

# Other Universities

2010.1.18. ANPhA Symposium  
Noro, T. (Kyushu Univ.)

# ~~Other Universities~~

**Kyushu University**

(present and new facilities)

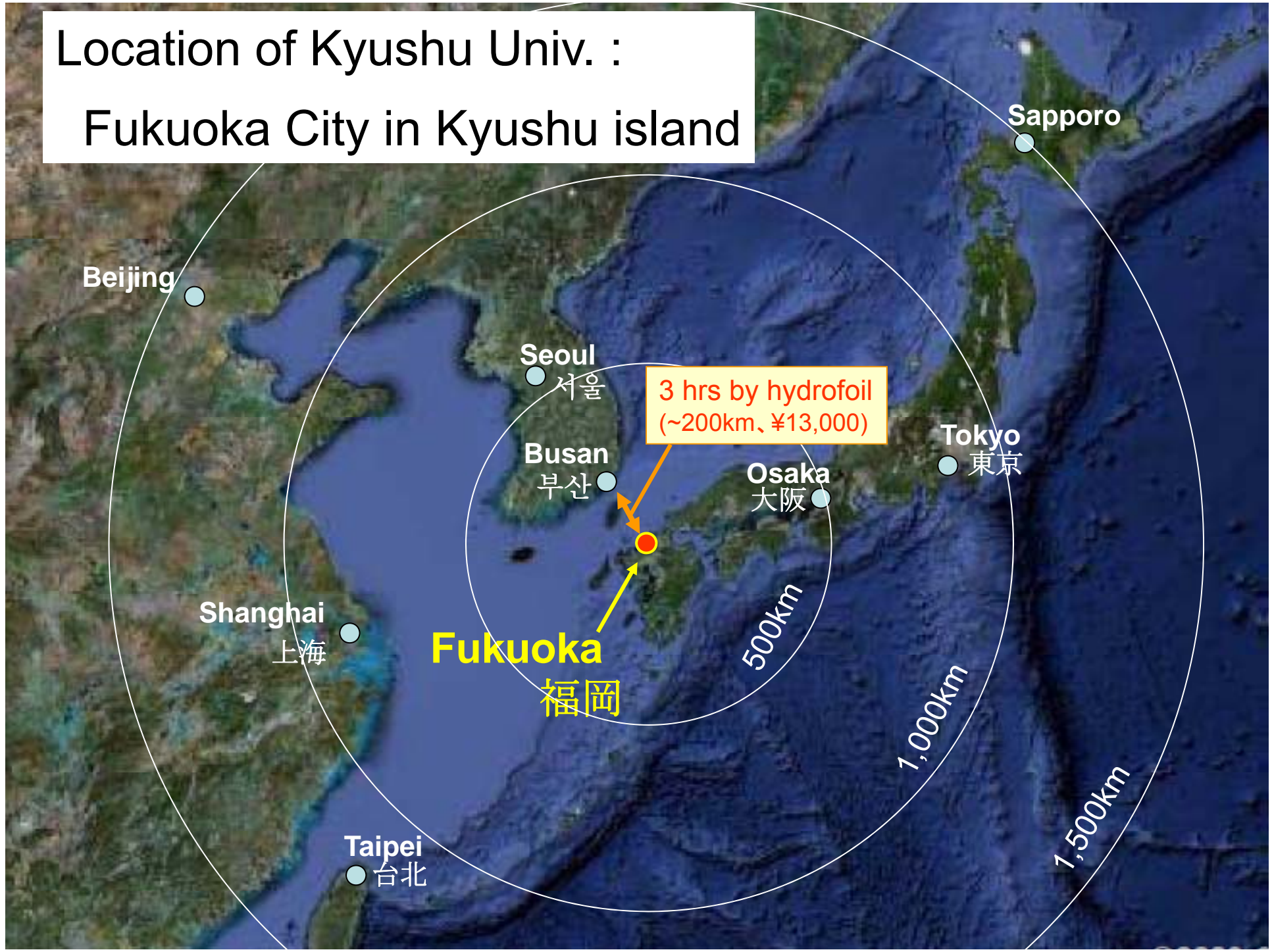
and

**Other Laboratories**

2010.1.18. ANPhA Symposium

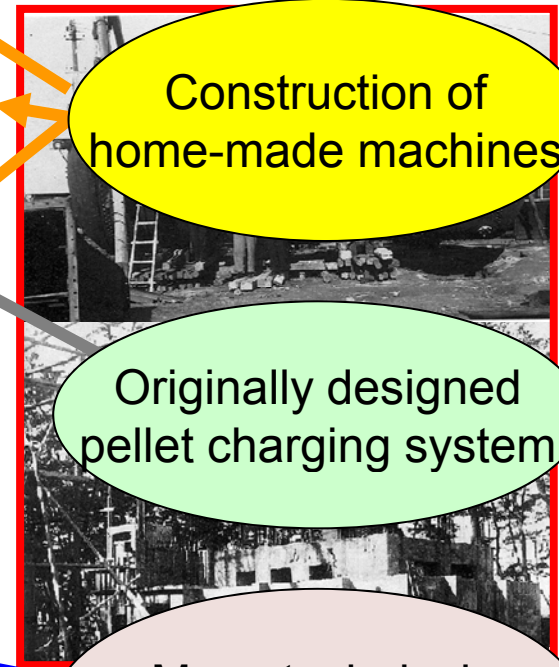
Noro, T. (Kyushu Univ.)

Location of Kyushu Univ. :  
Fukuoka City in Kyushu island



# Brief History of Accelerators in Kyushu University

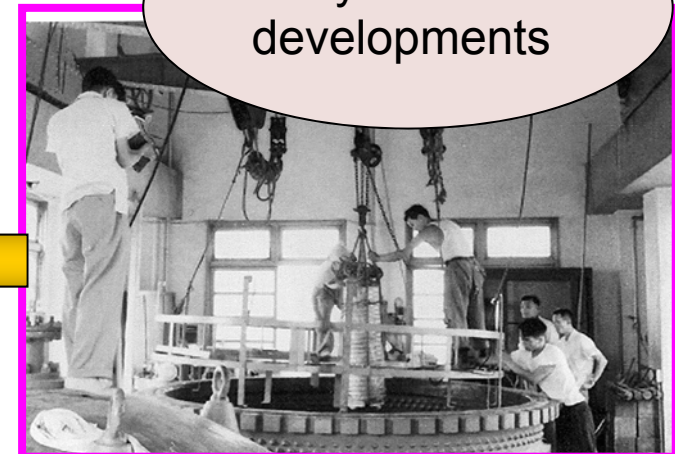
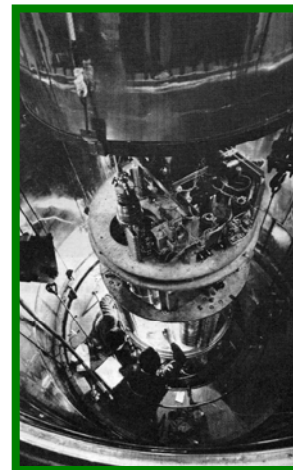
- 1943 **Construction of Van de Graaff accelerator**  
Terminal Voltage : 3 MV (1952)
- 1959 **Construction of Cock Croft Walton accelerator**  
Acceleration energy : 500 kV (1962)
- 1963 **Original pellet Chain Development (VdG)**  
Terminal Voltage : 7.5 MV (1970)
- 1972 **Construction of Tandem accelerator**  
Terminal Voltage : 11 MV (1980)
- Present activities with the Tandem accelerator
  - Few-nucleon system
  - $^{12}\text{C}$ -AMS
  - Astro-nuclear reaction



Construction of home-made machines

Originally designed pellet charging system

Many technical developments





# Kyushu University Tandem Laboratory

Old Van de Graaff



Tandem accelerator



Recoil-mass separator



付源室



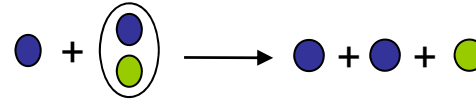
制御計数室



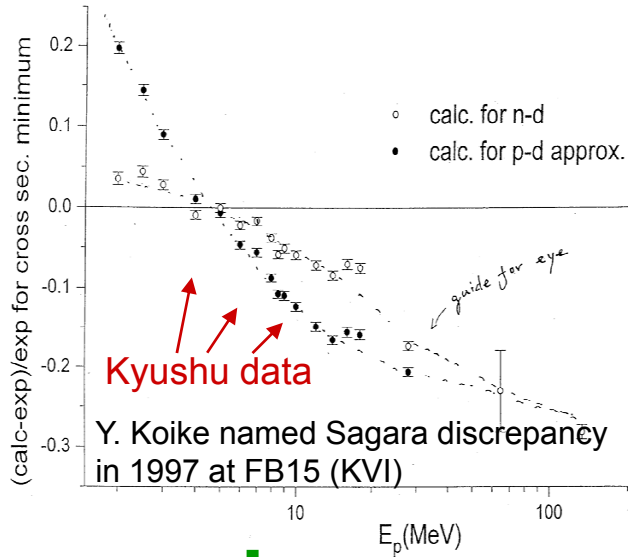
Large scatt. chamber



# Activities at KUTL : Study of three-nucleon system

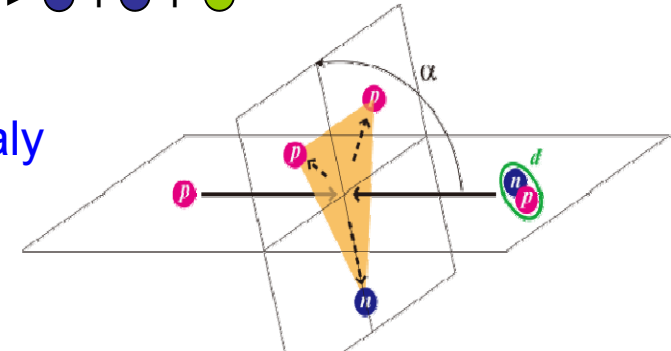


Comparison of world data with Faddeev calculations

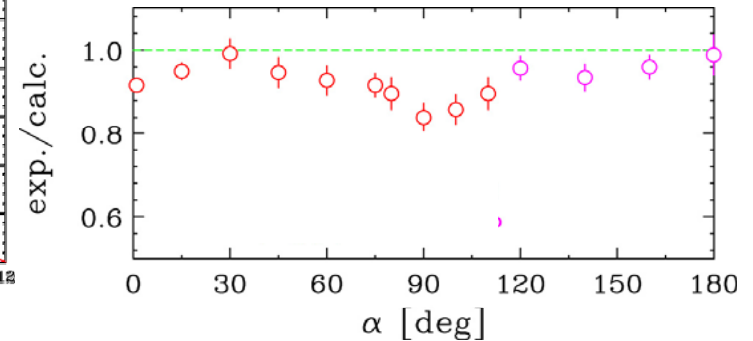
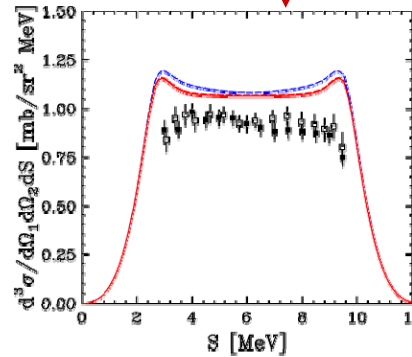
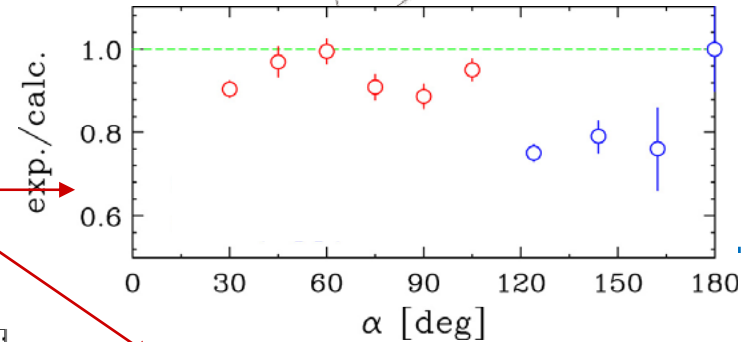


Existence of 3-body forces in scatt. system was realized.

Space-star anomaly in  $pd \rightarrow ppn$  c.s.

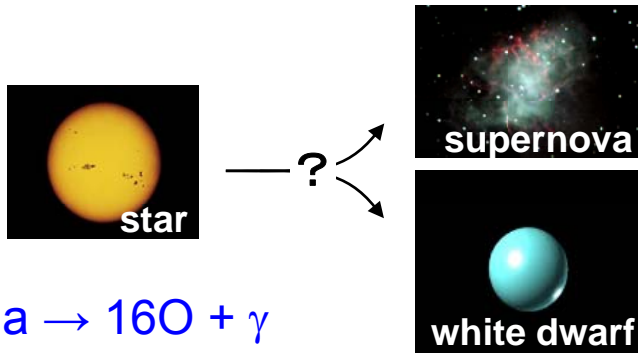


15% discrepancies

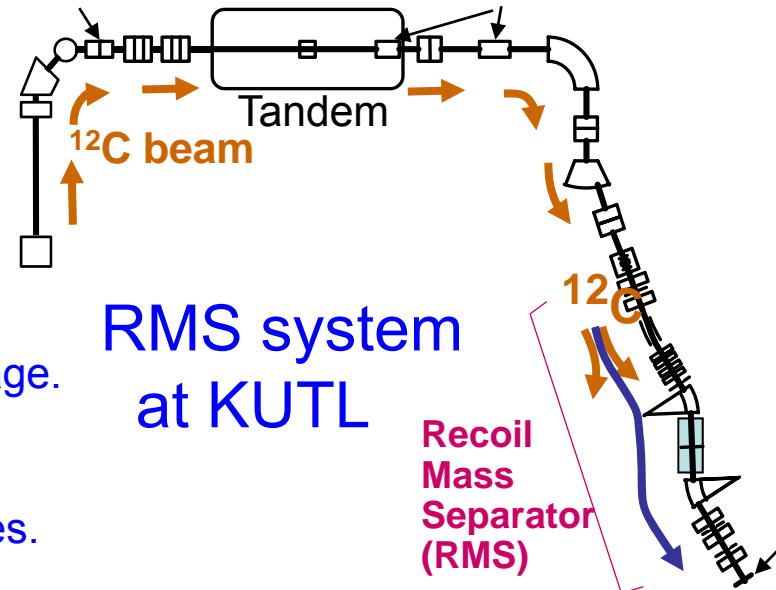


Very curious 3-body reaction dynamics. Systematic data are being accumulated at KUTL

# Activities at KUTL : Measurement of $^{12}\text{C} + \alpha \rightarrow ^{16}\text{O} + \gamma$ c.s.

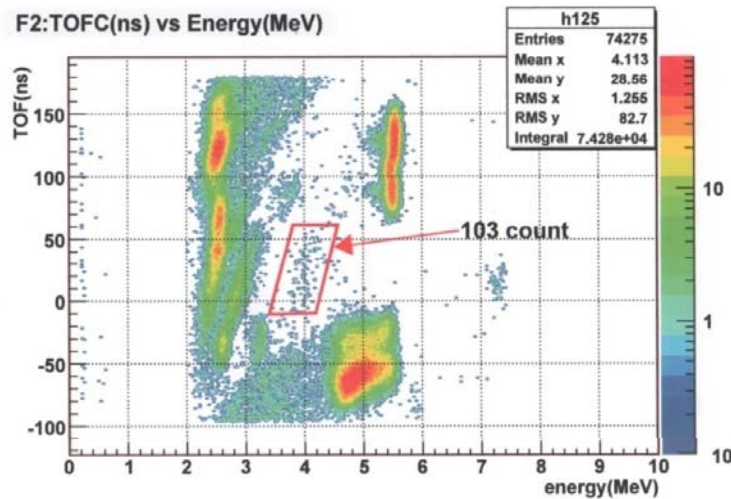


- Nuclear reaction which determines star's final stage.
- Quite small c.s. at stellar energy.
- Difficult to estimate because of nearby resonances.

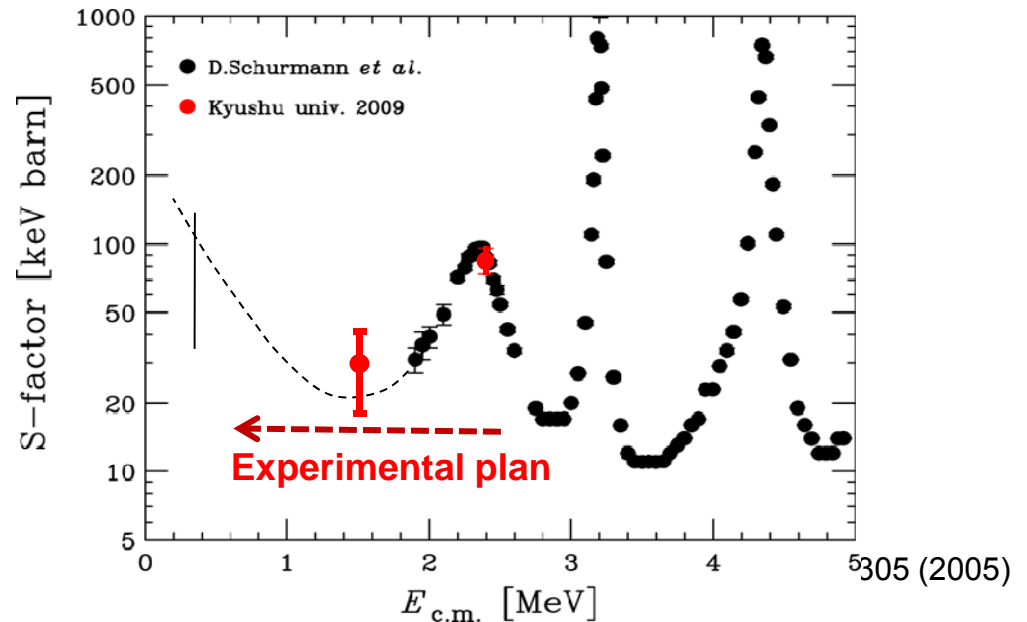


RMS system at KUTL

Recoil Mass Separator (RMS)



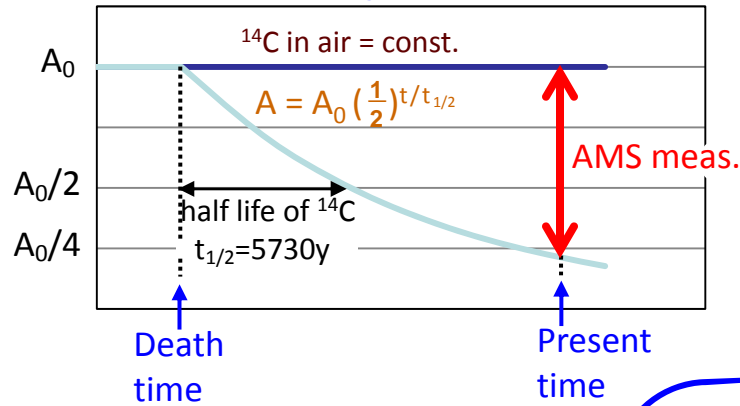
$E_{\text{c.m.}} = 1.5\text{MeV}$ , 103 cnts/10 h



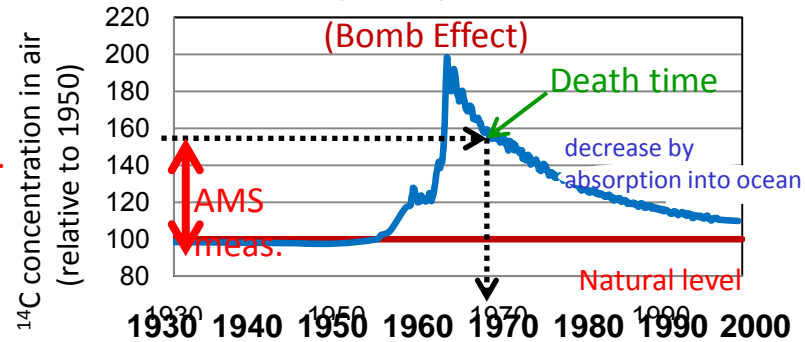
5305 (2005)

# Activities at KUTL : Accelerator mass spectroscopy

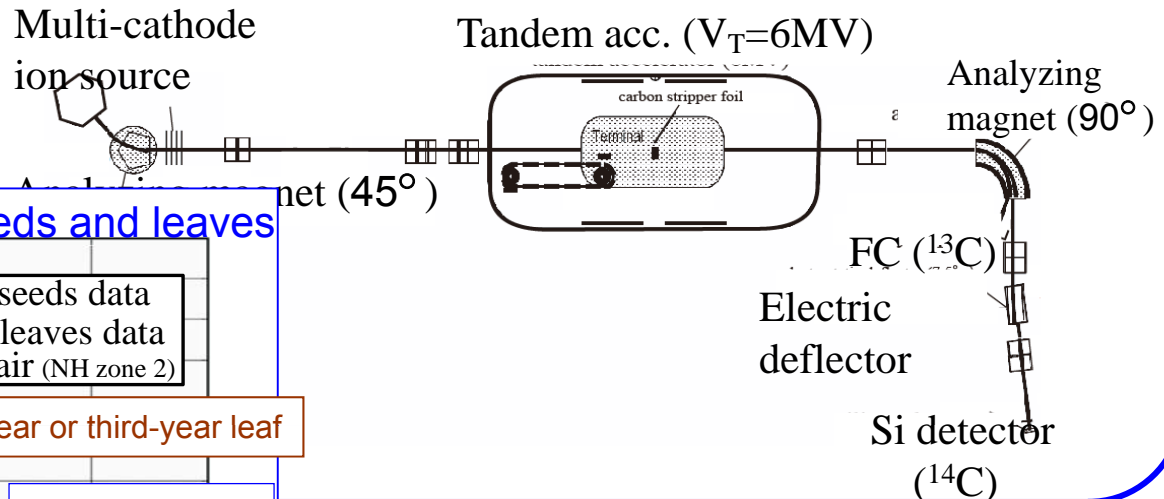
Usual  $^{12}\text{C}$  dating



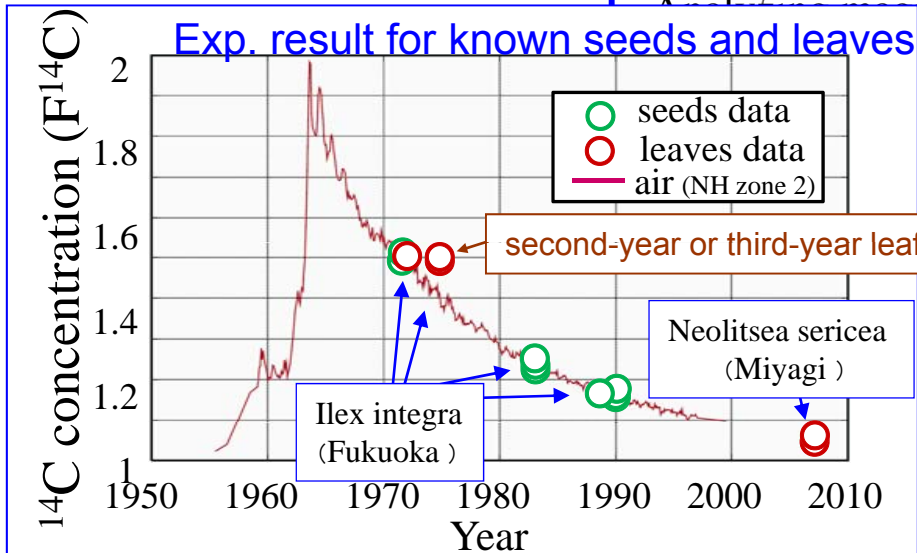
$^{12}\text{C}$  dating using bomb effect



AMS system at Kyushu University



Exp. result for known seeds and leaves



- Dating with 2~3y accuracy is possible.
- World standard  $^{12}\text{C}$  data can be used even for Fukuoka (sea-side) area.



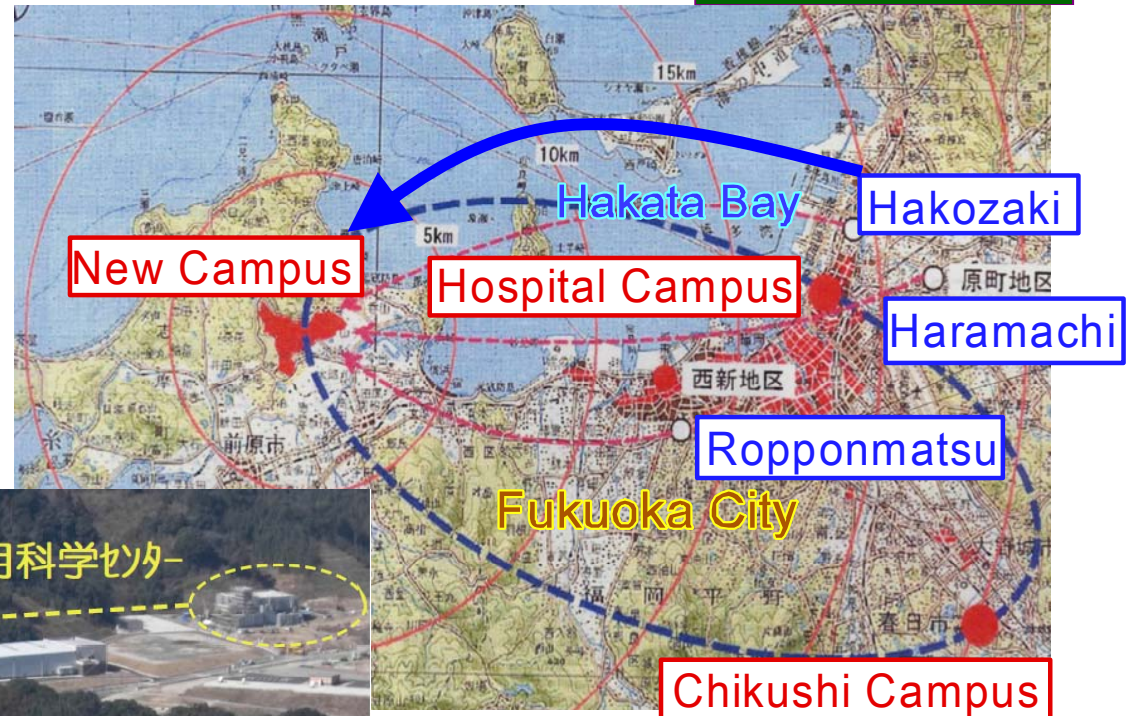
# Campus movement and construction of new facility

Schedule of the movement

2005-6 : Faculty of Engineering

2014- : Faculty of Science  
(planned)

The tandem accelerator  
is forced to shut down.



New accelerator facility is being constructed.

- Only an accelerator hall exists.
- Experimental area will be constructed when the tandem accelerator shuts down.

# Movement of a new accelerator from KEK

Main accelerator : FFAG Synchrotron  
( Fixed-Field Alternating Gradient )

- $E_p=150\text{MeV}$  ( 40MeV/u for heavy ions in future)
- Rapid acceleration (100Hz) owing to fixed mag. field
- Large acceptance (100~300  $\pi$  mm mr)
- Possibilities: Use as a storage ring? Acc. of plural isotopes?



**The test machine itself is now being installed at Kyushu Univ.**

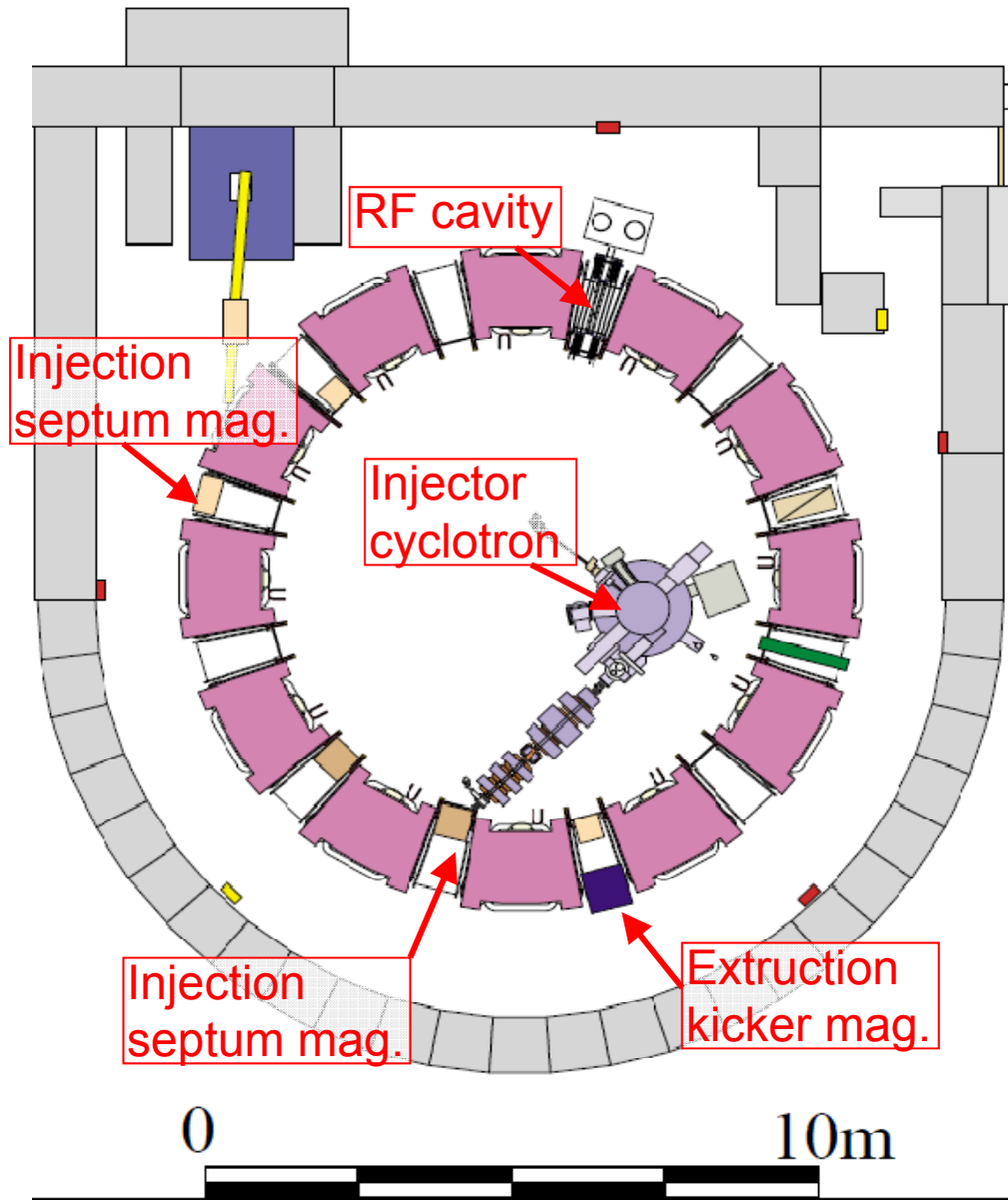


New type accelerator that Prof. Mori constructed firstly in the world.  
**Further development at Kyushu**

A machine with various possibilities  
**Challenges for new usage**



# Design values of the FFAG Synchrotron



magnet	Radial sector type (DFD-triplet)
Cell	12
K-value	7.62
Beam energy	12 $\Rightarrow$ 150 MeV ( 10 $\Rightarrow$ 125 MeV)
Radius	4.47 $\Rightarrow$ 5.20 m
Betatron tune	H: 3.69~3.80 V: 1.14~1.30
Max. field	F-field: 1.63 T
(along orbit)	D-field: 0.78 T
Circ. freq.	1.55~4.56 MHz
Repetition	100 Hz

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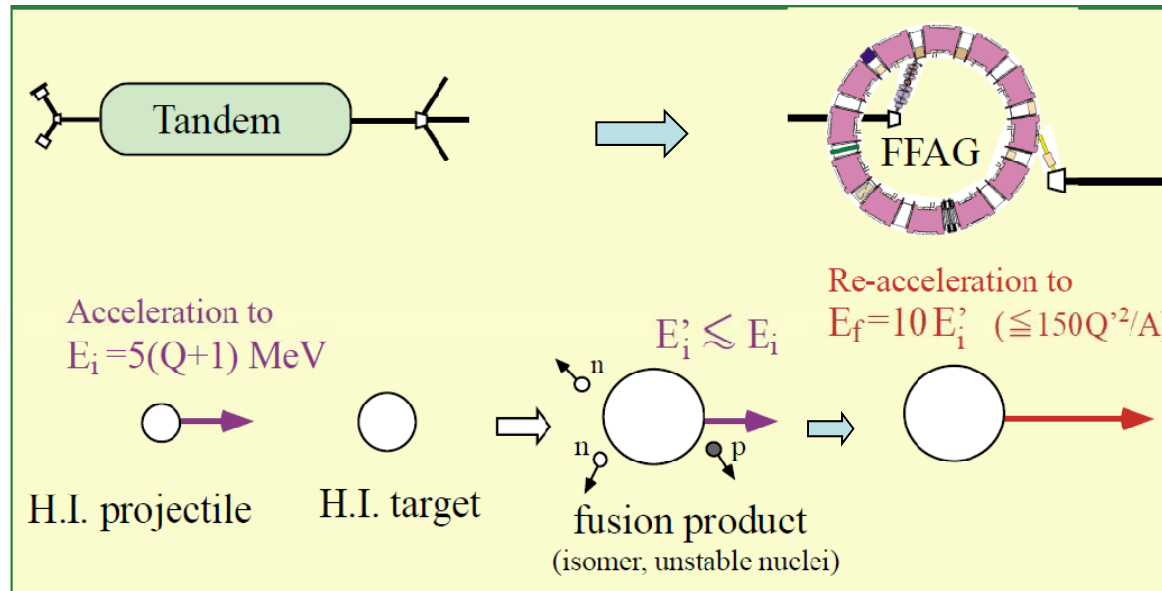


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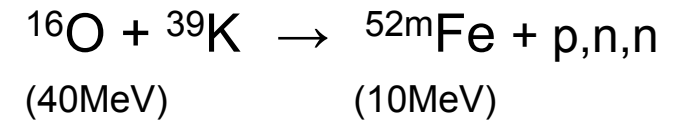
A machine with various possibilities  
**Challenges for new usage**



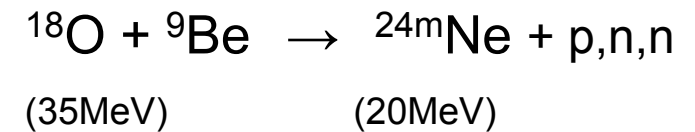
# Acceleration of isomers and unstable nuclei produced by low-energy nuclear fission



e.g.



$\Rightarrow$  (100MeV)



$\Rightarrow$  (200MeV)

## Advantage:

- High quality accelerated beam of short life nuclei

## Subjects

- Structure of high-spin isomer, Astro-nuclear data
- Diffusion process in material

## Requirement to accelerator

- Large acceptance (longitudinal and transverse)



**Construction by students and staff members**



**Present status of FFAG : alignment was completed**



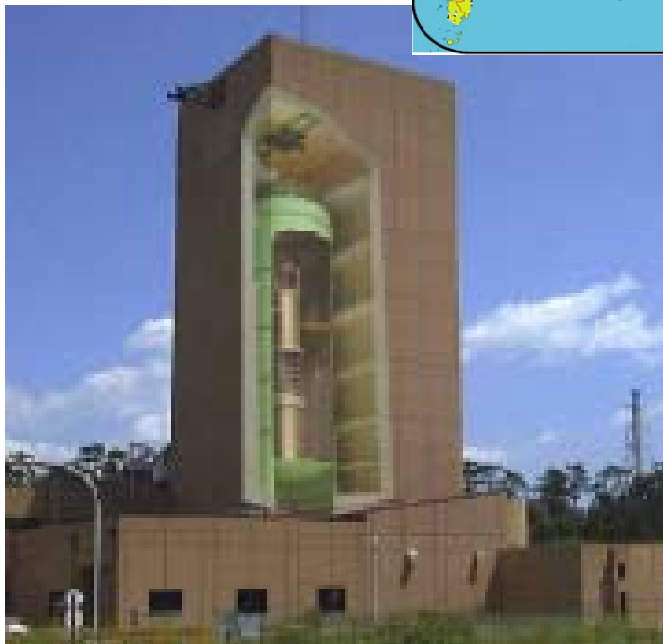
**Commissioning will start in March.**



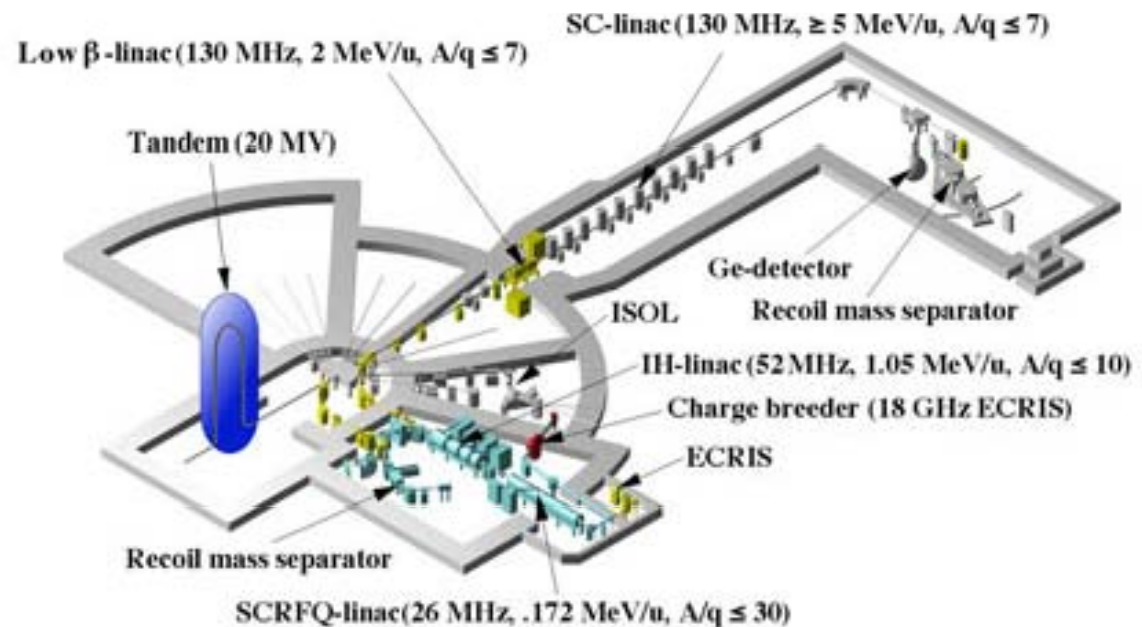




# JAEA Tokai Tandem Accelerator

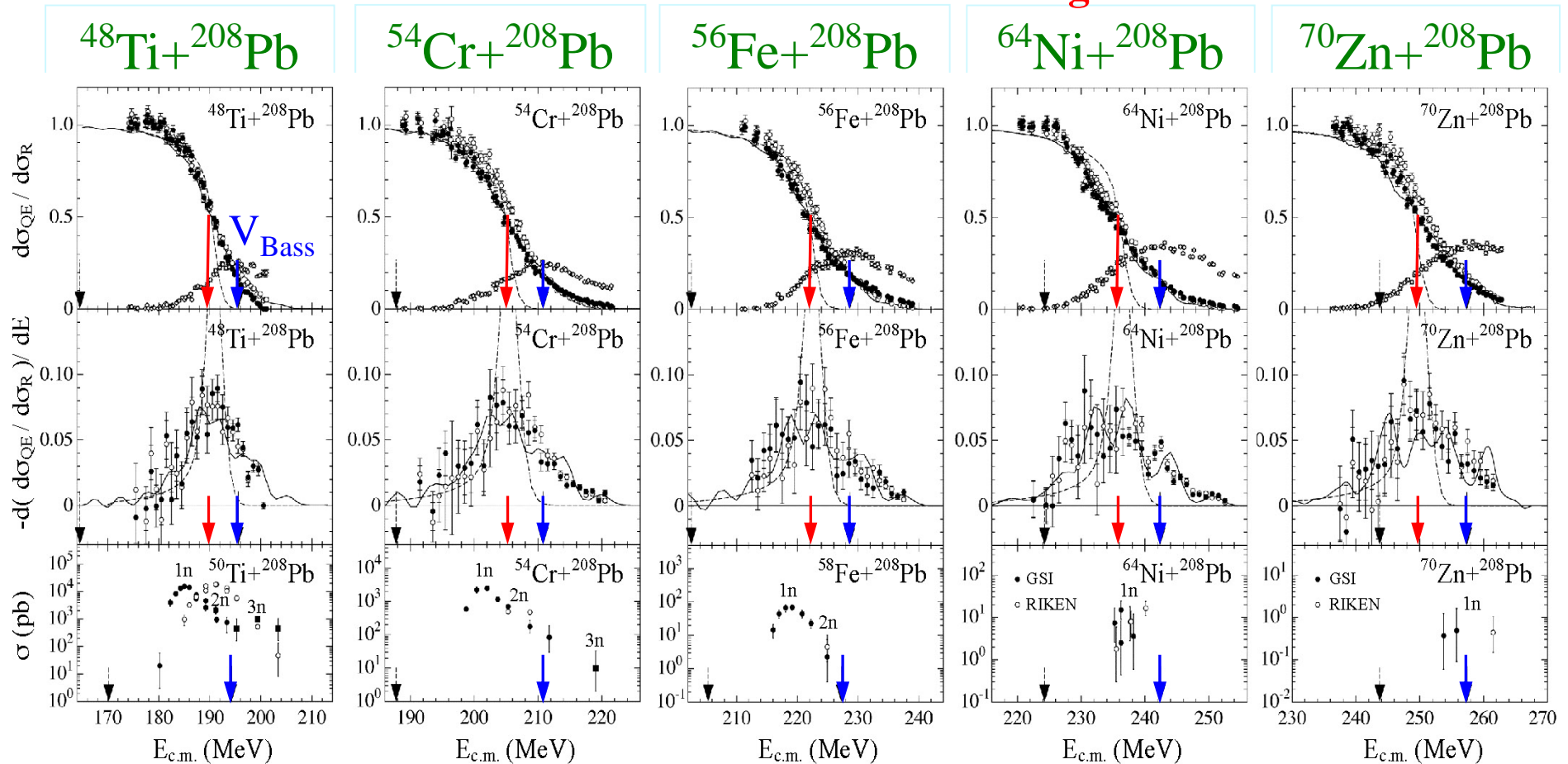


- 20UR Pelletron ( $V_T=20\text{MV}$ )
- Booster linac ( $\geq 5\text{MeV/u}$ )
- TRIAC (ISOL+linac)



# Measurement of barrier distributions for production of super-heavy elements by backward quasifree scattering

more than 20 incident energies



Present data 190.1MeV  
Bass potential 195.4MeV

205.8MeV  
210.7MeV

223.0MeV  
228.4MeV

236.0MeV  
242.2MeV

250.6MeV  
257.2MeV

Obtained barriers shift to lower energy side by 4~6MeV than the Bass barriers.

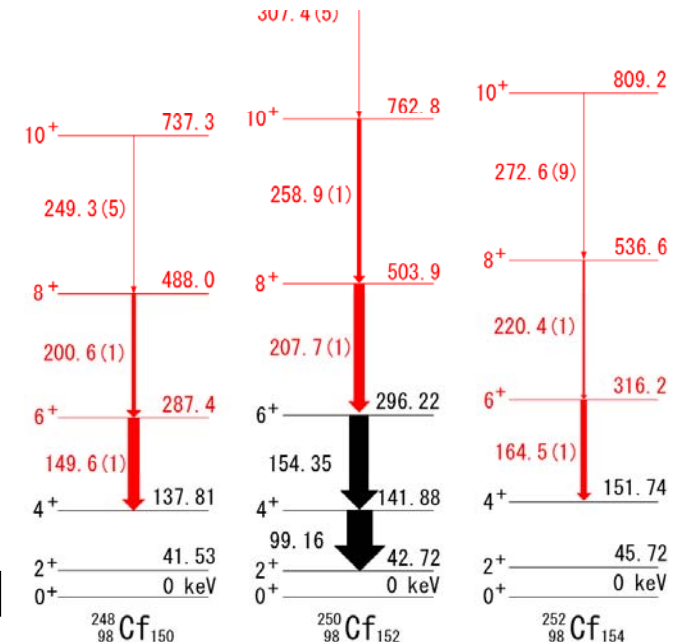
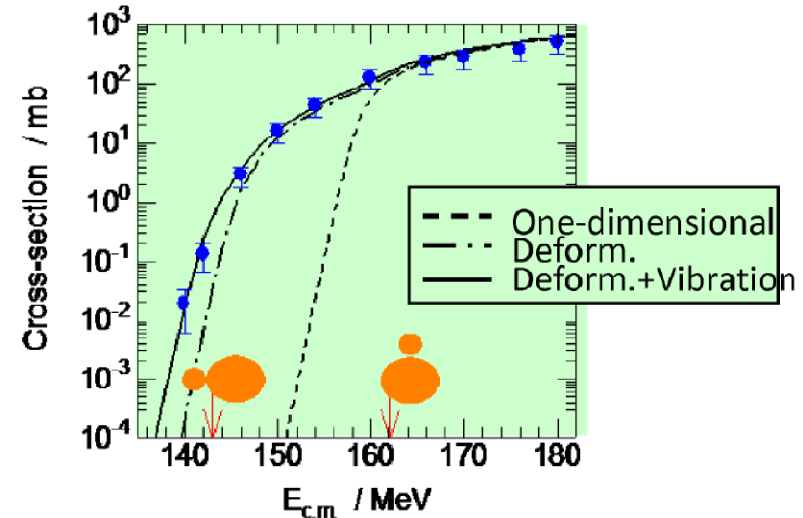
S. Mitsuoka *et al.*, Phys. Rev. Lett., 99 (2007) 182701

# JAEA Tokai Tandem Accelerator

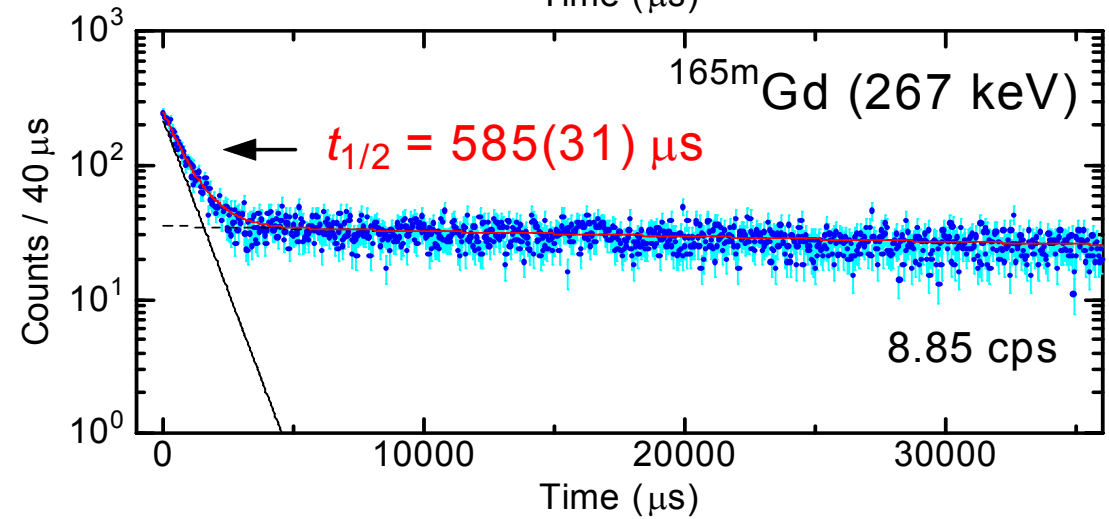
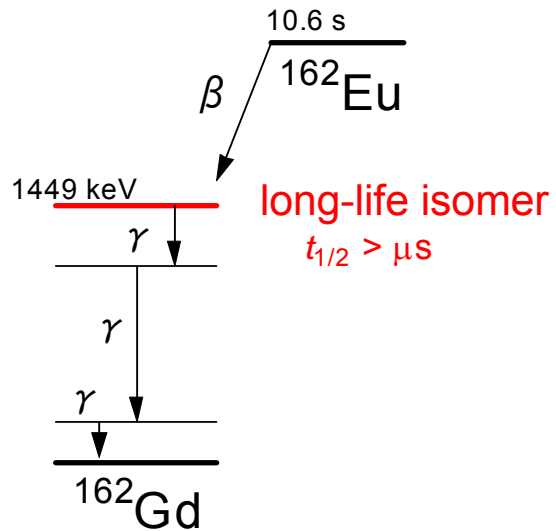
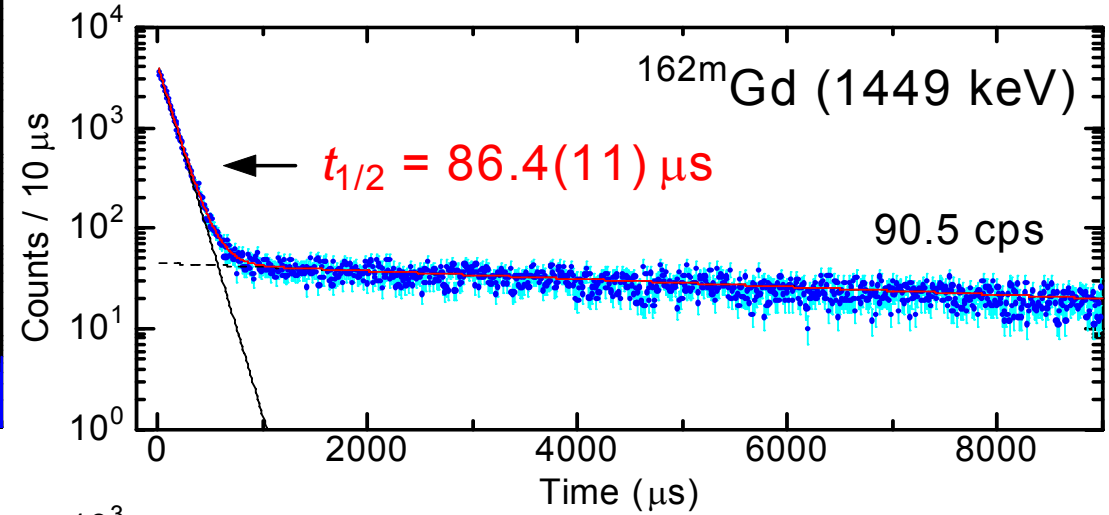
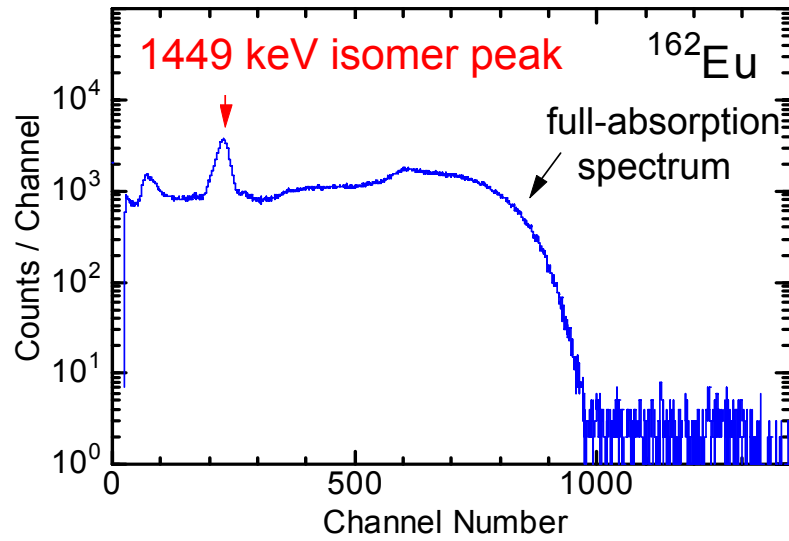
## Recent activities in nuclear physics

- Reaction mechanism in super-heavy nuclei
  - Orientation effect on fusion
- In-beam  $\gamma$ -spectroscopy for Cf isotopes
  - Life time of long-life isomers,  $^{162m}, ^{165m}\text{Gd}$  and discovery of  $^{163m}\text{Gd}$
- Nuclear chemistry for super-heavy elements
- $\beta$ - $\gamma$  spectroscopy using ISOL
  - Life time of long-life isomers,  $^{162m}, ^{165m}\text{Gd}$  and discovery of  $^{163m}\text{Gd}$

Full momentum transfer fission cross section



# Life-time measurement by using full-absorption BGO detector





# University of Tsukuba : Tandem accelerator



- 12UD Pelletron ( $V_T=12\text{MV}$ )
- Polarized  $p$  and  $d$  beams
- Many kinds of heavy ion beams

## Accelerated ion and intensity

H																		He
Li	Be											B	C	N	O	F	Ne	
Na	Mg											Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi				
		↑																
		Lanthanide																
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		

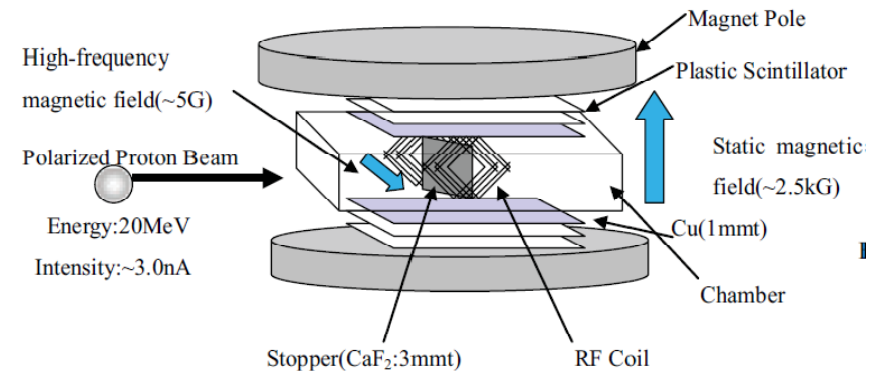
$1\ \mu\text{A} \sim$
$0.1\ \mu\text{A} \sim$
$0.01\ \mu\text{A} \sim$

# University of Tsukuba : Tandem accelerator

## Recent activities in nuclear physics

- Measurement of magnetic moment of unstable  $^{40}\text{Sc}$ .

- production of pol- $^{40}\text{Sc}$  by pol-p.
- $\beta$ -NMR method



- $\gamma$ -ray spectroscopy of  $^{26}\text{Si}$

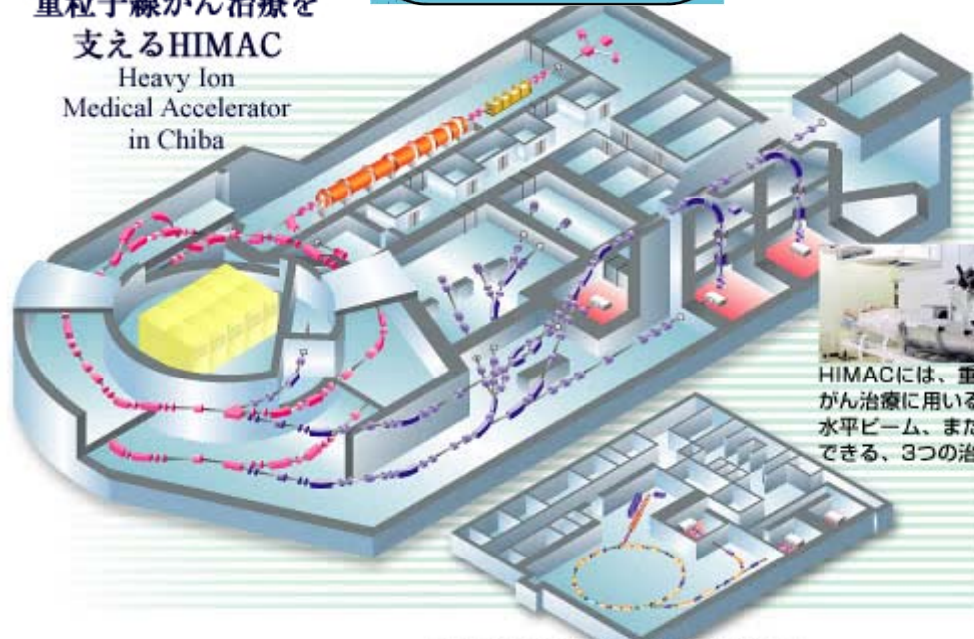
- for nuclear synthesis of  $^{26}\text{Al}$

- $^{36}\text{Cl}$  AMS (for environment science)

# National institute of radiological sci. : HIMAC



重粒子線がん治療を  
支えるHIMAC  
Heavy Ion  
Medical Accelerator  
in Chiba



HIMACには、重粒子線を効率的に  
がん治療に用いるため垂直ビーム、  
水平ビーム、またはその両方を照射  
できる、3つの治療照射室があります。

## ■小型重粒子線がん治療装置

放医研における装置小型化開発研究の成果は、2006(平成18)年度から  
建設が開始される群馬大学の重粒子線がん治療装置に採用されています。  
放医研は群馬大学に装置を建設するための技術的な支援を行っています。

- 800MeV/u heavy-ion beams  
He, C, N, O, Ne, Si, Ar,
- Available for nuclear physics  
only in night-time and weekend
- Unstable nuclear physics:
  - Elastic scattering
  - Inverse ( $p,2p$ )
  - Charge changing c.s.
  - ...
- Reaction cross section etc.

## An alternative to summary . . .

All (almost?) the facilities welcome international collaborations.

I hope that this meeting becomes opportunity for new international cooperation.

Thank you for your attention.