Proton elastic scattering

for the study of weakly bound nuclei

with SAMURAI

(1) ESPRI

(2) ^{6,8}He, ^{9,11}Li, ^{12,14}Be(p,p)

(3) Experimental setup

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Elastic Scattering of Protons with RI beam (ESPRI) project

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Motivation

Nuclear size and density distribution

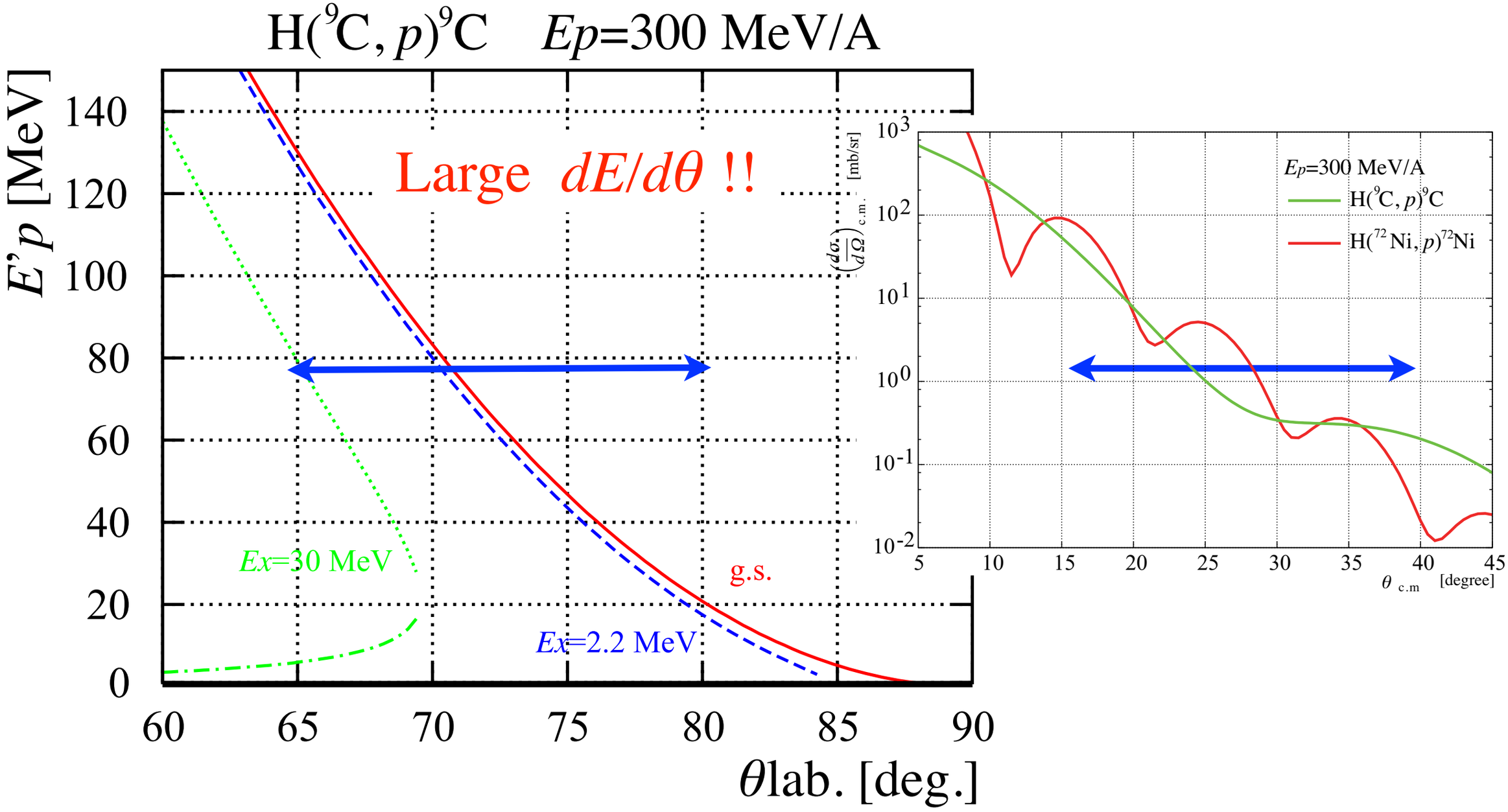
- Fundamental properties of nuclei
- Inputs and/or guidelines to describe the nuclear reactions and structures

	Stable nuclei	Unstable nuclei
Muonic atom	Charge radius	
Isotope shift	Charge radius	Charge radius
Interaction cross section		Charge radius
Electron scattering	Charge distribution	
Proton elastic scattering	Neutron distribution	
	Charge distribution / radius ●Charge radii are proportional to $A^{1/3}$ ●The diffuseness is independent of A, Neutron distribution ●Approximately equal to the proton distribution	Matter radius ● Matter radii have Isospin dependence. ●Skins arise from differences betwreen S_p and S_n. ●Halo is caused by the loosely bound nucleon(s).

Concerning the density distribution, experimetal data is rare !!

Elastic scattering of Protons with RI beams

Kinematics of ESPRI

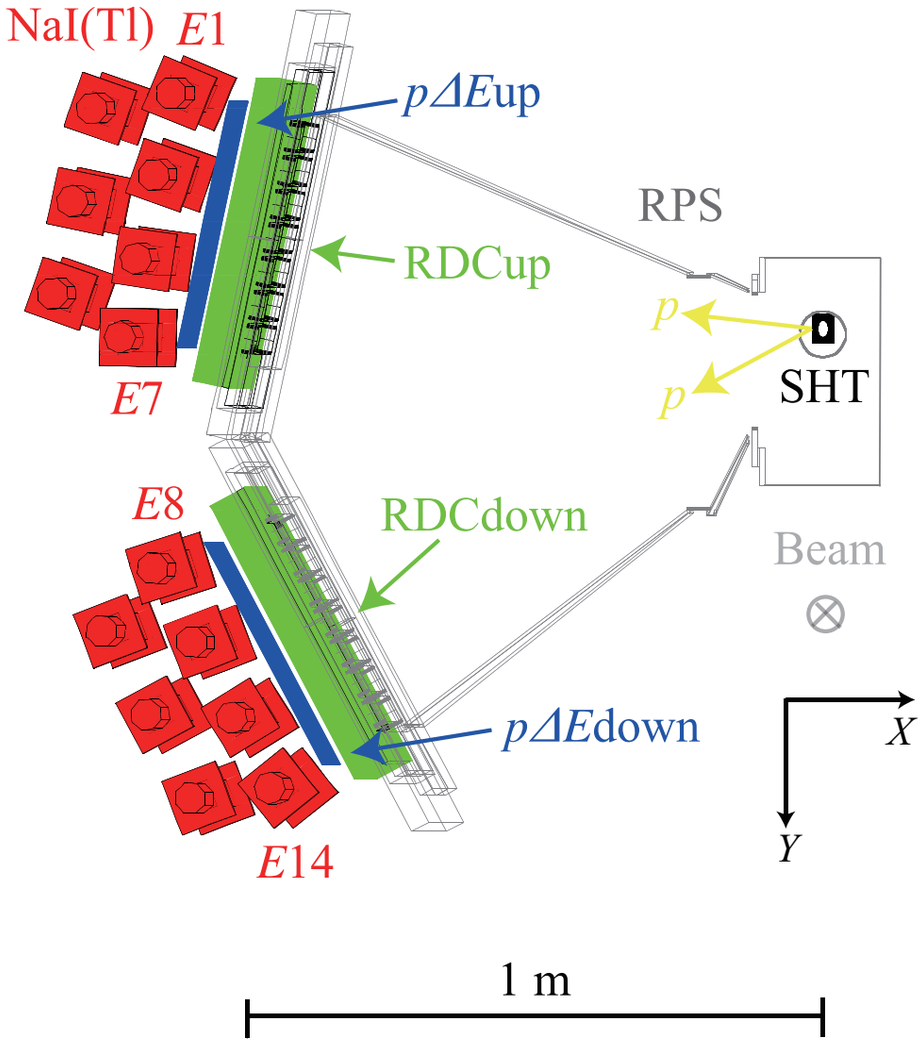


It has been difficult to measure in a wide momentum transfer region.

Experiments in the lower momentum transfer region (<1 fm^{-1}) have been done so far.

- RIKEN, GANIL,MSU : <100 MeV/A
- GSI (He, Li isotope) : 700 MeV/A

Recoil Proton Spectrometer (RPS)

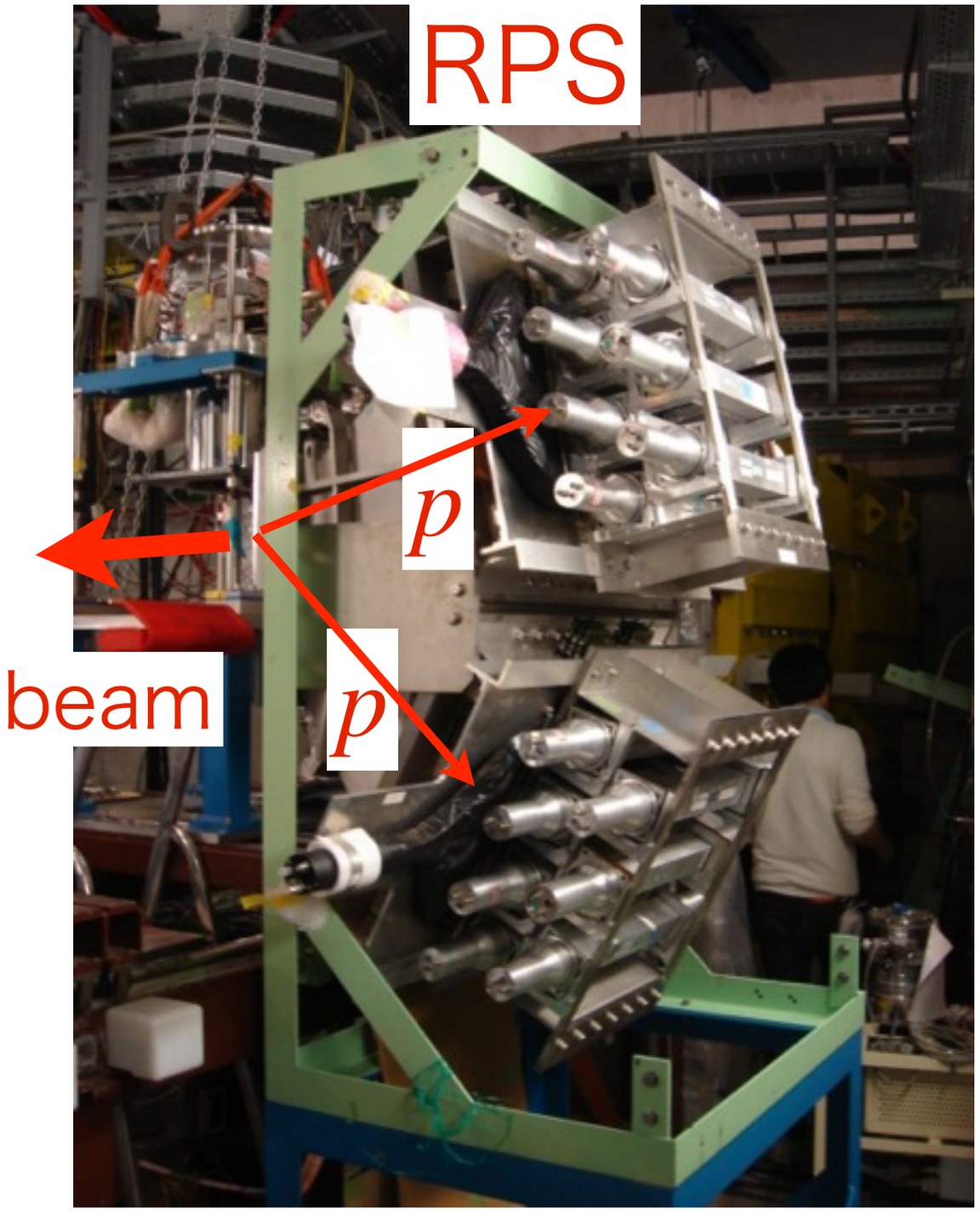


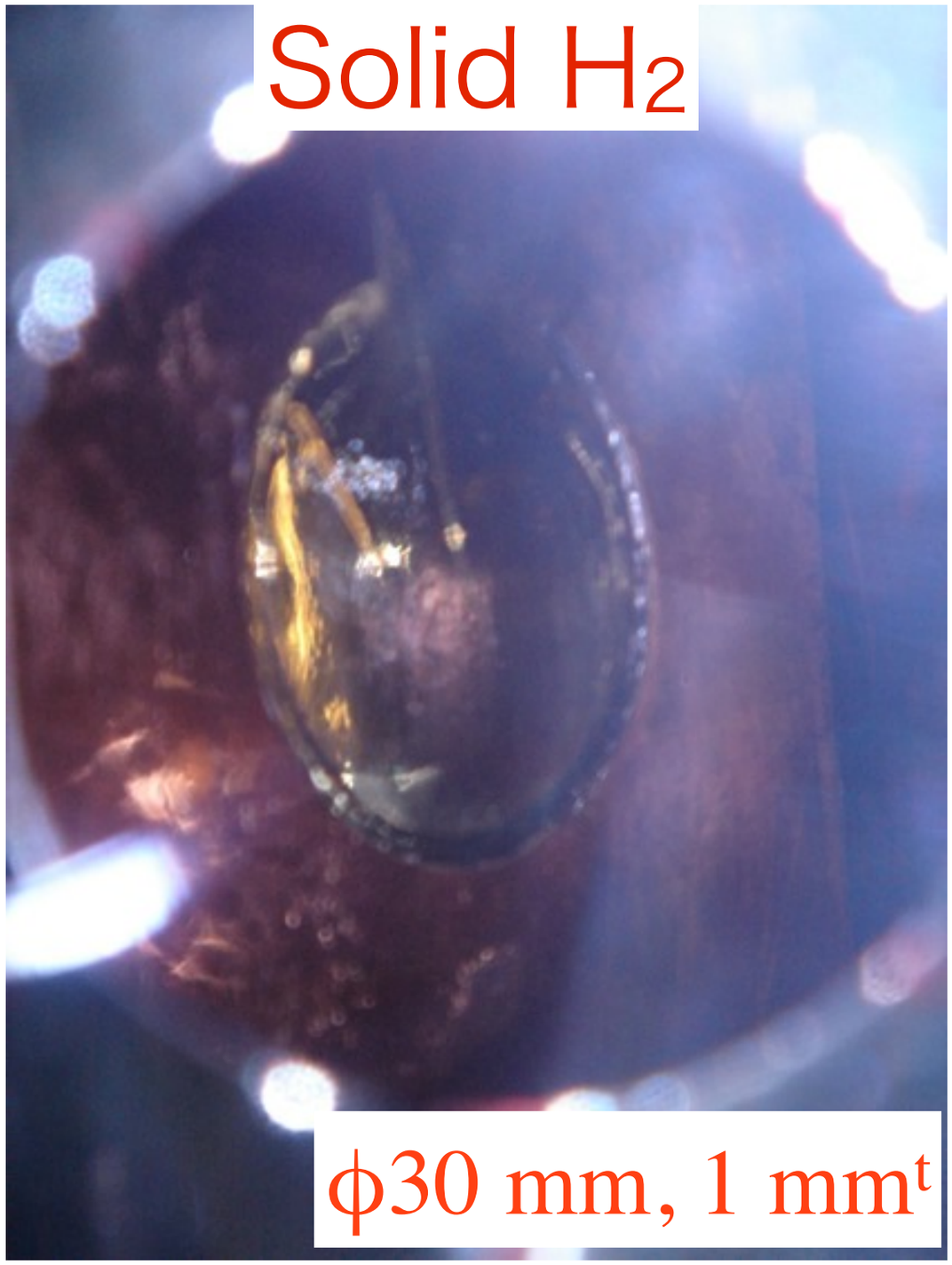
NIRS-HIMAC	GSI
FY2006: ^{9}C, ^{20}O	FY2009-2010: ^{66,70}Ni
2007: ^{20}O	
2008: ^{10,11}C	

q [fm^{-1}]	1 - 2
$\theta_{lab.}$ [deg.]	~66 - 80
$\Delta\Omega$ [msr/deg.]	~10
σ_{Ex} [MeV]	~0.4
S/N	>9: <1

	Solid H_2 (SHT)	RDC	$p\Delta E$	E
material	Para H_2	Ar+C_2H_6	Plastic	NaI(Tl)
effective area	ϕ 30 mm	436 x 436 mm^2	440 x 440 mm^2	431.8 x 45.72 mm^2
thickness	1 mm	69.4 mm	2.53 / 3.09 mm	50.8 mm
Resolution		500 μm	TOF : 0.1 nsec	0.3 %(80 MeV)

Recoil Proton Spectrometer (RPS)





Plane at RIBF

1. Weakly bound systems

Neutron rich : ^{6,8}He, ^{9,11}Li, ^{12,14}Be

Proton rich : A～10

2. Modification of shell structure

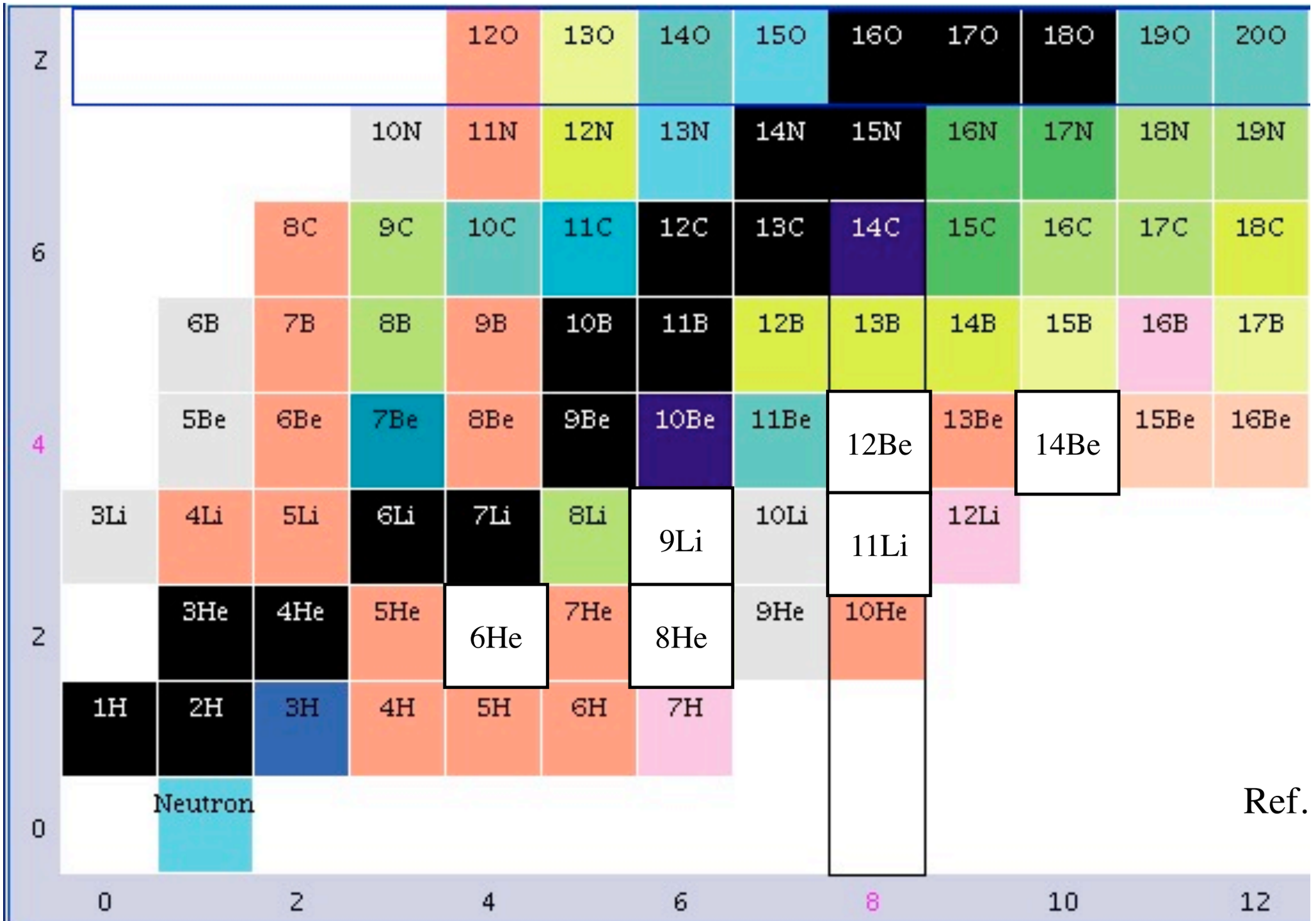
A=30～50

3. Asymmetric nuclear matter

A=70～100

Plane at RIBF

Neutron rich side : ^{6,8}He, ^{9,11}Li, ^{12,14}Be



Ref. NNDC

Combination with SAMURAI

	Sn	S_2n	E_x (1st)
^{6}He	1.87	**0.97**	1.80
^{8}He	2.57	**2.14**	3.10
^{11}Li	0.33	**0.30**	-
^{14}Be	1.85	**1.26**	-
^{9}Li	4.06	6.10	**2.69**
^{12}Be	3.17	3.67	**2.10**

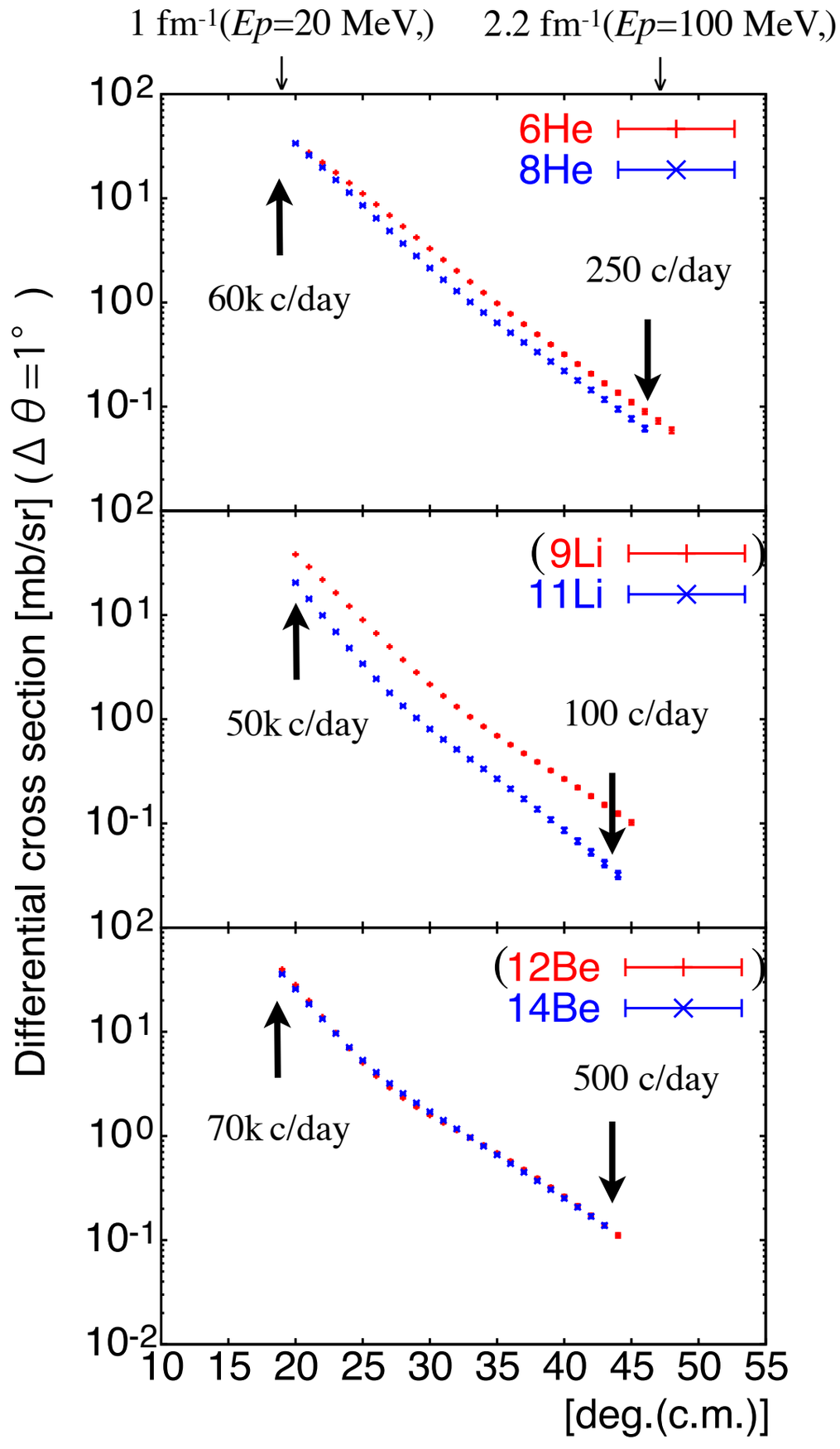
Data: NNDC

Yield

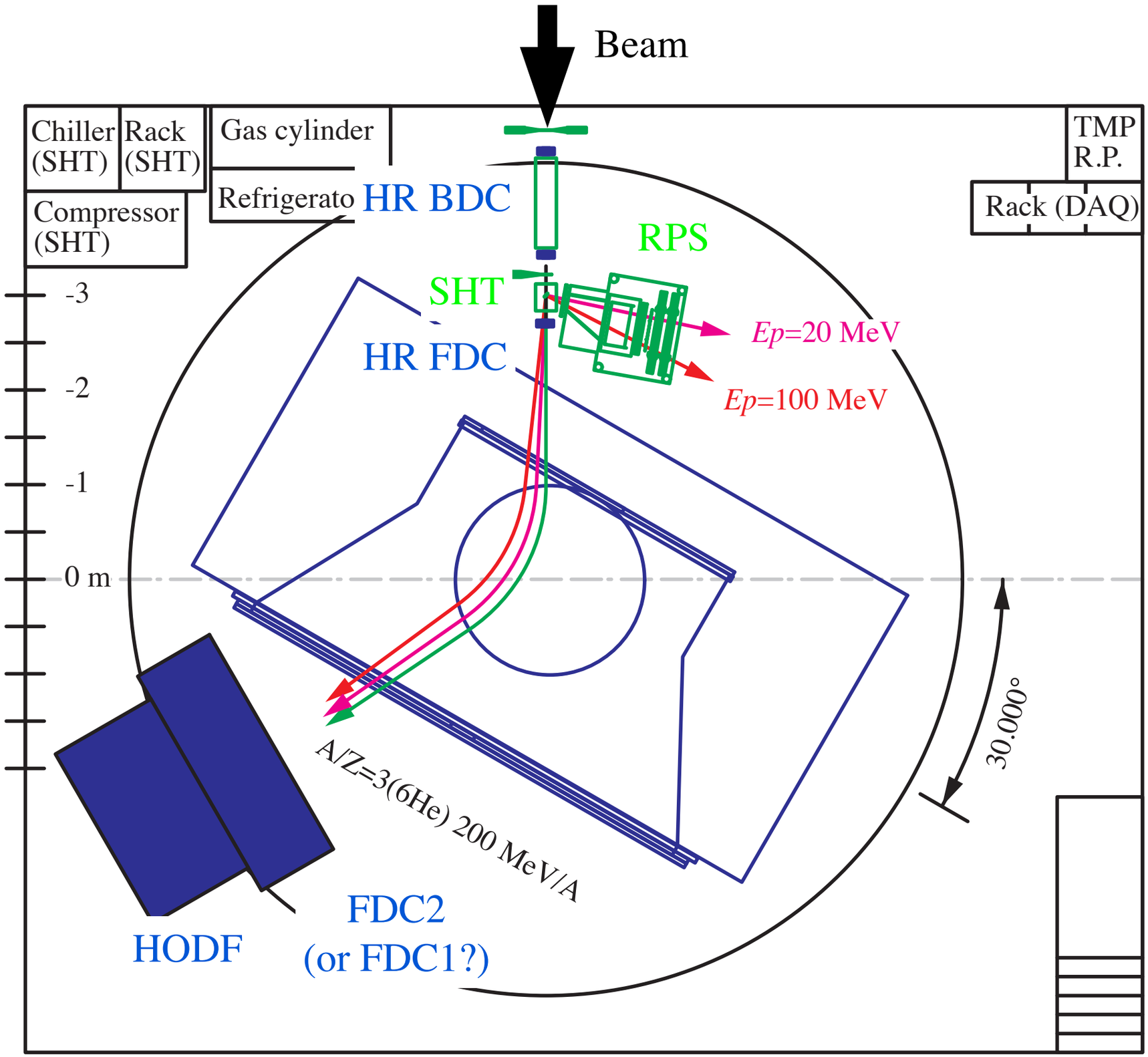
Primary beam : ^{18}O [250 MeV/A, 100 pnA]

	Yield (F7) [cps]	
6He	2.0×10^{7}	8Li: 7×10^{3}
8He	6.8×10^{5}	11Li: 4×10^{3}
9Li	9.3×10^{6}	11Be: 7×10^{3}
11Li	2.4×10^{5}	8He: 7×10^{3}
12Be	4.5×10^{6}	14Be: 2×10^{3}
14Be	1.0×10^{5}	11Li: 9×10^{3}

=Estimate Condition=
- Energy: 200 MeV/A
- Intensity: 0.2 Mcps
- SHT: 5 mm^{t} $\Leftrightarrow$(1 Mcps,1mm^{t})
- Efficiency: 100%



Experimental setup



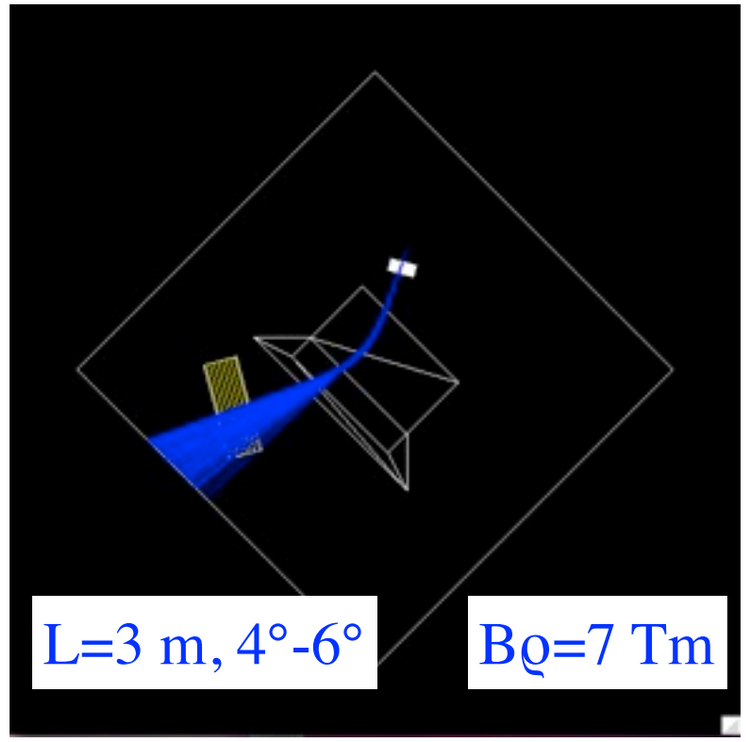
Detectors(we need)
- -BPC
- -BDC
- -FDC 1or2
- -HODF

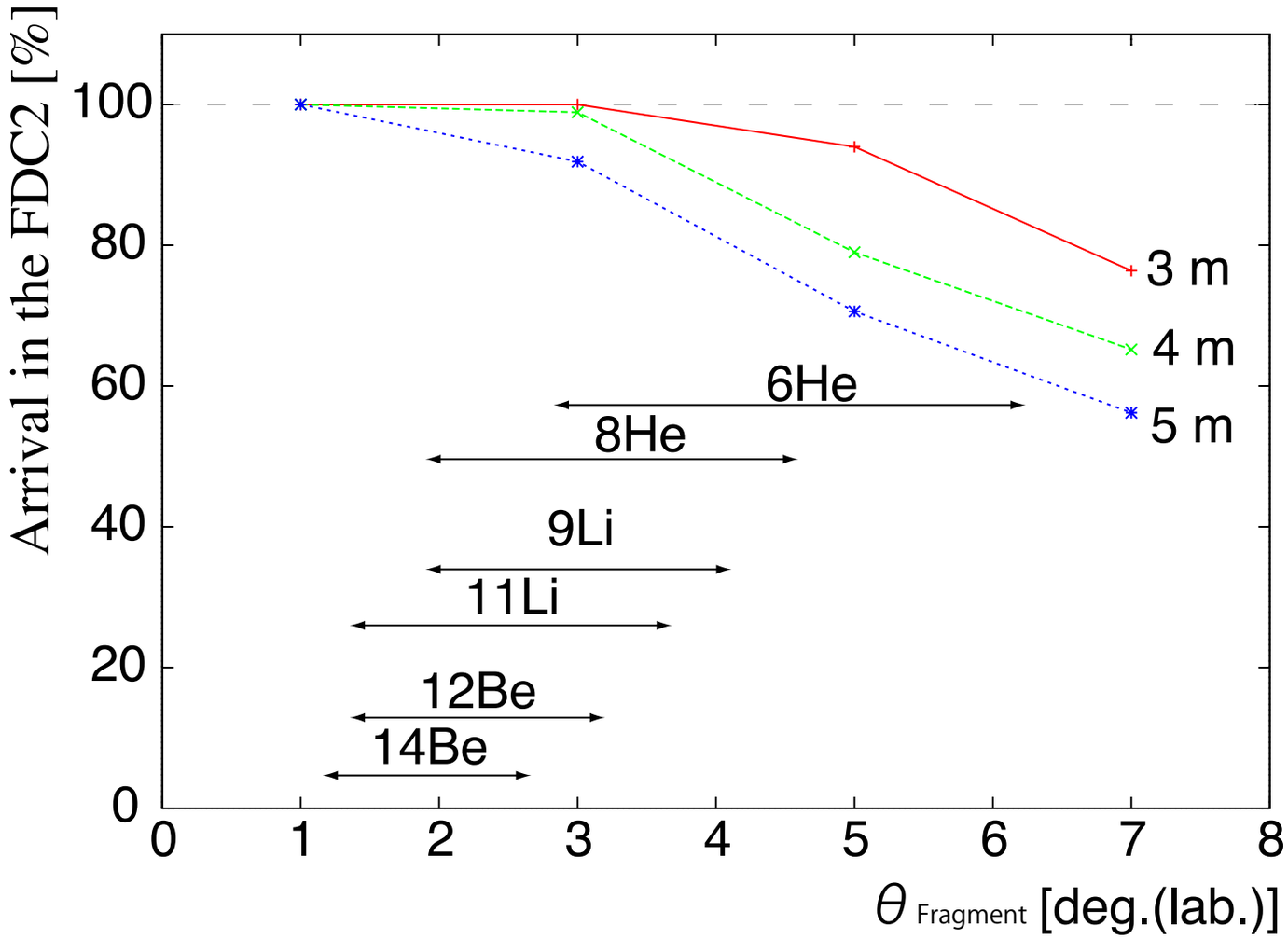
Requests/questions
1. Placement of our equipments near the RPS.
2. Short distance between the SHT and SAMURAI

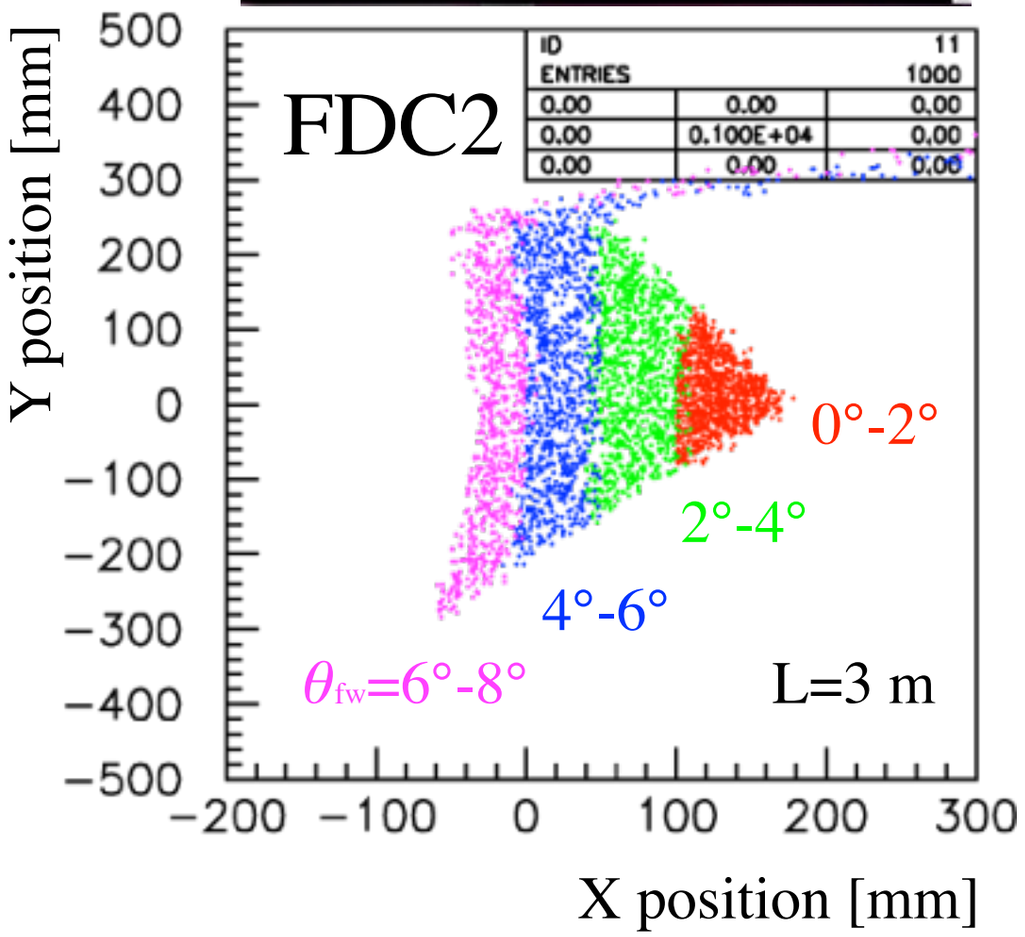
Experimental setup

		^{6}He	^{14}Be
q [fm-1]	T_p [MeV]	θ_{fw} [deg.]	θ_{fw} [deg.]
1	20	2.9	1.2
2.2	100	**6.2**	2.6

Field map(TOSCA):
Sato san
Program(GEANT4):
Isobe san







The others

- Most parts of the RPS are ready.
  We are lacking a stand for the RPS. It will be made in FY2011.

- We request of Big-RIPS that
  (1) the beam spread should be equal or less than 5-6 mm (rms) on the SHT.
  (The minor axis of the elliptical SHT is 21 mm (H).
  The beam spread at F7 is σ～3 - 4 mm estimated by LISE++.)

  (2) I want to use thick-Be-targets.
  3 - 5.5 g/cm^2 (primary beam: ^{18}O 250 MeV/A)

- How much can we expect DAQ Live time?
  (Can I obtain enough Live time, >90% ?)
  - Beam intensity: 10^5 - 10^6 Hz
  - Trigger rate: 10^3 - 10^4 Hz
  - RPS side: QDC 8 ch, TDC 8 ch (plastic)
    PHADC ～4 ch, TDC ～4 ch (NaI)
    multi-hit TDC ～30 hits (MWDC)

Summary

- I propose the measurements of proton elastic scattering on the neutron rich nuclei:
  ^{6,8}He, ^{9,11}Li ^{12,14}Be.
  - Beam energy: 200 MeV/A, beam intensity: 0.2 Mcps
  - Momentum transfer: 1 fm^{-1} to 2 fm^{-1}
  - High statistics

- We request following machine time.
  ^{6,8}He, ^{11}Li,^{14}Be: 1 day × 4 nuclei = 4 days
  ^{9}Li,^{12}Be: 5 day × 2 nuclei = 10 days
  Primary beam ^{18}O run = 1day
  Background run = 1day
  Circuit adjustment = 1day

  Total 17 days

- We need following equipments:
  BPC, BDC, FDC, HODOF, circuits, cable,....

- The RPS will be ready in FY2011.