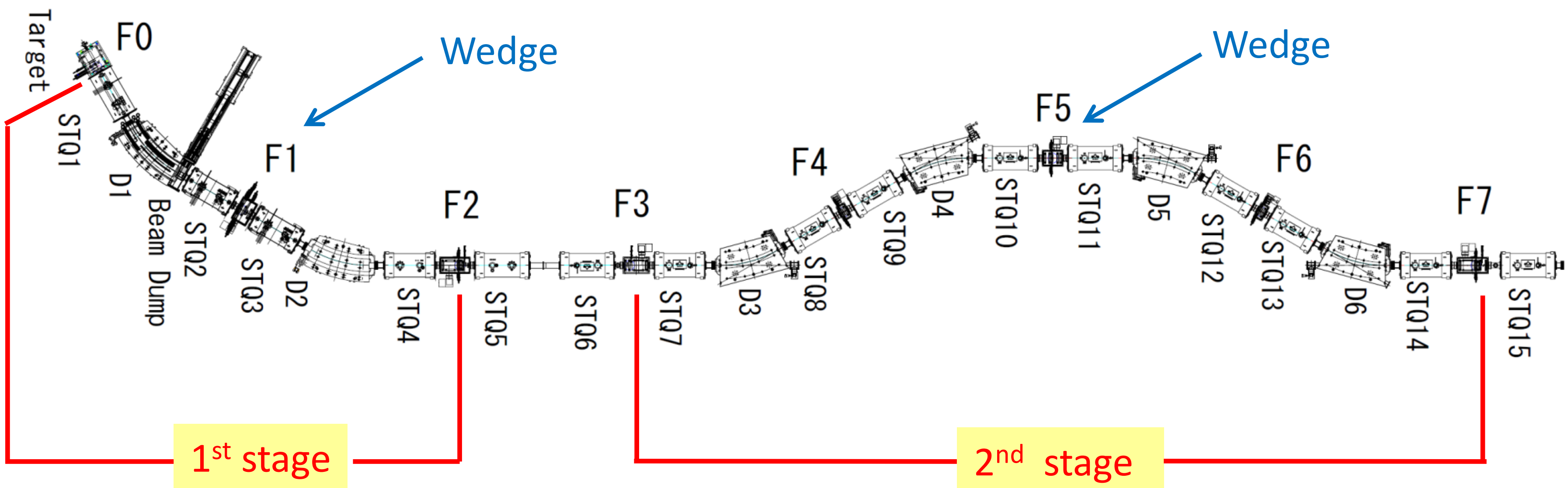
PPAC and analog signal TX/RX over optical fiber

Design, construction and R&D: H. Kumagai and T. Ohnishi

Naoki Fukuda
BigRIPS team, RIKEN Nishina Center

Layout of BigRIPS

Two-stage separator



Production
&
Separation

Particle identification
&
Two-stage separation

Detectors and particle identification at BigRIPS

ΔE-TOF-Bρ method with track reconstruction → Improve Bρ and TOF resolution

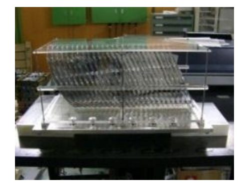
Measure ΔE,TOF, Bρ @ 2nd stage

↓ + isomeric γ-ray

Z, A/Q

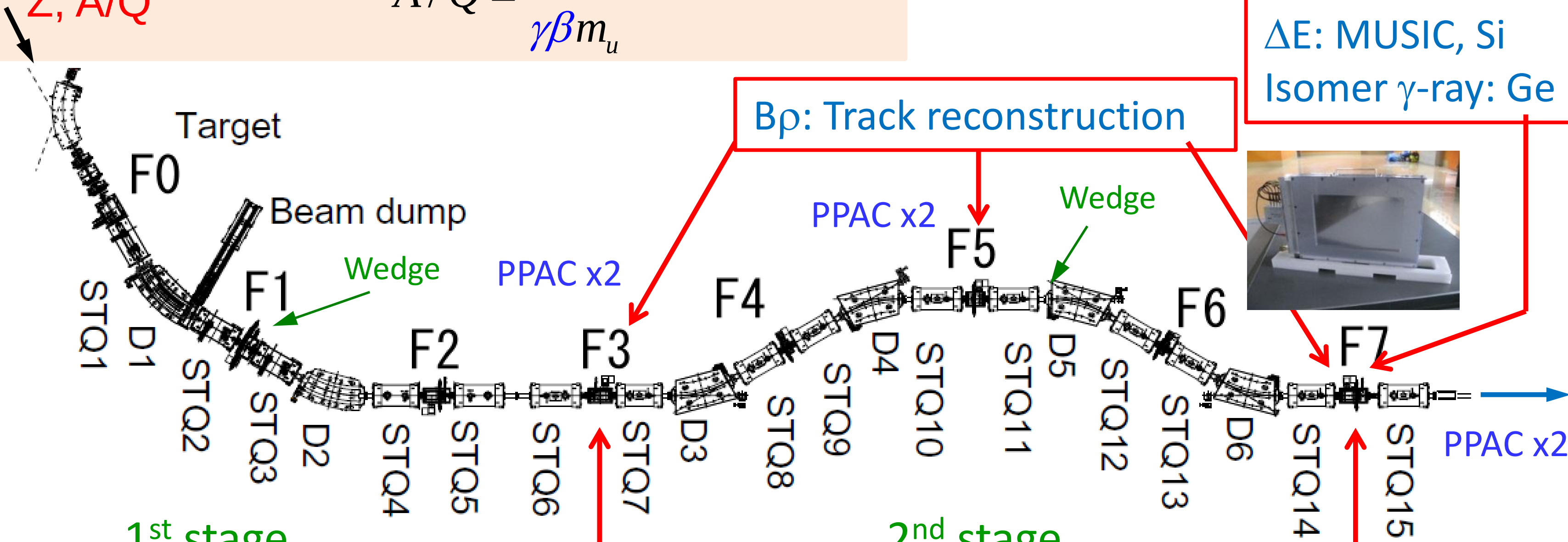
$$Z \leftarrow -dE/dx = \mathrm{f}\,(Z, \beta)$$

$$A/Q = \frac{B\rho}{\gamma\beta m_u}$$



ΔE: MUSIC, Si
Isomer γ-ray: Ge

Bρ: Track reconstruction



β: TOF

Plastic scintillator

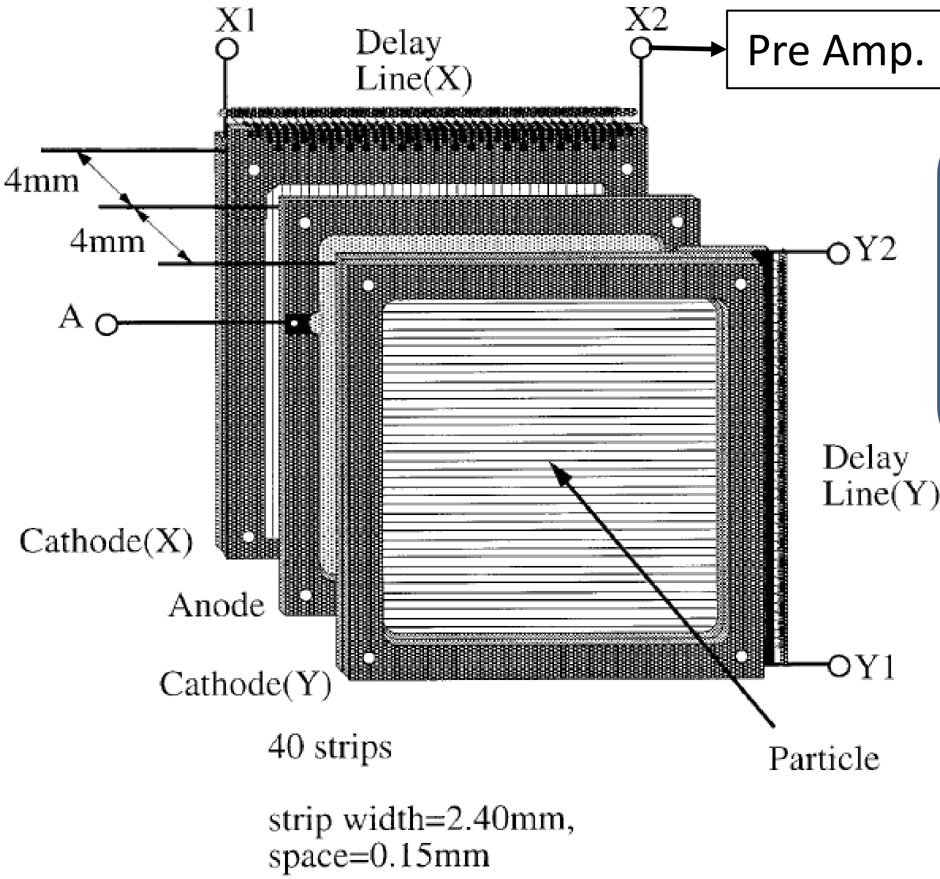
Parallel-Plate Avalanche Counter (PPAC) at BigRIPS

*The details are given in **H. Kumagai et al., NIM A470 (2001) 562***

- Delay-line read-out type that uses the fast electron pulses.
  → High counting rate : ~ 10^5 pps
  charge-division read-out type: 2 x 10^3 pps
  → Very wide dynamic range for nuclear charge *Z*
- Originally designed pre-amplifier
  → Large signal-to-noise ratio → High detection efficiency
- Usage of C_3F_8 gas at at pressure of 10-30 Torr
  - The rise time of the signal is fast.
  - C_3F_8 is not flammable.

Delay-line PPAC

Exploded view of the delay-line PPAC (100 x 100 mm^2)



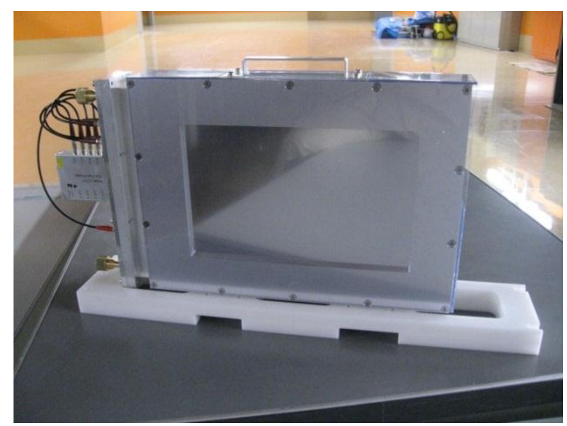
Pre Amp. → Fast Timing Amp. → CFD $\equiv T_{X2}$

$$P_X = k_X \times \frac{T_{X1} - T_{X2}}{2} \text{ (mm)}$$

$$P_Y = k_Y \times \frac{T_{Y1} - T_{Y2}}{2} \text{ (mm)}$$

k_X, k_Y: slope factors (typically 1.25 mm/ns)

Large window type : 240 mm x 150 mm



PPACs used at BigRIPS

List of PPACs used in BigRIPS

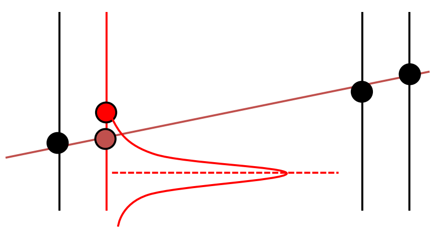
Dimension	Type	Focus
240 mm x 150 mm	Double	F3, F5, F7
150 mm x 150 mm	Double	F3, F7
240 mm x 150 mm	Single	F1, F2
150 mm x 150 mm	Single	F2
240 mm x 100 mm	Single	F4, F6

Position resolution with PPAC

Delayed-line Parallel plate avalanche counter
H. Kumagai et al., NIM A470 (2001) 562.
Position resolution : 1-1.5 mm (FWHM) in typical
 * Measurement with the fiber scint. (0.5mm)

The other evaluation reported by T. Oonishi 2008:

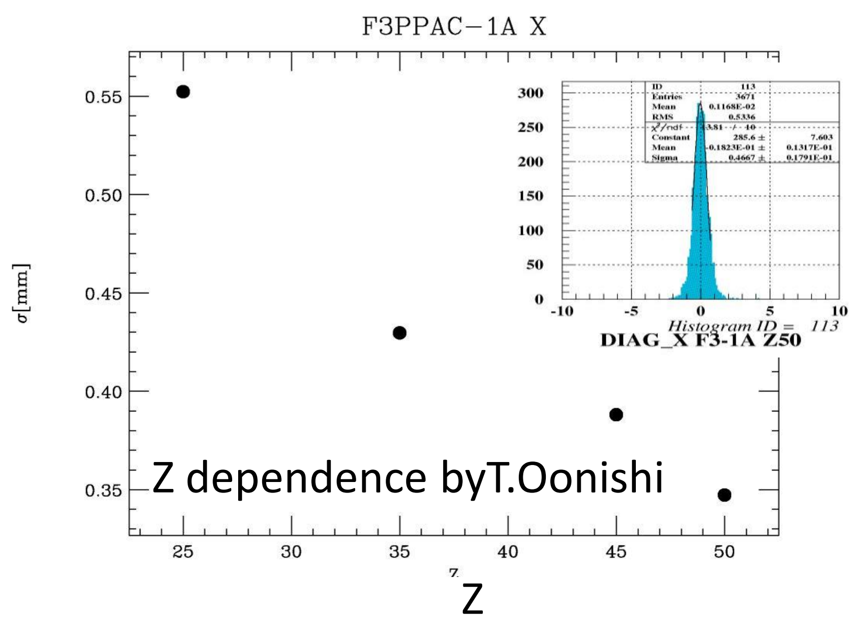
Residual distribution with respect to the tracking ray



Position resolution from Z=25 to 50

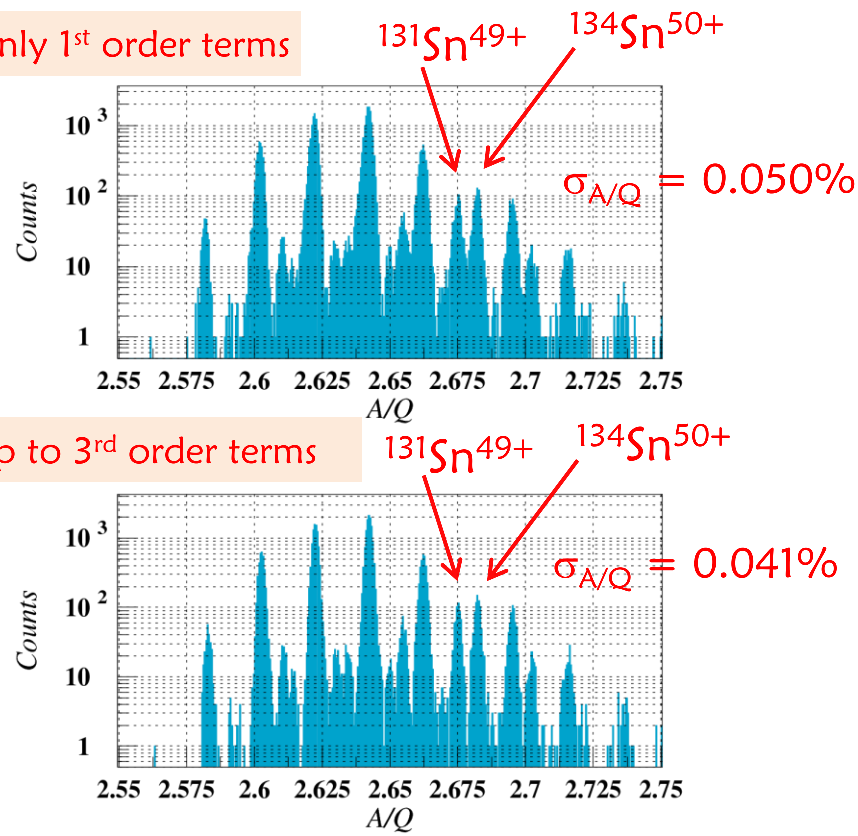
σ = 0.35 ～ 0.46 mm in typical
(FWHM: 0.8 ～ 1.1 mm)

* Z dependence observed



Resolution of A/Q

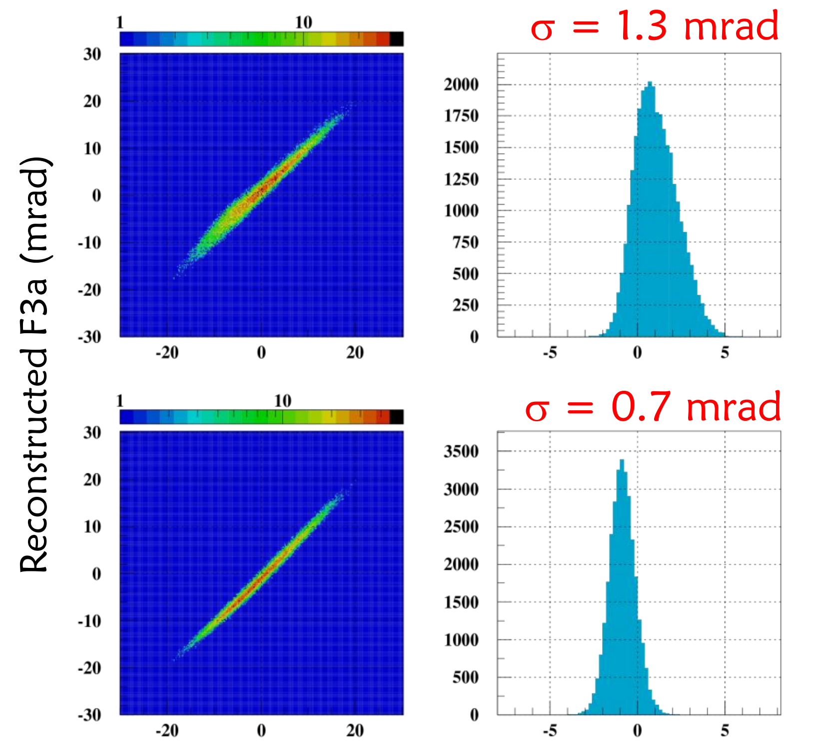
A/Q spectra for Sn isotopes



Typical resolution

Bρ: 0.037%, TOF(F3-F7): 0.017%

F3a deduced from track reconstruction



Z dependence of tracking efficiency for low Z

^{48}Ca 345MeV/A + Be 20 mm
A/Z=2 beam Bρ01= 4.75Tm

PPAC C_3F_8 30 Torr, HV 1640 V

^{12}C(Z=6) 241MeV/A

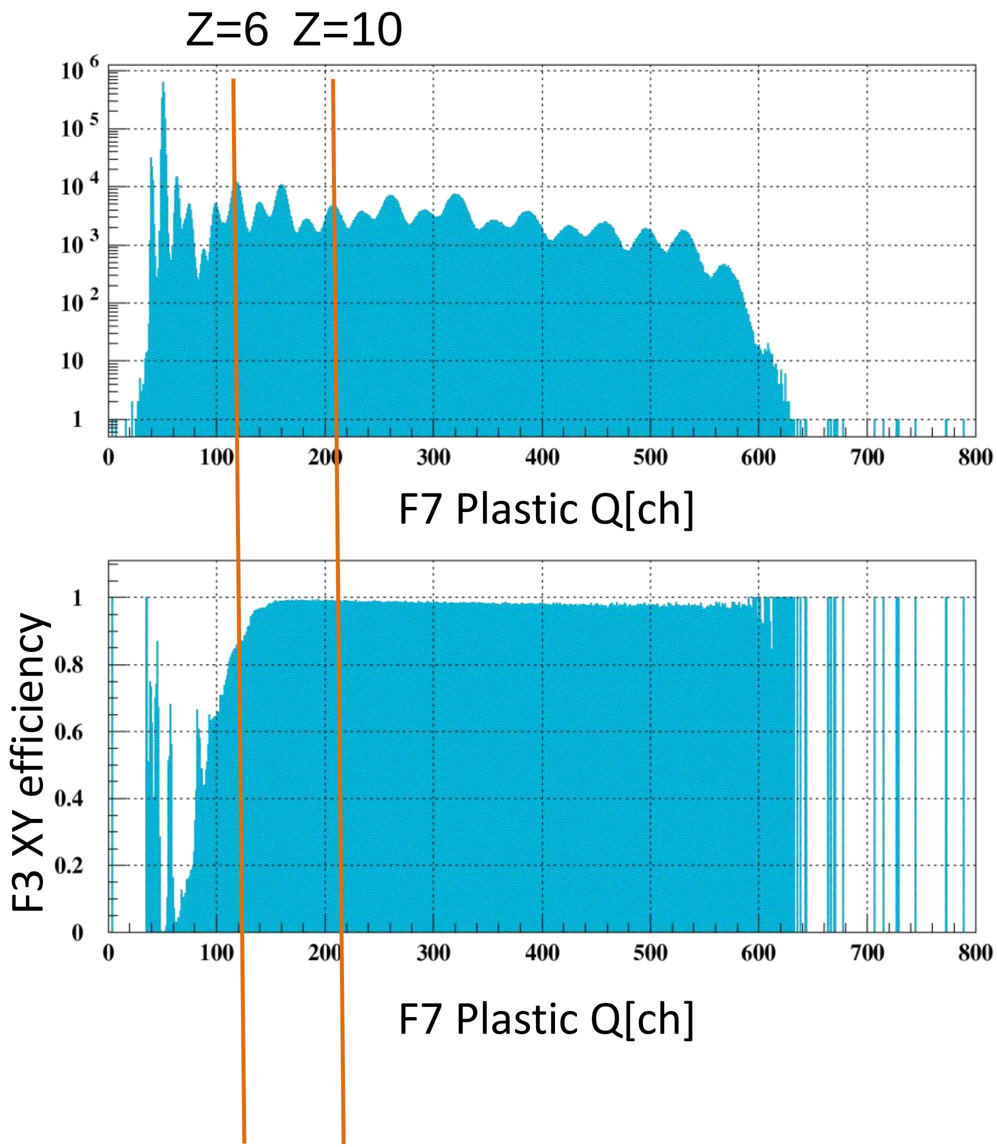
XY Track efficiency 85%

X track efficiency: 92%
(= Y track efficiency)

↓

One plane efficiency: 79%

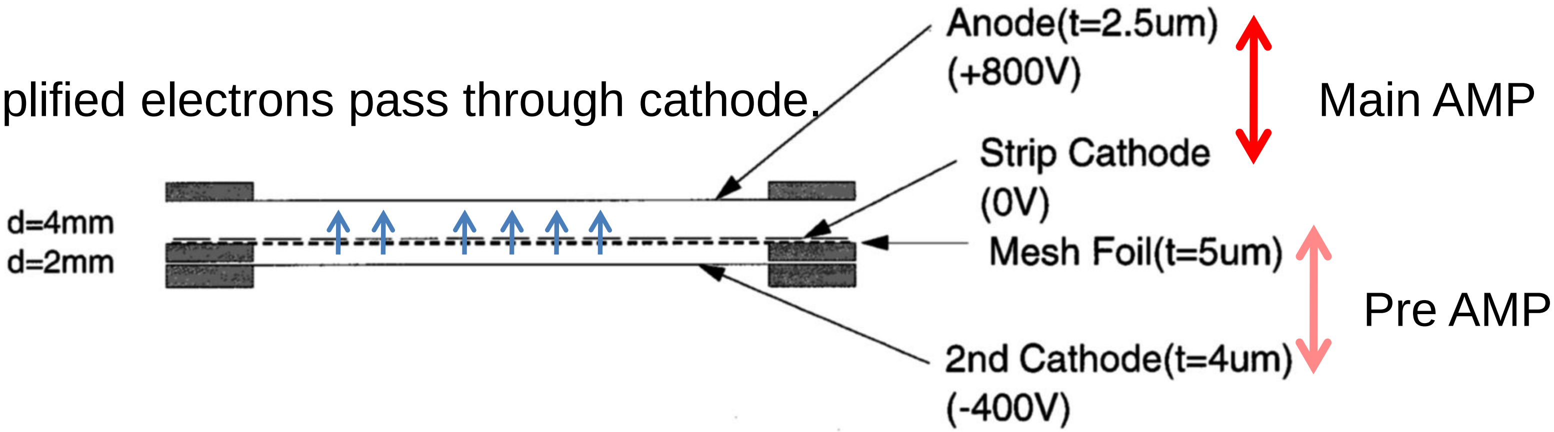
HV 1660V: ^{12}C effciency > 95 %



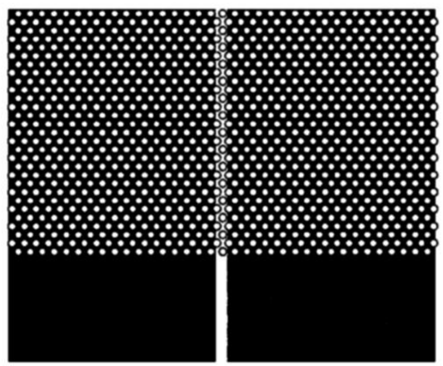
Tandem PPAC

H. Kumagai

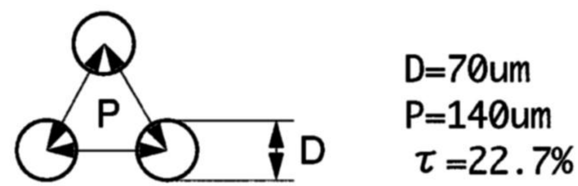
Pre-amplified electrons pass through cathode.



Gas : C4H10(10Torr)



Cathodeの拡大図(X10)

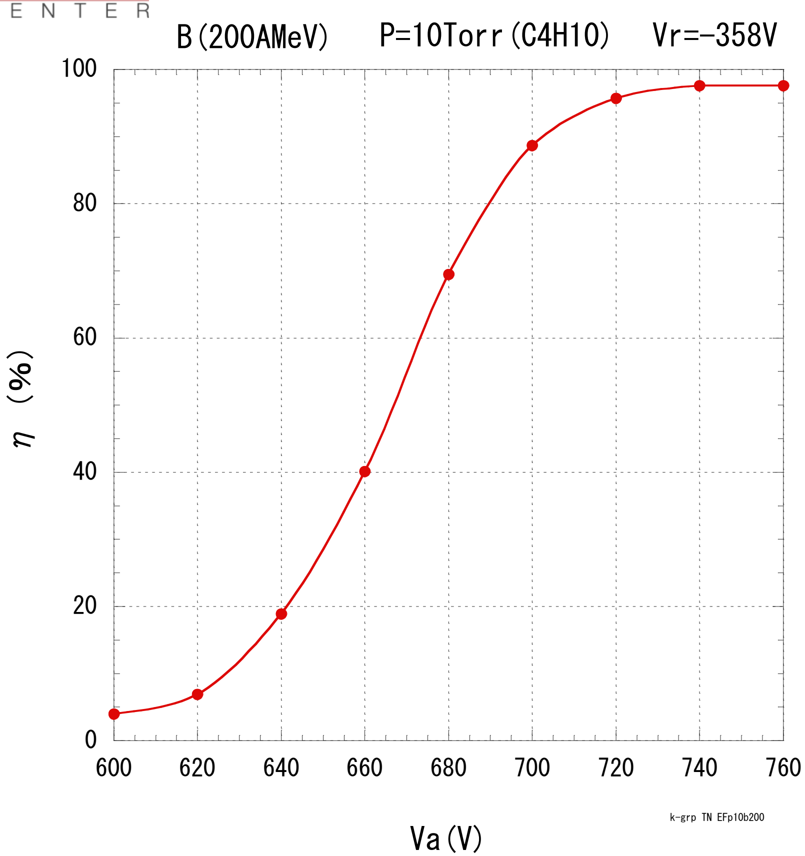


Meshのパターン

Large gain with low operation voltage → small damage on spark

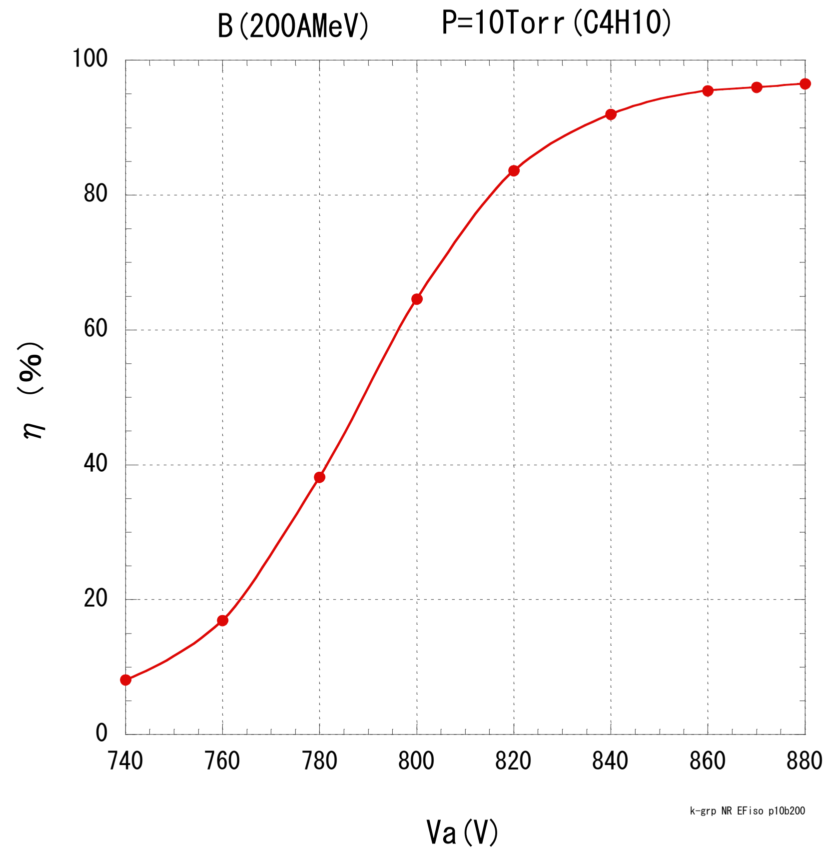
Detection efficiency for ^{12}B(200AMeV)

Tandem



HV 740V Eff. 98%

Normal



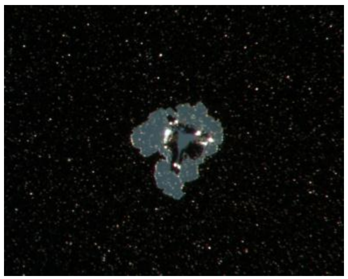
HV 880V Eff. 97%

Low operation voltage → Small damage at discharge

PPAC electrode:

- Al-evaporated mylar foil

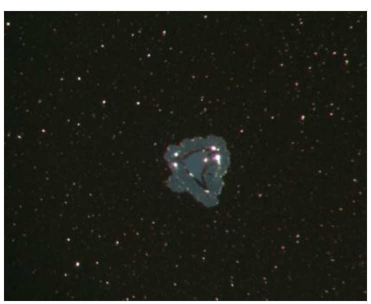
→ discharge behavior is not prefer to the PPAC operation



Cathode : Al(thickness 555 Å)

Cu-evaporate mylar foil

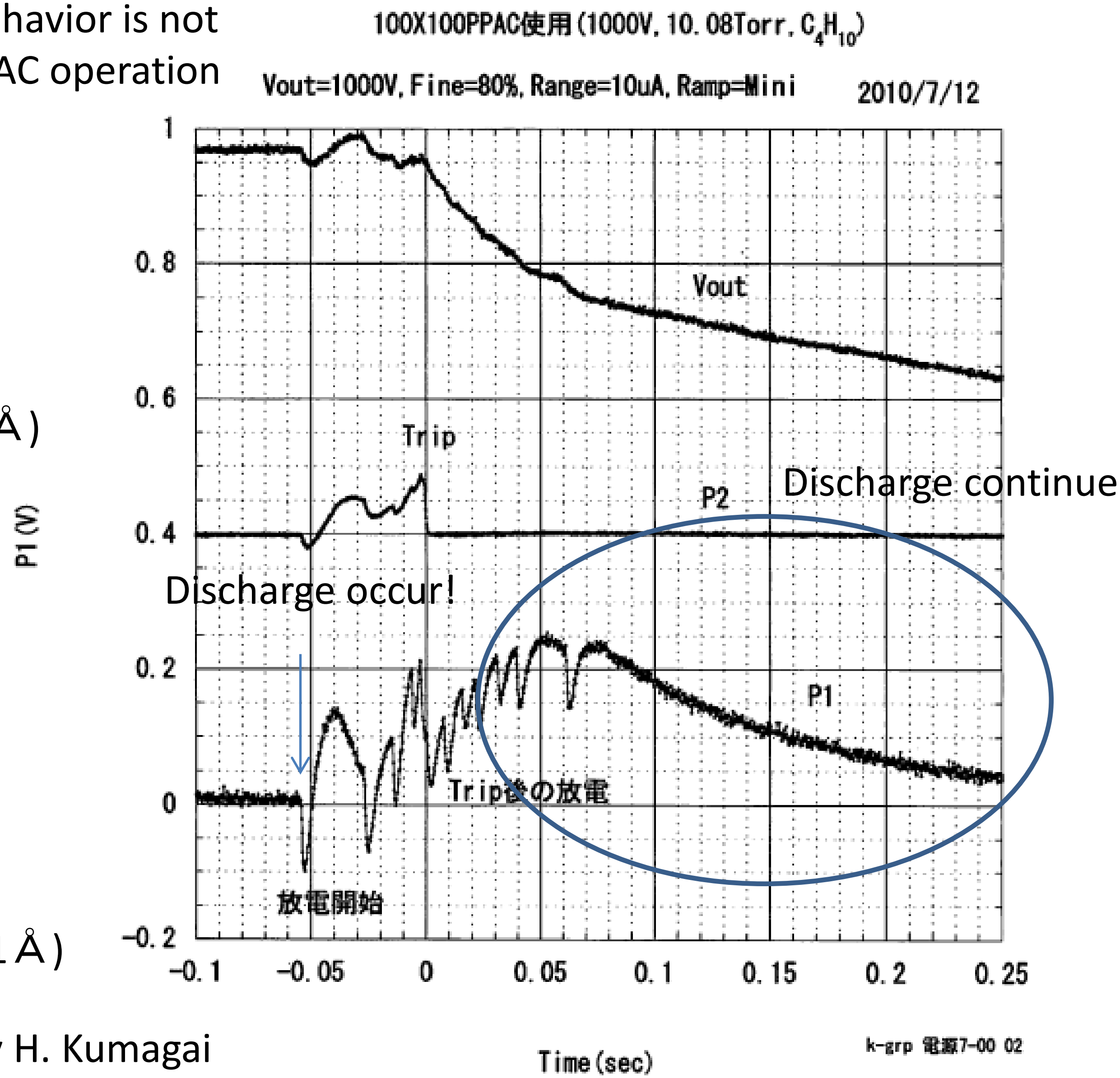
→ good result



Cathode: Cu(thickness 301 Å)

Photo’s and plots given by H. Kumagai

Observation of the discharging of Al-evaporated mylar foil



Analog signal TX/RX over optical fiber

RIKEN NiSHiNA CENTER

Read out system for BigRIPS

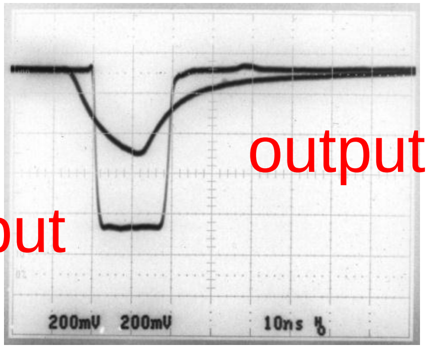
RIBF Experimental hall at B2F

～100 m

Counting room at B3F

Coaxial Cable : Large attenuation

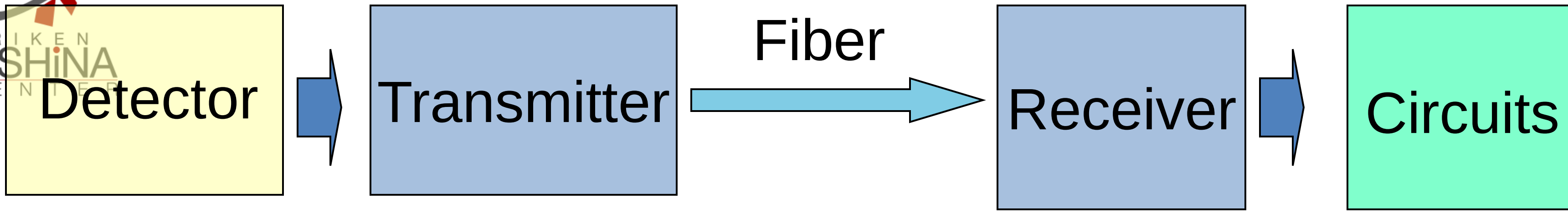
NIM



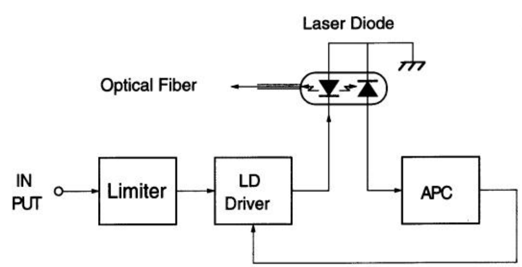
Transport system with optical fiber

- No attenuation
- Good linearity: higher order effect < 0.1%
- Small time jitters: < at least 30ps(σ)
- Radiation hardness

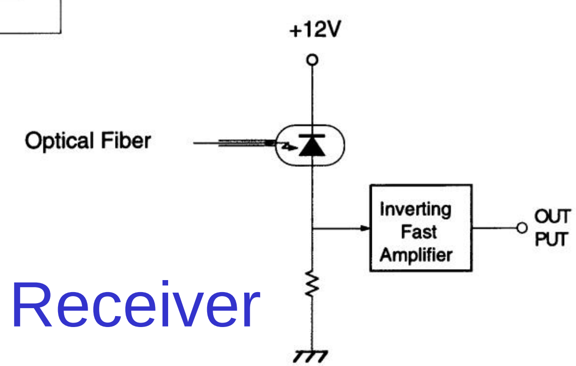
Fiber system using Laser diode



- 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.

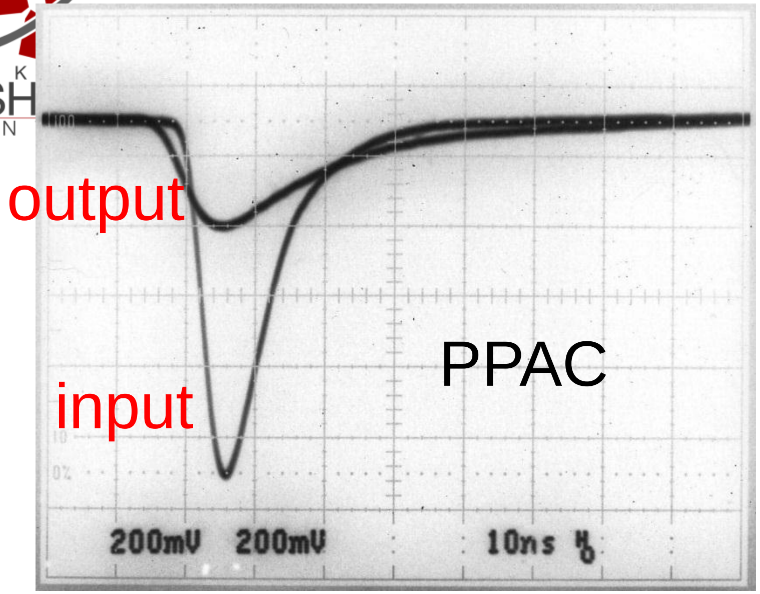


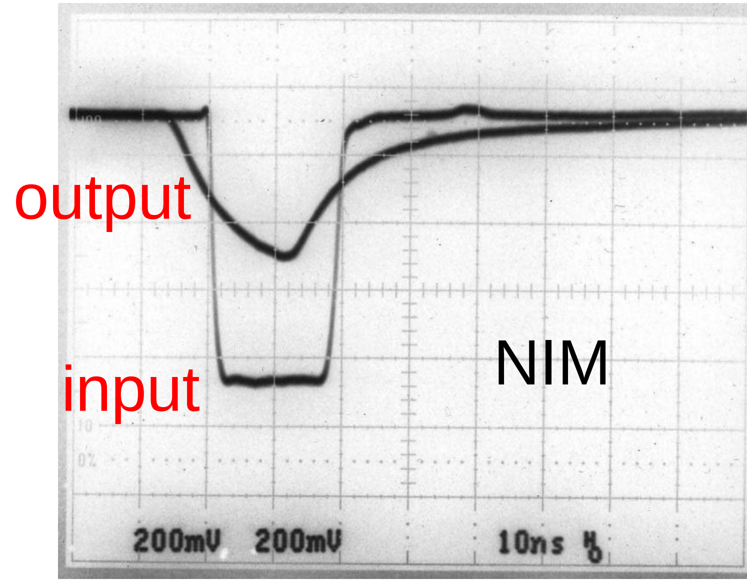
Transmitter



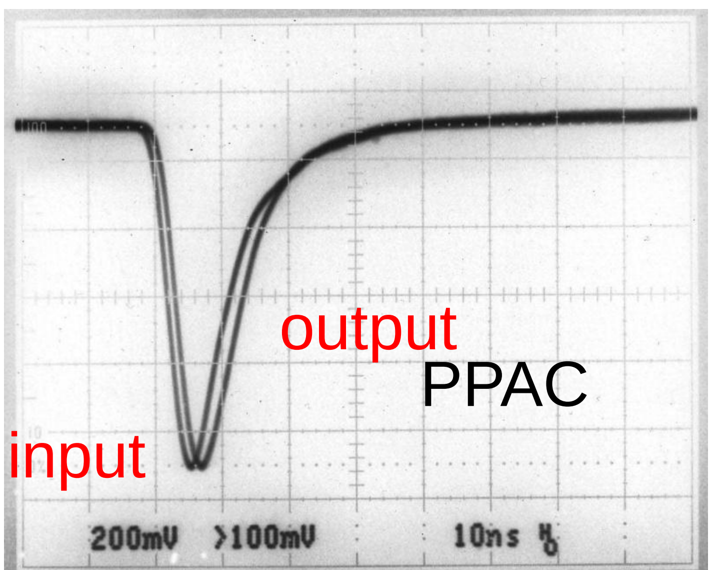
Receiver

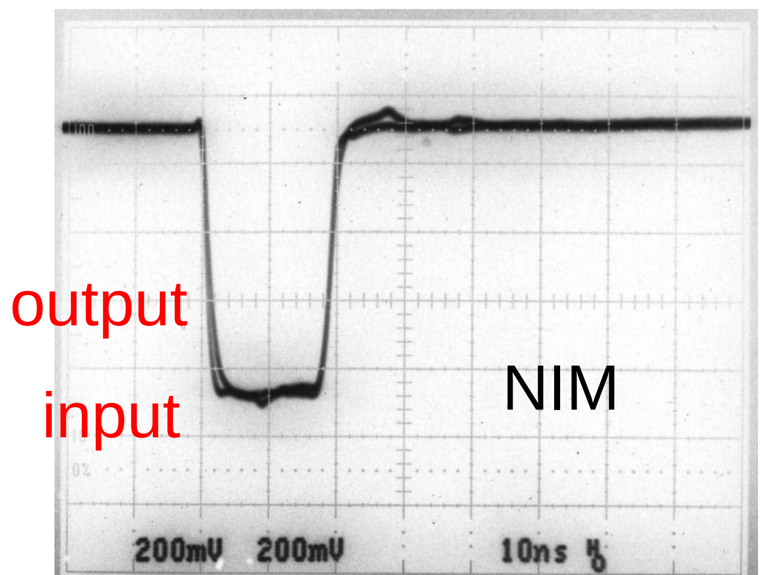
100 m Coaxial cable





100 m fiber cable

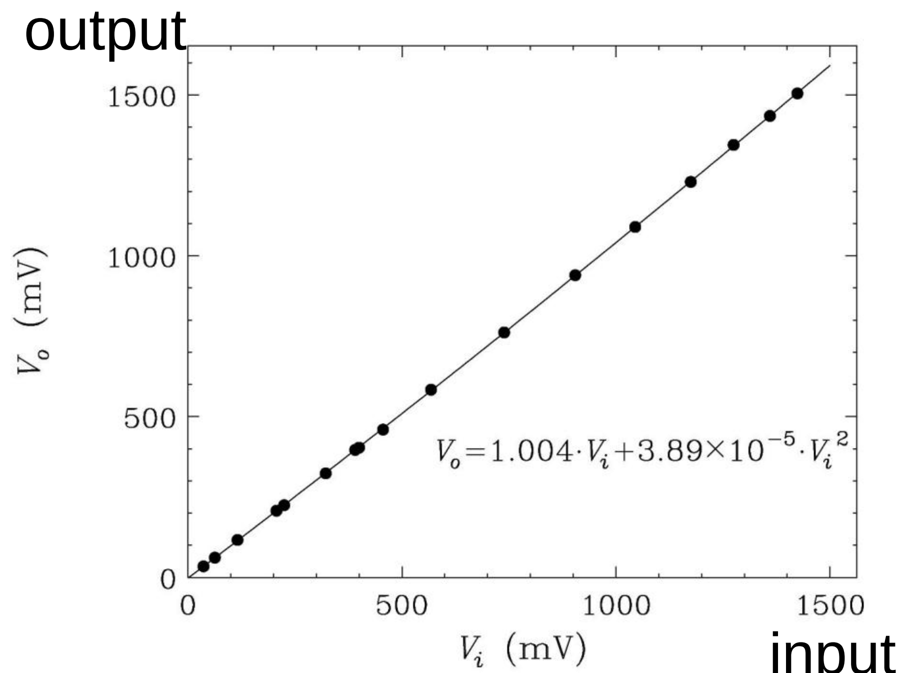




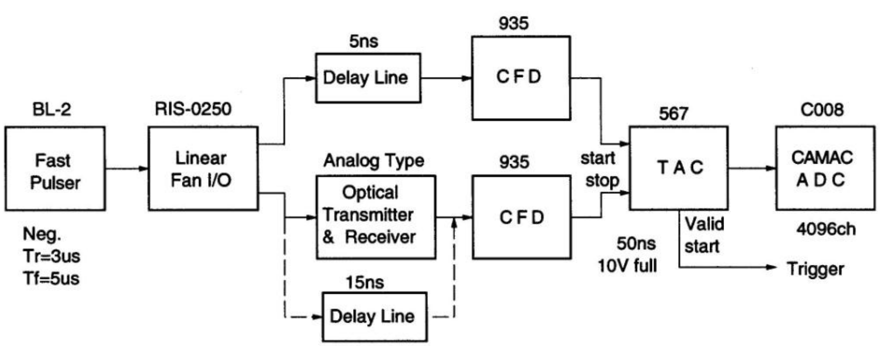
Linearity

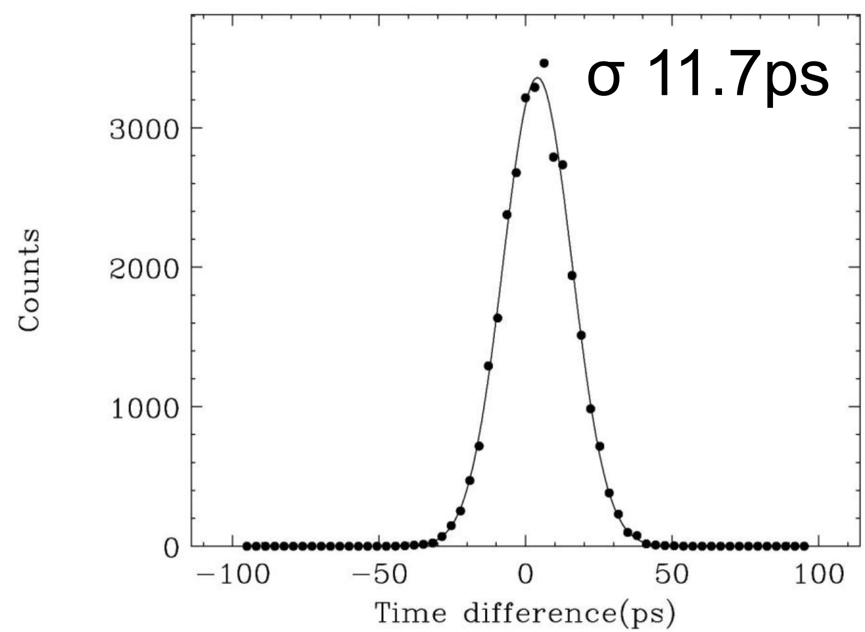
100 m Optical fiber

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



Time jitter





Measurement system: 10.7ps

Intrinsic jitter:σ 4.8 ps(σ)

Property of fiber system

- Temperature dependence

0.43%/1°C (Constant temperature oven)

⇨ Variation of laser diode's gain

- Rate dependence

AC coupling : base line shift at high rate

NIM signal case: 50ps time shift at 1 MHz

- Radiation damage

Using ^{70}Zn beam at RIKEN RILAC

No effect after 10^9 neutron irradiation

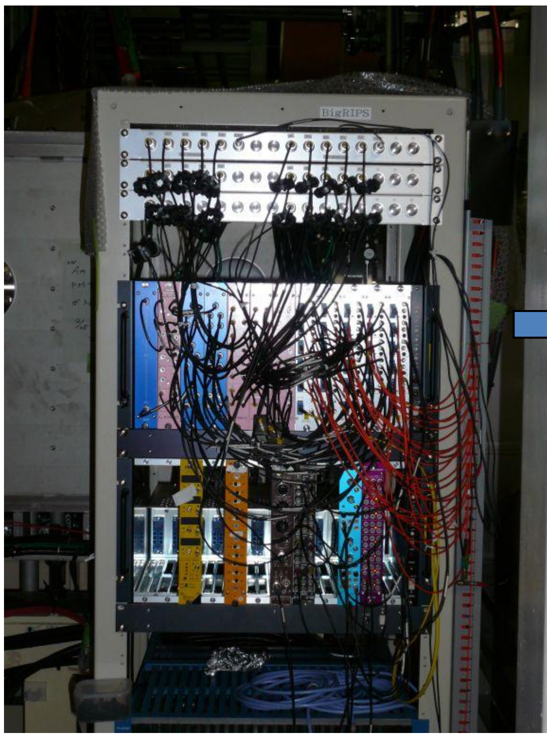
BigRIPS: ～100 channels are installed.

Optical fiber system +1.5μs Delay Box

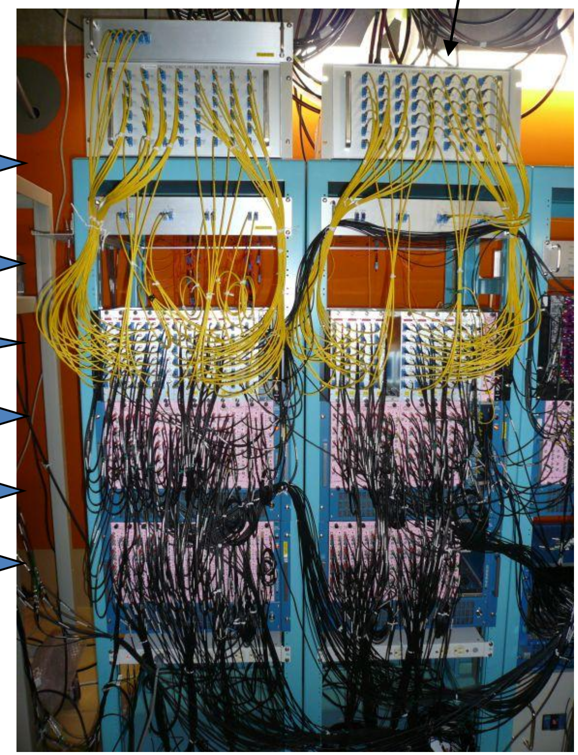
1Box:48ch 1.5μs delay

300m

F3



F1-F7



F1

F2

F4,6

F5

F7