Is there a dark decay of neutrons in ^{6}He ?

Le Joubioux Marius

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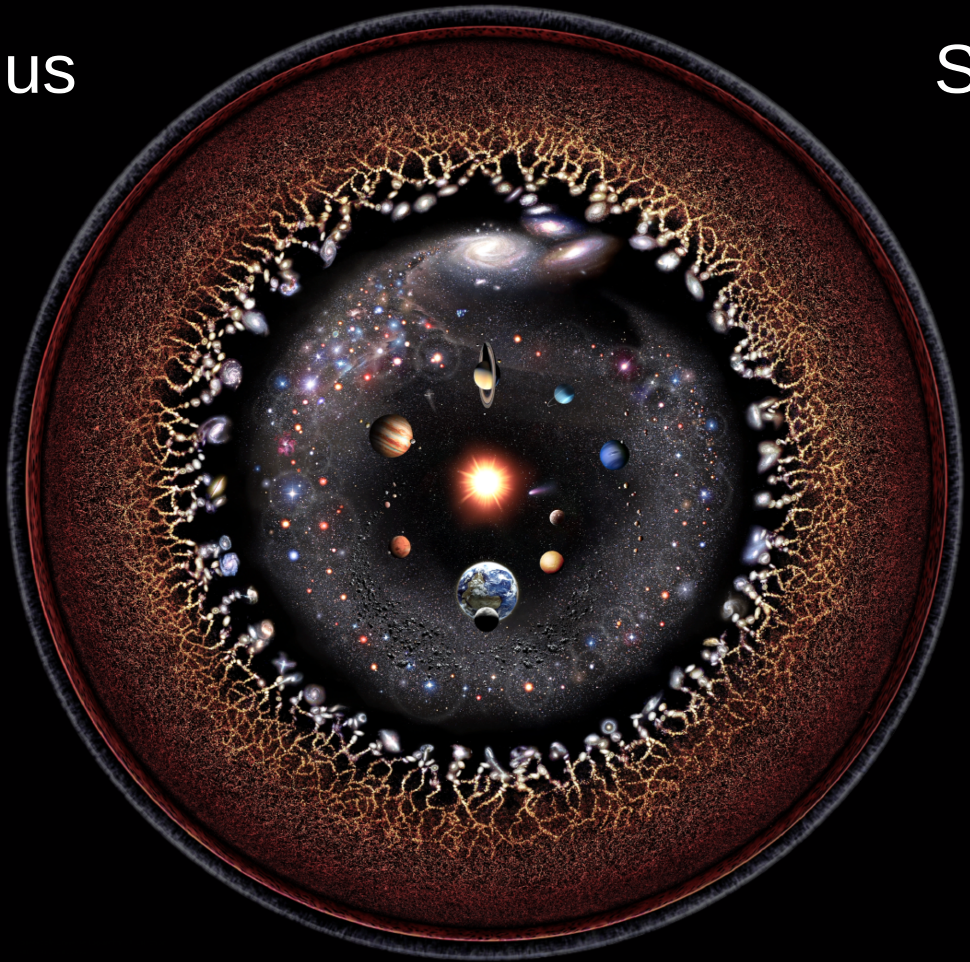
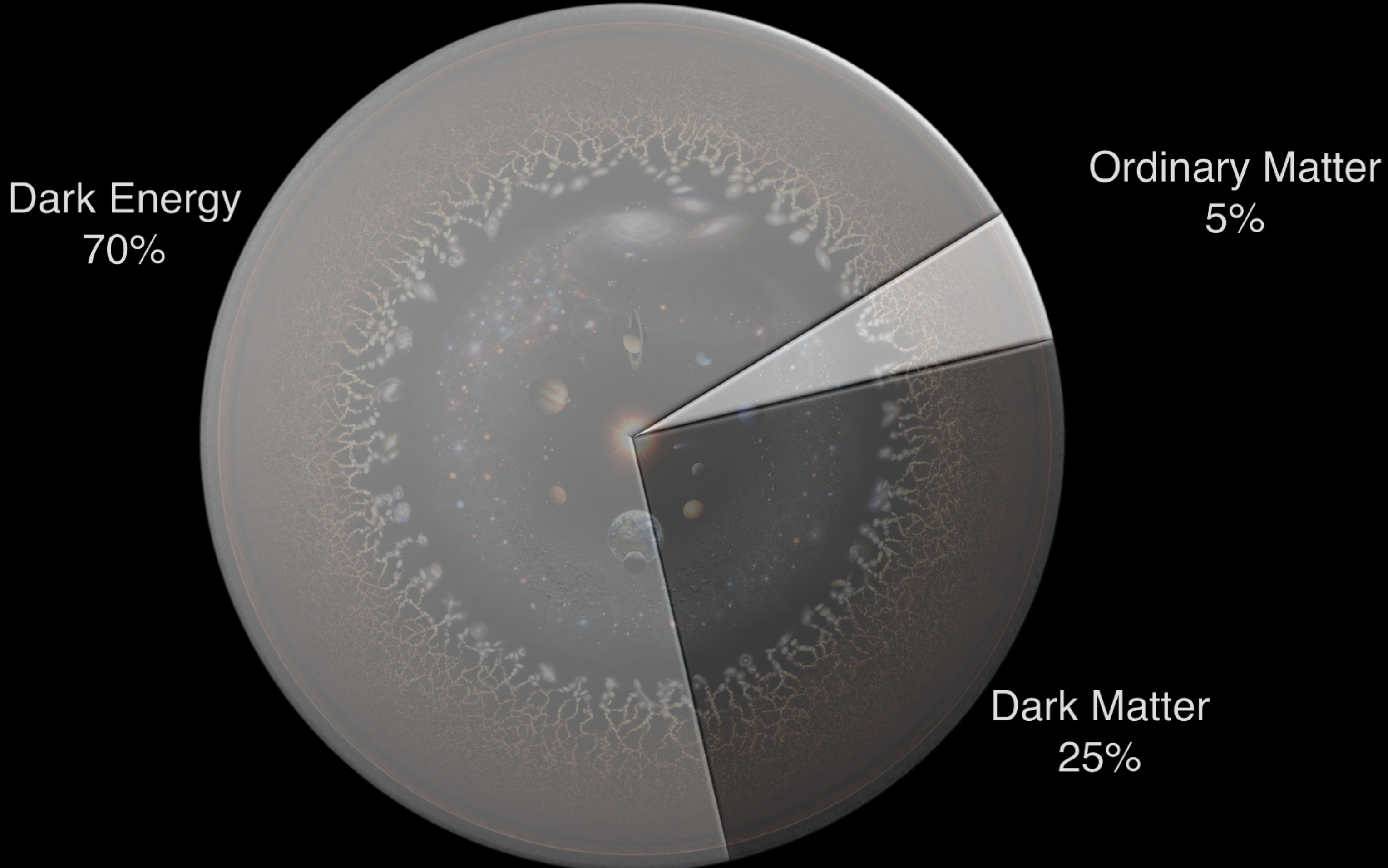


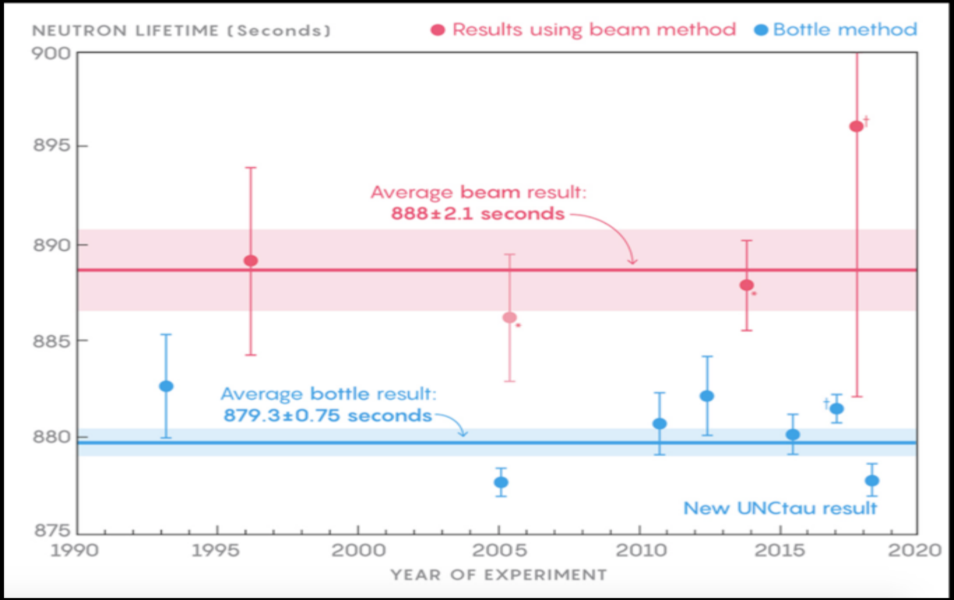
Image : Ruth Pöttgen

Estimated energy division in the universe



The neutron lifetime anomaly

W. Pattie Jr. et al, Science Science 11 May 2018 vol. 360 no. 6389 627-632



- The beam experiment counts protons emerging from a cold neutrons beam over time
  τ = 888±2.1 seconds
- The bottle experiment counts remaining ultra cold neutrons stored in a magneto-gravitational trap over time
  τ = 879.3±0.75 seconds

There is a ~1% discrepancy between the two experiments

Experimental bias

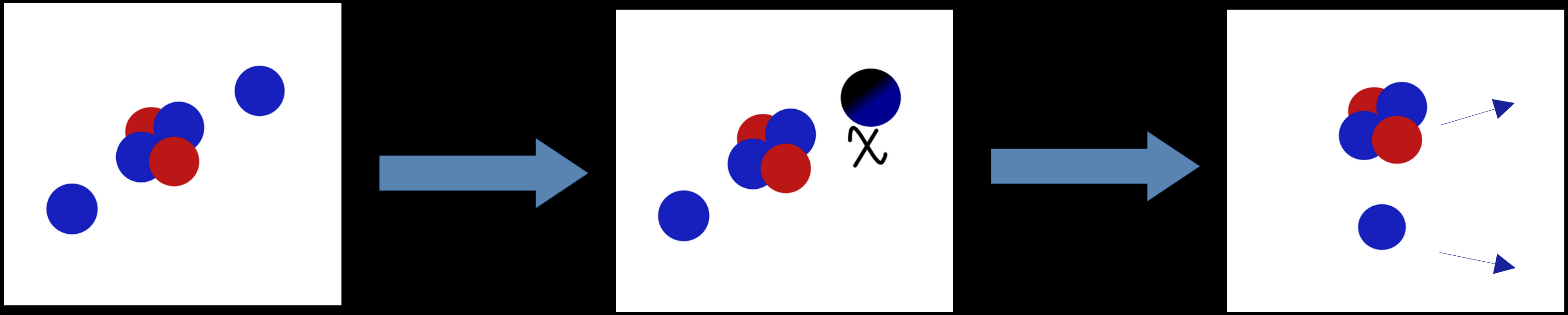
Neutron decay into SM particles excluded

Neutron decay into SM + dark matter or DM only [1]

[1] Bartosz Fornal and Benjamín Grinstein Phys. Rev. Lett. 120, 191801, 2018

^{6}He quasi-free neutron decay into dark matter

Mass difference between ^{9}Be and ^{8}Be + 2α ← Mass range [2] for the χ particle : 937.993 MeV < m_χ < $m_n - S_n$



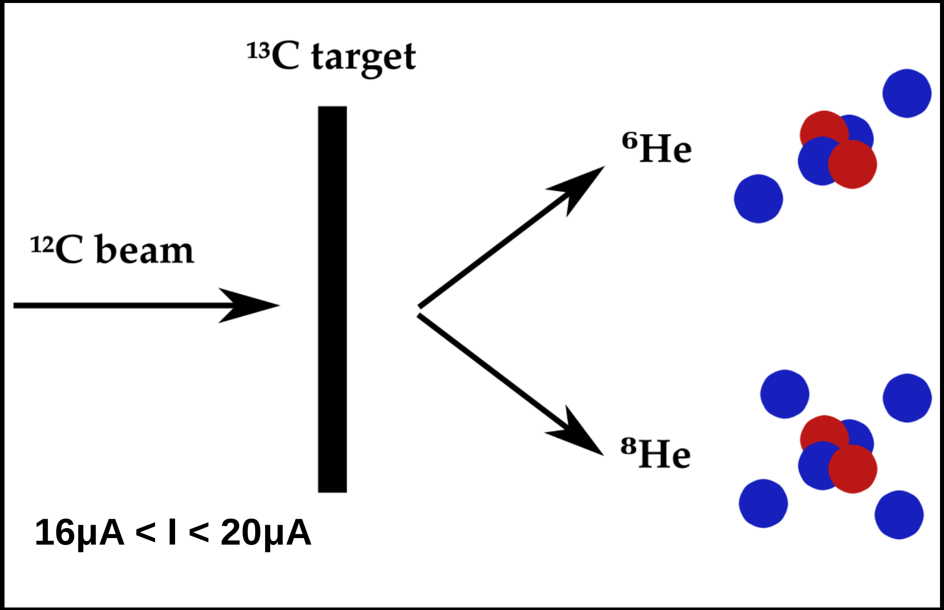
^{6}He nucleus → ^{5}He + χ → ^{4}He + n

^{6}He can only decay with an emitted neutron if we consider a dark decay channel : unique signature !

Estimated branching ratio upper limit of B = 1.2×10^{-5} [2]

[2] M. Pfützner and K. Riisager Phys. Rev. C 97, 042501(R), 2018

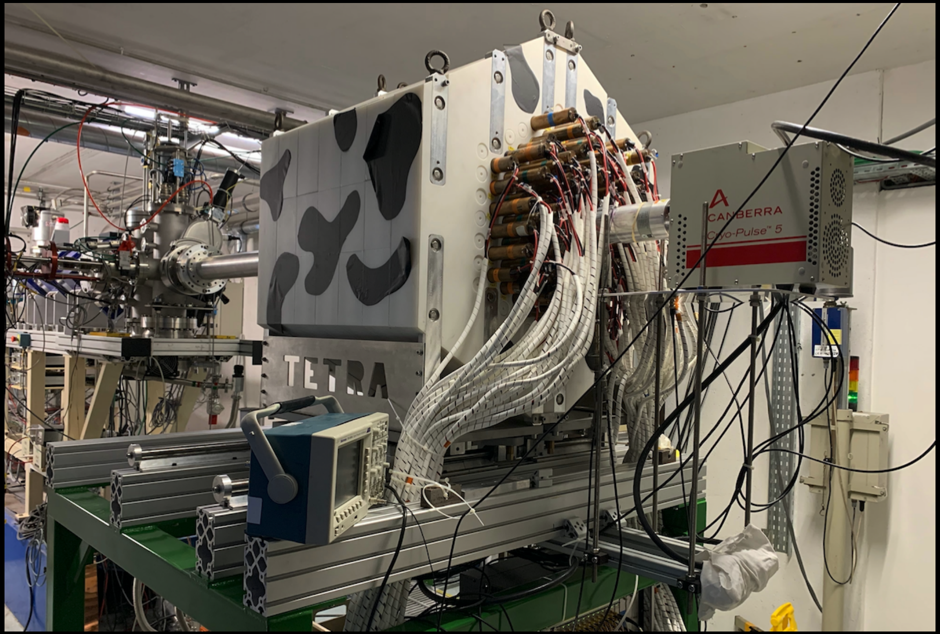
The E819S experiment at GANIL



About 10^8 pps of ^6He

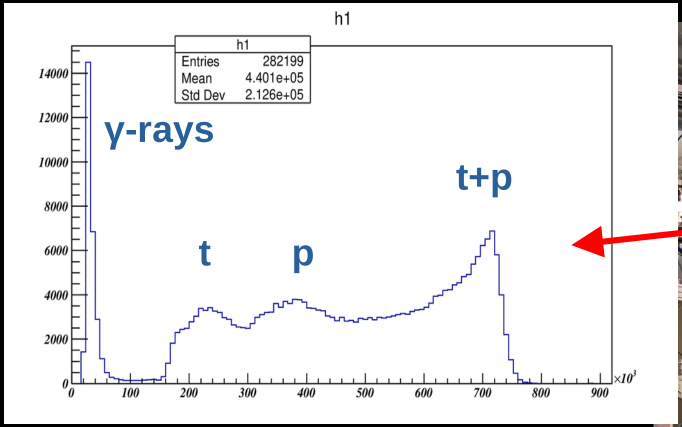
- SPIRAL1 facility used to produce low energy beam of $^6He^{1+}$ or $^8He^{1+}$ (25keV)
- Silicium detector placed in the LIRAT line
- Charge collecting device «*Ti*» to measure the primary ^{12}C beam intensity on target

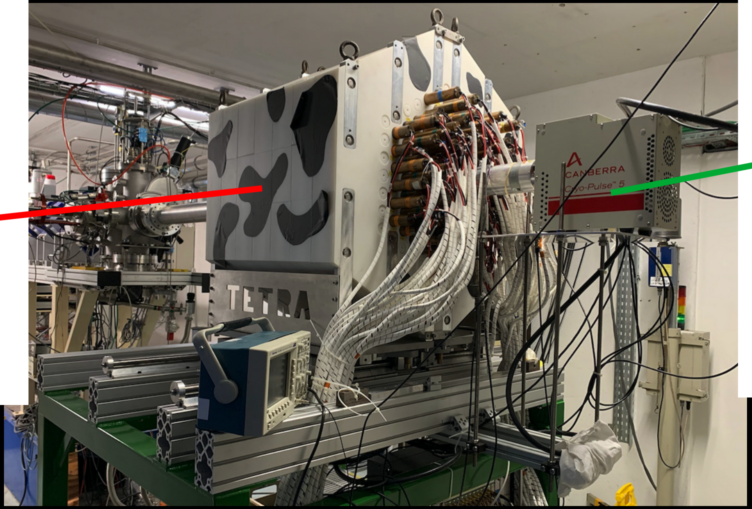
The E819S experiment at GANIL

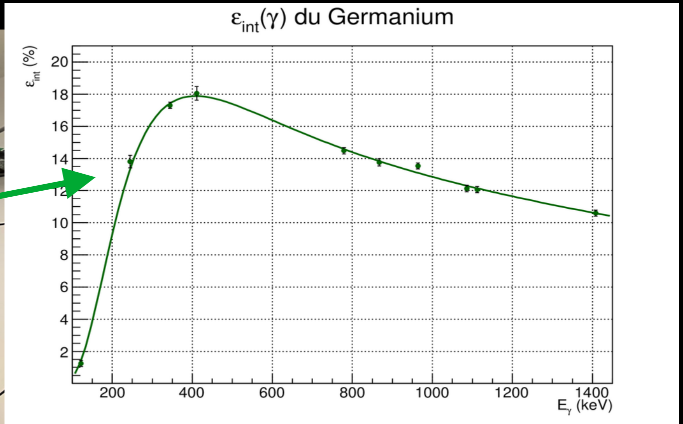


- Implanted particles are directed into a beamcatcher at the center of TETRA
- Neutron detector TETRA : ^{3}He gas counters calibrated with a ^{252}Cf source
- γ-ray detector : Germanium semiconductor calibrated with a ^{152}Eu source
- β-particle detector : Small solid angle plastic scintillator calibrated with a ^{36}Cl and a ^{90}Sr source (problem during the acquisition)

The E819S experiment at GANIL



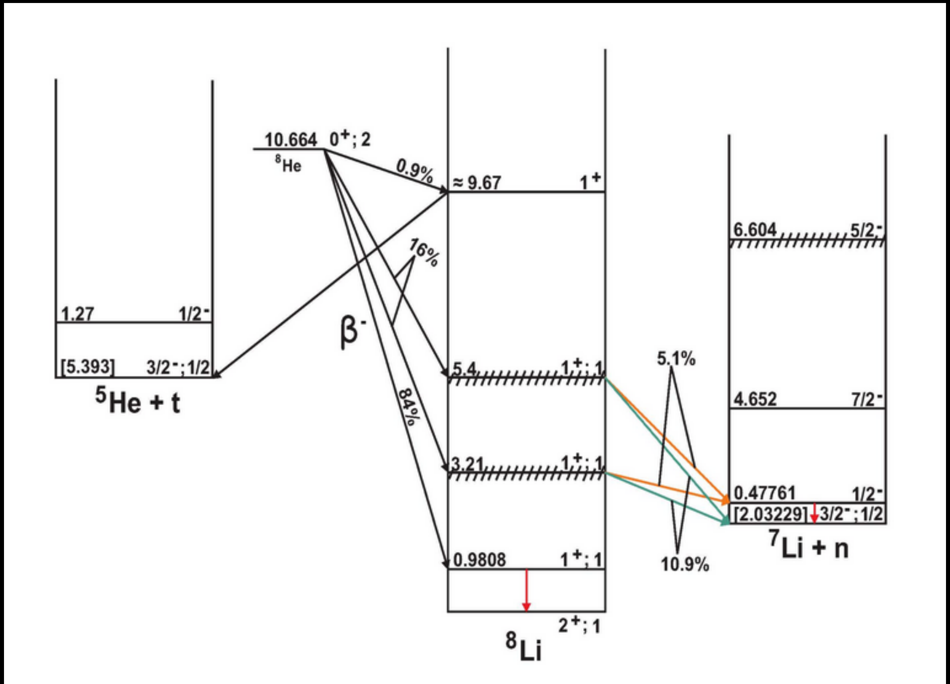




ε = 52% but due to some counters showing high sensitivity to β bremsstrahlung (γ-rays) we have ε ≈ 40% if we exclude some counters or ε ≈ 20% if we consider only the sum peak

Mean intrisic detection efficiency of the germanium. Data points are from ^{152}Eu source runs

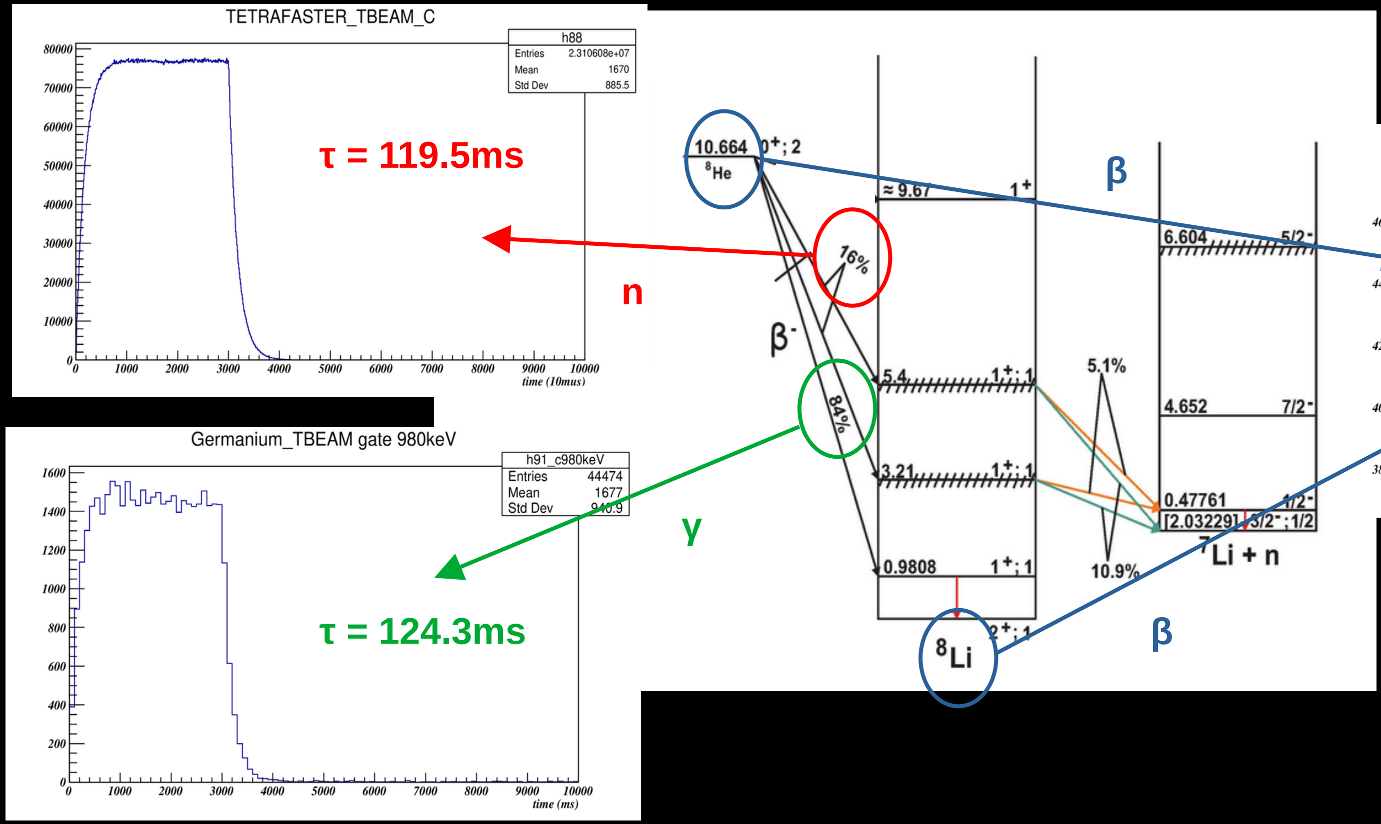
^{8}He beam as a benchmark with many observables

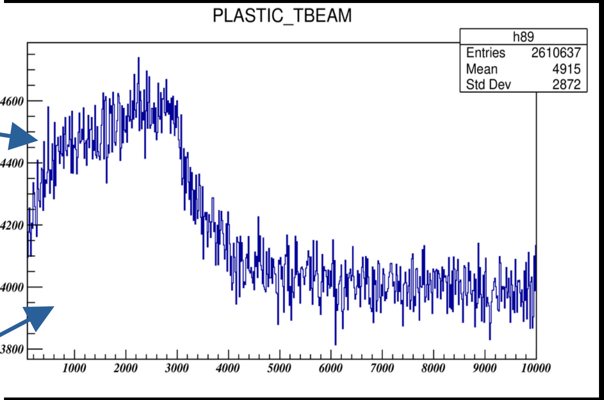


- β-decay channel with a branching ratio of 84% and a γ-ray at 980.8keV
- βn-decay channel with a branching ratio of 16% with a possible γ-ray at 477.6keV (branching ratio of 5.1% [3])
- Two types of run : one with a beamchopper (beamOn/beamOff) and one with a continous beam of ^{8}He

[3] T. Björnstad et al., Nucl. Phys. A Vol 366, 461, 1981

^{8}He beam as a reference with many observables





6 parameters to fit for the plastic due to the ^{8}Li filiation

Mean rate of implanted ^{8}He

We used the well-known γ-ray at 980.8keV as our reference to compute the mean rate of implanted ^{8}He

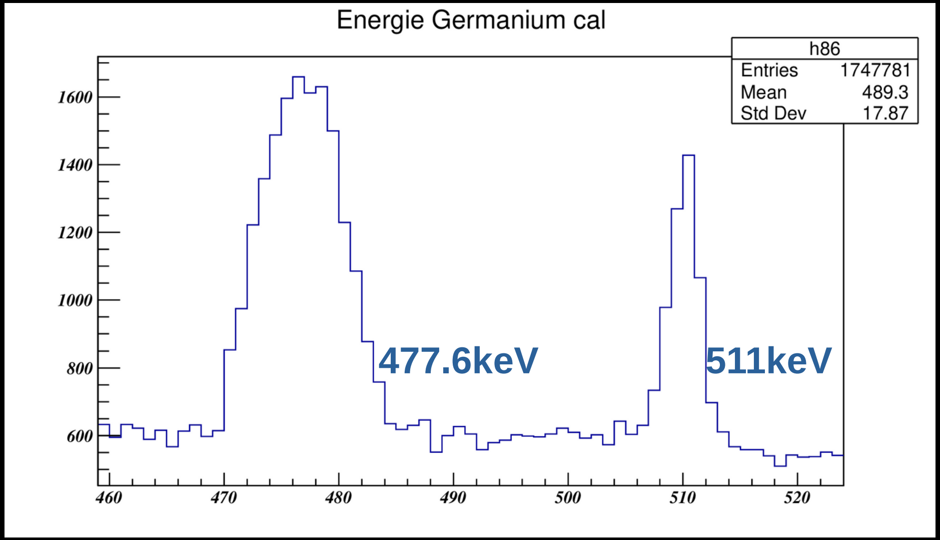
We found values between 1.40×10^5 and 4.62×10^5 particles per second

Values found with TETRA were in average about 20% higher

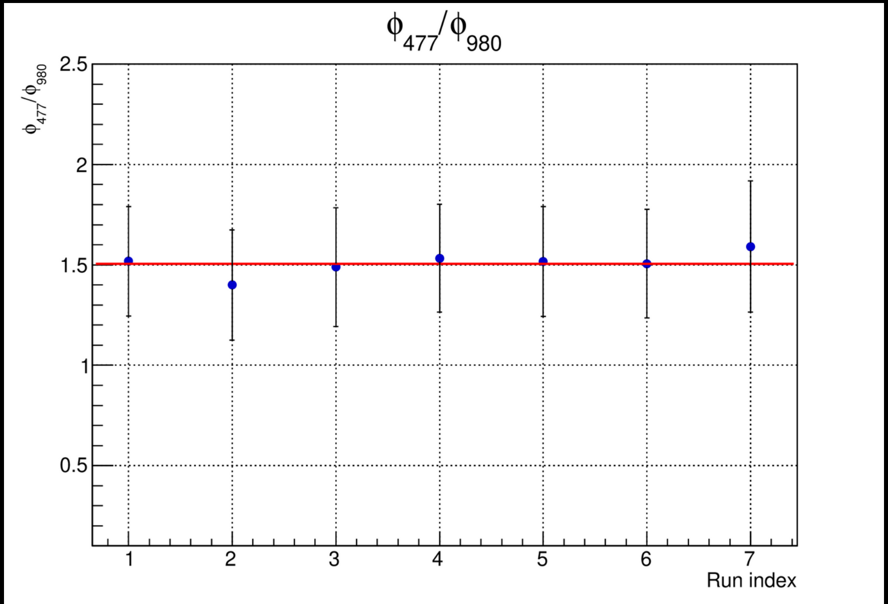
↙ Incorrect branching ratios of the ^{8}He decay scheme

↘ Difference between the neutron energy spectrum from the ^{252}Cf source and the ^{8}He decay
→ Might be improved with G4 or MCNPX simulations

Analysis of the γ-ray at 477.6keV



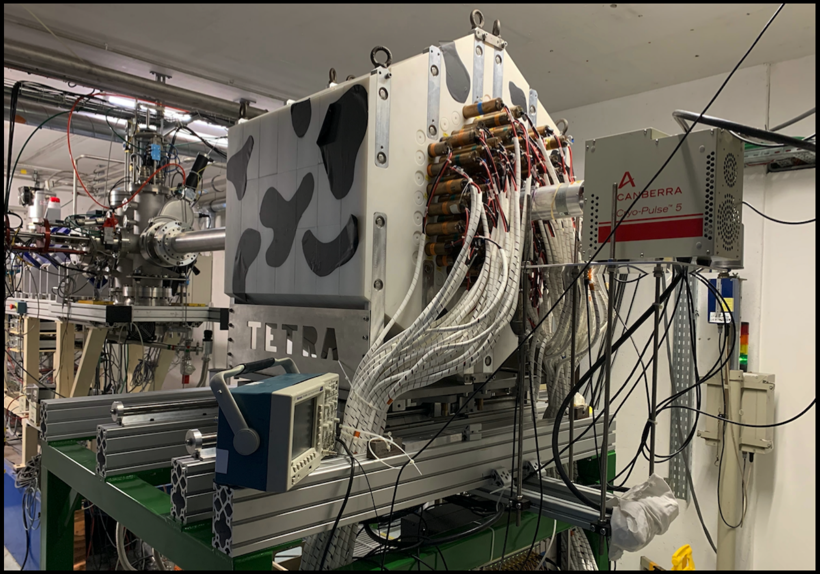
Peak broadening of the γ-ray due to a Doppler effect in the βn decay



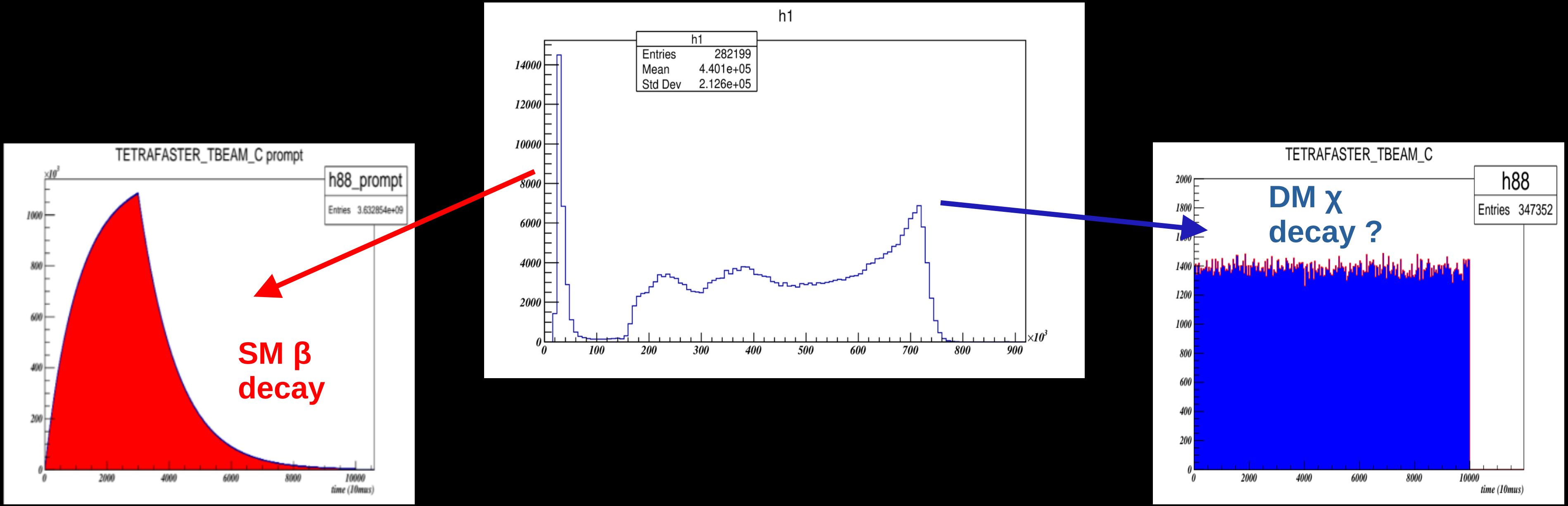
Mean rate of ^{8}He from the γ-ray at 477.6keV over the one at 980.8keV
→ New branching ratio of 7.67(54)%

Mean rate of implanted ^{6}He ?

- Computing the mean rate of implanted ^{6}He will be of great importance
- There is no γ-ray in its decay scheme for us to rely on
- Link the Silicium detector in the LIRAT line with the *Ti* and possibly the plastic with the help of the ^{8}He runs analysis



Get the final result



Stack data and look for an excess of neutrons with the ^{6}He beam → stringent upper limit for the dark matter decay channel !

Thanks for your attention !