

Mesure des durées de vie des états excités dans les isotopes de $^{82,83}\text{Se}$ et ^{92}Rb riches en neutrons

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ENCADRÉ PAR FRANÇOIS DIDIERJEAN

PLAN

I. INTRODUCTION

I. MESURE DES DURÉES DE VIE - ISOTOPES $^{82,83}\text{Se}$

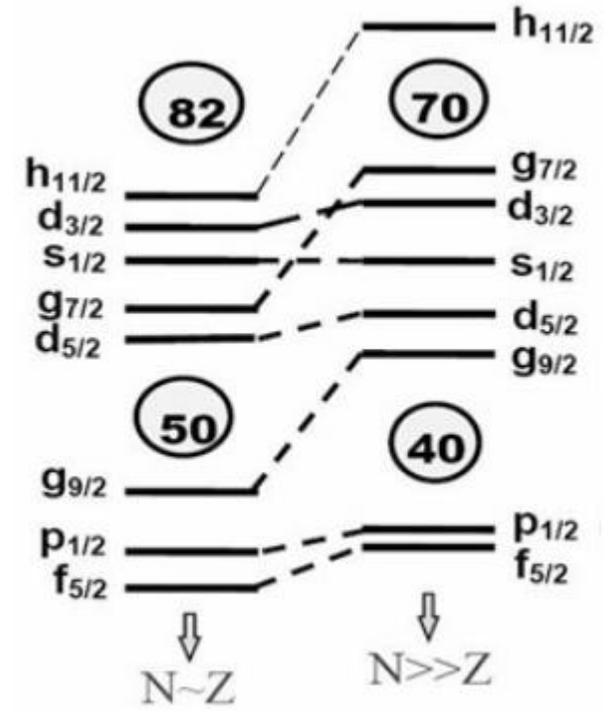
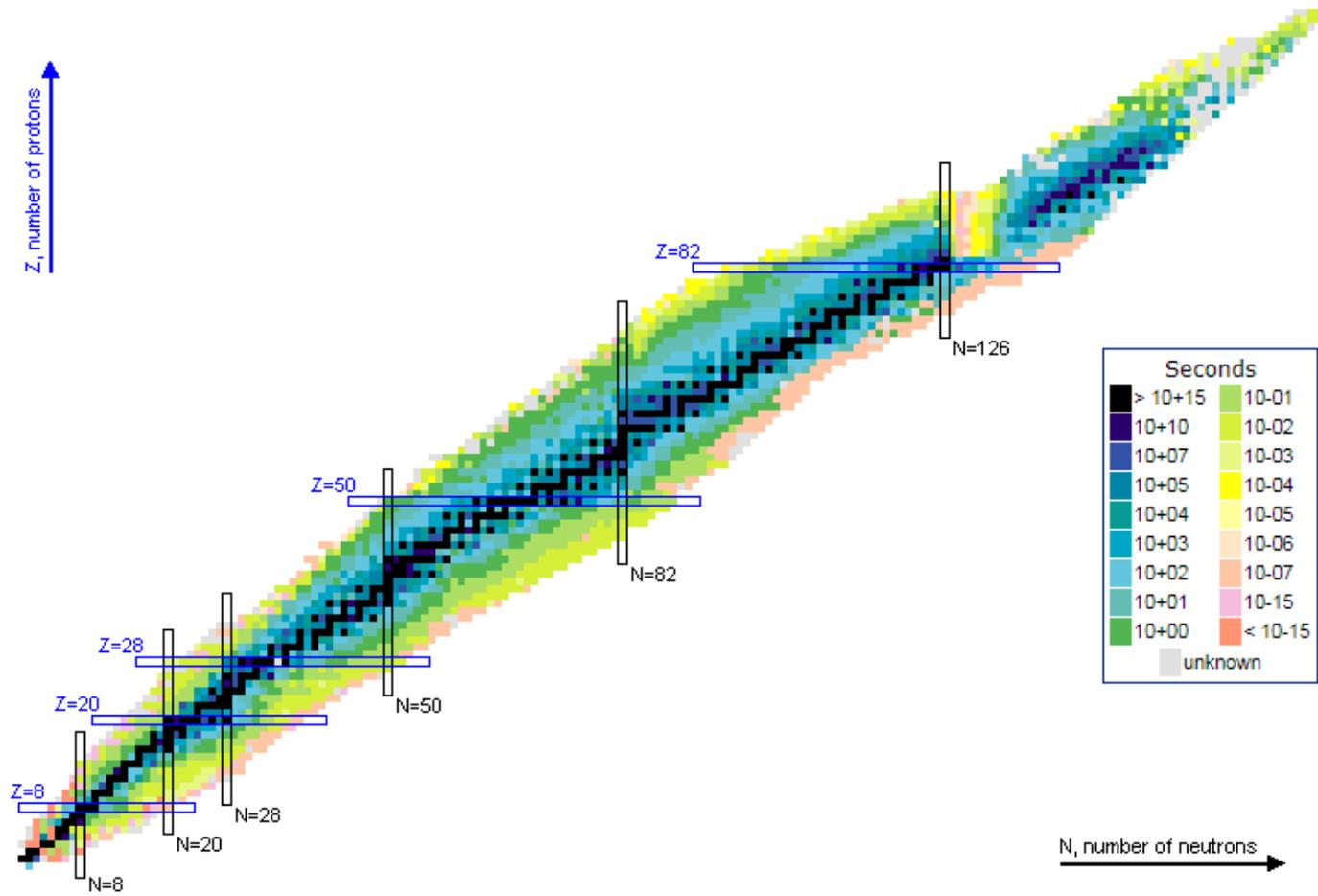
1. DISPOSITIF EXPÉRIMENTAL - AGATA
2. RDDS
3. RÉSULTATS
4. AMÉLIORATION DES FITS

II. ÉTUDE DE LA DÉCROISSANCE β DU ^{92}Rb

1. DISPOSITIF EXPÉRIMENTAL - ALTO
2. MESURE DE $T_{1/2}$
3. CALCUL DE P_n

III. CONCLUSION

INTRODUCTION



<https://www.nndc.bnl.gov/nudat2/>

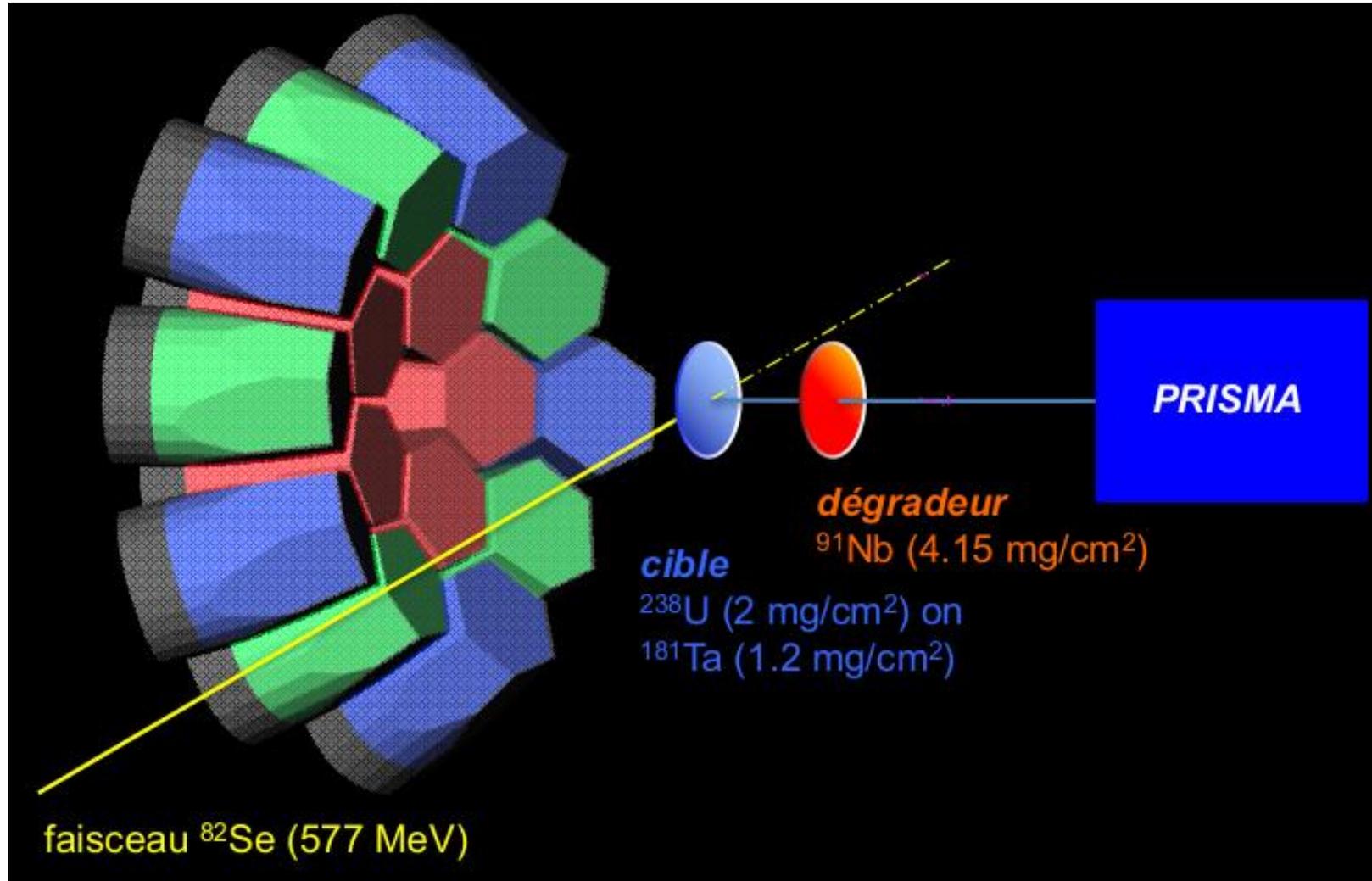
INTRODUCTION

Mesure de τ des états excités pour obtenir des informations sur la structure des noyaux.

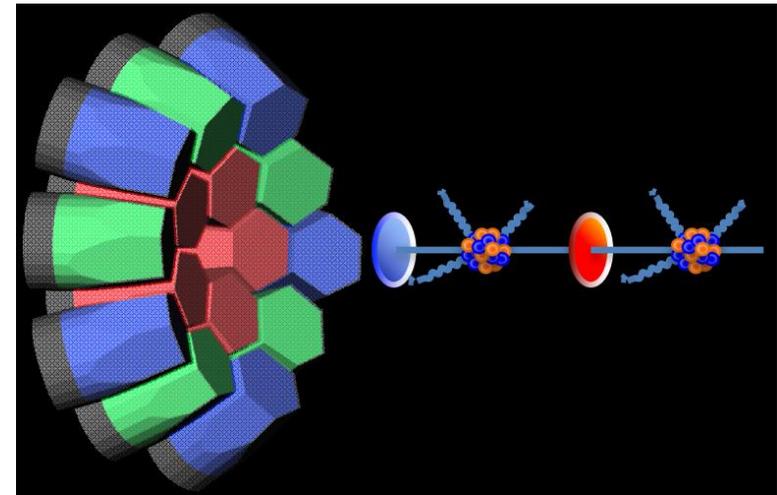
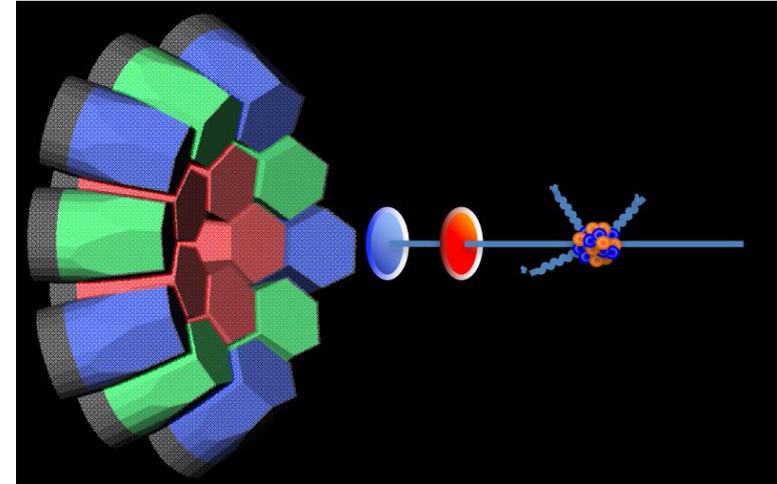
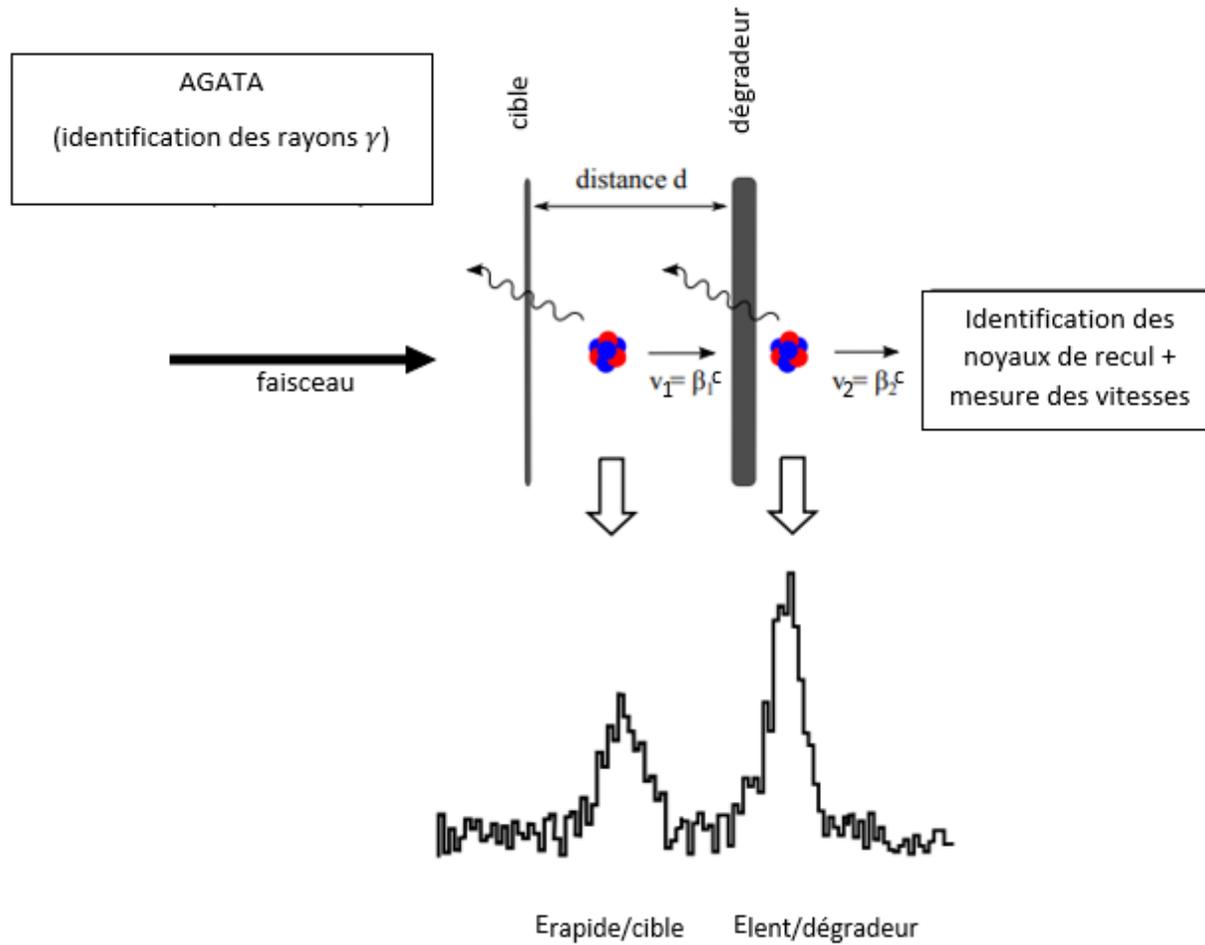
Mesure de $T_{1/2}$ et P_n pour des paramètres d'intérêt astrophysique.

Mesure des durées
de vie des états
excités – 82,83 *Se*

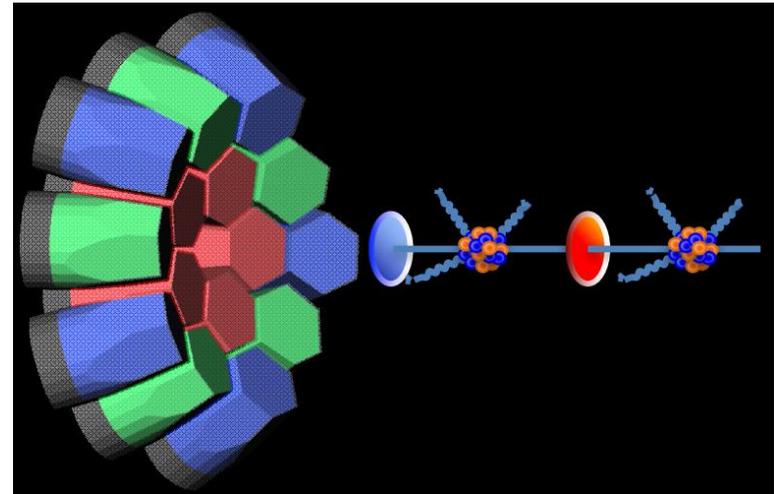
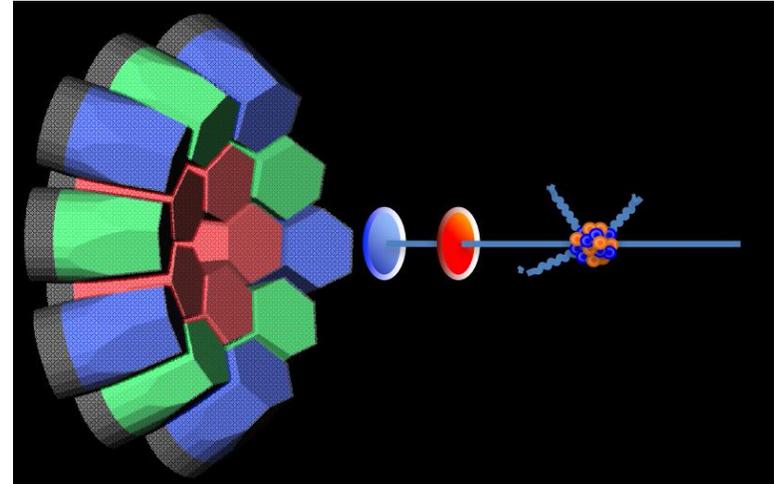
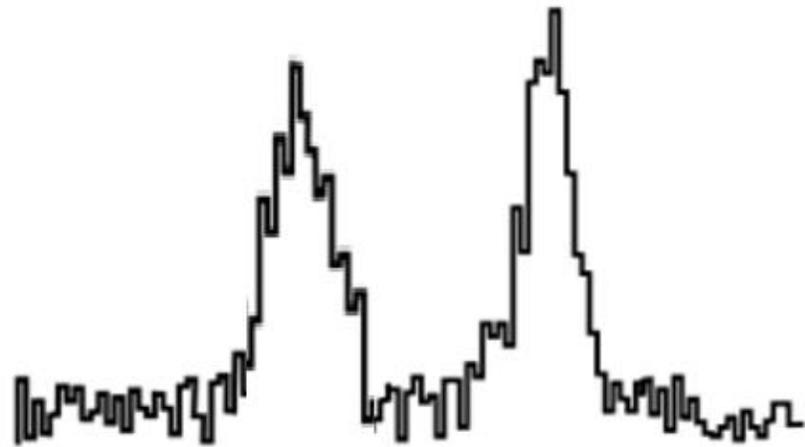
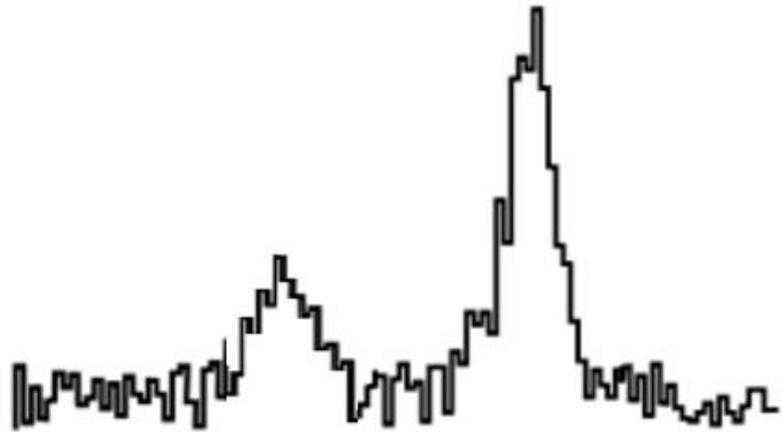
DISPOSITIF EXPÉRIMENTAL - AGATA



RDDS (RECOIL DOPPLER DISTANCE SHIFT)

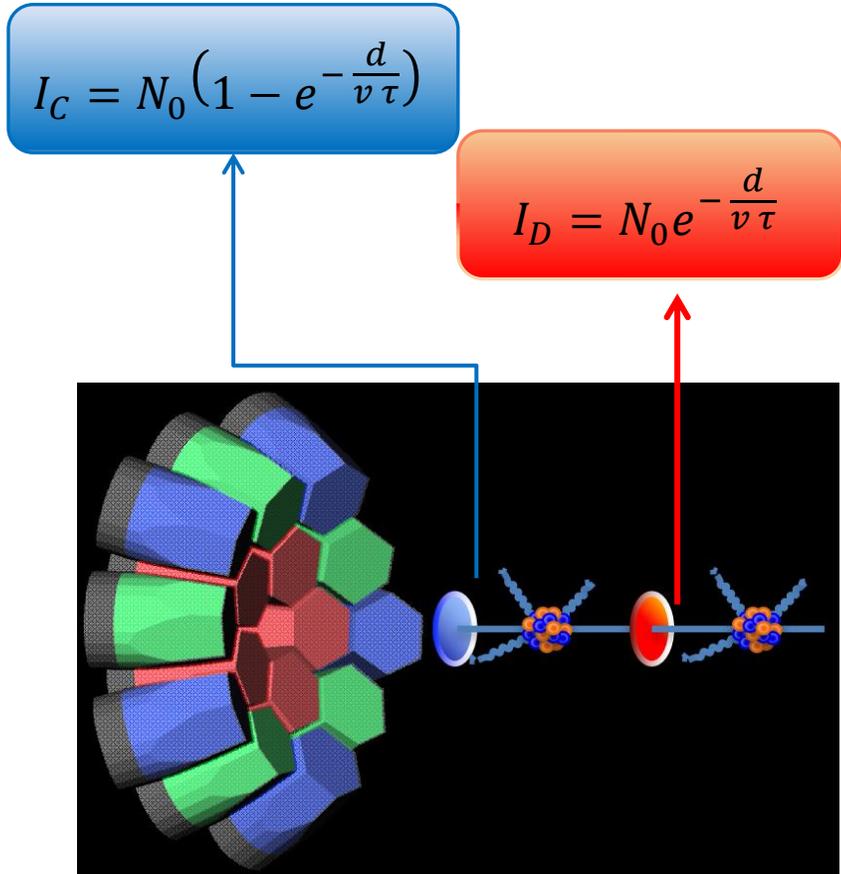
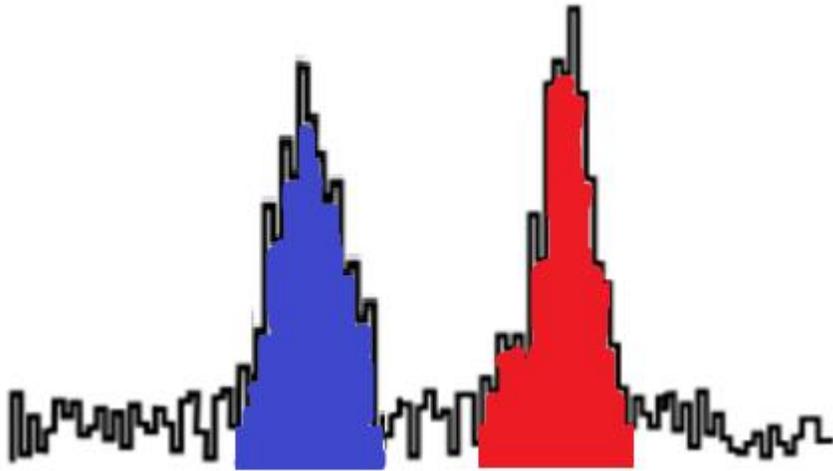


RDDS (RECOIL DOPPLER DISTANCE SHIFT)

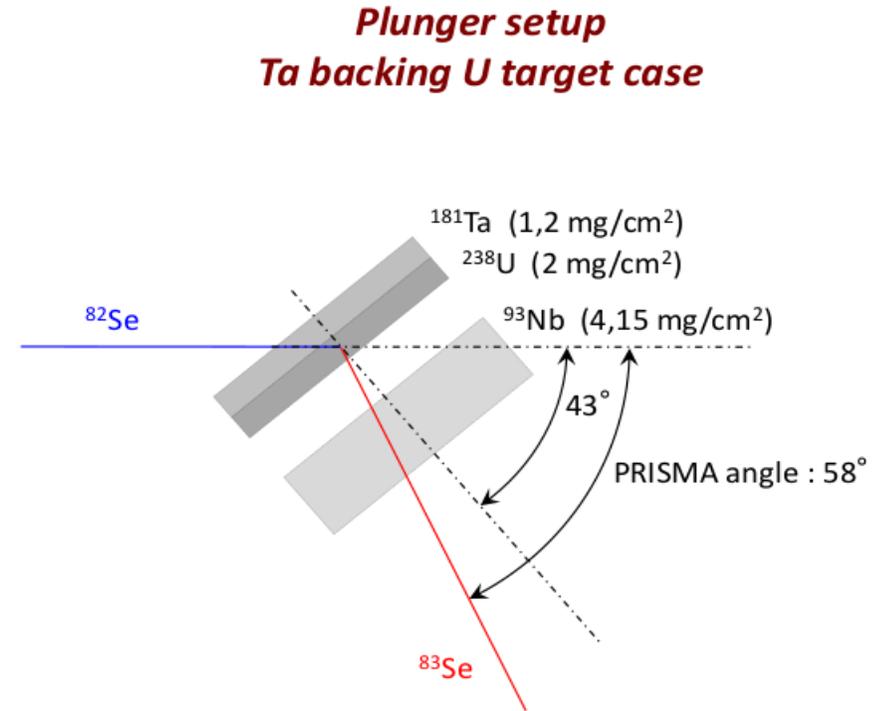
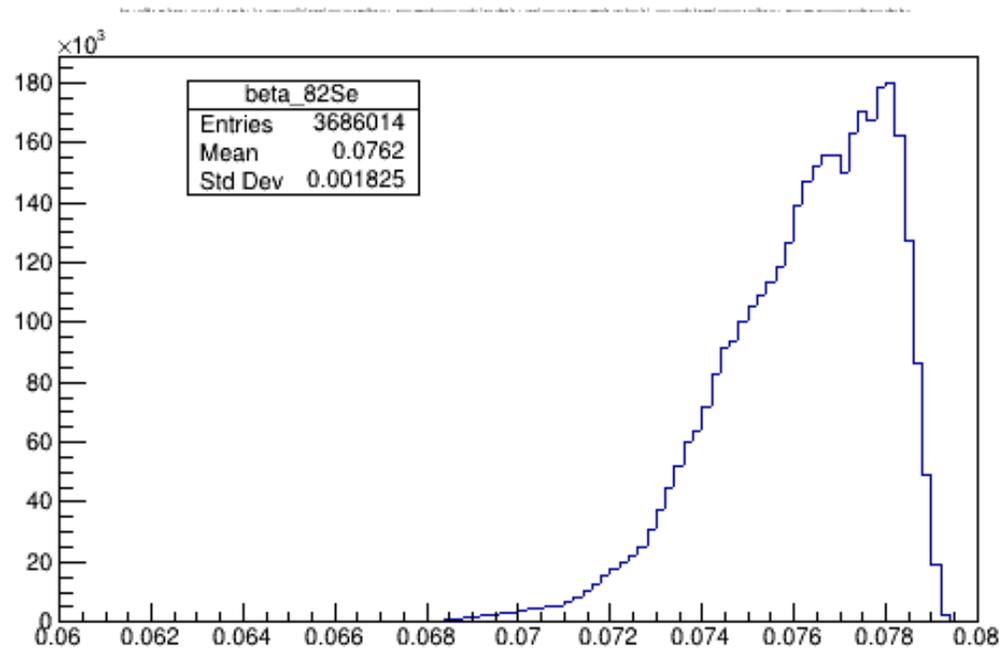


RDDS (RECOIL DOPPLER DISTANCE SHIFT)

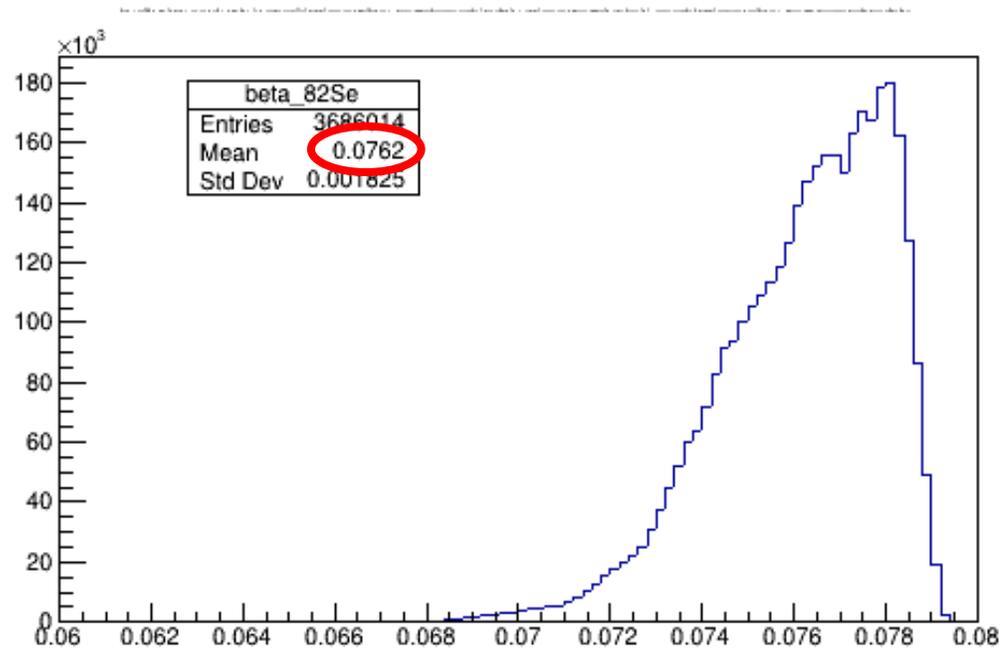
$$R = \frac{I_D}{I_C + I_D} = e^{-\frac{d}{v\tau}}$$



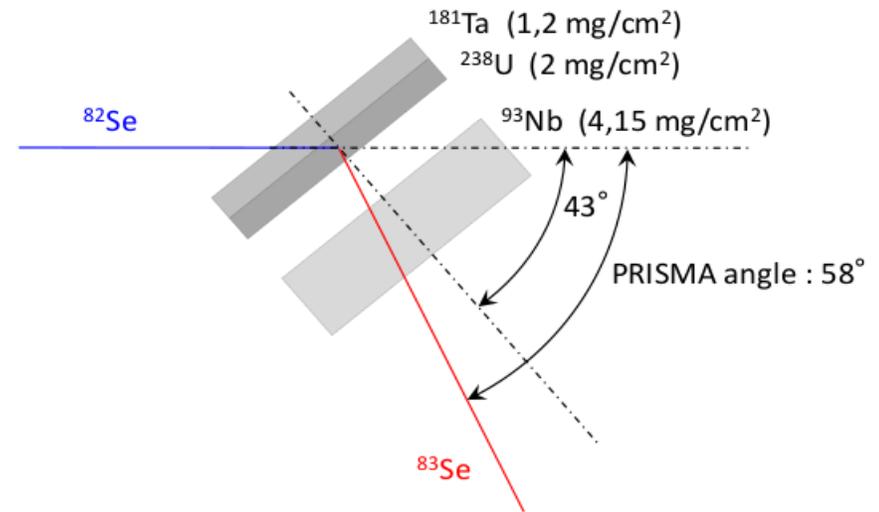
ESTIMATION DE LA VITESSE - ^{82}Se



ESTIMATION DE LA VITESSE - ^{82}Se



Plunger setup Ta backing U target case



ESTIMATION DE LA VITESSE - ^{82}Se

Table of Nuclides

A: 82, Element: Se, Z: 34, Q: 34

Stable

Ion mass = 81.8981 amu

Energy: 4.0373 MeV/u, Energy: 4.0323 AMeV

Brho: 0.69758 Tm, TKE: 330.647 MeV

Erho: 19.4343 MJ/C, Velocity: 2.78216 cm/ns

P: 7110.4 MeV/c, **Beta: 0.092803**

p_trnspt: 0.20913 GeV/c, Gamma: 1.004334

After:

| Block | Z \ Thickness | MeV/u | MeV | MeV | <Q> |
|----------|---------------|--------|---------------|--------|-------|
| M FP_PIN | Nb 4.3 mg/cm2 | 2.7161 | 222.45 | 108.2 | 23.96 |
| M FP_SCI | C9H10 100 mm | 0 | 0 | 222.45 | 0.00 |

Nb, Density [g/cm3]: 8.57

calculate reactions in this material:

State: Solid, Gas

Dimension: mg/cm2 & micron, g/cm2 & mm

Angle: Calculate, 15 degrees

Thickness at 0 degrees: 4.8424737 micron, 4.15 mg/cm2

Effective Thickness: 5.0132977 micron, 4.2963961 mg/cm2

Atoms / cm2: 2.78e+19

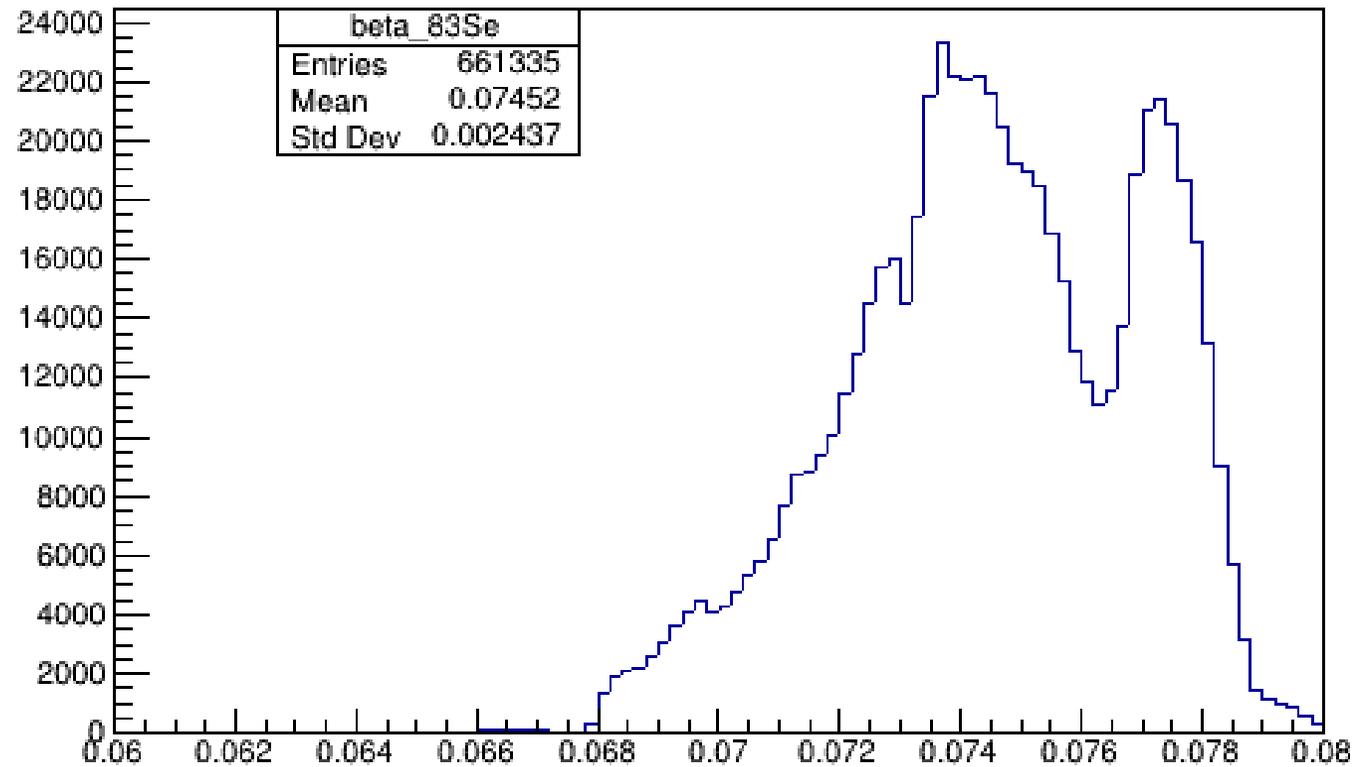
Set the spectrometer after this block using changes:

Compound dictionary

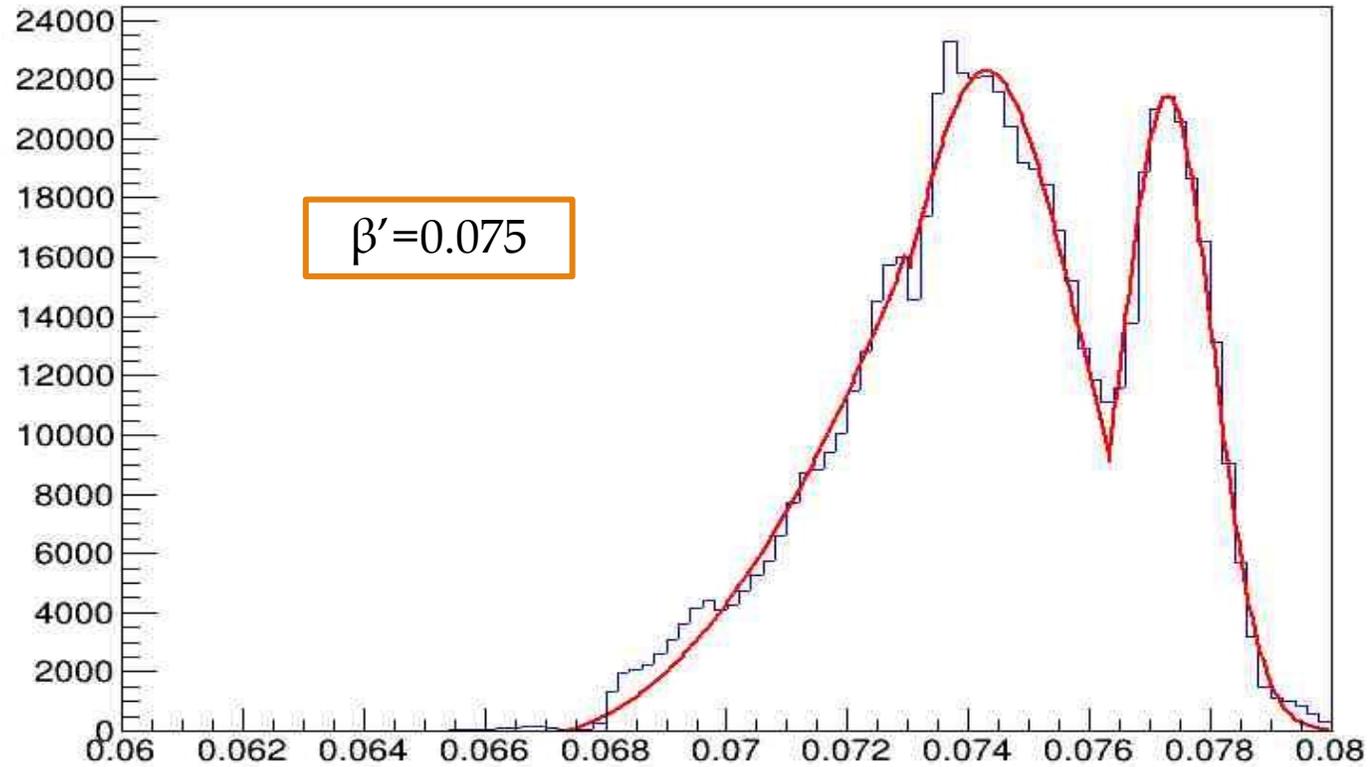
OK, Cancel

General setting of block, Calibration Resolution Thickness defect

ESTIMATION DE LA VITESSE - ^{83}Se



ESTIMATION DE LA VITESSE - ^{83}Se



ESTIMATION DE LA VITESSE - ^{83}Se

Element Z Q Table of Nuclides

Ion mass = amu

Energy MeV/u Energy AMeV
 Brho Tm TKE MeV
 Erho MJ/C Velocity cm/ns
 P MeV/c **Beta**
 p_trnspt GeV/c Gamma

After

| Block | Z \ Thickness | MeV/u | MeV | MeV | <Q> |
|--------|---------------|--------|---------------|--------|-------|
| FP_PIN | Nb 4.3 mg/cm2 | 2.6355 | 218.48 | 108.54 | 23.85 |
| FP_SCI | C9H10 100 mm | 0 | 0 | 218.48 | 0.00 |

Density [g/cm3]

calculate reactions in this material

State Solid Gas Dimension mg/cm2 & micron g/cm2 & mm Angle degrees

Thickness at 0 degrees micron mg/cm2 Effective Thickness micron mg/cm2

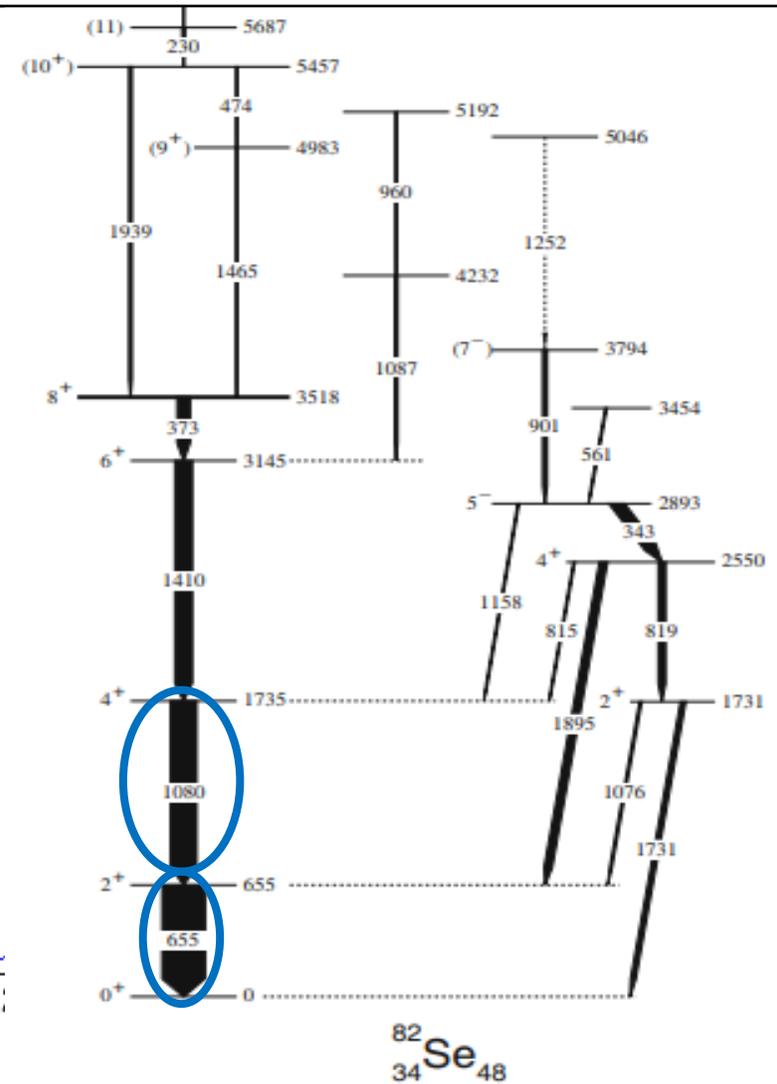
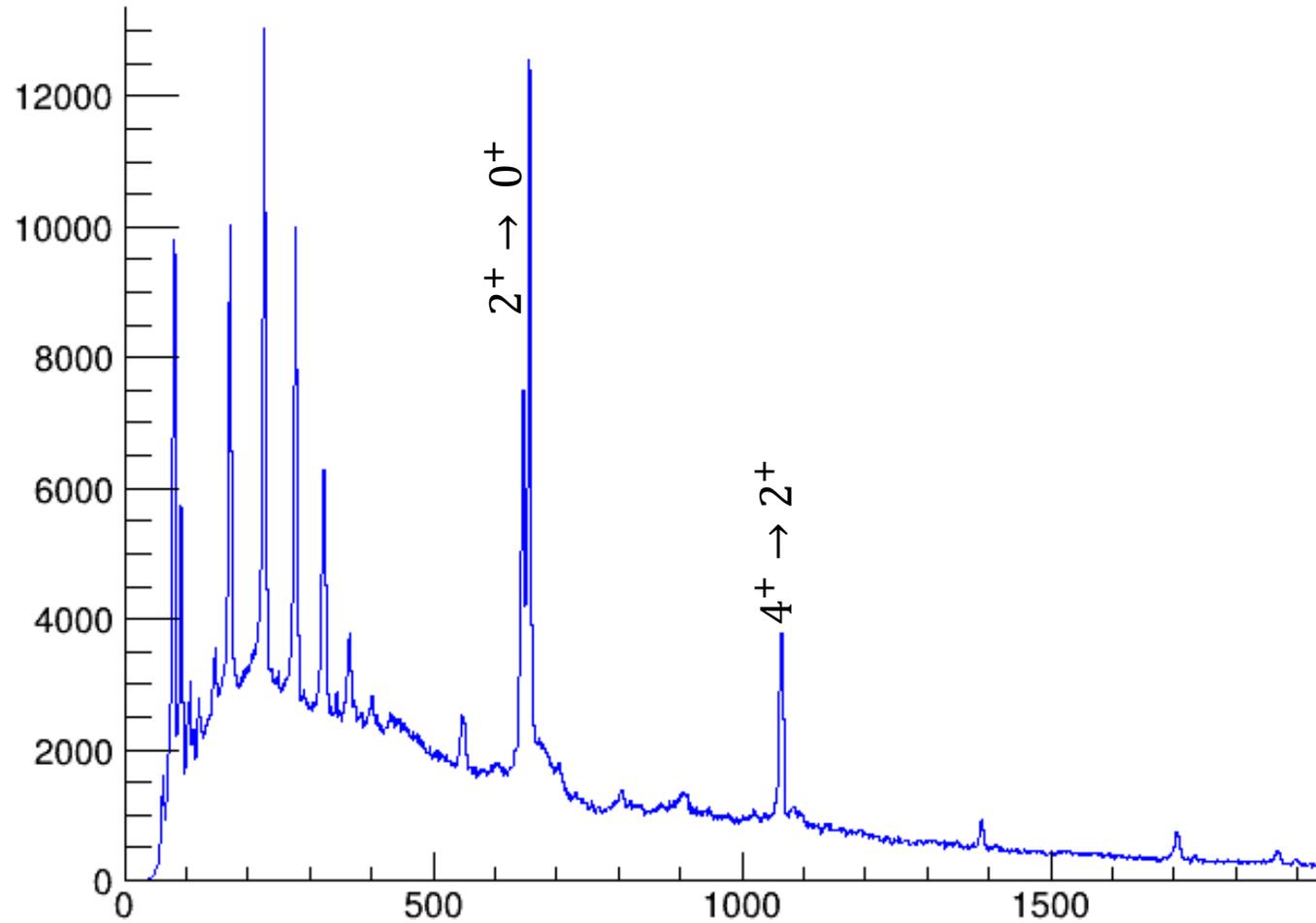
Set the spectrometer after this block using changes Atoms / cm2

ESTIMATION DE LA VITESSE - ^{83}Se

$$\beta \approx 9\%$$

$$\beta' \approx 7\%$$

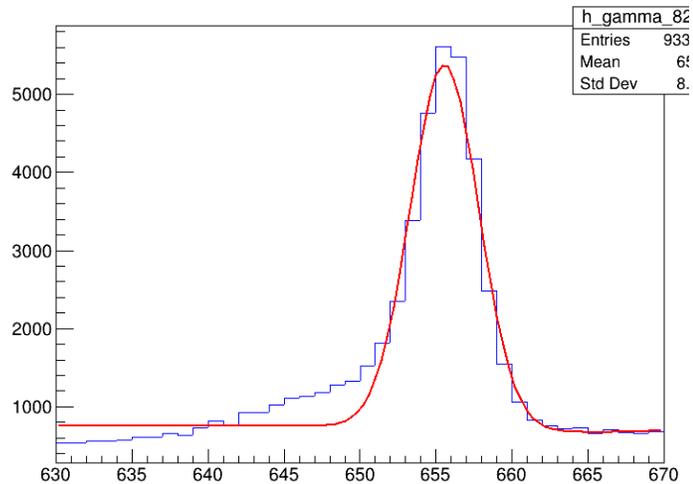
MESURE DES DURÉES DE VIE – RÉSULTATS ^{82}Se



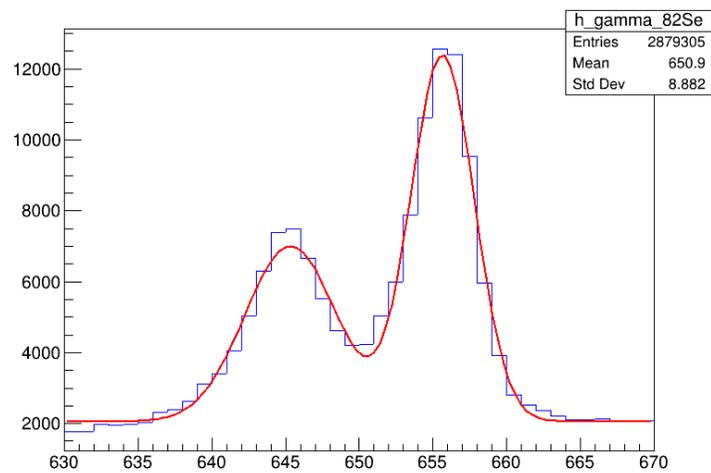
M.-G. Porquet et al. Eur. Phys. J. A 39, 295-306 (2009).

MESURE DES DURÉES DE VIE – RÉSULTATS ^{82}Se

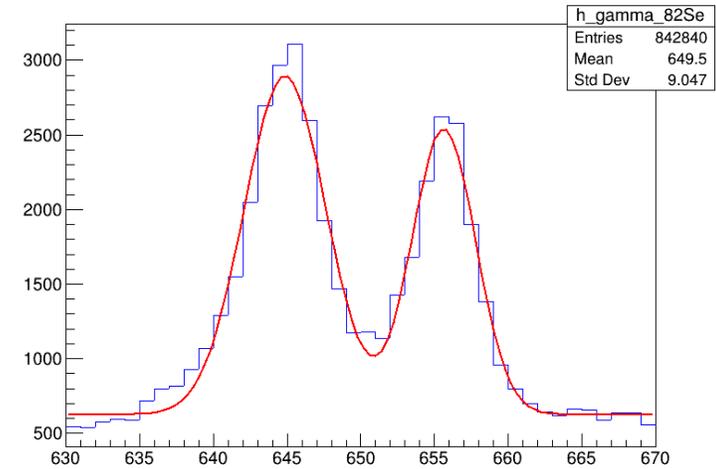
État excité 2^+



d=38 μm



d=257 μm



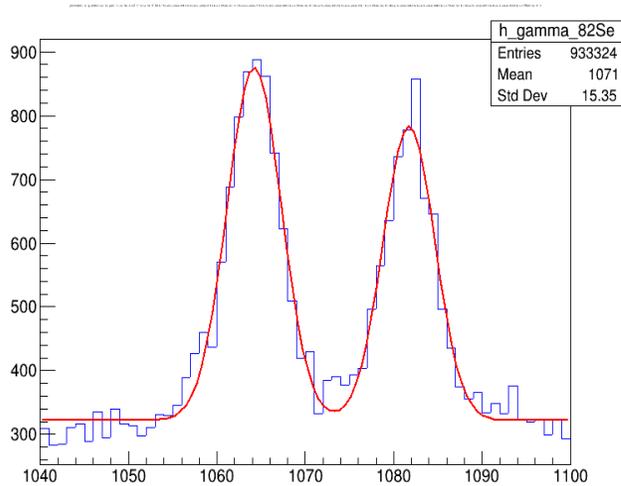
d=507 μm

| Distance | I_1 (coups) | I_2 (coups) | R | τ (ps) |
|-------------------|---------------|---------------|---------|-------------|
| 257 μm | 37220.8 | 58327.3 | 0.61045 | 22.7 |
| 507 μm | 15572.7 | 10877.3 | 0.41124 | 24.9 |

τ moyenne de l'ordre de la vingtaine de picosecondes

MESURE DES DURÉES DE VIE – RÉSULTATS ^{82}Se

État excité 4^+

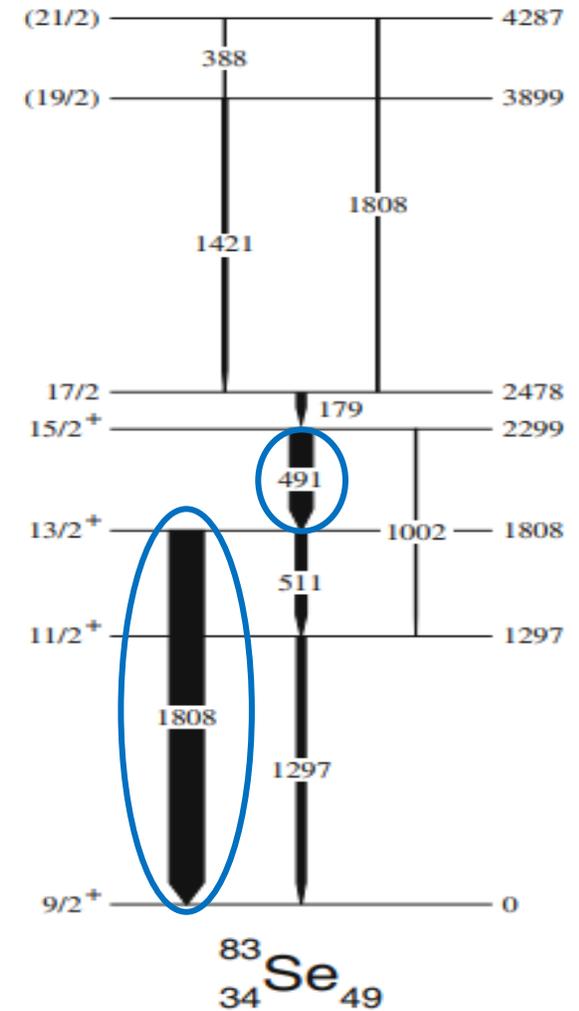
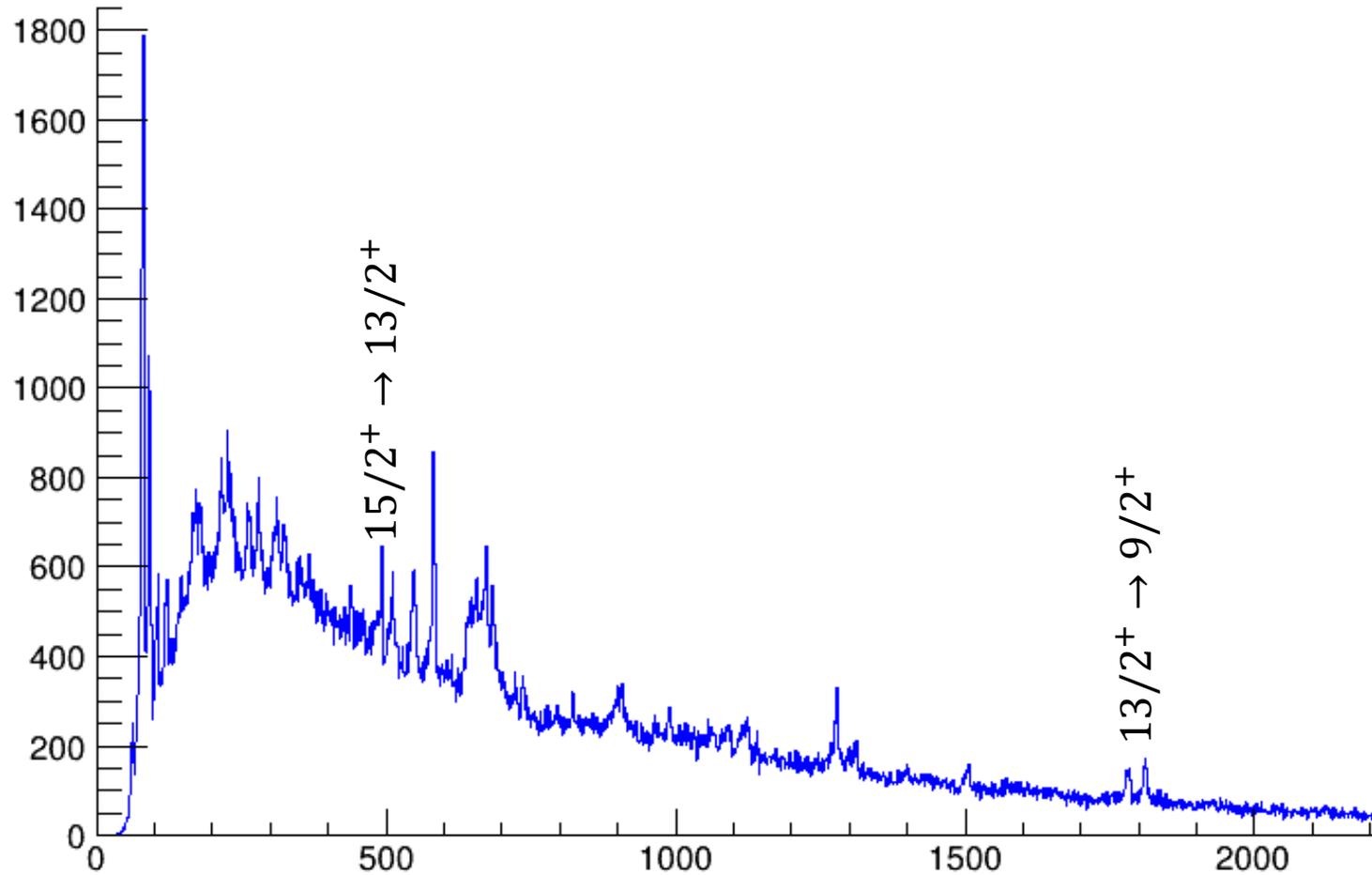


d=38 μm

$$\tau = 2.03 \text{ ps}$$

En accord avec les résultats déjà publiés
($\tau_{2^+} = 18.8 \text{ ps}$, $\tau_{4^+ \rightarrow 2^+} = 2.4 \text{ ps}$ Litzinger,
J. M. (2018) Mathematisch-Naturwissenschaftlichen Fakultät der
Universität zu Köln.)

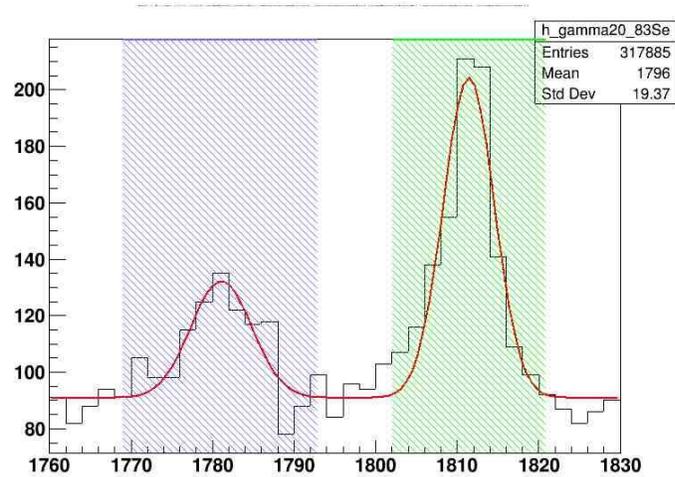
MESURE DES DURÉES DE VIE – RÉSULTATS ^{83}Se



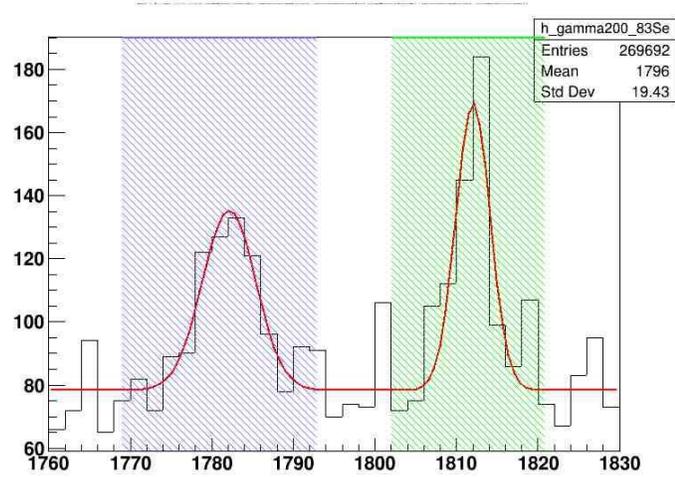
M.-G. Porquet et al. Eur. Phys. J. A 39, 295-306 (2009).

MESURE DES DURÉES DE VIE – RÉSULTATS ^{83}Se

État excité $13/2^+$



$d=38 \mu\text{m}$



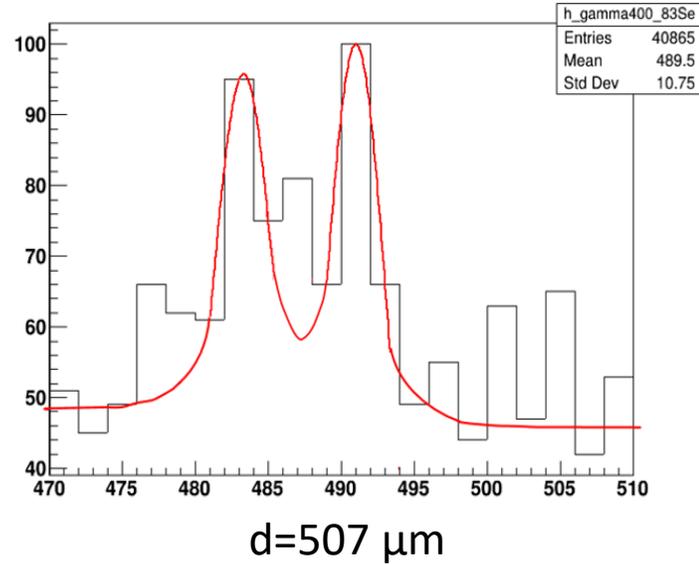
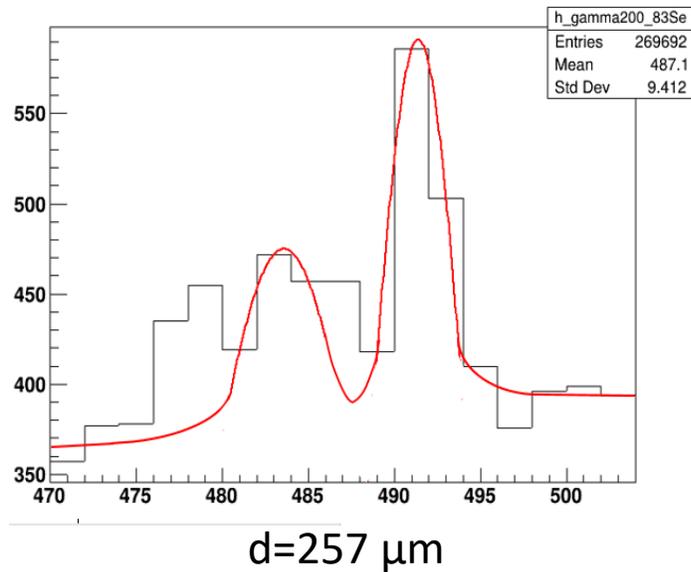
$d=257 \mu\text{m}$

τ moyenne ($13/2^+ \rightarrow 9/2^+$)
de l'ordre de la dizaine
de picosecondes

| Distance | I_1 (coups) | I_2 (coups) | R | τ (ps) |
|-------------------|---------------|---------------|----------|-------------|
| 38 μm | 387.552 | 890.817 | 0.697315 | 3.83245 |
| 257 μm | 465.894 | 479.982 | 0.507449 | 13.775 |

MESURE DES DURÉES DE VIE – RÉSULTATS ^{83}Se

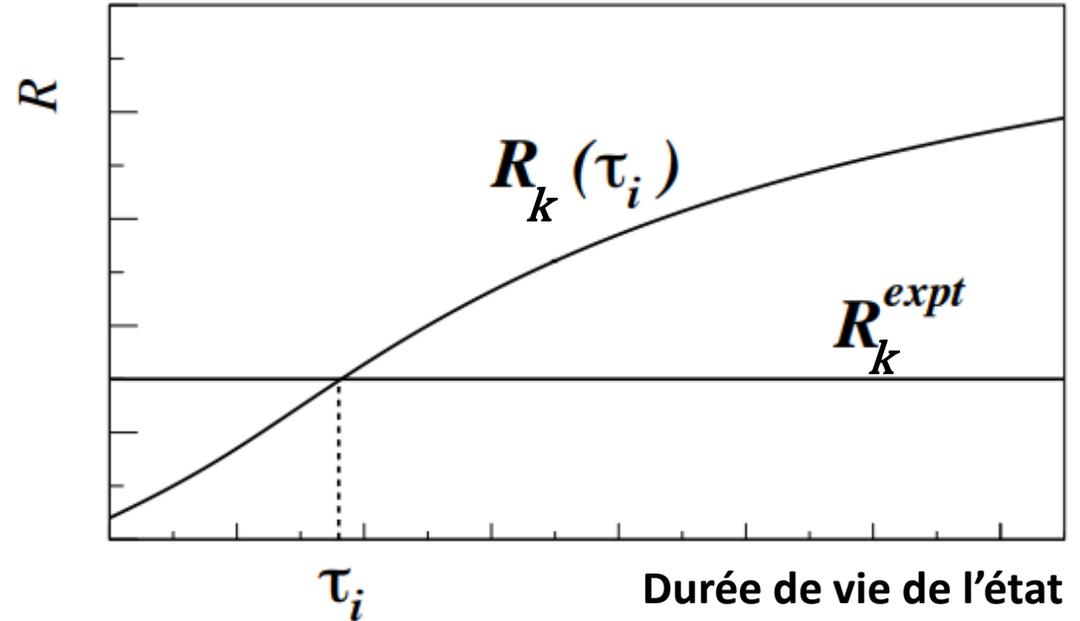
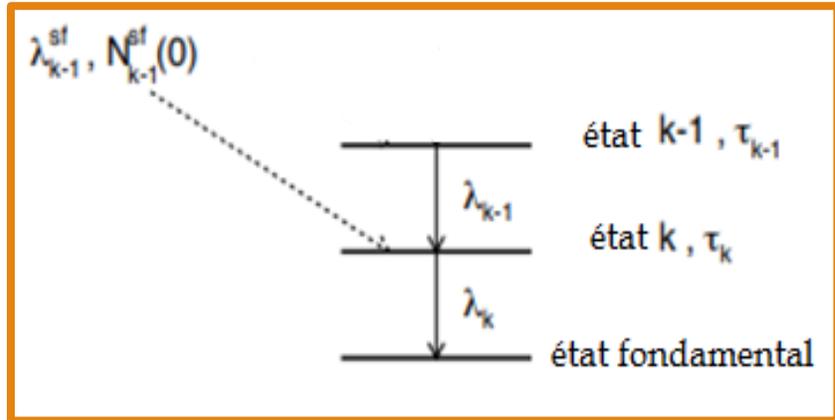
État excité $15/2^+$



$\tau_{\text{moyenne}}(15/2^+ \rightarrow 13/2^+)$
 de l'ordre de la
 vingtaine de
 picosecondes

| Distance | I_1 (coups) | I_2 (coups) | R | τ (ps) |
|-------------------|---------------|---------------|----------|-------------|
| 257 μm | 465.894 | 479.982 | 0.507449 | 13.775 |
| 507 μm | 98.3216 | 97.8441 | 0.498783 | 26.5019 |

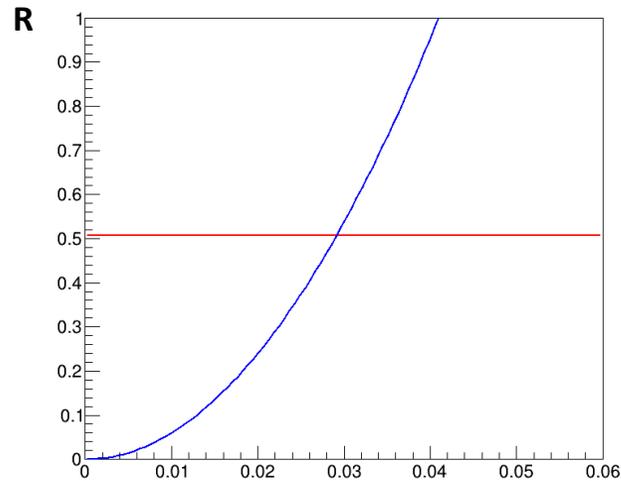
DURÉE DE VIE INTRINSÈQUE – RÉSULTATS ^{83}Se



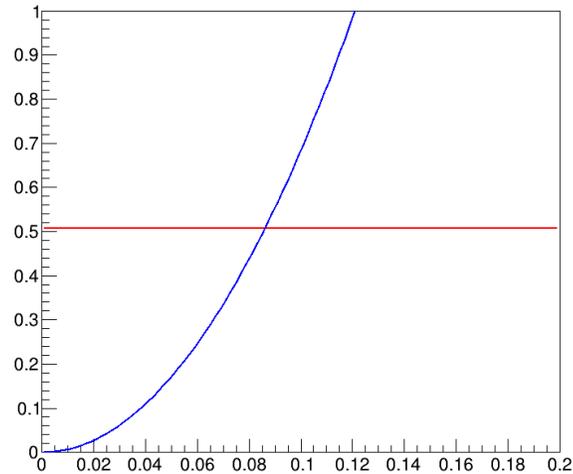
$$R_k = 1 - \frac{\xi}{N_k(0) + \sum_{n=1}^{k-1} N_n^{sf}(0)}$$

$$R_k^{exp} = \frac{I_c}{I_c + I_D}$$

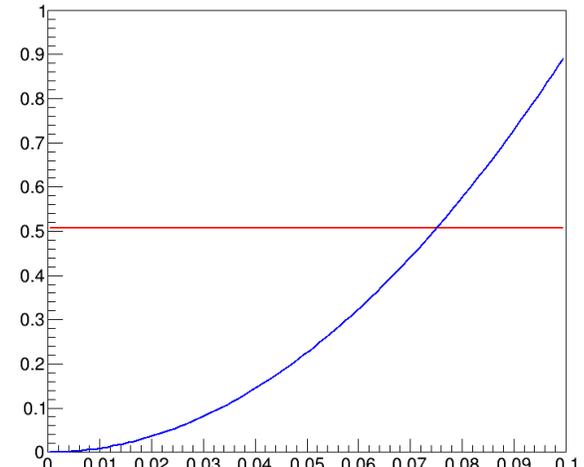
DURÉE DE VIE INTRINSÈQUE – RÉSULTATS ^{83}Se



$\tau_{sf} \ll \tau_{15/2^+}$



$\tau_{sf} \gg \tau_{15/2^+}$



$\tau_{sf} = \tau_{15/2^+}$

| | $\tau_{sf} \ll \tau_{15/2^+}$ | $\tau_{sf} \gg \tau_{15/2^+}$ | $\tau_{sf} = \tau_{15/2^+}$ |
|-------------------------------|-------------------------------|-------------------------------|-----------------------------|
| Durée de vie intrinsèque (ps) | 0.029 | 0.0861 | 0.075 |

τ_{int} est inférieure à la picoseconde

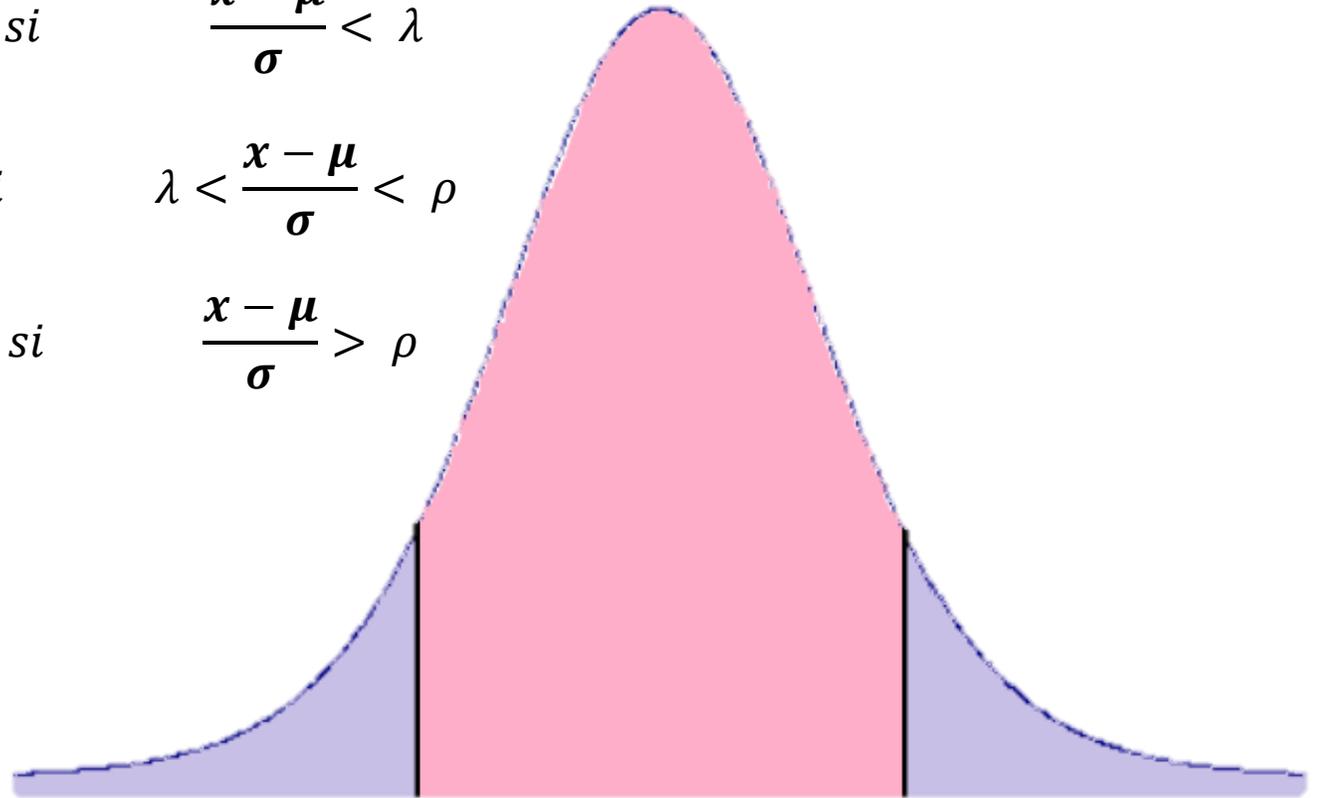
AMÉLIORATION DES FITS

$$f(x) = \begin{cases} h \cdot \left[e^{-\lambda \left(\frac{x-\mu}{\sigma} - \frac{\lambda}{2} \right)} + \frac{S}{\left(1 + e^{\frac{x-\mu}{\sigma}} \right)^2} \right] + b \\ h \cdot \left[e^{-\frac{1}{2} \left(\frac{x-\mu}{\sigma} \right)^2} + \frac{S}{\left(1 + e^{\frac{x-\mu}{\sigma}} \right)^2} \right] + b \\ h \cdot \left[e^{-\rho \left(\frac{x-\mu}{\sigma} - \frac{\rho}{2} \right)} + \frac{S}{\left(1 + e^{\frac{x-\mu}{\sigma}} \right)^2} \right] + b \end{cases}$$

$$\text{si } \frac{x-\mu}{\sigma} < \lambda$$

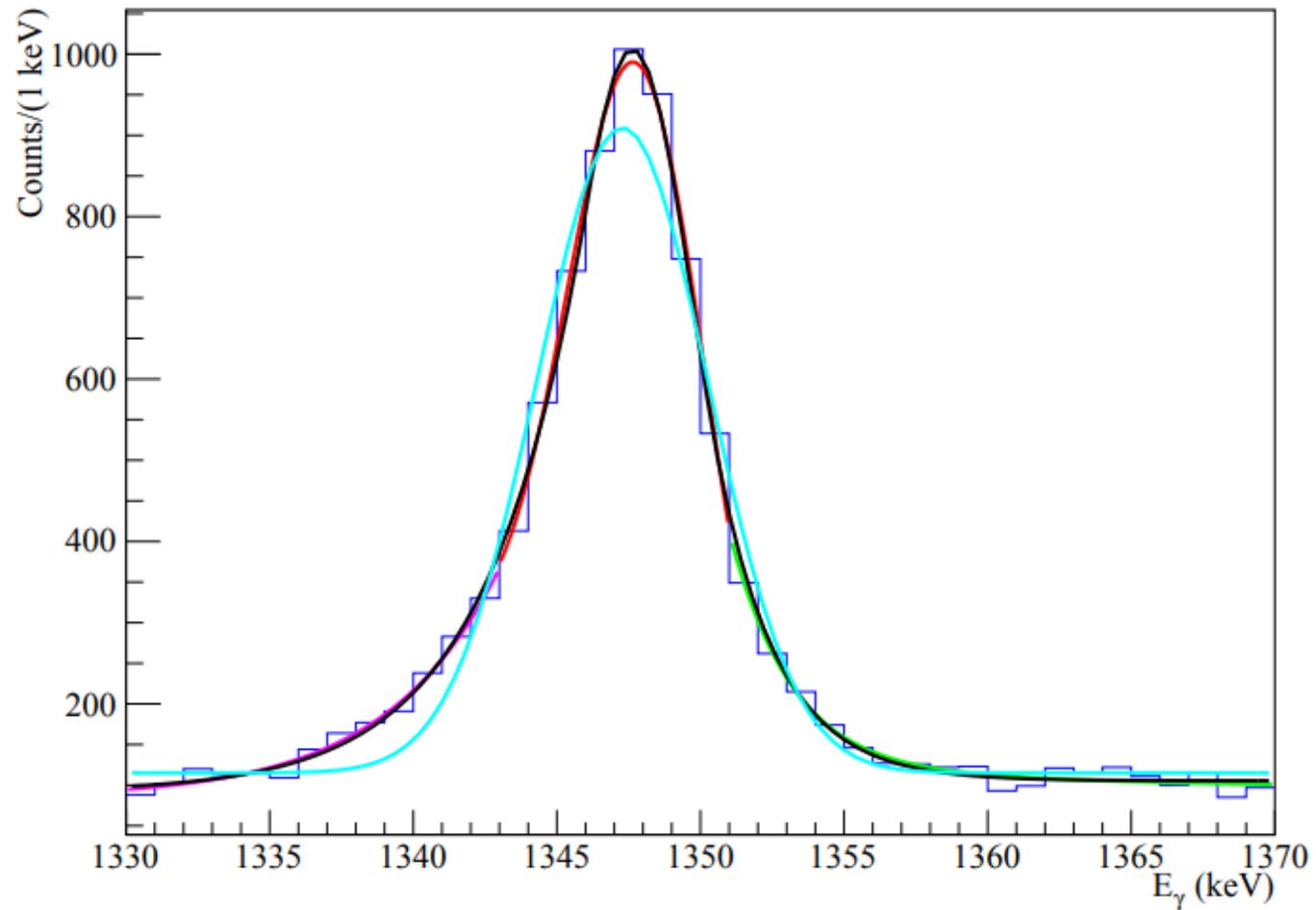
$$\text{si } \lambda < \frac{x-\mu}{\sigma} < \rho$$

$$\text{si } \frac{x-\mu}{\sigma} > \rho$$



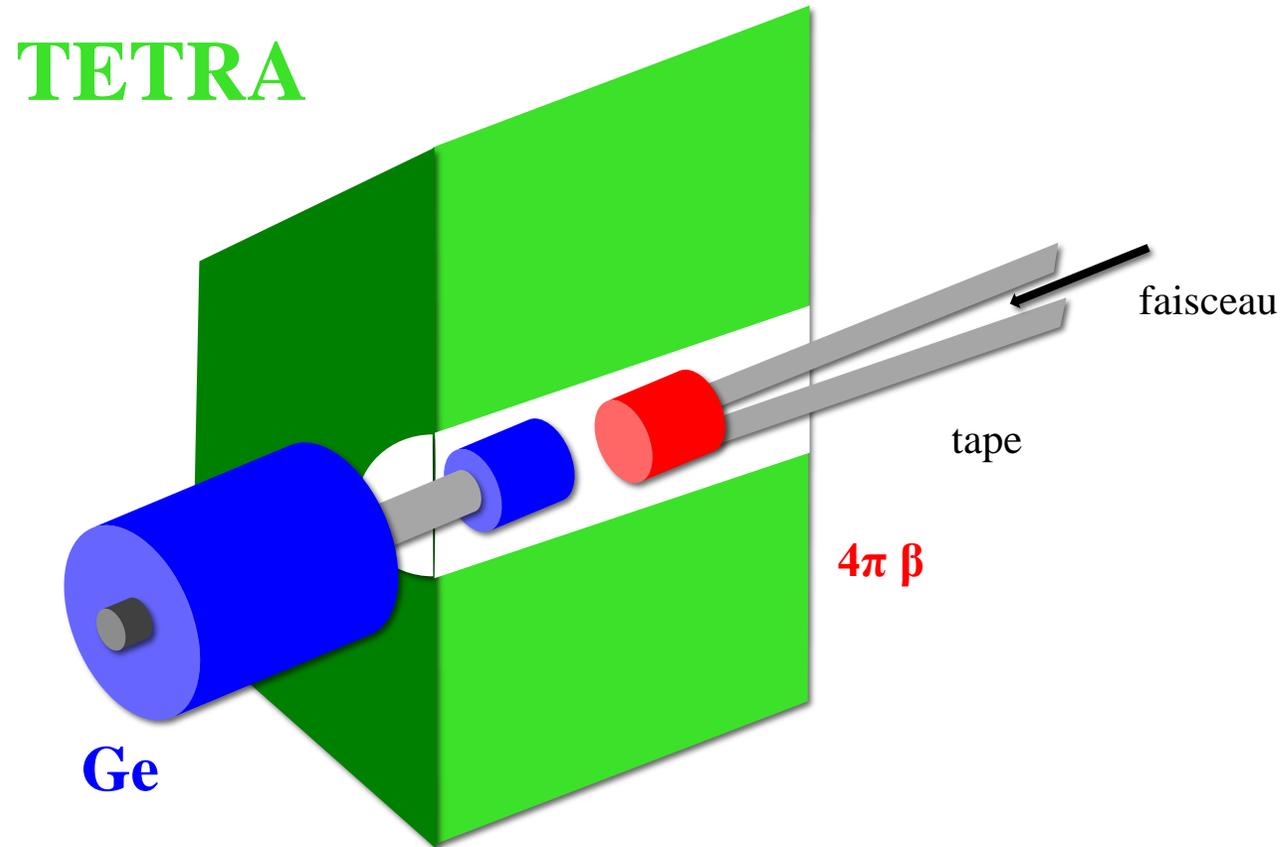
AMÉLIORATION DES FITS

^{82}Ge

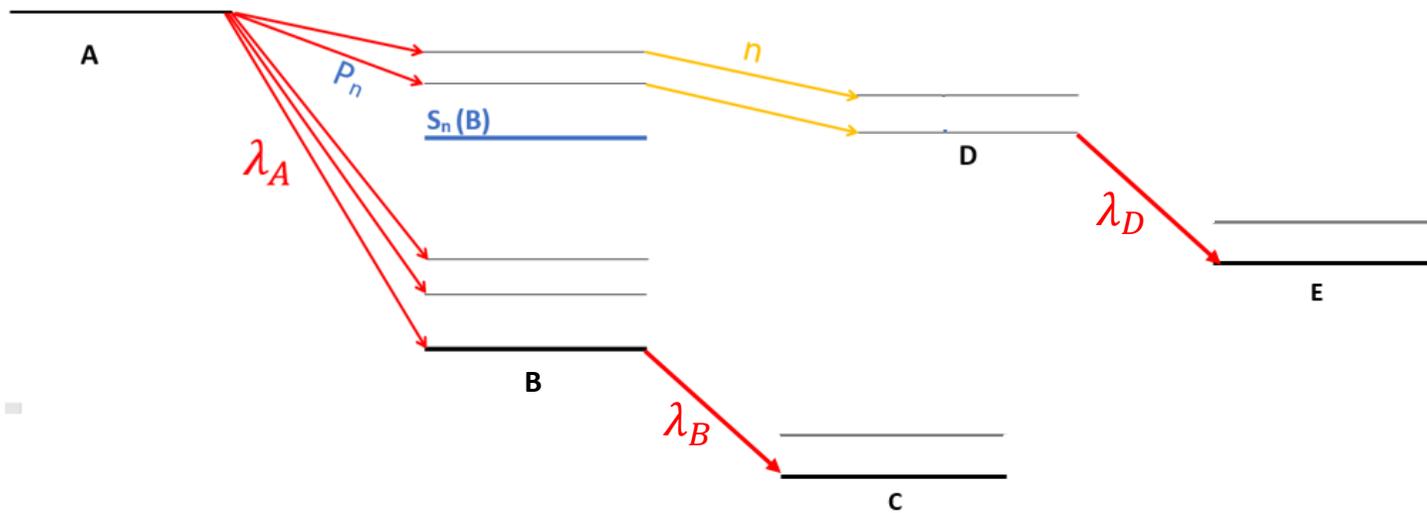


Décroissance β -
 ^{92}Rb

DISPOSITIF EXPÉRIMENTAL - ALTO



MESURE DE DEMI-VIE - DÉCROISSANCE β DE ^{92}Rb



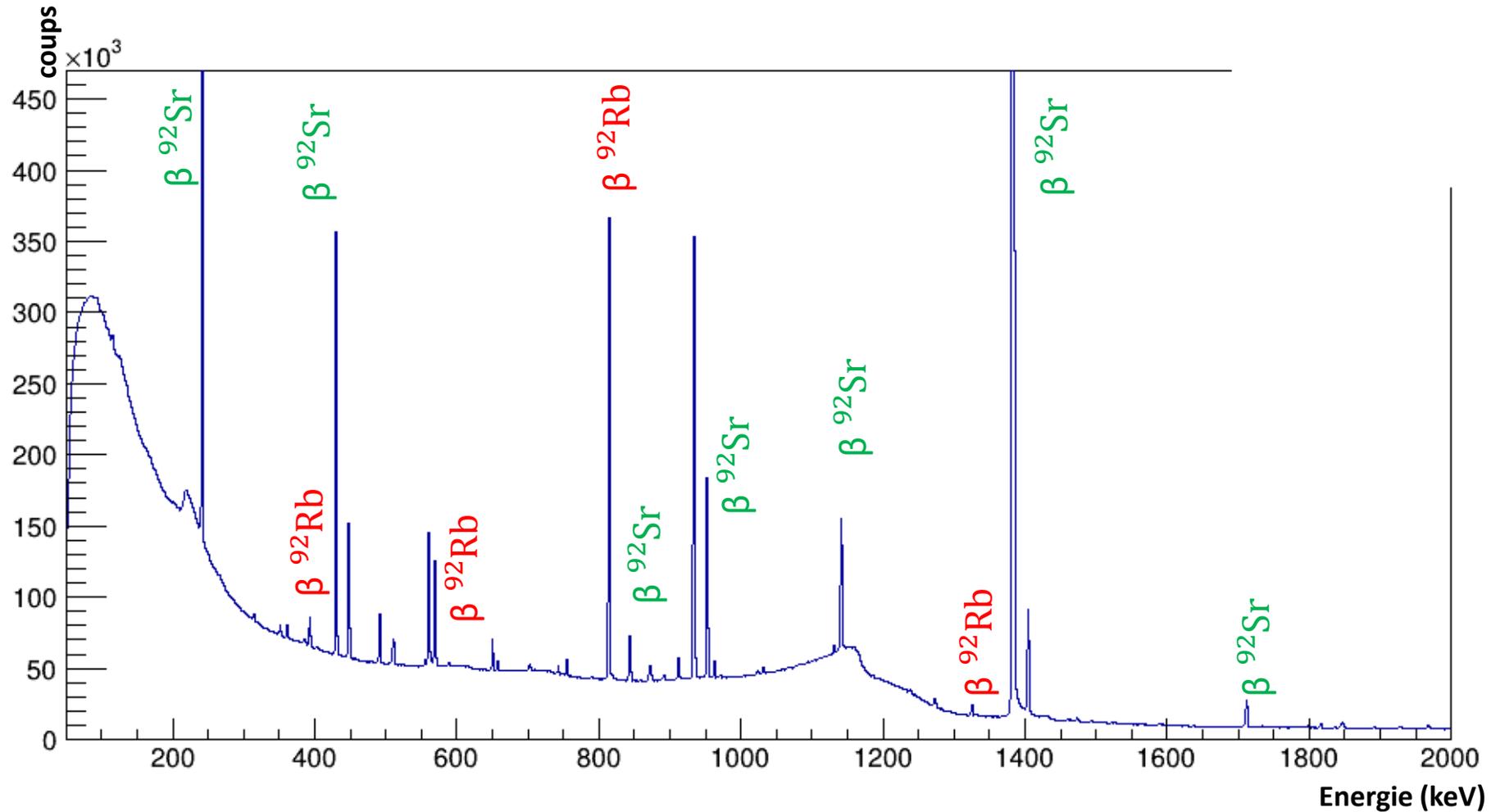
$$\left\{ \begin{array}{l} \frac{dN_A(t)}{dt} = \lambda_A \rho_A - \lambda_A N_A \\ \frac{dN_B(t)}{dt} = (1 - P_n) \lambda_A N_A - \lambda_B N_B \\ \frac{dN_D(t)}{dt} = P_n \lambda_A N_A - \lambda_D N_D \end{array} \right.$$

MESURE DE DEMI-VIE - DÉCROISSANCE β DE ^{92}Rb

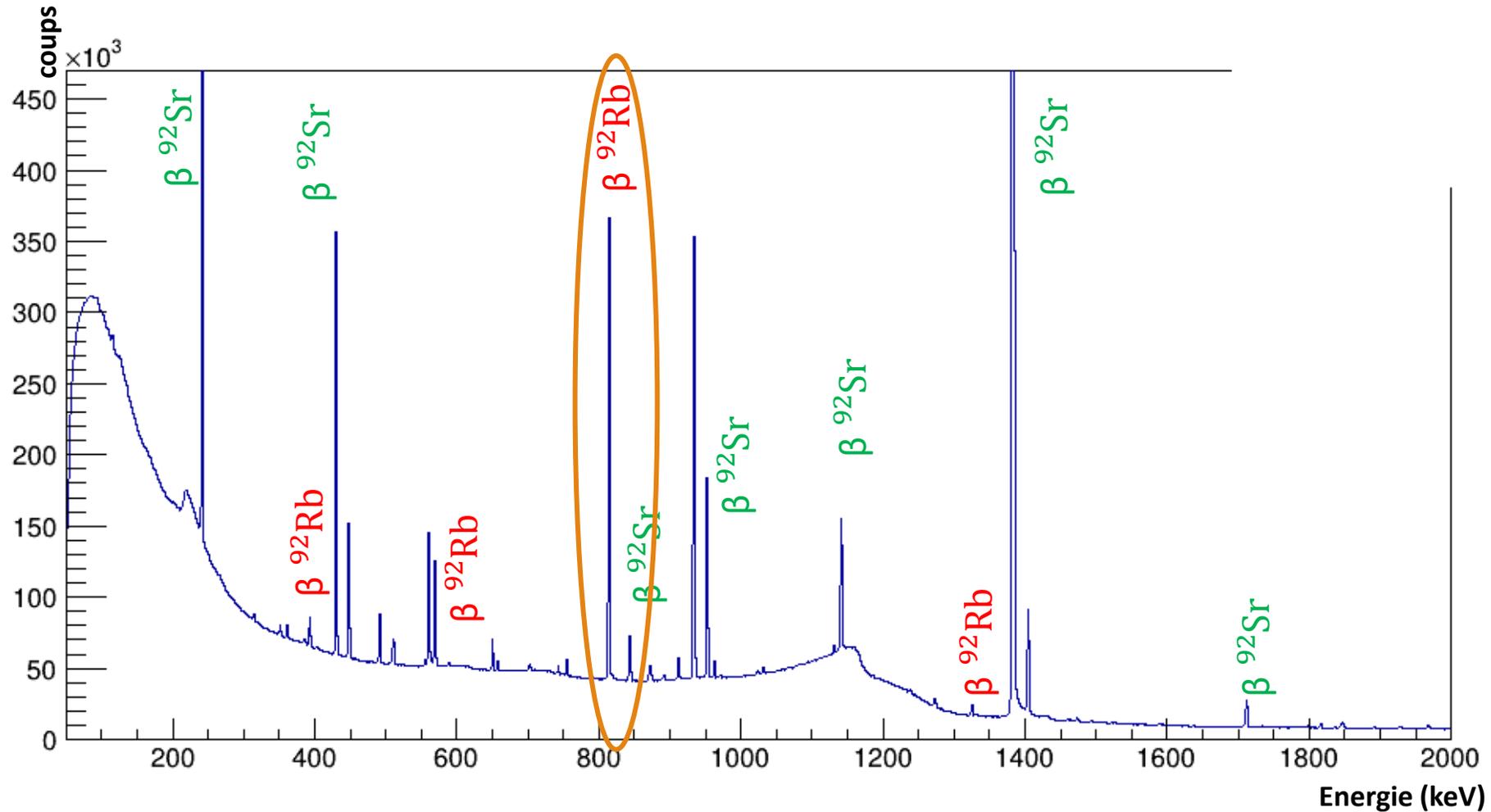
$$\left\{ \begin{array}{l} A_A(t) = \rho_A(1 - e^{-\lambda_A t}) \\ A_B(t) = \rho_A(1 - P_n) \left[1 + \frac{\lambda_B}{\lambda_A - \lambda_B} e^{-\lambda_A t} - \frac{\lambda_A}{\lambda_A - \lambda_B} e^{-\lambda_B t} \right] \quad \text{si } 0 \leq t \leq t_c \\ A_D(t) = \rho_A P_n \left[1 + \frac{\lambda_D}{\lambda_A - \lambda_D} e^{-\lambda_A t} - \frac{\lambda_A}{\lambda_A - \lambda_D} e^{-\lambda_D t} \right] \end{array} \right.$$

$$\left\{ \begin{array}{l} A_A(t) = \rho_A(1 - e^{-\lambda_A t_c}) e^{-\lambda_A(t-t_c)} \\ A_B(t) = \left[A_A(t_c)(1 - P_n) \frac{\lambda_B}{\lambda_B - \lambda_A} \right] e^{-\lambda_A(t-t_c)} + \left[A_B(t_c) - A_A(t_c)(1 - P_n) \frac{\lambda_B}{\lambda_B - \lambda_A} \right] e^{-\lambda_B(t-t_c)} \quad \text{si } t_c \leq t \leq t_a \\ A_D(t) = \left[A_A(t_c) P_n \frac{\lambda_D}{\lambda_D - \lambda_A} \right] e^{-\lambda_A(t-t_c)} + \left[A_D(t_c) - A_A(t_c) P_n \frac{\lambda_D}{\lambda_D - \lambda_A} \right] e^{-\lambda_D(t-t_c)} \end{array} \right.$$

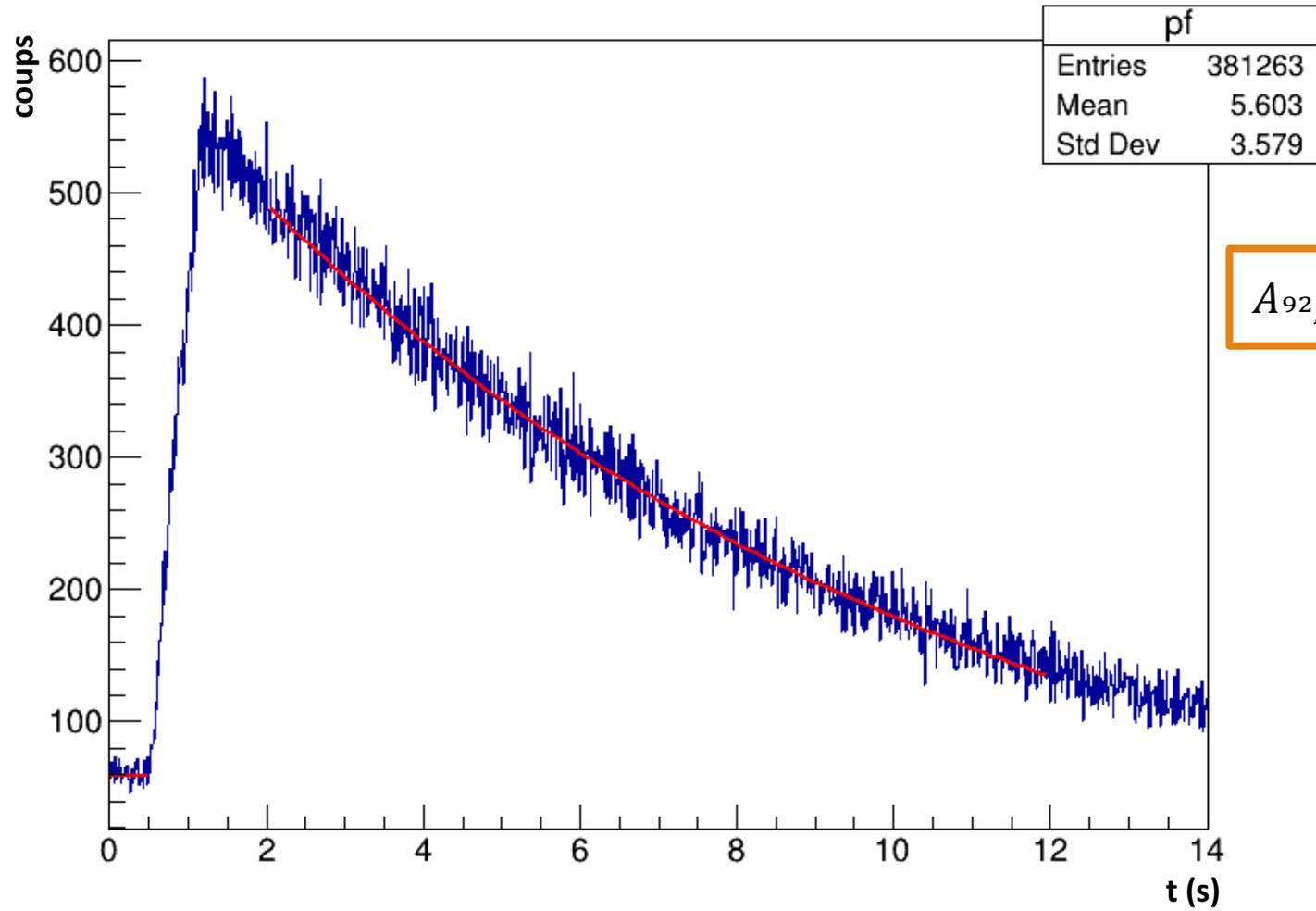
MESURE DE DEMI-VIE - DÉCROISSANCE β DE ^{92}Rb



MESURE DE DEMI-VIE - DÉCROISSANCE β DE ^{92}Rb



MESURE DE DEMI-VIE - DÉCROISSANCE β DE ^{92}Rb

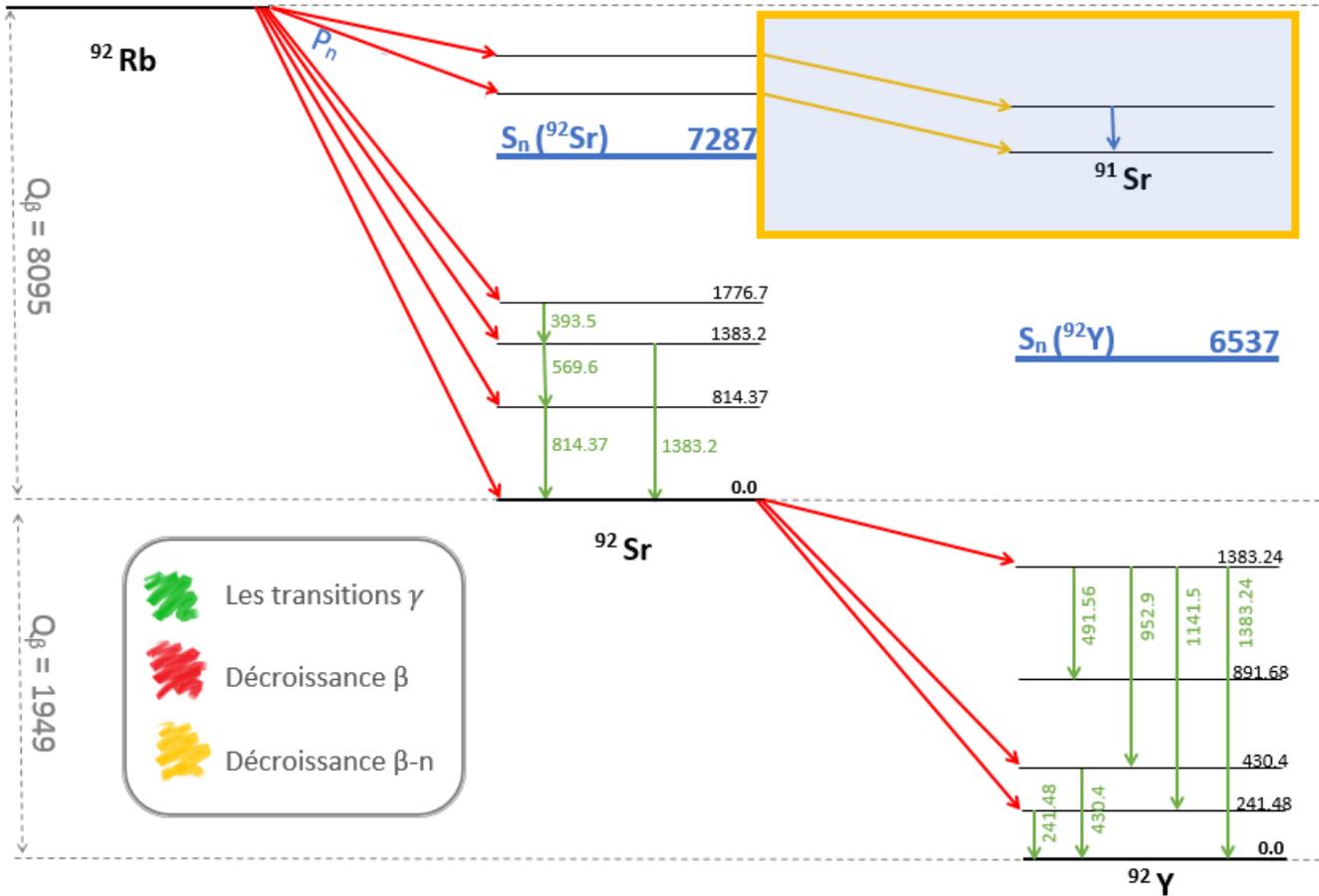


$$A_{^{92}\text{Rb}}(t) = \rho_{^{92}\text{Rb}} \left(1 - e^{-\lambda_{^{92}\text{Rb}} t_c}\right) e^{-\lambda_{^{92}\text{Rb}}(t-t_c)}$$

$$\lambda_{^{92}\text{Rb}} = 1.044 \text{ s}^{-1}$$

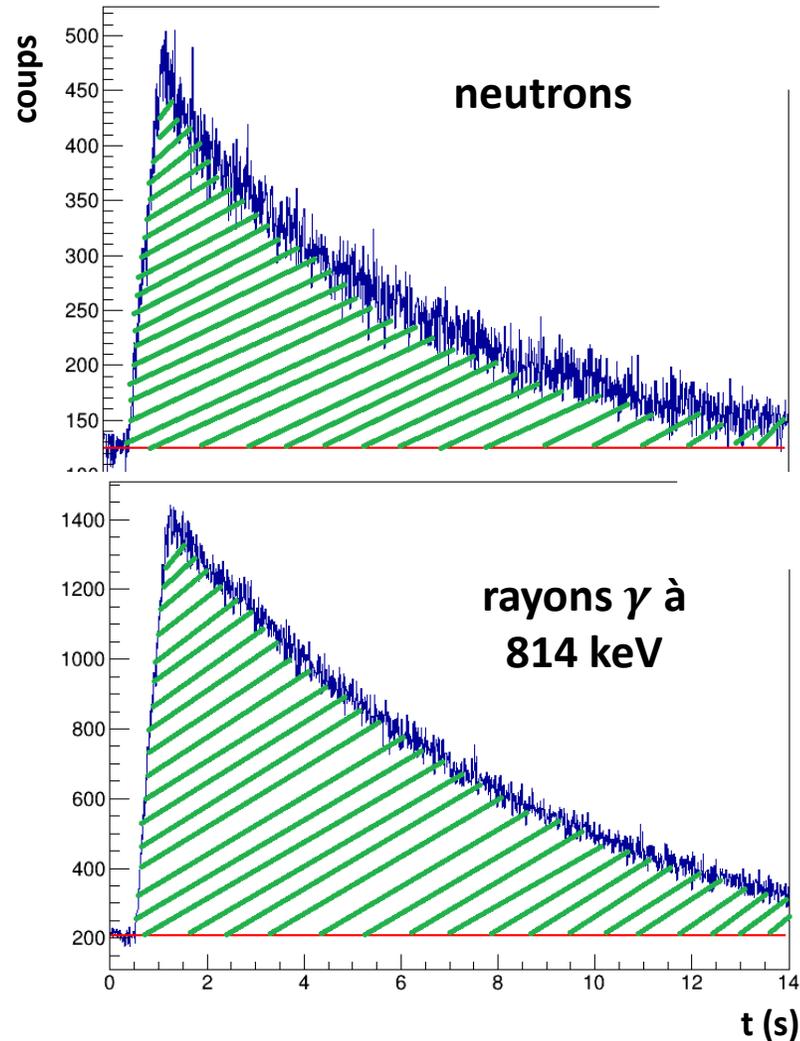
$$T_{1/2}(^{92}\text{Rb}) = 6.6 \text{ s}$$

CALCUL DE P_n



$$P_n = \frac{\text{nombre des neutrons}}{\text{nombre de } ^{92}\text{Rb}}$$

CALCUL DE P_n



$$\text{nombre des neutrons} = \frac{\text{Integral}_n}{\varepsilon_n}$$

$$\text{nombre de } ^{92}\text{Rb} = \frac{\text{Integral}_{\gamma-814\text{keV}}}{\varepsilon_\gamma \cdot I_{814\text{keV}}}$$

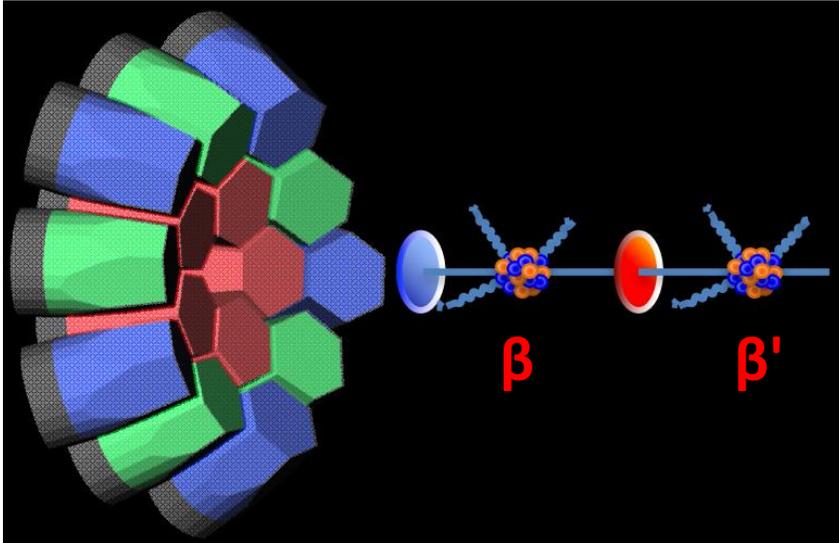
$$P_n = 0.01\%$$

CONCLUSION

1. Analyse des données AGATA+PRISMA sur la structure des noyaux riches en neutrons par la méthode RDDS
2. Mesure des probabilités P_n de décroissance β -neutron retardé avec ALTO-TETRA
3. Résultats en accord avec ceux qui sont déjà trouvés
4. Compétences : ROOT, LISE++, Langue française

Merci pour votre
attention

Diapositifs de réserve



β' mesurée par PRISMA
 β non mesurée mais $\beta > \beta'$

$$E_{\text{decalée}} = E_m + \Delta E_{\text{Doppler}} = E_m + E_m \beta \cos \theta$$

$$E_{\text{non_decalée}} = E_m + \Delta E_{\text{Doppler}} = E_m + E_m \beta' \cos \theta$$

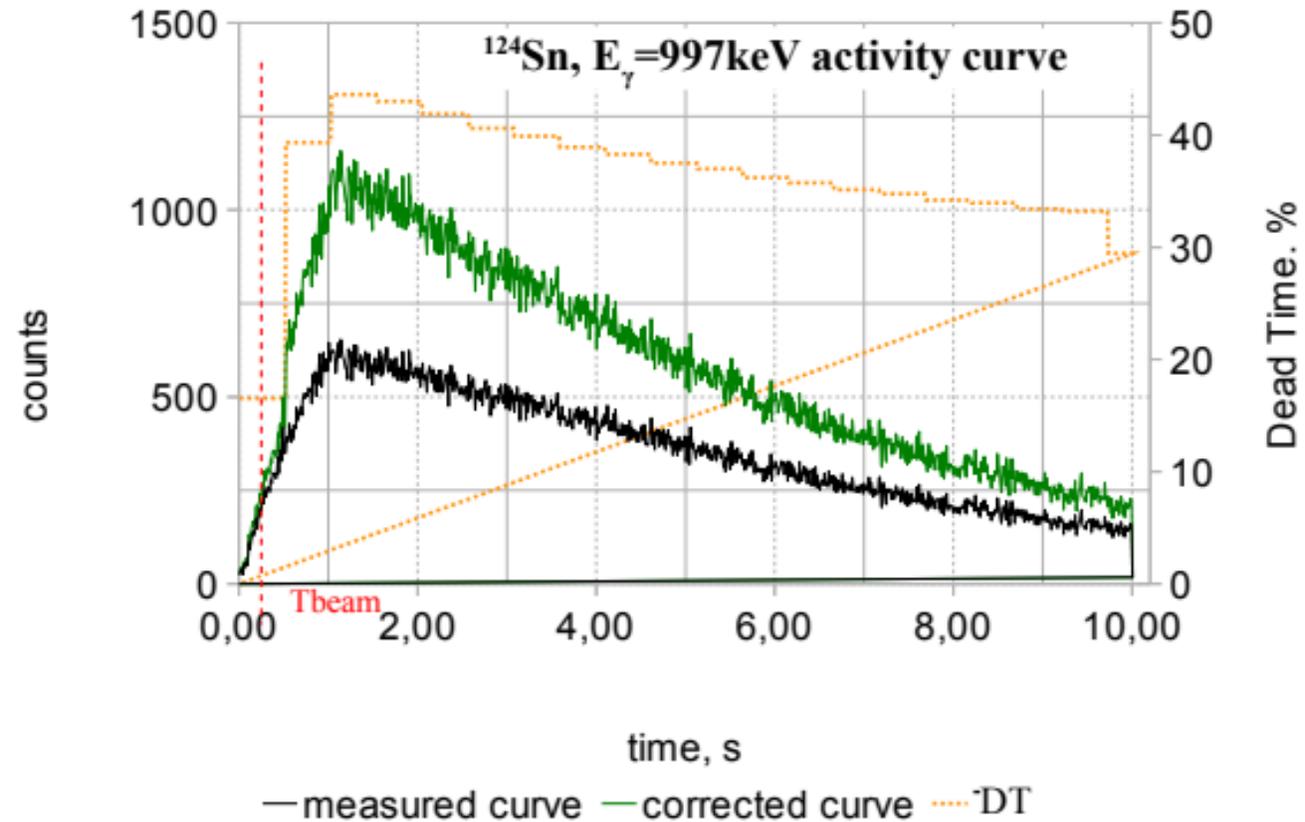
$$\Delta E = E_{\text{non_decalée}} - E_{\text{decalée}} = E_m \Delta \beta \cos \theta$$

$$\Delta \beta = \beta' - \beta < 0$$

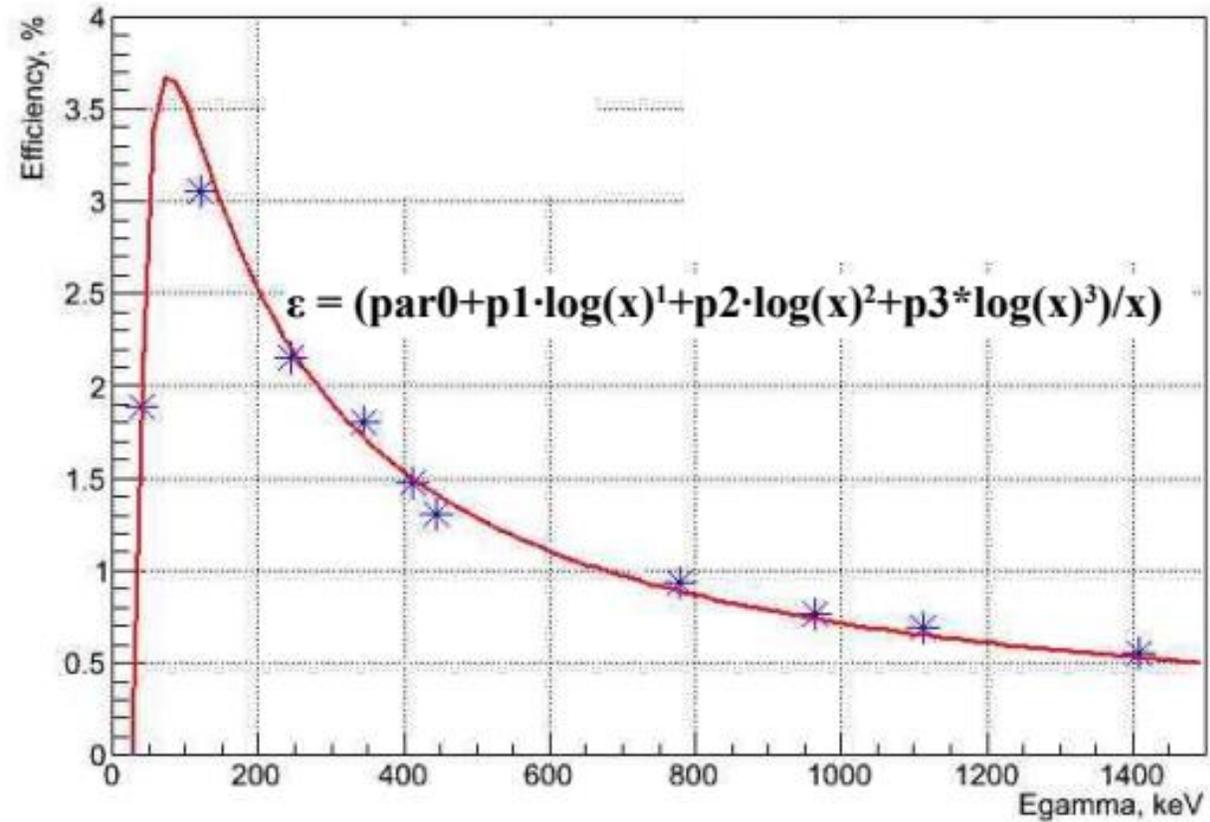
$$\cos \theta < 0$$

$$E_{\text{non_decalée}} > E_{\text{decalée}}$$

Diapositifs de réserve



Diapositifs de réserve



D. Testov et al. "Trial for the long neutron counter TETRA using ^{96,97}Rb radioactive sources", Journal of Instrumentation 14 (2019) P08002.