Search for γ decay of near-threshold states in light nuclei

Simone Bottoni

Università degli Studi di Milano
INFN Sezione di Milano

Collaborations

S. Bottoni[a,b], G. Corbari[a,b], S. Leoni[a,b], B. Fornal[c], A. Goasduff[d], S. Capra[a,b], D. Mengoni[e,f], E. Albanese[a,b], S. Ziliani[a,b], G. Benzoni[b], A. M. Sánchez-Benítez[g], A. Bracco[a,b], D. Brugnara[d], F. Camera[a,b], M. Ciemała[c], N. Cieplicka-Oryńczak[c], F. C. L. Crespi[a,b], J. A. Dueñas[h], A. Gadea[i], F. Galtarossa[f], E. Gamba[a,b], A. Gottardo[d], A. Gozzelino[d], J. Ha[f], Ł. W. Iskra[c], T. Marchi[d], R. Menegazzo[f], B. Million[b], D. R. Napoli[d], G. Pasqualato[e,f], J. Pellumaj[d,j], R. Pérez-Vidal[d,i], S. Pigliapoco[e,f], M. Polettini[a,b], C. Porzio[a,b,1], F. Recchia[e,f], K. Rezynkina[e,f], J J. Valiente-Dóbon[d], O. Wieland[b], I. Zanon[d], G. Zhang[e,f]

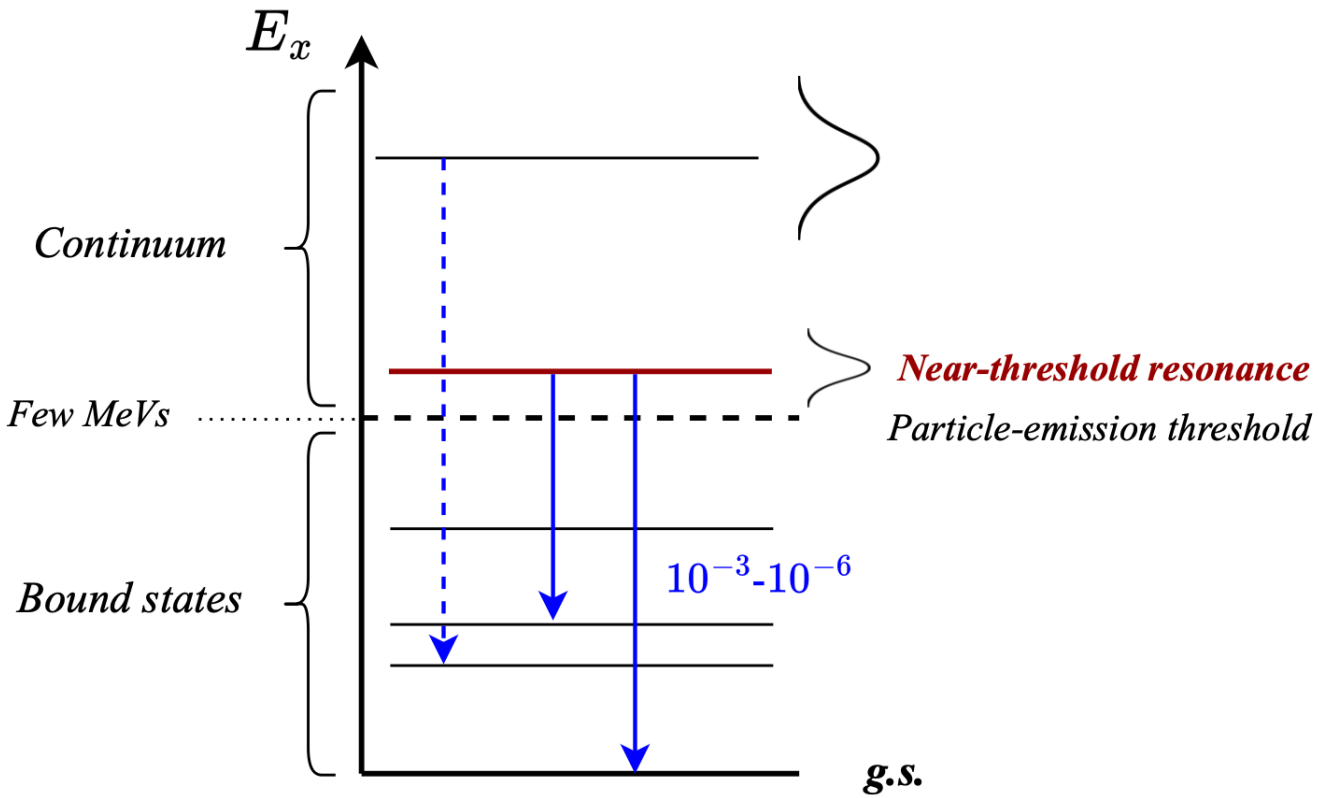
[a]Dipartimento di Fisica, Università degli Studi di Milano, Via Celoria 16, Milano, I-20133, Italy
[b]INFN Sezione di Milano, Via Celoria 16, Milano, I-20133, Italy
[c]Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, Krakow, PL-31342, Poland
[d]INFN Laboratori Nazionali di Legnaro, Viale dell'Università 2, Legnaro, I-35020, Italy
[e]Dipartimento di Fisica, Università degli Studi di Padova, Via Marzolo 8, Padova, I-35131, Italy
[f]INFN Sezione di Padova, Via Marzolo 8, Padova, I-35131, Italy
[g]Departamento de Ciencias Integradas y Centro de Estudios Avanzados en Física, Matemáticas y Computación (CEAFMC), Universidad de Huelva, Campus de El Carmen, Avda. de las Fuerzas Armadas, s/n., Huelva, E-21007, Spain
[h]Departamento de Ingeniería Eléctrica y Centro de Estudios Avanzados en Física, Matemáticas y Computación (CEAFMC), Universidad de Huelva, Campus de El Carmen, Avda. de las Fuerzas Armadas, s/n., Huelva, E-21007, Spain
[i]IFIC, CSIC-Universitat de Valencia, Catedrático José Beltrán 2, Valencia, E-46980, Spain
[j]Dipartimento di Fisica e Scienze della Terra, Università degli Studi di Ferrara, Via Giuseppe Saragat 1, Ferrara, I-44122, Italy

Collaborations

G. Corbari[a,b], S. Bottoni[a,b], M. Ciemała[c], S. Leoni[a,b], B. Fornal[c], R. V. F. Janssens[d,e], S. D. Pain[g], J. Okołowicz[f], M. Płoszajczak[f], F. C. L Crespi[a,b], M. Siciliano[h], E. Albanese[a,b], A. D. Ayangeakaa[d,e], G. Benzoni[b], S. Carmichael[i], M. Carpenter[h], K. Chipps[g], N. Cieplicka-Oryńczak[c], A. Cizewski[k], P. Copp[h], M. Febbraro[g], J. Forson[j], E. Gamba[a,b], H. Garland[k], G. Gilardy[k], J. Hooker[j], Ł. W. Iskra[c], H. Jayatissa[h], F. Kondev[h], K. Jones[j], M. D. Jones[d], T. Lauritsen[h], J. Li[h], D. Little[d], B. Million[b], C. Mueller-Gatermann[h], A. Palmisano[j], M. Polettini[a,b], C. Porzio[a,b,1], A. Ratkiewicz[l], W. Reviol[h], N. Sensharma[d,e], D. Seweryniak[h], H. Sims[k], S. Stolz[h], R. Toomey[k], C. Hummel[k], O. Wieland[b], G. Wilson[h,m], J. Wu[h], S. Zhu[n], S. Ziliani[a,b]

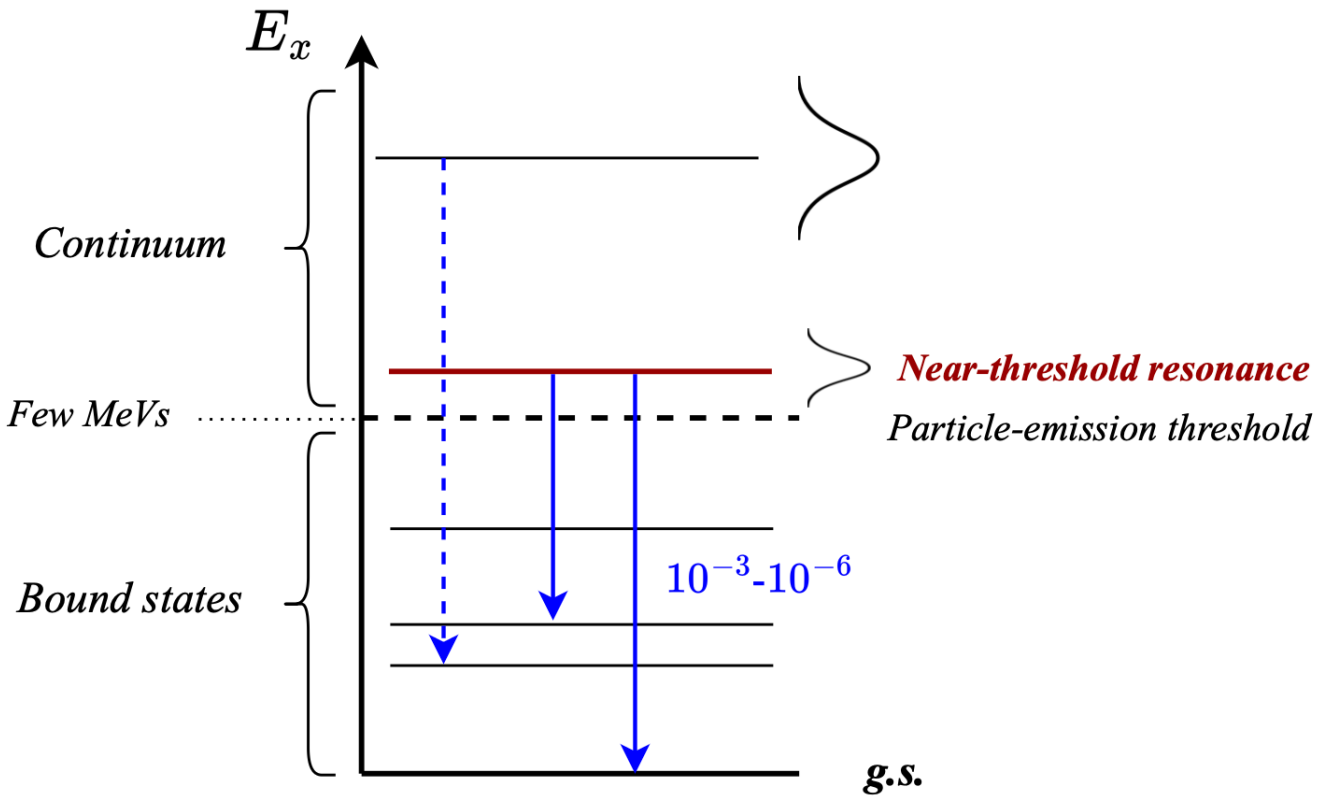
[a] *Università degli Studi di Milano, via Celoria 16, Milano, I-20133, Italy*
[b] *INFN Sezione di Milano, via Celoria 16, Milano, I-20133, Italy*
[c] *Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, Krakow, PL-31342, Poland*
[d] *University of North Carolina at Chapel Hill, 120 E. Cameron Ave, Chapel Hill, NC-27599, USA*
[e] *Triangle Universities Nuclear Laboratory, Duke University, 116 Science Drive, Durham, NC-27708-0308, USA*
[f] *GANIL,CEA/DRF-CNRS/IN2P3, Bd. Henri Becquerel, BP 55027, Caen, 14076, France*
[g] *Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, TN-37830, USA*
[h] *Argonne National Laboratory, 9700 S. Cass Avenue, Lemont, IL-60439, USA*
[i] *Notre Dame University, 236 Cavanaugh Dr, Notre Dame, IN-46556, USA*
[j] *University of Tennessee-Knoxville, 1408 Circle Dr, Knoxville, TN-37996, USA*
[k] *Rutgers University, 57 US Highway 1, New Brunswick, NJ-08901-8554, USA*
[l] *Lawrence Livermore National Laboratory, 7000 East Ave, Livermore, CA-94550, USA*
[m] *Louisiana State University, 230 Tower Dr, Baton Rouge, LA-70803, USA*
[n] *Brookhaven National Laboratory, 98 Rochester St, Upton, NY-11973-5000, USA*

THE STRUCTURE OF LIGHT NUCLEI AS OPEN QUANTUM SYSTEMS



Simone Bottoni

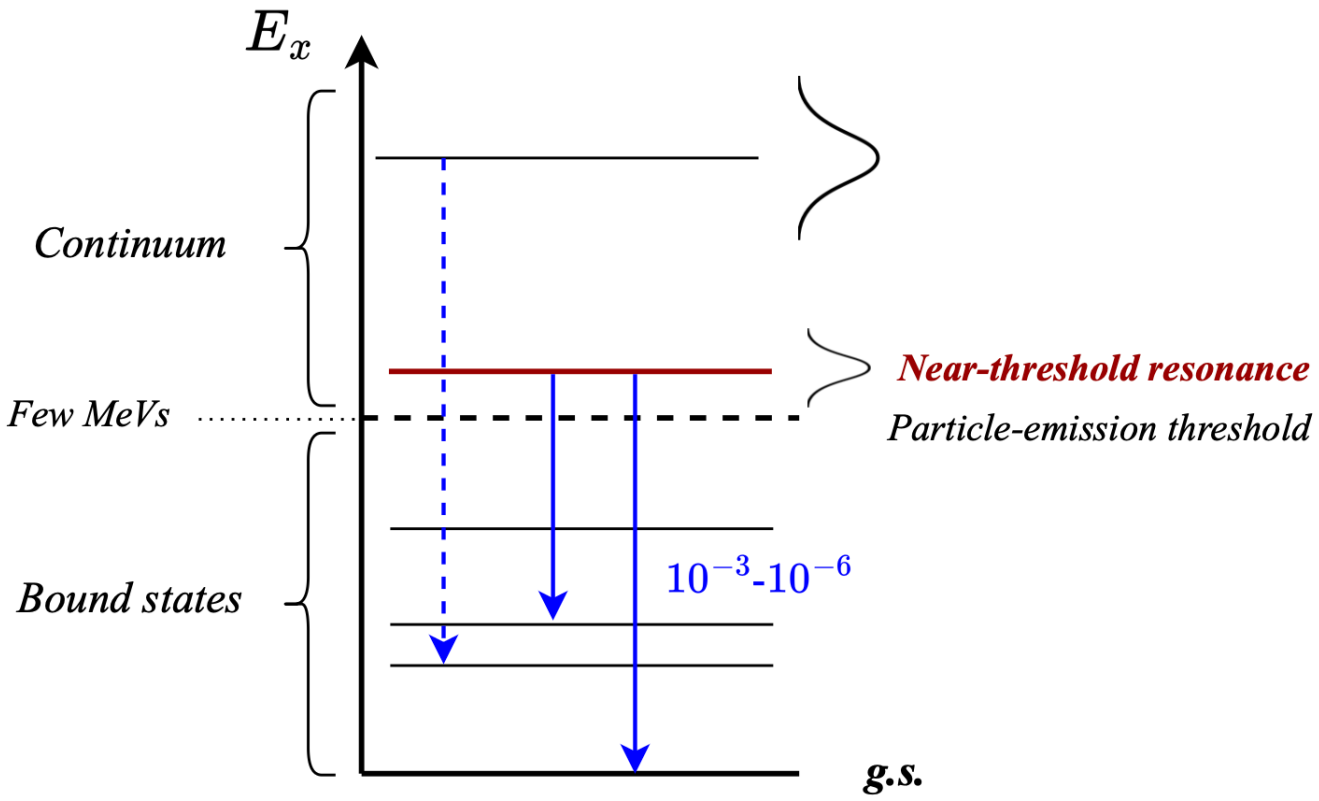
THE STRUCTURE OF LIGHT NUCLEI AS OPEN QUANTUM SYSTEMS



Relevant for understating:

- nuclear clustering
- collectivization
- nucleosynthesis (e.g. ^{12}C)

THE STRUCTURE OF LIGHT NUCLEI AS OPEN QUANTUM SYSTEMS



Relevant for understating:

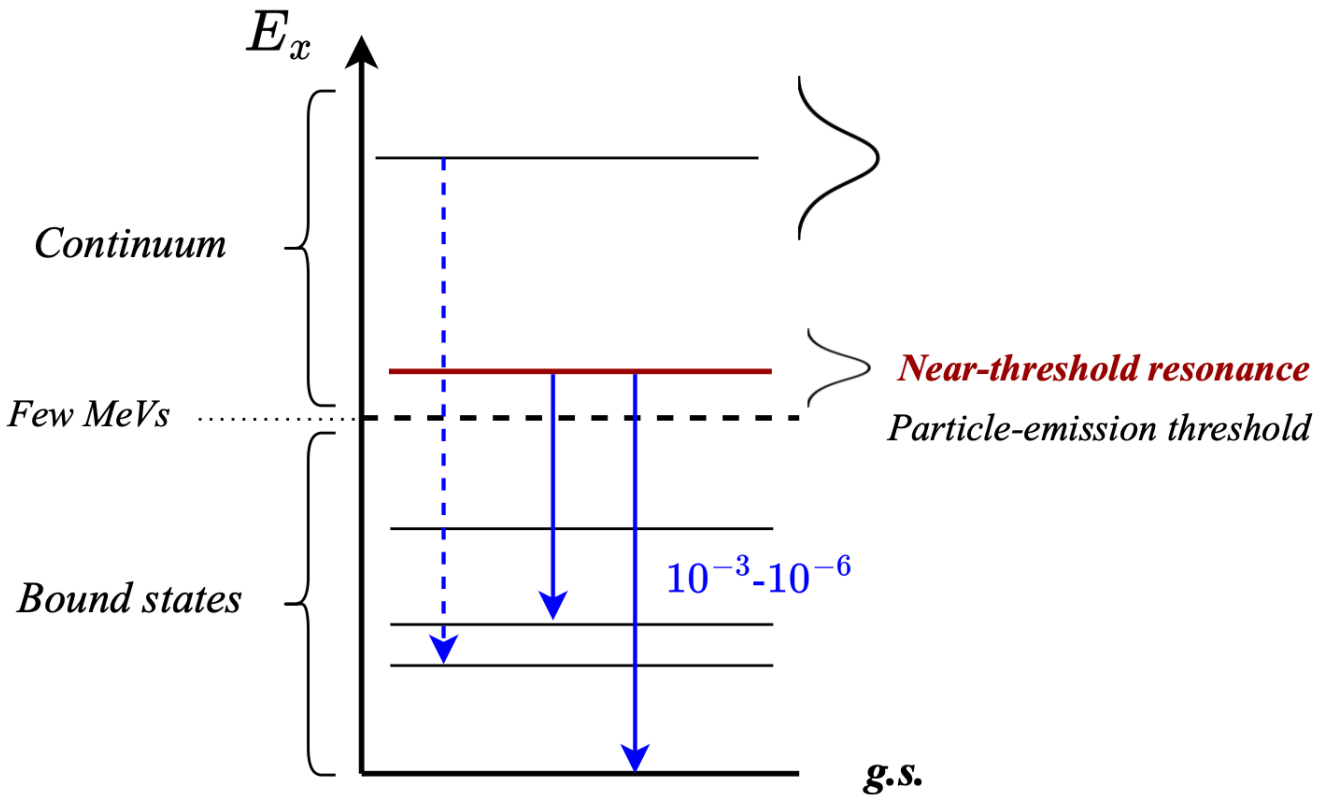
- nuclear clustering
- collectivization
- nucleosynthesis (e.g. ^{12}C)

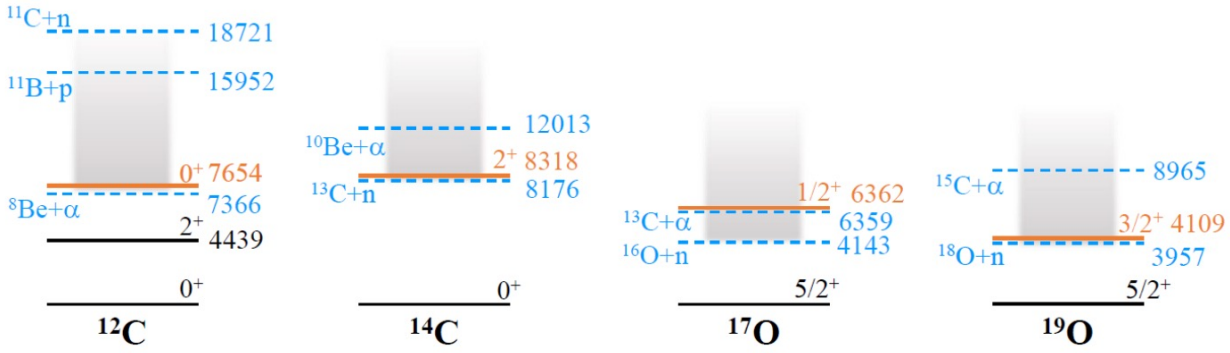
Shell Model Embedded in the Continuum (SMEC)

- coupling with continuum
- universal phenomenon
- core $\otimes$ particle/cluster
- enhanced γ-ray branches

J. Okołowicz *et al.*, Phys. Rep. **374**, 271 (2003)

THE STRUCTURE OF LIGHT NUCLEI AS OPEN QUANTUM SYSTEMS





Relevant for understating:

- nuclear clustering
- collectivization
- nucleosynthesis (e.g. ^{12}C)

Shell Model Embedded in the Continuum (SMEC)

- coupling with continuum
- universal phenomenon
- core ⊗ particle/cluster
- enhanced γ-ray branches

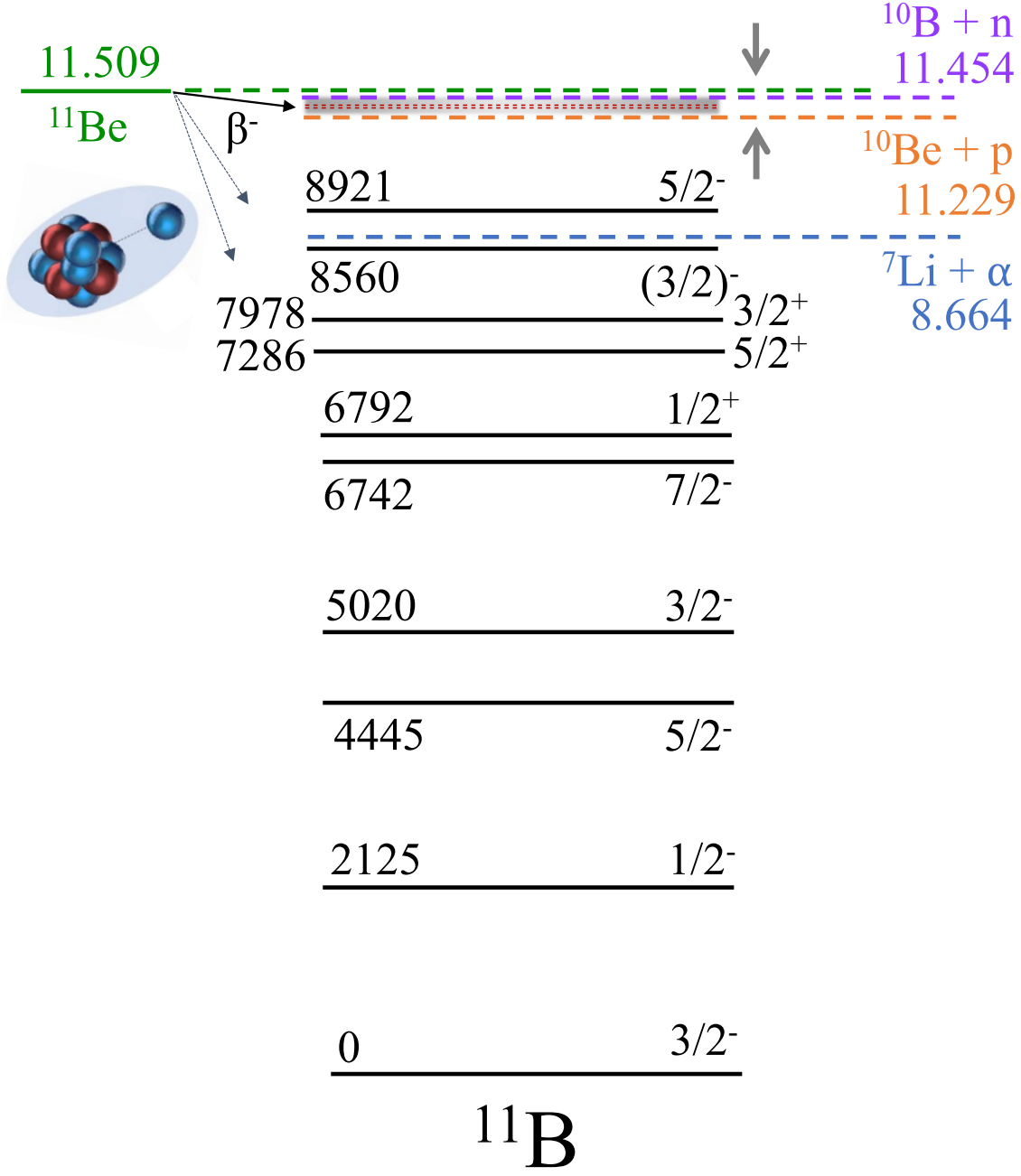
J. Okołowicz *et al.*, Phys. Rep. **374**, 271 (2003)

γ rays as probes to investigate the wavefunction

INPC

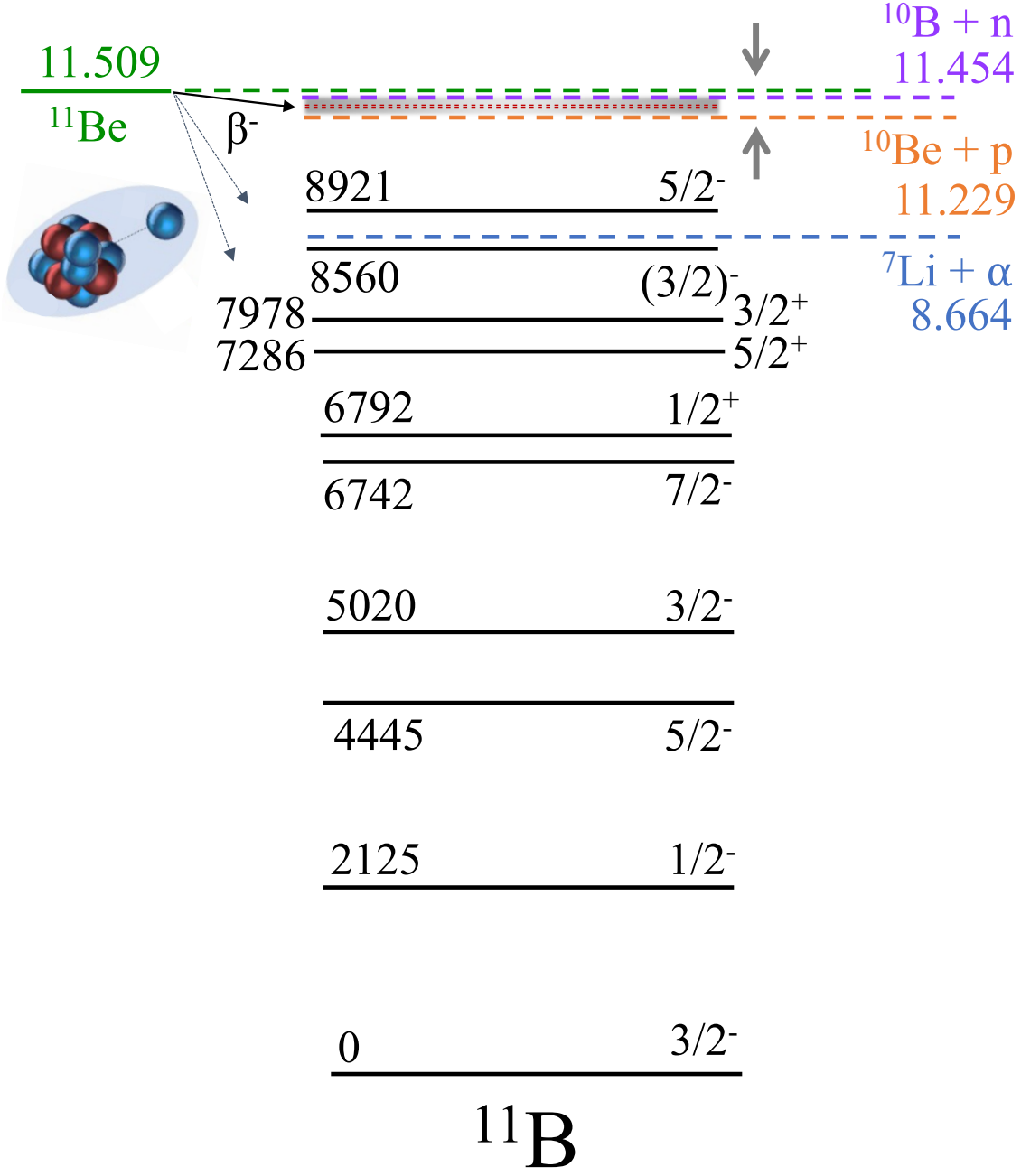
The case of ^{11}B

Simone Bottoni

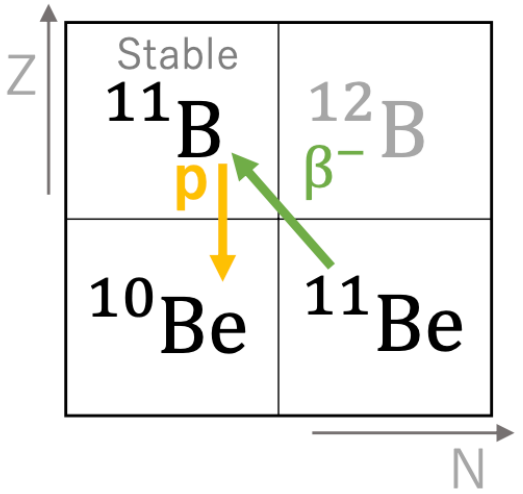


The case of ^{11}B

Simone Bottoni



EXTREMELY RARE DECAY IN NEUTRON-RICH NUCLEI



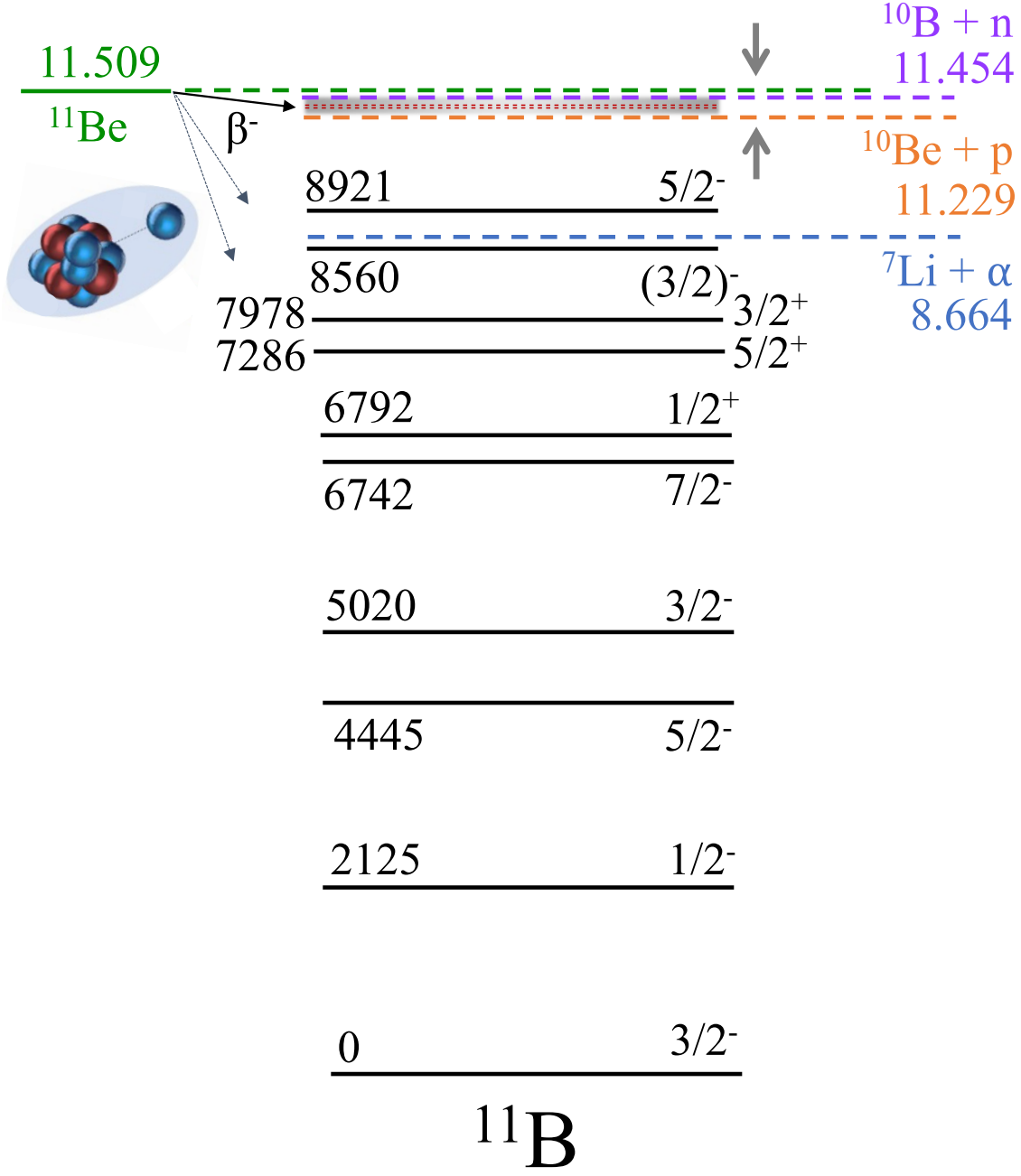
THEORY PREDICTION

$$b_p = 3 \times 10^{-8}$$

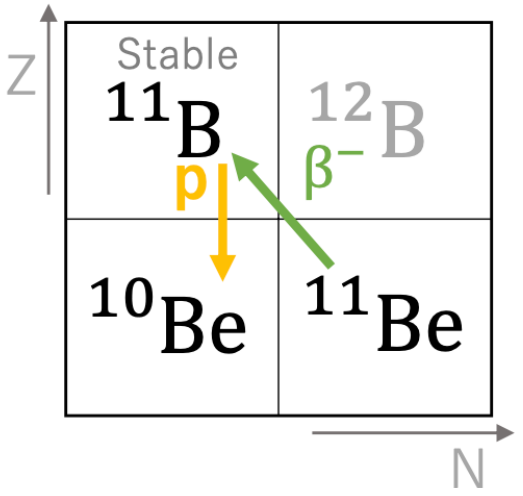
D. Baye *et al*, Phys. Lett. B **696,** 464 (2011)

The case of ^{11}B

Simone Bottoni



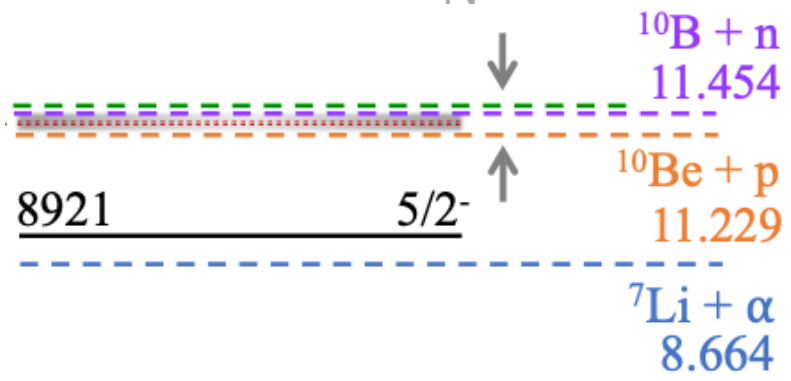
EXTREMELY RARE DECAY IN NEUTRON-RICH NUCLEI



THEORY PREDICTION

$b_p = 3 \times 10^{-8}$

D. Baye *et al*, Phys. Lett. B **696,** 464 (2011)

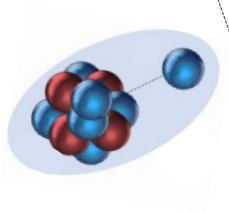


Very limited phase space!

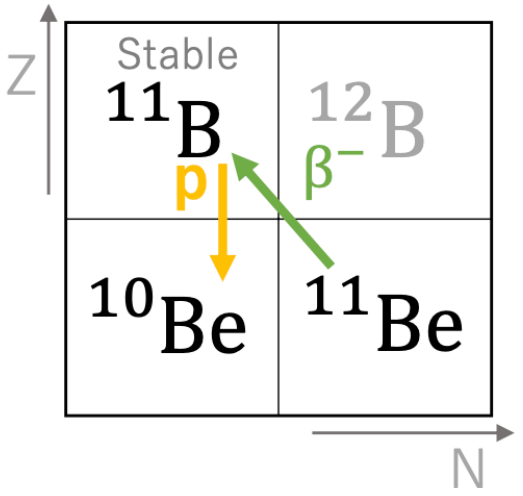
280 keV

The case of ^{11}B

Simone Bottoni



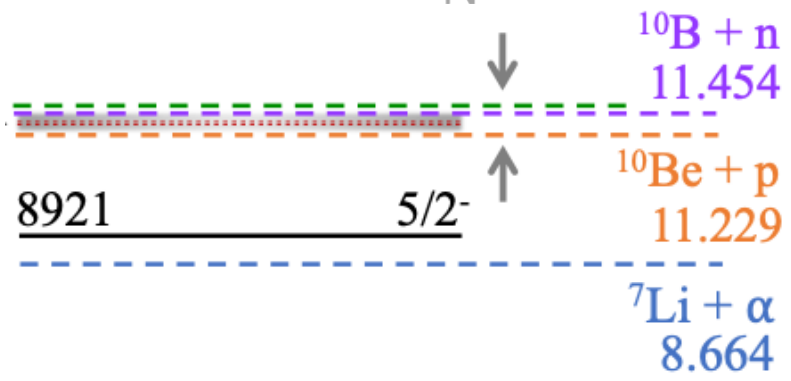
EXTREMELY RARE DECAY IN NEUTRON-RICH NUCLEI



THEORY PREDICTION

$$b_p = 3 \times 10^{-8}$$

D. Baye *et al*, Phys. Lett. B **696,** 464 (2011)



Very limited phase space!

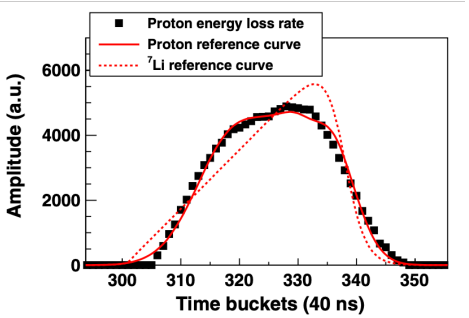
280 keV

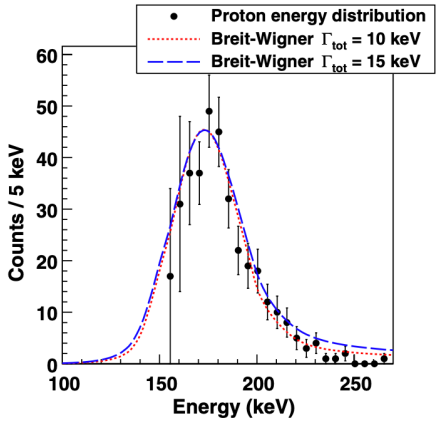
May this decay proceed through a near-threshold proton resonance?

INPC

DIRECT MEASUREMENT

β- decay of ^{11}Be with TPC @ TRIUMF





$$b_p = 1.3 \times 10^{-5}$$

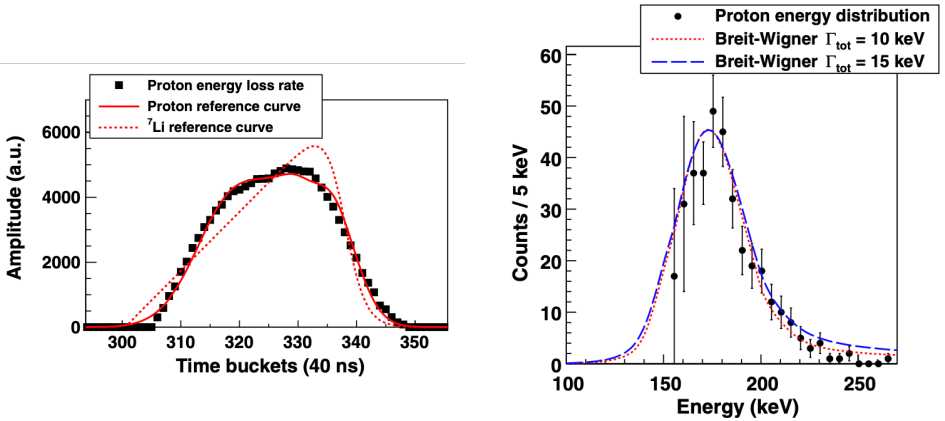
Y. Ayyad *et al.*, Phys. Rev. Lett. **123,** 082501 (2019)

The β-p decay of ^{11}Be

Simone Bottoni

DIRECT MEASUREMENT

β- decay of ^{11}Be with TPC @ TRIUMF

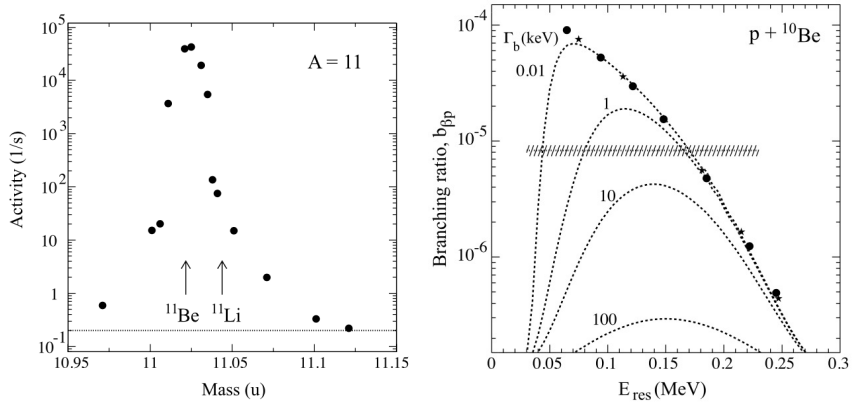


$b_p = 1.3 \times 10^{-5}$

Y. Ayyad *et al.*, Phys. Rev. Lett. **123,** 082501 (2019)

INDIRECT MEASUREMENT

production of ^{11}Be @ ISOLDE



$b_p = 8.3(9) \times 10^{-6}$ **$b_p < 2.2 \times 10^{-6}$**

K. Riisager *et al.*, Phys. Lett. B **732,** 305 (2014)

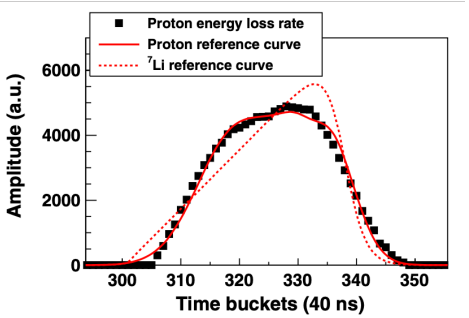
K. Riisager *et al.*, Eur. Phys. J. A **56,** 100 (2020)

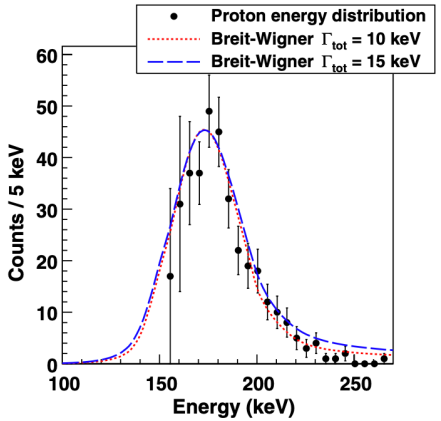
The β-p decay of ^{11}Be

Simone Bottoni

DIRECT MEASUREMENT

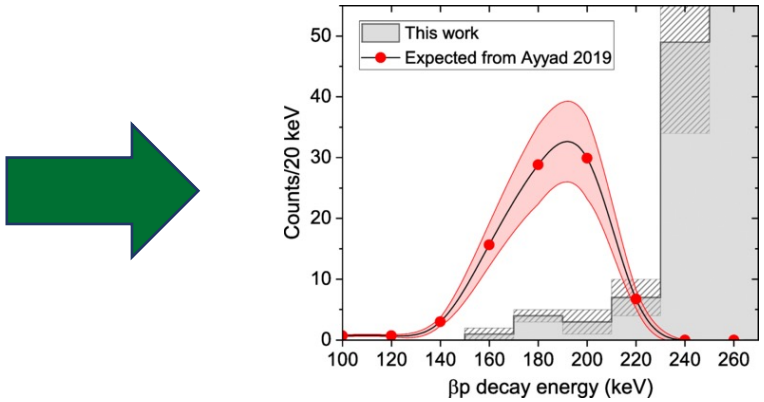
β- decay of ^{11}Be with TPC @ TRIUMF





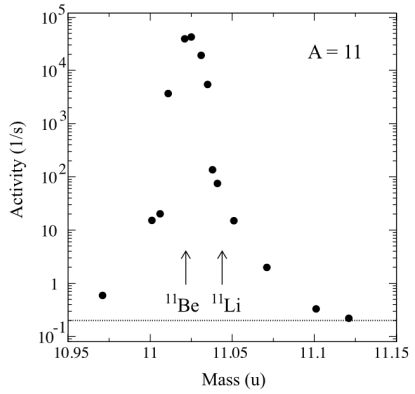
$b_p = 1.3 \times 10^{-5}$

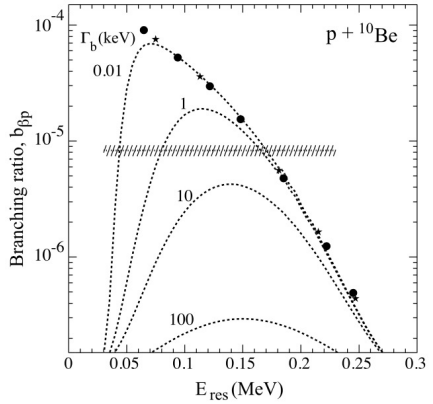
Y. Ayyad *et al.*, Phys. Rev. Lett. **123,** 082501 (2019)



INDIRECT MEASUREMENT

production of ^{11}Be @ ISOLDE





$b_p = 8.3(9) \times 10^{-6}$ **$b_p < 2.2 \times 10^{-6}$**

K. Riisager *et al.*, Phys. Lett. B **732,** 305 (2014)

K. Riisager *et al.*, Eur. Phys. J. A **56,** 100 (2020)

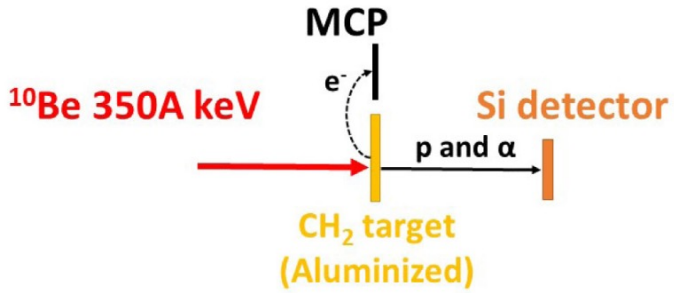
…see M. Pfutzner's talk…

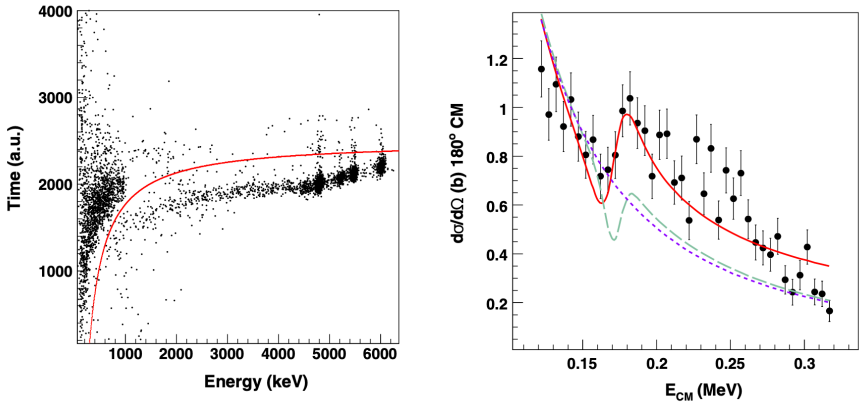
$b_p < 2.2 \times 10^{-6}$

N. Sokołowska *et al.*, Phys. Rev. C **110,** 034328 (2024)

THE ^{10}Be(p,p′) EXPERIMENT @ NSCL

Y. Ayyad *et al.*, Phys. Rev. Lett. **129,** 012501 (2022)





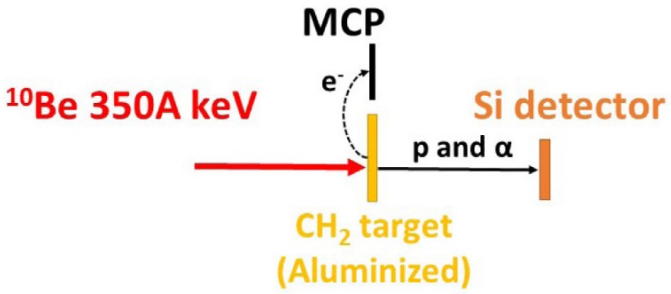
E_{res} =11400 (20) keV

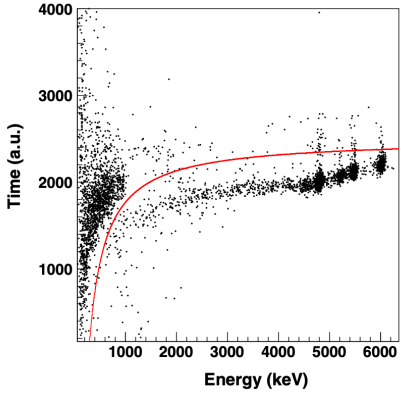
Γ_p =4.5 (11) keV

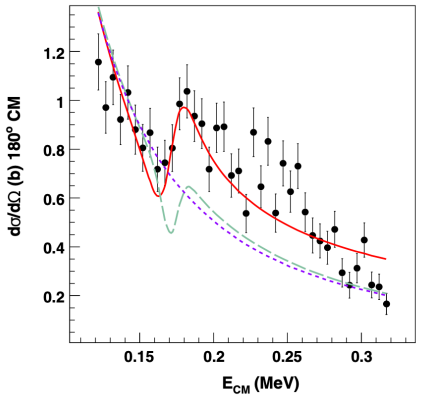
from the same authors: ^{10}B(d,p) @ HELIOS
presented at NS2024

THE ^{10}Be(p,p′) EXPERIMENT @ NSCL

Y. Ayyad *et al.*, Phys. Rev. Lett. **129,** 012501 (2022)







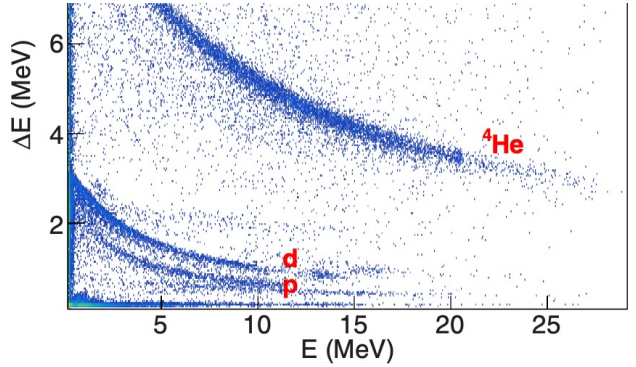
E_{res} =11400 (20) keV

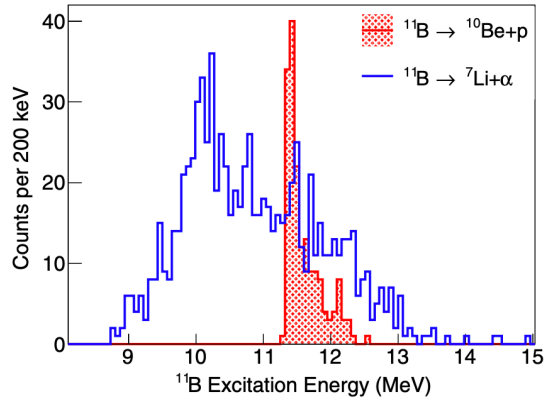
Γ_p =4.5 (11) keV

from the same authors: ^{10}B(d,p) @ HELIOS
presented at NS2024

THE ^{10}Be(d,n) EXPERIMENT @ FSU

E. Lopez-Saavedra *et al.*, Phys. Rev. Lett. **129,** 012502 (2022)

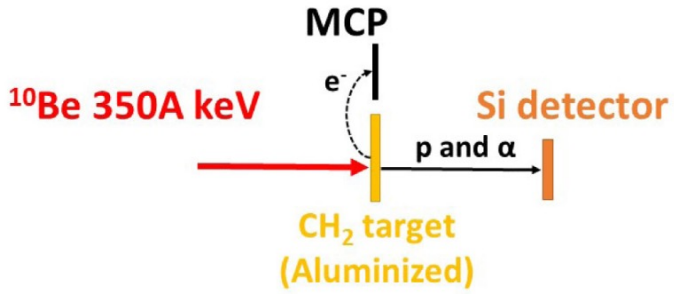


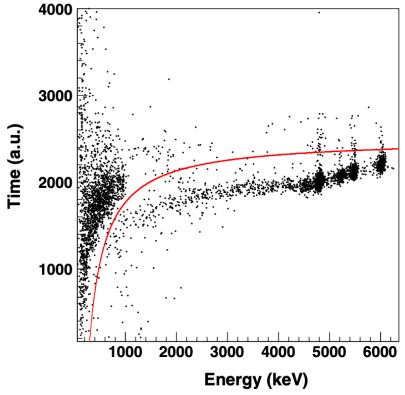


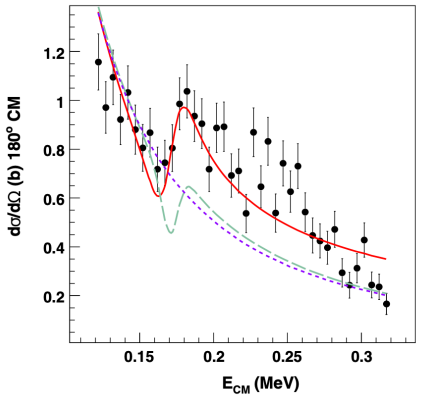
E_{res} =11440 (40) keV

THE ^{10}Be(p,p′) EXPERIMENT @ NSCL

Y. Ayyad *et al.*, Phys. Rev. Lett. **129,** 012501 (2022)







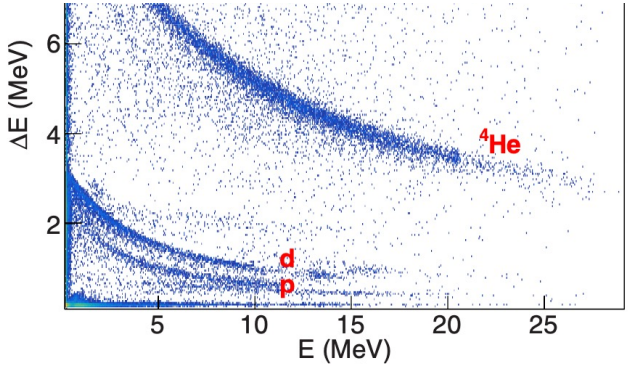
E_{res} =11400 (20) keV

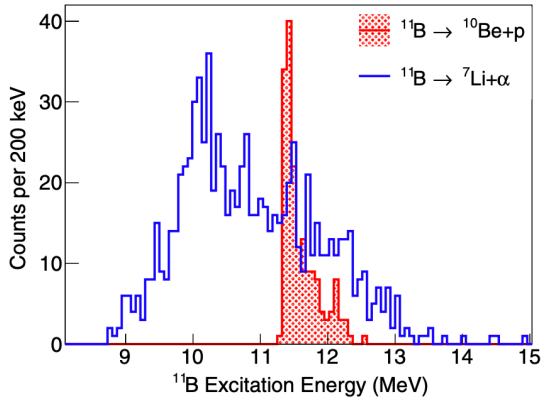
Γ_p =4.5 (11) keV

from the same authors: ^{10}B(d,p) @ HELIOS
presented at NS2024

THE ^{10}Be(d,n) EXPERIMENT @ FSU

E. Lopez-Saavedra *et al.*, Phys. Rev. Lett. **129,** 012502 (2022)





E_{res} =11440 (40) keV

THE ^{10}B(d,p) EXPERIMENT @ FSU

A. N. Kuchera *et al.*, Phys. Rev. C **110,** 054319 (2024)

no resonance observed

INPC

PHYSICAL REVIEW LETTERS **124,** 042502 (2020)

Convenient Location of a Near-Threshold Proton-Emitting Resonance in ^{11}B

J. Okołowicz,[1] M. Płoszajczak,[2] and W. Nazarewicz[3]

[1]*Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, PL-31342 Kraków, Poland*

[2]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM—CNRS/IN2P3, BP 55027, F-14076 Caen Cedex, France*

[3]*Department of Physics and Astronomy and FRIB Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

PHYSICAL REVIEW LETTERS **124,** 042502 (2020)

Convenient Location of a Near-Threshold Proton-Emitting Resonance in ^{11}B

J. Okołowicz,[1] M. Płoszajczak,[2] and W. Nazarewicz[3]

[1]*Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, PL-31342 Kraków, Poland*

[2]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM—CNRS/IN2P3, BP 55027, F-14076 Caen Cedex, France*

[3]*Department of Physics and Astronomy and FRIB Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

CONTINUUM COUPLING

open quantum systems

$$\mathcal{H}(E) = H_{\mathcal{Q}_0\mathcal{Q}_0} + W_{\mathcal{Q}_0\mathcal{Q}_0}(E)$$

coupling between bound
and scattering states

PHYSICAL REVIEW LETTERS **124,** 042502 (2020)

Convenient Location of a Near-Threshold Proton-Emitting Resonance in ^{11}B

J. Okołowicz,[1] M. Płoszajczak,[2] and W. Nazarewicz[3]

[1]*Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, PL-31342 Kraków, Poland*

[2]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM—CNRS/IN2P3, BP 55027, F-14076 Caen Cedex, France*

[3]*Department of Physics and Astronomy and FRIB Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

CONTINUUM COUPLING

open quantum systems

$$\mathcal{H}(E) = H_{\mathcal{Q}_0\mathcal{Q}_0} + W_{\mathcal{Q}_0\mathcal{Q}_0}(E)$$

coupling between bound
and scattering states

THE $J^\pi=1/2^+$ NEAR-PROTON STATE

1p-channel: $[^{10}\mathrm{Be}(0^+) \otimes \mathrm{p}(\mathrm{s}_{1/2})]^{1/2+}$

1n-channel: $[^{10}\mathrm{Be}(3^+) \otimes \mathrm{n}(\mathrm{d}_{5/2})]^{1/2+}$

collective mixing of
shell-model eigenstates

INPC

The SMEC model and the role of the continuum

PHYSICAL REVIEW LETTERS **124,** 042502 (2020)

Convenient Location of a Near-Threshold Proton-Emitting Resonance in ^{11}B

J. Okołowicz,[1] M. Płoszajczak,[2] and W. Nazarewicz[3]
[1]*Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, PL-31342 Kraków, Poland*
[2]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM—CNRS/IN2P3, BP 55027, F-14076 Caen Cedex, France*
[3]*Department of Physics and Astronomy and FRIB Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

CONTINUUM COUPLING

open quantum systems

$$\mathcal{H}(E) = H_{\mathcal{Q}_0\mathcal{Q}_0} + W_{\mathcal{Q}_0\mathcal{Q}_0}(E)$$

coupling between bound
and scattering states

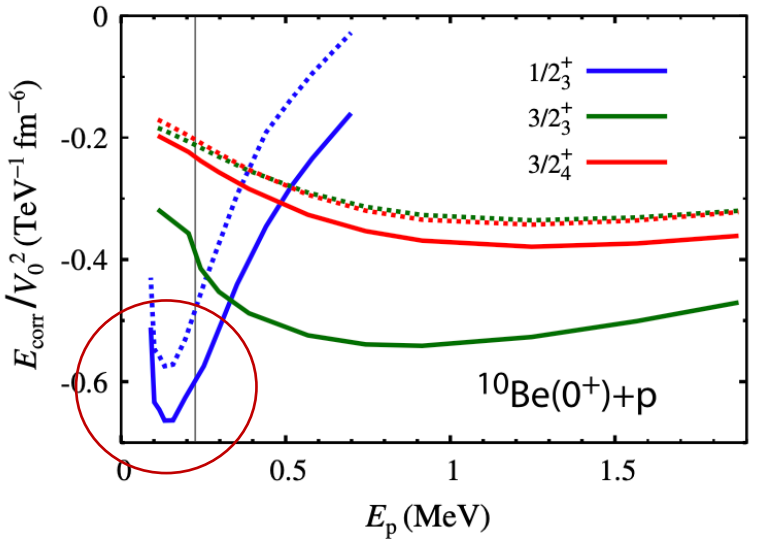
THE $J^\pi=1/2^+$ NEAR-PROTON STATE

1p-channel: $[^{10}\mathrm{Be}(0^+) \otimes \mathrm{p}(s_{1/2})]^{1/2+}$

1n-channel: $[^{10}\mathrm{Be}(3^+) \otimes \mathrm{n}(d_{5/2})]^{1/2+}$

collective mixing of
shell-model eigenstates

CORRELATION ENERGY



$$E^{J^\pi}_{\mathrm{corr};\alpha}(E) = \langle \Psi^{J^\pi}_\alpha(E) | W_{\mathcal{Q}_0\mathcal{Q}_0}(E) | \Psi^{J^\pi}_\alpha(E) \rangle$$

J. Okołowicz, M. Płoszajczak, and W. Nazarewicz
J. Phys. G: Nucl. Part. Phys. 49, 10LT01 (2022).

E_{res} =11371 keV

$b_\gamma = 0.98^{+168}_{-69} \times 10^{-3}$

The SMEC model and the role of the continuum

PHYSICAL REVIEW LETTERS **124,** 042502 (2020)

Convenient Location of a Near-Threshold Proton-Emitting Resonance in ^{11}B

J. Okołowicz,[1] M. Płoszajczak,[2] and W. Nazarewicz[3]
[1]*Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, PL-31342 Kraków, Poland*
[2]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM—CNRS/IN2P3, BP 55027, F-14076 Caen Cedex, France*
[3]*Department of Physics and Astronomy and FRIB Laboratory, Michigan State University, East Lansing, Michigan 48824, USA*

CONTINUUM COUPLING

open quantum systems

$$\mathcal{H}(E) = H_{\mathcal{Q}_0\mathcal{Q}_0} + W_{\mathcal{Q}_0\mathcal{Q}_0}(E)$$

coupling between bound and scattering states

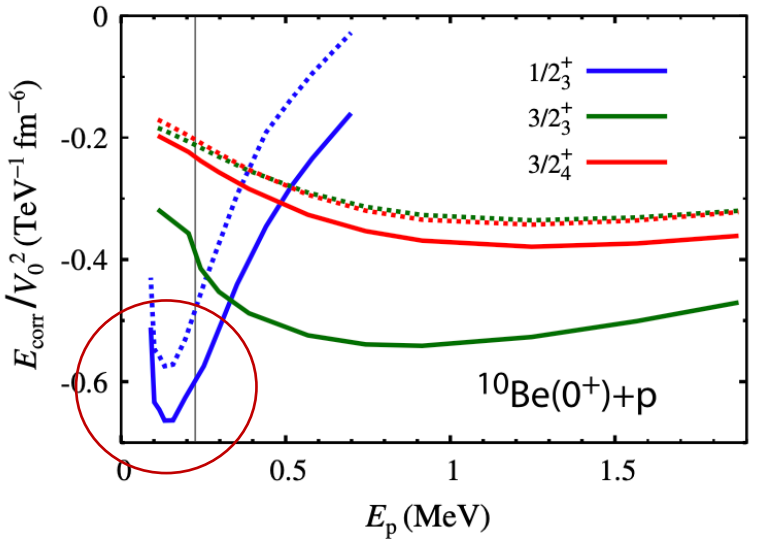
THE $J^\pi=1/2^+$ NEAR-PROTON STATE

1p-channel: $[^{10}\mathrm{Be}(0^+) \otimes \mathrm{p}(s_{1/2})]^{1/2+}$

1n-channel: $[^{10}\mathrm{Be}(3^+) \otimes \mathrm{n}(d_{5/2})]^{1/2+}$

collective mixing of shell-model eigenstates

CORRELATION ENERGY



$$E^{J^\pi}_{\mathrm{corr};\alpha}(E) = \langle \Psi^{J^\pi}_\alpha(E) | W_{\mathcal{Q}_0\mathcal{Q}_0}(E) | \Psi^{J^\pi}_\alpha(E) \rangle$$

J. Okołowicz, M. Płoszajczak, and W. Nazarewicz
J. Phys. G: Nucl. Part. Phys. 49, 10LT01 (2022).

E_{res} =11371 keV

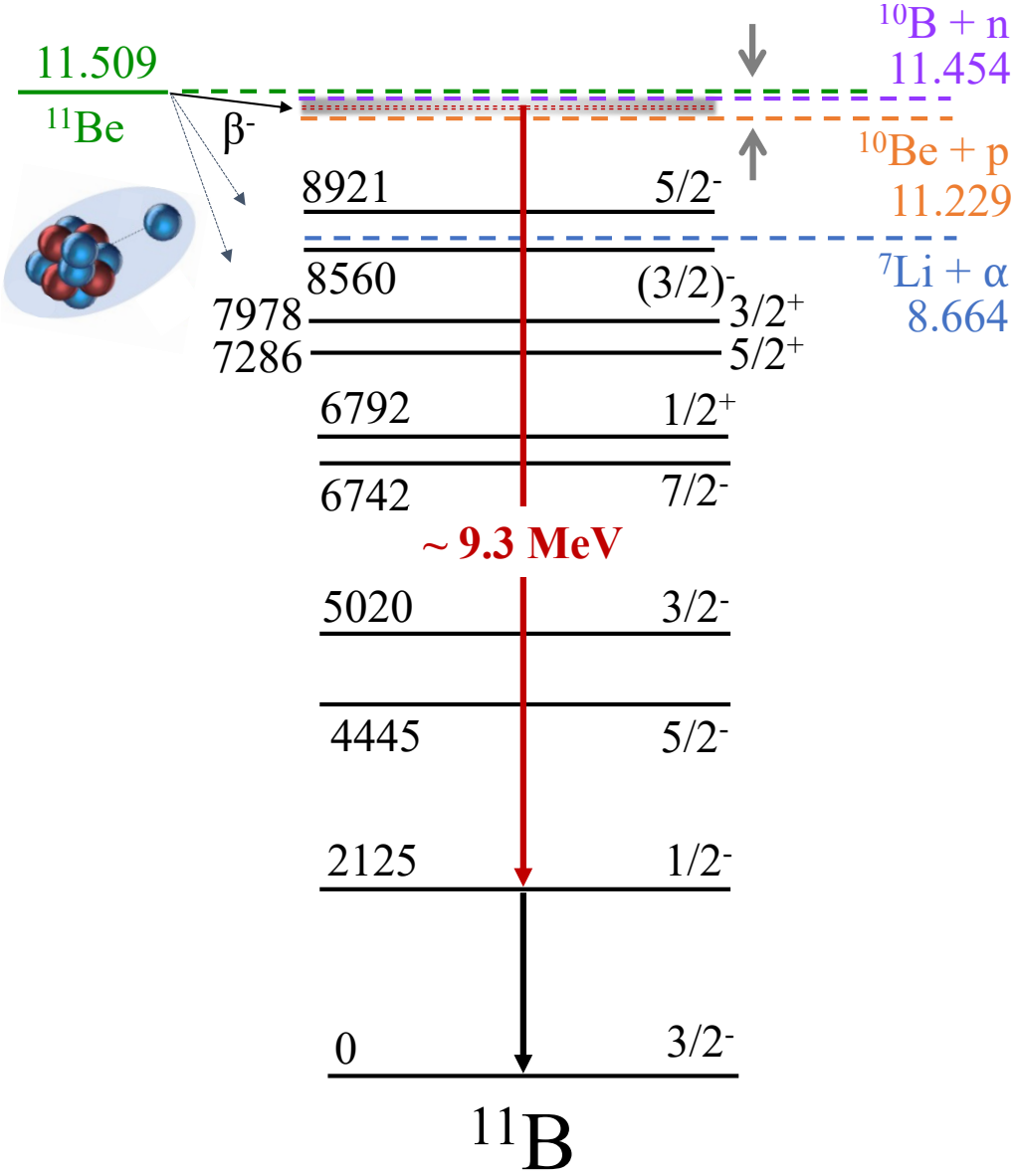
$b_\gamma = 0.98^{+168}_{-69} \times 10^{-3}$

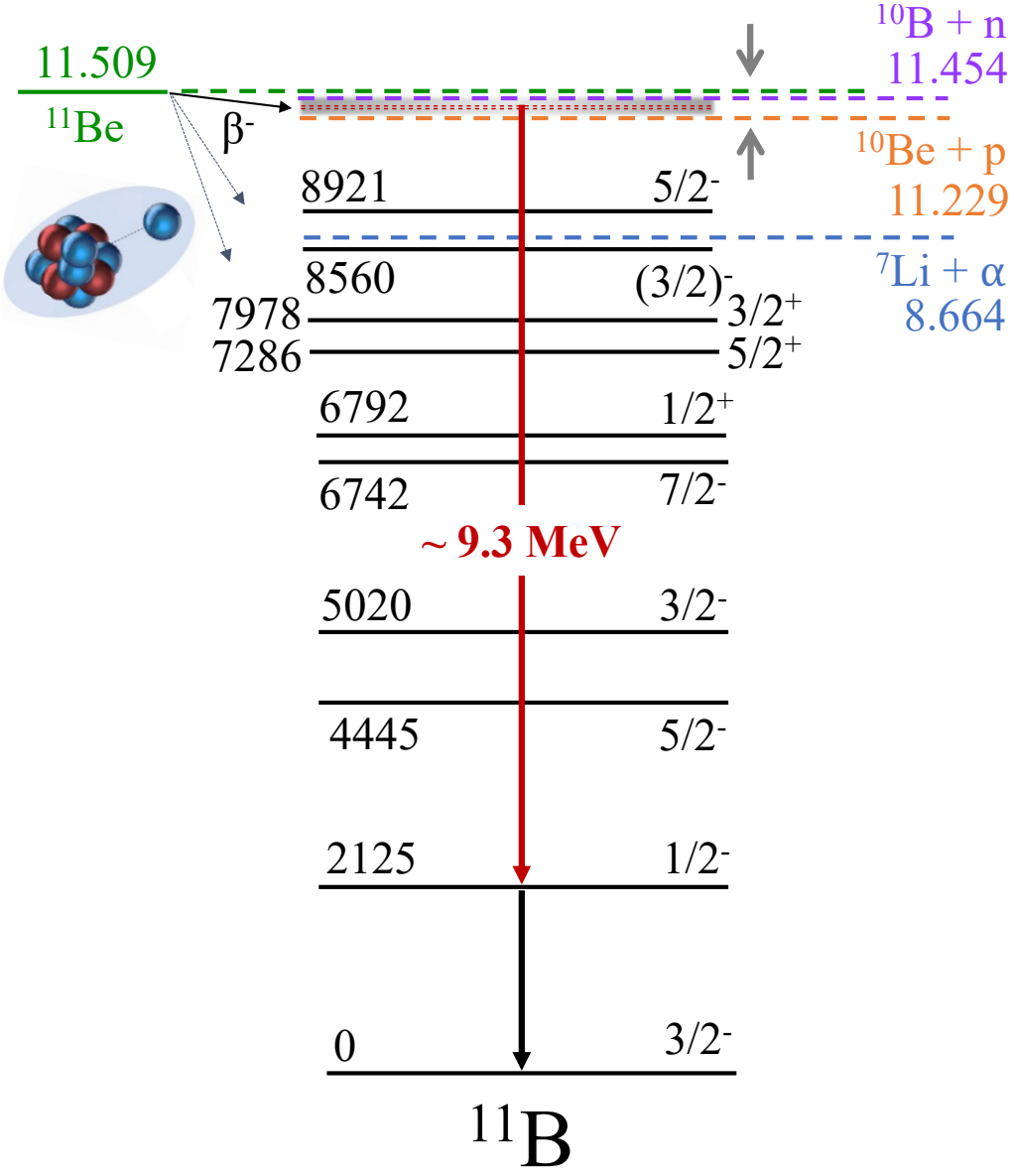
We may then use γ rays to probe the near-threshold resonance in ^{11}B

INPC

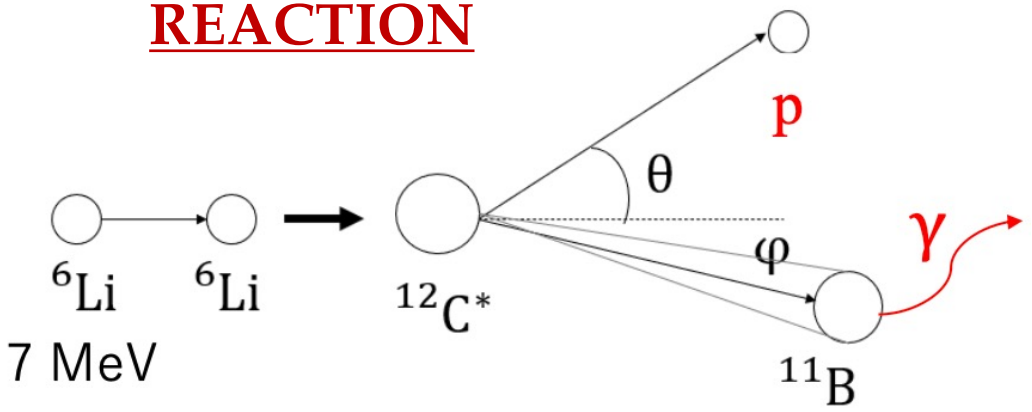
The experiment at LNL - INFN

Simone Bottoni



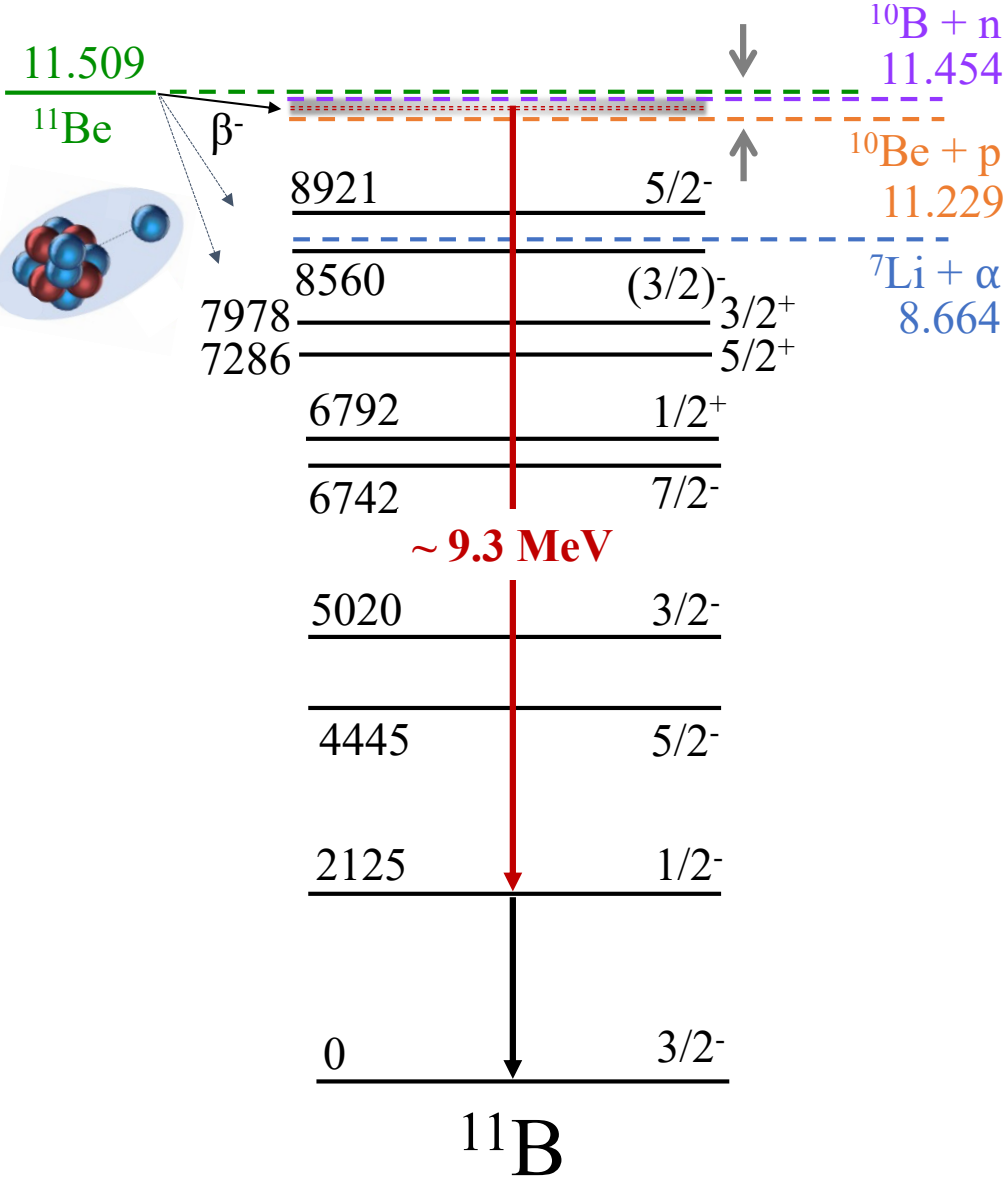


FUSION-EVAPORATION REACTION

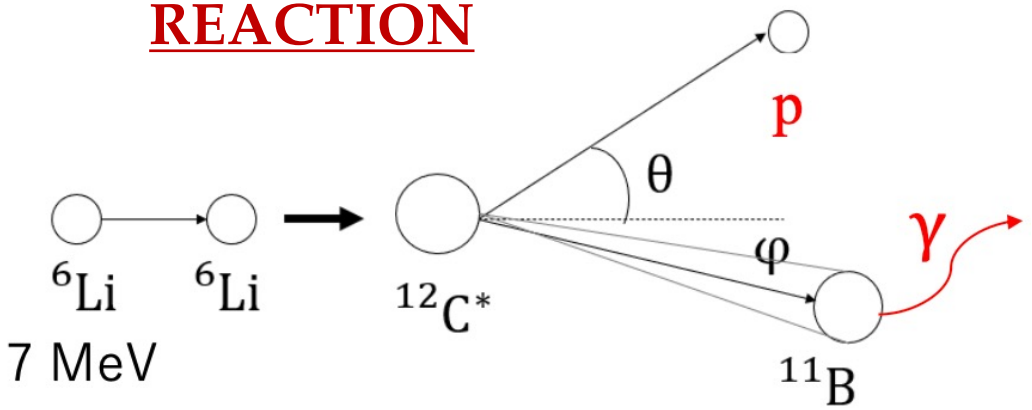


The experiment at LNL - INFN

Simone Bottoni



FUSION-EVAPORATION REACTION



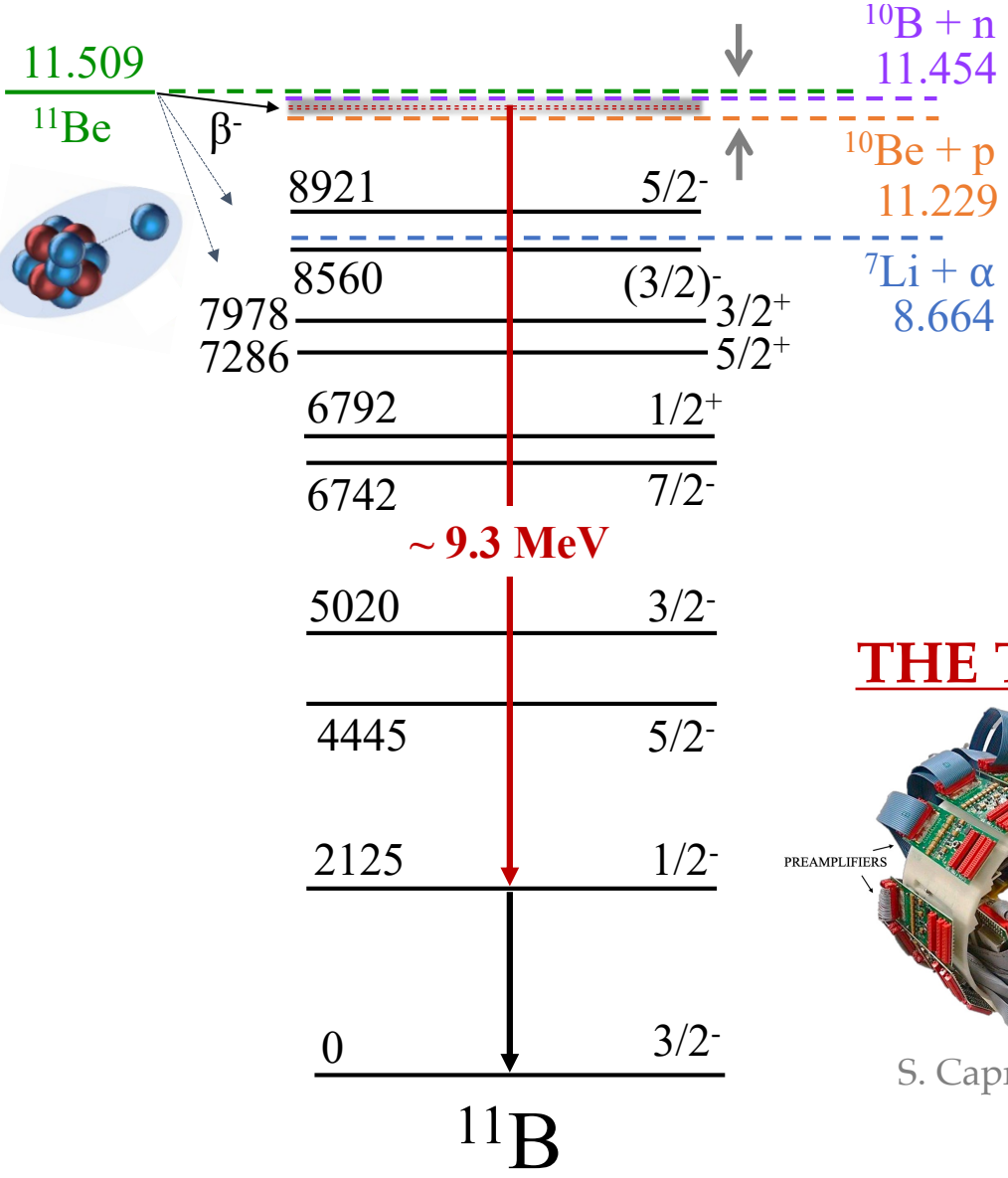
THE GALILEO HPGe ARRAY

- 20 singles detectors
- 10 triple clusters
- BGO shields

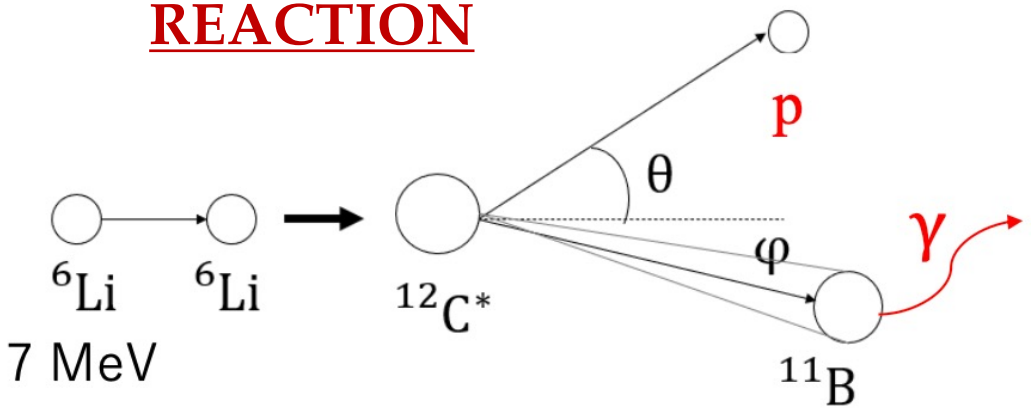
A. Goasduff *et al.*, NIMA **1015,** 165753 (2021)

The experiment at LNL - INFN

Simone Bottoni



FUSION-EVAPORATION REACTION



THE TRACE Si ARRAY

- 3 pixel-type
- ΔE – E
- PSA

S. Capra *et al.*, NIMA **935,** 178 (2019)

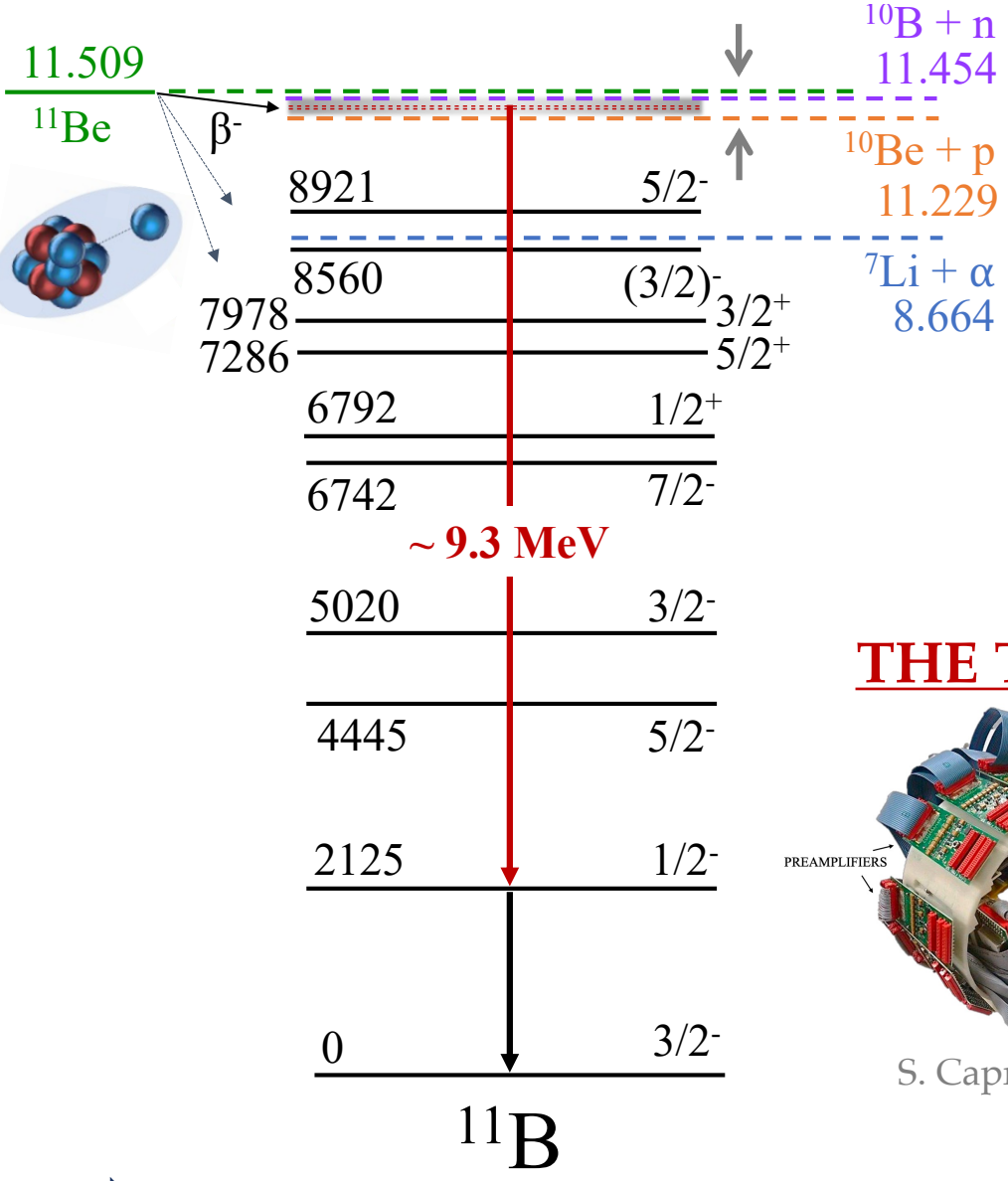
THE GALILEO HPGe ARRAY

- 20 singles detectors
- 10 triple clusters
- BGO shields

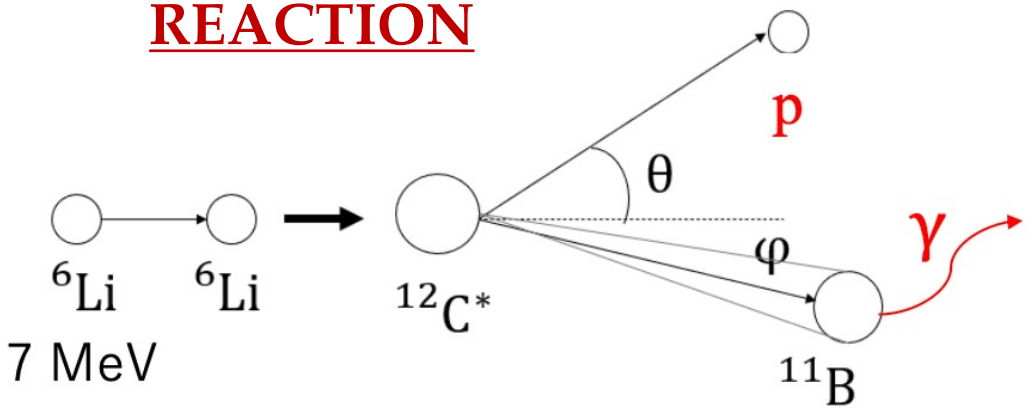
A. Goasduff *et al.*, NIMA **1015,** 165753 (2021)

The experiment at LNL - INFN

Simone Bottoni



FUSION-EVAPORATION REACTION



THE TRACE Si ARRAY

- 3 pixel-type
- ΔE – E
- PSA

S. Capra *et al.*, NIMA **935,** 178 (2019)

THE GALILEO HPGe ARRAY

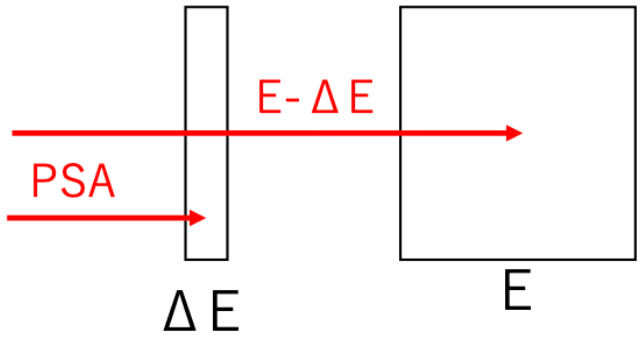
- 20 singles detectors
- 10 triple clusters
- BGO shields

A. Goasduff *et al.*, NIMA **1015,** 165753 (2021)

Particle-γ coincidences and kinematic reconstruction event by event

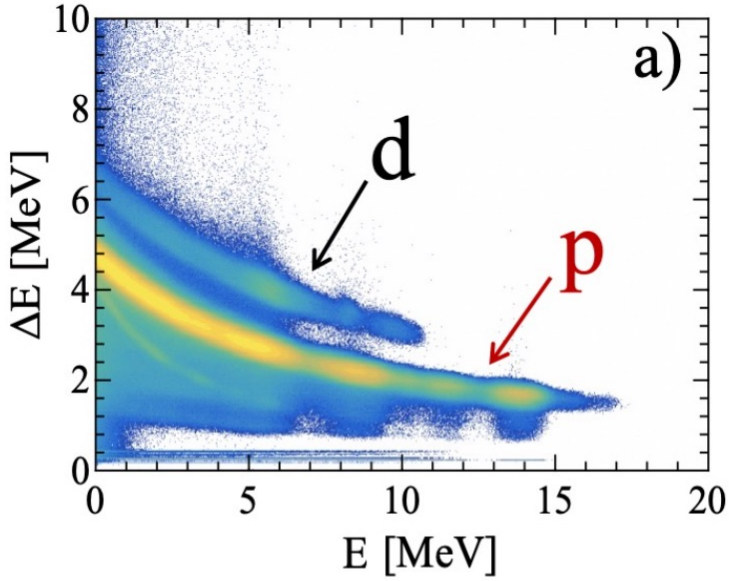
INPC

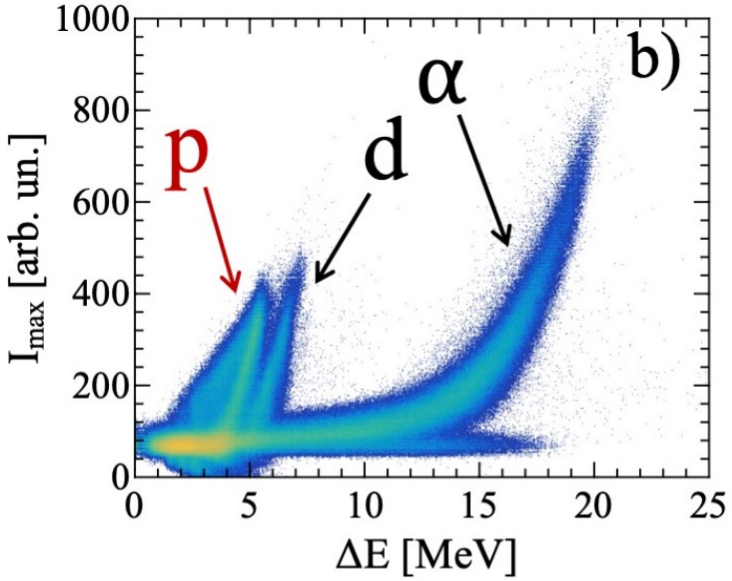
PARTICLE IDENTIFICATION AND GAMMA-RAY COINCIDENCES



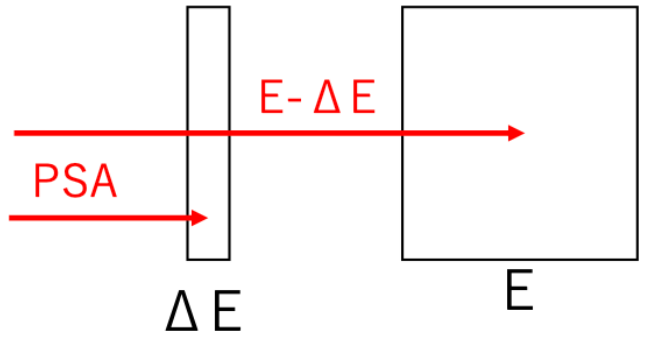
D. Mengoni *et al.*, NIM A **764,** 241 (2014)

N. Cieplicka *et al.*, EPJ A **54,** 209 (2018)



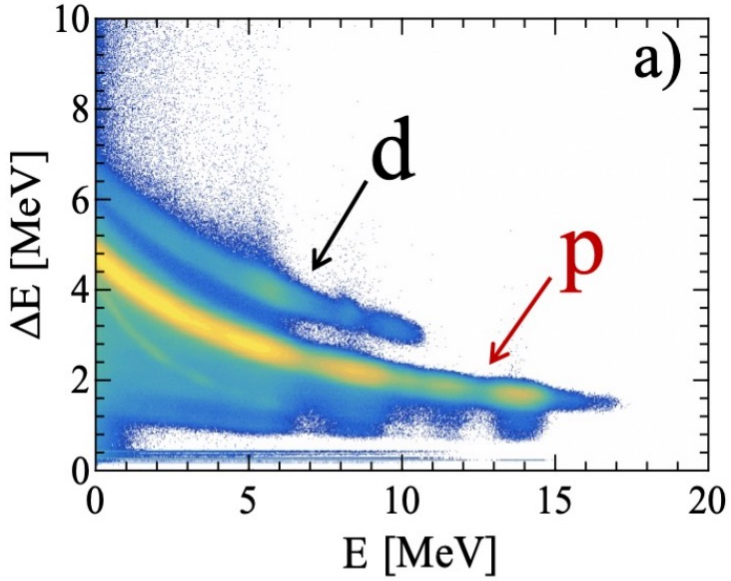


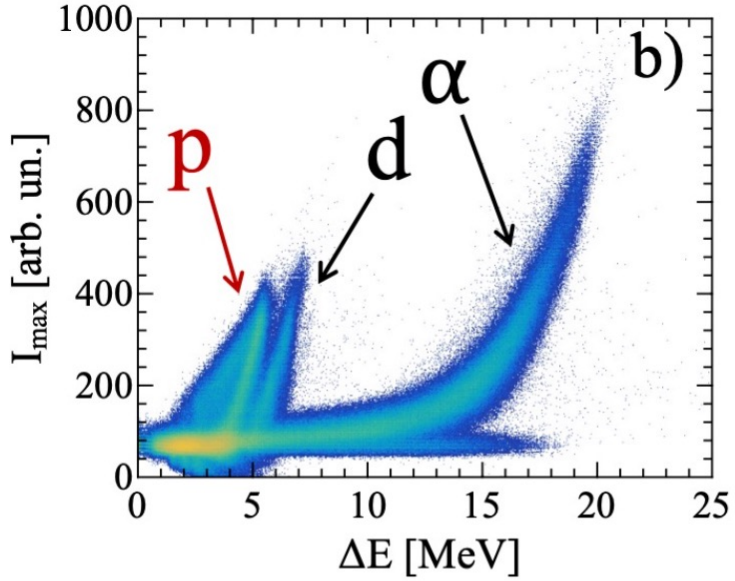
PARTICLE IDENTIFICATION AND GAMMA-RAY COINCIDENCES



D. Mengoni *et al.*, NIM A **764,** 241 (2014)

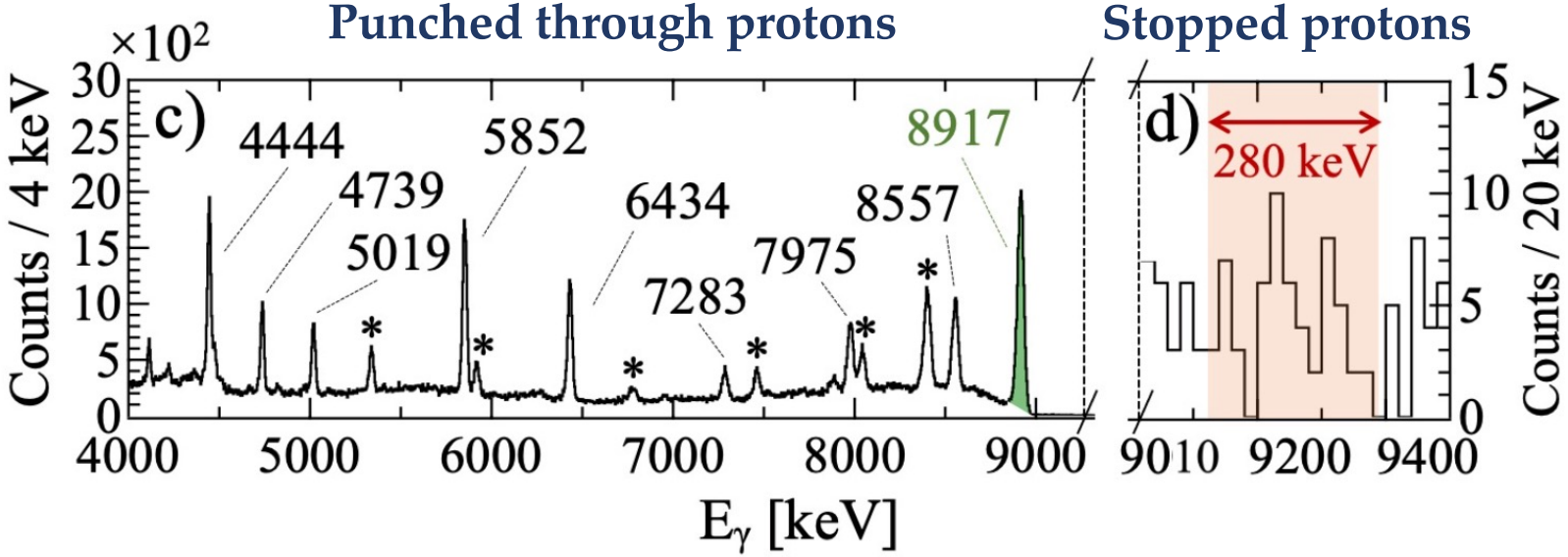
N. Cieplicka *et al.*, EPJ A **54,** 209 (2018)





Punched through protons

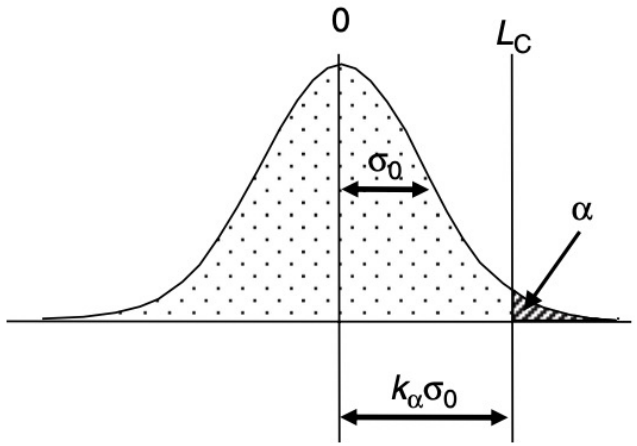
Stopped protons



Reference transition 8197 keV

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)



$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

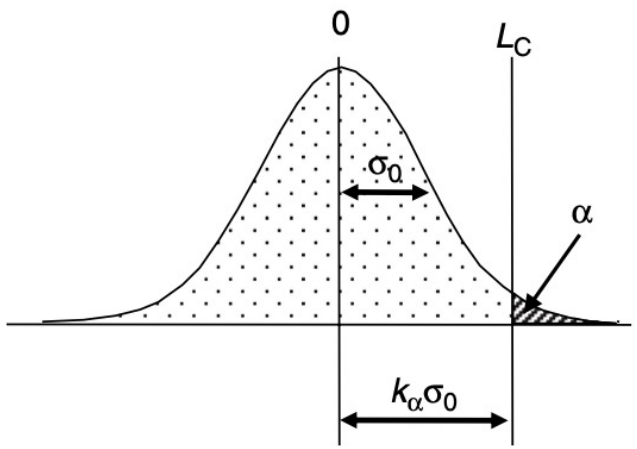
$$C - B > L_C$$

peak region background region

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

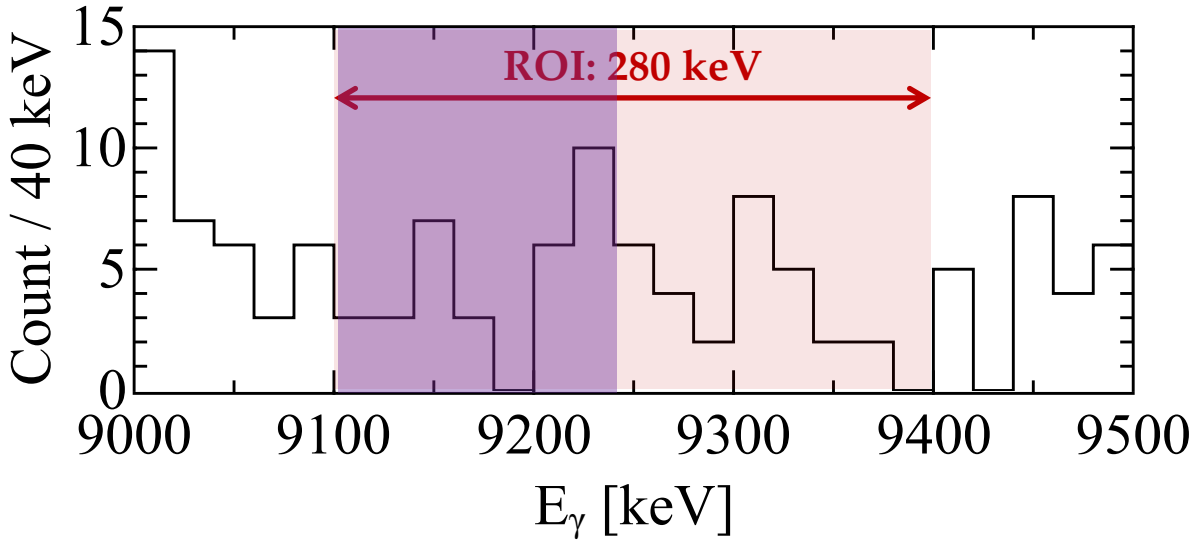


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

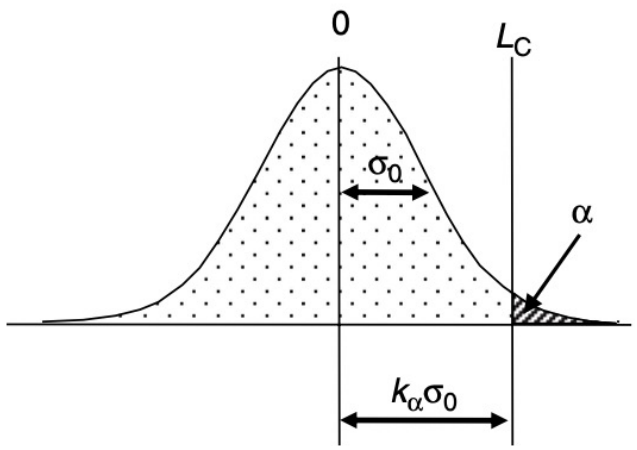
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

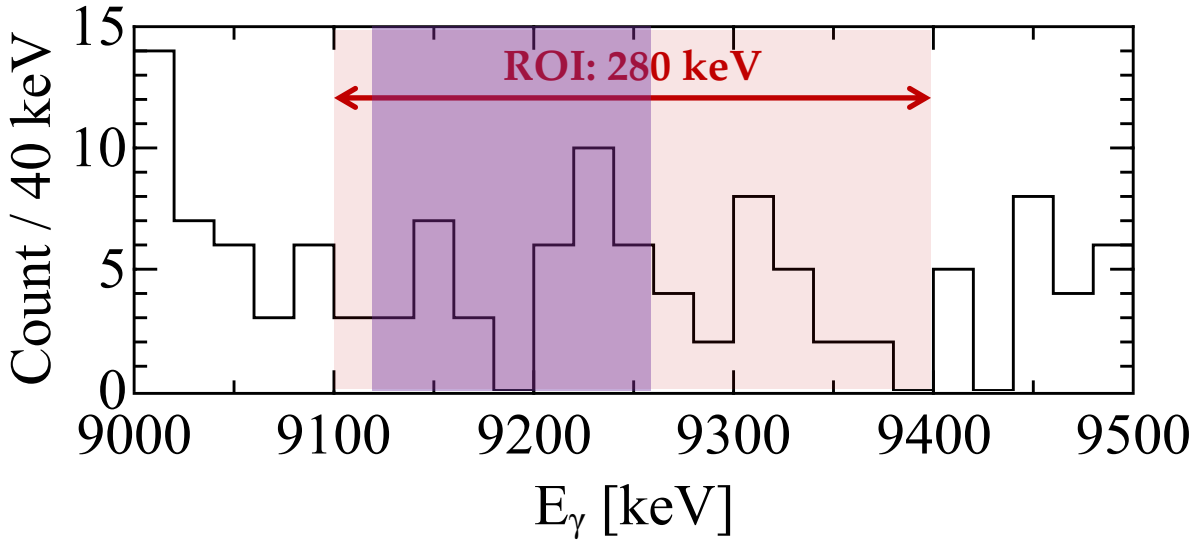


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

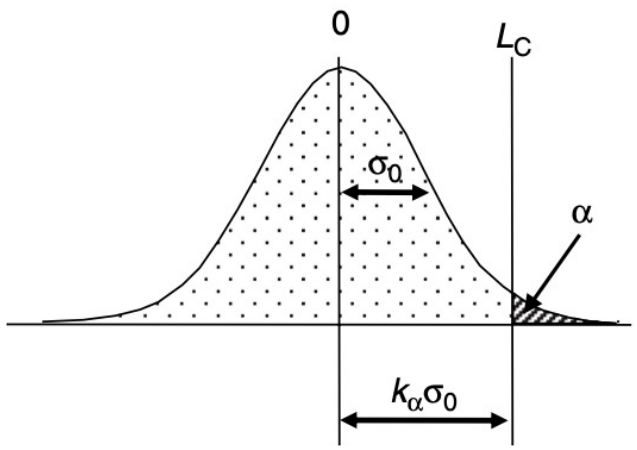
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

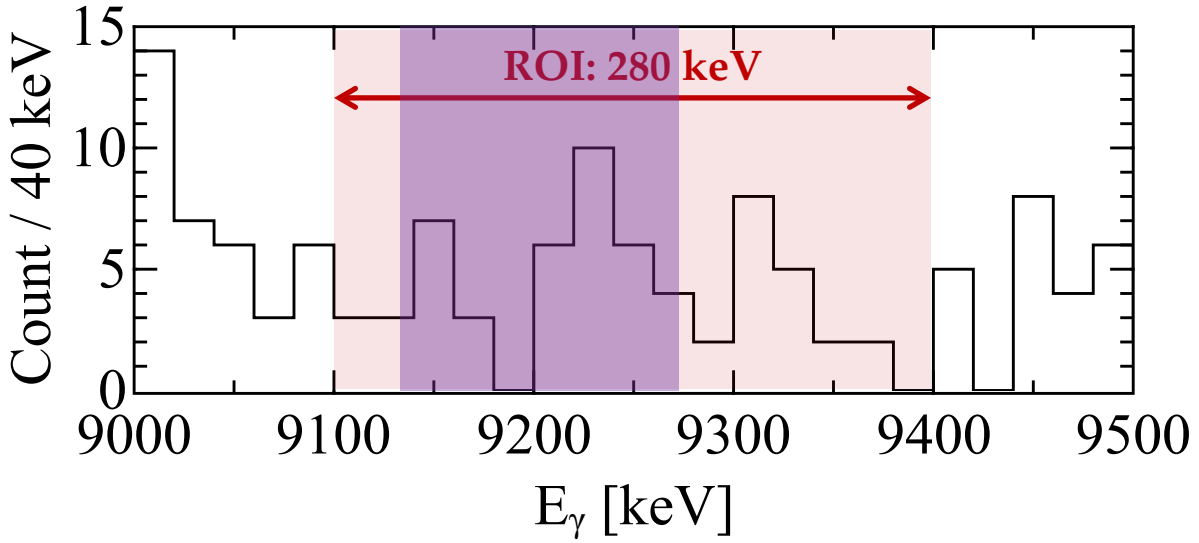


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

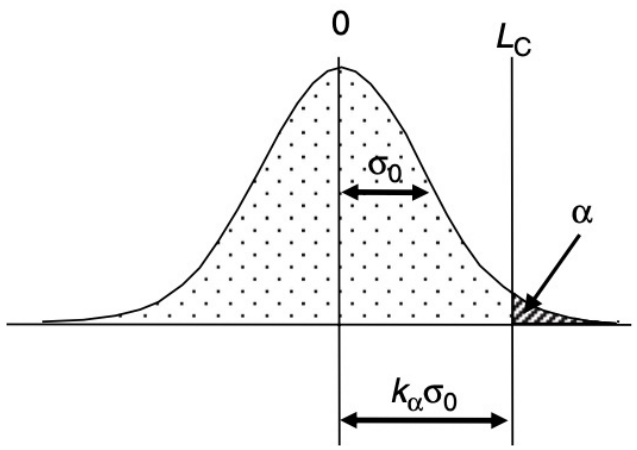
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

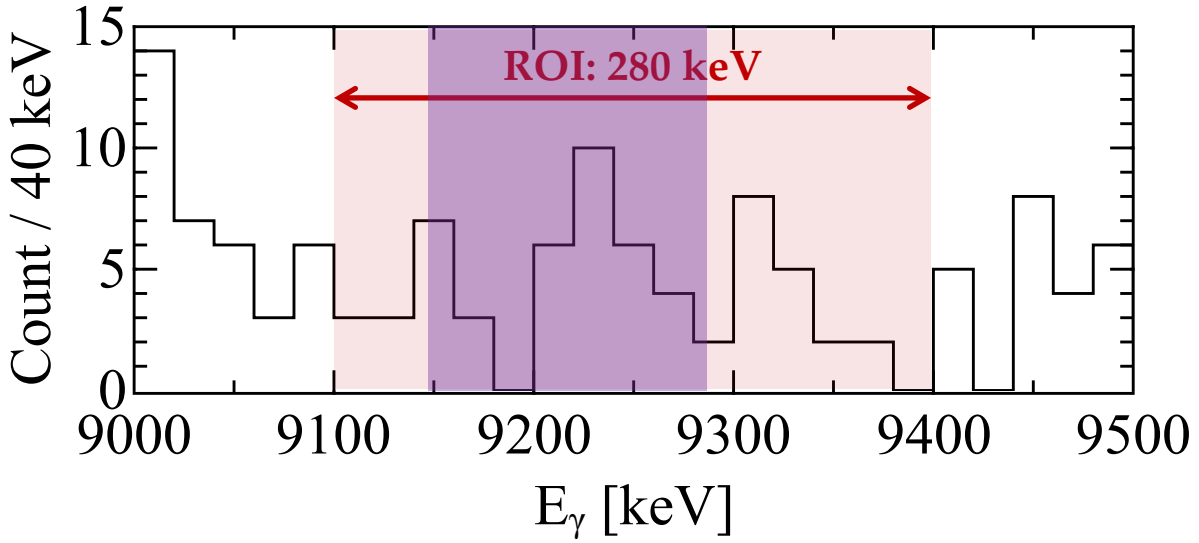


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

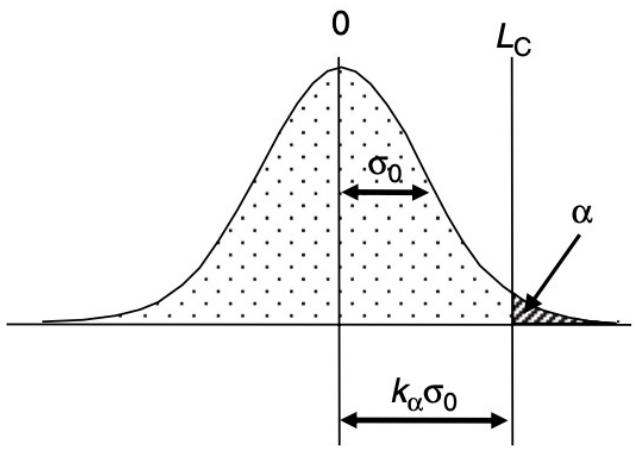
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

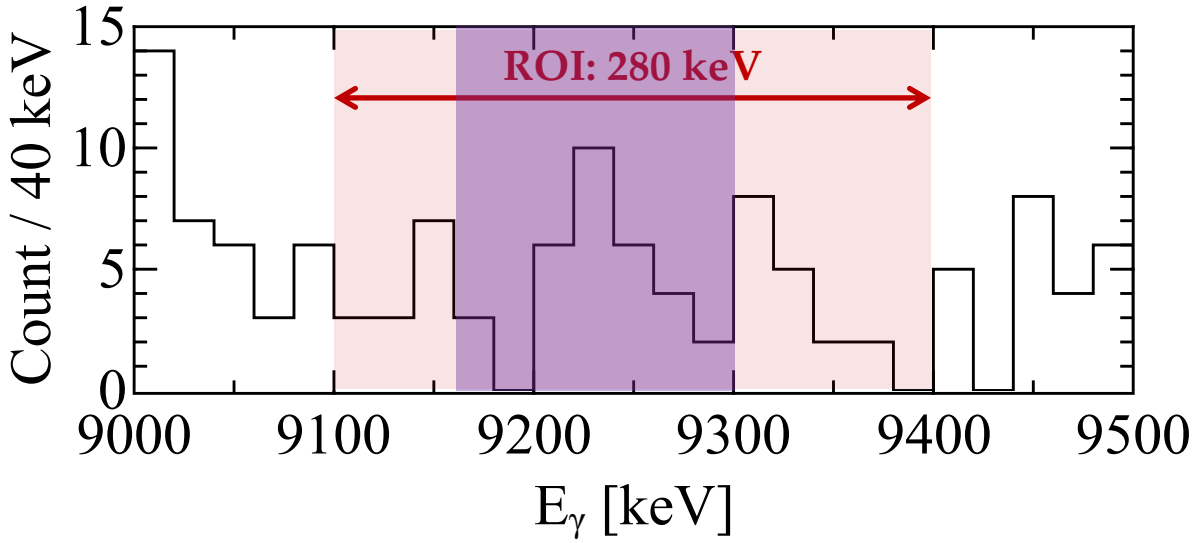


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

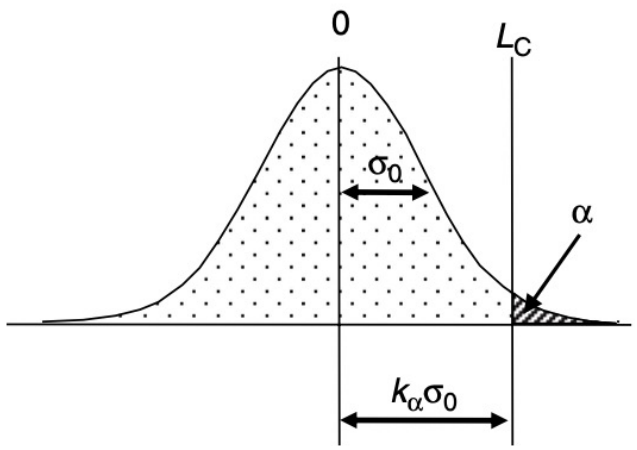
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

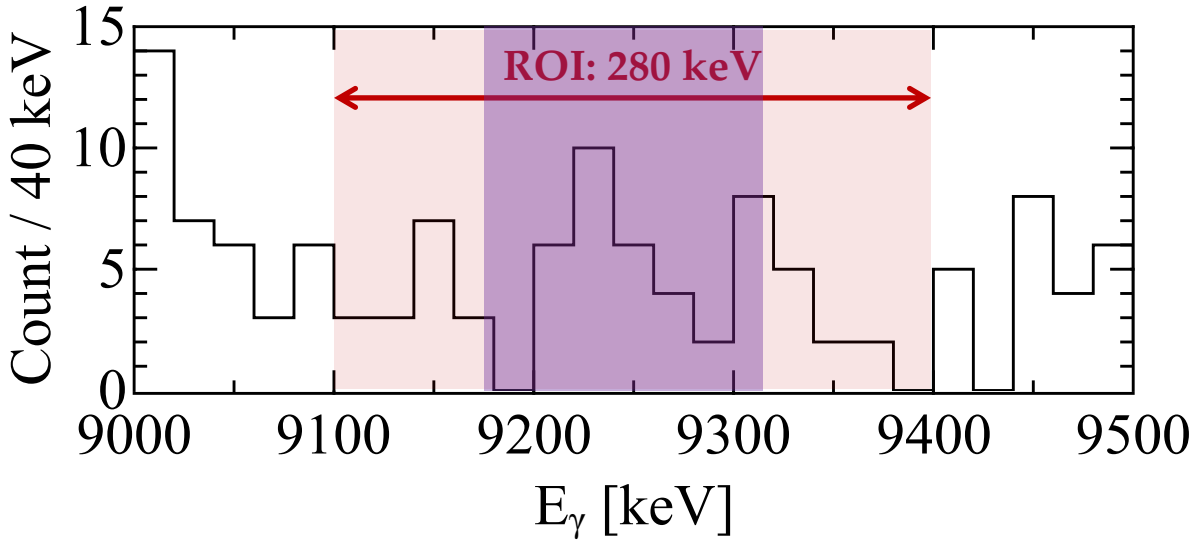


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

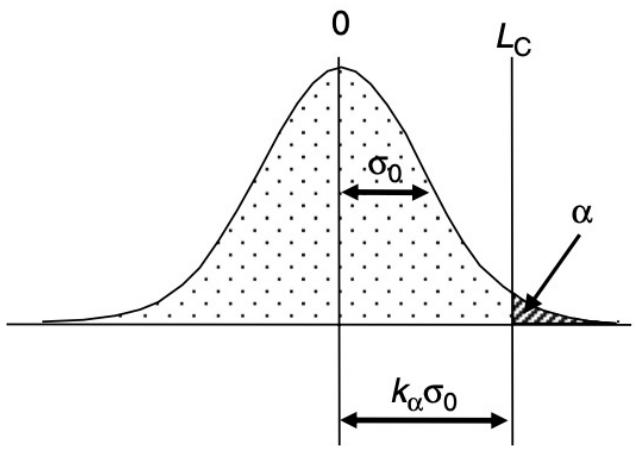
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

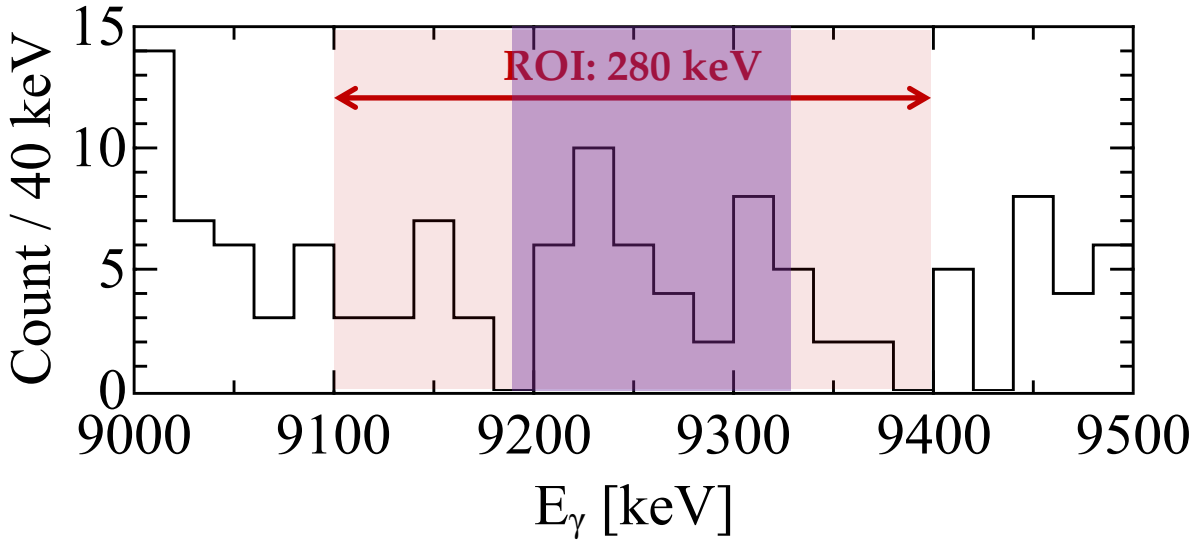


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

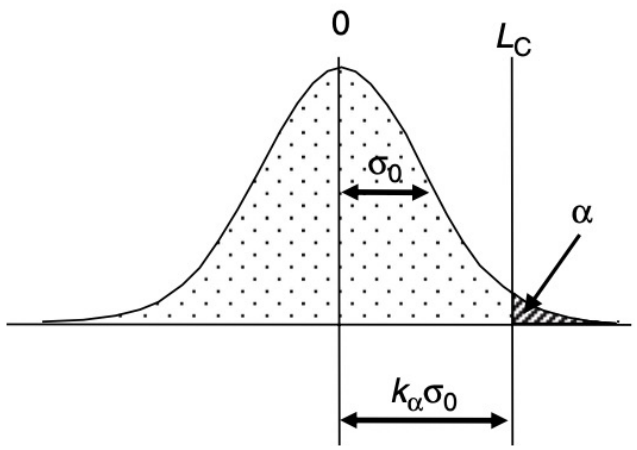
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

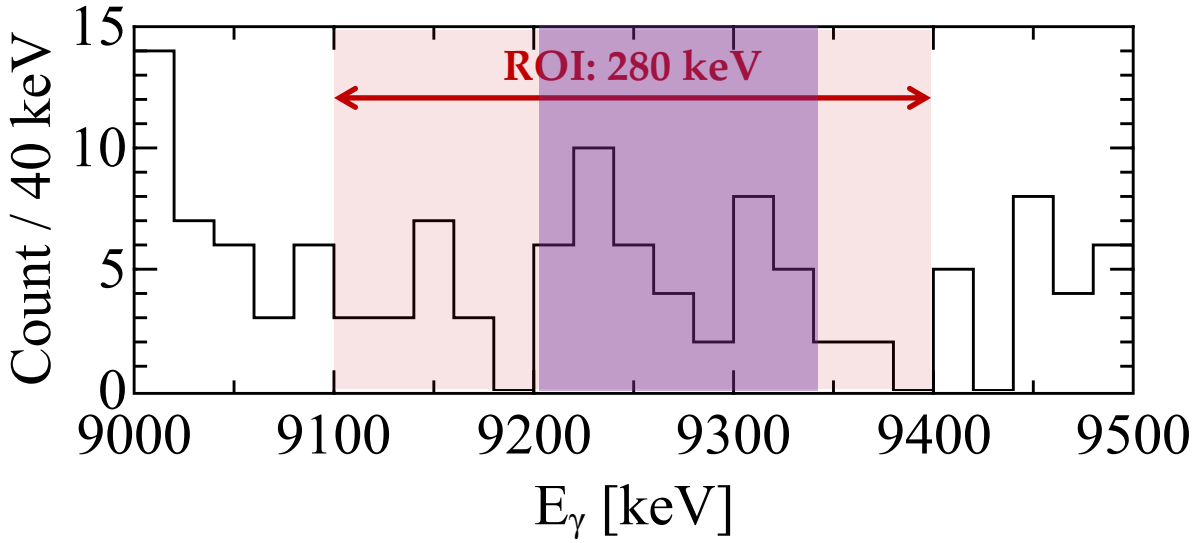


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

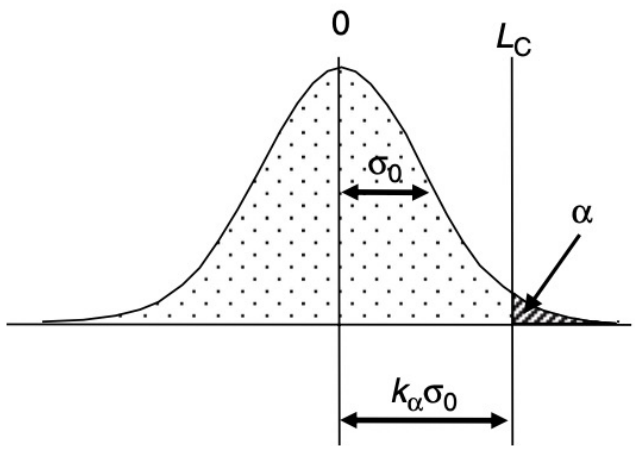
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

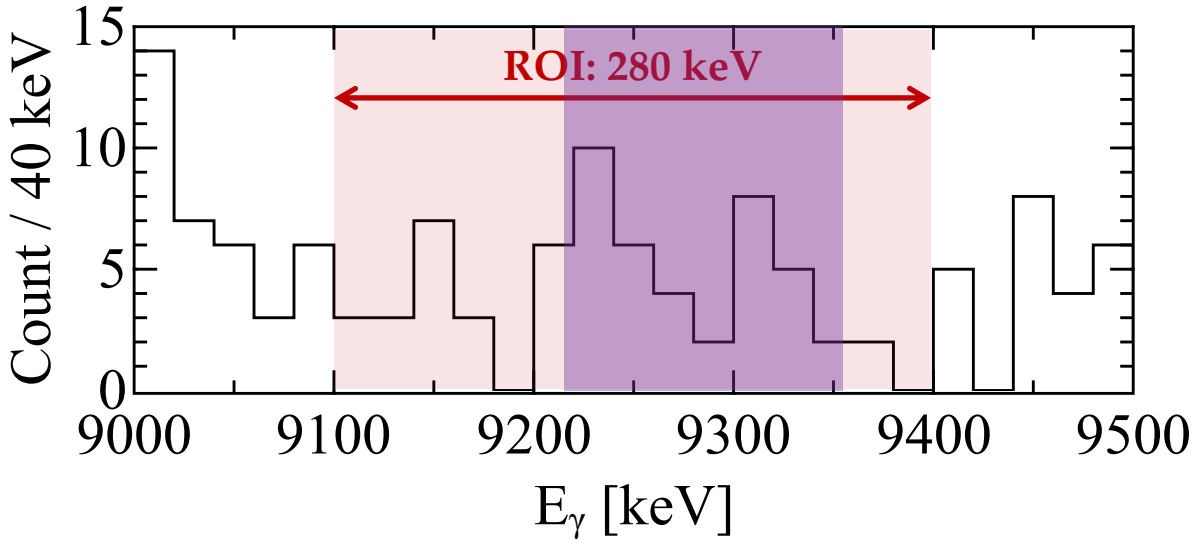


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

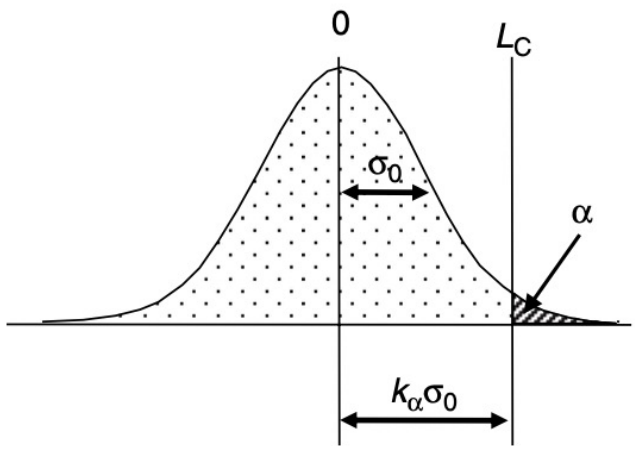
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

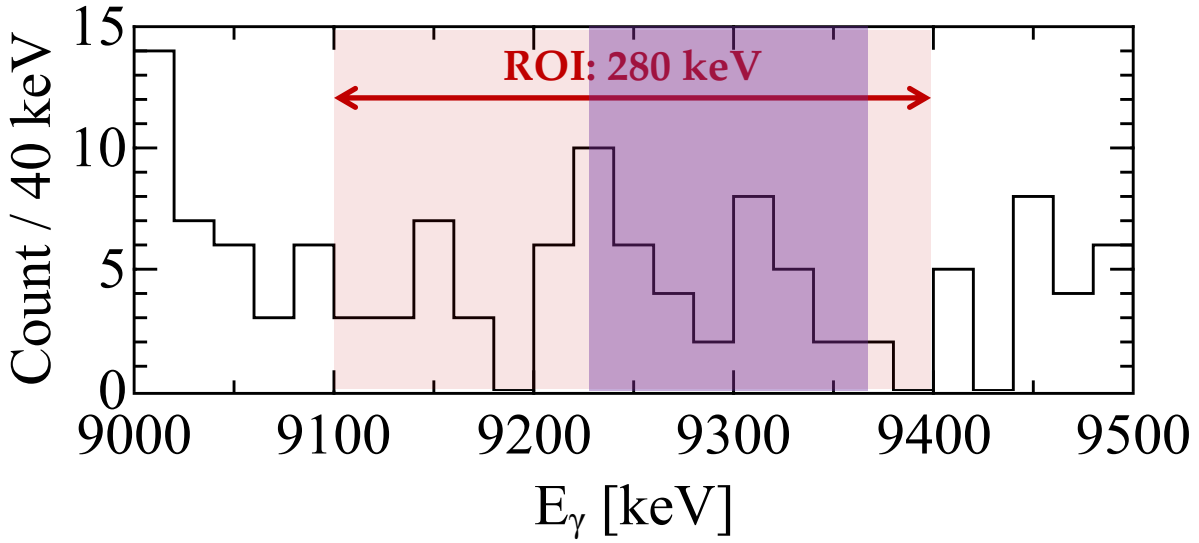


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

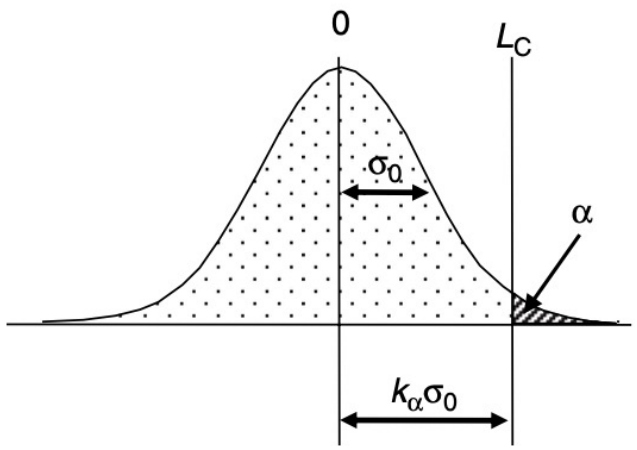
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

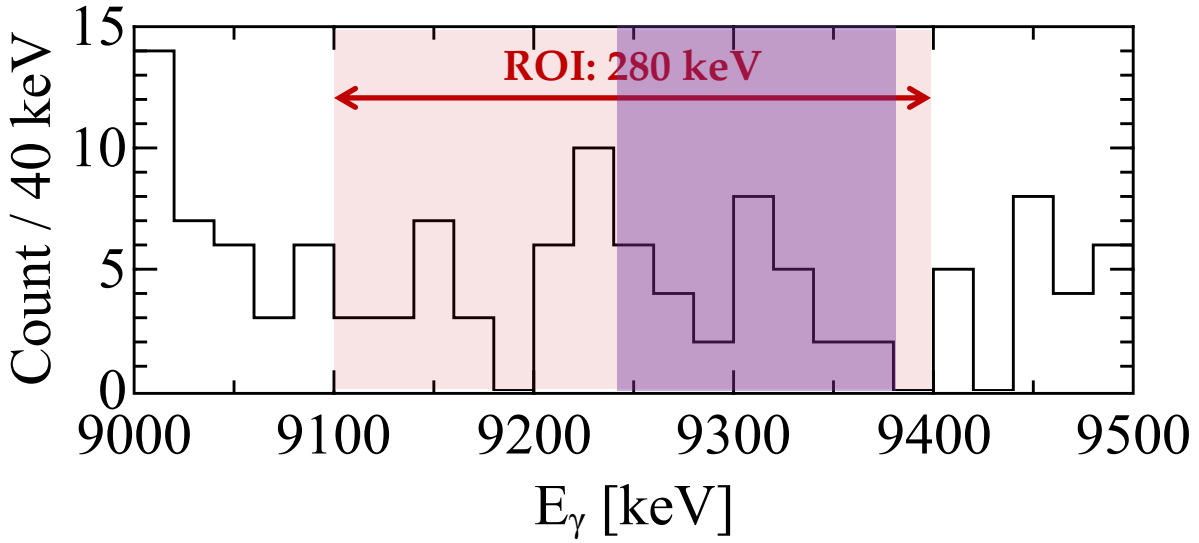


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

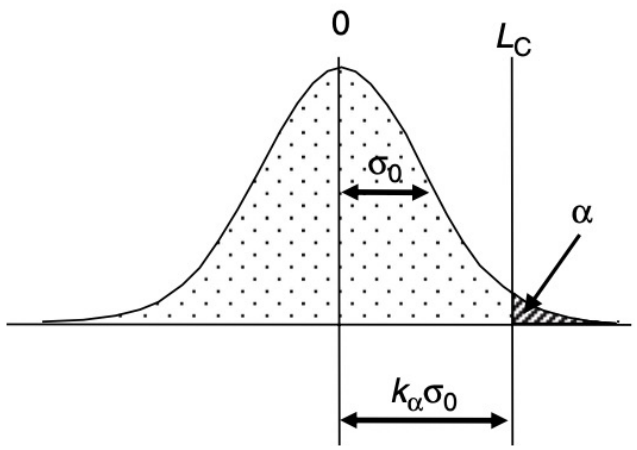
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

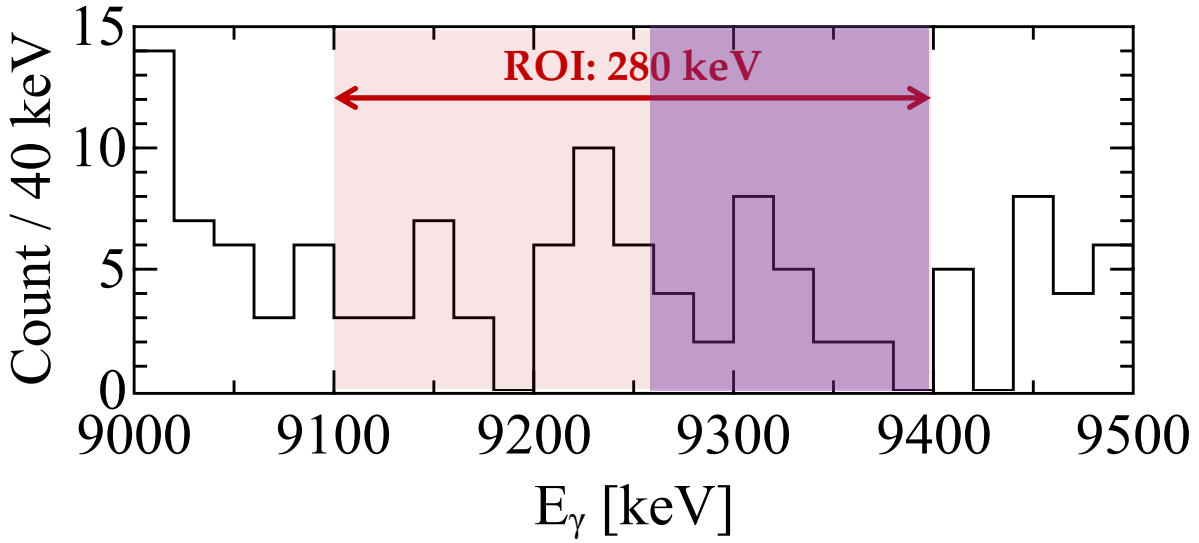


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

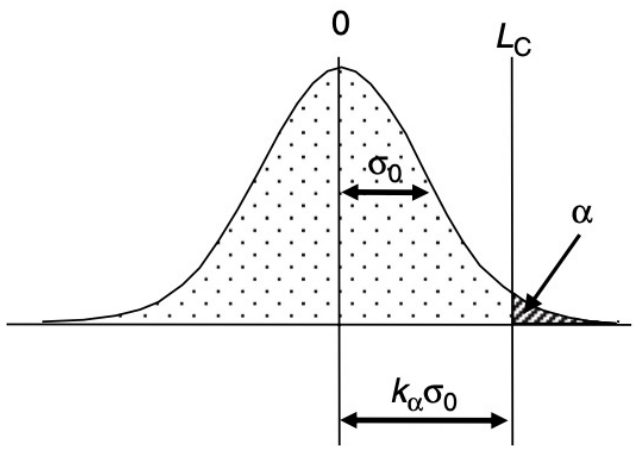
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

Simone Bottoni

STATISTICAL ANALYSIS OF THE GAMMA-RAY SPECTRUM

G. Gilmore, Practical Gamma Ray Spectrometry – 2nd edition, John Wiley and Sons (2008)

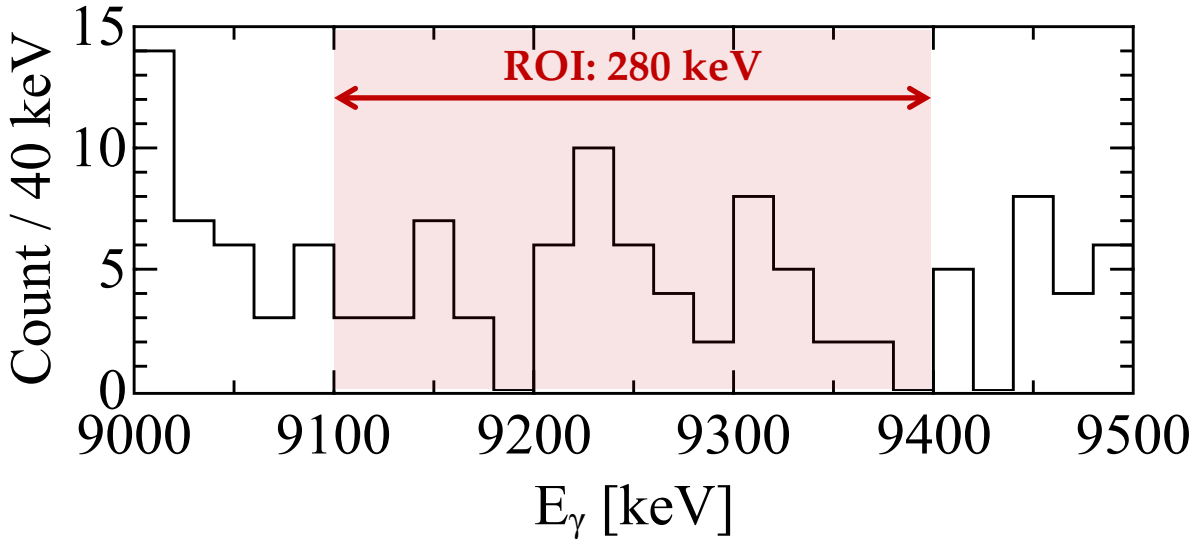


$$L_C = k_\alpha \sqrt{[B(1 + n/2m)]}$$

the measured number of counts is considered significant if

$$C - B > L_C$$

peak region background region



- Region of interest: 280 keV
- 120-keV moving window (3σ)
- 20-keV steps (1σ)

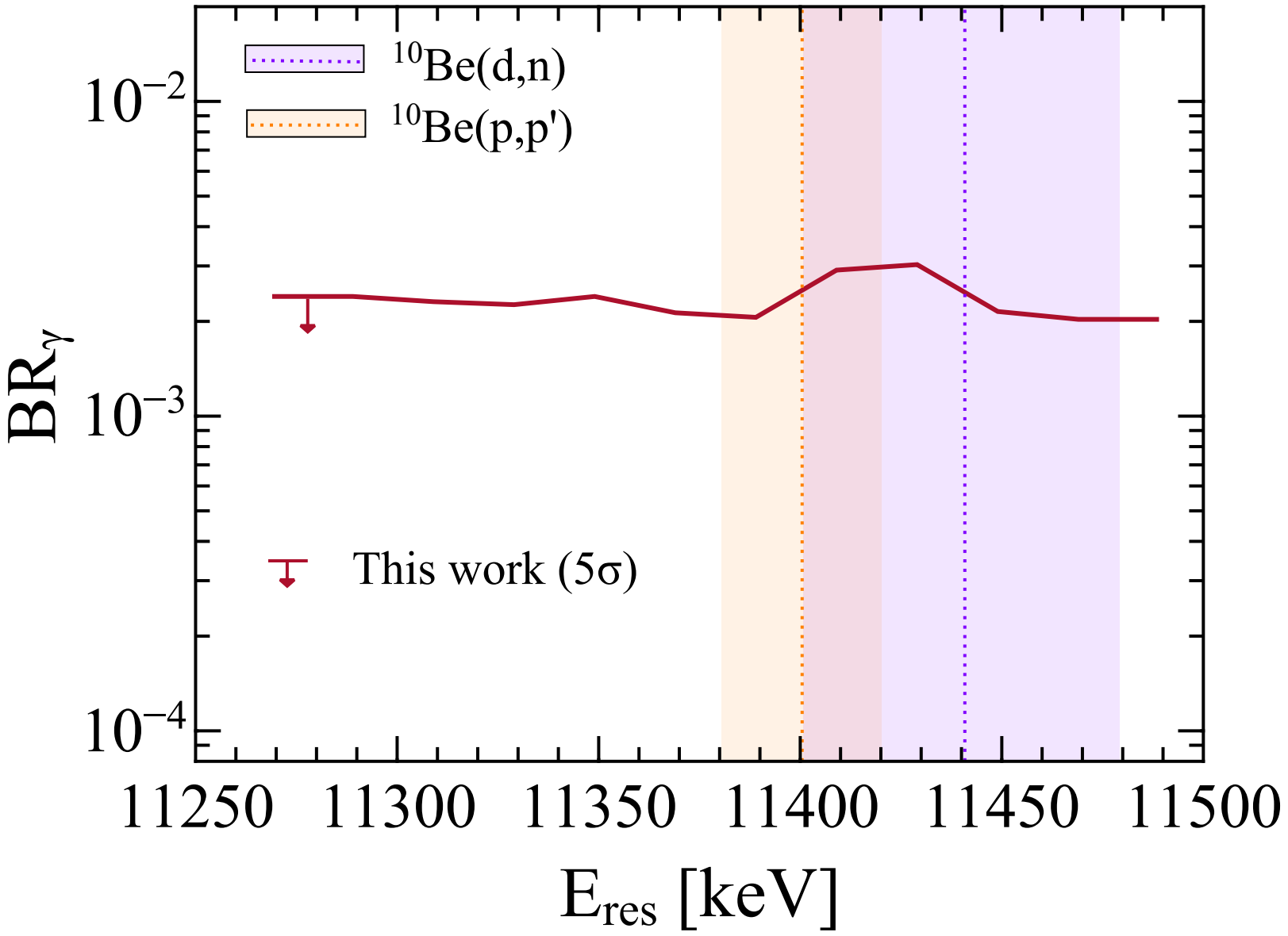
CONFIDENCE LEVEL

$$CL_L = CL_G^{1/M}$$

UPPER LIMIT

$$L_U = C + k_\alpha \sqrt{[C + B(1 + n/2m)]}$$

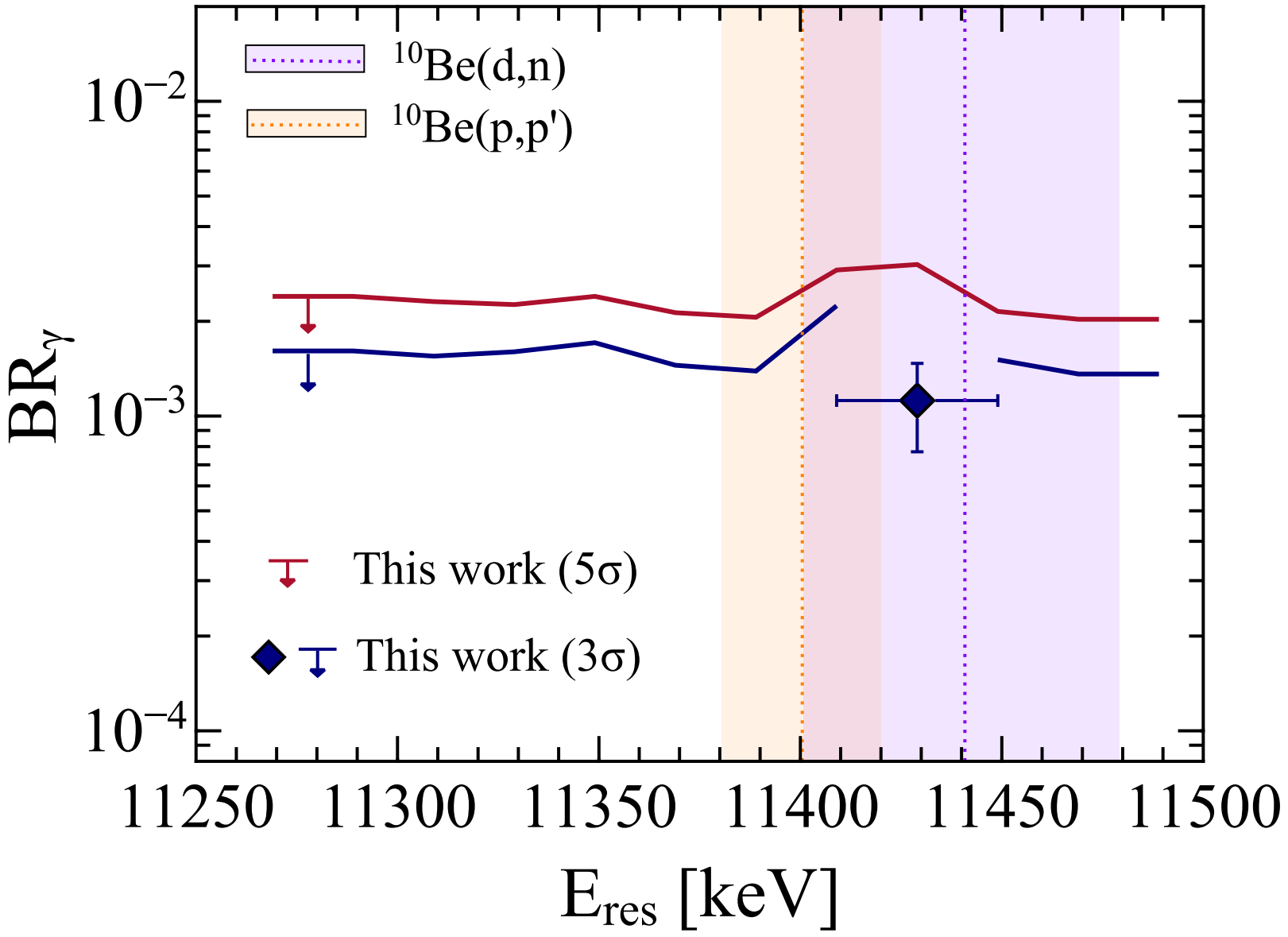
FINAL RESULTS



5σ global CL

no significant excess of counts

FINAL RESULTS



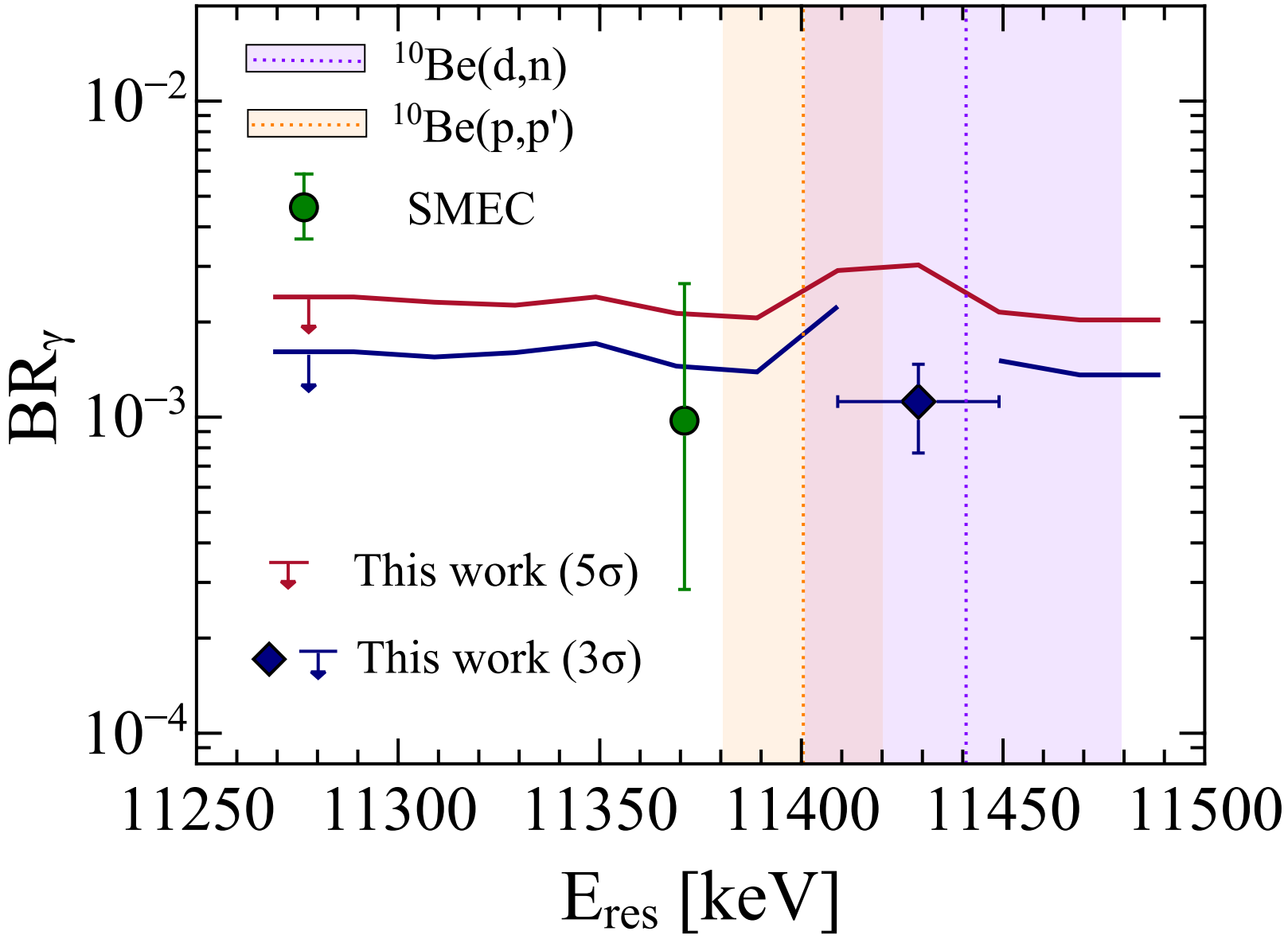
5σ global CL no significant excess of counts

3σ global CL

E_{res} =11429 (20) keV

b_γ =1.12(35) × 10^{-3}

FINAL RESULTS



5σ global CL no significant excess of counts

3σ global CL

E_{res} =11429 (20) keV

b_γ =1.12(35) × 10^{-3}

SMEC

E_{res} =11371 keV

$b_\gamma = 0.98^{+168}_{-69} \times 10^{-3}$

INPC

Phys. Lett. B 855, 138851 (2024)

Contents lists available at ScienceDirect

Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

Letter

Search for the γ decay of the narrow near-threshold proton resonance in ^{11}B

S. Bottoni [a,b,*], G. Corbari [a,b], S. Leoni [a,b], B. Fornal [c], A. Goasduff [d], S. Capra [a,b], D. Mengoni [e,f], E. Albanese [a,b], S. Ziliani [a,b], G. Benzoni [b], A.M. Sánchez-Benítez [g], A. Bracco [a,b], D. Brugnara [d], F. Camera [a,b], M. Ciemała [c], N. Cieplicka-Oryńczak [c], F.C.L. Crespi [a,b], J.A. Dueñas [h], A. Gadea [i], F. Galtarossa [f], E. Gamba [a,b], A. Gottardo [d], A. Gozzelino [d], J. Ha [e,f], Ł.W. Iskra [c], T. Marchi [d], R. Menegazzo [f], B. Million [b], D.R. Napoli [d], G. Pasqualato [e,f], J. Pellumaj [d,j], R.M. Pérez-Vidal [d,i], S. Pigliapoco [e,f], M. Polettini [a,b], C. Porzio [a,b,l], F. Recchia [e,f], K. Rezynkina [e,f], J.J. Valiente-Dóbon [d], O. Wieland [b], I. Zanon [d], G. Zhang [e,f]

Phys. Lett. B 855, 138851 (2024)

Contents lists available at ScienceDirect

Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

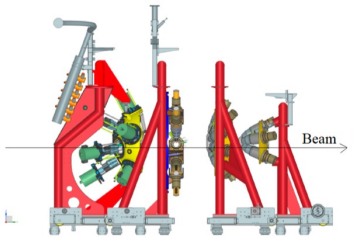
Letter

Search for the γ decay of the narrow near-threshold proton resonance in ^{11}B

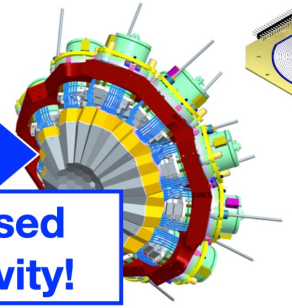
S. Bottoni [a,b,*], G. Corbari [a,b], S. Leoni [a,b], B. Fornal [c], A. Goasduff [d], S. Capra [a,b], D. Mengoni [e,f], E. Albanese [a,b], S. Ziliani [a,b], G. Benzoni [b], A.M. Sánchez-Benítez [g], A. Bracco [a,b], D. Brugnara [d], F. Camera [a,b], M. Ciemała [c], N. Cieplicka-Oryńczak [c], F.C.L. Crespi [a,b], J.A. Dueñas [h], A. Gadea [i], F. Galtarossa [f], E. Gamba [a,b], A. Gottardo [d], A. Gozzelino [d], J. Ha [e,f], Ł.W. Iskra [c], T. Marchi [d], R. Menegazzo [f], B. Million [b], D.R. Napoli [d], G. Pasqualato [e,f], J. Pellumaj [d,j], R.M. Pérez-Vidal [d,i], S. Pigliapoco [e,f], M. Polettini [a,b], C. Porzio [a,b,l], F. Recchia [e,f], K. Rezynkina [e,f], J.J. Valiente-Dóbon [d], O. Wieland [b], I. Zanon [d], G. Zhang [e,f]

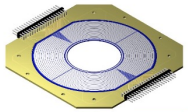
APPROVED EXPERIMENT AT LNL

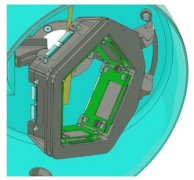
GALILEO+TRACE



AGATA+TRACE+SAURON







Increased Sensitivity!

GALILEO Phase II:
- 10 GTC with BGO
- 25 HPGE with BGO

TRACE prototype
- 3 ΔE-E telescopes
- Custom ASIC

AGATA:
- 1π configuration
- 13 ATC

Upgraded TRACE:
- 5 ΔE-E telescopes
- New FEE

Phys. Lett. B 855, 138851 (2024)

Contents lists available at ScienceDirect

Physics Letters B

journal homepage: www.elsevier.com/locate/physletb

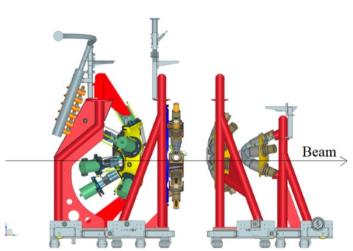
Letter

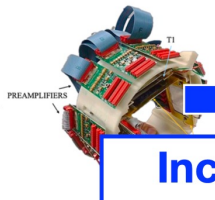
Search for the γ decay of the narrow near-threshold proton resonance in ^{11}B

S. Bottoni [a,b,*], G. Corbari [a,b], S. Leoni [a,b], B. Fornal [c], A. Goasduff [d], S. Capra [a,b], D. Mengoni [e,f], E. Albanese [a,b], S. Ziliani [a,b], G. Benzoni [b], A.M. Sánchez-Benítez [g], A. Bracco [a,b], D. Brugnara [d], F. Camera [a,b], M. Ciemała [c], N. Cieplicka-Oryńczak [c], F.C.L. Crespi [a,b], J.A. Dueñas [h], A. Gadea [i], F. Galtarossa [f], E. Gamba [a,b], A. Gottardo [d], A. Gozzelino [d], J. Ha [e,f], Ł.W. Iskra [c], T. Marchi [d], R. Menegazzo [f], B. Million [b], D.R. Napoli [d], G. Pasqualato [e,f], J. Pellumaj [d,j], R.M. Pérez-Vidal [d,i], S. Pigliapoco [e,f], M. Polettini [a,b], C. Porzio [a,b,1], F. Recchia [e,f], K. Rezynkina [e,f], J.J. Valiente-Dóbon [d], O. Wieland [b], I. Zanon [d], G. Zhang [e,f]

APPROVED EXPERIMENT AT LNL

GALILEO+TRACE

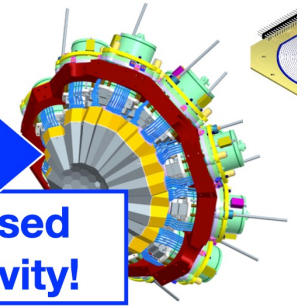


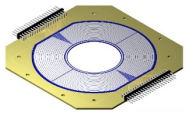


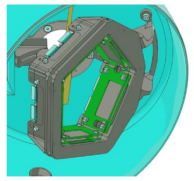
GALILEO Phase II:
- 10 GTC with BGO
- 25 HPGE with BGO

TRACE prototype
- 3 ΔE-E telescopes
- Custom ASIC

AGATA+TRACE+SAURON







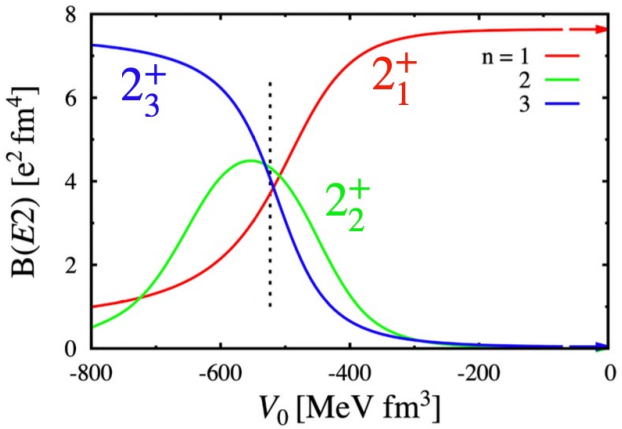
Increased Sensitivity!

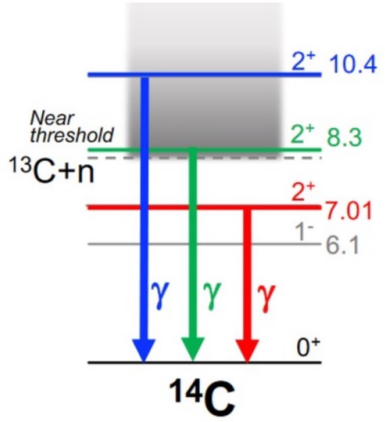
AGATA:
- 1π configuration
- 13 ATC

Upgraded TRACE:
- 5 ΔE-E telescopes
- New FEE

THE CASE OF ^{14}C

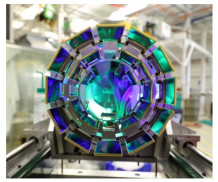
M. Ploszajczak, J. Okolowicz, J. Phys. Conf. Ser. 1643, 012156 (2020)





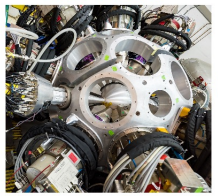
GODDESS

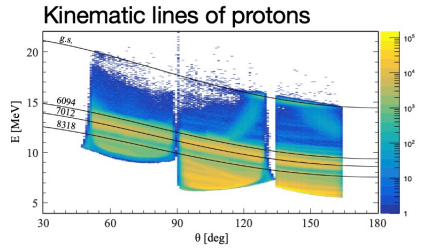
ORRUBA

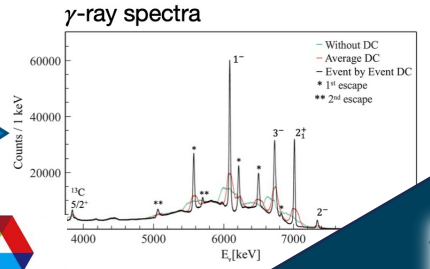


+

GRETINA







Argonne NATIONAL LABORATORY

ONGOING ANALYSIS

G. Corbari *et al.*

INPC

Thank you!

Simone Bottoni

Università degli Studi di Milano
INFN Sezione di Milano

INPC 2025

May 25-30, 2025
DCC, Daejeon, Korea