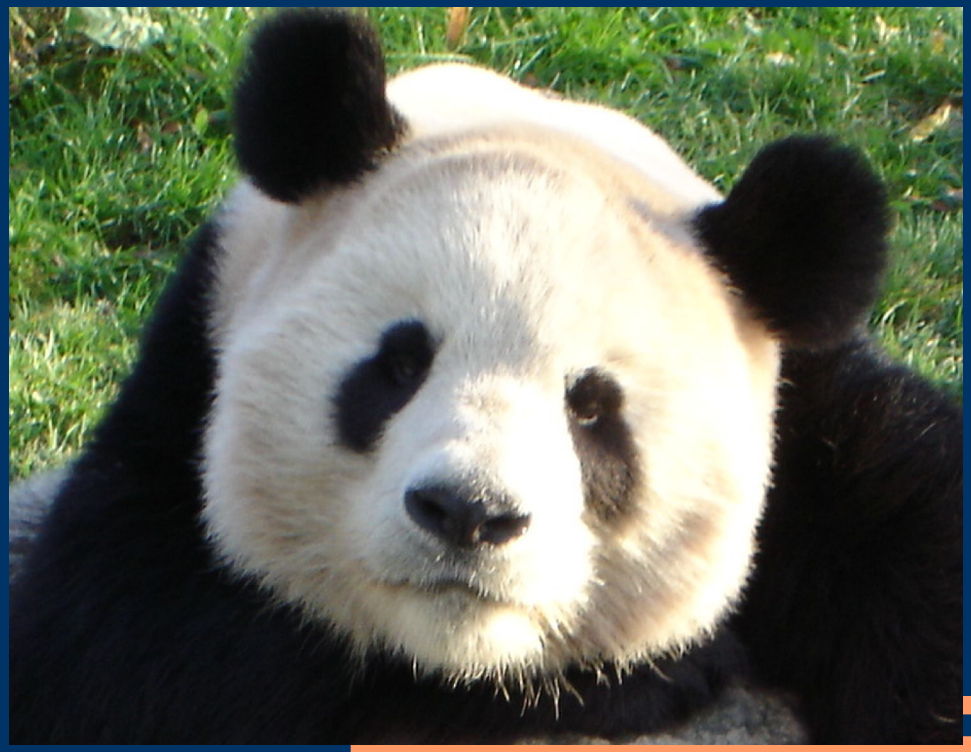
$in^{-}pp$ collisions at PANDA energies (E_{beam} = 14 GeV)



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Previous experiments

First (pp -> γ+ X) experiments were done at CERN:

at ISR (pp - collider, E_{cm} = 31, 45, 53 GeV):

- **R412 experiment (Darriulat et. al., 1976);**
- **R107 (Amaldi et. al., 1978); ….and many others.**

Also at Fermilab and BNL:

- **E557 (Baltrusaitis et. al. 1979, nBe, E = …**

pbar + p → gamma + X process at PANDA.

At June Collaboration meeting (02 - 06July, Dubna) we have proposed to study the

pbar + p → gamma + X

process at PANDA.

This talk (prepared for the experimentalists)

includes the results of Monte Carlo

simulation done with use of

Our Physical goal: To estimate the possibility of getting *the information about* ***proton structure functions***

$$f(x, Q^2)\ .$$

Main interest: *To estimate the size of the x-Q^2 kinematical region in which the* ***structure functions can be measured.***

The proton-antiproton cross section ($\sigma \leftarrow \sigma^{p\bar{p}}$)

in quark-parton model is expressed as follows:

$$\sigma = \int\int\int \mathrm{d}x_1\,\mathrm{d}x_2\,\mathrm{d}\hat{t}\; f_1(x_1, Q^2)\, f_2(x_2, Q^2)\, \frac{\mathrm{d}\hat{\sigma}}{\mathrm{d}\hat{t}}$$

Here f(x, Q^2) are the **structure functions,** $d\hat{\sigma} / d\hat{t}$ **is**

the $2 \rightarrow 2$ **parton** level ($p_1 + p_2 = p_3 + p_4$) cross section ;

$\hat{t} \equiv (p_3 - p_1)^2 = -Q^2$ is the square of transfered momentum,

$x_{1,2}$ is the energy fraction carried by a quark in a proton.

In our case, $d\hat{\sigma} \equiv d\sigma^{gq \rightarrow \gamma q}$,(or $d\sigma^{q\bar{q} \rightarrow \gamma g}$) and $Q^2 = (p_T^{\gamma})^2$

In ***pbar + p → gamma + X process***

(choosing pbar beam direction as the z-axis)

the role of the ***transferred momentum Q***

plays the ***photon transverse momentum***, i.e.

$$p_T^\gamma = Q$$

As it shall be shown below, at $E_{beam} = 14$ GeV

we can expect $p_T^\gamma < 2$ GeV, i.e,

$$Q^2 = (p_T^\gamma)^2 \quad ¿ 4\,GeV^2$$

This region is under study now at HERA and JLab .

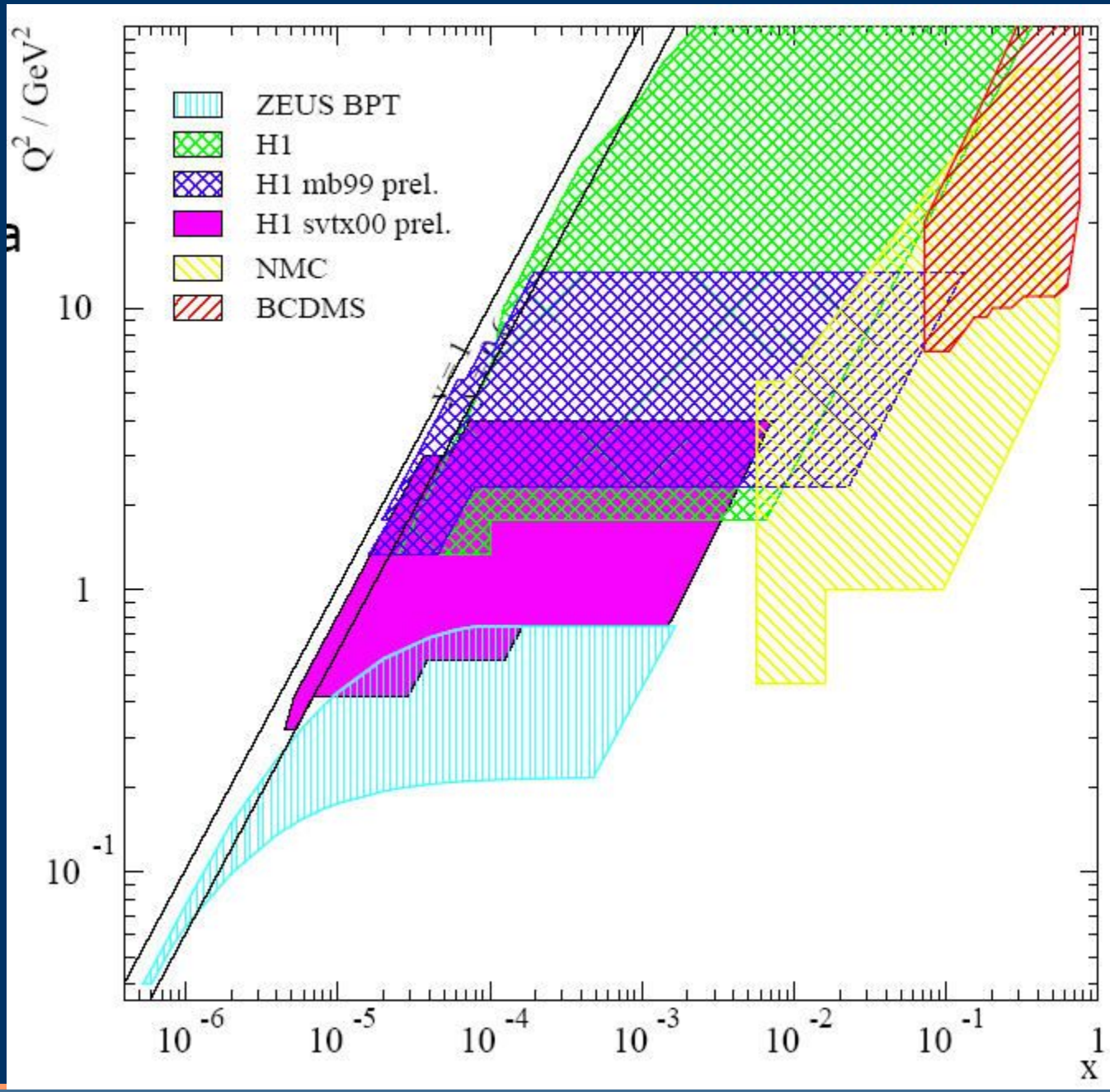
x-Q^2 plane

Regions covered by

Structure Function measurements

in **DIS** experiments

at low Q2**



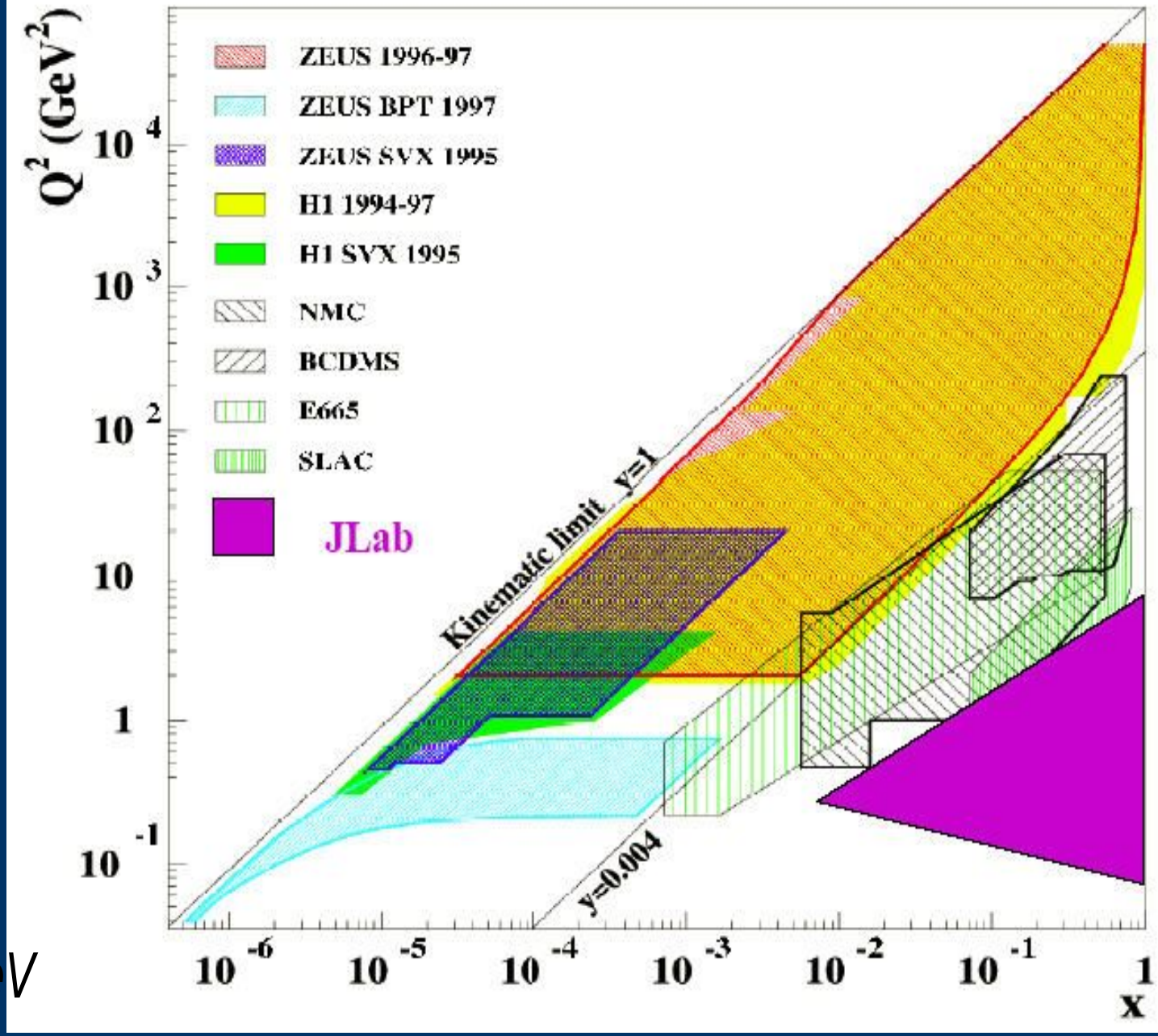
Nowadays there are new measurements

at low Q^2

at **JLab**

→

$0.1 < Q^2 < 8.0\,GeV$

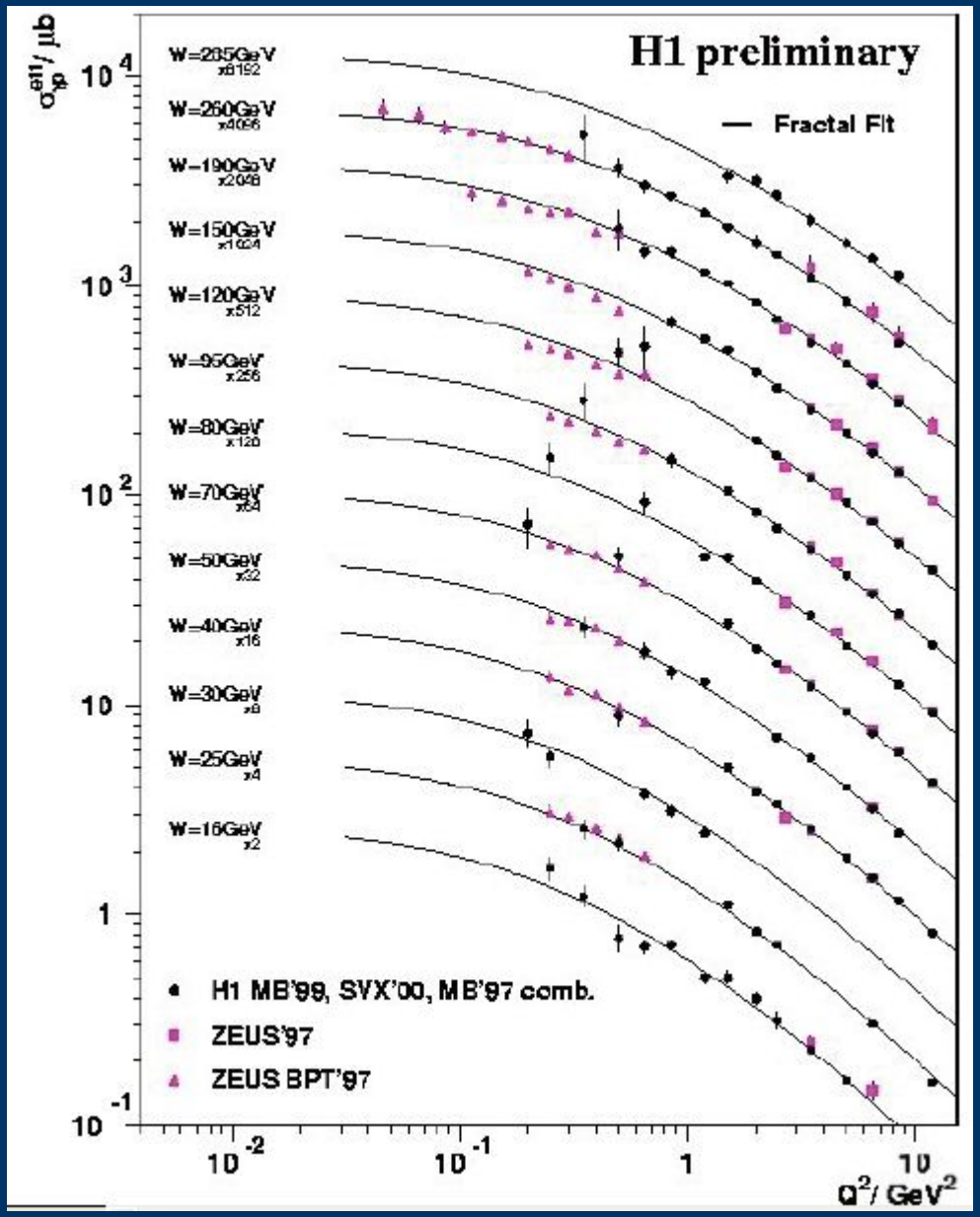


New measuremens and combination with old (97-98) results

at

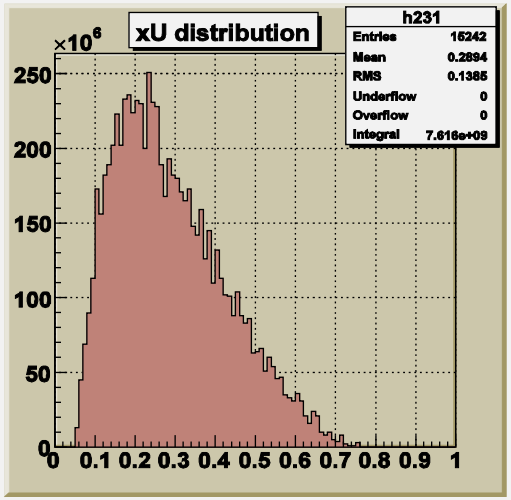
low Q^2

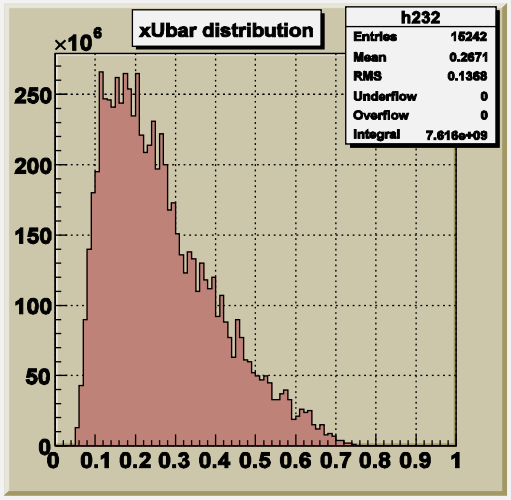
at **H1 and ZEUS →**

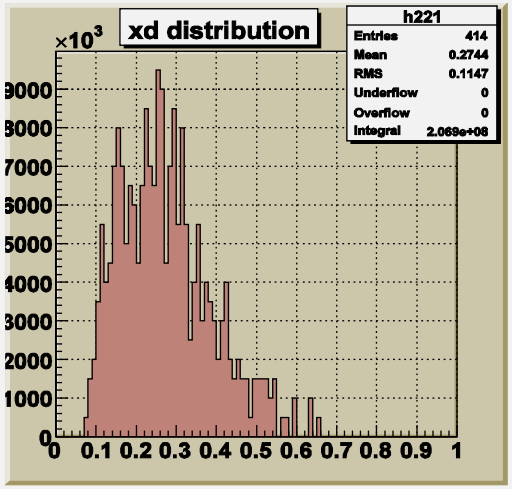


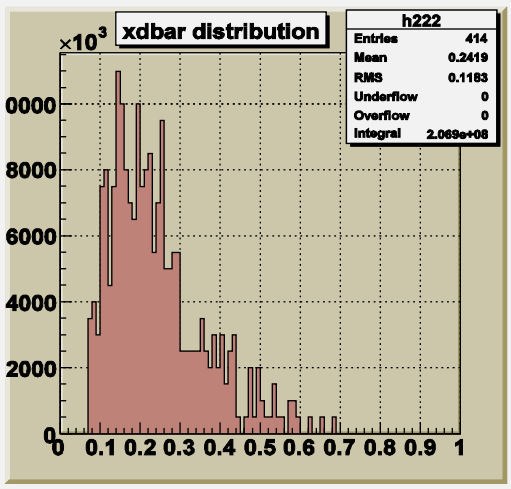
Structure functions distributions

xU/XUbar & xD/xDbar histograms





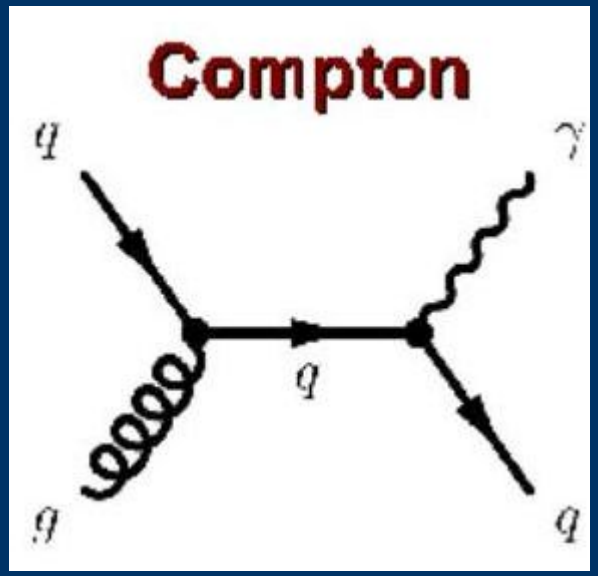


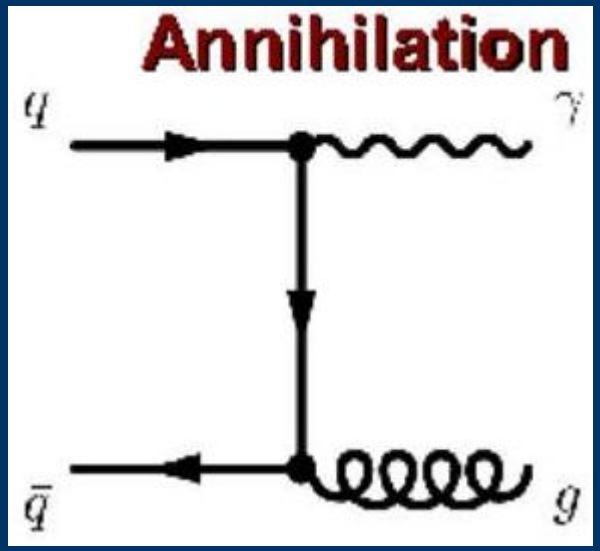


From these quark distributions we see that at PANDA energy PYTHIA predicts that the **x-variable** can cover the region

0.05 < x < 0.7

The ***pbar + p → gamma + X*** process
(different to DIS scattering)
is mainly defined by ***LO QCD*** diagrams:

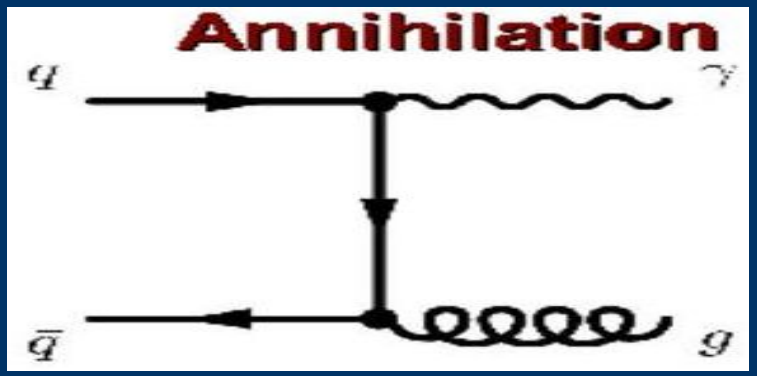


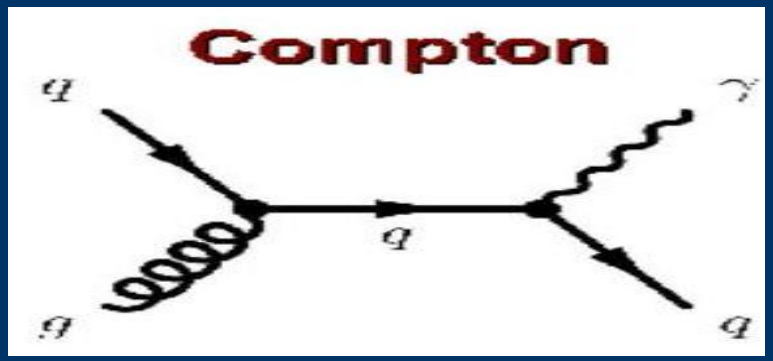


The " ***QCD Compton*** " diagram contribution makes ***the cross section of pbar + p → gamma + X*** process to be sensitive to the gluon distribution ***g (x, Q^2).***

The diagrams contribution

The contributions of both diagrams to the total cross section





Cross Sections

Total: σ = 2.9E-03 mb;

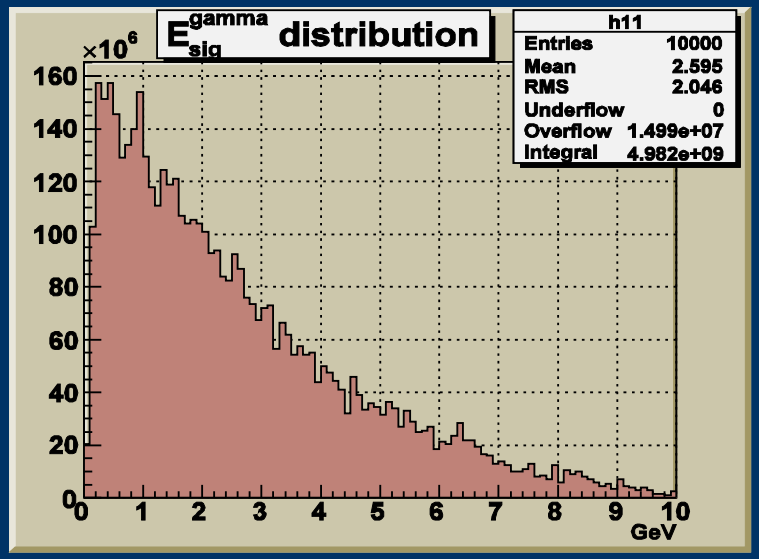
q + qbar → gluon + photon (62%):

σ = 1.78E-03 mb;

gluon + q → q + photon (38%):

σ = 1.10E-03 mb

Signal photons distributions

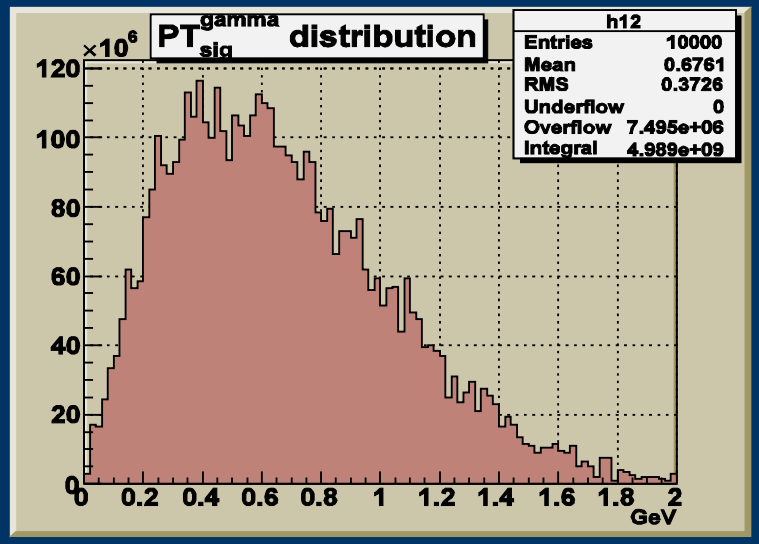


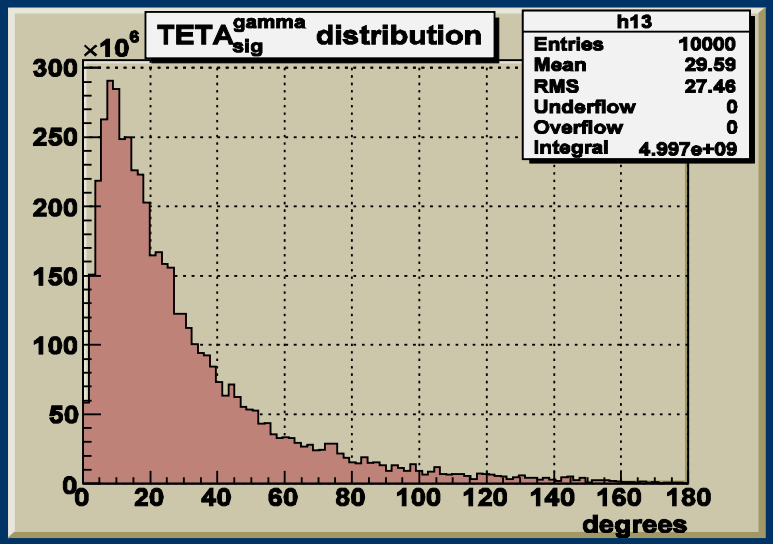
$0 \le E\gamma \le 10$ GeV, $\langle E\gamma \rangle = 2.6$ GeV

$0 \le PT\gamma \le 2$ GeV, $\langle PT\gamma \rangle = 0.67$ GeV

$0 \le \Theta\gamma \le 180°$, $\langle \Theta\gamma \rangle = 29.6°$

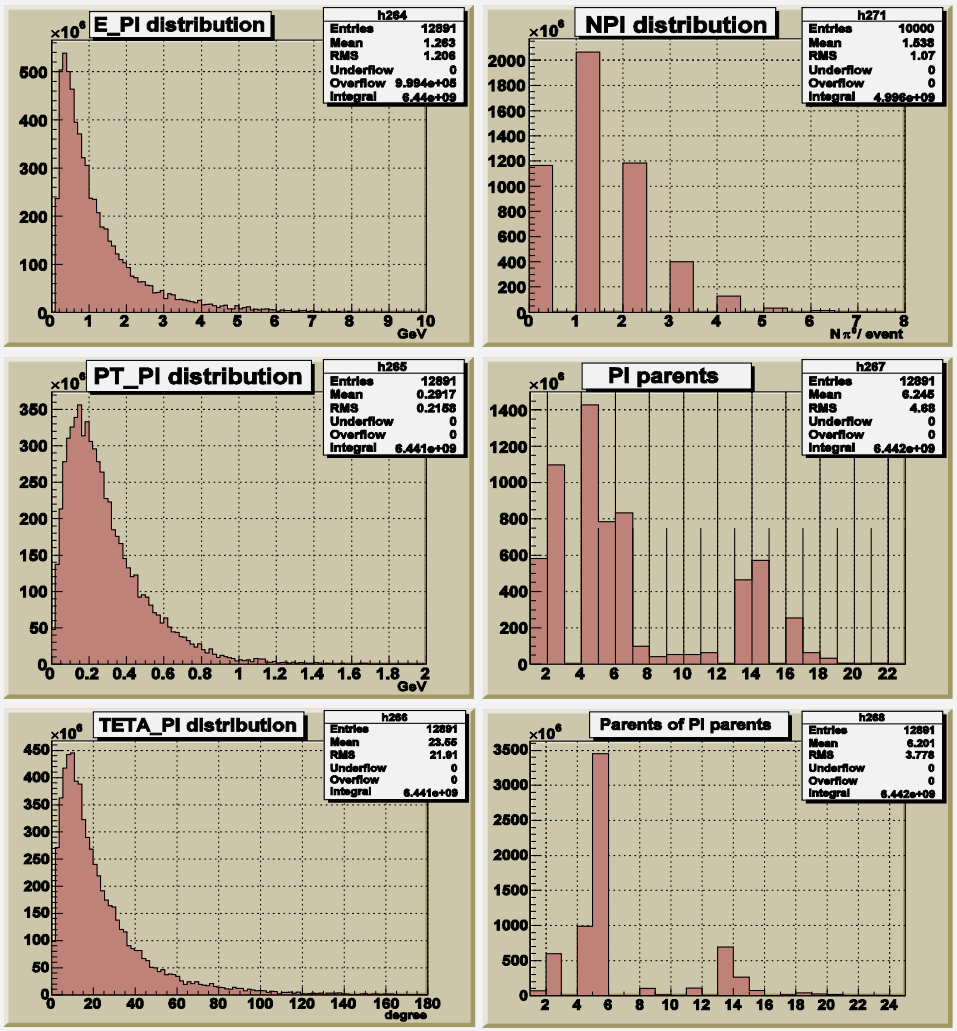
some $\Theta\gamma > 90°$





Neutral pions distributions

PI - distribution histograms



$0 \le E\gamma \le 7$ GeV, $\langle E\gamma \rangle = 1.2$ GeV

$0 \le PT\gamma \le 1$ GeV, $\langle PT\gamma \rangle = 0.29$ GeV

$0 \le \Theta\gamma \le 180°$, $\langle \Theta\gamma \rangle = 23.5°$
some $\Theta\gamma > 90°$

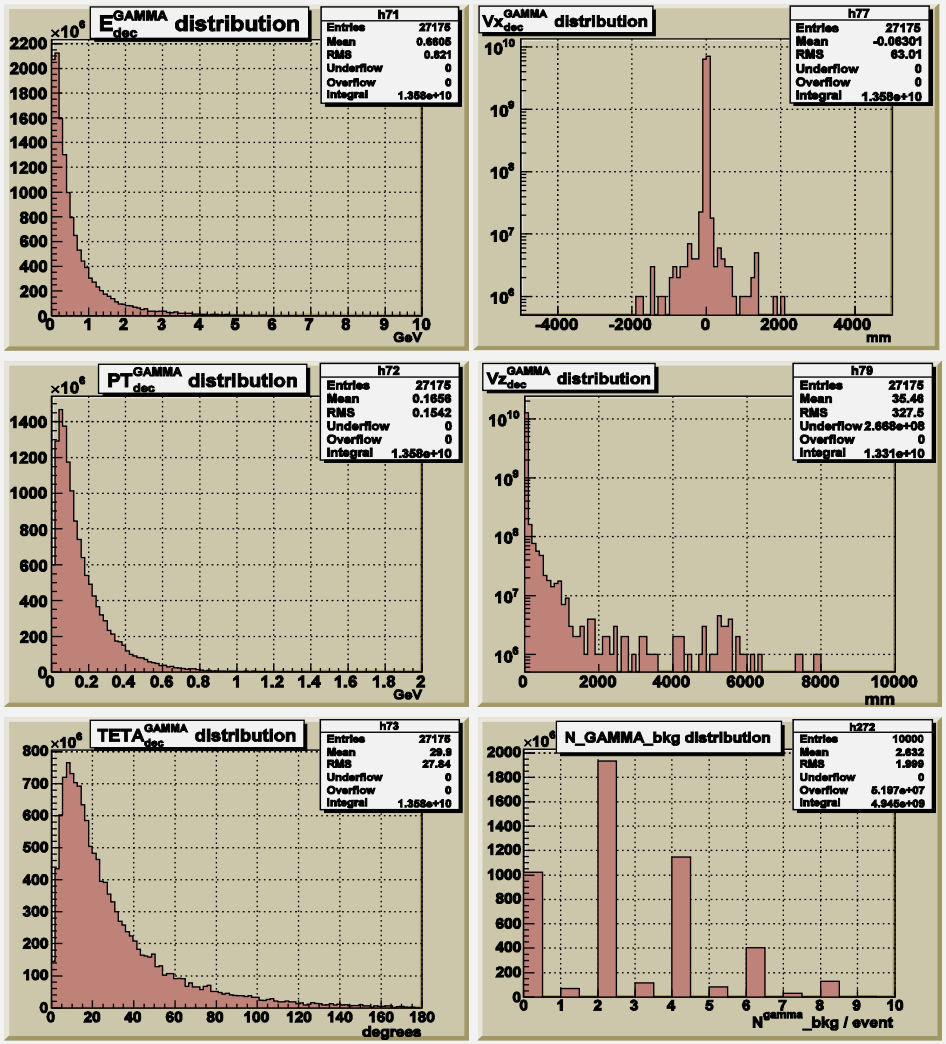
Up to 7 neutral pions in signal event.

Distribution of N_ π^0 / event well explains the one of N_ γ / event (with $\pi^0 \rightarrow 2\gamma$).

The most probable parents of π^0 are η, ρ+, strings and Δ^0

Fake photons distributions

Background Photons in signal events



$0 \le E\gamma \le 4$ GeV, $\langle E\gamma \rangle = 0.6$ GeV

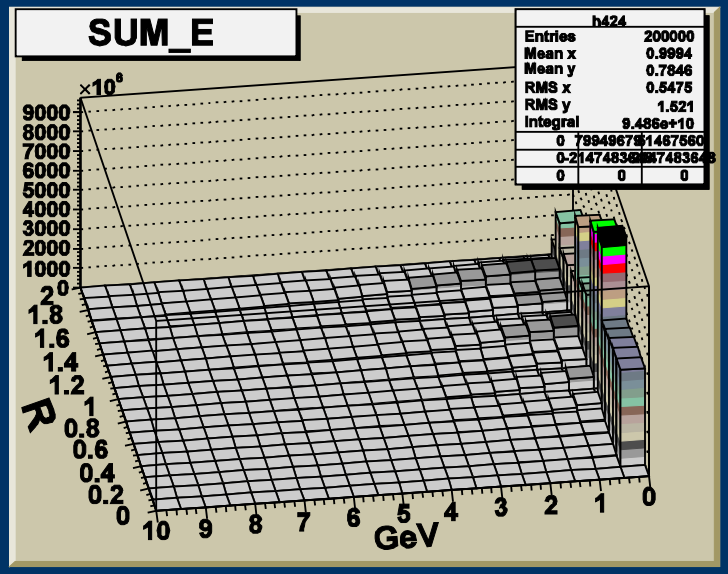
$0 \le PT\gamma \le 1$ GeV, $\langle PT\gamma \rangle = 0.16$ GeV

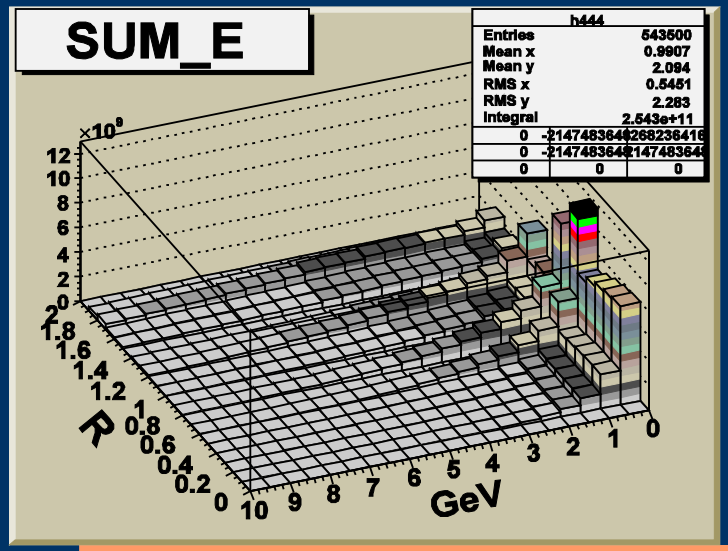
$0 \le \Theta\gamma \le 180°$, $\langle \Theta\gamma \rangle = 29.6°$
some $\Theta\gamma > 90°$

Vx, Vy, Vz distributions show mostly zero value

Up to 10 background photons in a signal event (in some few events up to 14)

Gamma isolation criteria





The plots show the distributions over ***summed energy*** of charged stable particles in the cones of radius $R = \sqrt{\eta^2+\varphi^2}$ respect to the

upper plot → **direct** photon

bottom plot → **fake** photon

Isolation criteria **E** (of charged particles) **=0** in the R=0.3

allows to separate 100% of fake photons with loss of 4.2% of signal events

Conclusion.

The simulation with PYTHIA (used as the first approximation) has shown that at PANDA energy *E beam = 14 GeV*

1. PANDA can make the measurement of proton structure functions in the regions:

$$Q^2 = (P_T^{\gamma})^2 < 4\ \text{GeV}^2 \qquad 0.05 < x < 0.7$$

2. We can separate the contribution of fake photons, which come from the decays of pions and other neutral mesons.

3. This measurement can have the advantage as it is very sensitive to gluon distribution.