

Electromagnetic processes at PANDA
TL form factors - Hard exclusive processes - Drell Yan
current activities



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Outline

Publications/release notes in progress

Monte Carlo event generators

Ongoing analyses

Publications/release notes in progress

EPJ manuscript No.
(will be inserted by the editor)

$$\bar{p}p \rightarrow \mu^+ \mu^-$$

Iris Zimmermann

Feasibility studies for the measurement of time-like proton electromagnetic form factors from $\bar{p}p \rightarrow \mu^+ \mu^-$ at PANDA FAIR

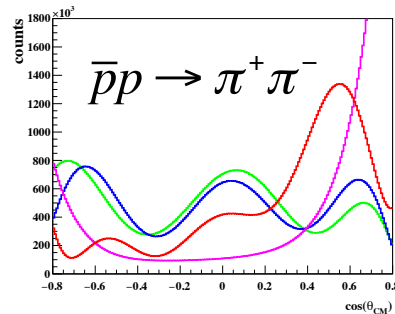
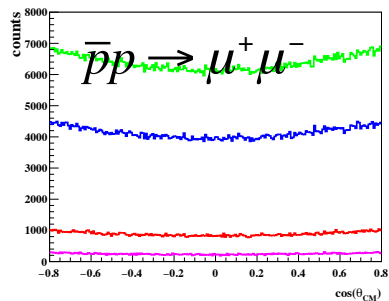
PANDA Collaboration

Helmholtz-Institut Mainz

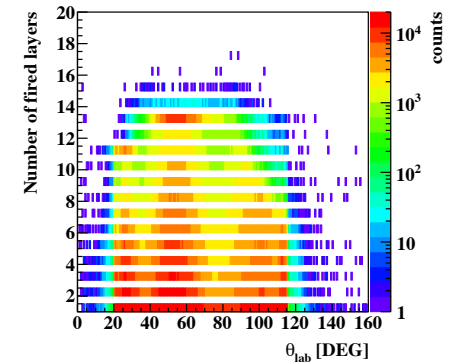
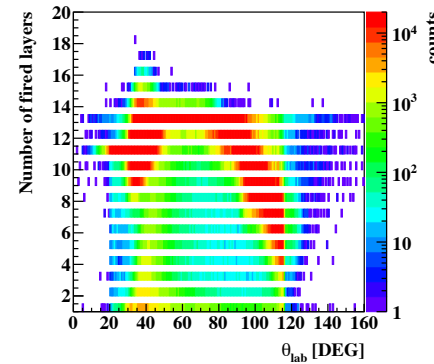
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Abstract This note reports on the simulation results for the future measurement of time-like proton electromagnetic form factors, G_E and G_M , using reactions of $\bar{p}p \rightarrow \mu^+ \mu^-$ at PANDA (FAIR). The electromagnetic form factors are fundamental quantities parameterizing the electric and magnetic structure of hadrons. This work estimates the achievable statistical and total precision with which the FF's can be measured at PANDA, based on the PandaRoot software framework. The most important background channel is $\bar{p}p \rightarrow \pi^+ \pi^-$, for which the suppression factors at different values of beam momentum are evaluated. The signal/background separation is based on a multivariate analysis, utilizing Boosted Decision Trees for data classification. A foreseen background subtraction is included in this study, based on realistic angular distributions of the expected pion contamination in the selected events. Systematic uncertainties are considered and the relative total uncertainties are presented.

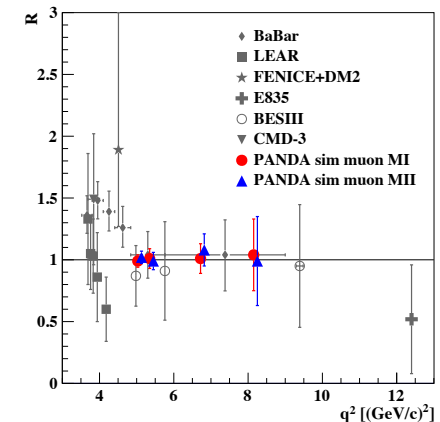
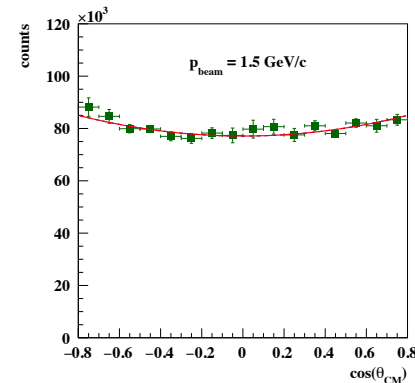
- **Signal and main background description (kinematics, models, event generators,...)**



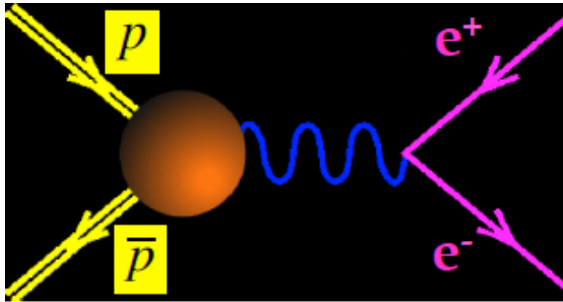
- **Event selection (Multivariate analysis)**
- **Background subtraction**



- **Results for Phase-3 (L=2 fb⁻¹) on $|G_E|$, $|G_M|$, R, cross section and effective form factor**

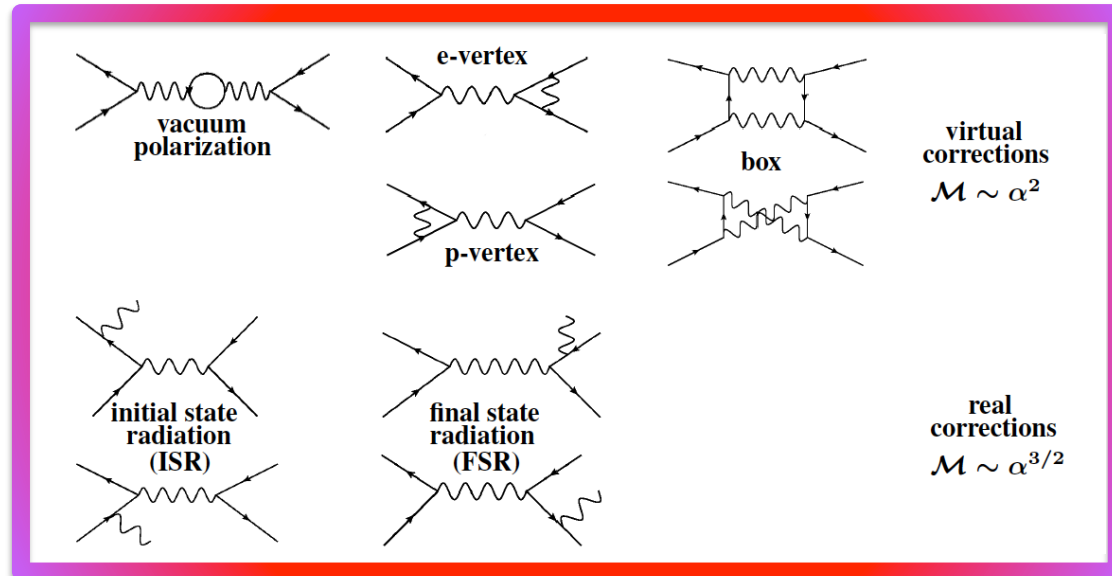
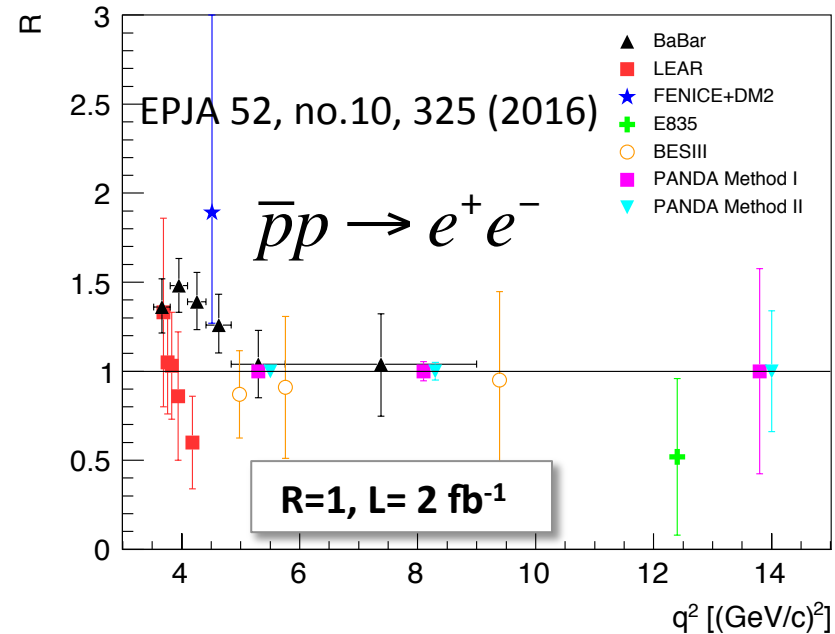


Radiative corrections on $p\bar{p} \rightarrow e^+e^-$ at PANDA Monte Carlo event generator (M. Zambrana et al.)



- At low q^2 , $\Delta R/R \sim$ few percent
- > **Radiative corrections will be needed**
- Existing package in PANDAROOT (PHOTOS) is not adequate
- **Development of a complete calculation/package for PANDA:**

See next talk by
E. Tomasi-Gustafsson



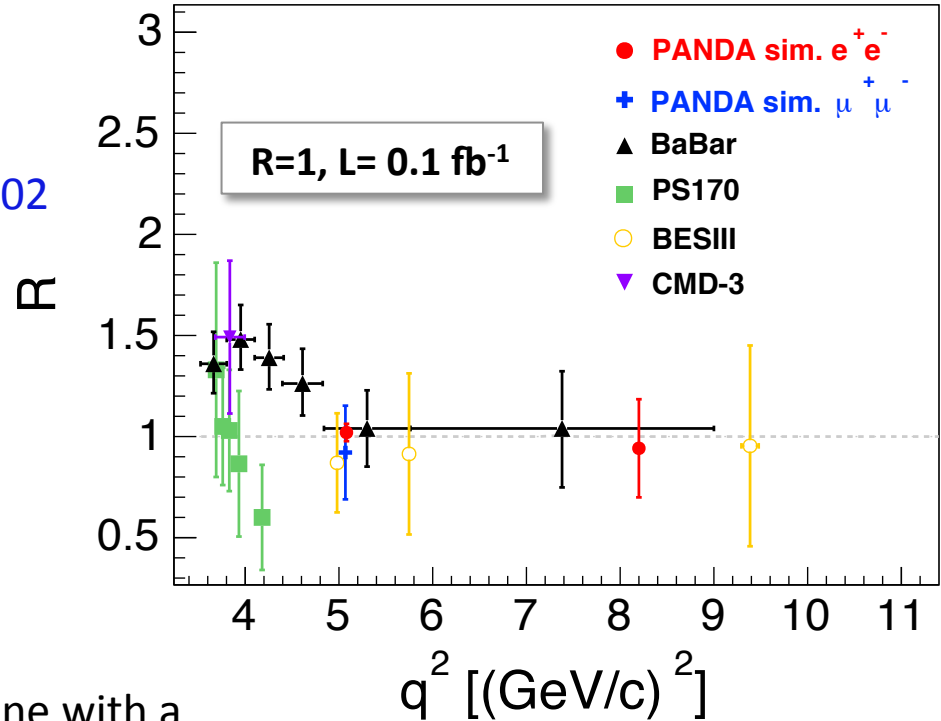
PANDA Phase1-simulations (proton form factors)

$$\bar{p}p \rightarrow e^+e^- \quad \bar{p}p \rightarrow \mu^+\mu^-$$

- Muon channel at $p=1.5$ GeV/c:
 $\Delta R/R \sim 21\%$, $\Delta\sigma/\sigma : 5.0\%$
[Approved Release Note RN-EMP-2017-002](#)

- Electron channel at $p=1.5 - 3.3$ GeV/c
 $\Delta R/R \sim 4\% - 26\%$, $\Delta\sigma/\sigma : 5.0\%$
[Release Note RN-EMP-2015-003](#)

- Comment from referees: Simulations done with a relatively old version of PANDAROOT (revision 25544). Check the results with a new version.



PANDA Phase1-simulations (proton form factors)

Event selection

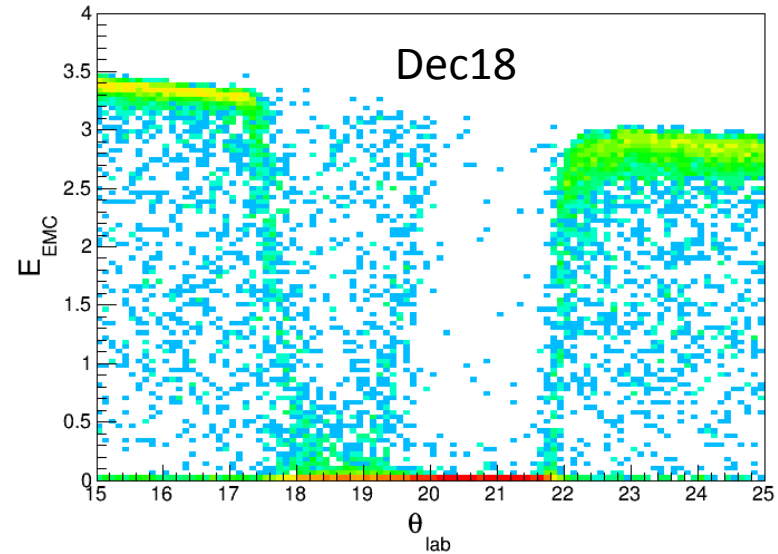
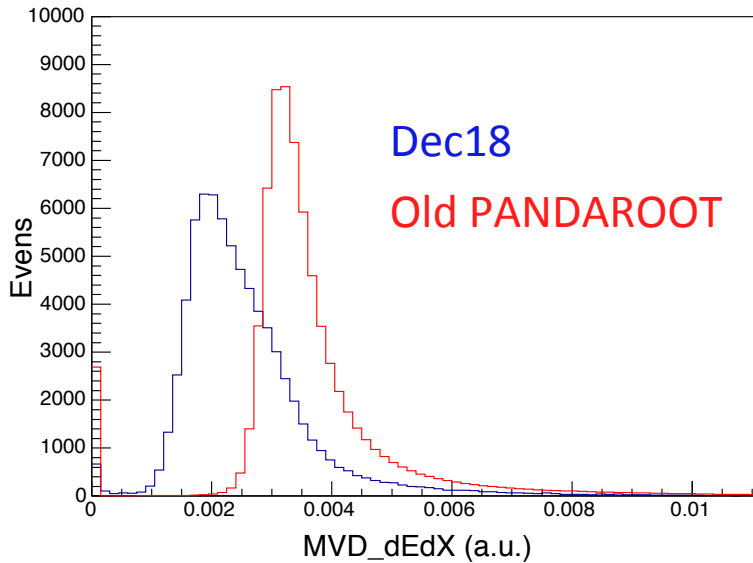
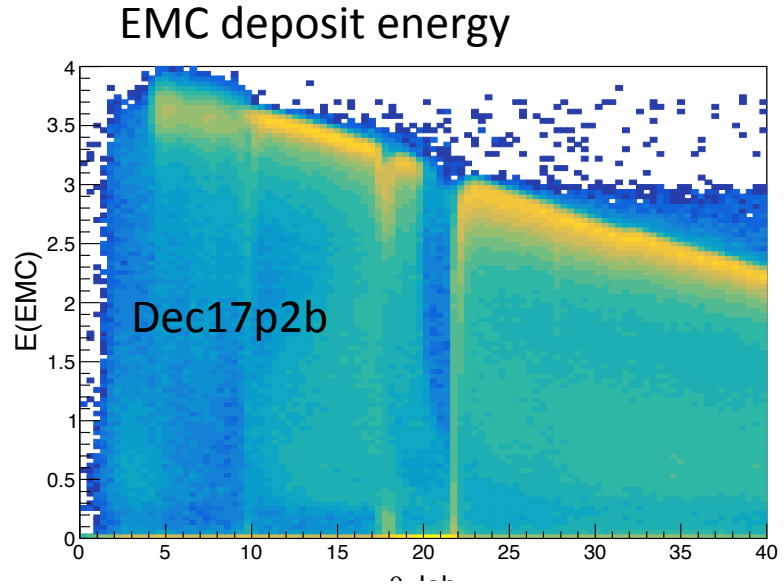
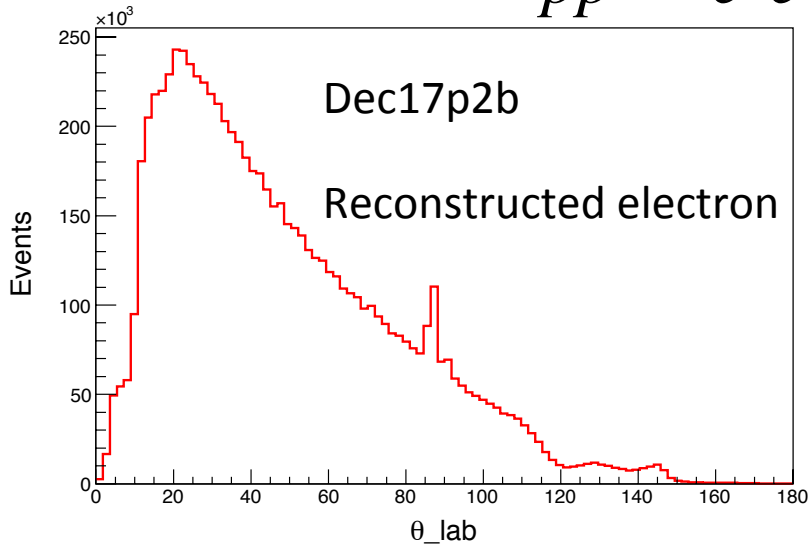
$$\bar{p}p \rightarrow e^+e^-$$

q^2	[GeV/c] ²	5.08	8.21
PID _c	[%]	>99	>99
PID _s	[%]	>10	>10
dE/dx_{STT}	[a.u.]	>6.5	>5.8
E_{EMC}/p	[GeV/GeV/c]	>0.8	>0.8
EMC LM	-	<0.66	<0.75
EMC E1	[GeV]	>0.35	>0.35
$\theta + \theta'$	[degree]	175 < $\theta + \theta'$ < 185	
$ \phi - \phi' $	[degree]	175 < $ \phi - \phi' $ < 185	
M_{inv}	[GeV/c]	-	>2.2

Signal efficiency	1.5 GeV/c (5.08 (GeV/c) ²)	3.3 GeV/c (8.21 (GeV/c) ²)
revision 25544	39.5%	44.4%
Dec17p2b (Dec18)	~33%	~31%

PANDA Phase1-simulations (proton form factors)

$$\bar{p}p \rightarrow e^+e^-$$

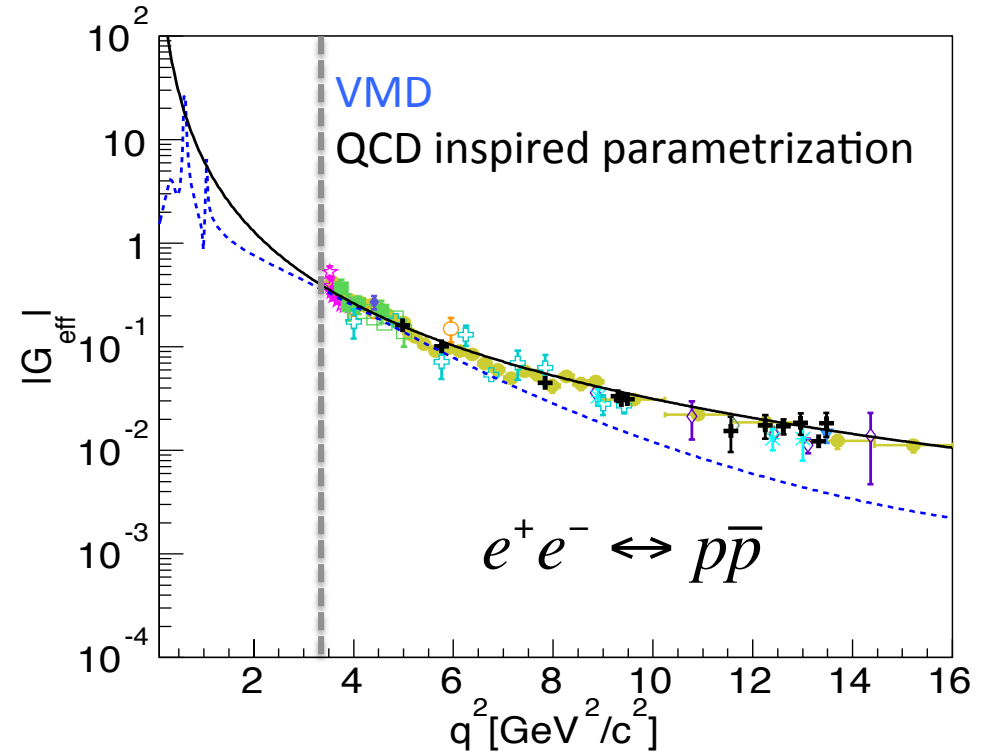
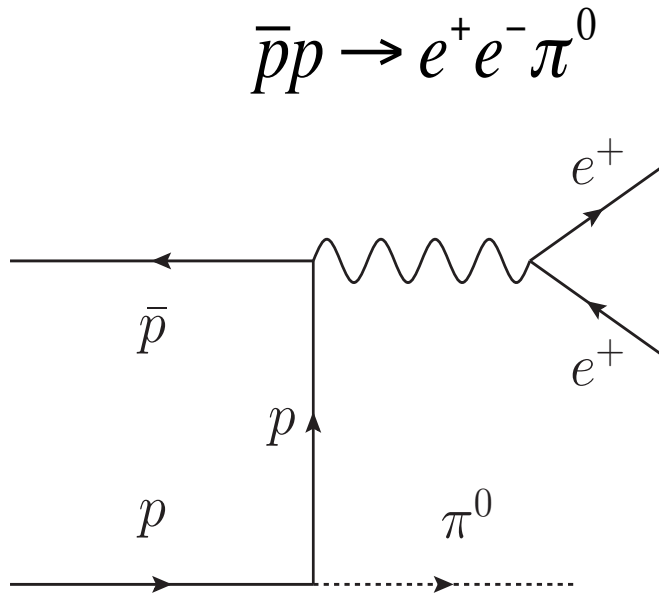


Analyses of electromagnetic processes

Signal	Physics	Status
$\bar{p}p \rightarrow e^+e^-$	FFs	Completed and published (P3) publication in progress (P1, 2)
$\bar{p}p \rightarrow \mu^+\mu^-$	FFs	Completed, publications in progress
$\bar{p}p \rightarrow e^+e^-\pi^0$	FFs below threshold	Analysis ongoing
$\bar{p}p \rightarrow \gamma^*\pi^0$ $\bar{p}p \rightarrow J/\psi\pi^0$	TDA's	Completed and published (P3)
$\bar{p}p \rightarrow \gamma\gamma$ $\bar{p}p \rightarrow \pi^0\gamma$	GDA's	
$\bar{p}p \rightarrow \mu^+\mu^-X$ $\bar{p}p \rightarrow e^+e^-X$	TMD PDFs	Analysis ongoing

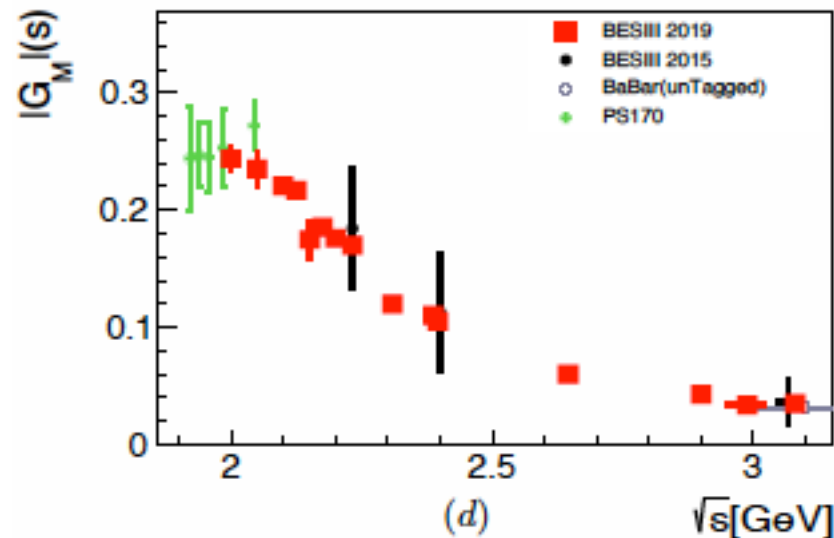
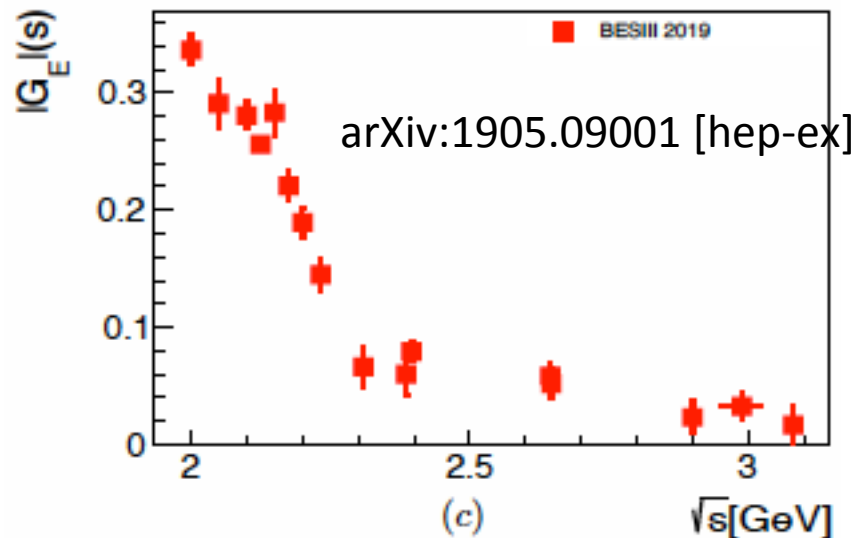
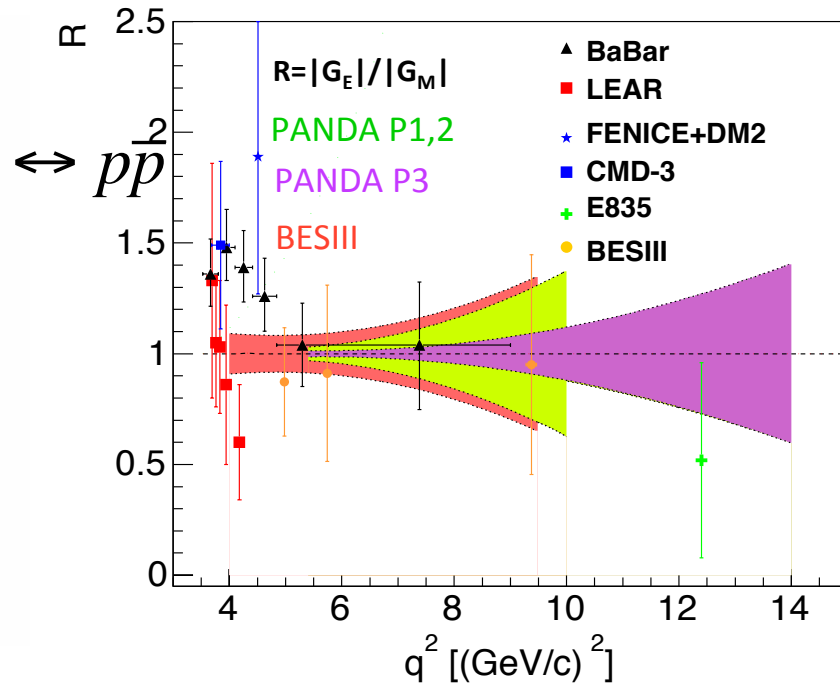
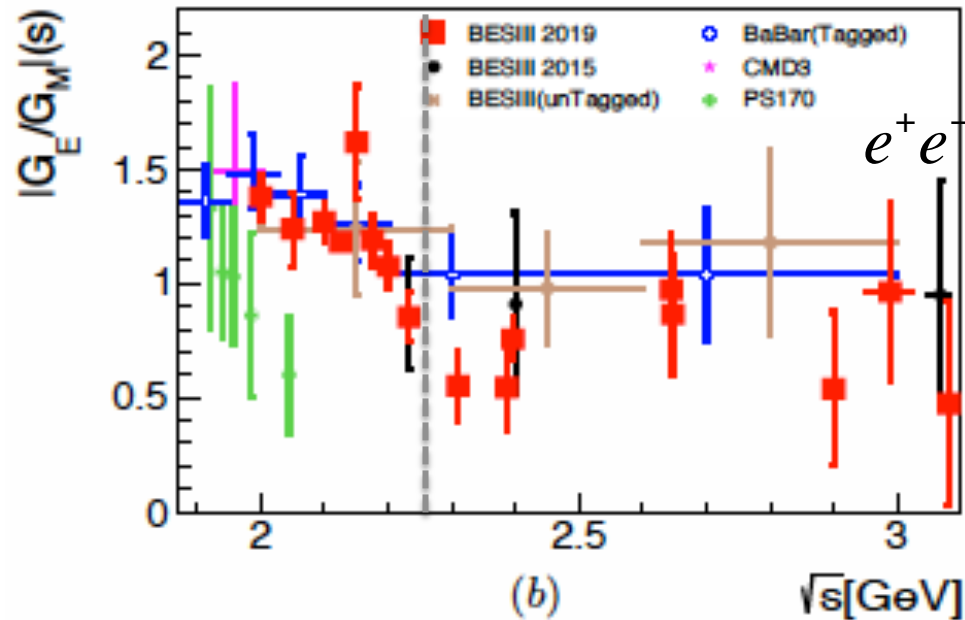
Backup Slides

Electromagnetic form factors of the proton in the unphysical region

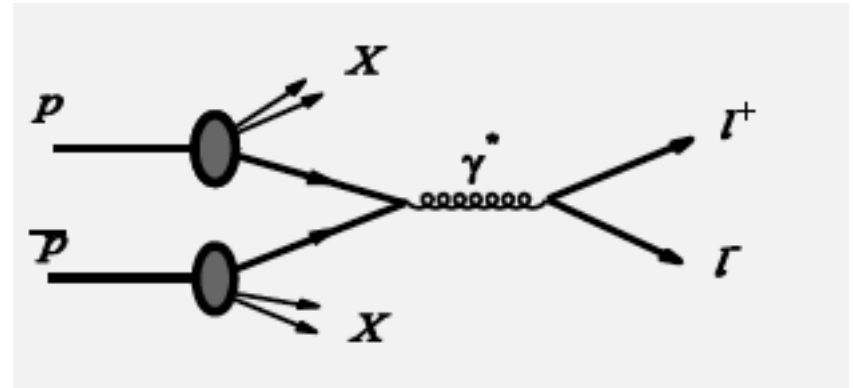
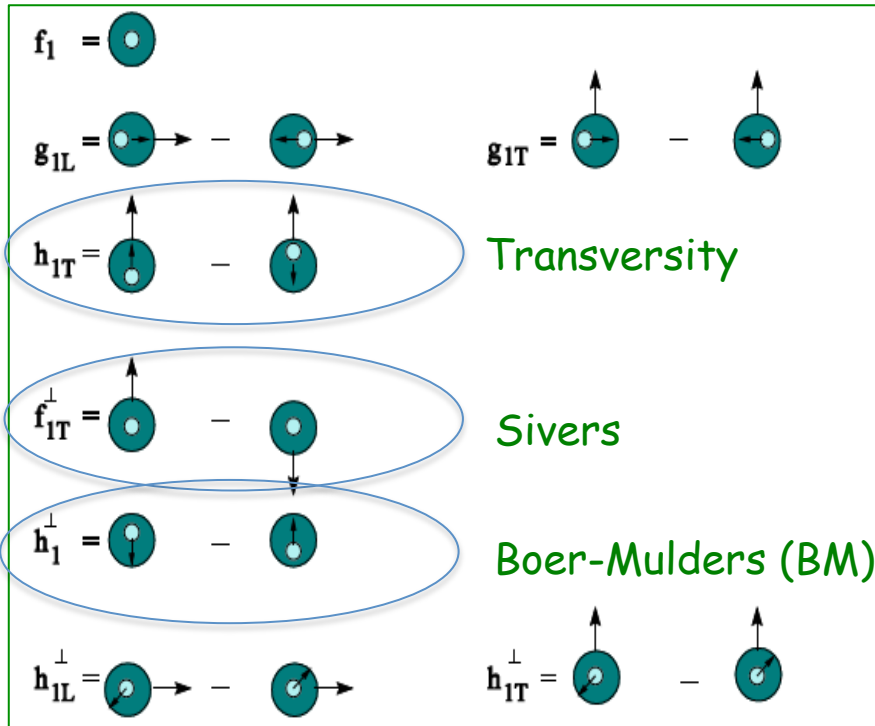


- Feasibility studies with PANDARoot are ongoing
- Development of an event generator for this process based on the existing calculations of the differential cross section is needed

TL Electromagnetic form factors of the proton (BESIII)



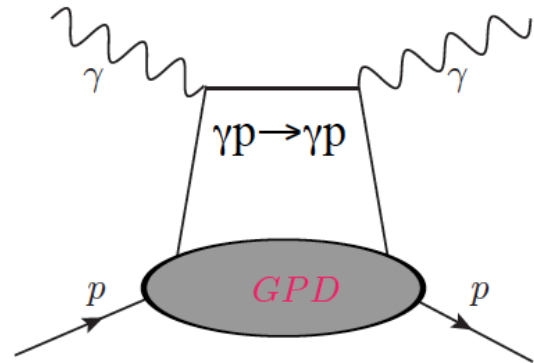
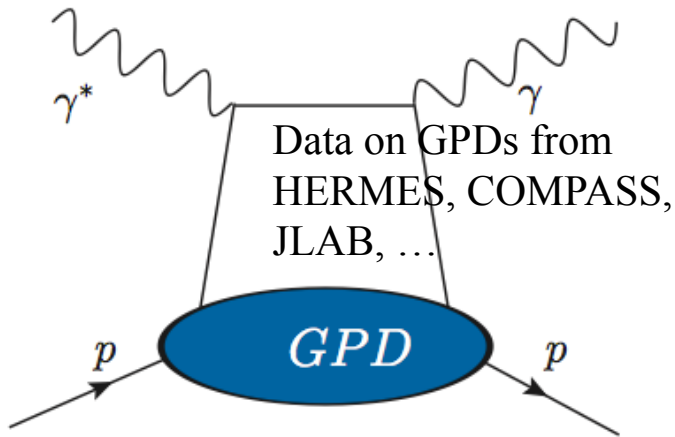
Drell-Yan at PANDA (Anna Skachkova)



- PANDA: Boer-Mulders with unpolarized proton-antiproton experiment; Sivers and Transversity with a polarized target

The main task - to determine if STT would be able to resolve a small kink of pion-to-muon trajectory as the most strong criterion of Signal and Background separation

Hard exclusive processes at PANDA

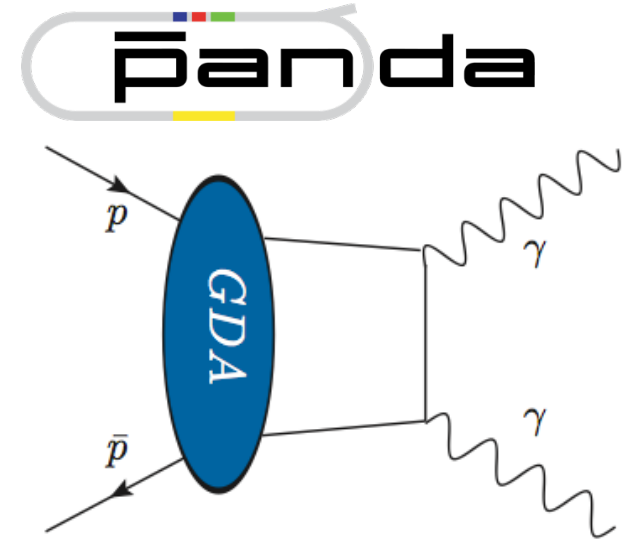


Wide Angle Compton Scattering

$t \leftrightarrow s$ channels
GPDs \leftrightarrow GDAs



GDAs



- Fermilab $ppbar \rightarrow \gamma\pi^0$ data [8.5 – 13.6] GeV²
 - Belle, CLEO, ... $\gamma\gamma \rightarrow ppbar$ data below 16 GeV²
 - Precise data at higher energies and with different processes are needed
- PANDA: $ppbar \rightarrow \gamma\gamma, \gamma M$ ($M = \pi^0, \eta, \rho^0, \phi$)

Time-Like Wide Angle Compton Scattering

Feasibility studies with
PANDARoot are needed