Study of the ^{7}He spectrum and decay products correlations in the (d,p)-reaction with ^{6}He (29 A·MeV) at ACCULINNA-2

Pavel Sharov for ACCULINNA collaboration

Outline:

- ^{7}He structure
- Recent ACCULINNA-2 experiment
  - Method
  - Preliminary results
- Studies of nuclei beyong drip-line in the (d,p) and (t,p) reactions

Correlation studies at ACCULINNA and ACCULINA-2

^{5}H: *M. S. Golovkov, et. al.*, PRL **93**, 262501 (2004)

^{5}H: *M. S. Golovkov, et. al.*, PRC **72**, 064612 (2005)

^{9}He: *M. S. Golovkov, et. al.*, PRC **76**, 021605(R) (2007)

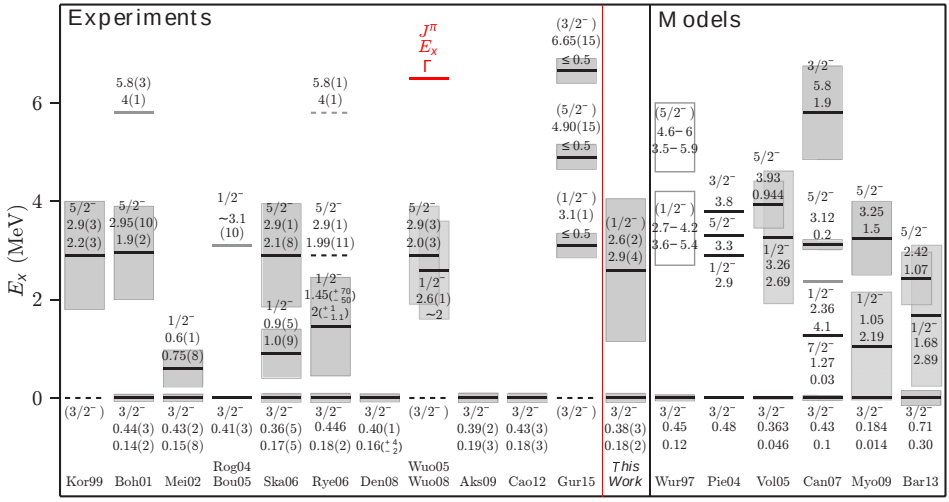
^{6}Be: *A. S. Fomichev, et. al.*, PLB **708**, 6—13 (2012)

^{10}He: *S. I. Sidorchuk, et. al.*, PRL **108**, 202502 (2012)

^{6}Be: *V. Chudoba, et. al.*, PRC **98**, 054612 (2018)

^{7}He structure

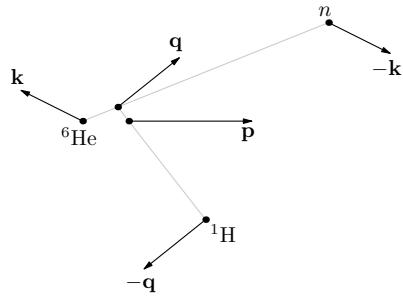
F. Renzi, et. al., PRC **94**, 024619 (2016)



- $1/2^-$-state proporties
- Ground State spectroscopic factor

"Inner" and "Outer" correlations for case of the (d, p) reaction

$$^2\mathrm{H}(^6\mathrm{He}, ^1\mathrm{H})^7\mathrm{He}$$



Some notations...

$$m_p = m_{^1\mathrm{H}} + m_{^6\mathrm{He}} + m_n,$$
$$m_q = m_{^1\mathrm{H}}(m_n + m_{^6\mathrm{He}})/(m_{^1\mathrm{H}} + m_n + m_{^6\mathrm{He}}),$$
$$m_k = m_n m_{^6\mathrm{He}}/(m_n + m_{^6\mathrm{He}}),$$
$$\mathbf{p} = \mathbf{p}_{\mathrm{beam}} + \mathbf{p}_{\mathrm{target}},$$
$$\mathbf{q} = \frac{m_{^1\mathrm{H}}}{m_{^1\mathrm{H}} + m_n + m_{^6\mathrm{He}}}\mathbf{p} - \mathbf{p}_p,$$
$$\mathbf{k} = \mathbf{p}_{^6\mathrm{He}} - \frac{m_{^6\mathrm{He}}}{m_n + m_{^6\mathrm{He}}}\mathbf{q} - \frac{m_{^6\mathrm{He}}}{m_{^1\mathrm{H}} + m_n + m_{^6\mathrm{He}}}\mathbf{p}.$$

Excitation energy

$$E^* = \frac{k^2}{2m_k}$$

"Outer" correlations

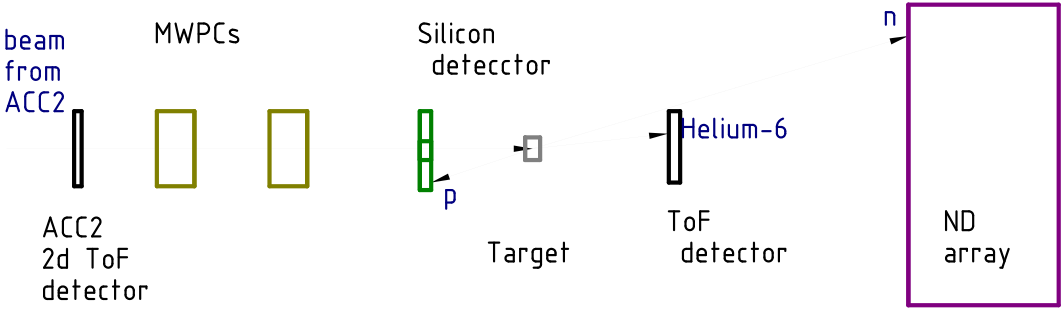
$$\cos\theta_{\mathrm{CM}} = (\hat{p} \cdot \hat{q})$$

"Inner" correlations

$$\cos\theta_q = (\hat{q} \cdot \hat{k})$$

Experimrntal setup and method

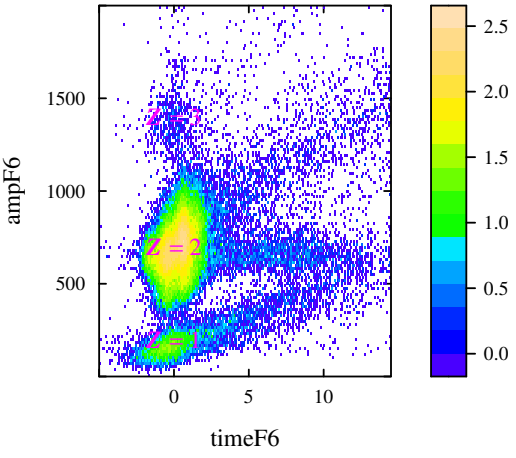
Experimental setup layout



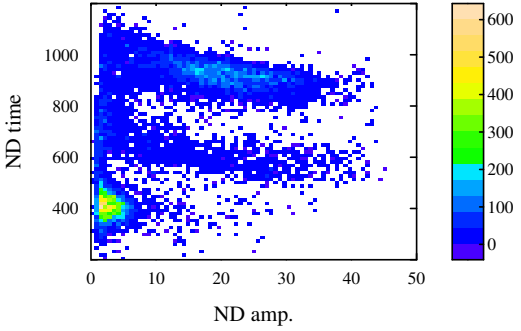
- Cryogenic deuterium target
- Silicon detectors for backward protons
- Scintillator for heavy fragment ToF measurement
- Neutron detector

Particle ID

Heavy fragment ID



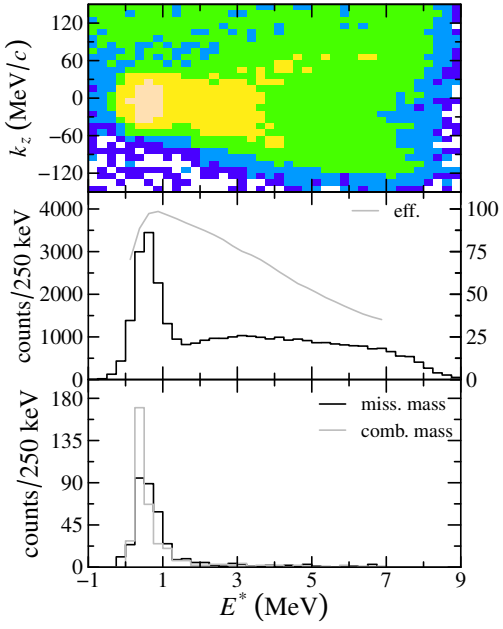
Neutrons ID



- Backward p doesn't need particle ID
- ΔE–ToF measurement allow to identify Z
- ND provides good separation of neutrons from γ and MIP,

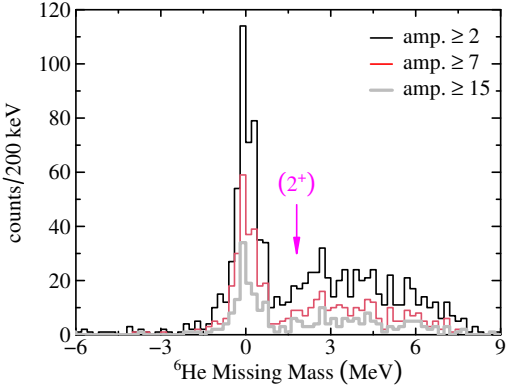
^{7}He spectrum

- ^{7}He spectrum has been measured for high energies.
- k_z distribution can be used for "inner" corellation studies.
- ^{7}He spectrum for low energy obtained in events with neutron coincidence with high resolution.

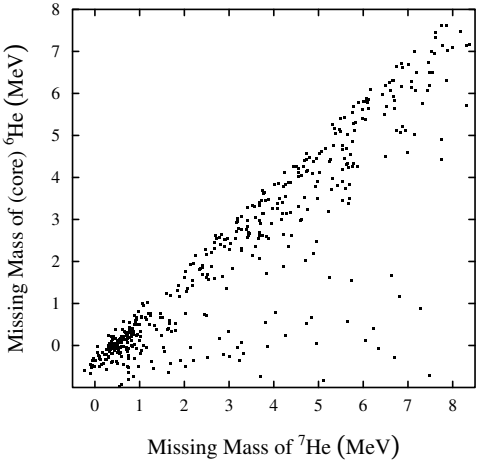


Events with neutron coincidence

Core excitation energy

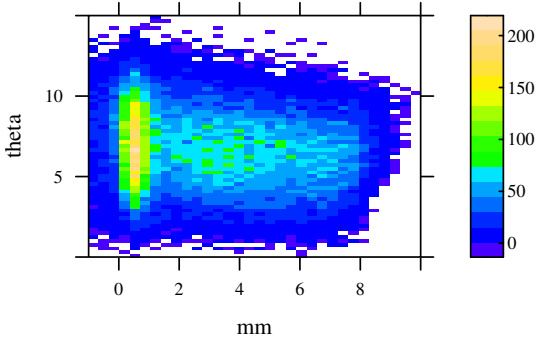


Core excitation vs. ^{7}He spectrum



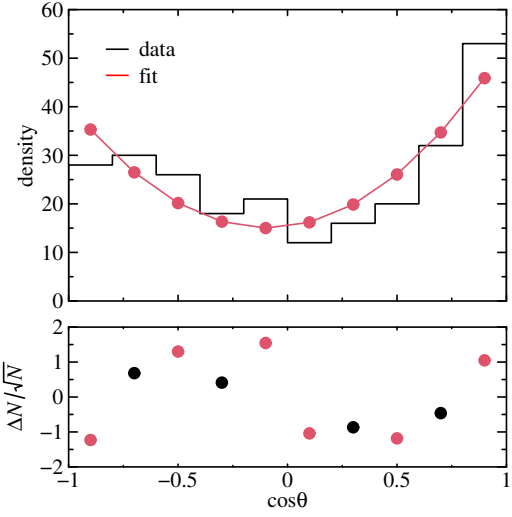
^{7}He correlations

θ_{CM}-distribution



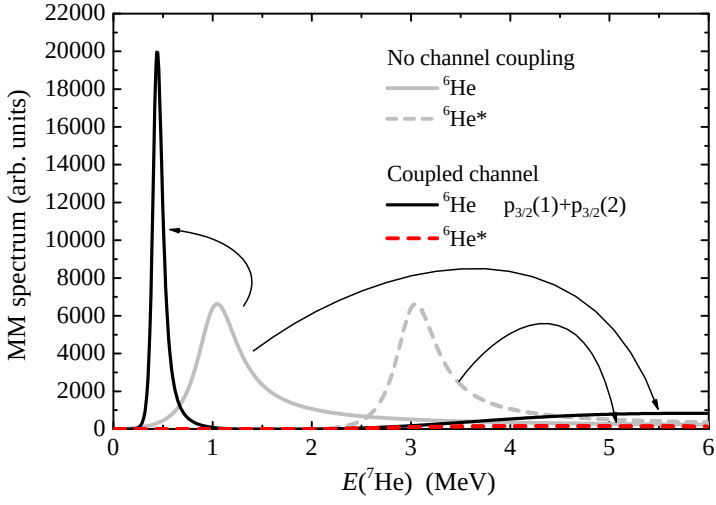
- Narrow range of the reaction angle
- No significant dependance of θ_{CM} from E^*

^{7}He g.s. correlation

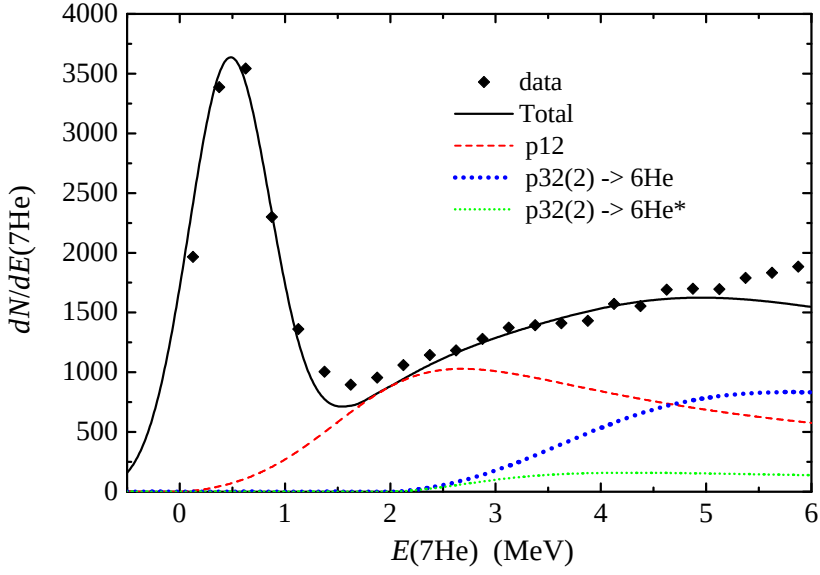


^{7}He structure in a multi-channel model

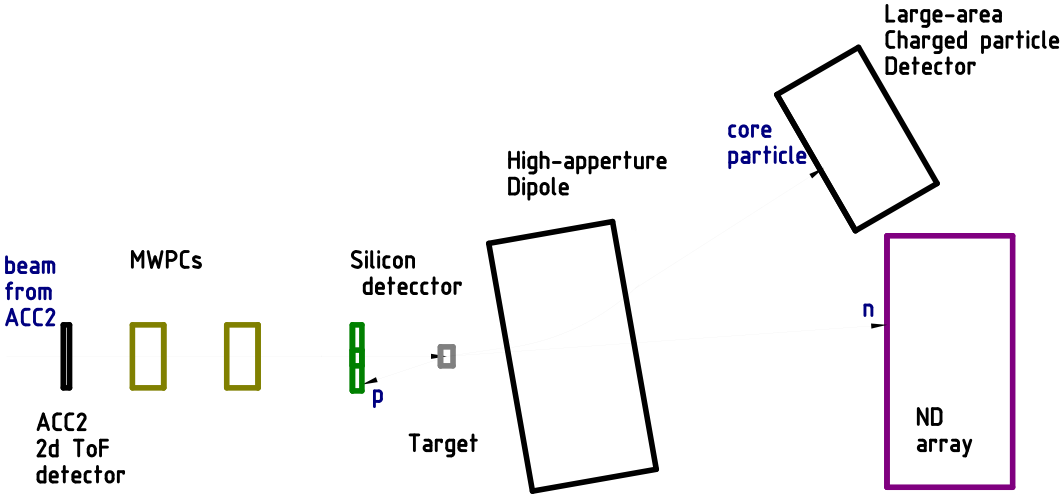
- $^6\mathrm{He} + n$ and $^6\mathrm{He}^* + n$ channels
- strong mixing in $3/2^-$



^{7}He spectrum decomposition



Studies of the nuclear structure in the (d, p) and (t, p) reactions



- Redundat kinematics: measuring invariant and missing mass.
- High-apperture magnet spectrometer
- Large-area detectors array for hodoscope system
- Neutron detectors array

Summary

- The preliminary results of the recent FLNR experiment dedicated to $^{7}\mathrm{He}$ spectrum studies have been reported.
- New data about the $^{7}\mathrm{He}$ have been obtained:
  - inclusive spectrum for wide range of E^{*}
  - Decay products correlation for $^{7}\mathrm{He}$ ground state
- A theoretical interpretation of the observed picture has been offered.
- The reported experiment is a part of wide research dedicated to studies of neutron-rich nuclei beyond nuclear drip-line.