

Searching for β - delayed protons from ^{11}Be

Natalia Sokołowska

Faculty of Physics of University of Warsaw

57. International Winter Meeting on Nuclear Physics
Bormio, January 2019

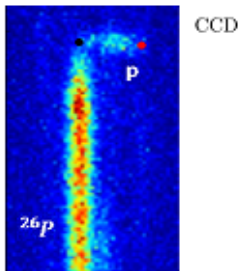
What's so interesting in that ?

What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)

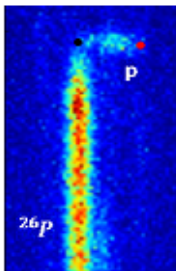
What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)

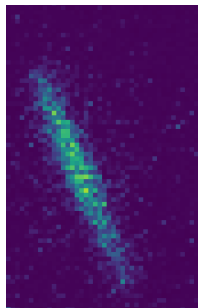


What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)



CCD



What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)
- β -delayed protons of ^{11}Be :

What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)
- β -delayed protons of ^{11}Be :
 - BR: $10^{-8} \sim 10^{-5}$

What's so interesting in that ?

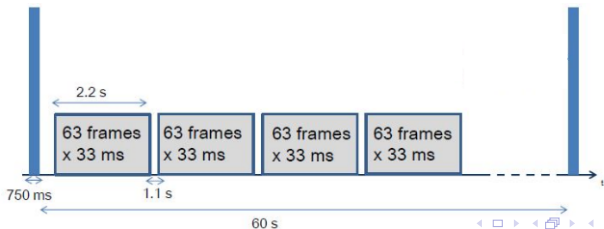
- the Optical Time Projection Chamber (*OTPC*)
- β -delayed protons of ^{11}Be :
 - BR: $10^{-8} \sim 10^{-5}$
 - $E \sim 200 \text{ keV}$

What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)
- β -delayed protons of ^{11}Be :
 - BR: $10^{-8} \sim 10^{-5}$
 - $E \sim 200 \text{ keV}$
- movie & bunched mode

What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)
- β -delayed protons of ^{11}Be :
 - BR: $10^{-8} \sim 10^{-5}$
 - $E \sim 200 \text{ keV}$
- movie & bunched mode



What's so interesting in that ?

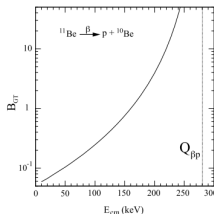
- the Optical Time Projection Chamber (*OTPC*)
- β -delayed protons of ^{11}Be :
 - BR: $10^{-8} \sim 10^{-5}$
 - $E \sim 200$ keV
- movie & bunched mode
- less and more exotic hypotheses...

What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)

- β -delayed protons of ^{11}Be :

- BR: $10^{-8} \sim 10^{-5}$
- $E \sim 200$ keV



- movie & bunched mode

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

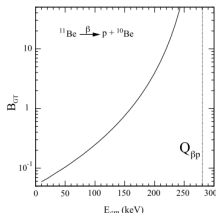
- less and more exotic hypotheses...

What's so interesting in that ?

- the Optical Time Projection Chamber (*OTPC*)

- β -delayed protons of ^{11}Be :

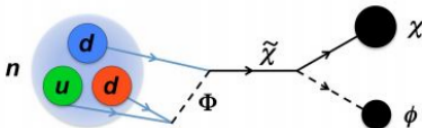
- BR: $10^{-8} \sim 10^{-5}$
- $E \sim 200$ keV



- movie & bunched mode


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

- less and more exotic hypotheses...



Summary

Summary



Searching for β^- -delayed protons from ^{11}Be

T. Di Liberto¹, M. Sisti¹, A. Casarà¹, W. Bracco¹, A. Fallorina¹, G. M. Innocenti¹, A. Ghidini¹, E. Sisti¹, G. Scamporrino¹, A. Kemp¹, A. Katsikis¹, C. Mancusi¹, K. Sliwa¹, M. Pittner², M. Pavesi², J. Ojeda², S. Ota², and the Collaboration

¹University of Pavia, Department of Physics, Pavia, Italy
²INFN, Laboratori Nazionali del Sud, Catania, Italy

Overview


β^- -Delayed charged-particle emission

- High Q-value nuclei approaching proton drip-line
- Population of higher excited states (e.g. 1^{-}) instead of the ground state
- Inelastic, intranuclear transitions
- Resonance in some nucleus with multiple β^- -decays

Dark matter


- Astrophysical predictions extremely low branching ratio ($\sim 10^{-10}$) and low energy (< 100 keV) of emitted proton
- World's most sensitive indirect measurements [1] β^- decay much larger than predicted
- May be the Dark Matter relic signal emergence in influence of the sub-structure of the nucleus
- Possible existence of a new invisible decay channel?
- Alternative setup sensitive to low-energy proton and sensitive to β^- particles \rightarrow Optical Time Projection Chamber [2]

Physics background



What are we looking for?
 - excited β^- decays
 - rarely $\beta\beta$
 - resonance energy spectrum of the proton drip line

Why does ^{11}Be decay to 1^{-} state?
 - weak β^- \rightarrow 1^{-} state
 - spin \rightarrow 1^{-} state
 - spin \rightarrow 1^{-} state
 - spin \rightarrow 1^{-} state




Proton energy spectrum of ^{11}Be decay
 - 10^{-4} probability
 - 10^{-4} probability
 - 10^{-4} probability

Dark hypothesis

Neutrons build β^- particles
 - They can decay into the 1^{-} state of ^{11}Be

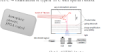
Neutrons build β^- particles
 - They can decay into the 1^{-} state of ^{11}Be



Neutrons build β^- particles
 - They can decay into the 1^{-} state of ^{11}Be

Optical Time Projection Chamber

OTPC \rightarrow combination of typical TPC with use of camera




The data structure and reconstruction principle
 - 10^{-4} probability
 - 10^{-4} probability
 - 10^{-4} probability


Bunched and mono mode

Big detector was produced in 2003 (2004) at INFN Laboratori Nazionali del Sud

- primary beam: protons, ^{11}Be , ^{12}C , ^{16}O , ^{20}Ne
 - ^{11}Be to OTPC

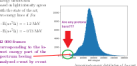


Start bunch of ^{11}Be in experiment with the detector
 - bunch of ^{11}Be ions
 - 10^{-4} probability
 - 10^{-4} probability



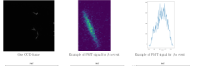
Analysis is ongoing...

Energy 100 keV
 - 10^{-4} probability
 - 10^{-4} probability
 - 10^{-4} probability



All ^{11}Be decays corresponding to the 1^{-} state are identified by the 10^{-4} probability
 - 10^{-4} probability
 - 10^{-4} probability

What do we looking for?



Energy 100 keV
 - 10^{-4} probability
 - 10^{-4} probability
 - 10^{-4} probability

Literature

[1] Sisti et al. Phys. Lett. B 688 (2010) 100
 [2] Di Liberto et al. Phys. Lett. B 711 (2012) 100
 [3] Sisti et al. Phys. Lett. B 711 (2012) 100
 [4] Sisti et al. Phys. Lett. B 711 (2012) 100