Parameterization of the η Fragmentation Functions From World e+e- and p+p Data

Christine Aidala, UMass Amherst
Joseph Seele, U. of Colorado, Boulder
Marco Stratmann, RIKEN
Werner Vogelsang, BNL

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Isn't This a pdf Session??

- In pQCD calculations, FF's, like pdf's, not directly calculable from theory—need to be measured and fitted experimentally
- As partonic scattering cross sections calculated at NLO or even NNLO now, extraction of polarized pdf's more limited by uncertainty on **FF's**
- The better we know the FF's for inclusive hadronic probes, the tighter constraints we can put on the polarized parton distribution functions!
- "Errors" in FF can propagate to pdf
  - E.g. gluon FF too small will result in gluon pdf's too large in analysis of p+p data!

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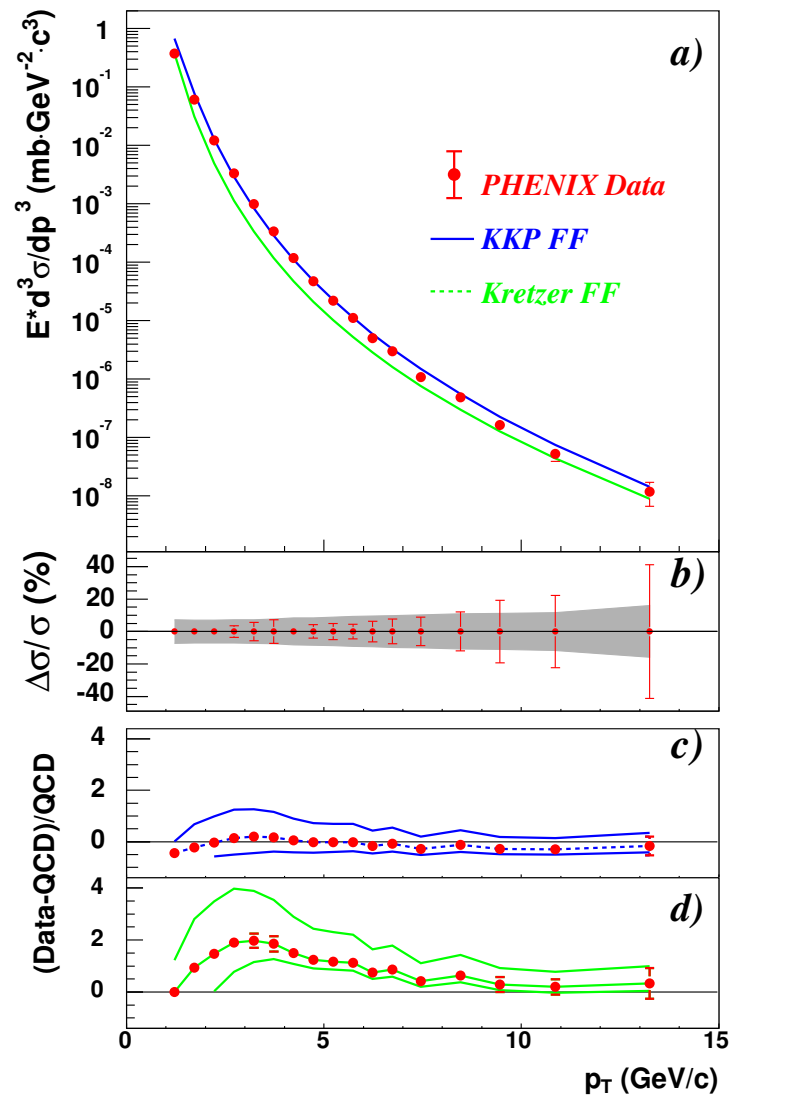

Main difference between Kretzer and KKP FF sets is D_g^{π}.

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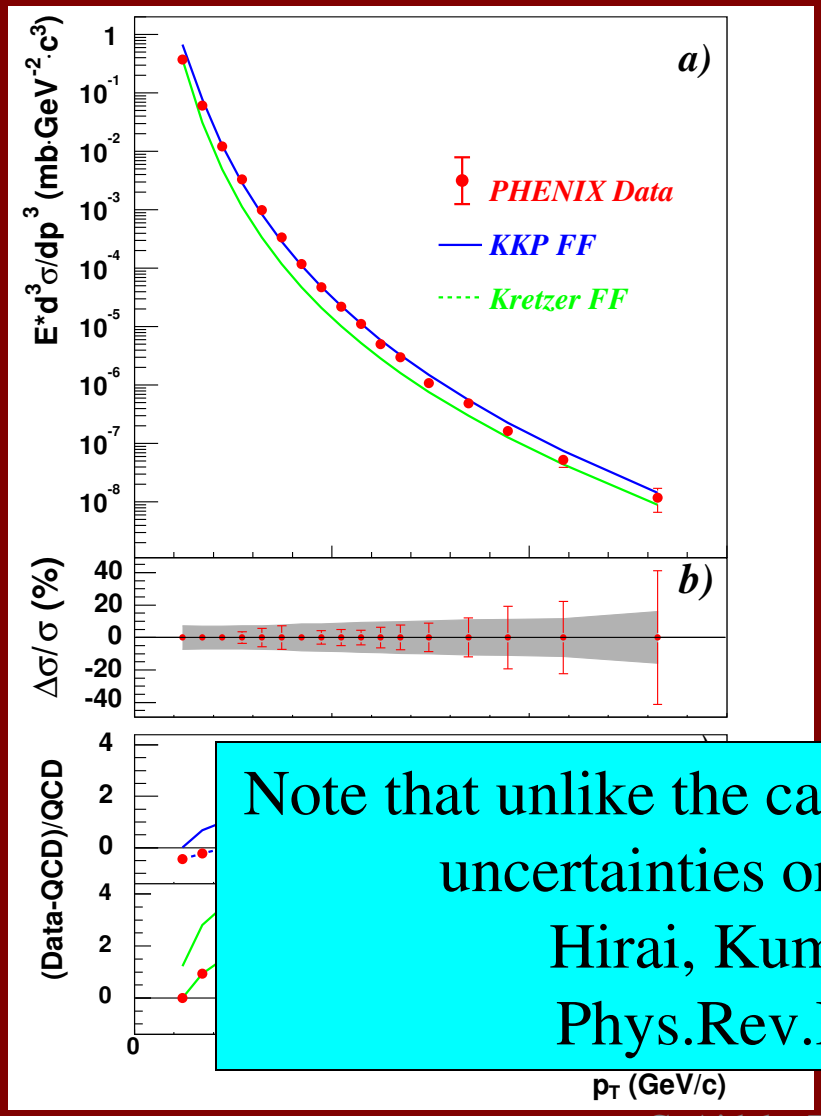

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Note that unlike the case of pdf's, attempts to quantify uncertainties on FF's just starting now:
Hirai, Kumano, Nagai, Sudoh,
Phys.Rev.D75:094009 (2007)

Using Hadronic As Well As e+e- Data

- FF's traditionally from e+e- data
  - Clean system!
  - Precise data from LEP
- But
  - Dominated by LEP measurements at M_Z → Weak scale dependence
  - Can't separate quarks from antiquarks
  - Not precise at large z, relevant for p+p collisions
- Framework now developed to extract FF's using all available data from deep-inelastic scattering and hadronic collisions as well as e+e-
  - de Florian, Sassot, Stratmann: PRD75:114010 (2007) and arXiv:0707.1506
- Hadronic collisions offer certain advantages over e+e-
  - Gluon fragmentation plays a larger role
  - Larger z
- But
  - Need high (collider) energies to avoid large scale dependences

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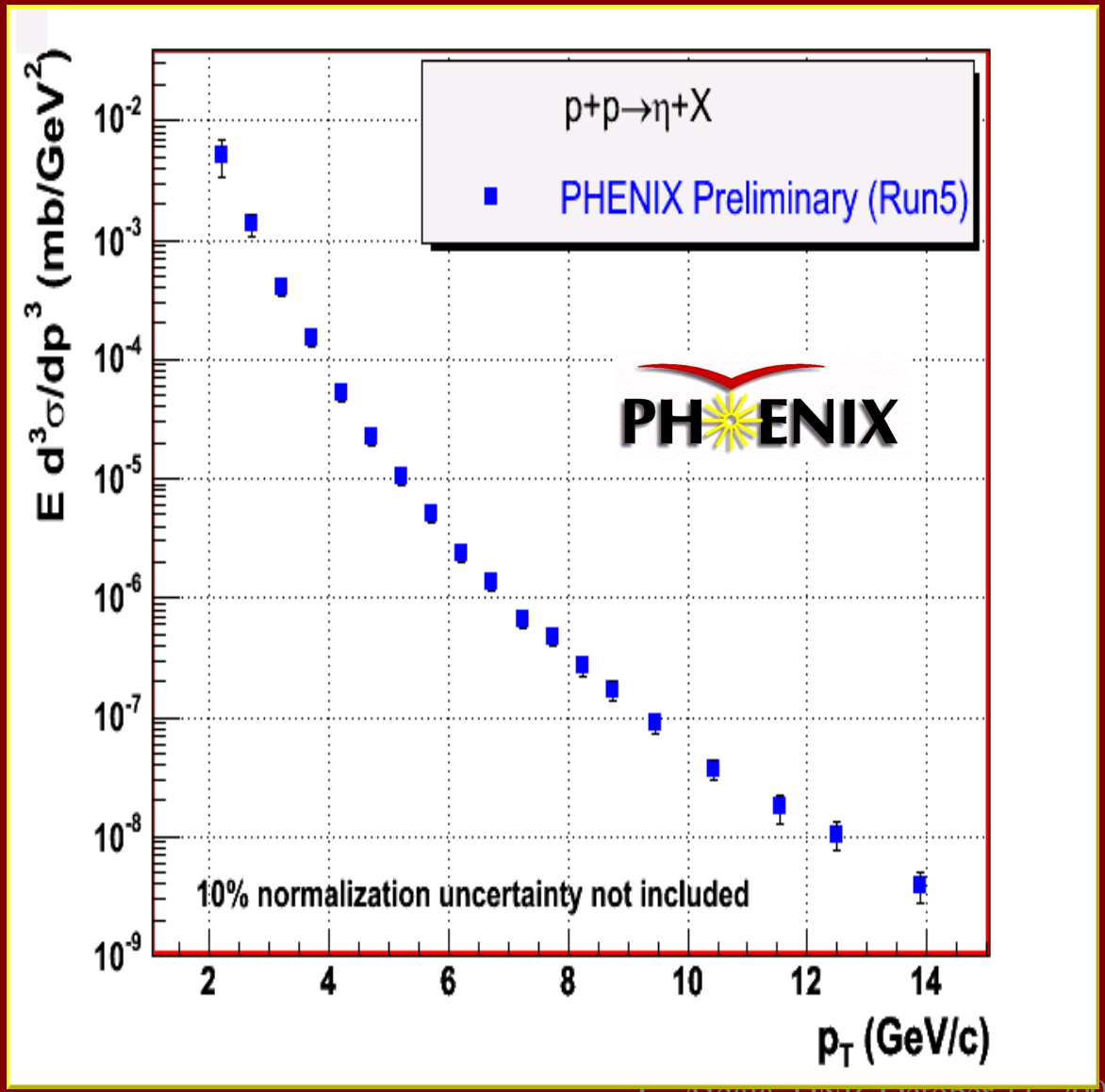
Improved FF's mean improved input to factorized pQCD calculations constraining polarized pdf's probed by inclusive hadronic asymmetries.

An Extreme Example: Cross Section and A_{LL} of η Meson



No η FF currently available in the literature!

PHENIX has made both cross section (PRC76: 034904 (2007)) and A_{LL} measurements, but no theoretical comparisons have thus far been possible . . .

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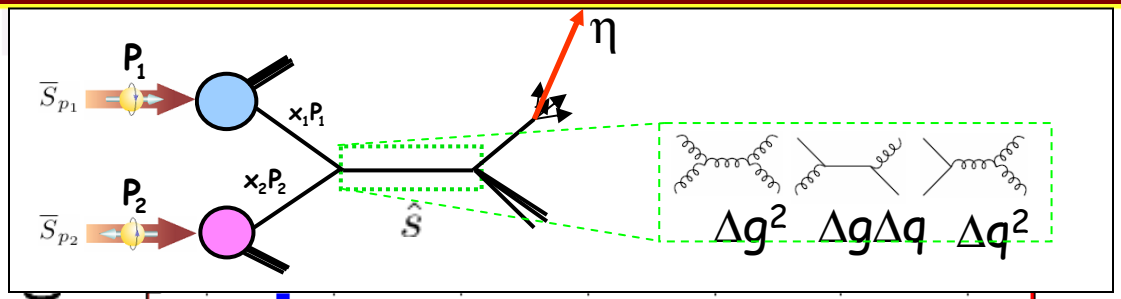

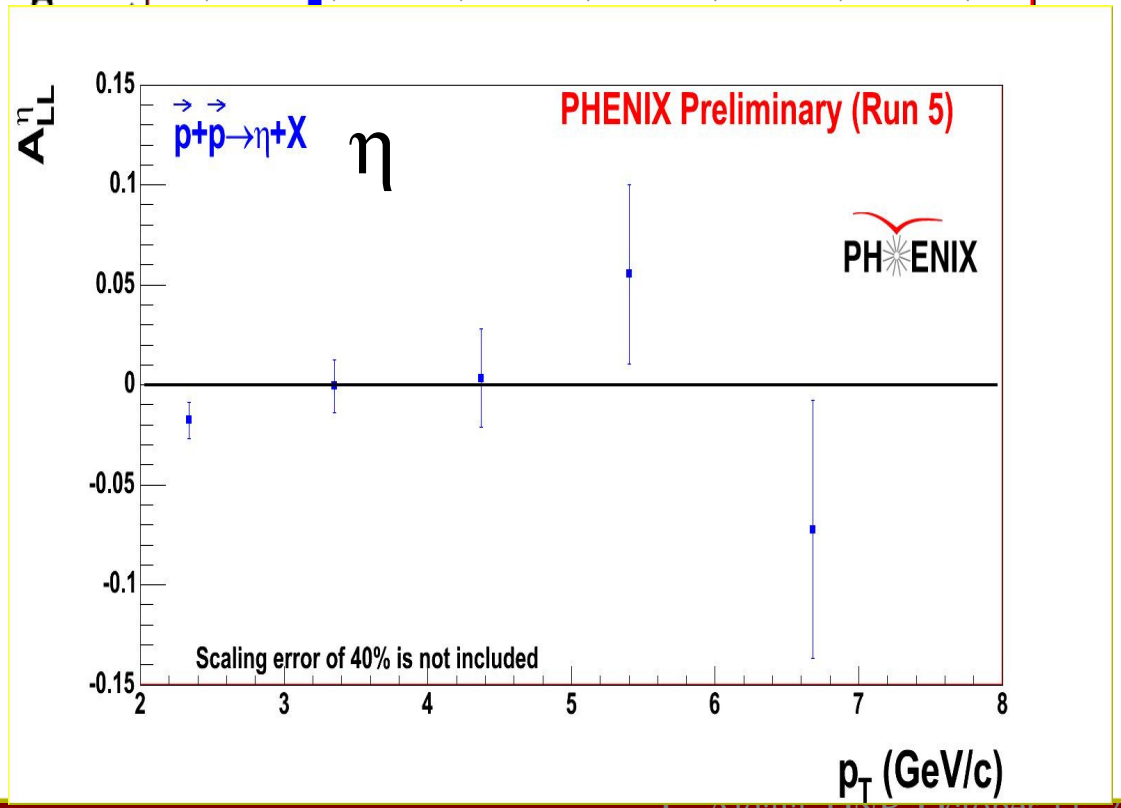

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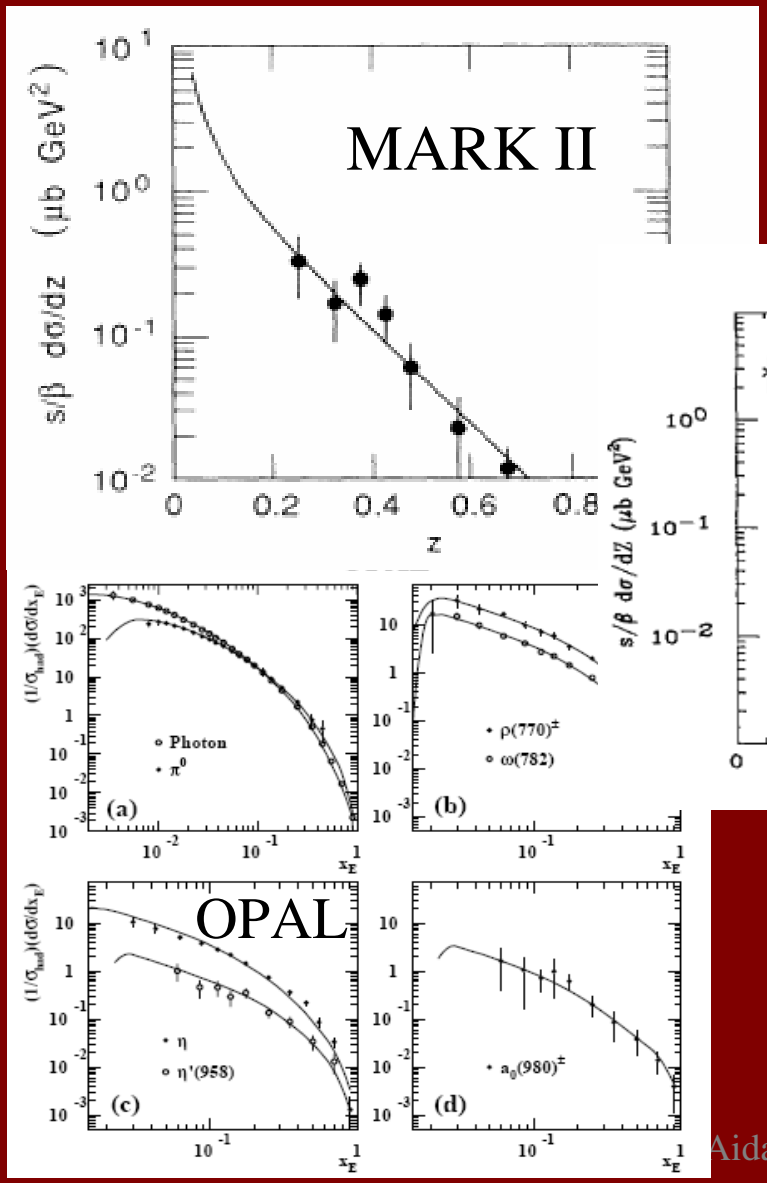

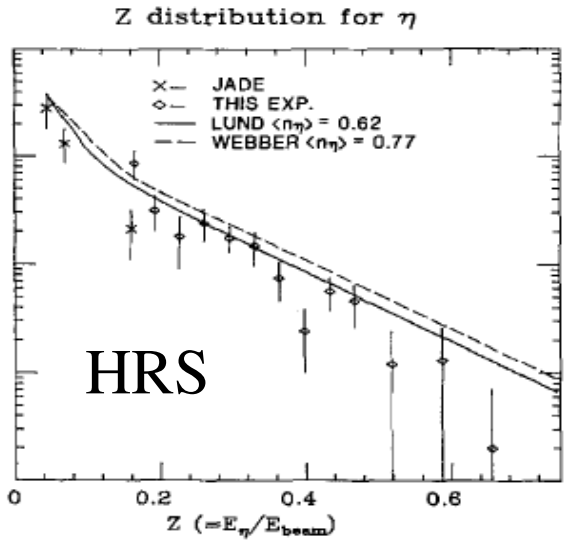

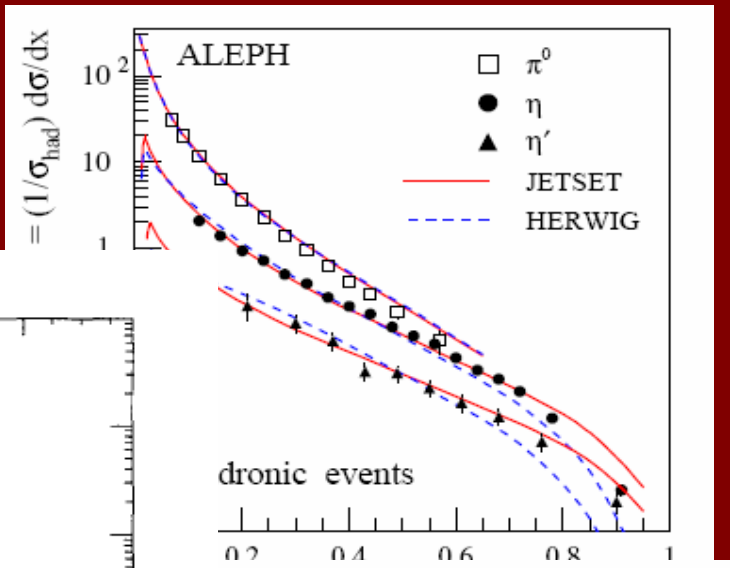

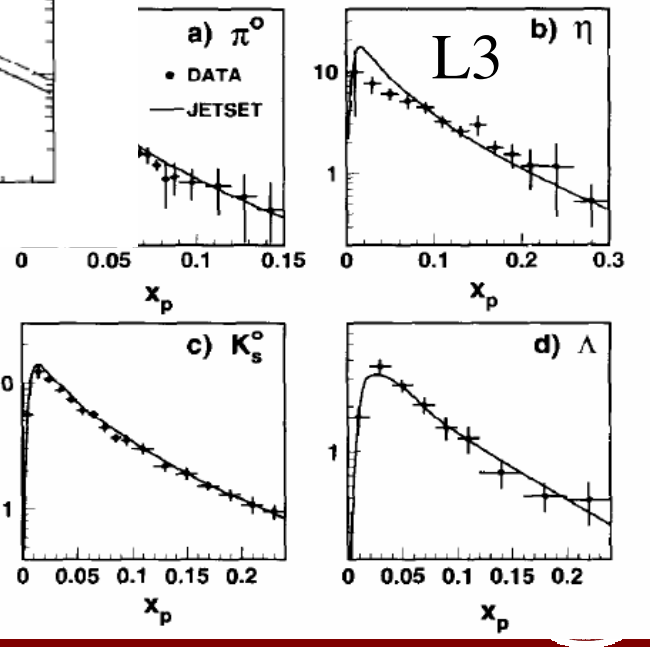

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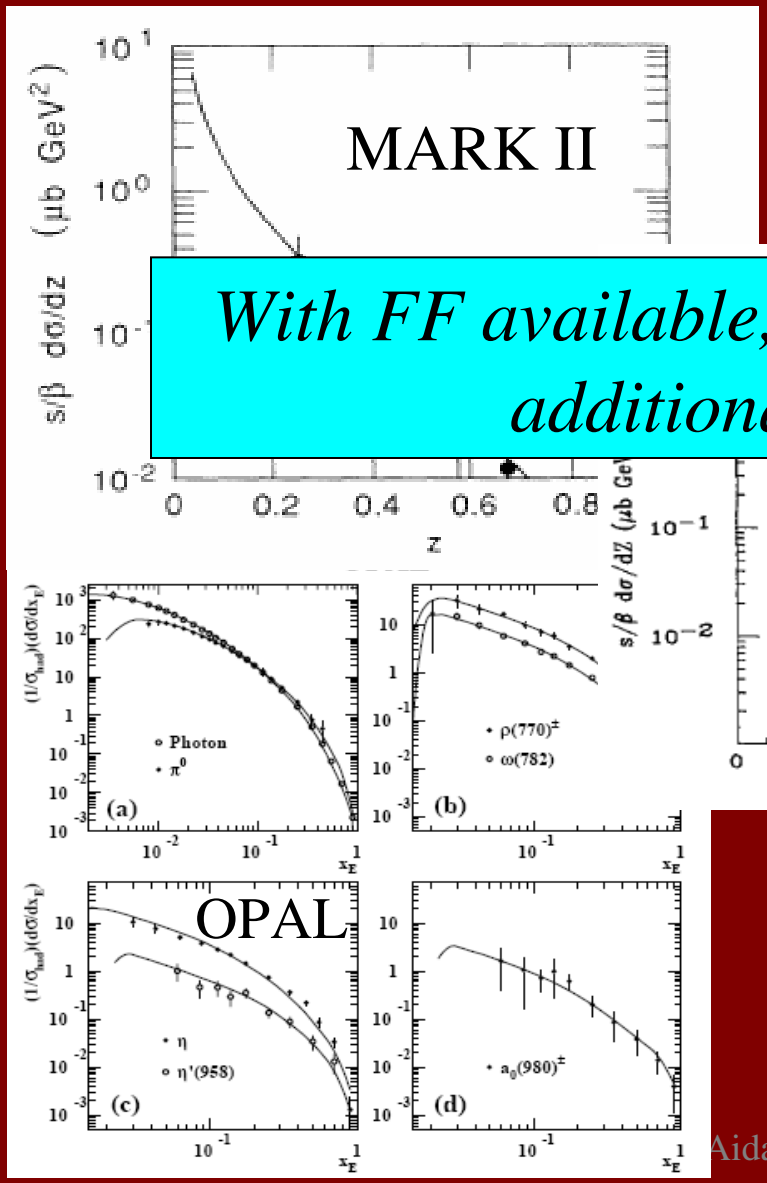
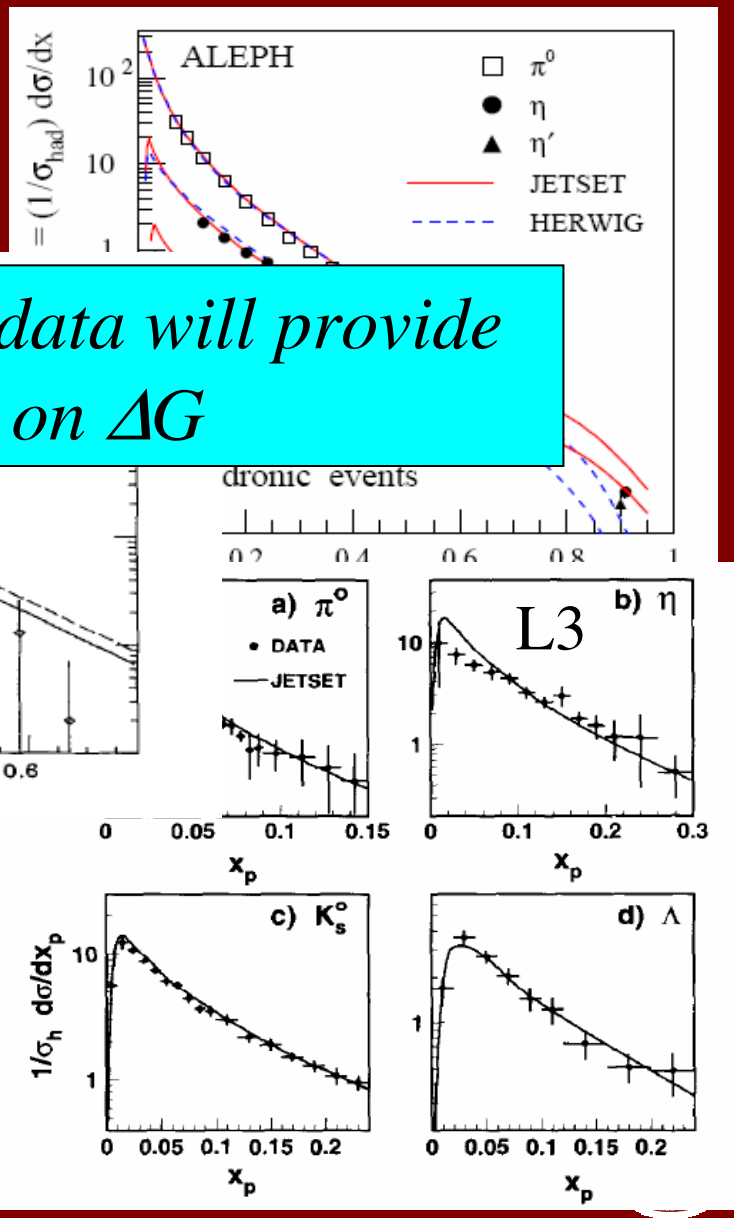




With FF available, asymmetry data will provide additional constraint on ΔG

Experiment	System	Energy (GeV)	# Points
ALEPH ’92	e+e-	91.2	8
ALEPH ’00	e+e-	91.2	18
ALEPH ‘02	e+e-	91.2	5
L3 ‘92	e+e-	91.2	3
L3 ’94	e+e-	91.2	8
OPAL	e+e-	91.2	9
ARGUS	e+e-	10	6
CELLO	e+e-	35	4
HRS	e+e-	29	13
JADE ’85	e+e-	34.4	1
JADE ‘’90	e+e-	34.9	3
MARK II	e+e-	29	7
PHENIX 2γ	p+p	200	12
PHENIX 3π	p+p	200	6
PHENIX ’05 prelim.	p+p	200	19

Parameterization of η FF

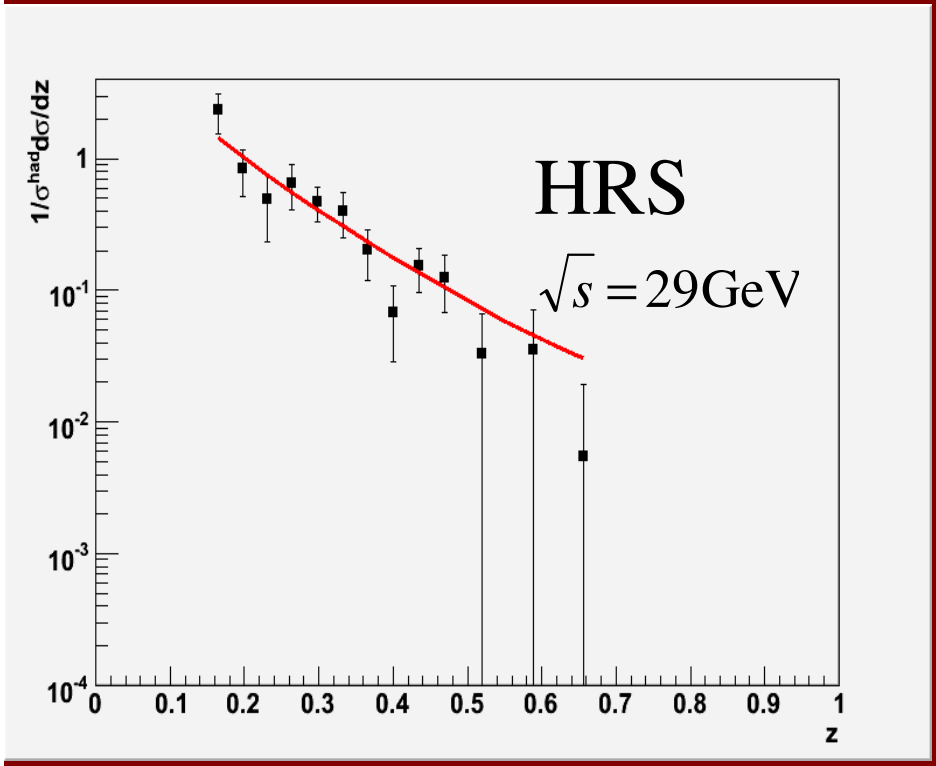
Followed method of de Florian, Sassot, Stratmann: PRD75:114010 (2007)

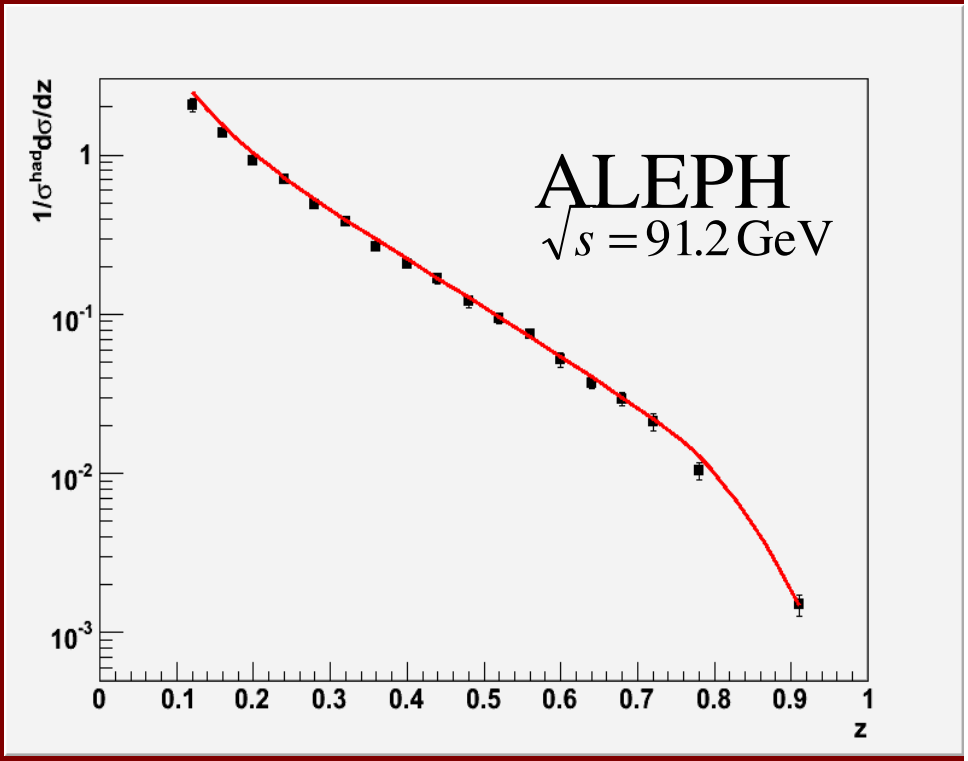
- FF's parameterized by

$$D(z,Q_0^2) = Nz^{\alpha}(1-z)^{\beta}(1+\gamma z)$$

- Inverse Mellin technique used for calculation of higher-order (NLO) hadronic cross sections
- 12 e+e-, 3 p+p (PHENIX) data sets included
- Used data for $z > 0.1$

Consistent Description of e+e- and p+p Data





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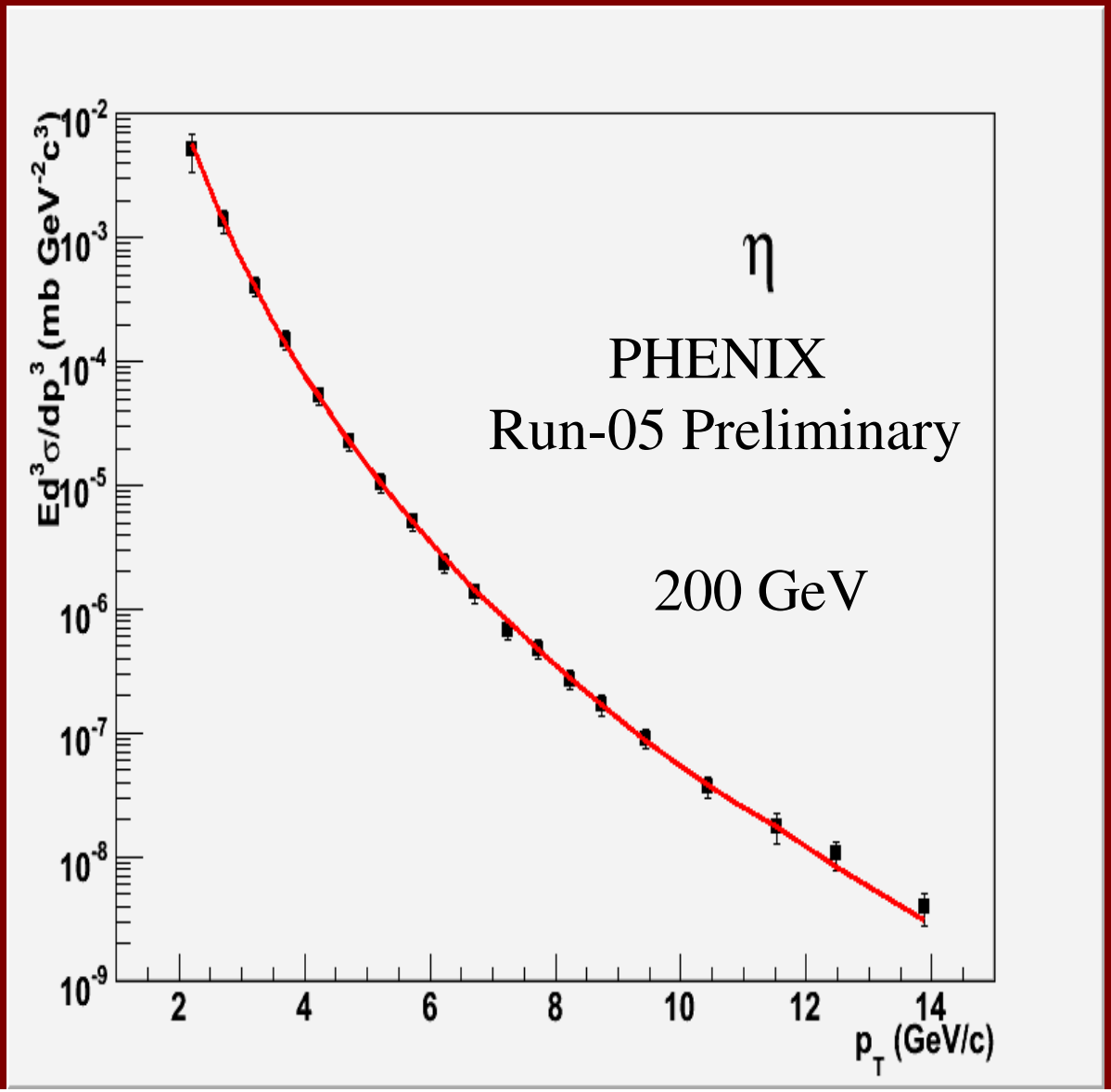
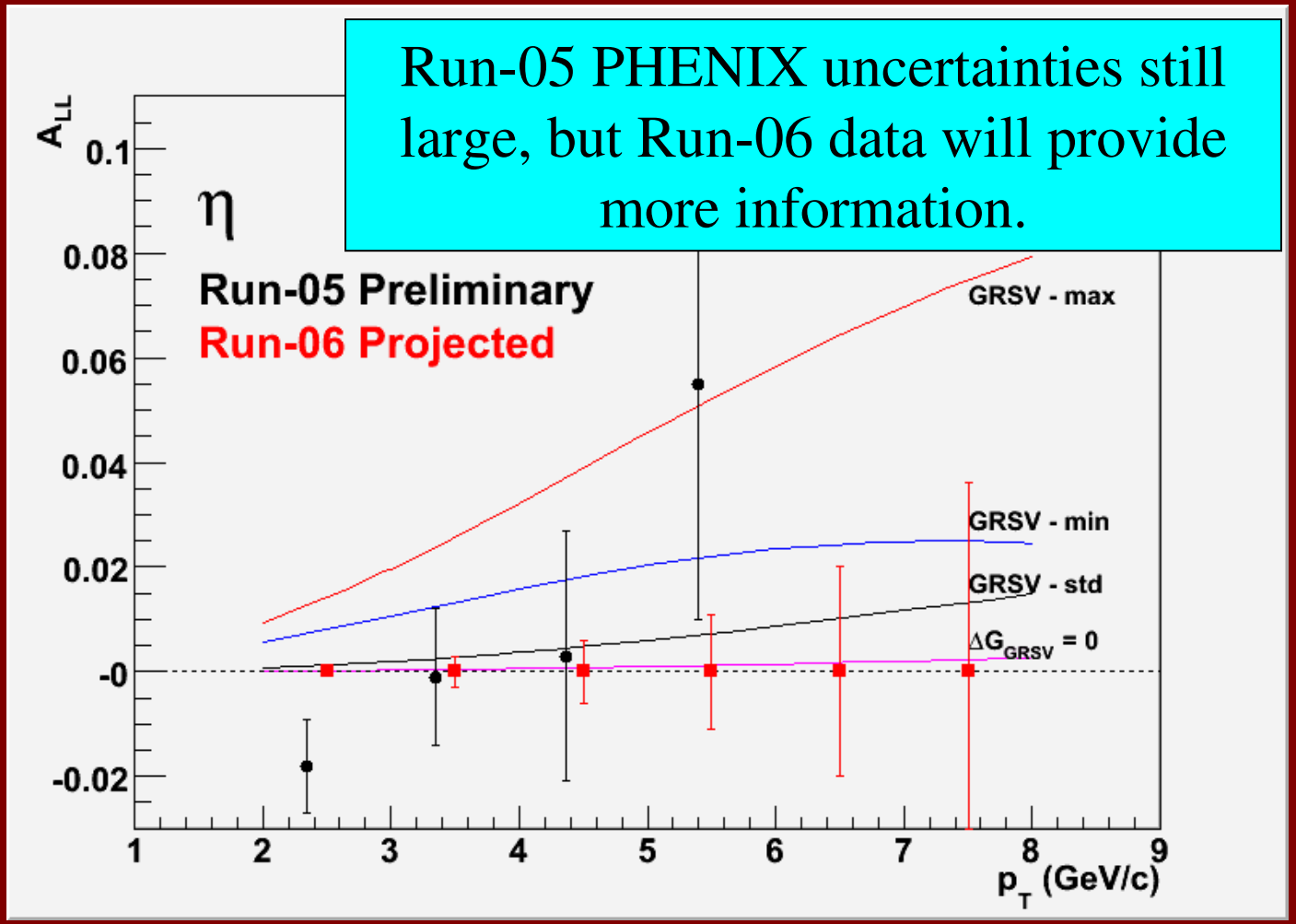
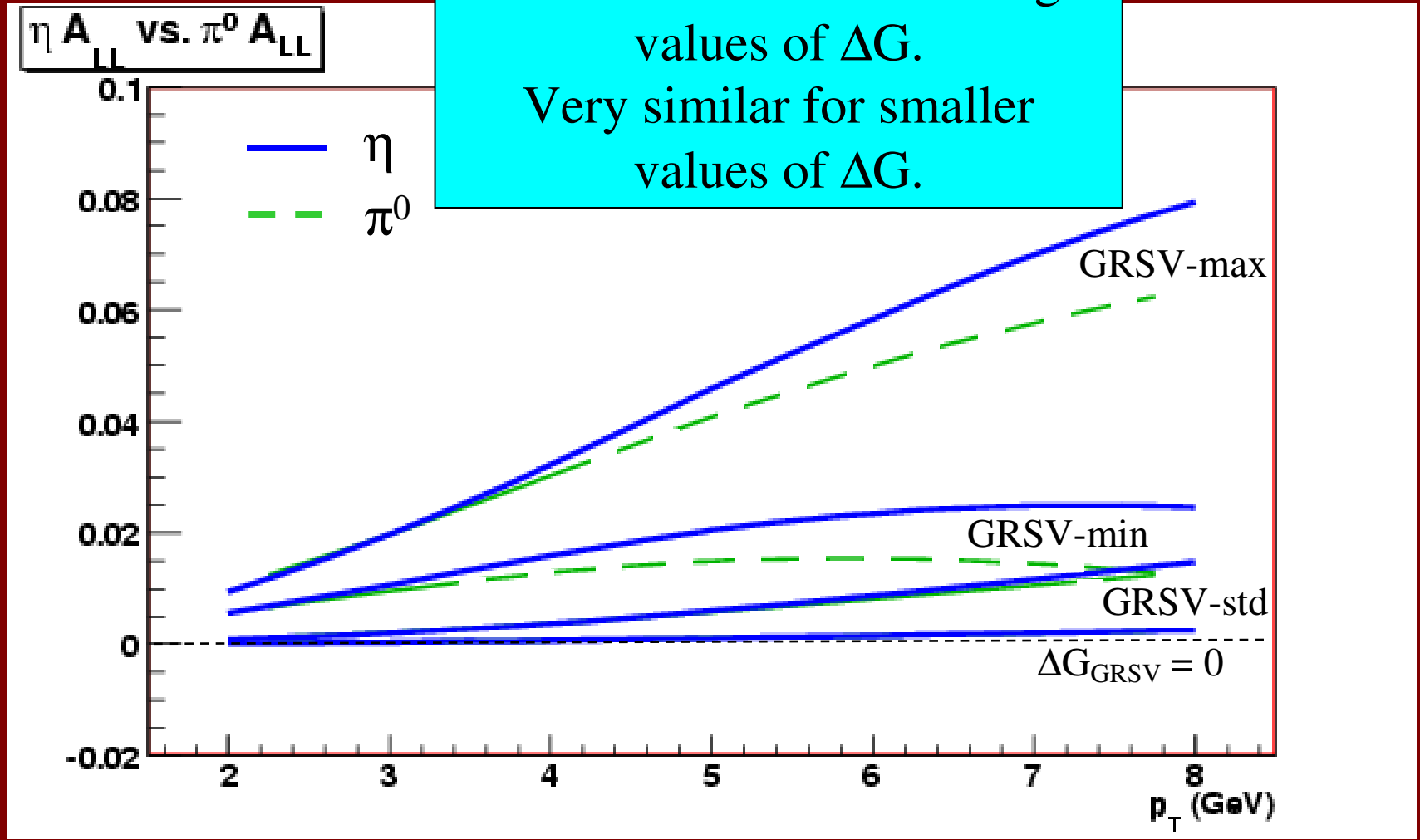


η A_{LL} vs. Theory



η vs. π^0 GRSV Predictions

Notable differences for large values of ΔG.
Very similar for smaller values of ΔG.



Conclusions and Prospects

- A consistent parameterization can be found to fit eta production in both e+e- and p+p data
- The availability of FF's for the eta makes both unpolarized and polarized pQCD calculations possible for the first time
  - PHENIX A_{LL} measurement can provide additional constraint on ΔG!
- Further work will involve attempts to estimate uncertainties and parameterize the flavor separation
  - Semi-inclusive DIS data would be helpful, as would precision measurements from B factories . . .

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With improved theoretical tools, global analysis of FF's similar to pdf analysis now possible.

Parameterization of the η FF just one example of how improved knowledge of FF's will help to constrain polarized parton distribution functions!

Extra Slides

χ^2 Values

- ==========
- TOTAL CHI**2 FROM E+E- : 1.372E+02
- TOTAL CHI**2 FROM PP : 8.410E+00
- TOTAL CHI**2 (SUM) : 1.457E+02
- ==========

- 122 data points total
  - 85 from e+e-
  - 37 from p+p
- Total χ^2/dof < 2
  - Surprisingly small for an analysis of a wide variety of data sets!