Towards a fragmentation model for Sherpa

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- The event generator Sherpa: scope and some applications
- A cluster fragmentation model for Sherpa
  - Cluster formation model
  - Cluster decay model
- Outlook

The Sherpa approach

Sherpa (Simulation of High Energy Reactions of PArticles) is a new multi-purpose event generator entirely written in C++

The scope:

- Full simulation of high energetic particle reactions at existing and future collider experiments, including e^+e^-, $\gamma\gamma$, $e\gamma$, $p\bar{p}$ and pp collisions
- Account for multi-jet production by using tree level multi-jet matrix elements combined with the parton shower à la CKKW

S. Catani,F. Krauss, R. Kuhn, B. Webber, JHEP 0111:063,2001

F. Krauss, JHEP 0208:015,2002

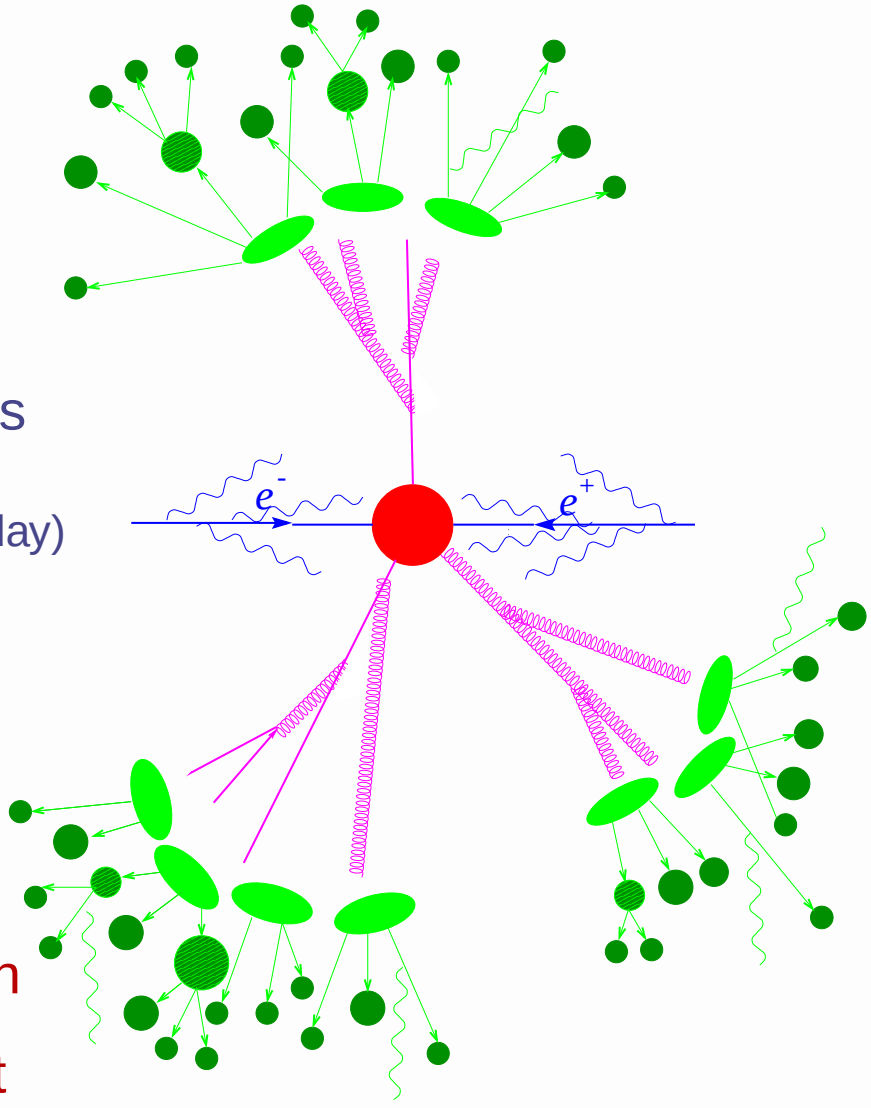
Features:

- Modular structure of independent physics modules
- Modules are interfaced through abstract handler classes
- Bottom-up approach (slim overhead that can be easily adapted)

The Sherpa approach for e^+e^- collisions

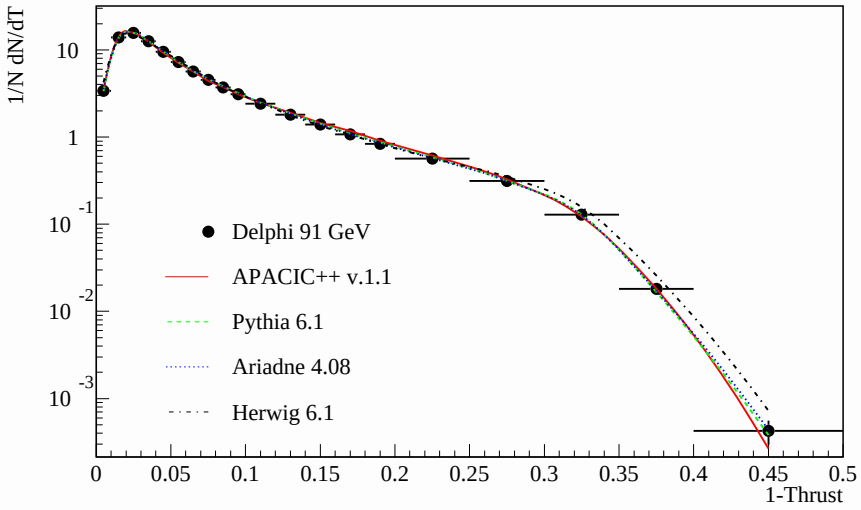
Split the simulation in parts:

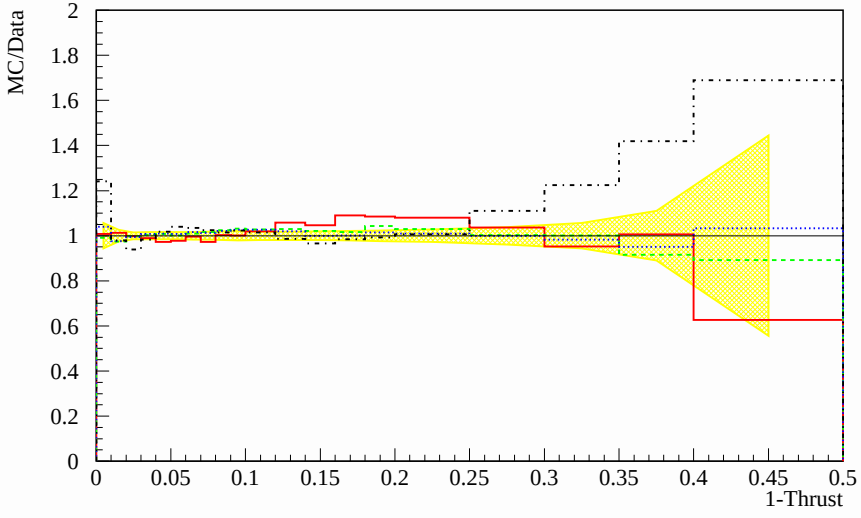
- Beam setup
  - Initial state radiation
  - Laser backscattering for $e\gamma$ and $\gamma\gamma$
- Hard Process and decays via multi-jet ME's
  - ➔ AMEGIC++ (see talk by S.Jadach on Thursday)
- Parton Shower
  - ➔ APACIC++
- Hadronization
  - ➔ interface to Pythia string fragmentation
  - ➔ own cluster model under development (not included in the official release yet)



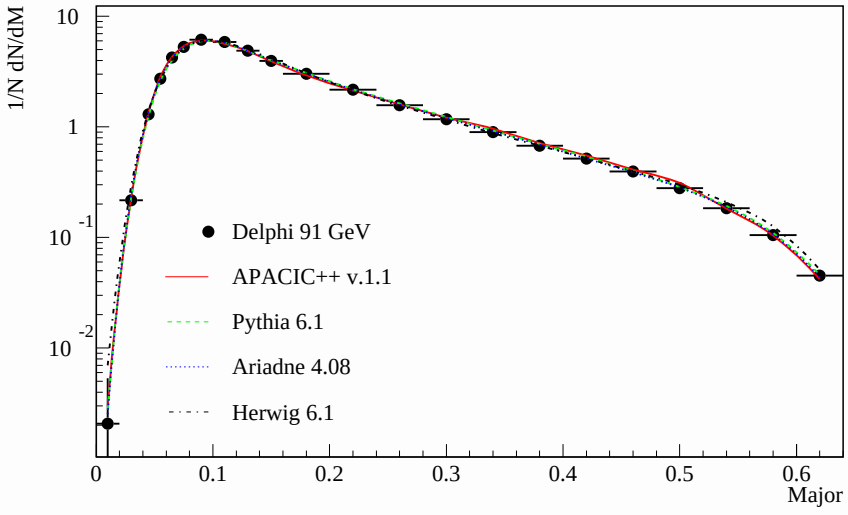
Sherpa: Event shapes

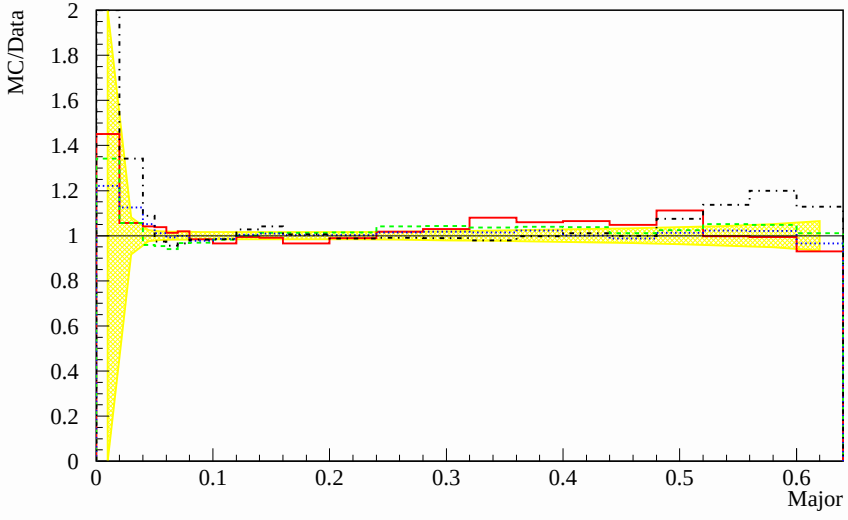
1 - Thrust





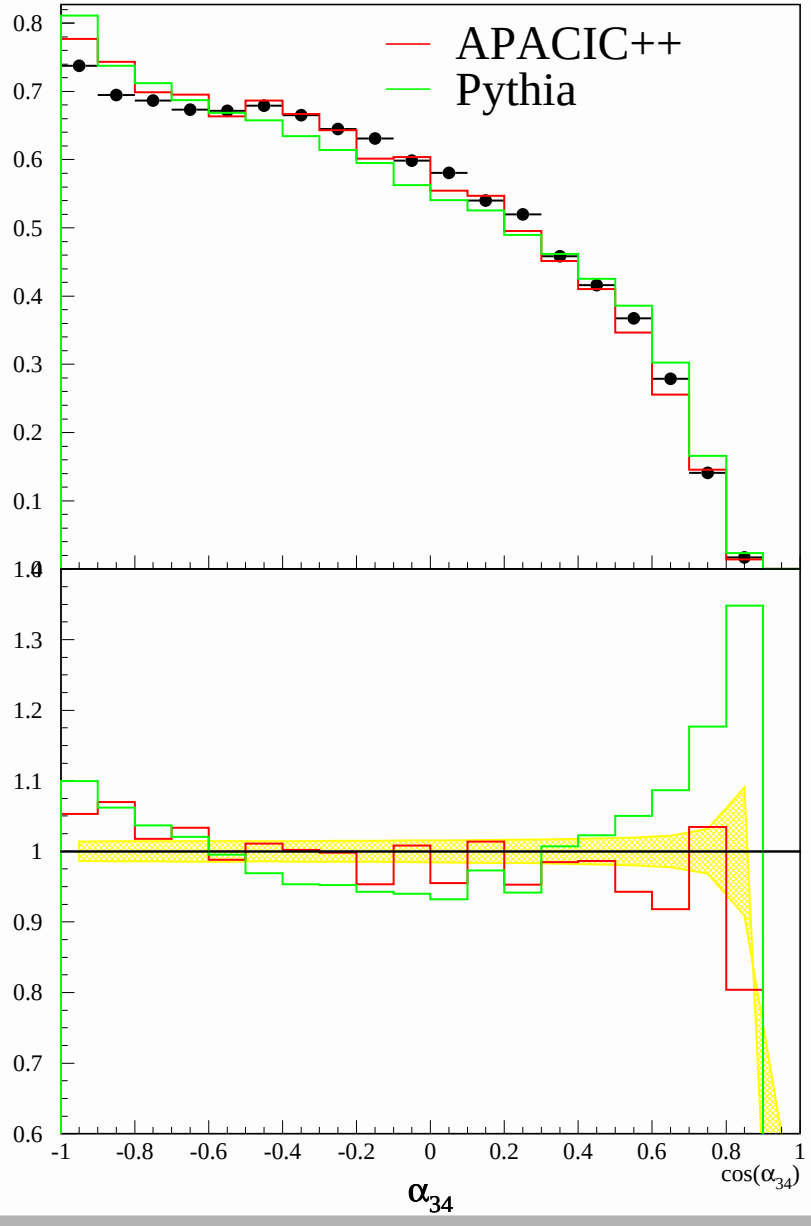
Major



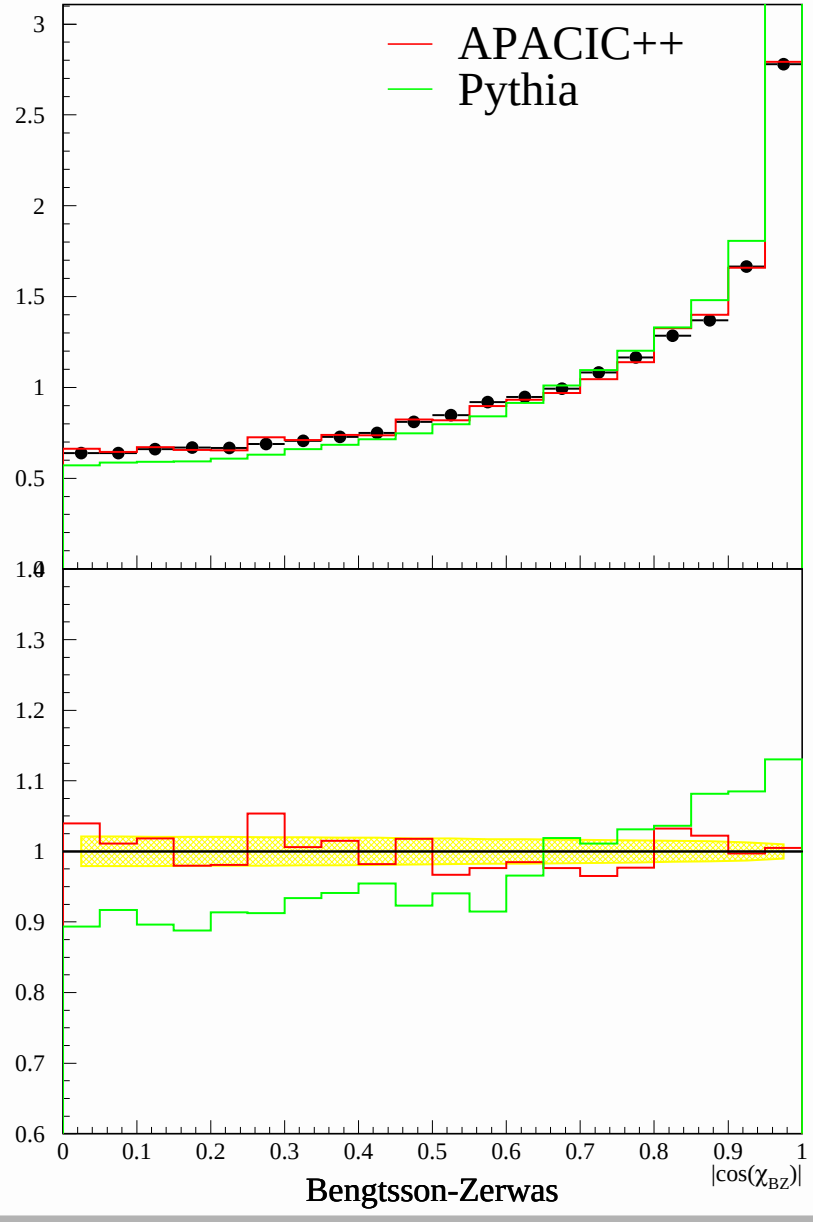


Sherpa: Four jet angles

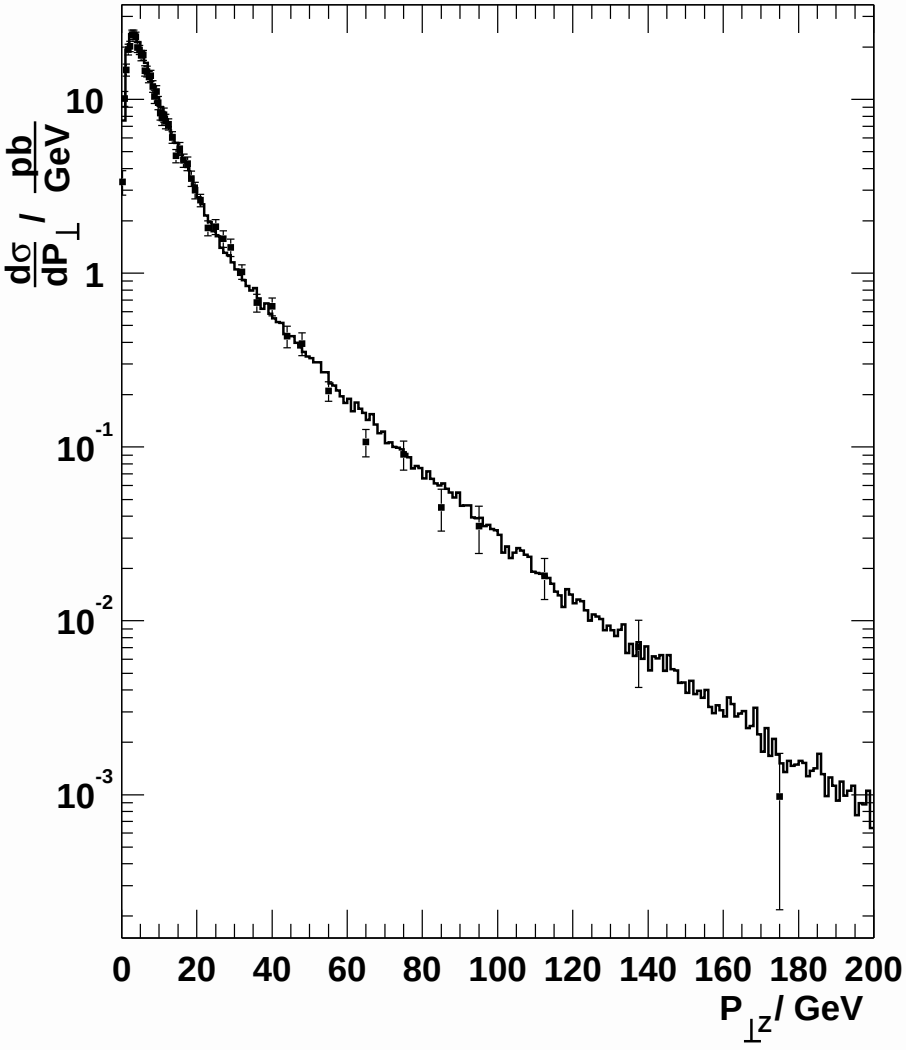
α_{34}

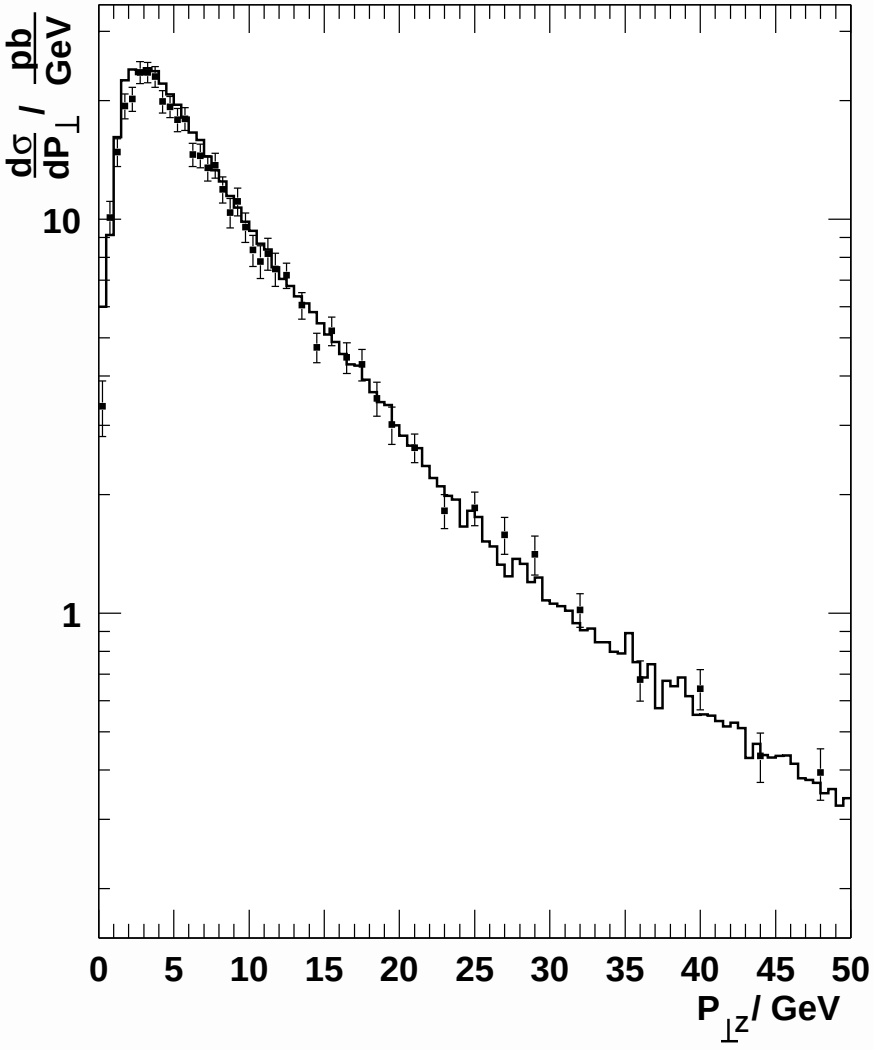


Bengtsson-Zerwas



Sherpa: inclusive Z production at Tevatron

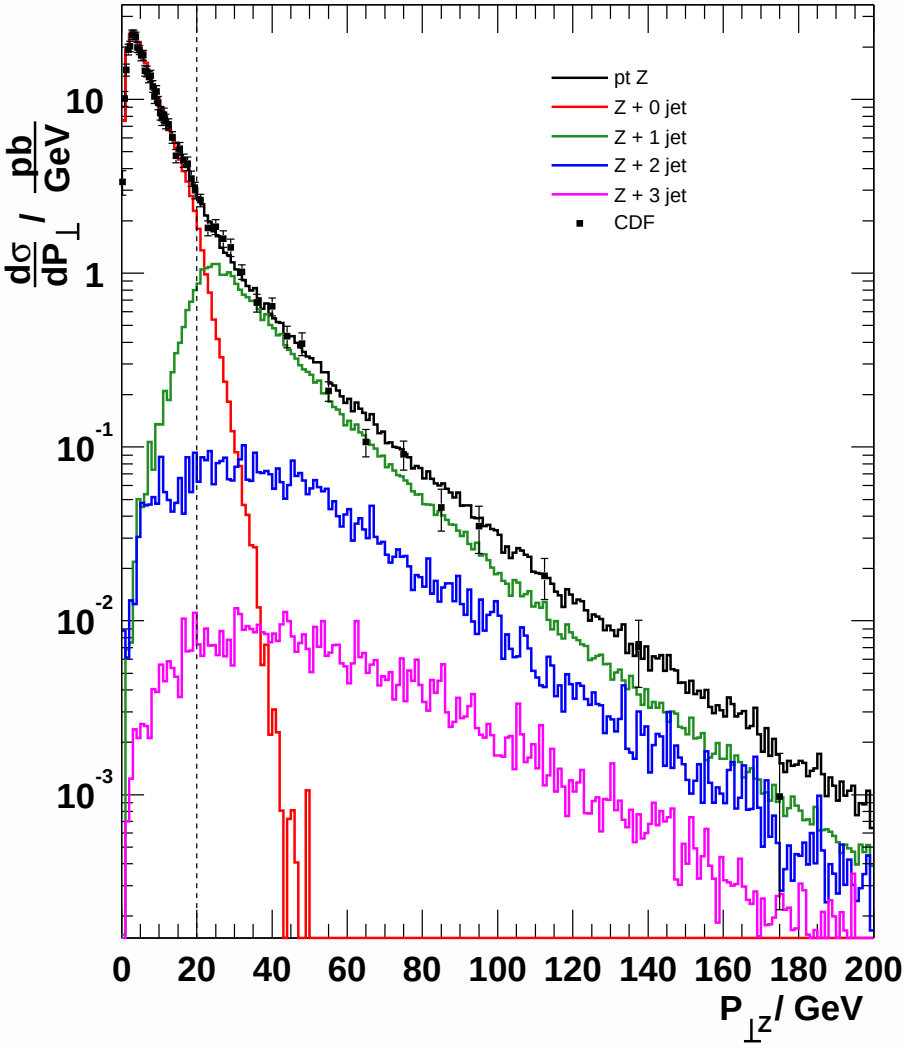


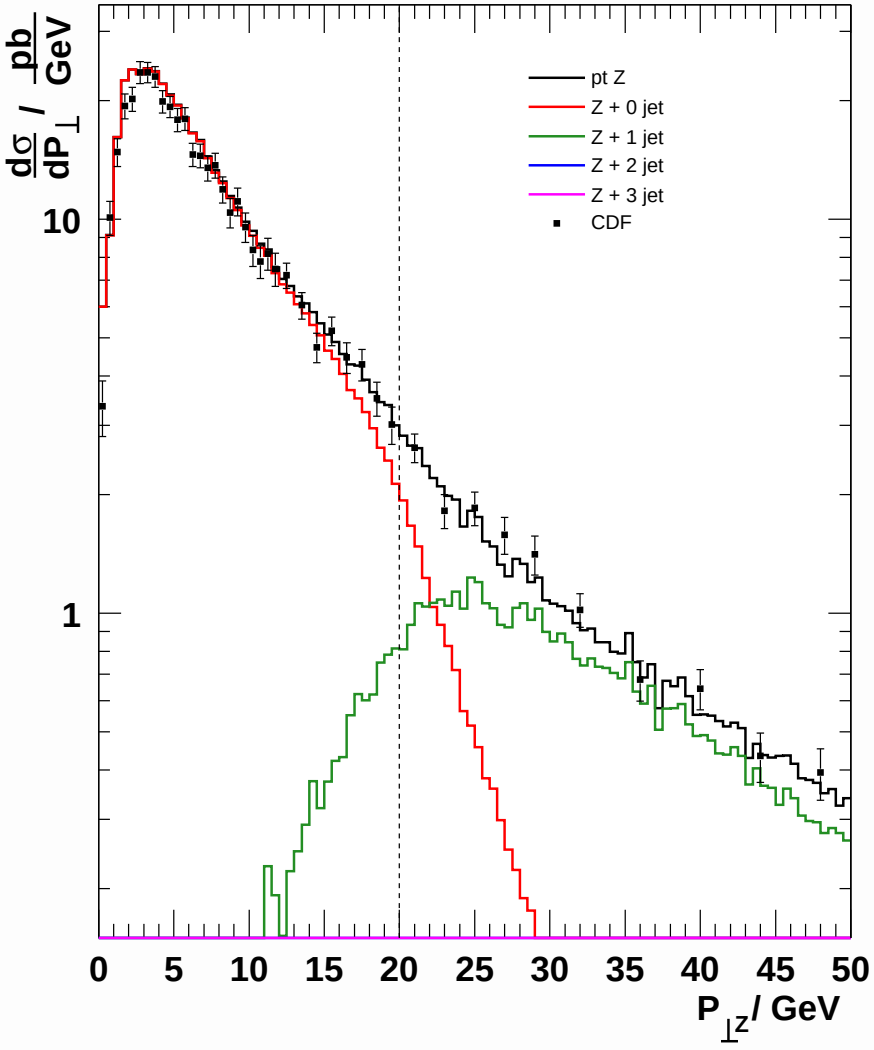


CDF Data : $P\bar{P} \to Z + X$ at $\sqrt{s} = 1.8\mathrm{TeV}$

Phys.Rev.Lett.84:845-850,2000

Sherpa: inclusive Z production at Tevatron





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Phys.Rev.Lett.84:845-850,2000

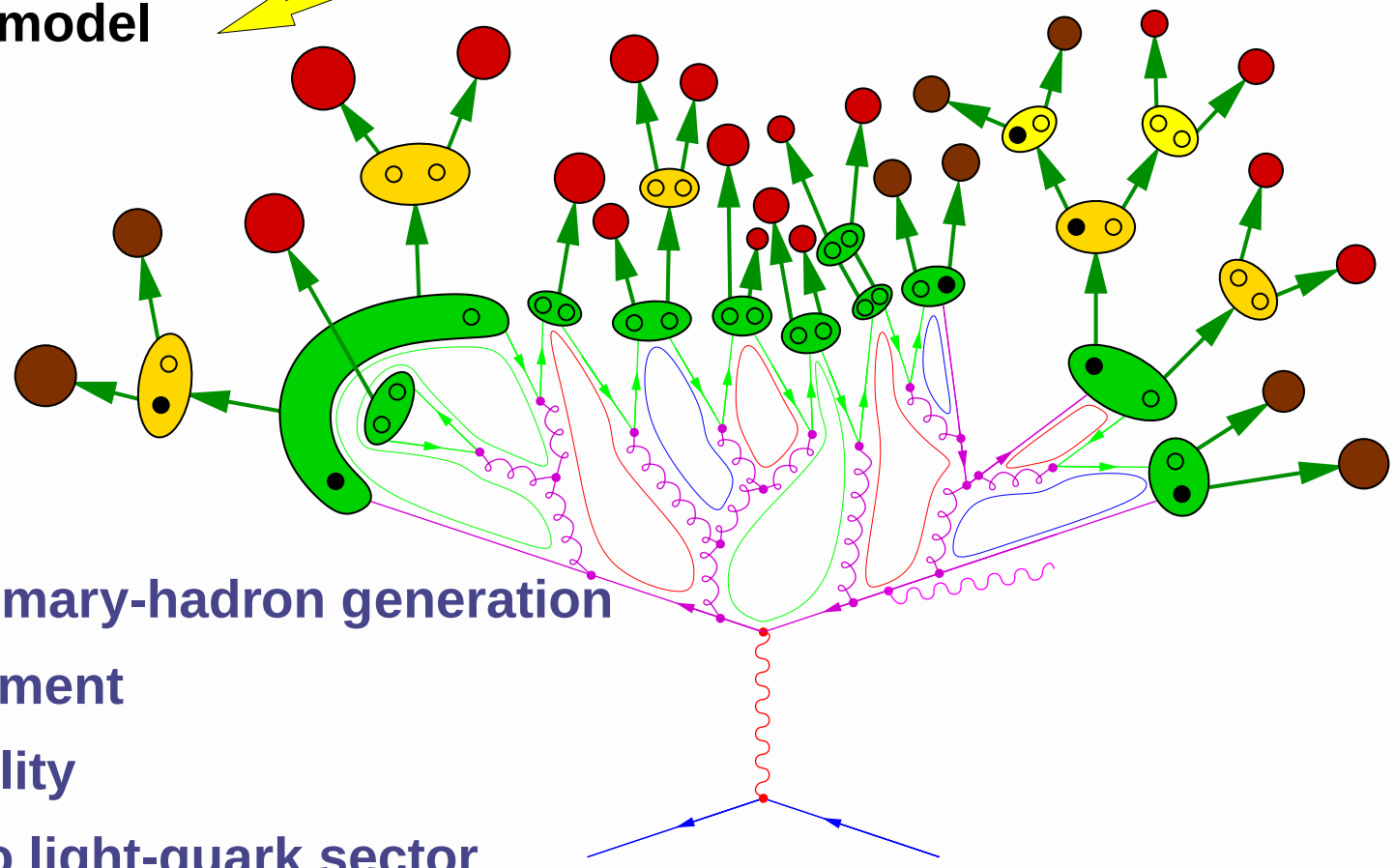
A Cluster-Hadronization Model for Sherpa

J. Winter et al, hep-ph/0311085

modelling the non-perturbative dynamics of a partonic system

- **Cluster-formation model**
- **Cluster-decay model**

light flavour pair production



Features:

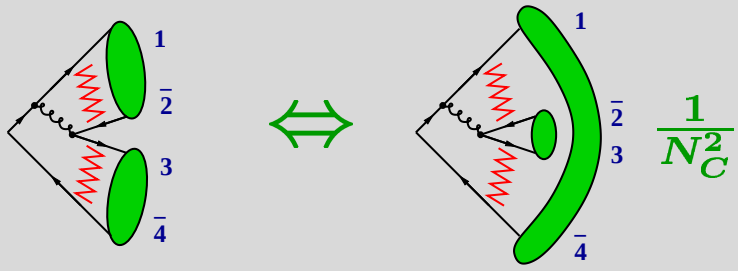
- **Parametrization of primary-hadron generation**
- **LPHD and preconfinement**
- **Locality and universality**
- **Currently restricted to light-quark sector**

Cluster-Formation Model

Parton shower ends up with colour-ordered parton list

- **Parton masses**
  → Constituent masses
- **Enforced gluon splitting**

$g \to q\bar{q}, \;\; g \to q_1 q_2 \overline{q_1 q_2}$

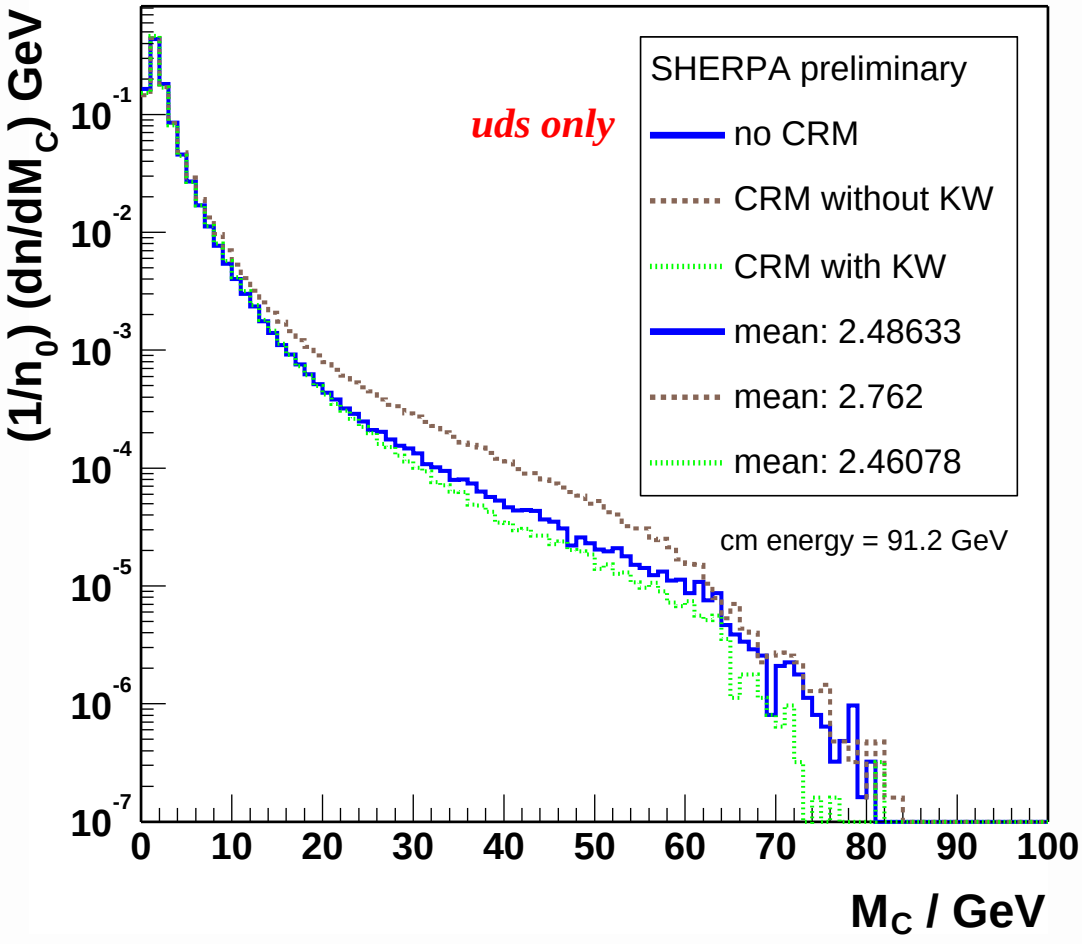


Soft Colour Reconnection

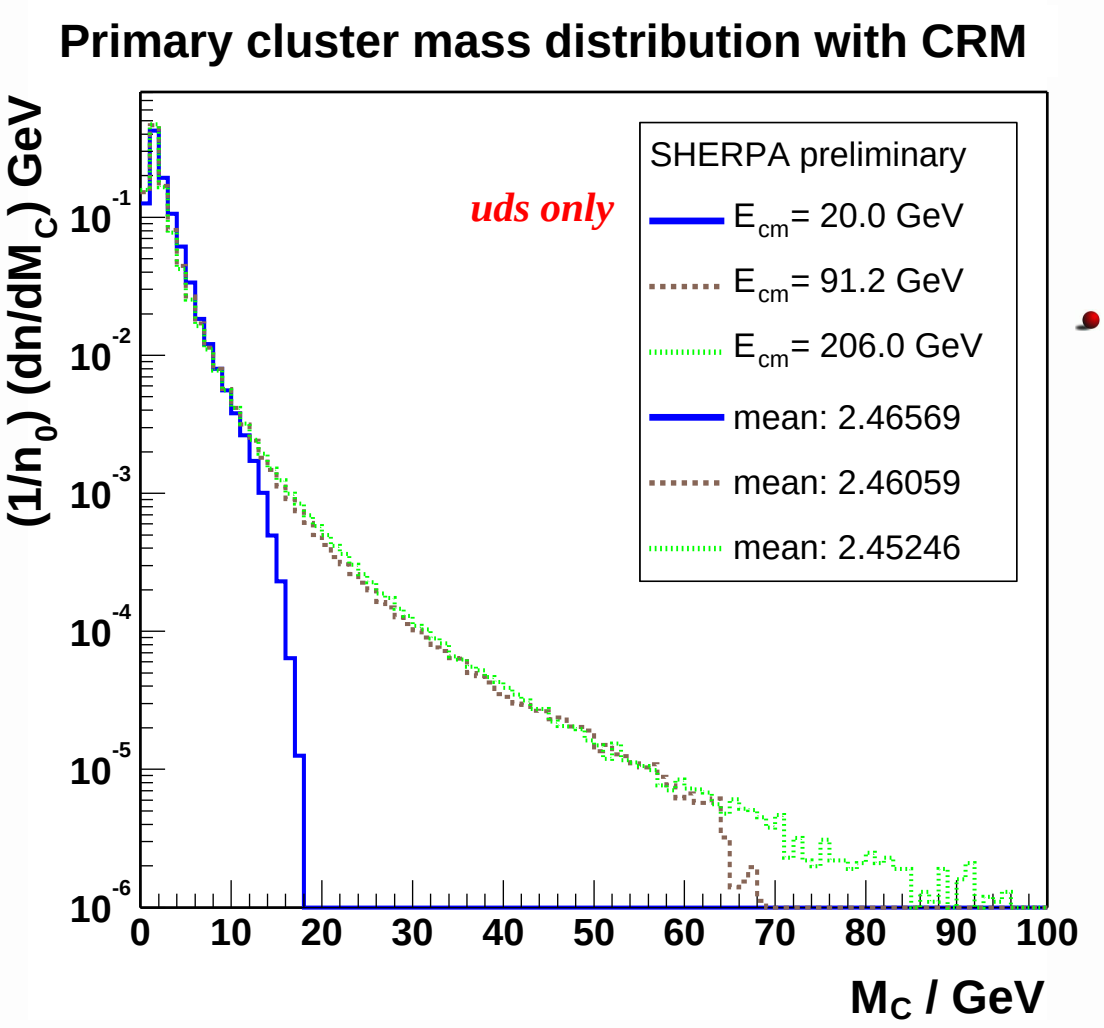
kinematical weight

$$W_{ij,kl} = \frac{t_0}{t_0 + (w_{ij} + w_{kl})^2}$$

Primary cluster mass distribution



Results for $e^+e^- \to \mathcal{H}$



- Primary cluster mass spectrum independent of cm energy of the hard subprocess

Cluster-Decay Model

Ansatz: Cluster mass $\Rightarrow$ transition type

- $M_{\mathcal{C}}$ **in hadron regime**

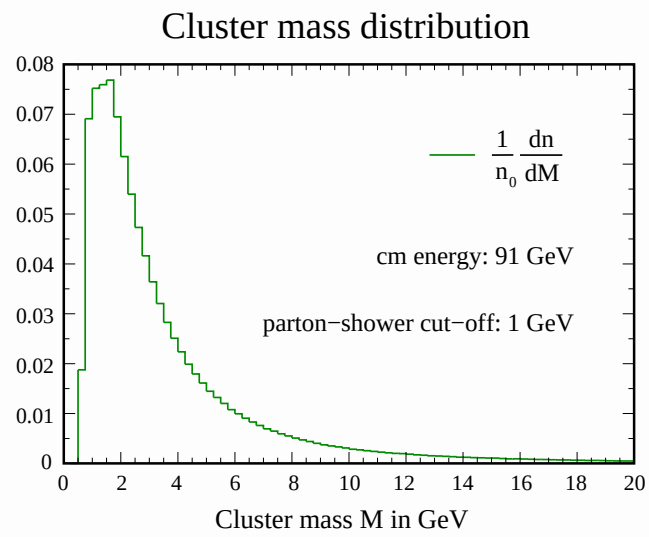
  $\rightarrow$ 1-body decay $\mathcal{C} \rightarrow \mathcal{H}$

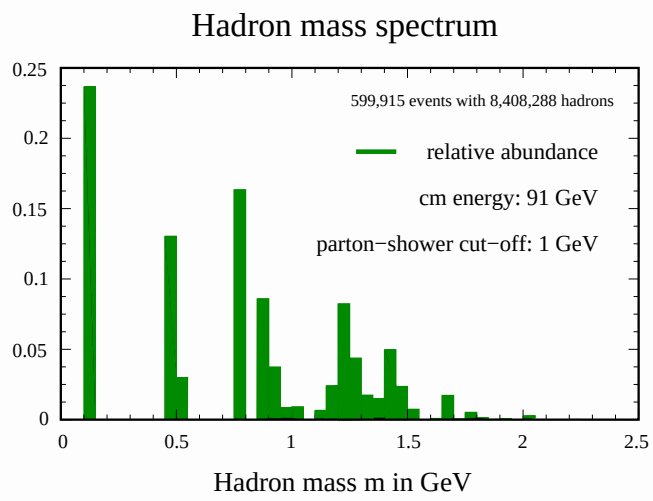
  weight: $\mathcal{W} = \exp\left(-\frac{Q^2}{Q_0^2}\right)^2$

- **else** 2-body decay $\mathcal{C} \rightarrow \mathcal{X}\mathcal{Y}$
  - determine $M_{\mathcal{X}}$ & $M_{\mathcal{Y}}$

    kinematics:
    $$p_{1,2} = \left(1 - \frac{Q_0}{M_C}\right) p_{1,2}^{\mathcal{C}}$$
    $$p_{\bar{f},f} = \frac{Q_0}{M_{\mathcal{C}}} p_{2,1}^{\mathcal{C}}$$
    $$Q_0 = \hat{Q}_0 \frac{M_C}{M_C + \hat{M}_0}$$

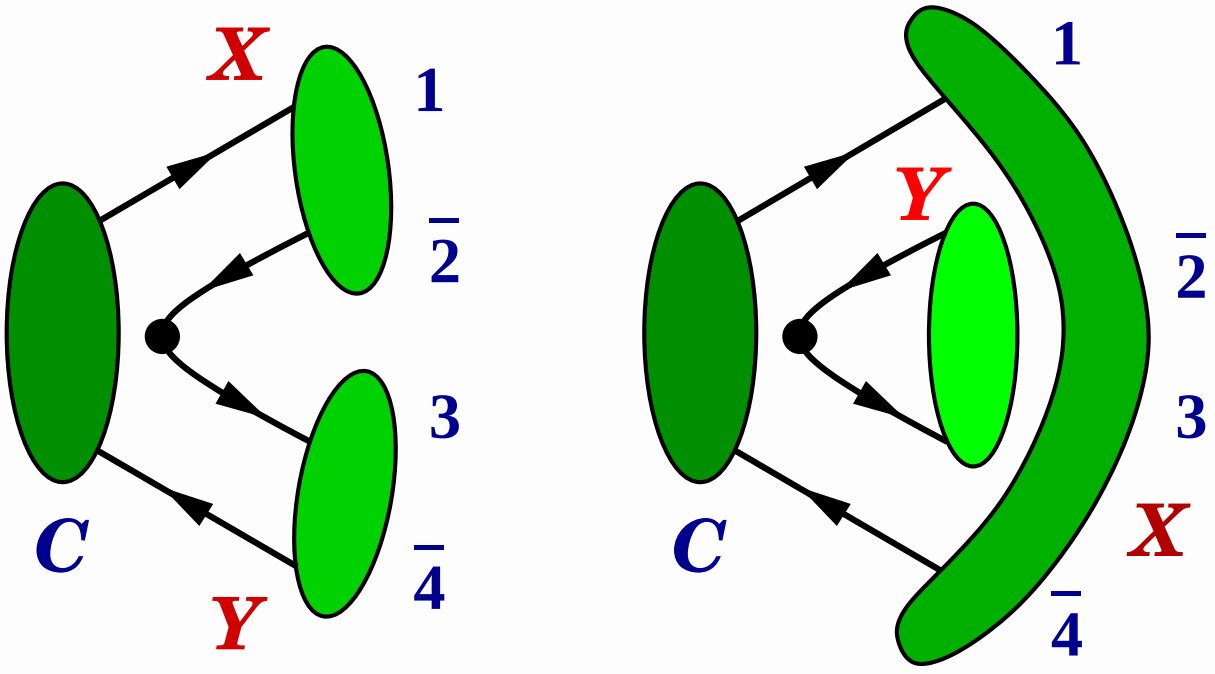
  - channel selection
    - $\mathcal{C} \rightarrow \mathcal{C}\mathcal{C}$ / $\mathcal{C} \rightarrow \mathcal{H}\mathcal{H}$
    - $\mathcal{C} \rightarrow \mathcal{C}\mathcal{H}$ / $\mathcal{H}\mathcal{C}$





Cluster-Decay Model: Soft Colour Reconnection

- direct and crossed flavour arrangement in cluster two-body decays

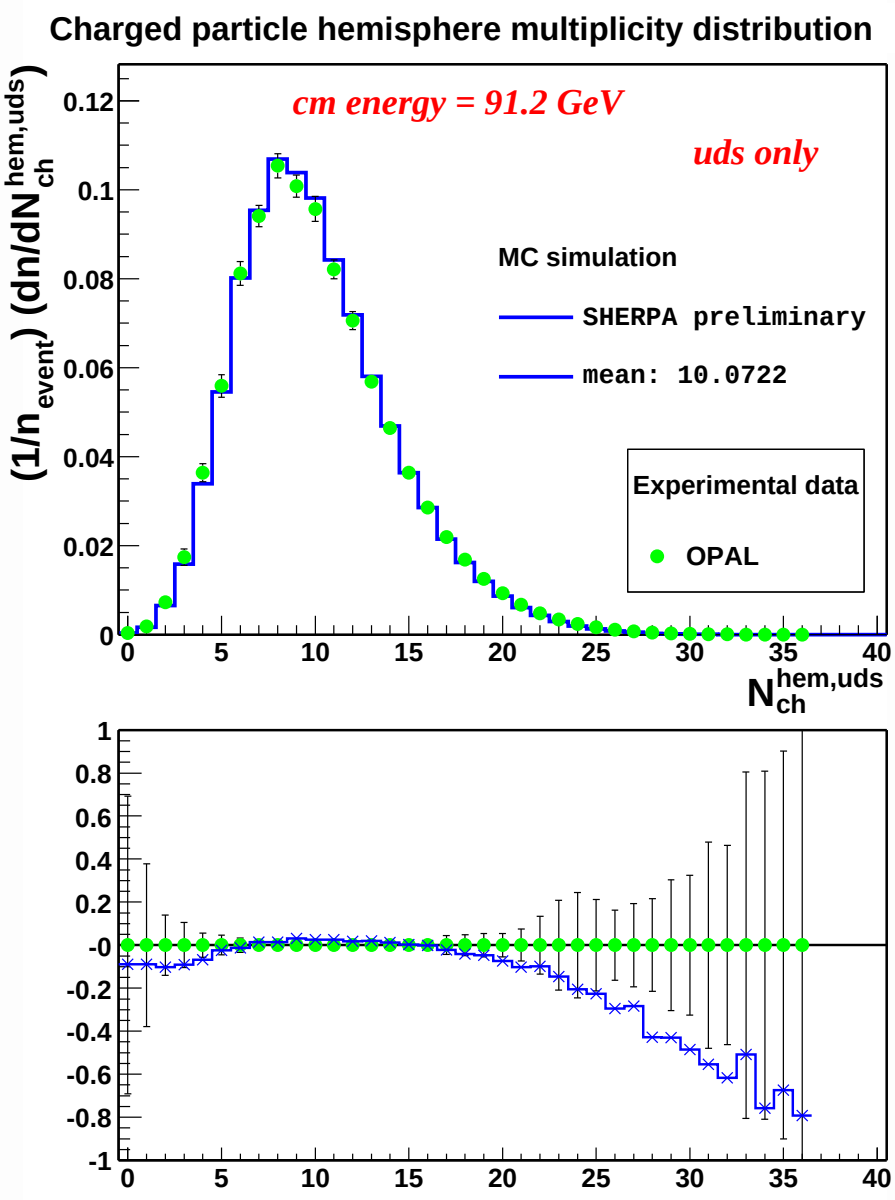


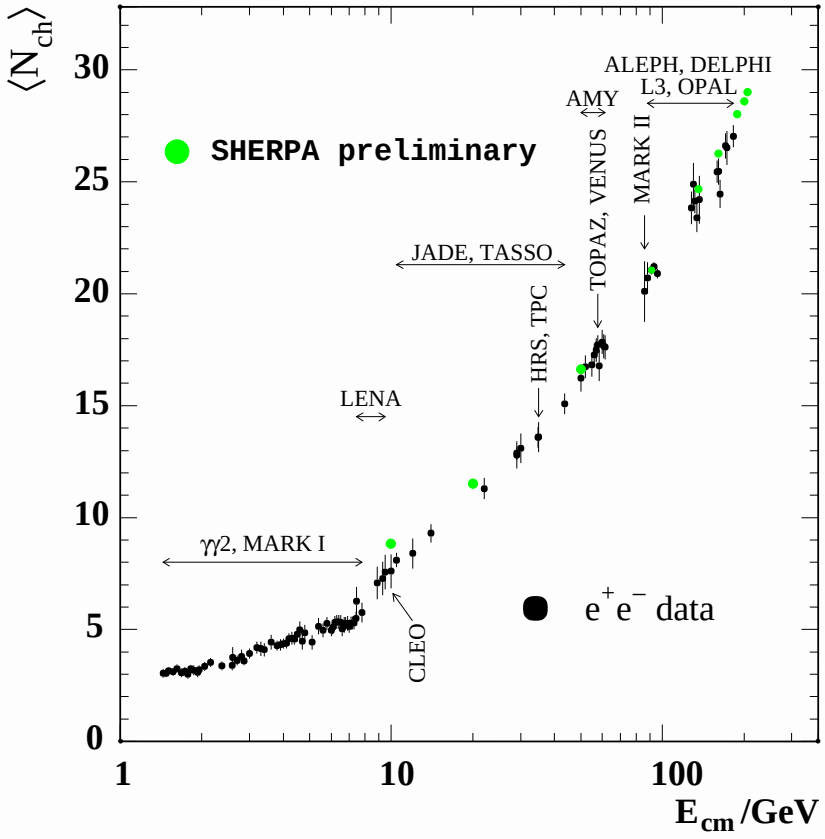
Results for $e^+e^- \to \mathcal{H}$

charged-particle multiplicities for uds events at Z-peak

	$\langle \mathcal{N}_{\rm ch}^{\rm uds} \rangle$	$\langle \mathcal{N}_{\pi^\pm}^{\rm uds} \rangle$	$\langle \mathcal{N}_{K^\pm}^{\rm uds} \rangle$	$\langle \mathcal{N}_{p,\bar{p}}^{\rm uds} \rangle$
PYTHIA-6.1(uds)	19.84	16.72	2.010	0.856
HERWIG-6.1(uds)	18.86	15.37	1.693	1.568
SHERPAα	20.15	16.83	2.018	1.047
DELPHI	19.94 ± 0.34	16.84 ± 0.87	2.02 ± 0.07	1.07 ± 0.05
SLD	20.048 ± 0.316	16.579 ± 0.304	2.000 ± 0.068	1.094 ± 0.043

Results for $e^+e^- \to \mathcal{H}$



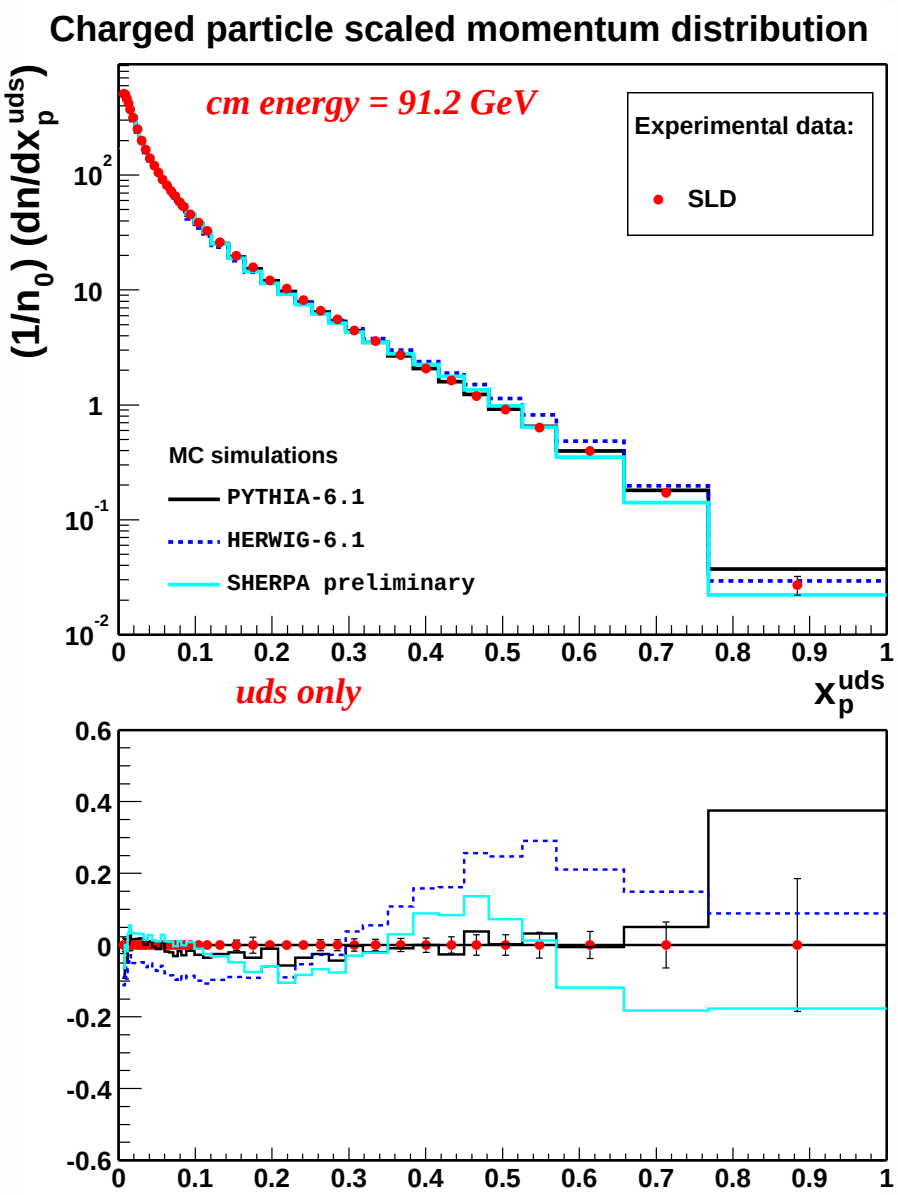


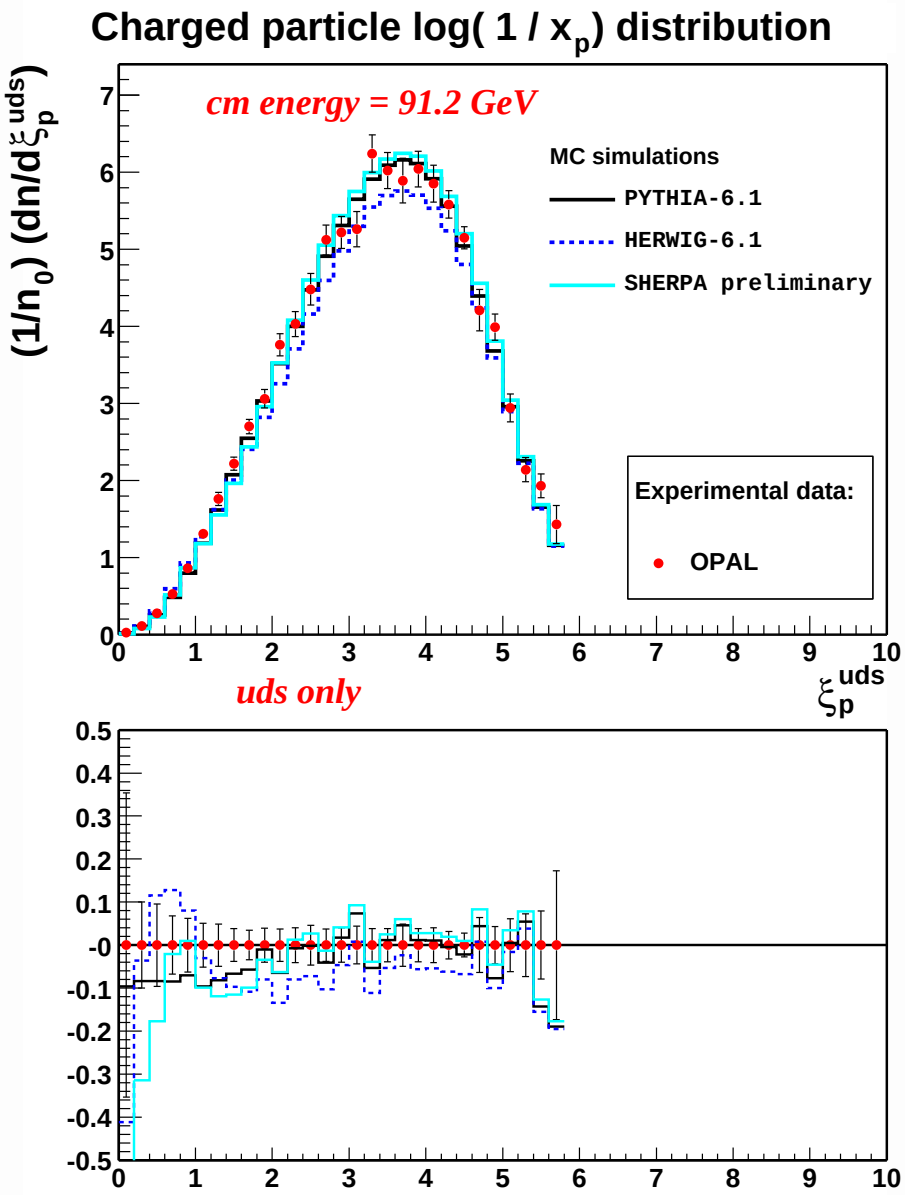
- Correction for heavy quarks

$$\langle \mathcal{N}_{ch} \rangle = \langle \mathcal{N}_{ch}^{uds} + f_c \delta_c + f_b \delta_b \rangle$$

$$\delta_c = 1.7 \pm 0.5 \ , \ \delta_b = 3.05 \pm 0.19$$

Results for $e^+e^- \to \mathcal{H}$





Conclusion/Outlook

Conclusion

Sherpa including the ME's of AMEGIC++ and the CKKW prescription to combine them with the PS is a powerful tool to attempt the description of LEP and Tevatron data and to study the extrapolation to LC and LHC energies

Outlook

- Extend cluster hadronization package
  - Treatment of heavy quark sector
  - Parameter tuning
  - Application to hadron collisions
- Study of soft colour reconnection model

Sources

- T. Gleisberg, S. Höche, F. Krauss, A. Schälicke, S. S. and J. Winter,

  JHEP 0402:056,2004

- current version SHERPAα-1.3 available under

  `http://www.physik.tu-dresden.de/~krauss/hep`