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Inelastic cross section measurements at GAINS on ^{14}N and $^{35, 37}Cl$

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[1] Horia Hulubei National Institute for Physics and Nuclear Engineering, Magurele, Romania
[2] Université de Strasbourg, CNRS, Strasbourg, France
[3] European Commission, Joint Research Centre, Geel, Belgium

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❖ Work Package 2

New nuclear data measurements for energy and non-energy applications

❖ Task 2.3

Neutron elastic and inelastic scattering and neutron multiplication cross sections
Task coordinator: IFIN-HH, partners: CNRS/IPHC, JRC

❖ Deliverable 2.4

Report on the ^{239}Pu, ^{233}U, ^{14}N and ^{35,37}Cl inelastic cross section measurements at GELINA

❖ Milestone 23

Completion of the ^{239}Pu, ^{233}U, ^{14}N and ^{35,37}Cl inelastic and (n,2n) cross section measurements at GELINA

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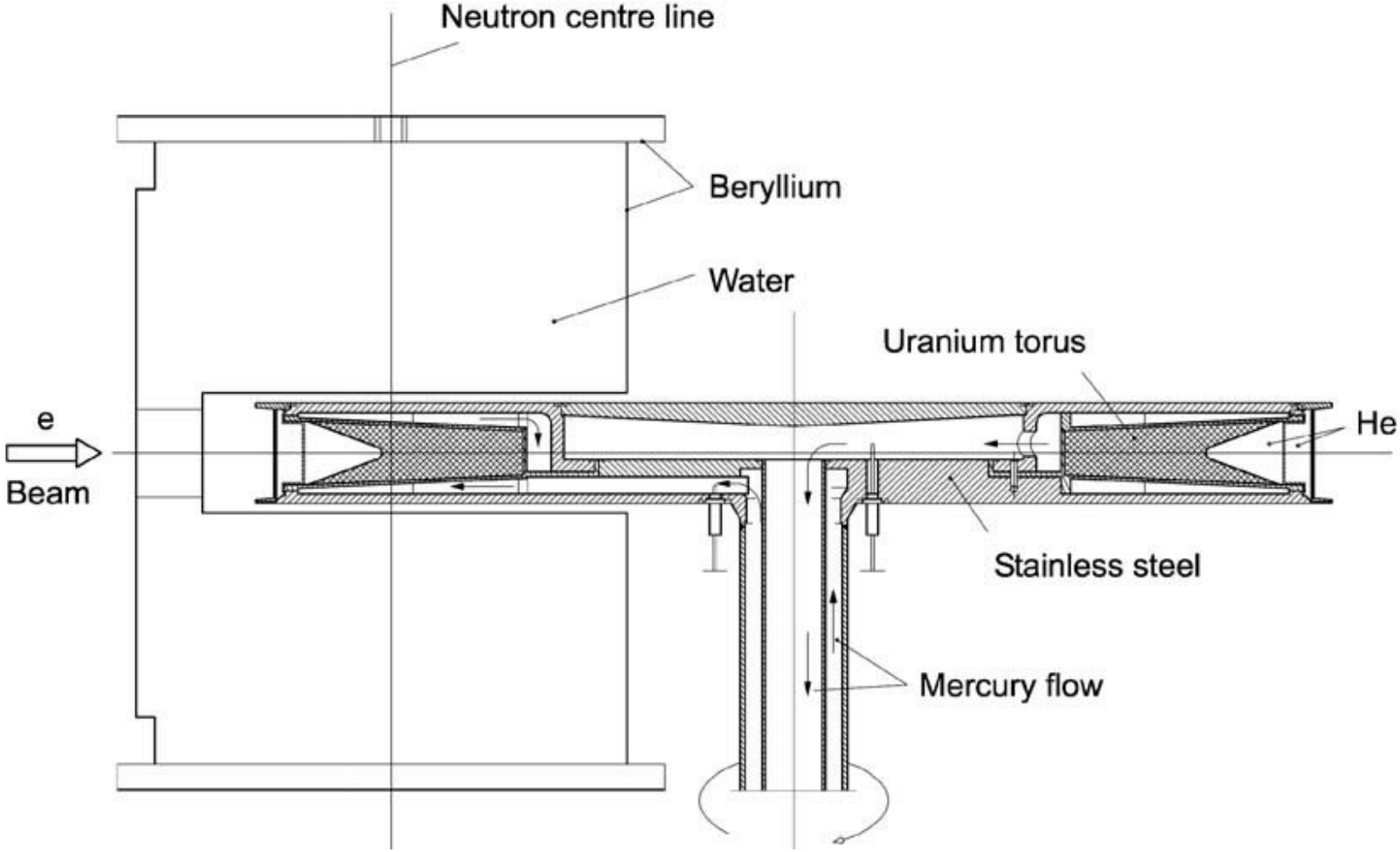
GELINA

Geel **E**lectron **LIN**ear **A**ccelerator



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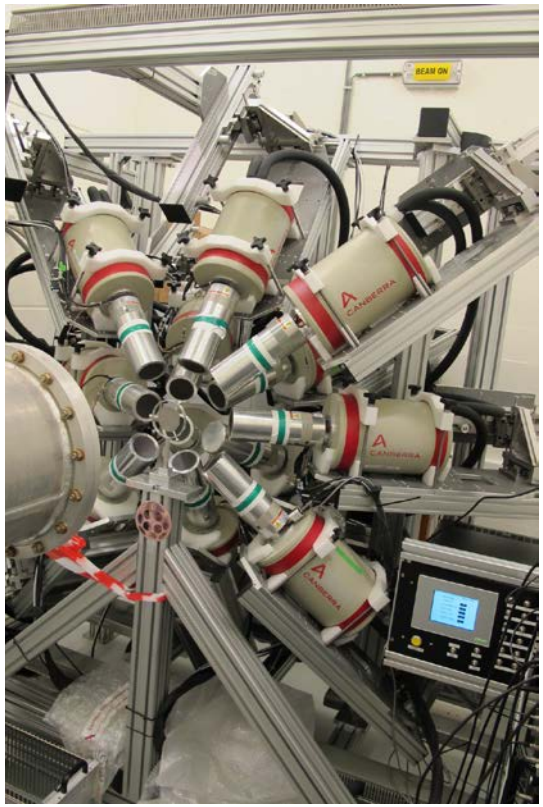
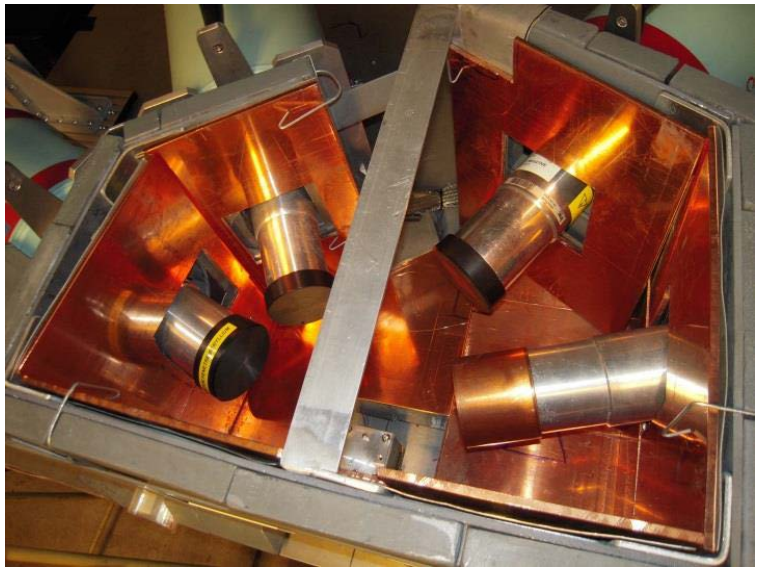
GAINS

Gamma **A**rray for **I**nelastic
Neutron **S**cattering



GRAPhEME

GeR**manium** array for **A**ctinides
PrEcise **ME**asurements



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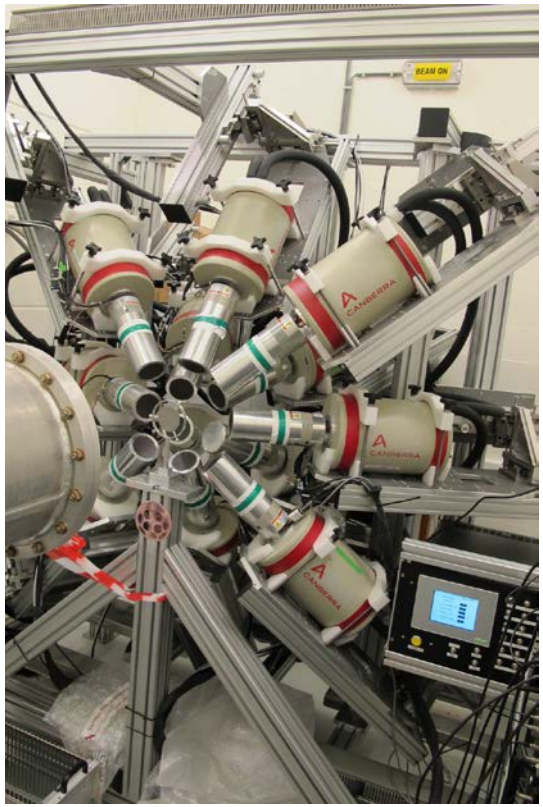

^{14}**N** - ^{35,37}**Cl**

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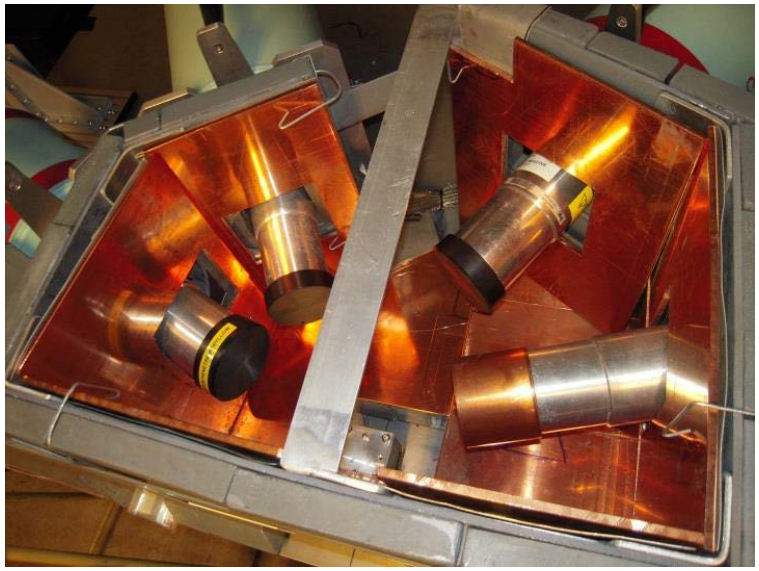

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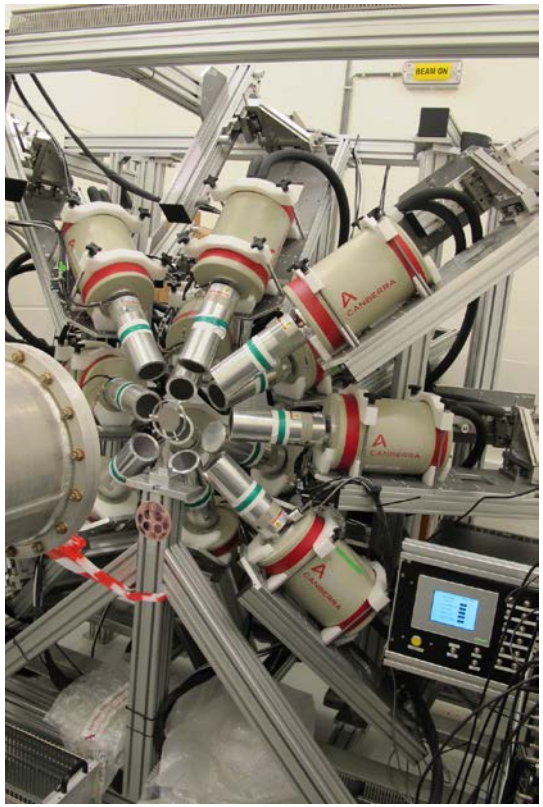

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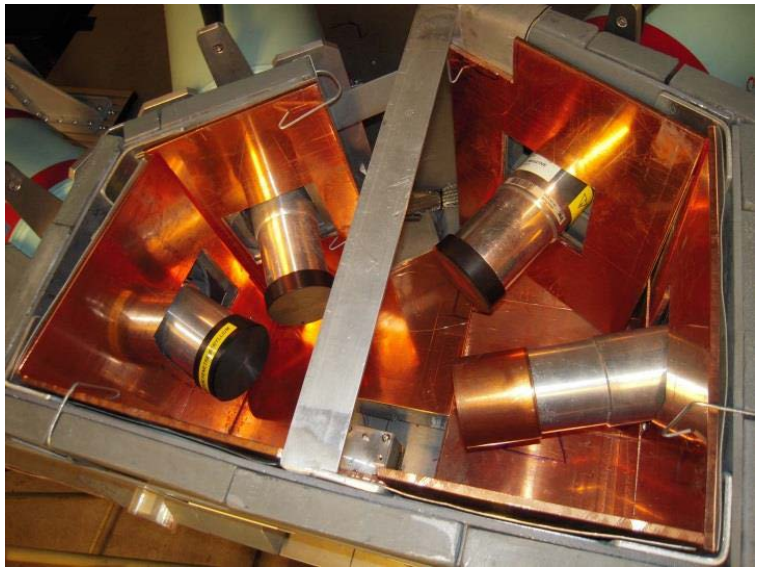

^{233}**U see** François Claeys talk

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GAINS

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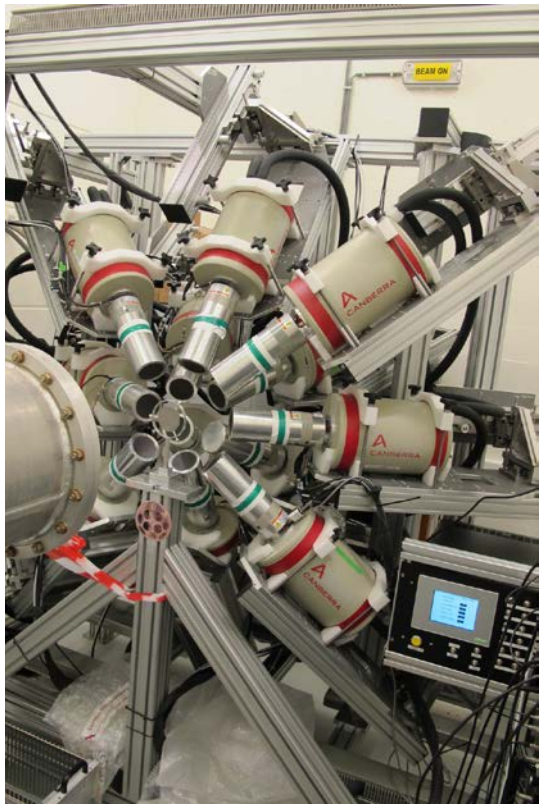

^{14}N - $^{35,37}Cl$

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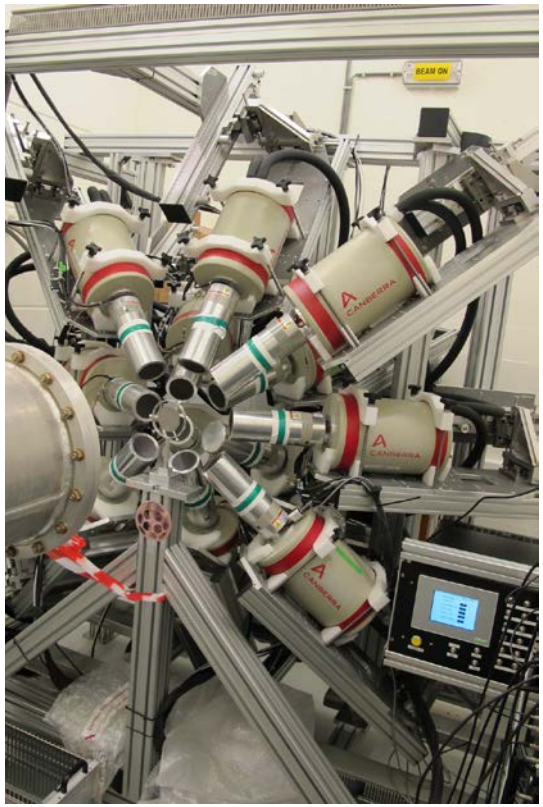

^{14}N - $^{35,37}Cl$

- precise knowledge of neutron inelastic scattering cross section is required due to their impact on the criticality coefficient of the fission reactors.

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GAINS

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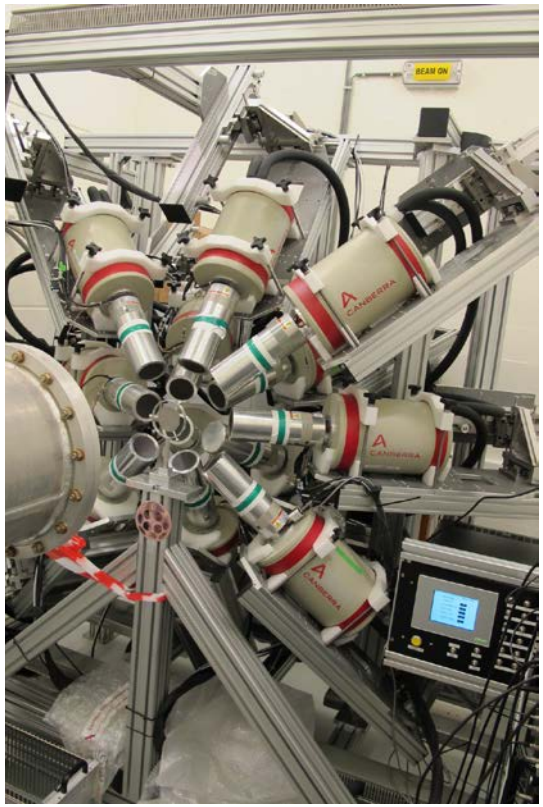

^{14}N - $^{35,37}Cl$

- precise knowledge of neutron inelastic scattering cross section is required due to their impact on the criticality coefficient of the fission reactors.
- isotopes of interest for development of nuclear facilities

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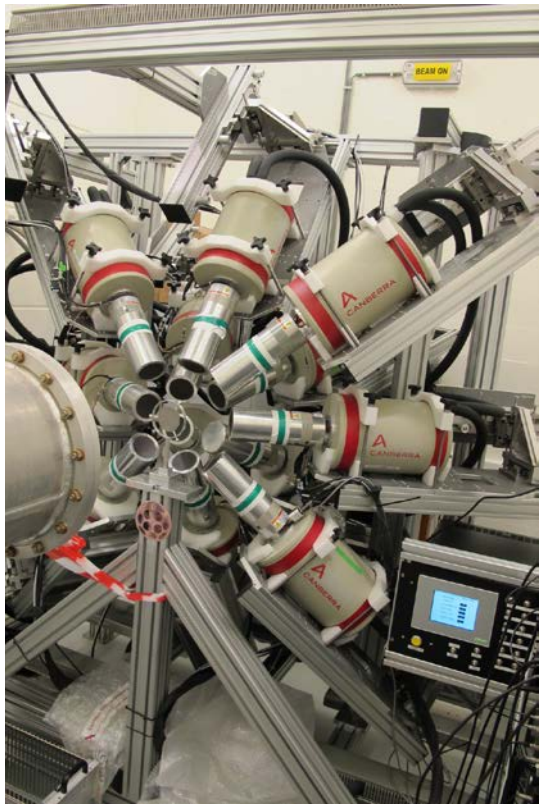

^{14}N - $^{35,37}Cl$

- precise knowledge of neutron inelastic scattering cross section is required due to their impact on the criticality coefficient of the fission reactors.
- isotopes of interest for development of nuclear facilities
- 14N represents 99.63% in natural nitrogen and is part of uranium nitride (UN, U2N3 and UN2), potential fuel for Gen IV Reactors.

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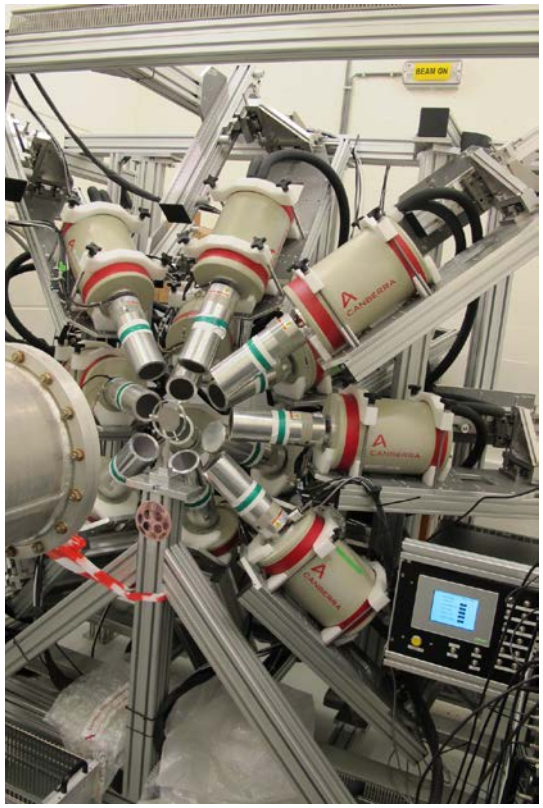

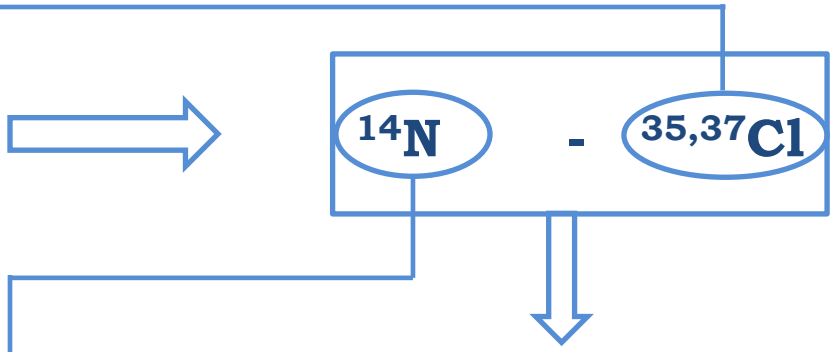

- precise knowledge of neutron inelastic scattering cross section is required due to their impact on the criticality coefficient of the fission reactors.
- isotopes of interest for development of nuclear facilities
- ^{14}N represents 99.63% in natural nitrogen and is part of uranium nitride (UN, U2N3 and UN2), potential fuel for Gen IV Reactors
- neutron-induced reactions on ^{35,37}Cl is very important for the development of the Fast Spectrum-Molted Salt Reactors based on chloride salts

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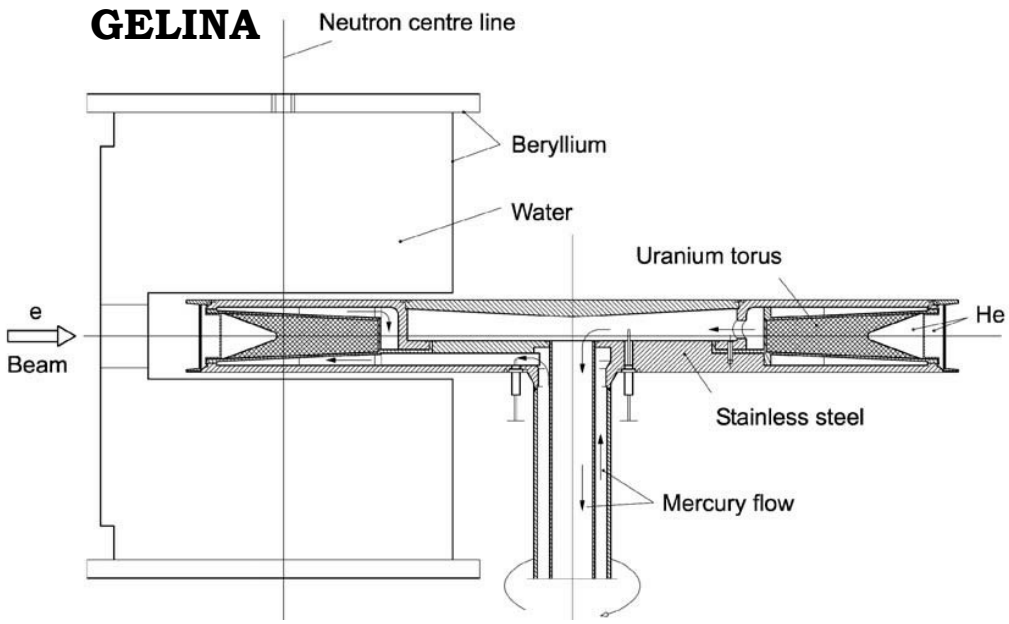
EXPERIMENTAL SETUP



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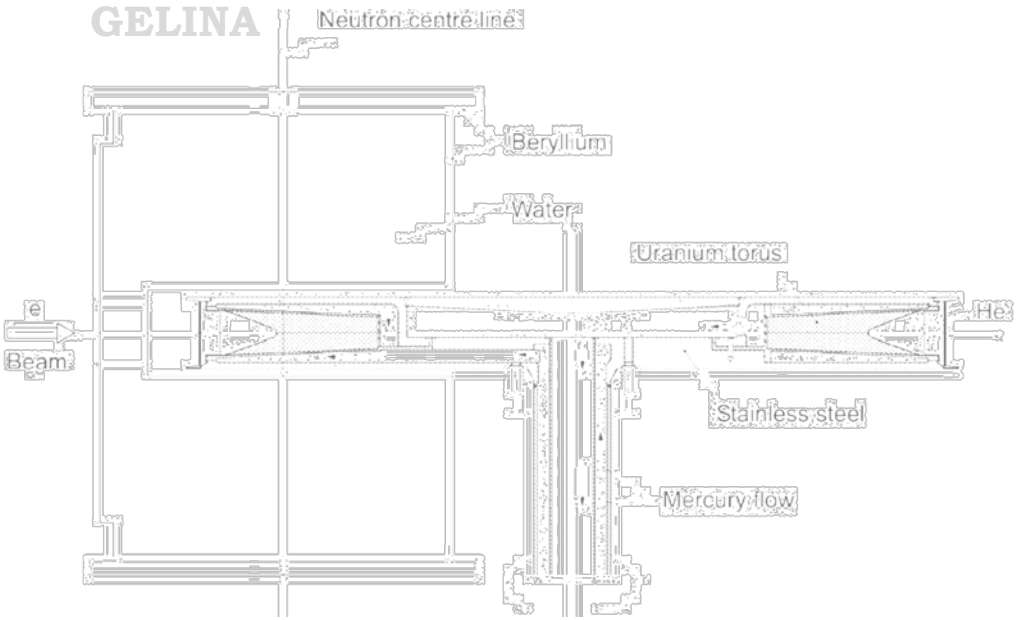
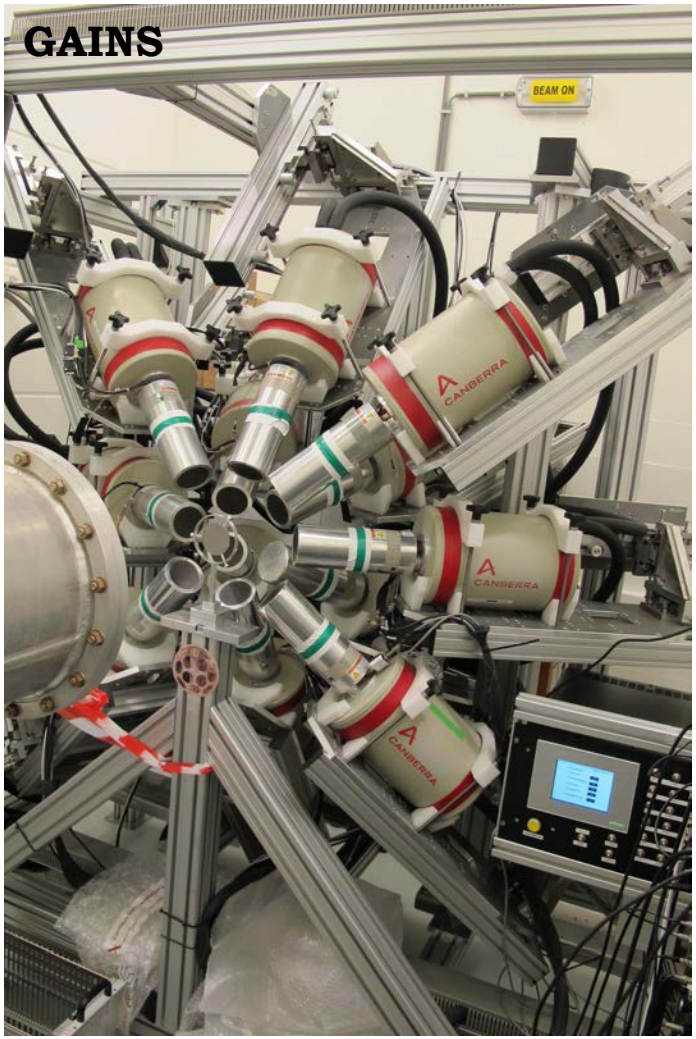
EXPERIMENTAL SETUP





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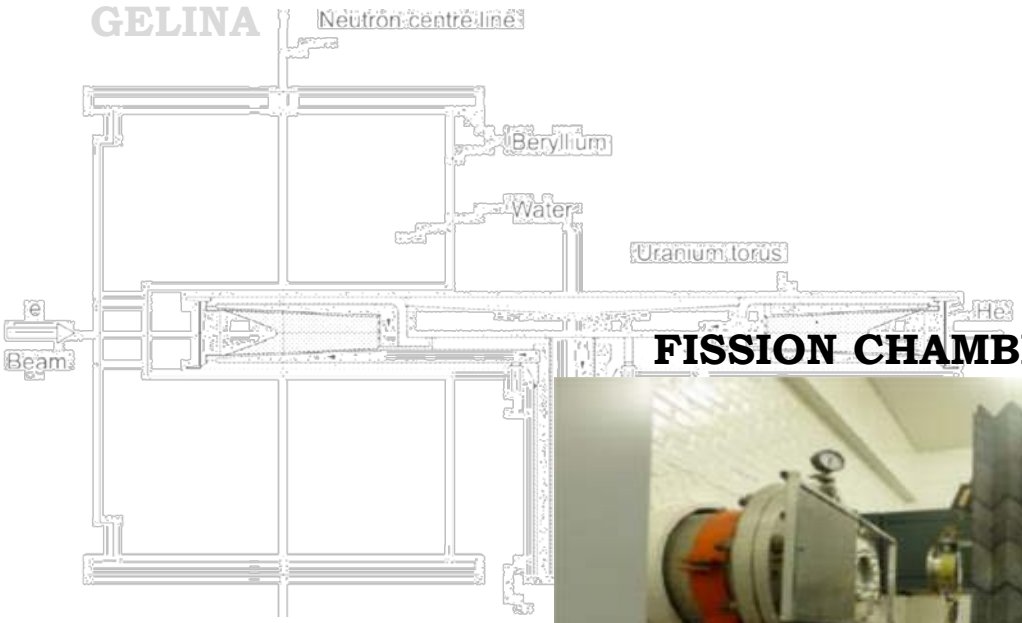

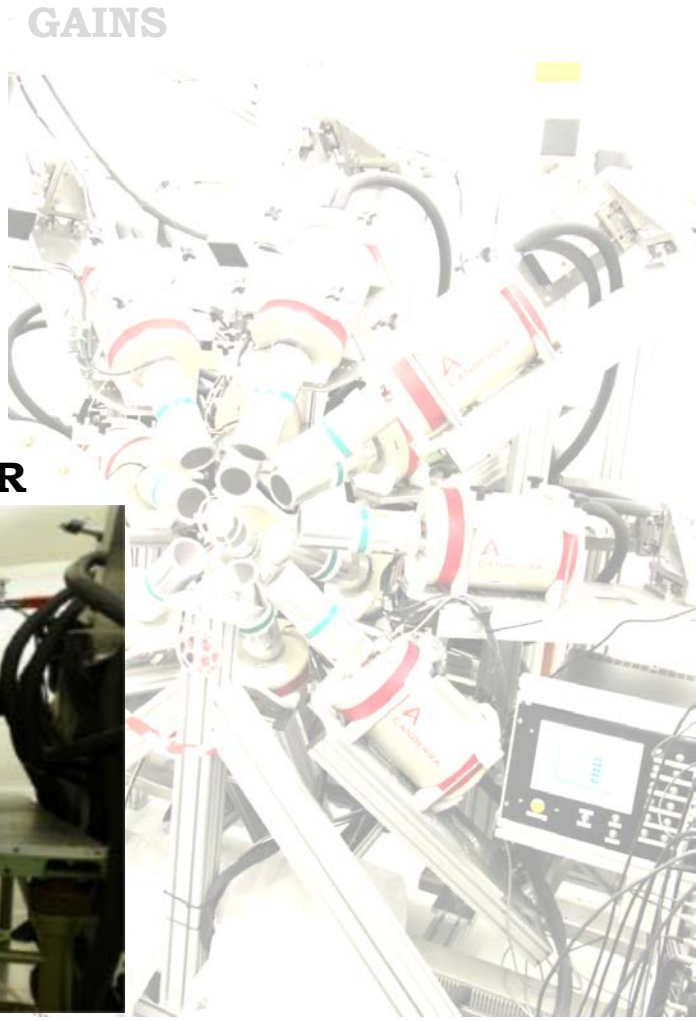

FISSION CHAMBER

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GELINA - Geel Electron LINear Accelerator

- Linear electron accelerator (Ee ≈ 70 - 140 MeV, Δt < 1 ns)
- Neutrons produced in the U target by photon induced reactions
- Multiuser facility
- Flight paths from 8 m up to 400 m in length
- The inelastic scattering experiments are done at FP3, 100 m measurement station.
- Neutron energy resolution: 3 keV at 1 MeV, 80 keV at 10 MeV

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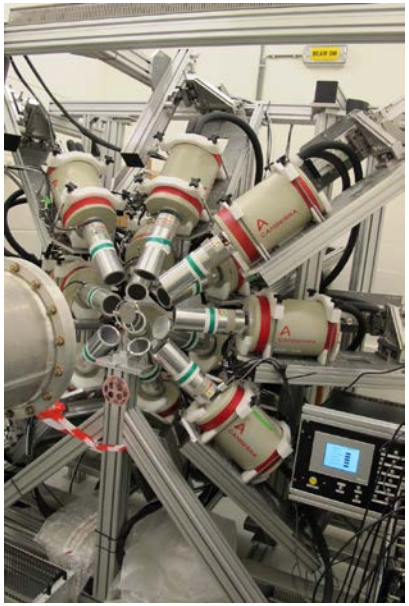
GAINS - **G**amma **A**rray for **I**nelastic **N**eutron **S**cattering

- 12 HPGe detectors @ 110º, 150º and 125º
- Relative efficiency: 100%
- FWHM ≈ 2.8 keV for the 1332 keV of ^{60}C0



Fission chamber

- to monitor the neutron flux

Digital acquisition:

- 12 bit amplitude resolution (4096 channels)
- 440 MS/s (2.38 ns)

Time of flight technique:

- n time of flight → En
- pulse amplitude → Eγ

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- γ -spectroscopy measurements coupled with time of flight method
- we extract cross sections <u>normalized to ^{235}U(n, fission) cross section</u>

HPGe detectors ⇒ γ yield + FC yield ⇐ Fission chamber

HPGe detector efficiency interpolation & extrapolation (via simulations - MCNP 6) → ⇓ ← Other corrections:
- MSC coefficients
- Fission chamber efficiency
- …

Differential γ-production cross sections

$$\frac{d\sigma}{d\Omega}(\theta_i, E_k) = \frac{1}{4\pi}\frac{Y_j(E_k)}{Y_{FC}(E_k)}\frac{\varepsilon_{FC}\sigma_U(E_k)}{\varepsilon_j}\frac{t_U}{t_s}\frac{A_U}{A_s}\frac{1}{c_{ms}(E_k)}$$

⇓

Angle-integrated γ-production cross section

$$\sigma(E_k) = 2\pi[w_{110^o}\frac{d\sigma}{d\Omega}(110^o, E_k) + [w_{150^o}\frac{d\sigma}{d\Omega}(150^o, E_k)]$$

Level scheme (ENSDF)

⇙ Level cross section

⇘ Total inelastic cross section

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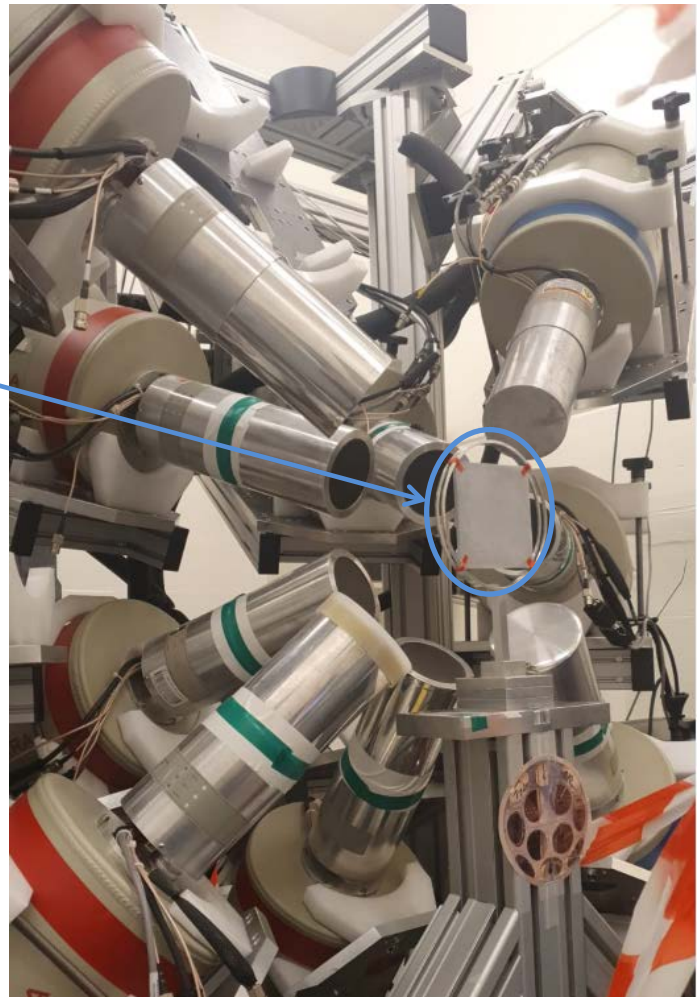
Status of the measurements

^{14}N - ongoing data taking

target: Si_3N_4

$^{35,37}Cl$ - next EUFRAT PAC



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Thank you!