Tuning Status

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Overview

Intro	–	for the new people in the room
Updates	–	what's happened recently
Plans	–	where we are going

Physics Validation and Global Comparisons

Systematic global validation is essential when testing models or developing general-purpose tunings.

Rivet is a validation/comparison framework for generators, based on the HepMC event record. It is used to

- ensure that generators describe a wide range of data
- regression-test generators between releases
- provide input for tunings

Used by us and being introduced in ATLAS, maybe CMS . . . .

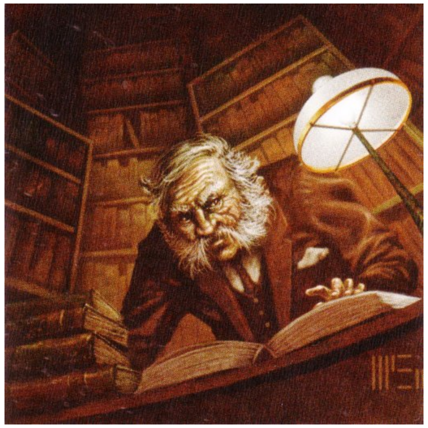
Rivet

Rivet is a library of tools (event shape calculators, jet algorithms, final state definitions, . . .) and so far about 40 analysis routines which use them.

- Command line tools for running generators, analysing events, making comparison plots
- Histograms can be auto-booked from reference data files
- Observables are automatically cached
- User analyses loaded as plugins
- Reference data is included in the Rivet release

Documentation, download etc:
http://projects.hepforge.org/rivet/

Professor



Professor is a tuning tool developed within MCnet.
It extends the tuning strategy used by Delphi.

- Sample N random points in parameter space and run the generator with those settings
- For each bin of each distribution use the N MC runs to fit an interpolation function in order to parametrise the MC output
- Construct overall χ^2 comparing this parametrisation with data and minimise
- Use different combinations of observables, weights etc. to get a feeling for stability, systematics . . .

http://projects.hepforge.org/professor/

Some Results – Pythia 6

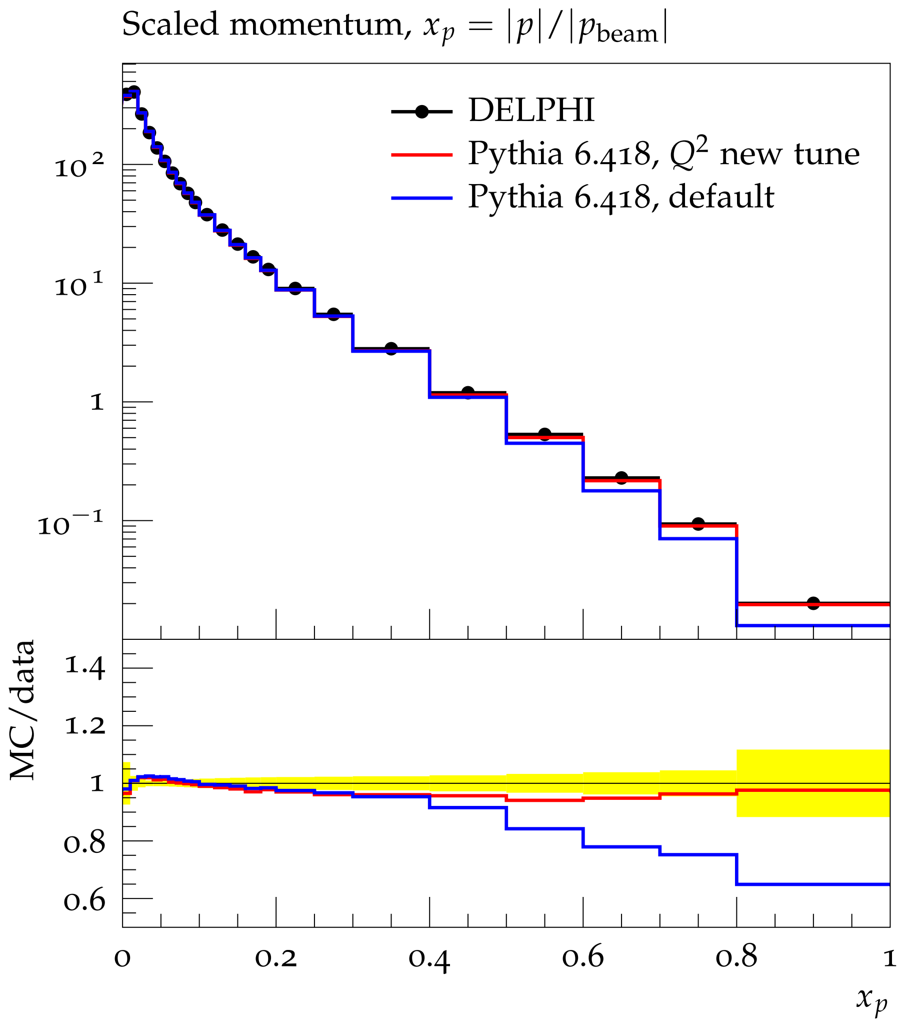
First production tune, shown in Perugia: Pythia 6

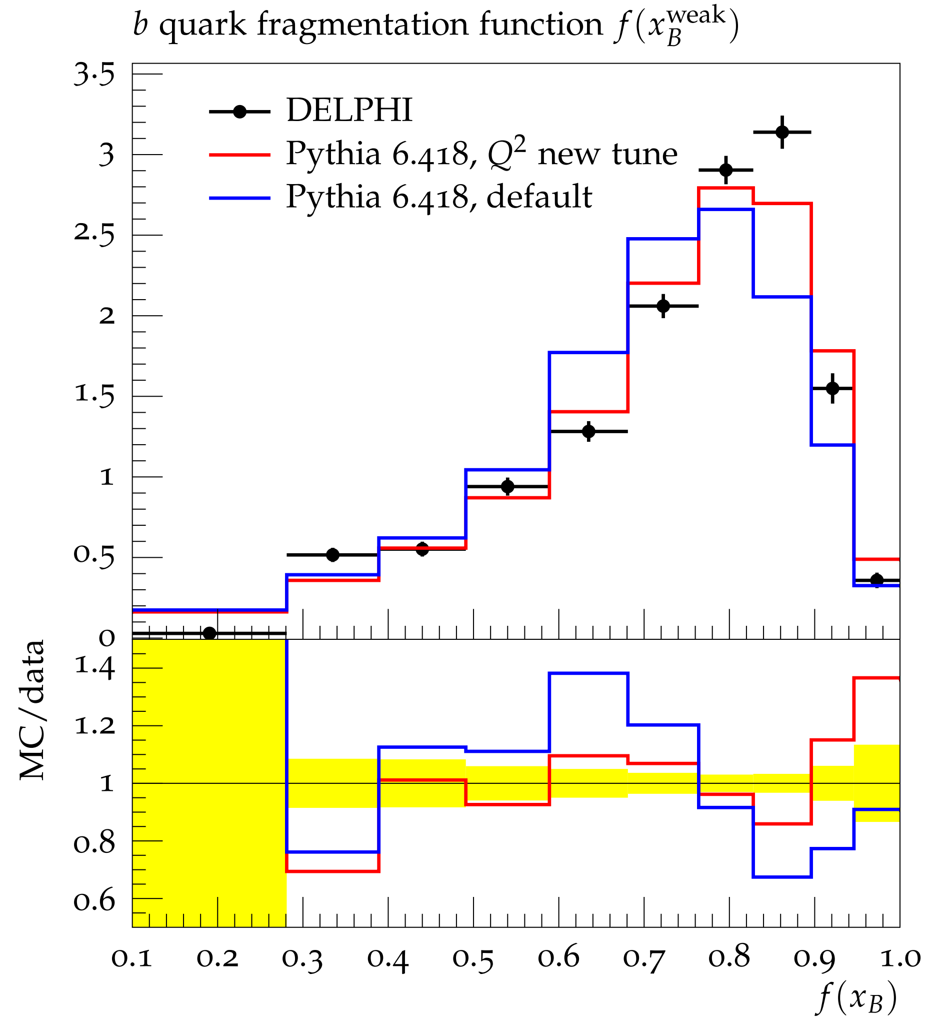
- Flavour parameters tuned to LEP/SLD identified particle multiplicity ratios (normalized to $\pi^{\pm}$).
- Fragmentation, hadronization (Q^2 and p_T ordered showers) tuned to LEP event shapes, b-frag., multiplicities, momentum spectra
- UE/MPI (only with Q^2 shower and old MPI model yet) tuned to Tevatron data: minbias, Drell-Yan, jet correlations, ...

We see many improvements. Even just the LEP tuning improved the agreement with Tevatron data!

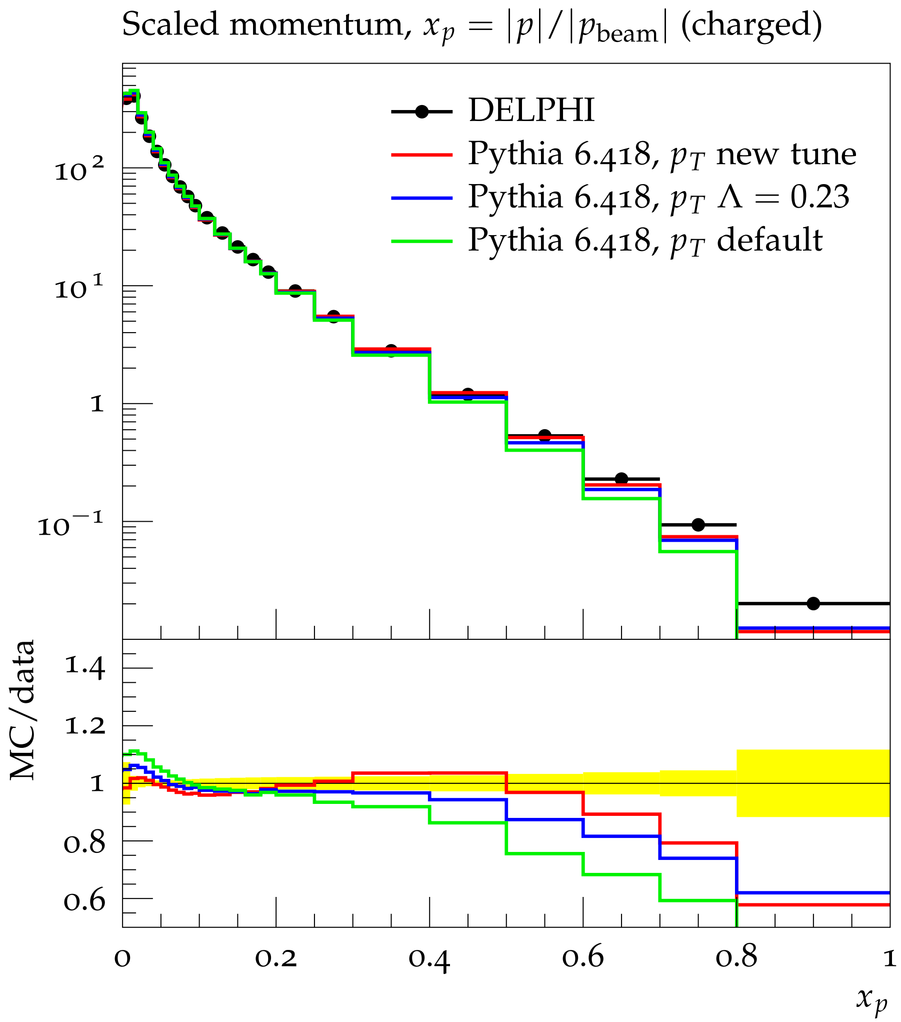
Paper is mostly finished.

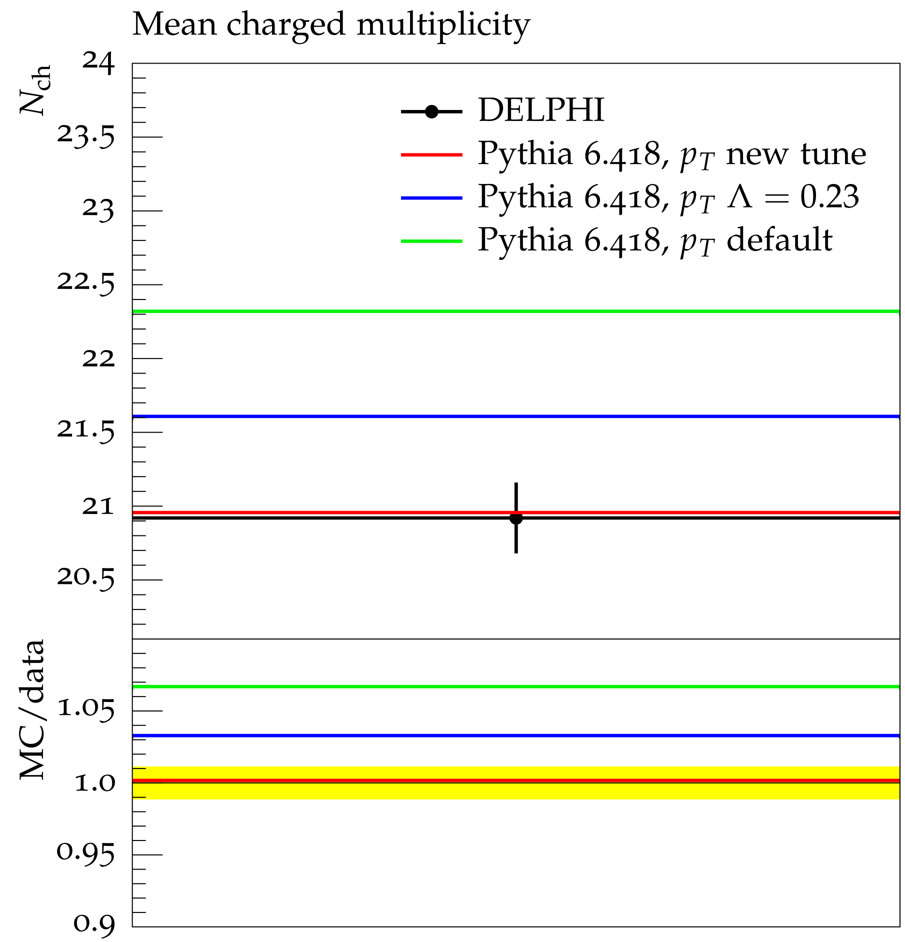
Pythia 6, Q^2 Ordered Shower, LEP



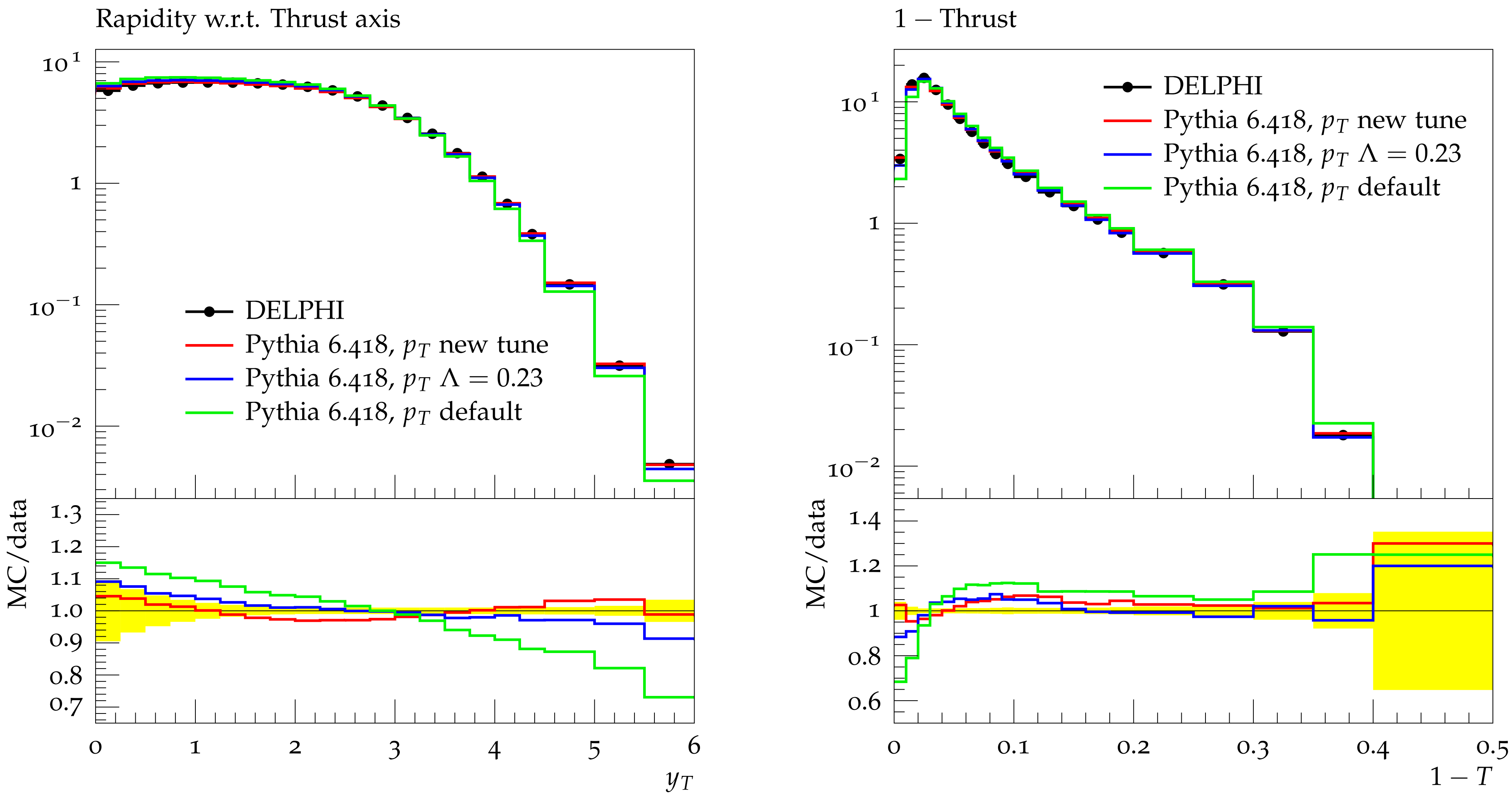


Pythia 6, p_T Ordered Shower, LEP

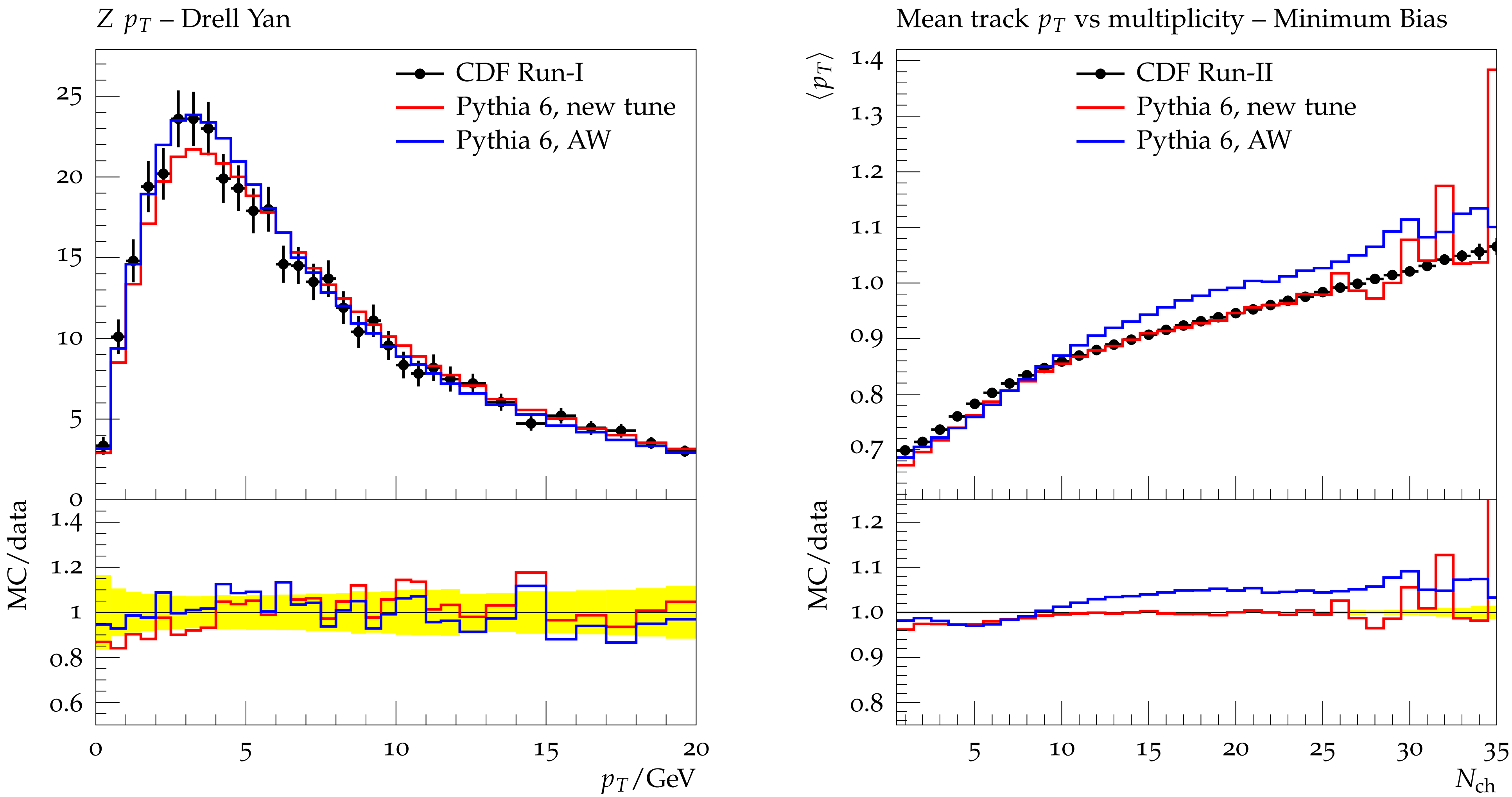




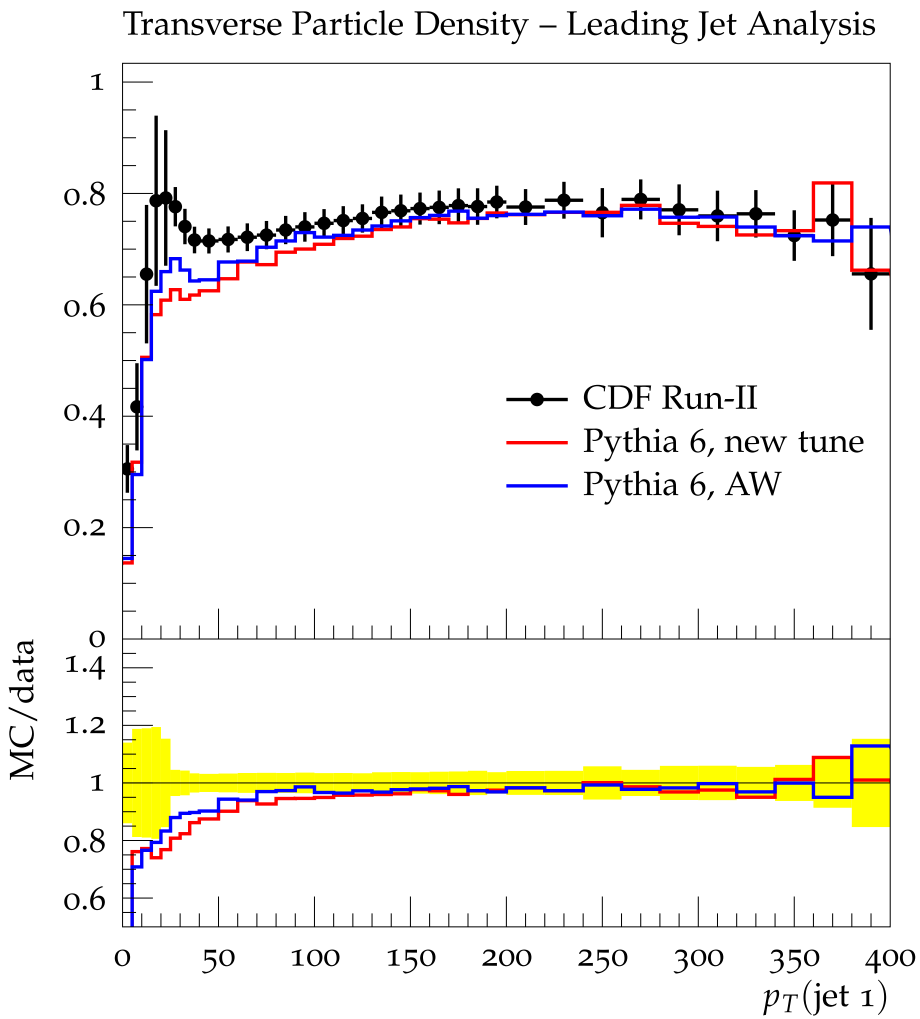
Pythia 6, p_T Ordered Shower, LEP

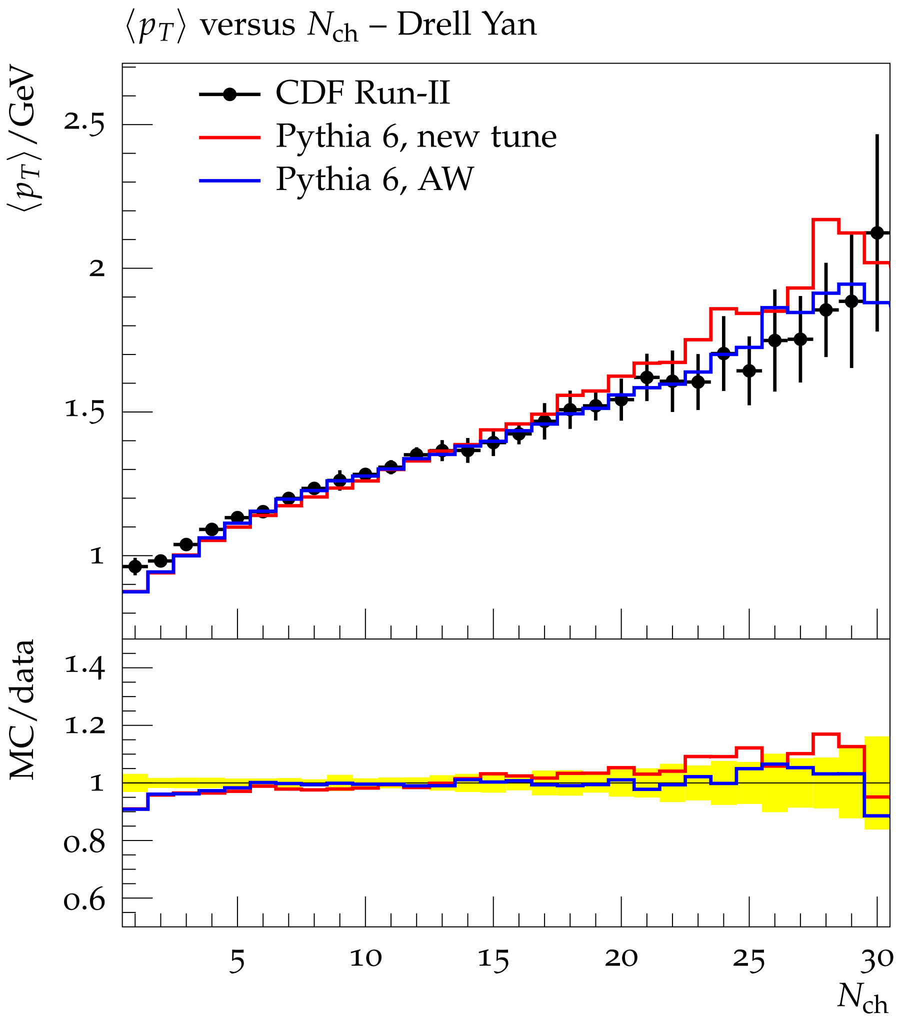


Pythia 6, Q^2 Ordered Shower, Tevatron



Pythia 6, Q^2 Ordered Shower, Tevatron





Hot of the Presses – Pythia 6

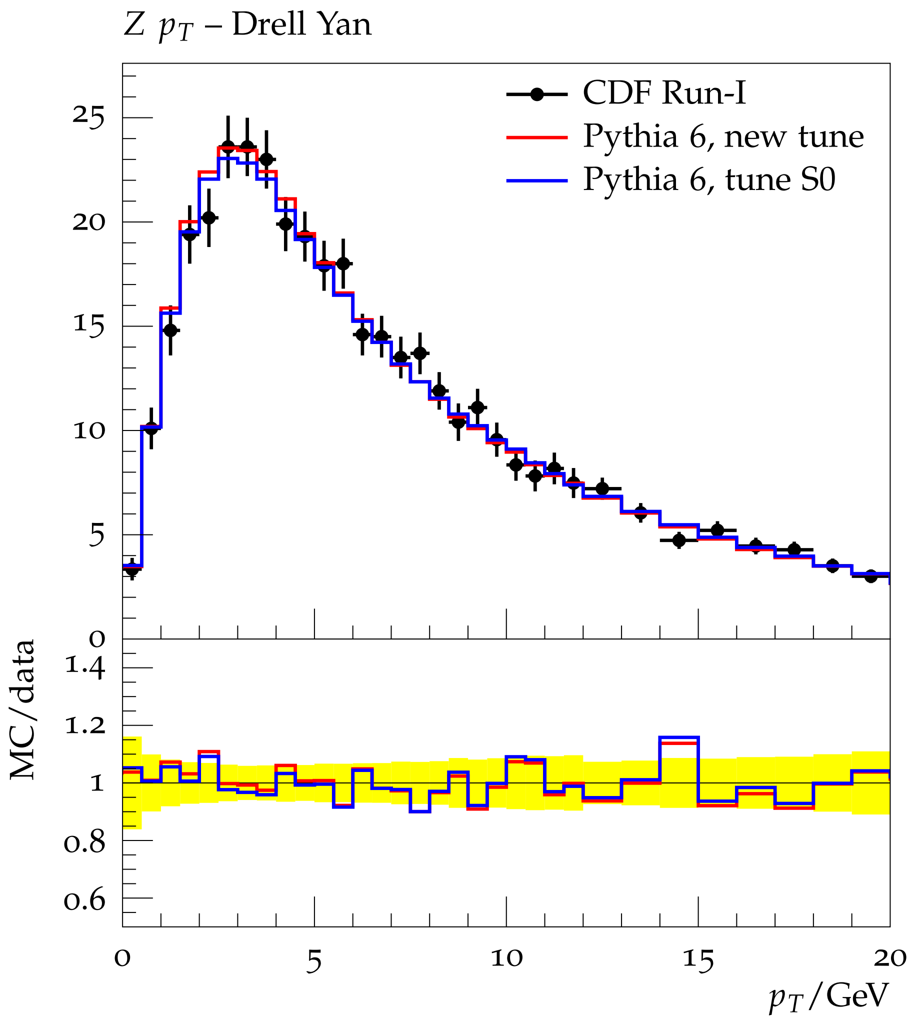
Tuning of the Pythia 6 p_T ordered shower and new MPI model to Tevatron data.

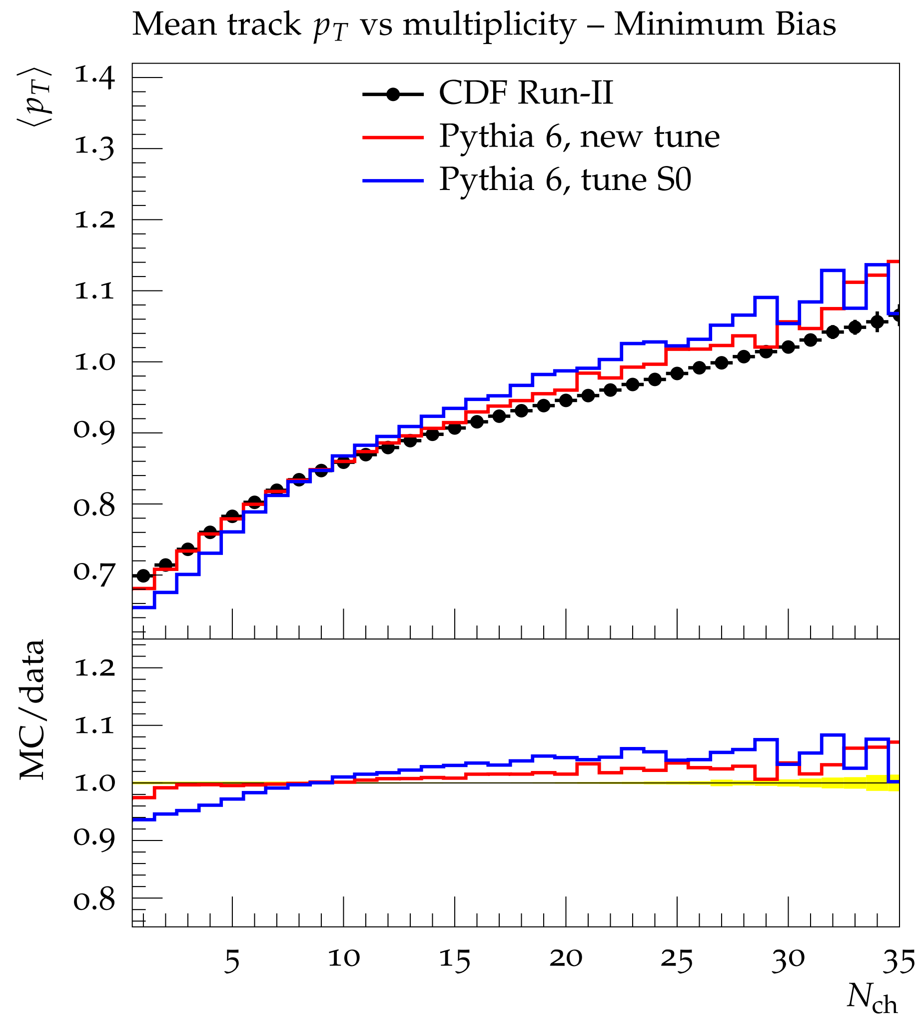
Will be finalized next week (Professor collaboration meeting in Lund).

More data available for this tune than for the Q^2 ordered tune – the Rivet development is always ongoing and largely driven by the tuning necessities.

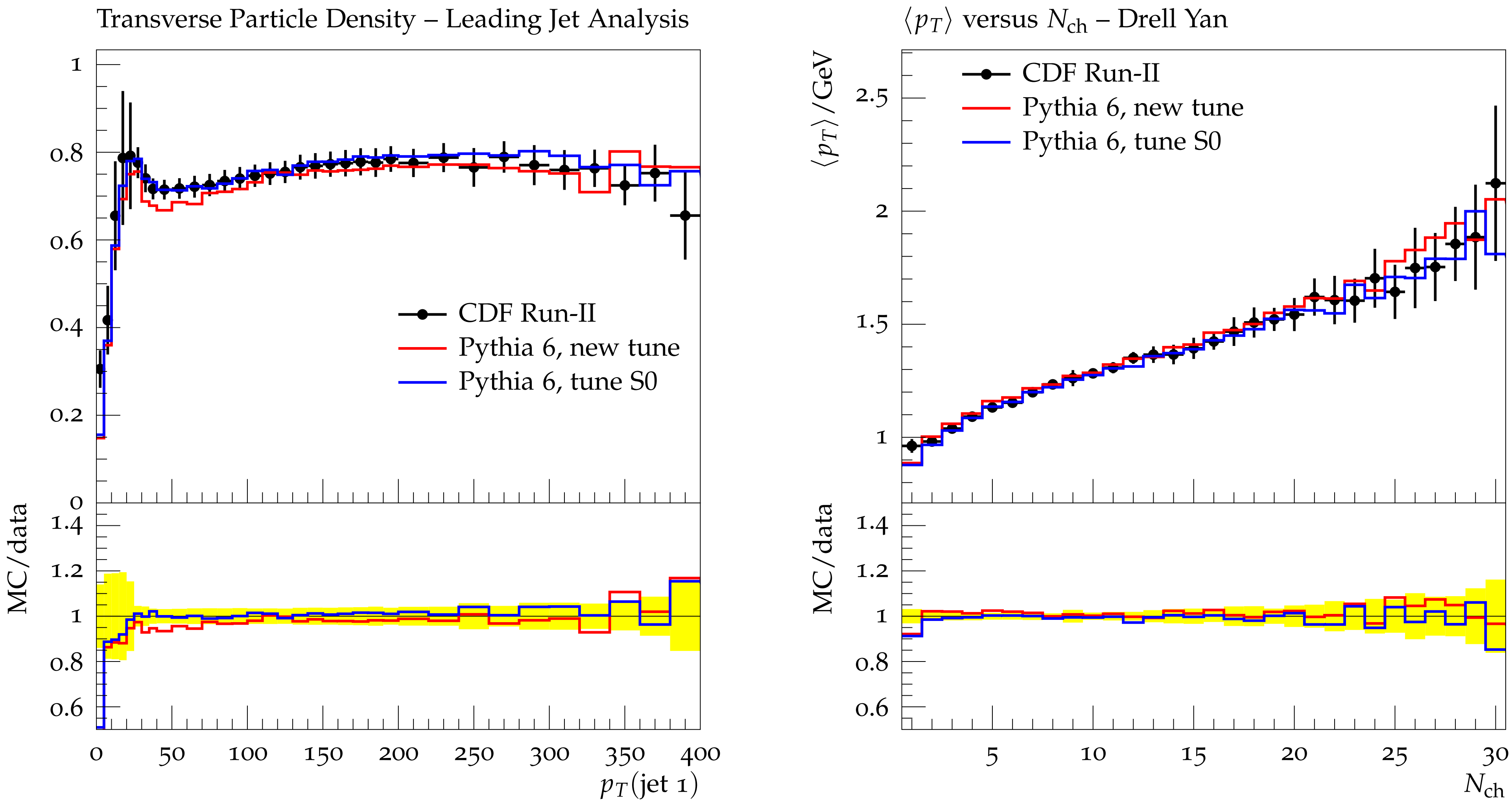
Here's a first peek on the results . . .

Pythia 6, p_T Ordered Shower, Tevatron

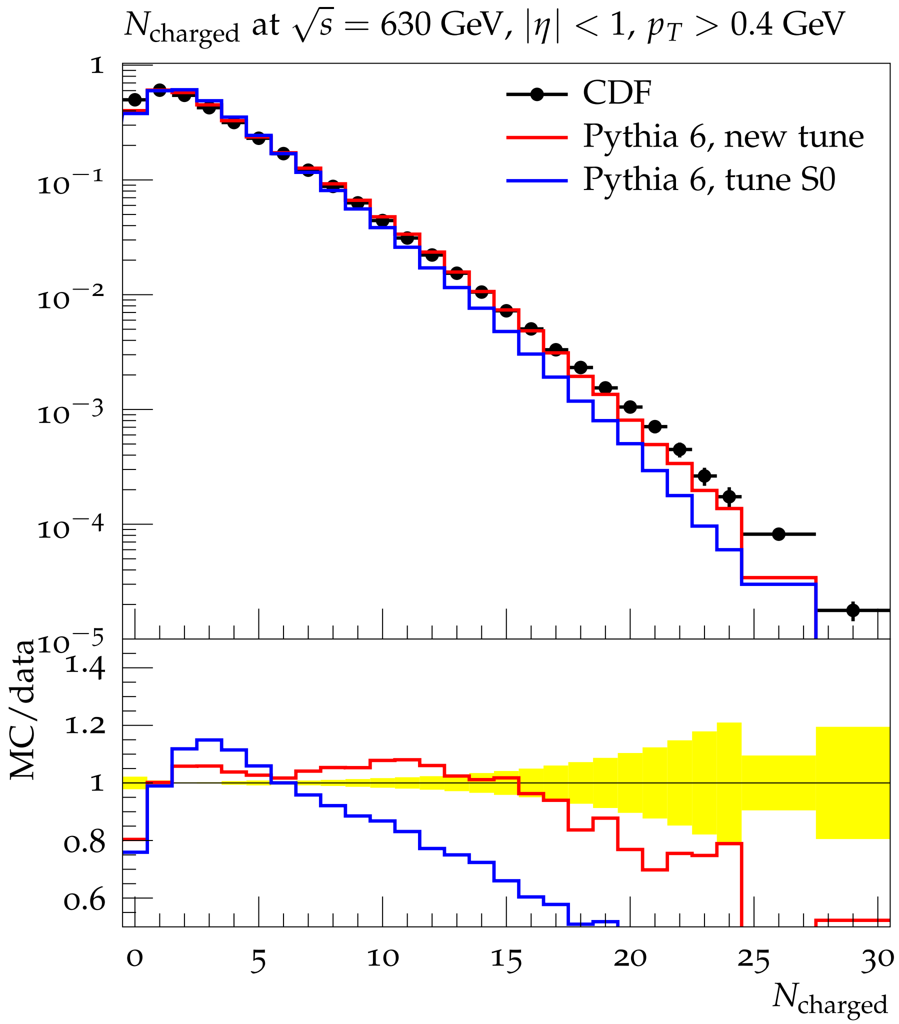


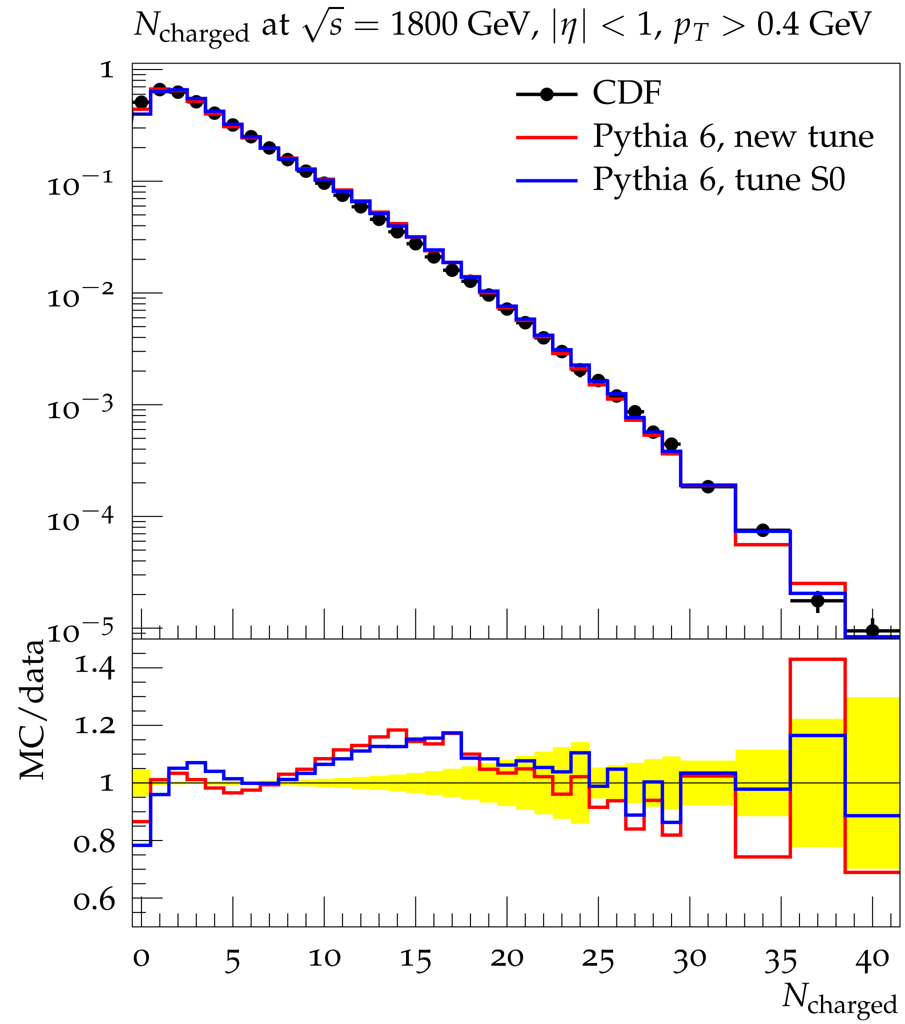


Pythia 6, p_T Ordered Shower, Tevatron



Pythia 6, p_T Ordered Shower, Tevatron





Summary and Outlook

- Pythia 6 successfully tuned (well, next week)
- Publications in progress
- Machinery works mostly smooth now
- Lots of additions/improvements in Rivet
- Coarse tune of what-will-be Sherpa-2.2 initiated
- Pythia 8 and Herwig in the queue

Backup Slides

Our tuning strategy

1. Choose a tuning interval for the parameters, then pick random points in parameter space and run the generator with these settings.

2. Interpolate between points $\Rightarrow$ prediction of the MC output at any specific parameter setting.

3. Fit this prediction to data (minimal χ^2).

4. Repeat the fit for different combinations of observables.

5. Choose the nicest set of parameters.

(already described and used in Z. Phys., C 73 (1996) 11–59)

1. Choosing parameters

Pick the parameters you want to tune:

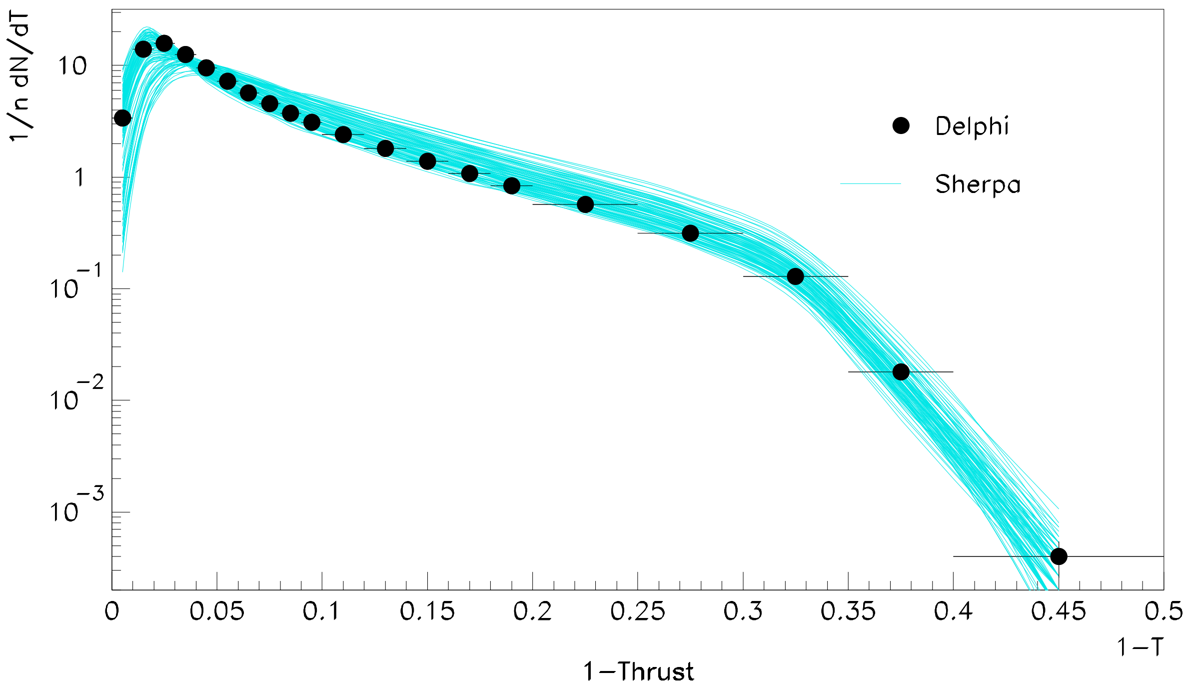
- Tune everything that is important.
- But remember: Each additional parameter adds one dimension to the parameter space.

Define parameter intervals:

- Make the interval large enough so that the result will not be outside.
- But remember: Cutting down 10 intervals by 10 % shrinks the volume of the parameter space by 2/3.

Now pick random points in parameter space and run the generator for each setting.

Calculating observables yields plots like this:



Every line corresponds to a certain parameter setting.

2. Predict the Monte Carlo

Get a bin by bin prediction for the MC response as function of the parameter set $\vec{p} = (p_1, p_2, \ldots, p_n)$.

Interpolate between the parameter points using a order polynomial:

$$MC^{(b)}(\vec{p}) \approx f^{(b)}(\vec{p}) = \alpha_0^{(b)} + \sum_i \beta_i^{(b)} p_i + \sum_{i \leq j} \gamma_{ij}^{(b)} p_i p_j$$

This takes the correlations between the parameters into account.

3. Fit the prediction to data

Using the interpolation we can predict the MC output for any set of parameters very fast. This prediction can be fitted to data, minimising the χ^2:

$$\chi^2(\vec{p}) = \sum_{\text{observables}} \sum_{\text{bins}} \frac{(X_{\text{data}} - X_{\text{MC}}(\vec{p}))^2}{\sigma_{\text{data}}^2 + \sigma_{\text{MC}}^2}$$

Include all the relevant data distributions in the fit!

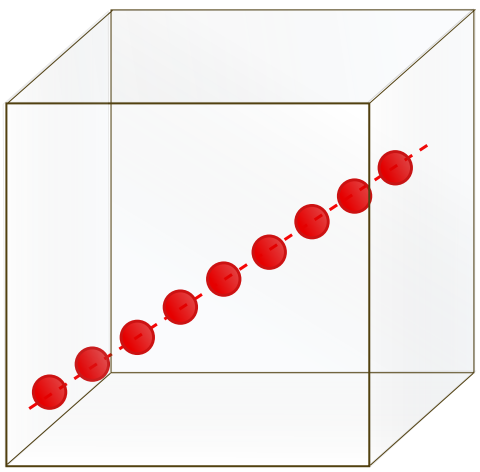
This fit only takes seconds (as compared to days or weeks for a brute force approach).

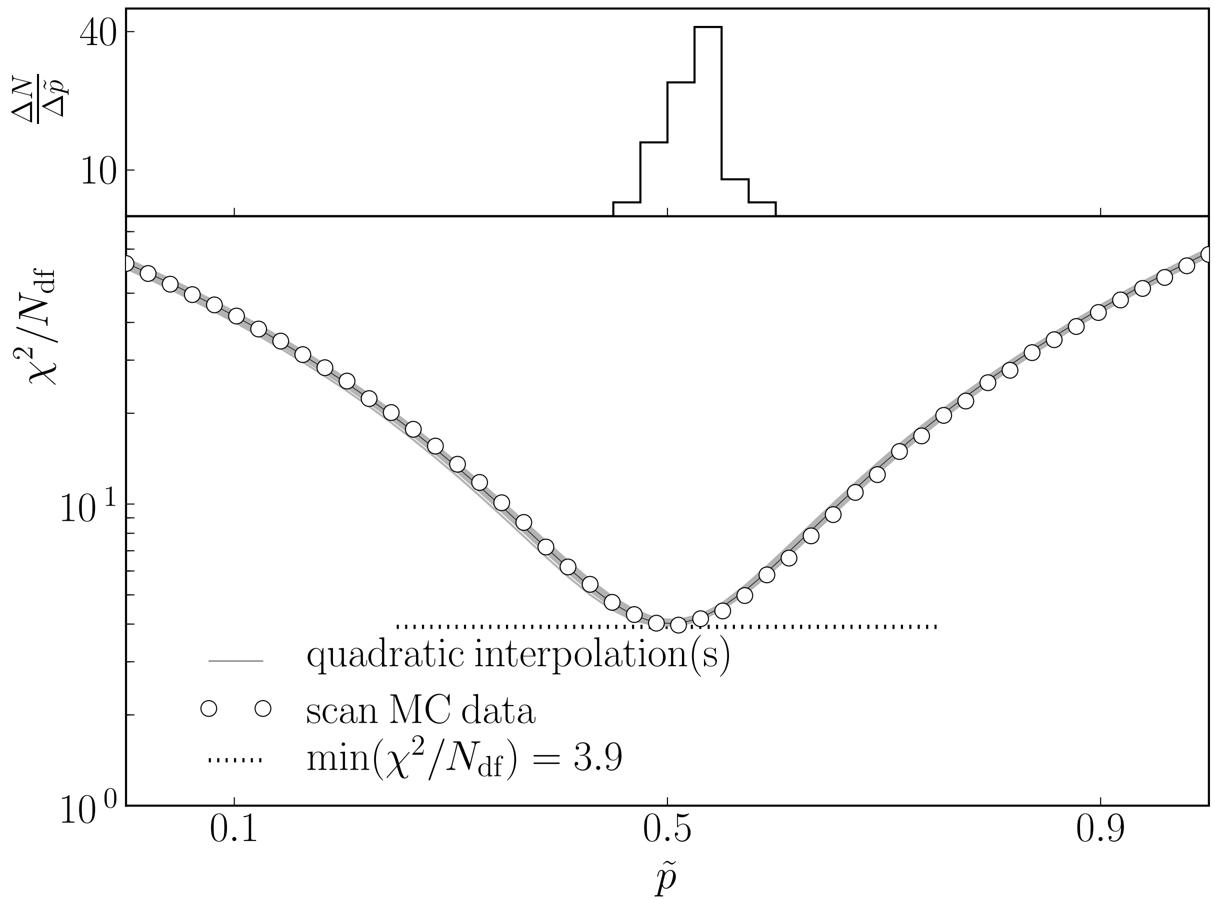
4. + 5. Use different data sets, pick nicest tune

Now we approach the artistic part:

- Use different combinations of observables.
- Put different weights on the observables.
- Learn something about correlations and stability of the tuning.
- Interpret the results in the model's context.
- Maybe adjust / fix parameters by hand.
- Pick the nicest result.

Verifying the Interpolation





Pythia 6 – New Tunings: LEP

Flavour parameters:

	default	tuned	
PARJ(1)	0.1	0.073	di-quark suppression
PARJ(2)	0.3	0.2	strange suppression
PARJ(3)	0.4	0.94	strange di-quark suppression
PARJ(4)	0.05	0.032	spin-1 di-quark suppression
PARJ(11)	0.5	0.31	spin-1 light meson
PARJ(12)	0.6	0.4	spin-1 strange meson
PARJ(13)	0.75	0.54	spin-1 heavy meson
PARJ(25)	1.0	0.63	η suppression
PARJ(26)	0.4	0.12	η' suppression

Pythia 6 – New Tunings: LEP

Fragmentation parameters:

	default	Q^2 shower	p_T shower	
MSTJ(11)	4	5	5	Lund-Bowler frag.
PARJ(21)	0.36	0.325	0.313	σ_q
PARJ(41)	0.3	0.5	0.49	a
PARJ(42)	0.58	0.6	1.2	b
PARJ(47)	1.0	0.67	1.0	r_b
PARJ(81)	0.29	0.29	0.257	Λ
PARJ(82)	1.0	1.65	0.8	PS cut-off

Pythia 6 – New Tuning: Tevatron

Tune uses LEP tuned parameters as shown before, Q^2 shower:

	default	tune DW	new tune	
PARP(62)	1.0	1.25	2.97	ISR cut-off
PARP(64)	1.0	0.2	0.12	ISR scale factor for α_s
PARP(67)	4.0	2.5	2.74	max. virtuality
PARP(82)	2.0	1.9	2.1	p_{T0}
PARP(83)	0.5	0.5	0.84	matter distribution
PARP(84)	0.4	0.4	0.5	matter distribution
PARP(85)	0.9	1.0	0.82	colour connection
PARP(86)	0.95	1.0	0.91	colour connection
PARP(90)	0.16	0.25	0.17	p_{T0} energy evolution
PARP(91)	2.0	2.1	2.0	intrinsic k_T
PARP(93)	5.0	15.0	5.0	intrinsic k_T cut-off