(n,α) measurement
on oxygen-16 and fluorine-19 with SCALP

The SCALP collaboration (LPC Caen, CEA, EAMEA, GANIL)
Spokesperson: LECOLLEY F.-R.

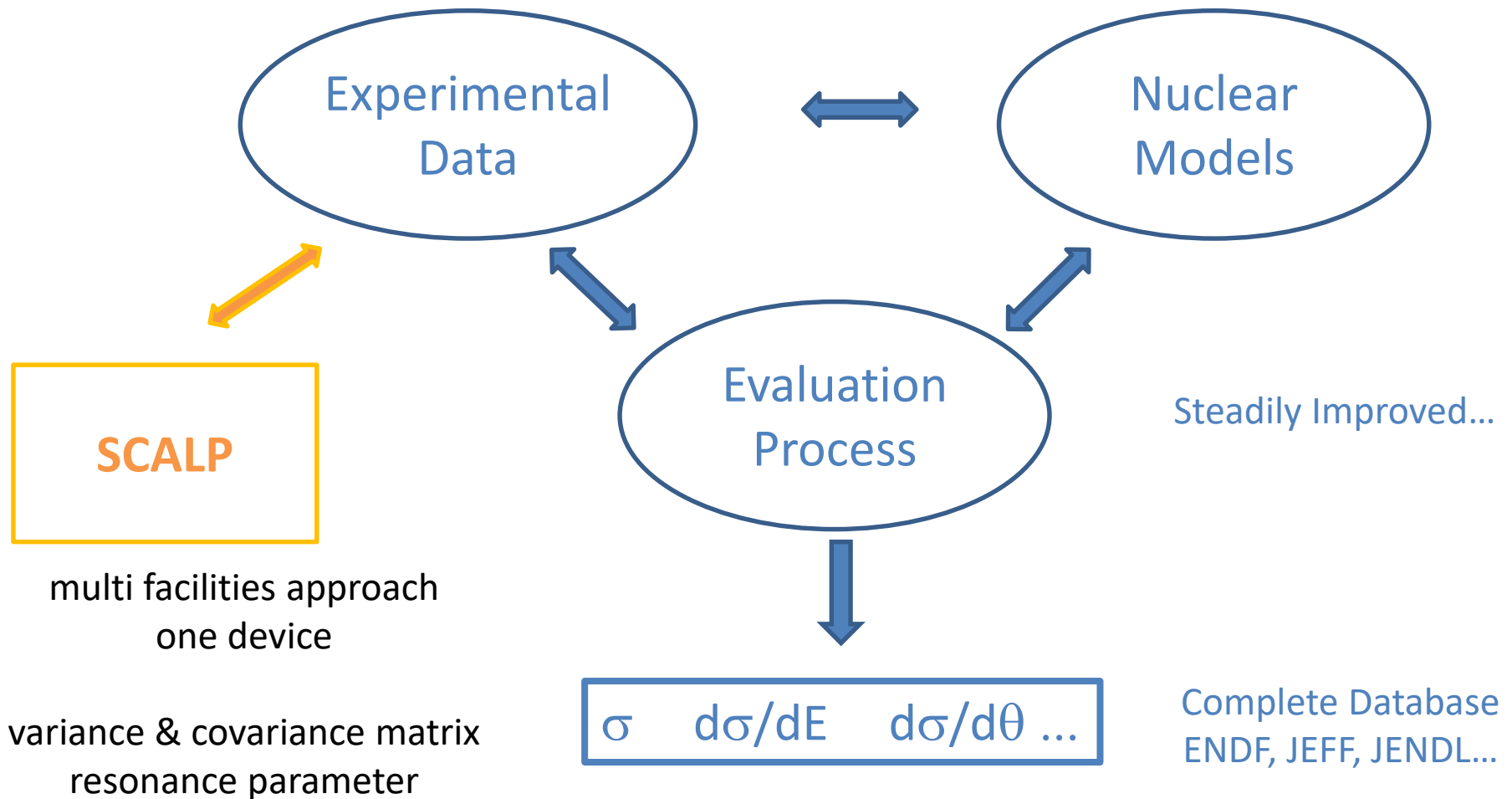SAC – nELBE – SCALP – 02/06/2022

(n,α) measurement on oxygen-16 and fluorine-19 with SCALP

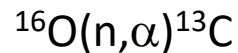## SCALP Scientific context – Nuclear data for nuclear energy

Experimental Data ↔ Nuclear Models

Evaluation Process

SCALP

multi facilities approach
one device

variance & covariance matrix
resonance parameter

Steadily Improved…

$\sigma \quad d\sigma/dE \quad d\sigma/d\theta \ ...$

Complete Database
ENDF, JEFF, JENDL…

(n,α) measurement on oxygen-16 and fluorine-19 with SCALP

SCALP Main goal (1)   at the beginning…

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

- measurement and evaluation

- (n,alpha) reactions of interest for nuclear reactors

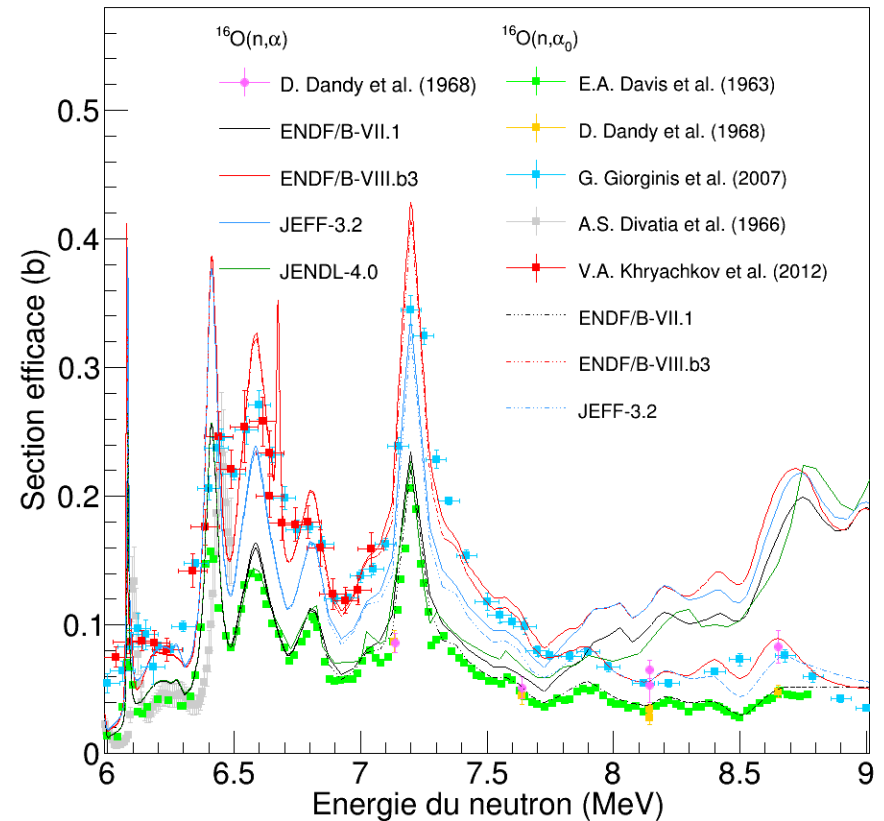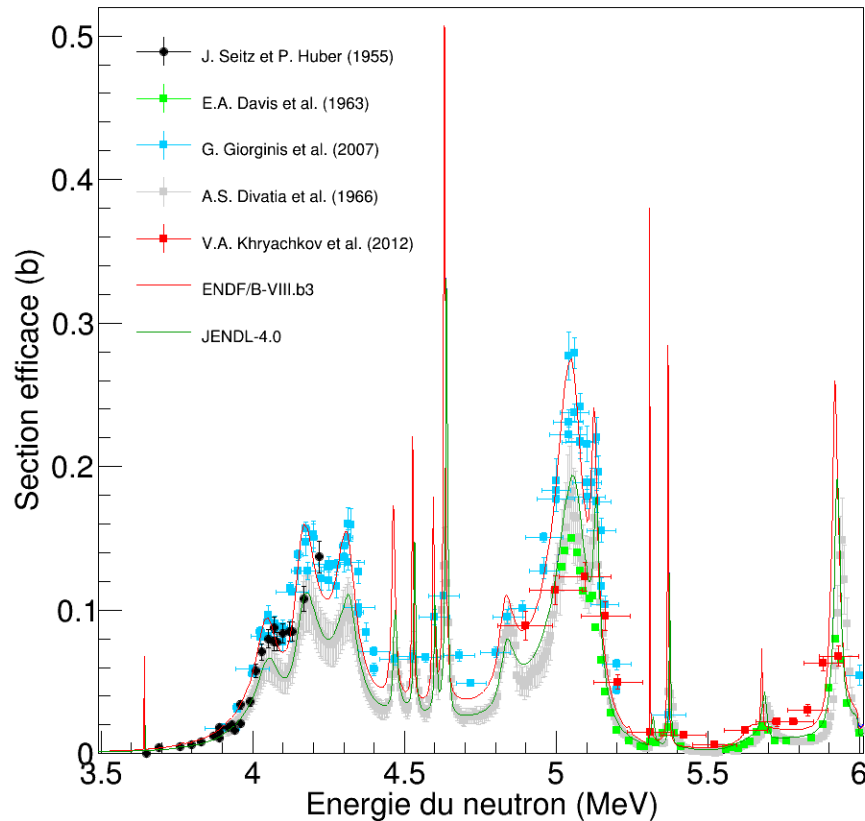- from threshold up to 20 MeV

Motivation

- NEA : HPRL & WPEC 26 (2005) & WPEC 40 (CIELO, 2015)

- sensitivity analysis (WPR, FR)

  ➢ large discrepancies (up to 30%)

  ➢ helium formation in fuel assemblies (± 7%)

  ➢ neutron multiplication factor (± 100 pcm)

SCALP Main goal (1)

Evaluation vs Exerimental Data ^{16}O (n,alpha) ^{13}C

(n,α) measurement on oxygen-16 and fluorine-19 with SCALP

SCALP Main goal (2)   … buy product and/or background…

$^{19}F(n,\alpha)^{16}N$ ● measurement and evaluation

● (n,alpha) reactions of interest for nuclear reactors
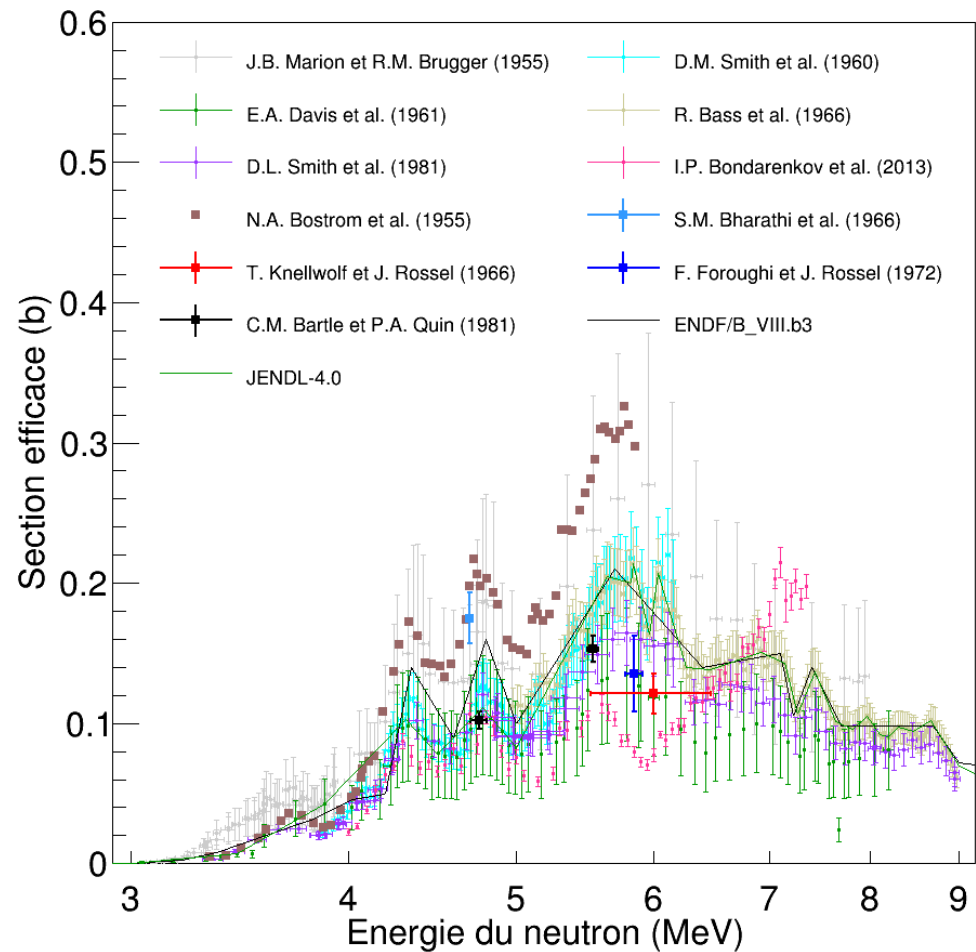
● from threshold up to 20 MeV

Motivation   ● no requirement

● no sensitivity analysis but potential interest for MSR

➢ large discrepancies (up to a factor 3)

➢ dominant contribution in our setup

➢ input parameter for nuclear models used in the evaluation process
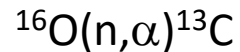
SCALP Main goal (2)

Evaluation vs Exerimental Data
^{19}F (n,alpha) ^{16}N

(n,α) measurement on oxygen-16 and fluorine-19 with SCALP

SCALP Main goal (1 & 2)

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

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

Large discrepancies

measurement vs measurement

measurement vs evaluation

evaluation vs evaluation

underline the need of new measurements

new setup

multi facilities approach

variance & covariance matrix, resonance parameter

➢ **new data sets for the theoretical approach and the evaluation process**

SCALP Experimental device – Brief description

the SCALP detector	● active gaseous target – CF_4 or CF_4 + CO_2(3%)
	● ionization chamber & 4 PM Tubes
	123 x 123 x 125 mm^3, 0 to 2 bar

deposited energy resolution	± 150 keV [CF_4]	± 220 keV [CF_4 + CO_2(3%)]
detector timing resolution	± 250 ps [CF_4]	± 700 ps [CF_4 + CO_2(3%)]

SCALP Experimental device – Response simulation (GEANT4 + ENDF/B-VII)

	Q (MeV)	Es (MeV)
$^{19}F(n,\alpha)^{16}N$	-1,52	1,61
$^{16}O(n,\alpha)^{13}C$	-2,22	2,36
$^{19}F(n,p)^{19}O$	-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

$CF4$ (CO_2, 3%) − 1 bar − d_{ToF} = 5 m

$\Delta E / E = 1\%$ - $\Delta t = 1$ ns

20 MeV   10 MeV

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

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

Energie deposee E_{dep} (MeV)

Temps de vol t_0 (ns)

unambiguous identification and selection of the reaction channel of interest
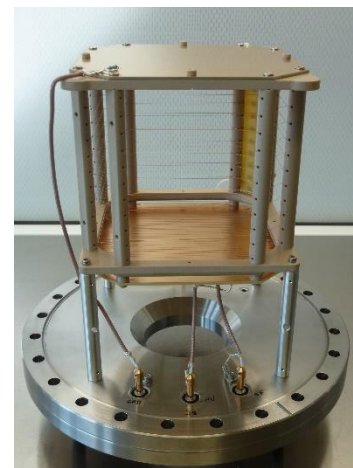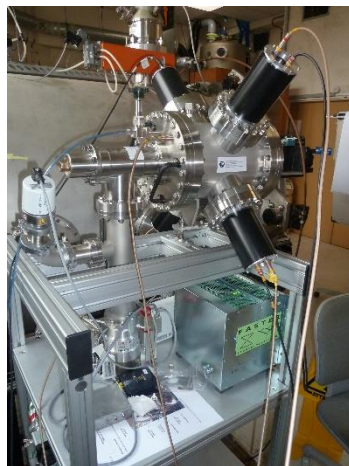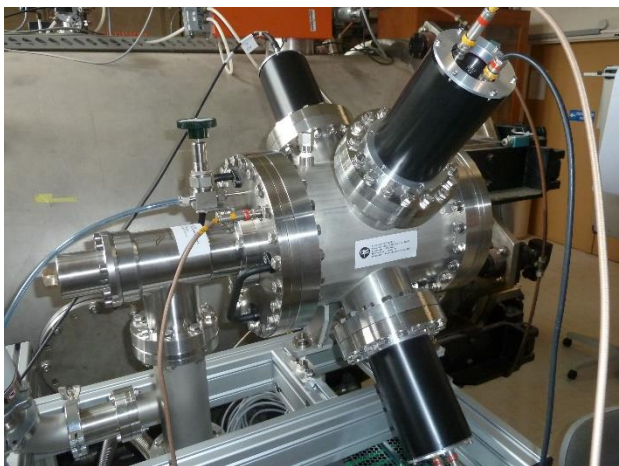
(n,α) measurement on oxygen-16 and fluorine-19 with SCALP

SCALP Experimental program   **one setup, different ToF facilities**

Those two steps are mandatory:

- we need measurement with pure CF4 in order to be able to remove background events coming from reaction on either fluorine or carbon when measuring with a mixture of CF4 and CO2,
- it will allow us to make comparison with the measurements performed at NFS in term of time-of-flight and energy resolution, data processing to retrieve (n,alpha) reaction, background contribution and its subtraction, systematic effects,
- it will also give us access to the (n,alpha) cross-section on fluorine 19 and oxygen 16 with two different facilities.

^{19}F(n,α)^{16}N, ^{16}O(n,α)^{13}C – new submission

1) with pure CF4   4 days (1% stat.err)
2) with a gas mixture CF4 – CO2 (3%)   10 days (3% stat.err)

with a break of at least 2 weeks to perform the gas exchange

at the GELINA facility (Geel, Belgium)
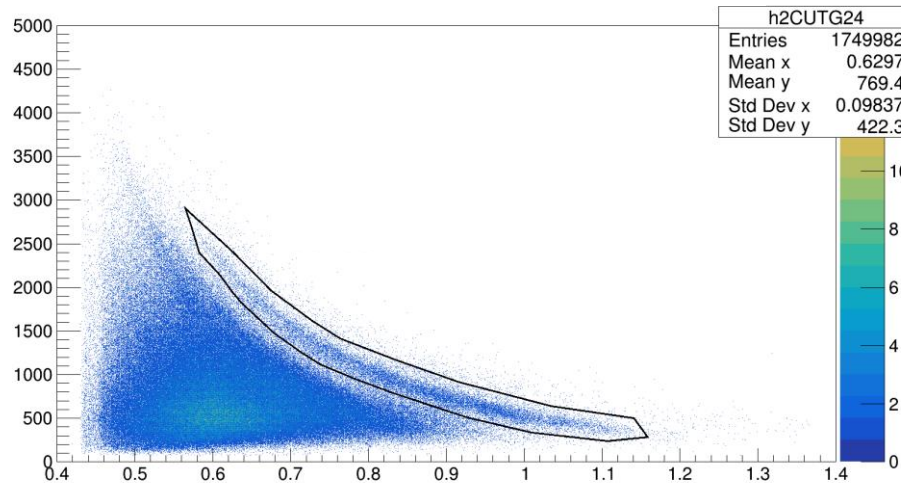^{19}F(n,α)^{16}N – accepted, waiting for scheduling

at the NFS facility (Caen, France)
^{19}F(n,α)^{16}N, ^{16}O(n,α)^{13}C – accepted, perform in october 2021

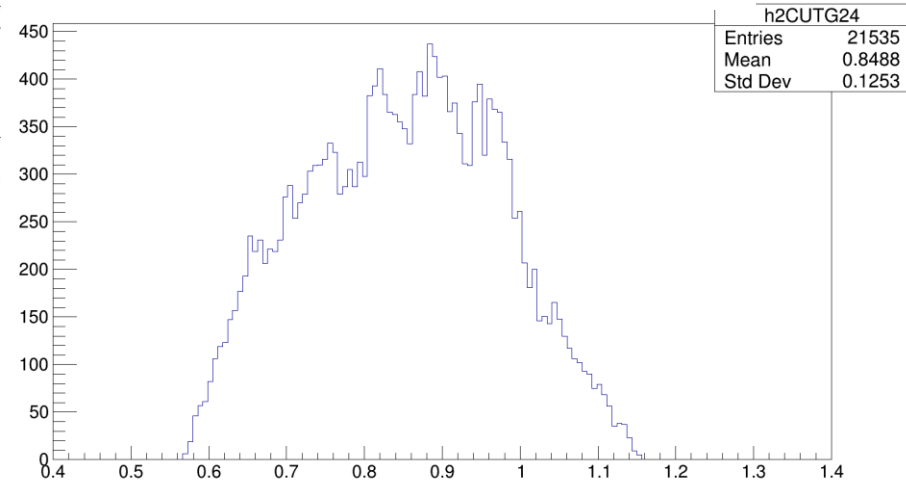# (n,α) measurement on oxygen-16 and fluorine-19 with SCALP

SCALP First measurement at NFS (Spiral2, GANIL, France)

Channel reaction identification

E_d vs tof_n (a.u.)

Number of events (2hours) $^{19}F(n,alpha)^{16}N$

tof_n (a.u.)

time of flight resolution of 1.2 ns with a flight path of around 30 m
500 ps our PMTs + 1ns RF signal
neutron energy resolution better than 1%
resonance parameter

(n,α) measurement on oxygen-16 and fluorine-19 with SCALP

To summarize…

SCALP detector is already fully operational
      Measurements were performed at NFS
      Preliminary results are very encouraging

Two measurements are envisaged at nELBE
      CF_4 – (n,α) on fluorine 19   (4 days, 1%)
      CF_4 + CO_2 (3%) – (n,α) on oxygen 16   (10 days, 3%)

The SCALP collaboration
LPC Caen	A. Chevalier (PhD) F.-R. Lecolley, J.-L. Lecouey, G. Lehaut, N. Marie
EAMEA	L. Manduci
CEA Cadarache	O. Bouland, O. Serot
GANIL	X. Ledoux