Direct measurement of the $^{19}F(p,\alpha)^{16}O$ reaction

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Overview

Astrophysical motivation

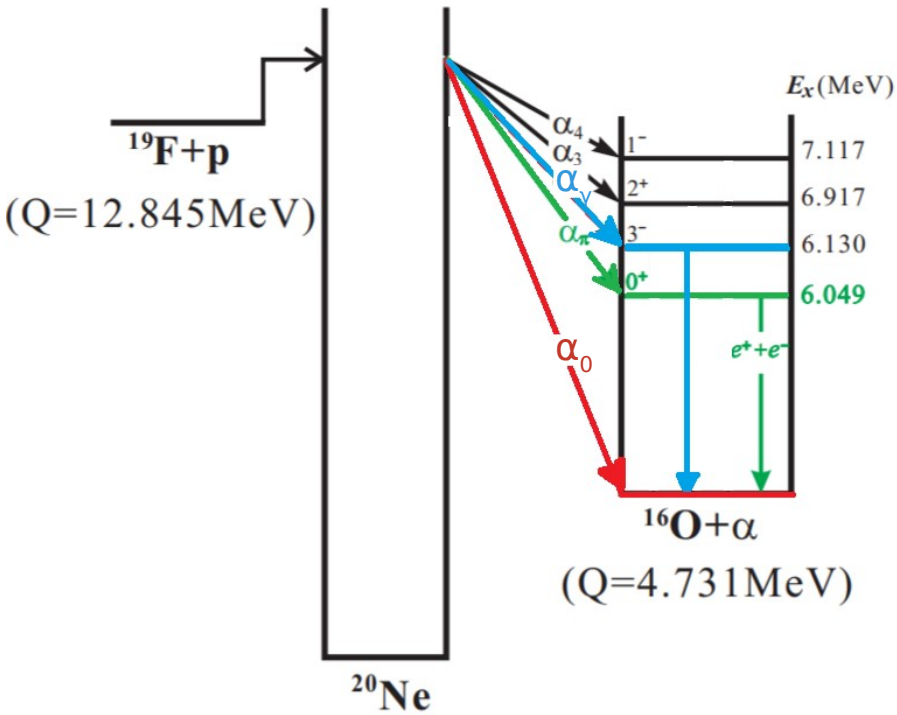
$^{19}F(p,\alpha_0)^{16}O$ reaction measured at INFN – LNS

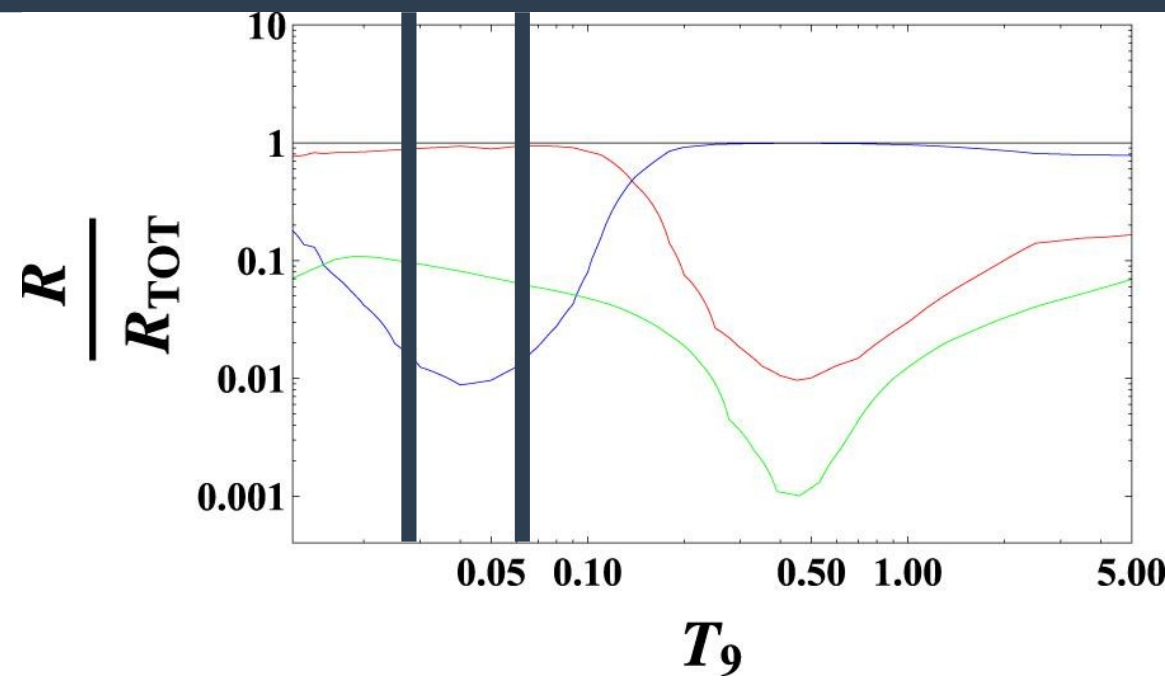
$^{19}F(p,\alpha_{\gamma,\pi})^{16}O$ upcoming measurement at IFIN - HH

Astrophysical motivation

Why is Fluorine important for astrophysics?

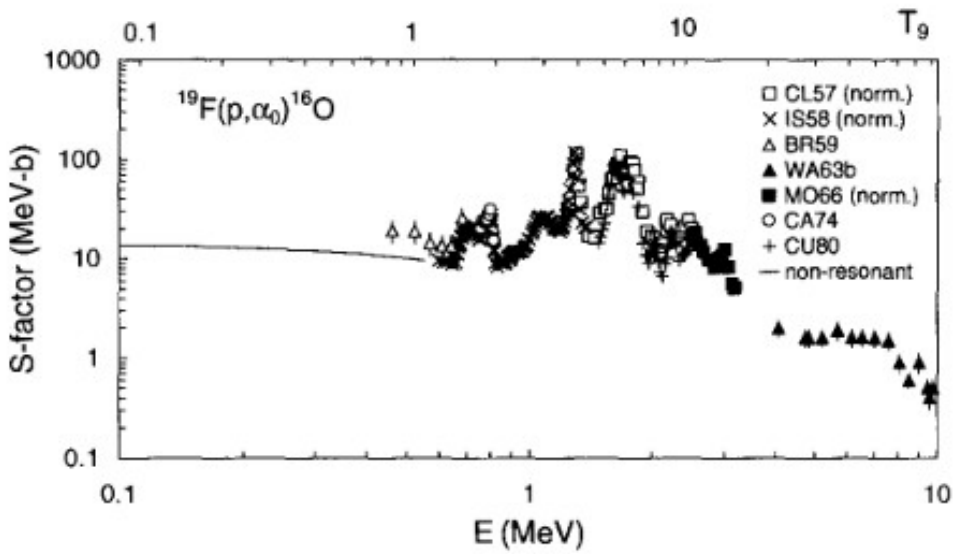
- AGB star nucleosynthesis;
- s-process elements analysis.

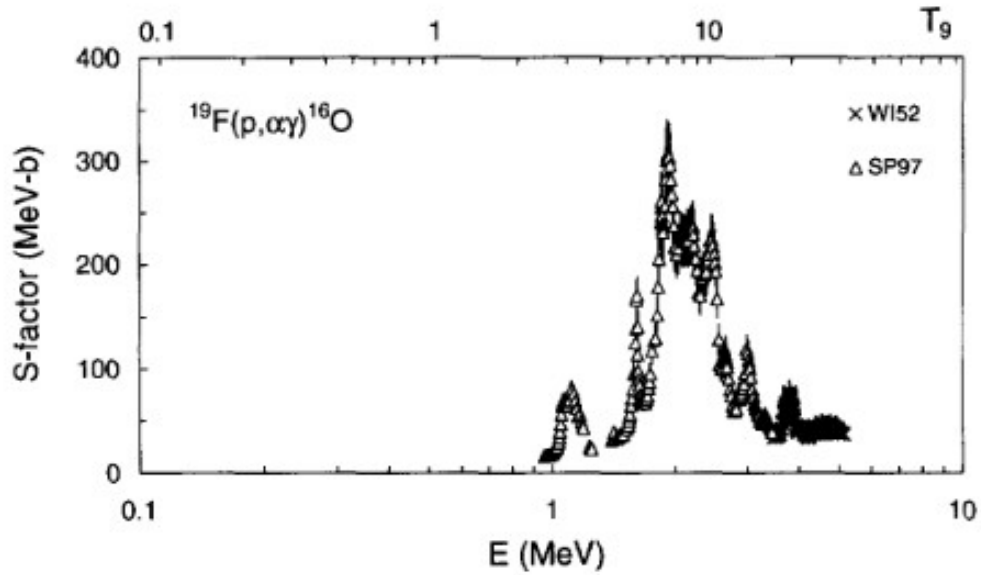


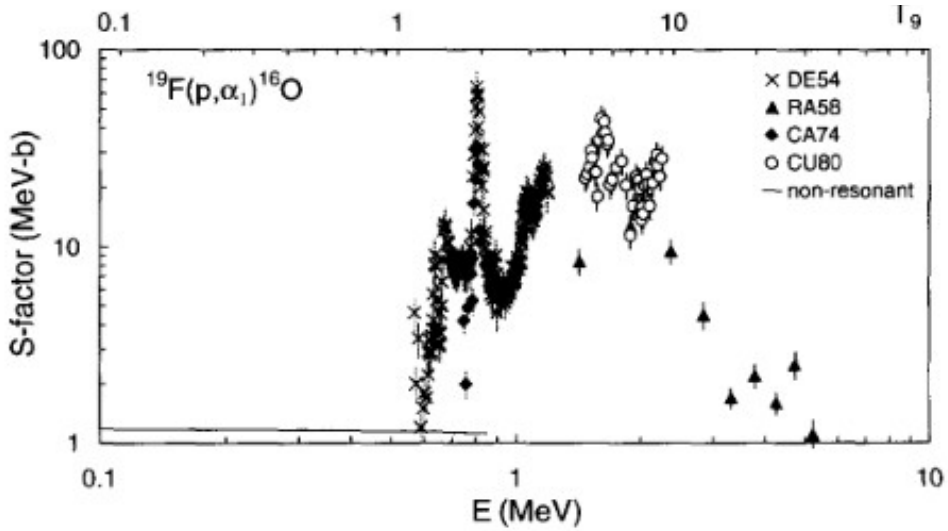


Each channel and its contribution to the total reaction rate. The black line corresponds to R/R_{TOT} =1. At very low temperatures, the (p,α_0) channel (red line) dominates the total rate. The (p,α_γ) channel (blue line) became dominant at least above T9 ≈ 0.2, while the (p,α_π) channel (green line) gives a maximum contribution of 20%.

Astrophysical motivation

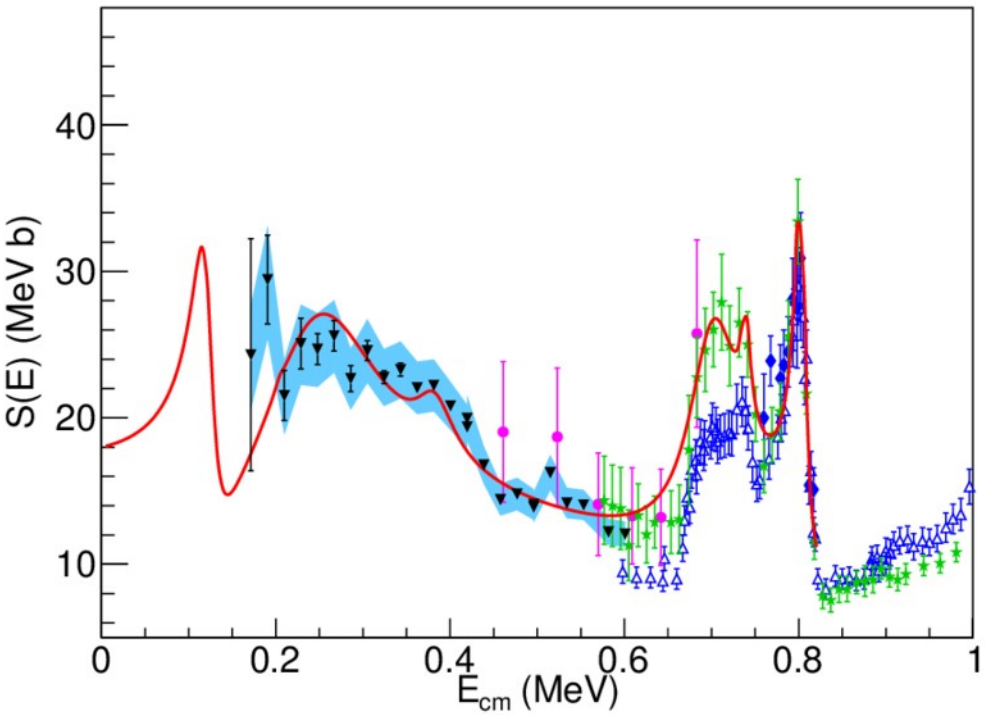




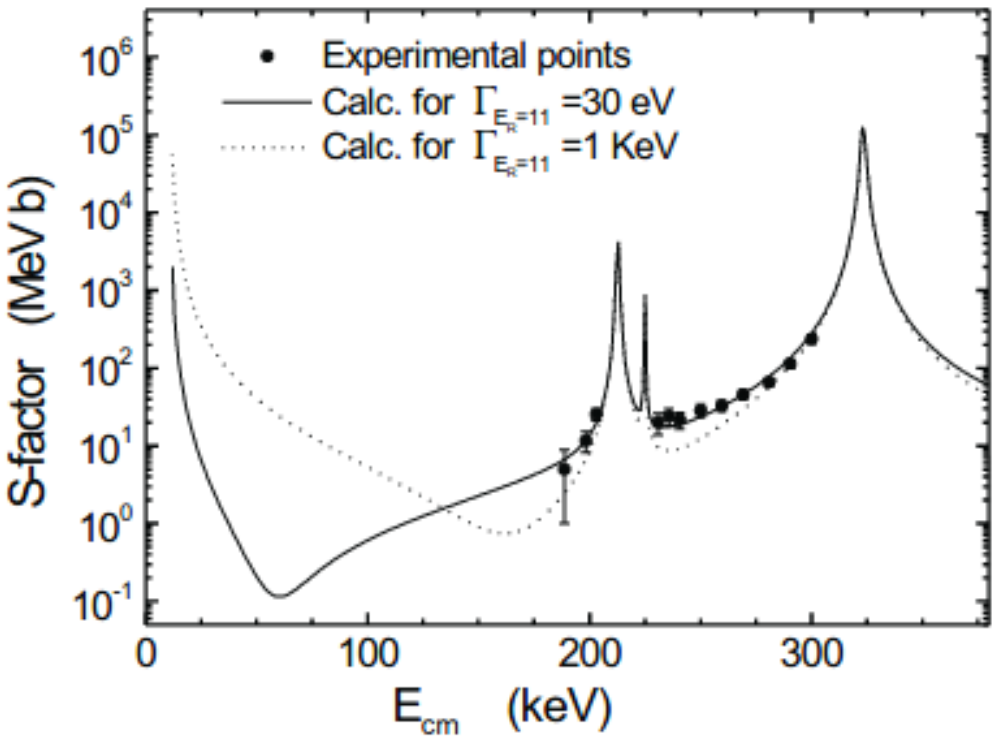


C. Angulo et al., Nuclear Physics A 656 (1999) 3-183

Astrophysical motivation



Lombardo, I., Dell'Aquila, D., Di Leva, A., et al. 2015, PhLB,748, 178

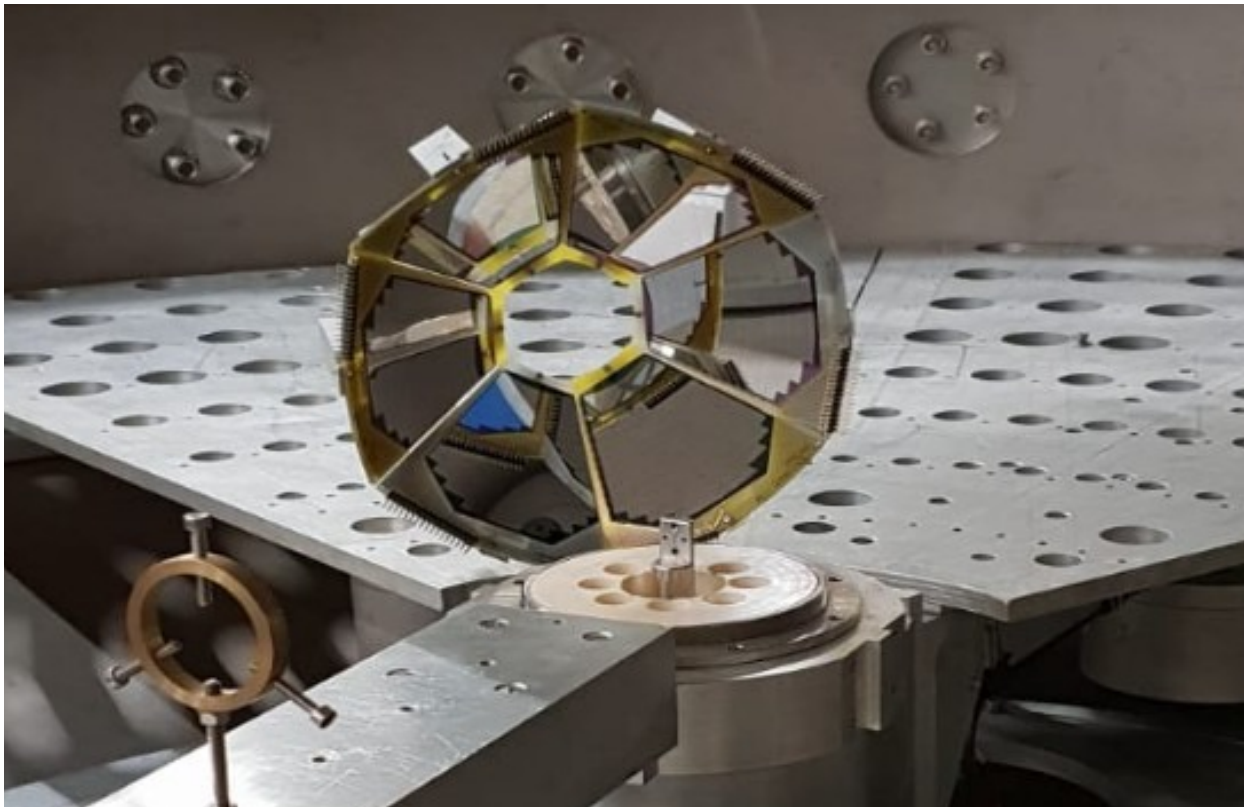


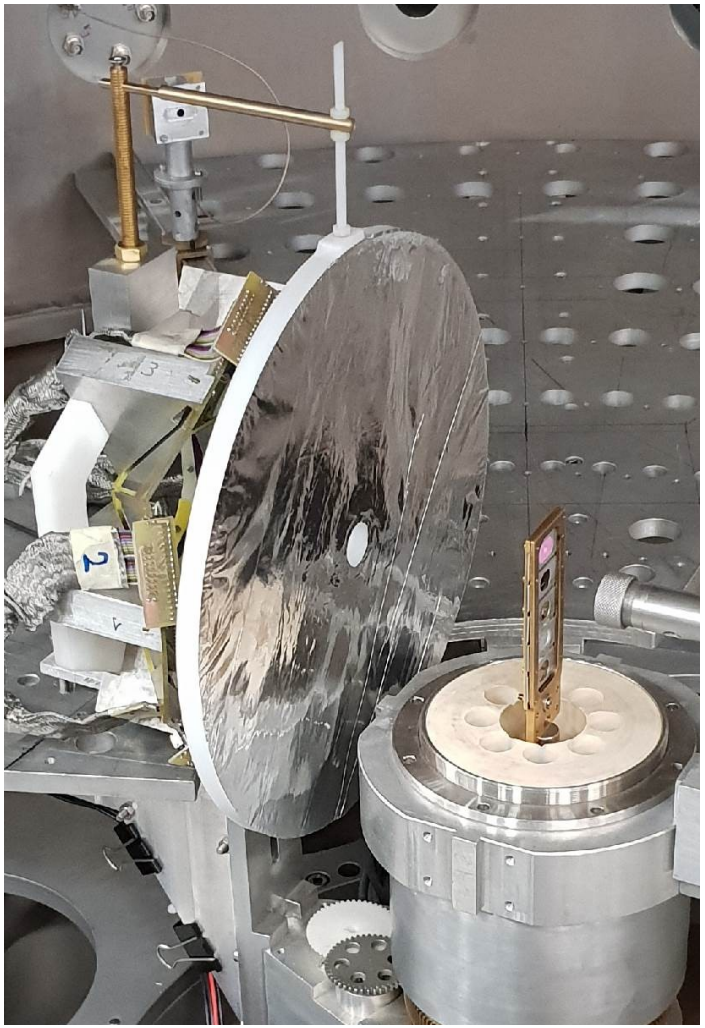
Spyrou, K., Chronidou, C., Harissopulos, S., et al. 2000, EPJA,7, 79

$^{19}F(p,\alpha_0)^{16}O$ reaction measured at INFN - LNS

- ^{19}F beam, energy range from 9 up to 18.5 MeV;
- Spot size on target of 1 mm;
- Intensities around 1 - 5 nA;
- Thin self supported polyethylene targets (CH_2) of about 100 μg/cm^2;
- Target placed at 90 degrees with respect to beam direction.

$^{19}F(p,\alpha_0)^{16}O$ reaction measured at INFN - LNS





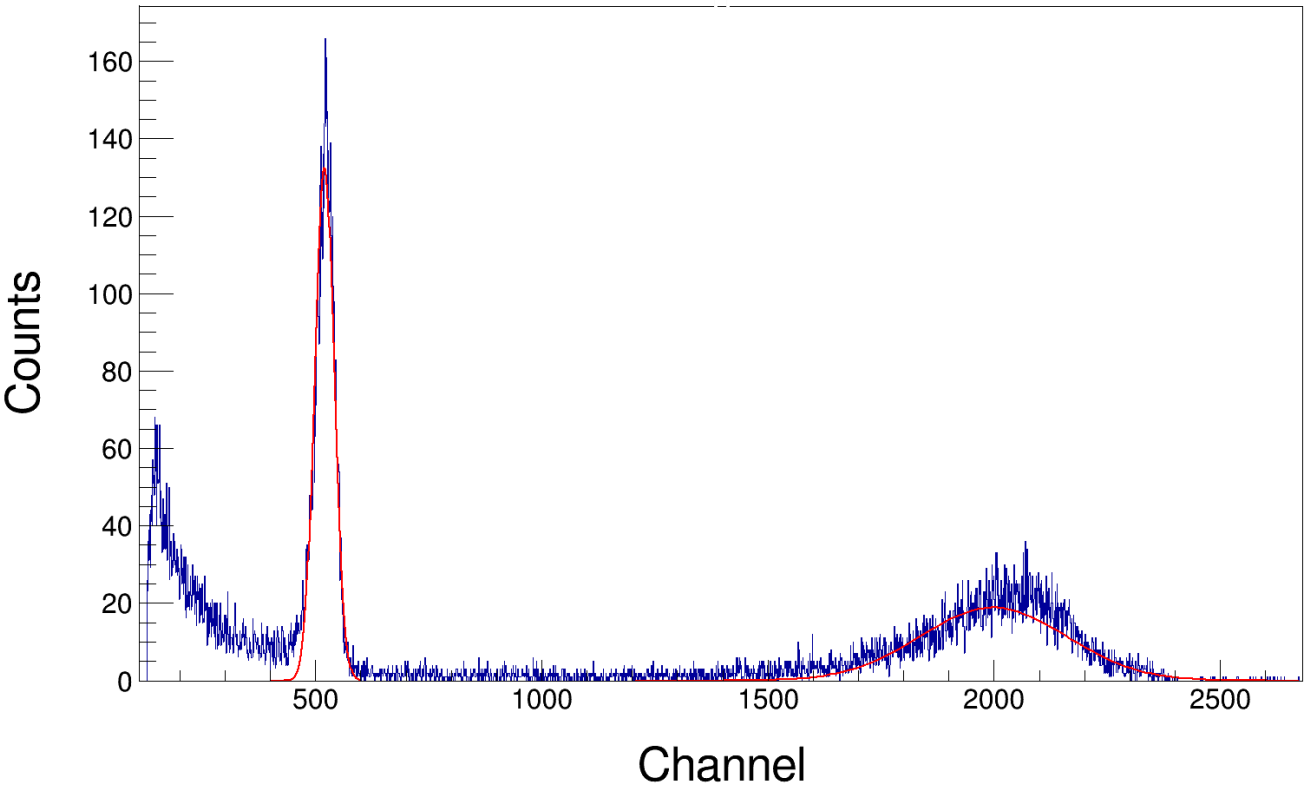
LHASA:

- YY1 detector
- 300 µm thick
- 16 strips
- 96 channels of associated electronics
- 10-34 degrees angular coverage

$^{19}F(p,\alpha_0)^{16}O$ reaction measured at INFN - LNS

Beam :

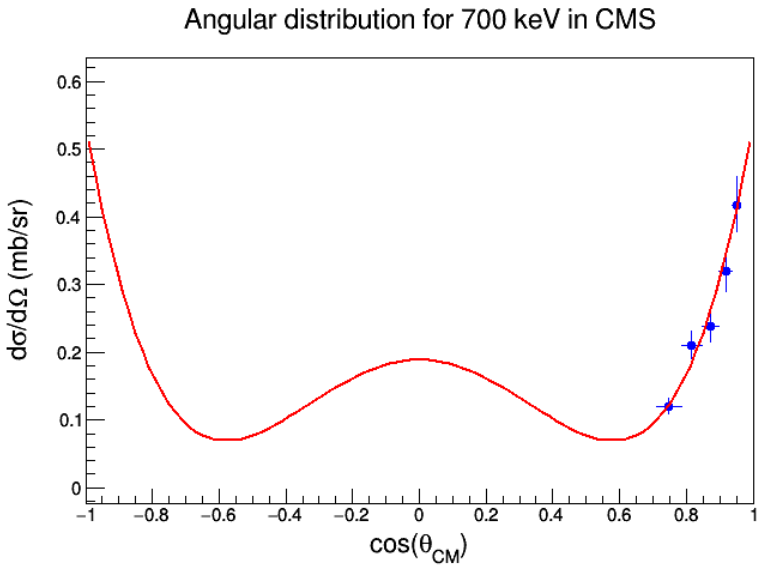
- Beam current is measured by means of a Faraday cup placed behind the target and a -300 V suppression voltage is applied to reduce secondary electron effects.

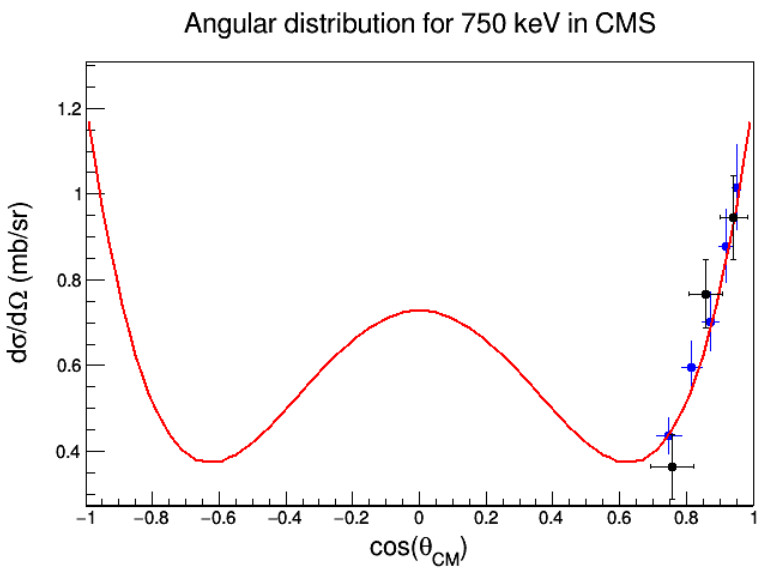


Target:

- Few µm thin CH_2;
- Photodiode placed at 45 degrees with respect to beam direction Used to check the number of particles in the target and its degradation.

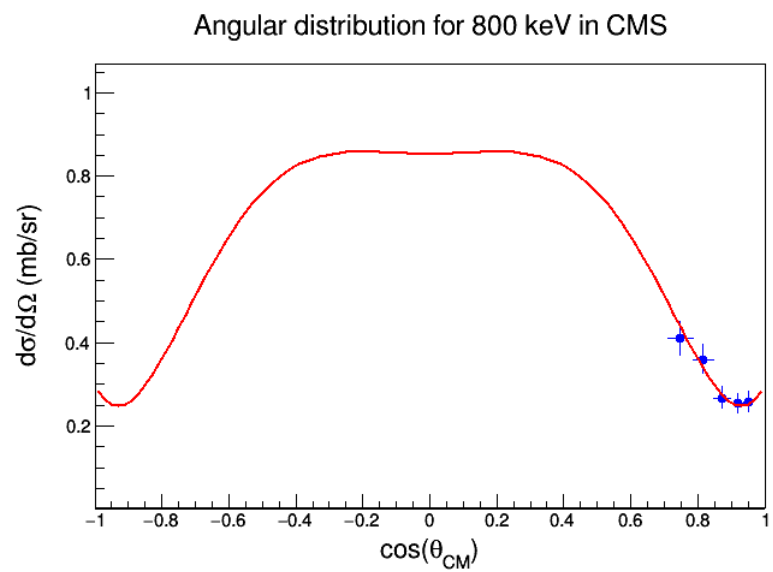
$^{19}F(p,\alpha_0)^{16}O$ reaction measured at INFN - LNS





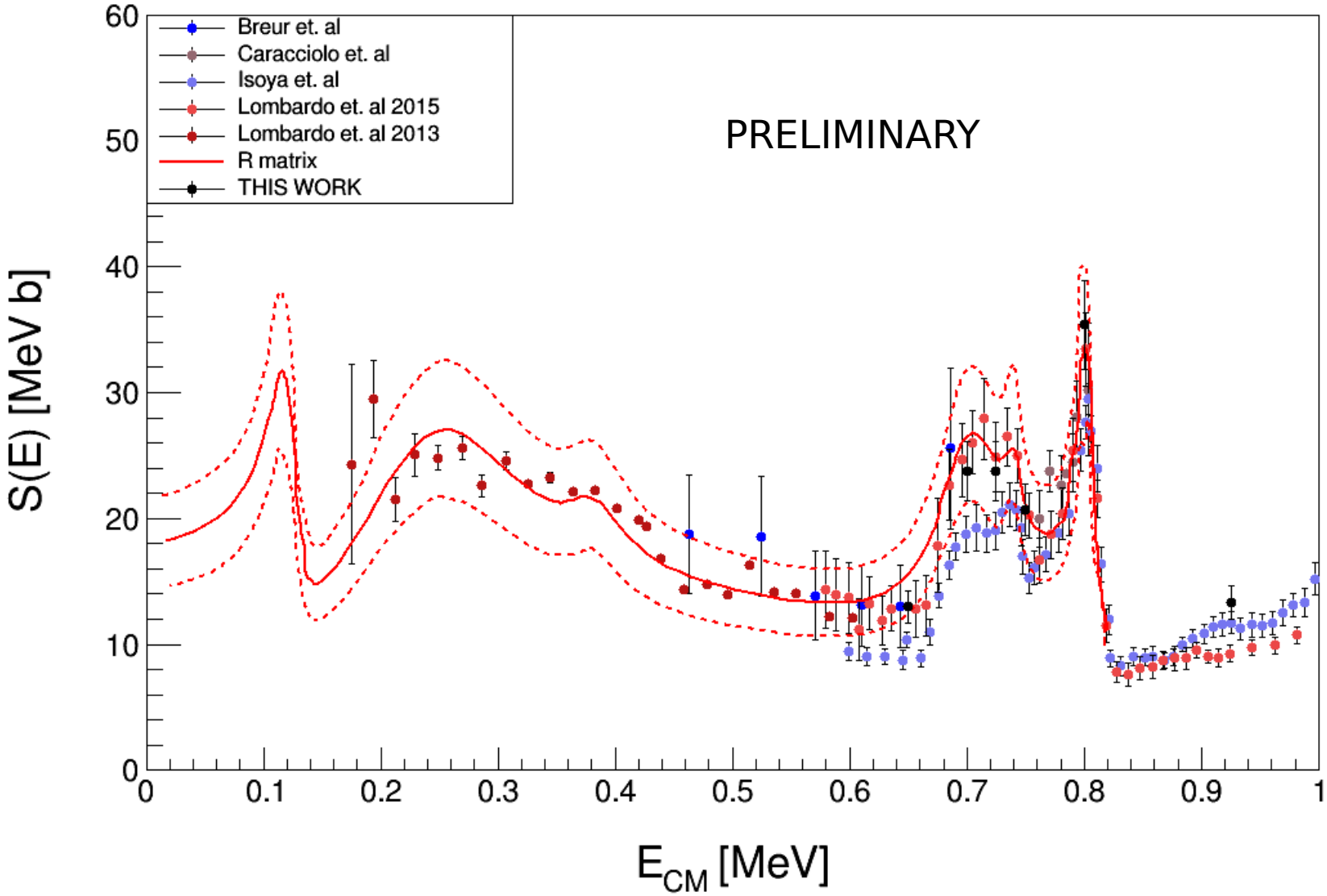
The number of reactions is calculated by integrating the scaled Legendre polynomial.

$$\sigma = \frac{N_{REACTIONS}}{N_{BEAM} \cdot N_{TARGET}}$$



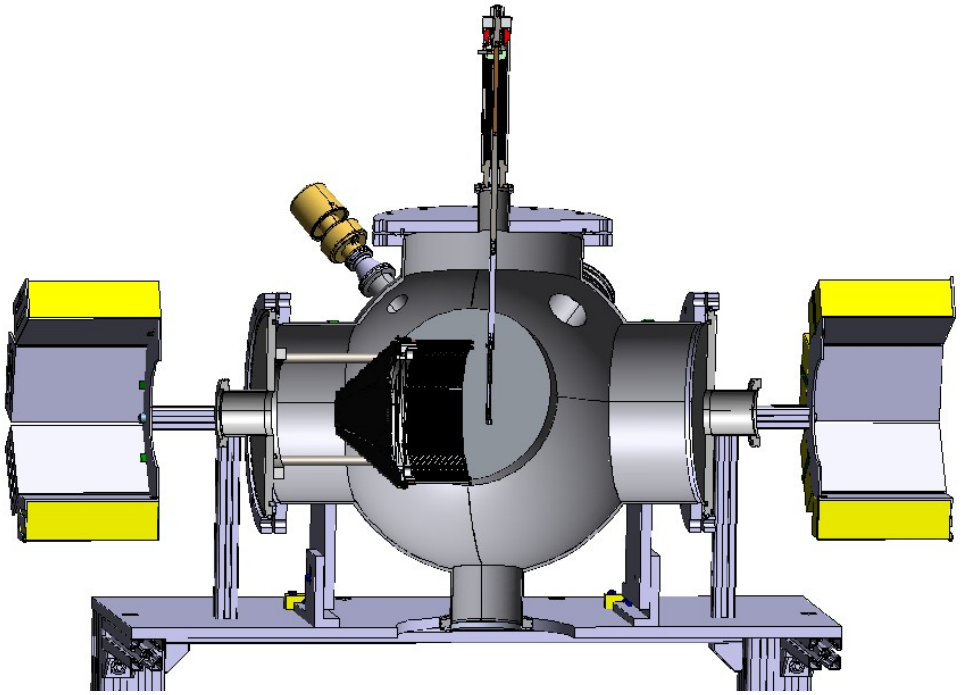
PRELIMINARY

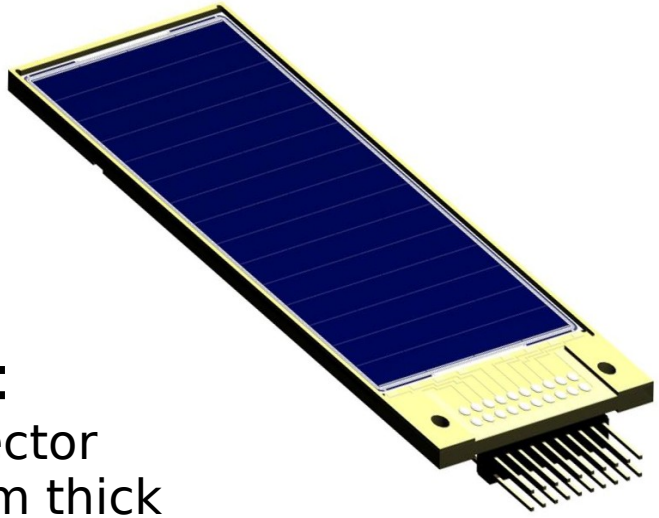
$^{19}F(p,\alpha_0)^{16}O$ reaction measured at INFN - LNS



$^{19}F(p,\alpha_{\gamma,\pi})^{16}O$ upcoming measurement at IFIN - HH

- 14 beam time days approved at the IFIN-HH 3 MV Tandem accelerator;
- Lithium beam energy: 8-12 MeV for calibrations;
- Fluorine beam energy: 7-15 MeV;
- Fluorine beam intensity: 5 pnA;
- Thin self suported CH_2 target;
- Online monitoring system of the target;
- ELISSA and LHASA coupled together for particle detection;
- Standard mesytesc electronic chain.

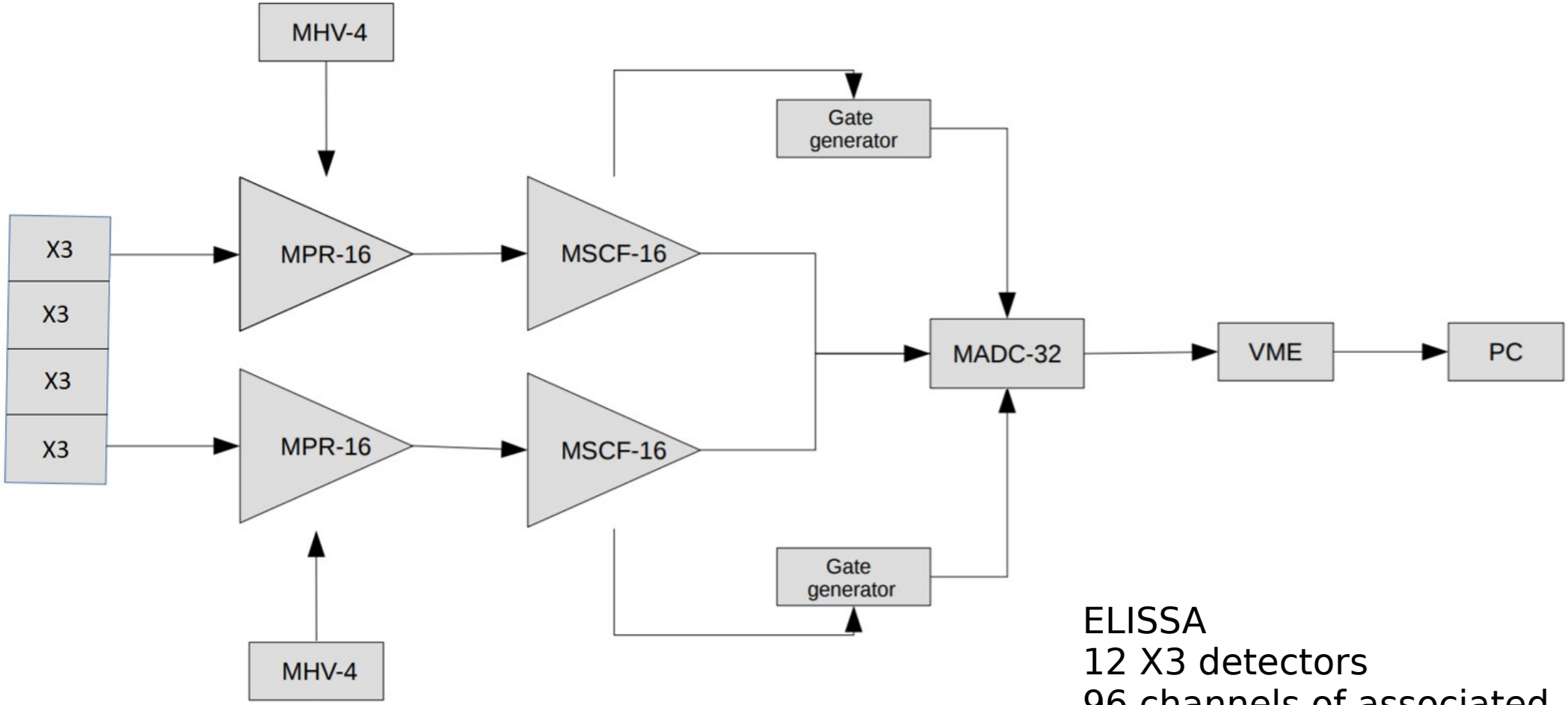




ELISSA:

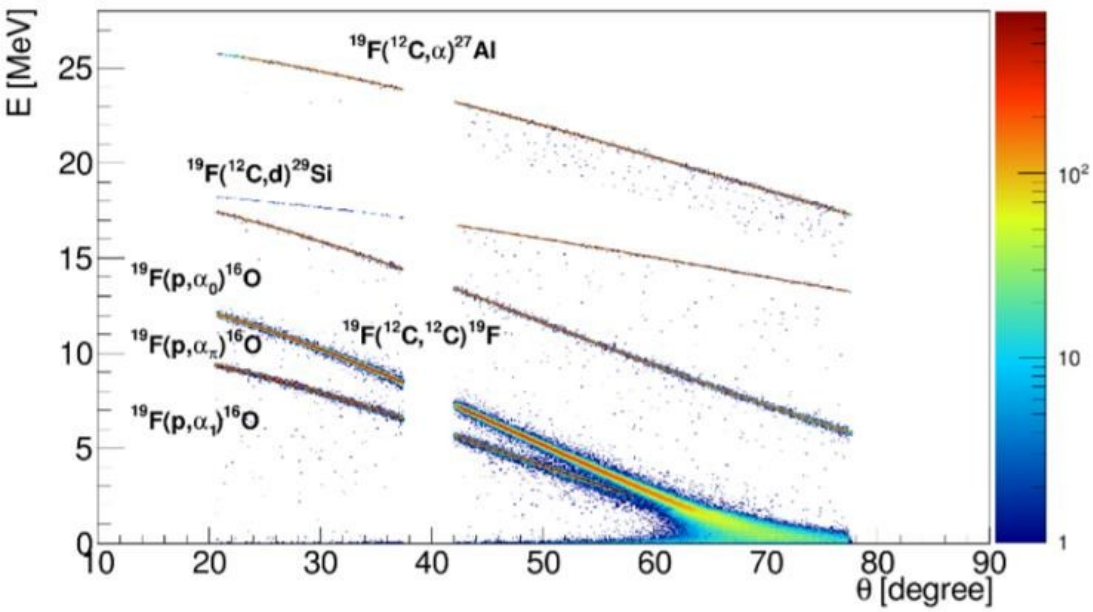
- X3 detector
- 1000 µm thick
- 4 PSD strips

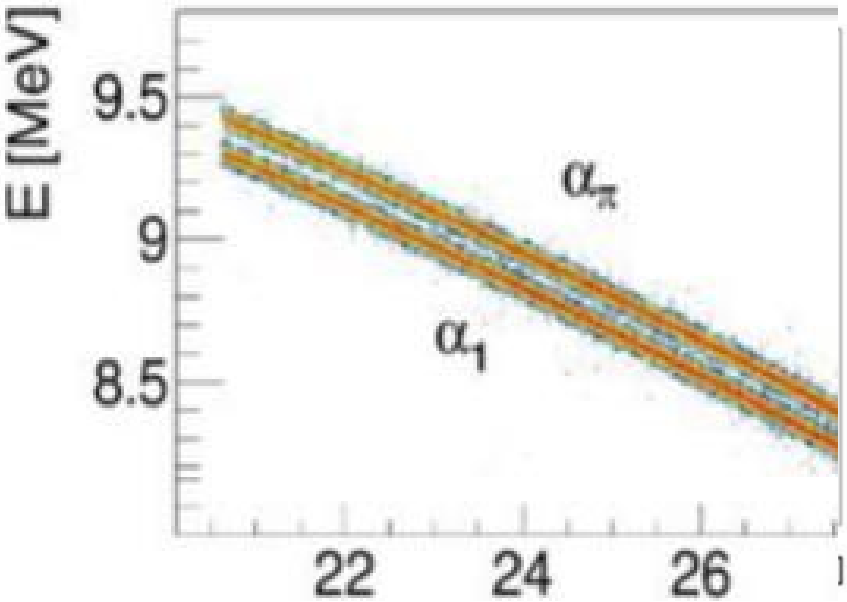
$^{19}F(p,\alpha_{\gamma,\pi})^{16}O$ upcoming measurement at IFIN - HH



ELISSA
12 X3 detectors
96 channels of associated electronics

$^{19}F(p,\alpha_{\gamma,\pi})^{16}O$ upcoming measurement at IFIN - HH



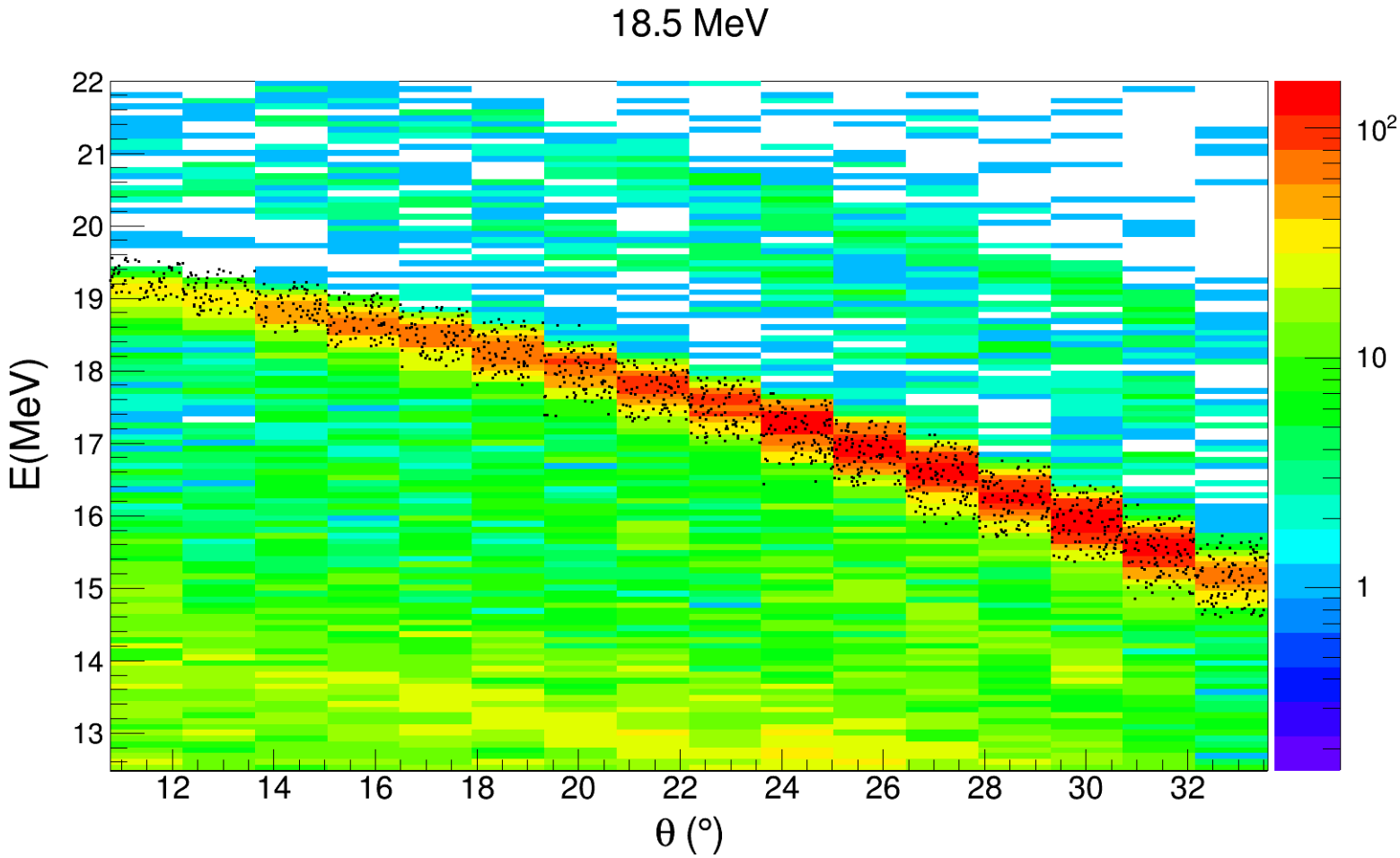


GROOT: MC tool for nuclear physics:

- based on G4 and ROOT
- user-friendly Qt GUI
- n-body MC generator
- detector resolution
- ASCII and ROOT output

A fast and complete GEANT4 and ROOT Object-Oriented Toolkit: GROOT – Lattuada D. et al
DOI: 10.1051/epjconf/201716501034

$^{19}F(p,\alpha_{\gamma,\pi})^{16}O$ upcoming measurement at IFIN - HH



Summary

- **Fluorine important for AGB star nucleosynthesis and s-process elements analysis;**
- **The discrepancy between the previous data sets in $^{19}F(p,\alpha_0)^{16}O$ reaction is solved;**
- **We are confident that we can separate α_γ and α_π in the upcoming experiment.**

Thank you!

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T. Madgearu for the collaboration:
G. L. Guardo, C. Matei, D. Lattuada, M. La Cognata, D. L. Balabanski, S. Romano, L. Lamia, R.G. Pizzone, A. Tumino