GT4: Quel est l'apport de la physique nucléaire à la compréhension de l'astrophysique

Short review (Nucleosynthesis) and perspectives

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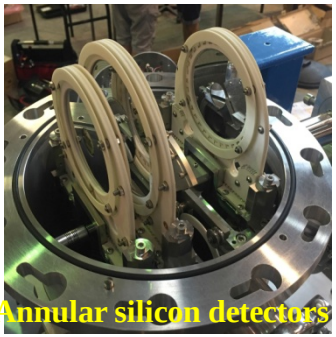
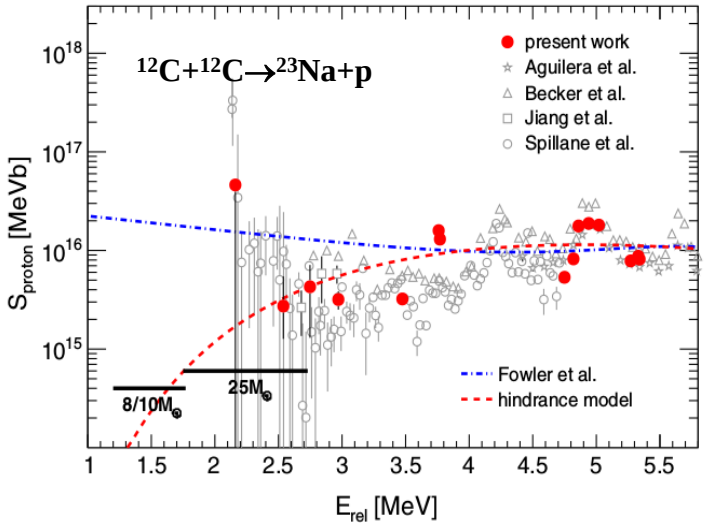
Assemblée générale du GDR RESANET **zoom, 09-10/12/2020**

Some of the open questions that were addressed in the 1st joint meeting GT4-GDR RESANET & OG (Nucleosynthesis) and the achievements since

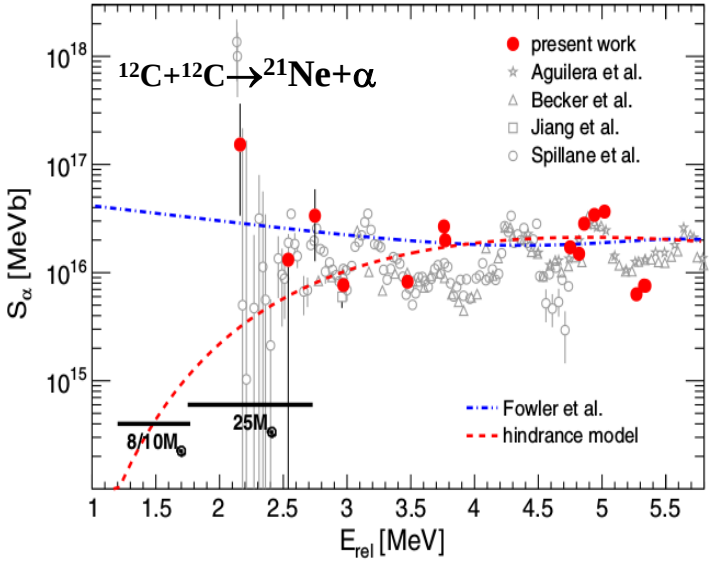
➢ **Carbon burning in massive stars**: Measurements of $^{12}C+^{12}C$ cross-sections using **STELLA** setup @ **Andromède**



Fruet+ PRL2020



→ The present results support strongly the fusion hindrance model @ deep sub-barrier energies for the 23Na+p exit channel



→ The present results support sthe fusion hindrance model @ deep sub-barrier energies for the $^{21}Ne+\alpha$ & exit channel & the presence of a resonance @ 2.14 MeV for the $^{21}Ne+\alpha$ exit channel

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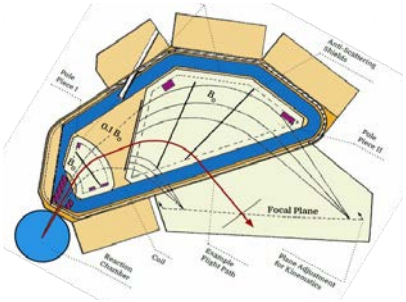
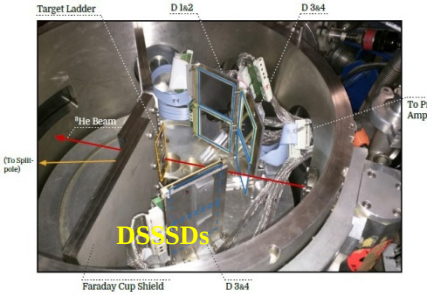
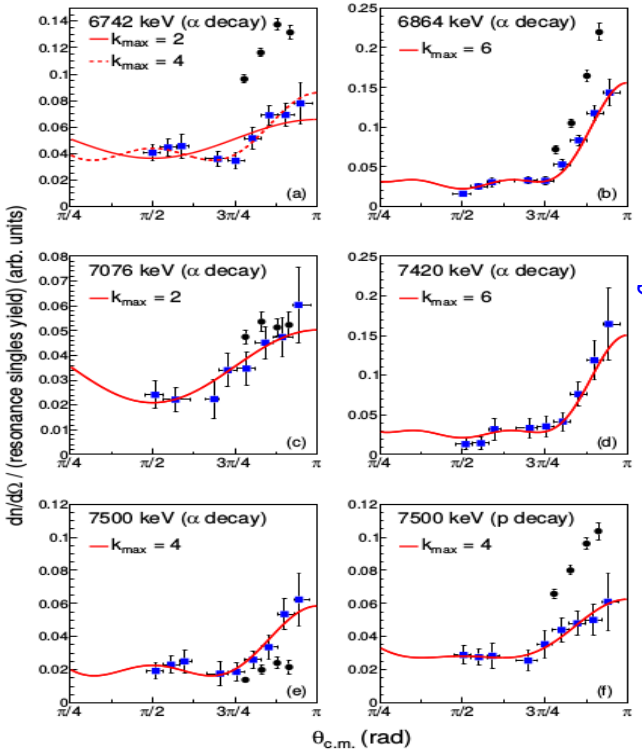
➢ **Classical novae** → The 4 key reactions with significant uncertainties:

- $^{25}Al(p,g)^{26}Si$
- $^{22}Na(p,\gamma)^{23}Mg$ **(Fougères+Thesis , analysis nearly finalyzed, AGATA/SPIDER/VAMOS/GANIL)**
- $^{30}P(p,\gamma)^{31}S$ **(Meyer+Thesis 2020 , SPLIT-POLE/ALTO)**
- **$^{18}F(p,\alpha)^{15}O$**: γ-ray emission ≤ 511 keV **Boulay+Thesis2016(GANIL)** & **Riley+ PRC 2020 (ALTO)**

↳ Studied via $^{19}F(^3He,t)^{19}Ne(p|\alpha)^{18}F|^{15}O$ using **SPLIT-POLE/DSSD/ALTO**







Riley+ PRC 2020

→ Confirmation of spin-parity and α-branching ratios in a single measurement (angular correlation analysis)

→ The role of the sub-threshold resonances to $^{18}F(p,\alpha)^{15}O$ reaction rate is clarified

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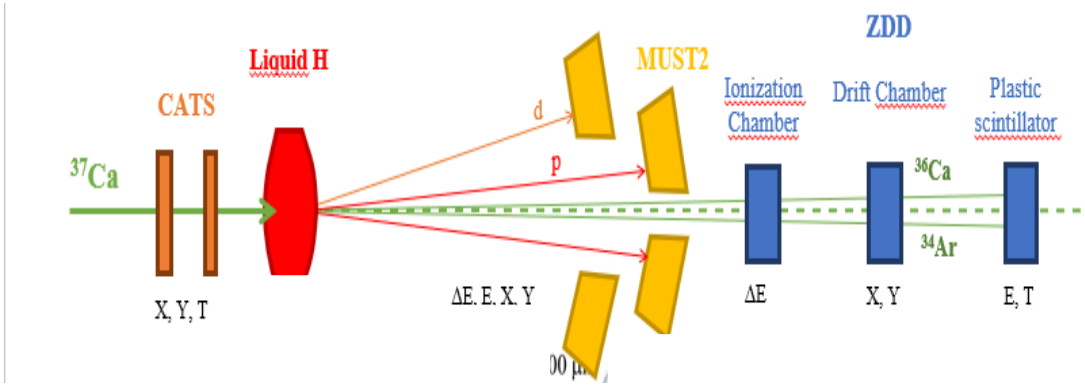
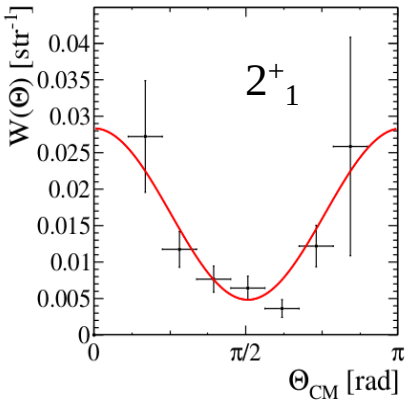
➢ **X-ray bursts Type I**→ Sensitivity studies have shown that only few tens of reactions play an important role.

- $^{15}O(\alpha,\gamma)^{19}Ne$ **Sanchez+ (Ongoing analysis, MUGAST/AGATA/VAMOS/GANIL 2019)**
- $^{35}K(p,\gamma)^{36}Ca$ **Lalanne+ PRC2020 to be submitted** (Hupin-GT1 talk)
  - ↳ Studied via $^{1}H(^{37}Ca,d)^{36}Ca\ (p)^{35}K$ using **MUST2@LISE/GANIL**

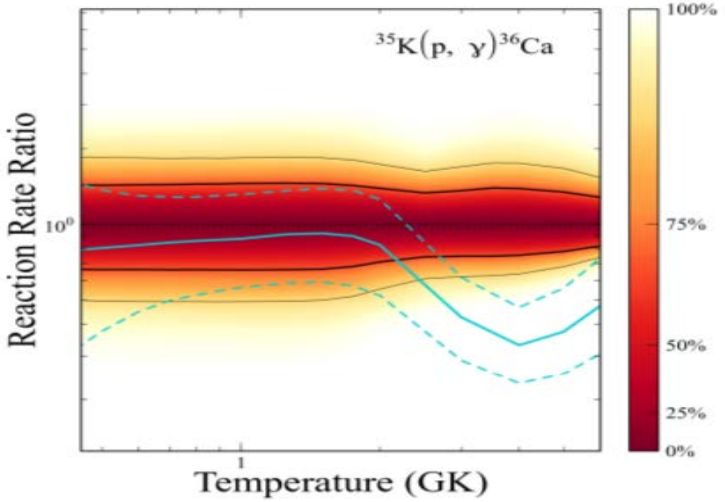




→ New resonances were measured and proton decay branching ratios were determined from the proton angular correlation measurements for the first time

→ The $^{35}K(p,\gamma)^{36}Ca$ reaction rate is now experimentally constrained.

→ $^{35}K(p,\gamma)^{36}Ca$ will not affect the shape of the X-ray bursts' light curve.



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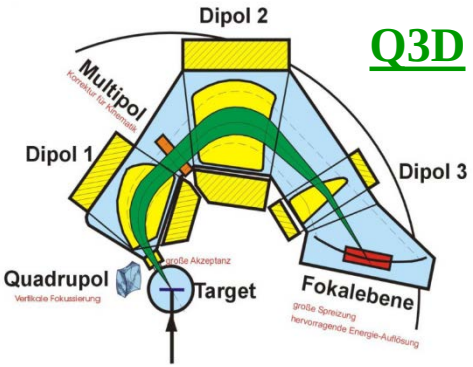
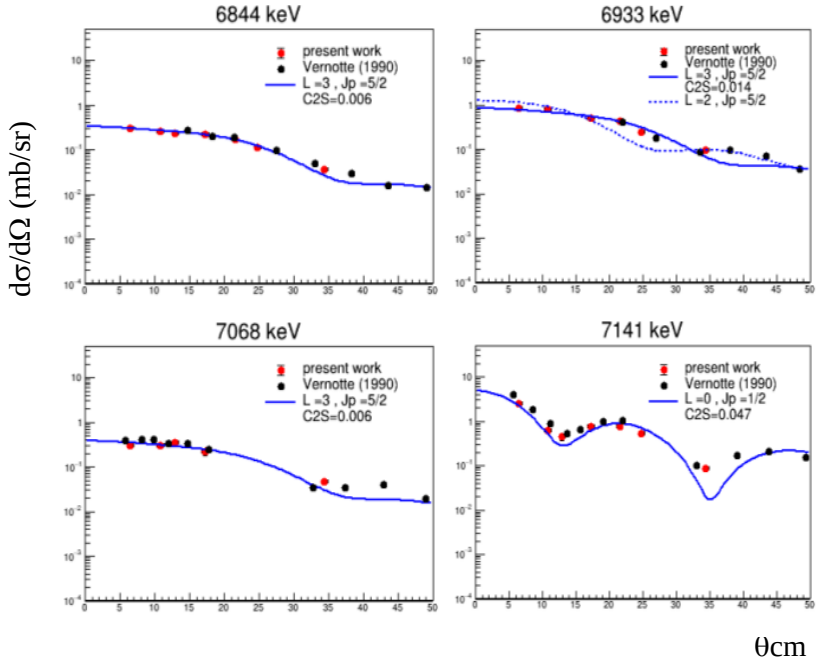
➢ **Globular clusters** → One of the main question in this field is what is the nature of the 1st generation of stars? need to improve the uncertainty of the reaction rate of 4 reactions.

◆ $^{39}K(p,\gamma)^{40}Ca$ **Adsley+(ongoing analysis DRAGON/TRIUMF 2019)**

◆ $^{30}Si(p,\gamma)^{31}P$ **Harrouz+PRC paper in progress**

↳ Studied via $^{30}Si(^{3}He,d)^{31}P$ using **Q3D@MLL**





→ Determination of Γ_p & resonance strengths of key resonances for the first time → constrain the $^{30}Si(p,\gamma)^{31}P$ reaction rate

Workshop organized with F. Hannachi, Orsay 12-13 june 2019 : What are the possibilities of experiments in nuclear astrophysics with lasers?

- **1 day dedicated to talks :**

→ Direct measurements of cross-sections of astrophysical interest: characteristics and challenges (**M. Heine -IPHC**)
→ Les plasmas lasers, description et diagnostic **(J. santos-CELIA**)
→ Accélérateurs d'ions dans l'interaction laser plasma: état de l'art (**F. Hannachi-CENBG**)
→ Détection d'observables nucléaires en milieu laser (**M. Tarisien-CENBG**)

- **1 day dedicated to discussions :**

→ For which kind of measurements the lasers/plasma could be used?
- The electron screening effects
- Nuclear reaction on isomers with short lifetime (>ns) produced by lasers and multi-incident particle reactions with the ultra intense beams accelerated with lasers
- Nuclear Properties in plasma environments

→ The technical difficulties

→ Perspectives: - Calculations of XS, production & detection to evaluate the feasibility
- propose a "already feasible" experiment for the next APOLLON call

Some ideas for GT4 workshops/meetings for the next two years

- A 1 day meeting on "globular clusters nucleosynthesis"

- A 1 day common GT1-GT4 workshop on "how our nuclear physics knowledge at the dripline impact our understanding of nucleosynthesis processes and supernova neutron star matter"

- A 2 days workshop on "X-ray bursts Type I:
  1. Probing neutron star physics using thermonuclear X-ray bursts
  2. Nucleosynthesis: is an experimental program at GANIL/SPIRAL1 really possible?"

- A 1 day workshop on r-process (experiments, theory & modeling)

- A 1 day workshop on p-process (experiments, theory & modeling)

- A joint RESANET-OG-GDRs workshop

Any other ideas of actions are welcome