

Rozdział 7

Separatory fragmentów na świecie



202

Separatory fragmentów

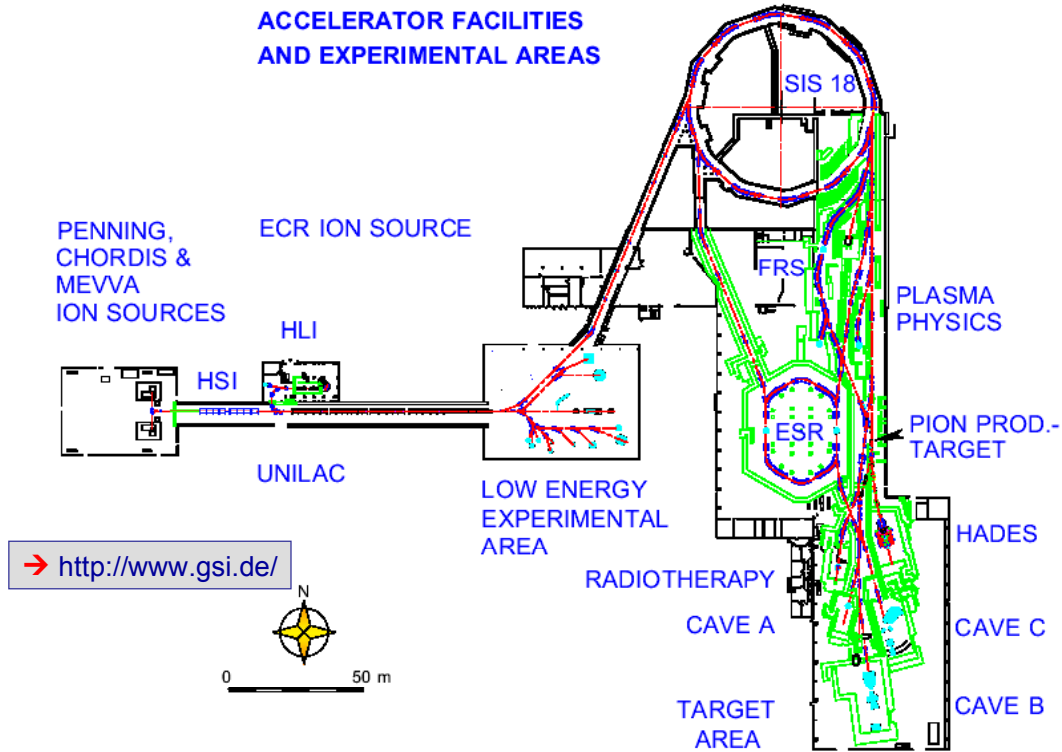
- ▶ **FRS** – **F**Ragment **S**eparator w GSI Darmstadt (Niemcy)
- ▶ **LISE** – **L**igne d'**I**ons **S**uper **E**pluchés w GANIL Caen (Francja)
- ▶ **A1900** – (**A**nalyser, **K**=1900) w NSCL/MSU East Lansing, MI (USA)
- ▶ **RIPS** – **R**adioactive **I**on **P**rojectile **S**eparator w RIKEN k. Tokio (Japonia)
- ▶ **ACCULINNA** – FLNR, Dubna (Rosja) – <http://159.93.28.88/flnr/>
- ▶ **RIBLL** – **R**adioactive **I**on **B**eam **L**ine at **L**anzhou, IMP, Lanzhou (Chiny)



203

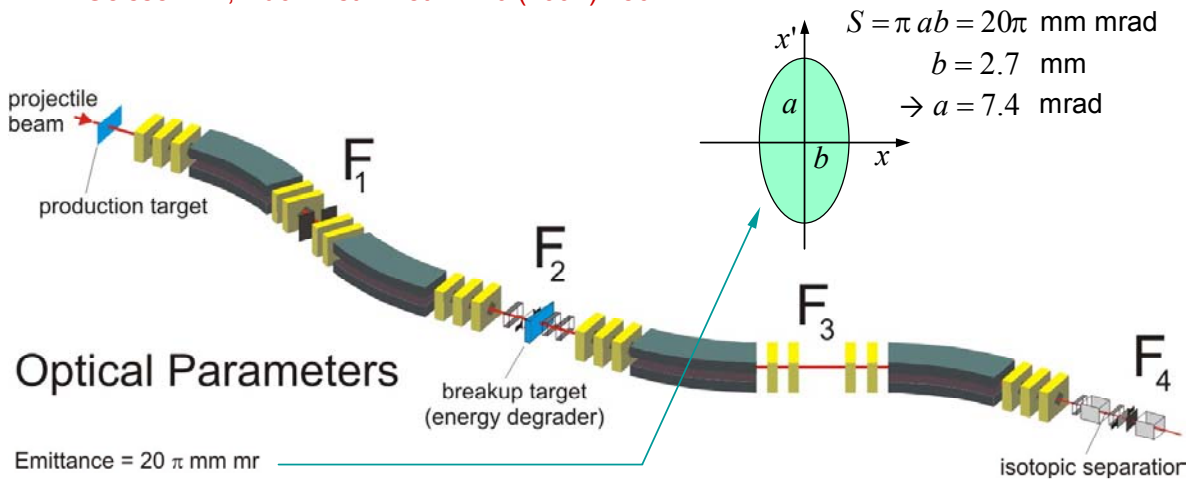
FRS w GSI Darmstadt

ACCELERATOR FACILITIES AND EXPERIMENTAL AREAS



204

H. Geissel i in., Nucl. Instr. Meth. B70 (1992) 286



Optical Parameters

Emittance = $20 \pi \text{ mm mrad}$

Solid angle = 0.32 msr

$B\rho_{\text{max}} = 18 \text{ Tm}$

$\Delta p / p = 2\% = \pm 1\%$

Resolving Power = 1600 at F_2

Achromatic at F_4

$$E_k / A = u(\gamma - 1) = u \sqrt{\left[\left(\frac{B\rho q}{3.107 A} \right)^2 + 1 \right] - 1}$$

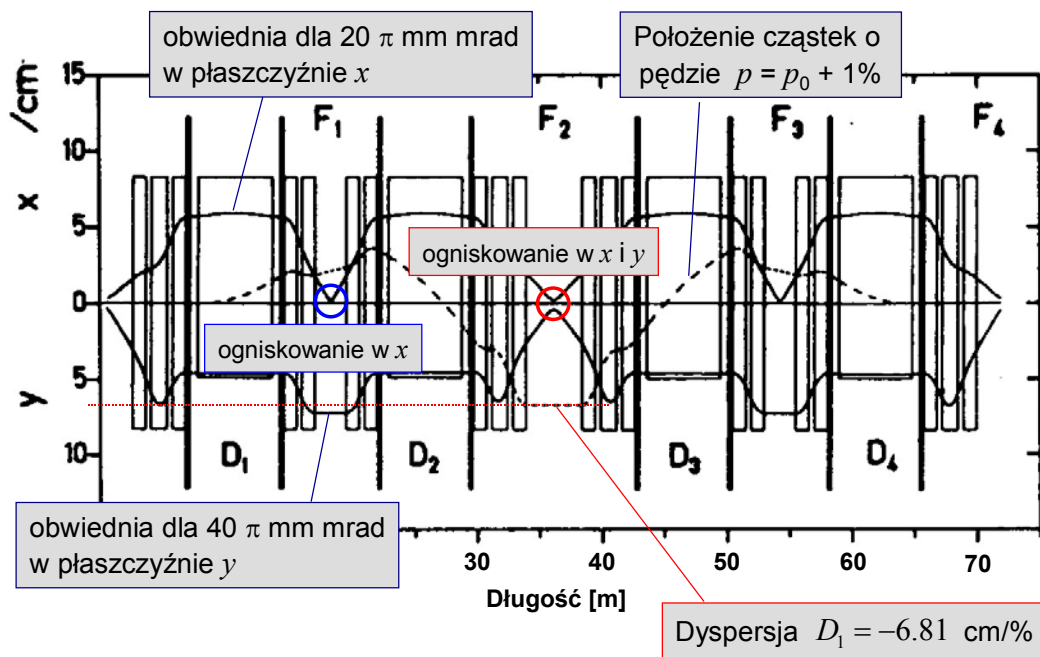
$^{238}\text{U} \rightarrow E_k = 1353 \text{ AMeV}$

$^{12}\text{C} \rightarrow E_k = 1923 \text{ AMeV}$

W praktyce energie wiązek pierwotnych : 100 – 1000 AMeV

205

Standardowy tryb achromatyczny



206

Różne tryby – zmienna optyka

▶ standardowy, achromatyczny

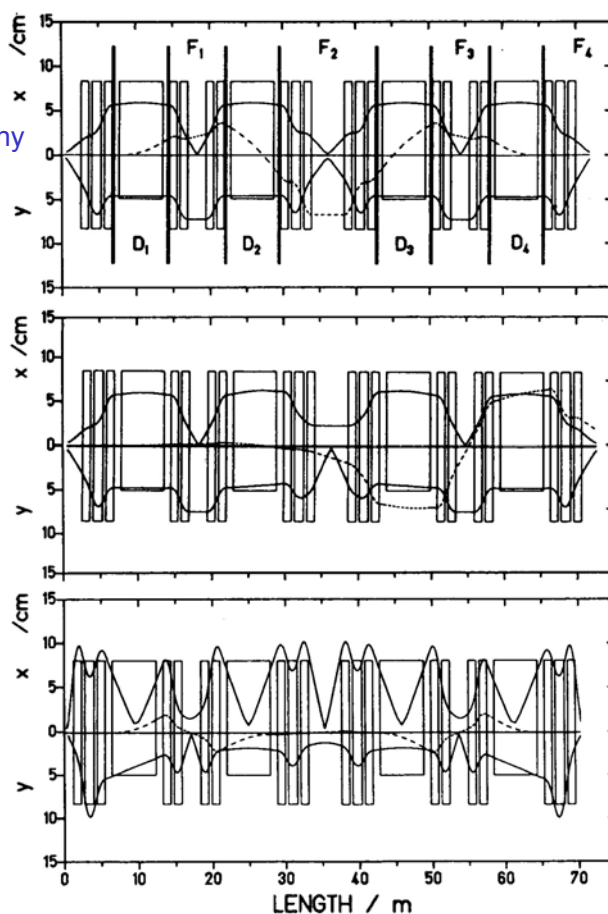
x : 20π mm mrad,
 y : 40π mm mrad,
 $\Delta p = 1 \%$

▶ tryb o dużej dyspersji

x : 20π mm mrad,
 y : 40π mm mrad,
 $\Delta p = 0.1 \%$
 $D = 17$ cm/%

▶ tryb o dużej transmisji

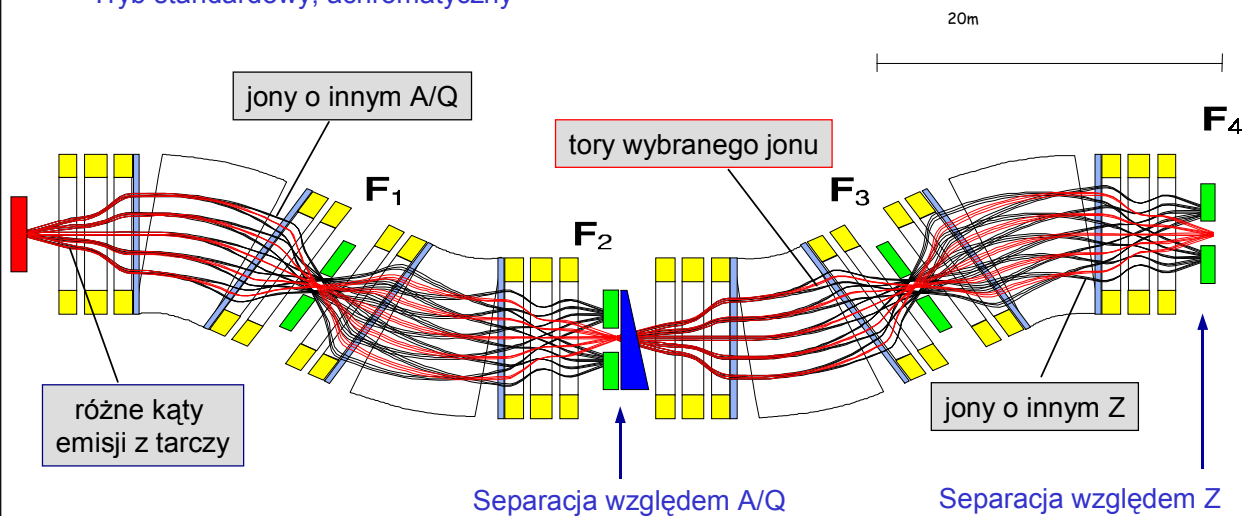
x : 220π mm mrad,
 y : 50π mm mrad,
 $\Delta p = 1 \%$



207

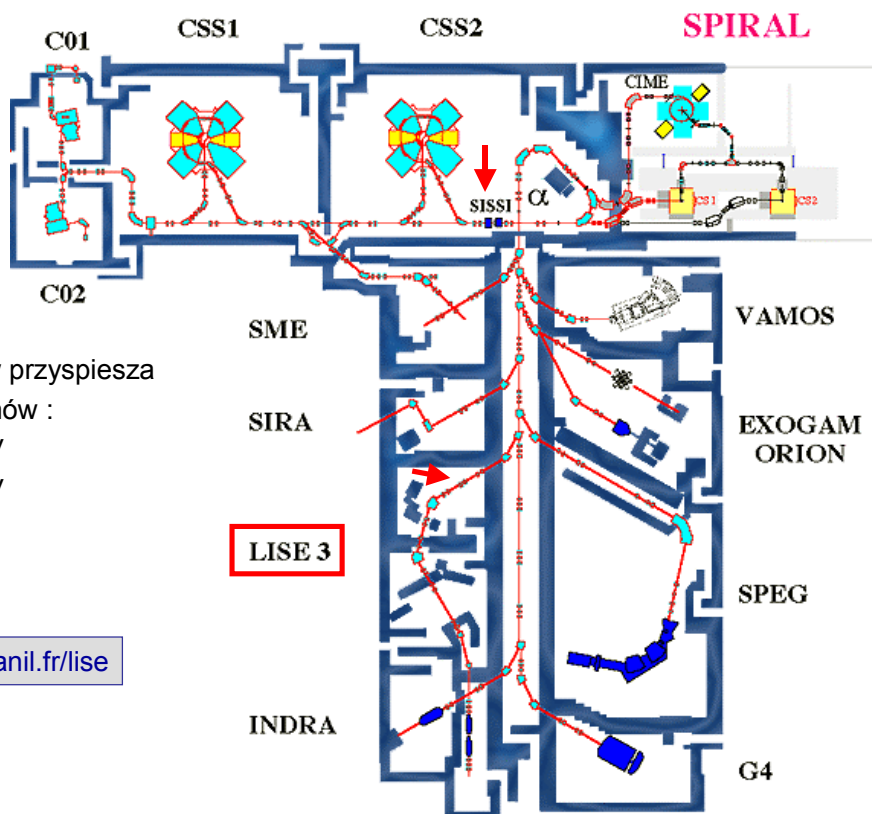
Optyka jonowa w innym przedstawieniu

Tryb standardowy, achromatyczny



208

LISE w GANIL



Układ cyklotronów przyspiesza

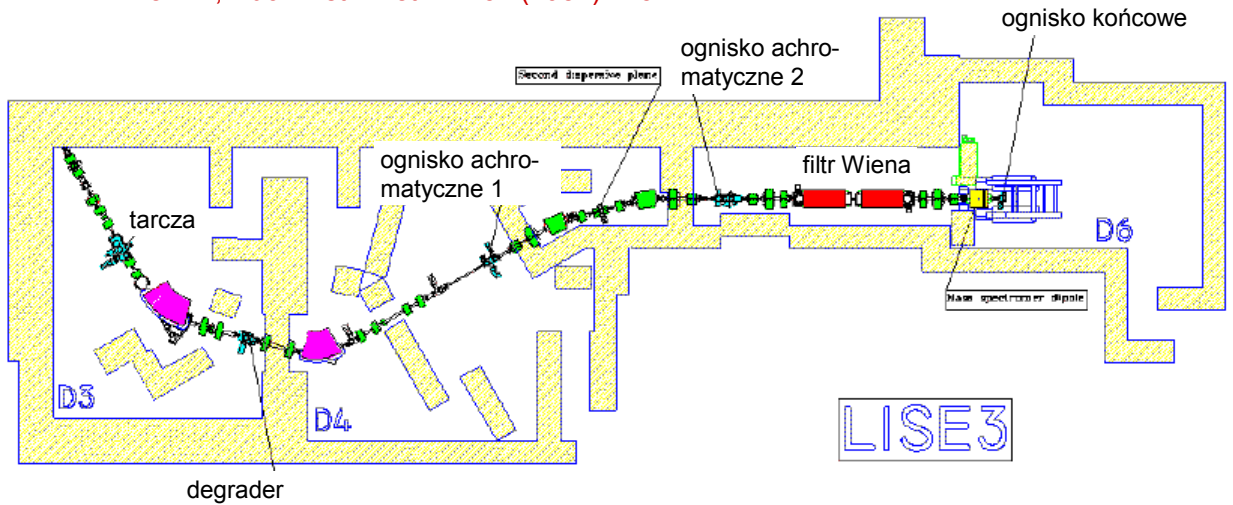
wiązki ciężkich jonów :

- C do 95 A MeV
- U do 25 A MeV

→ <http://www.ganil.fr/lise>



09



odległość tarcza – 1 ognisko (D4) : 19 m

odległość tarcza – ognisko końcowe (D6) : 42 m

$$B\rho_{1\max} = 4.3 \text{ Tm}$$

$$B\rho_{2\max} = 3.2 \text{ Tm}$$

$$\Delta\theta = \pm 17.4 \text{ mrad}$$

$$(\Delta p/p)_{\max} = \pm 2.5\%$$

$$D_1 = 17.3 \text{ mm}/\%$$

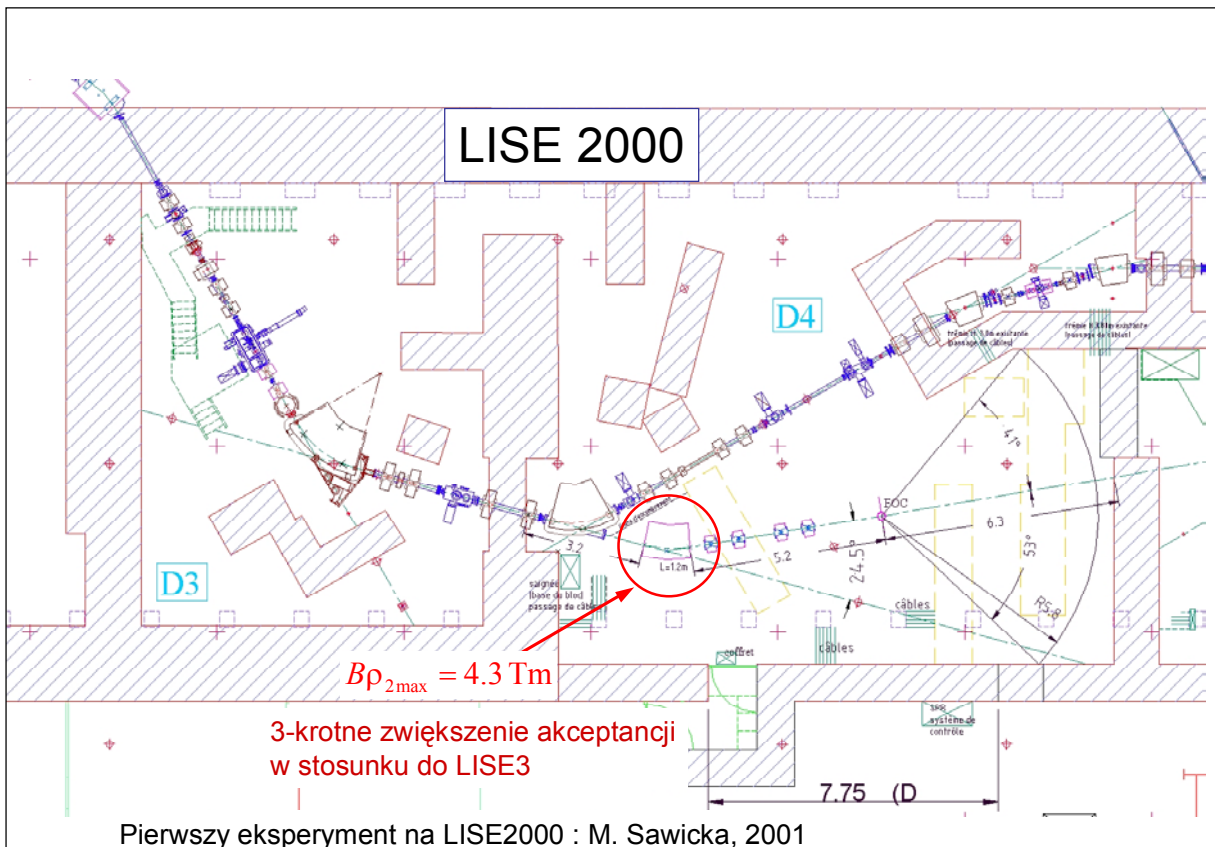
$$D_2 = 44.3 \text{ mm}/\%$$

$$V_2 = -2.57$$

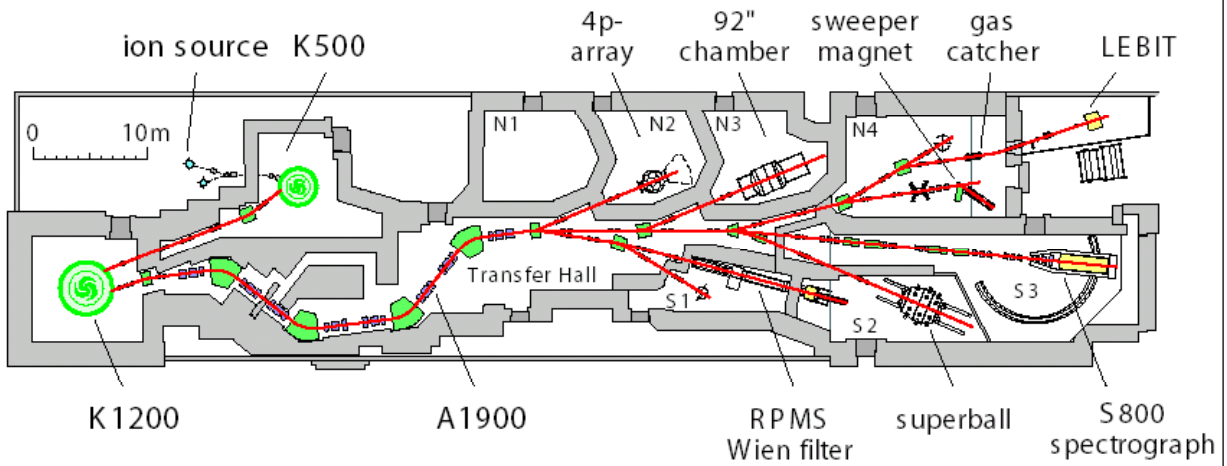
filtr Wiener : $E_{\max} = 350 \text{ kV}$

$$B = 0.01 - 0.1 \text{ T}$$

$$D_V = 3 \text{ cm}/\%$$

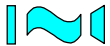


A1900 w NSCL/MSU

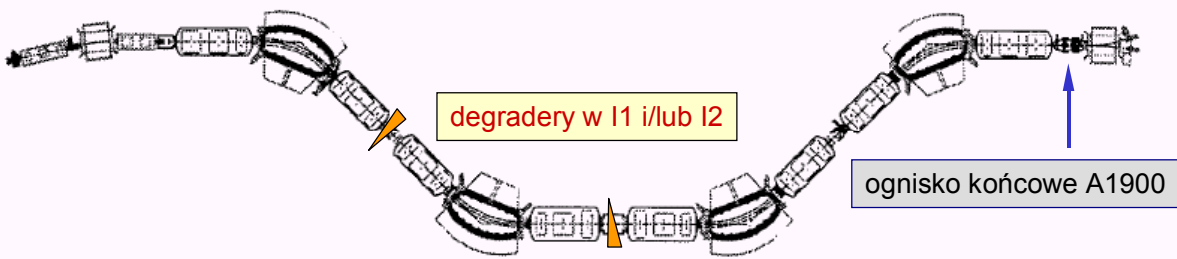


Wiązki : ^{16}O ≈ 200 AMeV
 ^{58}Ni 160 AMeV
 ^{124}Sn 120 AMeV
 ^{238}U 85 AMeV

<http://www.nsl.msu.edu/>

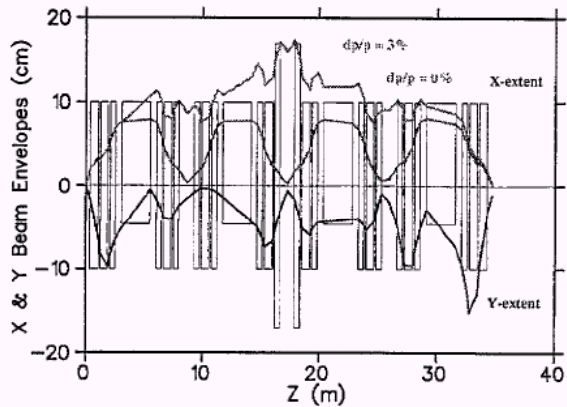


Morrisey i in., Nucl. Instr. Meth. B126 (1997) 316



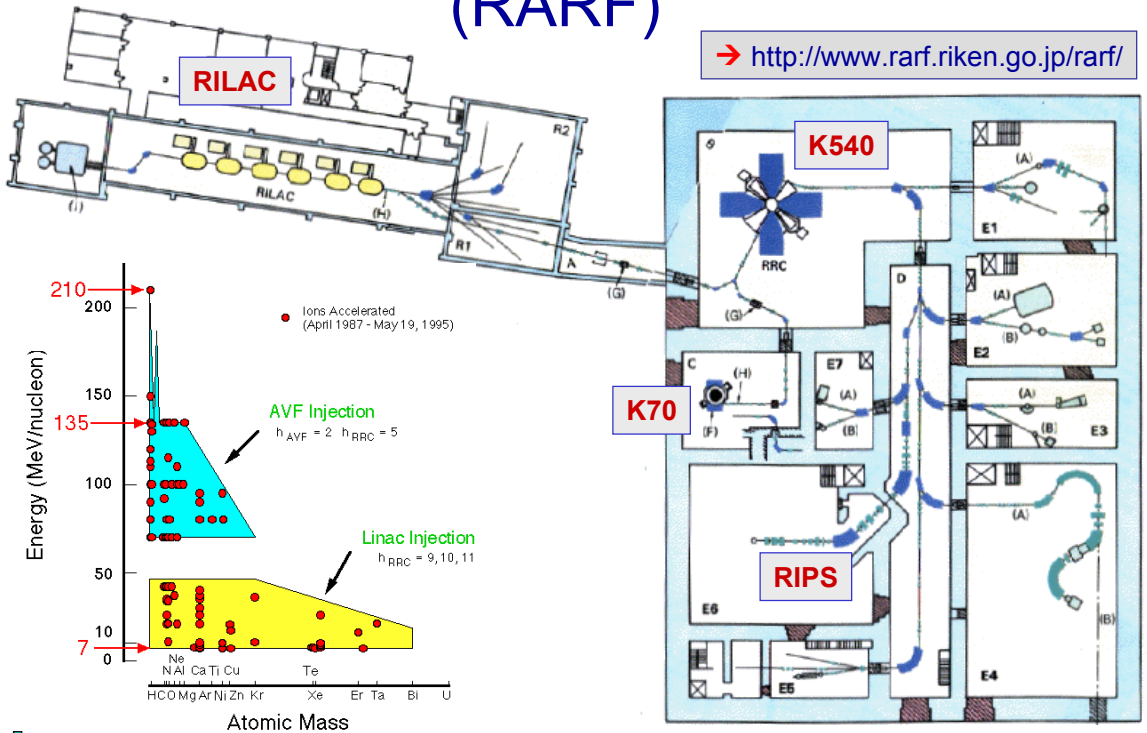
Wszystkie magnesy nadprzewodzące!

Długość : 35 m
 $B\rho_{\text{max}} = 6$ Tm
 $(\Delta p/p)_{\text{max}} = \pm 2.5\%$
 $\Omega = 8$ msr
 $D_1 = 5$ cm/%



RIKEN Accelerator Research Facility (RARF)

→ <http://www.rarf.riken.go.jp/rarf/>



214

RIPS w RIKEN

Długość : 27 m

$B\rho_{\max} = 5.76 \text{ Tm}$

$(\Delta p/p)_{\max} = \pm 3.0\%$

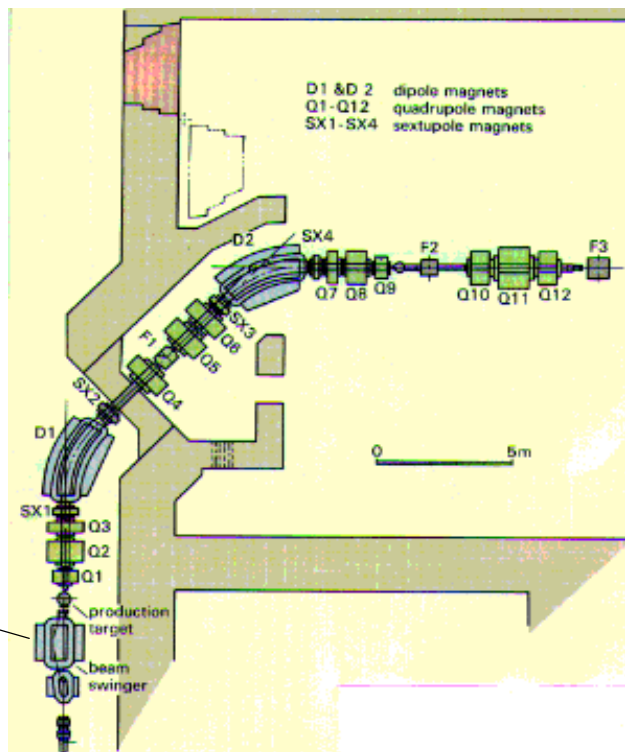
$\Delta\theta = \pm 40 \text{ mrad}$

$\Omega = 5 \text{ msr}$

$D_1 = 2.4 \text{ cm}/\%$

Odchylenie wiązki pierwotnej na tarczy : do 15°

→ polaryzacja fragmentów!

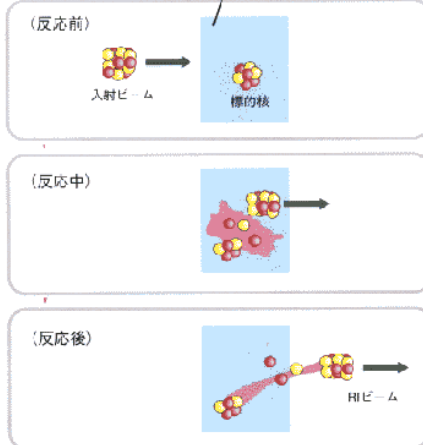
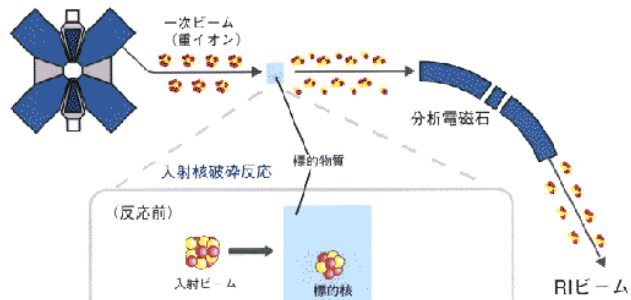


Kubo i in., Nucl. Instr. Meth. B70 (1992) 309

215

RIビームをつくる

RIビームは、高エネルギー重イオンビームから「入射核破砕反応」によって発生します。



高エネルギー重イオン(入射核)を標的中の原子核と衝突させると、その一部が削り取られて種々のRIが生成されます。そのなかから種類のRIを電磁分離しビームとして利用します。

この反応を用いて効率よくRIビームを生成するには、重イオンビームに核子あたり100 MeV(光速の約40%)以上のエネルギーをもつ必要があります。

