# STUDY OF NEUTRON INDUCED FISSION OF $^{237}$Np WITH FALSTAFF AT NFS

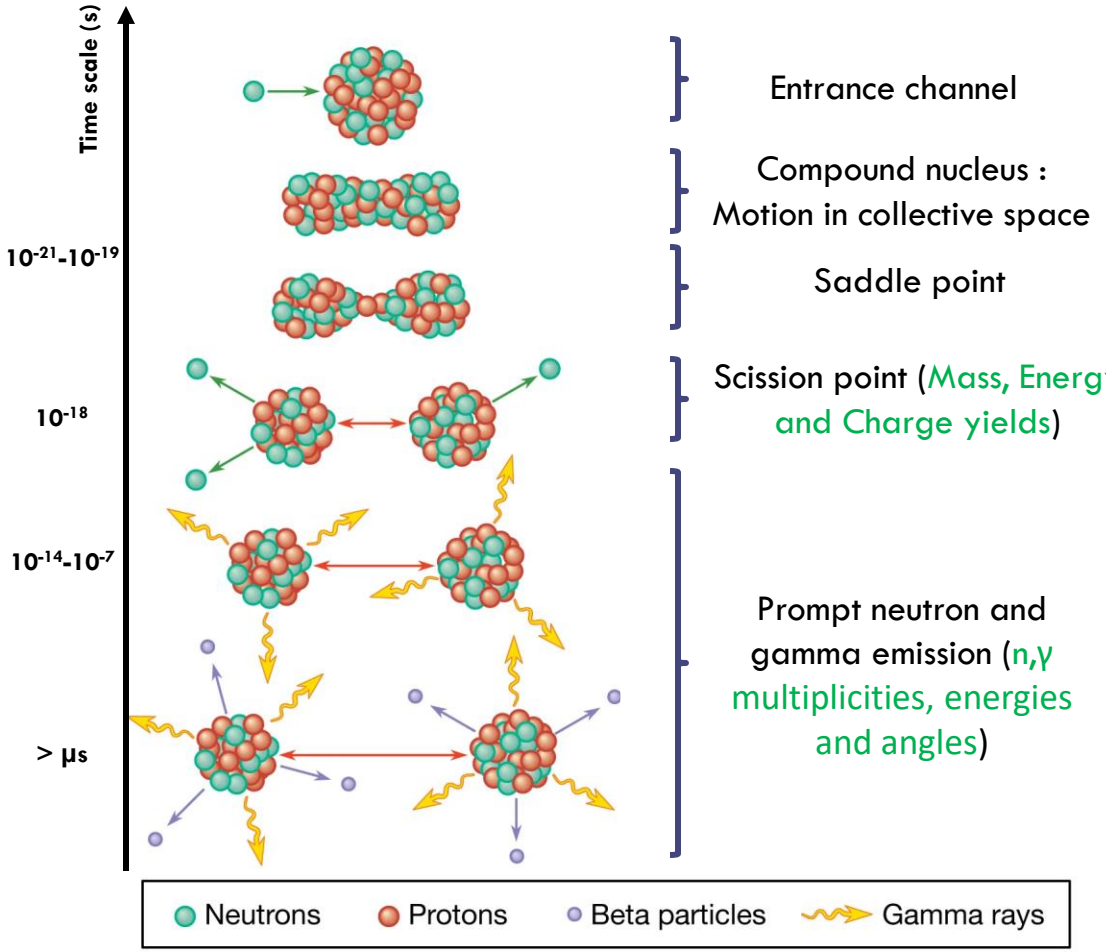
FIESTA24, 20-11-2024

**Deby Treasa KATTIKAT MELCOM**

# OVERVIEW

- Introduction & Motivation
- FALSTAFF Setup
- E878 Measurement @ NFS
- Preliminary Results
- Conclusions and future perspectives

# INTRODUCTION

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- Viewed as → Nuclear shape evolution

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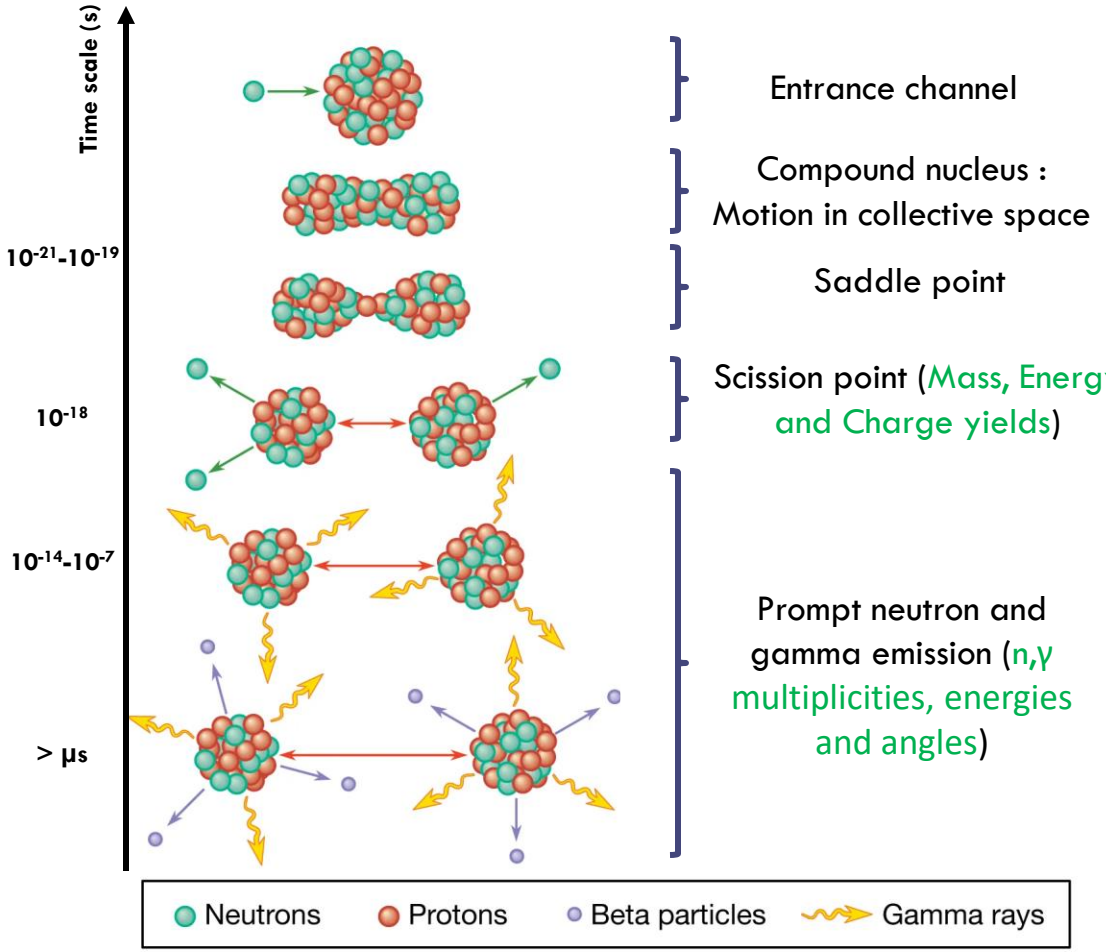


- Dynamic Process
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❖ Mass and charge of FF
Path : deformation potential, Structure → Evolution with E*

❖ Kinetic Energy
Inter fragment distance, Nuclei deformation

❖ Neutron emission from FF
E* sharing between fission fragments

❖ Gamma emission from FF
Angular momentum

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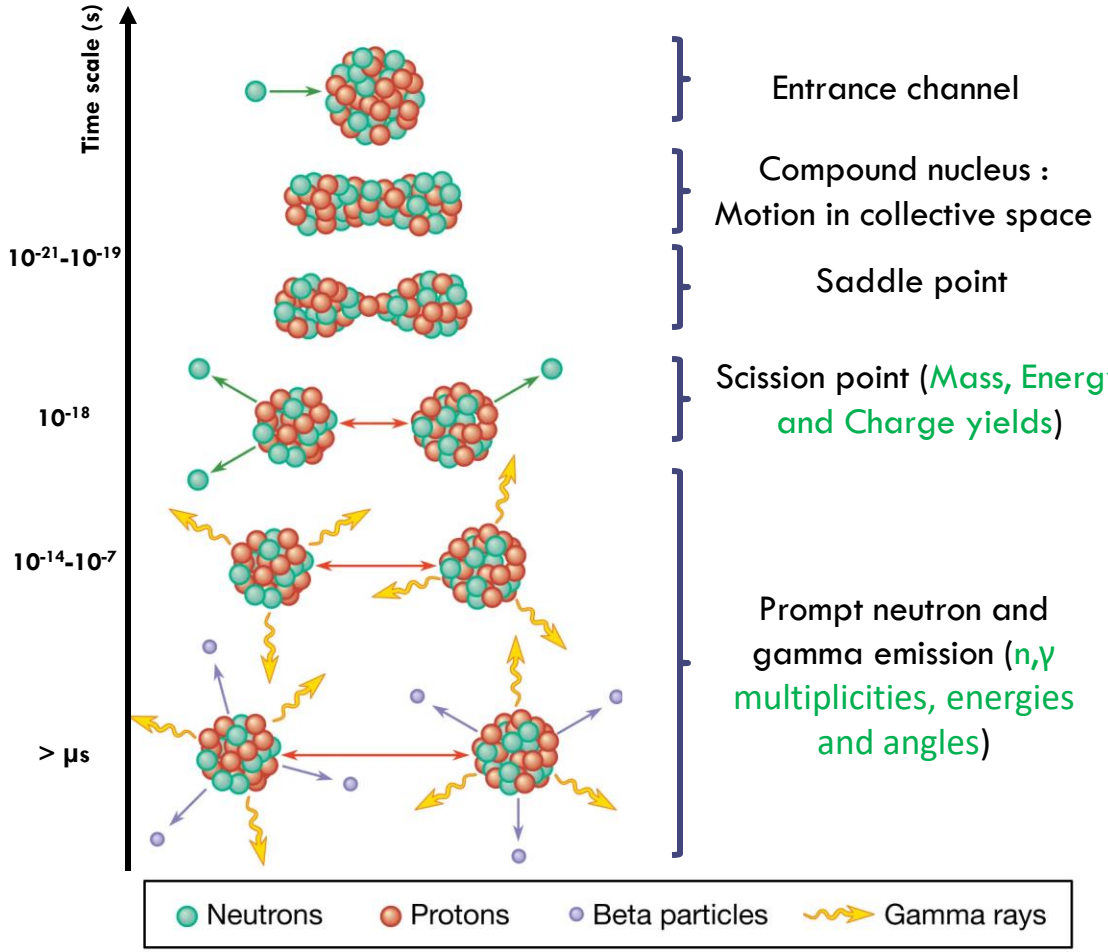


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Interest for applications : Reactor design and lifetime, Waste management, Energy release per fission, Radioprotection, …

# MOTIVATION

- Neutron multiplicity and fission yields:

  - important for reactor simulations

  - needed for model developed for data evaluation (libraries)

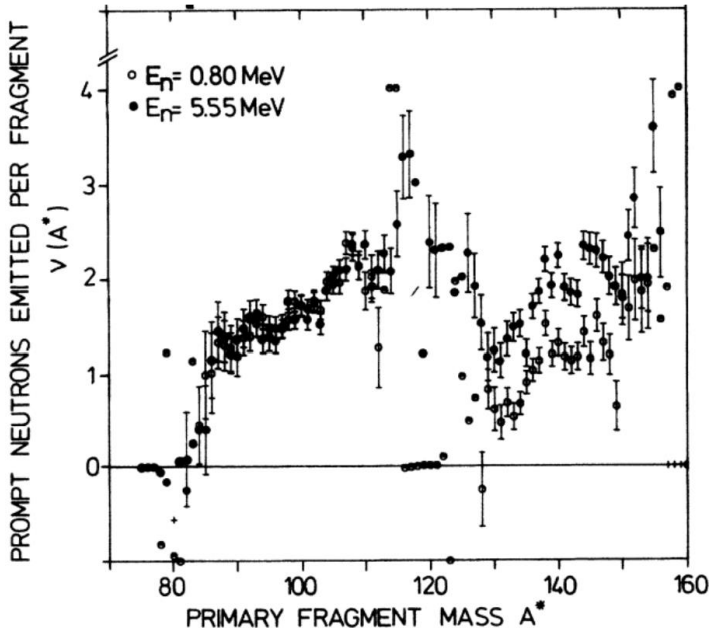
- For the development of phenomenological models (Fifrelin, Freya, GEF …)

  Experimental data :

  - Evolution with E*

  - Improve theoretical models

- Many data in thermal domain, but very few data in the fast energy domain for neutron induced fission of $^{237}$Np.




Naqvi *et.al*, Phys Rev C, 34, 218 *(1986)*

# FALSTAFF SETUP

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  - Actinide targets
  - Direct kinematics
- Fission fragment production as a function of excitation energy

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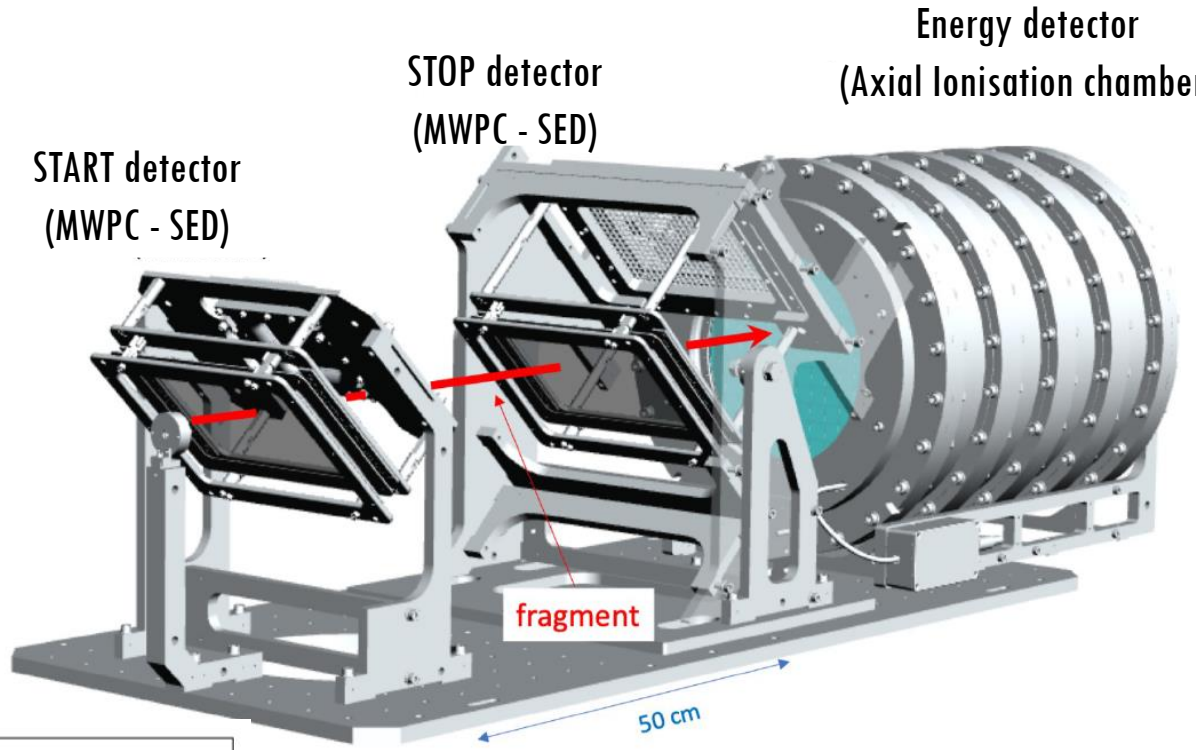
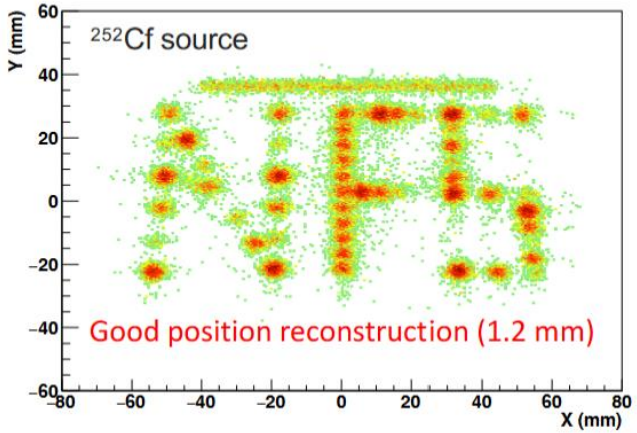
- Pair of Secondary Electron Detectors (Emissive foil + MWPC) for
  - Time of flight (σ(t) = 120 ps)
  - Position (σ(X,Y) = 1.2 mm)
- Axial ionisation chamber
  - Energy (σ(E)/E ~ 1%)



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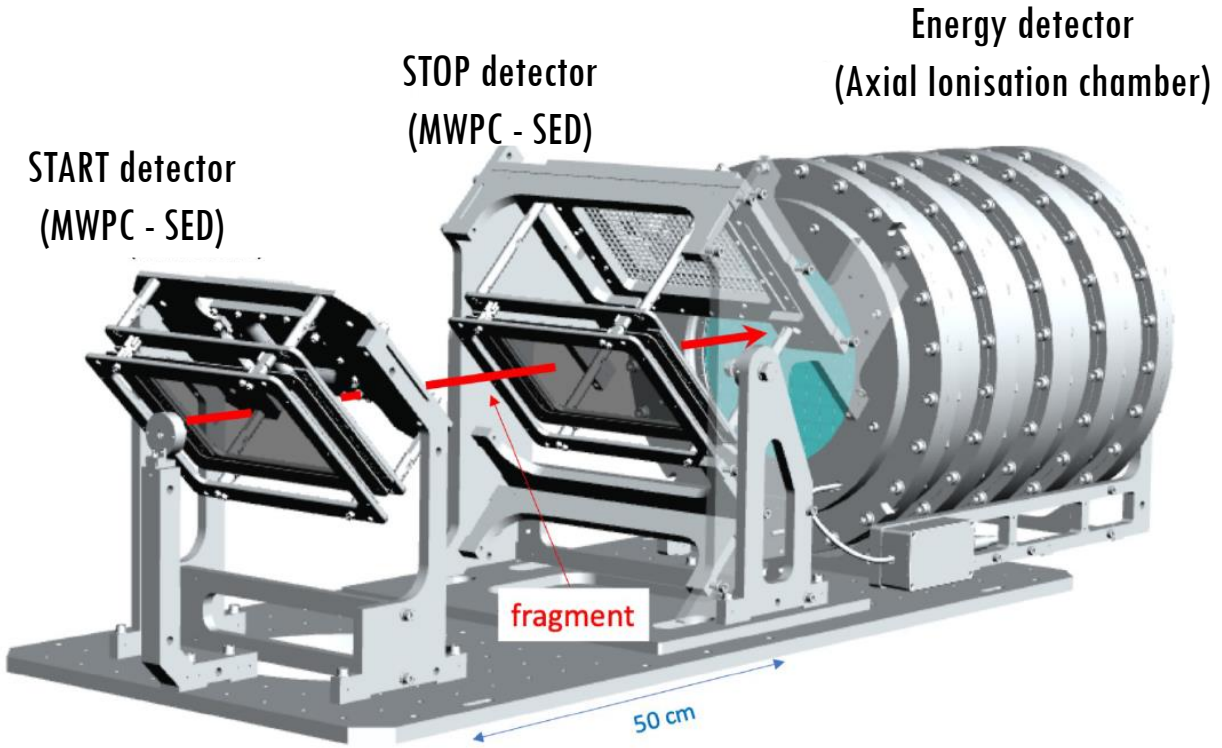
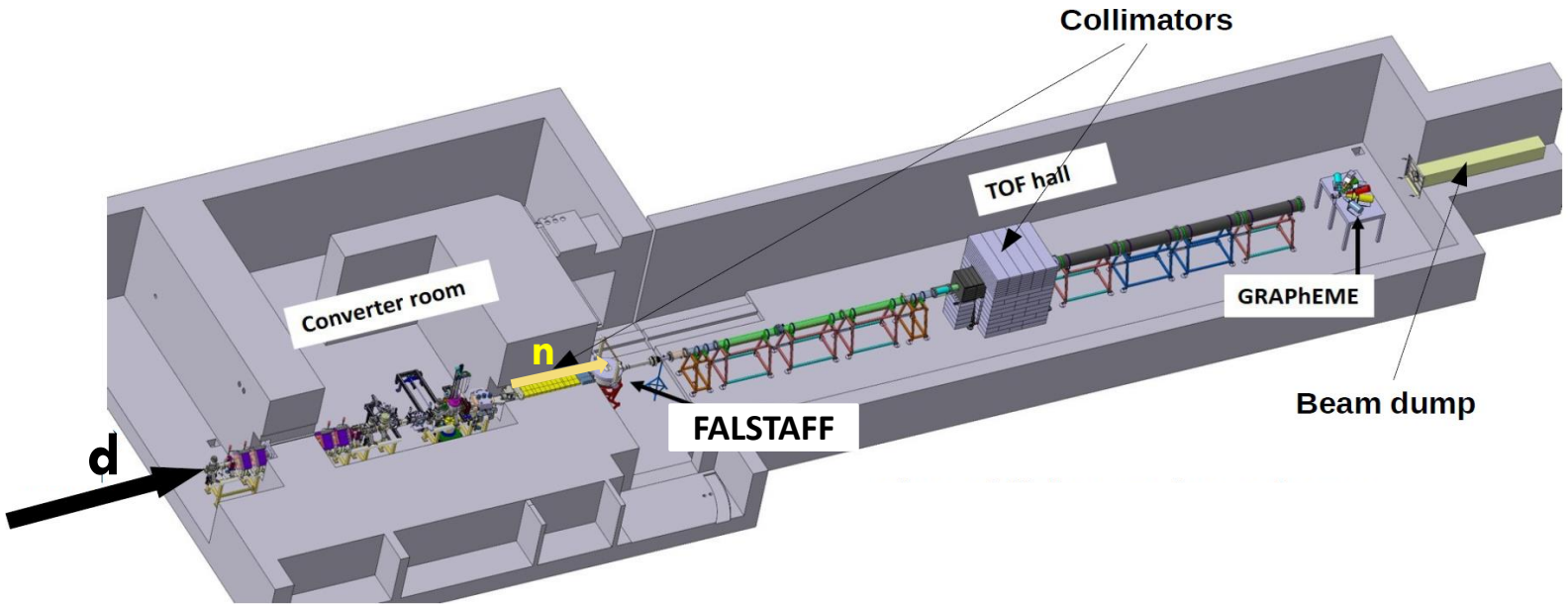



**Challenges :**

- Experimental mass resolutions
- Direct Kinematics → Low energy fragments (energy loss corrections), Charge identification

# E878 MEASUREMENT @ NFS




Neutron Beam @ NFS:

- Neutron beam production from d + $^{9}$Be reaction
- Neutron energy measured from the **TOF technique**

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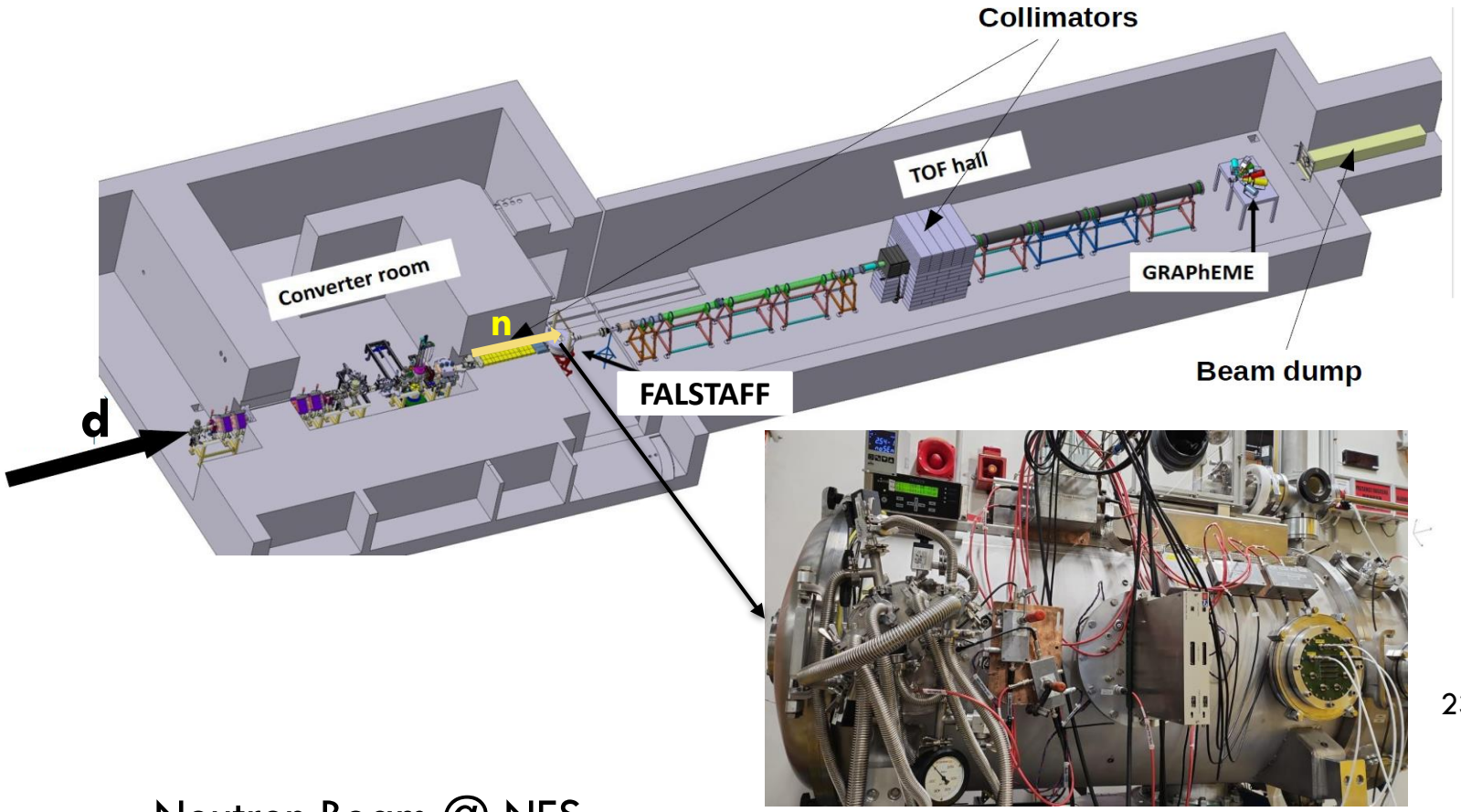
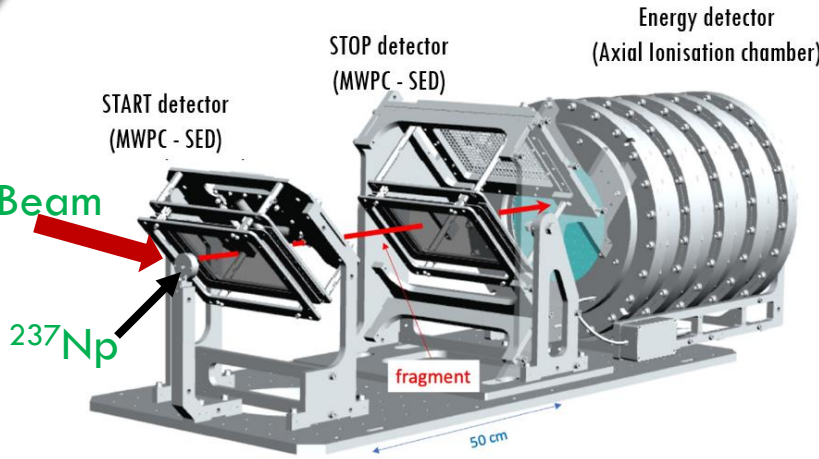
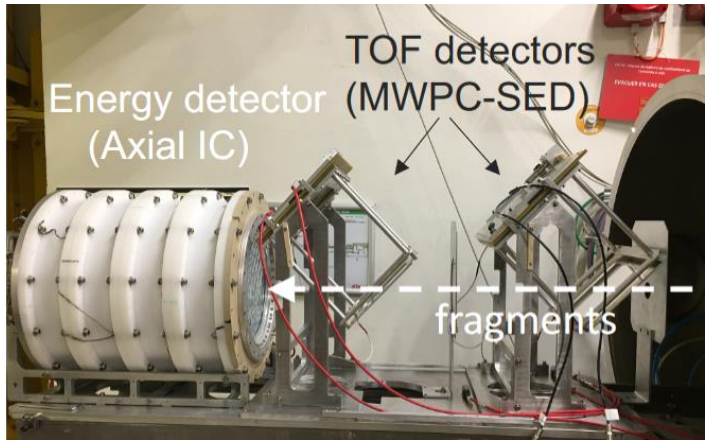





+2 LaBr3 detectors

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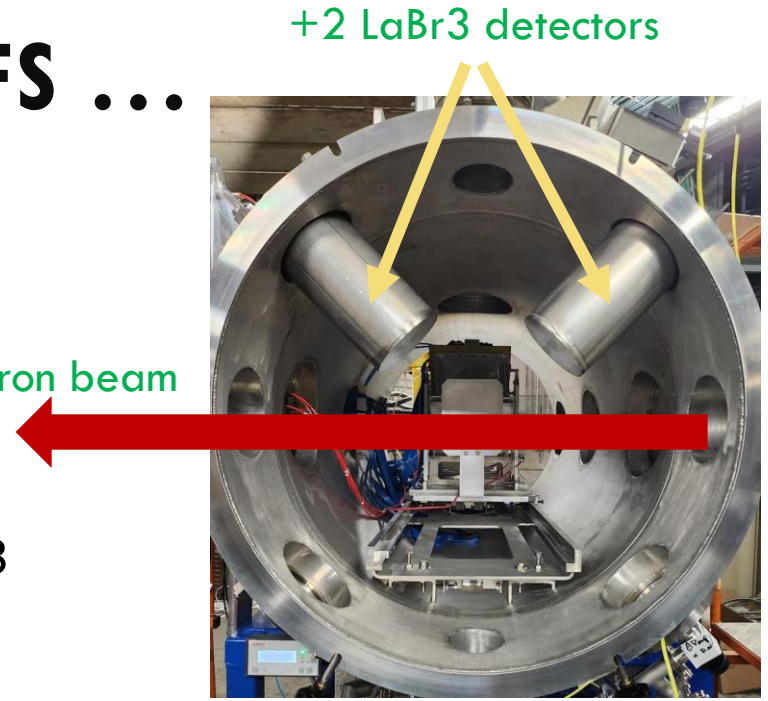
$^{237}$Np Target :

- JRC-Geel (100 % $^{237}$Np)
- Areal density : 204 µg/cm$^2$
- ϕ 30 mm
- Al backing, 0.25 mm

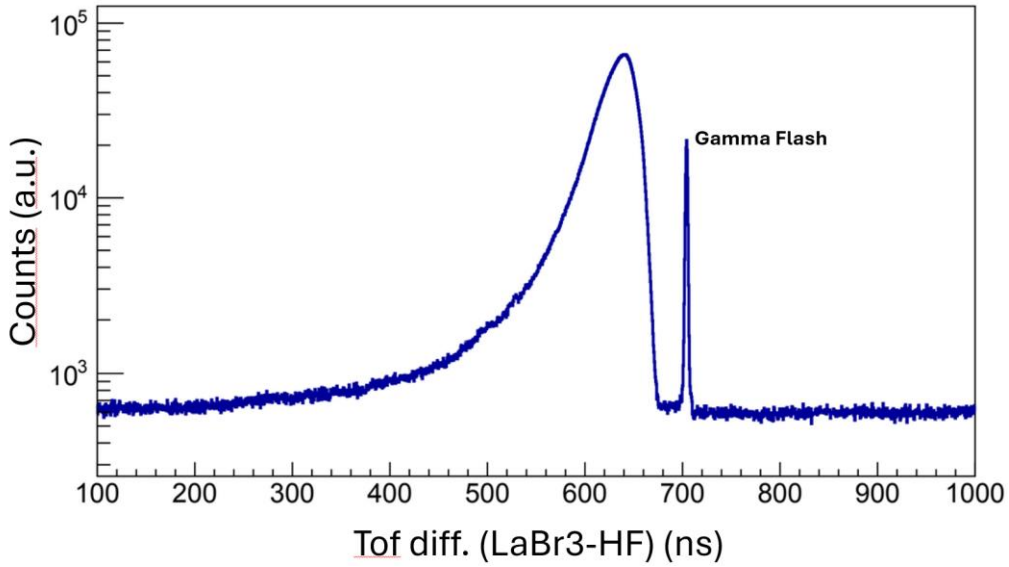
# E878 MEASUREMENT @ NFS …

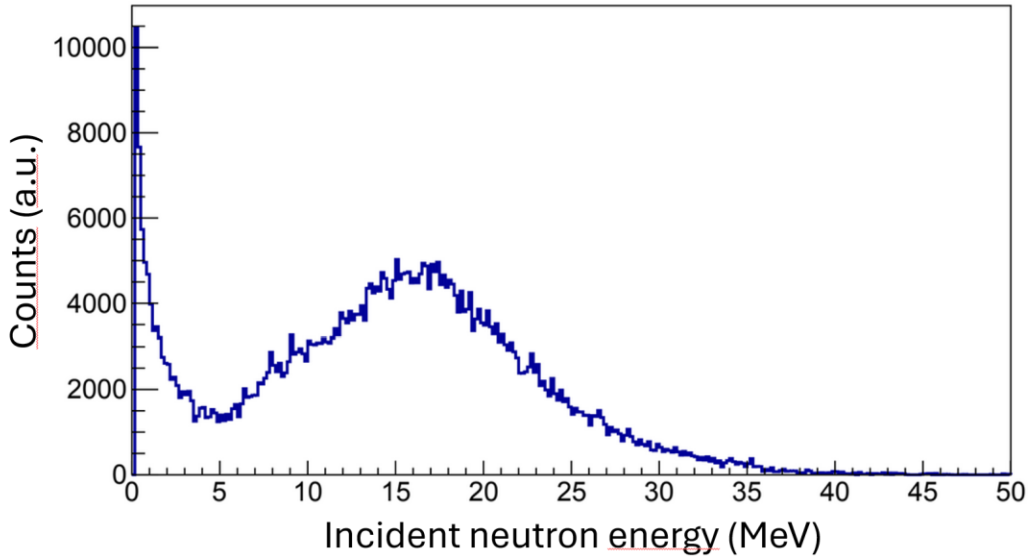



## Incident neutron energy spectra :

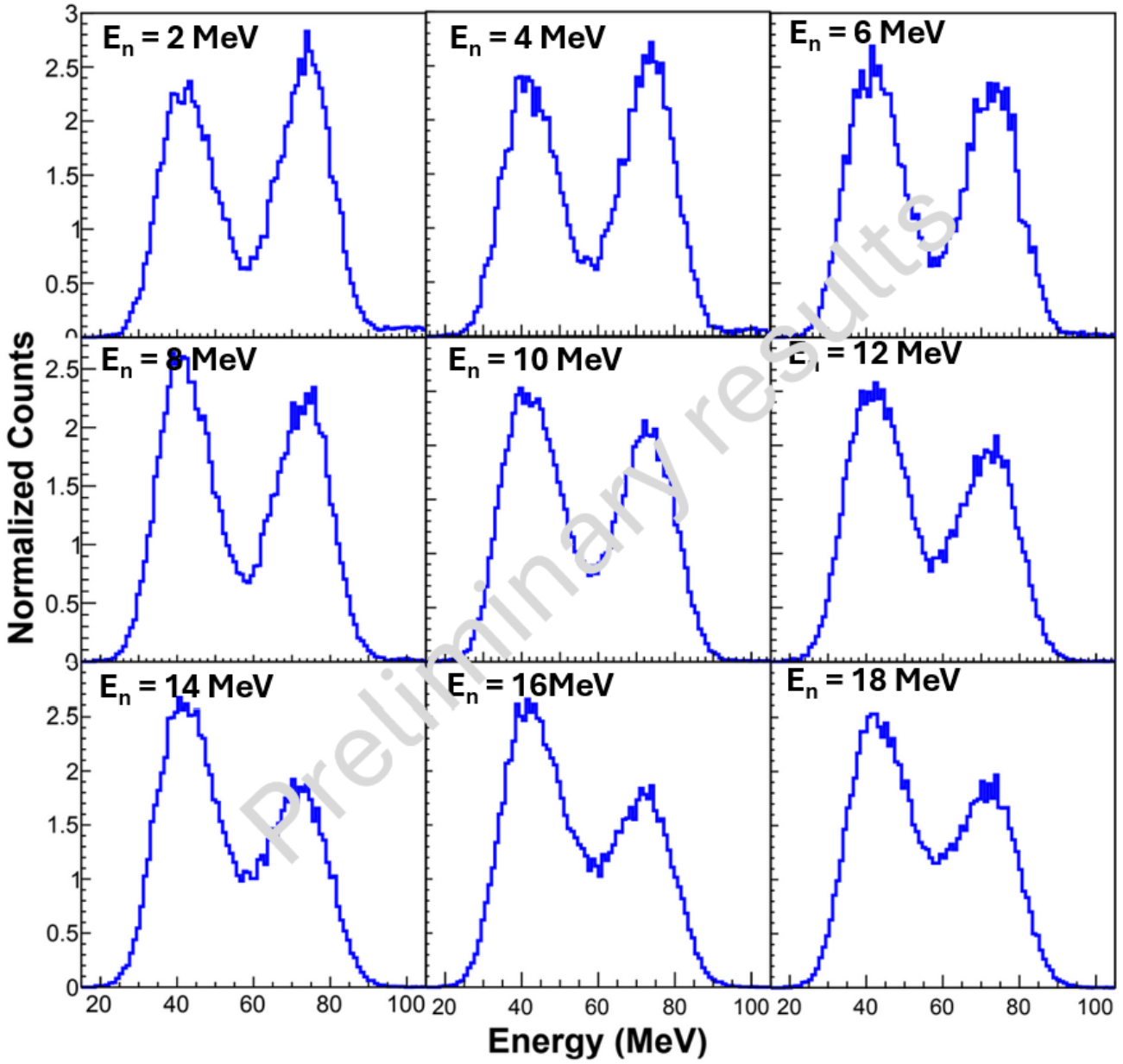
- Time reference : Low energy gamma flash from beam on converter.
- 2 LaBr3 detectors…
- Neutron time of flight spectra (in coincidence with FALSTAFF)

➔ Different TOF diff. combinations between HF, FALSTAFF and LaBr3

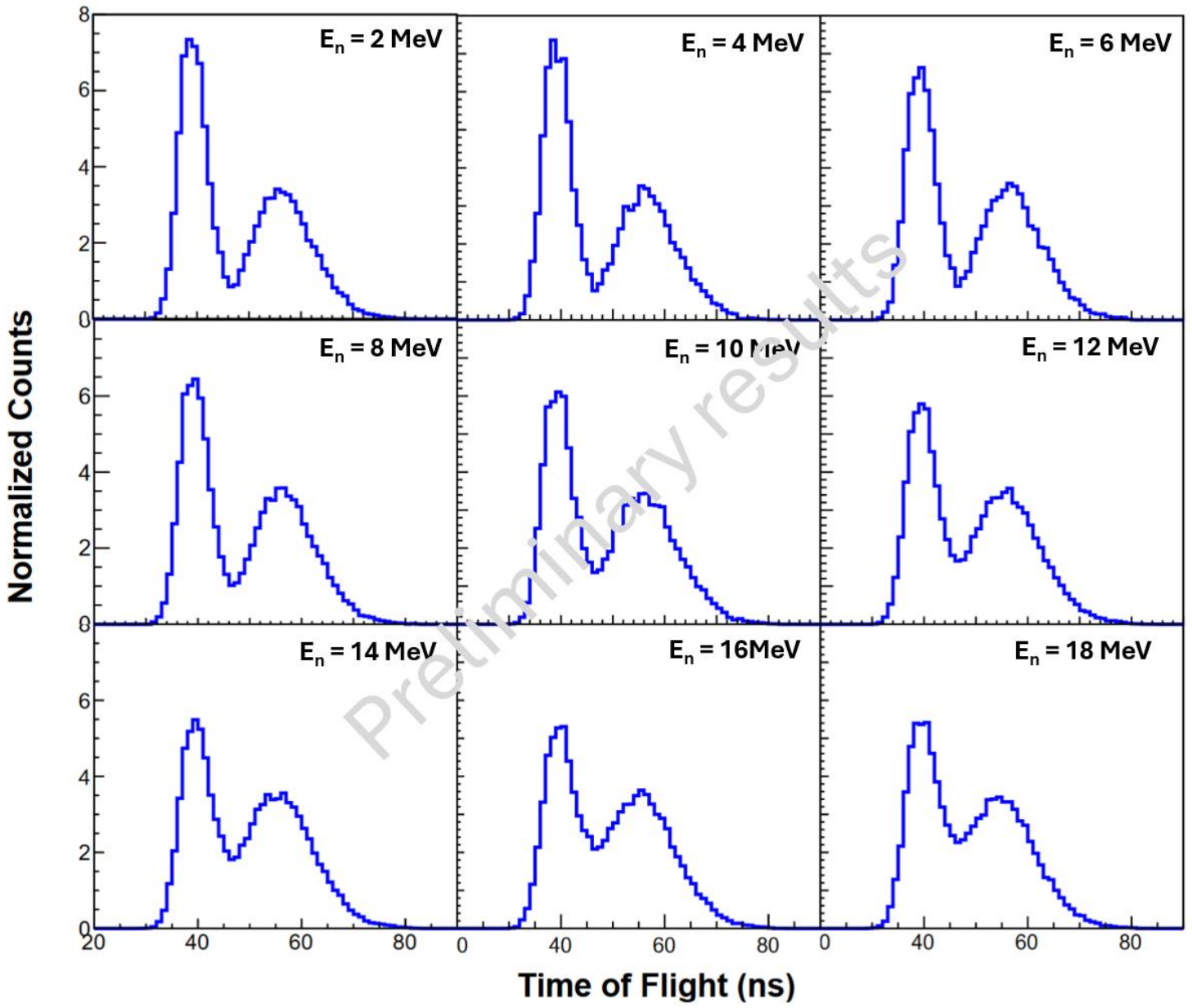


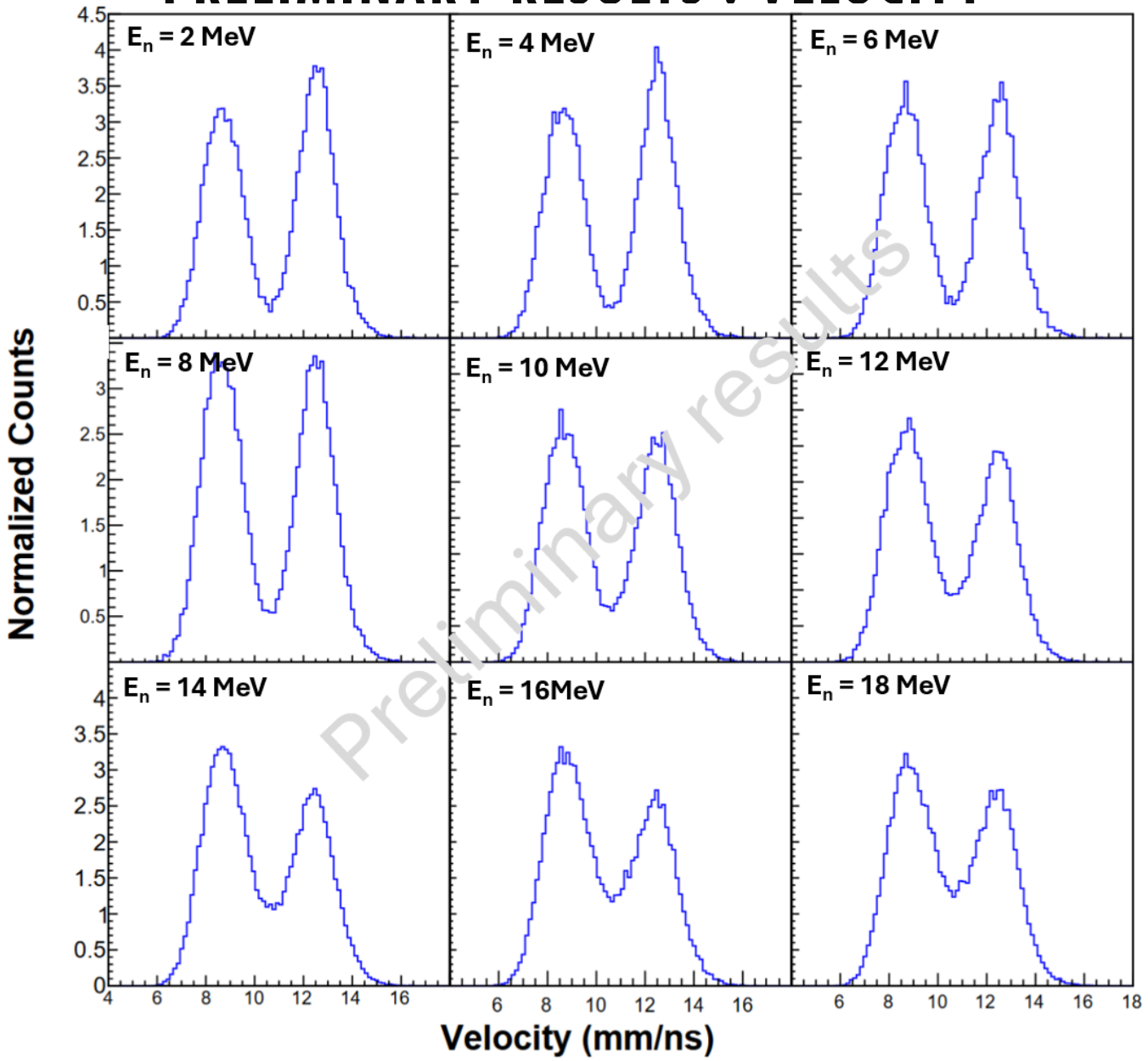
# PRELIMINARY RESULTS : RESIDUAL KINETIC ENERGY IN IC



# PRELIMINARY RESULTS : TIME OF FLIGHT

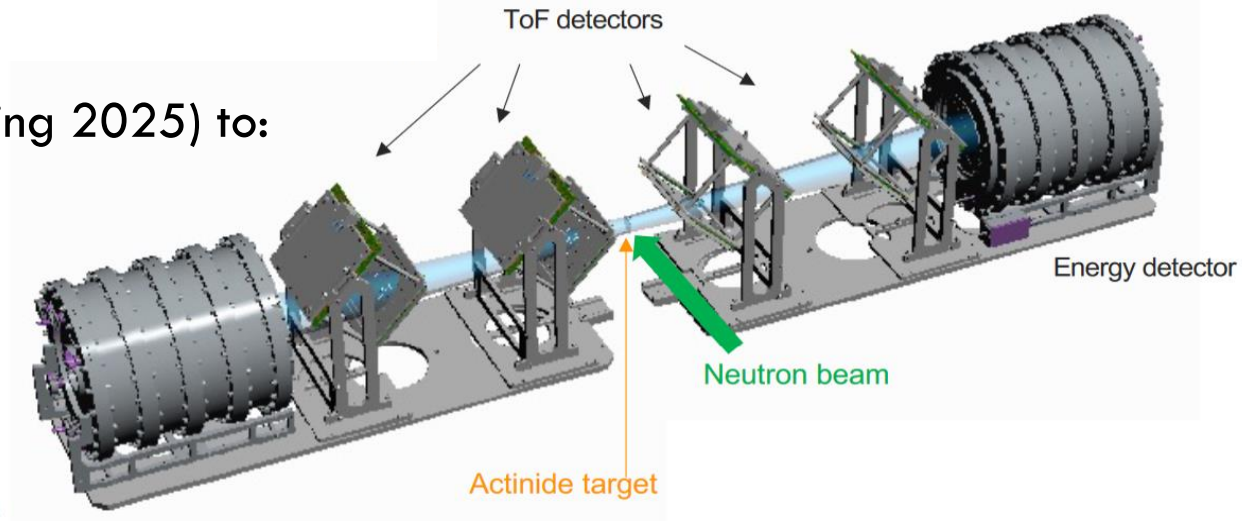


# PRELIMINARY RESULTS : VELOCITY



# CONCLUSIONS AND PERSPECTIVES

- Data analysis of $^{237}$Np (n,f) experiment to identify the **mass, energy** and **charge** of fission fragments and comparison with simulation as well as compare the results with E814 measurement of $^{235}$U are under progress.
- Development of the second arm (commissioning Spring 2025) to:
  - detect both fragments in coincidence
  - measure their kinetic energy
  - identify their mass pre & post evaporation
  - provide information on their nuclear charge




- Long measurements with 2 arms of FALSTAFF, using Cf source emitting fragments from both sides.
- $^{235}$U (n,f) experiment (2 arm) submitted to PAC 2024 (PAC meeting next week).
- Calibration of ionisation chamber with low energy stable beams of fission fragmet types.

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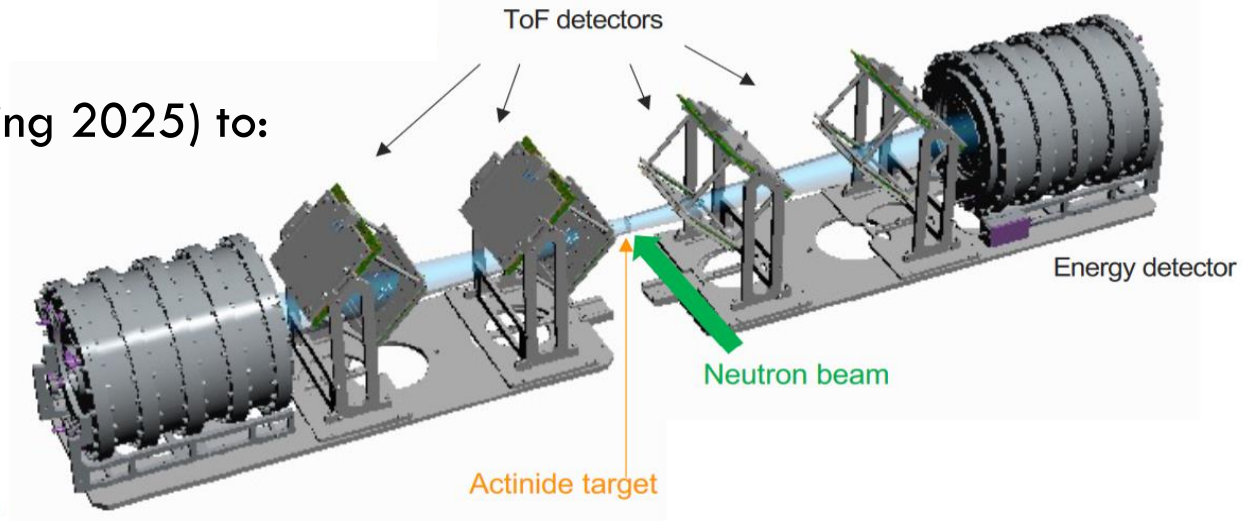


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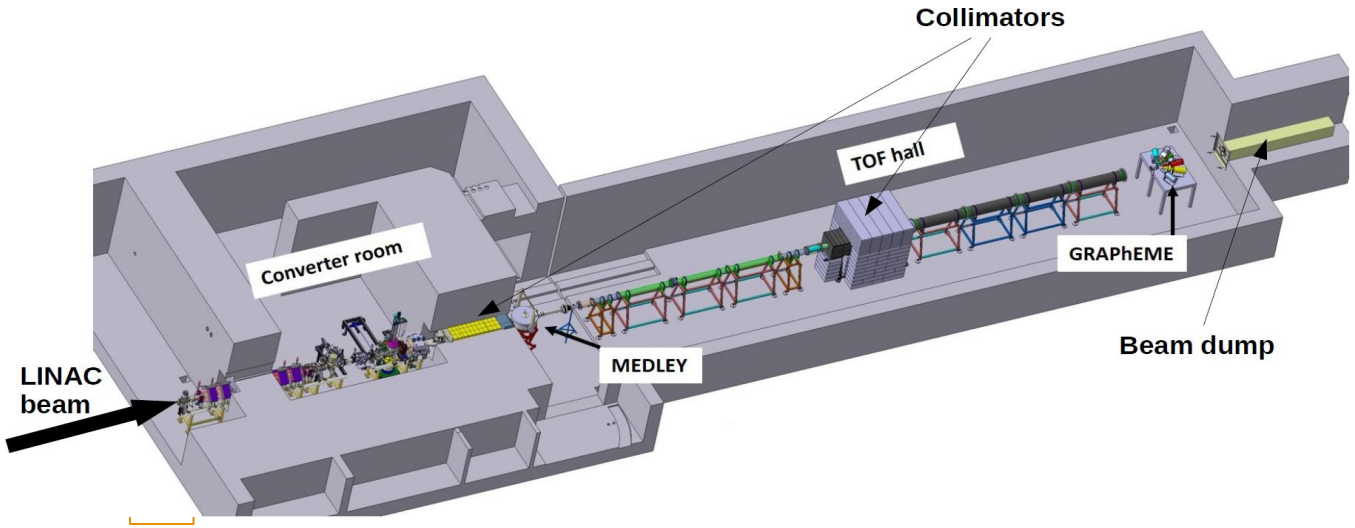
## THANK YOU!

# SUPLEMENTARY SLIDES

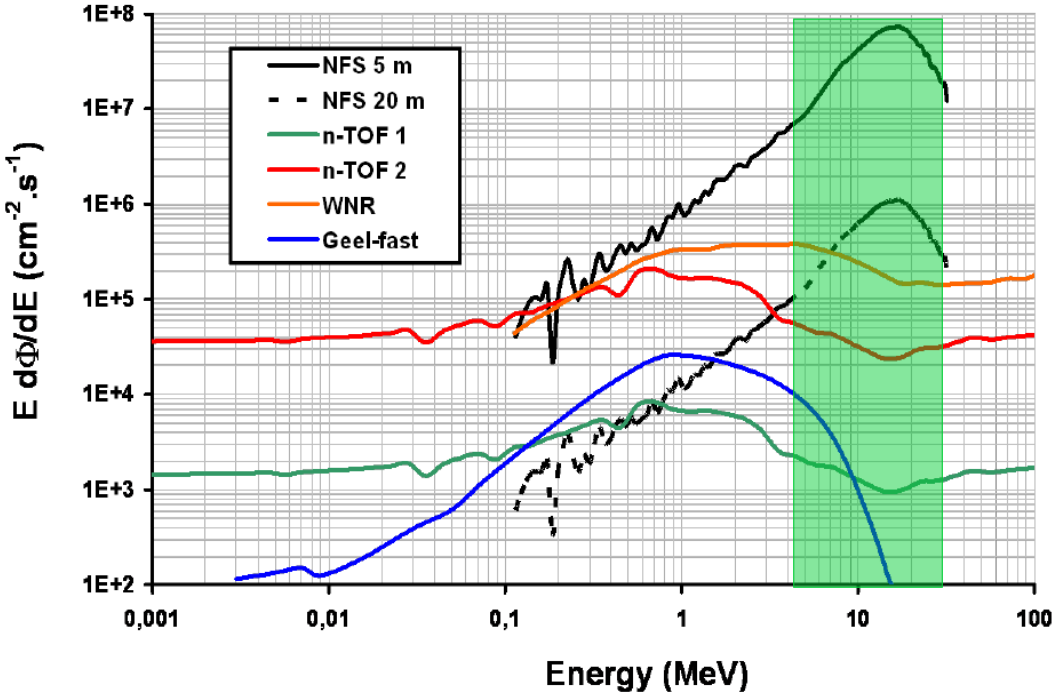
## Neutrons for science faclity

- **Converter/Irradiation room**:
  - Charged particles **irradiation station**
  - Neutrons production:
    - Reactions in **Li or Be converting targets.**
    - **3 m concrete collimator at 0 deg.** with conical inner shape: **1.7 cm radius beam**




- **Time-of-flight experimental room:**
  - 28 m long room
  - Neutron energy measured from the t**ime of flight technique**
  - **1 us fligh path** → bunch selector 1/100 (5mA → 50uA (3x$10^{14}$ d/s)
  - **secondary collimation** (13 cm → 2 cm beam spot radius)
  - **Water beam dump** → reduced backscatter neutrons
  - **Several setups** placed at the same time

# NFS



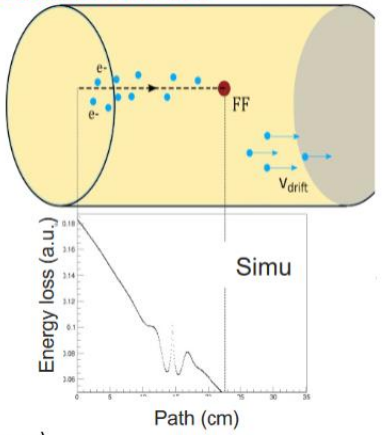

- **Neutron from 0.1 MeV to 40 MeV**
- 1 ns acelerator deviation :
  - **good energy resolution**
- High repetition rate :
  - **Reduced gamma-flash**
  - **Low instantaneous flux**

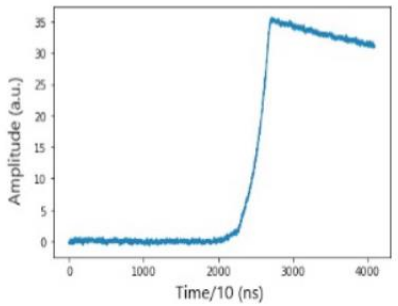
NFS offers a great opportunity to study n-induced fission

# Charge identification through energy loss profile measurement

Possible to identify fragment nuclear charge
using the energy loss profile and neural network

*Need data with identified fragment to « settle »*
*the neural network*
→ *FALSTAFF@VAMOS experiment (D. Ramos)*

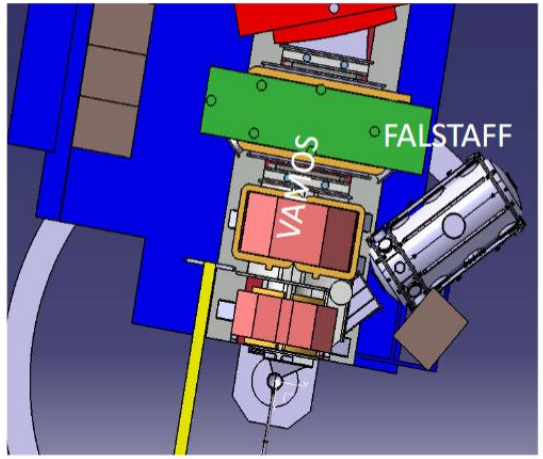


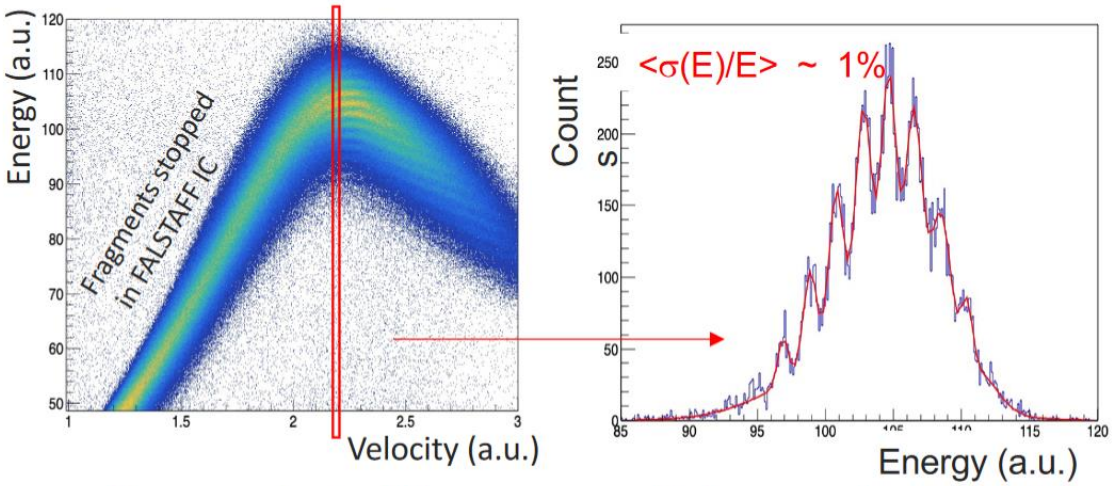

FALSTAFF @ VAMOS (test experiment, March 2022, PI D. Ramos)

$^{238}$U + C (Be) → fusion-fission main channel

- one fragment fully (Z,A,E) identified in VAMOS
- one fragment slowed down (small IC close to the target) and detected in FALSTAFF




**Additional information**




*See Indu Jangid poster*

*Charge analysis still in progress, preliminary results are promising*