Calibration source for Hyper-K

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Remind

Idea for HK

(1) Same as SK, LINAC and DT in every position

- Need if the solar neutrino spectrum is a target. (seems to be very hard.)

(2) Combination of several tools.

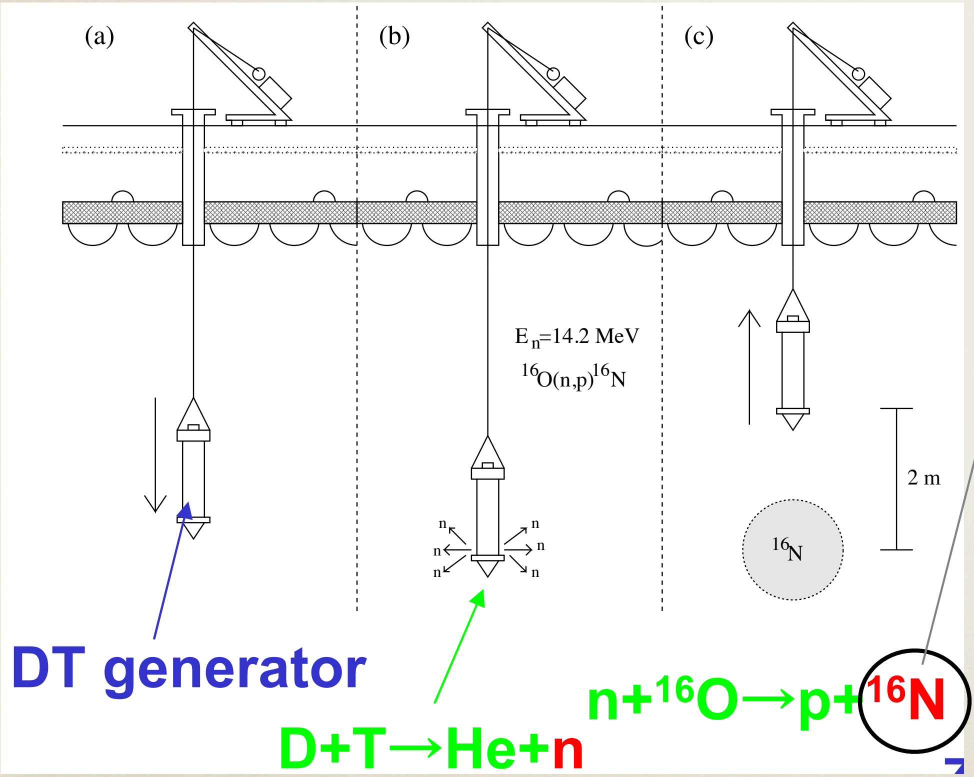
- Compare LINAC and DT in 40% coverage segmentation (if exist) or SK, and only DT in every position.

(3) Higher energy calibration is preferable for SN neutrinos

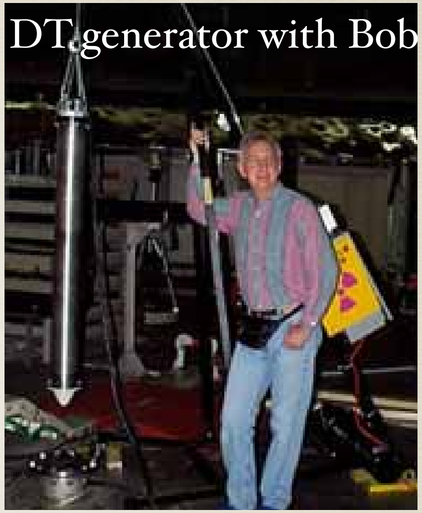
- Development new sources, e.g. pT generator (19.8MeV γ)

Remind

DT calibration in SK



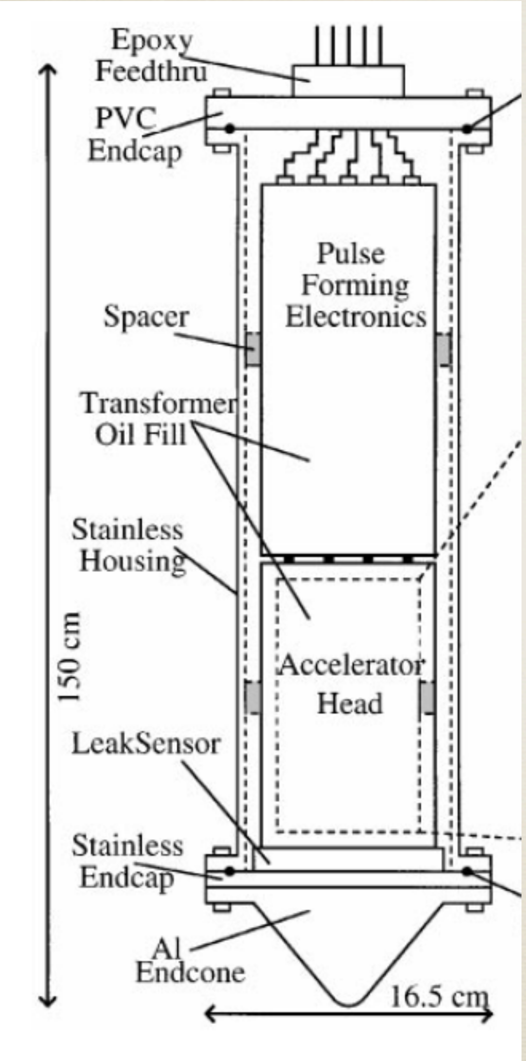
τ1/2=7.13sec
β 4.3 + γ 6.1 (66%)
β 10.4MeV (28%)
uniformly generated



DT generator with Bob

By Szymon

DT neutron generator



Currently used in SK

Thermo Scientific

- Custom MF Physics M A-211
- Original cost : ~$80k

14MeV neutrons

A-211 no longer available from Thermo-Sc.

By Szymon

DT neutron generator

DTG-MP 320

~$75k+10k

Specification

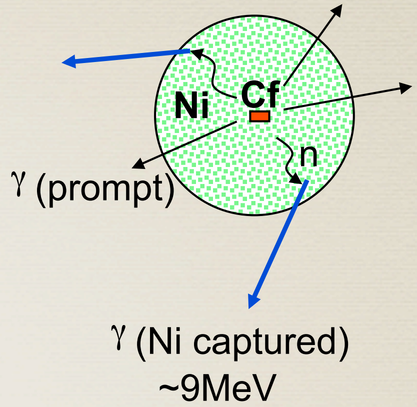
Yield	1.0 E+08 n/s
Neutron Energy	14MeV
Duty Factor	5% to 100%
Voltage	90 kV (Maximum Accelerator)
Current	60 μA (Beam)
Neutron Module	12.07 x 57.15 cm
Safety Features	keylock : on/off
	Emergency : on/off
	Normal-open and Normal-close interlocks
Remote Control	RS-232/RS-485
Weight	12 kg

Remind

Other calibrations

Nickel calibration


by Moriyama-san

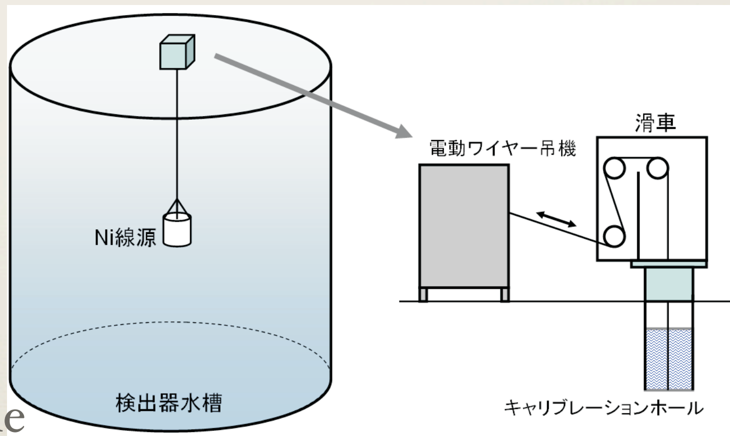


Ideal one photon level source

- Uniformly generated
- Stable
- easy to handle

Used for many purposes:

- 1 p.e. distribution
- QE measurement
- water quality (top-bottom asym.)
- trigger efficiency
- reconstructed vertex calibration
- angular dependence of energy scale
- etc..



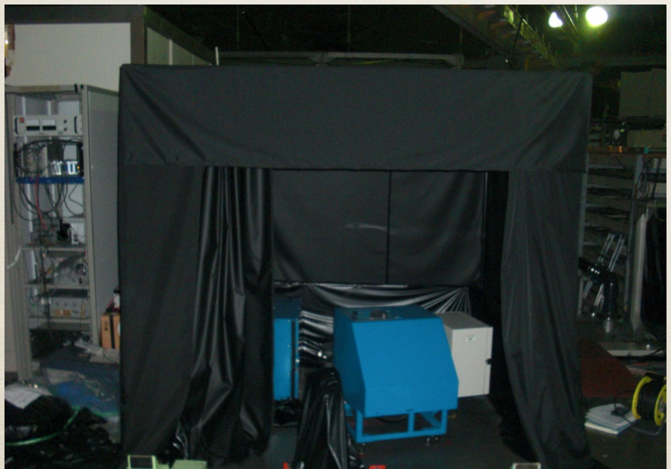
Monthly data taking

Principle of Nickel source

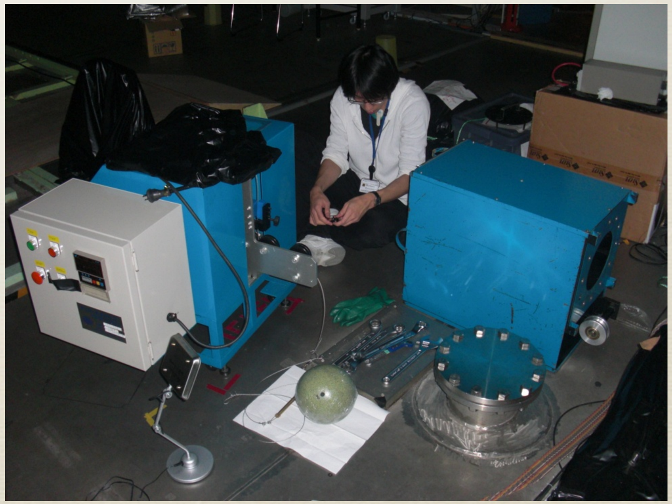
- Capture of thermal neutrons by Nickel, gammas with ~9MeV are emitted. (typically $^{58}Ni(n,\gamma)^{59}Ni$)
- Use ^{252}Cf as a neutron source.
  - ~97% alpha decay and ~3% spontaneous fission (SF).
  - For SF, ~3.8 neutrons with ~2MeV and ~9.7 gammas with ~8MeV (total).
- Protons in water or polyethylene, and nickel are as a neutron moderator (~90 micro sec.)
- The usual Nickel calibration is done by self trigger from γ events.

Comments on the nickel calibration in SK

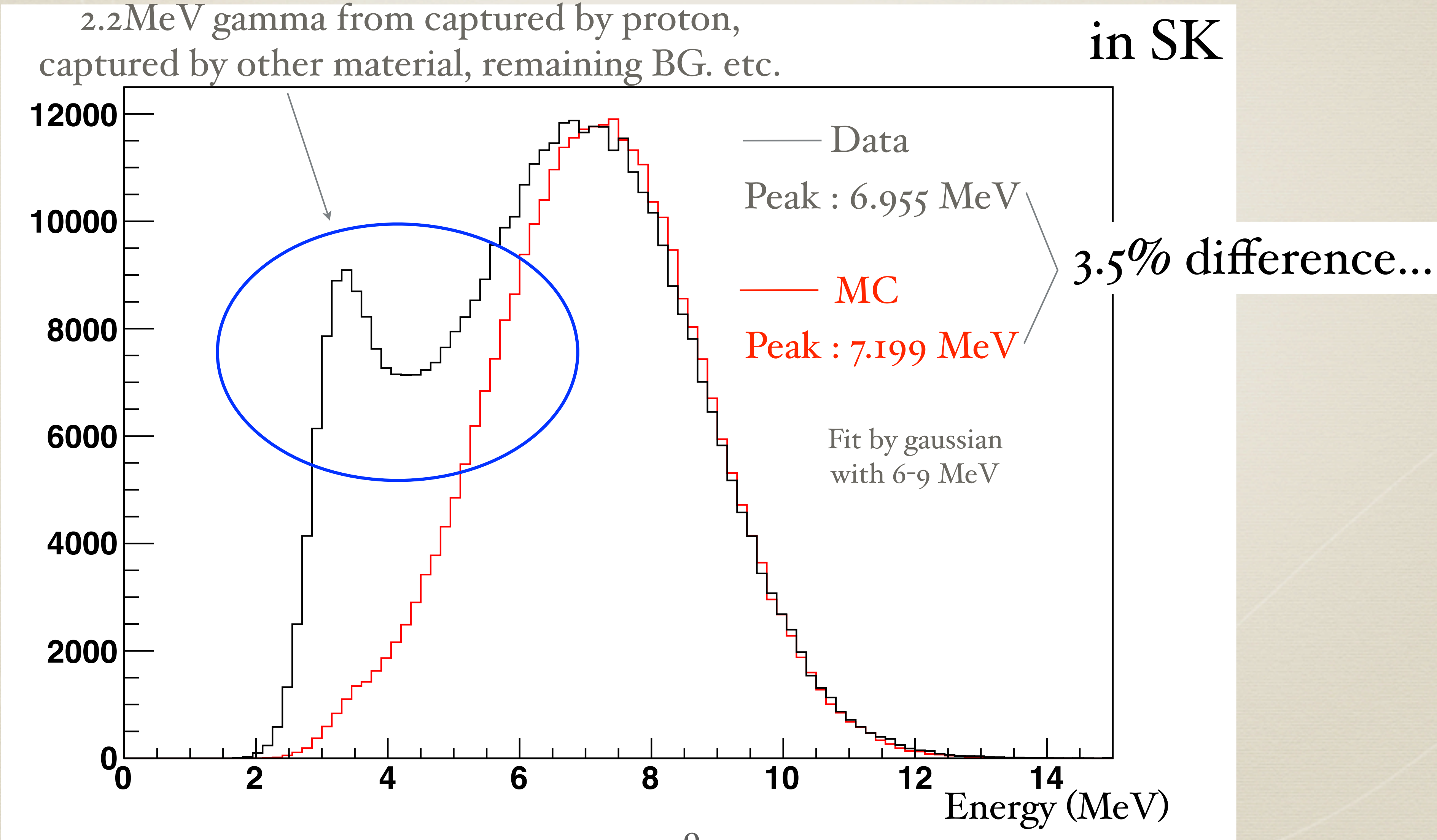
- The calibration method is established.
- Useful for the initial calibration, (gain determination, QE measurement etc.), the position calibration, the long term stability of the water quality, and so on.
- Need to develop a new equipment for introducing into the tank.
  - There are several manual works inside a dark room, now...



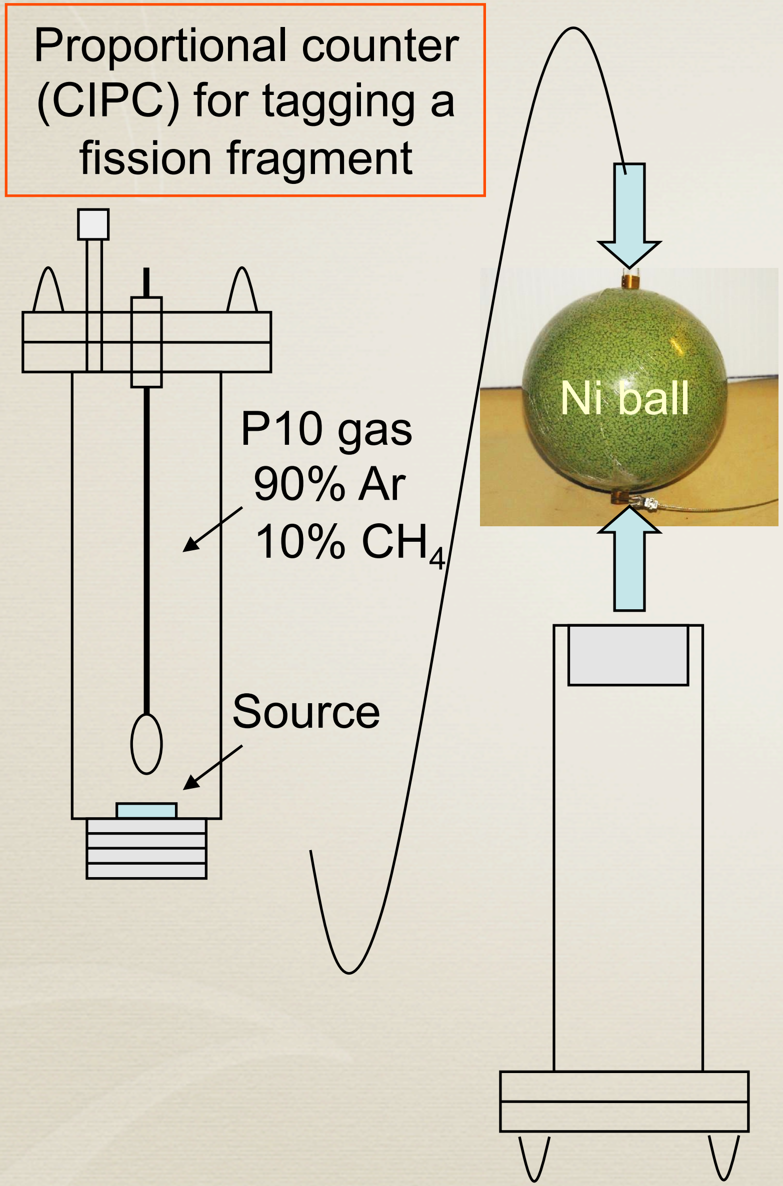
Dark room (by Obayashi-san)

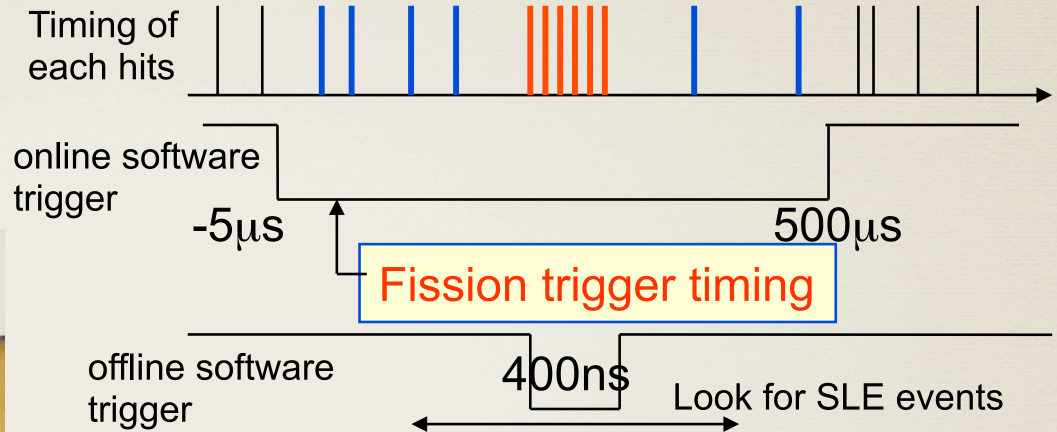


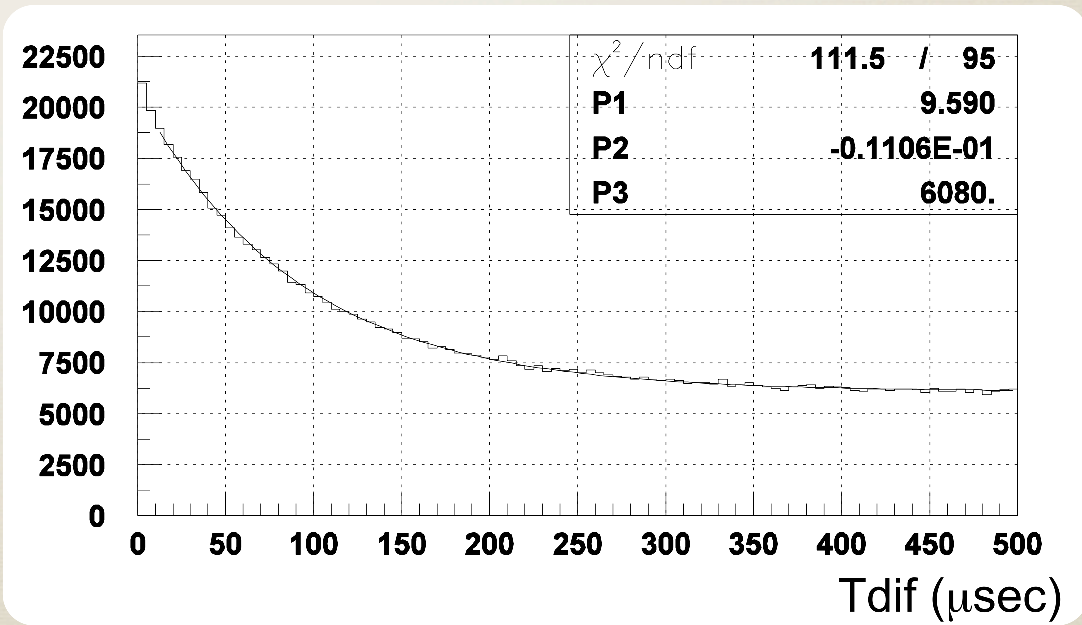
Cannot use it for the energy calibration?



Fission trigger



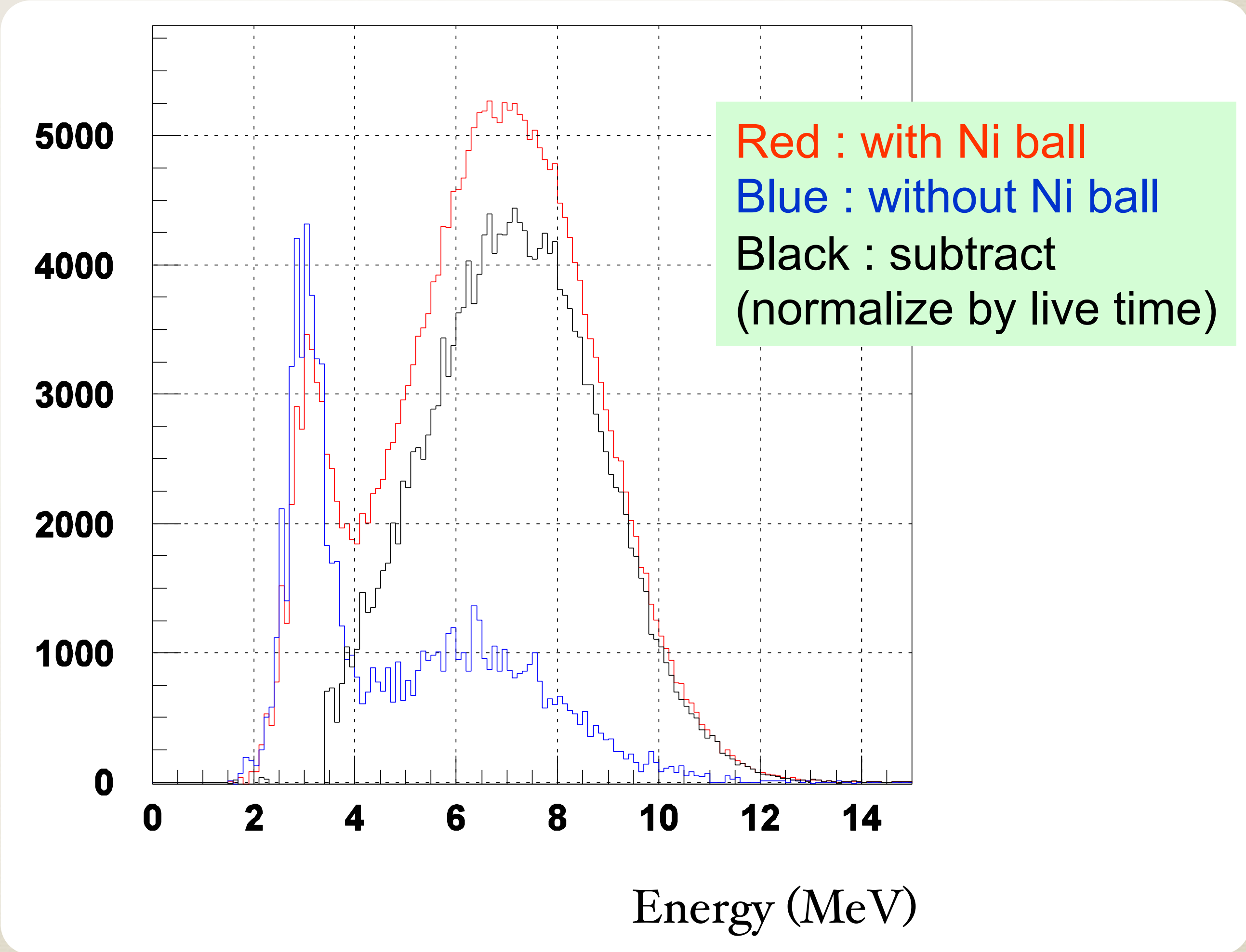




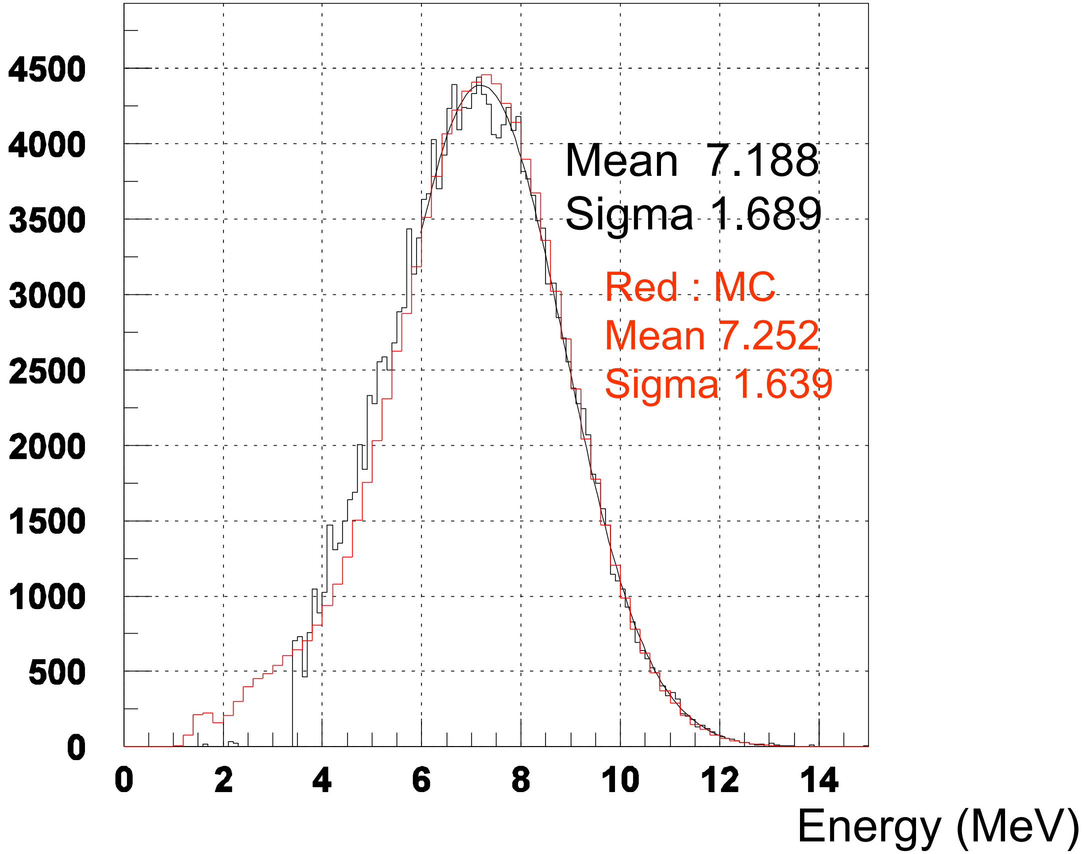
Test data taking in SK-IV

With Nickel ball

Without Nickel ball



Cannot use it for the energy calibration?



The data and MC become good agreement.
The energy shift is 0.9%, and resolution is also close.

Summary

* Several ideas are being considered for the HK calibration.
* The DT and Nickel is promising though we need to study in more detail.
  * New apparatus with modification for HK.
  * How to introduce into the detector.
* Keep considering different possibilities for source:
  * pT generator, LINAC, any more.

Cannot use it for the energy calibration?

Reaction	natural abundance of Nickel (%)	capture cross section (barns)	γ energy (MeV)
^{58}Ni(n,γ)^{59}Ni*	67.88	4.4	9.000
^{60}Ni(n,γ)^{61}Ni*	26.23	2.6	7.820
^{62}Ni(n,γ)^{63}Ni*	3.66	15	6.838
^{64}Ni(n,γ)^{65}Ni*	1.08	1.52	6.098