Development of WINDS for (p,n) measurements in inverse kinematics

Ken Yako (CNS)

Center for Nuclear Study

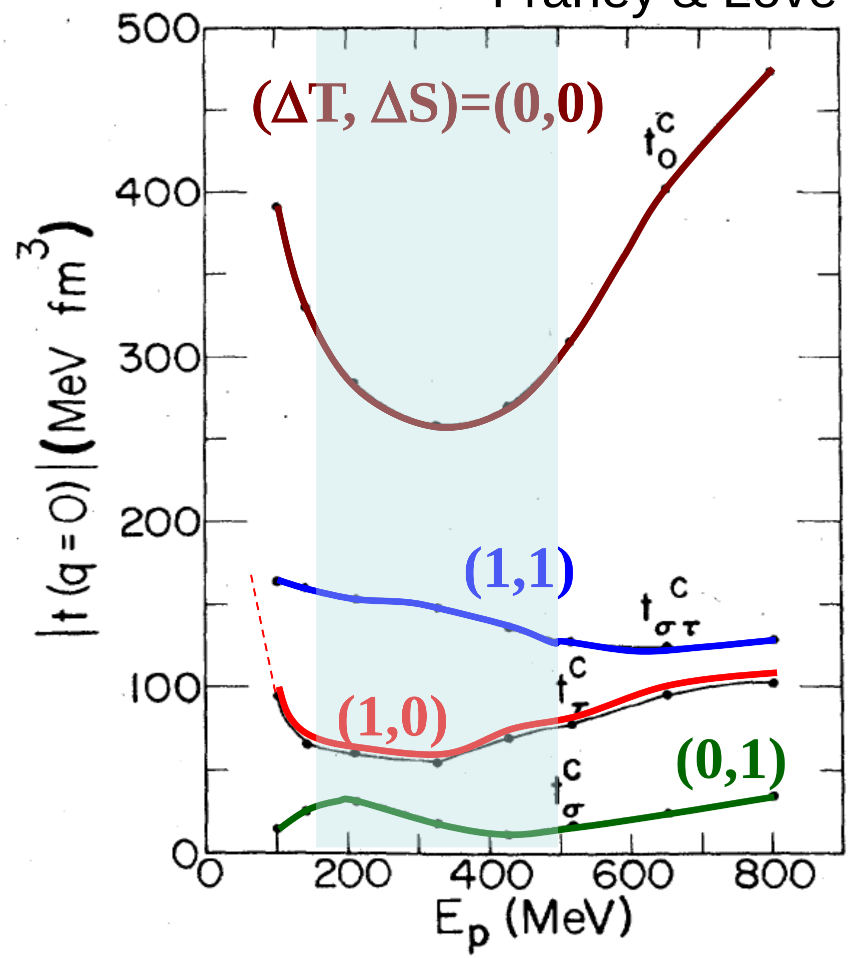
EMIS2012

Dec 5, 2012

Extending Charge-X reactions

Charge exchange reactions
at intermediate energies
⇒ excellent spectroscopic tool
of spin-isospin (ΔT=ΔS=1)
excitations

Franey & Love



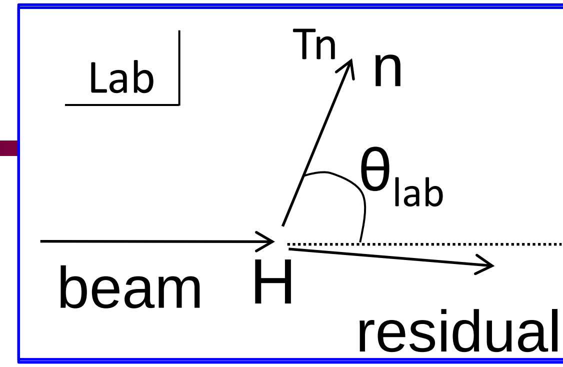
Intermediate energies

- Simple reaction mechanism
- $t_{\sigma\tau}$ is the largest apart from t_0^C.

⇒ GT transitions are most clearly seen.

Aim: extending the (p,n) work on unstable nuclei (at RIBF-RIKEN).

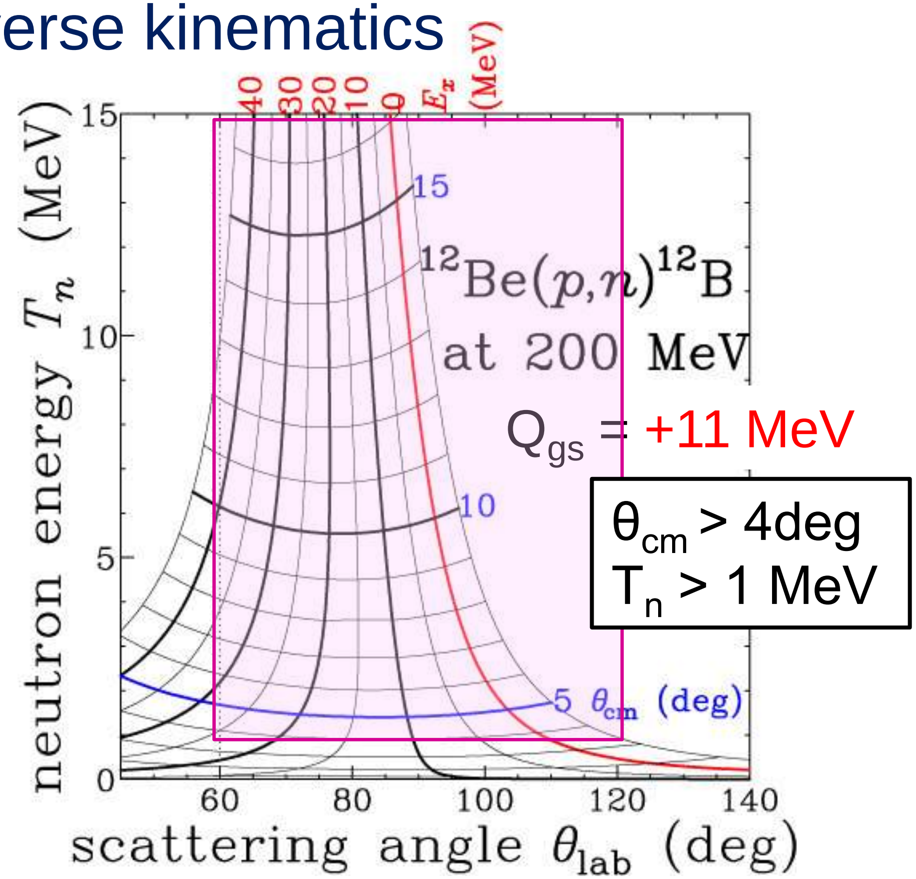
Inverse kinematics, angl-dist.



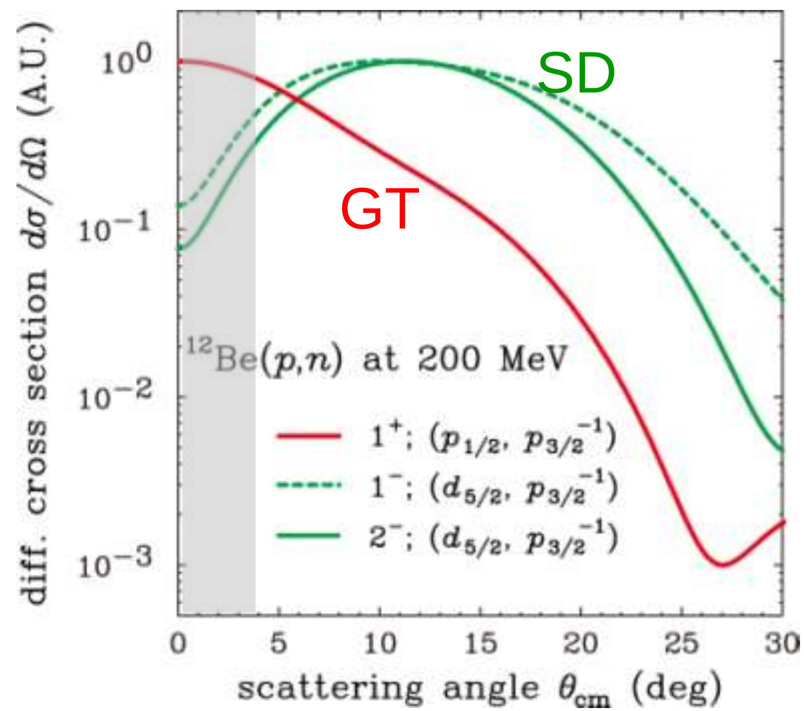
- missing mass : $(T_n, \theta_{lab}) \rightarrow (E_x, \theta_{cm})$

  T_n …Time-of-flight

Inverse kinematics



Angular distribution

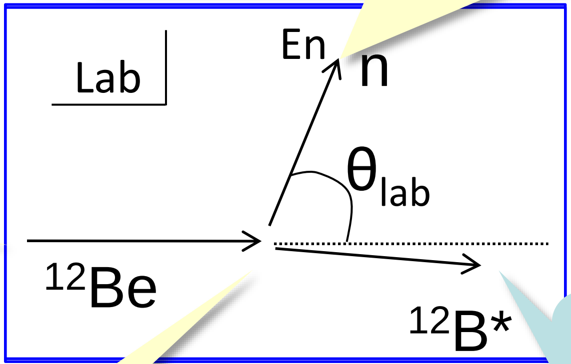


resolution of δE_x ~ 1 MeV, $\delta\theta_{cm}$ ~ 1 deg ⇒ δE_n ~ 0.8 MeV, $\delta\theta_{lab}$ ~1.3 deg

Overview of the (p,n) facility

Neutron detector
"WINDS"
TOF

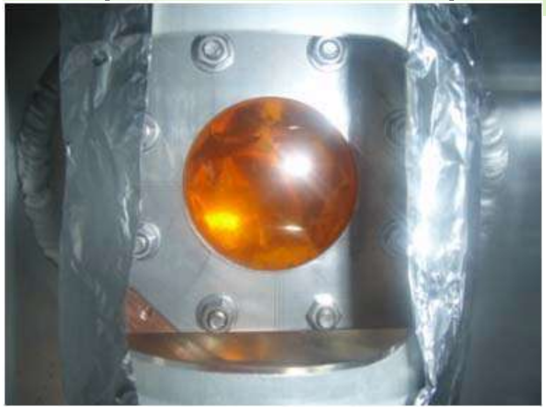
Unstable beam



SHARAQ
^{12}B, ^{11}B, or ^{10}B

14 mm^t, 40 mmΦ
Kapton wndw 25 μm^t

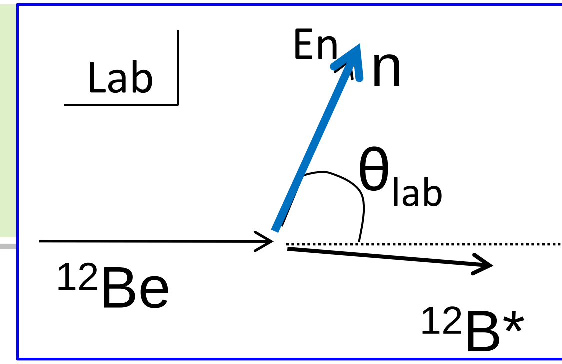
$LiqH_2$
target

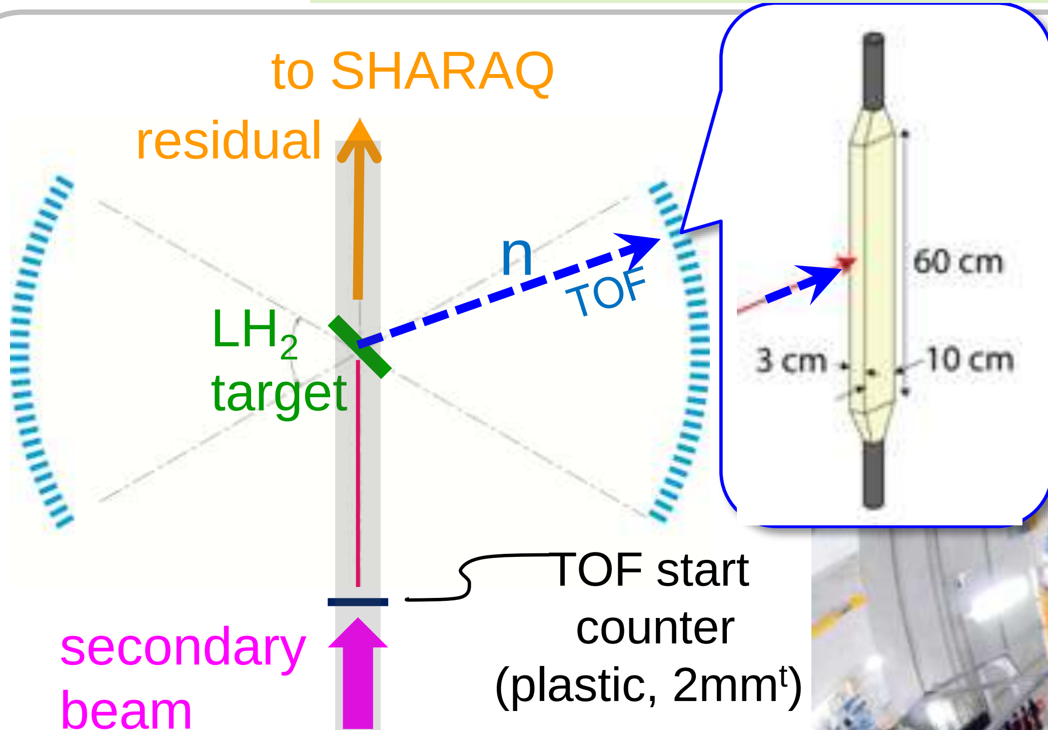


|δp/p| < 1%,
~5 msr

WINDS

"WINDS"
= Wide-angle Inverse-kinematics Neutron Detectors for SHARAQ





T_n (MeV)	1	10
TOF (ns)	130	30
Req. on δTOF (ns)	3.5	1.5

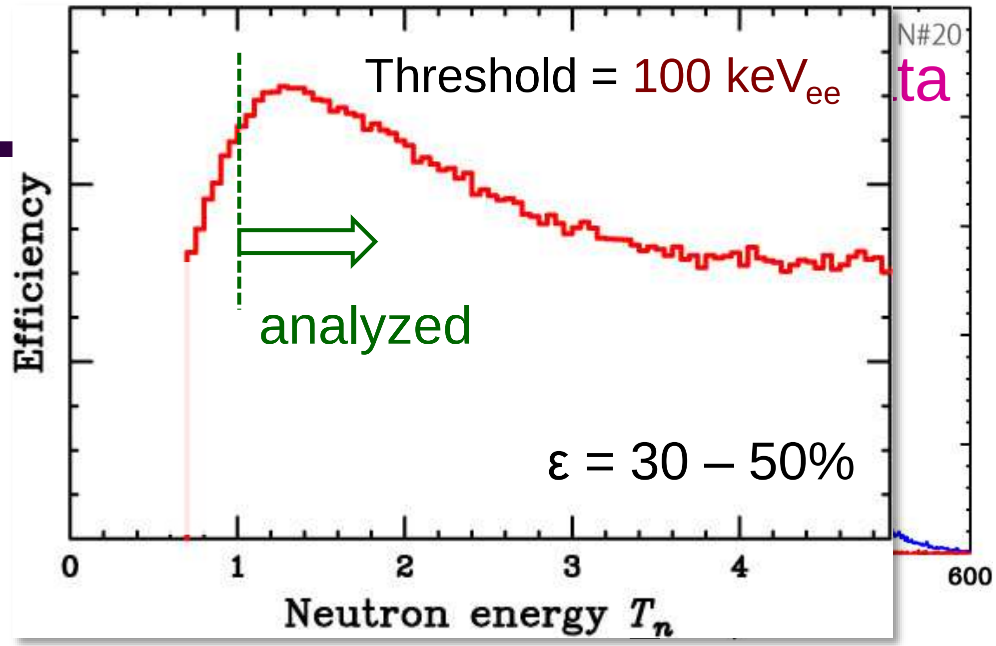
- 59 plastic scintillators (H7195 + BC408, 60 x 10 x 3 cm^3)
- θ = 60-120° , FPL = 180 cm

δTOF(WINDS): ~ 1.5 ns

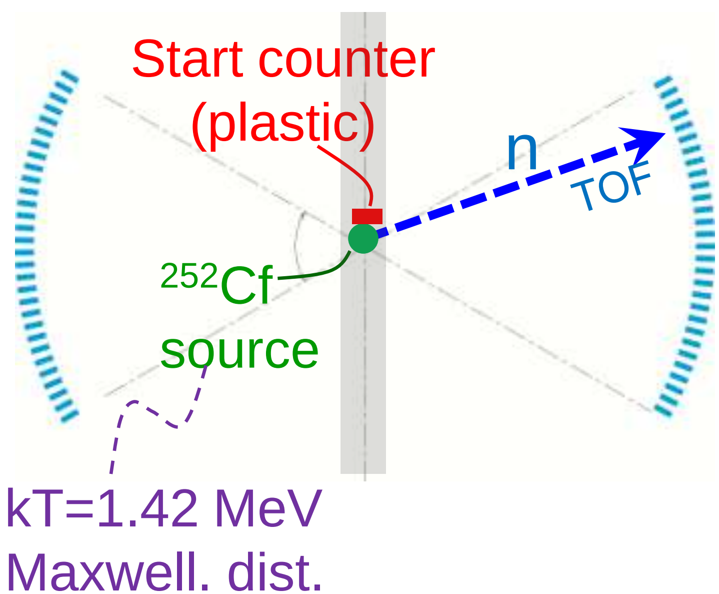
Calibration

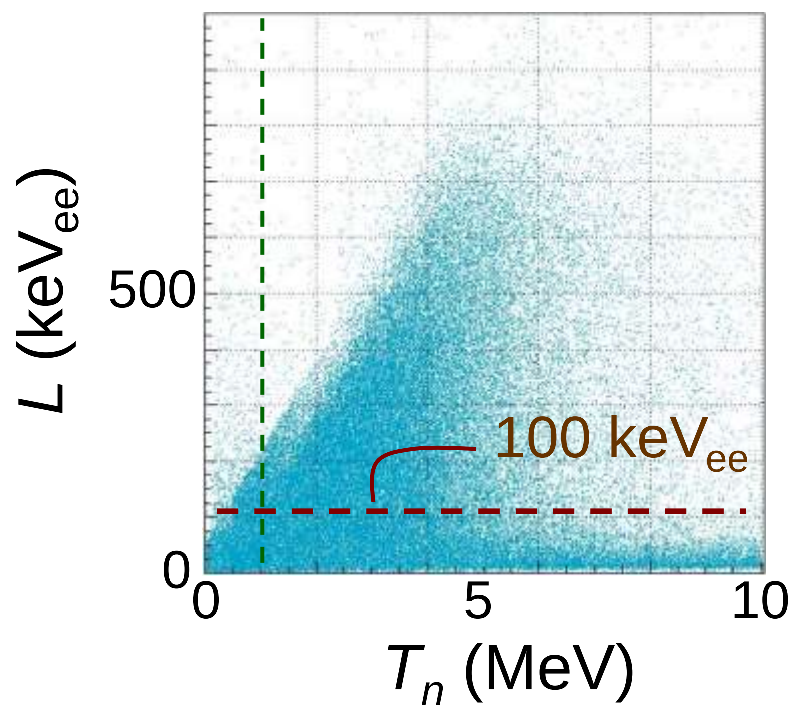
- Light output

$$L = \sqrt{Q_{up} Q_{down}}$$



- Efficiency (^{252}Cf)



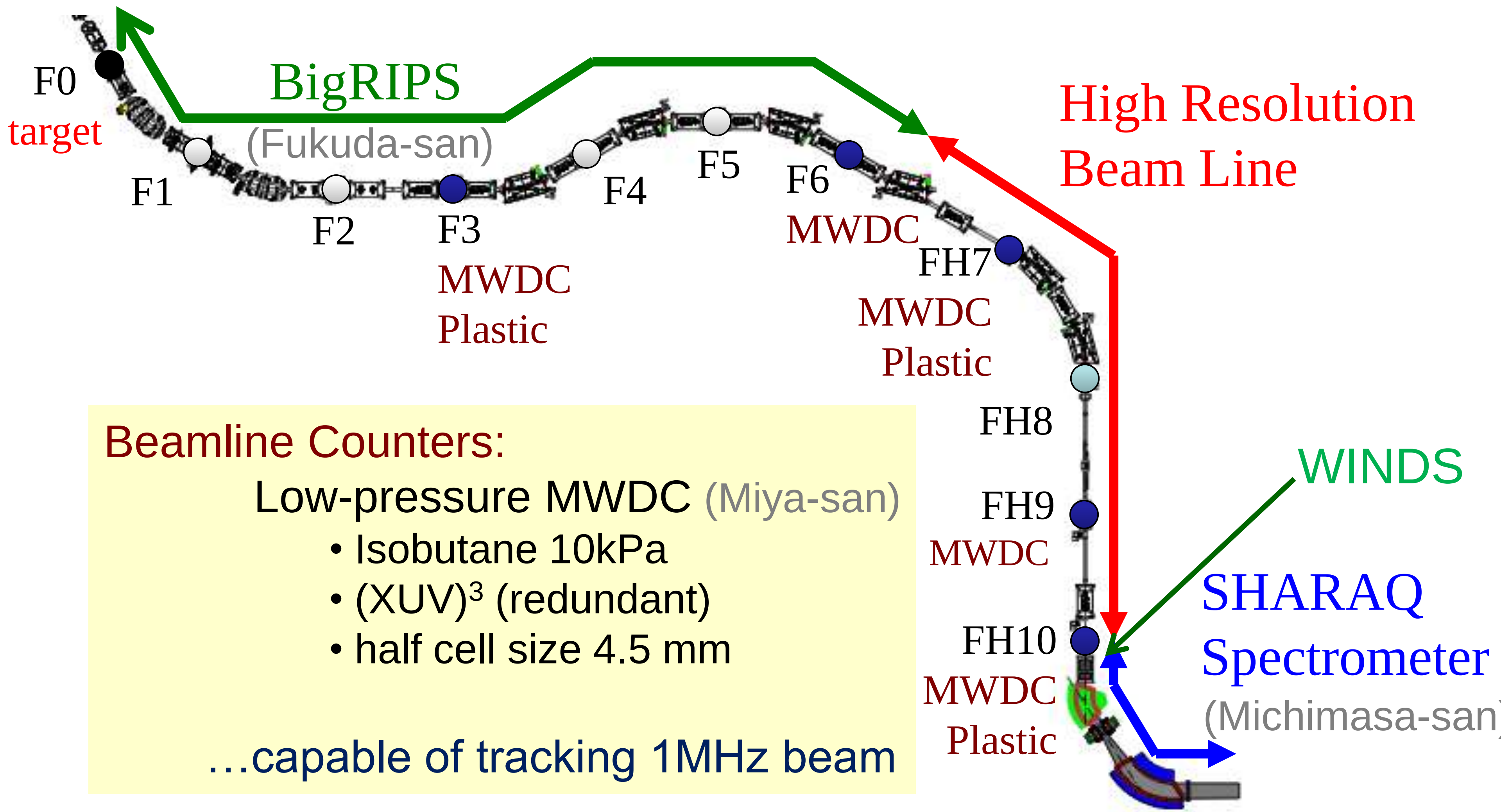


First experiment: ^{12}Be(p,n) reaction

- Beam line: BigRIPS + SHARAQ
- Primary beam: ^{18}O 250A MeV, 100-200 pnA
  - ¼ -freq. buncher @RILAC… pulse separation of 122 ns
- Primary target: Be, 20 mm^t
- Secondary beam: ^{12}Be 200A MeV,
  0.5 – 1 Mcps on target
  beam size Δx = 7 mm (in σ)
  Δy = 5 mm
- Secondary target: Liq H_2, 14 mm^t

Beam

- securing the TOF window: ¼ prescaled by beam buncher @RILAC
- beamline detectors



Beamline Counters:

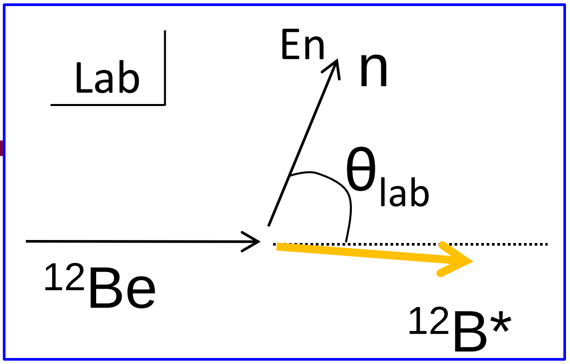
Low-pressure MWDC (Miya-san)

- Isobutane 10kPa
- (XUV)^3 (redundant)
- half cell size 4.5 mm

…capable of tracking 1MHz beam

SHARAQ

SHARAQ …high-resolution magnetic spectrometer constructed at RIBF by UT - RIKEN collaboration.



Maximum rigidity

6.8 Tm

Momentum resolution

d*p*/*p* = 1/14700

Angular resolution

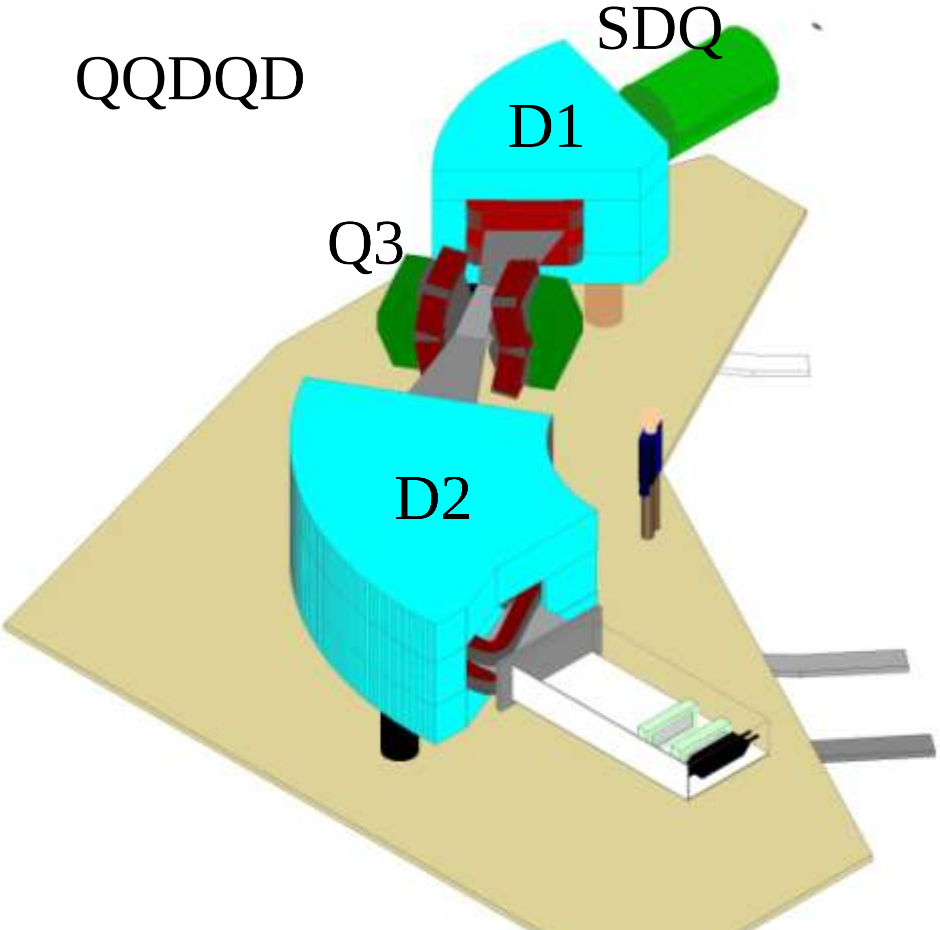
~ 1 mrad

Momentum acceptance

± 1%

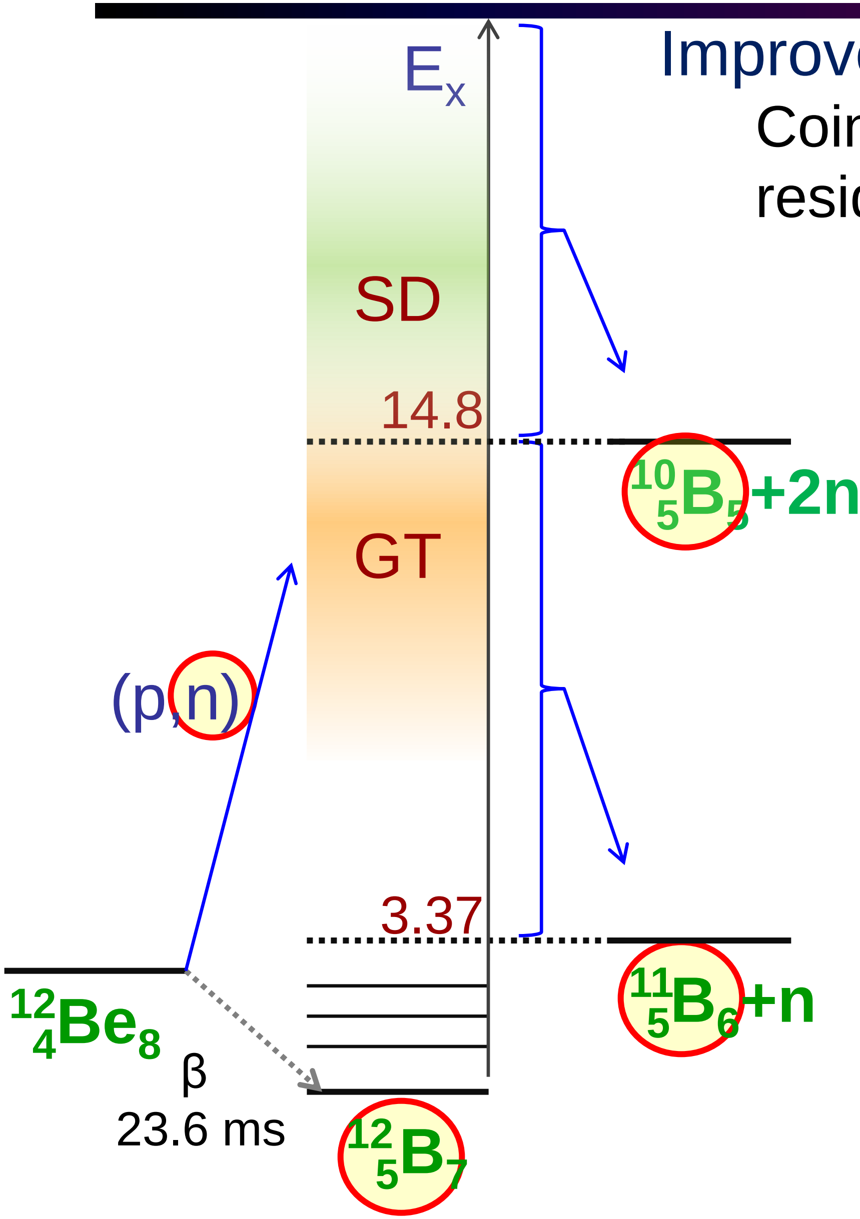
Angular acceptance

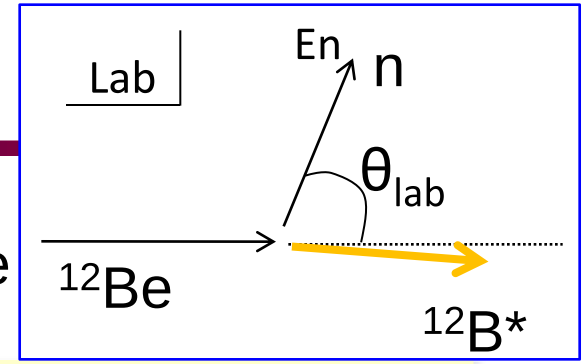
~ 5 msr



T.Uesaka. et al., NIMB B 266 (2008) 4218.

Coincidence measurement

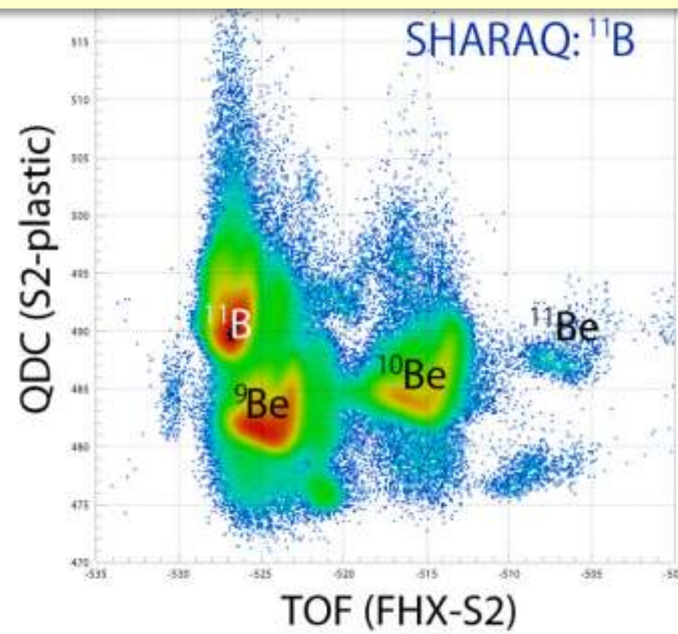




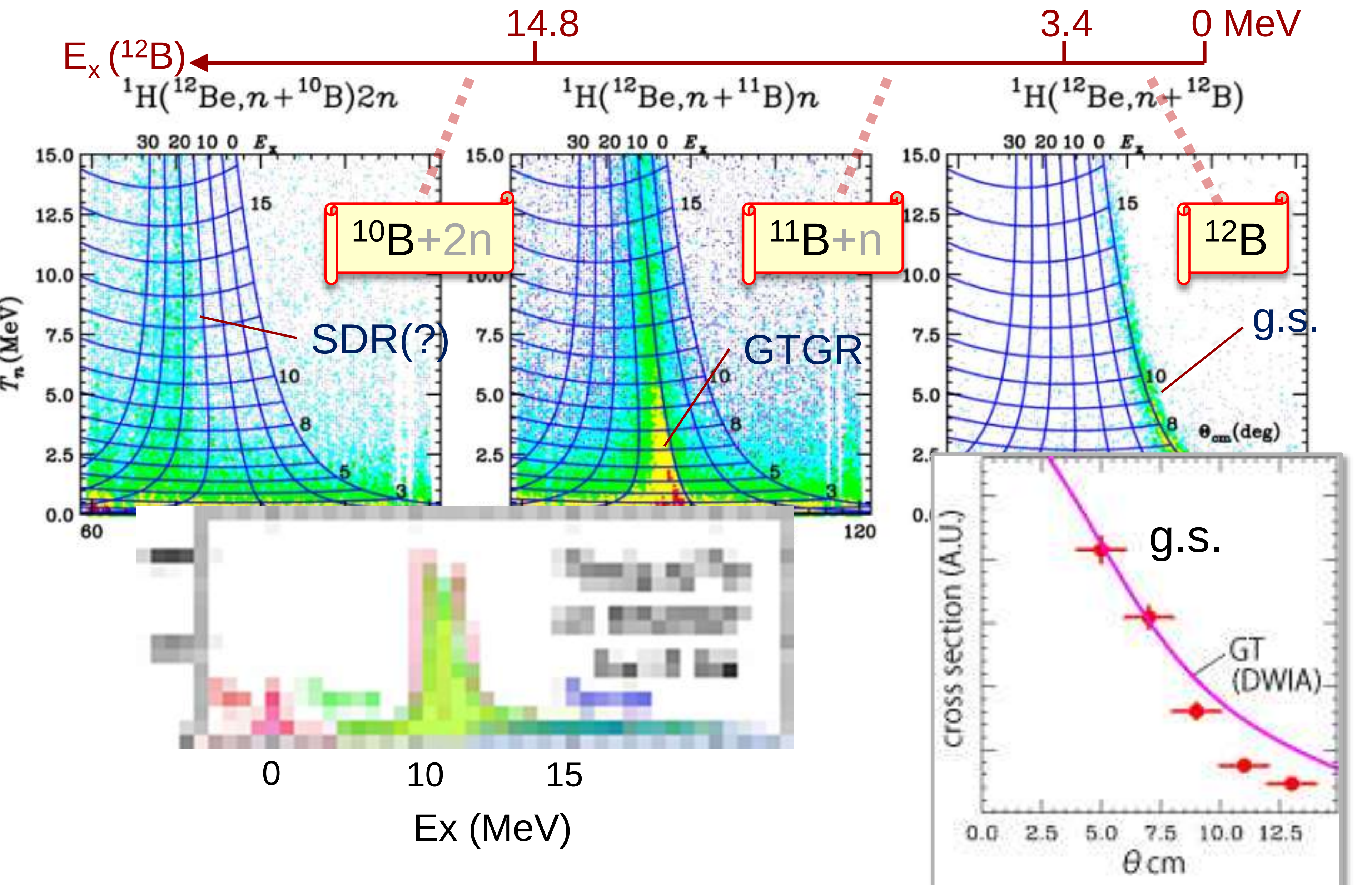
Improvement of S/N :

Coincidence with the residual particle

- $0<E_x< 3.4$ MeV
  → ^{12}B & n (100%)
- $3.4<E_x<14.8$ MeV
  → ^{11}B & n (70-96%)
- $E_x > 14.8$ MeV
  → ^{10}B & n

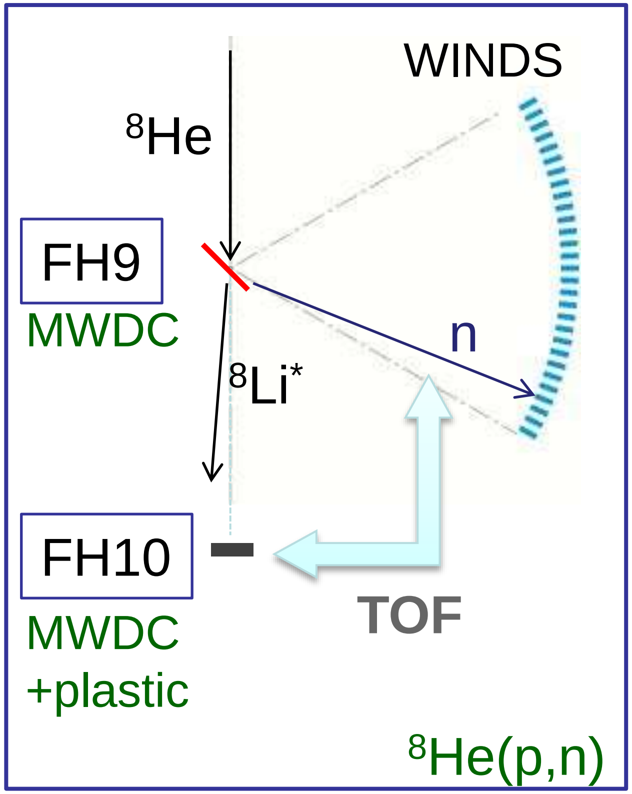


Preliminary spectra



Towards simpler system

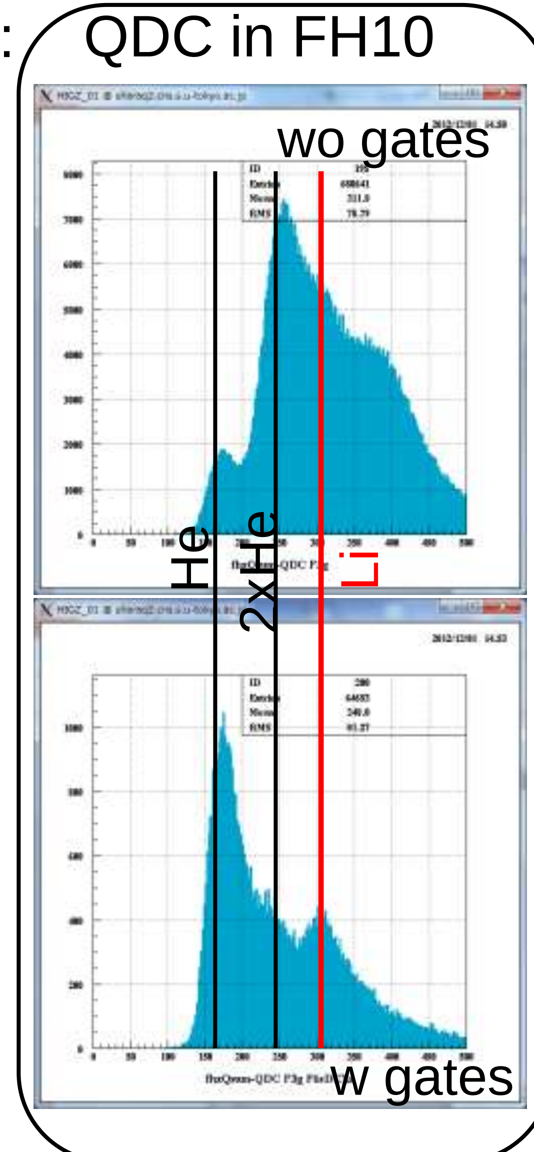
(apr2012) M. Kobayashi



- ☐ Identification of residual:
  SHARAQ
  → Beamline detectors
- ☑ Beam prescaling:
  Hardware
  (= 1/4-freq. buncher)
  → software cut
- ☐ Secondary Target:
  LH_2 → (polyethylene)
  - (Carbon)

… allows
parasite measurements.

Currently separation of residual
from the beam is insufficient



Summary

- We have developed a facility capable of (p,n) measurement on unstable nuclei at RIBF.
  - Neutron counter array "WINDS"
  - SHARAQ spectrometer
  - LH_2 target
  - Beamline detectors (tracking 1MHz beam)

- $^{12}Be(p,n)$ as the first measurement for n-rich nuclei

  …Data reduction is in progress.

Collaborators

CNS, UT:	K.Y., S. Shimoura, S. Michimasa, S. Ota, Y. Sasamoto, H. Tokieda, H. Miya, S. Kawase, T.L. Tang, C.S. Lee, M. Takaki, K. Kisamori, Y. Kikuchi, Y. Kubota, T. Fujii, R. Yokoyama
RIKEN:	T. Uesaka, H. Sakai, M. Sasano, M. Dozono, H. Matsubara, M. Kurata-Nishimura, Y. Yanagisawa, N. Inabe, T. Kubo, H. Takeda, T. Ohnishi, H. Baba, Y. Shimizu
Dep. of Phys., UT:	Z.-Y. Xu
RCNP:	K. Miki
Kyushu:	S. Sakaguchi
Kyoto:	T. Kawabata
MSU:	R.G.T. Zegers, S. Noji