Open Charm at EIC

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2nd Electron Ion Collider Workshop
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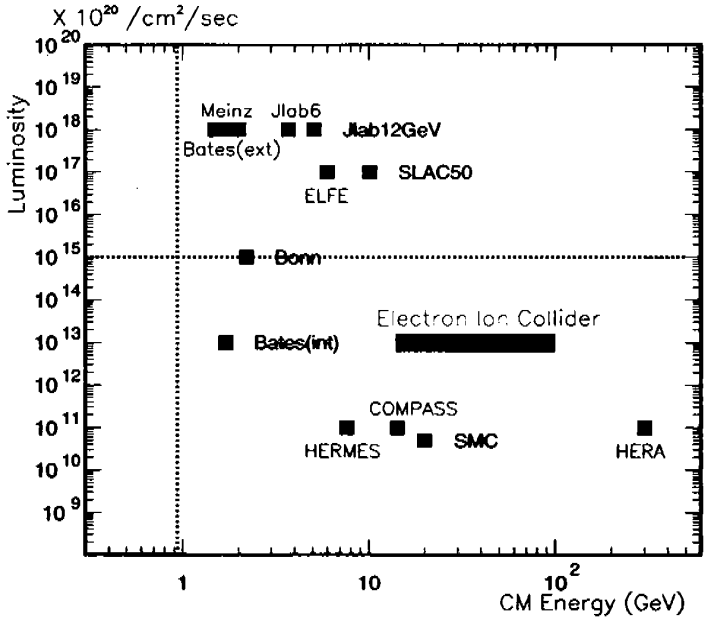


- Clean and complementary access to $\Delta G/G$
- Gluon distribution in nuclei
- Determination of charm mass ?

Charm Physics

hermes

Observable decay modes

- open charm

  $D^0 \longrightarrow K^+\pi^- \quad + \text{c.c.}$

  $D^0, D^+ \longrightarrow K^+\mu^- X \quad + \text{c.c.}$

  - requires very good PID
  - suffers from large combinatoric background
  - $D^0 \longrightarrow K^+\pi^-$ is the only decay mode into 2 particles, i.e. has the best signal/background ratio
  - K and μ from the vertex is a clear signature for charm

- J/ψ

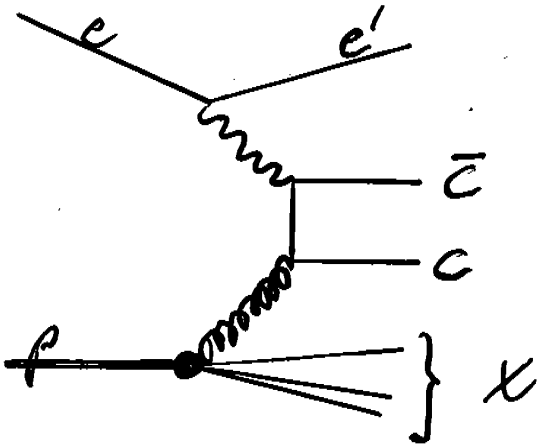
  $J/\psi \longrightarrow e^+e^-$

  $J/\psi \longrightarrow \mu^+\mu^-$

  - requires large acceptance
  - suffers from low rates
  - has almost no background

Production mechanisms

Open Charm

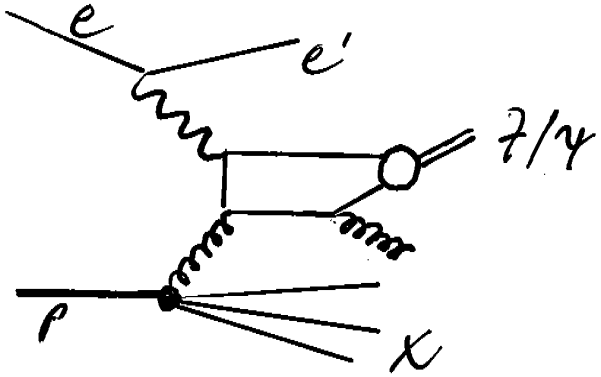


$$A_{\gamma N}^{c\bar{c}} \sim 1/1.2 \frac{\Delta G}{G}$$

$$A_{\gamma N}^{c\bar{c}} = \frac{1}{3} A_{eN}^{c\bar{c}}$$

$$= \frac{1}{3 f_{\beta} P_T} A^{exp}$$

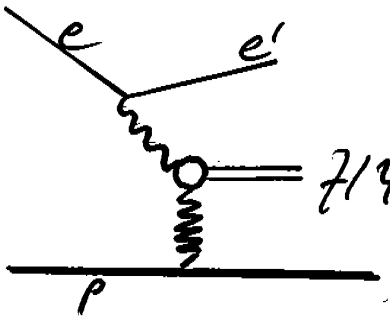
J/ψ



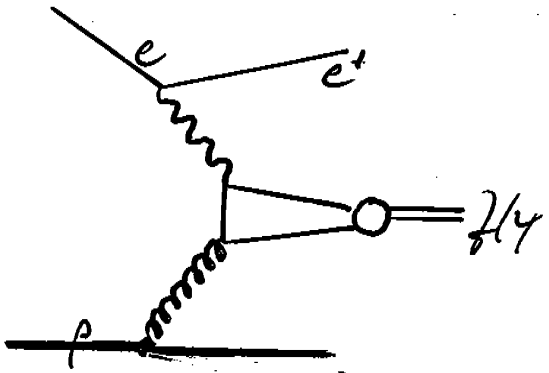
inelastic J/ψ production
dominated by CSM

$$A_{\gamma N}^{J/\psi} \sim 1/1.8 \frac{\Delta G}{G}$$

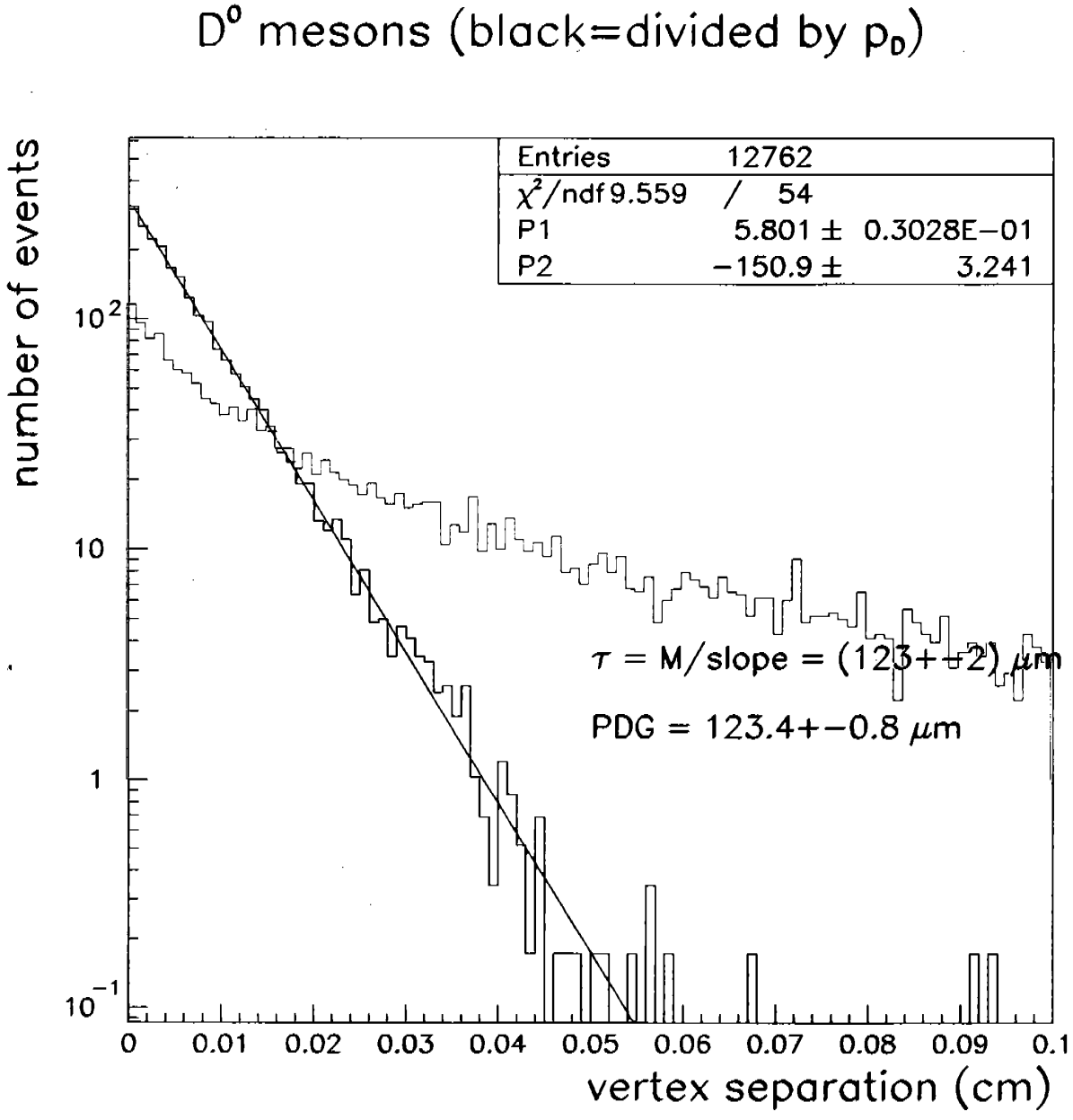
$z < 0.95$



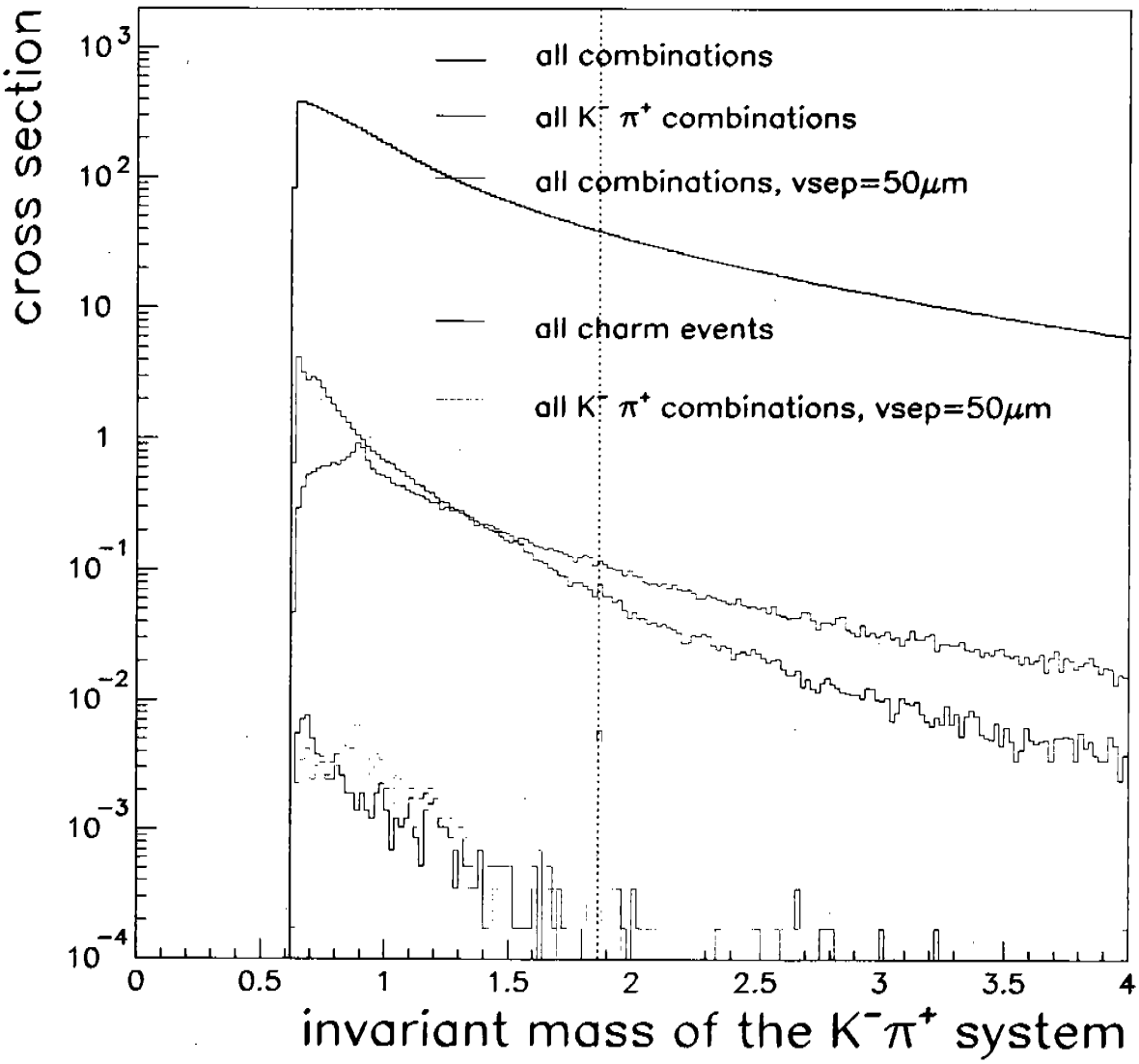
elastic diffraction
J/ψ production
$A \sim ?$, $z = 1$

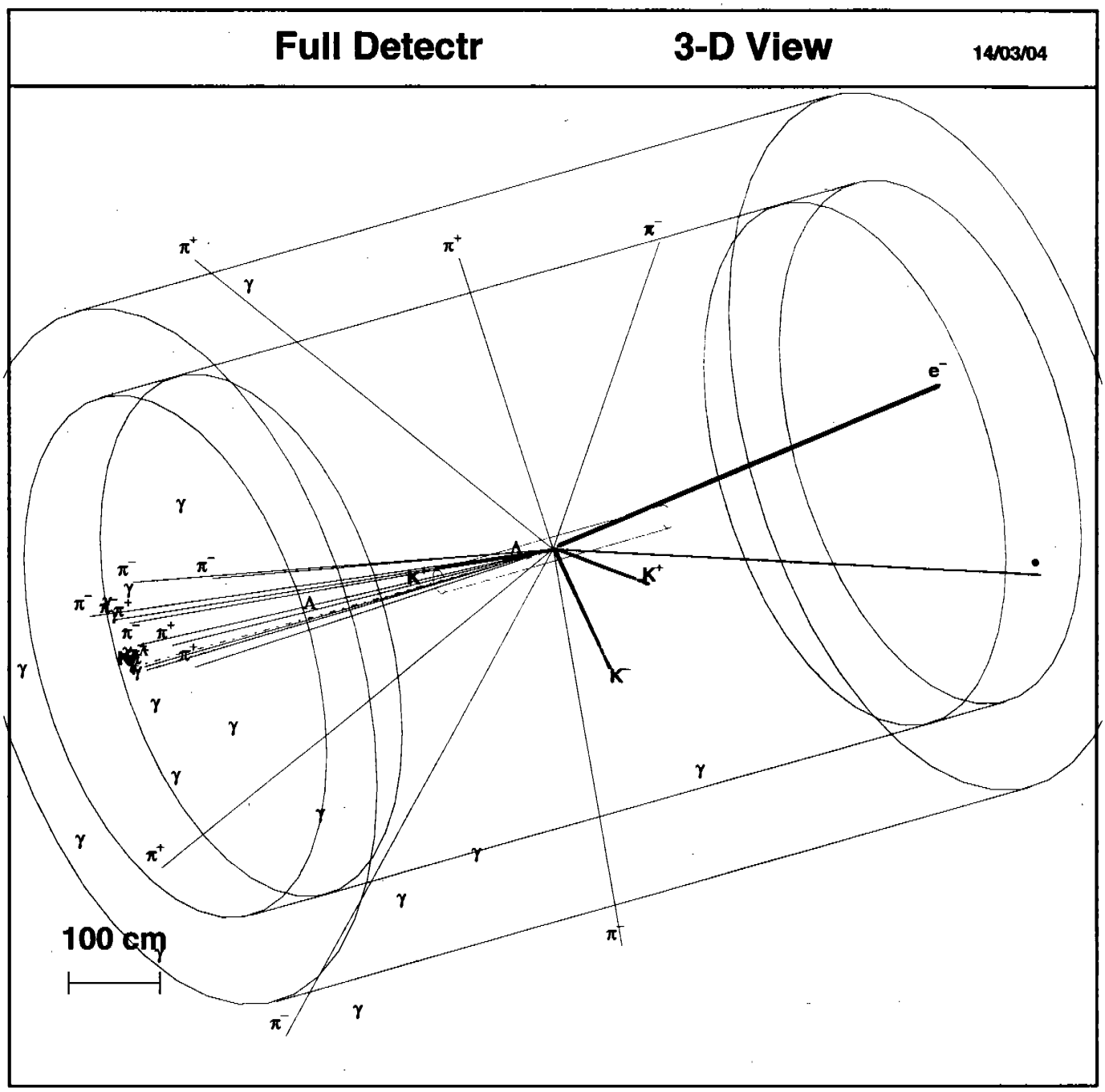


elastic non diffraction
$A \sim 1.0 \frac{\Delta G}{G}$ (?), $z \sim 1$

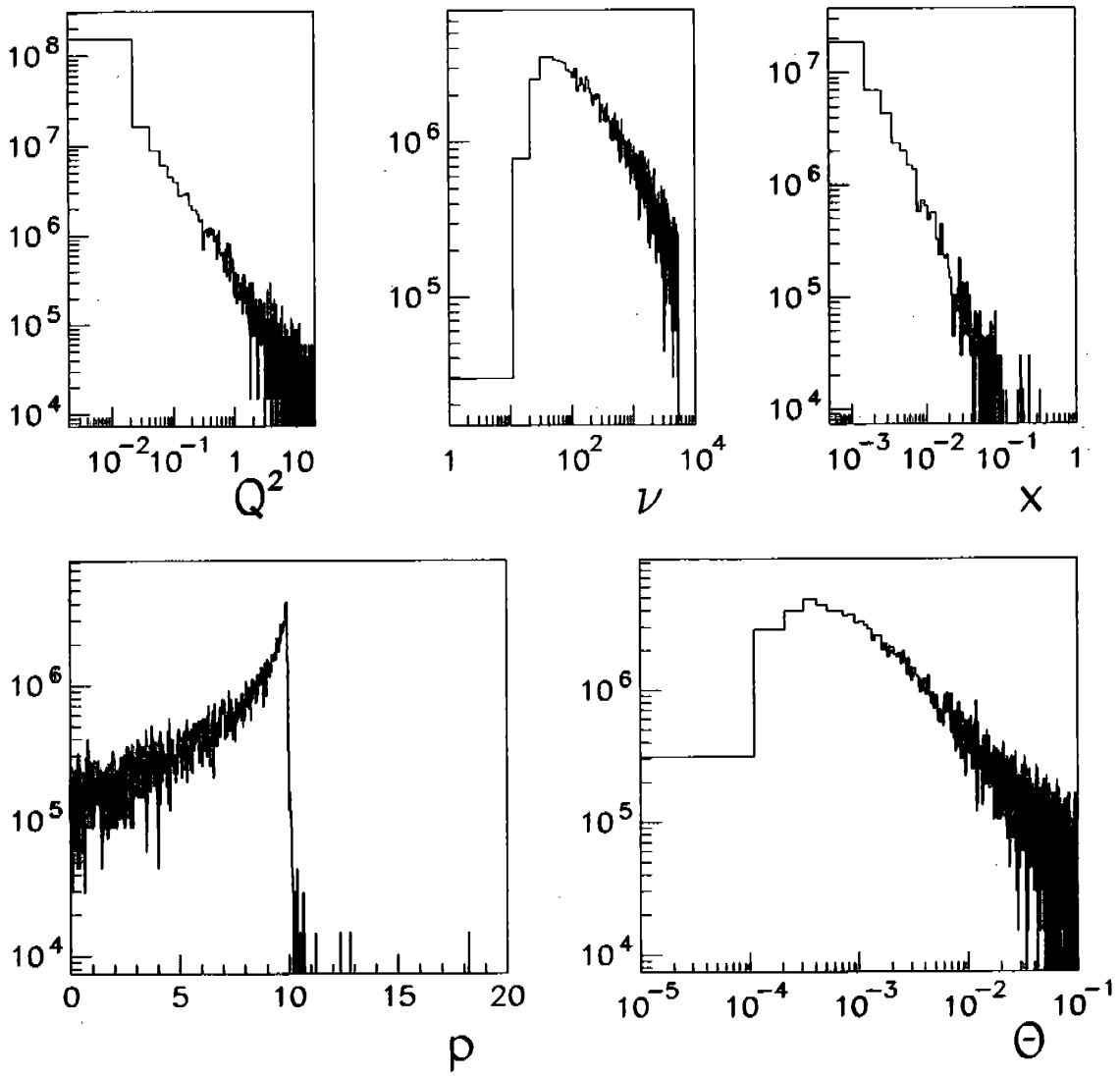

D⁰ mesons (black=divided by p_D)
Entries 12762
χ^2/ndf 9.559 / 54
P1 5.801 ± 0.3028E−01
P2 −150.9 ± 3.241
number of events
10^2
10
1
10^{-1}
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
vertex separation (cm)
τ = M/slope = (123+−2) μm
PDG = 123.4+−0.8 μm

PYTHIA – hadronic D0 decays




Full Detectr
3-D View
14/03/04
e⁻
K⁺
K⁻
100 cm

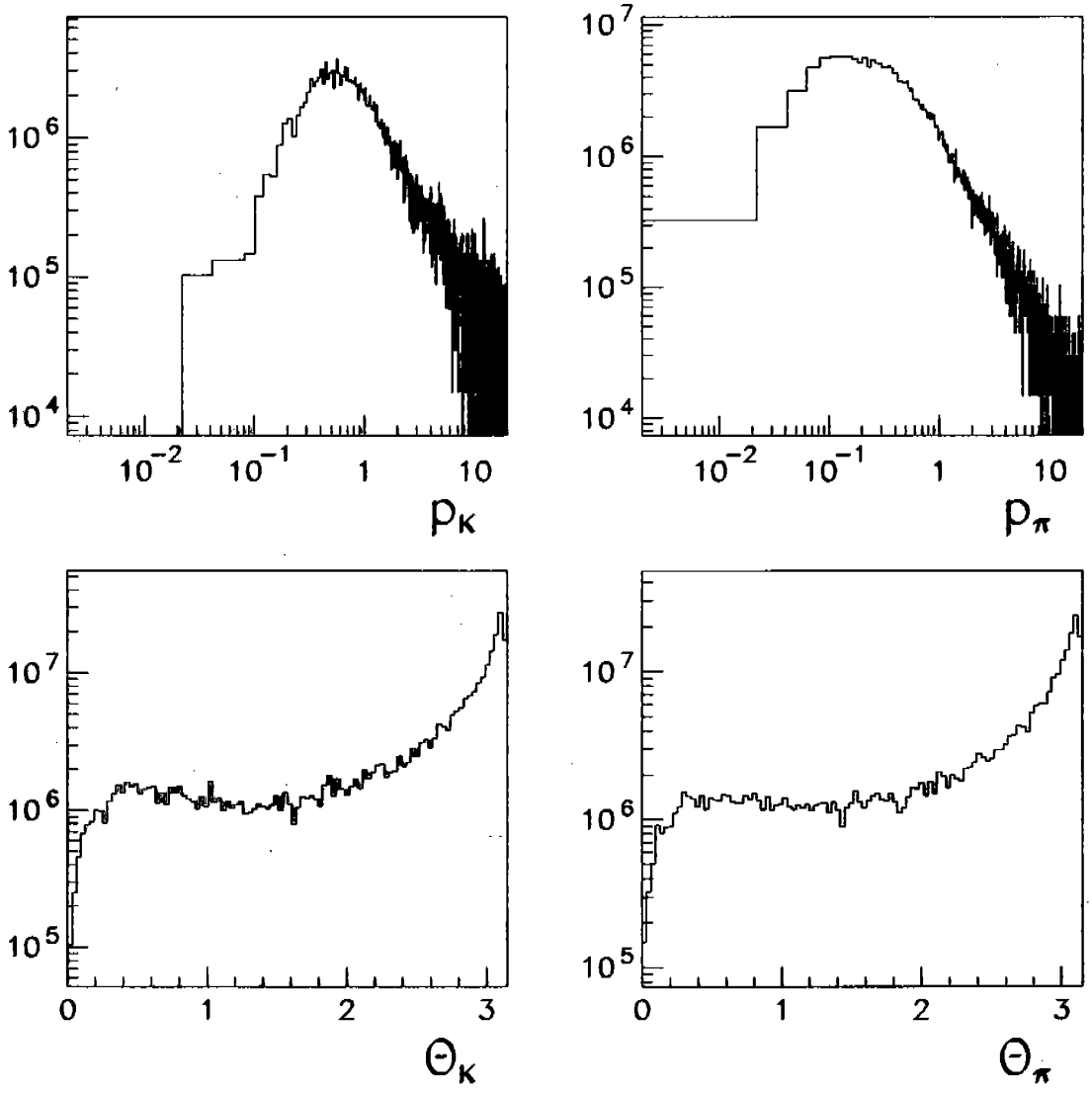
AROMA – kinematics of scattered lepton



→ Q^2 small → use m_c as hard scale

→ Θ_e very small → detection possibilities ?

AROMA – kinematics of decay particles



→ need π/K separation for $0.1 < p < 4$ GeV

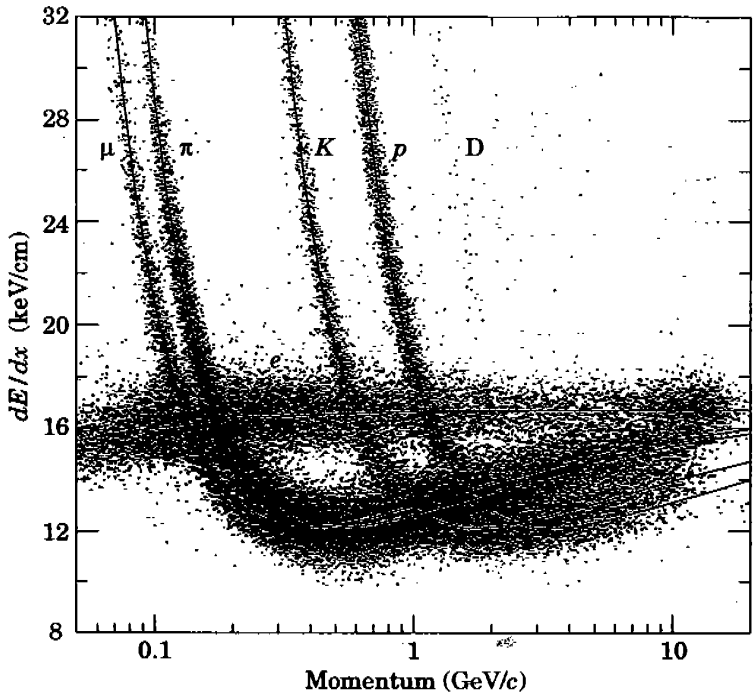


Figure 27.5: PEP4/9-TPC dE/dx measurements (185 samples @8.5 atm Ar-CH_4 80–20%) in multihadron events. The electrons reach a Fermi plateau value of 1.4 times minimum. Muons from pion decays are separated from pions at low momentum; π/K are separated over all momenta except in the cross-over region. (Low-momentum protons and deuterons originate from hadron-nucleus collisions in inner materials such as the beam pipe.)

Truncated mean dE/dx resolution depends on the number and size of samples, and gas pressure:

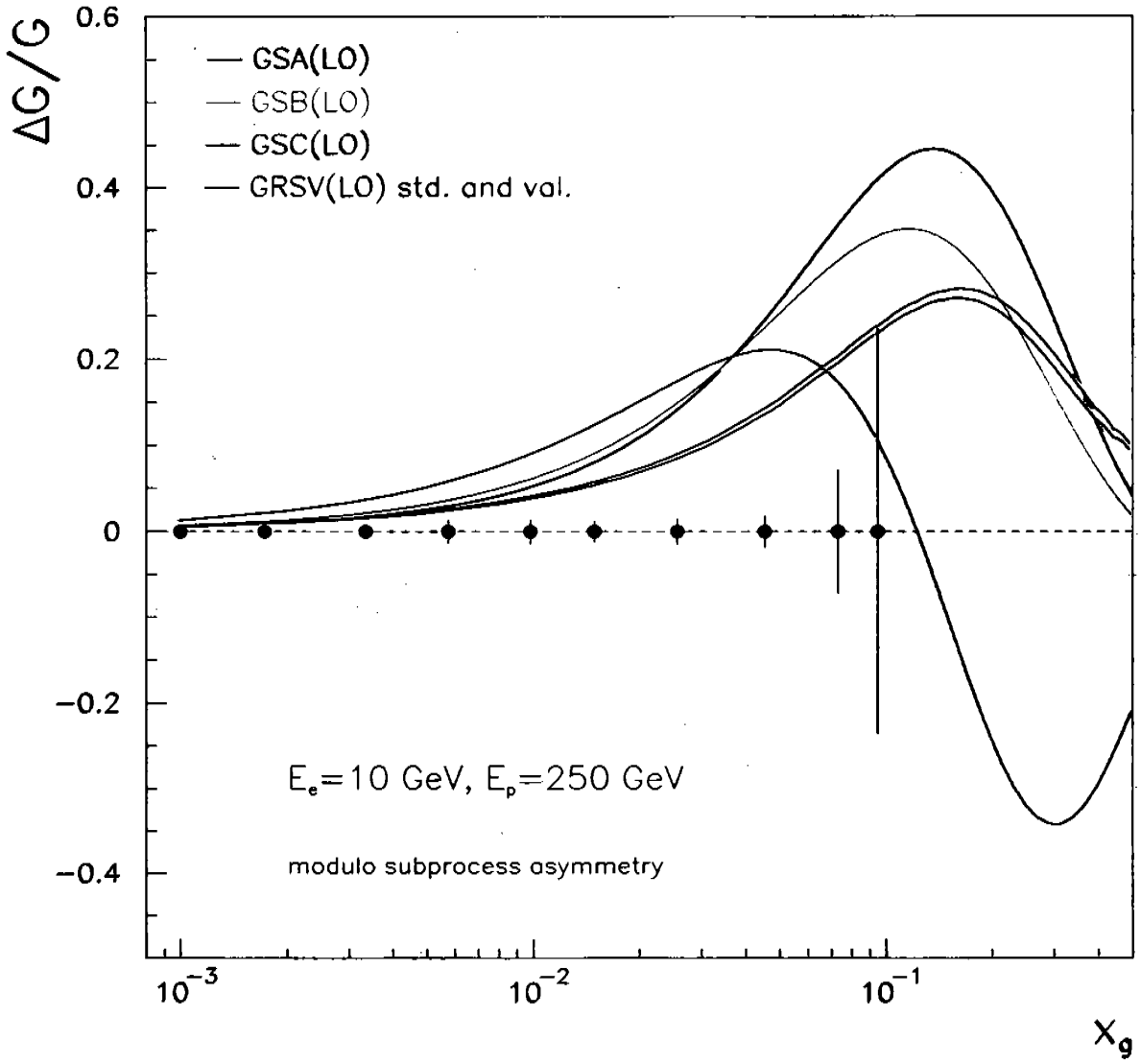
$$\sigma_{dE/dx} \propto N^{-0.43} \times (P\ell)^{-0.32} \ . \tag{27.12}$$

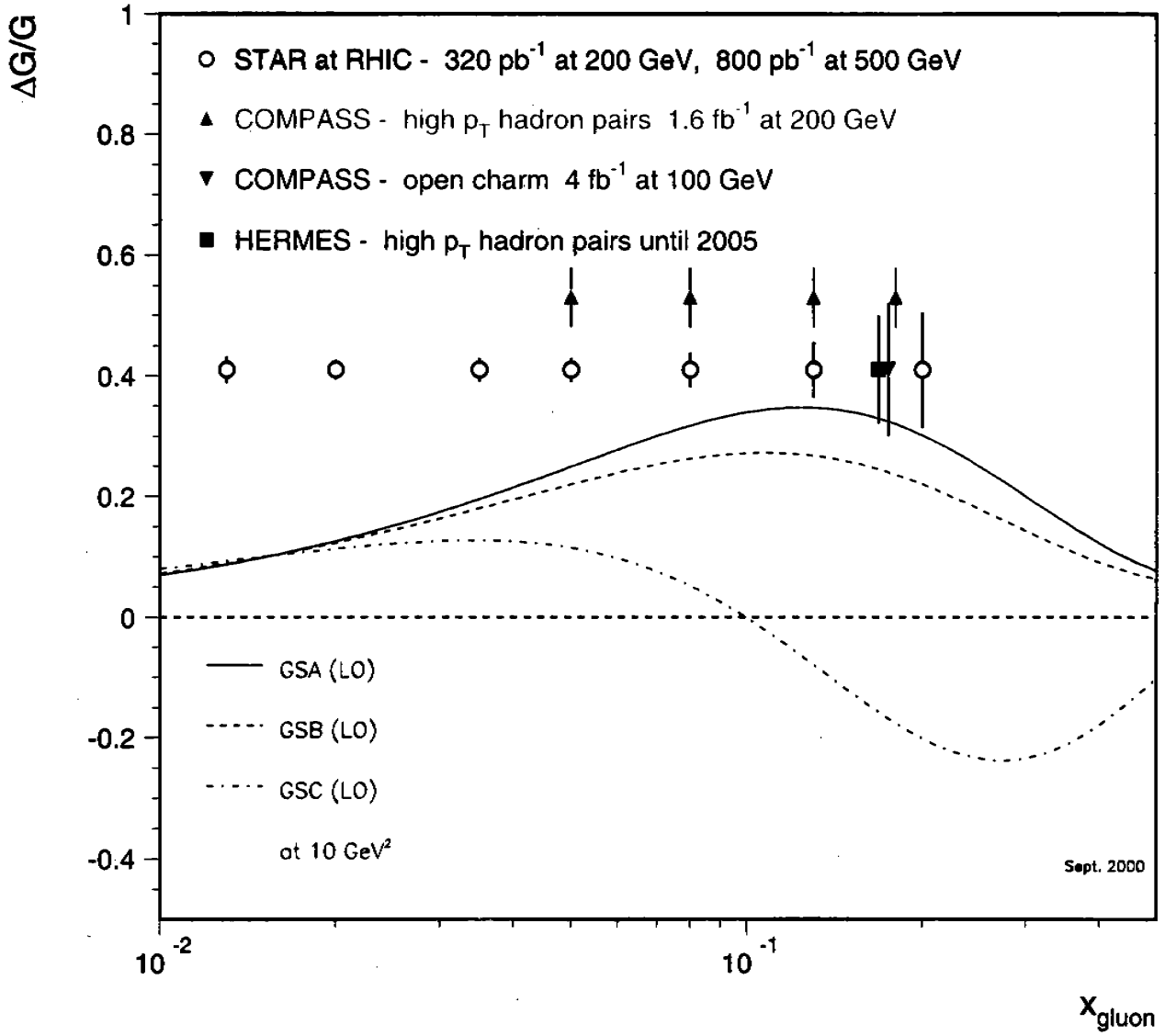
Here N is the number of samples, ℓ is the sample size, and P is the pressure. Typical dE/dx distributions are shown in Fig. 27.5. Good three-dimensional two-track resolutions of about 1–1.5 cm are routinely achieved.

$E \times B$ distortions arise from nonparallel E and B fields (see Eq. (27.7)), and from the curved drift of electrons to the anode wires in the amplification region. Position measurement errors include contributions from the anode-cathode geometry, the track crossing angle (α), $E \times B$ distortions, and from the drift diffusion of electrons

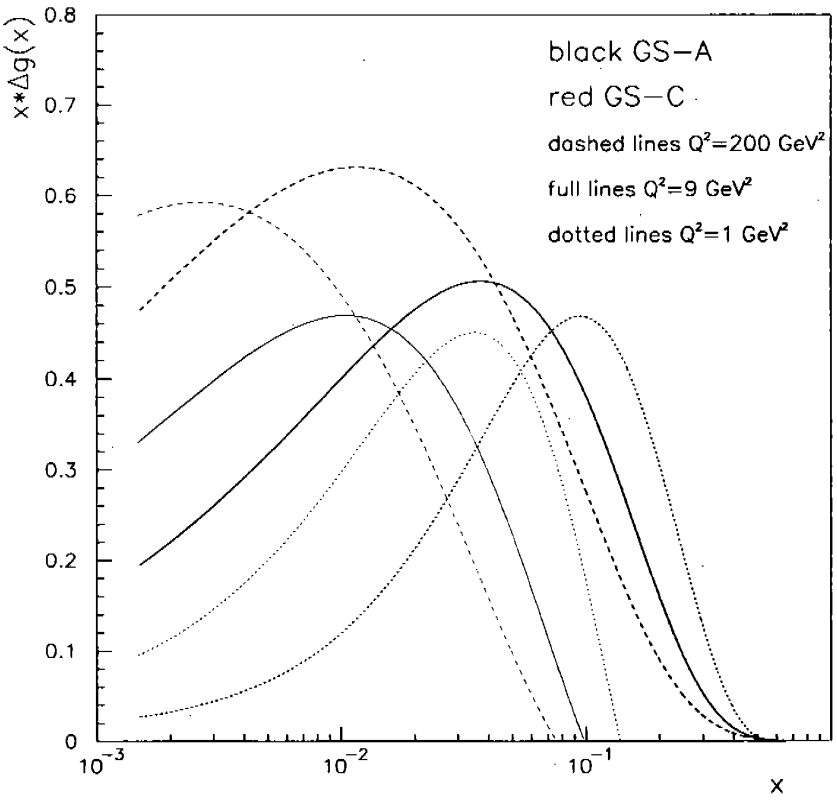
$$\sigma^2_{x \text{ or } y} = \sigma_0^2 + \sigma_D^2(1 + \tan^2\alpha)L/L_{\max} + \sigma_\alpha^2(\tan\alpha - \tan\psi)^2 \tag{27.13}$$

D^0 to $K^- \pi^+$ decays – 100 days at $L=10^{33}/cm^2/s^1$

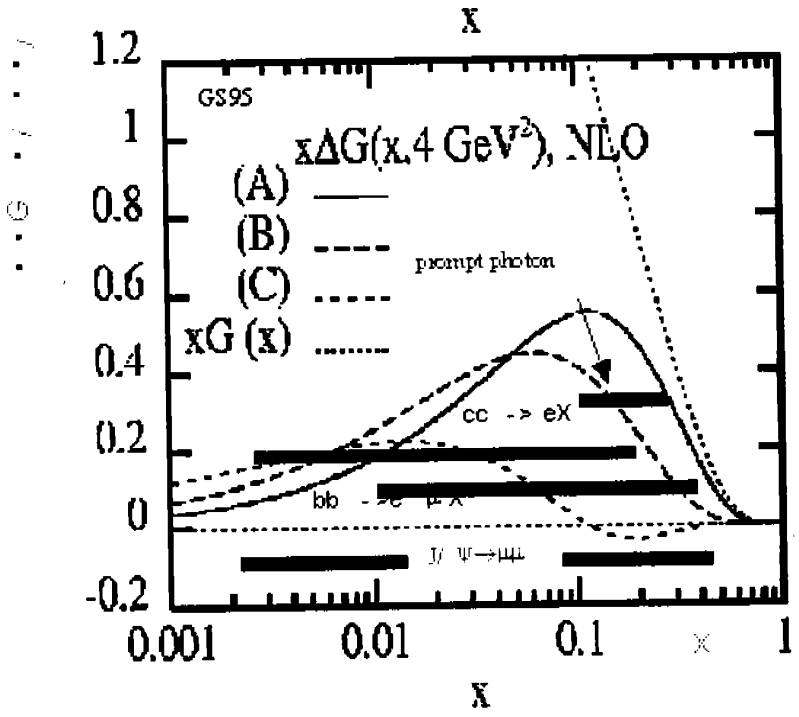



ΔG/G
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
STAR at RHIC - 320 pb-1 at 200 GeV, 800 pb-1 at 500 GeV
COMPASS - high pT hadron pairs 1.6 fb-1 at 200 GeV
COMPASS - open charm 4 fb-1 at 100 GeV
HERMES - high pT hadron pairs until 2005
GSA (LO)
GSB (LO)
GSC (LO)
at 10 GeV2
Sept. 2000
10-2
10-1
Xgluon

Polarised Gluon Distribution — which Q^2 ?



Summary & Outlook



- Open charm will allow precise measurement of $\Delta G/G$ at $0.001 < x_G < 0.1$ and at moderate scale
- Particle identification and vertex detection essential (background suppression)
- next steps:
  - include subprocess asymmetries in MC
  - investigate different decay channels
  - hidden charm (J/Ψ)
  - investigate center-of-mass energy dependence