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Experimental activities on (n,cp) reactions at GANIL-NFS

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Diego Ramos², Xavier Ledoux²,
and more participants in the Medley-team

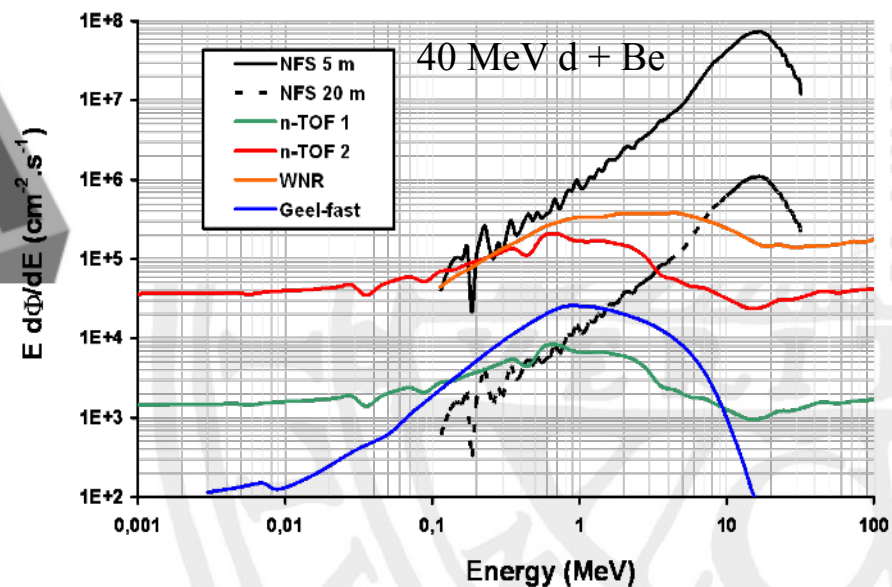
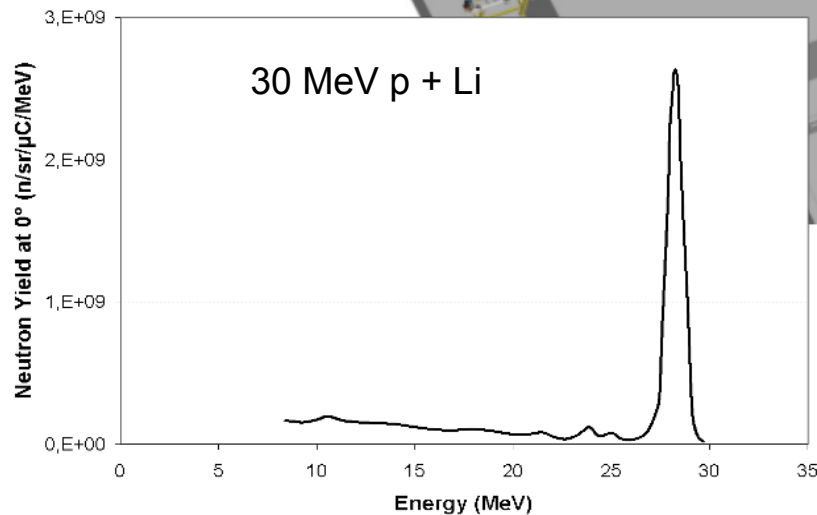
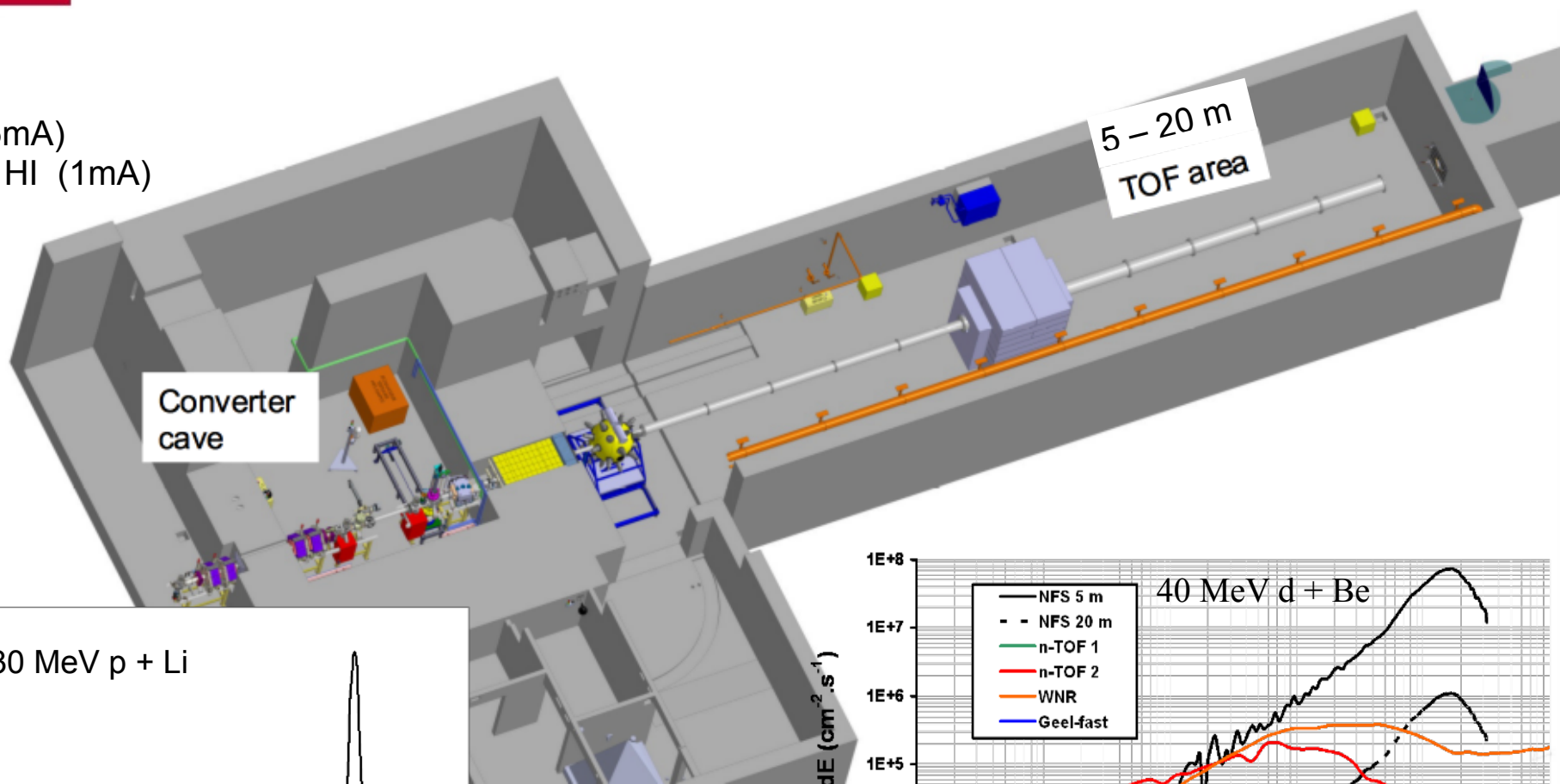
¹*Department of Physics and Astronomy, Uppsala University (Sweden)*

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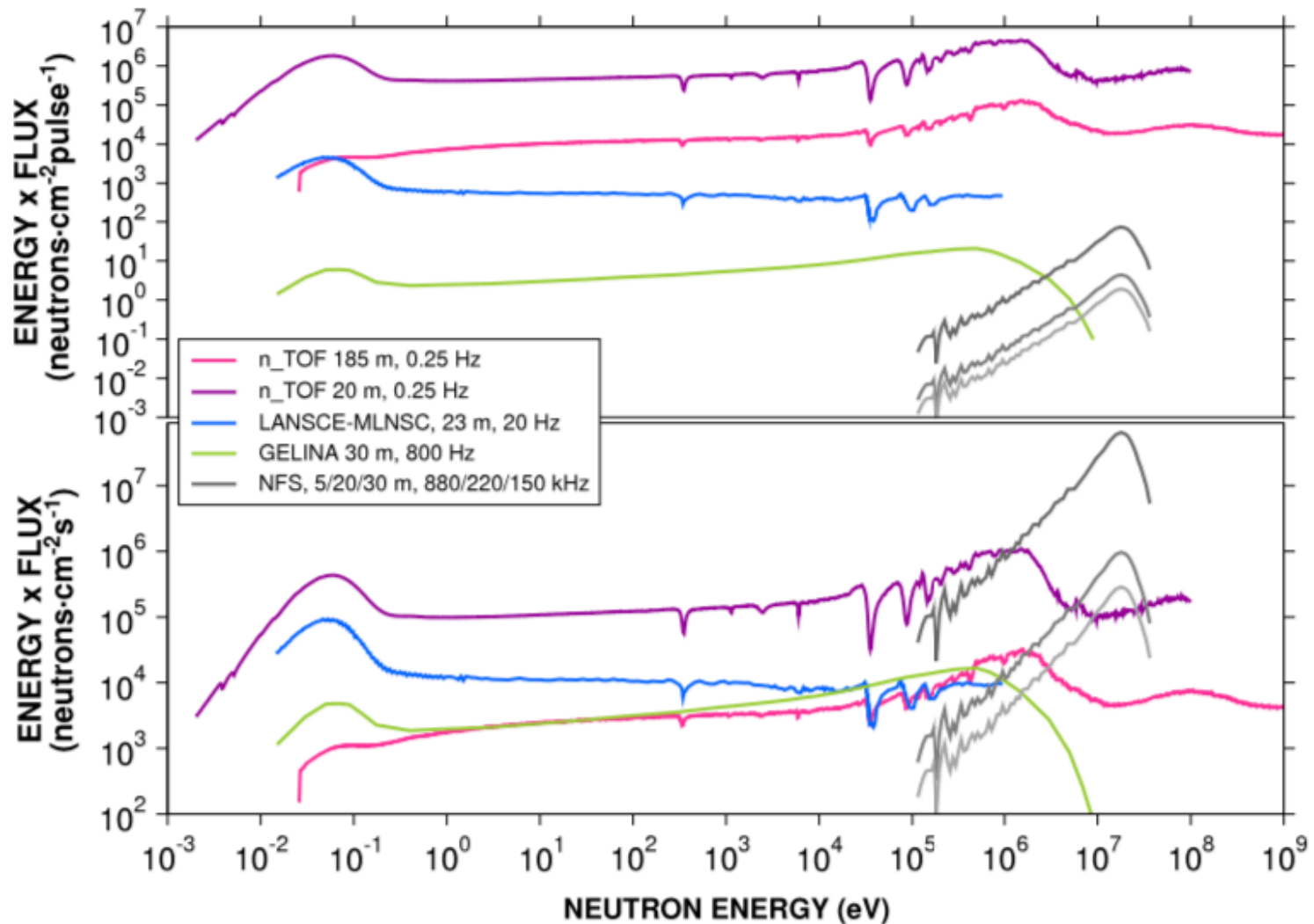
NFS at GANIL (Neutrons For Science)

LINAC:
33 MeV p,
40 MeV d (5mA)
14.5 A·MeV HI (1mA)





Comparison of neutron facilities

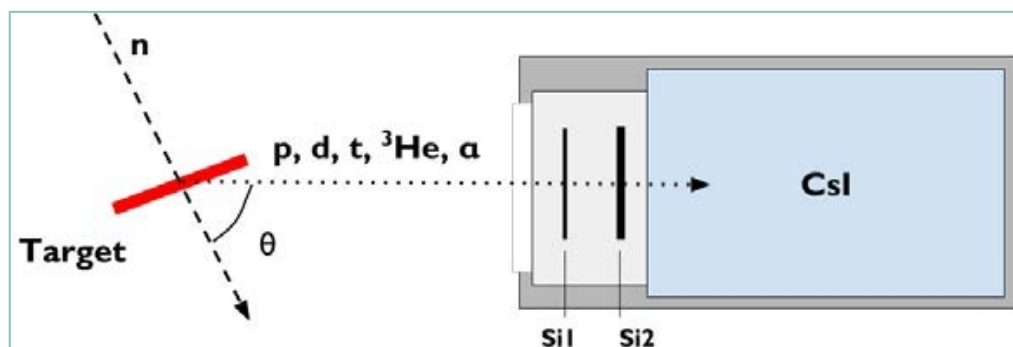


- To **measure**:
 - **double-differential cross-sections (DDX) for (n, LCP)**, as a function of neutron energy, in the range 1 - 40 MeV.
- And from it, we can **deduce**:
 - **single-differential cross-sections** with respect to the **secondary energy and angle** of the emitted particle;
 - **integrated (n, LCP) production cross sections** as a function of neutron energy.

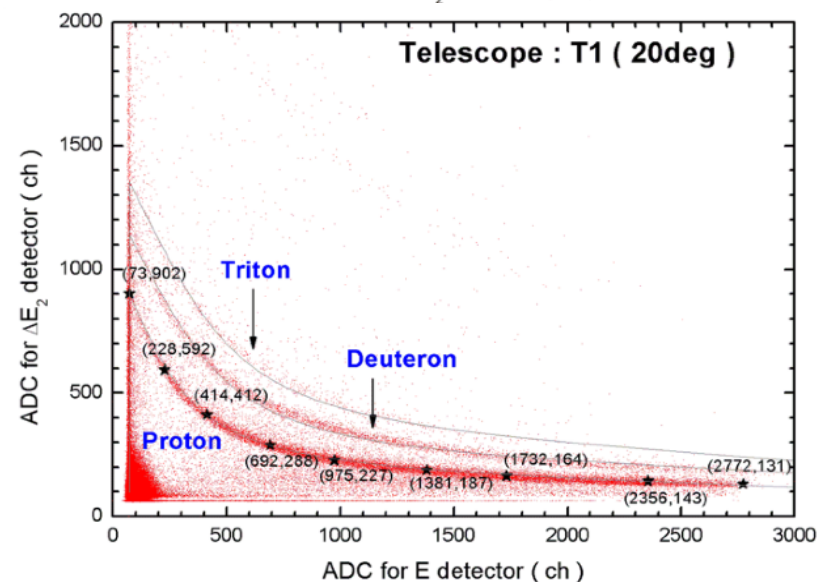
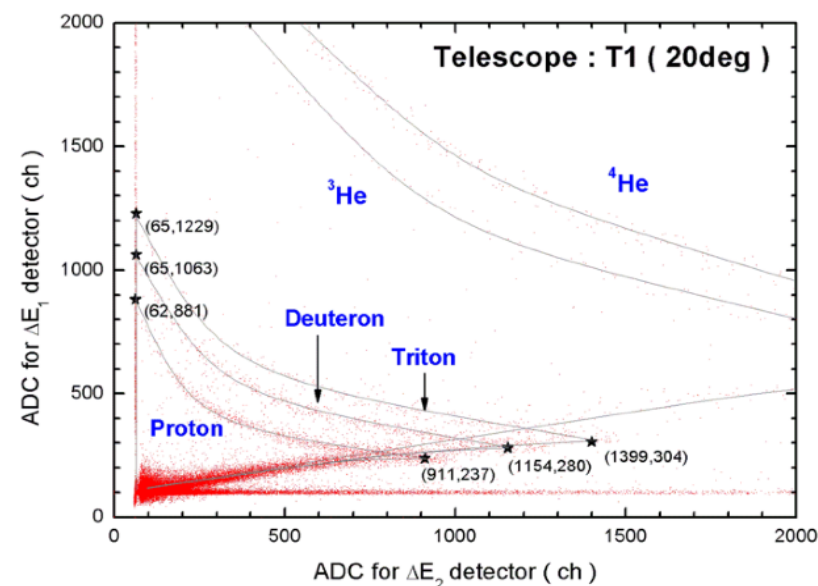
LCP (Light Charged Particle): p, d, t, ^3He , α .



The Medley setup

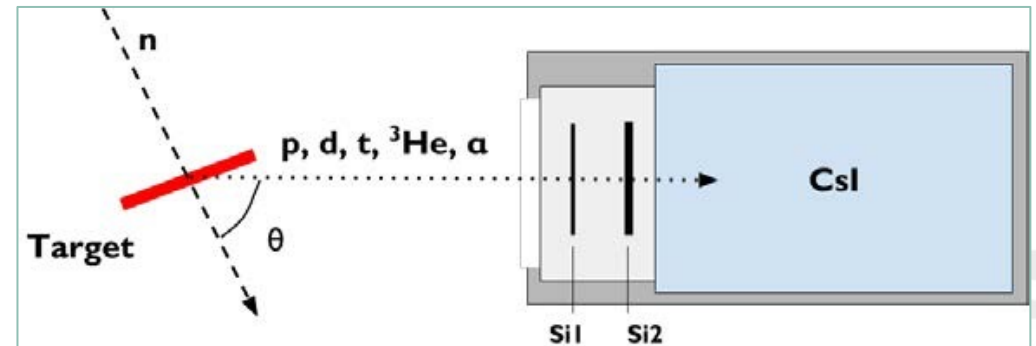
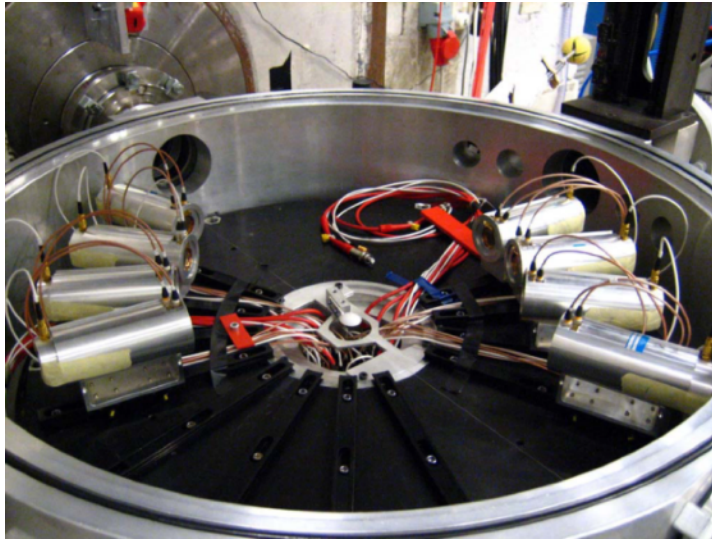


- Telescope with **3 elements (Si-Si-CsI)** for particle identification using **ΔE - ΔE -E**.
- **Able to cover a large dynamic range.**



Figs. from S. Pomp et al., EPJ Web of Conf. 8, 07013 (2010)

The Medley setup



S. Pomp et al., EPJ Web of Conf. 8, 07013 (2010)

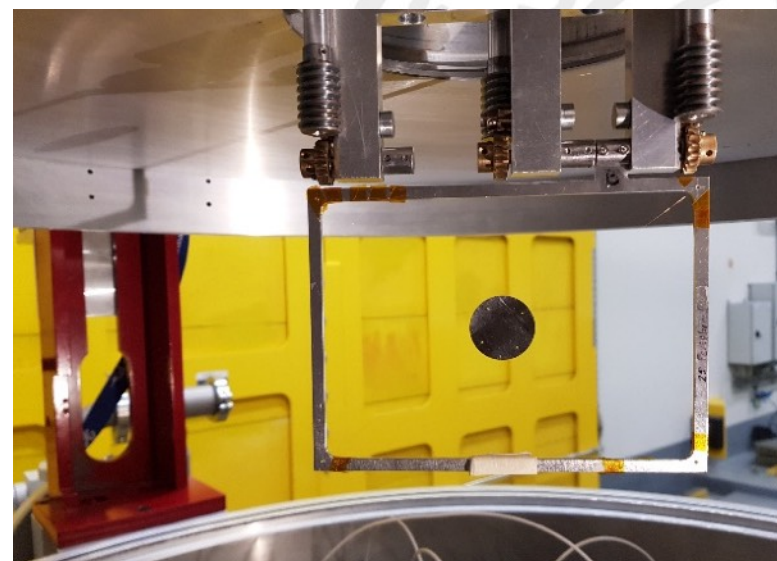
- **Medley**: Reaction chamber with **8 telescopes Si-Si-CsI(TI)** for light-ion identification.
 - **Si1**: 60 μm (ongoing upgrade to 20 μm); **Si2**: 500 - 1000 μm ; **CsI**: 5 cm;
 - ~24 mm in diameter, solid angle ~20 msr/telescope;
- **20° intervals** to measure angular distributions (covering from 20° to 160°). Detectors mounted on a rotatable table to cover forward and backward emission.
- Developed at Uppsala, it has been widely used in the past with the **QMN beam at the old TSL facility** (Uppsala).
- Neutron energy measured by the TOF between Si1 and radiofrequency from LINAC.



Medley at GANIL-NFS

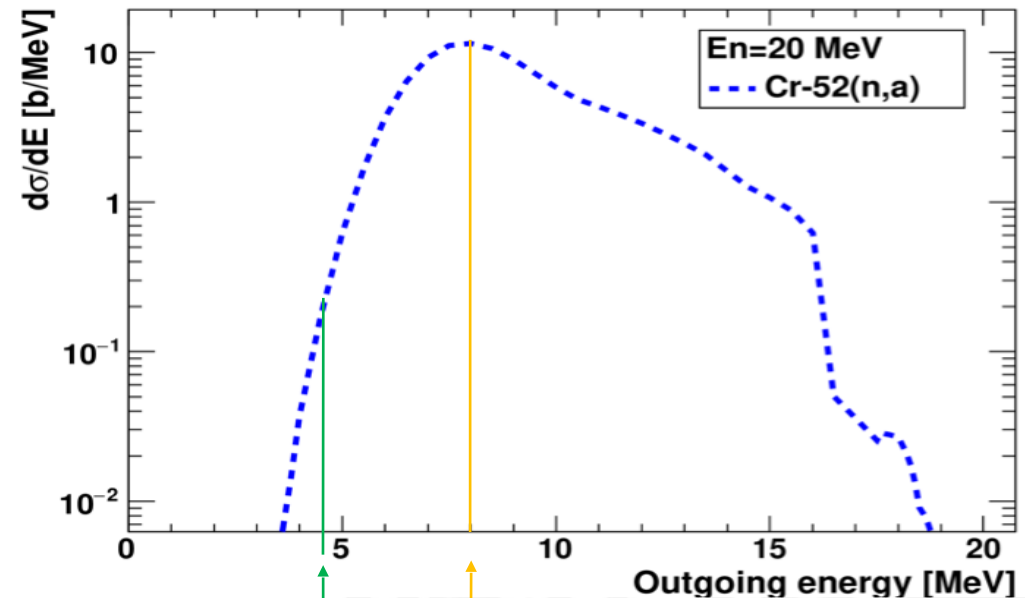


- The Medley chamber installed at the NFS facility.
- At ~5 m from the neutron production target.
- Targets are attached to frames by metallic wires.
- Three targets can be installed in Medley, and interchanged during the experiment without opening the chamber.
- One sample of CH_2 is used to measure the neutron flux using neutron-proton scattering.



Ongoing upgrades on the setup

- Use of “**ultra-thin**” **Silicon detectors in Si1** (20 μm , instead of 50 μm) to reduce the threshold energy for particle identification in ΔE -E.
- The fraction of lost particles will decrease, allowing for a more accurate determination of the cross-section.
- **Preamplifiers** matching the large capacitance of the detectors **are being developed at GANIL**, in close collaboration with the Uppsala group.
- Tested in 2021 campaign. To be used in 2022 campaign.



Threshold energy for identification of α -particles via ΔE - ΔE -E technique:

with current Si:s (50 μm thick)
with planned Si:s (20 μm thick)

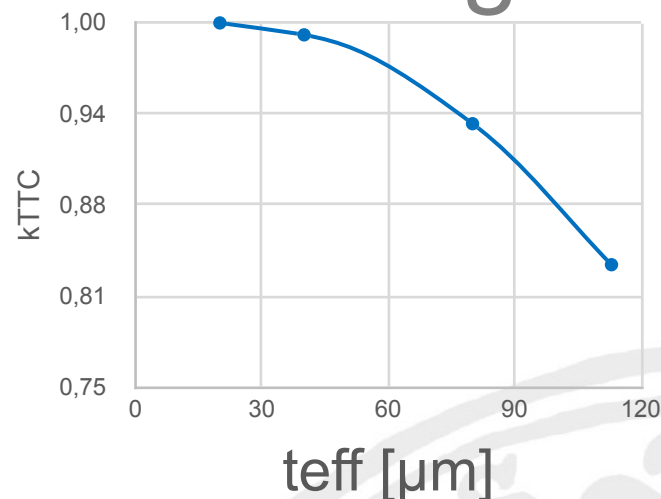
Target thickness

Optimization of Chromium target

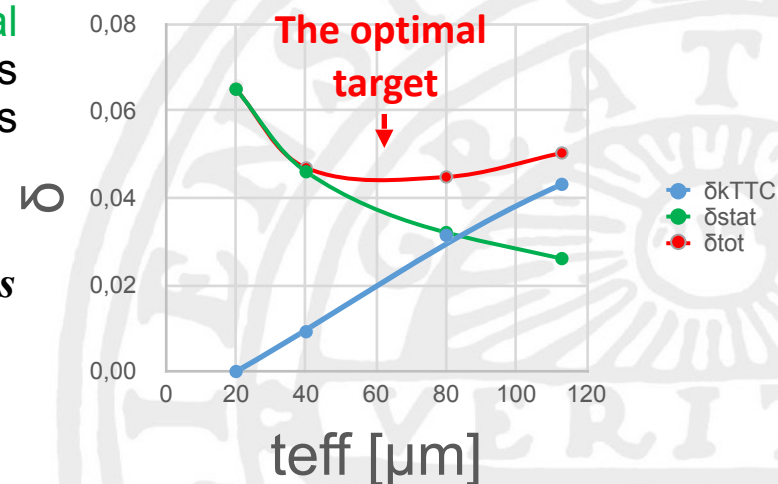
Case:

- natCr target,
18 x 18 mm area*
- Cr(n,xt) reaction
- $E_n = 30 \text{ MeV}$

Thick-target
correction (TTC)
factor as a function
of target thickness



Uncertainty of TTC factor, statistical
uncertainty, and total uncertainty as
functions of target thickness



Conclusions:

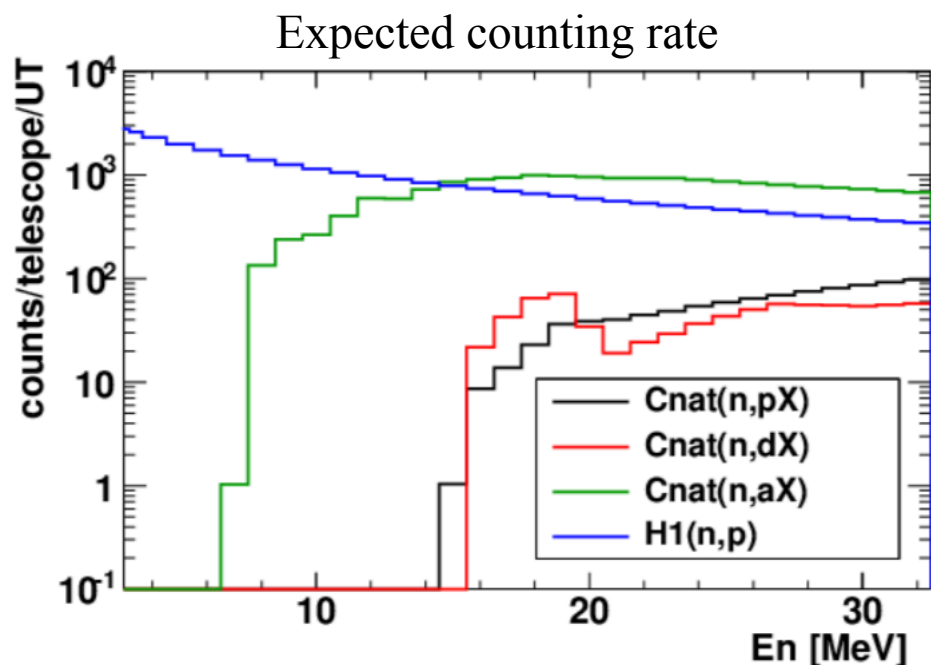
- the optimal Chromium target for triton detection is
~50-70 μm thick*
- alpha-particles will also be detectable
- the manufacturing of the target is feasible

*Available from Goodfellow Corp., on a Polyester backing

Alexander Prokofiev, GANIL PAC meeting, September 2020



About the C experiment

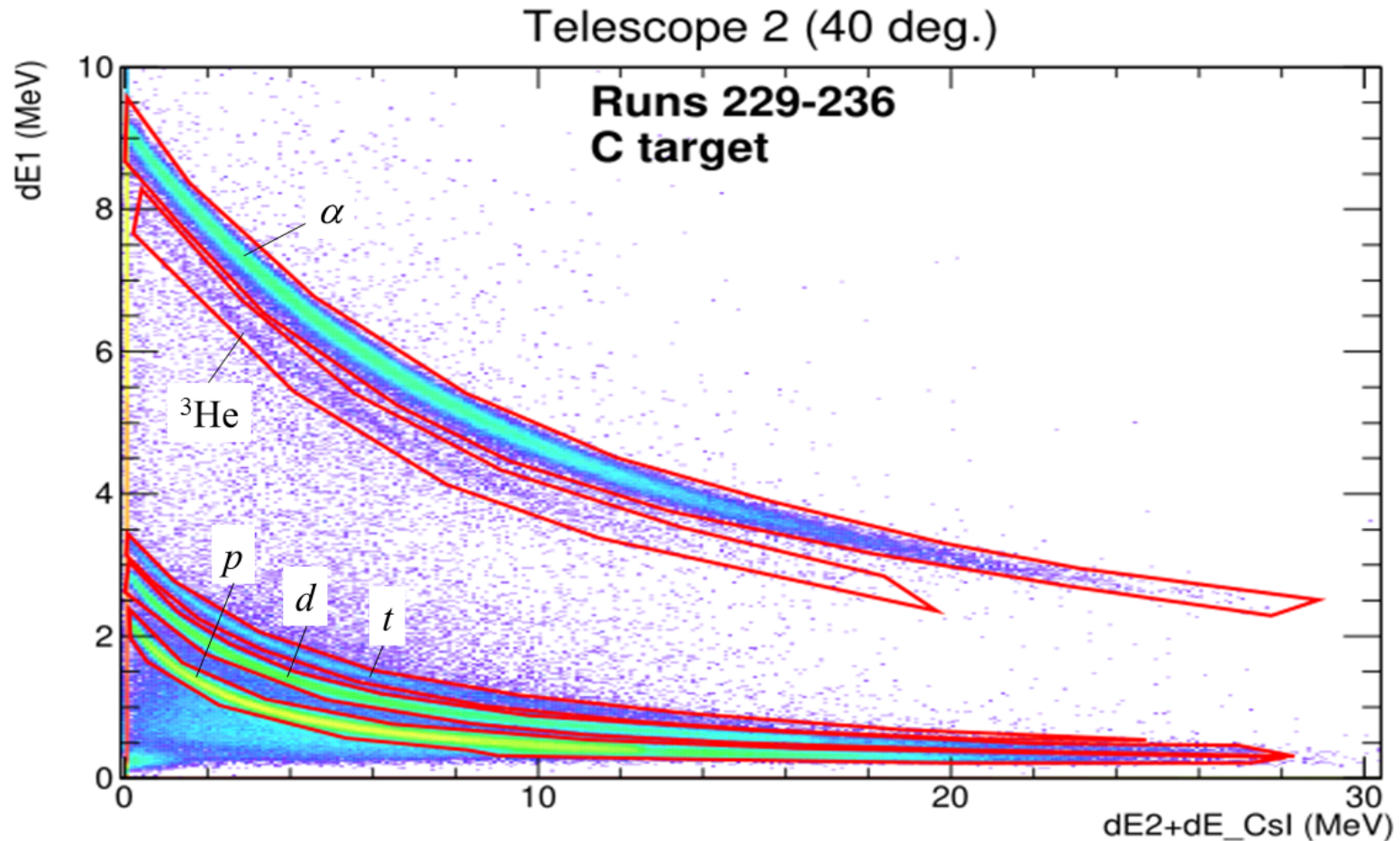


- For the C target (75 μm), during 8 UTs of beam time (1 UT= 8 h):
 - C(n,dX) with statistical uncertainty 4-8% in 1-MeV neutron energy bins.
 - C(n,pX) with statistical uncertainty 4-11% above 15 MeV neutron energy.
 - C(n, α X) has a much larger counting rate.

- Experiment planned for October 2021, but only part of the statistics could be collected, because of a problem with the neutron production target at NFS.
- To be completed next October 2022, together with another experiment on Cr.

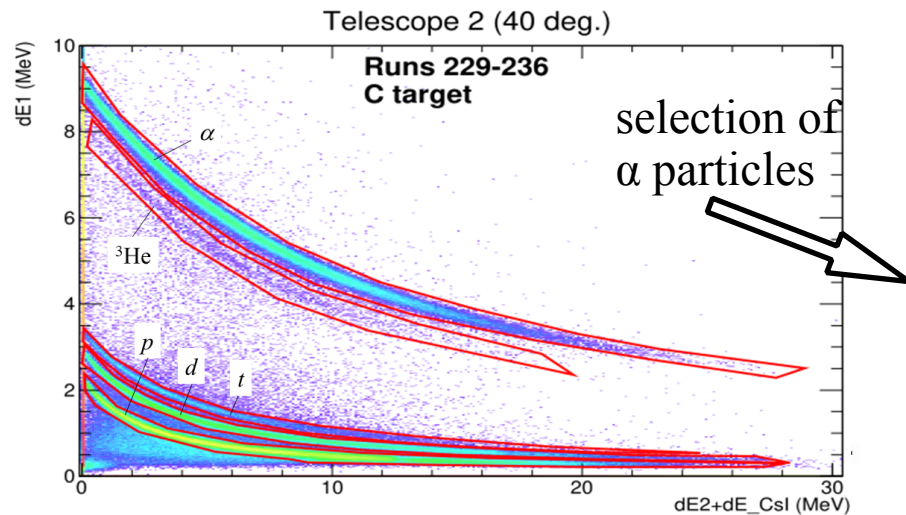
Ongoing data analysis on C experiment

- **First measuring run** at NFS in October 2021: **measurement of C**. Still pending of completing the experimental data taking in October 2022.
- Data analysis ongoing. Plots are **preliminary**.



Ongoing data analysis on C experiment

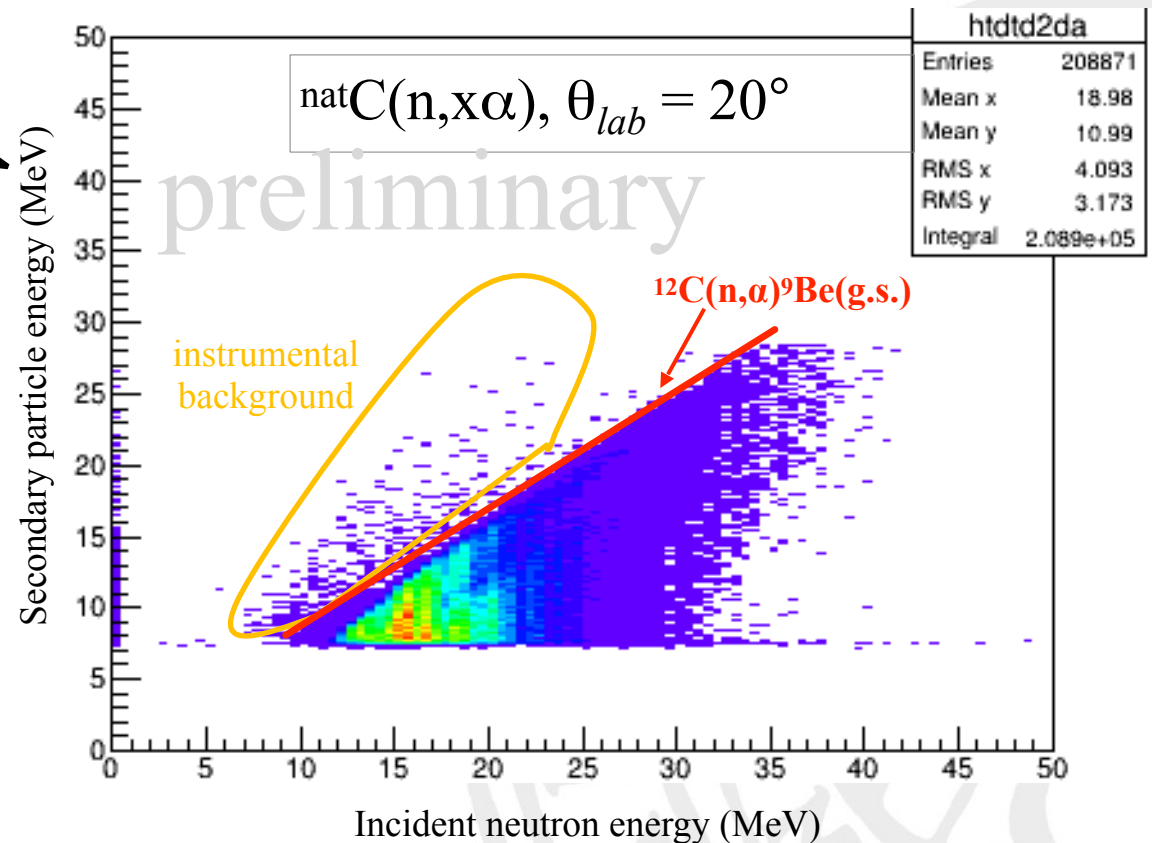
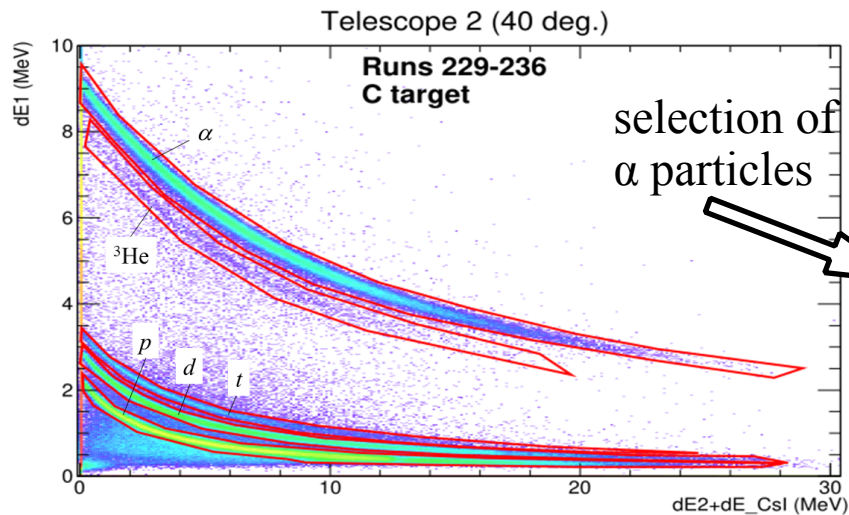
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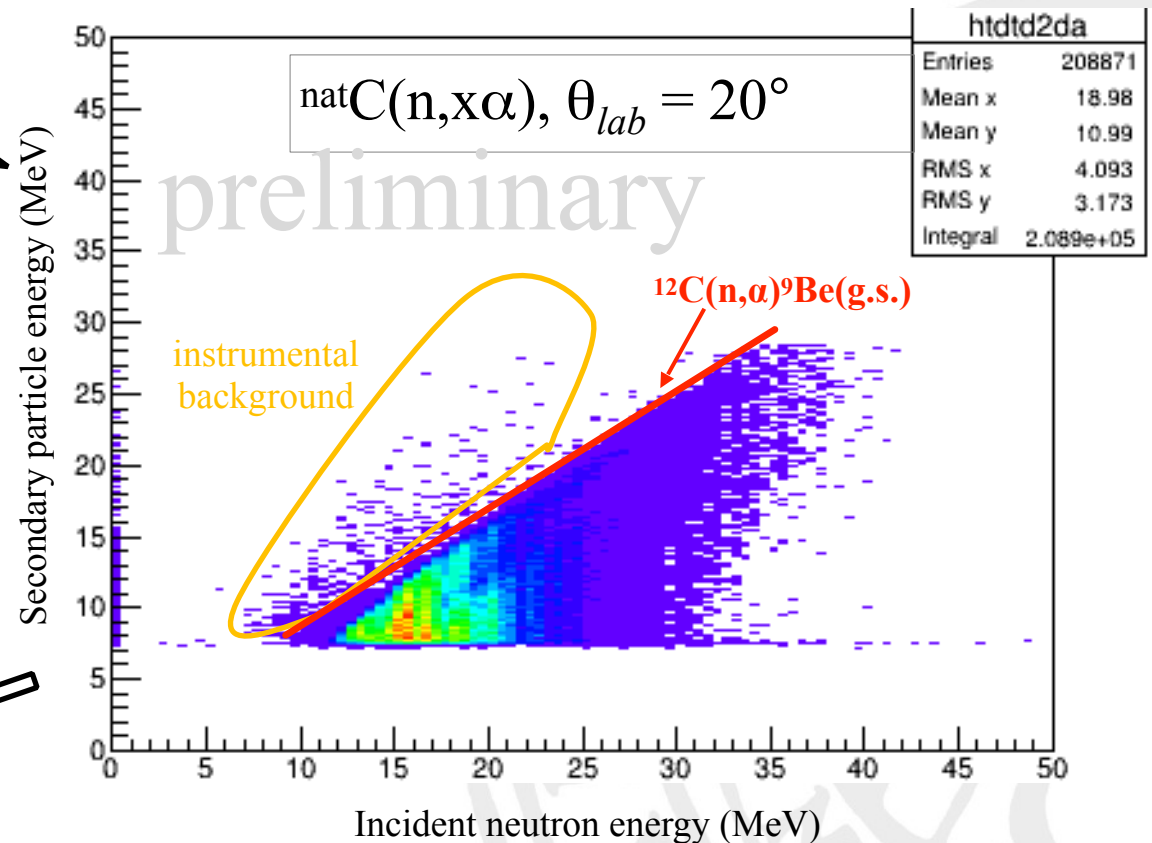
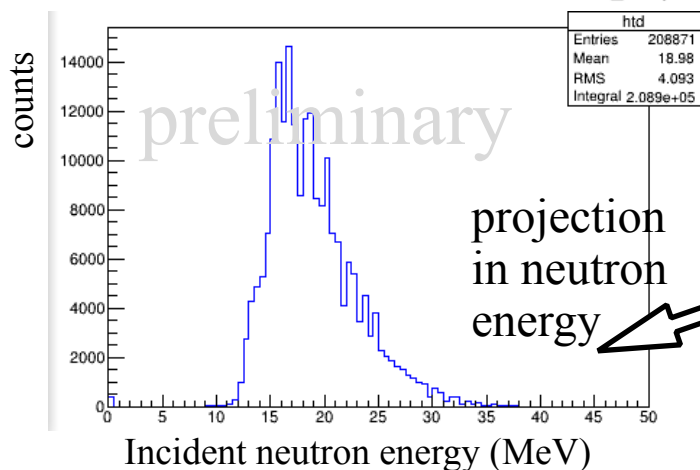
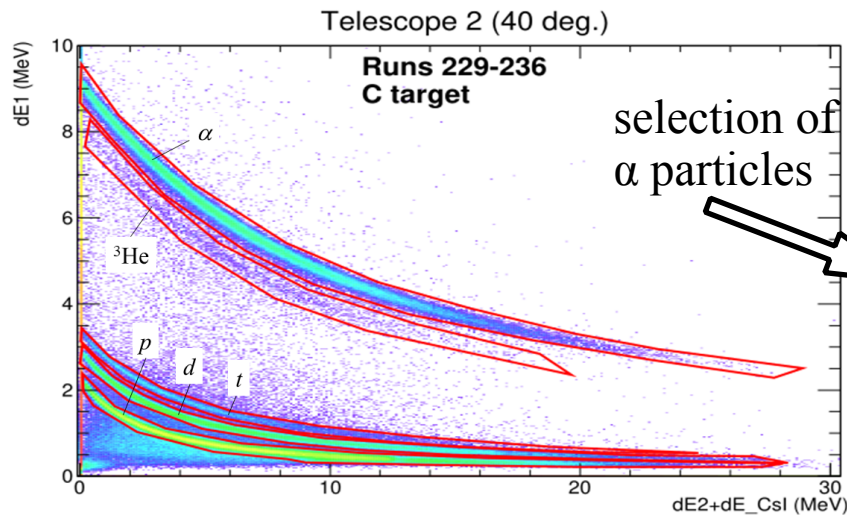
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Our current (n,cp) projects at NFS

I. LIONS (Light ION production Studies with Medley)

- To measure light-ion (p, d, t, ^3He , α) production cross sections in Carbon with neutrons.
- Experiment partially done in 2021. To be completed in Oct. 2022. Analysis ongoing.

II. GARIC (GAs pRoduction In Chromium by neutrons)

- To measure light-ion (p, d, t, ^3He , α) production cross sections in Chromium with neutrons.
- Experiment approved and to be done in Oct. 2022. Partially funded by EUROfusion.

III. Gas production in Iron by neutrons

- To measure light-ion (p, d, t, ^3He , α) production cross sections in Iron with neutrons.
- Proposal under preparation. Pre-study funded by EUROfusion.

- Our group from **Uppsala** is developing a scientific program at **GANIL-NFS** about the **study of (n,LCP) reactions**.
- The **Medley setup**, developed at Uppsala, consists on **3-element telescopes** for **particle identification** using $\Delta E-\Delta E-E$.
 - Being upgraded with thinner Silicons.
- Experiments on **C** and **Cr** are **being done at NFS**.
- A **proposal** to study **Fe** with Medley at NFS is in **preparation** (with funding from **Eurofusion**).
- **Synergies** with the planned program on (n,LCP) at n_TOF are, of course, expected, and participation/collaboration is very welcome!!

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Thank you for your attention!