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UNIVERSITÉ CAEN NORMANDIE

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RÉGION NORMANDIE

FRANCE 2030

AXIS 1: NUCLEAR PHYSICS CENTER

Scientific Advisory Board: meeting n°1

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ENSICAEN
ÉCOLE PUBLIQUE D'INGÉNIEURS
CENTRE DE RECHERCHE

LPC CAEN

CIMAP

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AXIS 1: NUCLEAR PHYSICS CENTER

WP2 – NFS Experiments

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CAESAR – WP 2 – NFS EXPERIMENTS

Description of work (where appropriate, broken down into tasks), lead partner and role of participants

In this WP, experiments will be conducted at Spiral2-NFS by LPC Caen using the SCALP detector consisting in measuring the cross-sections of fluorine and oxygen for (n,alpha) and (n,p) reactions The use of the SCALP detector (a scintillating Ionization Chamber developed at LPC) at NFS will contribute to reduce uncertainties on these cross-sections which have a strong impact on the precision of reactor and nuclear reaction modelling (and even on the prediction of fuel swelling in the case of alpha production). In addition, the LPC team will be involved in the precise characterization of the NFS neutron flux using various detectors, which will also contribute to reduce the cross-section measurement uncertainties.

These works will be conducted in collaboration with the GANIL-NFS team (for all experiments) as well as IPHC Strasbourg for the NFS beam characterization. Additional collaborators may join the collaboration during the projects.

This WP is divided in two tasks:

- Measurements of (n,alpha) and (n,p) cross-sections of fluorine and oxygen
- Characterization of the neutron flux delivered by the SPIRAL2-NFS facility

Deliverables (brief description and month of delivery)

- PhD defense (M7, Y5)
- Papers submission to international journals (M5,Y4 and M12, Y5)
- Oral presentations at international conferences (M1,Y4 and M2, Y5)
- WP reports (15 days before WP1 report)
- Milestones 1 : Proposals submitted to NFS PAC (M9, Y1 and M9, Y2)
- Milestones 2 : Short reports on experiments carried out (M3, Y4 and M3, Y5)

Safety optimisation of nuclear power plants: improvement of neutron cross-sections impacting the precision of reactor modelling and ageing of fuel pins for 3rd and 4th generation nuclear reactors

(n,alpha) cross-sections of ^{19}F and ^{16}O at the SPIRAL2-NFS facility
(n,p) cross-sections of ^{19}F at the SPIRAL2-NFS facility

the
SCALP project

THE SCALP PROJECT

the SCALP project

- measurement and evaluation
- (n,alpha) reactions of interest for nuclear reactors
- from threshold up to 20 MeV

$^{16}O(n,\alpha)^{13}C$

- NEA : HPRL & WPEC 26 (2005) & WPEC 40 (2015)
- sensitivity analysis (WPR, FR)

large discrepancies (up to 30%), helium formation in fuel cladding (± 7%), neutron multiplication factor (± 100 pcm)

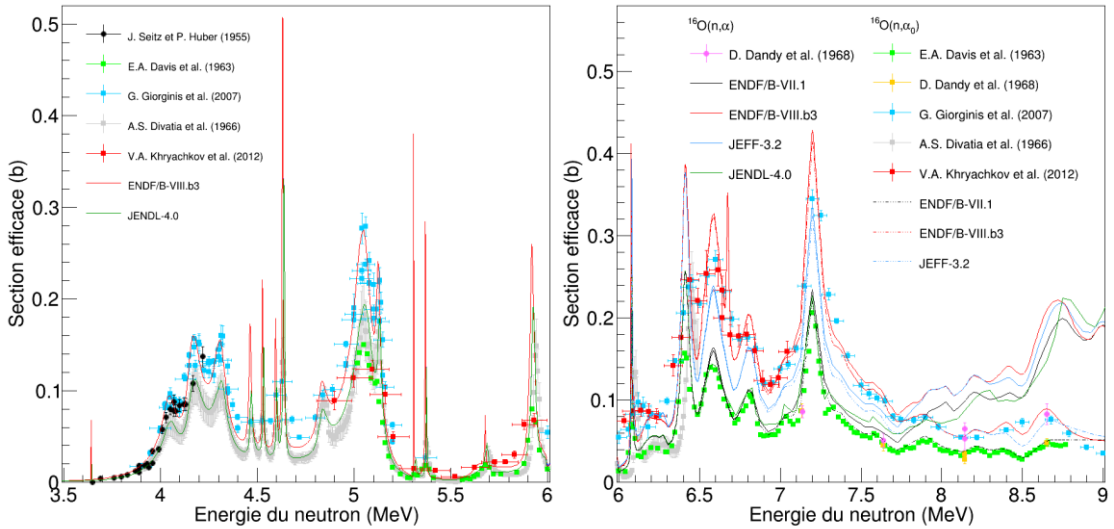
$^{19}F(n,\alpha)^{16}N$

- sensitivity analysis (MSR)

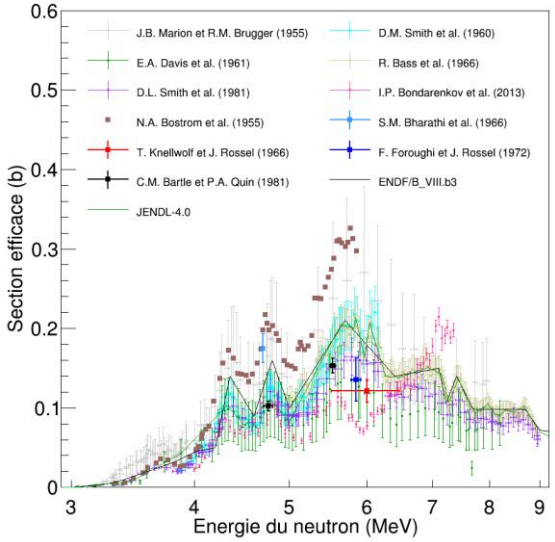
large discrepancies (up to afactor 3), neutron multiplication factor (± 40 - 130 pcm)

THE SCALP PROJECT

$^{16}O(n,\alpha)^{13}C$



$^{19}F(n,\alpha)^{16}N$



large discrepancies

- measurement vs measurement
- measurement vs evaluation
- evaluation vs evaluation

underline the need of new measurements

- with new setups
- using several facilities

main objective

to provide new data sets for the evaluation process

THE SCALP DETECTOR

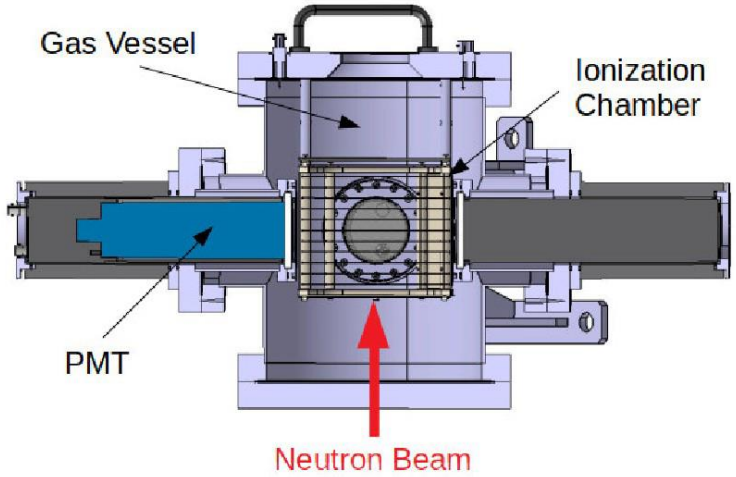
SCALP = Scintillating ionization Chamber for ALPha particle detection in neutron induced reaction

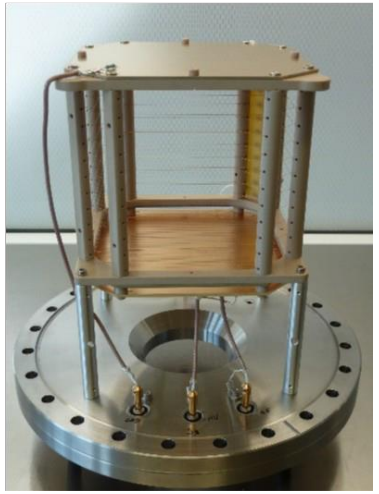
four PM tubes (PMT)

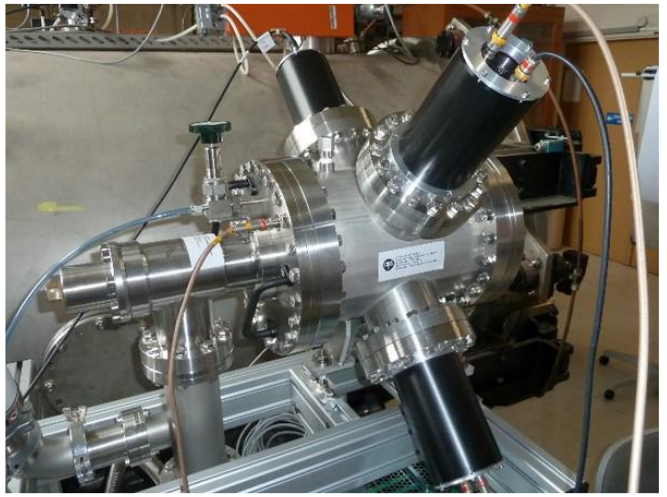
ionization chamber (IC)

neutron time-of-flight & deposited energy

Gaz	CF4	CF4 (CO2 3%)
energy resolution (IC)	150 keV (1σ)	220 keV (1σ)
time resolution (PMt)	820 ps (1σ)	820 ps (1σ)







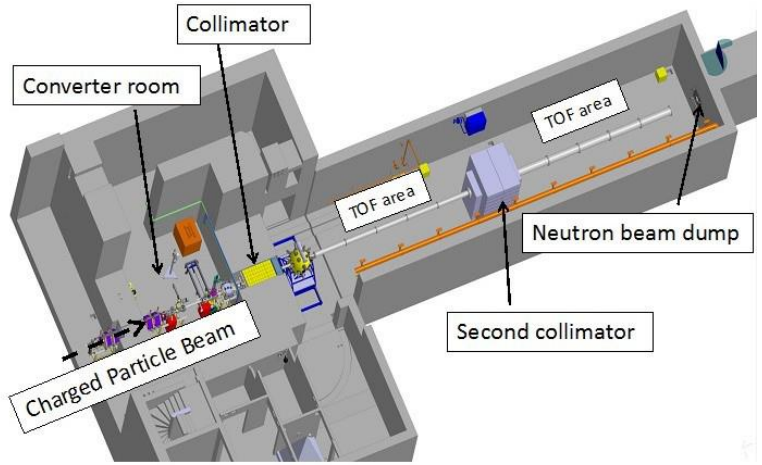
SCALP @ NFS (SEPT'21)

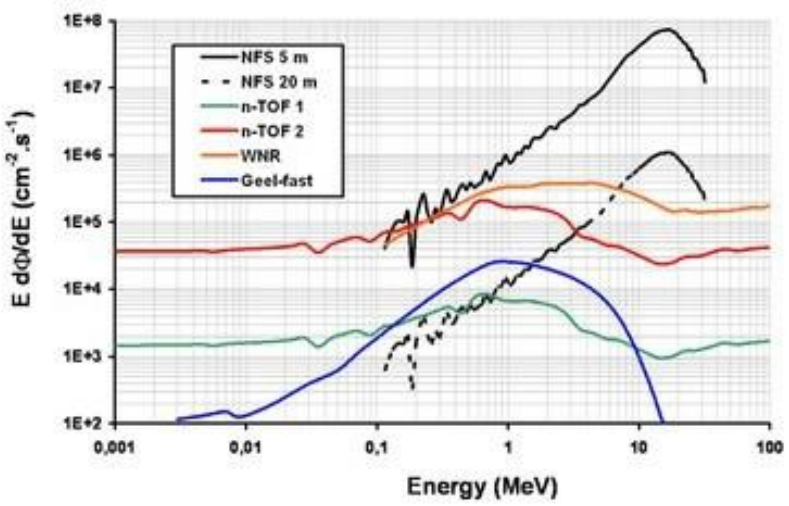
$^{19}F(n,\alpha)^{16}N$

NFS = Neutron For Science (SPIRAL2, GANIL)

SPIRAL 2	LINAG
HF	88 MHz (11.4 ns)
beam intensity	up to 5 mA
beam energy	up to 40 MeV

d + Be



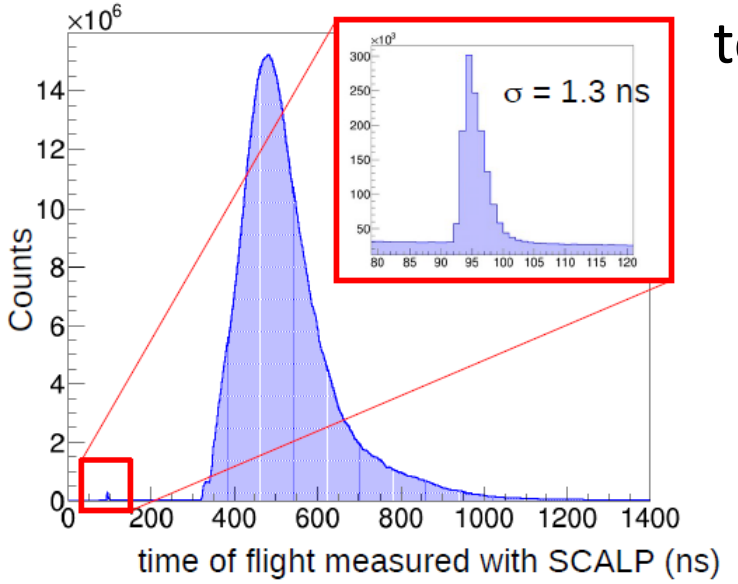


NFS	max	SCALP experiment
chopper	1/100	1/120
beam intensity	50 µA	7.5 µA
Flight distance	30 m	28 m

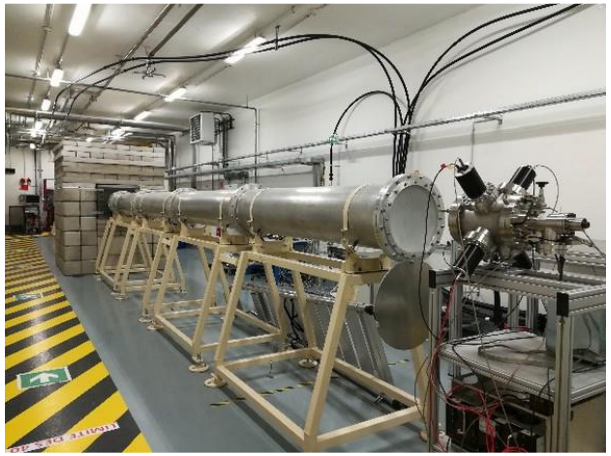
- no gamma flash…
- well suited to measurement between 1 and 40 MeV

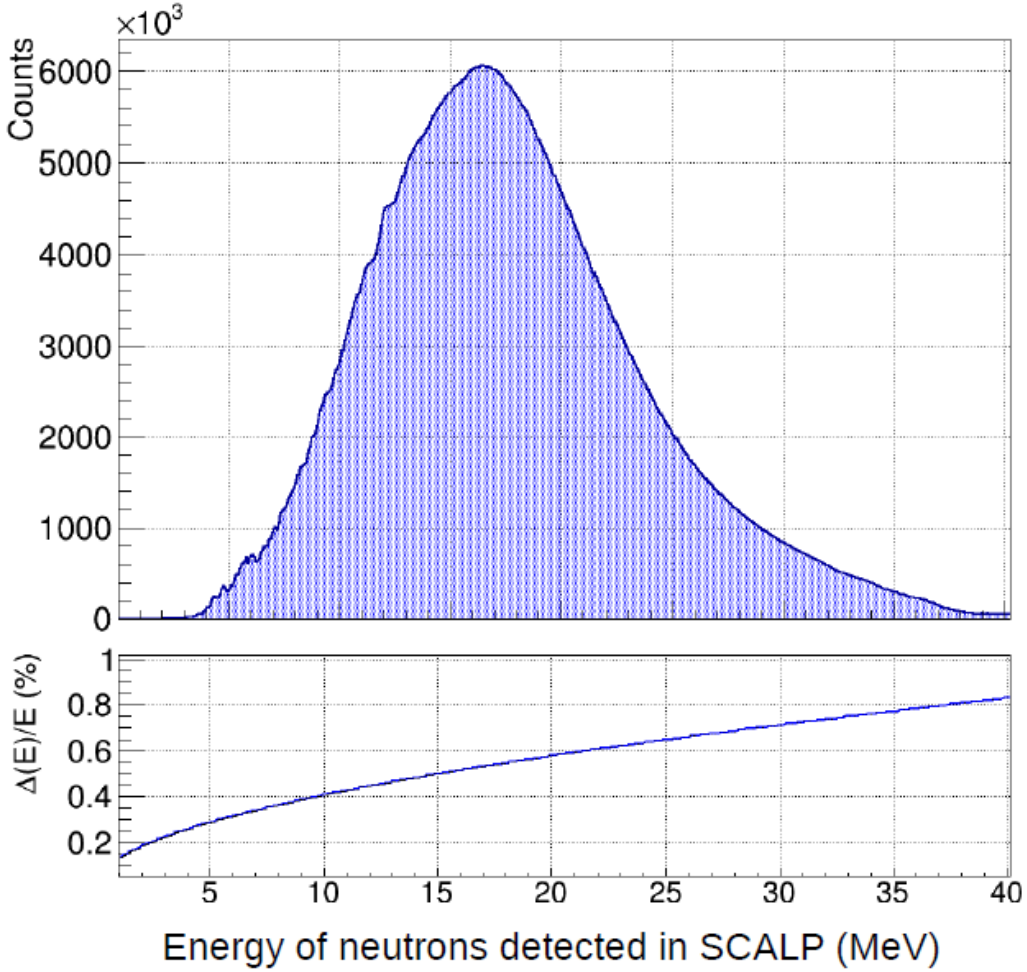
SCALP @ NFS (SEPT'21)

$^{19}F(n,\alpha)^{16}N$



$tof = t_{PMT} - t_{HF}$



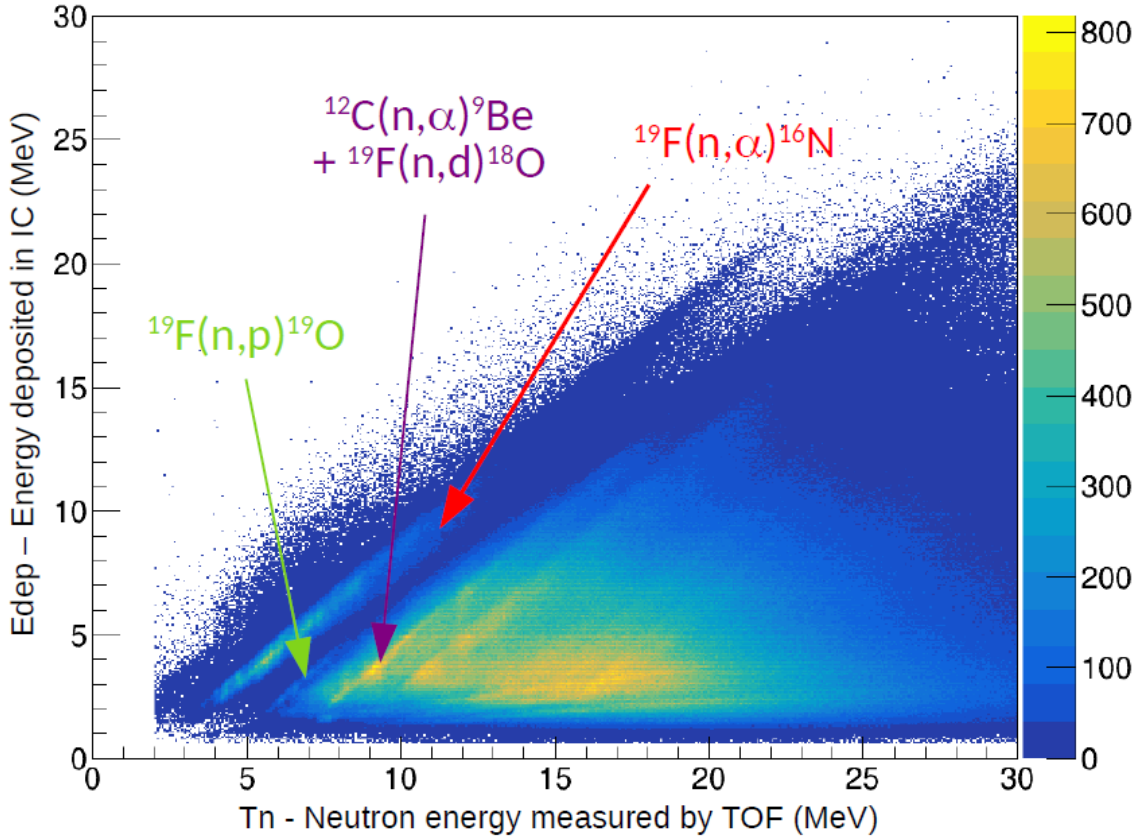


SCALP @ NFS (SEPT'21)

$^{19}F(n,\alpha)^{16}N$

two-bodies reactions $E_{dep} = T_n + Q$

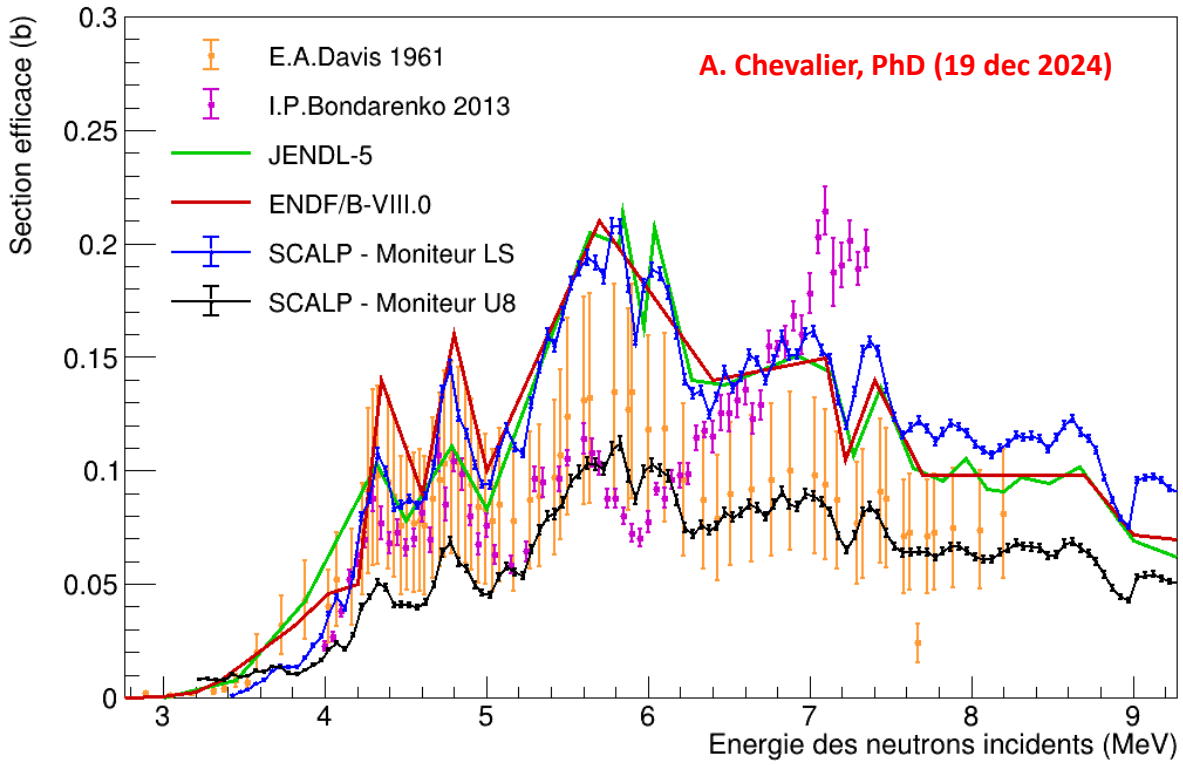
reaction	Q (MeV)	threshold (MeV)
$^{19}F(n,\alpha)^{16}N$	- 1.52	1.61
$^{19}F(n,p)^{19}O$	- 4.04	4.25
$^{19}F(n,d)^{18}O$	- 5.76	6.08
$^{12}C(n,\alpha)^{9}Be$	- 5.70	6.18
$^{19}F(n,t)^{17}O$	- 7,56	7,96



reaction channel identification matrix

(n,alpha) and (n,p) reactions on F-19 are well separated from other reactions

SCALP at NFS – First results



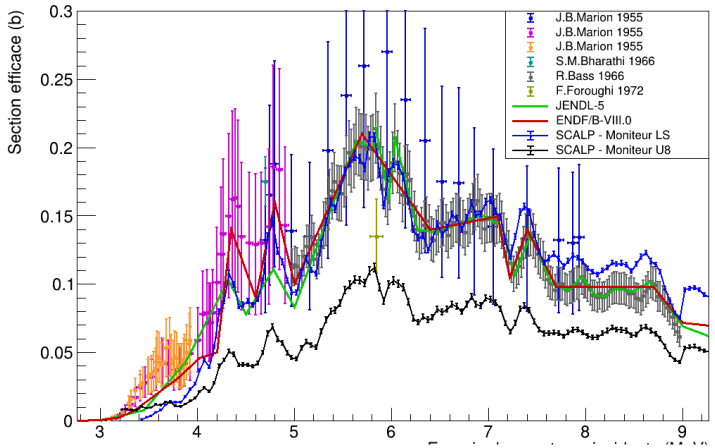
LS Monitor

- too thick…
- efficiency…
- (n,p), (n,C)…

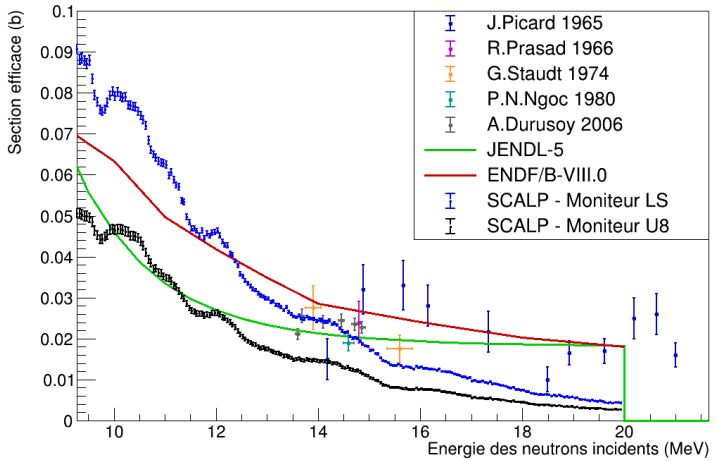
U8 Monitor

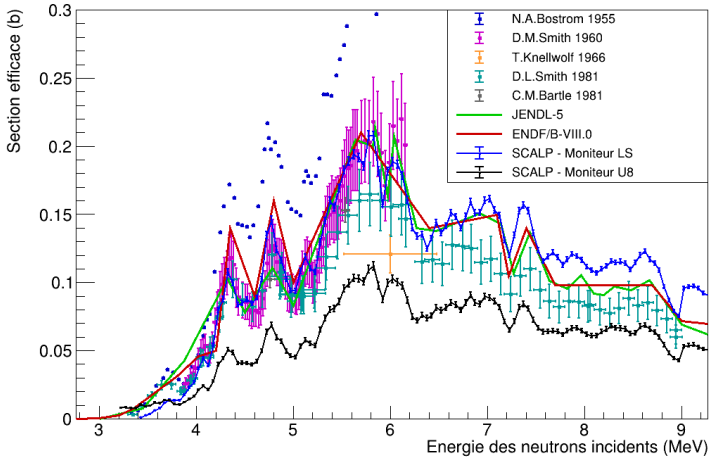
- from another experiment…
- located just after the first collimator…
- second collimator impact…

SCALP at NFS – First results



A. Chevalier, PhD (19 dec 2024)





++ continuous cross-section distribution
++ neutron energy resolution

-- normalization procedure
-- data contamination

CAESAR – WP 2 – NFS EXPERIMENTS STATUS

Ongoing

- SCALP modification
  - ➢ removal of hydrogenated materials (to remove data contamination)
  - ➢ increase in operating voltage (for (n,p) measurement)
- Improvement of the normalization procedure
  - ➢ via the (n,p) standard cross-section using MoNHaP (High Precision Neutron Monitor)

Deliverables

- Milestones 1 : Proposals submitted to NFS PAC (M9, Y1) done $^{19}F(n,alpha)^{16}N$

+ Master Thesis	spring'25	detector tests + data analysis (NFS O-16 and/or nELBE F-19, O-16)		
+ PhD	fall'25	NFS Exp. on F-19	+ MoNHaP & beam characterization	PhD defense (M7, Y5)
+ Post-Doc	fall'26	NFS Exp. on 16-0	+ MoNHaP & beam characterization	

these studies/measurements are mandatory

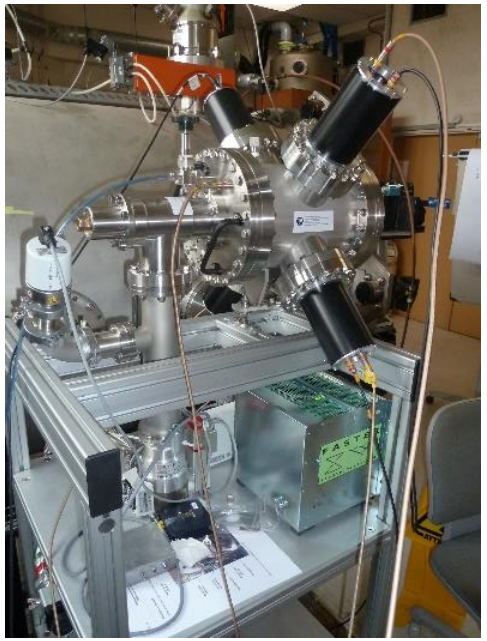
CAESAR – WP 2 – NFS EXPERIMENTS STATUS

To summarize…

SCALP detector is already fully operational
upgrade is ongoing, tests are required
first results are very promising

SCALP will be ready to run at NFS in september'25
(n,α) on fluorine 19 (8 UT, PAC ongoing)
the use of MoNHaP is mandatory

(n,α) on oxygen 16 (Fall'25 PAC)



The SCALP collaboration

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OPALE (IN2P3)
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