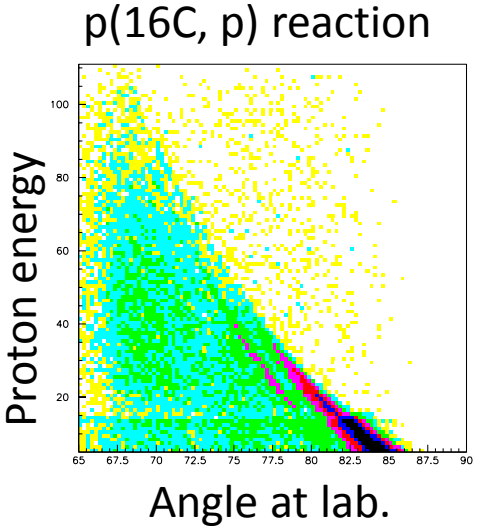
To perform scattering experiments with BigRIPS

-Study of high-intensity and high-Z secondary beam detection-

Juzo Zenihiro, RNC

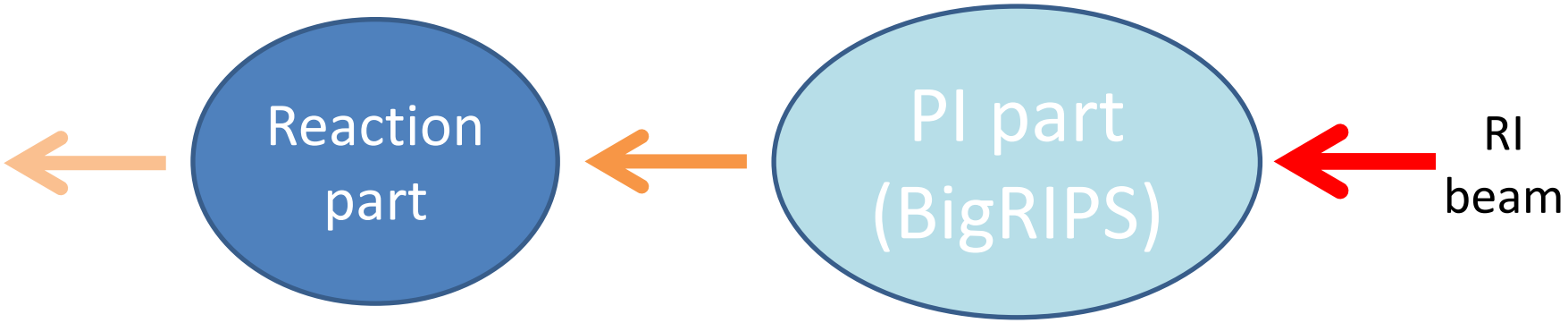
Background

- In recent years, more and more reaction experiments using high-intensity and/or high-Z RI beam have been proposed at RIBF.
- Some of them has been already performed.
  - 132Sn(p, n) (Sasano-san), 16C(p, p) elastic (ESPRI), etc.
- Planned experiments
  - (p, p) elastic & inelastic, polarized (p, p), (p,2p), (p, pa), etc.
- Let's take the case of **^{132}Sn** beam for ESPRI & CAT experiment as an typical example.
  - NP1112-RIBF79 (ESPRI) : p-elastic
  - NP1312-RIBF113 (CAT) : d-inelastic at 0-degree



Requirements

Assuming typical 1-week experiment



- ✓ Trigger detector
- ✓ Tracking detector
- ✓ Target

- ✓ TOF detector
- ✓ dE detector
- ✓ Tracking or position detector

Target thickness is typically about 10 mg/cm2

→ To get enough statistics, we need **10^5 cps** RI beam on target.

Experimental difficulties

10^5 cps heavy RI beam (Z ~ 50, total rate up to 10^6 cps) causes serious problems.

PI
- ✓ F3, F7 Plastic scintillator (TOF) → radiation damage
- ✓ Ion chamber (dE) → pile up
- ✓ PPAC (tracking) → radiation damage

reaction
- ✓ MWDC (tracking) → increase of multi-track events
- ✓ Trigger plastic scintillator →radiation damage

Some ideas

Particle Identification

- ✓ TOF : Diamond detector (SHARAQ, and → Sato-san's talk?)
- ✓ dE : 1. Ion chamber with flashADC (→ Sasano-san's talk),
  2. indirect energy loss with degrader (→ Fukuda-san's talk?)
  (3. Thin solid Ar(Xe) scintillator (ESPRI))
- ✓ Tracking : MWDC (SHARAQ BLD)

Beam tracking on target

- ✓ Tracking : new MWDC + Segmented trigger scintillator (ESPRI)

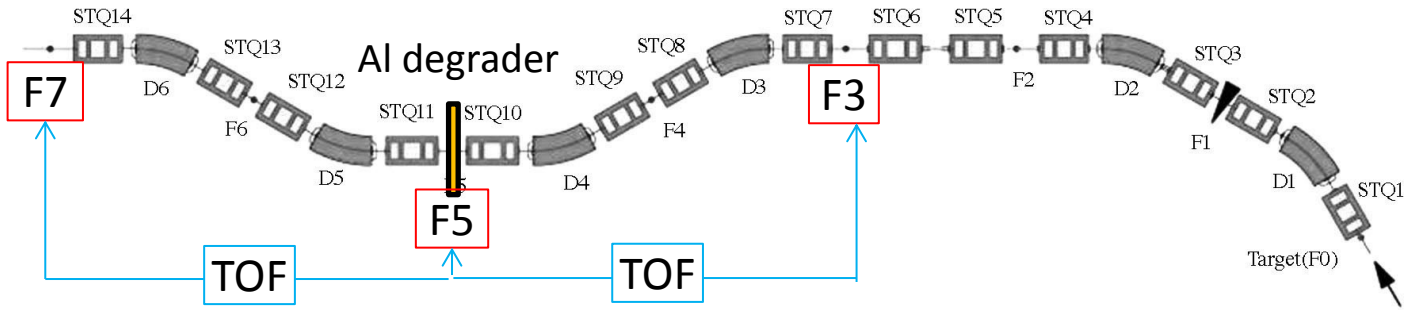
→ ESPRI Gr. made new MWDCs and prototype segmented scintillator. They were tested with high-intensity Xe beam at HIMAC (14H329).

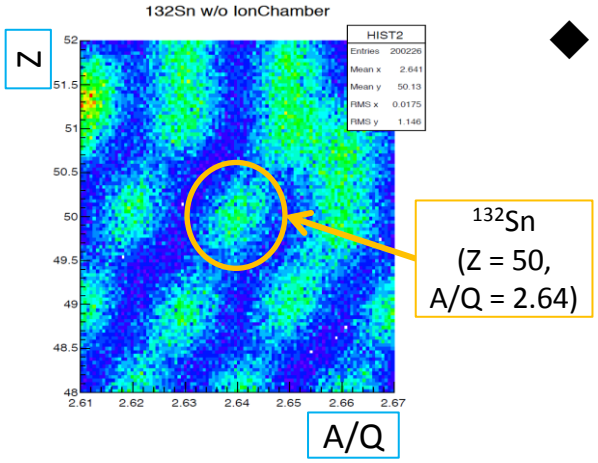
→ CNS Gr. also tested SHARAQ BLD and Diamond detector as well as CNS Active Target with Xe beam at HIMAC (H307).

Indirect energy loss measurement

New method

- Indirect measurement of energy loss
  - ✓ Energy loss in Al degrader (< 10 mm) at F5 detected by difference between F3-F5 & F5-F7 TOF+Bρ information.
  - ✓ MWDCs (or MWPC @F5 only) & TOF detectors at F3, F5, and F7
  - ✓ No need additional detector





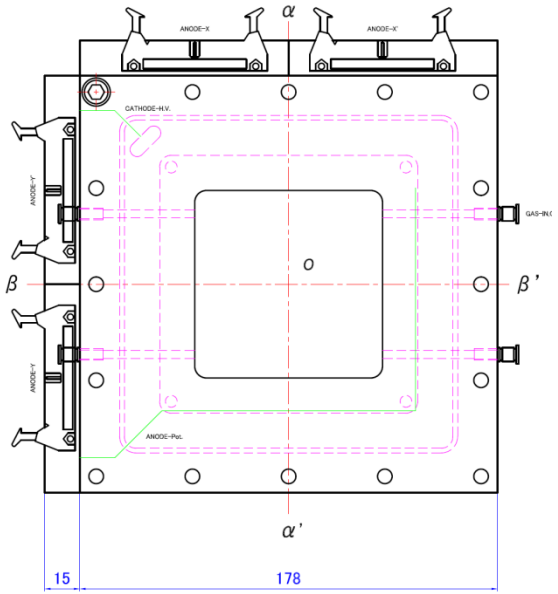
- Monte Carlo simulation result
  - ✓ Around 132Sn at 300MeV/u
  - ✓ ~5mm Al degrader at F5
  - ✓ Overall timing resolution : 100 psec in sigma
  - ✓ A/Q resolution : 0.2 % in sigma
  - ✓ w/o charge state

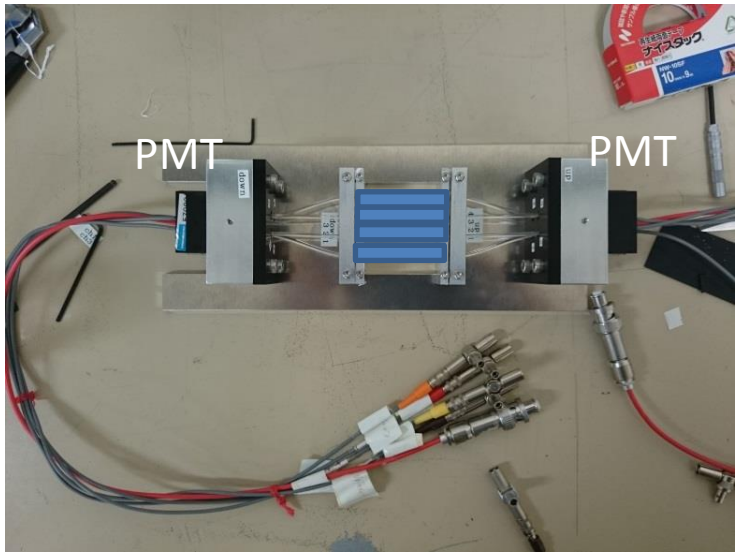
→ $\delta Z = 0.3$: worse than Ion chamber (~0.2), but not bad.

MWDCs and segmented scintillator

New 2 MWDCs (almost the same as SAMURAI BDCs)

- Design : 2.5mm wire spacing, 16ch x 8 planes (x,x',y,y',x,x',y,y')
- low-pressure mode operation : 20 ~ 100 Torr i-C4H10 gas
- Drift time : less than 100 nsec
- Good position resolution under high-intensity RI beam up to 10^6 pps of RI (Z ~ 50) is expected: r.m.s ~ 150um (PPAC : ~ 0.5 mm)



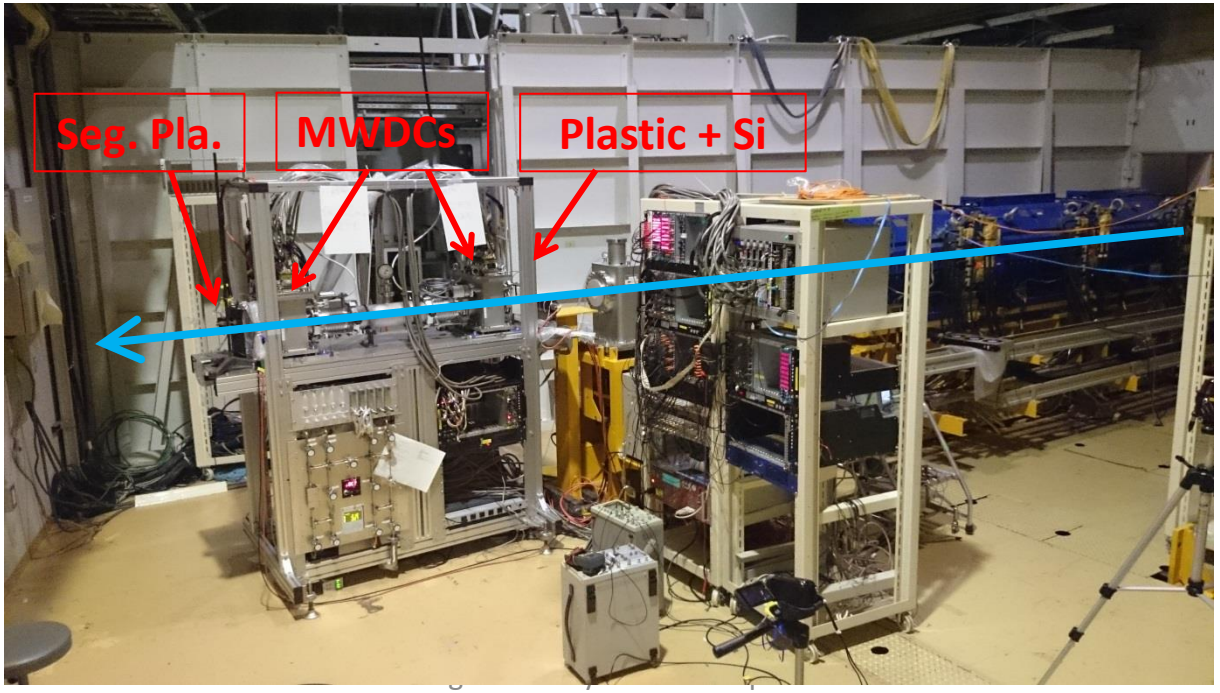


Segmented plastic scintillator (prototype)

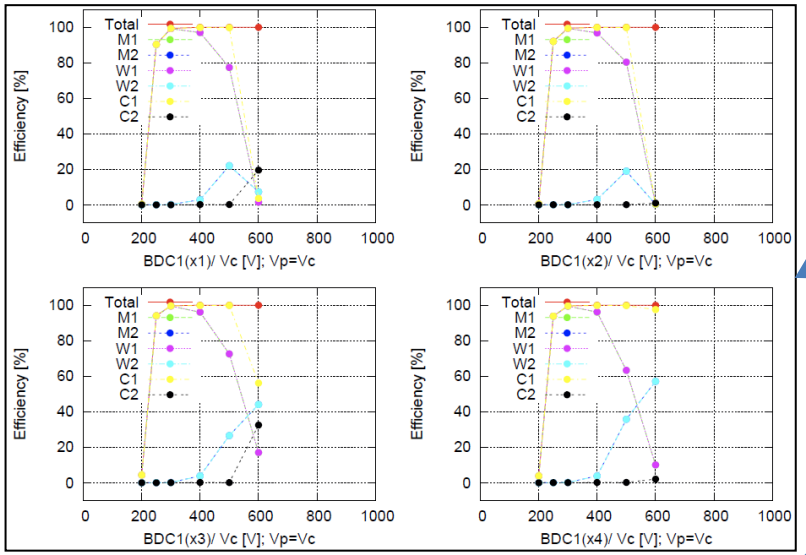
- 4 segments (1cm x 5 cm x 0.2mmt)
- 4ch multi-anode PMT
- To help multi track analysis

Test experiment at HIMAC (14H329)

- ^{132}Xe @ 200, 300, 400 MeV/u up to 10^6 cps
- New MWDCs and segmented scintillator were tested in July 2014.
- Offline analysis by Wen-san is now ongoing.
- From online analysis, we have already taken good efficiency curves and good position resolutions (less than 80 um in sigma).



Online

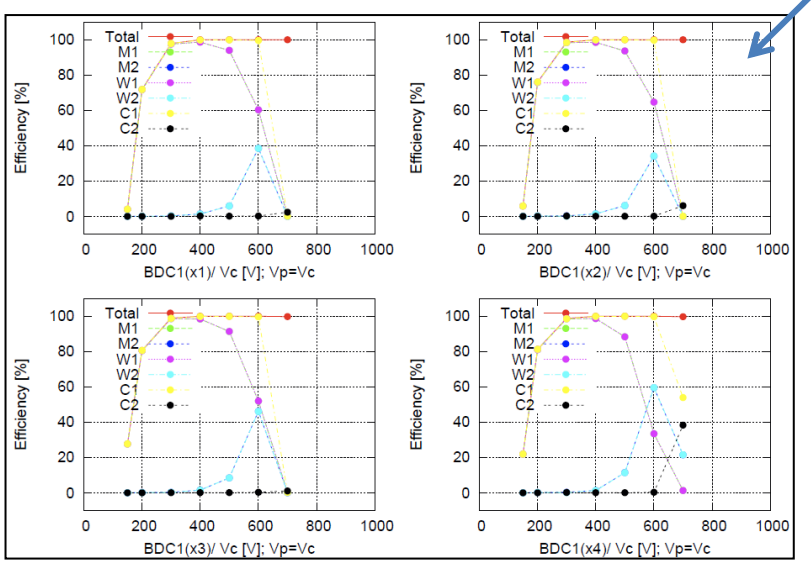


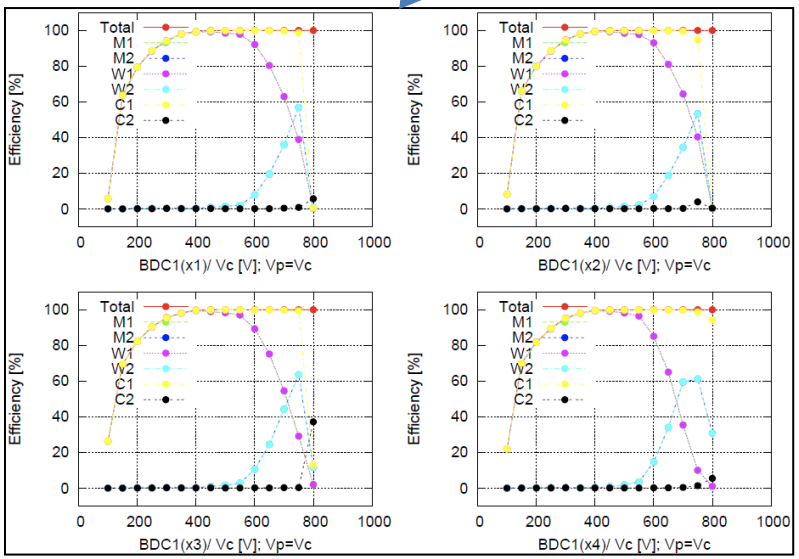
50 Torr

Efficiency curves (200MeV/u)

100 Torr

200 Torr





Summary

- To perform scattering experiment with RI beam, we need high-intensity RI beam (10^5 cps)
- We have found that present beam line detectors cannot tolerate such a high-intensity & high-Z beam.
  - Radiation damage
  - Pile up
  - Multi-track event
- Several ideas to solve the problems
  - Diamond detector, indirect energy loss measurement, etc.
- ESPRI Gr. has now developed new MWDC and segmented scintillator. Basic performance of MWDCs are checked by online. (long plateau and good position resolutions)
- CNS Active Target Gr. has also tested diamond detector and SHARAQ-BLD (MWDC)