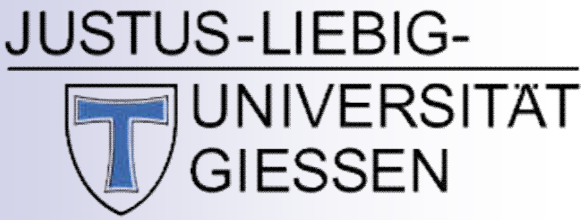
PANDA collaboration meeting

March 10, 2020

Accessing baryon-antibaryon Generalized Parton Distributions with PANDA

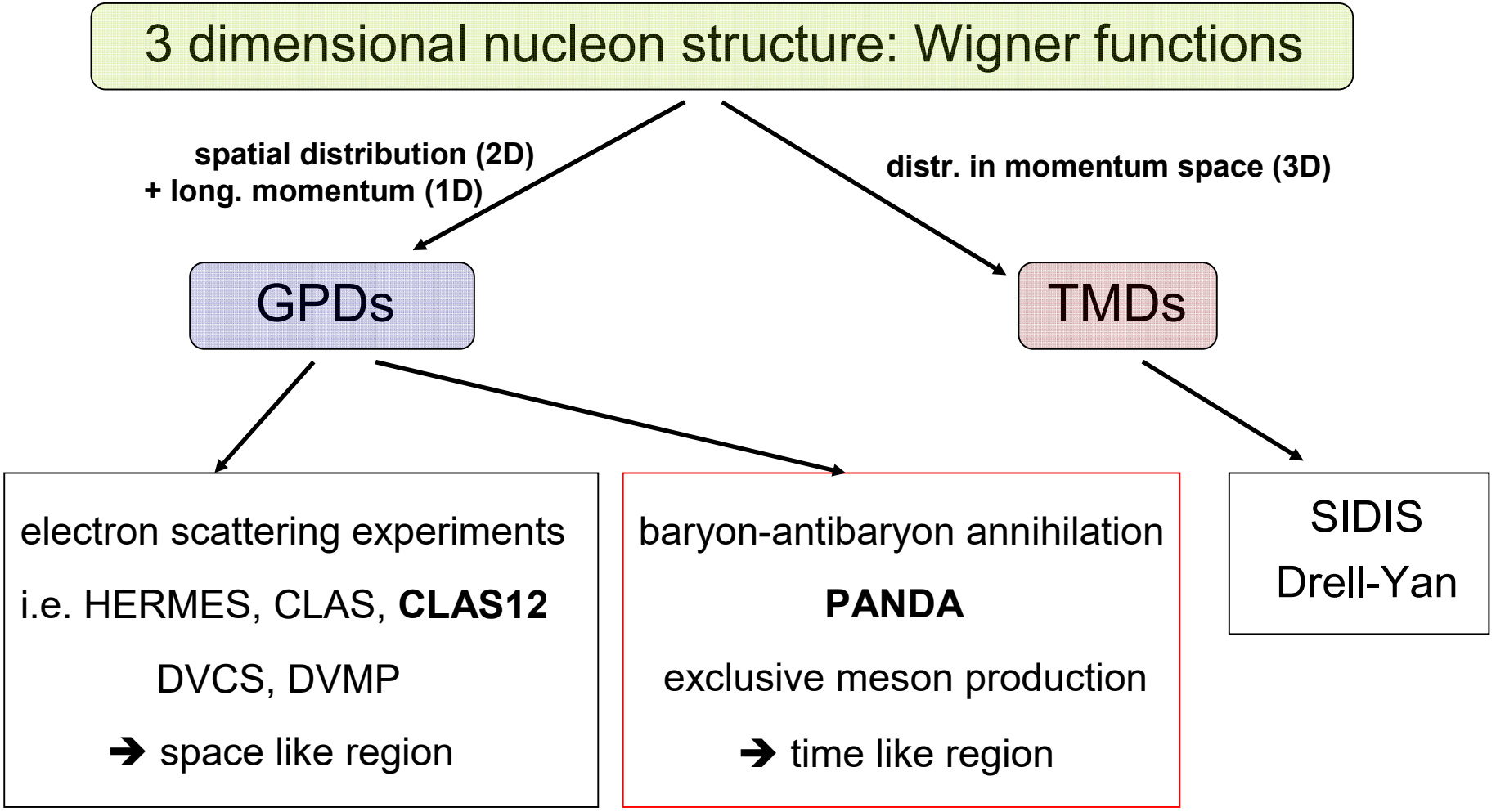


Stefan Diehl

Justus Liebig University Giessen

Physics Motivation

GPDs are an important component for the understanding of the 3D nucleon structure



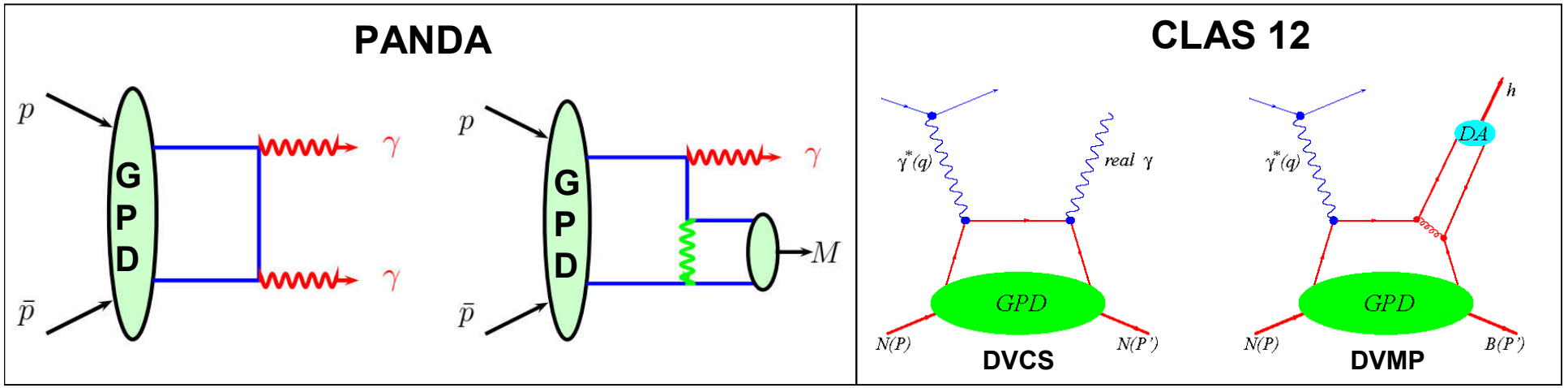
Physics Motivation

$p\bar{p} \rightarrow \gamma M$ at large Mandelstamm variables

process amplitudes factorizes:

hard partonic subprocesses + annihilation form factor

represent moments of baryon-antibaryon generalized parton distributions (GPDs)



Theoretical work and possible channels

Theoretical work for baryon-antibaryon GPDs:

- P. Kroll, A. Schäfer, The process p $\overline{\text{p}}$ → γ π^0 within the handbag approach, The European Physical Journal A 26, 89-98 (2005)
- P. Kroll, A. Schäfer, Probing moments of baryon-antibaryon generalized parton distributions at BELLE and FAIR, The European Physical Journal A 50, 1 (2014)

The process $\gamma\gamma \rightarrow B\overline{B}$ measured at BELLE can be used together with symmetry relations to predict the cross sections of $p\bar{p} \rightarrow \gamma M$

possible channels:

$p\ \bar{p} \rightarrow \gamma\ \gamma$ $\quad$ $p\ \bar{p} \rightarrow \gamma\ \pi^0$

old studies exist in the PANDA physics book

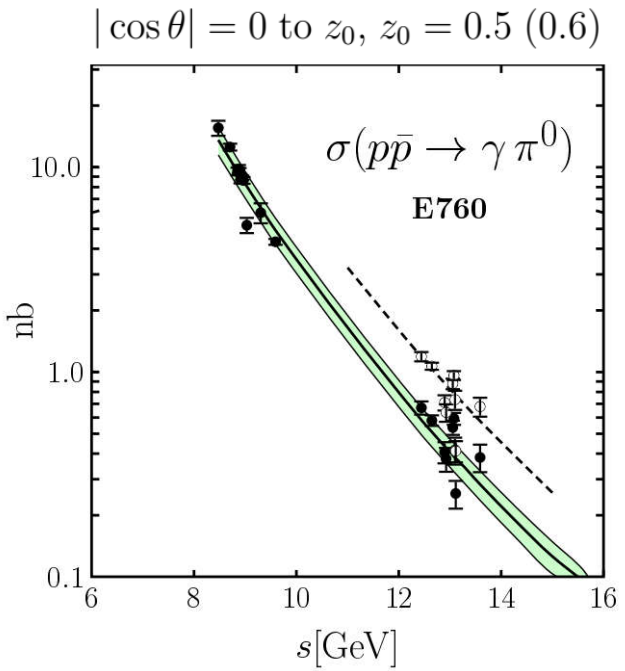
$p\ \bar{p} \rightarrow \gamma\ \eta$ $\quad$ $p\ \bar{p} \rightarrow \gamma\ \eta`$ $\quad$ $p\ \bar{p} \rightarrow \gamma\ \rho, \omega$

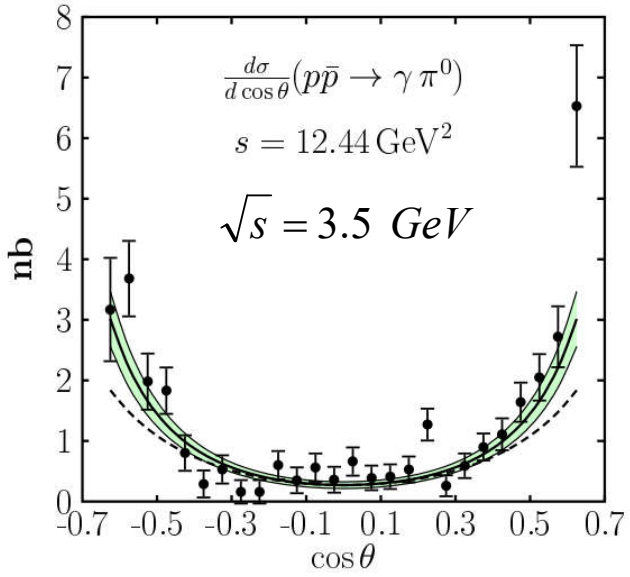
$p\ \bar{p} \rightarrow \gamma\ \phi$ $\quad$ $p\ \bar{p} \rightarrow \gamma\ J/\psi$ + other charmonium states

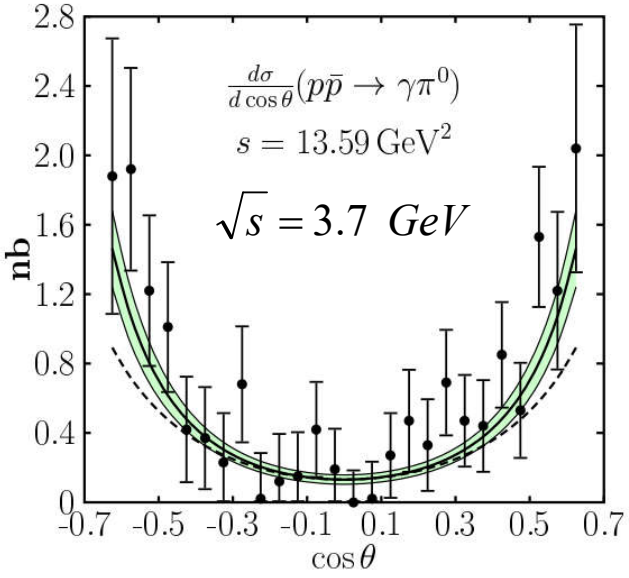
Phenomenology

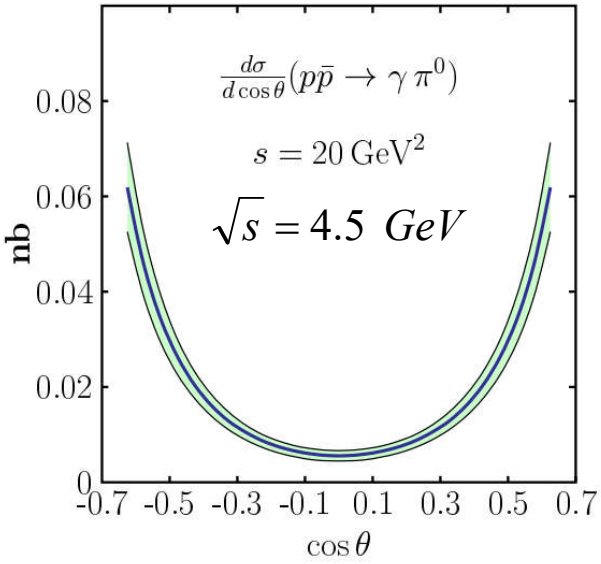
$$p\ \bar{p} \rightarrow \gamma\ \pi^0$$

P. Kroll, A. Schäfer, The process p p → γ π^0 within the handbag approach, The European Physical Journal A 26, 89-98 (2005)







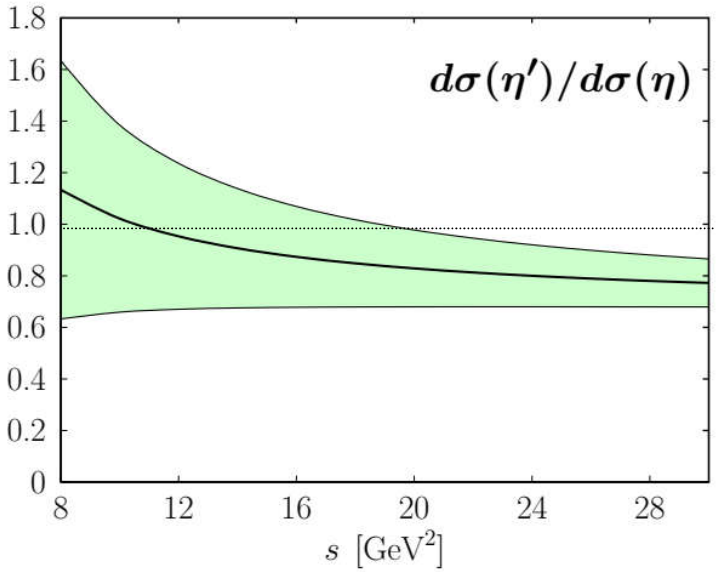


Phenomenology

P. Kroll, A. Schäfer, The European Physical Journal A 50, 1 (2014)

$$\frac{d\sigma/dt(p\bar{p}\to\gamma\eta')}{d\sigma/dt(p\bar{p}\to\gamma\eta)} = \tan^2\Phi_P \left|\frac{1+\kappa_P\cot\Phi_P}{1-\kappa_P\tan\Phi_P}\right|^2 \qquad \kappa_P = \sqrt{2}\,\frac{f_s\langle 1/\tau\rangle_{\eta_s}}{f_q\langle 1/\tau\rangle_{\eta_q}}\,\frac{e_s\rho_s}{e_u+e_d\rho_d}$$

$$\frac{d\sigma/dt(p\bar{p}\to\gamma\eta)}{d\sigma/dt(p\bar{p}\to\gamma\pi^0)} = \cos^2\Phi_P\left[\frac{f_q\langle 1/\tau\rangle_{\eta_q}}{f_\pi\langle 1/\tau\rangle_\pi}\,\frac{e_u+e_d\rho_d}{e_u-e_d\rho_d}\right]^2 |1-\kappa_P\tan\Phi_P|^2$$



Annihilation form factor:

$$R_i^\gamma(p\bar{p}) = e_u^2 F_i^u + e_d^2 F_i^d + e_s^2 F_i^s$$

$$F_i^d = \rho_d F_i^u \qquad F_i^s = \rho_s F_i^u$$

Feasability studies

signal	potential background
$p\ \bar{p} \to \gamma\ \gamma$	$p\ \bar{p} \to \gamma\ \pi^0$ $\quad$ $p\ \bar{p} \to \pi^0 \pi^0$
$p\ \bar{p} \to \gamma\ \pi^0 \to \gamma\ \gamma\ \gamma$	$p\ \bar{p} \to \pi^0\ \pi^0$
$p\ \bar{p} \to \gamma\ \eta \to \gamma\ \gamma\ \gamma$	$p\ \bar{p} \to \pi^0\ \eta$
$p\ \bar{p} \to \gamma\ \phi \to \gamma\ K^+\ K^-$	$p\ \bar{p} \to \pi^0\ \phi$ + hadronic background
$p\ \bar{p} \to \gamma\ J/\psi \to \gamma\ e^+\ e^-$	$p\ \bar{p} \to \pi^0\ J/\psi$ + leptonic background

➔ Simulations with pandaroot at $\sqrt{s} = 2.6\ GeV$ $\sqrt{s} = 3.4\ GeV$ $\sqrt{s} = 4.5\ GeV$

Feasability studies

First iteration (this work):

➔ Signal and background simulated separately for each channel (PHSP generator)

➔ Standard PID

➔ Simple exclusivity cuts on the missing mass, energy and momentum

+ cuts on the invariant particle mass

Next iteration:

➔ Try different PID methods

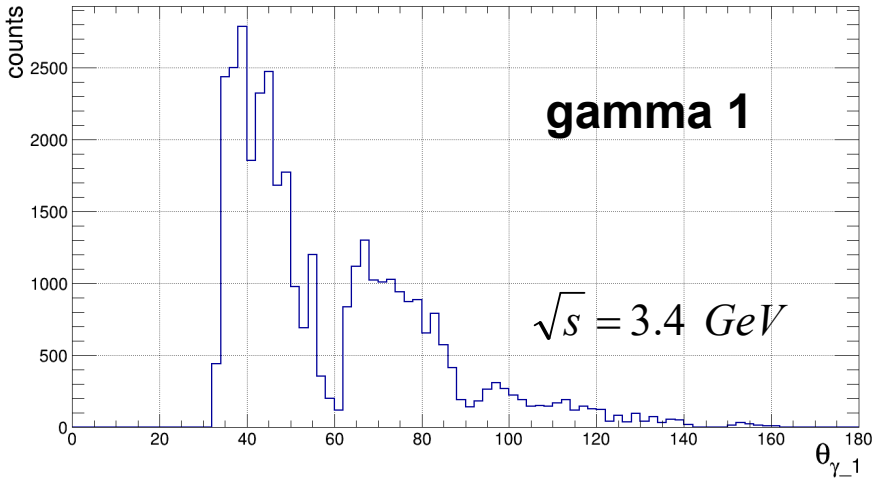
➔ Use a kinematic fitter to ensure exclusivity

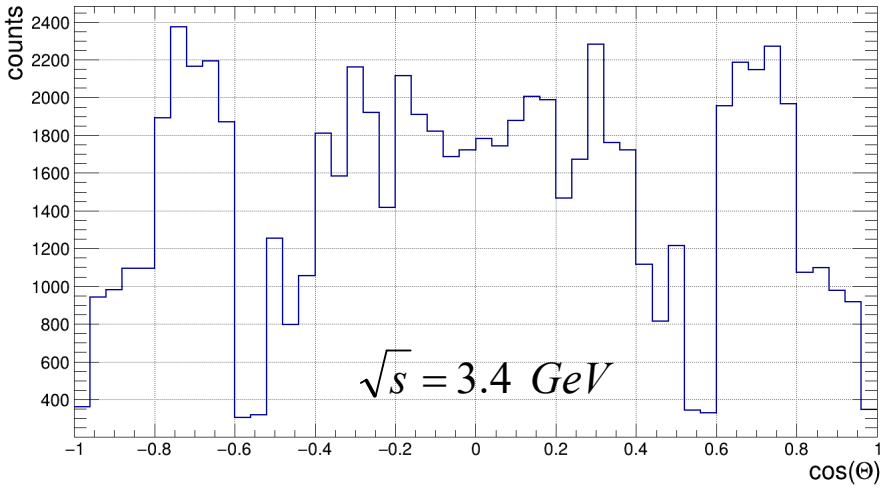
➔ Check cos(θ) acceptance

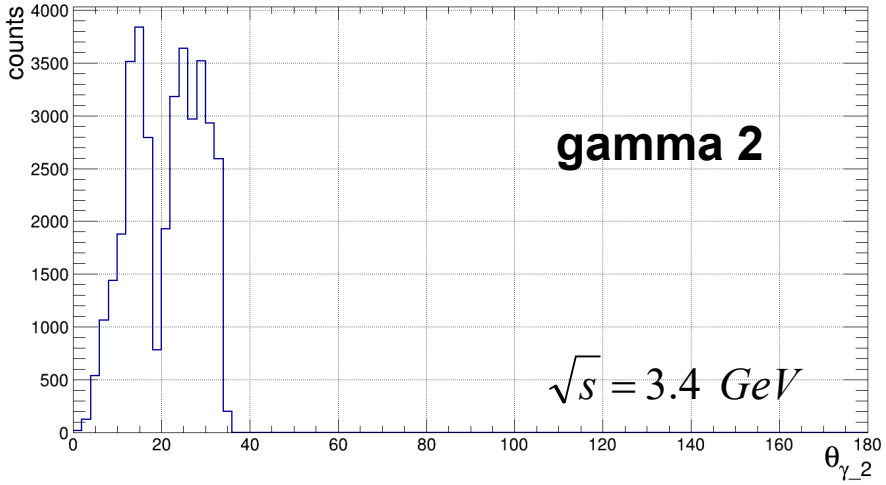
➔ …

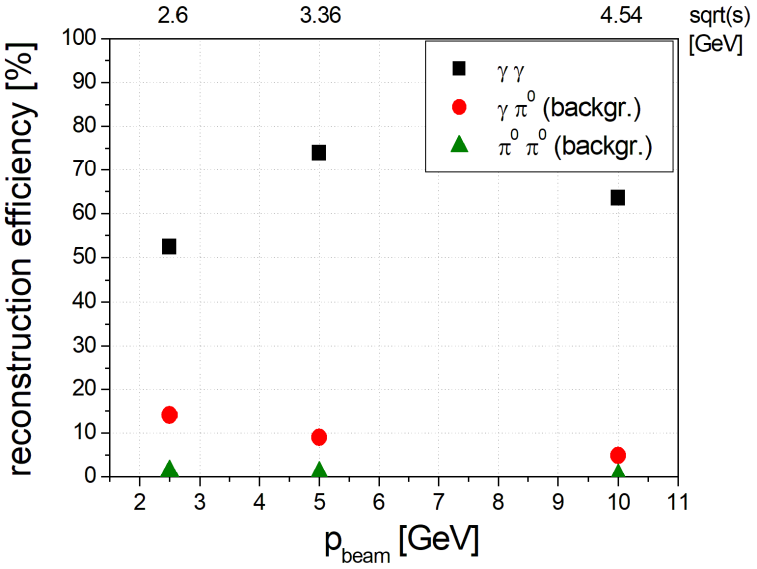
Feasability studies

$p\ \bar{p} \rightarrow \gamma\ \gamma$



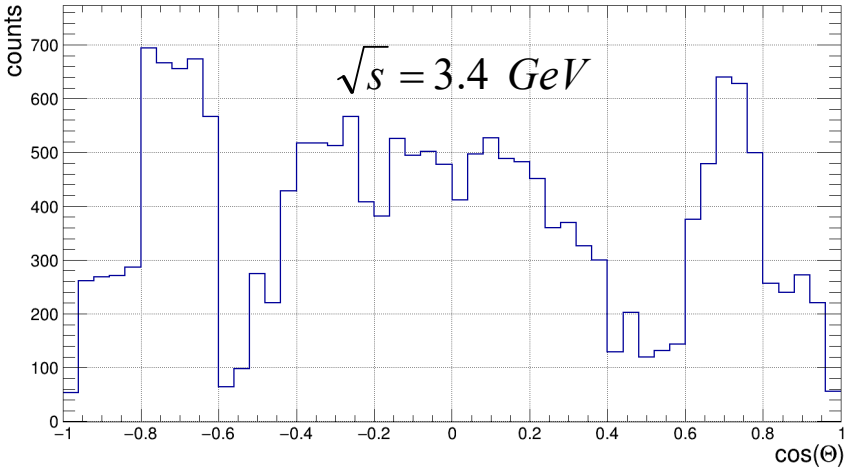


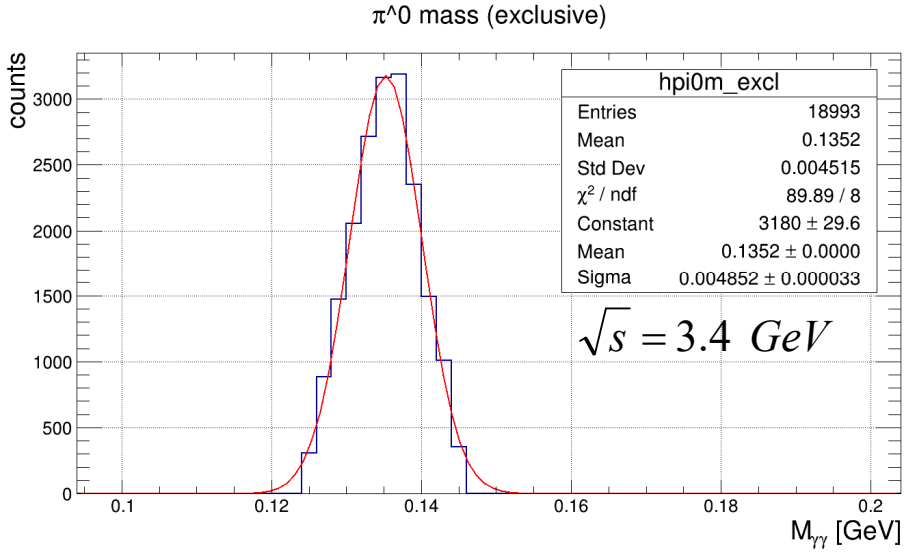


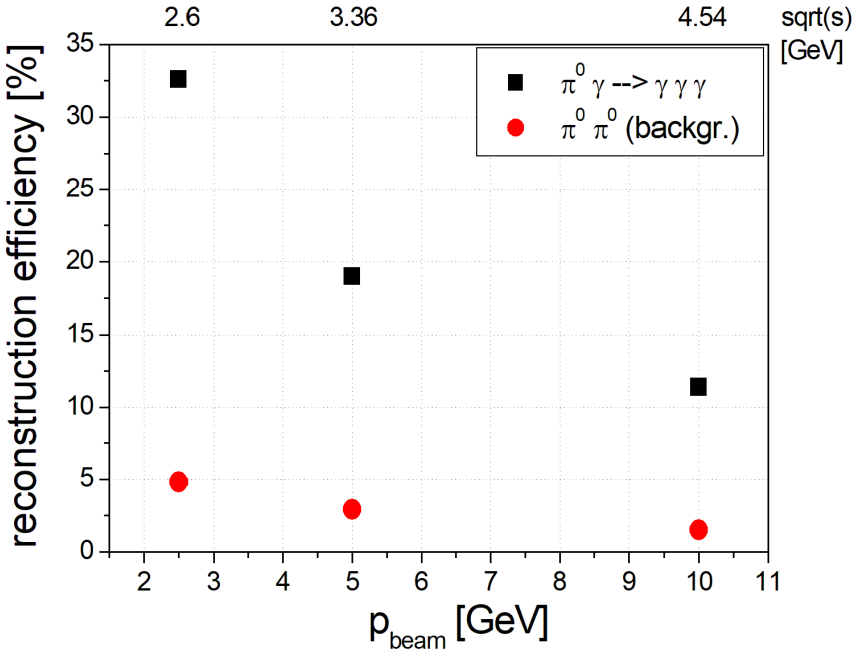


Feasability studies

$$p\ \bar{p} \rightarrow \gamma\ \pi^0 \rightarrow \gamma\ \gamma\ \gamma$$

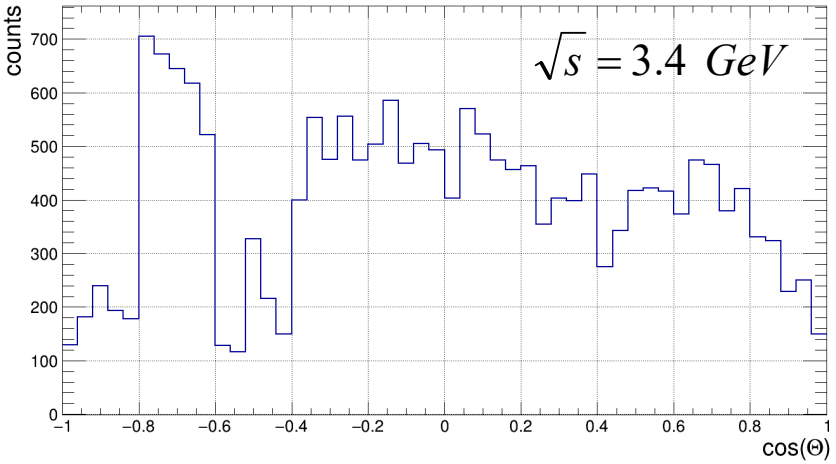


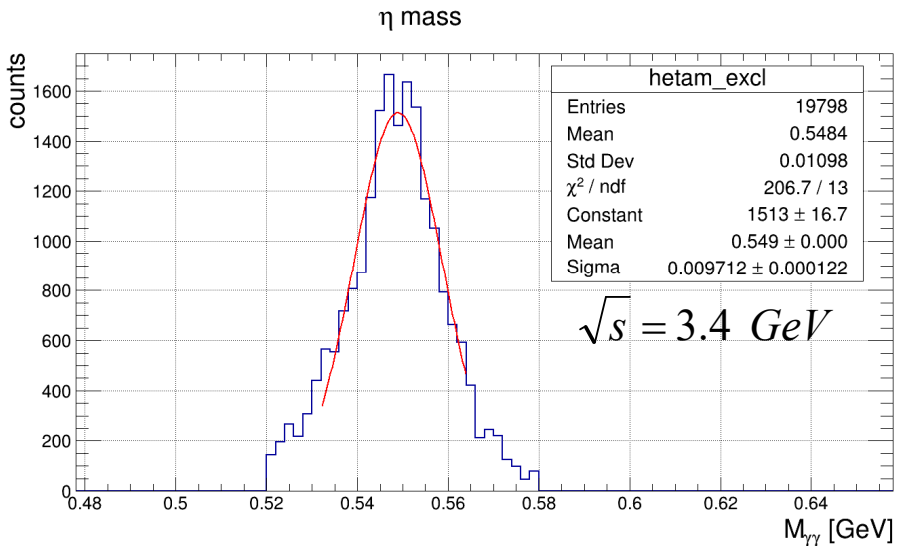


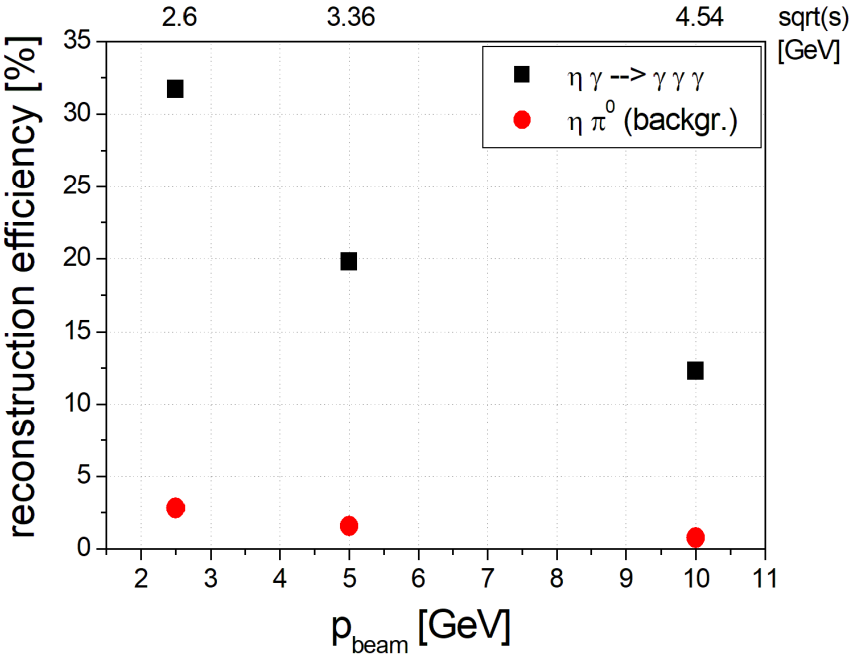


Feasability studies

$$p\ \bar{p} \rightarrow \gamma\ \eta \rightarrow \gamma\ \gamma\ \gamma$$

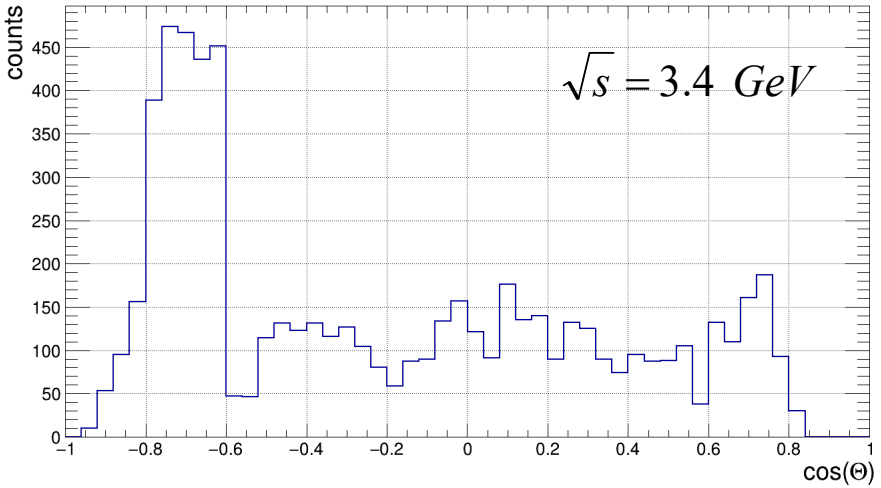


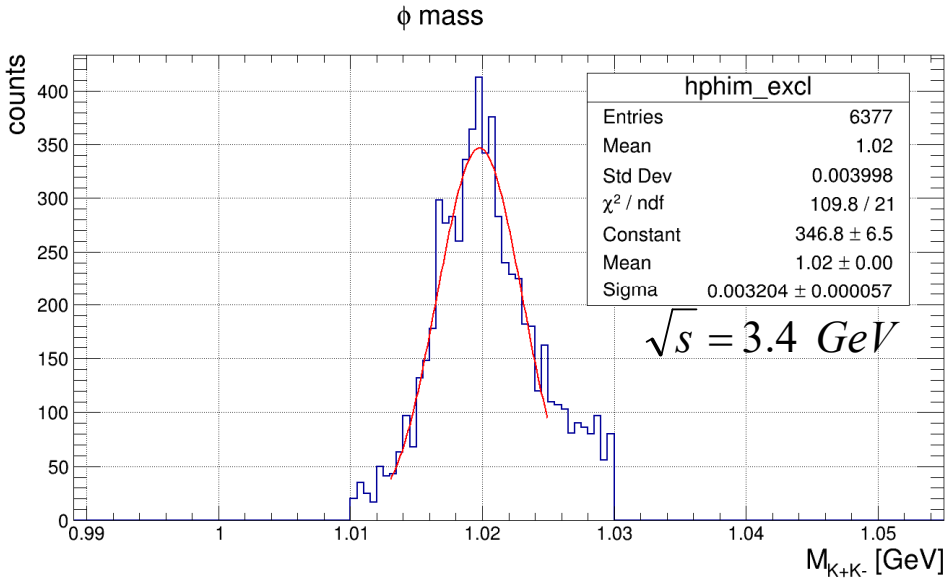


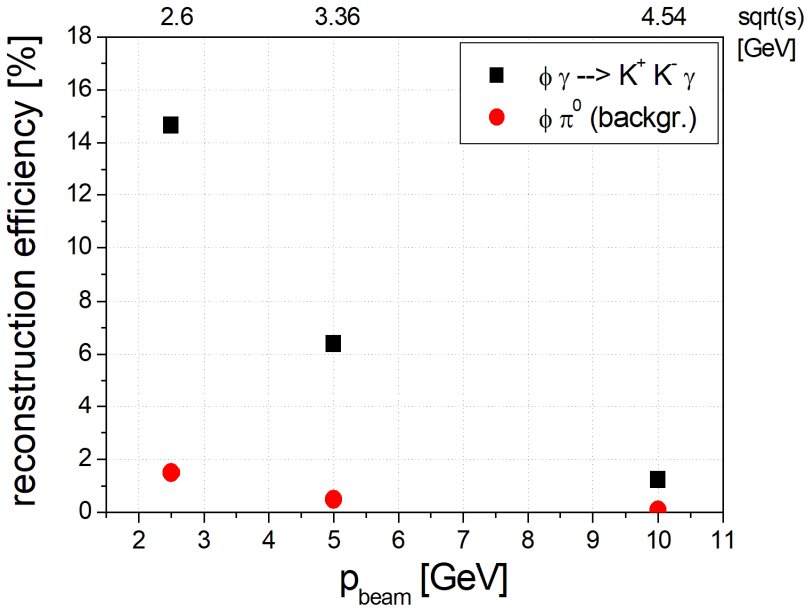


Feasability studies

$$p\ \bar{p} \rightarrow \gamma\ \phi \rightarrow \gamma\ K^+\ K^-$$

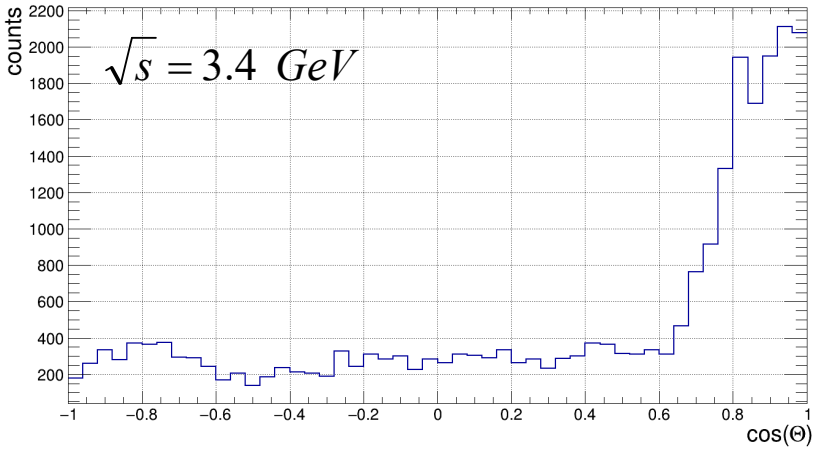


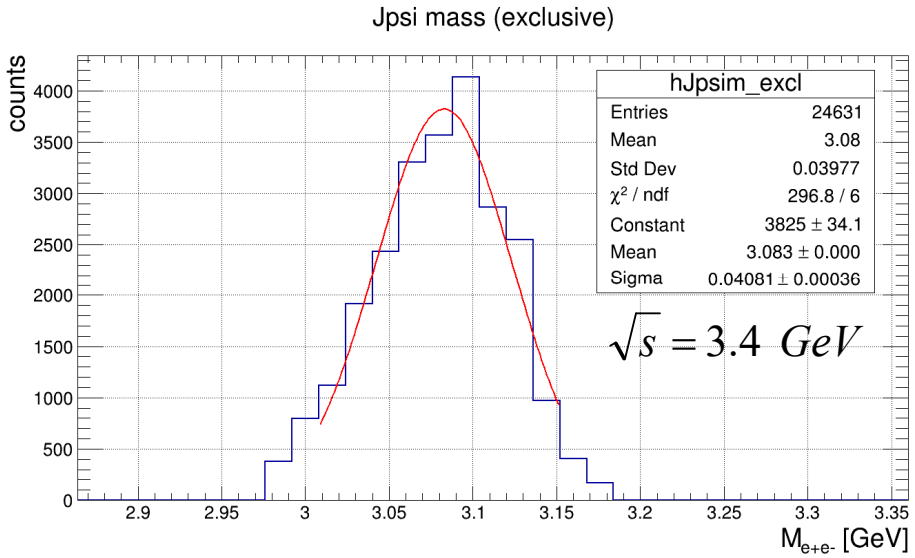


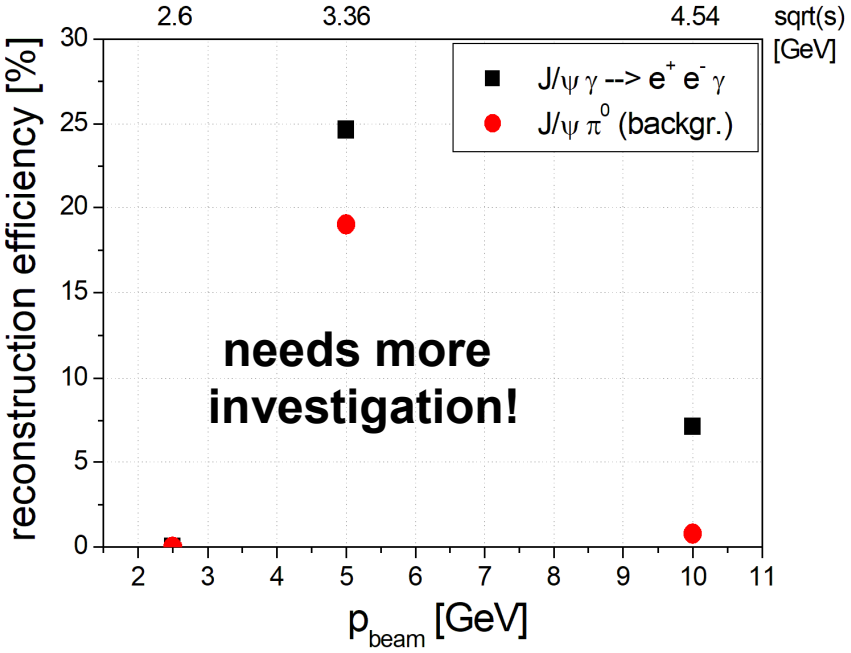


Feasability studies

$$p\ \bar{p} \rightarrow \gamma\ J/\psi \rightarrow \gamma\ e^+\ e^-$$







Summary and Outlook

- GPDs in the space like region are currently extensively studied at experiments like CLAS12.
- The study of time-like GPDs with PANDA can help us to get more detailed / additional insights into the 3D nucleon structure.
- First theoretical modells and predictions exist by Kroll and Schäfer.
- An initial feasability study has been done for different mesons.
- More detailed studies, including acceptance effects, count rate estimates, … are in progress.
- The GPD program can be extended to charmonium resonances and measurements can probably be done together with the spectroscopy program.