

First results of (n,alpha) measurements on F-19 with the SCALP detector





THE SCALP PROJECT

the SCALP project

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

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

large discrepancies (up to a factor 3)

- sensitivity analysis (MSR)

neutron multiplication factor ($\pm 40 - 130$ pcm)

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

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

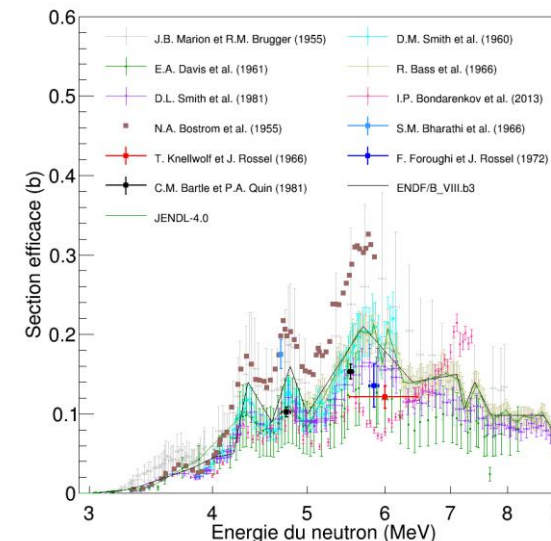
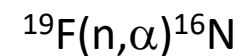
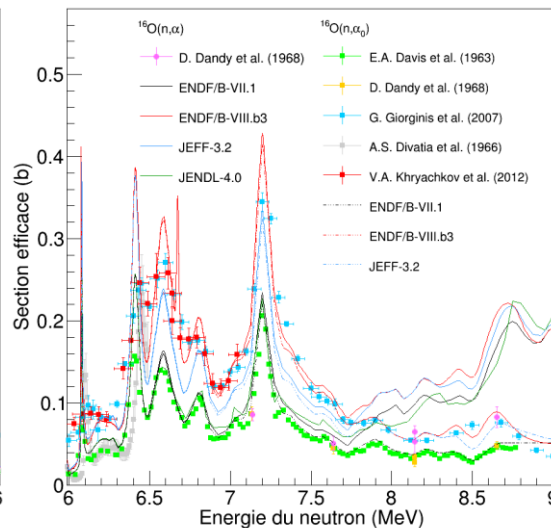
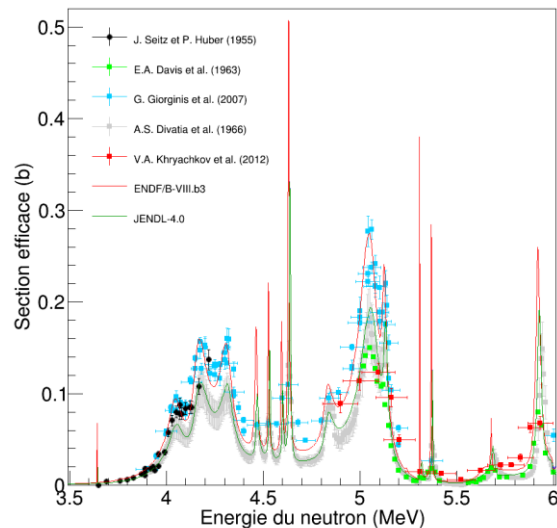
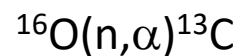
large discrepancies (up to 30%)

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

helium formation in fuel cladding ($\pm 7\%$)

neutron multiplication factor (± 100 pcm)

THE SCALP PROJECT



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

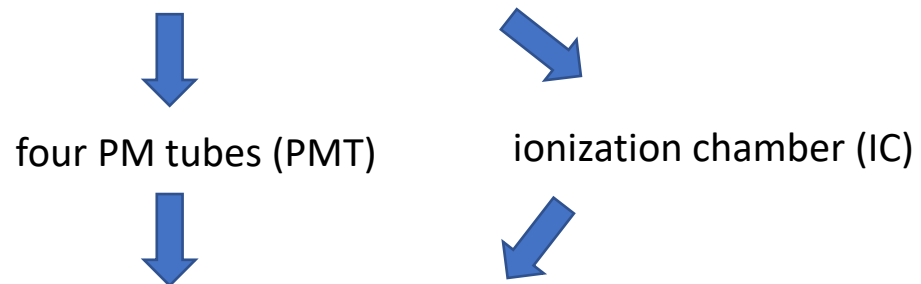
to provide new data sets for the evaluation process

the SCALP detector

at NFS (sept'21), at nELBE (feb'22)...

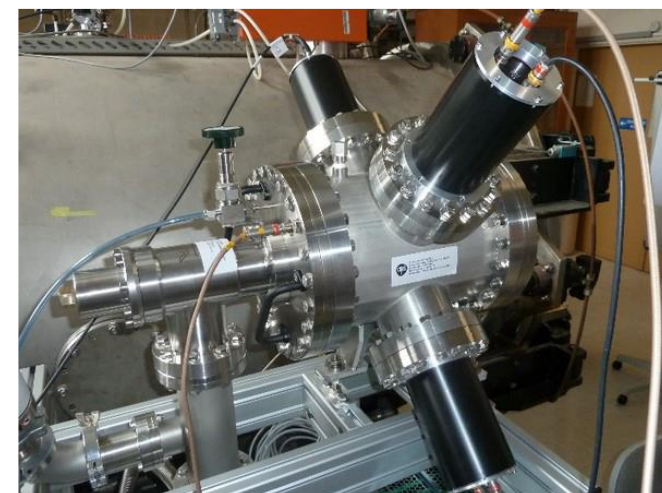
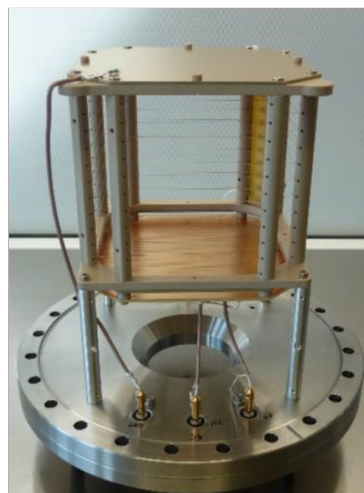
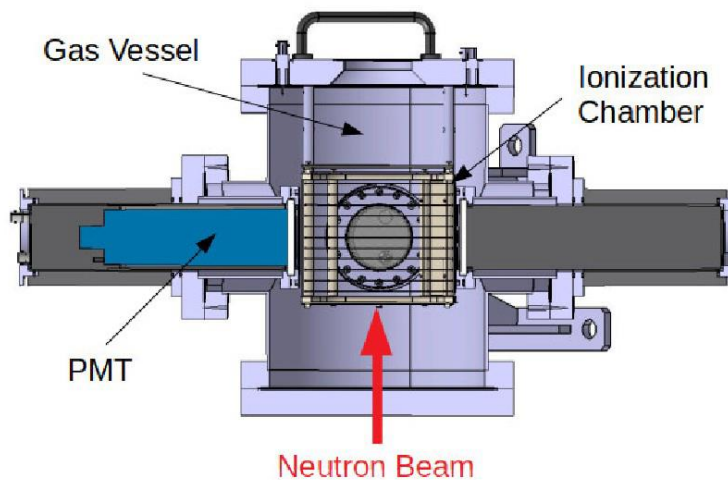
THE SCALP DETECTOR

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



neutron time-of-flight & deposited energy & drift time

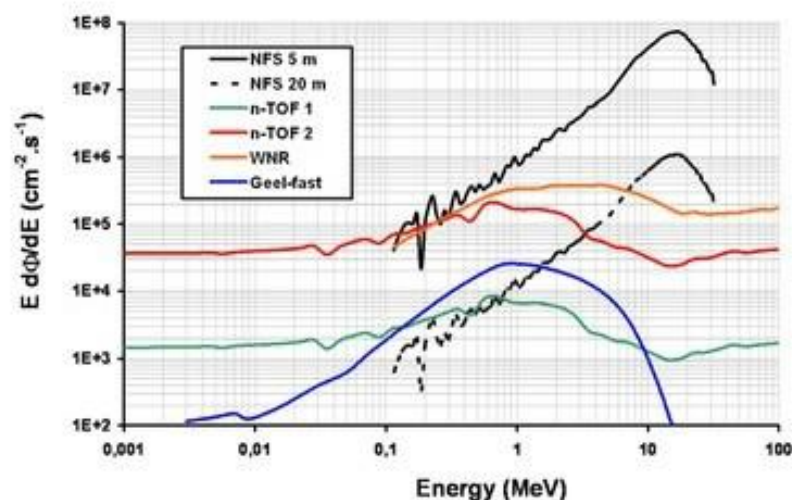
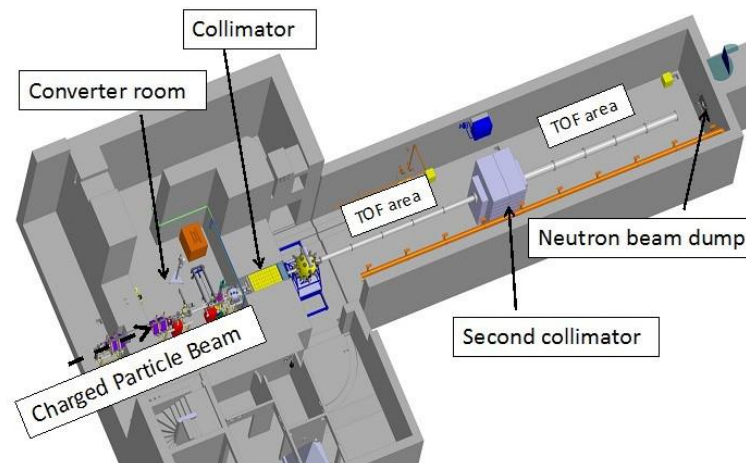
Gaz	CF4	CF4 (CO2 3%)
energy resolution (IC)	150 keV (1σ)	220 keV (1σ)
time resolution (PMT)	820 ps (1σ)	820 ps (1σ)



NFS = Neutron For Science (SPIRAL2, GANIL)

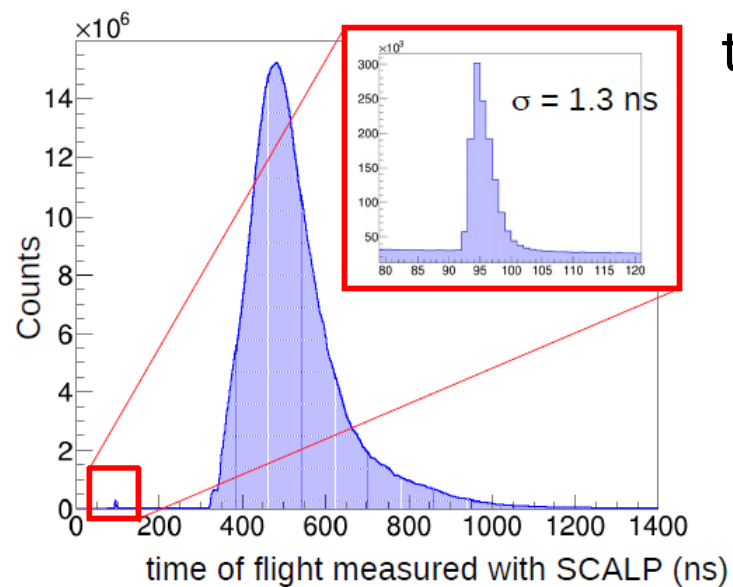
SPIRAL 2	LINAG
HF	88 MHz (1/11.4 ns)
beam intensity	up to 5 mA
beam energy	up to 40 MeV

d + Be

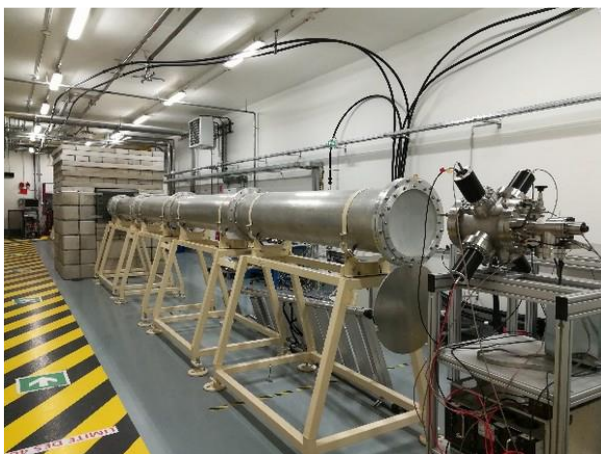
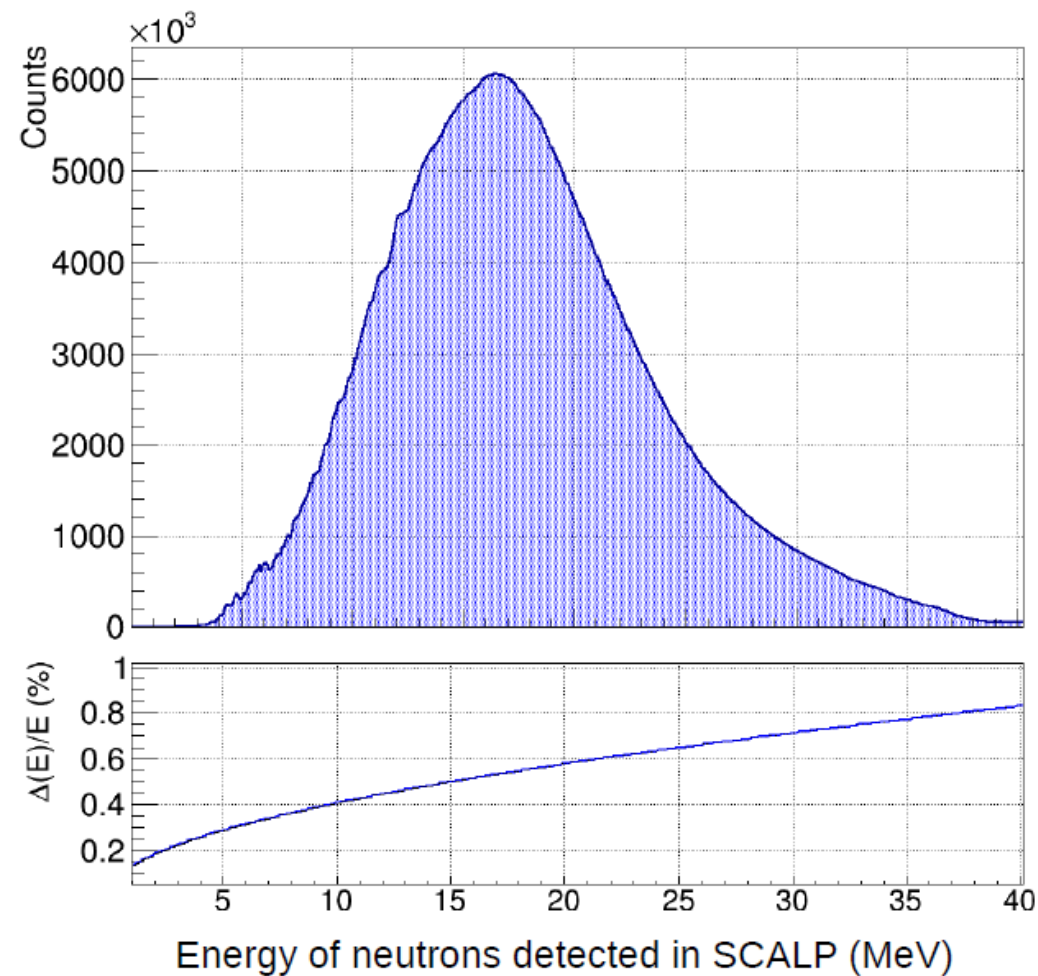


NFS	max	SCALP experiment
chopper	1/100	1/120
beam intensity	50 μA	7.5 μA
Flight distance	30 m	28 m

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

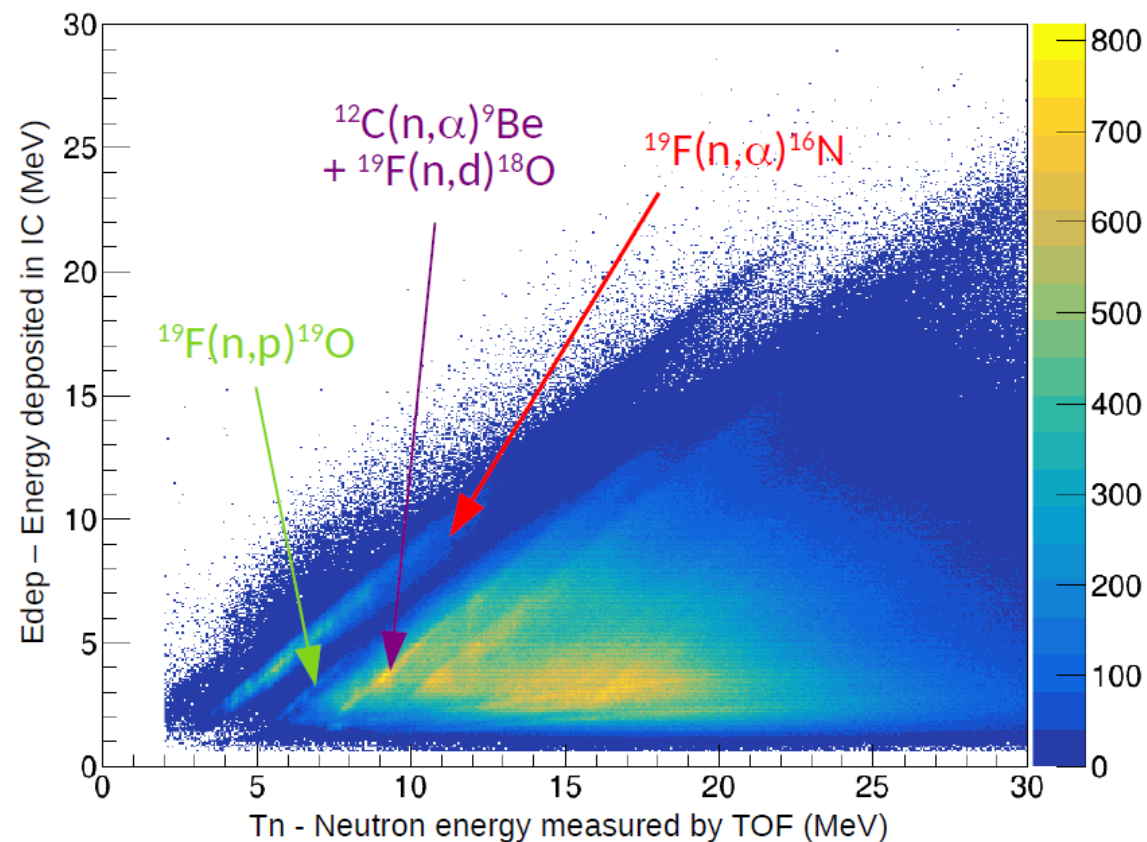


$$\text{tof} = t_{\text{PMT}} - t_{\text{HF}}$$



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

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

$$\sigma(T_n) = \frac{N(T_n)}{\epsilon(T_n) \eta^{19}_F L \Psi_{SCALP}(T_n)}$$

number of events
(identification matrix)

detector response (GEANT4)

nuclear density

active zone lenght

neutron flux at SCALP location
(LS/MM monitor or U8 monitor)

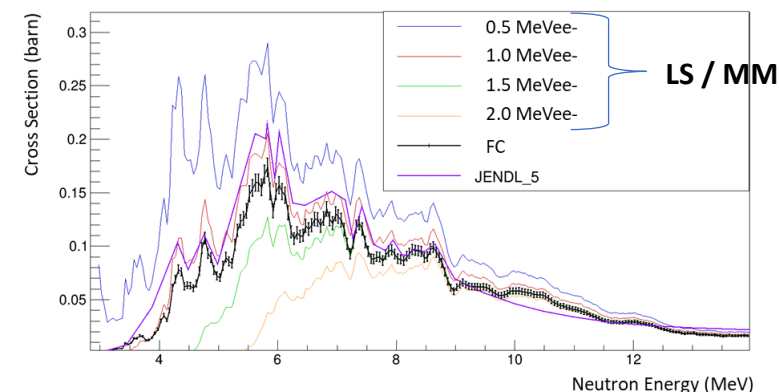
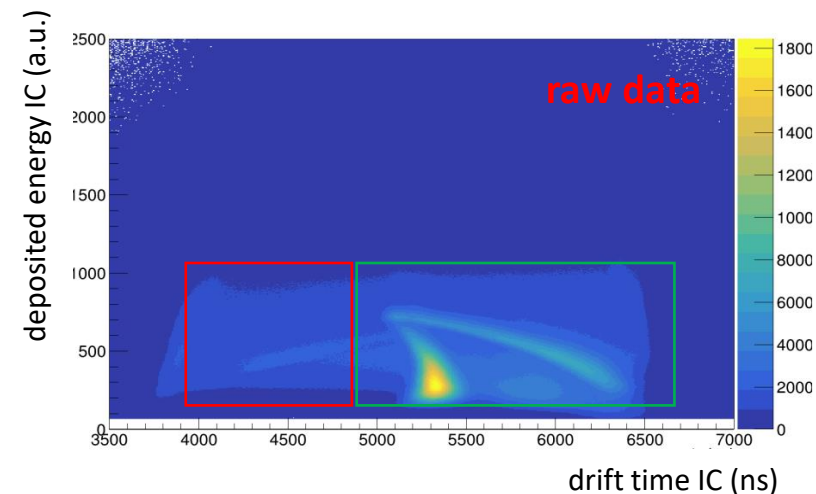
SCALP at NFS – First results & Encountered problems

Data contamination

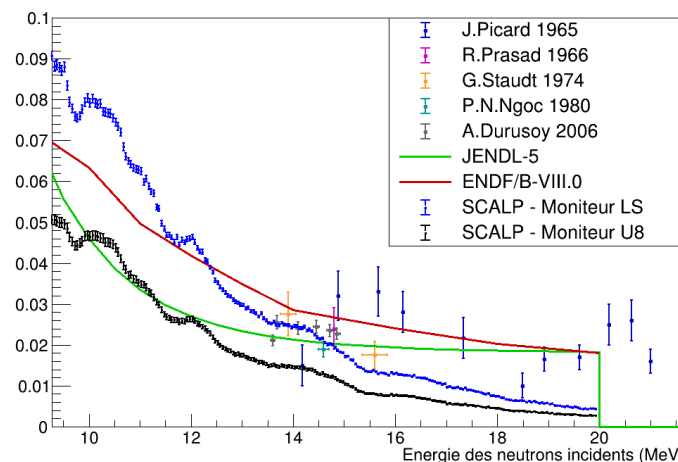
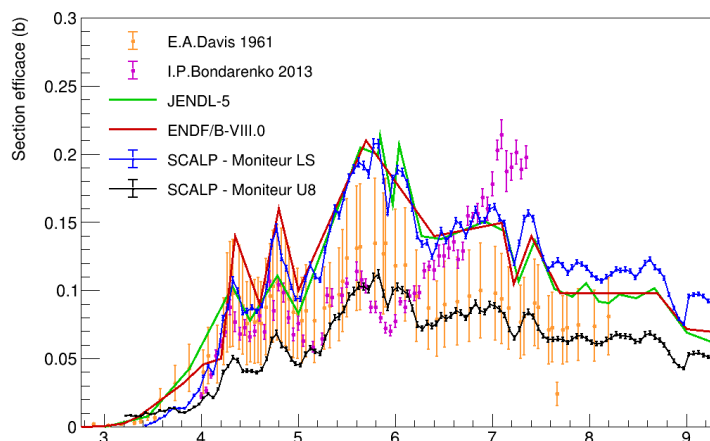
- associated to hydrogenated materials (cathode)
- loss of two third of the statistic
 - prohibitive for $^{16}\text{O}(n,\alpha)^{13}\text{C}$ measurement

Cross-section normalization / Neutron flux measurement

- LS / MM monitor
- U8 FC monitor

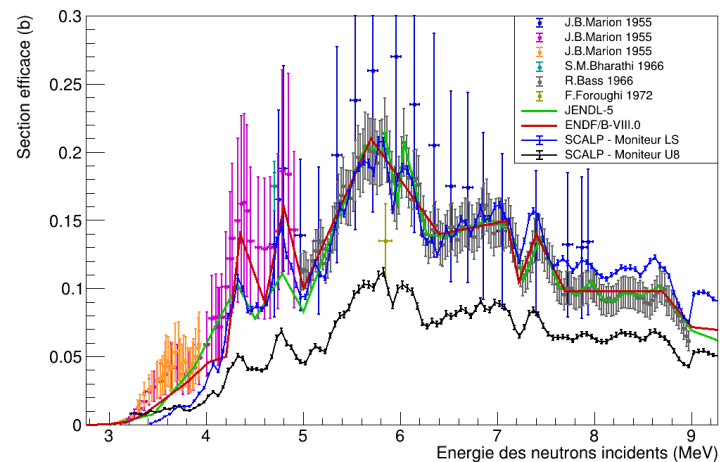


SCALP at NFS – First results & Encoutered problems



First results

A. CHEVALIER, PhD, 2024/12/19



confirmation of structures already observed + additionnal structures & data (9 – 13.5 MeV)

- ++ continuous cross-section distribution
- ++ neutron energy resolution ($< 0.6\%$ below 20 MeV)
- normalization procedure (just the order of magnitude)
- data contamination (prohibitive for O-16 measurements)

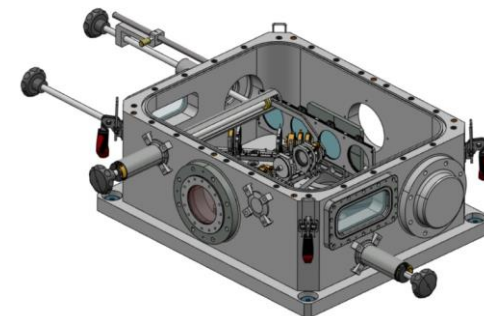
STATUS OF THE SCALP PROJECT

Ongoing

- SCALP modification
 - removal of hydrogenated materials (to remove data contamination)
 - increase in operating voltage (for (n,p) measurement)
- Improvement of the normalization procedure at NFS
 - via the p(n,n)p standard cross-section using MoNHaP (High Precision Neutron Monitor) neutron flux
 - via the U8 FC monitor neutron flux & beam spot
- Data analysis
 - NFS – ^{16}O not enough stat (data contamination)
 - nELBE – ^{19}F & ^{16}O normalization procedure ongoing for ^{19}F , not enough stat for ^{16}O

Experimental program

- | | | |
|--|--------|---|
| - Proposal submitted to NFS PAC (SPIRAL2, GANIL) | oct'25 | $^{19}\text{F}(\text{n},\alpha)^{16}\text{N}$ |
| - Proposal NFS PAC (SPIRAL2, GANIL) | oct'25 | $^{16}\text{O}(\text{n},\alpha)^{13}\text{C}$ |



THE SCALP PROJECT

To summarize...

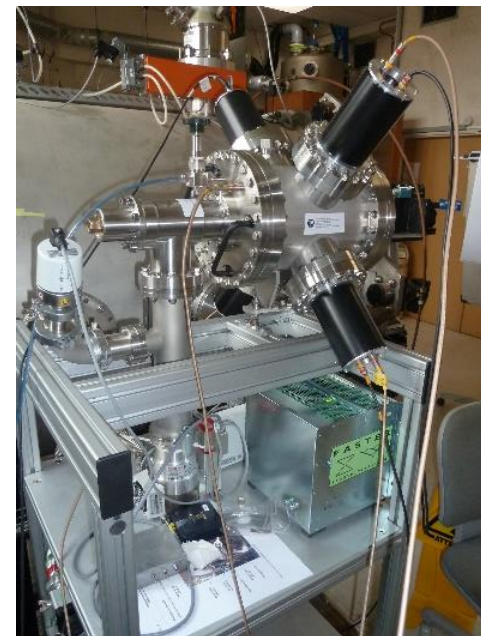
SCALP detector is already fully operational
 upgrade is ongoing, tests are required
 first results are very promising

SCALP will be ready to run at NFS in september'25
 (n, α) on fluorine 19 (PAC ongoing)
 the use of MoNH₂P is mandatory

(n, α) on oxygen 16 (Fall'25 PAC)

The SCALP collaboration

LPC Caen	A. Chevalier, F.-R. Lecolley, J.-L. Lecouey, N. Marie
EAMEA	L. Manduci
CEA	O. Bouland, O. Serot
GANIL	A.M. Frelin, X. Ledoux



OPALE (MP IN2P3)

NACRE (NEEDS, CNRS) SANDA & ARIEL (EC)

CaeSAR (France 2030, RN)

2023/03 – 2029/03 – WP2 NFS Experiments (1 PhD fall'25, 1 Post-Doc fall'26)