(n, $_x$n γ) measurements: interests and prospects at the Neutrons For Science facility.

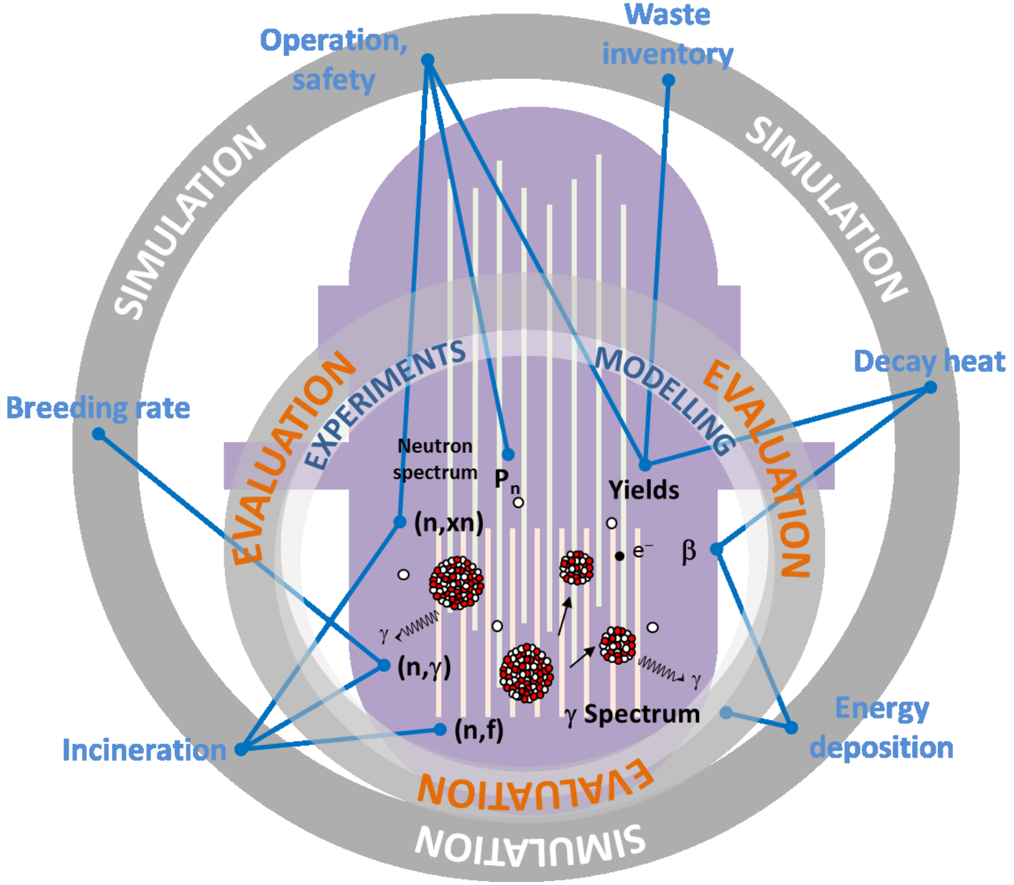
Nuclear Data for applications.

The case of fission reactors.

Nuclear reactor simulations are based on evaluated nuclear data which allow the full description of all involved reactions.

- Neutron energy: from 0.025 eV to a few 10 MeV
- Elements: Z from 1 to 98 (and above)
- Reactions: (n,f), (n,g), (n,*cp*), (n,*xn*), …
- Reaction products : n, g, e^-,*cp*, PF

Comprehensive description by simulations of such a complex system is not possible with just the experimental data.

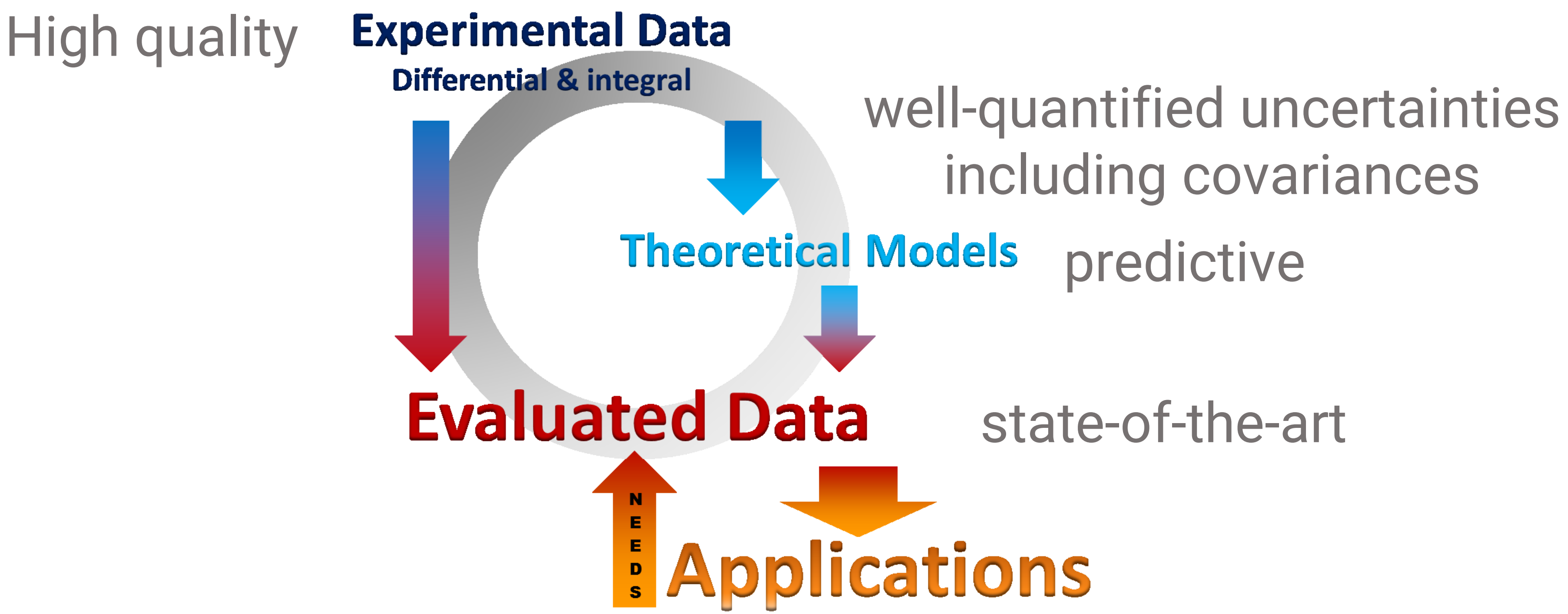


NACRE, le Noyau Au Coeur du RéactEur, M. Kerveno, HDR, Université de Strasbourg, 2018

Nuclear Data for applications.

The challenge of uncertainty.

To meet target uncertainties on nuclear data for applications, all the steps of the evaluation process must be improved.



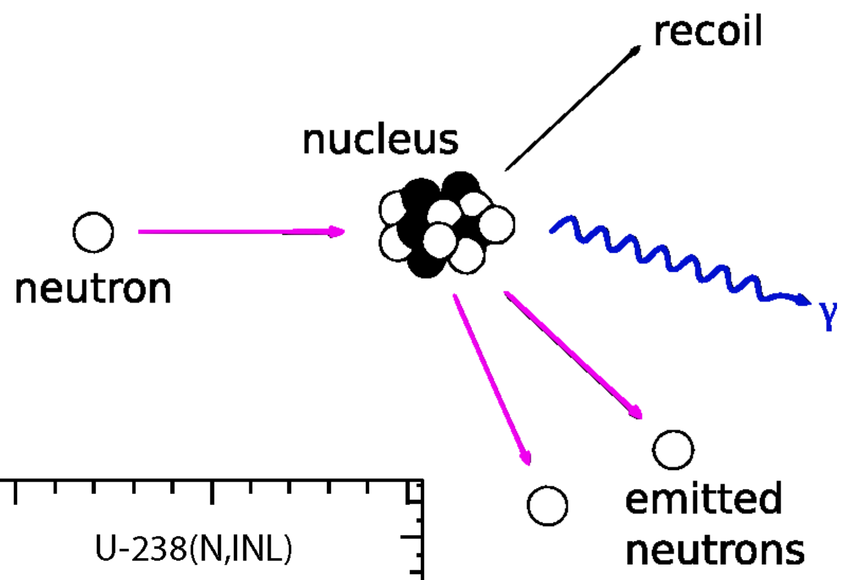
A large international community is involved in this field.

NACRE, le Noyau Au Coeur du RéactEur, M. Kerveno, HDR, Université de Strasbourg, 2018

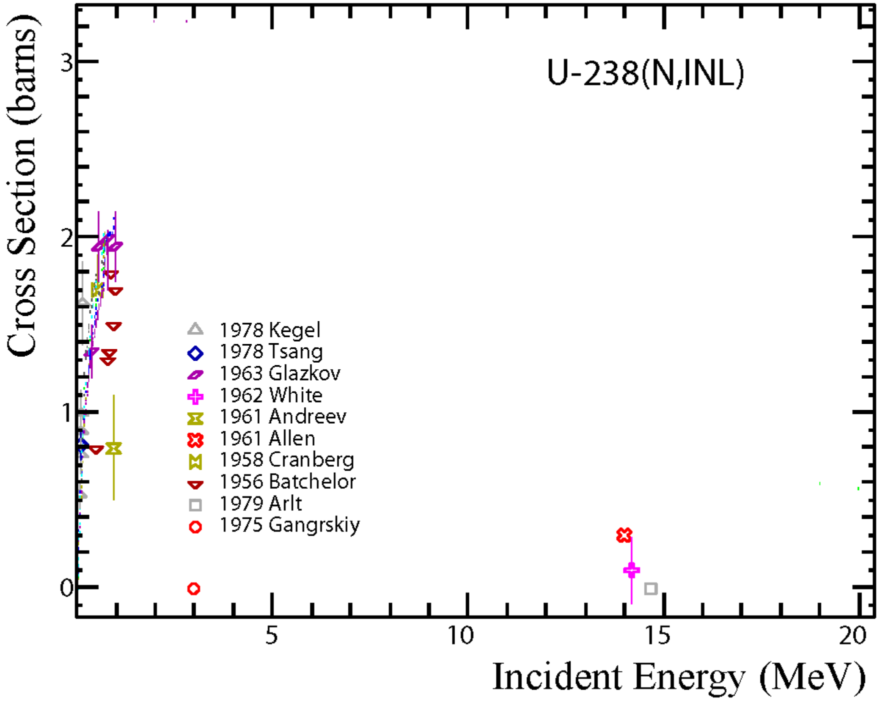
The case of (n, xn) reactions

Inelastic neutron scattering

- Energy loss mechanism for neutrons
- Production of gamma rays
- Interaction by nuclear force only
- Modify neutron multiplicity and creates new isotopes



Limited experimental knowledge for some isotopes.
Here : ^{238}U [EXFOR]



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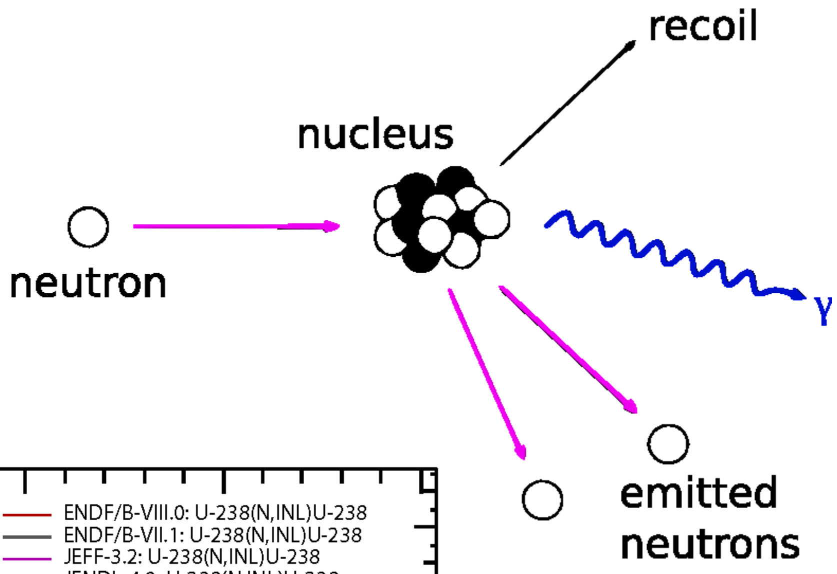
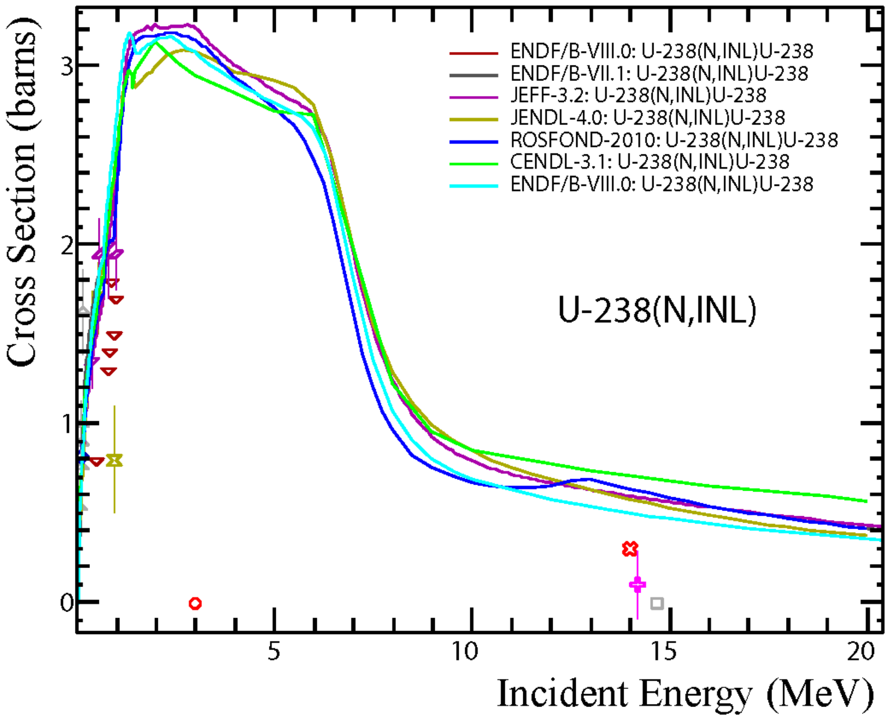


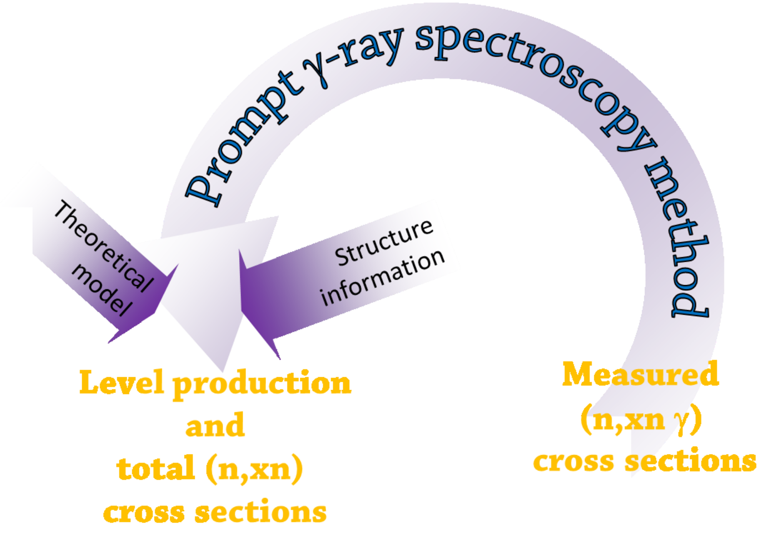
Limited experimental knowledge for some isotopes.
Impact on evaluations



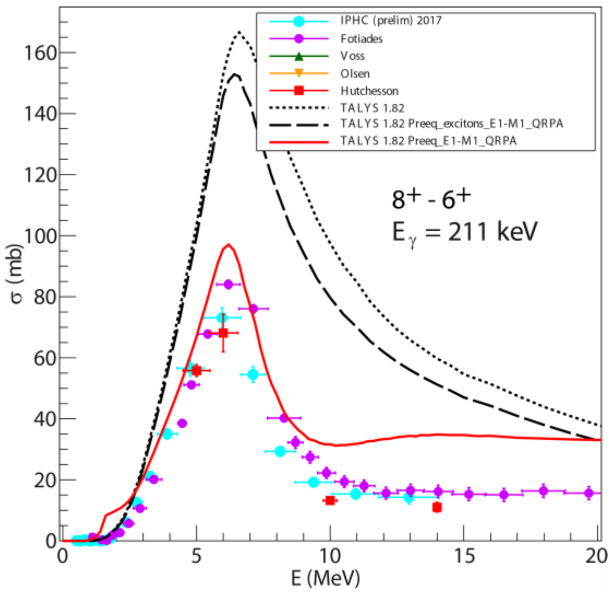
The case of (n, *x*n) reactions

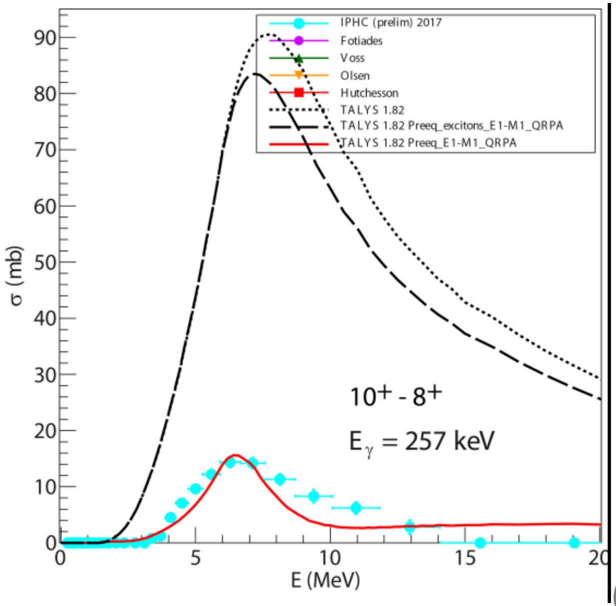
Measurement using (n, *x*n γ)

(n, *x*n γ) cross sections provide strong constrain on calculations
- Reaction mechanism
- Nuclear de-excitation
- Nucleus level structure



In Uranium, W, a microscopic approach (QRPA) in the pre-equilibrium stage strongly modifies the spin distribution compared to the *exciton* model and produces better agreement with the experimental results .



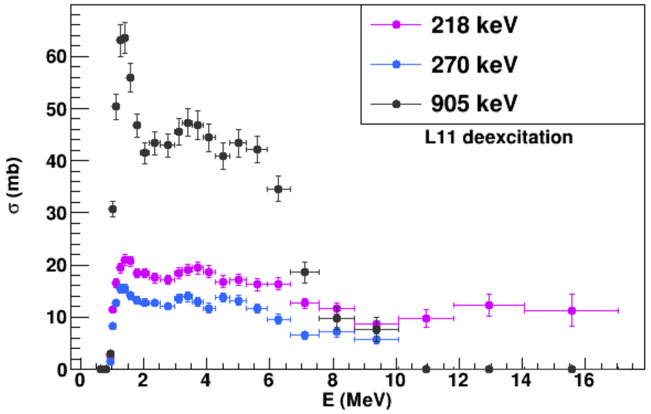


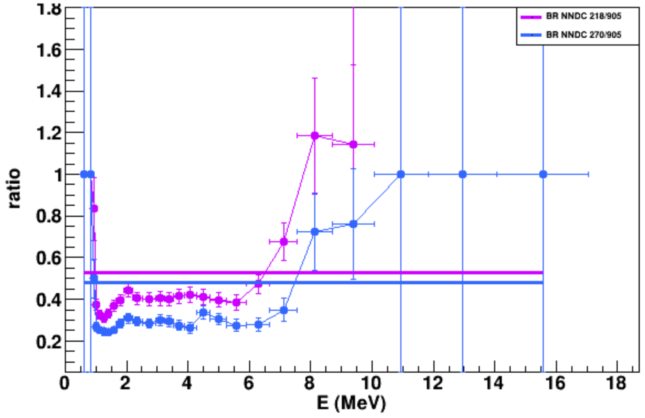
[M. Kerveno, M. Dupuis]

Constrains from experimental (n, xn γ) cross sections

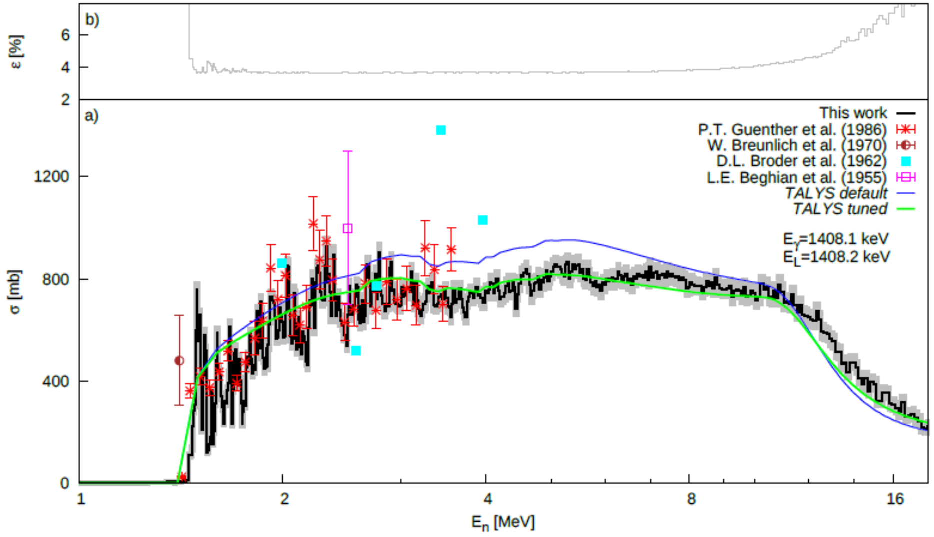
[M. Kerveno]

Experimental data reveal deviation from references branching ratios. Points to the limited structure knowledge in some isotopes (including 238-U) and biases in structure evaluation.





Adjusting the optical model parameters lead to a better agreement (both in shape and amplitude) with experimental results.



[Neutron inelastic scattering on 54Fe, A. Olacel et al., EPJ A, 54 (10), 183, 2018]

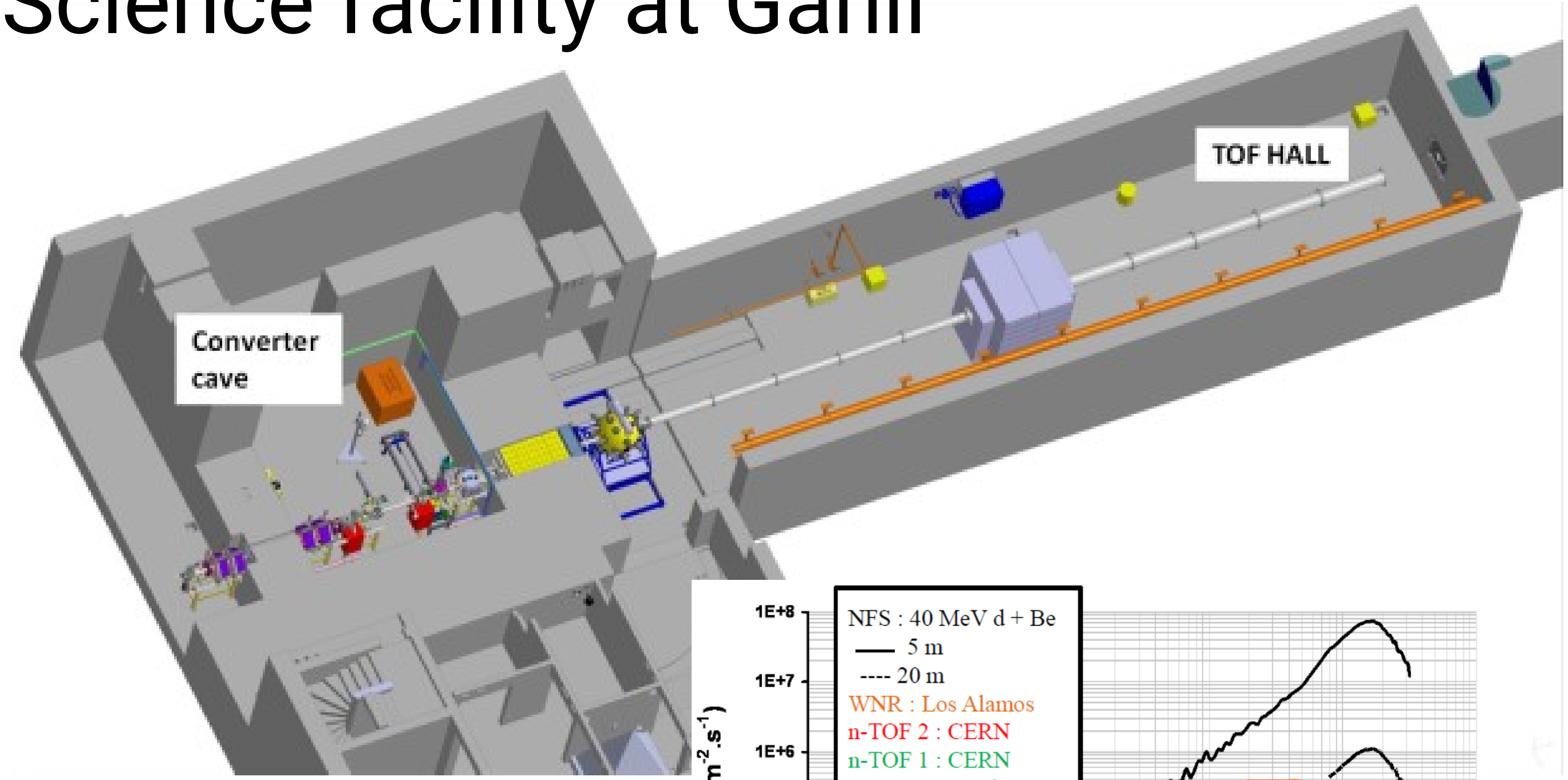
The Neutron for Science facility at Ganil

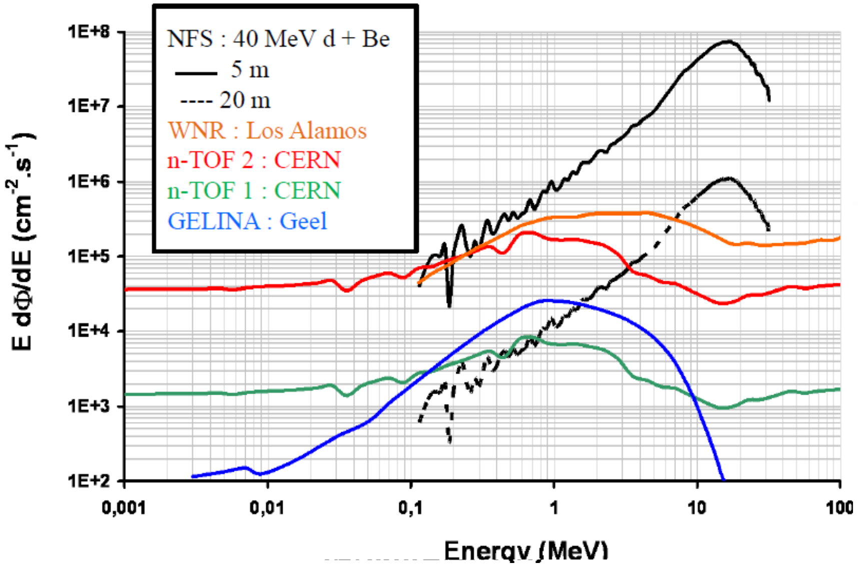
New beams and tools

- Part of Spiral2
- Use **p** and **d** beams from Linac to produce either a white neutron beam or quasi mono kinetic beam

- In the converter room: irradiation station

- Research for fission, fusion and medical applications





The Neutron for Science facility at Ganil

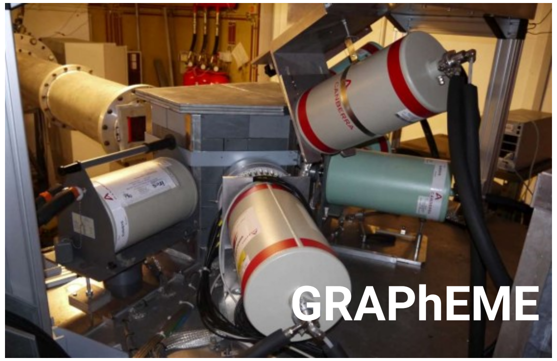
Prospects for (n, xn) studies with prompt γ-ray spectroscopy

- Validation of the prompt gamma ray method with double measurement in ^{90}Zr(n, 3n) reactions
  cross-section accessible by prompt and delayed allowing measurement in the same setup.
  (LoI day 1 for NFS)

- Combining Grapheme and Gains for spectroscopic studies.
  Sensitivity to high and low energies gamma rays with high efficiency.

- Measurements of U, Pu, Th (n, 2-3n) cross section
  Thanks to high flux at higher neutron energy.
  Using a long flight path with second collimator.

- Other measurements on Uranium, Plutonium with other methods to get more and more accurate data according to application needs.



The Neutron for Science facility at Ganil

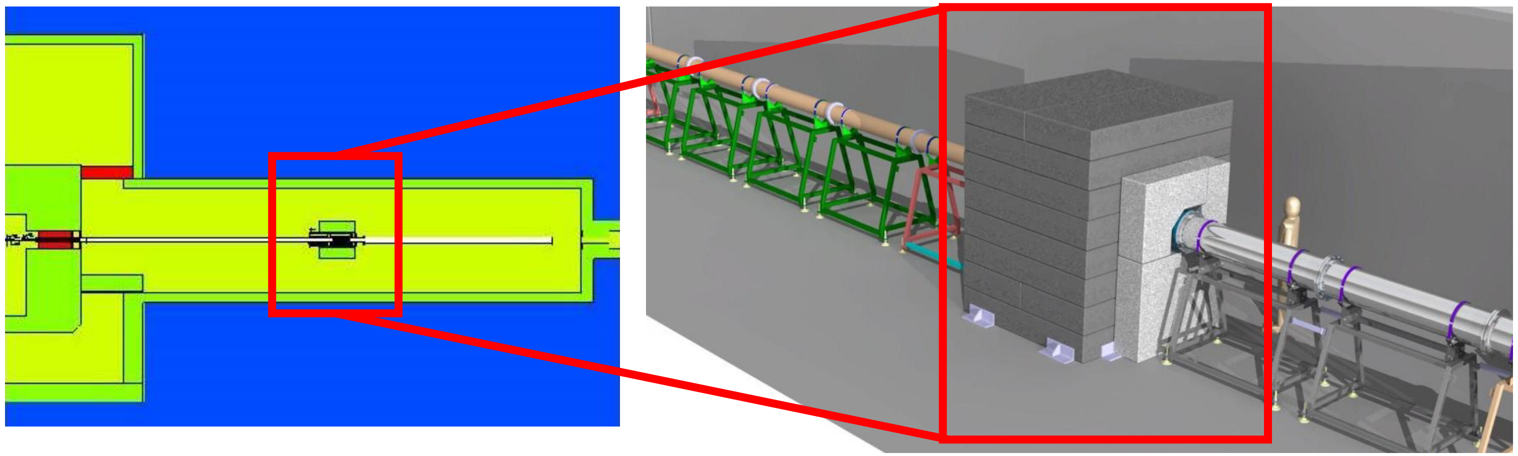
Long flight path collimator

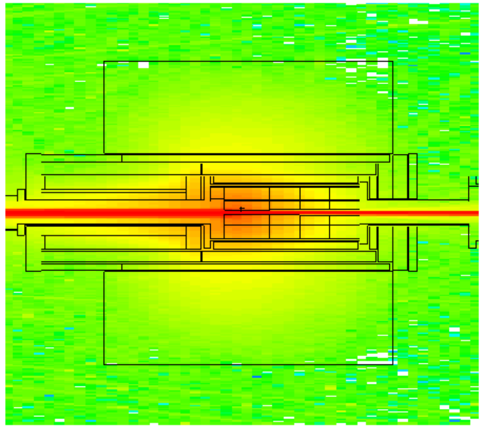
The long flight path allows ToF measurement when using continuous neutron spectrum.

The beam spread up to 15 cm wide at 28 meters from entering the experiment area.

The second collimator cuts the beam to 6 cm diameter, allowing a close configuration of detectors around the target.

IPHC is responsible of the design, conception and construction.





The Neutron for Science facility at Ganil

Beam line (installed feb. 2018)

The Neutron for Science facility at Ganil

Beam line (installed feb. 2018)

The Neutron for Science facility at Ganil

- is a **competitive** and **complementary** facility to the current running ones.

- interests **experimental teams** involved in **nuclear data for applications**

- included in the facility network supported by **EC-EURATOM project** (SANDA, ARIEL, NFRP2018 call 7)

The Neutron for Science facility at Ganil

Interests for(n, xn) and (n, xn γ) measurements

- Good quality nuclear data is needed for application development.
- Evaluated nuclear data is based on experimental data and models. Improvement are needed in both.

- (n, xn γ) reactions are a good way to constrain models on (n, xn)

- NFS facility will offer new opportunities for measurements.