FRAGMENTS, PANDA, COMPASS, PYTHIA, ASYMMETRIES, AND MORE.

“give us money enough, and we will move the world”

(slogan of the Brescia's Physical Society)

Andrea Bianconi

Inclusive and exclusive DIS: Bloom-Gilman-deRujula-Georgi-Politzer Duality

What would we find, comparing observables in inclusive dilepton production and exclusive processes like dilepton+diproton production?

Lepton scattering and hadron DIS: exclusive and inclusive data to compare.

Dilepton production: no exlcusive data over LEAR energies

Next generation of experiments: new opportunity.

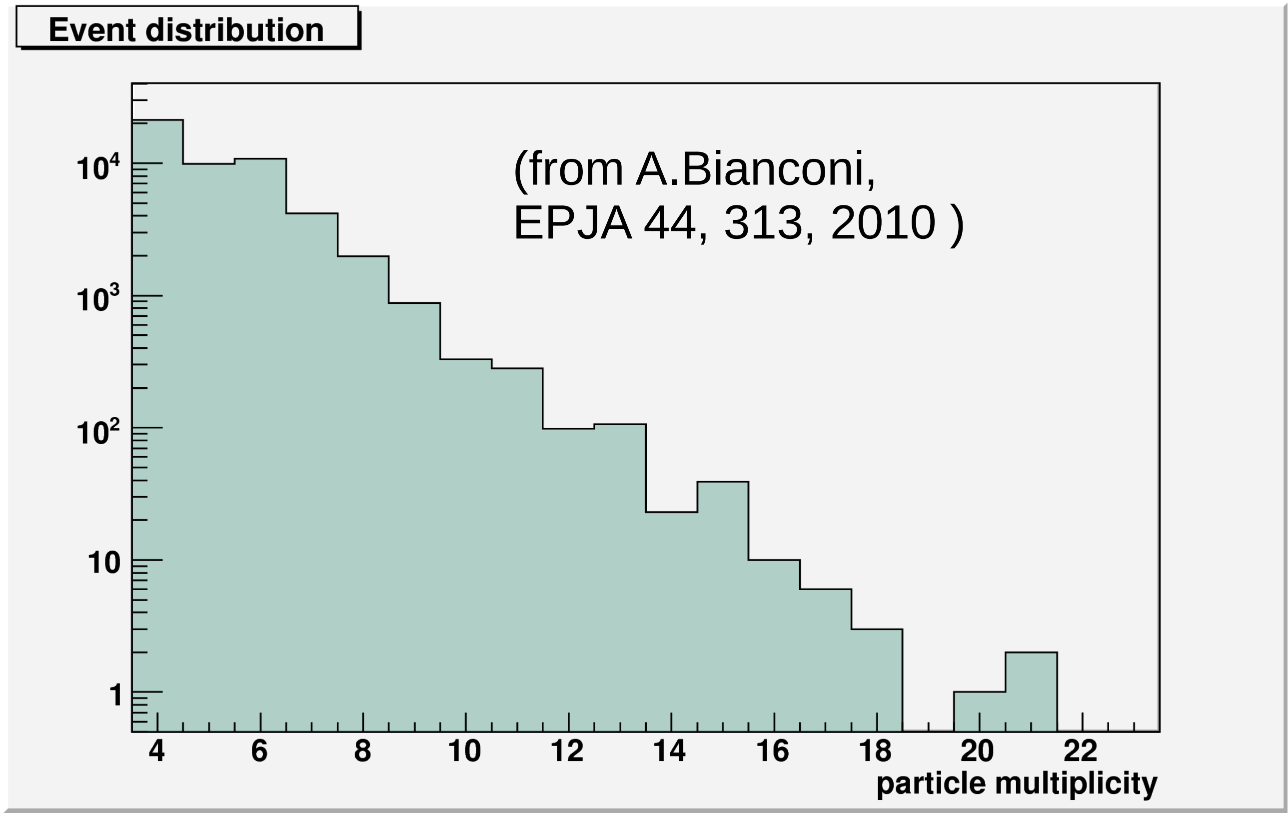
PANDA   (s = 30 GeV^2)

Pythia simulation

The number of the fragments
Is very small

An N-Nbar pair is
always present

Almost half of the events are
Dilepton plus N-Nbar only



total number	50000
no (anti)baryons	179
1 N-Nbar pair	49805
2 N-Nbar pairs	16
1 p-pbar	21765
1 n-nbar	20078
mixed pair	7993

4 / 1000 of the total

half with no more hadrons
or hard photons

Ratio p-pbar : n-nbar : mixed = 11 : 10 : 4

Means: u-ubar annihilation
+ random creation of u-ubar and d-dbar pairs.

Remark: the rather complex Pythia machine in these events becomes very basic:
Quark-diquark splitting,
No gluons,
Final state pair creation with random relative (soft) p.

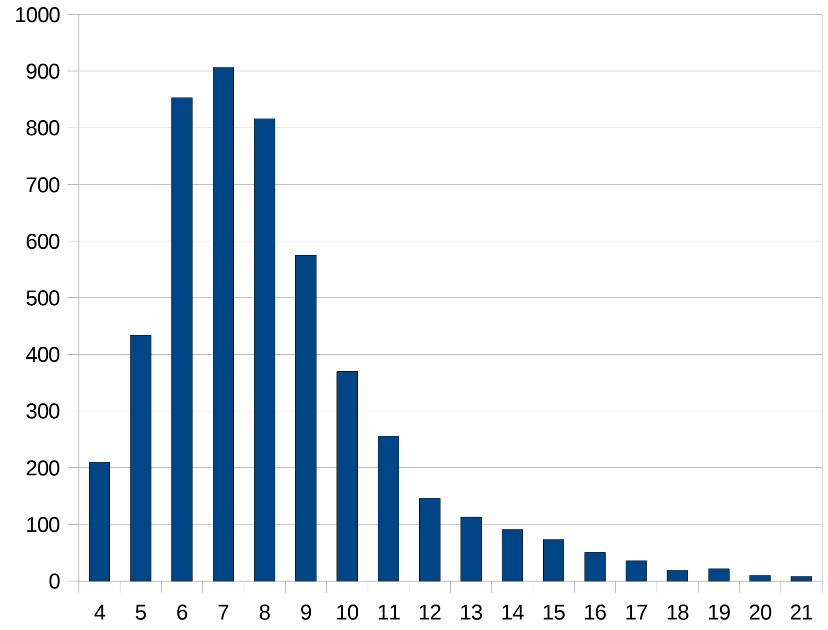
What about events in the Compass energy region ?

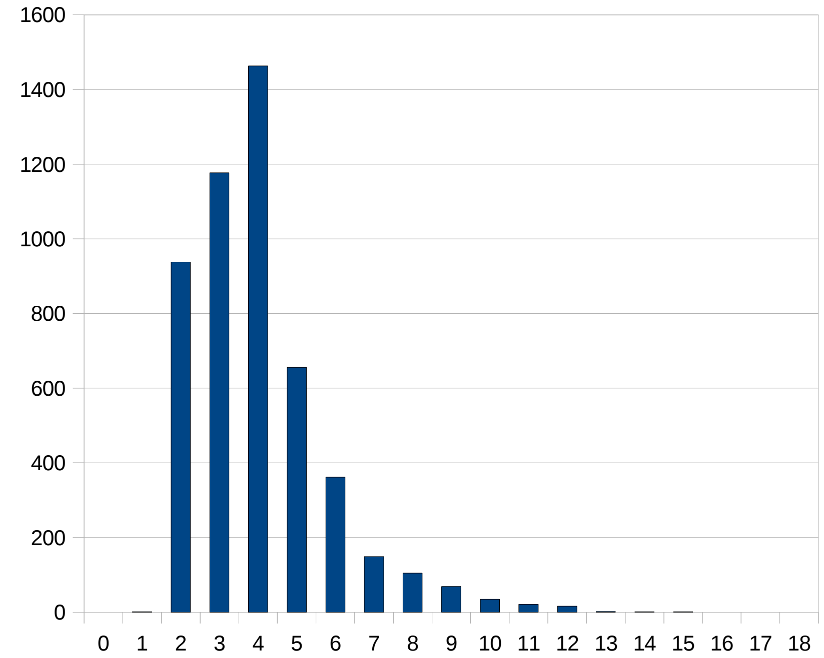
Antiproton-proton at s = 100 GeV^2

Final multiplicity distribution

Final hadron multiplicity distribution

4	209	0	0
5	434	1	1
6	853	2	938
7	906	3	1177
8	816	4	1463
9	575	5	656
10	370	6	362
11	256	7	149
12	146	8	105
13	113	9	69
14	91	10	35
15	73	11	21
16	51	12	16
17	36	13	2
18	19	14	1
19	22	15	1
20	10	16	0
21	8	17	0

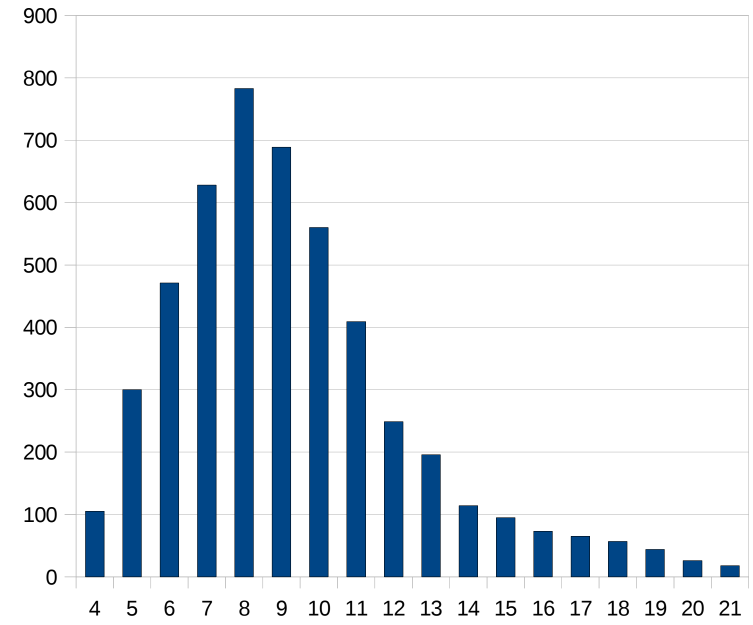




pi⁻– proton at s = 100 GeV^2

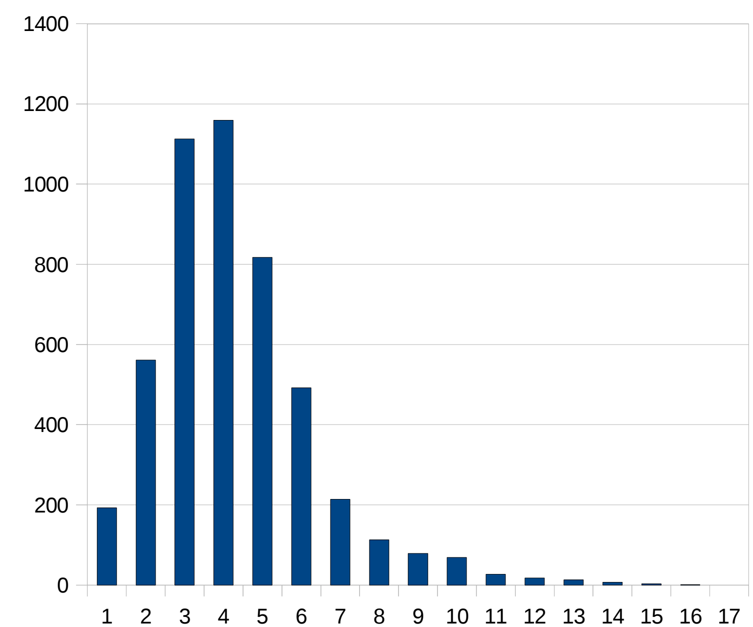
Final particle Multiplicity distribution

4	105
5	300
6	471
7	628
8	783
9	689
10	560
11	409
12	249
13	196
14	114
15	95
16	73
17	65
18	57
19	44
20	26
21	18



Final hadron multiplicity distribution

1	193
2	561
3	1113
4	1159
5	817
6	492
7	214
8	113
9	79
10	69
11	27
12	18
13	13
14	7
15	3
16	1
17	0



Antiproton-proton Drell-Yan

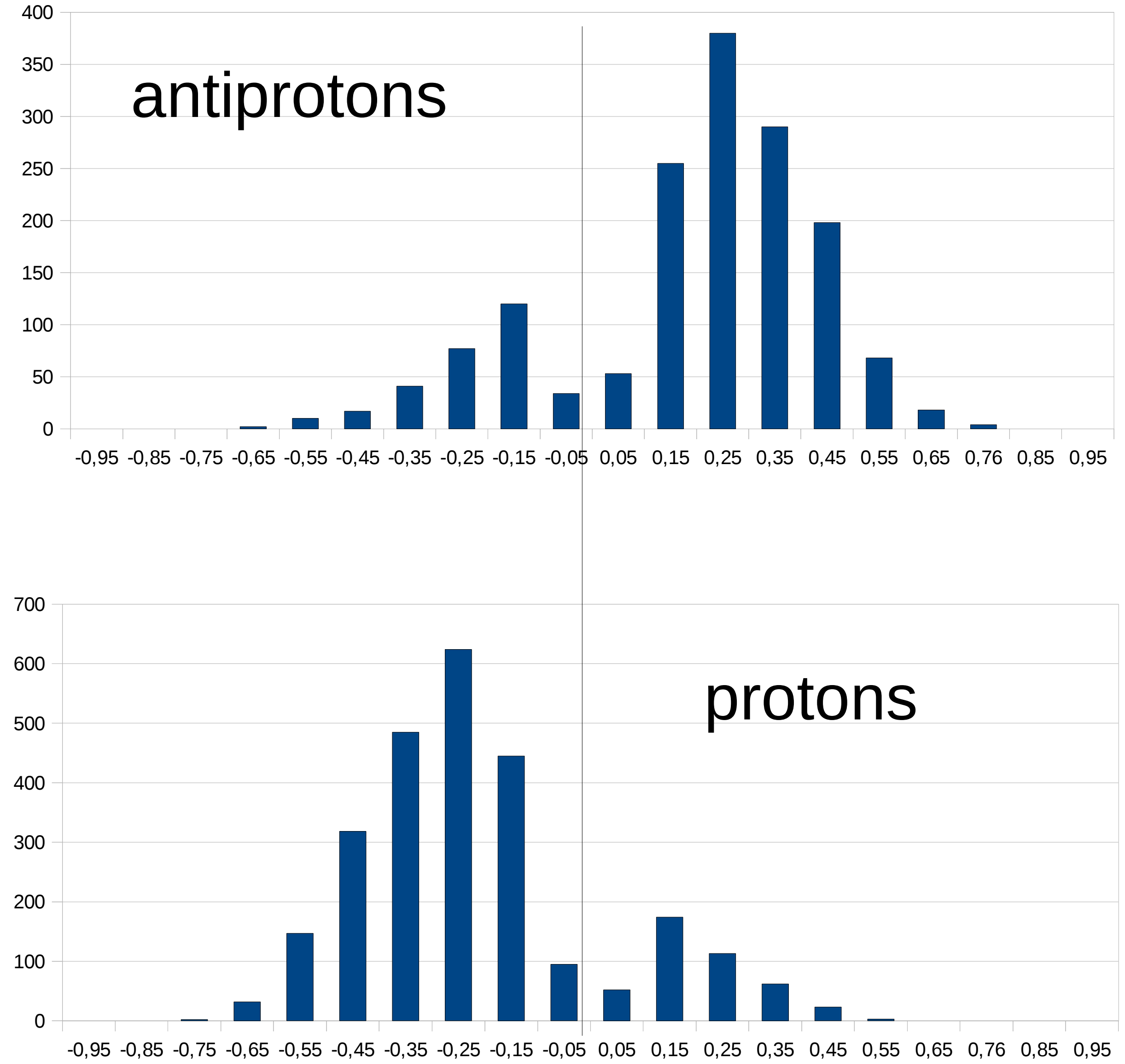
Final p and pbar in the collision C.M.

Distribution w.r.t.

$\pm$ p / pmax

(sign of pz / |pz|)

Strong correlation between initial and final momenta

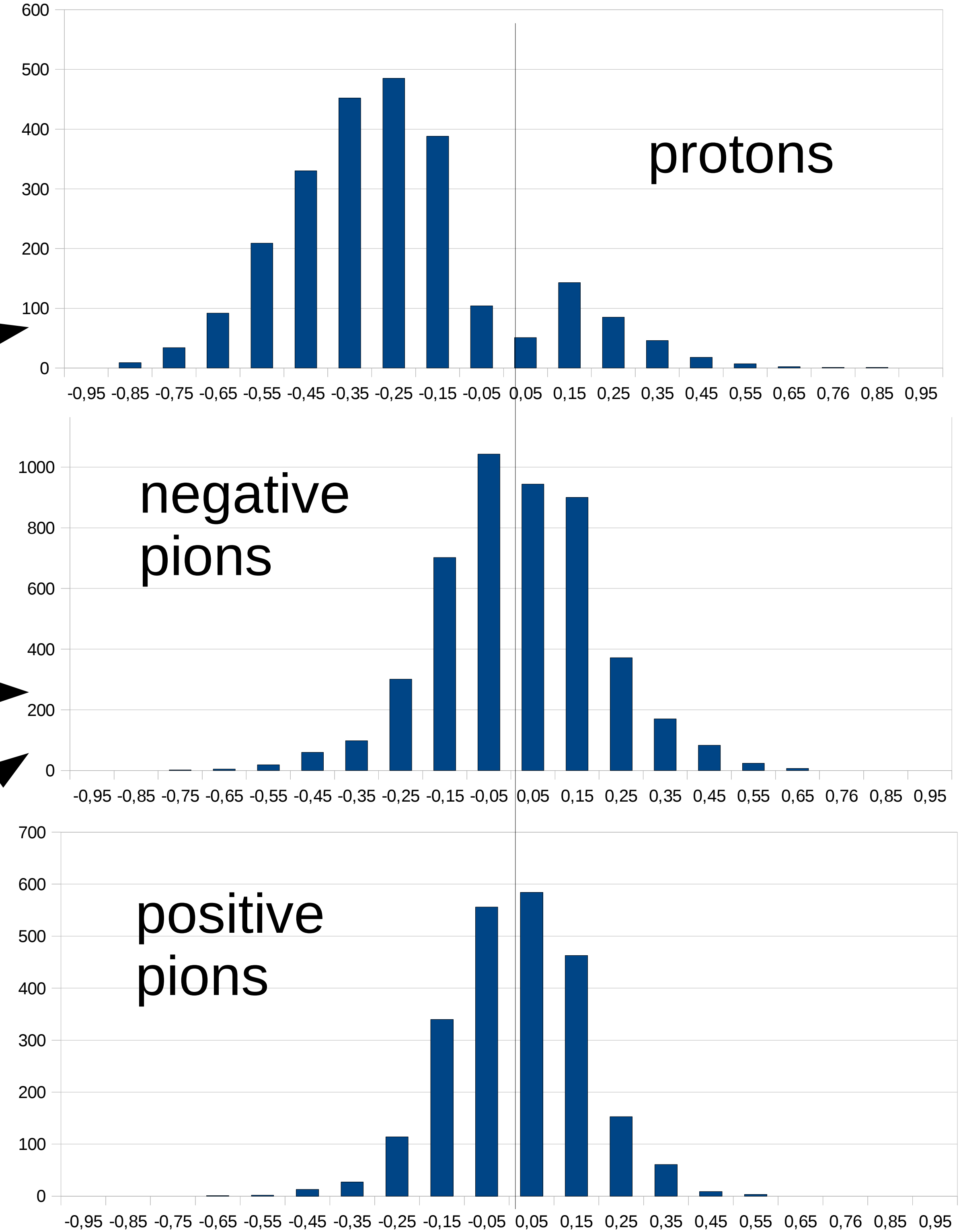


negative pion – proton Drell-Yan

Strong initial-final correlation

No initial-final correlation

Compare



Detailed Pythia event analysis: 3 ranges

PANDA: plain u-ubar + basic recombination: final N-Nbar pair

COMPASS: 2 / 3 primary final hadrons (Baryon and heavy meson)
decaying into N + pions / photons

S > 400 GeV^2: high-order Fok states, 1st-order QCD, cascading

Larger Q $\rightarrow$ smaller multiplicity

(total fragment invariant mass $M^2 \approx (1- x_1)(1- x_2)\, s$)

Mini-Pythia by AB:

Case A) Panda / lower Compass ($s = 100\ GeV^2$) 4-particle events:

Proton splits → diquark + T-polarized u with gaussian KT
Same for pbar
Soft transverse spin-orbit active-spectator rescattering → cos(2phi) asymmetry
T-spin dependent q-qbar into mu-mubar tensor → cos(2phi) asymmetry
Spectator recoil in initial splitting and in rescattering
→ Correlation between spectator azimuthal asymmetry and lepton cos(2phi) asymmetry.

Case B) Upper Compass regime ($s = 400\ GeV^2$) inclusive events

KT increased by multiple gluon radiation
(0–5 gluons, binomial-distributed with individual KT up to 3.5 GeV/c,
inspired by Chiappetta and Greco soft radiation model,
tuned on QT-distribution (252 GeV pi-N data by E615 with QT up to 5 GeV/c)

→ QT-distribution Gaussian at small QT, exponential at large QT.

Rescattering as above, → cos(2phi) asymmetry at large QT and small Q

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A) proton-antiproton exclusive events

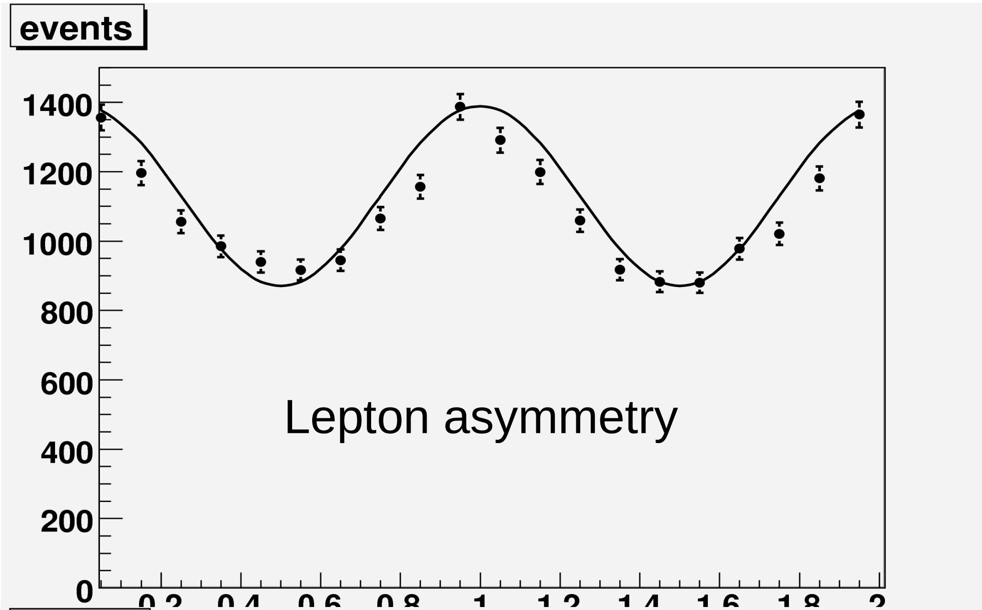
(AB, arXiv:0912.3872)

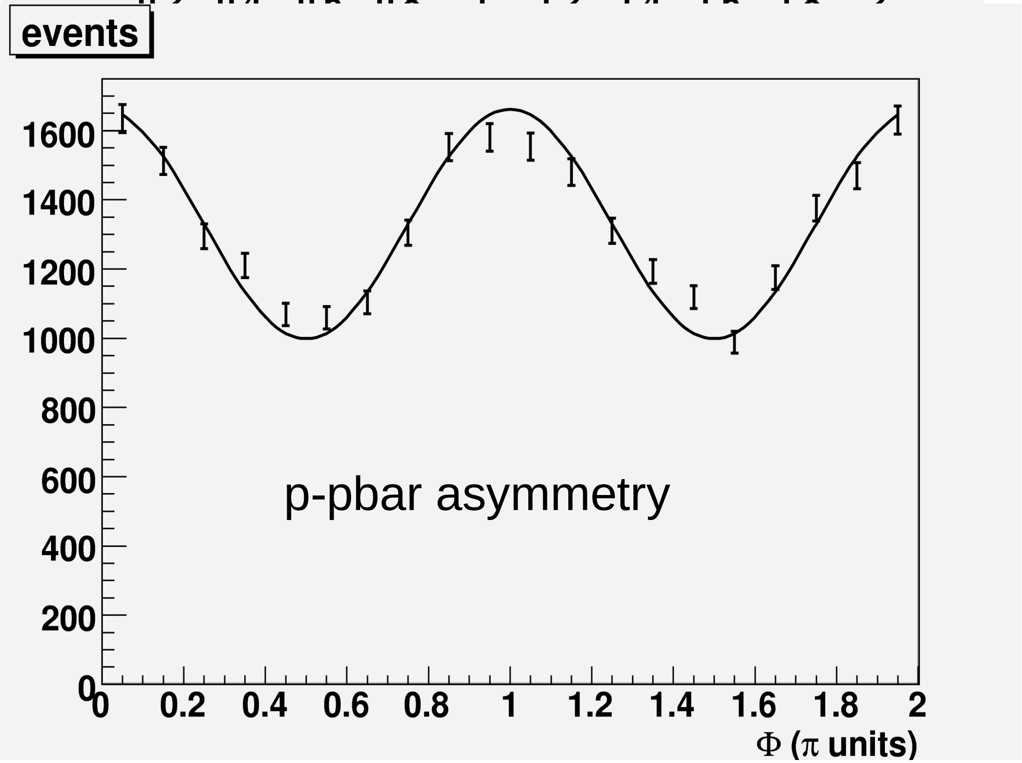
Phi = angle between relative and total momentum of p and pbar

Baseline: the hadronization stage just converts (anti)diquarks into p and pbar

Alternative 2: gaussian spread of the transverse relative momentum of the u-ubar pair created in the hadronization

Gaussian width (GeV/c)	Asymmetry
0	0.133
0.35	0.121
0.7	0.09





Alternative 3: strong spin-dependent higher twist effects in hadronization.

A theory is missing. Comparison between data and my prediction would separate Initial and final state effects, since I give asymmetry at spectator level

What do I expect? Bloom-Gilman-like duality suggests oscillations near inclusive values for lepton asymmetry.
Higher twist
Comparison of lepton and hadron asymmetries separates initial and final state effects

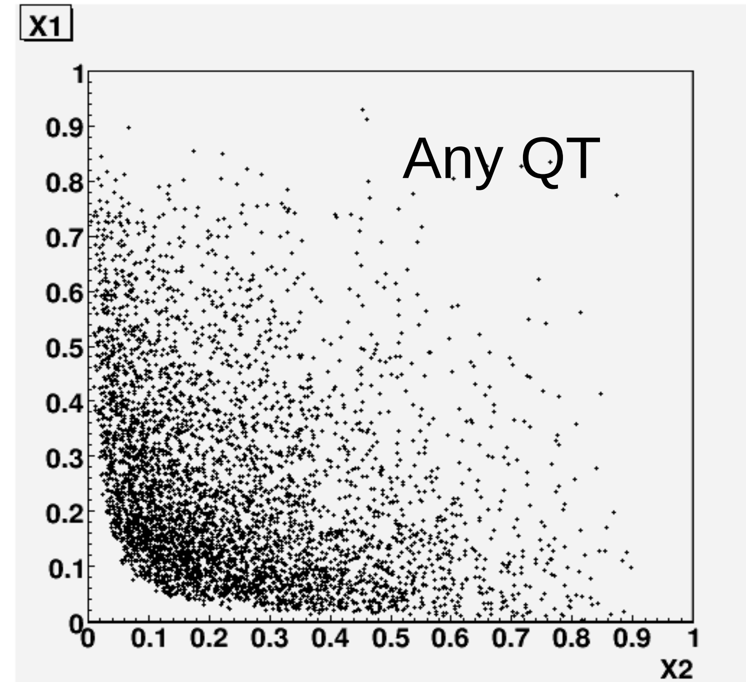
B) large QT > Q at 400 GeV^2

(A.Bacchetta, AB, M.Radici, work in progress)

Q > 1.75 GeV

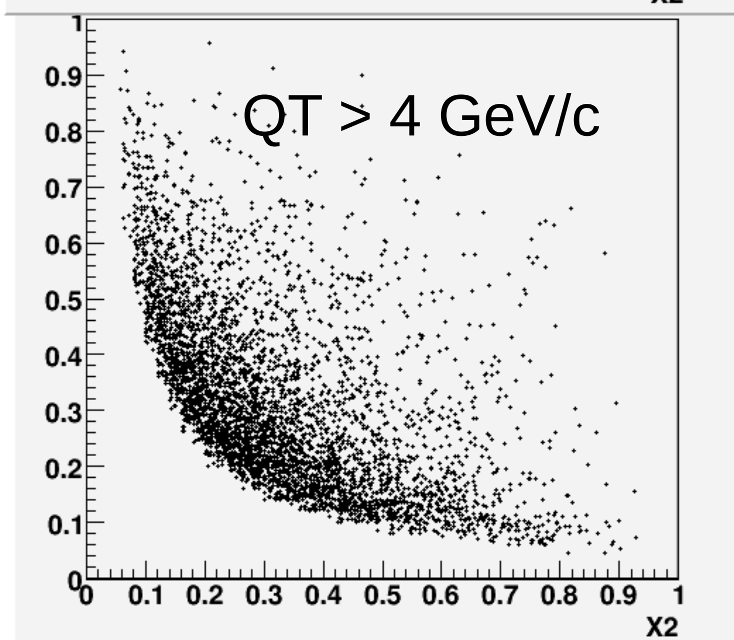
No J/psi contribution
(relevant at 2.5-3.5 GeV)

dominates
QT << QL ≈ Q



QT ≈ QL >> Q

$X_1 X_2 S$

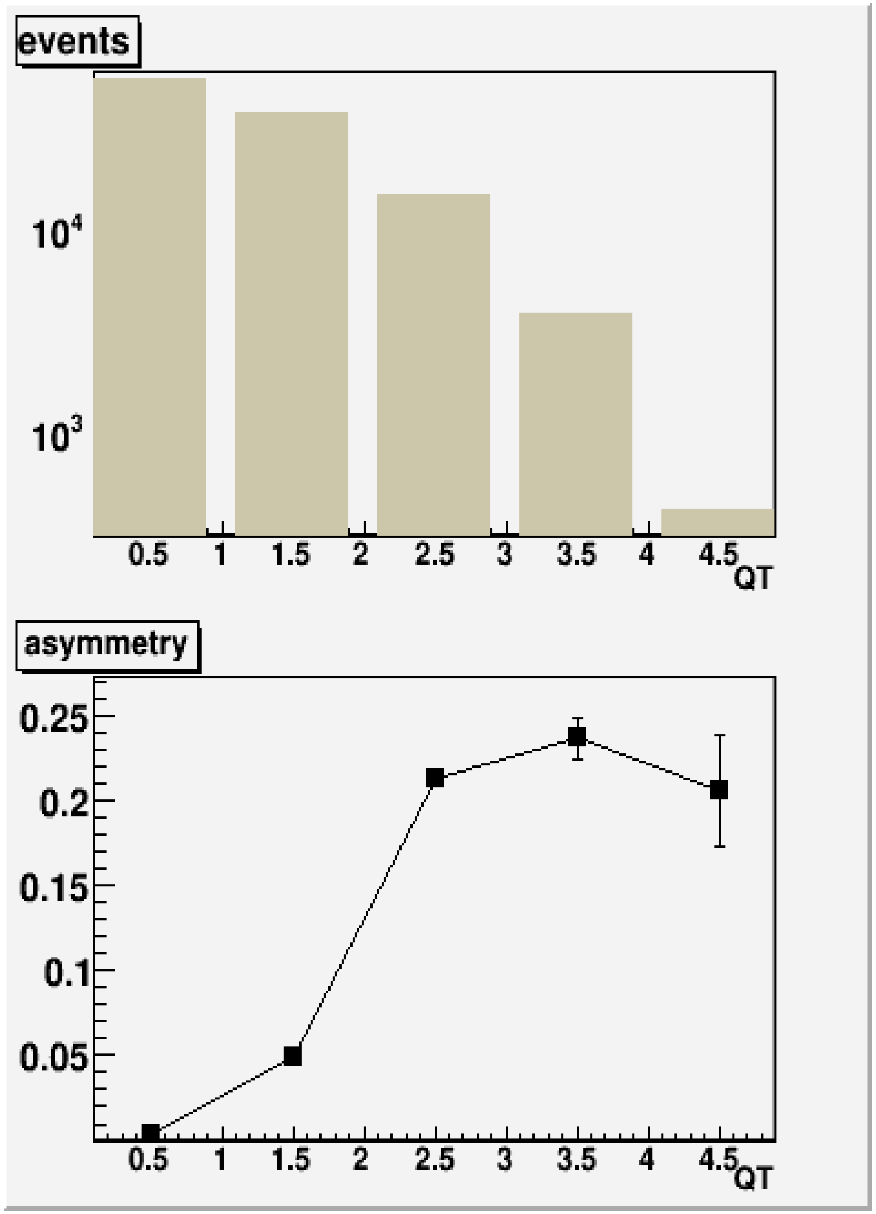


Distribution and asymmetry
for **1.75 < Q < 2.7 GeV**

In the **same** simulation

114,000 events with
Q > 4 GeV.

110,000 events with
1.75 < Q < 2.7 GeV



Optimistic model for cos(2phi) asymm
at largeQT, but for asymm < 30 %
the error bars do not depend
on the size of the asymmetry

Reference scale for QT: in E615 (500 GeV^2)
about a factor 1000 between QT- rates
at the peak (0.8 GeV/c) and at 5 GeV/c