The RISING Project

Technical Details for Fast Beam Proposals

RISING Collaboration

January 2003

Experiment #1

P. Mayet et al.:
Shape evolution in light n-rich nuclei

Nucleus of interest: ^{34}Mg (2 step fragmentation + lifetime)

Primary beam: ^{48}Ca 10^9 pps 400 MeV/u
Production target: ^{9}Be 4 g/cm^2 d/R=0.4

First step ^{48}Ca → ^{36}Si:
Secondary beam: ^{36}Si 312 MeV/u
Yield of ^{36}Si / incident ^{48}Ca: $1.2 \cdot 10^{-5}$ ($6.7 \cdot 10^{-2}$ mb)
Charge states after production target: fully stripped

Al degrader at S1:	-	-	} d/R= 0.85
Al degrader at S2:	8500 mg/cm^2	171 MeV/u	
Charge states after degraders:		fully stripped	

Energy at reaction target (S4): 160 MeV/u
Charge states at reaction target (S4): fully stripped

Slits:
S1 ± 10cm (open)
S2 ± 10cm (open)
S3 ± 10cm (open)

Transmission of ^{36}Si:		Yield / incident particle:
At S1 after slits:	72 %	$8.7 \cdot 10^{-6}$
At S2 after slits:	16 %	$1.9 \cdot 10^{-6}$
Total at S4: (σ_x(^{36}Si) = 1.6 cm)	15 %	$1.8 \cdot 10^{-6}$

Yield of ^{36}Si at S4 / all fragments: 0.5

Yield of ^{36}Si at S4 / incident ^{48}Ca:	$1.8 \cdot 10^{-6}$	(1800 pps)

Second step ^{36}Si → ^{34}Mg:

Reaction target at S4: ^{27}Al 1.2 g/cm^2 d/R= 0.4

Energy of ^{34}Mg behind the reaction target: 135 MeV/u

Yield of ^{34}Mg / incident ^{36}Si: $2.7 \cdot 10^{-5}$ (1.0 mb, $5 \cdot 10^{-2}$ pps)
Yield of ^{34}Mg / all nuclei: $1 \cdot 10^{-3}$ (without ^{36}Si)
Yield of ^{34}Mg / isotopes of Mg: $9 \cdot 10^{-3}$

Estimated pγ rate for ^{34}Mg (3% γ efficiency, 100% state population): 130 per day

Some additional information

Relative yield of Mg isotopes:

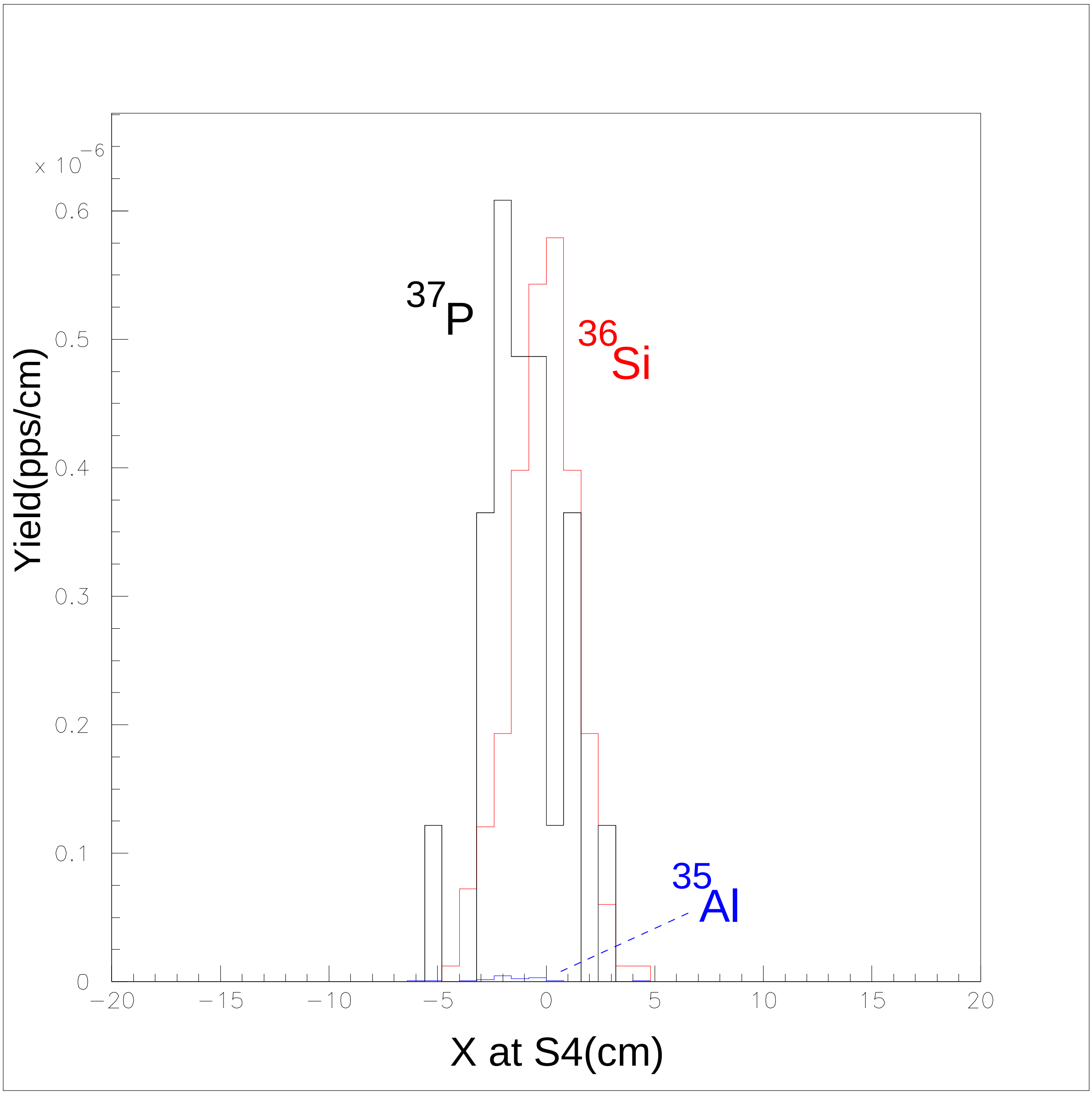
^{30}Mg	^{31}Mg	^{32}Mg	^{33}Mg	^{34}Mg
12	7	4	2	1

Slits:
S1 ± 10cm
S2 ± 10cm
S3 ± 10cm

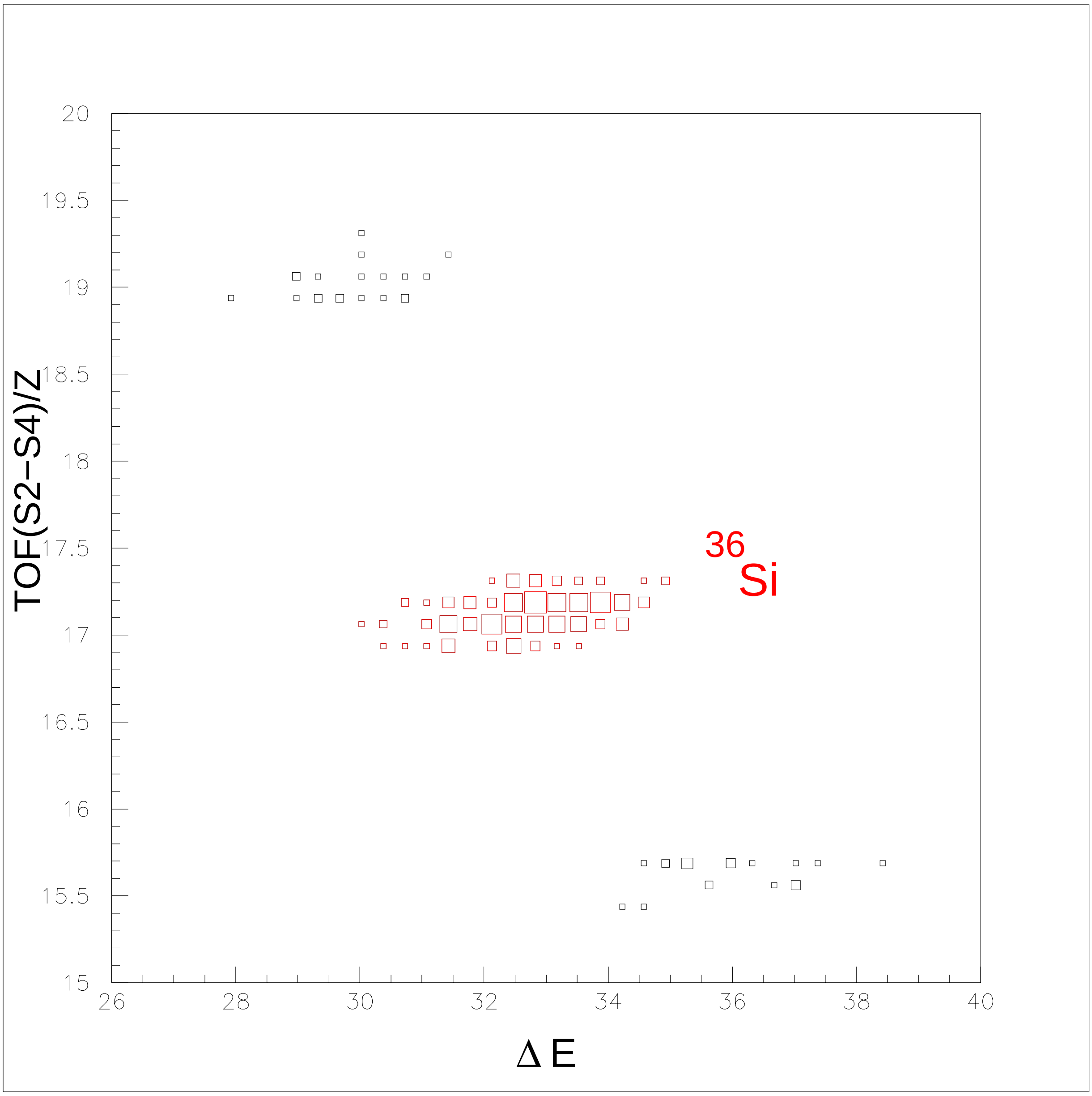
Reaction target ± 3.5cm

Yield of all fragments / incident ^{48}Ca after S1 slits: $1 \cdot 10^{-3}$ $(1 \cdot 10^{6}$ pps)
Yield of all fragments / incident ^{48}Ca before SC21: $3 \cdot 10^{-4}$ $(3 \cdot 10^{5}$ pps)
Yield of all fragments / incident ^{48}Ca before MUSIC at S4: $4 \cdot 10^{-6}$ $(4 \cdot 10^{3}$ pps)
Yield of all fragments / incident ^{48}Ca behind the reaction target: $3 \cdot 10^{-6}$ $(3 \cdot 10^{3}$ pps)

Bρ(D1) = 7.2083 Tm
Bρ(D2) = 7.2084 Tm
Bρ(D3) = 5.0638 Tm
Bρ(D4) = 5.0677 Tm



x 10^-6
0.6
0.5
0.4
0.3
0.2
0.1
0
Yield(pps/cm)
37P
36Si
35Al
-20
-15
-10
-5
0
5
10
15
20
X at S4(cm)



TOF(S2−S4)/Z
20
19.5
19
18.5
18
17.5
17
16.5
16
15.5
15
26
28
30
32
34
36
38
40
ΔE
36
Si

Experiment #2

M. Bentley et al.:
Isospin Symmetry and Coulomb Effects Towards the Proton Drip Line

Nucleus of interest: ^{45}Cr (2 step fragmentation)

Primary beam: ^{58}Ni 10^9 pps 600 MeV/u
Production target: ^{9}Be 6.3 g/cm^2 d/R=0.45

First step $^{58}Ni \rightarrow {}^{46}Cr$:
Secondary beam: ^{46}Cr 410 MeV/u
Yield of ^{46}Cr / incident ^{58}Ni: $3.1 \cdot 10^{-6}$ (0.014 mb)
Charge states after production target: fully stripped

Al degrader at S1:	-	-	} d/R= 0.6
Al degrader at S2:	5800 mg/cm^2	190 MeV/u	
Charge states after degraders:		fully stripped	

Energy at reaction target (S4): 164 MeV/u
Charge states at reaction target (S4): fully stripped

Slits:
S1 ± 10cm (open)
S2 ± 10cm (open)
S3 ± 10cm (open)

Transmission of ^{46}Cr:		Yield / incident particle:
At S1 after slits:	91 %	$2.9 \cdot 10^{-6}$
At S2 after slits:	46 %	$1.5 \cdot 10^{-6}$
Total at S4: ($\sigma_x(^{46}Cr)$ = 1.9 cm)	32 %	$1.0 \cdot 10^{-6}$

Yield of ^{46}Cr at S4 / all fragments: 0.2

Yield of ^{46}Cr at S4/ incident ^{58}Ni:	$1.0 \cdot 10^{-6}$	(1000 pps)

Second step $^{46}Cr \rightarrow {}^{45}Cr$:

Reaction target at S4: ^{9}Be 700 mg/cm^2 d/R= 0.3

Energy of ^{45}Cr behind the reaction target: 123 MeV/u

Yield of ^{45}Cr / incident ^{46}Cr: $1.7 \cdot 10^{-4}$ (3.55 mb, 0.17 pps)
Yield of ^{45}Cr / all nuclei: $4.4 \cdot 10^{-3}$ (without ^{46}Cr)
Yield of ^{45}Cr / isotopes of Cr: 0.98 (without ^{46}Cr)

Estimated pγ rate for ^{45}Cr (3% γ efficiency, 100% state population): 18 per hour

Some additional information

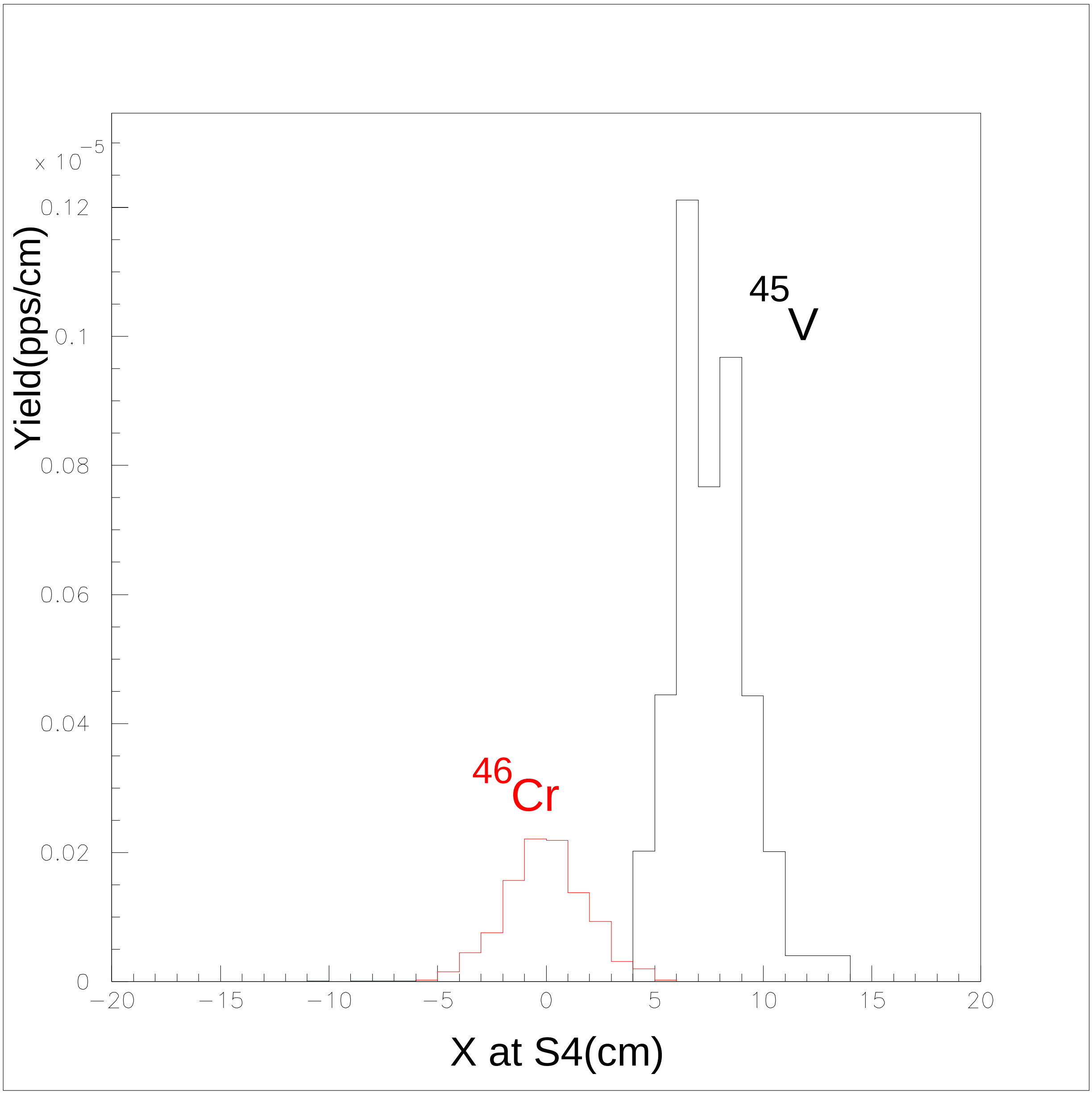
Nucleus of interest	Intermediate fragment	Yield of intermediate fragment at S4 / incident ^{58}Ni	Beam intensity of ^{58}Ni (limited by rate on detectors)	Estimated pγ rate (3% γ efficiency, 100% state population)
^{45}Cr	^{46}Cr	$1 \cdot 10^{-6}$	$1 \cdot 10^{9}$ pps	18 / h
^{45}Sc	^{46}Ti	$8 \cdot 10^{-4}$	$2.5 \cdot 10^{6}$ pps	440 / h
^{53}Ni	^{54}Ni	$8 \cdot 10^{-7}$	$1 \cdot 10^{9}$ pps	10 / h
^{53}Mn	^{54}Fe	$3 \cdot 10^{-3}$	$6.3 \cdot 10^{5}$ pps	580 / h

Slits:
S1 ± 10cm
S2 ± 10cm
S3 ± 10cm

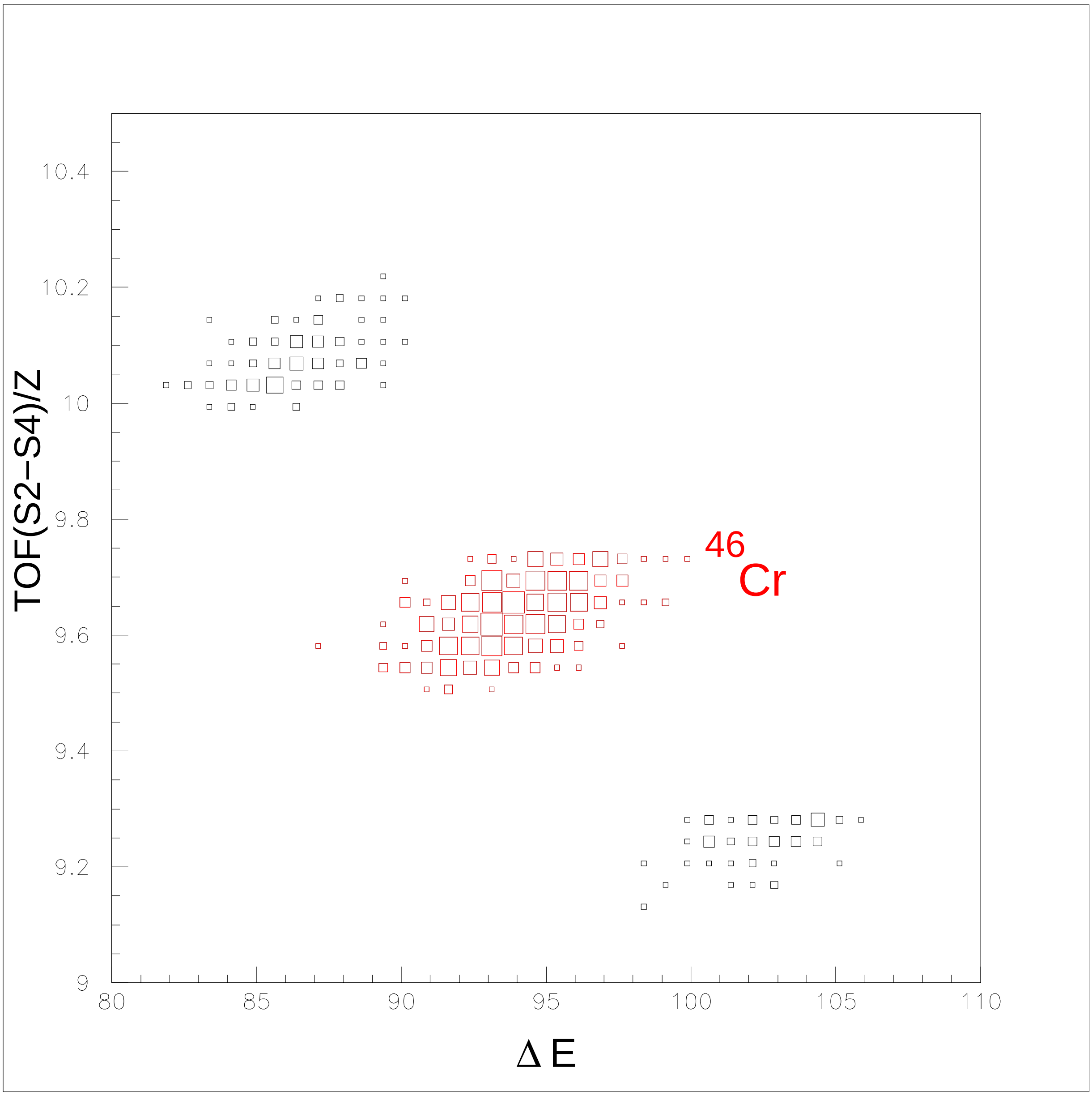
Reaction target ± 3.5cm

Yield of all fragments / incident ^{58}Ni after S1 slits: $3.2 \cdot 10^{-3}$ ($3.2 \cdot 10^{6}$ pps)
Yield of all fragments / incident ^{58}Ni before SC21: $2.9 \cdot 10^{-3}$ ($2.9 \cdot 10^{6}$pps)
Yield of all fragments / incident ^{58}Ni before MUSIC at S4: $5.4 \cdot 10^{-6}$ ($5.4 \cdot 10^{3}$ pps)
Yield of all fragments / incident ^{58}Ni behind the reaction target: $5.0 \cdot 10^{-6}$($5.0 \cdot 10^{3}$ pps)

Bρ(D1) = 6.1711 Tm
Bρ(D2) = 6.1717 Tm
Bρ(D3) = 3.9892 Tm
Bρ(D4) = 3.9899 Tm



× 10^-5
0.12
0.1
0.08
0.06
0.04
0.02
0
Yield(pps/cm)
45V
46Cr
−20
−15
−10
−5
0
5
10
15
20
X at S4(cm)


TOF(S2−S4)/Z
ΔE
46
Cr
10.4
10.2
10
9.8
9.6
9.4
9.2
9
80
85
90
95
100
105
110

Experiment No. 3

A. Bracco et al.

Gamma-decay of the GDR in the exotic nucleus ^{68}Ni via Coulomb excitation

Nucleus of interest:	^{68}Ni (GDR via Coulex)			
Primary beam :	^{86}Kr	10^{10} pps	700 MeV/u	
Production target:	^{9}Be	4 g/cm^2		$\frac{d}{R_t} = 0.26$

First stage $^{86}\text{Kr} \rightarrow {}^{68}\text{Ni}$:

Secondary beam:	^{68}Ni		584.0 MeV/u	
Yield of ^{68}Ni/incident ^{86}Kr		$9.5{\cdot}10^{-6}$		0.058 mb (EPAX2)
Charge states after prod. target			fully stripped	
Al degrader at S1				
Al degrader at S2		6167.8 mg/cm^2	415.3 MeV/u	$\frac{d}{R} = 0.41$
Charge states after degrader			fully stripped	
Energy at reaction target (S4)			400.2 MeV/u	
Charge states at target			fully stripped	

Slits :
S1 = ± 1.5 cm
S2 = ± 6 cm
S3 = ± 1.6 cm

Transmission of ^{68}Ni:		Yield/incident particle:
At S1, after slits	40.1 %	$3.8{\cdot}10^{-6}$
At S2, after slits	26.2 %	$2.5{\cdot}10^{-6}$
At reaction target(σ_x(^{68}Ni) = 0.70 cm)	24.5 %	$2.3{\cdot}10^{-6}$

Yield of ^{68}Ni at S4/all fragments: 0.22

Yield of ^{68}Ni at S4/incident ^{86}Kr	$2.3{\cdot}10^{-6}$	($2.3{\cdot}10^{4}$ pps

Second stage $^{68}\text{Ni} \rightarrow {}^{68}\text{Ni}^{\star}$:

Reaction target at S4	^{208}Pb	2 g/cm^2	400.3 MeV/u		$\frac{d}{R} = 0.14$
Energy of ^{68}Ni behind the reaction target:			362.0 MeV/u		
Yield of ^{68}Ni*(Coulex)/incident ^{68}Ni		$3.5{\cdot}10^{-3}$	(high energy part:		600 mb, 81 pps)
		$8.7{\cdot}10^{-4}$	(region of pygmy:		150 mb, 20 pps)

Estimated pγ rate in BaF$_2$ detectors(5 - 13 MeV Energy, (1.1 % γ eff. at 10 MeV)) : 64 hr.$^{-1}$

Estimated pγ rate in Ge detectors (15 - 17 MeV Energy, (0.4 % γ eff. at 15 MeV)) : 6 hr.$^{-1}$

Some additional information for FRS setting

Slits :
S1 = $\pm$ 1.5 cm
S2 = $\pm$ 6 cm
S3 = $\pm$ 1.6 cm

Reaction target = $\pm$ 3.5 cm (max.)

Yield of all fragments / incident particle before SC21 :	$5.1 \cdot 10^{-4}$ ($5.1 \cdot 10^{6}$)
Yield of all fragments / incident particle before MUSIC at S4 :	$1.0 \cdot 10^{-5}$ ($1.0 \cdot 10^{5}$)

$B\rho(D1) = 9.6691$ Tm
$B\rho(D2) = 9.6746$ Tm
$B\rho(D3) = 7.8722$ Tm
$B\rho(D4) = 7.8716$ Tm

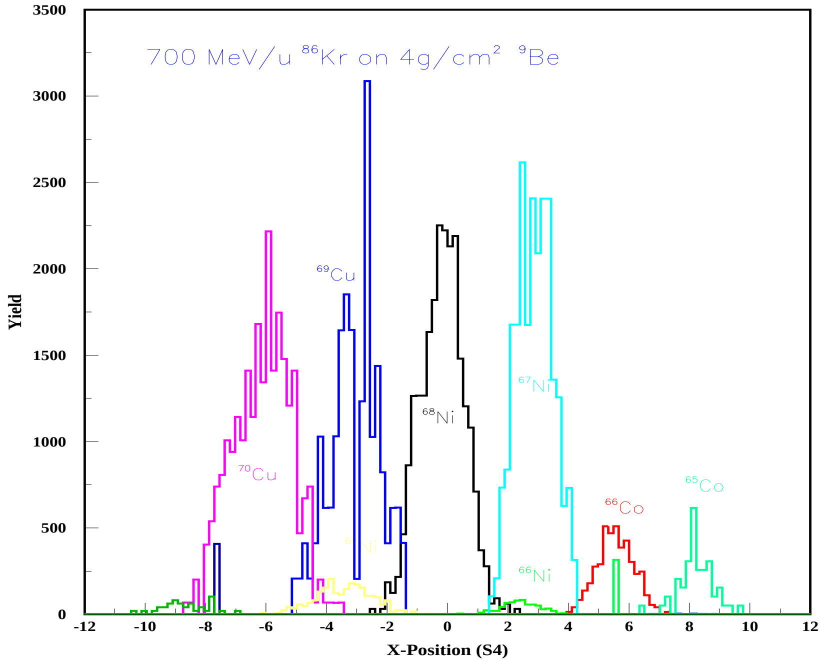


Figure 1: Position spectrum at S4 for ^{68}Ni setting

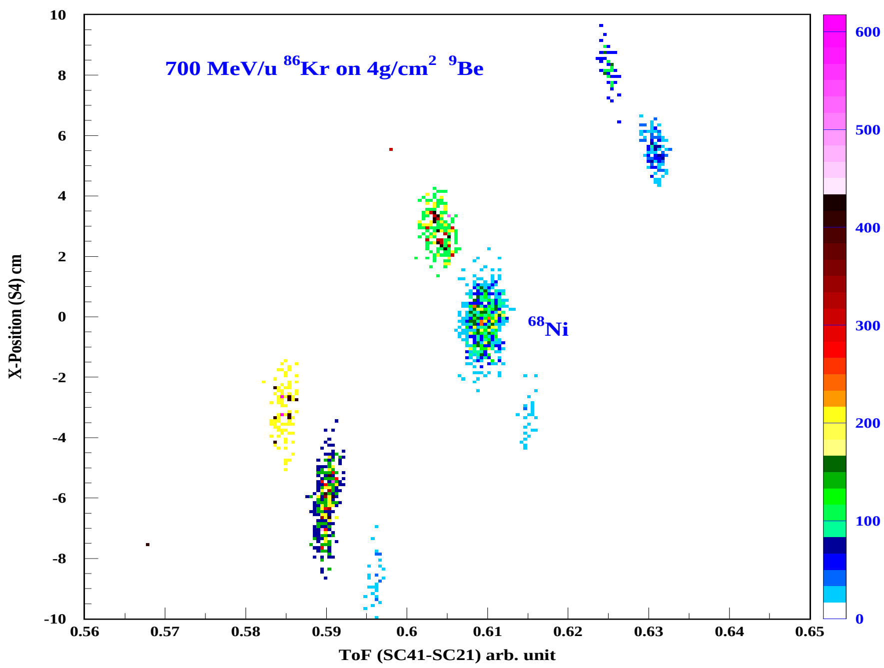


Figure 2: Time-of-flight vs Position plot for ^{68}Ni setting

Experiment #4

H. Grawe et al.:
Relativistic Coulex in N=28-34 and N=40-50 nuclei

Nucleus of interest: ^{50}Ca

Primary beam:	^{82}Se	10^9 pps	400 MeV/u	
Production target:	^{9}Be	2 g/cm^2		d/R=0.3

First step ^{82}Se→ ^{50}Ca:

Secondary beam:	^{50}Ca	330 MeV/u	
Yield of ^{50}Ca / incident particle			$5 \cdot 10^{-7}$ (4.8 10^{-3} mb)
Charge states after production target:		fully stripped	

Al degrader at S1:	-	-	} d/R= 0.78
Al degrader at S2:	7200 mg/cm^2	130 MeV/u	
Charge states after degraders:		fully stripped	

Energy at reaction target (S4):	108 MeV/u
Charge states at reaction target (S4):	fully stripped

Slits:
S1 ± 10cm (open)
S2 ± 10cm (open)
S3 ± 10cm (open)

Transmission of ^{50}Ca:		Yield / incident particle:
At S1 after slits:	67 %	$3.5 \cdot 10^{-7}$
At S2 after slits:	25 %	$1.3 \cdot 10^{-7}$
At reaction target:(σ_x(^{50}Ca) = 2 cm)	14 %	$7.4 \cdot 10^{-8}$

Yield of ^{50}Ca at S4 / all fragments: 0.19

Yield of ^{50}Ca at S4/ incident particle	$7.4 \cdot 10^{-8}$	(74 pps)

Second step ^{50}Ca → ^{50}Ca(2$^+$):

Reaction target at S4: ^{208}Pb 1000 mg/cm^2 d/R= 0.5

Energy of ^{50}Ca behind the reaction target: 78 MeV/u

Yield of ^{50}Ca(2$^+$) / incident ^{50}Ca: $5 \cdot 10^{-4}$ (250 mb, 0.04 pps)
Yield of ^{50}Ca(2$^+$) / isotopes of Ca (products of ^{50}Ca+^{208}Pb reaction): 0.43

Estimated pγ rate for ^{50}Ca(2$^+$) (3% γ efficiency at 1.3 MeV): 4 /h

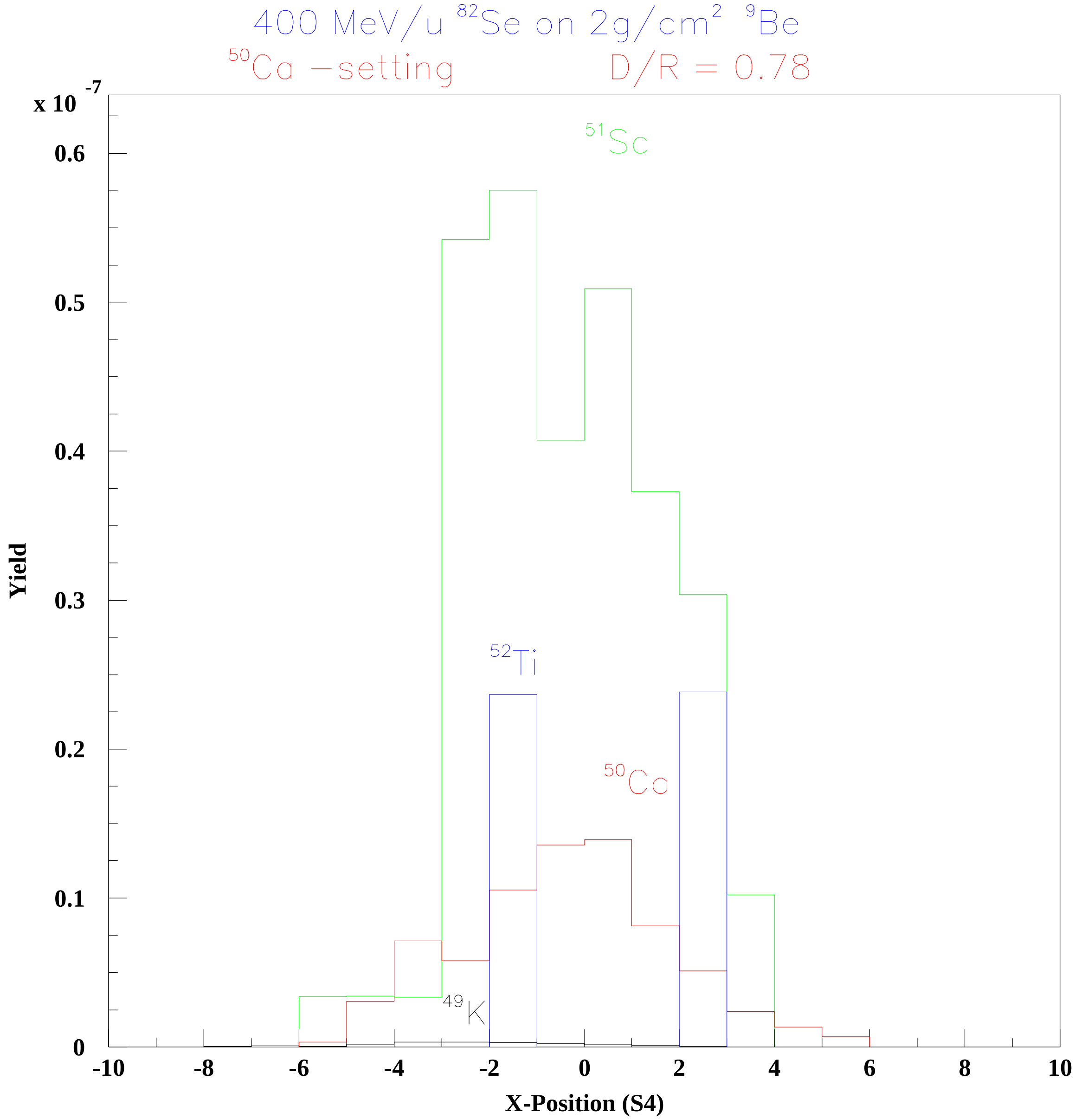
Some additional information for FRS setting

Slits:
S1 ± 10cm
S2 ± 10cm
S3 ± 10cm

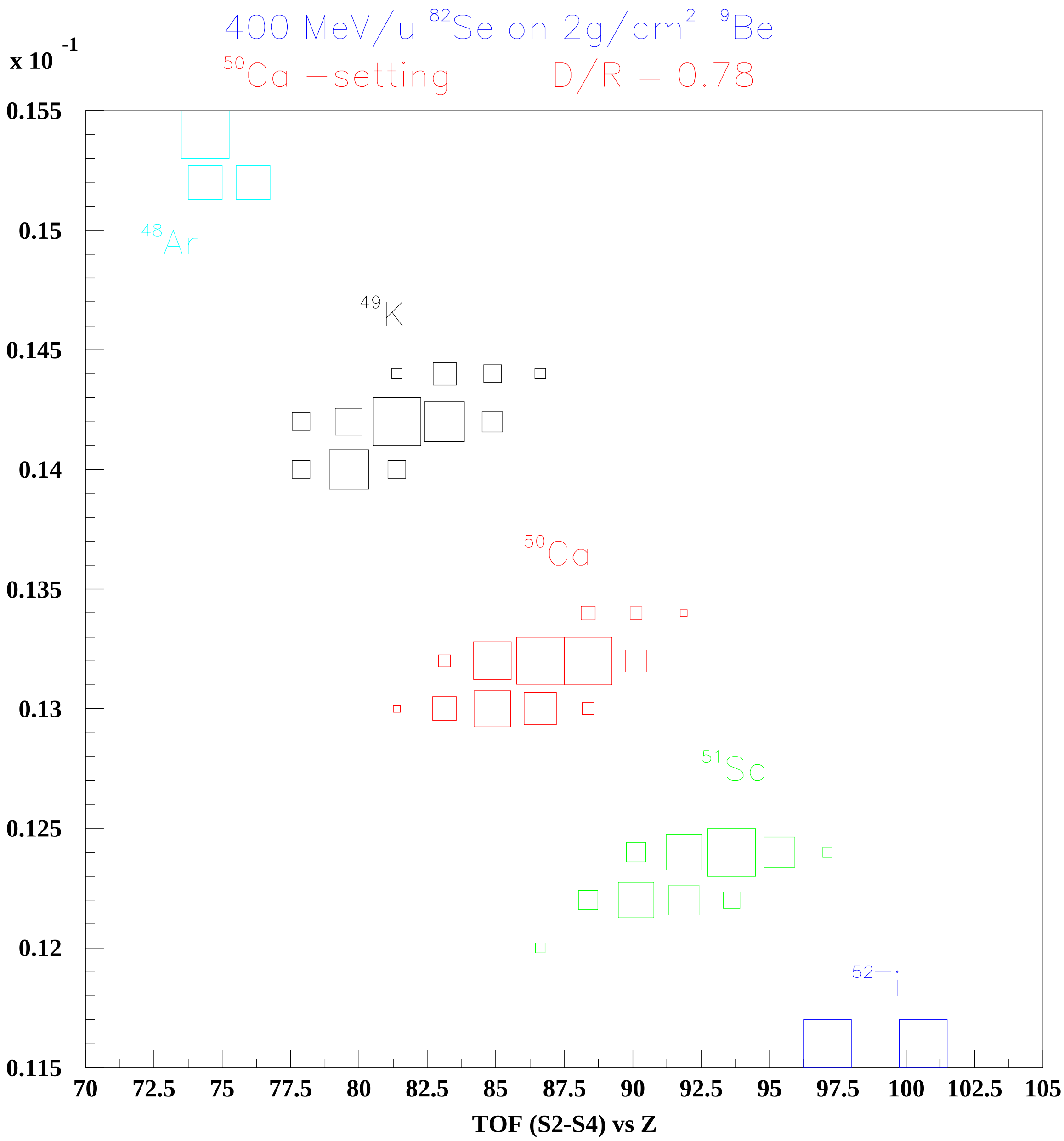
Reaction target ± 3.5cm

Yield of all fragments / incident particle before SC21: $5 \cdot 10^{-5}$ ($5\ 10^{4}$ pps)
Yield of all fragments / incident particle before MUSIC at S4: $4 \cdot 10^{-7}$ ($4\ 10^{2}$ pps)

$B\rho(D1) = 7.0840$ Tm
$B\rho(D2) = 7.0888$ Tm
$B\rho(D3) = 4.2318$ Tm
$B\rho(D4) = 4.2313$ Tm



400 MeV/u 82Se on 2g/cm2 9Be
50Ca -setting D/R = 0.78
x 10 -7
0.6
0.5
0.4
0.3
0.2
0.1
0
Yield
51Sc
52Ti
50Ca
49K
-10
-8
-6
-4
-2
0
2
4
6
8
10
X-Position (S4)



400 MeV/u 82Se on 2g/cm2 9Be
50Ca –setting D/R = 0.78
x 10 -1
0.155
0.15
0.145
0.14
0.135
0.13
0.125
0.12
0.115
48Ar
49K
50Ca
51Sc
52Ti
70
72.5
75
77.5
80
82.5
85
87.5
90
92.5
95
97.5
100
102.5
105
TOF (S2-S4) vs Z

Experiment #4

H. Grawe et al.:
Relativistic Coulex in N=28-34 and N=40-50 nuclei

Nucleus of interest: ^{66}Fe

Primary beam:	^{82}Se	10^9 pps	400 MeV/u	
Production target:	^{9}Be	2 g/cm^2		d/R=0.3

First step $^{82}Se \rightarrow {}^{66}Fe$:

Secondary beam: ^{66}Fe	331 MeV/u	
Yield of ^{66}Fe / incident particle		$3 \cdot 10^{-7}$ ($3.0\ 10^{-3}$ mb)
Charge states after production target:		fully stripped

Al degrader at S1:	-	-	
Al degrader at S2:	5000 mg/cm^2	154 MeV/u	d/R=0.70
Charge states after degraders:		fully stripped	

Energy at reaction target (S4):	130 MeV/u
Charge states at reaction target (S4):	fully stripped

Slits:
S1 ± 10cm (open)
S2 ± 10cm (open)
S3 ± 10cm (open)

Transmission of ^{66}Fe:		Yield / incident particle:
At S1 after slits:	94 %	$3.0 \cdot 10^{-7}$
At S2 after slits:	47 %	$1.5 \cdot 10^{-7}$
At reaction target:($\sigma_x(^{66}Fe)$ = 1.7 cm)	34 %	$1.1 \cdot 10^{-7}$

Yield of ^{66}Fe at S4 / all fragments: 0.23

Yield of ^{66}Fe at S4/ incident particle	$1.1 \cdot 10^{-7}$ (110 pps)

Second step $^{66}Fe \rightarrow {}^{66}Fe(2^+)$:

Reaction target at S4:	^{208}Pb	1000 mg/cm^2	d/R= 0.4

Energy of ^{50}Ca behind the reaction target: 96 MeV/u

Yield of $^{66}Fe(2^+)$ behind the reaction target / incident ^{66}Fe: $1.7 \cdot 10^{-3}$ (580 mb, 0.19 pps)
Yield of ^{66}Fe / isotopes of Fe (products of ^{66}Fe+^{208}Pb reaction): 0.55

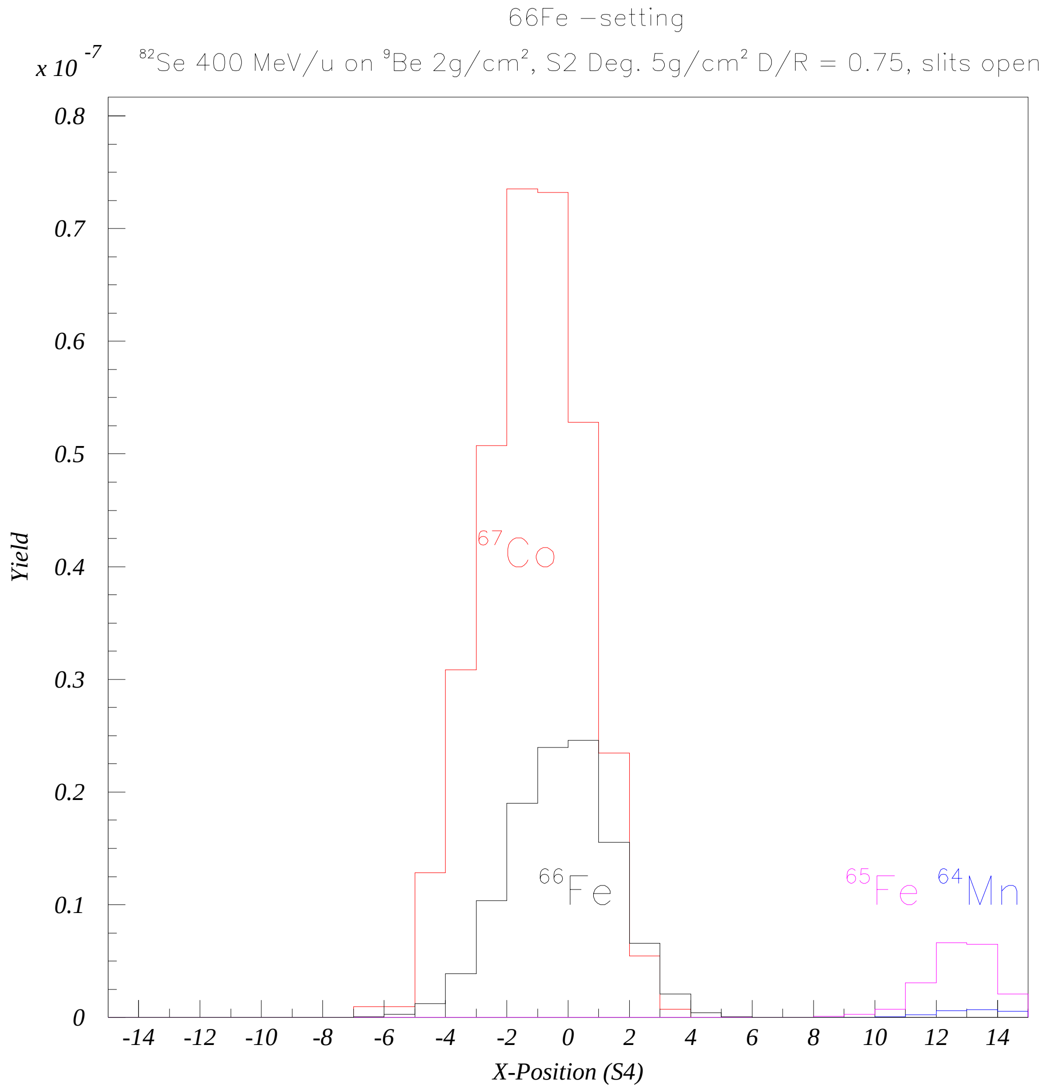
Estimated pγ rate for ^{66}Fe (3% γ efficiency): 21 /h

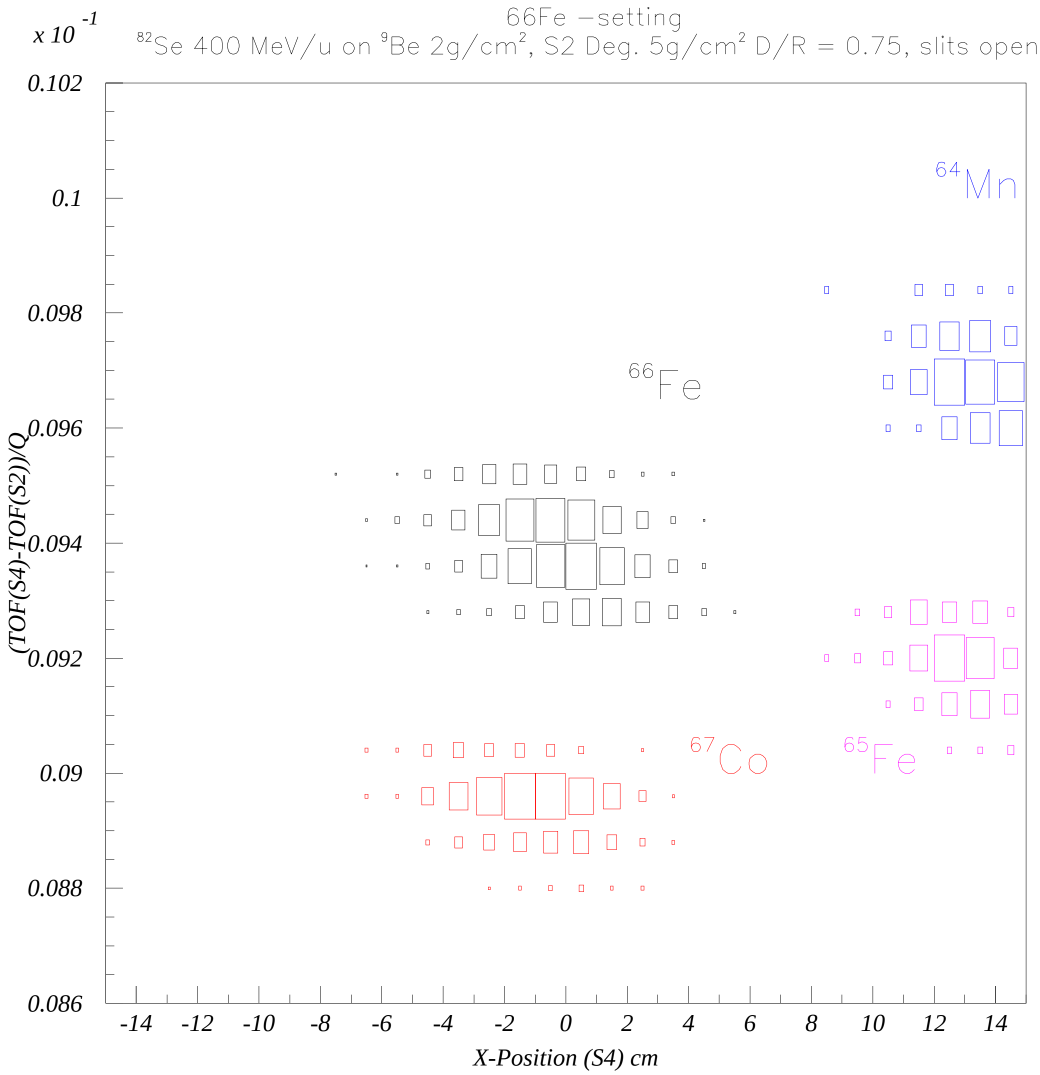
Some additional information for FRS setting

Reaction target ± 3.5cm

	Yield / incident particle	
Yield of all fragments before SC21:	$4 \cdot 10^{-5}$	(4×10^{4} pps)
Yield of all fragments before MUSIC at S4:	$4 \cdot 10^{-7}$	(4×10^{2} pps)

Bρ(D1) = 7.2085 Tm
Bρ(D2) = 7.2098 Tm
Bρ(D3) = 4.7232 Tm
Bρ(D4) = 4.7248
Tm




66Fe –setting
^{82}Se 400 MeV/u on ^{9}Be 2g/cm^{2}, S2 Deg. 5g/cm^{2} D/R = 0.75, slits open
x 10 $^{-1}$
(TOF(S4)-TOF(S2))/Q
X-Position (S4) cm
^{64}Mn
^{66}Fe
^{67}Co
^{65}Fe
0.102
0.1
0.098
0.096
0.094
0.092
0.09
0.088
0.086
-14
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
14

Experiment #4

H. Grawe et al.:

Relativistic Coulex in N=28-34 and N=40-50 nuclei

Nucleus of interest:	^{82}Ge			
Primary beam:	^{86}Kr	10^9 pps	450 MeV/u	
Production target:	^{9}Be	2 g/cm^2		d/R=0.25

First step ^{86}Kr→ ^{82}Ge:

Secondary beam: ^{82}Ge 380 MeV/u

Yield of ^{82}Ge / incident particle $1 \cdot 10^{-7}$ (1 10^{-3} mb)

Charge states after production target: fully stripped

Al degrader at S1:	-	-	} d/R= 0.73
Al degrader at S2:	5375 mg/cm^2	162 MeV/u	
Charge states after degraders:		fully stripped	

Energy at reaction target (S4): 133 MeV/u

Charge states at reaction target (S4): fully stripped

Slits:

S1 ± 10cm (open)

S2 ± 10cm (open)

S3 ± 10cm (open)

Transmission of ^{82}Ge:		Yield / incident particle:
At S1 after slits:	100 %	$1.0 \cdot 10^{-7}$
At S2 after slits:	68 %	$7.2 \cdot 10^{-8}$
At reaction target:(σ_x(^{82}Ge) = 1.6 cm)	59 %	$6.2 \cdot 10^{-8}$

Yield of ^{82}Ge at S4 / all fragments: 0.15

Yield of ^{82}Ge at S4/ incident particle	$6.2 \cdot 10^{-8}$	(62 pps)

Second step ^{82}Ge → ^{82}Ge(2$^+$):

Reaction target at S4: ^{208}Pb 200 mg/cm^2 d/R= 0.44

Energy of ^{82}Ge behind the reaction target: 91 MeV/u

Yield of ^{82}Ge(2$^+$) / incident ^{82}Ge: $8 \cdot 10^{-4}$ (290 mb, 0.05 pps)

Yield of ^{82}Ge(2$^+$) / isotopes of Ge (products of ^{82}Ge+^{208}Pb reaction): 0.38

Estimated pγ rate for ^{82}Ge(2$^+$) (3% γ efficiency at 1.3 MeV): 5 /h

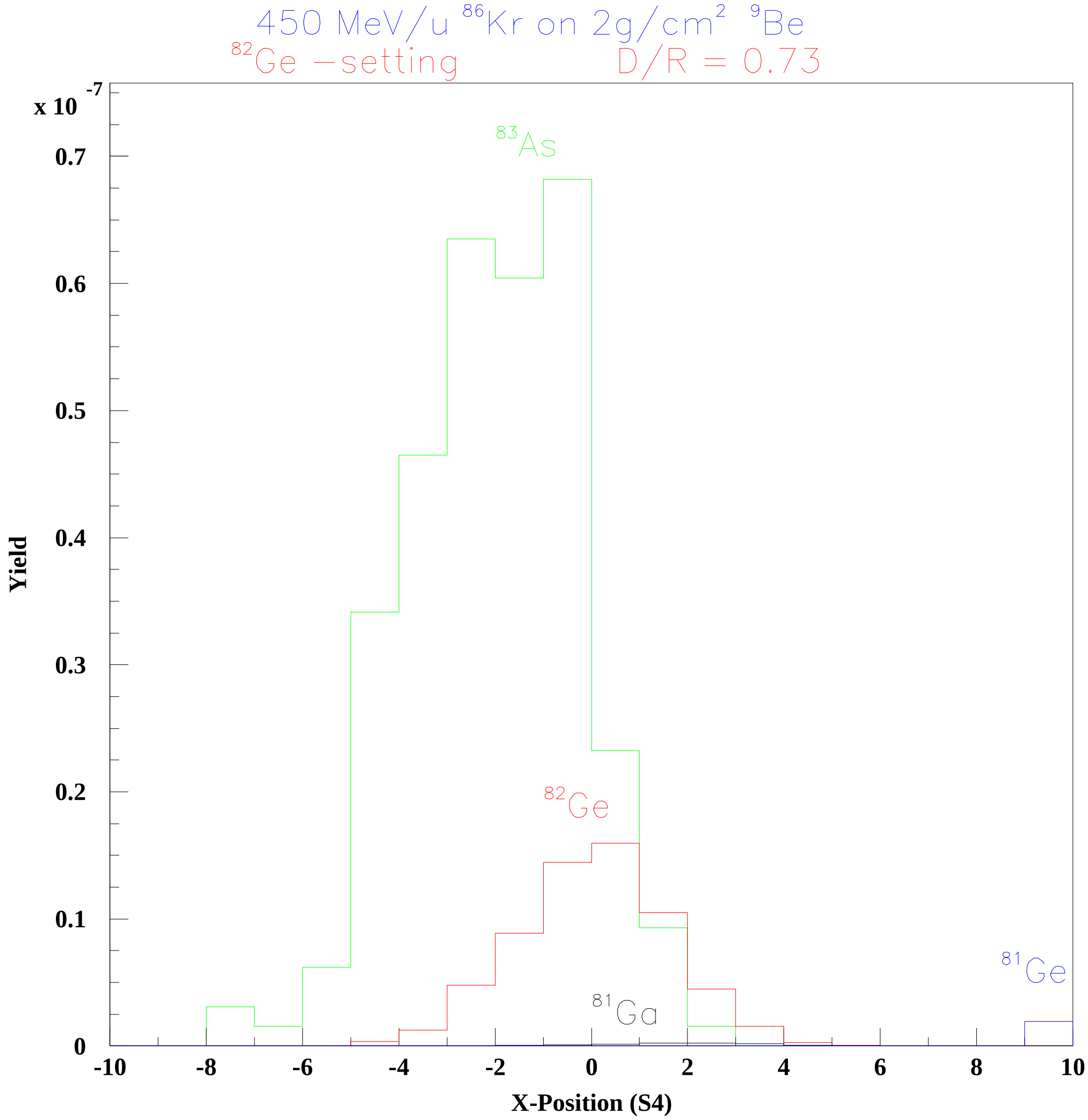
Some additional information for FRS setting

Slits:
S1 ± 10cm
S2 ± 10cm
S3 ± 10cm

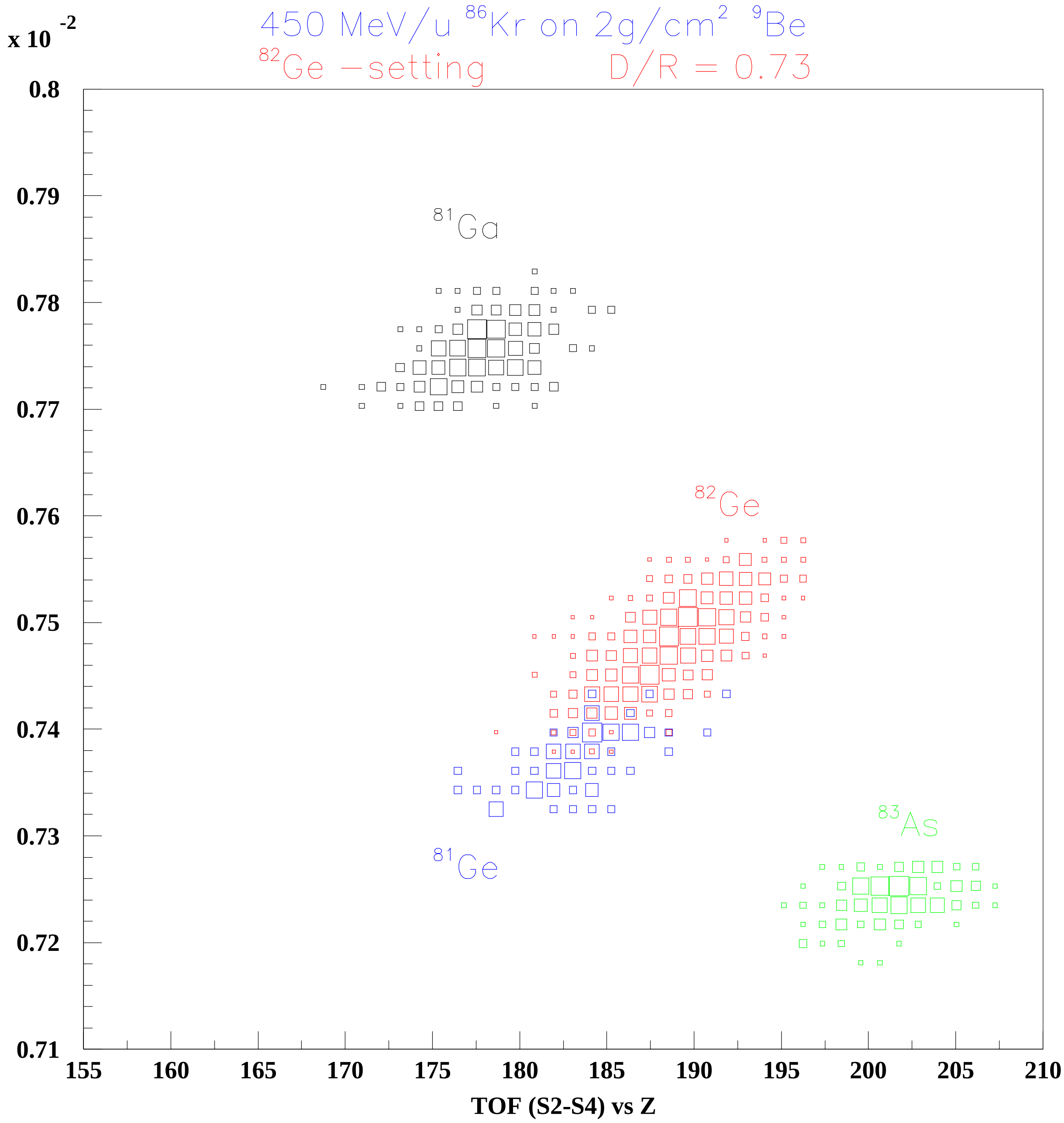
Reaction target ± 3.5cm

Yield of all fragments / incident particle before SC21: $5 \cdot 10^{-6}$ ($5\ 10^{3}$ pps)
Yield of all fragments / incident particle before MUSIC at S4: $4 \cdot 10^{-7}$ ($4\ 10^{2}$ pps)

Bρ(D1) = 7.8910 Tm
Bρ(D2) = 7.8910 Tm
Bρ(D3) = 4.9000 Tm
Bρ(D4) = 4.9000 Tm



450 MeV/u ⁸⁶Kr on 2g/cm² ⁹Be
⁸²Ge –setting
D/R = 0.73
x 10⁻⁷
Yield
⁸³As
⁸²Ge
⁸¹Ga
⁸¹Ge
X-Position (S4)



450 MeV/u ^{86}Kr on 2g/cm^2 ^{9}Be
^{82}Ge −setting D/R = 0.73
x 10^{-2}
0.8
0.79
0.78
0.77
0.76
0.75
0.74
0.73
0.72
0.71
^{81}Ga
^{82}Ge
^{83}As
^{81}Ge
155
160
165
170
175
180
185
190
195
200
205
210
TOF (S2-S4) vs Z

Experiment #5

D. Tonev et al.:

Investigation of the origin of mixed-symmetry states using relativistic COULEX of N=52 isotones

Nucleus of interest: ^{88}Kr (fission, Coulomb excitation)

Primary beam: ^{238}U 10^9 pps 750 MeV/u
Production target: ^{9}Be 1416 mg/cm^2 d/R=0.2

First step ^{238}U → ^{88}Kr:
Secondary beam: ^{88}Kr 744 MeV/u
Yield of ^{88}Kr / incident ^{238}U: $2.1 \cdot 10^{-3}$ (26 mb)
Charge states after production target: fully stripped

Al degrader at S1: 7500 mg/cm^2 } d/R= 0.9
Al degrader at S2: 8000 mg/cm^2 173 MeV/u
Charge states after degraders: fully stripped

Energy at reaction target (S4): 140 MeV/u
Charge states at reaction target (S4): fully stripped

Slits:
S1 ± 10cm (open)
S2 ± 10cm (open)
S3 ± 10cm (open)

Transmission of ^{88}Kr:		Yield / incident particle:
At S1 after degrader:	3.8 %	$8.0 \cdot 10^{-5}$
At S2 after degrader:	0.39 %	$8.2 \cdot 10^{-6}$
Total at S4: (σ_x(^{88}Kr) = 2.1 cm)	0.27 %	$5.7 \cdot 10^{-6}$

Yield of ^{88}Kr at S4 / all fragments: 0.36

Yield of ^{88}Kr at S4/ incident ^{238}U: $5.7 \cdot 10^{-6}$ (5700 pps)

Second step ^{88}Kr → ^{88}Kr(2^+):

Reaction target at S4: ^{208}Pb 400 mg/cm^2 d/R= 0.2

Energy of ^{88}Kr behind the reaction target: 122 MeV/u

Yield of ^{88}Kr(2^+_1) / incident ^{88}Kr: $3.2 \cdot 10^{-4}$ (200 mb, 1.8 pps)
Yield of ^{88}Kr(2^+_2) / incident ^{88}Kr: $8.0 \cdot 10^{-5}$ (50 mb, 0.46 pps)

Estimated pγ rate (3% γ efficiency): for ^{88}Kr(2^+_1) 194 per hour
for ^{88}Kr(2^+_2) 50 per hour

Some additional information

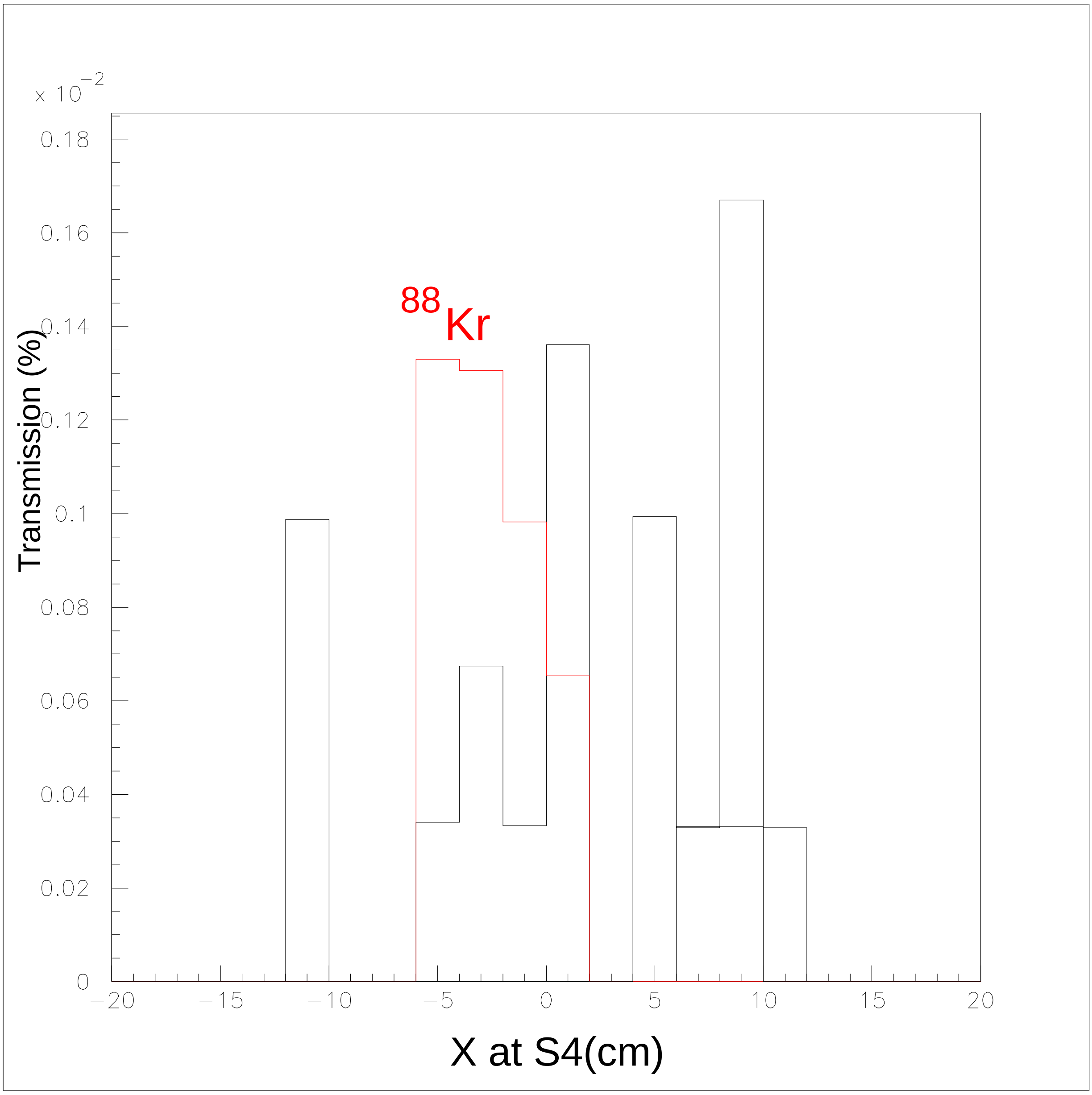
The fission cross section for ^{86}Se is 0.910 mb compared to 26 mb for ^{88}Kr.

Slits:
S1 ± 10cm
S2 ± 10cm
S3 ± 10cm

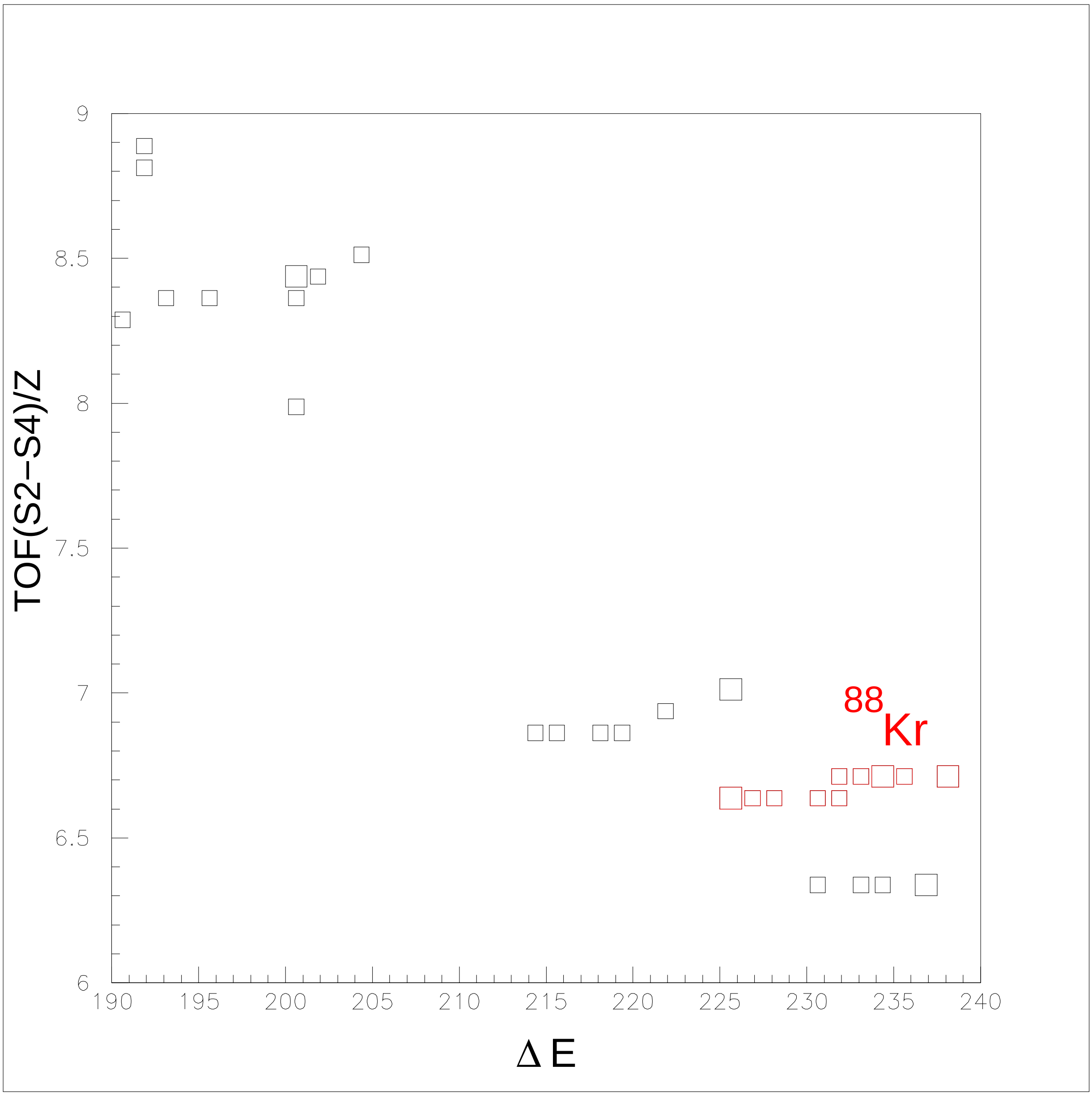
Reaction target ± 3.5cm

Yield of all fragments / incident ^{238}U after S1 degrader: $6.1 \cdot 10^{-3}$ ($6.1 \cdot 10^{6}$ pps)
Yield of all fragments / incident ^{238}U before SC21: $8.8 \cdot 10^{-4}$ ($8.8 \cdot 10^{5}$ pps)
Yield of all fragments / incident ^{238}U before MUSIC at S4: $2.6 \cdot 10^{-5}$ ($2.6 \cdot 10^{4}$ pps)
Yield of all fragments / incident ^{238}U behind the reaction target: $2.5 \cdot 10^{-5}$ ($2.5 \cdot 10^{4}$ pps)

Bρ(D1) = 10.648 Tm
Bρ(D2) = 8.9225 Tm
Bρ(D3) = 4.8265 Tm
Bρ(D4) = 4.8251 Tm



× 10⁻²
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Transmission (%)
88Kr
−20
−15
−10
−5
0
5
10
15
20
X at S4(cm)



TOF(S2−S4)/Z
ΔE
88Kr
9
8.5
8
7.5
7
6.5
6
190
195
200
205
210
215
220
225
230
235
240

Experiment #6

C. Fahlander et al.:
Relativistic Coulomb excitation of nuclei near ^{100}Sn

Nucleus of interest: ^{104}Sn

Primary beam:	^{124}Xe	10^9 pps	550 MeV/u	
Production target:	^{9}Be	4 g/cm^2		d/R=0.56

First step ^{124}Xe→ ^{104}Sn:

Secondary beam:	^{104}Sn	309 MeV/u	
Yield of ^{104}Sn / incident particle			$6.8\cdot 10^{-7}$ (4.5 10^{-3} mb)
Charge states after production target:		fully stripped	

Al degrader at S1:	-	-	} d/R= 0.55
Al degrader at S2:	1560 mg/cm^2	155 MeV/u	
Charge states after degraders:		fully stripped	

Energy at reaction target (S4):	95 MeV/u
Charge states at reaction target (S4):	fully stripped

Slits:
S1 ± 3cm
S2 ± 10cm (open)
S3 (-2;2.5)

Transmission of ^{104}Sn:		Yield / incident particle:
At S1 after slits:	87 %	$6.0 \cdot 10^{-7}$
At S2 after slits:	73 %	$5.0 \cdot 10^{-7}$
At reaction target:(σ_x(^{104}Sn) = 1.7 cm)	55 %	$3.7 \cdot 10^{-7}$

Yield of ^{104}Sn at S4 / all fragments: 0.06

Yield of ^{104}Sn at S4/ incident particle	$3.7 \cdot 10^{-7}$	(370 pps)

Second step ^{104}Sn → ^{104}Sn(2^+):

Reaction target at S4: ^{208}Pb 200 mg/cm^2 d/R= 0.26

Energy of ^{104}Sn behind the reaction target: 77 MeV/u

Yield of ^{104}Sn(2^+) / incident ^{104}Sn: $8 \cdot 10^{-5}$ (200 mb, 0.03 pps)
Yield of ^{104}Sn(2^+) / isotopes of Sn (products of ^{104}Sn+^{208}Pb reaction): 0.92

Estimated pγ rate for ^{104}Sn(2^+) (3% γ efficiency at 1.3 MeV): 3 /h

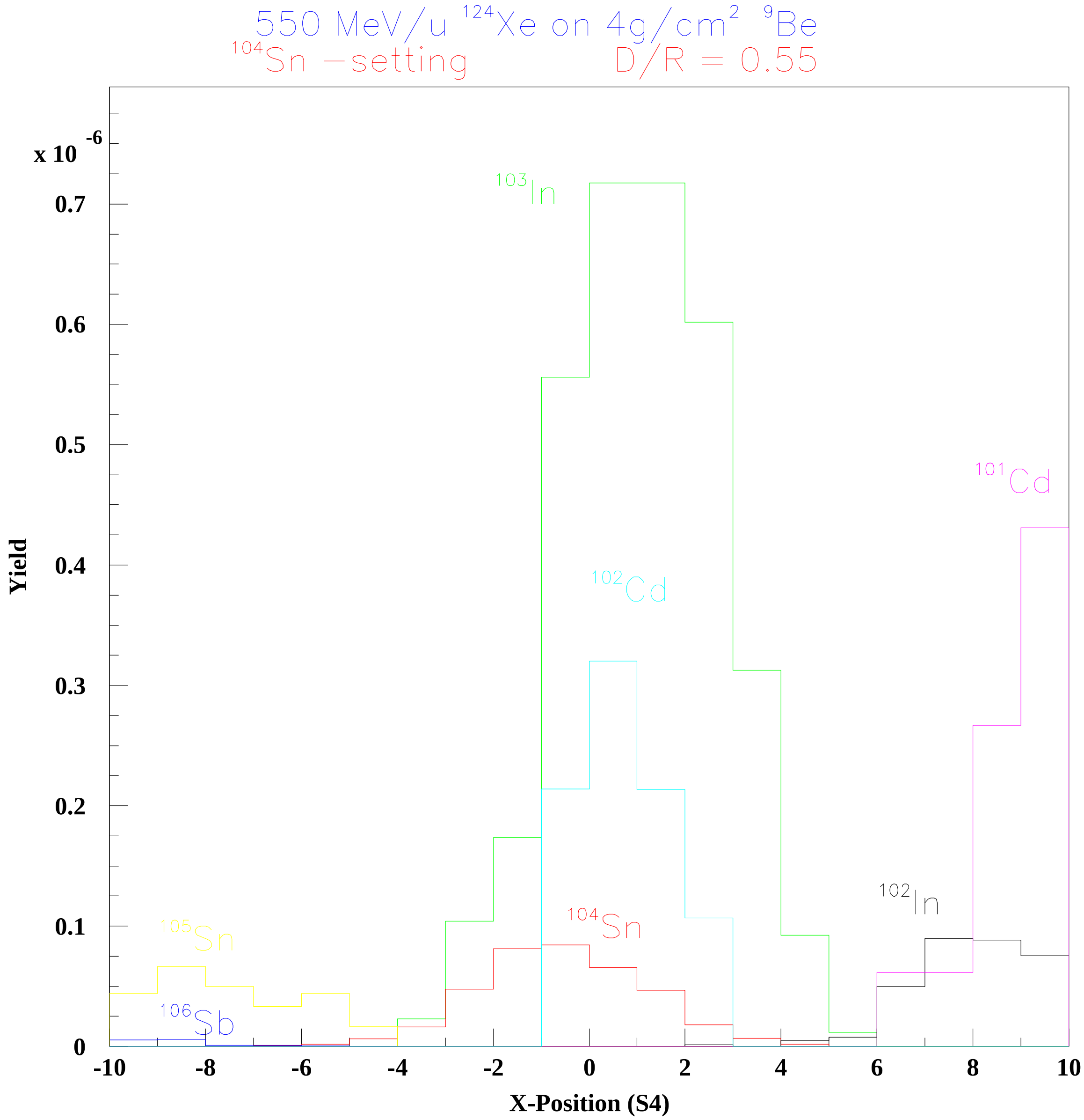
Some additional information for FRS setting

Slits:
S1 ± 3 cm
S2 ± 10 cm
S3 (-2;2.5) cm

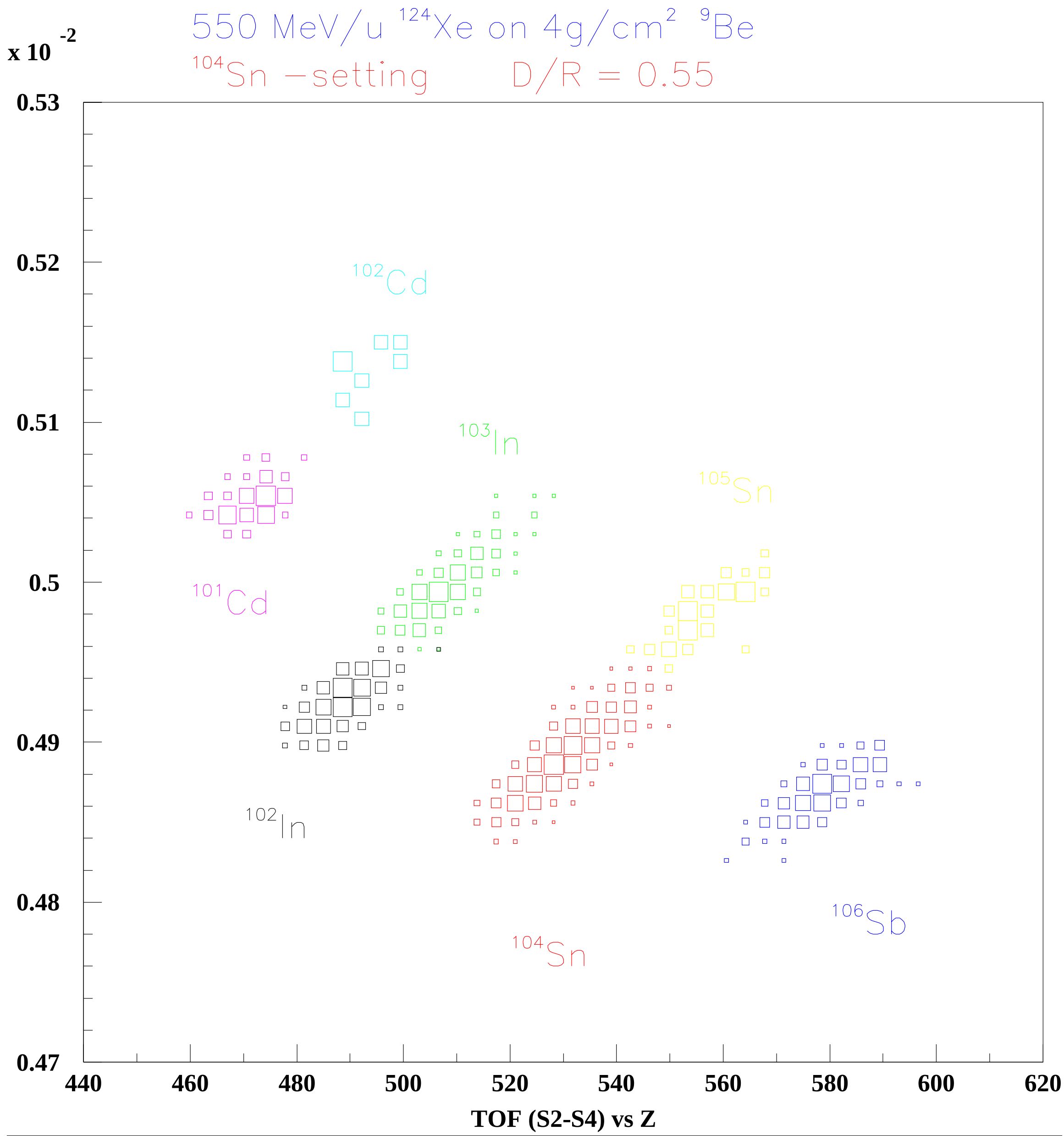
Reaction target ± 3.5cm

Yield of all fragments / incident particle before SC21:	$1.5 \cdot 10^{-4}$ ($1.5\ 10^{5}$ pps)
Yield of all fragments / incident particle before MUSIC at S4:	$6.4 \cdot 10^{-6}$ ($6.4\ 10^{3}$ pps)
Yield with slits open (all frag./ip before SC21):	$1.7 \cdot 10^{-4}$ ($1.7 \cdot 10^{5}$)
Yield with slits open (all frag./ip before MUSIC at S4):	$1.2 \cdot 10^{-5}$ ($1.2 \cdot 10^{4}$)
Transmission of ^{104}Sn with open slits:	63%

Bρ(D1) = 5.6856 Tm
Bρ(D2) = 5.6875 Tm
Bρ(D3) = 3.8845 Tm
Bρ(D4) = 3.8842 Tm



550 MeV/u 124Xe on 4g/cm2 9Be
104Sn –setting D/R = 0.55
x 10 -6
Yield
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
103In
102Cd
101Cd
102In
104Sn
105Sn
106Sb
-10
-8
-6
-4
-2
0
2
4
6
8
10
X-Position (S4)



550 MeV/u 124Xe on 4g/cm2 9Be
104Sn –setting D/R = 0.55
x 10 -2
0.53
0.52
0.51
0.5
0.49
0.48
0.47
102Cd
103In
105Sn
101Cd
102In
106Sb
104Sn
440
460
480
500
520
540
560
580
600
620
TOF (S2-S4) vs Z

Experiment #6

C. Fahlander et al.:
Relativistic Coulomb excitation of nuclei near ^{100}Sn

Nucleus of interest: ^{108}Sn

Primary beam: ^{124}Xe 10^9 pps 600 MeV/u
Production target: ^{9}Be 4 g/cm^2 d/R=0.5

First step ^{124}Xe→ ^{108}Sn:
Secondary beam: ^{108}Sn 377 MeV/u
Yield of ^{108}Sn / incident particle 5.0 10^{-4} (3 mb)
Charge states after production target: fully stripped

Al degrader at S1: 1770 mg/cm^2 263 MeV/u
Al degrader at S2: 930 mg/cm^2 158 MeV/u } d/R= 0.67
Charge states after degraders: fully stripped

Energy at reaction target (S4): 101 MeV/u
Charge states at reaction target (S4): fully stripped

Slits:
S1 ± 0.4 cm
S2 ± 3.0 cm
S3 ± 10 cm (open)

Transmission of ^{108}Sn:		Yield / incident particle:
At S1 after slits:	24 %	$1.2 \cdot 10^{-4}$
At S2 after slits:	9 %	$4.4 \cdot 10^{-5}$
At reaction target:(σ_x(^{108}Sn) = 1.7 cm)	8 %	$4.0 \cdot 10^{-5}$

Yield of ^{108}Sn at S4 / all fragments: 0.57

Yield of ^{108}Sn at S4/ incident particle	$4.0 \cdot 10^{-5}$	(4 10^4 pps)

Second step ^{108}Sn → ^{108}Sn(2^+):

Reaction target at S4: ^{208}Pb 200 mg/cm^2 d/R= 0.23

Energy of ^{108}Sn behind the reaction target: 85 MeV/u

Yield of ^{108}Sn(2^+) / incident ^{108}Sn: $1 \cdot 10^{-4}$ (200 mb, 4.6 pps)
Yield of ^{108}Sn(2^+) / isotopes of Sn (products of ^{108}Sn+^{208}Pb reaction): 0.87

Estimated pγ rate for ^{108}Sn(2^+) (3% γ efficiency at 1.3 MeV): 490 /h

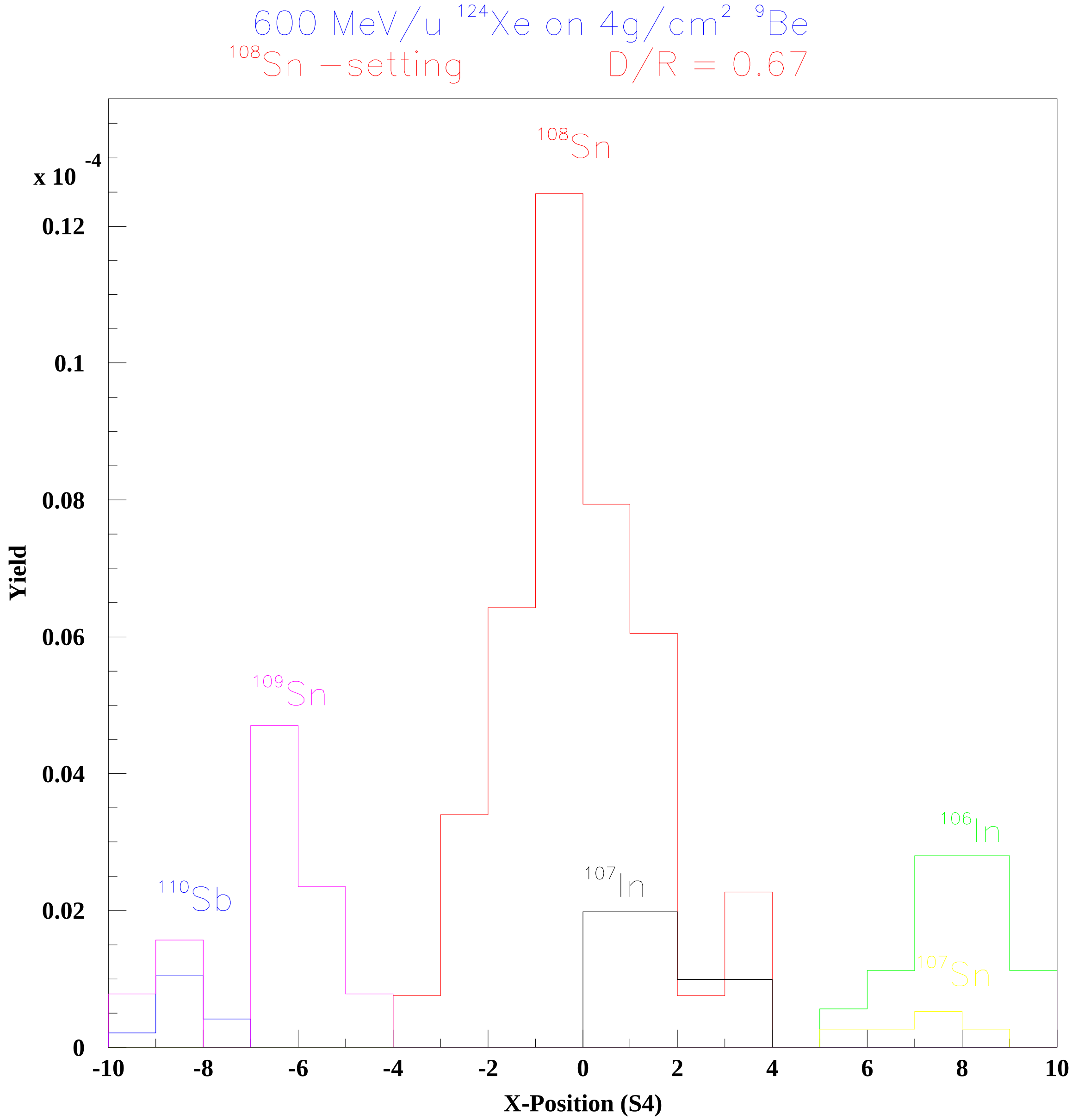
Some additional information for FRS setting

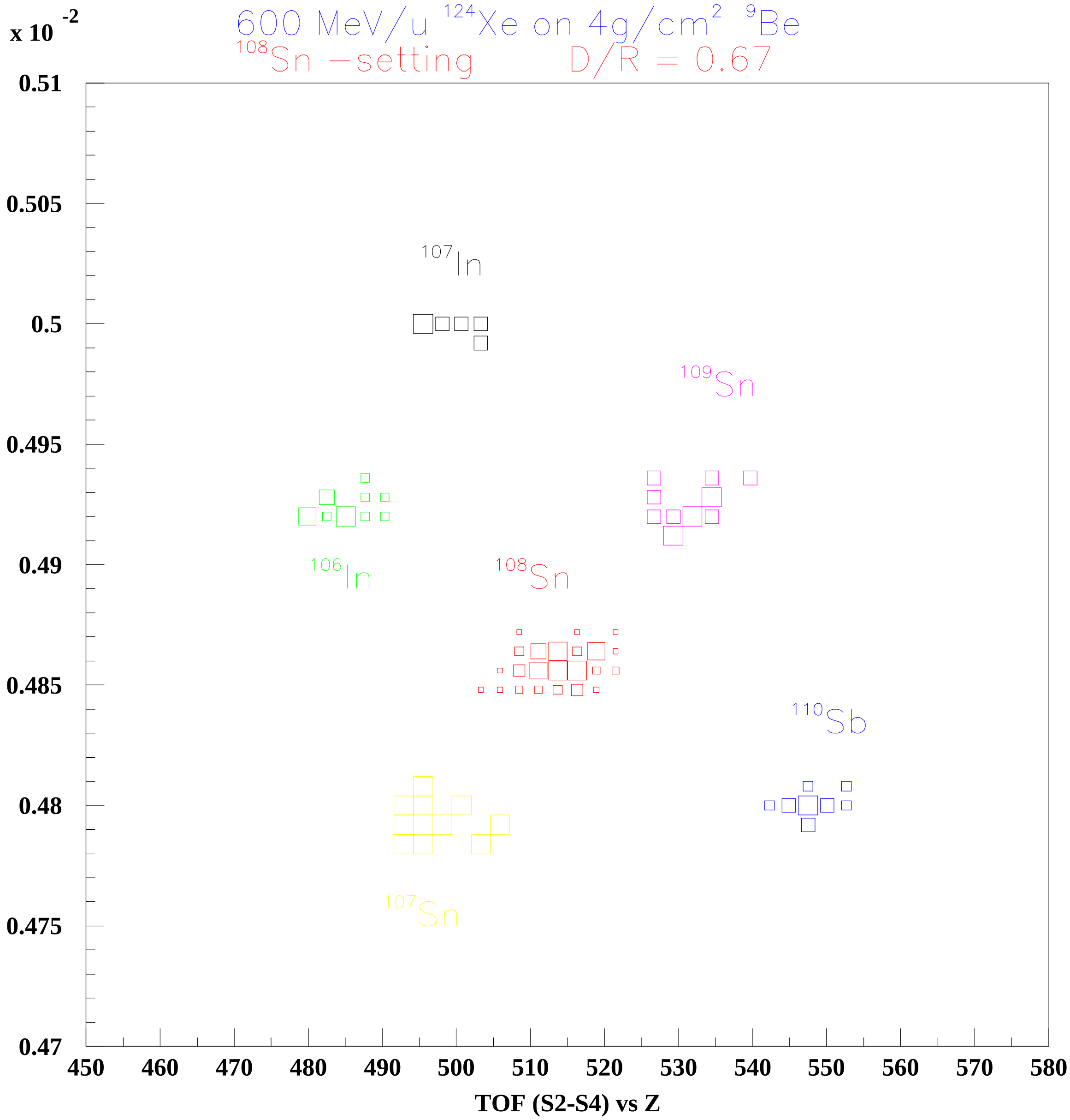
Slits:
S1 ± 0.4 cm
S2 ± 3.0 cm
S3 ± 10 cm (open)

Reaction target ± 3.5cm

Yield of all fragments / incident particle before SC21:	$5 \cdot 10^{-4}$ ($5\ 10^{5}$ pps)
Yield of all fragments / incident particle before MUSIC at S4:	$7 \cdot 10^{-5}$ ($7\ 10^{4}$ pps)
Yield with slits open (all frag./ip before SC21):	$6 \cdot 10^{-3}$ ($6 \cdot 10^{6}$)
Yield with slits open (all frag./ip before MUSIC at S4):	10^{-3} (10^{6})
Transmission of ^{108}Sn with open slits:	40%

Bρ(D1) = 6.6177 Tm
Bρ(D2) = 5.3945 Tm
Bρ(D3) = 4.0742 Tm
Bρ(D4) = 4.0742 Tm


600 MeV/u 124Xe on 4g/cm2 9Be
108Sn –setting
D/R = 0.67
x 10 -4
0.12
0.1
0.08
0.06
0.04
0.02
0
Yield
108Sn
109Sn
110Sb
107In
106In
107Sn
-10
-8
-6
-4
-2
0
2
4
6
8
10
X-Position (S4)



600 MeV/u ^{124}Xe on 4g/cm^2 ^{9}Be
^{108}Sn −setting D/R = 0.67
x 10 -2
^{107}In
^{109}Sn
^{106}In
^{108}Sn
^{110}Sb
^{107}Sn
0.51
0.505
0.5
0.495
0.49
0.485
0.48
0.475
0.47
450 460 470 480 490 500 510 520 530 540 550 560 570 580
TOF (S2-S4) vs Z

Experiment No. 7

G. de Angelis et al.

Nuclear magicity at Z ∼ 50 N ∼ 82 investigated through knock-out reaction of ^{132}Sn

Nucleus of interest:	^{132}Sn (Fission fragment, knock-out)			
Primary beam :	^{238}U	10^8 pps	700 MeV/u	
Production target:	^{208}Pb	1.5 g/cm^2		$\frac{d}{R_t} = 0.15$

First stage $^{238}U \rightarrow {}^{132}Sn$:

Secondary beam:	^{132}Sn		596.5 MeV/u	
Yield of ^{132}Sn/incident ^{238}U		$6.8 \cdot 10^{-5}$		15.4 mb (lit.)
Charge states after prod. target			fully stripped	
Al degrader at S1				
Al degrader at S2		6183.9 mg/cm^2	300.5 MeV/u	$\frac{d}{R} = 0.65$
Charge states after degrader			fully stripped	
Energy at reaction target (S4)			270.9 MeV/u	
Charge states at target			fully stripped	

Slits :
S1 = ± 2 cm
S2 = ± 3 cm
S3 = ± 10 cm

Transmission of ^{132}Sn:		Yield/incident particle:
At S1, after slits	5.9 %	$4.2 \cdot 10^{-6}$
At S2, after slits	1.6 %	$1.1 \cdot 10^{-6}$
At reaction target($\sigma_x(^{132}Sn) = 0.92$ cm)	1.2 %	$8.8 \cdot 10^{-7}$

Yield of ^{132}Sn at S4/all fragments: 0.05 (transmission only)

Yield of ^{132}Sn at S4/incident ^{238}U	$8.8 \cdot 10^{-7}$	($8.8 \cdot 10^1$ pps)

Second stage $^{132}Sn \rightarrow {}^{131}Sn^{\star}$:

Reaction target at S4	^{9}Be	1 g/cm^2	270.8 MeV/u	$\frac{d}{R} = 0.34$
Energy of ^{131}Sn behind the reaction target:			264.8 MeV/u	
Yield of ^{131}Sn/incident ^{132}Sn		$6.7 \cdot 10^{-3}$		100 mb, 0.59 pps
Yield of $^{131}Sn^{\star}$(l=2, $3s_{\frac{1}{2}}$)/incident ^{132}Sn		$6.0 \cdot 10^{-4}$		9 mb, 0.05 pps

Estimated pγ rate for ^{131}Sn (2.7 % γ eff. at 1.3 MeV)) : 57 hr.$^{-1}$

Estimated pγ rate for ^{131}Sn (l=2, $3s_{\frac{1}{2}}$) (2.7 % γ eff. at 1.3 MeV)) : 10 hr.$^{-1}$

Some additional information for FRS setting

Slits :
S1 = $\pm$ 2.0 cm
S2 = $\pm$ 3.0 cm
S3 = $\pm$10.0 cm

Reaction target = $\pm$ 3.5 cm (max.)

Yield of all fragments / incident particle before SC21 : $5.1 \cdot 10^{-4}$ ($5.1 \cdot 10^{6}$)
Yield of all fragments / incident particle before MUSIC at S4 : $1.0 \cdot 10^{-5}$ ($1.0 \cdot 10^{5}$)

$B\rho$(D1) = 10.6867 Tm
$B\rho$(D2) = 10.6839 Tm
$B\rho$(D3) = 7.0973 Tm
$B\rho$(D4) = 7.0974 Tm

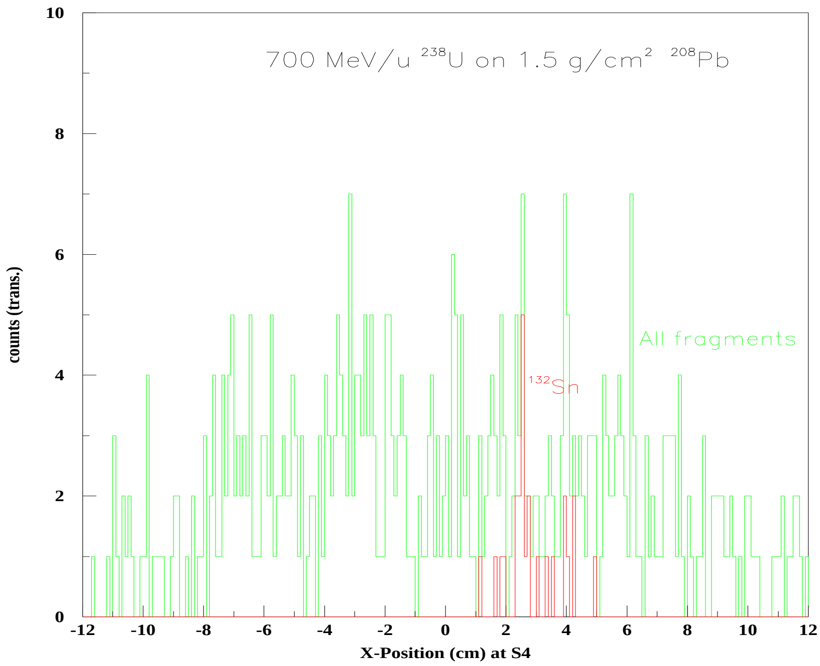


Figure 1: Position spectrum at S4 for ^{132}Sn setting (only transmission).

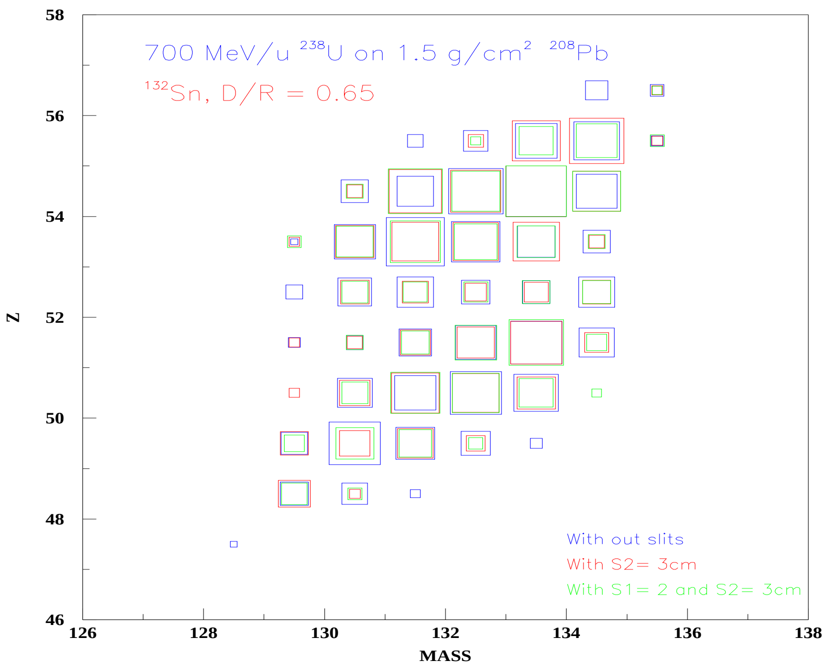


Figure 2: Mass vs z plot for ^{132}Sn setting (only transmission).

Experiment No. 8

A. Maj et al.

Coulomb excitation at intermediate energies -Angular distribution and particle - γ angular correlation measurement

Nucleus of interest:	^{132}Xe (Coulex)		
Primary beam :	^{132}Xe	10^5 pps	160 MeV/u
Production target:	None		

First stage $^{132}\mathrm{Xe} \rightarrow {}^{132}\mathrm{Xe}$:

Secondary beam:	^{132}Xe	158.8 MeV/u
Yield of ^{132}Xe/incident ^{132}Xe		
Charge states after prod. target		Not applicable
Al degrader at S1		none
Al degrader at S2		none
Charge states after degrader		not applicable
Energy at reaction target (S4)		105.3 MeV/u
Charge states after target		fully stripped

Slits :
S1 = $\pm$ 10 cm
S2 = $\pm$ 10 cm
S3 = $\pm$ 10 cm

Transmission of ^{68}Ni:			Yield/incident particle:
At S1, after slits	99.9 %		10^{-5}
At S2, after slits	99.9 %		10^{-5}
At reaction target(σ_x(^{132}Xe) = 1.1 cm)	99.5 %	$\sigma_a = 5.0$ mrad	10^{-5}
		$\sigma_E = 0.12$ MeV/u	

Yield of ^{132}Xe at S4/incident ^{132}Xe	~ 1	(10^5 pps)

Second stage $^{132}\mathrm{Xe} \rightarrow {}^{132}\mathrm{Xe}^{\star}$:

Reaction target at S4	^{208}Pb	50 mg/cm^2	105.3 MeV/u	$\frac{d}{R} = 0.05$
Energy of ^{132}Xe behind the reaction target:			97.2 MeV/u	
Yield of $^{132}\mathrm{Xe}^{\star}(2^+)$/incident ^{132}Xe		$7.2\cdot10^{-5}$		(500 mb, 7 pps)

Estimated pγ rate for ^{132}Xe (2.7 % γ eff. at 1.3 MeV) : 703 hr.$^{-1}$

Some additional information for FRS setting

Slits :
S1 = $\pm$ 10 cm
S2 = $\pm$ 10 cm
S3 = $\pm$ 10 cm

Reaction target = $\pm$ 3.5 cm (max.)

Yield of all fragments / incident particle before SC21 : 1 ($1 \cdot 10^5$)
Yield of all fragments / incident particle before MUSIC at S4 : 1($1.0 \cdot 10^5$)

$B\rho(D1) = 4.6174$ Tm
$B\rho(D2) = 4.6174$ Tm
$B\rho(D3) = 4.6174$ Tm
$B\rho(D4) = 4.6174$ Tm

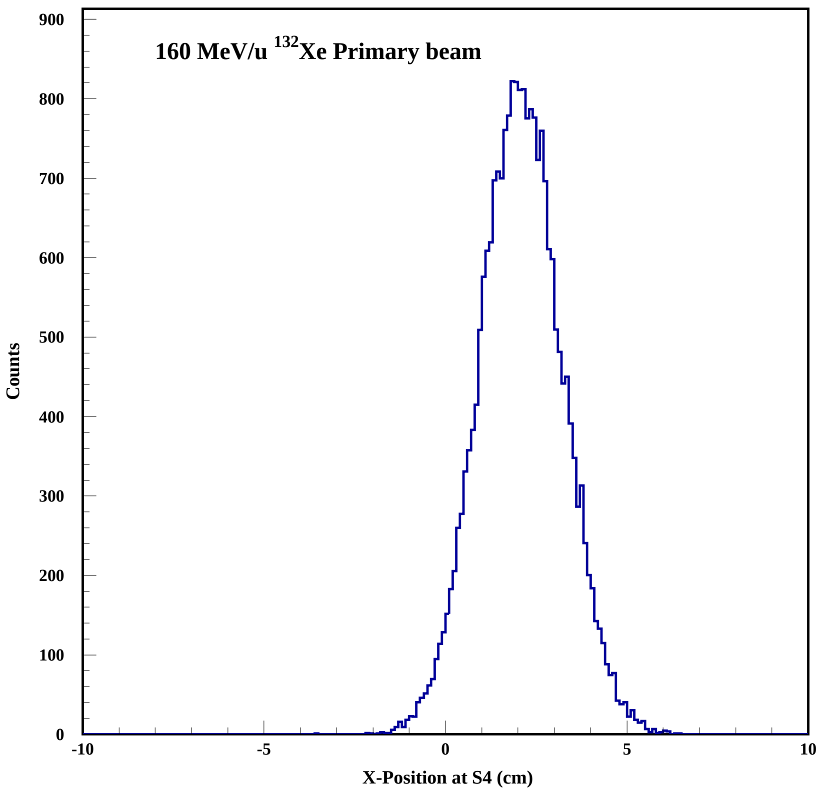


Figure 1: Position spectrum at S4 for ^{132}Xe Primary beam

Experiment No. 9

K.-H. Speidel et al.
Magnetic moments of Xenon and tellurium isotopes near doubly-magic ^{132}Sn at relativistic beam energies.

Nucleus of interest:	^{134}Te	(Coulex)		
Primary beam :	^{136}Xe	$1{\cdot}10^9$ pps	500 MeV/u	
Production target:	^{9}Be	2.5 g/cm^2		$\frac{d}{R_t} = 0.37$

First stage ^{136}Xe → ^{134}Te:

Secondary beam:	^{134}Te		370.7 MeV/u	
Yield of ^{134}Te/incident ^{136}Xe		$4.5{\cdot}10^{-5}$		0.4 mb (EPAX2)
Charge states after prod. target			fully stripped	
Al degrader at S1				
Al degrader at S2		3121.9 mg/cm^2	150.6 MeV/u	$\frac{d}{R} = 0.75$
Charge states after degrader			$Q_\circ$=0.85 Q_1=0.14	
Energy at reaction target (S4)			100.0 MeV/u	
Charge states at reaction target			$Q_\circ$=0.85	

Slits :
S1 = ± 1 cm
S2 = ± 3 cm
S3 = ±10 cm

Transmission of ^{134}Te:		Yield/incident particle:
At S1, after slits	67.8 %	$3.0{\cdot}10^{-5}$
At S2, after slits	48.2 %	$2.2{\cdot}10^{-5}$
At reaction target($\sigma_x(^{134}$Te$) = 1.5$ cm)	45.0 %	$2.0{\cdot}10^{-5}$

Yield of ^{134}Te at S4/all fragments: 0.91

Yield of ^{134}Te at S4/incident ^{136}Xe	$2.0{\cdot}10^{-5}$	($2.0{\cdot}10^4$ pps)

Second stage ^{134}Te → ^{134}Te*:

Reaction target at S4	^{208}Pb	50 mg/cm^2	100.0 MeV/u	$\frac{d}{R} = 0.05$
Energy of ^{134}Te behind the reaction target:			96.6 MeV/u	
Yield of ^{134}Te$^\star(2^+)$/incident ^{134}Te		$4.3{\cdot}10^{-5}$		300 mb, 0.9 pps

Estimated pγ rate for ^{134}Te (2^+) (3.0 % γ eff. at 1.3 MeV)) : 94 hr.$^{-1}$

Some additional information for FRS setting

Slits :
S1 = $\pm$ 1 cm
S2 = $\pm$ 3 cm
S3 = $\pm$10 cm

Reaction target = $\pm$ 3.5 cm (max.)

Yield of all fragments / incident particle before SC21 :	$7.9 \cdot 10^{-5}$ ($7.9 \cdot 10^{4}$)
Yield of all fragments / incident particle before MUSIC at S4 :	$2.8 \cdot 10^{-5}$ ($2.8 \cdot 10^{4}$)

Bρ(D1) = 7.8165 Tm
Bρ(D2) = 7.8165 Tm
Bρ(D3) = 4.7314 Tm
Bρ(D4) = 4.7314 Tm

Additional information for g-factor measurment

Ferromagnetic matiral :	Gadolinium (50 mg/cm^2)
External magnetic field :	$\sim$ 0.08 Tesla
Expected Transiant magnetic Field (TF) :	23 kTesla (p_{1s}=0.03, q_{1s}=0.5)
Expected precession angle ($\Phi^{exp}(2^+)$):	240 mrad
Count rate for both field direction (Up/Dn) :	10 hr.$^{-1}$ (1.0 % γ eff.)

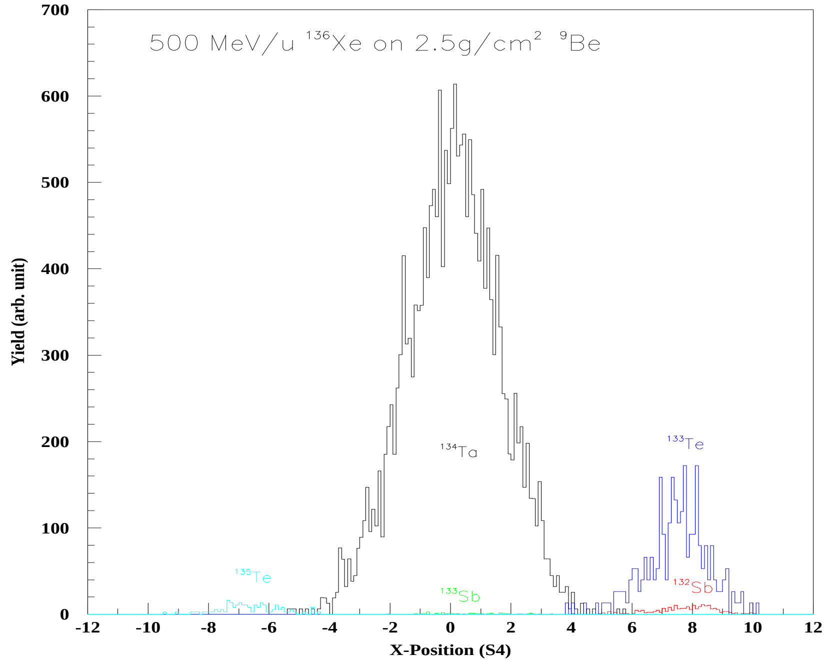


Figure 1: Position spectrum at S4 for ^{134}Te setting

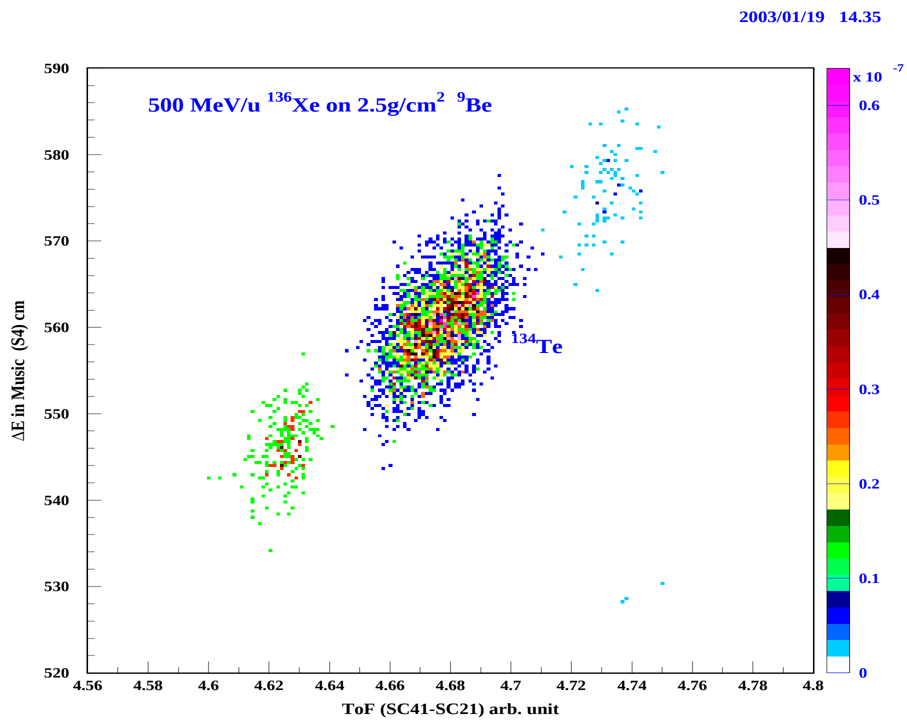


Figure 2: Time-of-flight vs energy loss in Music plot for ^{134}Te setting

Experiment No. 10

S. Mandal et al.

Search for stable octupole deformation in neutron-rich of $^{142-144}$Ba using relativistic Coulomb excitation.

Nucleus of interest:	^{142}Ba	(Coulex)		
Primary beam :	^{150}Nd	$5{\cdot}10^9$ pps	600 MeV/u	
Production target:	^{9}Be	4.0 g/cm^2		$\frac{d}{R_t} = 0.5$

First stage ^{150}Nd $\rightarrow$ ^{142}Ba:

Secondary beam:	^{142}Ba		382.9 MeV/u	
Yield of ^{142}Ba/incident ^{150}Nd		$7.7{\cdot}10^{-6}$		0.06 mb (EPAX2)
Charge states after prod. target			fully stripped	
Al degrader at S1				
Al degrader at S2		2450.0 mg/cm^2	198.0 MeV/u	$\frac{d}{R} = 0.63$
Charge states after degrader			$Q_\circ$=0.86	
			Q_1=0.13	
Energy at reaction target (S4)			153.0 MeV/u	
Charge states at reaction target			$Q_\circ$=0.86	

Slits :
S1 = -1,+2 cm
S2 = ± 3.5 cm
S3 = -2.7,+2.4 cm

Transmission of ^{142}Ba:		Yield/incident particle:
At S1, after slits	44.7 %	$3.5{\cdot}10^{-6}$
At S2, after slits	24.8 %	$1.9{\cdot}10^{-6}$
At reaction target(σ_x(^{142}Ba) = 1.1 cm)	23.4 %	$1.8{\cdot}10^{-6}$

Yield of ^{142}Ba at S4/all fragments: 0.12

Yield of ^{142}Ba at S4/incident ^{150}Nd	$1.8{\cdot}10^{-6}$	($9.0{\cdot}10^3$ pps)

Second stage ^{142}Ba $\rightarrow$ ^{142}Ba*:

Reaction target at S4	^{208}Pb	300 mg/cm^2	153.0 MeV/u	$\frac{d}{R} = 0.17$
Energy of ^{142}Ba behind the reaction target:			134.8 MeV/u	
Yield of ^{142}Ba*(3^-)/incident ^{142}Ba		$6.1{\cdot}10^{-6}$		7.0 mb, 0.06 pps

Estimated pγ rate for ^{142}Ba (3^-) (3.0 % γ eff. at 1.3 MeV)) : 6 hr.$^{-1}$

Some additional information for FRS setting

Slits :
S1 = -1,+2 cm
S2 = $\pm$ 3.5 cm
S3 = -2.7,+2.4 cm

Reaction target = $\pm$ 3.5 cm (max.)

Yield of all fragments / incident particle before SC21 : $1.4 \cdot 10^{-4}$ ($7.1 \cdot 10^{5}$)
Yield of all fragments / incident particle before MUSIC at S4 : $1.7 \cdot 10^{-5}$ ($8.7 \cdot 10^{4}$)

$B\rho$(D1) = 7.8391 Tm
$B\rho$(D2) = 7.8391 Tm
$B\rho$(D3) = 5.4024 Tm
$B\rho$(D4) = 5.4023 Tm

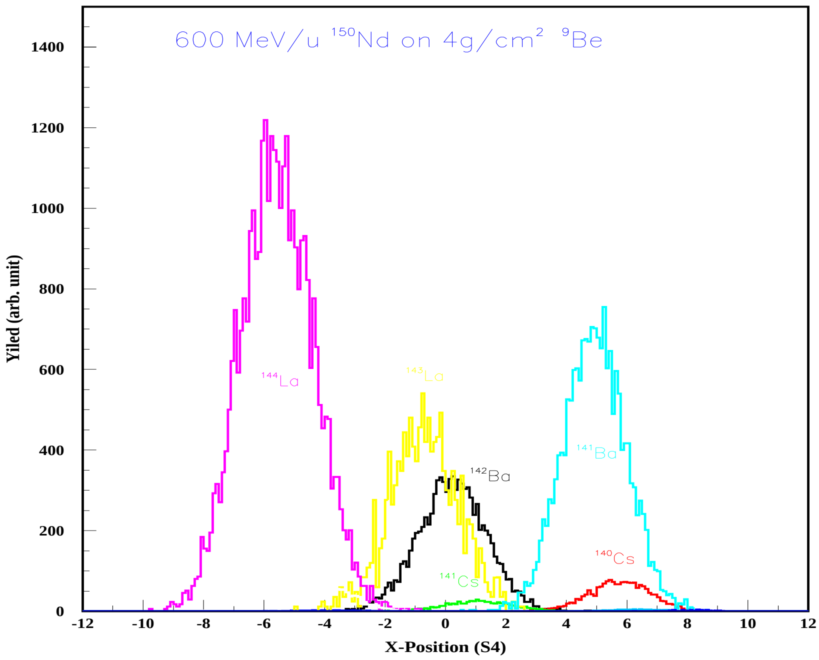


Figure 1: Position spectrum at S4 for ^{142}Ba setting

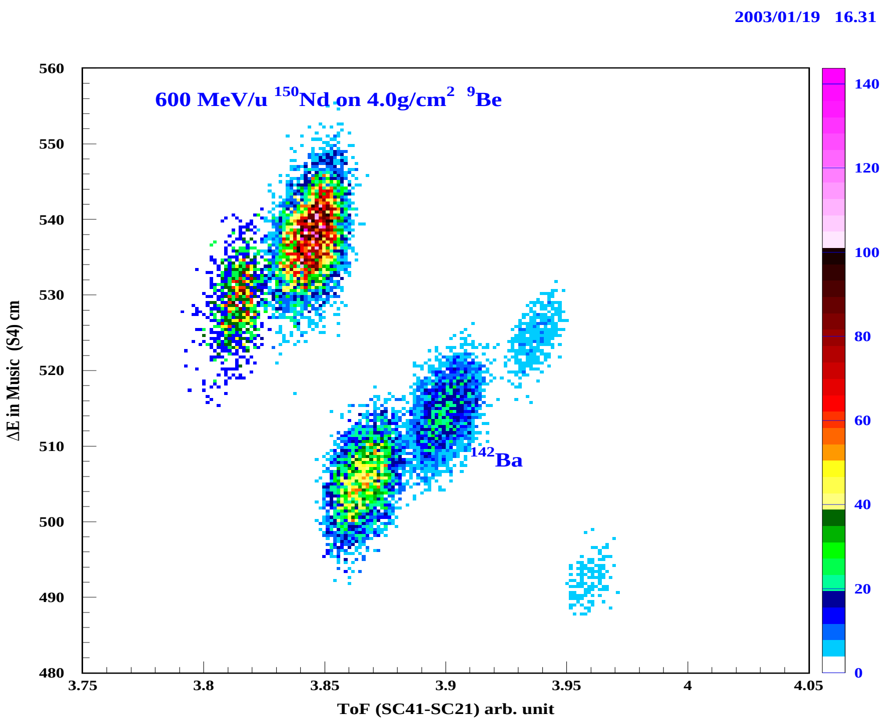


Figure 2: Time-of-flight vs energy loss in MUSIC plot for ^{142}Ba setting

Experiment #11

Zs. Podolyak, et al.:

Prompt gamma spectroscopy and isomer tagging.
Deformation of five-quasiparticle states in the A≈180 mass region

Nucleus of interest:	^{179}W			
Primary beam:	^{208}Pb	10^8 pps	1GeV/u	
Production target:	^{9}Be	1.6g/cm^2		d/R=0.13
Secondary beam	^{179}W		897 MeV/u	
Yield of ^{179}W / incident ^{208}Pb			$4.23\cdot 10^{-5}$ (0.952mb)(EPAXII:0.893 mb)	
Charge states after prod. target			fully stripped:74+(57.1%) 73+(33.5%) 72+(6.4%)	
Al degrader at S1	-		-	d/R=0.76
Al degrader at S2	8500 mg/cm^2		293.5 MeV/u	
Charge states after degraders			fully stripped:74+(65.8%) 73+(30.6%) 72+(3.6%)	
Energy at reaction target (S4)			234.5 MeV/u (74+)	
Charge states at reaction target (S4)			fully stripped:74+(100%)	

Slits:
S1 ±15mm(open for ^{179}W)
S2 ±40mm(open for ^{179}W)
S3 ±15mm(open for ^{179}W)

Transmission of ^{179}W(fully stripped):		Yield / incident particle:
At S1 after slits	93.5 %	$3.96\cdot 10^{-5}$
At S2 after slits	36.4 %	$1.02\cdot 10^{-5}$
At S4 (σ_x(^{179}W) = 1.5 cm)	32.5 %	$0.85\cdot 10^{-5}$

Yield of ^{179}W at S4 / all fragments 0.23

Yield of ^{179}W at S4 / incident ^{208}Pb	$8.5\cdot 10^{-6}$	($8.5\cdot 10^2$ pps)

Yield of I=35/2- isomer at S4(2.7%) 23.0/s

Second step: coulomb excitation

Reaction target at S4	^{208}Pb (300 mg/cm^2)	d/R=0.12
Energy of ^{179}W behind the reaction target:		215.2 MeV/u
Yield of ^{179}W(37/2-)/incident ^{179}W(35/2-):		$2*10^{-3}$ (2327mb)
Yield of ^{179}W(39/2-)/incident ^{179}W(35/2-):		$1*10^{-4}$ (123mb)

Estimated p γ rate for ^{179}W(37/2-)(3% γ efficiency &10% tagging efficiency): 0.5/h
Estimated p γ rate for ^{179}W(39/2-)(3% γ efficiency &10% tagging efficiency): $2.5\cdot 10^{-2}$/h

Some additional information for FRS setting

Slits:
S1 ± 15mm
S2 ± 40mm
S3 ± 15mm

Reaction target ± 35mm

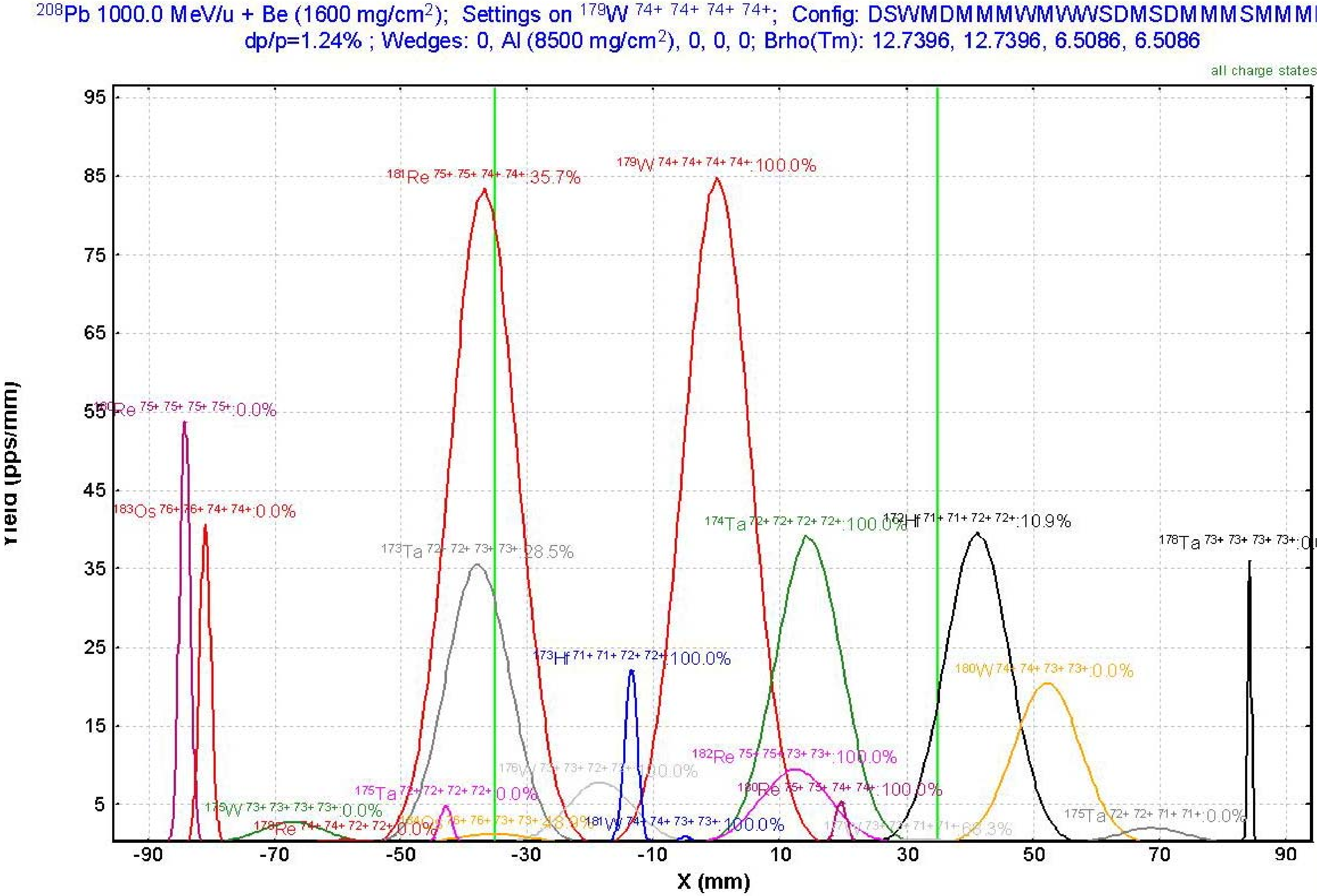
Yield of all fragments/ incident ^{208}Pb after S1 slits:	$2.9 \cdot 10^5$
Yield of all fragments/ incident ^{208}Pb before SC21:	$2.9 \cdot 10^5$
Yield of all fragments/ incident ^{208}Pb before MUSIC at S4:	$3.6 \cdot 10^3$
Yield of all fragments/ incident ^{208}Pb behind the reaction target:	$2.5 \cdot 10^3$

Bρ(D1) = 12.7 Tm

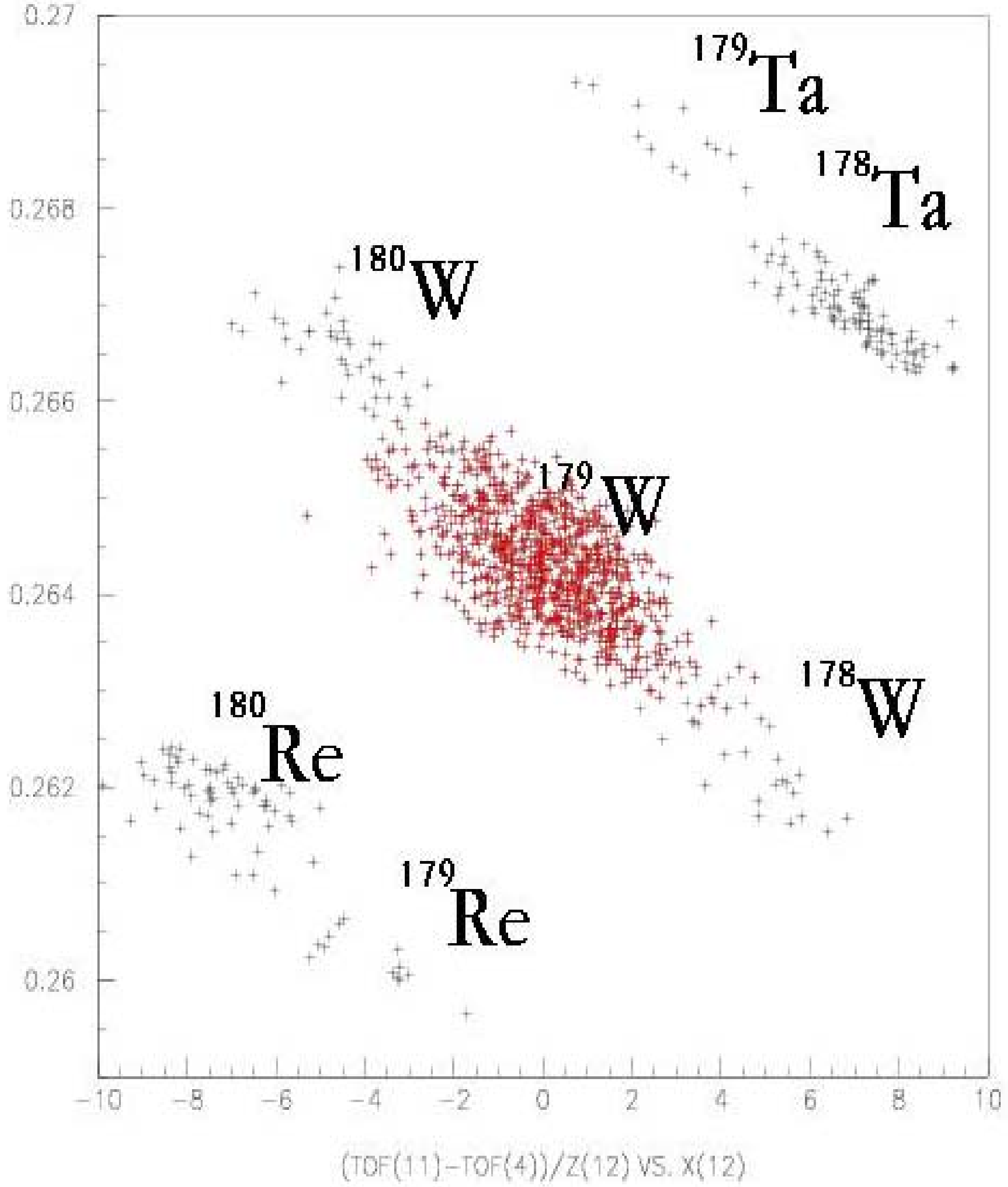
Bρ(D2) = 12.7 Tm

Bρ(D3) = 6.4 Tm

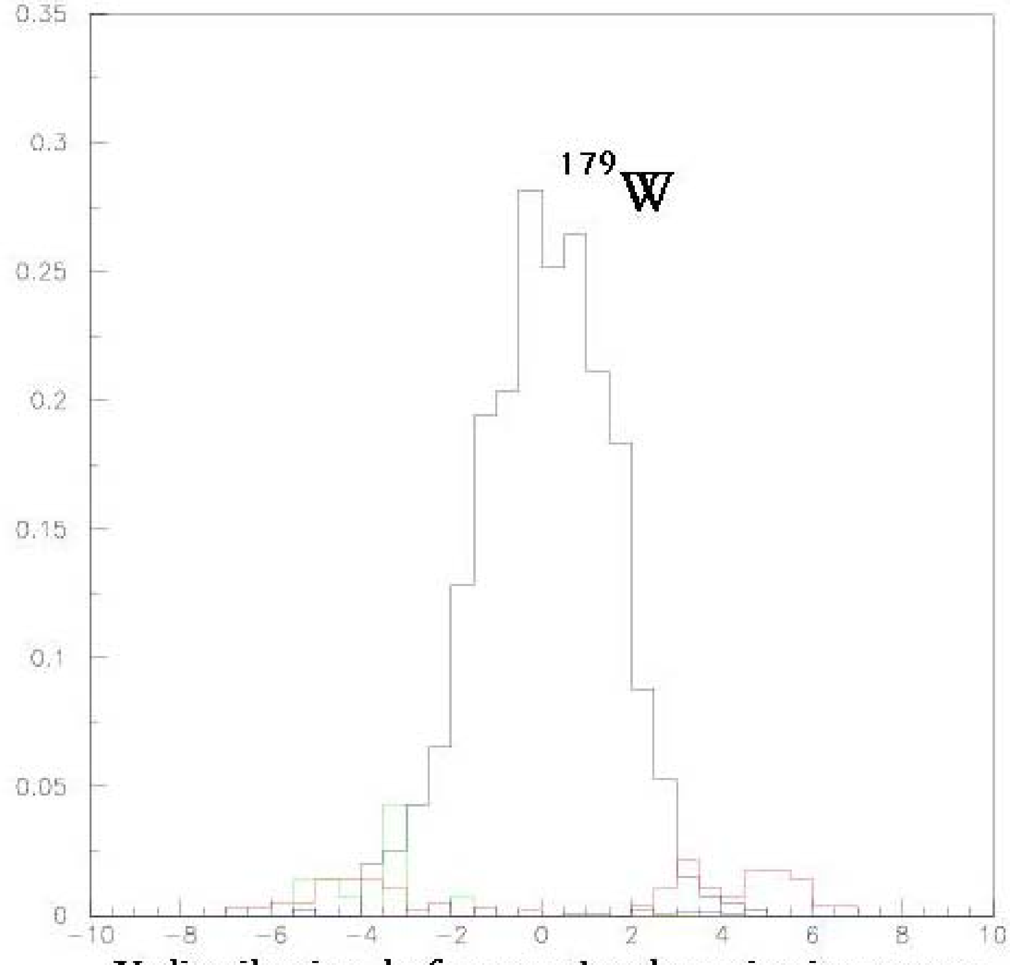
Bρ(D4) = 6.4 Tm



^{208}Pb 1000.0 MeV/u + Be (1600 mg/cm^2); Settings on ^{179}W 74+ 74+ 74+ 74+; Config: DSWMDMMMWMWWSDMSDMMMSMMMI
dp/p=1.24% ; Wedges: 0, Al (8500 mg/cm^2), 0, 0, 0; Brho(Tm): 12.7396, 12.7396, 6.5086, 6.5086
all charge states
Yield (pps/mm)
X (mm)
95
85
75
65
55
45
35
25
15
5
-90
-70
-50
-30
-10
10
30
50
70
90
^{181}Re 75+ 75+ 74+ 74+:35.7%
^{179}W 74+ 74+ 74+ 74+:100.0%
^{180}Re 75+ 75+ 75+ 75+:0.0%
^{183}Os 76+ 76+ 74+ 74+:0.0%
^{173}Ta 72+ 72+ 73+ 73+:28.5%
^{174}Ta 72+ 72+ 72+ 72+:100.0%
^{172}Hf 71+ 71+ 72+ 72+:10.9%
^{178}Ta 73+ 73+ 73+ 73+
^{173}Hf 71+ 71+ 72+ 72+:100.0%
^{180}W 74+ 74+ 73+ 73+:0.0%
^{182}Re 75+ 75+ 73+ 73+:100.0%
^{175}Ta 72+ 72+ 72+ 72+:0.0%
^{180}Re 75+ 75+ 74+ 74+:100.0%
^{175}W 73+ 73+ 73+ 73+:0.0%
^{181}W 74+ 74+ 73+ 73+:100.0%
^{175}Ta 72+ 72+ 71+ 71+:0.0%



0.27
0.268
0.266
0.264
0.262
0.26
-10
-8
-6
-4
-2
0
2
4
6
8
10
(TOF(11)-TOF(4))/Z(12) VS. X(12)
179Ta
178Ta
180W
179W
178W
180Re
179Re



X distribution before coulomb excitation target

Experiment No. 12

J. Gerl et al.

Investigation of the structure and deformation of $^{185-187}$Pb by γ-spectroscopy and lifetime measurements.

Nucleus of interest:	^{186}Pb (2 step fragmentation)			
Primary beam :	^{238}U	$5{\cdot}10^8$ pps	600 MeV/u	
Production target:	^{9}Be	1.6 g/cm^2		$\frac{d}{R_t} = 0.3$

First stage $^{238}U \rightarrow {}^{200}Rn$:

Secondary beam:	^{200}Rn		443.0 MeV/u	
Yield of ^{200}Rn/incident ^{238}U		$1.6{\cdot}10^{-4}$		2.06 mb (EPAX2) 0.01 mb (Exp.)
Charge states after prod. target	$Q_\circ$=0.56, Q_1=0.36, Q_2=0.07			
Al degrader at S1		986.6 mg/cm^2	442.9 MeV/u	
Al degrader at S2		807.2 mg/cm^2	359.2 MeV/u	$\frac{d}{R} = 0.63$
Charge states after degrader	$Q_\circ$=0.16, Q_1=0.46, Q_2=0.37			
Energy at reaction target (S4)			153.8 MeV/u	
Charge states after reaction target			$Q_\circ$=0.04	

Slits :
S1 = ± 1.0 cm
S2 = ± 3.0 cm
S3 = ± 10. cm

Transmission of ^{200}Rn:		Yield/incident particle:
At S1, after slits	32.6 %	$5.2{\cdot}10^{-5}$
At S2, after slits	3.5 %	$5.4{\cdot}10^{-6}$
At reaction target(σ_x(^{200}Rn) = 1.1 cm)	3.3 %	$5.3{\cdot}10^{-6}$

Yield of ^{200}Rn at S4/all fragments: 0.02

Yield of ^{200}Rn at S4/incident ^{238}U	$5.3{\cdot}10^{-6}$	($2.6{\cdot}10^3$ pps)

Second stage $^{200}Rn \rightarrow {}^{186}Pb$:

Reaction target at S4	^{27}Al	500 mg/cm^2	153.0 MeV/u	$\frac{d}{R} = 0.67$
Energy of ^{200}Rn behind the reaction target:			67.8 MeV/u	
Yield of ^{186}Pb/incident ^{200}Rn		$3.1{\cdot}10^{-5}$		2.9 mb, 0.08 pps
Yield of ^{186}Pb/all nuclei		$1.3{\cdot}10^{-1}$		
Yield of ^{186}Pb/isotopes of Pb		$2.0{\cdot}10^{-2}$		

Estimated pγ rate for ^{186}Pb (3.0 % γ eff. at 1.3 MeV)) : 9 hr.$^{-1}$

Some additional information

Yield of ^{185}Pb/incident ^{200}Rn: $1.3\cdot10^{-5}$, 1.2 mb, 0.03 pps

Estimated pγ rate for ^{185}Pb (3.0 % γ eff. at 1.3 MeV)) : 4 hr.$^{-1}$

Yield of ^{187}Pb/incident ^{200}Rn: $6.2\cdot10^{-5}$, 5.9 mb, 0.16 pps

Estimated pγ rate for ^{186}Pb (3.0 % γ eff. at 1.3 MeV)) : 18 hr.$^{-1}$

Slits :
S1 = ± 1.0 cm
S2 = ± 3.0 cm
S3 = ± 10. cm

Reaction target = ± 3.5 cm (max.)

Yield of all fragments / incident particle before SC21 : $1.6\cdot10^{-3}$ ($8.1\cdot10^{5}$)
Yield of all fragments / incident particle before MUSIC at S4 : $3.2\cdot10^{-4}$ ($1.7\cdot10^{5}$)

Bρ(D1) = 7.8395 Tm
Bρ(D2) = 6.8409 Tm
Bρ(D3) = 5.2980 Tm
Bρ(D4) = 5.2979 Tm

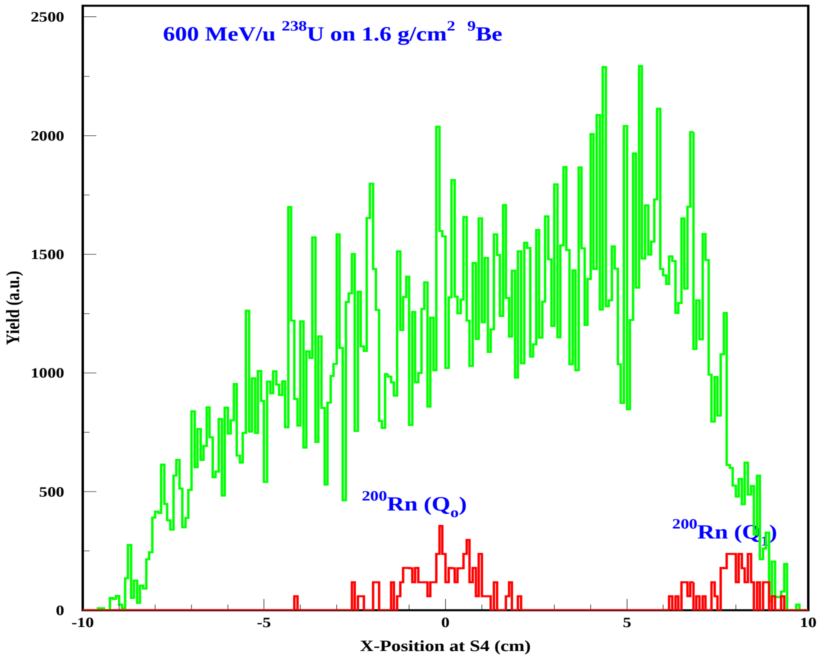


Figure 1: Position spectrum at S4 for ^{200}Rn setting

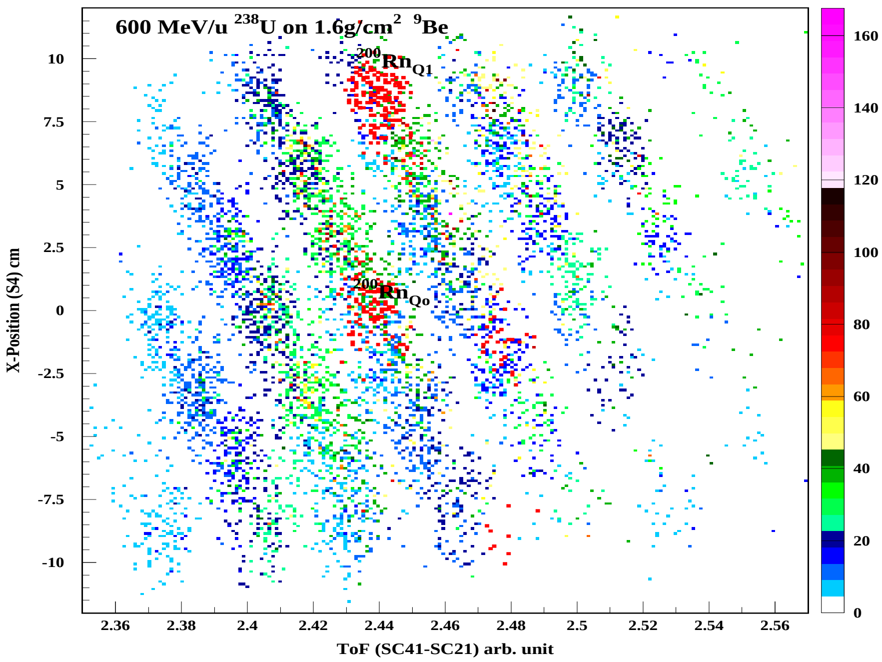


Figure 2: Time-of-flight vs Position plot for ^{200}Rn setting.