DE LA RECHERCHE À L'INDUSTRIE

Other fundings

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Characterization of the FALSTAFF spectrometer first arm: Study of ^{252}Cf and ^{235}U fission fragments

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1) Irfu, CEA, Université Paris-Saclay, France
2) GANIL, Caen, France
3) European Commission, Joint Research Centre, Geel, Belgium

Outlook

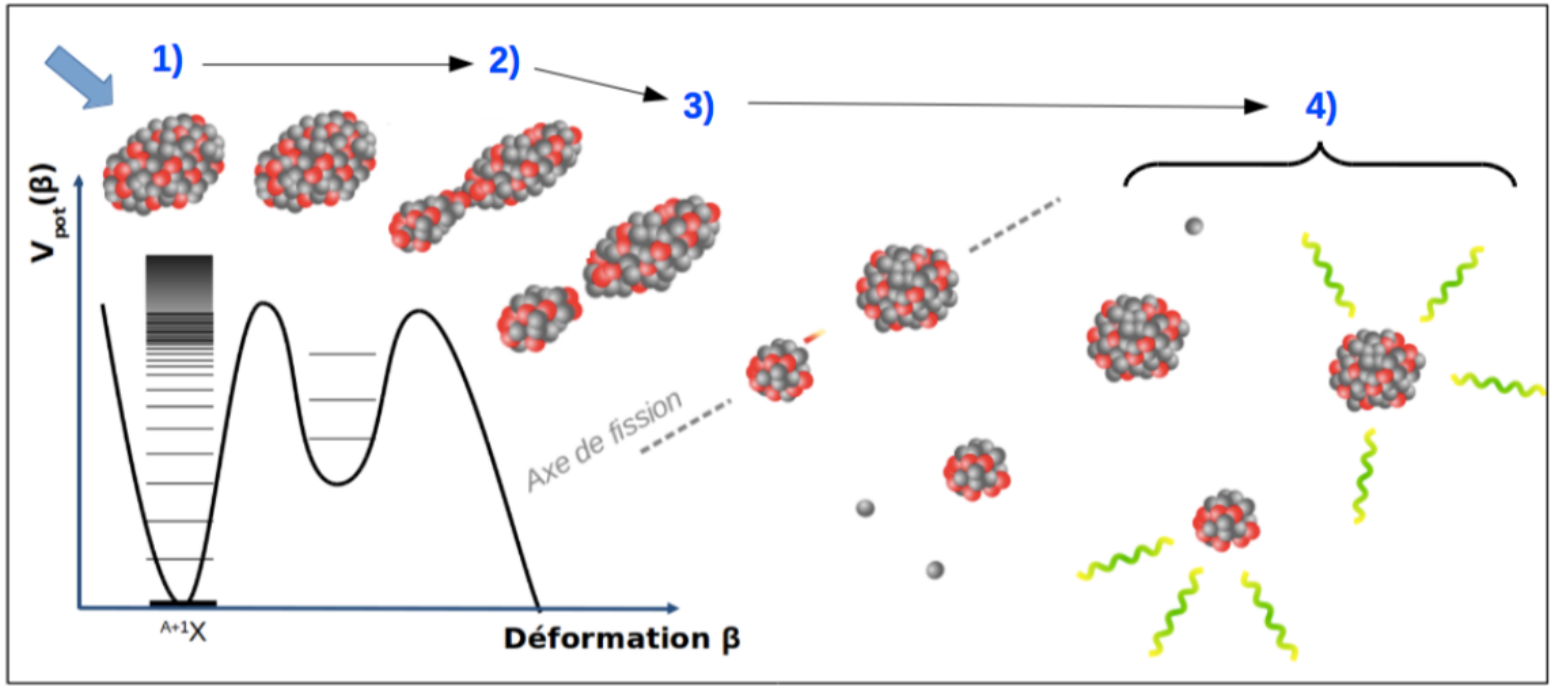
- Context
- Goals and Motivations
- Detectors
- ^{252}Cf and ^{235}U results
- Perspectives and Summary

Nuclear Fission

Splitting of a nuclei into two (+ a few neutron)

Fission process timeline

1) Formation of fissionning system
2) Deformation up to to saddle point
3) Deformation up to the scission point
4) De-excitation of primary fragments



Goals and Motivations

Study of actinide fission in the fast energy domain

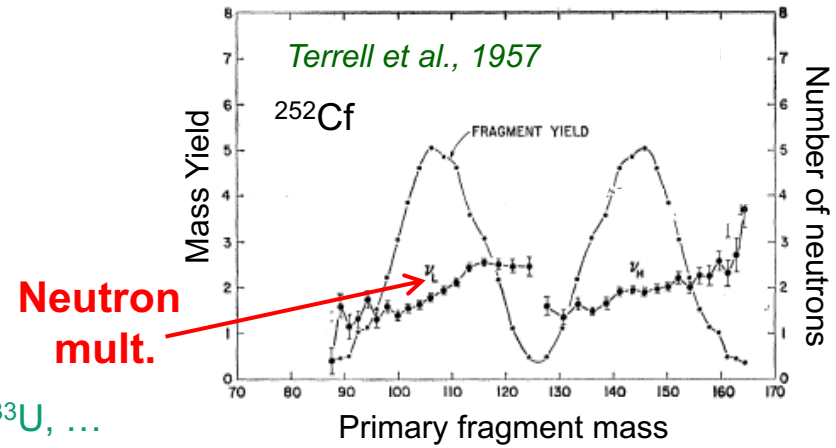
Fragments in coincidence
- Kinetic energies
- Final masses (after n evaporation)
- Initial masses (before n evaporation)
- Charge

Fragments + gamma

Fragments + neutrons

Actinides to study: ^{238,235}U, ^{239}Pu, ^{237}Np, ^{232}Th, ^{233}U, …

Experiment to be performed at NFS, …



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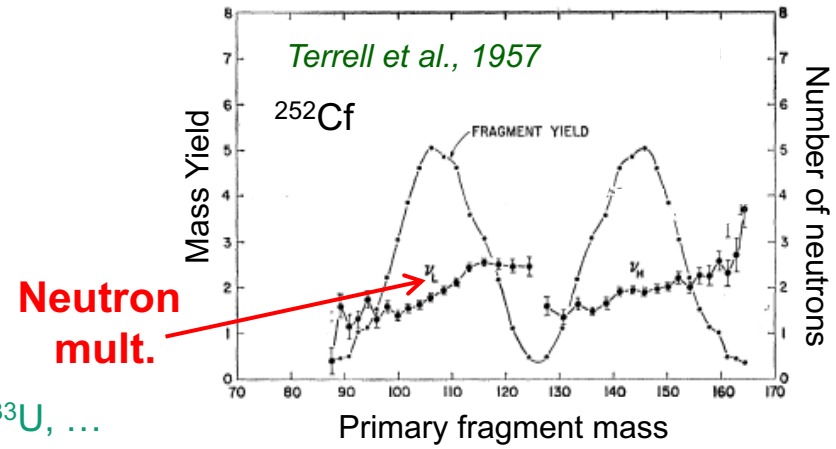
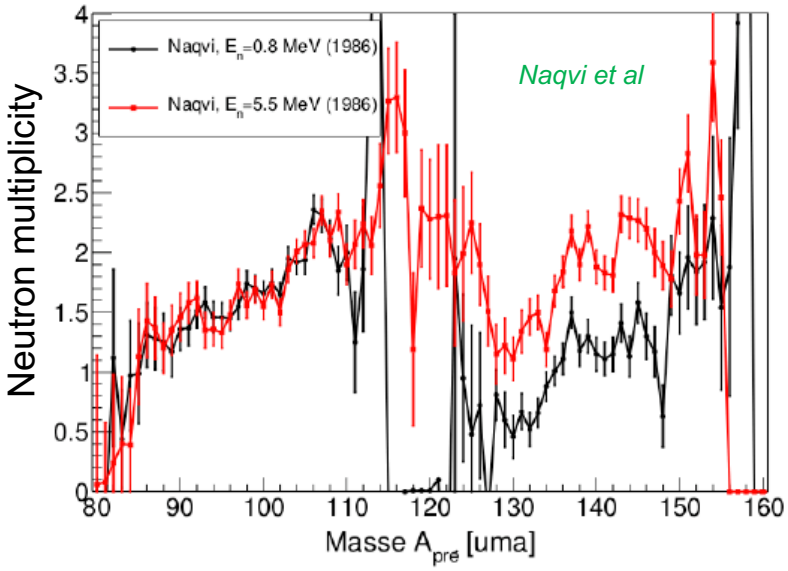
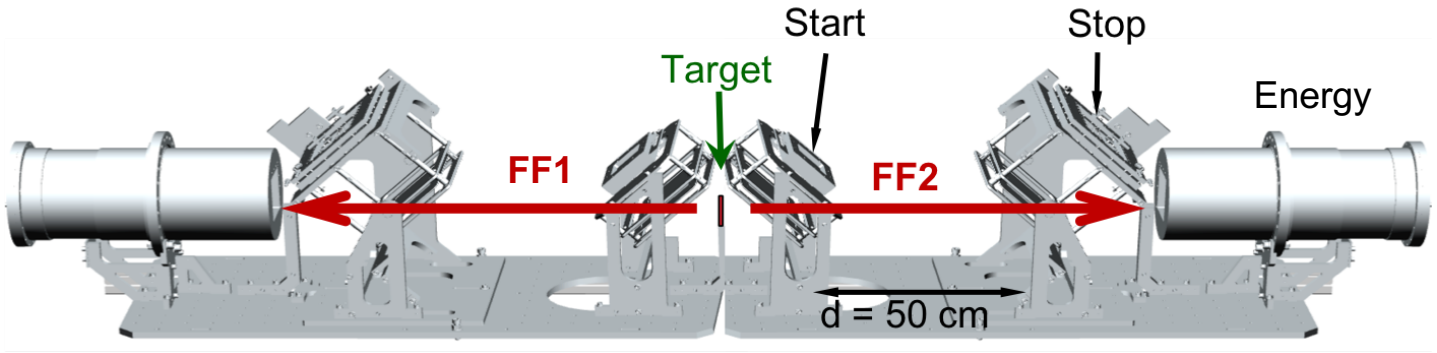


Data needed :

- Few data in the fast neutron energy domain
  - New generation **reactors**
    - Neutron multiplicity and fission yields
    - Important for ND libraries
  - Knowledge about **fission process**
    - energy sharing
    - deformation…



Method



FF mass before evaporation (A_{pre}) → The 2V method

- Hyp: n evaporation does not modify **average velocity**

Measurement using time-of-flight (ToF) method

- Timing resolution : σ_t **~ 150 ps**
- Spatial resolution : $\sigma_{X,Y}$ **~ 2 mm**

↓

Emissive foils + MWPC

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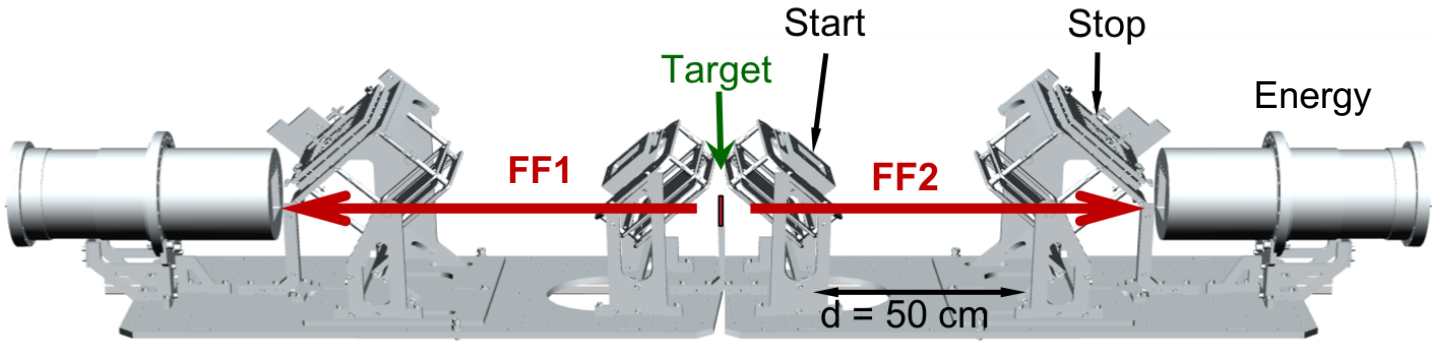

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FF mass after evaporation (A_{post}) → The EV method

- Energy loss corrections

Measurement using an energy detector + ToF

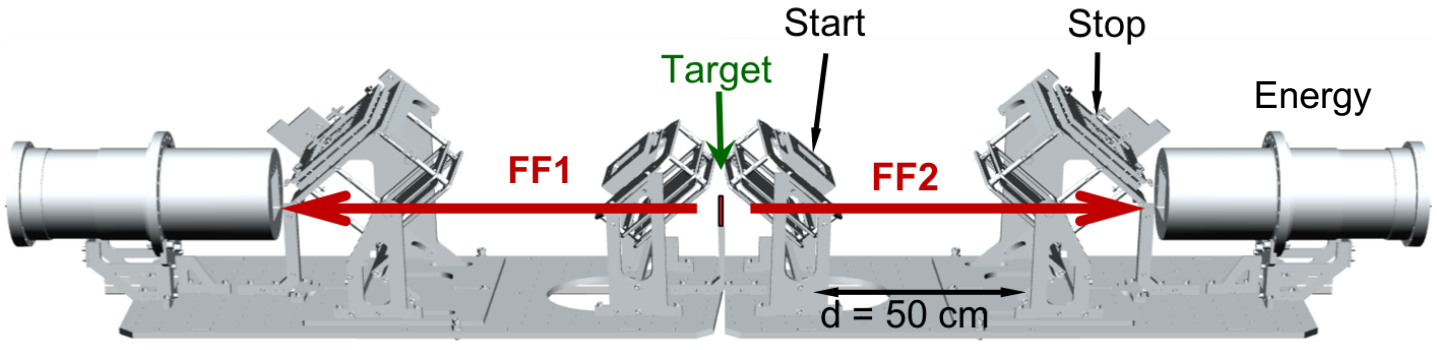
- Timing & position resolution similar to 2V
- Energy resolution **DE/E ~ 1 %**
- Energy loss profile →~Z

↓ **Emissive foils + MWPC**

Fragment energy losses
- Thickness/homog. of materials
- Track reconstruction
- Good calc. of DE

↓ **Axial ionization chamber**

Method



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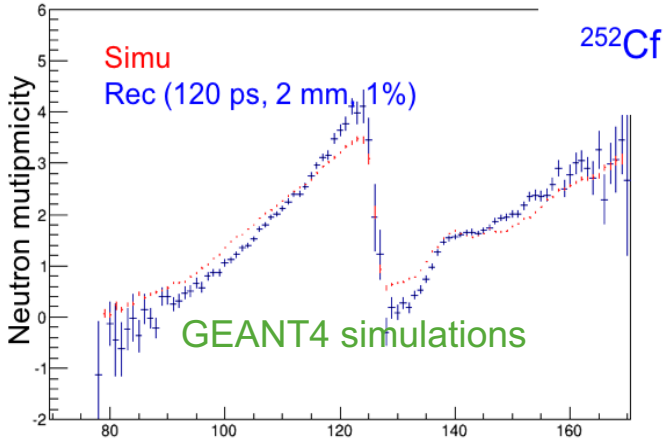
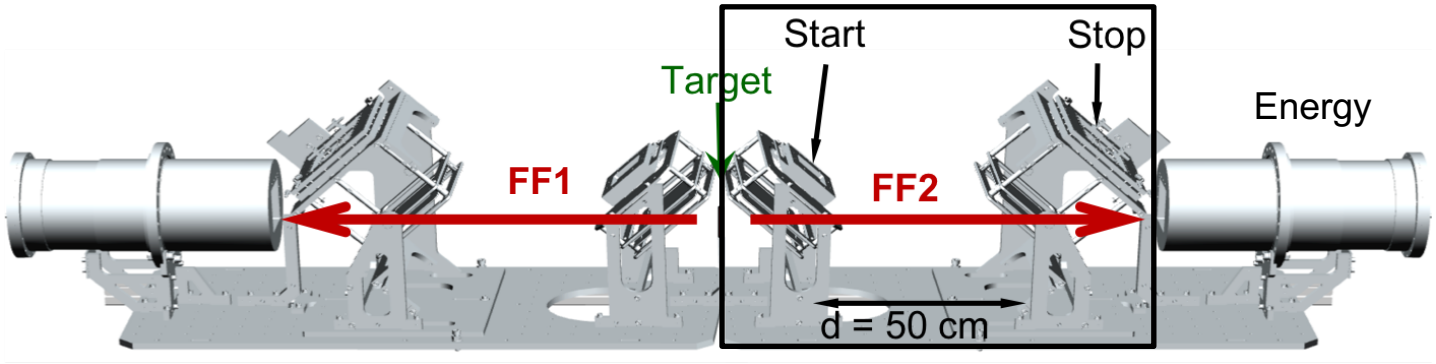
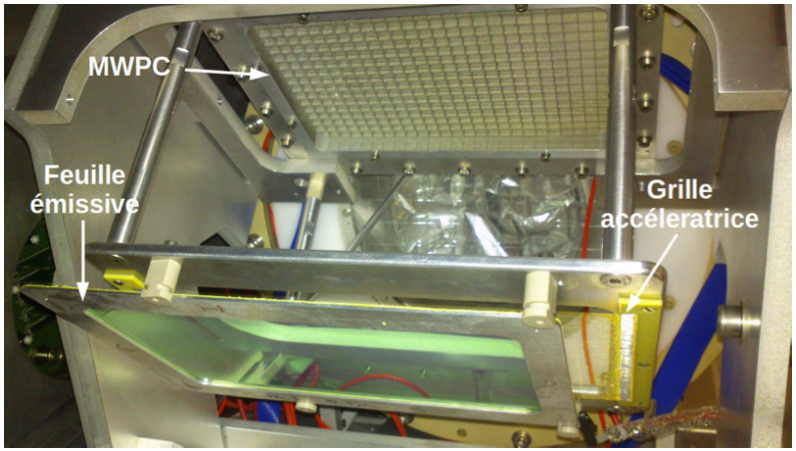


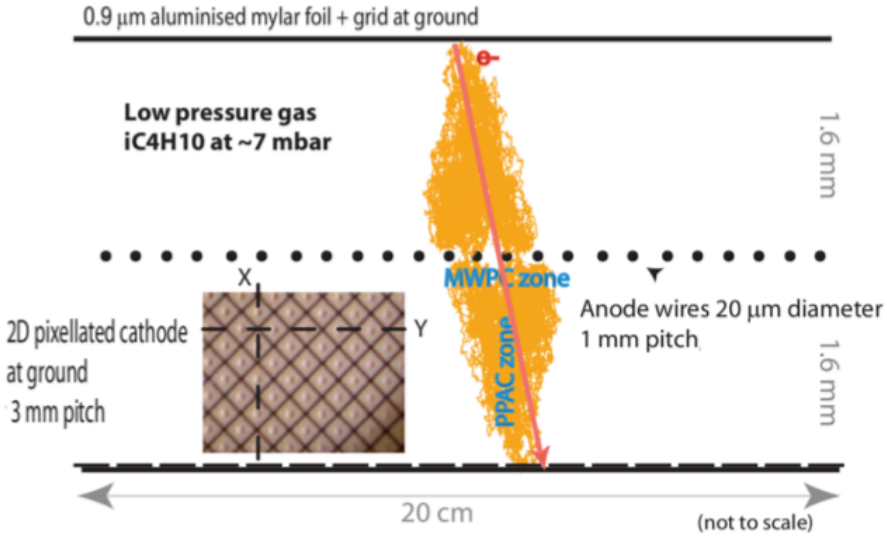
Axial ionization chamber

ToF Detectors





Stop (20x14 cm^2)



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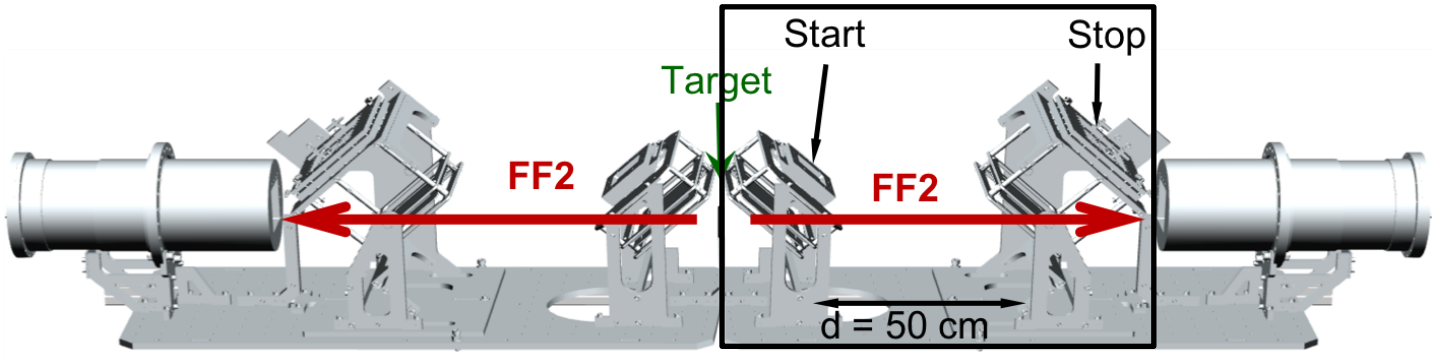
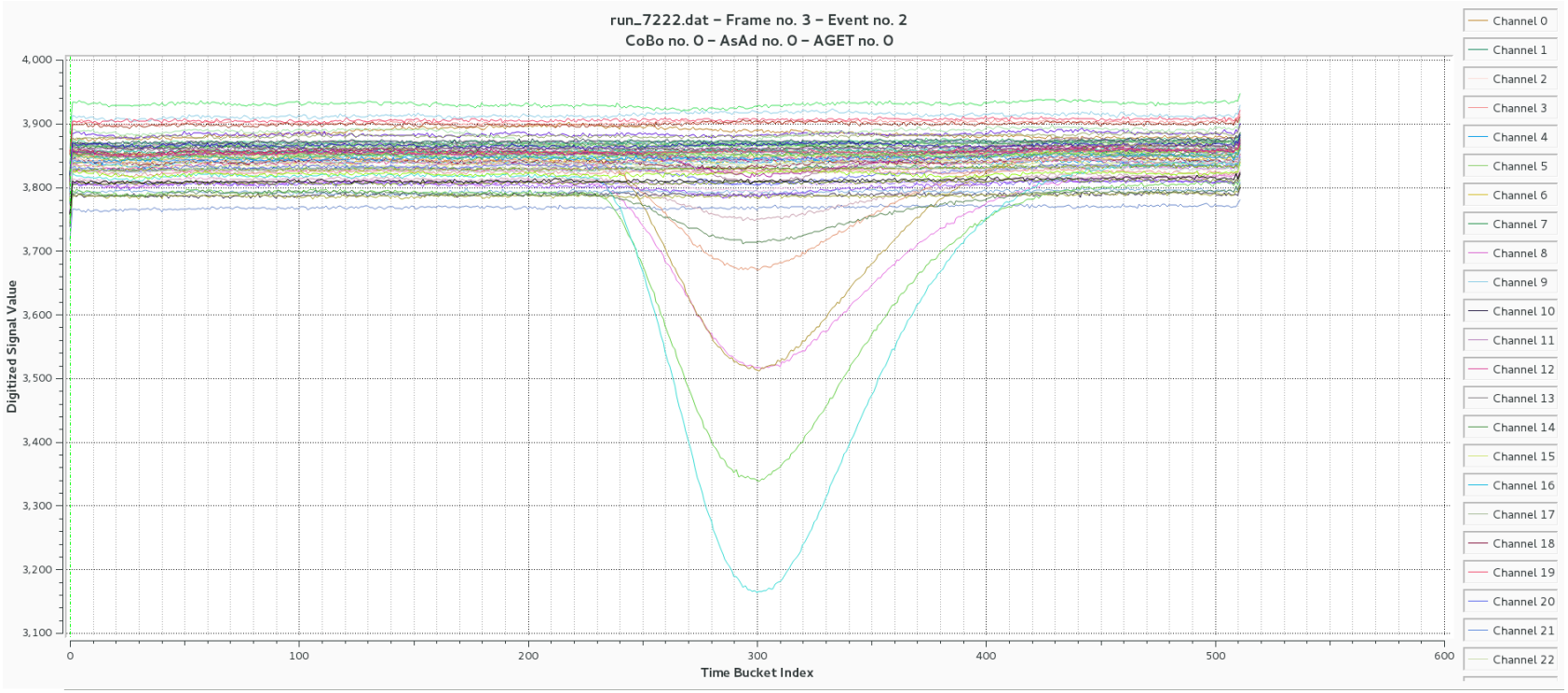


Position calculation



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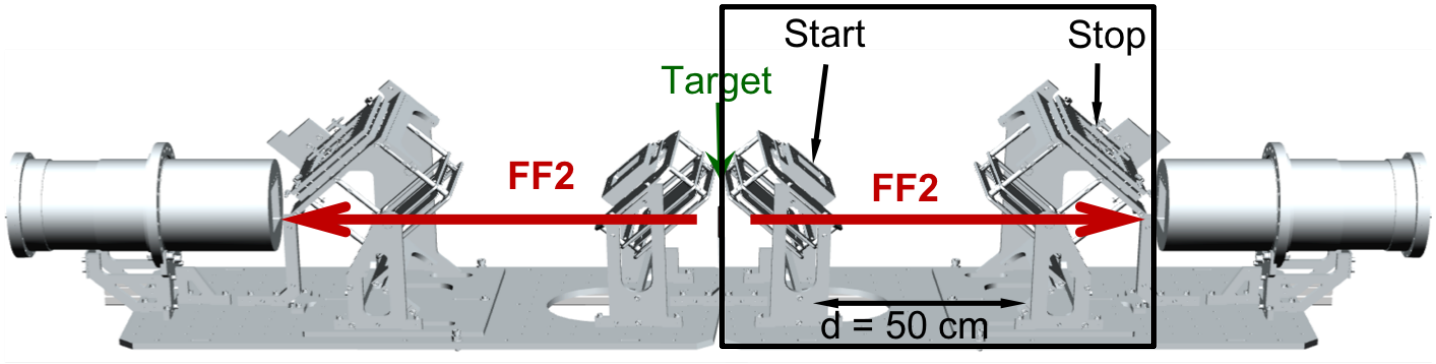
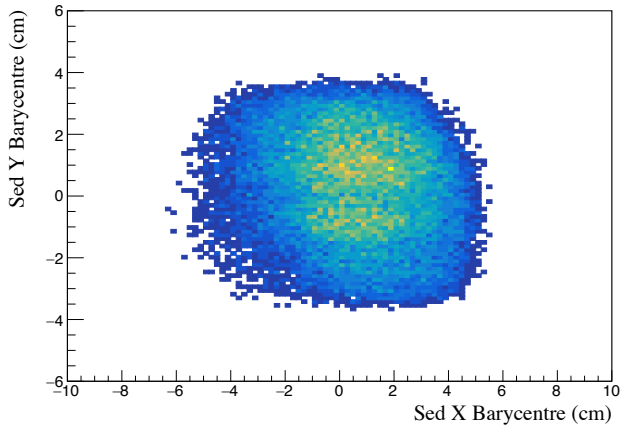
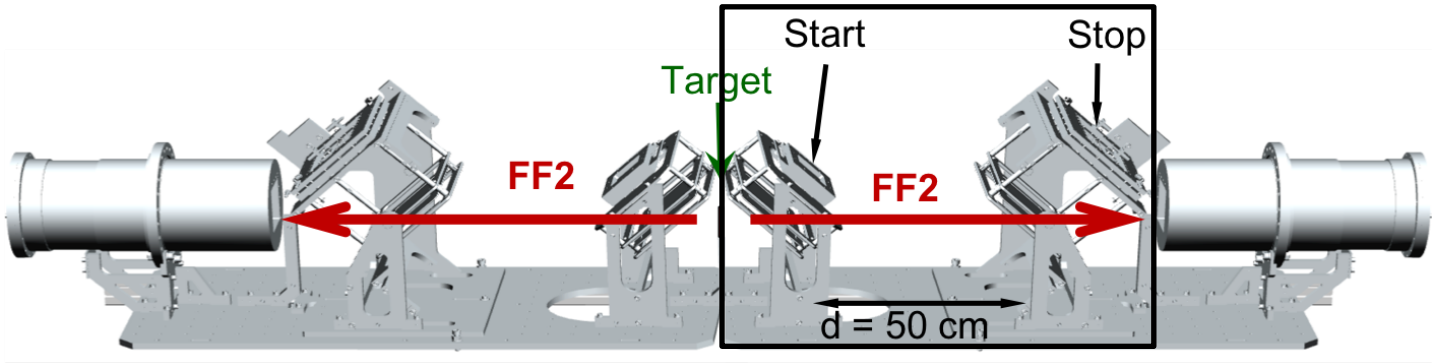
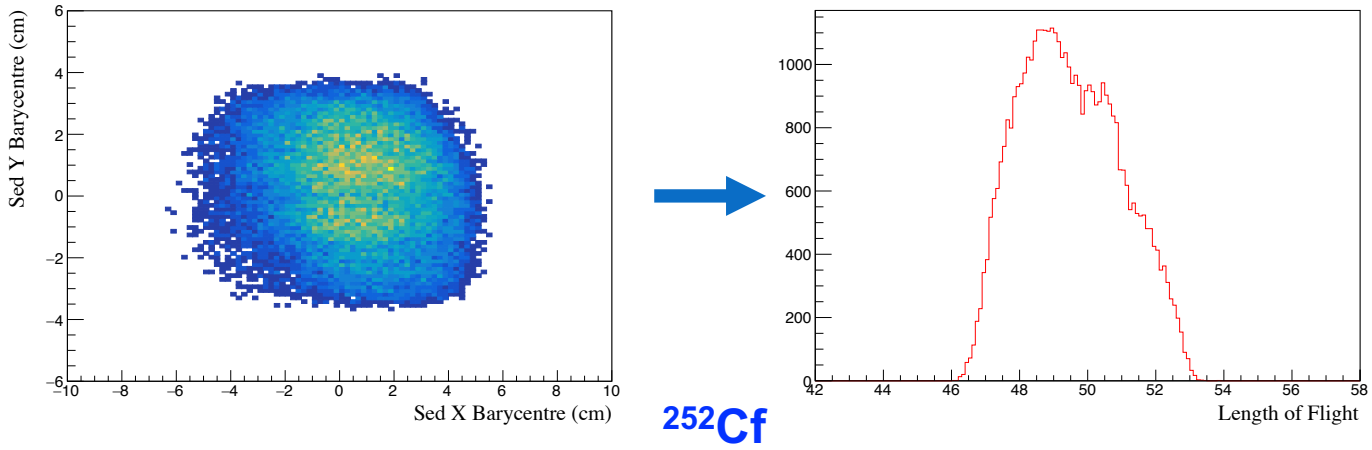




^{252}Cf

ToF Detectors





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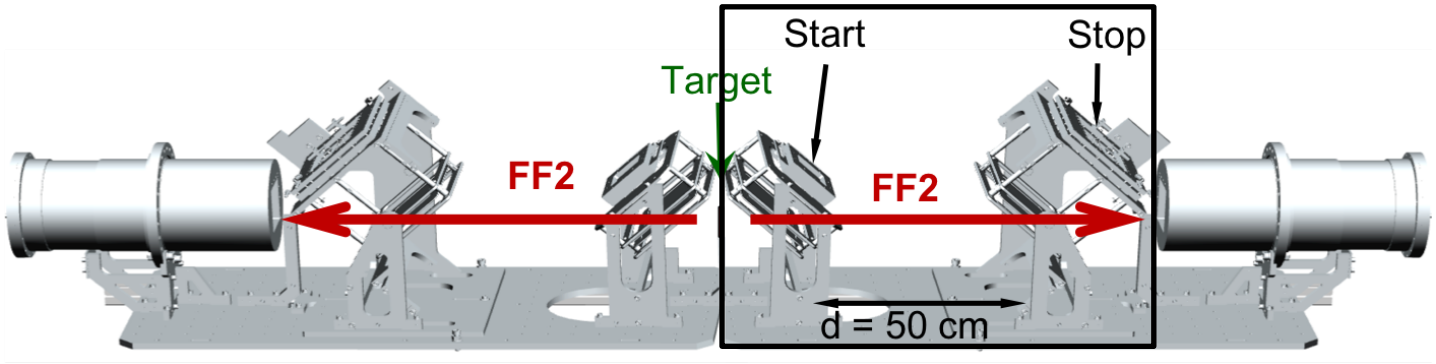

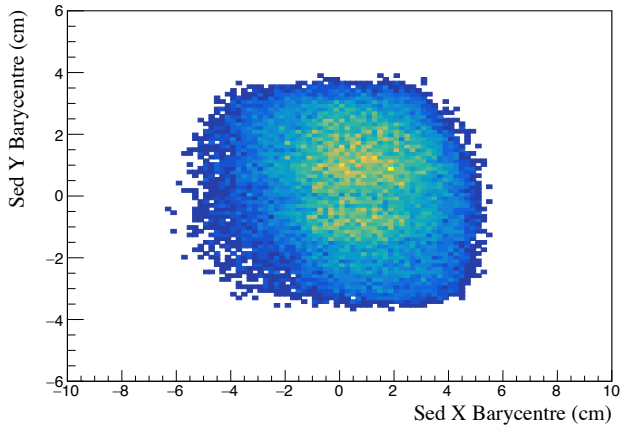

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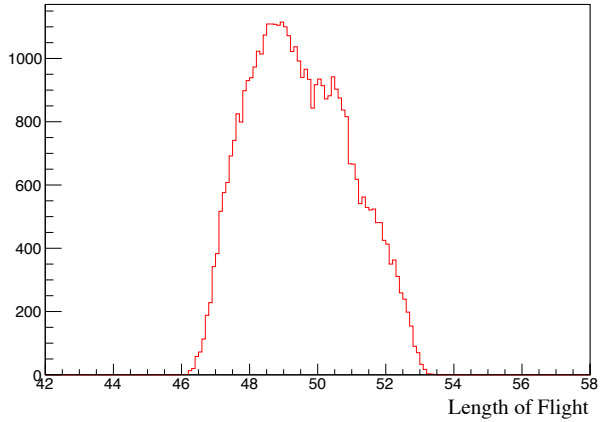

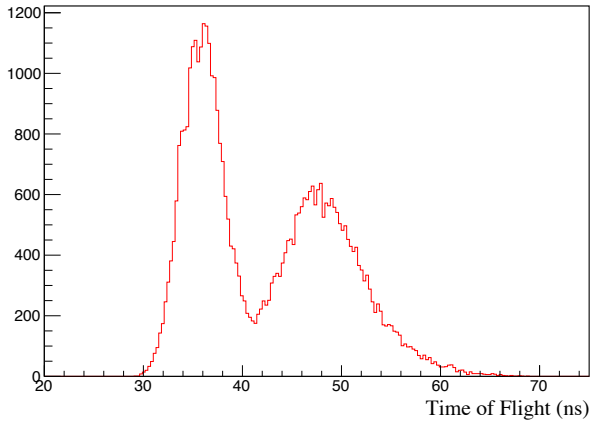

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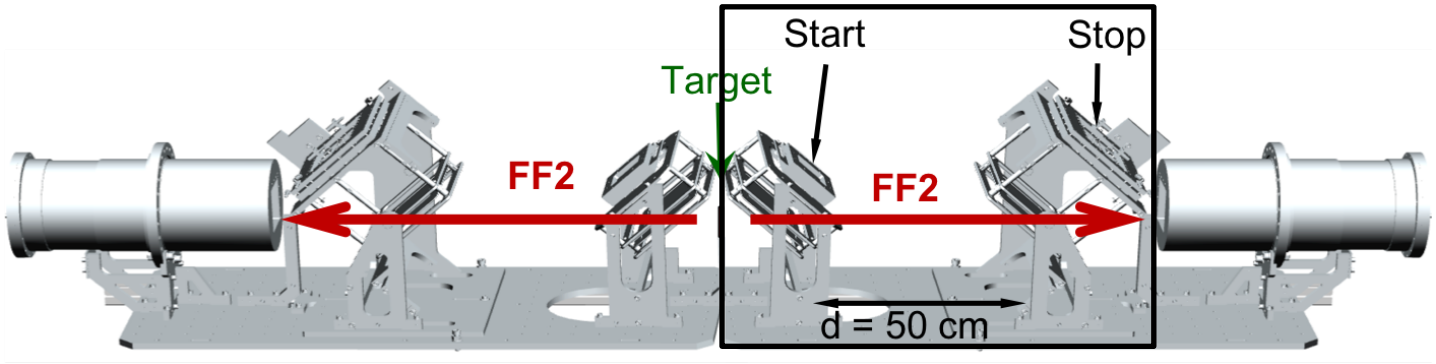

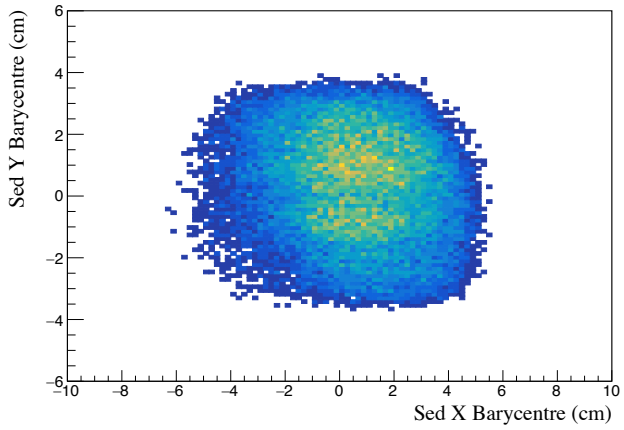

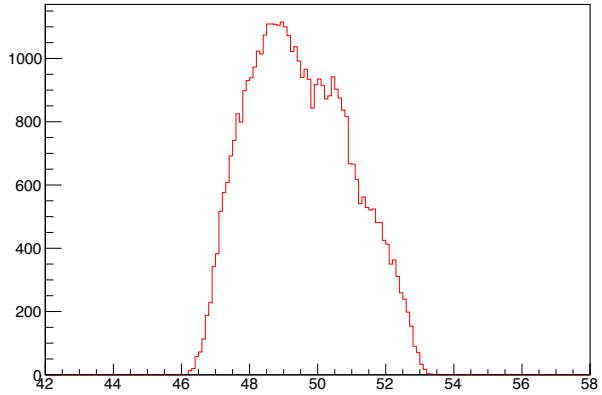

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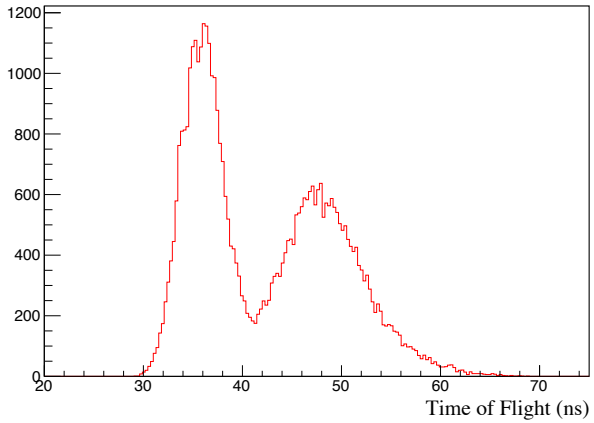

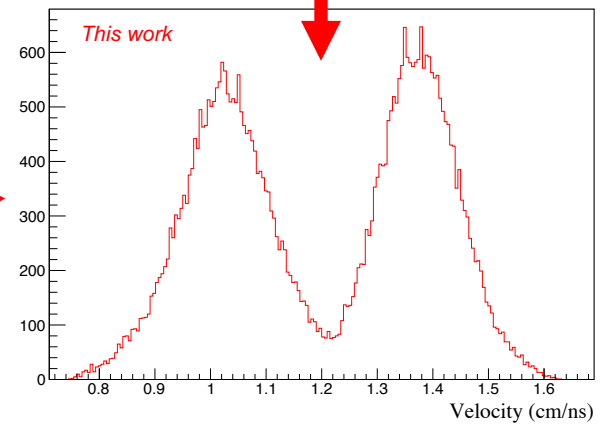

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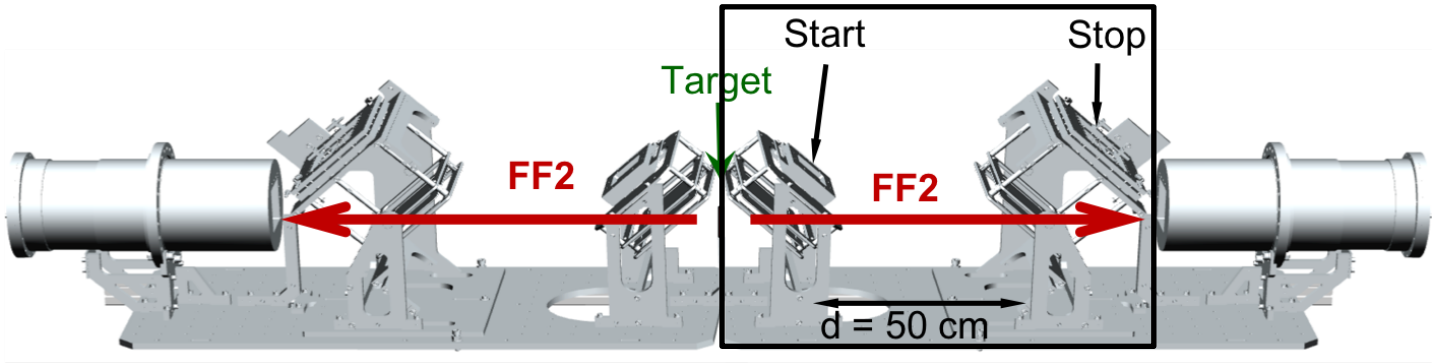
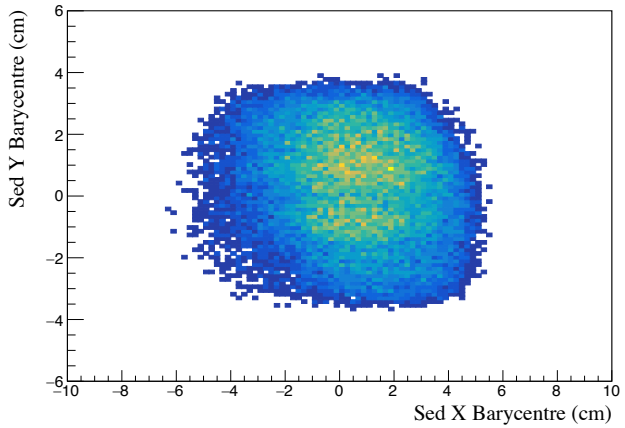
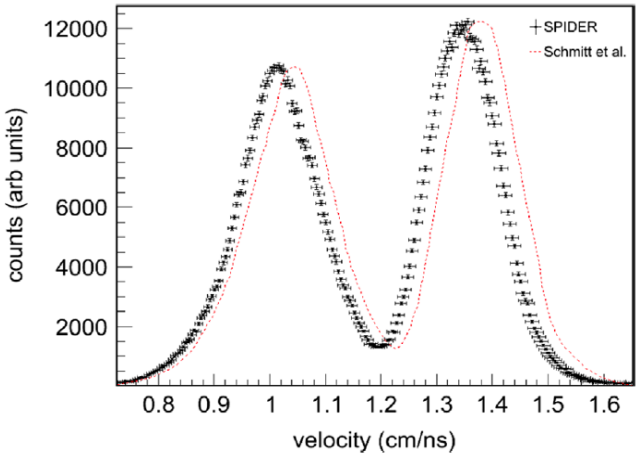
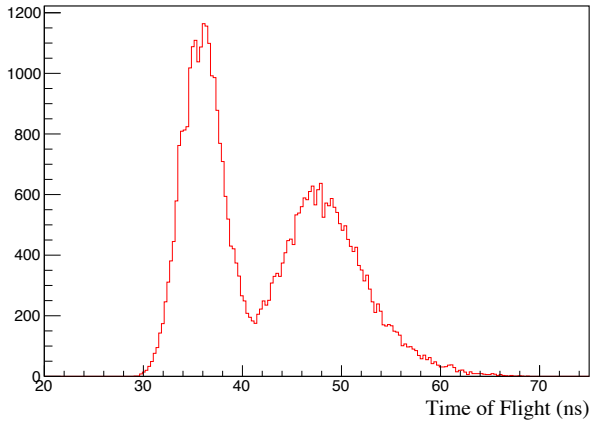
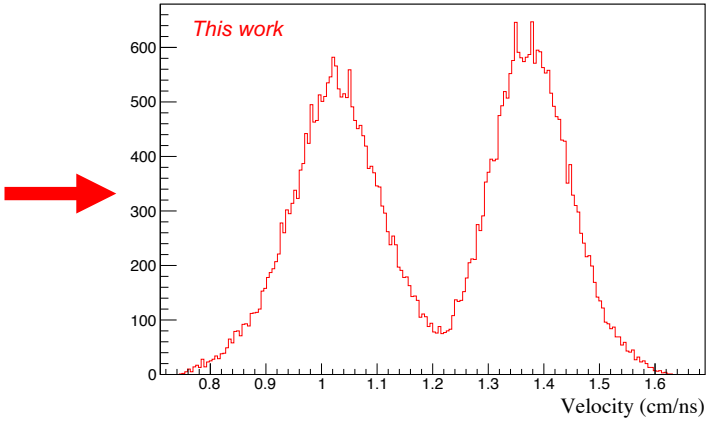


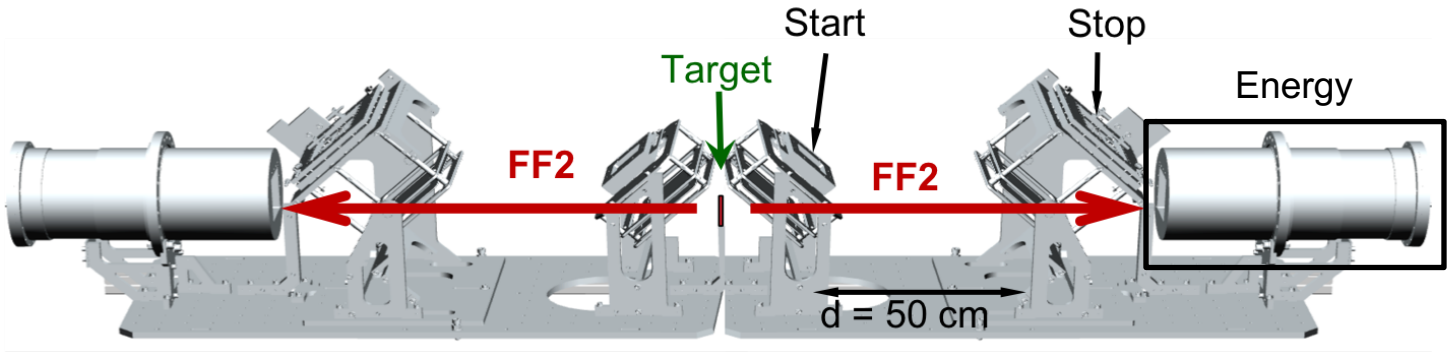


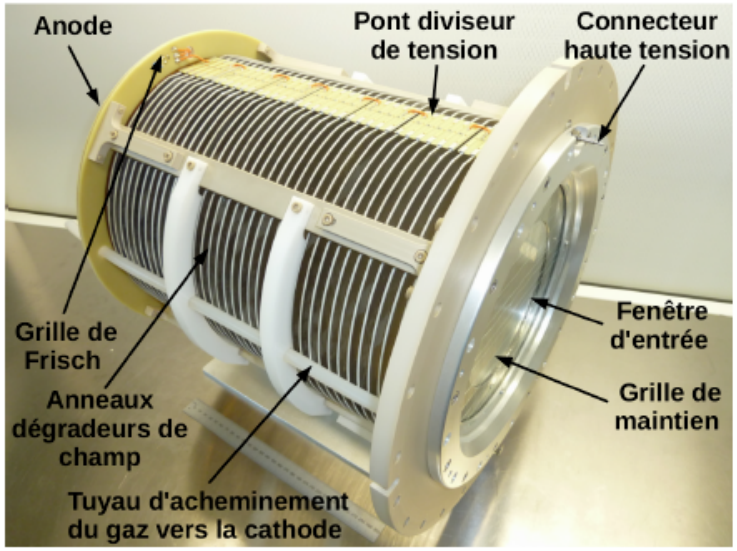


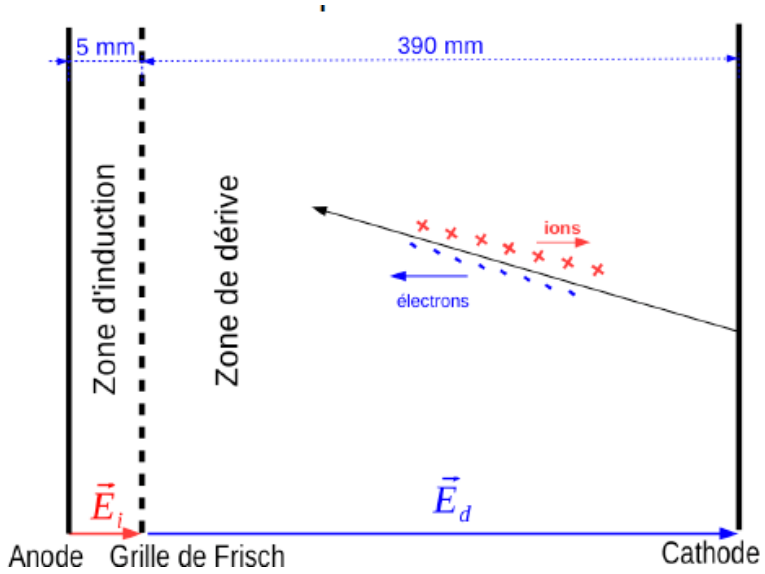




Energy Detector







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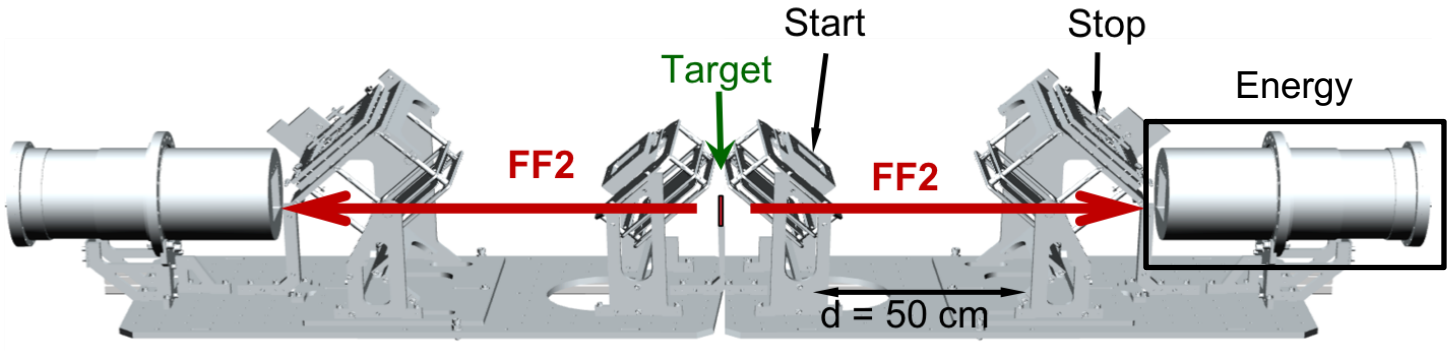
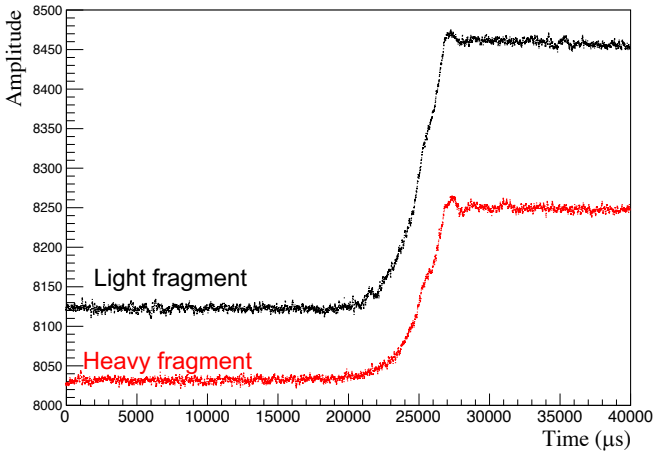


- Digitalization of anode signal
  - Possible to derivate
  - Smoothing methods



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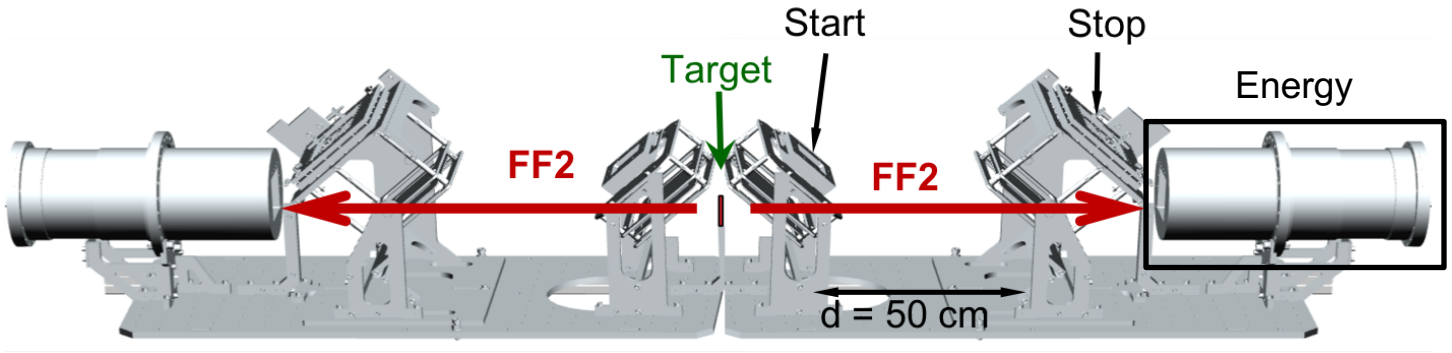

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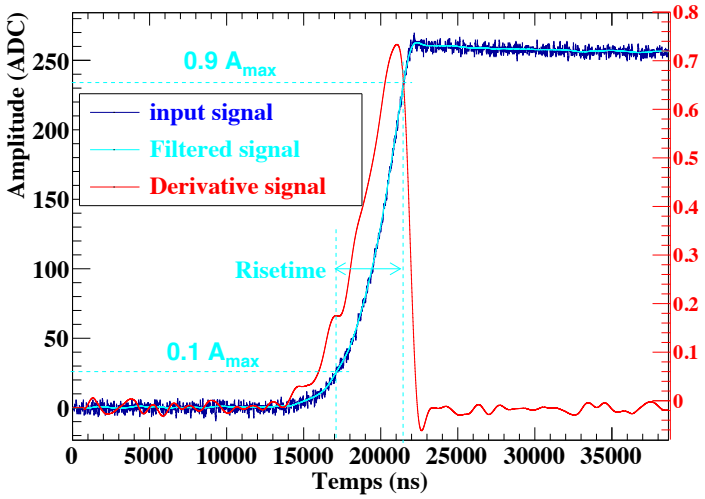

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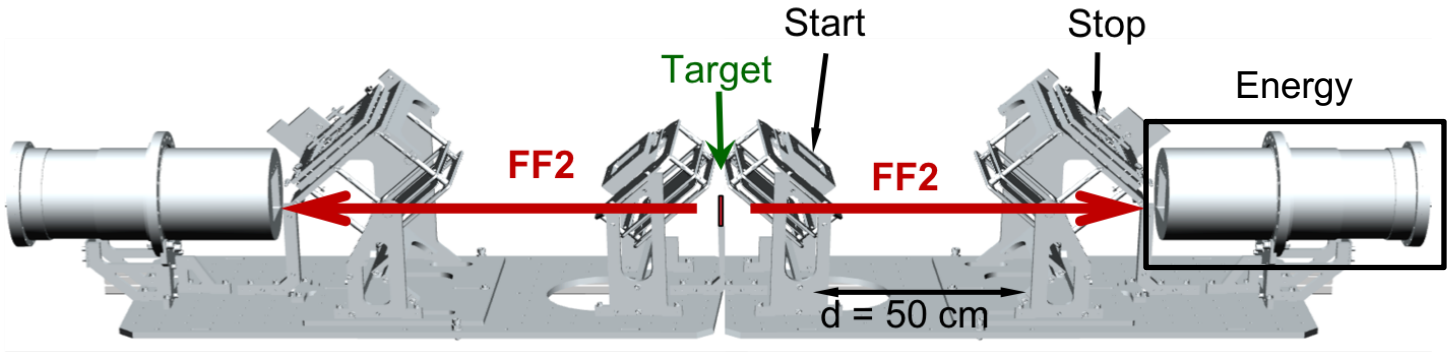

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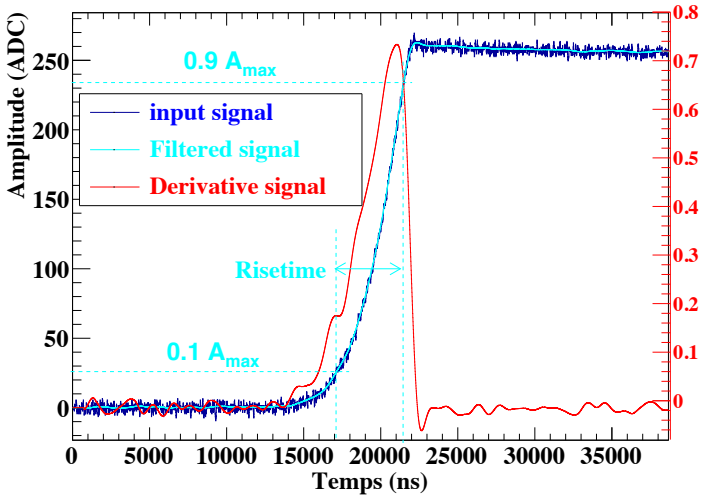
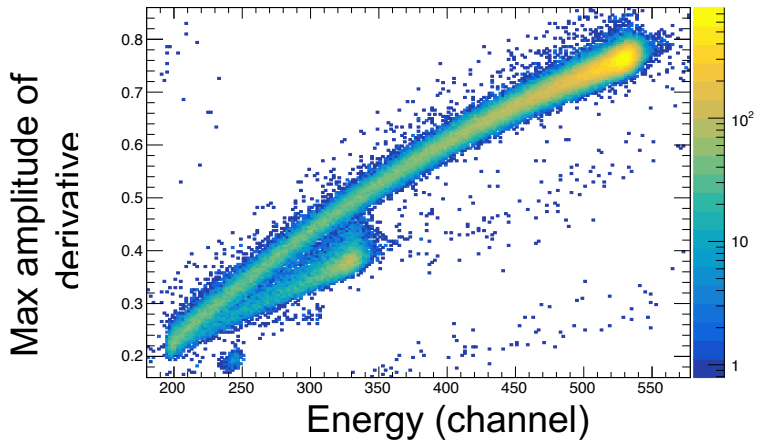


- Calibration experiment at IPNO
  - Energy and energy loss profile studies

- (Br, I) between 60-100 MeV
- Elastic scattering at 30°

E. Berthoumieux & A. Zamel



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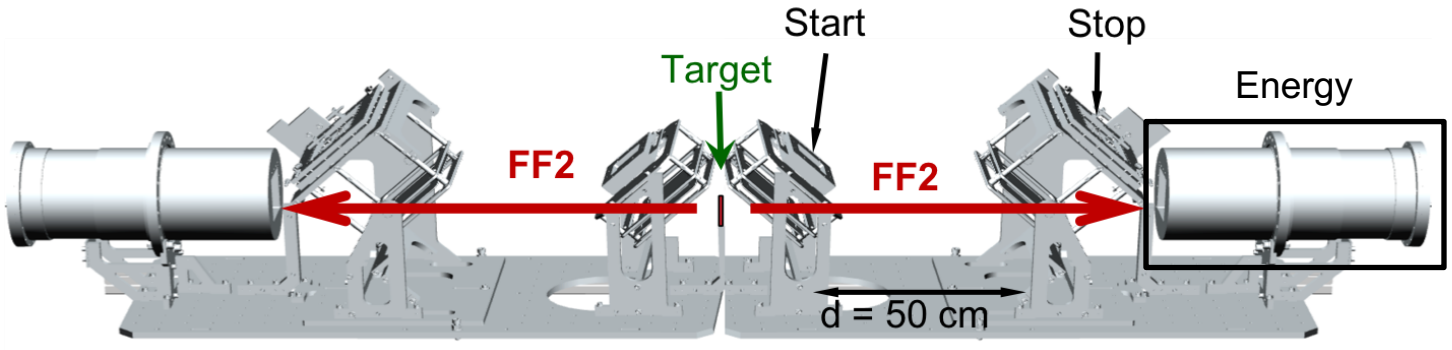
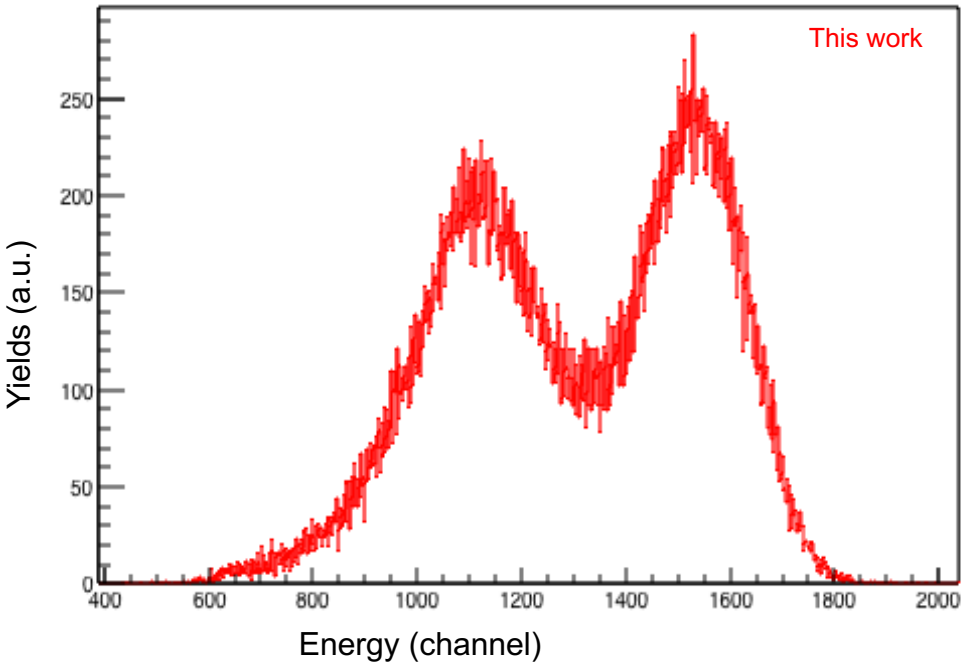
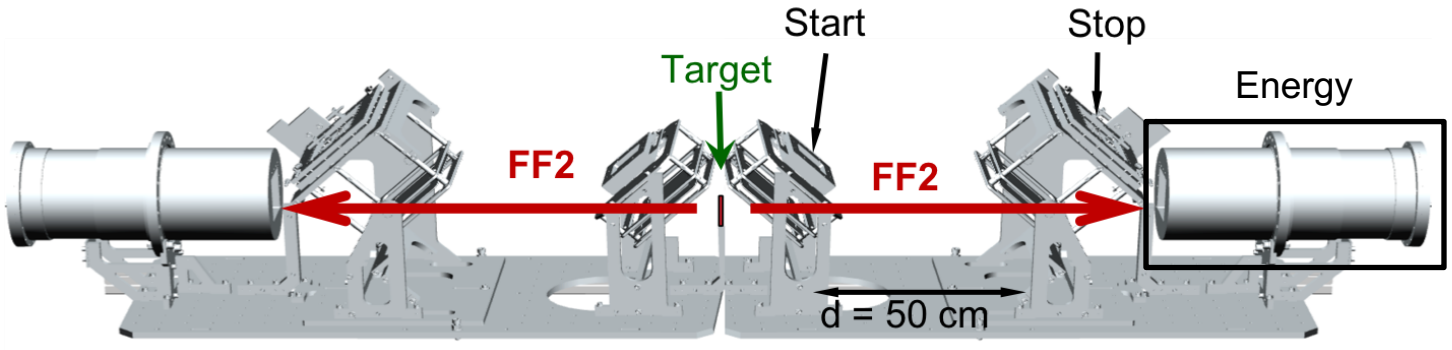


^{252}Cf source



Energy Detector



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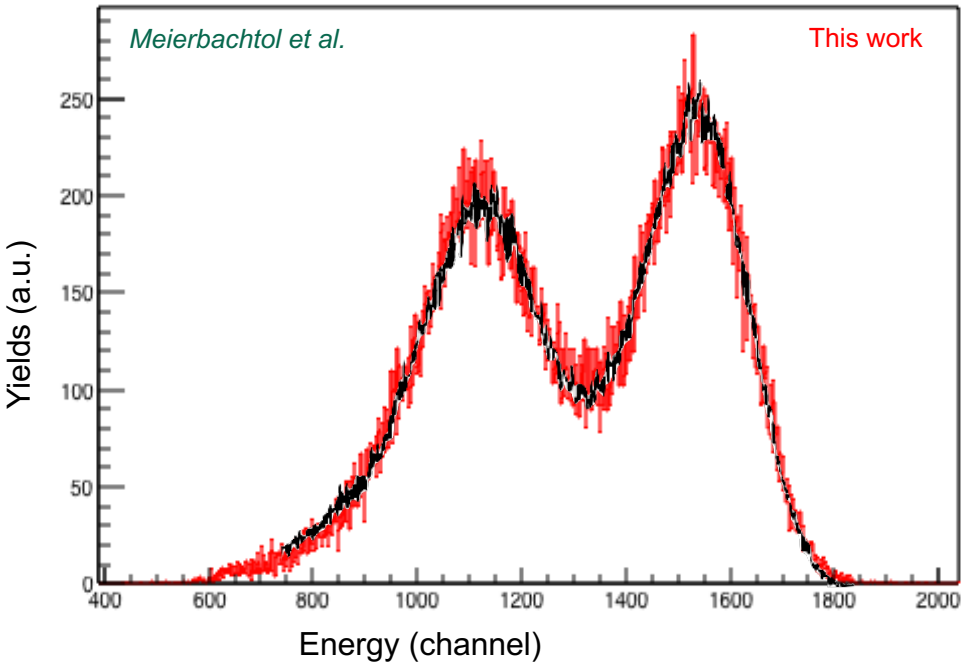
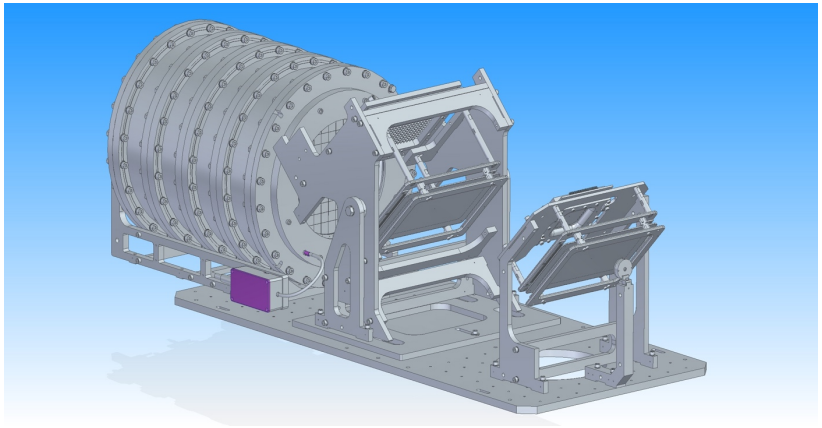
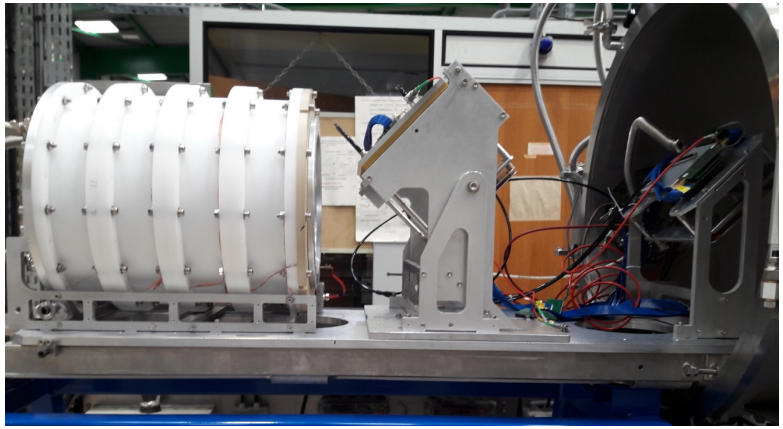


- Good agreement with literature
- Expected resolution

First Arm of FALSTAFF





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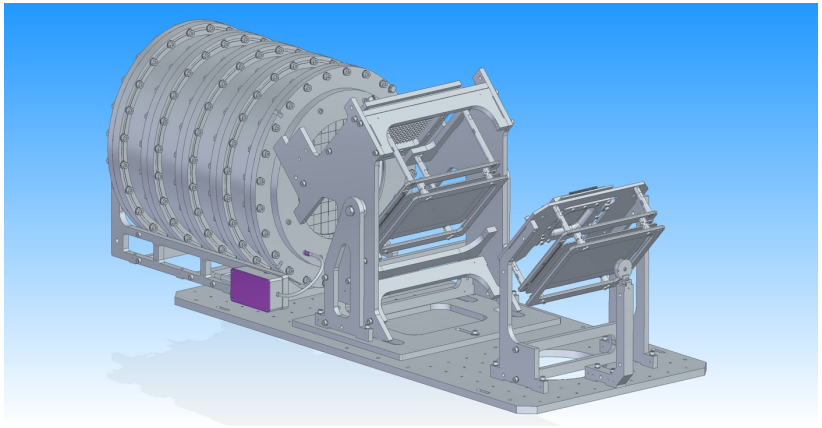
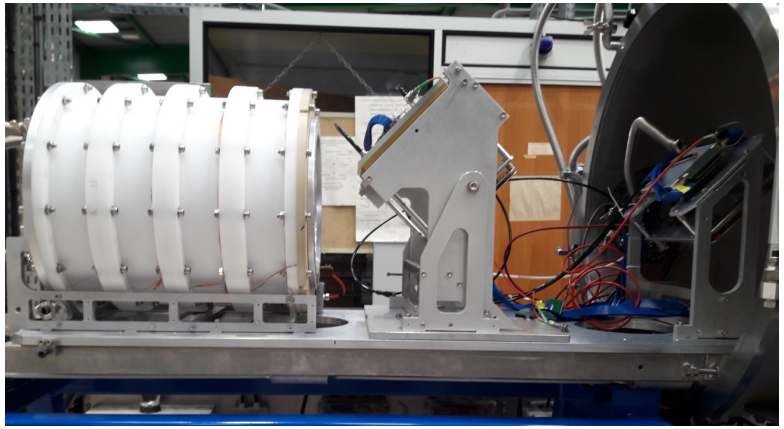
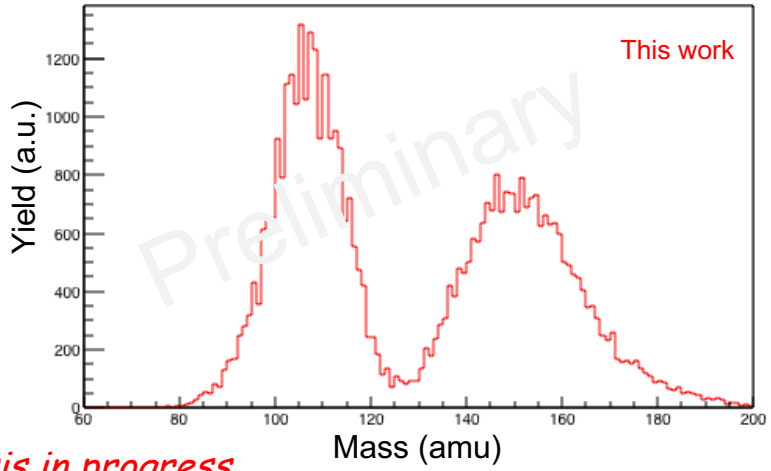




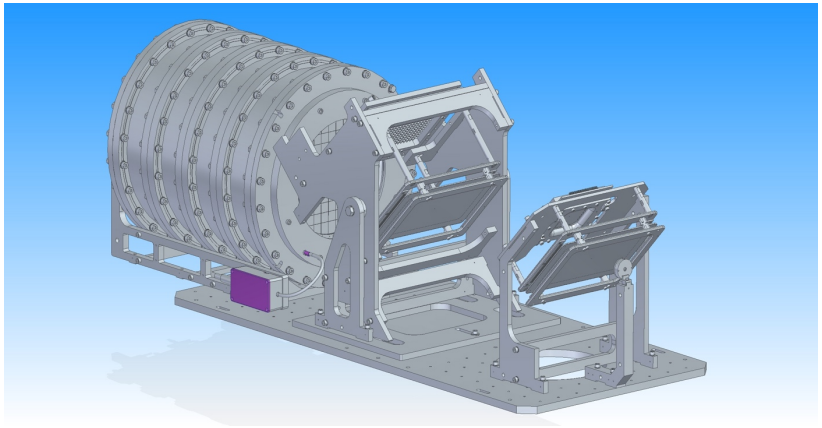
With a ^{252}Cf source …

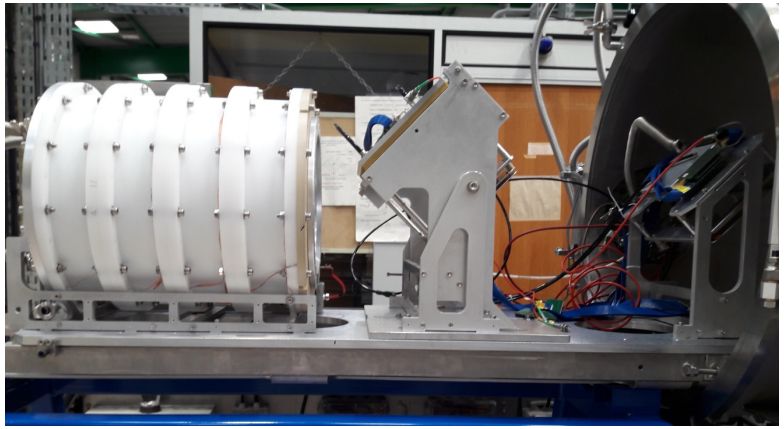
Iterative procedure
Energy loss corrections



Analysis in progress

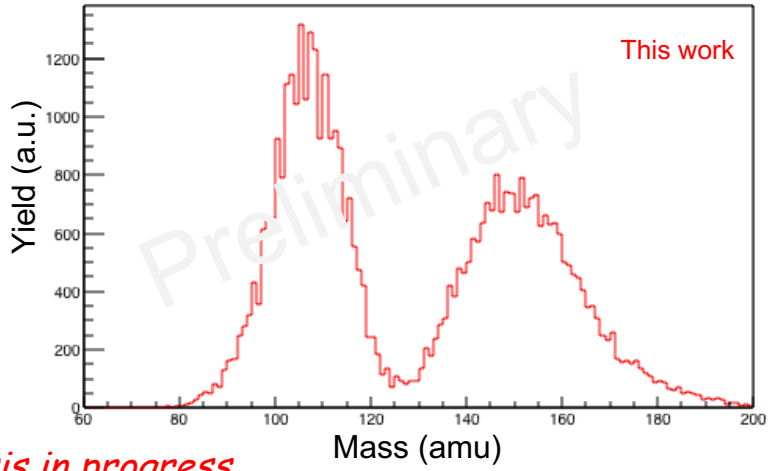
First Arm of FALSTAFF





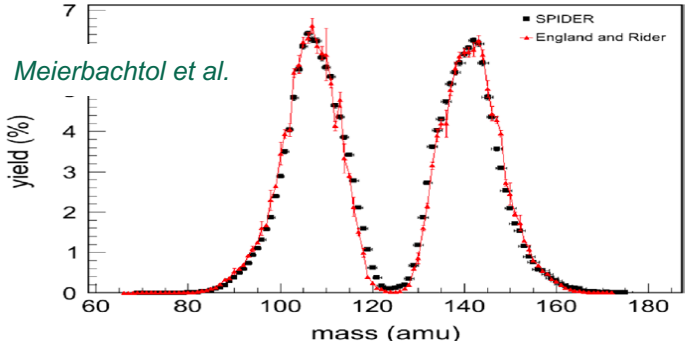
With a ^{252}Cf source …

Iterative procedure
Energy loss corrections

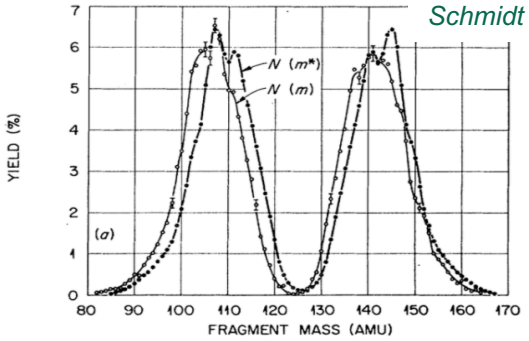


Analysis in progress

Meierbachtol et al.

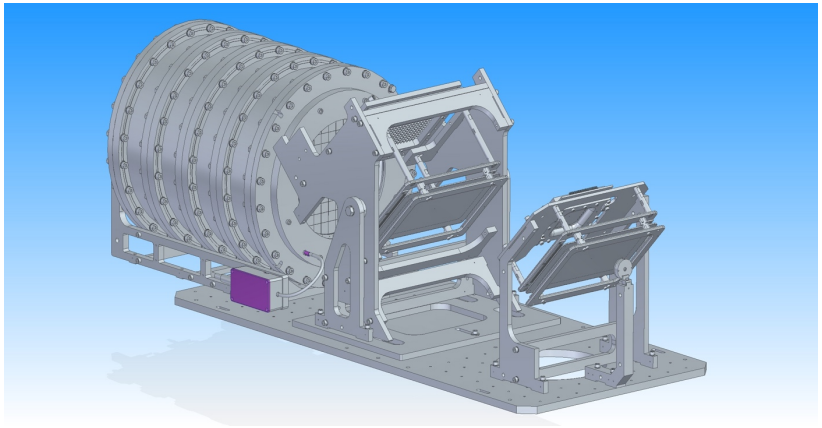


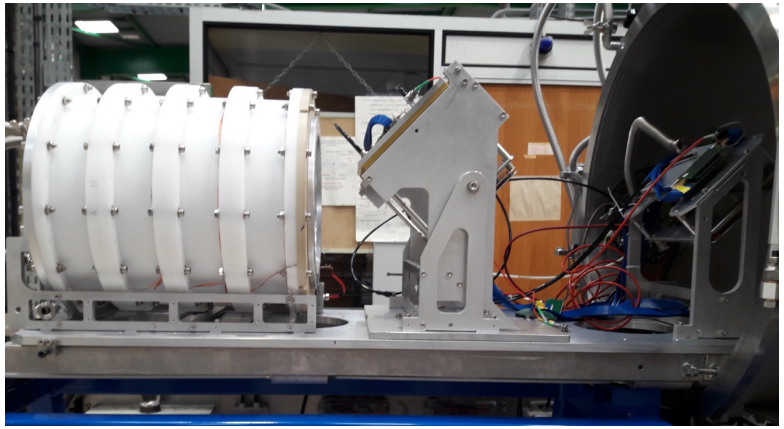
Schmidt et al.



Loss of heavy fragments due to start detector problem

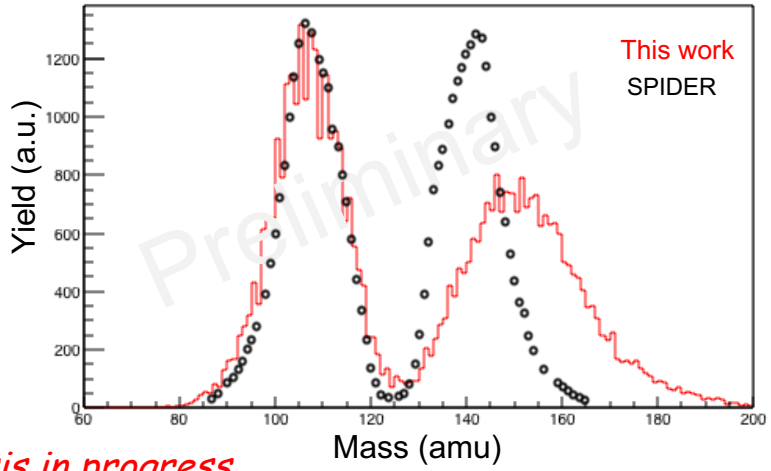
First Arm of FALSTAFF





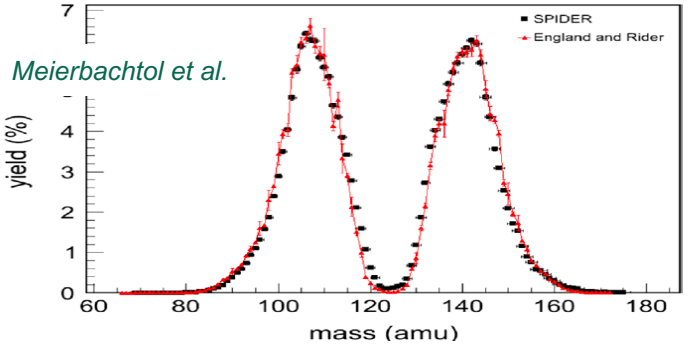
With a ^{252}Cf source …

Iterative procedure
Energy loss corrections



Analysis in progress

Meierbachtol et al.



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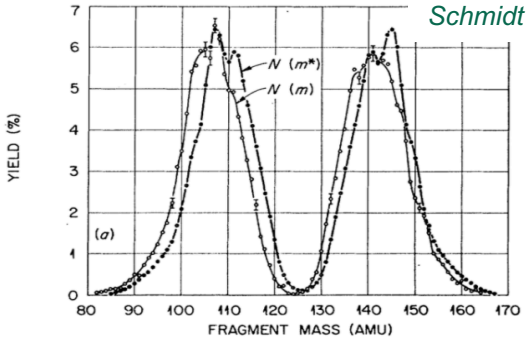
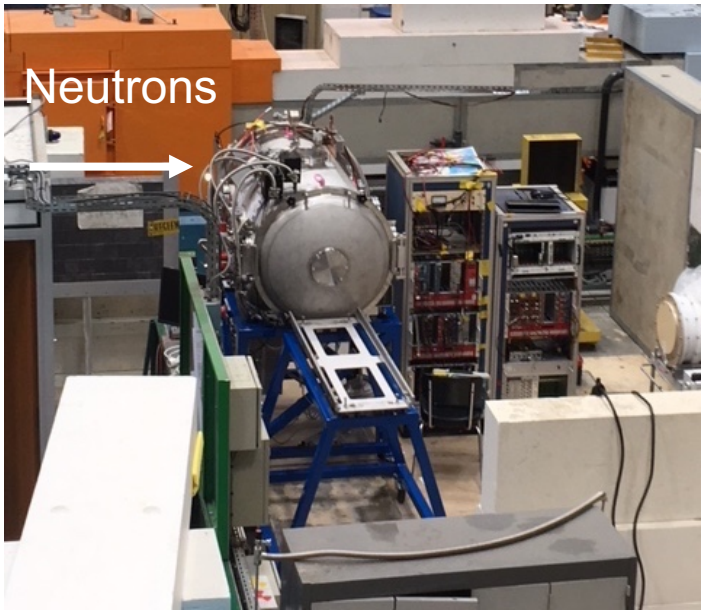


Loss of heavy fragments due to start detector problem

^{235}U results

Experiment at the Orphée reactor (Saclay)

- ✓ Target : ^{235}U (8 & 20 μg, ϕ= 1 cm), CEA/DIF
- ✓ Thermal beam : 10^8 n/cm^2/s
- ✓ Two parts : June 2018, Sept-Oct 2018



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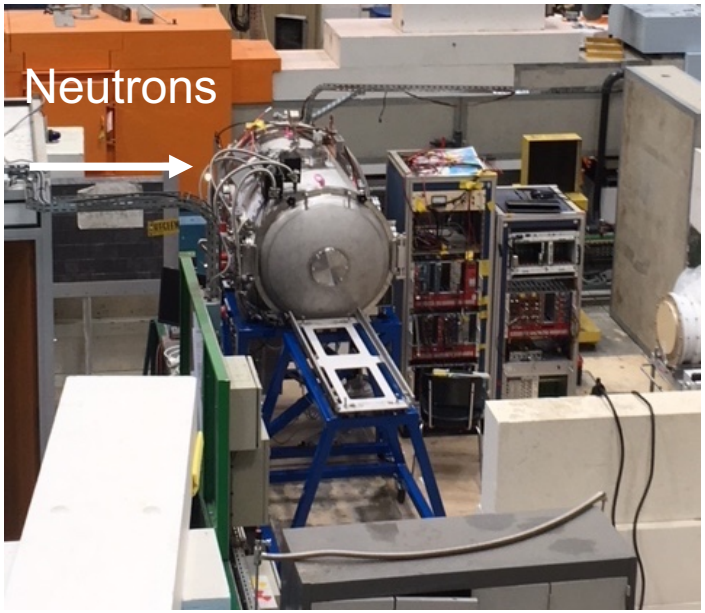
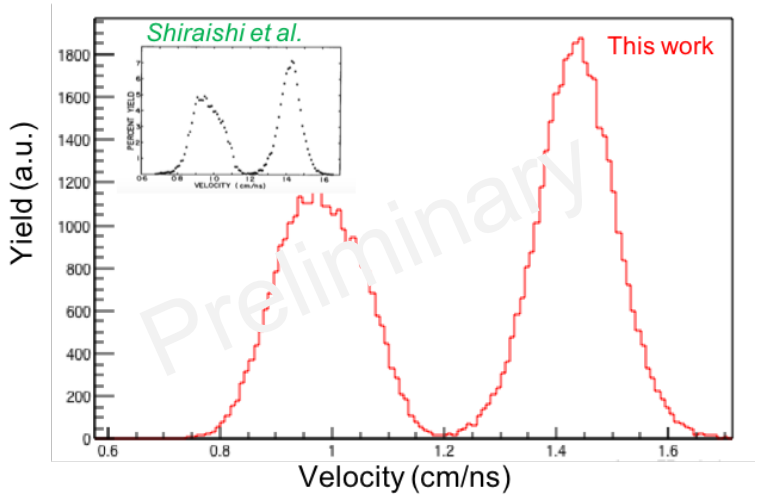


Analysis in progress



^{235}U

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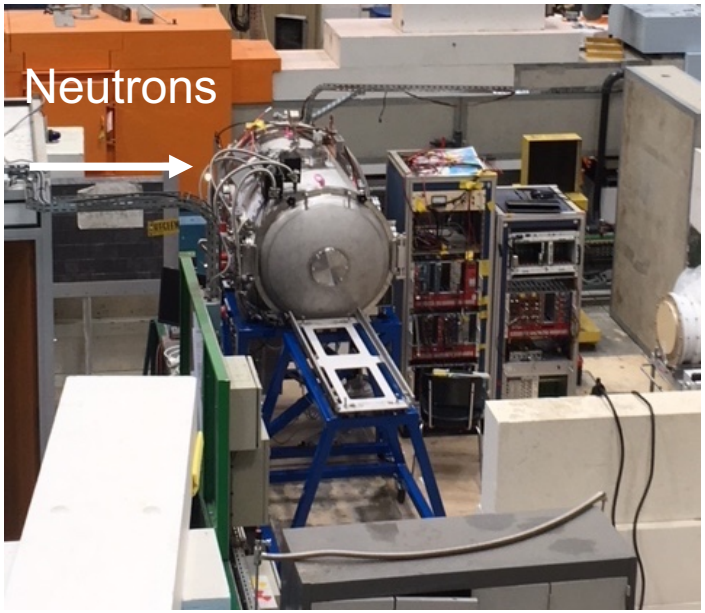
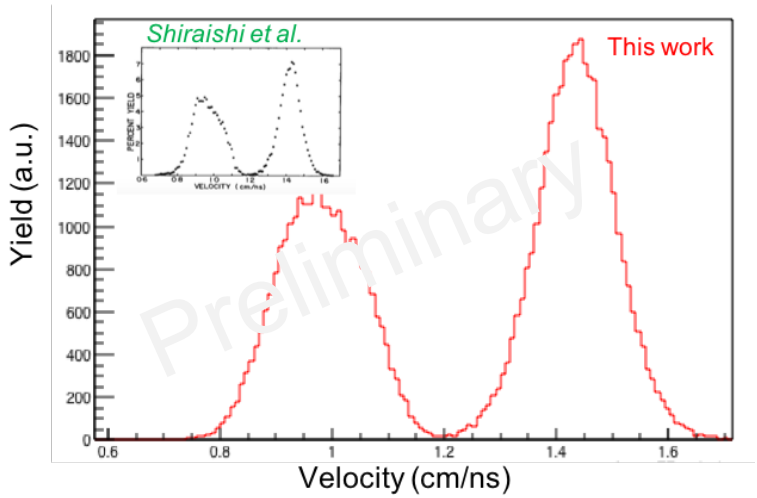
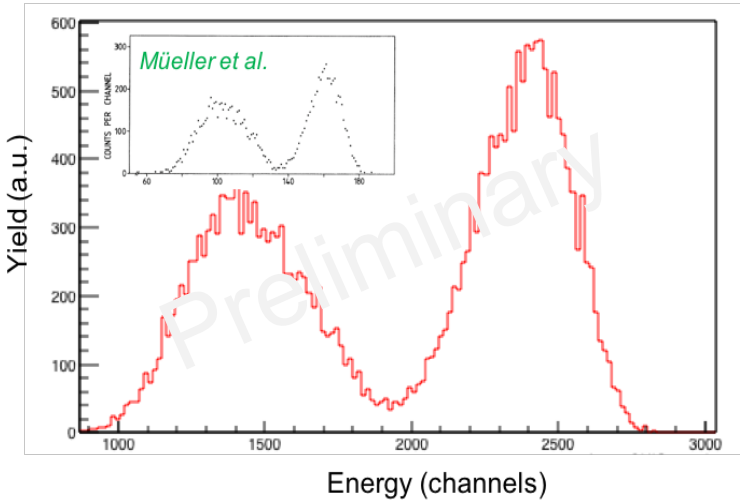


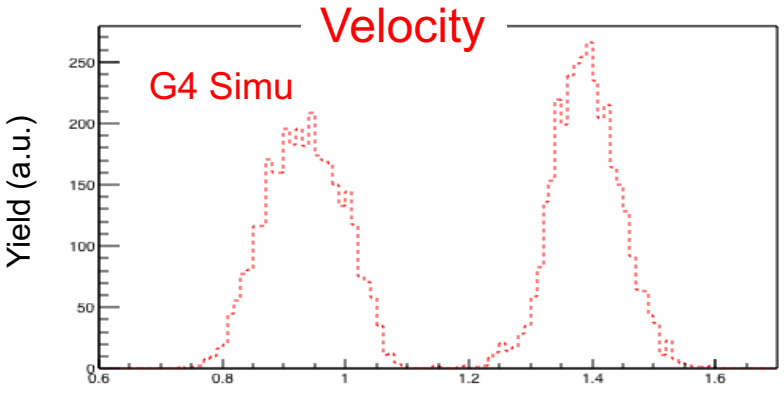
Analysis in progress

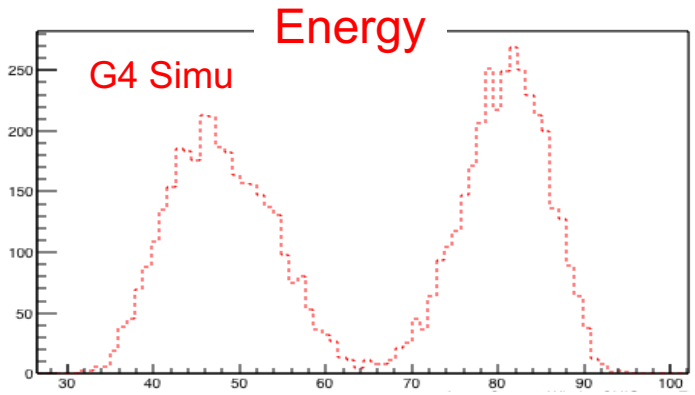


^{235}U



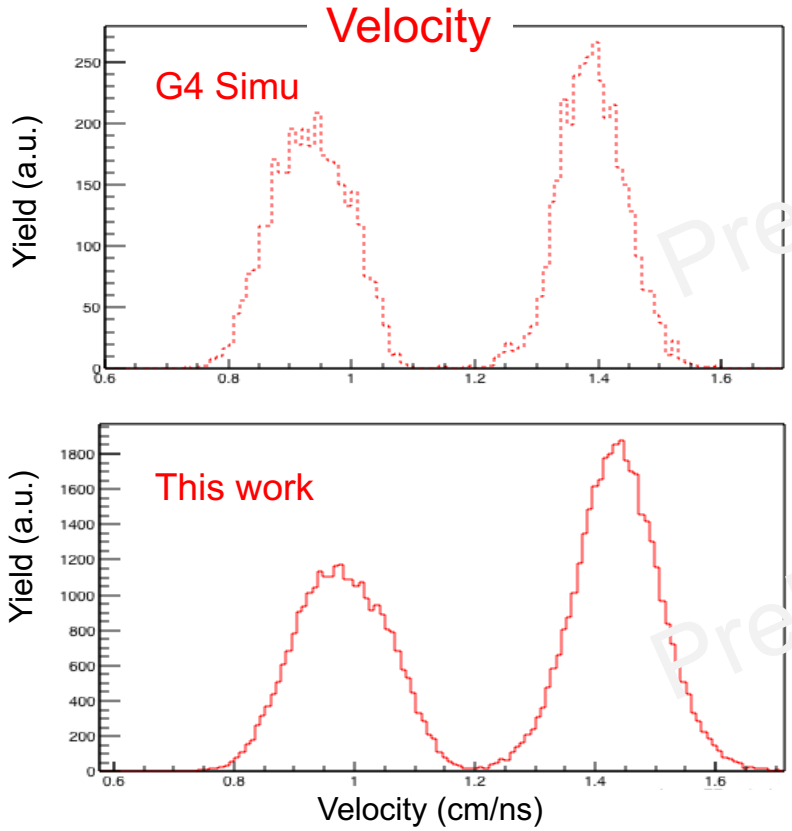
Comparisons Data & G4 Simulations



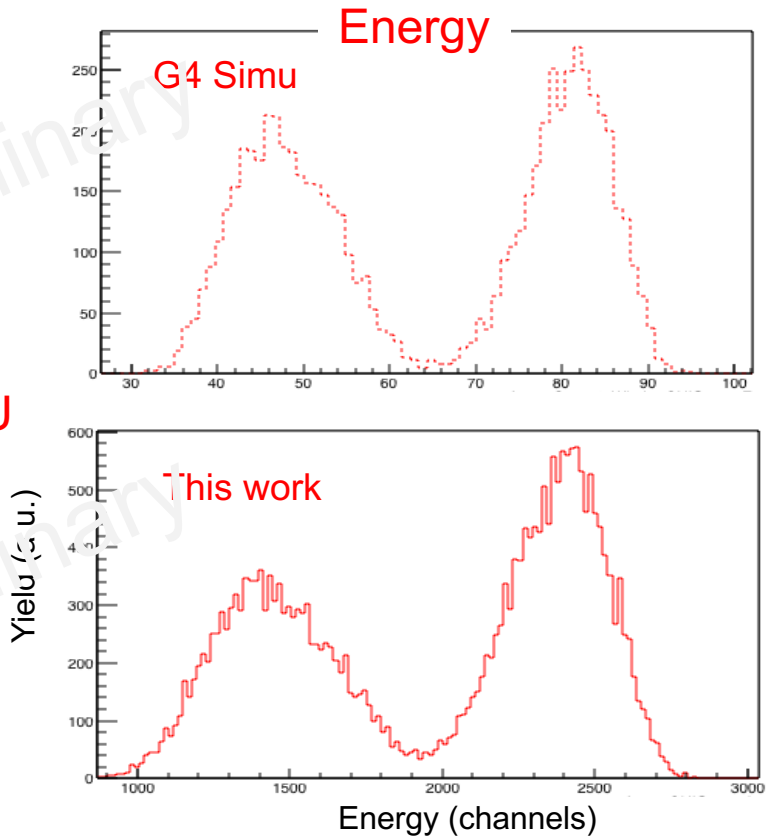


^{235}U

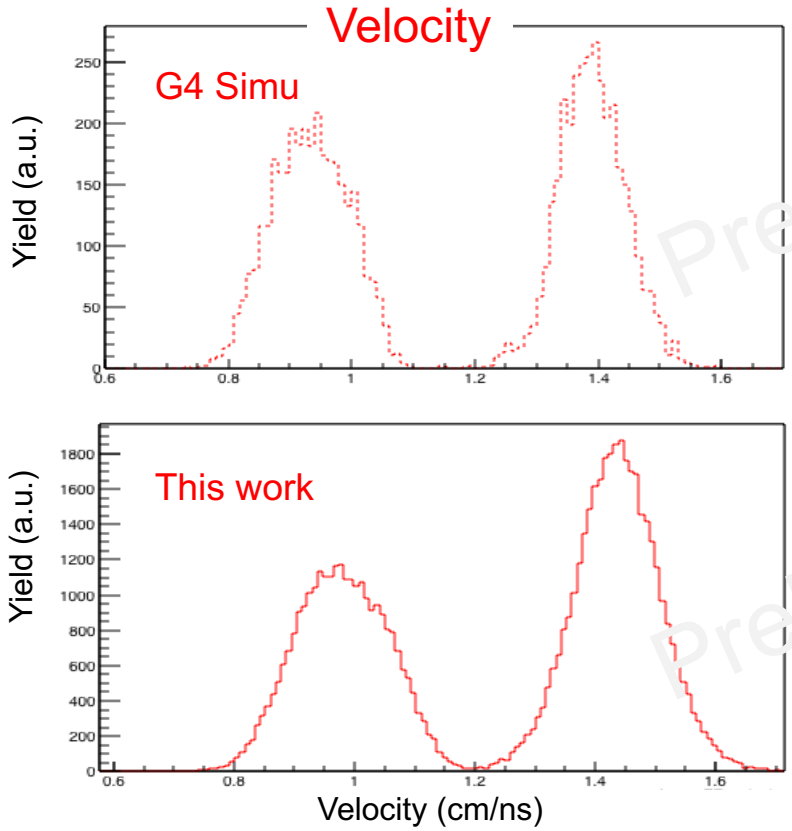
Comparisons Data & G4 Simulations



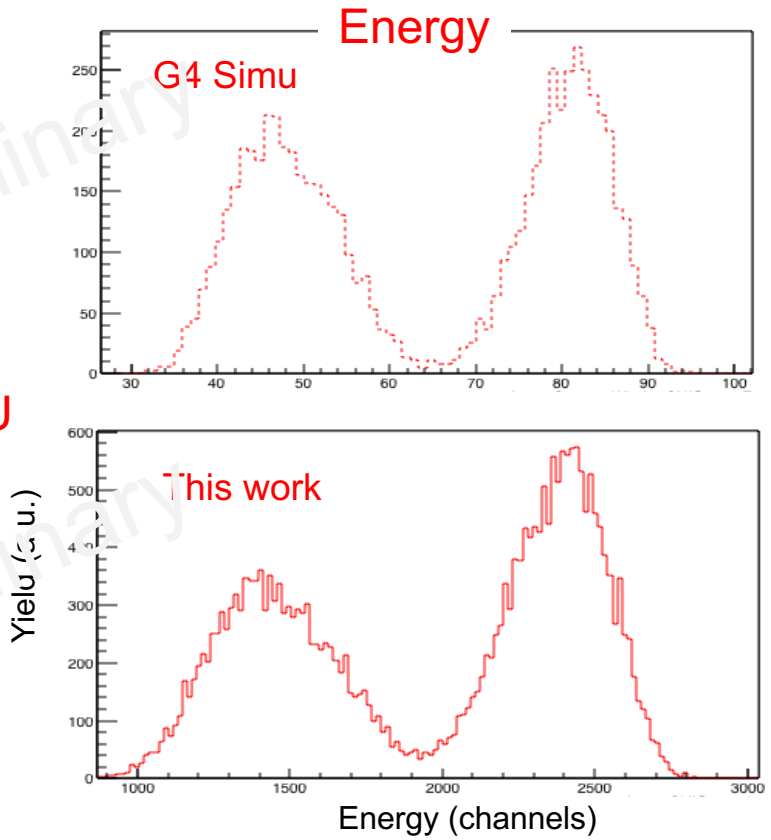
^{235}U



Comparisons Data & G4 Simulations

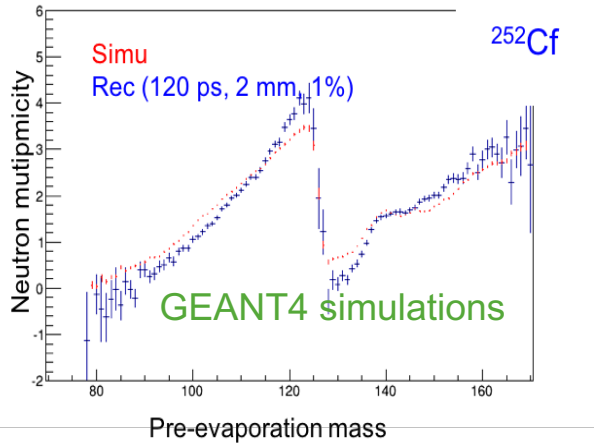


^{235}U

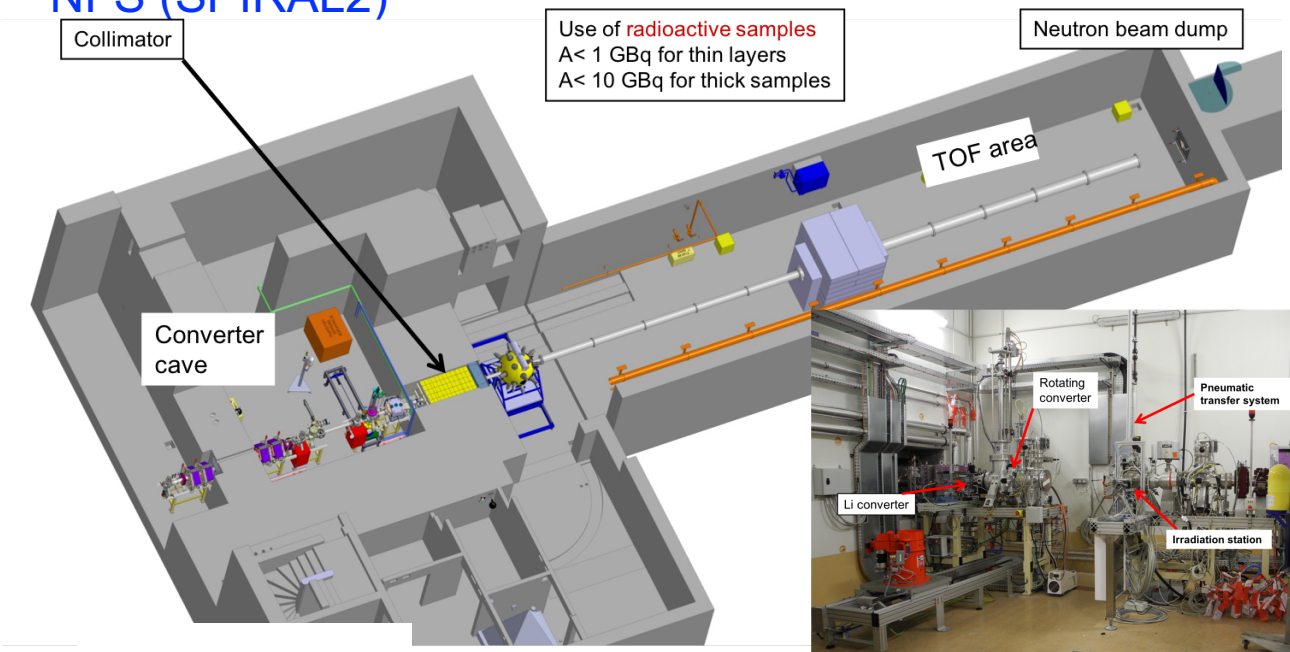


- Rather good agreement
- Inhomogeneities not taken into account
- Other variables to be compared

Exp. resolutions probably suitable for 2-arm studies



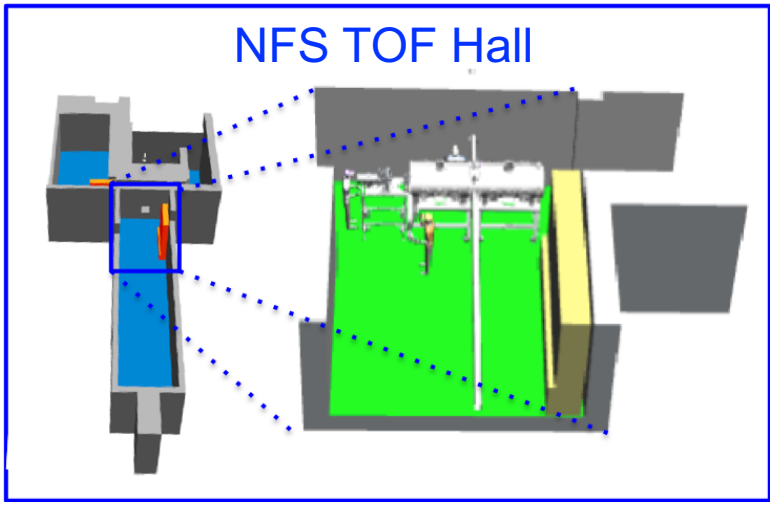
NFS (SPIRAL2)



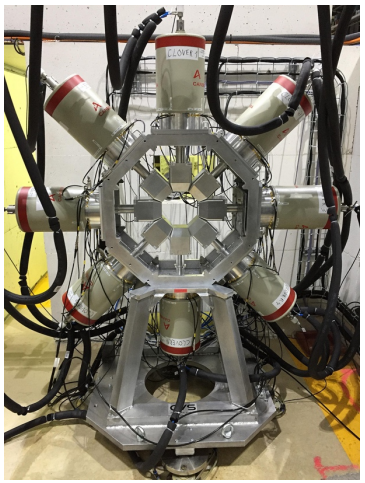
In 2021 : FALSTAFF @ NFS

- 2nd arm to fund and build

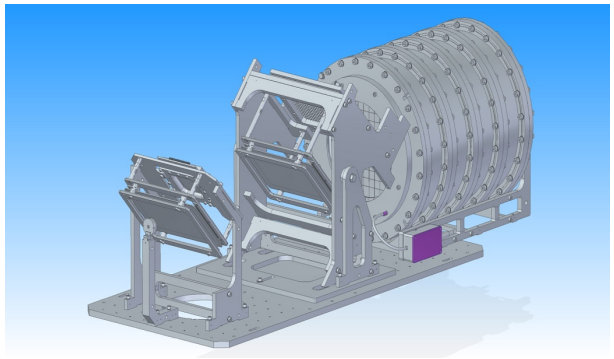
- Mult neut vs fragment mass
- $^{238\text{-}235}U$, ^{239}Pu, ^{232}Th, ^{237}Np



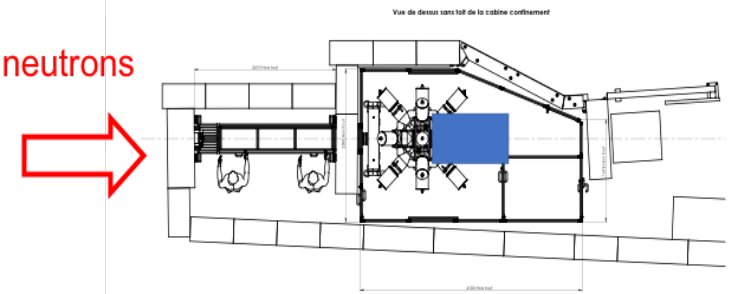
FIPPS



FALSTAFF



neutrons



T. Materna

(γ γ f) measurements

- Nuclear data in thermal fission with the best identification ever
- Calibrate Falstaff with fully identified fission fragments

Method :

- FALSTAFF : E,V of one fragment → filter events with A_1 with $\delta A_1 = 2$
- FIPPS : - identification of one γ-ray transition to the second fragment → (A_2, Z_2)
  - study of other γ-rays from the cascade in the second fragment

→ Study of FF de-excitation and measurement of the fission yields

Summary

- First arm of FALSTAFF is running with source AND neutron beam
- Expected resolutions seem to be reached

  - ✓ Very promising results with the first arm of FALSTAFF
  - ✓ Room for improvement

- Expecting the funding of the second arm
- Preparation of the experiment at FIPPS

Open to new collaborations !

Performance validation of the FALSTAFF first arm:

^{252}Cf and ^{235}U fission fragment characterisation

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1) Irfu, CEA, Université Paris-Saclay, France
2) GANIL, Caen, France
3) European Commission, Joint Research Centre, Geel, Belgium

Thanks to:

- DEDIP: P. Legou, M. Combet, M. Kebbiri, A. Marcel, J-P. Mols
- DPhN : P. Champion
- Irfu : E. Blanchard
- DPN/CEA-DIF : A. Chatillon, G. Bélier, V. Méot
- Orphée Team