CLAS12 Deep Virtual ϕ

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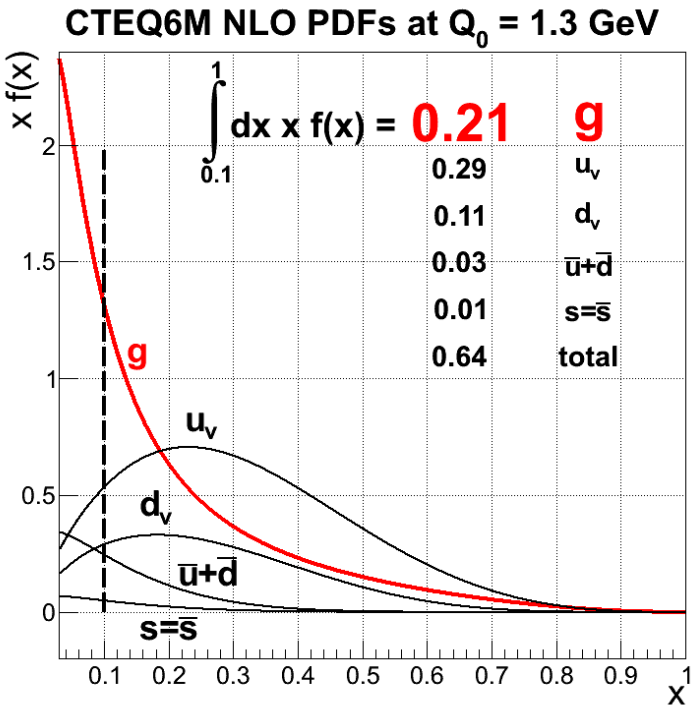
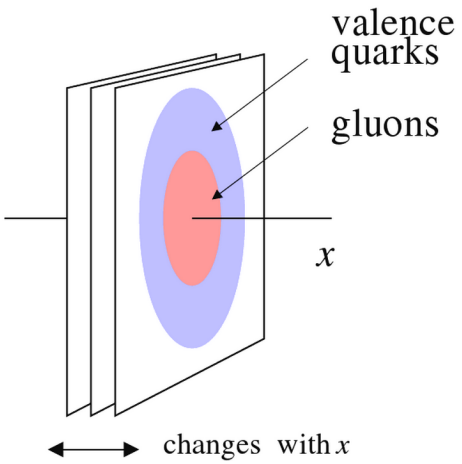
Outline

Introduction / Motivations

Gluons at large x

E12-12-007





- Large glue density at $x > 0.1$

  PDF from global fits
  (F_2 evolution, $\nu_{\mathbf{DIS}}$, jets)

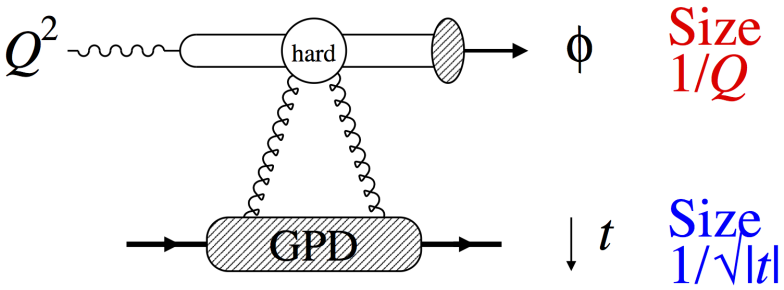
  Gluons carry more than 30%
  of the momentum for $0.1 < x$

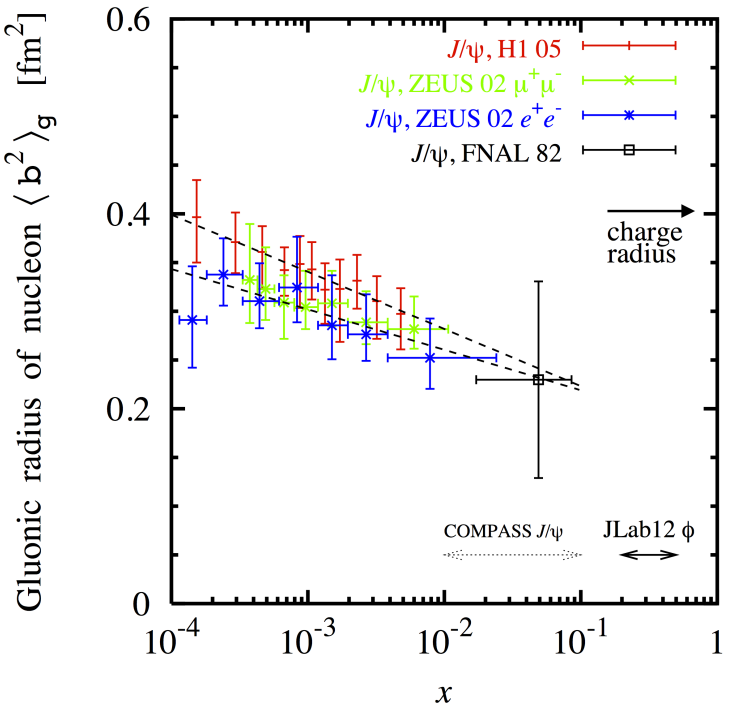
- 3D imaging of the nucleon

  spatial distribution of valence quarks :
  elastic scattering, DVCS, ...

  Nucleon gluonic radius ?
  exclusive ϕ

Nucleon gluonic radius at 11 GeV





- Exclusive ϕ electroproduction as the best probe of gluon GPD at 11 GeV

  Dominance of small-size configurations at $Q^2 \sim$ few GeV^2

  GPD = Universal gluon form factor

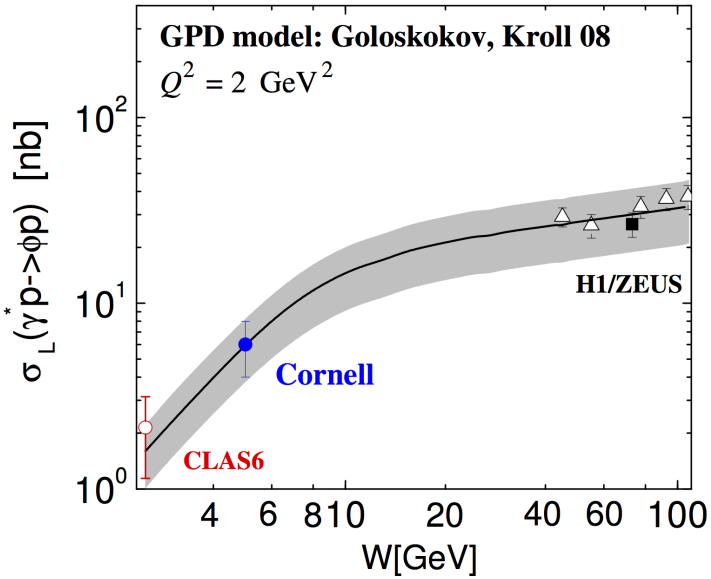
- Gluonic radius as a function of x

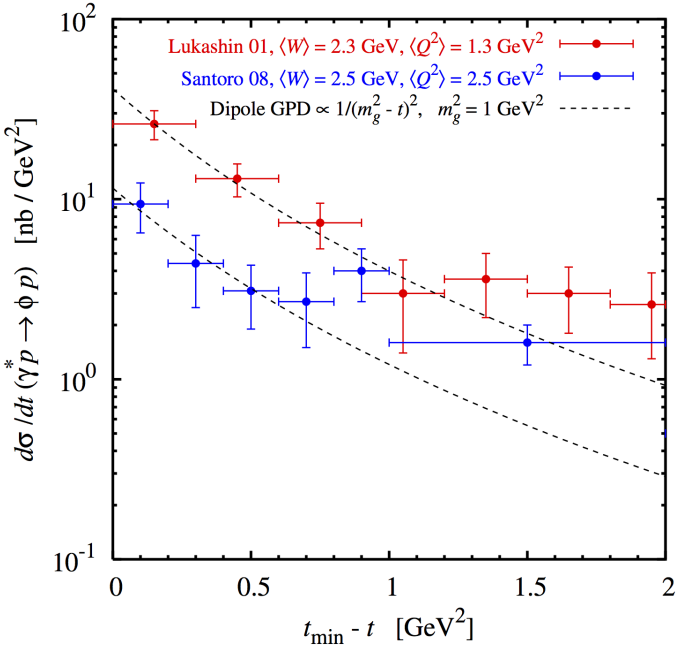
  Small x : radius grows through parton diffusion

  $x < 0.01$ measured: J/ψ and ϕ at HERA H1/ZEUS and Fermilab

  $x > 0.1$ unknown range : ϕ with CLAS12

GPD description of ϕ production





- Goloskokov-Kroll 2008 model

  includes finite size of $q\bar{q}$ pairs
  (Sudakov suppression)

  Describes well available cross-section data

- Gluonic radius at 4 and 6 GeV from CLAS data consistent with extrapolation from higher energy

  dipole mass $m_g^2 \sim 1$ GeV^2

CLAS12 Exclusive ϕ electroproduction

Analysis of the cross-section in two steps :

- Test the approach to small-size regime, through model-independent features

  When do t-slopes become independent of Q^2 ?
  How does W-dependence change with Q^2 ?
  L/T ratio and s-channel helicity conservation

- Extract the gluonic radius accross the valence region from the *relative* t-dependence of the differential cross-section

  Average gluonic radius : model independent
  Change with x : use GPD models (e.g. Double-Distribution)

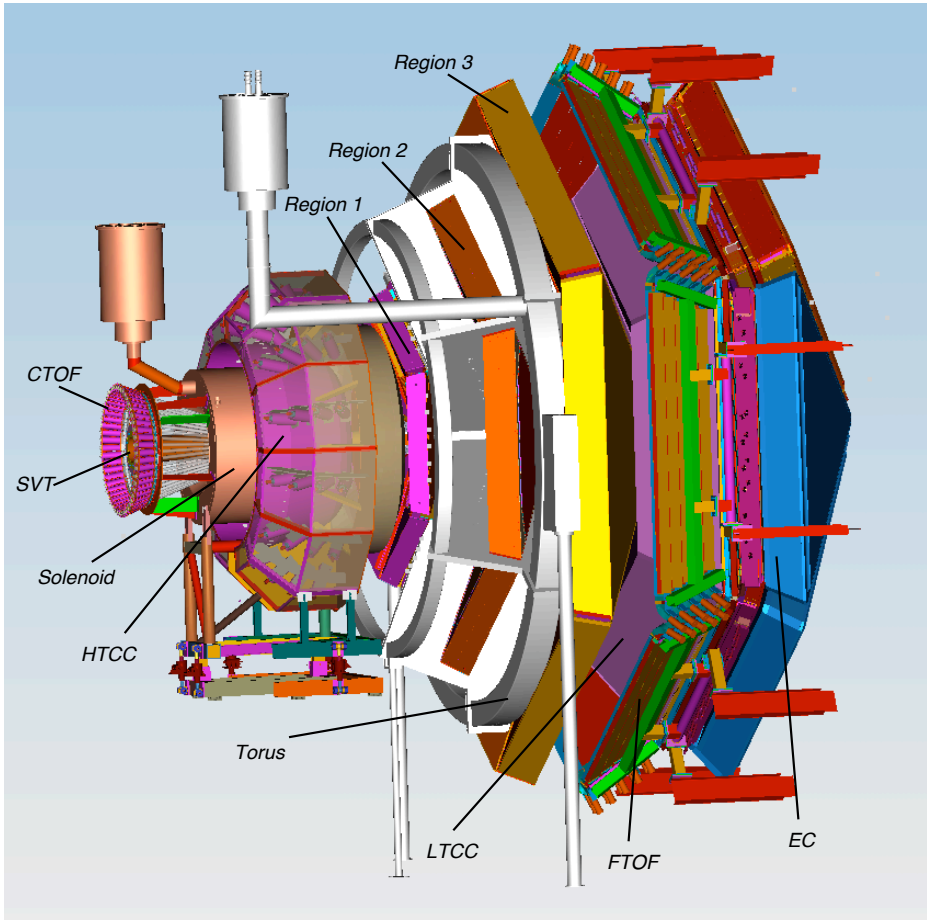
$$\frac{\frac{d\sigma}{dt}(t)}{\frac{d\sigma}{dt}(t=0)} \propto \frac{\langle H^g(t)\rangle^2}{\langle H^g(t=0)\rangle^2} \quad + E^g \text{ contribution}$$

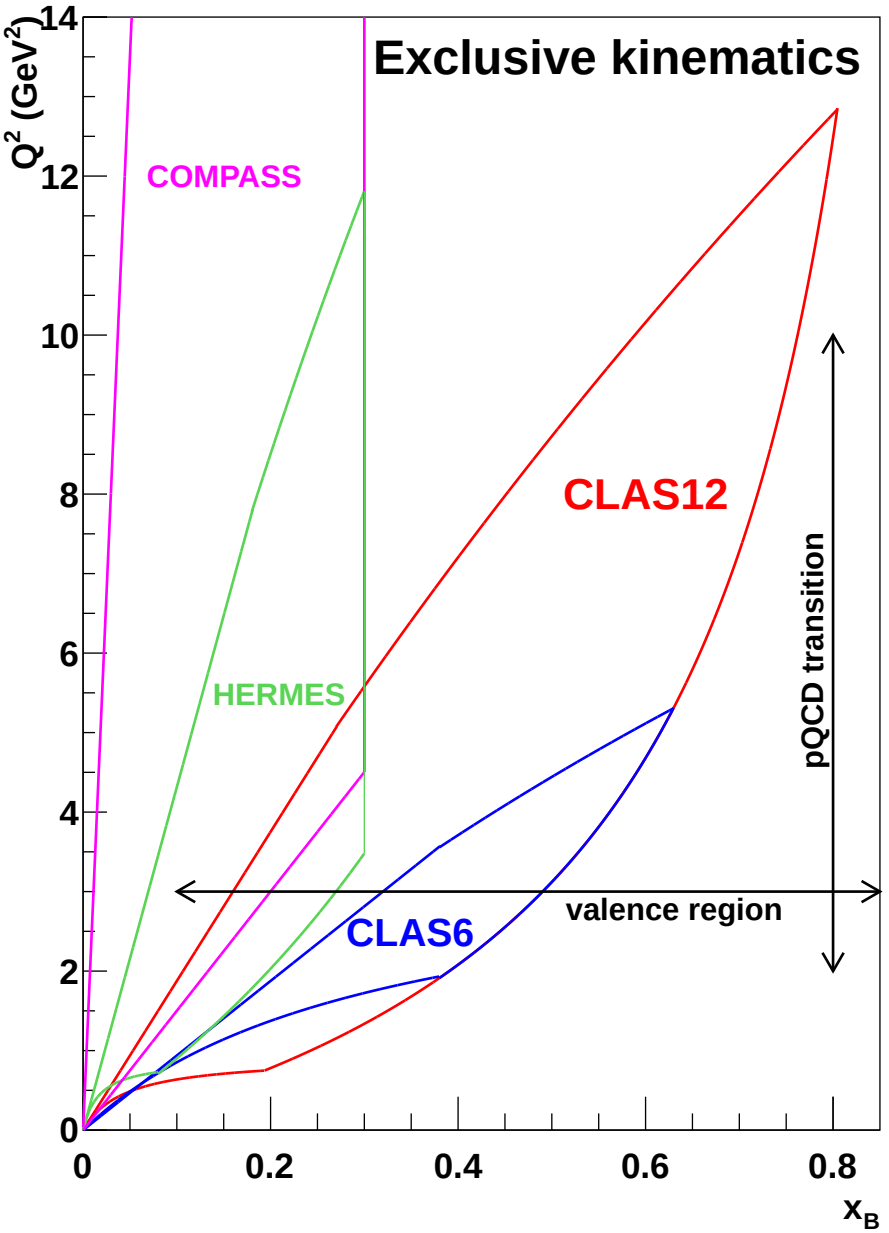
$$\hookrightarrow \langle b^g \rangle^2$$

CLAS12 experiment

CLAS12:

Higher energy
Higher luminosity
Better hermeticity





The CLAS12 detector

Baseline equipments

Forward Detector (FD)

- TORUS magnet (6 coils)
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter

Central Detector (CD)

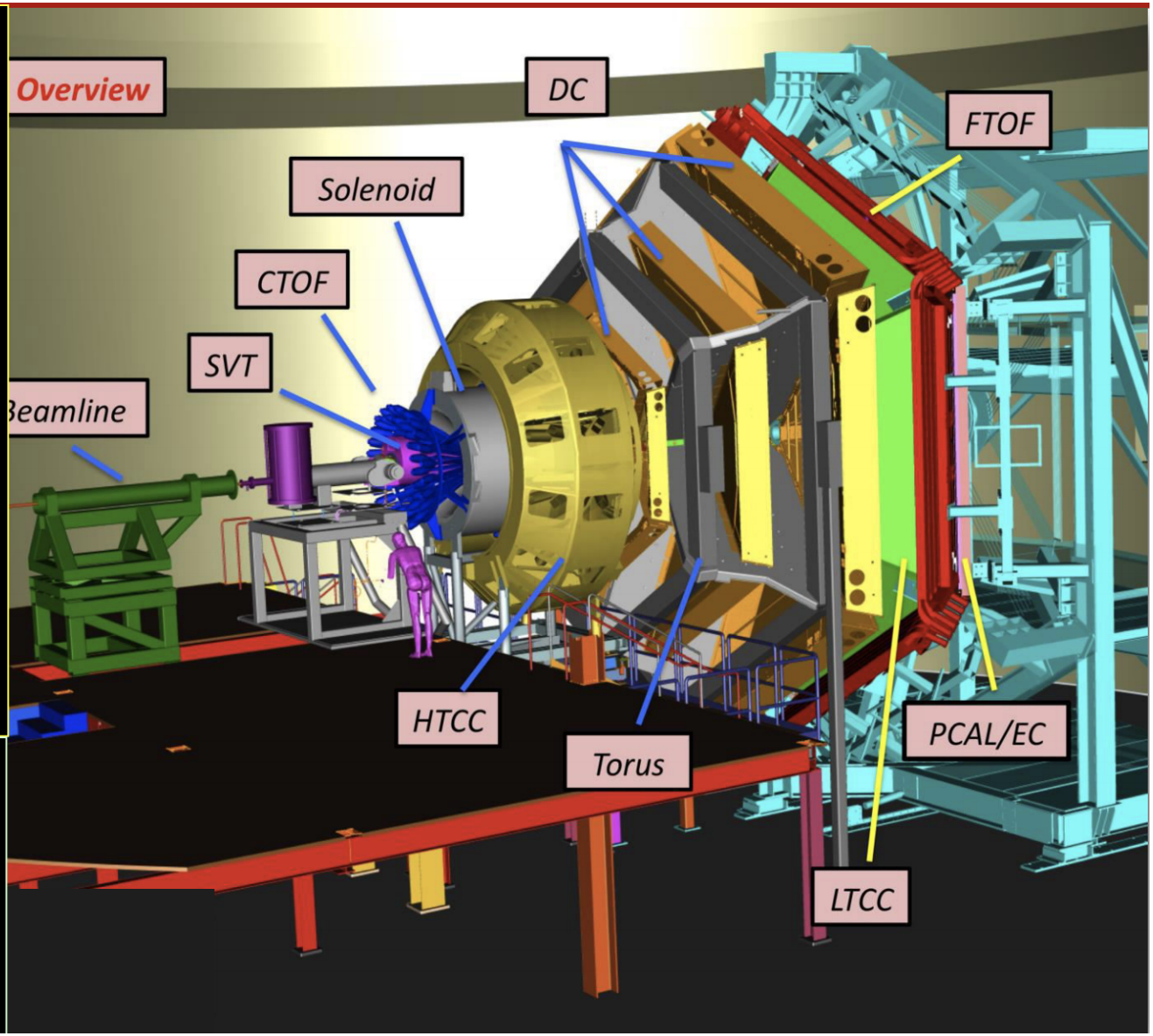
- SOLENOID magnet
- Barrel Silicon Tracker
- Central Time-of-Flight

Beamline

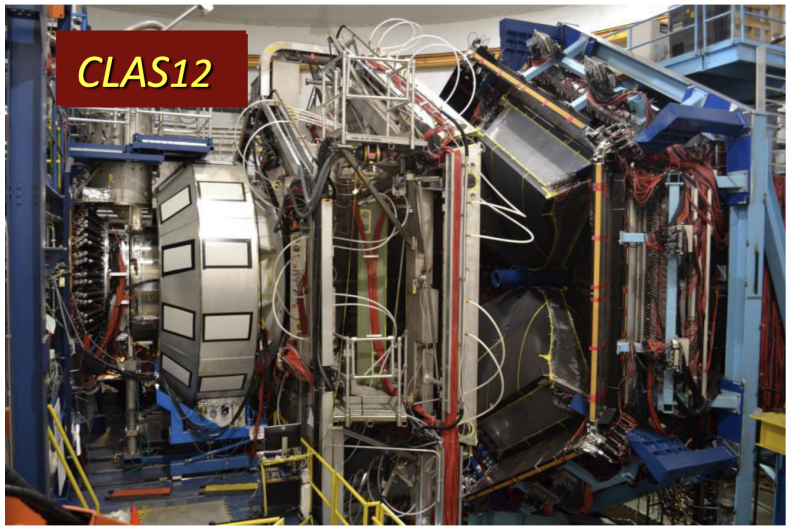
- Polarized target (transv.)
- Moller polarimeter
- Photon Tagger

Upgrades to the baseline & under construction

- RICH detector (FD)
- Forward Tagger (FD)
- Neutron detector (CD)
- Micromegas (CD)
- Polarized target (long.)

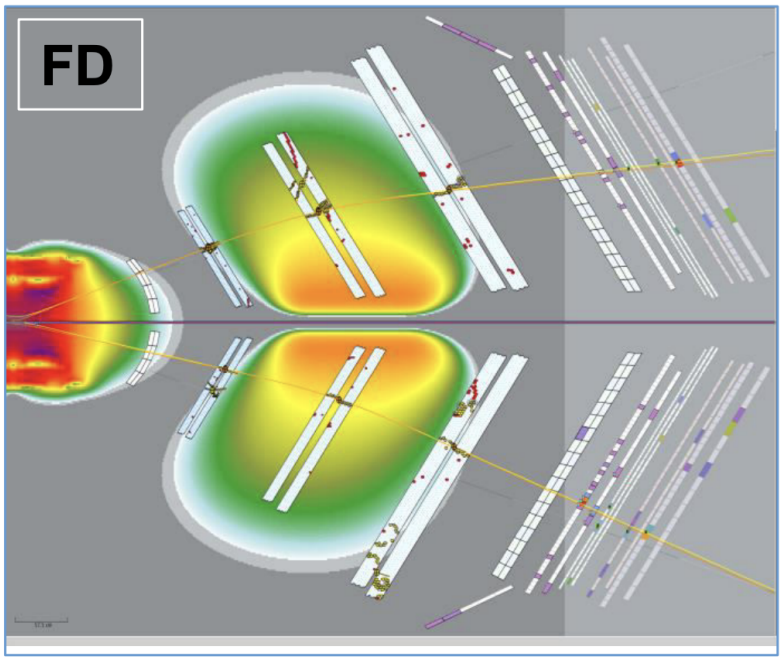


CEBAF Large Acceptance Spectrometer



CLAS12 is a package of two complementary spectrometers

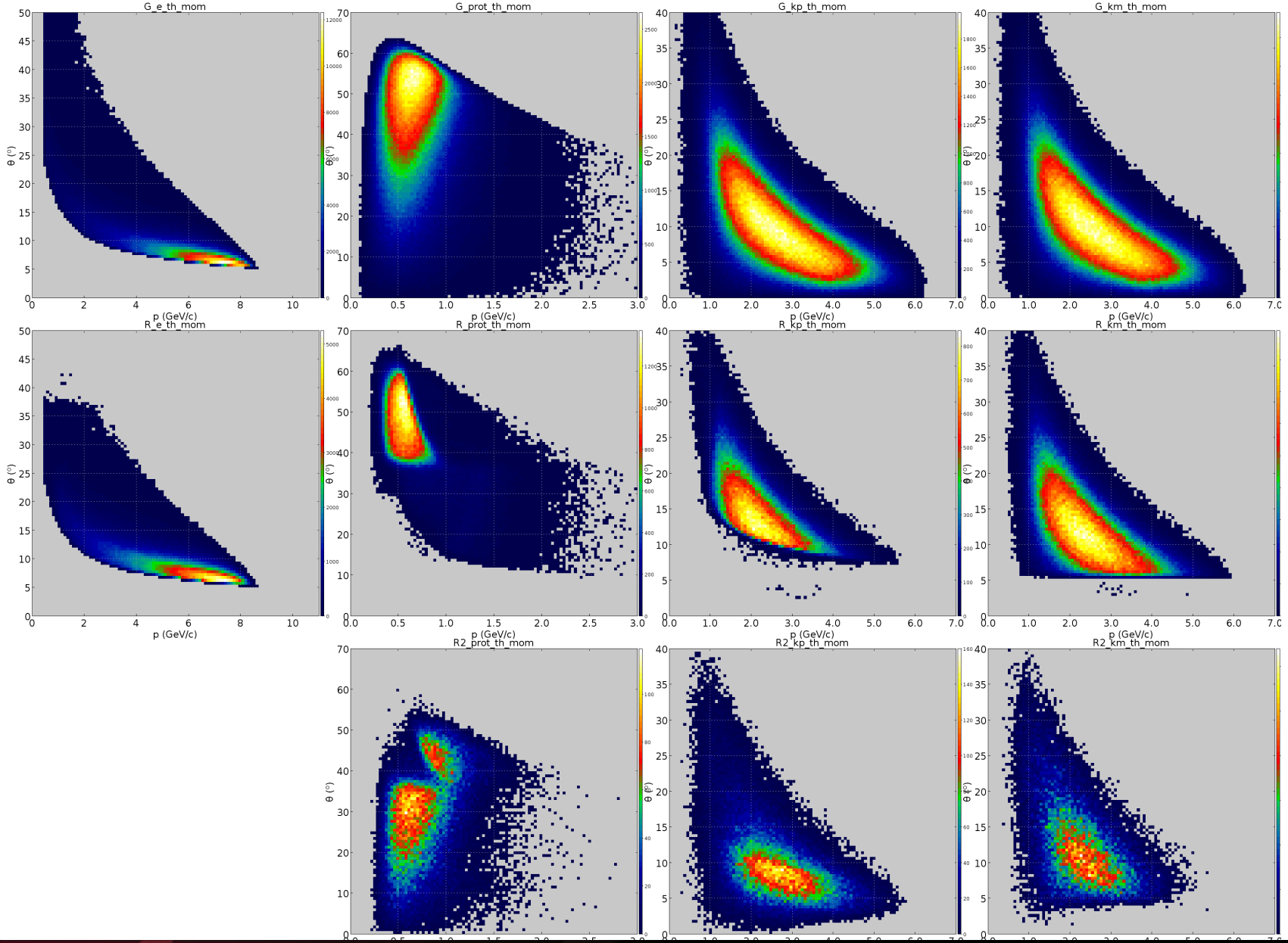
The central detectors in a solenoid field



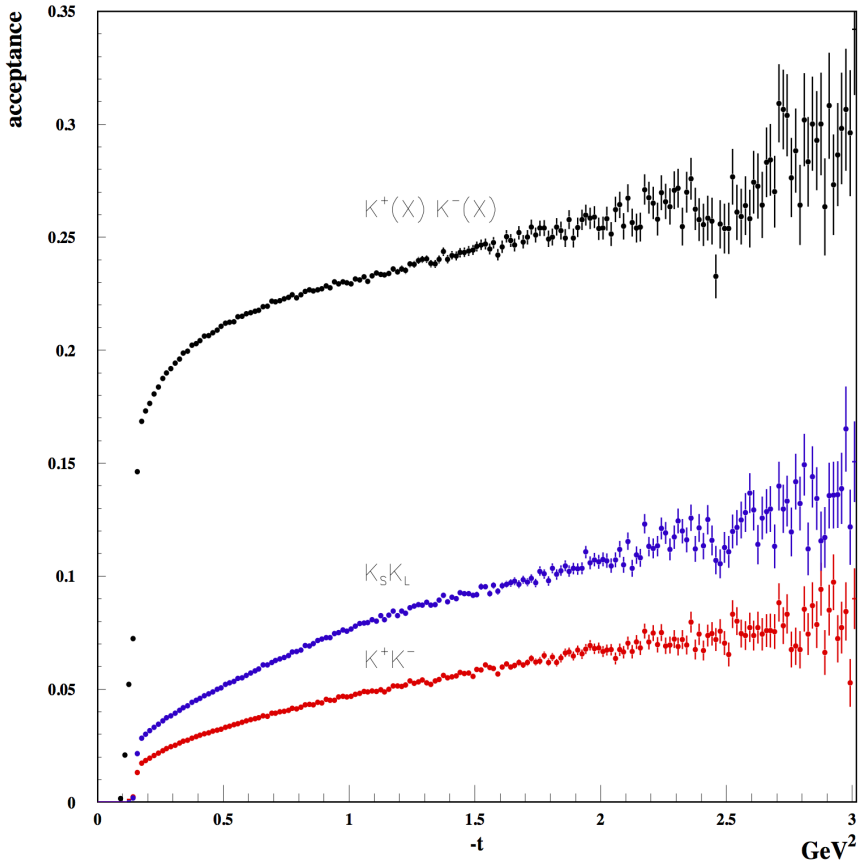
The forward detectors around a toroidal field
DIS experiments are interested in high Q^2 data

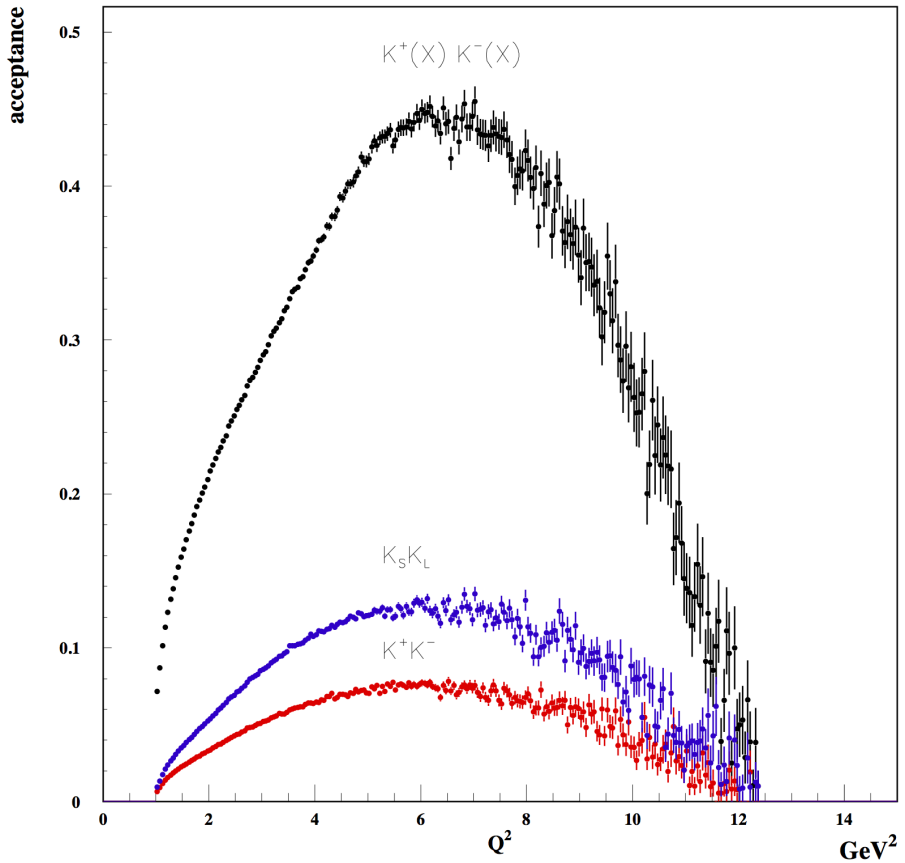
Ordinary torus polarity is **negative inbending** Reactions with several negative particles in the forward direction may benefit from **negative outbending** polarity

$0.05 < x_B < 0.8$, $0.8 < Q^2 < 14$, $0.01 < -t < 5$, $\theta_e > 4^\circ$, $W > 1.5$, $E' > 0.5$
5 cm long target ; Torus Fields : $\pm 1.0, \pm 0.75$; Sol. Field : 1.0, 0.7
Desired config : torus +0.75 and sol 0.7 (negative outbending)



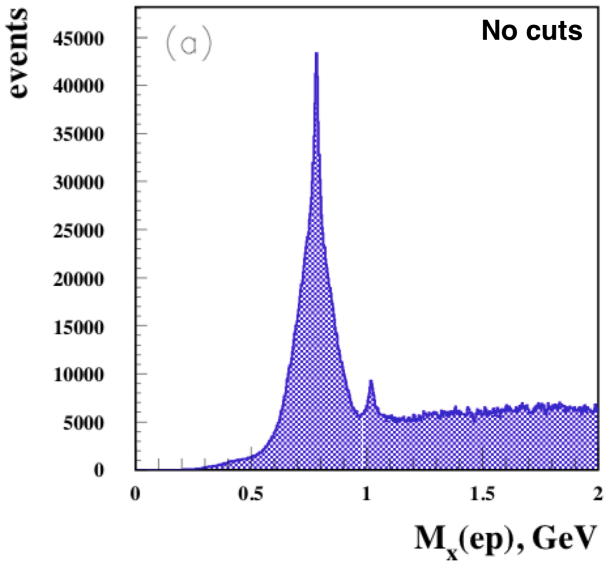
Acceptance

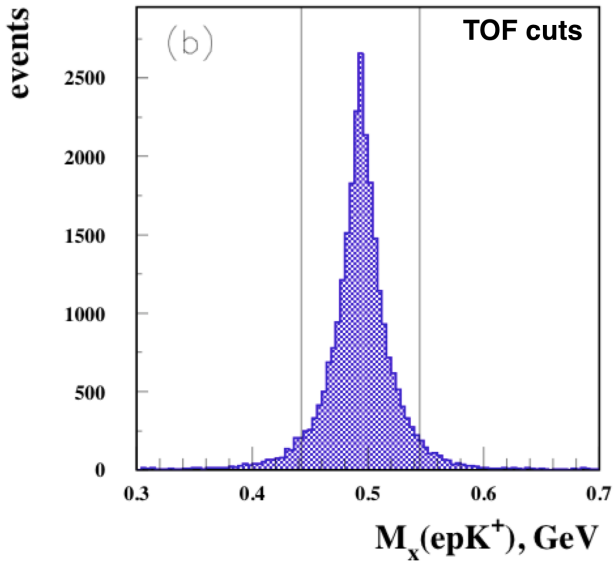


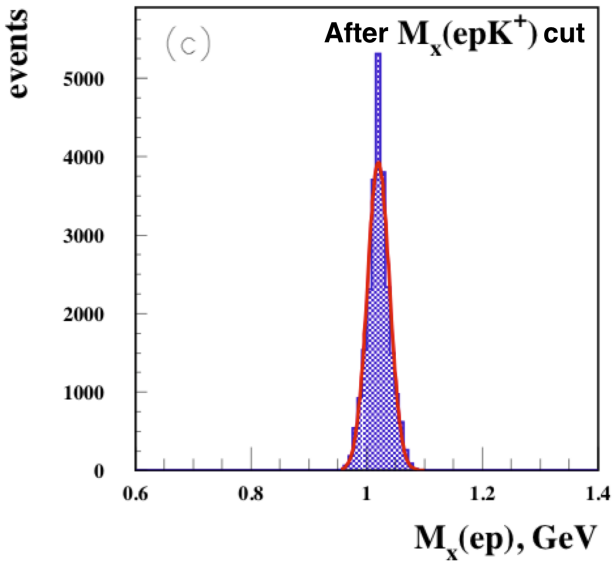


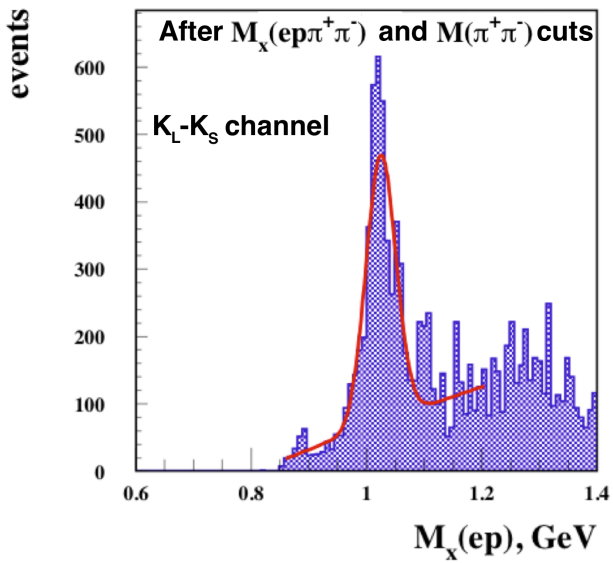
Control over acceptance systematic errors using several channels

Particle identification









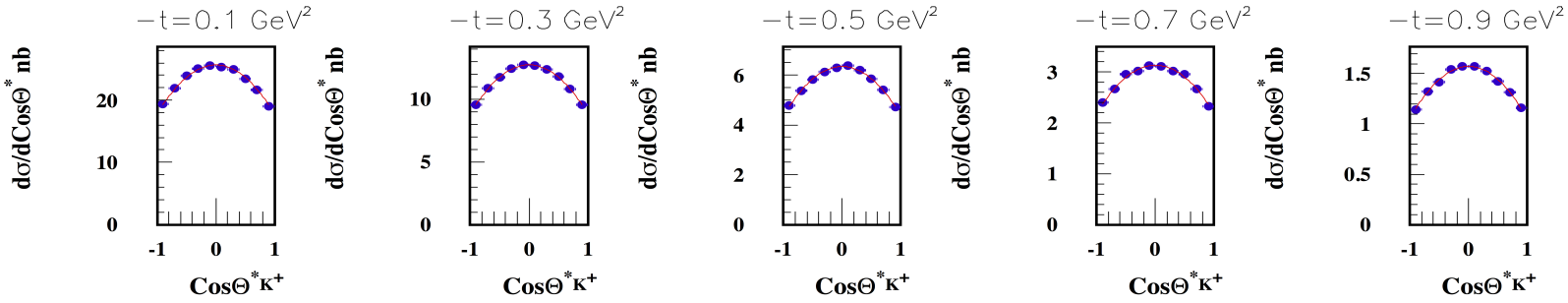
Charged hadrons identified with TOF

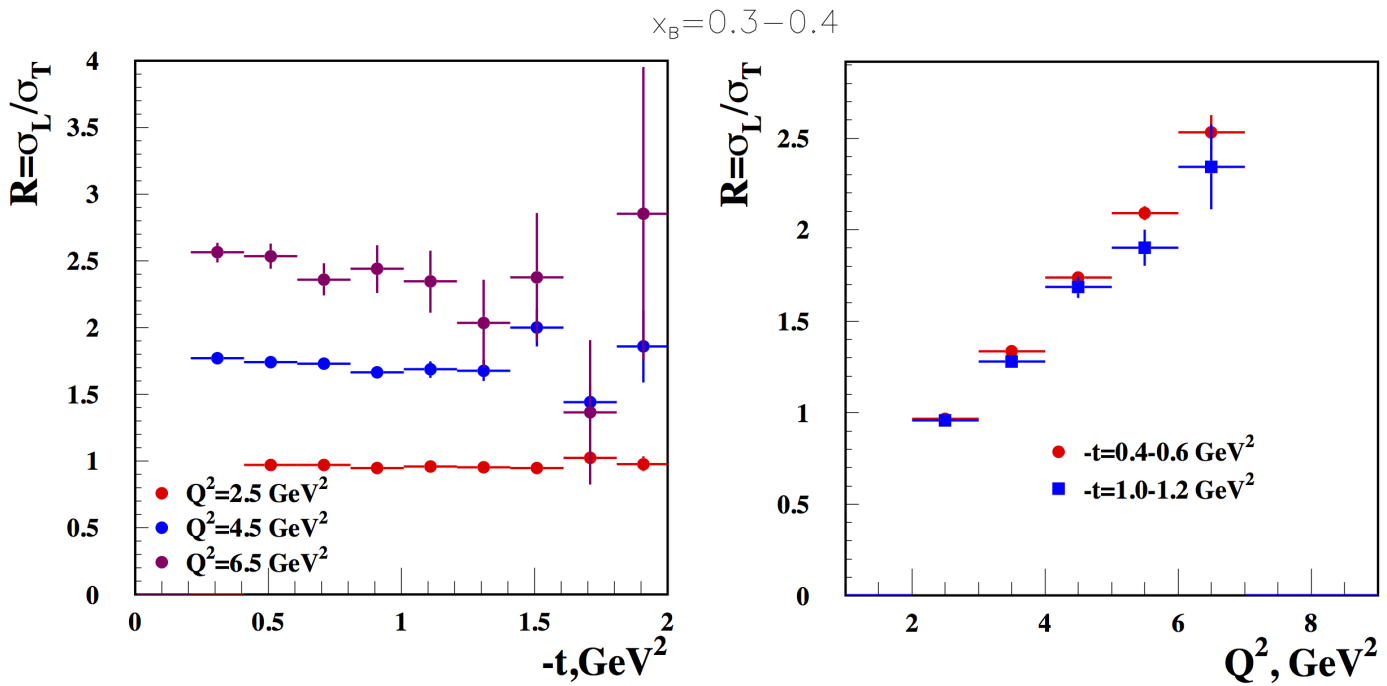
$2.5\sigma_t$ illustrated, up to 6 GeV/c

Large background essentially suppressed for the charged kaon channel

Remaining background in the neutral kaon mode can be subtracted

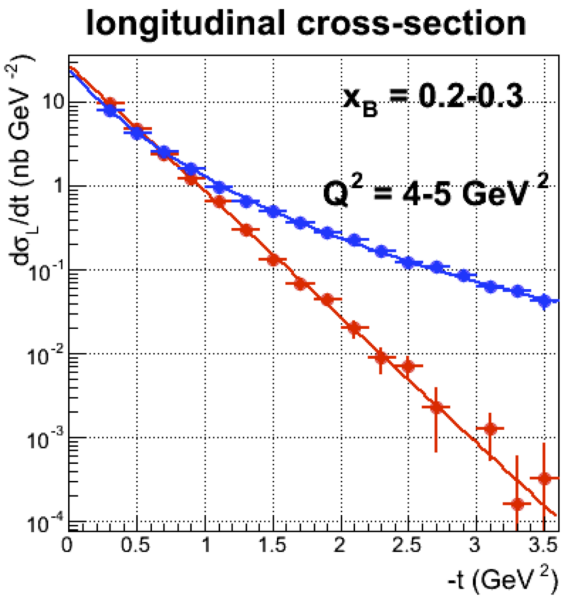
Extraction of the LT-ratio

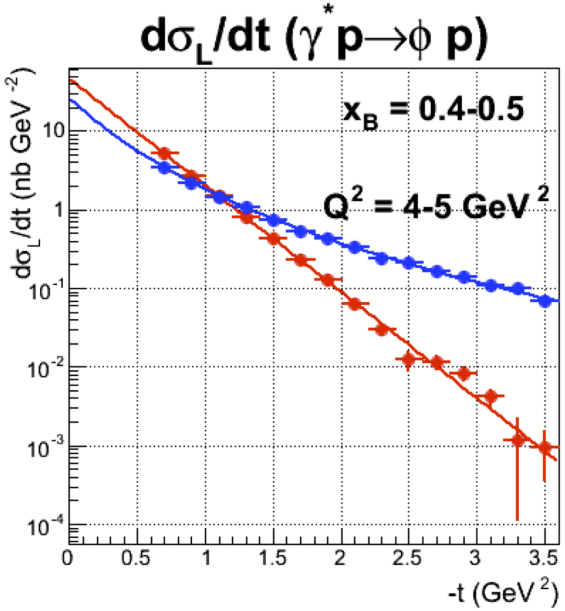


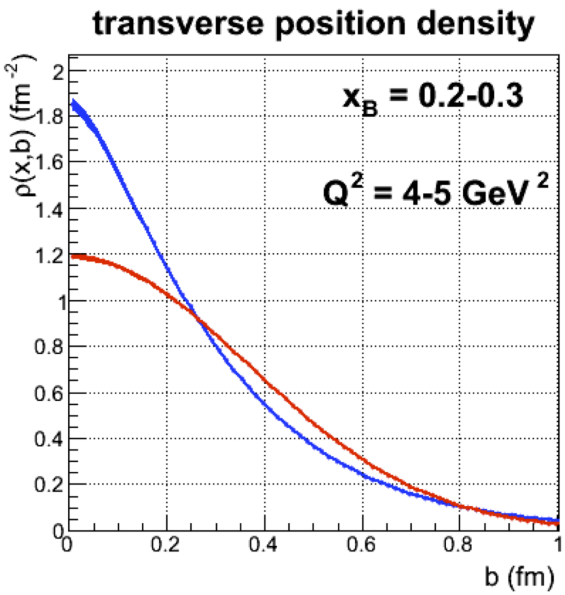


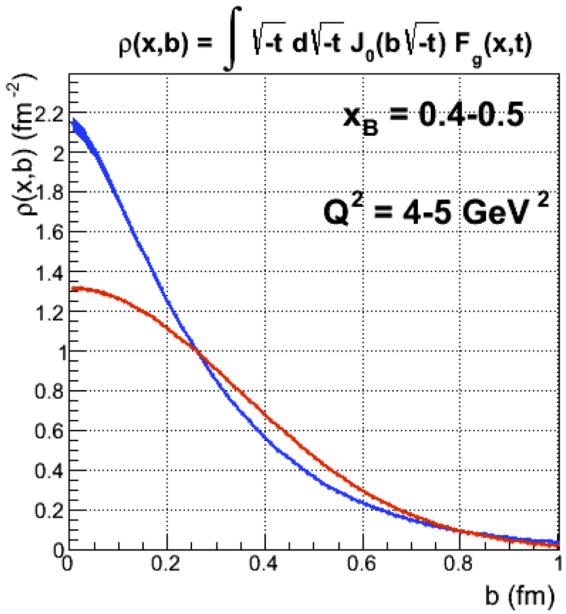
$$\frac{\mathrm{d}\sigma}{\mathrm{d}\cos\theta} = \frac{3}{4}\left[(1-r_{00}^{04}) + (3r_{00}^{04}-1)\cos^2\theta_H\right] \quad , \quad R = \frac{r_{00}^{04}}{\epsilon(1-r_{00}^{04})}$$

Extraction of gluonic profiles









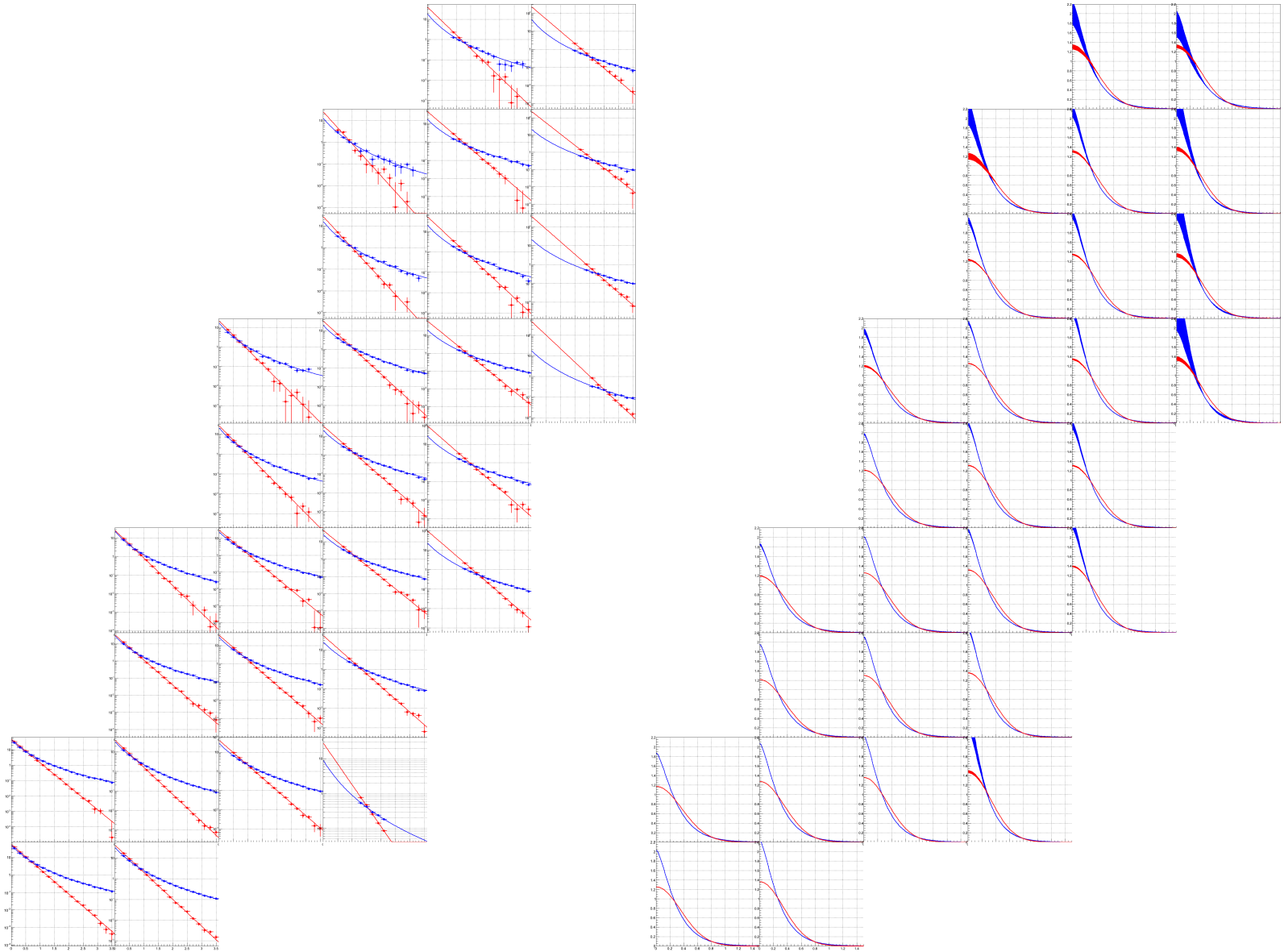
Longitudinal cross-section

Corresponding sensitivity in transverse position space

$$b = 1/\sqrt{-t}$$

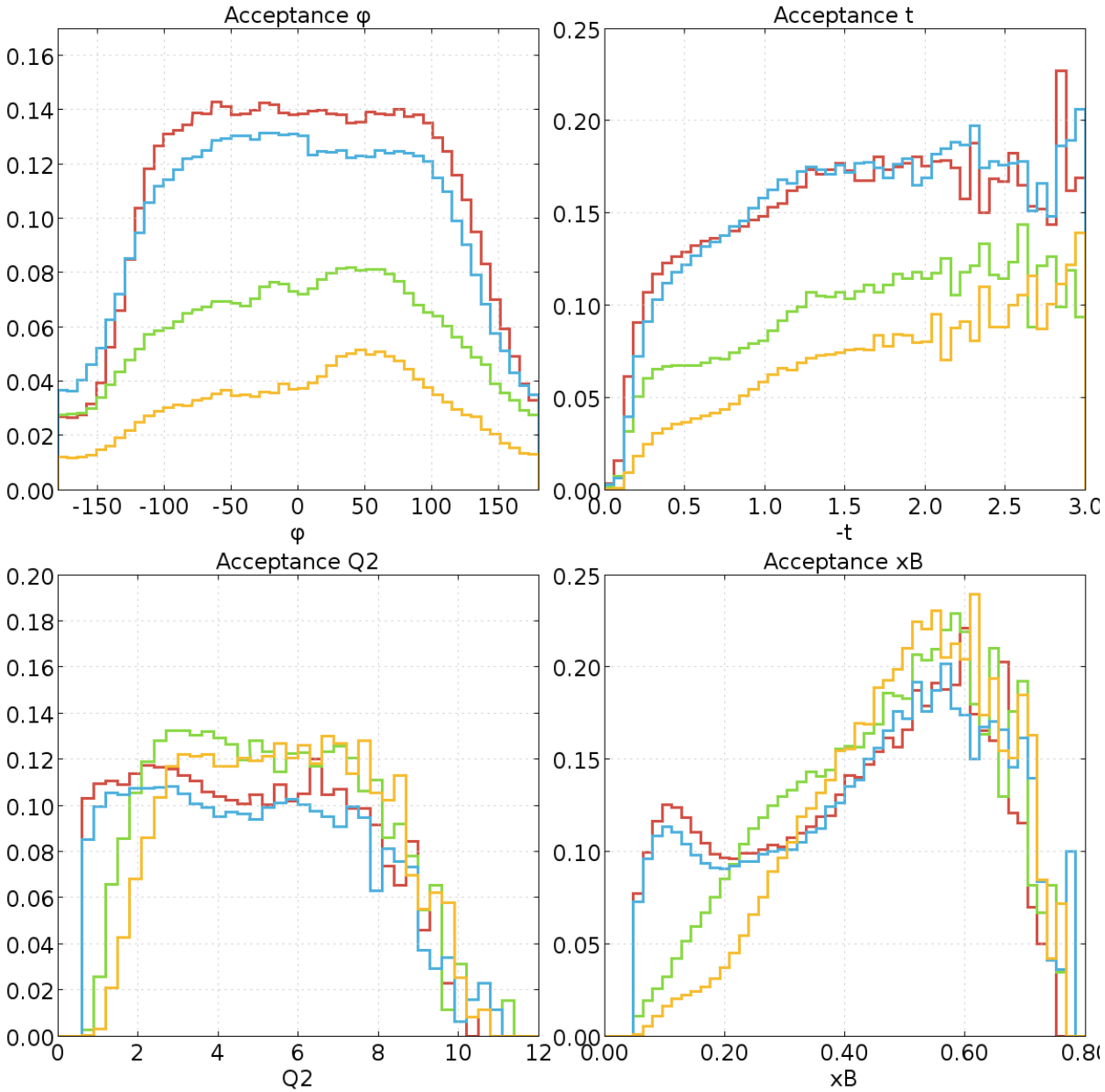
Error propagation study
Skewness $\xi \neq 0$ neglected

Projected gluonic radius



Fully Integrated Acceptances Table, results given in %

	Torus -1 / Sol 1 Torus -1 / Sol 1	Torus -0.75 / Sol 0.7 Torus -0.75 / Sol 0.7	Torus 1 / Sol 1 Torus 1 / Sol 1	Torus 0.75 / Sol 0.7 Torus 0.75 / Sol 0.7
single e	28	40	52	54
proton	11	14	20	20
K+	32	31	14	18
K-	15	19	32	31
Full Excl	0.15	0.37	0.68	0.95
p miss	0.6	1.9	2.4	3.0
K+ miss	0.5	0.8	3.8	3.6
K- miss	1.5	2.1	0.98	1.4
One miss	2.6	4.9	7.1	8.1



1D Integrated Acceptances

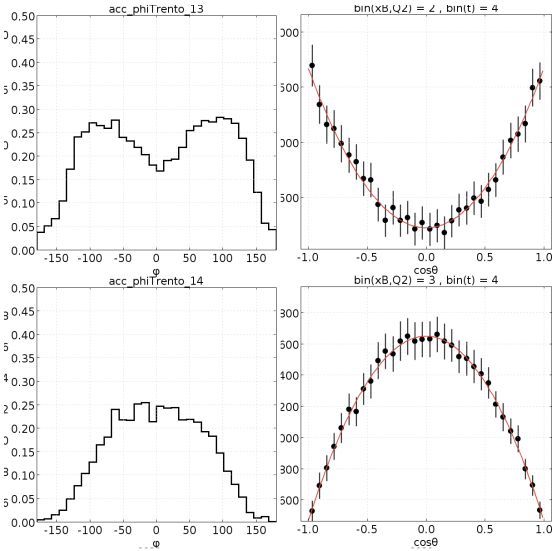
Torus 0.75 / Sol 0.7

Torus 1 / Sol 1

Torus -0.75 / Sol 0.7

Torus -1 / Sol 1

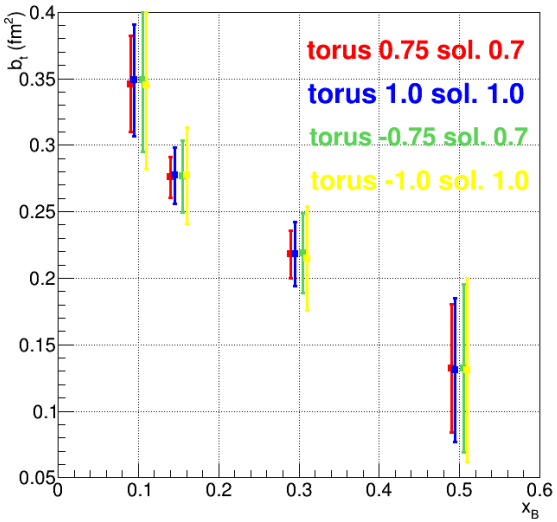
Projected Results for Deep ϕ t-slopes



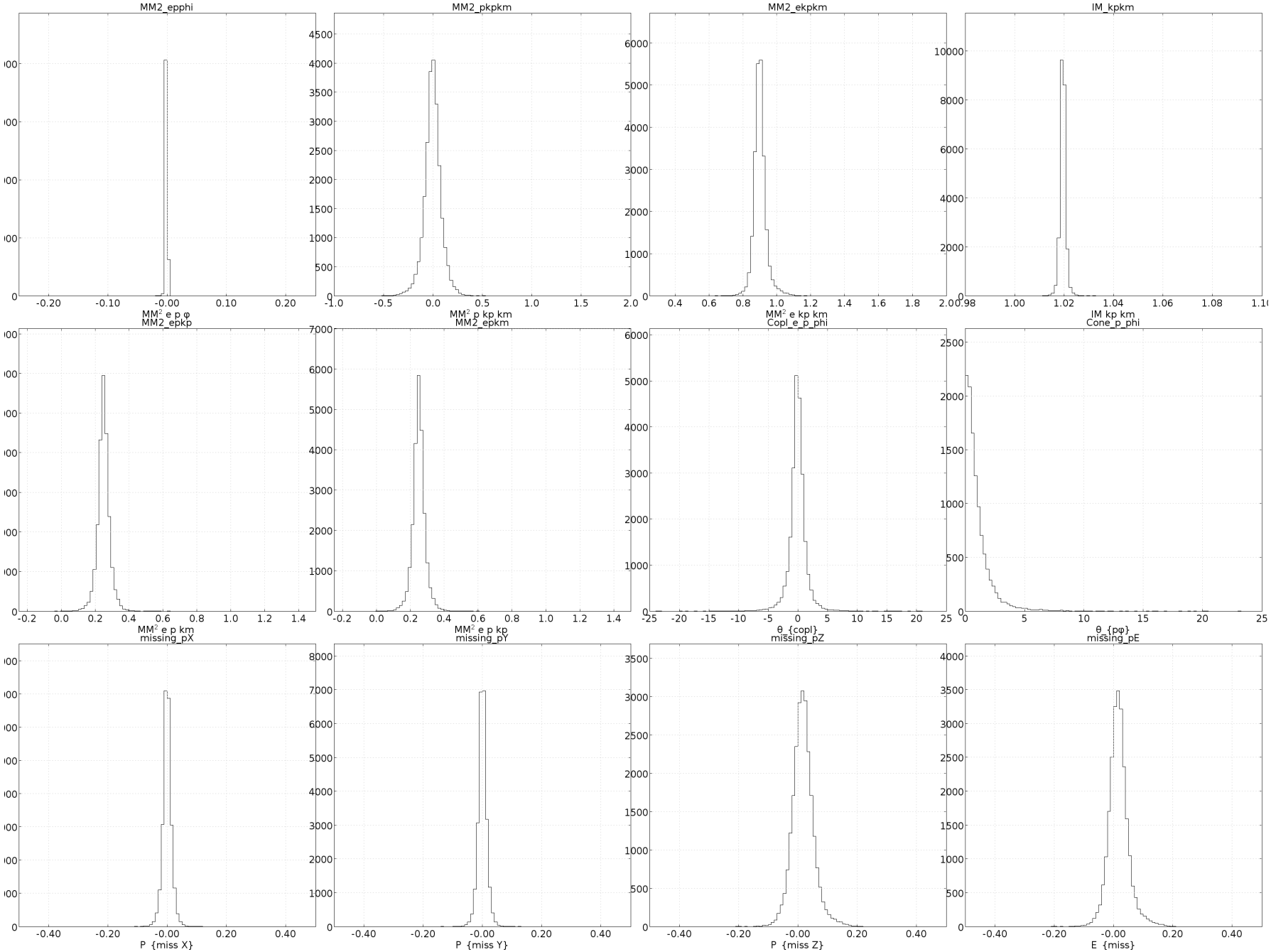
Left column : ϕ acceptances
used for amplitude extraction in **SCHC test**

Right column : $\cos\theta_{CM}$ of meson decay
allows **separation of σ_L and σ_T** under SCHC

Deep ϕ σ_L t-slopes

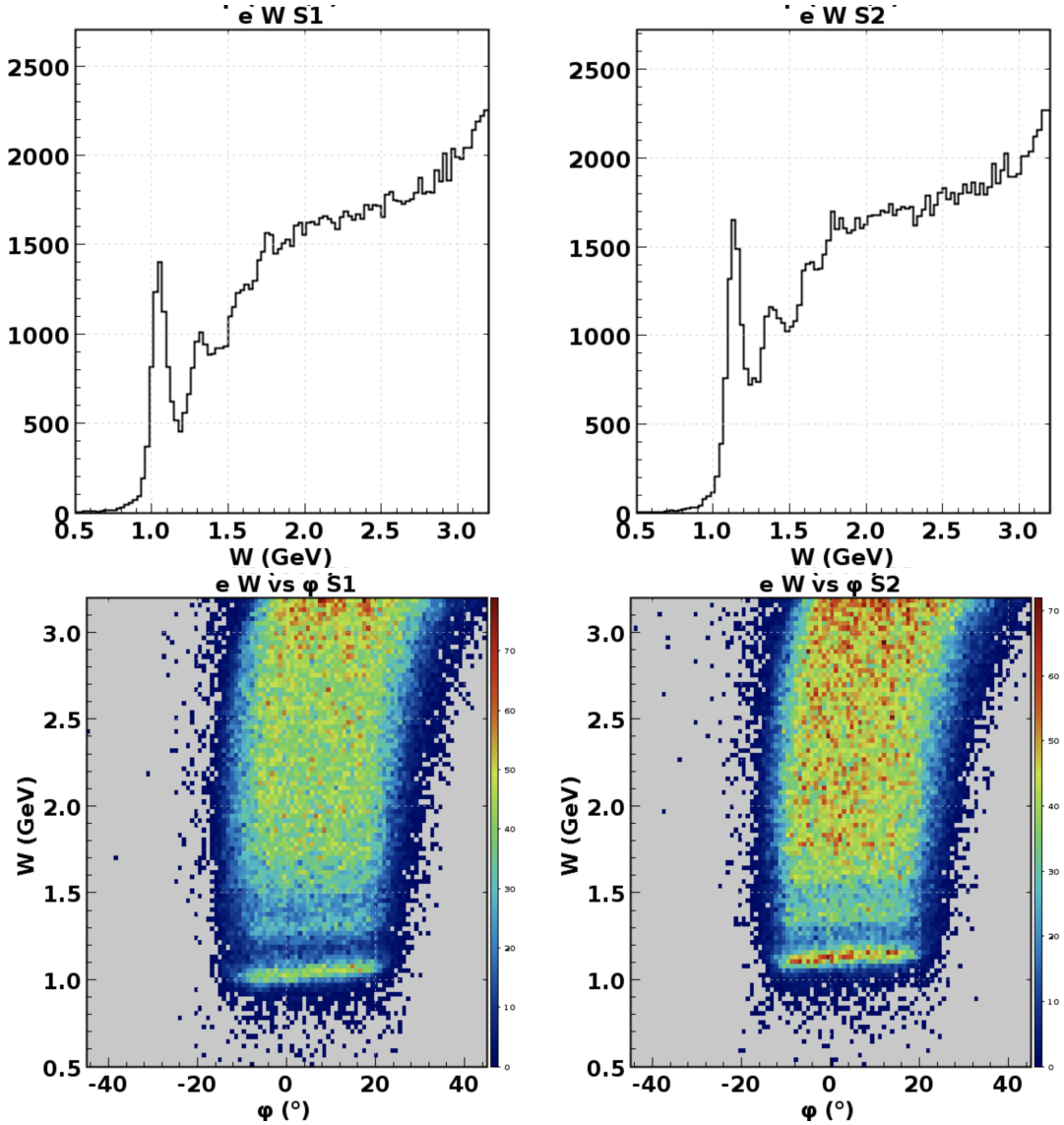


σ_L t-slopes extracted for different magnetic fields
Lower field and negative outbending torus are prefered

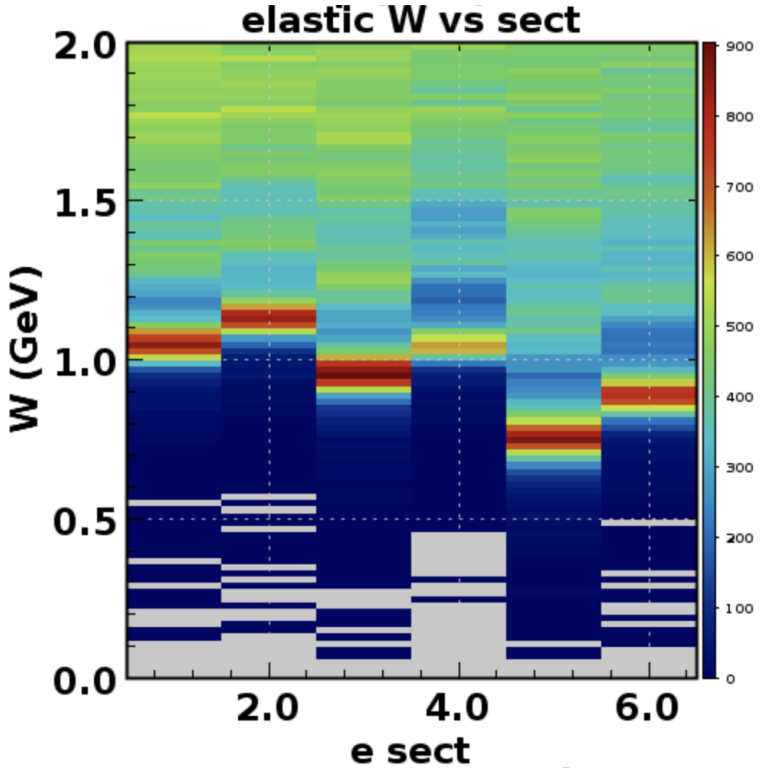

MM2_epphi
MM2_pkpkm
MM2_ekpkm
IM_kpkm
MM2 e p φ
MM2_epkp
MM2 p kp km
MM2_epkm
MM2 e kp km
Copl_e_p_phi
IM kp km
Cone_p_phi
MM2 e p km
missing_pX
MM2 e p kp
missing_pY
θ_{copl}
missing_pZ
θ_{pφ}
missing_pE
P_{miss X}
P_{miss Y}
P_{miss Z}
E_{miss}

CLAS12 preliminary results

CLAS12 elastic and alignement



Electron inclusive spectrum at 7 GeV shows a clear elastic peak as well as higher resonance regions
However the elastic peak location depends on the track azimuthal angle, both inside the sectors and from sector to sector
The main culprit currently investigated is detector alignement



Data Selection

Here we only consider Fully exclusive final state $ep \rightarrow ep\mathrm{K}^+\mathrm{K}^-$ detected

Analysis based on ep "train": DST skimmed for identified electron and proton in coincidence

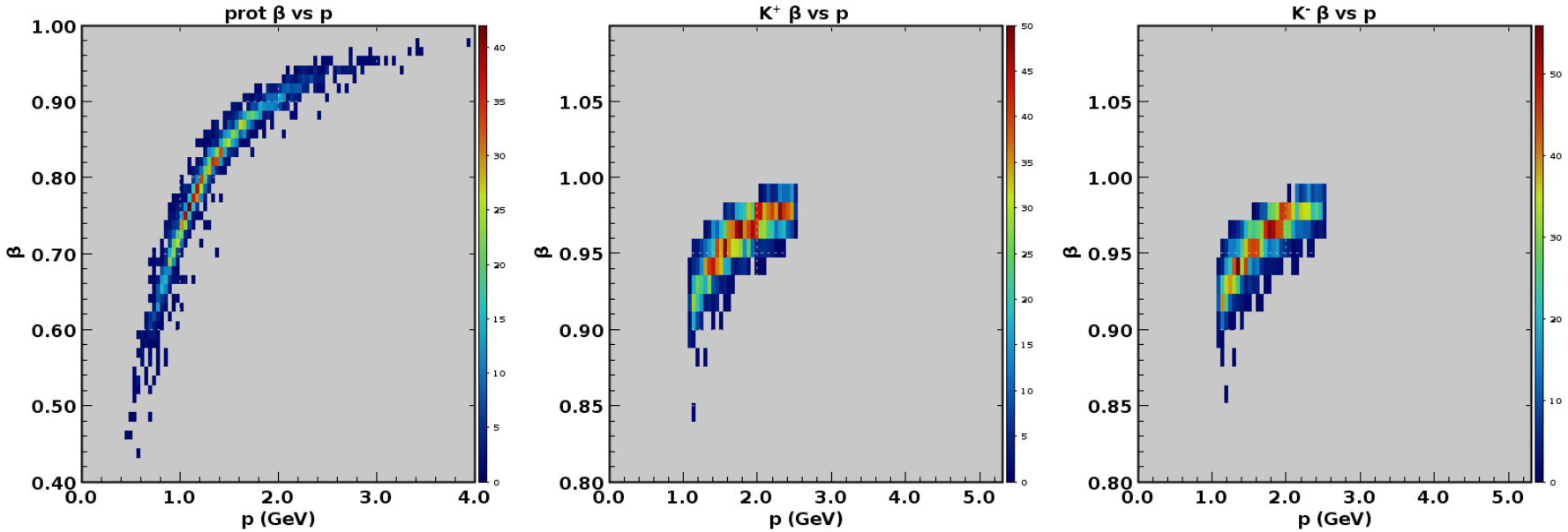
The data presented here corresponds to less than 3% of the PAC approved data All plots shown

next correspond to the same final selection of events EB PID:

- Electron: $p > 1.75$ GeV, $\theta > 7^\circ$, $|v_z| < 20$ cm, $\theta > 17^\circ \times (1 - \frac{p}{7\ \mathrm{GeV}})$
- Proton: $0.4 < p < 4$ GeV, $15 < \theta < 75^\circ$, $|v_z| < 20$ cm
- Kaons: $1.1 < p < 2.5$ GeV, $\theta < 35^\circ$, $|v_z| < 20$ cm

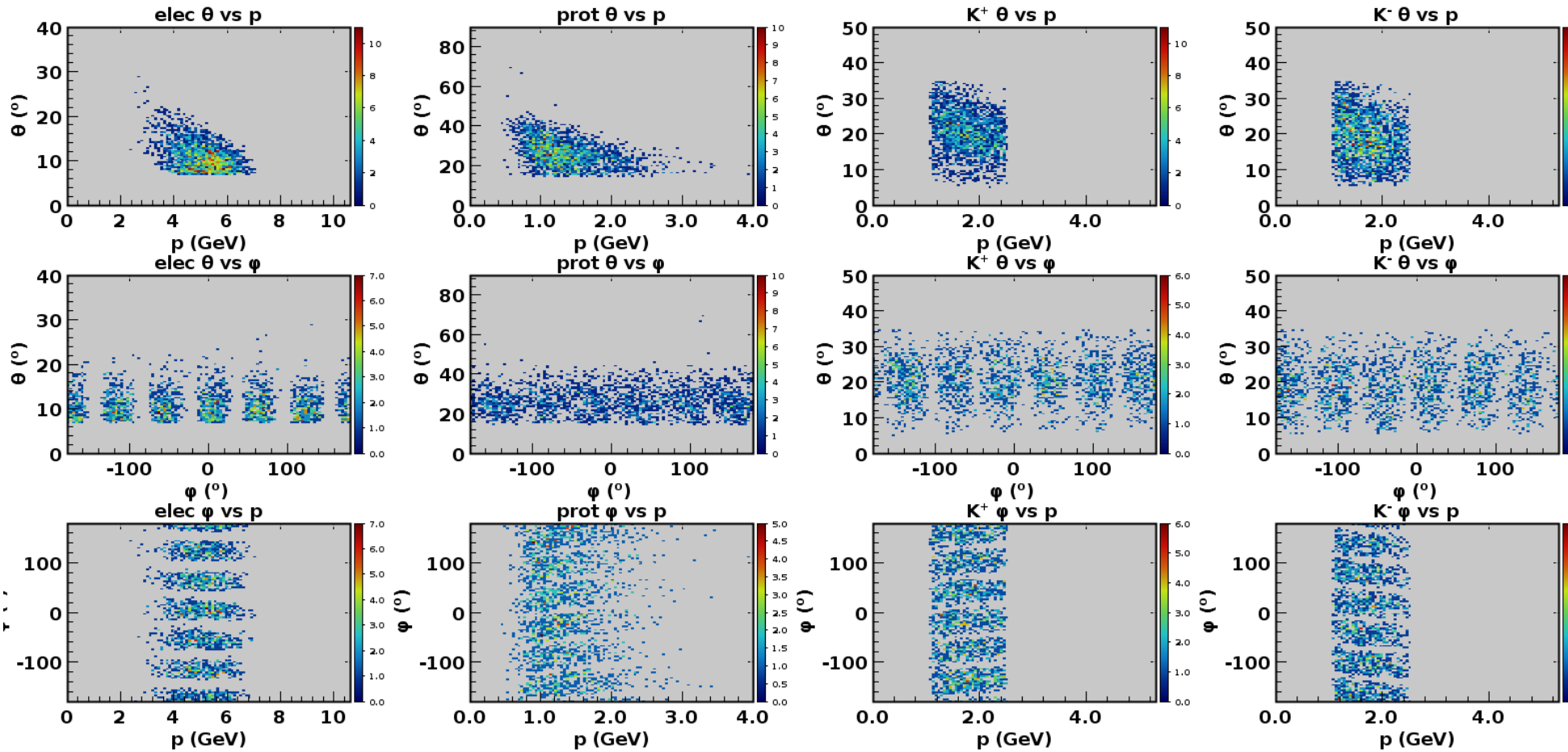
Hadron PID: β vs p

Restricted momentum range to avoid pion contamination

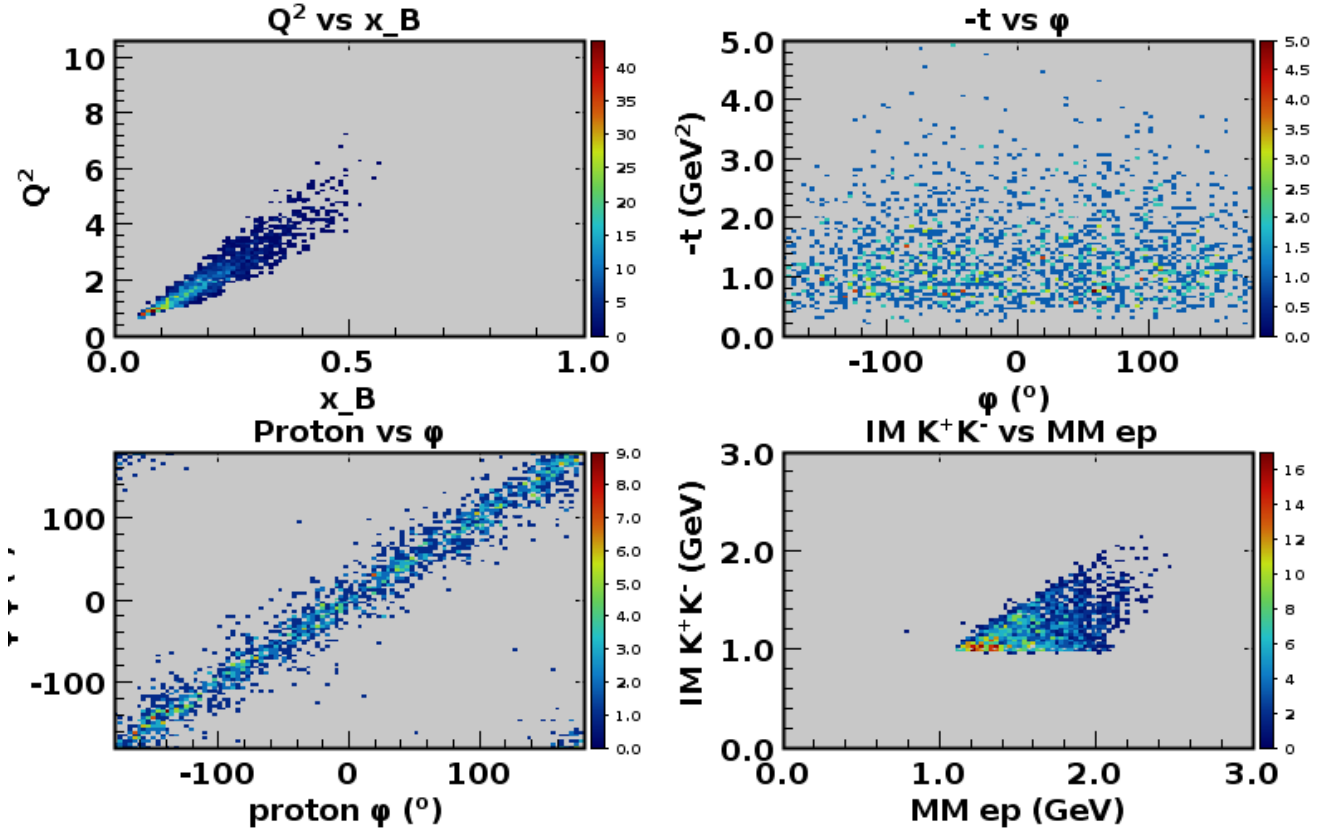


Note: these distributions are obtained only from PID cut
Inbending and Outbending presented together

Kinematical distributions



Exclusivity



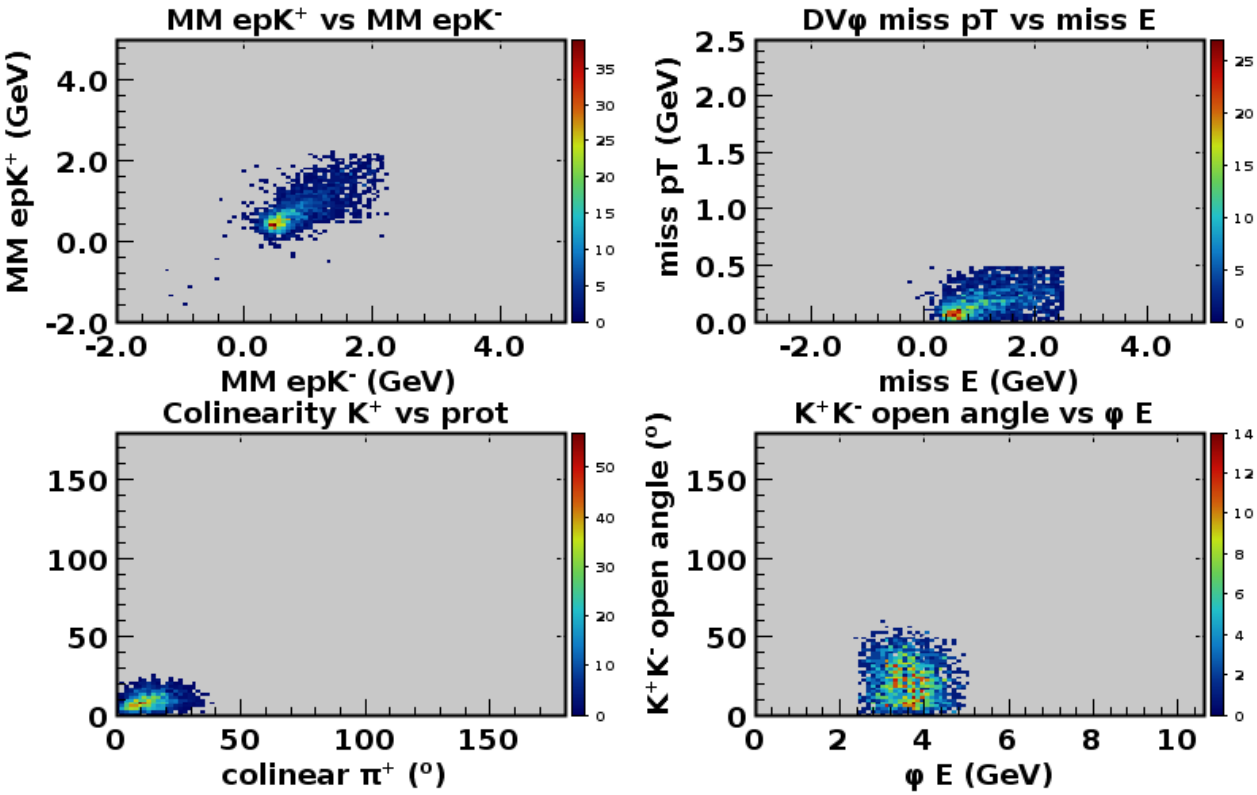
$IM_{K^+K^-} < 3$ GeV $\quad MM_{ep\to epX} < 3$ GeV

$MM_{ep\to epK^+X} < 2.25$ GeV $\quad MM_{ep\to epK^-X} < 2.25$ GeV

$E_{ep\to epK^+K^-X} < 2.5$ GeV $\quad p_{\perp ep\to epK^+K^-X} < 2.5$ GeV $\quad MM_{ep\to epK^+K^-X} < 0.6$ GeV

$\theta(p, ep \to eK^+K^-) < 40°$ $\quad \theta(K^+, ep \to epK^-) < 30°$ $\quad \theta(K^-, ep \to epK^+) < 30°$

Exclusivity



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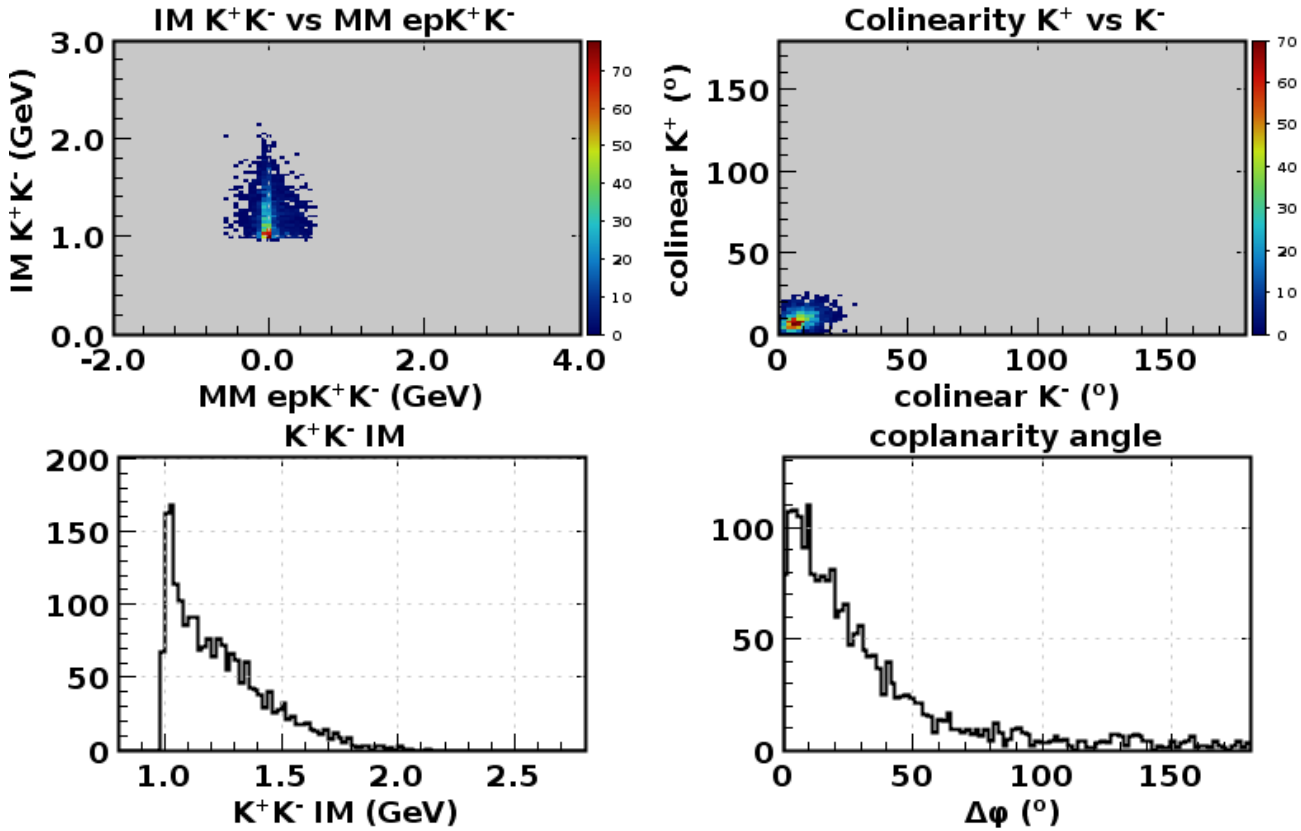
Exclusivity



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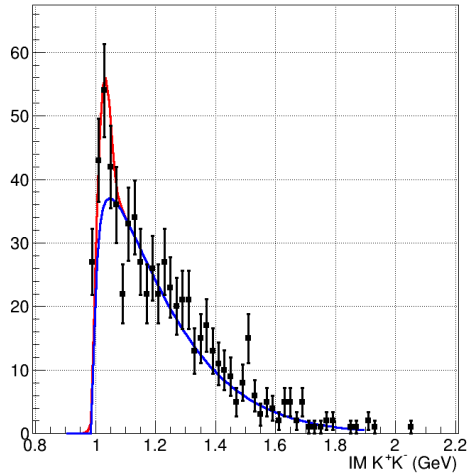
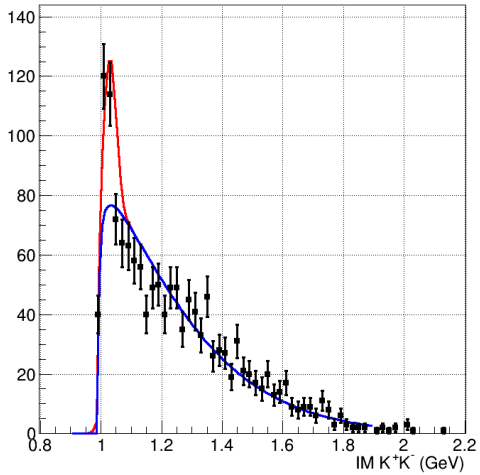
Mass Spectrum and background

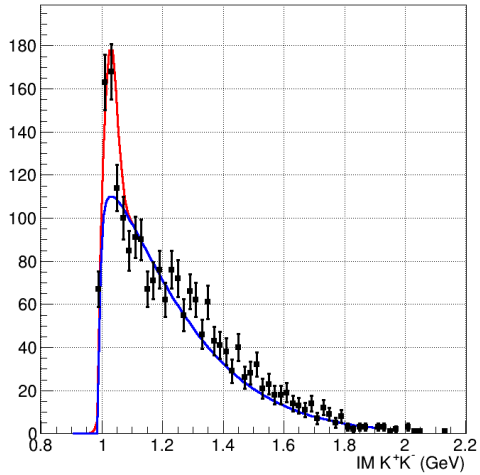
Inbending dataset



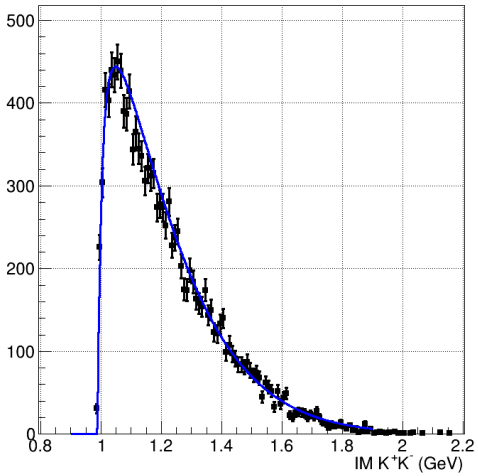
Outbending dataset



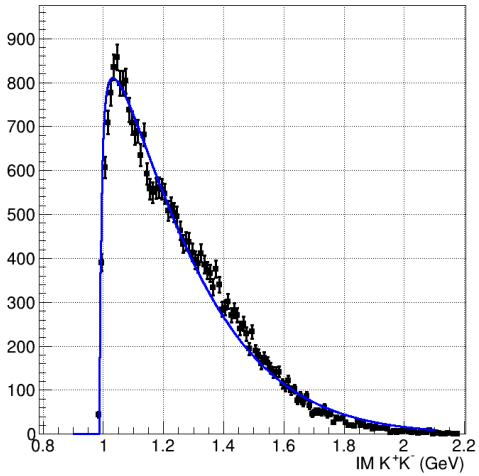
Combined datasets



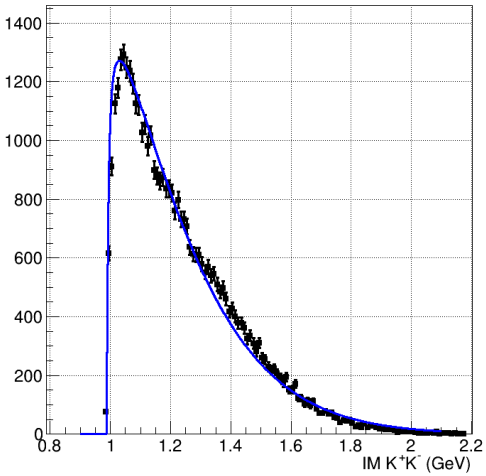
Inbending dataset background

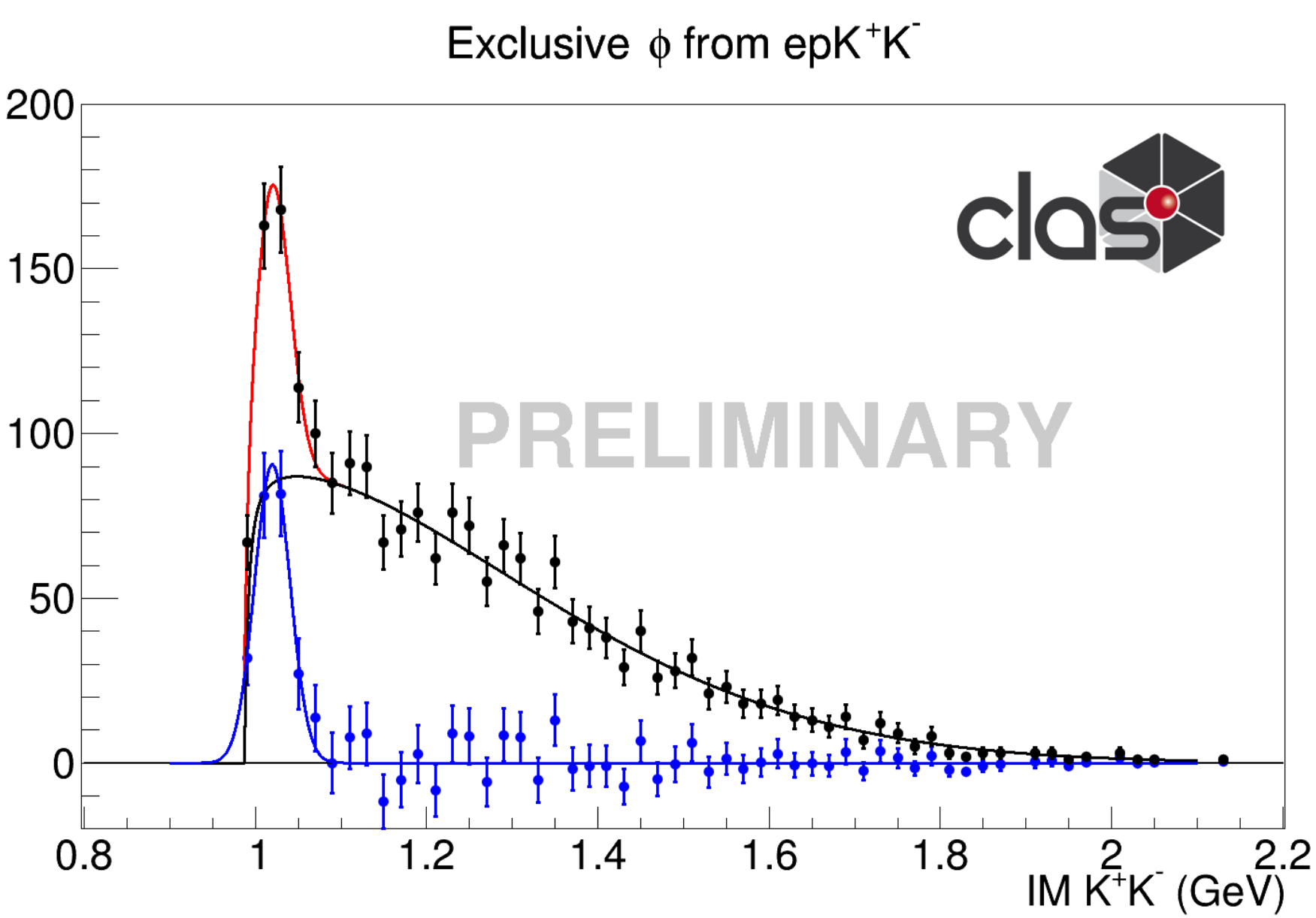


Inbending dataset background



Combined datasets background




Exclusive ϕ from epK+K-
200
150
100
50
0
0.8
1
1.2
1.4
1.6
1.8
2
2.2
IM K+K- (GeV)
PRELIMINARY

Outlook / Beyond CLAS12

Outlook / Beyond CLAS12

- Deeply Virtual ϕ production: gluonic radius in the valence region
- CLAS12 data taking started, preparation for pass 1 well underway
- Observation of fully exclusive ϕ events
- Beyond CLAS12: ϕ and $J\Psi$ at EIC
- Simulations for EIC: individual channels, and full inclusive for background estimations
- Shared resources for EIC simulations?