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Final ERINDA User Meeting and Scientific Workshop
1-3 Oct 2013
CERN, Geneva

Development of a neutron converter for studies of neutron-induced fission fragments at the IGISOL facility

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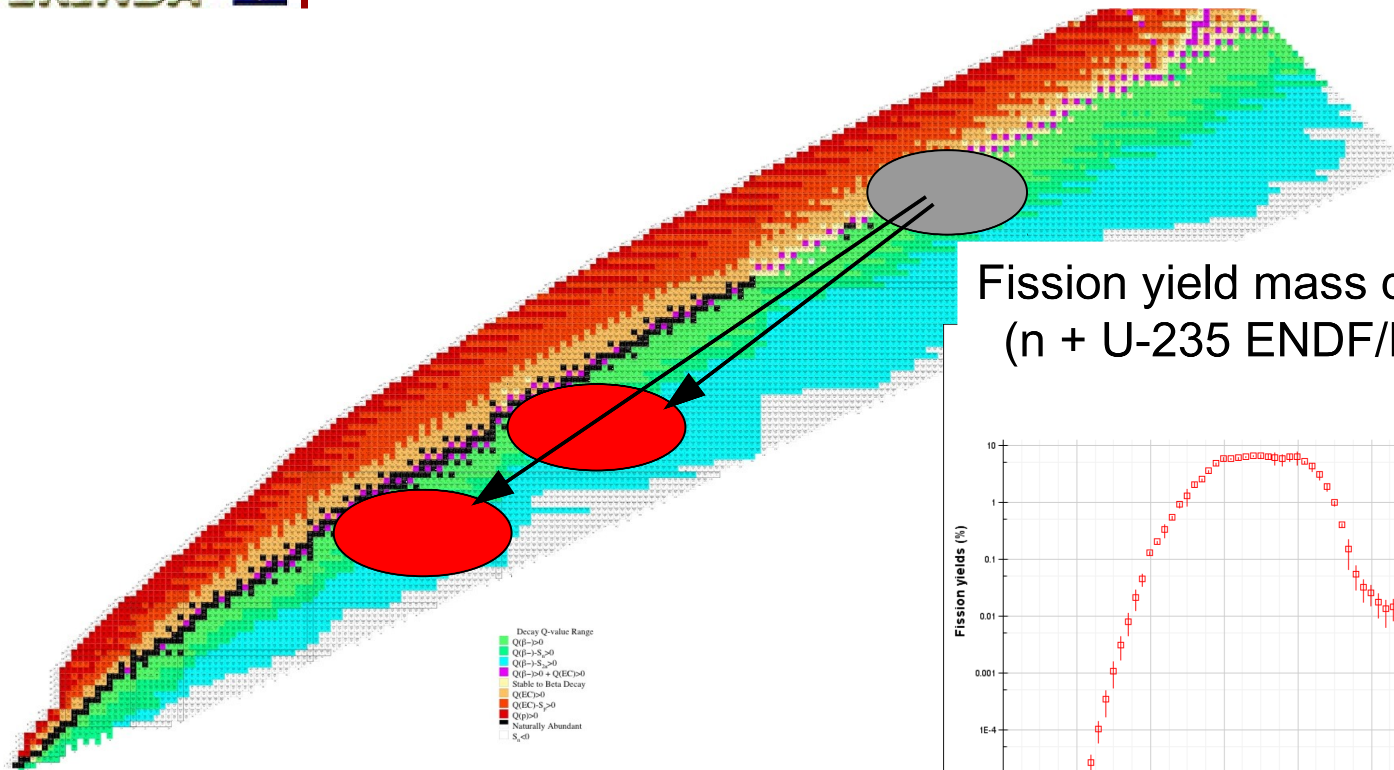
Uppsala University, Sweden
Department of Physics
University of Jyväskylä, Finland

R. Bedogni et al.,
INFN, Laboratori di Frascati, Roma, Italy

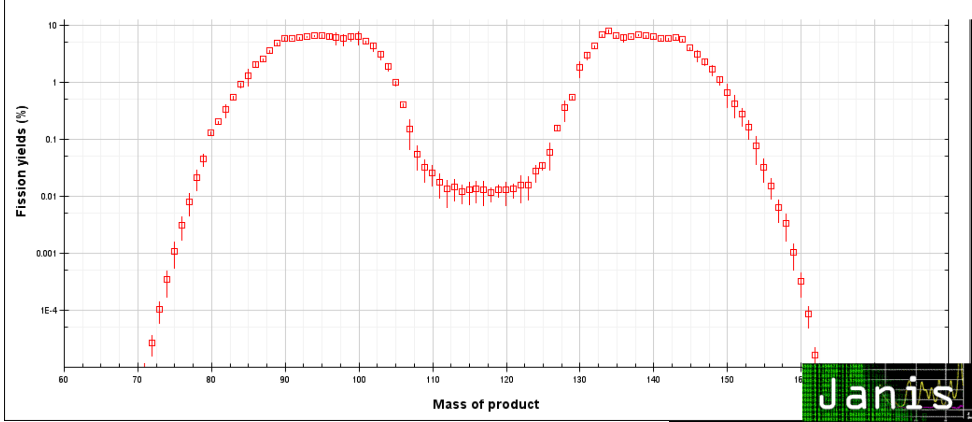
A. Prokofiev, E. Passoth
The Svedberg Laboratory, Uppsala, Sweden

Motivation

Fission yields are well known for thermal LWR (> 60 years of experience), but...



Fission yield mass distribution E = 0.025 eV
(n + U-235 ENDF/B-VII.1)



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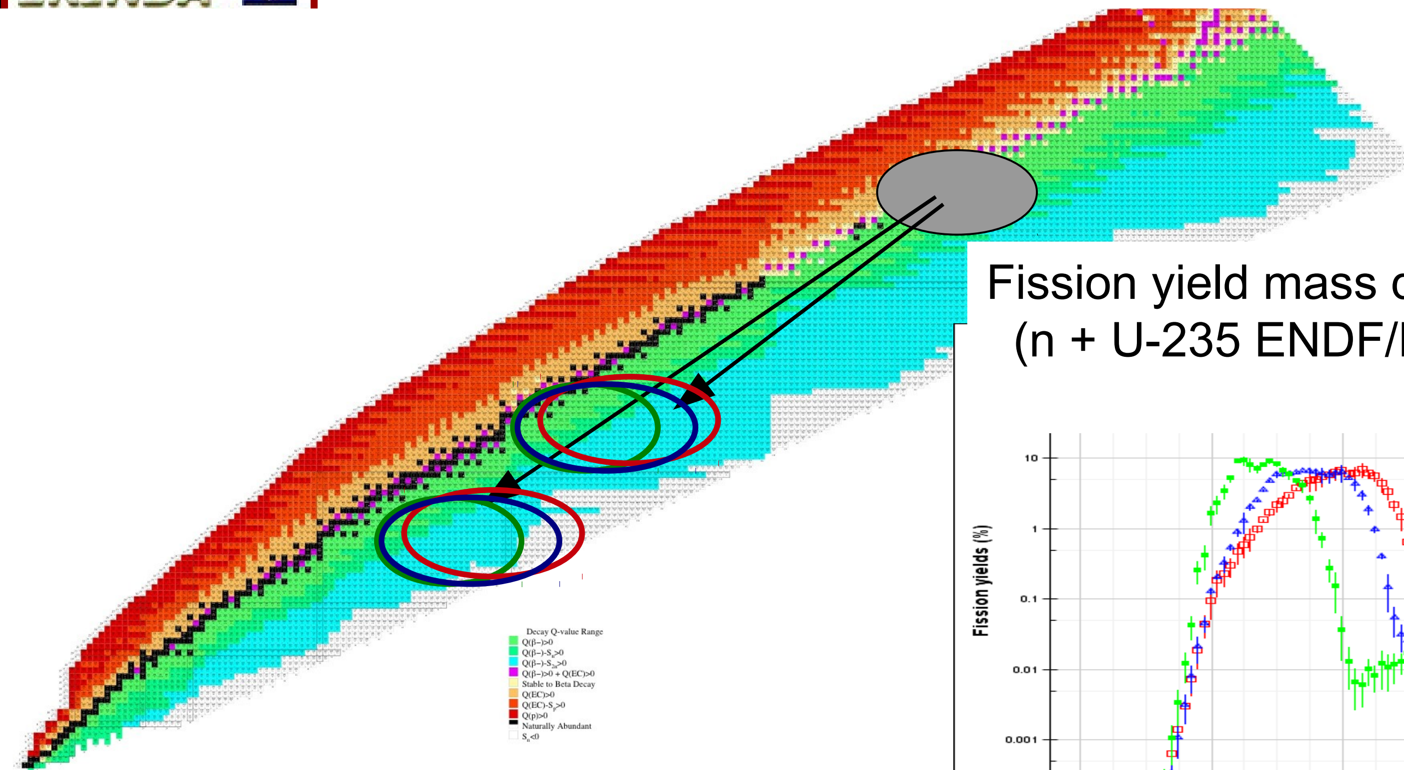
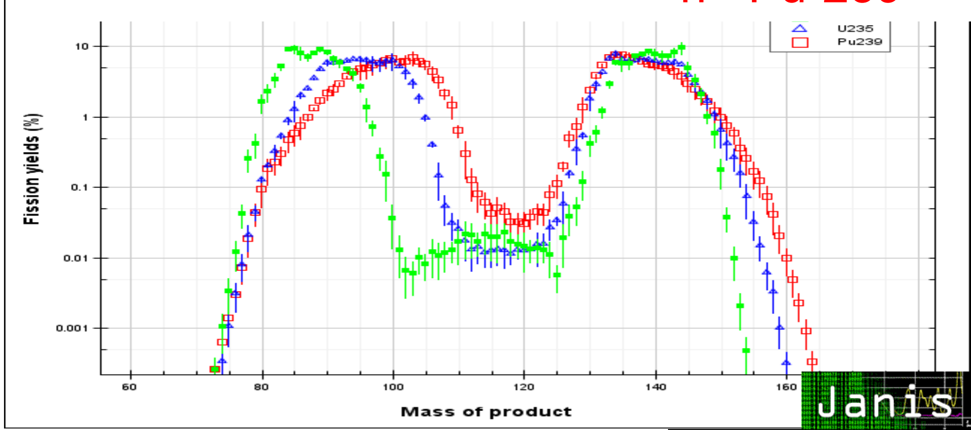
Fission yields are well known for thermal LWR (> 60 years of experience), but...

The fission yields vary with energy and with initial nuclide



Fission yield mass distribution n + Th-229
(n + U-235 ENDF/B-VII.1) n + U-235
n +Pu-239



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Motivation

Fission yields are well known for thermal LWR (> 60 years of experience), but...

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Of importance for:

- **information about the composition of the resulting spent fuel** (repository, P&T, Gen-IV)**,**
- **various safety measures** (decay heat, fission gas production,criticality, dosimetry, safeguards, delayed neutrons)**,**
- **information about neutron poisoning** (significant descripancies between different evaluations, especially for Xe-135, Sm-149, Gd-157)**,**
- **improvement of burnup predictions,**
- **theoretical development**

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Experimental methods

Reactor-based experiments not feasible

- Real LWR-spectra would be nice

  Gamma spectroscopy

  Chemical mass spectroscopy

  → How to measure on short-lived nuclides?
- Fast reactors (not available yet)
- Research reactors

→ **Accelerator-based experiments**

Experimental methods

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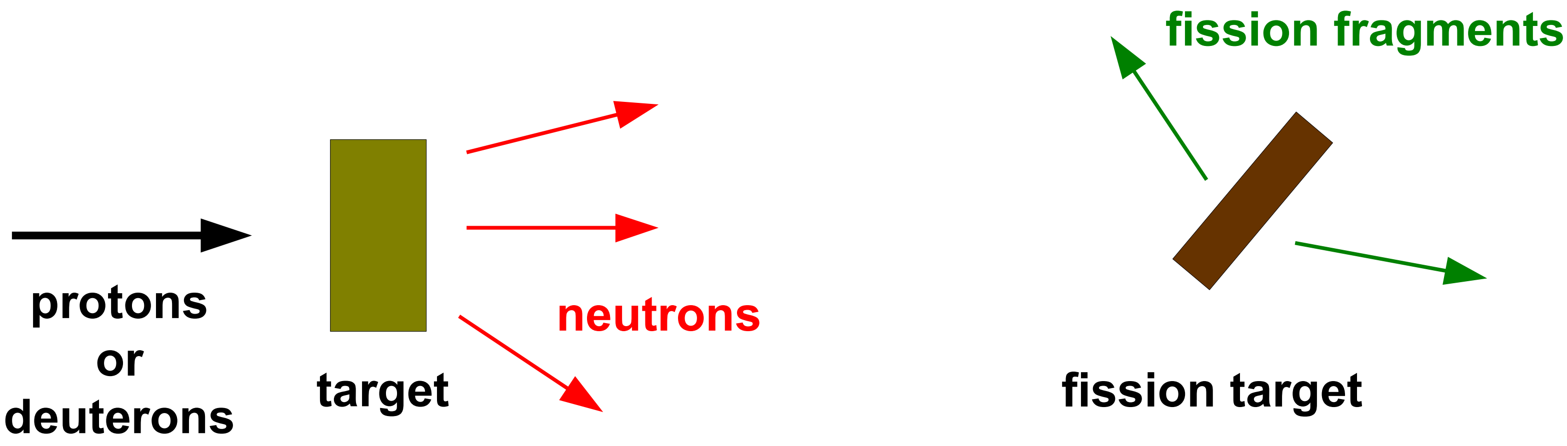

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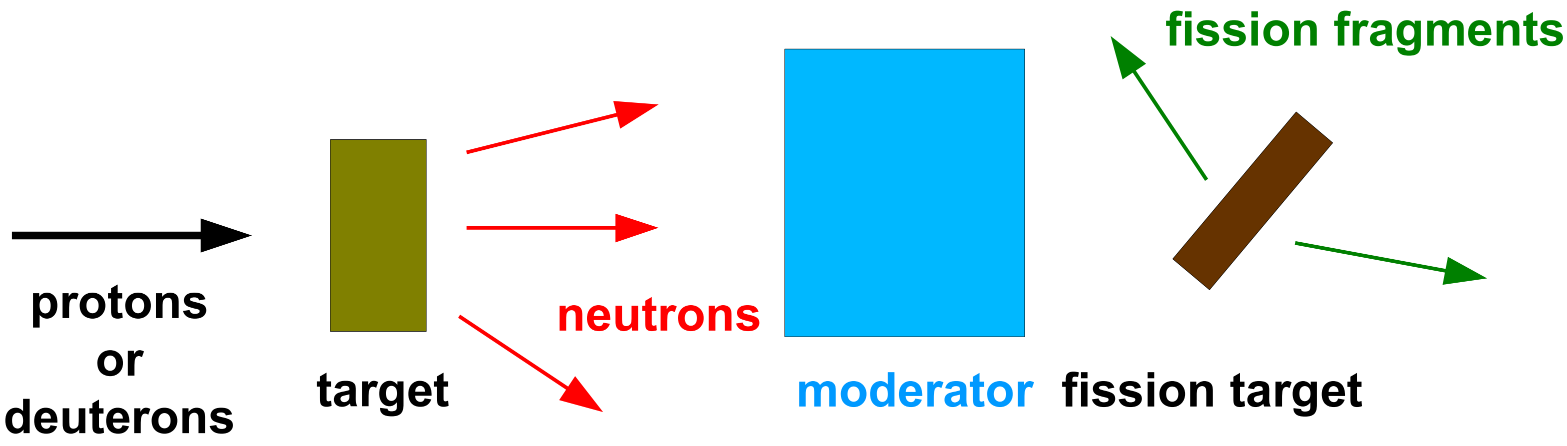

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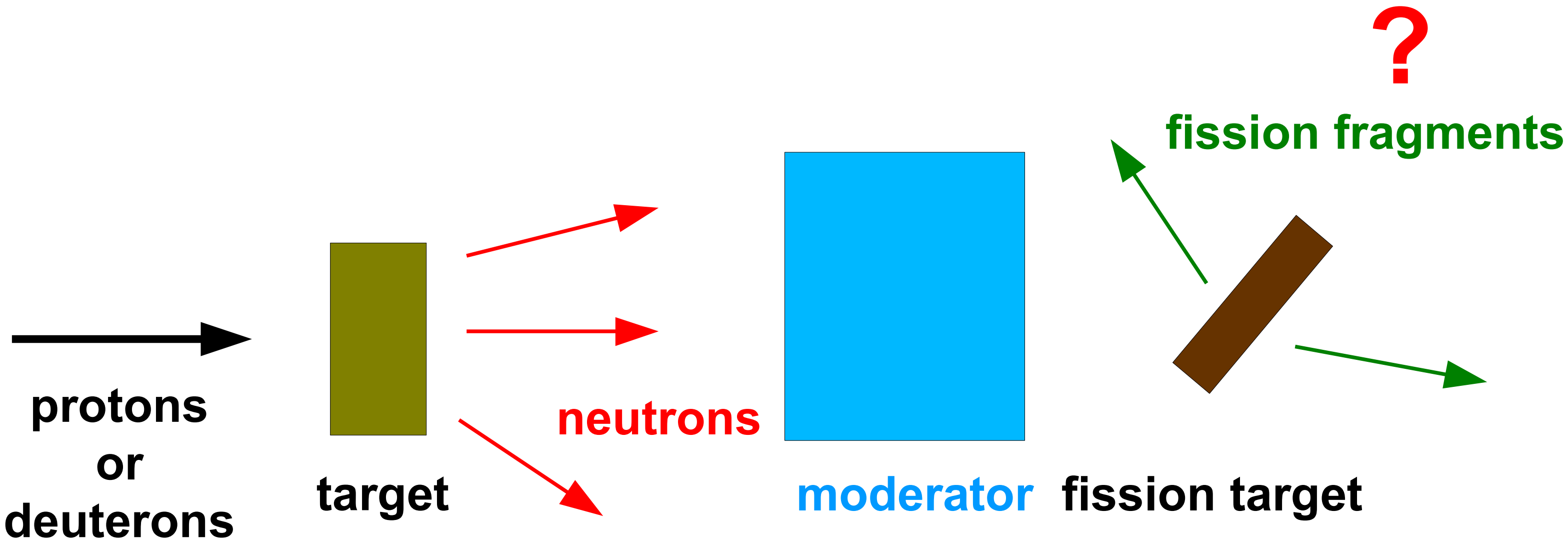
Experimental methods

How to measure the fission fragments?

- We want to be able to identify every nuclide, not only the mass.
- With online isotope separation and penning trap this can be done. → **Jyväskylä!**



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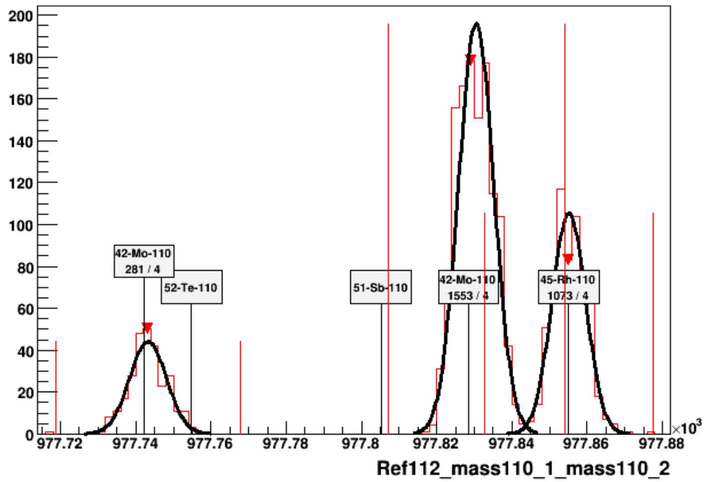
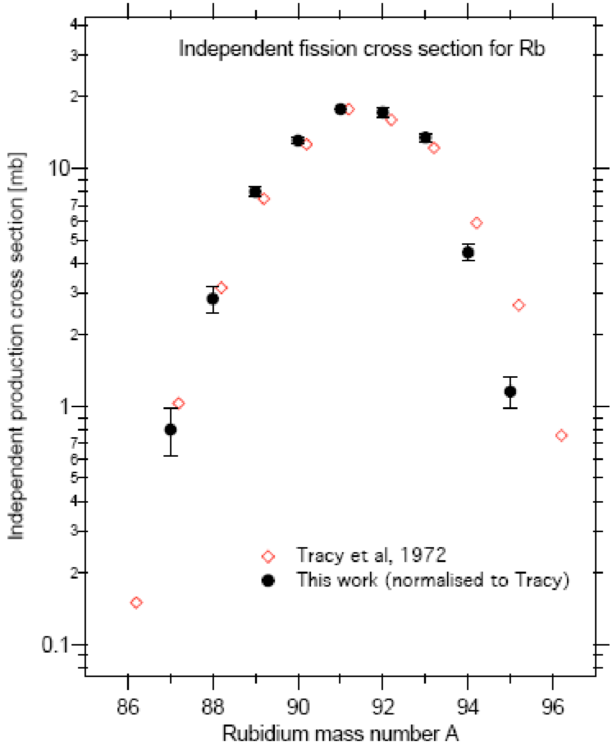
The IGISOL method is promising

Each nuclide is identified by its unique frequency in the Penning trap.

Enables high precision measurements of fission fragment yields



50 MeV p + U-238



P. Karvonen, PhD thesis (2010)

Tests have been performed with p + U-238 and p + Th-232

IGISOL-JYFLTRAP was recently moved and upgraded with a new cyclotron

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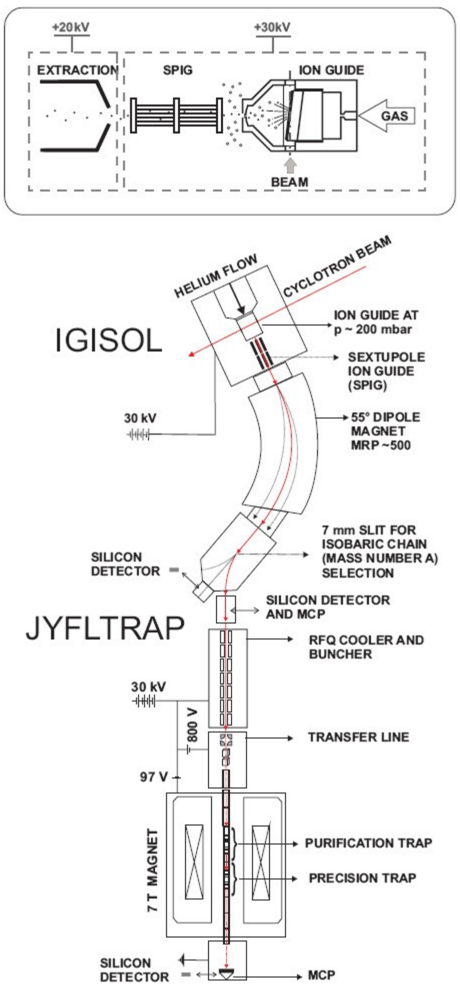
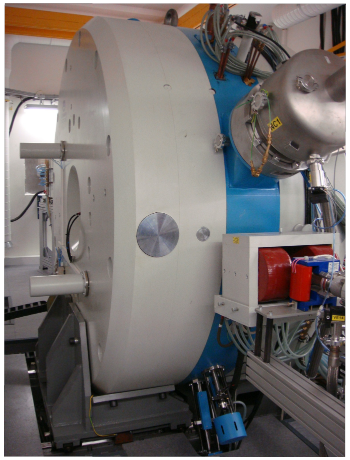
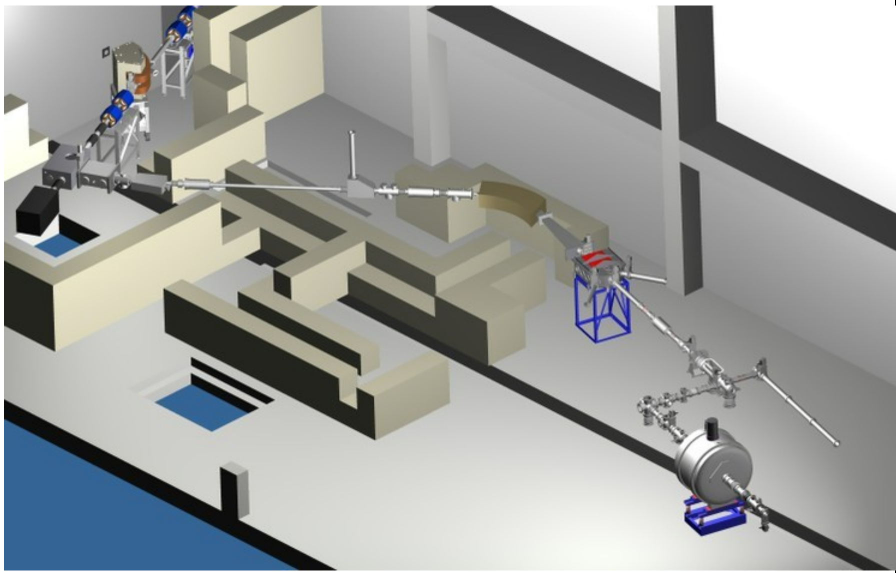




MCC30/15 Cyclotron
p: 18 – 30 MeV
D: 9 – 15 MeV
Current: > 100 μA

Also possible to use the old K-130 cyclotron, could give ~ 4000 hours/year



H. Penttilä *et al.*, Eur. Phys. J. A 48, (2012) 43

Do not miss the talk by Dmitry Gorelov – Wednesday 11:10

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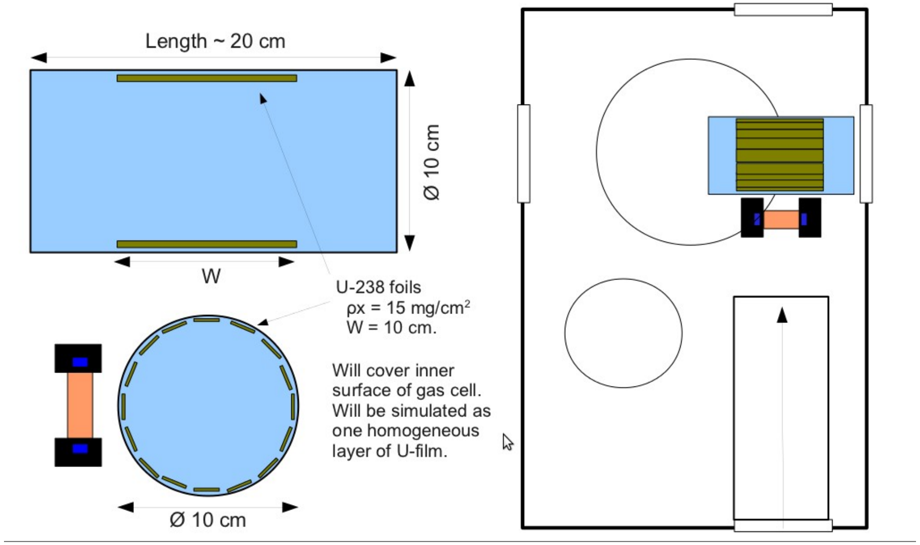
Objective:

To design a neutron production target for neutron-induced fission yields

M. Lantz (et al...), ERINDA short term visit 6 weeks in Jyväskylä (2011-2012)



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Objective:

To design a neutron production target for neutron-induced fission yields

How to design a neutron source?

→ Neutron production/intensity
→ Neutron energy distribution
→ Cooling issues
→ Activation issues
→ Flexible and easy to use design
→ Can we imitate reactor spectra?

N.B. Compromise for two parallel research fields

→ Nuclear data for applications and basic research
→ High energy neutron source for basic research with unstable (exotic) nuclides

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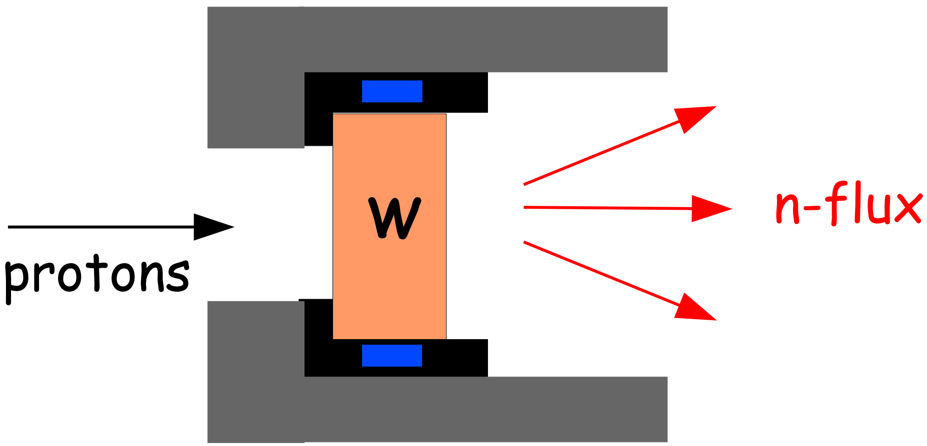
FLUKA

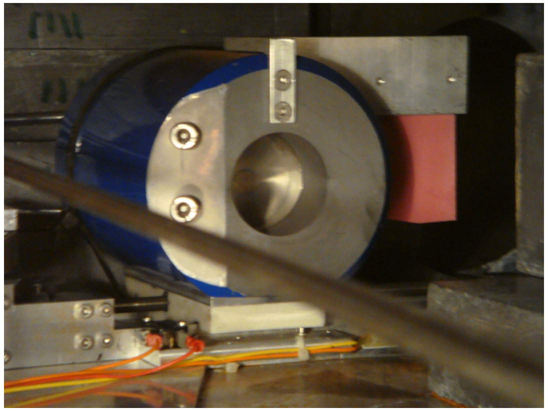
Flair

MCNPX

COMSOL MULTIPHYSICS

First approach: Look at ANITA target

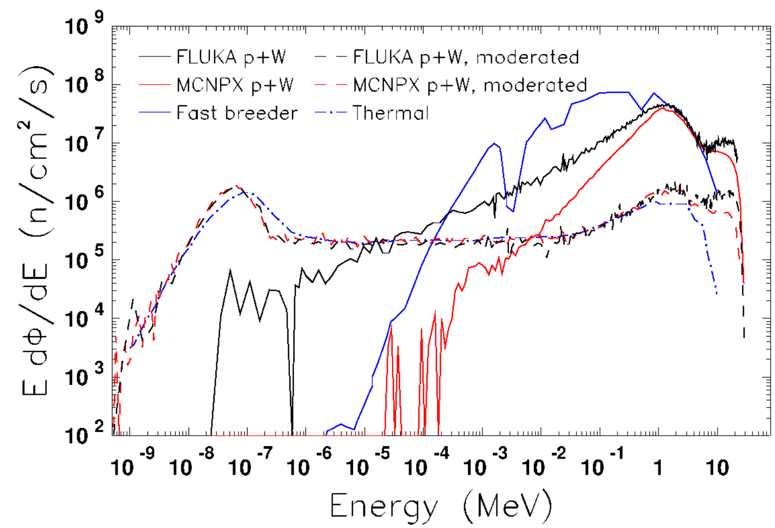




20 - 175 MeV p + W
White neutron source @ TSL

Also p + Be considered
First discarded for practical reasons, later reconsidered.

Can we imitate fast spectra?
Can we imitate LWR spectra?



Closing in on a final design

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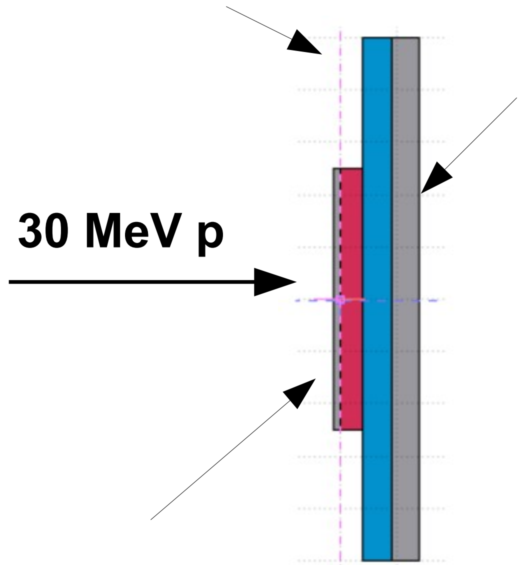
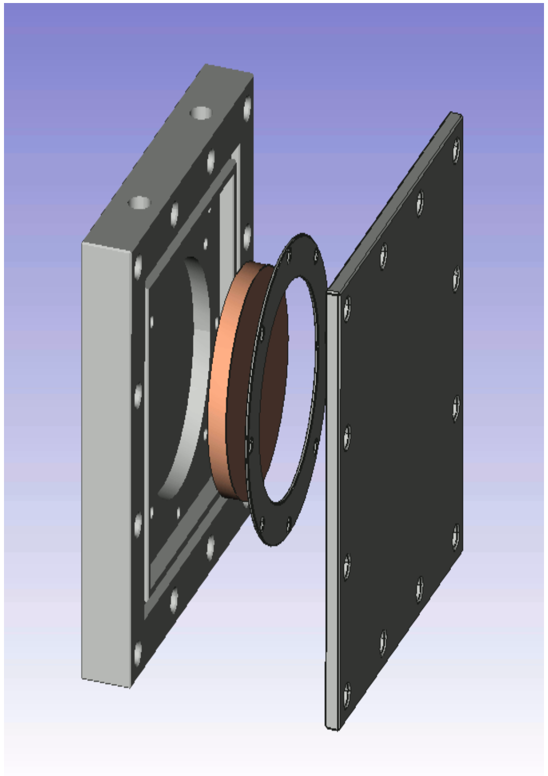
Water cooling on back side (5 mm)

Aluminium back plate



5 mm Be-disc



Design: D. Gorelov

The protons will stop in the cooling water

→ ~ 5% reduction in neutron yield

→ Less hydrogen buildup in Be

→ Less need for cooling

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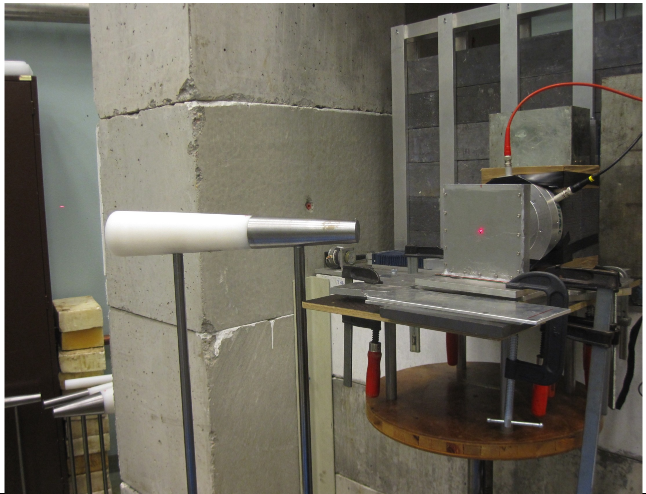
Benchmark experiment @ TSL

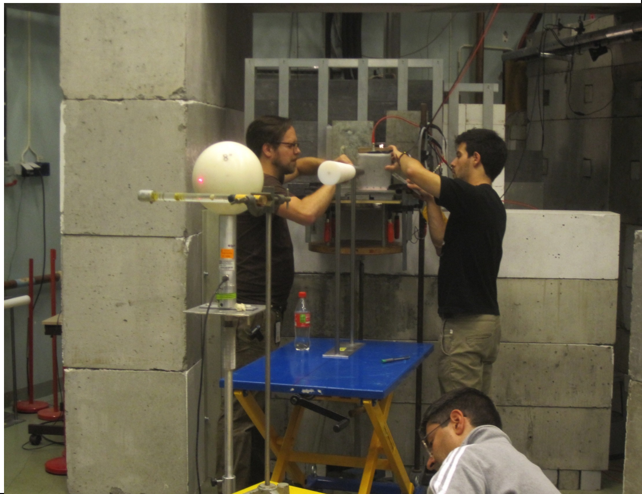
June 2012, ERINDA-funded

Spokesperson: Roberto Bedogni, Rome

Talk by Andrea Mattera earlier today

Purpose: To have a controlled measurement over the entire energy range in order to compare with Monte Carlo codes (and other experiments).





What kind of neutron spectra will we get?

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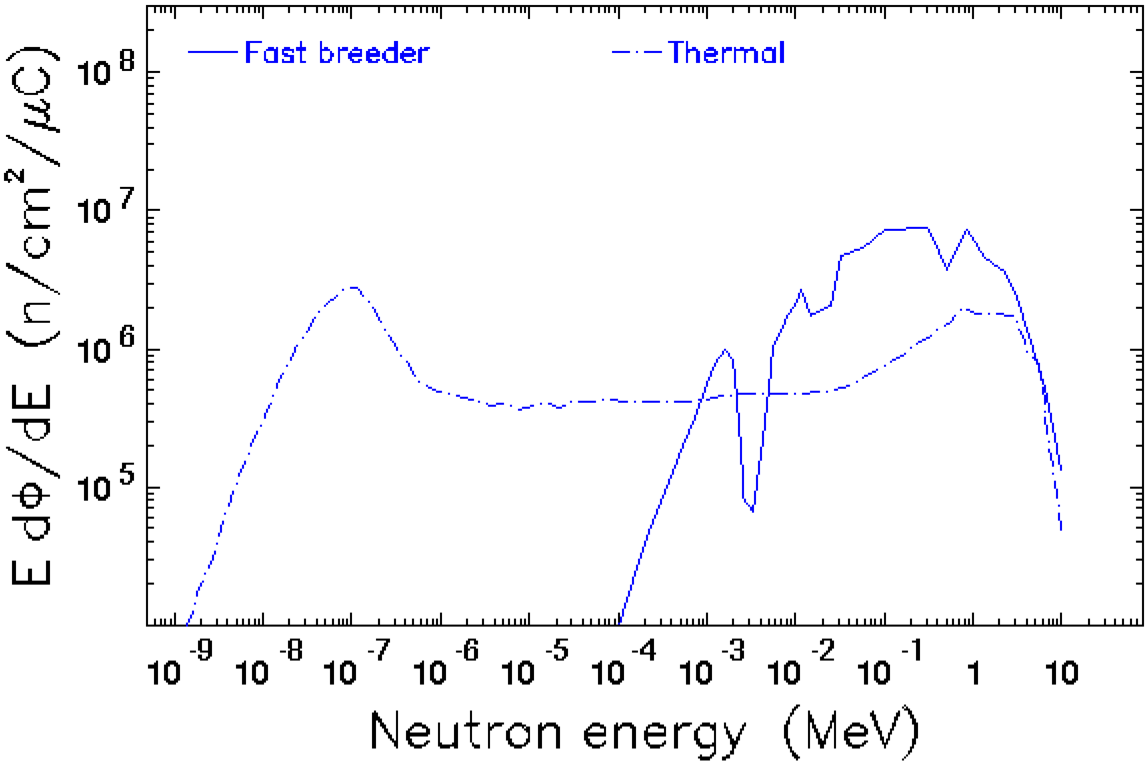
Imitate reactor spectra?



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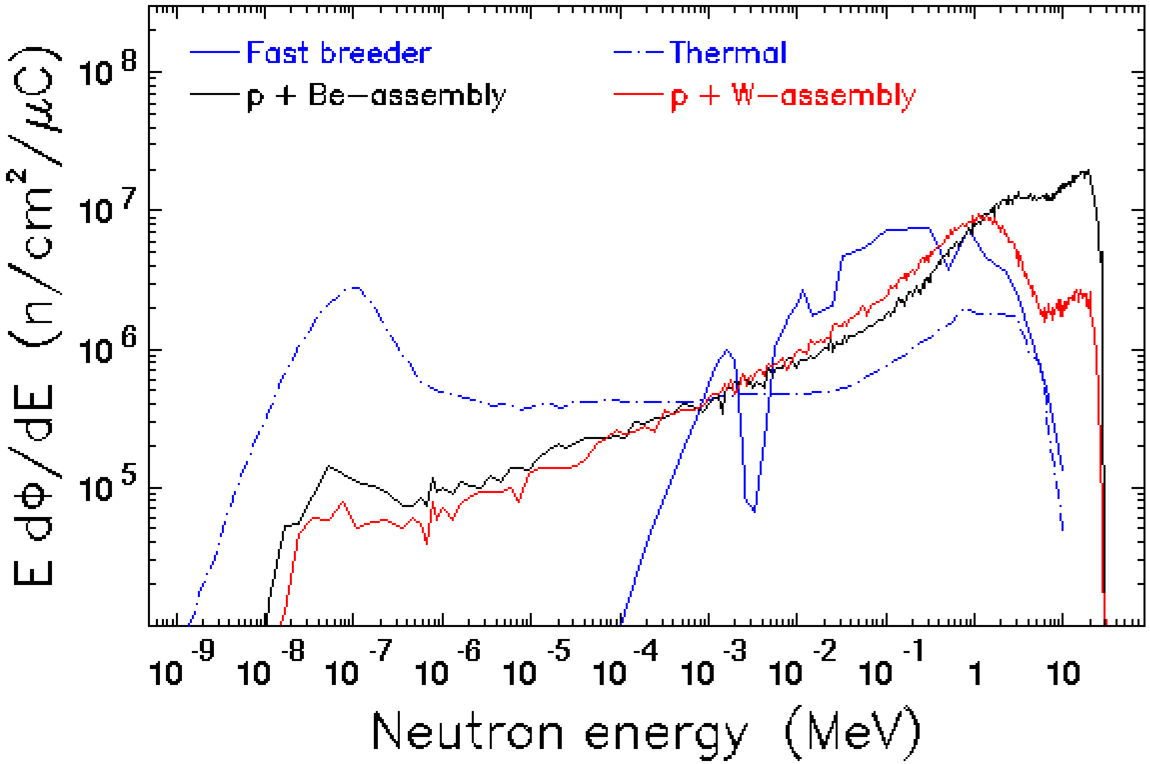
Imitate reactor spectra?



We can vary a number of parameters

Projectile, Energy, Converter material, ...

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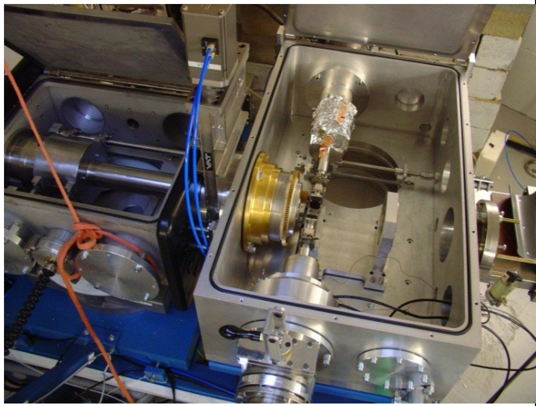
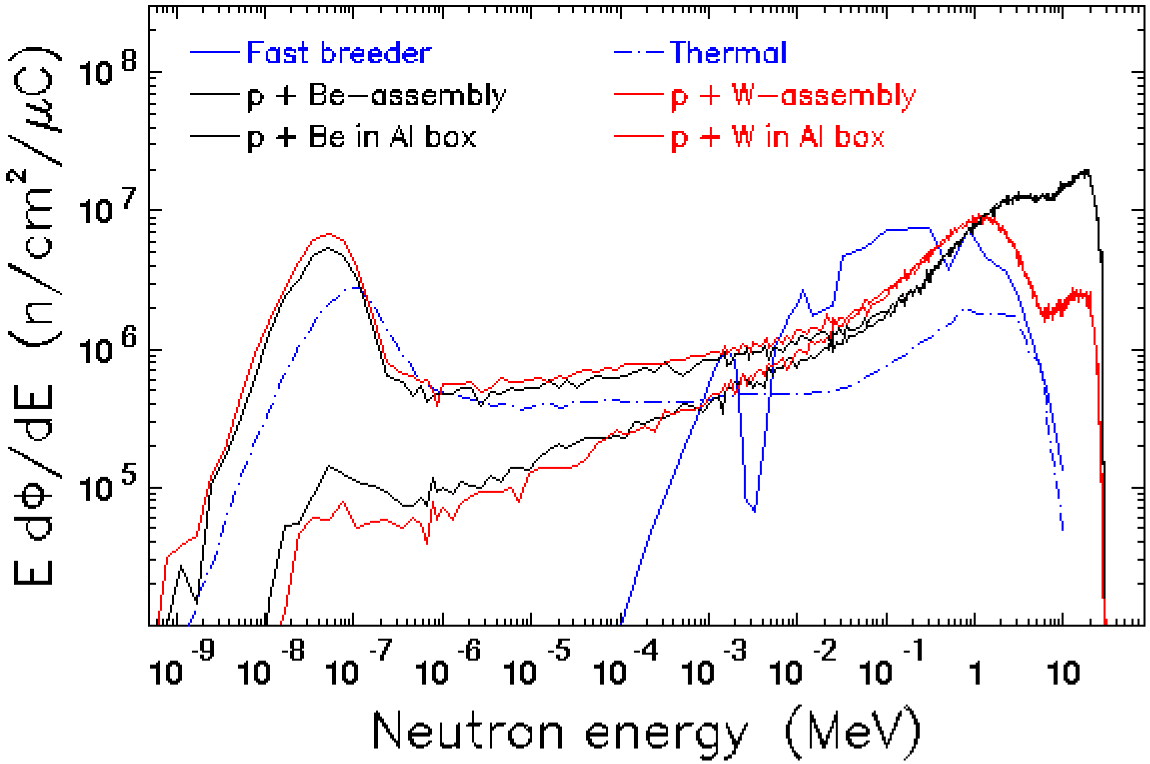
Effect of IGISOL Al-box





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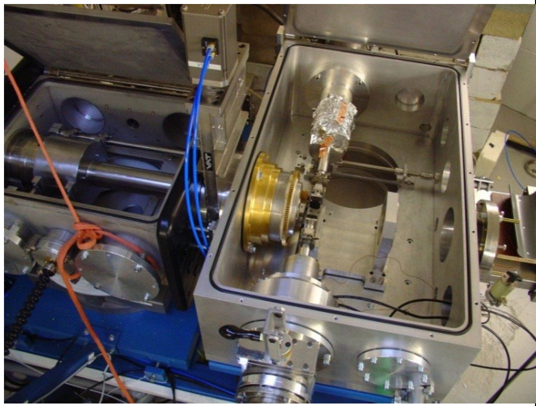
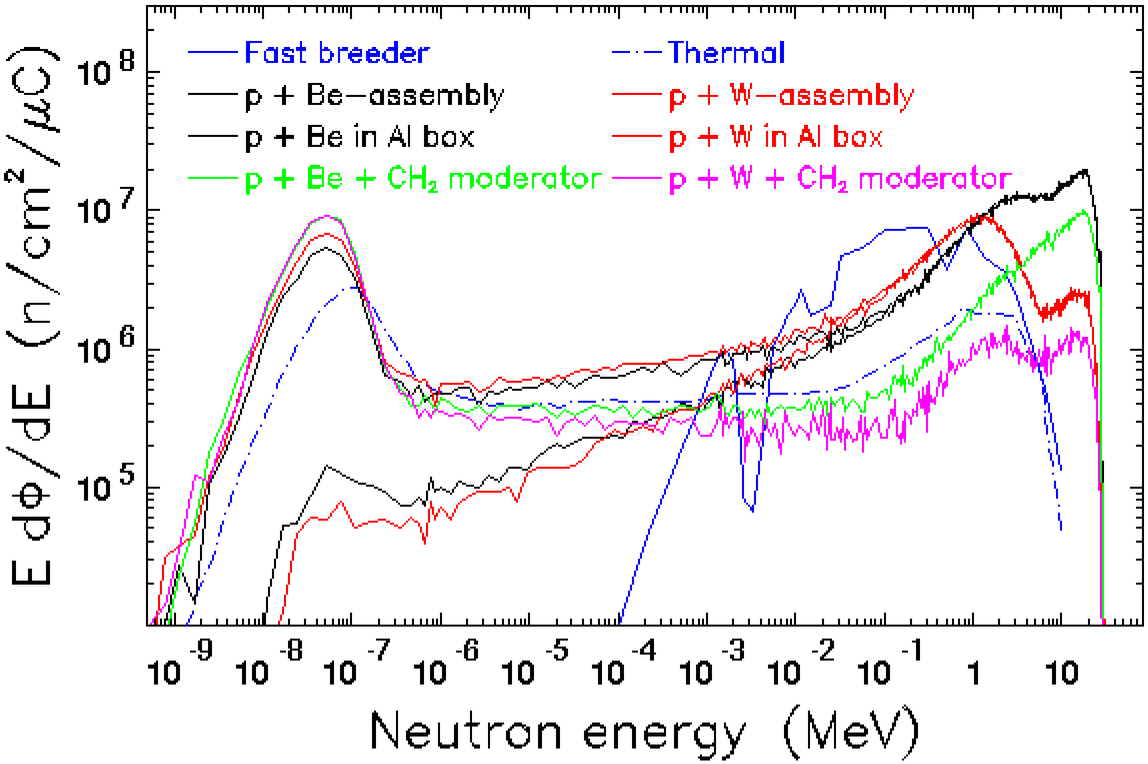


Moderator still plays a role



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Effect of IGISOL Al-box

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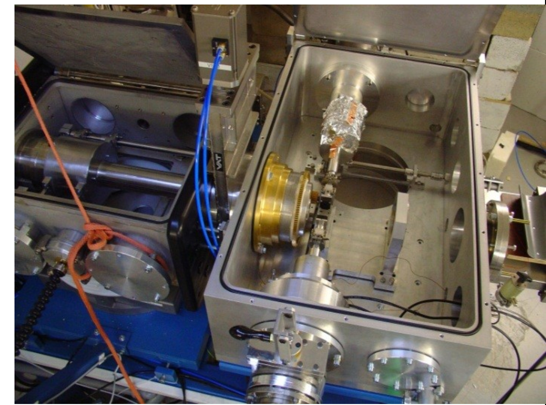
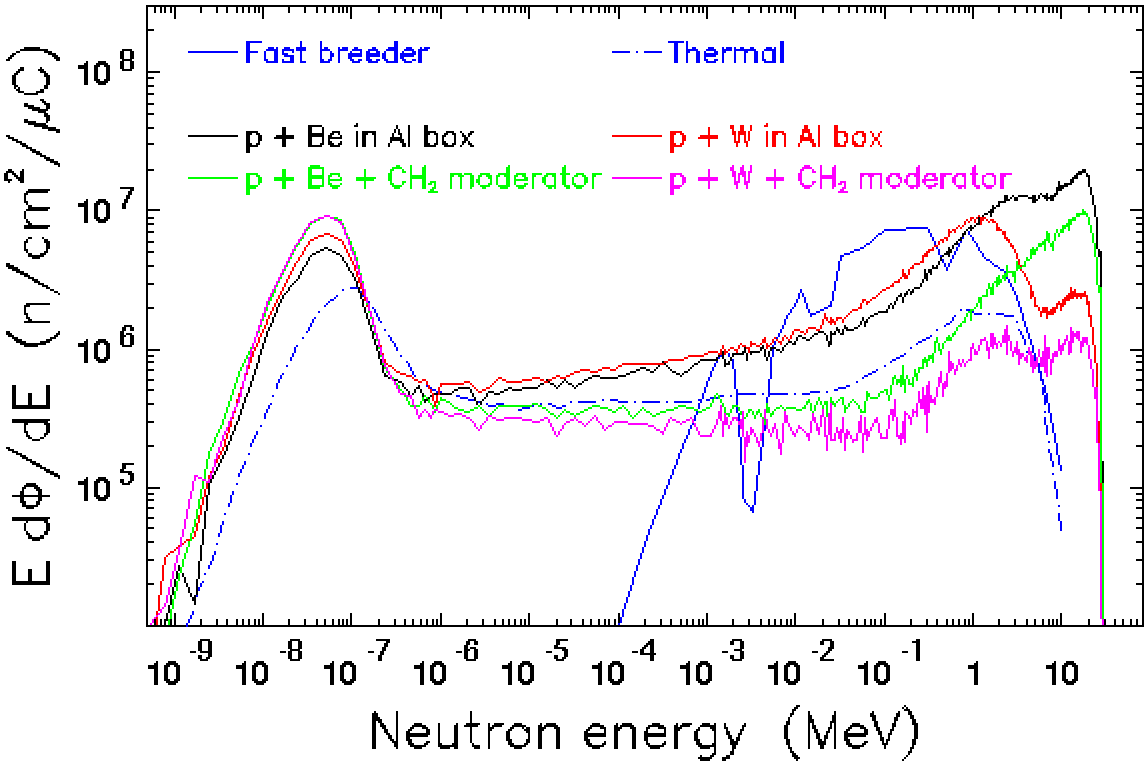
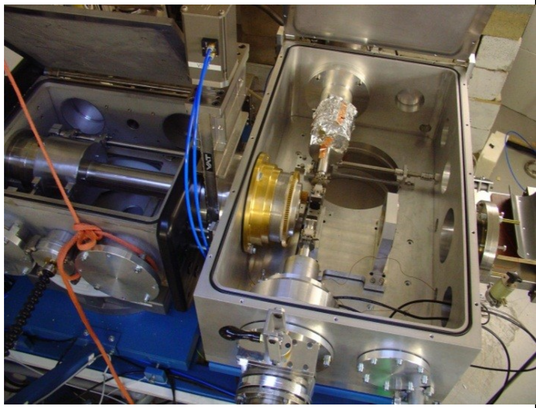
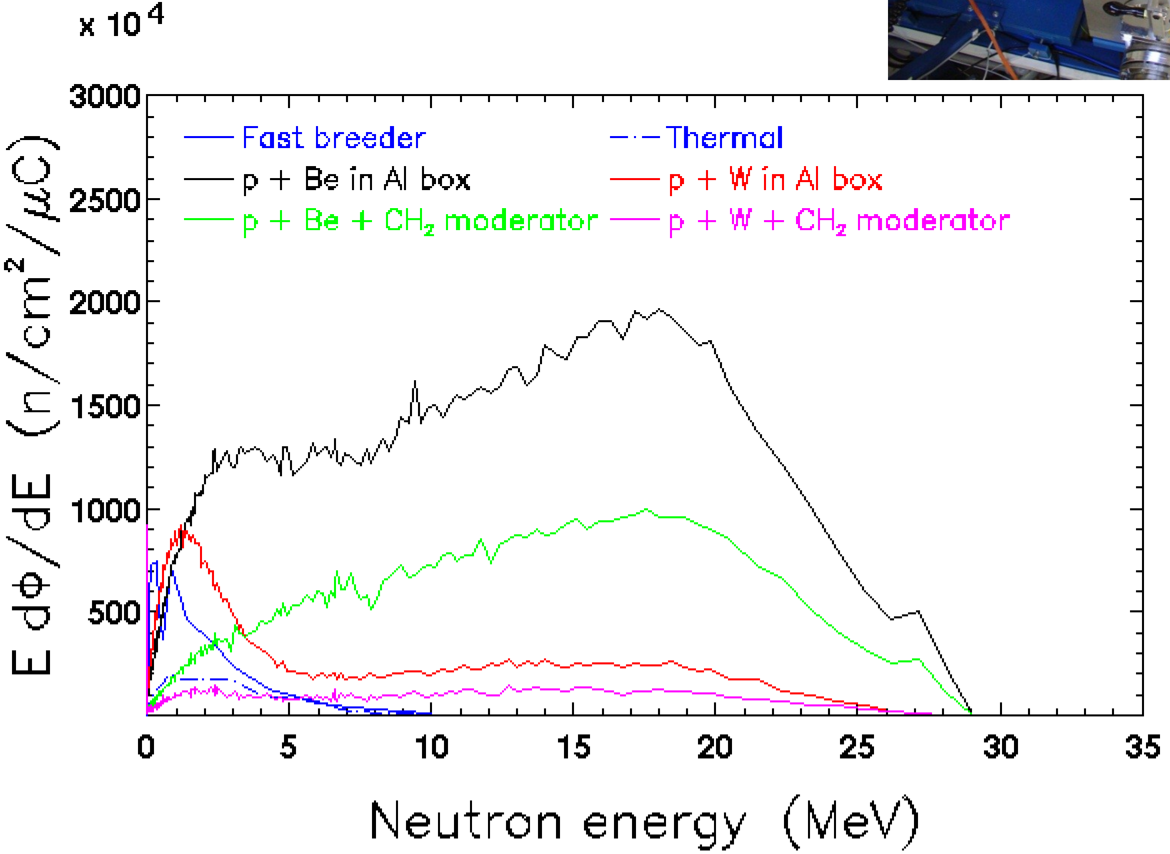




The high energy part

Of interest for JYFL research





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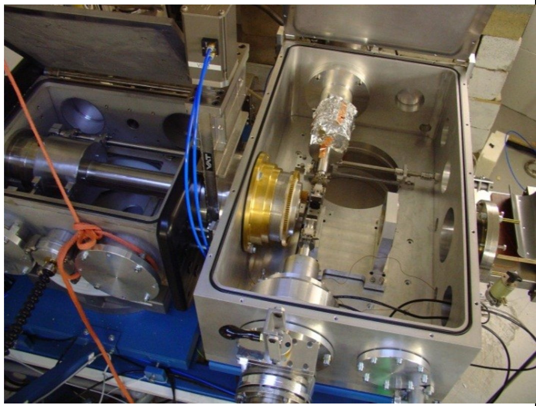
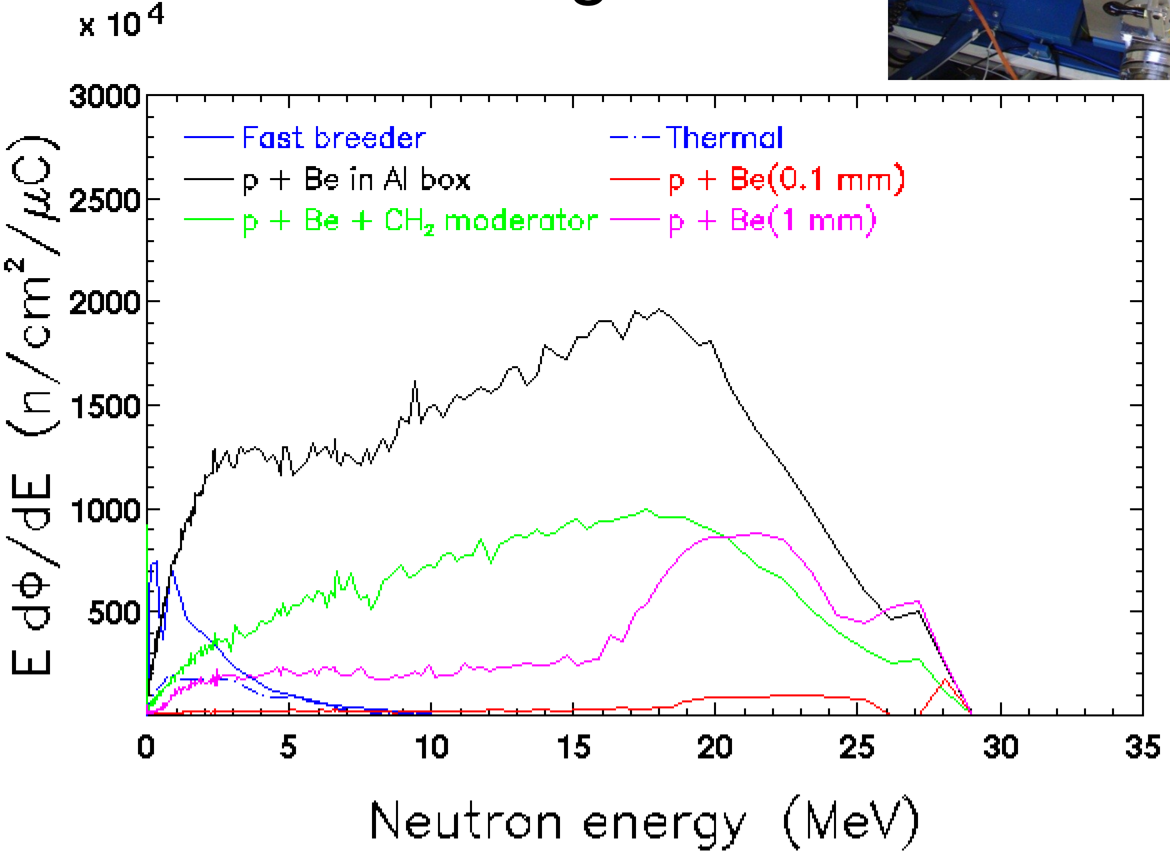
The high energy part



Effects of thin Be targets



Unfolding procedure from different measurements

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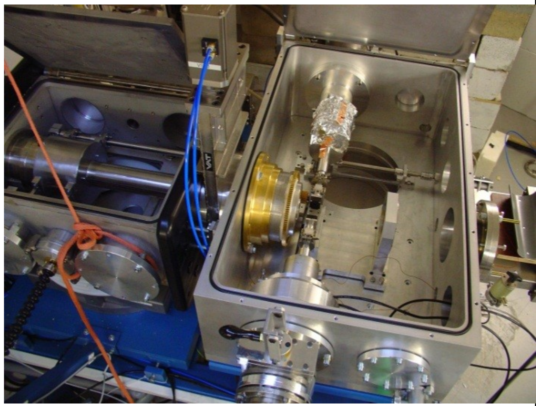
The high energy part



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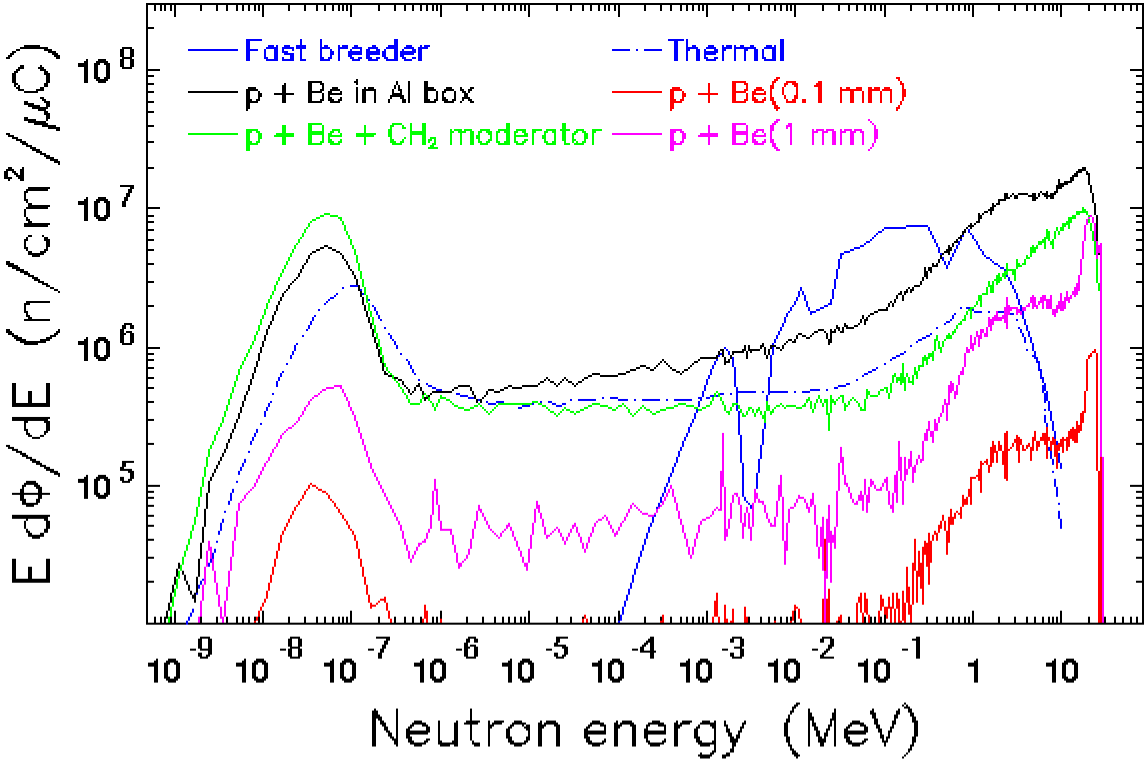

Unfolding procedure from different measurements

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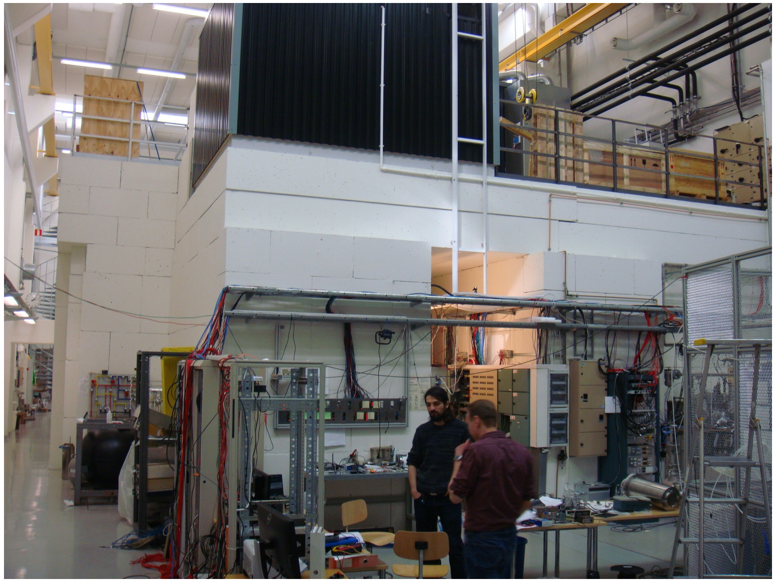
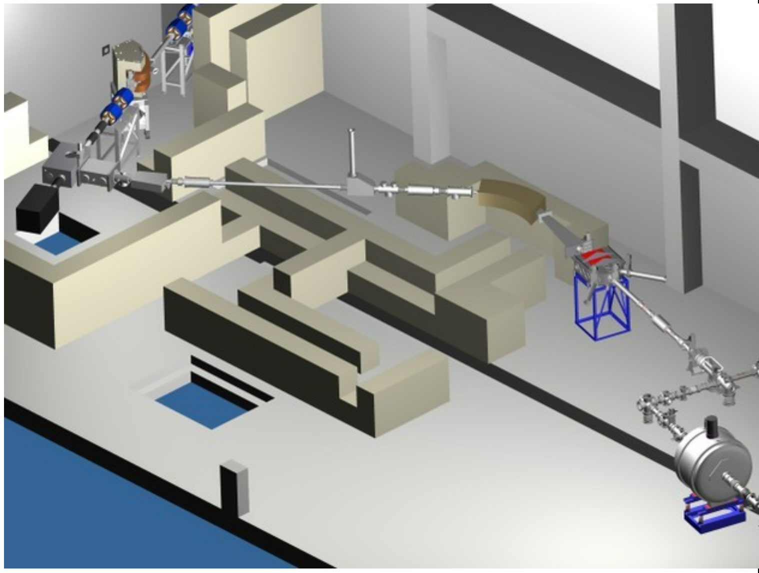
Other issues

→ Sort out MC code discrepancies
→ Gamma-induced effects
→ Activation (radiation protection, waste?)
→ Radiation protection in JYFLTRAP area





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Summary and future plans

→ Upgraded facility at IGISOL-JYFLTRAP will be interesting place for high quality fission yield studies in view of Gen-IV reactors and used fuel issues

→ Neutron spectra background dominated by scattering from IGISOL Al-chamber

→ General design of high intensity neutron source done but several issues left to sort out
- MC code issues
- Practical design details (build it!)
- Vary parameters for different neutron spectra
- Cooling and activation

→ Have benefitted from ERINDA short term visit

→ Articles coming...

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Financers for the Uppsala AlFONS projekt

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Swedish Nuclear Fuel and Waste Management Co. (SKB)