October 30, 2020

DNP2020

Fall Meeting of the Division of Nuclear Physics
of the American Physical Society
Oct. 29 – Nov. 1, 2020 *Now Virtual Meeting!*
~~Hyatt Regency Hotel, New Orleans, LA~~

APS physics

N→N* transition GPD measurements with CLAS12 at JLAB

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for the CLAS collaboration

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Physics Motivation

3D structure of the ground state nucleon: Classical GPDs

➔ Measured with processes like DVCS, DVMP, …

3D structure of excited nucleon states: transition GPDs

8 twist-2 GPDs:

unpolarized:

$$\int_{-1}^{1} dx H_M(x;\xi;t) = 2G_M^*(t)$$

$$\int_{-1}^{1} dx H_E(x;\xi;t) = 2G_E^*(t)$$

$$\int_{-1}^{1} dx H_C(x;\xi;t) = 2G_C^*(t)$$

$$\int_{-1}^{1} dx H_4(x;\xi;t) = 0$$

Jones-Scardon EM FF for the N → transition

polarized:

$$\int_{-1}^{1} dx C_1(x;\xi;t) = 2C_5^A(t)$$

$$\int_{-1}^{1} dx C_2(x;\xi;t) = 2C_6^A(t)$$

$$\int_{-1}^{1} dx C_3(x;\xi;t) = 2C_3^A(t)$$

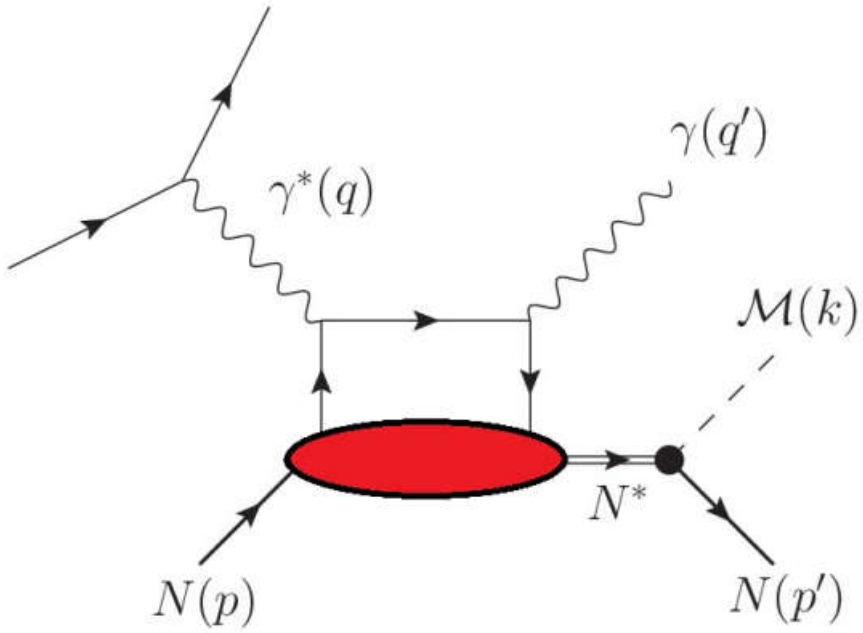
$$\int_{-1}^{1} dx C_4(x;\xi;t) = 2C_4^A(t)$$

Adler form factors

Experimental Access to Transition GPDs

Experimental access: Non diagonal DVCS process

$$\gamma^* p \to N^* \gamma \to p \; meson \; \gamma$$



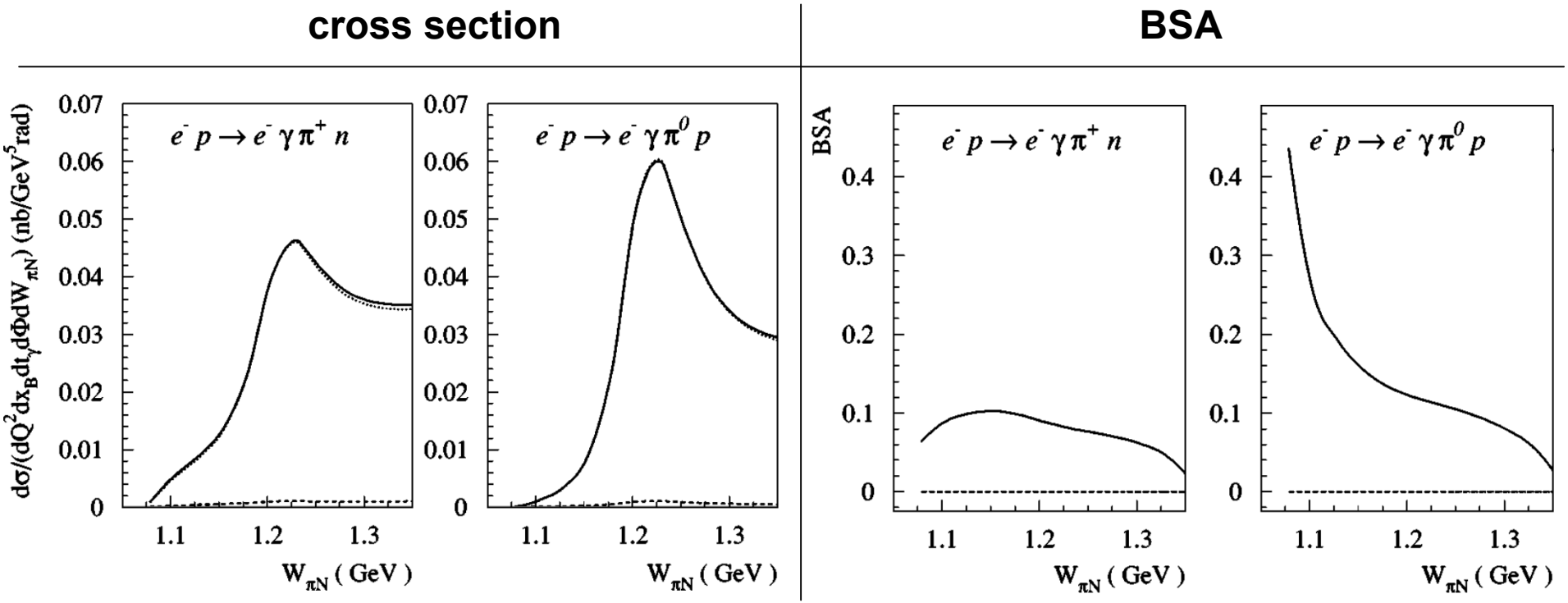
process factorizes for

$-q^2$; $(p+q)^2$ – large; $\quad x_B = \dfrac{-q^2}{2p\cdot q}$ – fixed;

$-t = -(p'-p)^2$; $\quad W^2_{\mathcal{M}N} = (p'+k)^2$ of hadronic scale

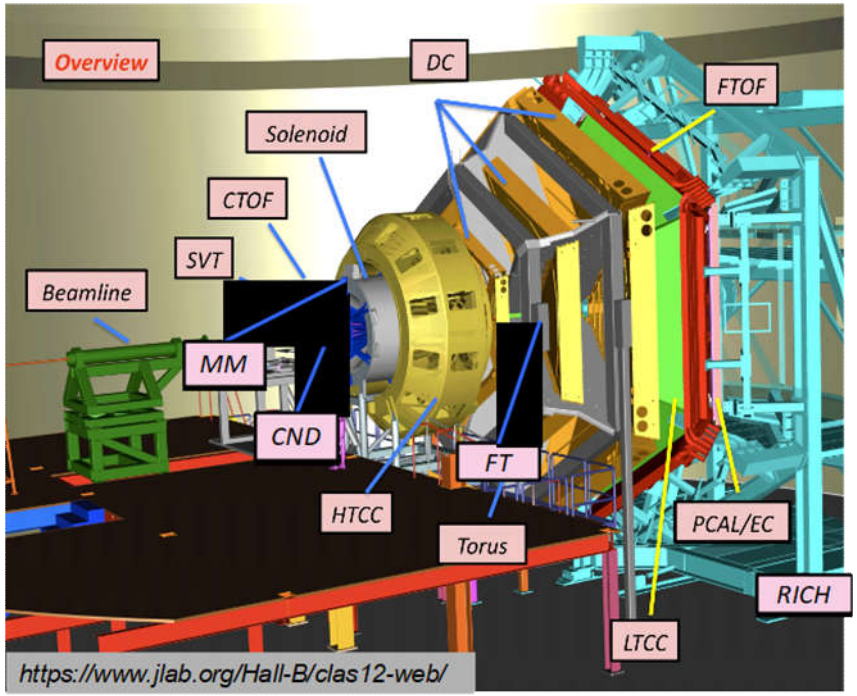
First Theoretical Description of the Δ Region

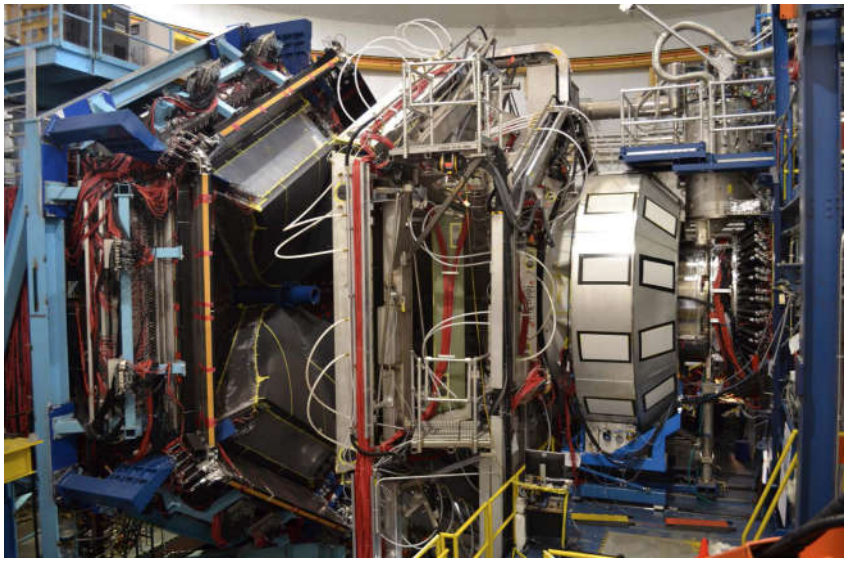
P.A.M Guichon, L.Mosse, M. Vanderhaeghen, Phys. Rev. D68 (2003) 034018



E_e = 6 GeV, Q^2 = 2.5 GeV, x_B = 0.3, t_γ = -0.5 GeV²

CLAS12 Experimental Setup in Hall B





➔ Data recorded with CLAS12 during fall of 2018

➔ 10.6 GeV electron beam ➔ 87 % average polarization ➔ liquid H_2 target

➔ Analysed data ~ 20 % of the approved RG-A beam time

Experimental Observables

Two final states have been studied:

$$\gamma^* p \rightarrow N^* \gamma \rightarrow p\pi^0\gamma \rightarrow p\gamma\gamma\gamma$$

$$\gamma^* p \rightarrow N^* \gamma \rightarrow n\pi^+\gamma$$

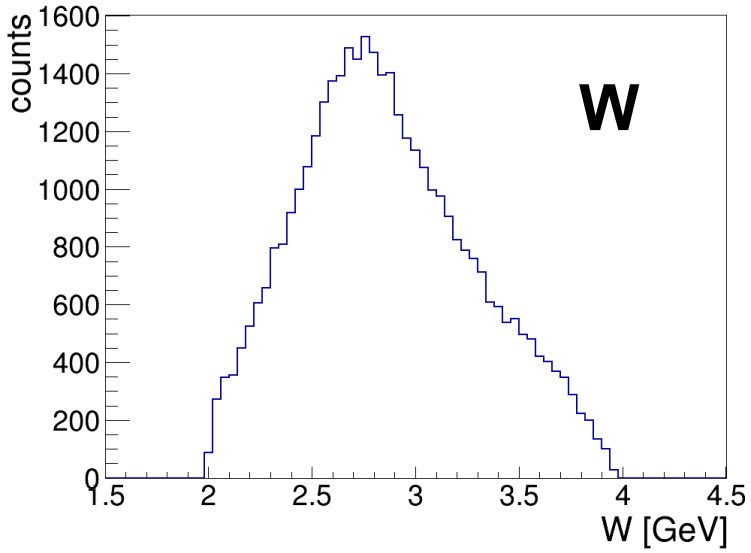
Kinematic cuts:

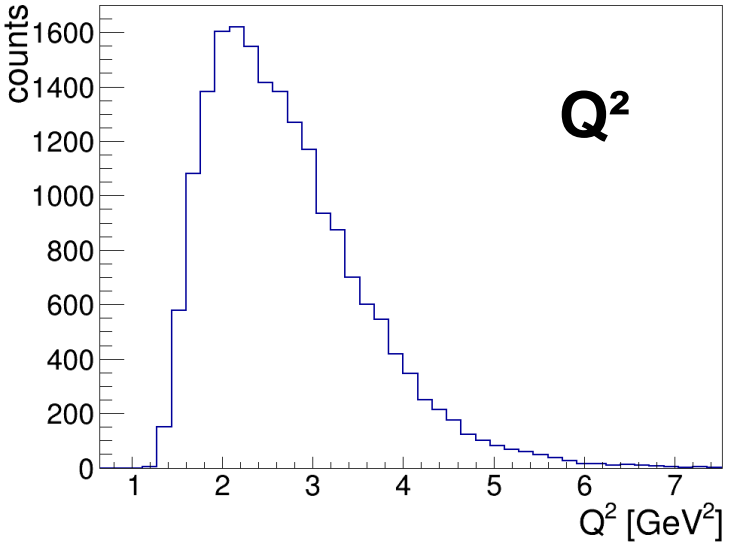
W > 2 GeV $Q^2 > 1$ GeV² y < 0.8 -t < 2 GeV²

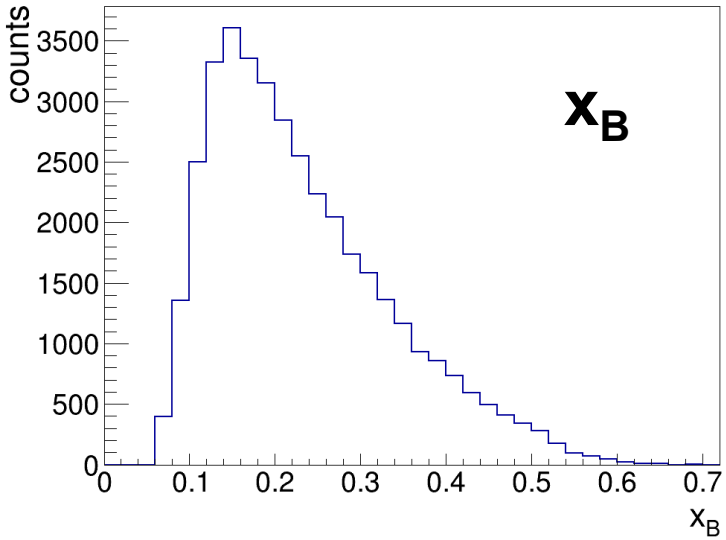
$E_{DVCS} > 2$ GeV

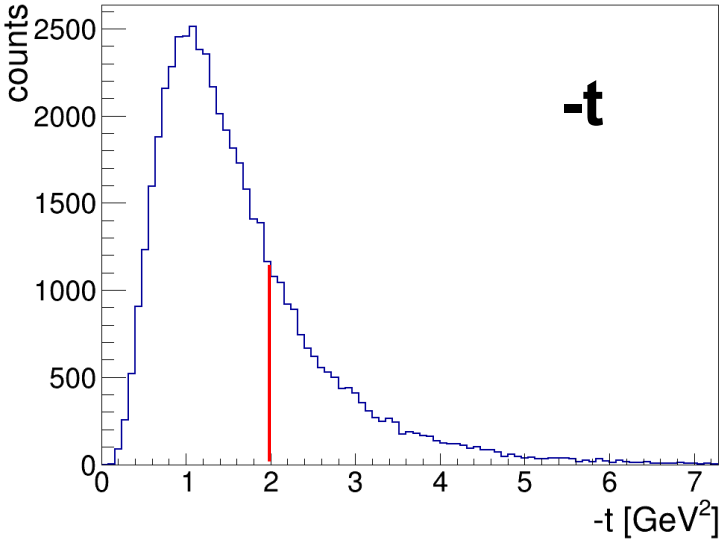
➔ A series of exclusivity cuts has been applied to select fully exclusive events

Accessible Kinematic Region



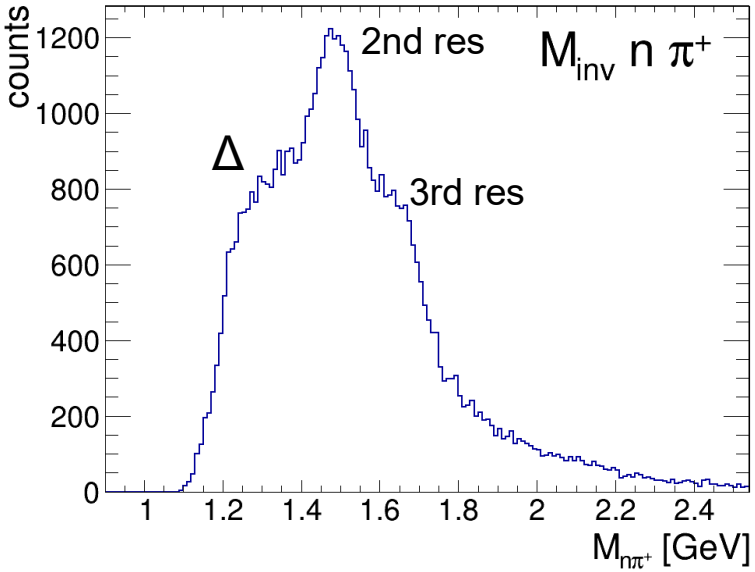




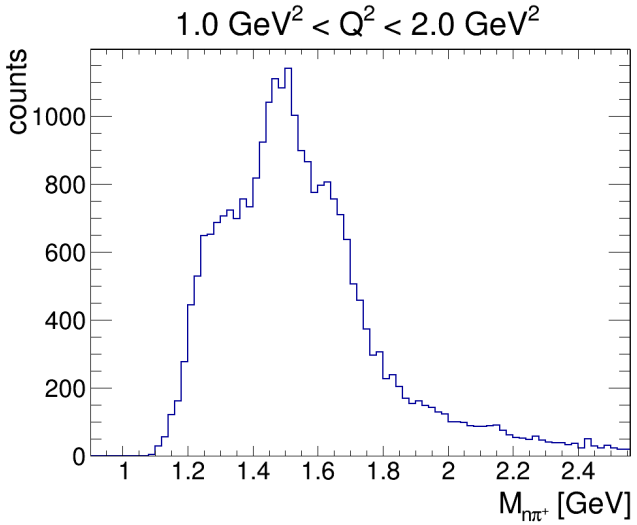


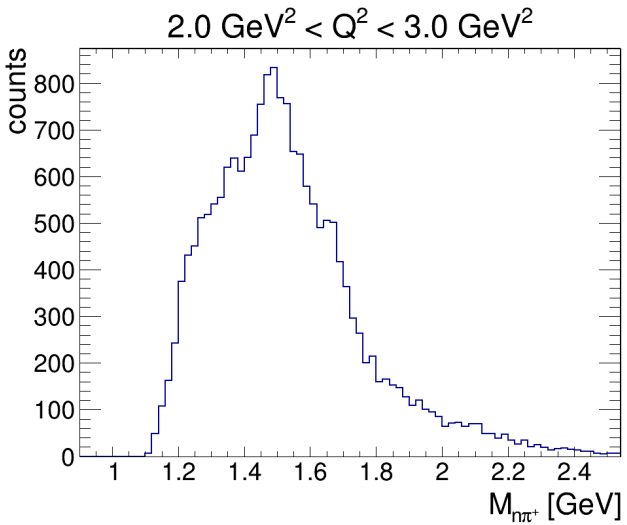
Resonance Mass Spectrum for $N^* \rightarrow n\pi^+$

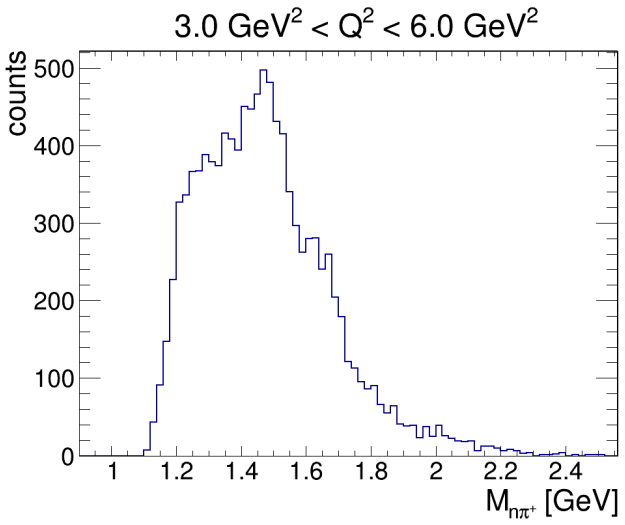
$en\pi^+\gamma$



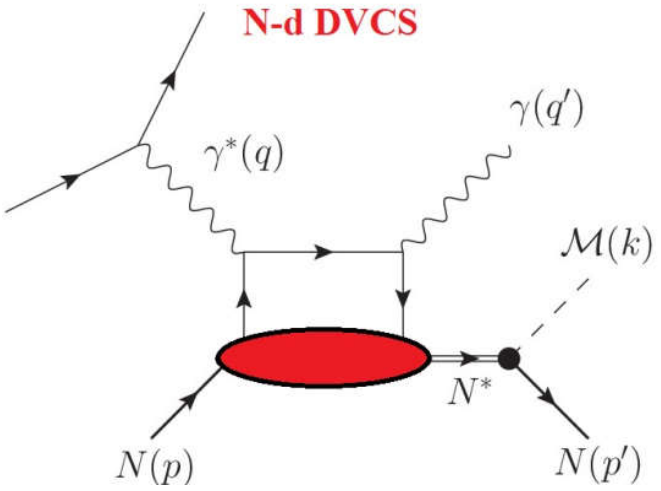
preliminary





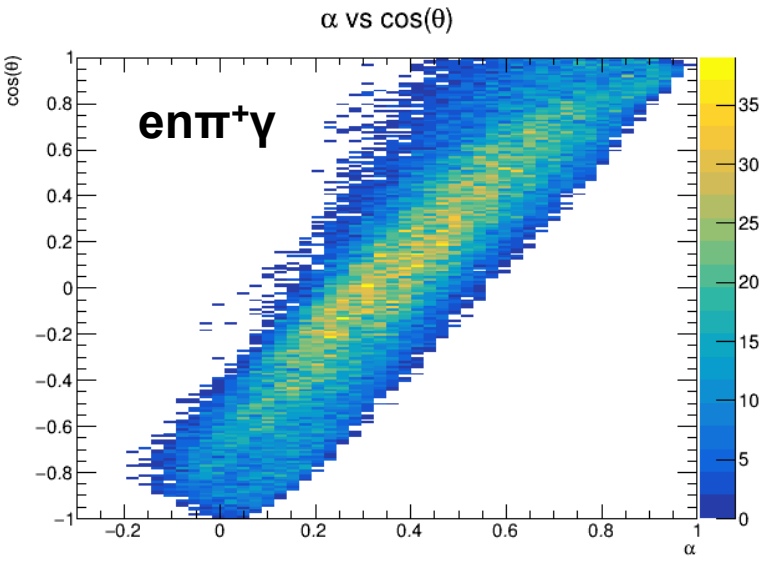


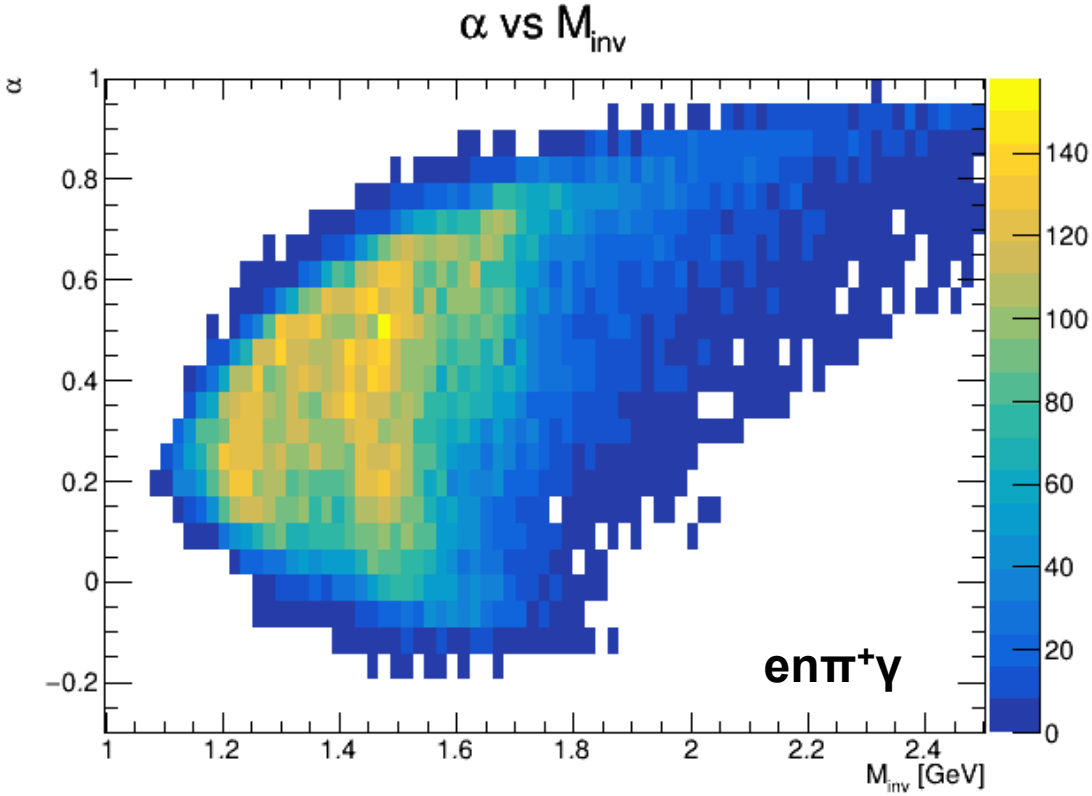
The Pion Longitudinal Momentum Fraction



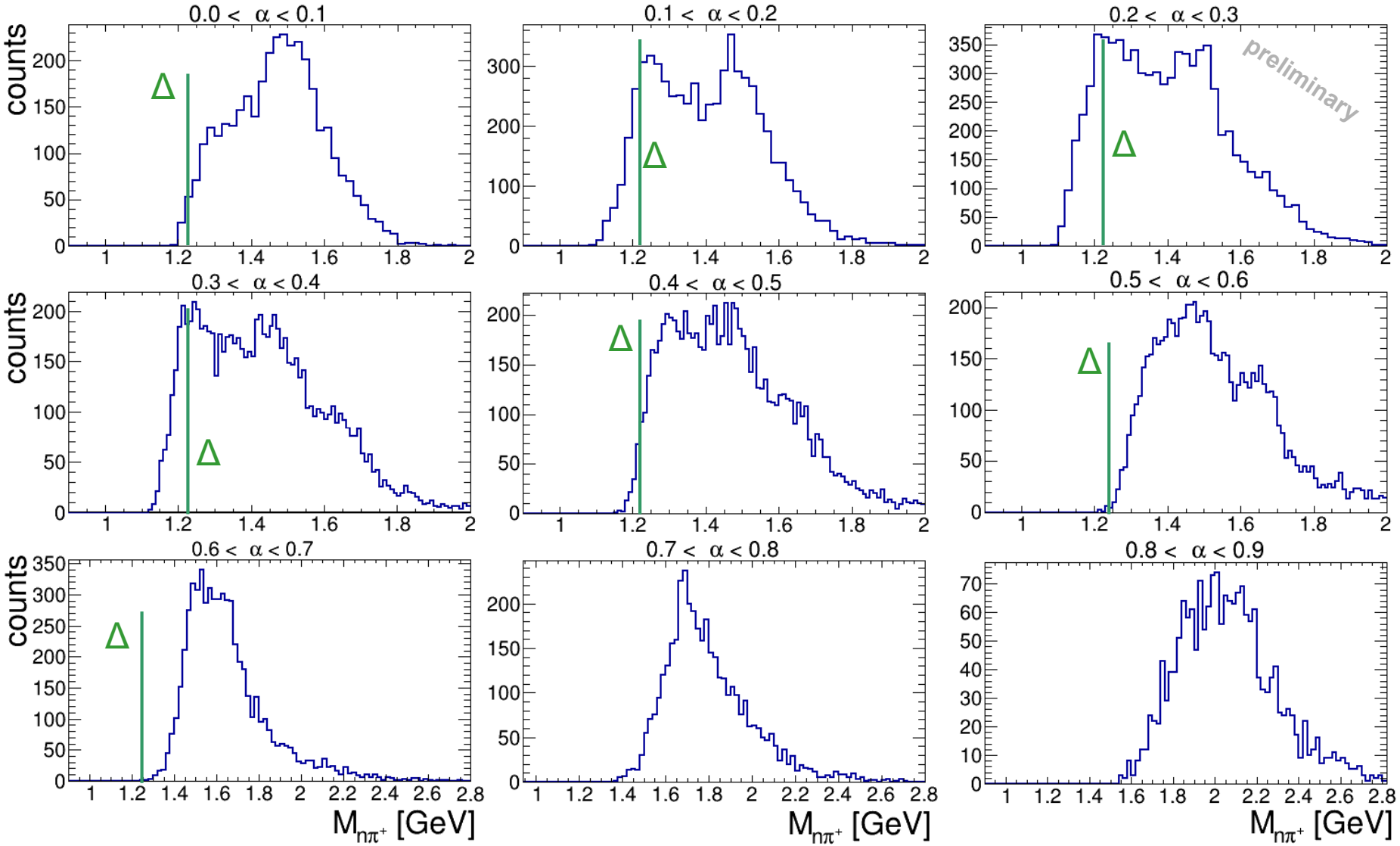
$$\alpha = \frac{(p'+k)\cdot k}{(p'+k)^2}$$

$$H_i^{(0)}\,(x, \xi, \alpha, t, W^2)$$



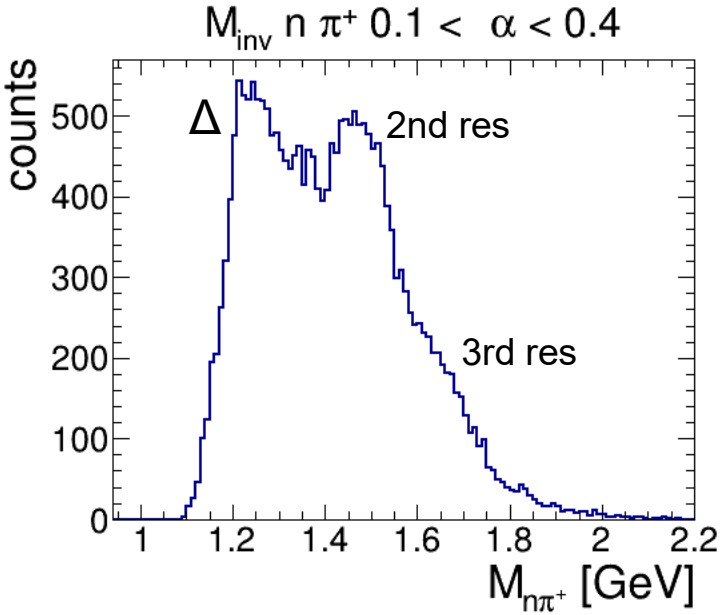


Resonance Mass Spectrum in Bins of α for $N^* \rightarrow n\pi^+$



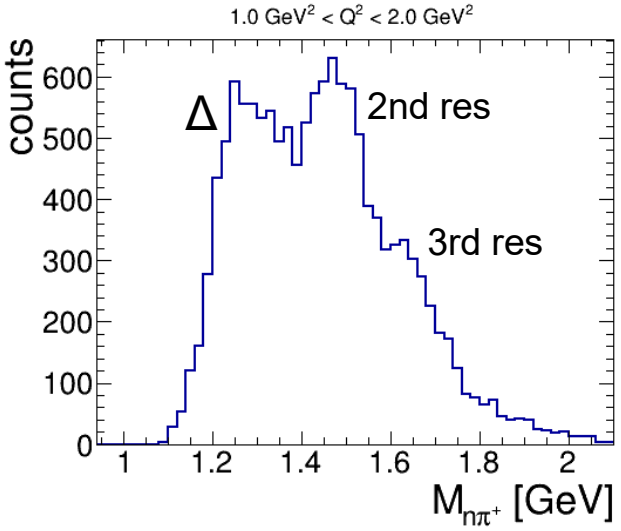
Resonance Mass Spectrum for 0.1 < α < 0.4

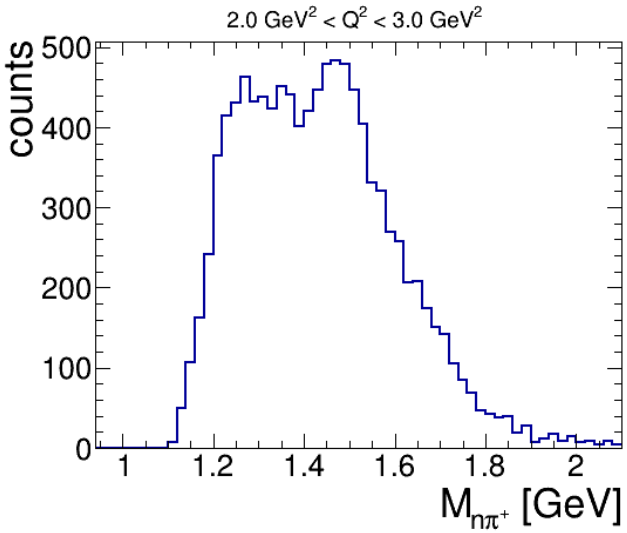
enπ⁺γ

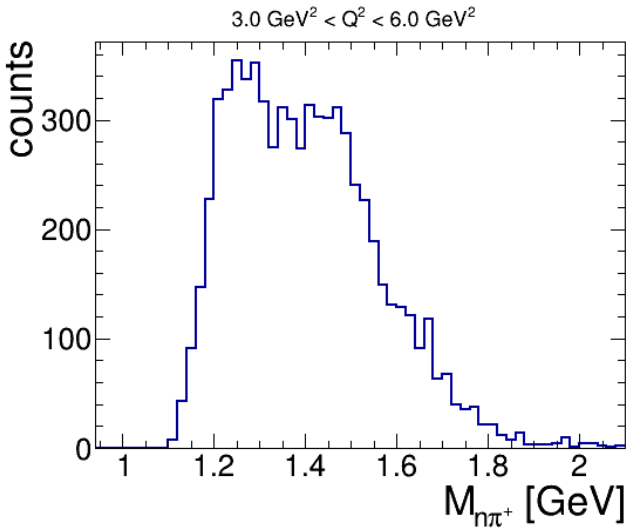


preliminary

Q² dependence:

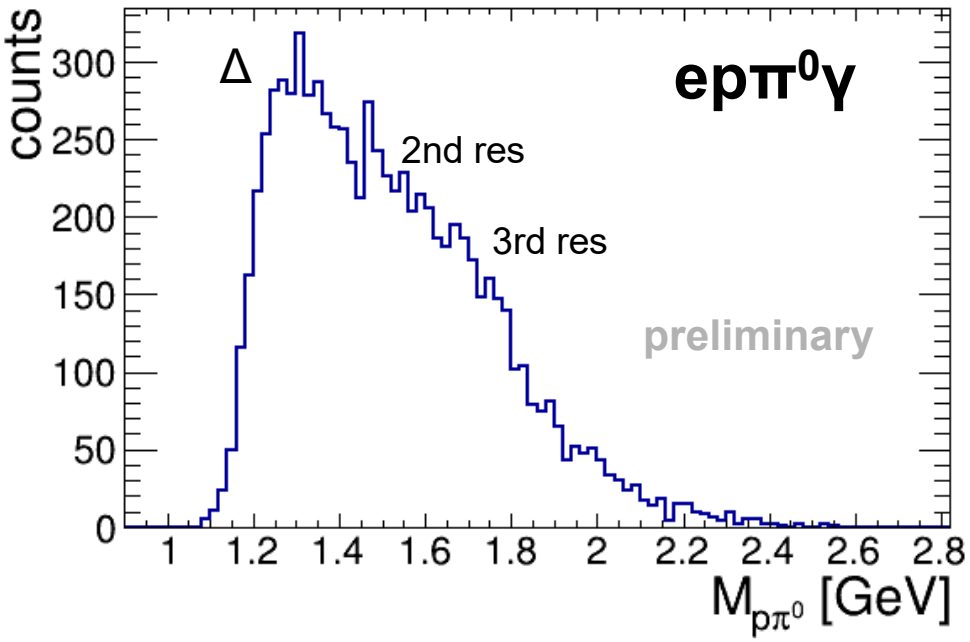




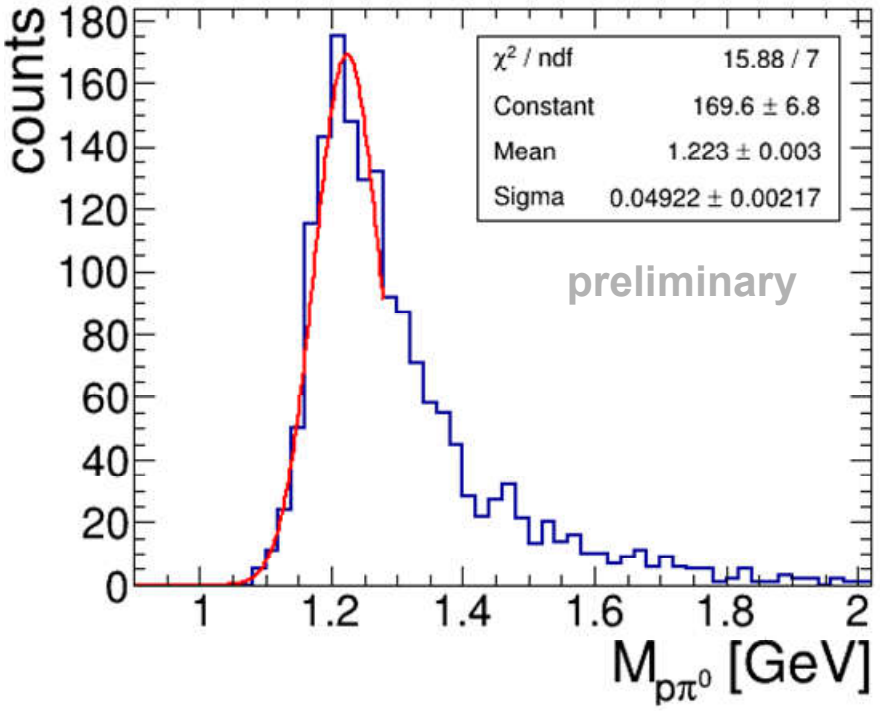


Resonance Mass Spectrum for N* → pπ⁰

full spectrum, no cuts



0.1 < α < 0.4

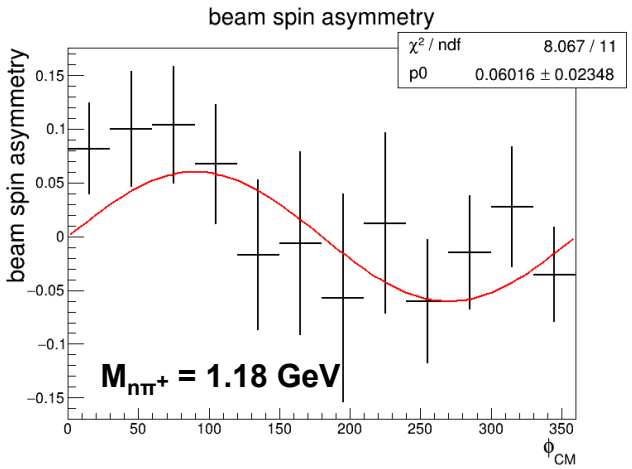


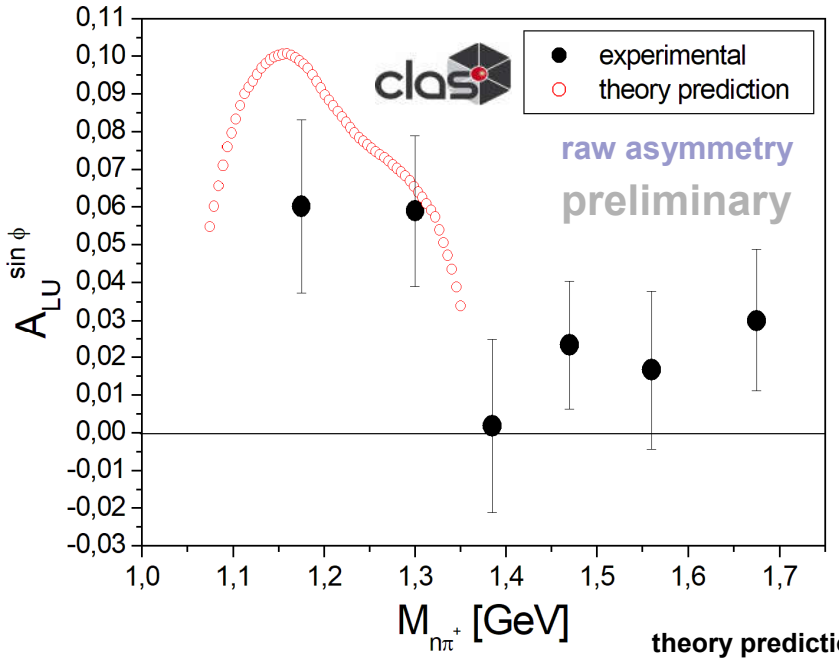
➔ Also for the pπ⁰ final state, a cut on α helps to separate clean Δ events

Beam spin asymmetries

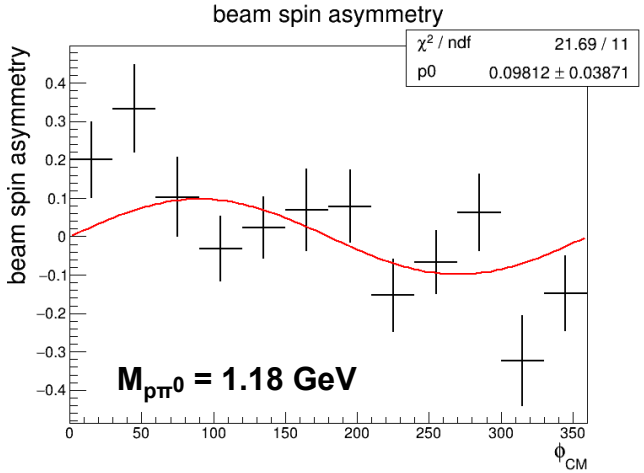
$$A = \frac{1}{P}\frac{N^+ - N^-}{N^+ + N^-} \approx A_{LU}^{\sin\phi}\sin\phi$$

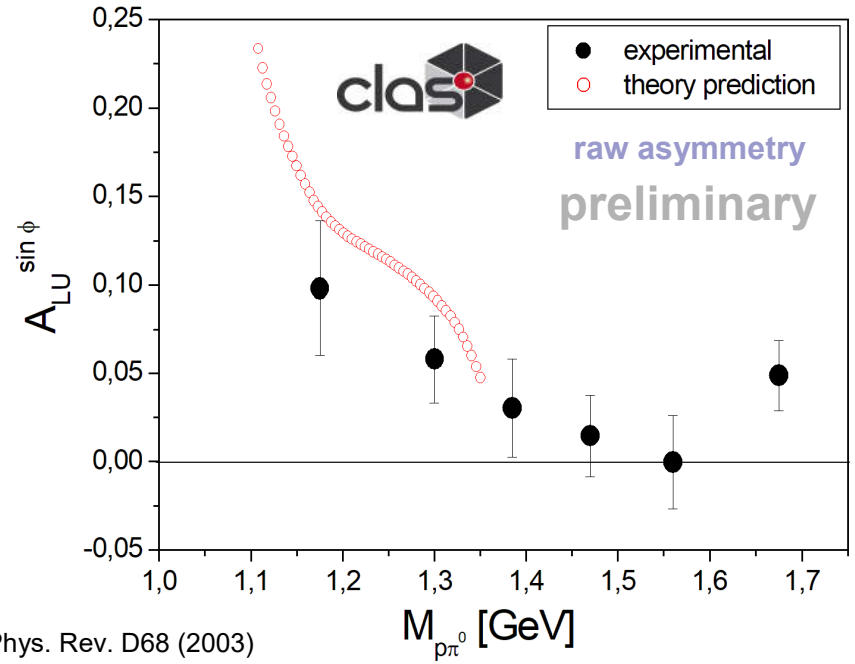
enπ⁺γ





epπ⁰γ





theory prediction: Phys. Rev. D68 (2003)

Conclusion and Outlook

- CLAS12 in combination with the upgraded CEBAF provide excellent conditions to measure the non-diagonal DVCS process
- Resonance structures can be identified in the pion – nucleon invariant mass spectrum
- A cut on the pion longitudinal momentum fraction α can help to separate the Δ resonance
- A first BSA extraction provides a qualitative agreement with transition GPD based theory predictions