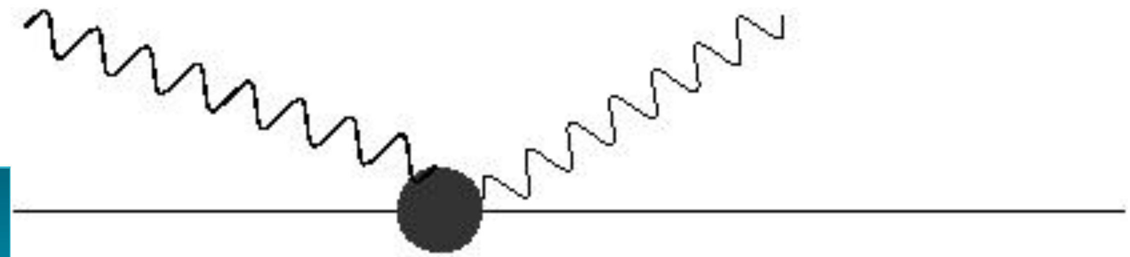


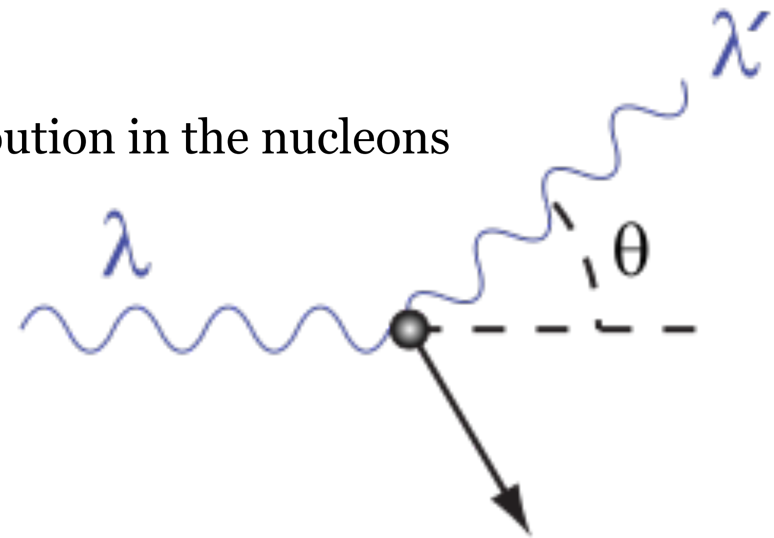
Inelastic Compton Scattering on The Deuteron

Neutron Polarizability Extraction

CD 2015

Berhan Demissie
GWU

Nucleon Polarizabilities



- Measure stiffness of charge and current distribution in the nucleons

- Nucleon mass splitting ~ $\beta_{p-n} = \beta_p - \beta_n$
  Walker-Loud et al PhysRevLett.108.232301
  Gasser et al arXiv:1506.6747

  ➔ Mirror Nuclei

  ➔ Big Bang Nucleosynthesis (BBN)

Two photon response processes :
Compton Scattering

Effective Field Theory

- Effective Lagrangian of Nucleons and Mesons which satisfy unitarity, analyticity, Lorentz, CPT, chiral symmetries.

➡ **Model independent**

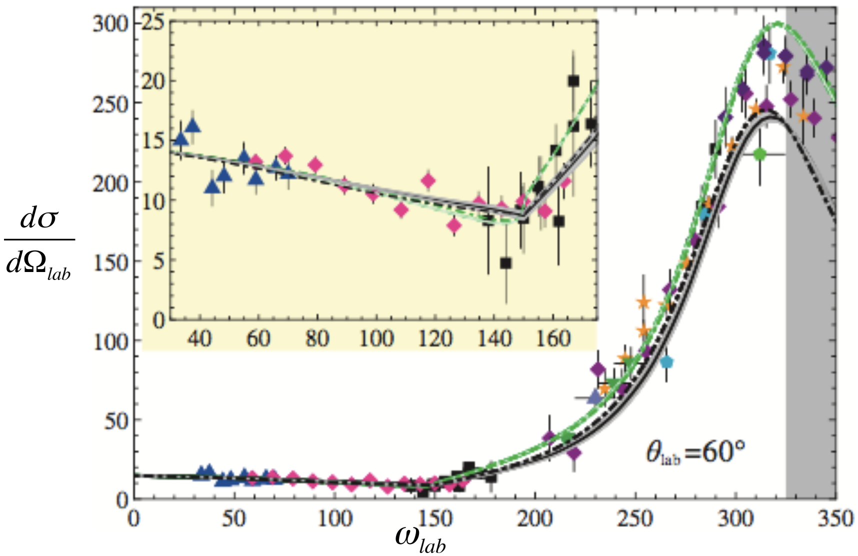
- Counting rule and Expansion Parameters:

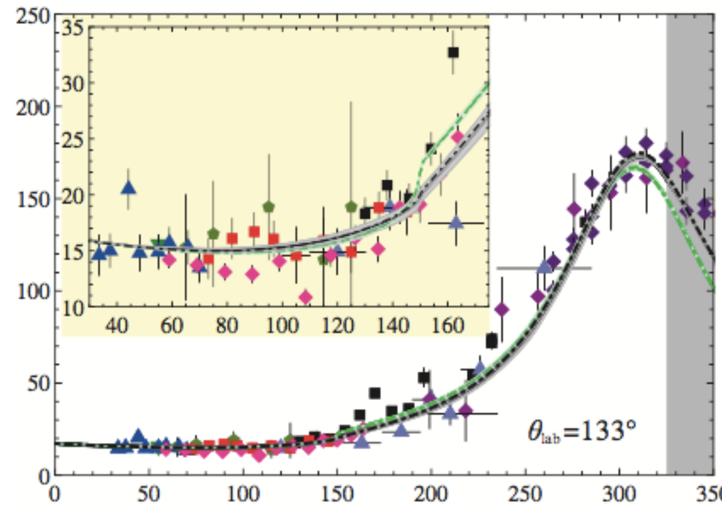
$$\frac{Q(=q, m_\pi, m_\Delta - m)}{\Lambda}$$ ➡ **Well-defined uncertainties ~ Q^{n+1}**

Latest values from p(γ,γ)p and d(γ,γ)d

$\omega \sim m_\pi$ upto N⁴LO **$\omega \sim M_\Delta - M_N$ Upto NLO**

- Pion and Δ(1232) degrees of freedom





McGovern et al, 2013 ,Eur. Phy. J. A

$\alpha_p = 10.7 \pm 0.4(\text{stat}) \pm 0.2(\text{Baldin}) \pm 0.3(\text{theory})$

$\beta_p = 3.1 \mp 0.4(\text{stat}) \pm 0.2(\text{Baldin}) \mp 0.3(\text{theory})$

$\alpha_n = 11.1 \pm 1.8(\text{stat}) \pm 0.4(\text{Baldin}) \pm 0.8(\text{theory})$

$\beta_n = 3.1 \mp 1.8(\text{stat}) \pm 0.4(\text{Baldin}) \mp 0.8(\text{theory})$

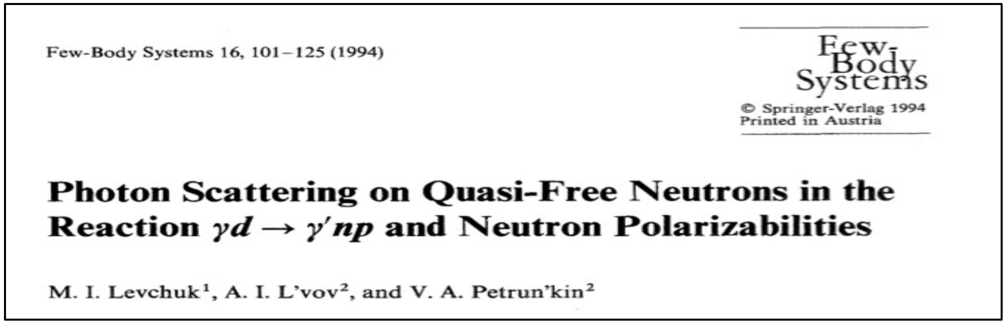
✓ **Treat all Compton data within the same framework**

✓ **Corroborate and improve accuracy of α_n and β_n independently**

- *d(γ,γn)p in χEFT*

$d(\gamma,\gamma n)p \sim n(\gamma,\gamma)n$

Non χEFT Approach


Few-Body Systems 16, 101–125 (1994)

Few-Body Systems
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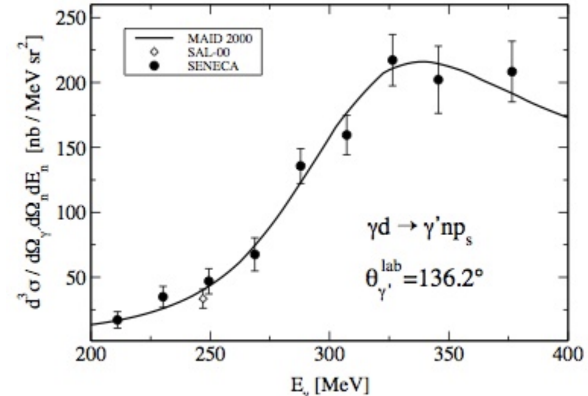
Printed in Austria

Photon Scattering on Quasi-Free Neutrons in the Reaction $\gamma d \to \gamma' np$ and Neutron Polarizabilities

M. I. Levchuk[1], A. I. L'vov[2], and V. A. Petrun'kin[2]



Kossert et al PhyRevLett.88.162301

NQFP- neutron quasi-free peak kinematic region

- Ep $\leq$ 1.1 MeV
- Polarizability sensitive E_γ : 200-400MeV

$$\alpha_n = 12.5 \pm 1.8(\text{stat.})^{1.1}_{-0.6}(\text{syst.}) \pm 1.1(\text{mod.})$$

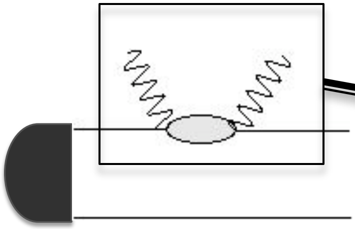
$$\beta_n = 2.7 \mp 1.8(\text{stat.})^{0.6}_{-1.1}(\text{syst.}) \mp 1.1(\text{mod.})$$

Re-Analysis in χEFT Approach

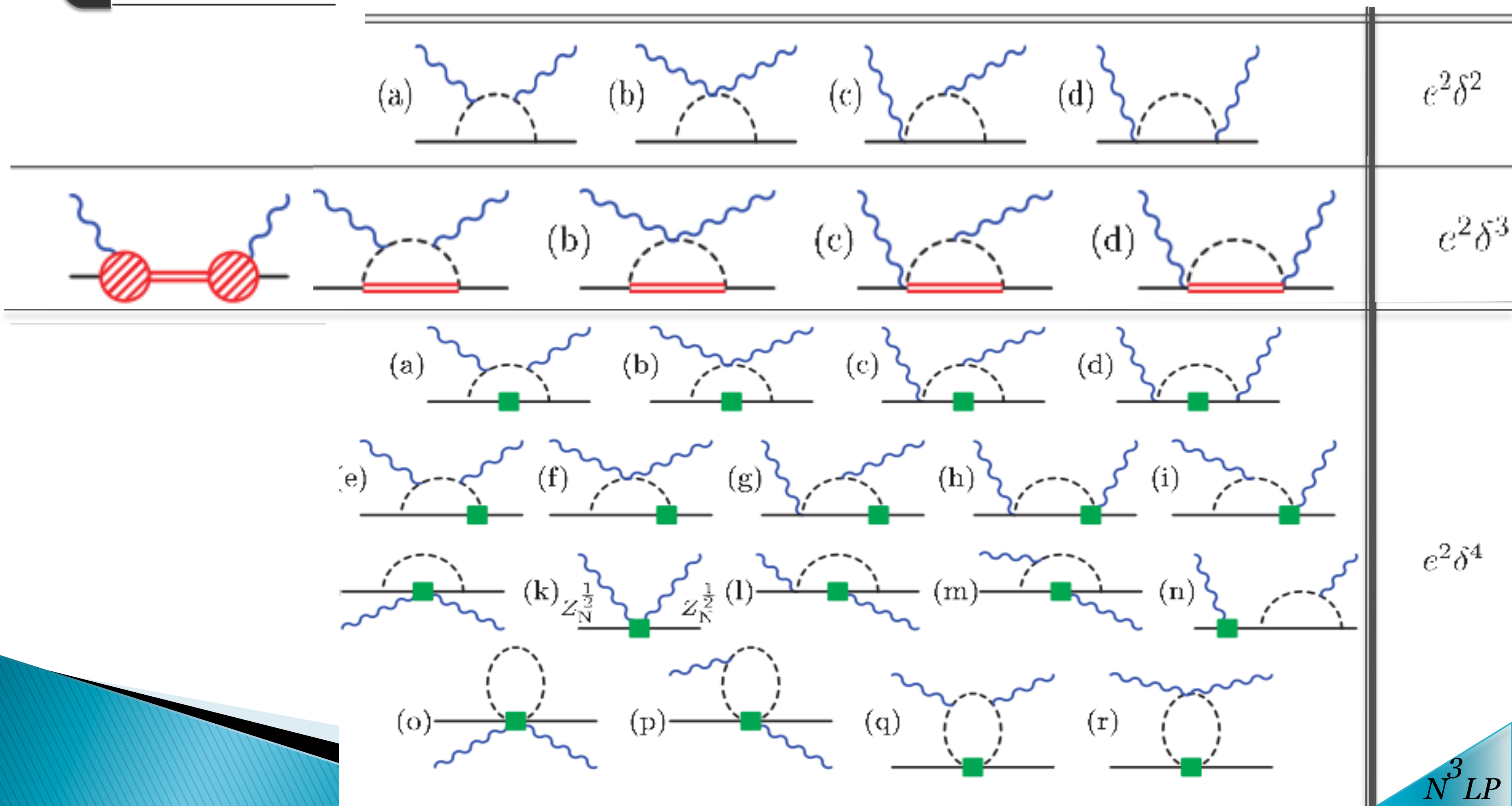
- Model independent
- Well controlled uncertainties
- Treatment of the channel in χEFT

→ All Compton scattering data in the same framework

Impulse Approximation

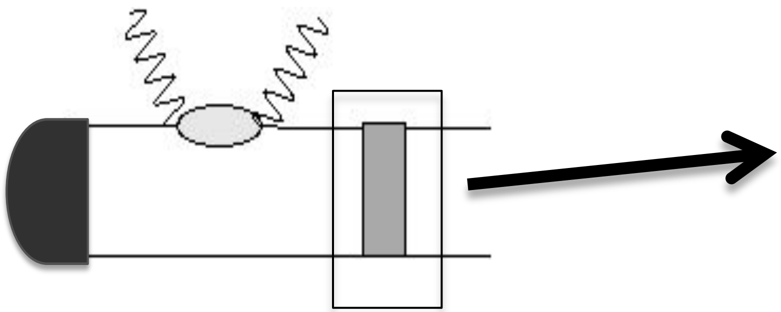


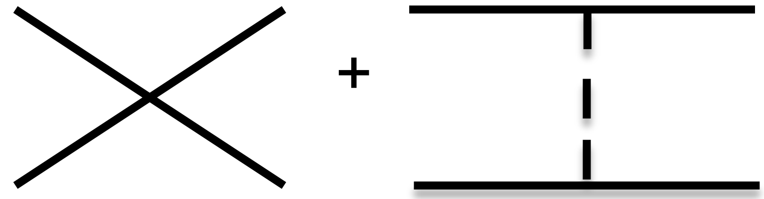
Born +



N^3LP

Final State Interaction





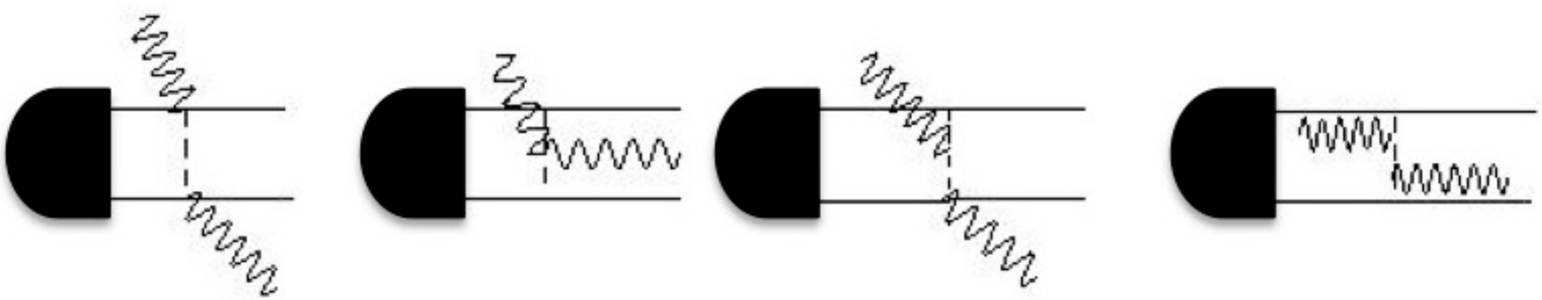
$V_{ct} = C_s + \sigma1 \bullet \sigma2\ C_t$

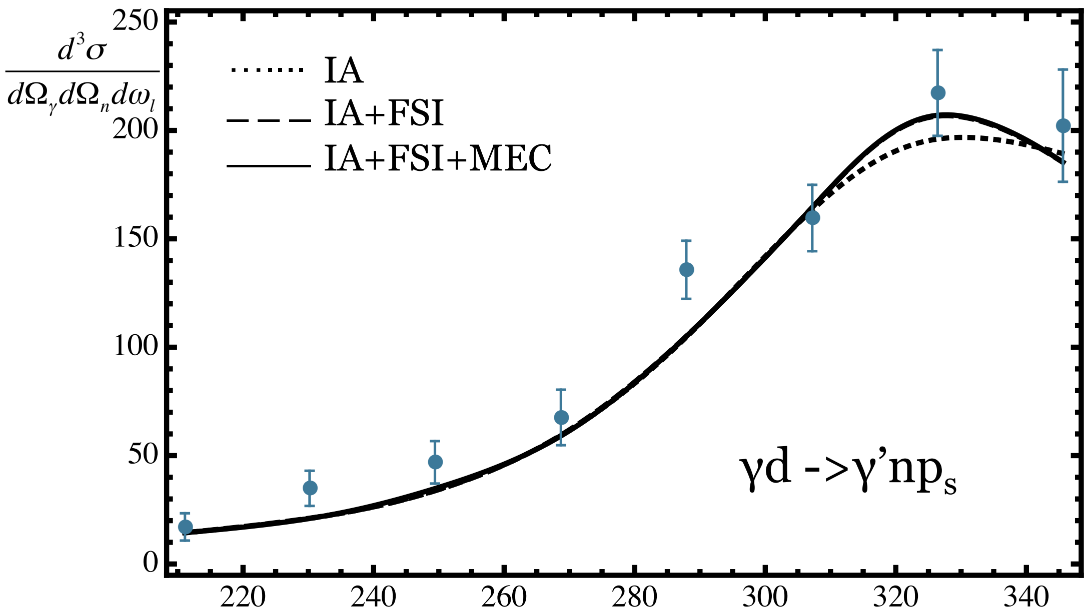
$V_{1\pi}$

C_s and C_t fixed

- n p bound system : deuteron
  - ✓ $E_b = 2.224$
- n p scattering
  - ✓ scat. length = -23.7

Meson Exchange Current

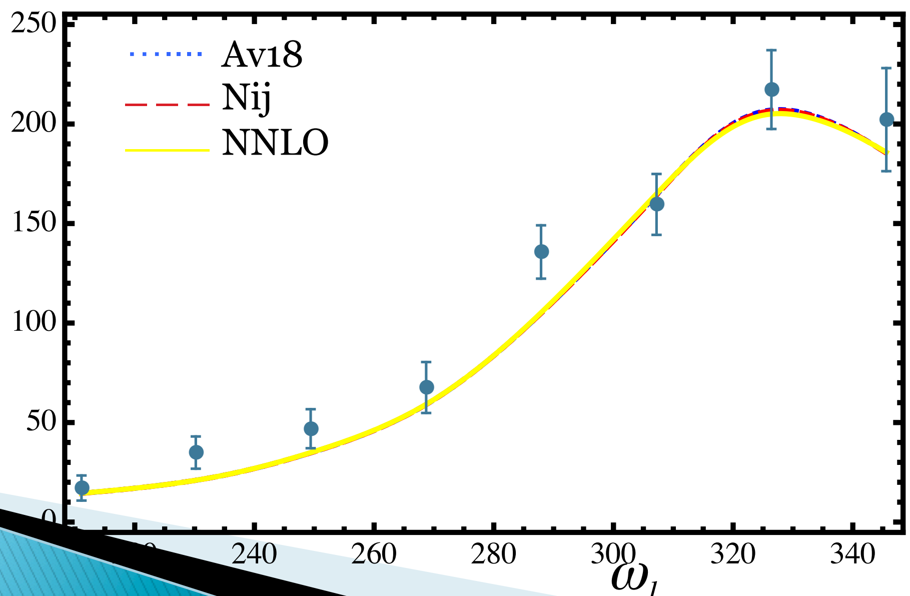




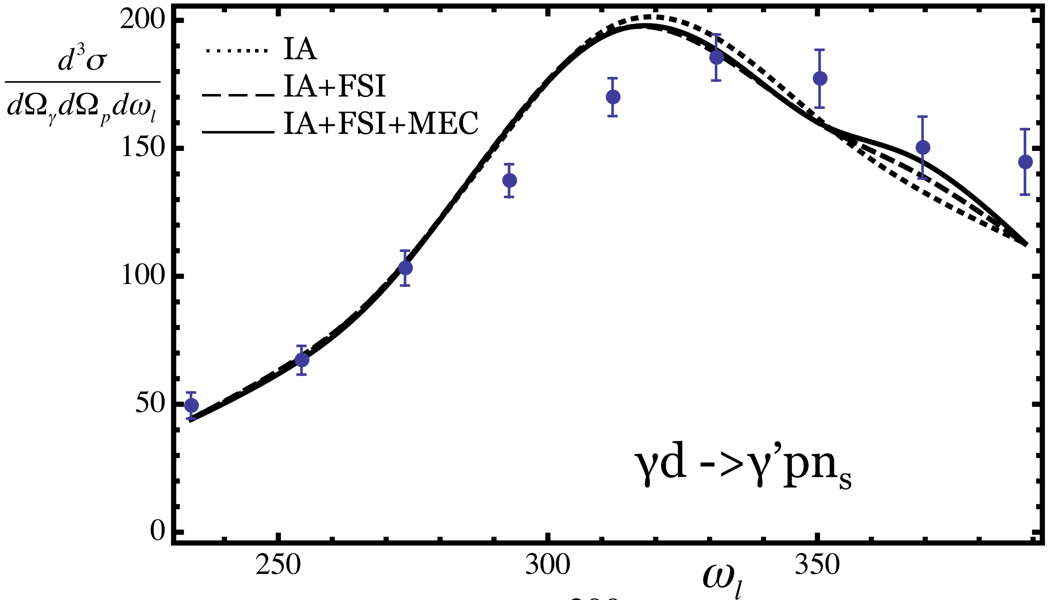
Currently established values

- $\alpha_n = 11.55$ $\beta_n = 3.65$

χ^2 /d.o.f = 1.2



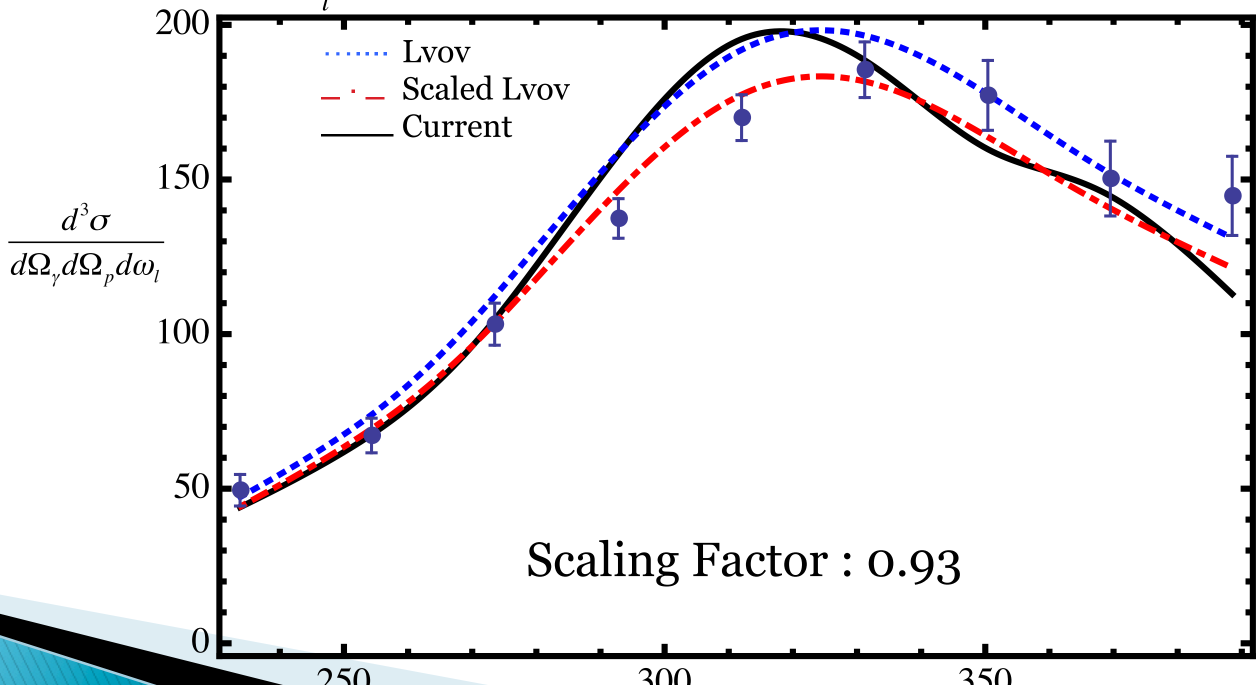
No significant deuteron wave function dependence.



Currently established values

- $\alpha_p = 10.65$ $\beta_p = 3.15$

χ^2 /d.o.f = 3.4



Future Goals

- Improve the description of proton quasi-free region
    - ✓ Establish consistent description of data from elastic Compton on the proton and quasi-free proton from inelastic Compton on the deuteron
- Extract α_n and β_n
- Extract $\gamma^{(n)}_{\pi}$
- Implementation which separates inelastic Compton events from elastic ones for Hiγs experiments

N^7LP

Conclusion

- Neutron polarizability from $\gamma n \longrightarrow \gamma n$

- χEFT is - model independent
  - well defined uncertainties

- Analyze all Compton data using the same framework – χEFT

- data-theory consistency shows discrepancy

- Stay tuned for more !

Thank You