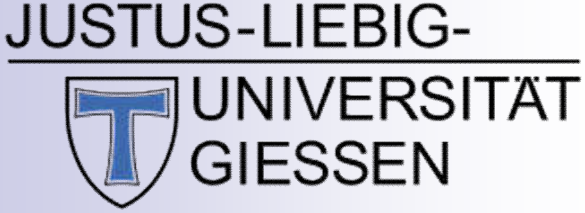
CLAS collaboration meeting

November 14, 2019, Newport News, VA

Measurement of transition GPDs and baryon spectrosopy in non-diagonal DVCS



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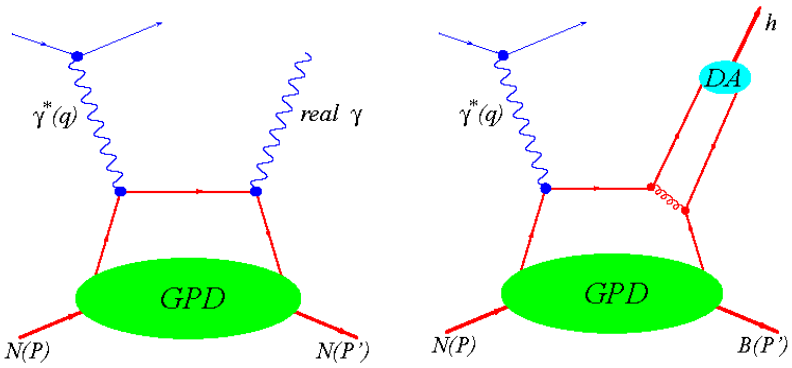
Theory collaboration: M. Polyakov, K. Semenov-Tian-Shansky

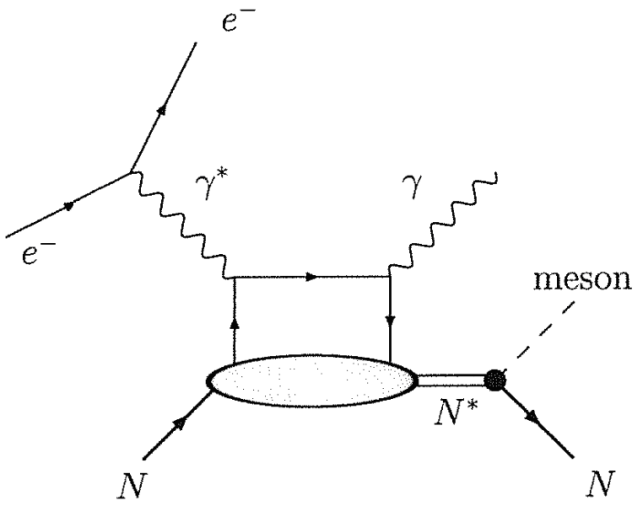
Introduction

Classical **DVCS** can only access chiral-even GPDs (chirality conservation)



DVMP can acess chiral-odd (transversity) GPDs, but process includes a pion DA

non-diagonal DVCS can access chiral-odd quark GPDs without the involvement of a DA



➔ Transversity GPDs provide access to the transverse spin densities inside the nucleon

➔ Transversity density appears due to spin-orbit correlations in the quark wave functions

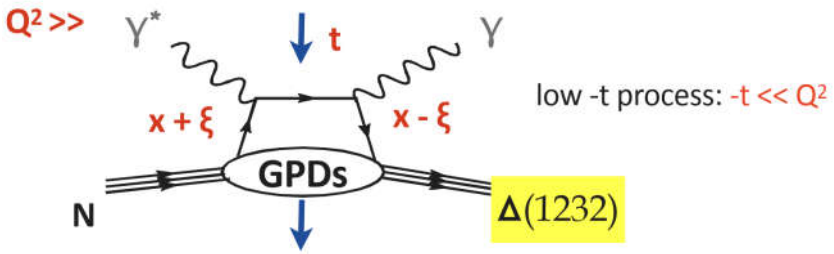
➔ Important contribution to solve the spin-puzzle of the nucleon

Introduction

$$\gamma^* + N \rightarrow \gamma + N^* \rightarrow \gamma + [meson + N]$$

Factorisation for: $Q^2 >> M_{N\pi}^2 > 1GeV^2$ $\quad |t| << m_N^2 \approx 0.9GeV^2$ $\quad |t|/Q^2 << 1$

<u>Special, theoretically well described case</u>: N →Δ(1232) magnetic dipole GPD



8 twist-2 **GPDs(x, ξ, t):** 4 unpolarized, 4 polarized

unpolarized GPDs: H_M, H_E, H_C, H_4

$$\int_{-1}^{+1} H_M(x,\xi,t) = 2G_M^*(t)$$
$$\int_{-1}^{+1} H_E(x,\xi,t) = 2G_E^*(t)$$
$$\int_{-1}^{+1} H_C(x,\xi,t) = 2G_C^*(t)$$
$$\int_{-1}^{+1} H_4(x,\xi,t) = 0$$

Jones-Scardon em FFs for N→Δ

➔Similar relations for polarized GPDs

Large N_C:

$$H_M(x,\xi,t) = 2\frac{G_M^*(0)}{\kappa_V}\{E^u(x,\xi,t) - E^d(x,\xi,t)\}$$

$$G_M^*(t) = \frac{G_M^*(0)}{\kappa_V}\int_{-1}^{+1}\{E^u(x,\xi,t) - E^d(x,\xi,t)\}$$

$$= \frac{G_M^*(0)}{\kappa_V}\{F_2^p(t) - F_2^n(t)\}$$

- Extension to higher resonances is planed

Baryon spectroscopy based on non-diagonal DVCS

Baryon spectroscopy with classical probes:

➔ **Hadronic probes** like πN do not access to the quark-gluon structure of the resonances

➔ **Photo- and electro excitation**: QCD excitation operators are clearly defined, but provide no gluonic degrees of freedom

→ Limited potential for the excitation of gluonic and multi-quark states.

→ Limitation by fixed spin of 1

Non diagonal DVCS can overcome these drawbacks

→ Formalism similar to the electro excitation of N* at low photon virtualities

Advantages: Excitation of N* in non-diagonal DVCS by well defined quark-gluon operators, given by the QCD factorization theorem

$$\langle N^* | \overline{\psi}_\alpha(0) P e^{iq\int_0^z dx_\mu A^\mu} \psi_\beta(z) | N(p) \rangle$$

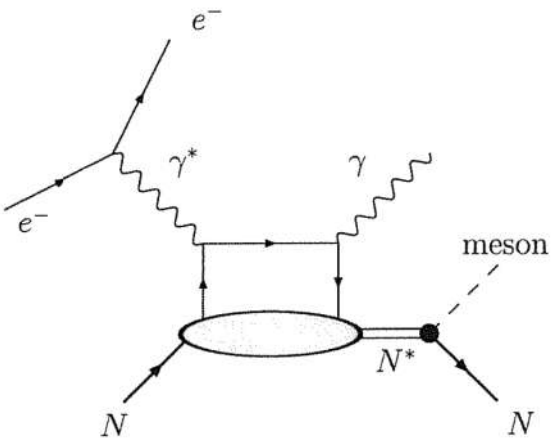
➔ Contain explicitly gluonic degrees of freedom

➔ Non-local which enables the excitation of resonances with arbitrary spin (i.e. 20-plet of the SU(6) spin-flavour group)

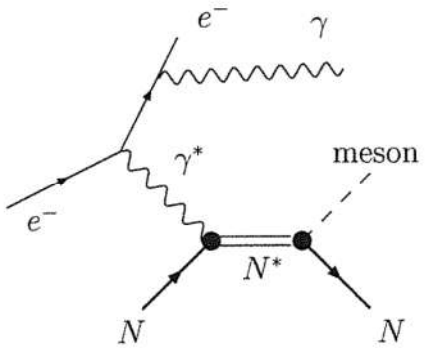
➔ Also exotic configurations will be directly accessible

Background reactions and investigated channels

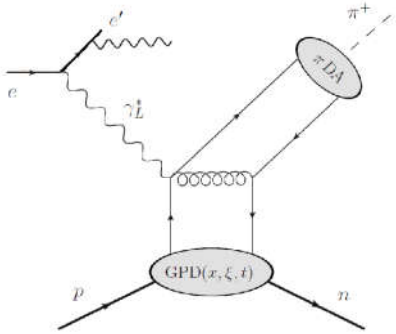
non diagonal DVCS



Bethe - Heitler



deeply virtal meson production with radiative photon



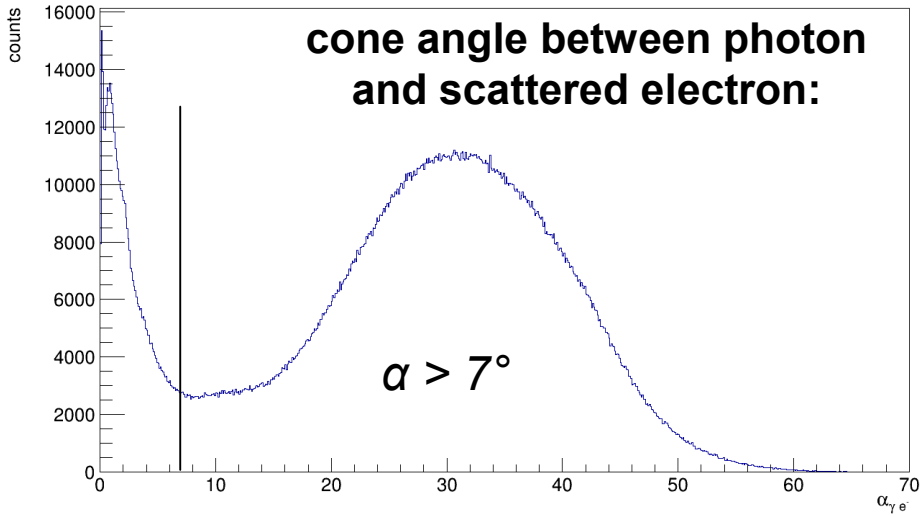
suppressed for small -t values

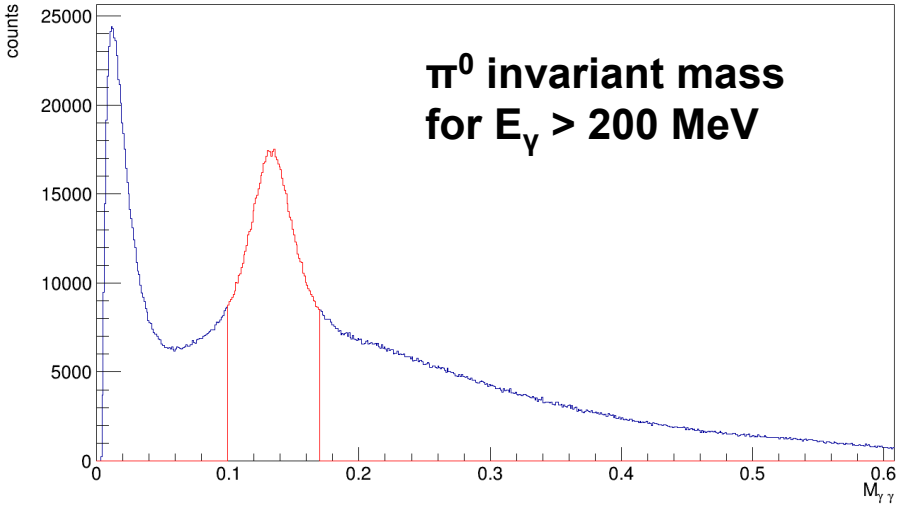
suppression by a cone angle cut and a
cut on the minimal energy for the DVCS photon

Studied reactions:

$$\gamma^* p \to N^* \gamma \to p\ \pi^0 \gamma \to p\ \gamma\ \gamma\ \gamma \qquad \gamma^* p \to N^* \gamma \to n \pi^+ \gamma$$

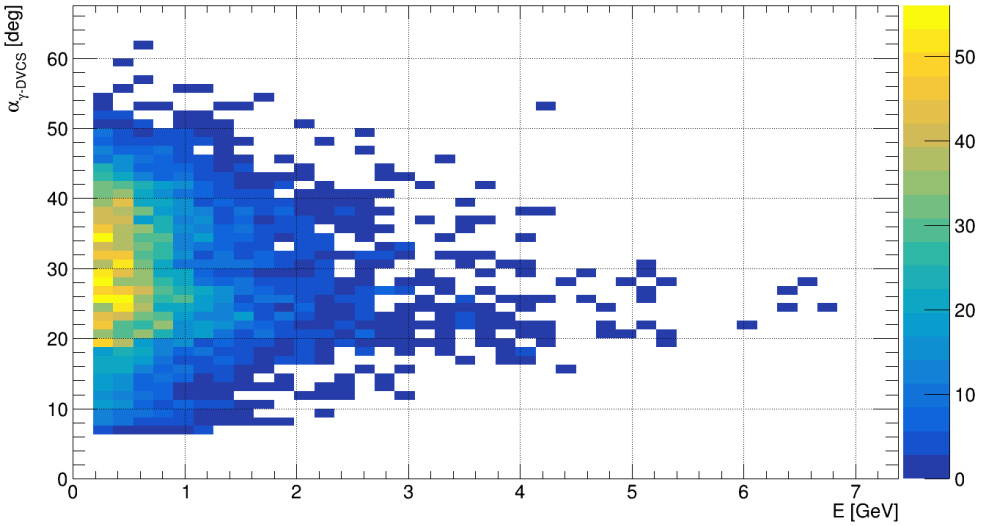
Rejection of radiative photons and π^0 selection





DVCS photon cone angle vs. energy:

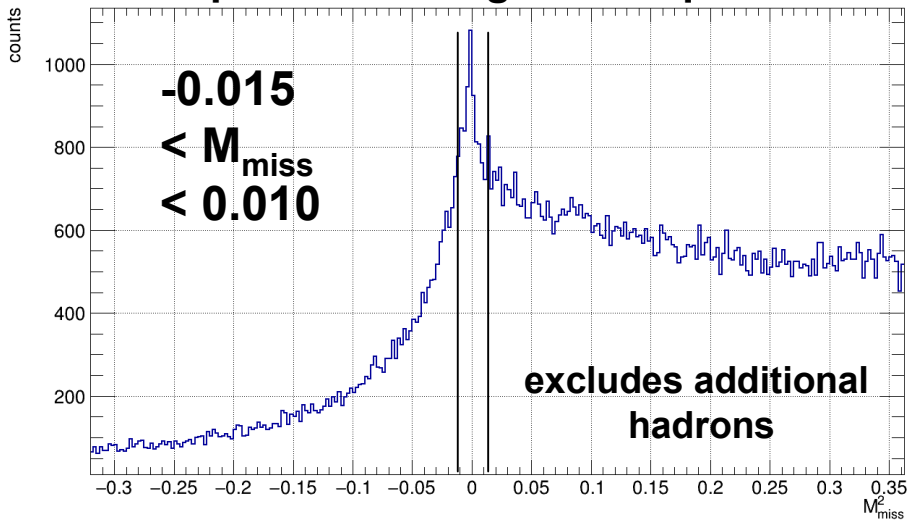
→ photons contributig to the π^0 have been rejected



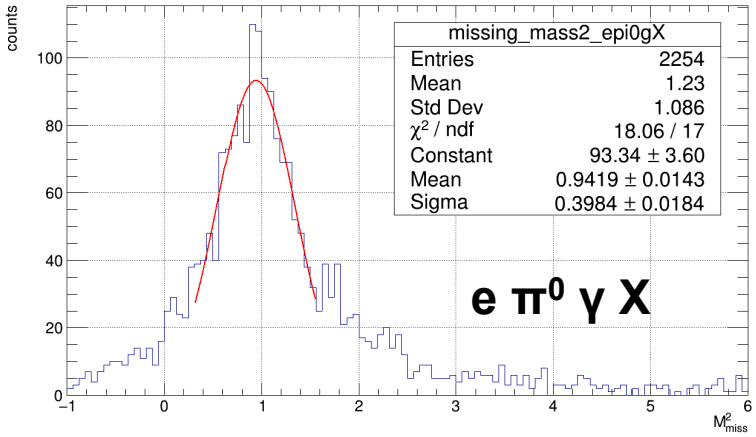
Exclusivity cuts for e p π^0 γ

• all particles detected

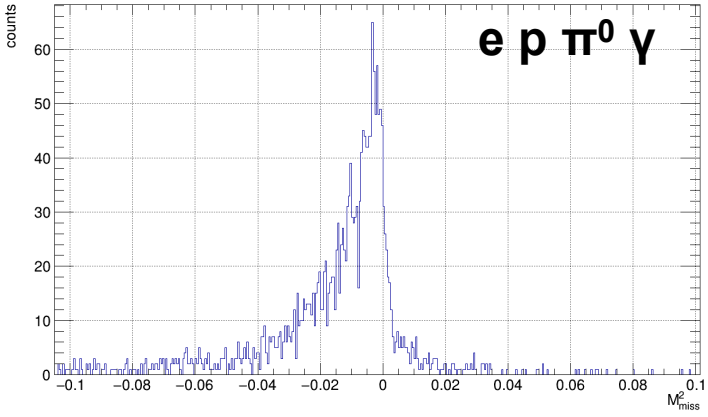
e p π^0 X missing mass squared



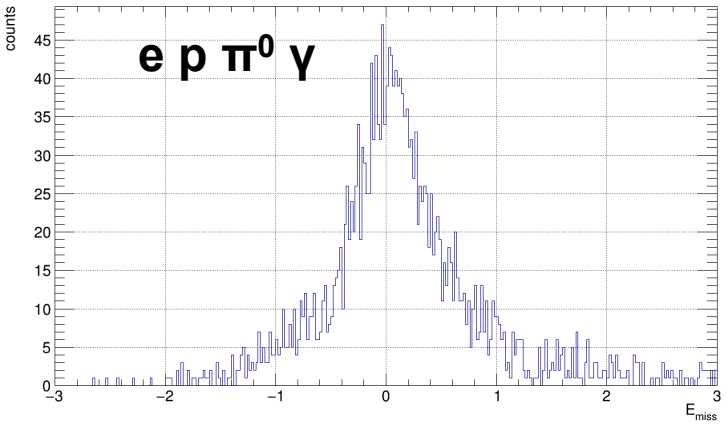
missing proton



exclusive missing mass



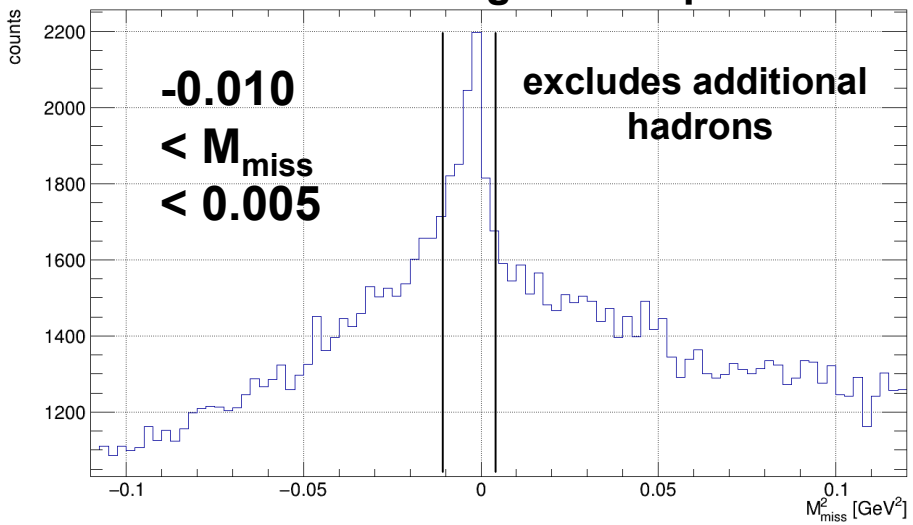
exclusive missing energy



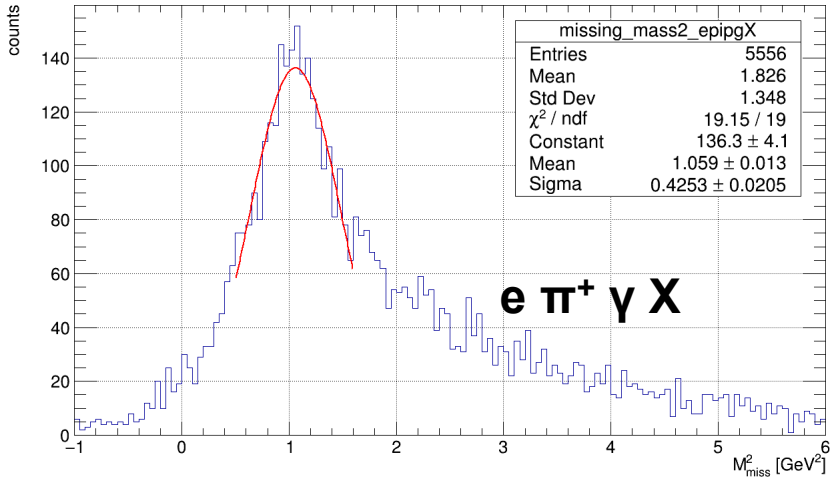
Exclusivity cuts for e n π^+ γ

• all particles detected

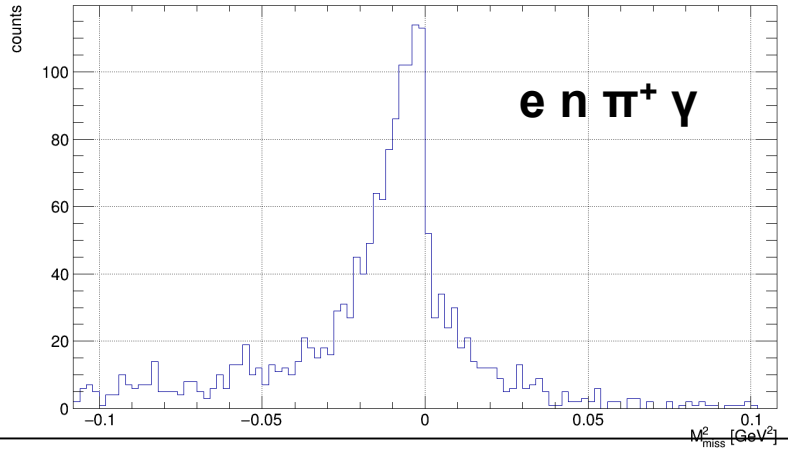
e n π^+ X missing mass squared



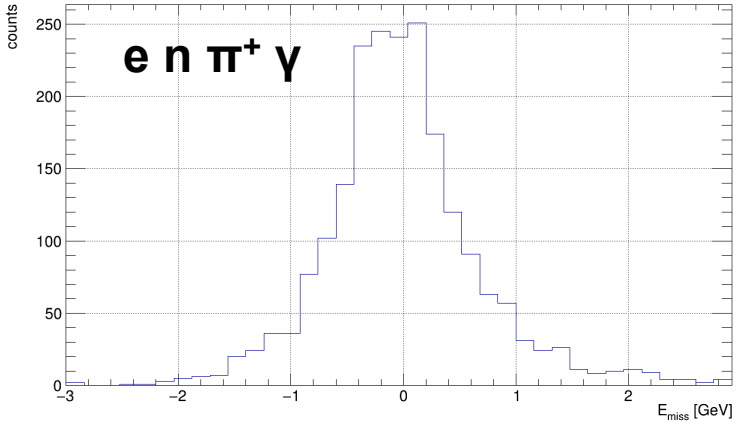
missing neutron



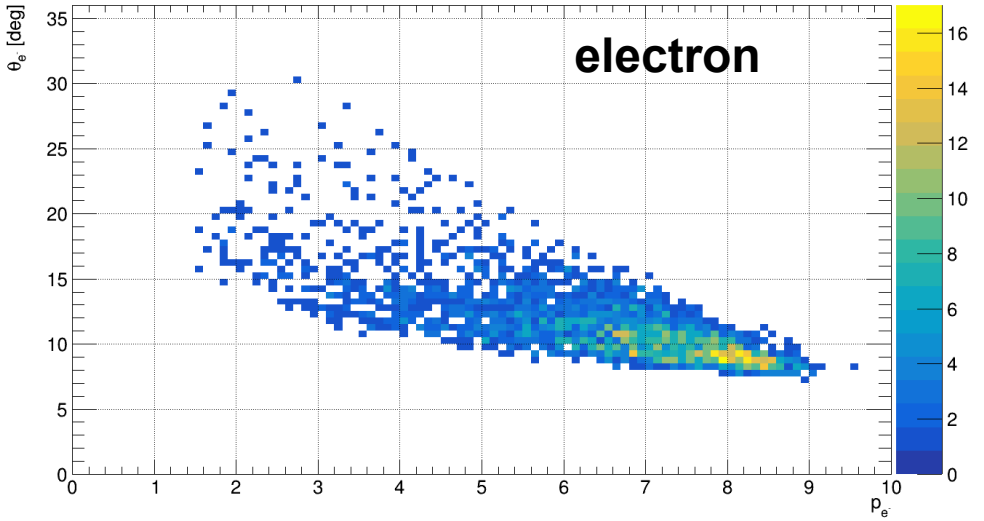
exclusive missing mass

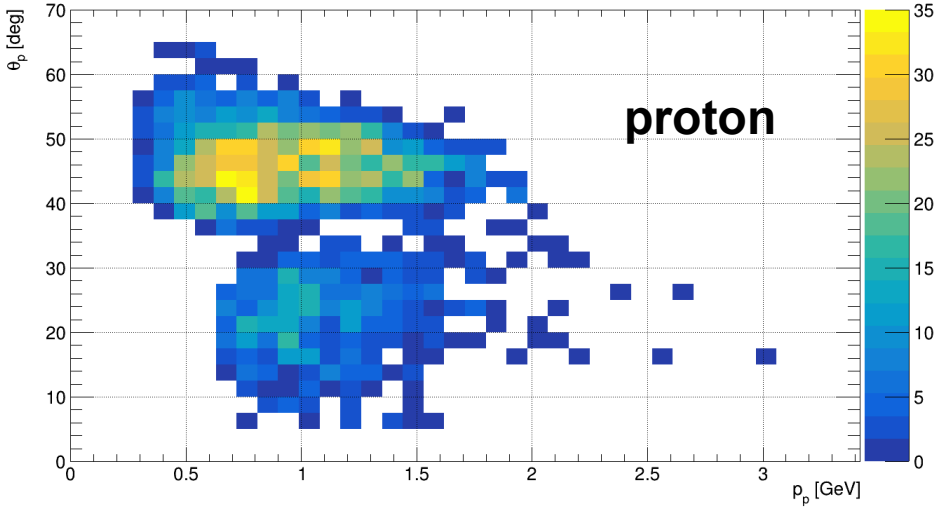


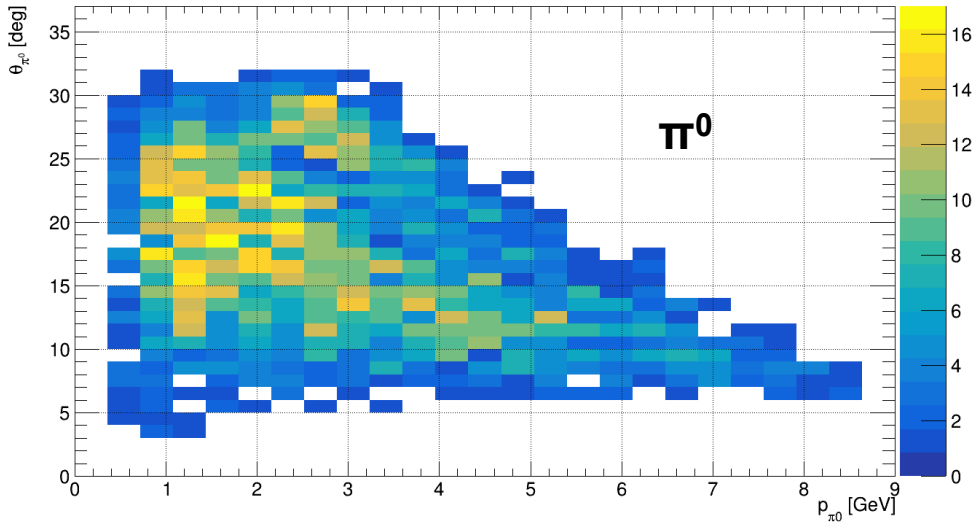
exclusive missing energy

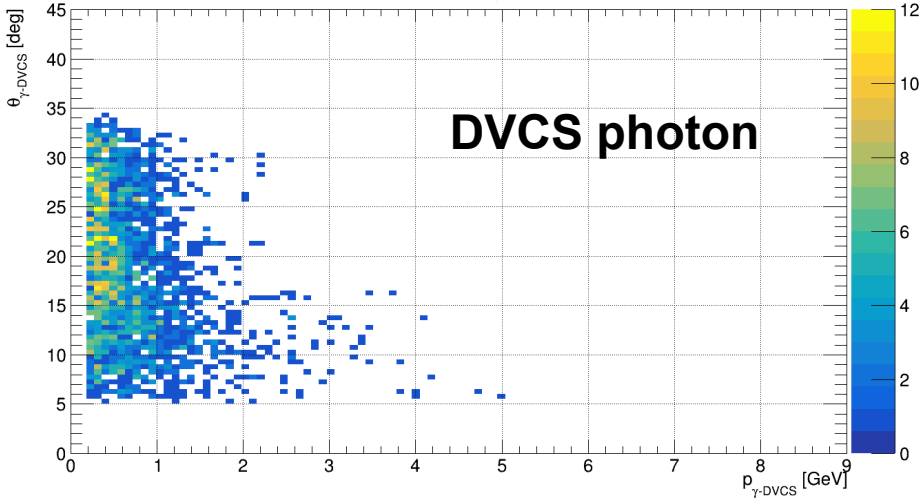


particle distributions for e p π^0 γ

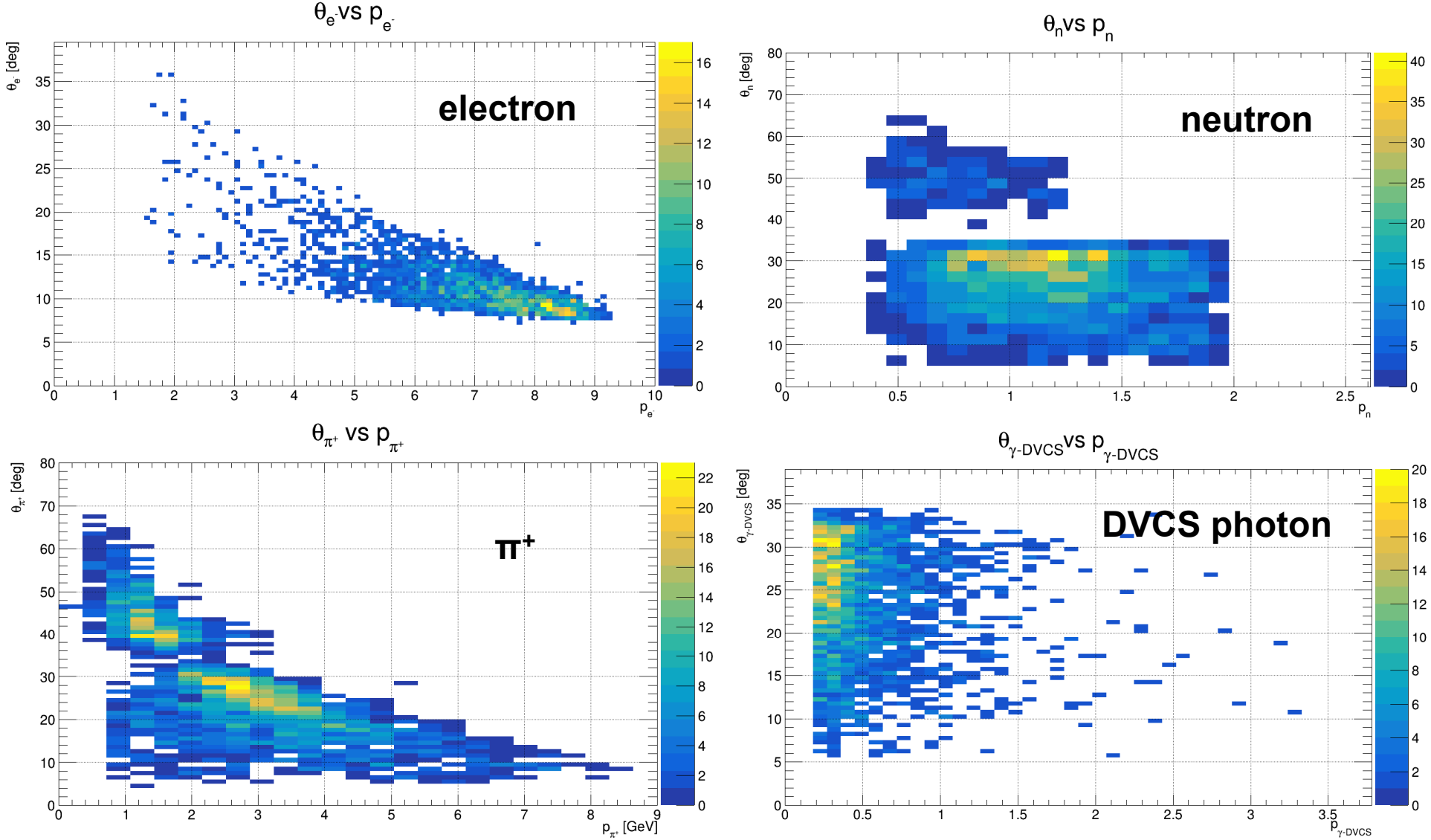




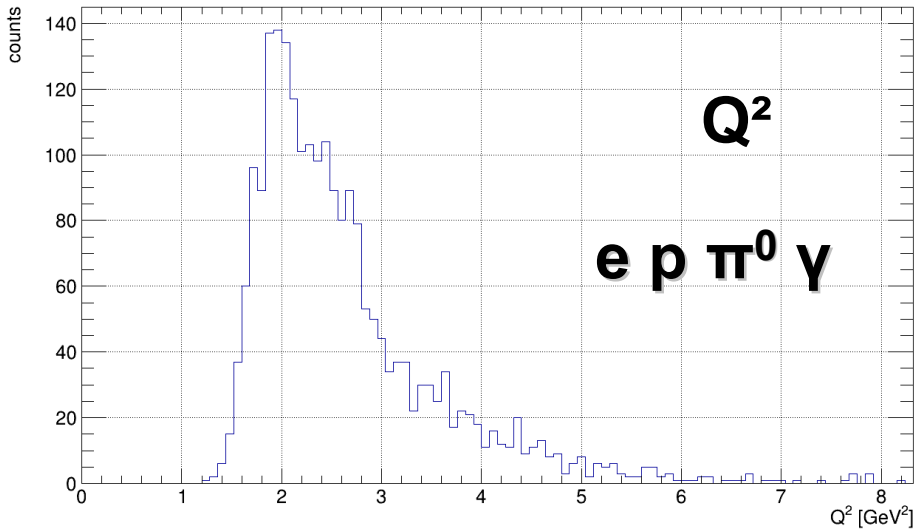


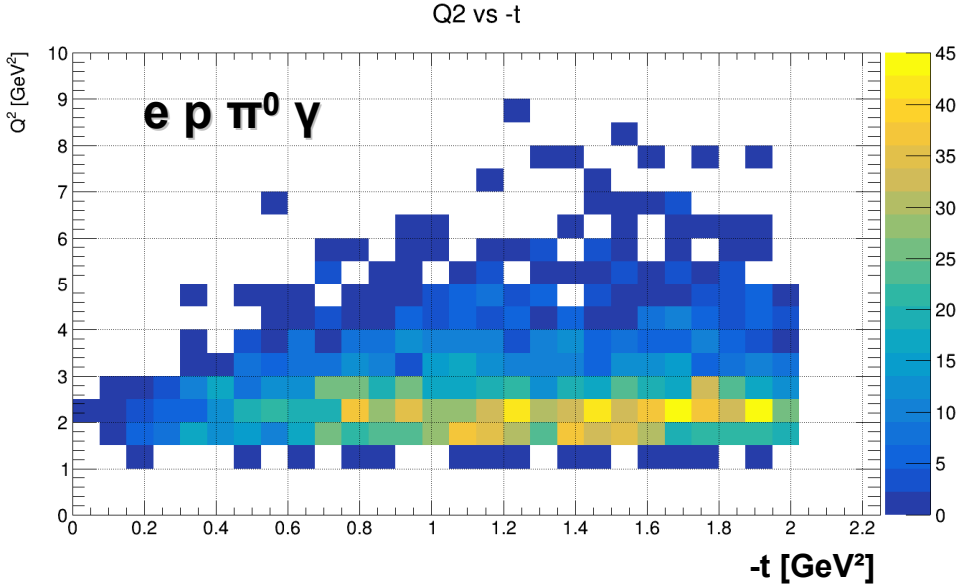


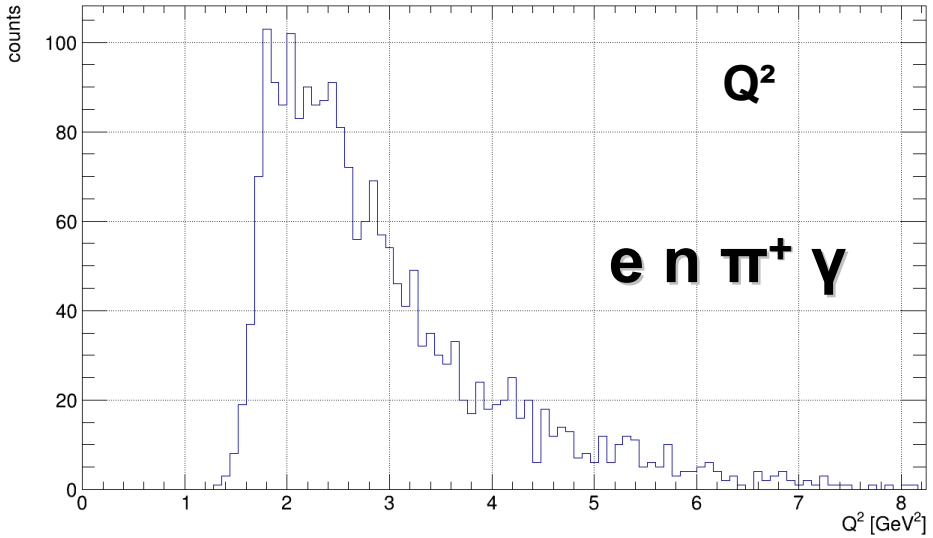
particle distributions for e n π^+ γ

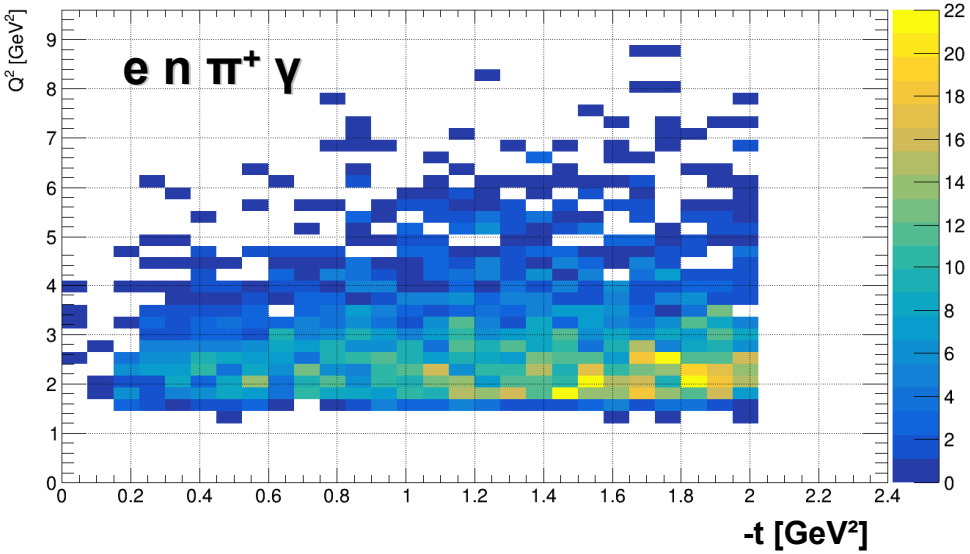


Kinemtaic distributions

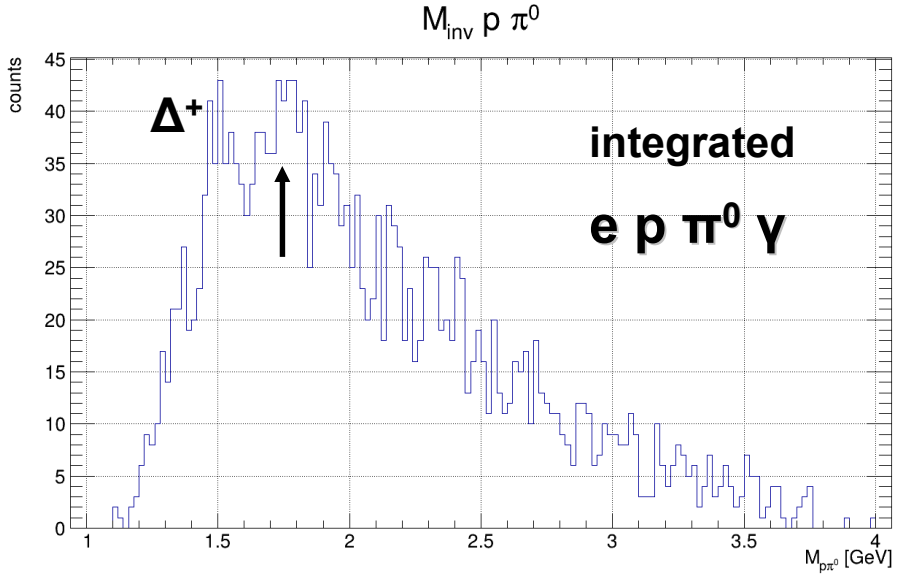


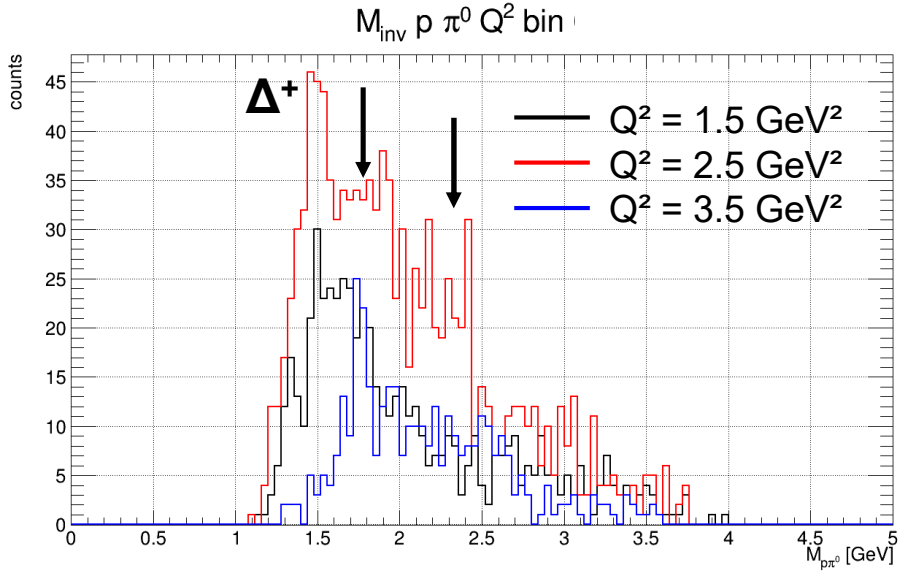




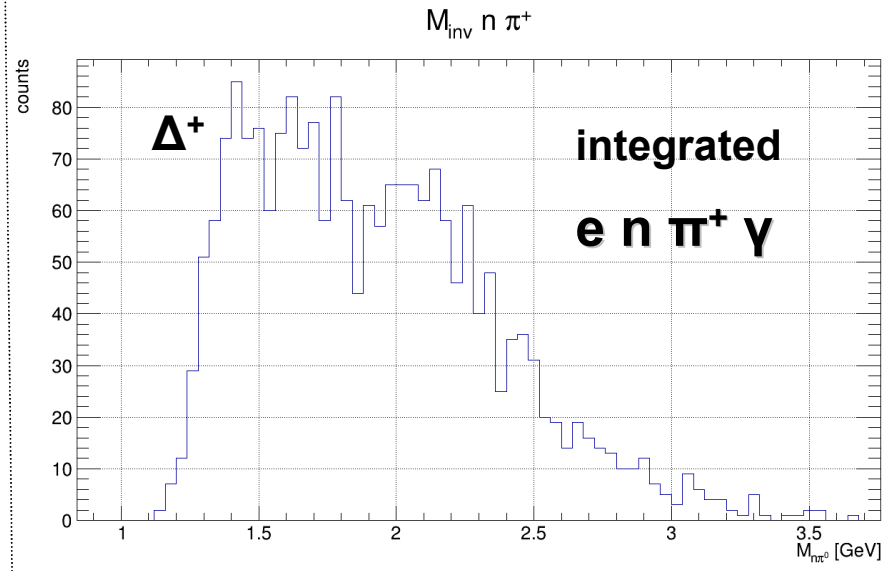


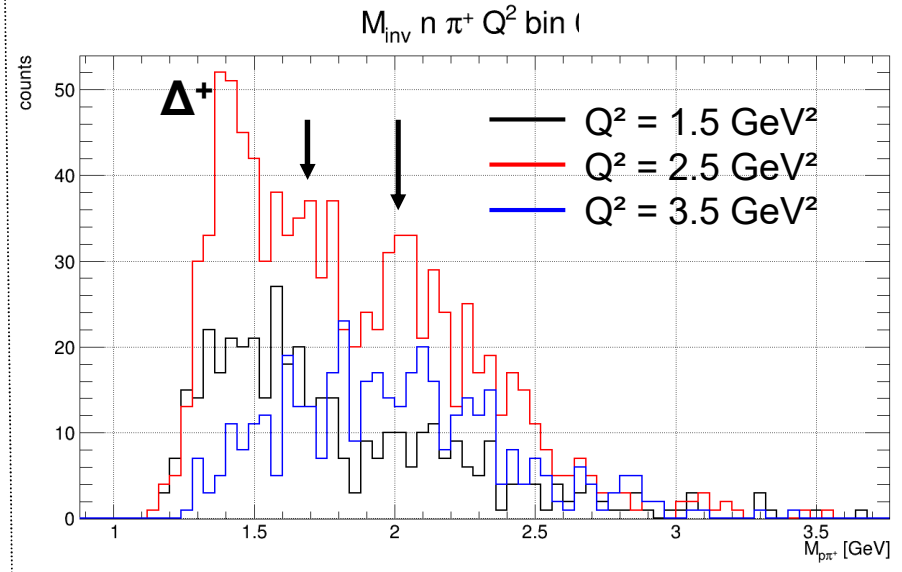
resonance mass for e p π^0 γ



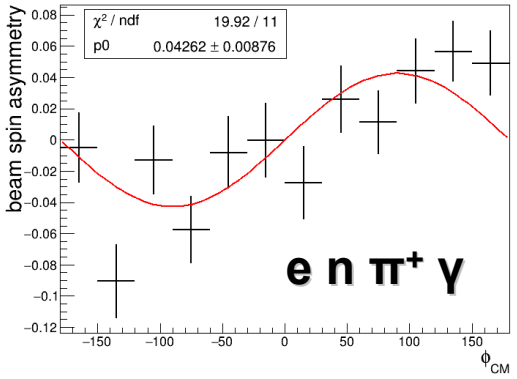


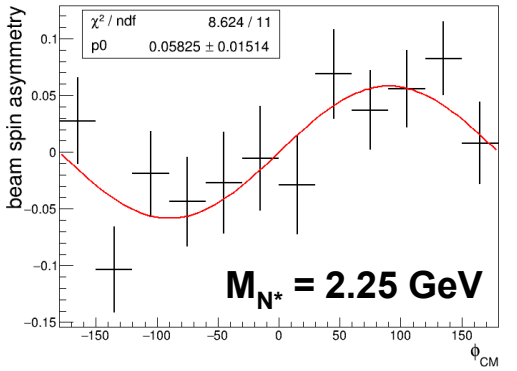
resonance mass for e n π^+ γ

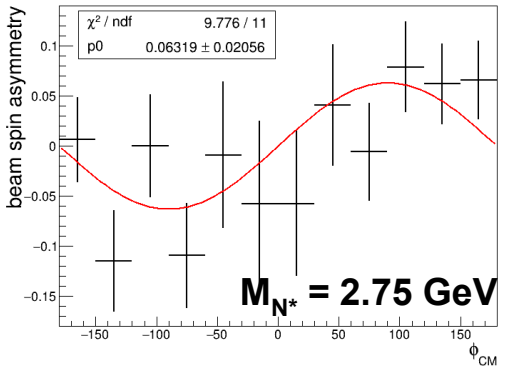


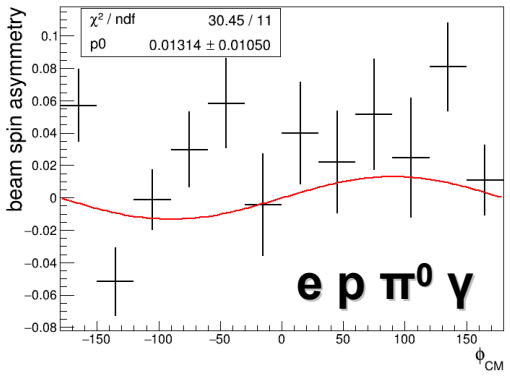


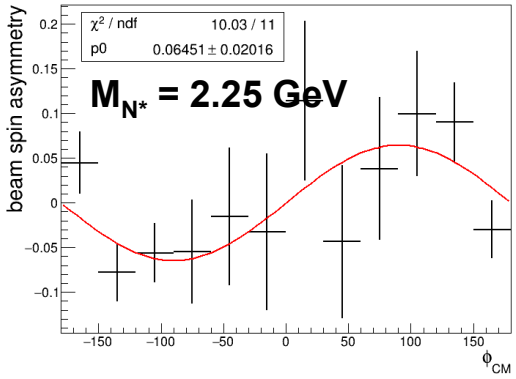
First look into beam spin asymmetry

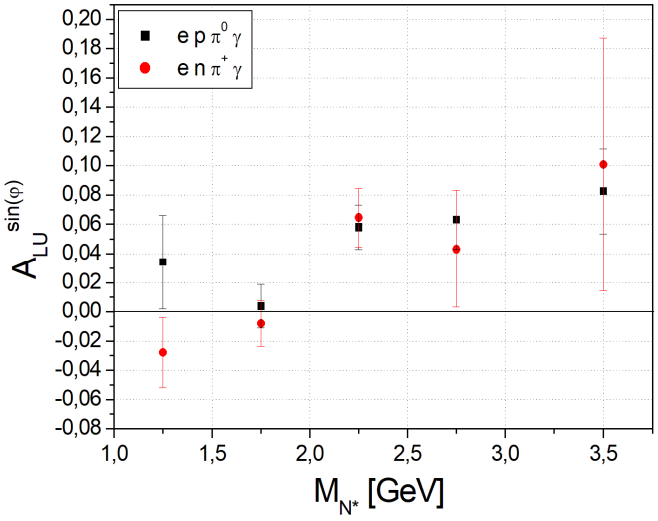


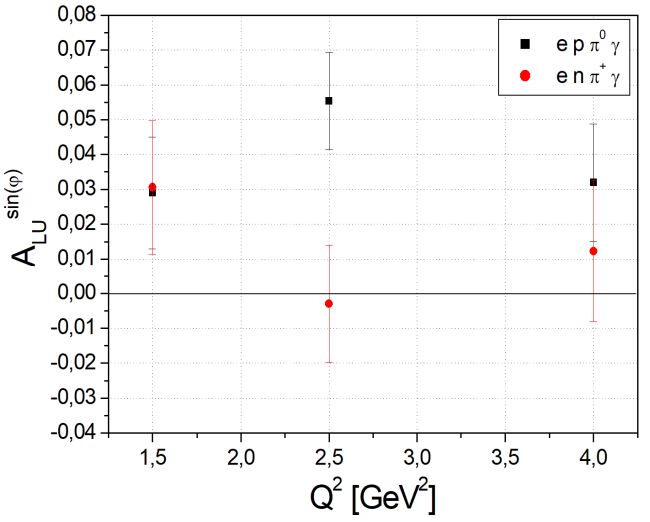












➔BSA can give acess to the phase of the GPDs!

Outlook

• Available statistics from the DNP dataset (~3 % of RGA, 6 % of recorded data)

Estimate of statistics: integrated over all N* masses ➔ Δ region ~ 20 % or less

	present analysis $\|t\| < 2$ GeV²	present analysis $\|t\| < 1$ GeV²	recorded $\|t\| < 2$ GeV²	recorded $\|t\| < 1$ GeV²	RGA $\|t\| < 2$ GeV²	RGA $\|t\| < 1$ GeV²
strict	2.200	750	36.700	12.200	73.000	24.500
loose	35.000	11.700	583.300	194.500	1.167.000	389.000

• A PAC proposal will be prepared for next summer

• Possible approval of additional beamtime for CLAS12 (maybe with dedicated trigger), if we can show that the concept is working