# Preliminary results of the study of gamma-ray transitions in $^{11}C$ and $^{11}B$ nuclei in $^{9}Be(^{3}He,n\gamma)^{11}C$ and $^{9}Be(^{3}He,p\gamma)^{11}B$ reactions

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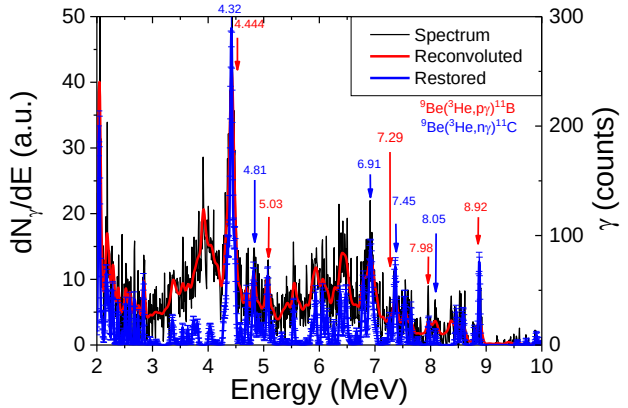
# Motivation

High-temperature plasma with various plasma mixes: H, D, T, $^4$He, **$^3$He**, $^6$Li…

**$^9$Be** is the main impurity in the tokamak plasma.

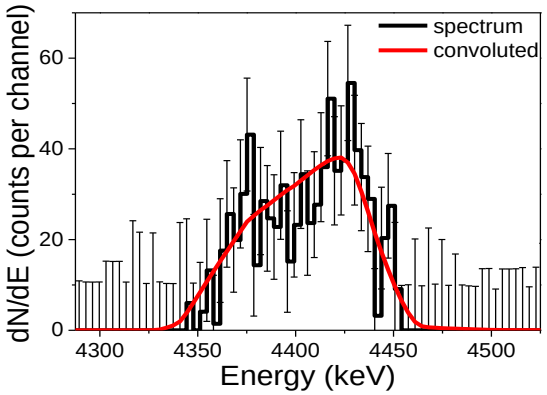
## Analysis of the gamma lines intensity

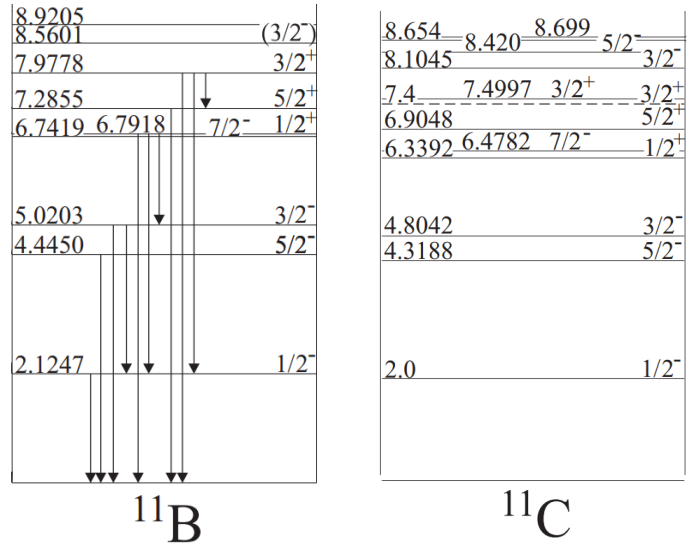
*Shevelev A.E. et al, Nucl. Fusion **53** (2013) 123004*

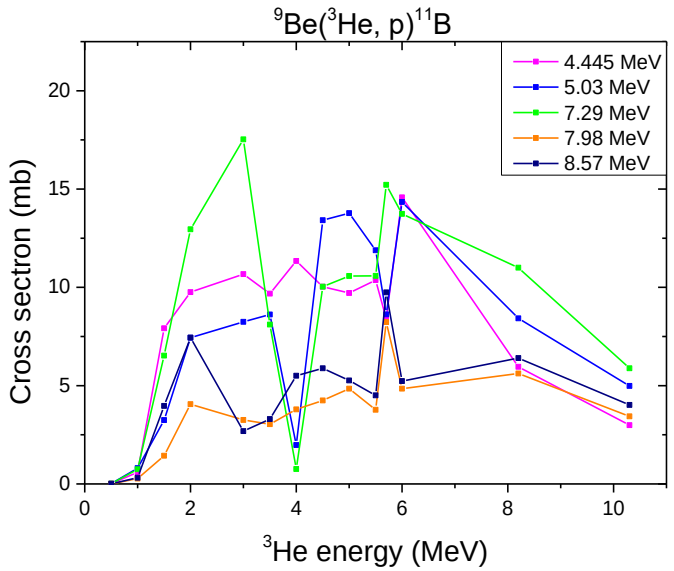


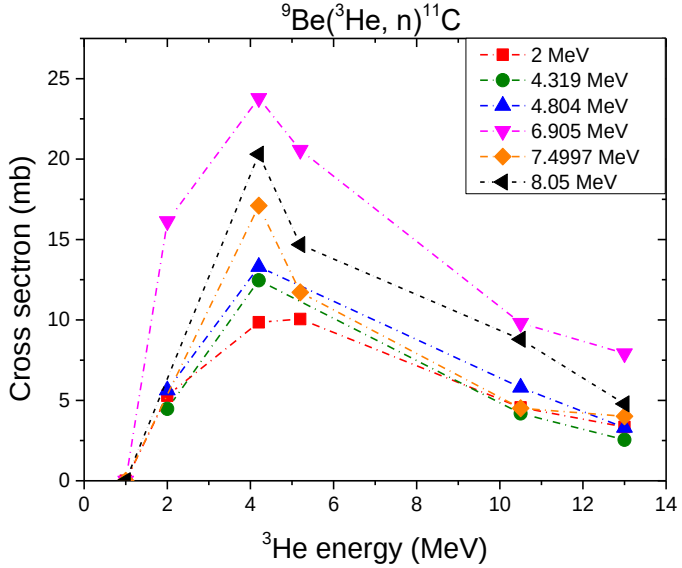

## Analysis of the gamma line Doppler shape

*Kiptilyi V. G., et al., Vopr. At. Nauki Tekh., Ser.: Fiz. Yad. Reakt., Spec. Iss., 223, 1997*




**$^9$Be($^3$He, pγ)$^{11}$B,** $Q$ = 10.3228 MeV

**$^9$Be($^3$He, nγ)$^{11}$C,** $Q$ = 7.5580 MeV


*W.R. Coker et al Nuclear Physics A91 (1967) 97-111*

*C.S. Lin, W.S. Hou, M. Wen Chinese Journal of Physics 19 (1981) p.99*

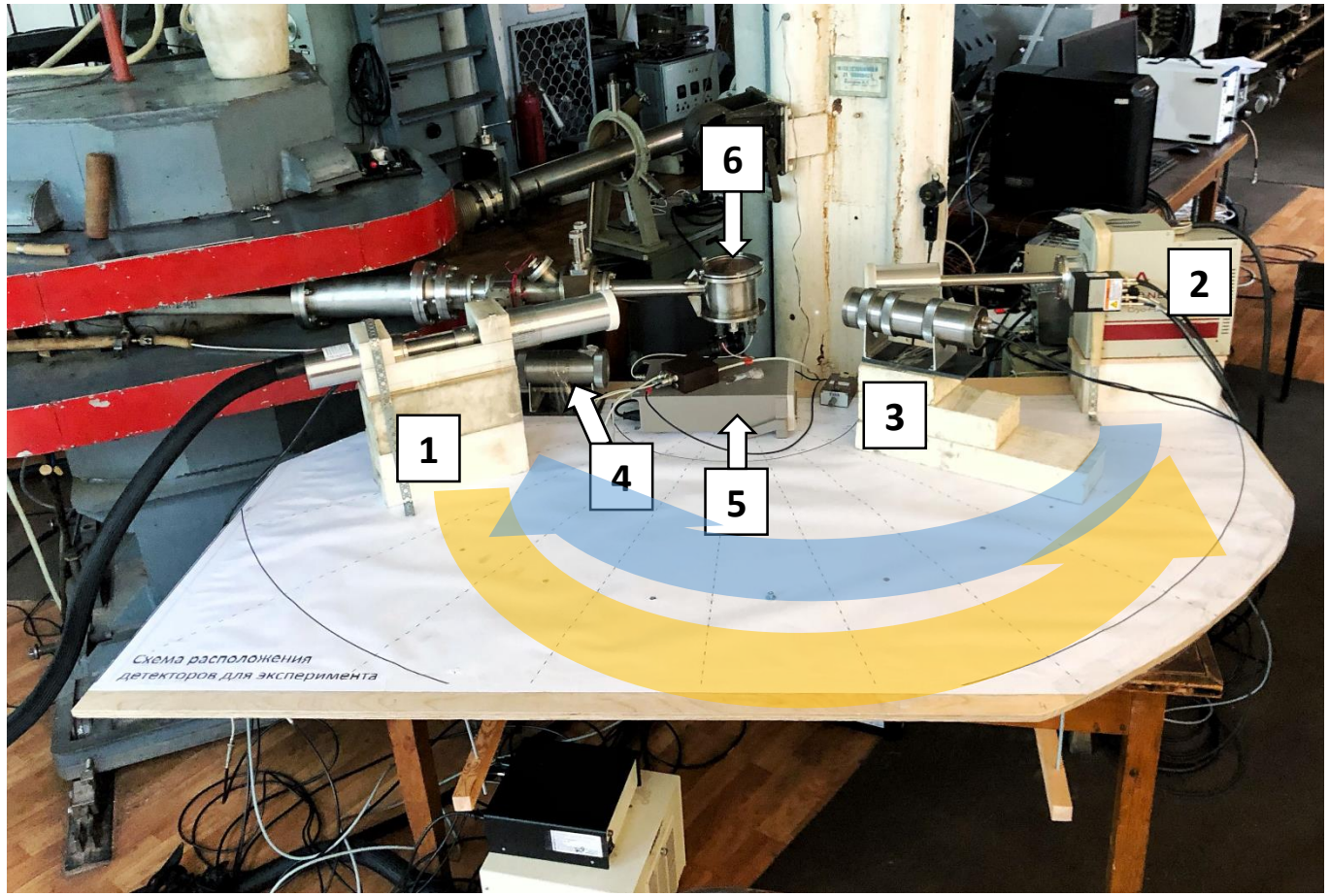
*S Hinds and R Middleton 1960 Proc. Phys. Soc. 75 754*

*L. van der Zwan, et al Canadian Journal of Physics, (1963) 41(7) 1036-1046*

*H.Fuchs, et. al. Nuclear Physics A 234 (1974) 61*

*J.H.Towle, B.E.F.Macefield, Nuclear Physics 66 (1965) 65*

# Experiment




1) HPGe spectrometer ORTEC GMX45P4-83-CW-PL;

2) HPGe spectrometer CANBERRA GR5021;

3) Compact neutron spectrometer BC-501A;

4) Gamma-spectrometer (monitor) $LaBr_3(Ce)$;

5) Amperemeter;

6) Reaction chamber.

Distance from the spectrometers to the target: **30 cm;**

Thickness of a beryllium target: **212 μg/cm².**

**Energy of $^3$He ions**: 1.52, 2.14, 2.49, 2.79, 3.10, 3.40, 3.70, 4.00, 4.50, 5.00, 6.00, 7.01 MeV

**Angle of view**: 0°, 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150°

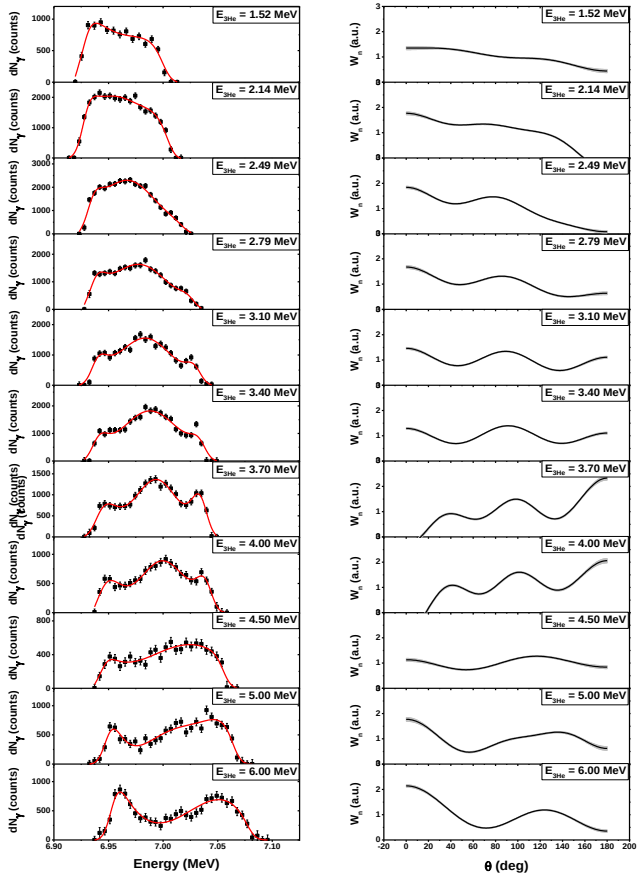
**Huge amount of data to process!**

# Results

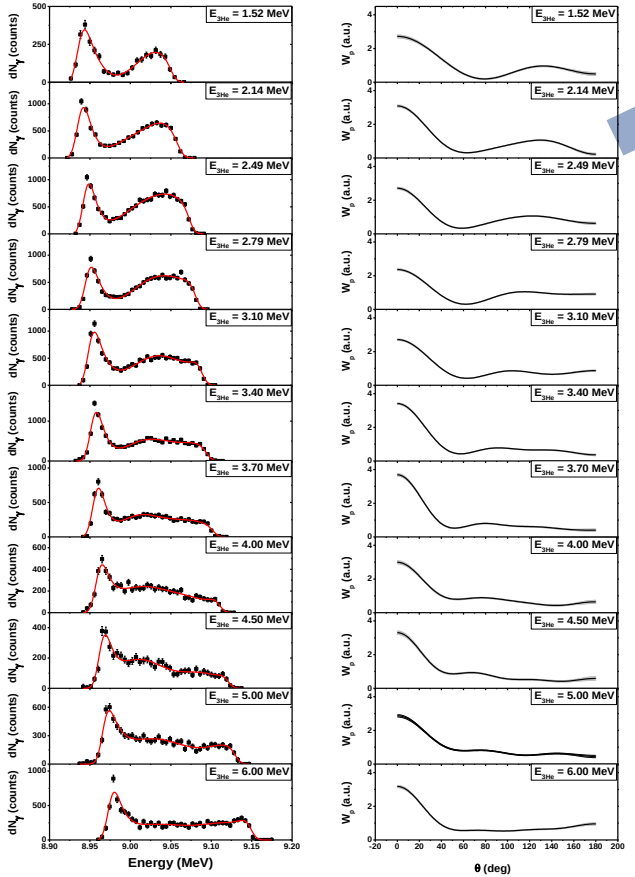
Angular distribution of protons and neutrons: $W_{p,n}(\theta) = \sum_{k=0}^{6} A_k \cdot P_k(cos\theta)$

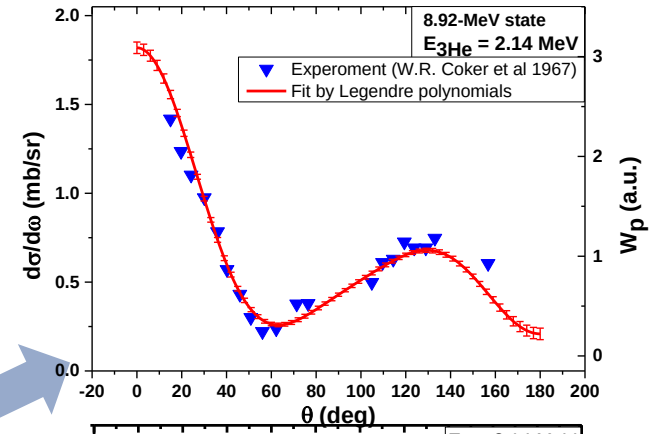
Angular distribution of gamma quanta: $W_\gamma(\theta) = \sum_{k=0,2,4} A_k \cdot P_k(cos\theta) \longrightarrow \boldsymbol{\sigma = 4 \cdot \pi \cdot A_0}$

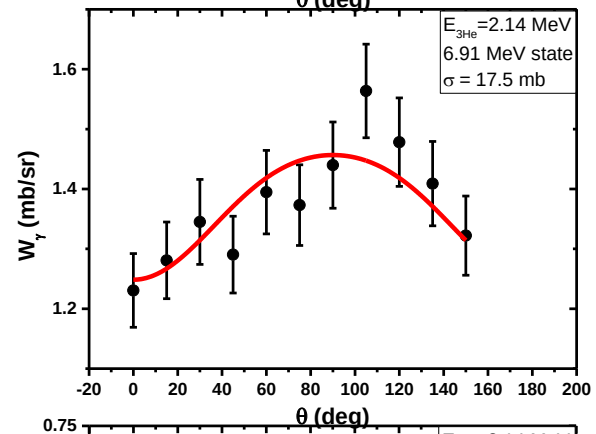
## $^{9}$Be($^{3}$He, nγ)$^{11}$C, 6.90-MeV state

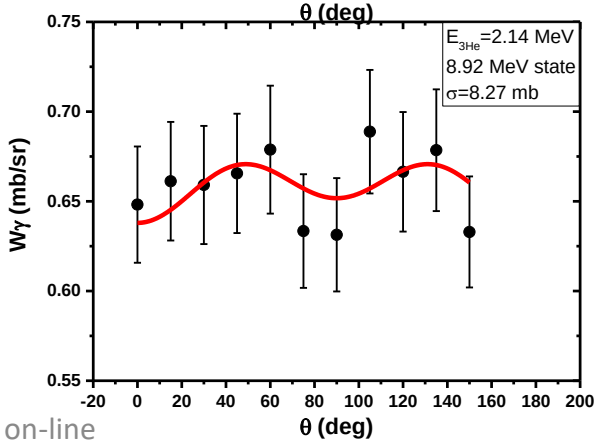



## $^{9}$Be($^{3}$He, pγ)$^{11}$B, 8.92-MeV state



# Conclusion

Main results of study of gamma-transitions in $^{11}C$ and $^{11}B$ nuclei:

- The experimental series on the irradiation of a beryllium target with a $^{3}He$ beam was carried out. The **energy range of $^{3}He$** ions was **from 1.52 to 7 MeV**. Angles of view were 0°, 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150°;
- Big data set was collected;
- **Angular distribution of proton emission** upon the population of the 8.92-MeV level of the $^{11}B$ nucleus in reaction $^{9}Be(^{3}He,p\gamma)^{11}B$ relative to the $^{3}He$ beam direction was obtained at different energies. Angular distribution of proton emission at the $^{3}He$ energy of 2.14 MeV was compared the previous results at the same energy (*W.R. Coker et al Nuclear Physics A91 (1967) 97-111*). The results are in a good agreement;
- **Angular distribution of neutron emission** upon the population of the 6.90-MeV level of the $^{11}C$ nucleus in reaction $^{9}Be(^{3}He,n\gamma)^{11}C$ relative to the $^{3}He$ beam direction was obtained at different energies;
- **Angular distribution of gamma-emission** upon the population of the 6.90-MeV level of the $^{11}C$ in $^{9}Be(^{3}He,n\gamma)^{11}C$ and 8.92-MeV level of the $^{11}B$ in $^{9}Be(^{3}He,p\gamma)^{11}B$ relative to the $^{3}He$ beam direction of the 2.14 MeV energy was obtained;
- **Partial cross-sections** of the 6.90-MeV transition of the $^{11}C$ and 8.92-MeV transition of the $^{11}B$ nuclei were estimated.

## Thank you for attention!