EPOS

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Contents

1. Parton evolution and Pomerons in EPOS 3
2. Multiple scattering in EPOS 23
3. Collectivity in EPOS 54
4. EPOS Summary 79
Parton evolution and Pomerons in EPOS
1.1 Parton evolution

A fast moving proton emits successively partons (mainly gluons), quasi-real (large gamma factors)
... which can be probed by a virtual photon (emitted from an electron)

\[
\text{proton} \quad \text{photon} \quad \text{proton and photon} \quad \text{momentum}
\]

\[
\text{color dipole} \quad \rightarrow \text{Color dipole}
\]

\[
p \quad k \quad \text{and } k \text{ are proton and photon momentum}
\]

\[
\text{photon splits into } q \quad q\bar{q}
\]
What precisely the photon “sees” depends on two kinematic variables,

the virtuality

\[ Q^2 = -k^2 \]

and the Bjorken variable

\[ x = \frac{Q^2}{2pk} \]

which probes partons with momentum fraction \( x \). It determines also the approximation scheme to compute the parton cloud.
\[ s - \lambda = x \ln Q \]

DGLAP: summing to all orders of \( \alpha_s \ln Q^2 \)

BFKL: summing to all orders of \( \alpha_s \ln \frac{1}{x} \)

Linear equations
BFKL (Balitsky, Fadin, Kuraev, and Lipatov):

\[
\frac{\partial \varphi(x, q)}{\partial \ln \frac{1}{x}} \frac{\alpha_s N_c}{\pi^2} \int d^2 k K(q, k) \varphi(x, k)
\]

with \( xg(x, Q^2) = \int_0^{Q^2} \frac{d^2 k}{k^2} \varphi(x, k) \),

DGLAP (Dokshitzer, Gribov, Lipatov, Altarelli and Parisi):

\[
\frac{\partial g(x, Q^2)}{\partial \ln q^2} = \int_x^1 \frac{dz}{z} \frac{\alpha_s}{2\pi} P(z) g\left(\frac{x}{z}, Q^2\right)
\]
Very large $\ln 1/x$ : Saturation domain

Non-linear effects

Gluon from one cascade is absorbed by another one
1.2 pp scattering (linear domain)

Same evolution as in proton-photon (causality)
Different way of plotting the same reaction

\[ 0.5 \log(x^+/x^-) \]

in off-shell nucleon \( t=0 \) time

inelastic scattering diagram
Corresponding cut diagram

referred to as “cut parton ladder”
= amplitude squared of the inelastic diagram
Corresponding elastic diagram

referred to as “(uncut) parton ladder”
1.3 Soft domain

Very small $\ln Q^2$: No perturbative treatment!

But one may use the hypothesis of **Lorentz invariance** and **analyticity** of the T-matrix. One starts with a partial wave expansion of the T-matrix (Watson-Sommerfeld transform):

$$T(t, s) = \sum_{j=0}^{\infty} (2j + 1) T(j, s) P_j(z)$$

with $t \propto z - 1$, $z = \cos \theta$, $P_j$: Legendre polynomials.
With $\alpha(s)$ being the right-most pole of $T(j, s)$ one gets for $t \to \infty$:

$$T(t, s) \propto t^{\alpha(s)}$$

and assuming crossing symmetry one gets the famous asymptotic result

$$T(s, t) \propto s^{\alpha(t)}$$

with the “Regge pole”

$$\alpha(t) = \alpha(0) + \alpha' t$$
Perturbative: Parton ladder

T-matrix computed (DGLAP)

Soft: Soft Pomeron

gluon fields

T-matrix parametrized

\[ T_{\text{soft}}(\hat{s}, t) = 8\pi s_0 i \gamma_{\text{Pom-parton}}^2 \left( \frac{\hat{s}}{s_0} \right)^{\alpha_{\text{soft}}(0)} \times \exp(\lambda_{\text{soft}} t) \]

with

\[ \lambda_{\text{soft}} = 2R_{\text{Pom-parton}}^2 + \alpha'_{\text{soft}} \ln \frac{\hat{s}}{s_0}. \]
Interaction cross section,

\[ \sigma_{\text{soft}}(\hat{s}) = \frac{1}{2\hat{s}} 2\text{Im} \ T_{\text{soft}}(\hat{s}, 0), \]

\[ = 8\pi \gamma_{\text{part}}^2 \left( \frac{\hat{s}}{s_0} \right)^{\alpha_{\text{soft}}(0) - 1} \]

which grows too fast
1.4 Semihard Pomeron
Space-time picture of semihard Pomeron

\[
\sigma_{\text{hard}}^{jk}(\hat{s}, Q_0^2) = \frac{1}{2\hat{s}} 2\text{Im} \ T_{\text{hard}}^{jk}(\hat{s}, t = 0)
\]

\[
= K \sum \int dx_B^+ dx_B^- dp_\perp^2 \frac{d\sigma_{\text{Born}}^{ml}}{dp_\perp^2}(x_B^+ x_B^- \hat{s}, p_\perp^2)
\]

\[
\times E_{\text{QCD}}^{jmml}(x_B^+, Q_0^2, M_F^2) E_{\text{QCD}}^{kl}(x_B^-, Q_0^2, M_F^2) \theta(M_F^2 - Q_0^2),
\]

One knows (Lipatov, 86): amplitude is imaginary, and nearly independent on \( t \Rightarrow (\text{with } R_{\text{hard}}^2 \simeq 0) : \)

\[
T_{\text{hard}}^{jk}(\hat{s}, t) = i\hat{s} \sigma_{\text{hard}}^{jk}(\hat{s}, Q_0^2) \exp \left( R_{\text{hard}}^2 t \right)
\]
Semihard amplitude:

\[ iT_{\text{semihard}}(\hat{s}, t) = \sum_{jk} \int_0^1 \frac{dz^+}{z^+} \frac{dz^-}{z^-} \times \text{Im} \, T^j_{\text{soft}} \left( \frac{S_0}{z^+}, t \right) \, \text{Im} \, T^k_{\text{soft}} \left( \frac{S_0}{z^-}, t \right) \, iT^{jk}_{\text{hard}}(z^+ z^- \hat{s}, t) \]

(valid for \( s \rightarrow \infty \) and small parton virtualities except for the ones in the ladder)
2 Multiple scattering in EPOS

in collaboration with T. Pierog and B. Guiot

2.1 Single scattering  

(single Pomeron)

somewhat simplified
2.2 Multiple scattering

Be $T$ the elastic (pp, pA, AA) scattering T-matrix $\Rightarrow$

$$2s \sigma_{\text{tot}} = \frac{1}{i} \text{disc } T$$

Basic assumption: Multiple “Pomerons”

$$iT = \sum_{k} \frac{1}{k!} \{iT_{\text{Pom}} \times \ldots \times iT_{\text{Pom}}\}$$
Example: 2 “Pomerons”
Evaluate

\[
\frac{1}{i} \text{disc} \{ iT_{\text{Pom}} \times \ldots \times iT_{\text{Pom}} \}
\]

using “cutting rules” :

A “cut” multi-Pomeron diagram amounts to the sum of all possible cuts
Example of two Pomerons
Using “Pomeron = parton ladder + soft”, we have (first diagram)
Using a simplified notation for "cut" and "uncut" Pomeron

one gets ...
2.3 Complete result (strict energy conservation)

(Drescher, Hladik, Ostapchenko, Pierog, and Werner, Phys. Rept. 350, 2001)

For pp, pA, AA:

\[
\sigma_{\text{tot}} = \sum_{\text{cut } P} \int \sum_{\text{uncut } P} \int
\]

Dotted lines: Cut Pomerons (parton ladders)
\[
\sigma^{\text{tot}} = \int d^2 b \int \prod_{i=1}^{A} d^2 b_i^A \, dz_i^A \, \rho_A(\sqrt{(b_i^A)^2 + (z_i^A)^2}) \\
\prod_{j=1}^{B} d^2 b_j^B \, dz_j^B \, \rho_B(\sqrt{(b_j^B)^2 + (z_j^B)^2}) \\
\sum_{m_1 l_1} \ldots \sum_{m_{AB} l_{AB}} (1 - \delta_{0\Sigma m_k}) \int \prod_{k=1}^{AB} \left( \prod_{\mu=1}^{m_k} dx_{k,\mu}^+ dx_{k,\mu}^- \prod_{\lambda=1}^{l_k} d\tilde{x}_{k,\lambda}^+ d\tilde{x}_{k,\lambda}^- \right) \left\{ \frac{1}{m_k!} \frac{1}{l_k!} \prod_{\mu=1}^{m_k} G(x_{k,\mu}^+, x_{k,\mu}^-, s, |\vec{b} + \vec{b}_A^\pi(k) - \vec{b}_B^\tau(k)|) \right. \\
\left. \prod_{\lambda=1}^{l_k} G(\tilde{x}_{k,\lambda}^+, \tilde{x}_{k,\lambda}^-, s, |\vec{b} + \vec{b}_A^\pi(k) - \vec{b}_B^\tau(k)|) \right\} \\
\prod_{i=1}^{A} \left( 1 - \sum_{\pi(k)=i} x_{k,\mu}^+ - \sum_{\pi(k)=i} \tilde{x}_{k,\lambda}^+ \right)^\alpha \\
\prod_{j=1}^{B} \left( 1 - \sum_{\tau(k)=j} x_{k,\mu}^- - \sum_{\tau(k)=j} \tilde{x}_{k,\lambda}^- \right)^\alpha \right\}
\]
Complicated due to strict energy conservation
=> 10,000,000-dimensional integrals, not separable

but doable:

- Parameterizations for $G(x^+, x^-, s, b)$
- Analytical integrations
- Employing Markov chain techniques to generate configurations $K$
  according to multidimensional probability distributions $f(K) = \frac{\sigma_K}{\sigma_{\text{tot}}}$
$\sigma_K :$

\[ \sum_{\text{uncut } P} \int \]

Dotted lines : Cut Pomerons
Full lines : Uncut Pomerons
2.4 Configurations via Markov chains

the heart of EPOS, see Phys. Rept. 350, 2001

We construct sequences of random configurations

\[ K_1, K_2, K_3, \ldots K_t, \ldots \]

such that \( f_t(K_t) \) converges towards \( f(K) \) for \( t \to \infty \)

like a physical process reaching equilibrium
The law changes step by step \((f_t \rightarrow f_{t+1})\):

\[
f_{t+1}(K) = \sum_{K'} f_t(K') \, p(K' \rightarrow K).
\]

The transition probability \(p\) has to be chosen properly to assure convergence towards \(f\)

**Sufficient condition: detailed balance**

\[
f(K') \, p(K' \rightarrow K) = f(K) \, p(K \rightarrow K').
\]
Metropolis:

One can prove that a $p(K \rightarrow K')$ of the form

$$w(K \rightarrow K') \times \min \left( 1, \frac{f(K')}{{f(K)}} \frac{w(K' \rightarrow K)}{w(K \rightarrow K')} \right)$$

with any choice of $w$ fulfills detailed balance!!

But still $w$ needs to be chosen in an intelligent way ... even then long iterations,

but the method allows to generate very complex configurations according to very complex laws
2.5 Parton saturation

Computing the expressions $G$ for single Pomerons: A cutoff $Q_0$ is needed (for the DGLAP integrals).

Taking $Q_0$ constant leads to a power law increase of cross sections vs energy (=> wrong)

because non-linear effects like gluon fusion are not taken into account
Solution: Instead of a constant $Q_0$, use a dynamical **saturation scale** for each Pomeron:

$$Q_s = Q_s(N_{IP}, s_{IP})$$

with

$N_{IP} = \text{number of Pomerons connected to a given Pomeron (whose probability distribution depends on } Q_s)$

$s_{IP} = \text{energy of considered Pomeron}$
Parton distributions

\[ \frac{dn}{dp_t} \]

\( p_t \)

\( Q_s \)

\( \langle p_t \rangle \)

\[ \Rightarrow \text{Increase of } \langle p_t \rangle \text{ with multiplicity} \]
2.6 “Outside to inside” parton production

How to reconstruct the Pomerons?
(knowing the properties of the Pomeron ends)

Having the end partons $i, j$, how to get the intermediate ones (like $m, k$ etc)? We iterate from outside to inside!
Actually the diagram $k$ to $j$ corresponds to $\sigma_{\text{hard}}^{kj}(\hat{s}, Q_1^2, Q_2^2)$, already used to generate multiple scattering configurations.
Probability of single emission $m \rightarrow k$:

$$\text{prob}(\xi, Q^2) = d\xi \frac{dQ^2}{Q^2} \Delta^m(Q_1^2, Q^2) \frac{\alpha_s}{2\pi} P^k_m(\xi) \sigma^{kj}_{\text{hard}}(\hat{\xi}, Q^2, Q_2^2)$$

with a given parton $j$ on the other end.

**Attention: emission on one side depends on existing parton the the other end!**

=> precalculation of cross sections, tabulations, interpolation ....
Recent: Heavy quark (Q) production in EPOS framework

as light quark production

In any of the ladders

- **during SLC** (space-like cascade)
- **during TLC** (time-like cascade)
- **in Born**

but $m_Q$ non-zero (1.3, 4.2) matrix elements, kinematics
2.7 From partons to strings

Electron-positron annihilation

Color field between two color charges => relativistic string

X. Artru, Phys. Rep. 97 (83) 147
High pt gluon emission in $e^+e^-$

Kinky relativistic string
Cut Pomerons

(cut parton ladders)

Two kinky relativistic strings (at least)
Theoretical framework: Classical string theory
Nambu, Scherk, Rebbi ... 1969-1975

String:
two-dimensional surface

\[ x(\sigma, \tau) \]

in Minkowski space

Action \[ S = \int L d\tau d\sigma, \quad L \propto \sqrt{|\det g|} \]
String evolution

$$x^\mu (\sigma, \tau) = x_0 + \frac{1}{2} \int_{\sigma - \tau}^{\sigma + \tau} g^\mu (\xi) d\xi,$$

Mapping partons => string initial conditions
String decay within $dA$

$$dP \propto dA$$

(area law)
**pp:**
Parton ladder = color flux tubes = 2 kinky strings

(here no IS radiation, only hard process producing two gluons)
which expand and break via the production of quark-antiquark pairs

String segment = hadron. Close to “kink”: jets
Unless we have many color flux tubes

=> core + corona
3 Collectivity in EPOS

- Core-corona separation (pp, pA, AA)

- EPOS 3:
  - Hydrodynamic expansion of core
  - Statistical decay of fluid (Grand canonical, big systems)

- EPOS LHC:
  - Effective flow, droplet decay
    (like resonance decay, small systems)

- “Unification”: Microcanonical decay (small and big)
3.1 Microcanonical hadronization of plasma droplets

- No need to match dynamical part of hydro evolution
- Energy and flavor conservation for small systems
- Needed to “unify” EPOS LHC and EPOS3
Grand canonical decay, $T = 130$ MeV

$V = 50$ fm$^3$; $V = 1000$ fm$^3$
Microcanonic decay
of given volume in its CMS into $n$ hadrons

\[
dP = C_{\text{vol}} C_{\text{deg}} C_{\text{ident}}
\times \delta(E - \Sigma E_i) \delta(\Sigma \vec{p}_i) \prod_A \delta_{Q_A, \Sigma q_{A_i}} \prod_{i=1}^n d^3 p_i
\]

\[
C_{\text{vol}} = \frac{V^n}{(2\pi\hbar)^{3n}}, \quad C_{\text{deg}} = \prod_{i=1}^n g_i, \quad C_{\text{ident}} = \prod_{\alpha \in S} \frac{1}{n_\alpha!}
\]

($n_\alpha$ is the number of particles of species $\alpha$, $S$ is the set of particle species)

Different from decay rate of a massive particle (using LIPS), where asymptotic states are defined over an infinitely large volume (see Becattini et al, EPJC35:243-258,2004).  \[ E_i = \sqrt{p_i^2 + m_i^2} \]
Microcanonical decay

$$dP \propto d\Phi_{\text{NRPS}} = \delta(M - \Sigma E_i) \delta(\Sigma \vec{p}_i) \prod_{i=1}^{n} d^3 p_i$$

- Hagedorn 1958 methods to compute $\Phi_{\text{NRPS}}$
- Lorentz invariant phase space (LIPS) (James 1968)
- Hagedorn methods used for decaying QGP droplets (Werner, Aichelin, 1994, Becattini 2003)
- 2012 (Bignamini, Becattini, Piccinini) compute $\Phi_{\text{NRPS}}$ via the Lorentz invariant phase space (LIPS)
- Hagedorn integral method can be made very efficient at large \( n \) (new), but it is VERY time consuming at small \( n \)

- LIPS method very fast for small \( n \), gets time consuming at large \( n \)

- around \( n \approx 30 - 40 \) both methods work (=> checks)
Hagedorn integral method

The phase-space integral:

\[ \phi_{\text{NRPS}}(M, m_1, \ldots, m_n) = (4\pi)^n \int \prod_{i=1}^{n} p_i^2 \delta(E - \sum_{i=1}^{n} E_i) W(p_1, \ldots, p_n) \prod_{i=1}^{n} dp_i, \]

with the “random walk function” \( W \) (angular integral)

\[ W(p_1, \ldots, p_n) := \frac{1}{(4\pi)^n} \int \delta(\sum_{i=1}^{n} p_i \times \vec{u}_i) \prod_{i=1}^{n} d\Omega_i \]
We obtain (Werner, Aichelin 94)

\[ \phi(M, m_1, \ldots, m_n) = \int_0^1 dr_1 \cdots \int_0^1 dr_{n-1} \psi(r_1, \ldots, r_{n-1}) \]

\[ \psi = \frac{(4\pi)^n T^{n-1}}{(n-1)!} \prod_{i=1}^n p_i E_i W(p_1, \ldots, p_n), \]

with \( z_i = r_i^{1/i}, x_i = z_i x_{i+1}, s_i = x_i T, t_i = s_i - s_{i-1}, \)
\( E_i = t_i + m_i, T = M - \sum_{i=1}^n m_i \)

Suitable for MC provided \( W \) is known
The random walk function may be written as

\[
W(p_1, \ldots, p_n) = \frac{1}{(4\pi)^n} \frac{1}{(2\pi)^3} \int \int e^{-i\lambda \sum p_j \hat{p}_j} \prod_{j=1}^{n} d\Omega_j d^3 \lambda,
\]

which gives

\[
W = \int_{0}^{\infty} F(\lambda) \, d\lambda
\]

with

\[
F(\lambda) = \frac{1}{2\pi^2} \lambda^2 \prod_{j=1}^{n} \frac{\sin p_j \lambda}{p_j \lambda}.
\]

**New: using the fact that for large \( n \)**

\[
\prod_{j=1}^{n} \frac{\sin p_j \lambda}{p_j \lambda} \approx \exp\left(-P^2\lambda^2\right), \quad P = \sqrt{\frac{1}{6} \sum_{j=1}^{n} p_j^2}
\]
With $F_0(\lambda) = F(\lambda) \times \exp(P^2\lambda^2)$:

$$W = \int_0^\infty F(\lambda) \, d\lambda = \frac{1}{P} \int_0^\infty F_0 \left( \frac{x}{P} \right) \times \exp\left( -x^2 \right) \, dx$$

with $F_0$ being a slowly varying function of $x$, which allows to use the Gauss-Hermite formula

$$W \approx \frac{1}{P} \sum_{k=1}^{K} w_{j_k}^{GH} F_0 \left( \frac{x_{j_k}^{GH}}{P} \right),$$

with nodes and weights $x_{j_k}^{GH}$ and $w_{j_k}^{GH}$ found in text books.

With only six nodes we get excellent results.
Sampling hadron configurations $K = \{h_1, \ldots, h_n; \vec{p}_1, \ldots, \vec{p}_n\}$ via Markov chains

We construct sequences of random configurations $K_1, K_2, K_3, \ldots K_t, \ldots$

such that $f_t(K_t)$ converges towards $f(K)$ for $t \to \infty$

with $f = \text{microcanonical probability distribution}$
The law changes step by step ($f_t \rightarrow f_{t+1}$):

$$f_{t+1}(K) = \sum_{K'} f_t(K') \, p(K' \rightarrow K).$$

with $p(K \rightarrow K')$ of the form

$$w(K \rightarrow K') \times \min \left( 1, \frac{f(K')}{f(K)} \frac{w(K' \rightarrow K)}{w(K \rightarrow K')} \right)$$
3.2 Grand canonical limit

For very large $M$ we should recover the “grand canonical limit” for single particle spectra:

$$f_k = \frac{g_k V}{(2\pi \hbar)^3} \exp \left( -\frac{E_k}{T} \right),$$

The average energy is

$$\bar{E} = \frac{g_k V}{(2\pi \hbar)^3} \sum_k \int_0^\infty E_k \exp \left( -\frac{E_k}{T} \right) 4\pi p^2 dp$$

Changing variables via $E_k dE_k = pdp$, and using $K_1(z) = z \int_1^\infty \exp(-zx)\sqrt{x^2 - 1} dx$, and $3K_2(z) = z^2 \int_1^\infty \exp(-zx)\sqrt{x^2 - 1}^3 dx$, 

\[ \bar{E} = \frac{4\pi g_k V}{(2\pi \hbar)^3} m^2 T \left( 3TK_2 \left( \frac{m}{T} \right) + mK_1 \left( \frac{m}{T} \right) \right). \]

The microcanonical decay of an object of mass \( M \) and volume \( V \) should converge (for \( M \to \infty \)) to the GC single particle spectra with \( T \) obtained from \( M = \bar{E} \).
3.3 Comparing GC et MiC decay

We consider a complete (?) set of hadrons
($\approx 400$, PDG list)

We check the effect of

- energy conservation
- flavor conservation
GC decay, $E/V = 0.333$ GeV/fm$^3$  $T=164$ MeV

\[ \frac{dN}{dp} \text{ (GeV/c)}^{-1} \]

\[ p \text{ (GeV/c)} \]

\[ V=150 ~\text{fm}^3 \]
GC+MiC decay, $E/V = 0.333$ GeV/fm$^3$  M=200 GeV

$\pi\ K\ p\ \Lambda\ \Xi\ \Omega$

$M = 200$ GeV

$V=600$ fm$^3$

$\times \frac{1}{4}$

good test for Metropolis proposal
GC+MiC decay, $E/V = 0.333$ GeV/fm$^3$  M=100 GeV

GrCan + MiCan

$V=300$ fm$^3$  \times \frac{1}{2}$
GC+MiC decay, $E/V = 0.333$ GeV/fm$^3$  $M=50$ GeV

$\pi \, K \, p \, \Lambda \, \Xi \, \Omega$

$M = 50$ GeV

$V=150$ fm$^3 \times 1$
GC+MiC decay, $E/V = 0.333 \text{ GeV/fm}^3$  $M=25 \text{ GeV}$

$\pi$, $K$, $p$, $\Lambda$, $\Xi$, $\Omega$

$M = 25 \text{ GeV}$

GrCan + MiCan

$V = 75 \text{ fm}^3$

$\times 2$
GC+MiC decay, $E/V = 0.333 \text{ GeV/fm}^3 \quad M = 12.5 \text{ GeV}$

$\pi \quad K \quad p \quad \Lambda \quad \Xi \quad \Omega$

$M = 12.5 \text{ GeV}$

$V = 37.5 \text{ fm}^3 \times 4$

$dn/dp \ (\text{GeV/c})^{-1}$

$p \ (\text{GeV/c})$
GC+MiC decay, $E/V = 0.333 \text{ GeV/fm}^3$, $M=6.25 \text{ GeV}$

$\pi K p \Lambda \Xi \Omega$

$M = 6.25 \text{ GeV}$

$V = 18.75 \text{ fm}^3 \times 8$
3.4 Particle ratios to pions vs $\left< \frac{dn_{\text{ch}}}{d\eta} (0) \right>$

**Graph:**
- **Circles:** $pp$ (7 TeV)
- **Squares:** $pPb$ (5 TeV)
- **Stars:** $PbPb$ (2.76 TeV)

Data partly collected by A. G. Knospe

Refs:

and data points from Rafael Derradi de Souza, SQM2016
Proton to pion ratio  (sofar GC)

![Graph showing proton to pion ratio](image)

**Core hadronization:**

$T = 164 \text{ MeV}, \mu_B = 0$

**Statistical model fit**

(horizontal black line)

A. Andronic et al.,

arXiv:1611.01347

$T = 156.5 \text{ MeV}, \mu_B = 0.7 \text{ MeV}$

**Legend:**

- Full lines = pp (7 TeV)
- Thick lines = pp (7 TeV)
- Thin lines = pPb (5 TeV)
- Circles = pp (7 TeV)
- Squares = pPb (5 TeV)
- Stars = PbPb (2.76 TeV)
Omega to pion ratio (GC)

EPOS 3.210

ALICE (black)

ratio to \( \pi \)

\[ \Omega \]

\[ \frac{\text{dn}_{\text{ch}}}{\text{d}\eta(0)} > \]

thick lines = pp (7TeV)
thin lines = pPb (5TeV)
circles = pp (7TeV)
squares = pPb (5TeV)
stars = PbPb (2.76TeV)
4 EPOS Summary

- Based on “semihard Pomerons” (parton ladders)
- Multiple scattering via Gribov-Regge approach, employing cutting rules
- Realizing configurations via Markov chains
- Consistent “outside to inside” parton production
- “Natural” parton-string mapping
- Core-corona separation, hydrodynamic expansion of core (=> flow)
- Statistical hadronization (new: microcanonical)