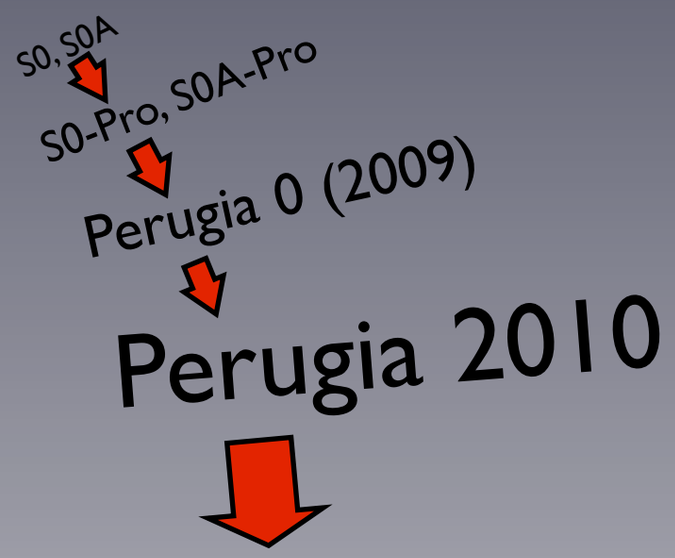


"Tuning Monte Carlo Generators: The Perugia Tunes"
arXiv:1005.3457, updated March 2011)

The Perugia 2011 Tunes

P. Skands (CERN)

& Lessons from LHC Event-Shape, UE, & strangeness measurements

All plots taken from: mcplots.cern.ch

Motivations

Incorporate LHC Data at 7 TeV

- **Min-Bias** incl Baryons (yields + transport) and Strangeness (while still keeping an eye on LEP yields)
- **UE** (+ energy scaling; slightly underpredicted by Tevatron tunes)
- Provide several systematic "Tune variations"

More consistent matching with AlpGen, …

- Use same α_s and Λ_{QCD} values for all ISR+FSR
  (partially motivated by CMS event shapes)

α_s

$\alpha_s(m_Z)$ (equivalently Λ_{QCD}) fitted to LEP event shapes

- Λ_{QCD} = 0.26 GeV (1-loop, 5 flavours, "PYTHIA MC scheme")

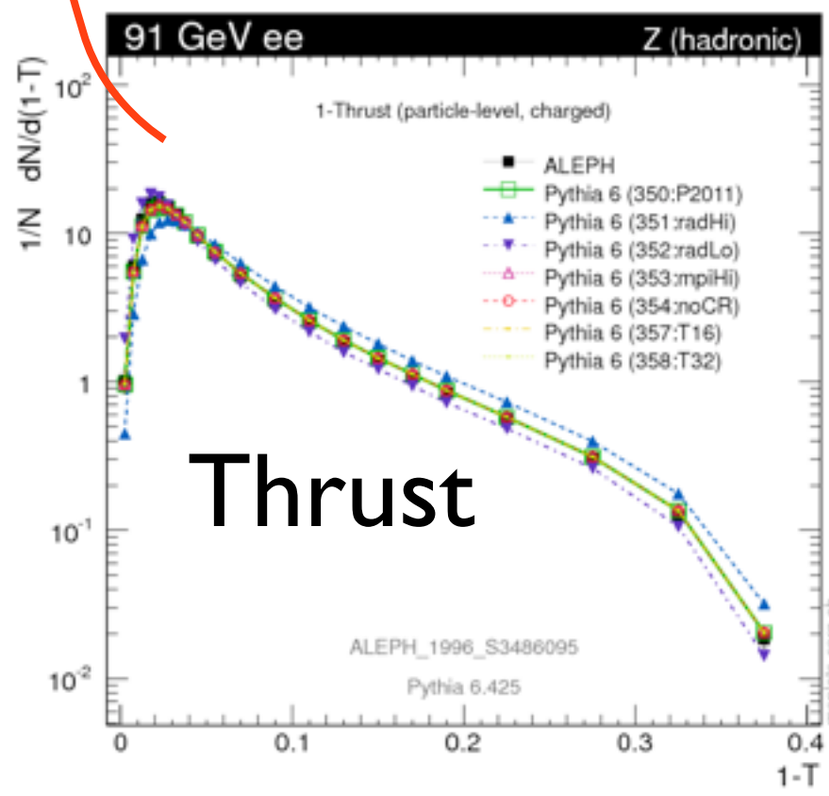
  → + easier and more consistent ME matching

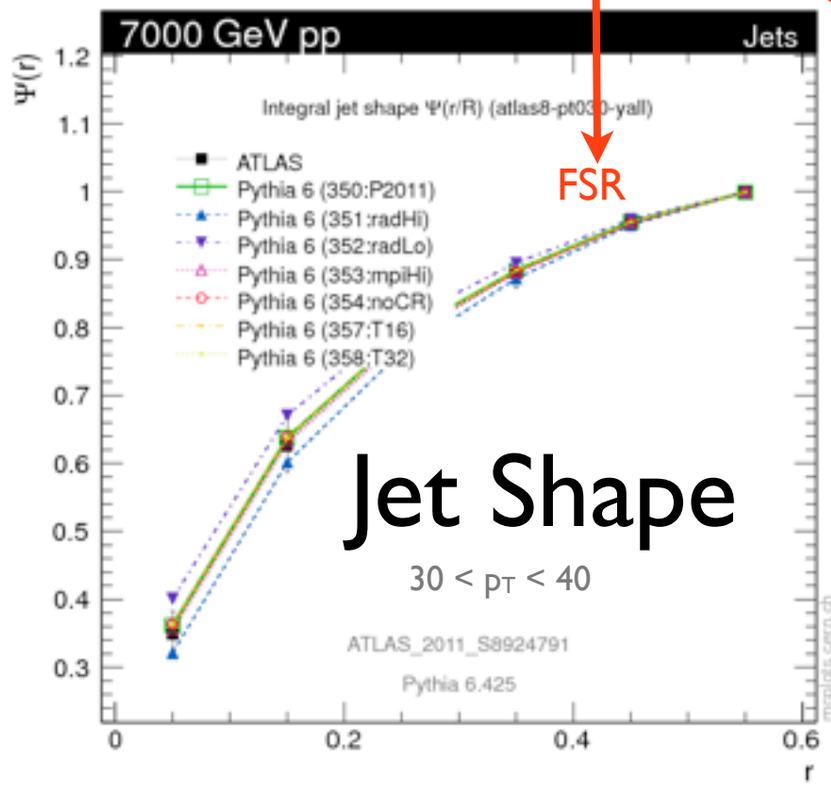
+ 2 tune variations

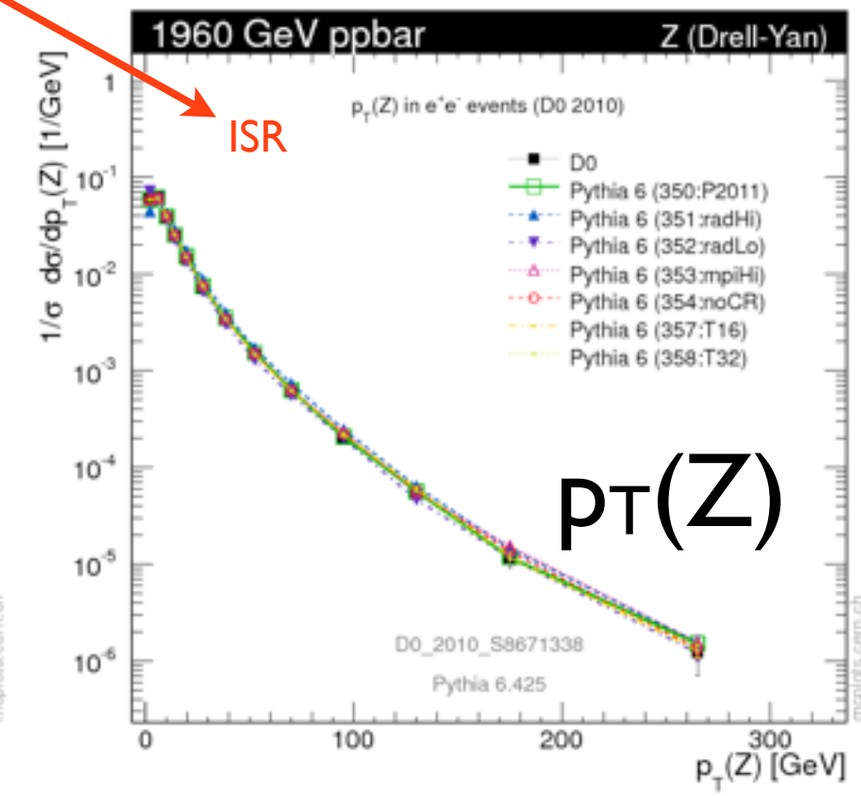
radHi: Λ = 0.52

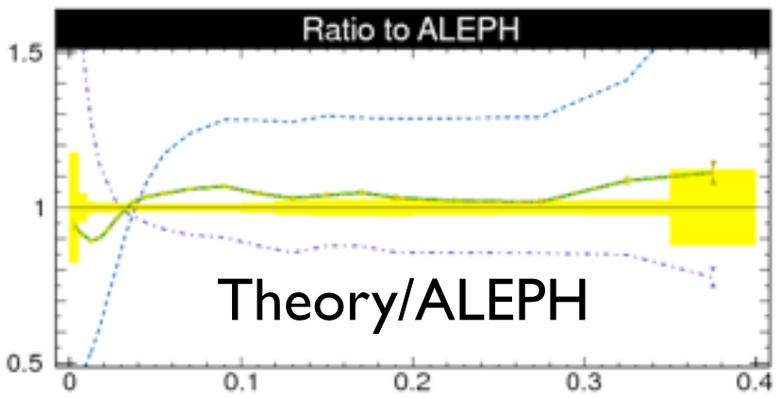
radLo: Λ = 0.13

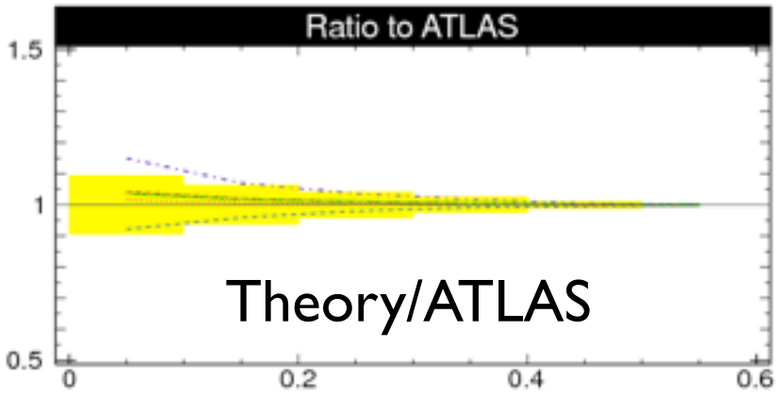
See updated arXiv:1004.3457

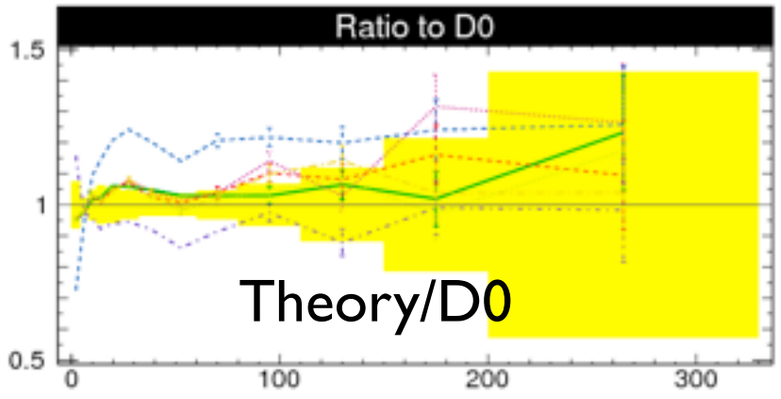








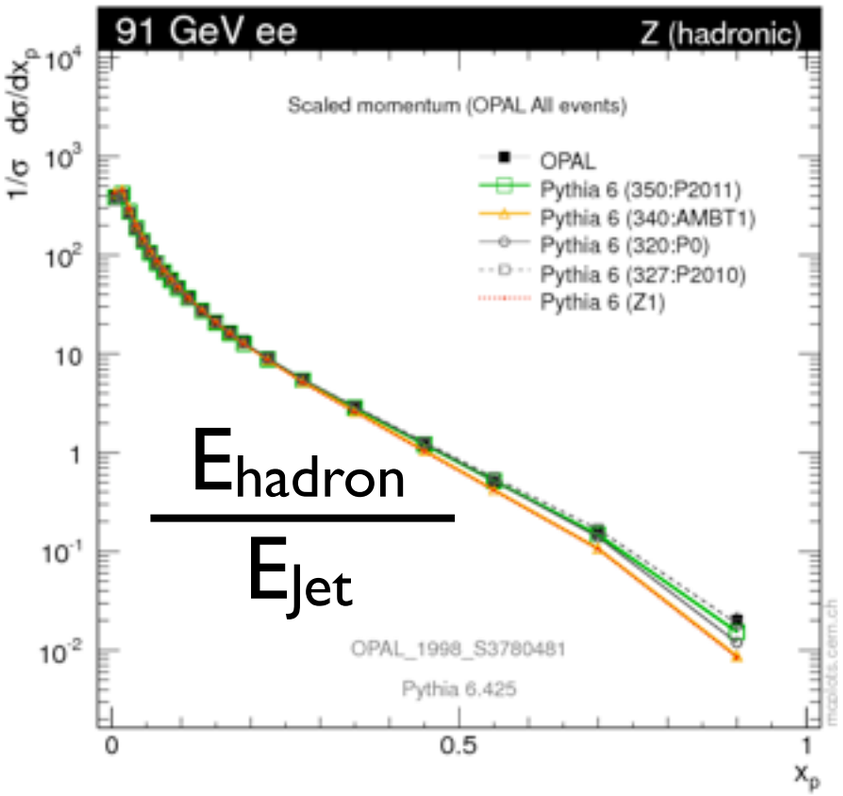


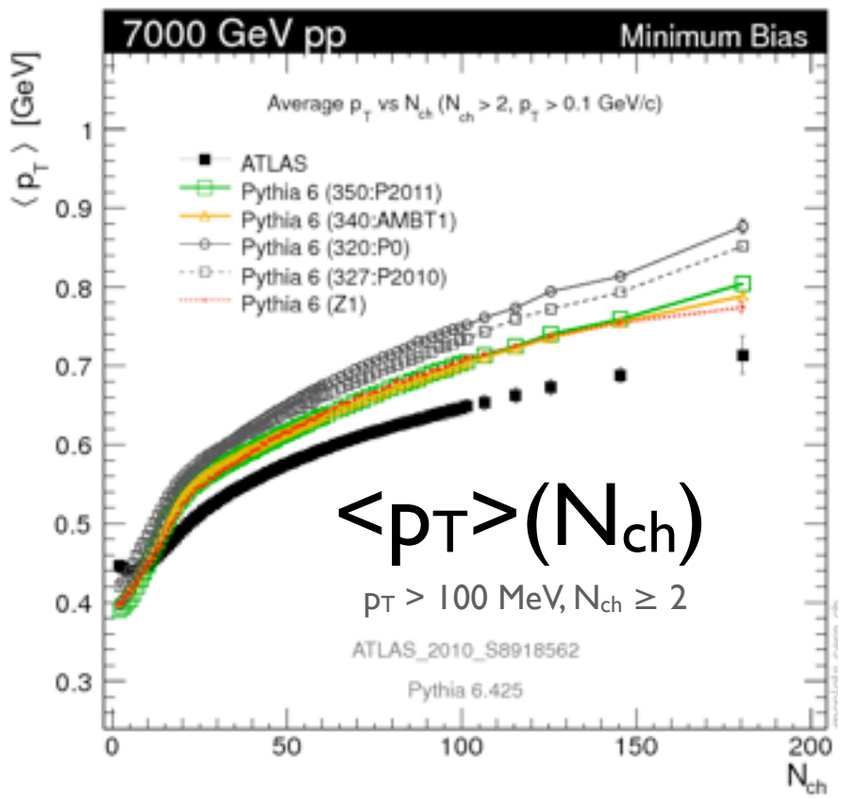


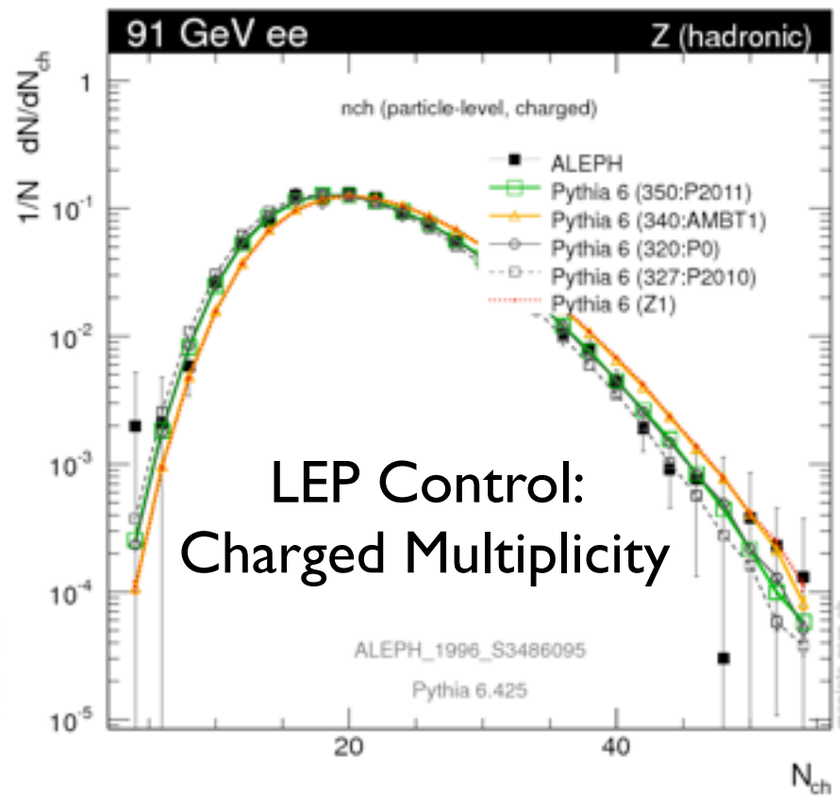
Fragmentation

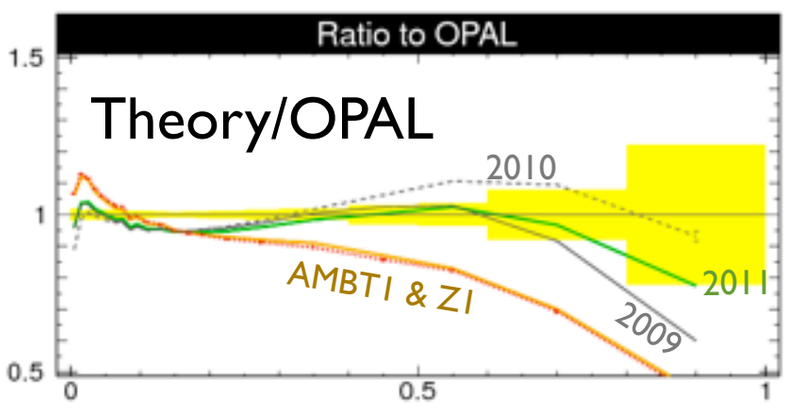
Slightly softer particle spectrum than 2010

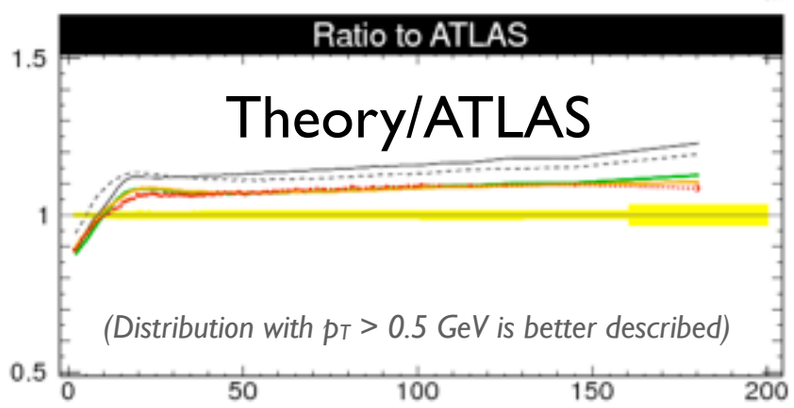
(motivated by min-bias pT>100 MeV measurements)

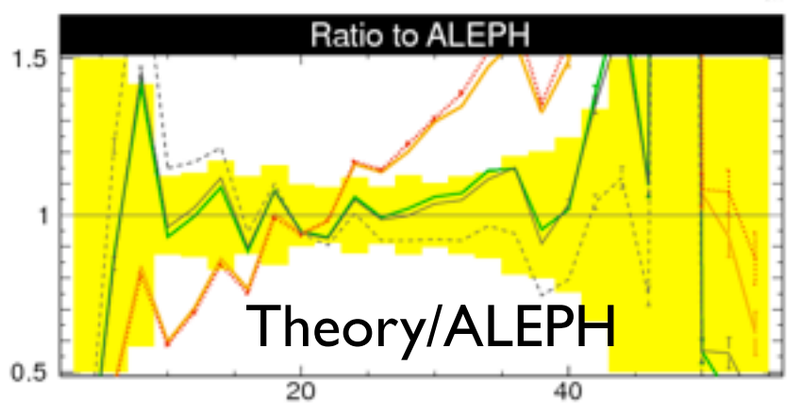












Strangeness

Λ/K (and Ξ, Ω) ratios already low at LEP

- Removed additional strange-Baryon suppression coming from "popcorn" mechanism
  - PARJ(6) from 0.5 → 1.0 & PARJ(7) from 0.5 → 1.0
  - (NB: may affect baryon-baryon correlations!)
- Also considered K/π, K^*/K, ρ/π, φ/π, p/π, Λ/p, Ξ, Ξ^*, Ω
  - … and the LHC baryon transport measurements, like $\overline{\Lambda}/\Lambda$ vs rapidity

*Apologies: no plots to show today (but changes **are** in there)*

Strangeness

Total yields (4π, all p_T) and N/N_{ch} percentages

	Perugia 0 (S320)		Perugia 2010 (S327)		Perugia 2011 (S350)			Z1 (341)	
< Nch > =	72.64		79.39		96.78			98.27	
< Nrho0> =	5.01	6.90%	5.84	7.36%	7.12	7.36%		8.29	8.44%
< NK0S > =	3.31	4.56%	3.77	4.75%	4.34	4.49%	←20%→	5.03	5.12%
< NK0* > =	2.44	3.37%	2.41	3.04%	3.18	3.29%	←40%→	5.39	5.49%
< Nphi0> =	0.28	0.39%	0.30	0.38%	0.36	0.38%	←100%→	0.86	0.87%
< Np+ > =	6.40	8.81%	6.82	8.59%	7.89	8.15%		8.18	8.33%
< NDel+> =	0.80	1.11%	0.98	1.23%	1.23	1.27%		1.32	1.34%
< NLam0> =	1.21	1.67%	1.43	1.80%	1.90	1.96%		1.89	1.92%
< NCas+> =	0.10	0.13%	0.12	0.15%	0.17	0.18%	←30%→	0.14	0.14%
< NCas*> =	0.016	0.022%	0.022	0.027%	0.042	0.043%	←50%→	0.029	0.029%
< NOmg-> =	0.0025	0.0034%	0.0042	0.0052%	0.0085	0.0088%	←100%→	0.0038	0.0039%

Compared to Perugia 0 and 2010 tunes:
Perugia 2011 has larger absolute yields, and larger strange baryon fractions

Compared to Z1: Perugia 2011 has fewer strange mesons, more strange baryons

Heavy-particle p_T spectra

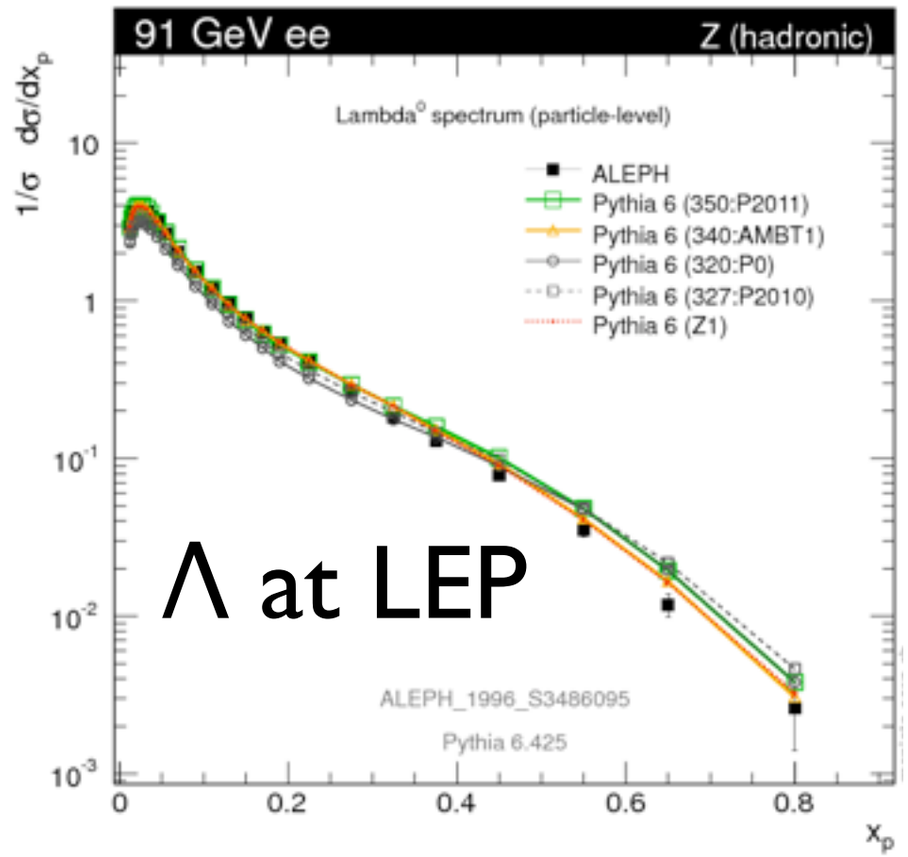
The p_T spectra of heavier particles remains a problem!

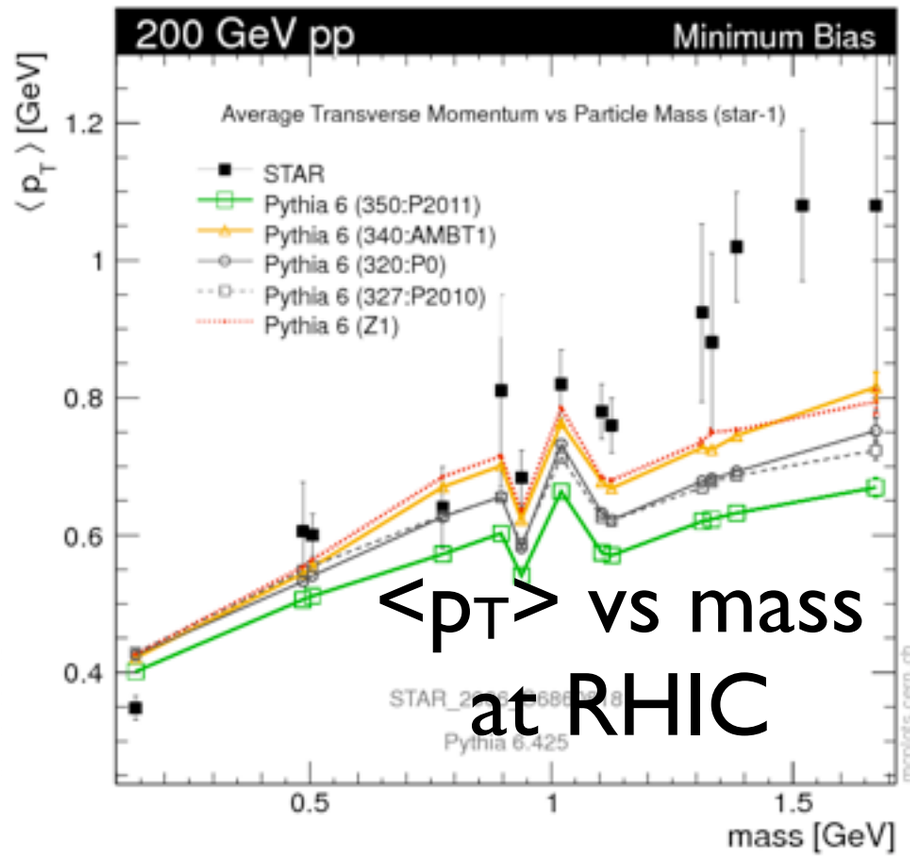
Too hard at LEP

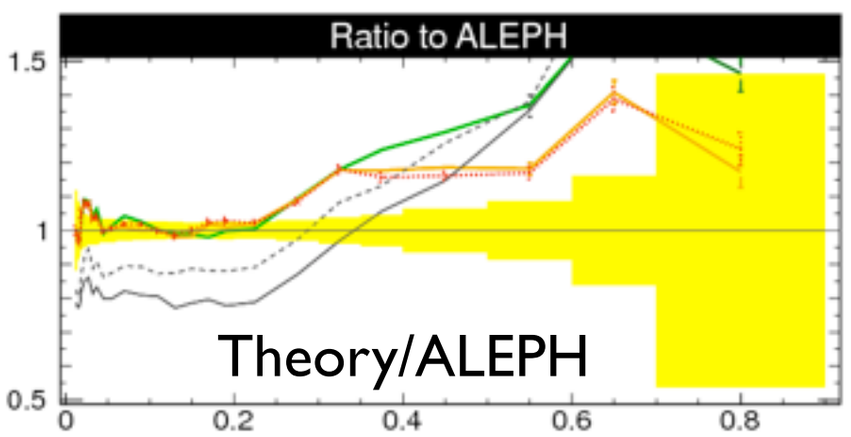
Too soft at RHIC

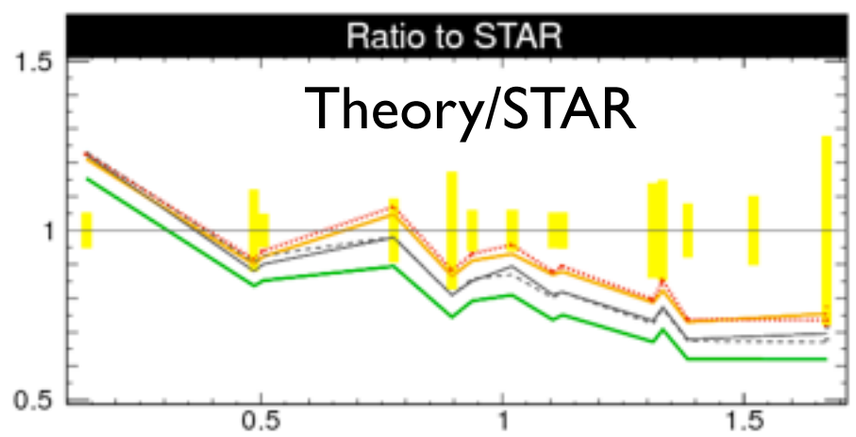
Would be interesting to get constraints from *pp* in processes harder than Min-Bias, *e.g.*, inside jets

Note also: the mismodeling of the p_T spectra can make comparisons of yields with p_T cuts misleading



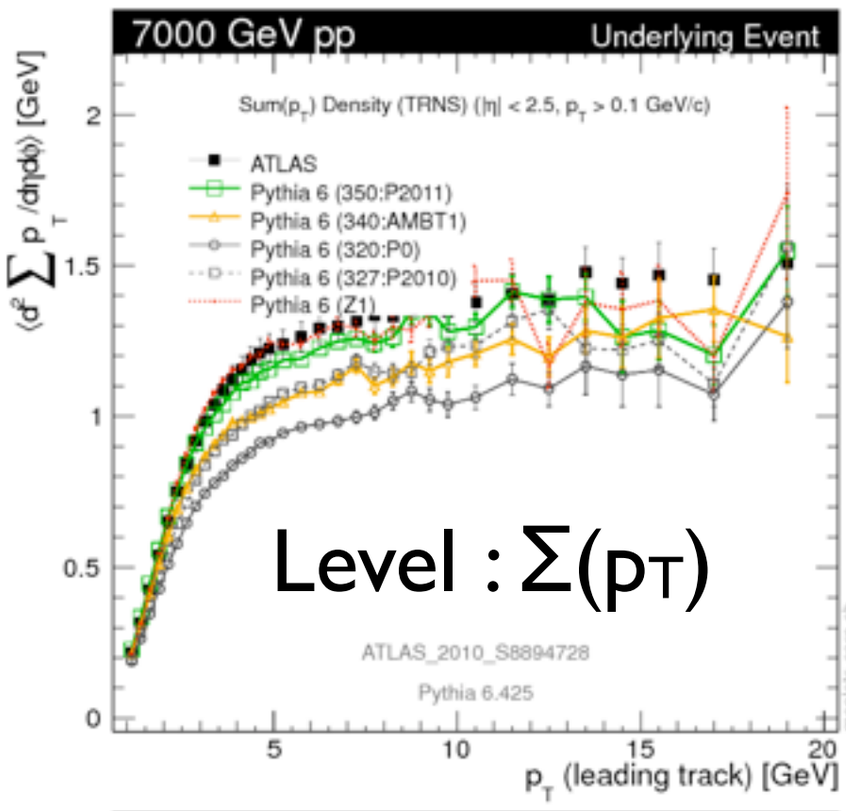


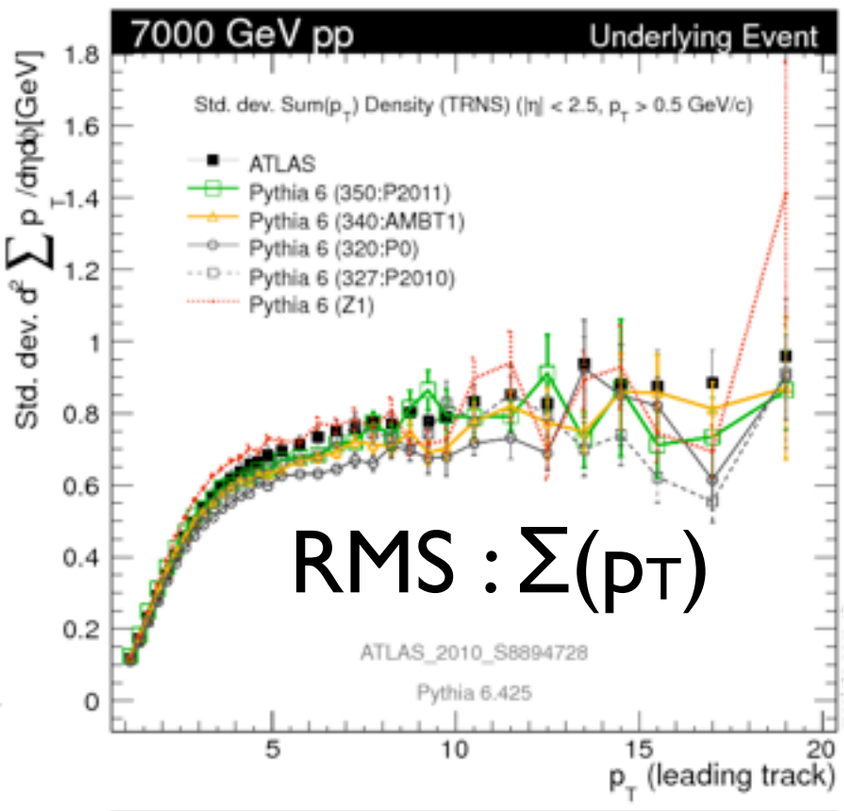


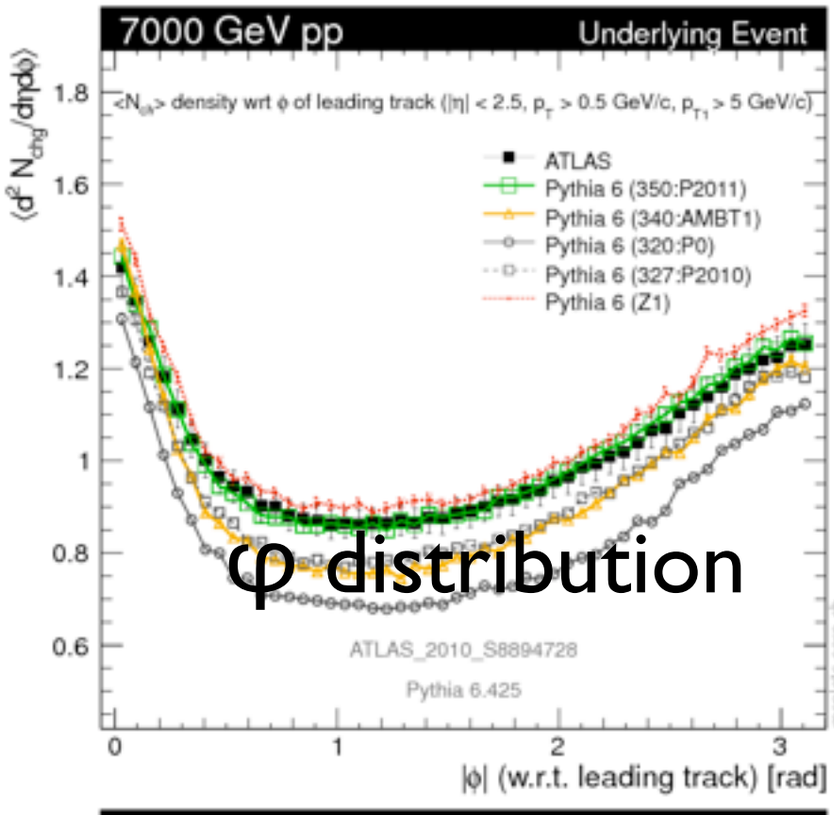


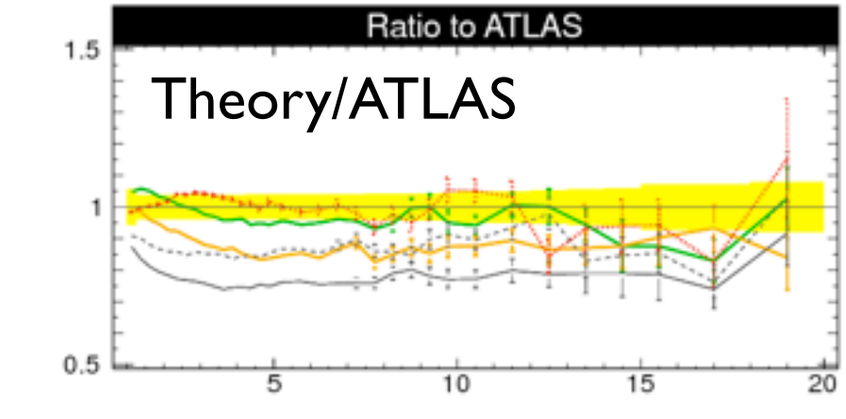
Underlying Event

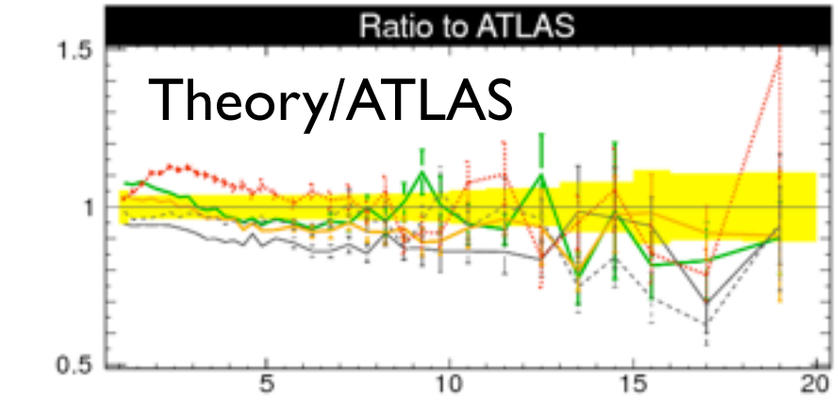
Level, fluctuations, and distribution reasonably well understood at this point *(next step: particle composition?)*

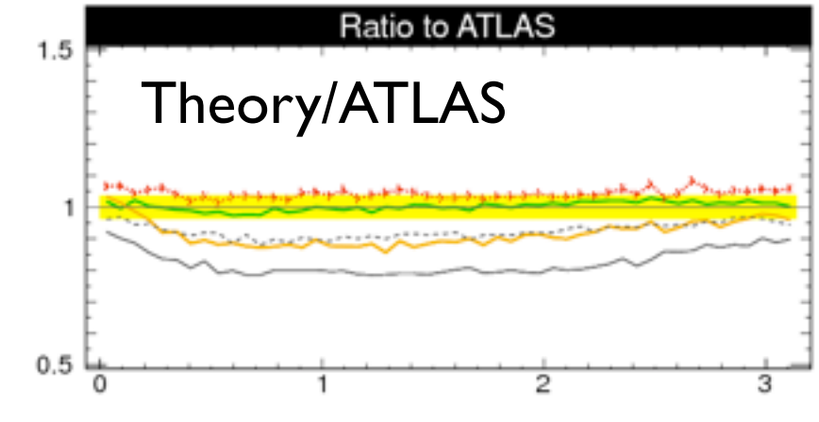










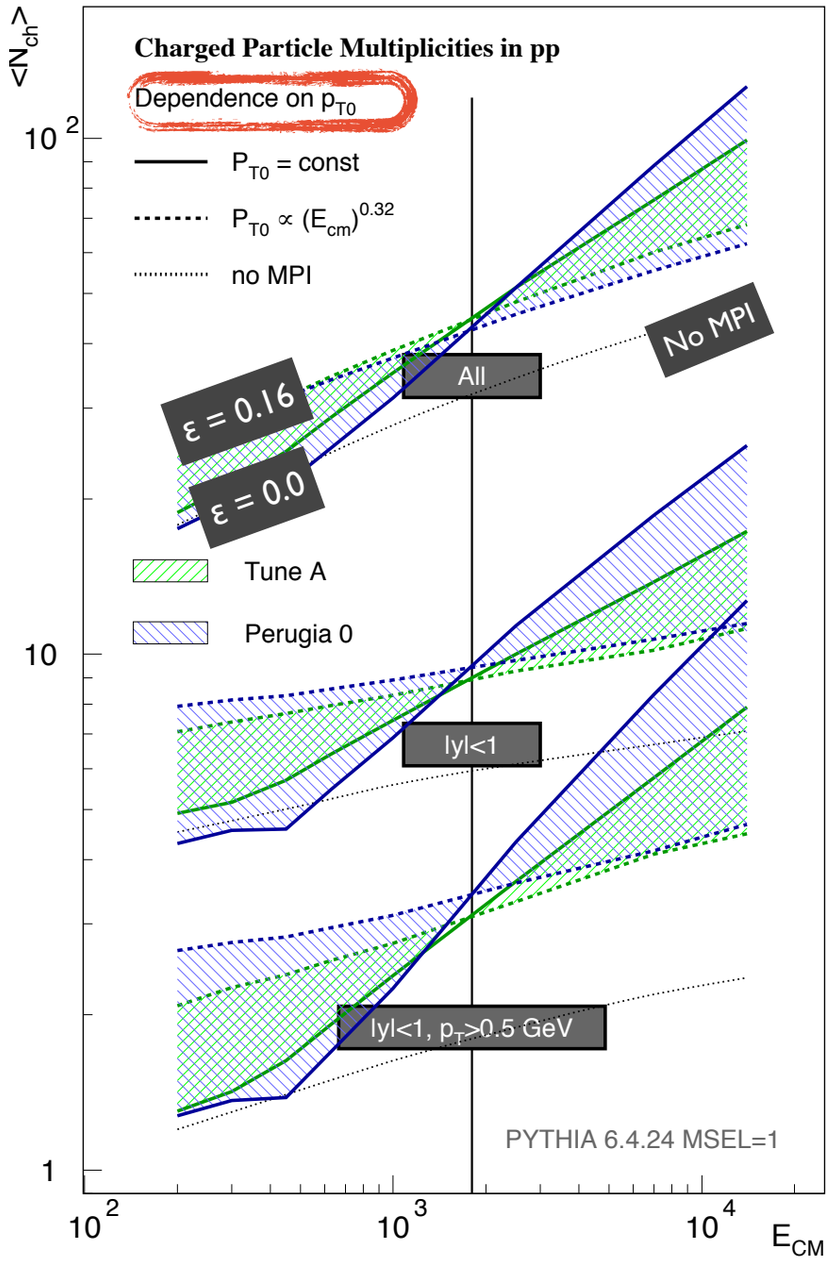


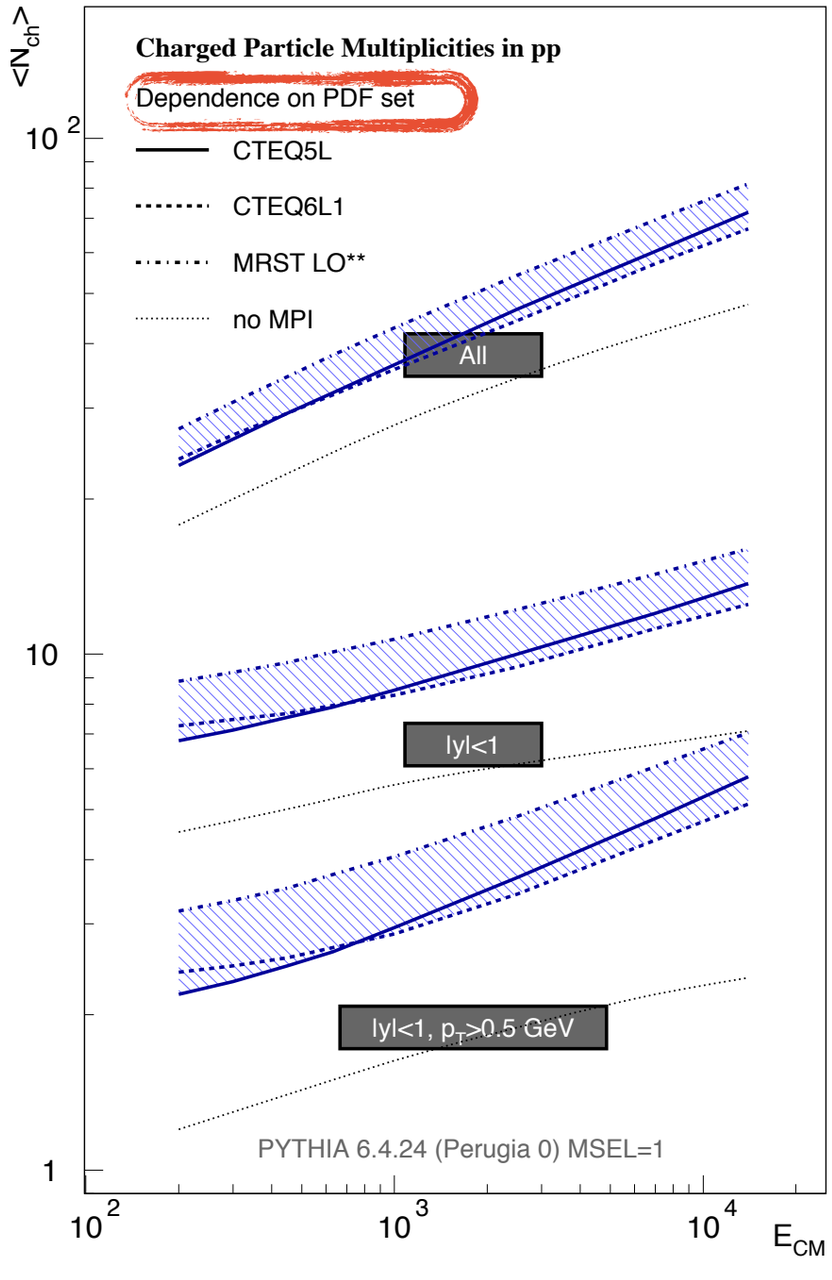
Energy Scaling

Depends on p_{T0} cutoff and PDF set:

H. Schulz & PS, EPJC 71 (2011) 1644
(arXiv:1103.3649 [hep-ph])

Average Multiplicity vs ECM





Perugia 2011
(CTEQ5L)
PARP(90) = 0.26
→ ε = 0.13

Perugia 2011 C
(CTEQ6L1)
PARP(90) = 0.22
→ ε = 0.11

+ 2 variaton tunes provided (using CTEQ5L) with different scalings away from 7 TeV
T16 : ε = 0.08
T32 : ε = 0.16

2011

Central Tune + 9 variations

Perugia 2011 Tune Set

(350)	Perugia 2011	Central Perugia 2011 tune (CTEQ5L)	
(351)	Perugia 2011 radHi	Variation using $\alpha_s(\frac{1}{2}p_\perp)$ for ISR and FSR	Harder radiation
(352)	Perugia 2011 radLo	Variation using $\alpha_s(2p_\perp)$ for ISR and FSR	Softer radiation
(353)	Perugia 2011 mpiHi	Variation using $\Lambda_{\rm QCD} = 0.26\,\text{GeV}$ also for MPI	UE more "jetty"
(354)	Perugia 2011 noCR	Variation without color reconnections	Softer hadrons
(355)	Perugia 2011 M	Variation using MRST LO** PDFs	UE more "jetty"
(356)	Perugia 2011 C	Variation using CTEQ 6L1 PDFs	
(357)	Perugia 2011 T16	Variation using `PARP(90)=0.16` scaling away from 7 TeV	
(358)	Perugia 2011 T32	Variation using `PARP(90)=0.32` scaling away from 7 TeV	
(359)	Perugia 2011 Tevatron	Variation optimized for Tevatron	~ low at LHC

Can be obtained in standalone Pythia from 6.4.25

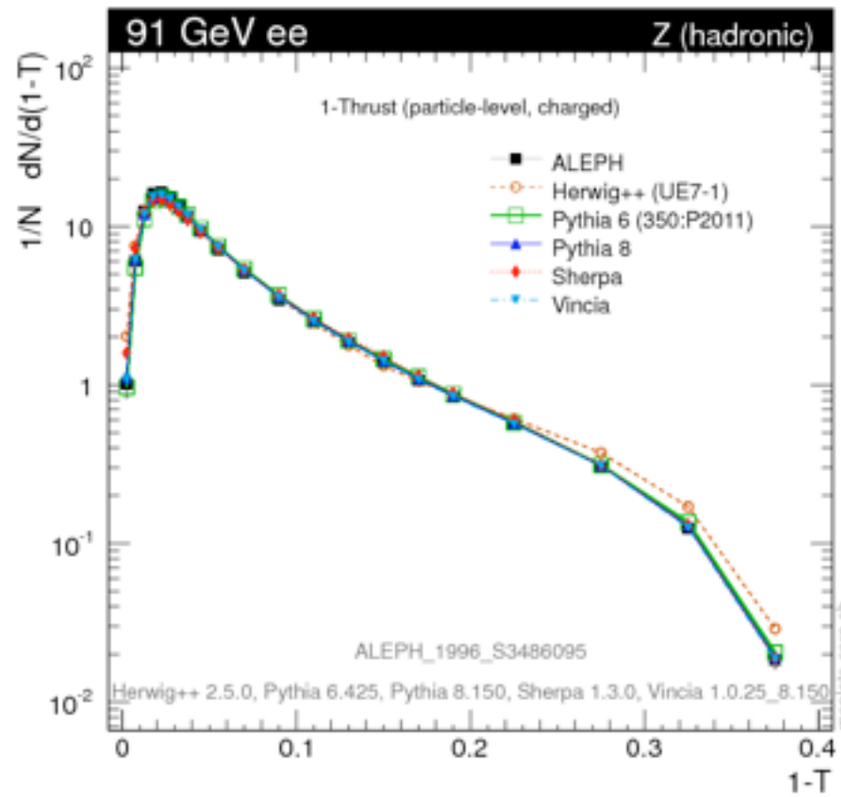
MSTP(5) = 350	MSTP(5) = 351	MSTP(5) = 352	MSTP(5) = …
Perugia 2011	Perugia 2011 radHi	Perugia 2011 radLo	…

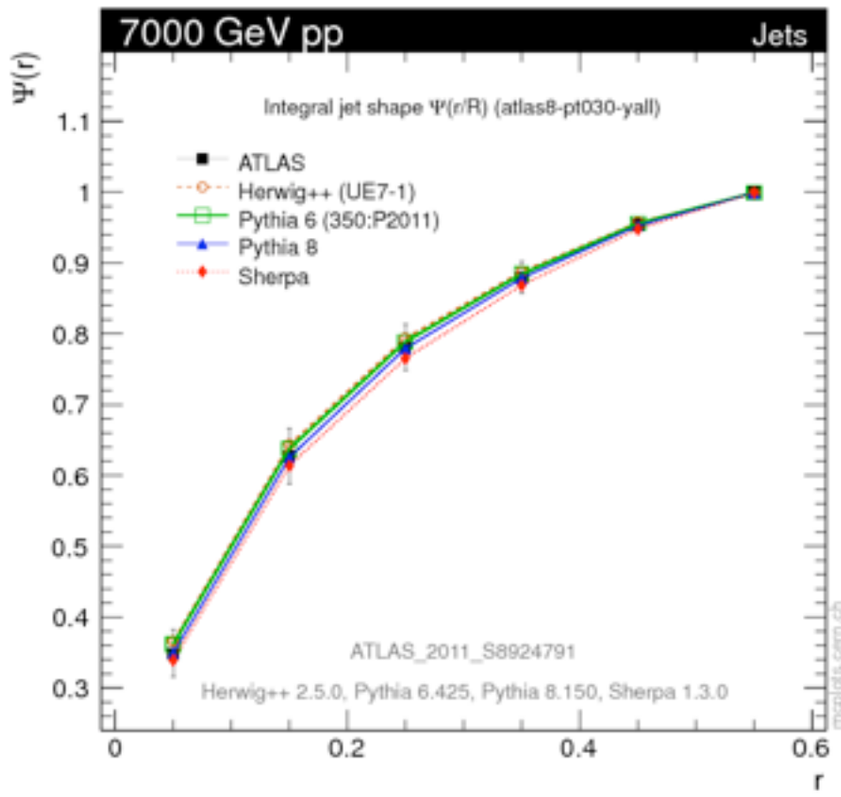
Additional Plots

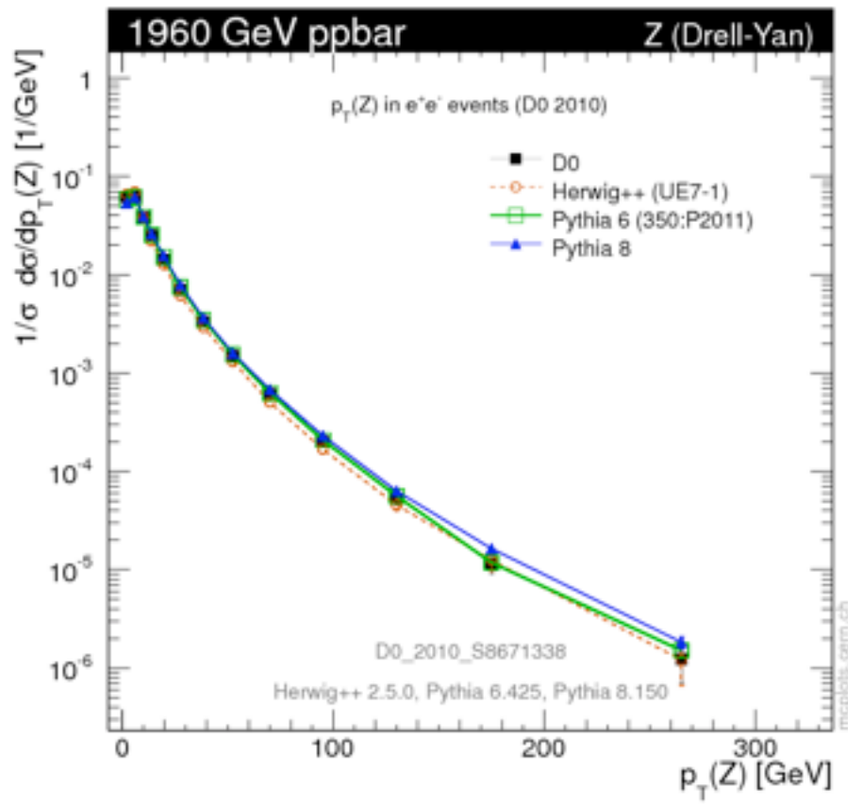
Strangeness & Comparisons to Other Generators

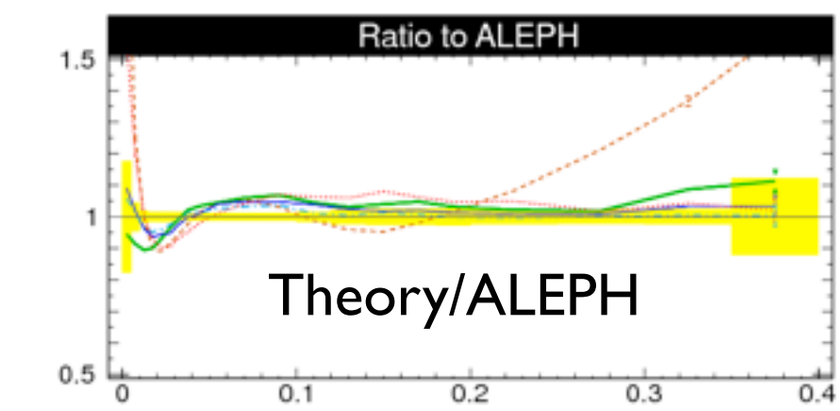
FSR and ISR

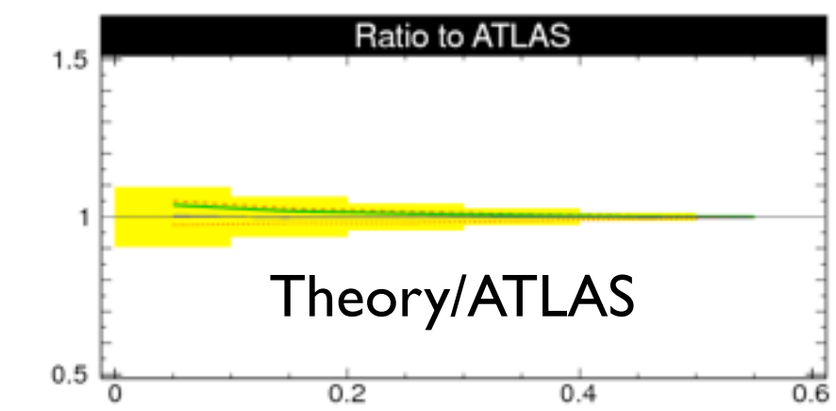
Known feature: Herwig++ has too much hard FSR

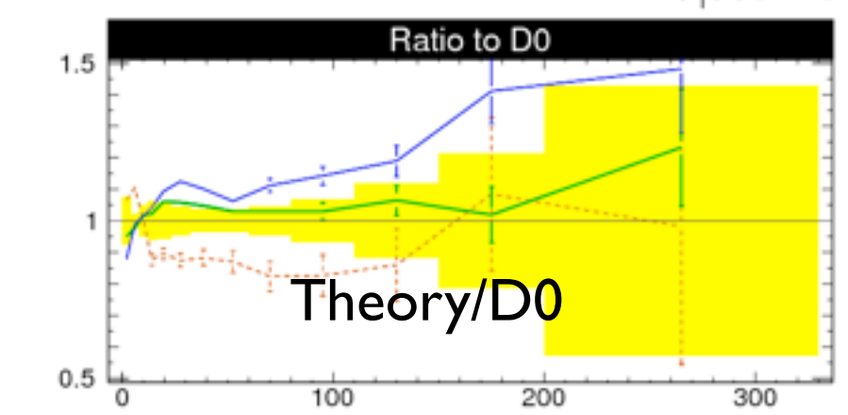






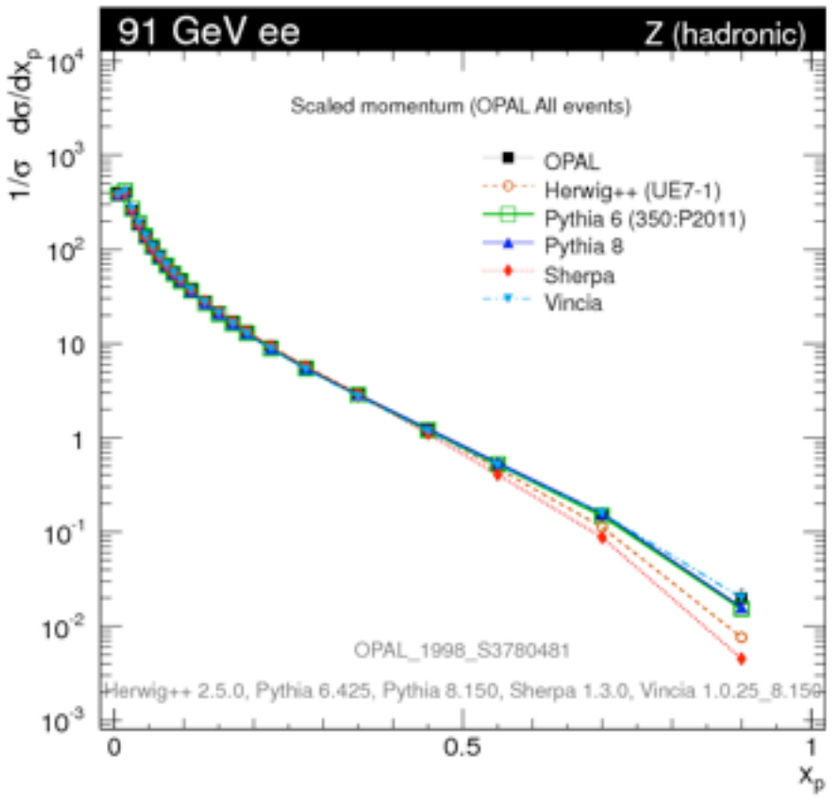


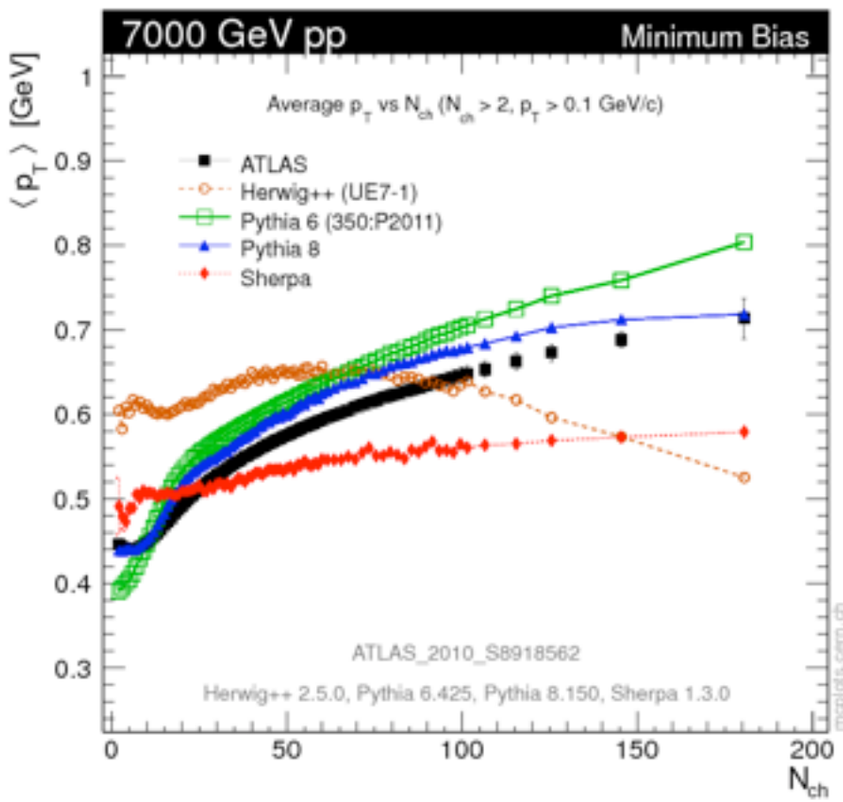


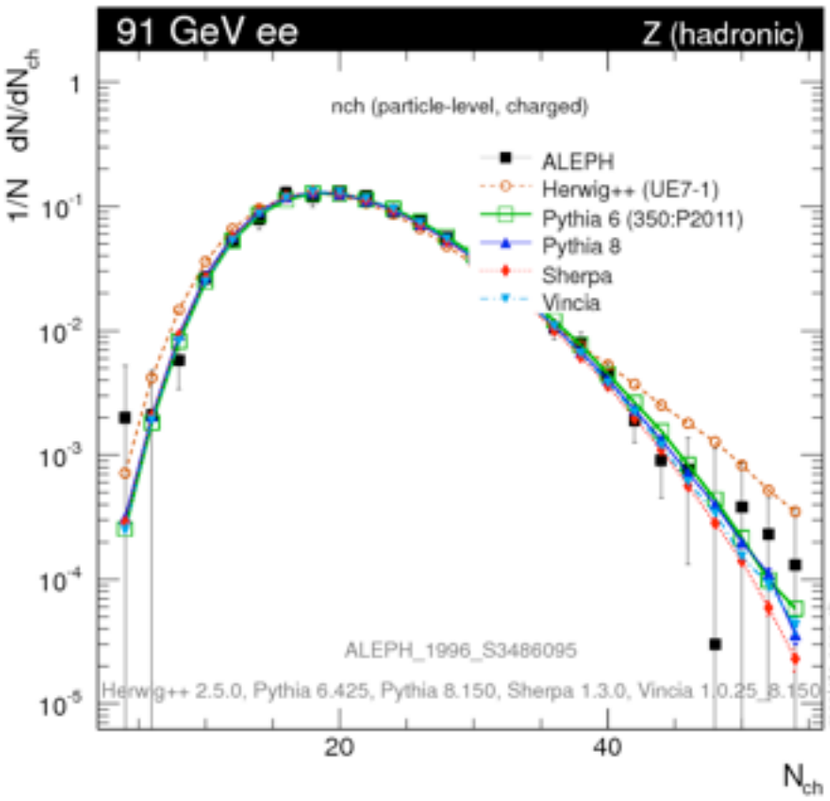


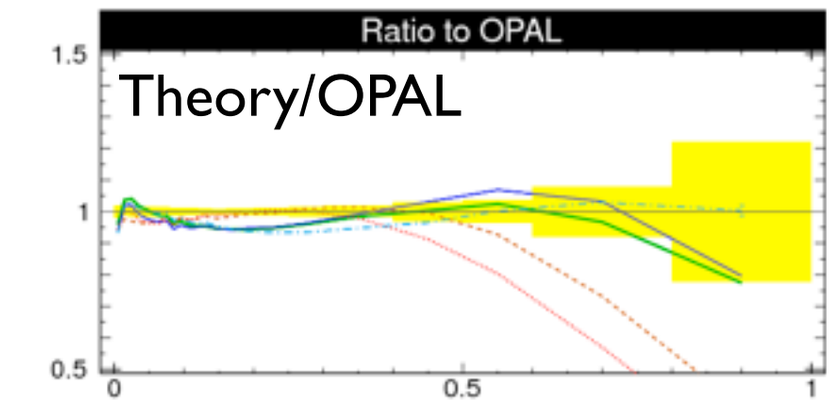
Fragmentation

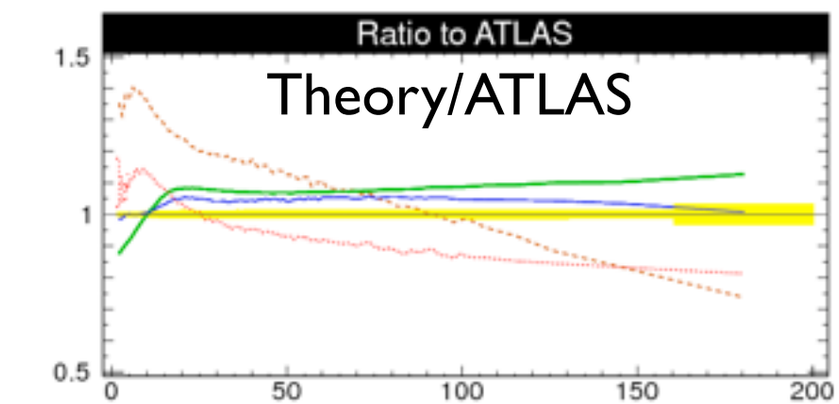
Herwig++ & Sherpa: slightly soft fragmentation

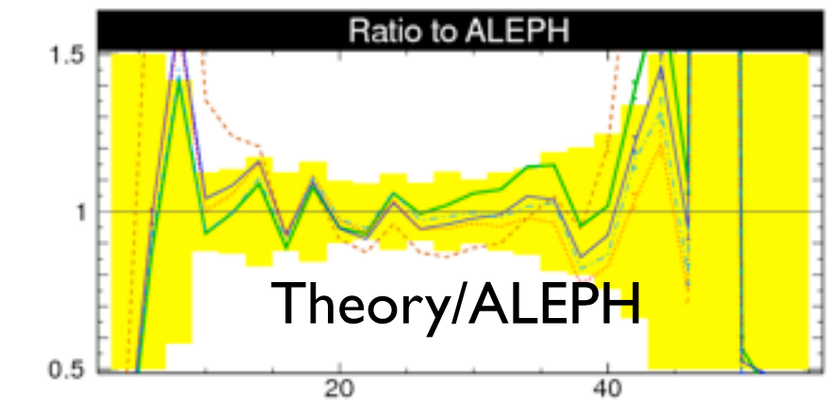






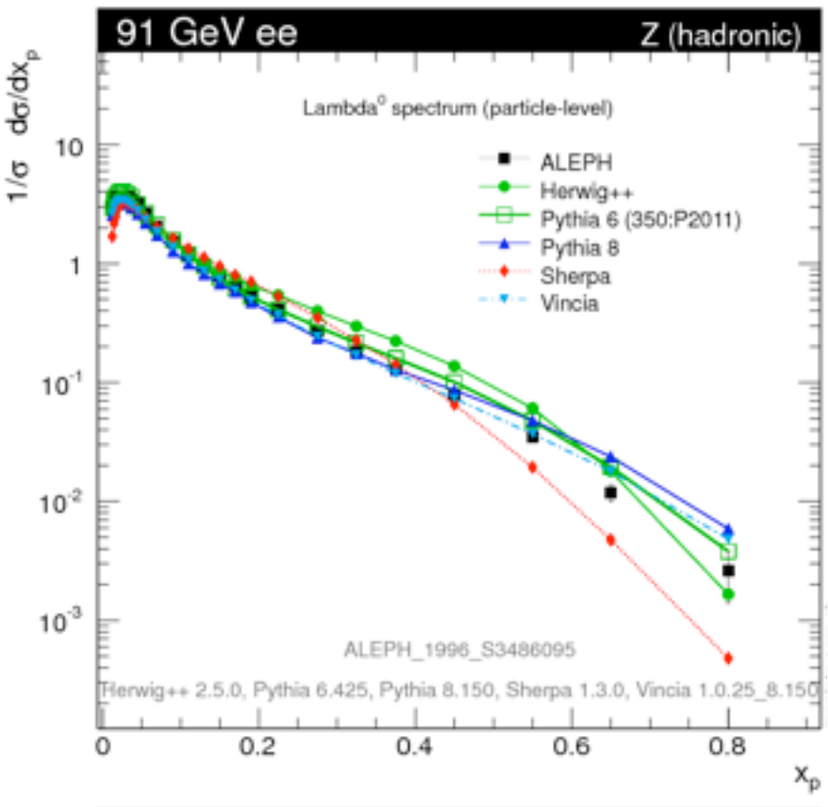


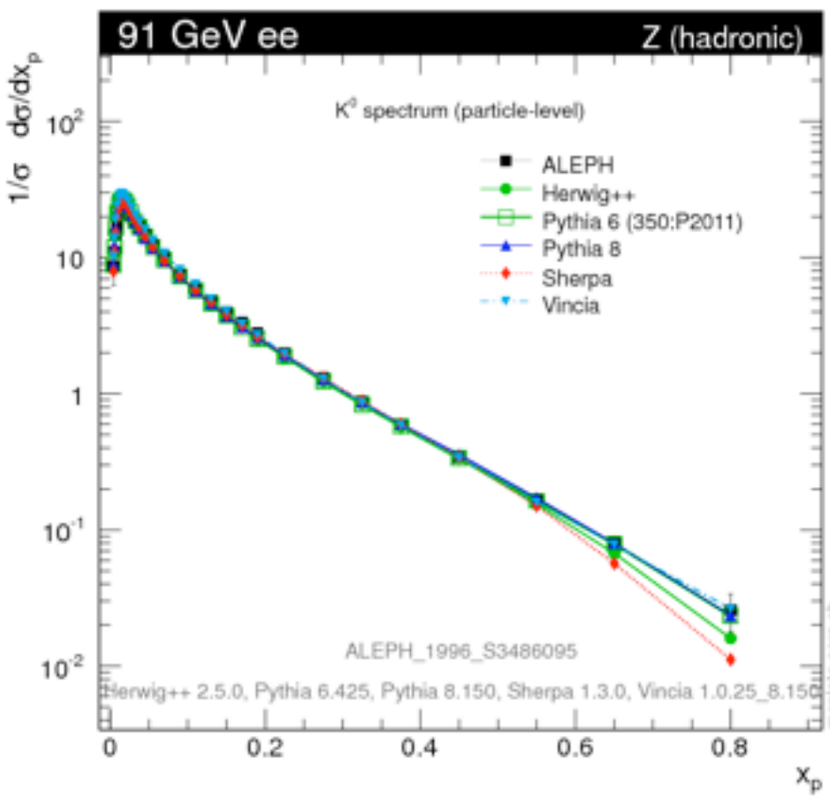


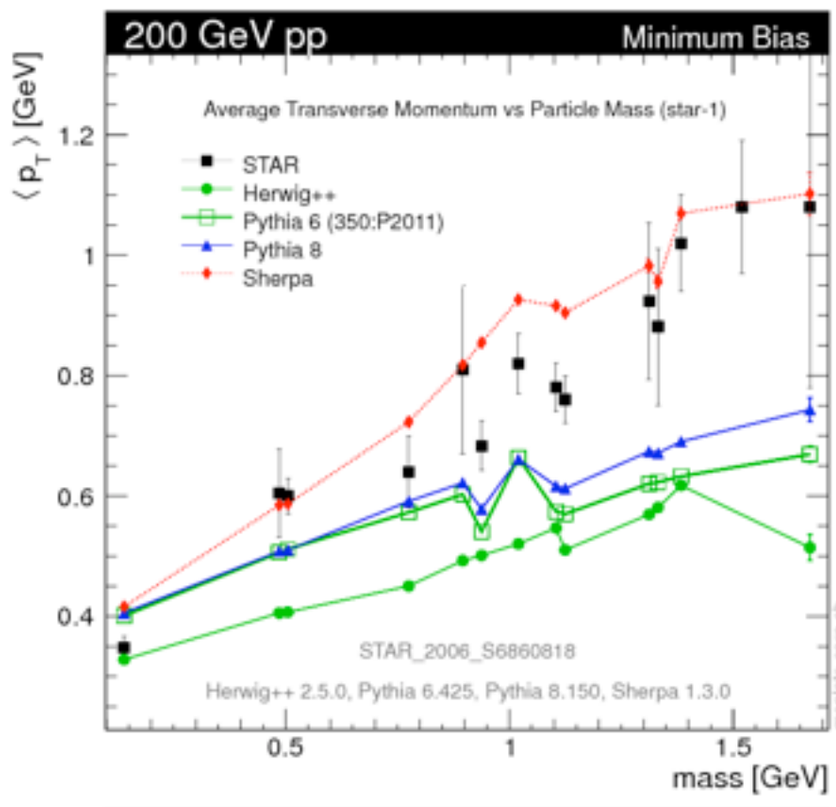


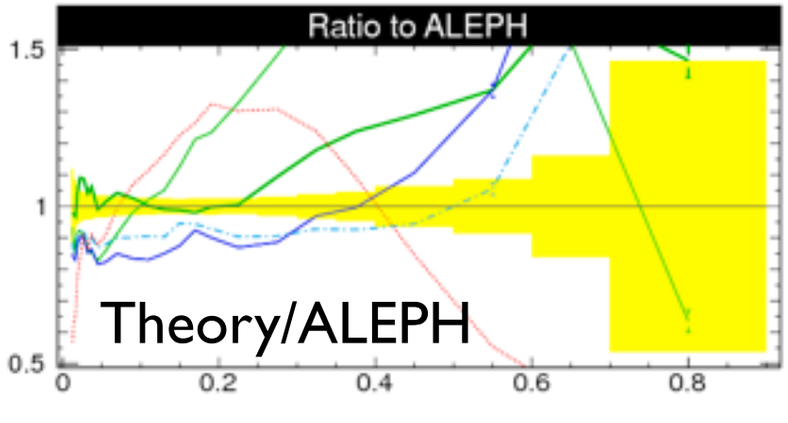
Strangeness

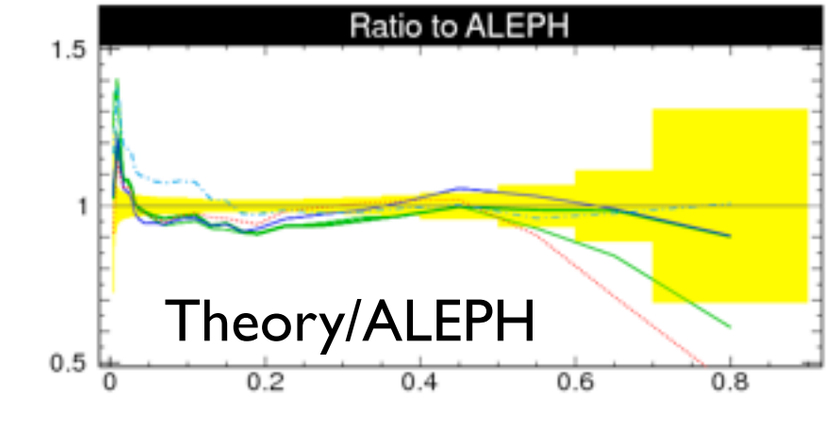
Baryon spectra difficult in all models

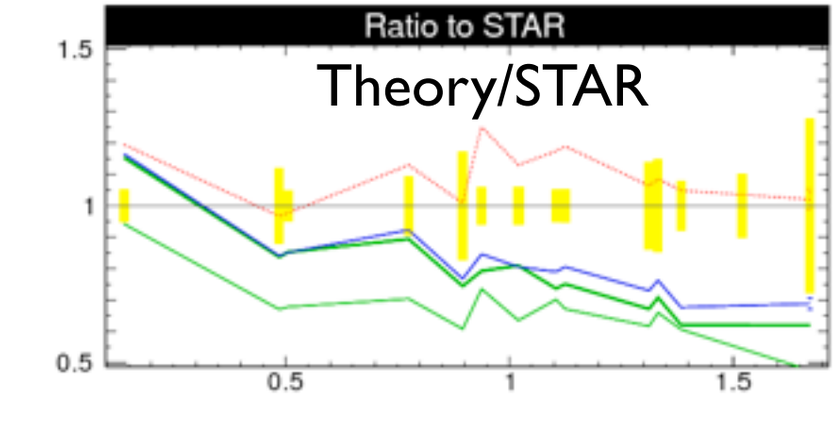












UE

Awaiting new Herwig++ tunes