

# Data Analysis for the $^{144}\text{Sm}(n,\alpha)^{141}\text{Nd}$ Reaction at $E_n = 4.0, 5.0$ and $6.0$ MeV

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# Outline



- Introduction
- Measurements
- Results



# $^{144}\text{Sm}(n,\alpha)^{141}\text{Nd}$



- ❑ No measurement data exist
- ❑ Significant discrepancies in all evaluated data libraries
- ❑ Abundance

$^{144}\text{Sm}$	$^{147}\text{Sm}$	$^{148}\text{Sm}$	$^{149}\text{Sm}$	$^{150}\text{Sm}$	$^{152}\text{Sm}$	$^{154}\text{Sm}$
3.07%	14.99%	11.24%	13.82%	7.38%	26.75%	22.75%

- ❑ Reaction Q-value for  $^{144}\text{Sm}(n,\alpha)^{141}\text{Nd} = 7.872 \text{ MeV}$



# II. Measurements.

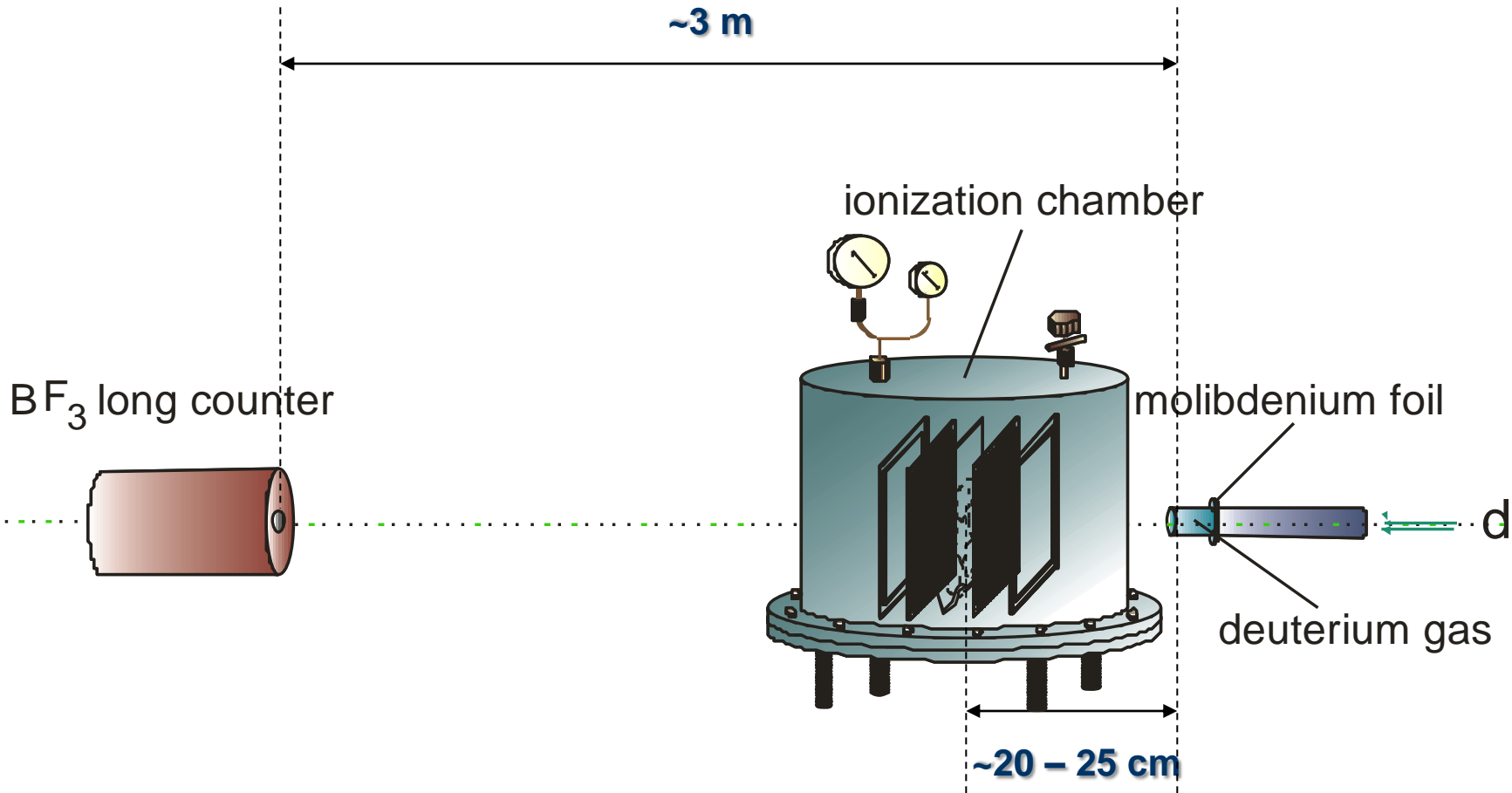


**4.5 MV Van de Graaff Accelerator**  
**Institute of Heavy Ion Physics in Peking University**





# Setup of experiment



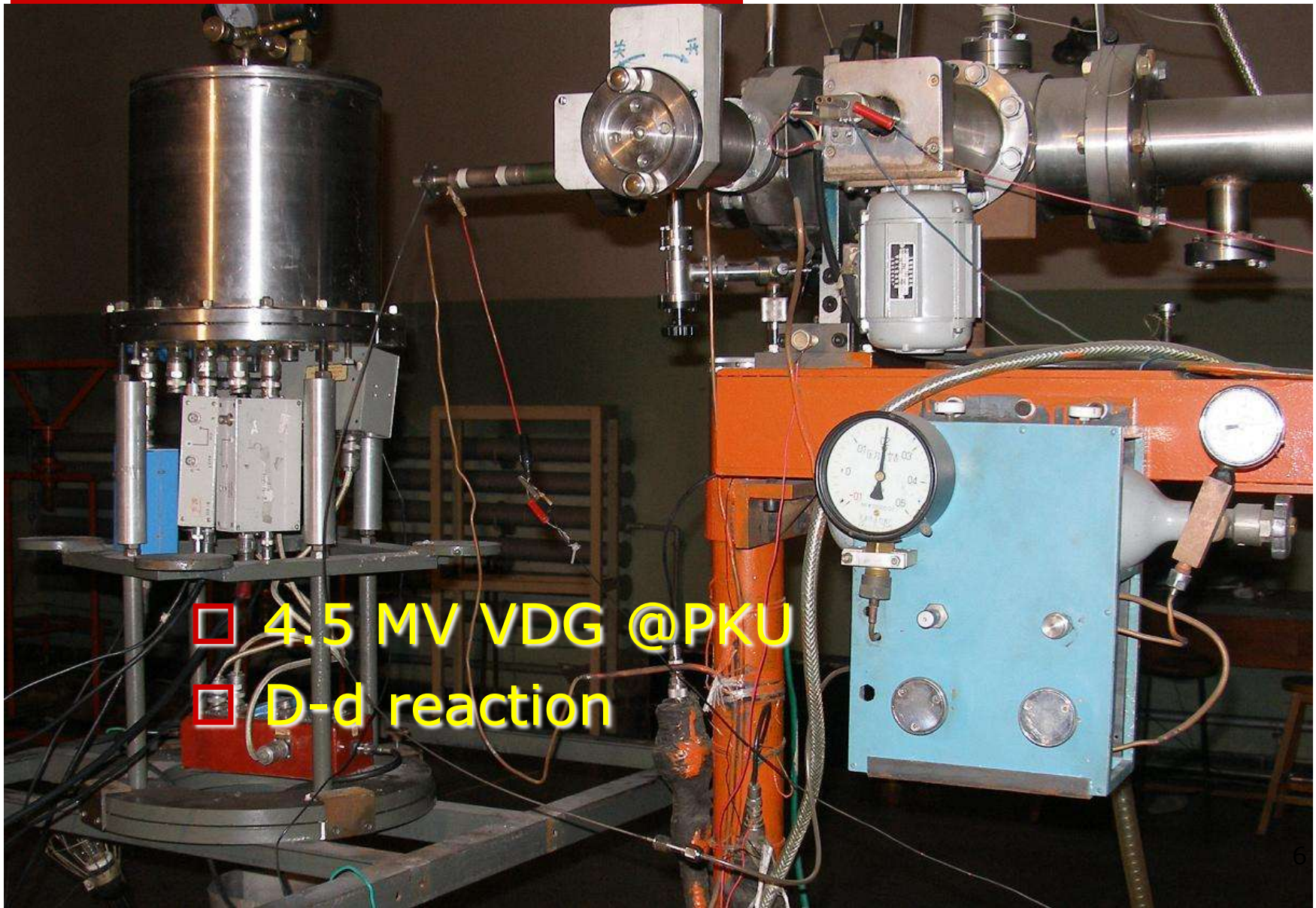
**3 parts:** ③  
**flux measurement**  
 $\text{BF}_3 + {}^{238}\text{U}(n,f)$

②  
**particle detector**  
GIC

①  
**neutron source**  
d-d



# Neutron source



- 4.5 MV VDG @PKU
- D-d reaction



# Neutron source



**Deuterium gas target (3.0atm, 2.0cm)**  
**d beam  $\sim 3 \mu\text{A}$**   
 **$E_n = 4.0 \pm 0.21, 5.0 \pm 0.16, 6.0 \pm 0.12 \text{ MeV}$**



# GIC

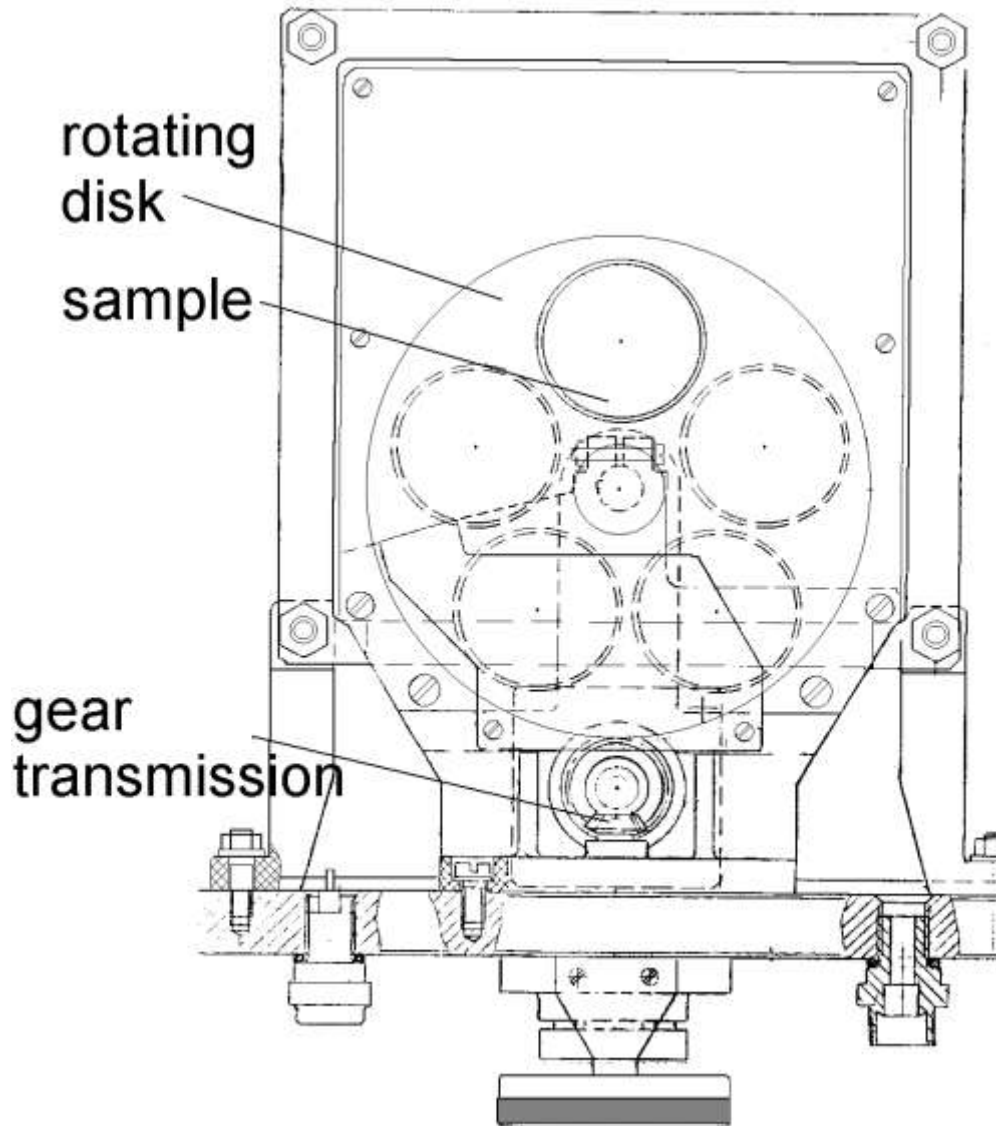
- Twin GIC  
back to back:  $\sim 4\pi$
- 5 back-to-back  
sample positions
- Working gas:  
Kr+2.83%CO<sub>2</sub>,  
1.55 atm
- distances:  
cathode-grid 61.0 mm  
grid-anode 15.0 mm  
anode-shield 9.0 mm





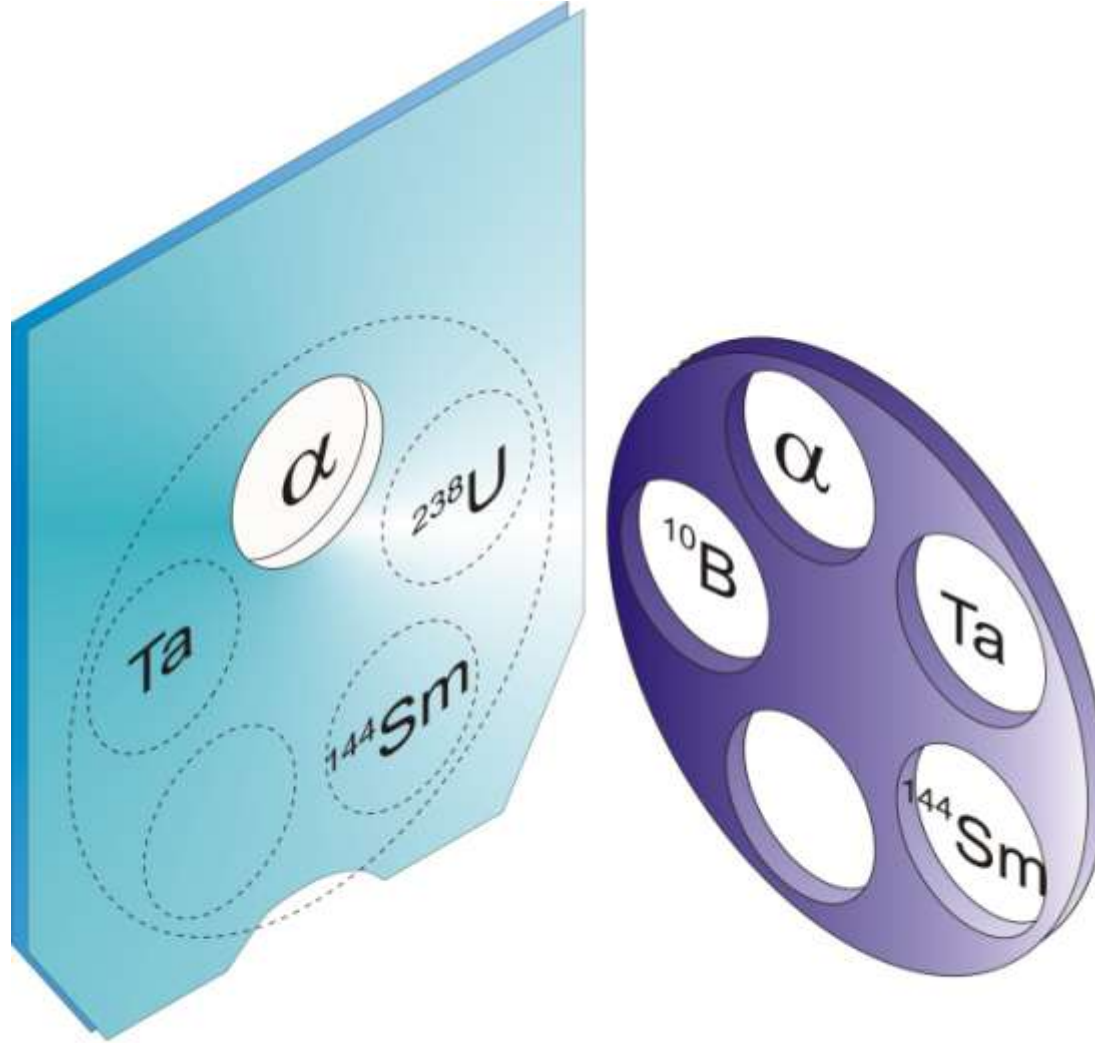


# Sample changer





# Sample positions



forward section

backward section



# Samples of $^{144}\text{Sm}$

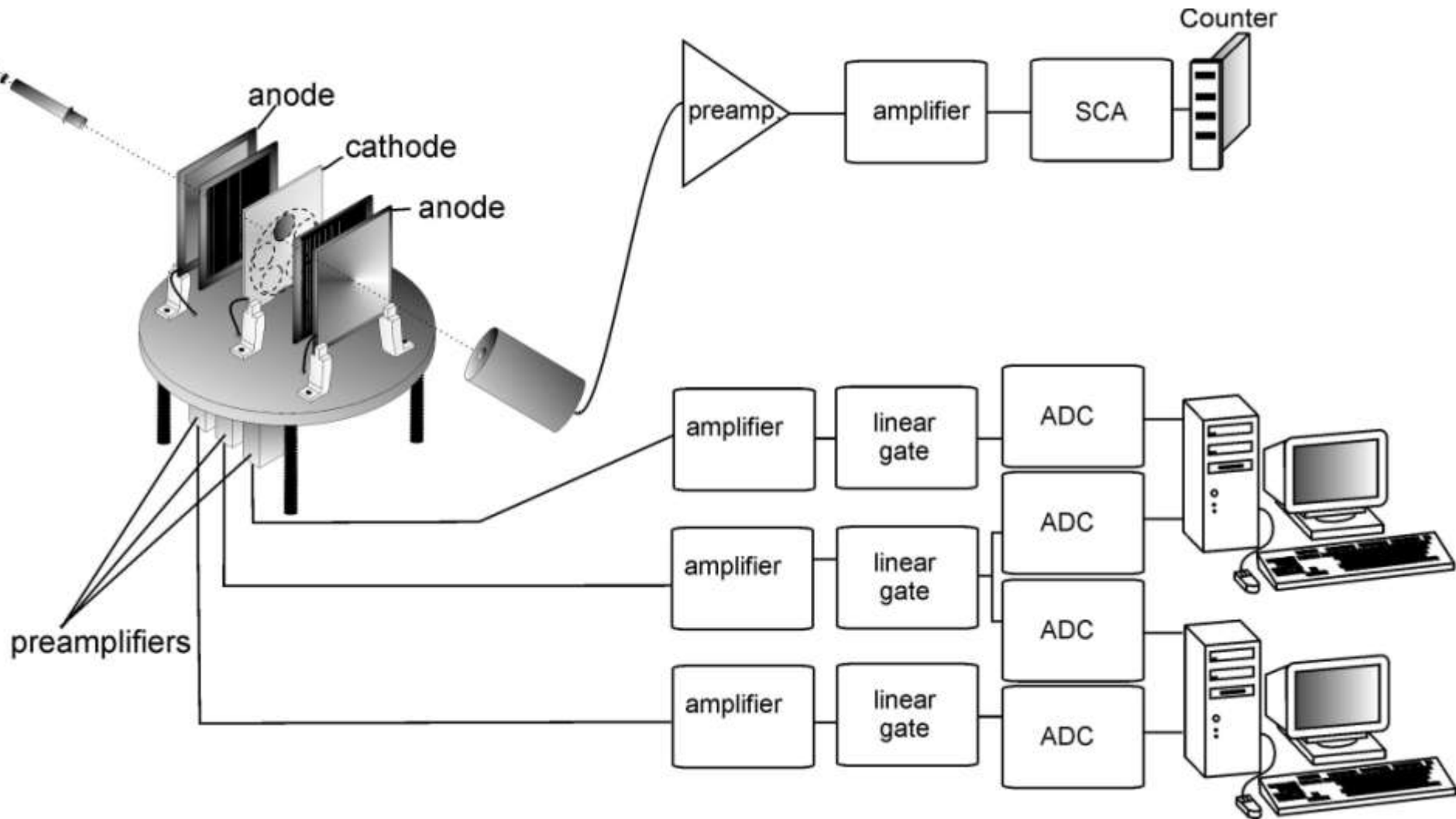


Material  
enriched  $^{144}\text{Sm}$  94.6%  
 $\text{Sm}_2\text{O}_3$   
Forward 0.0645 g  $\text{Ø}44$  mm  
Backward 0.0506 g  $\text{Ø}44$  mm





# Electronics



Block diagrams of the electronics.



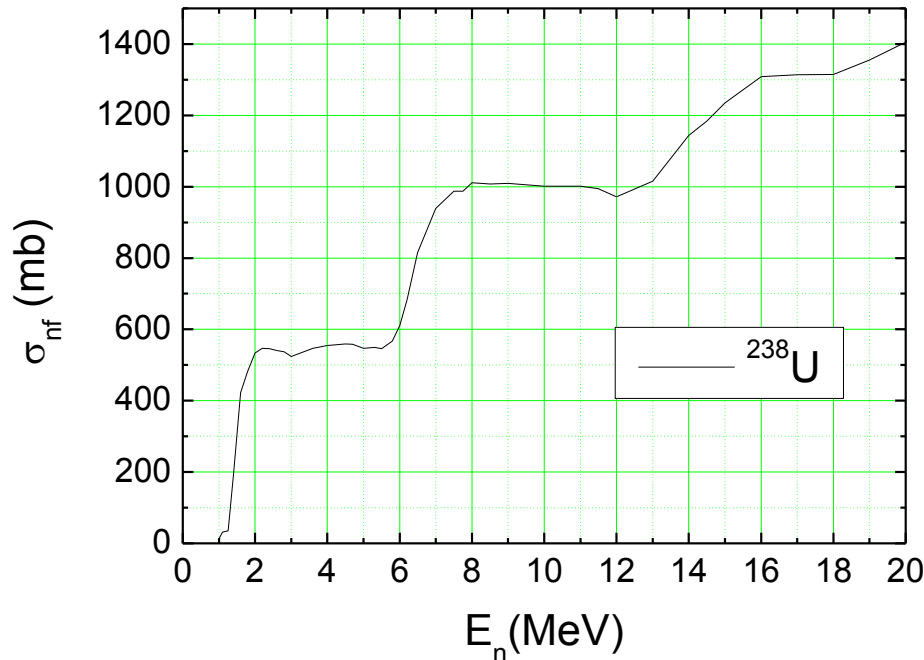
# Flux calibration



□  $^{238}\text{U}$  fission &  $\text{BF}_3$  long counter

ENDF/B-VII

$^{238}\text{U}_3\text{O}_8$	99.999%	$7.85 \pm 0.1$ ( $^{238}\text{U}$ only)	Ta $\varnothing 45\text{mm}$
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$^{238}\text{U}$  fission cross section  
as a function of the neutron energy.





# Data Processing



- ❑ Energy calibration
- ❑  $0/180^\circ$  ,  $90^\circ$  line determination
- ❑ Spectrum projection
- ❑ E loss correction
- ❑ Counts determination
- ❑ Flux determination
- ❑ Theoretical and Monte Carlo calculations
- ❑ Self absorption and threshold loss correction (fission & alpha counts)
- ❑ Correction for alpha loss from higher excited states

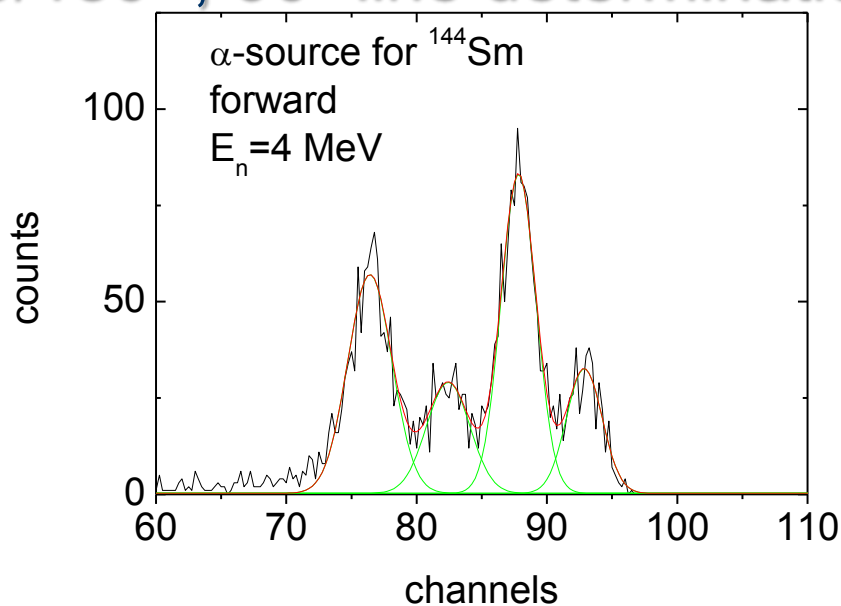
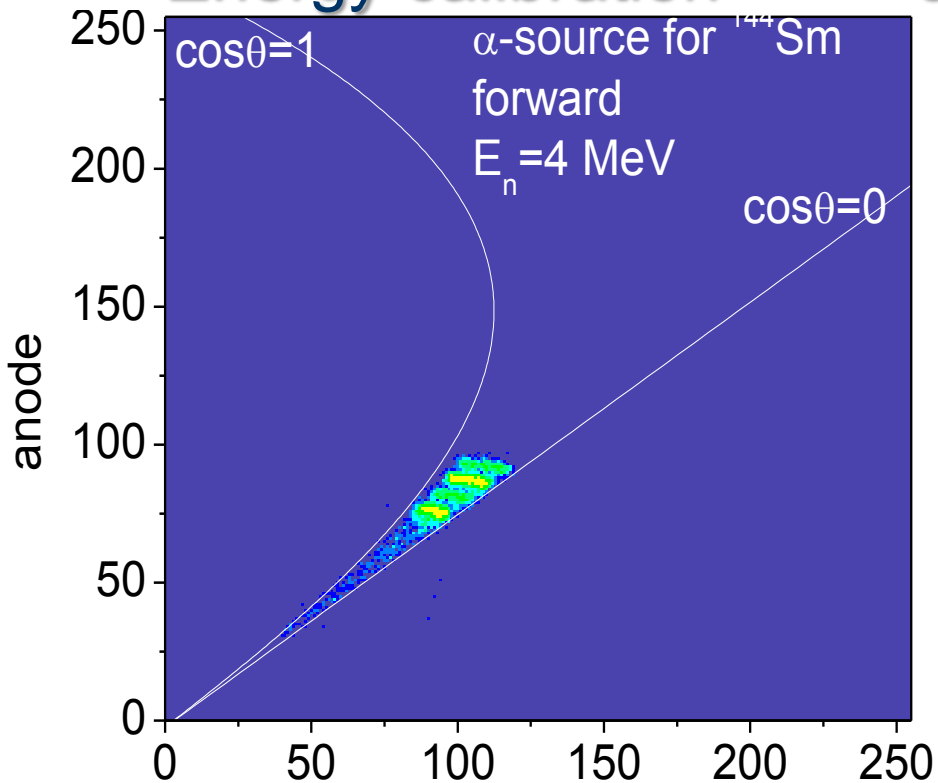


# III. Results

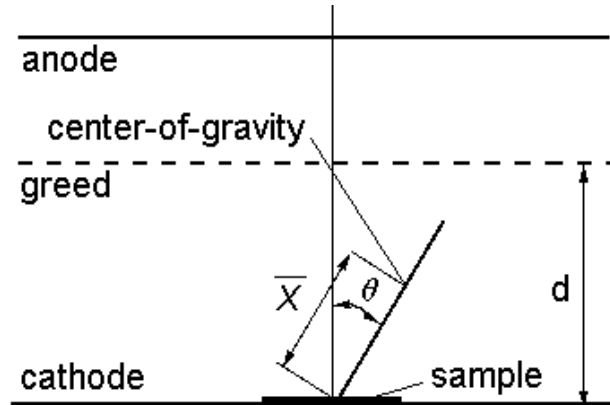


## Energy calibration

## 0/180°, 90° line determination

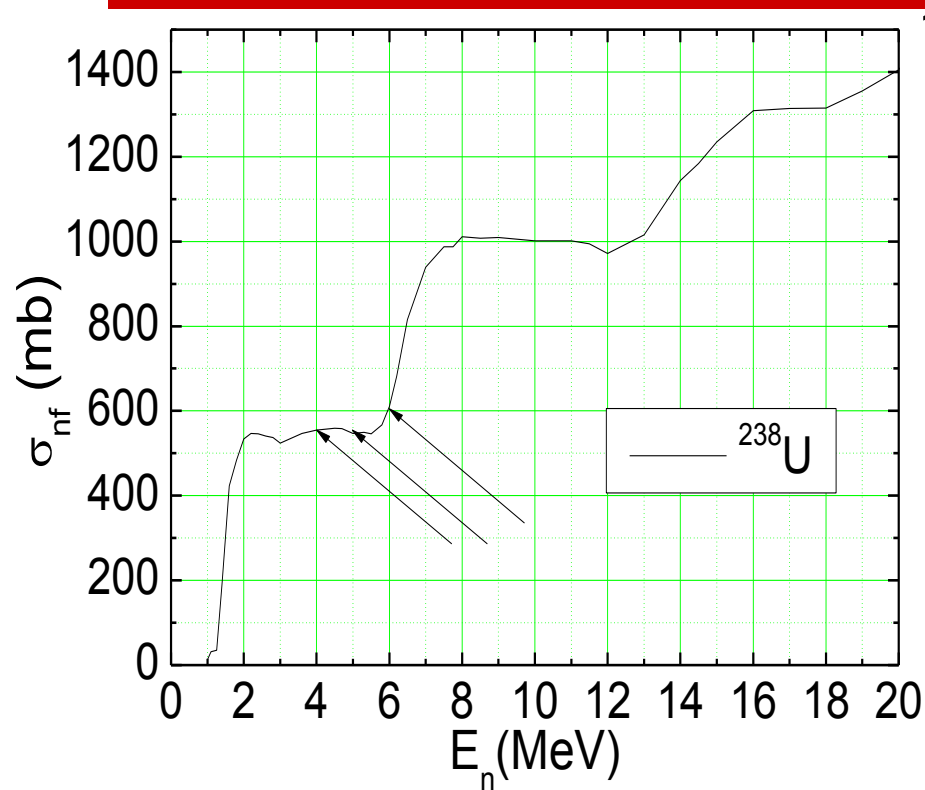


$^{234}\text{U}$	$^{238}\text{Pu}$	$^{239}\text{Pu}$	$^{244}\text{Cm}$
Energies for calibration (MeV)			
4.775	5.155	5.499	5.805

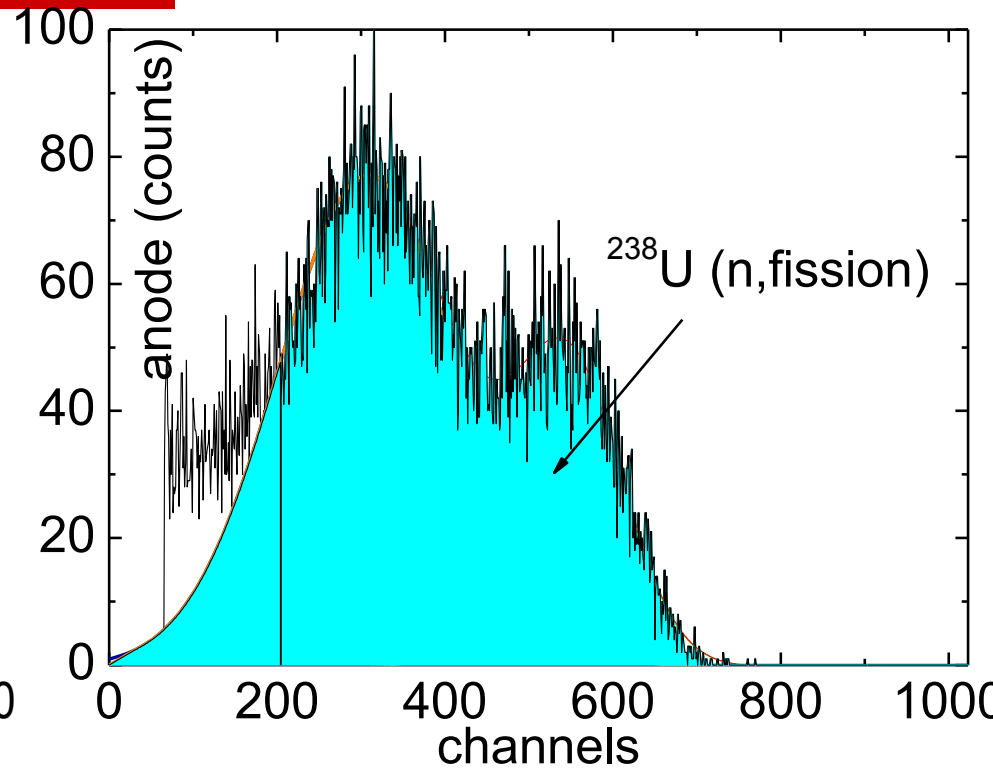




# Flux determination



$^{238}\text{U}$  fission cross section  
ENDF/B-VII.1-library



The anode spectrum of the  
 $^{238}\text{U}$  fission fragments  
at  $E_n = 4.0$  MeV

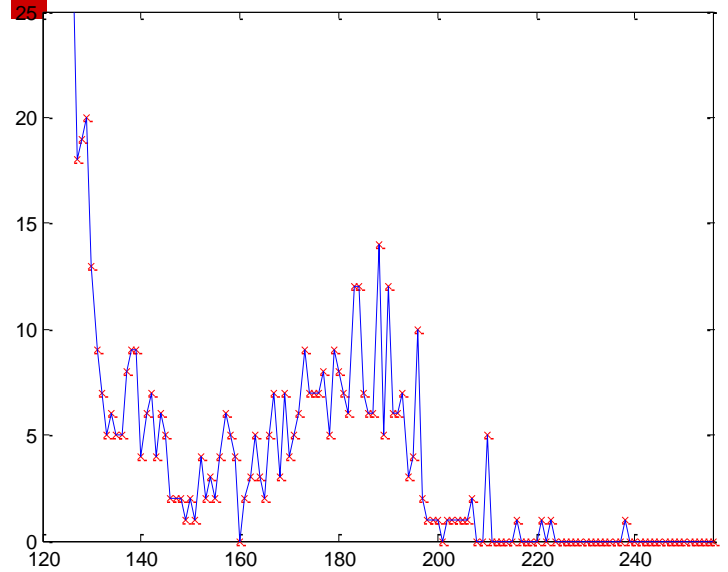
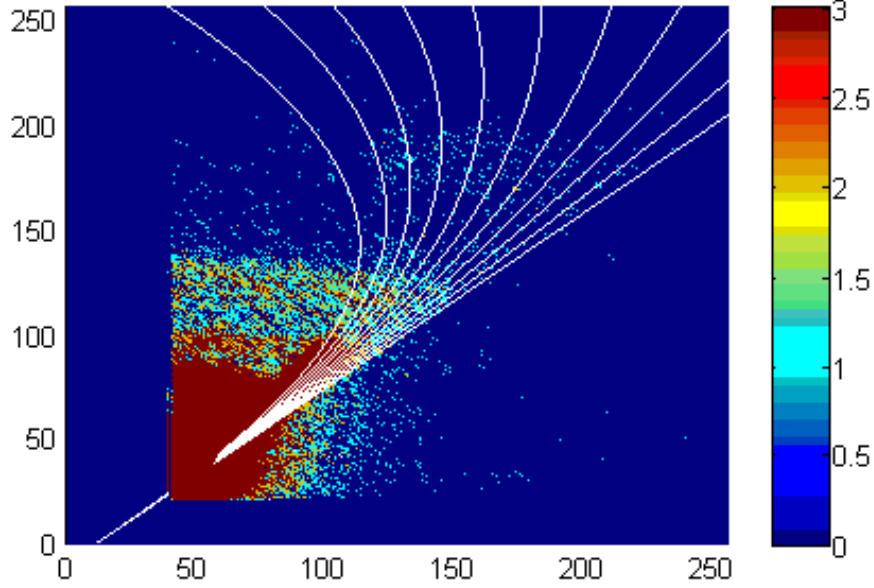




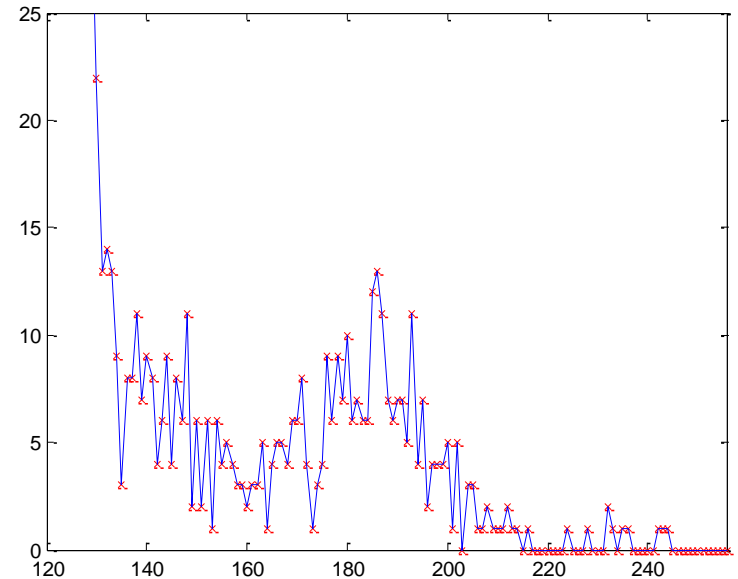
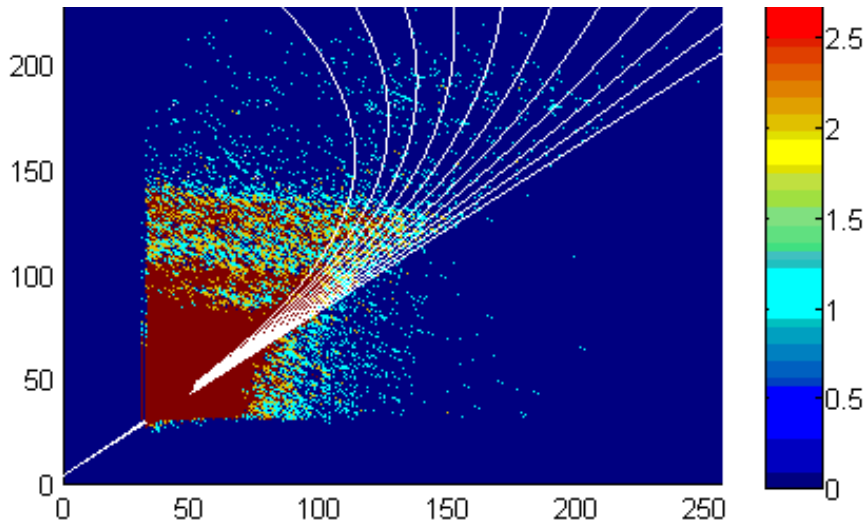
# $^{144}\text{Sm}$ $E_n = 4$ MeV



forward

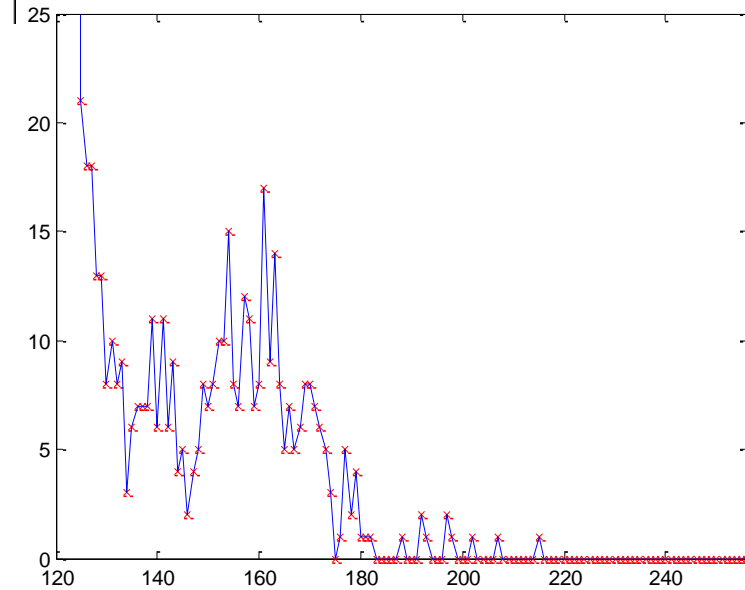
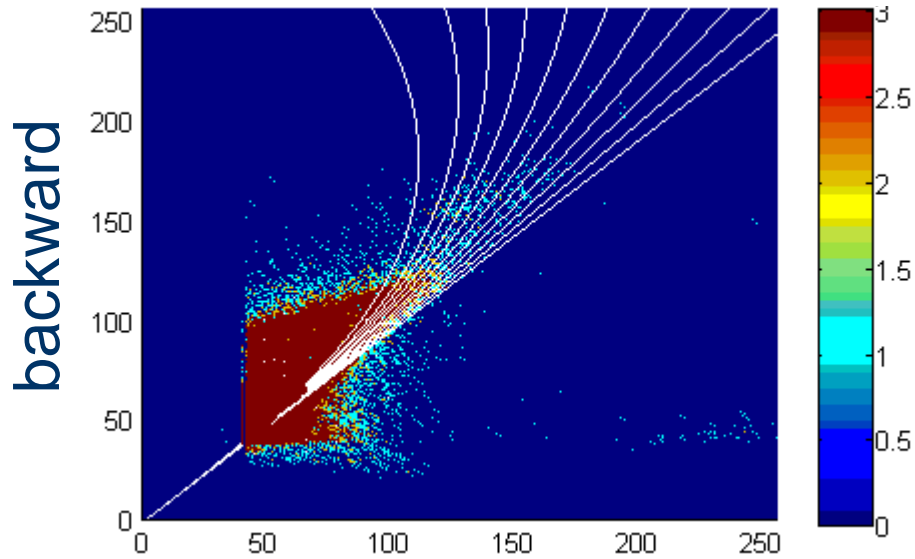
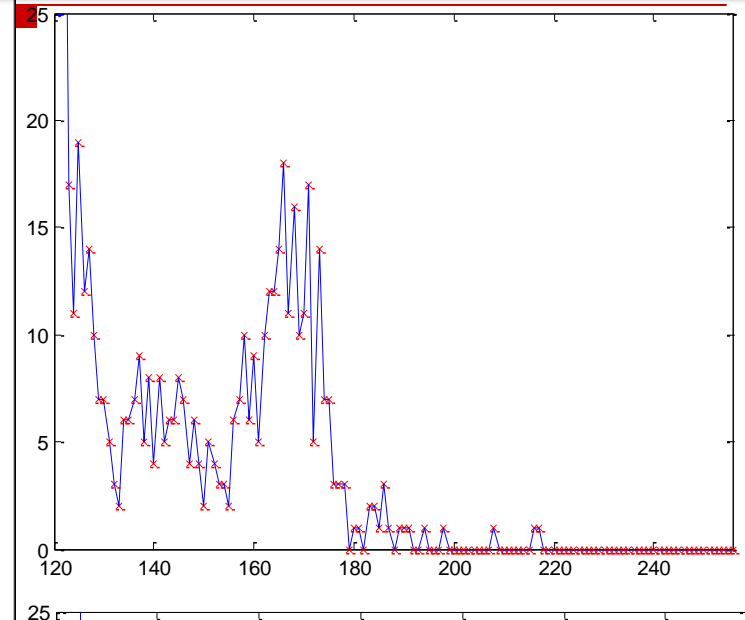
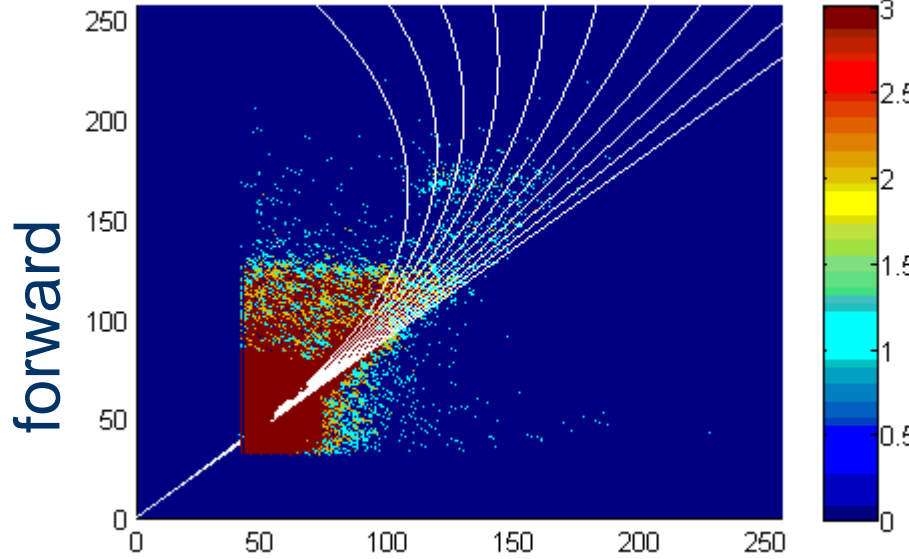


backward



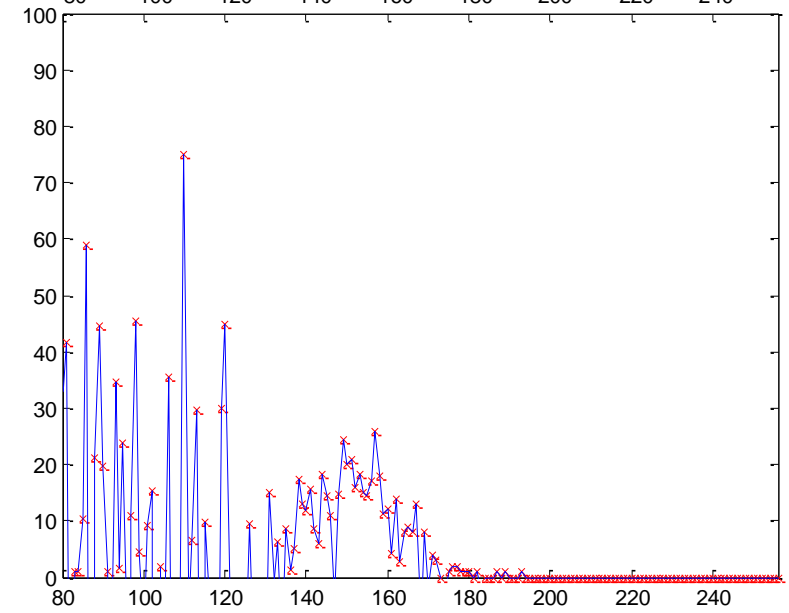
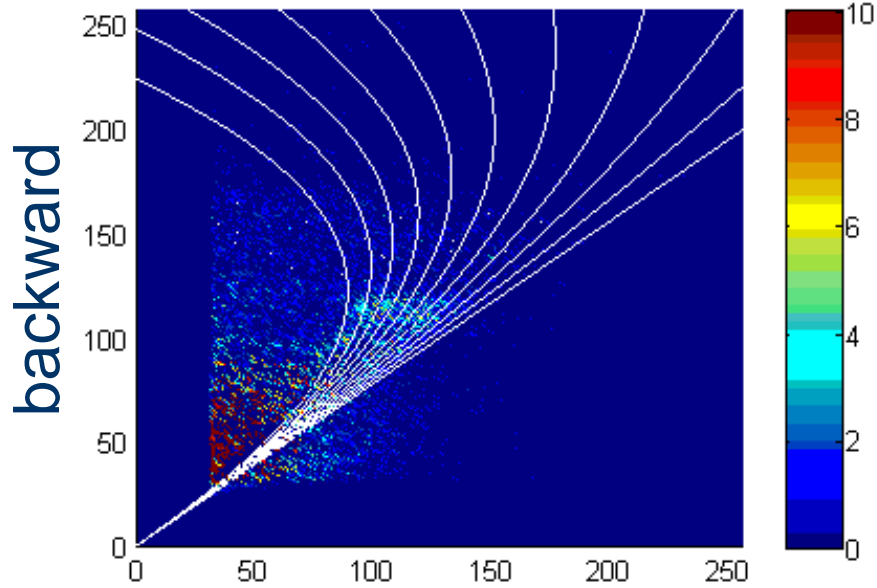
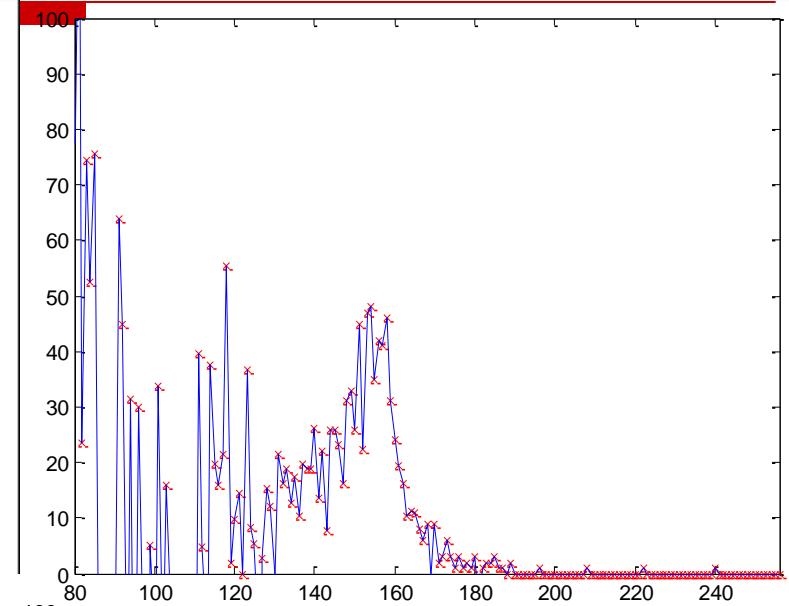
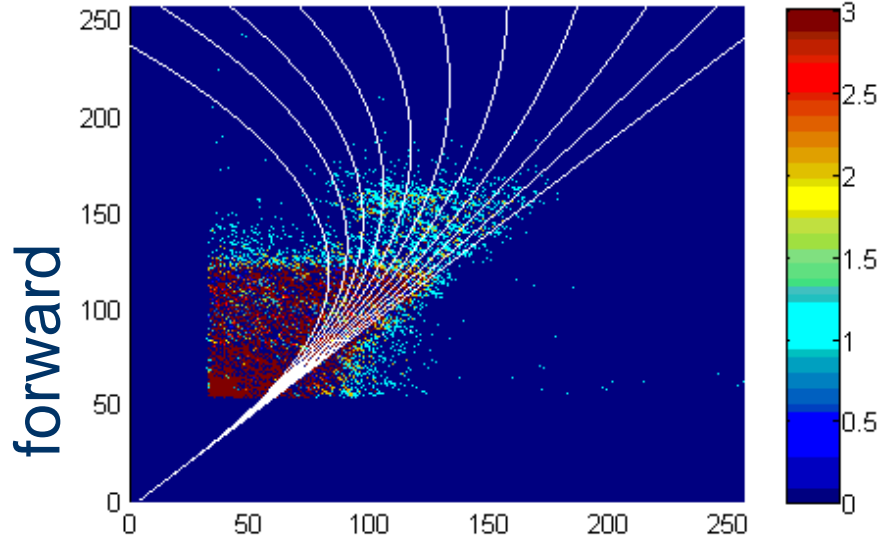


# $^{144}\text{Sm}$ $E_n = 5$ MeV





# $^{144}\text{Sm}$ $E_n = 6$ MeV



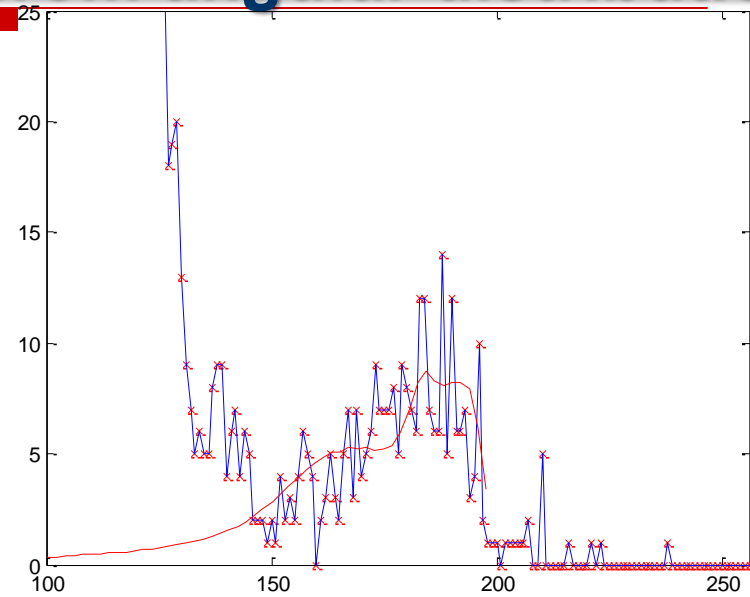
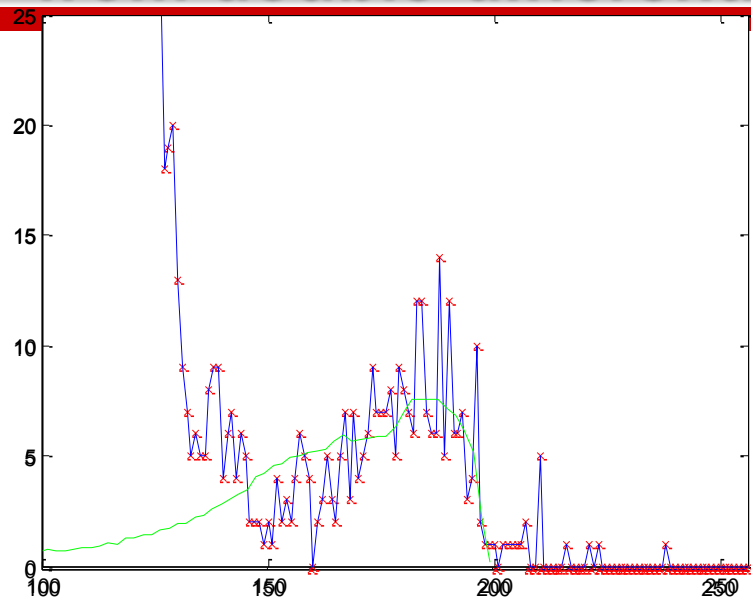


# $^{144}\text{Sm}$ $E_n = 4$ MeV

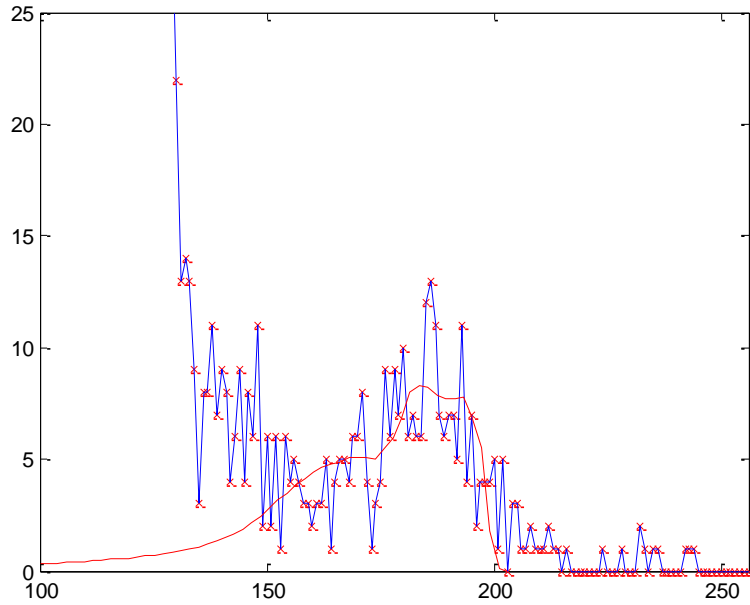
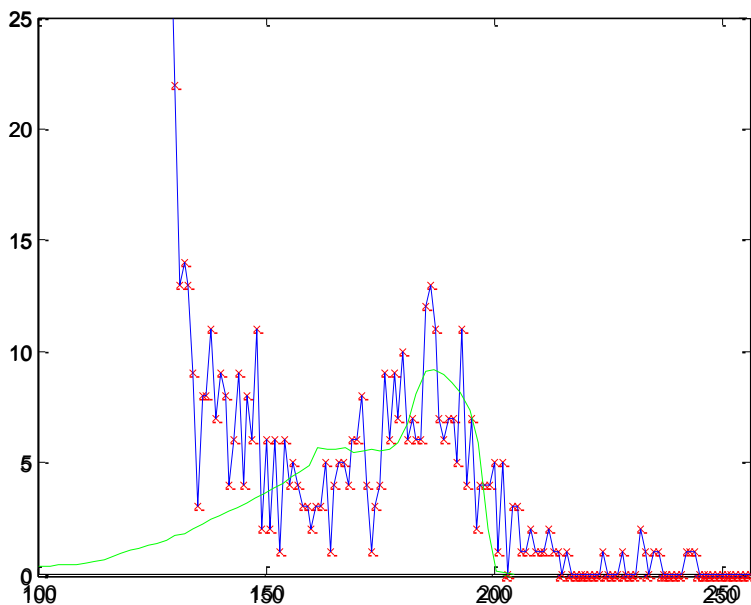


from double-differential from angular distribution

forward



backward



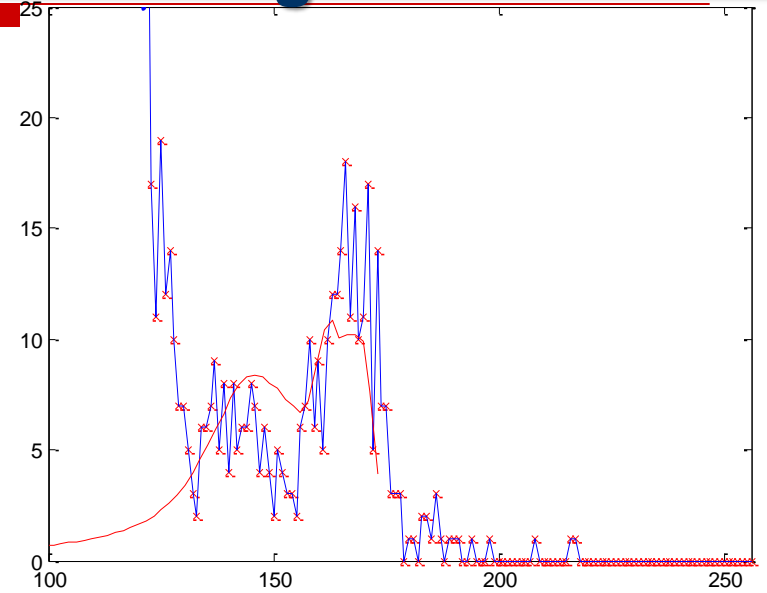
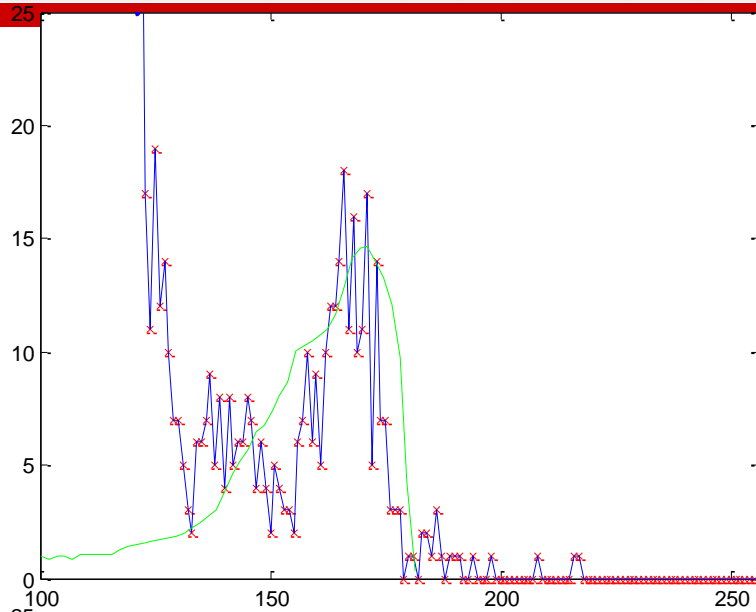


# $^{144}\text{Sm}$ $E_n = 5$ MeV

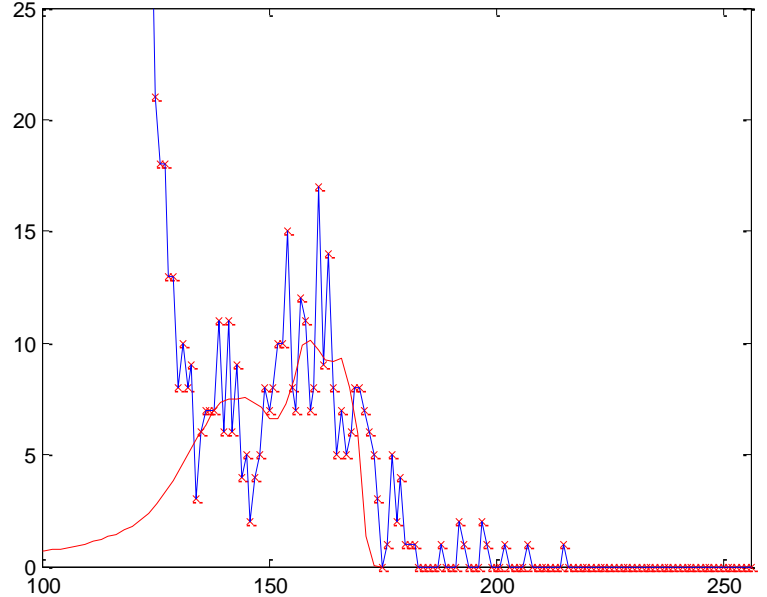
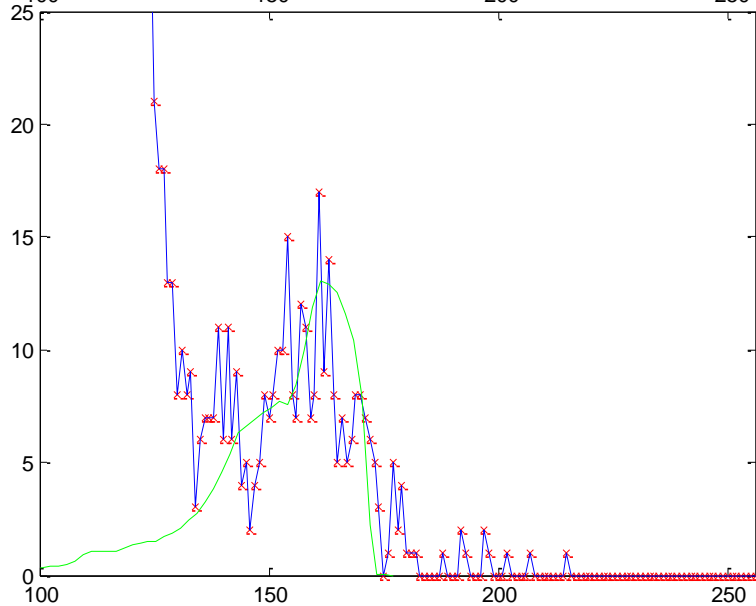


from double-differential from angular distribution

forward



backward



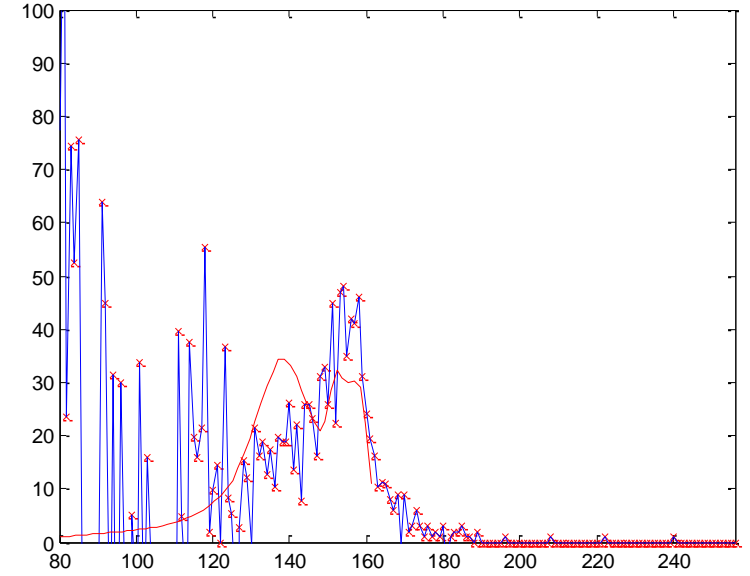
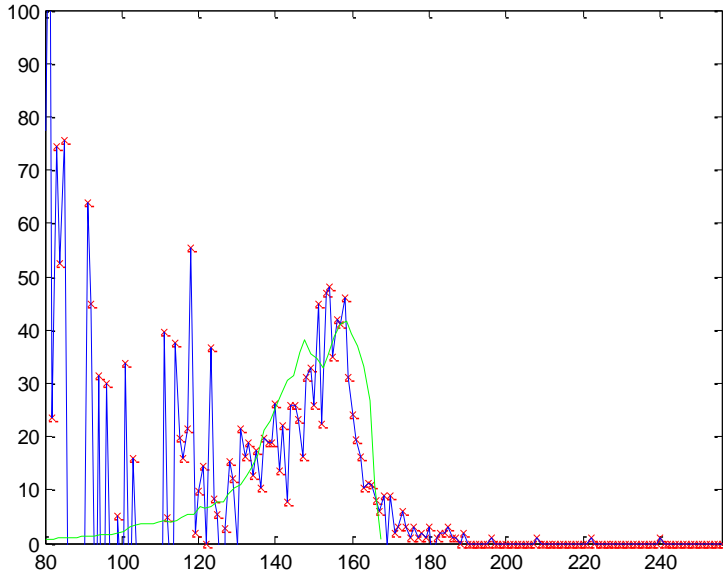


# $^{144}\text{Sm}$ $E_n = 6$ MeV

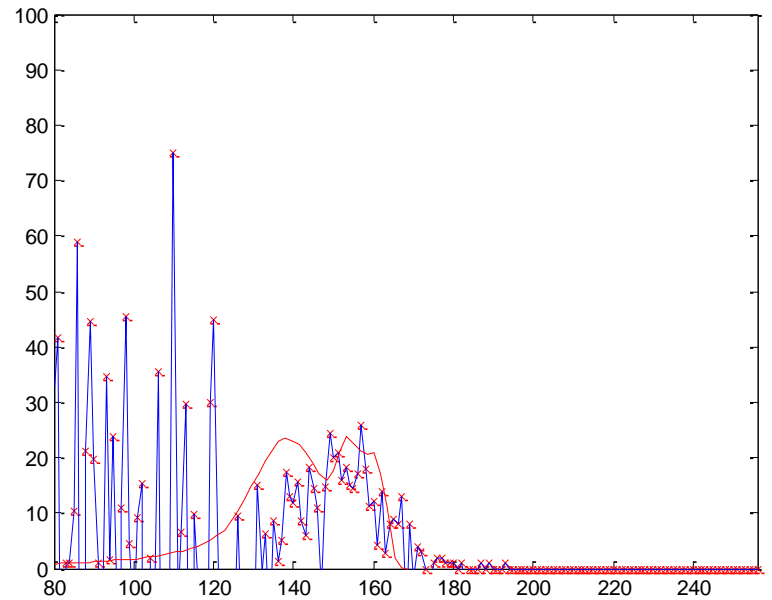
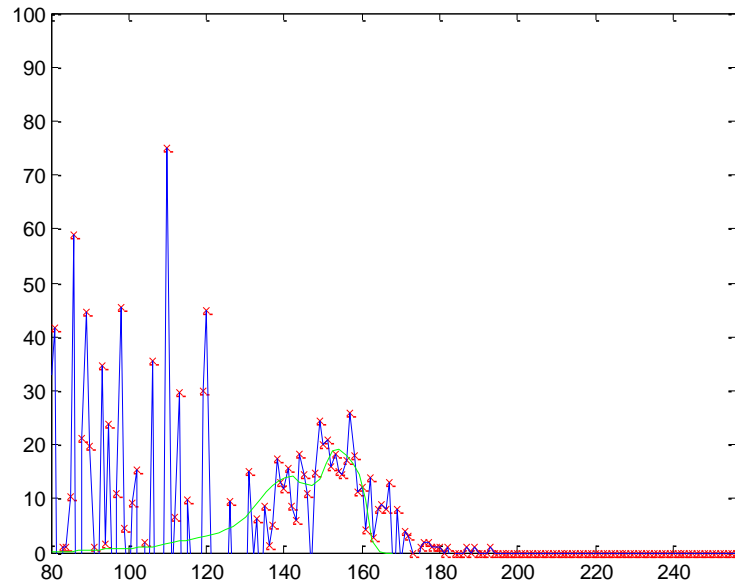


## from double-differential from angular distribution

forward



backward





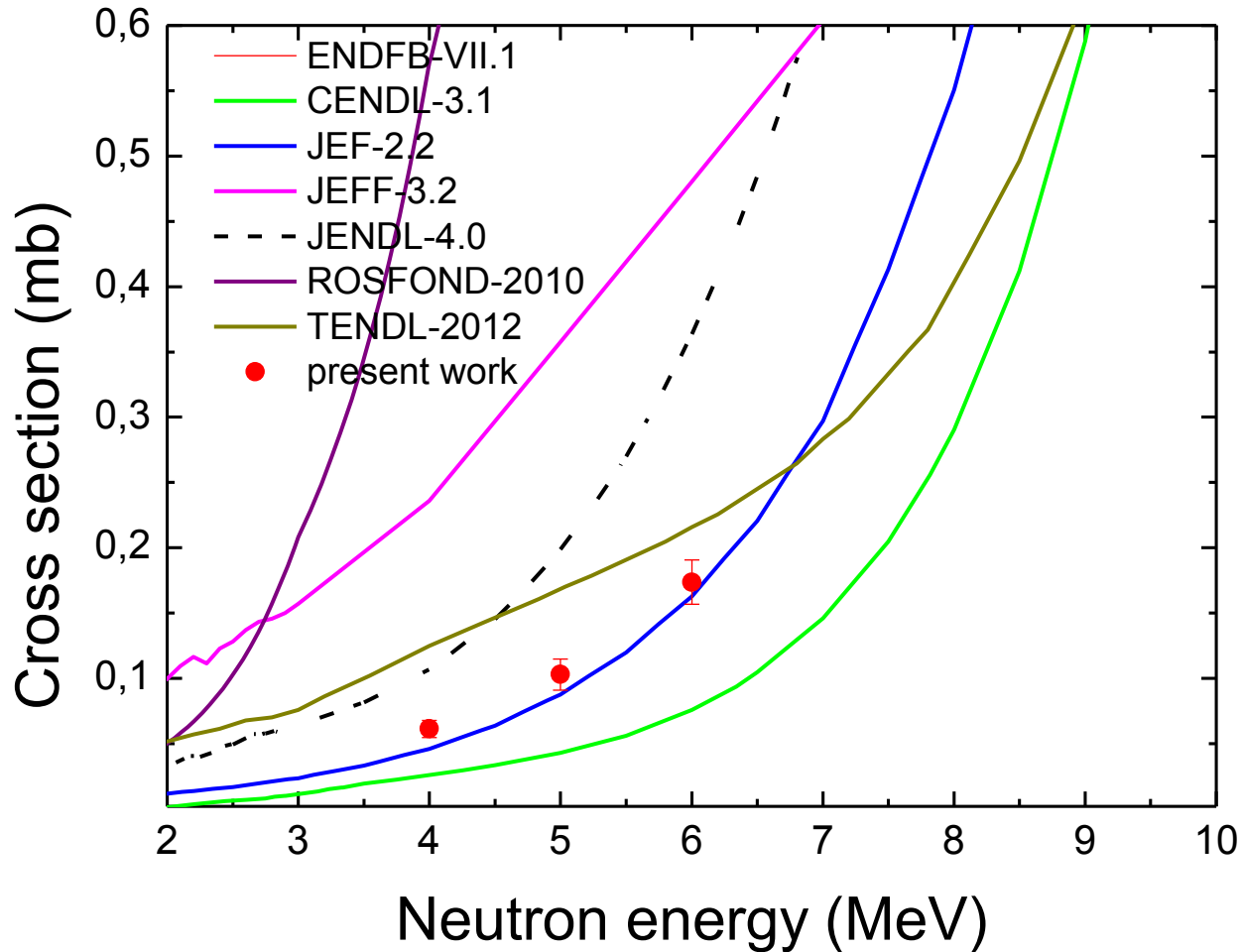
# Data analysis results ( $^{144}\text{Sm}$ )



	4 for.	4 back.	5 for.	5 back.	6 for.	6 back.
counts	264	252	220	243	887	423
ratio	0.76	0.76	0.79	0.81	0.76	0.67
cross section (mb)	0.0276	0.0337	0.0431	0.0598	0.1020	0.0717
	$0.0613 \pm 0.0065$		$0.1029 \pm 0.012$		$0.1737 \pm 0.017$	



# Data analysis results ( $^{144}\text{Sm}$ )







# Summary



- $^{144}\text{Sm}(n, \alpha)^{141}\text{Nd}$  cross sections were measured at  $E_n = 4.0, 5.0, 6.0$  MeV
- Data were compared with existing evaluations
- Before the cross sections and forward/backward ratios in the laboratory reference system were measured for  $^{147}\text{Sm}(n, \alpha)^{144}\text{Nd}$  at 5.0 and 6.0 MeV(2007),  $^{143}\text{Nd}(n, \alpha)^{140}\text{Ce}$  at 4.0, 5.0 and 6.0 MeV(2008), and  $^{149}\text{Sm}(n, \alpha)^{146}\text{Nd}$  at 6.0 MeV(2009).

**Thank you!**