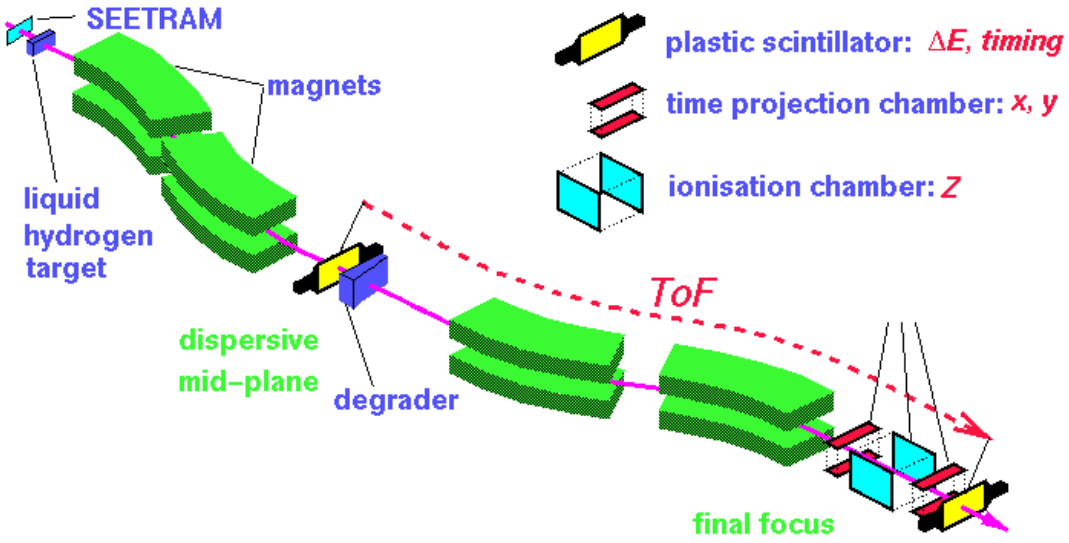
Residual nuclei in the spallation reaction Fe + p at 1500, 1000, 750, 500 and 300 MeV/A

Motivations.

- Iron is the most important material in the composition of an ADS's window. We want to calculate changes in the chemical composition dues to the proton irradiation.
- These new isotopic cross sections will allow testing the spallation codes in the light nuclei region where no many data were avalaible up to now.
- Astrophysics : secondary nuclei production in the cosmic-ray propagation through the galaxy.

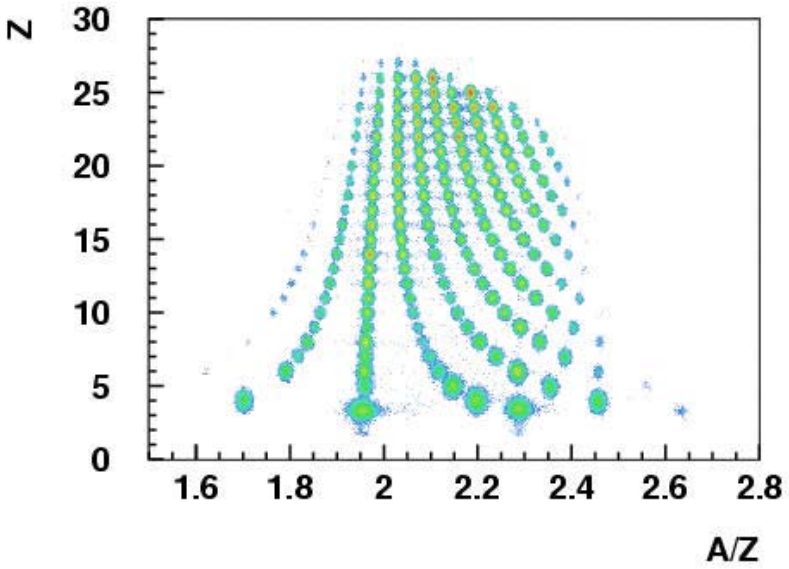
Experimental results



a) Residual nuclei produced in the Fe + p reaction at 1000 MeV/A

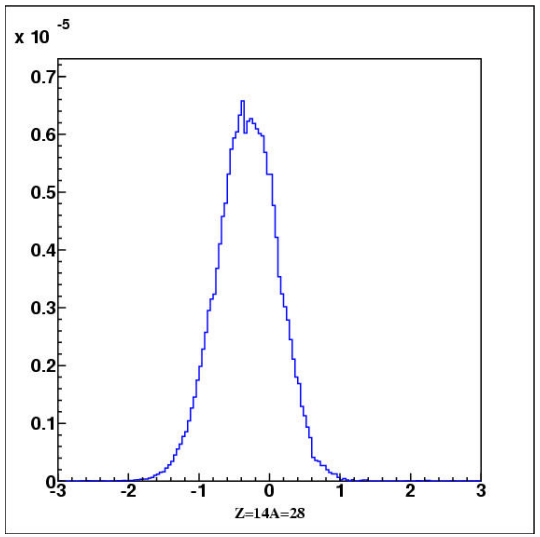
b) Velocity distribution of ^{28}Si at 1000 MeV/A

a)

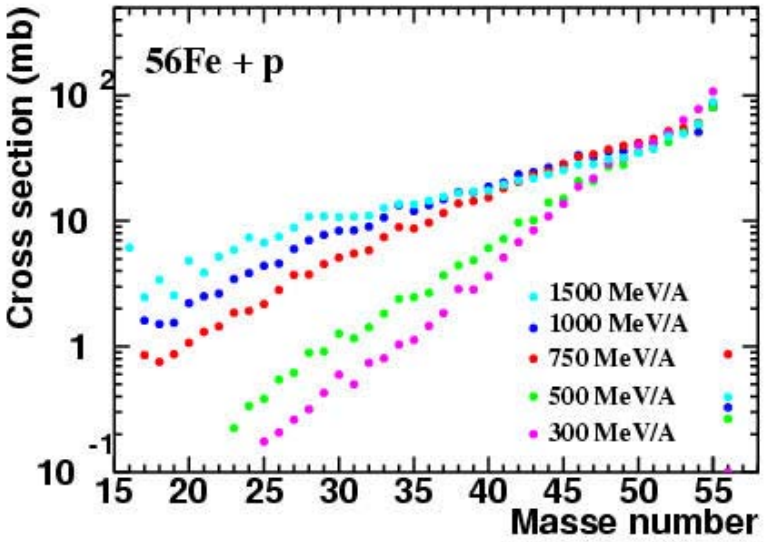


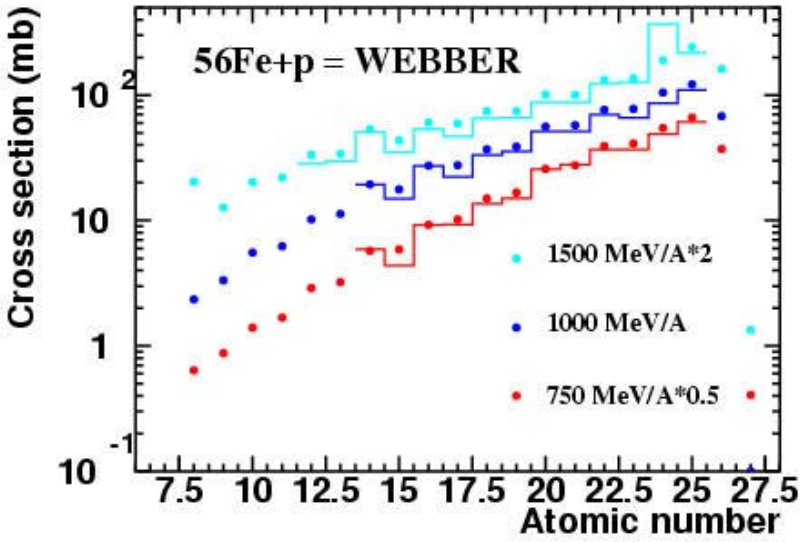
b)

Z=14 A=28



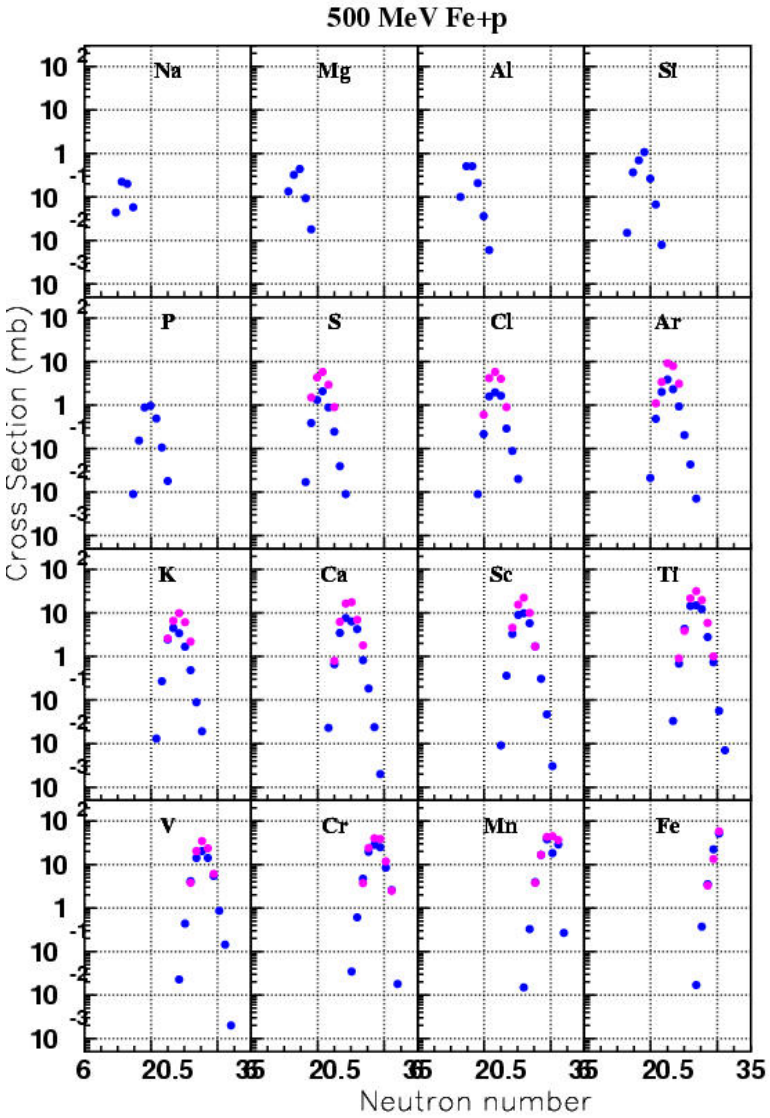
Experimental results : Mass and charge distributions

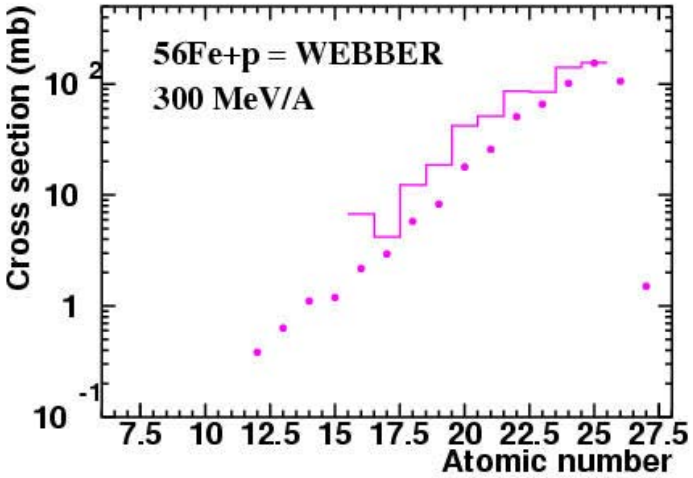




- Experimental mass distribution of the residues at 1500, 1000, 750, 500 and 300 MeV/A
- Comparison of the charge distribution with the experimental data of Webber et al.(Phys. Rev. C 41, 2 1990 533-546)

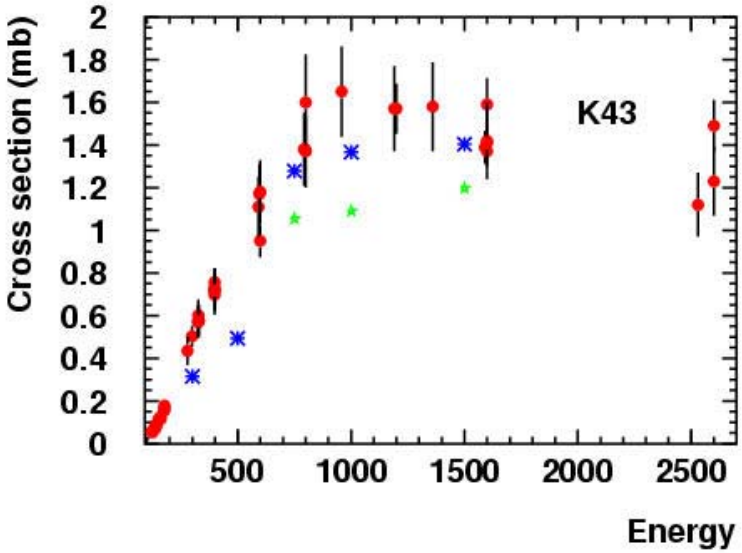
Experimental results : Problems with low energies

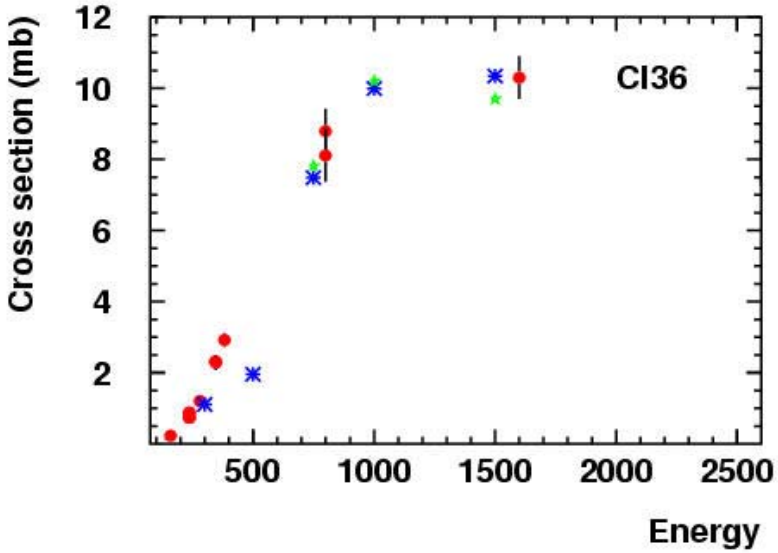




Energy	σ total	σ incl	σ Kox
1500	787	730	735
1000	751	728	733
750	681	718	715
500	478	697	668
300	465	669	605

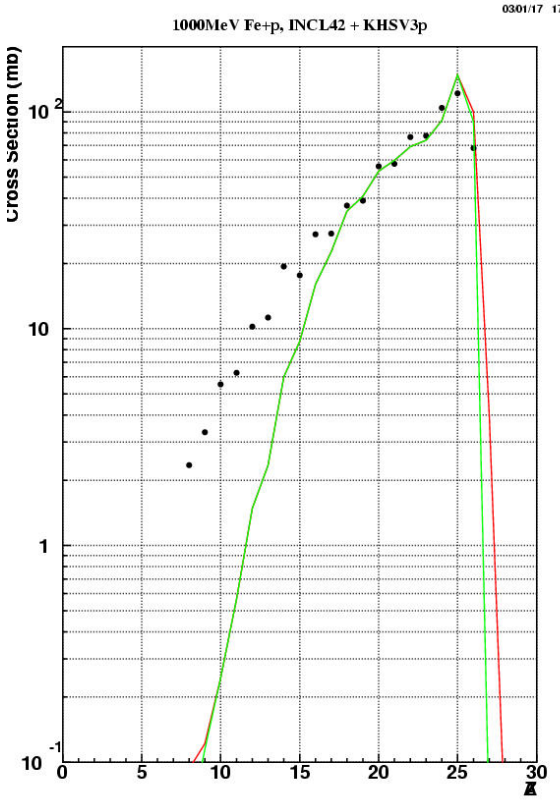
Experimental results : Comparison with data from the direct kinematics.

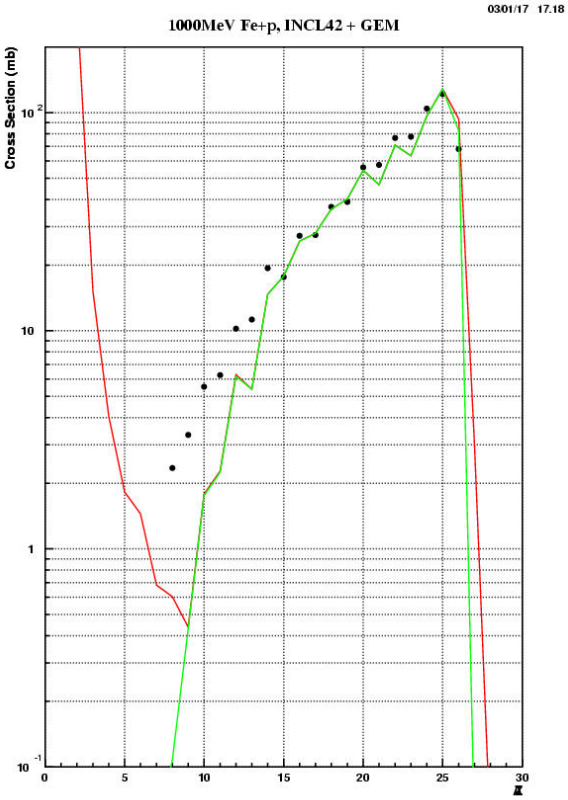


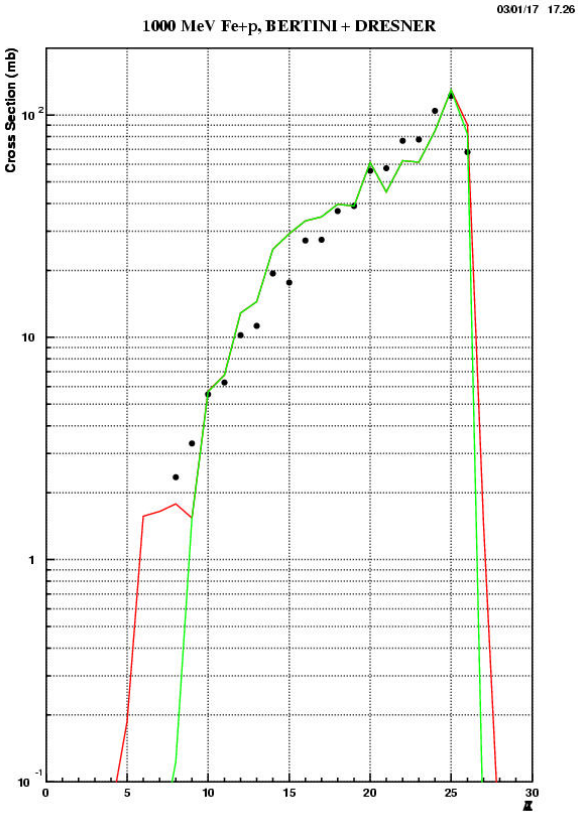


Excitation fonctions for two isotopes created in direct kinematics and detected by gamma spectroscopy (R.Michel et al. Nucl. Instr. Meth. Phys. Res. B 129 (1997) 153-193
Good agreement, in general, at high energies for the 14 available isotopes.

Spallation codes : intranuclear cascade + evaporation





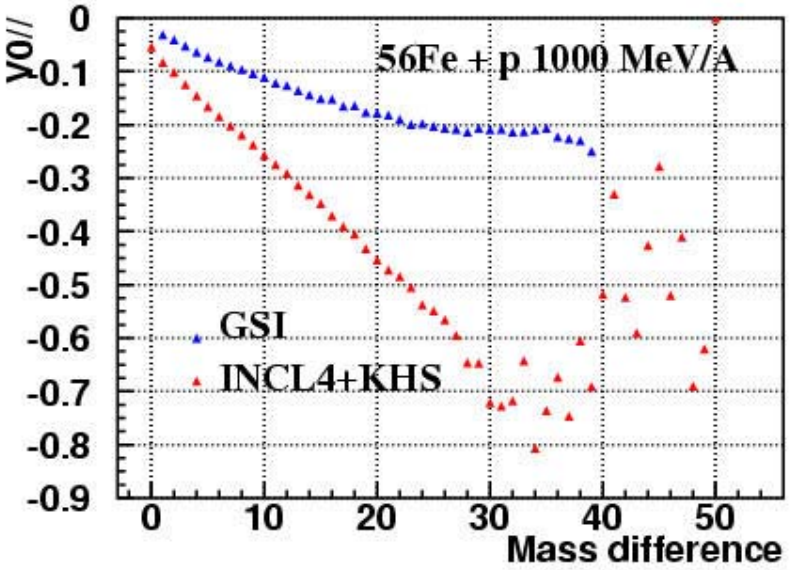


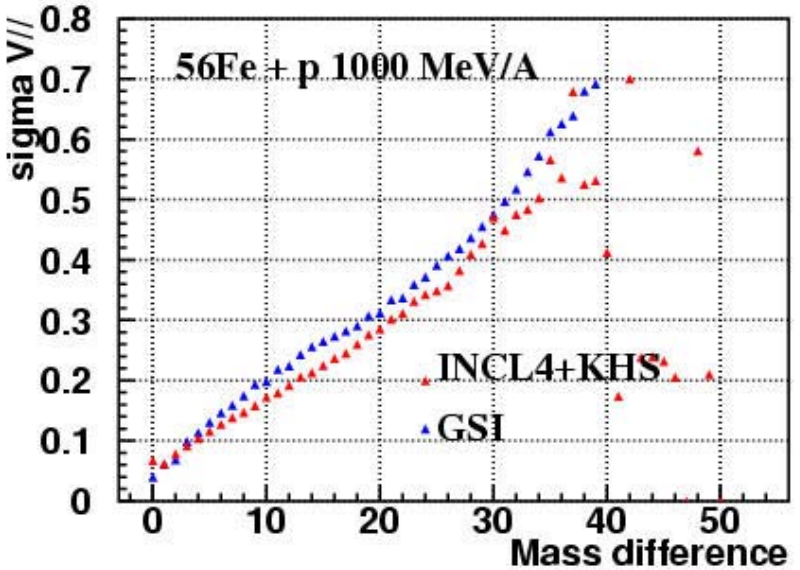
INCL4 + KHS

INCL4 + GEM

BERTINI +DRESNER

Kinematic properties of the residues.

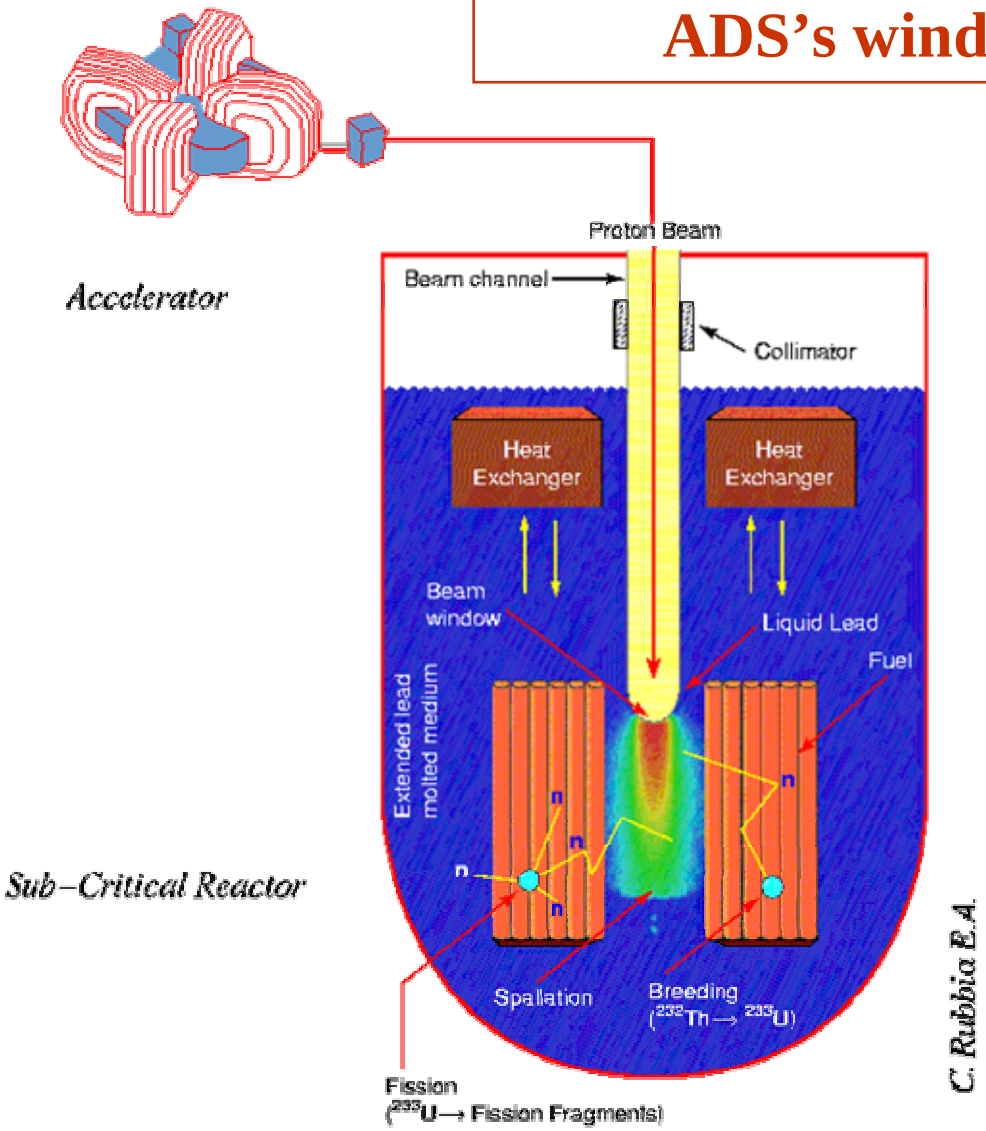




Mean velocity versus Δ A.

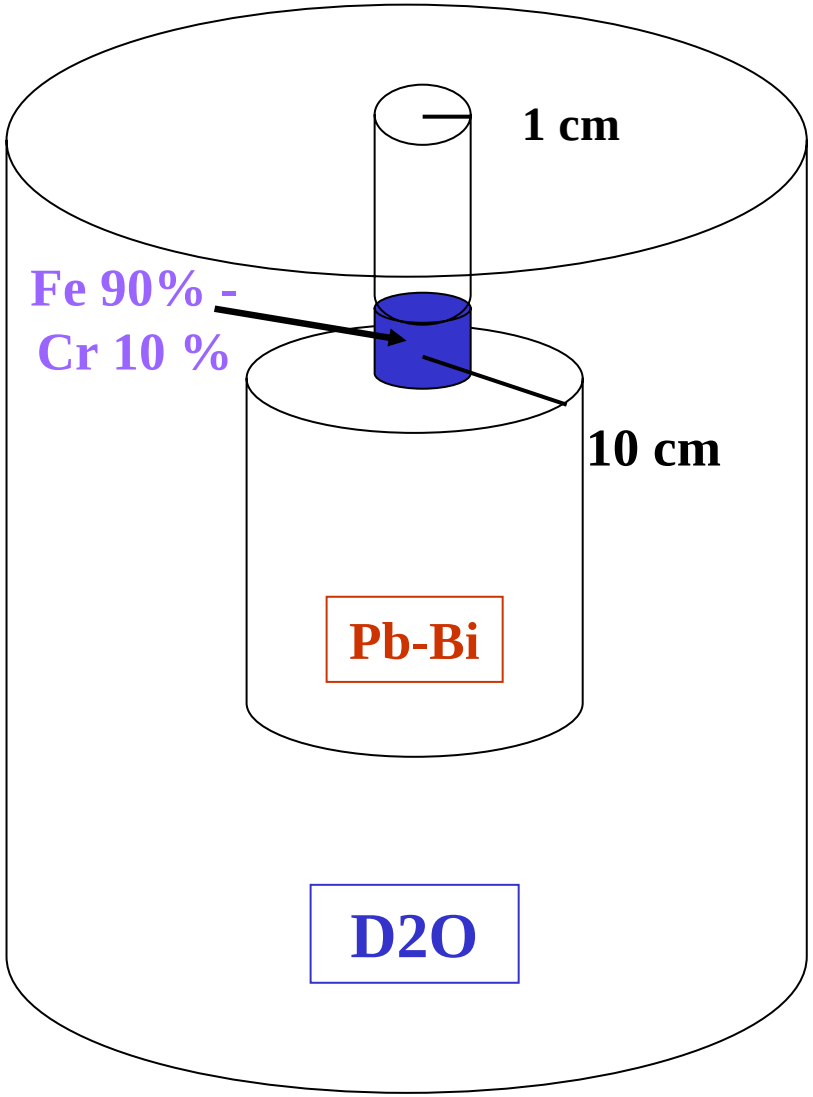
Velocity width versus Δ A.

ADS's window.

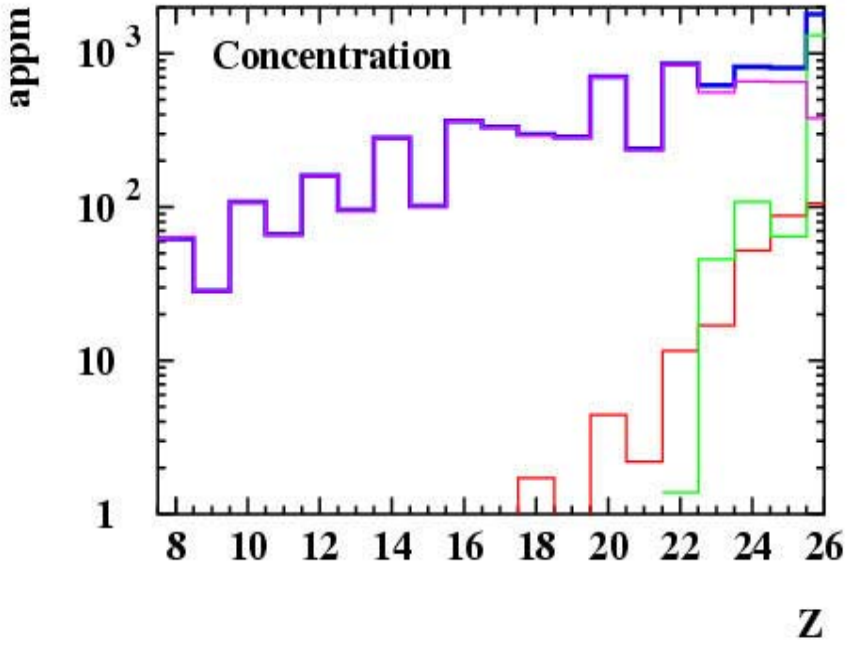


- Spallation Products
- Dislocation loops, bubbles, voids
- Dissolution or precipitation
- -Displacement per atom (dpa)
- **Selection Criteria : Resistance to heat deposition, irradiation effects and Pb-Bi corrosion, liquid metal embrittlement.**
- **Industrial grade: Availability and good transformability into semi products of various geometry . ⇒ Ferretic martensitic steels T91, EM10.**

Concentrations of the spallation residues



Chemical elements created in a window Fe 90% - Cr 10 % after one year of irradiation by a 31.8 μA /cm^{2}proton beam at 1000 MeV.



Conclusion and Outlook

- New experimental data of the residues in the reaction Fe+p at 1500, 1000, 750, 500 et 300 MeV/A :cross sections and velocity distributions.
- Good agreement with other experimental data at high energies.
- Problem with the total reaction cross section at 500 and 300 MeV/A : Normalisation, transmission?. Possibility of renormalisation.
- Existence of a saturation in the residue recoil velocity at every energy : fragmentation process?
- Application of the experimental data at 1000 MeV/A . Calculation of the different chemical concentrations in a window Fe 90% - Cr 10 % irradiated during one year by a 31.8 $\mu A / cm^2$ proton beam.
- Next : -dpa calculations.
  -Changes with the proton beam energy.