LUNA NEWSLETTER

LABORATORY FOR UNDERGROUND NUCLEAR ASTROPHYSICS

Some LUNA Members at the latest LUNA GM in Budapest, January 2019

A Note From the Spokesperson

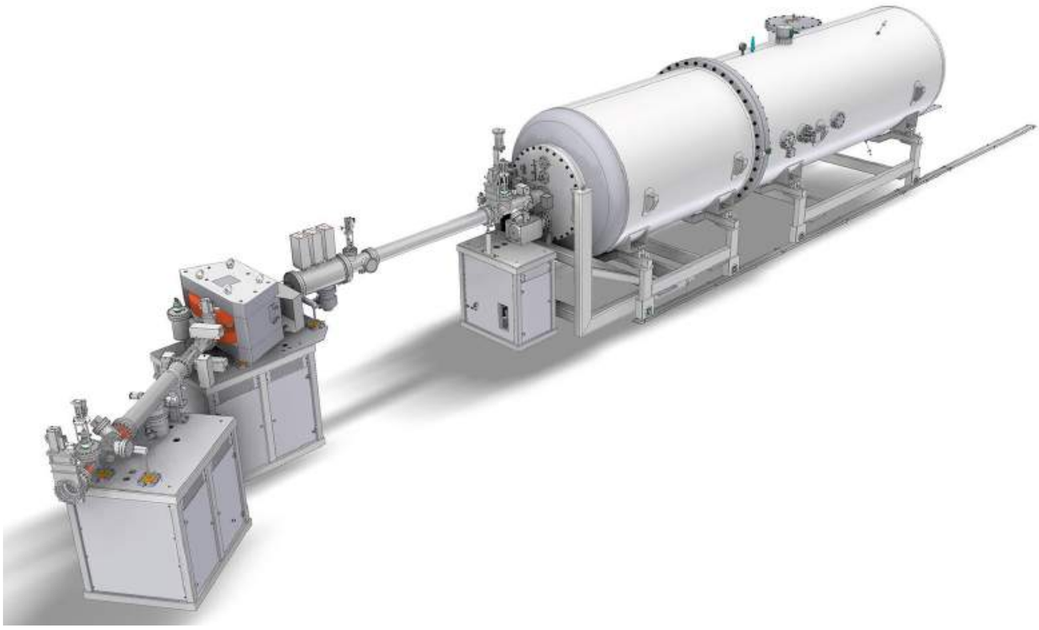
BY PAOLO PRATI

Greetings from LUNA and welcome to the third issue of this newsletter! The year 2018 was rich of events. The new LUNA-MV accelerator has been recently assembled at the manufacturer site and will soon undergo its testing phase. The works for its installation deep underground at Gran Sasso have started as well: the structure of the new accelerator room is basically finished and the installation of related plants will be completed in the coming months. The work was intense at the 400 kV accelerator too with a set of experiments devoted to important processes as $^{13}C(\alpha,n)^{16}O$; $^{22}Ne(\alpha,\gamma)^{26}Mg$ and $^{2}H(p,\gamma)^{3}He$. Preliminary updates on some of these are reported in the newsletter even if data analysis is still underway. Time and efforts have been also devoted to technological upgrades of the historical LUNA laboratory. Finally, some of the young researchers of the LUNA Collaboration have made important steps forward in their career: to all of them warm congratulations! I hope you'll enjoy this newsletter!

NEWS FROM THE LABORATORY

Updates on LUNA-MV

BY GIANLUCA IMBRIANI



*3D-CAD layout of the LUNA-MV Singletron system (**Sen et al. NIMB (2018)**)*

The Laboratori Nazionali del Gran Sasso (INFN) and the LUNA collaboration are working to finalise the installation of a new accelerator, LUNA-MV, by the end of 2019 or the beginning of 2020. The accelerator, to be installed in the North part of Hall-B at LNGS, is a high-current, light-ion 3.5 MV single-ended machine, developed by High Voltage Engineering (HVE) to meet the stringent requirements on beam intensity and stability of the LUNA-MV project. The accelerator is equipped with a 10 GHz ECR ion source designed to provide intense beams of H^+ (~1 mA), $^4He^+$, $^{12}C^+$ and $^{12}C^{2+}$. The machine ensures energy stability below 10^{-5}, terminal voltage ripple of 1.5×10^{-5} and uninterrupted operations time greater than 24 h. The in-line Singletron™ accelerator tube has a special voltage gradient design to allow high current beam transport with minimal transmission losses over the entire terminal voltage range of 300 kV–3.5 MV (**https://doi.org/10.1016/j.nimb.2018.09.016**). The accelerator is presently under testing at the HVE factory in Amersfoort (The Netherlands).

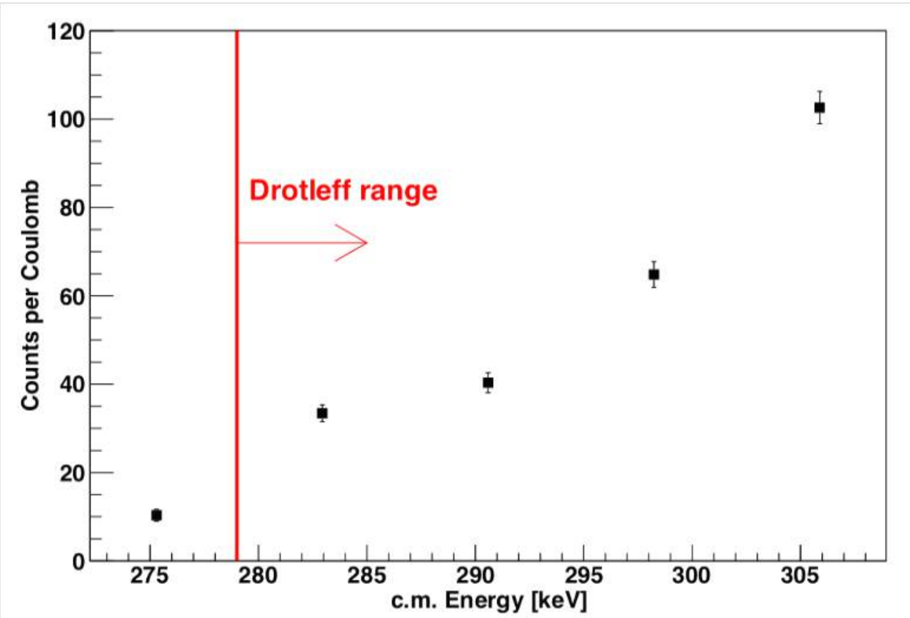
While work on the accelerator is in progress at HVE, INFN is committed to prepare all the other parts of the new facility i.e. a shielded room for the accelerator and two beam lines, an underground building to host the control room and other technical services, all the technological plants. The building has been entirely designed by the LNGS technical division and is mostly finished, while all the technological plants for the LUNA-MV facility have been initially defined by the LNGS technical division and then detailed in the final and constructive design by an external company (STAIN srl), selected through a public tender. Given the particular location of the future LUNA-MV facility, a Quantitative Risk Analysis and an Analysis of the Environmental Impact of the installation have also been carried out.

A New Investigation of the Neutron Source Reaction $^{13}C(\alpha,n)^{16}O$

BY ANDREAS BEST AND GIOVANNI CIANI

The $^{13}C(\alpha,n)^{16}O$ reaction is the major neutron source for the synthesis of heavy elements through the slow neutron capture process. In low-mass AGB stars, the temperature of interest is around 100–200 MK, which translates into an effective energy range, the Gamow window, between approximately 140 and 230 keV. The reaction has been the object of intense investigation over the past few decades with both direct and indirect approaches. However, open questions remain on its absolute cross section and its extrapolation into the Gamow window, especially because of the hitherto unclear influence of a near-threshold state in ^{17}O.

At the LUNA 400kV accelerator, we have measured the $^{13}C(\alpha,n)^{16}O$ reaction cross section down to the lowest energy measured to date, by exploiting the strongly suppressed neutron background deep underground. The experimental setup is shown in the picture. It includes a purpose-built high-efficiency neutron detector array consisting of ultra-low intrinsic background ^{3}He-counters embedded in a block of polyethylene surrounding a ^{13}C-enriched target. To further suppress the background, a novel pulse-shape discrimination analysis of the signals from the counters has also been developed [1].



Our preliminary results, shown in the figure, go beyond the current state-of-the-art both in terms of lowest energy ever achieved by a direct measurement (see previous limit established by Drotleff et al [2]) and highest precision obtained (here about 10%, compared to uncertainties of up to 50% or higher for data points below 400 keV in previous measurements). Data analysis is ongoing, and we are preparing for a final beam time in 2019, pushing the energy limit even further down.

PUBLICATIONS

[1] J Balibrea et al. NIM A 906 (2018) 103
[2] Drotleff et al. APJ 414 (1993) 735

The ^{22}Ne(a,γ)^{26}Mg reaction

BY ANTONIO CACIOLLI

The ^{22}Ne(α,γ)^{26}Mg reaction (Q-value = 10.6 MeV) is a competitor to the ^{22}Ne(α,n)^{25}Mg neutron source for the astrophysical s-process. In the energy range of LUNA400, only ^{22}Ne(α,γ)^{26}Mg is energetically accessible: the ^{22}Ne(α,n)^{25}Mg channel opens only above the reaction threshold of E_α > 564 keV. The study of ^{22}Ne(α,n)^{25}Mg is part of the LUNA-MV science program. There is a possible resonance in ^{22}Ne(α,γ)^{26}Mg at E_α = 395 keV, which is presently only constrained by indirect data, with reported upper limits in the 10^{-9} - 10^{-15} eV range. If confirmed at the 10^{-9} eV level, the 395 keV resonance would effectively shut down the ^{22}Ne(α,n)^{25}Mg neutron source for temperatures below 300 MK, affecting a wide range of astrophysical s-process scenarios.
Using an enriched ^{22}Ne gas target and the experimental setup from the ^{22}Ne(p,γ)^{23}Na experiment with the 4π BGO, an attempt has been made to improve our knowledge of this resonance. A preliminary analysis of initial data shows no additional beam-induced background, confirming the sensitivity of the setup, and no resonance signal. A new shielding of borated polyethylene was added to the setup in April 2018 and preliminary tests show a further background reduction due to neutron suppression around the region of interest for the ^{22}Ne(α,γ)^{26}Mg. Data taking will be completed in spring 2019 and the data analysis is planned to close by the end of 2019.

Figure. Setup under construction without shielding (left panel) and with shield (right panel) during alignment.

RECENTLY PUBLISHED

The ^{22}Ne(p,γ)^{23}Na Reaction

BY ANTONIO CACIOLLI

The ^{22}Ne(p,γ)^{23}Na reaction takes place as part of the neon-sodium cycle of hydrogen burning, and may explain the observed anti-correlation between sodium and oxygen abundances in globular cluster stars. In a previous study performed at LUNA, three resonances at E_p = 156.2, 189.5, and 259.7 keV had recently been observed and later confirmed by another collaboration. In a renewed study at LUNA, we have re-measured those three resonance strengths with improved uncertainties and, in addition, we have further pushed the detection limits on two putative resonances down to negligible strength values for astrophysics.
Thanks to the very high efficiency of the present 4π-BGO setup [1], we have been able to directly measure the direct capture component of the cross section for the first time at such low energies and to establish a new updated thermonuclear reaction rate with unprecedented precision [3].

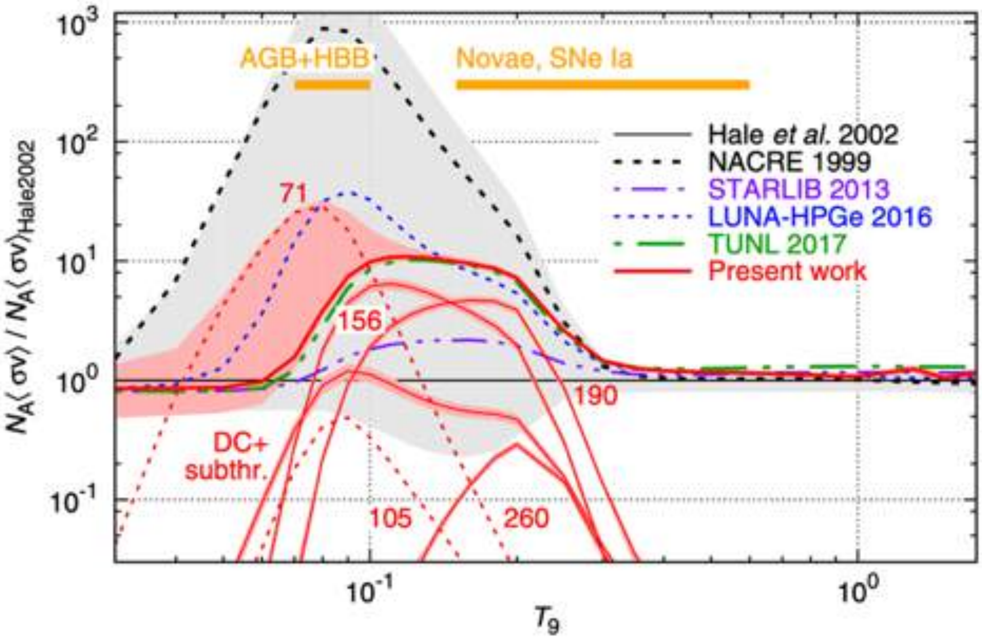


Figure: Thermonuclear reaction rate for the $^{22}Ne(p,\gamma)^{23}Na$ reaction from previous evaluations and from previous experiments and the present work [3], normalised to the rate of Hale et al. [2].

REFERENCES AND PUBLICATIONS

[1] F Ferraro et al., EPJA 54 (2018) 44

[2] Hale et al., PRC 65 (2001) 015801

[3] F. Ferraro et al., PRL 121 (2018) 172701

Hydrogen Burning and the $^{18}O(p,\alpha)^{15}N$ reaction

BY CARLO BRUNO

The $^{18}O(p,\alpha)^{15}N$ reaction influences the abundance of ^{15}N, ^{18}O and ^{19}F isotopes [1] critical to constrain a wide variety of stellar models. For example the O isotopic ratios observed in asymptotic giant branch (AGB) stars of different masses [2] can be used to probe the nucleosynthesis and mixing in these stars. Furthermore, the $^{18}O/^{16}O$ abundance ratio is critical [3] in classifying stardust oxide and silicate grains that originally condensed in AGB stars, novae and supernovae and can be found preserved in meteorites.

At energies of astrophysical interest, the reaction rate of the $^{18}O(p,\alpha)^{15}N$ reaction (Q-value=3.98 MeV) is dominated by a complex interference pattern involving three resonances at approximately E_p=151, 600 and 800 keV having the same spin-parity $J^{\pi}=1/2^{+}$. Tensions between datasets have been reported [4] at relevant energies below 1 MeV. A direct measurement at or close to energies of astrophysical interest is especially challenging because of the low cross-sections involved (< 1 nb). An experimental campaign aimed at measuring the cross-section of the $^{18}O(p,\alpha)^{15}N$ reaction in the energy range E_p=60-360 keV has recently been completed at the LUNA-400 accelerator using the same reaction chamber successfully employed for the investigation of the $^{17}O(p,\alpha)^{14}N$ reaction [5,6] show in the figure. Cross-sections lower than 1 pb/sr were measured at E_p=60 keV. A multi-channel R-matrix analysis of our and other data available in the literature was performed. Over a wide temperature range, T = 0.01 – 1.00 GK, our new astrophysical rate is both more accurate and precise than recent evaluations.

Stronger constraints can now be placed on the physical processes controlling nucleosynthesis in AGB stars with interesting consequences on the abundance of ^{18}O in these stars and in stardust grains, specifically on the production sites of oxygen-rich Group II grains. Results from our measurement at LUNA have just been published [7].

REFERENCES AND PUBLICATIONS

[1] M. Lugaro *et al.*, Astrophys. J. **615**, 934 (2004)
[2] C. Abia *et al.*, Astron. and Astrophys. **599**, A39 (2017)
[3] M. Lugaro *et al.*, Nature Astronomy **1**, 0027 (2017)
[4] M. La Cognata, et al., Astrophys. J. **723**, 1512 (2010)
[5] C.G. Bruno *et al.*, Eur. Phys. J. A **51**, 94 (2015)
[6] C.G. Bruno *et al.*, Phys. Rev. Lett. **117**, 142502 (2016)
[7] C.G. Bruno *et al.*, Phys. Lett. B. (2019) in press (**https://doi.org/10.1016/j.physletb.2019.01.017**)

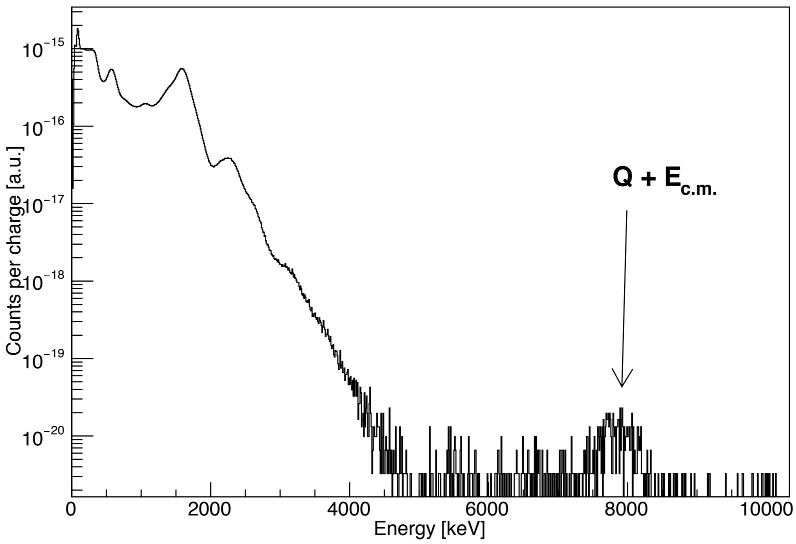
BRIEF UPDATES

Hydrogen Burning and the $^{18}O(p,\gamma)^{19}F$ reaction

BY GIANLUCA IMBRIANI

The observation of oxygen isotopes in the atmospheres of giant stars sheds light on mixing processes operating in their interiors. Because of the very strong correlation between nuclear burning and mixing processes, it is important to reduce the uncertainty on the cross sections of the nuclear reactions involved.

At LUNA, many reactions related to hydrogen shell-burning have been measured over the last few years, including a recent determination of the $^{18}O(p,\gamma)^{19}F$ reaction cross section. While the $^{18}O(p,\alpha)^{15}N$ channel is thought to be dominant, the (p,γ) channel can still be an important component in stellar burning in giants, depending on its cross section at low energies. So far only extrapolations from higher-energy measurements existed and recent estimates varied by orders of magnitude. Such large uncertainties have called for an experimental reinvestigation of this reaction. To directly reach the lowest energy to date, we measured the $^{18}O(p,\gamma)^{19}F$ cross section (Q = 7993.6 keV) using a high-efficiency 4π–BGO summing detector. Both the low-energy direct capture and the resonant contributions were determined directly for the first time down to 85 keV. The figure shows a sum-energy spectrum for the 90 keV (E_p = 95 keV) resonance clearly showing a gamma-ray peak at the expected position. Results from this measurements have recently been submitted for publication [1].



PUBLICATIONS

[1] A. Best et al. (2019) under review

Hydrogen Burning and the ^{23}Na(p,γ)^{24}Mg reaction

BY GIANLUCA IMBRIANI

The ^{23}Na(p,γ)^{24}Mg reaction links the NeNa and the MgAl cycles in hydrogen burning. It plays a significant role in the Asymptotic Giant Branch (AGB) phase of stellar evolution, in particular for massive and super-massive AGB stars which experience Hot Bottom Burning.
At temperatures of $50 < T < 110$ MK, narrow resonances at E_p = 140 and 251 keV are the main contributors to the reaction rate, in addition to the direct capture, which dominates in the lower part of the temperature range.
We have measured the cross section of this reaction using two complementary approaches: a high-efficiency measurement of the 140 keV resonance with a 4π BGO detector, and high-resolution study of the 251 keV resonance with an HPGe detector. Thanks to the reduced cosmic ray background at LUNA, we were able to observe, for the first time in a direct measurement, a signal from the 140 keV resonance, to determine the resonance strength of the 251 keV resonance and to observe new gamma-ray transitions for the decay of the corresponding state in ^{24}Mg at E_X = 11931 keV. A significant reduction in the uncertainty of the reaction rate for the temperature window of interest has been obtained, which is expected to play an important role in the nucleosynthesis of massive-AGB and super-AGB stars. Results from the recently completed data analysis will be published soon.

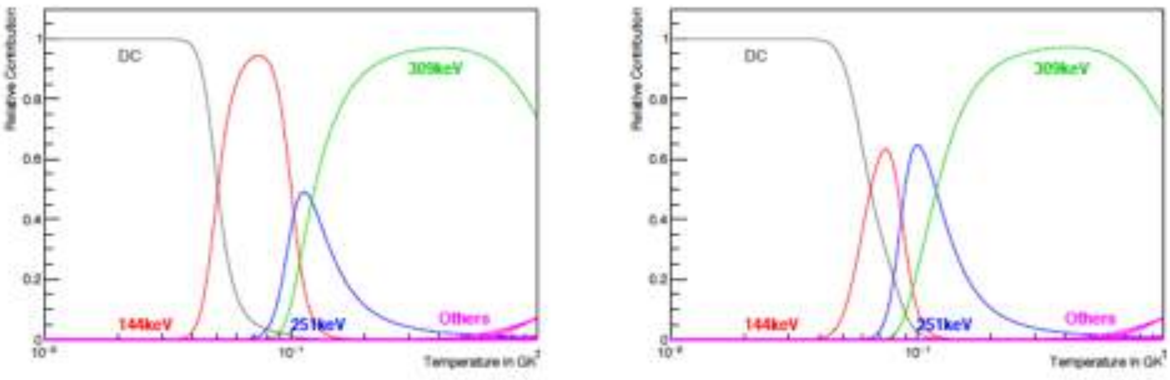


Figure. Direct capture (DC) and resonant fractional contributions to the reaction rate as a function of temperature, assuming an upper limit for the 144 keV resonance strength as given by Cesaratto et al. [1] (left panel) or 1/10 of that value (right panel).

REFERENCES

[1] Cesaratto et al., PRC 88 (2013) 065806

The ^{6}Li(p,γ)^{7}Be reaction and the ^{6}Li Primordial Abundance

BY ROSANNA DEPALO

The ^{6}Li(p,γ)^{7}Be reaction takes part in Big Bang Nucleosynthesis and contributes to lithium depletion during the pre-main sequence phase of stellar evolution. Its cross section is poorly constrained at the energies of astrophysical interest, especially since the claimed discovery of a resonance at centre of mass energy of 195 keV [1]. A new direct measurement of the ^{6}Li(p,γ)^{7}Be cross section was performed at LUNA. The ^{6}Li+p excitation function was measured on six targets made of three different compounds: lithium oxide, lithium tungstate and lithium chloride. The proton beam energy range between 80 and 400 keV was explored, spanning completely the energy range of the new tentative resonance. In order to evaluate the absolute ^{6}Li(p,γ)^{7}Be cross section, the target composition and thickness should be accurately known. The targets used for the LUNA measurements were characterized at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) using two independent techniques: Nuclear Reaction Analysis and Elastic Recoil Detection Analysis (ERDA). The data analysis is still ongoing, and results are expected soon.

REFERENCES

[1] J. J. He et al. Phys. Lett. B **725**, 287 (2013)

The $^2H(p,\gamma)^3He$ reaction and the Primordial Deuterium Abundance

BY FRANCESCA CAVANNA

Observed abundances of primordial deuterium are currently more accurate than theoretical predictions [1], mainly because Big Bang Nucleosynthesis calculations are hampered by the paucity of data for the deuterium burning reaction $^2H(p,\gamma)^3He$ cross section at the relevant energies [2]. A new measurement with a few % accuracy is very important to push down the BBN uncertainty on deuterium abundance to the same level of observations and to eventually constrain possible new physics effects: the D/H ratio is, in fact, very sensitive to the number of relativistic degrees of freedom N_{eff} and can therefore contribute to settle tight bounds on the number of equivalent neutrino flavours.

At LUNA, we have undertaken a long campaign to measure the $^2H(p,\gamma)^3He$ cross section directly at BBN energies (30 - 300 keV, in 30-50 keV steps). The experiment took place in two phases, using a BGO setup for high efficiency and an HPGe detector for high resolution, respectively [3,4]. The data taking has just been completed and we expect initial publications by the end of 2019. Stay tuned!

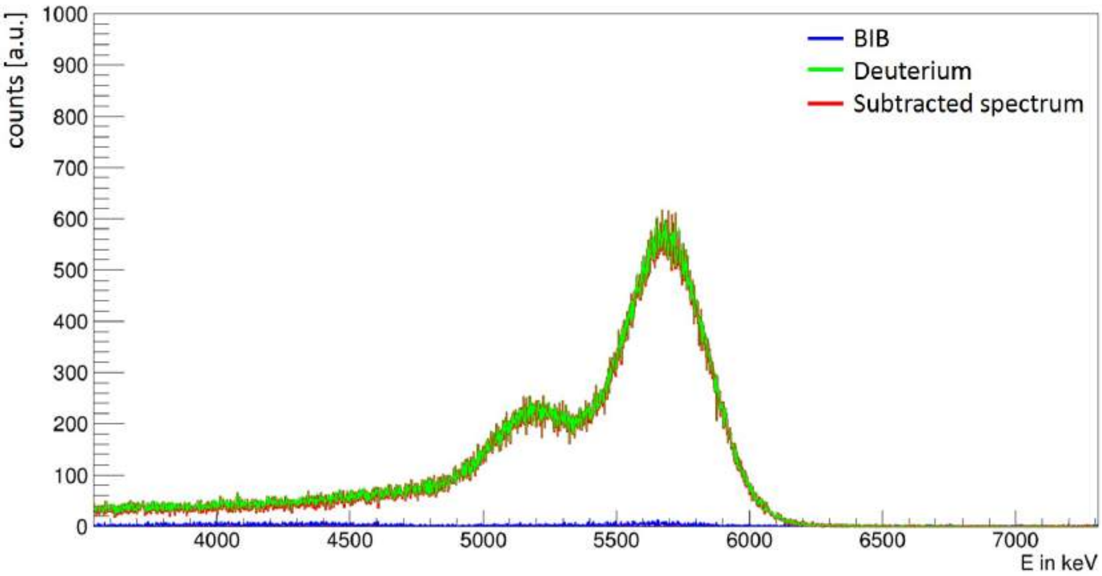


Figure. Sample spectrum obtained at proton beam energy of 150 keV with the BGO detector setup.

REFERENCES

[1] R.J. Cooke et al., Astrophysical Journal 855, 102 (2018)
[2] L. Ma et al., Phys. Rev. C 55, 558 (1997)
[3] V. Mossa, PhD thesis, Bari University (2017)
[4] F. Ferraro et al., European Physical Journal A, 54, 44 (2018)

MEMBER SPOTLIGHT

Denise Piatti

Hometown: Piazzatorre, a wonderful village located on the Bergamo pre-Alps (Italy, of course!)

Education: PhD in Physics at the University of Padua (Italy)

Current Position: Post-Doctoral Research Fellow, INFN of Padua (Italy)

What is the focus of your research? How much time do we have…?

Presently, I am working on two different projects at LUNA. First, the study of the $^{22}Ne(\alpha,\gamma)^{26}Mg$ reaction at the gas-target station of LUNA 400kV, where we are investigating the poorly constrained 395 keV resonance. The initial data taking campaign is now complete and I am working at the data analysis. A second campaign is planned with an improved experimental setup. Second, I am focussed on the study of the $^{6}Li(p,\gamma)^{7}Be$ reaction. I took part in all experimental phases, from target preparation at the National Laboratories of Legnaro, to target characterisation at Helmholtz-Zentrum Dresden-Rossendorf Laboratories, to data taking at LUNA. Now I am working at extracting the experimental S factor from our data.

What do you like most about LUNA?

I like the fact that LUNA was a pioneering project in Nuclear Astrophysics. I also like the fact that the LUNA collaboration has members from all over Europe and we help each other the best we can during experiments at Gran Sassno and during the data analysis, for which we share complementary experience, expertise and facilities. Something fascinating is also that every day at LUNA is different: one day you are mounting the setup with your knees on the floor or your arms holding lead bricks, and another day you are sitting in your office analysing data.

How do you spend your free time? I love travelling and if I'm not, I'm planning for the next trip! But this is not an every-day hobby. I like doing sport and cooking. I also love Padua, walking or riding my bike through its streets is always a surprising experience.

What are your goals for the future? It is hard to say. Life is so often unpredictable and having long term goals may not be the best way to proceed. But I have some hopes for my future and doing research in Nuclear Astrophysics is definitely one of them!

SCIENTIFIC OUTPUT

Publications

JANUARY 2018 - DECEMBER 2018

- **A Boeltzig** *et al. Improved background suppression for radiative capture reactions at LUNA with HPGe and BGO detectors* **Journal of Physics G: Nuclear and Particle Physics 45 (2018) 025203**

- **F Ferraro** *et al. A high-efficiency gas target setup for underground experiments, and redetermination of the branching ratio of the 189.5 keV* $^{22}Ne(p,\gamma)^{23}Na$ *resonance* **European Physical Journal - A 54 (2018) 44**

- **F Cavanna** *et al. Erratum: Three New Low-Energy Resonances in the* $^{22}Ne(p,\gamma)^{23}Na$ *Reaction [PRL 115, 252501 (2015)]* **Physical Review Letters 120, 239901(E) (2018)**

- **D Bemmerer** *et al. Effect of beam energy straggling on resonant yield in thin gas targets: The cases* $^{22}Ne(p,\gamma)^{23}Na$ *and* $^{14}N(p,\gamma)^{15}O$ **Europhysics Letters 122, 52001 (2018) (Editor Choice)**

- **F Ferraro** *et al. Direct Capture Cross Section and the* E_p*=71 and 105 keV Resonances in the* $^{22}Ne(p,\gamma)^{23}Na$ *Reaction* **Physical Review Letters 121, 172701 (2018)**

Invited Talks

JANUARY 2018 - DECEMBER 2018

- M Aliotta, ChETEC Summer School, 10-20 April 2018, Bucarest (Romania)
- M Aliotta, European Nuclear Physics Conference, 2-7 September 2018, Bologna (Italy)
- C Broggini, Frontiers Research in Astrophysics, 28 May - 2 June 2018, Mondello (Italy)
- CG Bruno, 41st Symposium on Nuclear Physics, 8-11 January 2018, Cocoyoc (Mexico)
- CG Bruno, European Nuclear Physics Conference, 2-7 September 2018, Bologna (Italy)
- A Caciolli, 5th International Solar Neutrino Conference, 11-14 June 2018, Dresden (Germany)
- A Caciolli, Carpatian Summer School of Physics, 1-14 July 2018, Sinaia (Romania)
- R Depalo, 13th international conference on nucleus-nucleus collisions, 4-8 December 2018, Saitama (Japan)
- A Guglielmetti, 5th International Solar Neutrino Conference, 11-14 June 2018, Dresden (Germany)
- A Guglielmetti, Società Italiana di Fisica, 17-21 September 2018, Rende (Italy)
- C Gustavino, 56th International Winter Meeting on Nuclear Physics, 23-28 January 2018, Bormio (Italy)
- C Gustavino, Frontiers Objects in Astrophysics and Particle Physics, 20-26 May 2018, Vulcano (Italy)
- G Imbriani, 5th International Solar Neutrino Conference, 11-14 June 2018, Dresden (Germany)
- P Prati, XV Nuclei in the Cosmos Conference, 24-29 June 2018, Assergi (Italy)
- O Straniero, Frontiers Objects in Astrophysics and Particle Physics, 20-26 May 2018, Vulcano (Italy)

CONGRATULATIONS TO…

Carlo Bruno (University of Edinburgh, UK) for winning the 2015-2017 European Physical Society Nuclear Physics PhD thesis prize, awarded to the best three PhD theses in Nuclear Physics in Europe in 2015-2017

Giovanni Ciani (Gran Sasso Science Institute, Italy) for successfully defending her PhD thesis on *Cross section of the* $^{13}C(\alpha,n)^{16}O$ *reaction at low energies* in January 2019.

Federico Ferraro (University of Genoa, Italy) for winning the INFN Villi Prize awarded to the best thesis in Nuclear Physics in 2017.

Viviana Mossa (University of Bari, Italy) for successfully defending her PhD thesis on *Study of the* $^{2}H(p,\gamma)^{3}He$ *reaction in the Big Bang nucleosynthesis energy* in March 2018.

Francesca Pantaleo (University of Bari, Italy) for successfully defending her PhD thesis on *Direct cross section measurement of the* $^{18}O(p,\gamma)^{19}F$ *reaction at LUNA* in March 2018.

Denise Piatti (University of Padua, Italy) for successfully defending her PhD thesis (summa cum laude) on *The Study of* $^{22}Ne(\alpha,\gamma)^{26}Mg$ *and* $^{6}Li((p,\gamma)^{7}Be$ *Reactions at LUNA* in December 2018.

JOB OPPORTUNITIES

Interested in working with us at LUNA? Please consider the following opportunities for PhD studentships and Post-Doctoral Fellowships. These are typically highly selective international competitions and normally require strong academic records and, in the case of post-doctoral jobs, proven research experience and leadership potential. If you think you meet these requirements, please get in touch to discuss things further.

PhD Studentships

- **GRAN SASSO SCIENCE INSTITUTE (GSSI, Italy)**. Calls for applications are issued once a year, typically in **April**. Studentships are for **3 years,** which include a one-year compulsory attendance to training courses. Successful applicants will receive a gross stipend of €16,200/year. Accommodation and meals in L'Aquila are provided free of charge. For further details, please visit: **http://gssi.infn.it**

  If interested in applying, please contact: Dr Alba Formicola (**alba.formicola@lngs.infn.it**)

- **SCOTTISH UNIVERSITY PHYSICS ALLIANCE (SUPA, UK)**. Calls for applications are issued once a year, with deadline at the end of **January**. Studentships are typically for **3.5 years** with a stipend of about £12,000/year with additional funds for fieldwork. For further details, please visit: **http://apply.supa.ac.uk/apply**

  If interested in applying, please contact: Prof Marialuisa Aliotta (**m.aliotta@ed.ac.uk**)

In addition, please note that PhD scholarships are awarded once a year at most Italian universities. Calls are normally published in the summer. If you are interested in applying for a studentships to work at LUNA please refer to PhD positions available at the following universities: Bari, Genova, Milano, Napoli, Padova, Torino. Alternatively, get in touch with a member of the LUNA Collaboration based at any of those institutions (see **luna.lngs.infn.it** for the full list of LUNA members).

Post-Doctoral Positions and Fellowships

- **INFN POST-DOCTORAL FELLOWSHIPS FOR EXPERIMENTAL PHYSICS (ITALY).** These fellowships are for non-Italian citizens only. Eligible applicants must hold a PhD title (or equivalent) obtained by no more than 8 years prior to the call deadline (typically in **November**). Time-limit extensions apply. The fellowship is initially for one year with the possibility for a second-year extension. Annual gross salary is €36,000. For further details, please visit: **https://reclutamento.infn.it/ReclutamentoOnline/#!bandi/FELLOWSHIP**

  If interested in applying, please contact any of the INFN members of the LUNA Collaboration

- **ROYAL SOCIETY NEWTON INTERNATIONAL FELLOWSHIPS (UK).** The scheme provides the opportunity for the best **early stage post-doctoral researchers** from all over the world to work at UK research institutions for a period of two years. Eligible candidates should have completed their PhD by the time funding starts. They should have no more than **7 years of active full time postdoctoral experience** at the time of application. Applicants are normally agreed with the host institution (in this case, the School of Physics and Astronomy - University of Edinburgh) well in advance of the intended deadline. Newton Fellowships last for **2 years**. Funding consists of £24,000 per annum for subsistence costs, and up to £8,000 per annum research expenses, as well as a one-off payment of up to £2,000 for relocation expenses. Application rounds are typically in **March** and **September**. For further details, please visit: **https://royalsociety.org/grants-schemes-awards/grants/newton-international/**

  If interested in applying, please contact: Prof Marialuisa Aliotta (**m.aliotta@ed.ac.uk**)

- **ROYAL SOCIETY UNIVERSITY RESEARCH FELLOWS (UK).** The scheme provides the opportunity to build an independent research career. Those appointed are expected to be strong candidates for permanent posts in universities at the end of their fellowships. The Fellowships are for **5 years** with a possible 3 year extension. The basic salary, commensurate with the applicant's skills, responsibilities, expertise and experience, can be up to a maximum of £39,708.70 per annum. Eligible candidates must posses a PhD title and between **3-8 years of post-doctoral research experience** by the application deadline. Applications are normally agreed with the host institute (in this case, the School of Physics and Astronomy - University of Edinburgh). Shortlisted applicants will be invited for interview at the Royal Society in **early-mid April**. For further details, please visit: **https://royalsociety.org/grants-schemes-awards/grants/university-research/**

  If interested in applying, please contact: Prof Marialuisa Aliotta (**m.aliotta@ed.ac.uk**)

- **STFC ERNEST RUTHERFORD FELLOWSHIPS (UK).** These are highly prestigious and highly competitive fellowships that may lead to permanent academic posts. The Fellowships are for **5 years** with a typical salary of £33,000-35,000/year (depending on level of experience). Eligible candidates must have 5 years of postgraduate research experience, with normally a minimum of 2 years of post-doctoral experience. Applications MUST be agreed with the host institute (in this case, the School of Physics and Astronomy - University of Edinburgh), where a pre-selection based on CV and a draft research plan takes place by the **end of August each year.** Selected applicants will have to submit a full research proposal to STFC for further consideration. Candidates who pass the STFC pre-selection process in January will be invited for interviews in Swindon (UK) in February. Posts normally start in September. For further details, please visit: **http://www.stfc.ac.uk/funding/fellowships/ernest-rutherford-fellowship/**

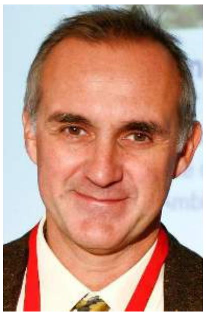
  If interested to apply, please contact: Prof Marialuisa Aliotta (**m.aliotta@ed.ac.uk**)

Please note that additional opportunities may arise from time to time within individual groups of the Collaboration. For updates, please consult the Job Opportunities page at the Collaboration website at **http://luna.lngs.infn.it**

THE COLLABORATION - CONTACT US

The LUNA Collaboration comprises about 40 researchers from the following Institutions:

- **INFN**, Assergi LNGS, Lecce, Roma (Italy)
- **GSSI**, L'Aquila (Italy)
- **Universities** and **INFN** of **Bari, Genova, Milano, Napoli, Padova, Torino** (Italy)
- **Konkoly Observatory,** Budapest (Hungary)
- **MTA ATOMKI**, Debrecen (Hungary)
- **HZDR**, Dresden (Germany)
- **University of Edinburgh**, Edinburgh (UK)
- **Osservatorio Astronomico di Collurania**, Teramo (Italy)



For any question about LUNA, or if you are interested in joining the Collaboration, please contact the LUNA Spokesperson: Prof Paolo Prati (**paolo.prati@ge.infn.it**)

For any question about this Newsletter, please contact the Chair of the Editorial Board: Prof Marialuisa Aliotta (**m.aliotta@ed.ac.uk**)