Az X17 bozon γγ-bomlásának keresése

Nagy Ádám

Debreceni Egyetem + MTA Atomki

How can we choose between the different interpretations?

PRL **117,** 071803 (2016) PHYSICAL REVIEW LETTERS week ending 12 AUGUST 2016

Protophobic Fifth-Force Interpretation of the Observed Anomaly in ^{8}Be Nuclear Transitions

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(Received 3 May 2016; published 11 August 2016)

JHEP
Published for SISSA by Springer
Received: *September 23, 2016*
Revised: *October 24, 2016*
Accepted: *October 28, 2016*
Published: *November 8, 2016*

Possible explanation of the electron positron anomaly at 17 MeV in ^8Be transitions through a light pseudoscalar

Ulrich Ellwanger[a,b] and Stefano Moretti[b]

Study the $\gamma\gamma$-decay of X(17) in ^{4}He

- Vector particle (1+) or axialvector (0-)? If axialvector than it can decay by $\gamma\gamma$ emission.

$$\cos(\Theta) = 1 - \frac{m_x^2}{2E_1E_2}$$

Study the angular correlation with modern, highly efficient $LaBr_3$ detectors.

The double-gamma decay

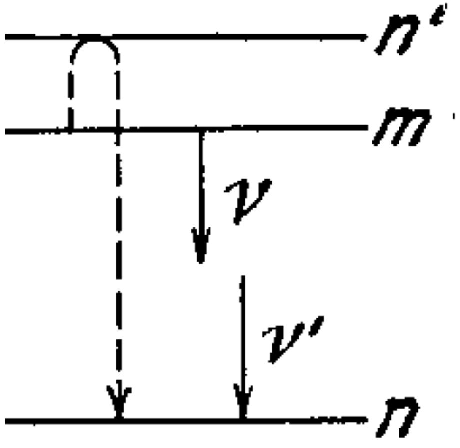


Fig.4
M. Göppert-Mayer, Ann.Wiss. (1931)

First discussed by Maria Göppert-Mayer in her doctoral thesis in 1929

M. Göppert-Mayer, Über Elementarakte mit zwei Quantensprüngen

Second order process (10^{-6} weaker)

- $E_0 = E_1 + E_2$
- E_1, E_2 are continuous

studied inverse in atomic physics

- *M. Lipes et al., PRL 15, 690 (1965)*
- *P.H. Mokler et al., Phys. Scr. 69, C1 (2004)*
- *K. Ilakovac et al., Rad. Phys. Chem. 75, 1451 (2006)*

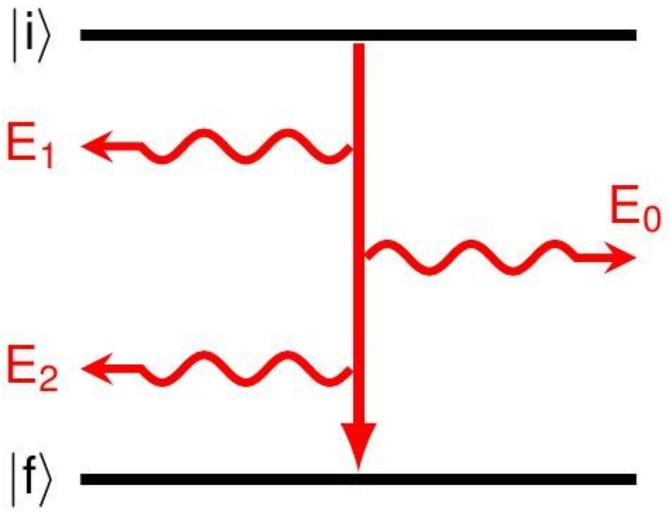
The double-gamma decay in nuclear physics

$\gamma\gamma$-decay only known in a special case:
$0^+ \rightarrow 0^+$ (^{90}Zr, ^{40}Ca, ^{16}O)

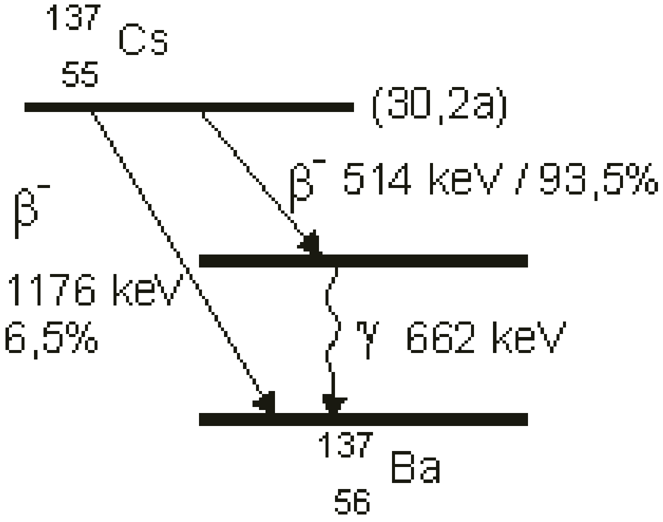
- *J. Schirmer et al., PRL 53, 1897 (1984)*
- *J. Kramp et al., NPA 474, 412 (1987)*

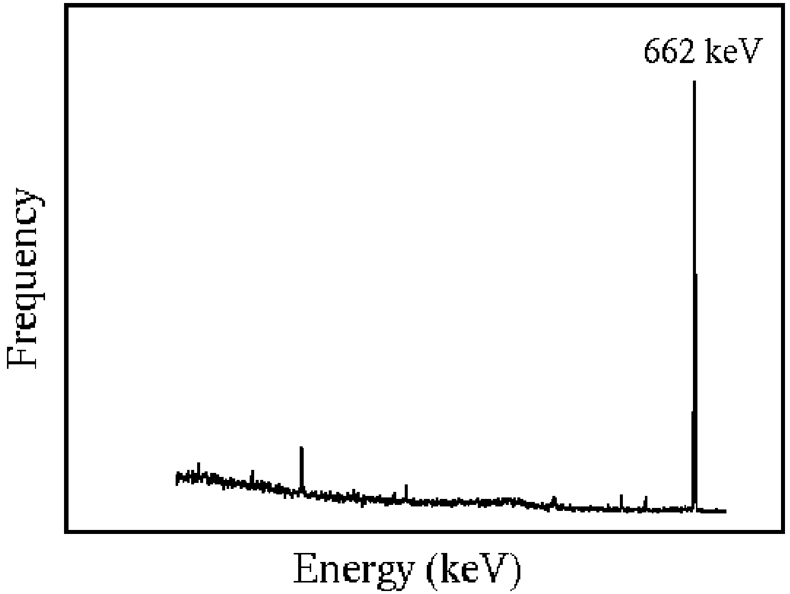
never observed in competition to allowed single γ-transition

- *W. Beusch et al., Helv Phys. Acta 33, 363 (1960)*
- *J. Kramp et al., NPA 474, 412 (1987)*
- *V.K. Basenko et al., Bull. Russ. Acad. 56, 94 (1992)*
- *C.J. Lister et al., Bull. Am. Phys. Soc. 58(13), DNP.CE.3 (2013)*



Search for $\gamma\gamma/\gamma$ - decay in ^{137}Cs γ - standard





- Study 662-keV transition in ^{137}Ba
- use radioactive ^{137}Cs -source

Summary

- Observation of the competetive double-gamma decay
- Measurement of the energy sharing and angular distributions

- Branching ra … a)
- Determinatio … a_{E3M1}
- M2E2-decay … e

Walz et al., *Nature* **526**, 406 (2015)

- Formally s … NME
- Related to Symmetry Parameter of Nuclear EoS ?
- Access to aspects of NME for 0νββ - decay ?

Double γ-decay in ^{4}He

(M. Suffert and R. Berthollet, Nucl., Phys. A318 (1979) 54.)

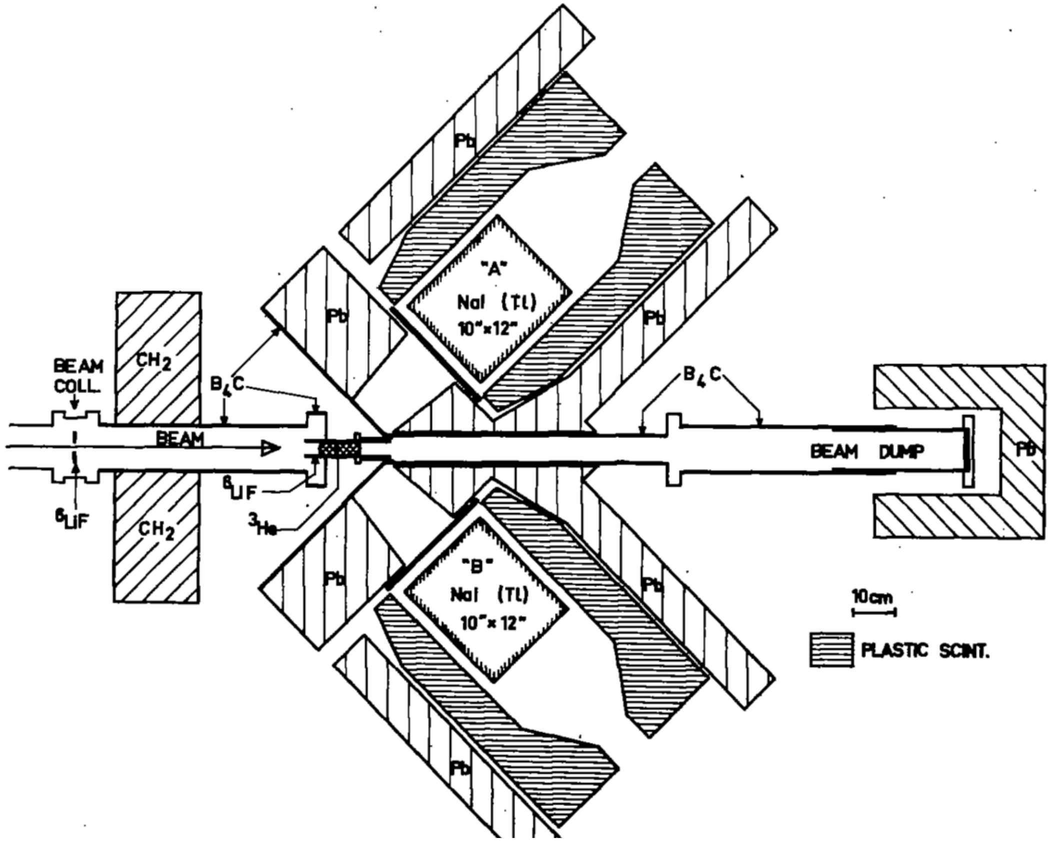
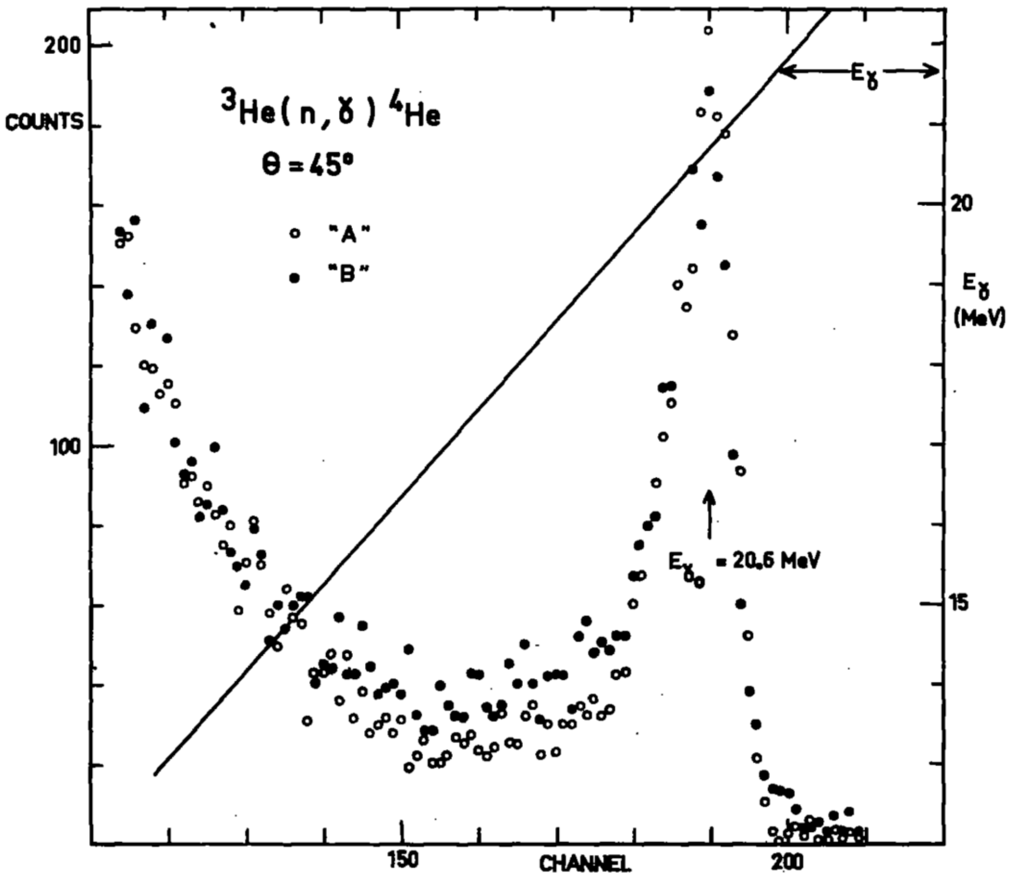
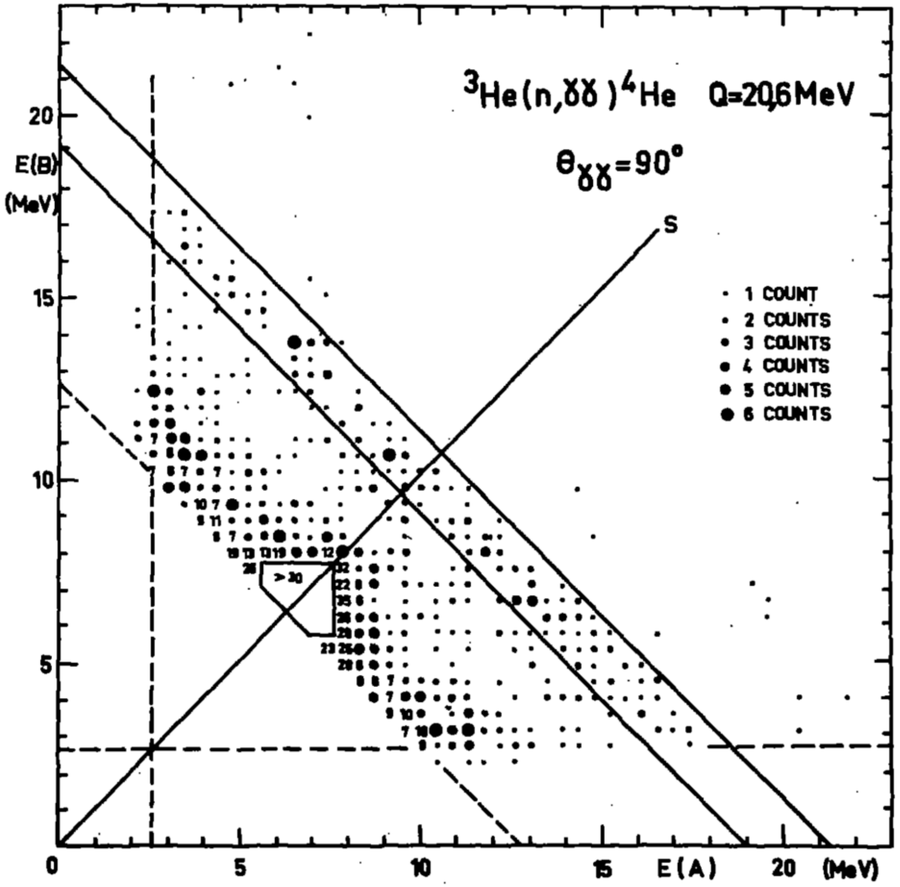


Fig. 1. Scheme of the experimental set-up.

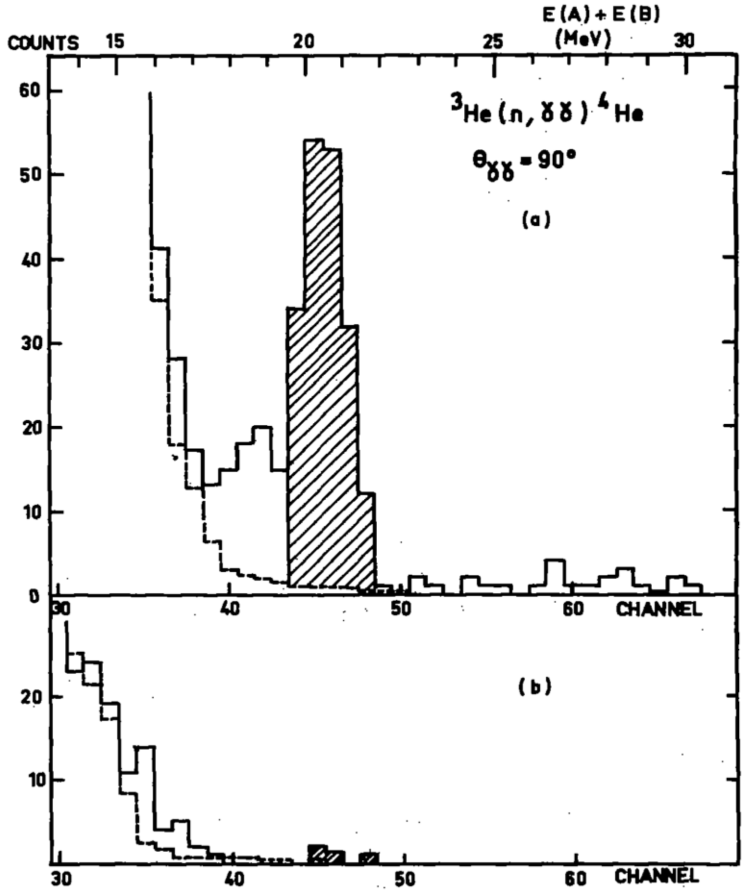
Singles spectra of detector „A" and detector „B" from the $^{3}He(n, \gamma)^{4}He$ reaction



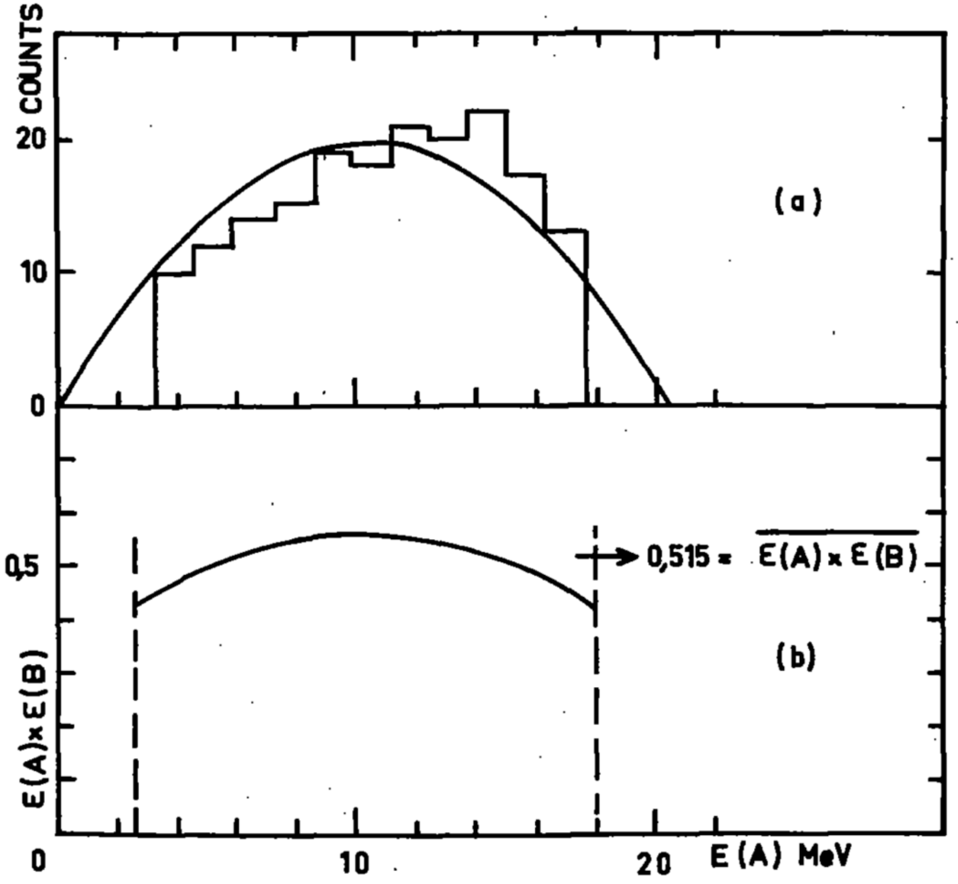
Number of coincidences as a function of the pulse heights E(A) and E(B). The counts between the two parallel solid lines were used for the 2y cross-section determination.



Sum-spectra (projection on OS . axis) . Solid line : real+random coincidences . Dotted line : random coincidences. Shaded area : counts used for 2y cross section determination . (a)^{3}He+n spectrum
(b) Spectrum with 5 cm of lead between target and detector B.



(a) Projection on E(A) of counts between the two parallel solid lines of fig. 3. Solid line : shape corresponding to E(A) x E[20 .6-E(A)] . (b) The product of full-energy peak efficiencies ε(A) x ε(B) as a function of E(A)[E(A)+E(B) = 20 .6 MeV] .

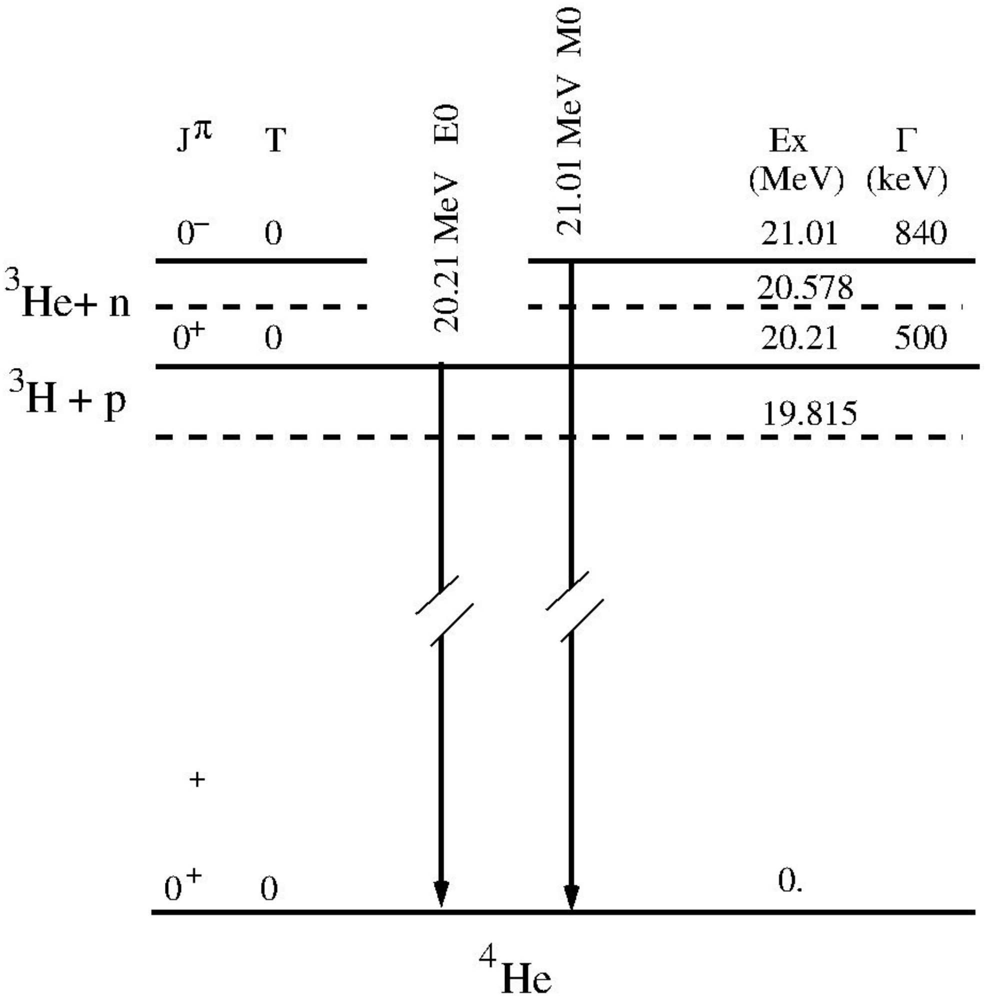


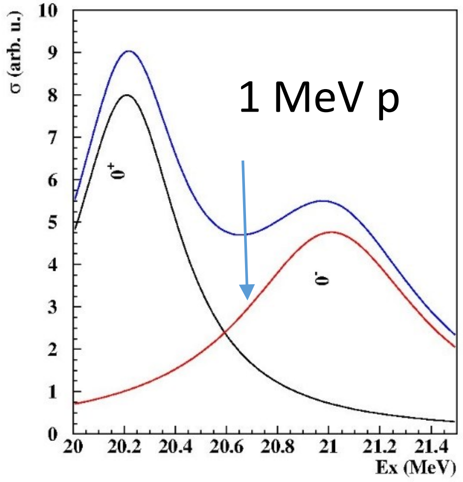
Conclusion

- The most recent theoretical calculations taking into account the p+ ^3H resonance at E≈ 20 .2 MeV give Q(2γ) = 1 .18 μb and R ≈ 0.03 i.e . about ten times less .

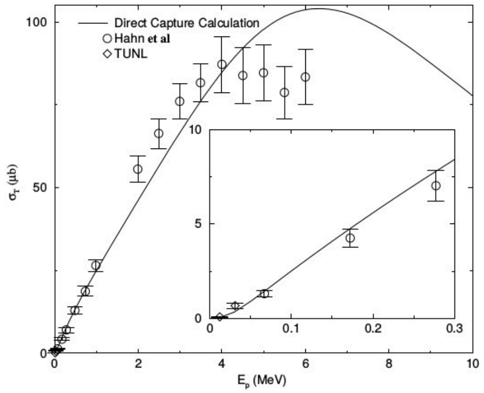
- H. C. Lee, F. C. Khanna, M. A. Lone and A. B. McDonald, Phys . Lett . 65B (1976) 201

Study of the 21 MeV M0 transition in ^{4}He excited by ^{3}He+n, and t+p reactions



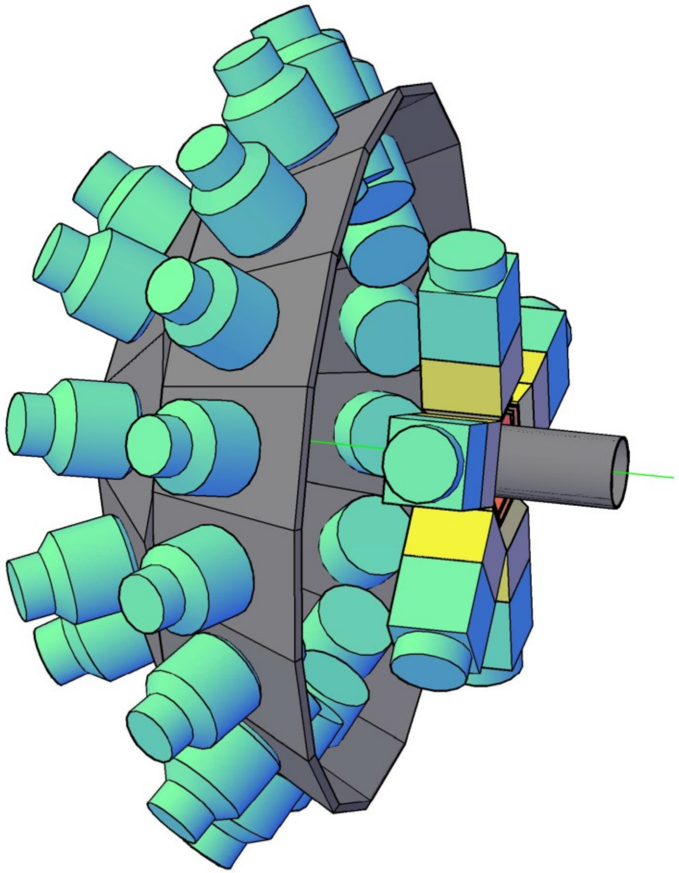


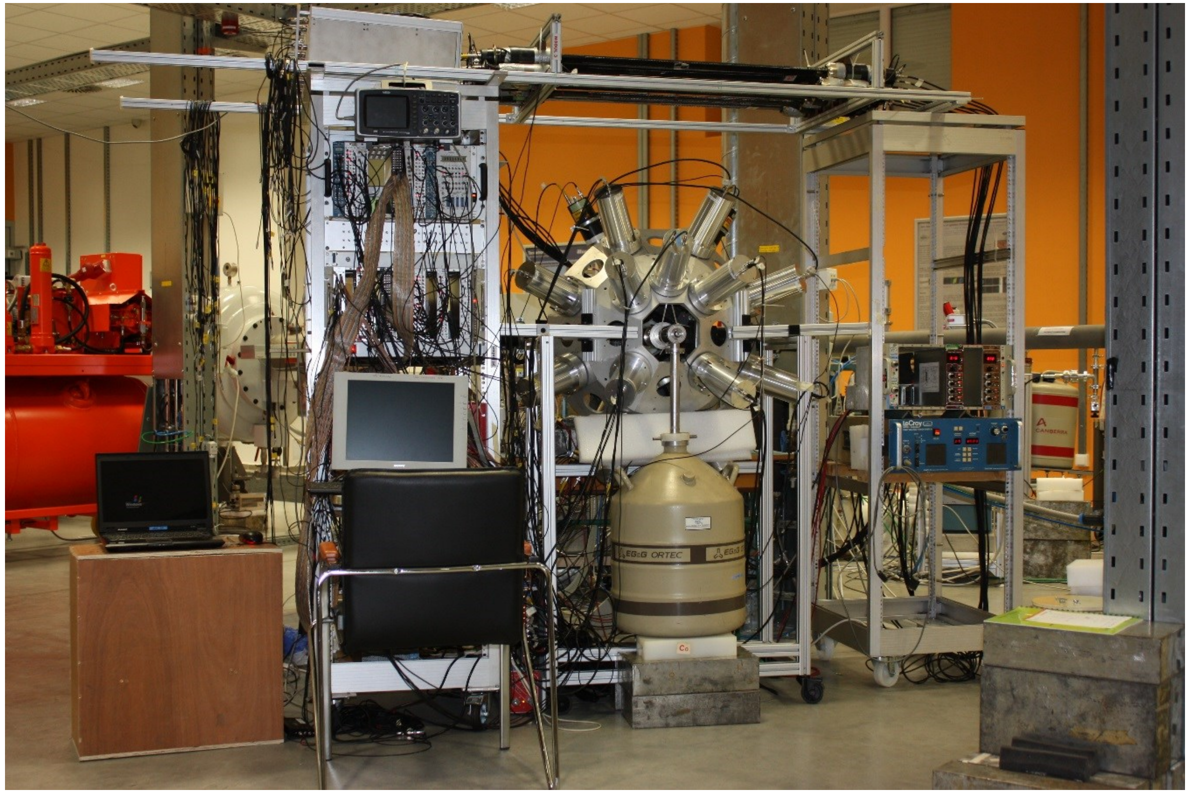
Overlapping 0⁺ and 0⁻ states



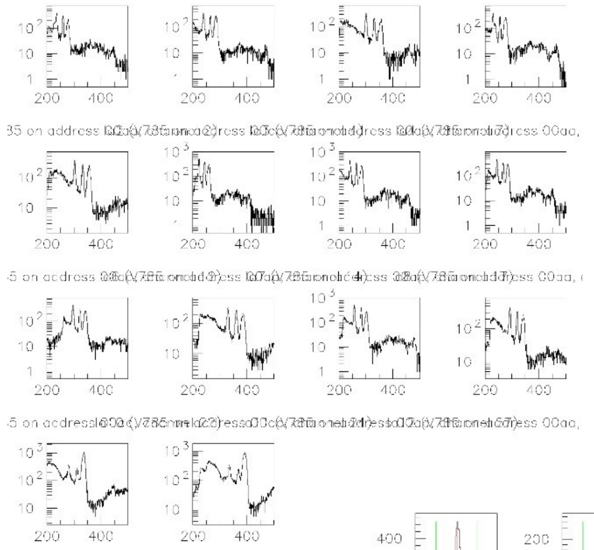
γ-ray production with direct proton capture. A source of background.

The experimental setup in Debrecen including both the e^+e^- and the γ-ray spectrometers

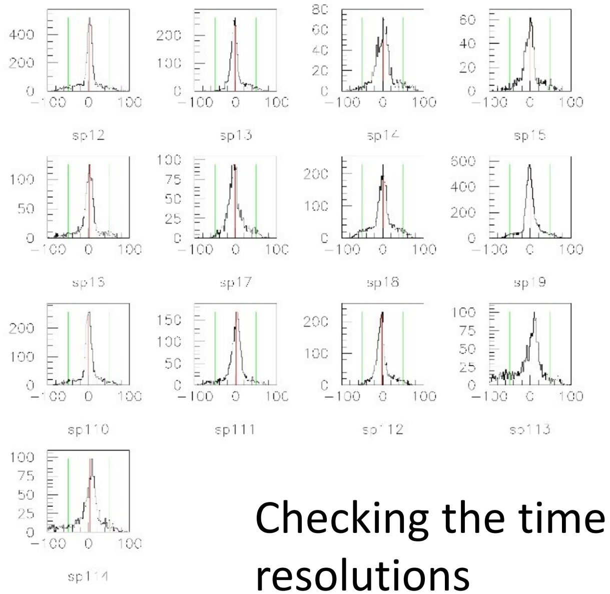




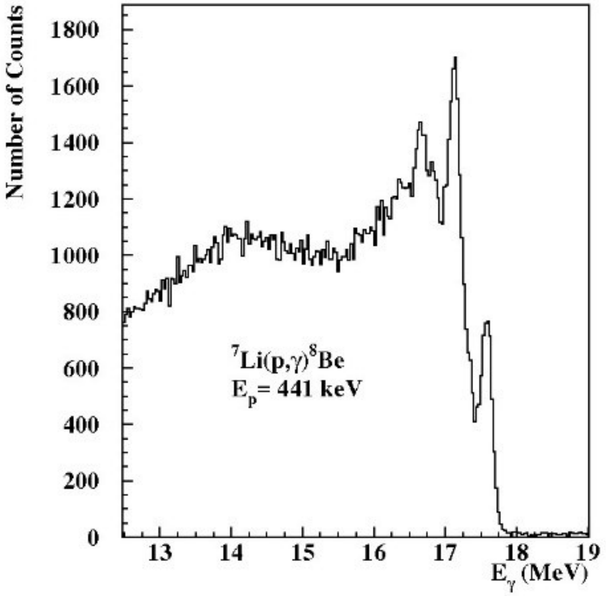
Calibration of the $LaBr_3$ γ-ray spectrometers



Checking the energy resolutions with a ^{60}Co source

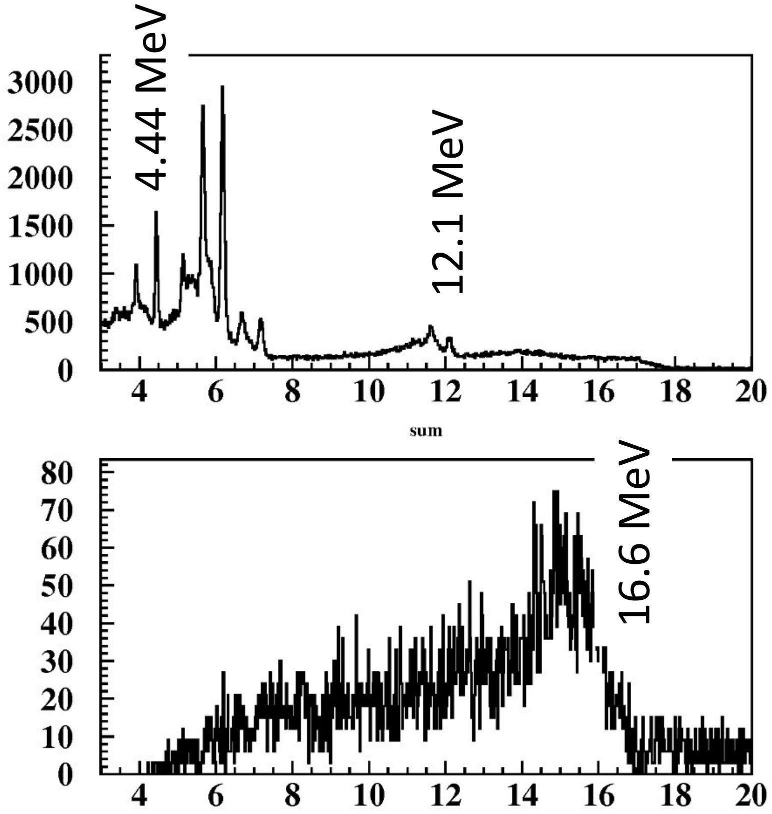


Checking the time resolutions

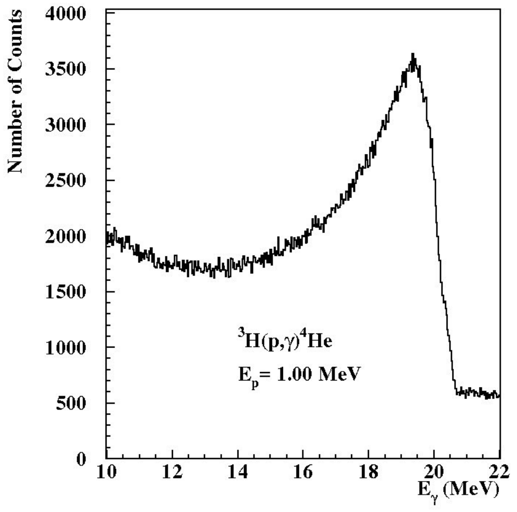


Calibration with the 17.6 MeV transition in ^8Be

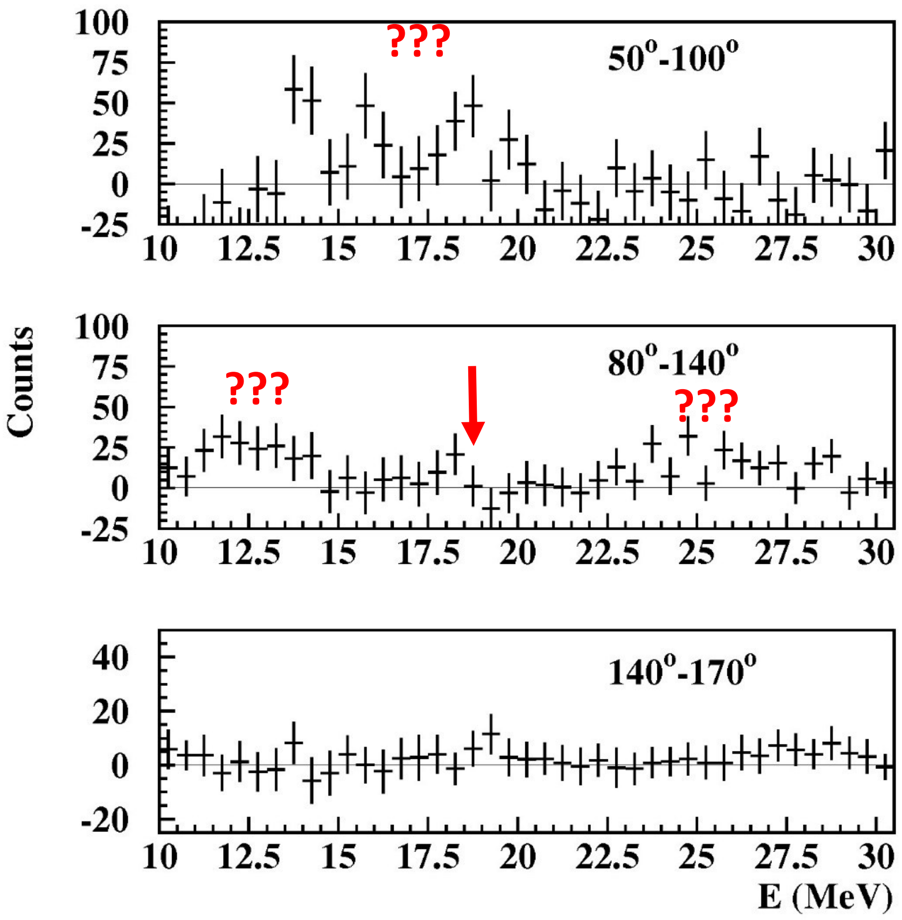
Calibration with the 12.1 – 4.44 MeV γγ cascade in ^{12}C using the 11B(p,γ) reaction at E_p=675 keV.



Two photon sum-energy distributions measured at different angular regions (very preliminary)

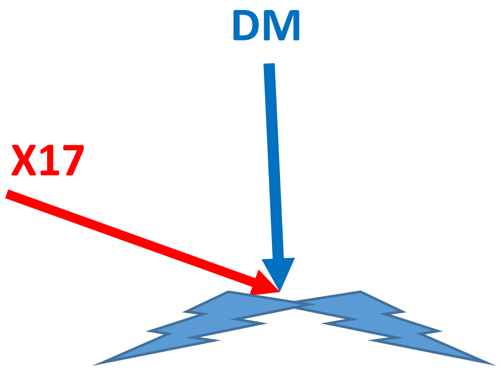


A typical γ-ray spectrum.
The proton energy loss in the target was about 400 keV, so the photo peak was washed out.

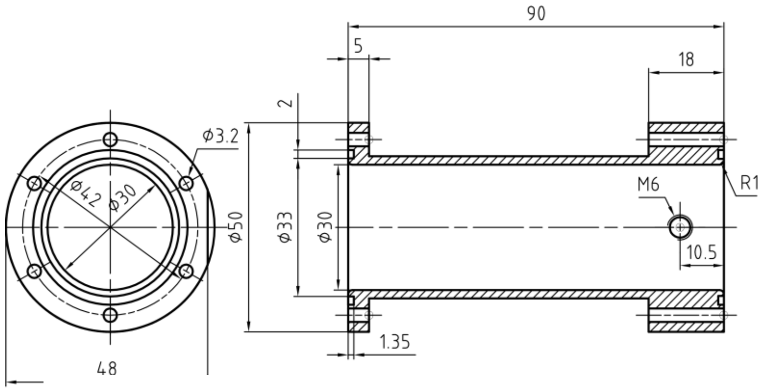


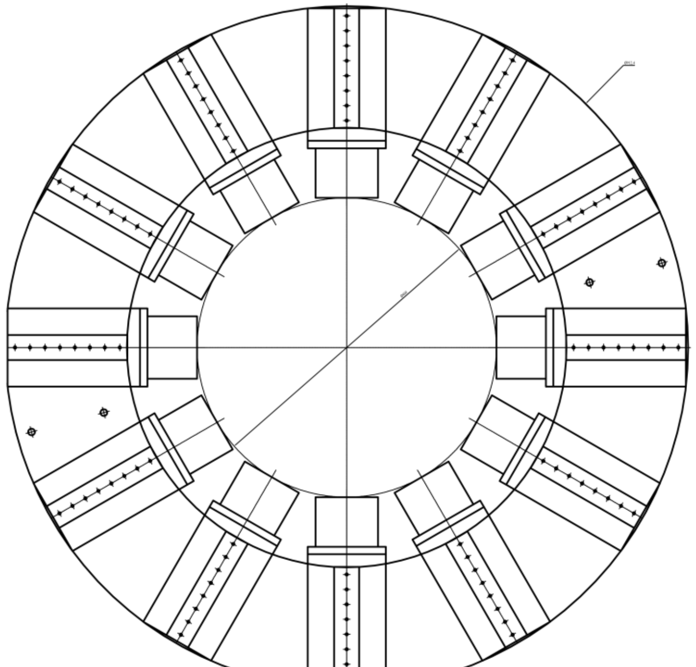
Sum energy spectra for coincident detectors.

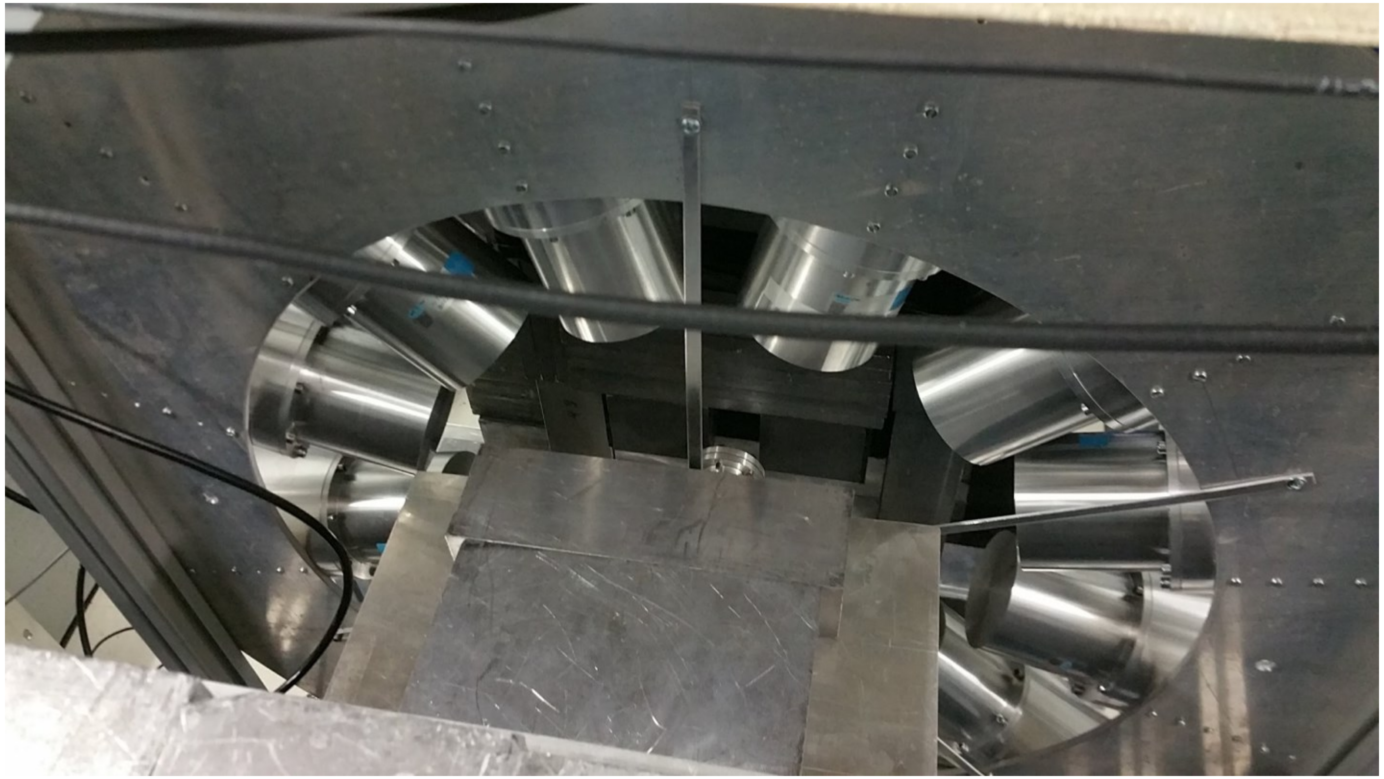
Energy release from DM collision???



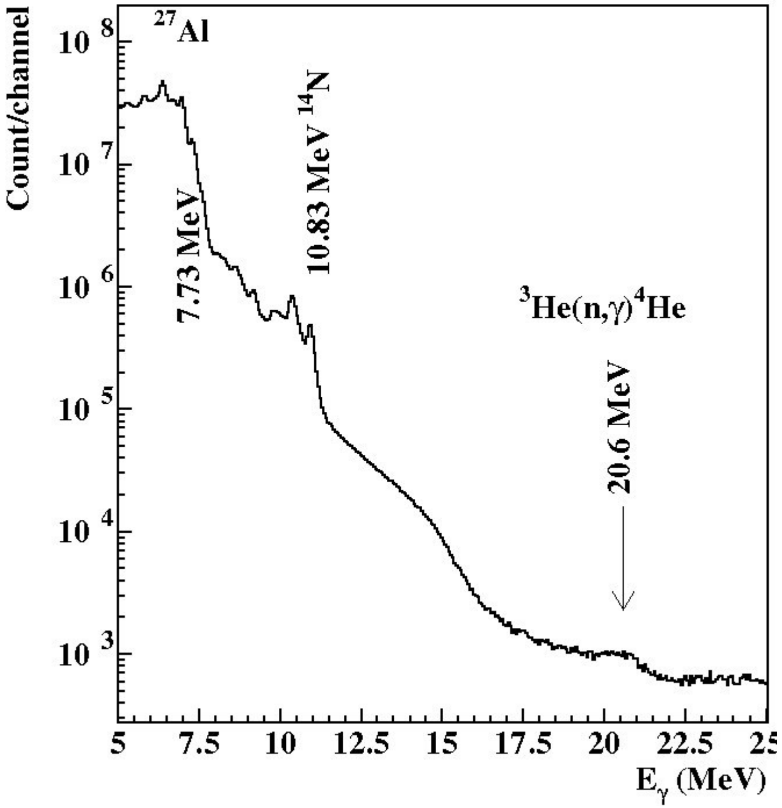
The experimental setup in Garching



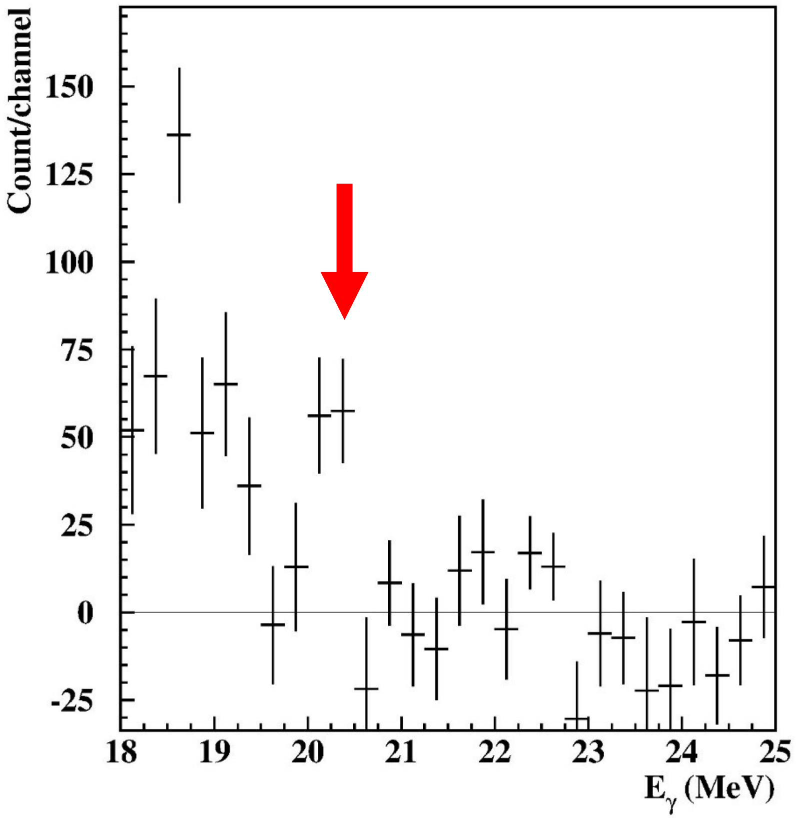




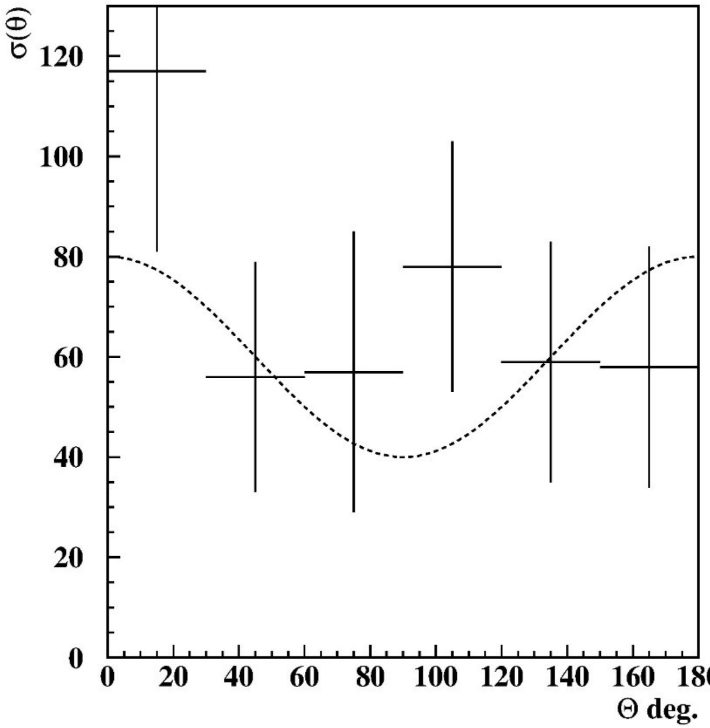
The first results in Garching



A typical singles γ-ray spectrum



Typical sum-energy spectra for coincident detectors



Preliminary γγ-angular correlation

Conclusion, future plans

- The contribution of the random coincidences and cosmic rays was too much, compared to the effect, however the results are very challenging!
- We are planning to repeat the experiments.

Thank you very much for your attention!