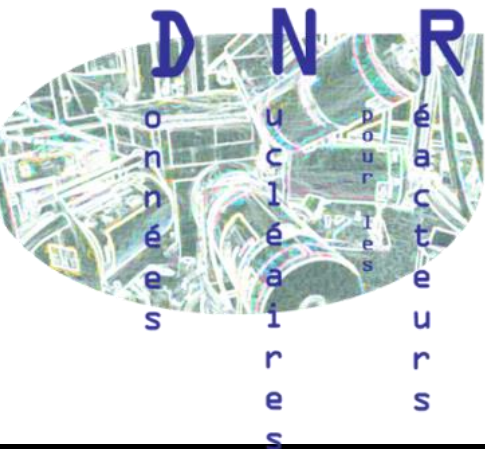


groupe

Données Nucléaires pour les Réacteurs

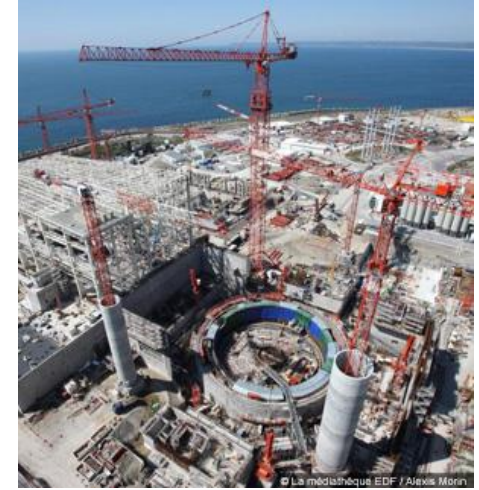
(Nuclear Data for Reactors)



Challenges for nuclear energy today

Economicals:

- A power plant costs several millions € to build
- The spent waste processing represent 2 to 6 % of the kWh price.



Safety:

- Proliferation
- Accident prevention
- Handling of radioactive waste

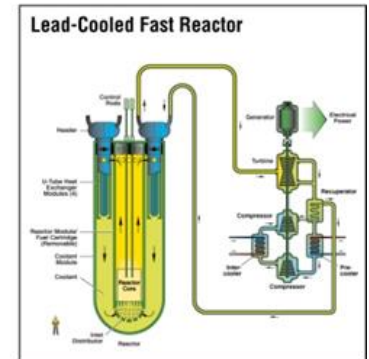
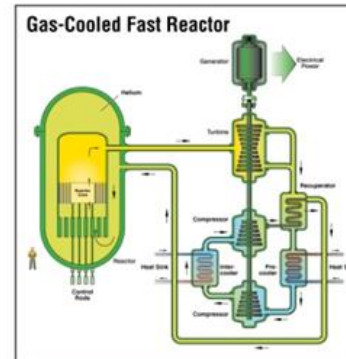
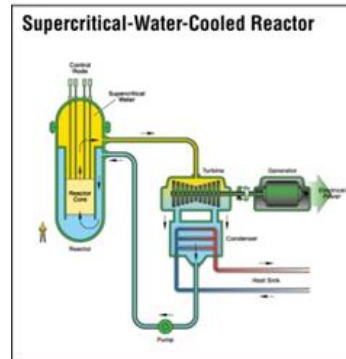
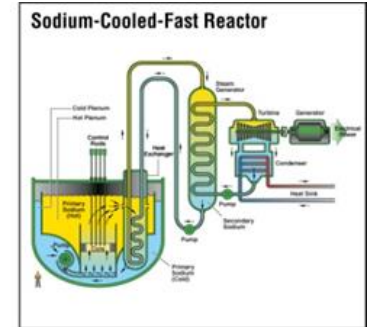
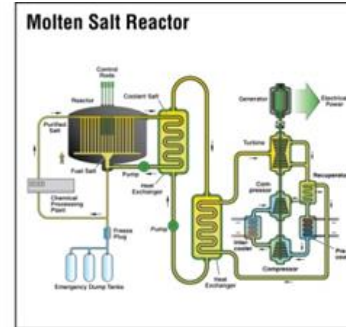
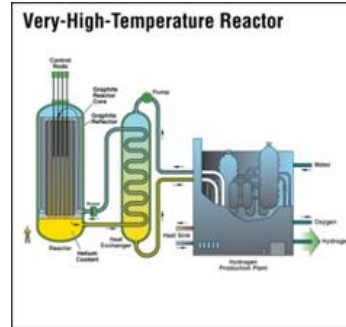
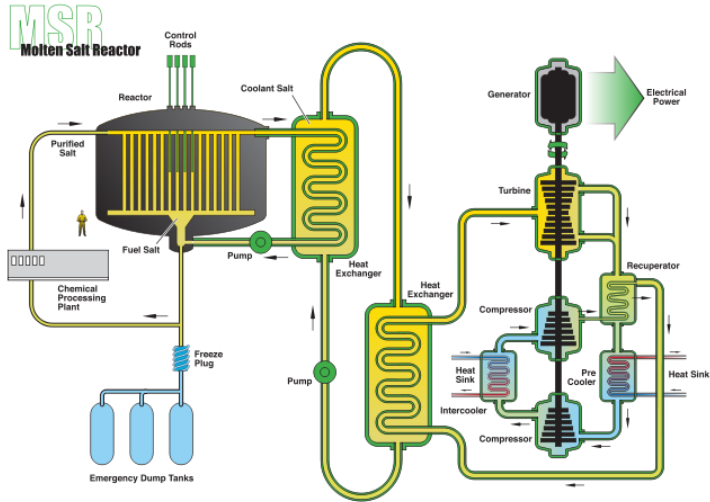
Sustainability:

- Aging power plants
- Limited ressources in ^{nat}U
- Storage of radioactive waste



Tomorrow's reactors are already underway

- New designs
- New fuels



Benefits:

- ✓ Fast neutrons → Waste transmutation
- ✓ ^{232}Th → Reduce actinides production
- ✓ ^{232}Th , ^{238}U → sur-generator cycles

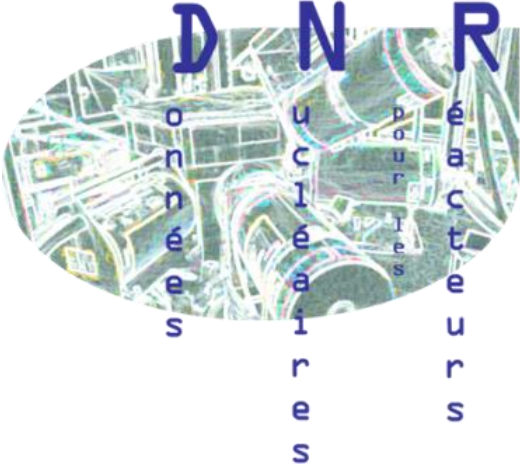
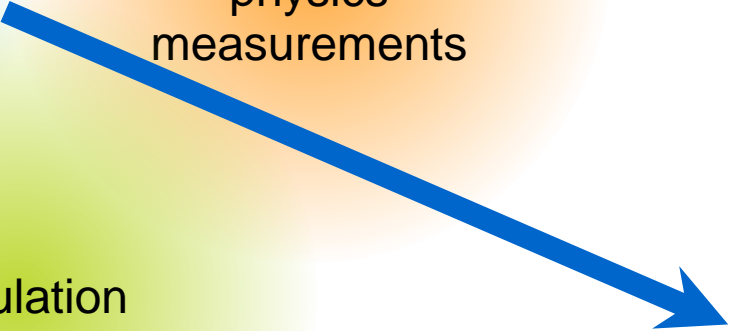
Developpement and risk analysis with numerical simulations

Nuclear Data for Reactors

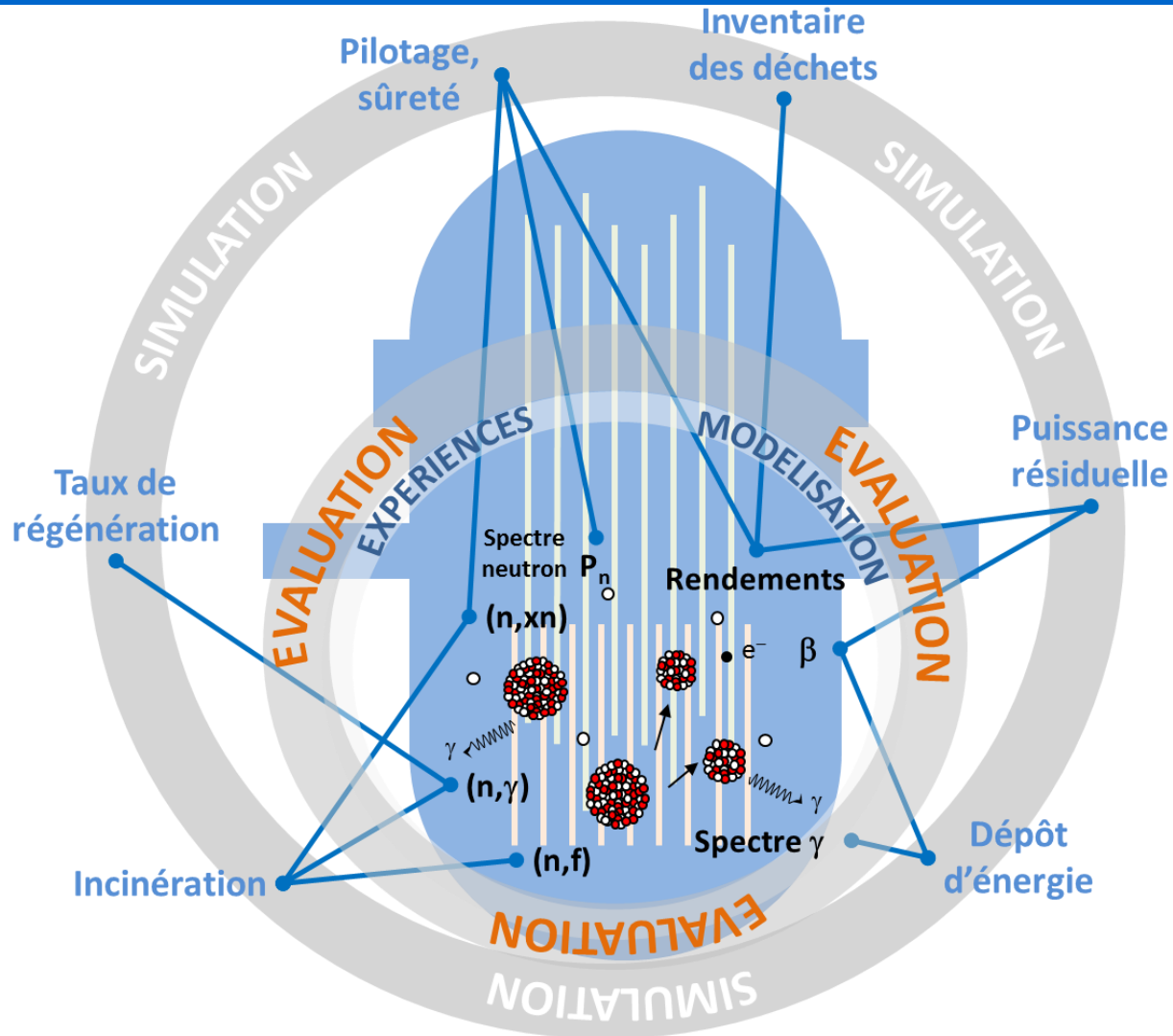
Economic constraints
Safety requirements

Advanced
fundamental
physics
measurements

Simulation
capacity



Nuclear Data for Reactors



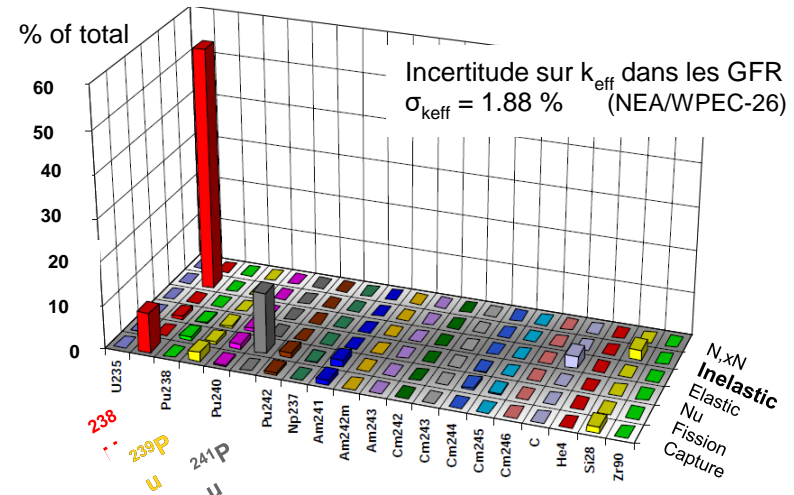
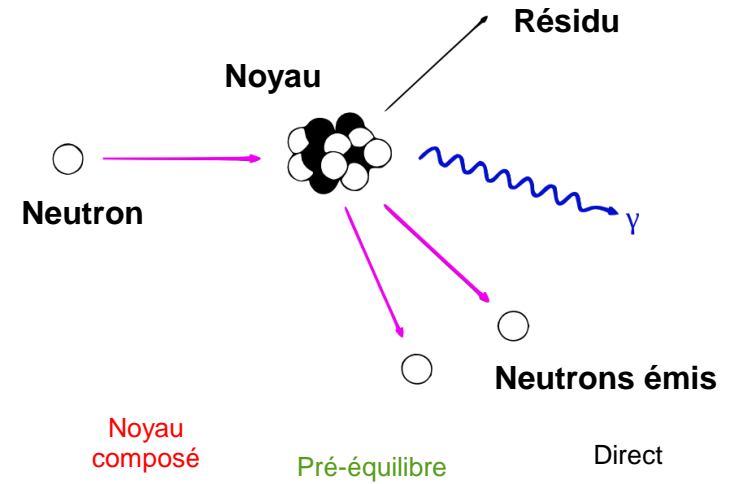
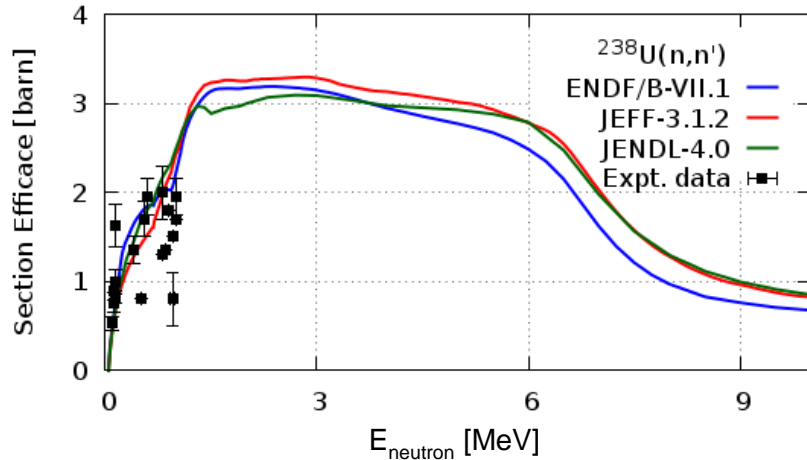
Nuclear Data for Reactors

(n, xn) : reactions of interest for evaluations

Change the number of neutrons, their energy and produce new isotopes.

Uncertainties on $\sigma_{238\text{U}(n,n')}$ limit the precision of criticality and power calculations.

Few experimental data for isotopes of interest in next generation reactors.



The team *Données Nucléaires pour les Réacteurs* @IPHC



Philippe Dessagne
(DR)



Maëlle Kerveno
(CR)



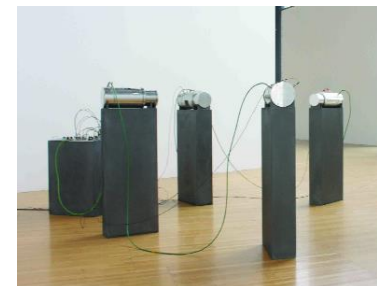
Greg Henning
(CR)



Francois Claeys
(Doctorant)



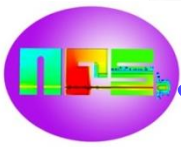
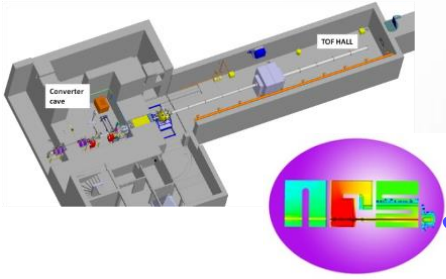
Elise Alloin
(artiste in residence)



Collaborations

- Developpement of experimental setups
- Complementary measurements
- Interpretation of results
- Improvement of models

European programs
Link with NEA, AIEA



Experimental setup

- Electrons accelerated on Uranium target
- Fission induced neutrons
- Pulsed beam (800 Hz)
- E_n between eV and 20 MeV
- Our setup at 30 m



- Fission chamber to measure the incoming flux.
- Large Sample ($\varnothing > 55$ mm)
- Détection of γ rays emitted in (n,xn) reactions by 6 planar HPGe

Measurement campaigns

2005 – 2010 :

^{235}U

2009 – 2010 :

^{232}Th

2009 – 2012 :

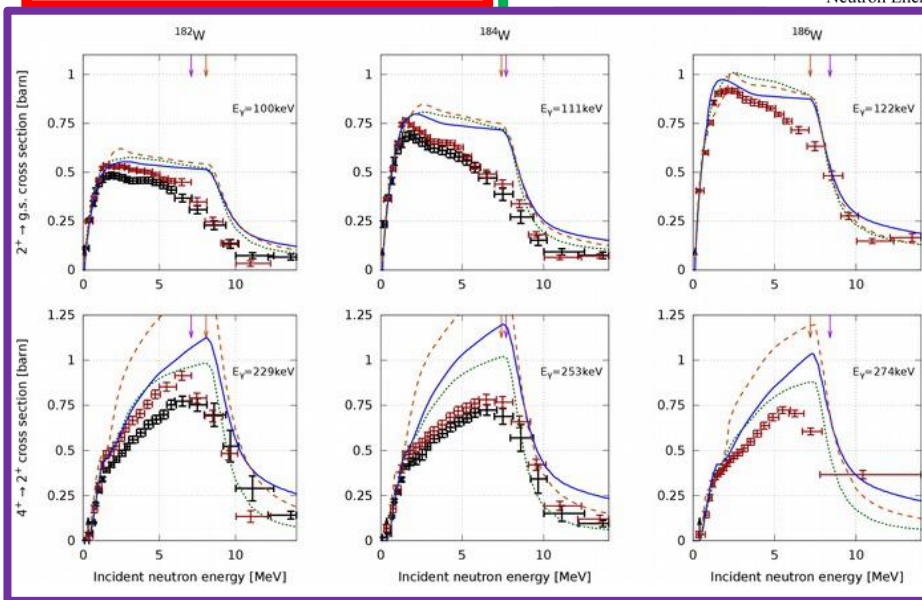
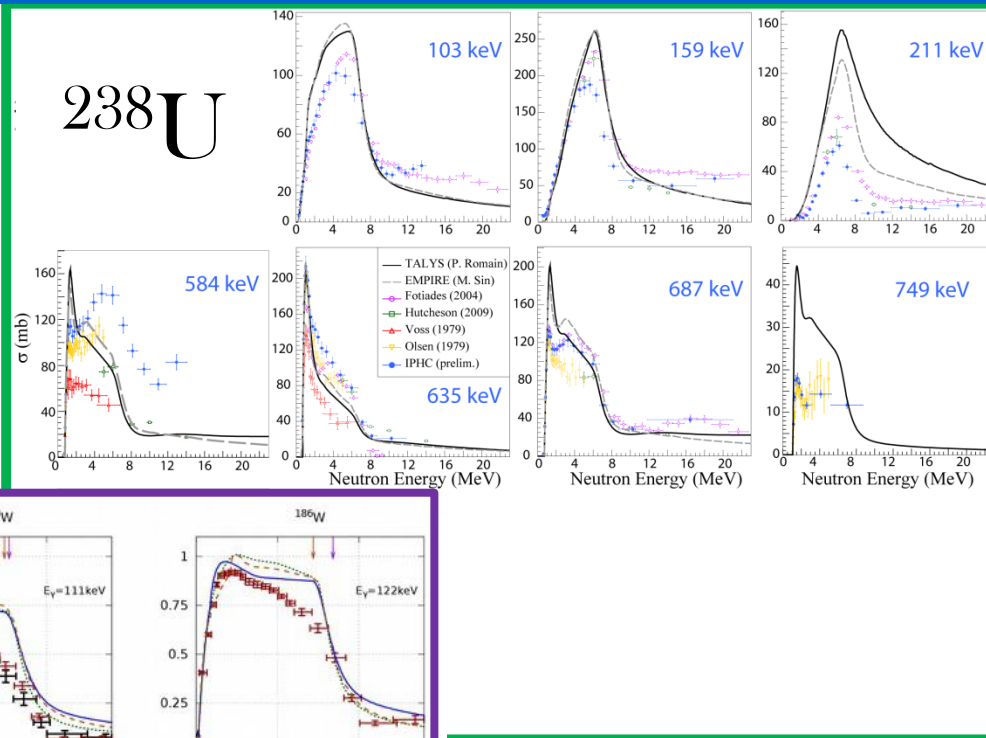
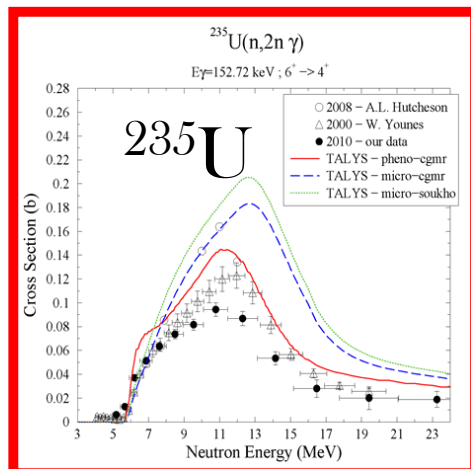
$\text{nat}, 182, 183, 184, 186\text{W}$

2011 – 2012 – 2013 :

^{238}U

2014 :

natZr



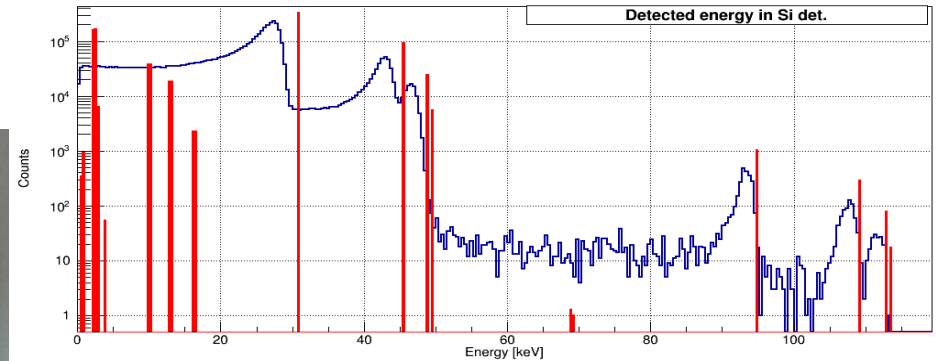
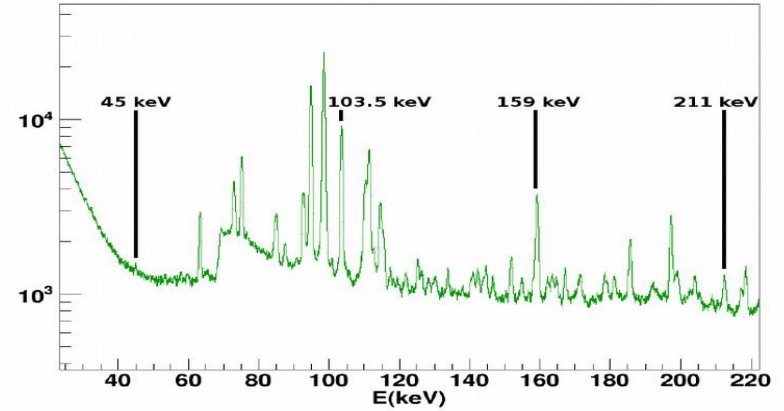
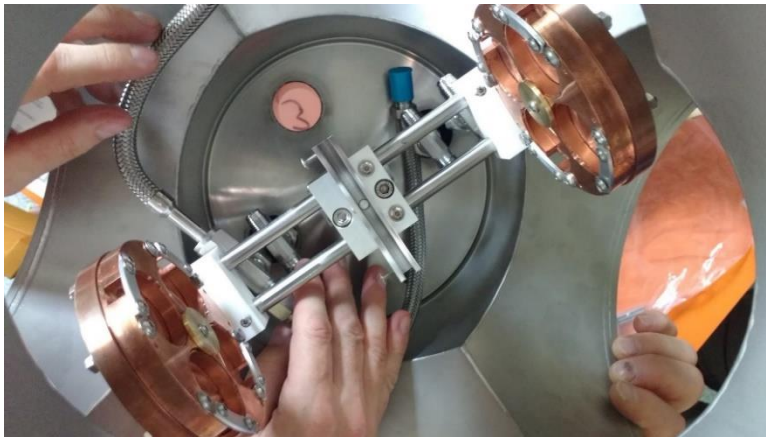
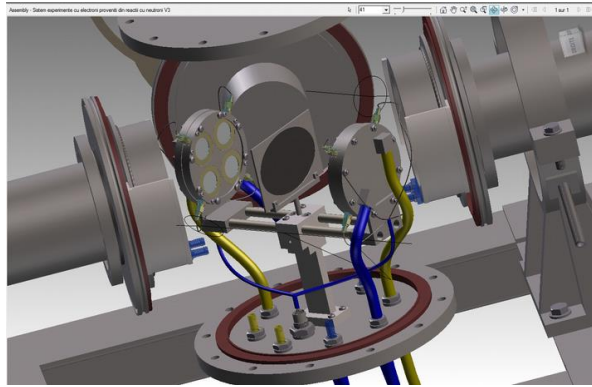
Challenges ahead

- Low energy gamma rays are hard to detect because they are *converted*.
- $(n, xn \gamma)$ gives only a partial picture: we need theory to go back to the total (n, xn) cross section.
- Many other nuclei of interest, but highly radioactive.

Converted transition spectroscopy

Conversion electron spectroscopy

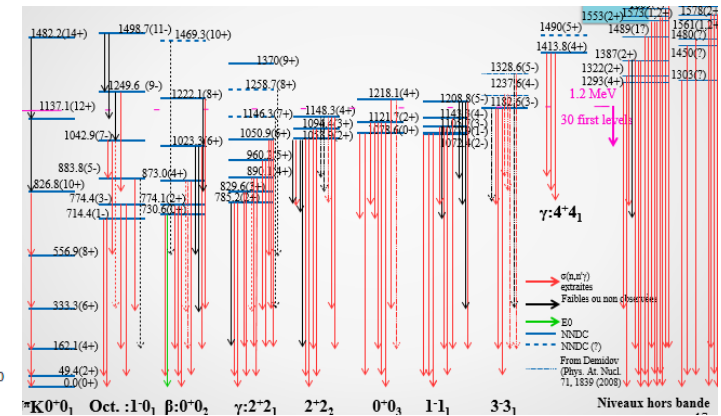
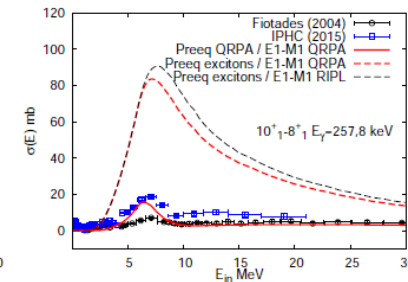
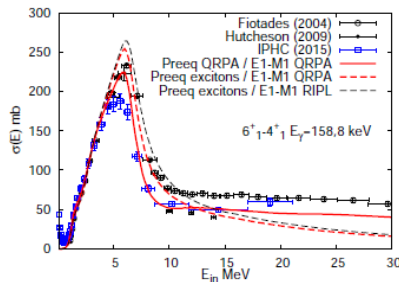
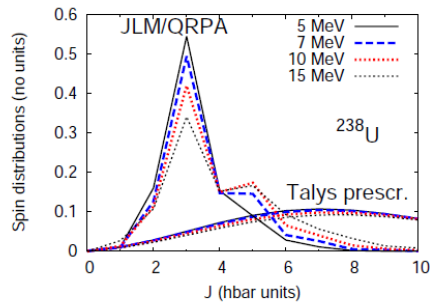
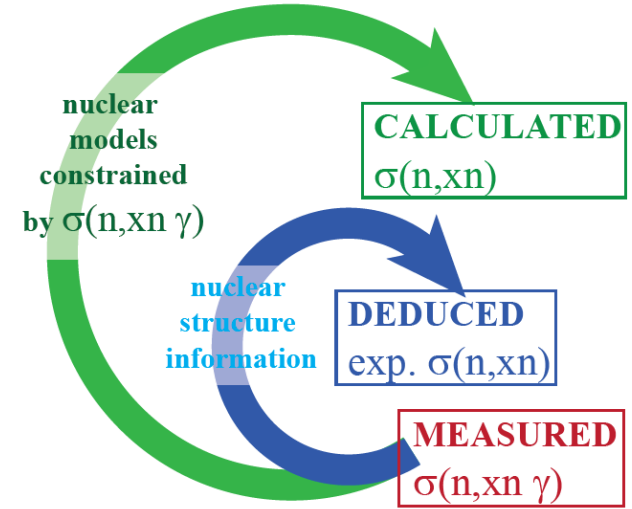
- For highly converted transitions
- Within European program CHANDA.



Topic of TIPP to come

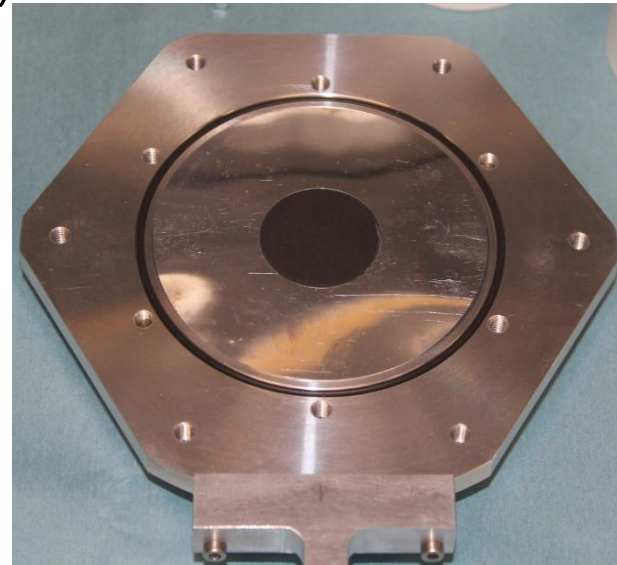
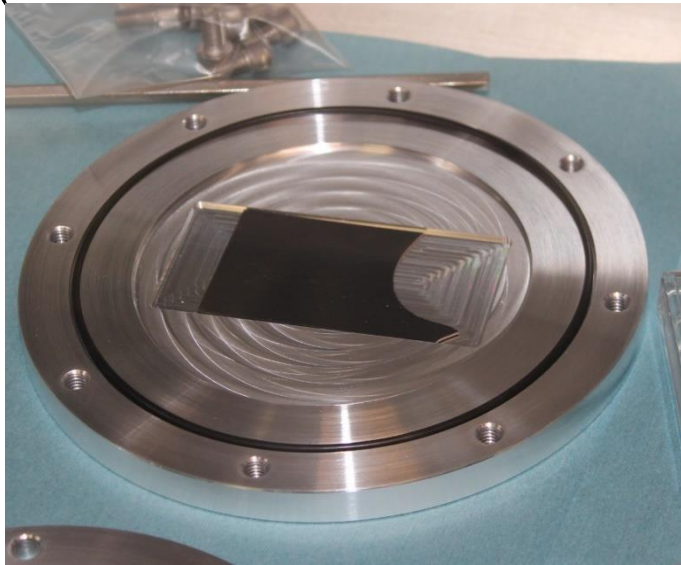
From (n,xn gamma) to (n,xn)

- (n, xn γ) gives only a partial picture: we need theory to go back to the total (n, xn) cross section...
- Need input of nuclear structure, reaction codes.
- Inferring the (n, xn) cross section requires work, attention to the uncertainties and possible correlations between measurements.
- Collaboration with theoreticians and evaluators to improve the models.



Highly radioactive nuclei

- Many other nuclei of interest, but highly radioactive.
- Upgraded the setup a few years ago, and the acquisition in September 2018.
- ^{233}U (4500 times more radioactive than ^{235}U) recorded 2016-2018



- ^{239}Pu (29500 times more radioactive than ^{235}U) : target in preparation.

Internship and Thesis Subject

Determining the neutron inelastic scattering cross section off ^{232}Th from measured $(n, xn \gamma)$ cross sections.

- Based on the thesis work of E. Party (defended Sept 2019).
 - From data recorded at JRC-Geel using Grapheme in 2009-2010.
 - From extracted $(n, n' \gamma)$ cross section, with the help of
 - Level structure information
 - Model predictions
- You will try to deduce the total inelastic scattering (n, n') cross section
- With a special attention to uncertainties.

Come discuss with us in building 24

 <http://www.iphc.cnrs.fr/Offres-de-stage-these.html>