

Challenging ${}^7\text{Be}(n,\alpha)$ and ${}^7\text{Be}(n,p)$ cross-sections measurement at CERN

M. Barbagallo, N. Colonna, A. Musumarra, J. Andrejewski, L. Cosentino, E. Maugeri, B. Langhans, J. Perkowski, M. Mastromarco, A. Gawlik,, D. Schumann, A. Mengoni, P. Finocchiaro F. Kappeler, L. Damone, A. Pappalardo, O. Aberle, S. Heinitz, R. Dressler, E. Chiaveri and the **n_TOF collaboration**.

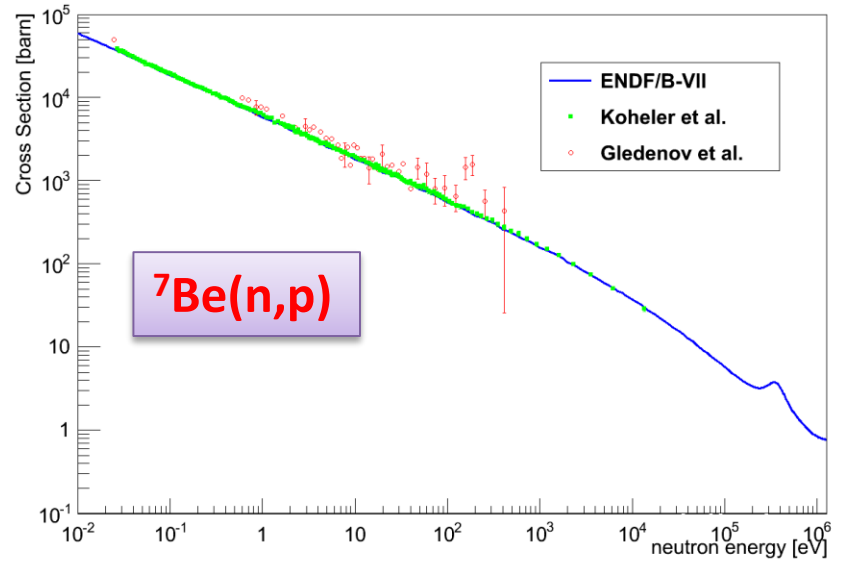
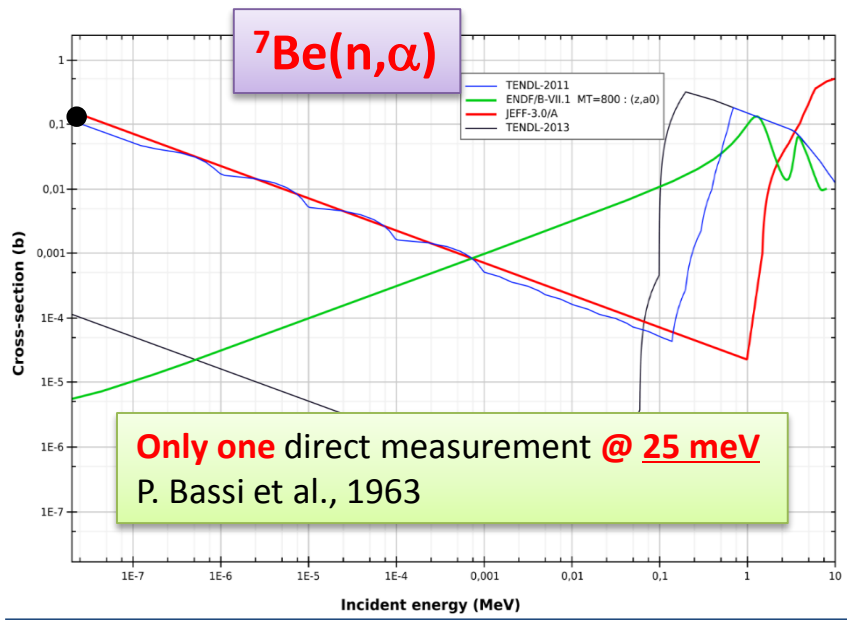
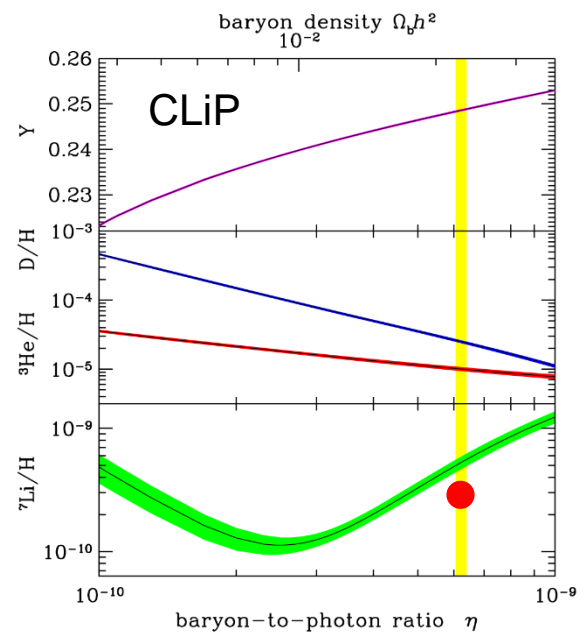
K. Johnston, J. Schell, J. M. Correia, M. Borges-Garcia, U. Koester, B. Marsh, T. Goodacre, R. Catherall, A. Bernardes, T. Stora, J. Ballof, B. Crepieux.

Cosmological Lithium Problem and ${}^7\text{Be}$

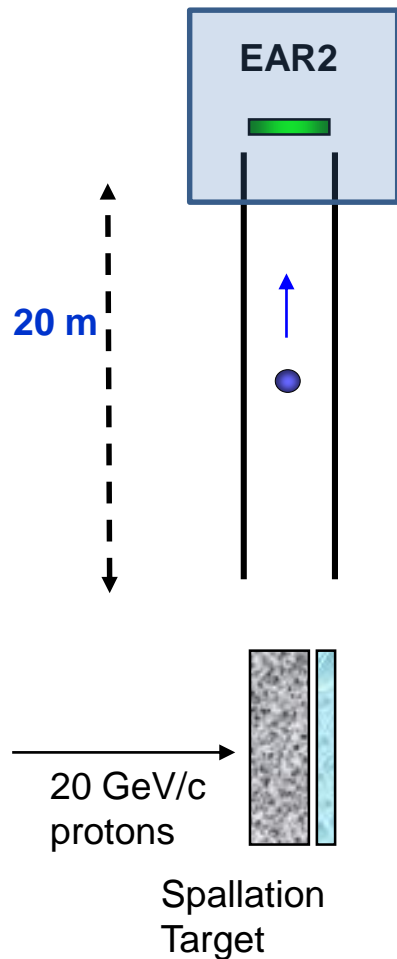
A serious discrepancy (factor 2-4) between the predicted abundance of ${}^7\text{Li}$ and value inferred by measurements (Spite et al.)

Approximately 95% of primordial ${}^7\text{Li}$ is produced from the electron capture decay of ${}^7\text{Be}$ ($T_{1/2}=53.2$ d).

${}^7\text{Be}$ is destroyed via (n,p) and (p,x) , (d,x) , $({}^3\text{He},x)$, ... reactions. Small contribution of the (n,α) reactions according to **estimated** cross section.



EAR2 further extends the measurement capability of the n_TOF facility



The much higher flux in EAR2 allows to:

- measure **short-lived radioisotopes** (down to a few weeks)
- collect data on a much **shorter time**
- **measure (n, charged particle) reactions with thin samples**
- measure samples of **very small mass ($\ll 1$ mg)**

Two different measurements at n_TOF

(CERN-INTC-2014-049/INTC-P-417)

i) $n+{}^7\text{Be} \rightarrow \alpha+\alpha$

(4 μg , PSI)

- Coincidences technique

(2015)

ii) $n+{}^7\text{Be} \rightarrow p+{}^7\text{Li}$

(100 ng, PSI+ISOLDE)

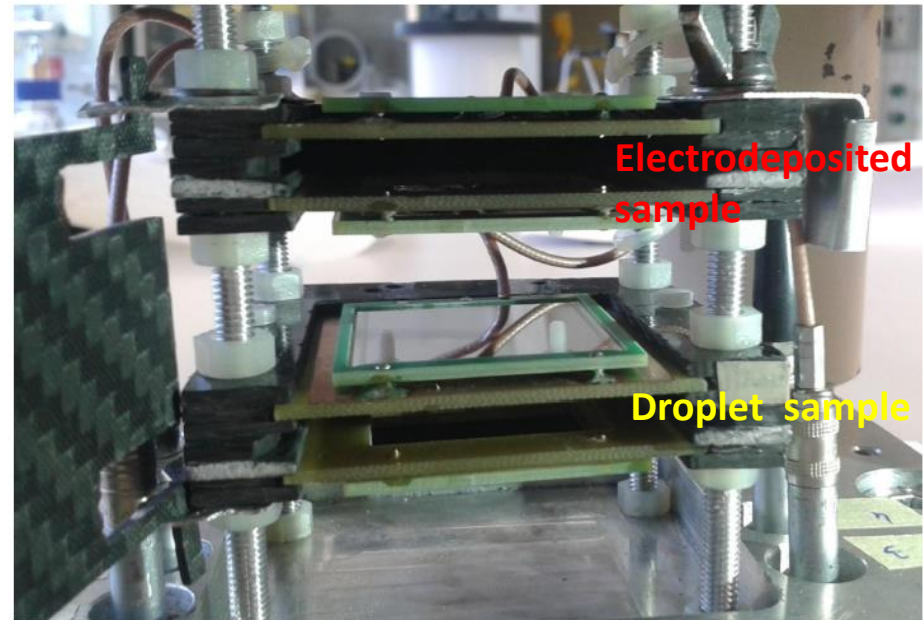
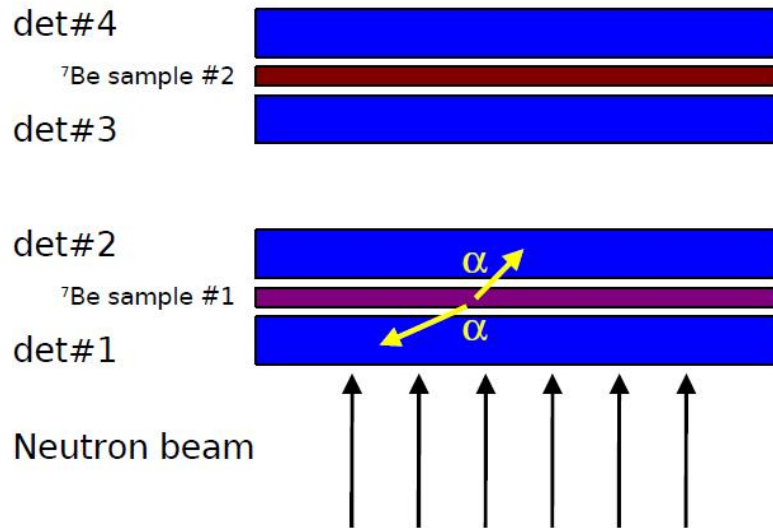
- Telescope technique

(2016)

Silicon detectors **directly inserted in the beam** ($3 \times 3 \text{ cm}^2$ active area, $140 \mu\text{m}$ thickness)

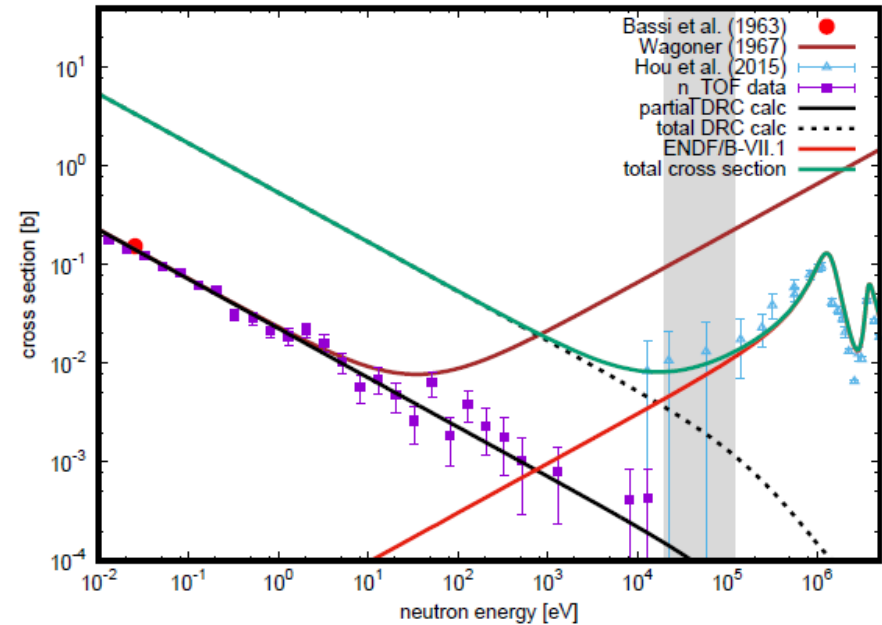
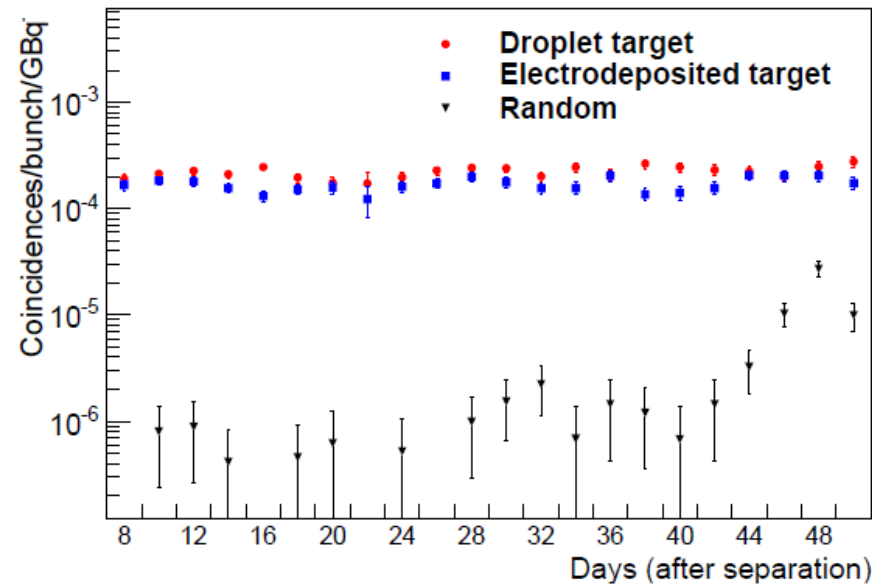
Detection of high energy α -particles (Q value 19 MeV)

Strong rejection of background (sample preparation)



- L. Cosentino et al., "Experimental setup and procedure for the measurement of the $^7\text{Be}(n,\alpha)$ reaction at n_TOF", NIM A 830 (2016) 197-205
- M. Barbagallo, " $^7\text{Be}(n,\alpha)$ and $^7\text{Be}(n,p)$ cross-section measurement for the Cosmological Lithium Problem at the n_TOF facility at CERN", accepted for publication on "Il Nuovo Cimento".

Results of the ${}^7\text{Be}(n,\alpha)$ measurement



“

M. Barbagallo et al., *“The ${}^7\text{Be}(n,\alpha){}^4\text{He}$ reaction and the Cosmological Lithium Problem: measurement of the cross section in a wide energy range at n_TOF (CERN)”* Submitted to Physical Review Letter

of the cross section estimates currently used in BBN calculations. Although new measurements at higher neutron energy may still be needed, the present results hint to a minor role of this reaction in BBN, leaving the long-standing Cosmological Lithium problem unsolved.

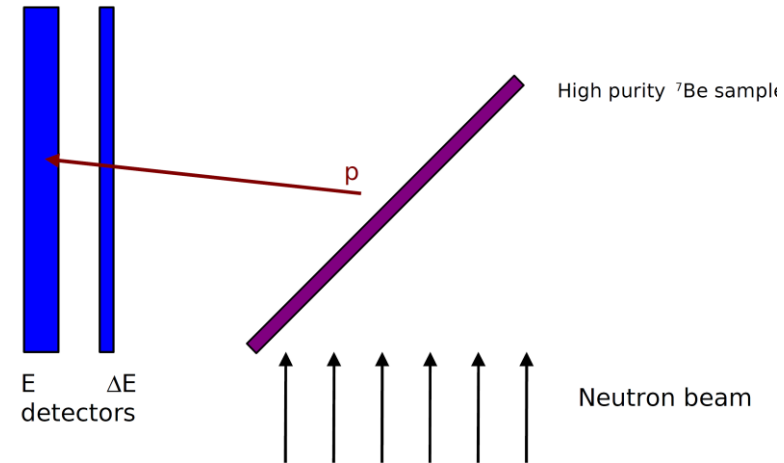
PACS numbers: 23.40.-s, 24.10.Lx, 28.20.Fc

Silicon telescope **outside of the beam.**

Detection and identification of protons of 1.4 MeV and 1 MeV



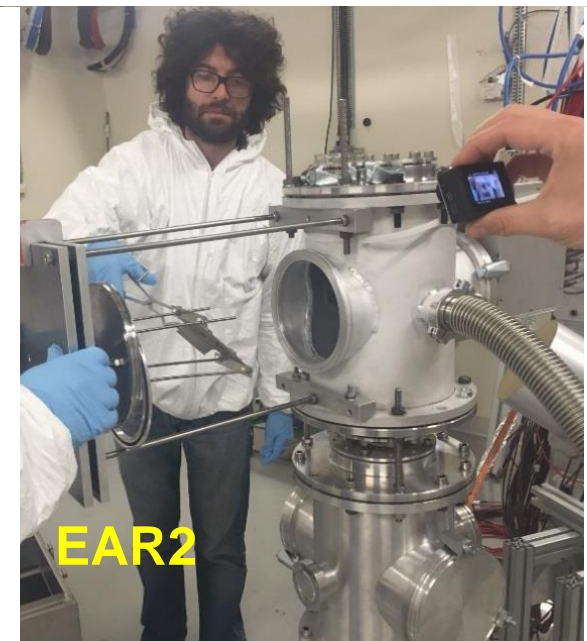
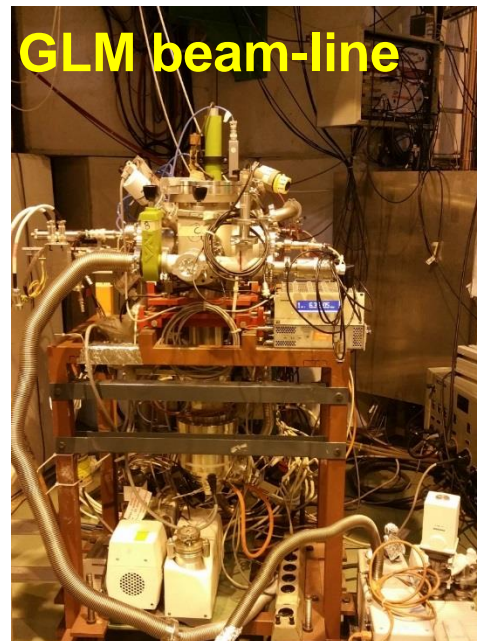
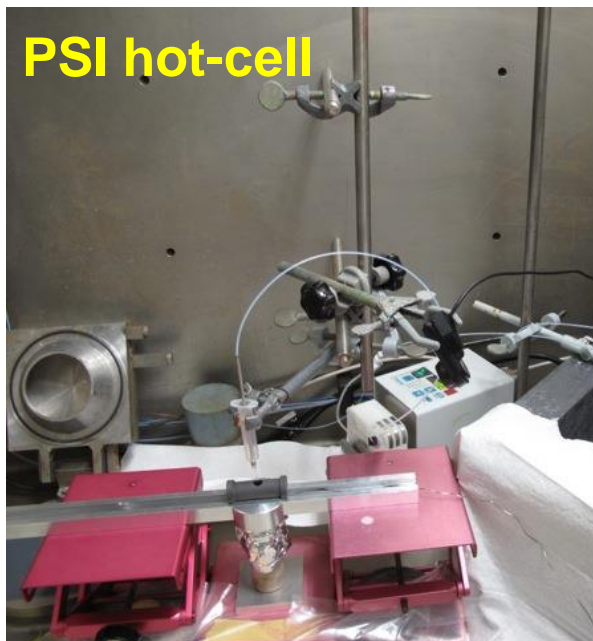
1 GBq high purity sample needed



- **First joint n_TOF-ISOLDE experiment**
- First time ever measurement of a neutron induced reaction cross-section using a target produced with a radioactive beam.

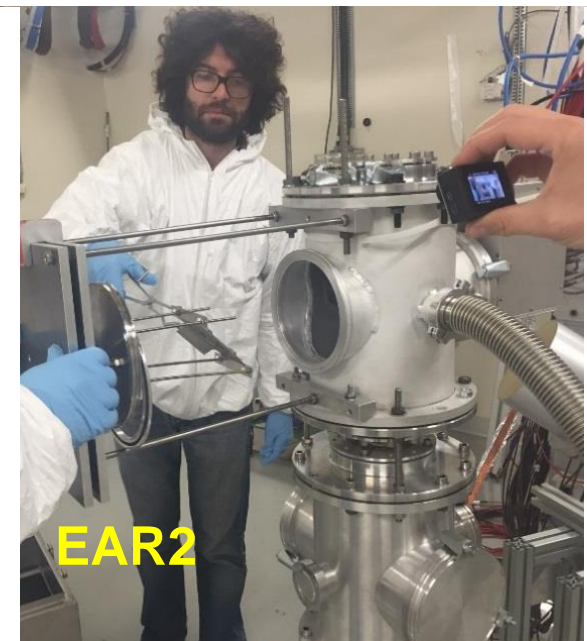
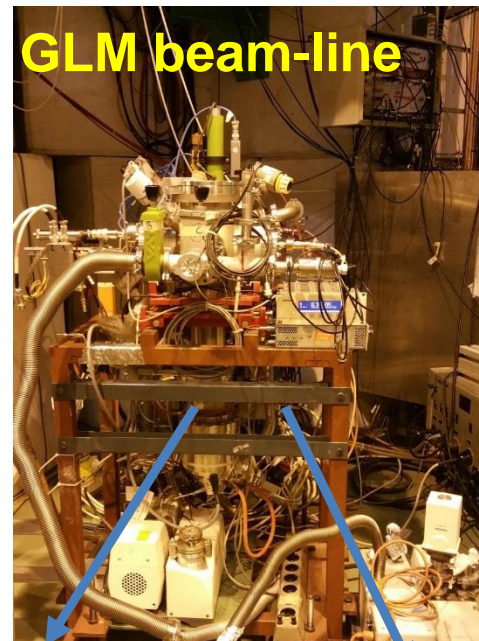
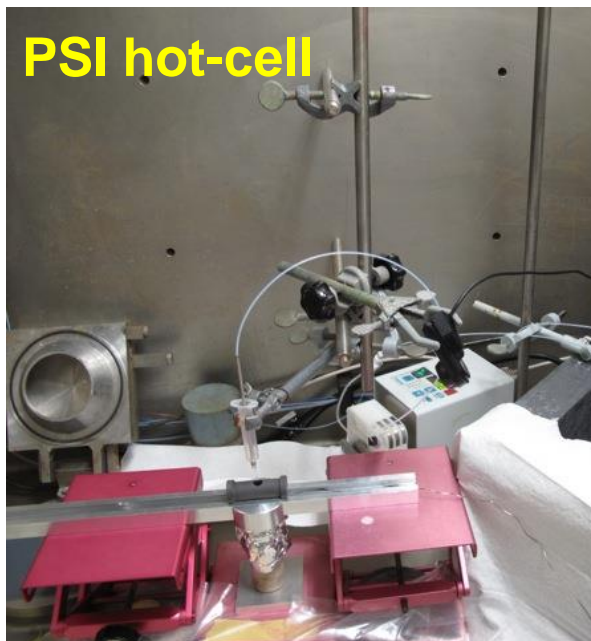
A three steps experiment:

- Extraction of 200 GBq from water cooling of SINQ spallation source at PSI
- Implantation of 30 keV ${}^7\text{Be}$ beam on suited backing using ISOLDE-GLM off-line separator (and RILIS)
- Measurement at n_TOF-EAR2 using a silicon telescope



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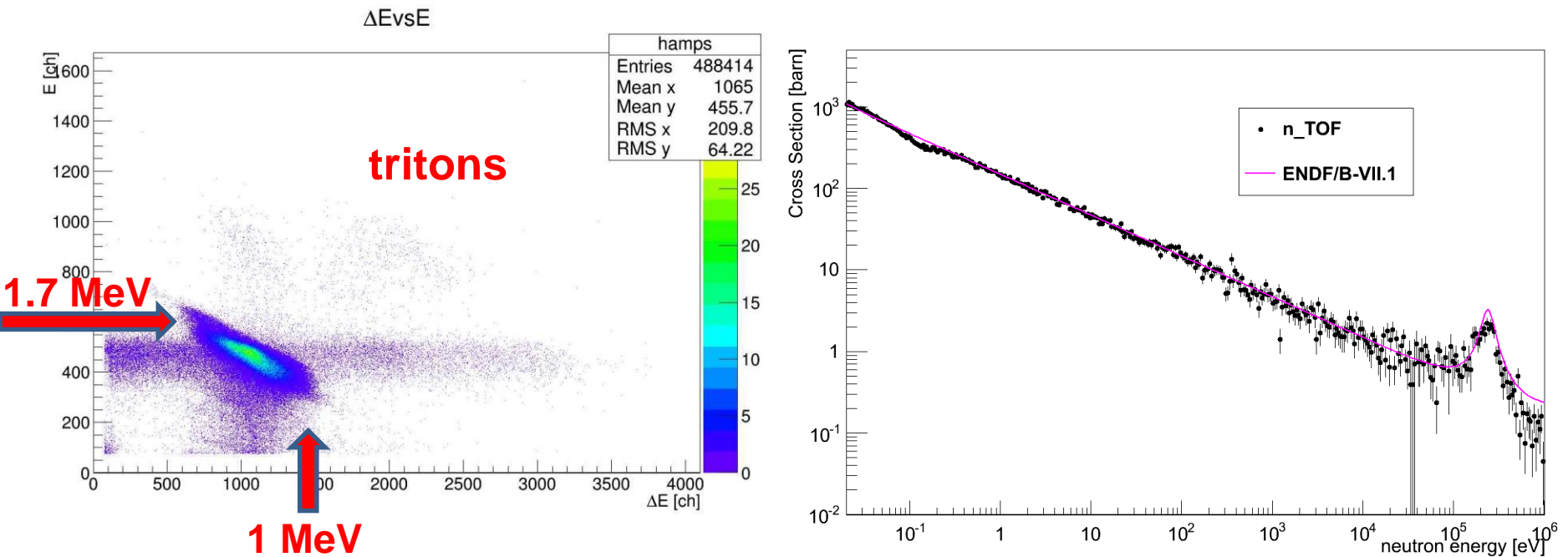
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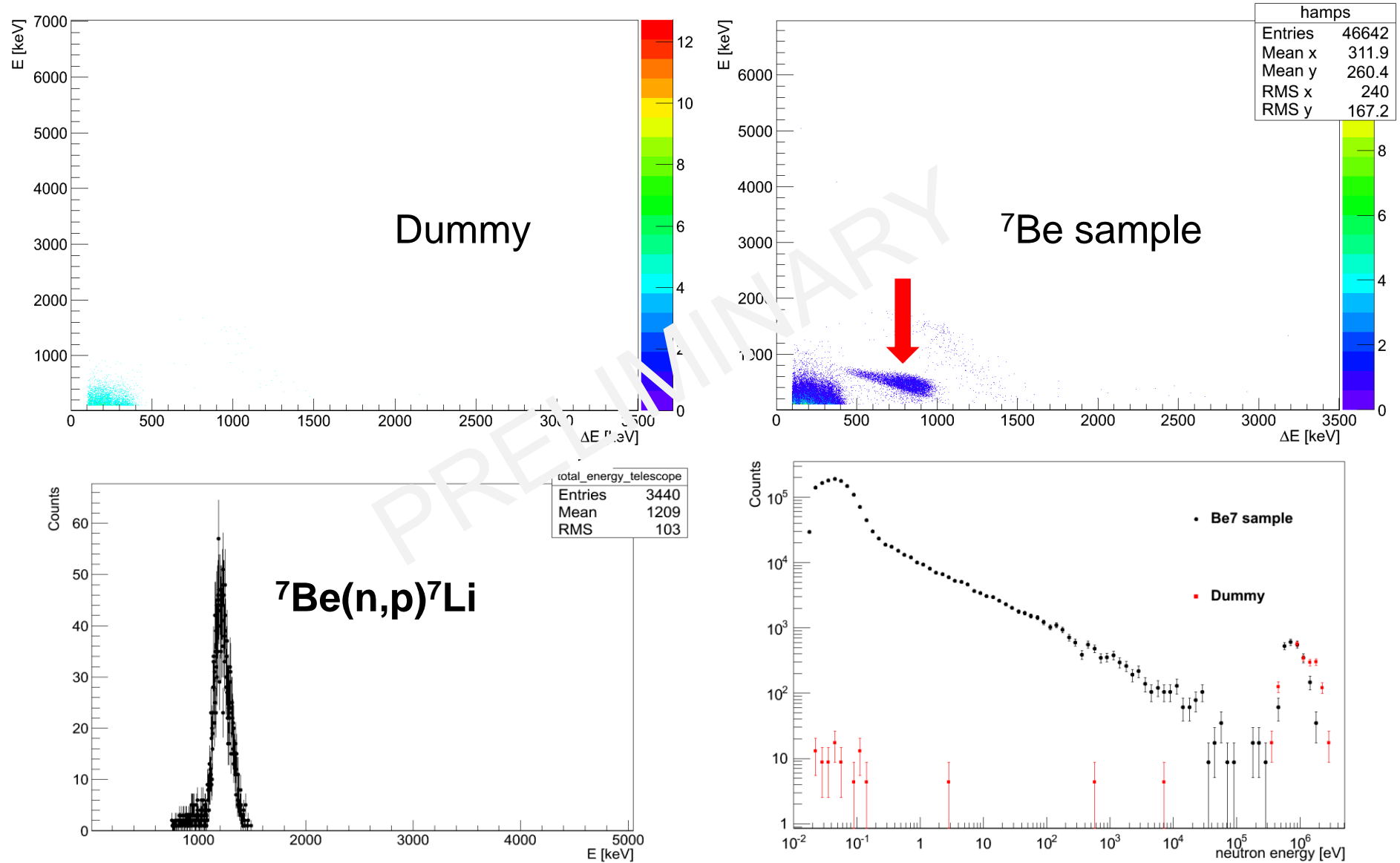
20 MBq (16/04)

1.1 GBq (14/05)

The detection system was characterized using the well-known $^6\text{Li}(n,\alpha)$ reaction.



Upper energy limit for detection --> 1 MeV neutron energy



- Uncertainties in nuclear data strongly affect the Big Bang Nucleosynthesis calculations for the abundance of ${}^7\text{Li}$ and could probably explain (at least shade new light on) the **Cosmological Lithium Problem**.
- **${}^7\text{Be}(n,\alpha){}^4\text{He}$ cross-section has been measured for the first time in a wide energy range**, using **n_TOF-EAR2** neutron beam and two samples prepared at **PSI**. Although they **hint to a minor role of this reaction in BBN**, the results obtained for this measurement reveal that the reaction rate currently used in BBN calculation requires substantial revision.
- The **${}^7\text{Be}(n,p){}^7\text{Li}$ cross-section measurement** has been performed at **n_TOF-EAR2**, using a **1.1 GBq** pure sample implanted at **GLM beam line of ISOLDE**, starting from a 200 GBq ${}^7\text{Be}$ solution collected at **PSI**.
- Preliminary results from the **${}^7\text{Be}(n,p){}^7\text{Li}$ cross-section measurement** are more than extremely encouraging, **already proving that a final answer on the role of this reaction in BBN can be provided by this experiment**.
- **The first fruitful collaboration between the n_TOF and the ISOLDE facilities and teams.**