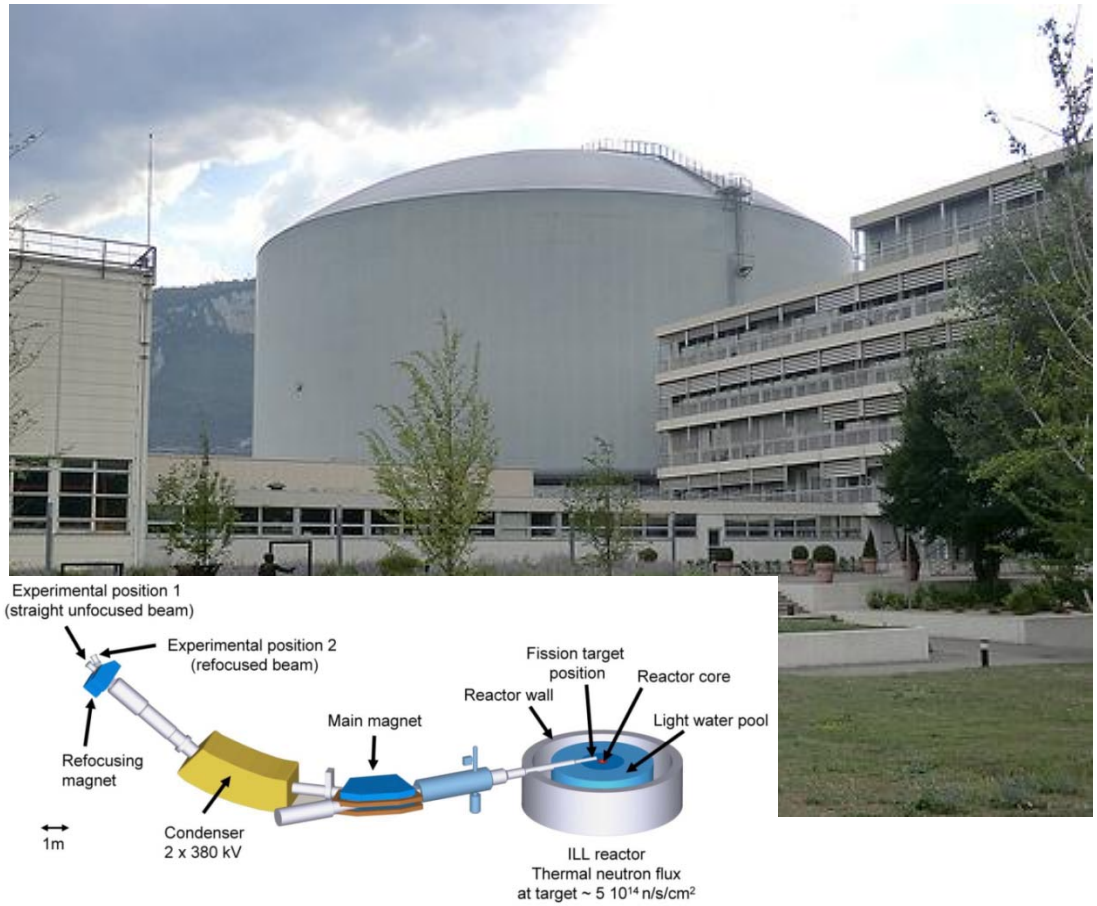
Measurement of the fission mass yields of Am242 at the Lohengrin Spectrometer



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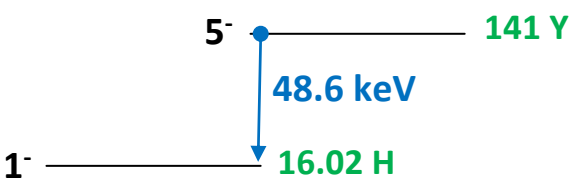
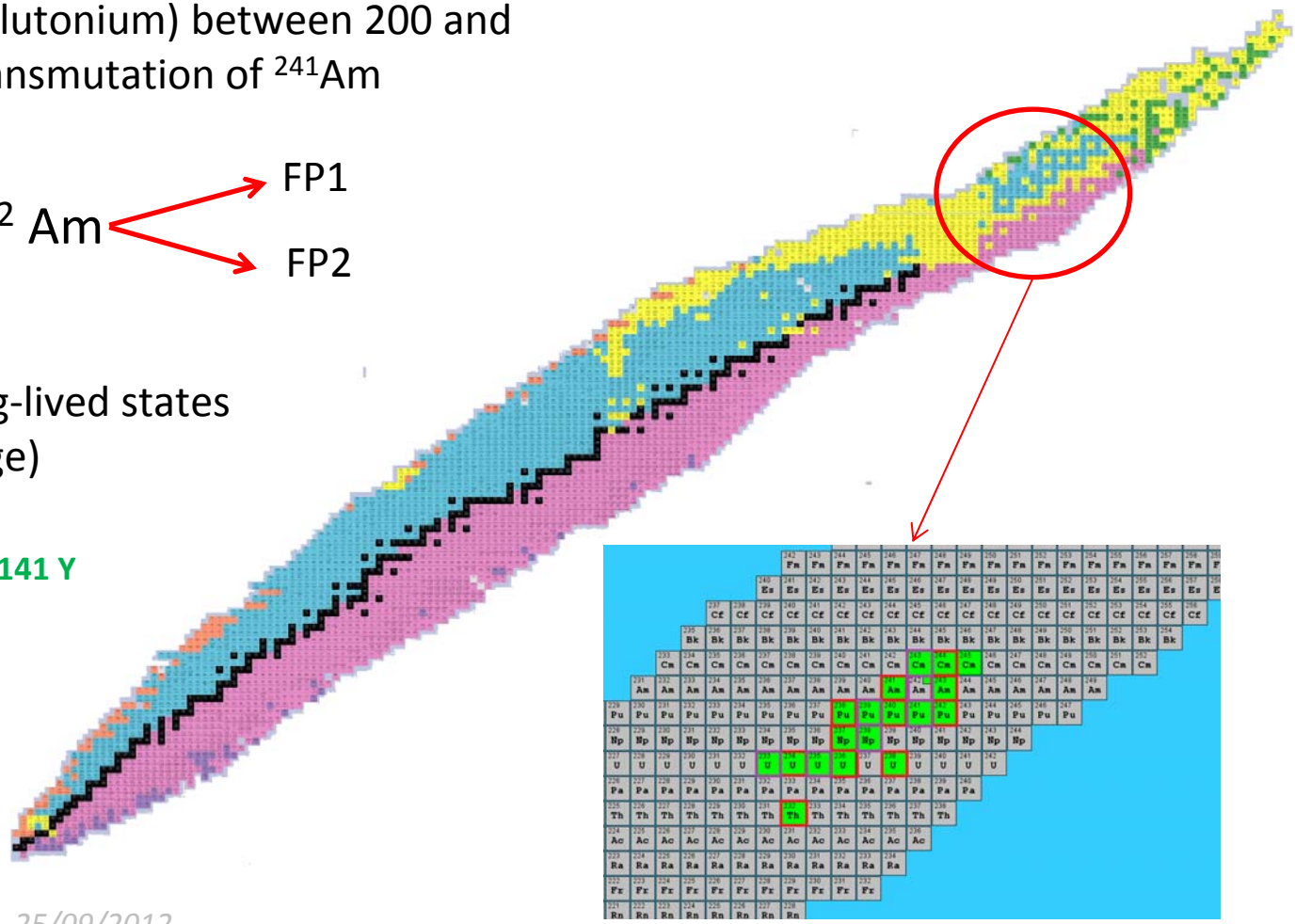
^{242}Am(Z=95)

- ^{241}Am : 90% of the radiotoxicity of the nuclear waste (without plutonium) between 200 and 1000 years -> Transmutation of ^{241}Am

$$n + {}^{241}\mathrm{Am} \rightarrow {}^{242}\mathrm{Am} \rightarrow \mathrm{FP1},\ \mathrm{FP2}$$

- ^{242}Am : two long-lived states Z=95 (odd charge)

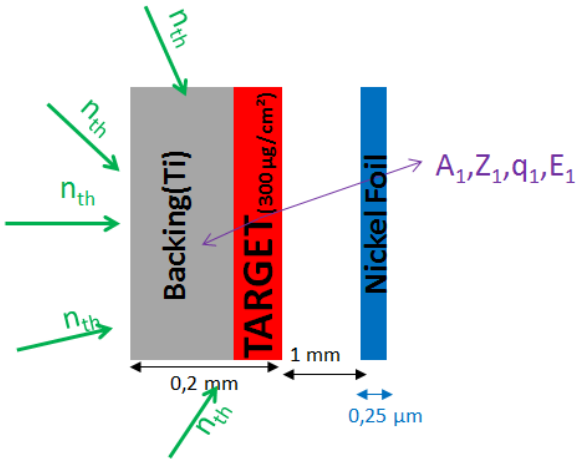




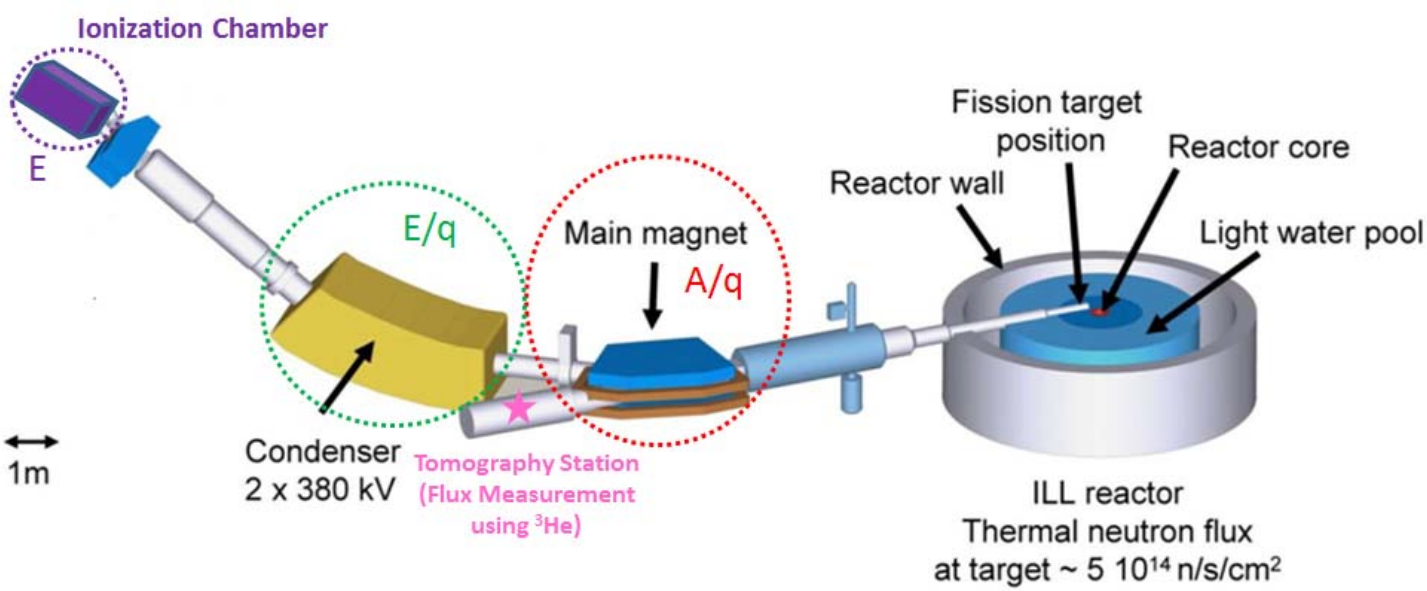
PLAN

- Experimental Set-up & Analysis Method
- Energy and Charge Distributions
- Uncertainties Determination
- Results

Experimental setup

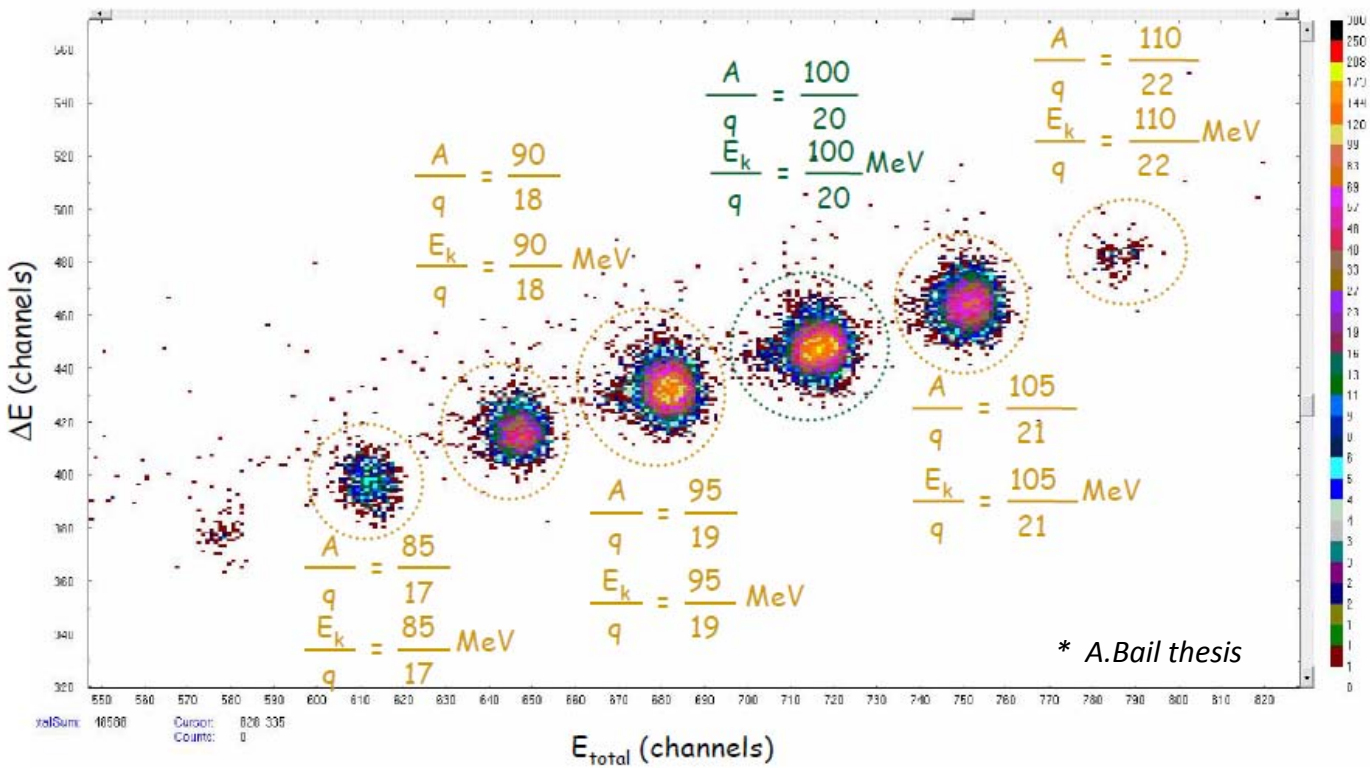


- ❑ High neutron flux Reactor
- ❑ Target
- ❑ Magnet: Selection A/q
- ❑ Condenser: Selection: E/q
- ❑ Detector: E



How do we measure the energy of the fragment ?

- ΔE-E Ionisation Chamber



E-> E/q->A/q->A **=>Y(A,E,q)**

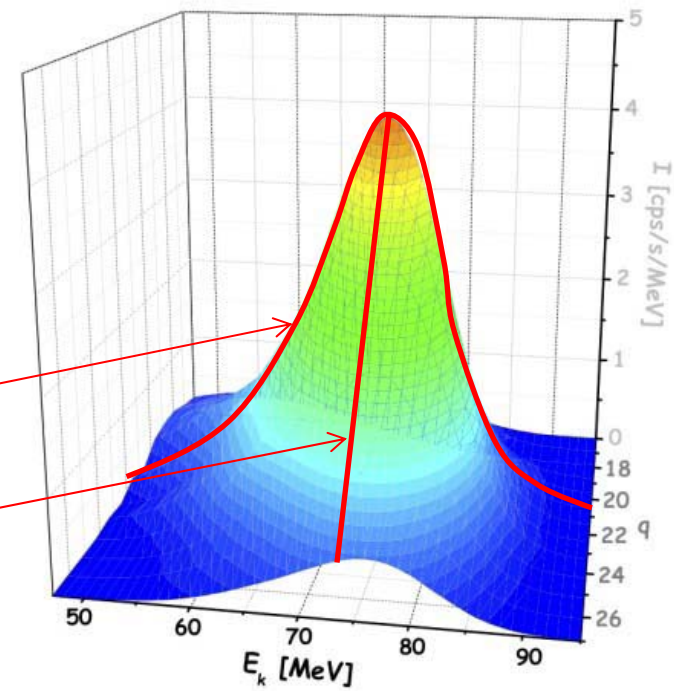
How to calculate the fission yields ?

$$Y(A) = \sum_q \int_E Y(A,q,E)dE$$

- Energy Distribution for a given q
- Charge Distribution for a given E

$$Y(A) = \frac{\int Y(A,\bar{q},E)dE \times \sum_q Y(A,q,\bar{E})}{Y(A,\bar{q},\bar{E})}$$

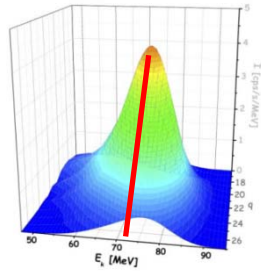
Valid if no correlation between E and q



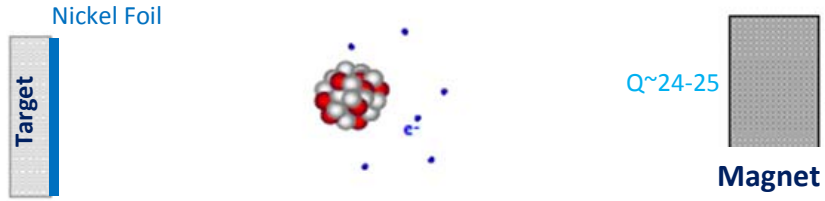
N(A,q,E) according to q and E

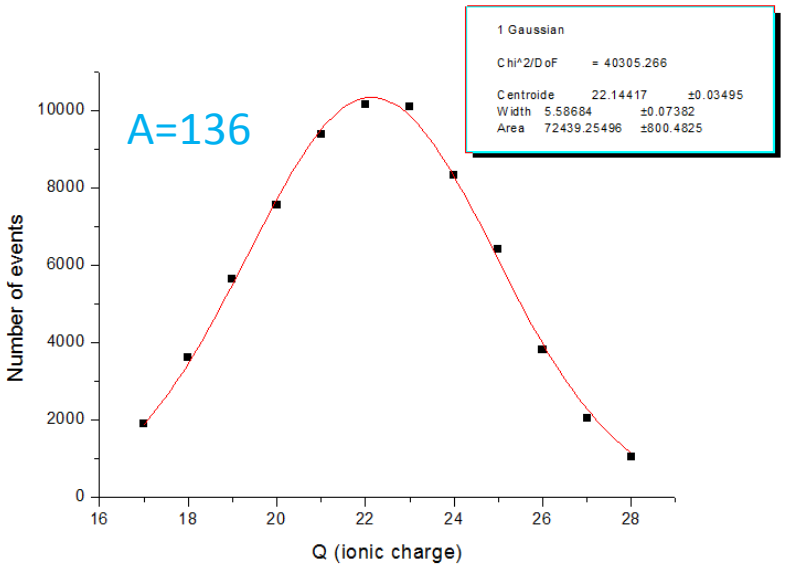
- **In reality we have a correlation but its influence on Y(A) in less than 3%**

Q-Distribution

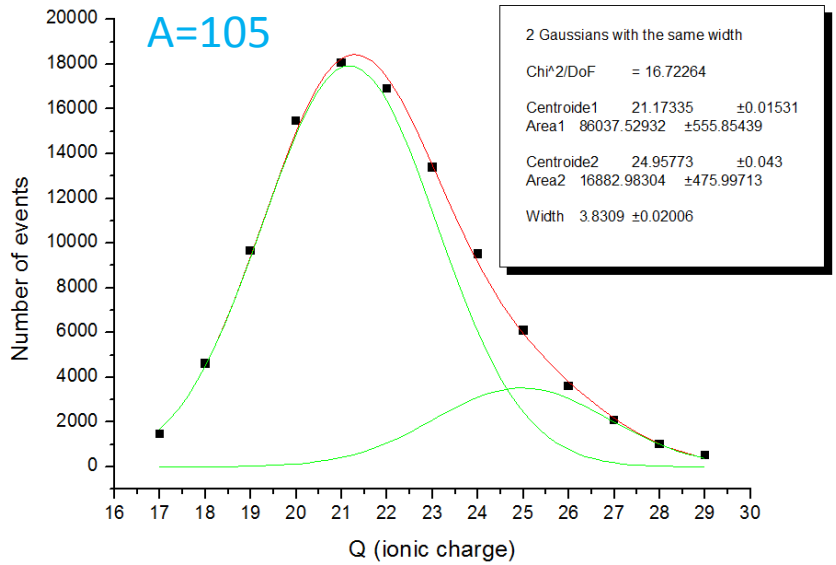


- Example of Q-distribution : two differents cases
- Measured Charge is determined at the last crossed material (Nickel)



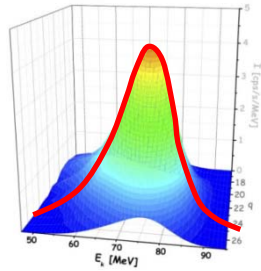


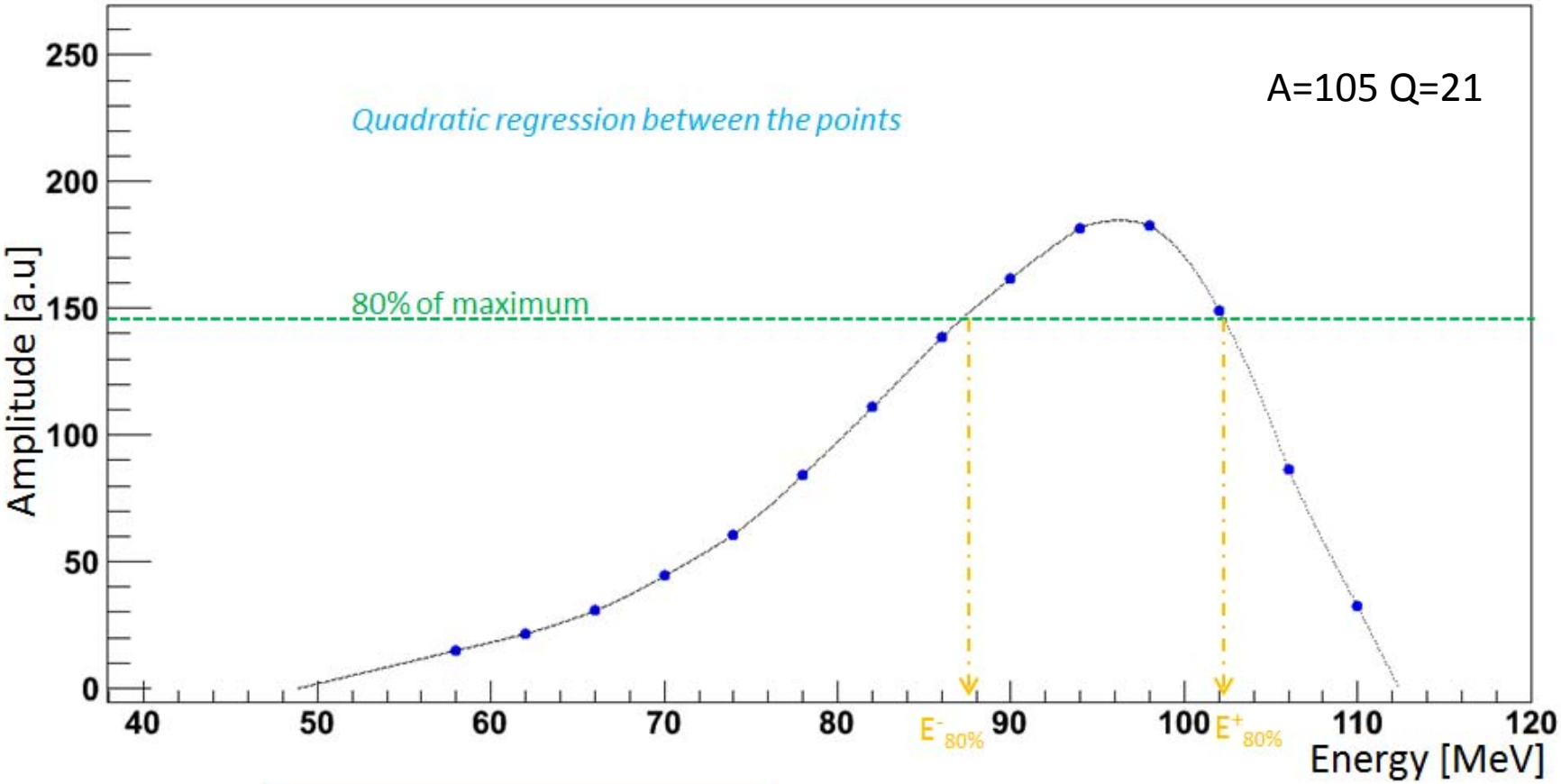
Without nanosecond isomer



With nanosecond isomer

E-Distribution

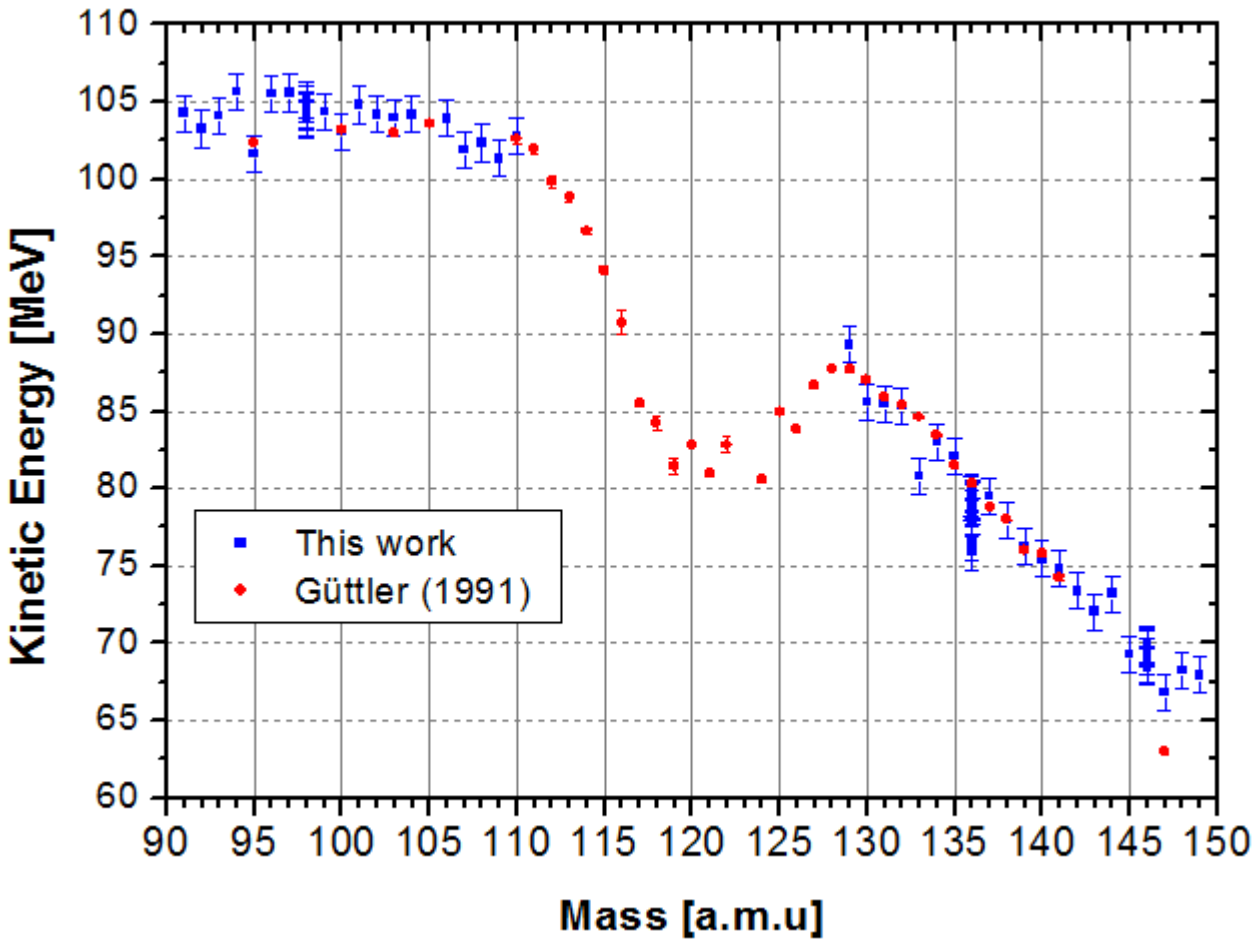




$$KE = (E^+_{80\%} + E^-_{80\%})/2$$

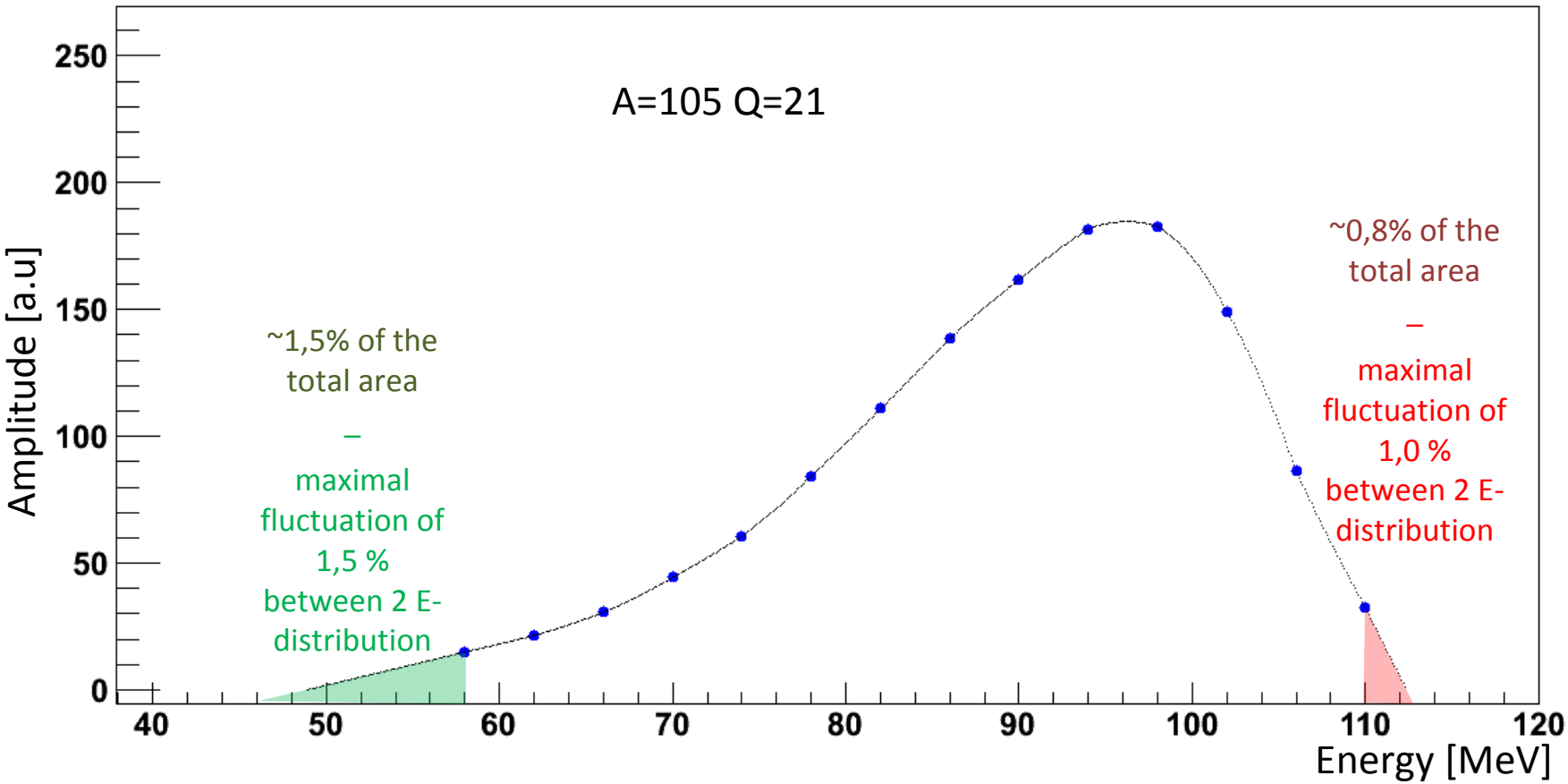
- 0.6 MeV for determination of KE
- 0.6 MeV for (q,E) correlation

Kinetic energy as a fonction of the fragment mass



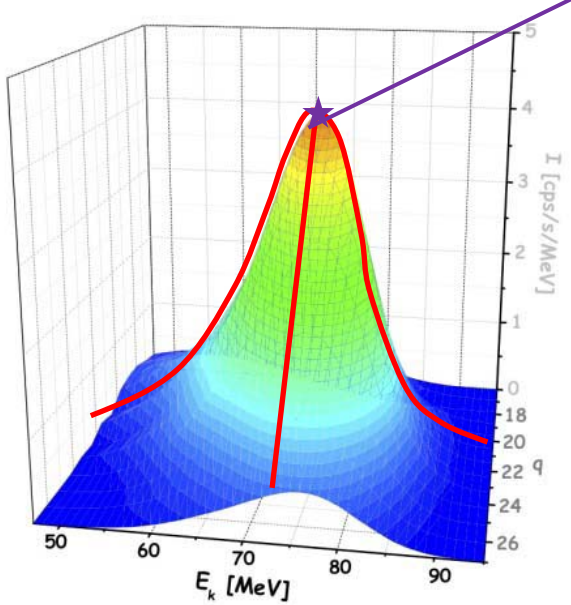
E-Distribution

- Statistic errors:
  - ~ 1%
- Systematics errors:
  - 1,5% low energy part
  - 1,0% high energy part

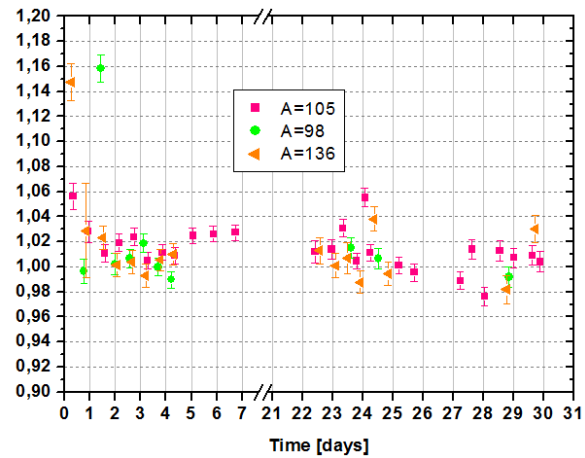


Determination of the systematic error

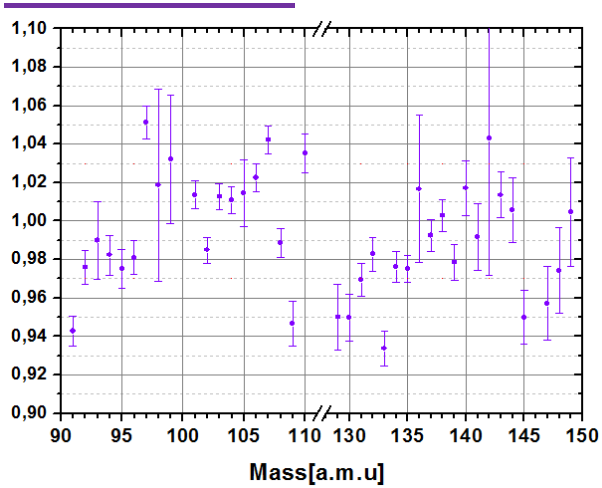
This point is known twice



For the same mass as a function of time:



For all masses:



σ ~ 3%

Sources of relative uncertainties and their respective contributions.

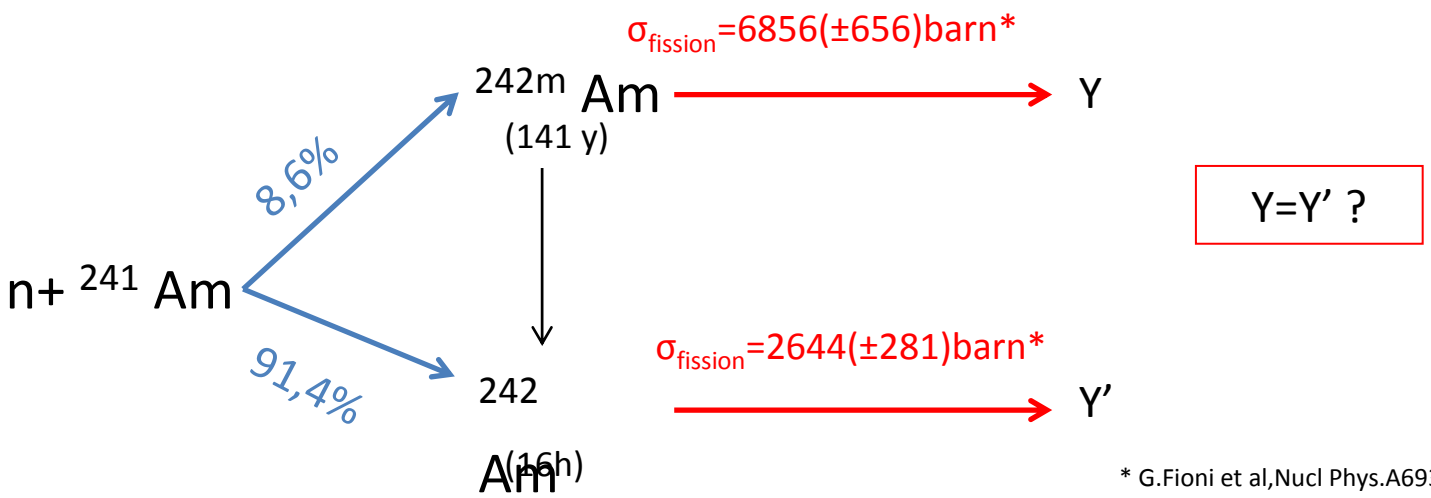
Source	Contribution
Statistical	~1 %
Extrapolation of the low part of the energy distribution	1.5 %
Extrapolation of the high part of the energy distribution	1%
Discrepancies between the two measurements of the common point	3%
Normalisation	?
Total of the systematic error	3.5%

Fission Yields of Am-242

- Objectives of the experiment :

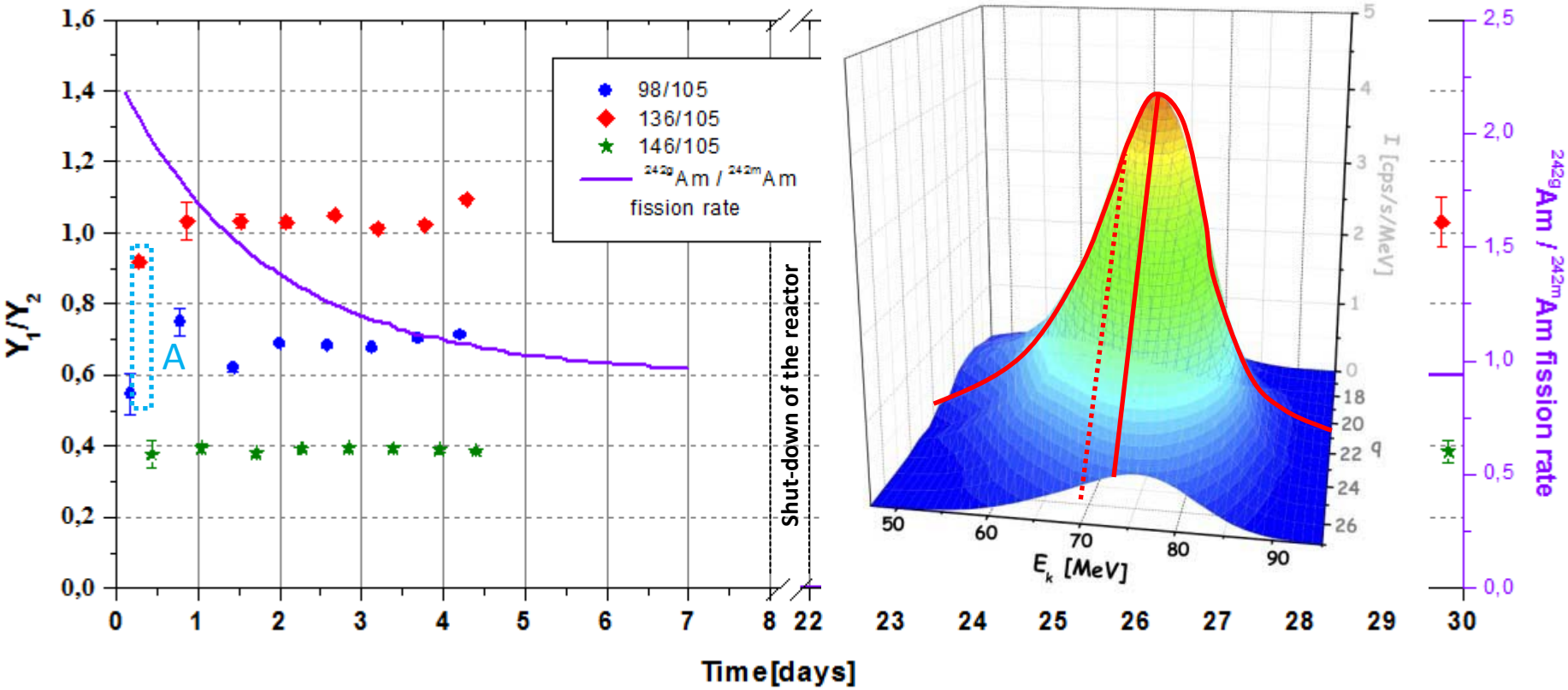
- Fission Mass Yields from Am-241(2n,f)

- Is there any difference between the fission yields of Am-242(n,f) and Am-242m(n,f) ?



* G.Fioni et al,Nucl Phys.A693(2001) 546
O.Bringer,Ph.D Thesis,INP Grenoble, October 2007

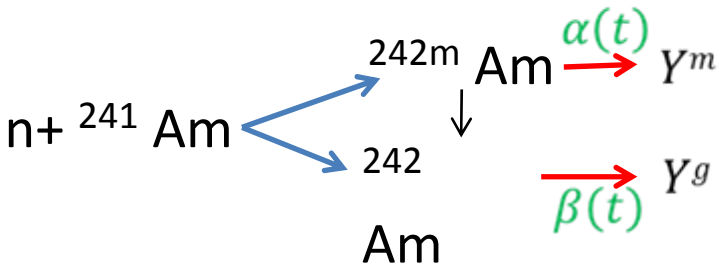
How do we proceed to observe a possible difference ?



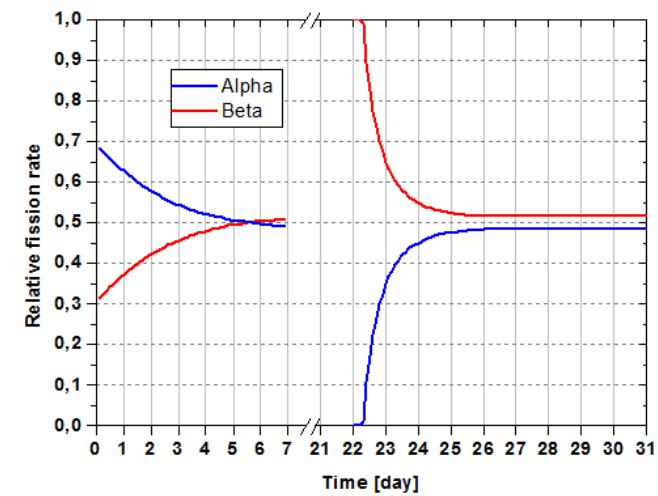
A: Strong evolution of the properties of the target (large energy shift)

B: vaccum problem

What is the maximum possible difference ?



$$Y = \alpha(t) * Y^m + \beta(t) * Y^g$$



$$\begin{cases} Y_1{}^g = (1+X) * Y_1{}^m \\ Y_2{}^g = (1+X') * Y_2{}^m \end{cases}$$

$$\alpha(t) + \beta(t) = 1$$

$$\frac{Y_1(t)}{Y_2(t)} = \frac{\alpha(t) * Y_1{}^m + \beta(t) * Y_1{}^g}{\alpha(t) * Y_2{}^m + \beta(t) * Y_2{}^g}$$

$$\frac{Y_1(t)}{Y_2(t)} = \frac{(1+\beta(t) * X) * Y_1{}^m}{(1+\beta(t) * X') * Y_2{}^m}$$

$$(1)\ \gamma(t) = \frac{Y_1(t)}{Y_2(t)} = \frac{Y_1{}^m}{(1+\beta(t) * X') * Y_2{}^m}$$

Hypothesis: X=0.

General case : $\Gamma \sim 1$

$$\Gamma(t_1, t_2) = \frac{\gamma(t_1)}{\gamma(t_2)} = \frac{(1+\beta(t_1) * X')}{(1+\beta(t_2) * X')}$$

$\sigma_\Gamma = |\beta(t_2) - \beta(t_1)| * \sigma_{X'}$ for X'=0

with $|\beta(t_2) - \beta(t_1)|_{max}$=0,17 and σ_Γ~0,08
(0,04 for all σ_γ)

$\sigma_{X'} \sim 0{,}47$

If we know $Y_1{}^m$ et $Y_2{}^m$ then:

$\beta(t_2)$=0,5 during the measurement of the masses so σ_Γ~0,11
(0,04 for all σ_γ and 0,07 for σ_{Ym})

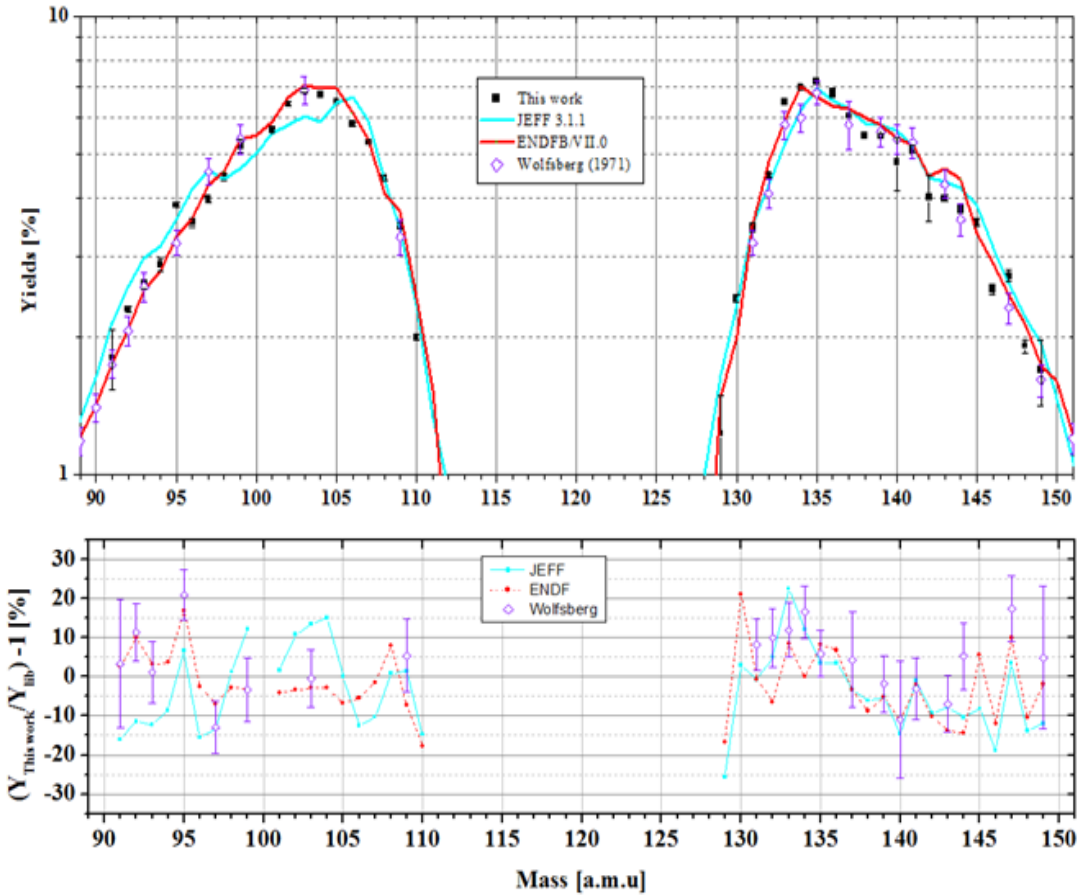
$\sigma_{X'} \sim 0{,}22$

Conclusions

Normalisation
Y_{105}=6,5%

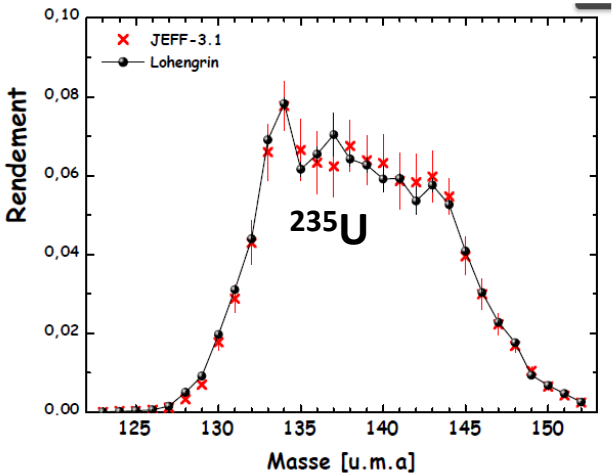
- No difference between the yields: quantification on-going.
- If you assume they are equal …

Only statistical error

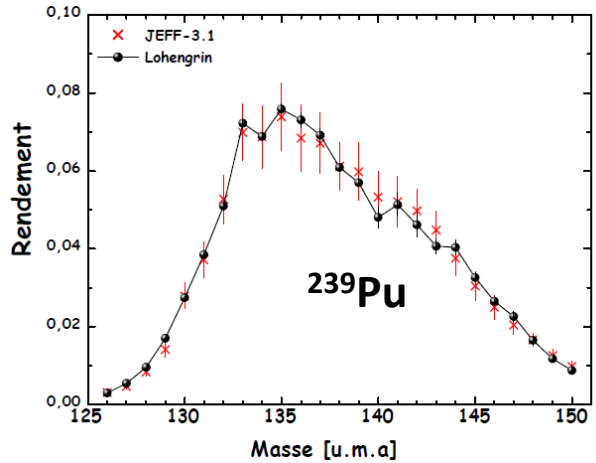


Future

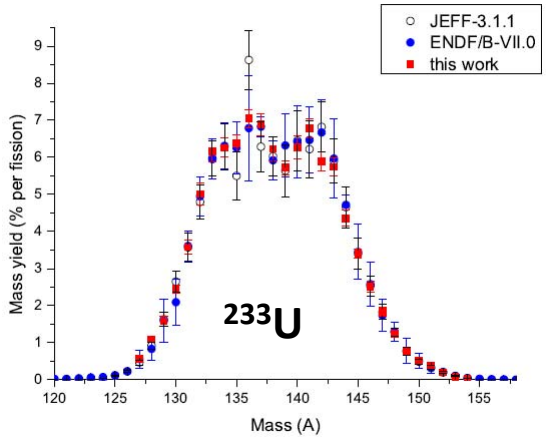
- Isotopic fission yields

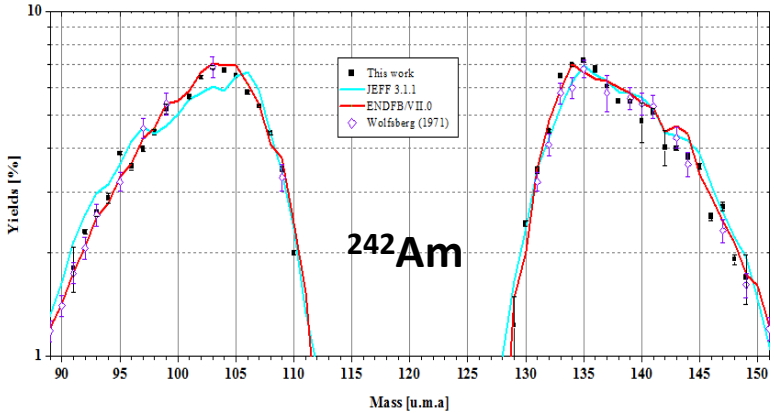


** A.Bail Thesis*



** Meeting GEDEPEON Jan 2011*
G.Kessedjian (F.Martin thesis (on-going))

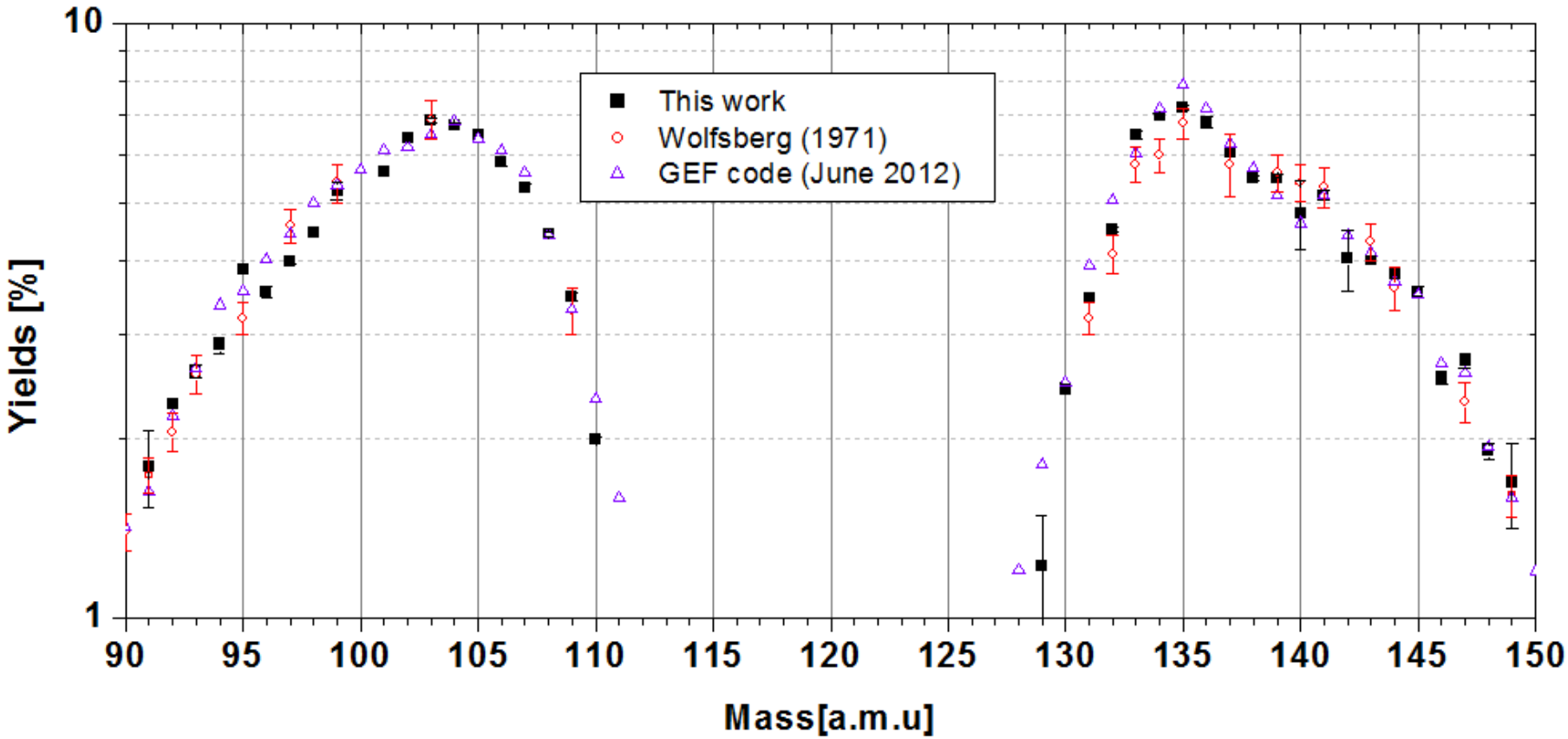




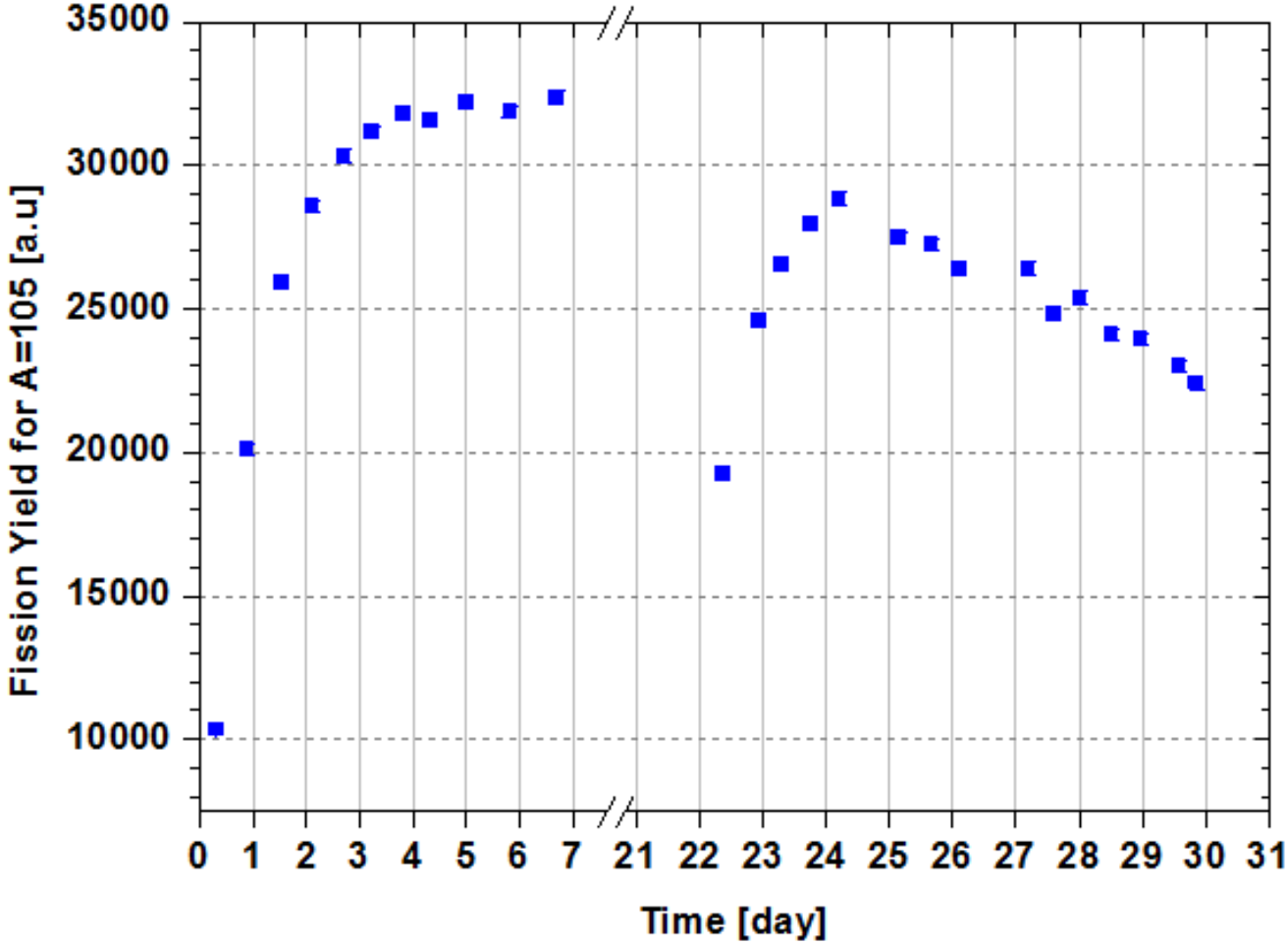
Thank you
for your attention

Back-up

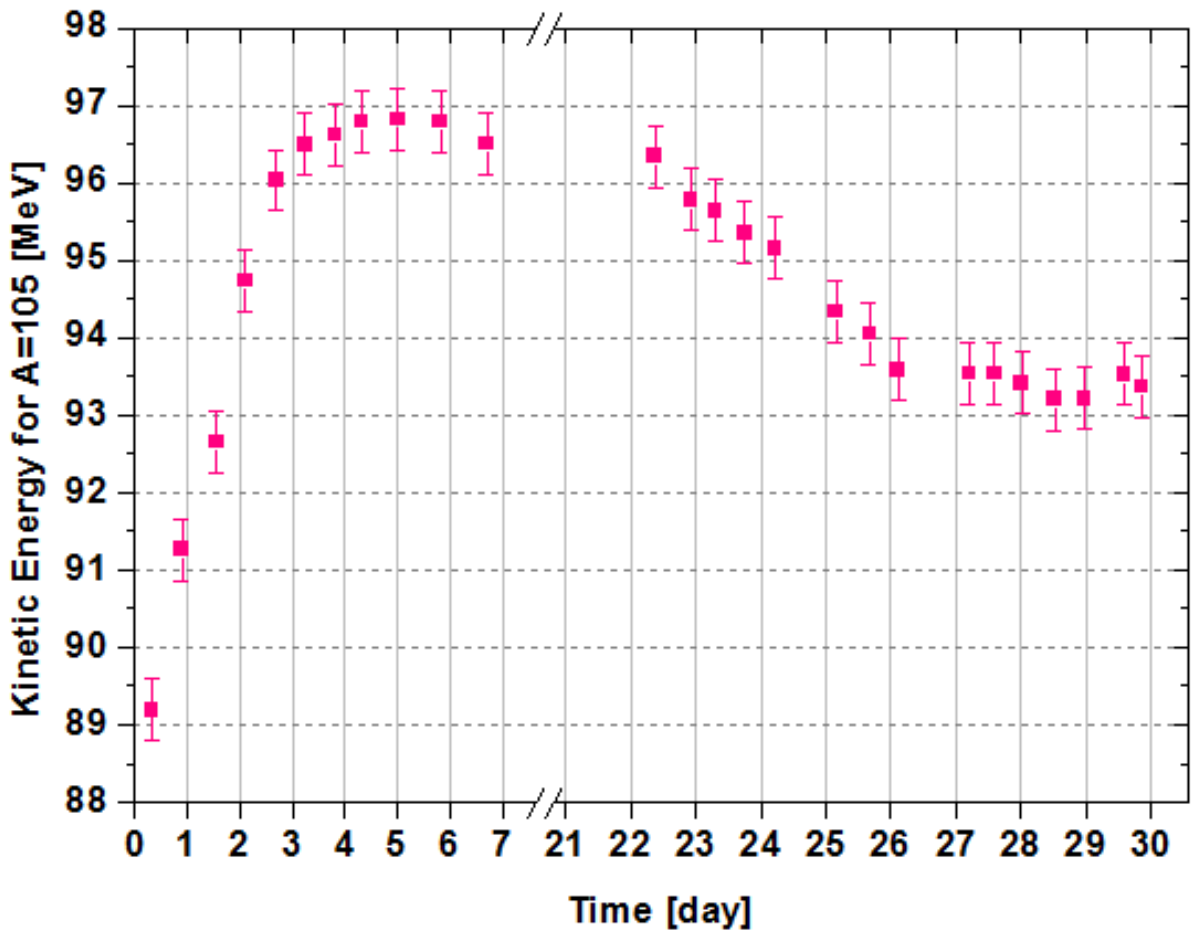
Comparaison with the GEF code(June 2012)



Number of fissions



Evolution of the kinetic energy as a function of time



FWHM of the energy distribution as a function of time