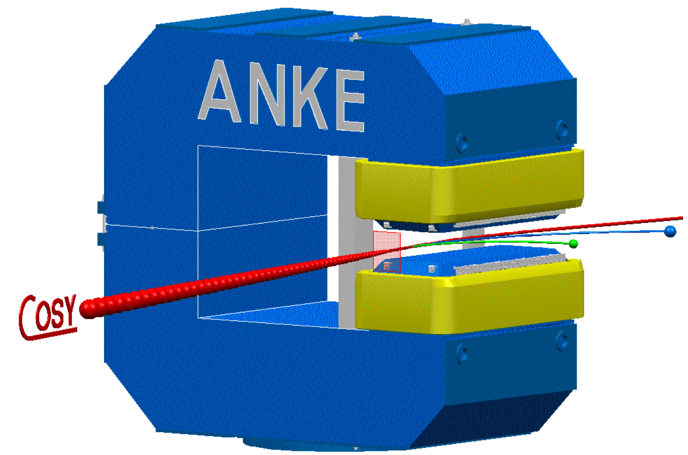
Caucasian-German School and Workshop in Hadron Physics
(Tbilisi 2006)



Investigation of the ^{3}He η Final State in dp-Reactions at ANKE

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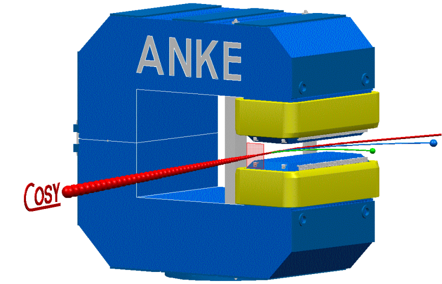
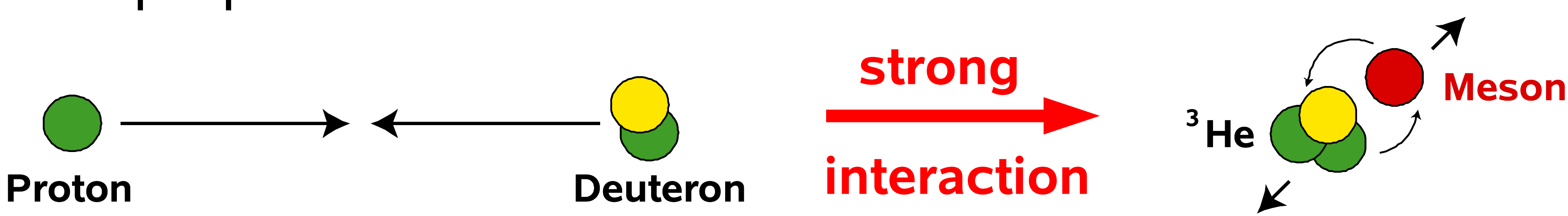
Münster

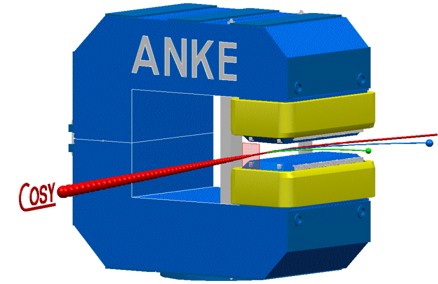
Motivation for measurements to study the ^{3}He η interaction



- Situation:
  - Existence of an attractive ^{3}He η interaction
  - Open question: "Does a bound state exit?"
- How to measure the ^{3}He η interaction?
  - Taking advantage of the effect of final state interactions on reaction cross sections near threshold
  - Production experiment $dp \to {}^3$He η
  - The ^{3}He η scattering length is closely related to the properties of a bound state



Correlation of Cross Sections and ^{3}He η scattering length

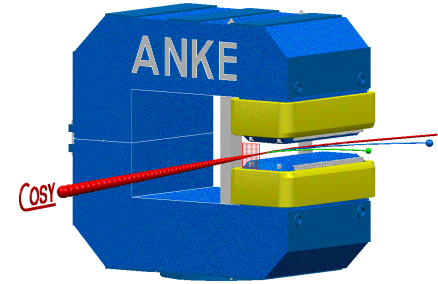


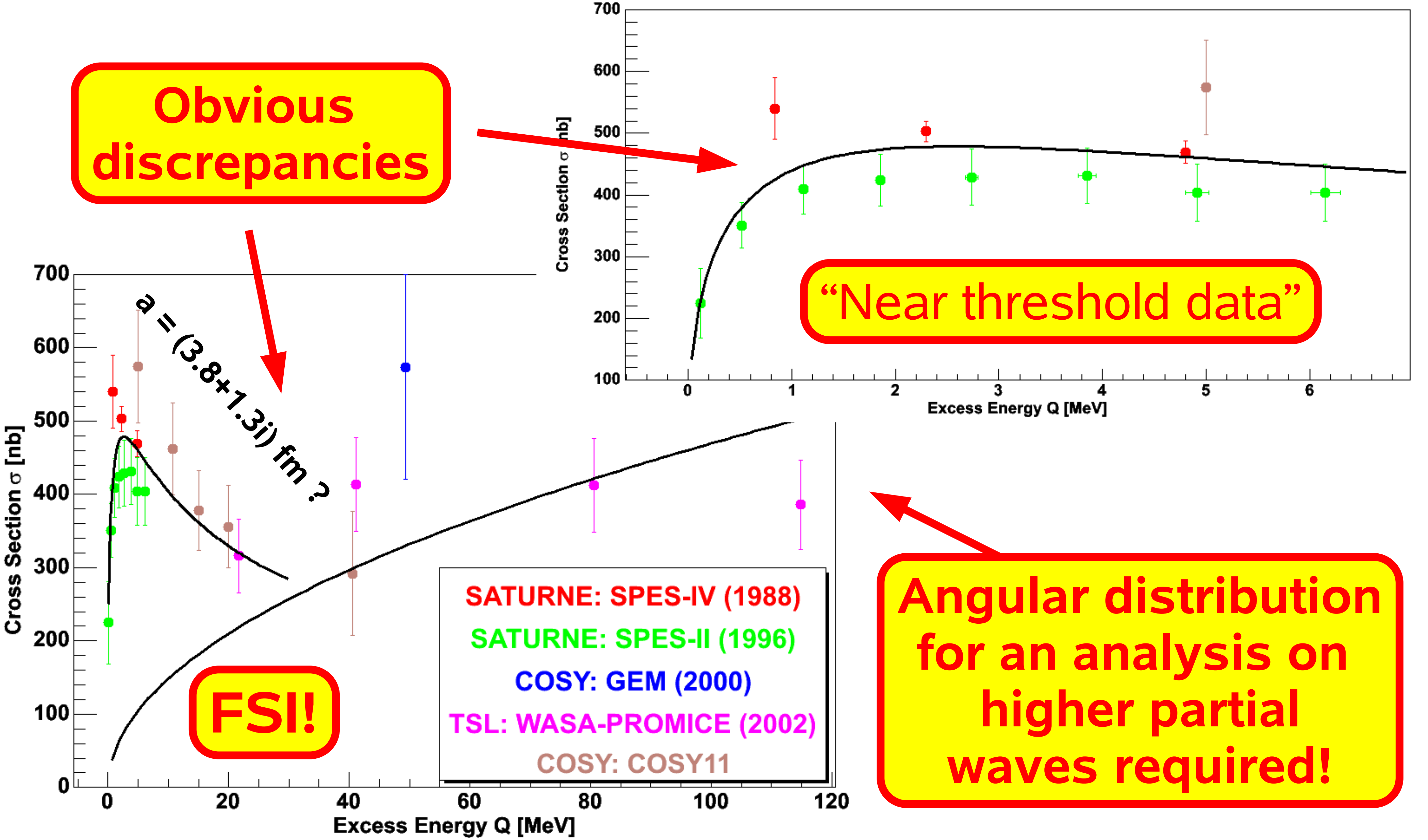
$$\frac{p_i}{p_f}\left(\frac{d\sigma}{d\Omega}\right) = |f|^2 = |f_B \cdot FSI|^2 = \left|\frac{f_B}{1 - i \cdot p_f \cdot a}\right|^2 = \frac{f_B^2}{1 + p_f^2 |a|^2 + 2 p_f \Im(a)}$$

- p_i, p_f: initial and final state center of mass momentum
- $(d\sigma/d\Omega)$: differential cross section
- f: scattering amplitude
- f_B: production amplitude
- a: scattering length of the ^{3}He η system

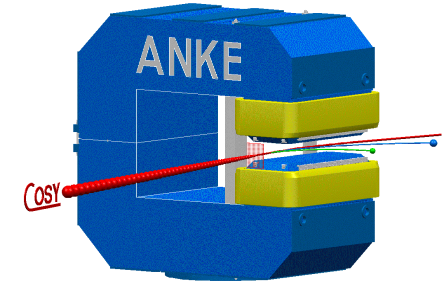
Fit in **three** variables of the energy dependency of the cross section (absolute height f_B; shape Re(a), Im(a))

Motivation for new measurements on the reaction $dp \rightarrow {}^3He\,\eta$

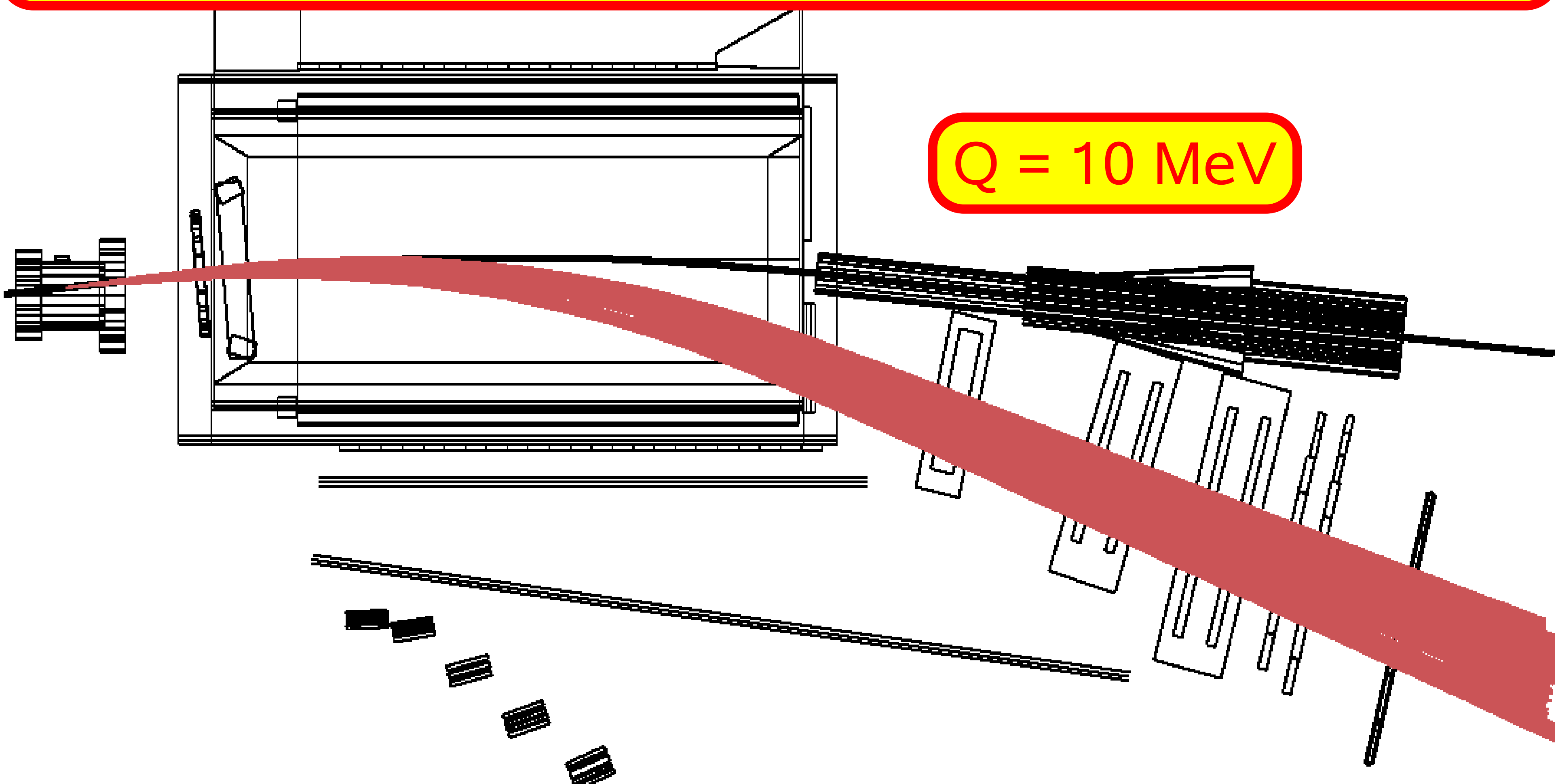




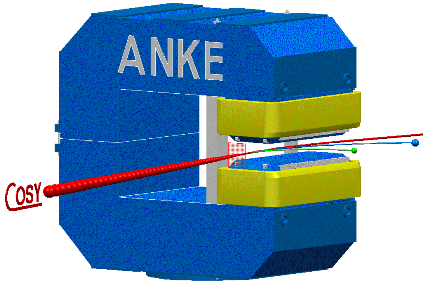
Measurements on the reaction $dp \to {}^{3}He\,\eta$ at ANKE



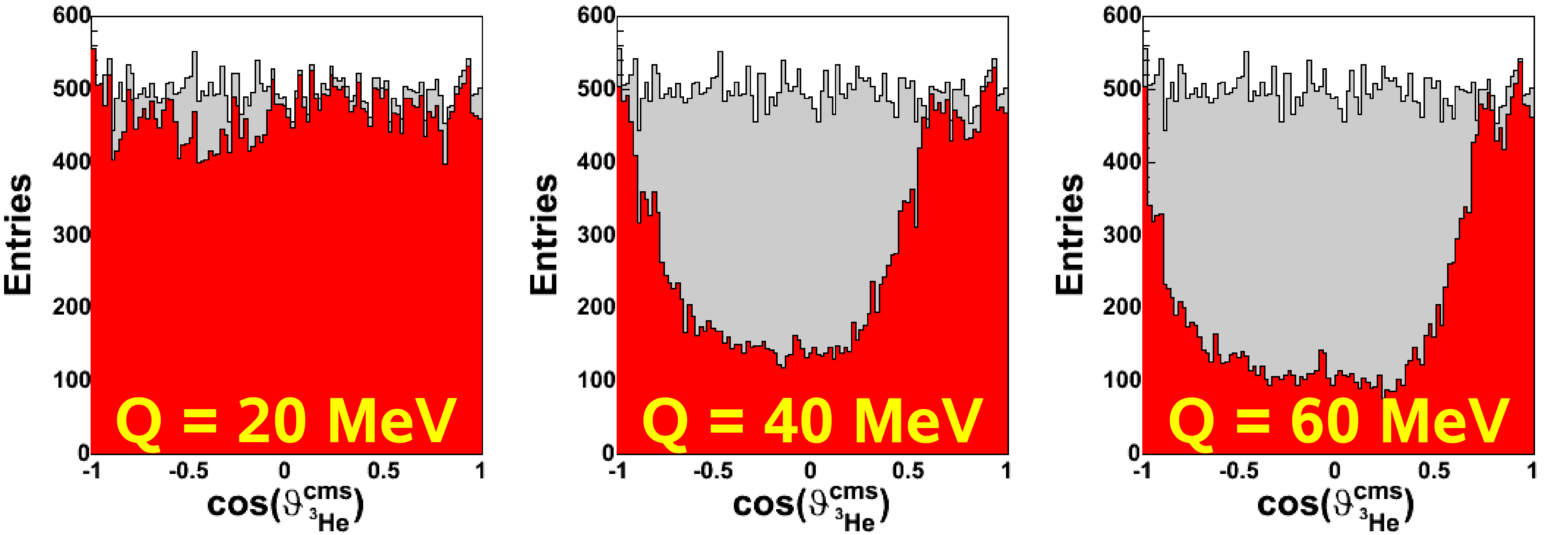
- Momentum reconstruction of the ^{3}He (magn. spectrometer)
- Identification of the ^{3}He nuclei via “dE-vs.-p”-method
- Reconstruction of the η meson via missing mass technique



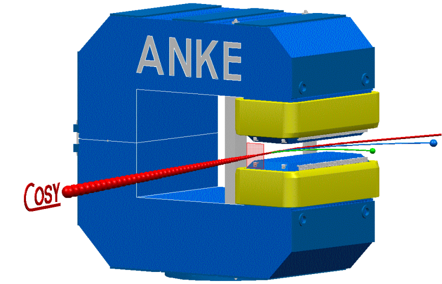
Angular Acceptance for the reaction $dp \rightarrow {}^3He\, \eta$ at ANKE



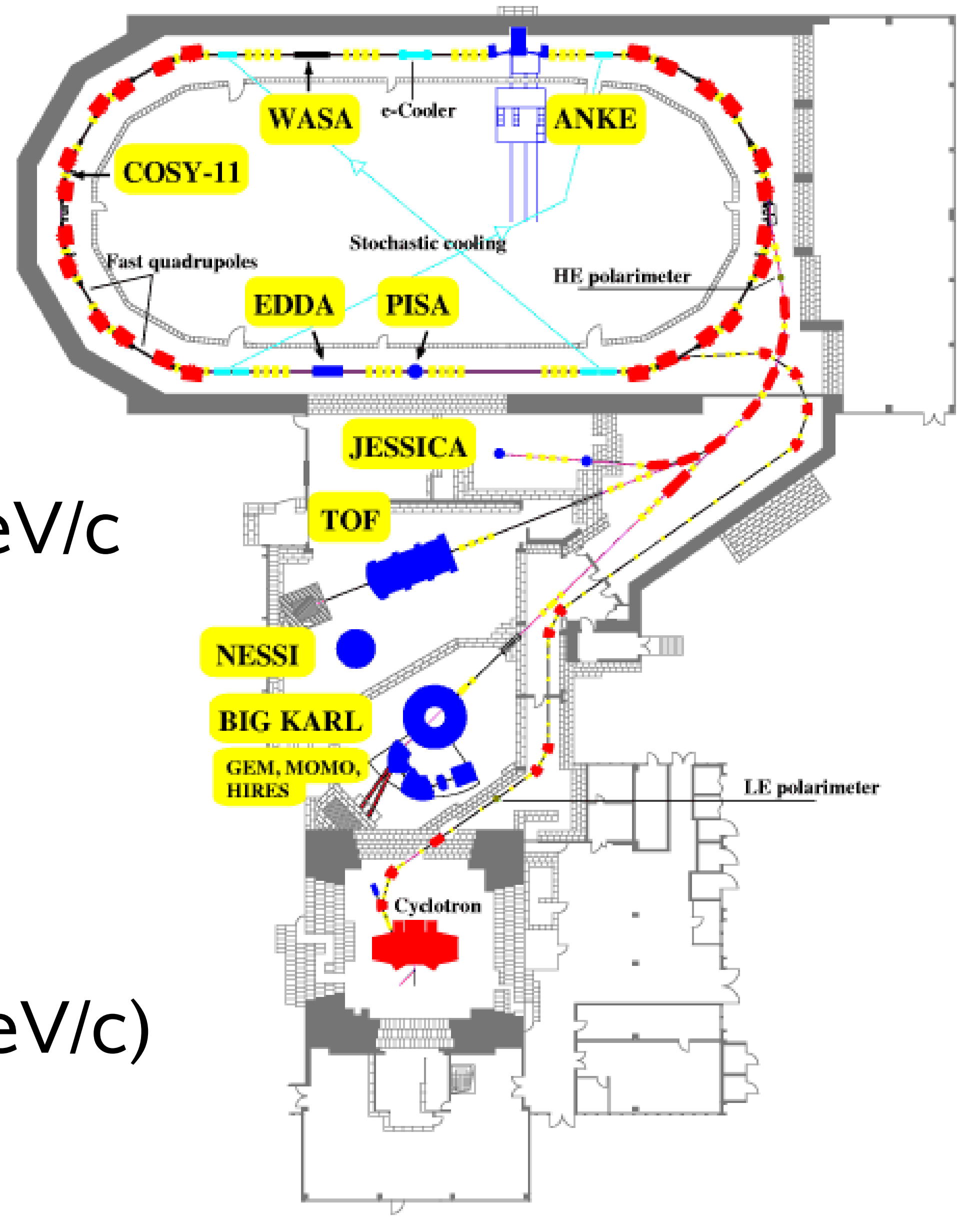
- Geometrical acceptance in wire chambers:
  - $Q \leq 20$ MeV: "acceptance" ≈ 100 %
    (acceptance limited by gaps between the scintillation layers)
  - Q = 40MeV, 60 MeV: Full angular acceptance!



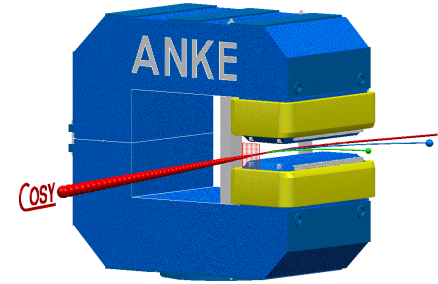
COSY beamtime for $dp \to {}^{3}\mathrm{He}\,\eta$ measurement at ANKE in Jan. 05



- COSY can provide a continuously ramped beam
  - Excess energy range
    $-4\ \mathrm{MeV} \le Q \le 12\ \mathrm{MeV}$
  - Beam momentum range
    $3.120\ \mathrm{GeV/c} \le p \le 3.191\mathrm{GeV/c}$
  - Subthreshold and near threshold region
- Fixed beam momenta:
  - Q = 20, 40, 60 MeV
    (p = 3.224, 3.308, 3.391 GeV/c)
  - Partial wave analysis

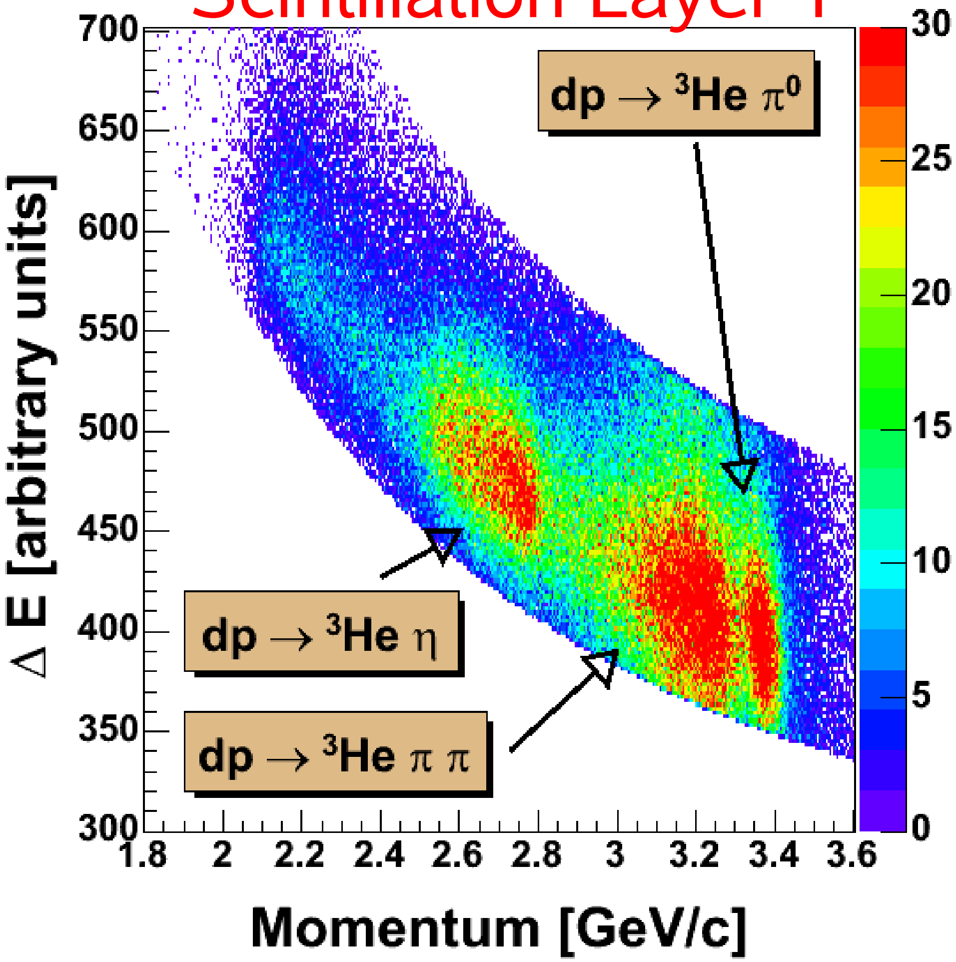


Identification of ^{3}He nuclei "dE-vs.-Momentum" method

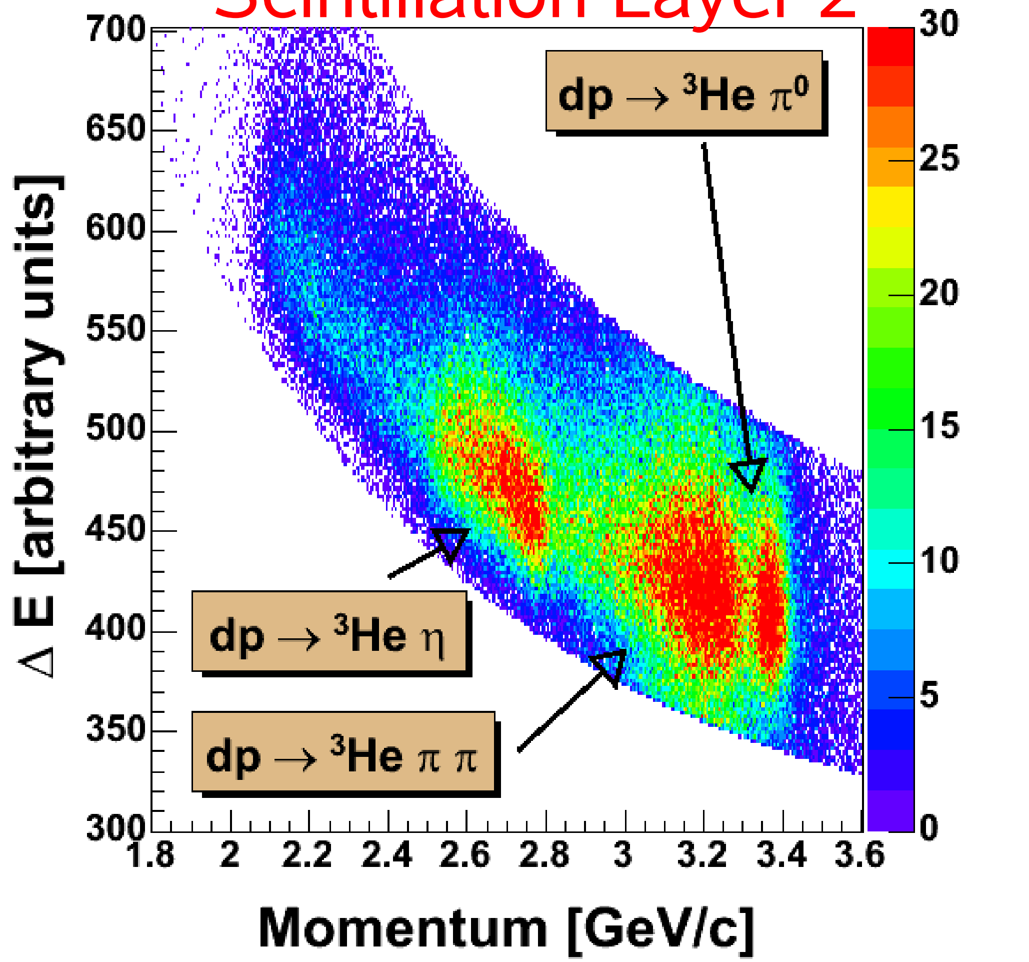


- Three scintillation layers are used to identify the ^{3}He
- Spectra with a cut on all three layers are shown!

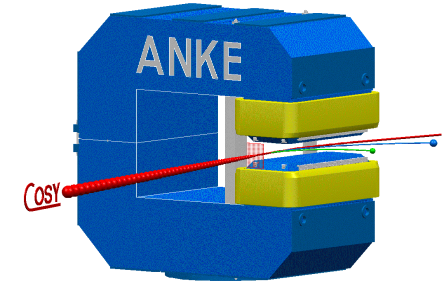
Scintillation Layer 1



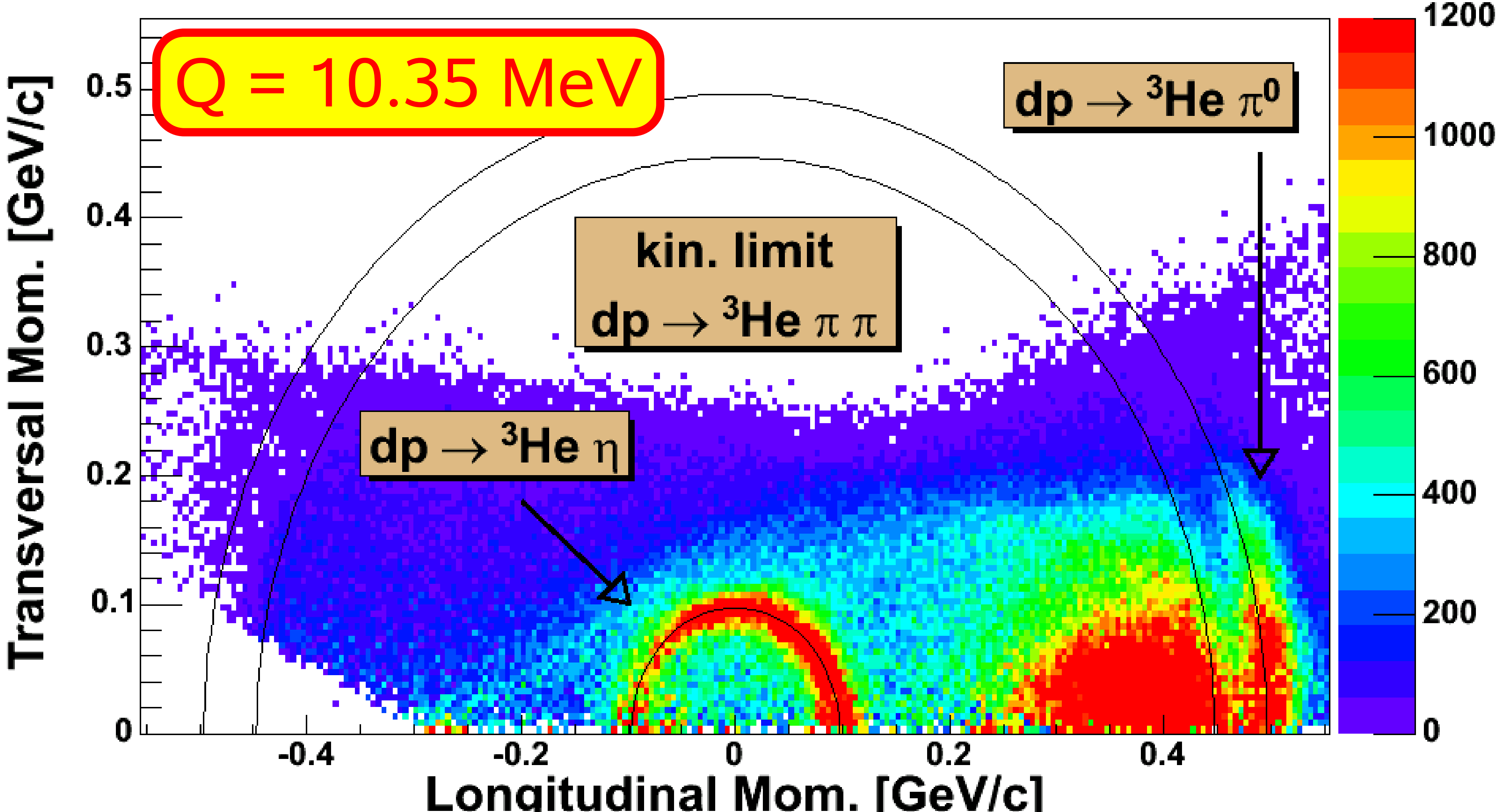
Scintillation Layer 2



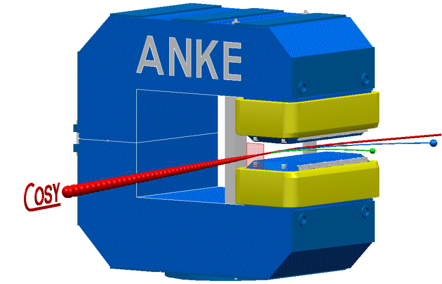
Identification of the reaction dp→^{3}He η via momentum ellipse



- Event weight: 1/Transv. Mom → correction of density on ellipse



Missing mass distribution and background description

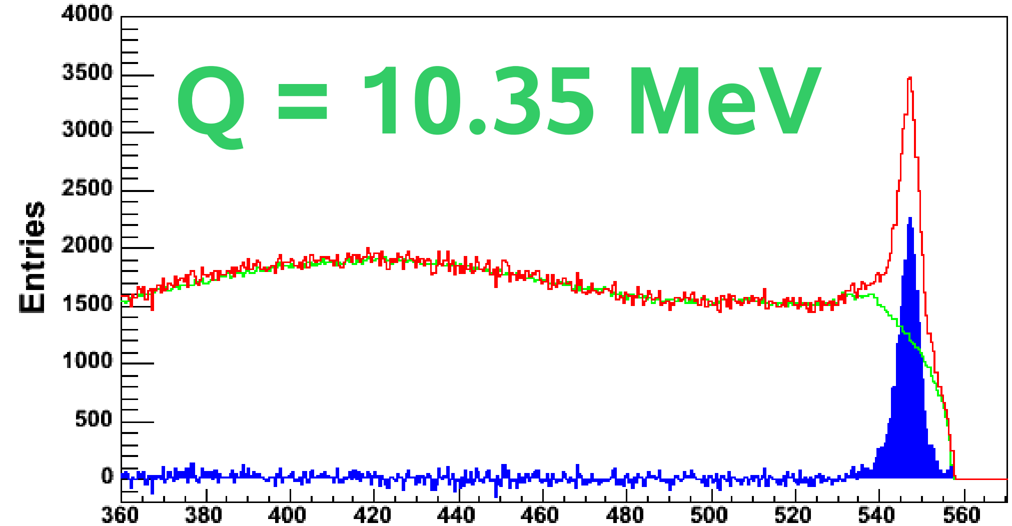


- Situation: Peak on kinematical limit
- Idea: Use subthreshold data for background description
- Upscaled ^{3}He- and beam-momentum to η data

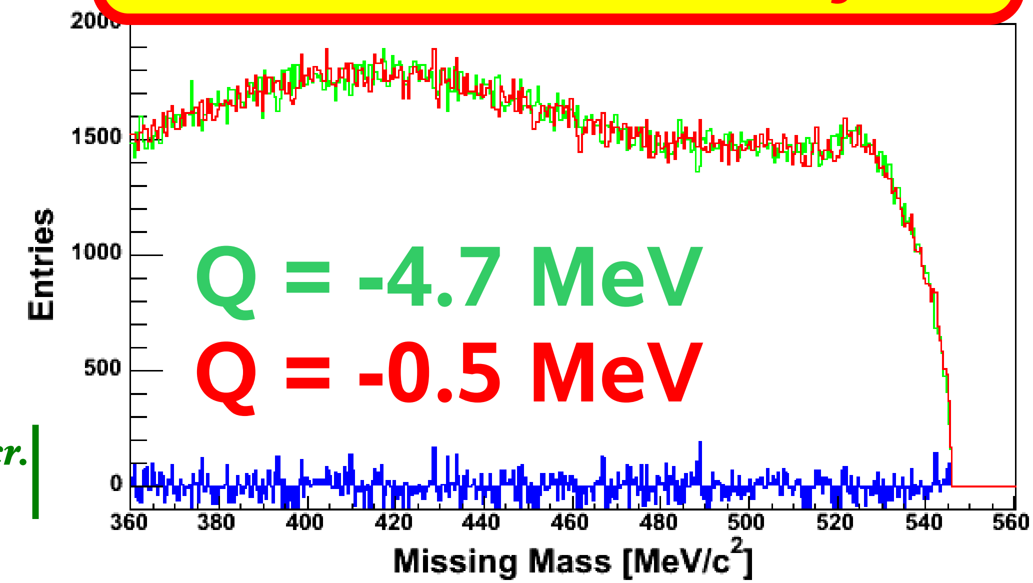
$$\vec{p}_{reconstr.}^{\,backgr.\ description} = \frac{p_{beam}^{\eta\ data}}{p_{beam}^{subthreshold}} \cdot \vec{p}_{reconstr.}^{\,subthreshold}$$

- "Scaled" Missing Mass for background description

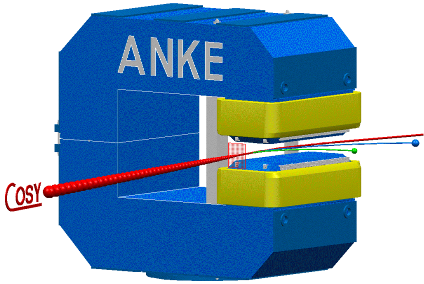
$$MM = \left| P_{beam}^{\eta\ data} + P_{target} - P_{reconstr.}^{backgr.\ descr.} \right|$$

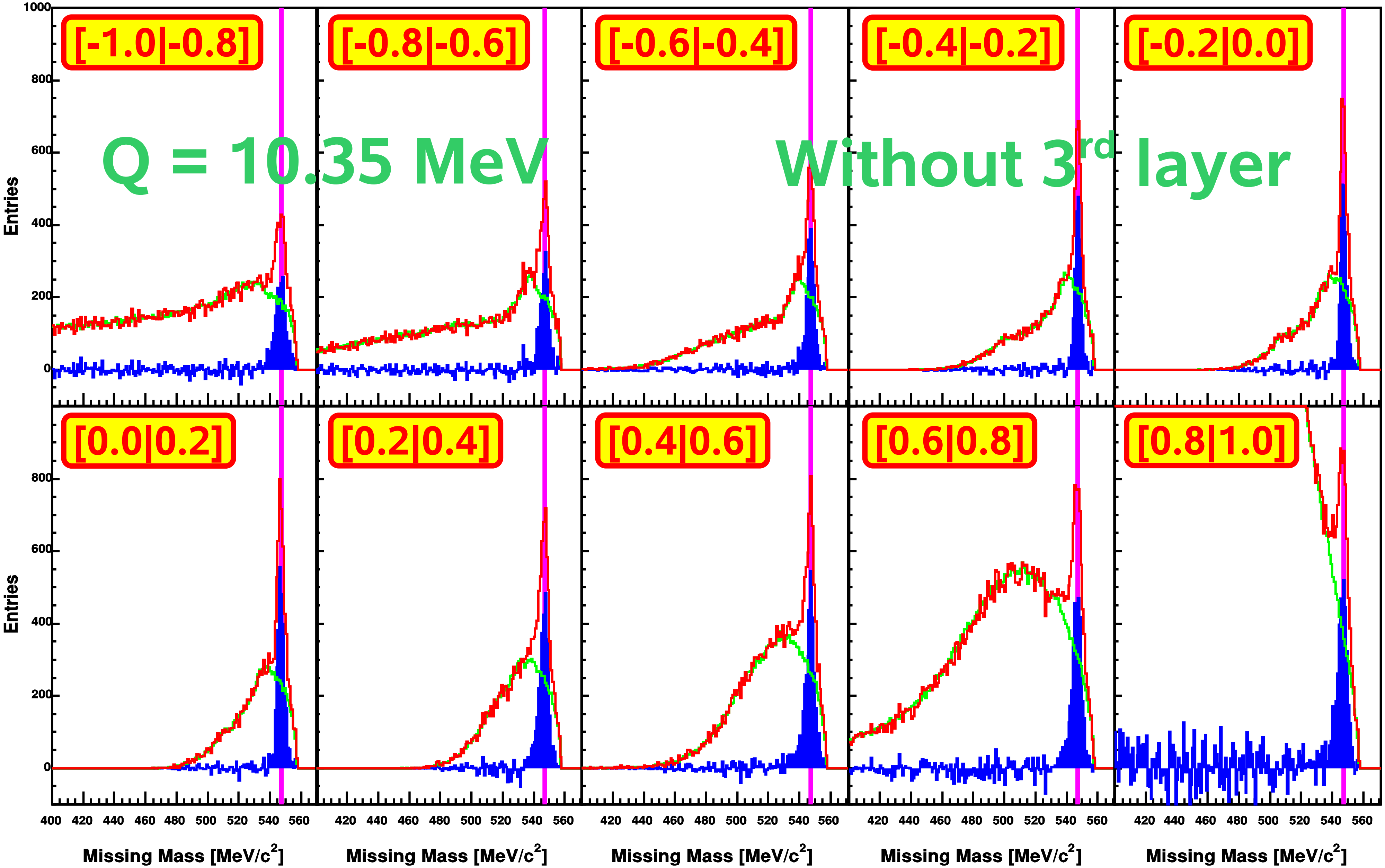


Without 3rd scintillation layer !!!

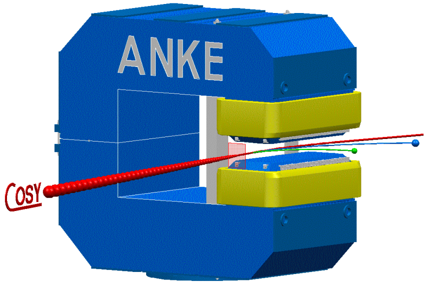


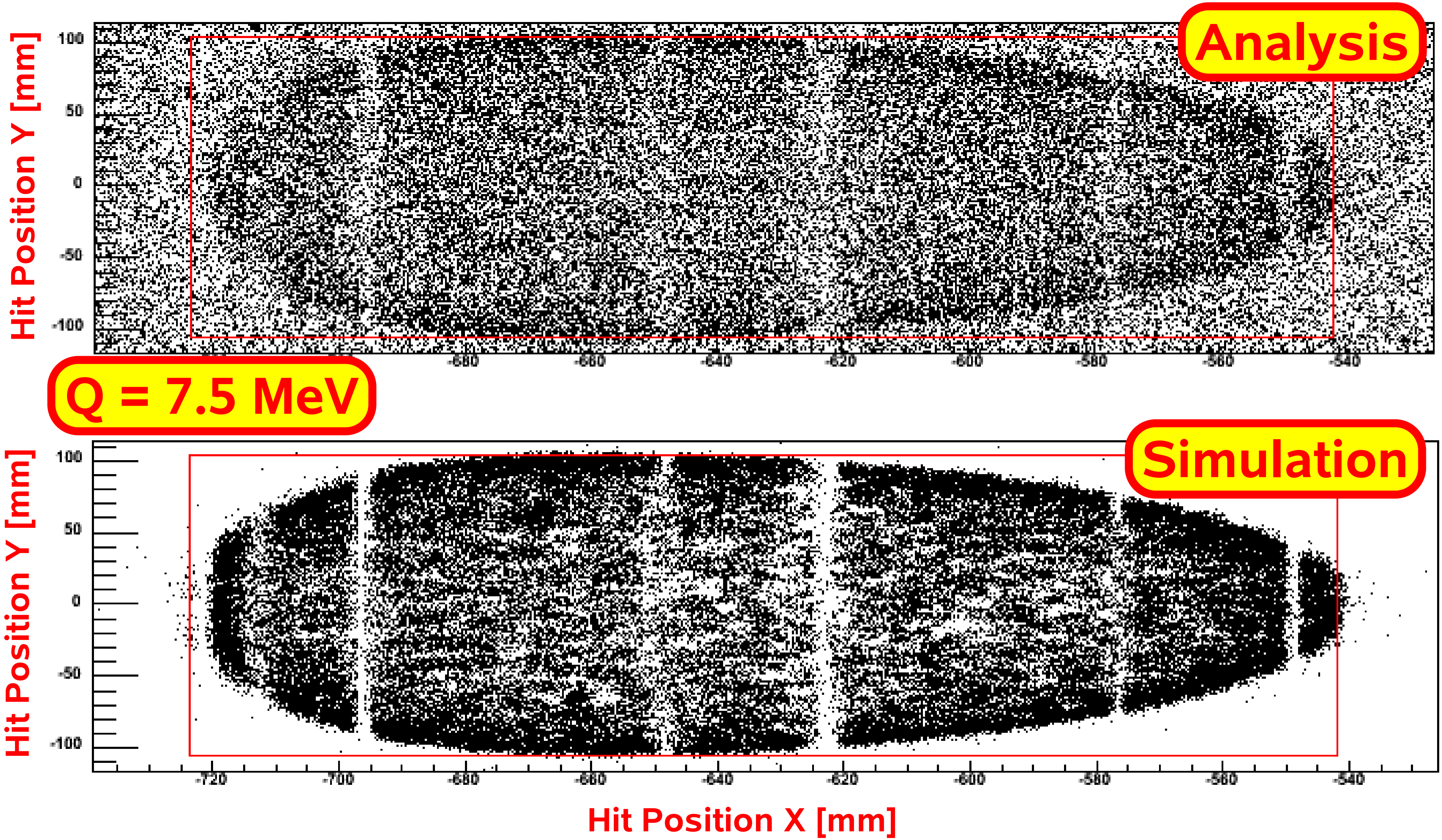
Missing mass angular distribution



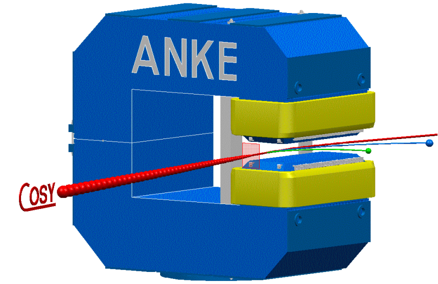


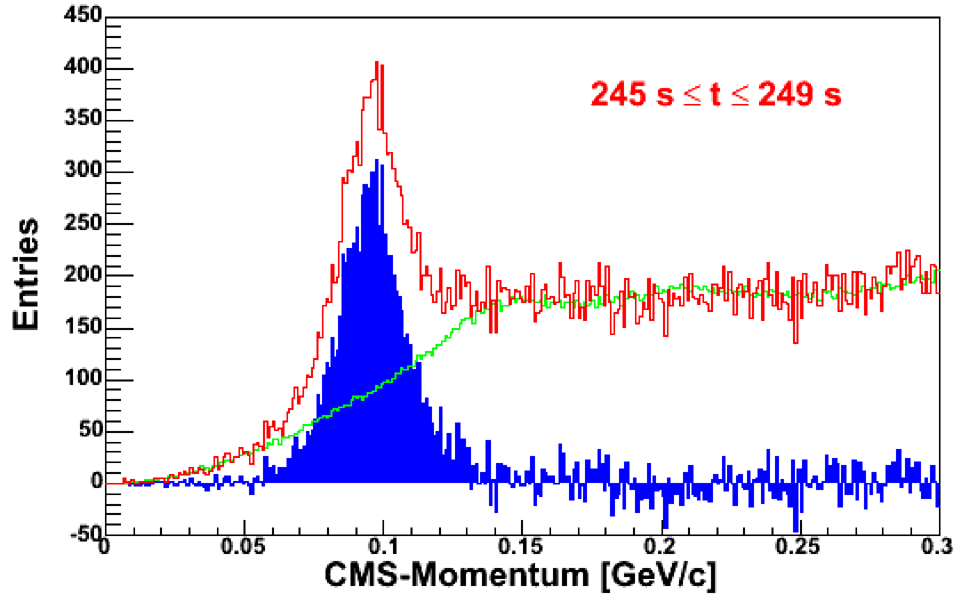
Geant4-simulations and acceptance correction

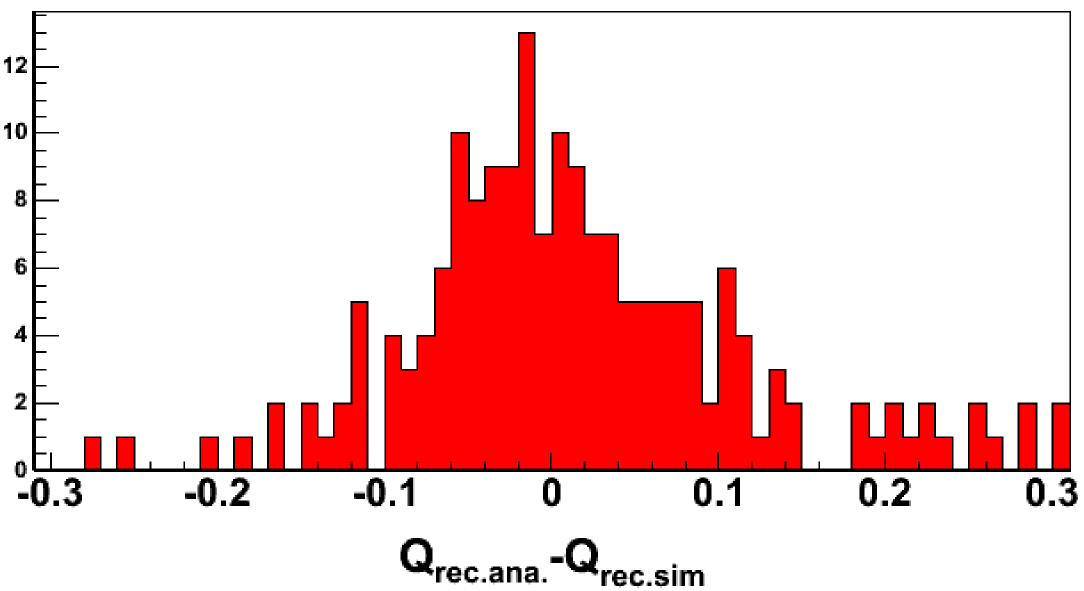


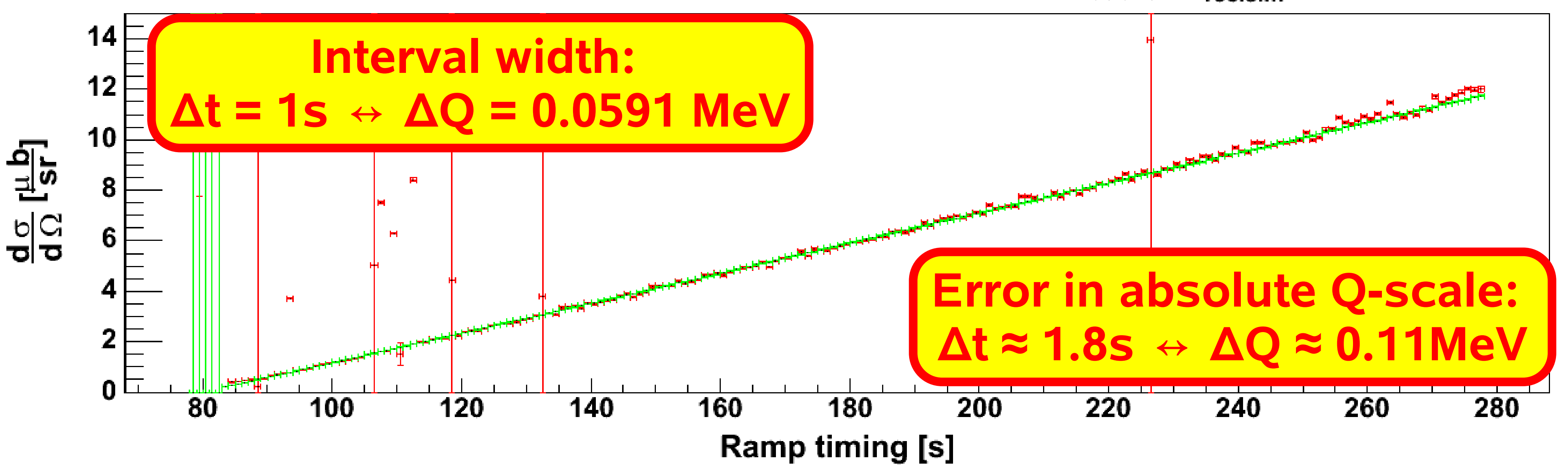


Excess Energy reconstruction for the continuous ramp

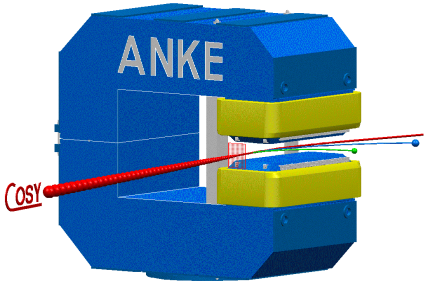


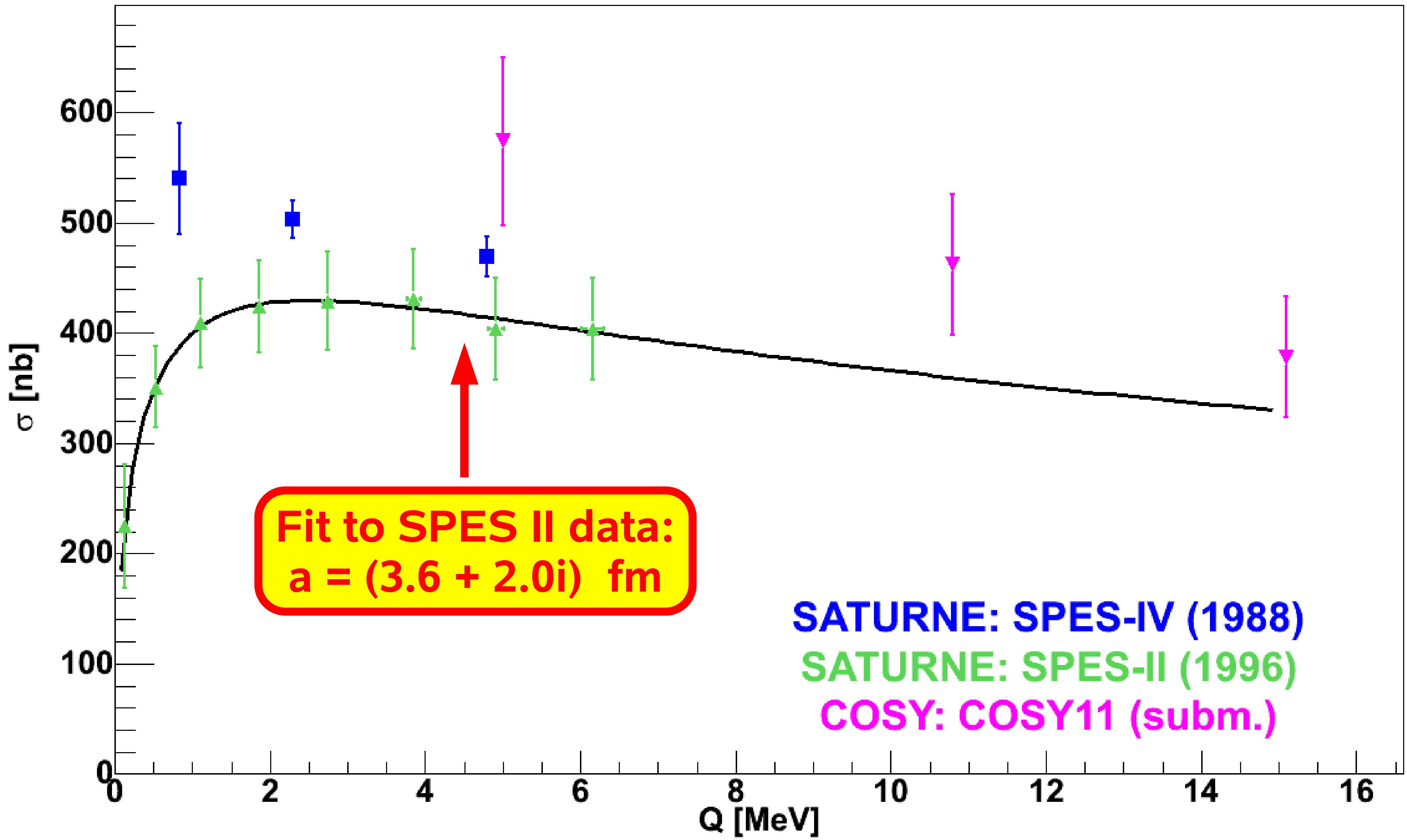




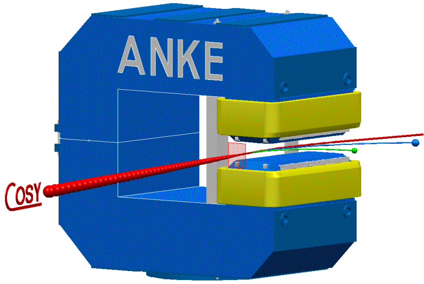


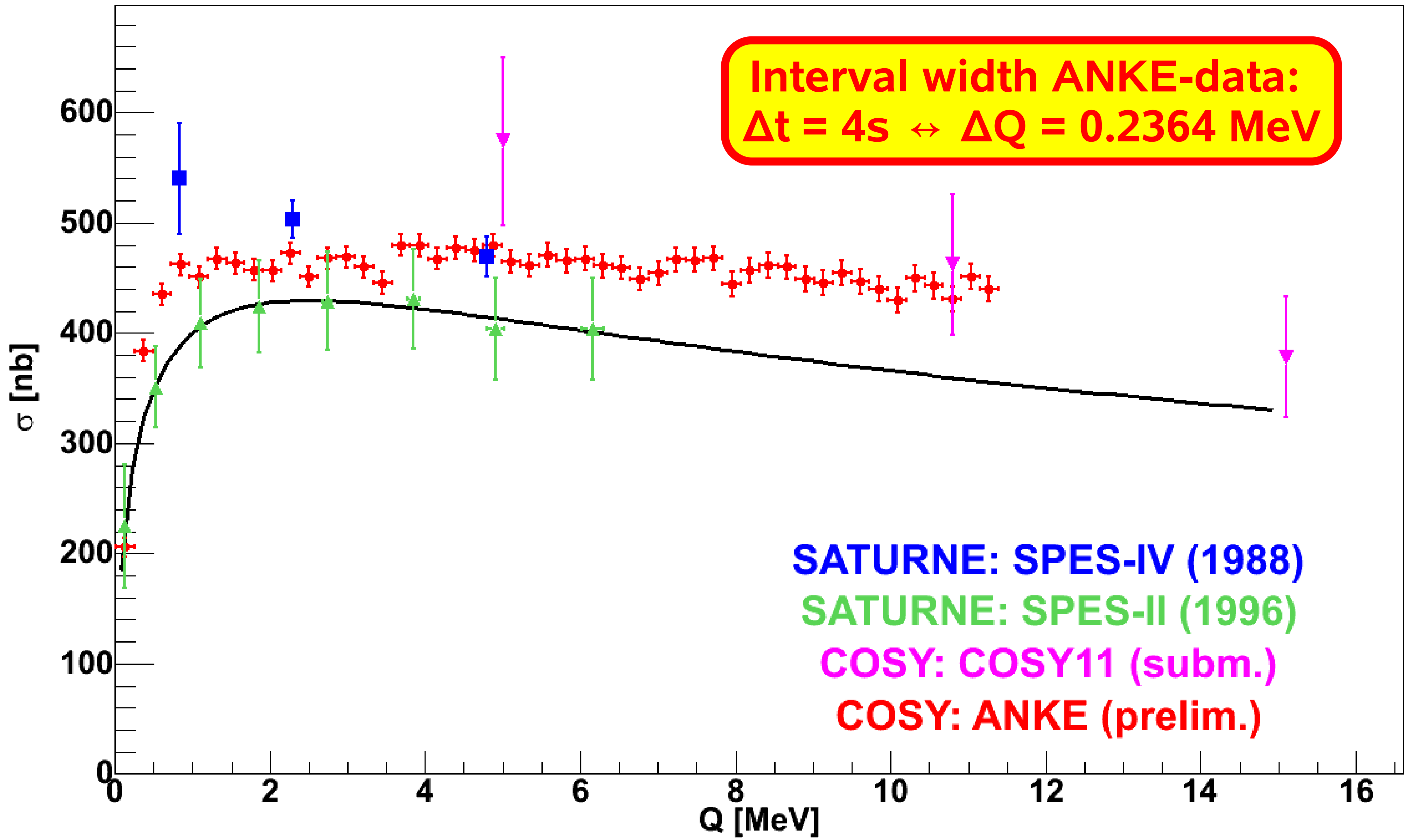
Excitation function existing data base





Preliminary excitation function





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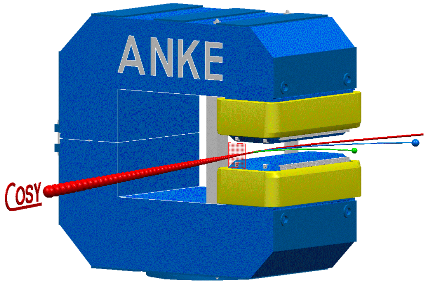

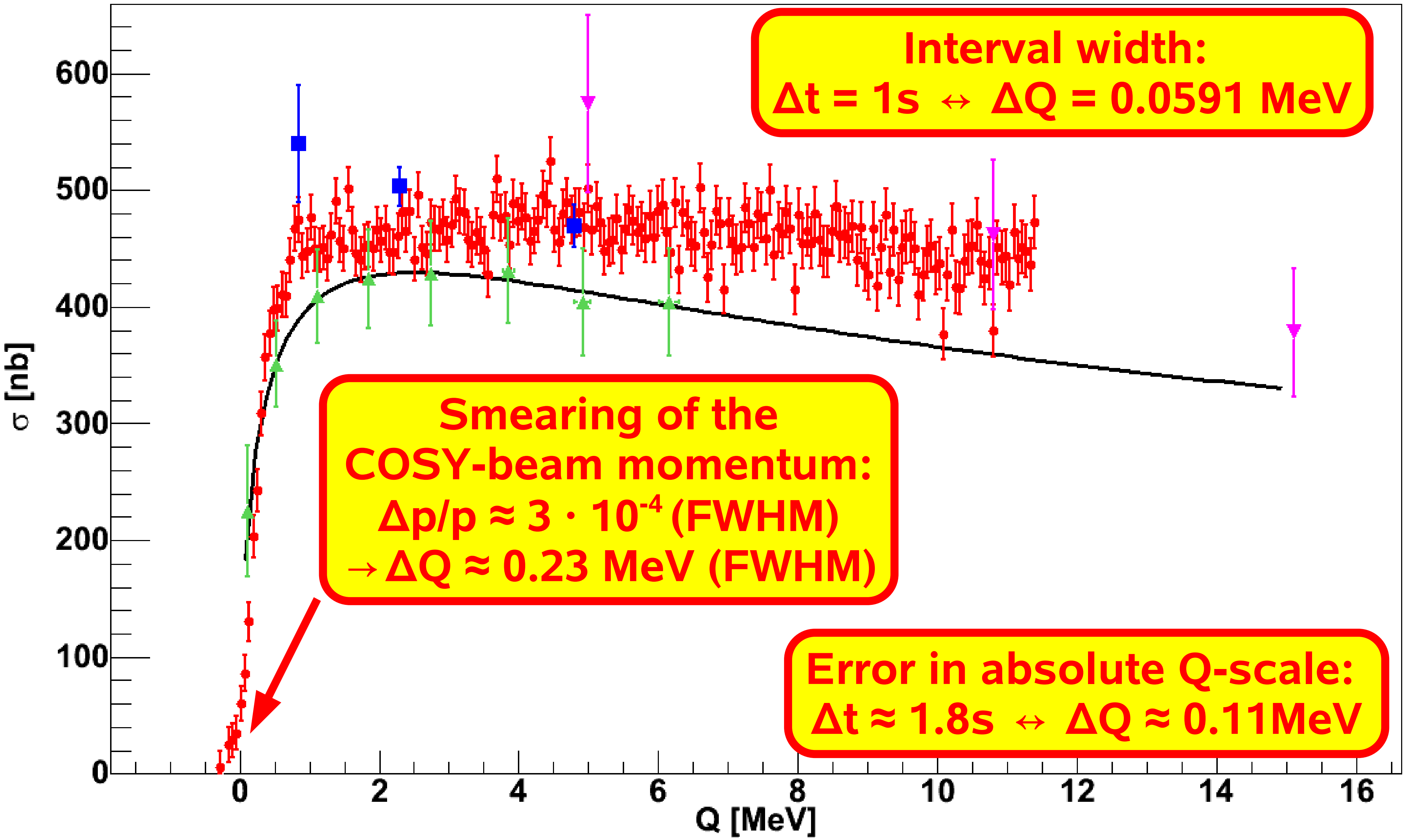

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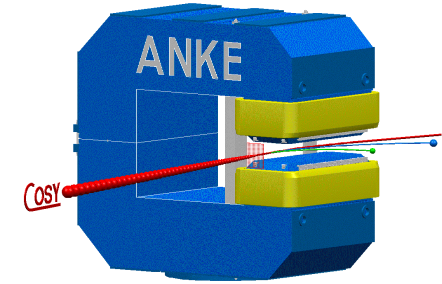

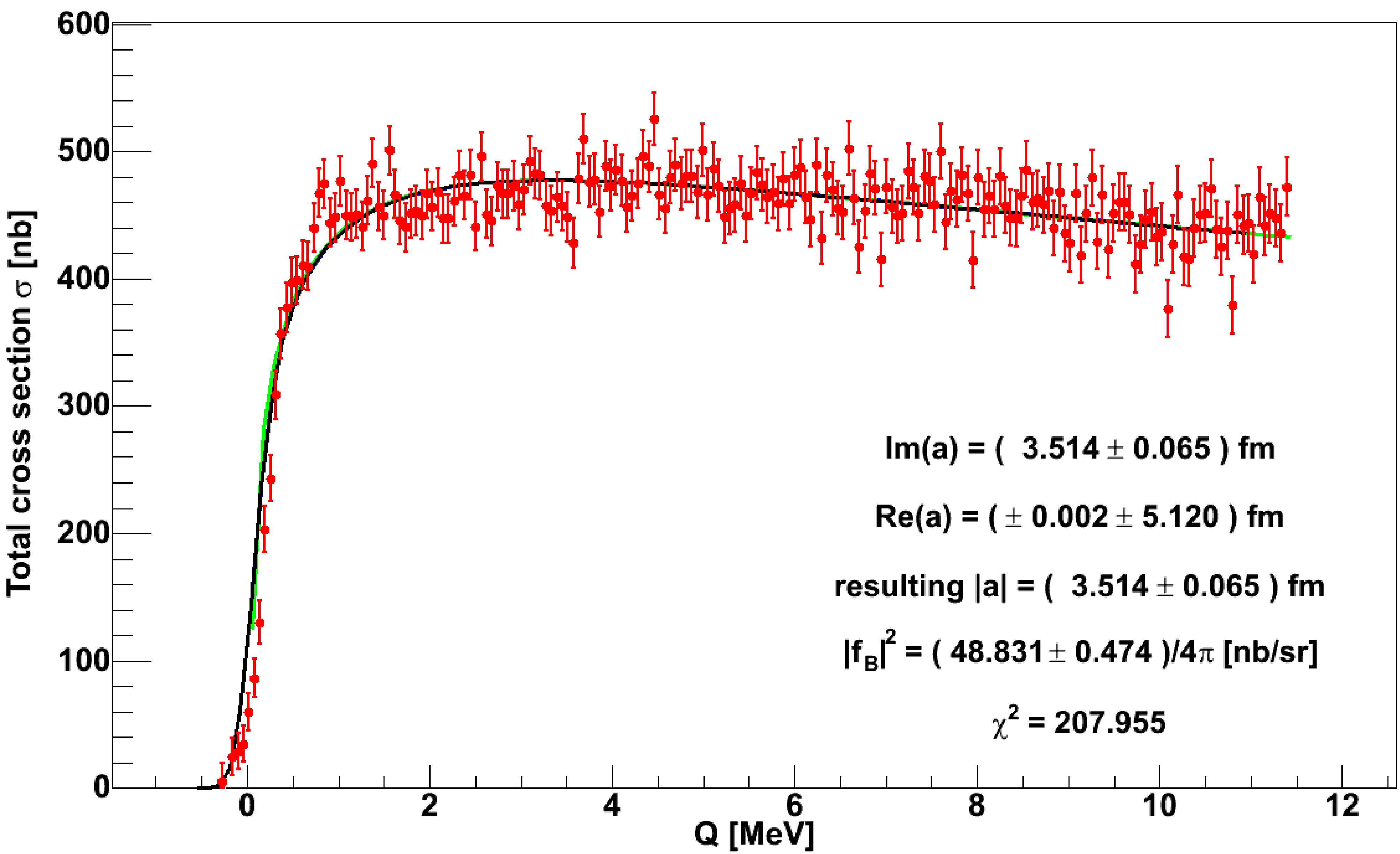

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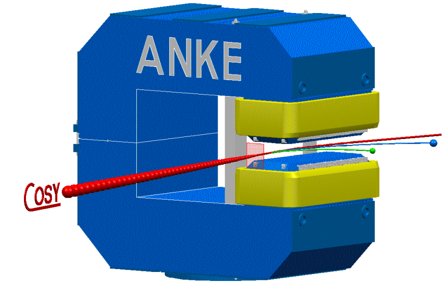

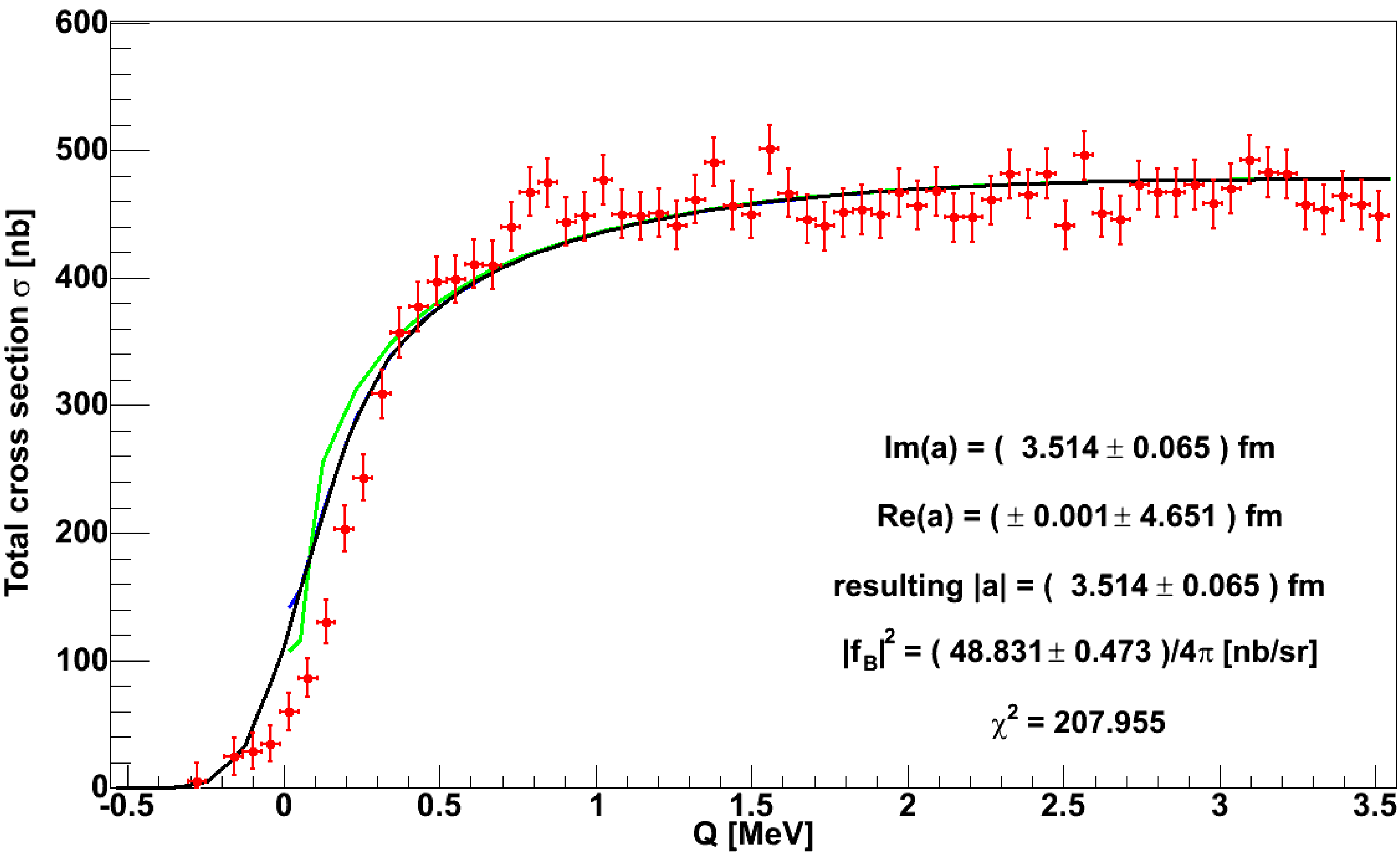

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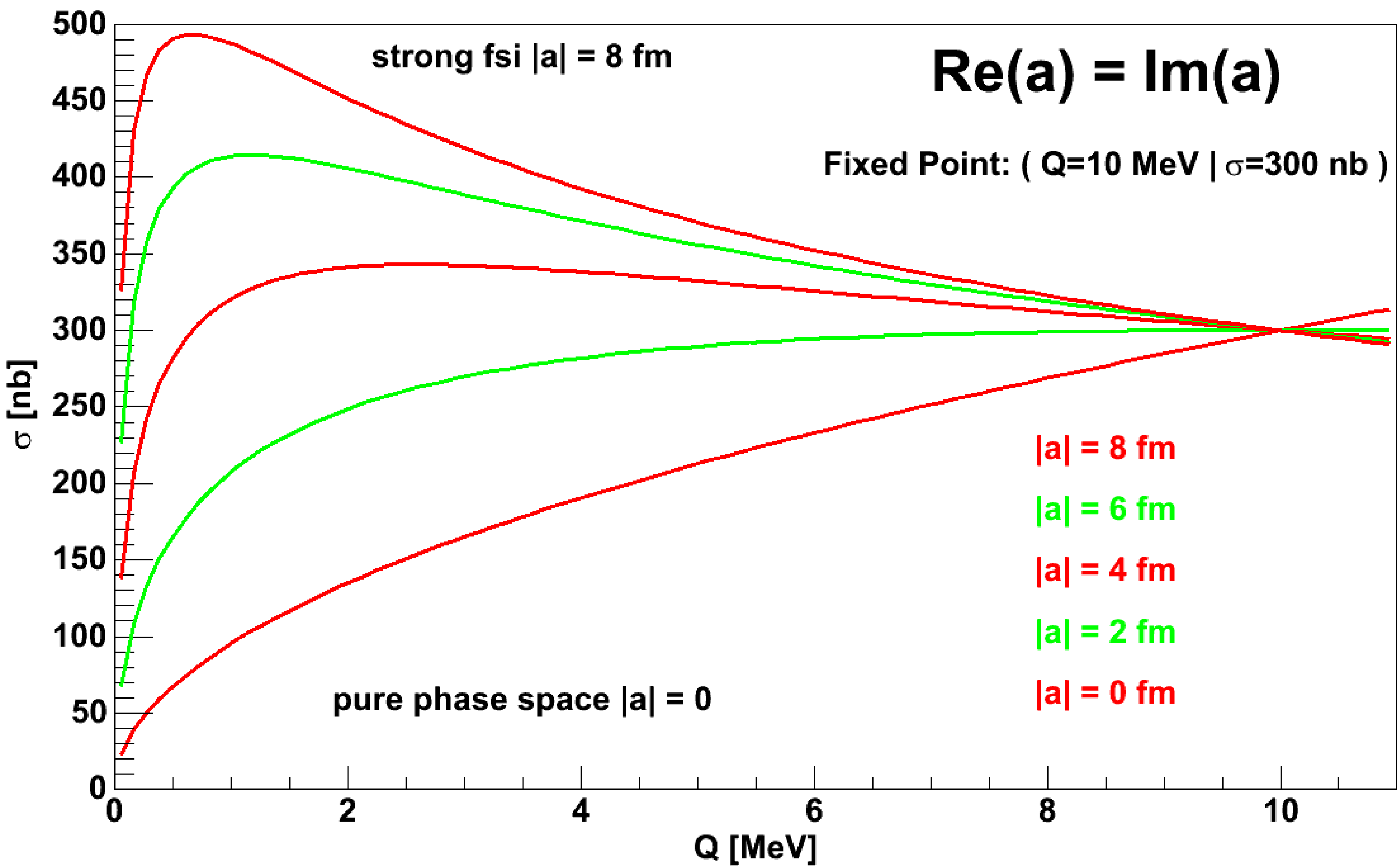

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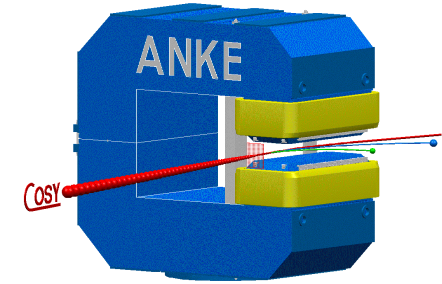
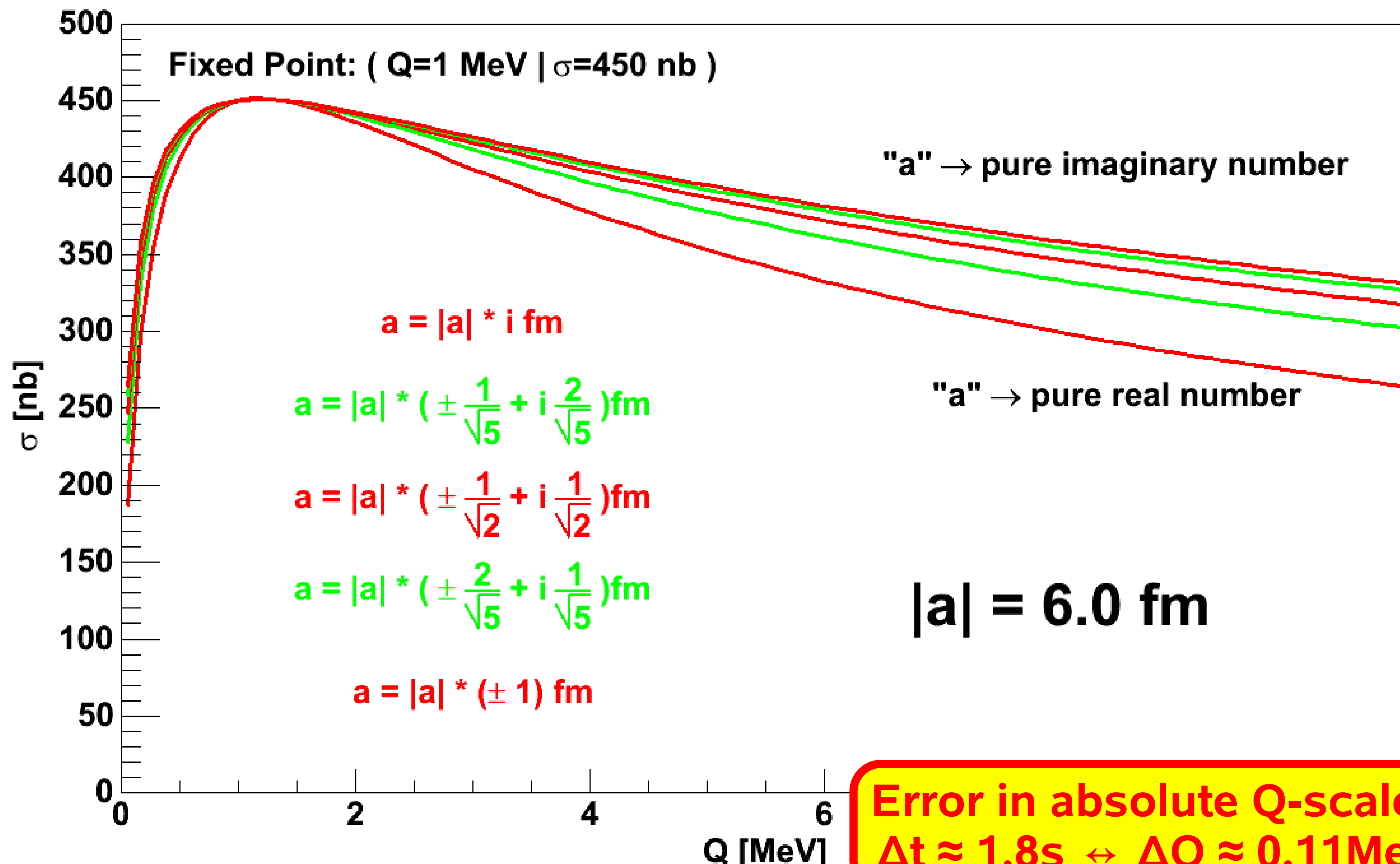
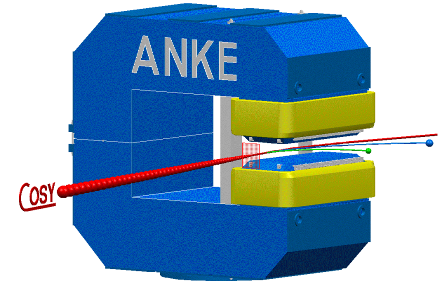
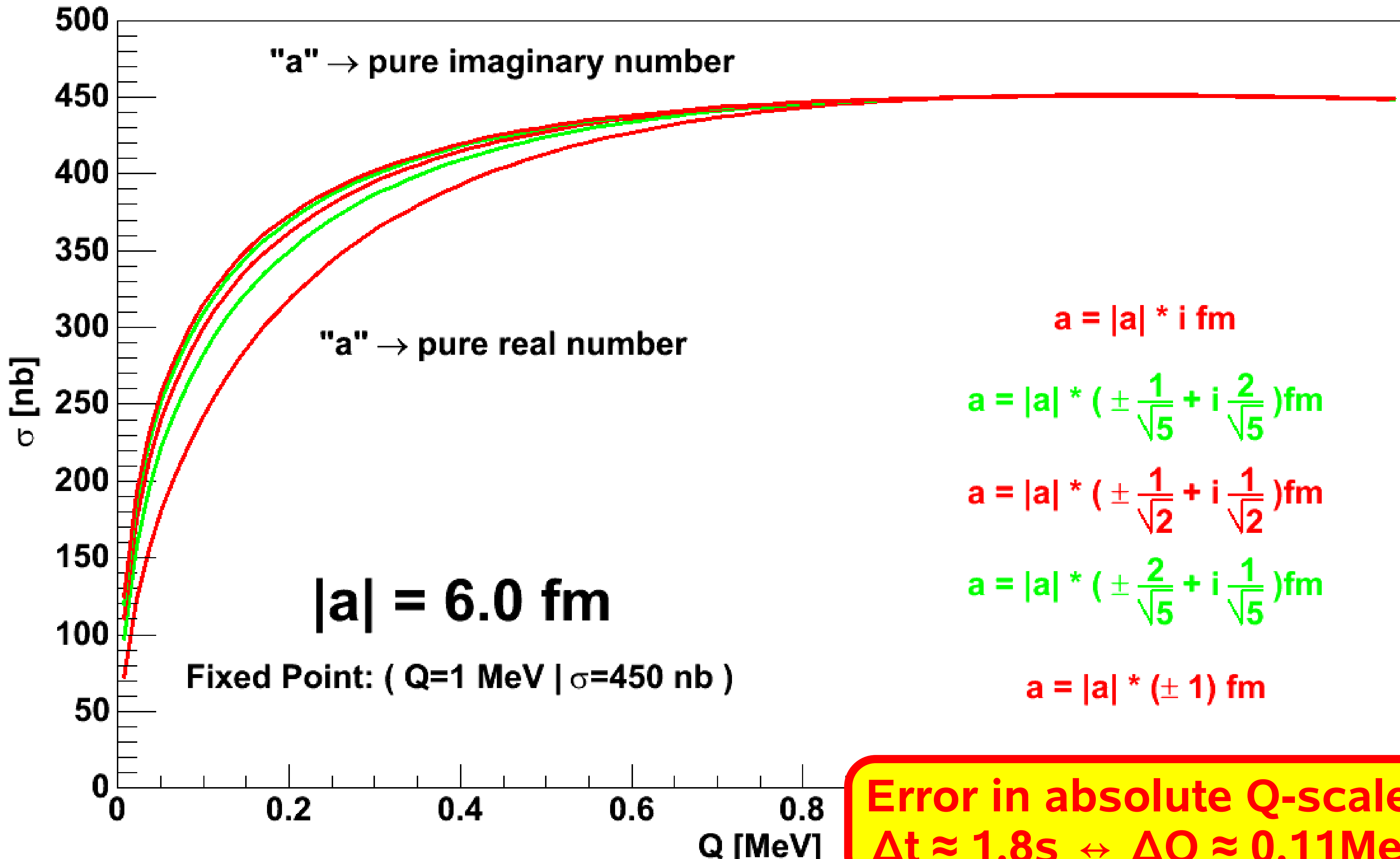




Error in absolute Q-scale:
$\Delta t \approx 1.8s \leftrightarrow \Delta Q \approx 0.11 MeV$

Preliminary excitation function





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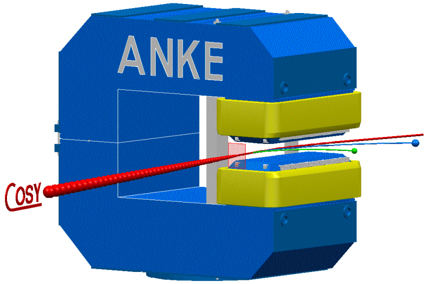

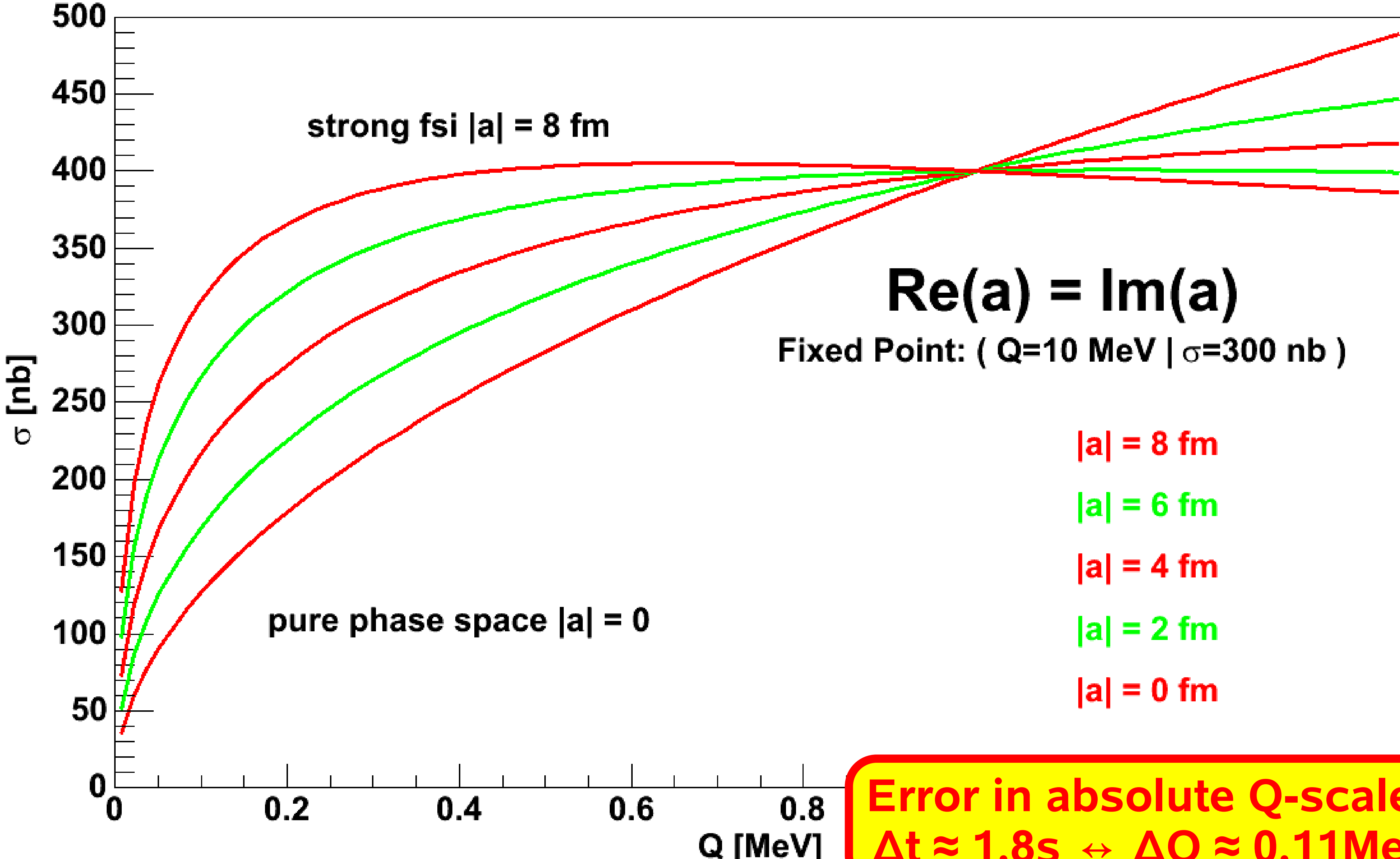

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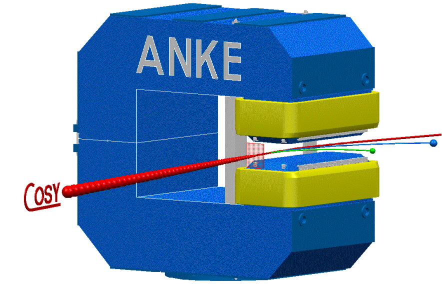
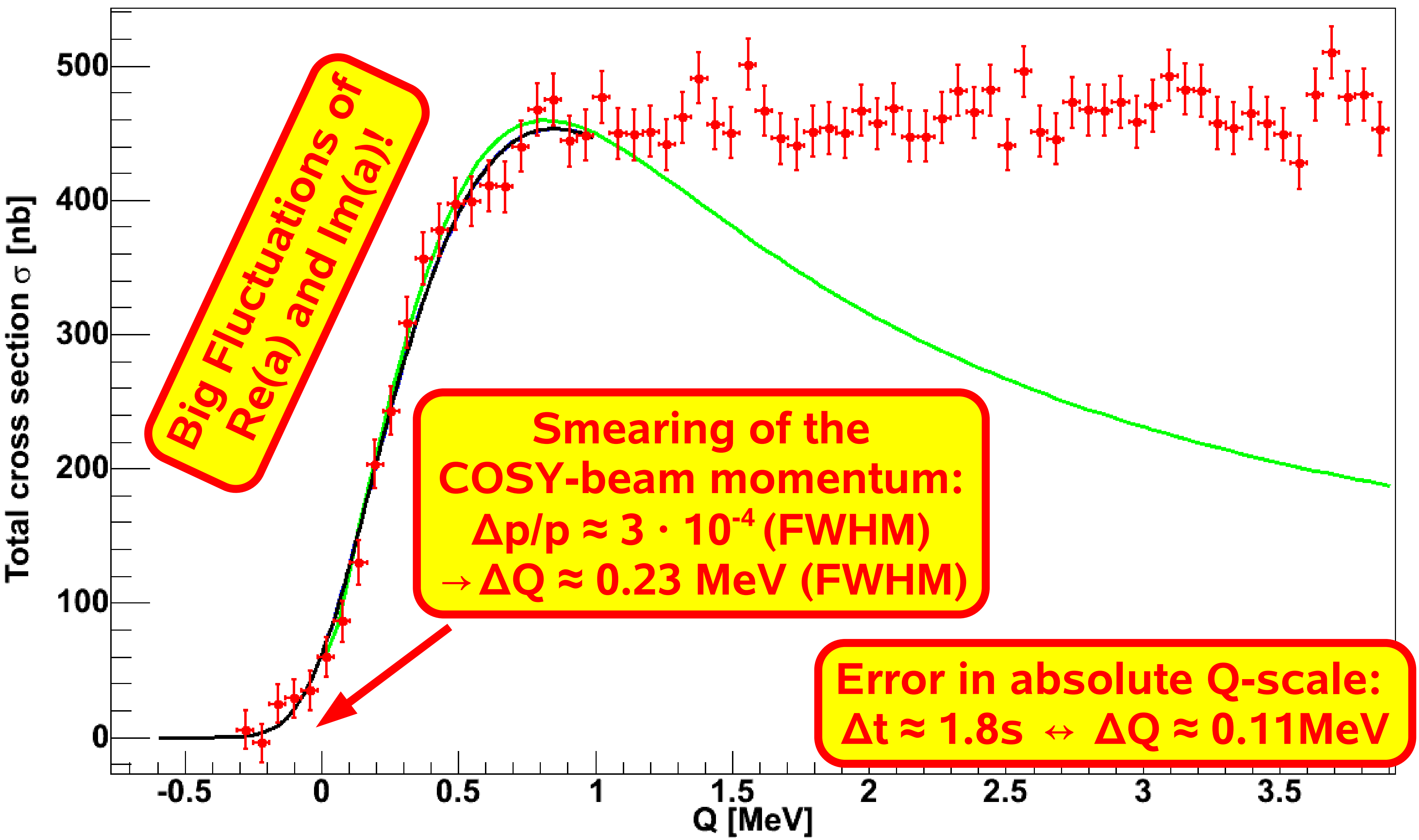
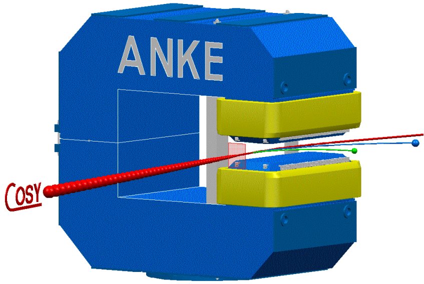
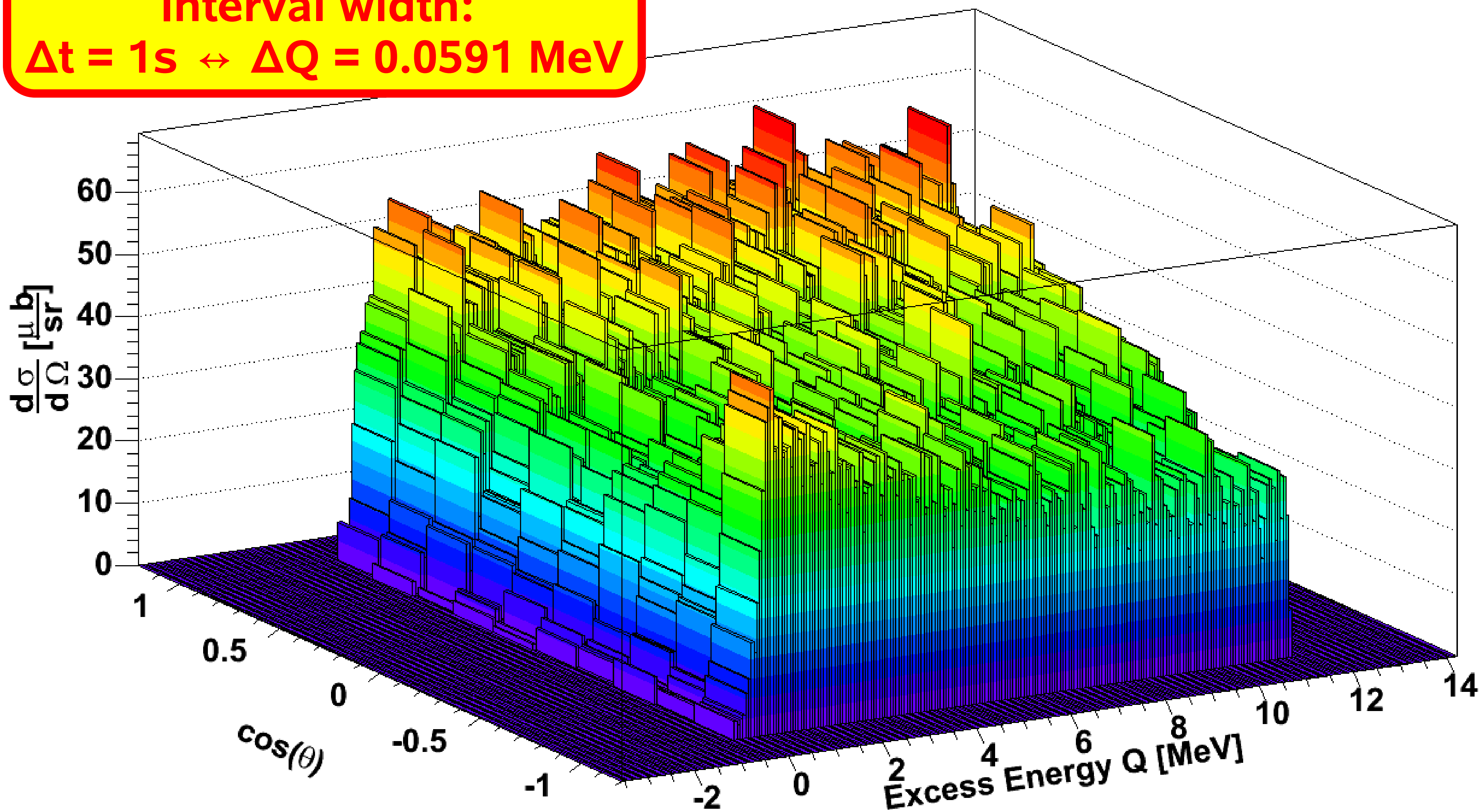




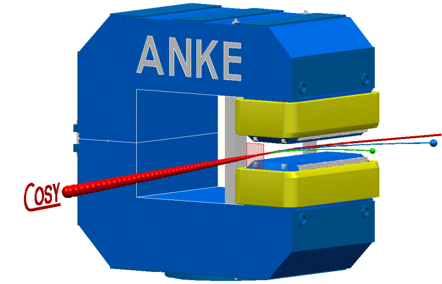
Preliminary angular distribution



Interval width:
Δt = 1s ↔ ΔQ = 0.0591 MeV



Preliminary angular distribution



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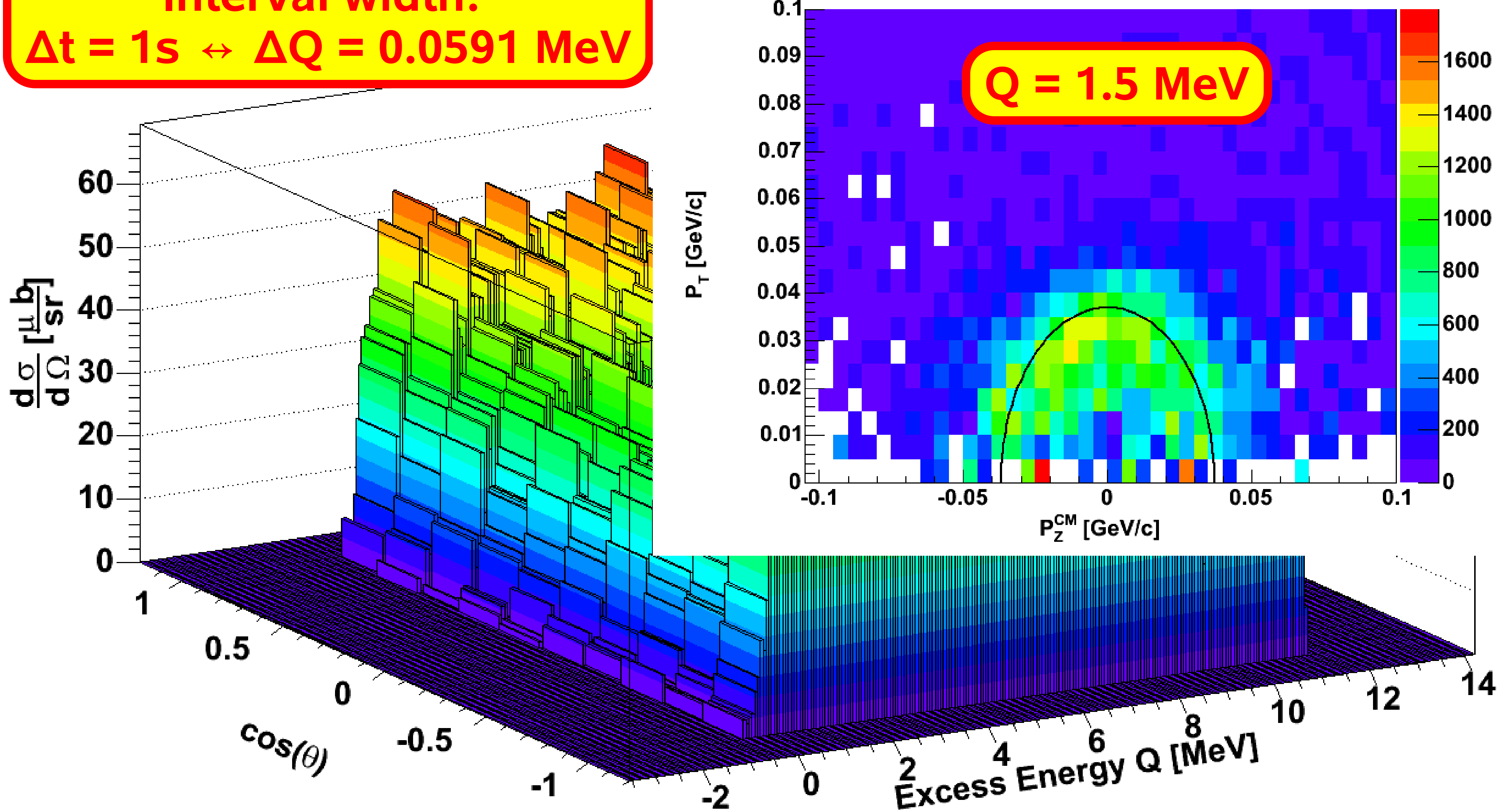

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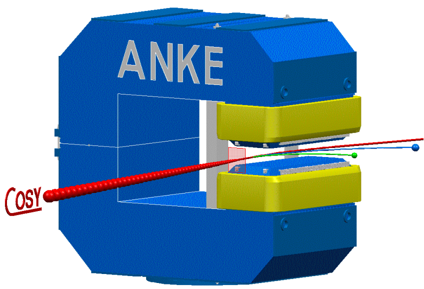

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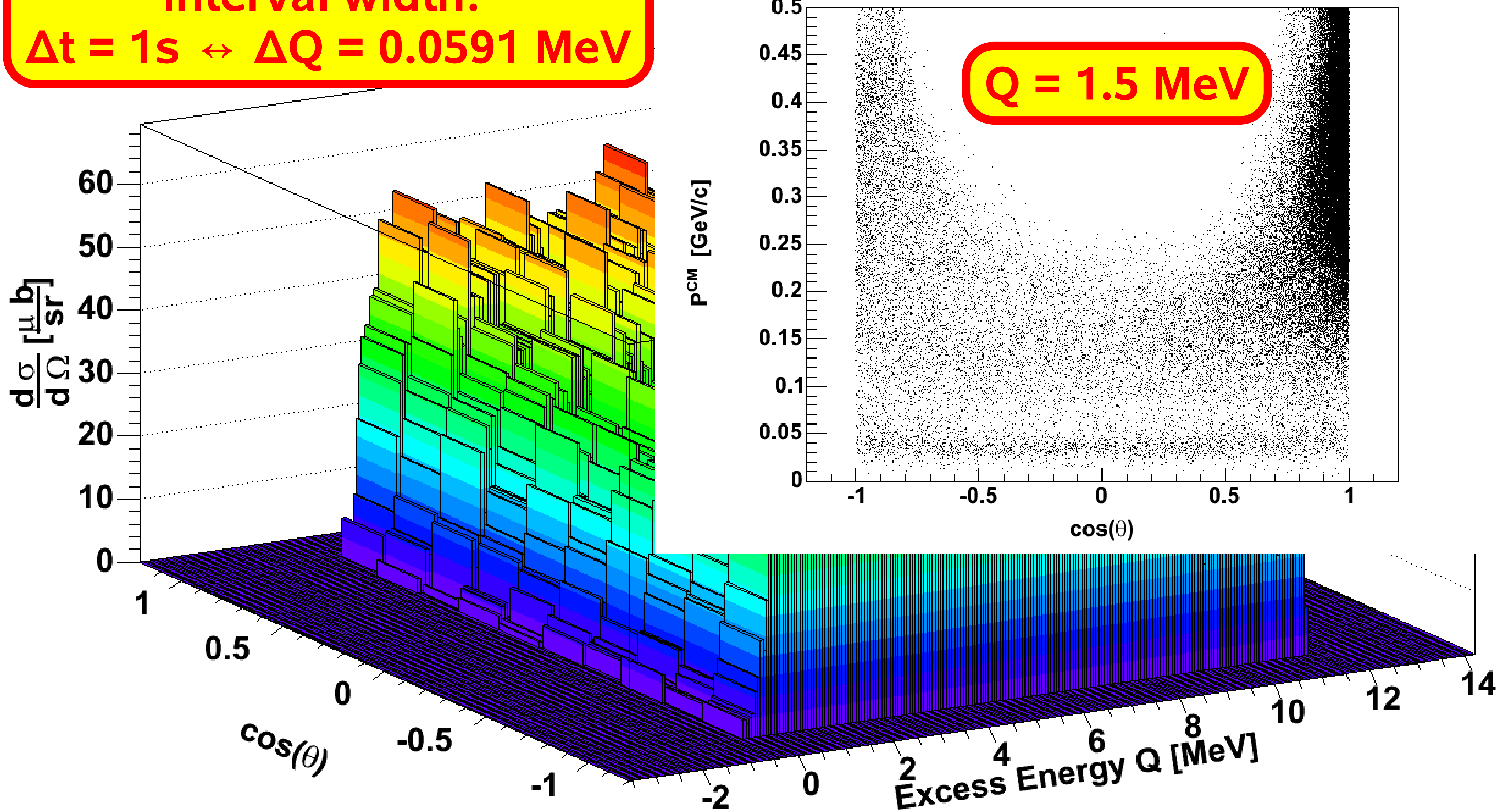

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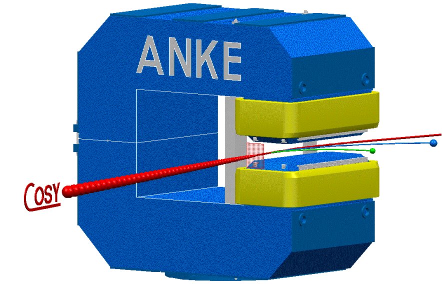

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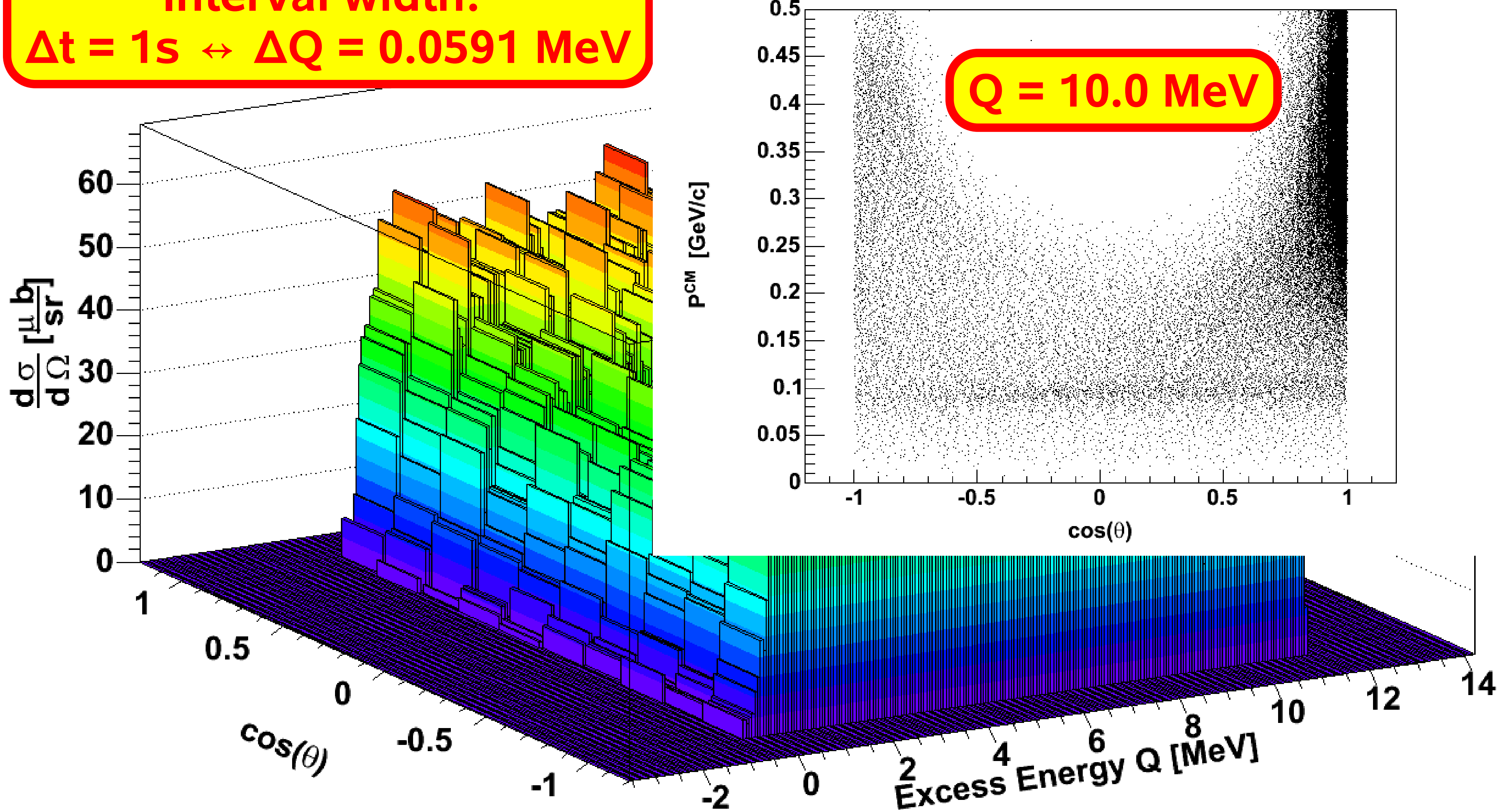
$\Delta t = 1s \leftrightarrow \Delta Q = 0.0591$ MeV



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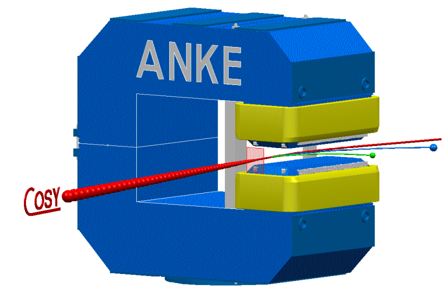

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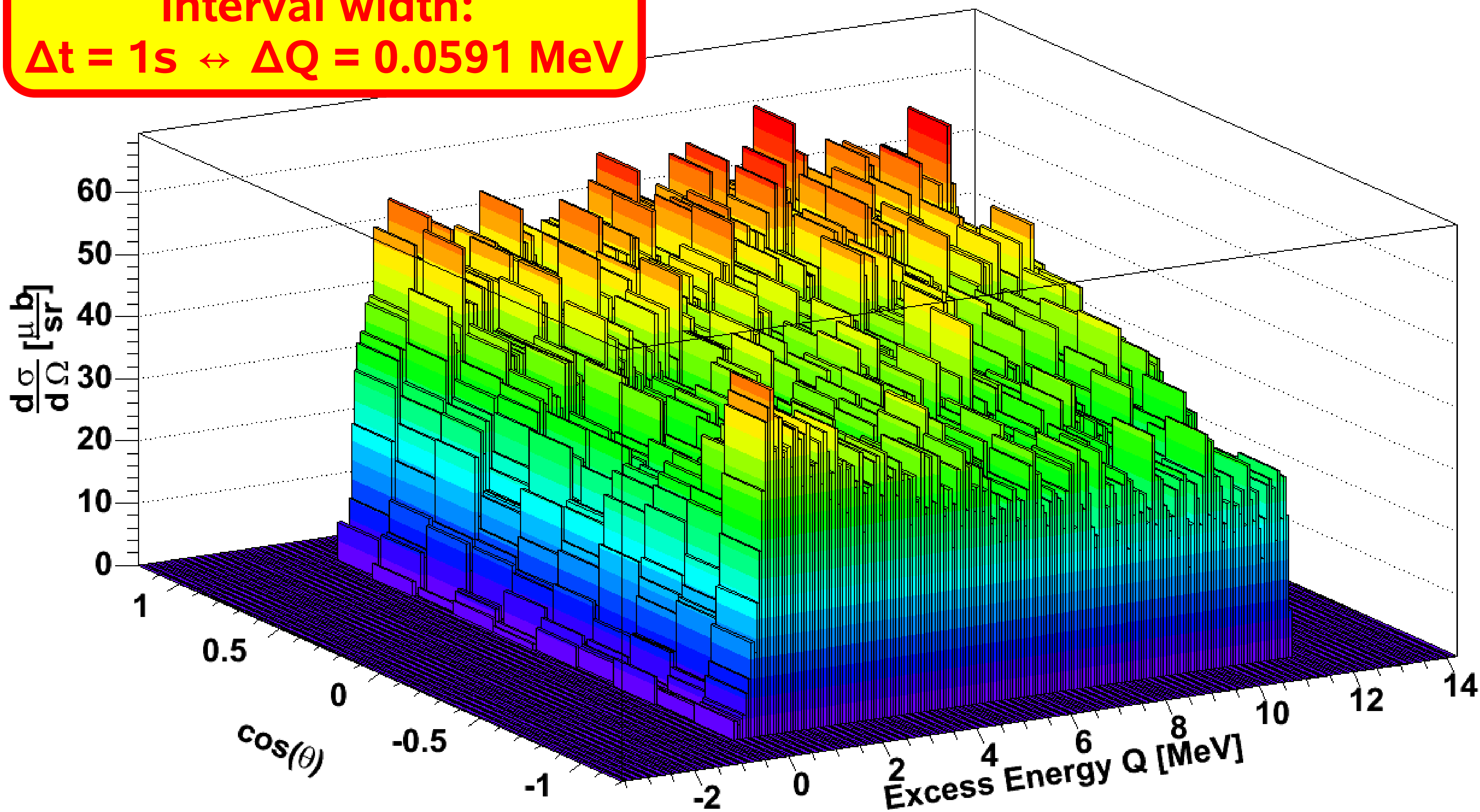
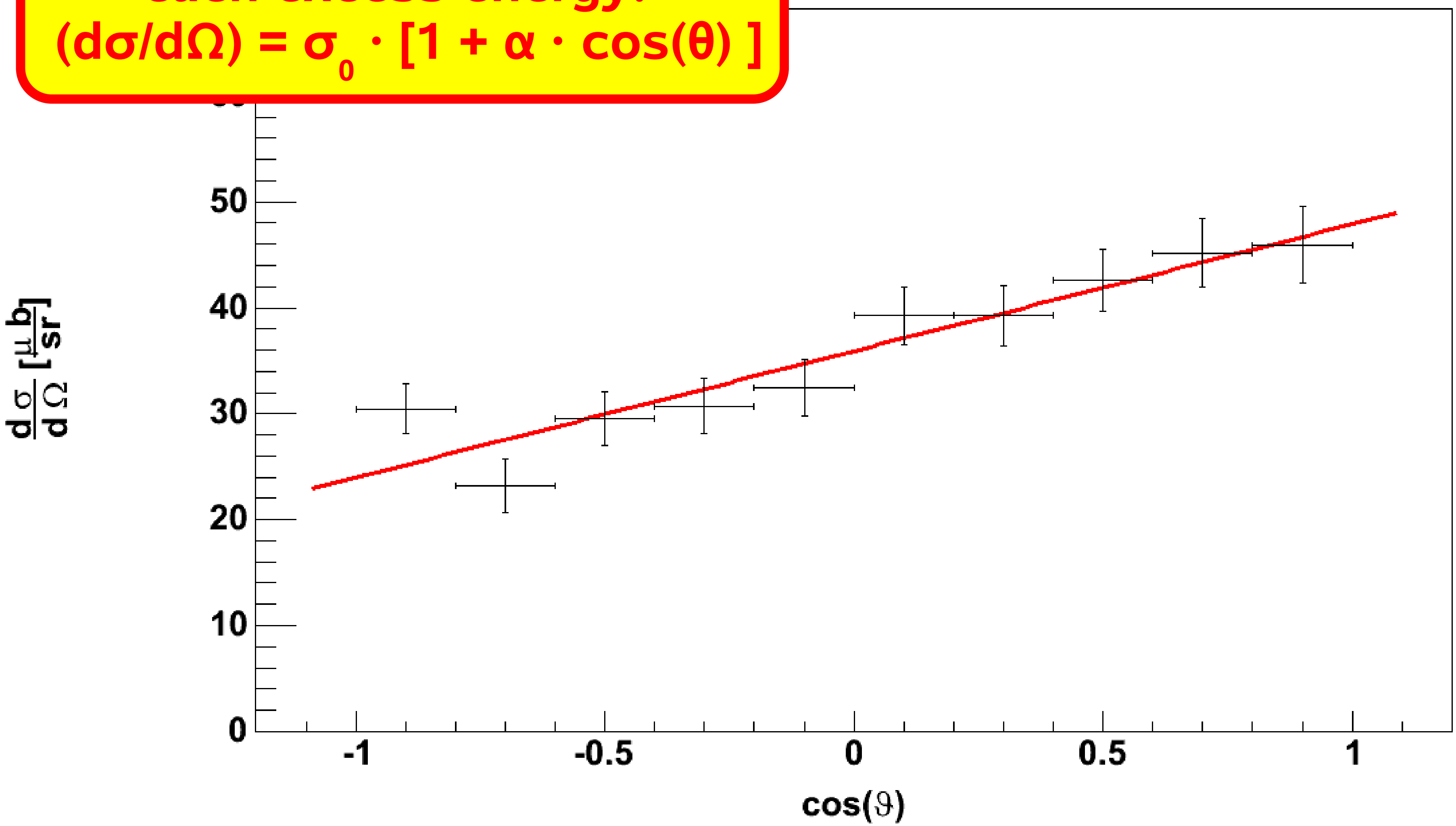
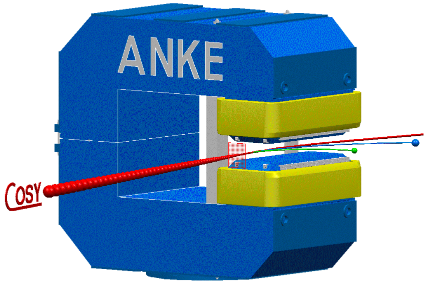


Preliminary angular distribution

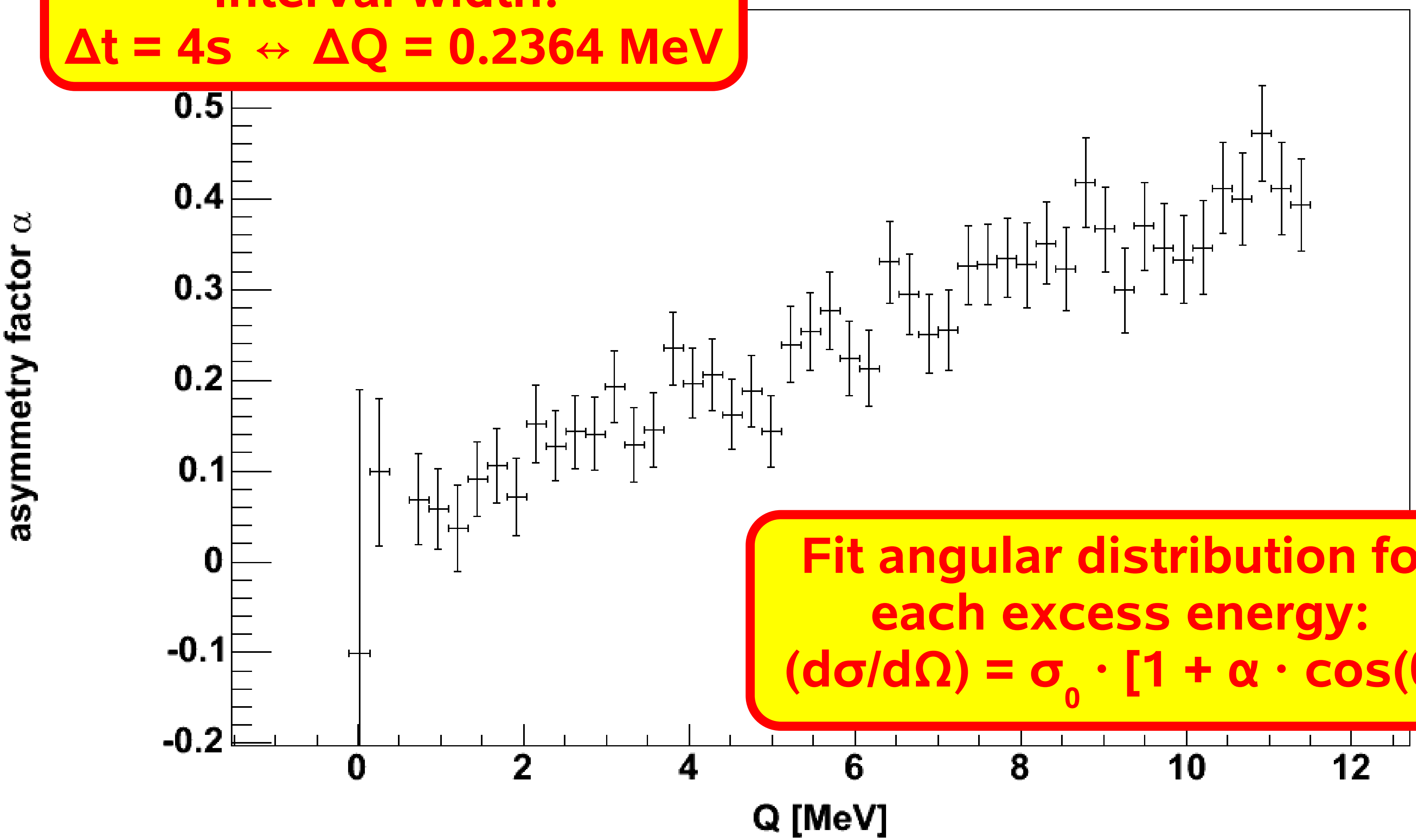
Idea: Fit function for each excess energy:
$(d\sigma/d\Omega) = \sigma_0 \cdot [1 + \alpha \cdot \cos(\theta)]$



Preliminary angular distribution

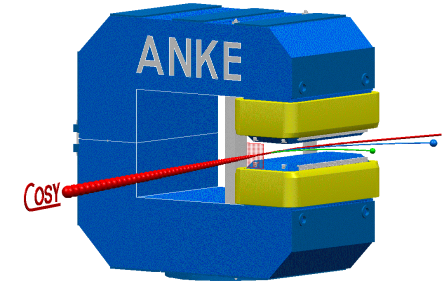


Interval width:
$\Delta t = 4s \leftrightarrow \Delta Q = 0.2364$ MeV



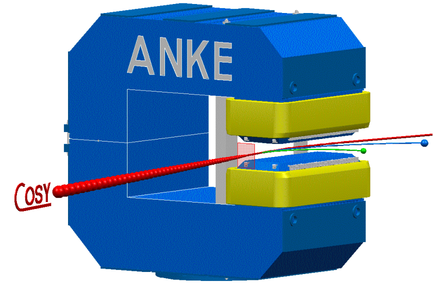
Fit angular distribution for each excess energy:
$(d\sigma/d\Omega) = \sigma_0 \cdot [1 + \alpha \cdot \cos(\theta)]$

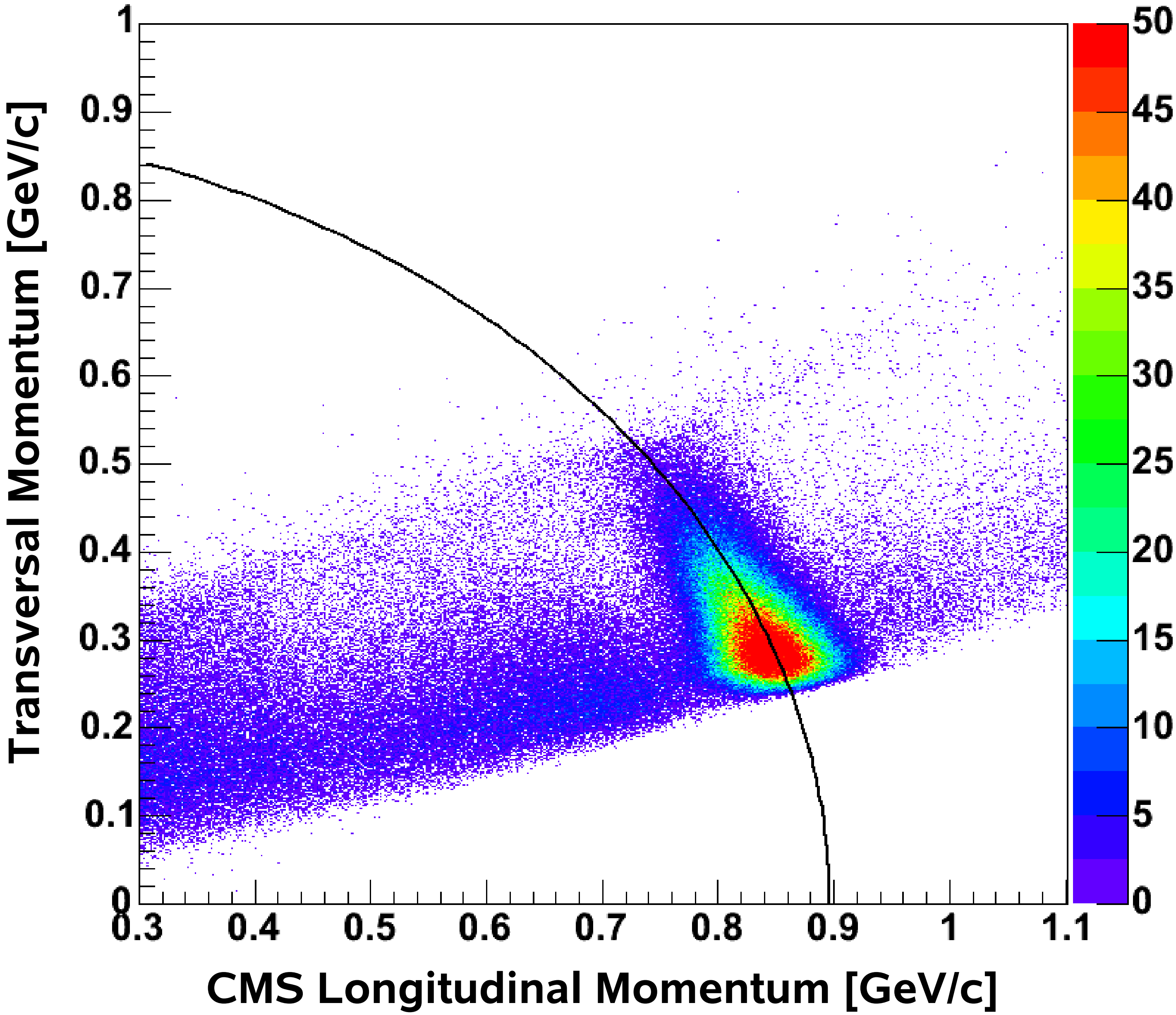
Summary
Outlook

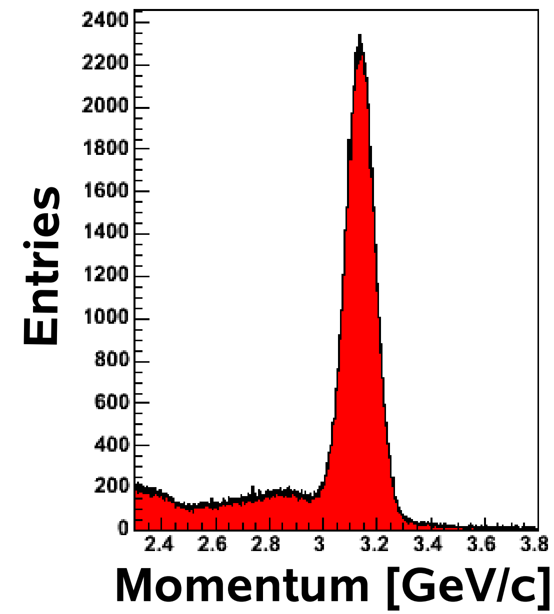


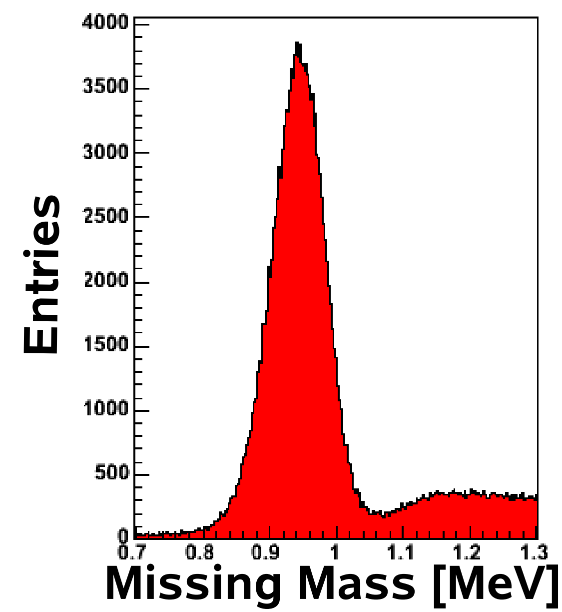
- Calibration of the detection system, except:
  - Absolute excess energy (only fine tuning)
  - Angular distribution (only fine tuning)
- Absolute normalization via dp-elastic scattering (Michael Papenbrock, diploma thesis in preparation)
- Study of higher excess energy data (Q=20, 40, 60 MeV)
- Study of polarised data of February 2005
- Preparation for the polarised $dp \rightarrow {}^3He\ \eta$ beamtime in second half of 2007

Normalization via dp-elastic scattering

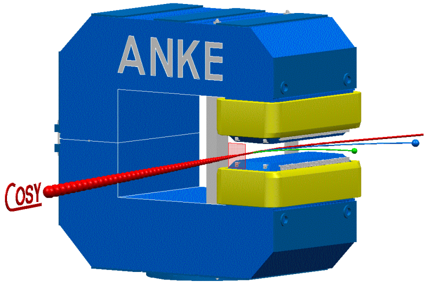




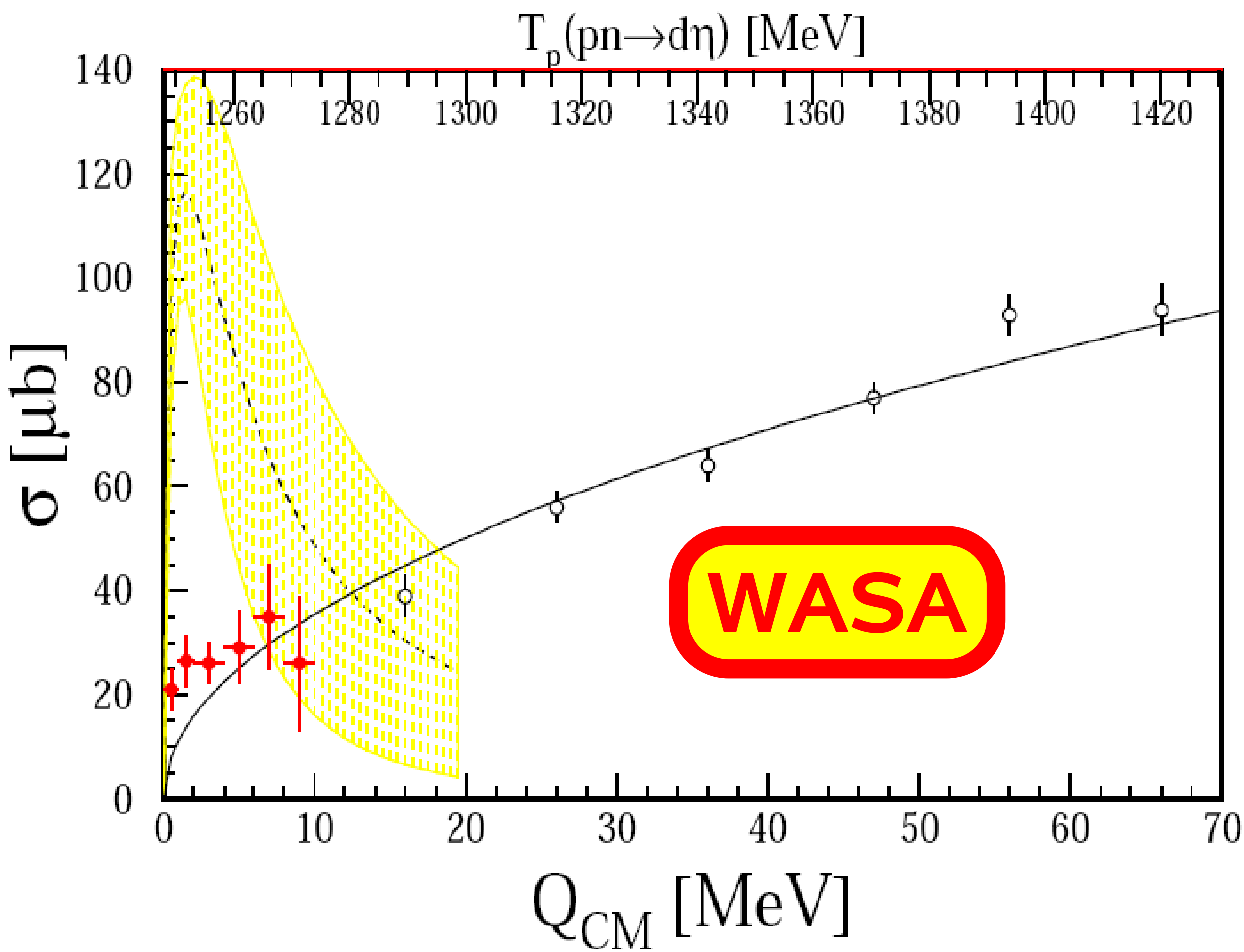


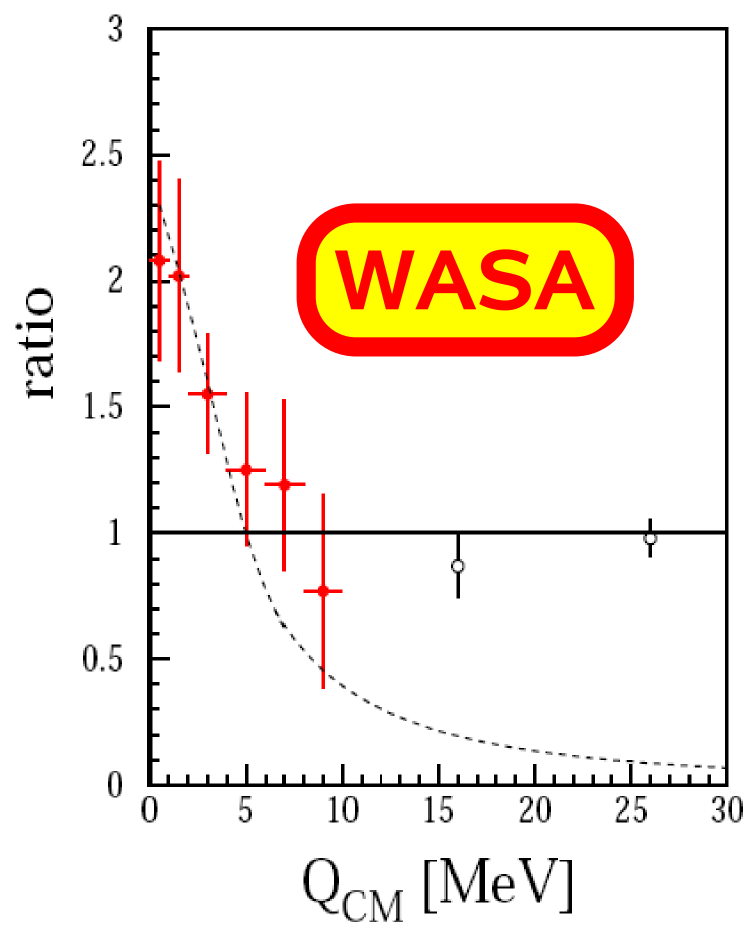


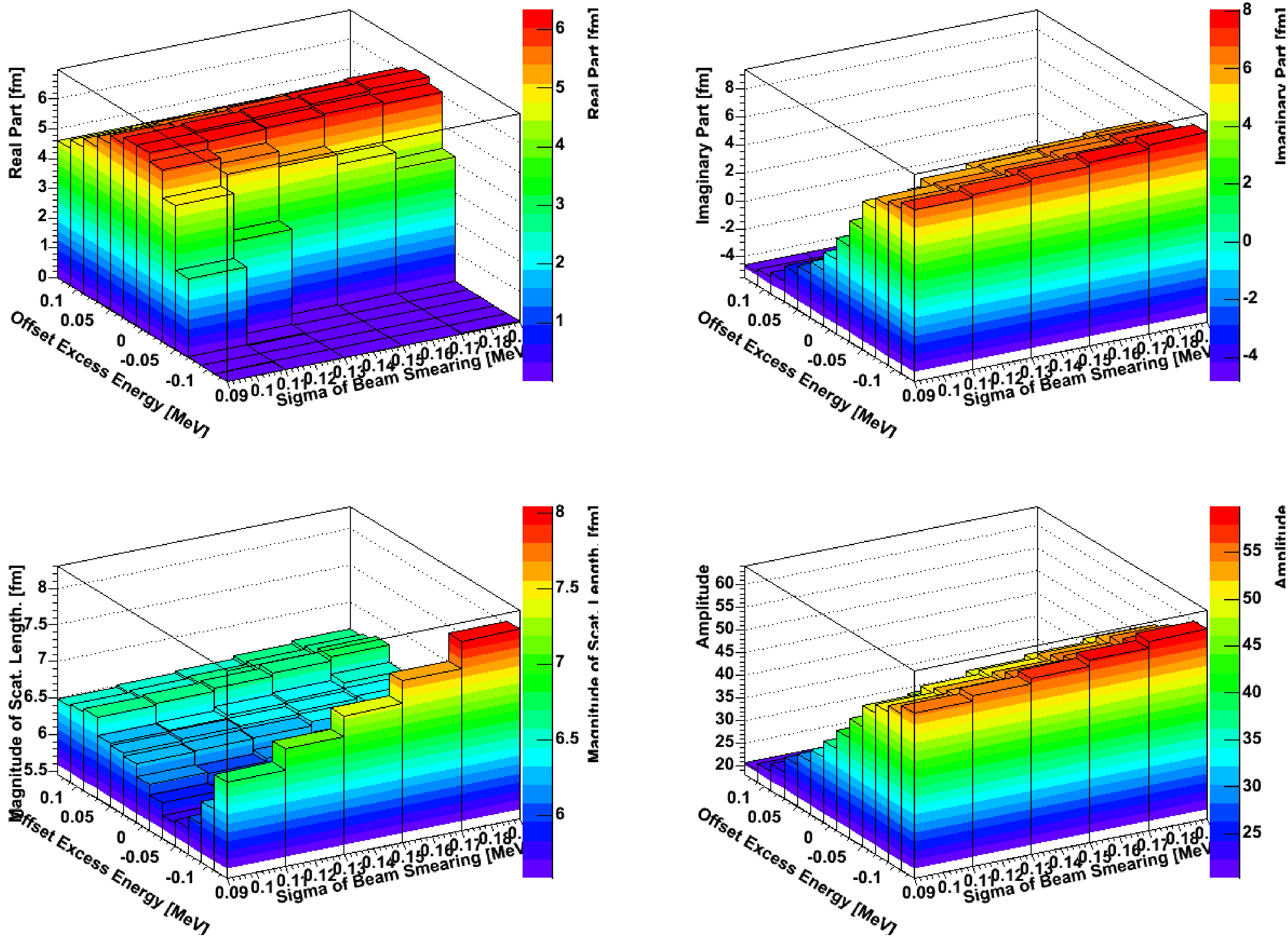
Comparison with the d η system in the reaction pn→dη

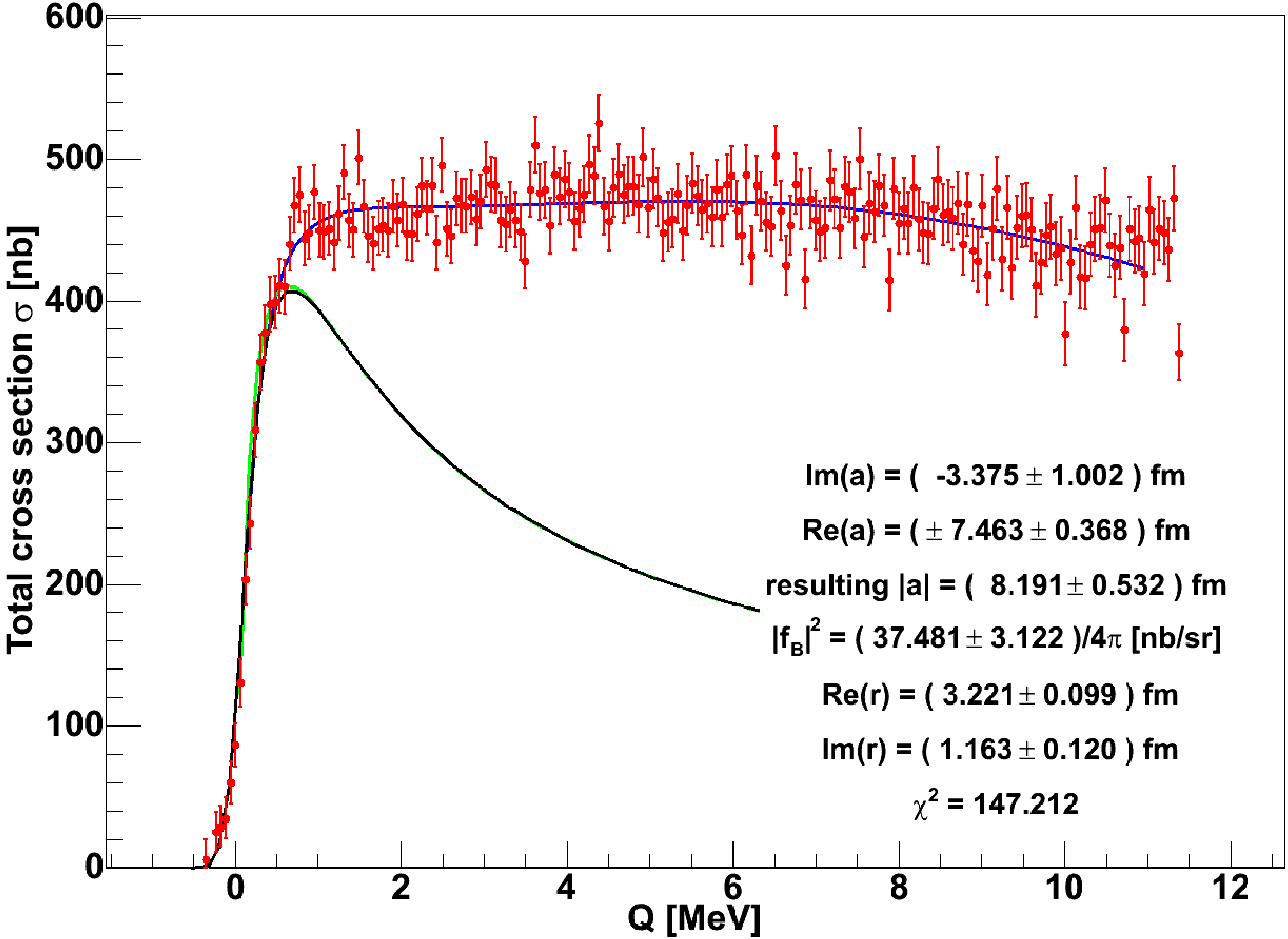


- Study of the reaction pn→dη using the spectator model
- Direct reconstruction of deuteron and η meson

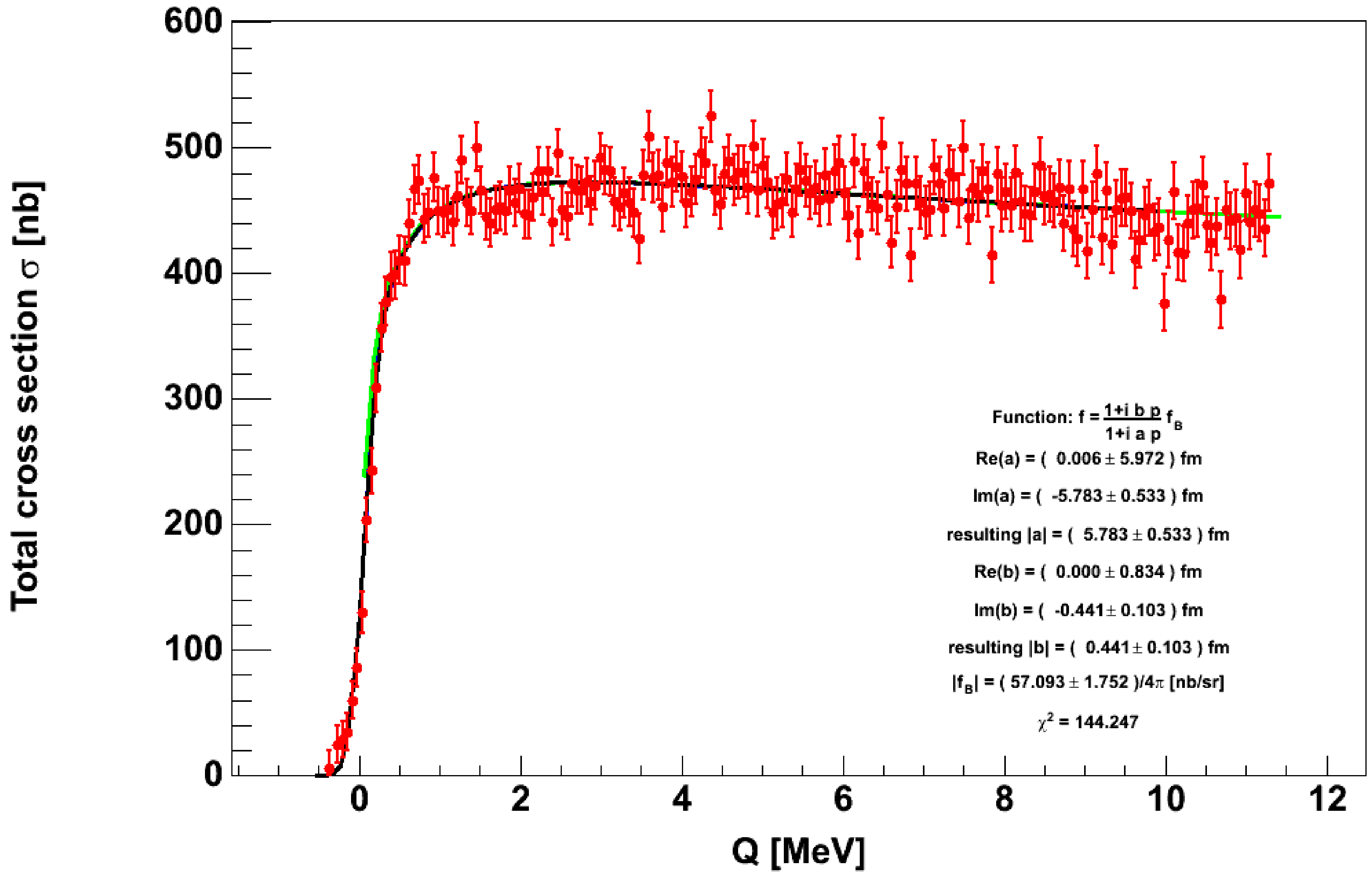




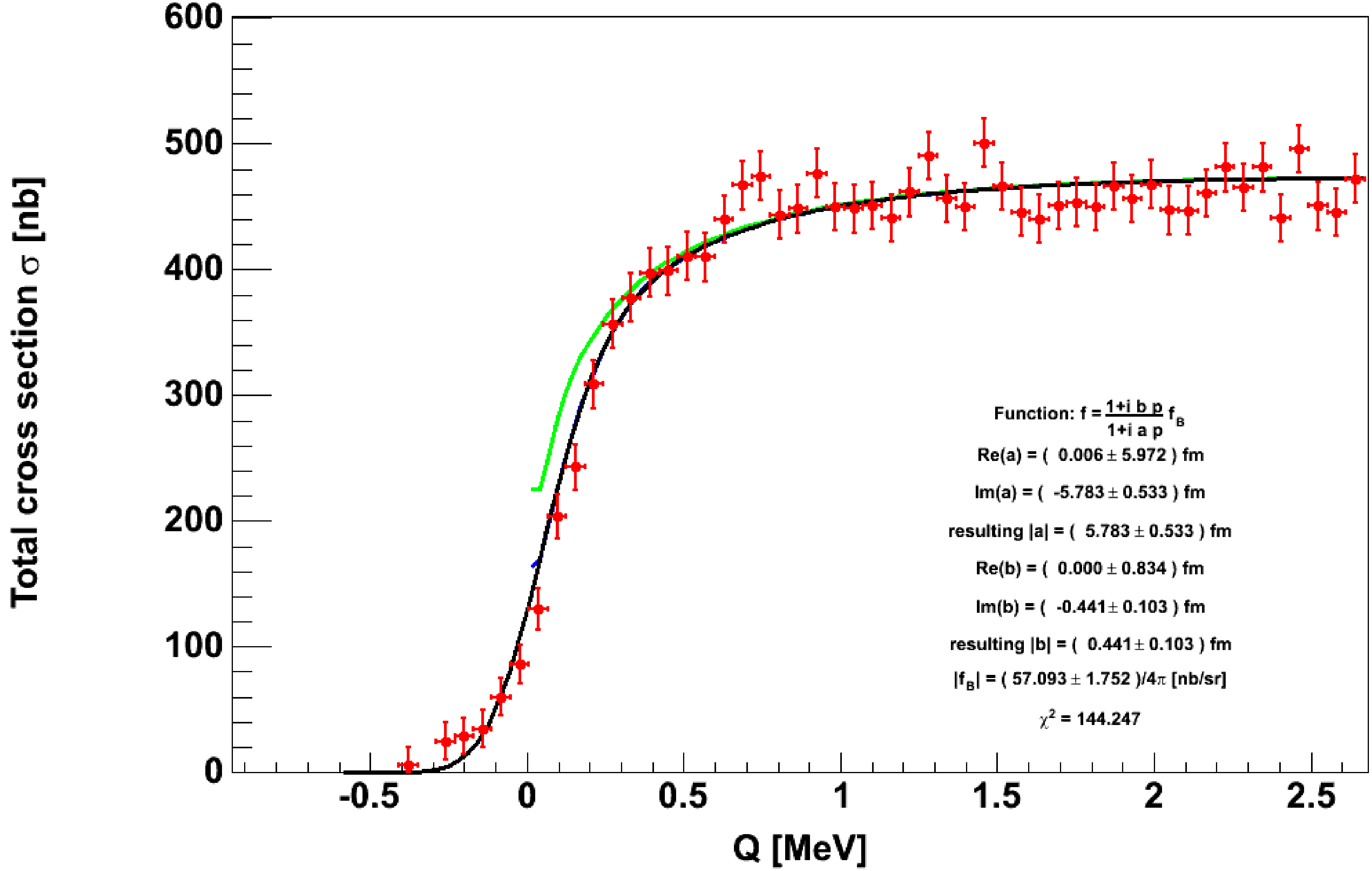

Real Part [fm]
Offset Excess Energy [MeV]
Sigma of Beam Smearing [MeV]
Imaginary Part [fm]
Magnitude of Scat. Length. [fm]
Amplitude



Total cross section σ [nb]
Q [MeV]
Im(a) = (-3.375 ± 1.002) fm
Re(a) = (± 7.463 ± 0.368) fm
resulting |a| = (8.191 ± 0.532) fm
$|f_B|^2$ = (37.481 ± 3.122)/4π [nb/sr]
Re(r) = (3.221 ± 0.099) fm
Im(r) = (1.163 ± 0.120) fm
χ^2 = 147.212



Total cross section σ [nb]
Q [MeV]
Function: f = (1+i b p)/(1+i a p) f_B
Re(a) = (0.006 ± 5.972) fm
Im(a) = (-5.783 ± 0.533) fm
resulting |a| = (5.783 ± 0.533) fm
Re(b) = (0.000 ± 0.834) fm
Im(b) = (-0.441 ± 0.103) fm
resulting |b| = (0.441 ± 0.103) fm
|f_B| = (57.093 ± 1.752)/4π [nb/sr]
χ² = 144.247



Total cross section σ [nb]
Q [MeV]
Function: f = (1+i b p)/(1+i a p) f_B
Re(a) = (0.006 ± 5.972) fm
Im(a) = (-5.783 ± 0.533) fm
resulting |a| = (5.783 ± 0.533) fm
Re(b) = (0.000 ± 0.834) fm
Im(b) = (-0.441 ± 0.103) fm
resulting |b| = (0.441 ± 0.103) fm
|f_B| = (57.093 ± 1.752)/4π [nb/sr]
χ^2 = 144.247