FFF Meeting - 13 January 2021

Feebly interacting light particles: motivations and hints

Consider particle physics at low energy:

QED + Weak processes + Strong Interactions

γ, $m_\gamma = 0$

$\mu \longrightarrow e\, \nu_\mu\, \bar{\nu}_e$

$n \longrightarrow p\, e\, \bar{\nu}_e$

Baryons $m_{p,n} = 1\text{GeV}$

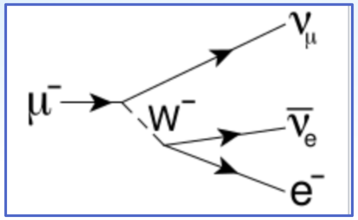
π's $m_\pi \ll 1\text{GeV}$

They both originate from $\Lambda \sim 100\text{GeV}$

Massless γ 'leaks down' (gauge + SM Higgs mechanism)

Dim=6 Fermi operator induced by heavy particles exchange

($M_{heavy} \gg$ available energy)



"Would be" massless π's 'leak down' from the GeV scale because they are Goldstone Bosons (NGB) of a (slightly broken) global symmetry.

Enrico Nardi

BSM effective interactions can arise from the exchange of new heavy particles (up to, say, $M_{new} \lesssim 10^5$ GeV).

(example: the type of effective operators invoked to explain the B anomalies)

For this type of effects: higher energies, better chances of discovery

Light, Feebly Interacting Particles (FIPs) can 'leak down' from some dynamics at very large scales (say, 10^{10} GeV or even more).

'Hidden photons' (spin-1 bosons of some hidden local symmetry) or

'Axion Like Particles' (ALPs: spin-0 NGB of some global symmetry)

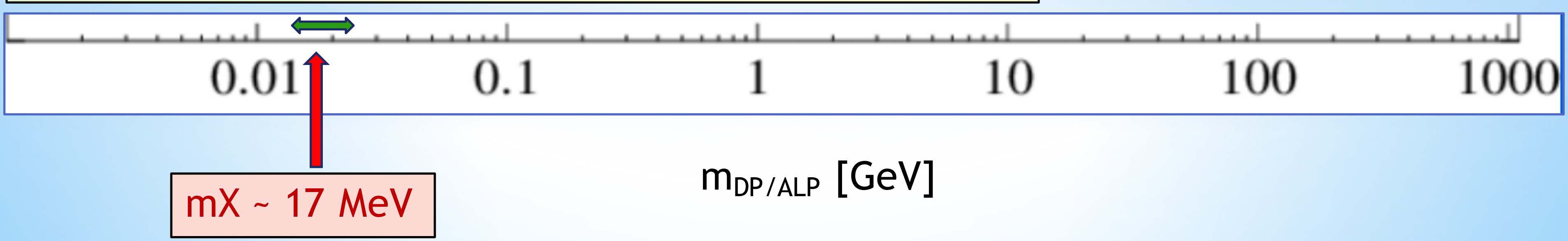
are **naturally light** (energetically accessible) and **feebly interacting.**

For this type of new physics: high intensity beams, high statistics,
high precision experiments.

- A certain number of anomalies are seen in low energy experiments.
- $(g\text{-}2)_\mu$ and $(g\text{-}2)_e$ [a new determination of α suggests $(g\text{-}2)_e$ is OK]
- τ_n determination: ‘bottle’ versus ‘beam’
- Proton radius: *e*-spectroscopy/scattering vs. μ-spectroscopy
- Cosmological ^{7}Li abundance: 3-5 times lower w.r. standard BBN
- ^{8}Be anomaly in nuclear transitions [Atomki collab.]

For all of them explanations in terms of DP/ALPs have been proposed. I will only describe the ^{8}Be anomaly, because:

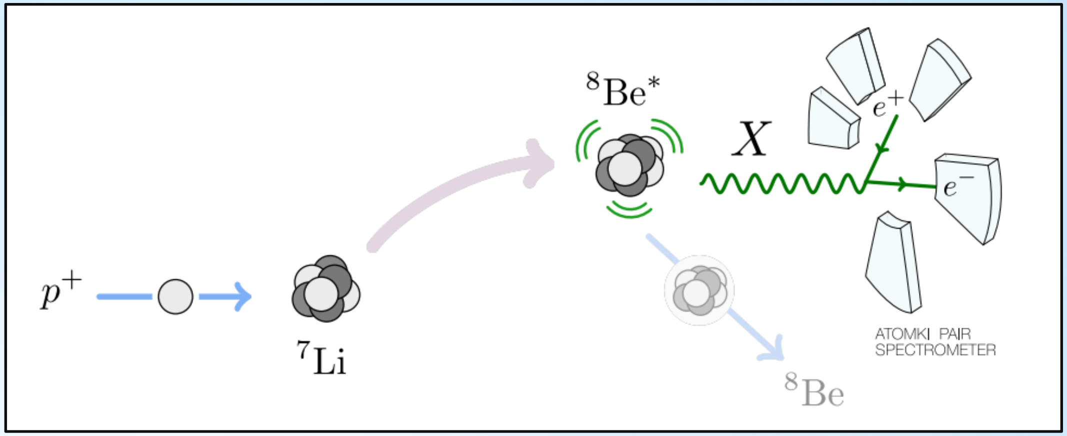
$\sqrt{s}$ (E_{cdm}) of the LNF e^+ beam on fixed target: 15-23 MeV



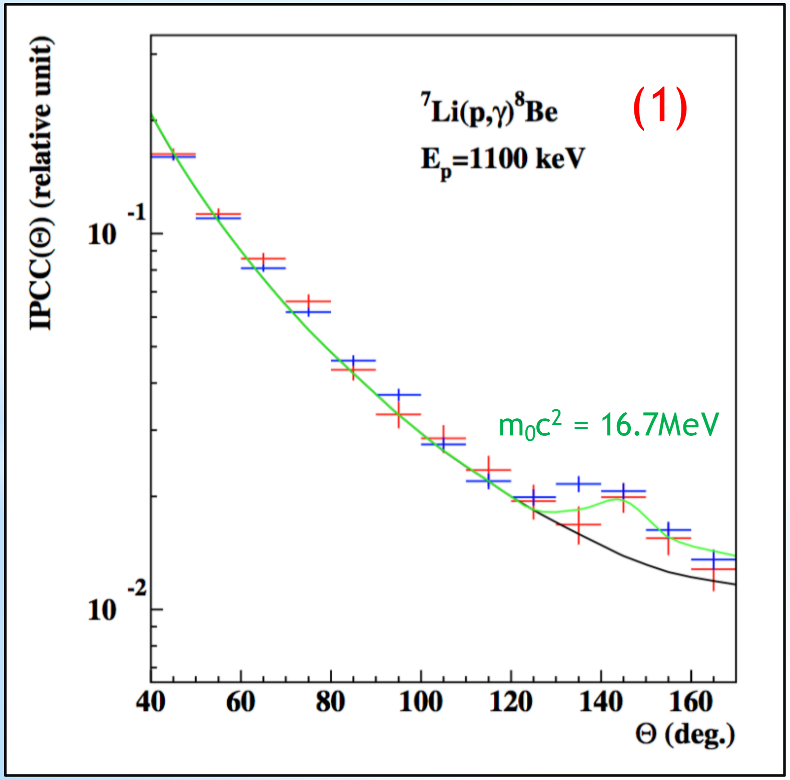
The Nucl. Phys. Experiment (2016):

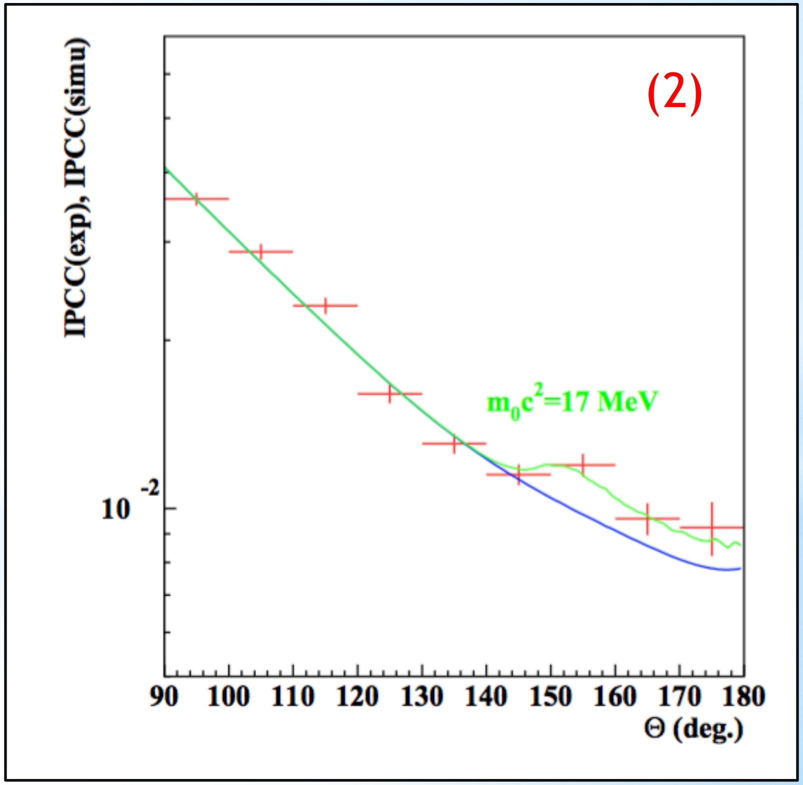
(1) $^8Be^*$(18.15MeV) → ^8Be

(2) $^8Be^*$(17.64MeV) → ^8Be



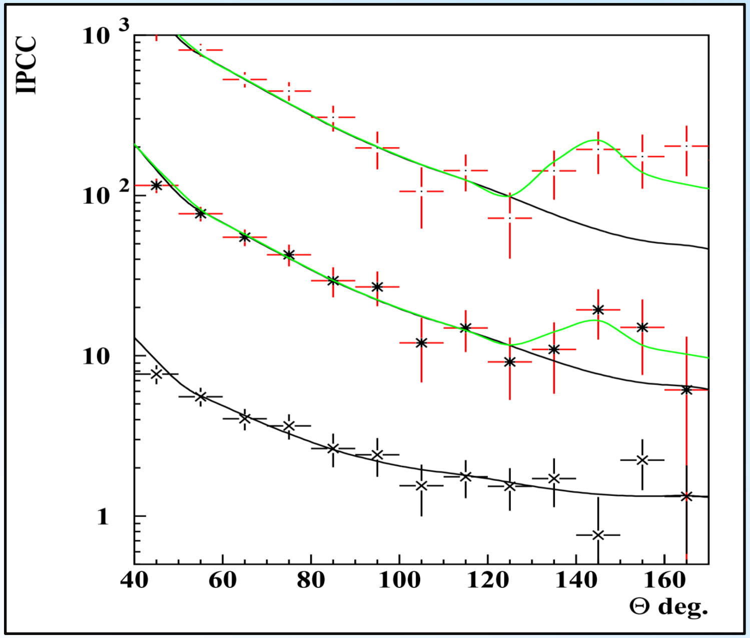
Results:





(3) $^{12}C^*$(18.39MeV) → ^{12}C

(summer 2018 – unpublished)



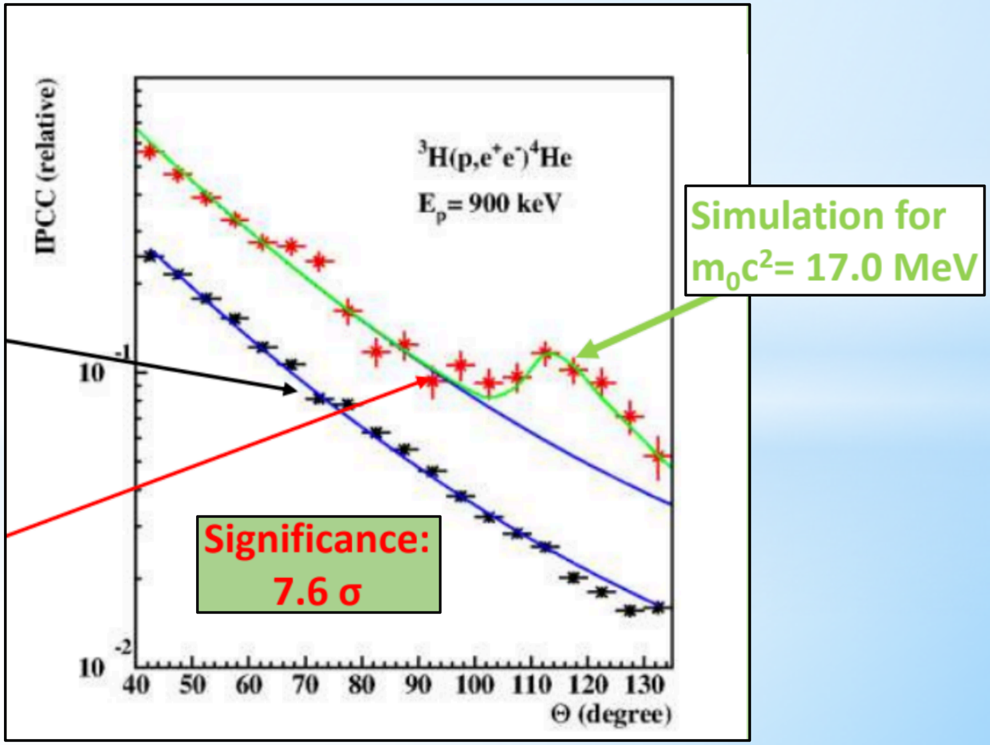
(4) $^4He^*$ (21MeV) → ^4He

e-Print: 1910.10459 [nucl-ex], see also *Acta Phys.Polon.B* 50 (2019) 3, 675

Most recent proceedings resuming the ^8Be and ^4He results (2020):

EPJ Web of Conferences **232**, 04005 (2020)

Confirmation of the existence of the X17 particle



In 2017 we carried out a first study of the possibility of ruling out or confirm the anomaly. The ^{8}Be issue is still open

PHYSICAL REVIEW D 97, 095004 (2018)

Resonant production of dark photons in positron beam dump experiments

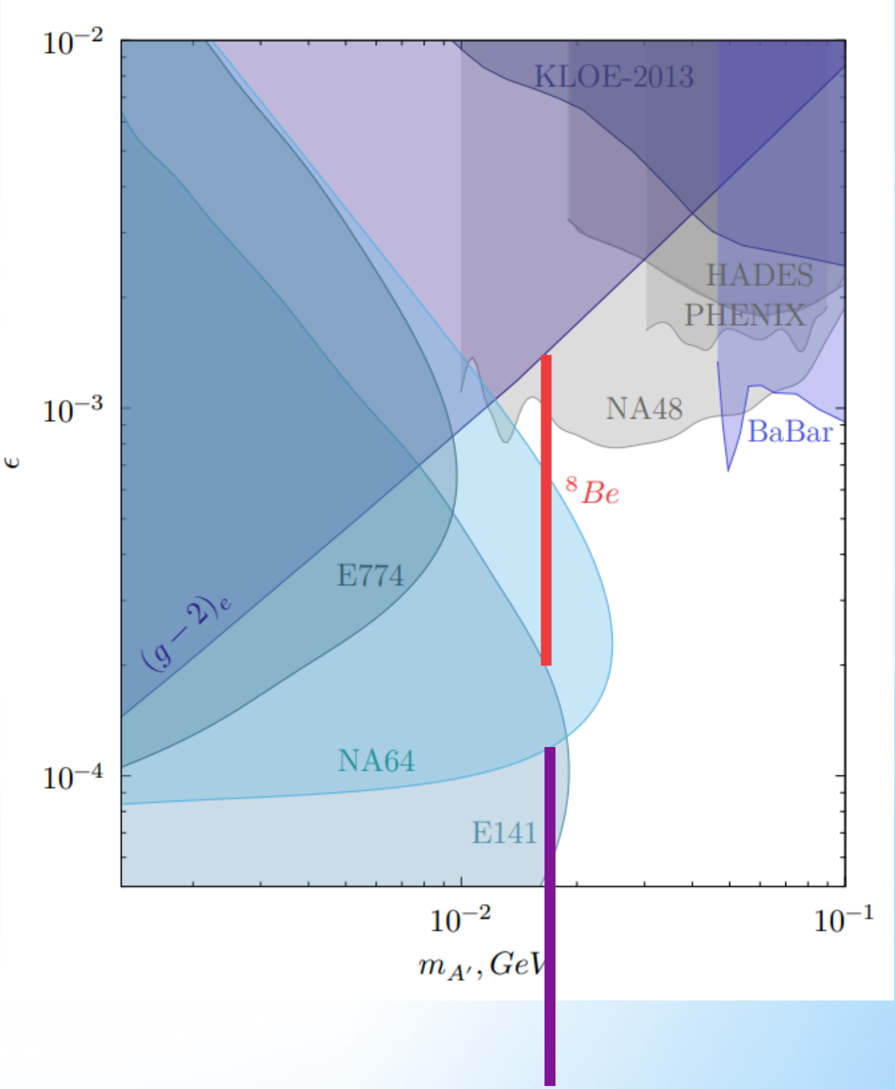
Enrico Nardi,[1,*] Cristian D. R. Carvajal,[2] Anish Ghoshal,[1,3] Davide Meloni,[3,4] and Mauro Raggi[5]

Present status:

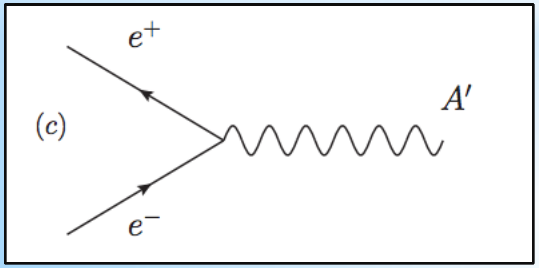
NA64 Collaboration:

Improved limits on a hypothetical X(16.7) boson ……..

Phys.Rev.D 101 (2020) 7, 071101



Closing completely the 17MeV window for the ^{8}Be **A’** boson is challenging, but the energy-tunable positron beam @LNF is a unique facility to produce **A’** on resonance via e^+ annihilation off atomic electrons, and might be able to acclompish this goal.



THANK YOU FOR YOUR ATTENTION