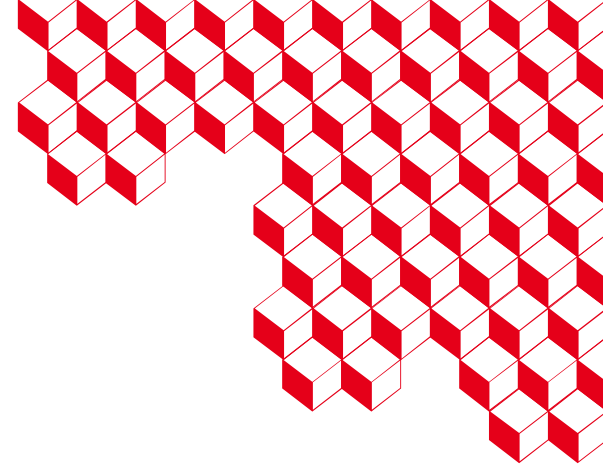




VENDETA: A New Neutron Detector Array for Precise PFNS Measurements at Los Alamos

Cyril LENAIN

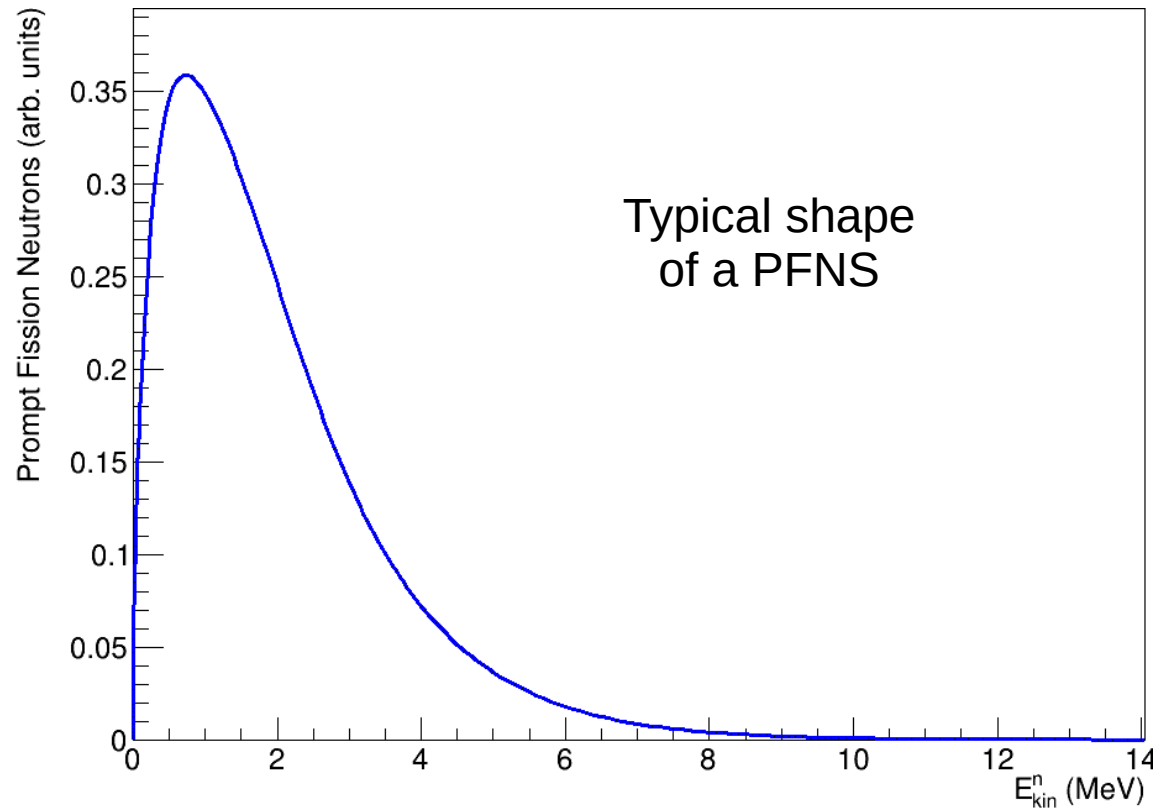
Postdoctoral researcher

With Julien Taieb and Benoit Mauss

Prompt Fission Neutron Spectra (PFNS)

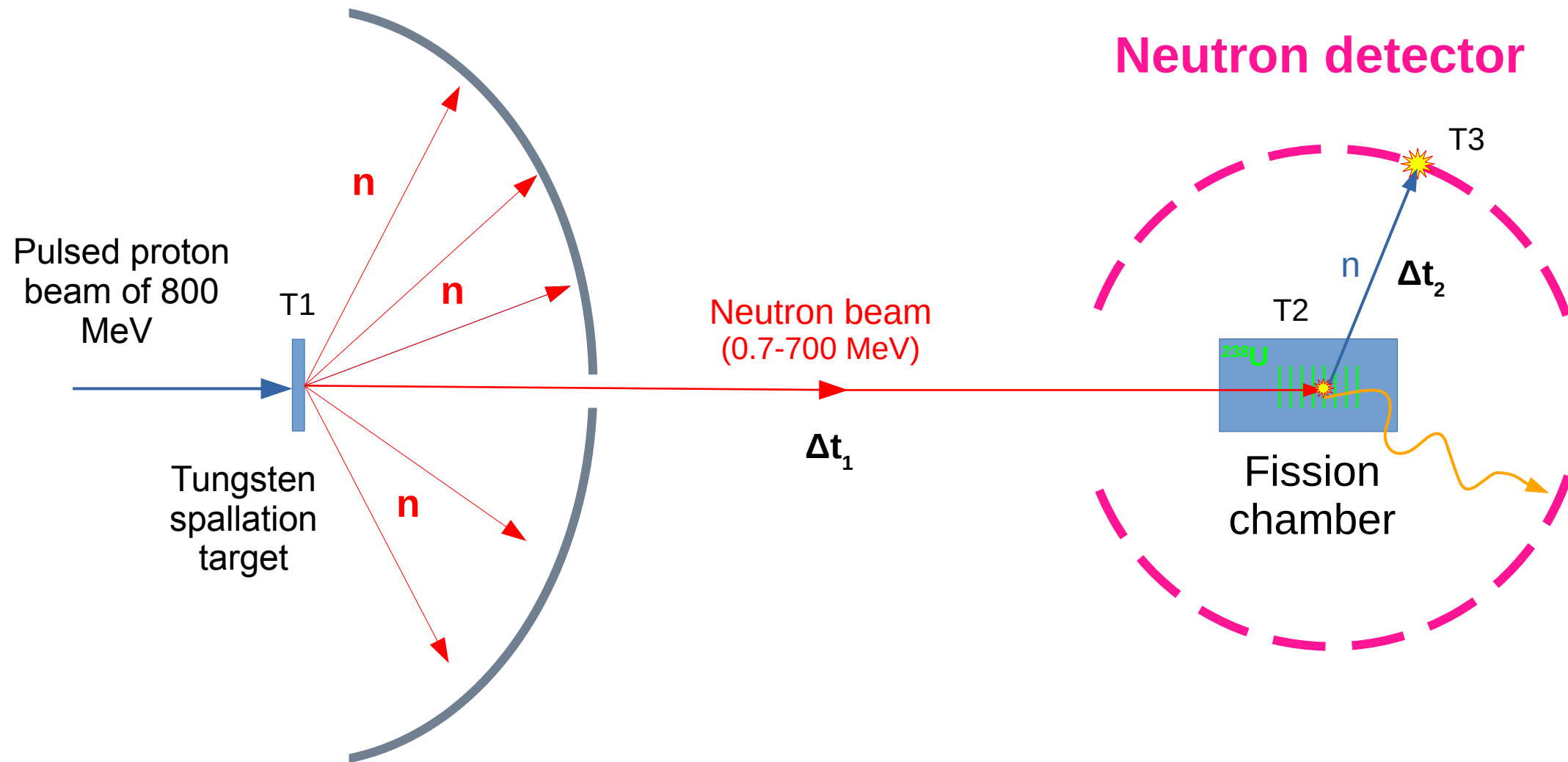
→ Energy distribution of neutrons emitted after a fission reaction

- Depends on the actinide considered
- Depends on the incident energy
- Plays a fundamental role in neutron transport codes
- Impacts for nuclear applications
- The vast majority of neutrons are between 0.1 and 4 MeV



→ Challenge: measuring both low and high-energy neutrons

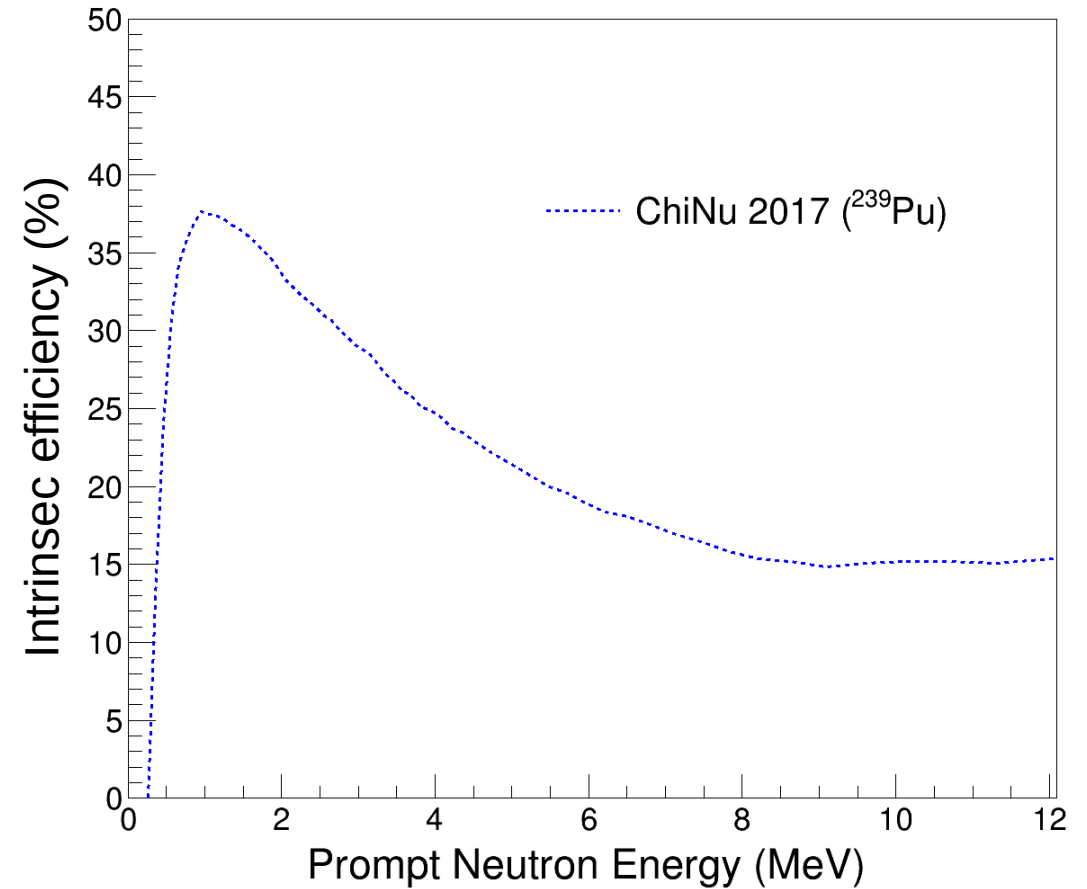
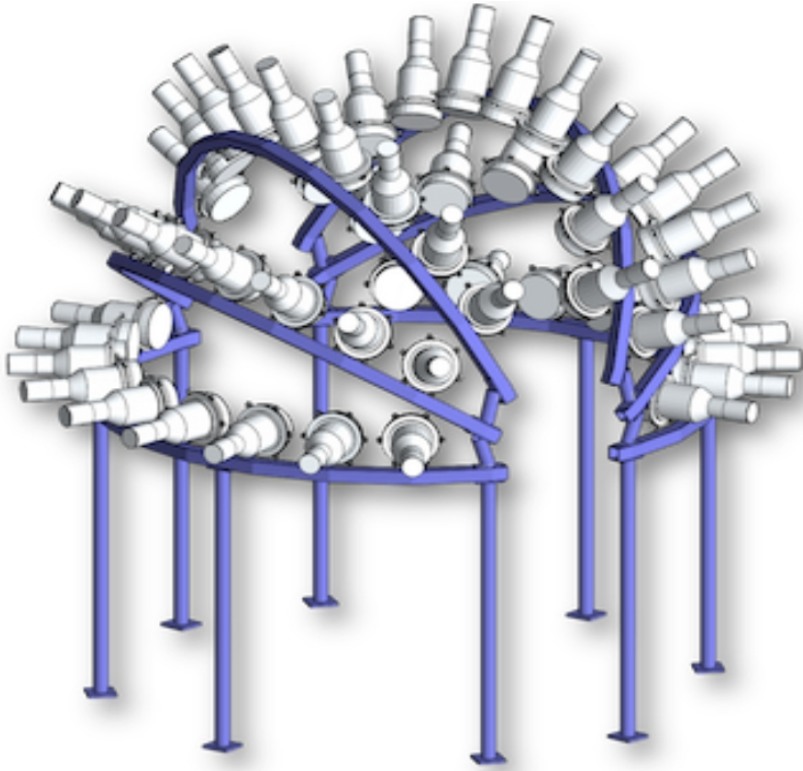
Principle of the PFNS measurement at Los Alamos



Neutron detection over the past 10 years



ChiNu

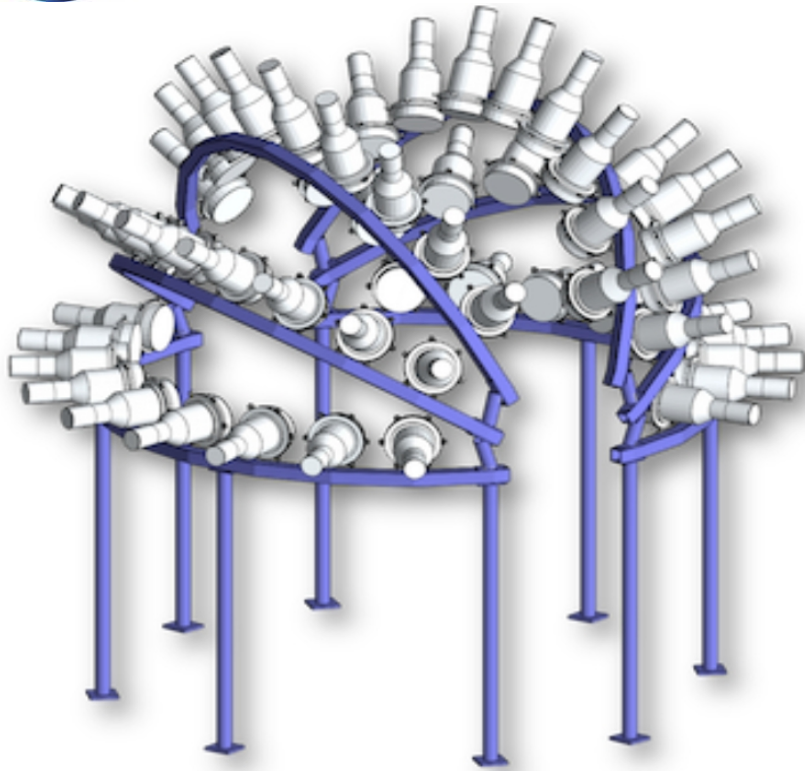


- Efficiency measured using a ^{252}Cf source
- Need to improve efficiency and to lower the Threshold

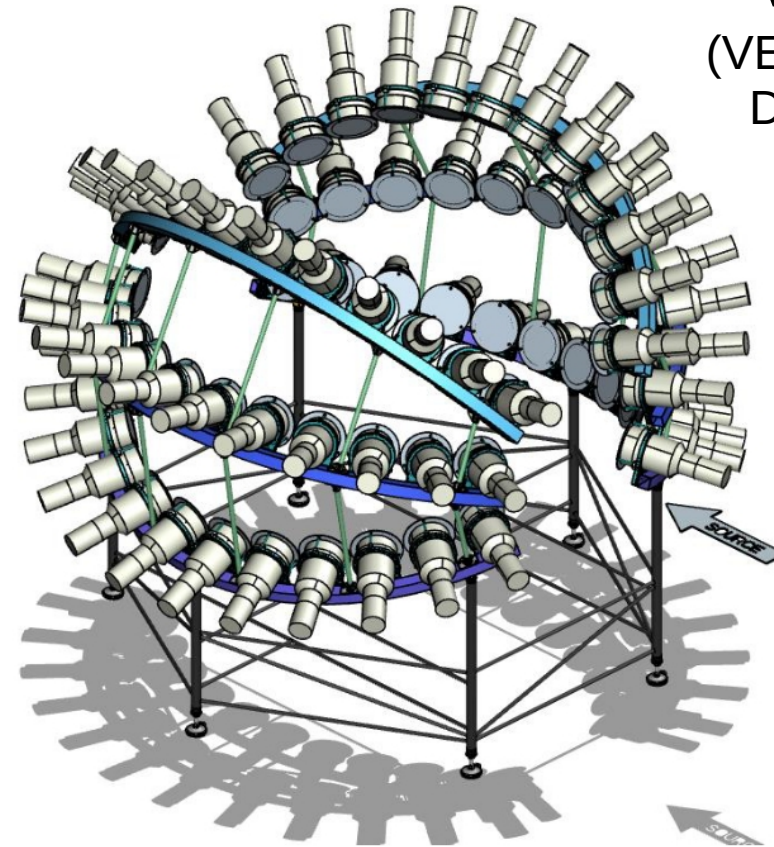
New neutron detector VENETA



ChiNu



2022



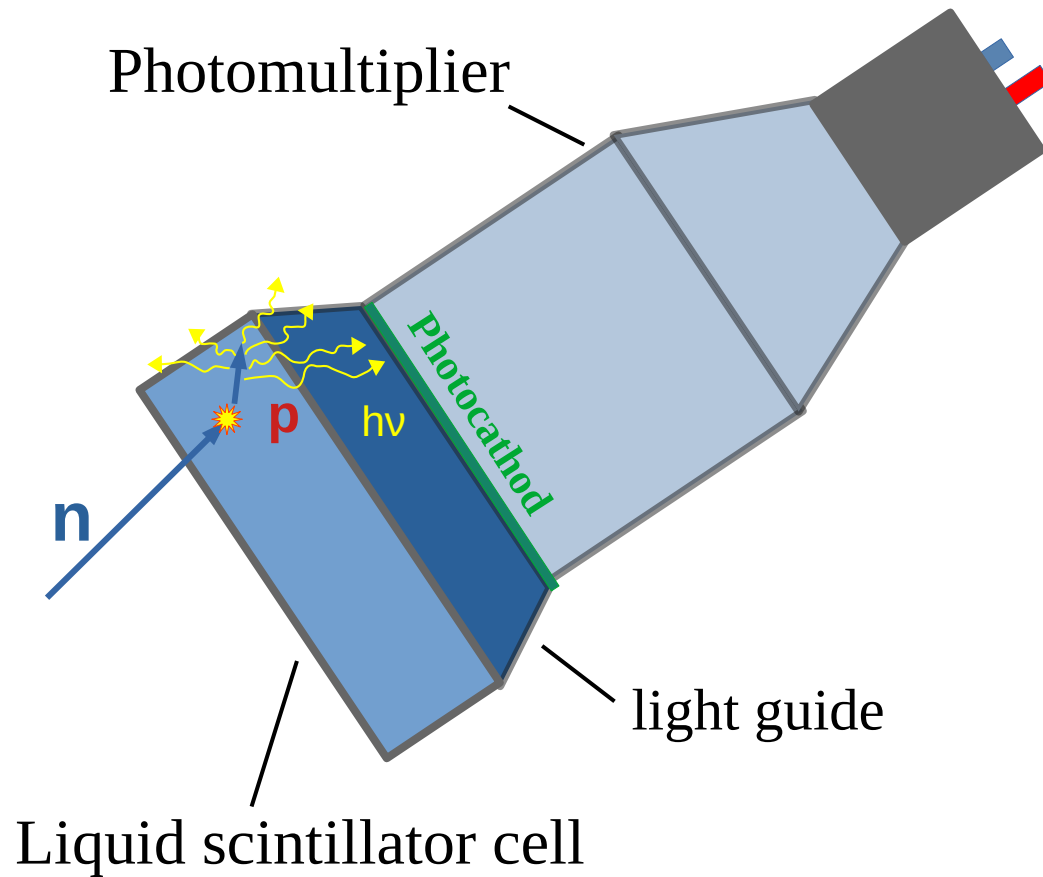
VENETA
(VERsatile Neutron
DETECTOR Array)



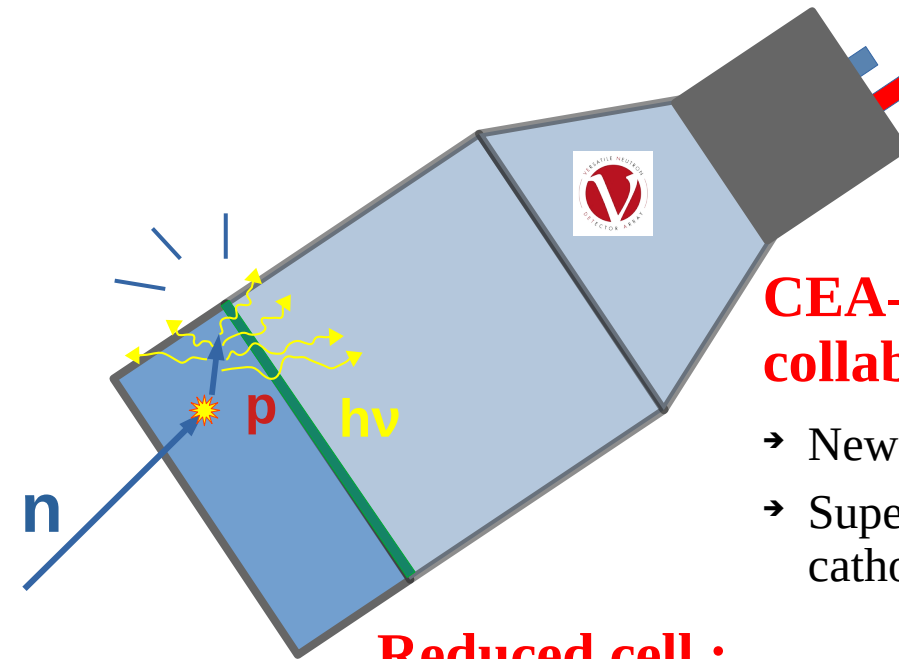
« More cells, but smaller »

New neutron detector VENDETA

ChiNu



VENDETA



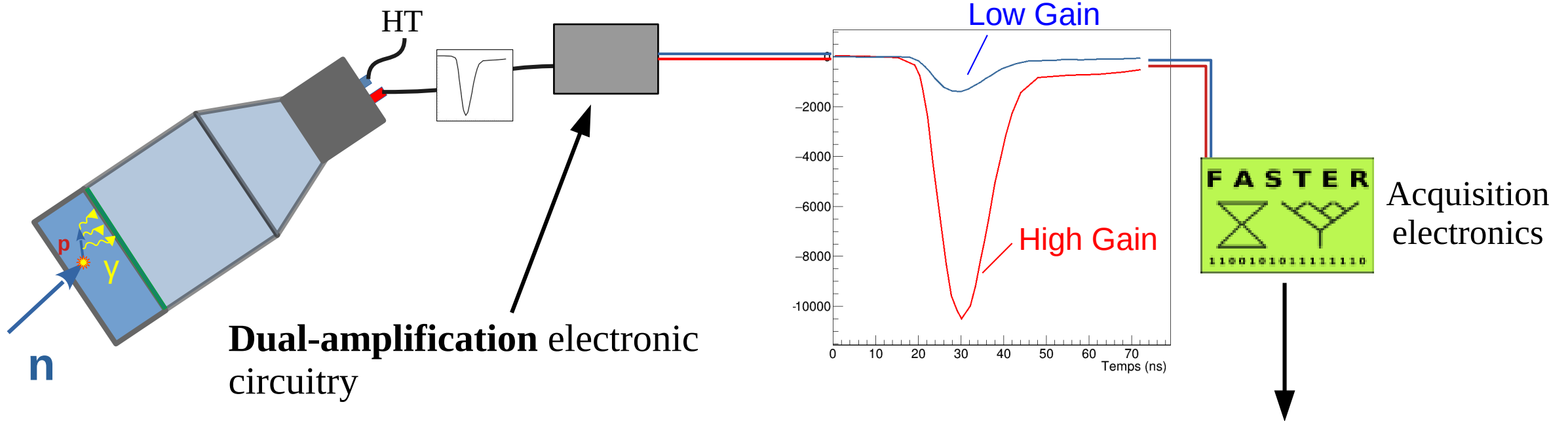
CEA-Hamamatsu collaboration :

- New PMT
- Super Bialkali photocathode

Reduced cell :

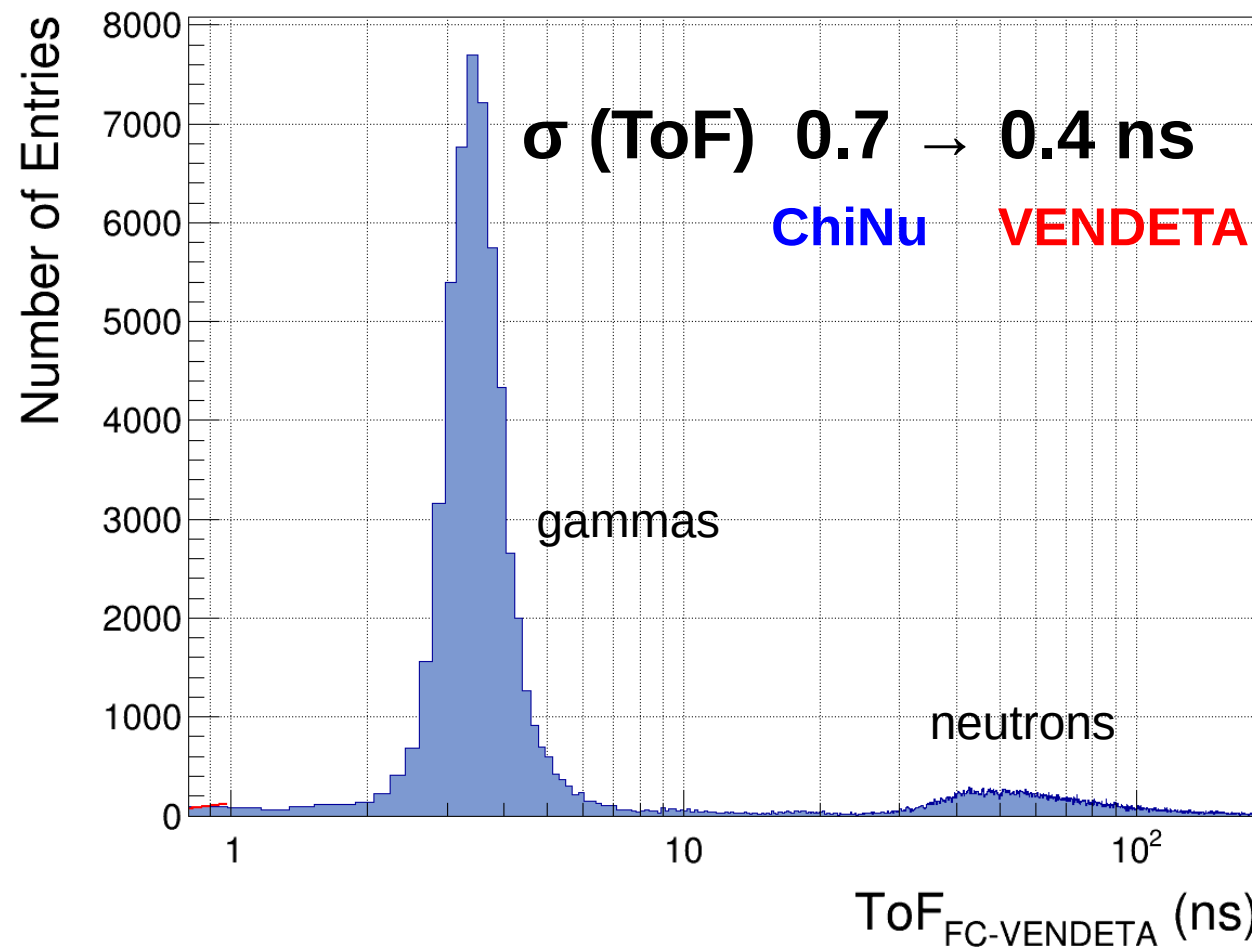
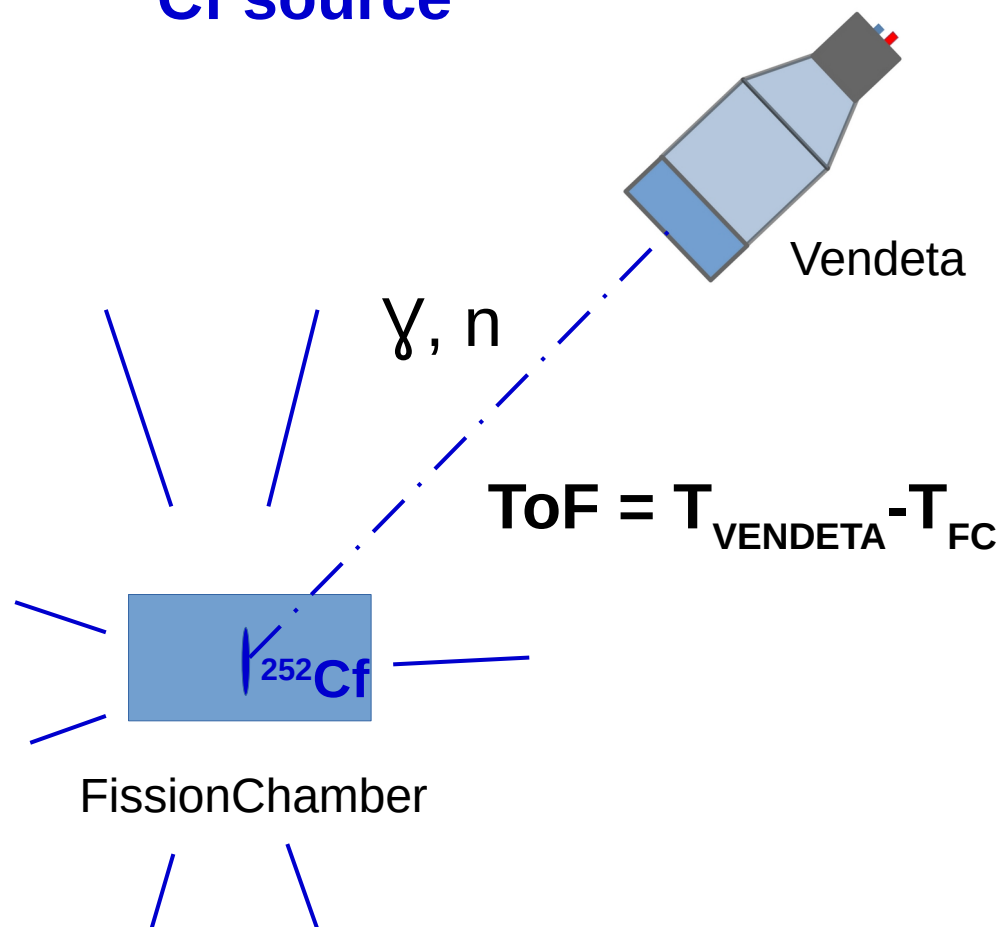
- Removal of the light guide
- Improved light collection: lower threshold and increased efficiency
- Less scattering

New neutron detector VENDETA

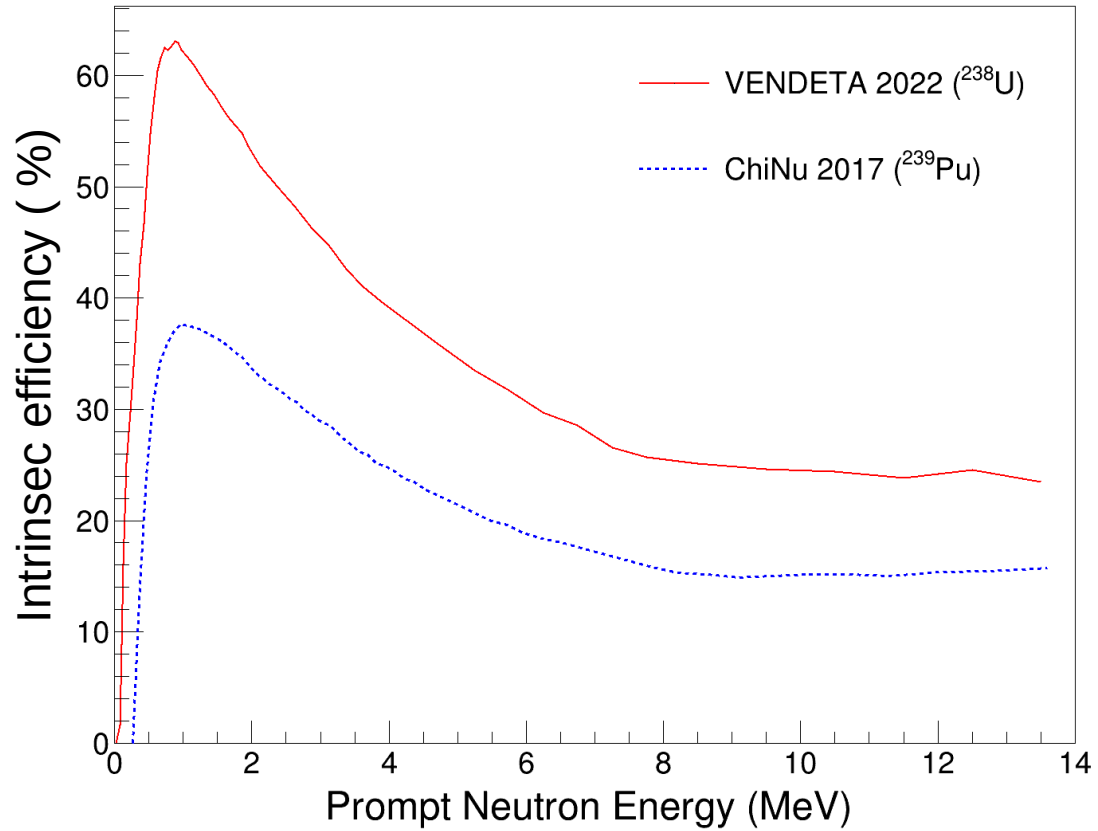


VENETA performances: Time resolution

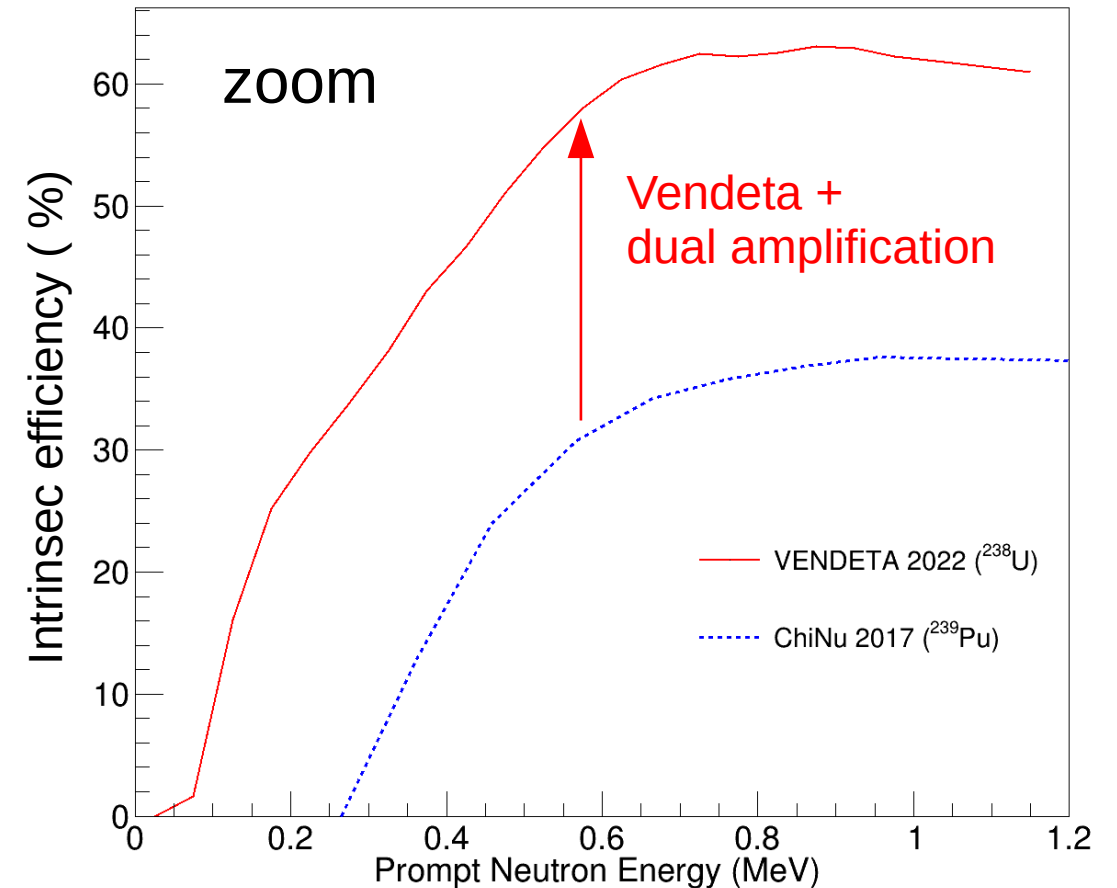
^{252}Cf source



VENDETA performance: efficiency

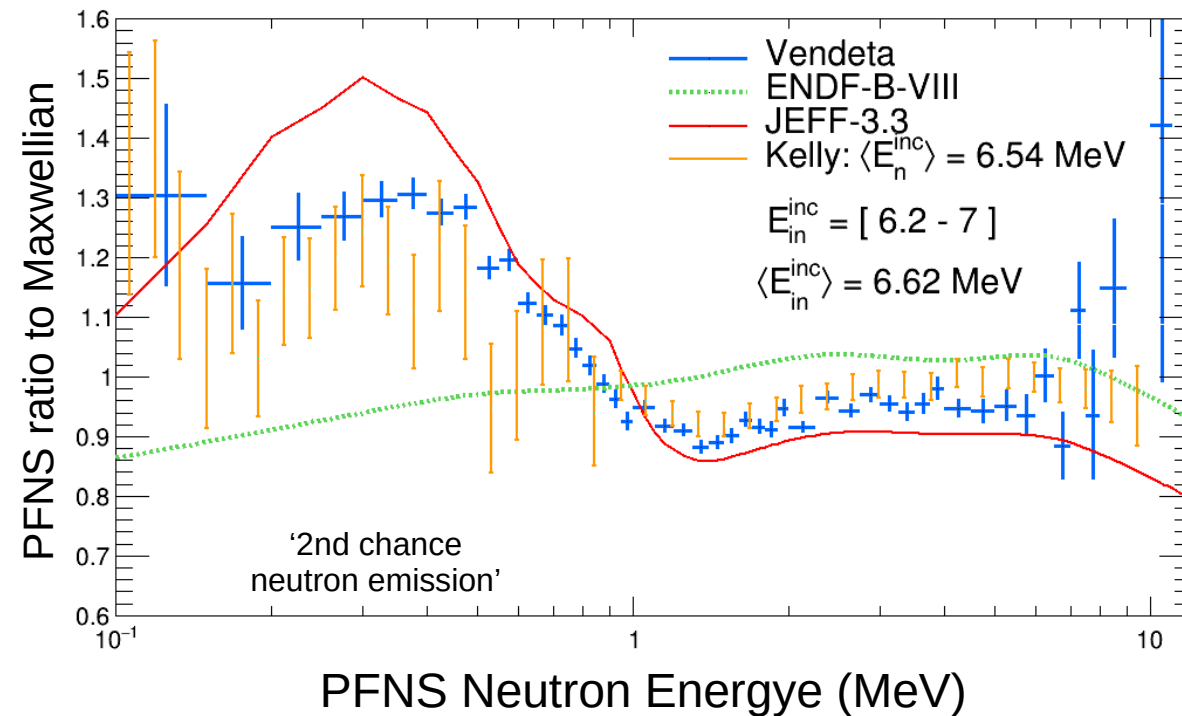
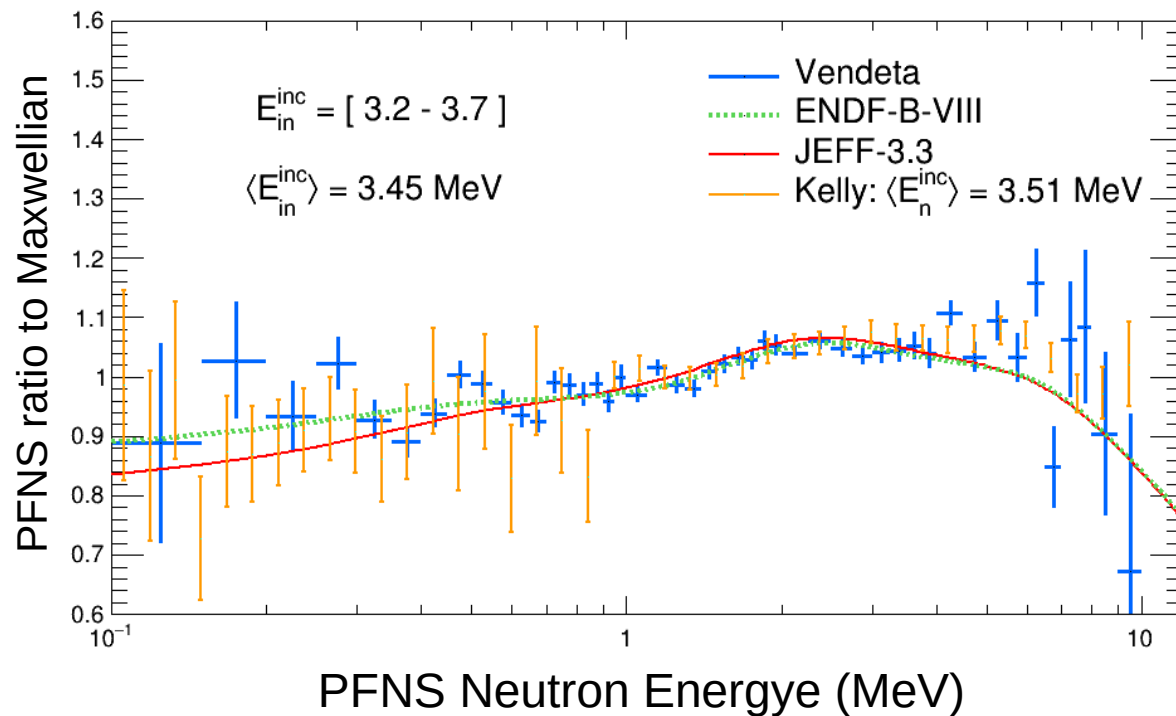


- Efficiency measured using a ^{252}Cf source
- Improved efficiency
- pic : 38% -> 64%



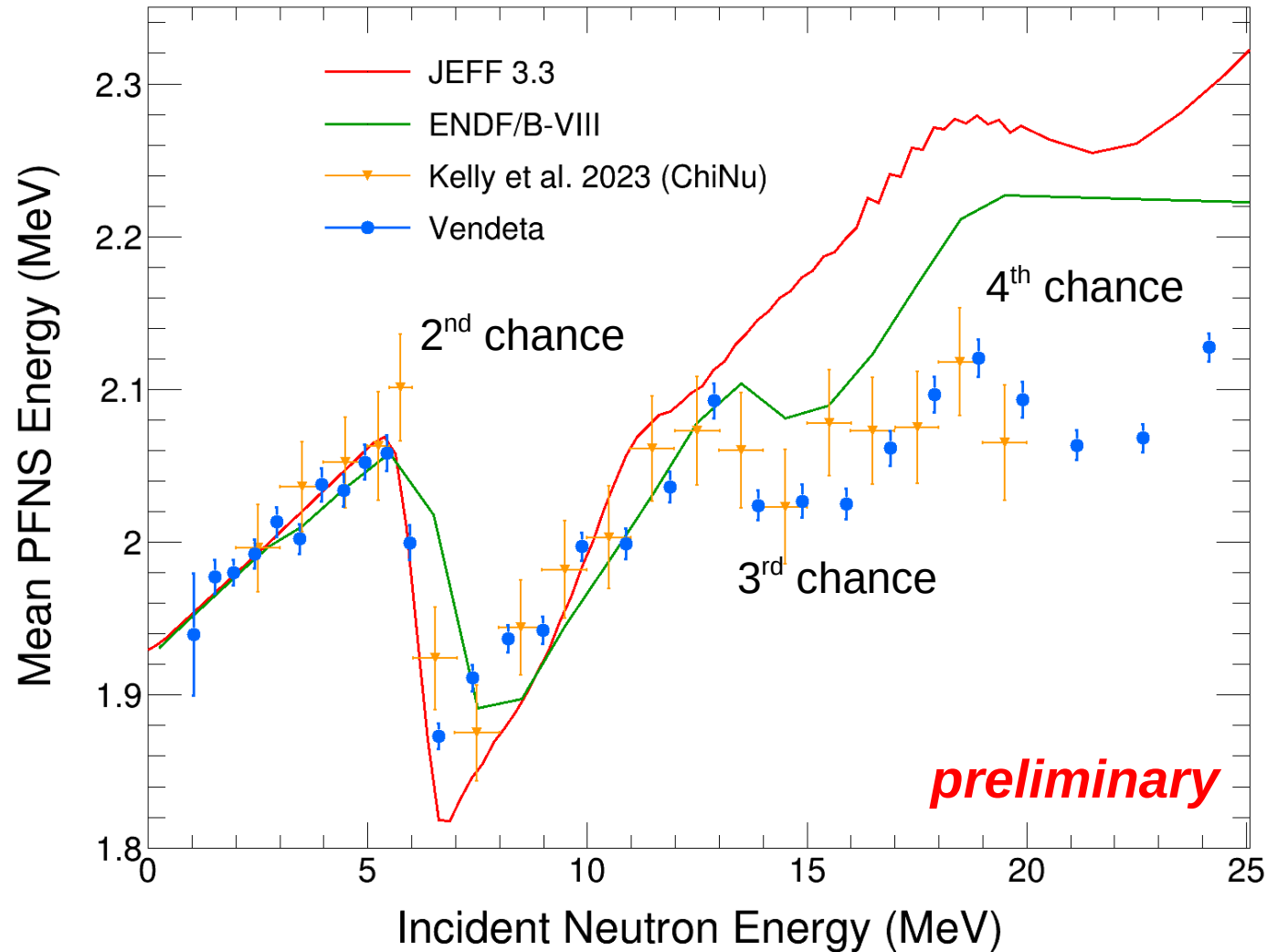
- Lower threshold : 250 keV -> 100 keV
- ChiNu VENDETA

Results : PFNS $^{238}\text{U}(n,f)$



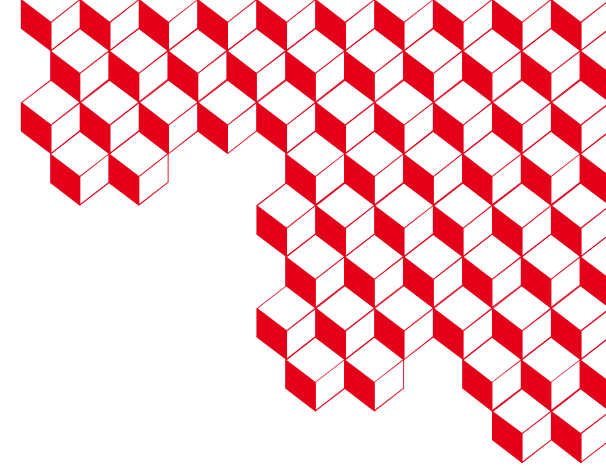
Results: Mean Neutron Energy $^{238}\text{U}(n,f)$

- Significant gain in precision ($< 0,6 \%$)
- New data at low incident energy
- Consistent with ChiNu (Kelly et al. 2023)
- Deviation from the ongoing evaluation JEFF 3.3 and ENDF



Conclusion

- VENDETA a new neutron detector with good efficiency and very low threshold
- First successful experiment completed in 2022
- Promising results on ^{238}U showing a precision on the Mean PFNS $< 0.6\%$ and nubar $< 0.4\%$ (being finalized)
- New measurements of PFNS / nubar planned : ^{240}Pu ^{239}Pu



Thank you

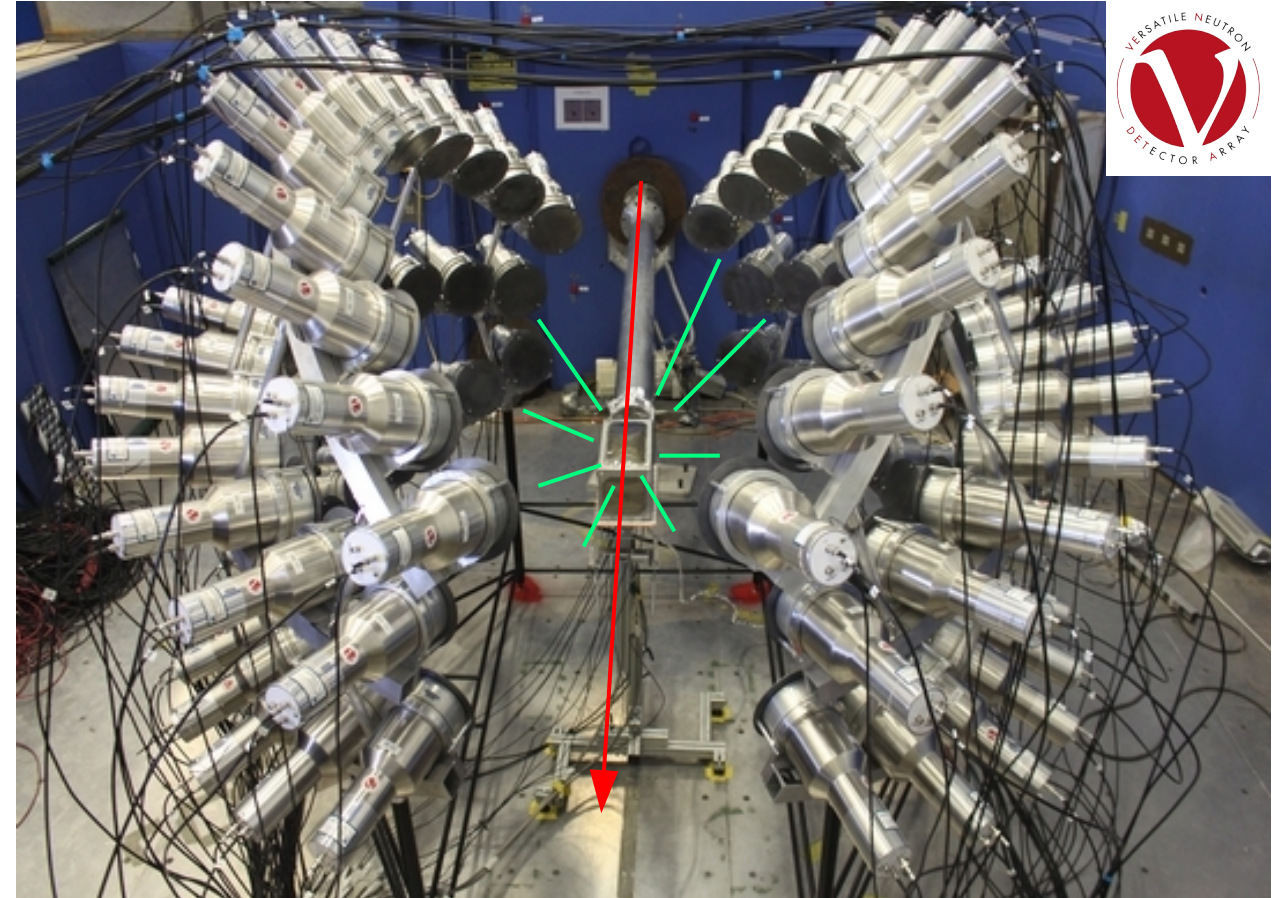
Cyril Lenain
Postdoctorant
cyril.lenain@cea.fr



Backup

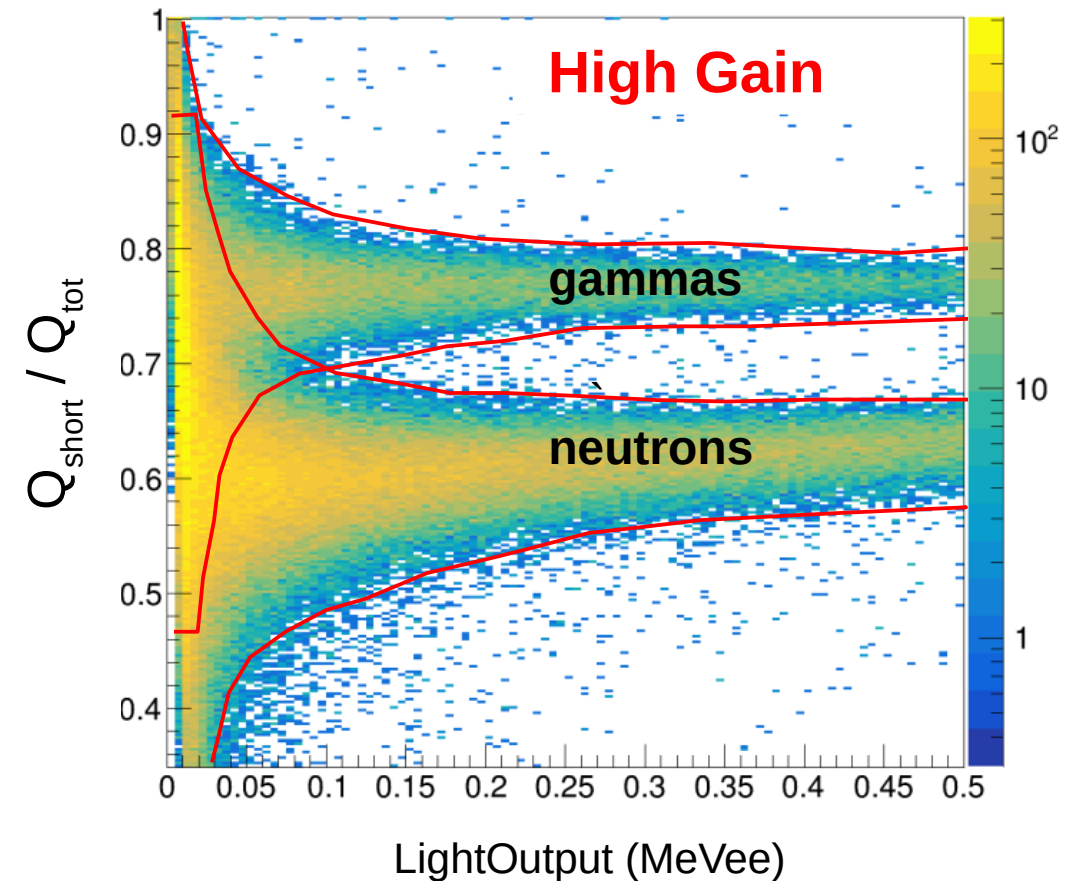
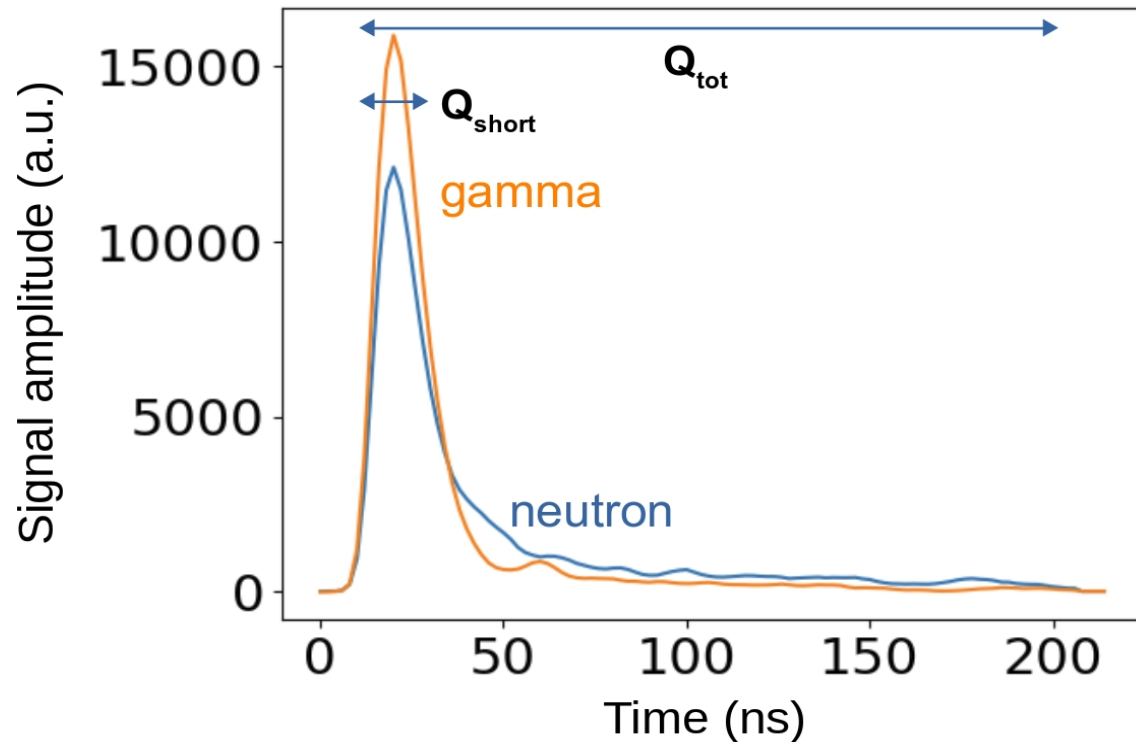
New neutron detector VENDETA

- 54->72 liquid scintillator detectors
 - Larger angular coverage
 - Larger segmentation
 - Lower threshold / better efficiency
- > Better precision on the PFNS / nubar



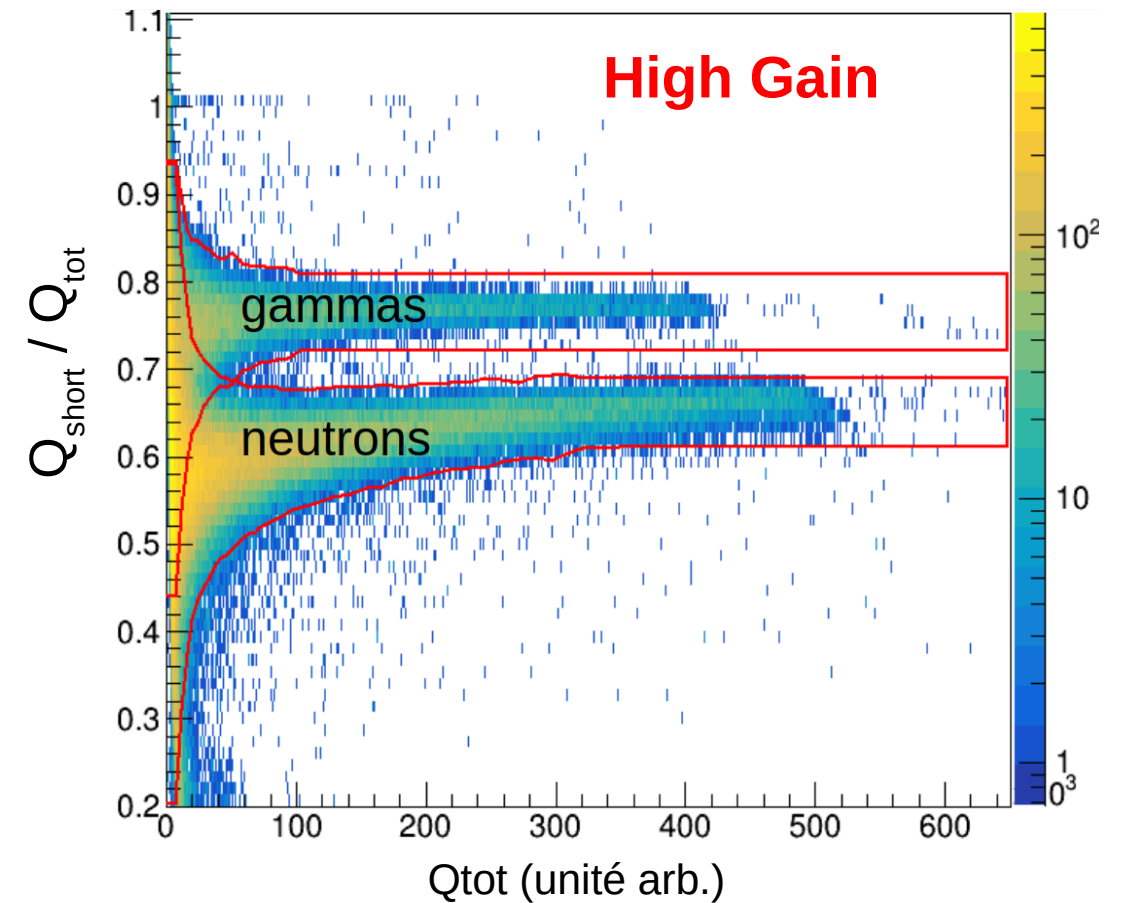
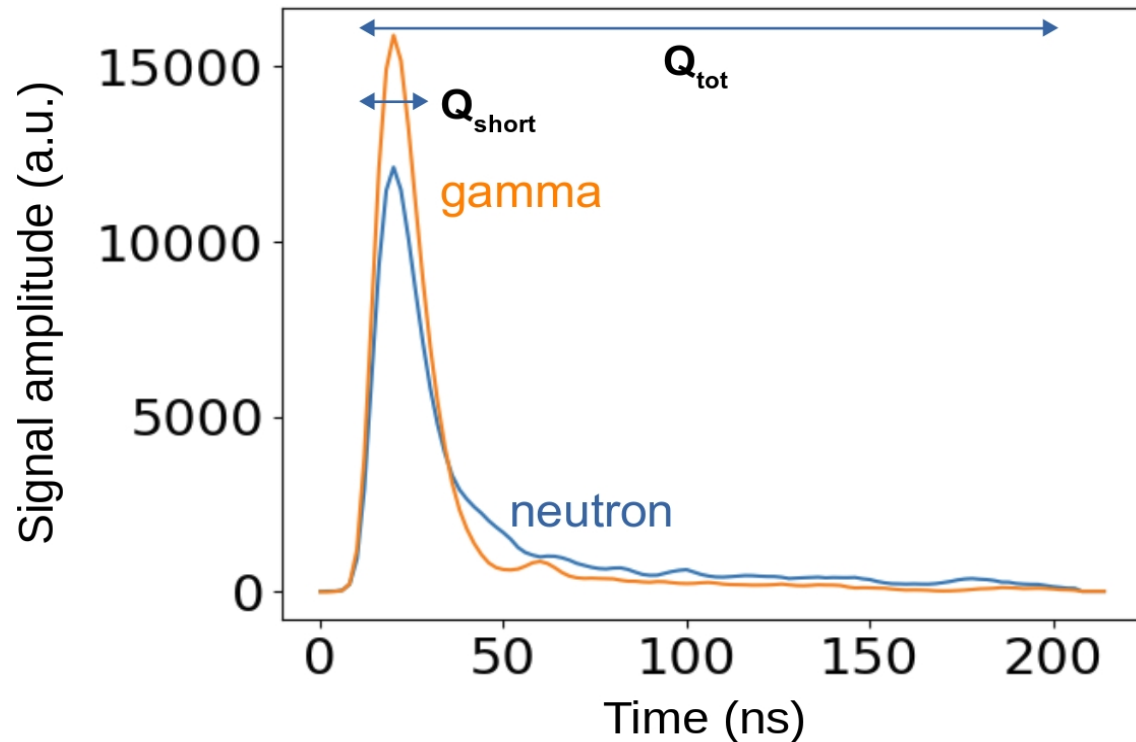
VENDETA performances: discrimination neutron / gamma

VENDETA signals

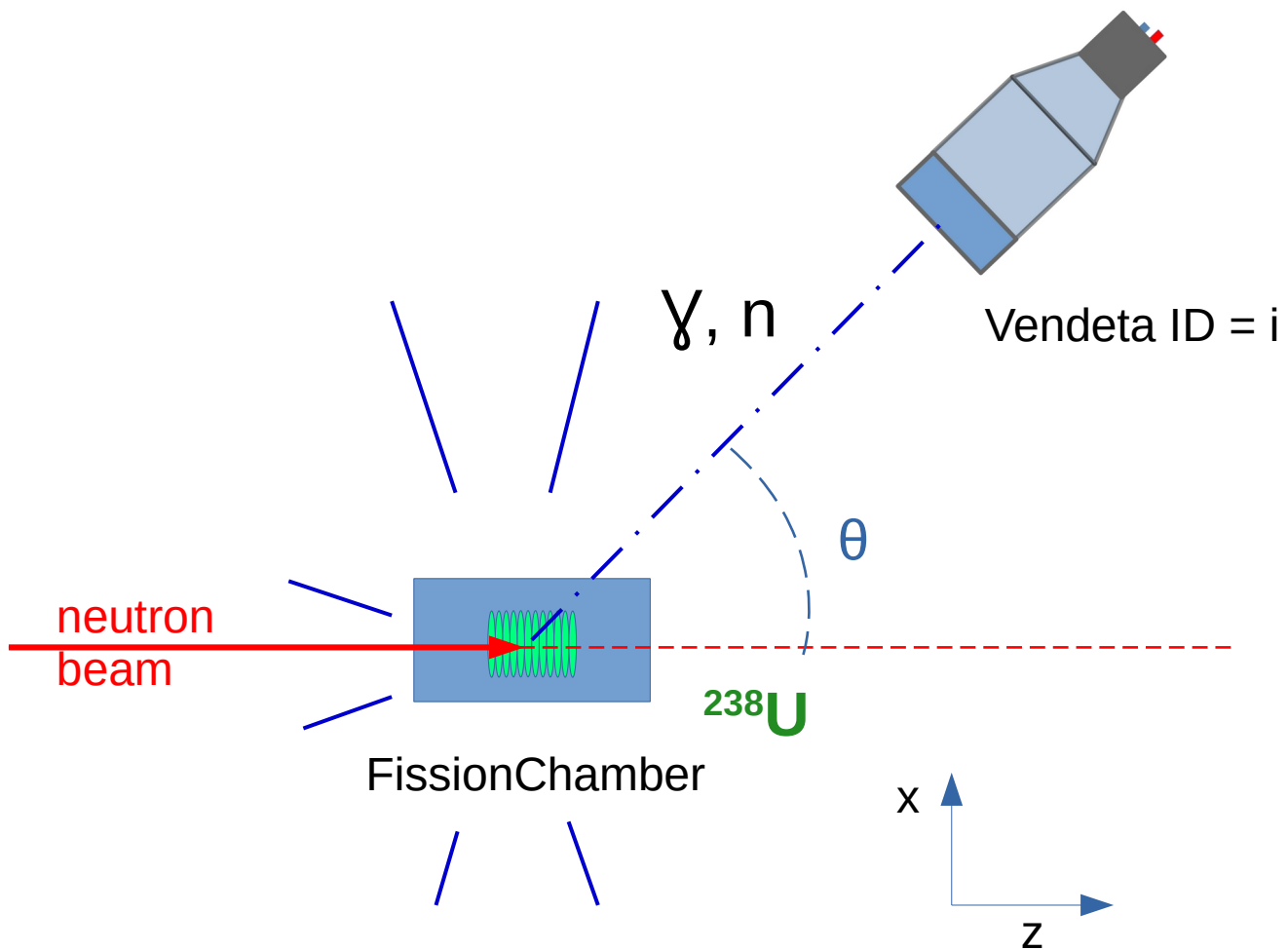
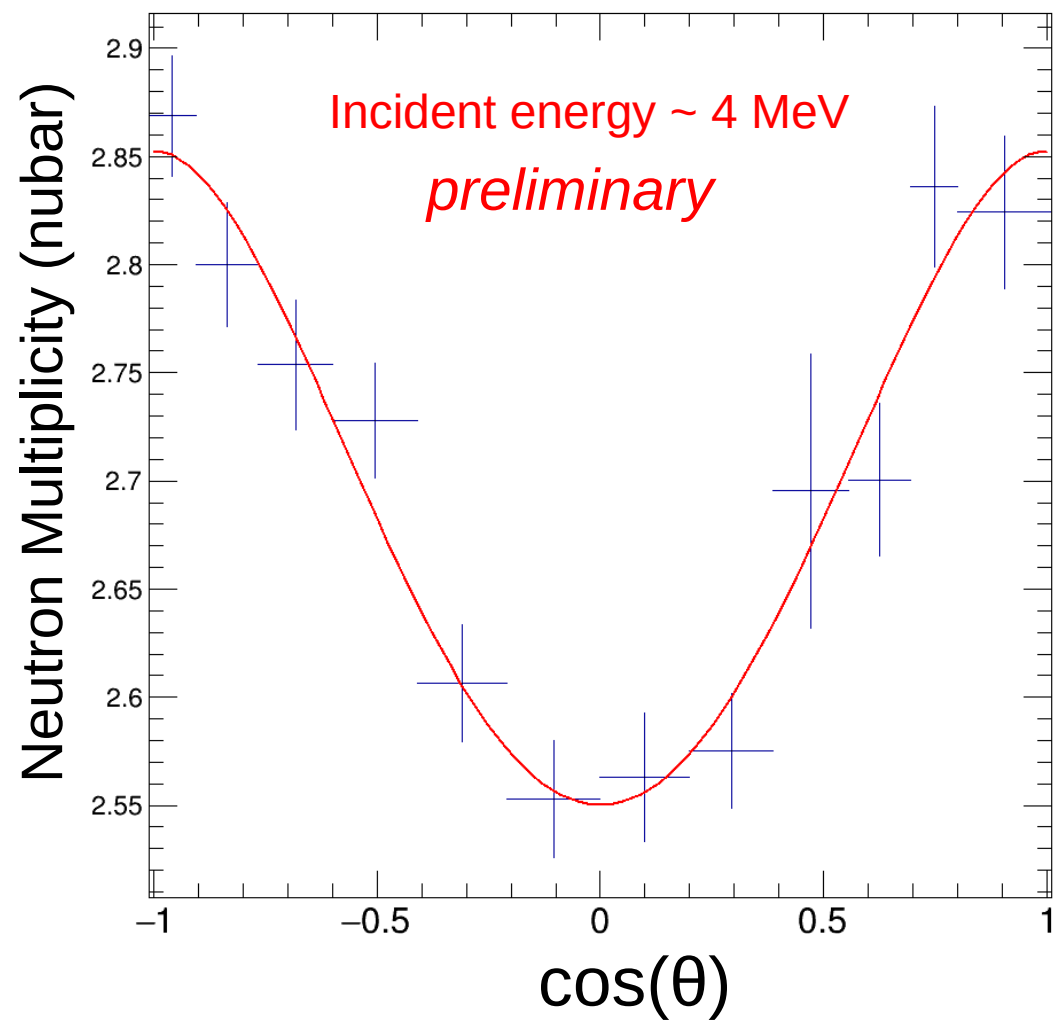


VENETA performances: discrimination neutron / gamma

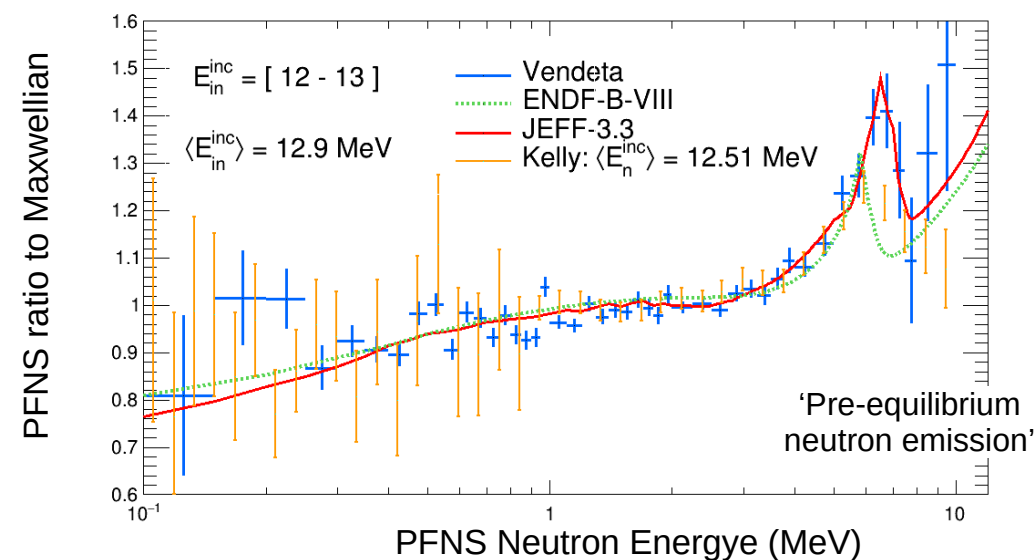
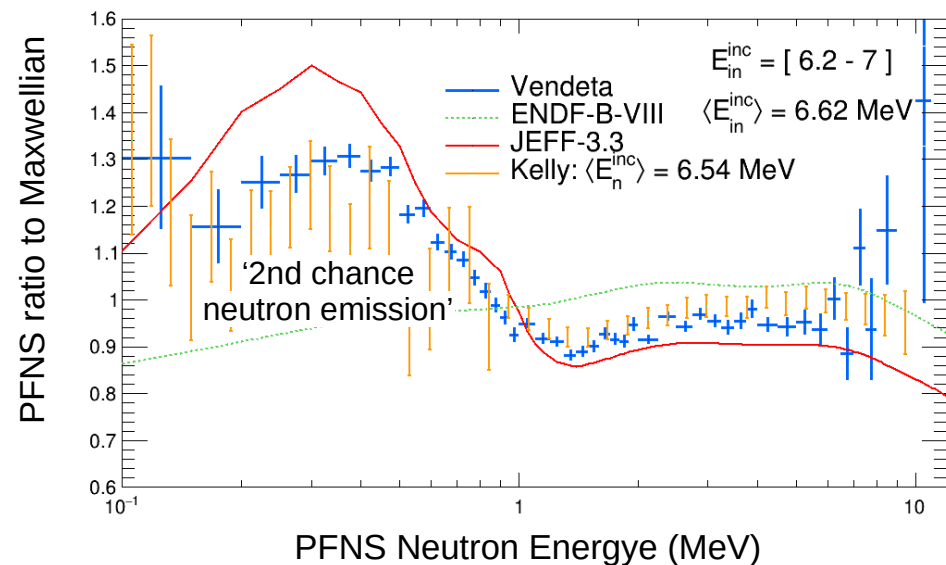
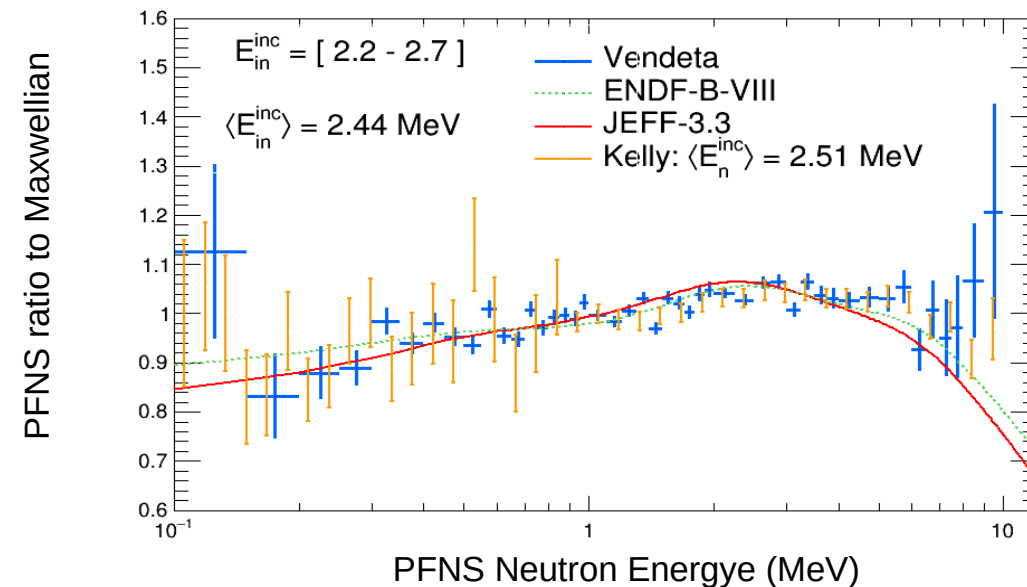
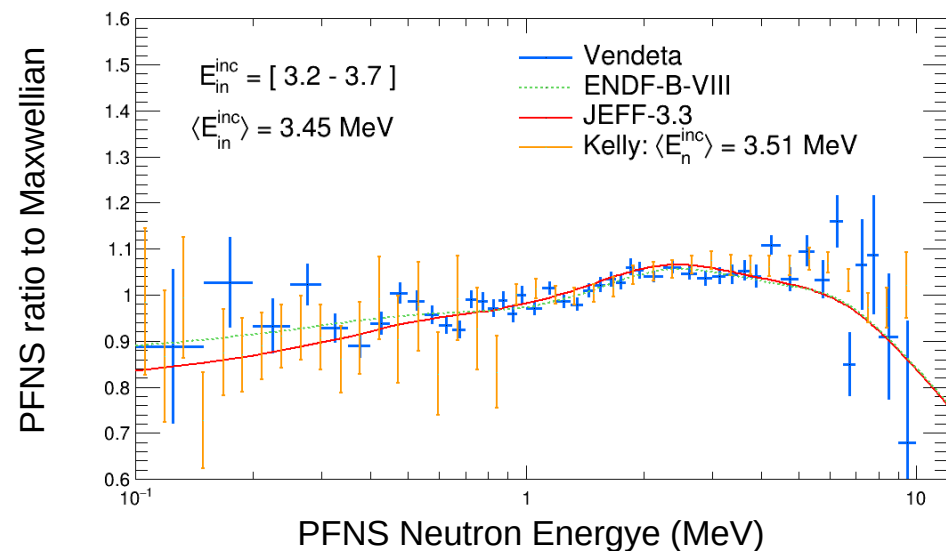
VENETA signals



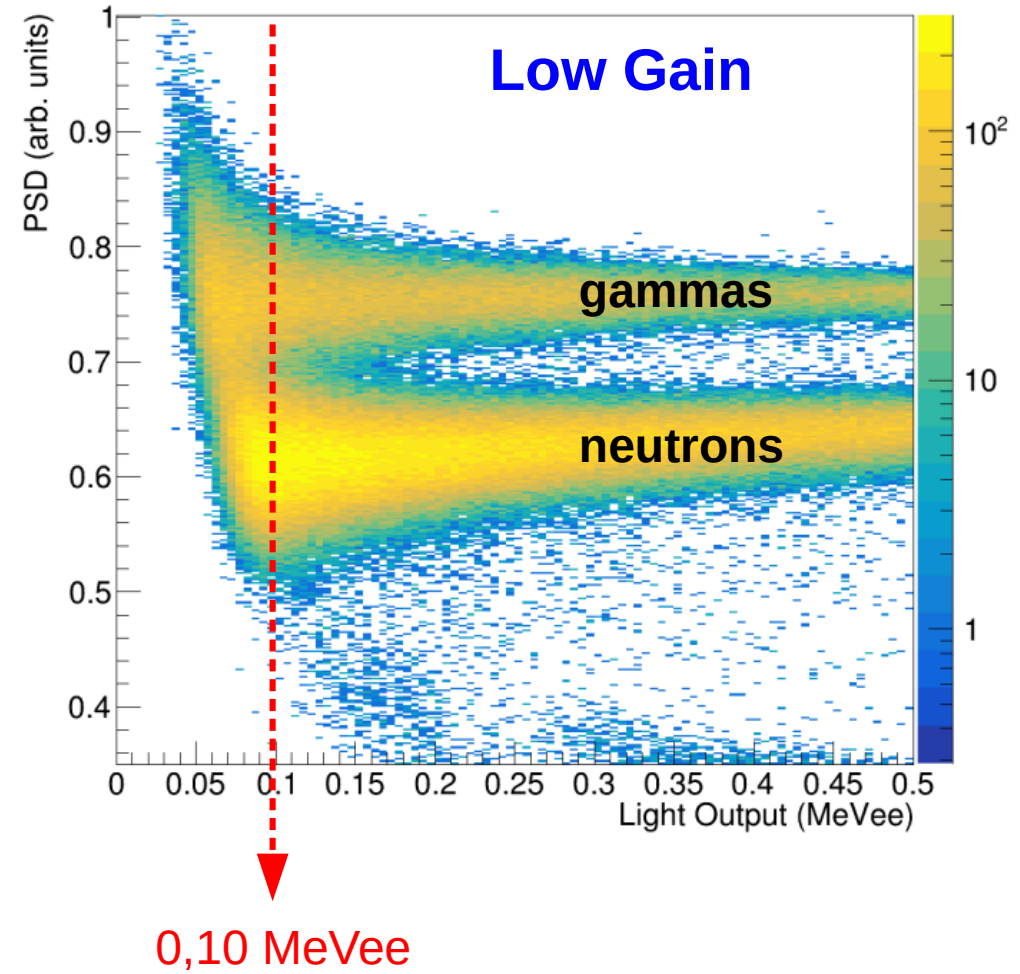
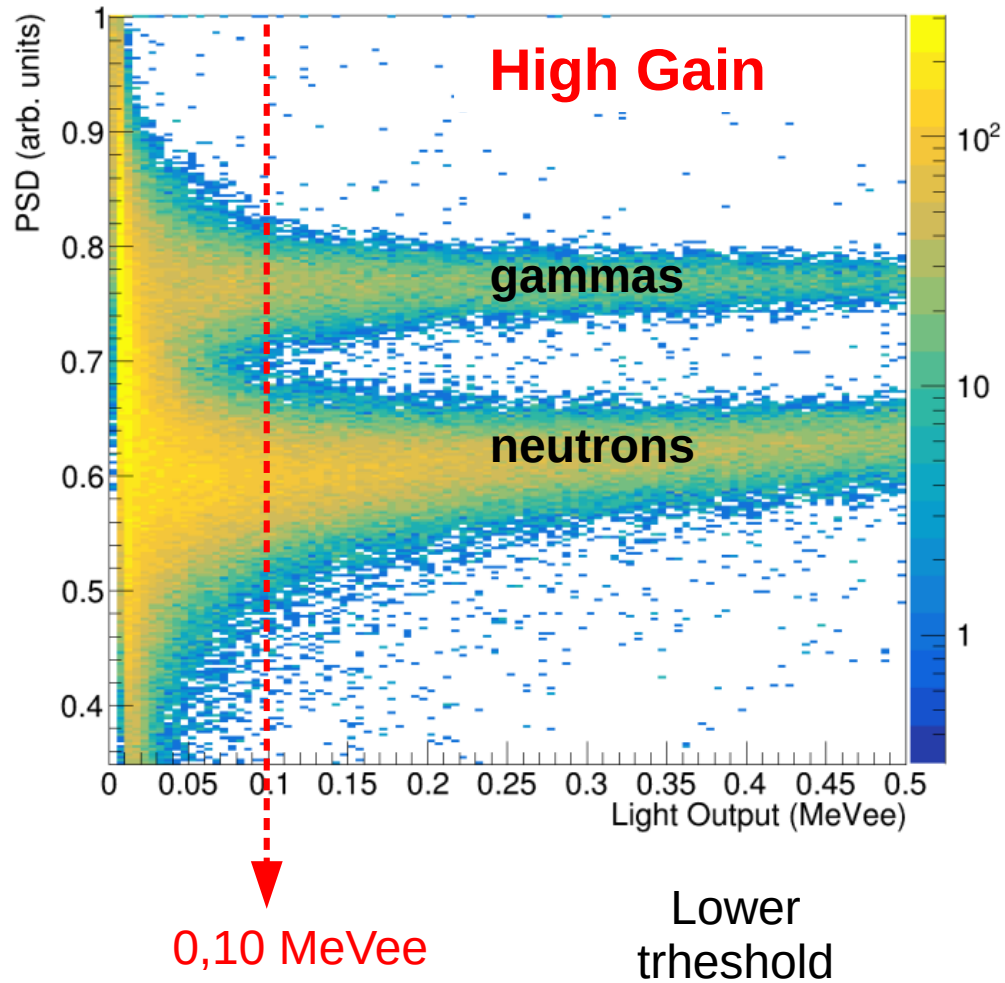
Results: Neutron Angular distribution



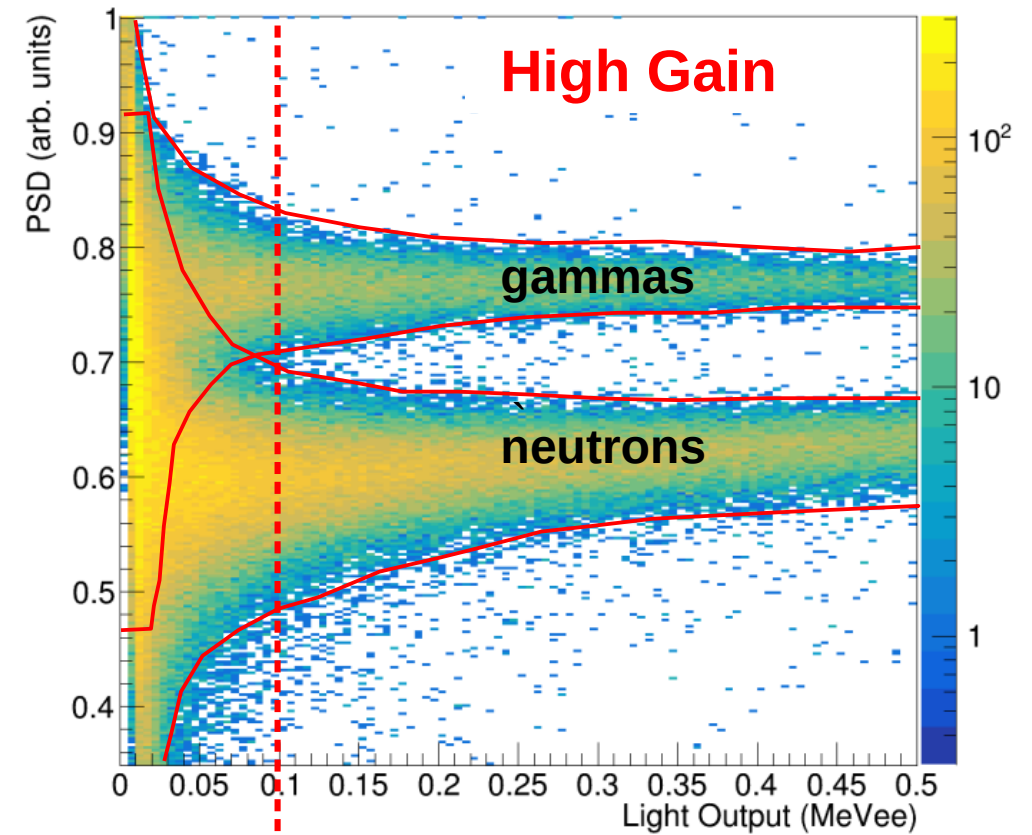
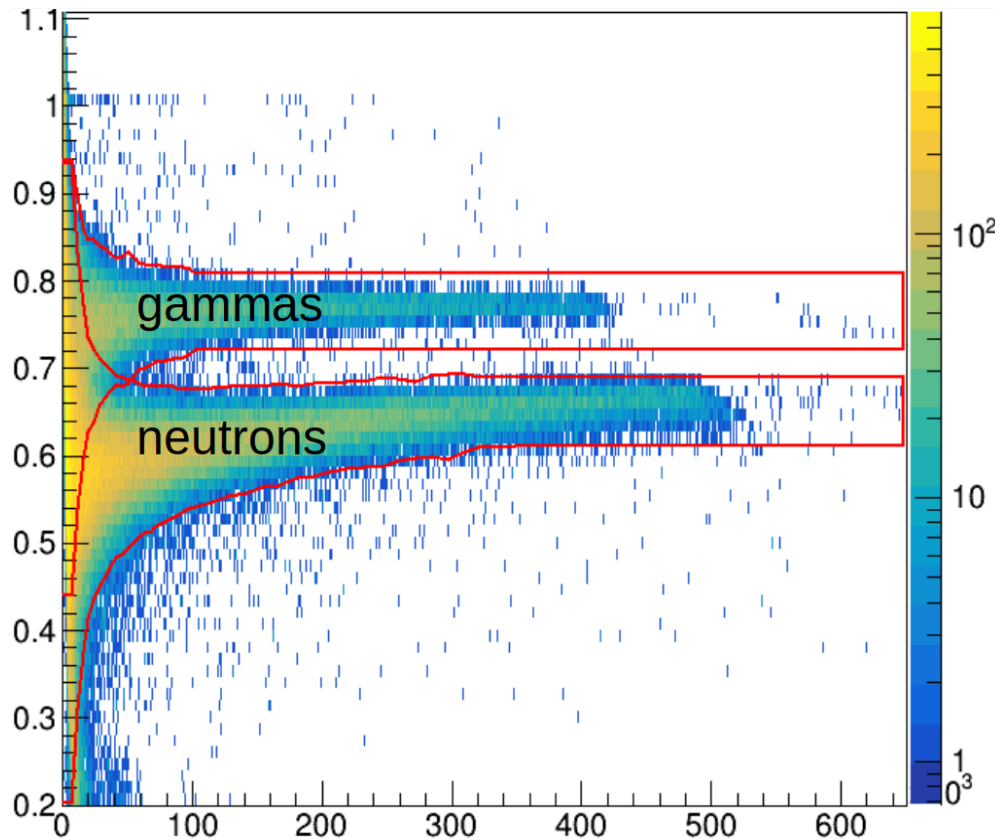
Results : PFNS $^{238}\text{U}(n,f)$



VENETA performances: discrimination neutron / gamma



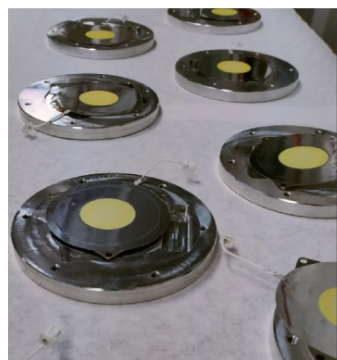
VENETA performances: discrimination neutron / gamma



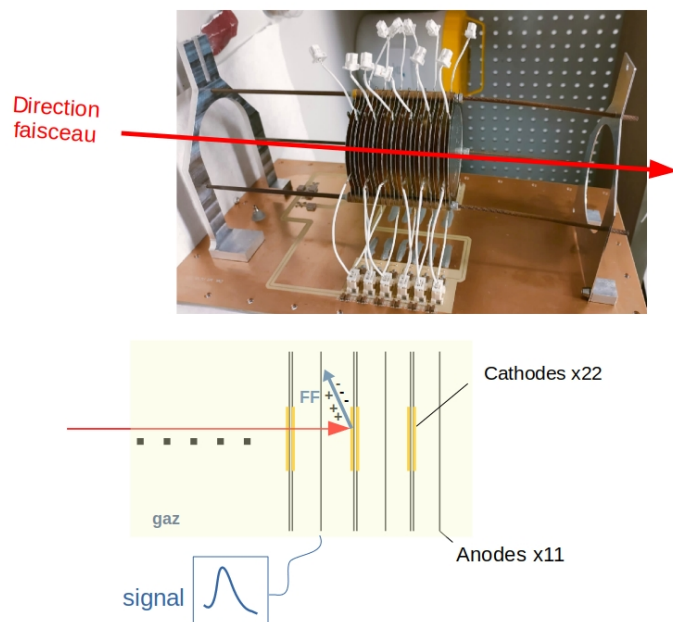
0,10 MeVee

Dispositif expérimental

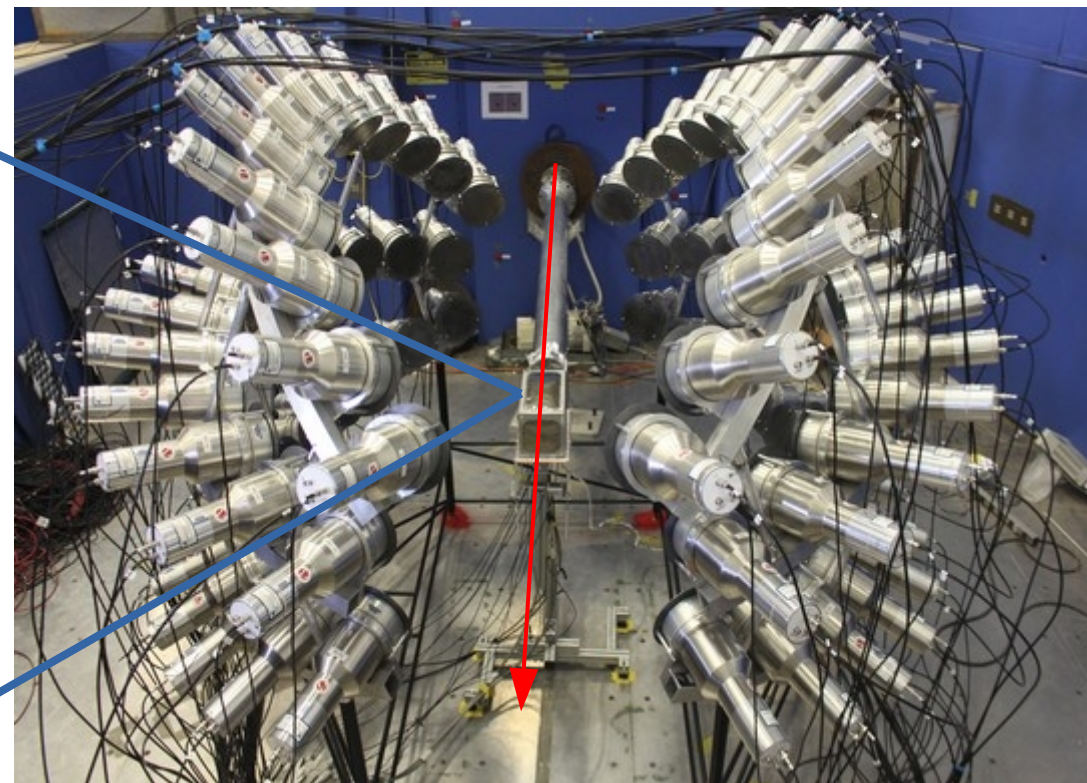
Fission Chamber



Cibles d'U238

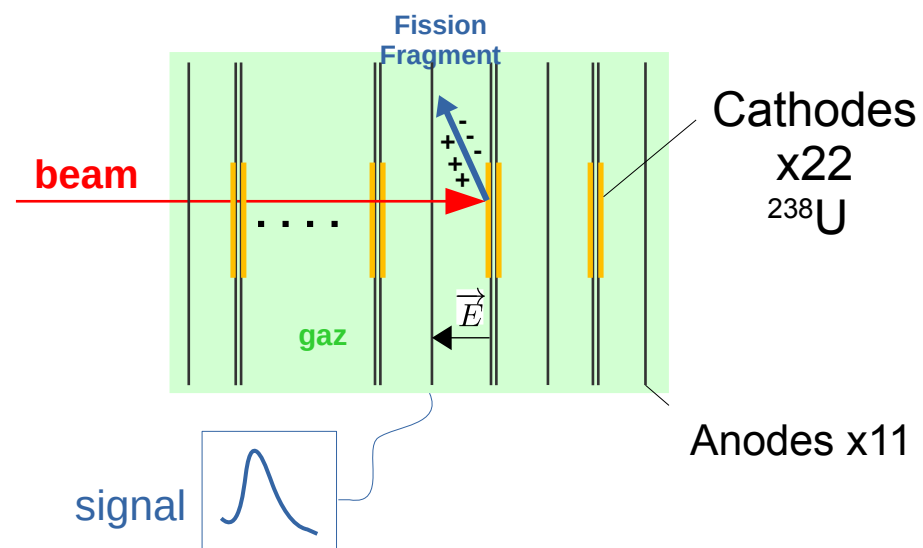
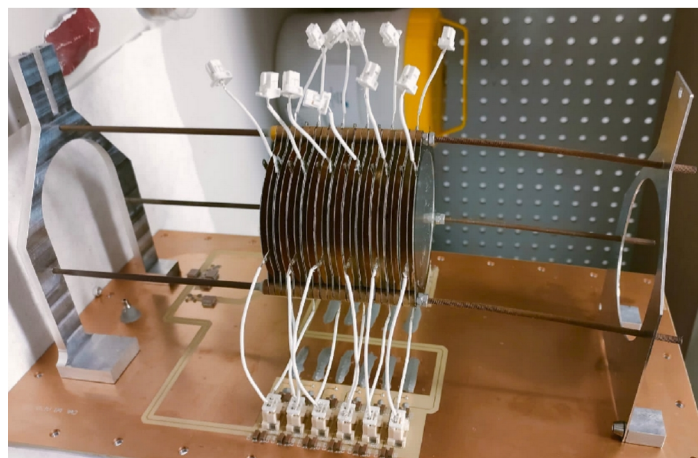
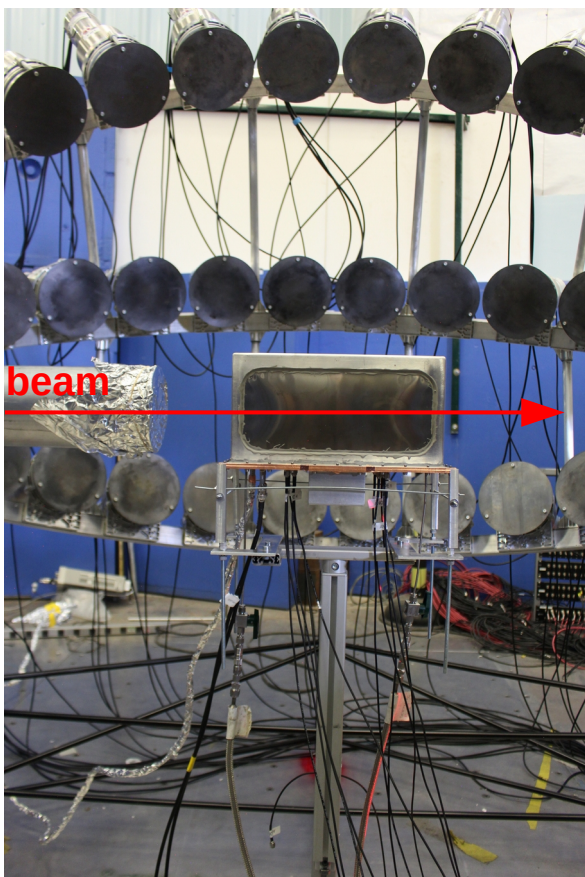


VENETA

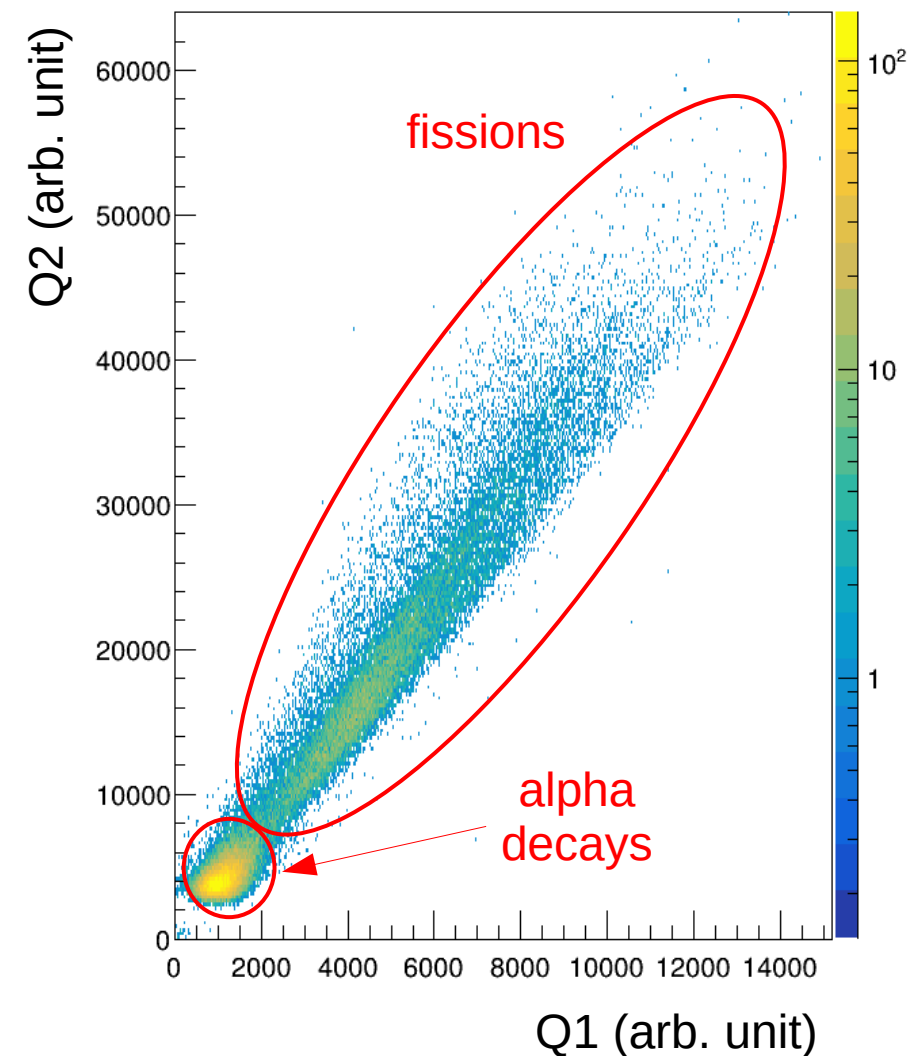


Fission Chamber

'We detect the fission fragment'



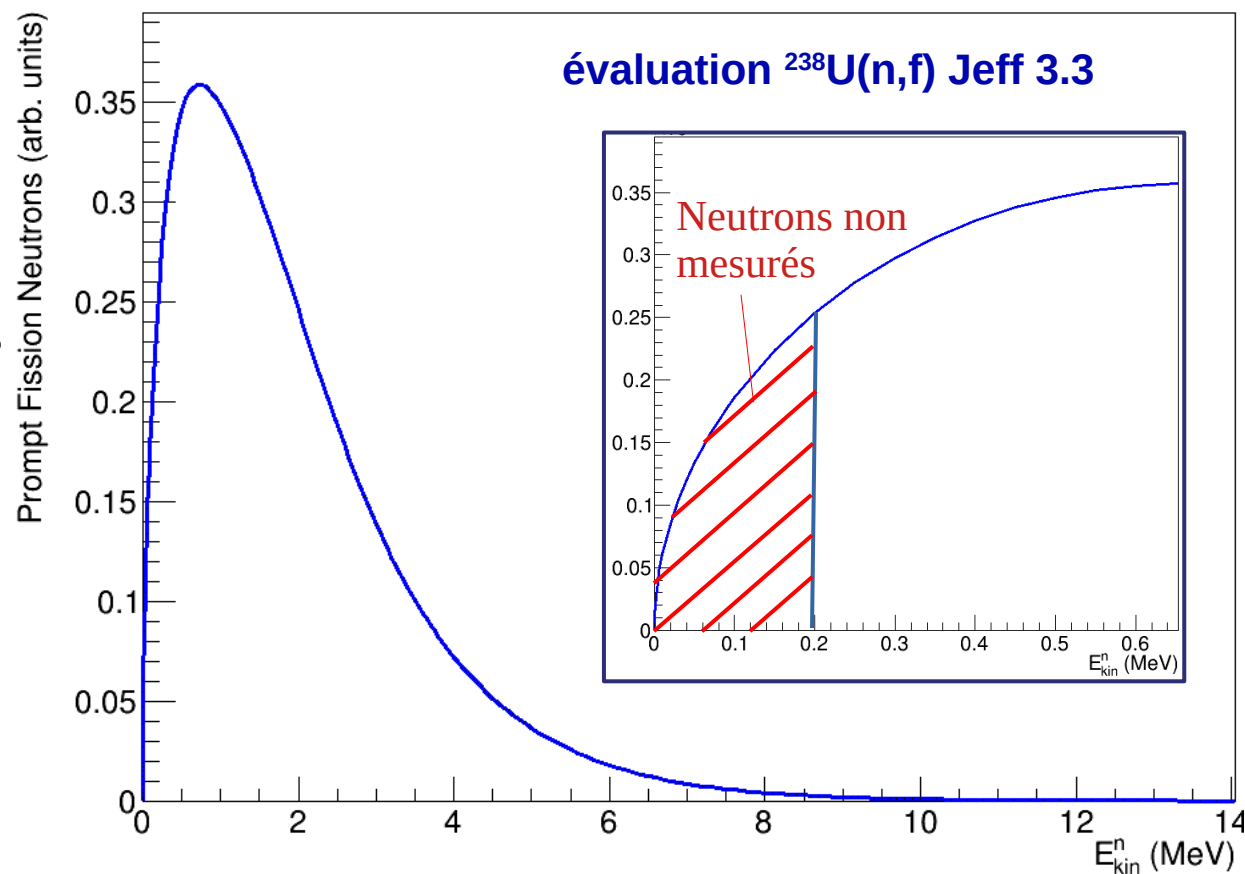
Pulse shape analysis



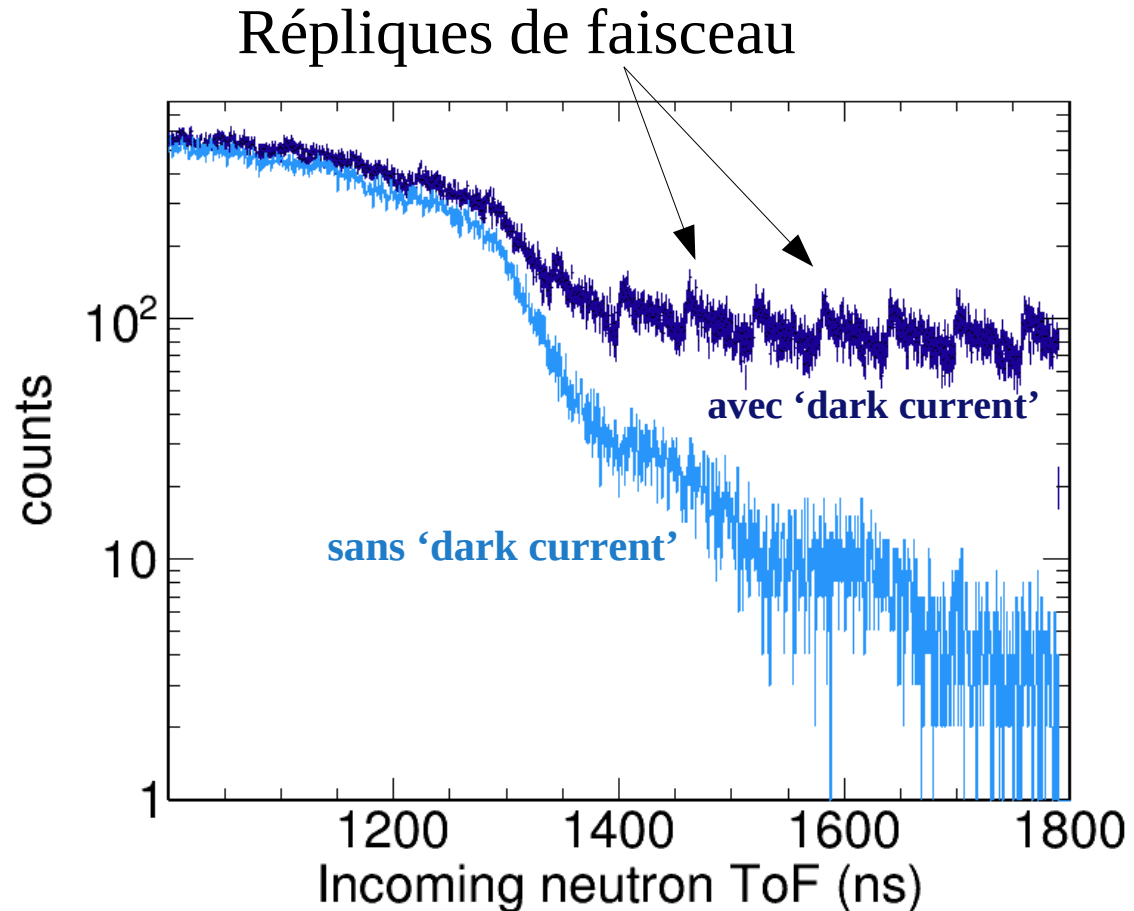
Seuil en énergie à partir duquel un neutron peut être détecté et traité

Forme d'un PFNS ^{238}U

- Exemple d'un seuil à 0.2 MeV
- 4 % des neutrons non mesurés
- Fort impact sur la précision du nubar

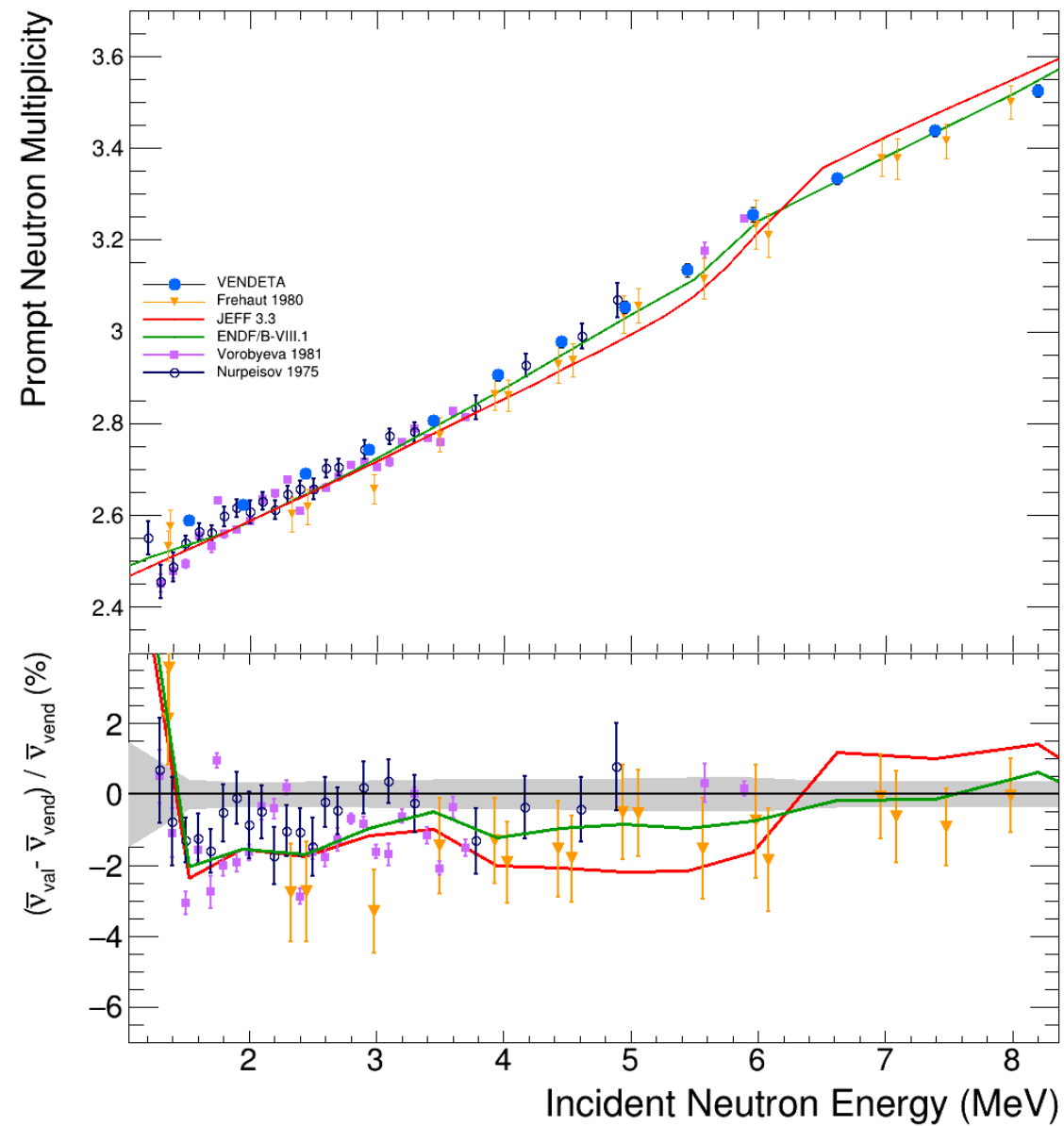
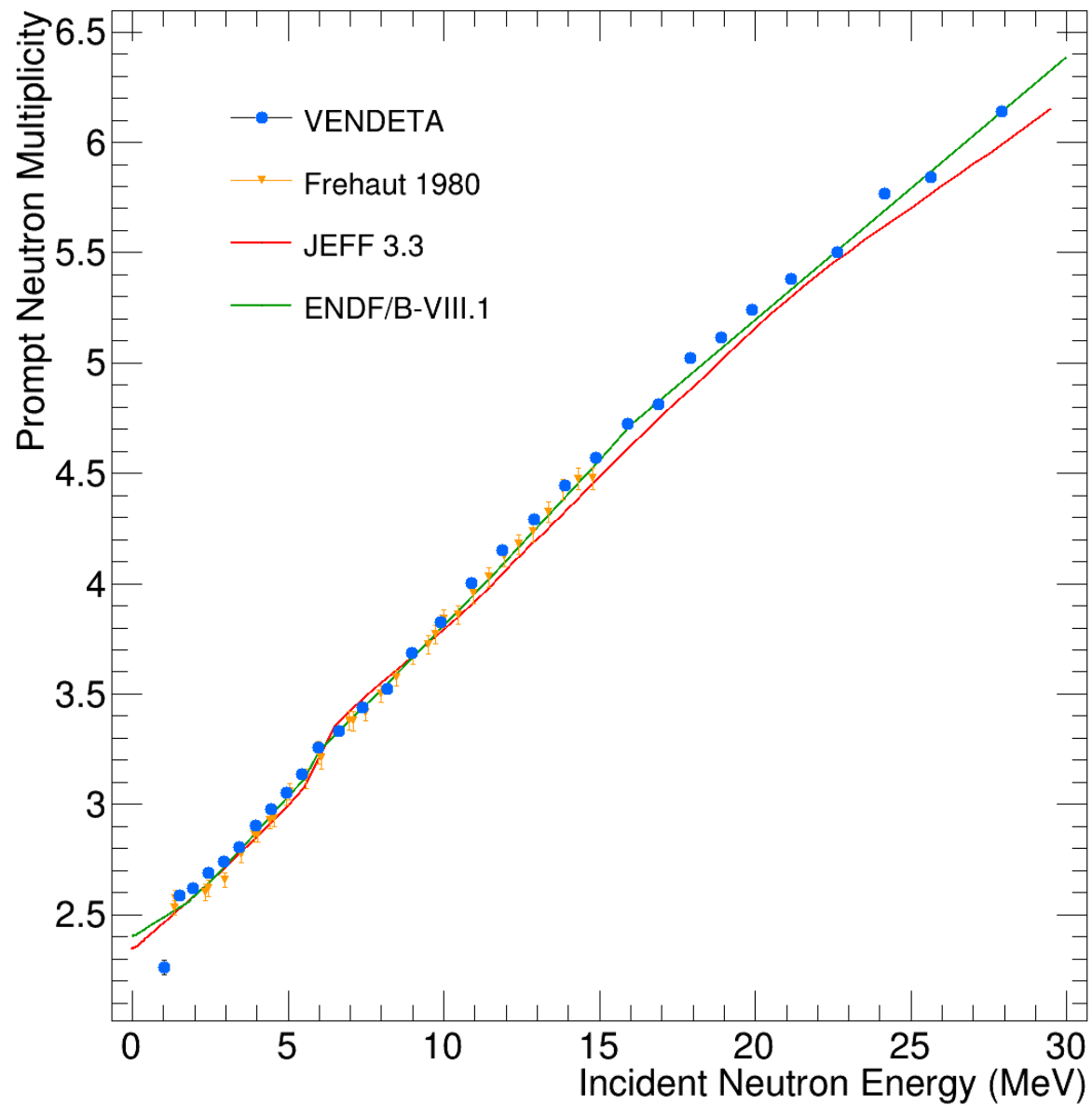


Résultats préliminaires de l'analyse de l' ^{235}U



Un problème d'accélérateur :

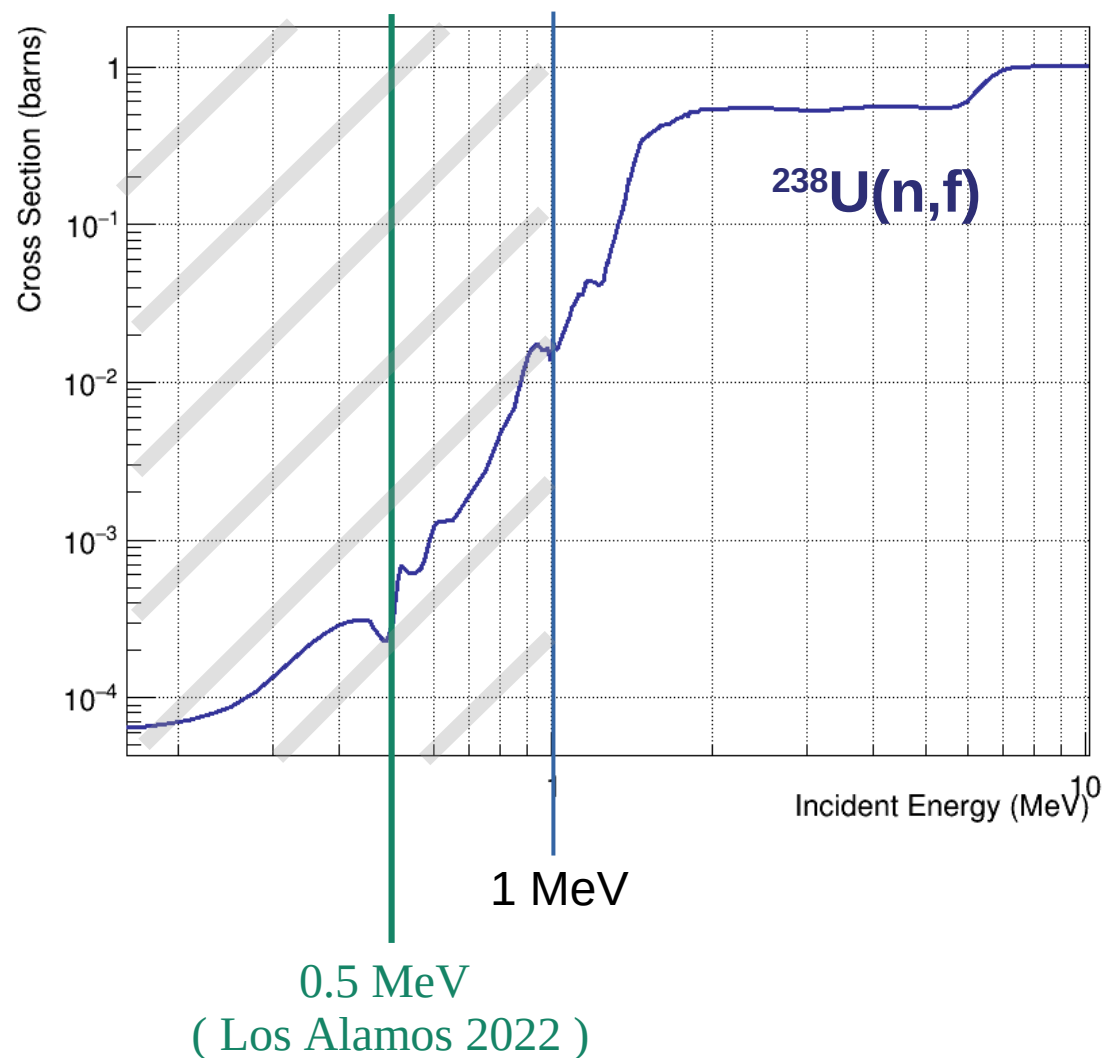
- Pollution de faisceau relicat sur l'ensemble des énergies incidentes
- En partie supprimé durant l'expérience
- Fort impact à basse énergie incidente
- Un défis supplémentaire
- Méthode de correction en cours de test sur les données ^{235}U



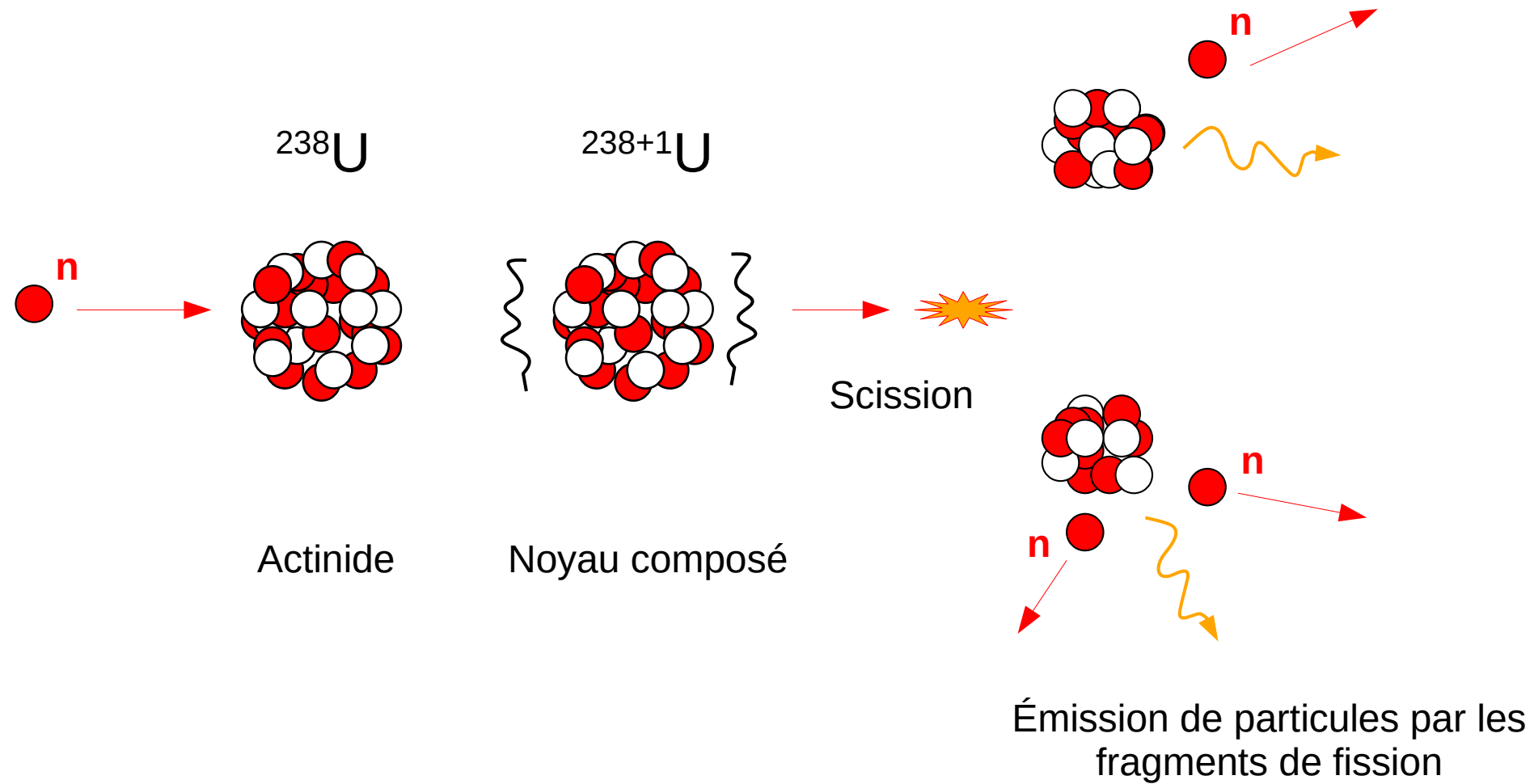
La mesure de PFNS pour l' ^{238}U

Section efficace $^{238}\text{U}(n,f)$ en fonction de l'énergie incidente

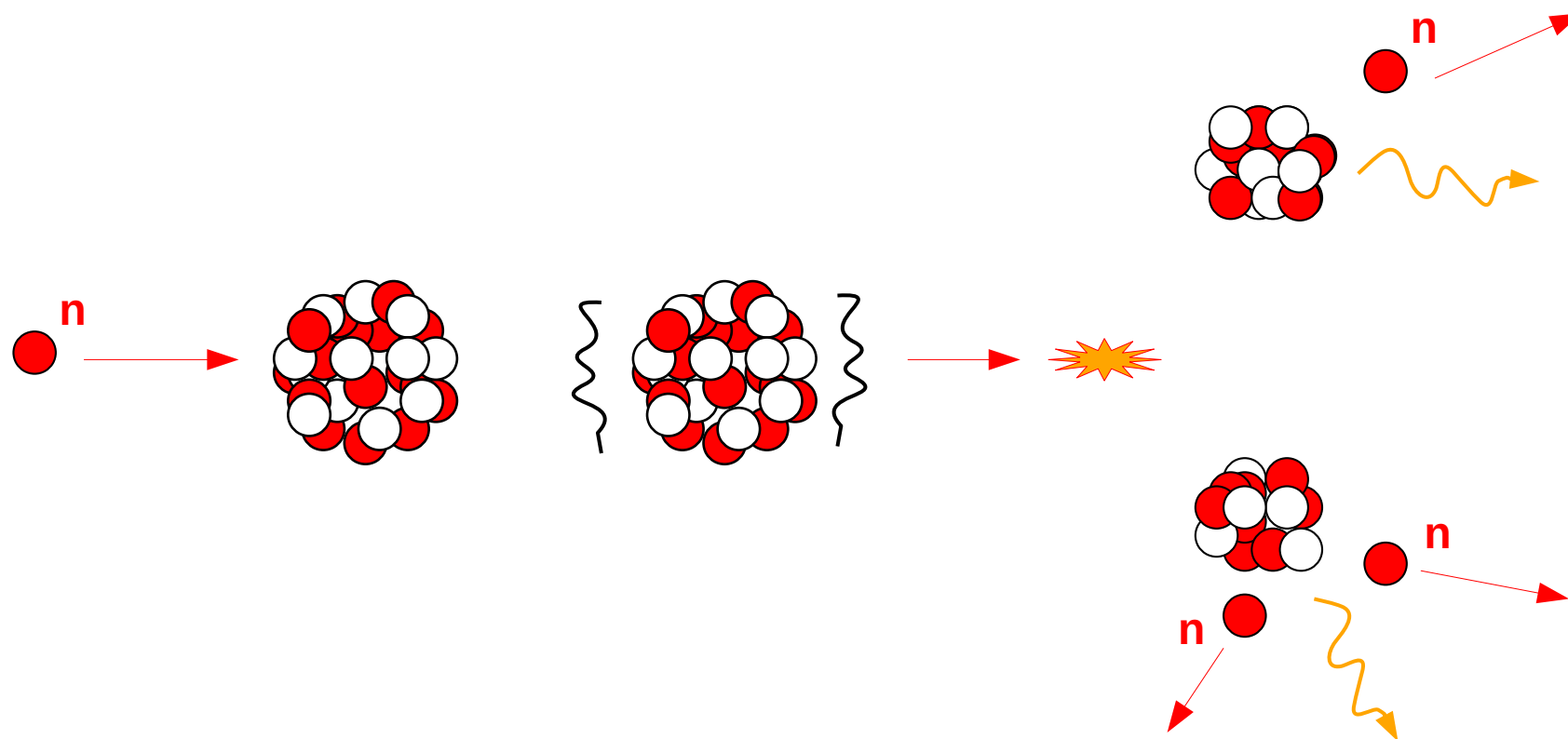
- Très peu de données sur l' ^{238}U
- Aucune mesure < 1 MeV
 - Chute de section efficace à basse énergie
 - Défi expérimental



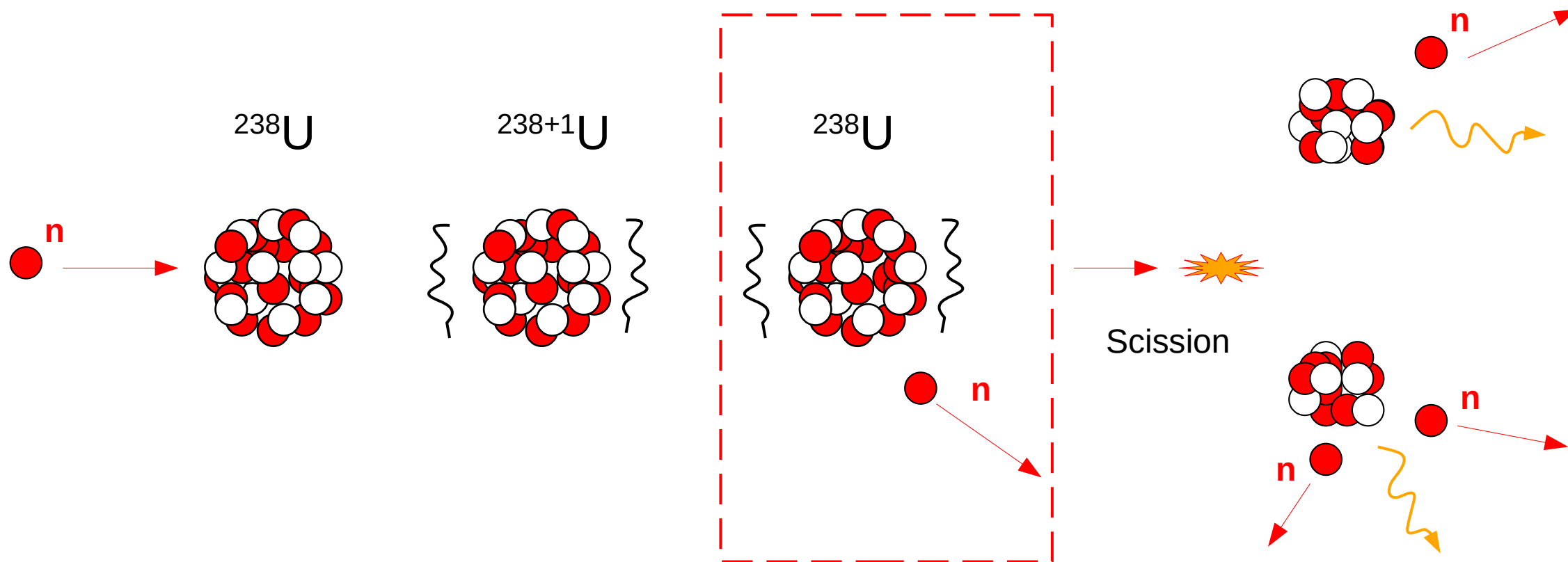
La Fission induite par neutron



La Fission induite par neutron



La Fission de 2^{ème} chance



La Fission de 2^{ème} chance

