ChETEC-INFRA 2° General Assembly
Padova & Online: May 31, June 1 2022

WP 8 HIGHLIGHTS

"Progress report on helium carbon and neutron capture reactions»

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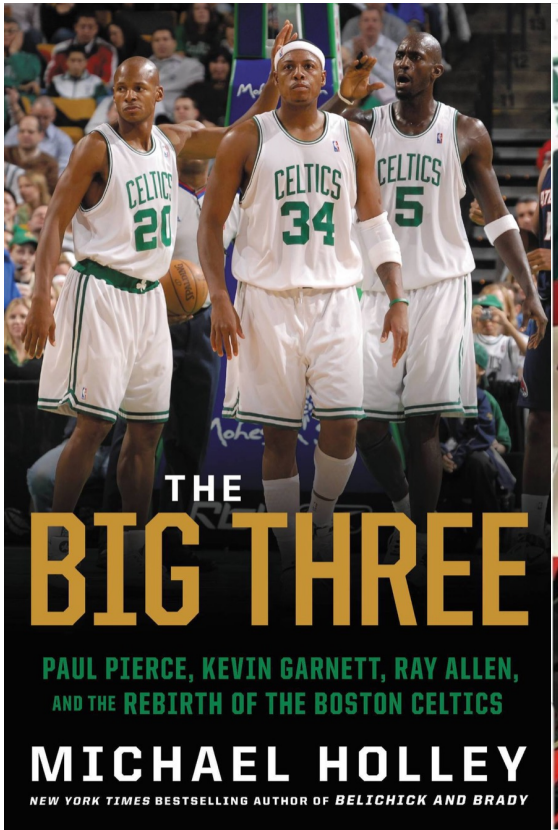
Our Big-Three

^{12}C(α,γ)
^{12}C+^{12}C
^{22}Ne(α,n)



I will share my slot with Tanja Heftrich who will report on the status of the server in Frankfurt and on the (neutron) database ASTRAL

D8.3 Report to GA on plans for two workshops to discuss complementary reaction studies
D8.7 Key publication with description of methods and results for analysis of Big Three reactions

Where we are with the deliverables

First workshop organized last April in Rome
Second workshop … it might be in December at ECT* … but it has to be discussed
…

Topical meeting of IReNA - FA1 and ChETEC-INFRA
Nuclear reaction measurements in **Underground Laboratories**

April 5-8, 2022 - Rome Global Gateway, Rome, IT

Welcome

The Focus Area 1 (FA1) of the International Research Network for Nuclear Astrophysics (IReNA) is concerned with the determination of nuclear reaction rates of critical astrophysical importance in the laboratory using a broad range of experimental approaches, including heavy ion storage rings, deep underground laboratories, intense photon beams, neutron beams, and recoil separators at stable and rare isotope accelerator facilities.

Within FA1 topical meetings will be organized. The first edition is organized jointly between IReNA and the European network activity ChETEC-INFRA. It will take place April 5-8, 2022 at the Rome Global Gateway of the University of Notre Dame located in the center of Rome, IT.

The intention of this topical workshop is to collect information, discover possible synergies and synchronize future activities at different underground laboratories in Europe and the United States. The format of the workshop allows for few overview presentations on key topics in the morning sessions and intensive discussions during afternoon breakout sessions. The goal of the workshop is a road-map for the next 1-2 decades outlining the experimental program in the underground laboratories.

Program – in short

Monday (April-4, 2022)
Arrival
Tuesday (April-5, 2022)
Hydrogen burning
Wednesday (April-6, 2022)
Helium burning
Thursday (April-7, 2022)
Carbon burning
Friday (April-8, 2022)
Neutron sources

Organizing Committees:

•Local: Gianluca Imbriani (INFN Naples), Alba Formicola (INFN Rome), Aurora Tumino (INFN Catania), Anna Ricigliano (Rome Gateway)

•International: Zach Meisel (Ohio), Rene Reifarth (Goethe-Frankfurt), Michael Wiescher (Notre Dame), Janet Weikel (Notre Dame), Daniel Bemmerer (Dreden)

Very successful meeting in hybrid approach, covering the topics around the Big-three reactions with talks and intensive discussion. About 70 participants, 20% online

From Helium Burning Discussion [Focus on $^{12}C(\alpha,\gamma)$]

- What uncertainty do we need for 12C(a,g)?

15% for core & shell he-burning - as compared to existing 20% uncertainty for these temperatures
15% is the minimum needed, 10% would be "the last word"

- What measurements do we need to do?

Only E1 cross section direct measurements are consistent with each other. Everything else needs improved.
Any direct measurement of 12C+4He (gamma or recoil or both) able to compete with the 16N data on the reduced width of the subthreshold 1-state,
16N(beta-alpha) new data - Argonne results were limited by available beam-time.
R-matrix: ERNA data & ANCs from alpha-transfer data have a dominant role in the fit.
Direct low-energy measurements are extremely important because of uncertainties in the extrapolation.

- What theory calculations are needed?

Bayesian optimization
Timeline for ab-initio is ~5-7yrs from now
Value of alpha-cluster calculations?

- What are some other "holy grail"s of helium burning?

Triple-alpha: 10% in 100-400MK region …but what about uncertainty from screening?

…

From **Carbon Burning Discussion [Focus on $^{12}C+^{12}C$]**

- Recent direct measurements are not consistent in all energy ranges, why?

Gamma angular distribution: isotropic assumption is not granted
Angular distribution effect arising from the different angular coverages in experiments.
Broadening by Doppler shift
In many of the direct measurements, the integrated yield across the target is reported which isn't the same as the cross section.

- How low in energy can go direct measurements?

STELLA and LUNA-MV should be able to go below 2 MeV, in particular for the gamma-rays experiment, at LNGS you can get more than 4 orders of magnitude less environmental background.

-For high-density environments (e.g. neutron star envelopes), how well do we understand screening effects?

-THM results: new experimental deuteron angular distributions. Good agreement with DWBA calculations in the experimental range.

-The hindrance is proposed as a global model. If hindrance exists in 12C+12C, it must appear in the carbon isotope system. The 12C+13C measurement rules out the hindrance prediction while confirming other models.

From **Neutron Sources Discussion [Focus on ^{13}C(α,n) and +^{22}Ne(α,n)]**

^{13}C(α,n) Recent direct measurements are consistent, further, they are consistent with THM and ANC measurements.

New measurements are planned at both JUNA and LUNA MV. JUNA aims for measurements as low as 200 keV. JUNA also plans for higher precision, higher energy measurements.

However, very close to a consensus rate!

^{22}Ne(α,n) still largely unknown. Several evaluations of the reaction rate exist, based on theoretical calculations. No direct measurements at the relevant energies, many spectroscopy studies of the levels involved.

A claim that needs to be debated and confirmed: the neutron strength is equal to the gamma strength.

Recent revaluation of the 22Ne(a,n) reaction rate: substantially decreased due to updated nuclear data. This results in significant changes to the nucleosynthesis in the weak branch of the s-process.

Thank you for your attention!