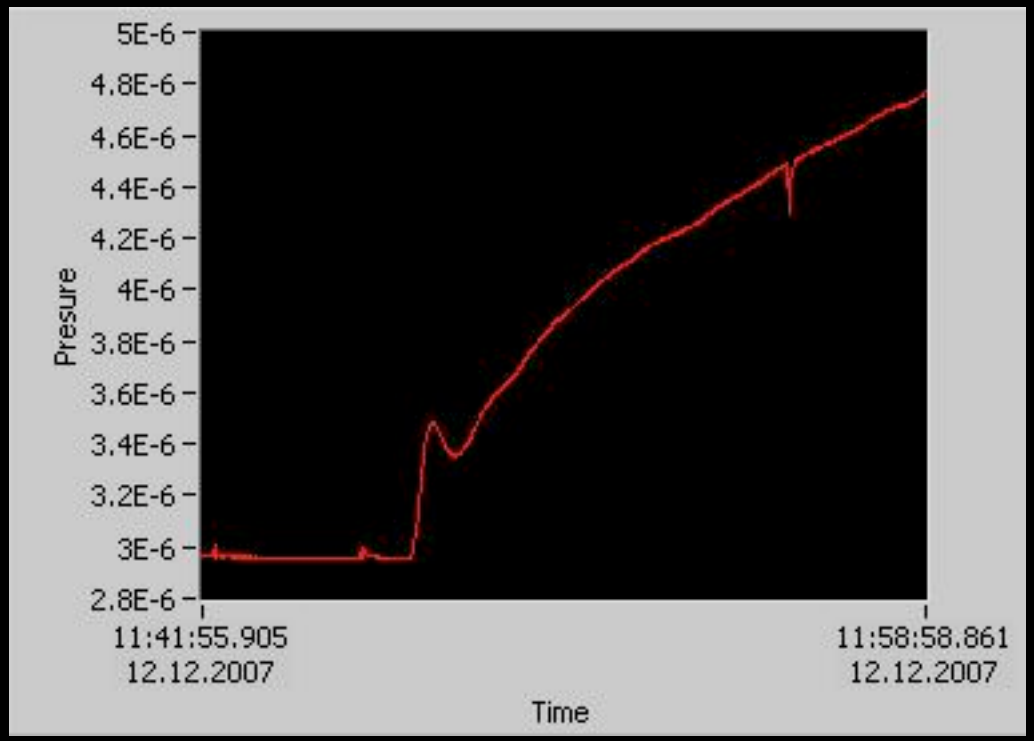


Spec of C-W accelerator

	Nominal	Measured at PSI
Terminal energy range	300 - 900 keV	200 - 1100 keV
Energy ripple	< 500 V_{rms}	< 50 V_{rms}
Angular divergence	< (5 x 5) $mrad^2$	~ (4 x 4) $mrad^2$
Spot size at 3 m	< (3 x 3) cm^2	< 1 cm^2
Energy setting reproducibility	0.1 %	ok
Energy stability FWHM	0.1 %	ok
Range of current	(1 - 100) μA	(0.1 -135) μA
Current stability	3 %	ok
Current reproducibility	10 %	ok
Start-up time	< 20 min	< 15 min
X-ray level from the tank (500 keV)	< 2 μSv/hr @ 1 μA	< 0.1 μSv/h
	< 5μSv/hr @ 100 μA	< 0.1 μSv/h @ 50 μA
X-ray level in the πE5 area	-	0.5* - 3** μSv/h @ 1 μA
	-	14*** - 280* μSv/h @ 50 μA

* > 60 keV, on the Al Faraday cup
** > 10 keV, on the Al Faraday cup
*** > 60 keV, 3 cm from the beam line

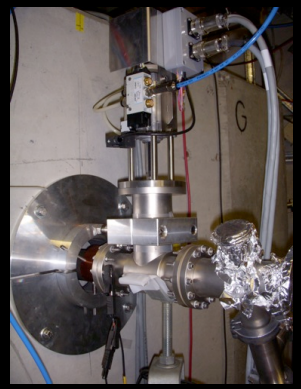
Operation of C-W accelerator



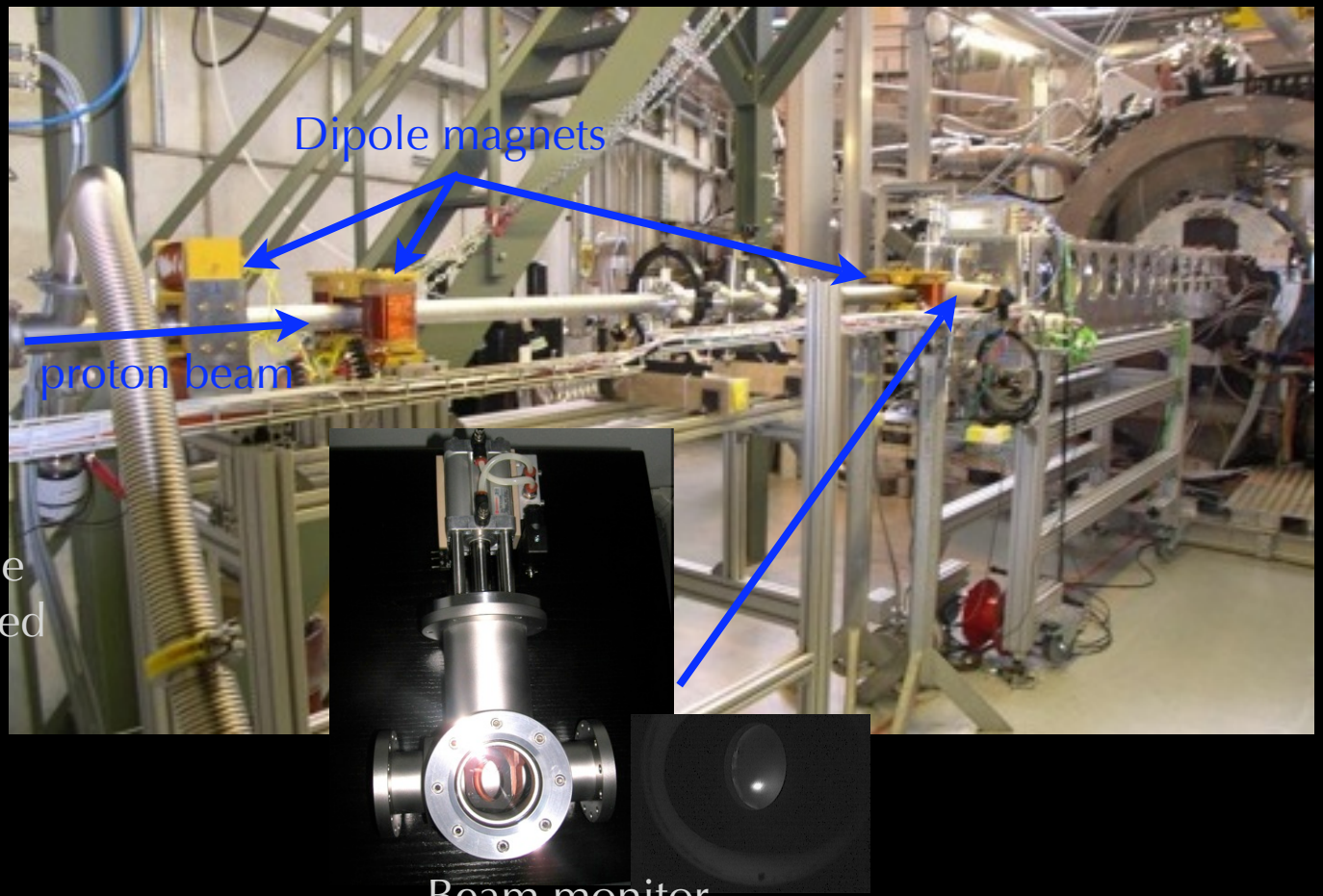
H2 inlet is regulated with thermo-leak
It takes ~15-20 min to stabilize

- Mainly these 4 parameters are needed to operate
  - Amount of H_2 gas inlet
  - RF probe voltage
  - RF extraction voltage
  - Accelerator terminal voltage
- It's not so difficult, so possible to operate after some training

Beam line



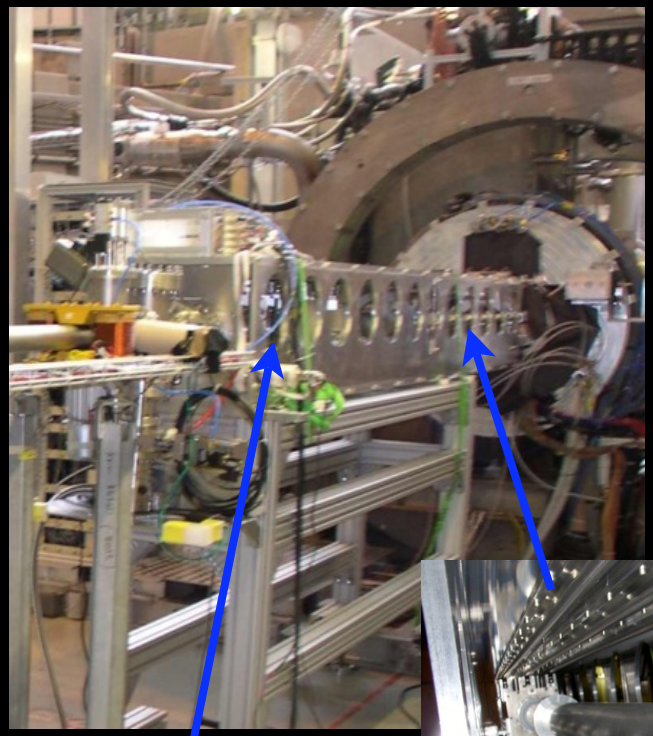
Beam shutter
Beam current can be measured when closed



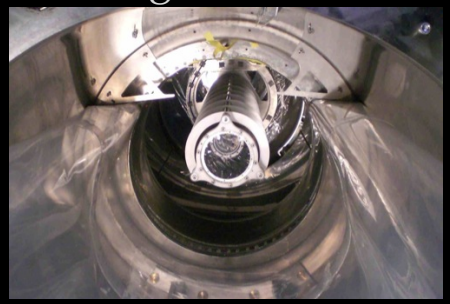
Beam monitor
with quartz crystal

Proton beam line is opposite way from μ beam line
Proton beam line is dismounted when H_2 target is installed

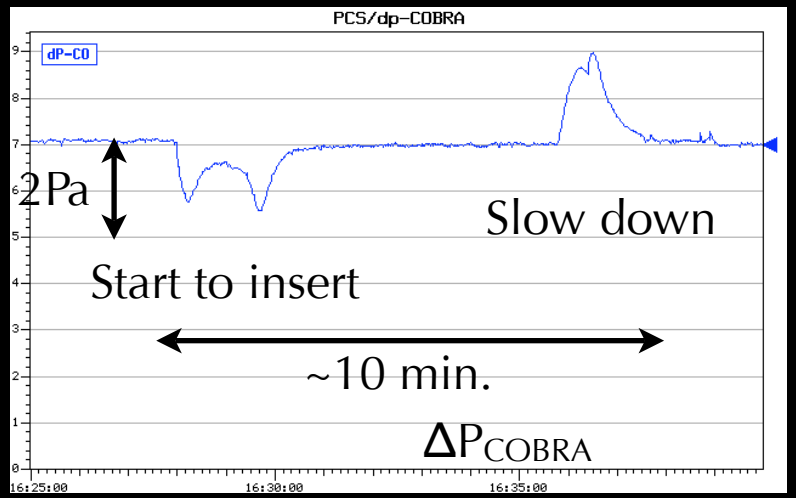
Target insertion system

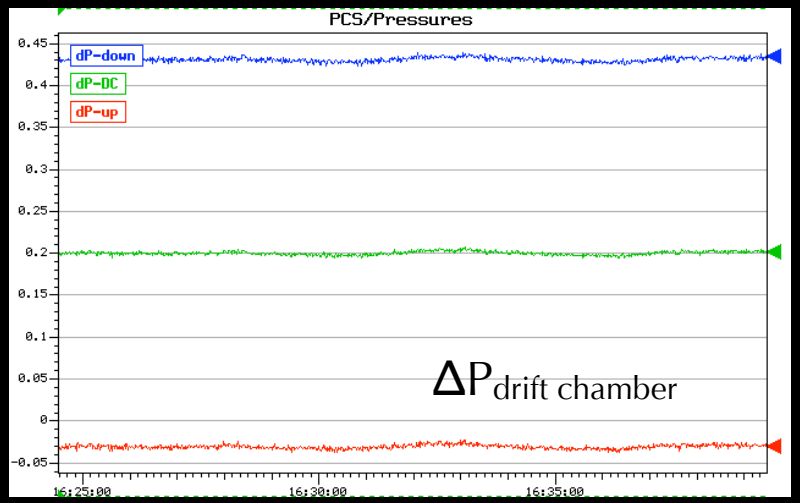


Rubber bellows inside
COBRA for
Target insertion

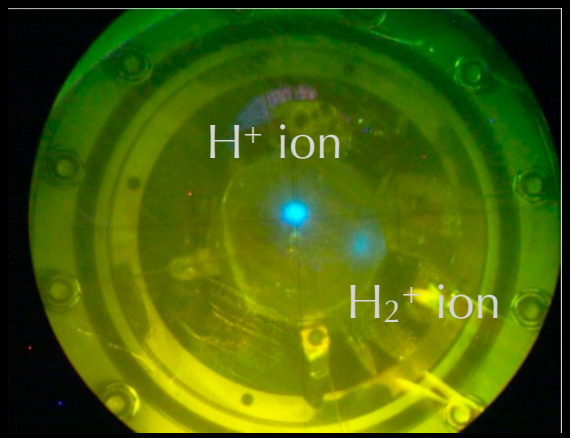


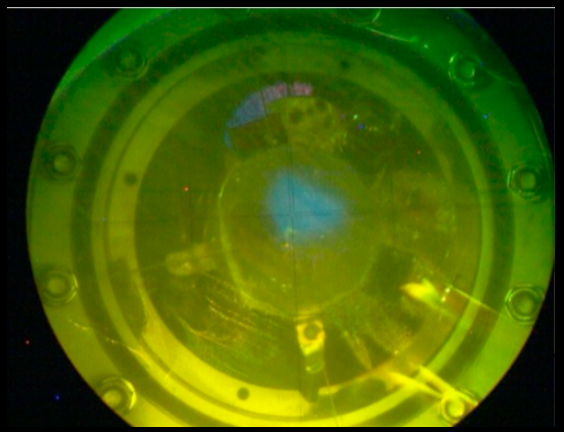
Bellows and rails for Target insertion
To keep pressure of DC,
pressure difference should be < few Pa
Insertion takes ~10 min.



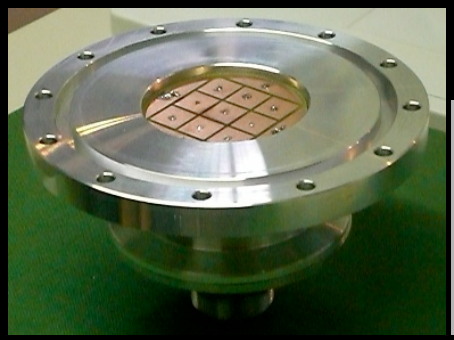


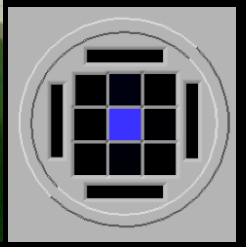
Beam centering and focusing





C-W extraction voltage changes the focusing
Quartz crystal target used to be helpful

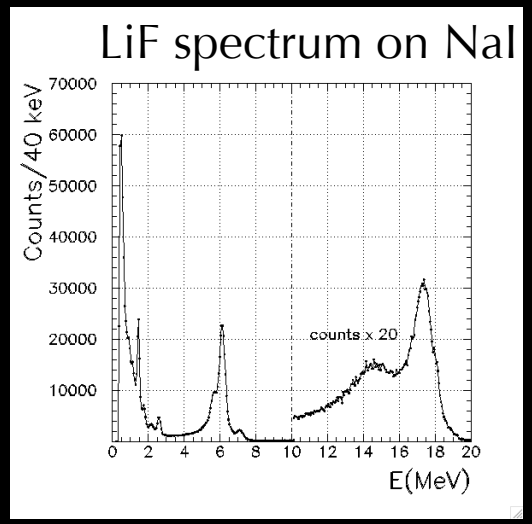




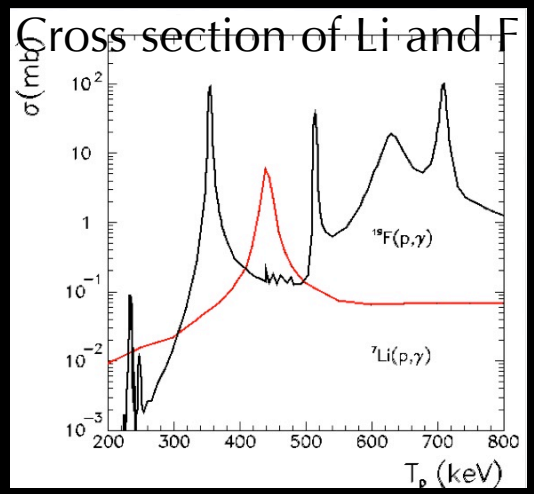
Pixel target is used to measure the beam spot

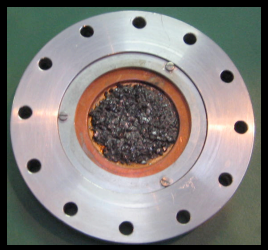
Because of COBRA field, we should bend the beam with a bit big angle to reach the center

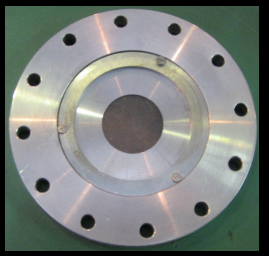
Target



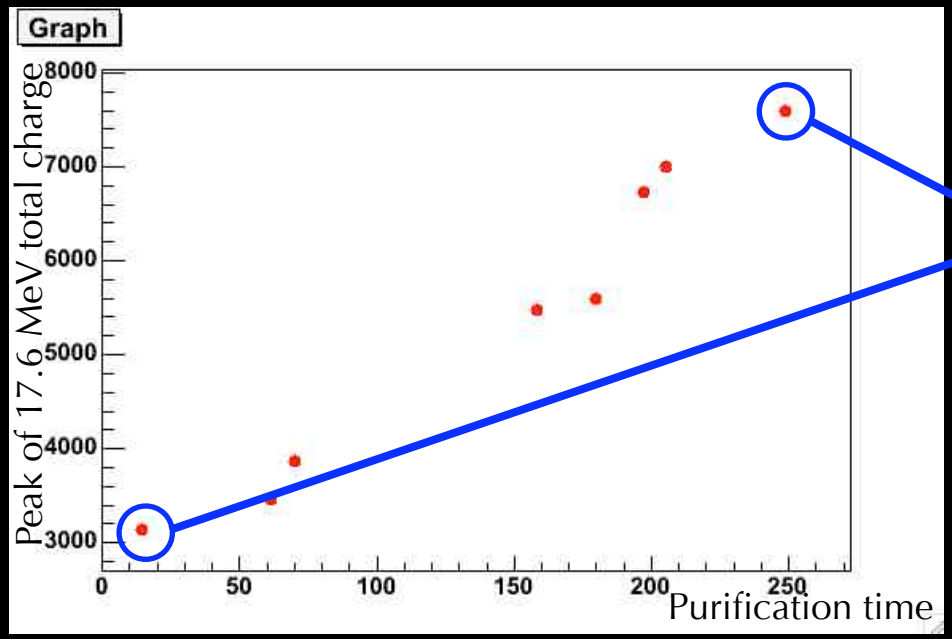
- LiF crystal
  - Easier to handle compared to Li alone
  - But ^{19}F has other lines (~6 MeV)
  - Rate (17.6 MeV) ~1.8 kHz /μA
- Metallic B and B_4C tested



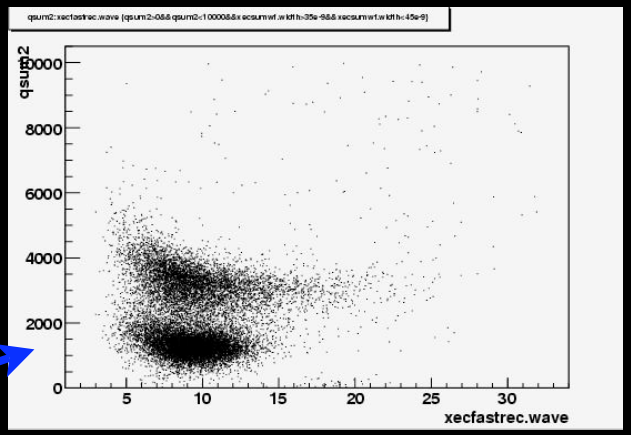


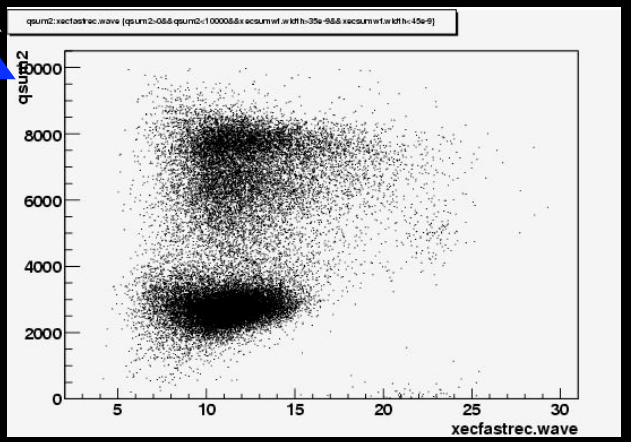


Monitoring



We could monitor the purification
increased the total amount of detected light

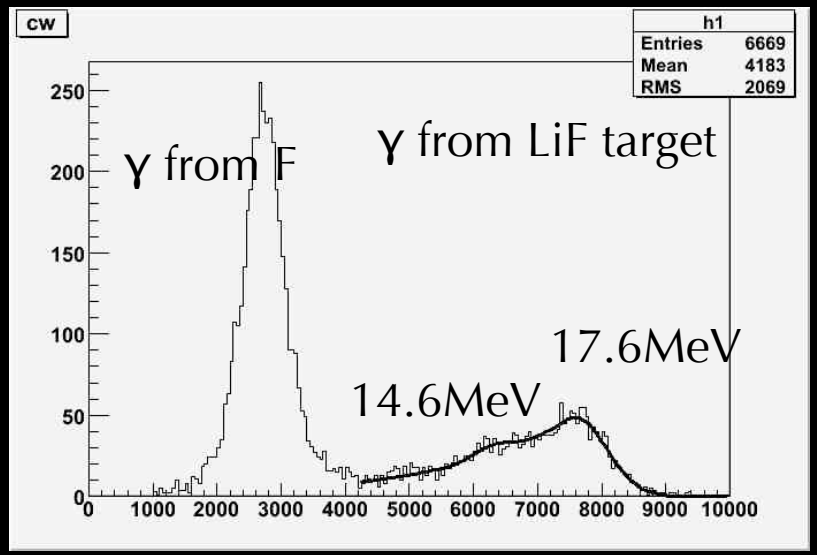


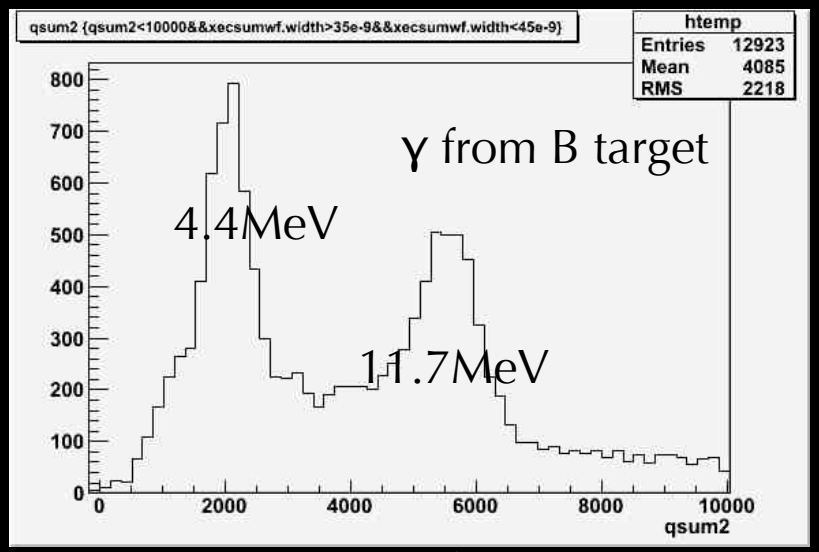


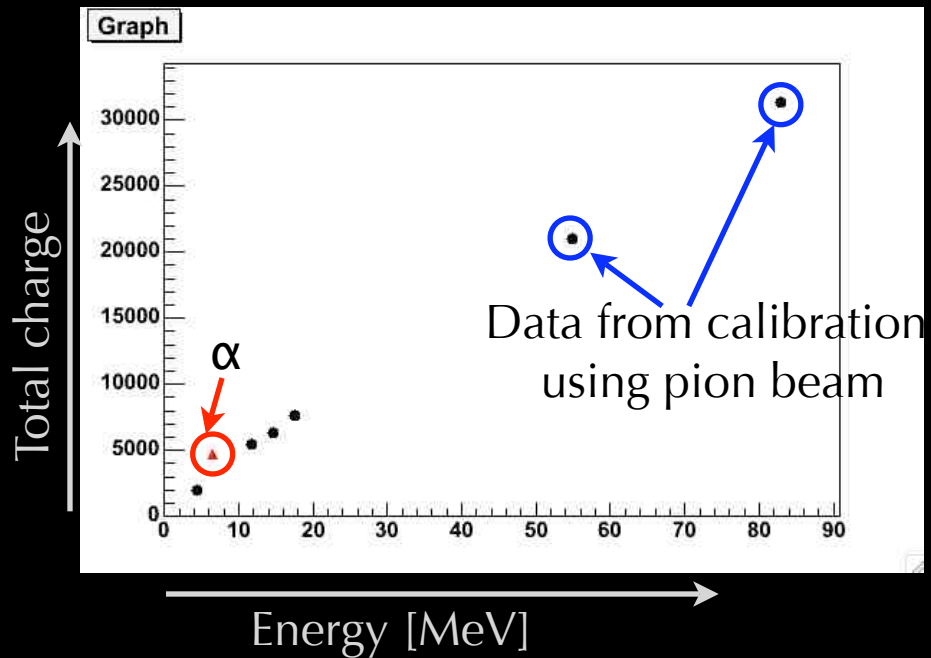
Total charge

Reconstructed γ flight distance in xenon

Linearity







There seems to be linearity for γ
But the amount of light from γ is small

Summary

- Cockcroft-Walton accelerator is installed
- Operation of accelerator and data taking was done successfully
- Gamma-ray from nuclei reaction is helpful for monitoring and calibration of Liq. Xe detector

End