Initial Fissile Nuclei (IFN) Analyzer

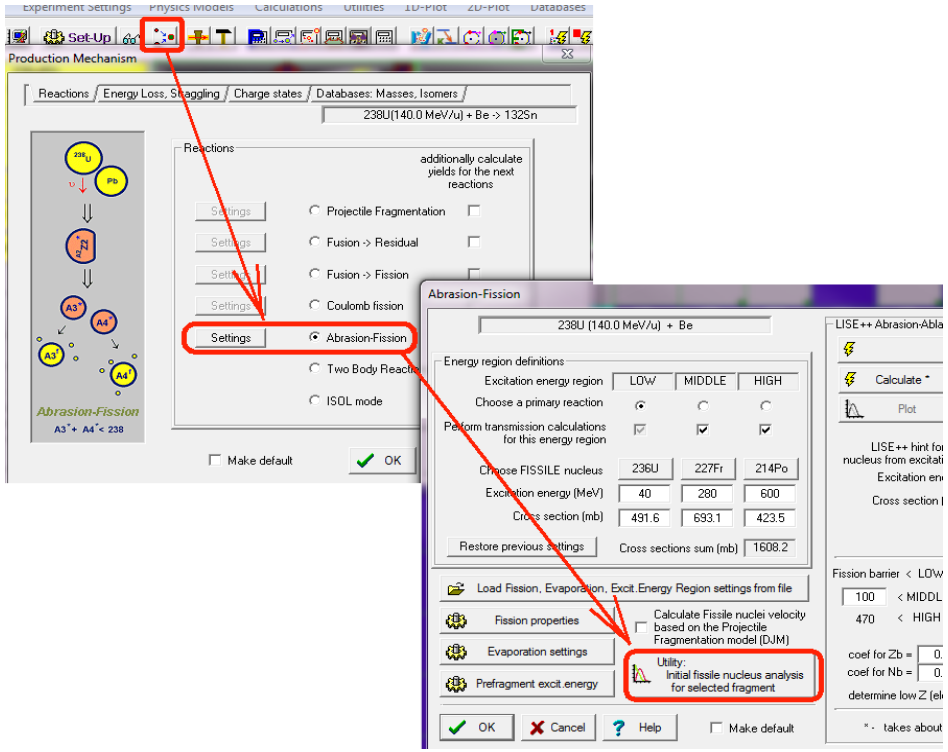
v.11.0.27	02/15/19
v.11.0.37	02/28/19 *update*
v.11.0.38	03/01/19 *correction**

** - correction at the IFN3 model.*

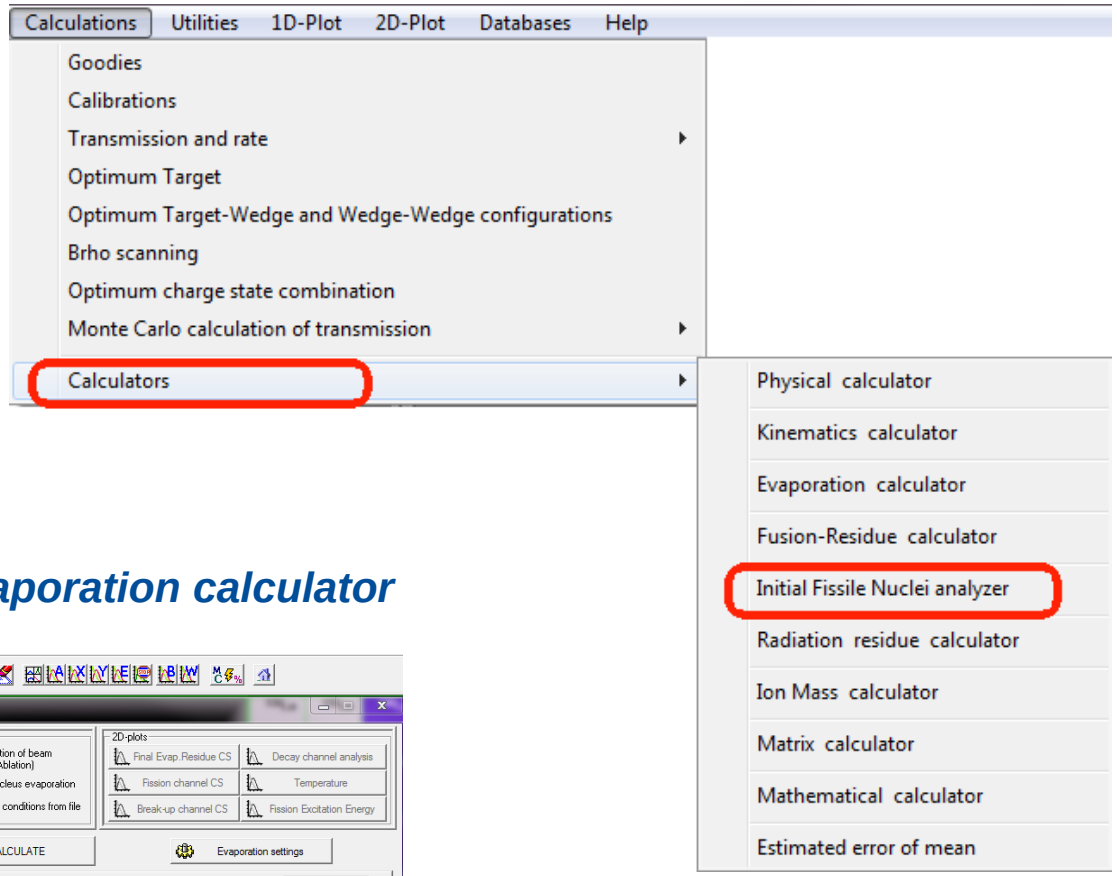
- How to run the utility
- 1st step calculation
  - ➢ Reaction mechanism settings
  - ➢ IFN area settings
  - ➢ Results
- 2nd step calculation
  - ➢ Settings (N_{points}, Statistics, Output)
  - ➢ Analysis result output
    - *Initial (Parent) Fissile Nuclei [IFN]*
    - *Final Fission Fragment [FFF]*
- Batch file mode
- First results
  - ➢ IFN analysis for isotopes of Z=26,30,32*,36,40,41,42,45*,50,56,62,67,71 *(* - includes IFN plots)*
  - ➢ Comparison of results by the 3EER, IFN1, and IFN3 models
- Next Steps

How to run the utility?

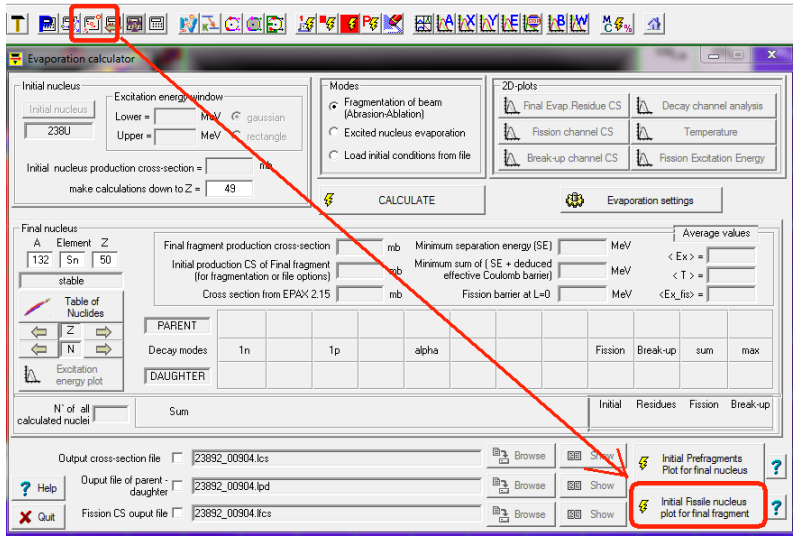
1. From the Abrasion-Fission dialog



3. From the Calculators menus



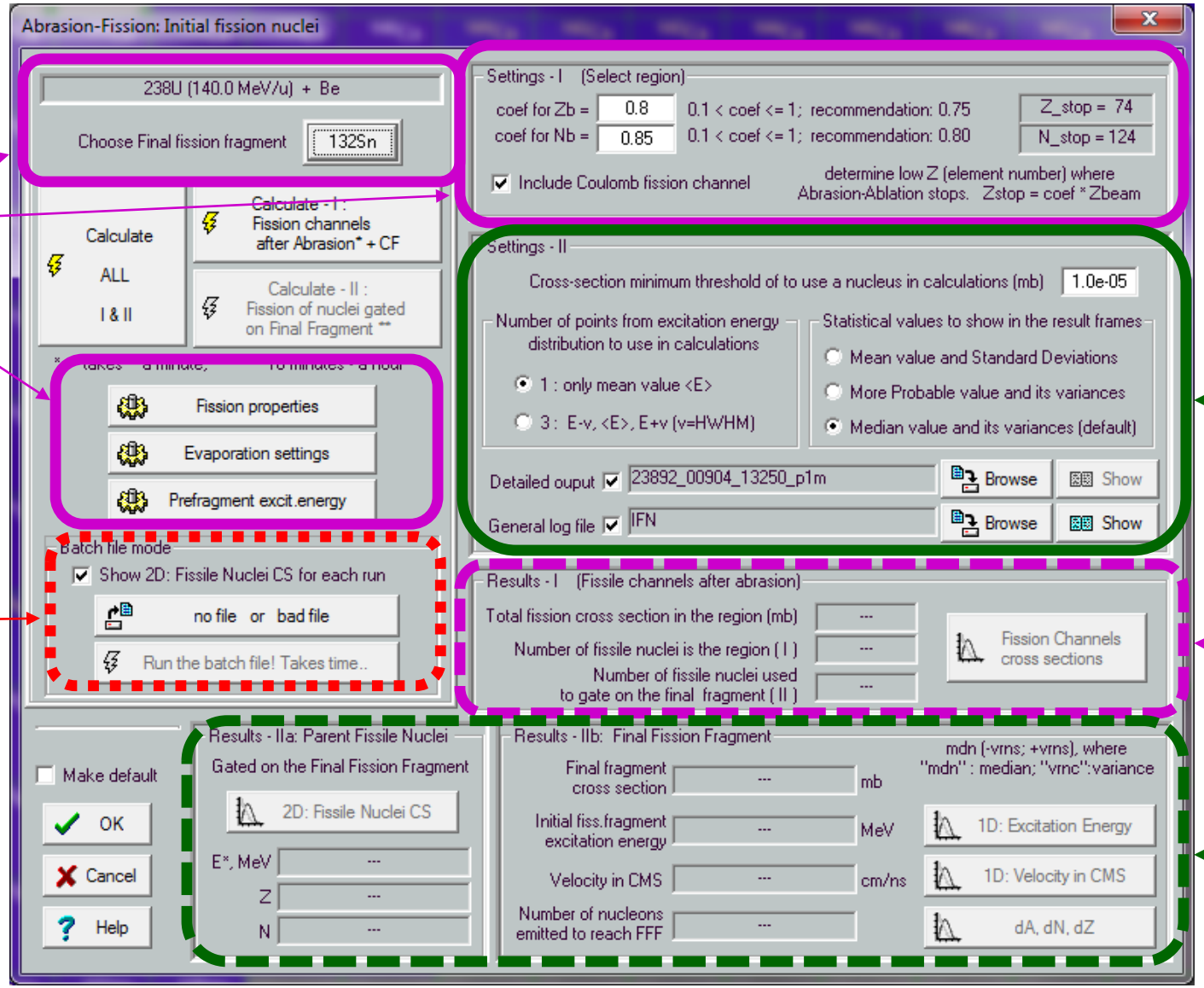
2. From the Evaporation calculator



Initial Fissile Nuclei (IFN) dialog

1st step settings

Bath mode settings and run



2nd step settings

1st step results

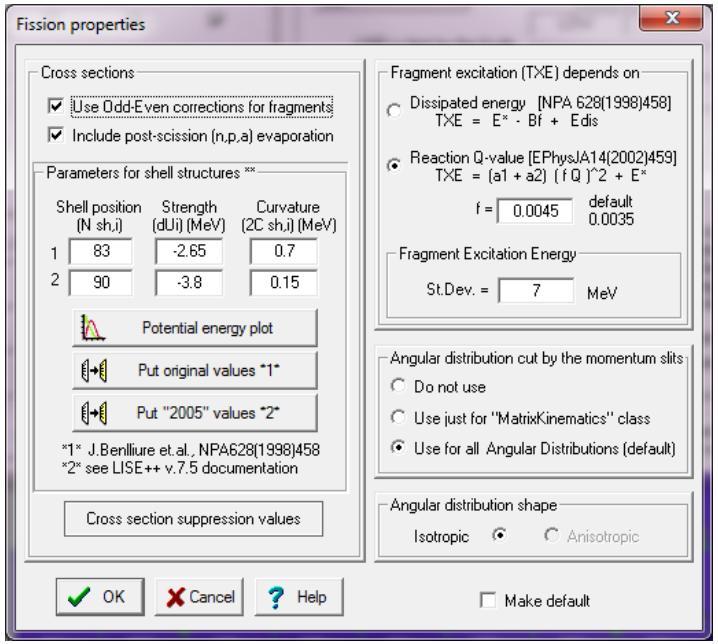
2nd step results

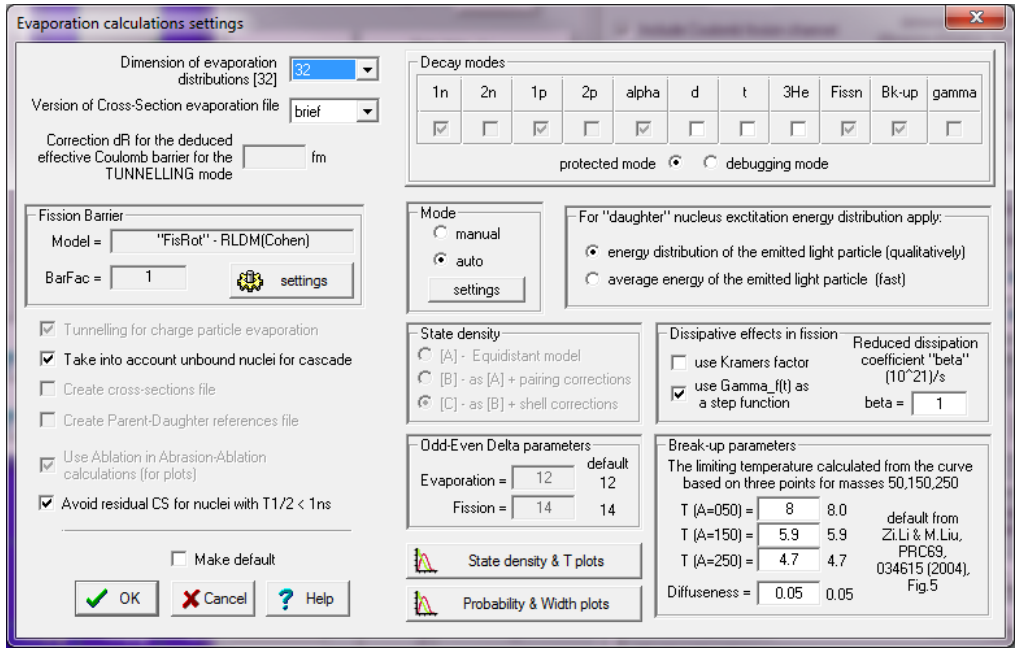
Reaction mechanism settings : default values

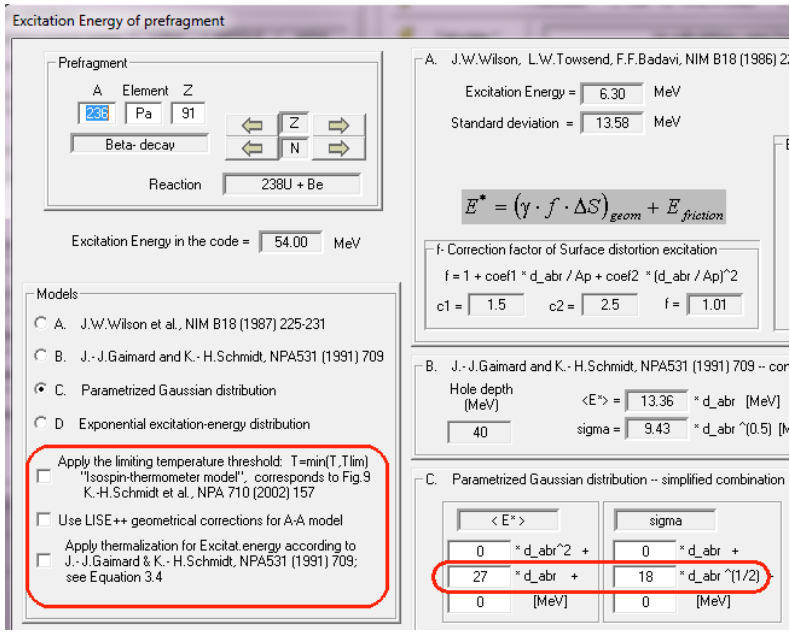
Fission properties

Evaporation settings

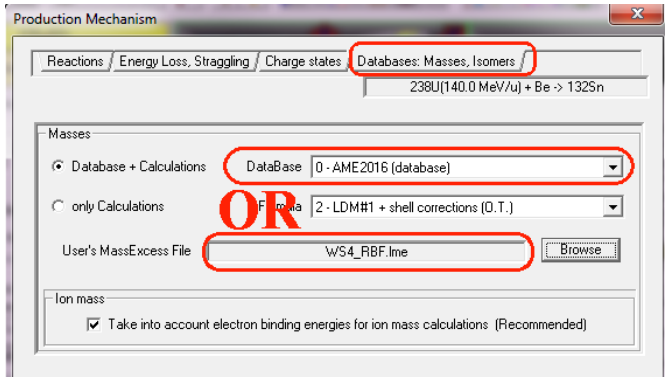
Prefragment excit.energy







Mass table model



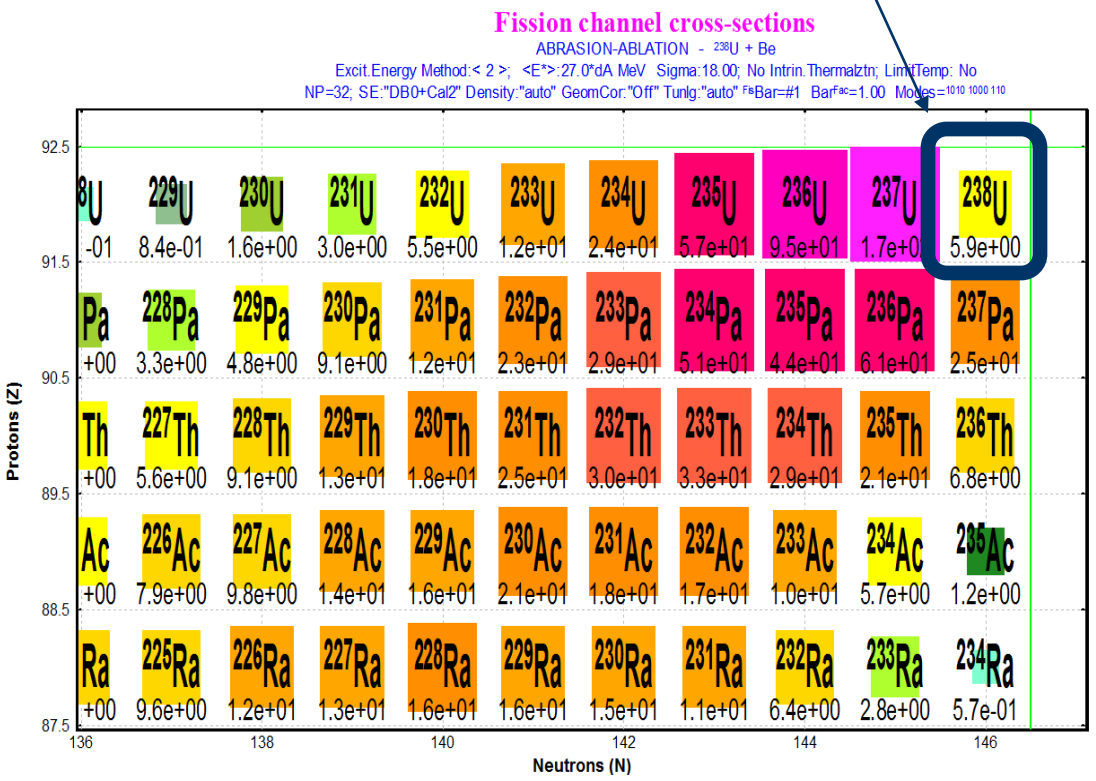
The default file* can be loaded from here
http://lise.nscl.msu.edu/10_1/fission.lpp

** as well used in the current calculations*

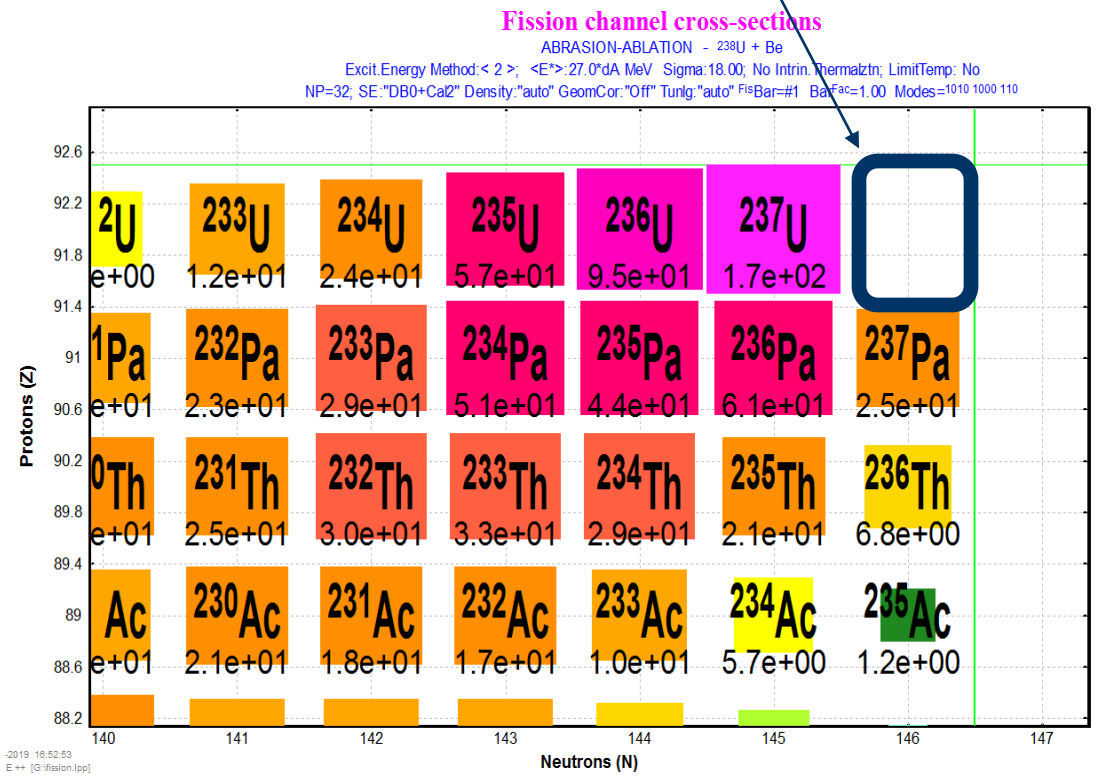
Reaction mechanism settings: Coulomb fission channel

238U (140.0 MeV/u) + Be

☑ Include Coulomb fission channel



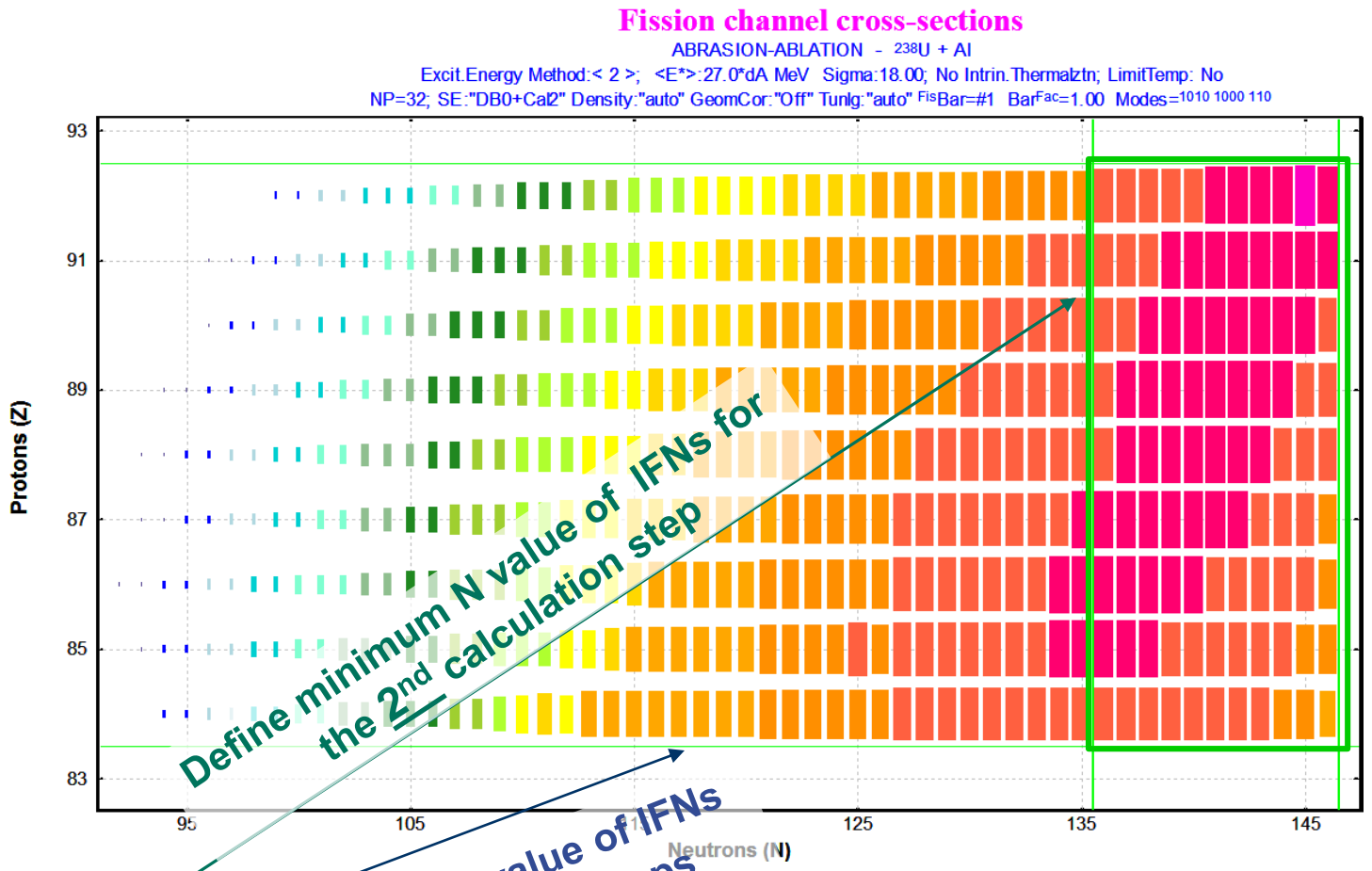
☐ Include Coulomb fission channel

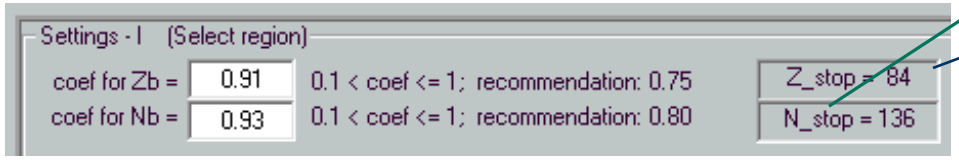


Important for heavy targets !

(though already sufficient for Z ≥13, so for ^{238}U(140 MeV/u) + Al → CoulFis=46mb

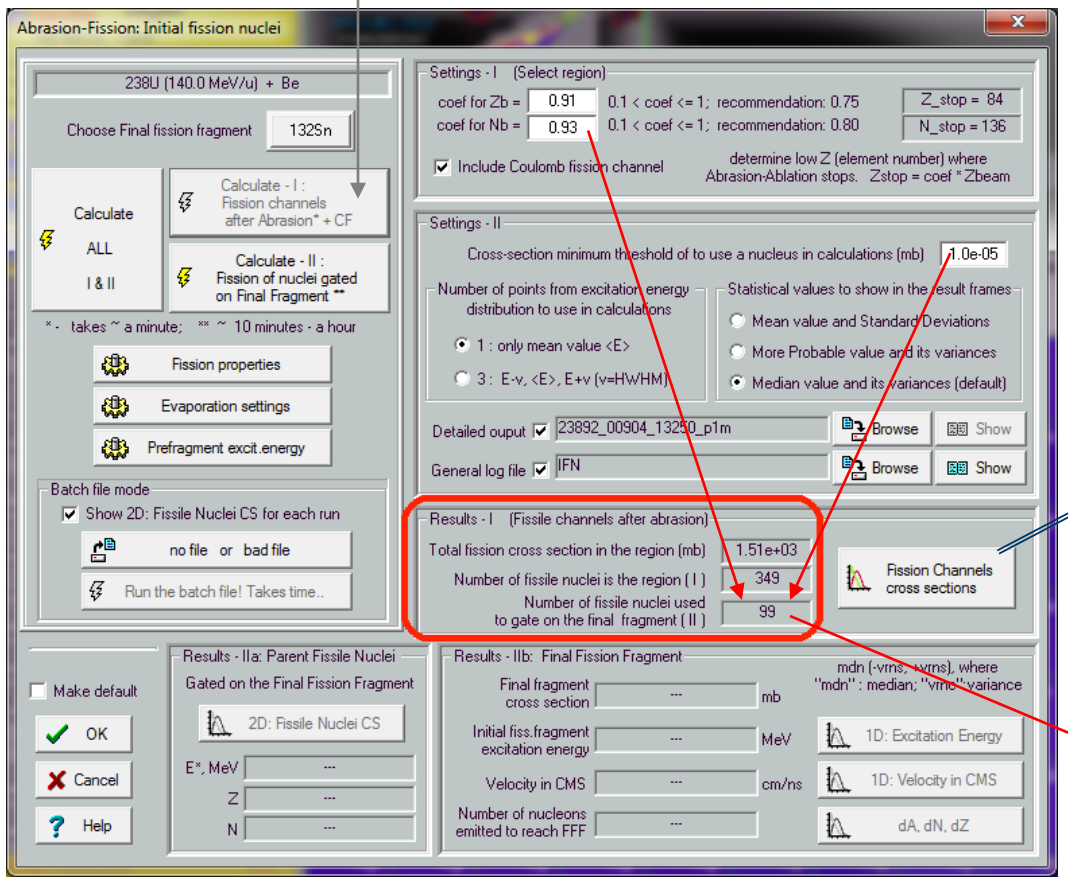
IFN area settings

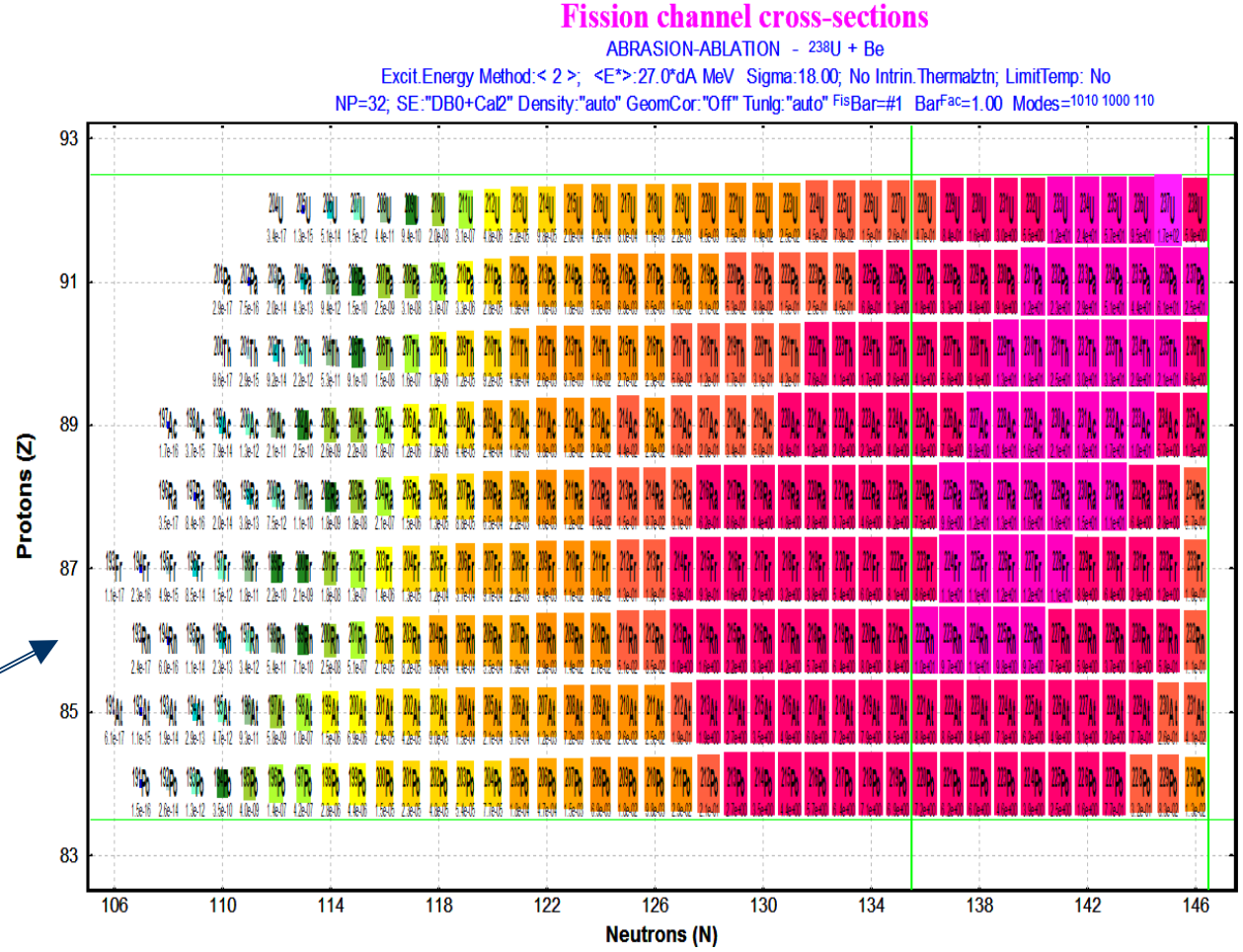




1st step calculation results

Not enable
(gray color)





99 isotopes will be used for the 2nd step calculations gated by the selected region (Z_stop, N_stop) and the cross-section threshold value (2nd step settings) from 349 isotopes calculated at Step #1.

2nd step calculation settings: N_p

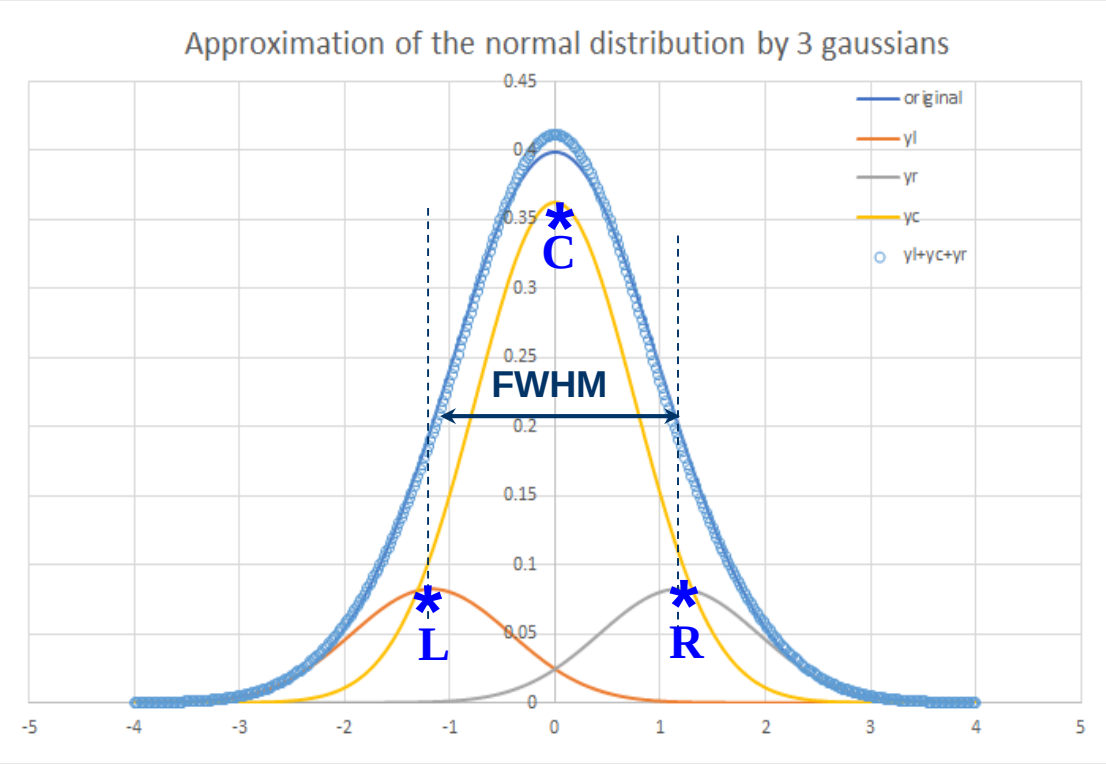
Number of points from excitation energy distribution to use in calculations

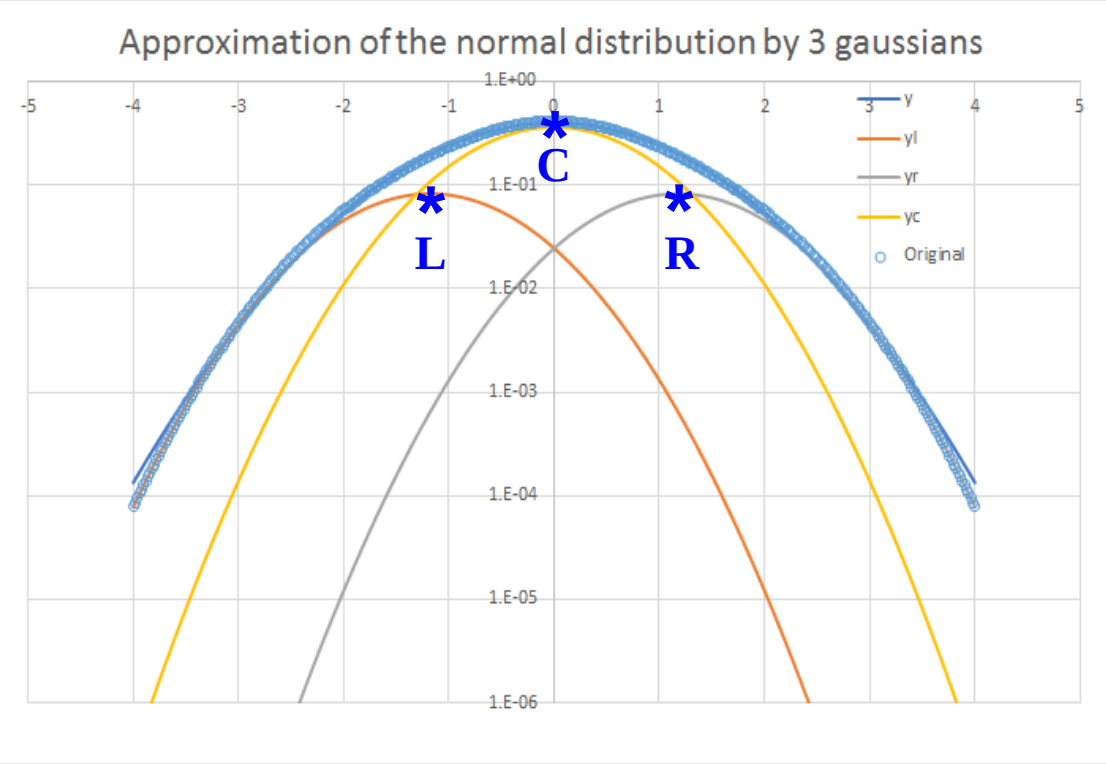
- (•) 1 : only mean value <E> → IFN1
- ( ) 3 : E-v, <E>, E+v (v=HWHM/2) → IFN3

Using 3 excitation energy points
(and evidently it takes 3 times more than IFN1 method)

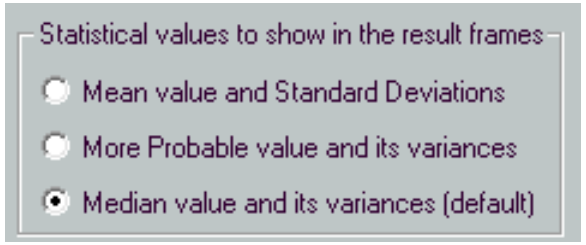
Sigma2 = 0.75627* Sigma1

AreaL	15.64%
AreaC	68.72%
AreaR	15.64%



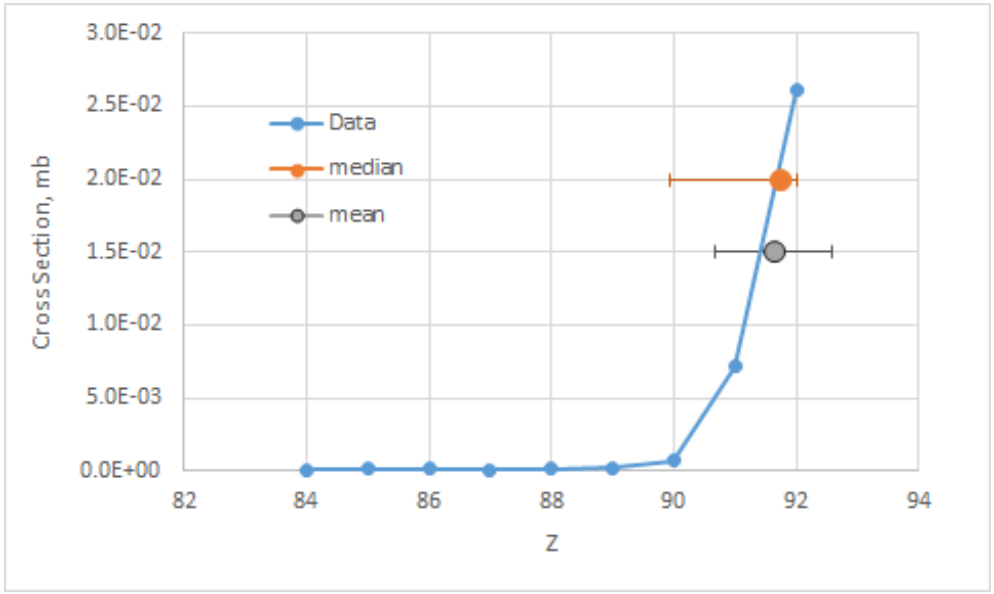


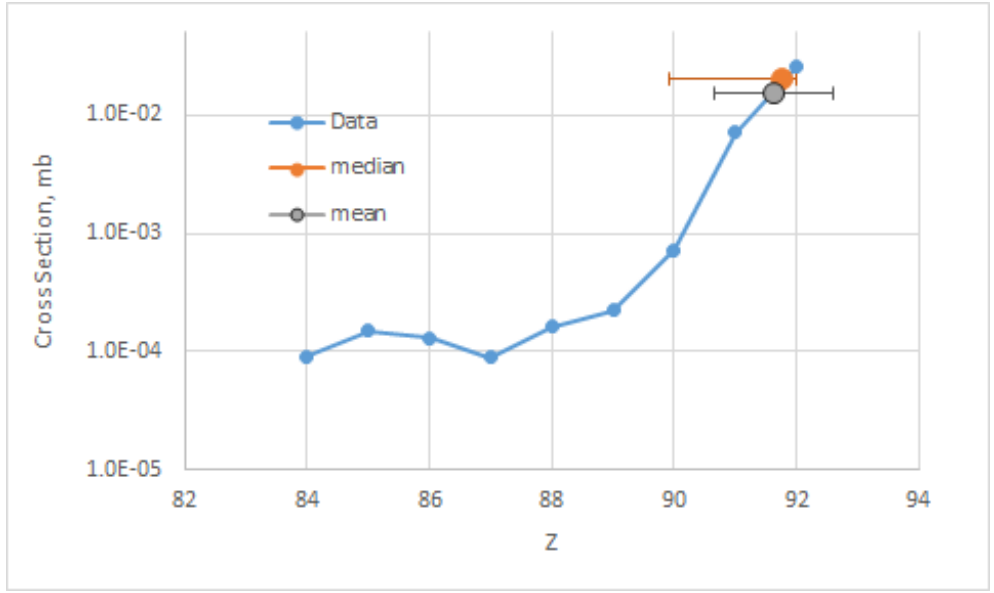
2nd step calculation settings: Statistics



with “more probable value” choice might be troubles in the case of two similar peaks

recommended





2nd step calculation settings: Outputs

Detailed output file for the selected final fission fragment (FFF)

LISE++ proposes automatically file name,
The user can browse manually

Beam Target Fragment N_p Statistics

Region (0,1,2)

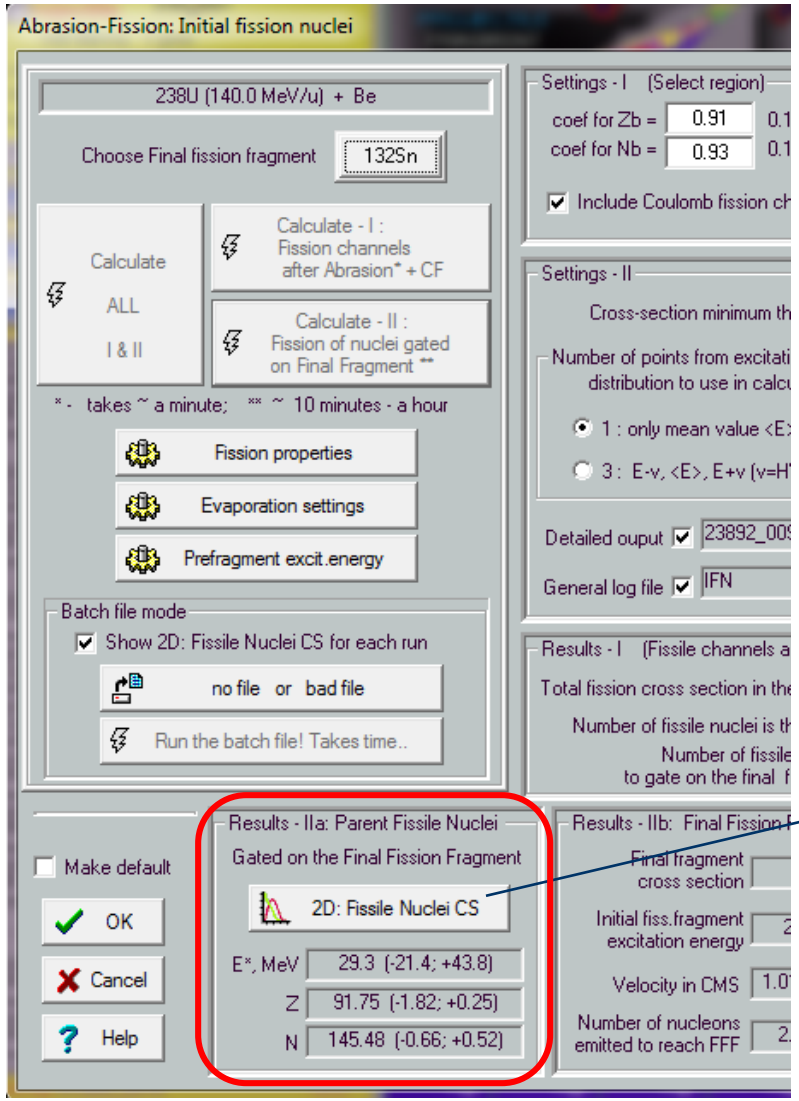
!~	El	Z	N	Pri	CS	E*	Vcm	dN	dZ
1	237U	92	145	0	1.33E-02	26.99	1.014	2.749	0
2	237Pa	91	146	0	5.56E-03	31.14	1.002	3.464	0
3	236U	92	144	0	6.41E-04	31.36	1.004	3.121	0
4	235U	92	143	0	1.06E-05	38.04	0.984	3.556	0
5	234U	92	142	0	5.86E-08	51.79	0.956	4.814	0
6	233U	92	141	0	3.02E-09	68.28	0.953	5.468	0
12	236Pa	91	145	0	1.57E-03	36.77	0.983	3.686	0
13	235Pa	91	144	0	2.75E-05	48.72	0.959	4.934	0
14	234Pa	91	143	0	4.70E-06	55.06	0.956	5.3	0
15	233Pa	91	142	0	4.46E-07	69.38	0.929	5.777	0
16	232Pa	91	141	0	1.42E-07	75.83	0.922	5.539	0
22	236Th	90	146	0	4.26E-04	44.01	0.957	4.925	0

Calculation result information for each calculation run.
Important in the Batch mode!

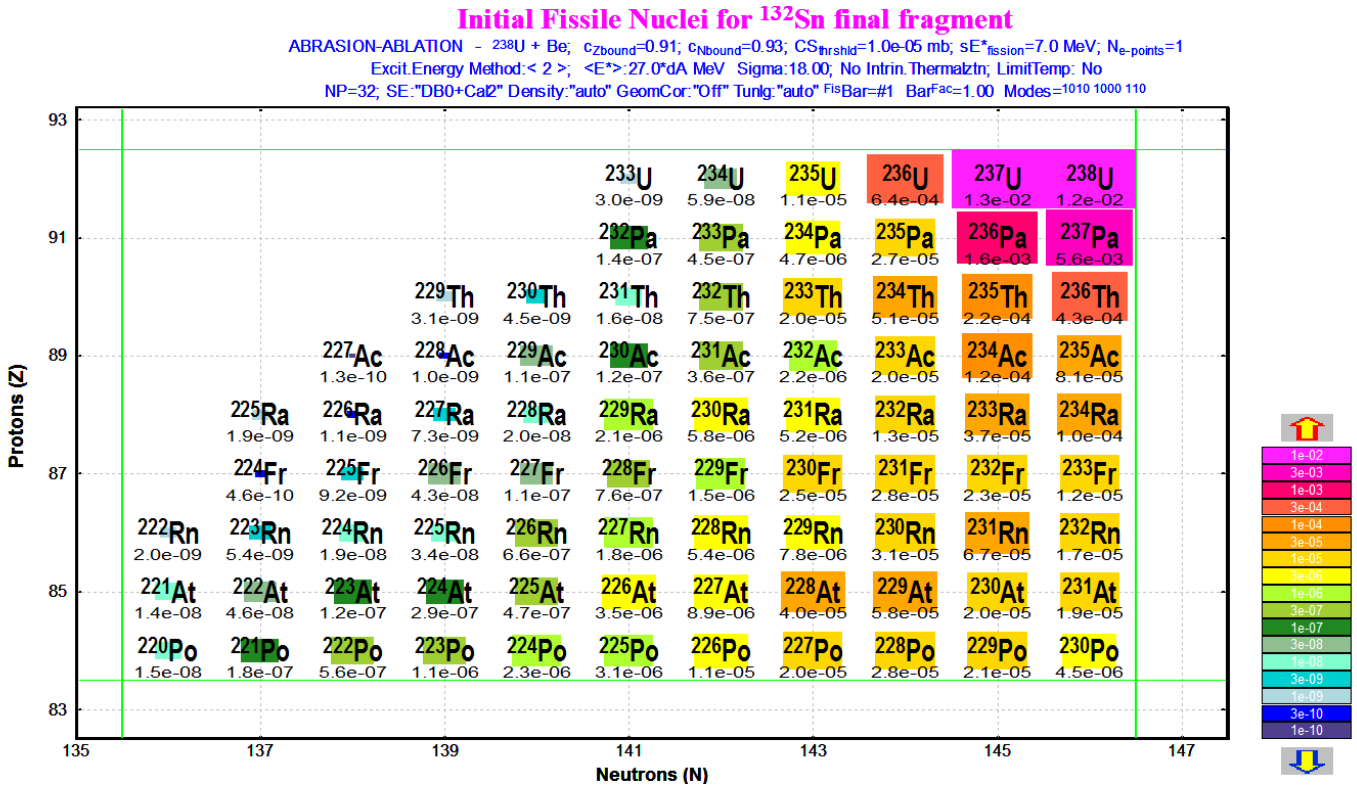
c:\user\c\lise_pp_11\CrossSections\IFN.log

! Date	Stop Time	Elapsed	El	Zff	Nf	Zstop	Nstop	Thrshld	TotalCS	N_FisN	Nused	N_P	Zpfn	-sZpfn	+sZpfn	Npfn	-sNpfn	+sNpfn	E*pfn	-sE*pfn	+sE*pfn	CSf	E*iff	-sE
19-02-19	14:52:45	35.4	132Sn	50	82	86	140	1.00e-05	1.336e+03	267	48	1	91.61	1.31	0.39	145.17	0.37	0.83	37.95	20.19	35.76	2.073e-02	29.60	6.1
19-02-19	14:54:44	110.0	132Sn	50	82	86	140	1.00e-05	1.336e+03	267	48	3	91.65	1.00	0.35	144.84	1.09	0.45	17.32	15.44	20.81	2.652e-01	19.15	6.0
19-02-19	19:35:49	96.7	132Sn	50	82	86	140	1.00e-05	1.336e+03	267	48	1	91.61	1.31	0.39	145.17	0.37	0.83	37.95	20.19	35.76	2.073e-02	29.60	6.1
20-02-19	17:00:44	5.4	110Rh	45	65	89	143	1.00e-05	9.770e+02	147	15	1	91.30	1.08	0.70	143.64	0.64	0.94	64.91	29.25	41.48	8.207e+00	41.84	10
20-02-19	17:00:50	5.4	111Rh	45	66	89	143	1.00e-05	9.770e+02	147	15	1	91.48	1.18	0.52	144.07	0.73	1.04	55.51	26.24	41.15	1.626e+01	38.18	8.8
20-02-19	17:00:55	5.4	112Rh	45	67	89	143	1.00e-05	9.770e+02	147	15	1	91.53	1.12	0.47	144.41	0.93	0.74	50.04	24.17	38.47	1.553e+01	35.02	7.8
20-02-19	17:01:01	5.4	113Rh	45	68	89	143	1.00e-05	9.770e+02	147	15	1	91.57	1.10	0.43	144.63	1.05	0.59	46.10	22.77	36.19	1.861e+01	34.11	7.3
20-02-19	17:02:43	4.8	110Rh	45	65	90	142	1.00e-05	8.428e+02	108	14	1	91.34	0.86	0.66	143.43	0.89	1.12	68.94	30.88	38.59	9.318e+00	44.13	11
20-02-19	17:02:48	4.8	111Rh	45	66	90	142	1.00e-05	8.428e+02	108	14	1	91.50	0.97	0.50	143.93	1.25	0.83	56.97	26.90	39.06	1.700e+01	38.88	9.3
20-02-19	17:02:52	4.7	112Rh	45	67	90	142	1.00e-05	8.428e+02	108	14	1	91.55	0.95	0.45	144.37	1.08	0.77	50.27	24.26	36.36	1.567e+01	35.13	7.9
20-02-19	17:02:57	4.8	113Rh	45	68	90	142	1.00e-05	8.428e+02	108	14	1	91.59	0.94	0.41	144.62	1.16	0.59	45.86	22.69	33.29	1.848e+01	34.04	7.3
20-02-19	17:03:32	5.2	110Rh	45	65	90	142	1.00e-05	8.428e+02	108	14	1	91.34	0.86	0.66	143.43	0.89	1.12	68.94	30.88	38.59	9.318e+00	44.13	11
20-02-19	17:03:39	6.4	111Rh	45	66	90	142	1.00e-05	8.428e+02	108	14	1	91.50	0.97	0.50	143.93	1.25	0.83	56.97	26.90	39.06	1.700e+01	38.88	9.3
20-02-19	17:03:43	4.7	112Rh	45	67	90	142	1.00e-05	8.428e+02	108	14	1	91.55	0.95	0.45	144.37	1.08	0.77	50.27	24.26	36.36	1.567e+01	35.13	7.9
20-02-19	17:03:48	4.8	113Rh	45	68	90	142	1.00e-05	8.428e+02	108	14	1	91.59	0.94	0.41	144.62	1.16	0.59	45.86	22.69	33.29	1.848e+01	34.04	7.3

2nd step calculation results: Initial Fissile Nuclei (IFN) gated to the selected Final Fission Fragment (FFF) - a

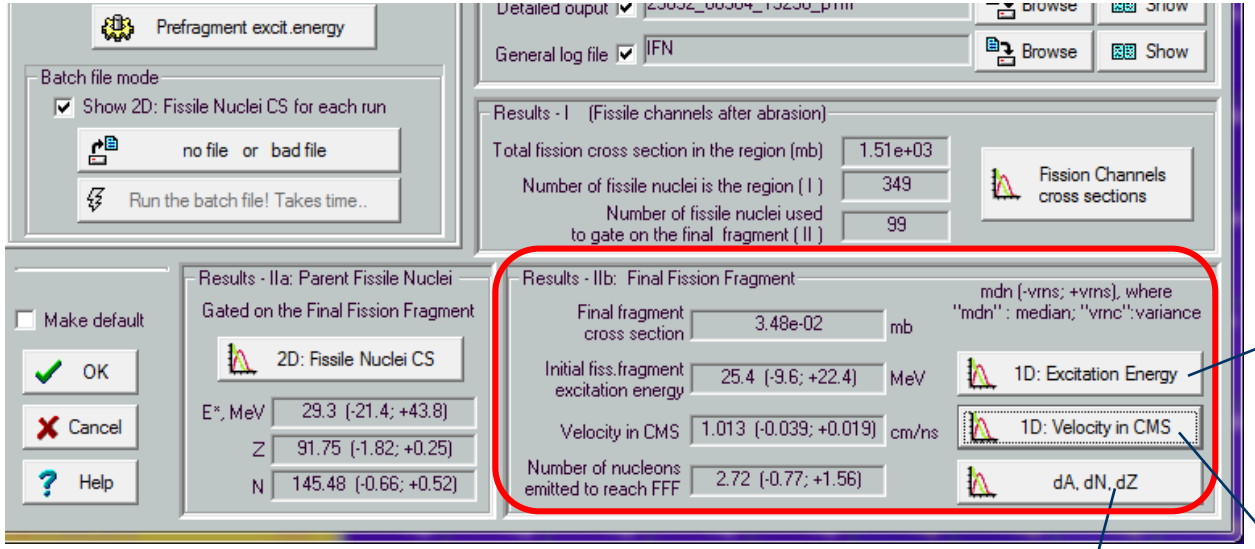


FFF=^{132}Sn, N_p=1; Small IFN region (99)



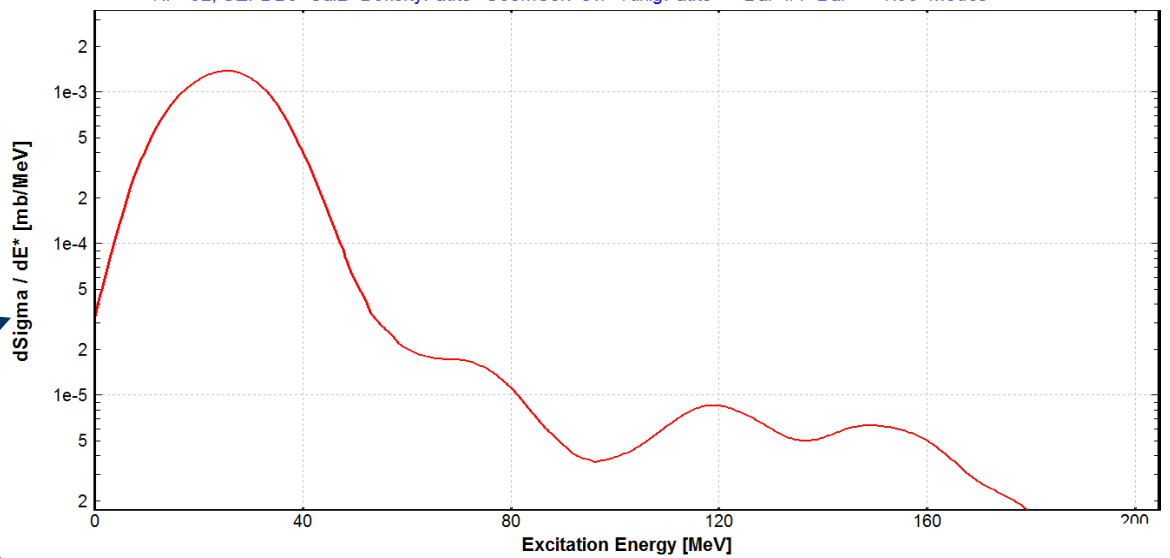
2nd step calculation results: Final Fission Fragment (FFF) - a

FFF=^{132}Sn, N_p=1; Small IFN region (99)



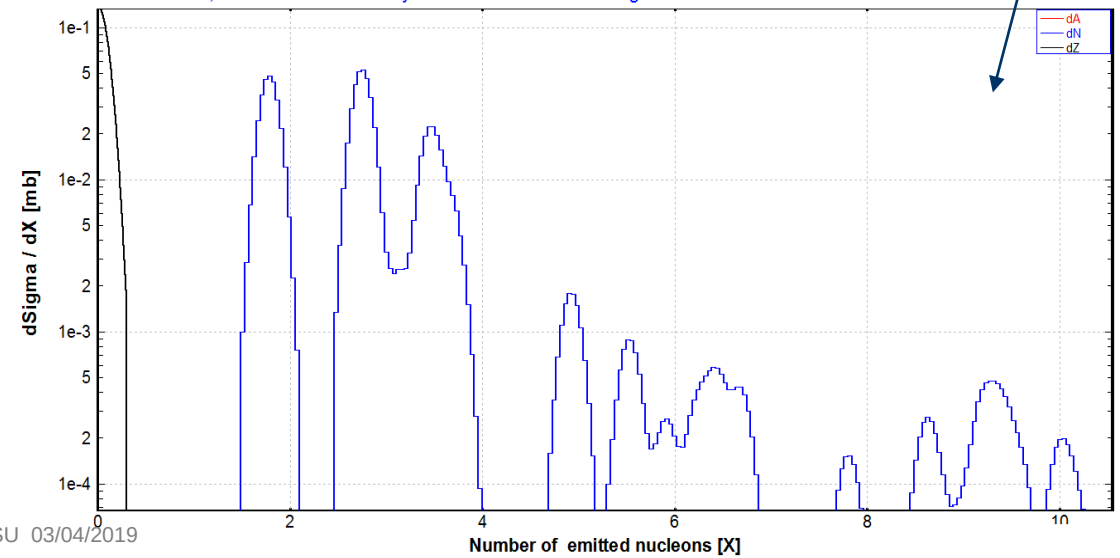
Excitation energy of initial fission fragments coming to ^{132}Sn final fragment

ABRASION-ABLATION - ^{238}U + Be; c_{Zbound}=0.91; c_{Nbound}=0.93; $CS_{thrshld}$=1.0e-05 mb; $sE^*_{fission}$=7.0 MeV; $N_{e\text{-}points}$=1
Excit.Energy Method:< 2 >; <E*>:27.0*dA MeV Sigma:18.00; No Intrin.Thermalztn; LimitTemp: No
NP=32; SE:"DB0+Cal2" Density:"auto" GeomCor:"Off" Tunlg:"auto" ^{Fis}Bar=#1 Bar^{Fac}=1.00 Modes=1010 1000 110



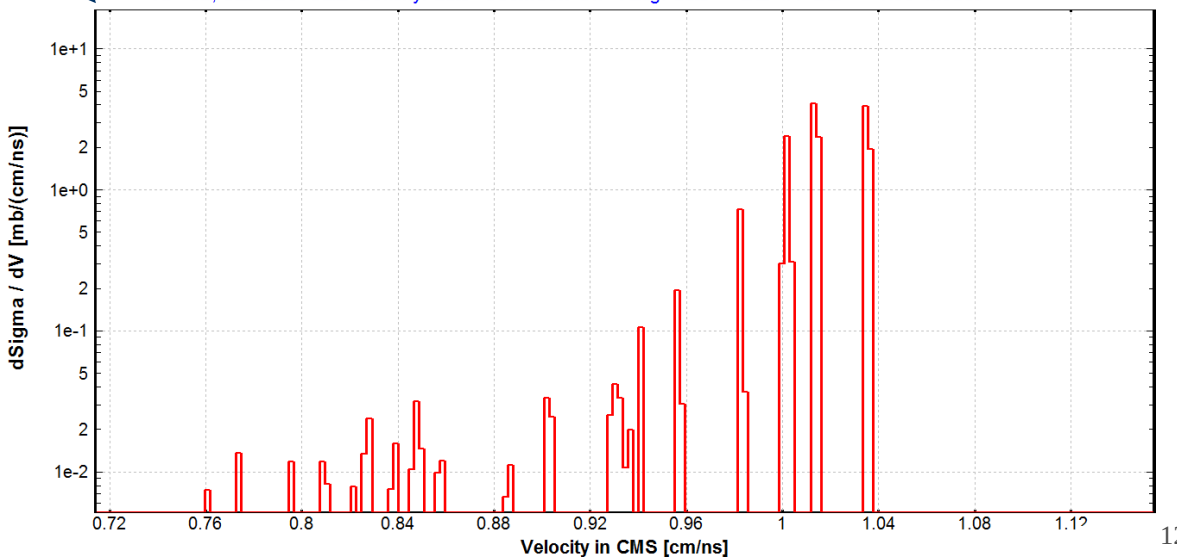
Emitted nucleons from initial fission fragment coming to ^{132}Sn

ABRASION-ABLATION - ^{238}U + Be; c_{Zbound}=0.91; c_{Nbound}=0.93; $CS_{thrshld}$=1.0e-05 mb; $sE^*_{fission}$=7.0 MeV; $N_{e\text{-}points}$=1
Excit.Energy Method:< 2 >; <E*>:27.0*dA MeV Sigma:18.00; No Intrin.Thermalztn; LimitTemp: No
NP=32; SE:"DB0+Cal2" Density:"auto" GeomCor:"Off" Tunlg:"auto" ^{Fis}Bar=#1 Bar^{Fac}=1.00 Modes=1010 1000 110

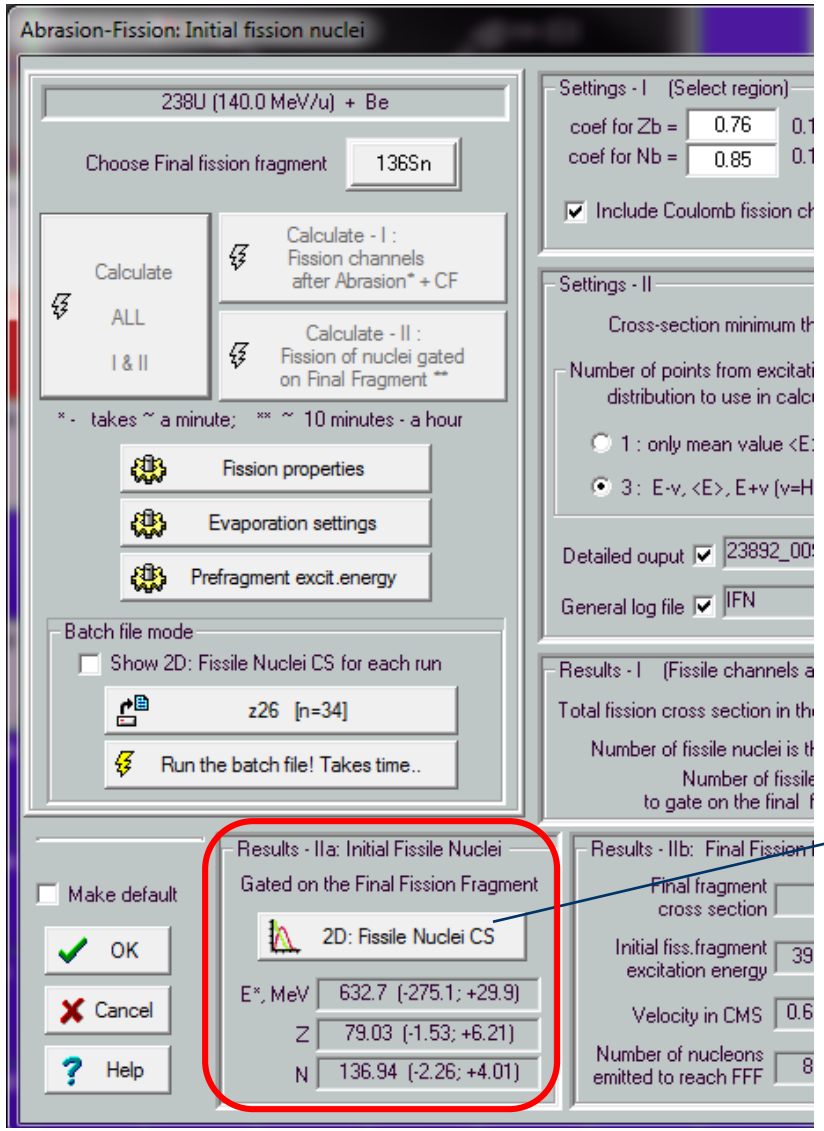


^{132}Sn final fragment velocity in CMS

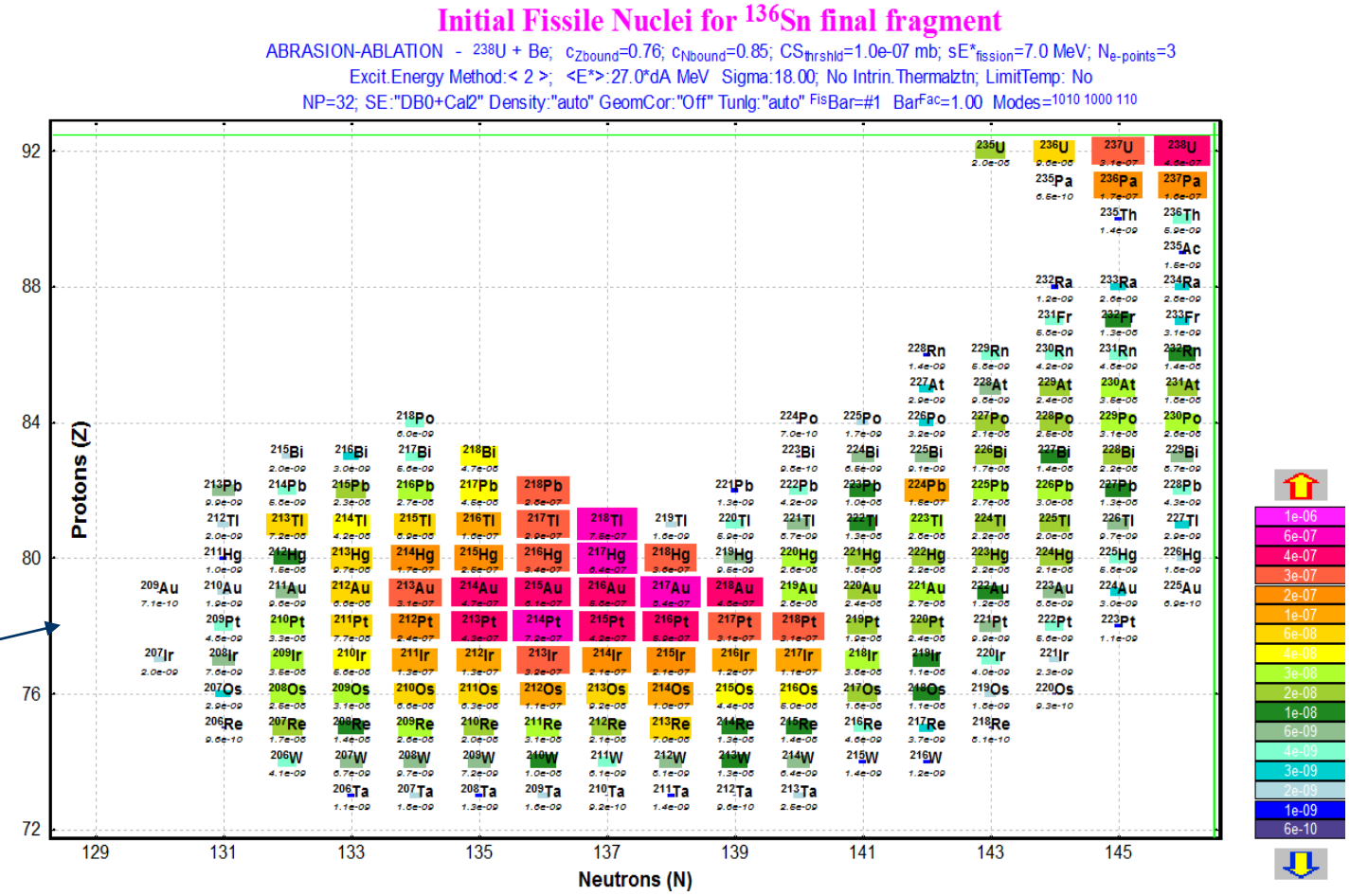
ABRASION-ABLATION - ^{238}U + Be; c_{Zbound}=0.91; c_{Nbound}=0.93; $CS_{thrshld}$=1.0e-05 mb; $sE^*_{fission}$=7.0 MeV; $N_{e\text{-}points}$=1
Excit.Energy Method:< 2 >; <E*>:27.0*dA MeV Sigma:18.00; No Intrin.Thermalztn; LimitTemp: No
NP=32; SE:"DB0+Cal2" Density:"auto" GeomCor:"Off" Tunlg:"auto" ^{Fis}Bar=#1 Bar^{Fac}=1.00 Modes=1010 1000 110



2nd step calculation results: Initial Fissile Nuclei (IFN) gated to the selected Final Fission Fragment (FFF) - b

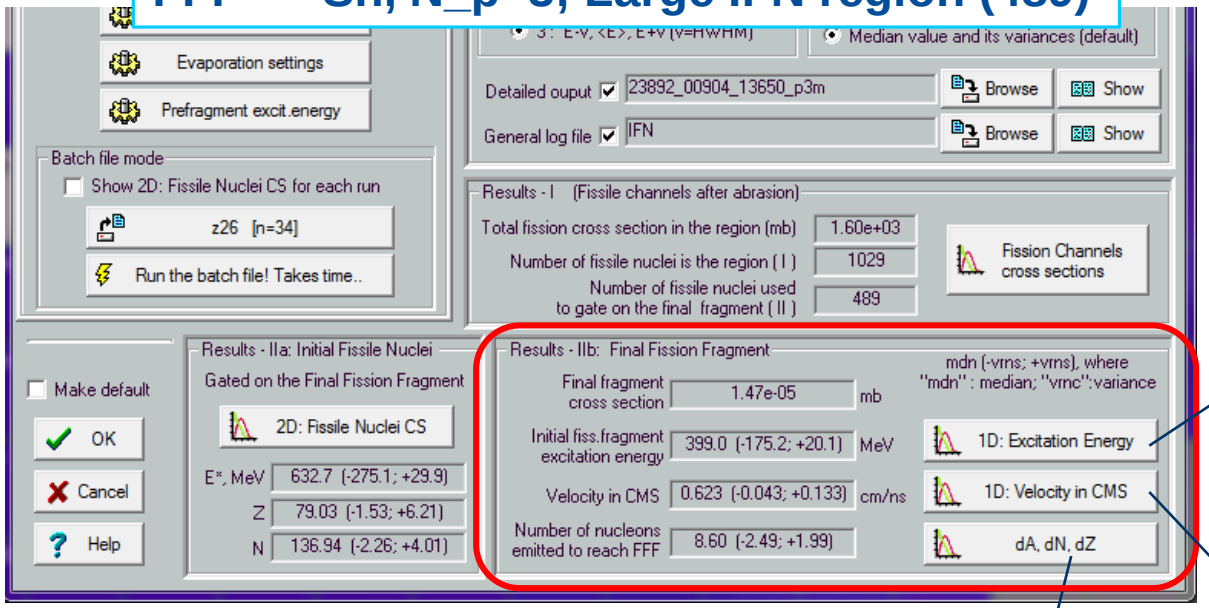


FFF=^{136}Sn, N_p=3; Large IFN region (489)



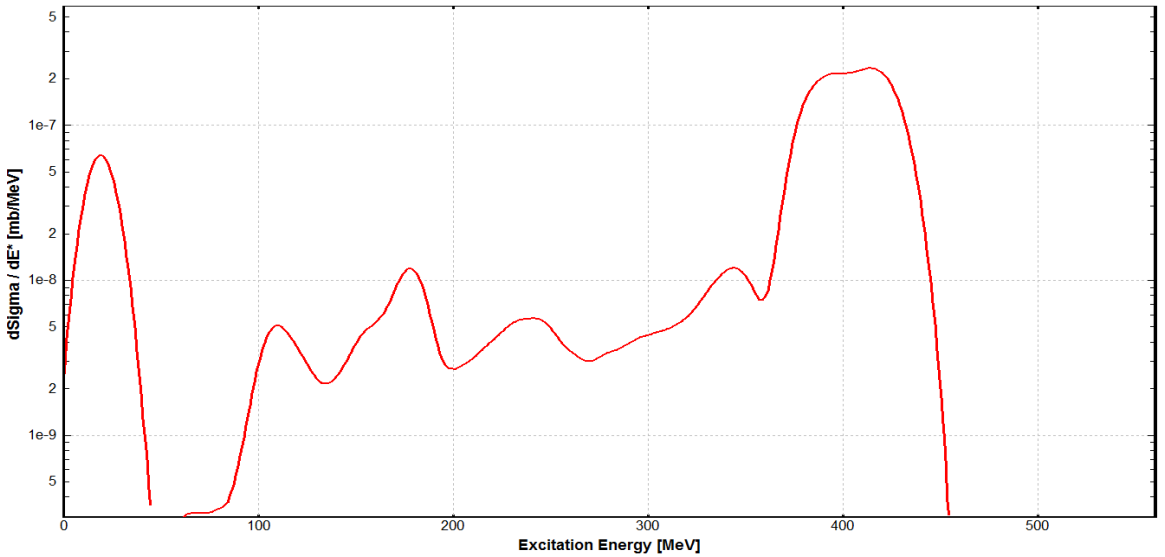
2nd step calculation results: Final Fission Fragment (FFF) - b

FFF=^{136}Sn, N_p=3; Large IFN region (489)



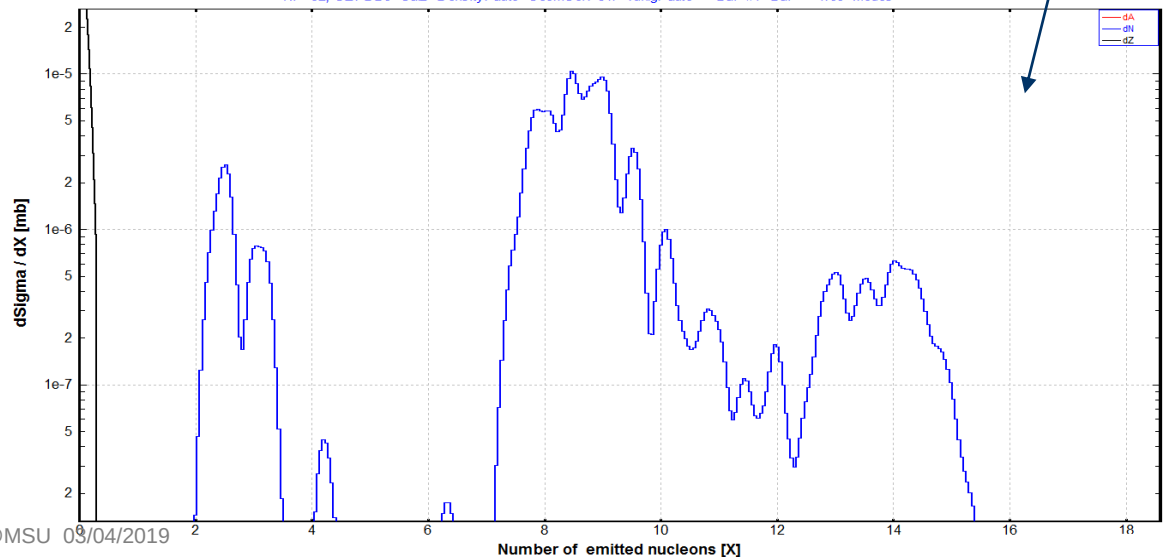
Excitation energy of initial fission fragments coming to ^{136}Sn final fragment

ABRASION-ABLATION - ^{238}U + Be; c_{Zbound}=0.76; c_{Nbound}=0.85; $CS_{thrshld}$=1.0e-07 mb; $sE^*_{fission}$=7.0 MeV; $N_{e\text{-}points}$=3
Excit.Energy Method:< 2 >; <E*>:27.0*dA MeV Sigma:18.00; No Intrin.Thermaltn; LimitTemp: No
NP=32; SE:"DB0+Cal2" Density:"auto" GeomCor:"Off" Tunlg:"auto" ^{Fis}Bar=#1 Bar^{Fac}=1.00 Modes=1010 1000 110



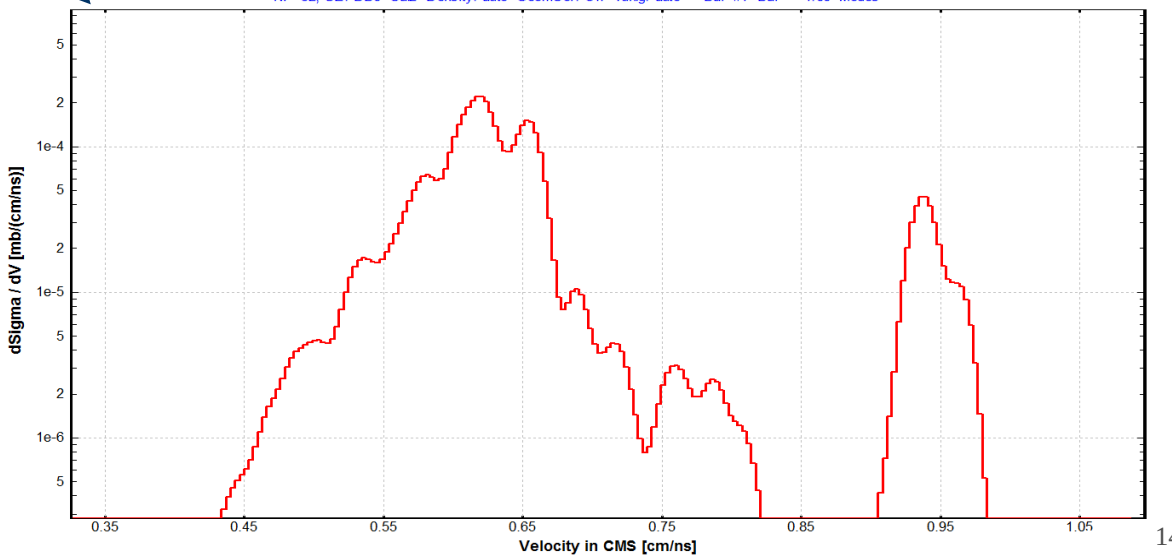
Emitted nucleons from initial fission fragment coming to ^{136}Sn

ABRASION-ABLATION - ^{238}U + Be; c_{Zbound}=0.76; c_{Nbound}=0.85; $CS_{thrshld}$=1.0e-07 mb; $sE^*_{fission}$=7.0 MeV; $N_{e\text{-}points}$=3
Excit.Energy Method:< 2 >; <E*>:27.0*dA MeV Sigma:18.00; No Intrin.Thermaltn; LimitTemp: No
NP=32; SE:"DB0+Cal2" Density:"auto" GeomCor:"Off" Tunlg:"auto" ^{Fis}Bar=#1 Bar^{Fac}=1.00 Modes=1010 1000 110

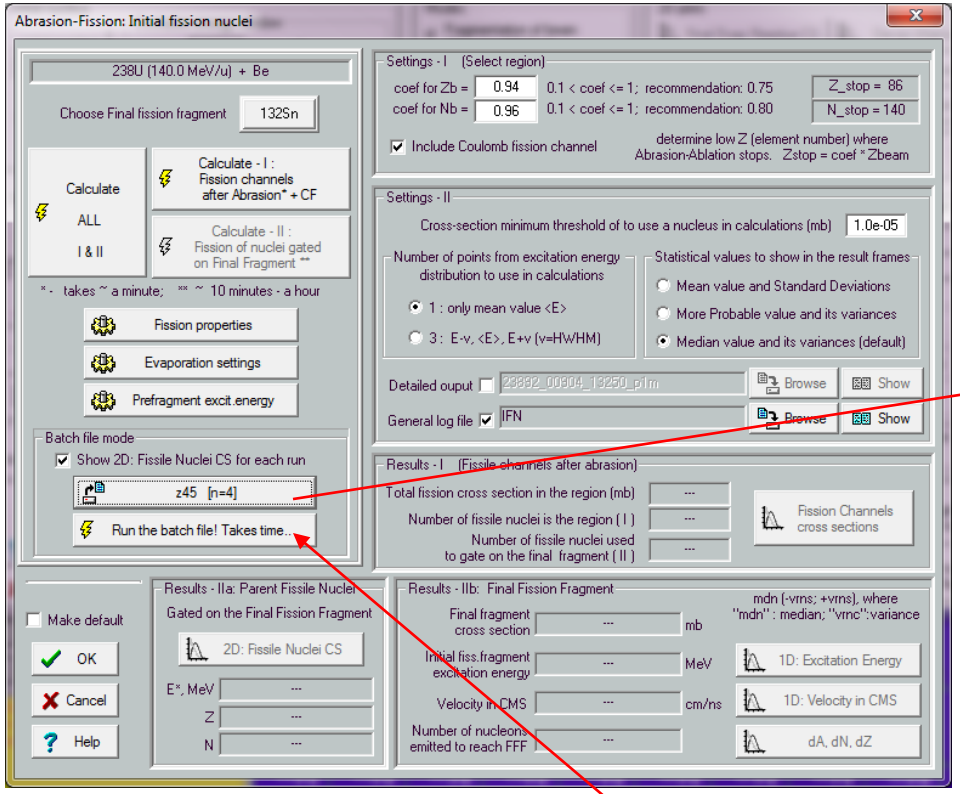


^{136}Sn final fragment velocity in CMS

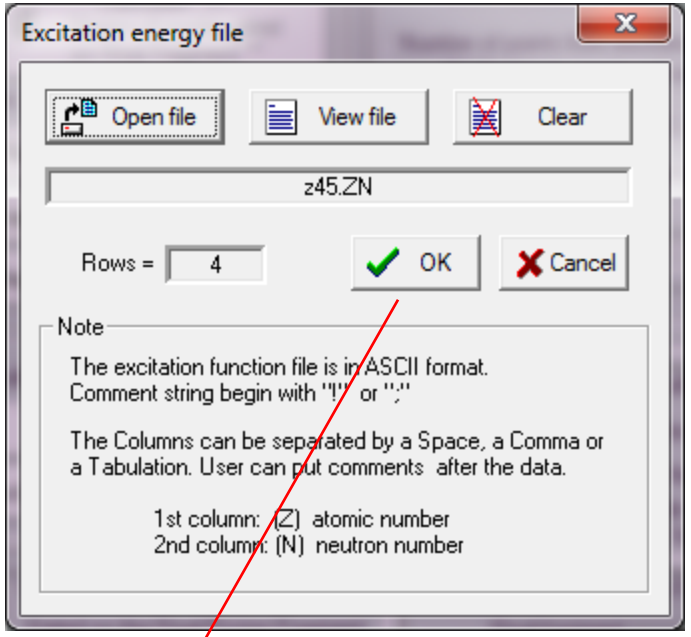
ABRASION-ABLATION - ^{238}U + Be; c_{Zbound}=0.76; c_{Nbound}=0.85; $CS_{thrshld}$=1.0e-07 mb; $sE^*_{fission}$=7.0 MeV; $N_{e\text{-}points}$=3
Excit.Energy Method:< 2 >; <E*>:27.0*dA MeV Sigma:18.00; No Intrin.Thermaltn; LimitTemp: No
NP=32; SE:"DB0+Cal2" Density:"auto" GeomCor:"Off" Tunlg:"auto" ^{Fis}Bar=#1 Bar^{Fac}=1.00 Modes=1010 1000 110



Batch mode



"ZN" extension
Two-columns (Z,N) file

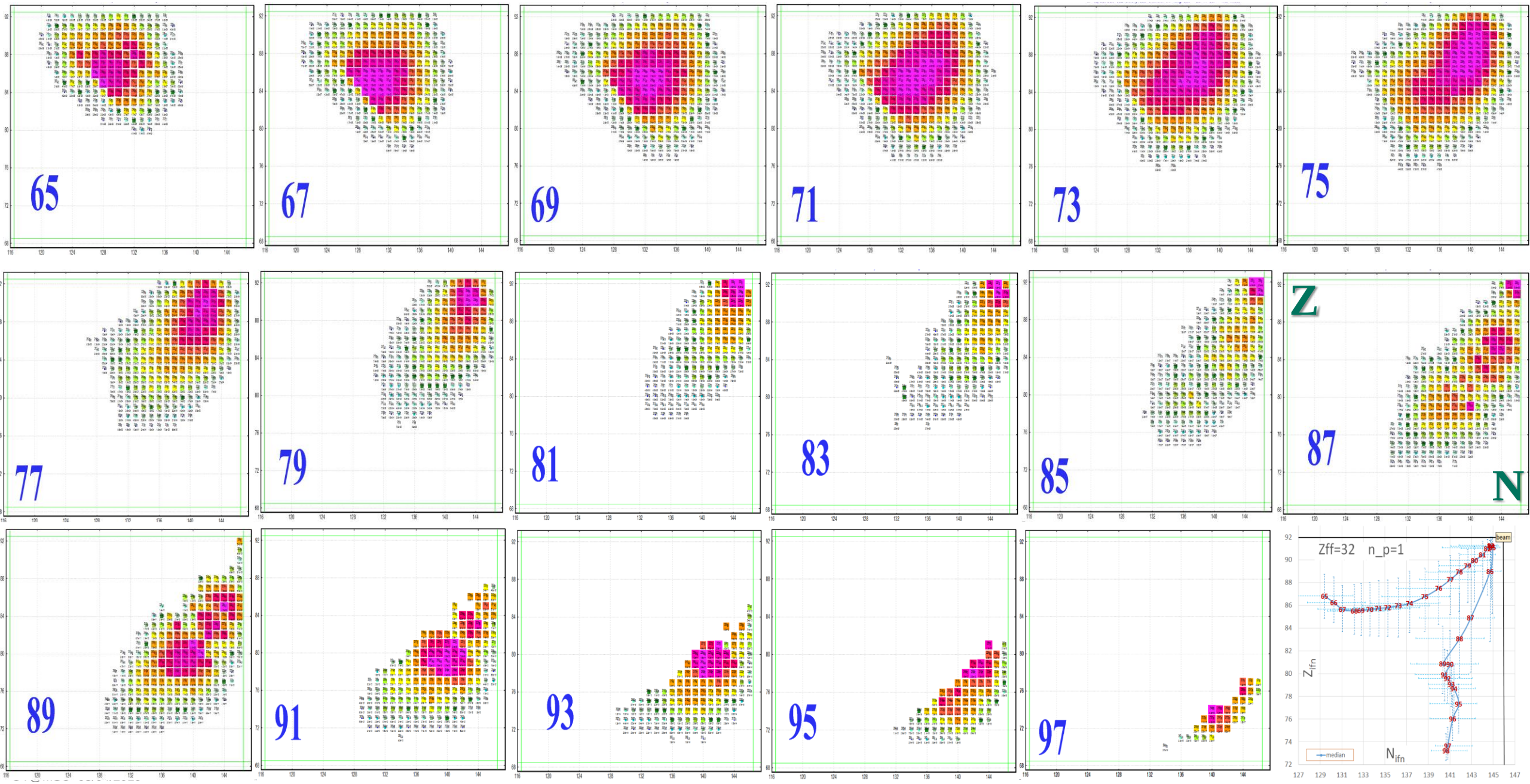


RUN

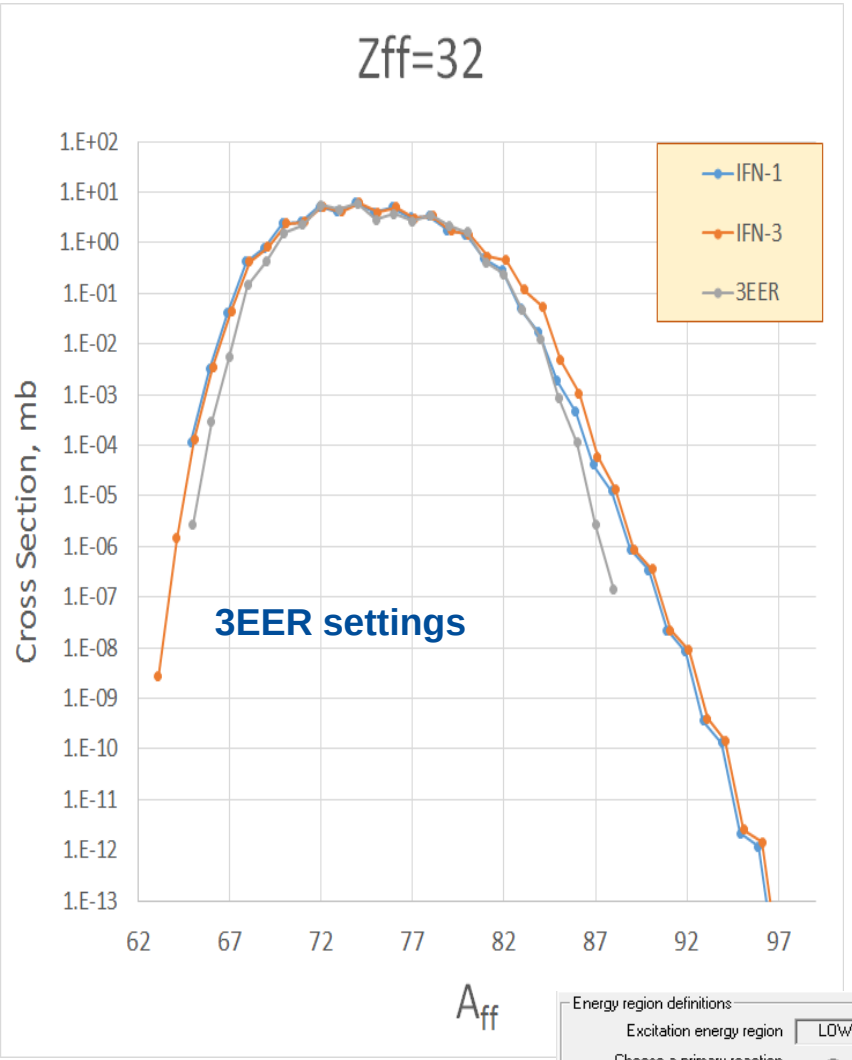
It takes time!

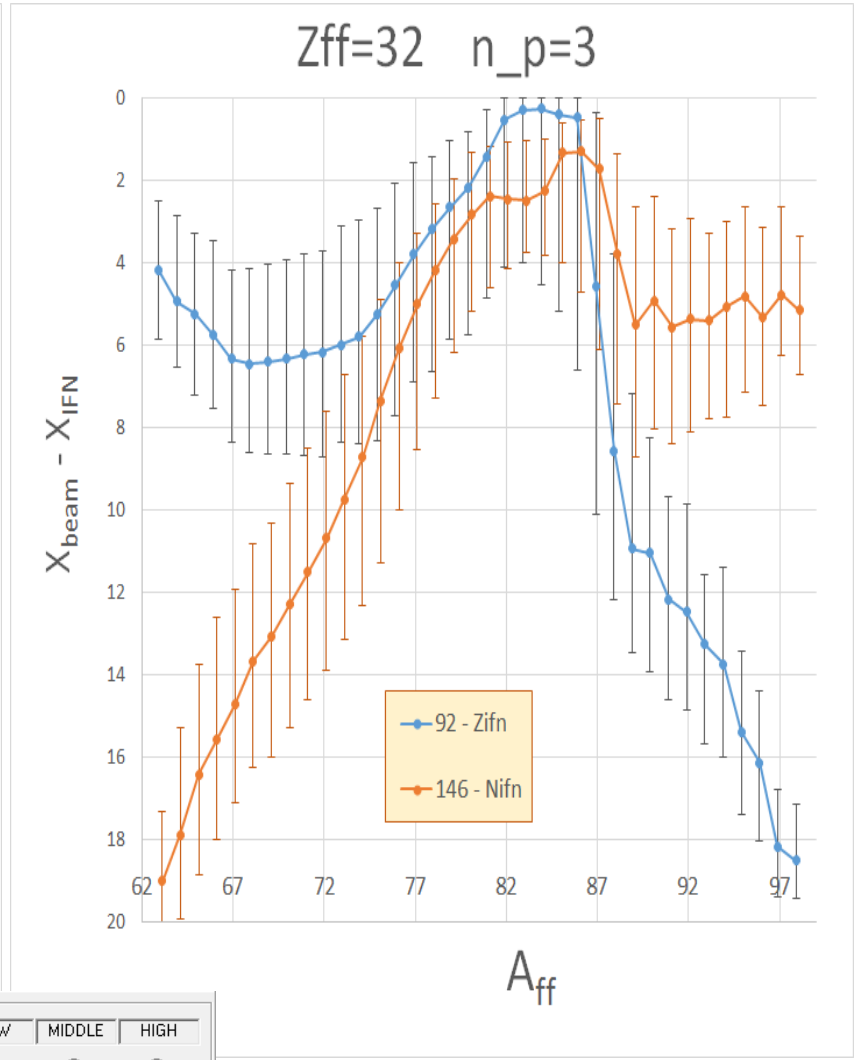
1st and 2nd steps settings will be used for all runs!

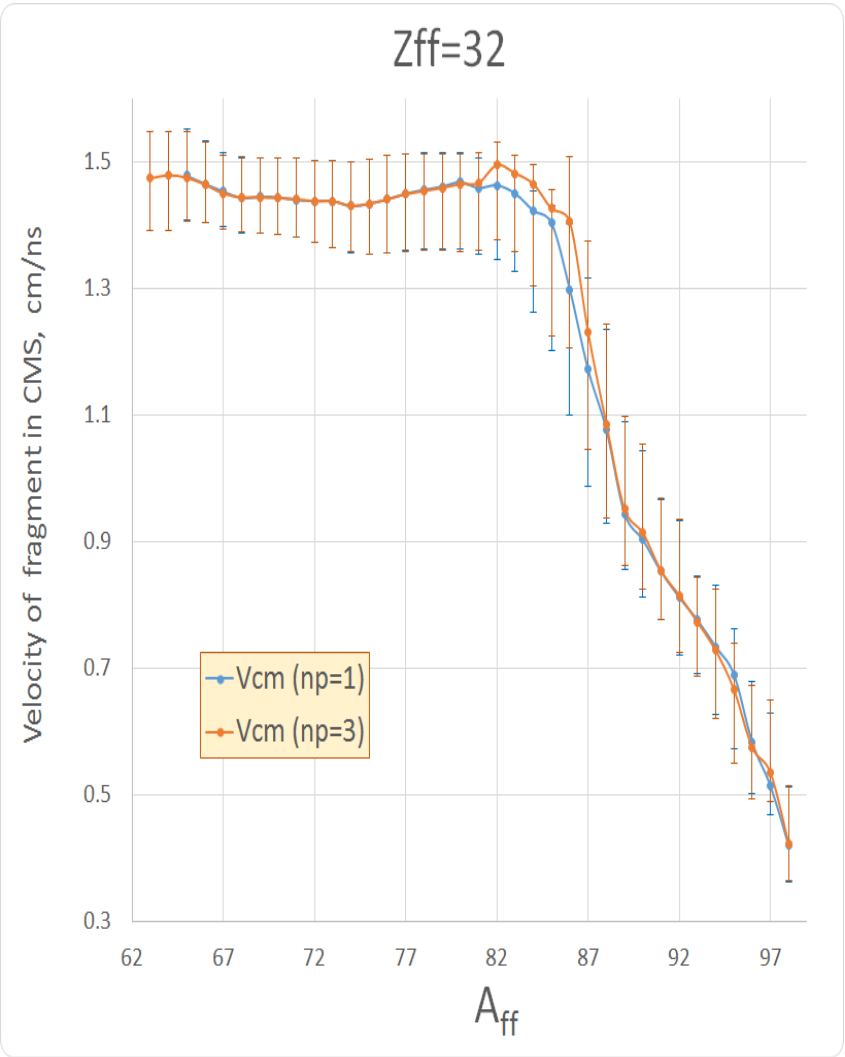
Initial Fissile Nuclei (IFN) for final Ge-isotopes (Z=32)

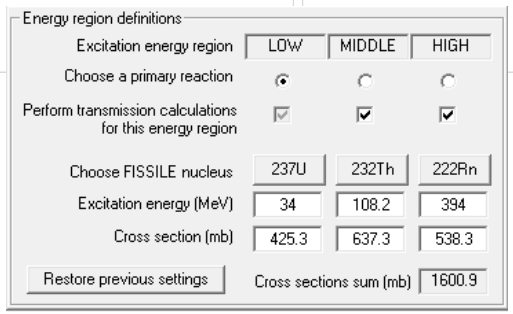


IFN-analysis for final Ge-isotopes (Z=32) : a

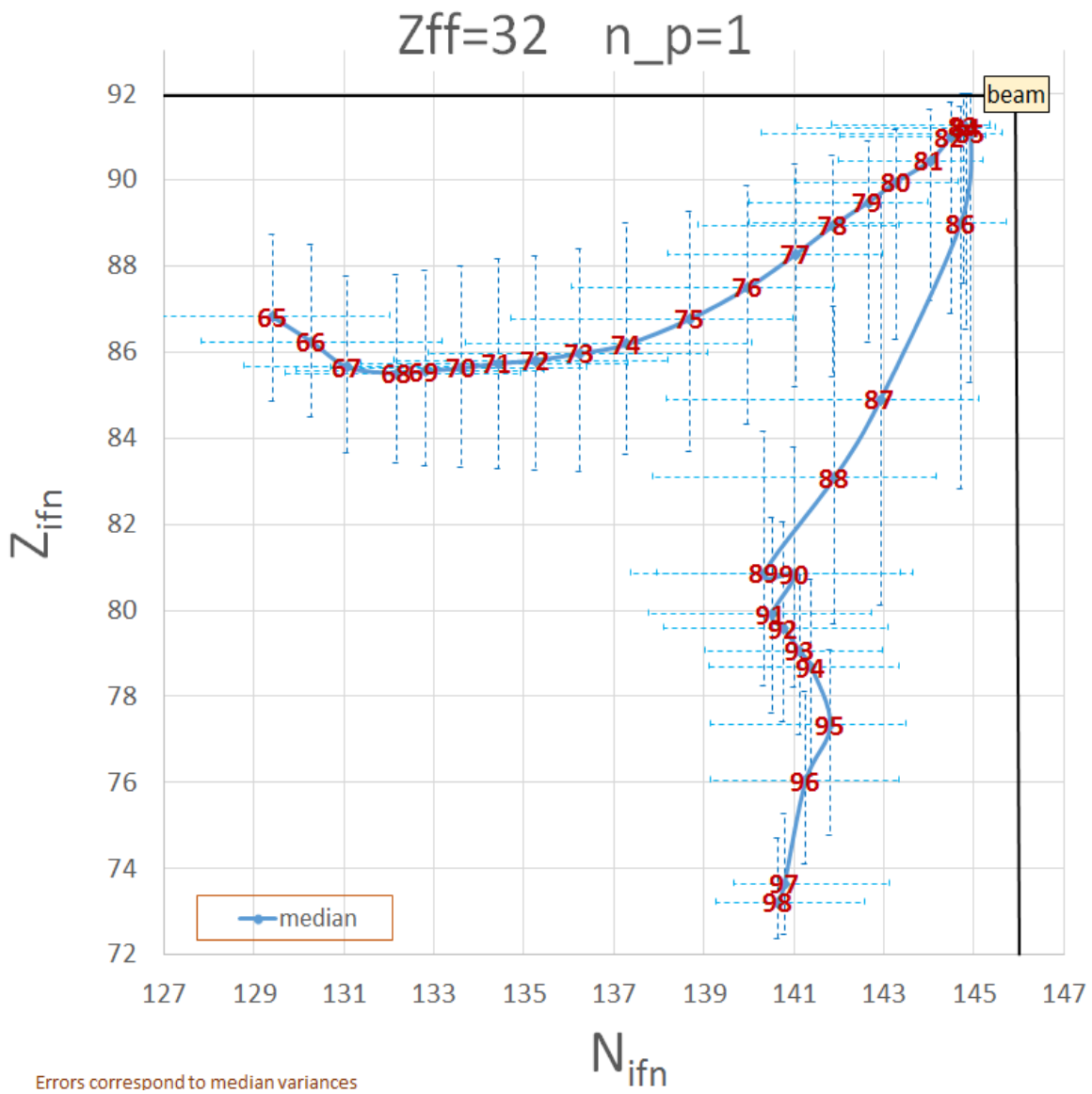


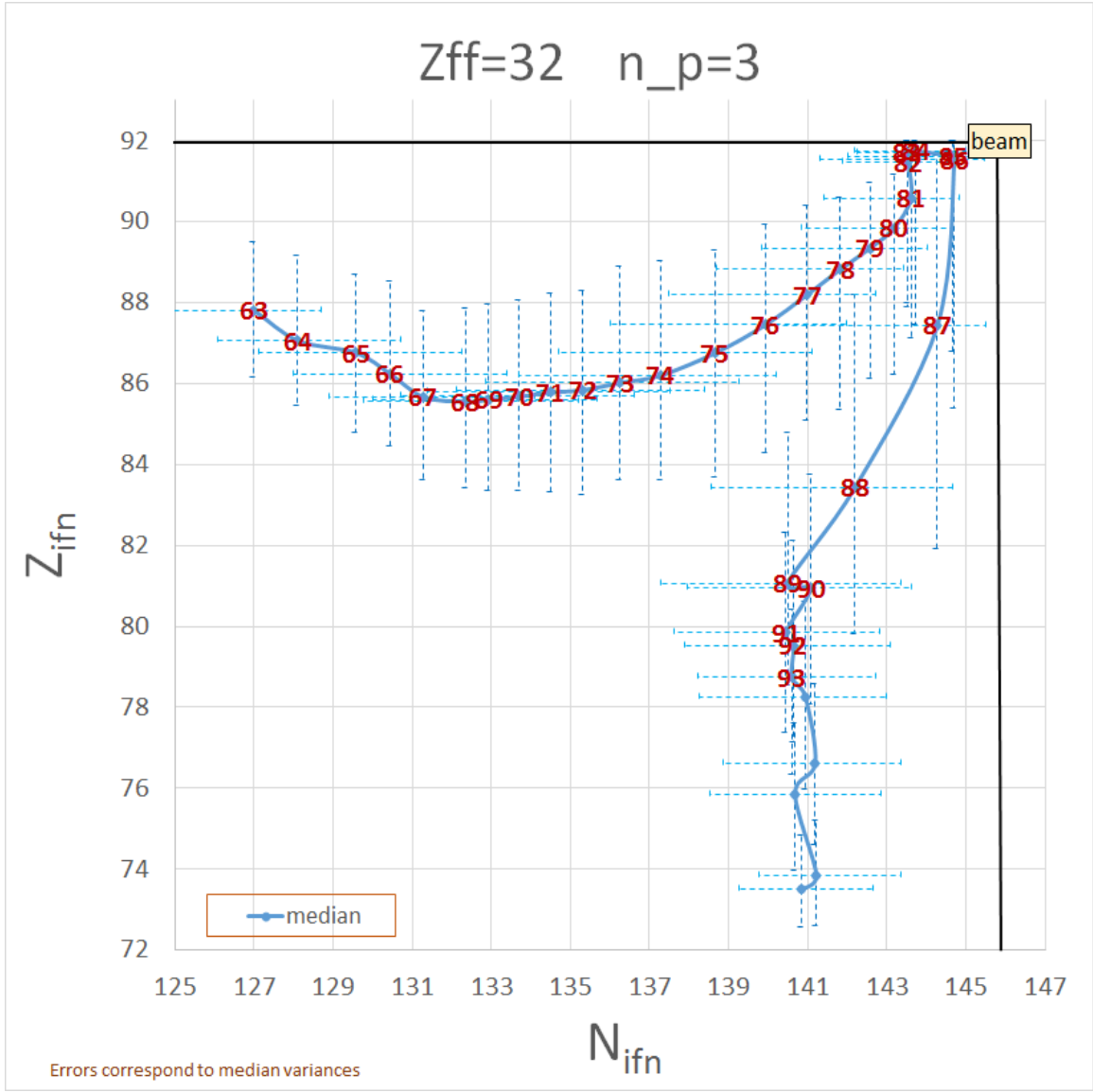




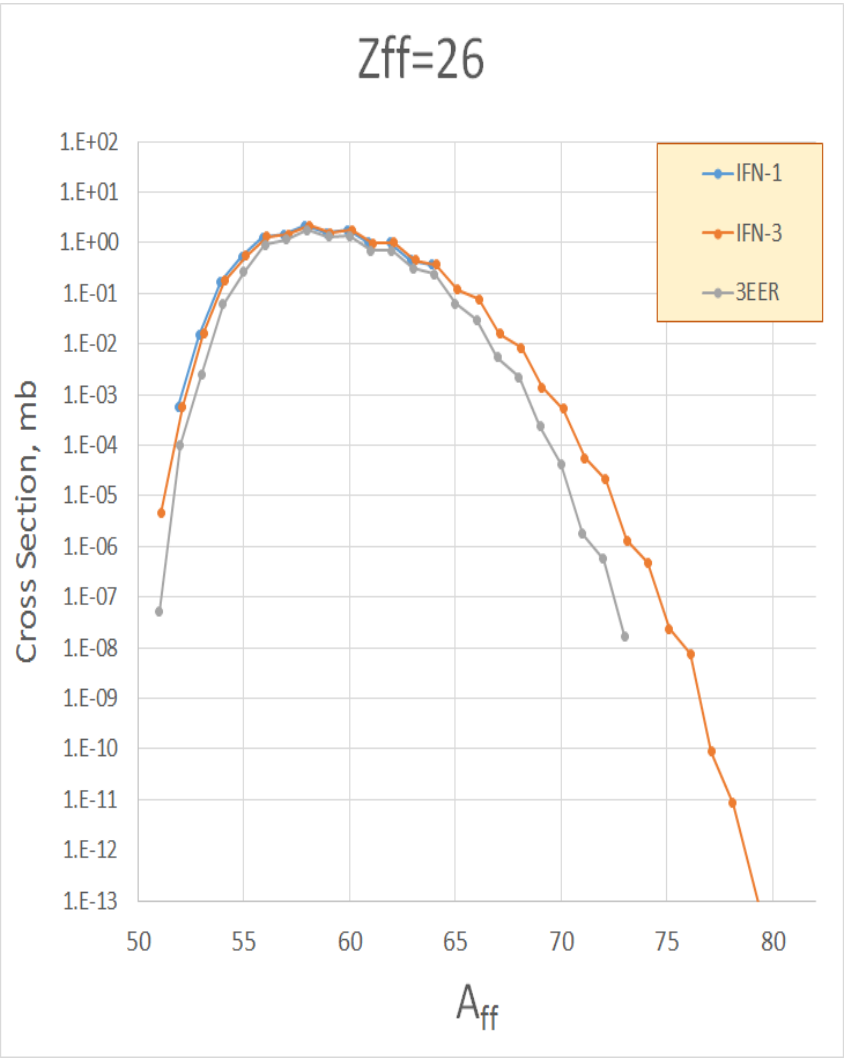


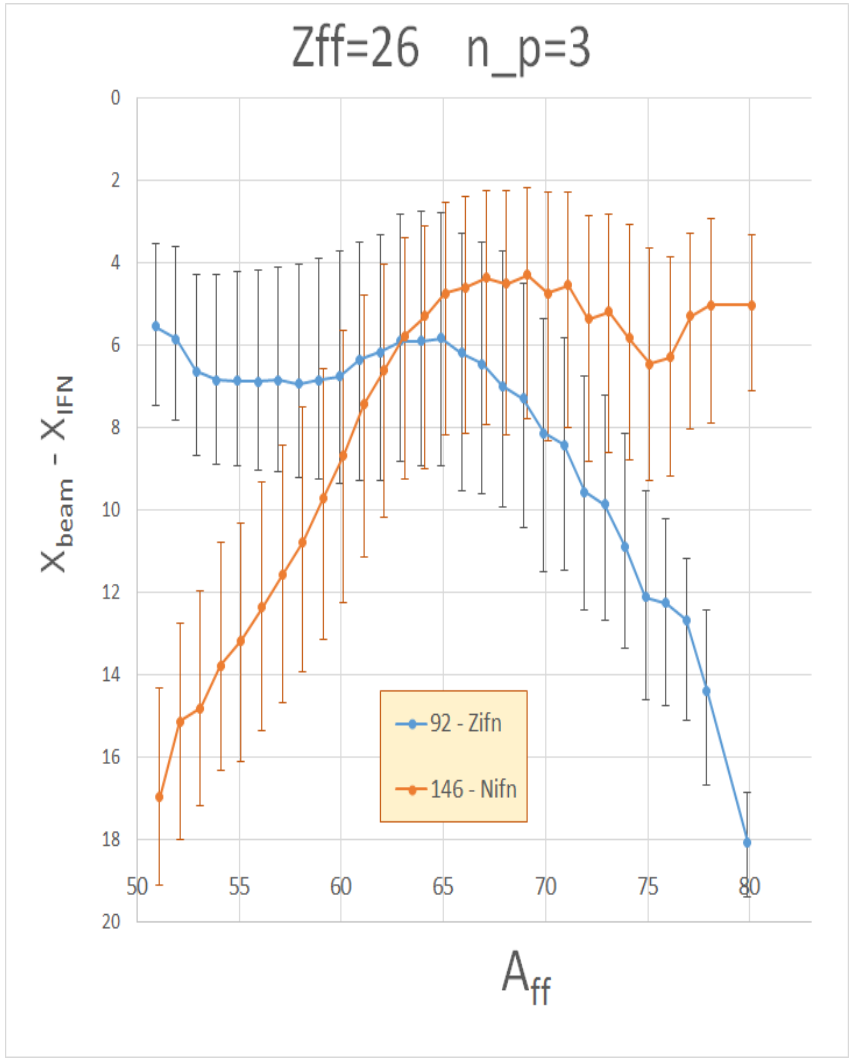
IFN-analysis for final Ge-isotopes (Z=32) : b

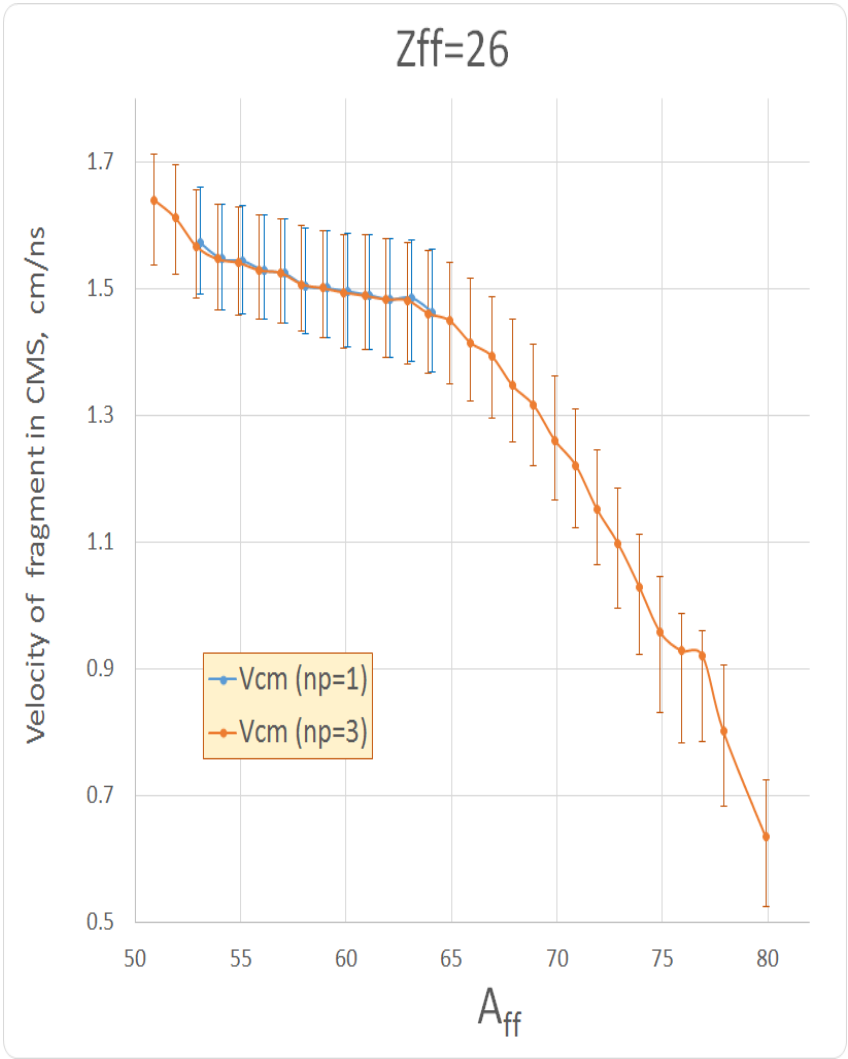




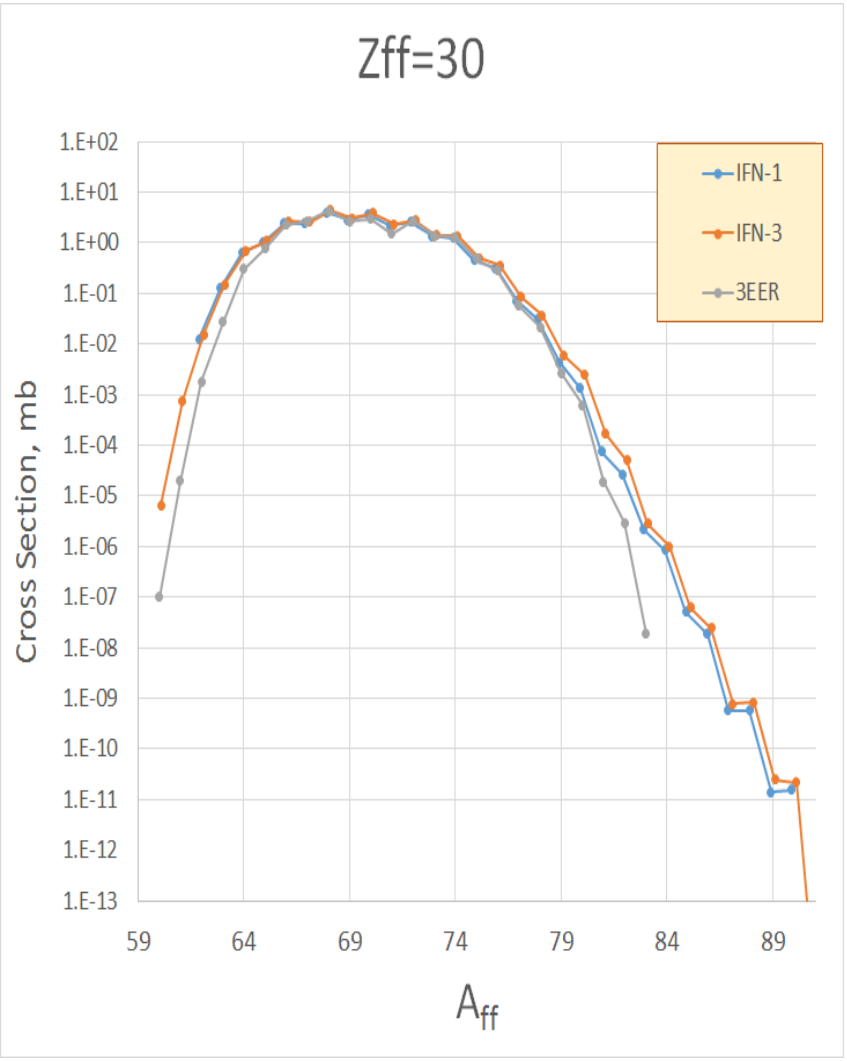
IFN-analysis for final Fe-isotopes (Z=26)

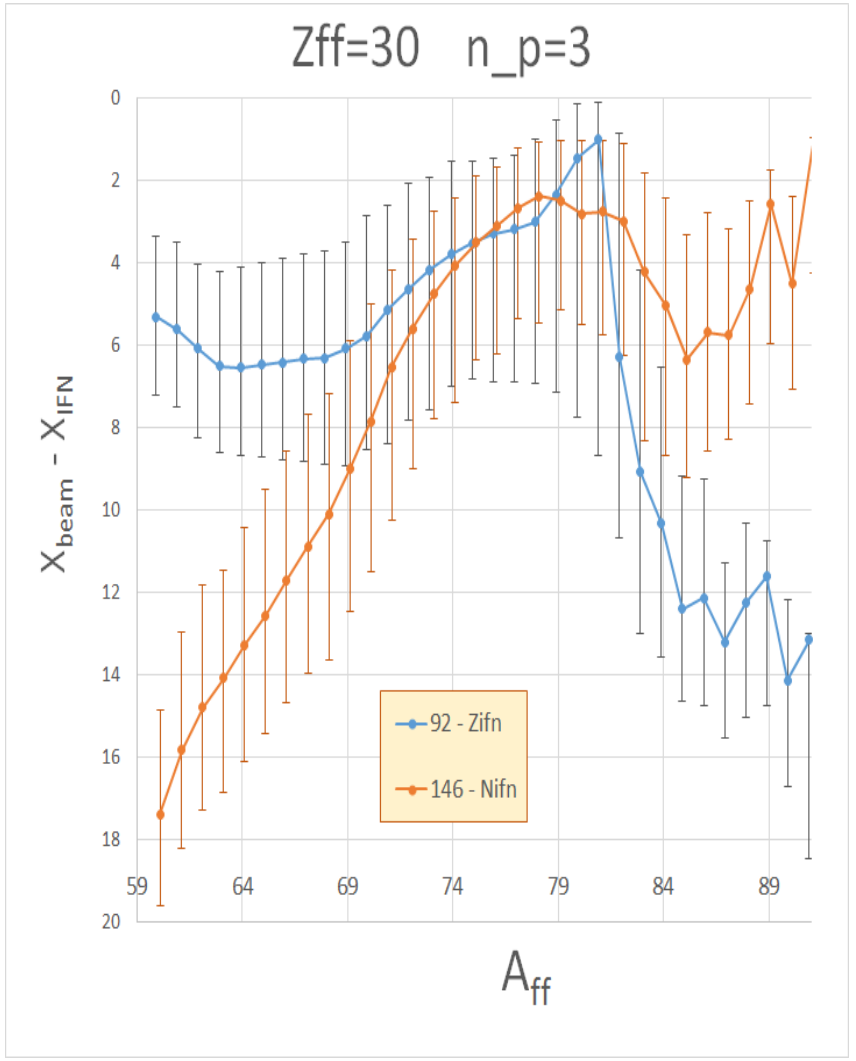


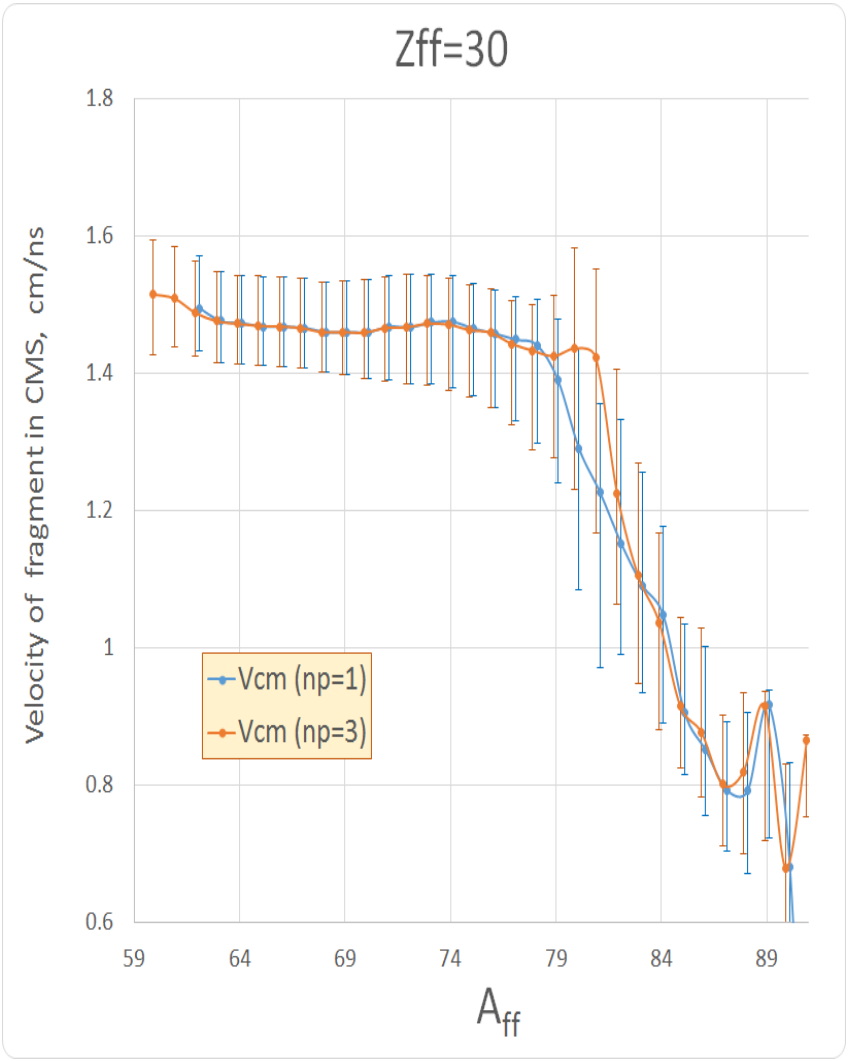




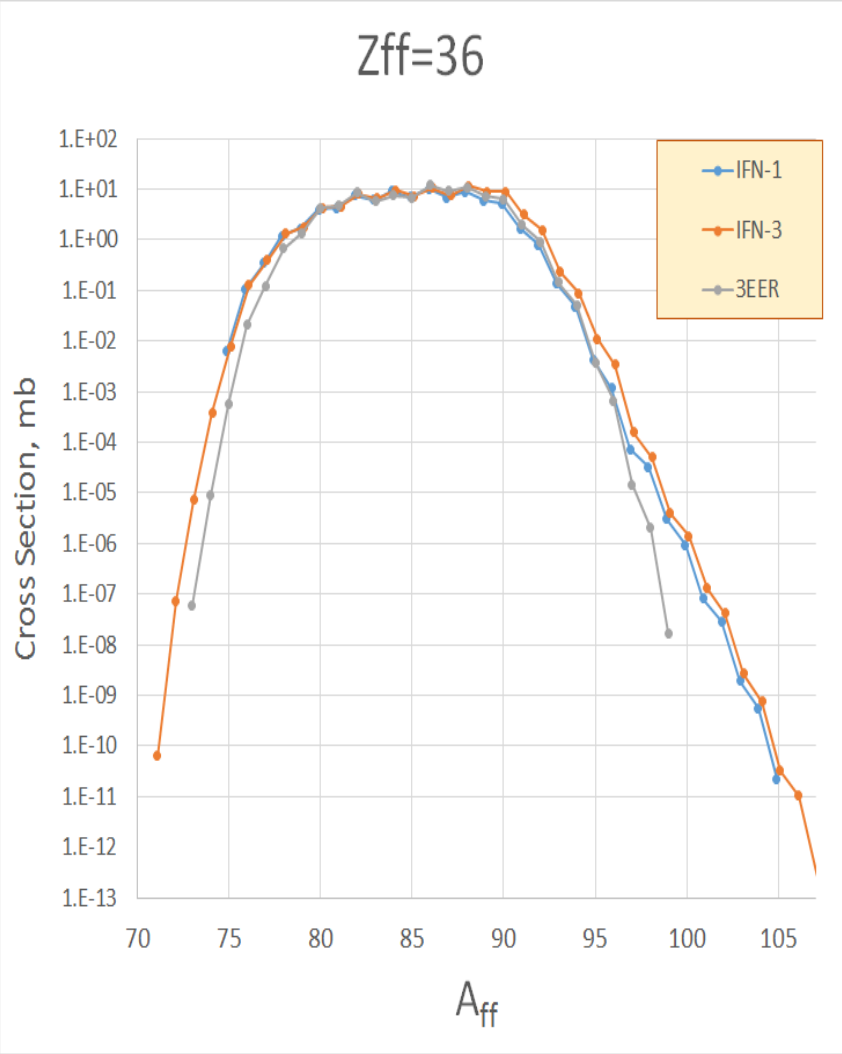
IFN-analysis for final Zn-isotopes (Z=30)

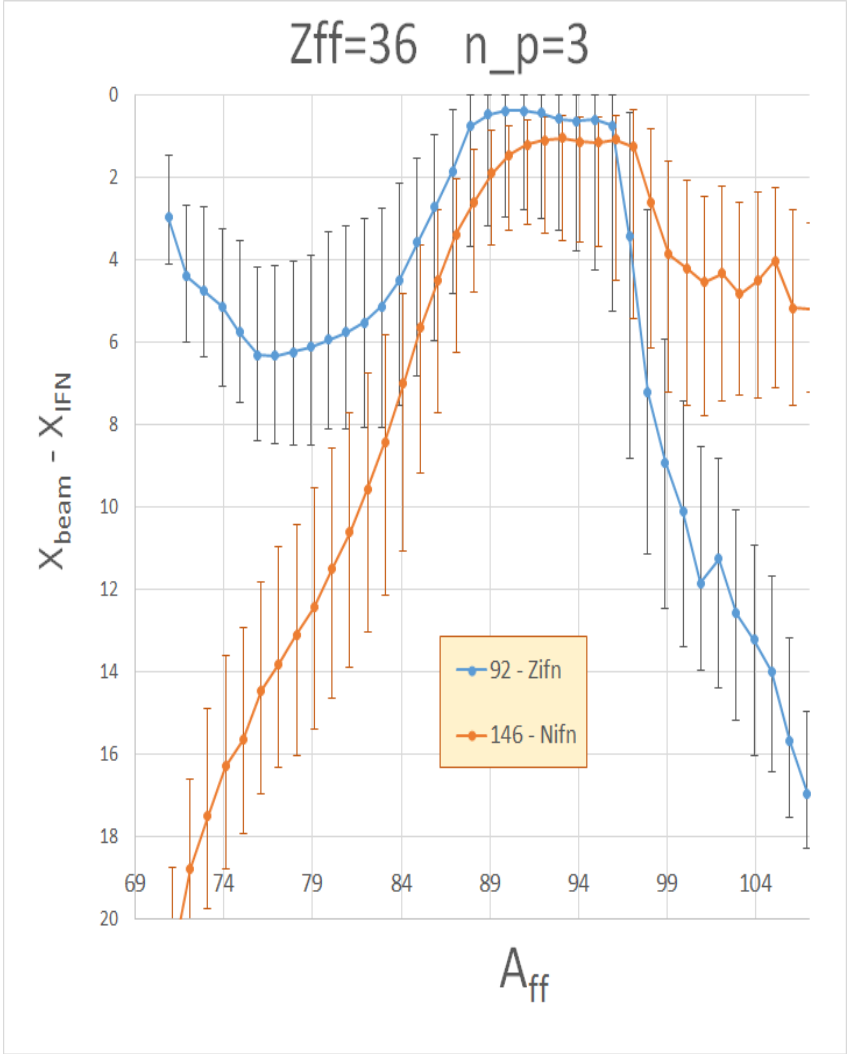


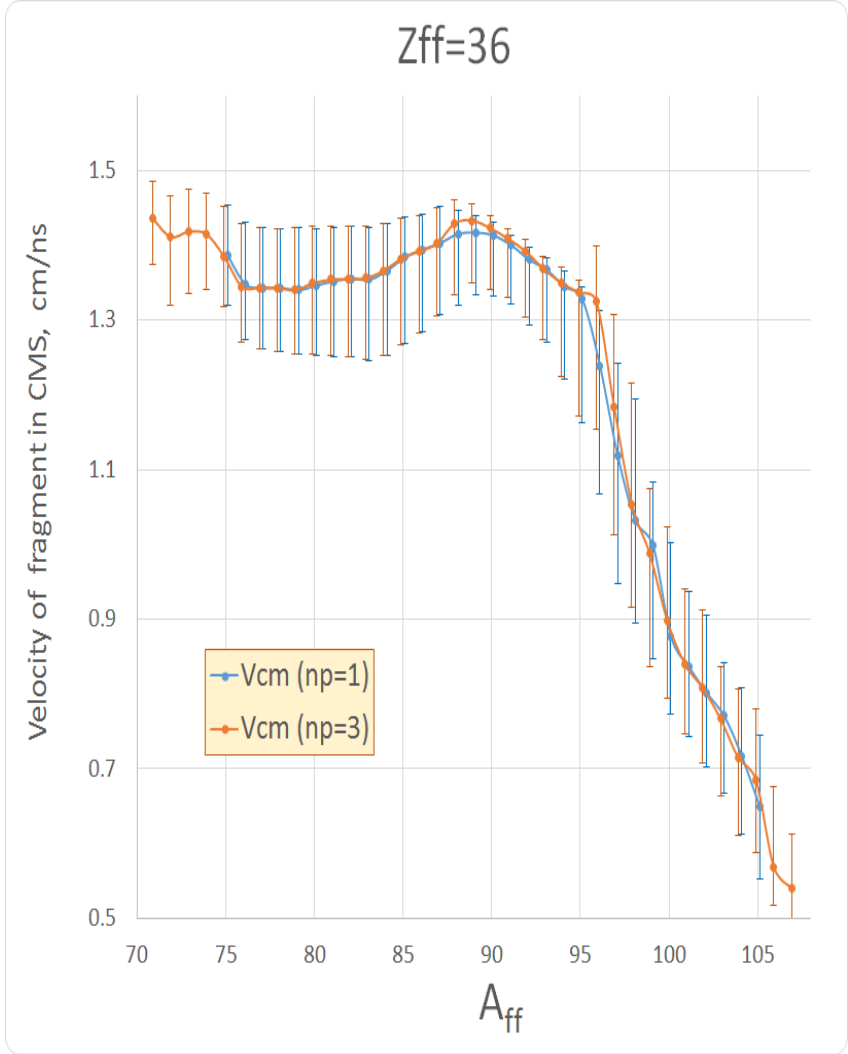




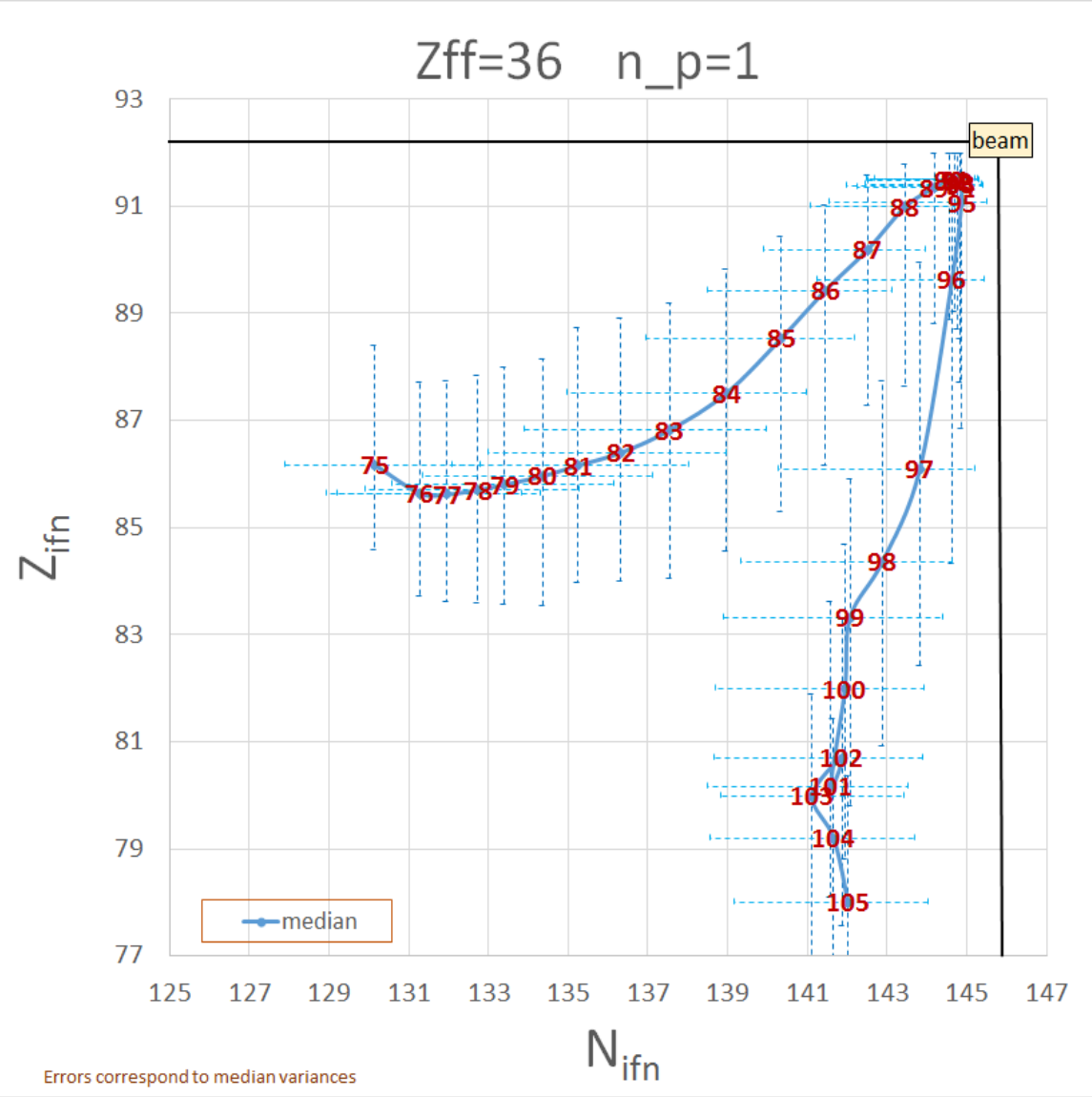
IFN-analysis for final Kr-isotopes (Z=36) : a

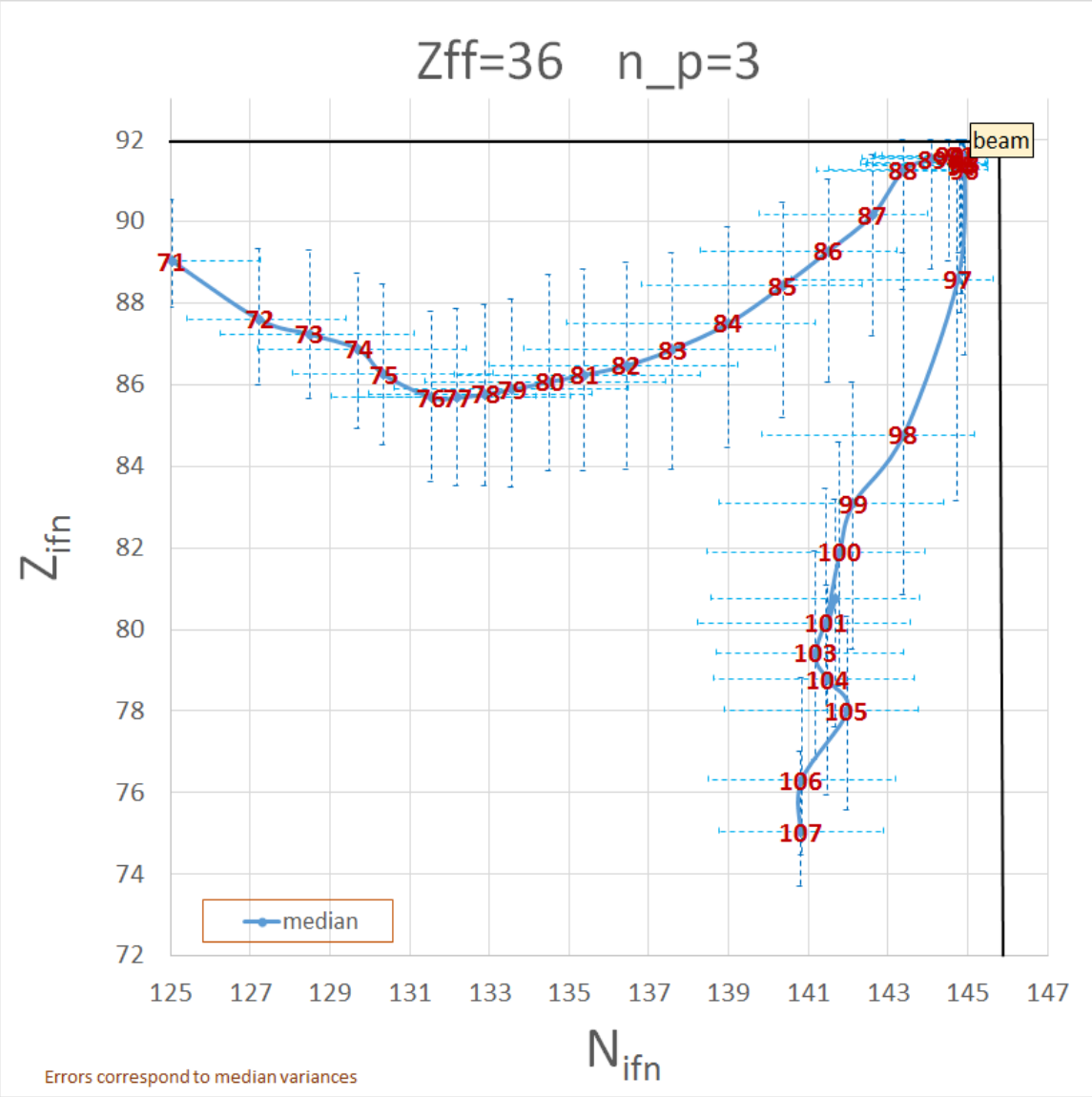




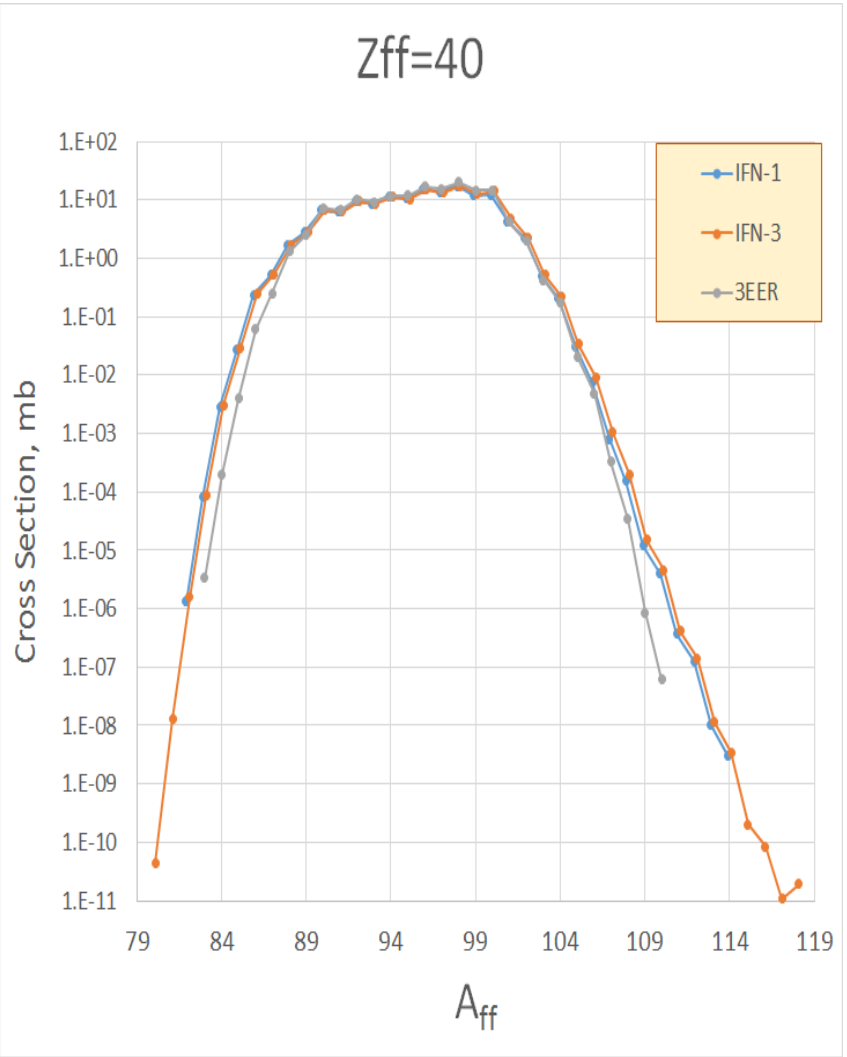


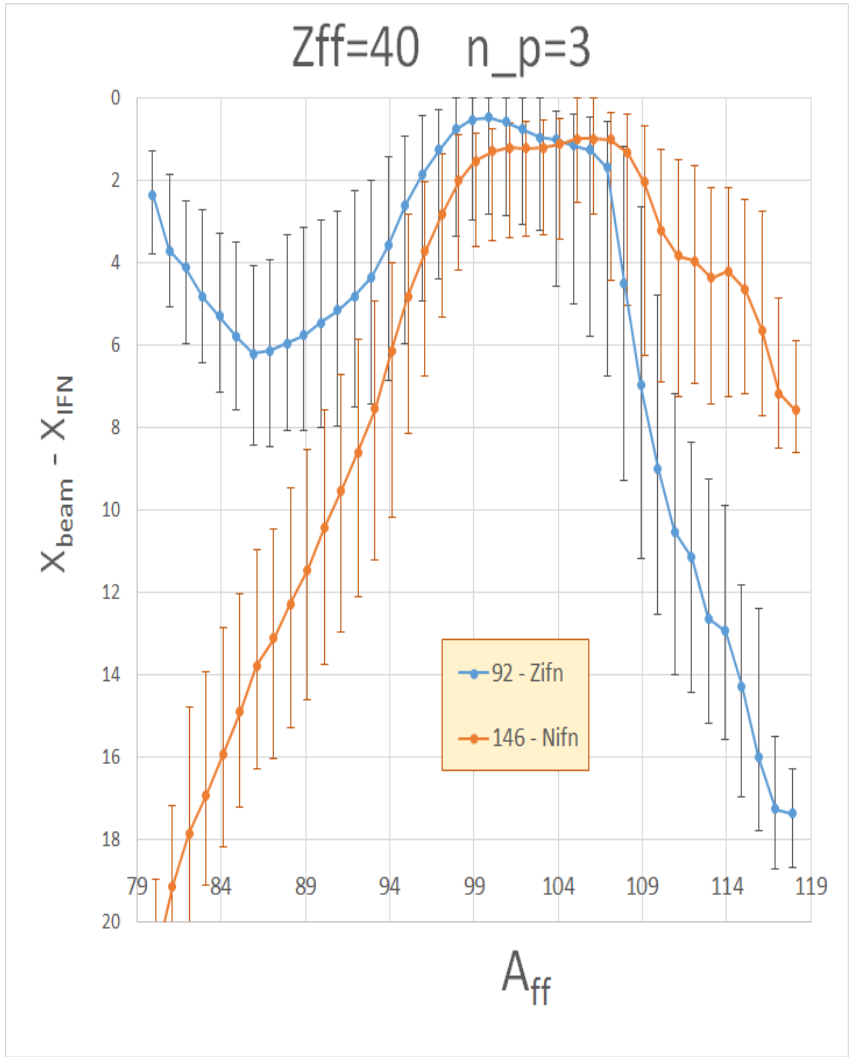
IFN-analysis for final Kr-isotopes (Z=36) : b

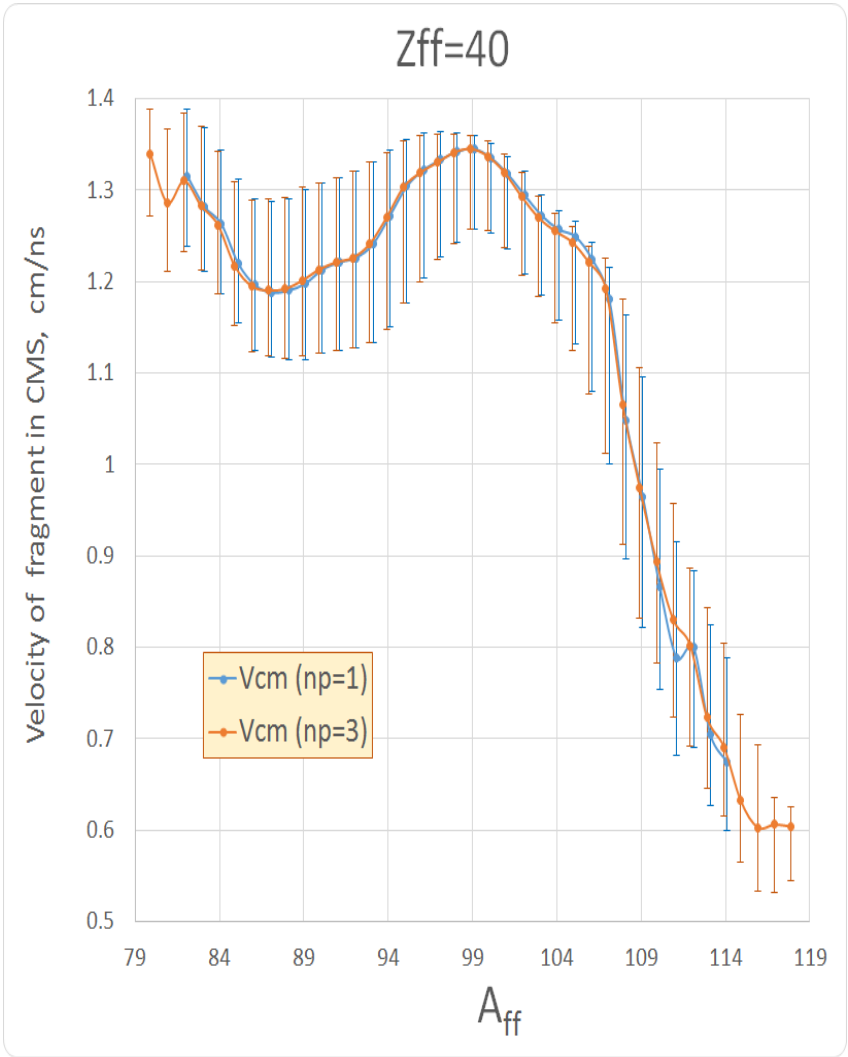




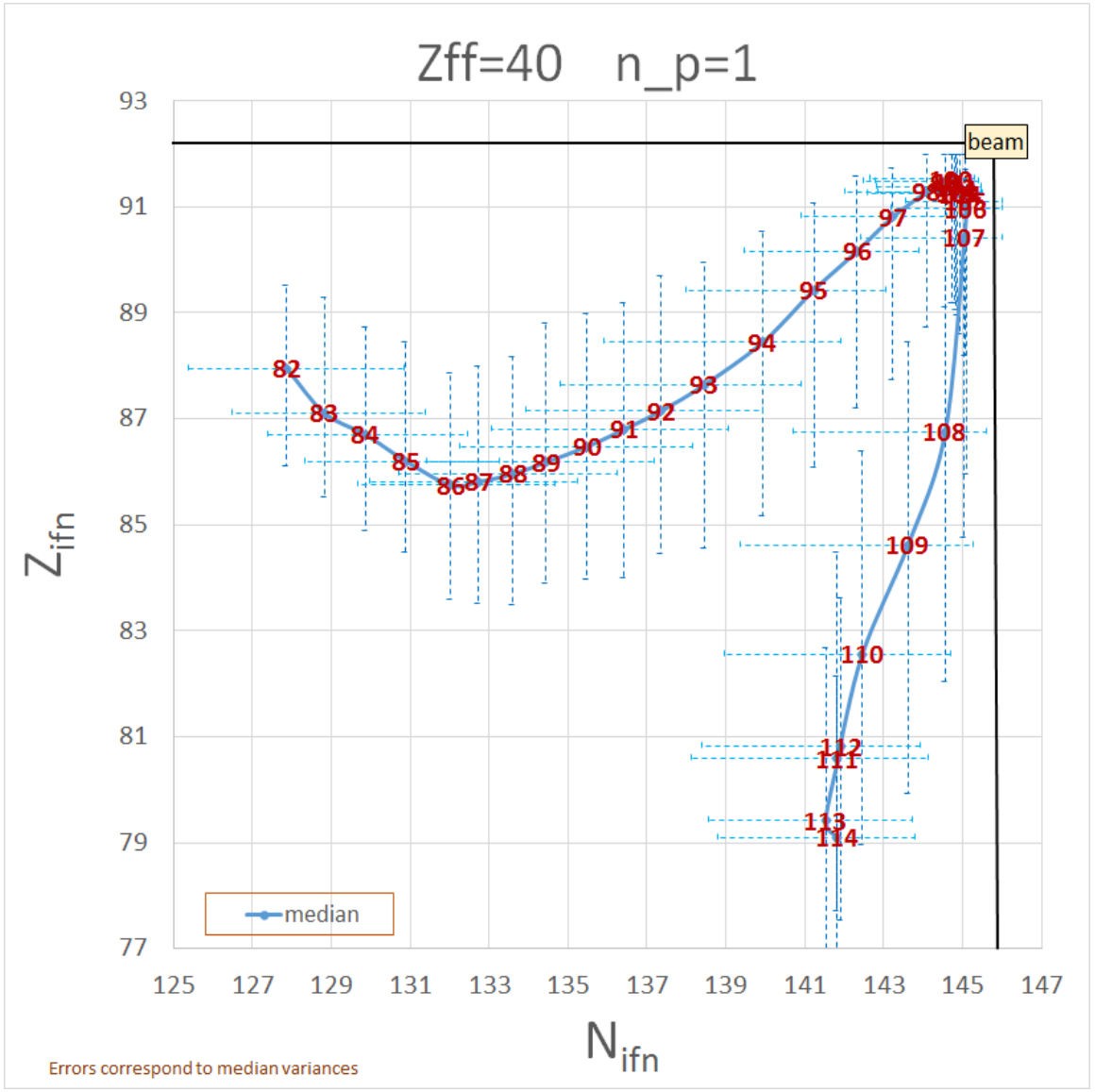
IFN-analysis for final Zr-isotopes (Z=40) : a

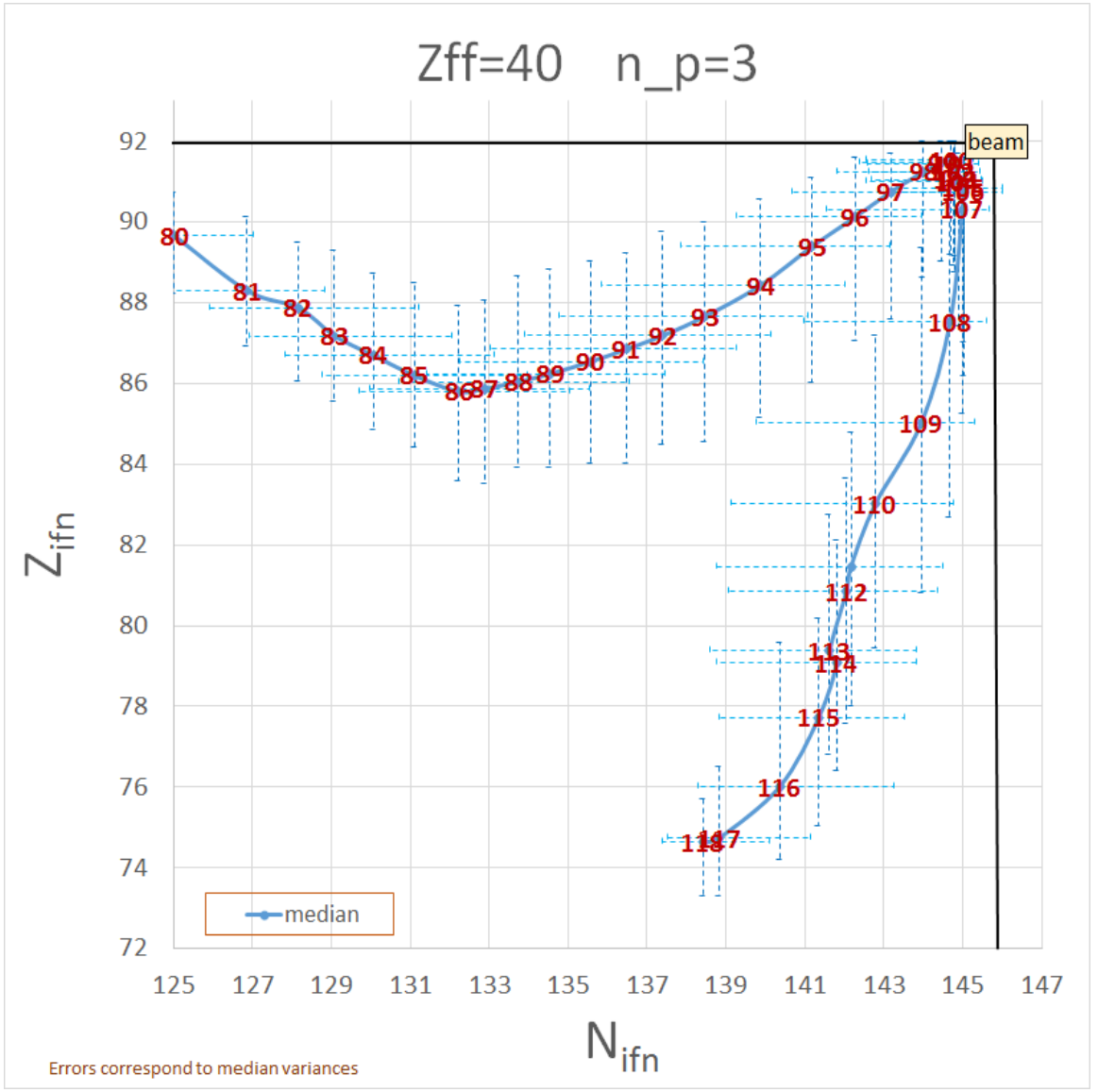




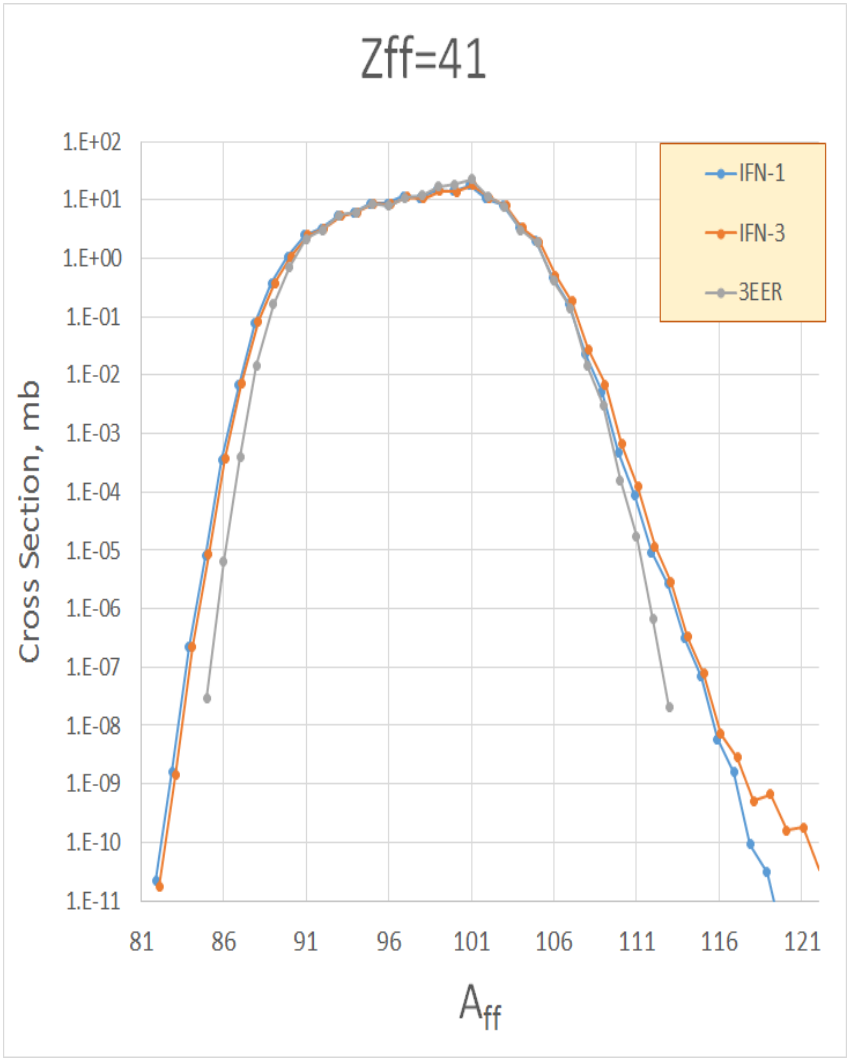


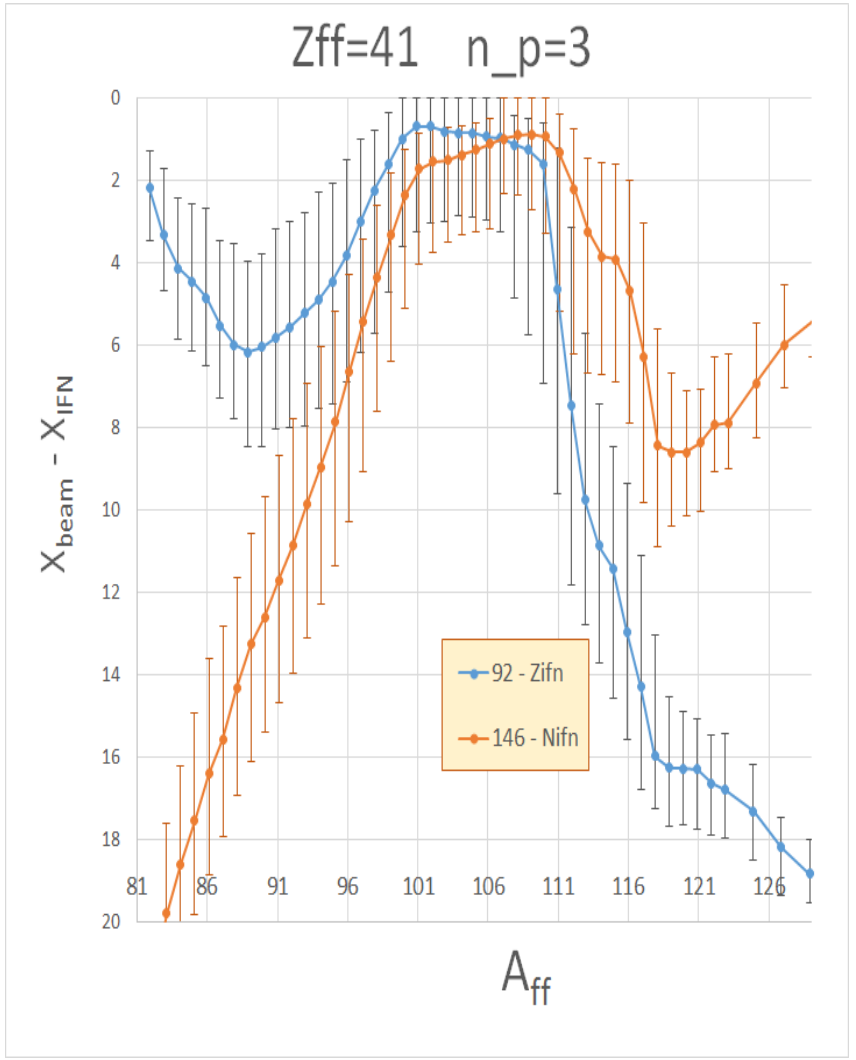
IFN-analysis for final Zr-isotopes (Z=40) : b

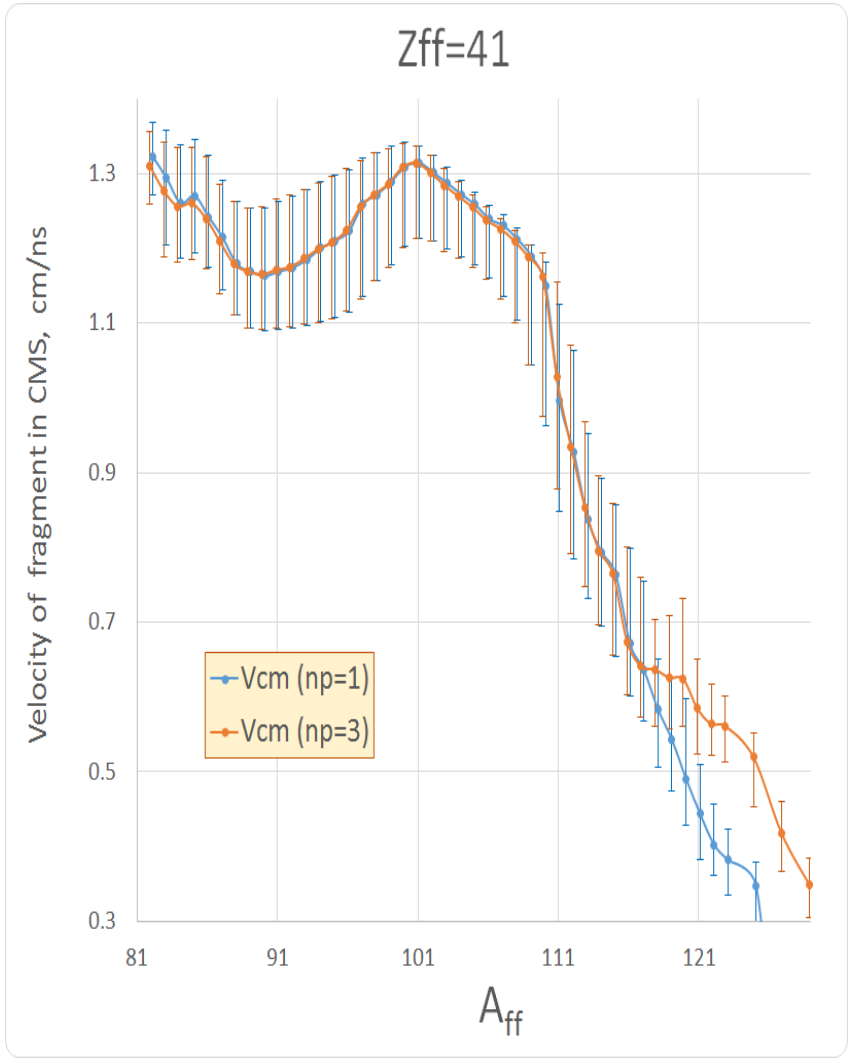




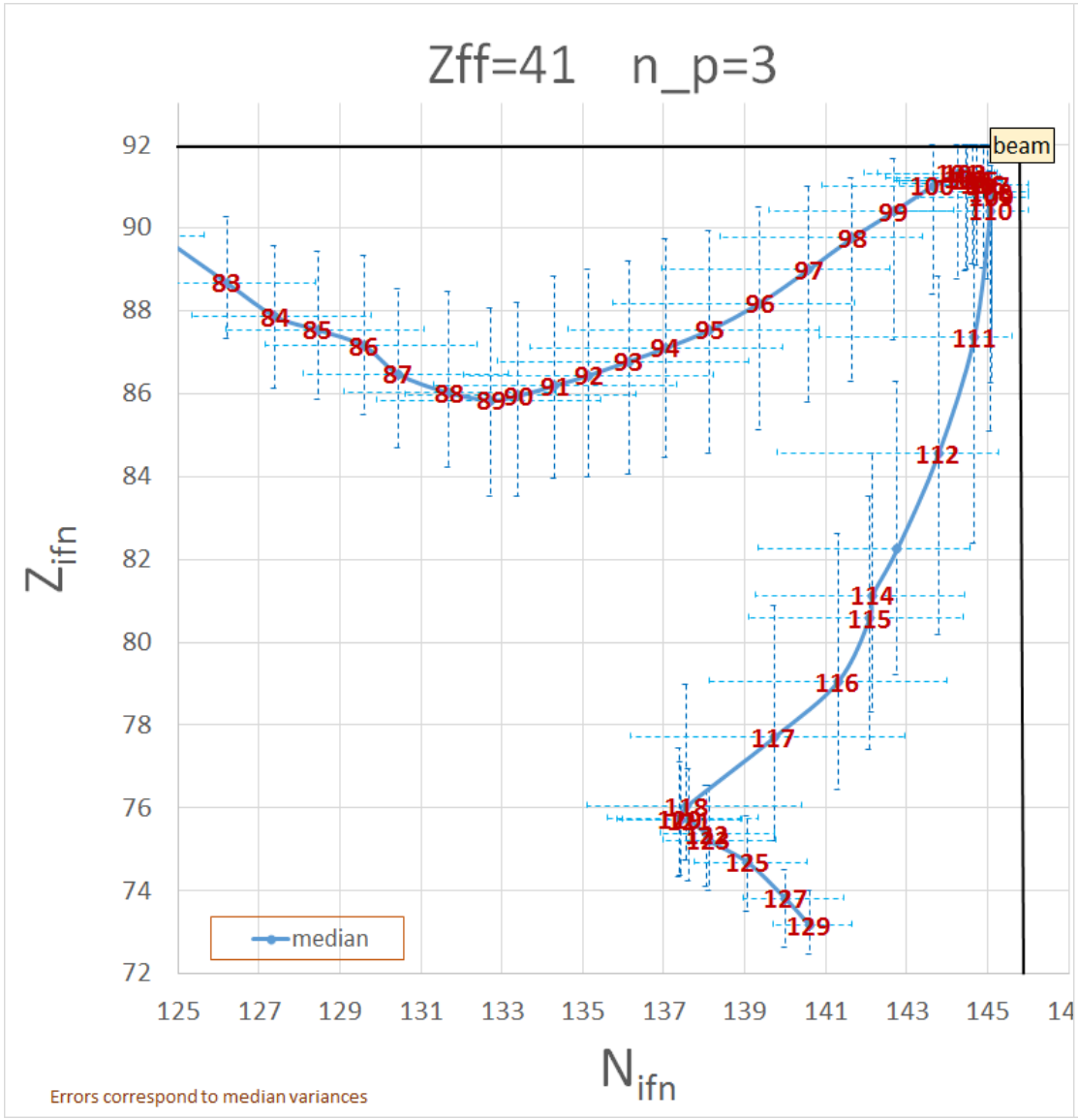
IFN-analysis for final Nb-isotopes (Z=41) : a

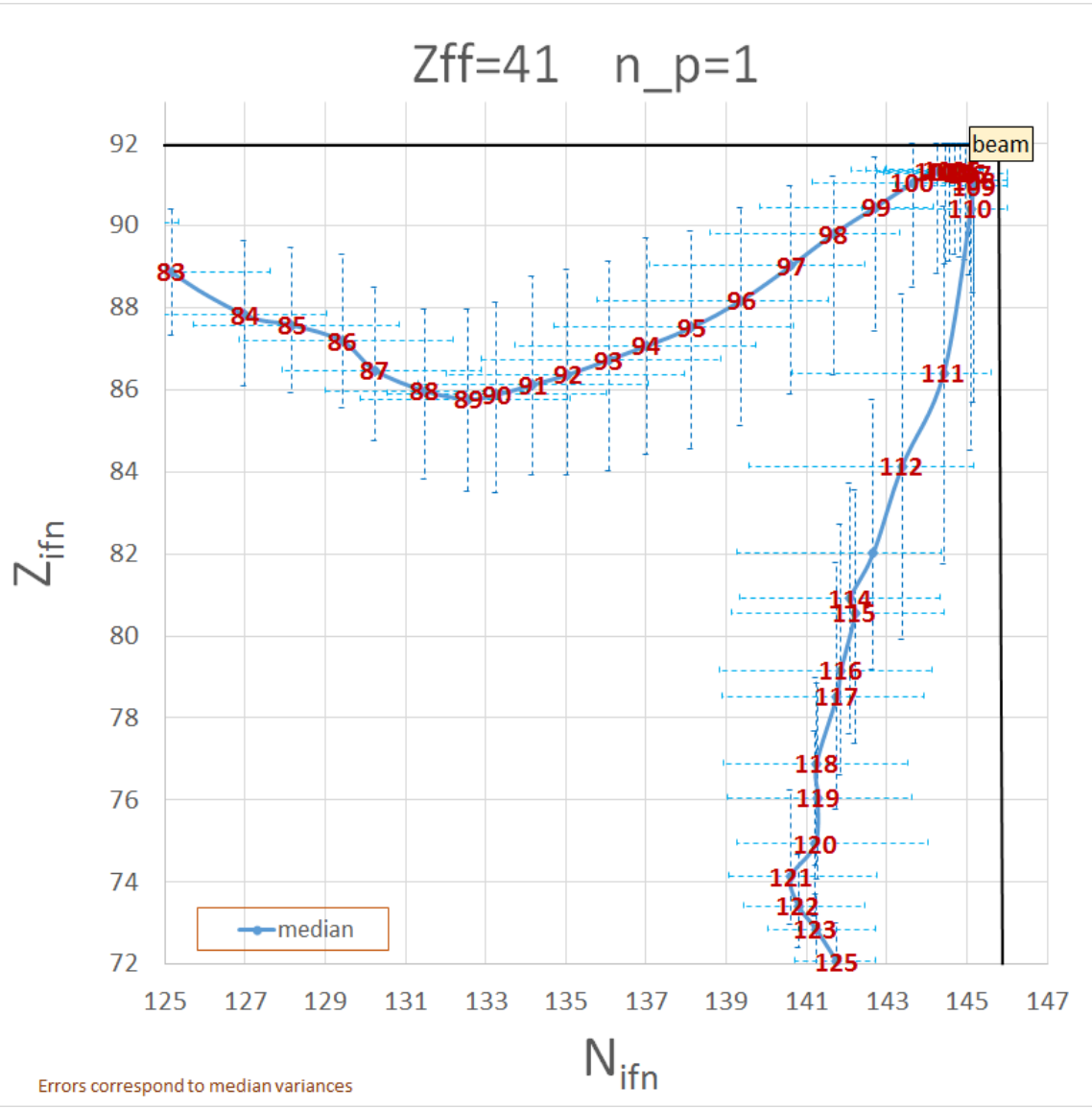




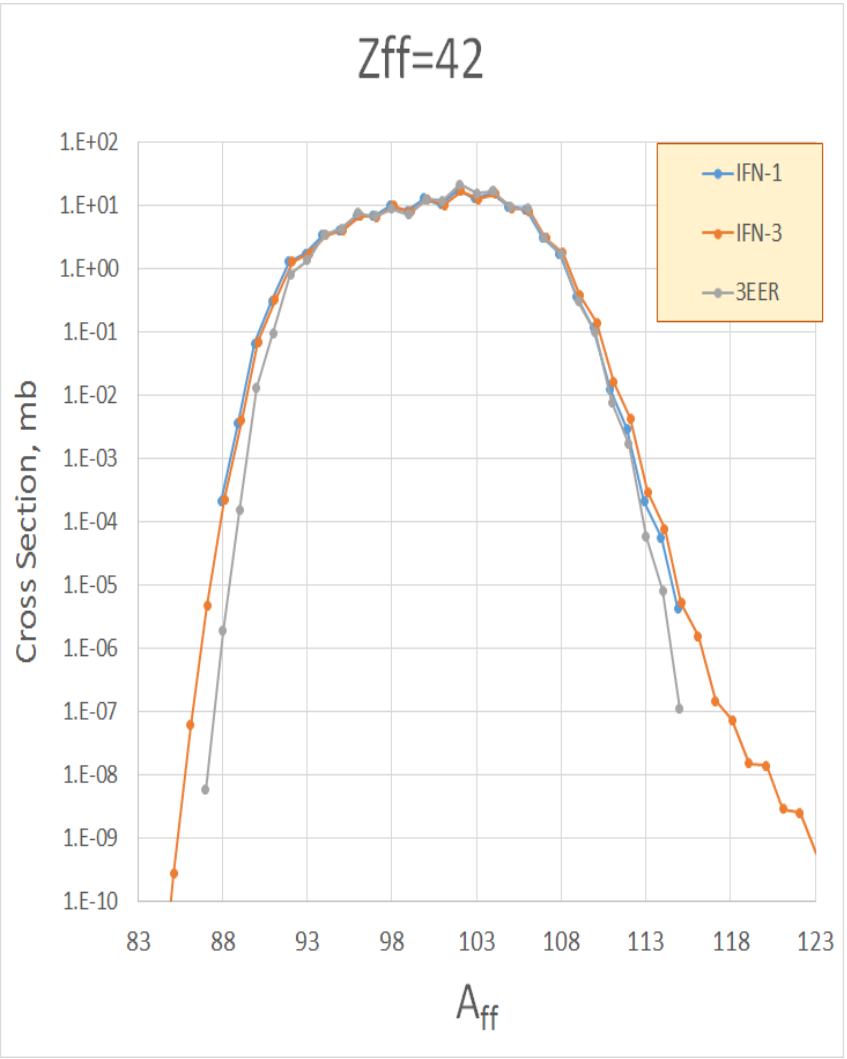


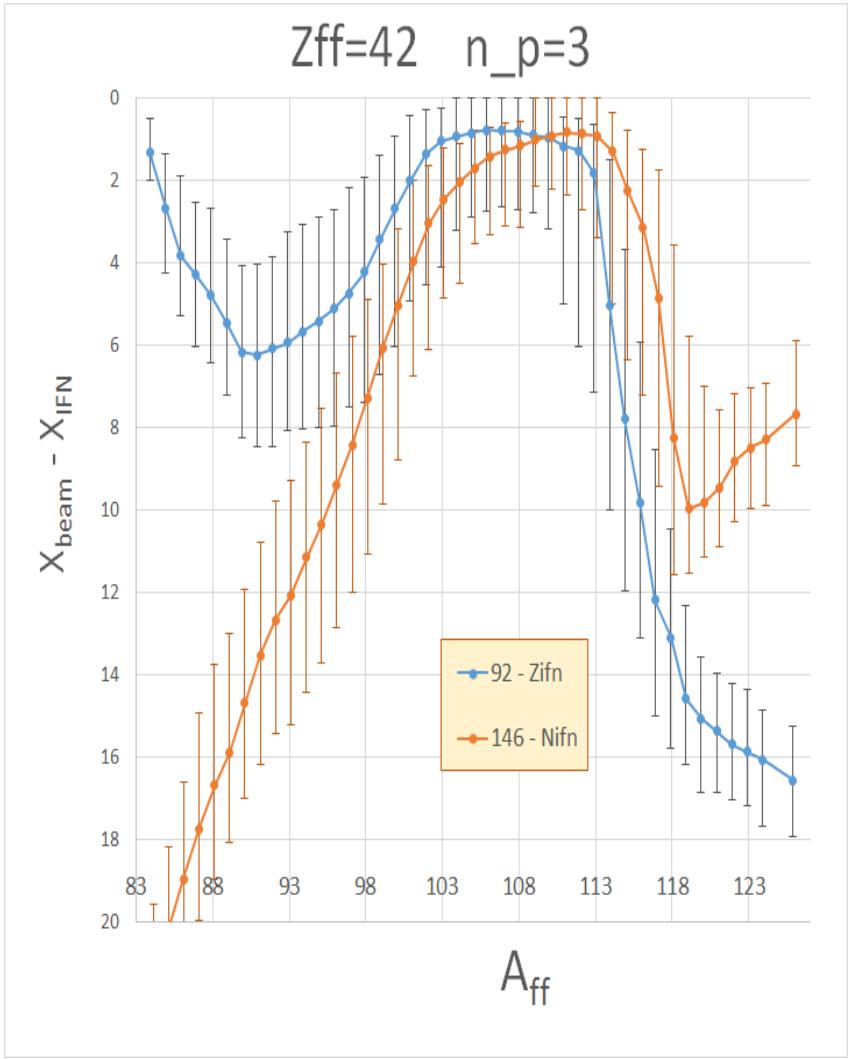
IFN-analysis for final Nb-isotopes (Z=41) : b

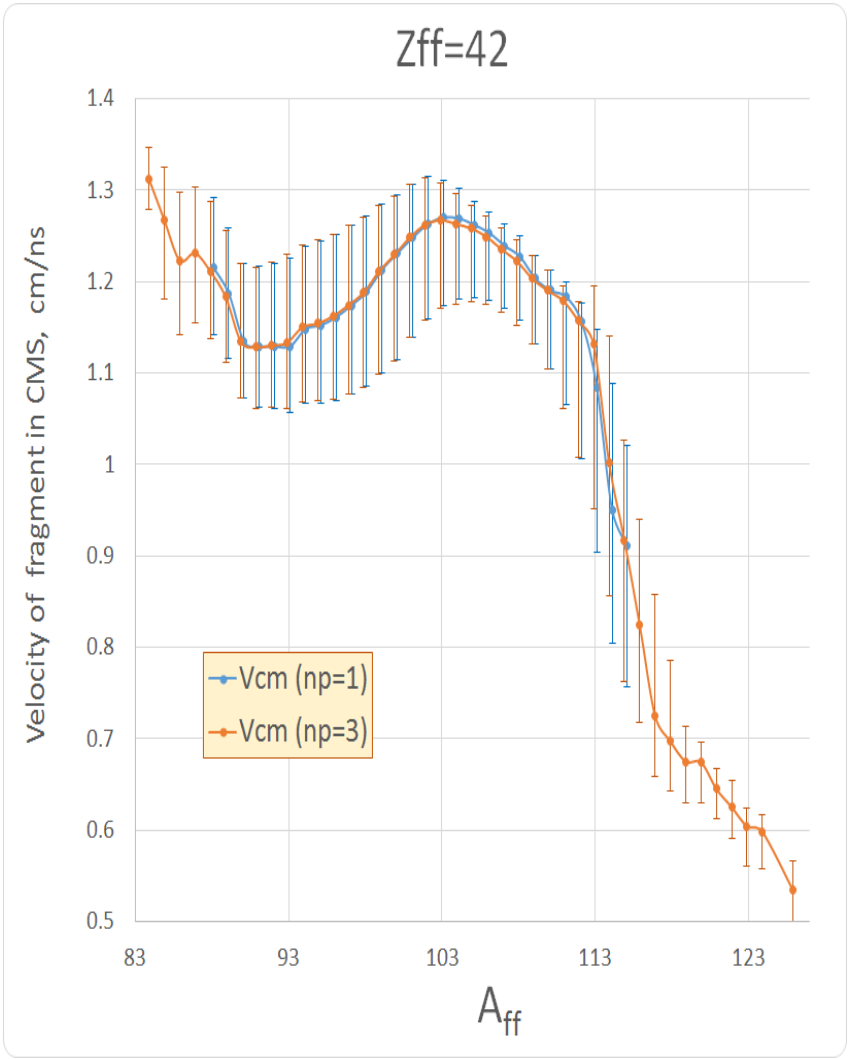




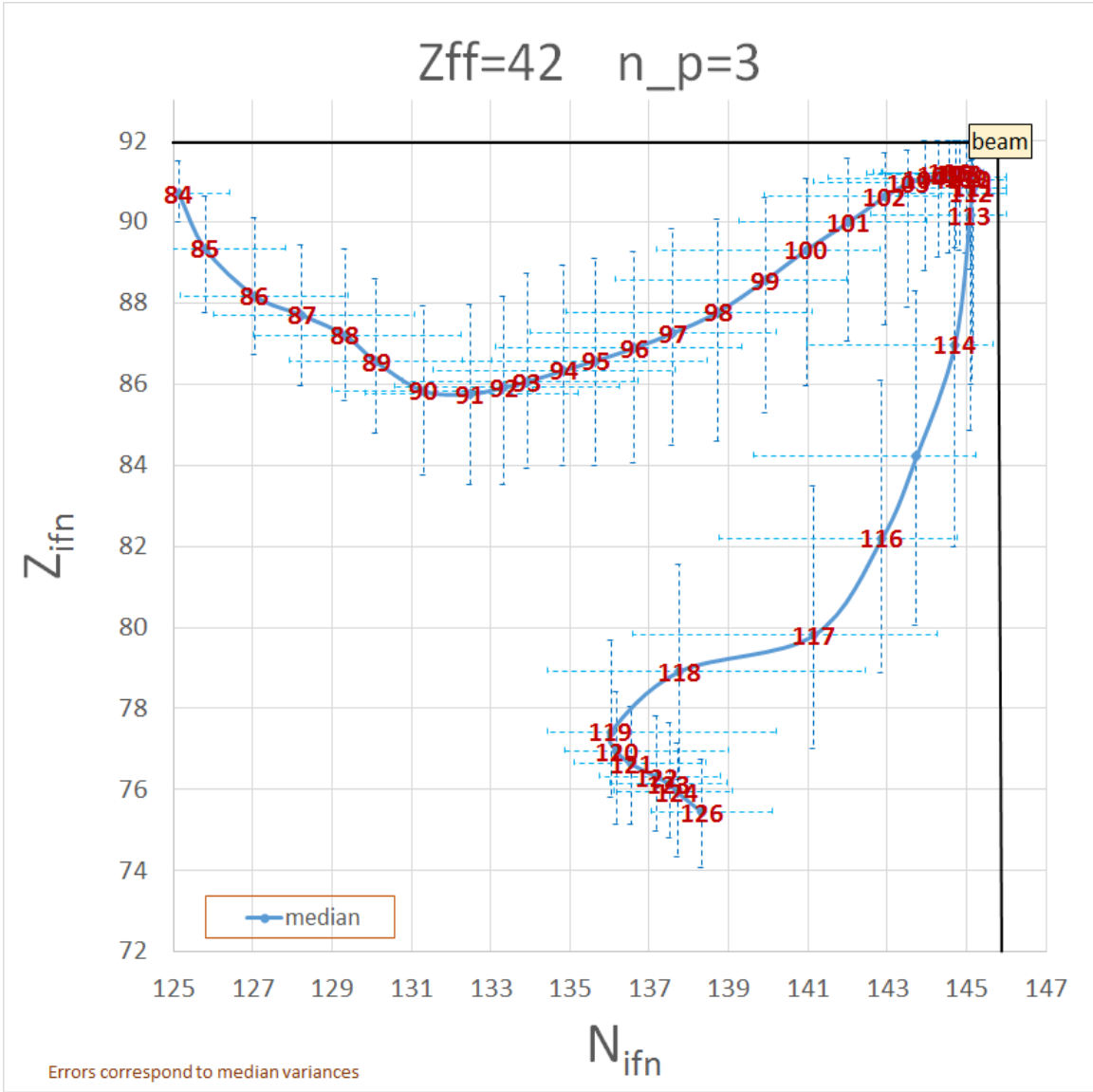
IFN-analysis for final Mo-isotopes (Z=42) : a

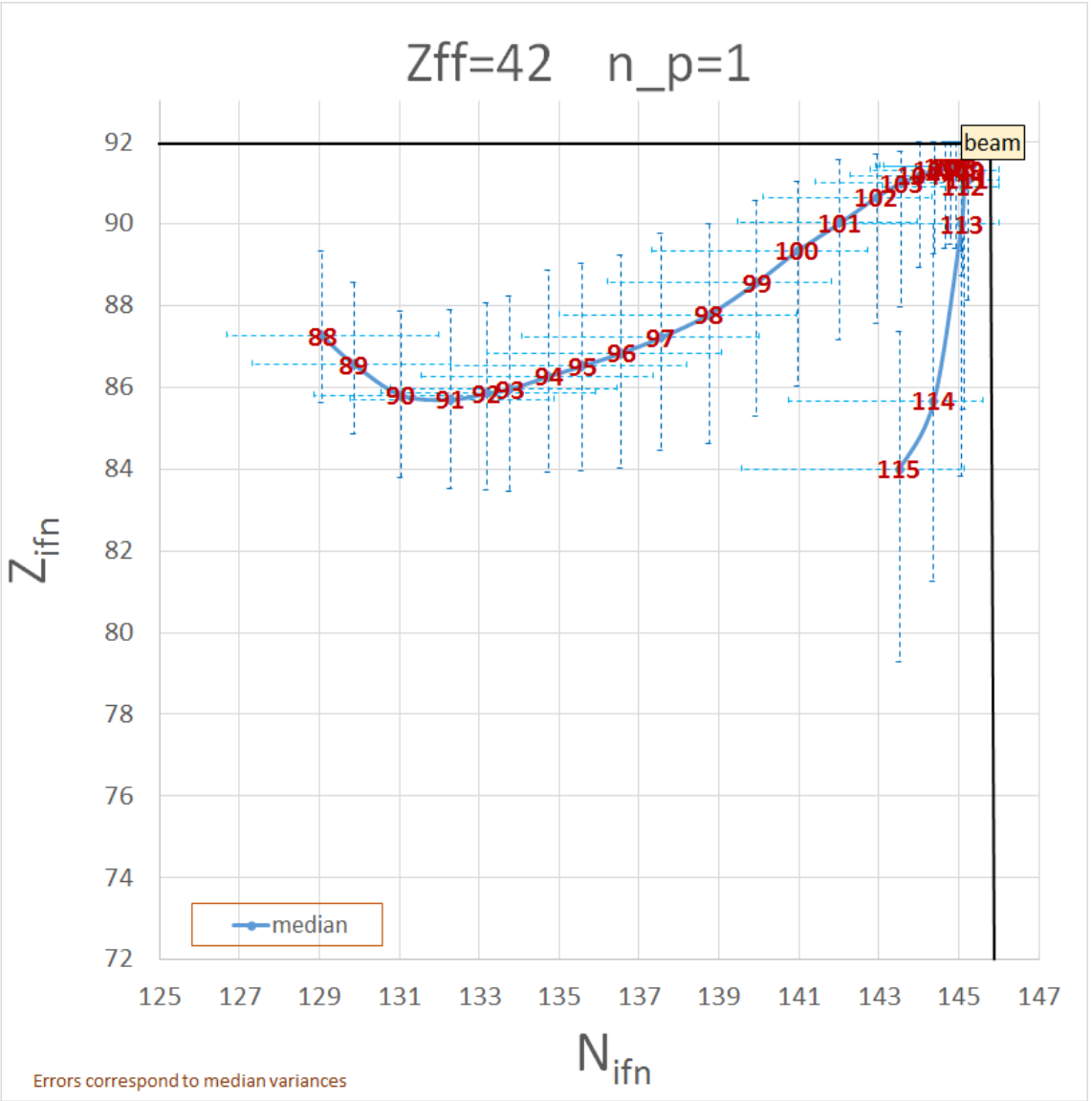




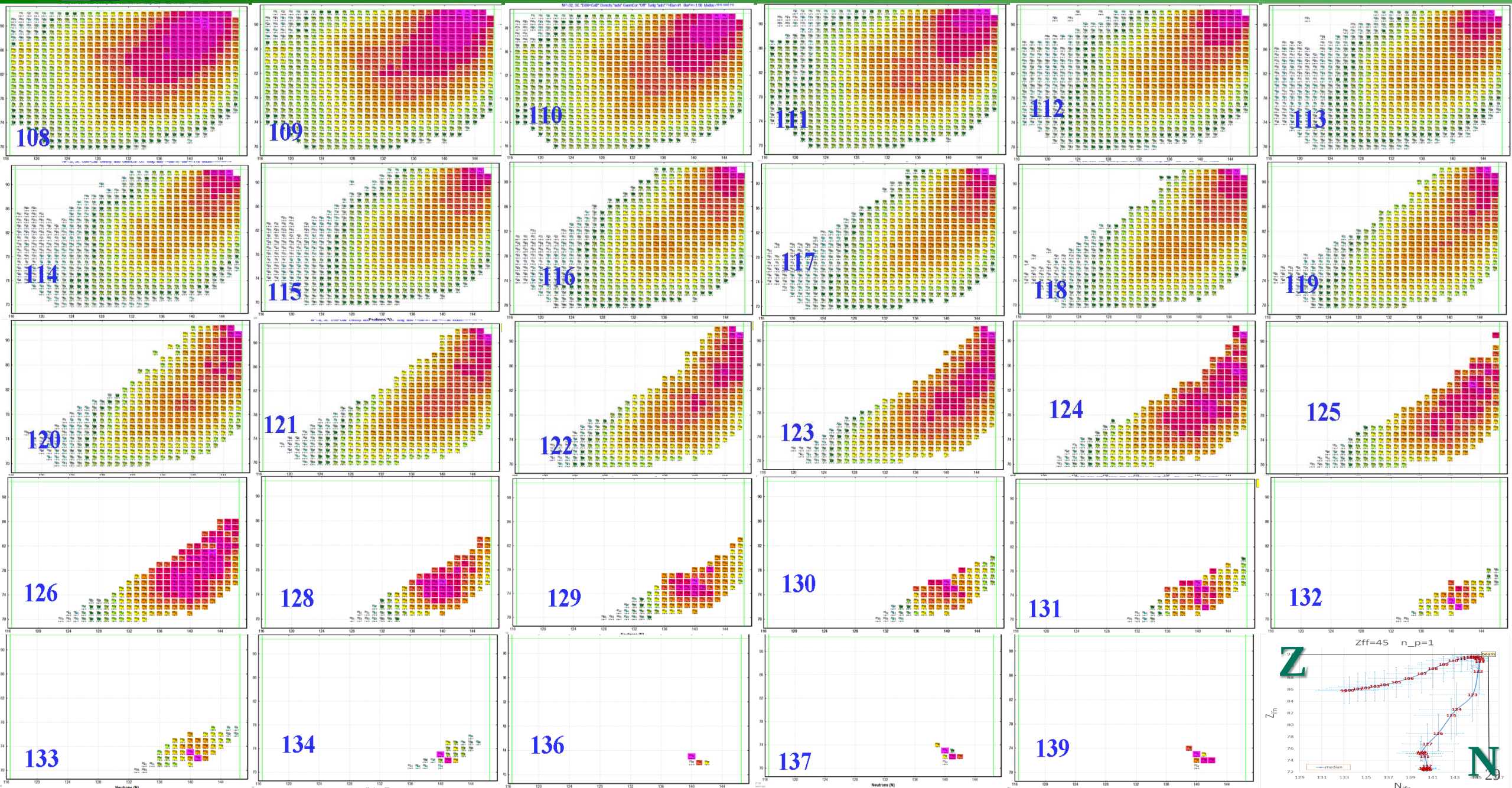


IFN-analysis for final Mo-isotopes (Z=42) : b

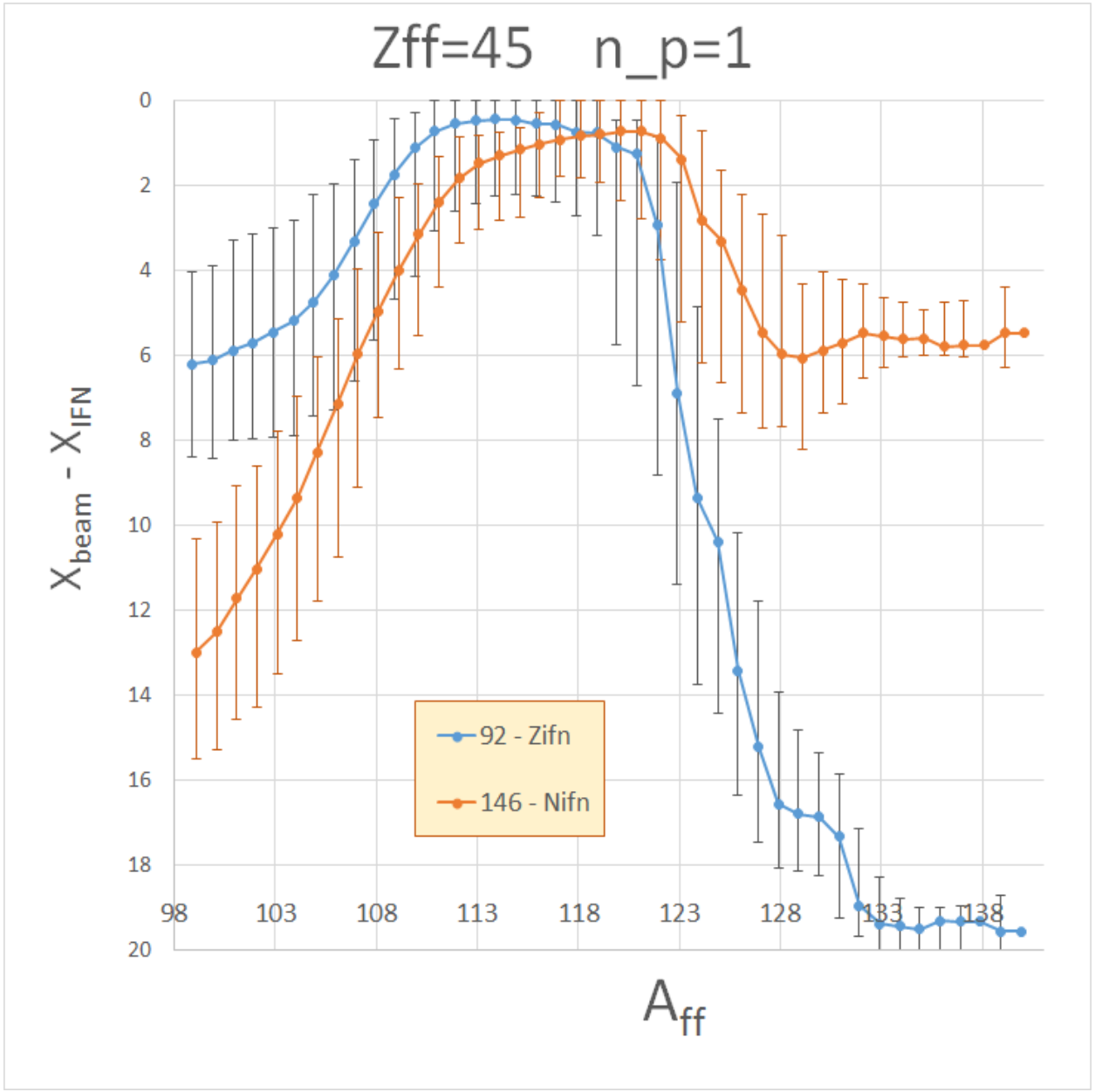


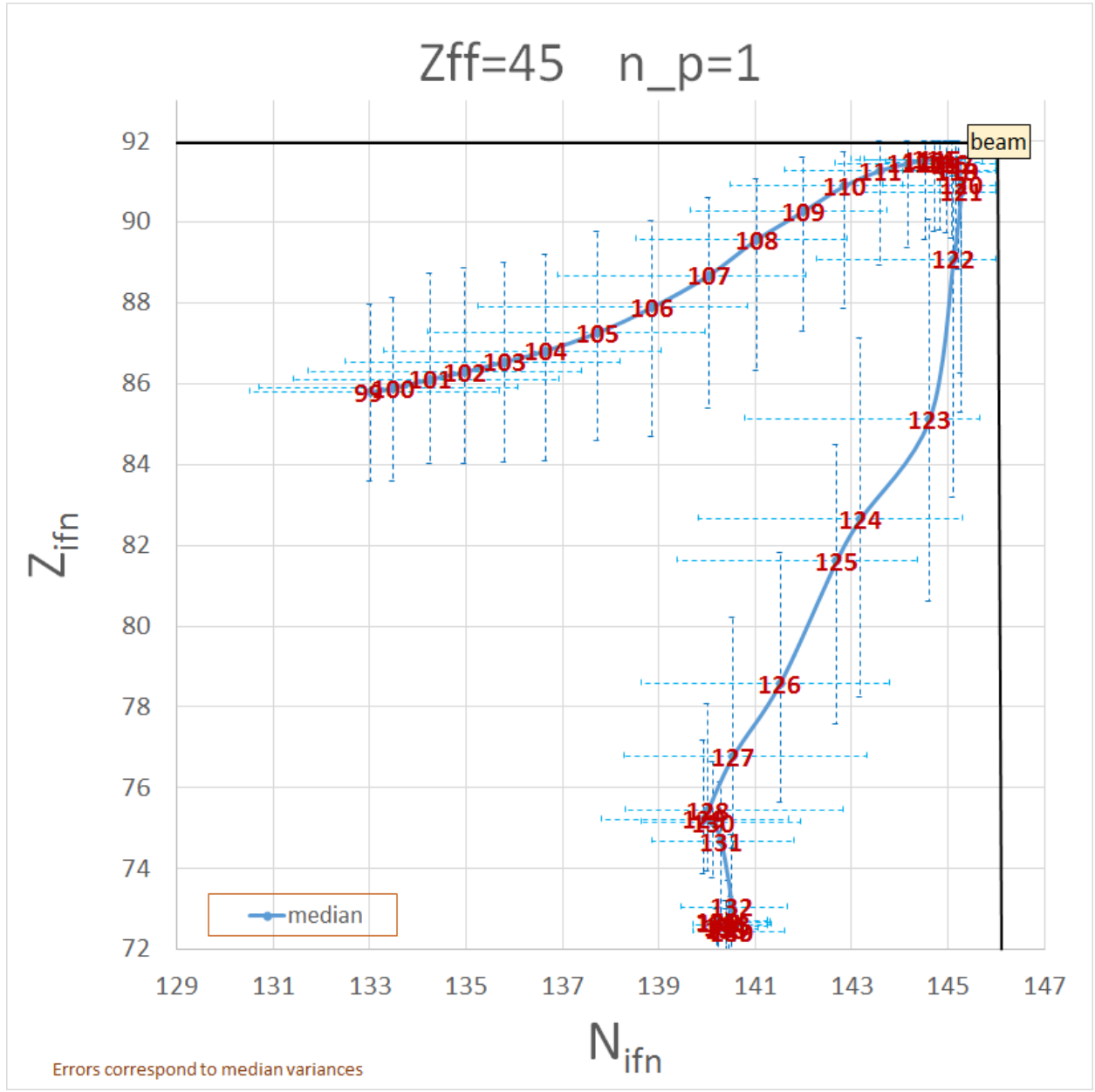


Initial Fissile Nuclei (IFN) for final Rh-isotopes (Z=45)

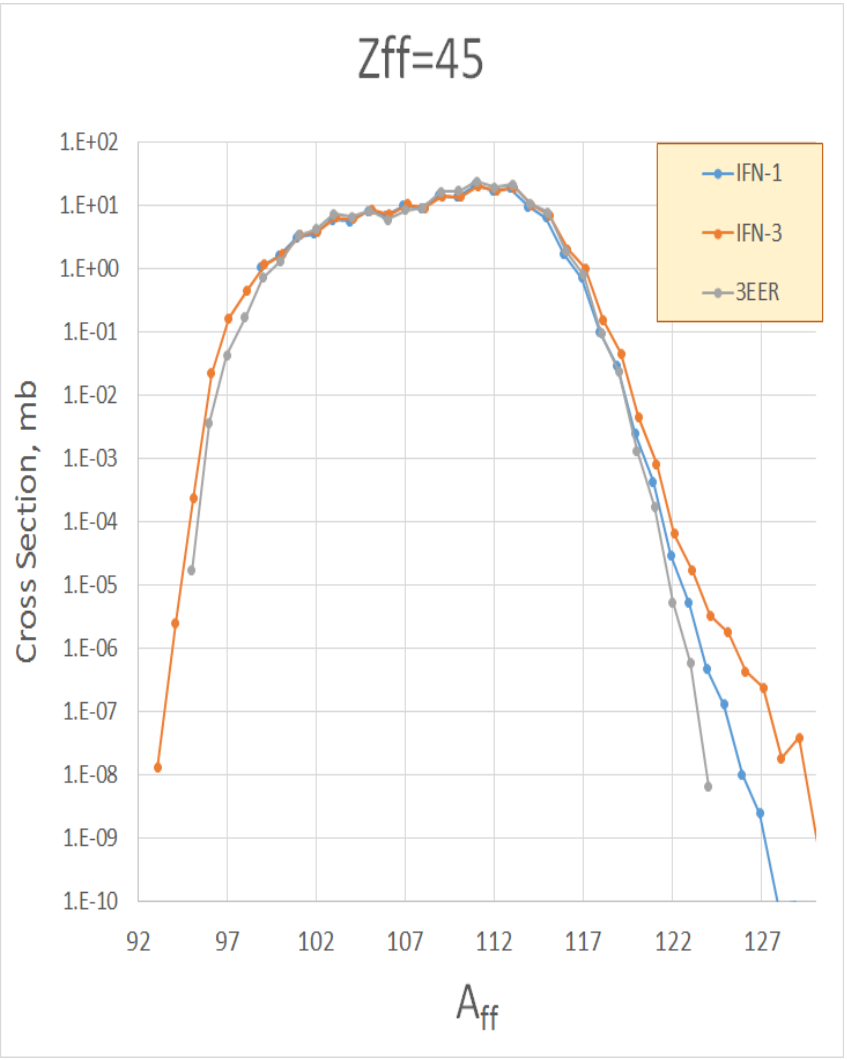


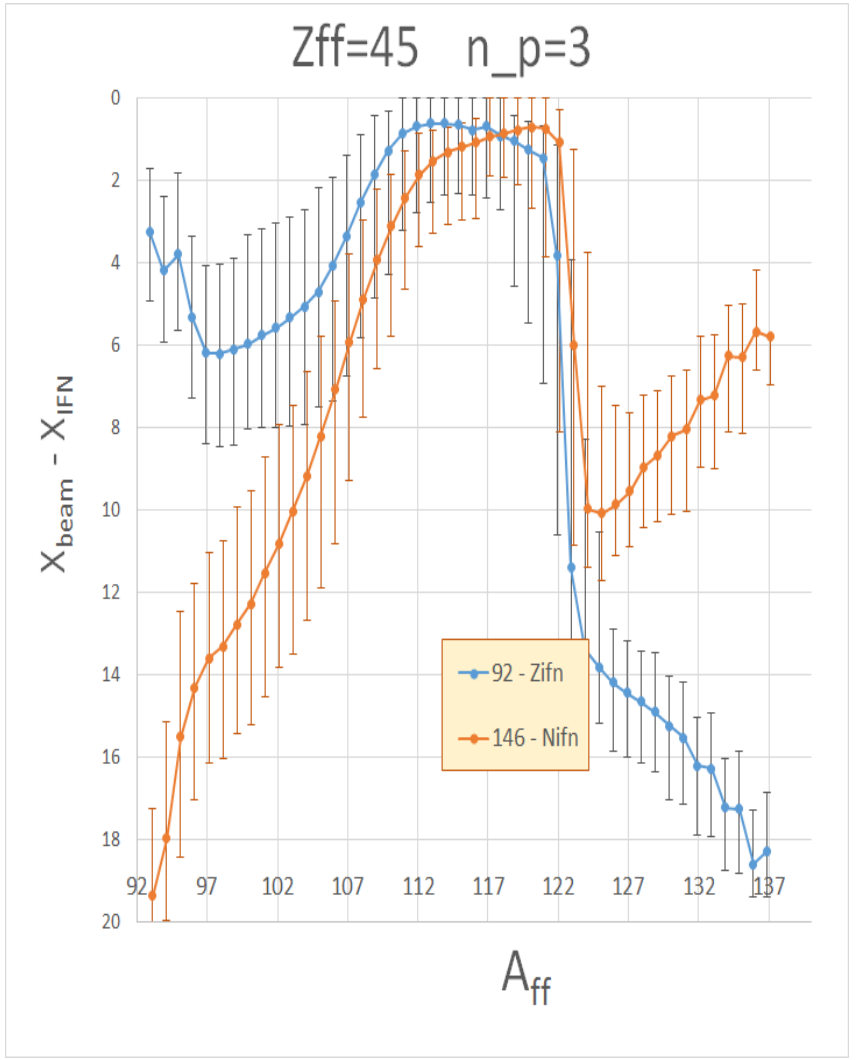
IFN-analysis for final Rh-isotopes (Z=45)

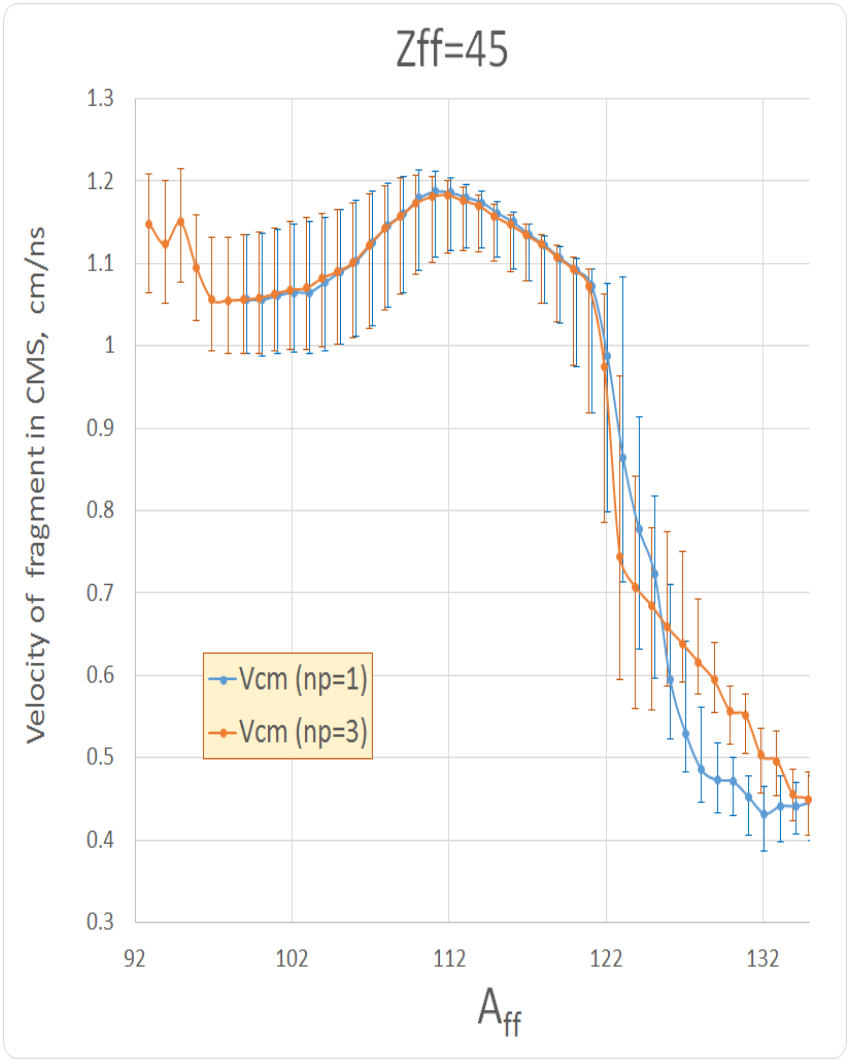




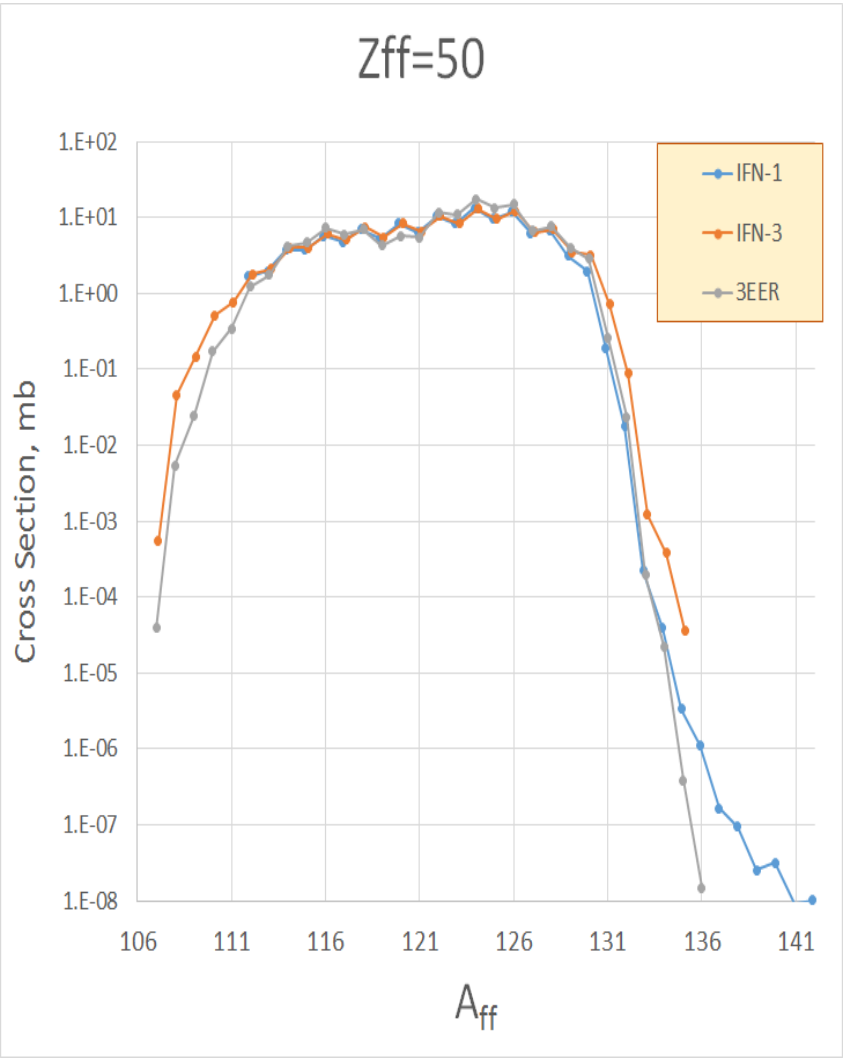
IFN-analysis for final Rh-isotopes (Z=45)

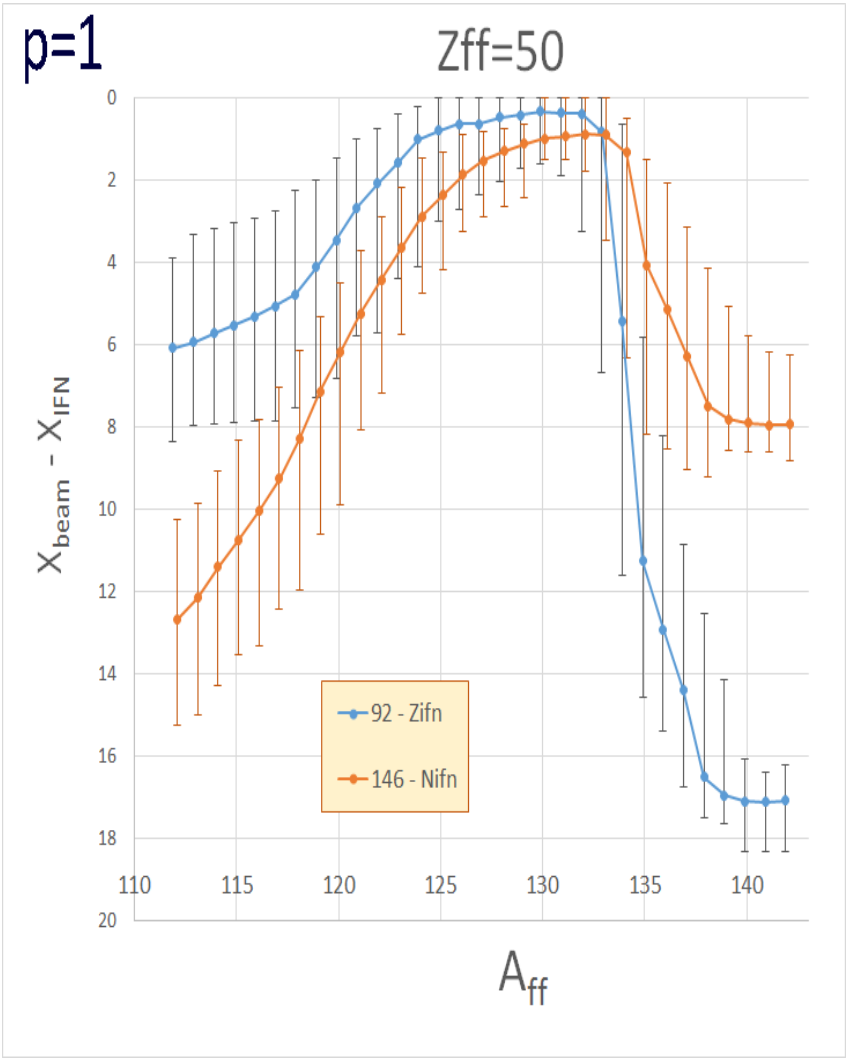


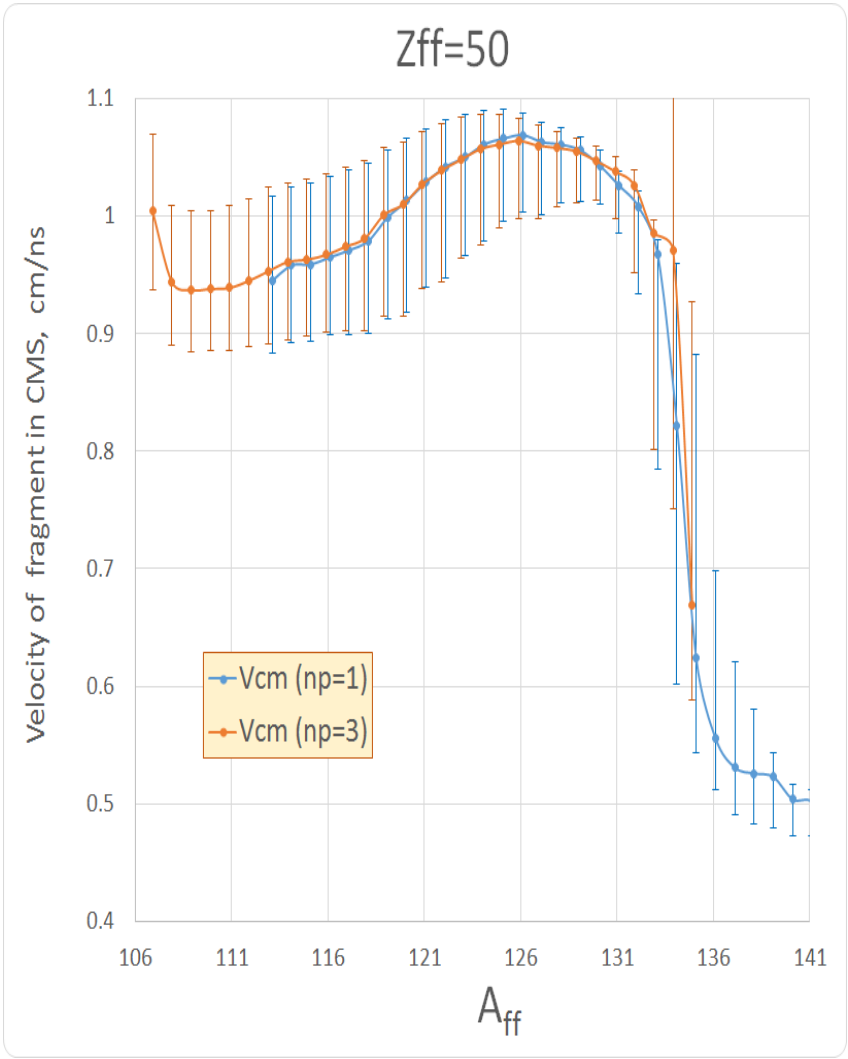




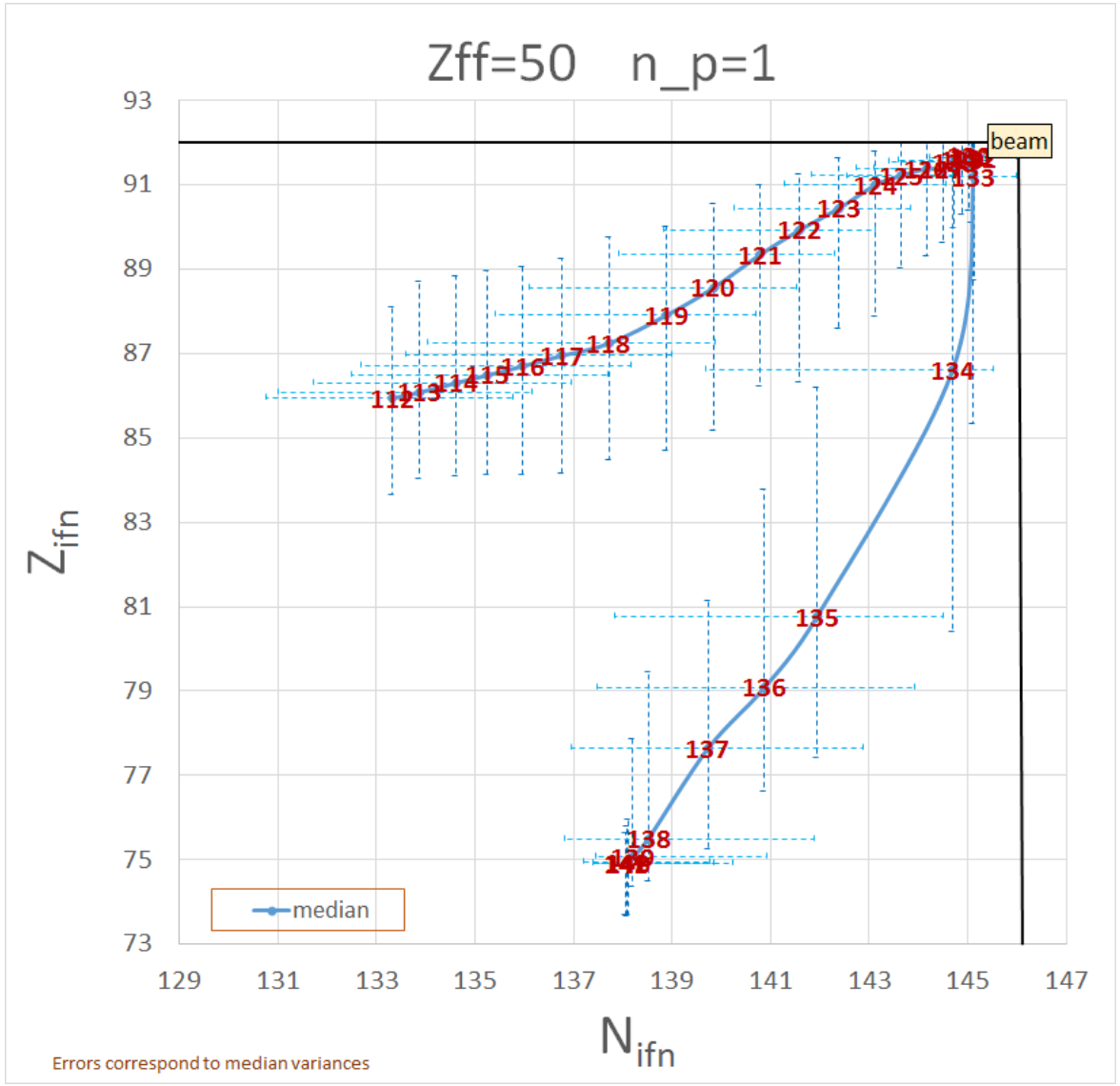
IFN-analysis for final Sn-isotopes (Z=50) : a

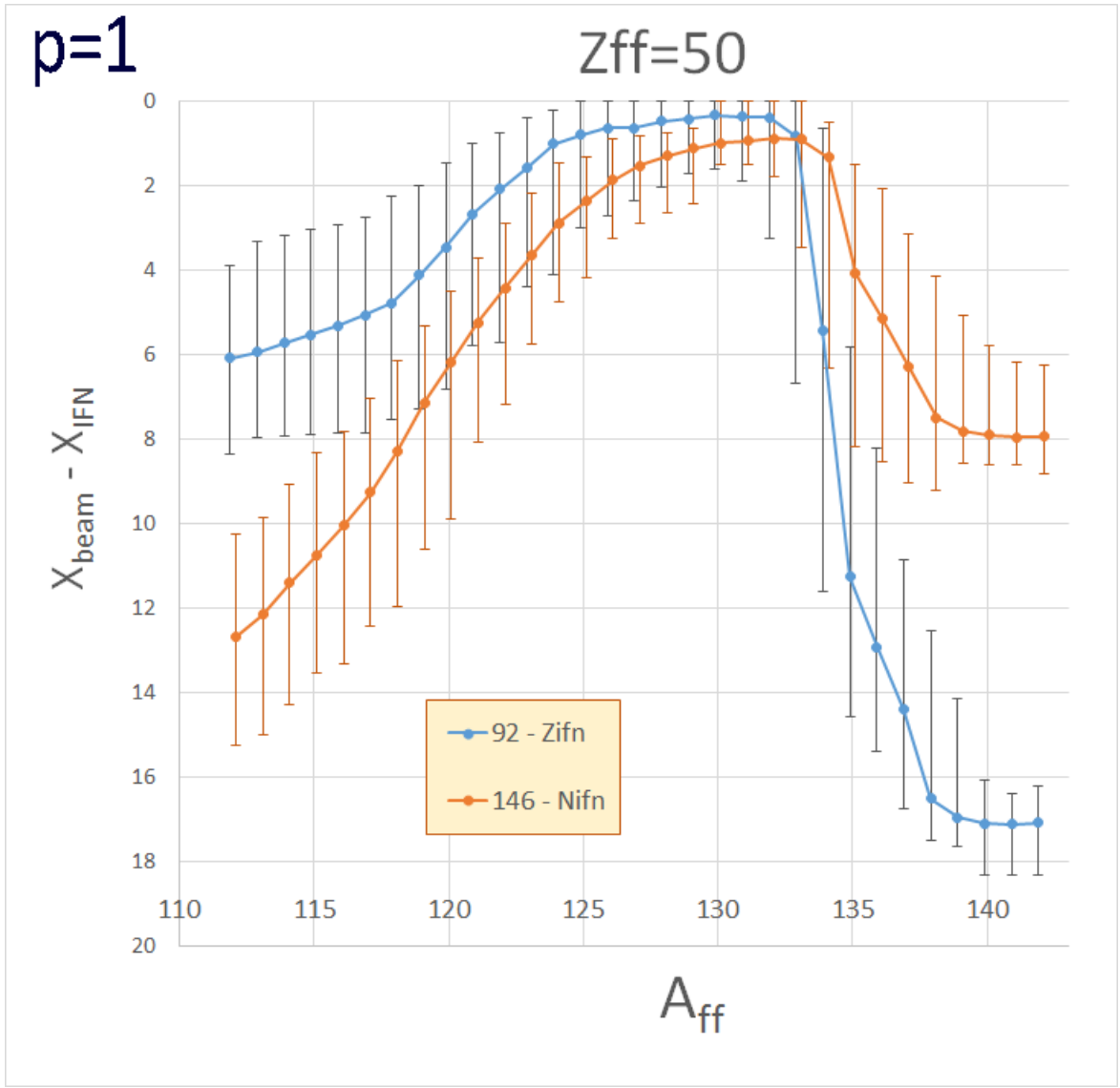




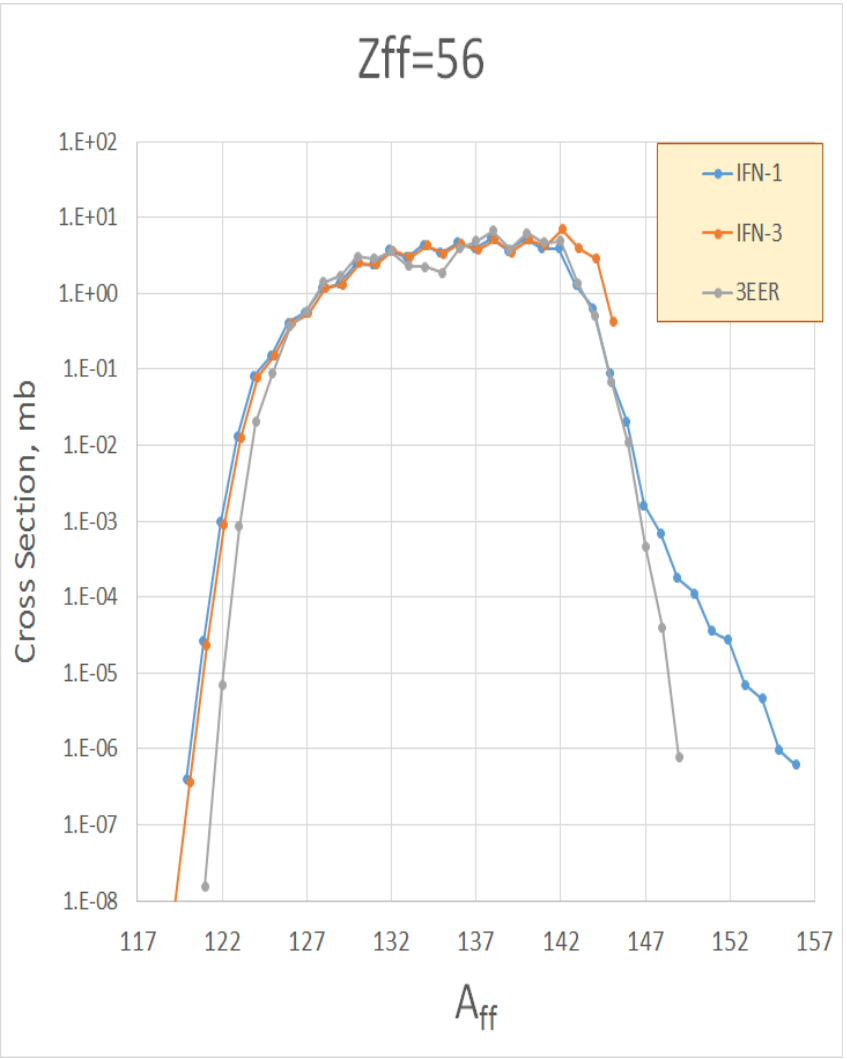


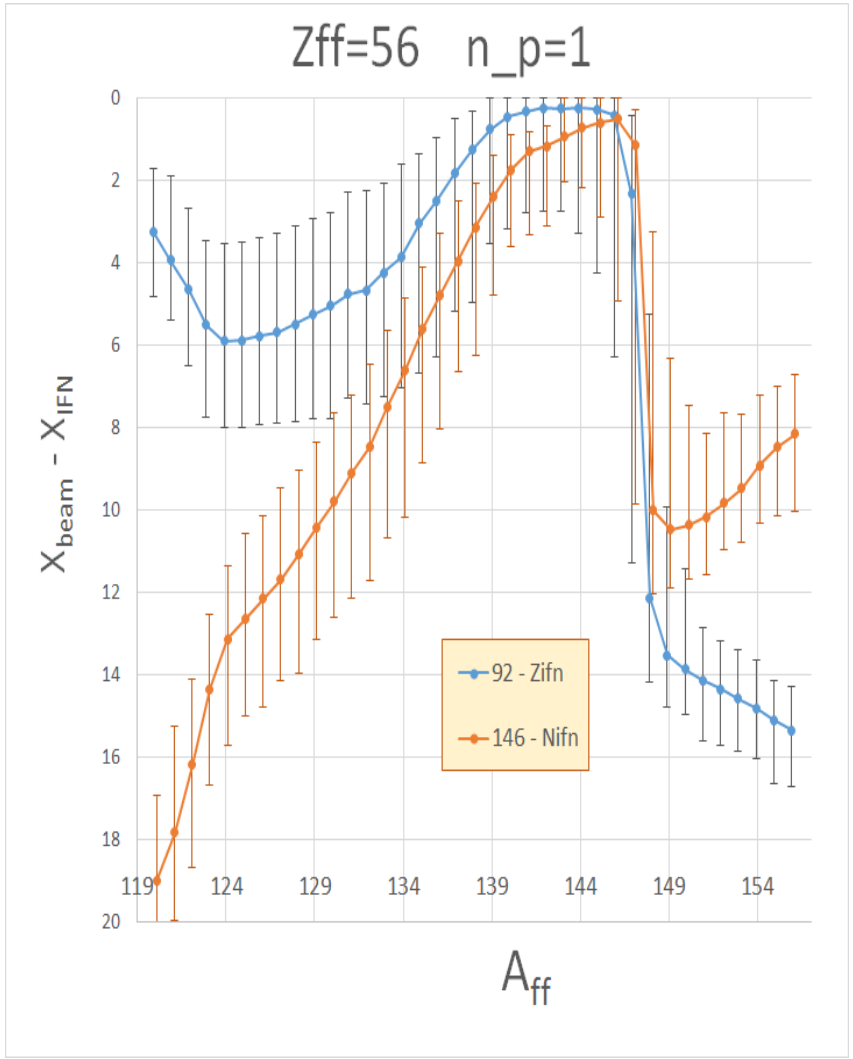
IFN-analysis for final Sn-isotopes (Z=50) : b

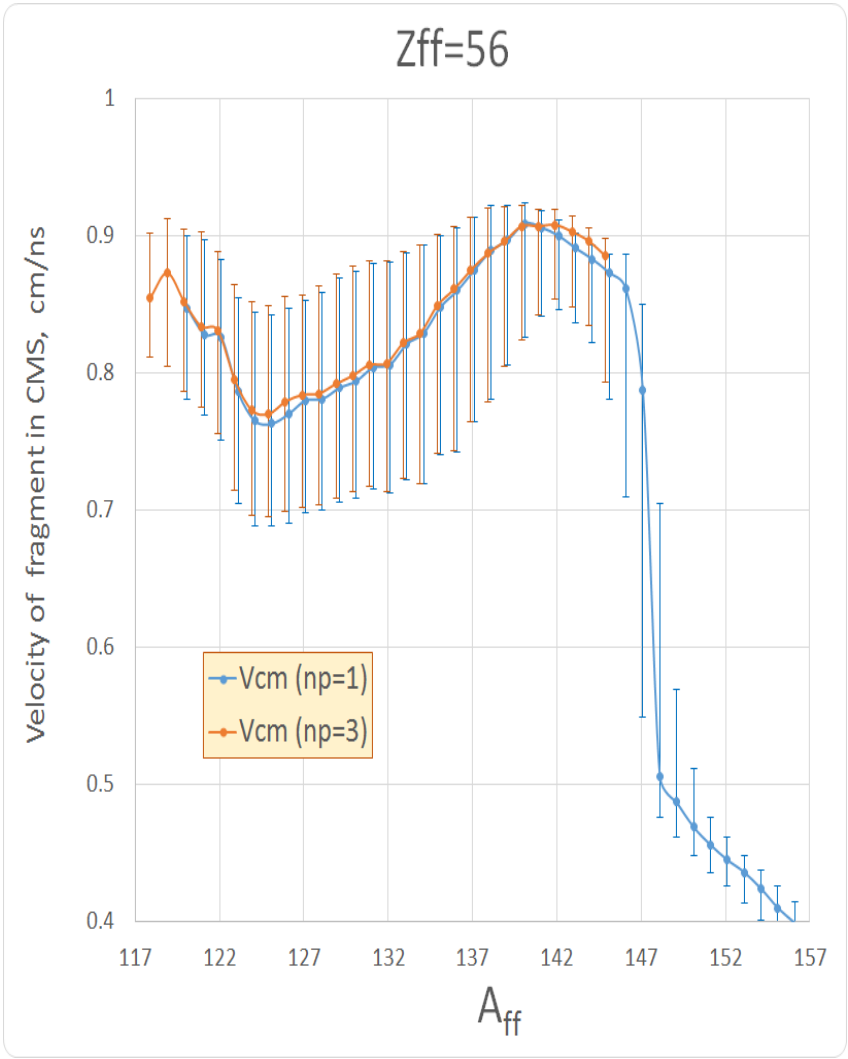




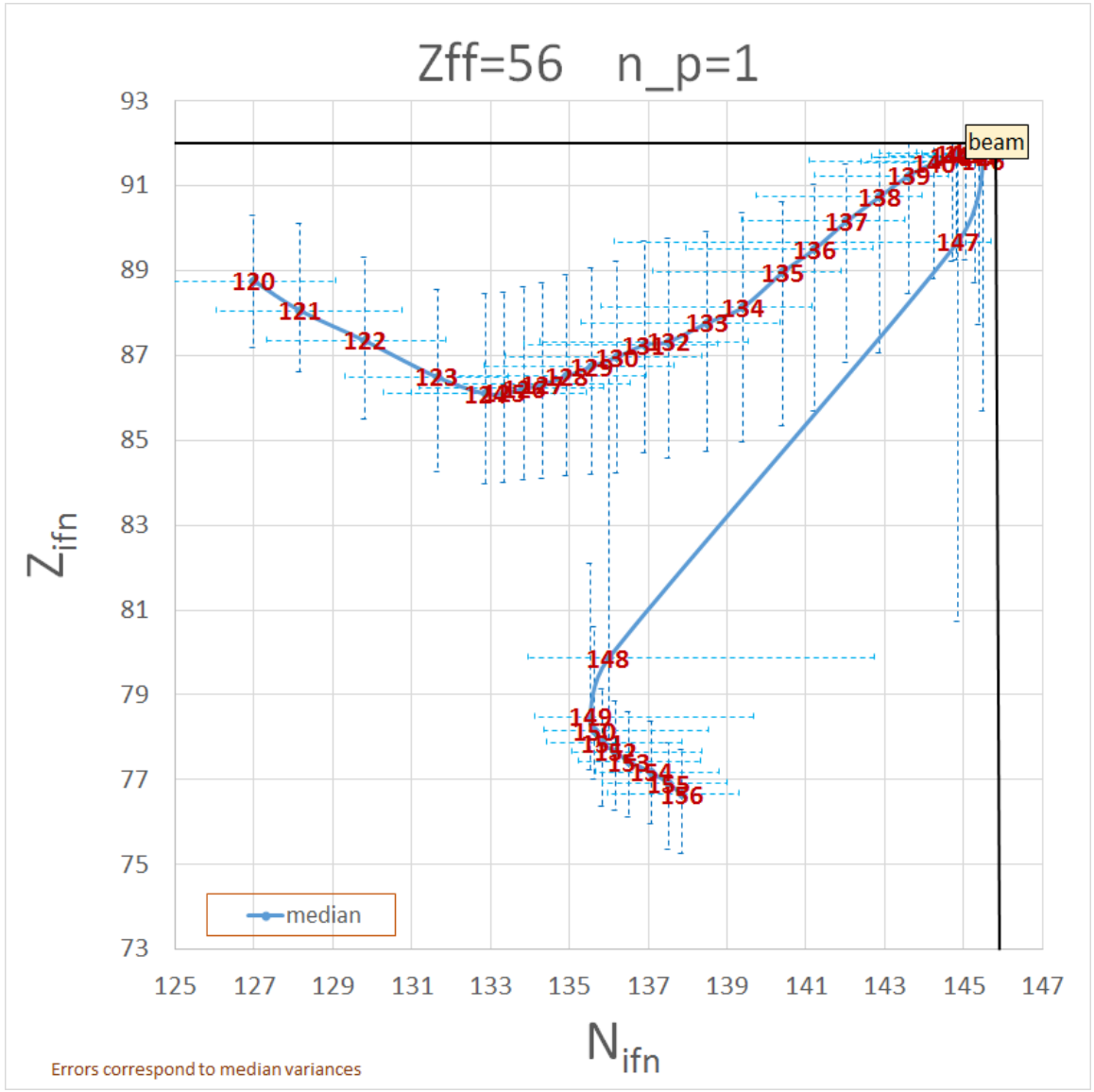
IFN-analysis for final Ba-isotopes (Z=56) : a



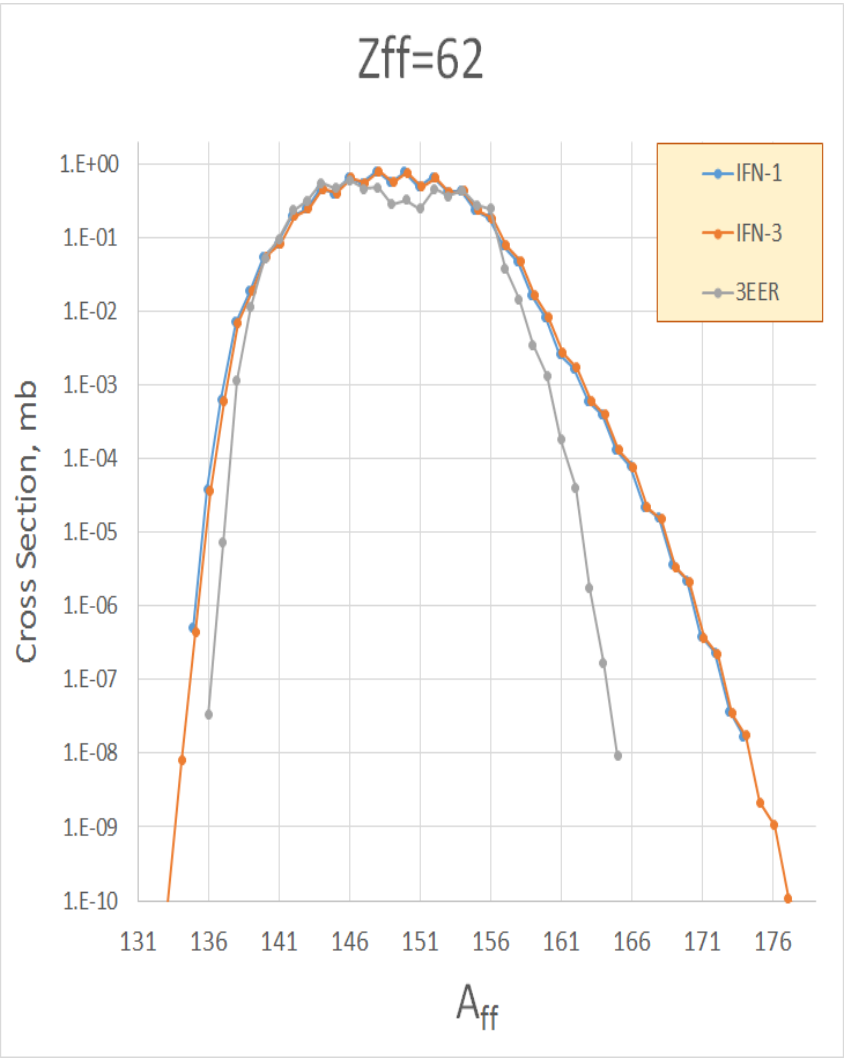


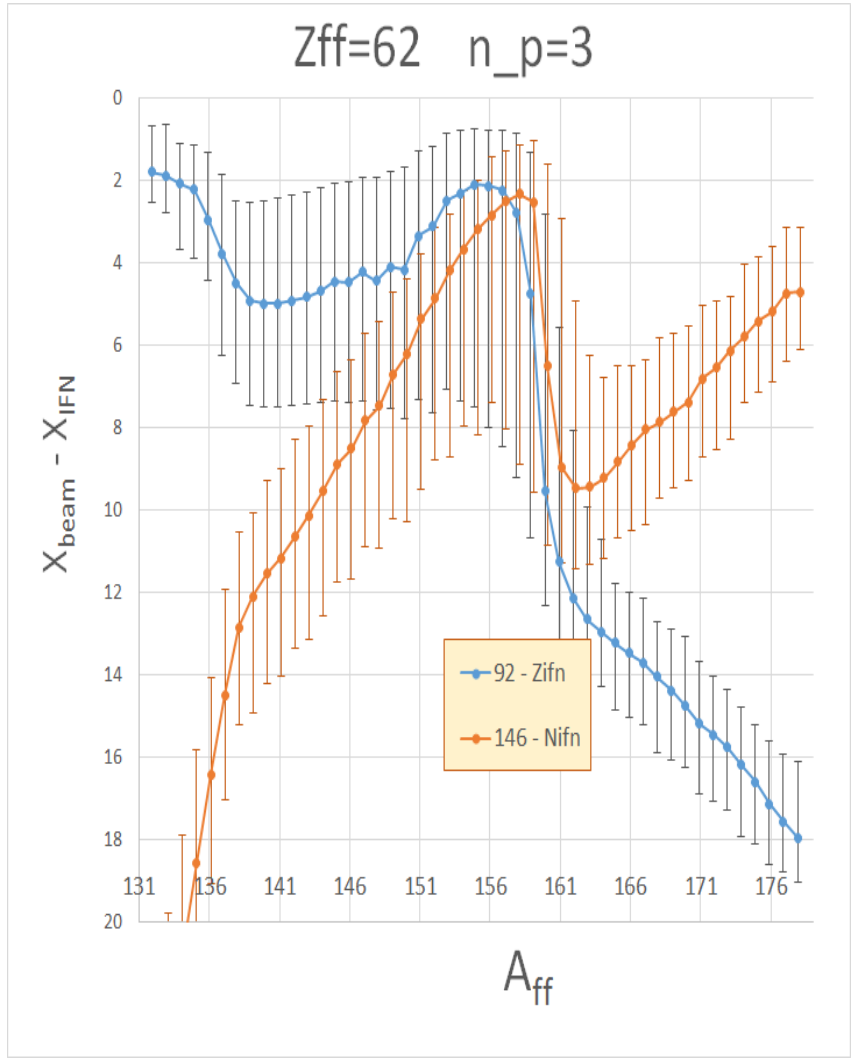


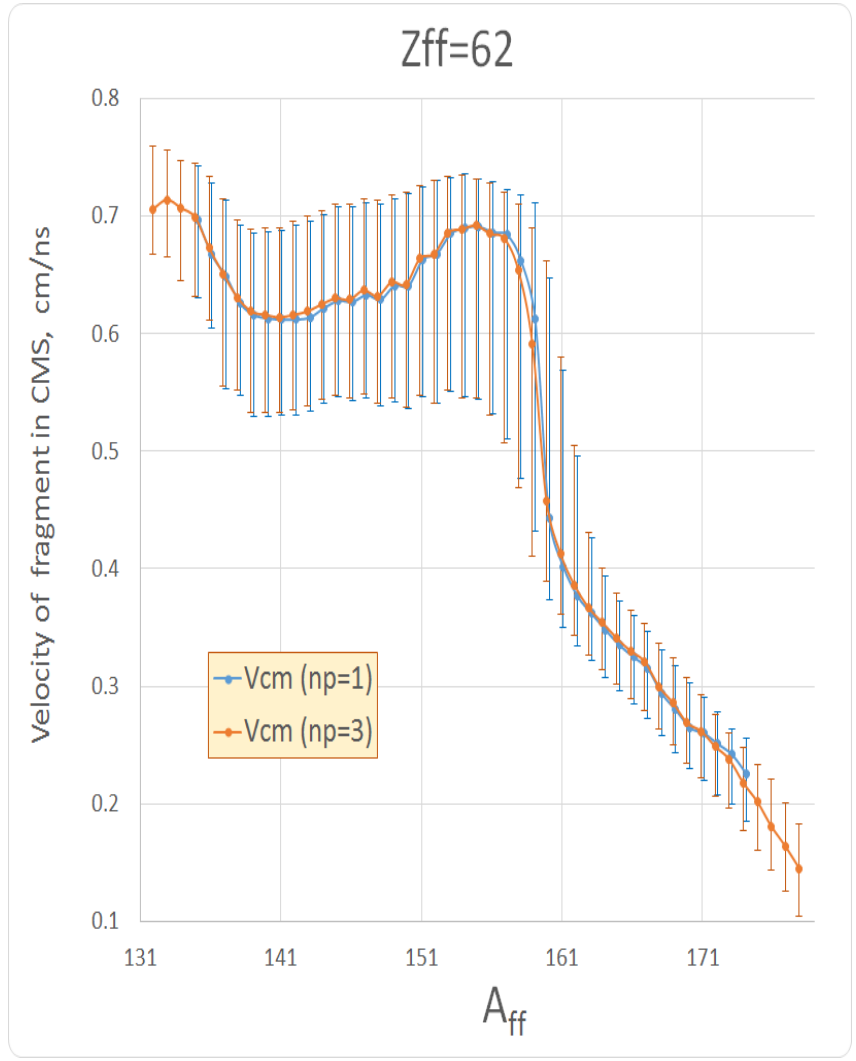
IFN-analysis for final Ba-isotopes (Z=56) : b



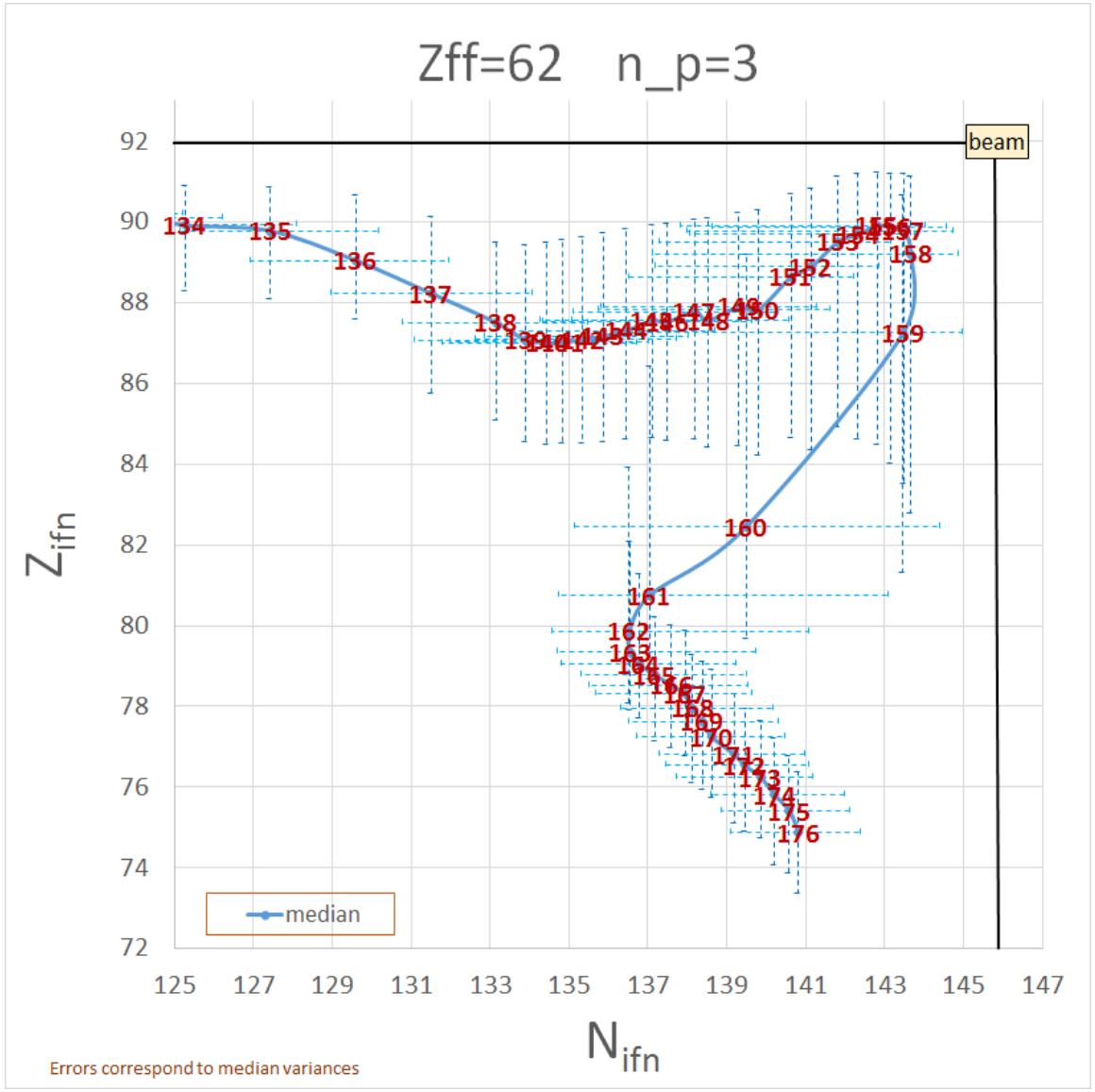
IFN-analysis for final Sm-isotopes (Z=62) : a

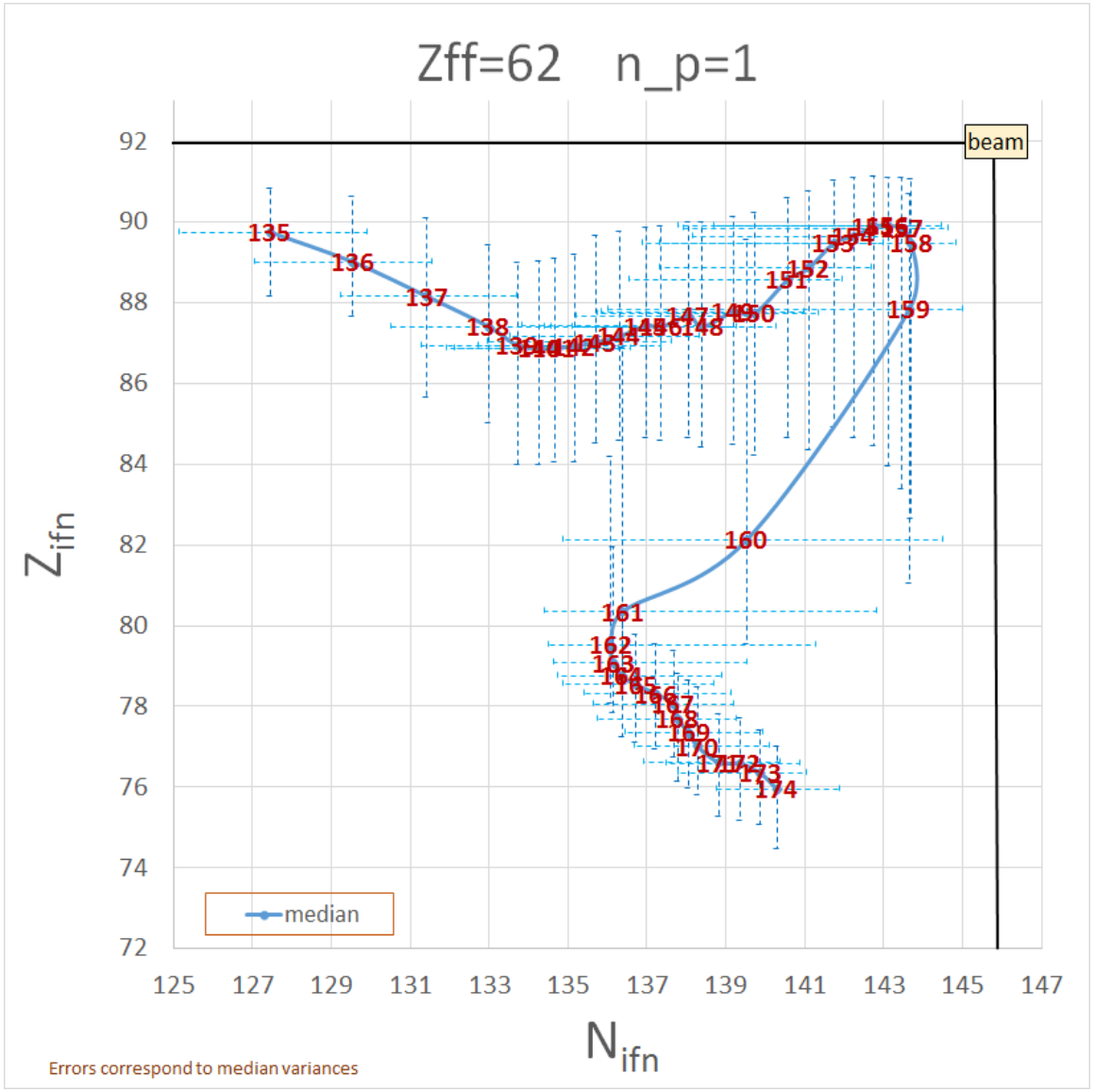




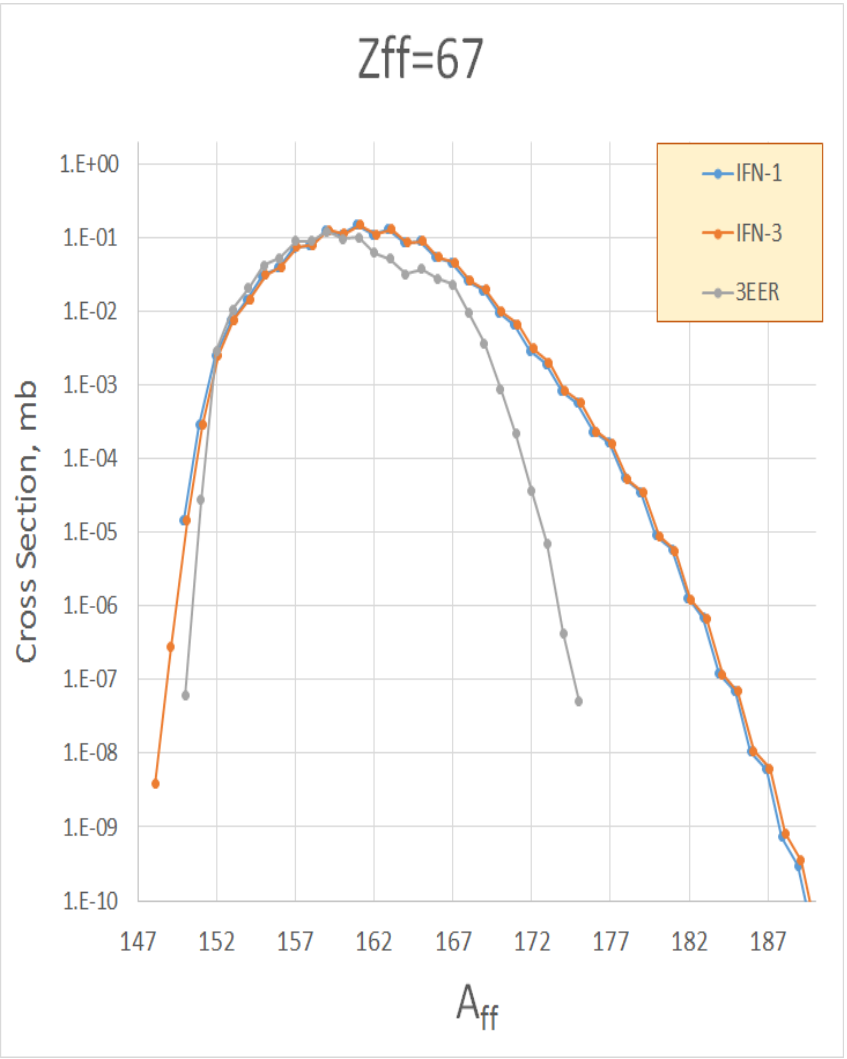


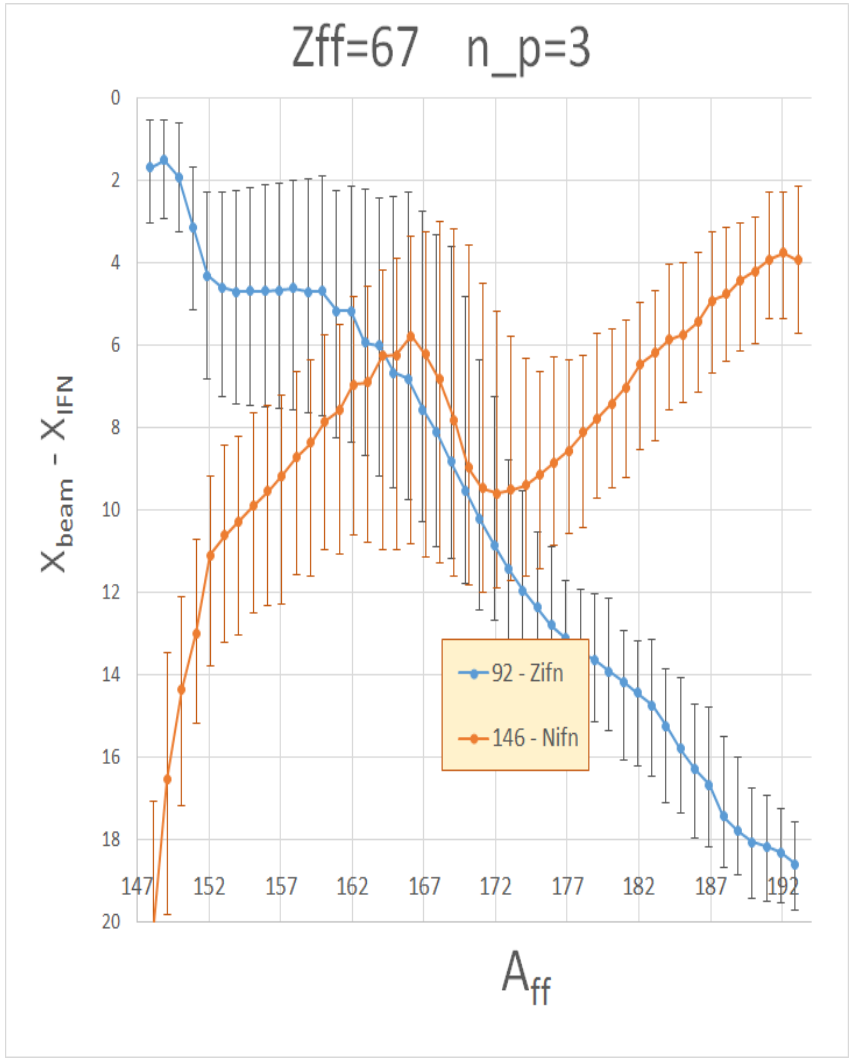
IFN-analysis for final Sm-isotopes (Z=62) : b

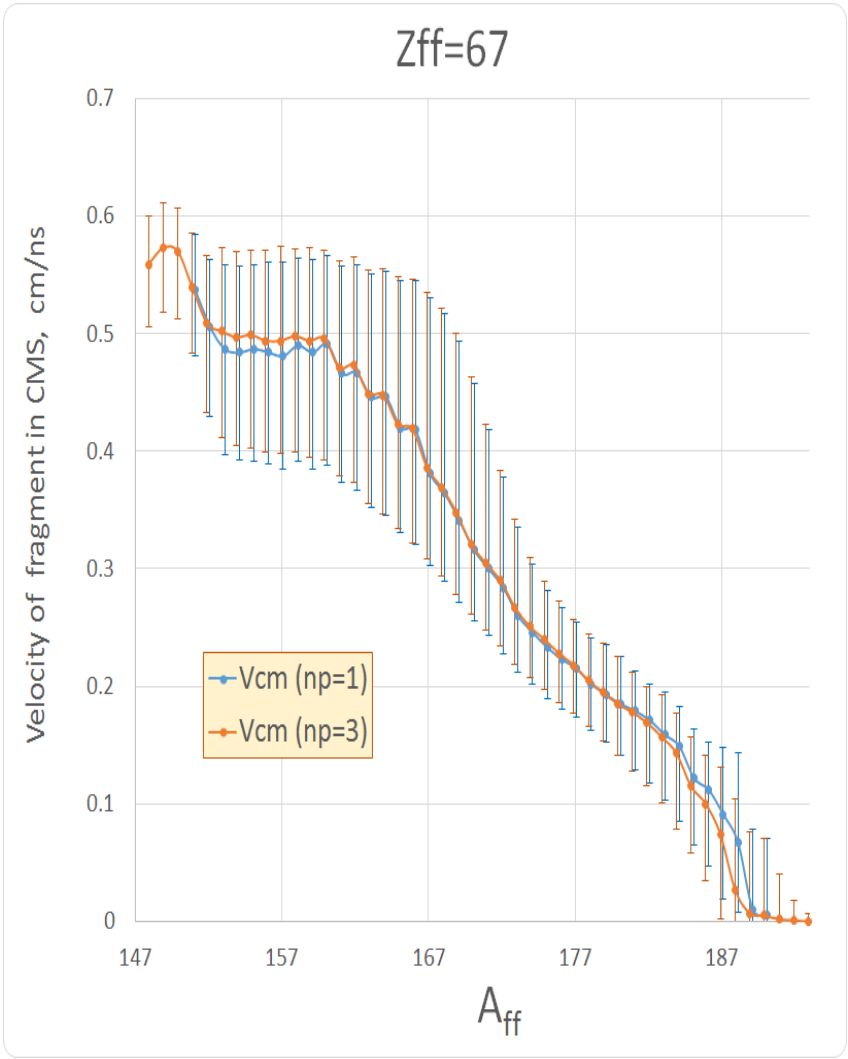




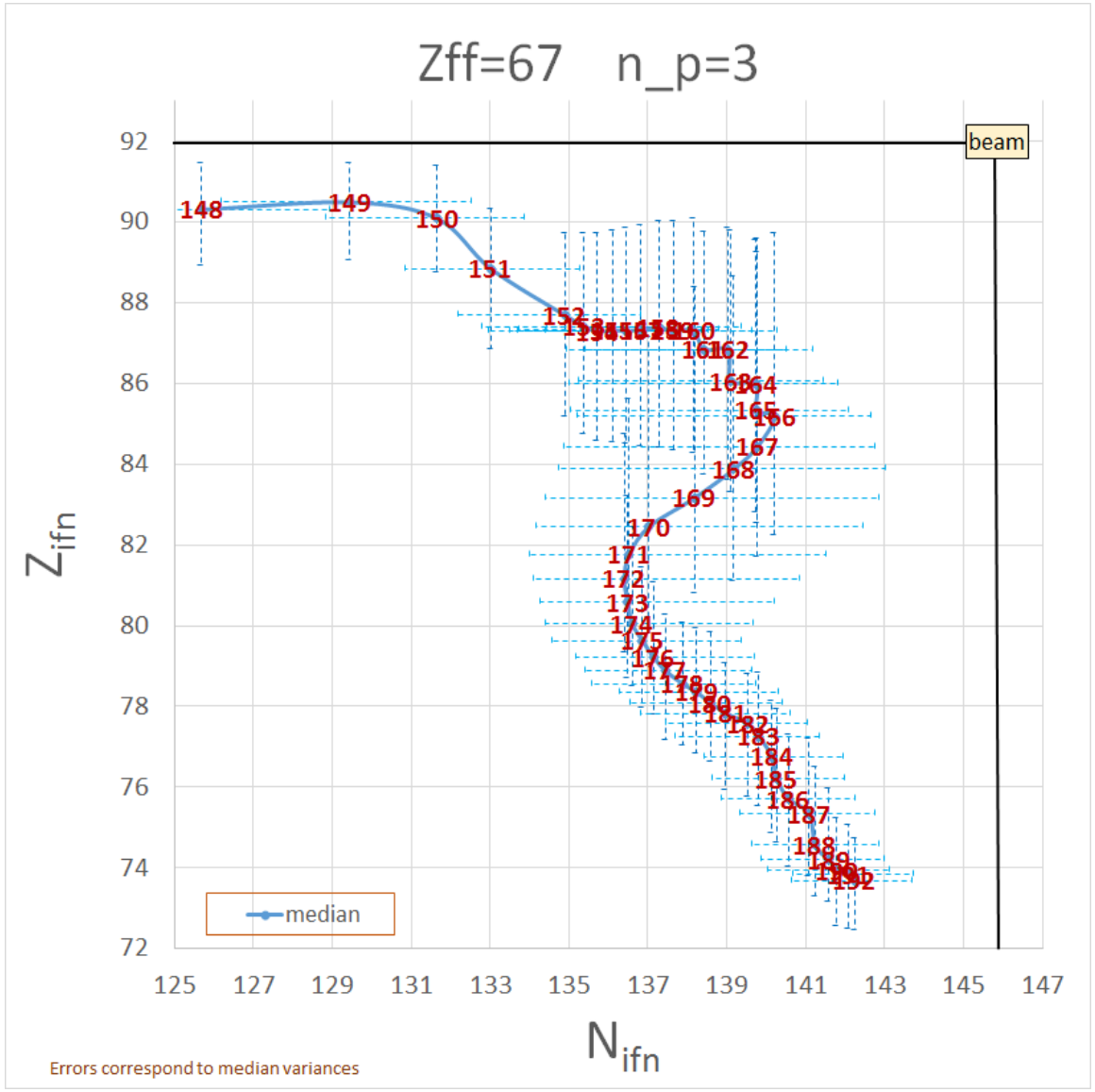
IFN-analysis for final Ho-isotopes (Z=67) : a

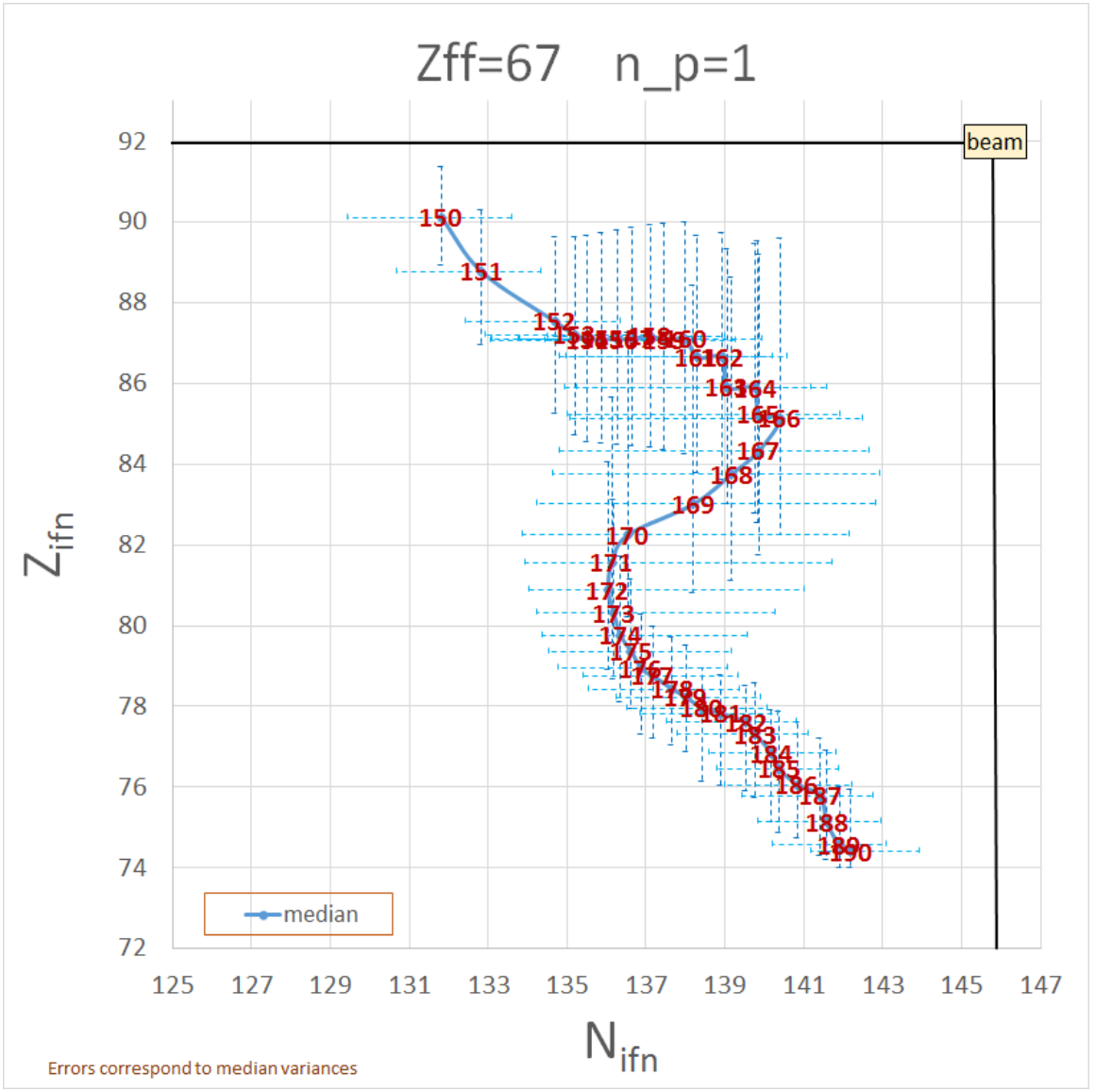




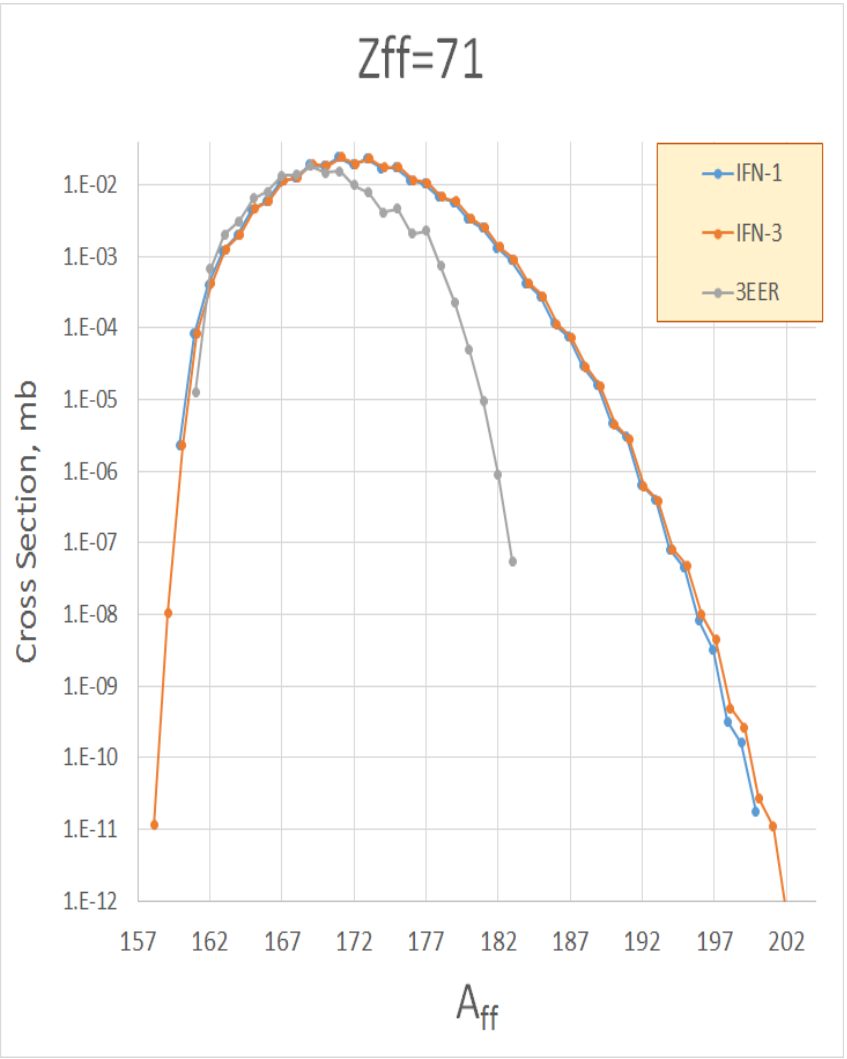


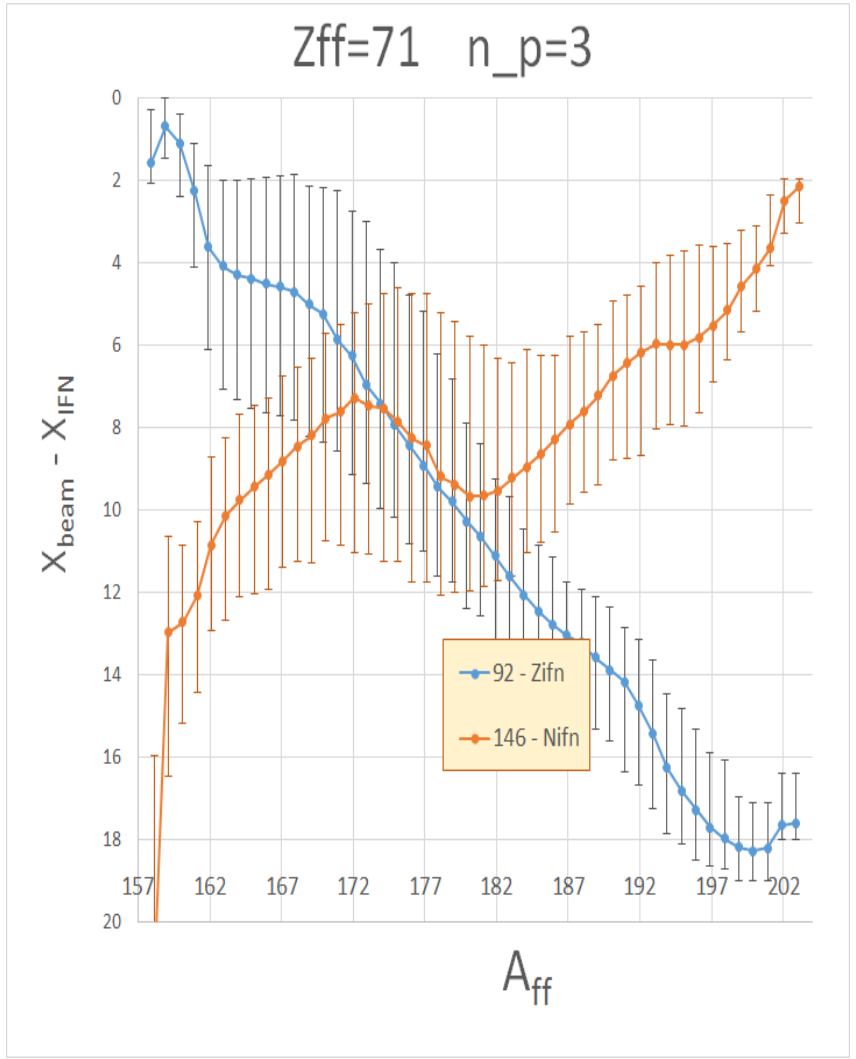
IFN-analysis for final Ho-isotopes (Z=67) : b

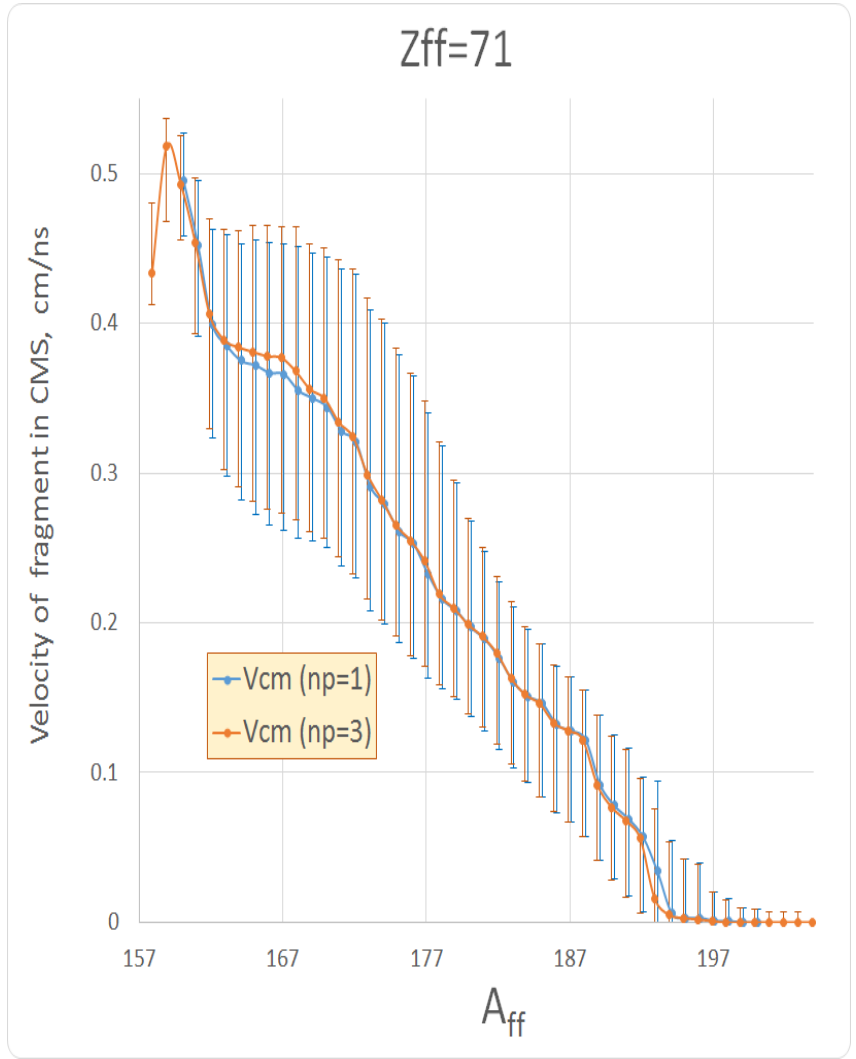




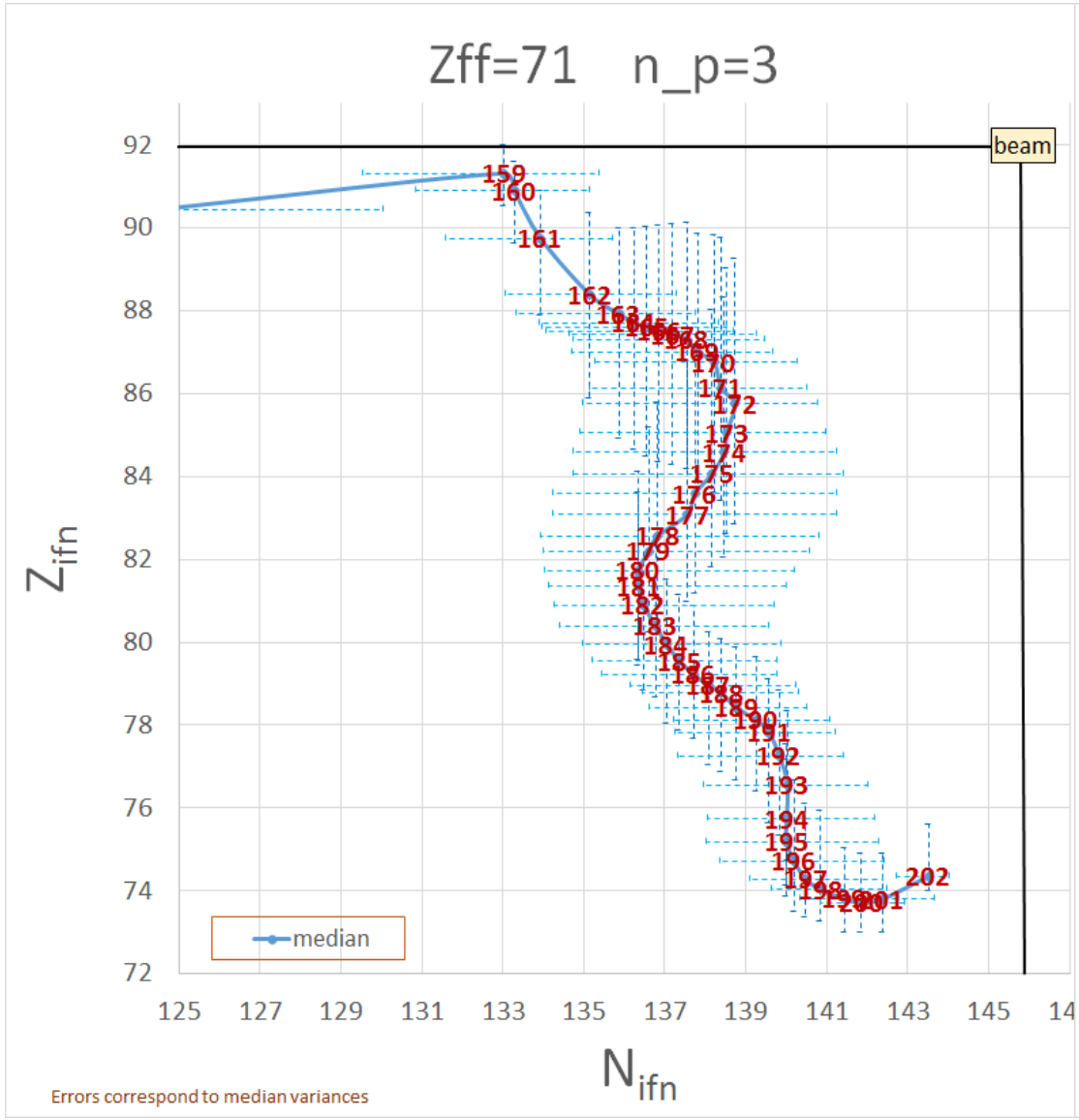
IFN-analysis for final Lu-isotopes (Z=71) : a

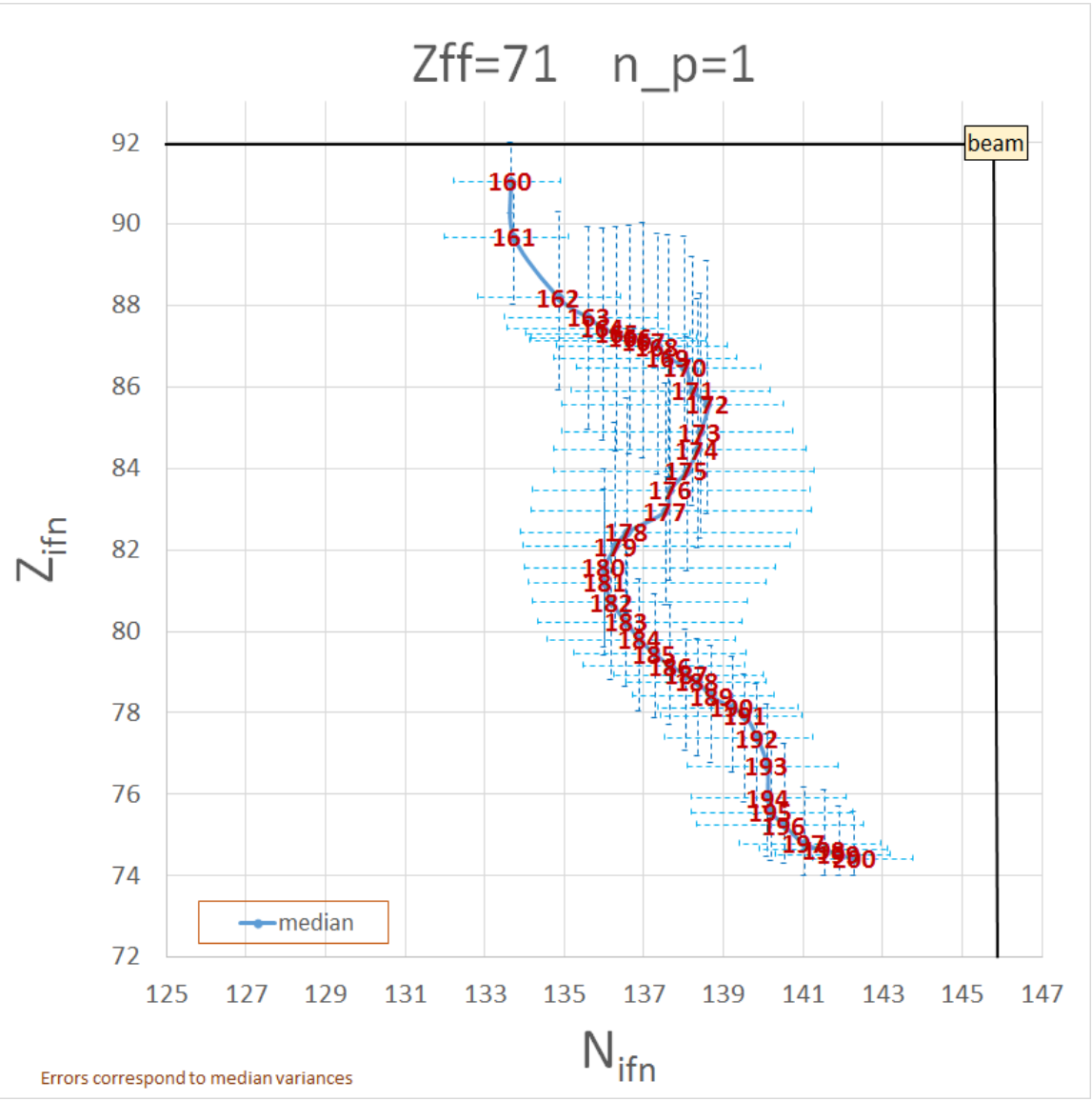




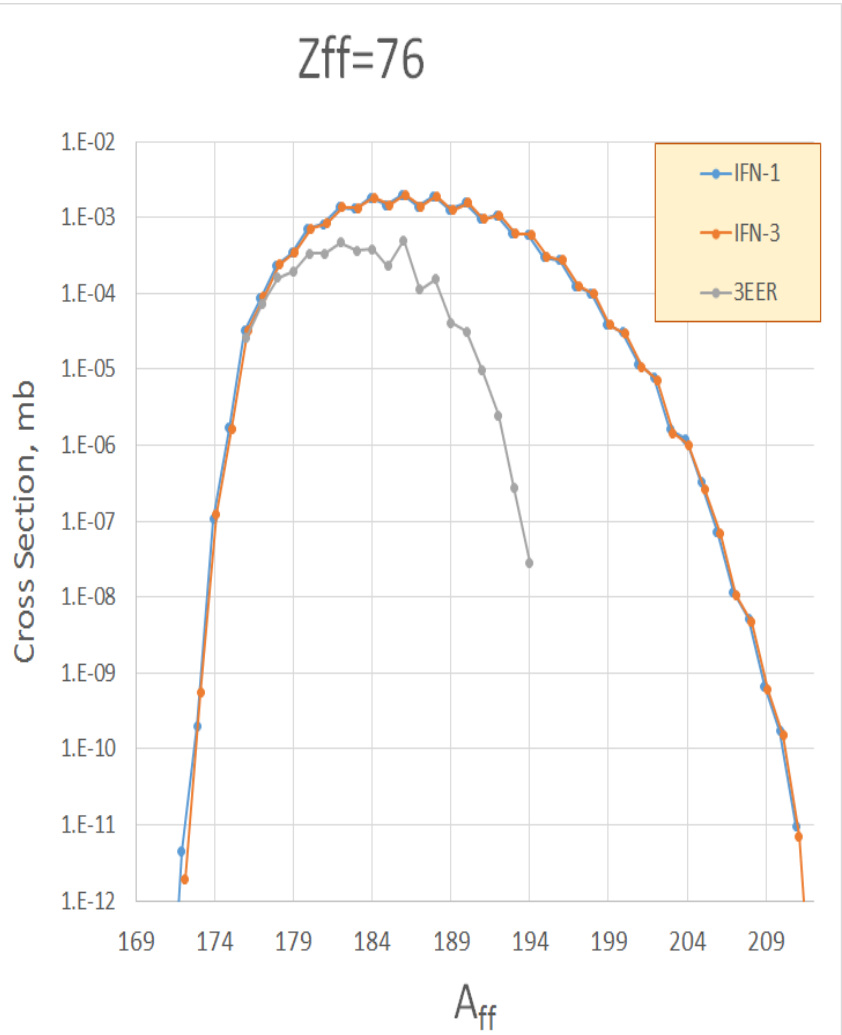


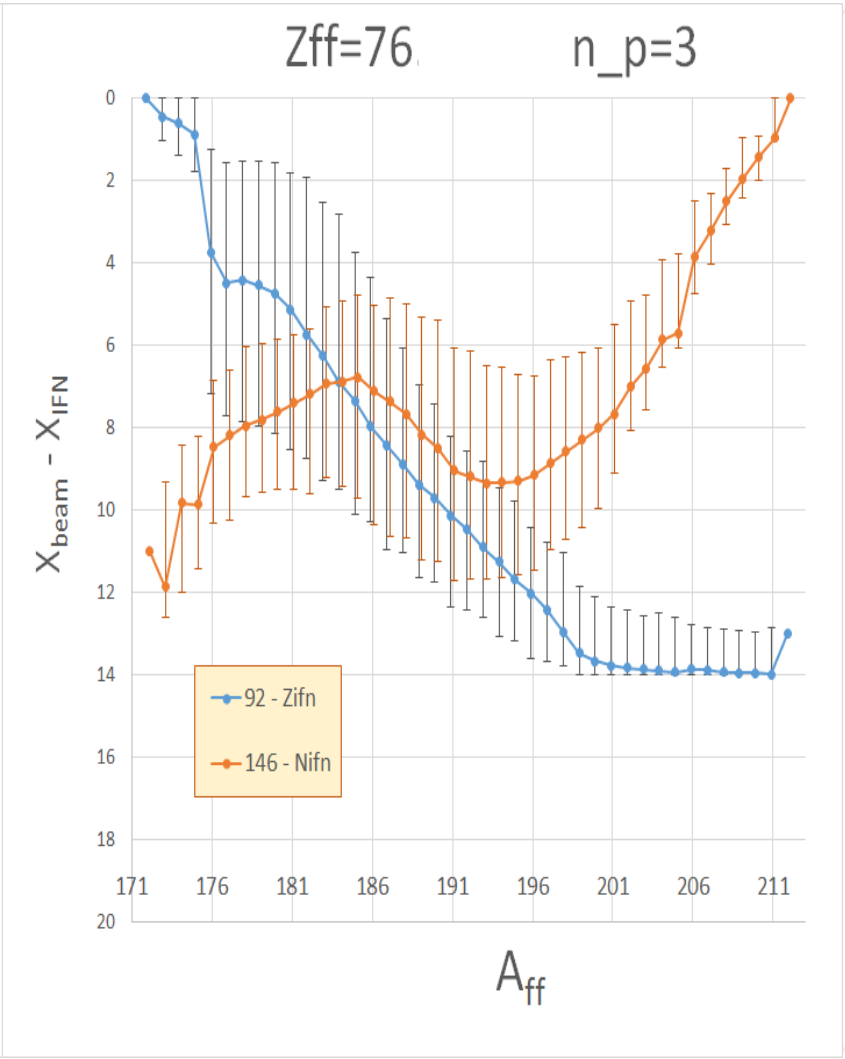
IFN-analysis for final Lu-isotopes (Z=71) : b

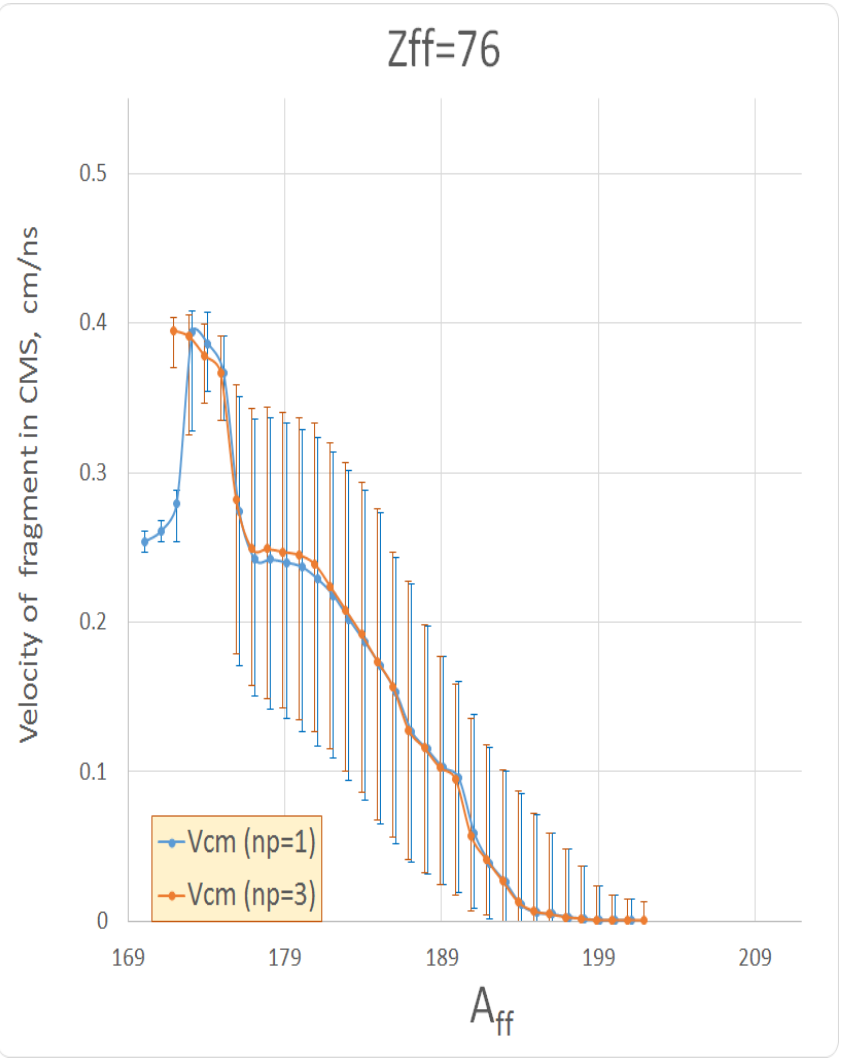




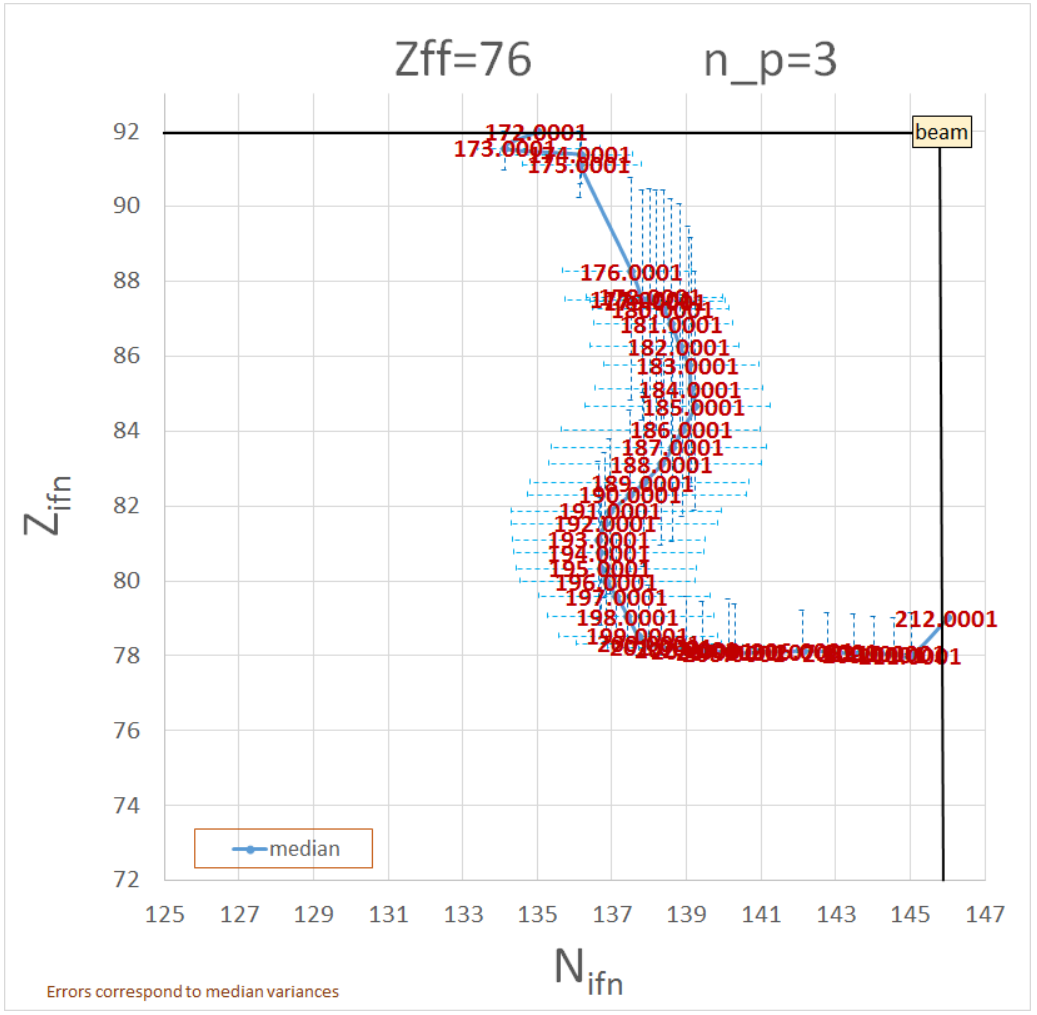
IFN-analysis for final Os-isotopes (Z=76) : a

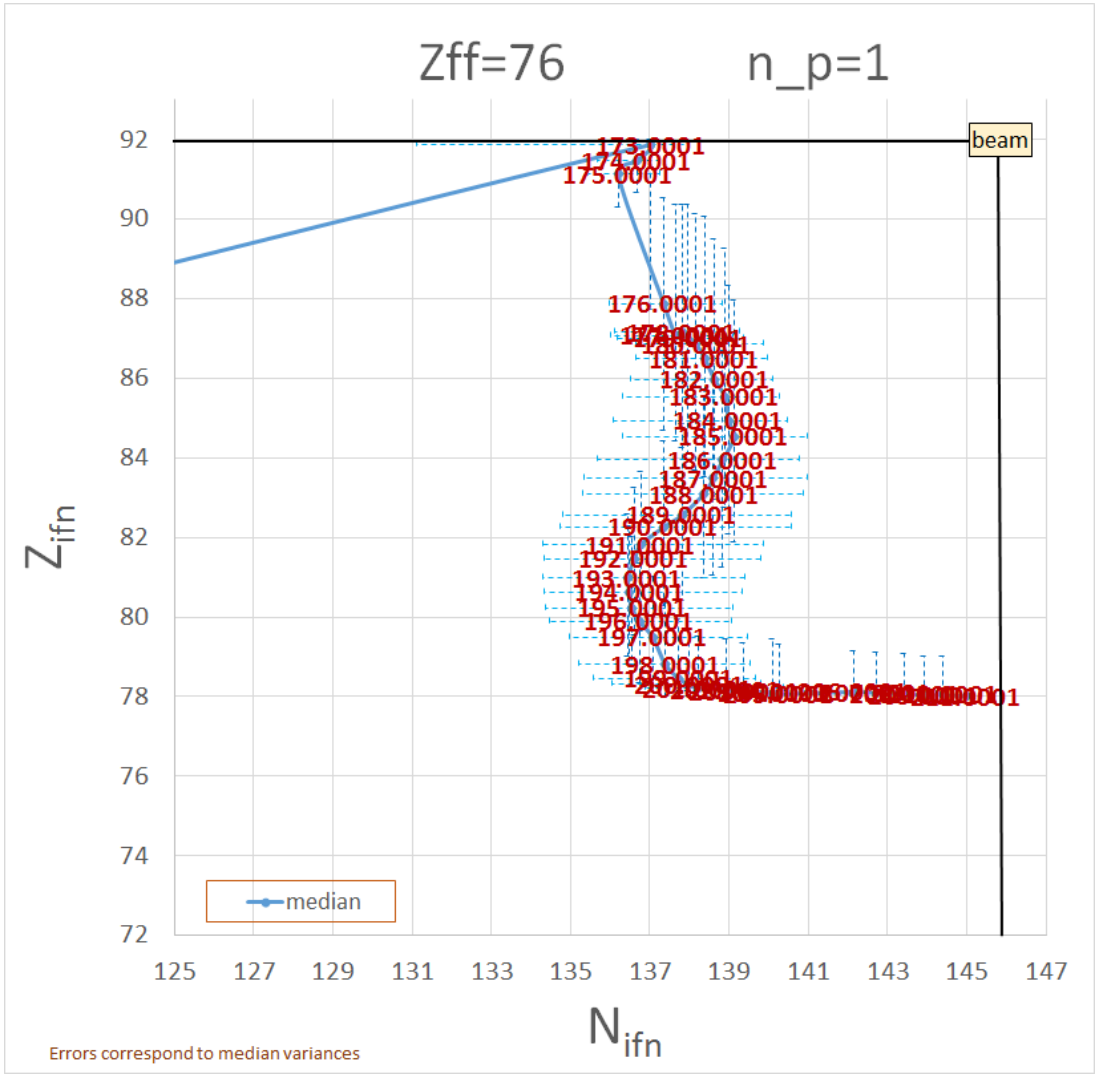






IFN-analysis for final Os-isotopes (Z=76) : b





Comparison of results by the 3EER, IFN1, and IFN3 models

					Quality for		
method	Excitation enrgy points	Number of fissle nuclei	calculation time		low Z	High Z	Remark
3EER	1	3	minutes for all Z		bad reproduction for both edges of isotope distributions	very bad reproduction for neutron-rich isotopes	
IFN1	1	defined by user (recommended >200)	~ 10 minutes for one FFF calculation	~ hour for detail one FFF calculation	moderate reproduction for neutron-rich isotopes	the same	less sensitive to Low Ex than IFN3
IFN3	3		3 times longer than IFN1				

Next steps

- Utility calculation speed optimization
- Using the new utility try to define Fission, Evaporation, AA excitation energy parameters for best agreement with experimental data
- Generate Z-full range IFN1 and IFN3 tables for different targets (and energies?)
- Develop new Abrasion-Fission mode to use IFN tables, that provides more fast and qualitative yield calculations