

# New Measurements of Deuteron Compton Scattering at MAX-lab

- Importance of Deuteron Compton Scattering (DCS)
- Results of previous experiments
- Efforts of the Compton@MAX-lab collaboration
- Future Plans and Goals

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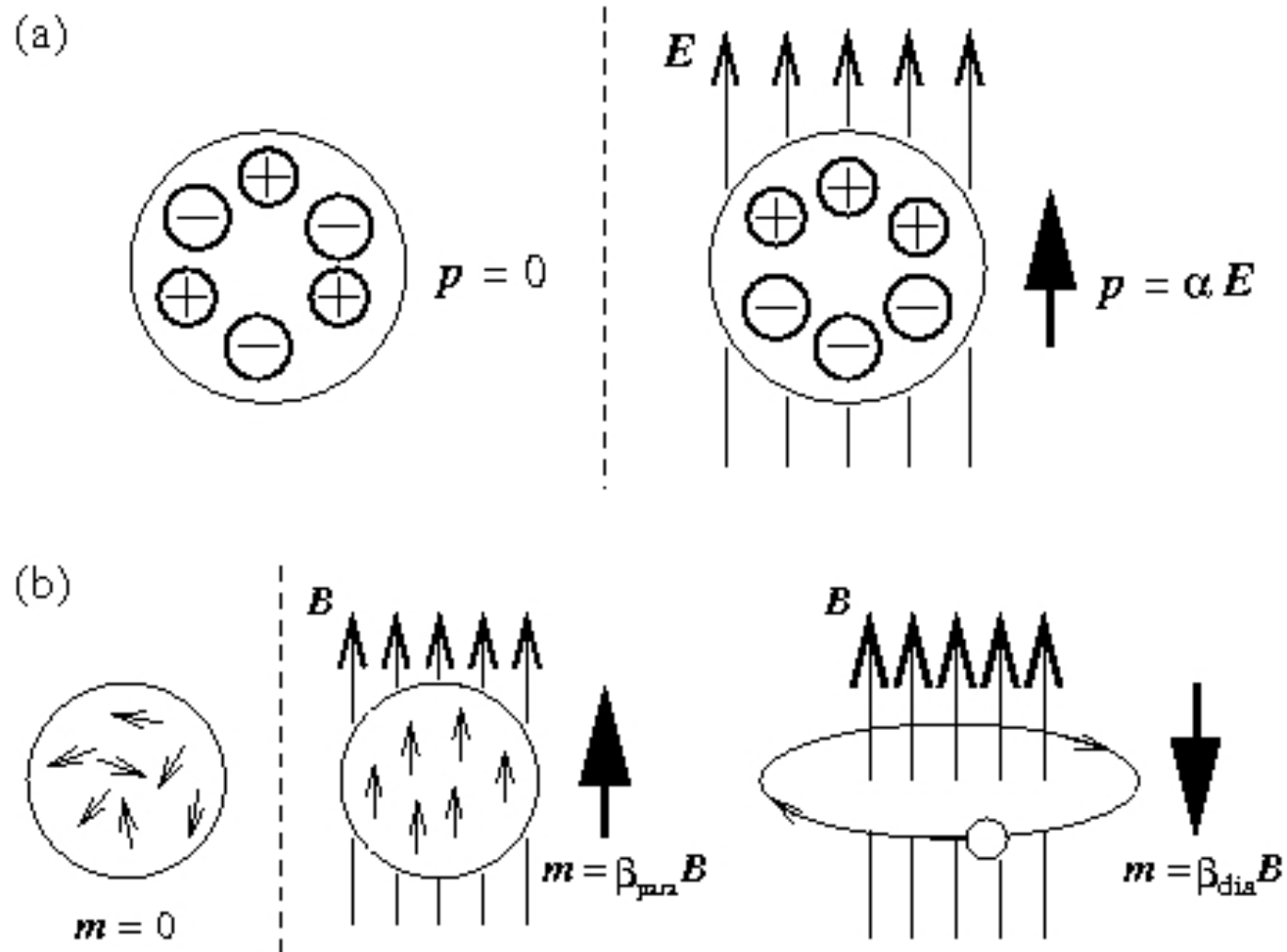
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# Background: Polarizability



# Compton Scattering and Polarizabilities

Classical Compton cross section:

$$\sigma_N \approx r_0^2 \left| Q_N - \frac{2\omega^2}{M_N^2} \right|^2 \approx Q_N^2 r_0^2 - 2Q_N r_0 \alpha_N \omega^2 + O(\omega^4)$$

Point-like  
(Thomson) term

NLO term  
due to polarizability

In the Low Energy Approximation ( $\omega < m_\pi$ ), the cross section is:

- Sensitive to  $\alpha+\beta$  at forward angles
- Sensitive to  $\alpha-\beta$  at back angles

# Proton and Neutron

- Proton

- Use of hydrogen target
- Thomson term is non-zero -> sensitive to  $\alpha, \beta$  at  $O(\omega^2)$
- Well – known :  $\alpha = 12.0 \pm 0.6$  and  $\beta = 1.9 \mp 0.6$

All units are  $10^{-4} \text{ fm}^3$  (M.Schumacher Prog. Part. Nucl. Phys 55)

- Neutron

- No free neutron target
- Thomson term is zero -> sensitive to  $\alpha, \beta$  at  $O(\omega^4)$
- Types of neutron experiments:
  - Neutron scattering from heavy nuclei (nA)
  - Quasi-free Compton scattering (QFCS) from deuteron
  - Coherent Compton scattering (CohCS) from deuteron

# Deuteron

	<b>Advantages</b>	<b>Potential “Concerns”</b>
<b>QFCS</b>	<p>Measure proton and neutron scattering simultaneously</p> <p>Can use the proton measurement to determine systematic uncertainties</p>	<p>Scattering from (uncharged) neutron requires higher <math>E_\gamma</math></p> <p>Sensitive to higher order terms and model dependence</p>
<b>CohCS</b>	<p>Charged nucleus -&gt; sensitive to the sum of the <i>nucleon</i> polarizabilities (<math>\alpha_p + \alpha_n</math>) <i>at <math>O(\omega^2)</math></i></p>	<p>Need to know the <b>proton</b> polarizability</p> <p>Scattering from meson currents within nucleus</p>

# Neutron Polarizabilities

- Current *recommended* average:

- $\alpha_n = 12.5 \pm 1.7$
  - $\beta_n = 2.7 \mp 1.8$

} Not as good as it appears!

- However, the various experiments yield:

- nA scattering:  $\alpha_n = 12.6 \pm 2.5$  (Debated uncertainty)

- QFCS:  $\alpha_n = 12.5 \pm 2.3$  (Only one precise result)

- CohCS:  $\alpha_n = 8.8 \pm 3.8$

# Coherent DCS

Three data sets:

$E \sim 50, 70$  MeV (Illinois, Lund)

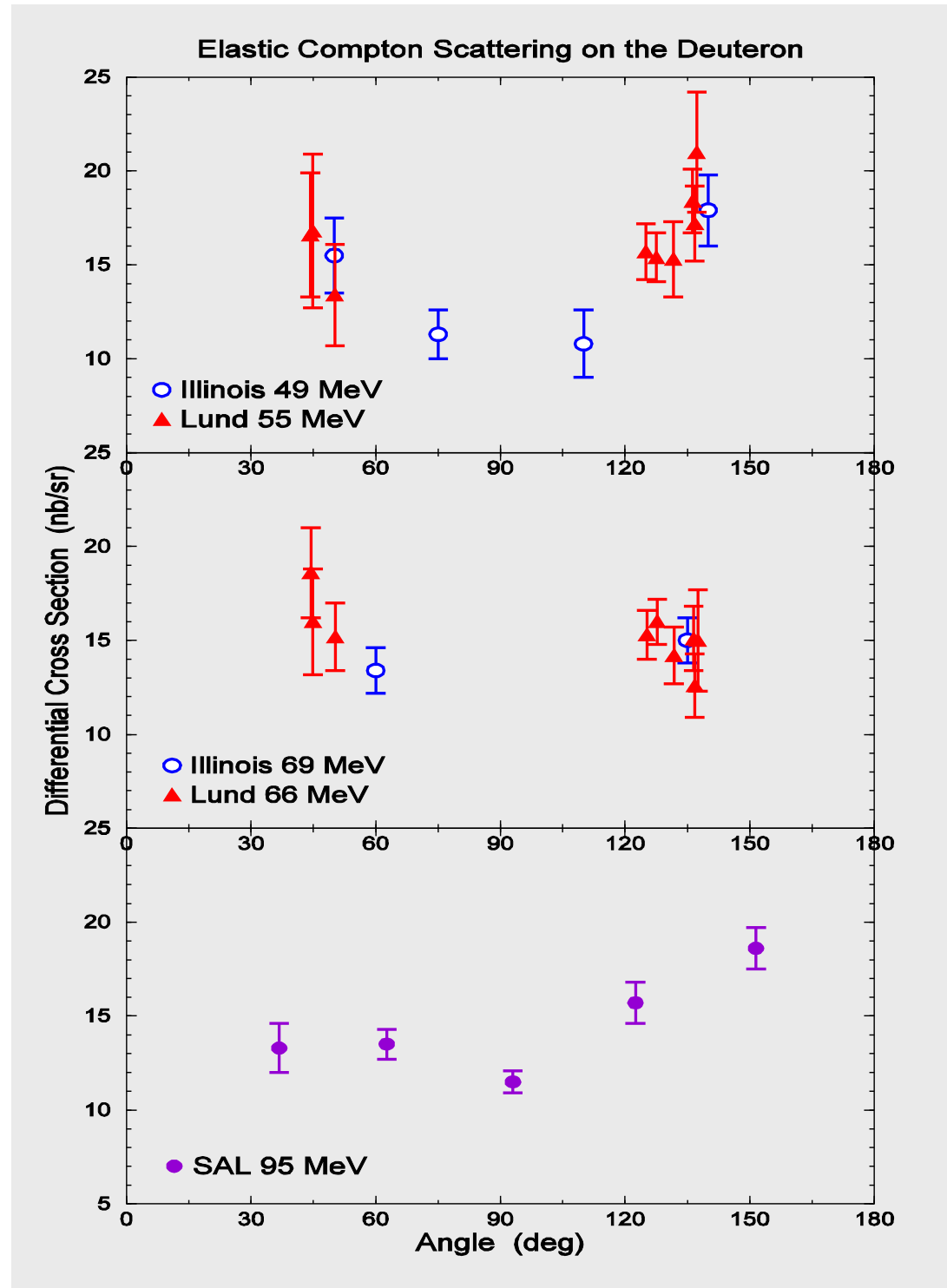
$E = 95$  MeV (SAL)

“Issues” with current data:

Large statistical uncertainties  
(commonly  $> 7\%$ )

Wide energy bins  
( $\Delta E$  is 6 - 20 MeV)

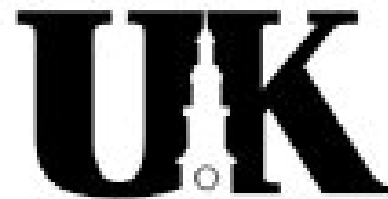
Limited kinematic coverage



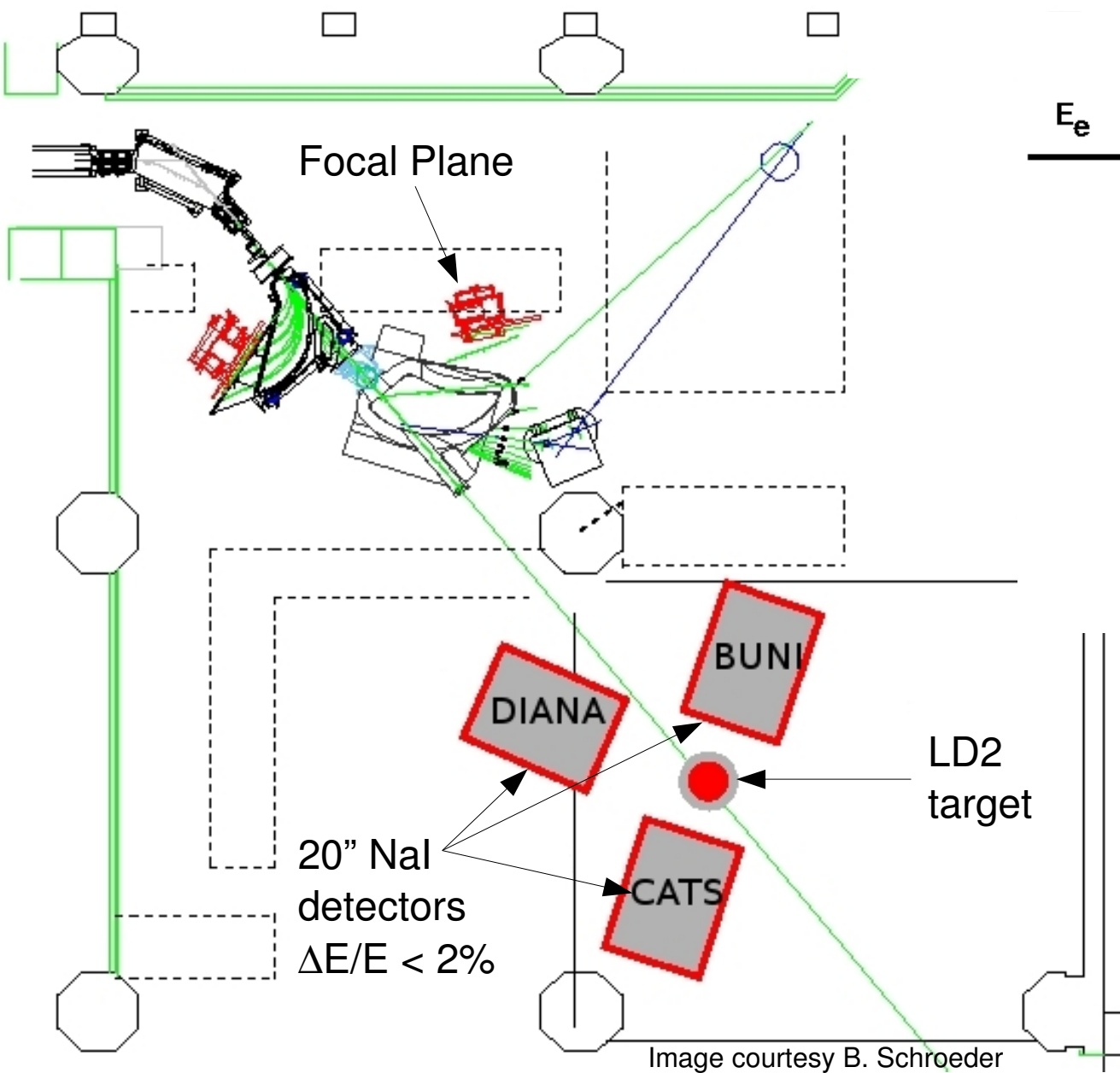
# Compton@MAX-lab Collaborators



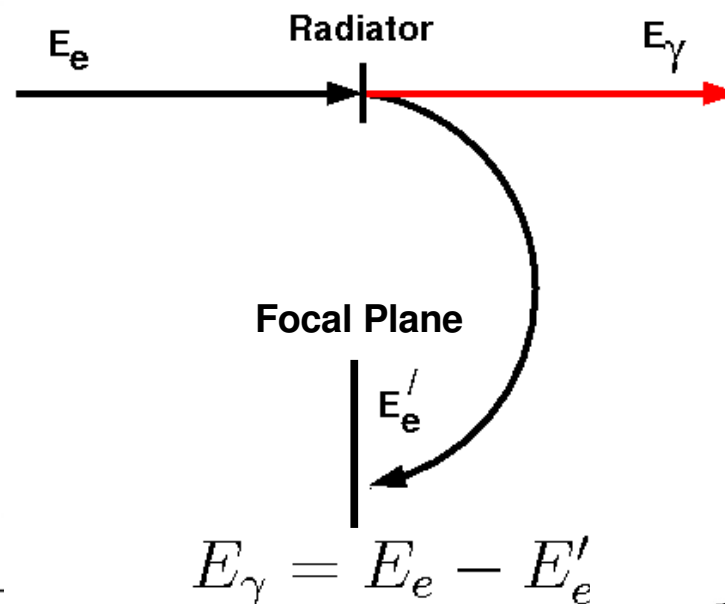
- Lund University and MAX-lab
- The George Washington University
- University of Kentucky
- University of Illinois at Champaign-Urbana
- Duke University and TUNL
- University of Glasgow



# Experimental Setup



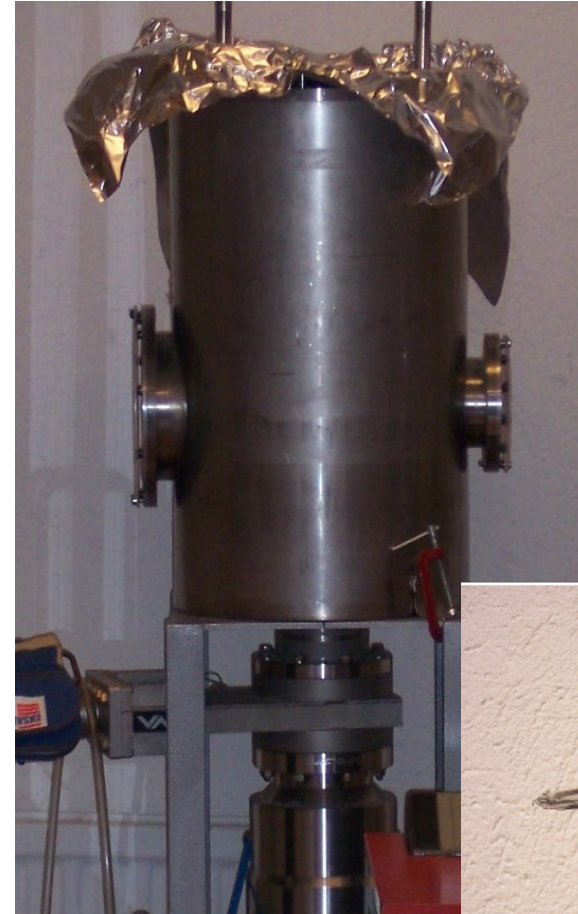
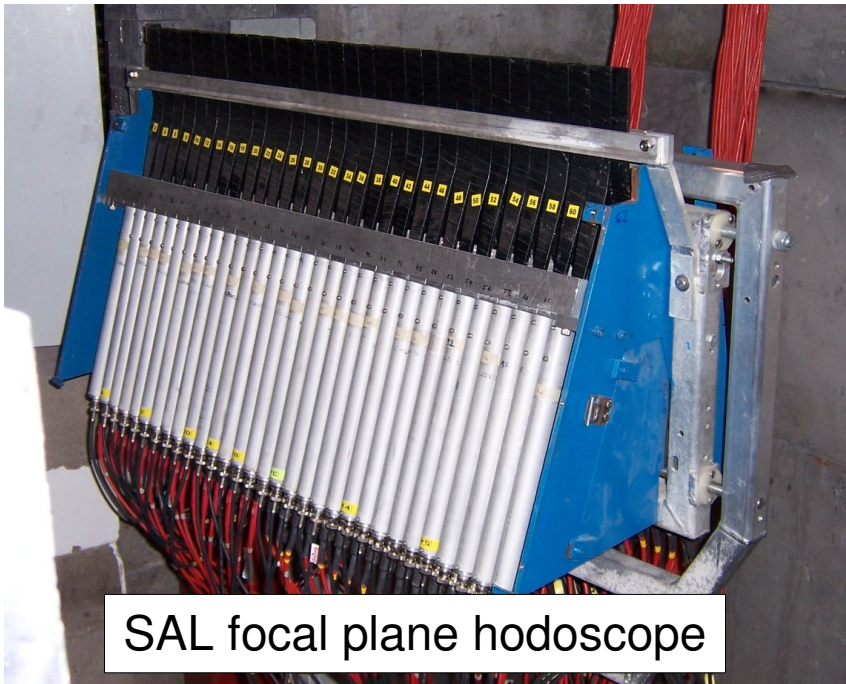
## The tagging mechanism



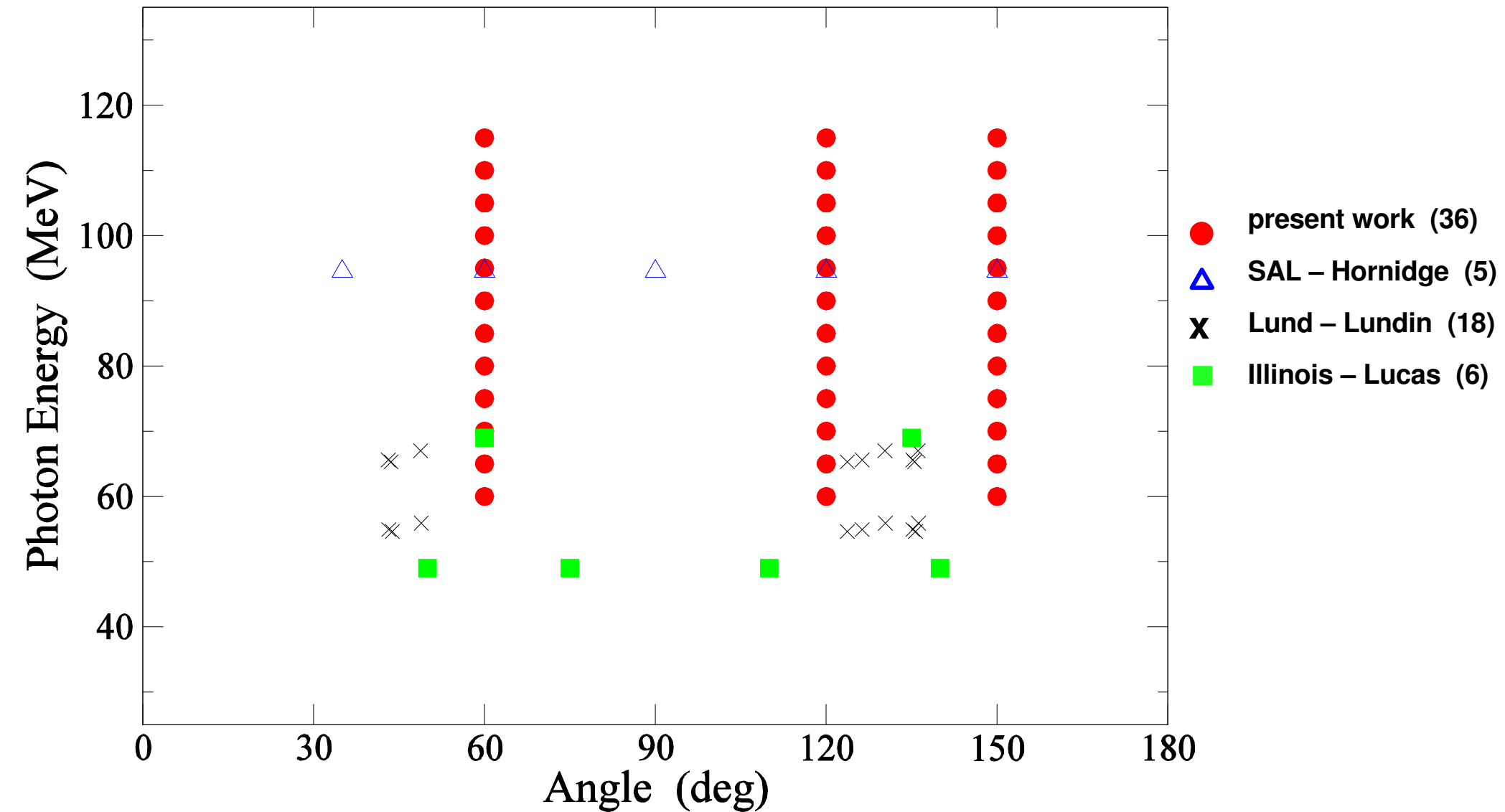
$d(\gamma, \gamma')/d$  @  
MAX-lab



# Apparatus

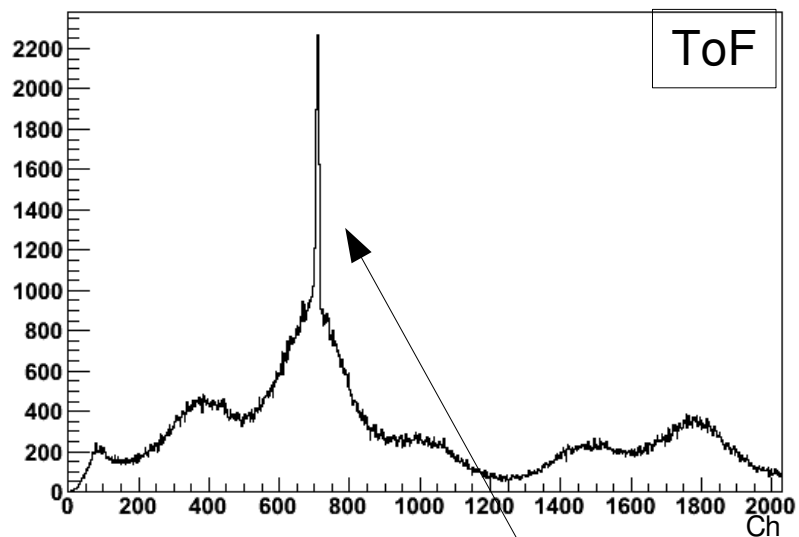


# Kinematic Coverage

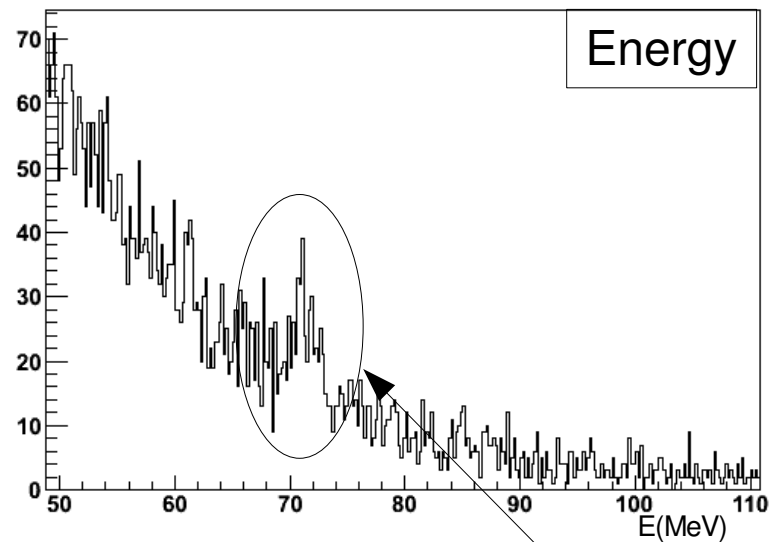


# Spectra from MAX-lab

**Carbon**

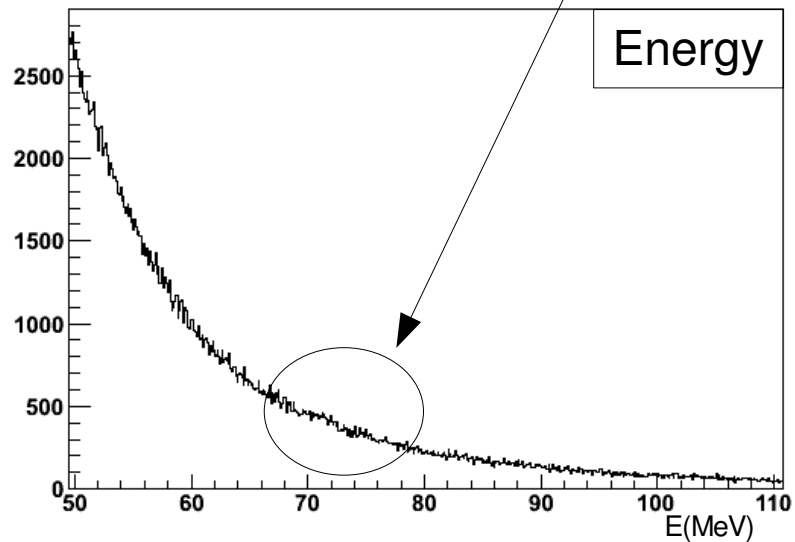
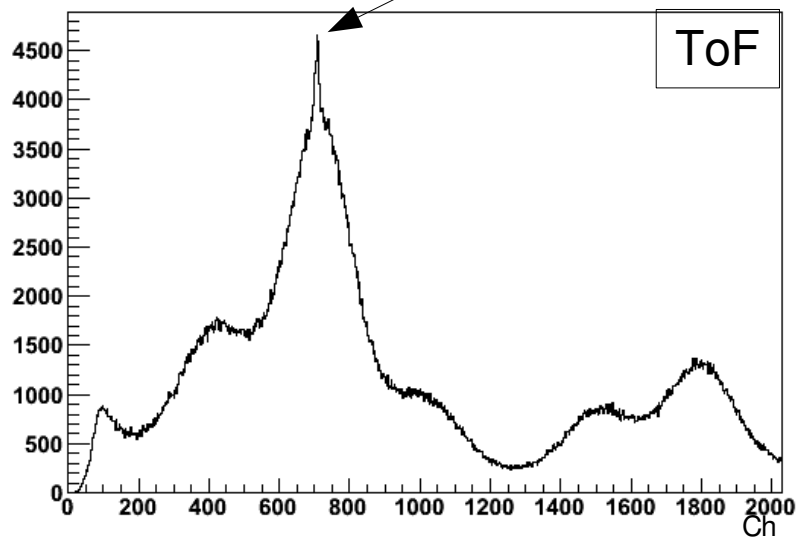


Prompt Peak



Elastic Peak

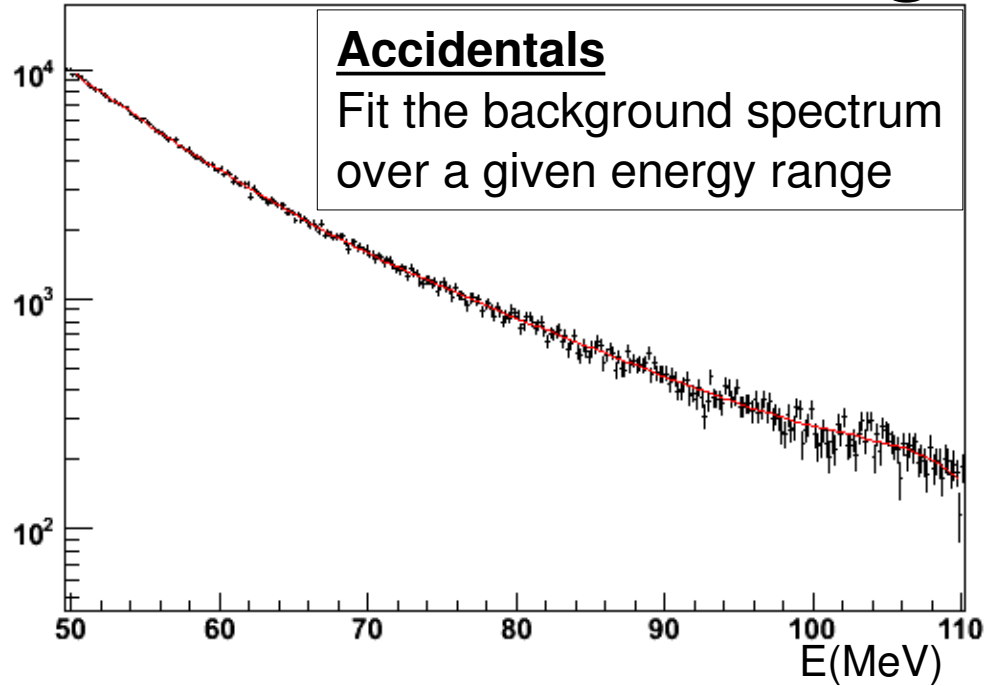
**Deuterium**



# Removing Backgrounds

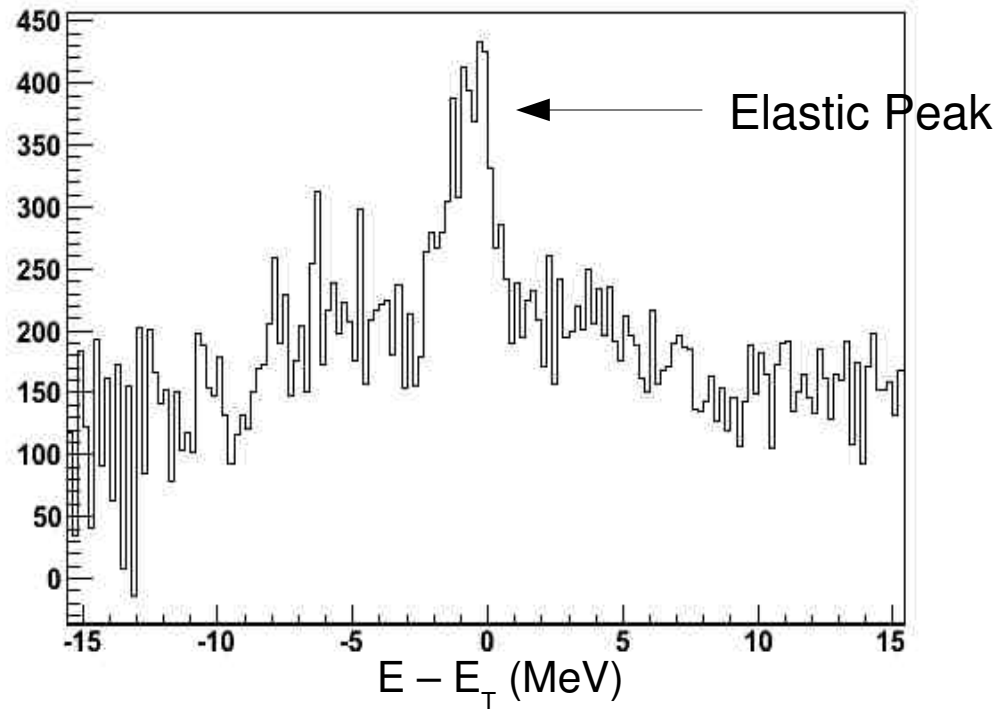
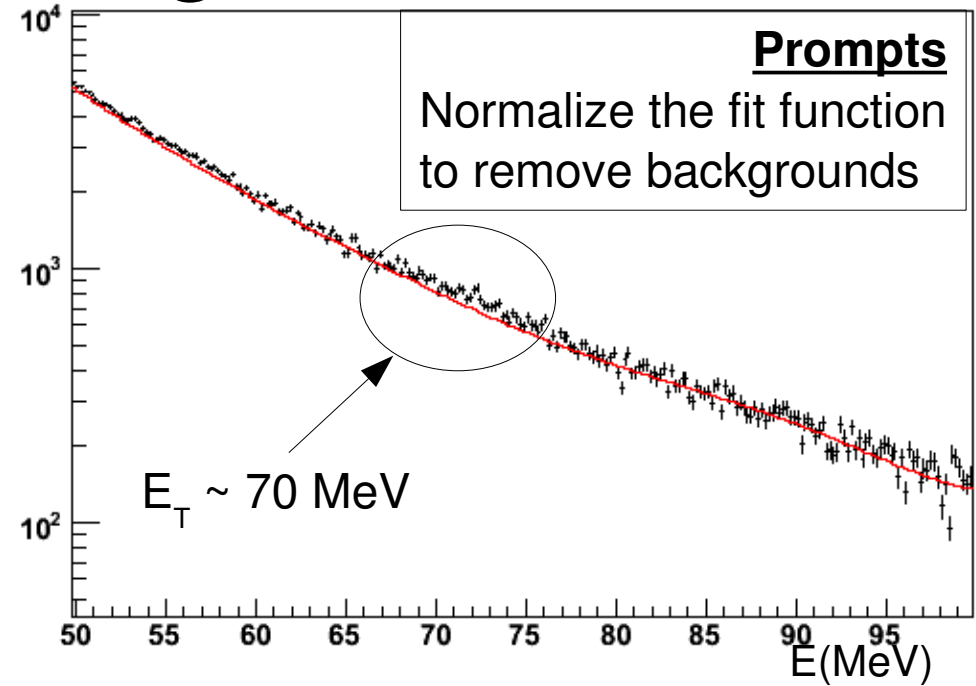
## Accidentals

Fit the background spectrum over a given energy range

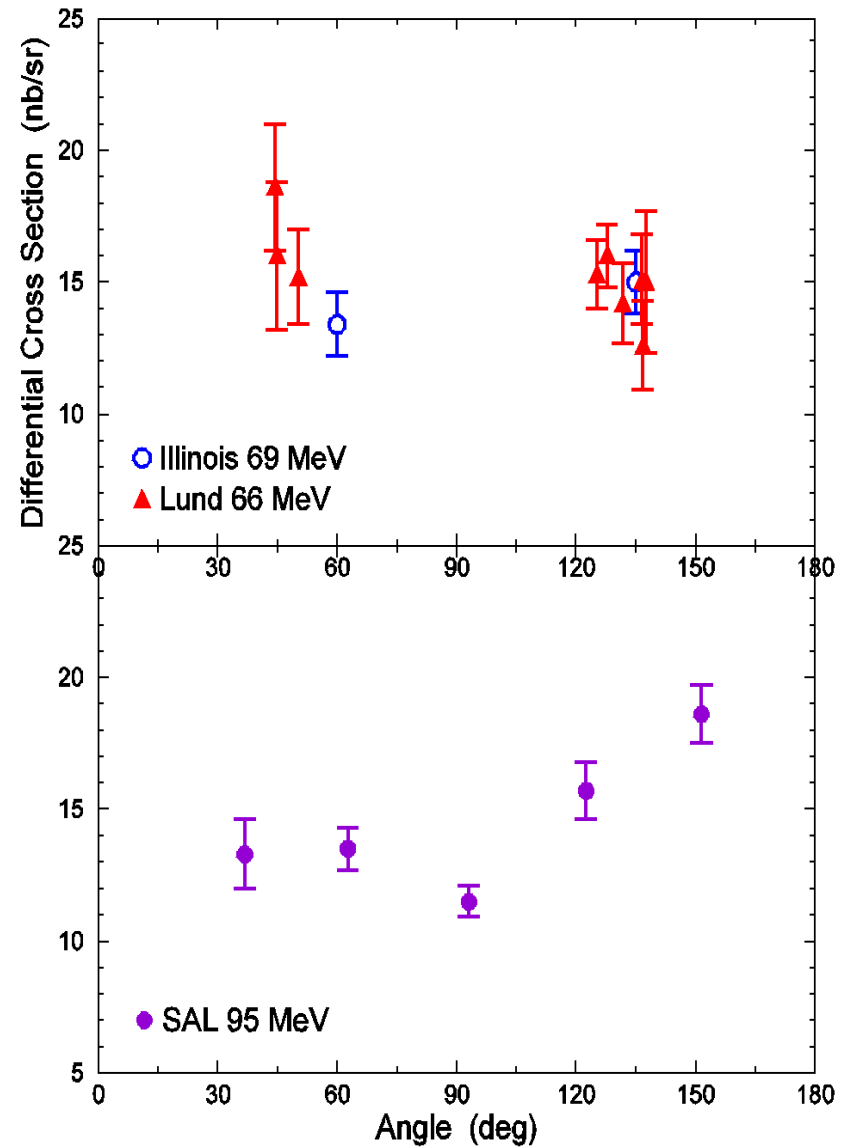
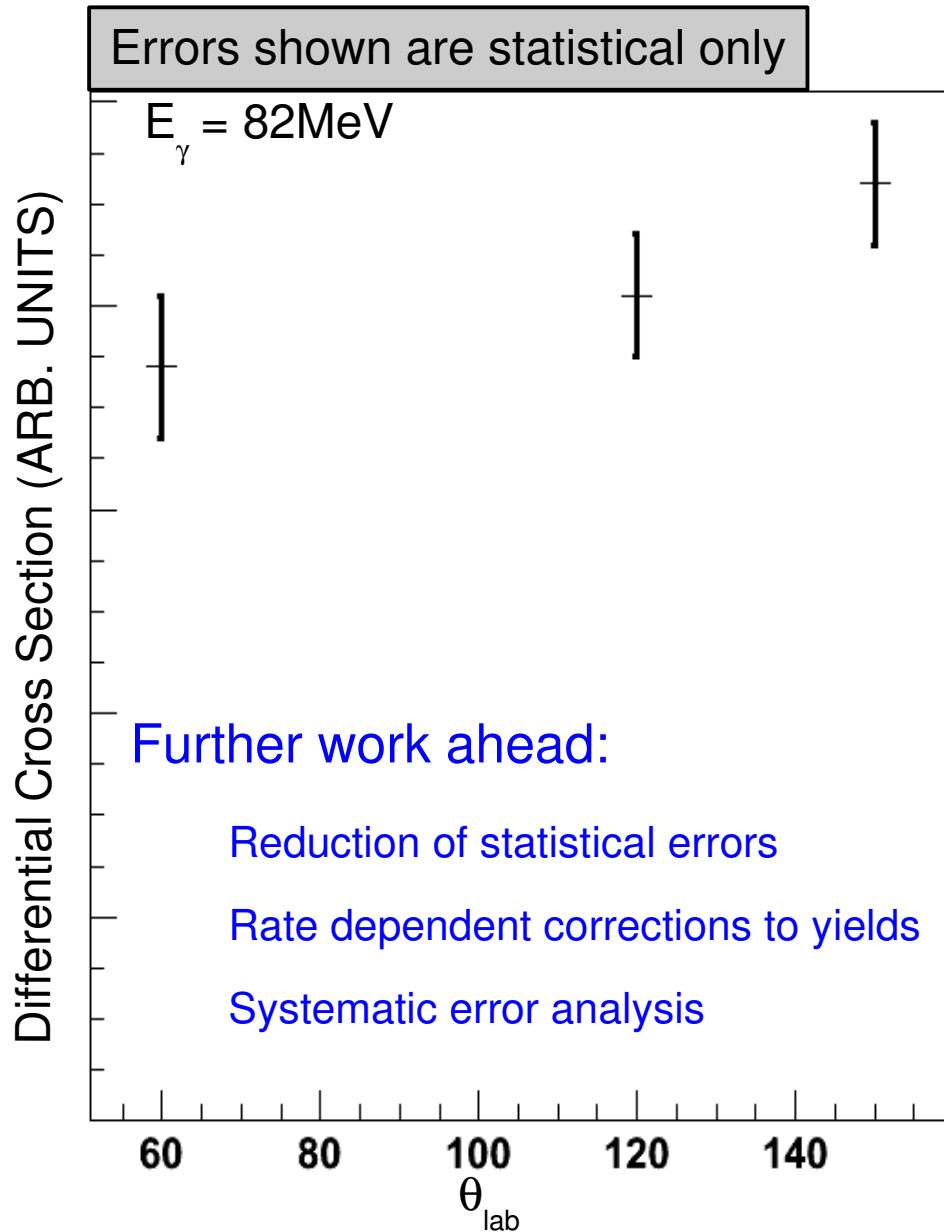


## Prompts

Normalize the fit function to remove backgrounds



# *Preliminary* Cross Sections



# Looking Ahead

- Have a complete data set at  $E_\gamma$  from 67-95 MeV
- Some test data at  $E_\gamma$  from 95-115 MeV
  - 4 week production run at this energy in November

[Stay current at http://www.maxlab.lu.se/kfoto/ExperimentalProgram/np006/np006.html](http://www.maxlab.lu.se/kfoto/ExperimentalProgram/np006/np006.html)

## Anticipated Results

Obtain cross section uncertainties  $\leq 5\%$

$$\Rightarrow \text{Extract } \Delta(\alpha_d - \beta_d) \leq 5\%$$