

Recent results of SuperHeavy Element Research using GARIS at RIKEN

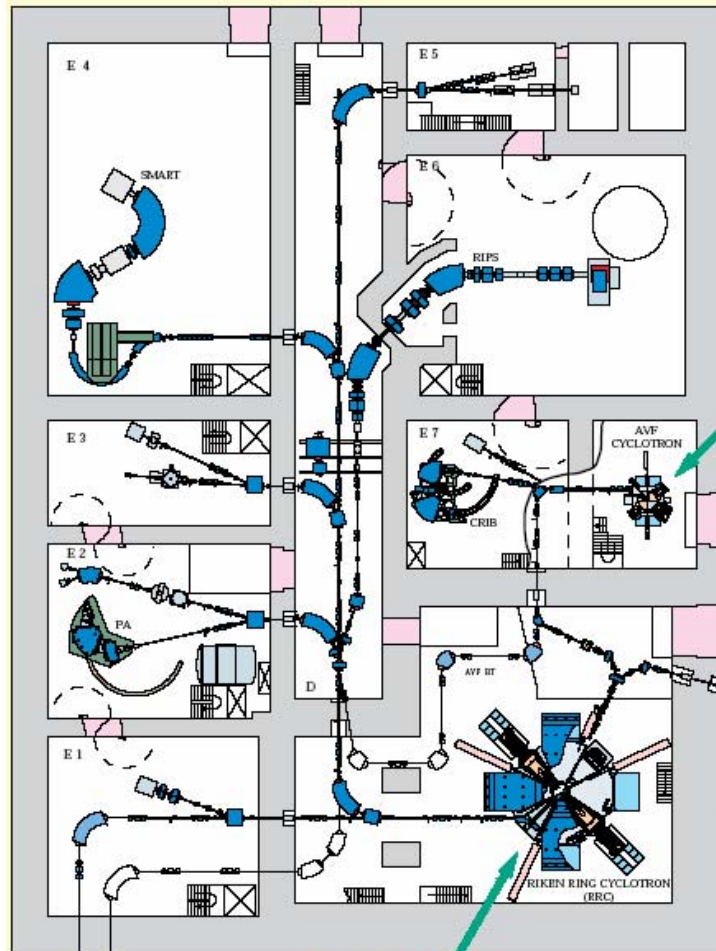
3rd Workshop on
Recoil Separator for Superheavy Element Chemistry
August 27, 2004
GSI

Kouji Morimoto
and **RIKEN SHE group**
RIKEN (The Institute of Physical and Chemical Research)
JAPAN

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- **Summary**

RIKEN Accelerator Research Facility



IRC (2004)
RIBF

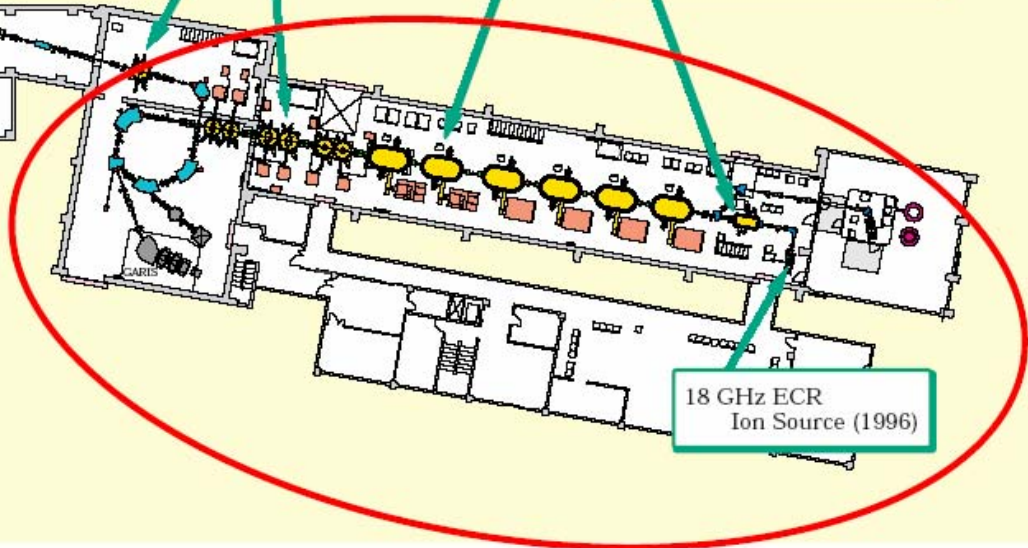
RRC
Ring Cyclotron (1986)
K 540 MeV
18 MHz ~ 40 MHz
h=5 (AVF), h=9, 10, 11 (Linac)

AVF Cyclotron (1989)
K 70 MeV
12 MHz ~ 24 MHz
10 GHz ECR Ion Source
& Polarized Ion Source

CSM
Charge State Multiplier (2001)
Acceleration Cavity: 6
Deceleration Cavity: 1 (3)
36 MHz ~ 76 MHz
E ≤ 6 MeV/u

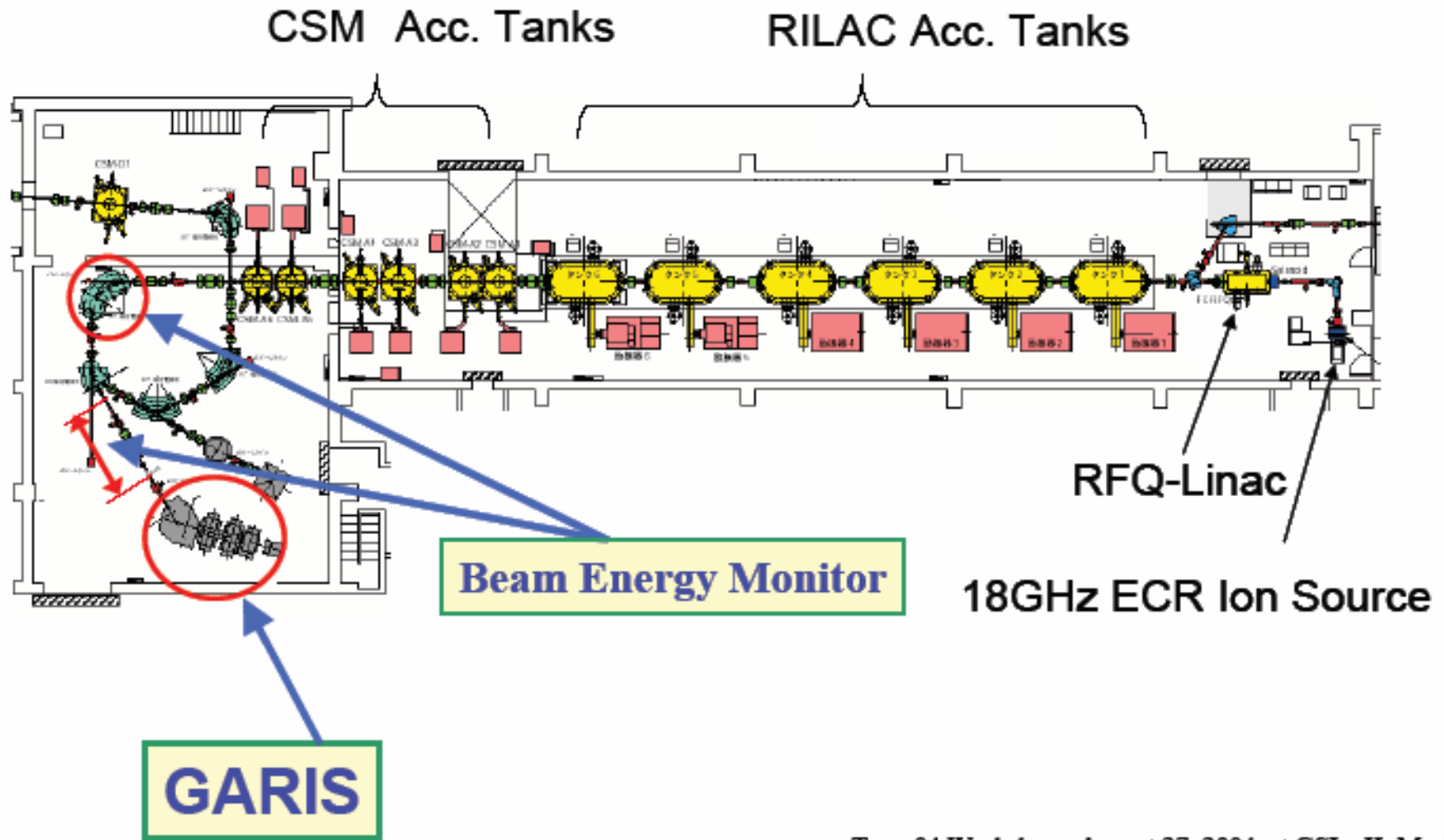
RILAC
Heavy Ion Linac (1981)
Acceleration Cavity: 6
18 MHz ~ 42 MHz
E ≤ 3 MeV/u

Frequency Variable RFQ Linac (1996)
18 MHz ~ 39 MHz

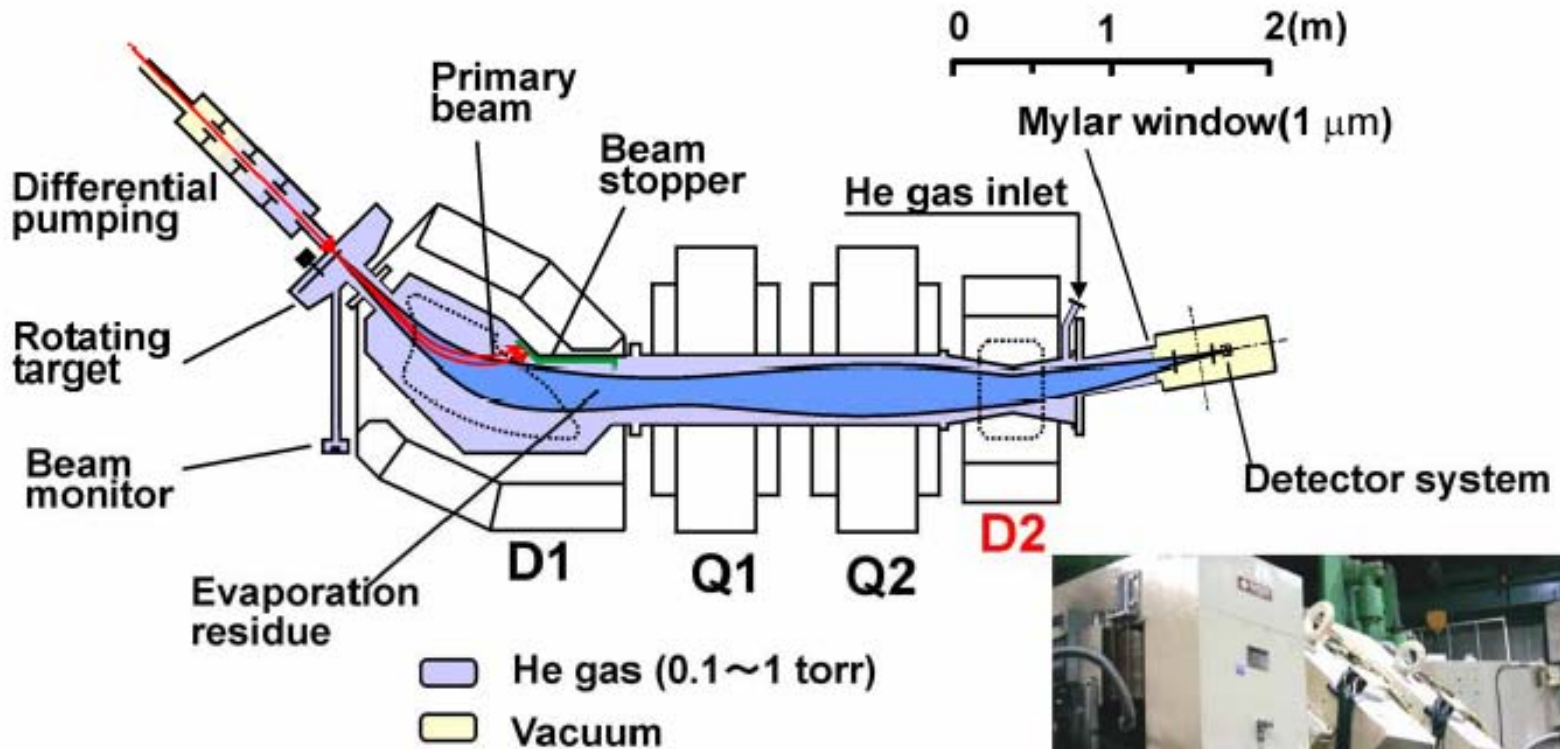


18 GHz ECR Ion Source (1996)

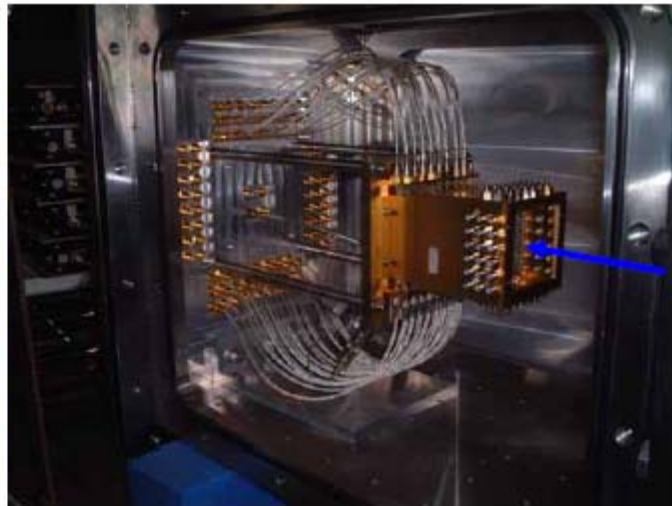
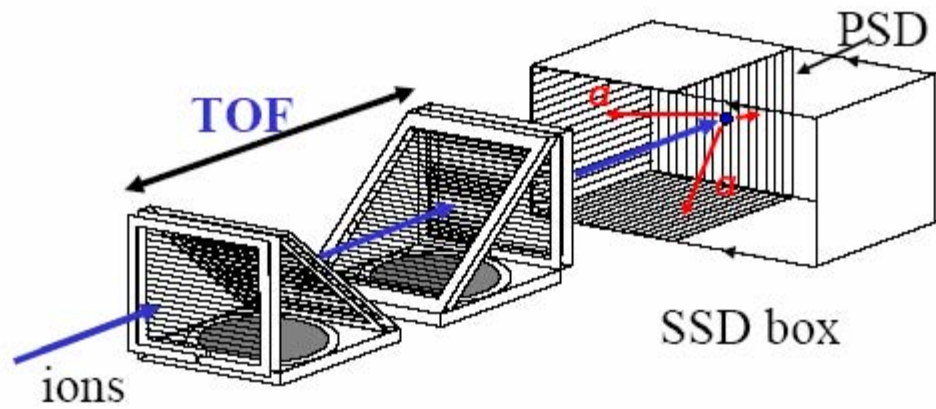
RILAC Facility



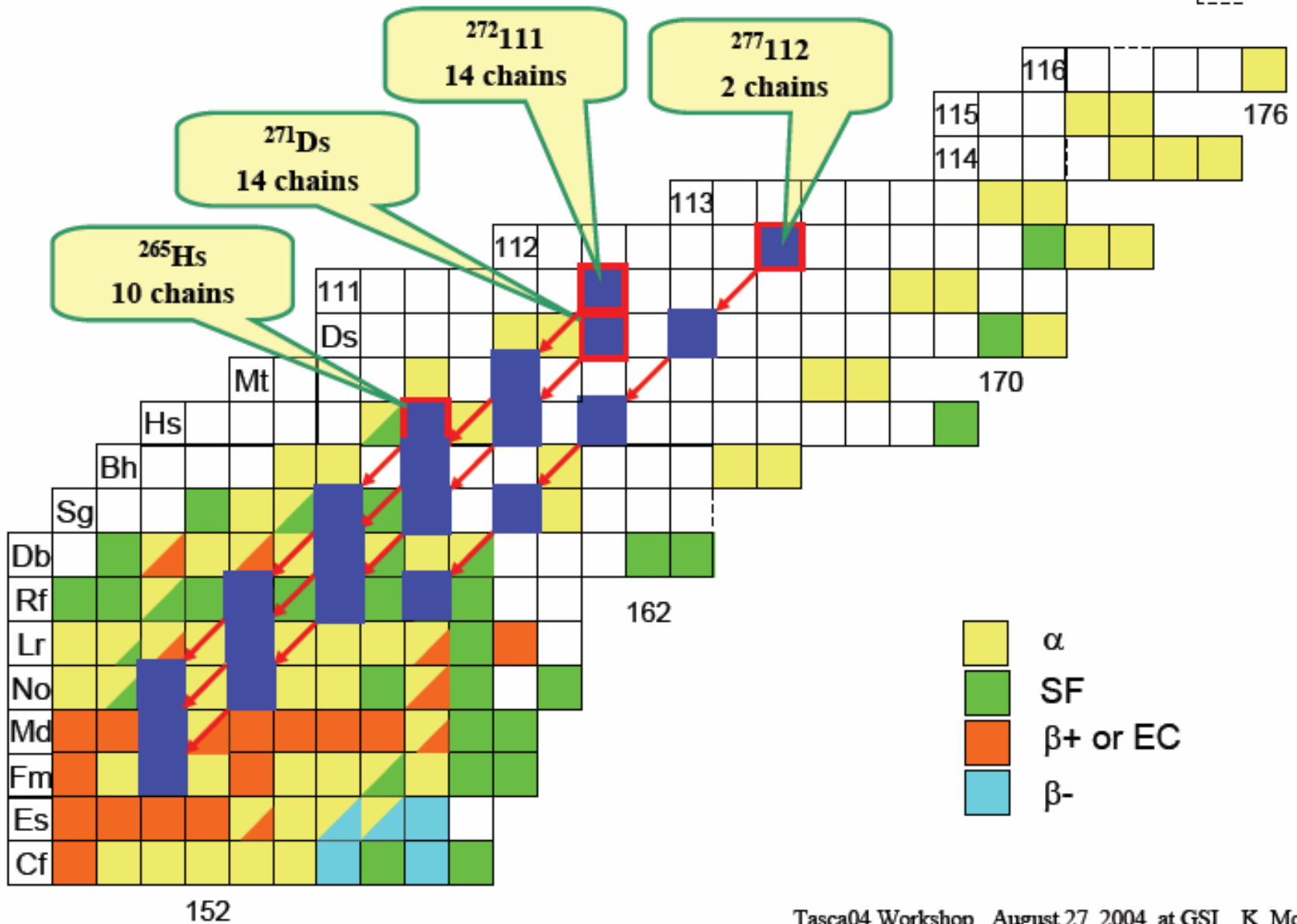
RIKEN GARIS(Gas-filled Recoil Ion Separator)



Focal Plane Detectors



Reactions studied at GARIS





Eur. Phys. J. A. **02** (2004) 257.

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$^{208}\text{Pb}(^{64}\text{Ni}, n)^{271}\text{Ds}$ Experimental condition

Beam ^{64}Ni 0.4~1 μA

E(lab.)MeV	ion dose	day	events
310	1.0×10^{18}	14	1
313	1.0×10^{18}	12	4
316	1.1×10^{18}	7	9
320	1.0×10^{18}	7	0
total	4.1×10^{18}	40	14

Target ^{208}Pb 190~250 $\mu\text{g}/\text{cm}^2$ (98% enriched)
evaporated on 30 $\mu\text{g}/\text{cm}^2$ C
covered by 10 $\mu\text{g}/\text{cm}^2$ C

B_p (GARIS) 2.05 Tm

P (GARIS) 75 Pa

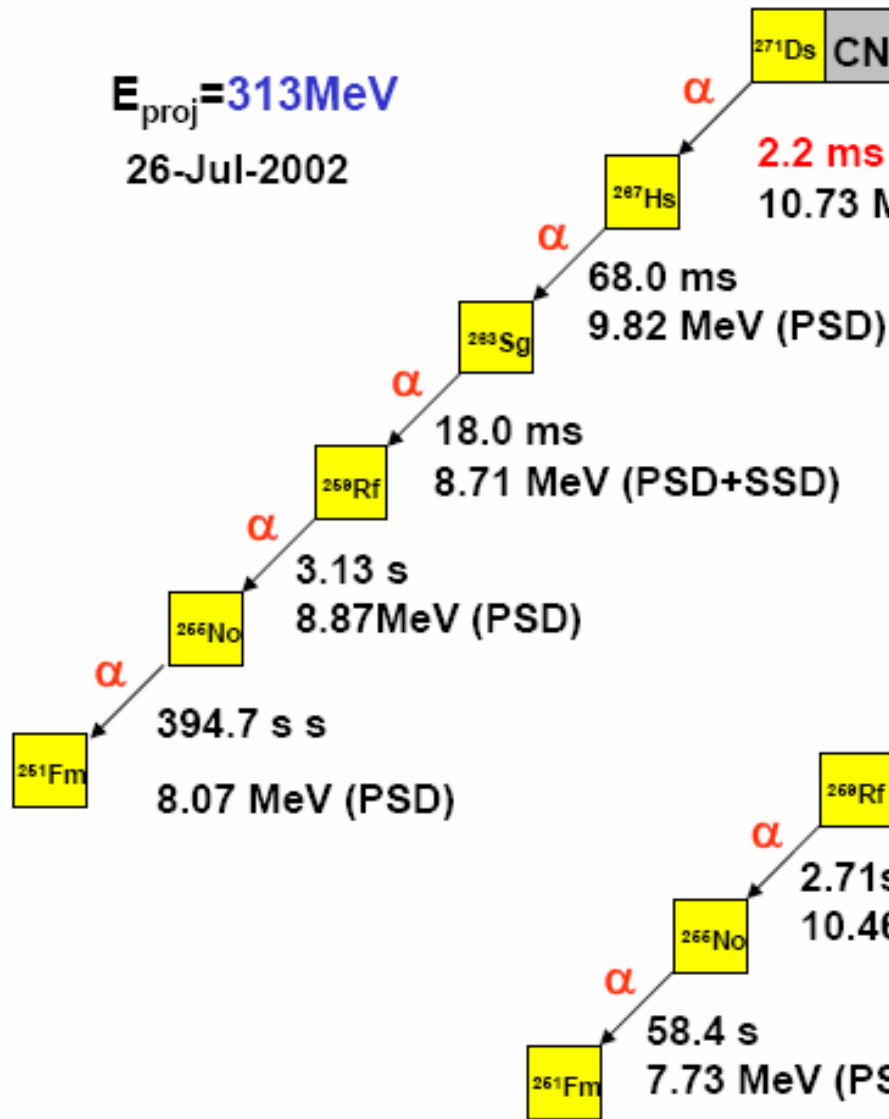
ϵ (GARIS) 0.8

Total Counting rate 10~20 cps

$^{208}\text{Pb}(^{64}\text{Ni},n)^{271}\text{Ds}$

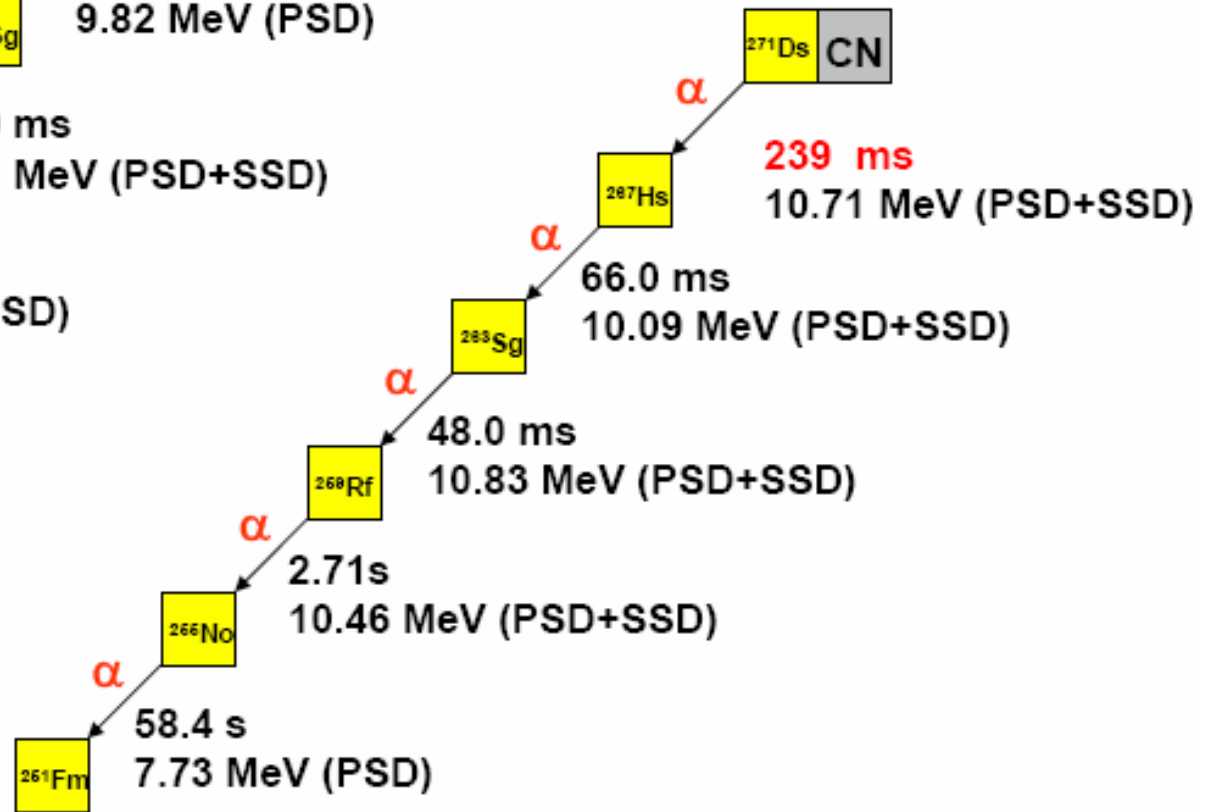
$E_{\text{proj}} = 313\text{MeV}$

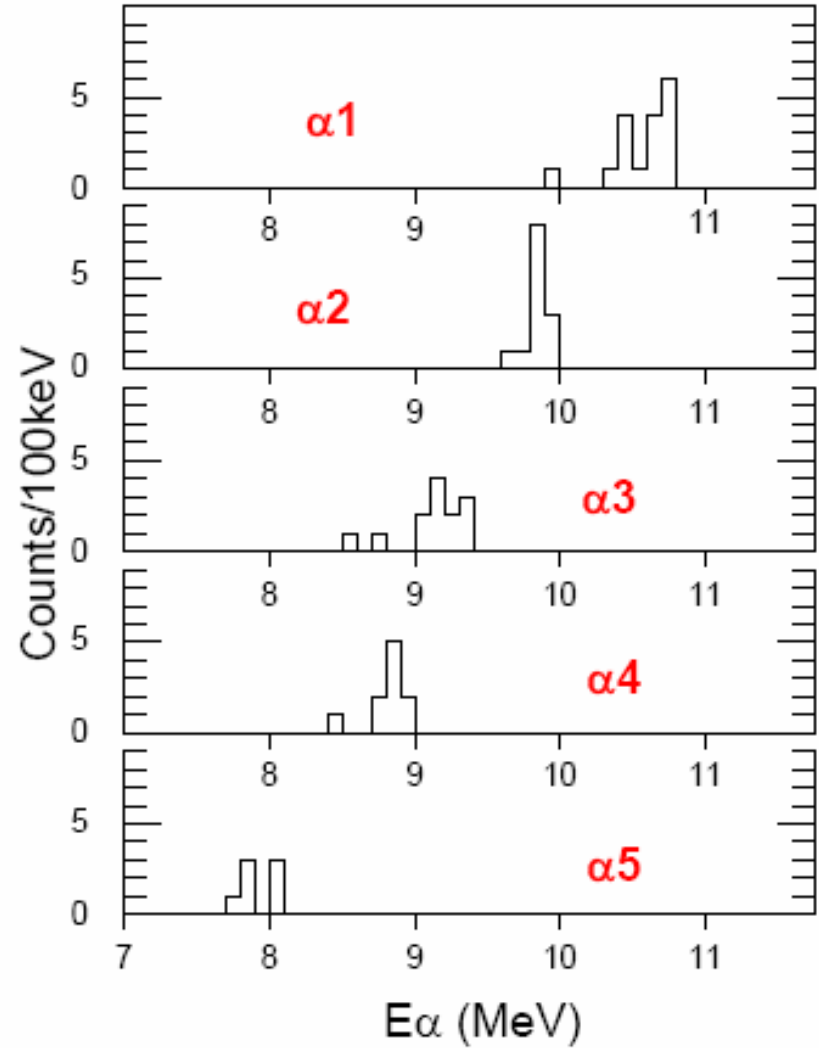
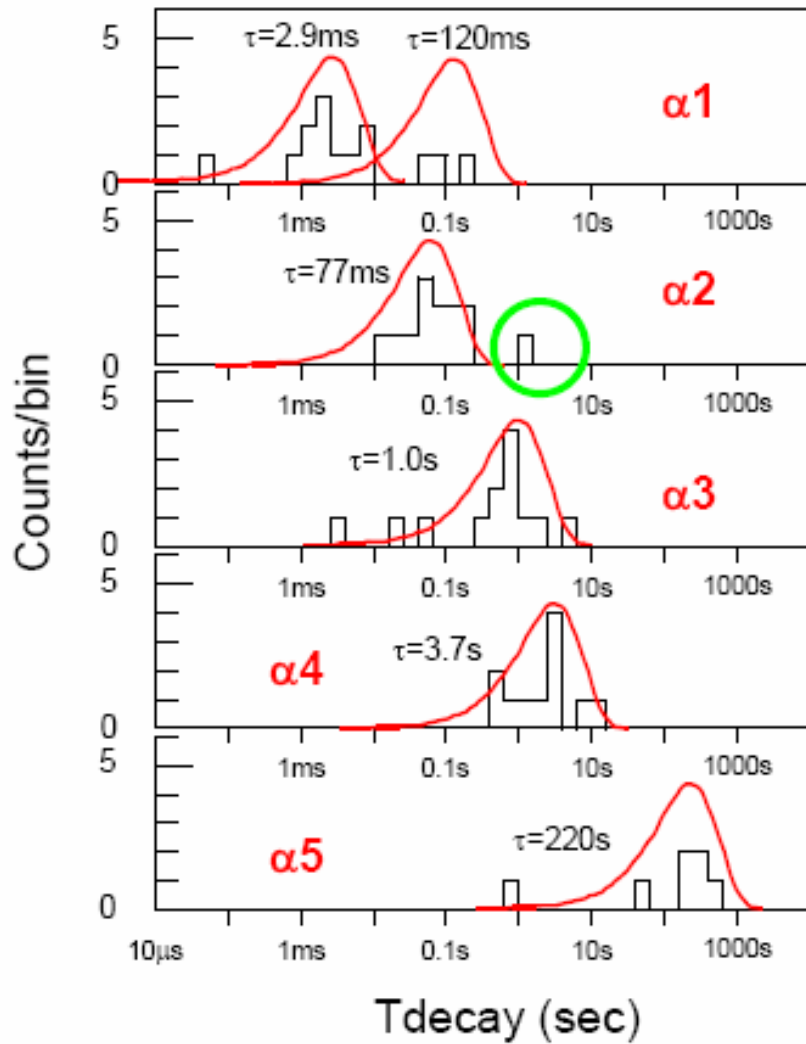
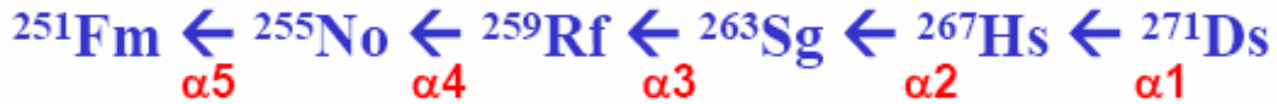
26-Jul-2002



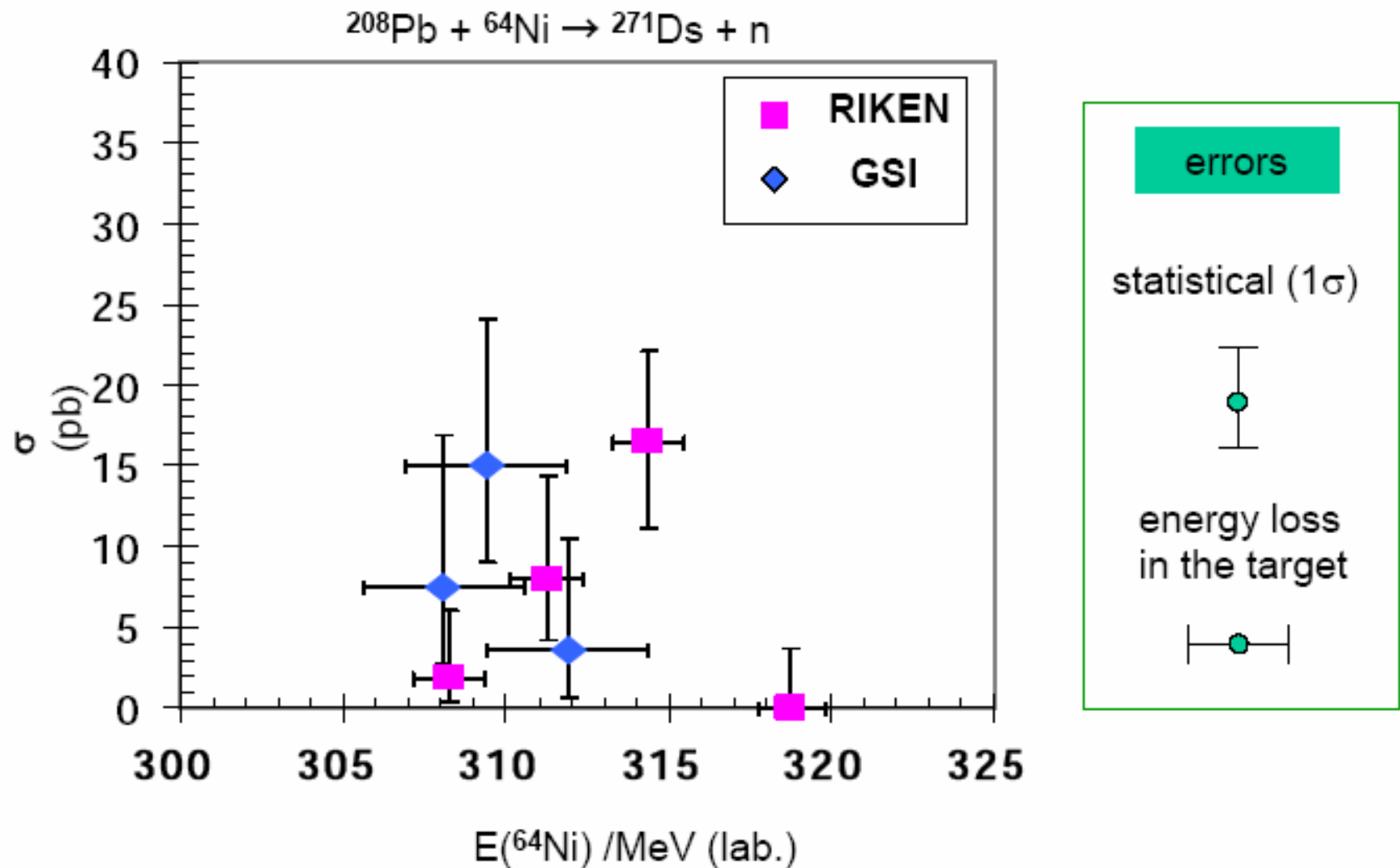
$E_{\text{proj}} = 313\text{MeV}$

25-Sep-2002





Excitation function of $^{208}\text{Pb}(^{64}\text{Ni},n)^{271}\text{Ds}$





Nuclei	n		T_{1/2}		
²⁷¹Ds	11	1.63	+0.44 -0.29	ms	improved
^{271m}Ds	3	69	+56 -21	ms	confirmed
²⁶⁷Hs	12	52	+13 - 8	ms	improved
^{267m}Hs	1	0.80	+3.8 -0.38	s	possible

$$E_{\text{opt}}(\text{lab.}) = 314 \text{ MeV}$$

$$E_{\text{opt}}(\text{cm}) = 240 \text{ MeV}$$



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Experimental condition $^{209}\text{Bi}(^{64}\text{Ni},n)^{272}\text{111}$

Beam ^{64}Ni 0.7~1.8 μA

E(lab.)MeV	ion dose	day	events
320	2.0×10^{18}	8	3
323	8.2×10^{18}	34	11
326	2.5×10^{18}	8	0
total	1.27×10^{19}	50	14

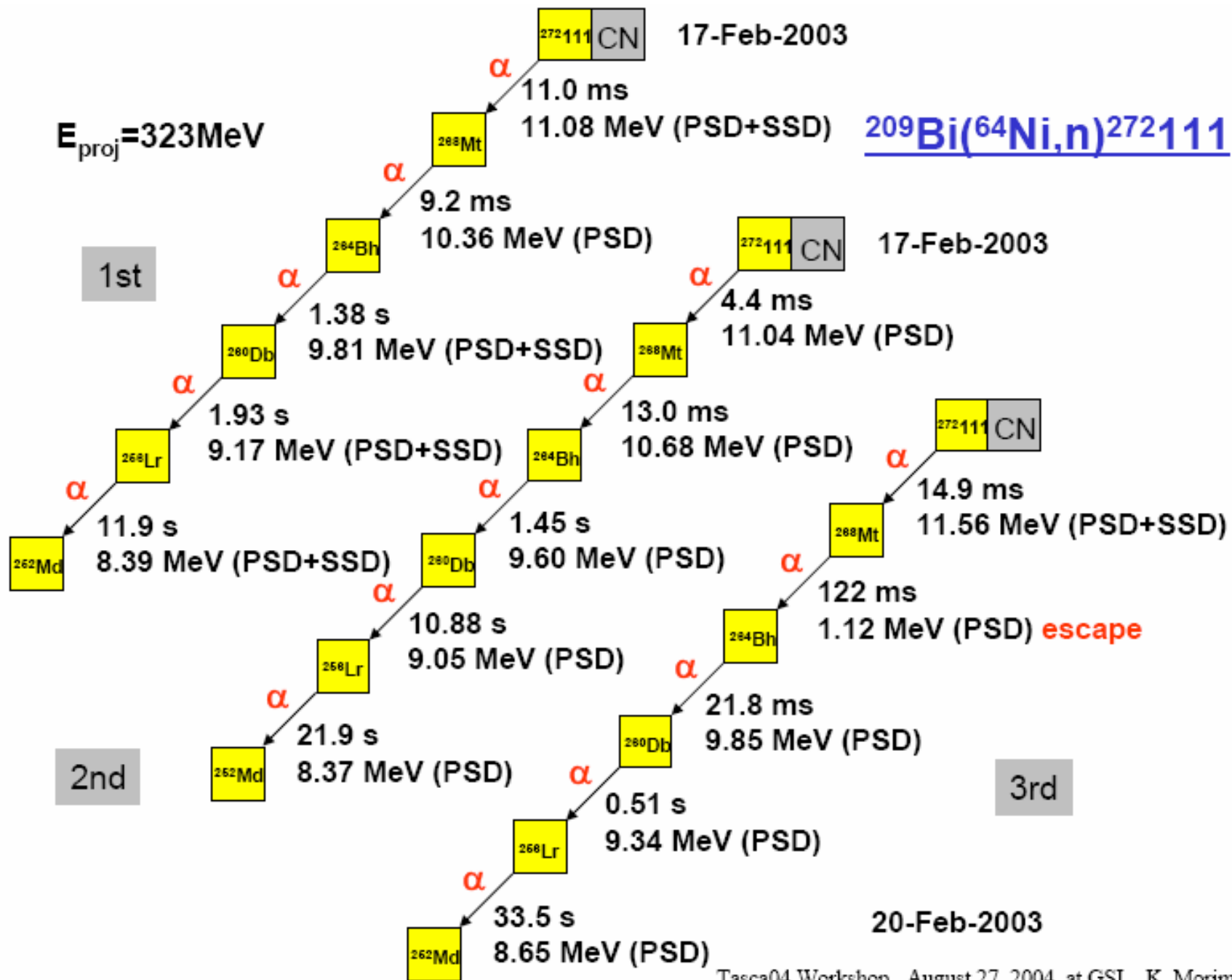
Target ^{209}Bi 210~310 $\mu\text{g}/\text{cm}^2$
evaporated on 30 $\mu\text{g}/\text{cm}^2$ C
covered by 10 $\mu\text{g}/\text{cm}^2$ C

B ρ (GARIS) 2.05 Tm

P (GARIS) 75 Pa

ϵ (GARIS) 0.8

Total Counting rate 2~10 cps

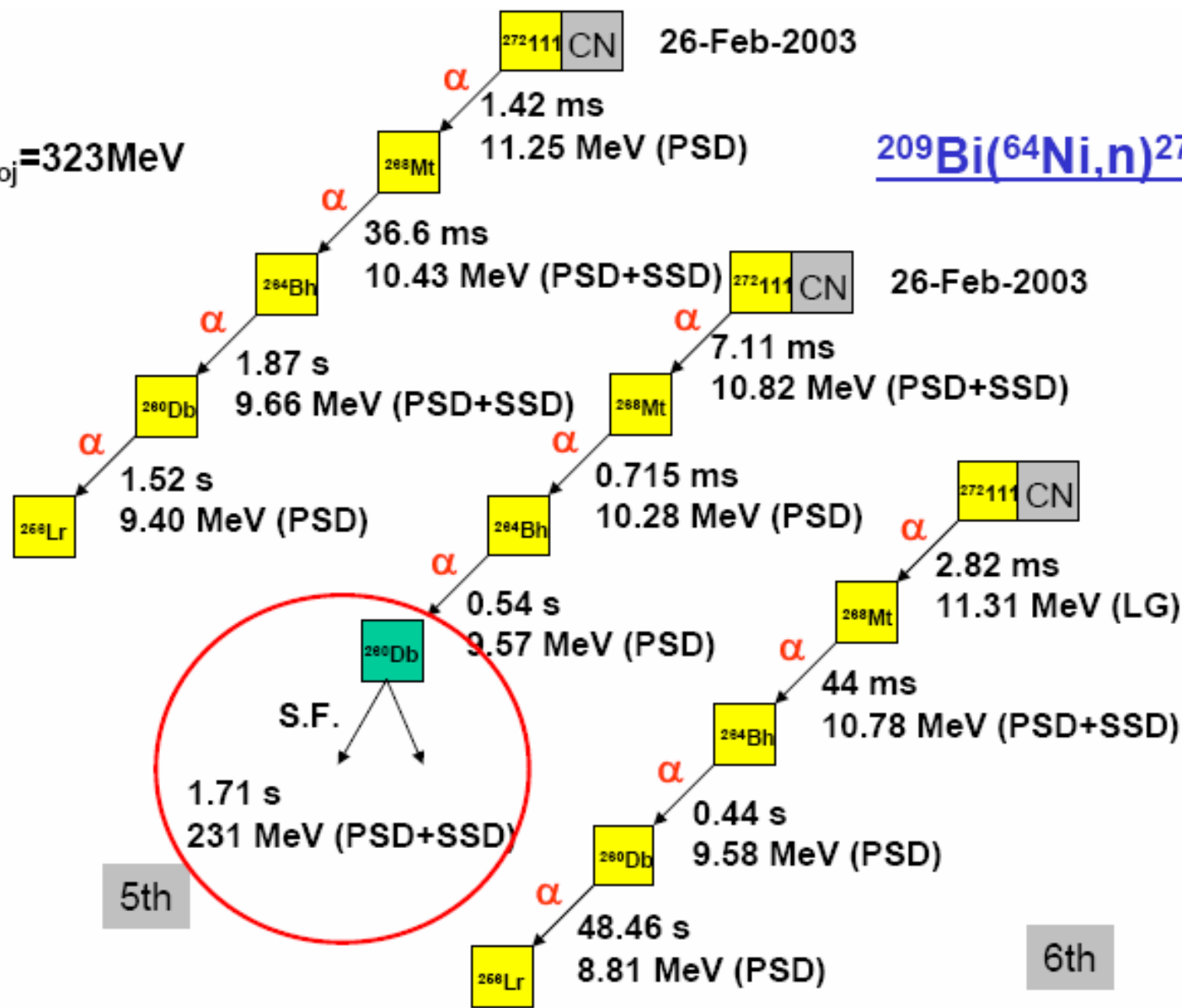


26-Feb-2003

$^{209}\text{Bi}(^{64}\text{Ni},n)^{272111}$

$E_{\text{proj}}=323\text{MeV}$

4th



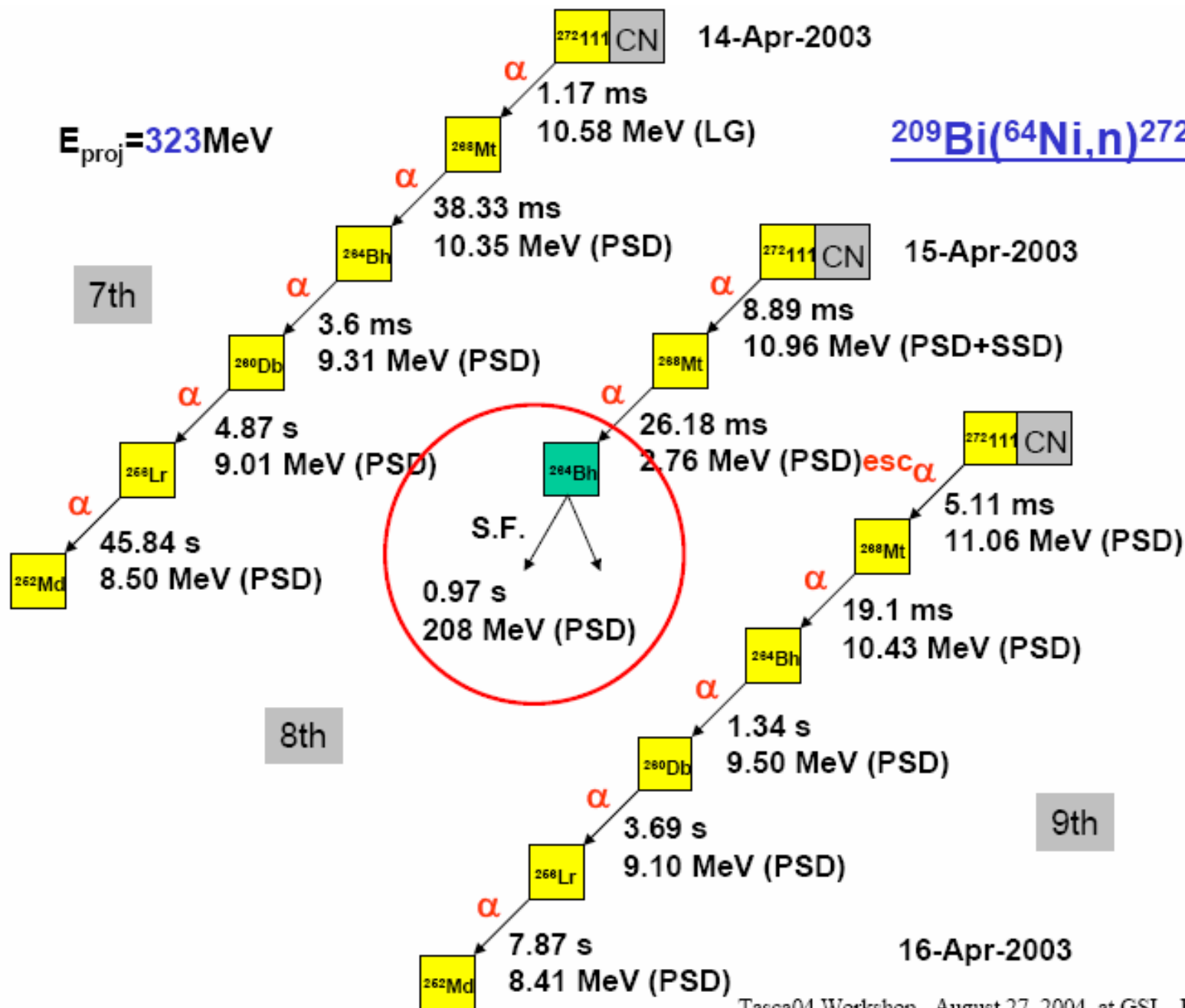
5th

6th

8-Apr-2003

$^{209}\text{Bi}(^{64}\text{Ni},n)^{272111}$

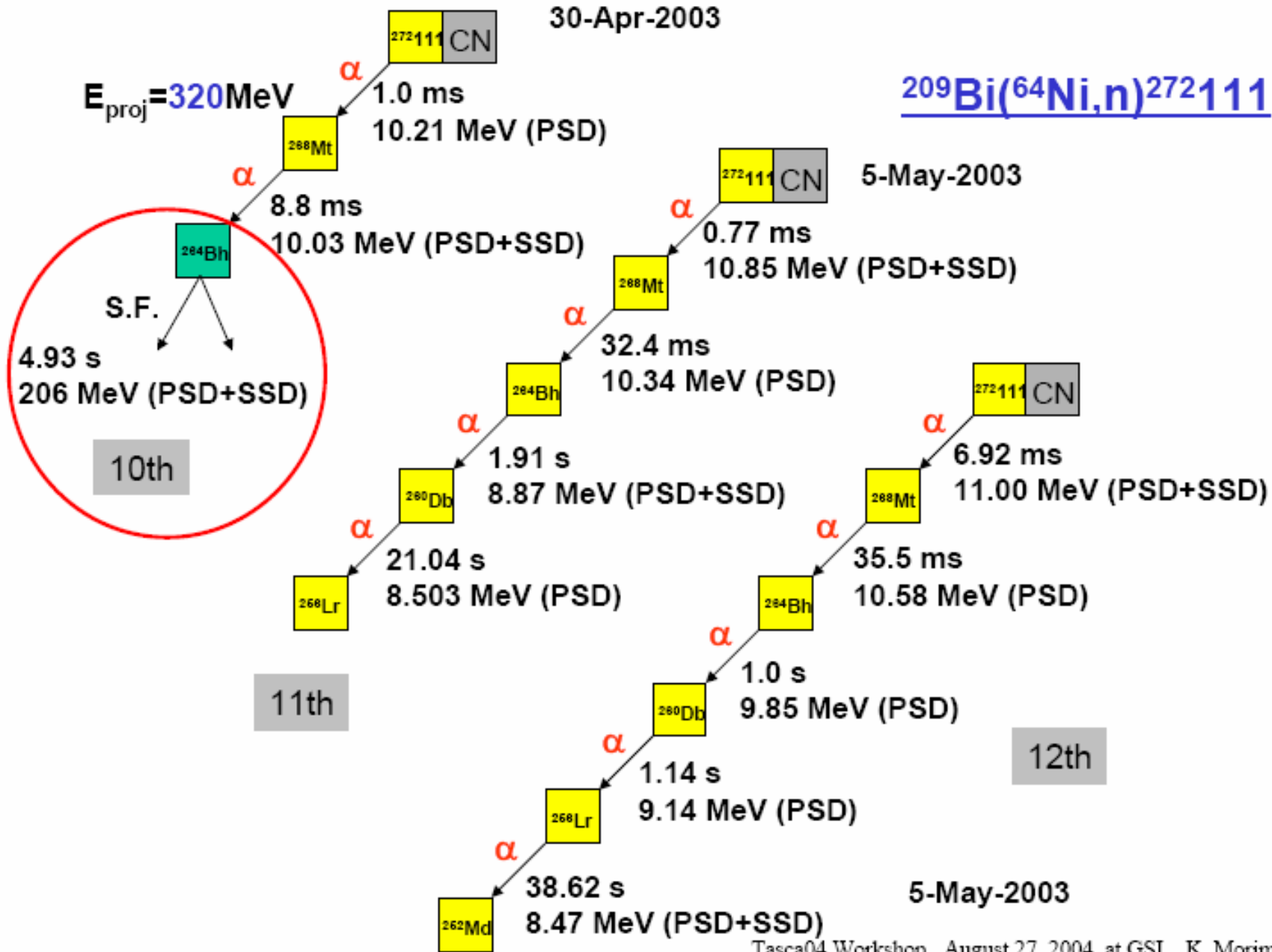
$E_{\text{proj}}=323\text{MeV}$



30-Apr-2003

209Bi(64Ni,n)272111

$E_{proj} = 320 \text{ MeV}$



5-May-2003

11th

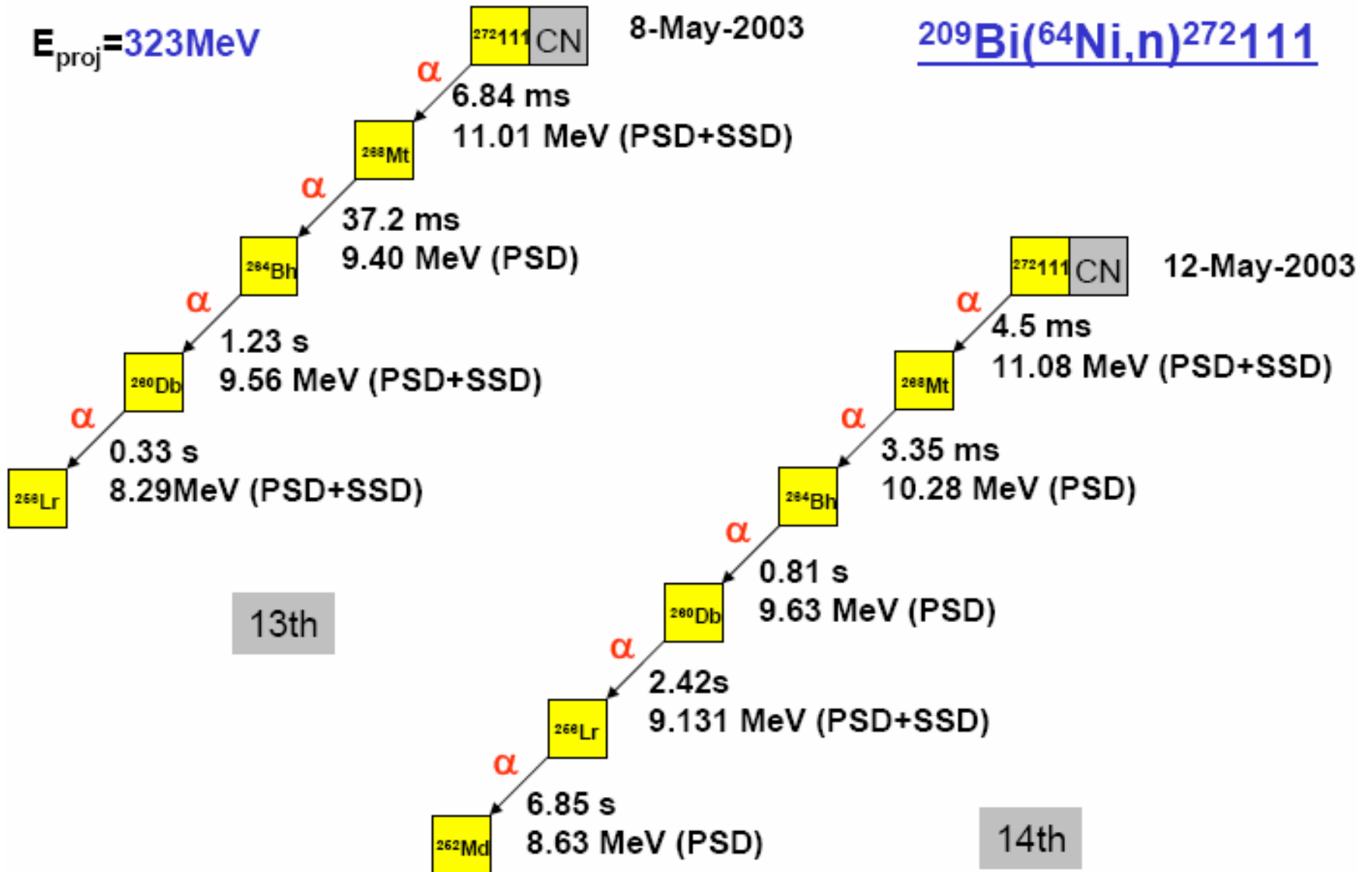
12th

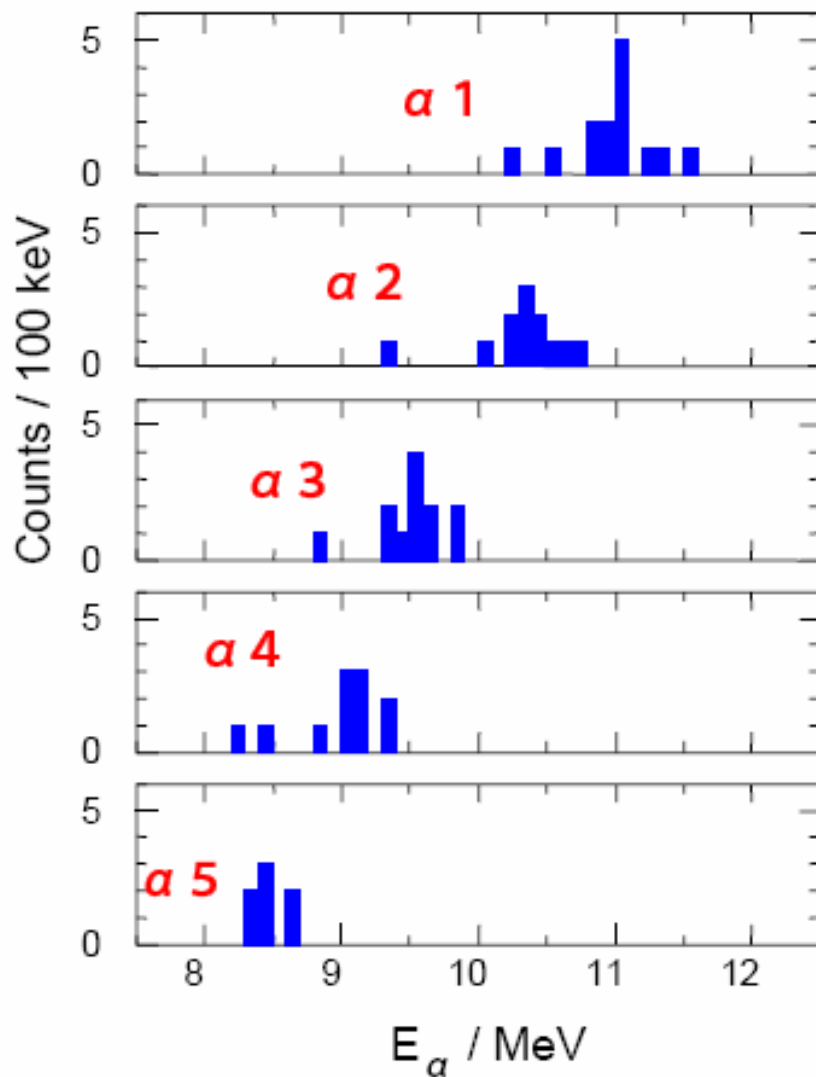
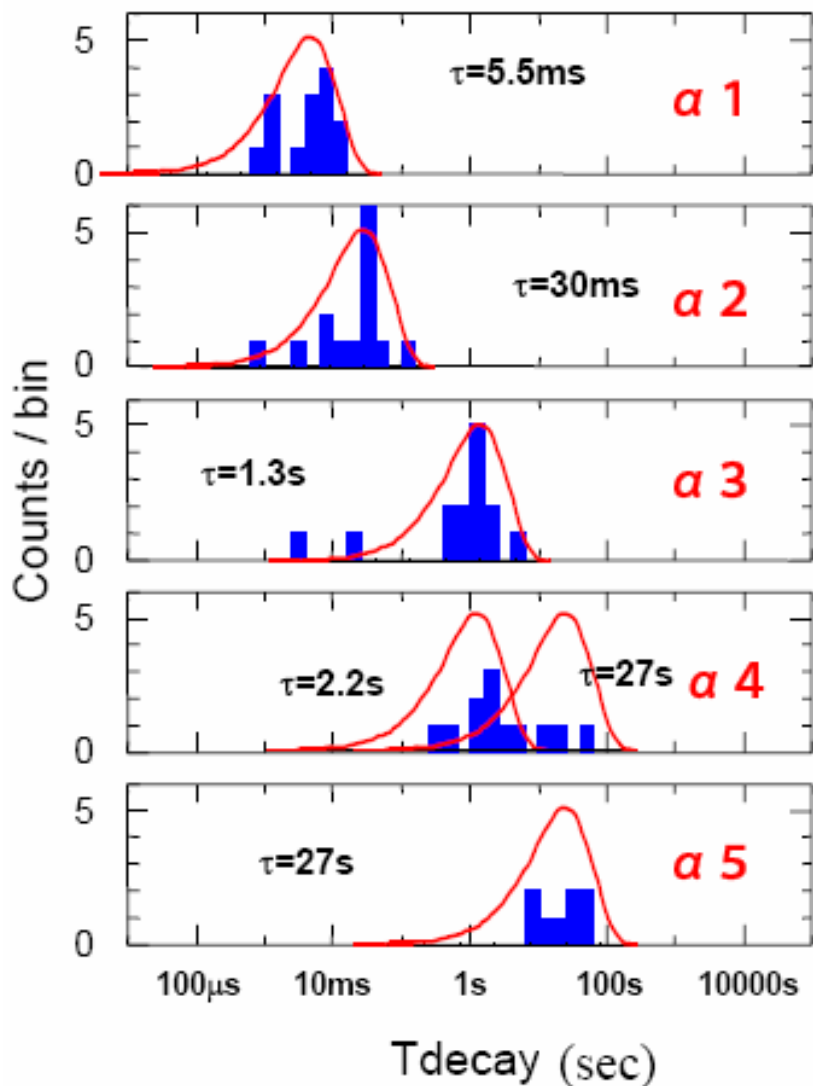
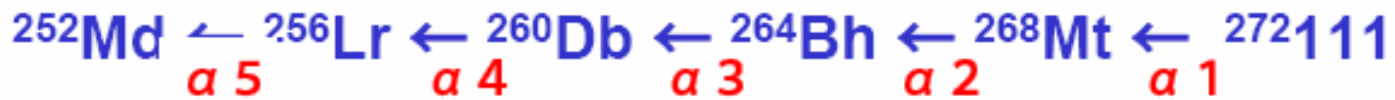
5-May-2003

$E_{\text{proj}} = 323 \text{ MeV}$

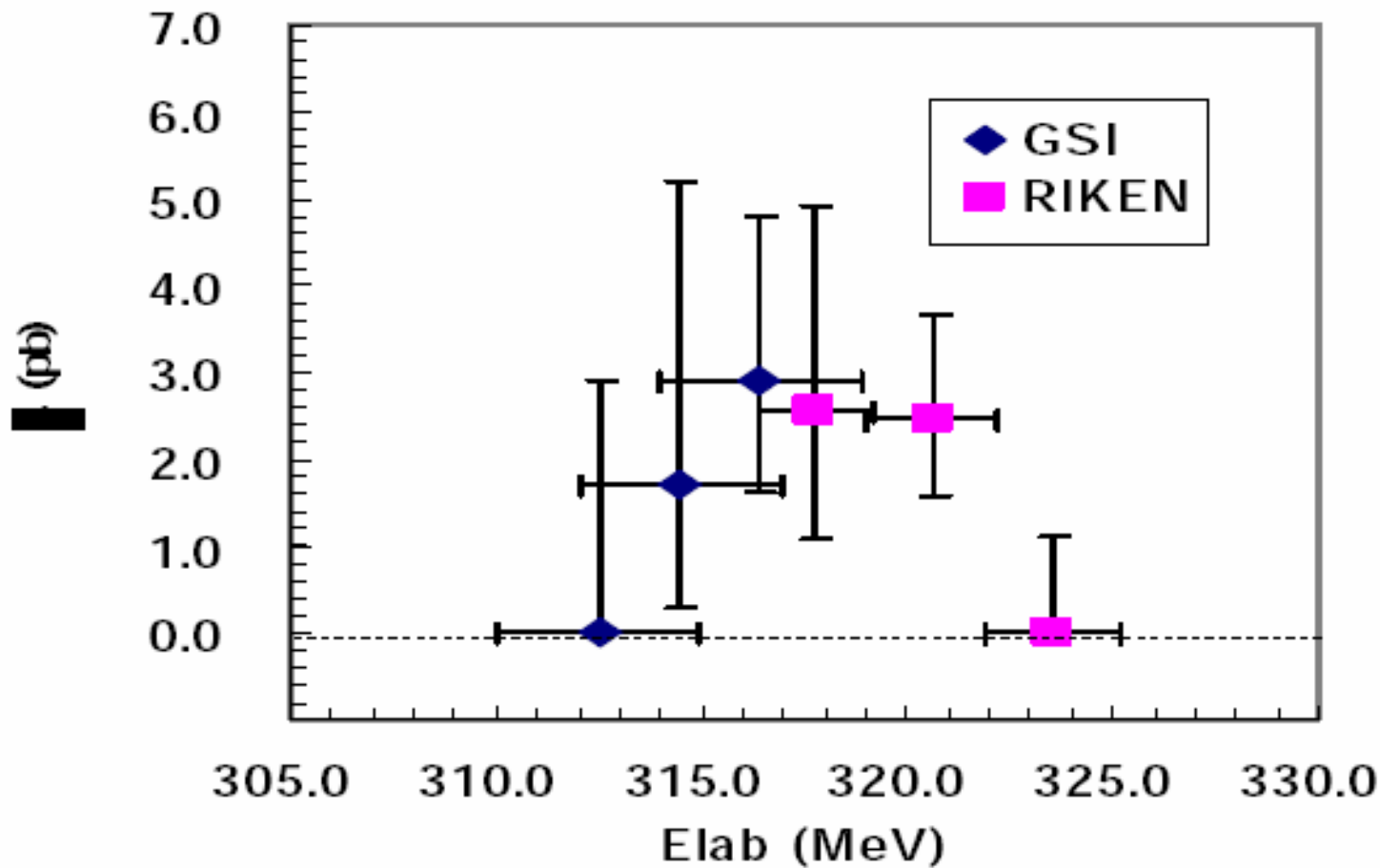
8-May-2003

$^{209}\text{Bi}(^{64}\text{Ni},n)^{272111}$





Excitation function of $^{209}\text{Bi}(^{64}\text{Ni},n)^{272}\text{111}$



Summary of $^{209}\text{Bi} + ^{64}\text{Ni} \rightarrow ^{272}111 + n$

Nuclei	RIKEN				
	n	$T_{1/2}$	E_{α}	$E_{\text{fiss.}}$	
			MeV		
$^{272}111$	14	3.8 +1.4 - 0.8 ms	10.2~11.56		
^{268}Mt	14	21 +8 - 5 ms	9.4~10.77		
^{264}Bh	14	0.89 +0.31 - 0.19 s	8.86~9.83	208 206	
^{260}Db	12	5.7 +2.3 - 1.3 s	8.35~9.4	231	
^{256}Lr	8	18 +10 - 5 s	8.35~8.65		

$E_{\text{opt(lab.)}} = 319 \text{ MeV}$

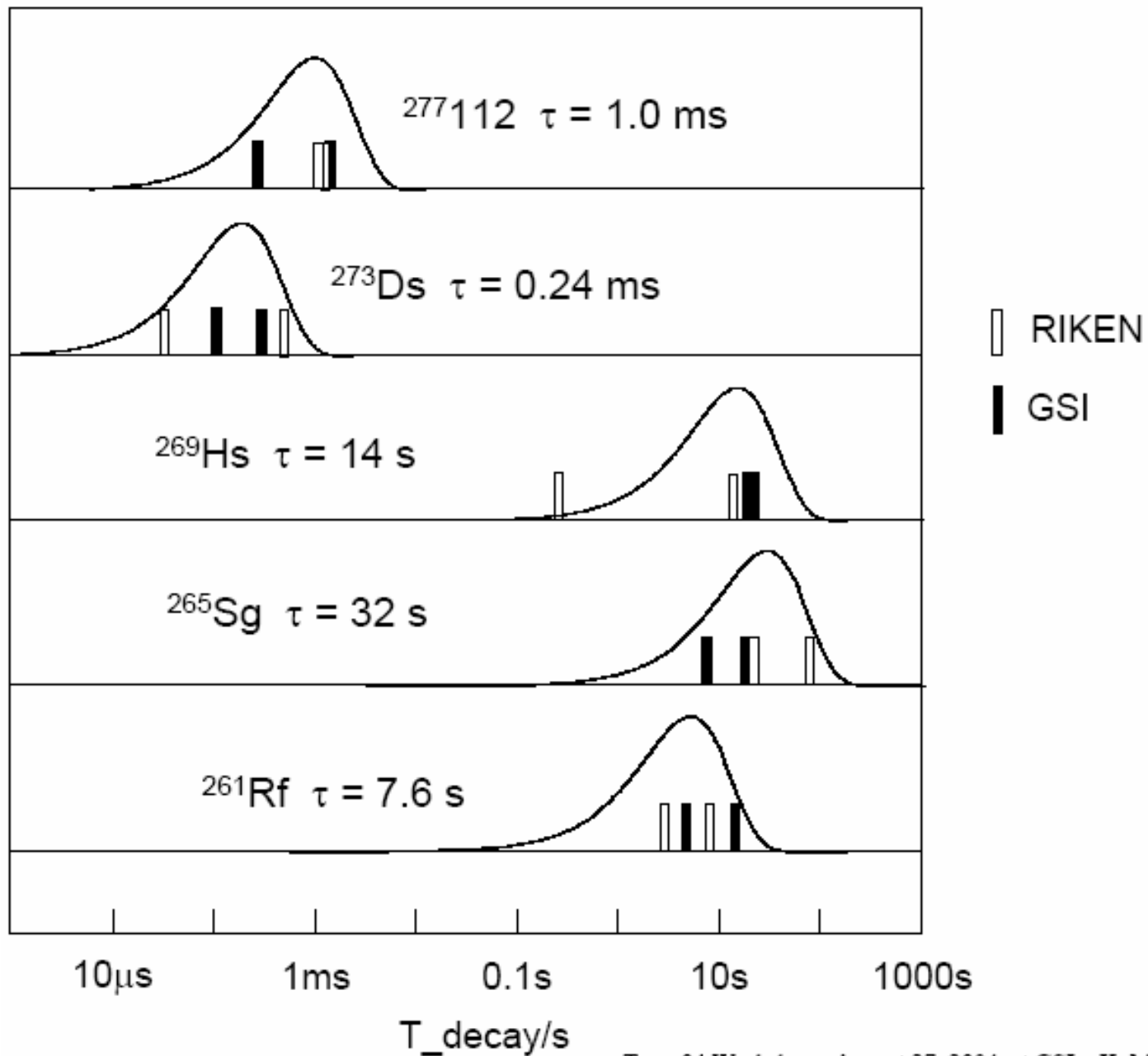
$E_{\text{opt(cm)}} = 244 \text{ MeV}$

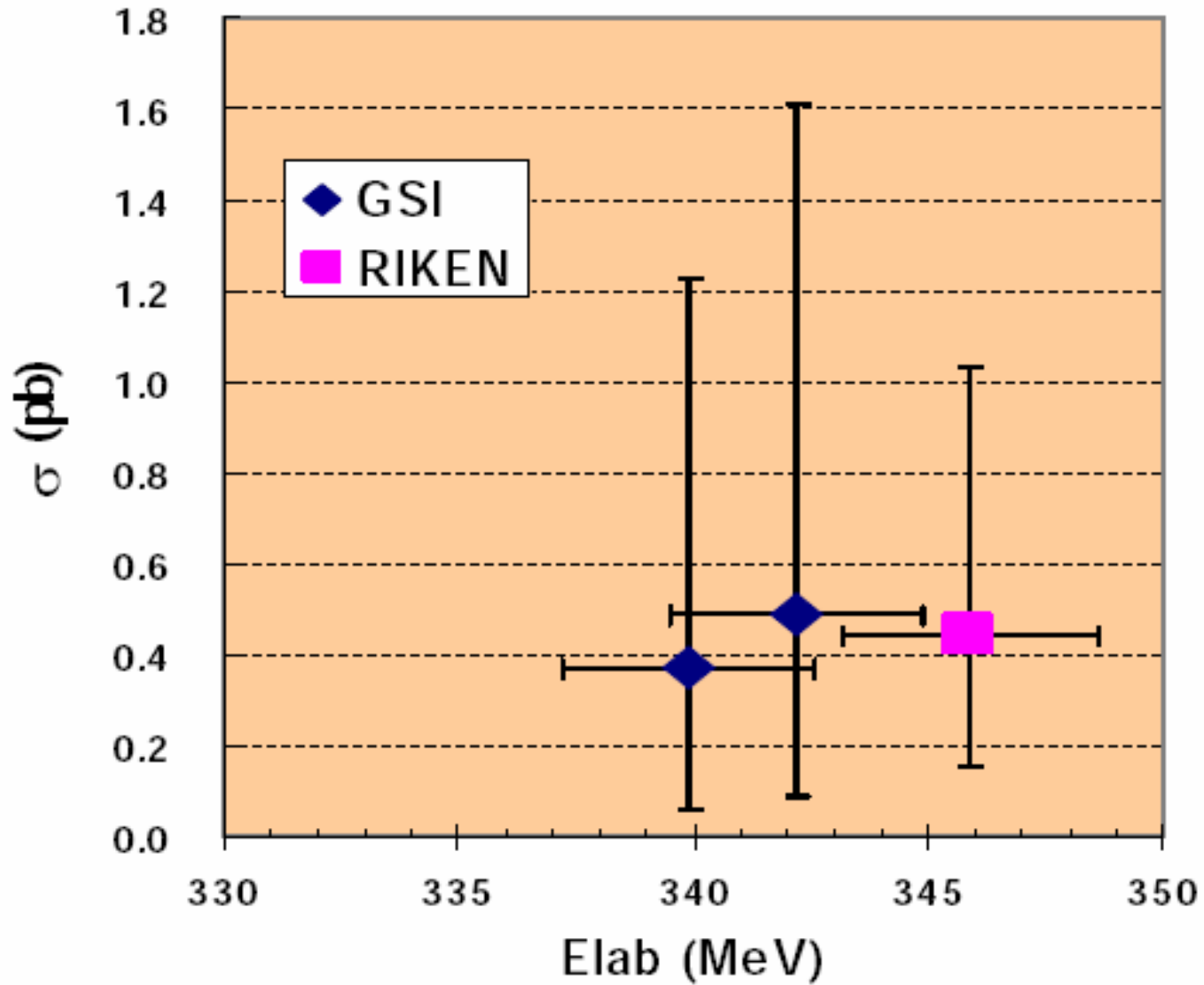


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Experimental condition $^{208}\text{Pb}(^{70}\text{Zn}, n)^{277}\text{112}$

period	2004/4/2 ~ 2004/5/24
Beam Energy	<u>346 MeV</u> at target half depth
Total Dose	4.4×10^{18}
Target Thickness	$450 \mu\text{g}/\text{cm}^2$
number of events	2
σ	$0.44^{+0.59}_{-0.29} \text{ pb}$
Irradiation time	693 Hours (28.9 Days)
Beam Intensity	$1.76 \times 10^{12} /\text{s}$ (0.3 p- μA)
Total counting rate	$\sim 1 \text{ cps}$

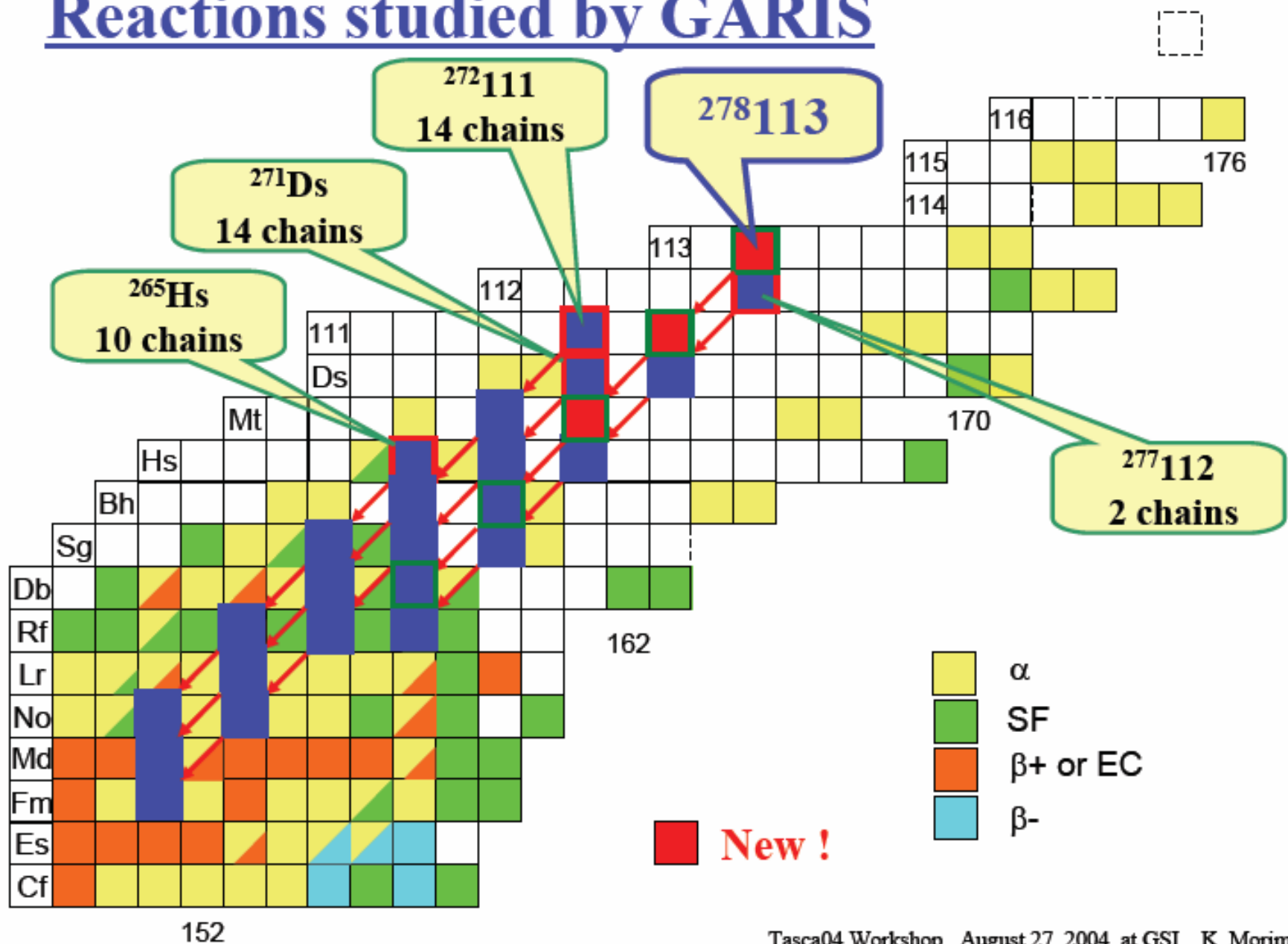


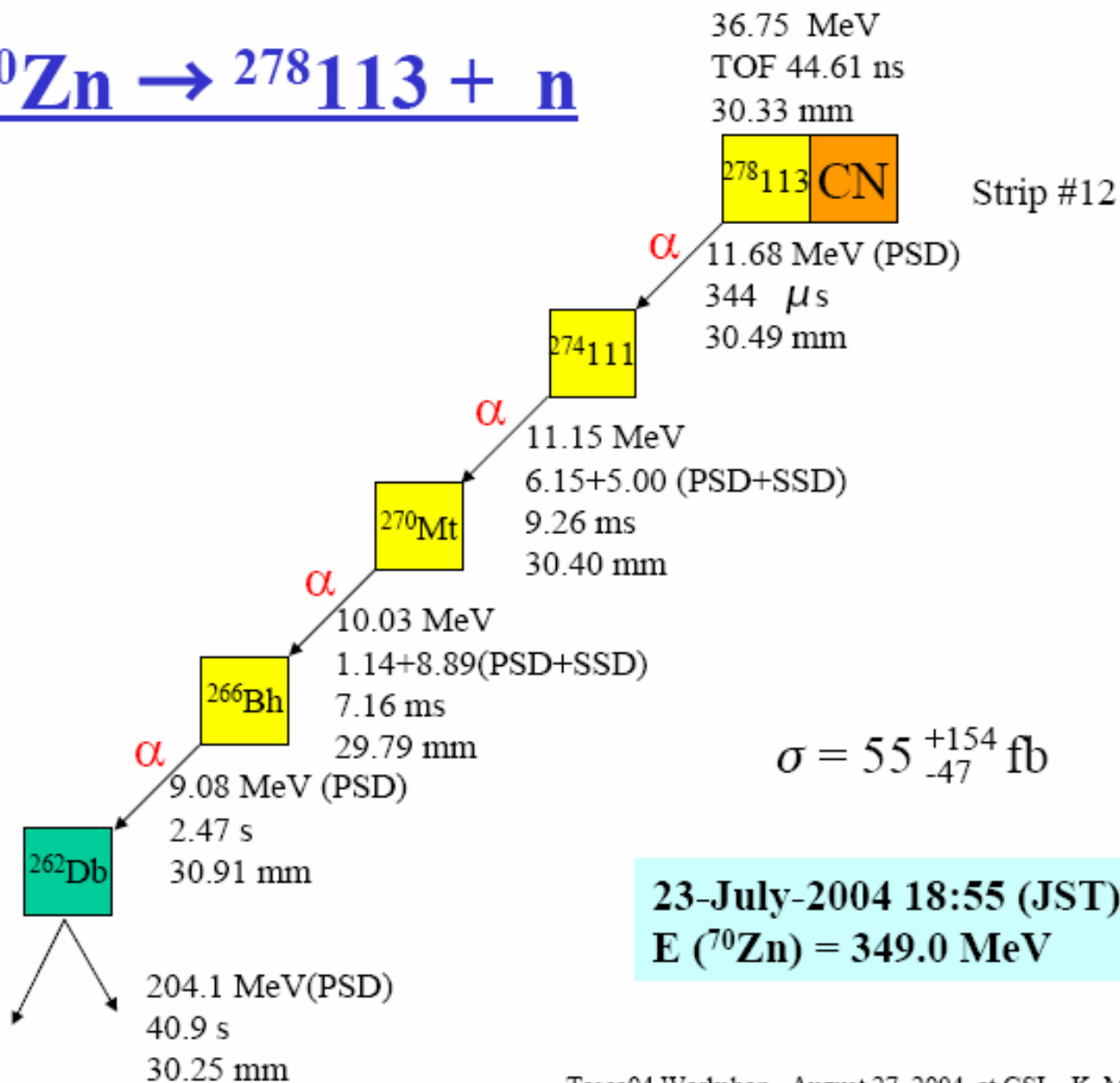




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K. Morita, K. Morimoto, D. Kaji et al.

Reactions studied by GARIS

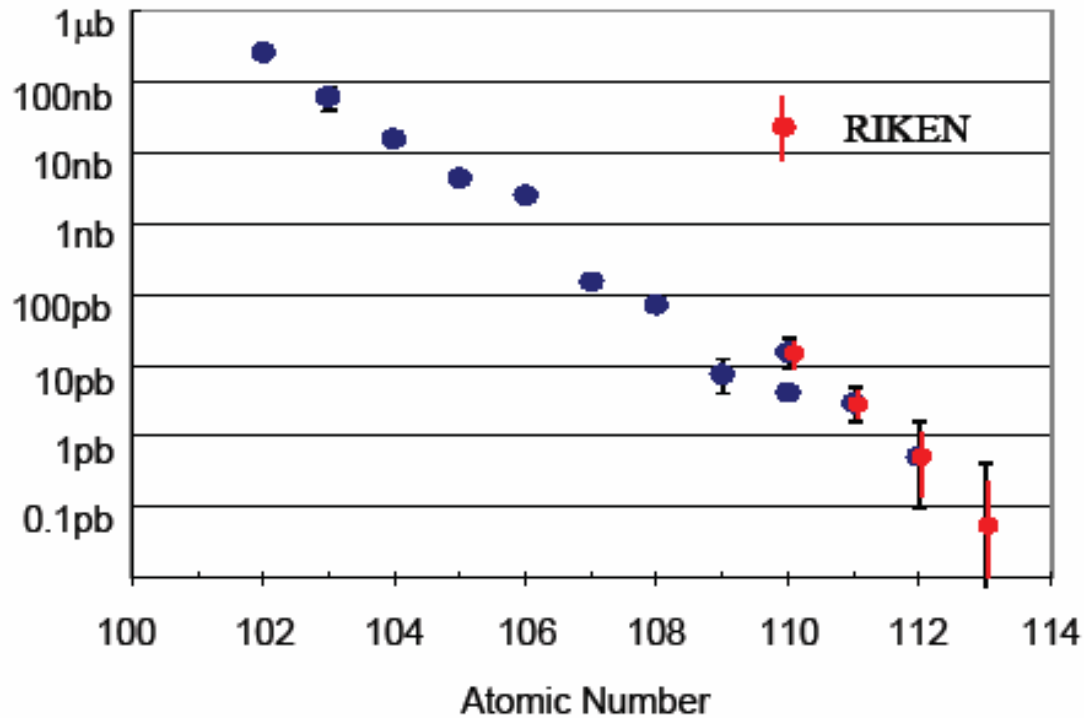




Summary

^{265}Hs	10	chains	
$^{271}\text{110}$ (Ds)	14	chains	
$^{272}\text{111}$	14	chains	
$^{277}\text{112}$	2	chains	
$^{278}\text{113}$	1	chain	New!

$^{208}\text{Pb}, ^{209}\text{Bi}(\text{HI}, 1\text{n})$ reaction



Members



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