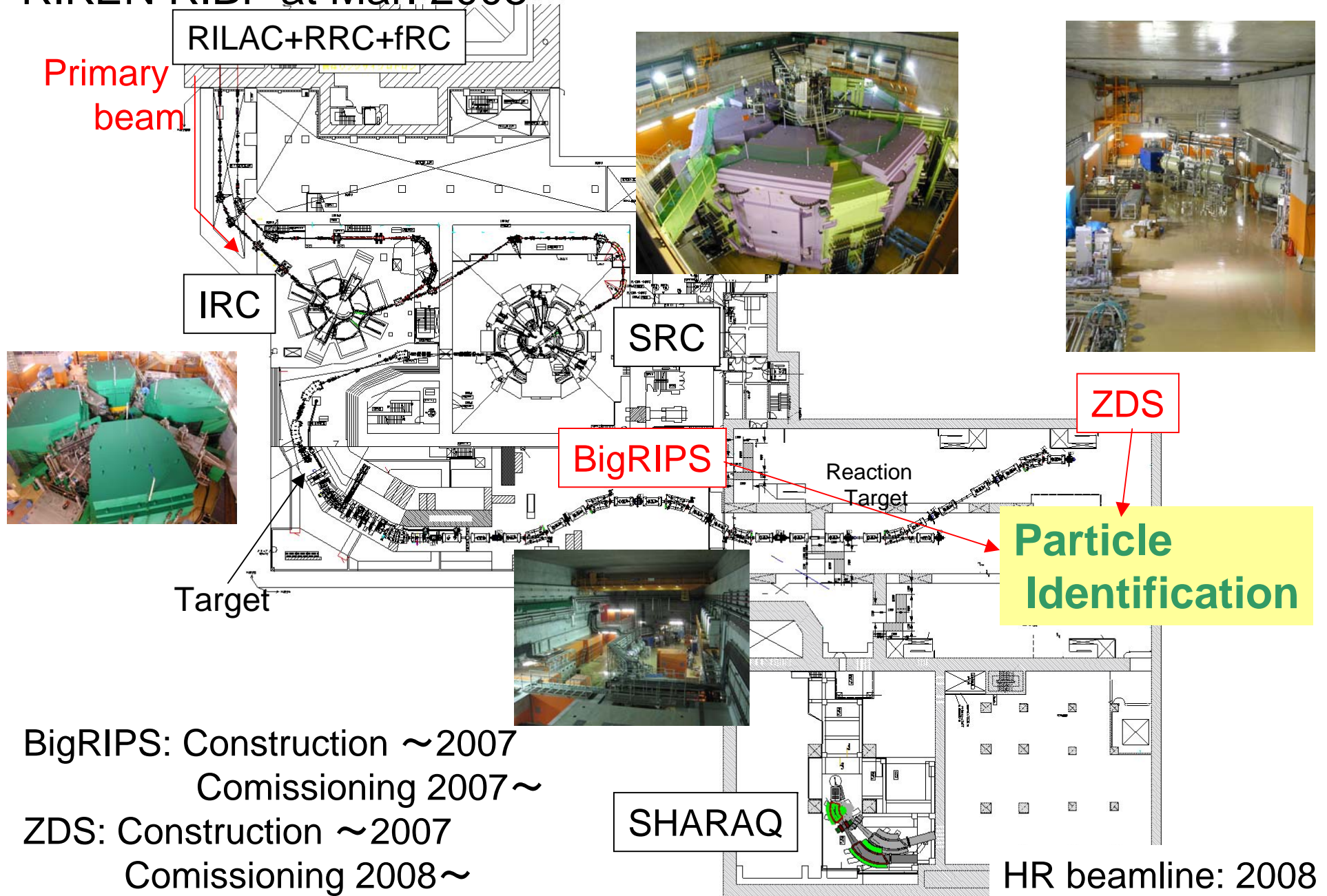


Requirements  
for  
BigRIPS  
and  
ZeroDegreeSpectrometer

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# RIKEN RIBF at Mar. 2008

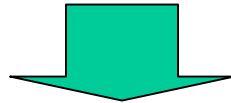


BigRIPS: Construction ~2007  
Comissioning 2007~  
ZDS: Construction ~2007  
Comissioning 2008~  
SHARAQ: Instllation ~2007

HR beamline: 2008  
SAMURAI: 2008~

# Particle identification of RI beam

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

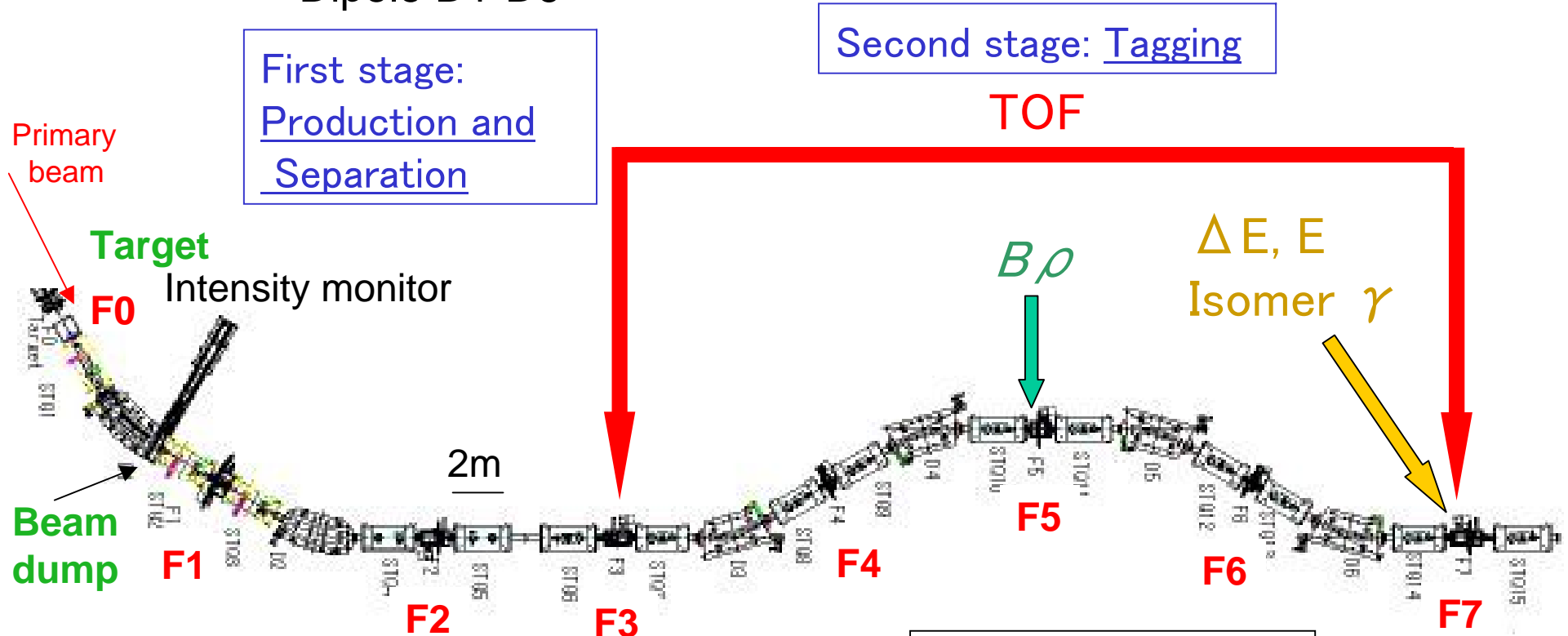


## B $\rho$ - $\Delta E$ -TOF method

B $\rho$	→	Position detector	→	A/Q, P
TOF	→	Timing detector	↗	
$\Delta E$	→	Energy loss detector	↘	Z
Z $\neq$ Q		More information: E	→	A

$$\begin{aligned} \text{TOF} &= L/\beta & \Delta E &\sim Z^2/\beta^2 \\ \text{B}\rho &= A/Q \cdot \beta \cdot \gamma & E/\beta^2 &\sim A \end{aligned}$$

# BigRIPS Superconducting Quadrupole: STQ1-14 Dipole D1-D6



First stage:  
Production and Separation

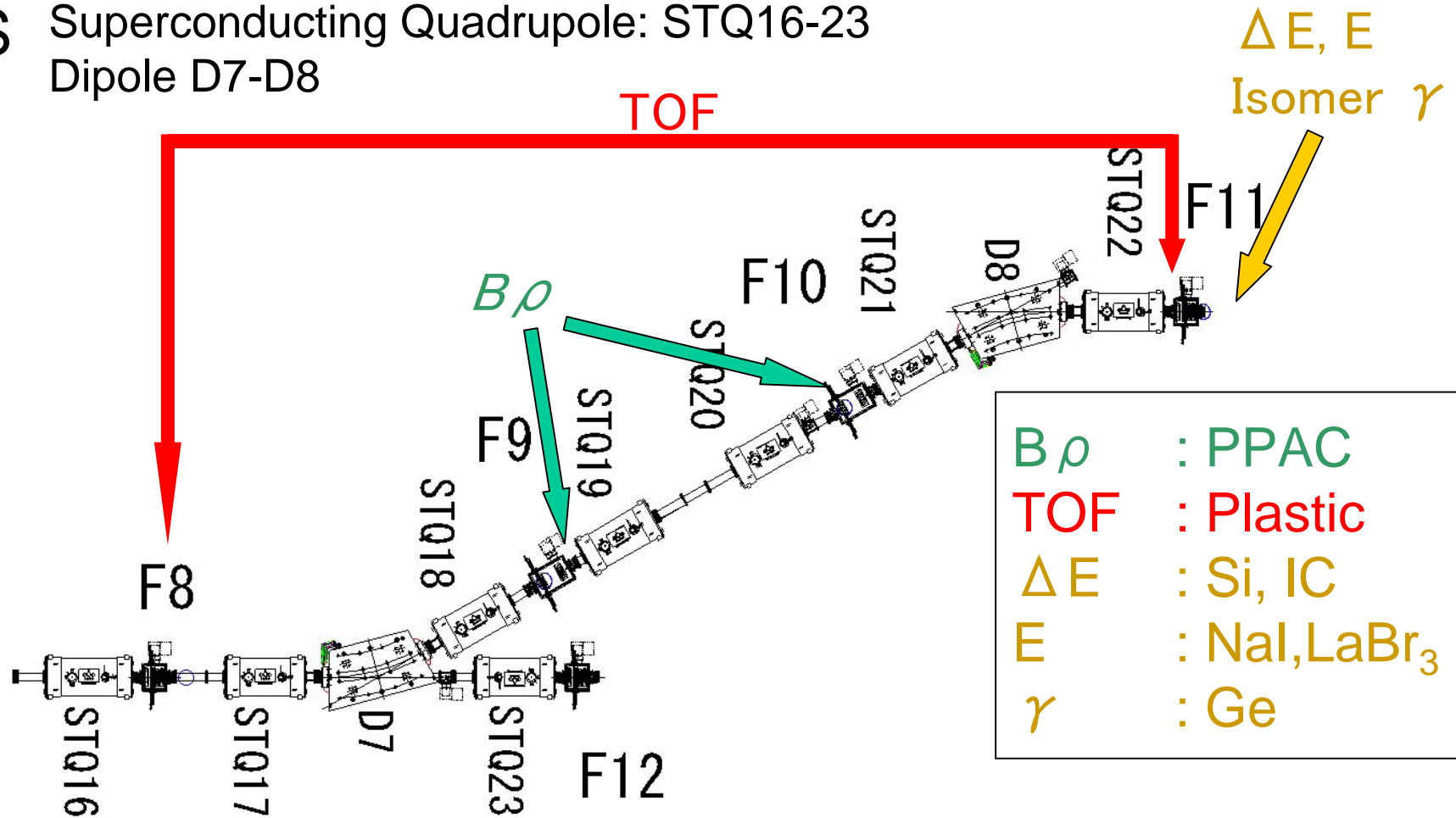
Second stage: Tagging

Parameters:

$\Delta\theta = 80$ mr	$\Delta\phi = 100$ mr
$\Delta p/p = 6\%$	$B\rho = 9$ Tm
$L \sim 77$ m	$P/\Delta P \sim 1300(1^{st})$
	$3300(2^{nd})$

$B\rho$	: PPAC
TOF	: Plastic
$\Delta E$	: Si, IC
E	: NaI
$\gamma$	: Ge

# ZDS Superconducting Quadrupole: STQ16-23 Dipole D7-D8



Parameters: L ~ 37 m

- Achromatic mode

Large acceptance:  $\Delta\theta = 90$  mr,  $\Delta\phi = 60$  mr,  $\Delta p/p = 6\%$ ,  $\underline{P/\Delta P=1240}$

High resolution :  $\Delta\theta = 40$  mr,  $\Delta\phi = 60$  mr,  $\Delta p/p = 6\%$ ,  $\underline{P/\Delta P=2100}$

- Dispersive mode

$\Delta\theta = 40$  mr,  $\Delta\phi = 60$  mr,  $\Delta p/p = 4\%$ ,  $\underline{P/\Delta P=4100}$

# Requirements for detectors

**BigRIPS**  $\pm 3\sigma$  separation in  $A/Q$ ,  $Z$ ,  $A$

Example  $Z=50$ ,  $A=138$

$A/Q$  resolution

$$A/Q = 138/50 = 2.76 \quad A/Q = 135/49 = 2.755$$

$$\Delta(A/Q)/(A/Q) = 1.774 \times 10^{-3} \quad \longrightarrow \quad \text{Required } \sigma = 2.95 \times 10^{-4}$$

BigRIPS 2<sup>nd</sup> Stage: 33mm/% F3-F7 47m 253nsec@250AMeV

$B\rho$  resolution:  $1.52 \times 10^{-4}$   $\longrightarrow$  Pos res.  $\sigma < 0.5$  mm

TOF res. :  $2.53 \times 10^{-4}$   $\longrightarrow$  Timing res.  $< 64$  ps ( $\sigma$ )

$Z$  resolution

$$\Delta Z/Z = 1/50 \quad \text{Required } \sigma = 3.3 \times 10^{-3}$$

$$\underline{\Delta E \text{ resolution } \sigma: 0.66 \%}$$

$A$  resolution

$$\Delta A/A = 1/138 \quad \text{Required } \sigma = 1.2 \times 10^{-3}$$

$$\underline{E \text{ resolution } \sigma = 0.12\%}$$

$$TOF = L/\beta$$

$$B\rho = A/Q \cdot \beta \cdot \gamma$$

$$\Delta E \sim Z^2/\beta^2$$

$$E/\beta^2 \sim A$$

**ZDS**

$\pm 3\sigma$  separation in A/Q, Z, A

Example Z=50, A=138

$$\Delta(A/Q)/(A/Q) = 1.774 \times 10^{-3} \quad \longrightarrow \quad \text{Required } \sigma = 2.95 \times 10^{-4}$$

F8-F11 36.8m 198nsec@250AMeV

1)ZDS Dispersive mode:  $P/\Delta P=4100$

2)ZDS Achromatic mode(High resolution):  $P/\Delta P=2100$

3)ZDS Achromatic mode(Large acceptance):  $P/\Delta P = 1240$

1)ZDS Dispersive mode:  $P/\Delta P=4100$

F8-F11 (x|d) = 41mm/%

$$\begin{array}{l} B\rho \text{ resolution: } 1.22 \times 10^{-4} \\ \text{TOF res. : } 1.67 \times 10^{-4} \end{array} \quad \longrightarrow \quad \begin{array}{l} \text{Pos res. } \sigma < 0.5 \text{ mm} \\ \text{Timing res. } < 33 \text{ ps } (\sigma) \end{array}$$

## 2) ZDS Achromatic mode (High resolution): $P/\Delta P = 2100$

$$F8-F9 (x|d) = -21\text{mm}/\%, (x|x) = -1.0$$

$$B\rho \text{ resolution: } 1.42 \times 10^{-4} \quad \text{TOF res. : } 1.60 \times 10^{-4} \quad \Rightarrow \quad \begin{array}{l} \text{Pos res. } \sigma < 0.3 \text{ mm} \\ \text{Timing res. } < 31 \text{ ps } (\sigma) \end{array}$$

(Pos res.  $\sigma < 0.5 \text{ mm}$ , T res.  $< 21 \text{ ps}$ )

$\pm 2 \sigma$  separation

$$B\rho \text{ resolution: } 2.38 \times 10^{-4} \quad \text{TOF res. : } 2.31 \times 10^{-4} \quad \Rightarrow \quad \begin{array}{l} \text{Pos res. } \sigma < 0.5 \text{ mm} \\ \text{Timing res. } < 46 \text{ ps } (\sigma) \end{array}$$

## 3) ZDS Achromatic mode (Large acceptance): $P/\Delta P = 1240$

$$F8-F9 (x|d) = -24\text{mm}/\%, (x|x) = -2.0$$

$\pm 2 \sigma$  separation

$$B\rho \text{ resolution: } 3.23 \times 10^{-4} \quad \text{TOF res. : } 1.83 \times 10^{-4} \quad \Rightarrow \quad \begin{array}{l} \text{Pos res. } \sigma < 0.4 \text{ mm} \\ \text{Timing res. } < 36 \text{ ps } (\sigma) \end{array}$$

$\pm 3 \sigma$  separation

$$\begin{array}{l} \text{Pos res. } \sigma < 0.1 \text{ mm} \\ \text{Timing res. } < 35 \text{ ps } (\sigma) \end{array}$$

$$\begin{array}{l} \text{Pos res. } \sigma < 0.3 \text{ mm} \\ \text{Timing res. } < 19 \text{ ps } (\sigma) \end{array}$$



# Summary

- Requirements for  $\pm 3\sigma$  separation in A/Q, Z, A

## BigRIPS

Pos res.  $\sigma < 0.5$  mm  
Timing res.  $< 64$  ps ( $\sigma$ )  
 $\Delta E$  resolution  $\sigma$ : 0.66 %  
E resolution  $\sigma$ : 0.12 %

## ZDS

Pos res.  $\sigma < 0.3$  mm  
Timing res.  $< 31$  ps ( $\sigma$ )

Large acceptance mode  
 $\pm 2\sigma$  separation

- Other requirements

- Large effective area

$$240 \times 150 \text{ mm}^2$$

- Tolerance for high rate

$$\sim 10^6 \text{ Hz}$$