FROM RESEARCH TO INDUSTRY

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DEVELOPMENTS OF COMPACT ACCELERATOR NEUTRON SOURCE

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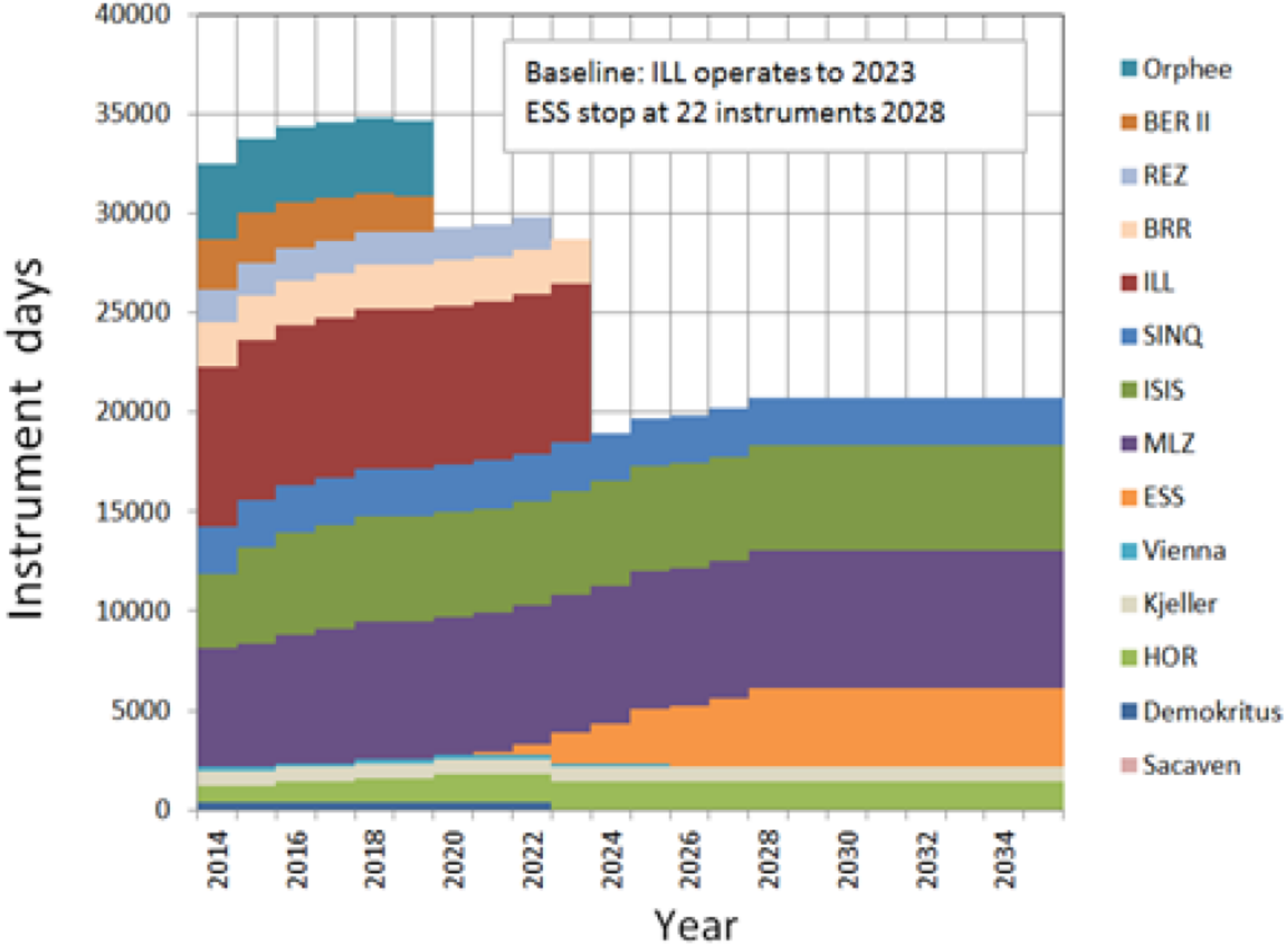
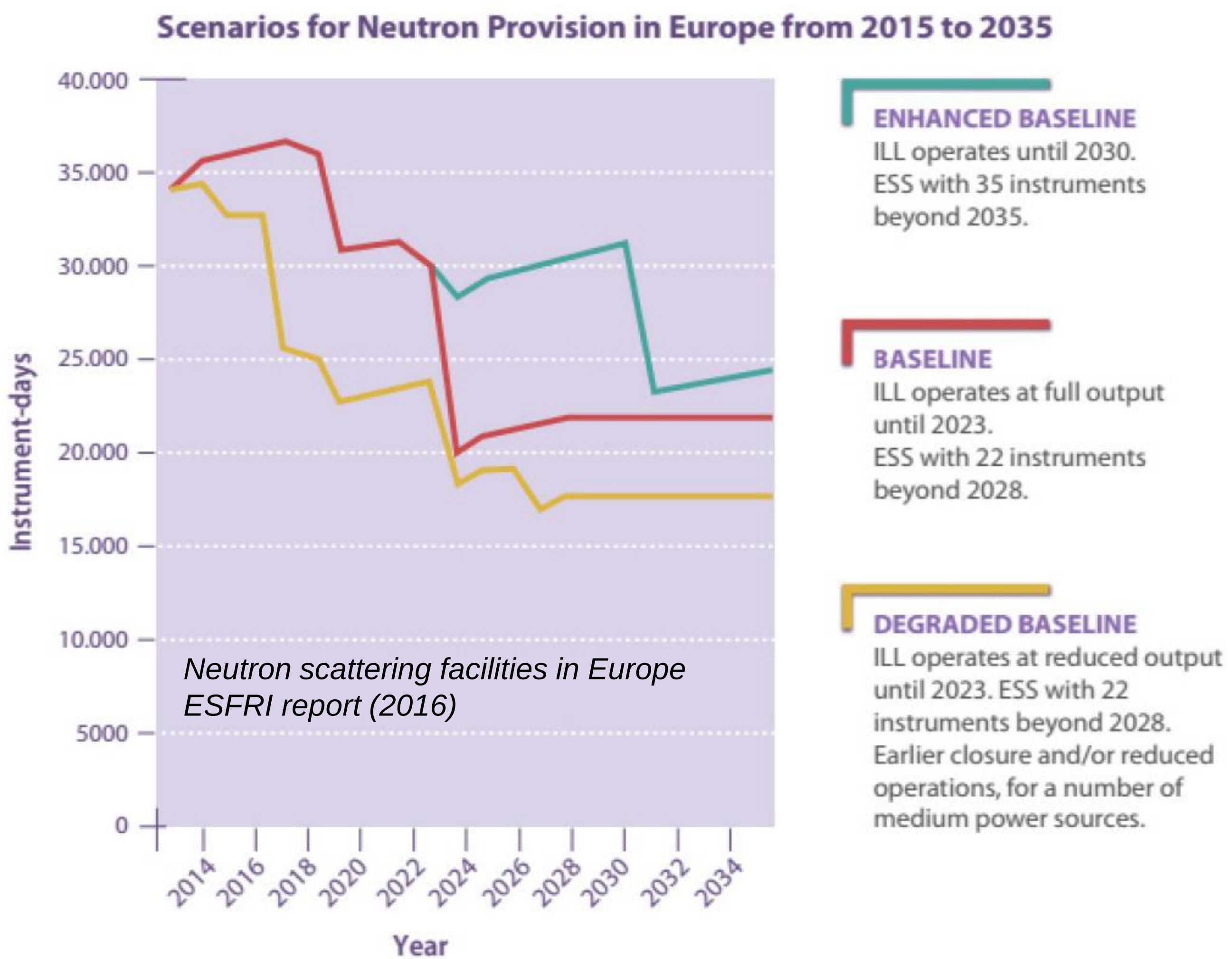
BASELINE SCENARIO FOR NEUTRONS IN EUROPE

Neutron scattering facilities in Europe, ESFRI report (2016)



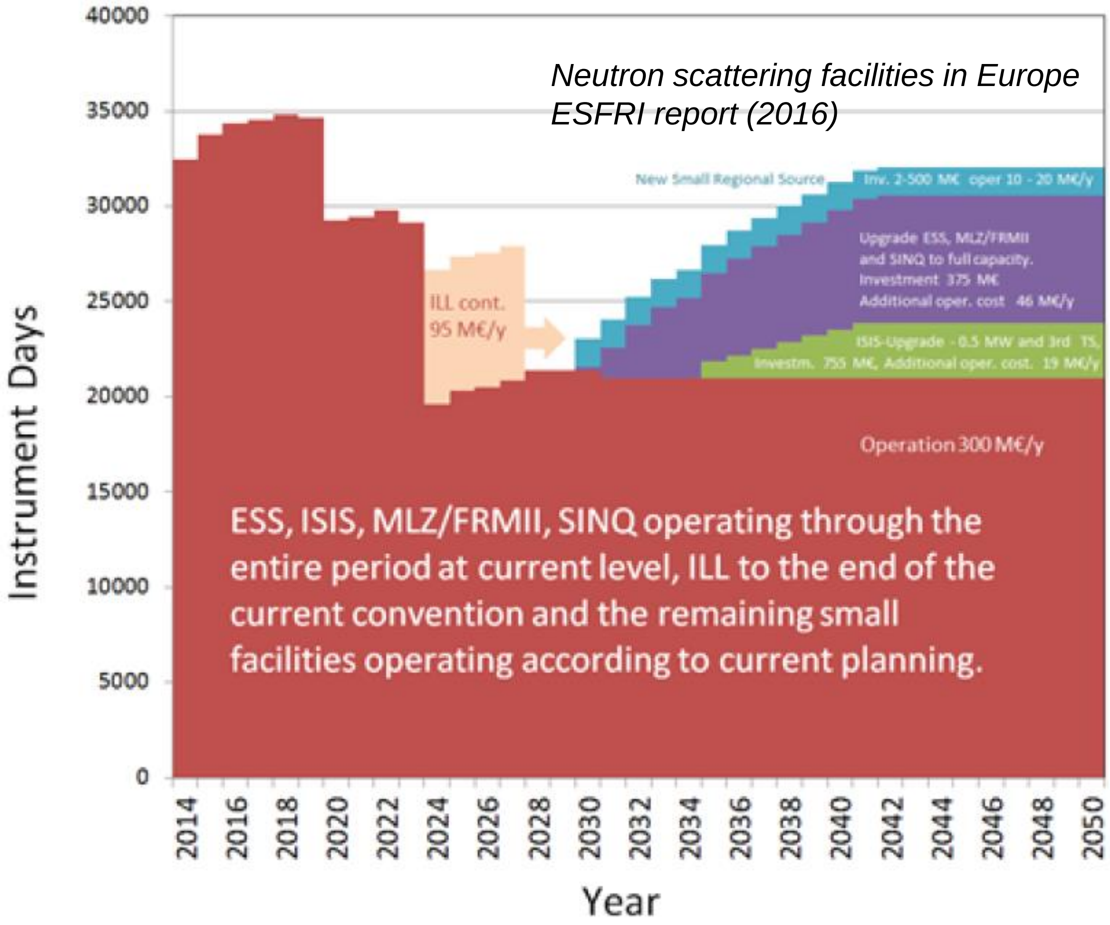
Main reactor-based neutron sources would stop in the next decade

GLOBAL SCENARIOS FOR NEUTRONS IN EUROPE



Neutron scattering facilities in Europe
ESFRI report (2016)

A POSSIBLE SCENARIO FOR NEUTRONS IN EUROPE

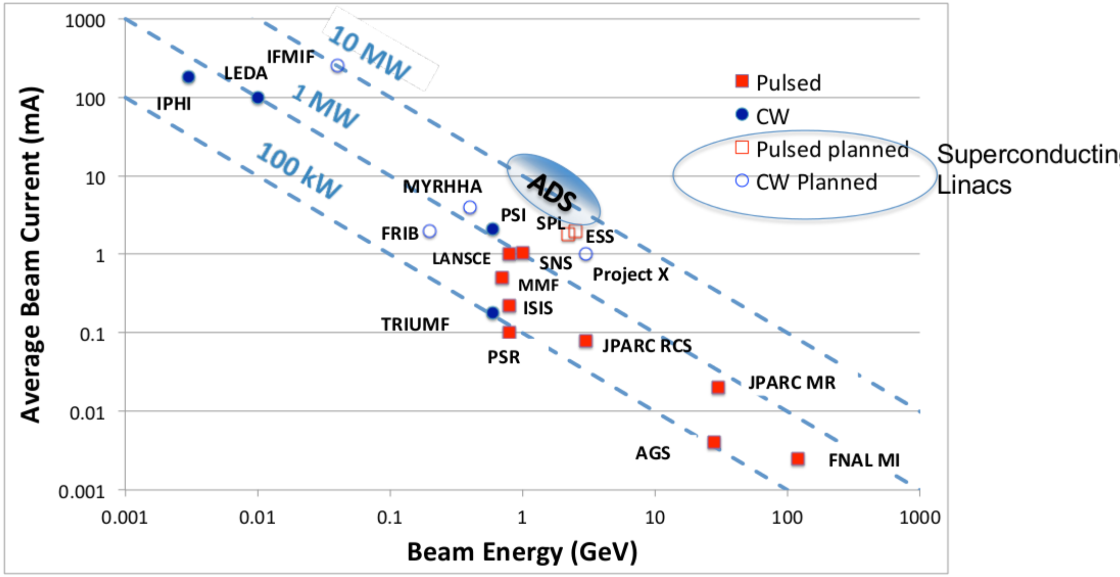


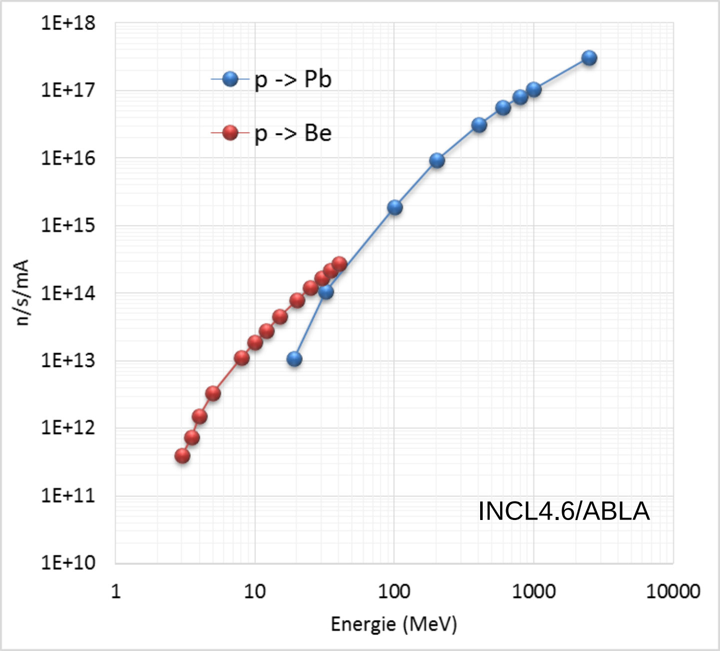
- Very unlikely to be any new research reactors built in Europe
- Sources need to cost <€300M to be affordable by individual countries
- Energy costs need to be minimized and science production needs to be maximized

→ Compact Accelerator Neutron Source (CANS)

HIGH-INTENSITY ACCELERATOR OPPORTUNITIES

High-intensity accelerators



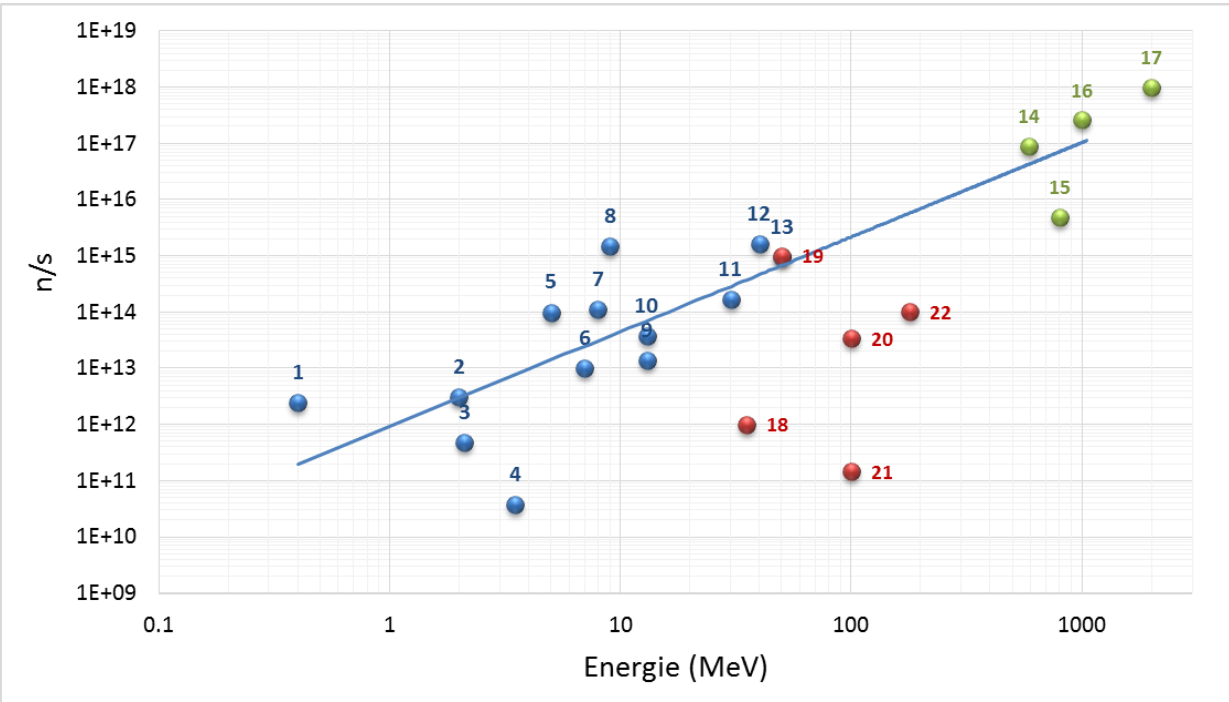


Low-energy p- or d-induced reactions

To produce at least : 10^{12} n/s/mA x 100 mA = 10^{14} n/s in the target

To be competitive for experiments (~10^{9} n/cm^{2}/s on the instrument)

STATUS OF ACCELERATOR-BASED NEUTRON SOURCES IN THE WORLD



1	HINEG2
2	PKUNIFTY
3	Franz
4	KUANS
5	Legnaro
6	RANS
7	iBNCT
8	IFMIF-Lipac
9	LENS
10	CPHS
11	Kurri
12	SARAF 2
13	ESS Bilbao

14	PSI (SINQ)
15	ISIS TS2
16	SNS
17	ESS

18	HUNS
19	Ariel
20	Gelina
21	Pohang
22	Orela

A. Letourneau, Nuclear Data 2016

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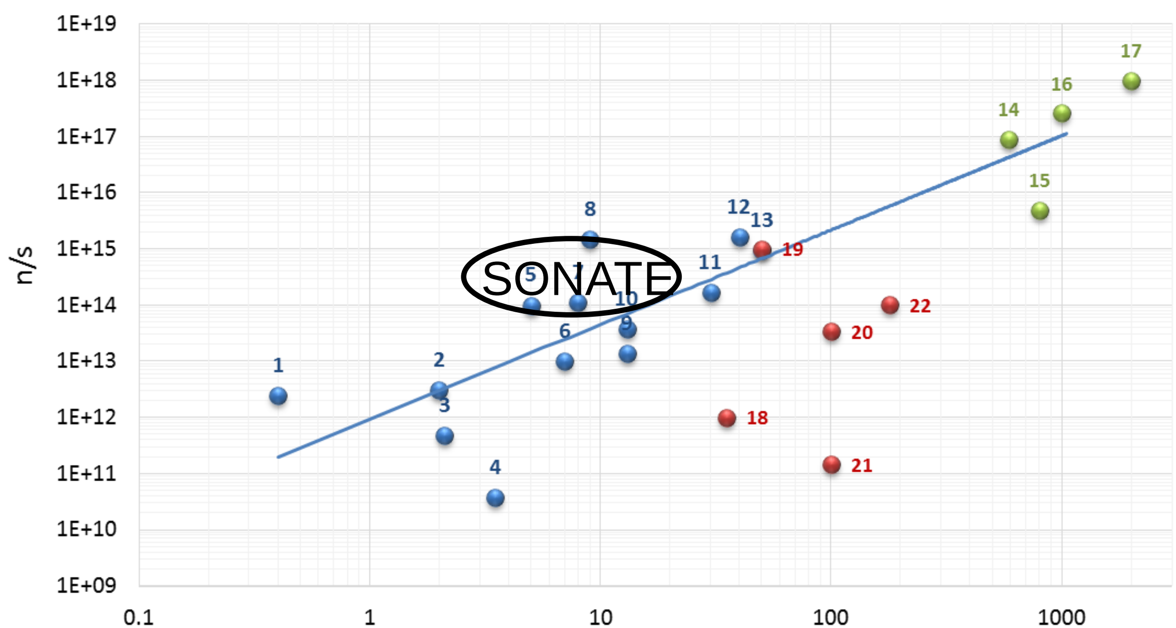

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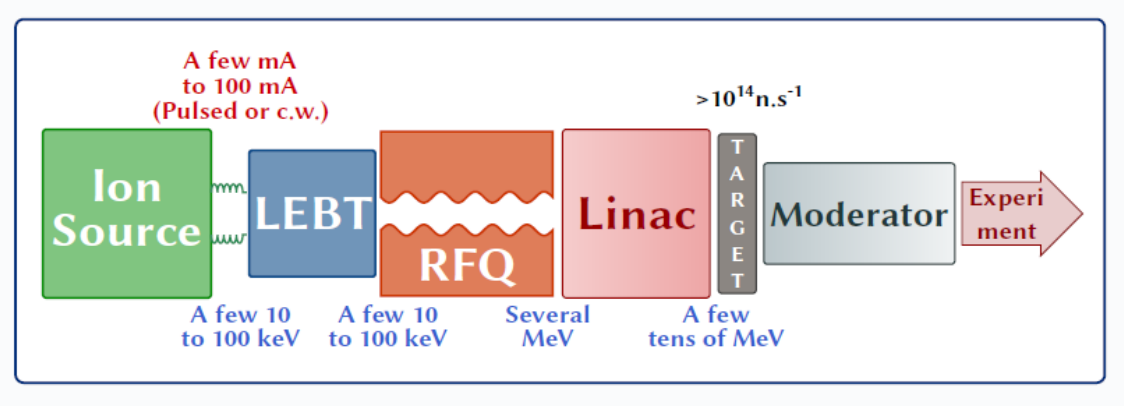
MAIN CHALLENGES FOR CANS DEVELOPMENTS

Accelerator

- Strong space charges (emittance growth, beam halo… and beam losses)
- Beam dynamics can be challenging
- Even very small losses can be harmful and can cause: activation, quench of SRF cavities, machine damages due to power deposition

→ Need expertise in high intensity accelerator technology

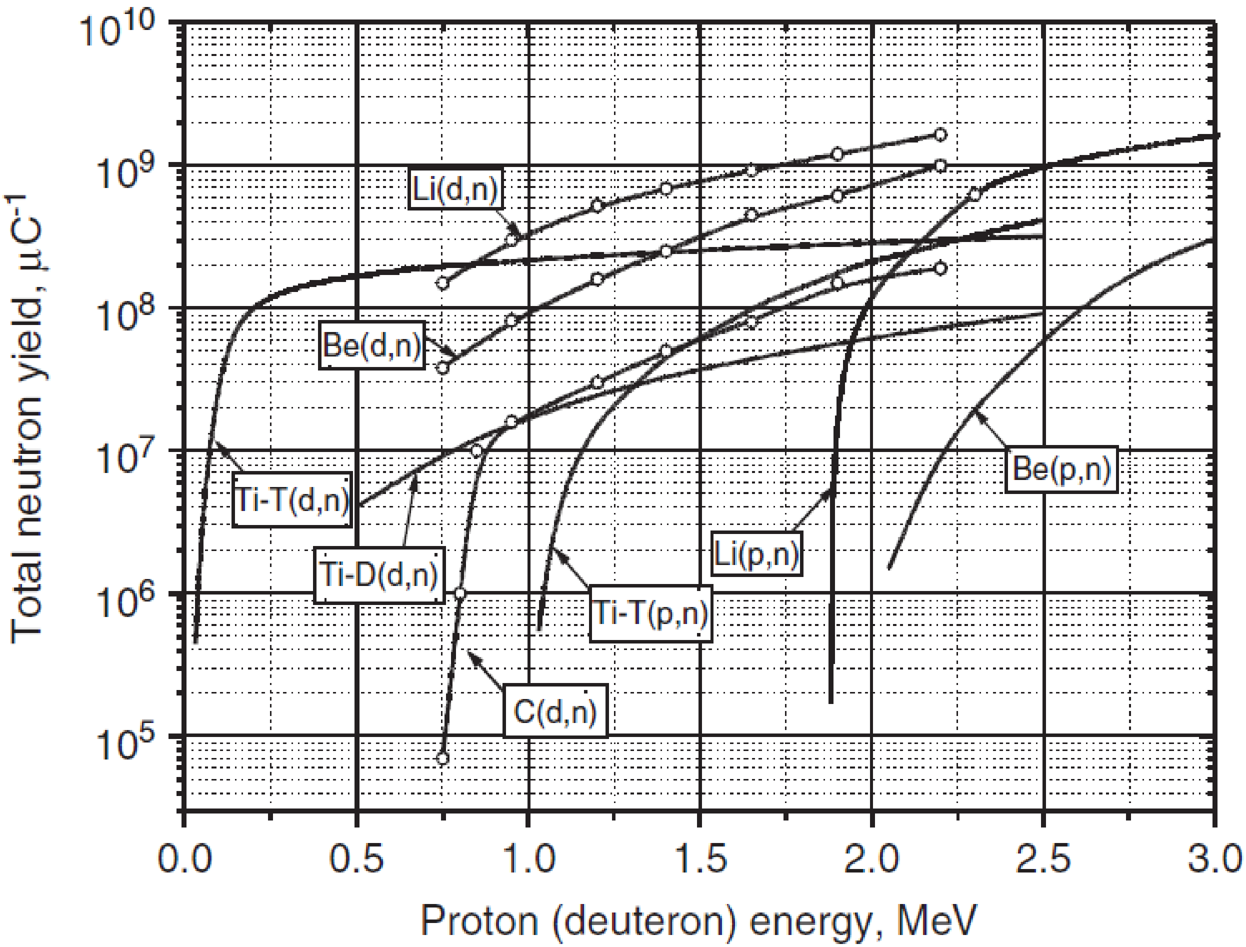


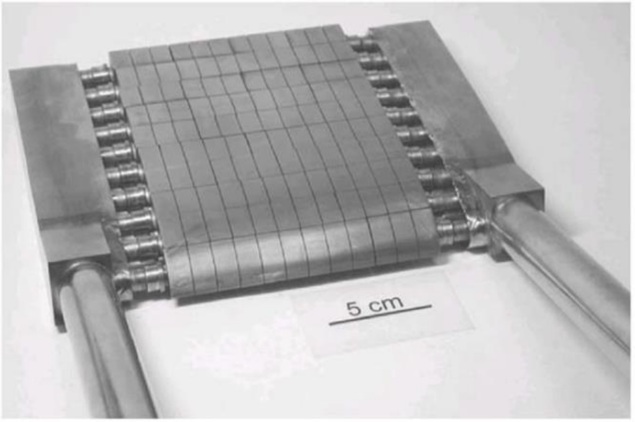
Target/Moderator/Reflector

- Heat removale from the target
- Optimize the target/moderator assembly for neutron production and time-pulse

→ Validated and Predictive Monte-Carlo simulation tools

WHICH REACTION TO PRODUCE NEUTRONS ?



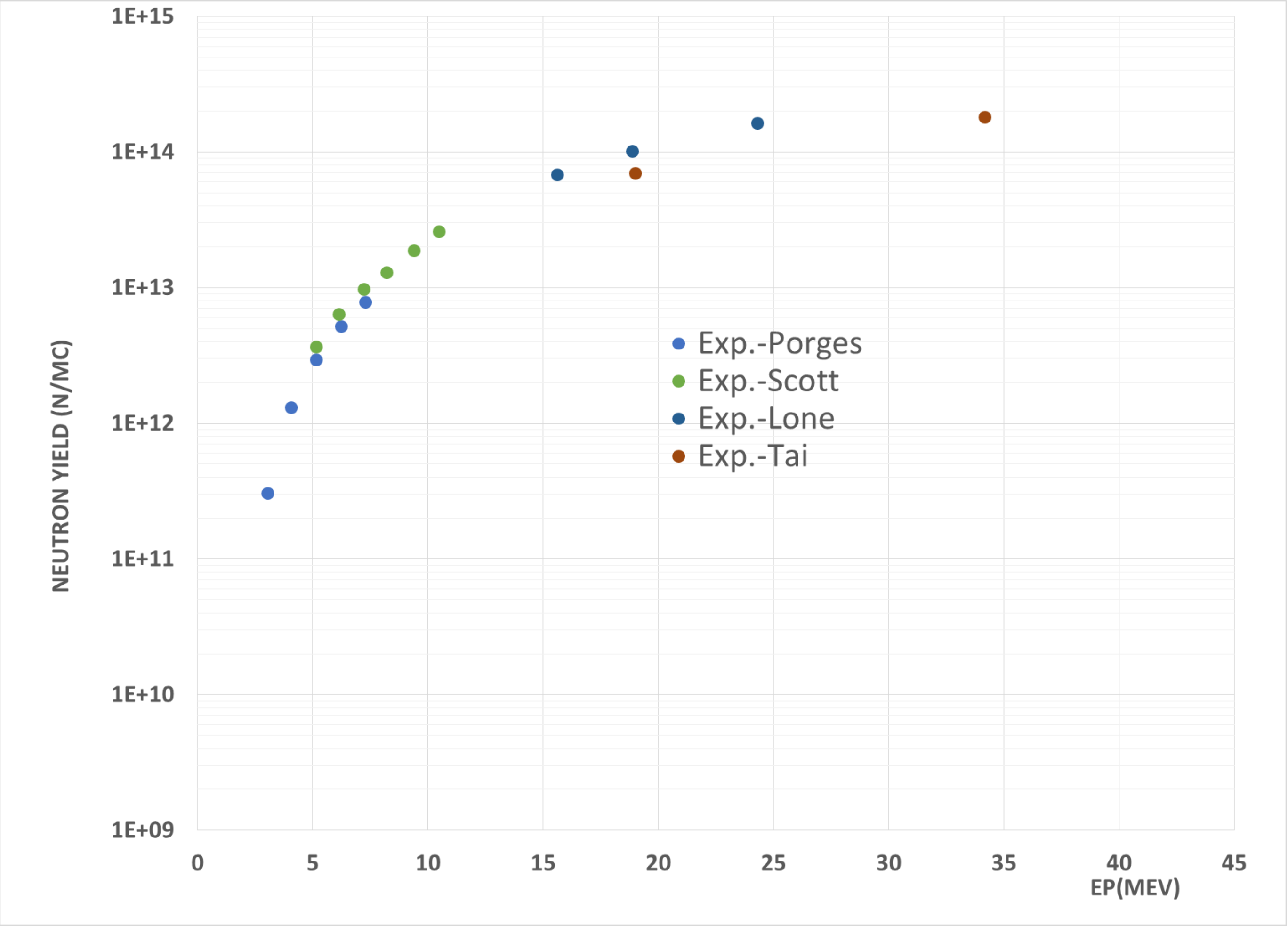


Prototype Beryllium target J.Esposito et al., Applied Radiation and Isotopes 67 (2009) S270–S273)

Be(p,n) the best compromise regarding heating of target (<10 kW) and radioprotection

A. Letourneau, Nuclear Data 2016

NEUTRON PRODUCTION IN BE(N,P)



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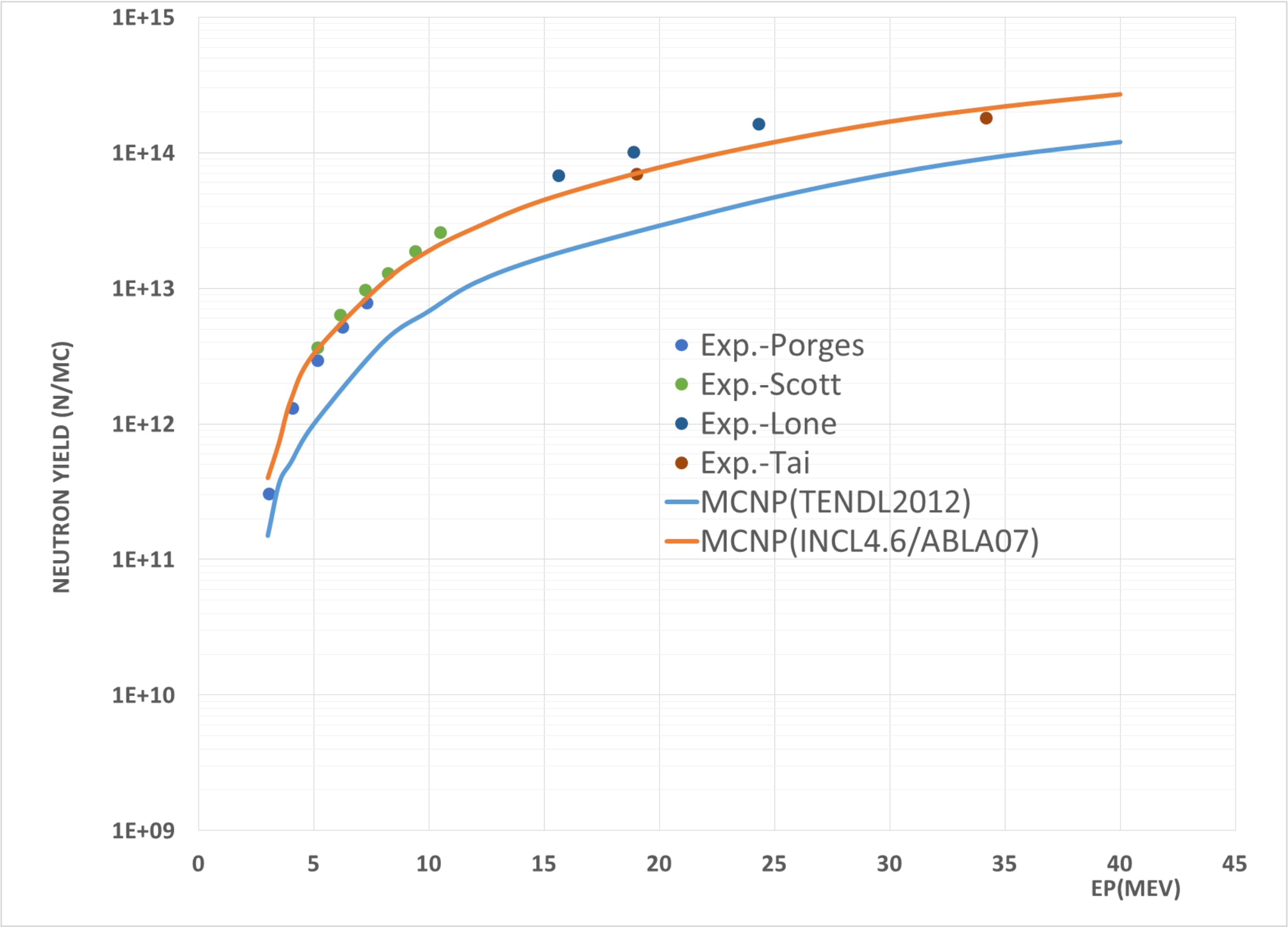
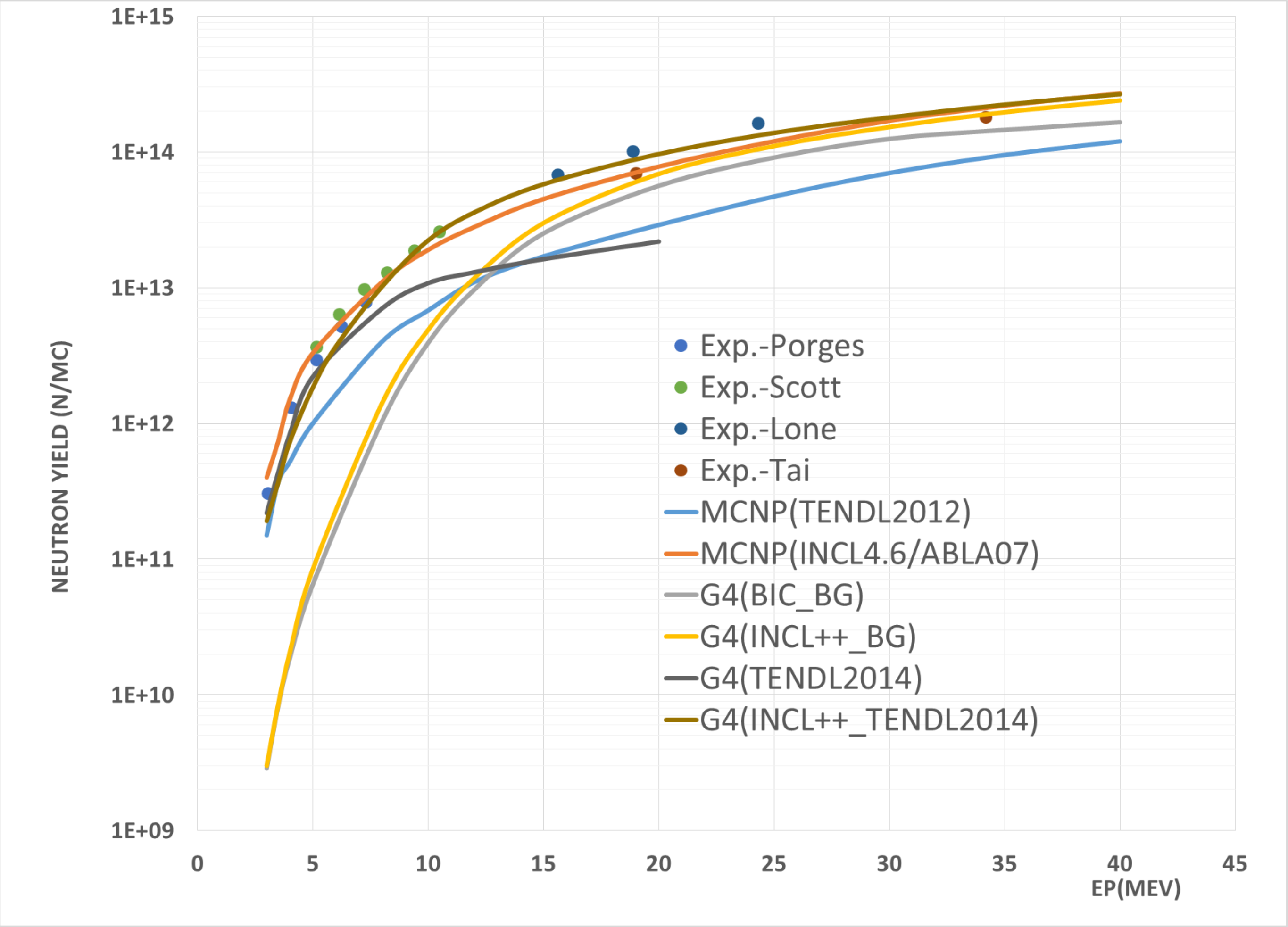


NEUTRON PRODUCTION IN BE(N,P)



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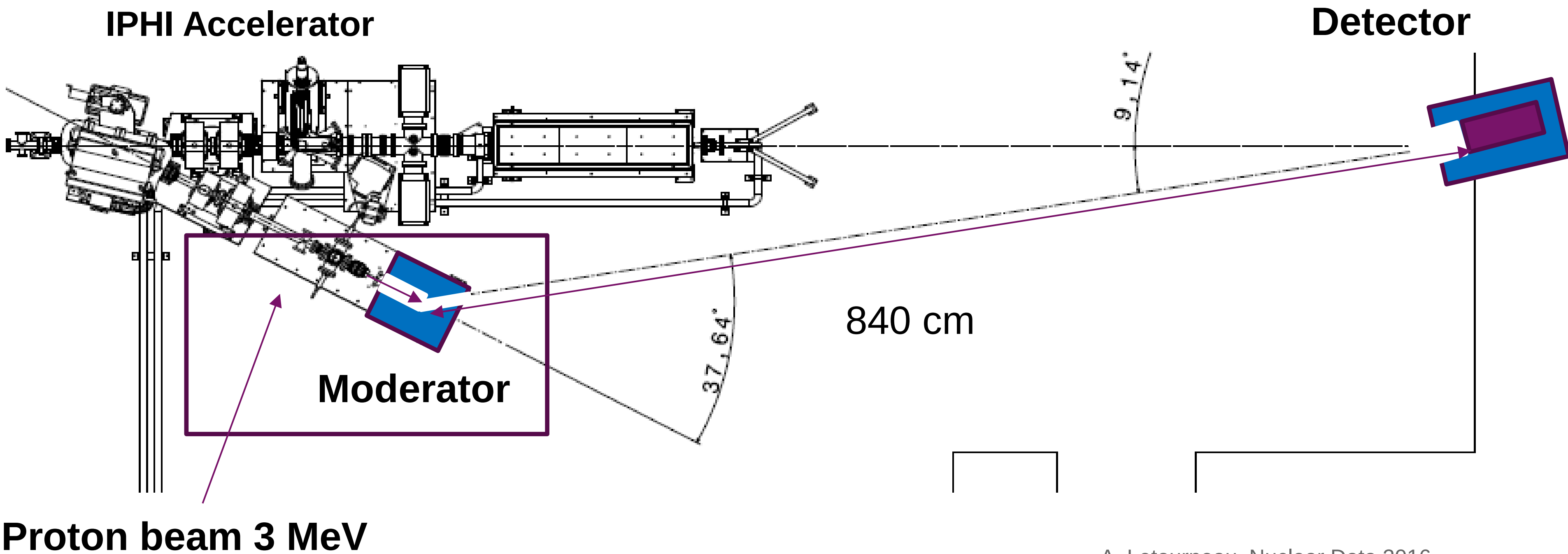
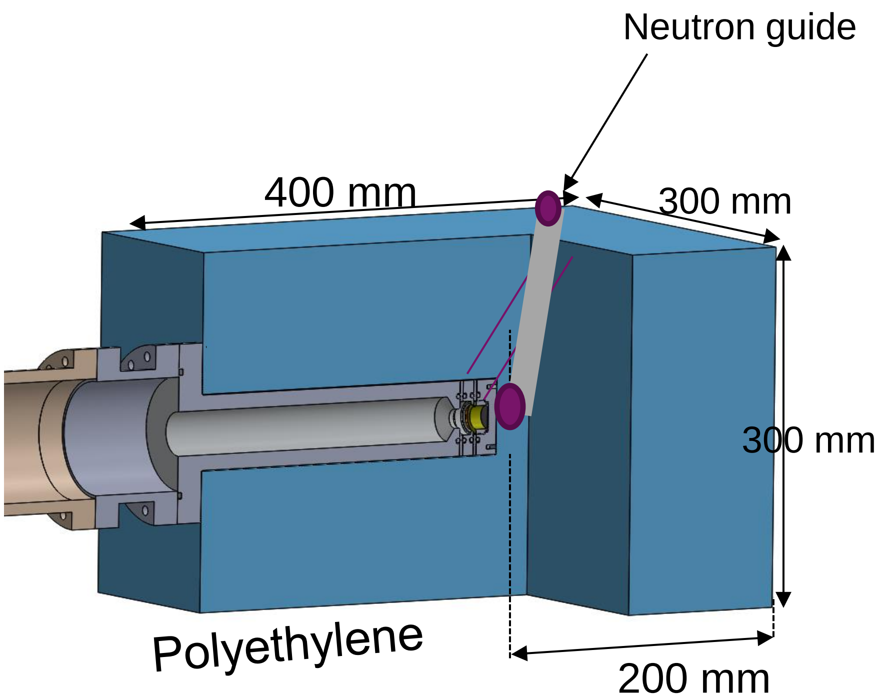
TESTS IN SACLAY WITH IPHI INJECTOR

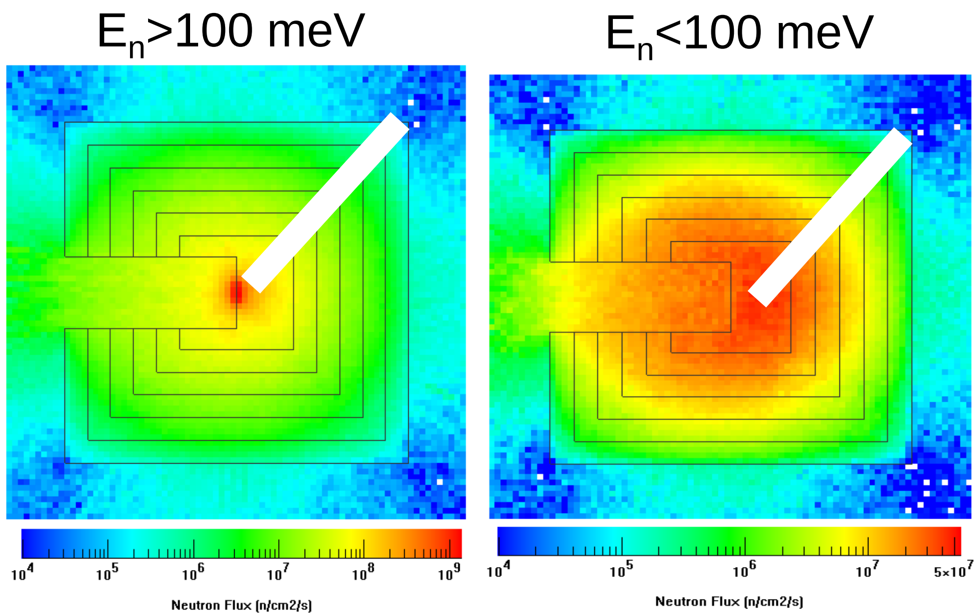
- Proton beam 3 MeV and the current between 2.6 and 3.2 μA (~1.88E+13 proton/s),
- Moderator in **polyethylene (blue)** : 30 x 40 cm,
- Angle of detector 38 degree,
- The distance from the target to **detector (violet)**: 840 cm.
- 4 days of measurements at ~3 μA (3.6 10^{17} protons on Be target)



TARGET/MODERATOR ASSEMBLY

- A neutron guide (cylinder hole and vacuum) at 38 degree,
- Diameter of neutron guide 20 mm,
- He3 detector shielded by polyethylene and B4C to avoid reflected neutron on the walls





Simulated neutron density

EXPERIENCE TEST WITH IPHI

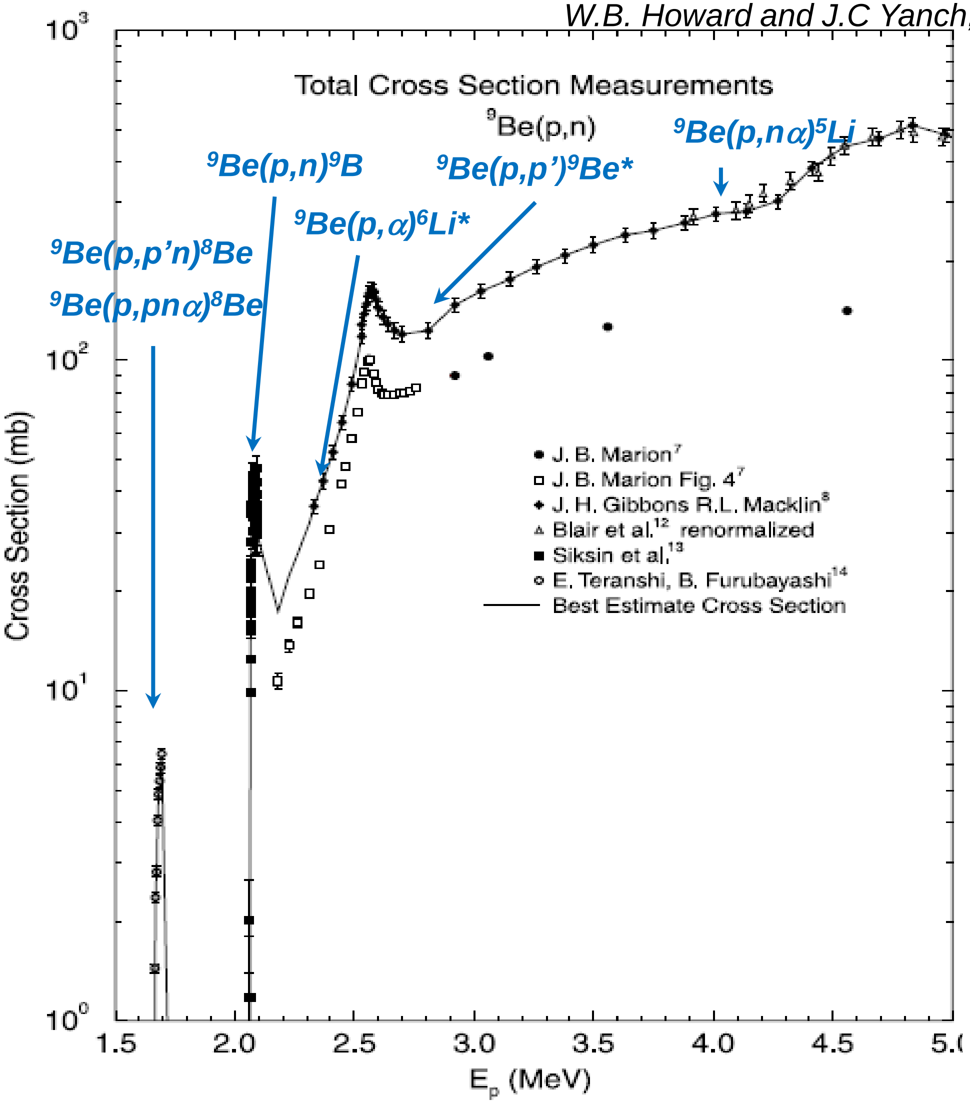
Polyethylene Moderator

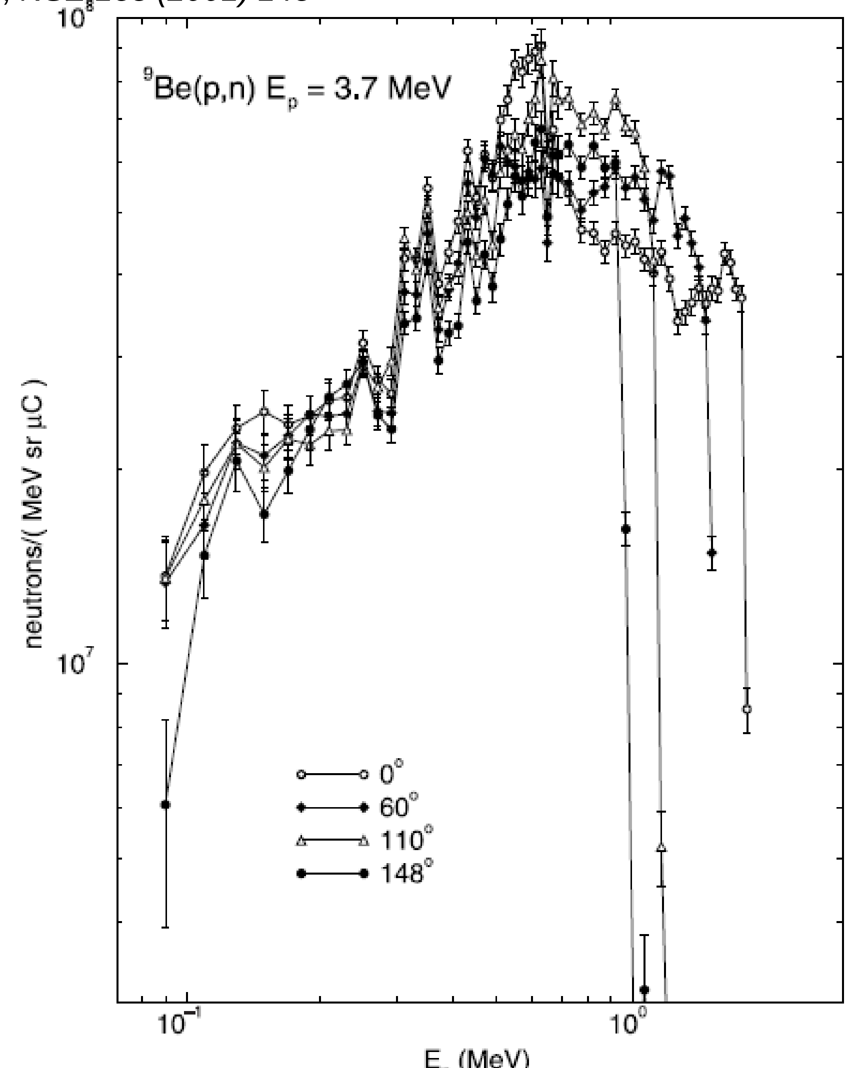
Be target (inside)

^{3}He detector shielded with polyethylene and B_4C (8 m from the target)

^{9}BE(P,N) REACTION AT LOW ENERGY

W.B. Howard and J.C Yanch, NSE 138 (2001) 145





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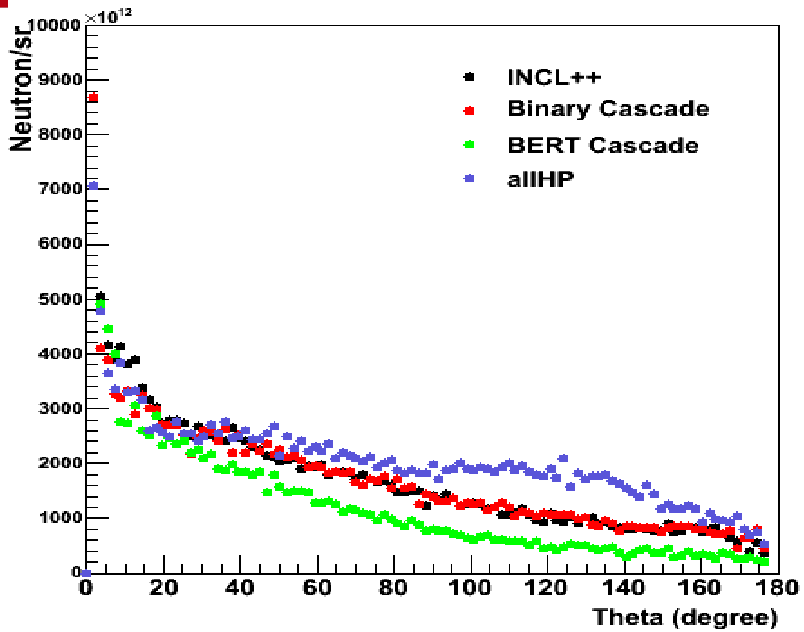
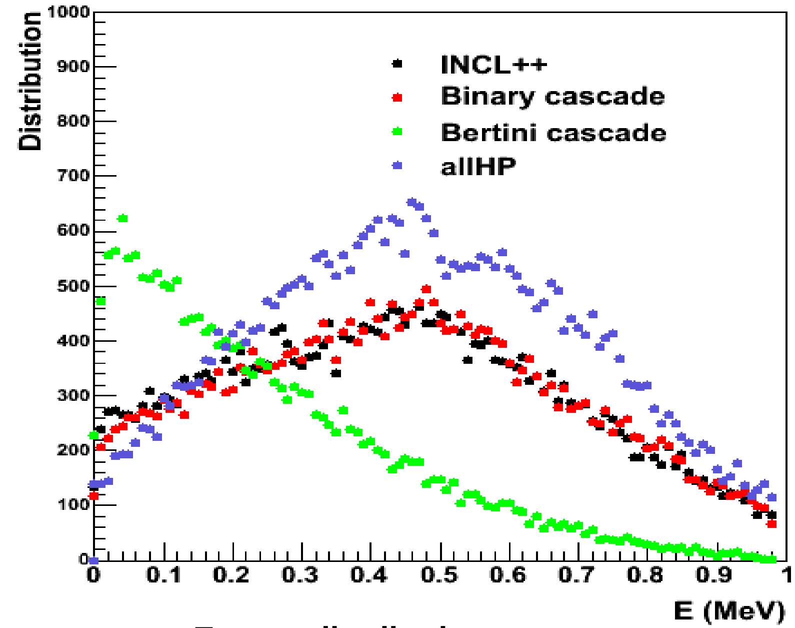
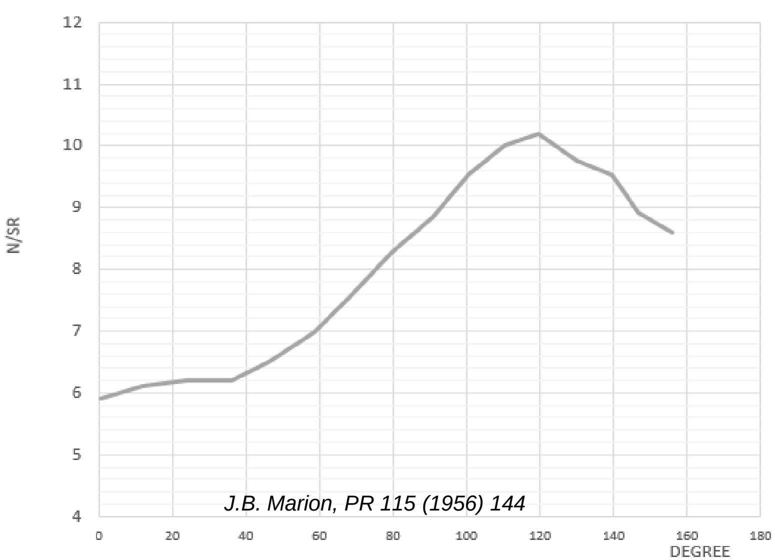
GEANT4 NEUTRON PRODUCTION IN ^{9}BE(P,N)

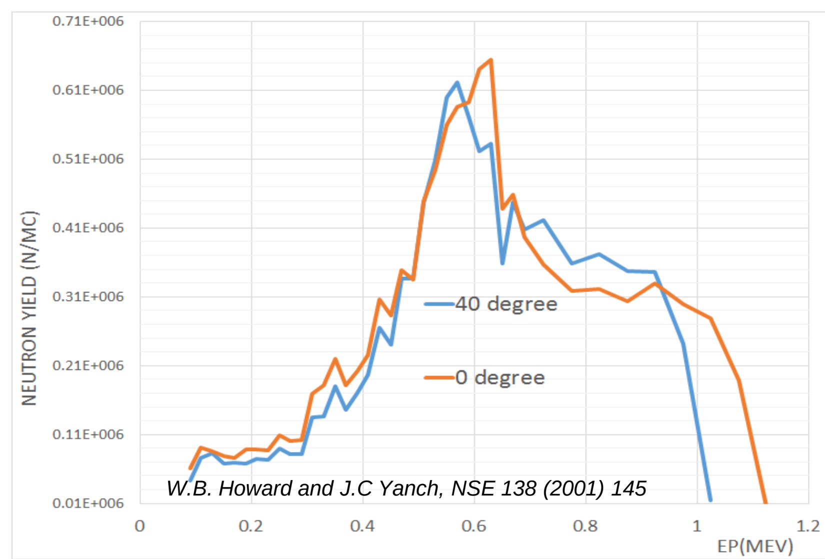


Angular distribution

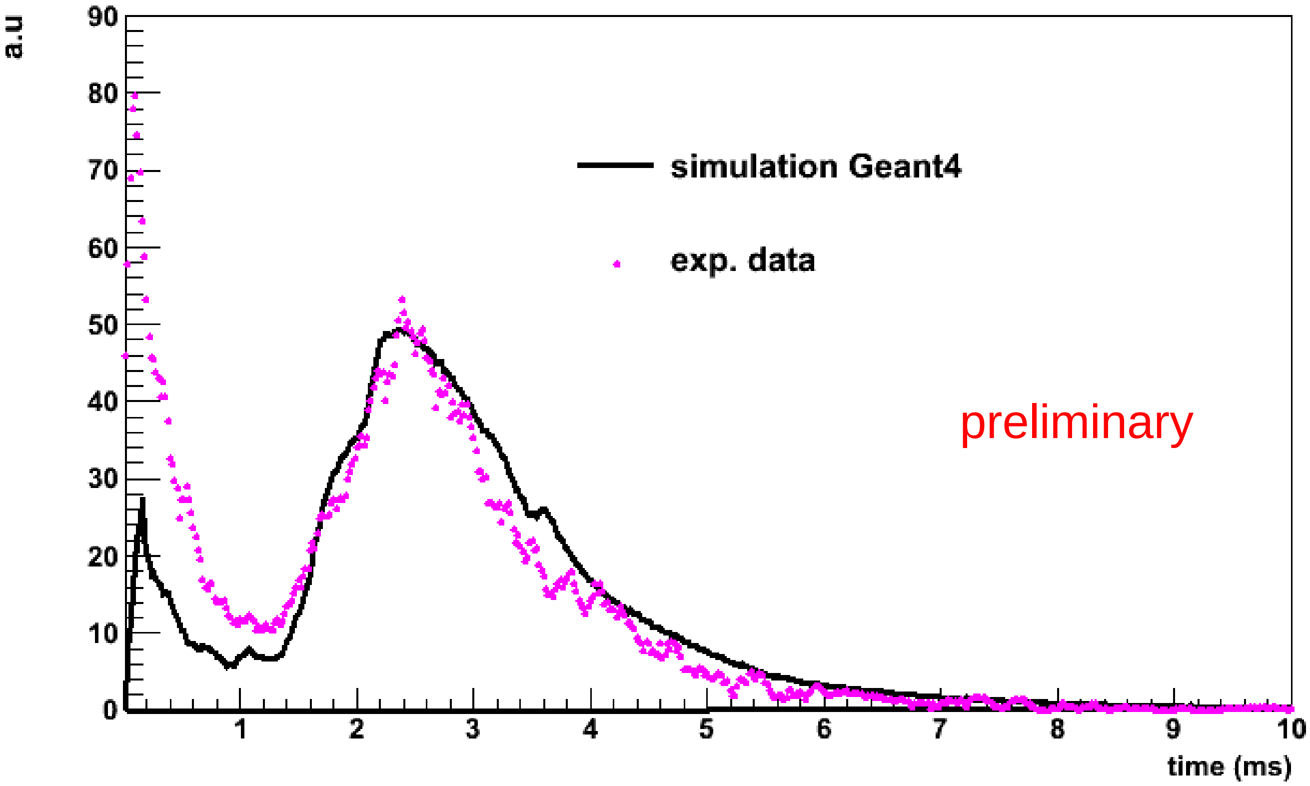


Energy distribution





PRELIMINARY RESULTS ON TIME OF FLIGHT

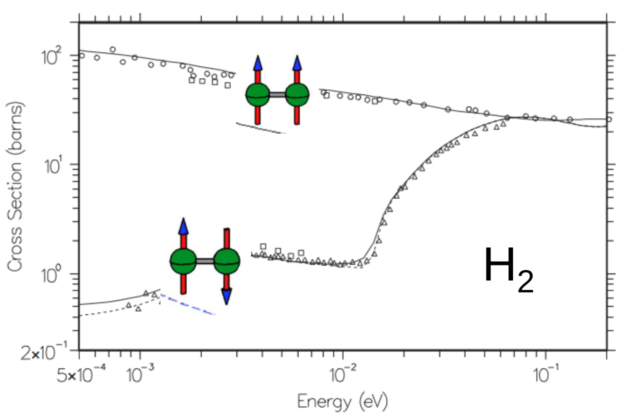


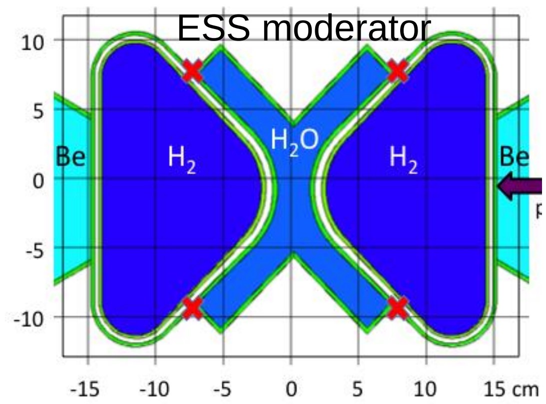
- Quite good agreement between experience and simulation
- Fast neutrons seems to be underestimated in the simulation
- Analysis still in progress

CONCLUSIONS AND PERSPECTIVES

- **Growing interest** for Compact Accelerator Neutron Source based on high intensity accelerators

- The **target/moderator/reflector** assembly is a key issue:
  - double-differential neutron production cross sections for Be(p,n), Li(p,n) reactions are needed to constraint models
  - accurate nuclear data based on thermal cross sections are needed for various materials to develop high-brillance cold moderators





- SONATE project in Saclay: 20 MeV proton on Be target using IPHI injector
  - Tests at 3 MeV using polyethylene moderator already preformed
  - Next step: test of other moderators

THANK YOU FOR YOUR ATTENTION