BigRIPS 及び BigRIPS検出器

理化学研究所原子核研究技術開発グループ
BigRIPS 開発チーム
大西哲哉

1: Introduction

Particle identification of RI beam

- We can select nuclei of interest.
- Experiment with several nucleus can be done at same time.

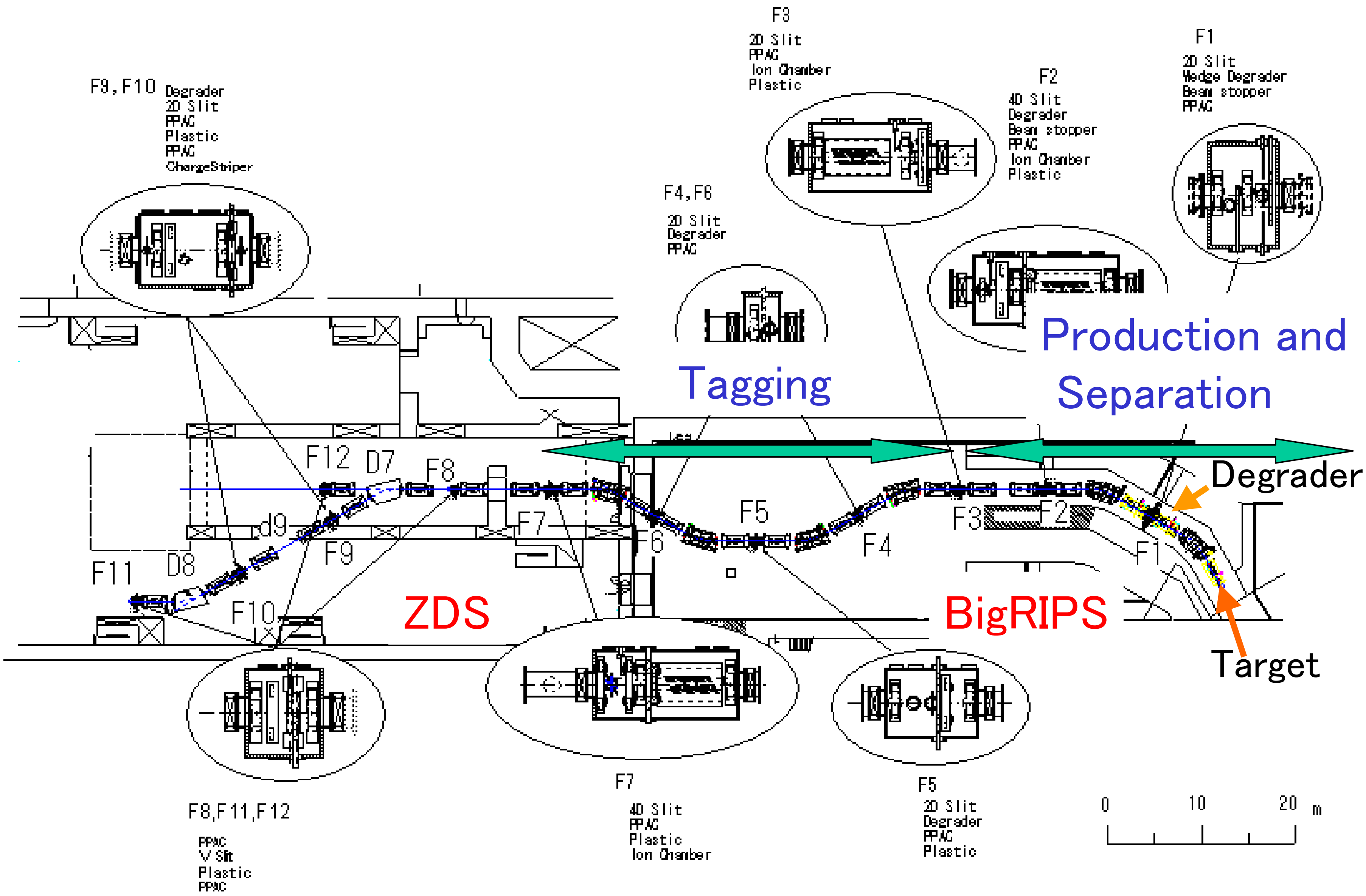
↓

<u>Bρ−ΔE−TOF method</u>

Bρ	⇨	Position detector	⇨	A/Q, P
TOF	⇨	Timing detector		
ΔE	⇨	Energy loss detector	⇨	Z

Z≠Q More information: E ⇨ A

BigRIPS & ZDS



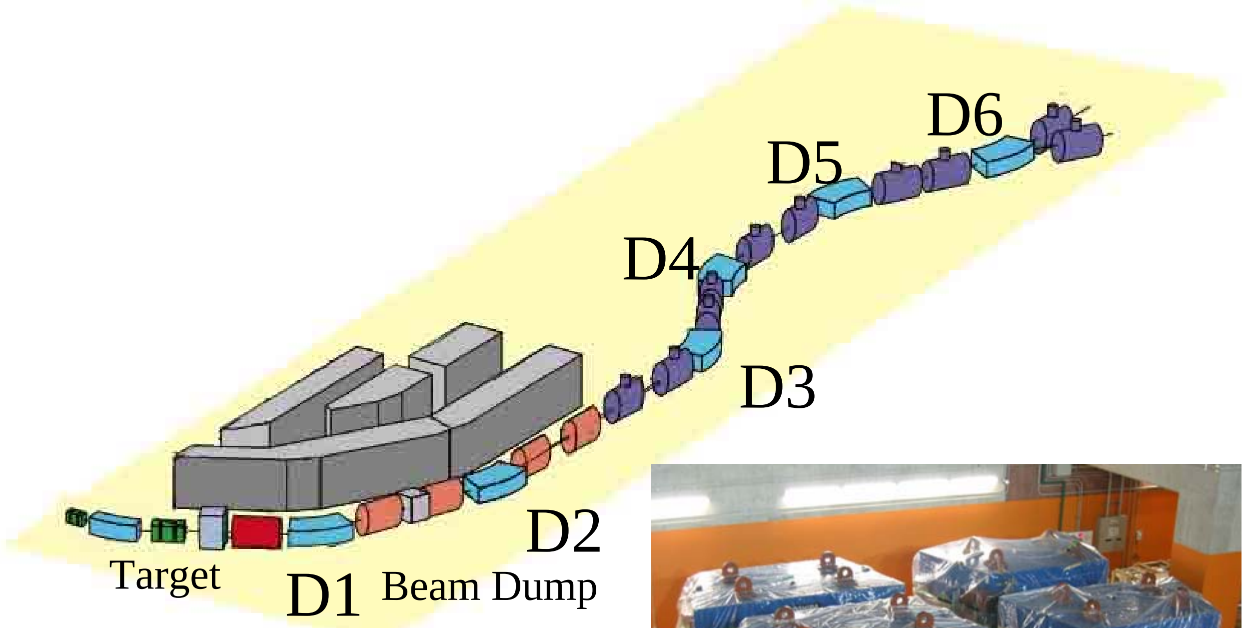
F3
2D Slit
PPAC
Ion Chamber
Plastic
F1
2D Slit
Wedge Degrader
Beam stopper
PPAC
F2
4D Slit
Degrader
Beam stopper
PPAC
Ion Chamber
Plastic
F9,F10
Degrader
2D Slit
PPAC
Plastic
PPAC
ChargeStriper
F4,F6
2D Slit
Degrader
PPAC
Production and Separation
Tagging
F12
D7
F8
Degrader
F7
d9
F6
F5
F3
F2
F4
F9
F1
F11
D8
F10
ZDS
BigRIPS
Target
F7
4D Slit
PPAC
Plastic
Ion Chamber
F5
2D Slit
Degrader
PPAC
Plastic
F8,F11,F12
PPAC
V Slit
Plastic
PPAC
0
10
20
m

Dipoles

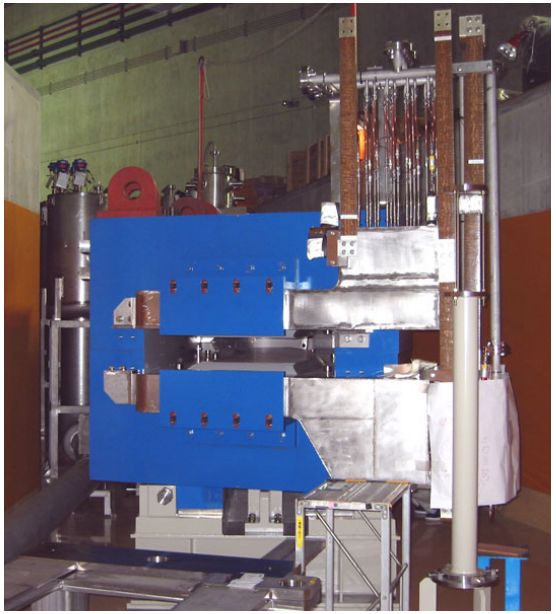
Normal Conducting

H-Shaped Sector

Bending Radius	6 m
Bending Angle	30 degree
Pole Gap	140 mm
Max. Field	1.6 T
Max. Current	1000 A
Current Density	5.6 A/mm^2
Turn/Coil	100
Weight	60 Ton



D3-D4 in BigRIPS Hall



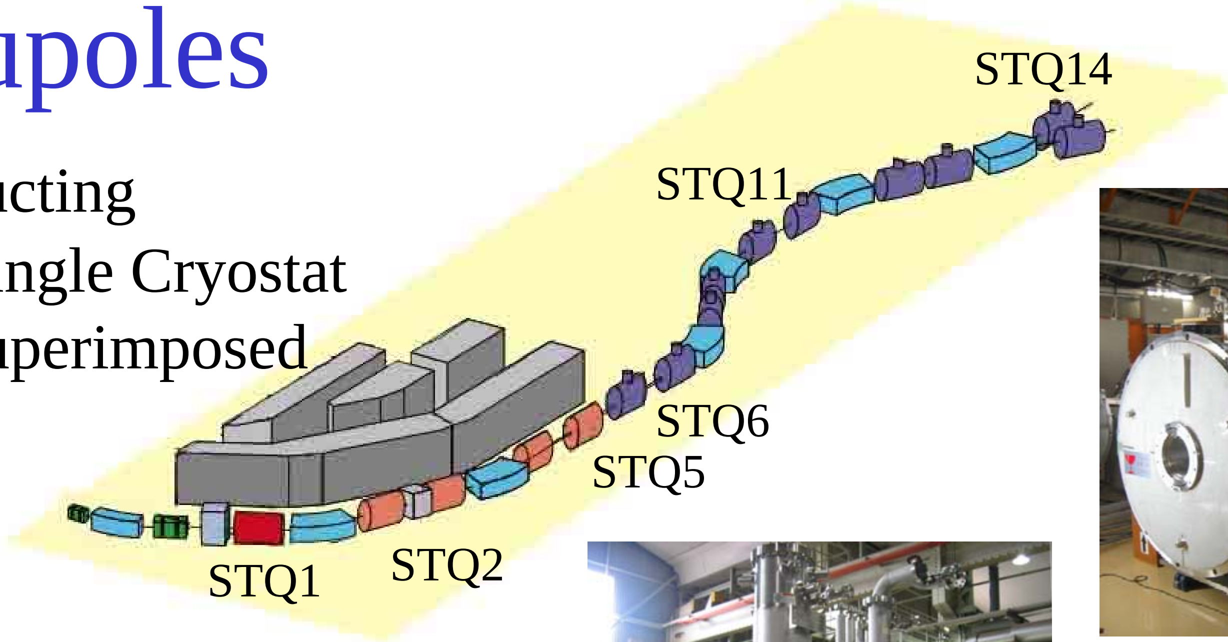
D1 - Almina Cement Insulated Coil

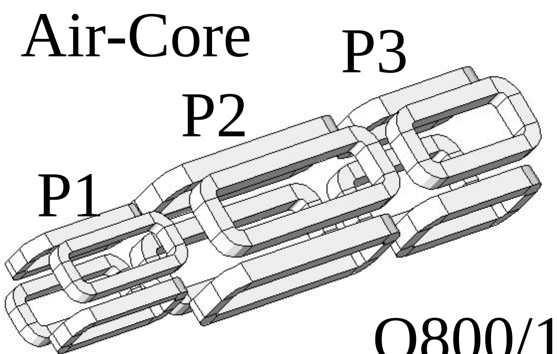
Quadrupoles

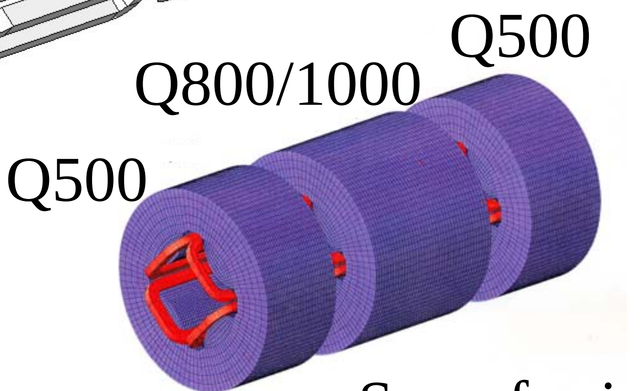
Superconducting

Triplet in Single Cryostat

Hexapole superimposed







Superferric

Cryostat cooled by Cryogenic plant

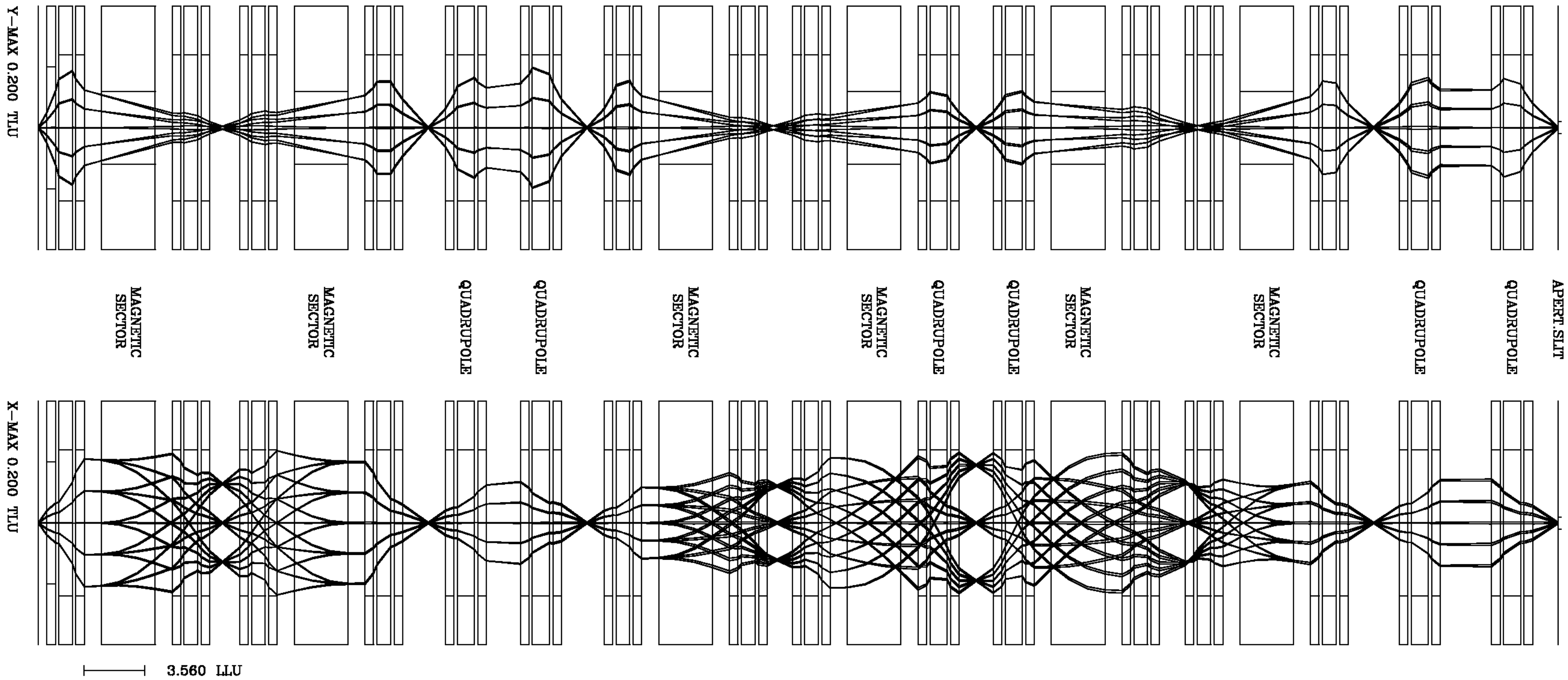
⇩

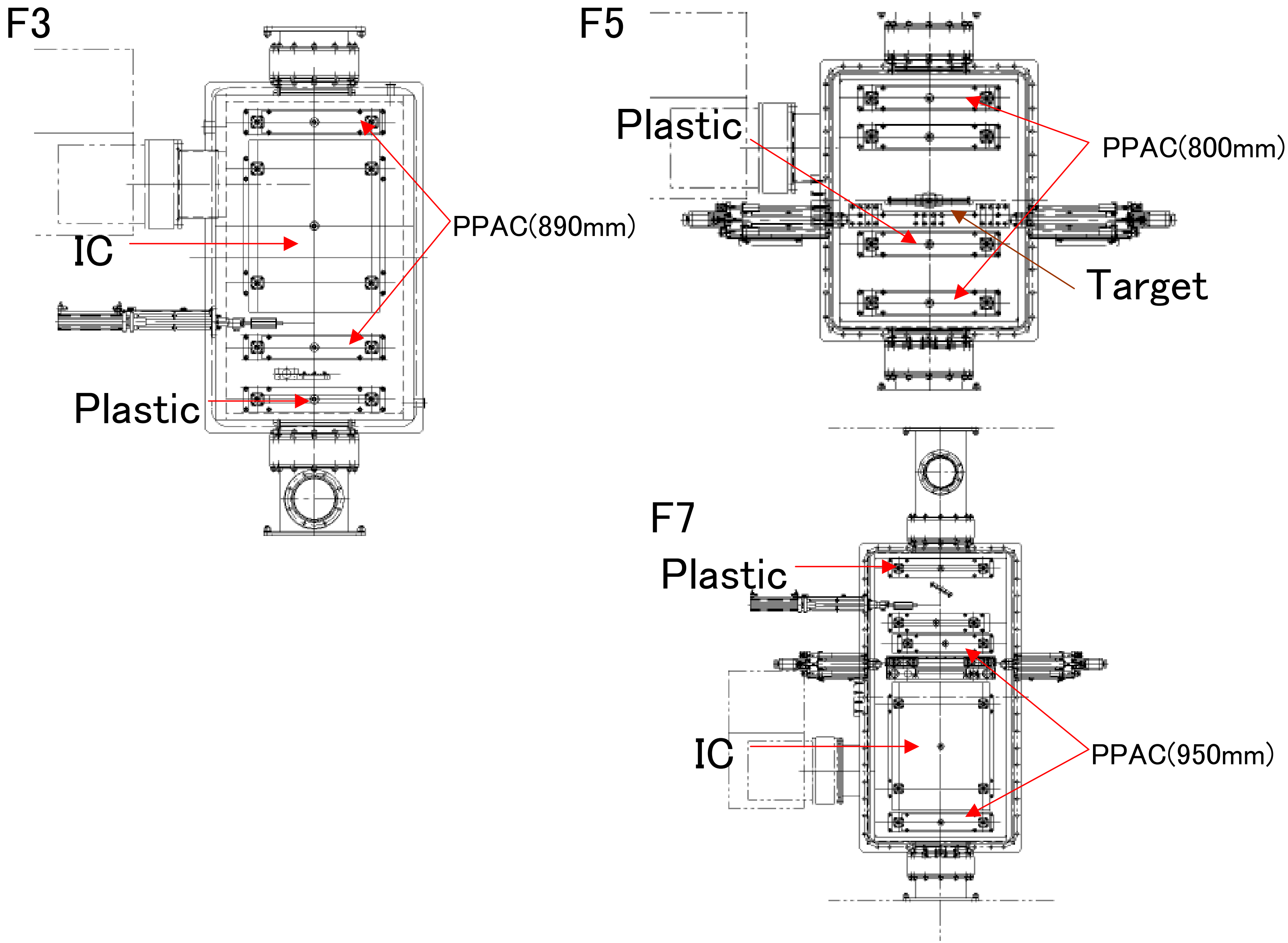
BigRIPS Cave

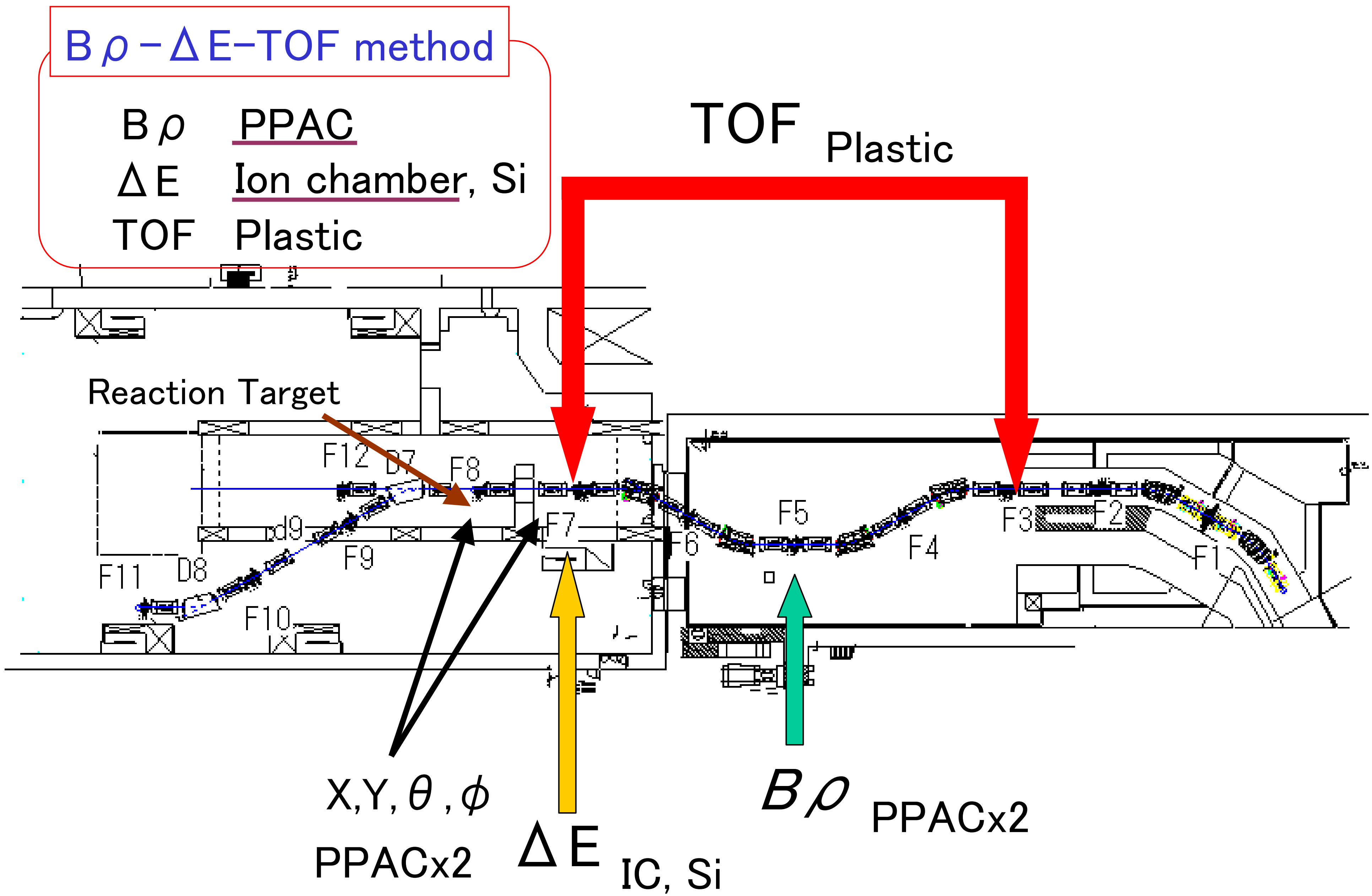
Cryostat with Cryocoolers

⇩

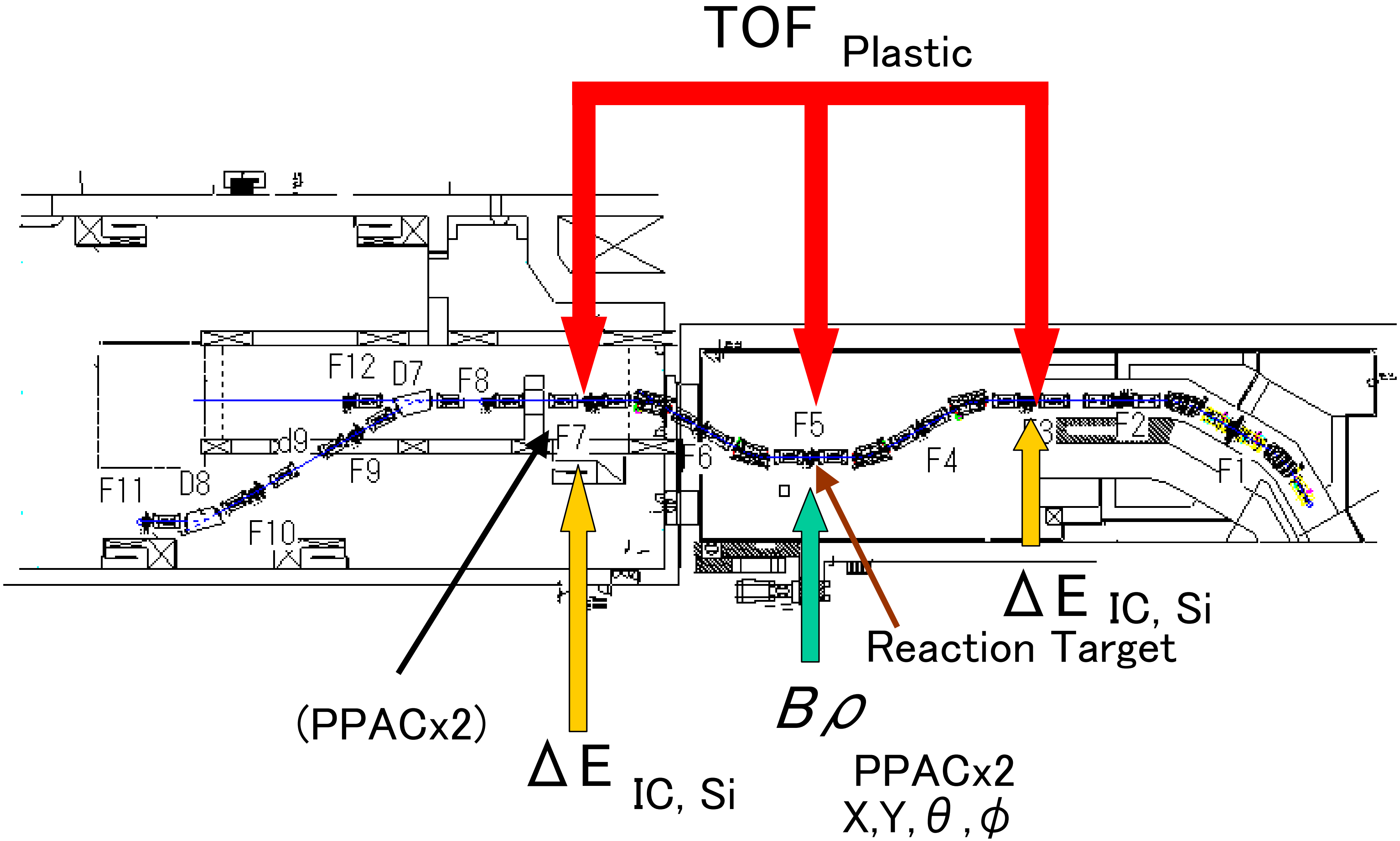
BigRIPS Hall

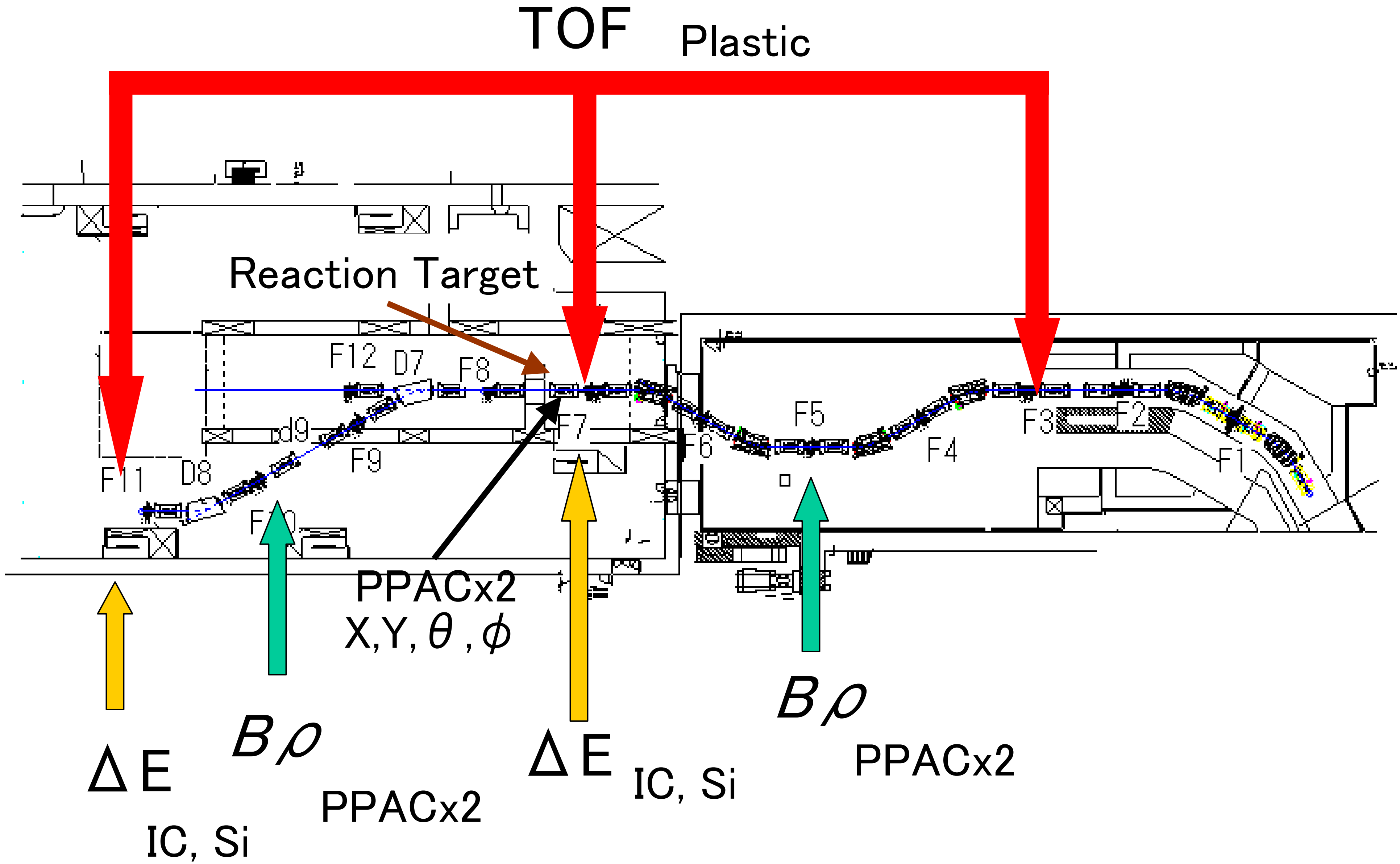

Y-MAX 0.200 TLU
MAGNETIC SECTOR
MAGNETIC SECTOR
QUADRUPOLE
QUADRUPOLE
MAGNETIC SECTOR
MAGNETIC SECTOR
QUADRUPOLE
QUADRUPOLE
MAGNETIC SECTOR
MAGNETIC SECTOR
QUADRUPOLE
QUADRUPOLE
APERT.SLIT
X-MAX 0.200 TLU
3.560 LLU


F3
IC
PPAC(890mm)
Plastic
F5
Plastic
PPAC(800mm)
Target
F7
Plastic
IC
PPAC(950mm)


Bρ−ΔE−TOF method
Bρ PPAC
ΔE Ion chamber, Si
TOF Plastic
TOF Plastic
Reaction Target
F12
D7
F8
F7
F6
F5
F4
F3
F2
F1
d9
F9
F11
D8
F10
X,Y, θ , φ
PPACx2
ΔE IC, Si
Bρ PPACx2

Transmission method





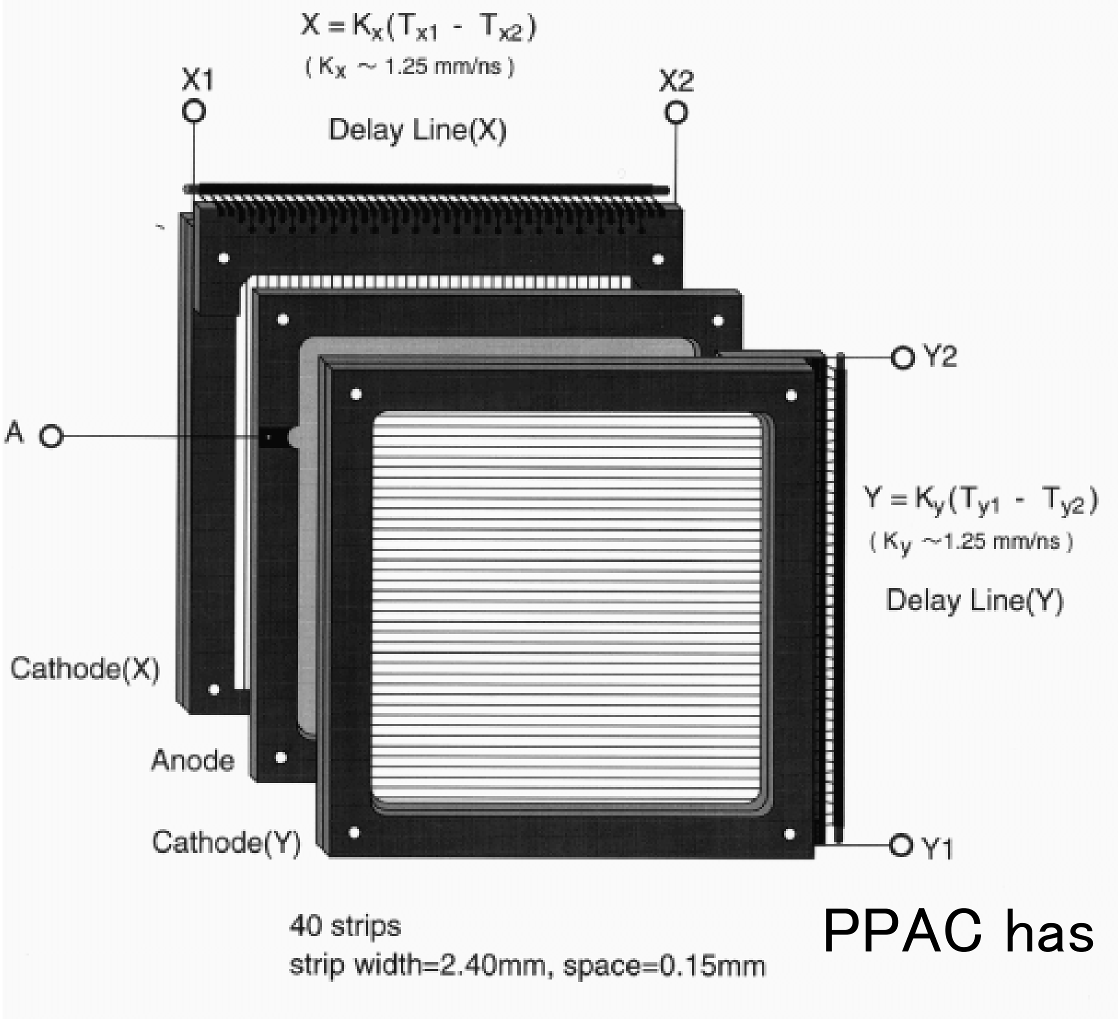
TOF
Plastic
Reaction Target
F12
D7
F8
F7
F6
F5
F4
F3
F2
F1
F11
D8
d9
F9
F10
PPACx2
X,Y, θ , φ
ΔE
IC, Si
Bρ
PPACx2
ΔE
IC, Si
Bρ
PPACx2

2: Detectors

Position detector: PPAC

DL–PPAC: Delay Line Parallel Plate Avalanche Counter

H. Kumagai et al., Nucl. Instr. and Meth. A470(2001)562.



Gas: C_3F_8 10～30 Torr

HV: 800 ～1800 V

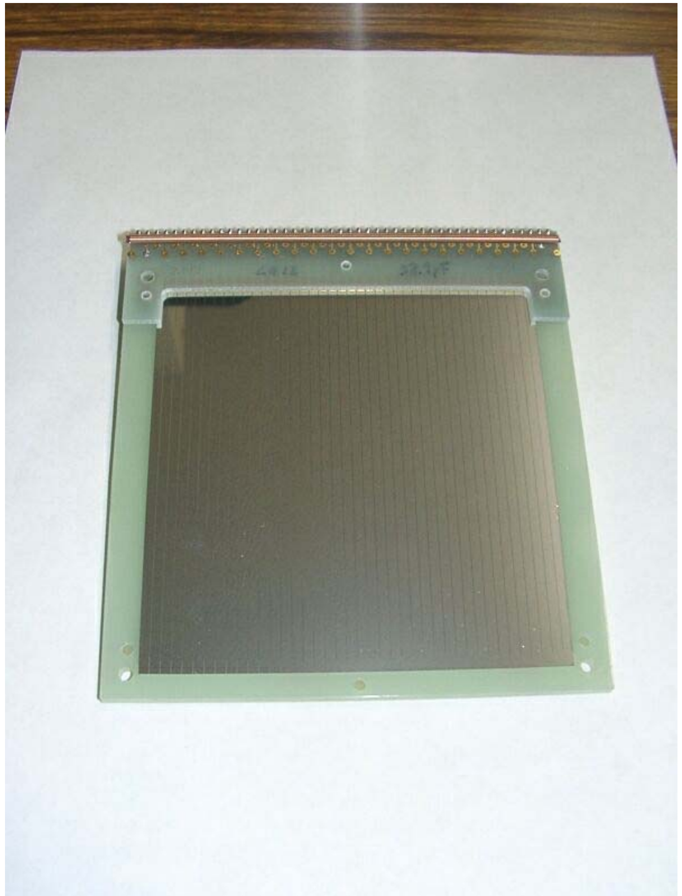
Anode,Cathode:
2 μm Mylar

Window:
4～12 μm Al–Mylar

PPAC has been already used in RIPS.

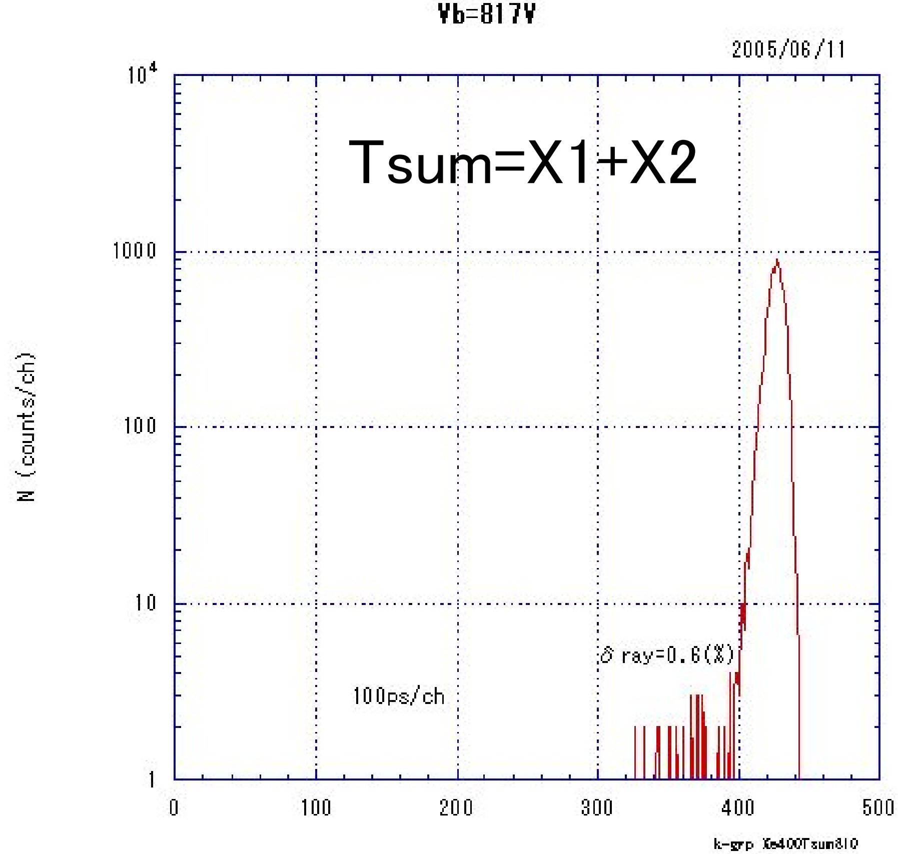
Counting rate: ～10^6 Hz


BLOW



Performance Test for heavy nuclei at high energy

^{132}Xe @400MeV/A at HIMAC



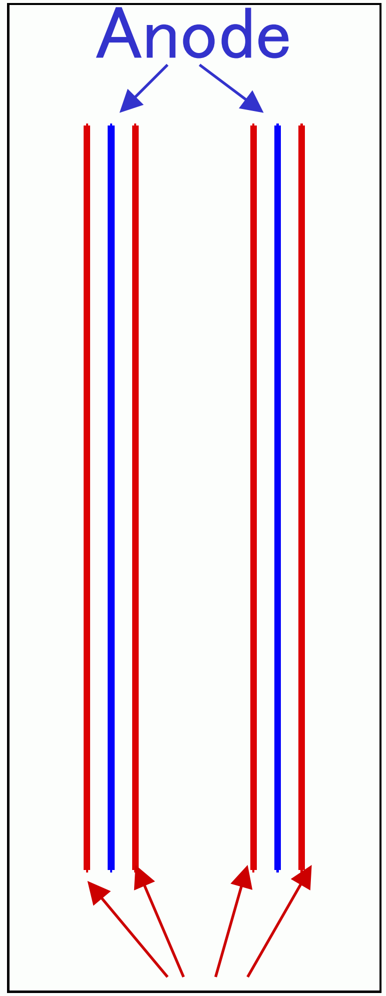
Resolution

Position $\sigma = 0.27$ mm(r.m.s)

Timing $\sigma = 0.1$ ns(r.m.s)

DL-PPAC for BigRIPS

Effective area: 240 mm x 150 mm



To avoid the effect of δ-ray,
we set the double layer.

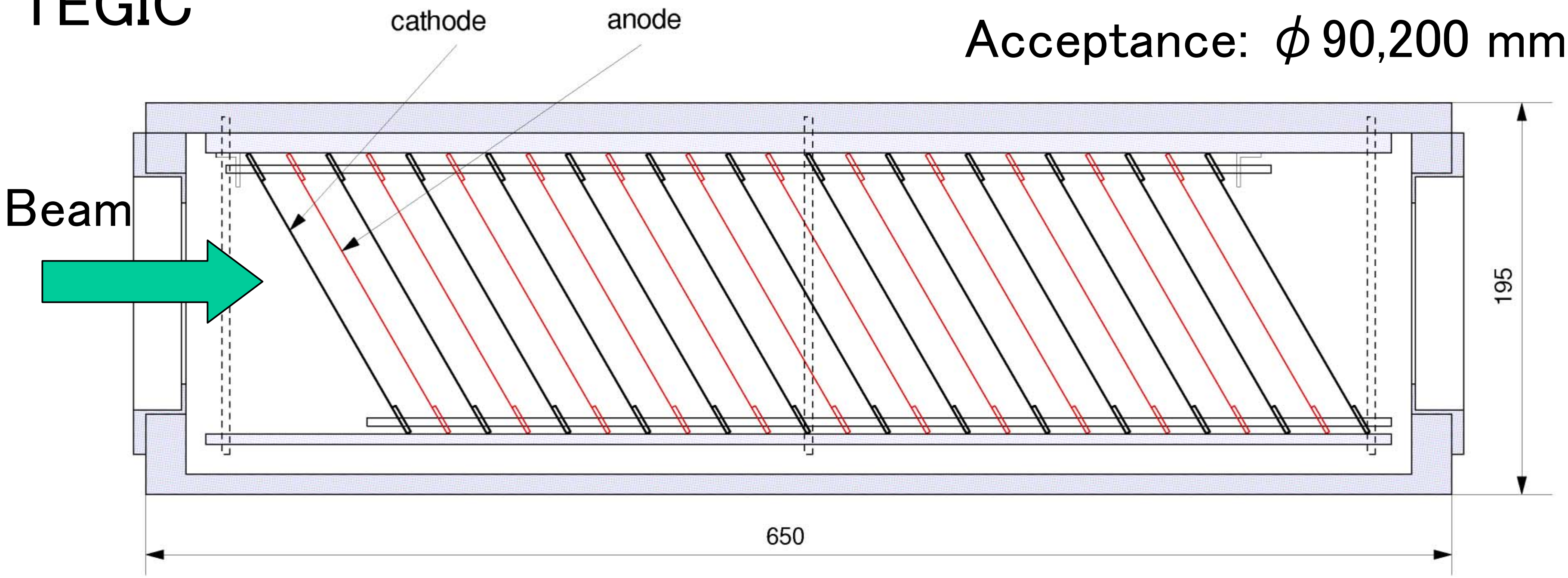
→ High efficiency

ΔE detector: Ion chamber

K. Kimura et al., Nucl. Instr. and Meth. A538(2005)608

TEGIC

Acceptance: ϕ 90,200 mm



Drift length : 2 cm

Anode: 12

Electrode : 4 μm Mylar

Cathode: 13

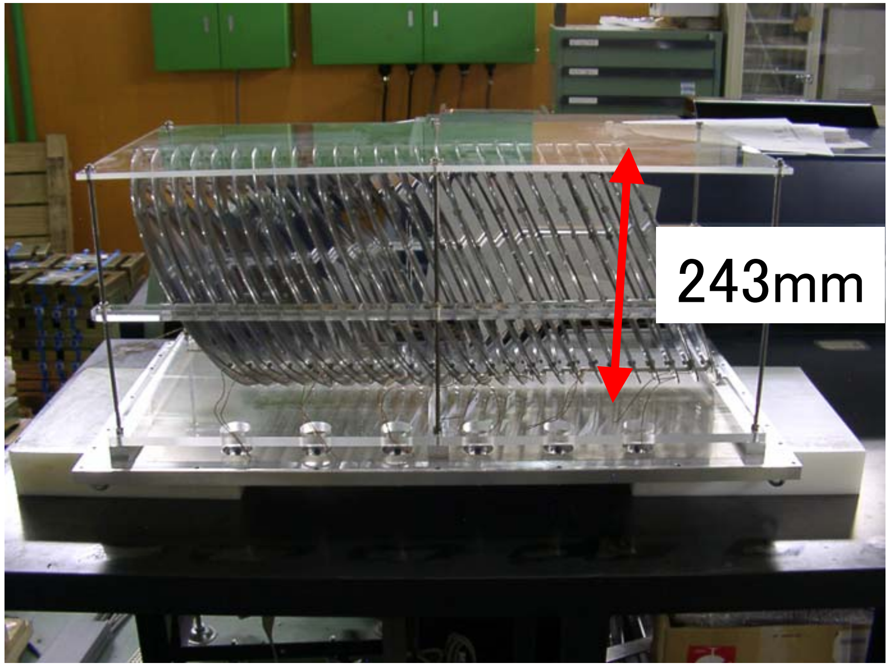
Tilted angle : 30°

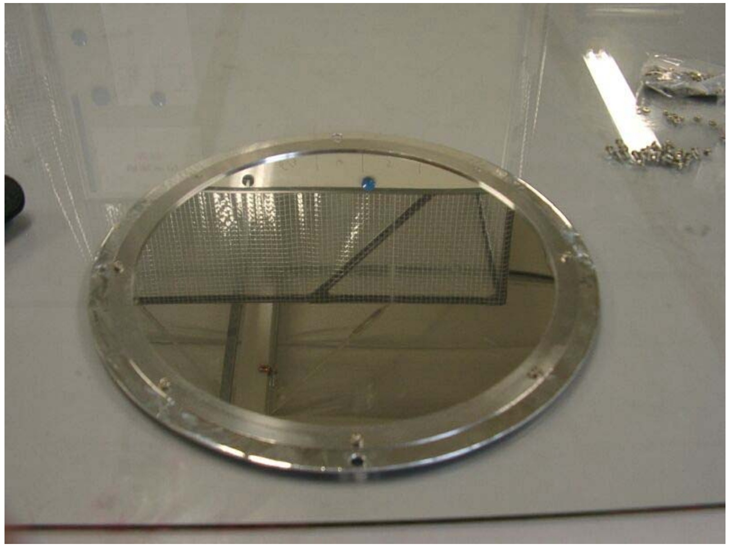
Window :50 μm Capton

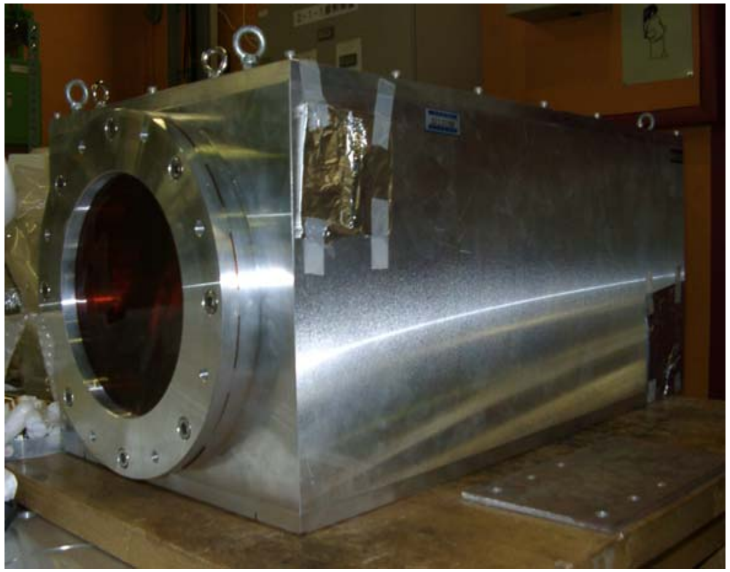
- Short drift length for high counting rate.
- Stacked structure for large signal.
- Tilted electrodes to avoid the effect of recombination.

ϕ 90 mm

ϕ 200 mm







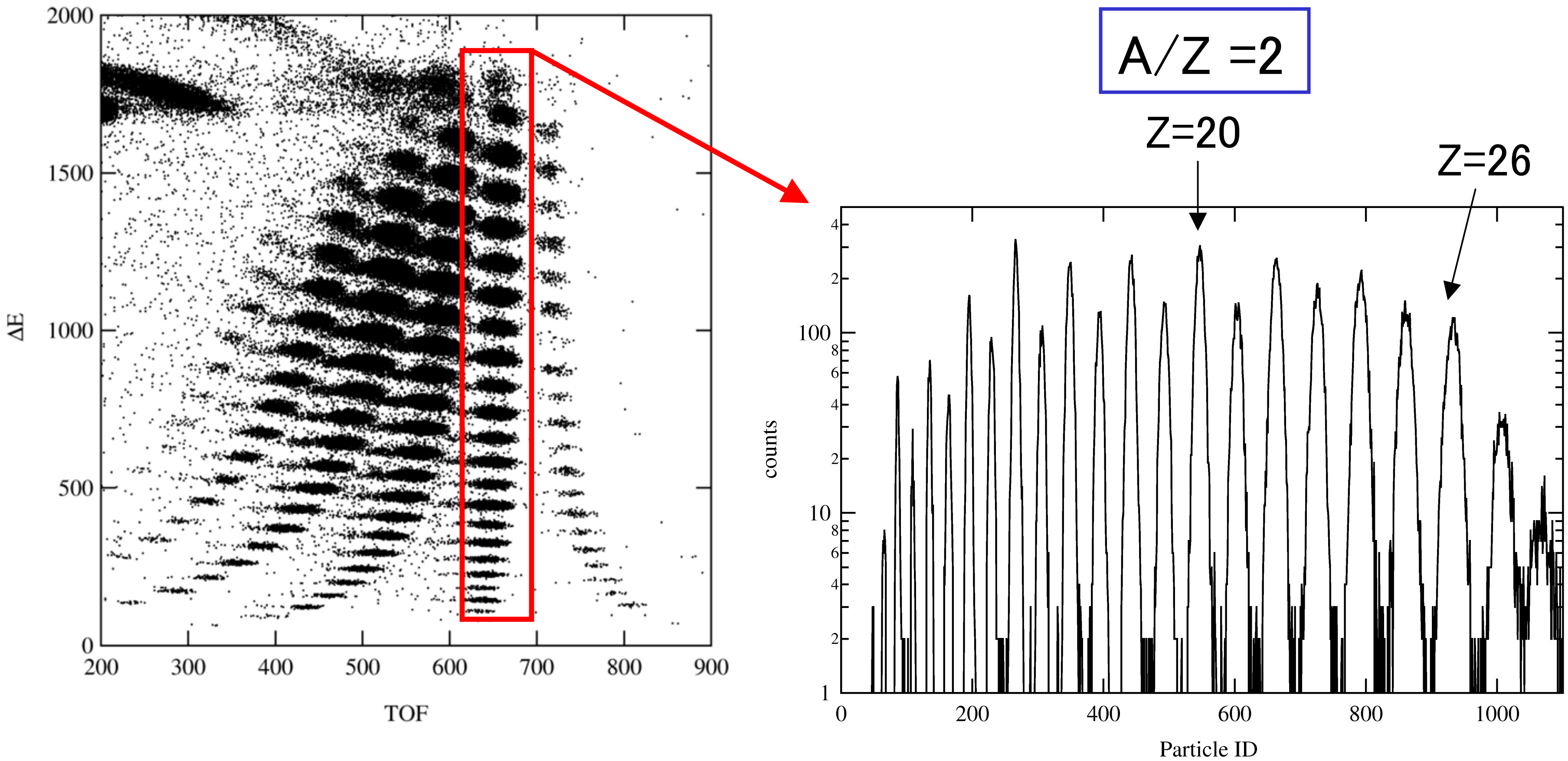
Performance test

RIKEN E1C

ϕ 90 mm

HV:500V, P-10:740 Torr

^{56}Fe at 90MeV/A



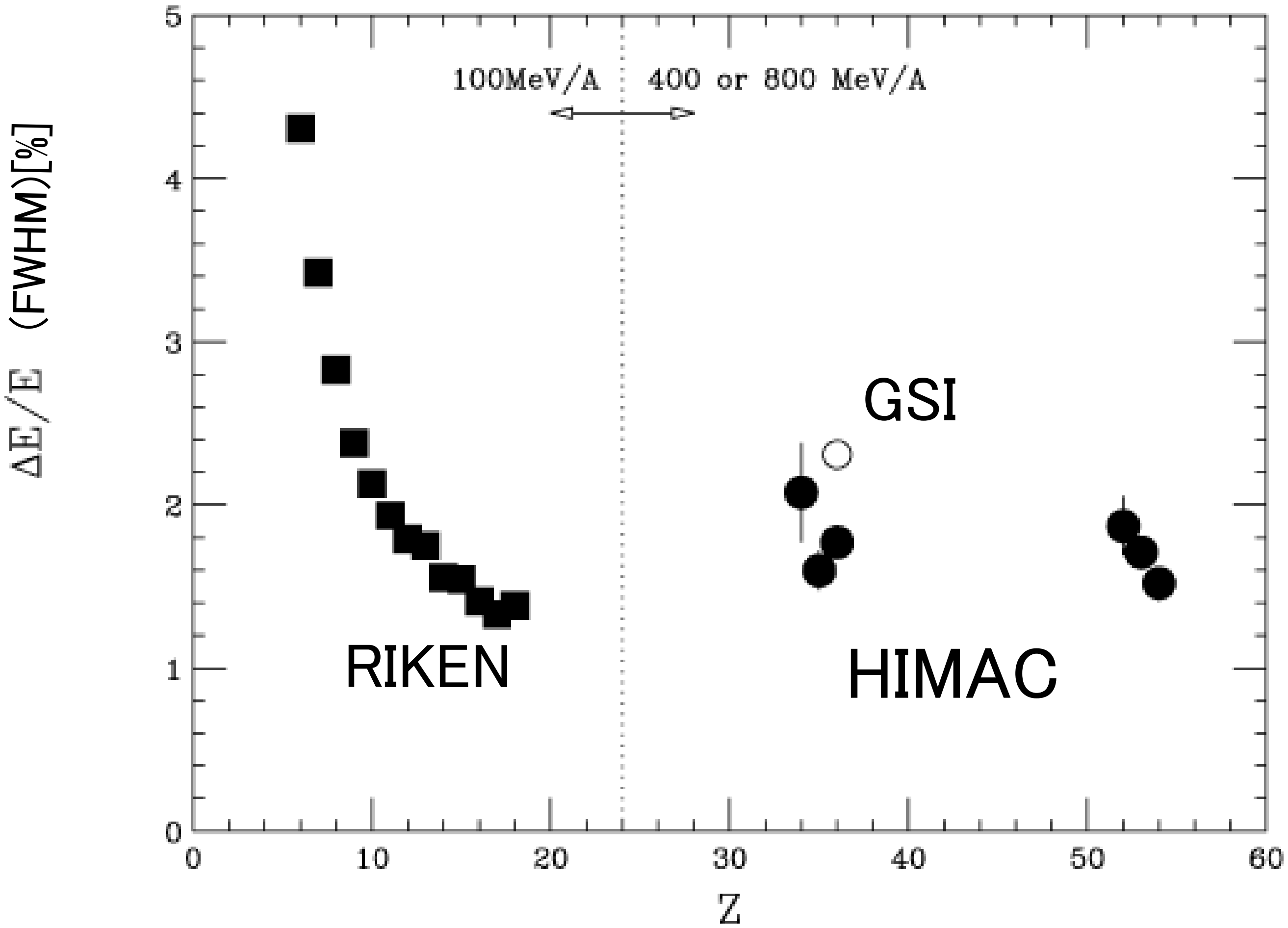
ToF: Plastic

$\Delta E/E \sim < 2\%$(FWHM)

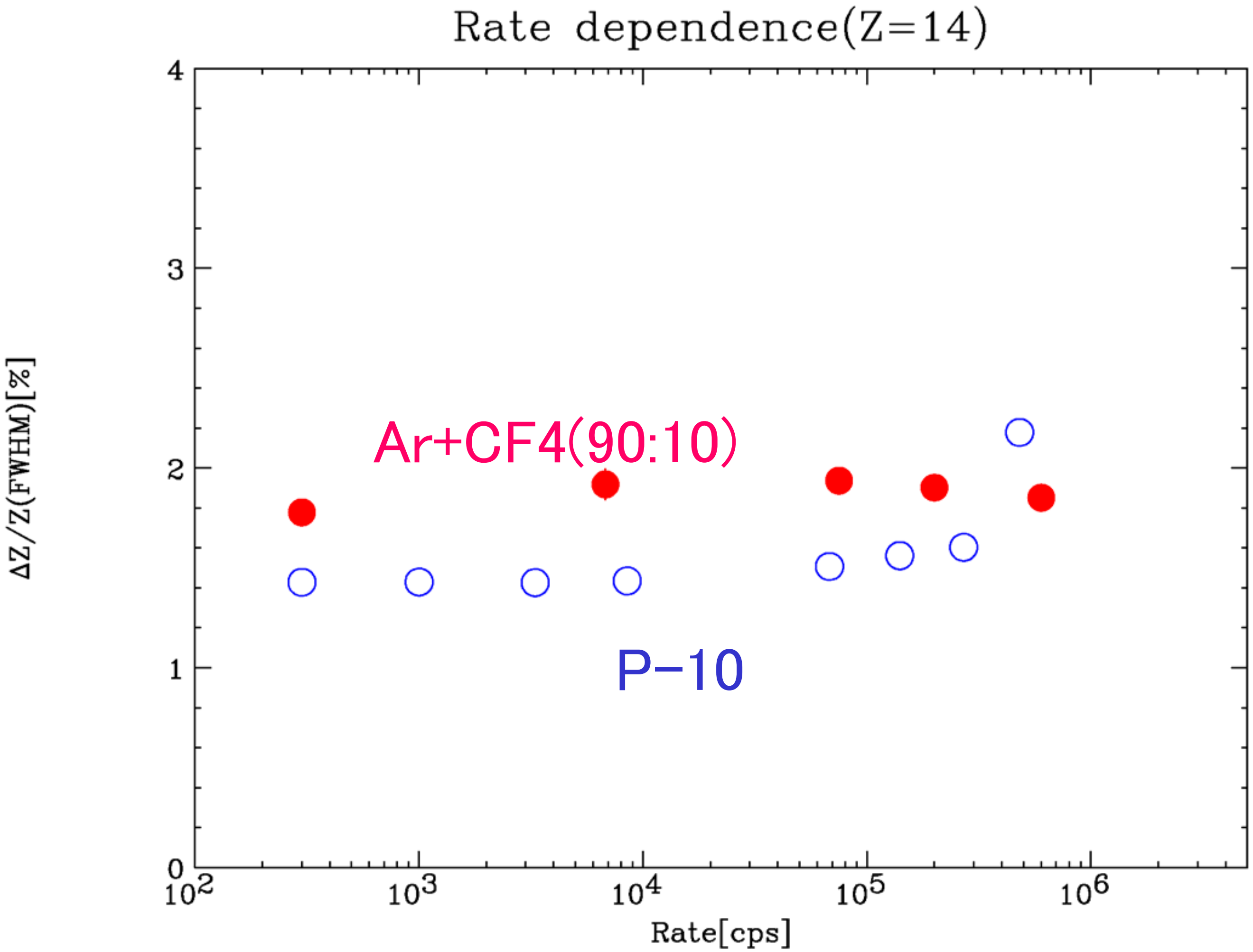
Performance for heavy ion at high energy

^{86}Kr 400MeV/A: HIMAC ^{132}Xe 400MeV/A: HIMAC
800MeV/A: GSI (φ200 mm)

ΔE Resolution of TEGIC



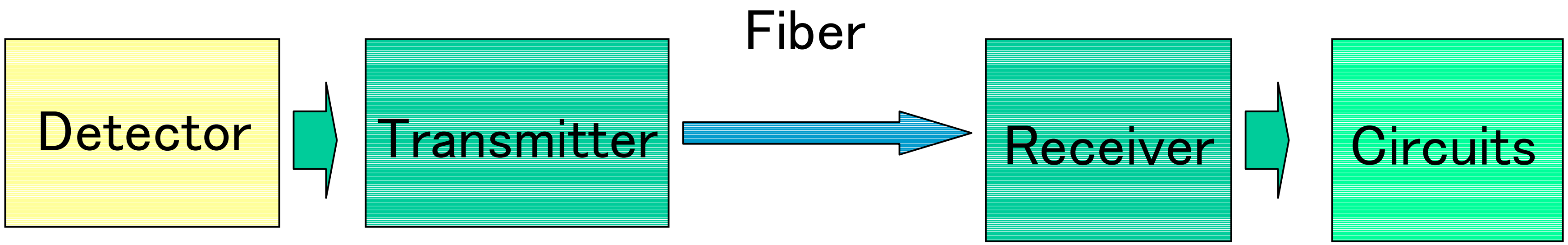
Rate dependence



Rate: 10^6 Hz ⇒ Development of circuit

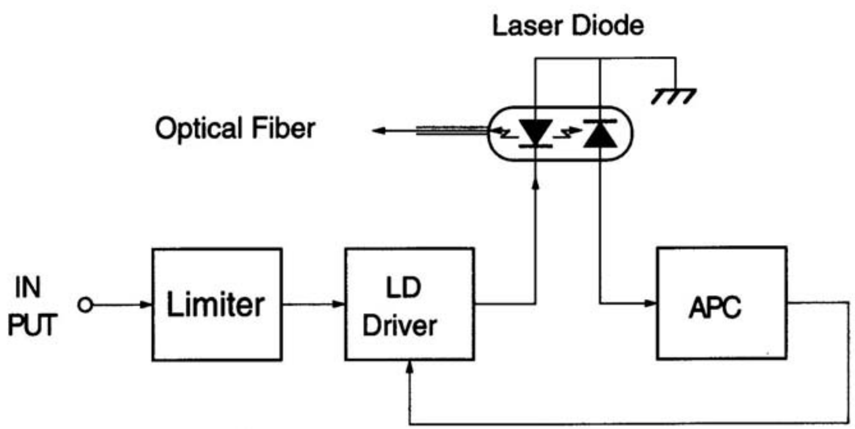
3: Readout system

Signal transport system with optical fiber

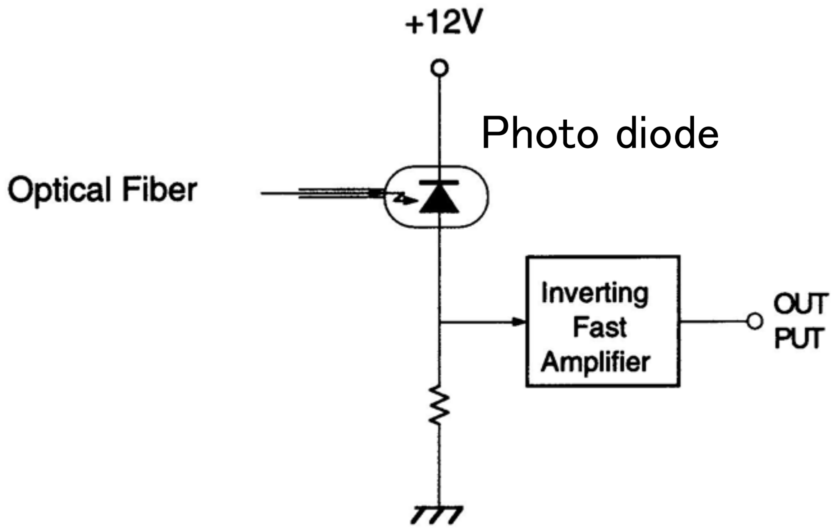


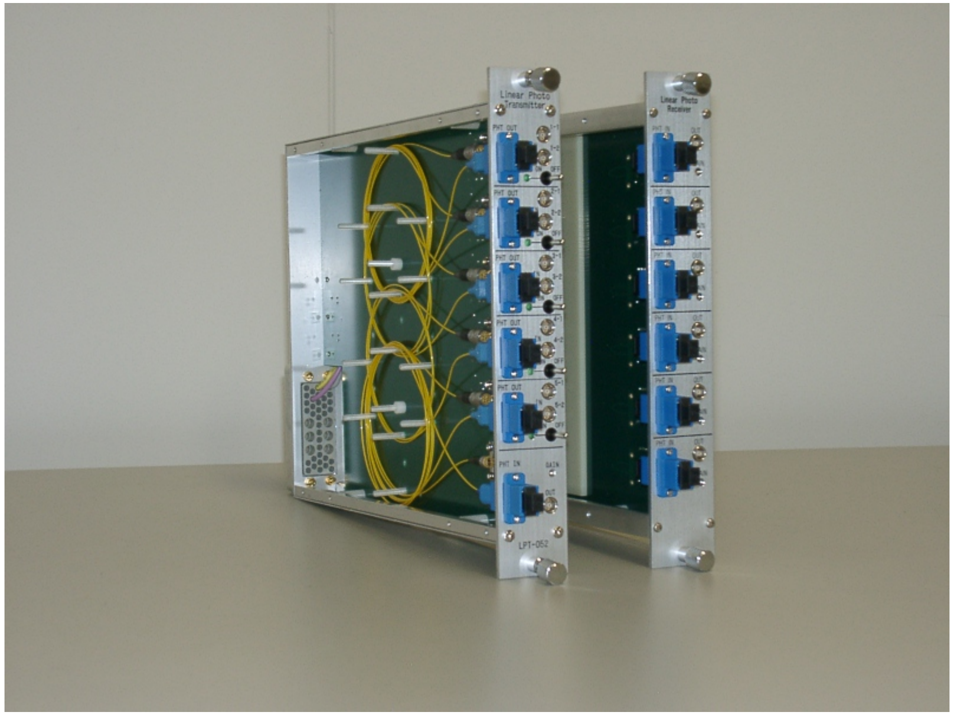
- We can transport with long distance (>100m)
- The electric ground level of the detector is isolated from that of the counting room
- It is easy to add a long delay time.

Transmitter

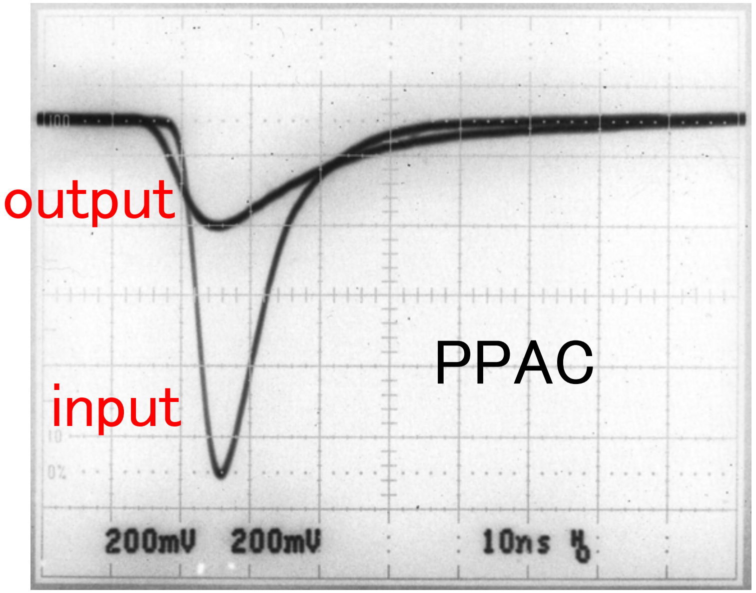


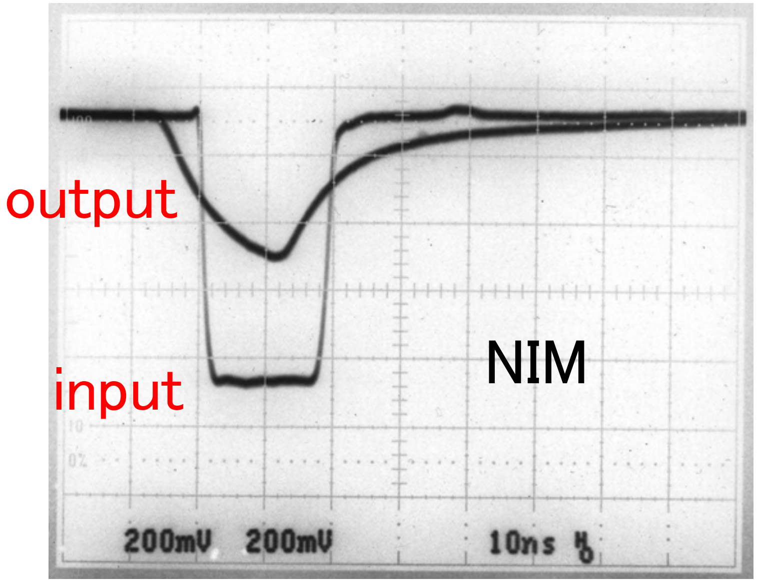
Receiver



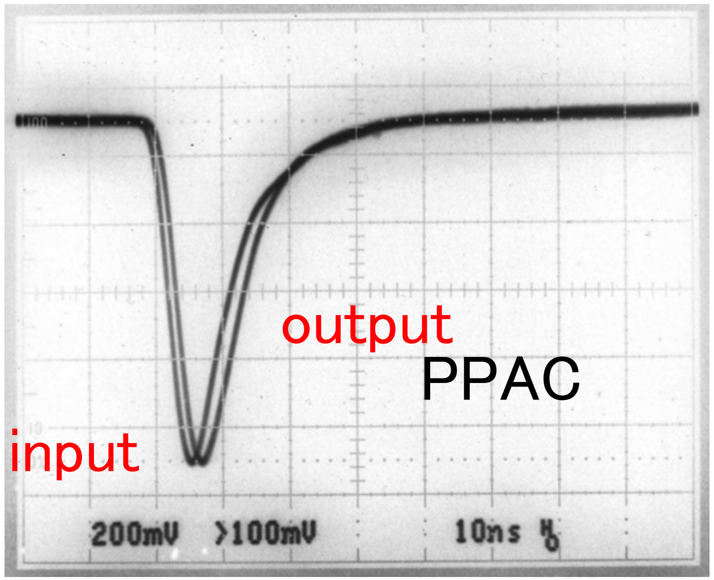


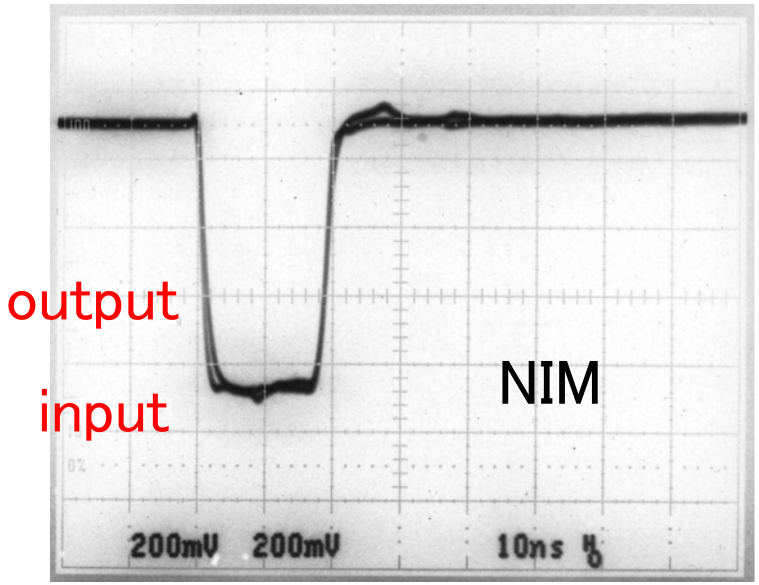
100 m Coaxial cable



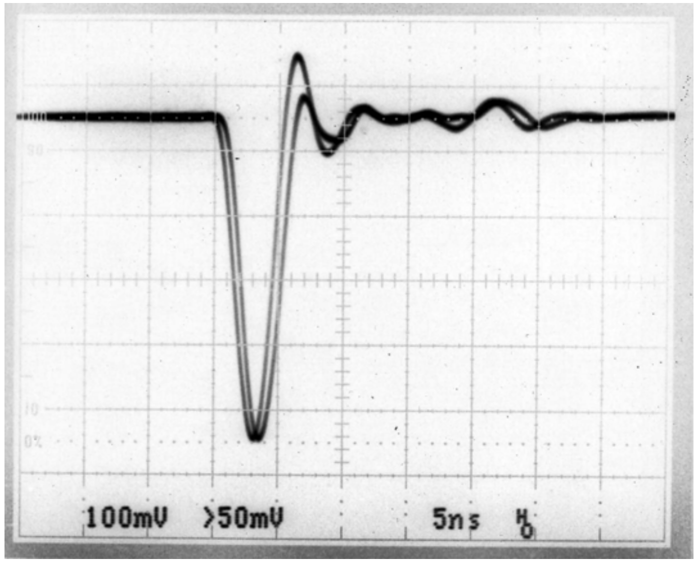


100 m fiber cable

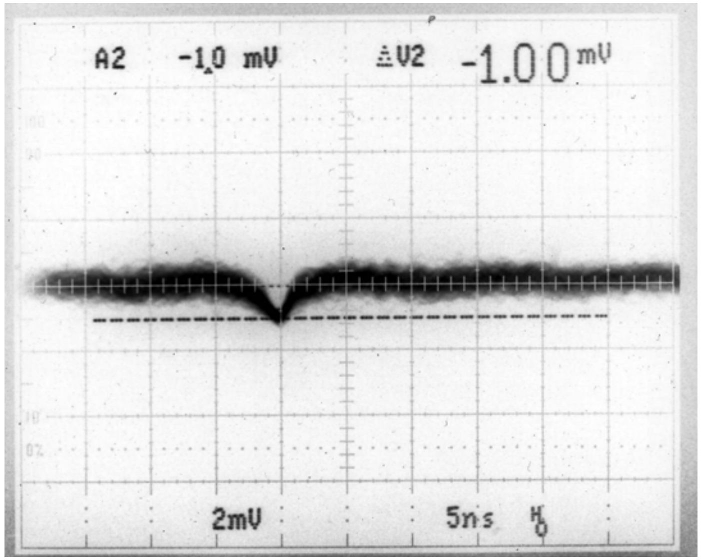




Fast signal

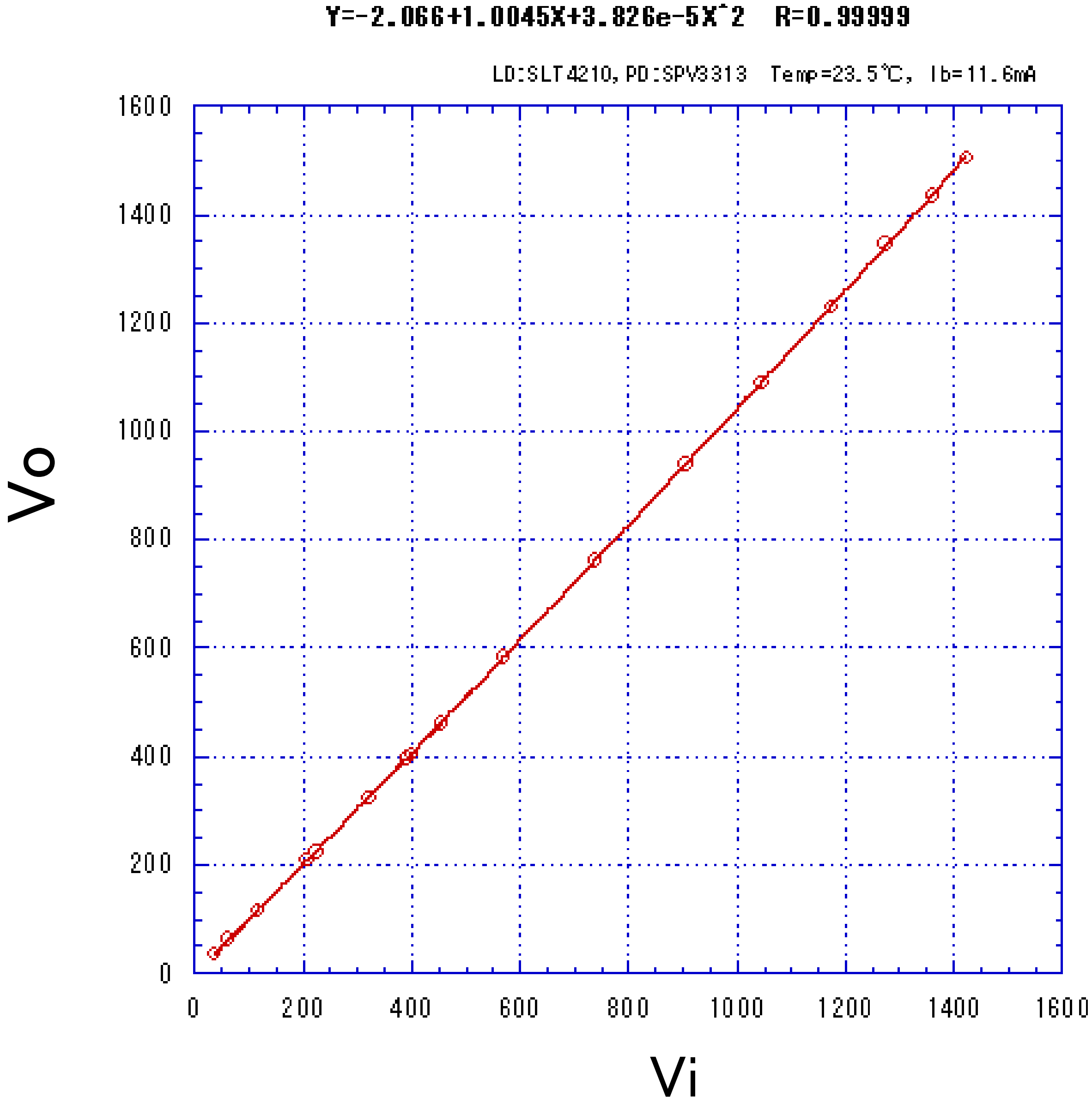


Noise



Linearity

$$V_o = -2.066 + 1.0045 \times V_i + \underline{3.826 \times 10^{-5}} V_i^2$$



4: DAQ

Requirement and Condition

- Analog signal can be transported with optical fiber.
- The total number of channel at a time
  is not so much. (～ 50 ch)
- It is required that
  assets of CAMAC modules are applied.
- Network based DAQ system is required
  to combine with User's DAQ system

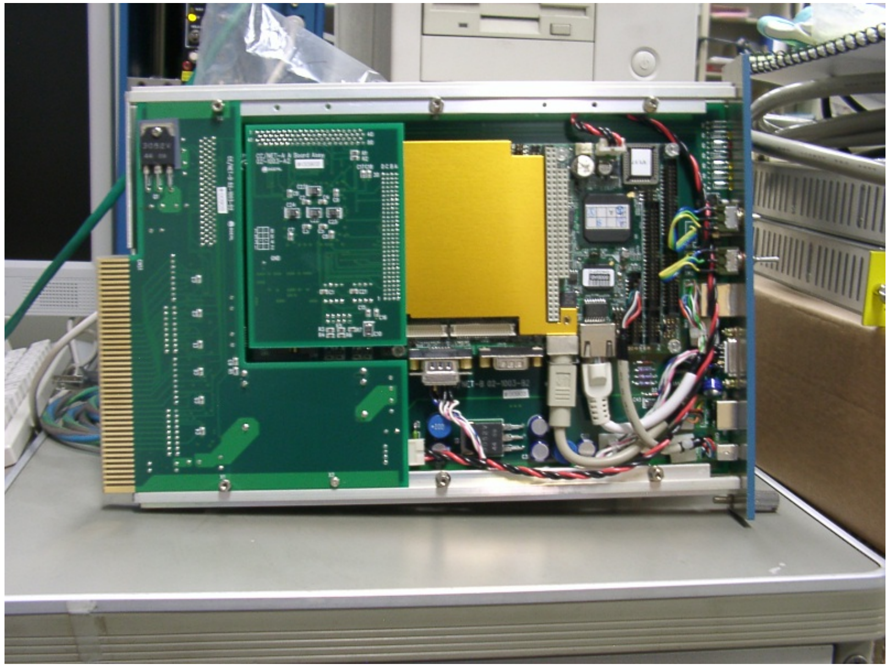
Network based CAMAC DAQ system with CC/NET

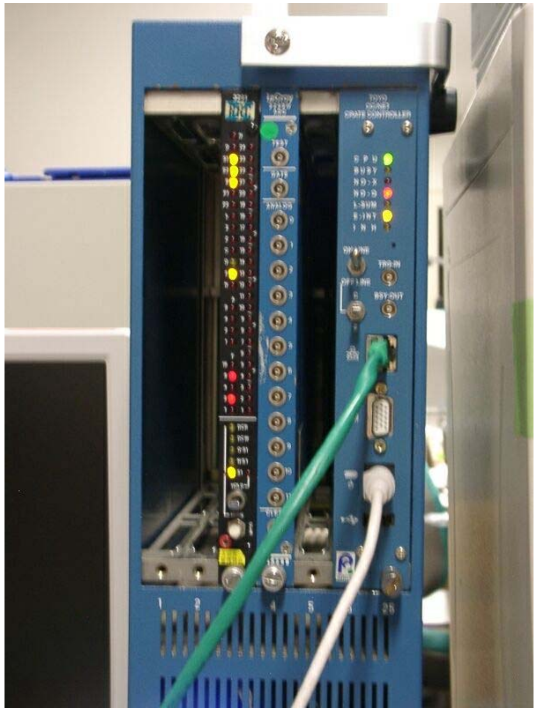
CC/NET

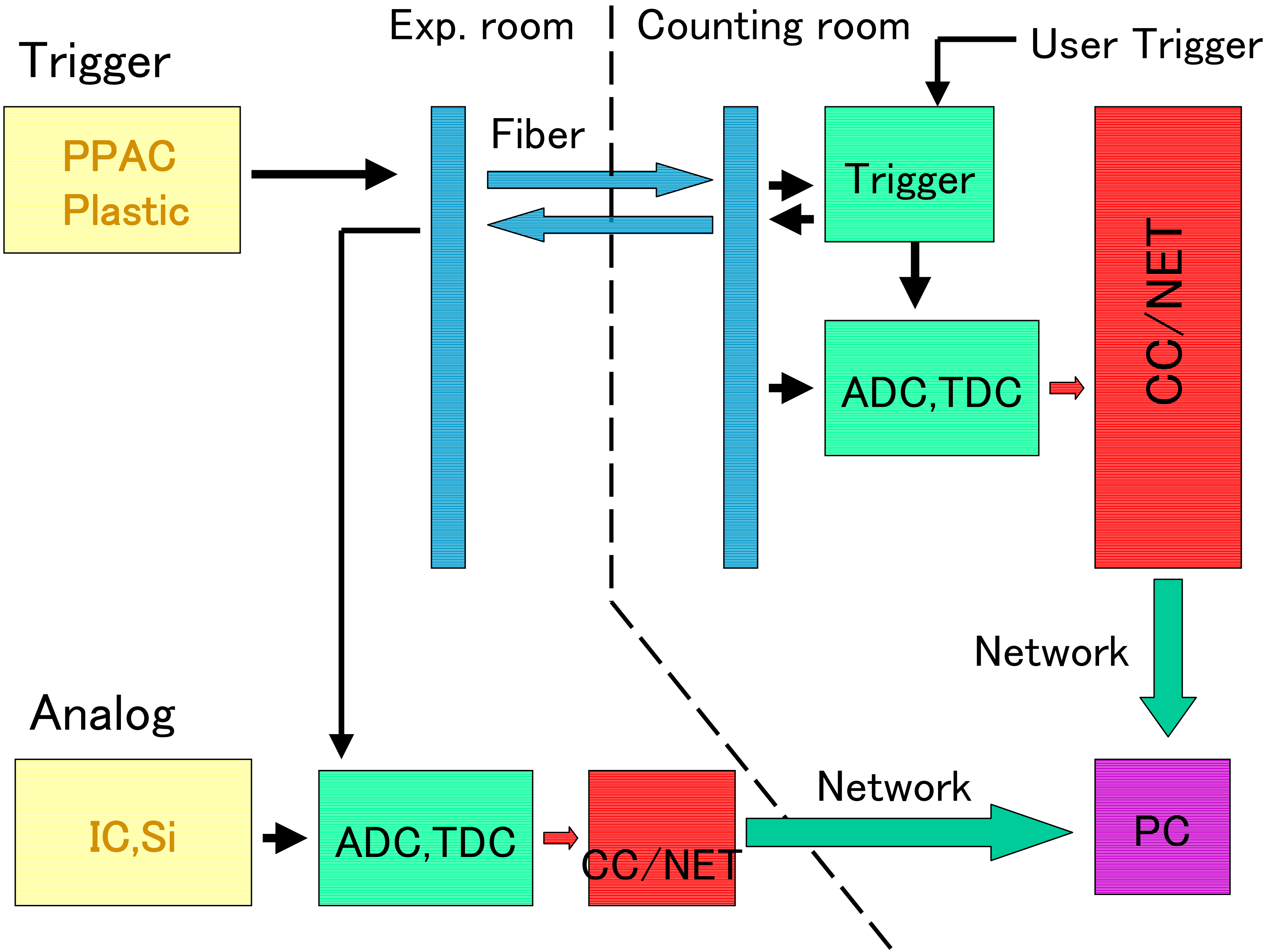
Pipe line CAMAC controller
with PC104plus single board computer

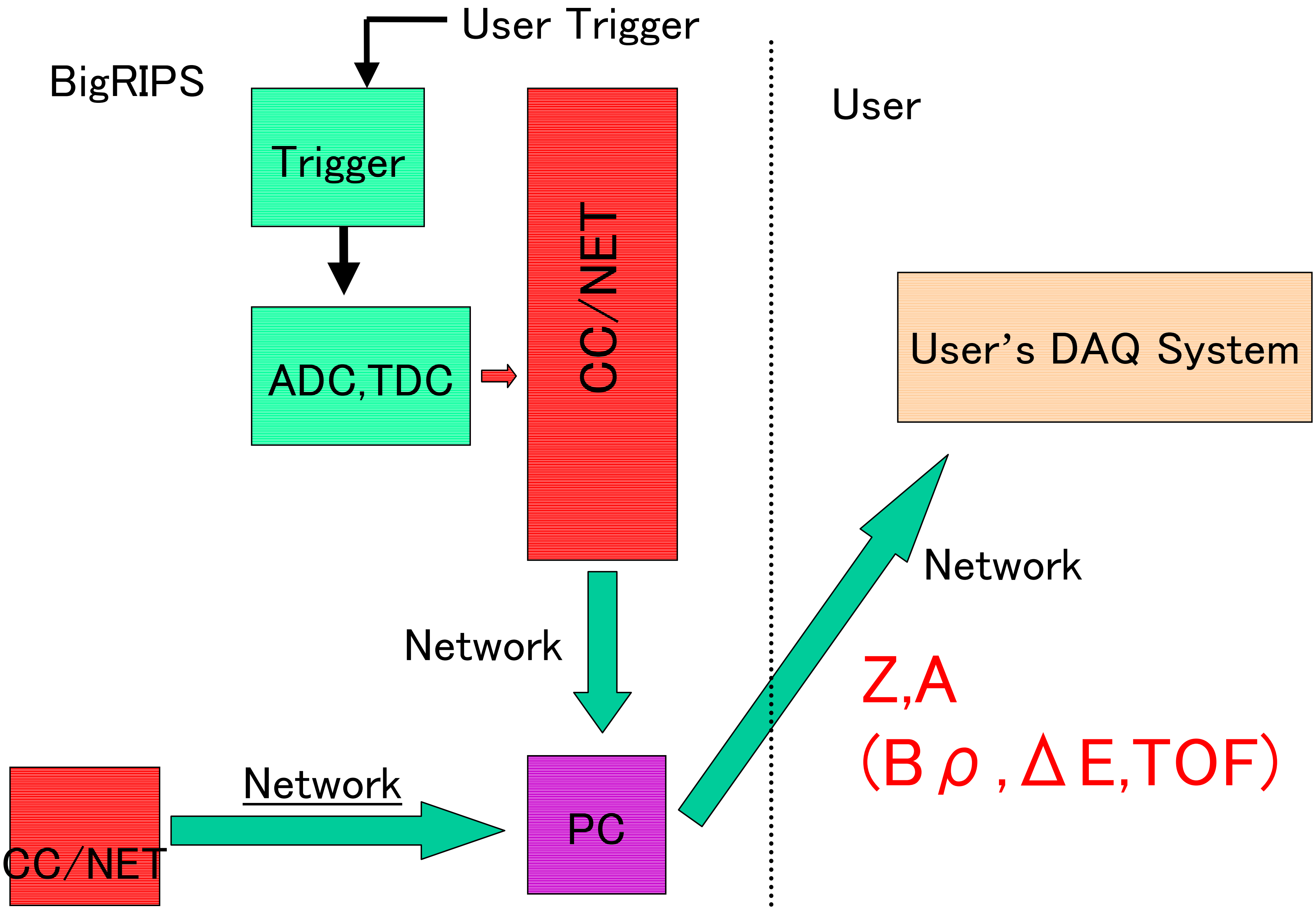
1 CAMAC access : 1 μ sec + (40 nsec overhead)

This module has been developed by KEK online group.

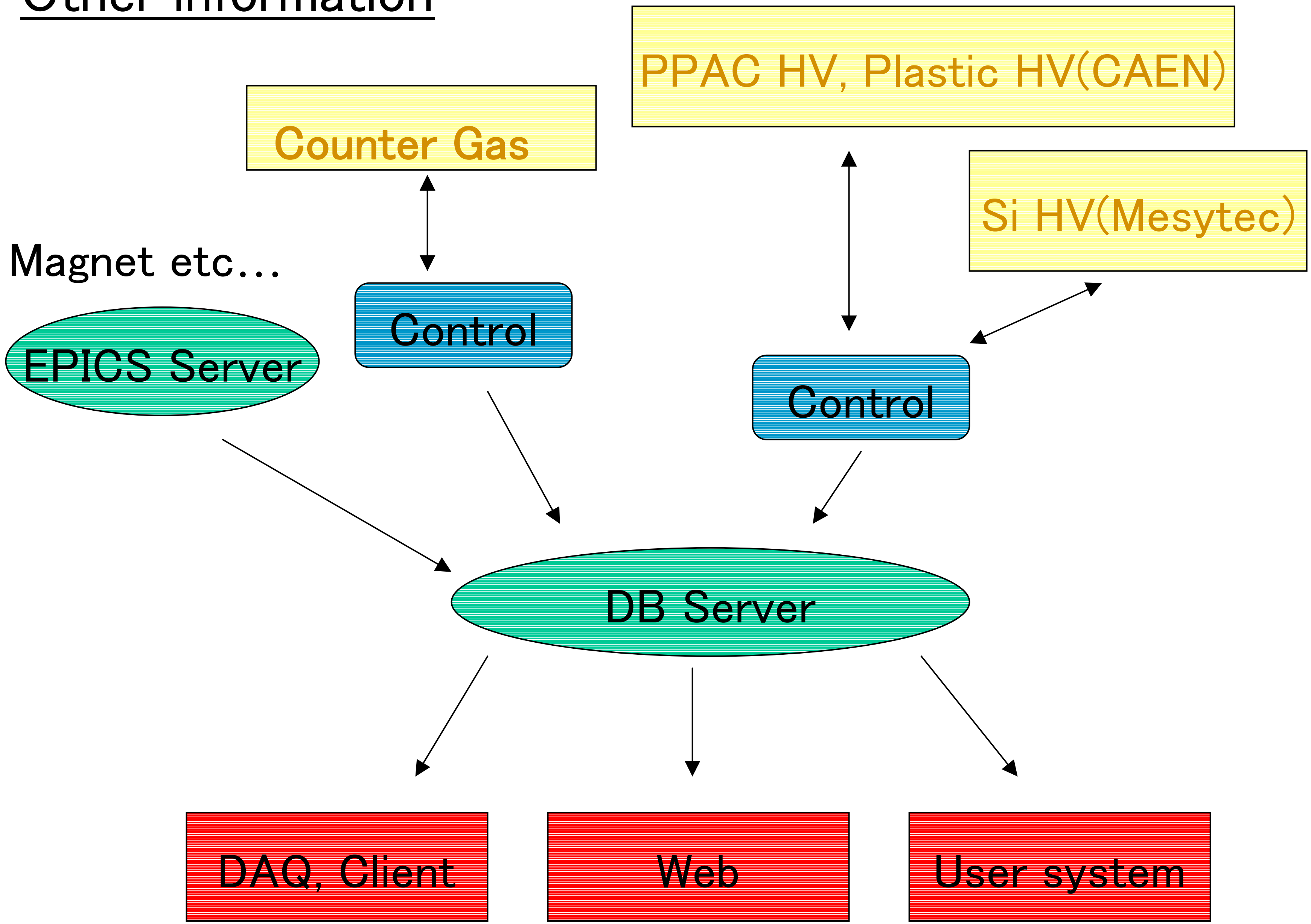





Exp. room
Counting room
User Trigger
Trigger
PPAC
Plastic
Fiber
Trigger
CC/NET
ADC,TDC
Network
Analog
IC,Si
ADC,TDC
CC/NET
Network
PC


User Trigger
BigRIPS
User
Trigger
CC/NET
User's DAQ System
ADC,TDC
Network
Network
Z,A
(Bρ, ΔE,TOF)
Network
PC
CC/NET

Other information



5: Summary

Detectors: PPAC, IC

Proto-type detectors have been developed.

Construction and development are going on.

Readout system

Signal transport system with optical fiber has been developed.

DAQ system: CC/NET

The proto-type system is under construction.

All detectors and DAQ system are scheduled to be ready at Autumn 2006.