Requirements of detector for SHARAQ

Tomohiro Uesaka
CNS, University of Tokyo

S. Shimoura, A. Saito, S. Michimasa, H. Miya,
H. Sakai, T. Kawabata, K. Nakanishi, Y. Sasamoto,
(University of Tokyo)
T. Kubo, Y. Yanagisawa
(RIKEN Nishina Center)
G.P.Berg
(Notre Dame)

Energy resolution

$\Delta E \sim 500 keV$ for $A=12$、$E/A=300MeV$ particle

$0.5MeV/(300 \times 12)MeV = 1.3 \times 10^{-4}$

$\rightarrow$ corresponds to momentum resolution of $p/\Delta p \sim 15000$

Angular resolution $\Leftrightarrow$ momentum transfer resolution

crucial in experiments with heavy ion beams,

where momentum of beam particle is huge

ex. ^{12}N, 300MeV/A   9GeV/c

CRITERION: $\Delta q < 0.1$ fm^{-1}

$\Delta q \sim$ p(beam) $\times \Delta\theta$ $\rightarrow$ $\Delta\theta < 2$ mrad

$\Delta\theta = 1$ mrad

Maximum rigidity

6.8 Tm

Momentum resolution
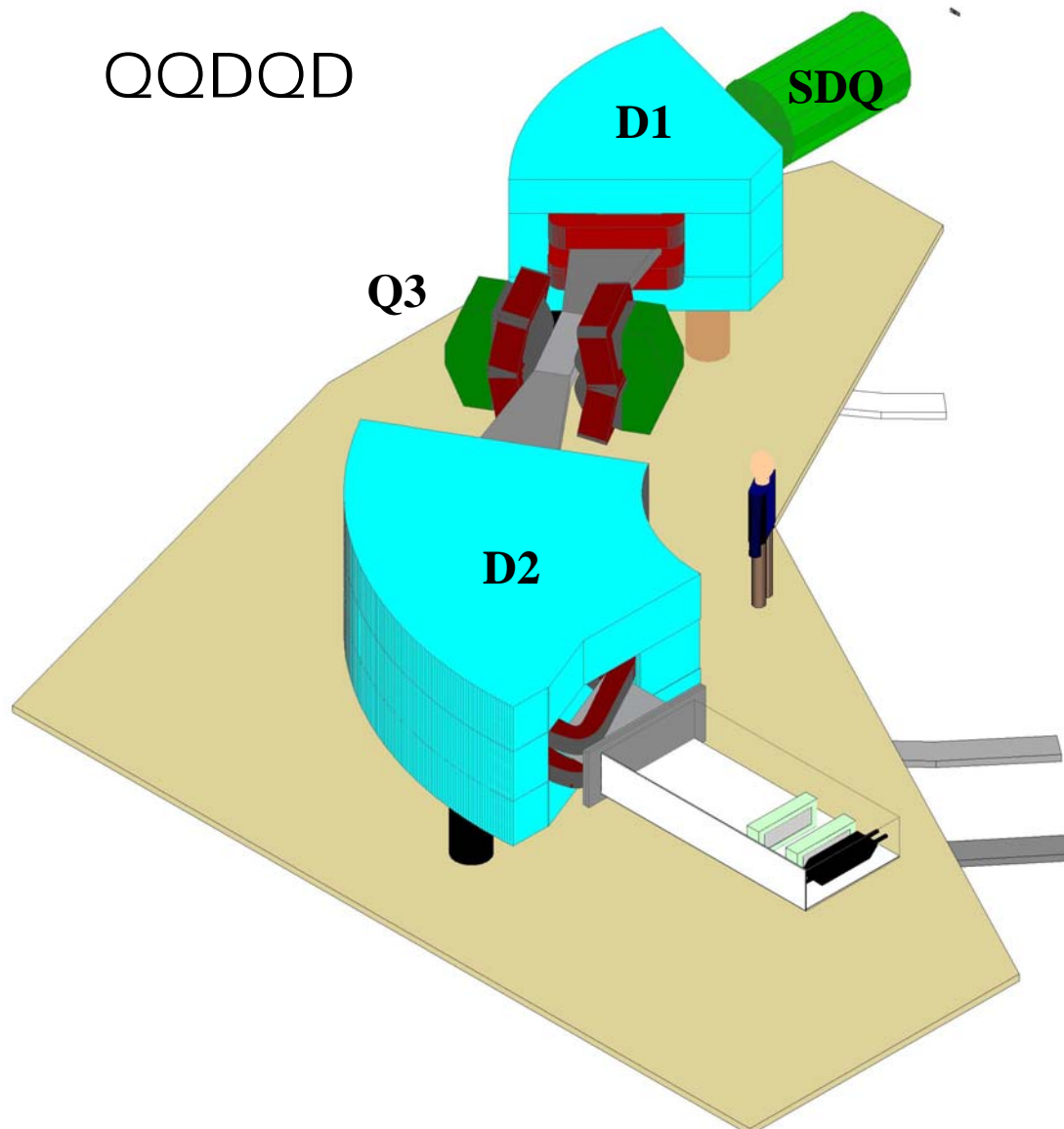
dp/p = 1/14700

Angular resolution

~ 1 mrad

Momentum acceptance

± 1%

Angular acceptance

~ 5 msr

QQDQD

SDQ

D1

Q3

D2

CNS

$$\begin{array}{cccccc} x & \theta & y & \phi & t & \delta \\ \begin{pmatrix} -0.3974 & -0.0000 & 0.0000 & 0.0000 & 0.0000 & -5.8582 \\ -0.7727 & -2.5164 & 0.0000 & 0.0000 & 0.0000 & 0.6608 \\ 0.0000 & 0.0000 & -0.0000 & -2.3039 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.4340 & -0.1971 & 0.0000 & 0.0000 \\ -0.2948 & -0.9073 & 0.0000 & 0.0000 & 1.0000 & -0.0279 \\ 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 1.0000 \end{pmatrix} \end{array}$$

Small horizontal magnification of 0.4

→ **Δx of FP detectors should be < 0.4 mm**
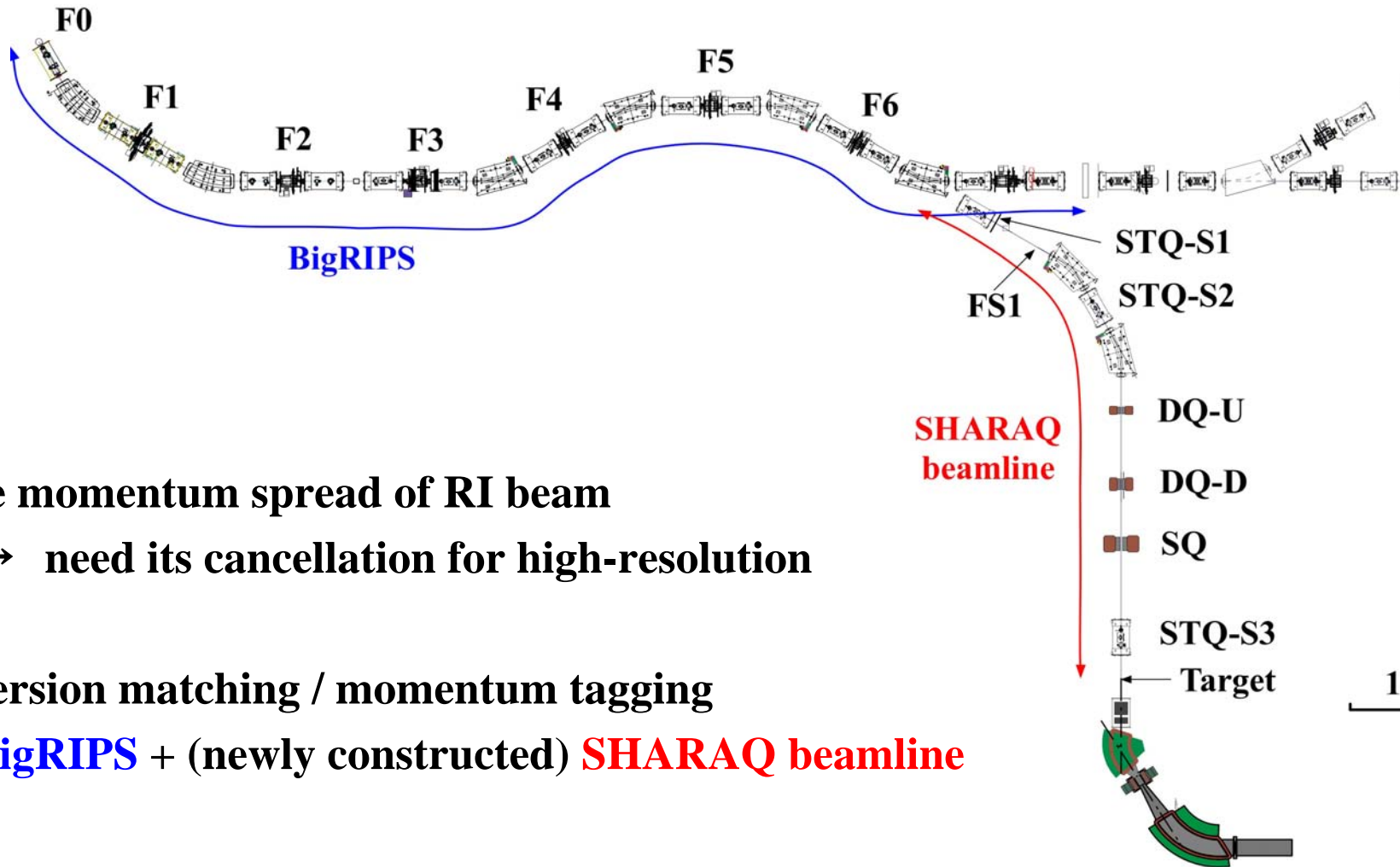
(image size of 1 mm is assumed)

Angular magnification in horizontal plane of 2.5

CRDC is being made under UT-GANIL collaboration
→ **Michimasa's talk**

requirement for Δy is more or less relaxed, ~ 1–2 mm.

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large momentum spread of RI beam
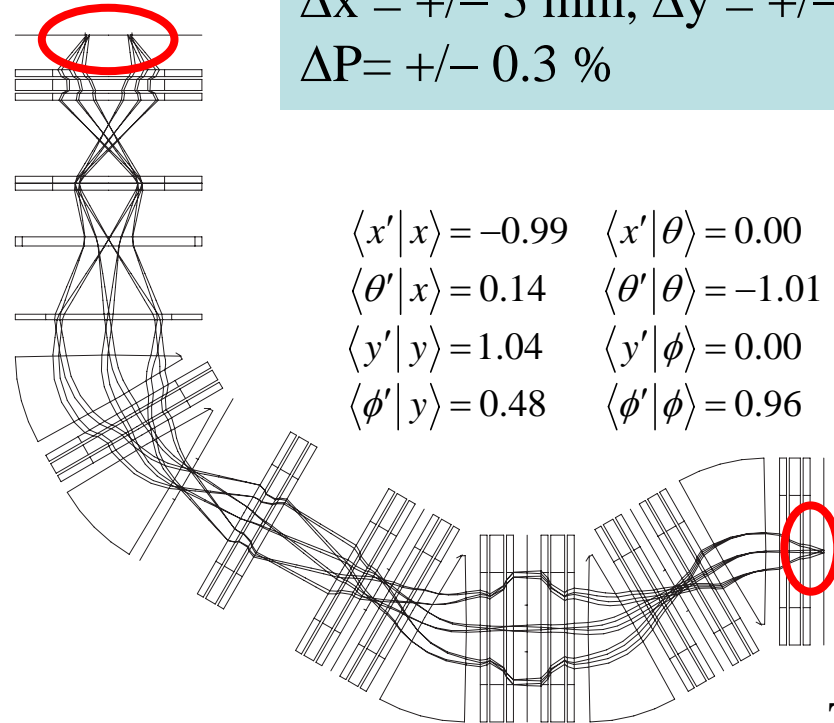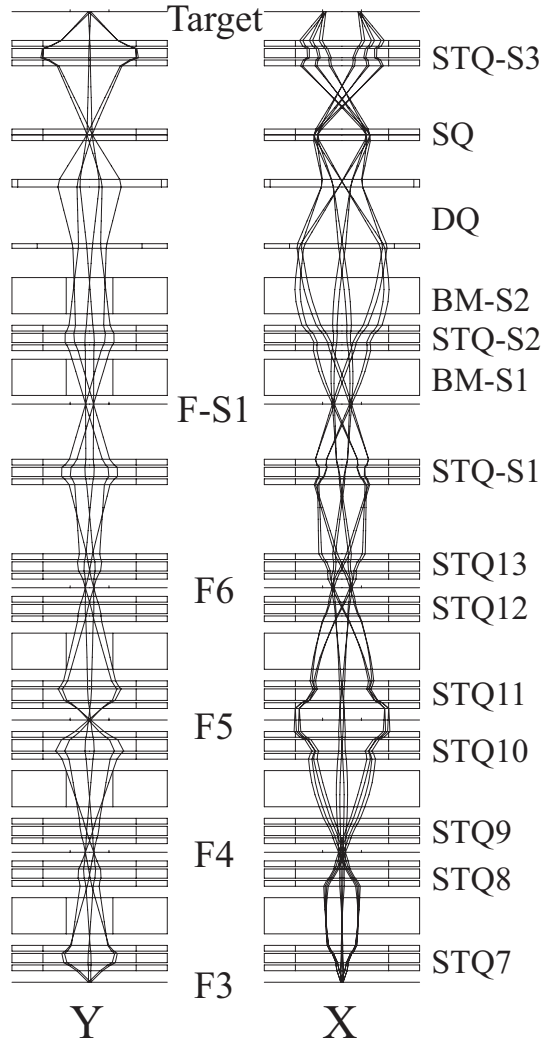
→ **need its cancellation for high-resolution**

dispersion matching / momentum tagging

BigRIPS + (newly constructed) SHARAQ beamline

(lateral) dispersion matching for high momentum resolution

angular dispersion matching for high angular resolution

Target
STQ-S3
SQ
DQ
BM-S2
STQ-S2
BM-S1
F-S1
STQ-S1
STQ13
F6
STQ12
STQ11
F5
STQ10
STQ9
F4
STQ8
STQ7
F3
Y
X

$\Delta\theta_x = +/- 10$ mr, $\Delta\theta_y = +/- 30$ mr, $\Delta x = +/- 3$ mm, $\Delta y = +/- 3$ mm, $\Delta P = +/- 0.3$ %

$\langle x'|x \rangle = -0.99$ $\langle x'|\theta \rangle = 0.00$ $\langle x'|\delta \rangle = -14.76$
$\langle \theta'|x \rangle = 0.14$ $\langle \theta'|\theta \rangle = -1.01$ $\langle \theta'|\delta \rangle = 4.79$
$\langle y'|y \rangle = 1.04$ $\langle y'|\phi \rangle = 0.00$
$\langle \phi'|y \rangle = 0.48$ $\langle \phi'|\phi \rangle = 0.96$

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In the dispersion matched mode, trajectories at F3 and before the target are measured.

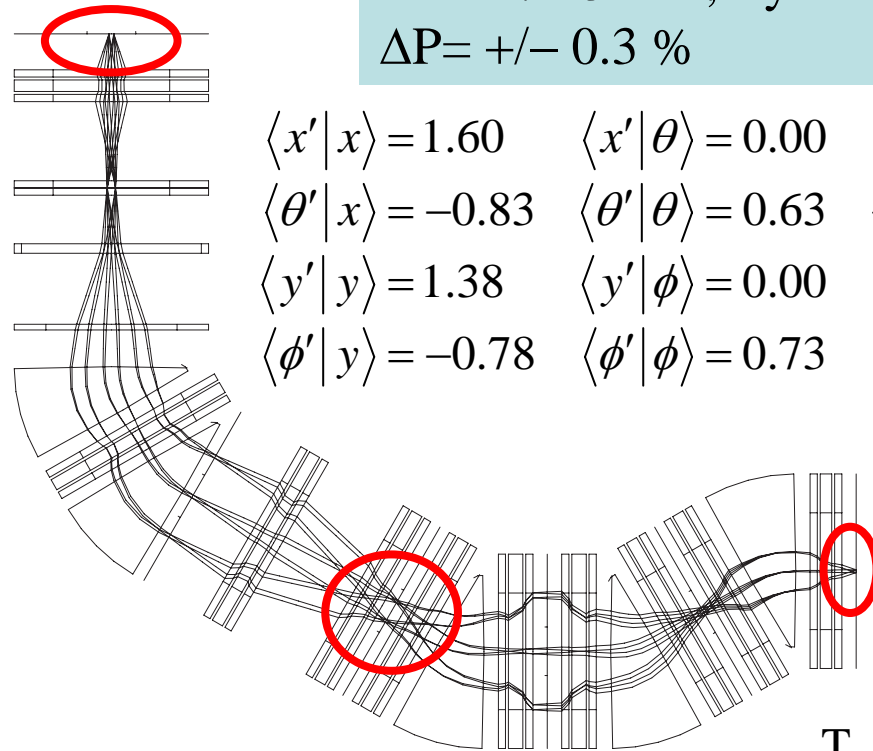T. Uesaka, Center for Nuclear Study, University of Tokyo

Target

STQ-S3
SQ
DQ
BM-S2
STQ-S2
BM-S1
F-S1
STQ-S1
STQ13
F6
STQ12
STQ11
F5
STQ10
STQ9
F4
STQ8
STQ7
F3
Y   X
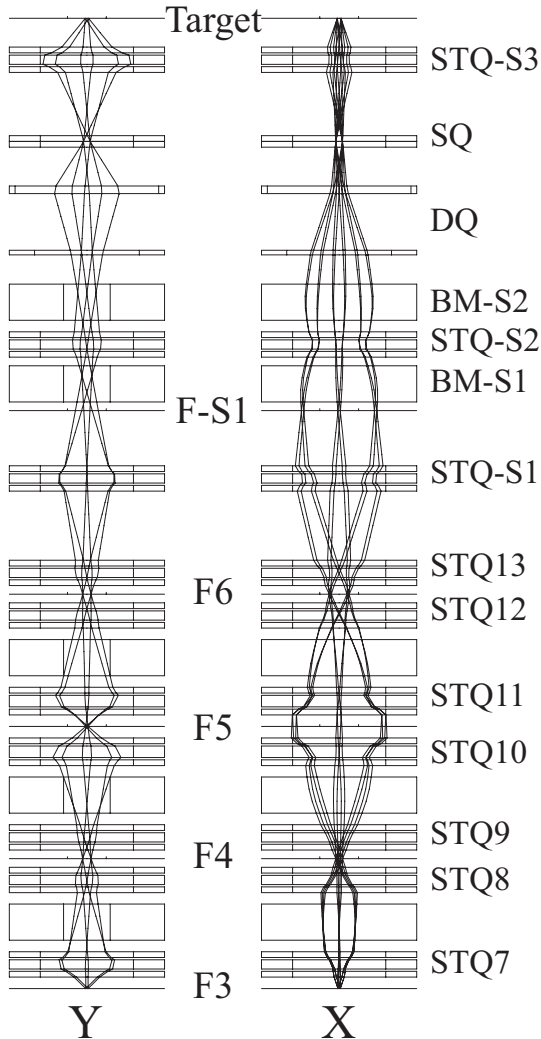
$\Delta\theta_x = +/- 20$ mr, $\Delta\theta_y = +/- 30$ mr, $\Delta x = +/- 3$ mm, $\Delta y = +/- 3$ mm, $\Delta P = +/- 0.3$ %

$$\langle x'|x \rangle = 1.60 \qquad \langle x'|\theta \rangle = 0.00 \qquad \langle x'|\delta \rangle = -0.00$$
$$\langle \theta'|x \rangle = -0.83 \qquad \langle \theta'|\theta \rangle = 0.63 \qquad \langle \theta'|\delta \rangle = -0.47$$
$$\langle y'|y \rangle = 1.38 \qquad \langle y'|\phi \rangle = 0.00$$
$$\langle \phi'|y \rangle = -0.78 \qquad \langle \phi'|\phi \rangle = 0.73$$

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In the achromatic mode, trajectories at F6 are needed to be measured for momentum tagging.

In the case of achromatic transport

F0

F1

F2   F3

F4

F5

F6

BigRIPS

FS1

STQ-S1

STQ-S2

SHARAQ
beamline

DQ-U

DQ-D

SQ

STQ-S3

Target

10

F3:
beam position
(image size)
Δx ~ 1 mm
rate > 10^6 Hz

F6:
tagging of beam
momentum
Δx < 1 mm

before target:
beam position and
incident angle
Δx < 1 mm
$\Delta \theta$ < 1 mrad
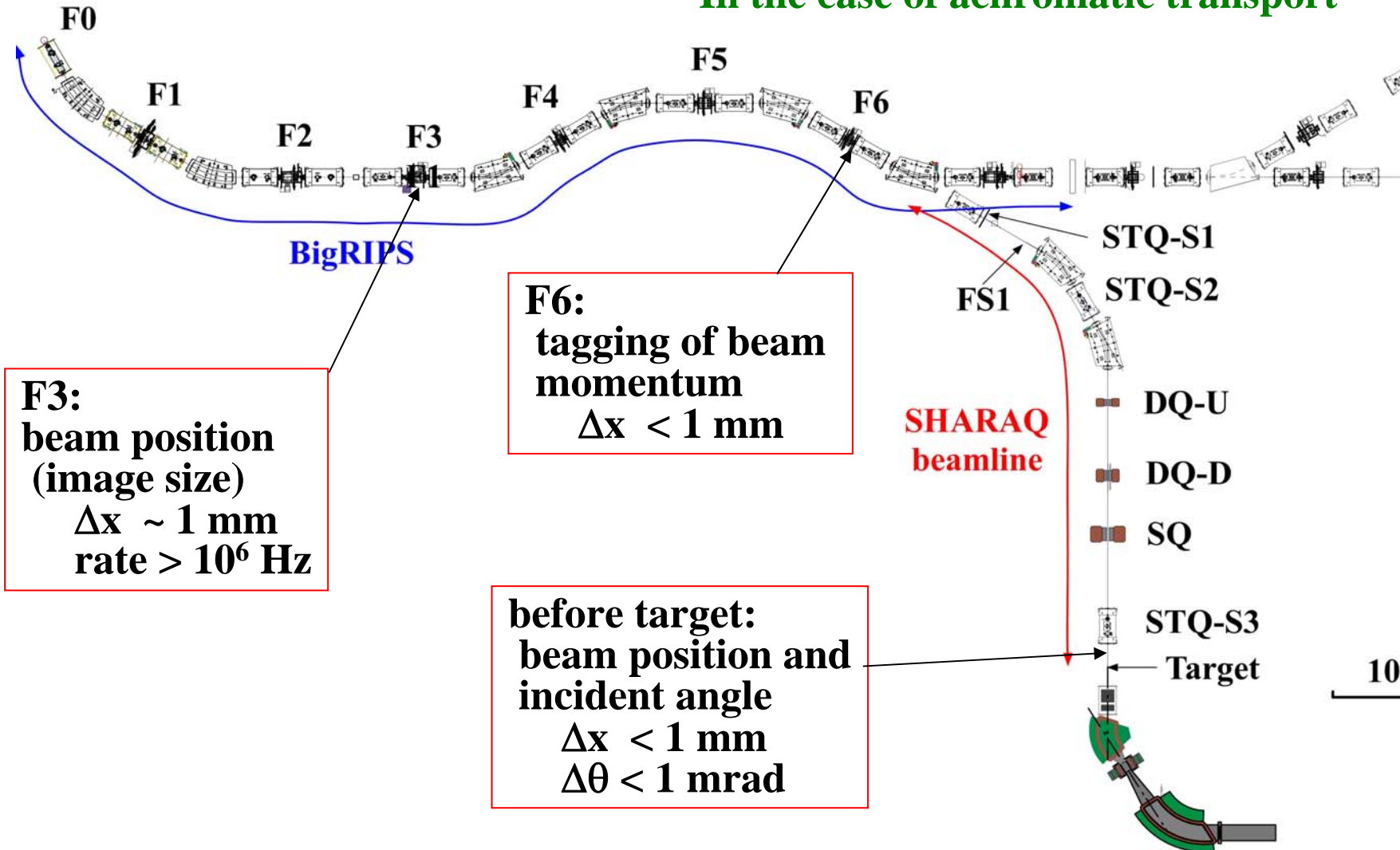
- **should determine the beam trajectory with**

    $\Delta x \sim 0.5$ **mm**

    $\Delta \theta < 1$ **mrad**

- **should not spoil the energy/angular resolutions**

    $\Delta E < 0.5$ **MeV**

    $\Delta \theta < 1$ **mrad**

    $Z < 10$: **multiple scattering limits the detector thickness.**

    $x/X_0 \sim 10^{-4}$

- **should work at $\sim 10^6$ particle/sec**

> **Low-pressure MWDC can be the solution.**
> $\rightarrow$ **Saito's talk**
> **works at a higher beam rate?**
> **Z=1 particles**

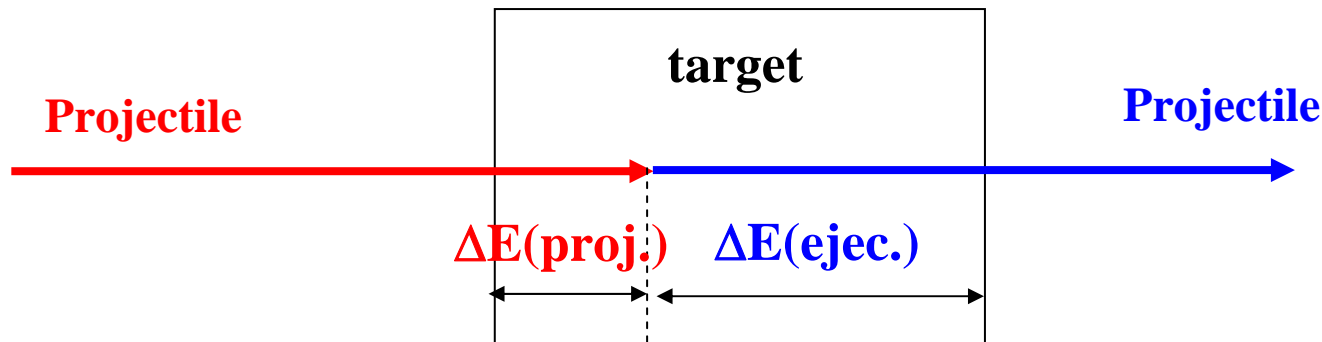**In many cases, target thickness is most critical.**

ex. charge exchange reaction:

energy loss difference between projectile and ejectile.

For a better use of SHARAQ,

we need a "next-generation TARGET system" such as

an active target, or a multi-layered target

with a sensitivity to reaction point.

target

Projectile → ← Projectile

$\Delta E(proj.)$ $\Delta E(ejec.)$

Summary

- **The high-resolution SHARAQ spectrometer**
  is being constructed at RI beam factory
  by University of Tokyo, in collaboration with RIKEN.

- **Demands for FP and beam-line detectors are presented**
  $\Delta x < 0.5$ mm
  $\Delta \theta < 1$ mrad
  $\rightarrow$ **Michimasa's and Saito's talks**

- **F3 detector: high rate (>MHz)**
  need frgeturther development

- **Active**