Sensitivity study of neutron flux with beam position for EAR2

J. Balibrea-Correa, J. Pavon-Rodriguez,F. Garcia-Infantes, M. Sabaté-Gilarte,V. Vlachoudis, V. Babiano-Suarez,
J. Lerendegui-Marco, C. Domingo-Pardo, I. Ladarescu, A. Tarifeño-Saldivia

European Research Council
MINISTERIO DE CIENCIA E INNOVACIÓN
Financiado por la Unión Europea NextGenerationEU
Plan de Recuperación, Transformación y Resiliencia
AGENCIA ESTATAL DE INVESTIGACIÓN

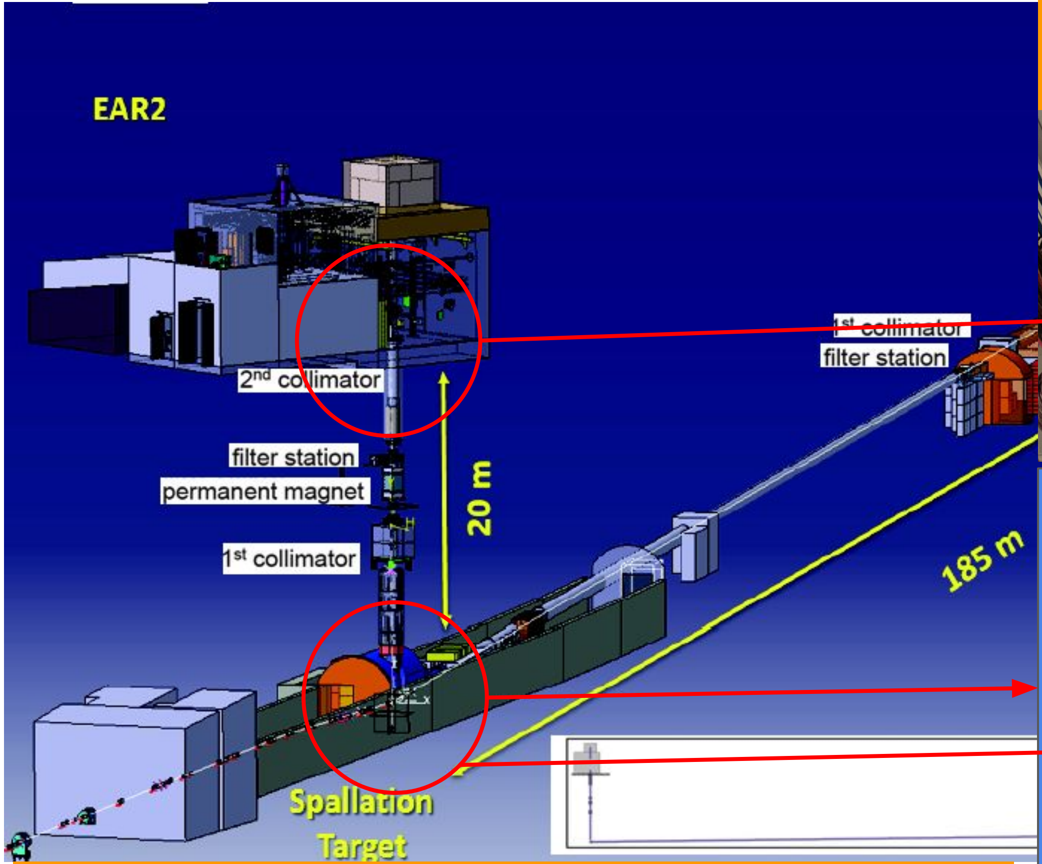
nTOF

VNIVERSITAT DE VALÈNCIA
CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

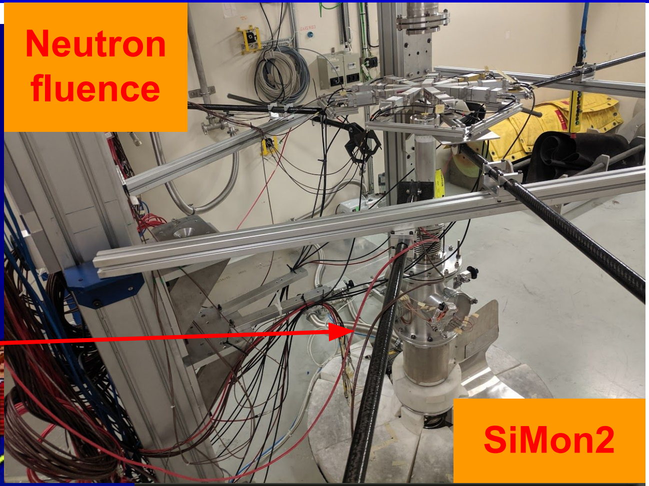
Outline

- Proton & neutron beam monitors at n_TOF
- Neutron & proton monitors correlation
- Results
- Summary & Conclusions

Beam monitors @ n_TOF

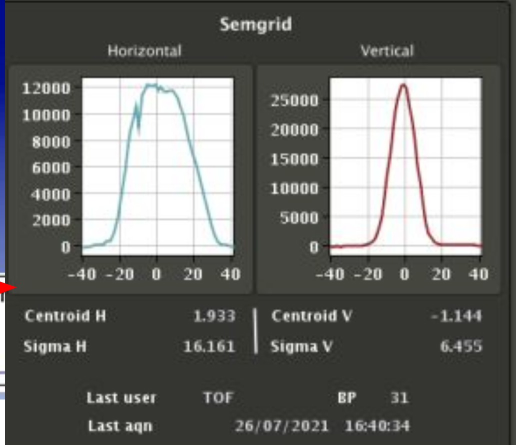


Neutron fluence



SiMon2

BCT



Proton intensity, position & size bunch by bunch

n_TOF beam monitors information

Do we need to include TIMBER data in the ROOTFILES? (Not an easy task!)

Thus, for individual pulses we have information from:

- Proton beam monitors:
  - Proton Pulse intensity (BCT)
  - Proton Pulse position (SEMGRID)
  - Proton Pulse spatial width (SEMGRID)

I_i , x_i , y_i , σ_{ix} , σ_{iy}

Data in TIMBER

- Neutron beam monitors:
  - Counts registered by detector monitor (SiMon)

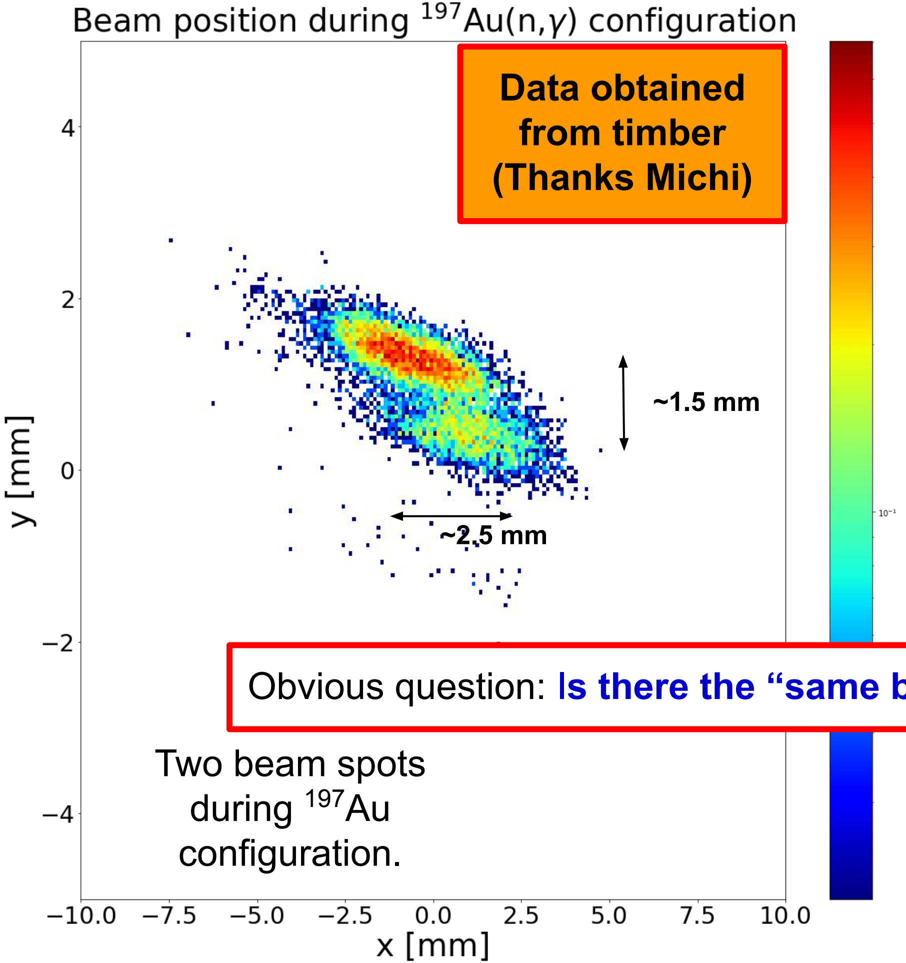
$c_i(En)$

Data in ROOTFILES

During the commissioning there was a **impact point sensitivity study** to set operation margins for PS:

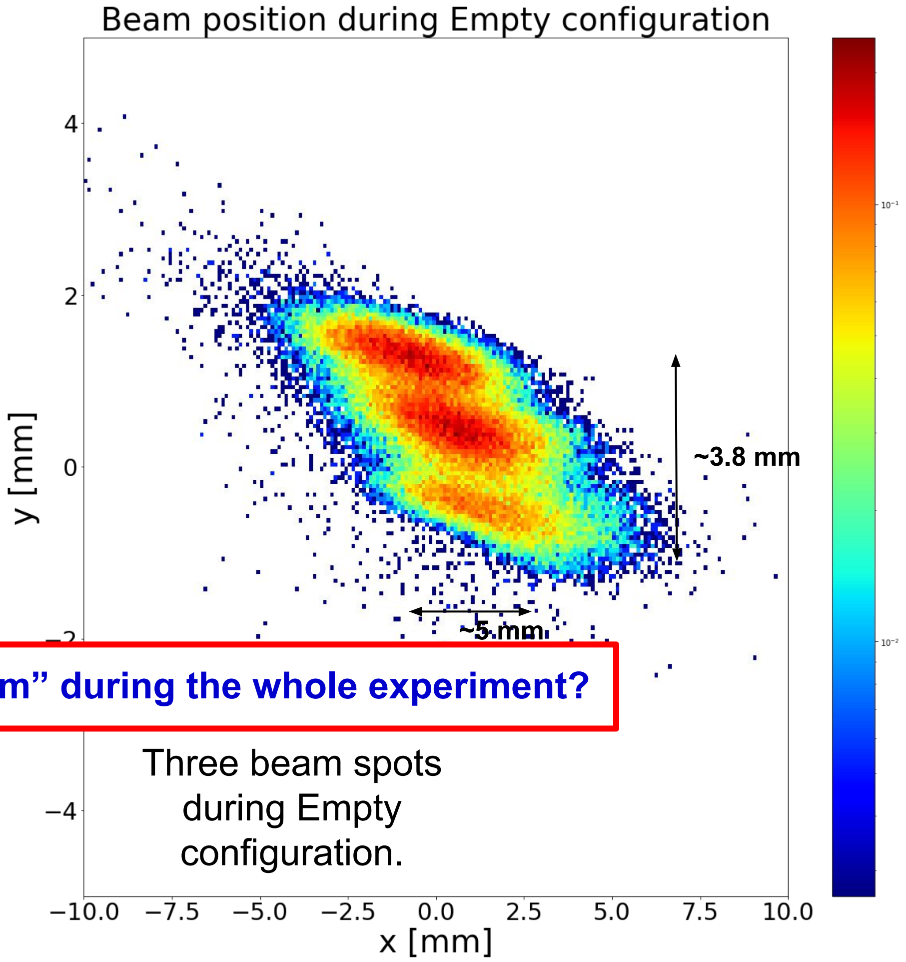
- **+/- 10 mm** in the **x-axis**
- **+/- 3 mm** in the **y-axis**
- If **3 high intensity** pulses in a row **out** of the margins →**Interlock**

Beam spots during ^{94}Nb campaign



Data obtained from timber (Thanks Michi)

Two beam spots during ^{197}Au configuration.



Three beam spots during Empty configuration.

Obvious question: **Is there the "same beam" during the whole experiment?**

Data & model for monitoring

Combined **SEMGRID** data from Timber and **SILI** from ROOTFILES **bunch by bunch** for **~80000 dedicated proton pulses**:

BCT	**Counts SILI $E_{th}<E_n<$ 10 keV**				**SEMGRID information**			
Intensity/10^{12}	c_1	c_2	c_3	c_4	x	y	σ_x	σ_y
8.212580	139.0	171.0	126.0	168.0	0.062085	1.259025	39.078119	13.186662
8.245336	165.0	173.0	133.0	161.0	1.787825	1.193445	32.111586	13.226895
8.232977	166.0	147.0	162.0	175.0	1.068300	1.304377	34.252768	13.200376
8.225536	156.0	150.0	146.0	160.0	0.909891	1.040212	29.437202	13.223696
8.217737	168.0	150.0	171.0	162.0	0.245381	1.213969	30.466211	13.142971

Amplitude corrected by gain drift

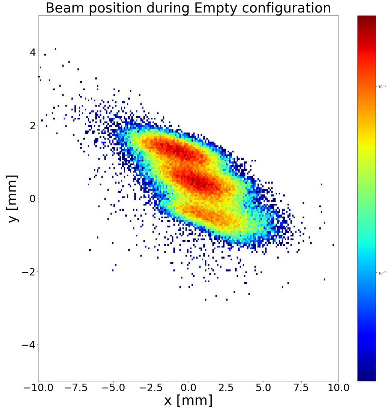
Simplest data modelling of c_i:

- It is dominated by the number of protons (α_P).
- Corrections because of the impact position x and y (α_x,α_y).

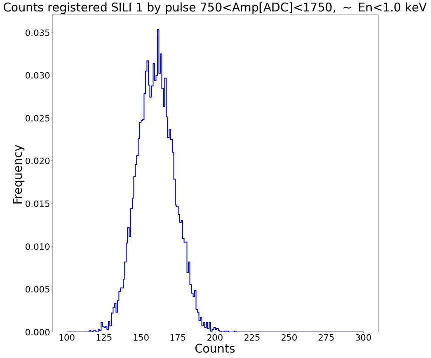
$$c_i \sim Poisson\left(\mu_i = N_{p,i} \cdot \alpha_P + \alpha_x \cdot x_i + \alpha_y \cdot y_i\right)$$

Likelihood function for experimental data

SEMGRID



SIMON2



Results from fitting procedure

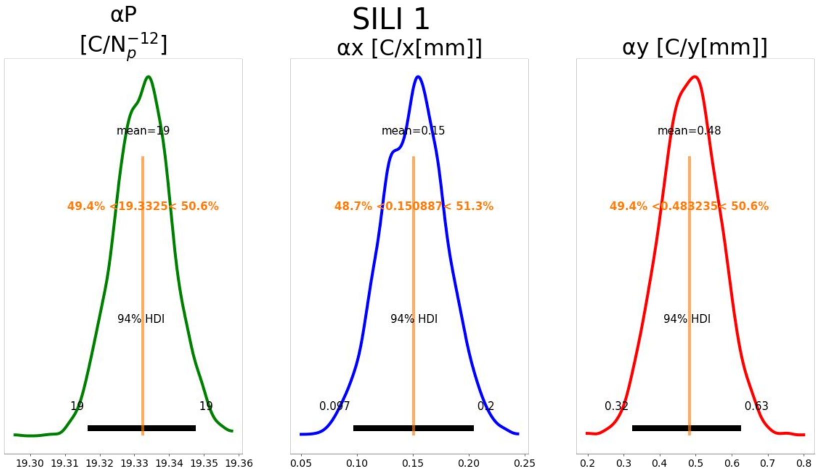
P(model|data) calculation made using PyMC3 library:

- Markov Chain Monte Carlo (MCMC).
- Similar library to RooFit but based in theano.
- Relaxed prior $\alpha_P \in [0,50]$ $\alpha_x, \alpha_y \in [-50,50]$

Absolute values of the different parameters for neutron energy range: $E_{th} < E_n < 10$ keV:

SILI	α_P[1/10^{12}p]	α_x[1/mm]	α_y[1/mm]
1	19.332(8)	0.15(3)	0.48(8)
2	19.426(8)	0.18(3)	0.58(8)
3	18.586(8)	0.19(3)	0.60(8)
4	19.253(8)	0.14(3)	0.58(8)

Marginal distributions after minimization process



Results from fitting procedure

Integrated neutron flux in the neutron energy from 0.01 eV range up to 1 keV seems to be sensitive to both axis of the proton beam:

- **~0.35%/mm** in **y**-axis →Compatible with prev. studies
- **~0.12%/mm** in **x**-axis

This work is **compatible** with **Exp. Sensitivity & MC** simulations shown by **J. A. Pavon & F. Garcia-Infantes**

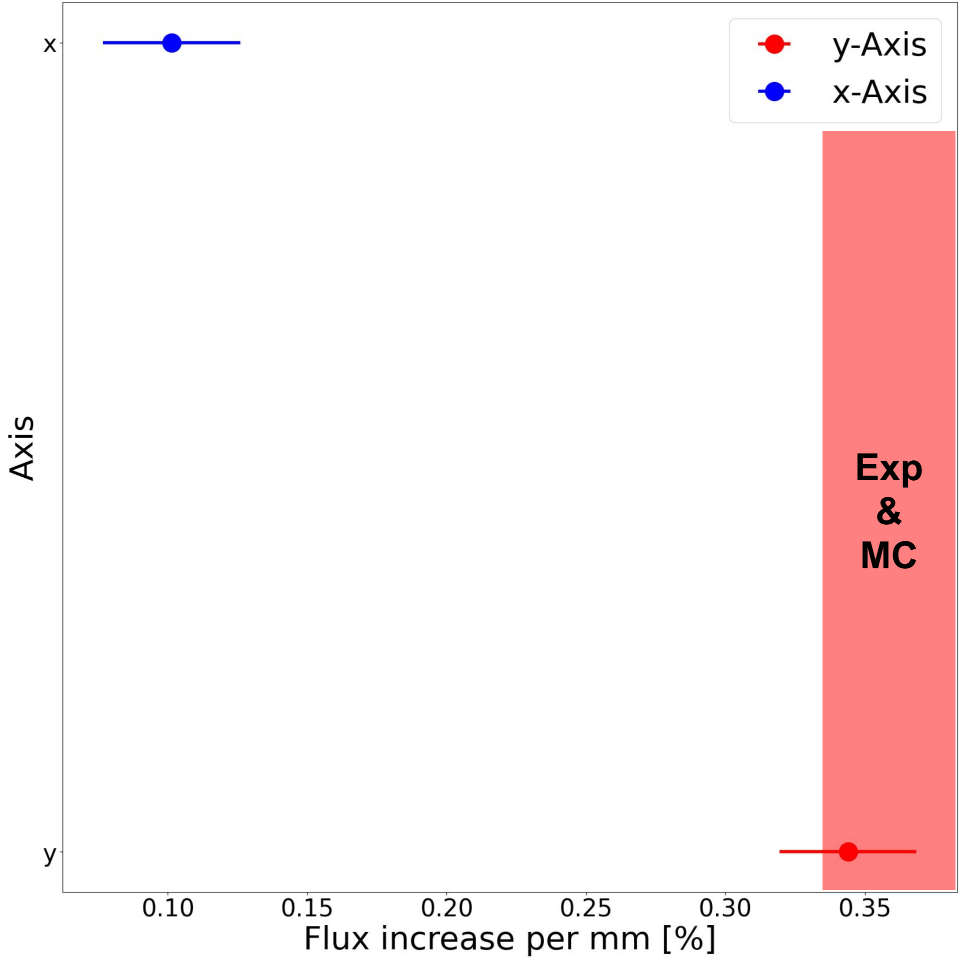
Using **only safety margin** we end-up with **usual ~3% uncertainty** associated to the **beam monitors**

⇓

Normalization between **configurations (3%)** →**Wash out/Confuse** with **other systematics**

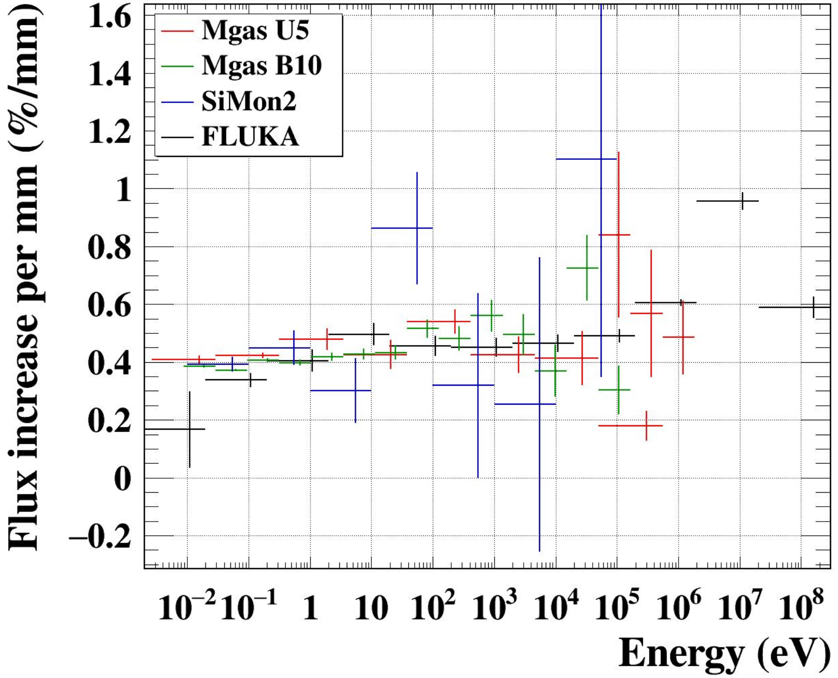
⇓

Can we do better including beam position given by SEMGRID?

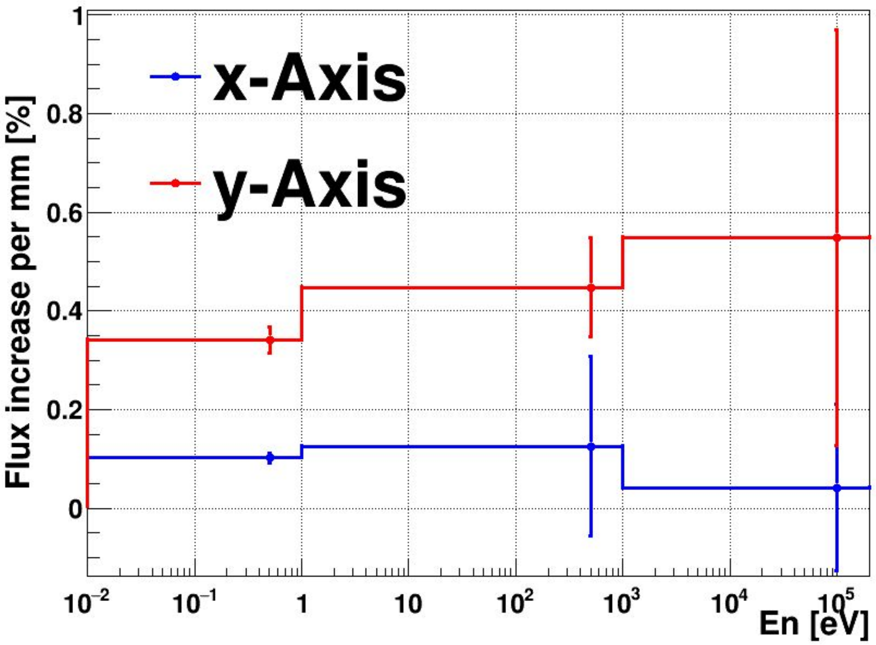


Results as a function of E_n

Courtesy of
J. A Pavon & F. Garcia-Infantes.



This work



Results as a function of E_n:

- **Consistent** results in y-axis **with dedicated** sensitivity **measurement & MC**
- **Might be problematic** for **flux & background** subtraction **depending** on the **number** of **beam spots** during the **experiment!**

Summary and conclusions

- **All beam monitors** should be used in the **analysis**:
  - **Better control** of beam position during analysis might reduce **associated systematics to beam.**
  - **Combine TIMBER** and **ROOTFILES it is not an easy task** as it is →XNCALS might delay data processing.

- The results from **this work** are in **agreement** with previous **dedicated sensitivity analysis**:
  - **~0.35%/mm** in **y**-axis →Consistent with prev. studies
  - **~0.12%/mm** in **x**-axis →Not reported

$0.01 < E_n$ [eV] < 1 keV

- The results from **this work** are in **agreement** with **MC** simulations made by **J. A. Pavon & F. Garcia-Infantes.**

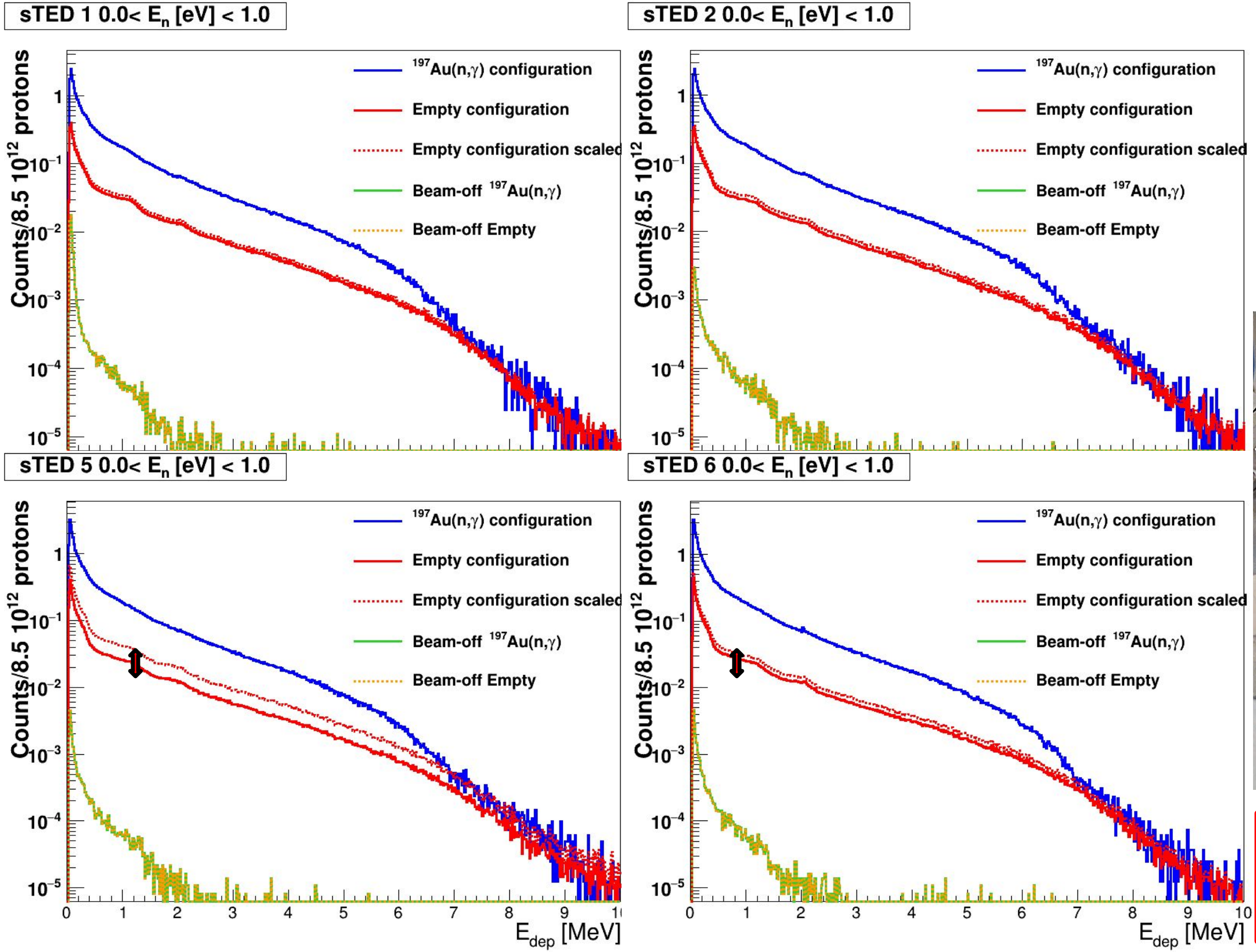
- The neutron **flux shape** depends on the **proton beam spot**:
  - **Might be problematic** for **normalization**
  - **Background** subtraction
  - Do we have an **effect** on the **neutron** beam **spot position**?

- I think it would be a **very good idea** to use a **neutron imaging system** and perform the same type of analysis:
  - Beam spot at different **position**? →**Better understanding** of the **neutron flux** in **EAR2**
  - Different **size**? →**Better understanding** for **small samples**, (n,ɣ) experiments

Thank for your attention!

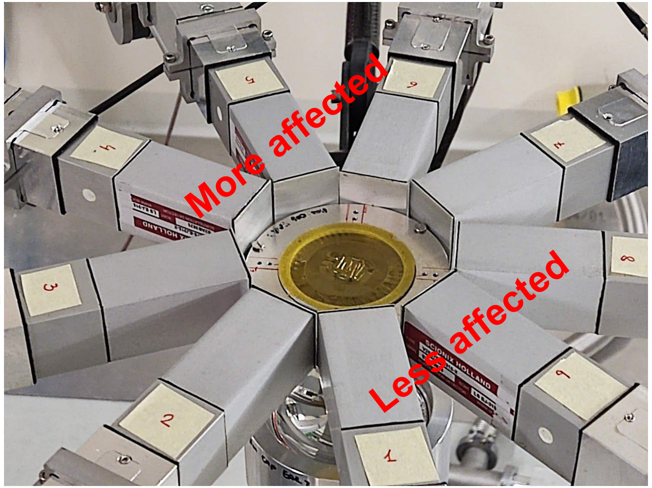
Backup

Gold configuration ^{94}Nb campaign



^{94}Nb campaign:

- Comparison between **^{197}Au** (signal) and **Empty** configurations (background) @ 0.01< En[eV] < 1.
- It depends on the sTED?



Is there any relationship with the beam position?