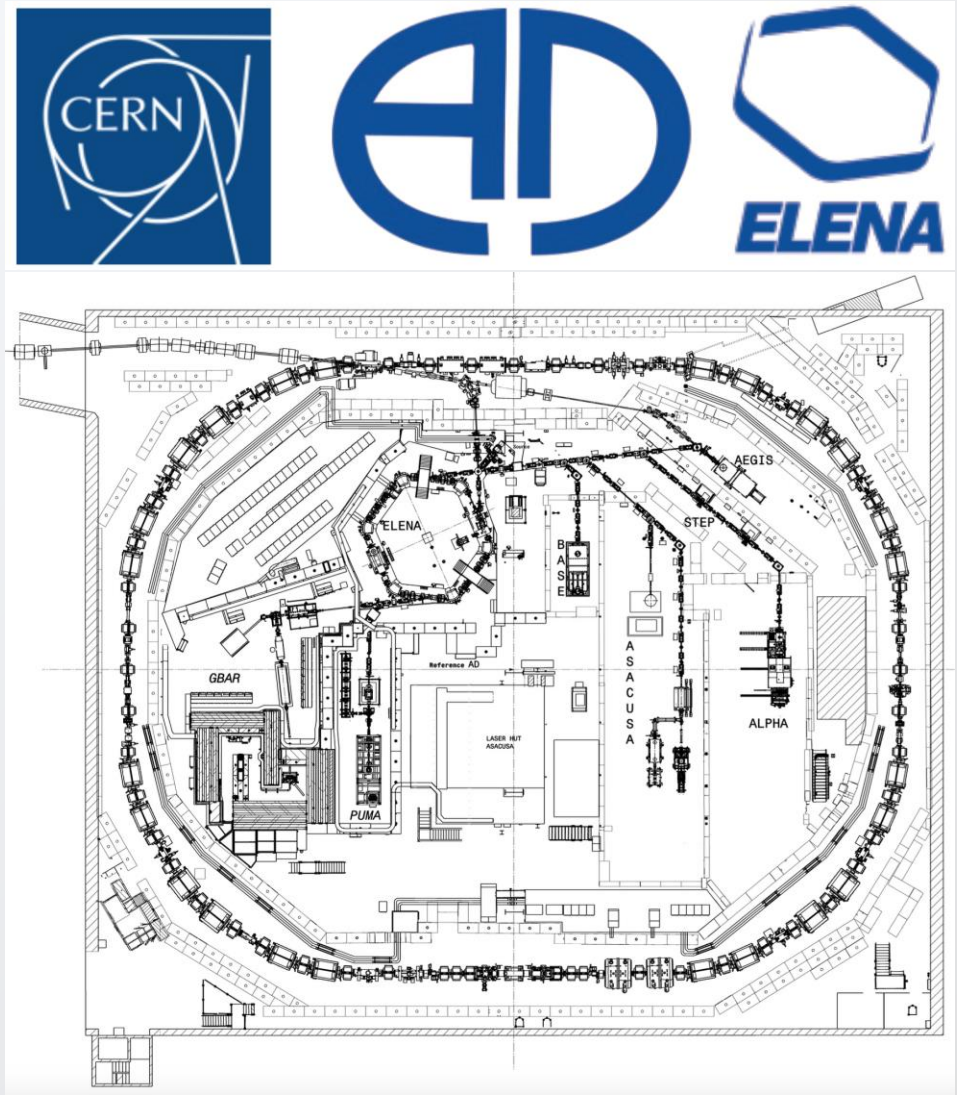


Perspective for low-energy antimatter physics at AEGIS

Fundamental physics goal NorCC roadmap

What are the plausible theoretical models explaining the experimentally observable beyond-Standard Model phenomena?

How can gravity be included in the same theoretical framework as particle and nuclear physics?

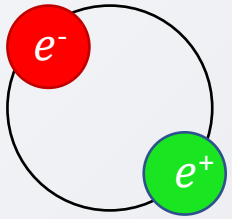
What is the origin of the dark matter?

What is the origin of the large matter/antimatter unbalance ?

And even some nuclear physics!

Antimatter: Ps laser cooling

Positronium (Ps)



PHYSICAL REVIEW LETTERS **132,** 083402 (2024)

Editors' Suggestion | Featured in Physics

UiO and NTNU

Positronium Laser Cooling via the 1^3S-2^3P Transition with a Broadband Laser Pulse

Nytt antimaterie-resultat vekker begeistring

Forskerne har lykkes med å kjøle ned positronium med laser. Teknikken gjør en rekke nye antimaterie-eksperimenter mulige.

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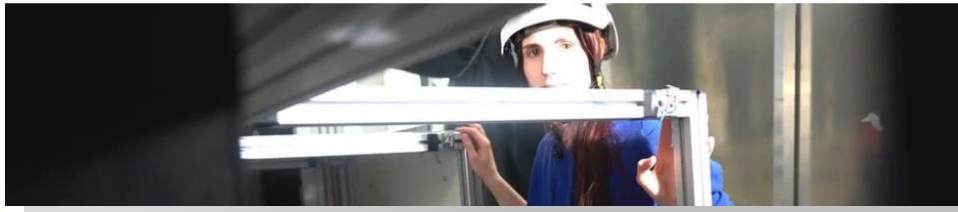
Science

Antimatter: Scientists freeze positronium atoms with lasers

18 hours ago



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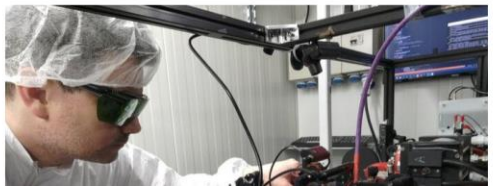
Des lasers refroidissent une particule furtive mi-matière, mi-antimatière

Deux équipes de chercheurs, au CERN et au Japon, ont réussi à ralentir des positroniums, formés d'un électron et d'un positron, et extrêmement fugaces, afin de pouvoir mieux mesur leurs propriétés. Un tour de force qui ouvre de nouvelles perspectives en physique fondamentale et appliquée.

Par David Larousserie
Publié aujourd'hui à 18h00 · Lecture 3 min.

Ajouter à vos sélections

Article réservé aux abonnés



News / Technology / Science / In a first, CERN scientists carry out laser cooling of Positronium

Premium

In a first, CERN scientists carry out laser cooling of Positronium

Physicists representing 19 European and one India research group comprising the Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy (AEgIS) collaboration announced this scientific achievement on Thursday.

Written by Anjali Marar
Bengaluru | Updated: February 29, 2024 13:34 IST

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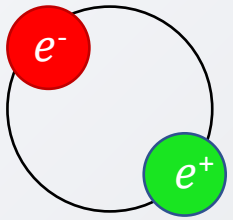
Antimatter: BSM physics with Ps

Positronium (Ps)

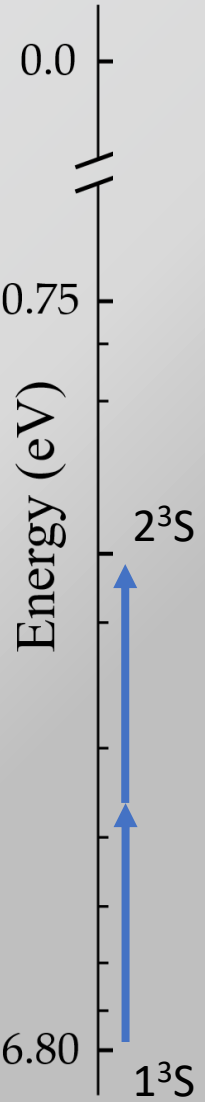


PHYSICAL REVIEW LETTERS **132,** 083402 (2024)

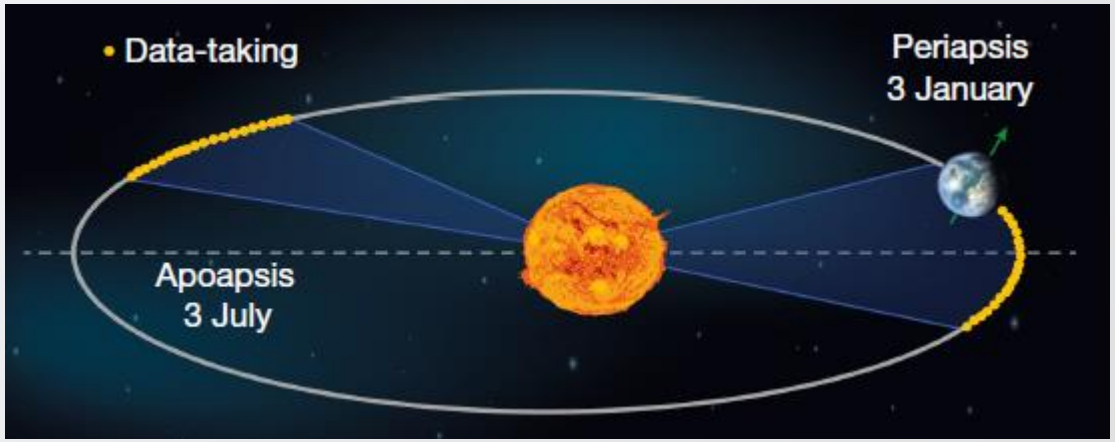
Editors' Suggestion | Featured in Physics

Positronium Laser Cooling via the 1^3S-2^3P Transition with a Broadband Laser Pulse

Next: 1^3S-2^3S precision spectroscopy of Positronium



Gravitational redshift



Reproduced from Borchert et al. (BASE collaboration), Nature 601 (2022) 53-57

Tests:

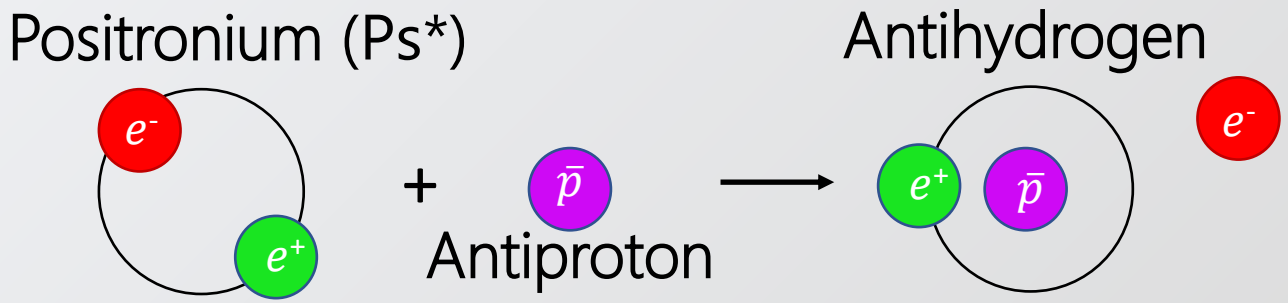
- Bound state QED
- (beyond the QCD) axion-like particles
- 5th fundamental force
- Test of C and P symmetries

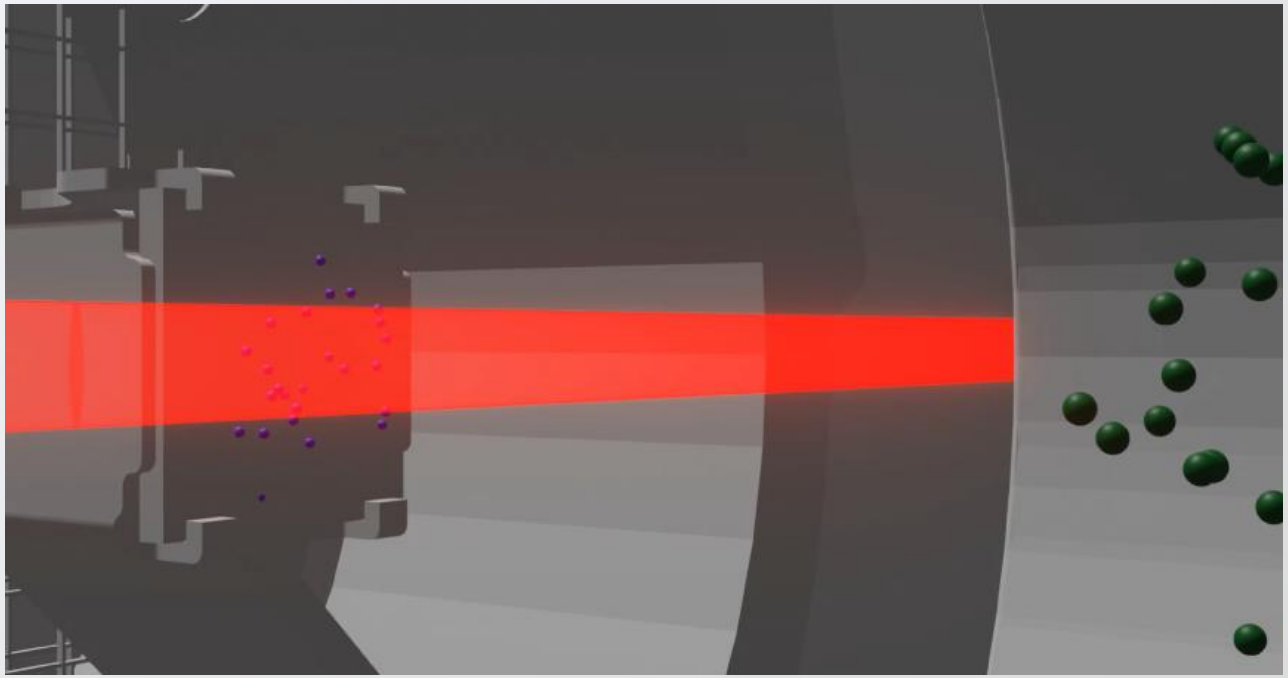
Precision spectroscopy of positronium: Testing bound-state QED theory and the search for physics beyond the Standard Model

G.S. Adkins [a], D.B. Cassidy [b], J. Pérez-Ríos [c,*]

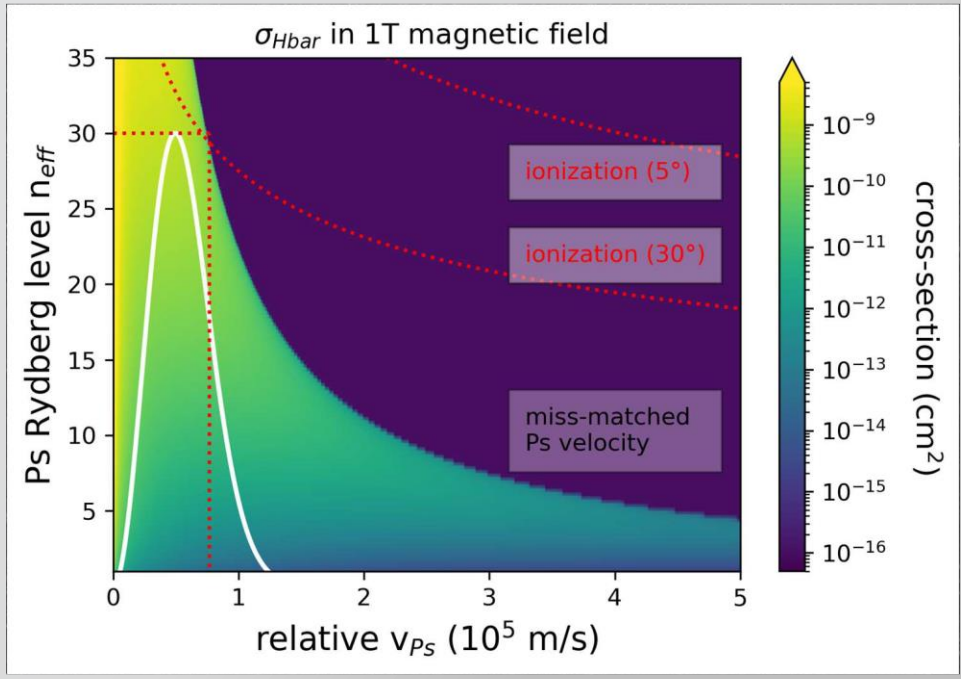
Antimatter: gravity on antihydrogen

Amsler et al. (AEgIS)
Comm Phys 4:19 (2021)





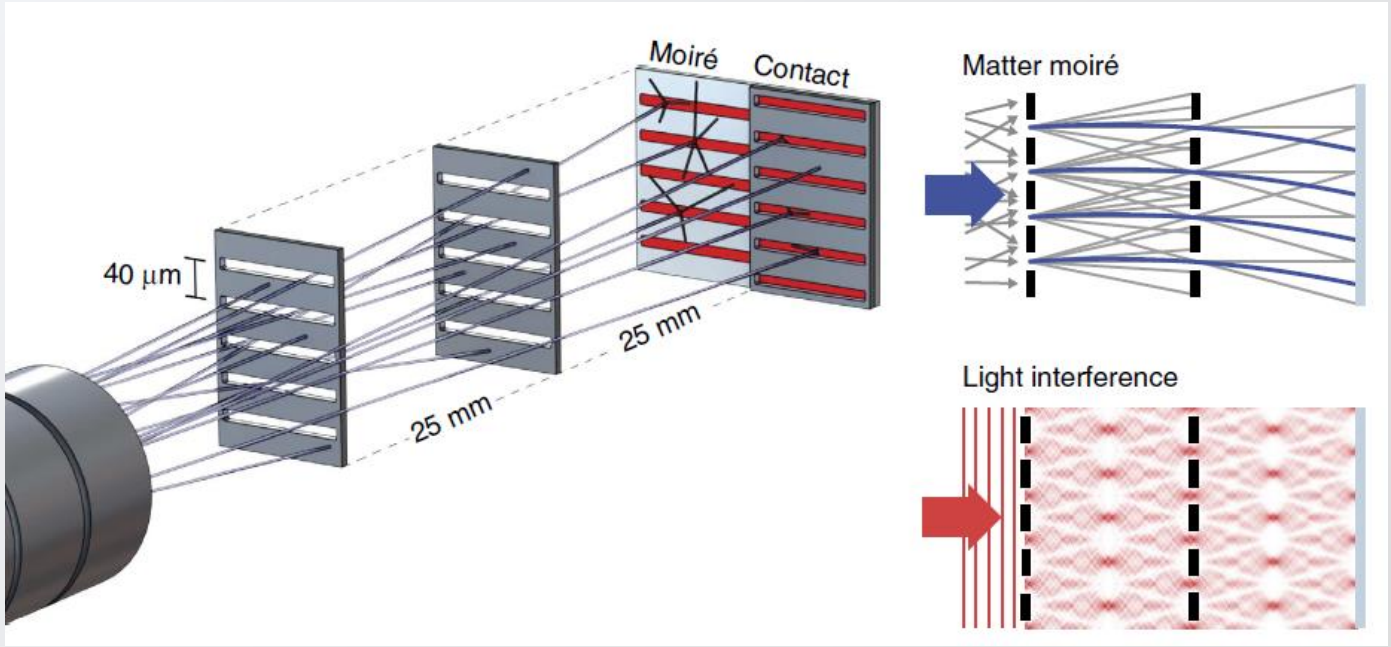
Credits Olivia Adams (CERN, 2023)

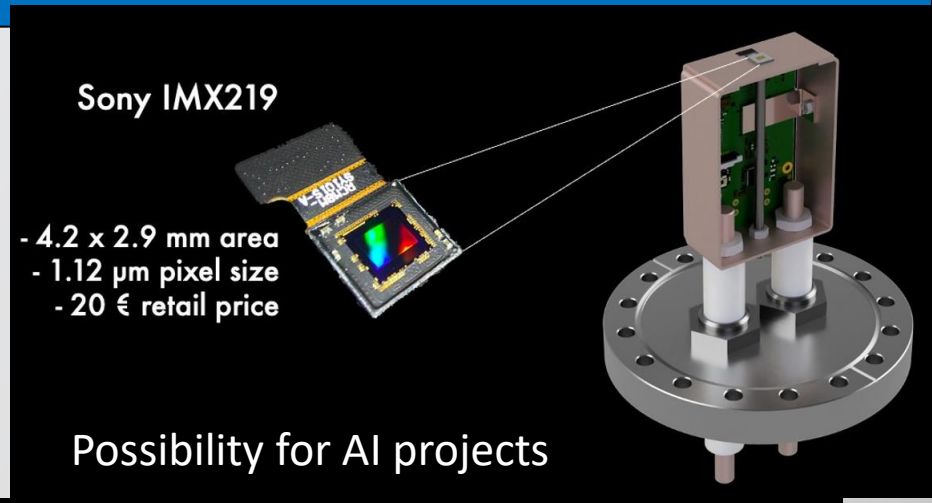


See Antonello et al. (AEgIS collaboration)
PRA 102, 01310 (2020) for Ps self-ionization in B field

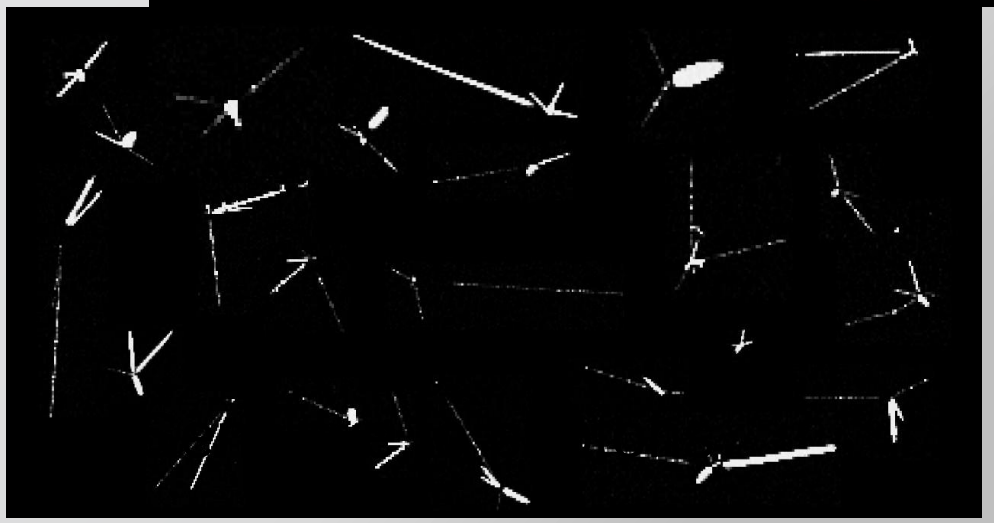
ARTICLE
Received 5 Nov 2013 | Accepted 27 Jun 2014 | Published 28 Jul 2014
DOI: 10.1038/ncomms5538
OPEN

A moiré deflectometer for antimatter





Possibility for AI projects



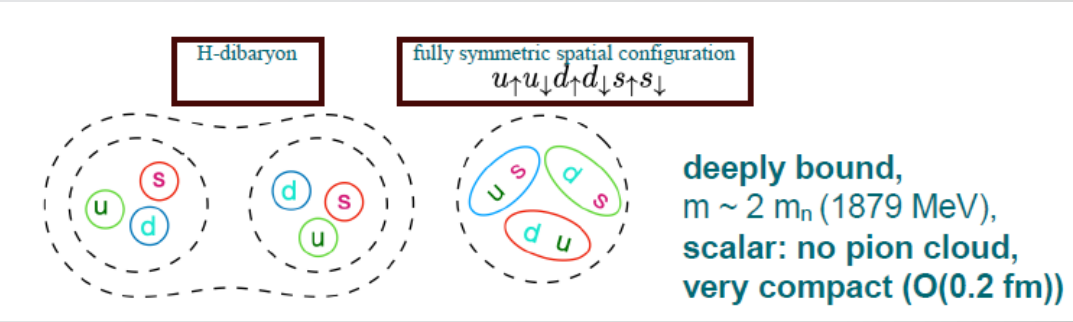
Resolution to antiproton vertices << 2.0 μm

In collaboration with: Technical University of Munich

Search for a sexaquark dark matter candidate

Doser, M., Farrar, G. & Kornakov, G. Searching for a dark matter particle with anti-protonic atoms. *Eur. Phys. J. C***83**, 1149 (2023). https://doi.org/10.1140/epjc/s10052-023-12319-8

The sexaquark S is a hypothesized deeply bound, long-lived or stable 0+ state of *uuddss* quarks with **B=+2, S=–2 and Q=0.**



- If $m_S < m_\Lambda + m_p + m_e = 2.054$ GeV → decay must be **doubly-weak and its lifetime would be greater than the age of the Universe**.
- Direct detection experiments have not yet probed the relevant mass.
- The stability of neutron stars is not affected by the sexaquarks, due to deconfinement.

Difficult to detect:

• The S is **neutral** and a **flavor singlet**, so it does **not couple to photons**, **pions** and most other mesons, nor does it leave a track in a detector.

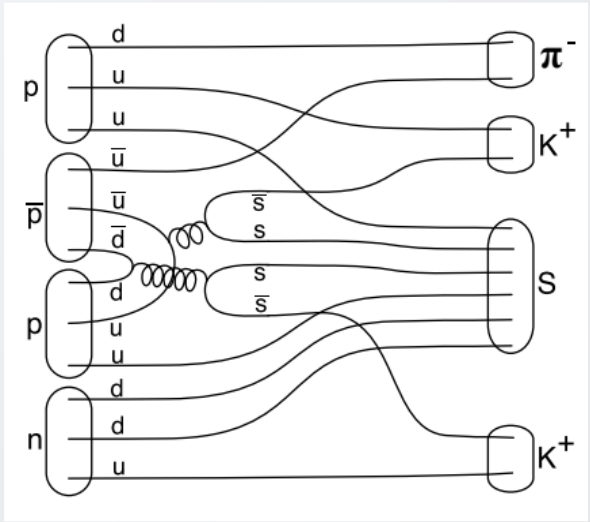
• The S has **no pion cloud** and is expected to be **more compact than ordinary baryons**. This means the amplitude for interconversion between S and baryons is small.

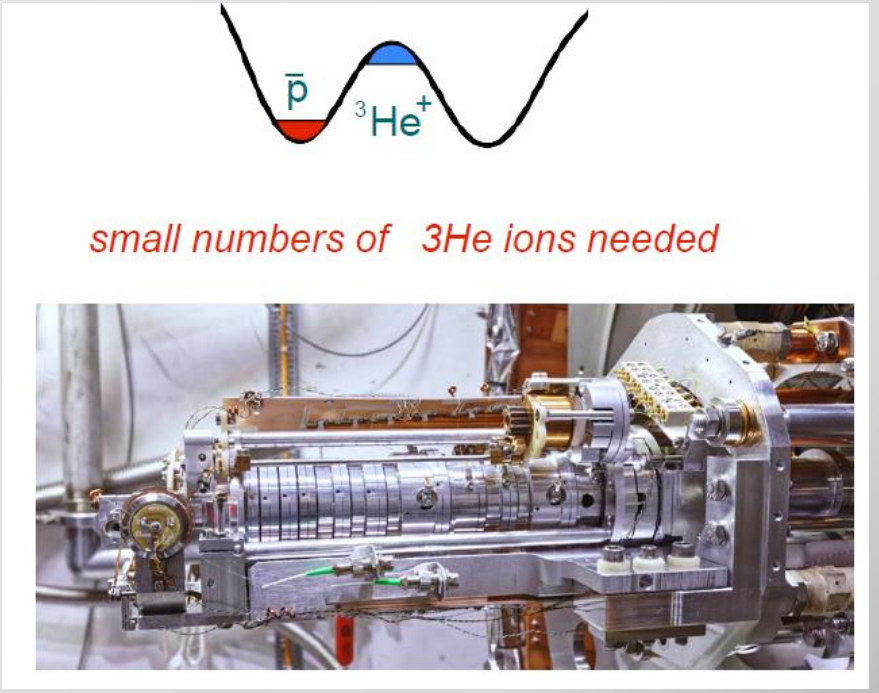
• The mass of the S makes it **difficult to distinguish from** the much more copious **neutron**.

Credits G. Kornakov

The antiprotonic ^{3}He atoms probe

$(p\ ^3He) \rightarrow S(uuddss) + K^+K^+\pi^-$





no other known SM process produces such a signature
production at rest allows full kinematic reconstruction of all particles (except S)

Formation mechanism for antiprotonic atoms can be used to test the existence of the S sexaquark (uuddss)

Expected rate ~10^{-9}

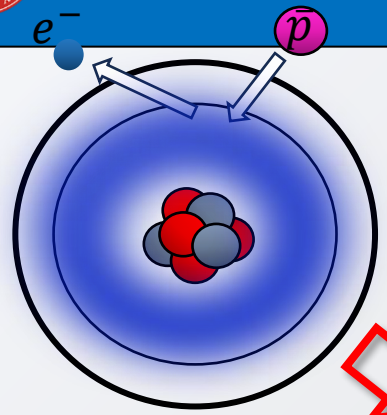
$m_{\bar{p}} + m_p + m_p + m_n \sim 3750$ MeV

requires multi-nucleon annihilation !
other multi-nucleon annihilations seen at O(10^{-5}) - ASTERIX, OBELIX

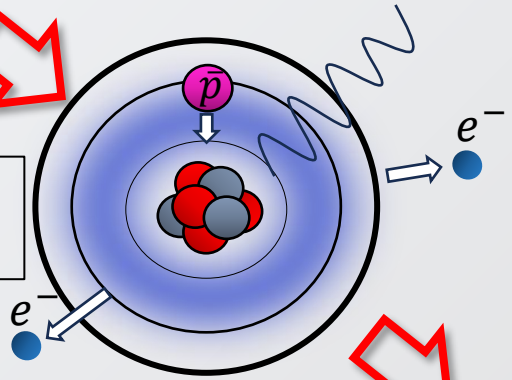
Detection scheme: silicon strip/pixel?

Credits G. Kornakov

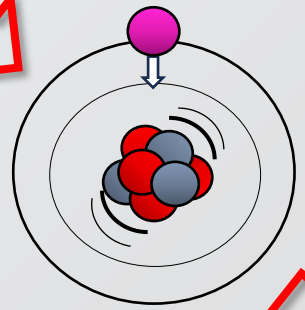
Nuclear physics: probing nuclei surfaces



Capture of the antiproton in a **high-n Rydberg state**.

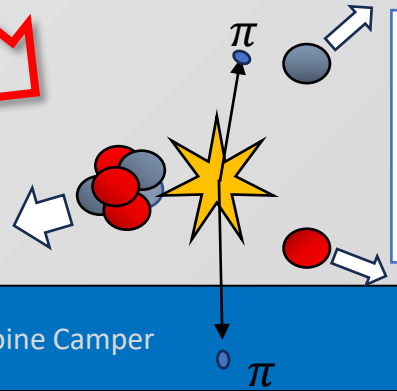


Cascade emitting x-rays and Auger electrons.



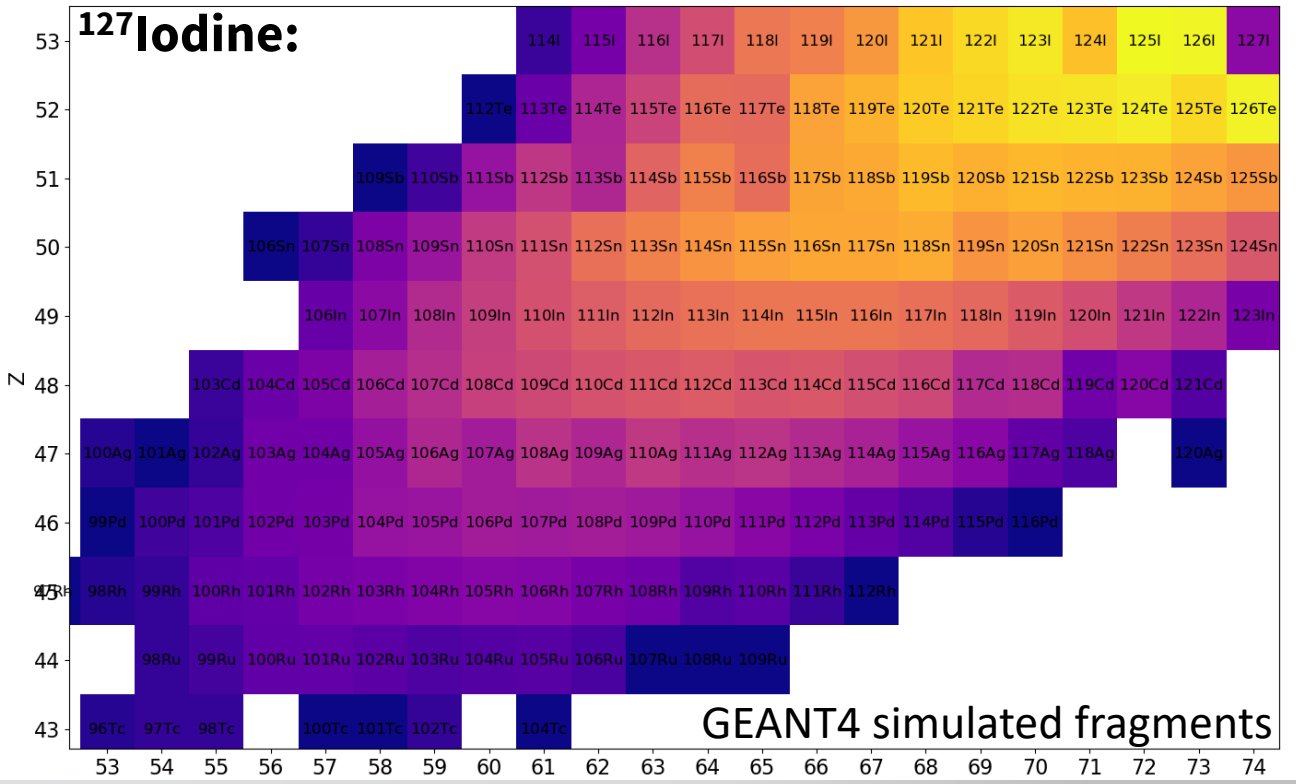
Antiproton approaching stripped nucleus, **strong interaction influences orbitals**.

X-ray linebroadening caused by **annihilation with nuclear perifery**.



Credits F. Parnefjord Gustafsson

Antiproton-induced nuclear fragmentation on ^{127}Iodine:



- Fragmentation ratios $R_{np} = Y(N-1)/Y(Z-1)$ give insight into the nuclear periphery.