Università degli Studi della Campania *Luigi Vanvitelli*

Dipartimento di Matematica e Fisica

Electron and proton capture on 7Be

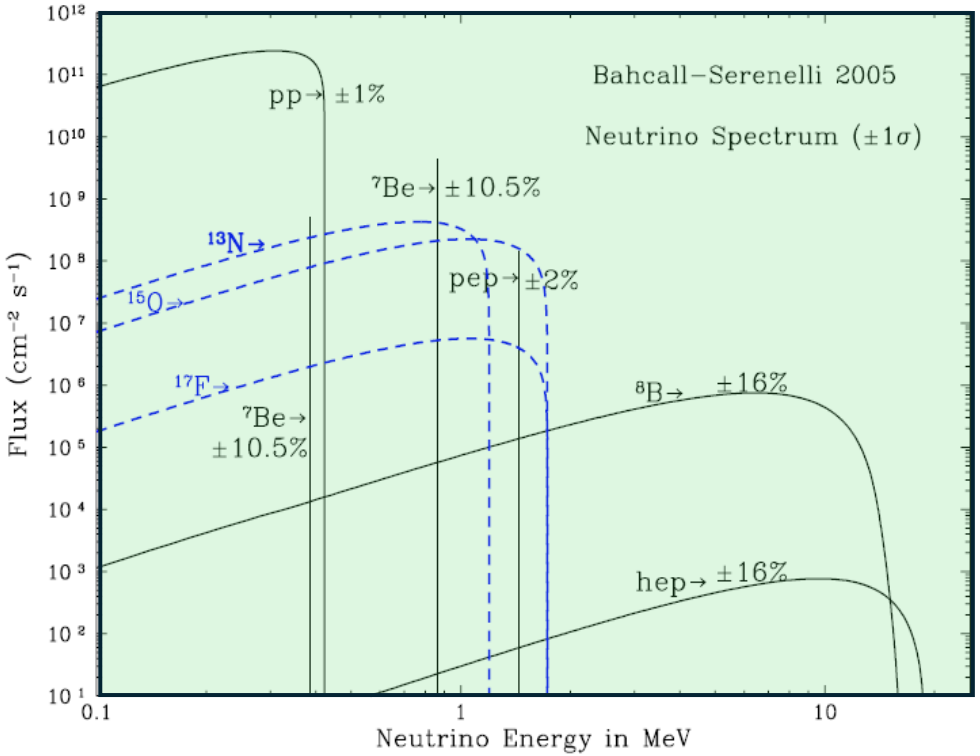
L. Gialanella – ERNA and AsBeST collaborations

Istituto Nazionale di Fisica Nucleare

^{7}Be is a rare but important isotope in astrophysics

Electron and proton capture on 7Be

L. Gialanella – ERNA and AsBeST collaborations



Hydrogen burning

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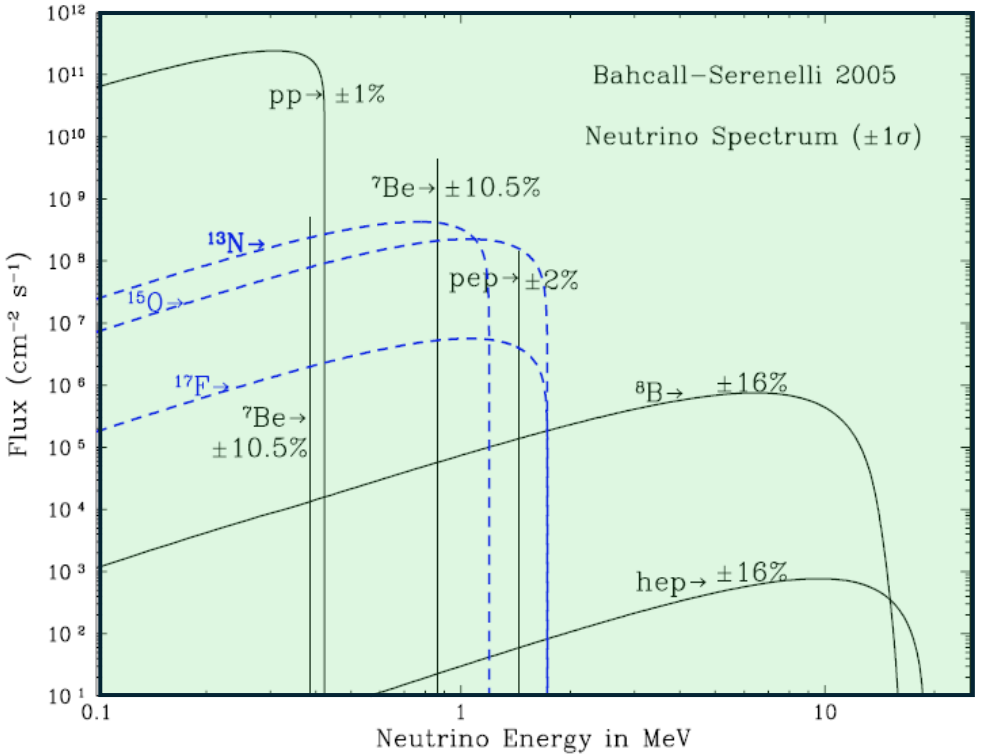
Electron and proton capture on 7Be

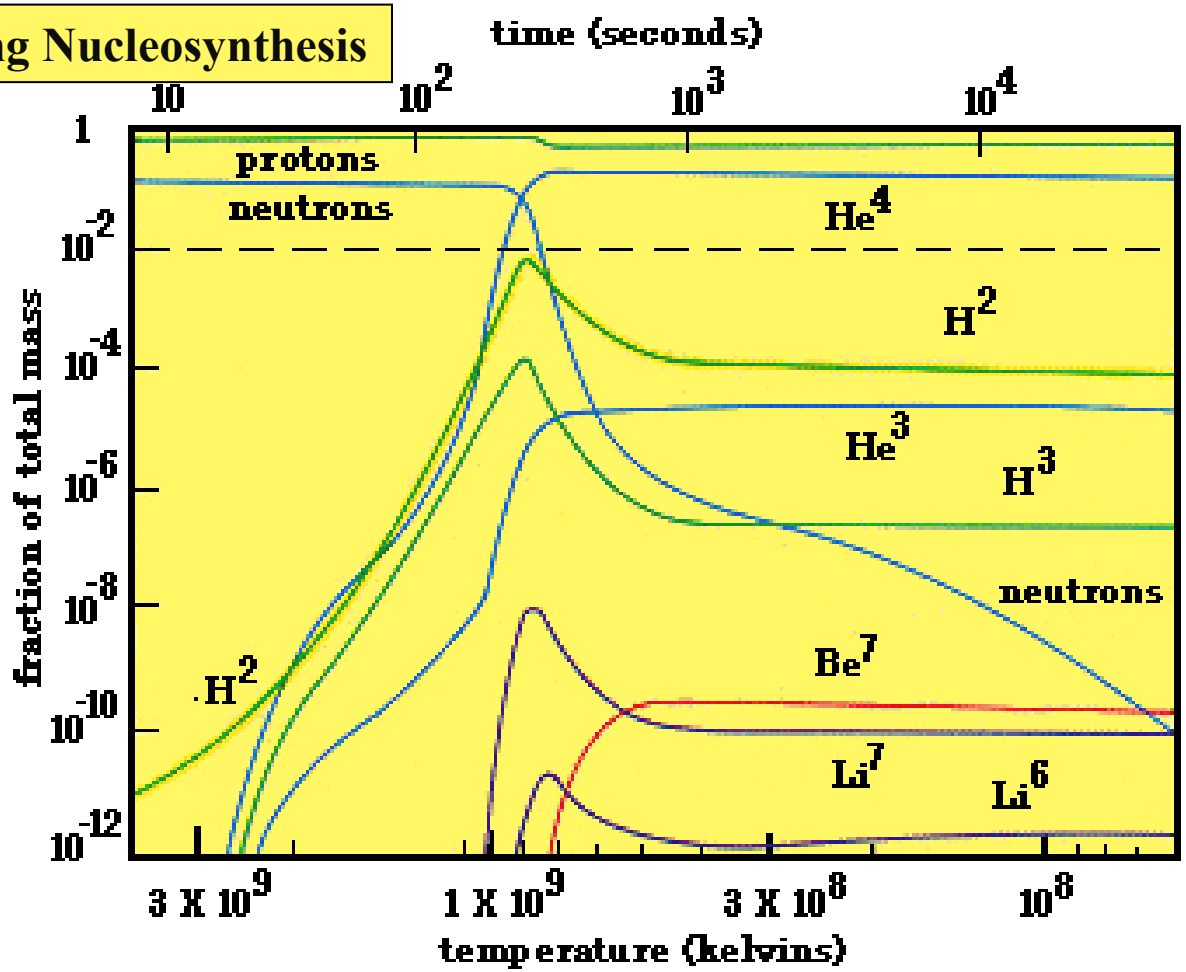
L. Gialanella – ERNA and AsBeST collaborations

INFN Istituto Nazionale di Fisica Nucleare



Hydrogen burning

Big Bang Nucleosynthesis



^{7}Be production: ^{3}He(^{4}He,γ)^{7}Be

^{7}Be destruction: ^{7}Be(p,γ)^{8}B EC decay to ^{7}Li

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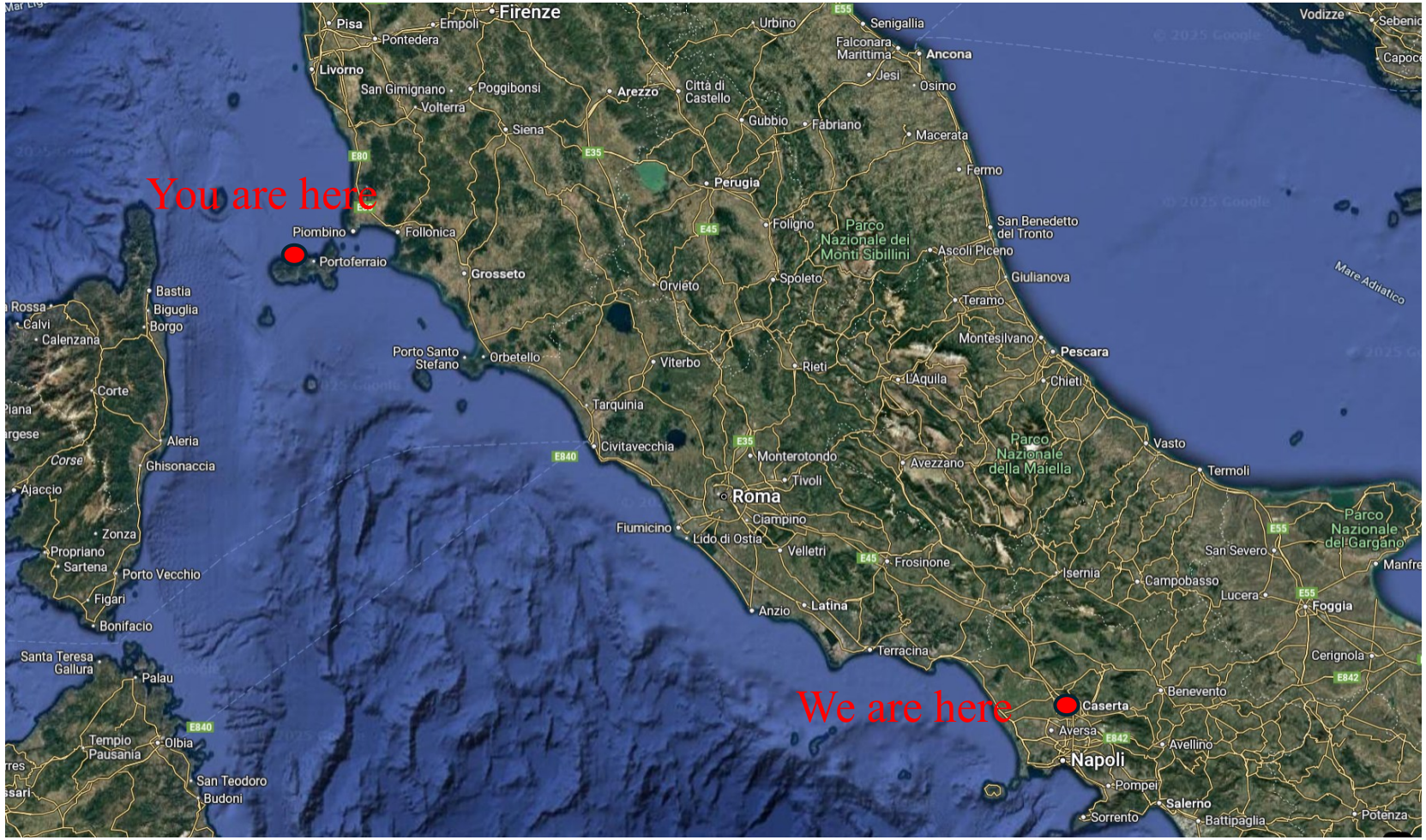
Dipartimento di Matematica e Fisica

PoLaR (Reseach Laboratory Hub)
Caserta, Italy

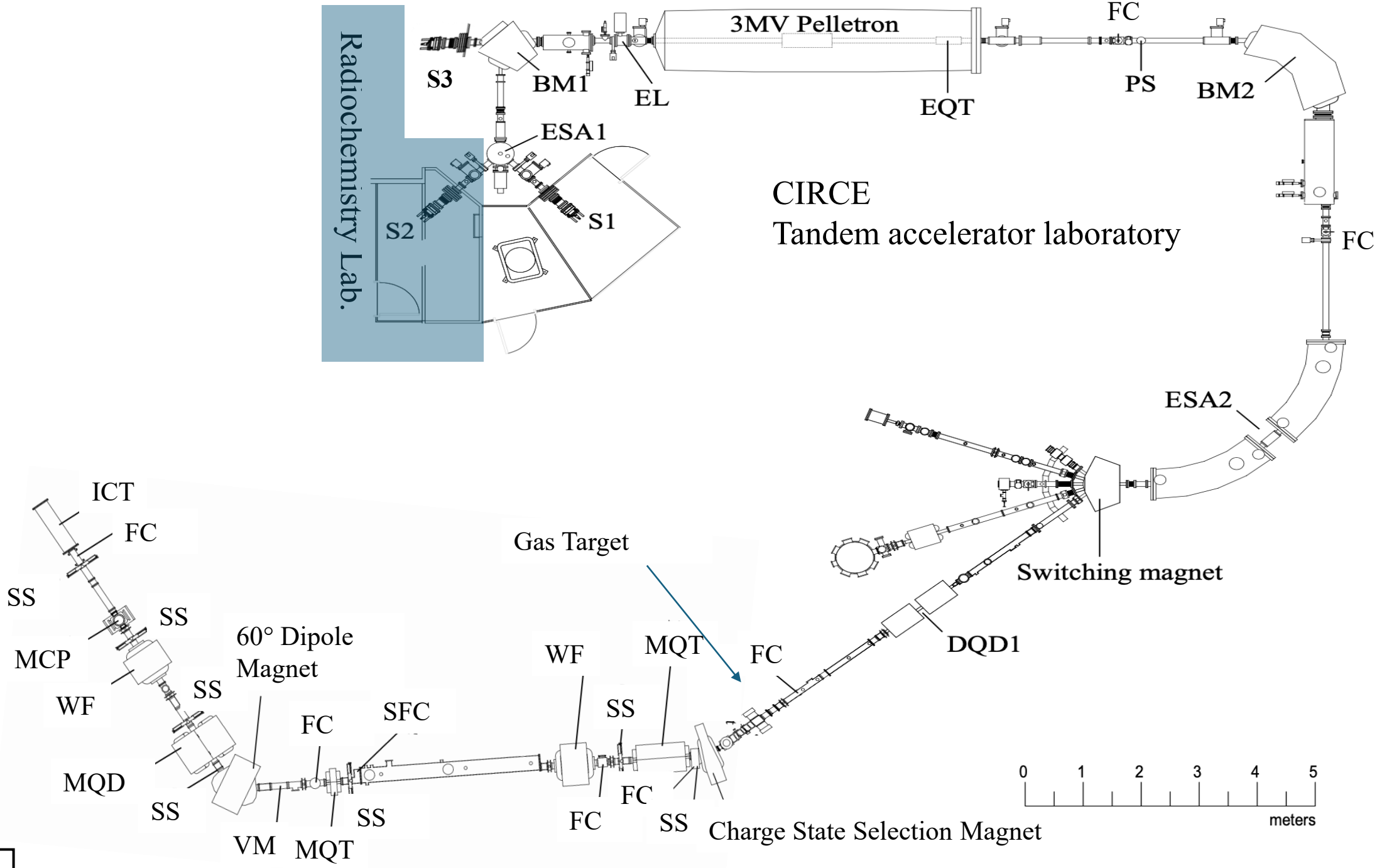


Università degli Studi della Campania *Luigi Vanvitelli*

Dipartimento di Matematica e Fisica

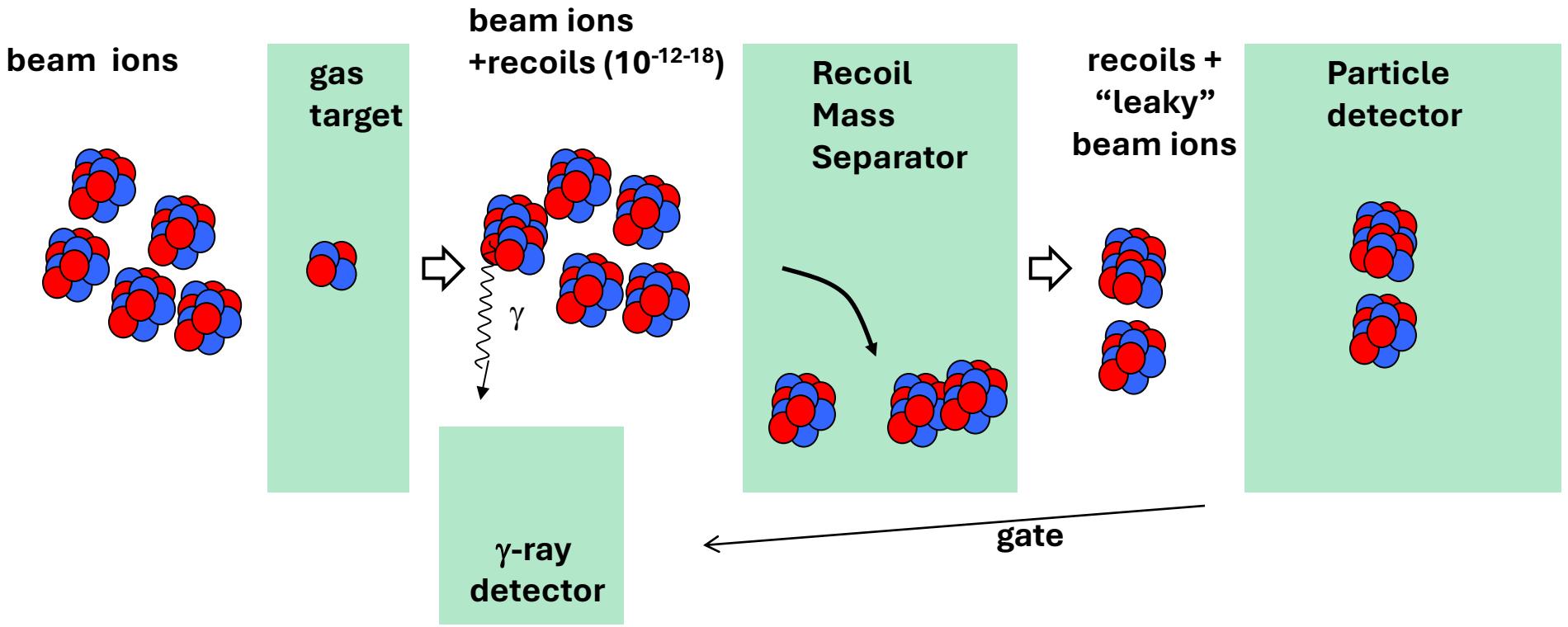
PoLaR (Reseach Laboratory Hub)
Caserta, Italy

CIRCE Tandem Accelerator Laboratory


Radiochemistry Lab.
S3
BM1
EL
3MV Pelletron
EQT
FC
PS
BM2
FC
ESA1
S2
S1
CIRCE
Tandem accelerator laboratory
ESA2
ICT
FC
SS
SS
MCP
WF
SS
60° Dipole
Magnet
MQD
SS
VM
FC
MQT
SFC
SS
Gas Target
WF
MQT
SS
FC
FC
SS
FC
Switching magnet
DQD1
Charge State Selection Magnet
0
1
2
3
4
5
meters

Off line ^{7}Be production via ^{7}Li(p,n)^{7}Be

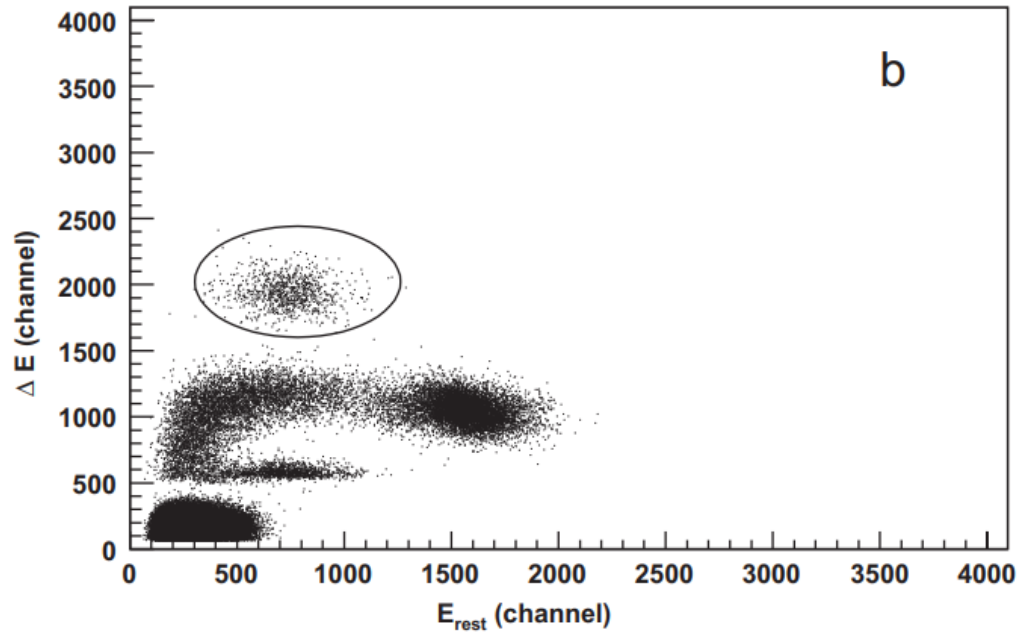
RMS : working principle



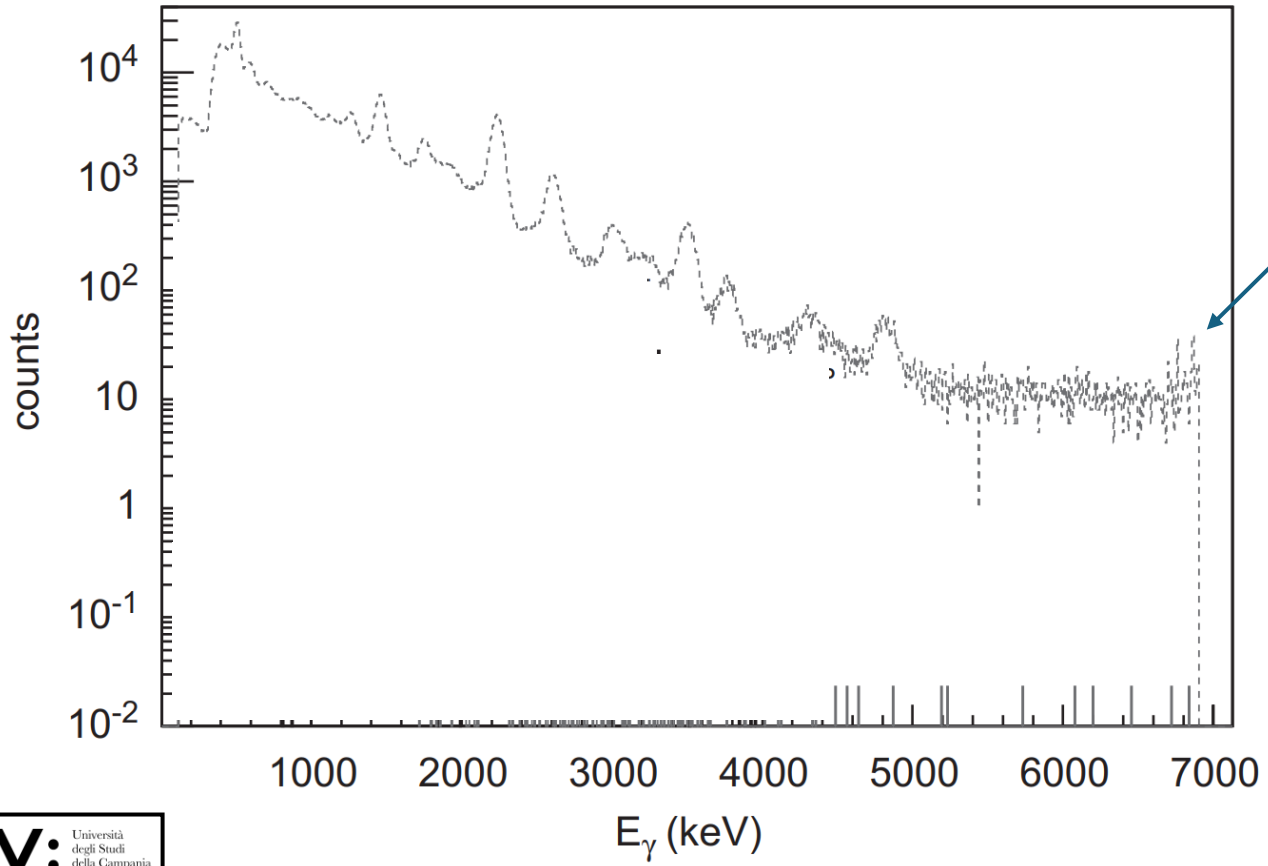
$$N_{recoils} = N_{projectiles} \times n_{target} \times \sigma \times T_{ERNA} \times \underline{\Phi}_q \times \varepsilon_{part}$$

$$N_\gamma = N_{recoils} \times \varepsilon_\gamma$$

ERNA at Ruhr Unversitaet Bochum:
$^{3}He(^{4}He,\gamma)^{7}Be$

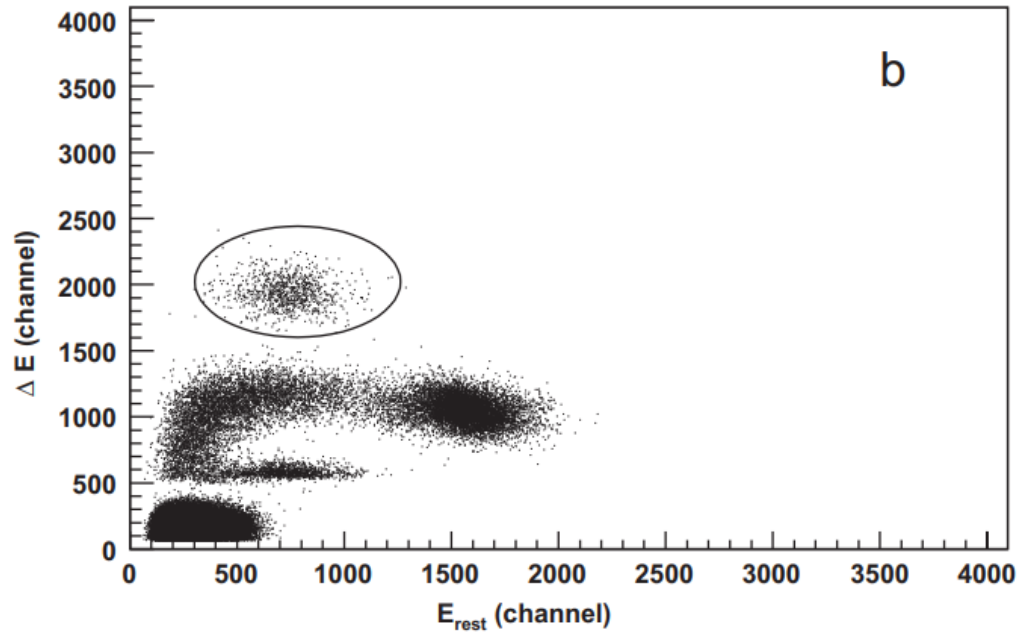


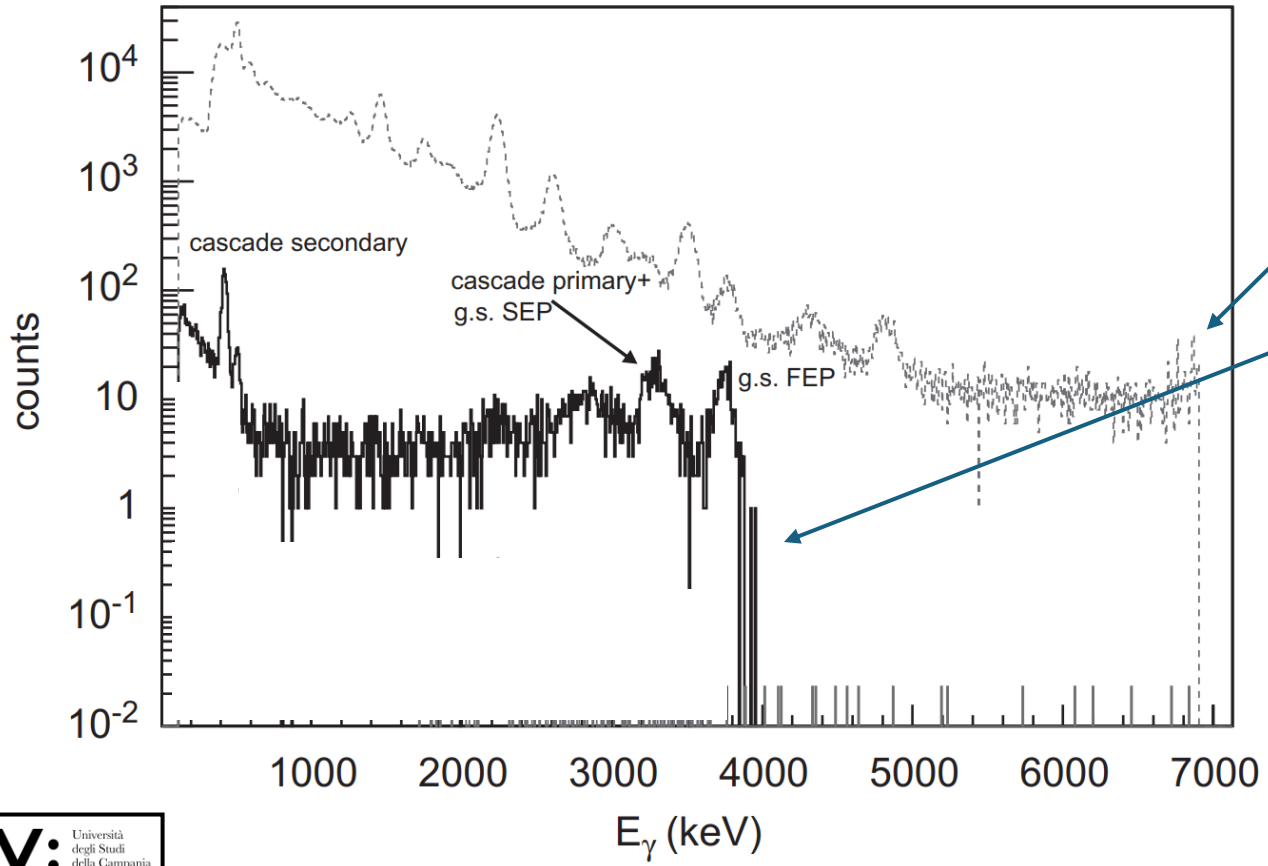
Coincidence condition with any ion



Di Leva et al, Phys.Rev. Lett. 102(2009)
Di Leva et al Nucl. Instr. Meth. A (2008)

ERNA at Bochum:
$^{3}He(^{4}He,\gamma)^{7}Be$





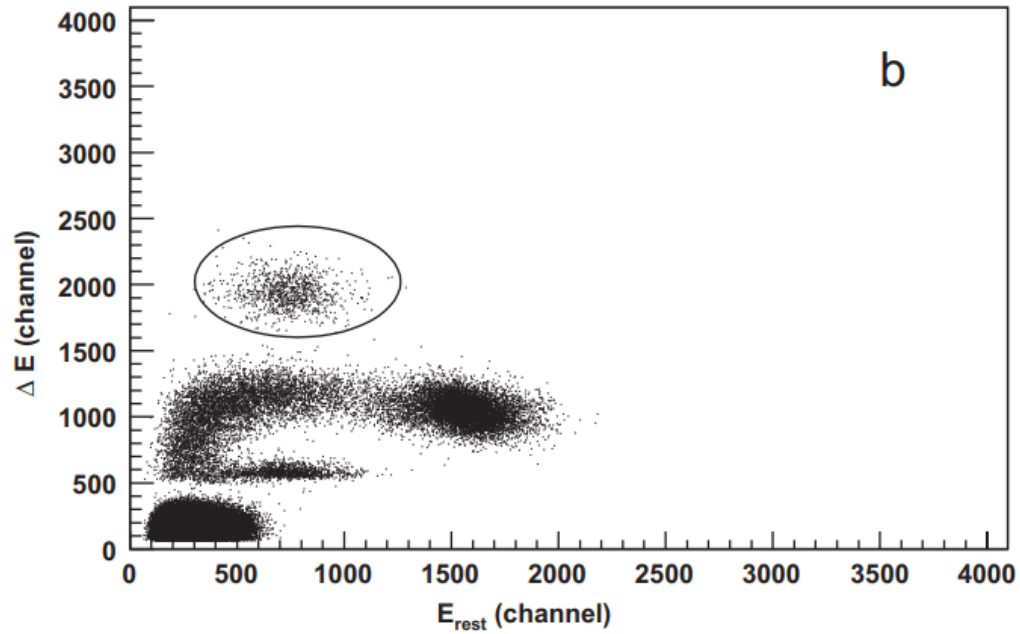
Coincidence condition with any ion

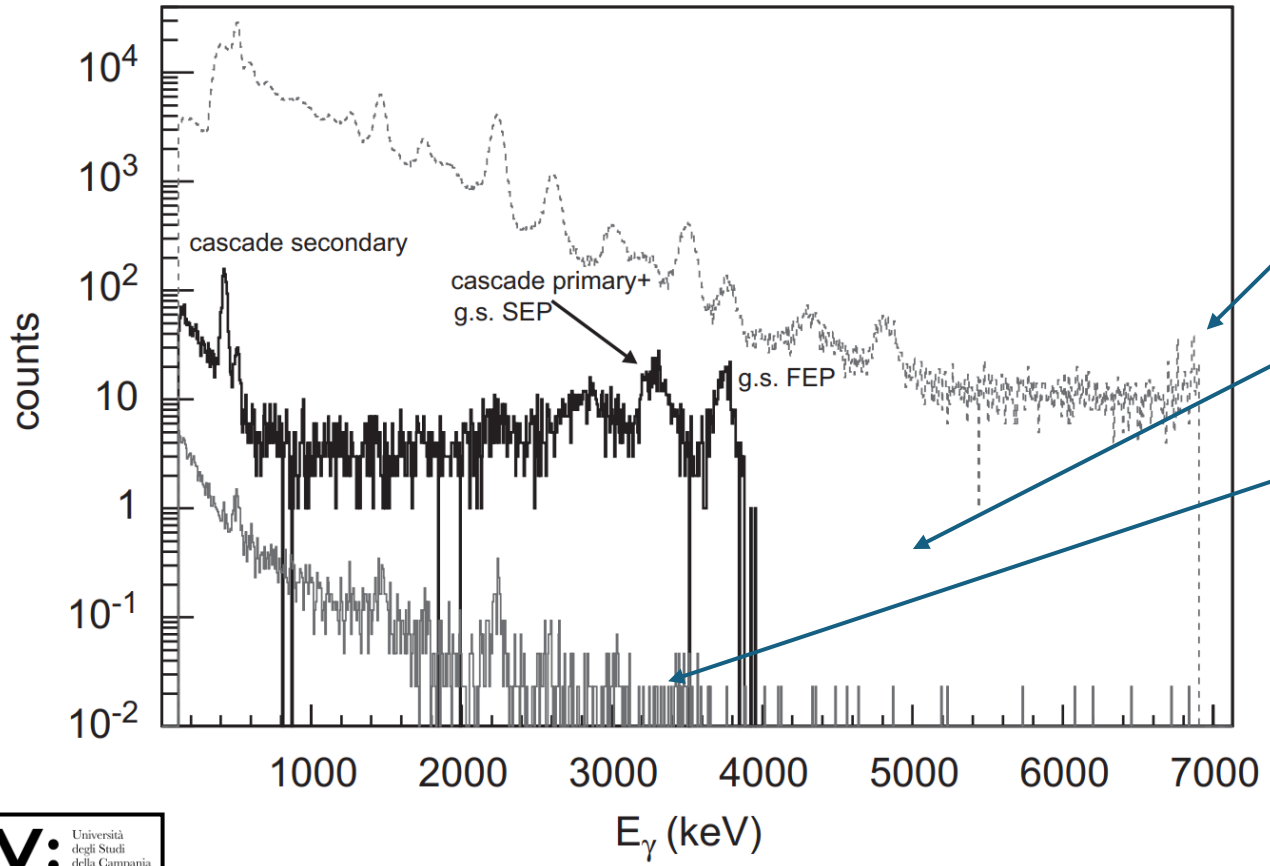
Coincidence condition with 7Be ions

Overall γ–ray background suppression ~ 10^{-5}
NOTE: with no passive shielding

Di Leva et al, Phys.Rev. Lett. 102(2009)
Di Leva et al Nucl. Instr. Meth. A (2008)

ERNA at Bochum:
$^{3}He(^{4}He,\gamma)^{7}Be$





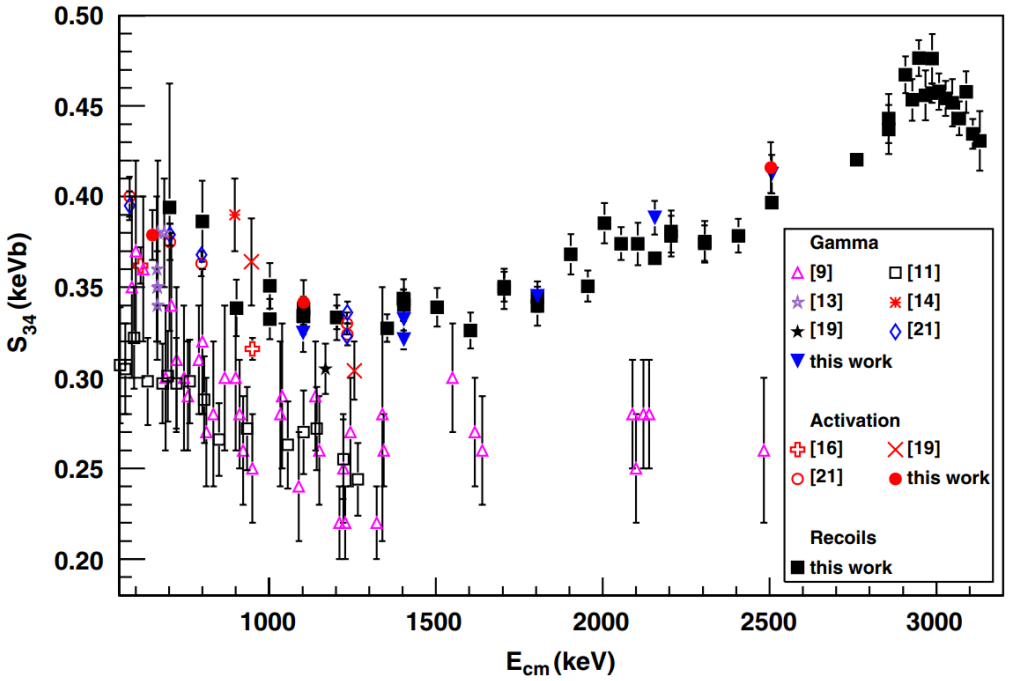
Coincidence condition with any ion

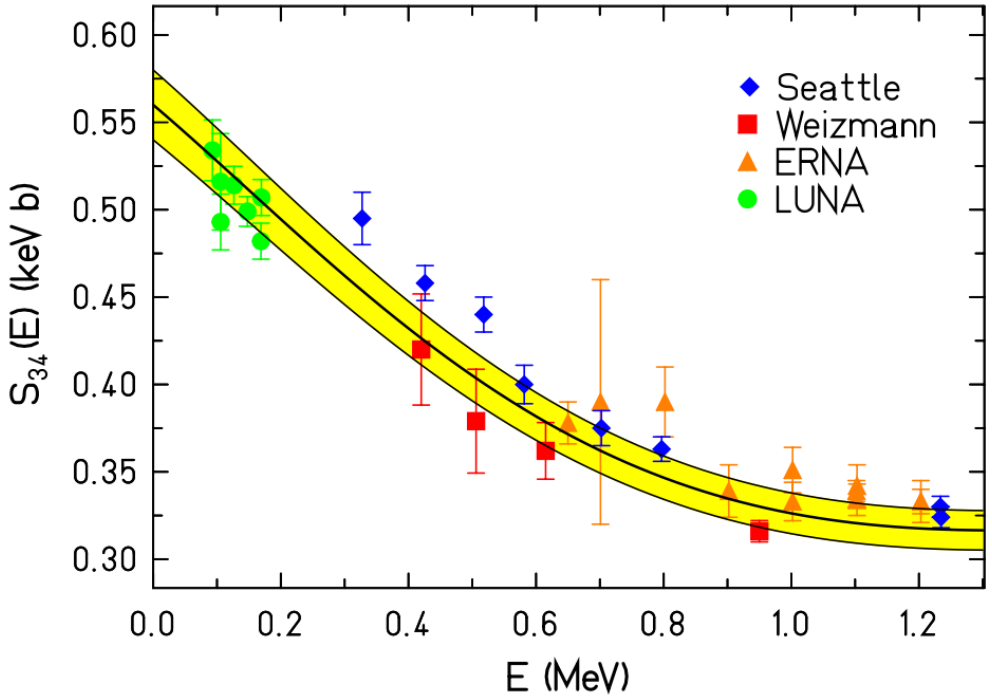
Coincidence condition with 7Be ions

Normalized coincidence with leaky ions,
i.e. residual background

Overall γ–ray background suppression ~ 10^{-5}
NOTE: with no passive shielding

Di Leva et al, Phys.Rev. Lett. 102(2009)
Di Leva et al Nucl. Instr. Meth. A (2008)





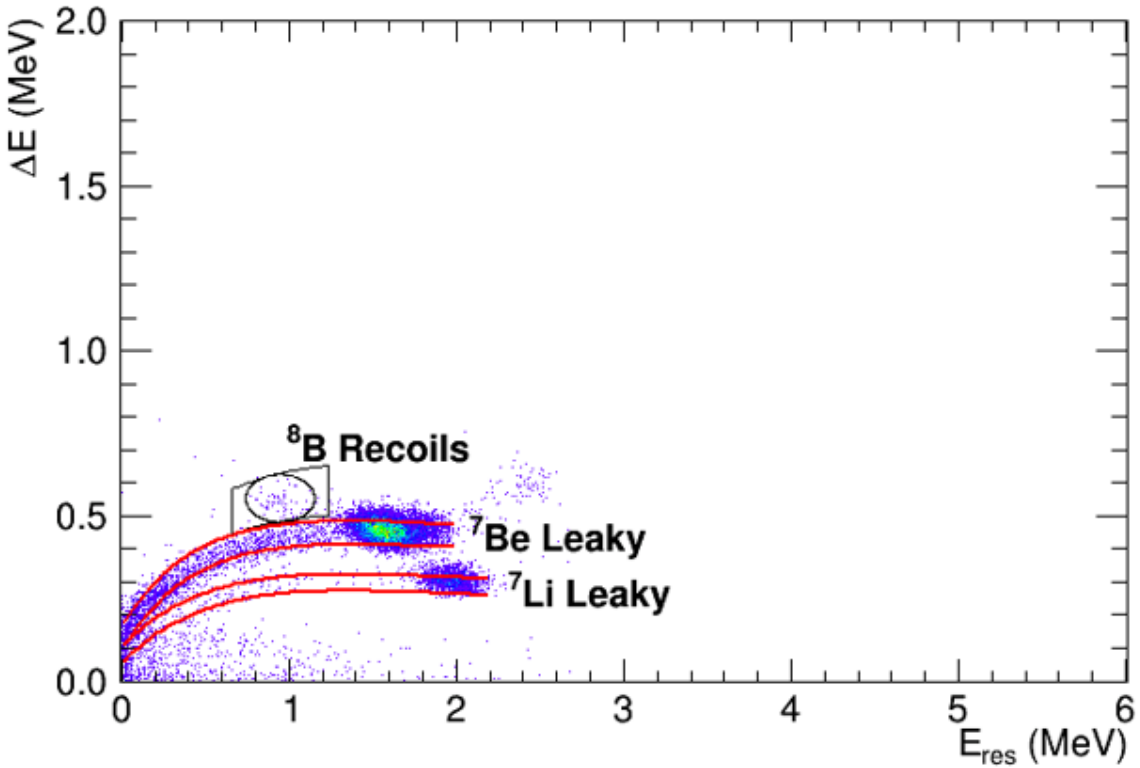
For a recent evaluation:

Solar fusion III: New data and theory for hydrogen-burning stars

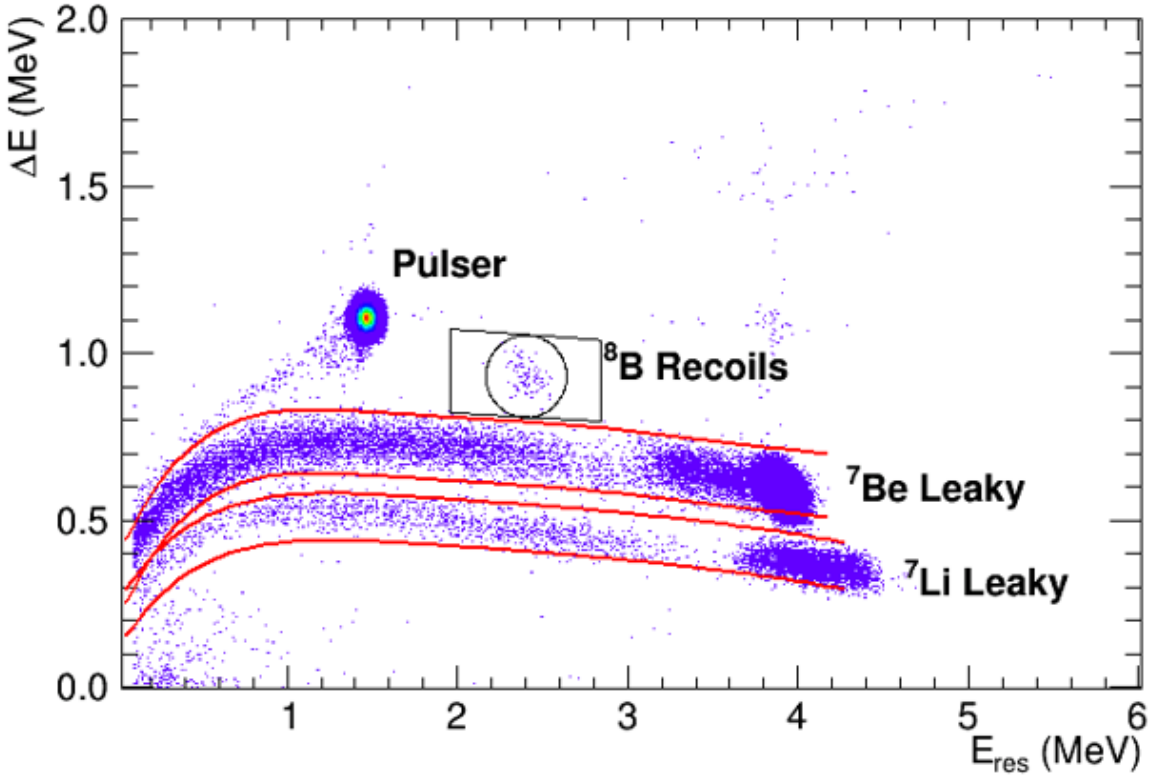
B. Acharya et al.

Rev. Mod. Phys. - Accepted 4 April, 2025

$^{7}Be(p,\gamma)^{8}B$

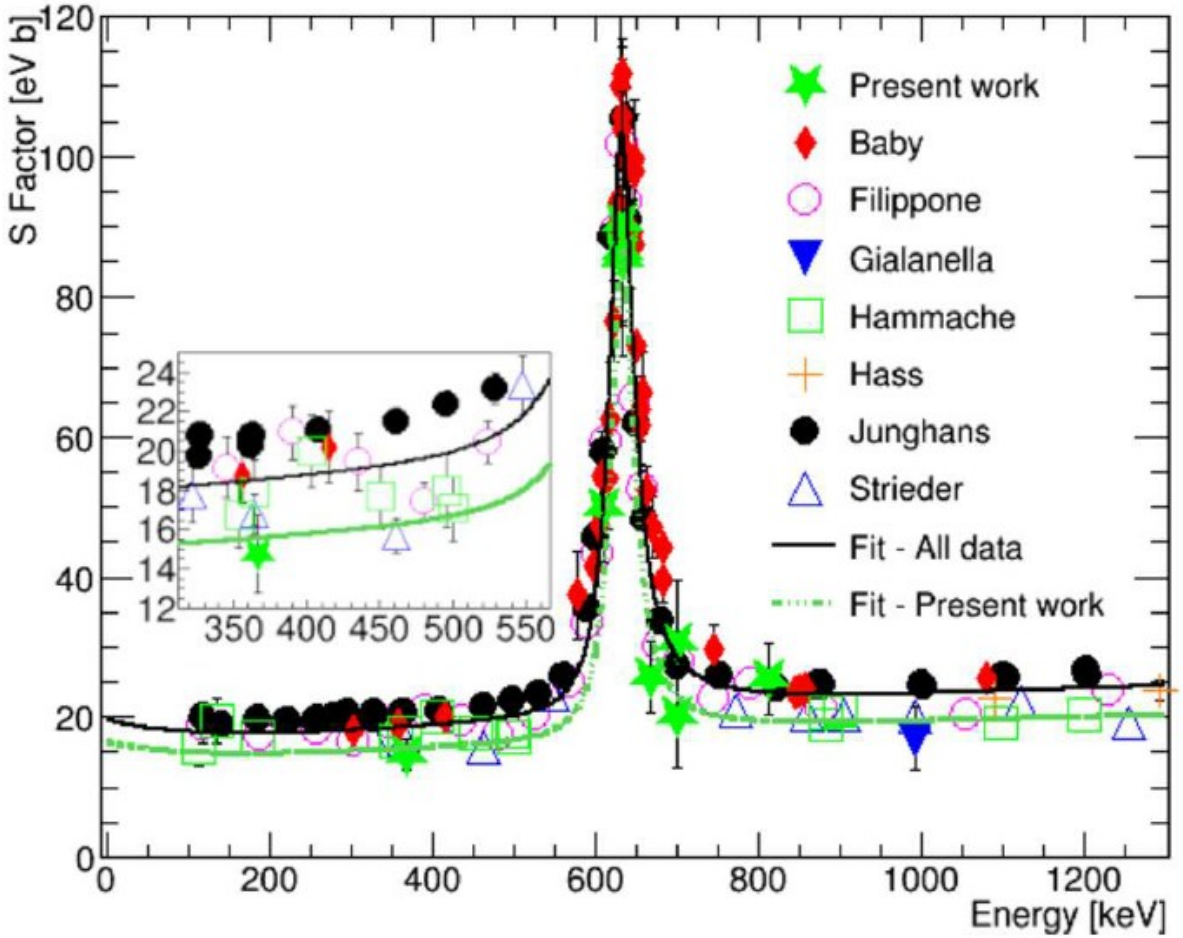


E=367 keV

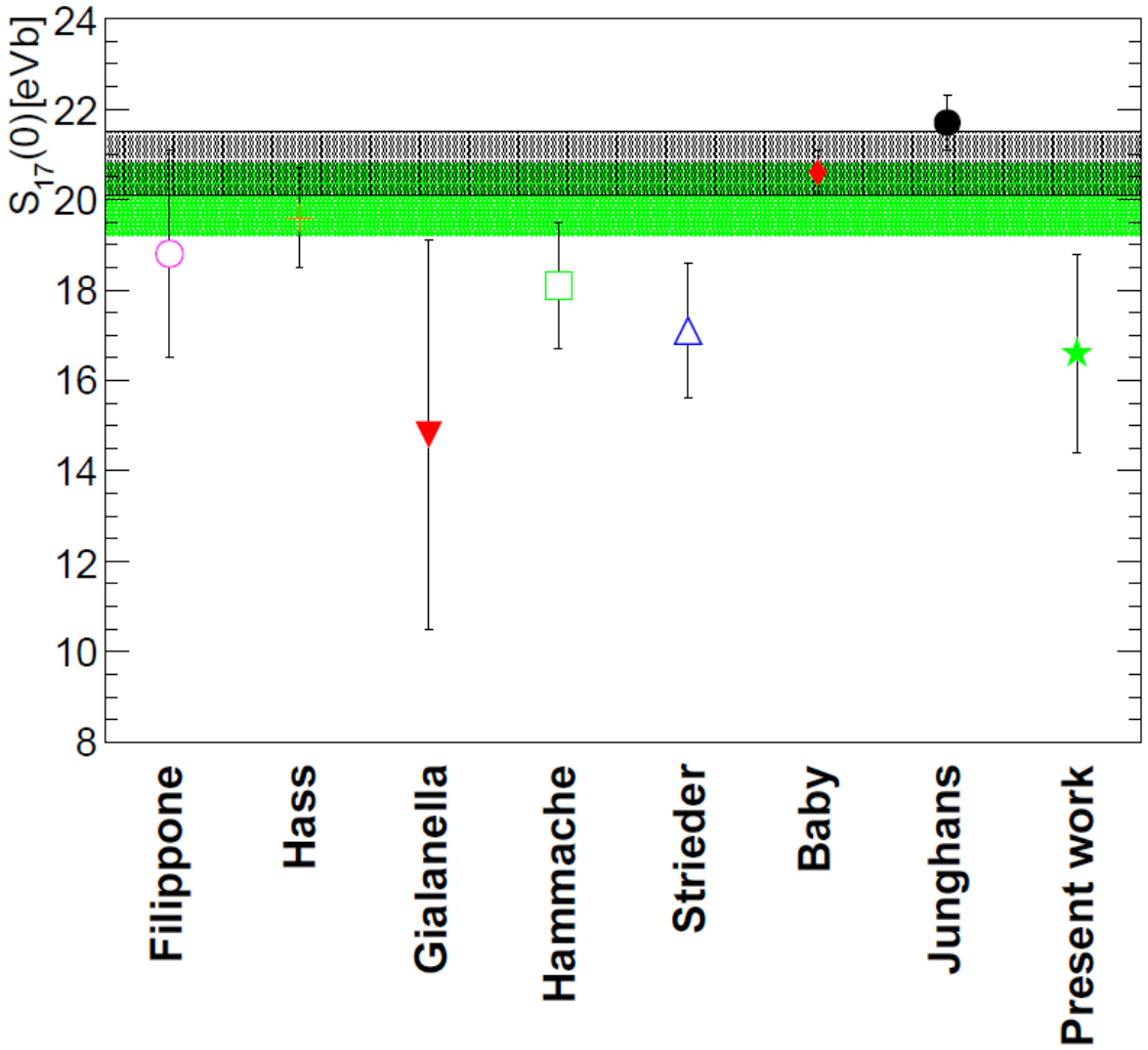


E=632 keV

$^{7}Be(p,\gamma)^{8}B$



Buompane et al, Phys.Lett. B 824(2022)
Buompane et al Eur. Phys. J. A 54(2018)



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B. Acharya et al.
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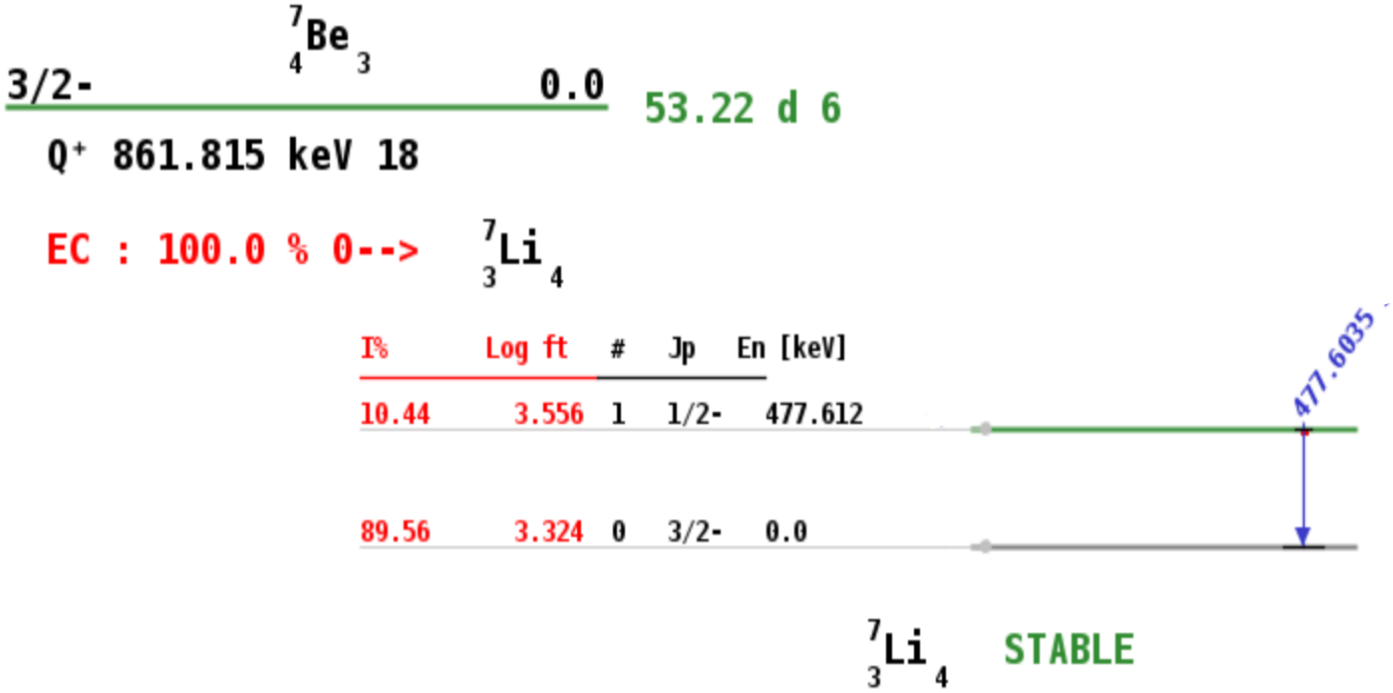
^{7}Be EC decay to ^{7}Li

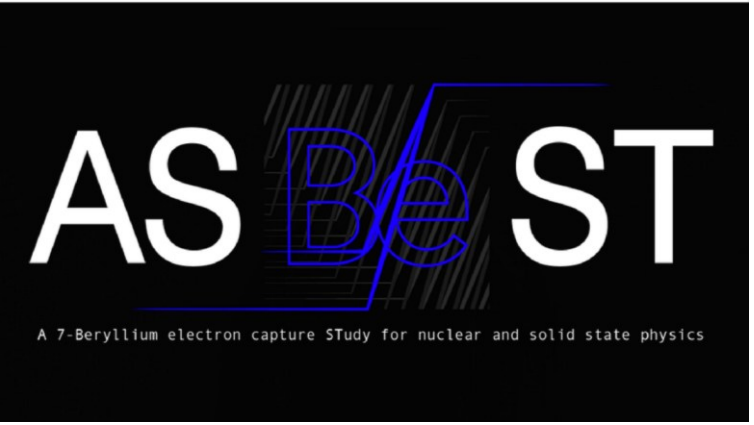


$t_{1/2}=\kappa/f_0\xi$

$\xi=B_F+B_{GT}$

f_0 is determined by the environmental conditions

- **ionization state**
- **chemical bounds**



A 7-Beryllium electron capture STudy for nuclear and solid state physics (ASBeST)

MUR
Ministero dell'Università e della Ricerca

How can we change f_0 in a laboratory?

In solid state environments

Università degli Studi della Campania *Luigi Vanvitelli*

Dipartimento di Matematica e Fisica

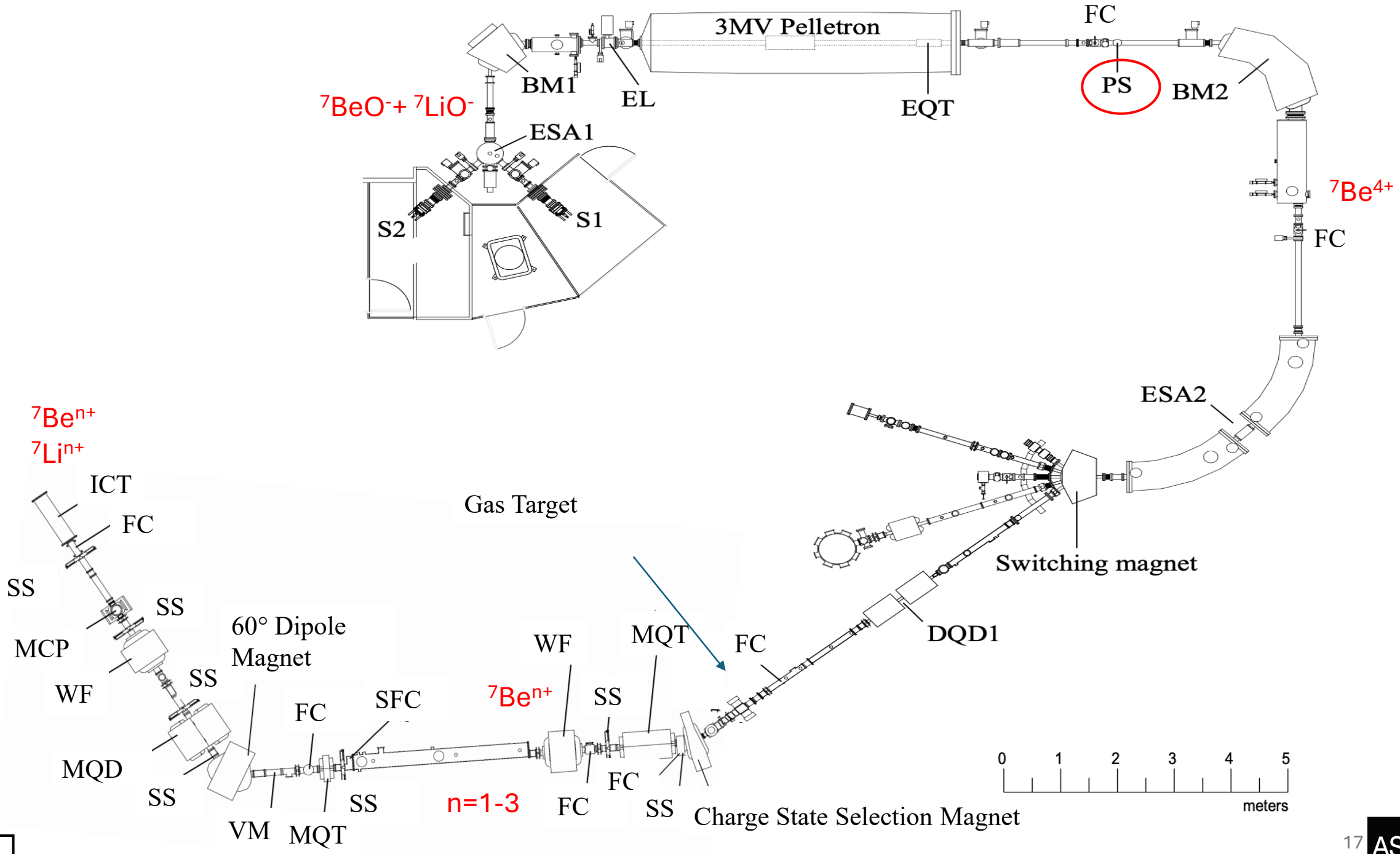
Università di Salerno
Dipartimento di Ingegneria Industriale

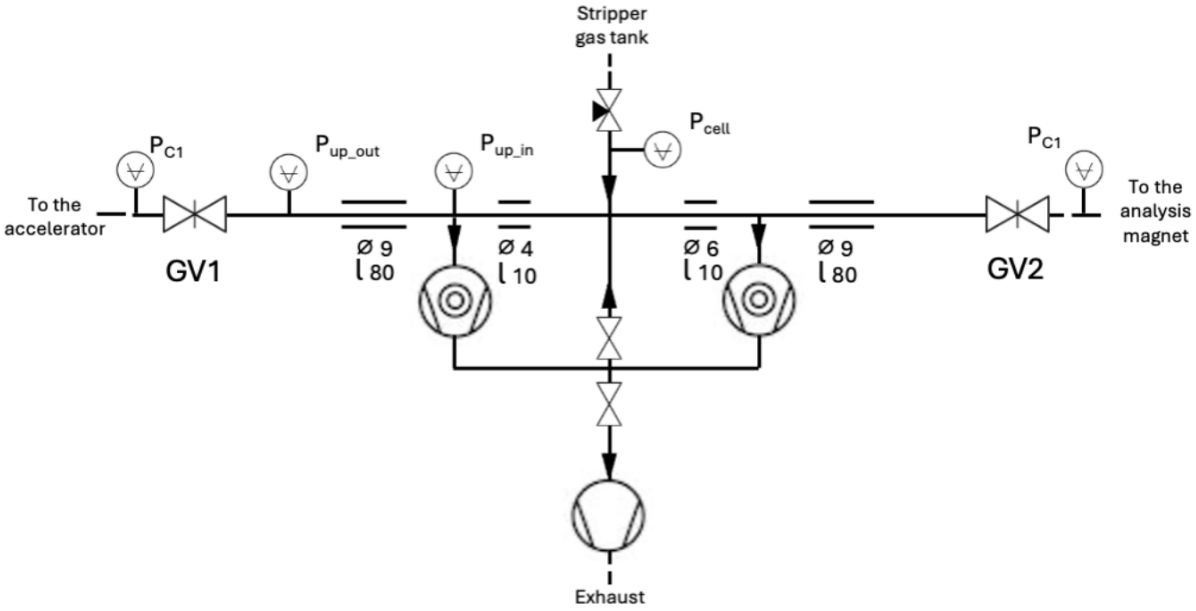
INFN LNGS

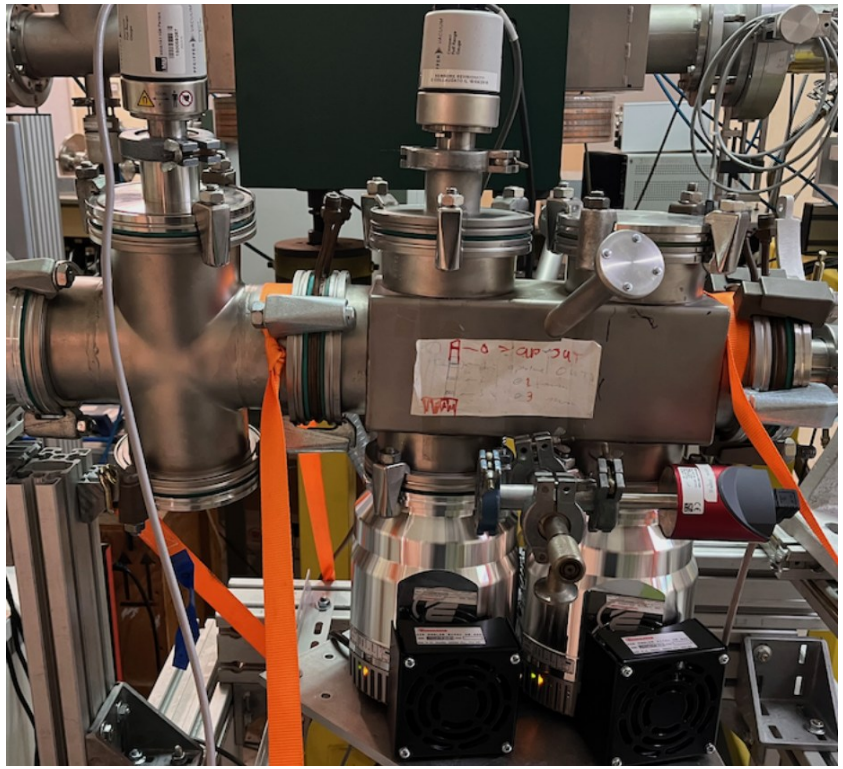
In ions

INFN ROMA

IMM Institute for Microelectronics and Microsystems


3MV Pelletron
FC
PS
BM2
BM1
EL
EQT
$^{7}BeO^{-}$+ $^{7}LiO^{-}$
ESA1
S2
S1
$^{7}Be^{4+}$
FC
ESA2
$^{7}Be^{n+}$
$^{7}Li^{n+}$
ICT
FC
Gas Target
SS
SS
MCP
60° Dipole Magnet
SS
WF
MQT
FC
DQD1
Switching magnet
SFC
FC
$^{7}Be^{n+}$
WF
SS
MQD
FC
SS
n=1-3
FC
SS
Charge State Selection Magnet
VM
MQT
SS
0 1 2 3 4 5
meters

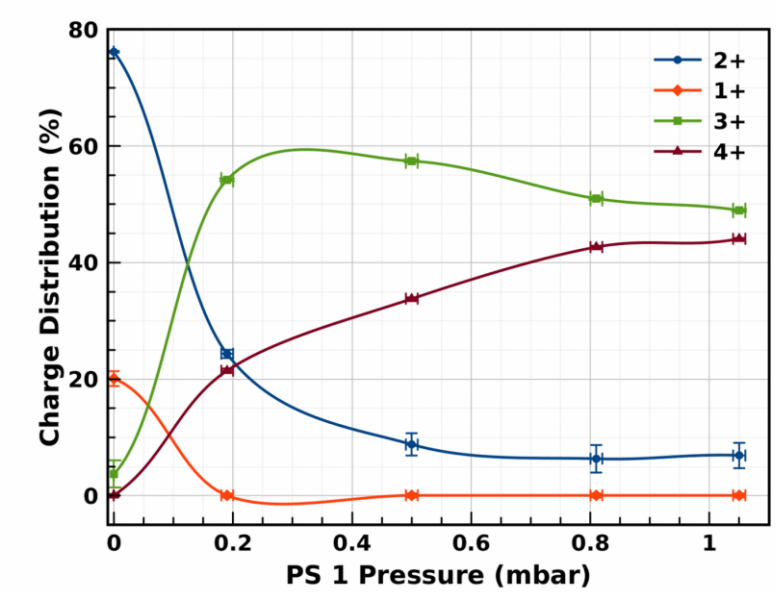

Stripper
gas tank
P_cell
P_C1
P_up_out
P_up_in
P_C1
To the
accelerator
To the
analysis
magnet
Ø 9
l 80
Ø 4
l 10
Ø 6
l 10
Ø 9
l 80
GV1
GV2
Exhaust

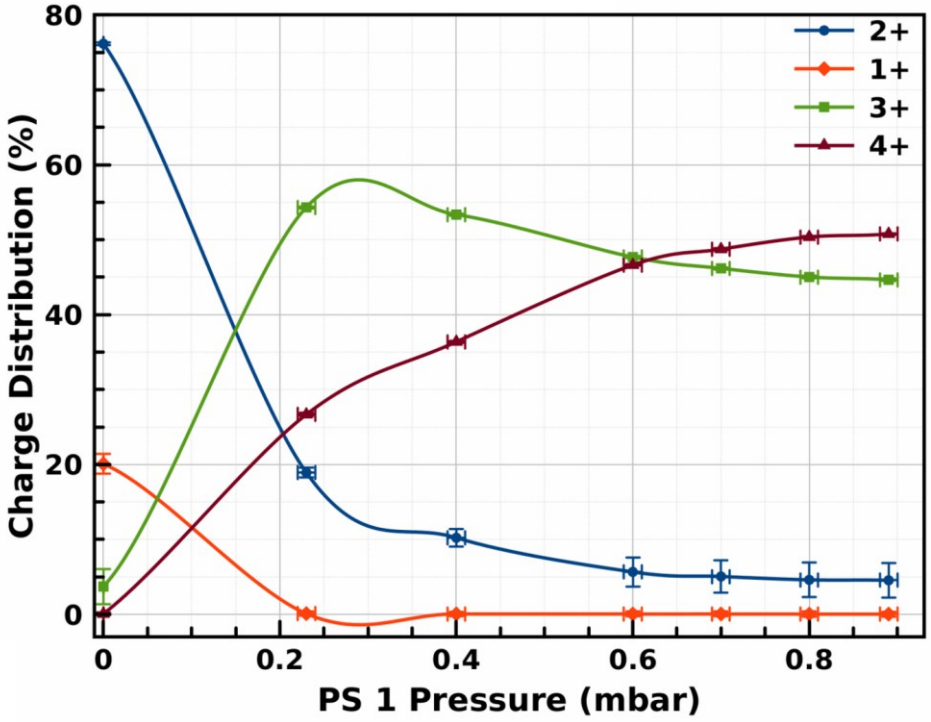


Ar gas

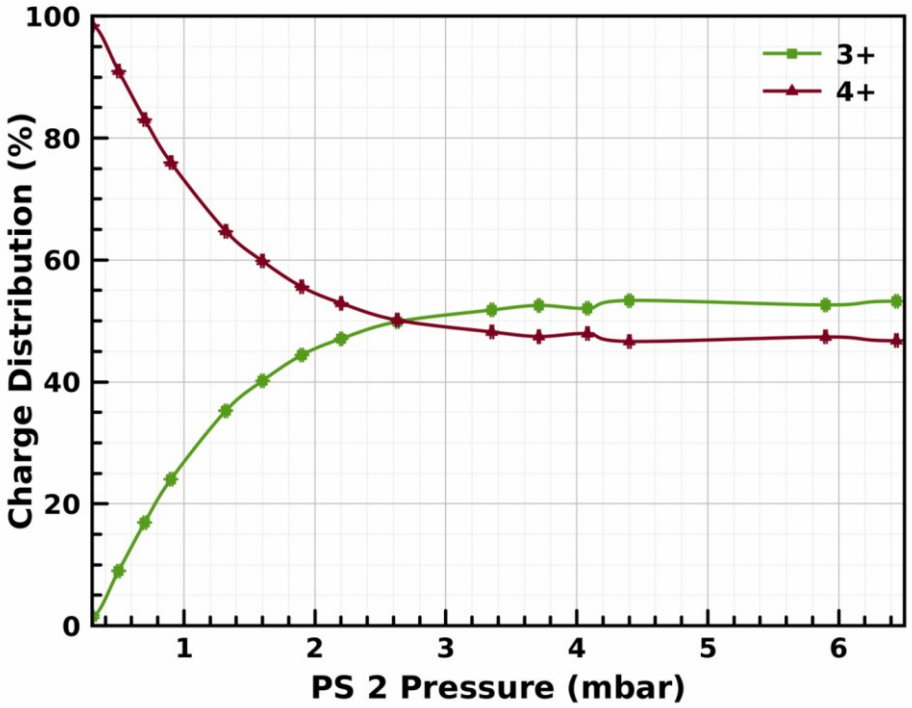
N2 gas

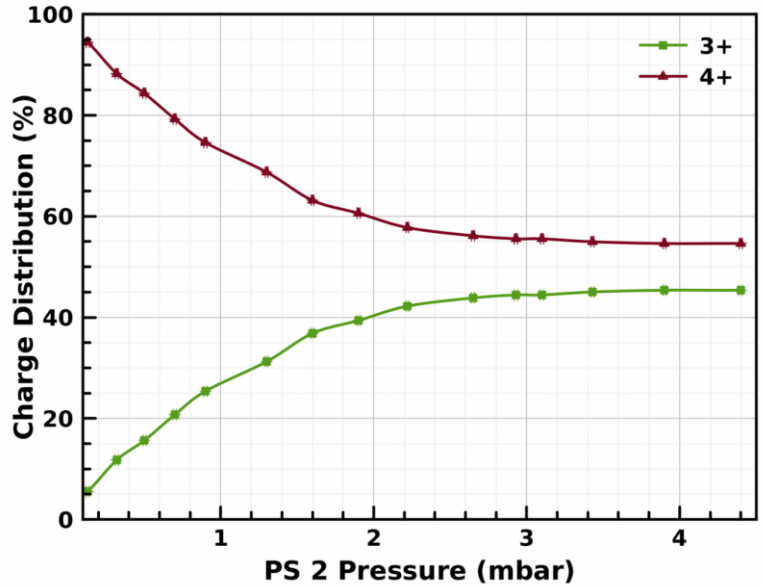
1st charge exchange





2nd charge exchange





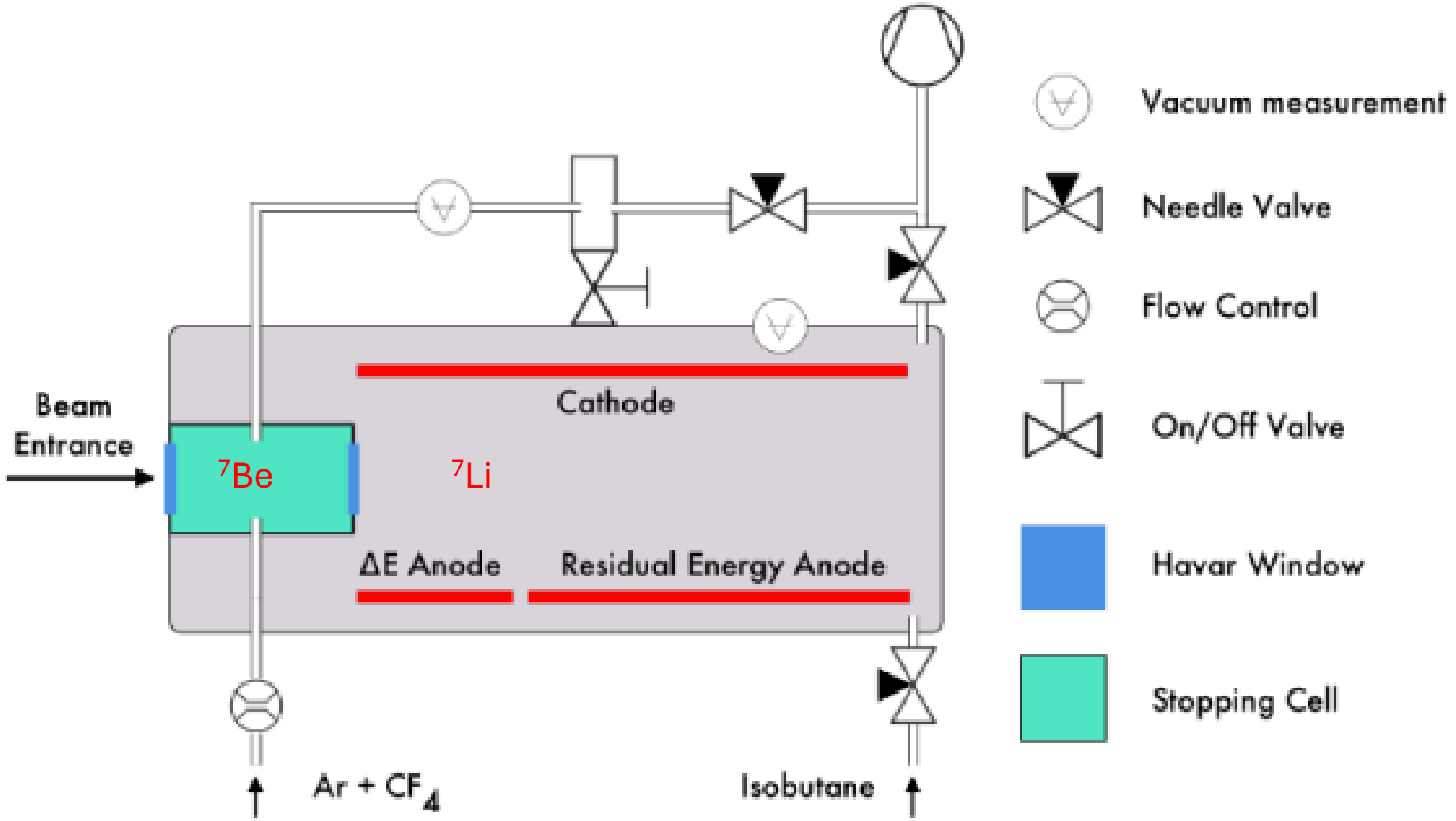


Fig WP1.2.1 Scheme of the setup of the Ionization Chamber with the additional cell.

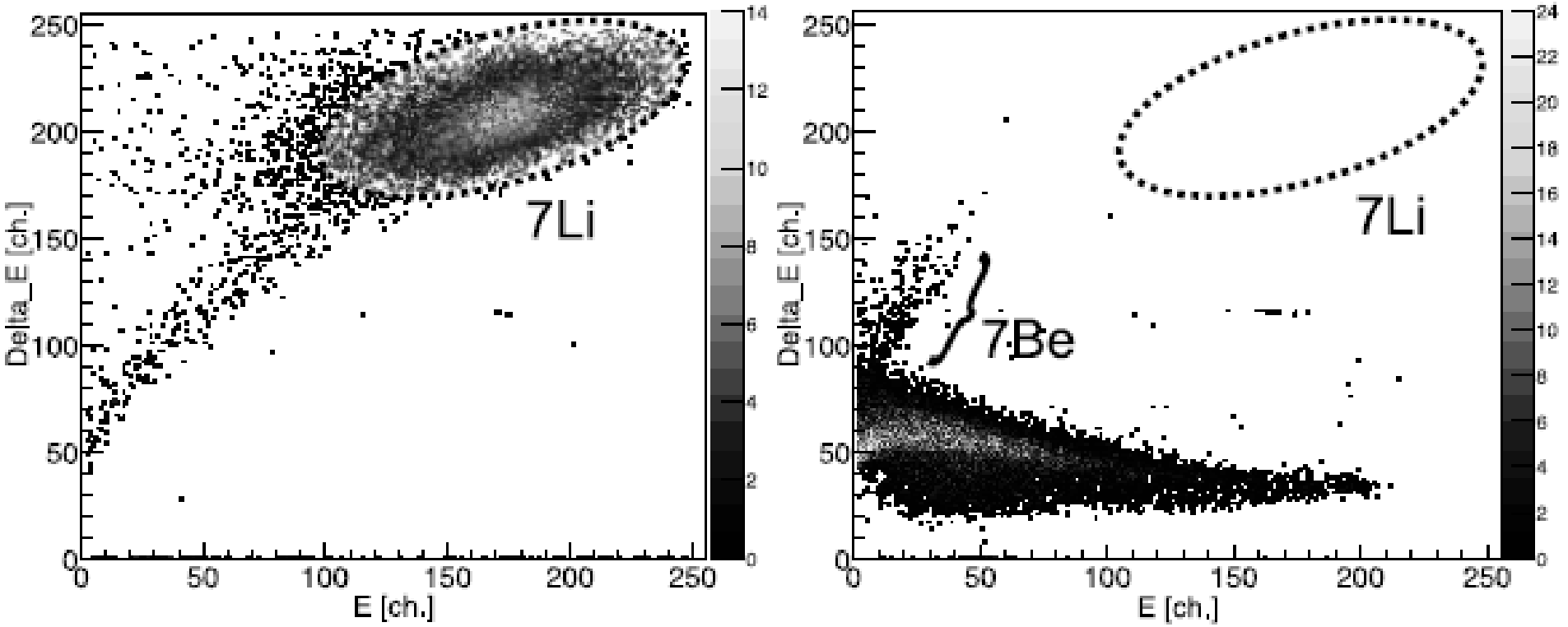


Fig. WP 1.2.2 $\Delta E/E$ matrices with a test ^{7}Li beam (left) and a ^{7}Be beam (right). ^{7}Li spot is circled in the matrices. ^{7}Be ions may channel through windows causing events on the left of the matrix.

1. A long run with high intensity ^{7}Li beam injected shows that ^{7}Li is sufficiently suppressed
2. We plan to use 40 GBq to reach above 500 counts in the 3+ charge states

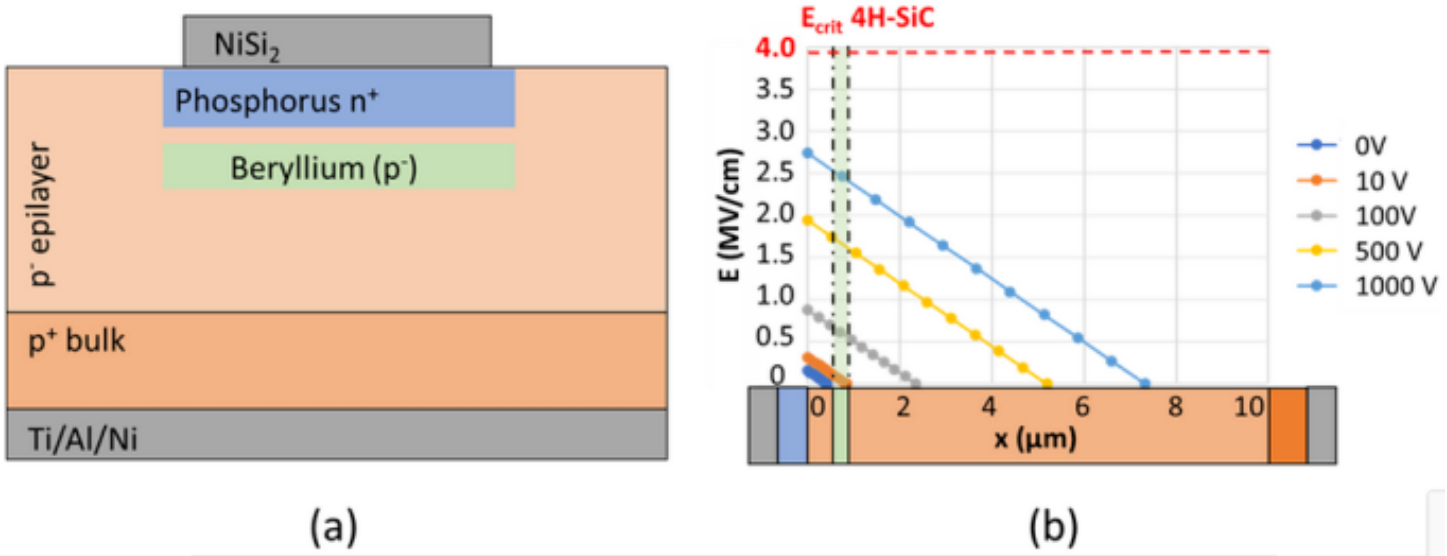
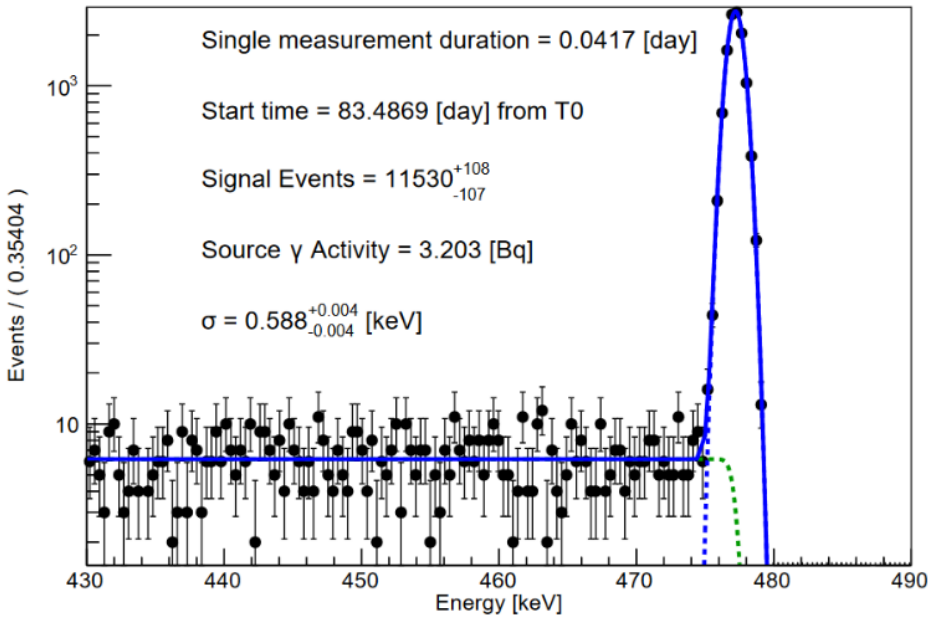


Figure WP2.1.1 layout of the devices used to constrain the NME of the 7Be decay (a); electric field in different positions of the epitaxial layer in different reverse bias conditions (b). In order to highlight the location close to the junction, the pictures in (a) and (b) are not in scale.

In the meanwhile, a high precision and accuracy measurement of the ^{7}Be halfllife at LNGS

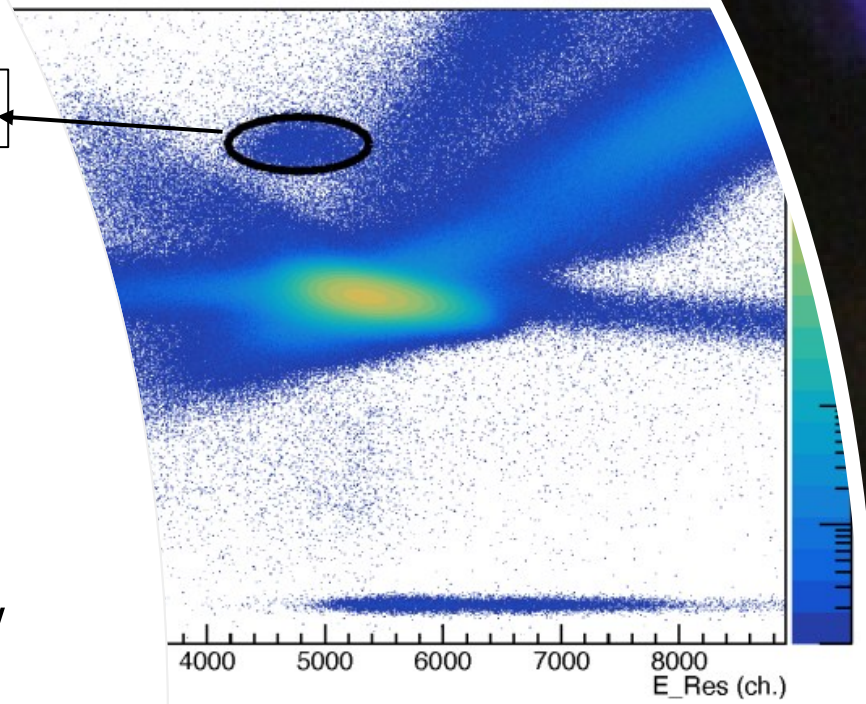


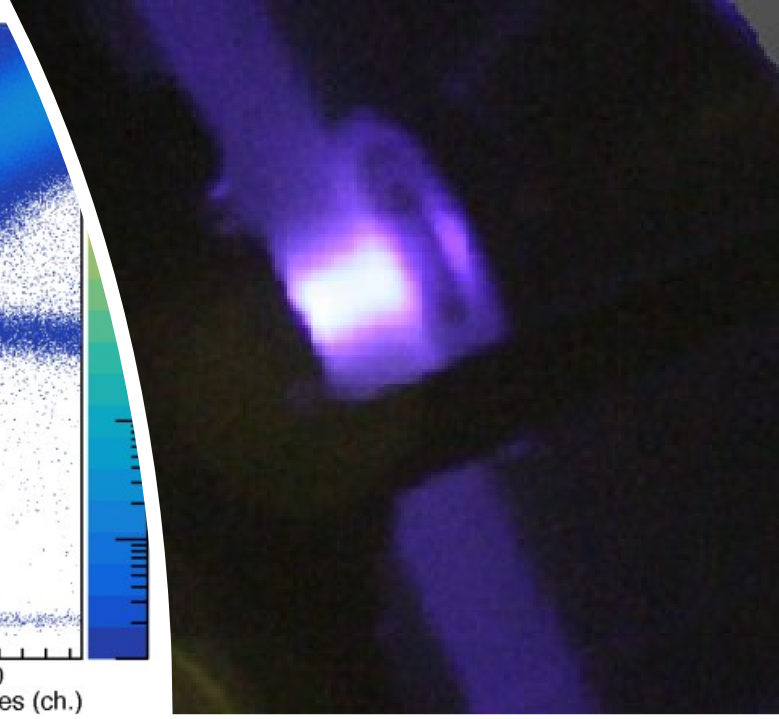
$T_{1/2}$ = 53.284 ± 0.016 d
Santonastaso et al Journal of Physics G 52, Issue 3

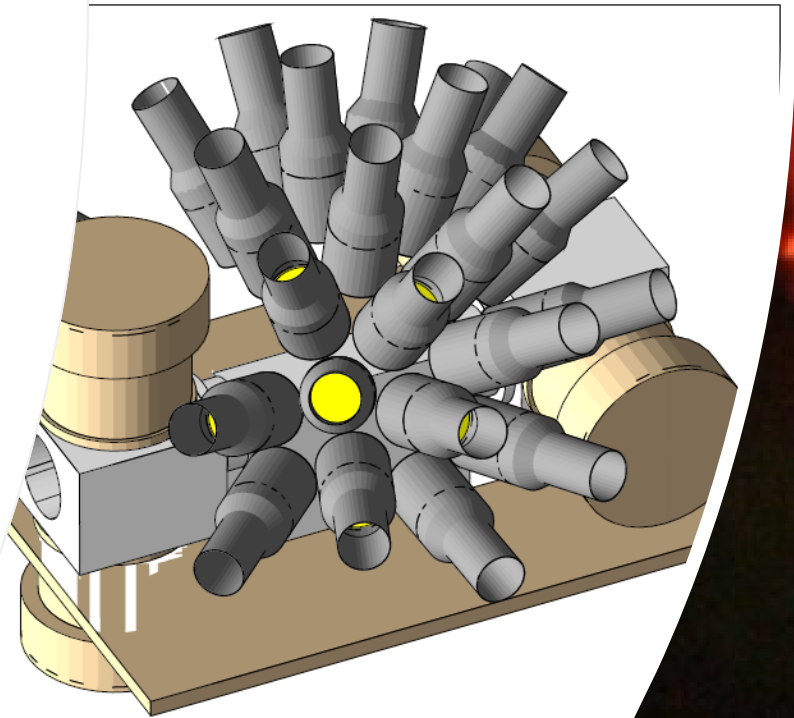
Outlook:

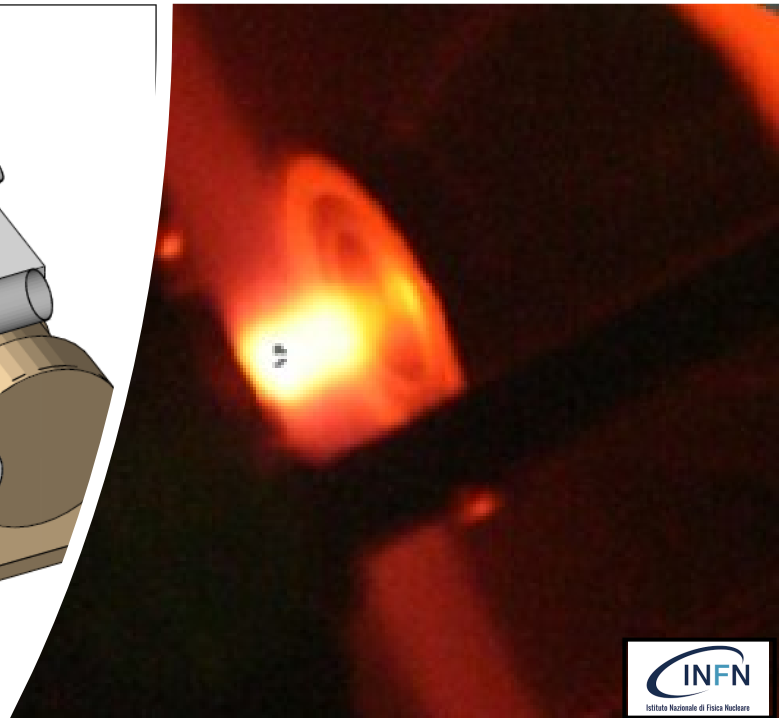
1. Complete 7Be EC measurements when enough 7Be will be available

2. Measurements of $^{12}C(\alpha,\gamma)^{16}O$ with the new jet target and NaI array









Voir en français

ALICE detects the conversion of lead into gold at the LHC

Near-miss collisions between high-energy lead nuclei at the LHC generate intense electromagnetic fields that can knock out protons and transform lead into fleeting quantities of gold nuclei

ERNA detects the conversion of carbon into oxygen at CIRCE

Low-energy head-on collisions between carbon and helium nuclei at CIRCE fortunately cross the Coulomb barrier and transform carbon into fleeting quantities of oxygen nuclei.