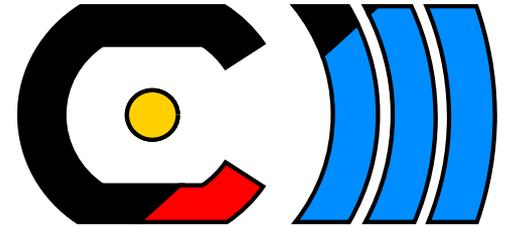


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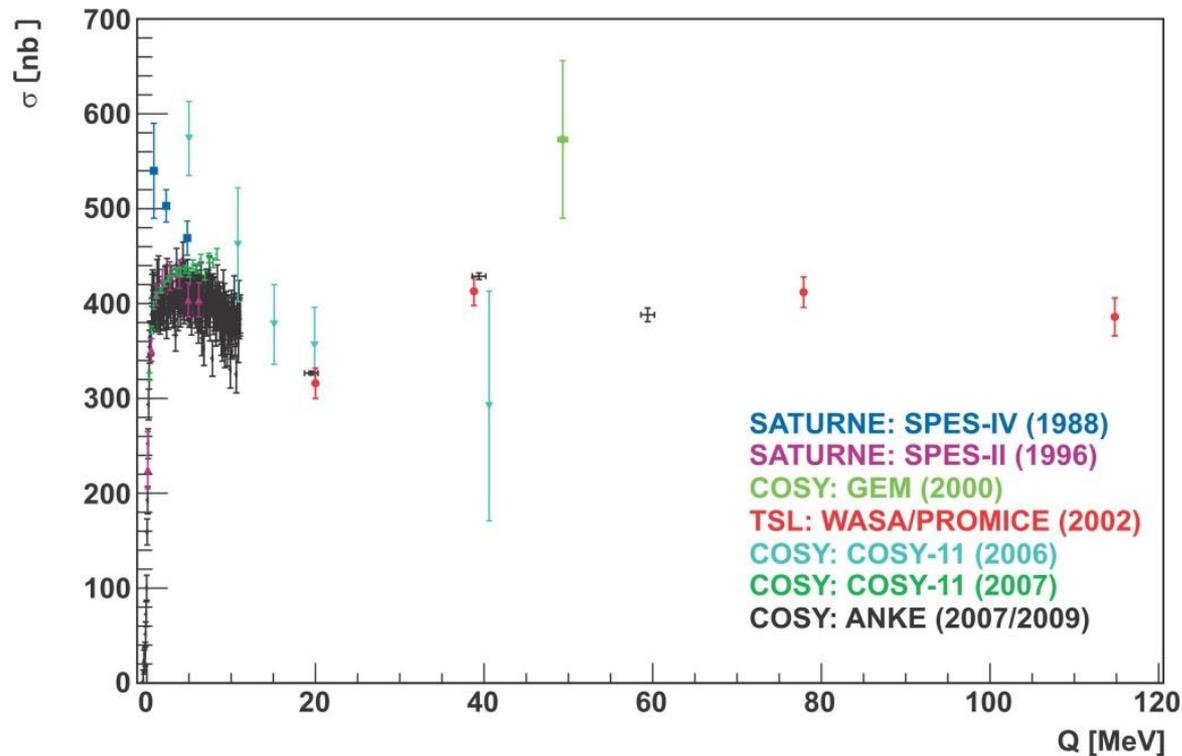


Total and Differential Cross Section of the  
Reaction  $p + d \rightarrow {}^3\text{He} + \eta$  at 49 and 60 MeV  
Excess Energy

Florian Bergmann

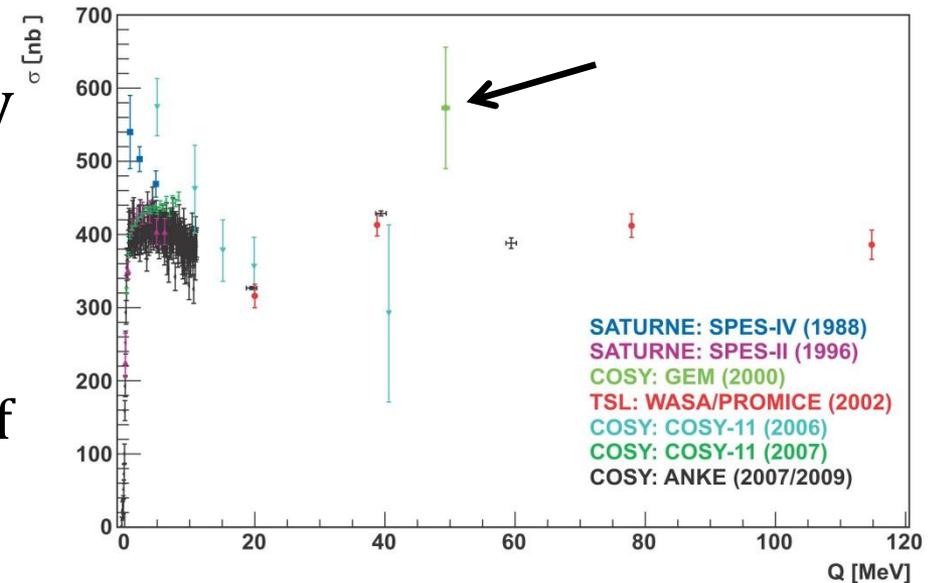
MESON 2012 – May/June 2012

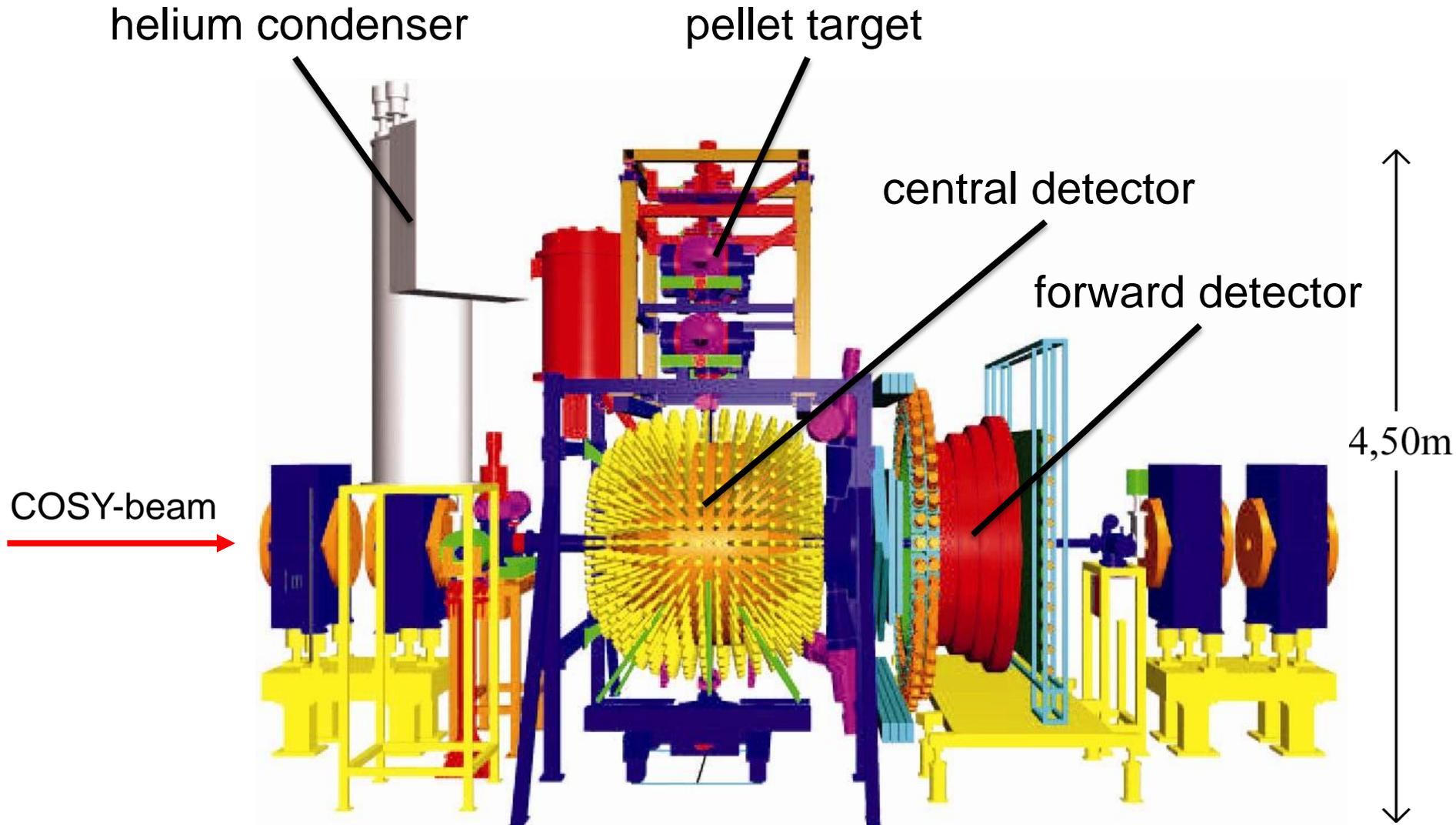
Total  $p + d \rightarrow {}^3\text{He} + \eta$  cross sections (only statistical errors):



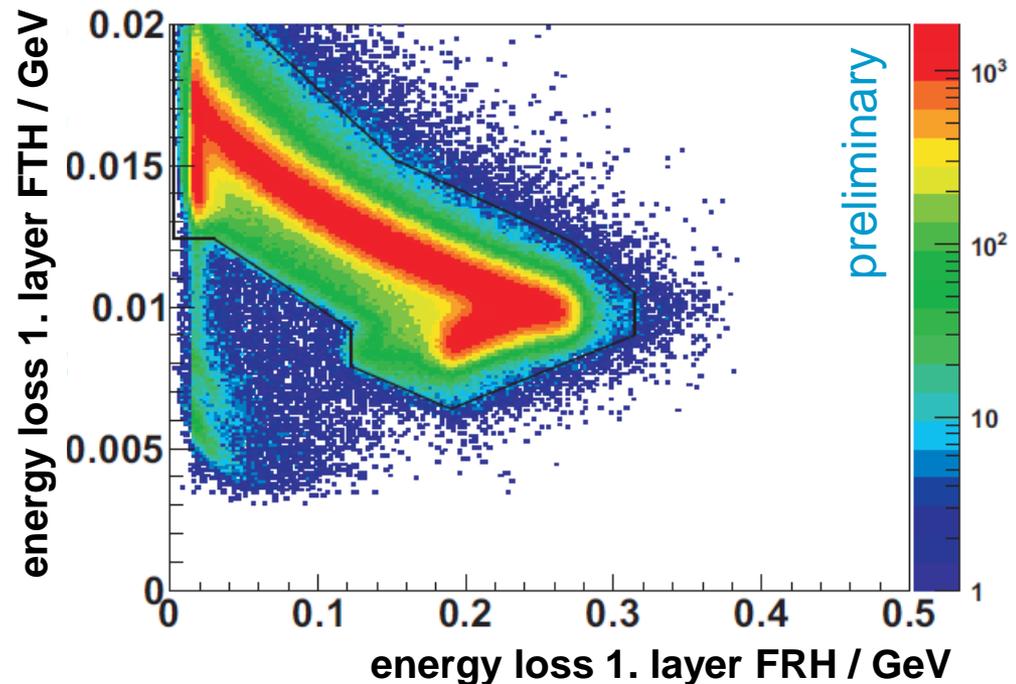
- Enhancement within the first MeV excess energy caused by a strong final state interaction
- ➔ Evidence for an  $\eta$ - ${}^3\text{He}$  bound state
- Excitation function is well known near the production threshold

- Larger uncertainties at higher excess energies
- Data from WASA/PROMICE and ANKE show a cross section plateau between 40 and 120 MeV
- 49 MeV GEM data point might indicate a cross section increase above this plateau
- A peak-like structure would be of high interest for studies of the reaction and the final state interaction
- Enhancement can also be an artifact of different normalizations ( $\approx 15\%$ )

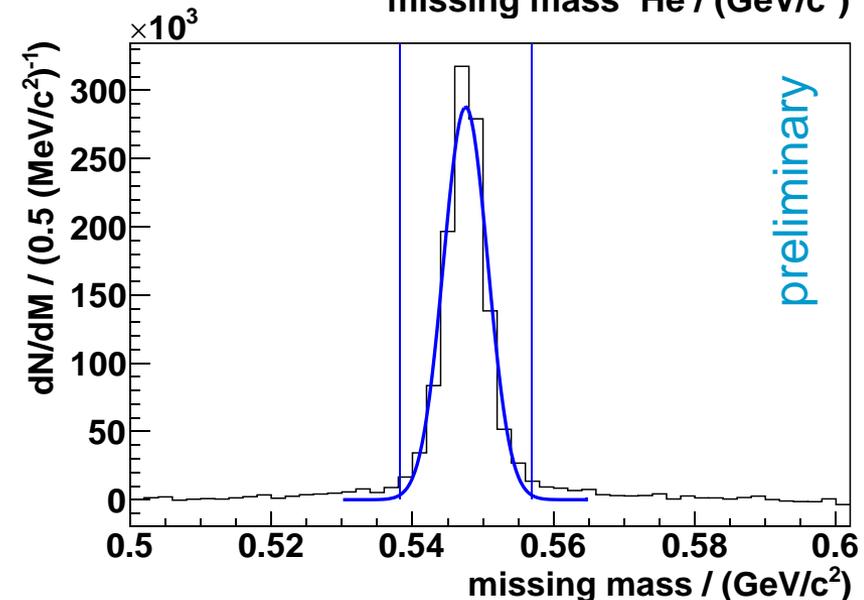
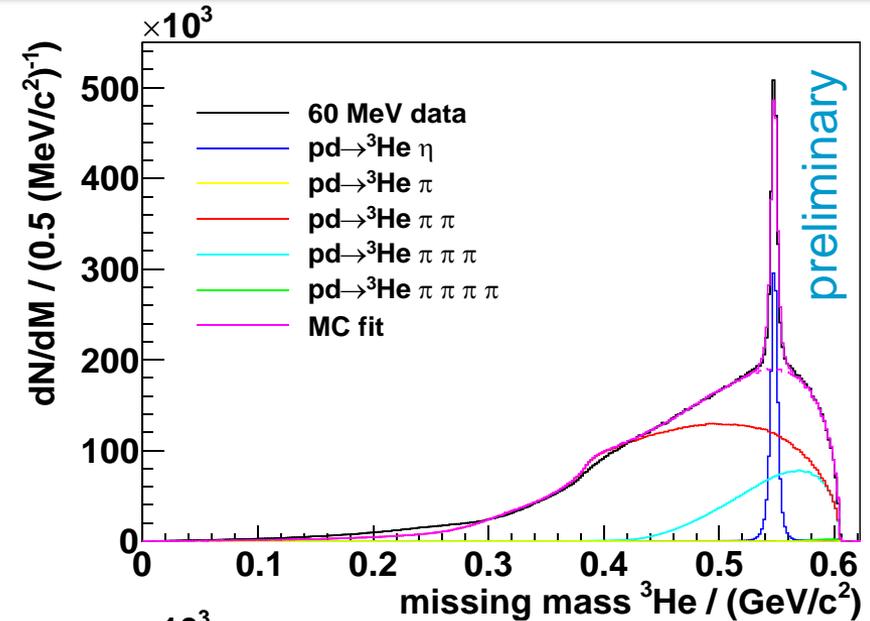


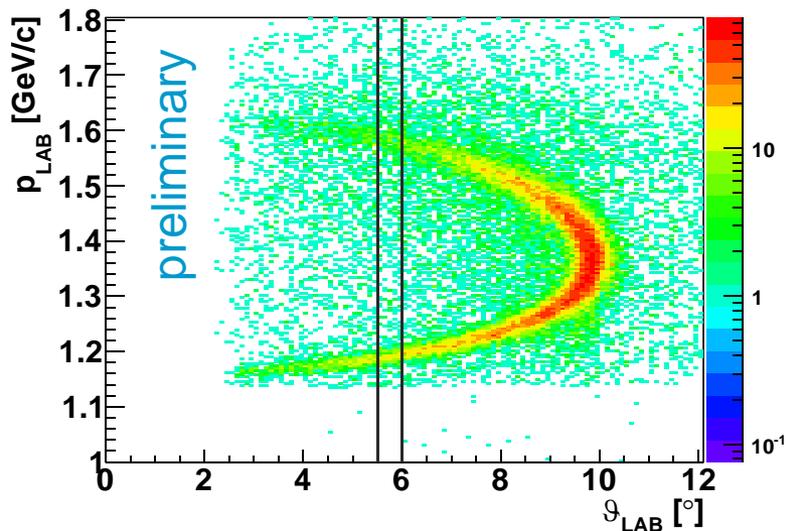


- Data for the reaction  $p + d \rightarrow {}^3\text{He} + \eta$  at 60 MeV excess energy were taken with WASA-at-COSY setup (decay studies)
- To verify the GEM data point additional data were taken at 49 MeV
- Relative normalization of both data sets possible
- Data taken at same run period August/September 2009 to minimize systematic uncertainties
- Preselection on  $p + d \rightarrow {}^3\text{He} + X$  events via  ${}^3\text{He}$  identification in  $\Delta E - E$  plot (energy loss in Forward Trigger Hodoscope versus energy loss in Forward Range Hodoscope)

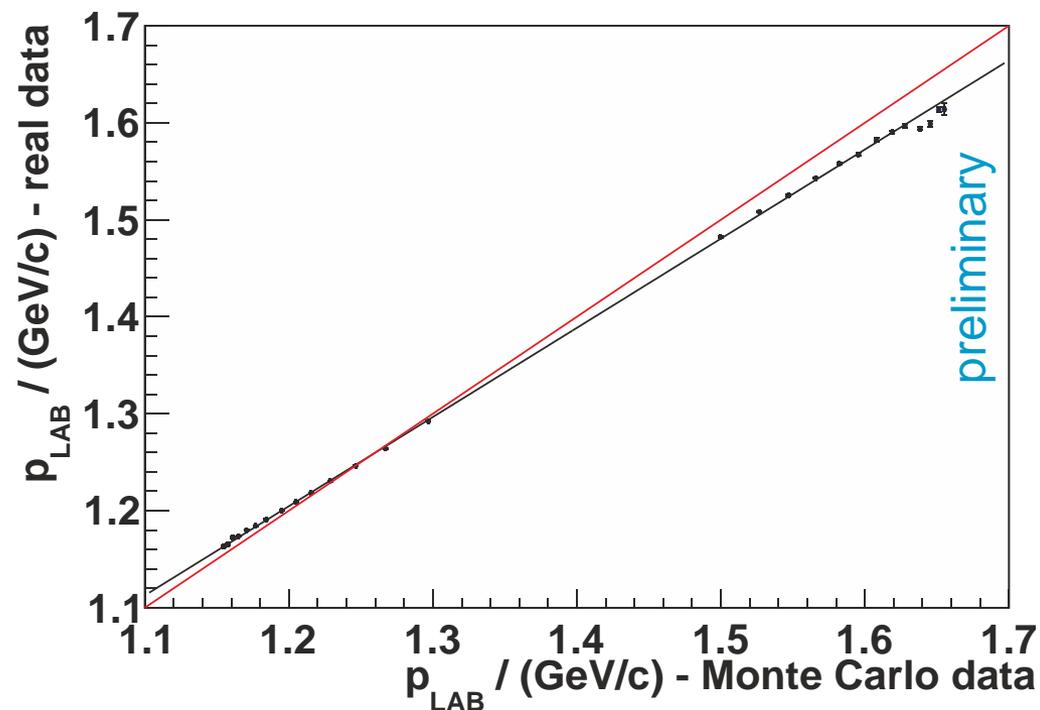
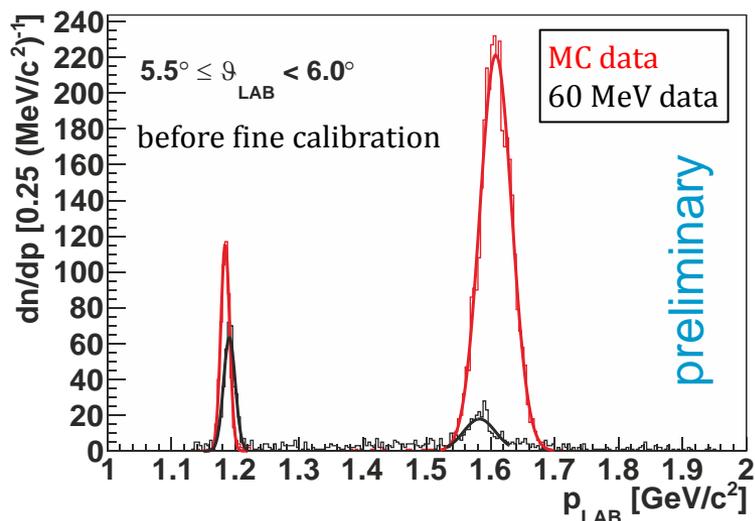


- The number of  $\eta$  events are extracted from the missing mass spectra of different angular ranges
- The background for each  $\cos \vartheta_{\text{CMS}}$  bin is fitted with MC simulations and subtracted
- The peak is fitted with a Gaussian distribution to determine the  $3\sigma$  area
- The events are counted in this area and are corrected to 100%
- The extracted  $\eta$  numbers are corrected for the detector acceptance

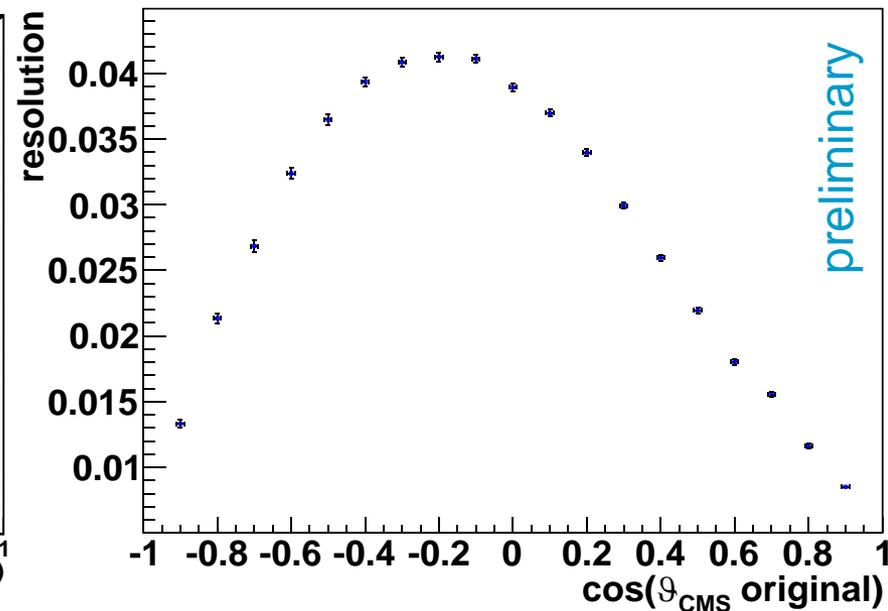
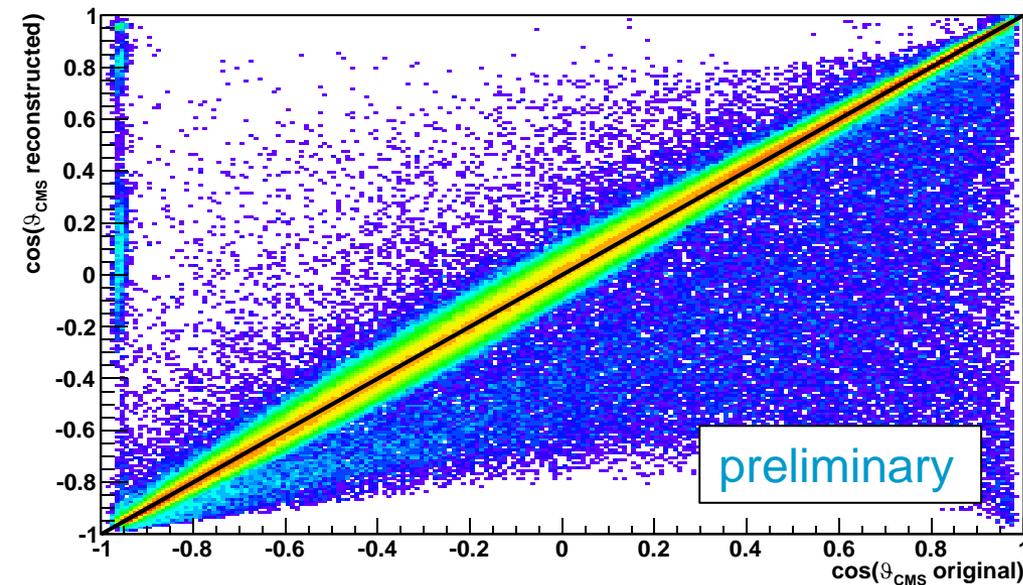


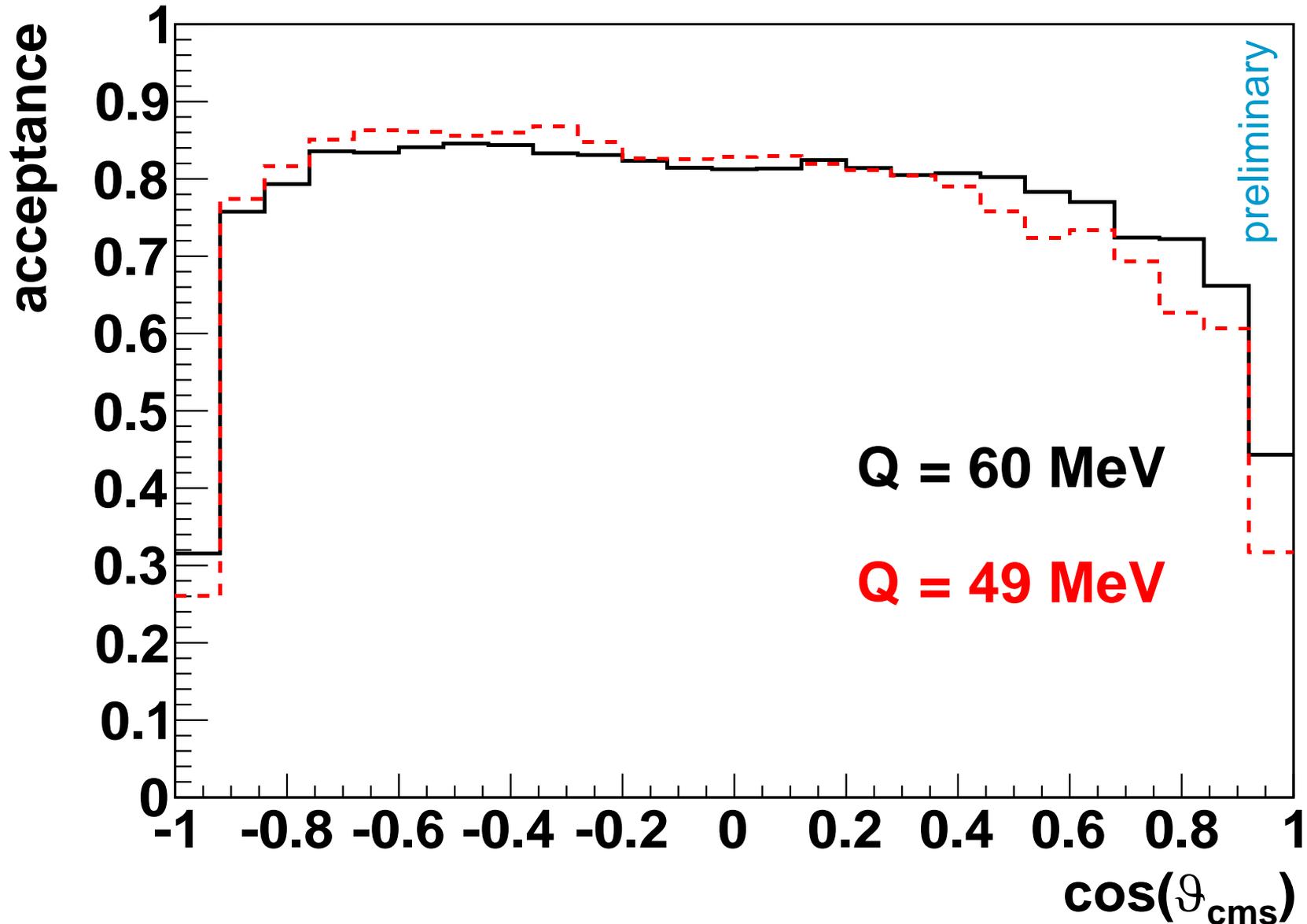


- Comparison between MC data and measured data
- Linear fit for momenta correction
- Further corrections (e.g.  $\varphi$  dependent)



- For an appropriate  $\cos(\vartheta_{\text{CMS}})$  binning check reconstruction via Simulations
  - Fit projections of spectrum with Gaussian to get the standard deviation
- Binwidth: 0.08
- 25 bins





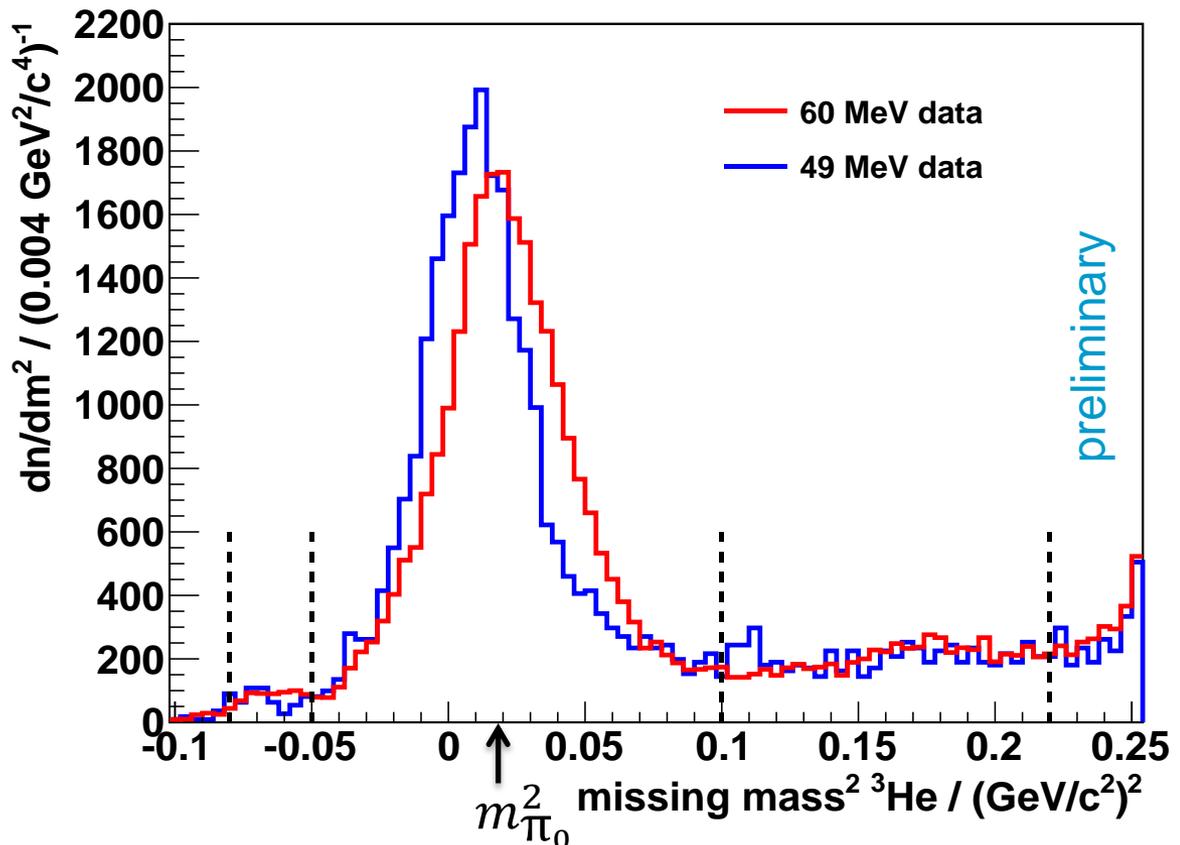
- Aim: determination of the ratio  $\frac{\sigma(49 \text{ MeV})}{\sigma(60 \text{ MeV})}$
- ➔ Relative normalization via the single pion production  $p + d \rightarrow {}^3\text{He} + \pi^0$
- The excess energies for the single pion production are  $Q = 462 \text{ MeV}$  and  $Q = 473 \text{ MeV}$  respectively for the two data samples
- The phase space volume changes by approximately 1 % only:

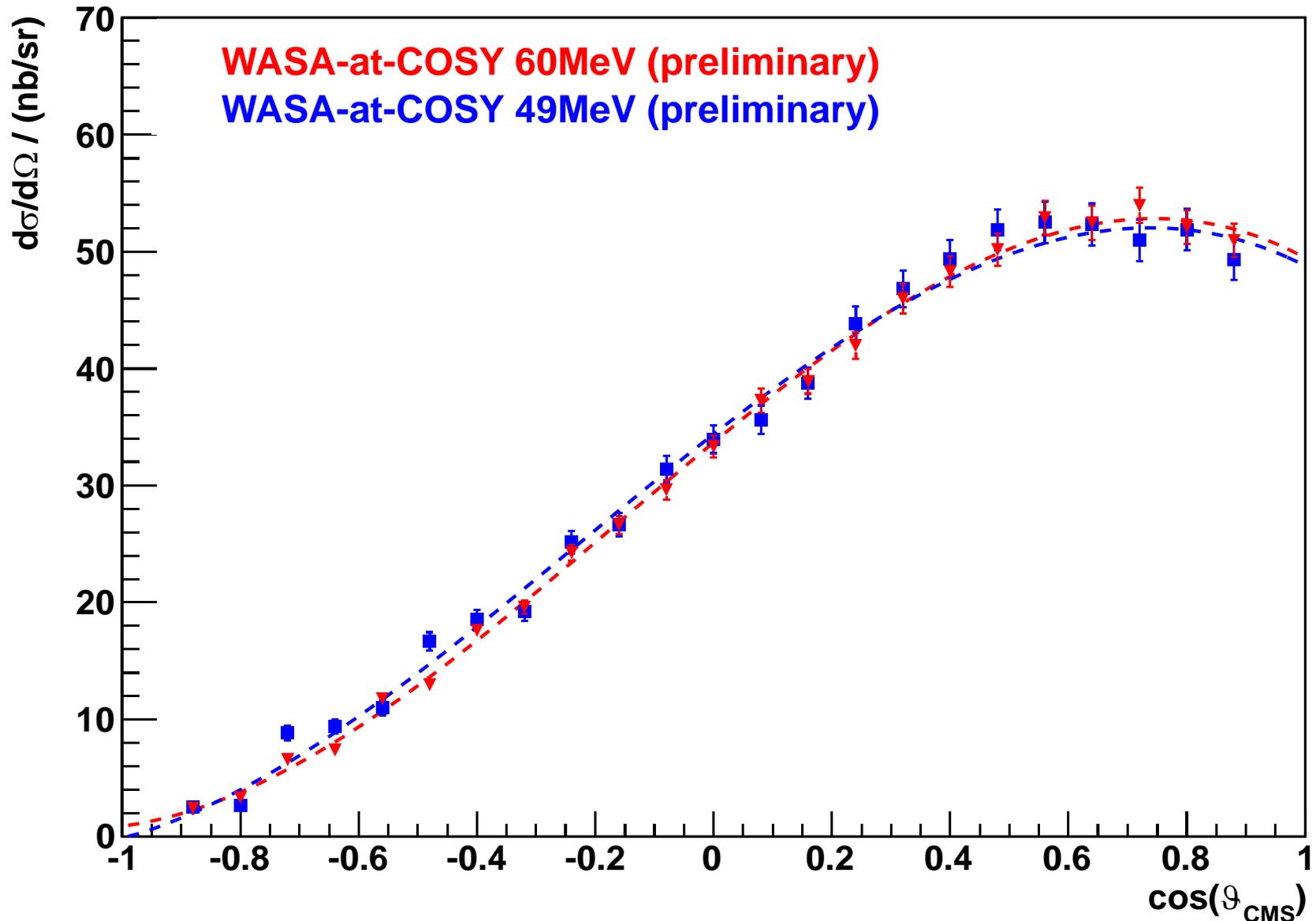
$$\sqrt{\frac{Q = 473 \text{ MeV}}{Q = 462 \text{ MeV}}} \approx 1,01$$

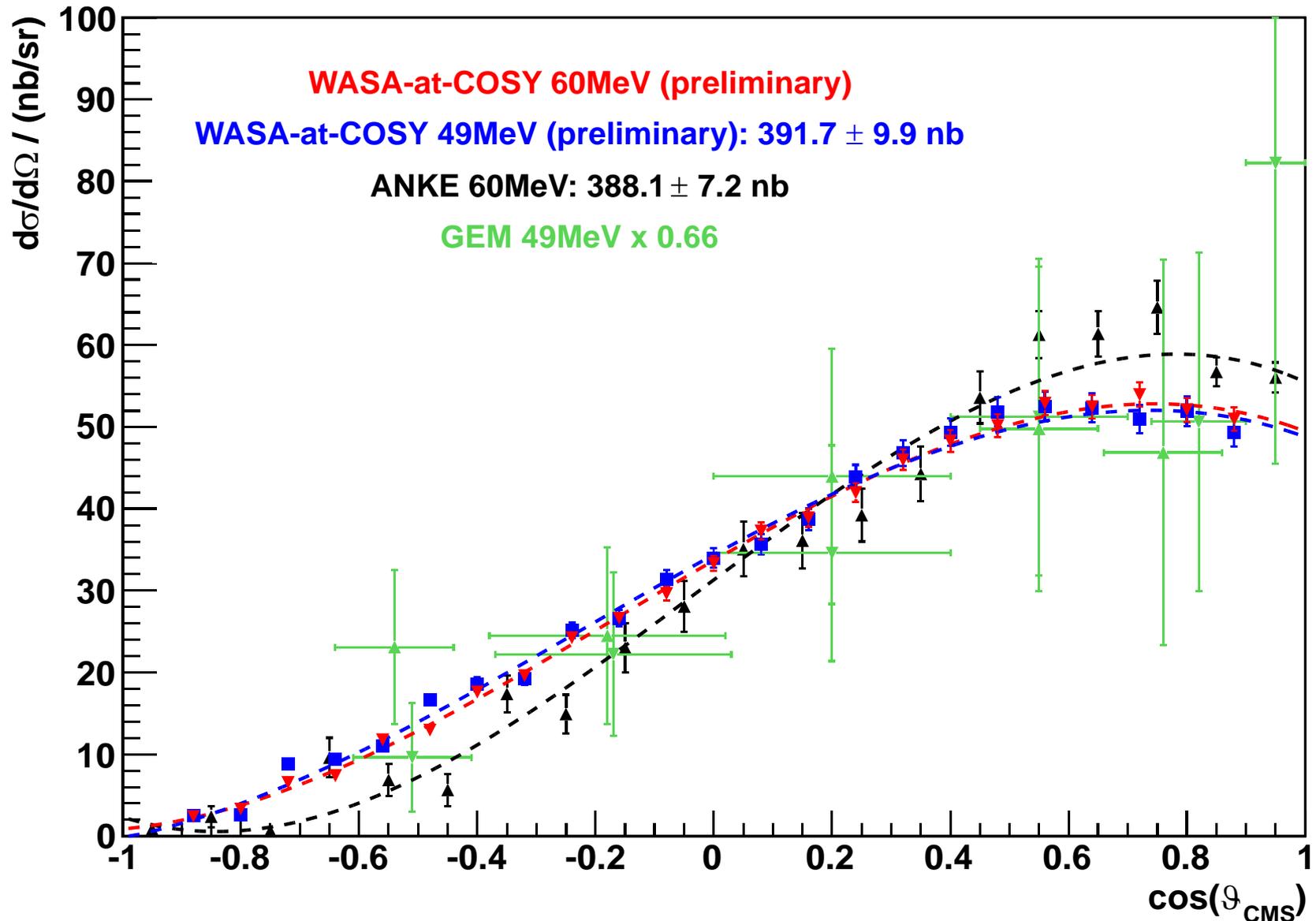
- ➔ The  $\pi^0$  ratio corresponds to the ratio of the integrated luminosities and is used as normalization factor
- ➔ Absolute normalization to the 60 MeV ANKE cross section

- Momenta correction for  $\pi^0$  production: Same correction for 49 and 60 MeV data
- Scaling via background
- Next:
  - Fit background and subtract it from the spectra
  - Count number of  $p + d \rightarrow {}^3\text{He} + \pi^0$  events

→ Normalization factor







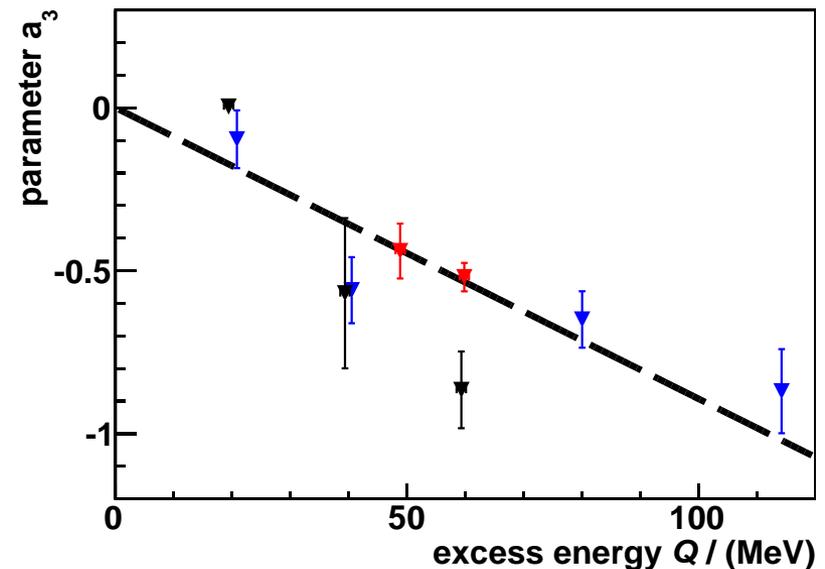
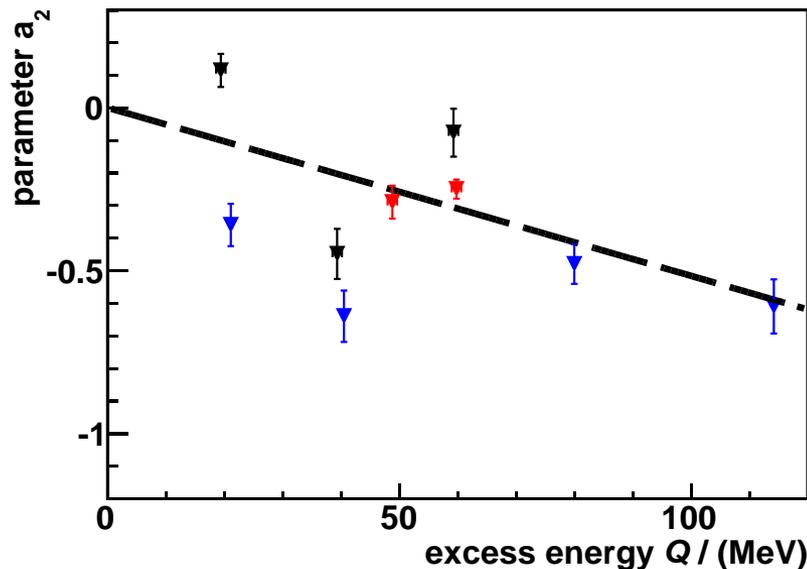
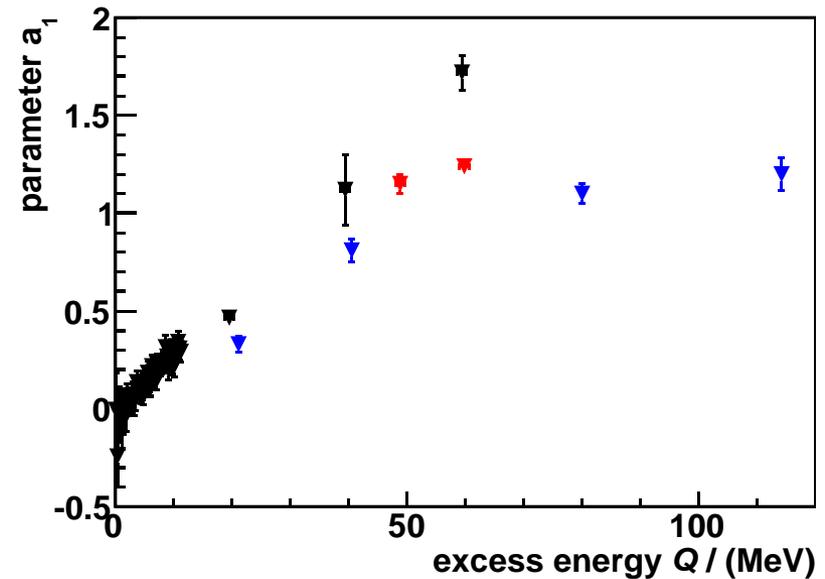
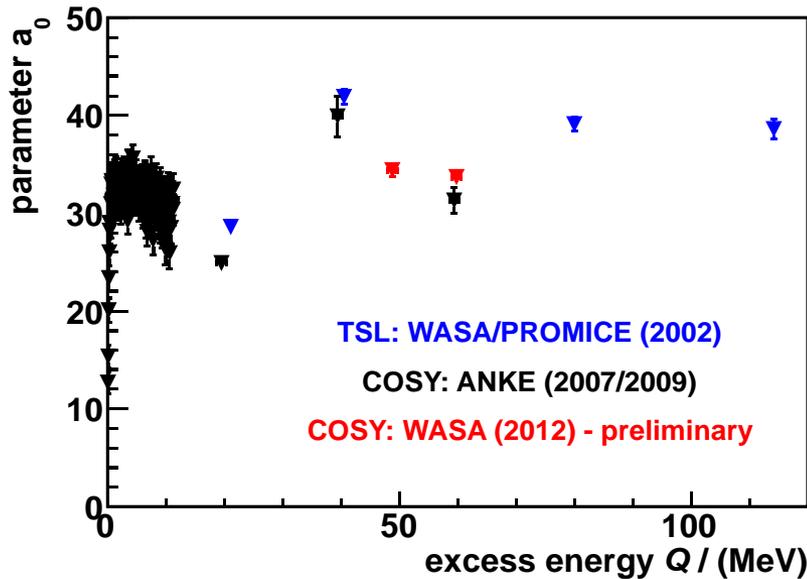
- For each energy differential cross section bins 2 – 24 are fitted by a third order polynomial:

$$\frac{d\sigma}{d\Omega} = a_0 \cdot \left[ 1 + \sum_{n=1}^3 a_n (\cos(\vartheta_{\text{CMS}}))^n \right]$$

preliminary

$Q / \text{MeV}$	$a_0 / (\text{nb/sr})$	$a_1$	$a_2$	$a_3$	$\chi^2 / \text{ndf}$
48.8	$34.4 \pm 0.4$	$1.15 \pm 0.03$	$-0.29 \pm 0.03$	$-0.44 \pm 0.05$	2.83
59.8	$33.7 \pm 0.3$	$1.24 \pm 0.02$	$-0.25 \pm 0.02$	$-0.52 \pm 0.03$	2.11

- ➔ Compare with polynomial fits obtained for existing WASA/PROMICE and ANKE data





- Angular distributions of the  $p + d \rightarrow {}^3\text{He} + \eta$  reaction at 49 and 60 MeV excess energy were extracted
- Total and differential cross sections have been determined by a normalization to the 60 MeV ANKE data
- 49 and 60 MeV total and differential cross sections determined by WASA-at-COSY agree within their uncertainties with each other

$$\sigma_{\text{WASA}}^{\text{prel.}}(49 \text{ MeV}) = (391.7 \pm 9.9)\text{nb} \pm 57 \text{ nb normalization error}$$

- A cross section increase at 49 MeV excess energy has not been observed