SSRI Workshop at Kyoto Univ.

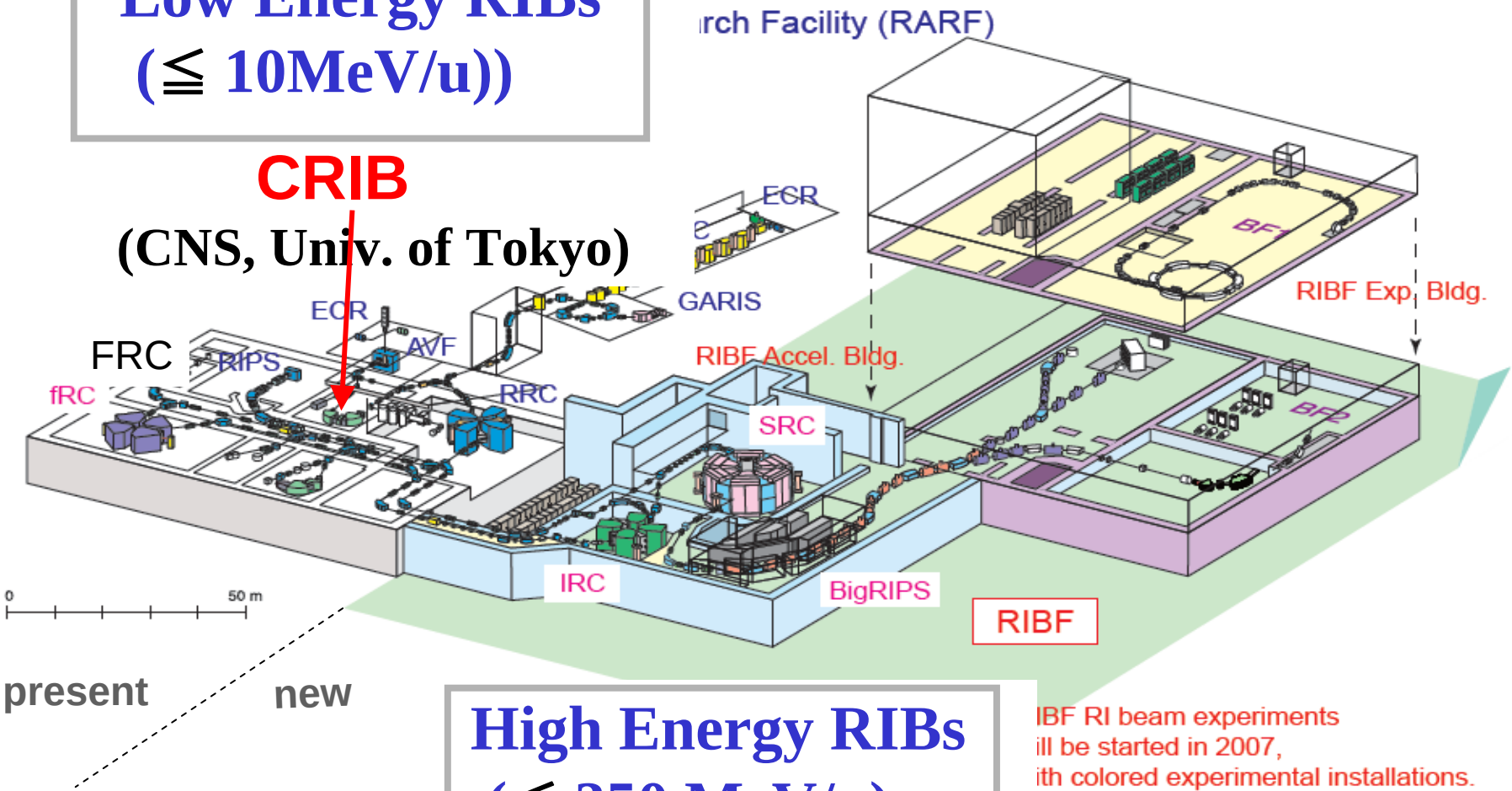
CRIB Status and Progress

1. AVF Upgrade Project
2. Low-Energy RIB Separator CRIB
3. Possibility

RIKEN RIBF Facility

Low Energy RIBs
(≦ 10MeV/u))

CRIB
(CNS, Univ. of Tokyo)



High Energy RIBs
(≦ 350 MeV/u)

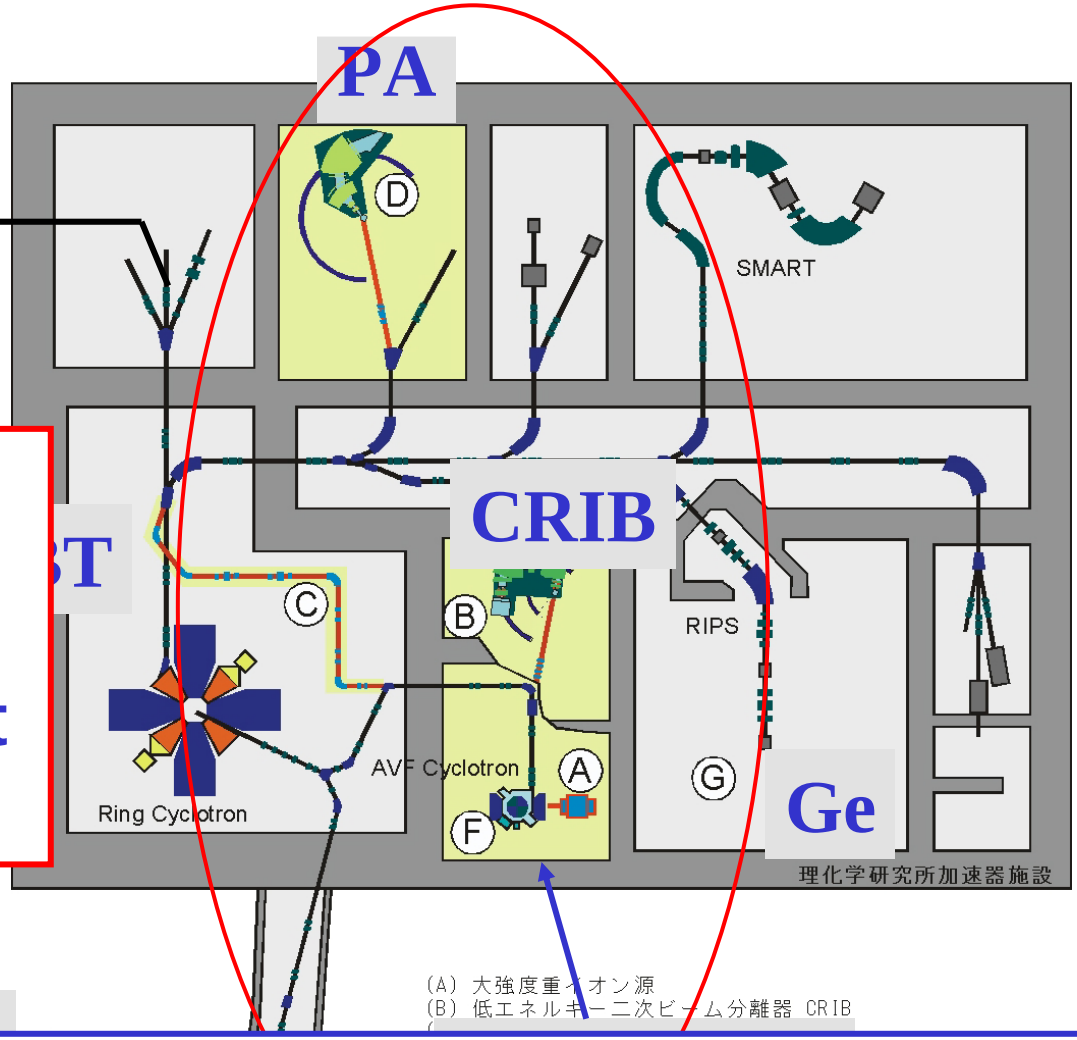
IBF RI beam experiments
ill be started in 2007,
ith colored experimental installations.

CNS Facilities at RIKEN

(Under CNS-RIKEN joint venture)

RIBF

AVF Upgrade Project (CNS-RIKEN Joint Project)

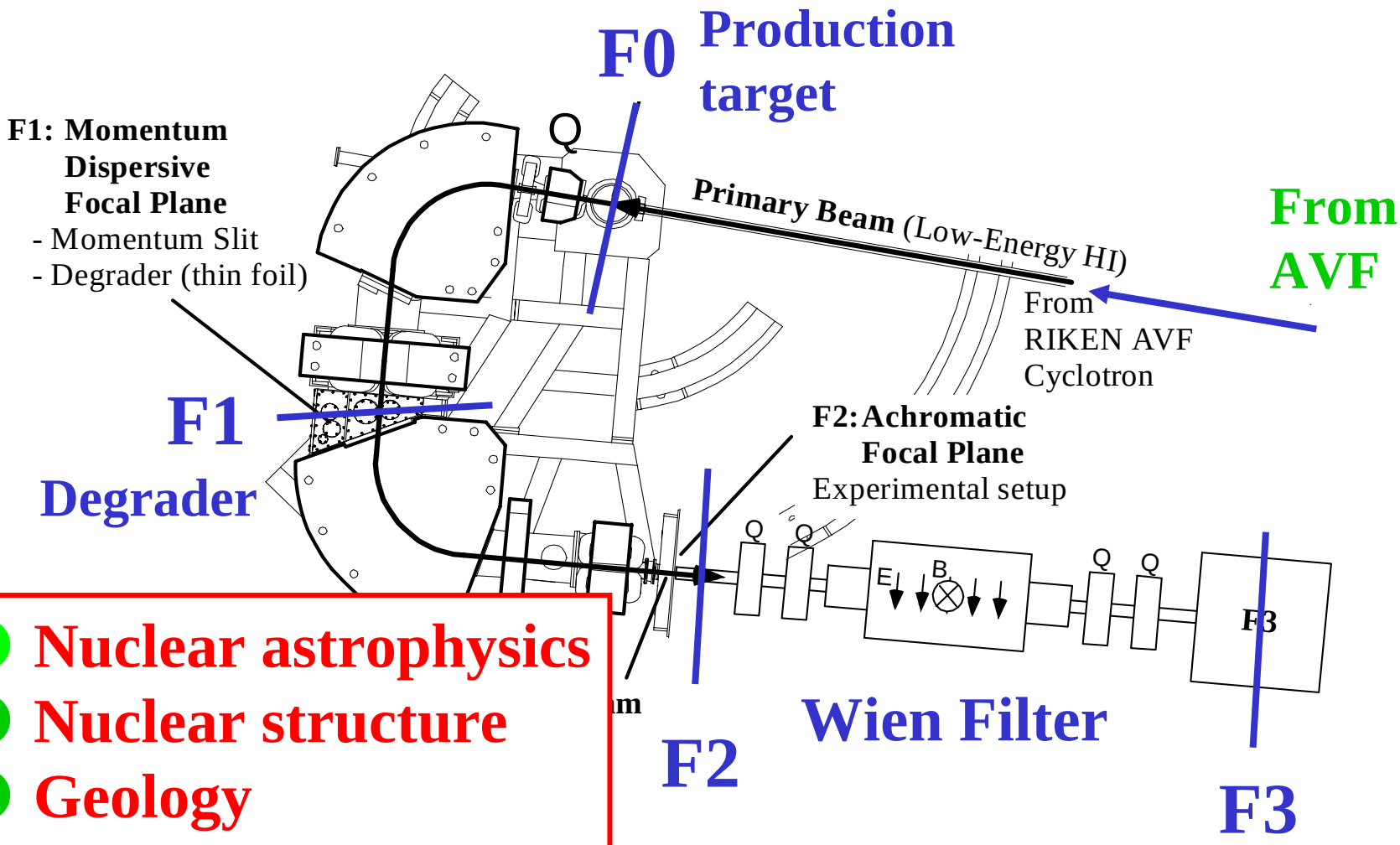


Parallel p
system (T

CNS-BT

- **Major part of AVF operation is now available for CRIB.**

Low-energy in-flight RI beam separator CRIB



- Nuclear astrophysics
- Nuclear structure
- Geology
- ...

Magnetic Separator Section of CRIB (F0—F2)

- Solid angle: 5.6 mSr (75 mr × 75 mr)
- Maximum magnetic rigidity:1.28 Tm
- Radius of central orbit: 0.9 Tm

Large acceptance for (p,n) reaction

$p(^{14}N,^{14}O)n$

at $E/A(^{14}N)$ = 8.4 MeV

$\Delta\theta$ (^{14}O) = ±2°

$\Delta P/P$ (^{14}O) = ±3.5%

- F0 (target) → F1

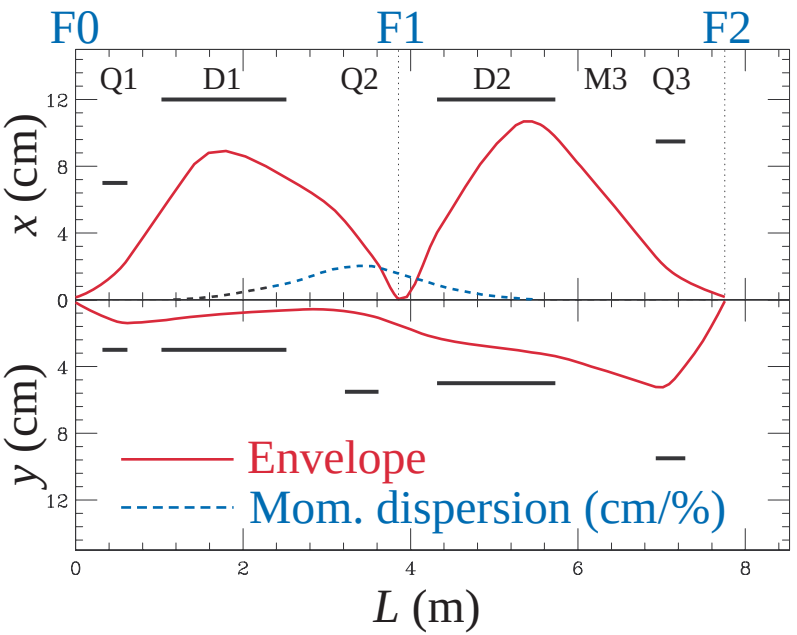
(dispersive focal plane)

Horizontal magnifiction: 0.3
Momentum dispersion: 1.6 m
Momentum acceptance: ±7.5%
Momentum resolution: P/ΔP = 800

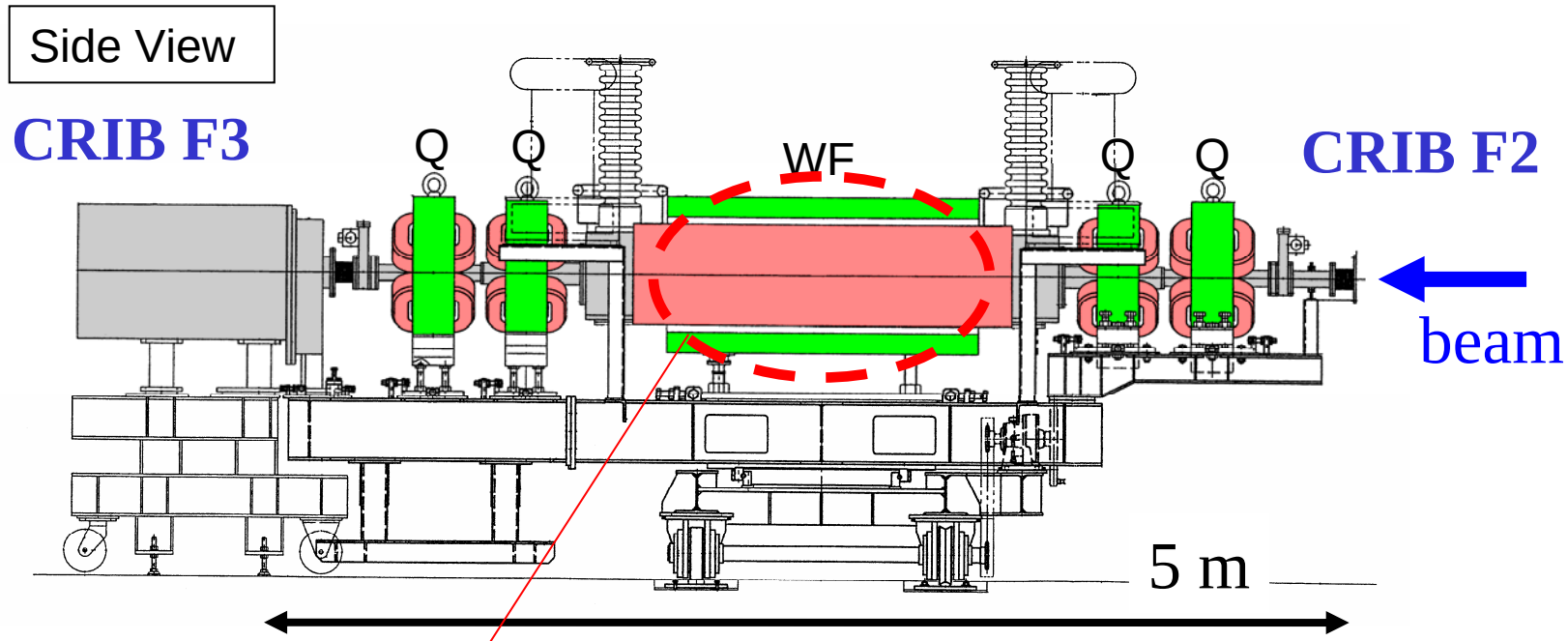
- F0 (target) → F2

(achromatic focal plane)

Magnification
Horizontal: 1.2
Vertical: 0.5
Momentum dispersion: 0.00

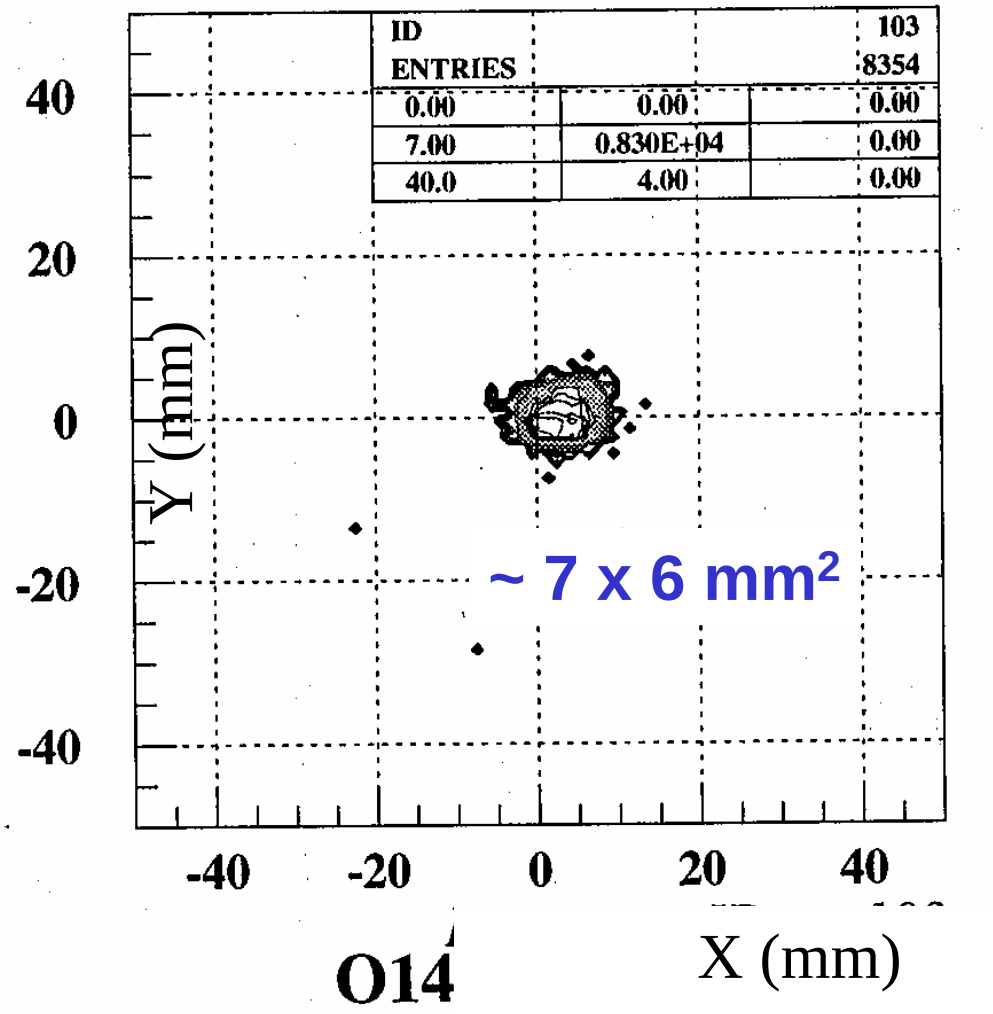


Wien Filter Section of CRIB (F2—F3)



Total length:	5 m
Length of velocity-separation section:	1.5 m
Max. horizontal electric field:	E = 50kV/cm (±200 kV / 8 cm)
Max. vertical magnetic field:	B = 0.3 T

Beam Size of ^{14}O at F3



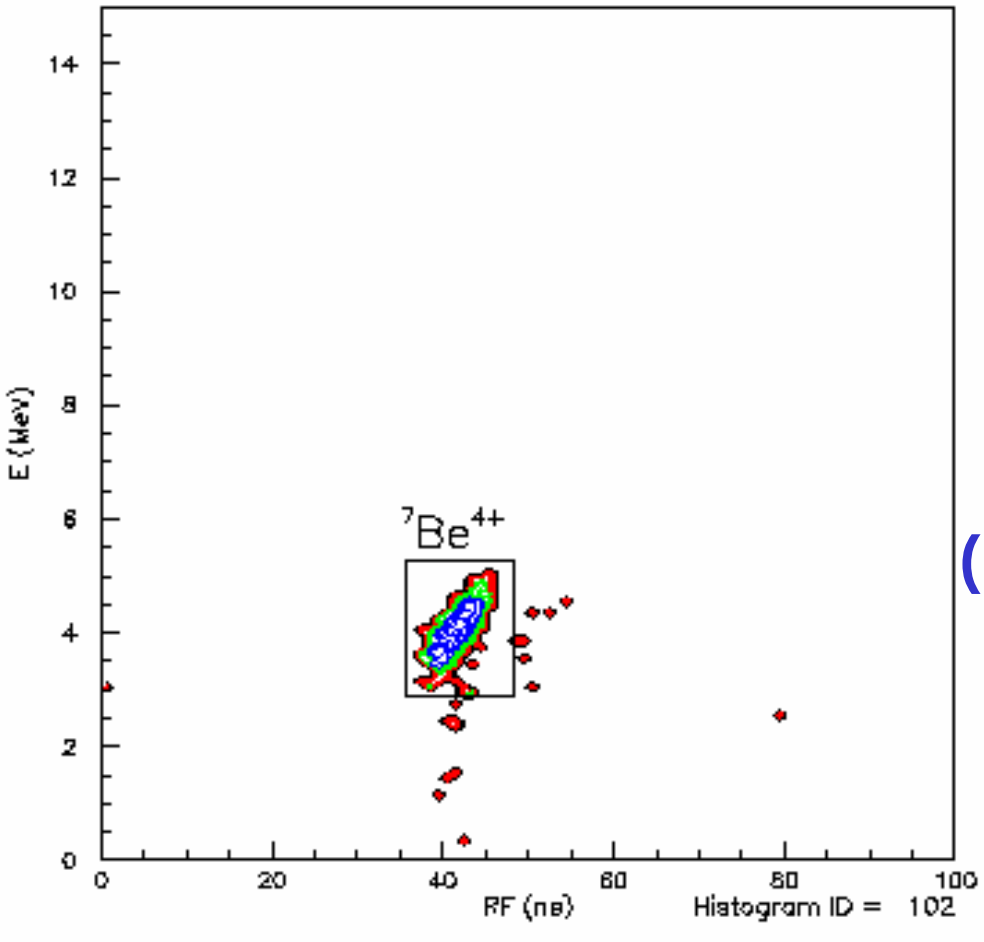
- Wien Filter -> 100 % ^{14}O of > 10^6 aps
- Without a degrader
- Small spot size

Higher order correction

↓

Smaller RI beam spot size !

^{7}Be Beam Production at CRIB



4-MeV ^{7}Be beam of 6x10^{6} aps available ! (w/ 0.5 pμA)

More beam available !
(> 50 pμA)
(Limited by the production target)

^{7}Be(p,γ)^{8}B Reaction:

; Solar model, first generation stars

Direct Method with RI Beams

RIB intensities		reaction type
10^4 pps	→	Resonant scattering w/thick target method eg. ^{22}Mg+p
10^6 pps	→	Rearrangement reactions eg. (α,p), (α,n), (d,p), . . .
10^8 pps	→	(p,γ), (α,γ), . . .

Total system development;

1. Ion source
2. Accelerator
3. Beam transport
3. Production target
5. Separator

Radioactiv Beams produced by CRIB (A<20)

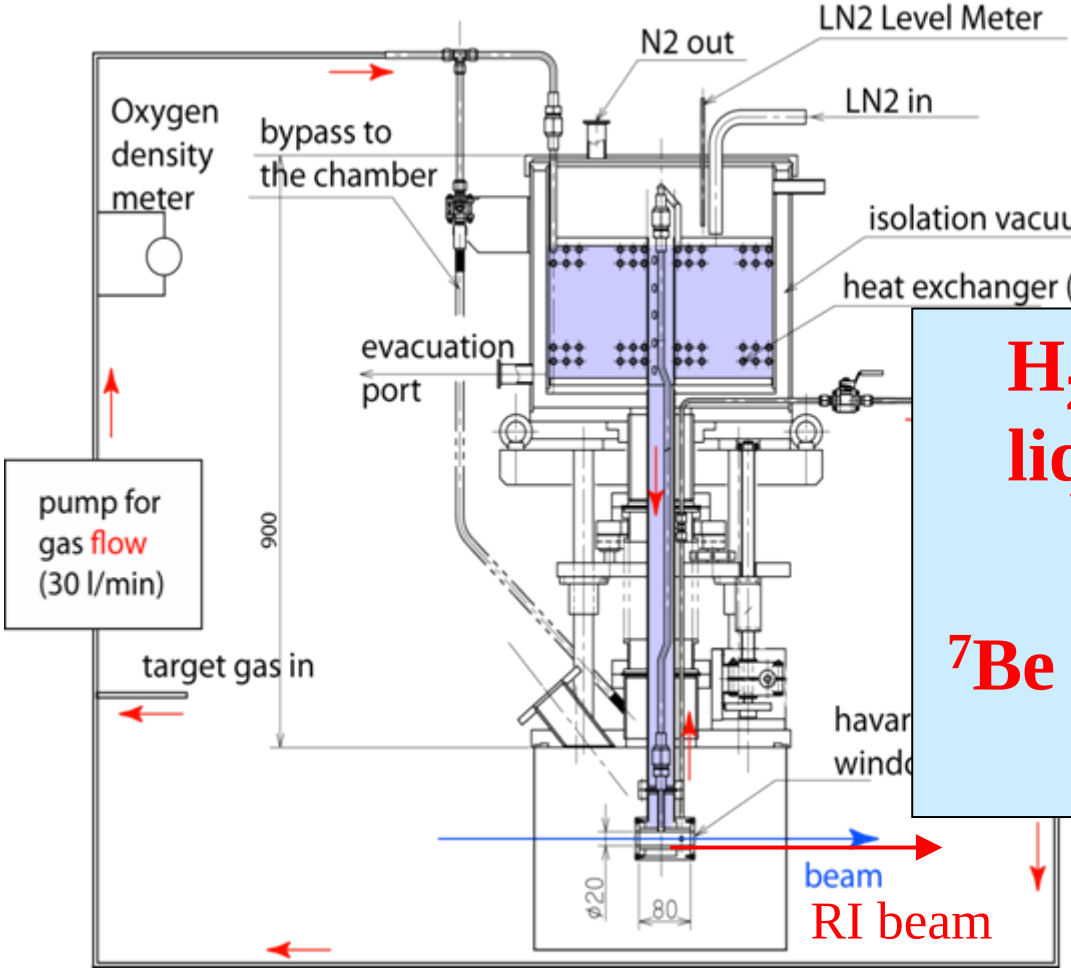
Secondary Beam	Primary Beam	Reaction	Target (mg/cm2)	Intensity (1/sec)	Purity
$^{7}Be^{4+}$ 8.1 *A* MeV	$^{7}Li^{3+}$ 150 pnA	(p,n)	H_2 gas (0.67)	3×10^{5}	100%
$^{10}C^{6+}$ 6.1 *A* MeV	$^{10}B^{4+}$ 200 pnA	(p,n)	CH_4 gas (1.33)	1.6×10^{5}	90 %
$^{13}N^{7+}$ 6.5 *A* MeV	$^{13}C^{5+}$ 500 pnA	(p,n)	H_2 gas (0.33)	2×10^{5}	95 %
$^{14}O^{8+}$ 6.7 *A* MeV	$^{14}N^{6+}$ 500 pnA	(p,n)	CH_4 gas (1.33)	1.7×10^{6}	80 %
$^{18}F^{9+}$ 2.7 *A* MeV	$^{18}O^{4+}$ 500 pnA	(p,n)	H_2 gas (0.67)	1.5×10^{5}	98%
^{11}C 3.4 *A* MeV	$^{10}B^{4+}$ 200 pnA	(^{3}He,np)	^{3}He gas (0.25)	1.7×10^{4}	17 %
^{12}N 3.9 *A* MeV	$^{10}B^{4+}$ 200 pnA	(^{3}He,n)	^{3}He gas (0.25)	2.5×10^{3}	3 %
^{8}Li 6.5 *A* MeV	$^{7}Li^{3+}$ 330 pnA	(d,p)	D_2 gas (1.33)	2×10^{5}	98 %
^{17}N 2.0 *A* MeV	$^{18}O^{6+}$ 750 pnA	(^{9}Be,^{10}B)	Be foil (2.5)	1×10^{5}	25 %

Radioactive Beams Produced by CRIB (A>20)

Secondary Beam	Primary Beam	Reaction	Target (mg/cm^2)	Intensity	Purity
^{21}**Na** 4.2 *A* MeV	^{20}Ne^{8+} 200 pnA	**(^{3}He,np)**	^{3}He gas (0.25)	**2.3×10^4**	**12 %** **no WF**
^{22}**Mg** 4.6 *A* MeV	^{20}Ne^{8+} 200 pnA	**(^{3}He,n)**	^{3}He gas (0.25)	**6.6×10^3**	**3 %** **no WF**
^{25}**Al** 4.0 *A* MeV					**%** **no WF**
^{26}**Si** 4.0 *A* MeV	^{24}Mg^{8+} 125 pnA	**(^{3}He,n)**	^{3}He gas (0.25)	**3×10^3**	**1.5 %** **no WF**
^{23}**Mg** 4.0 *A* MeV	^{24}Mg^{8+} 125 pnA	**(d,t)**	D_2 gas (0.33)	**3.2 ×10^4**	**12 %** **no WF**
^{39}**Ar^{15+}** 4.0 *A* MeV	^{40}Ar^{11+} 120 pnA	**(3He,α)**	^{3}He gas (1.0)	**3.2 ×10^4**	**20 %**

With room-temperature target !

Low-Temperature Production Target



Flow ≦100 lit/min.

Features:

- Lq. N_2 cooling (automatic refill)

for the better cooling power (<100 W) and

flow
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beam.

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system.

- Hydrogen room sensor.

H_2 target cooled by liquid Nitrigen

^{7}Be ~ 2x10^8 achieved !

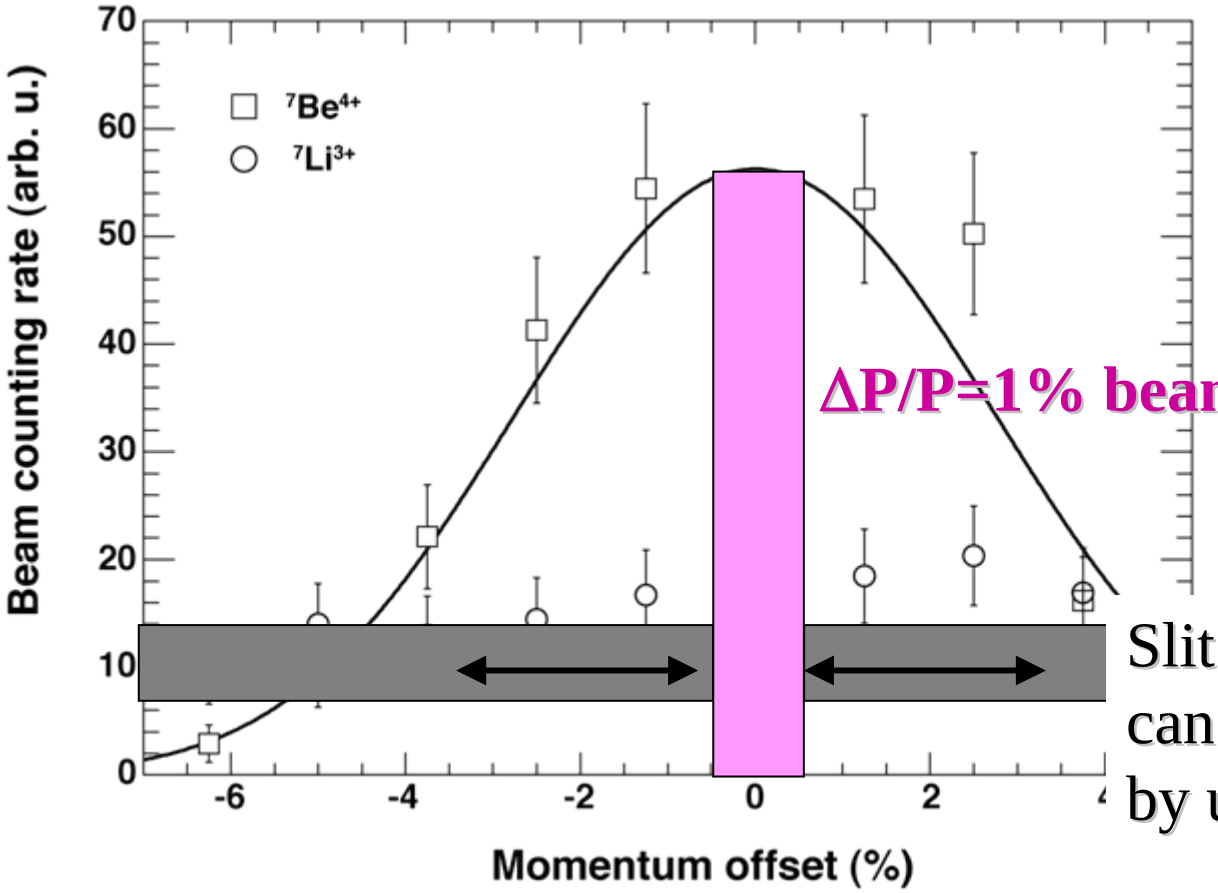
with 1.4 pμA

Low-T target: ^{7}Be production test results

- Primary beam: $^{7}Li^{2+}$ 5.57 MeV/u, 2.8 eμA at maximum (The cooled target worked with a heat load of 7.4 W).
- Target H_2 gas thickness:
  - Thickness was measured by ^{7}Li beam energy loss.
  - 760 Torr, 8cm, 2.3 mg/cm^2 …85K achieved.
- Secondary beam: $^{7}Be^{4+}$, 4.0 MeV/u, purity 75% (without degrader/ WF).
  - $2x10^8$ pps was achieved.

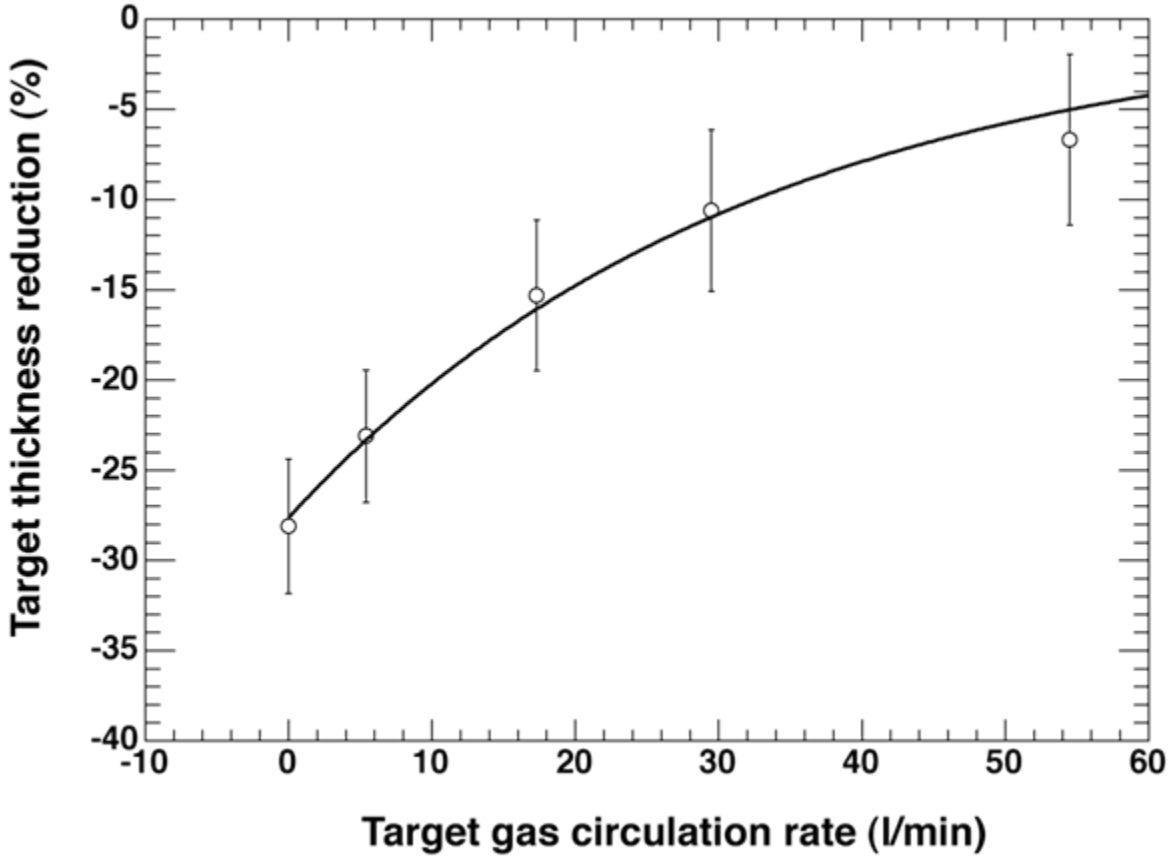
Momentum distribution of ^{7}Be

- Large momentum spread due to the energy straggling was observed (FWHM=6.4%).



Target thickness reduction

- Target thickness reduction effect (max. 30%) was observed for the 2.7 μA beam, 2.3 mg/cm^2 target.
- The effect could be minimized by the circulation (max. 55l/min).



In Progress

Ion Source;

- Installation of Super-conducting ECR

  --tuning stage now, will be on-line next spring/summer
- Development of charge breeder IS

AVF cyclotron;

- Redesigning the central region

  -- redesign the spiral deflector, install it next year

  => expand the acceleration ability to H=1 and 3

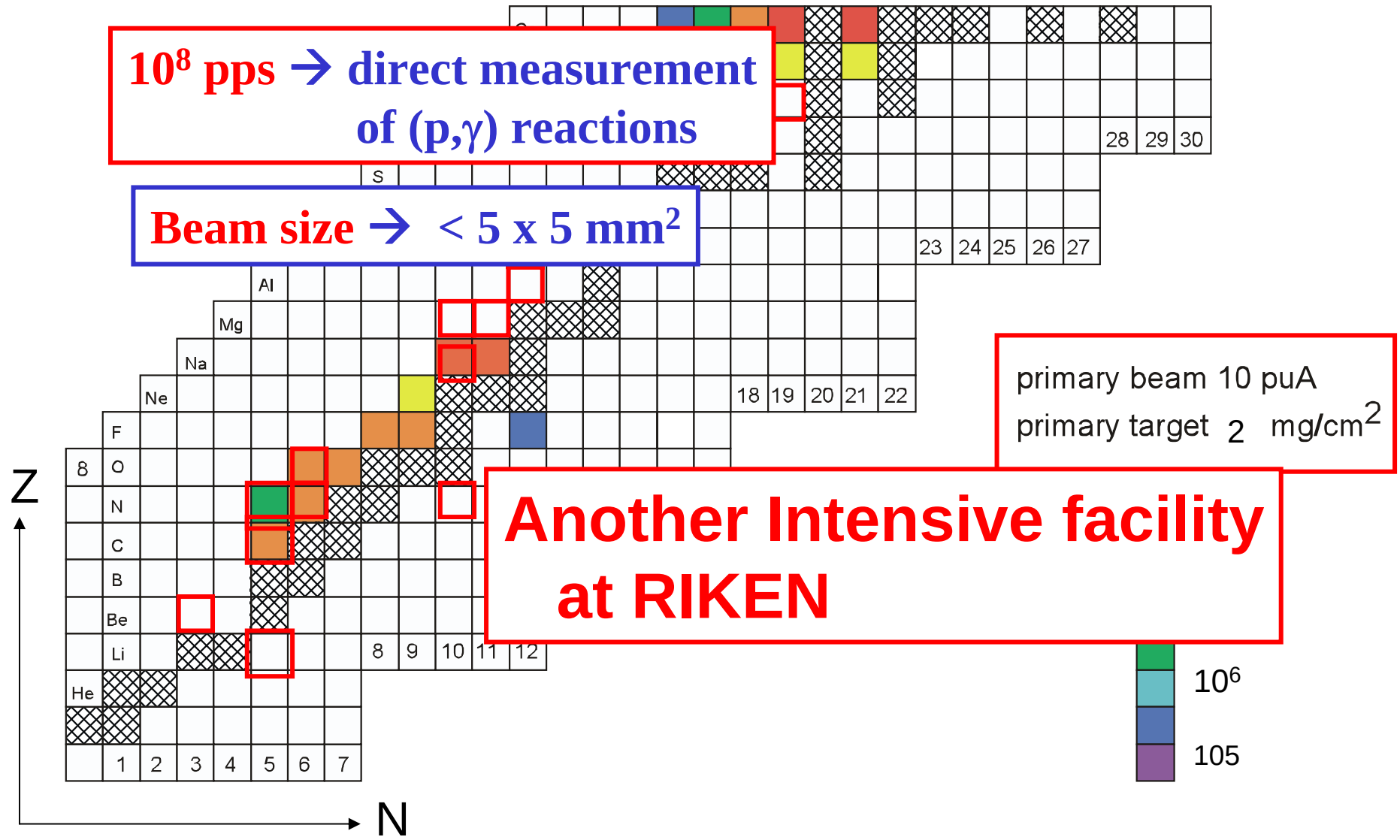
  efficient transport through the AVF (increase the beam x~2-3)
- Installed a new grazer-lens

  => better beam transmission and better emitance

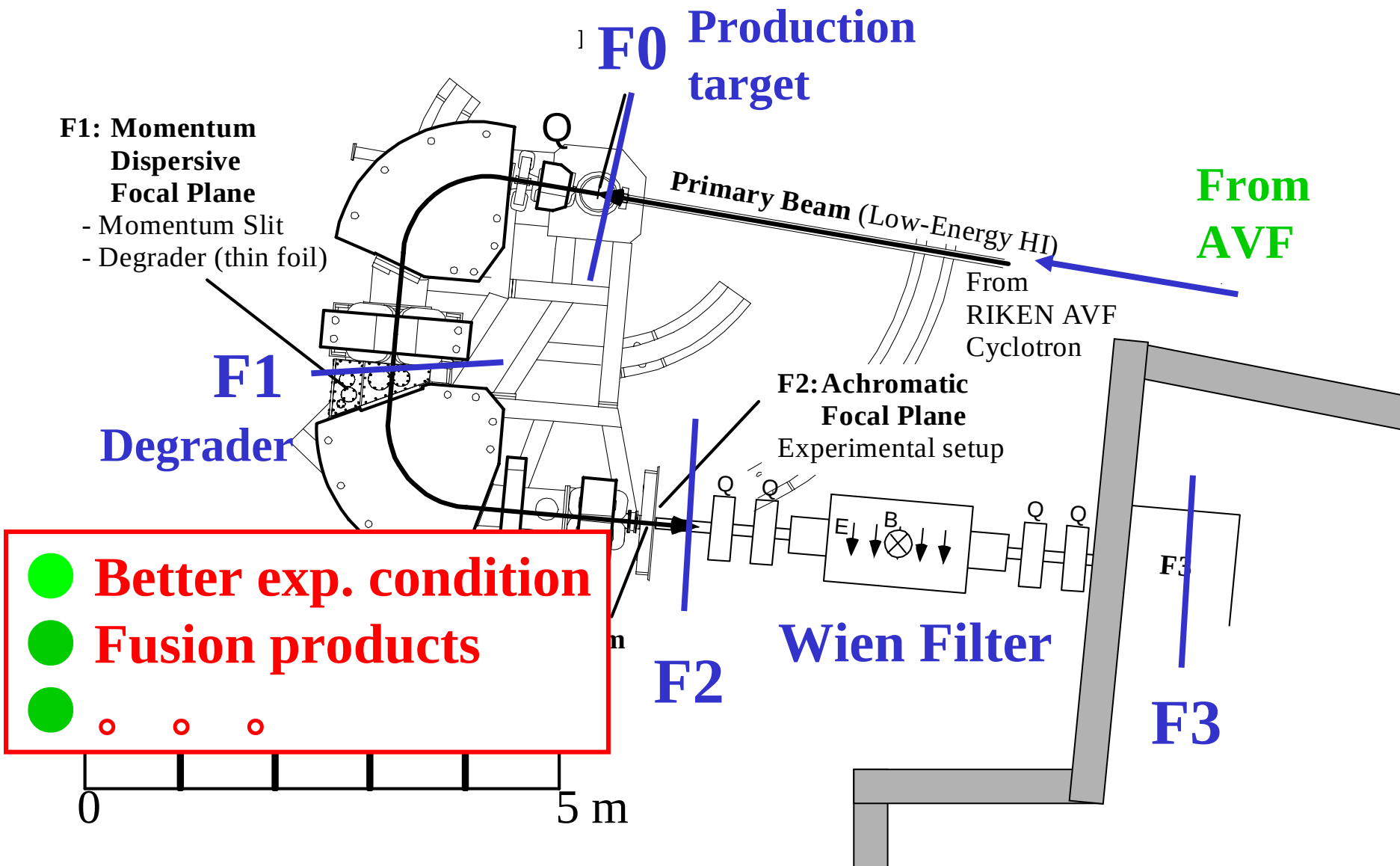
CRIB;

- Installed multi-pole element for smaller RI beam size
- Tuning Liq.N cooling target

Low-Energy RIB intensity to be reached at CRIB



Low-energy in-flight RI beam separator CRIB



• Major part of AVF operation will be available for CRIB (& PA) now on

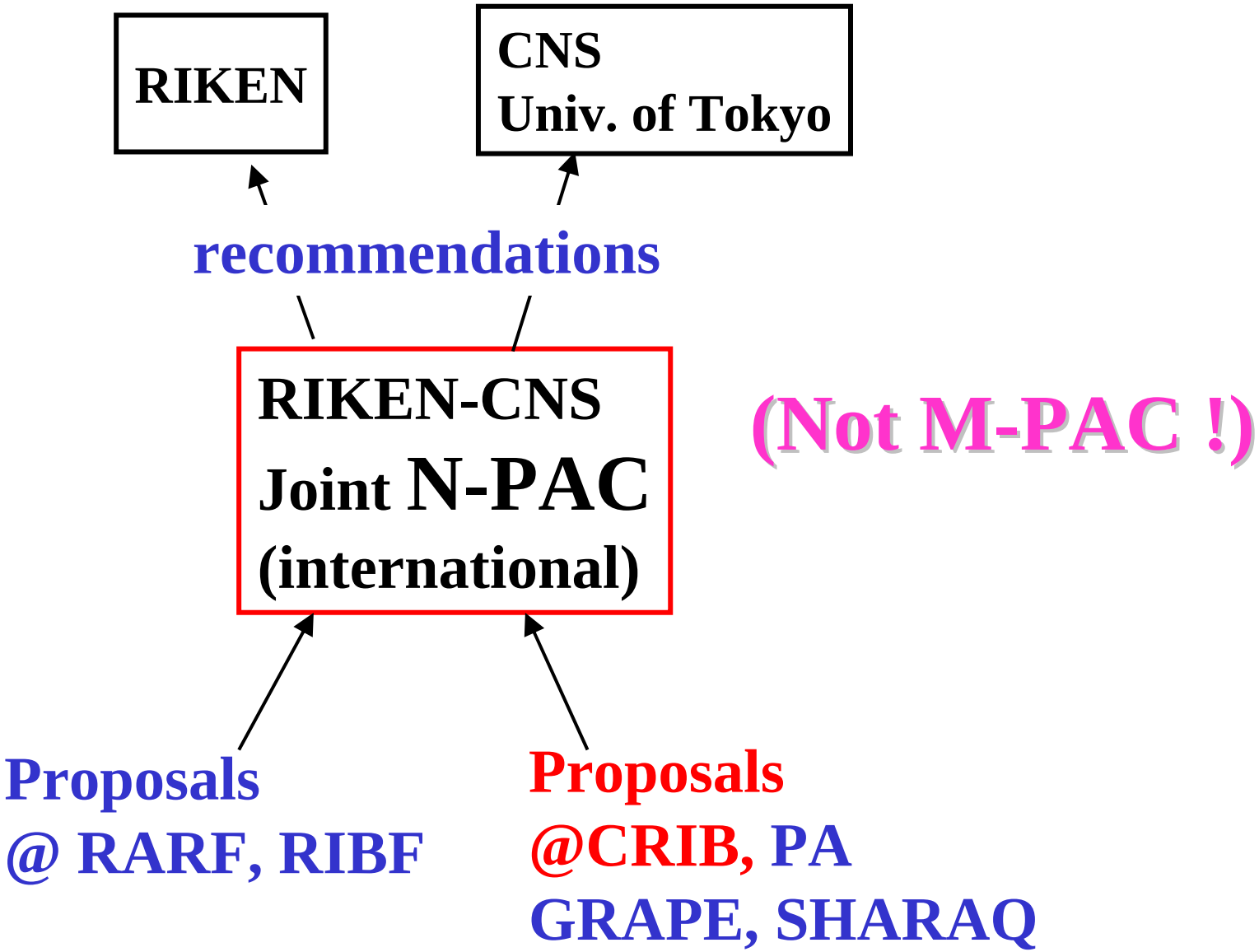
Joint PAC of CNS and RIKEN
Next dead line; 10th of December
(2 times a year)

2006 fall collaborations at CRIB;
9 experiments; 27 days
Kyushu, Korea, Canada, RIKEN, CNS

2006 Spring collaborations at CRIB;
8 experiments; 20 days

on Nuclear Astrophysics, Nuclear Physics
Material Science

How to use the CRIB ?



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N-PAC at

http://rarfaxp.riken.go.jp/~miyauchi/alpha/UserGuide/

http://www.cns.s.u-tokyo.ac.jp/crib/crib-intro.html