Efficient method of adding NLO corrections into ladder of the initial state parton shower

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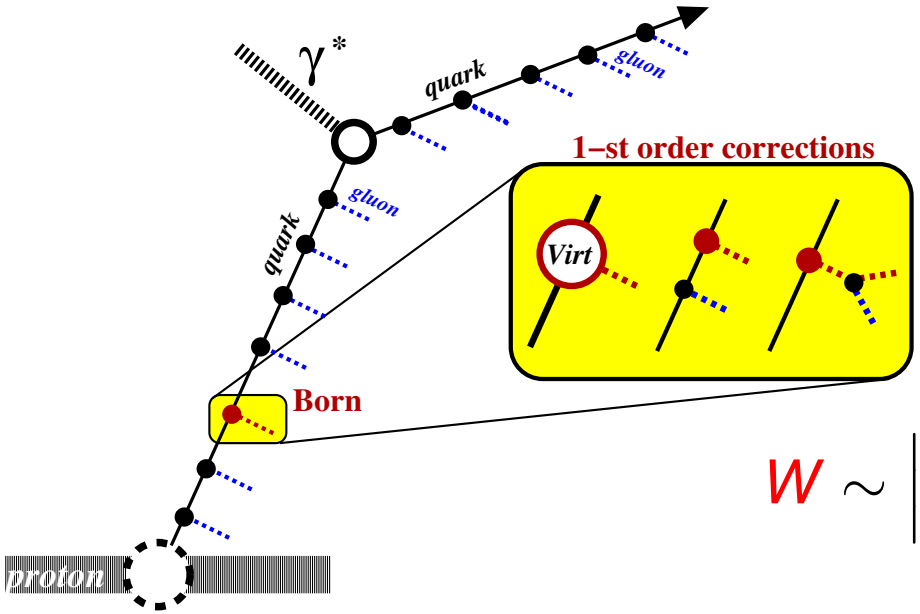
Towards NNLO hard process + NLO parton shower

- Simplified method of introducing **NLO** corrections to **hard process** Febr. 2012 workshop at CERN. (arxiv.org/abs/1103.5015, arxiv.org/abs/1209.4291) An alternative to MC@NLO and POWHEG.
- MC parton shower with **NLO-corrected kernels** in the fully unintegrated/exclusive MC form is pursued, RADCOR 2009 (arxiv.org/abs/1102.5083). Feasible, but **slow/inefficient** method,
- **More efficient** variant with the "kT-ordering within the angular ordering" is reported here, preliminary!
- Most of results still at the "feasibility study" stage:(

NLO-corrected middle-of-the-ladder kernel, $\sim C_F^2$



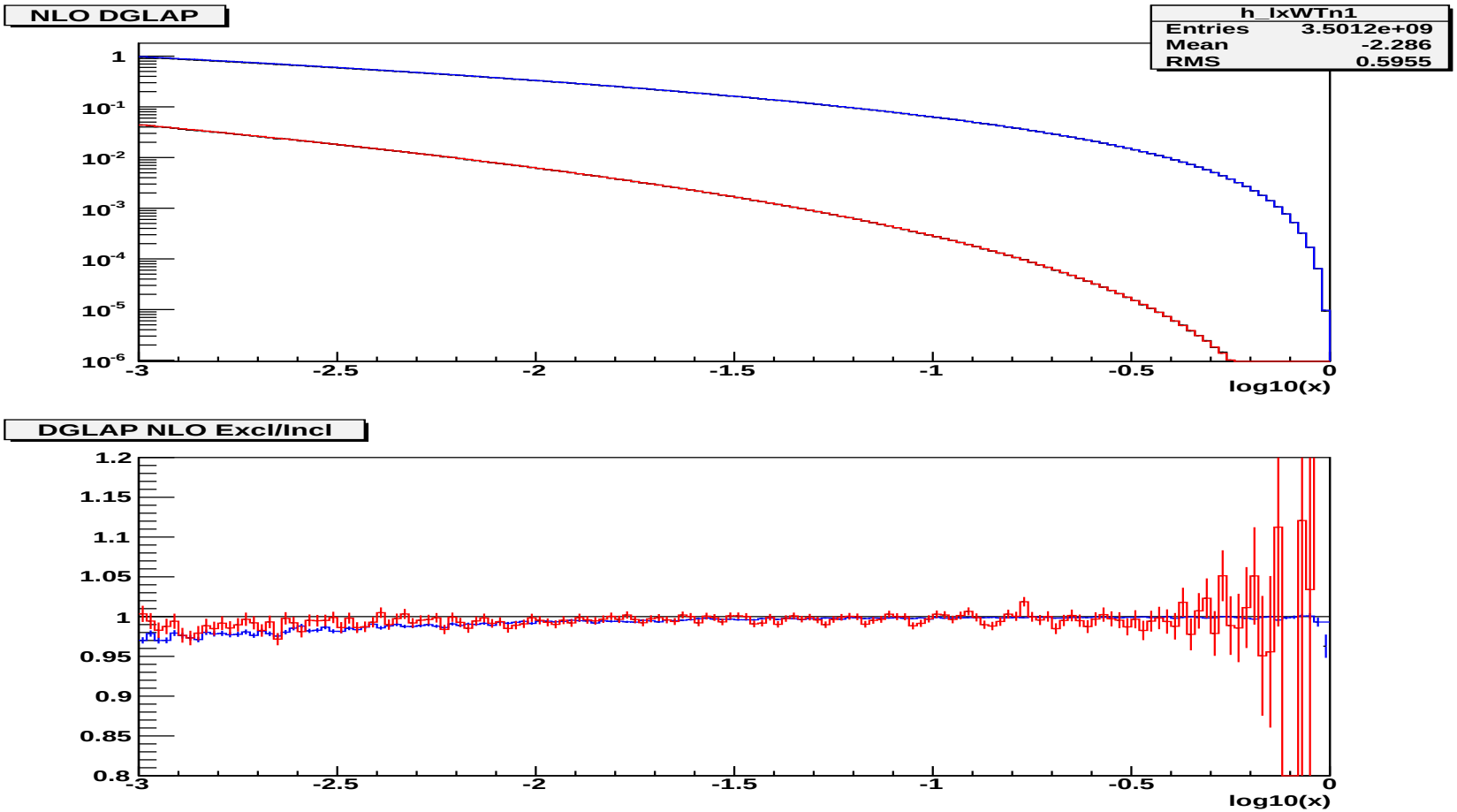
$$W \sim \left| \; \right|^2 = \left| \; + \; \right|^2 - \left| \; \right|^2$$

$$\bar{D}_B^{[1]}(x,Q) = e^{-S_{ISR}} \sum_{n=0}^{\infty} \left\{ \left| \; \right|^2 + \sum_{p=1}^{n} \left| \; \right|^2 + \sum_{p=1}^{n} \sum_{j=1}^{p-1} \left| \; \right|^2 \right\} = e^{-S_{ISR}} \left\{ \delta_{x=1} + \right.$$

$$\left. + \sum_{n=1}^{\infty} \left(\prod_{i=1}^{n} \int_{Q>a_i>a_{i-1}} d^3\eta_i \; \rho_{1B}^{(1)}(k_i) \right) \left[1 + \sum_{p=1}^{n} \beta_0^{(1)}(z_p) + \sum_{p=1}^{n} \sum_{j=1}^{p-1} W(\tilde{k}_p, \tilde{k}_j) \right] \delta_{x=\prod_{j=1}^{n} x_j} \right\}.$$

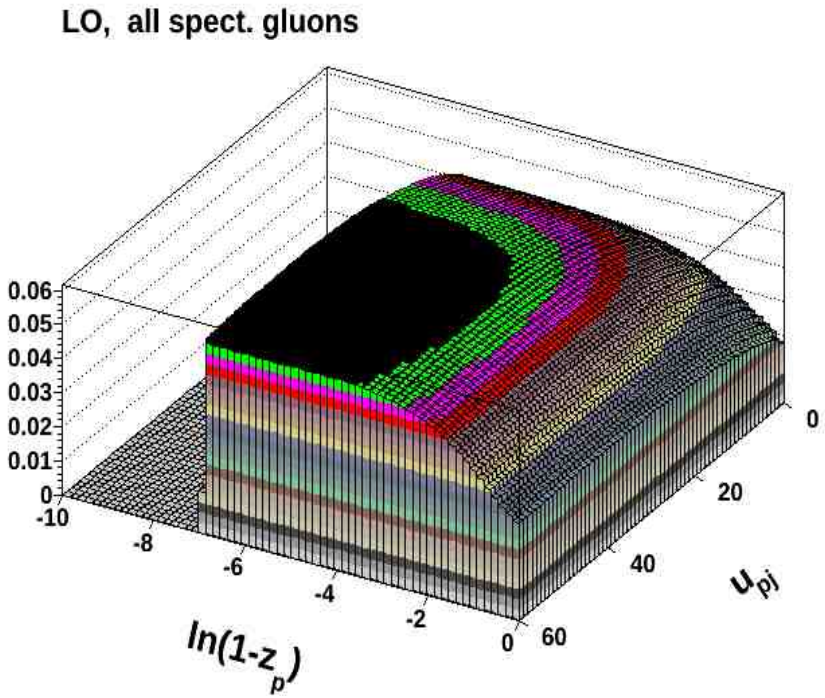
RADCOR 2009 test for NLO-corrected ladder

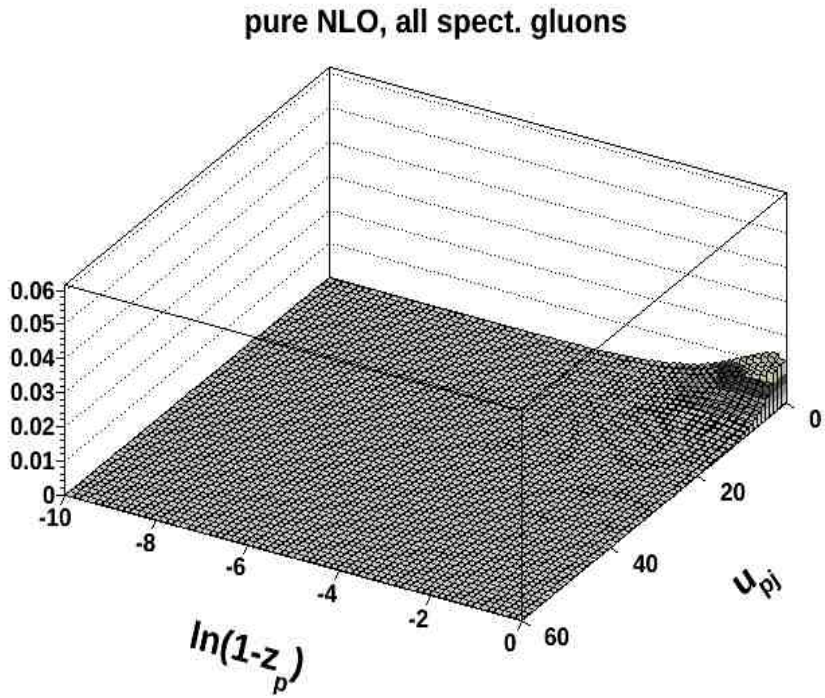
RADCOR 2009: NLO MC vs. analyt. NLO kernels. Perfect agreement



Single ladder, 1GeV-1TeV, 1 or 2 kernels NLO-corrected (3G ev.)

Location and size of the (real) NLO correction in the ladder on the Sudakov log space



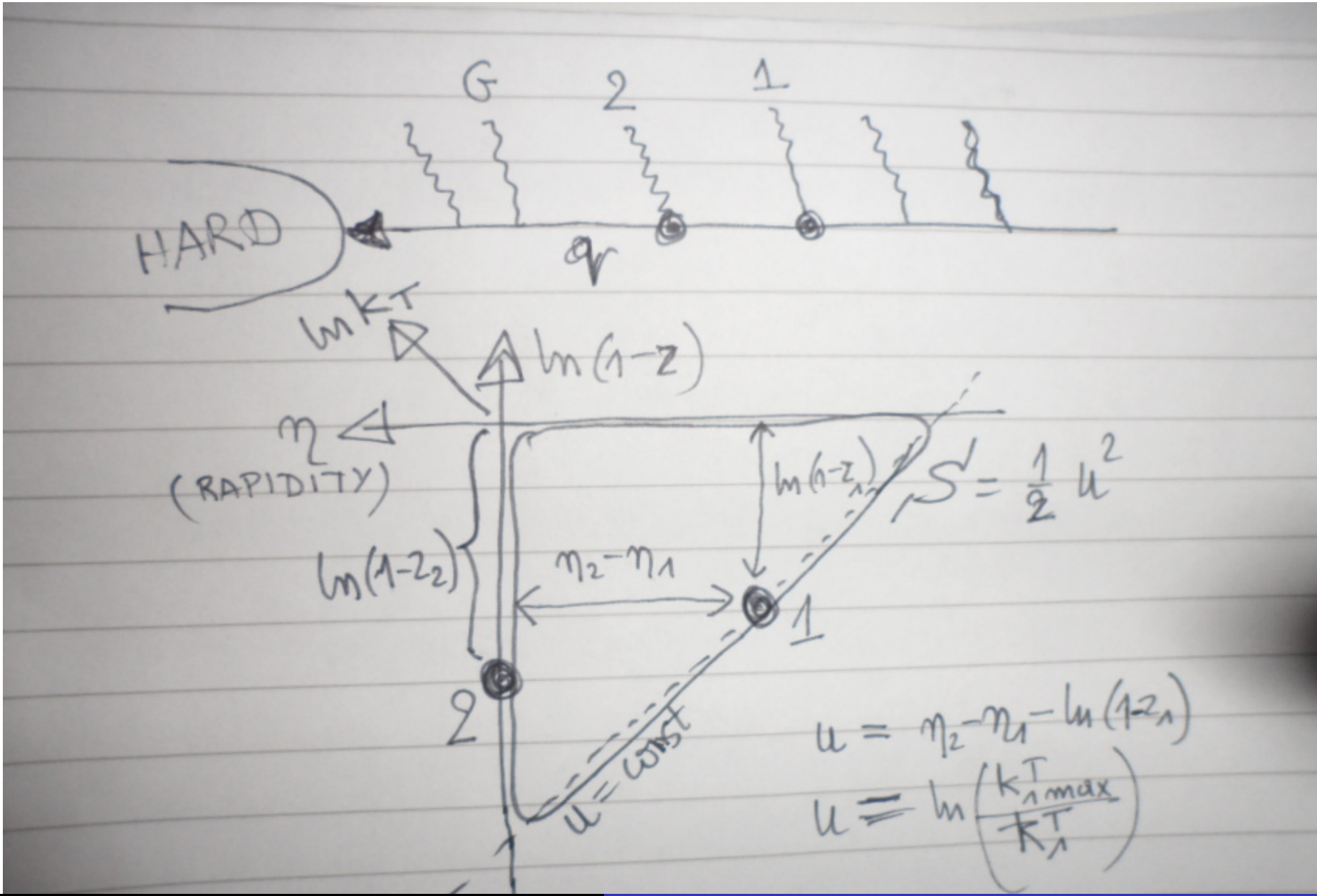


LO inclusive distribution features triple-log IR/coll. singularity, seen as a plateau in 2-dim. projection.

NLO correction IR/coll. finite, nonzero in the corner of the size ~ 1.

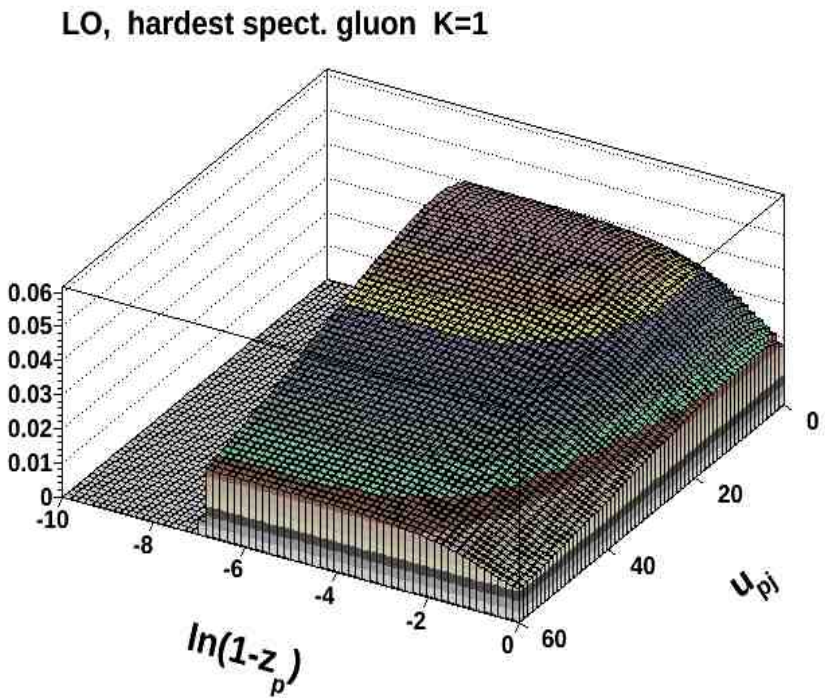
Kinematics of for 2 gluons in the ladder

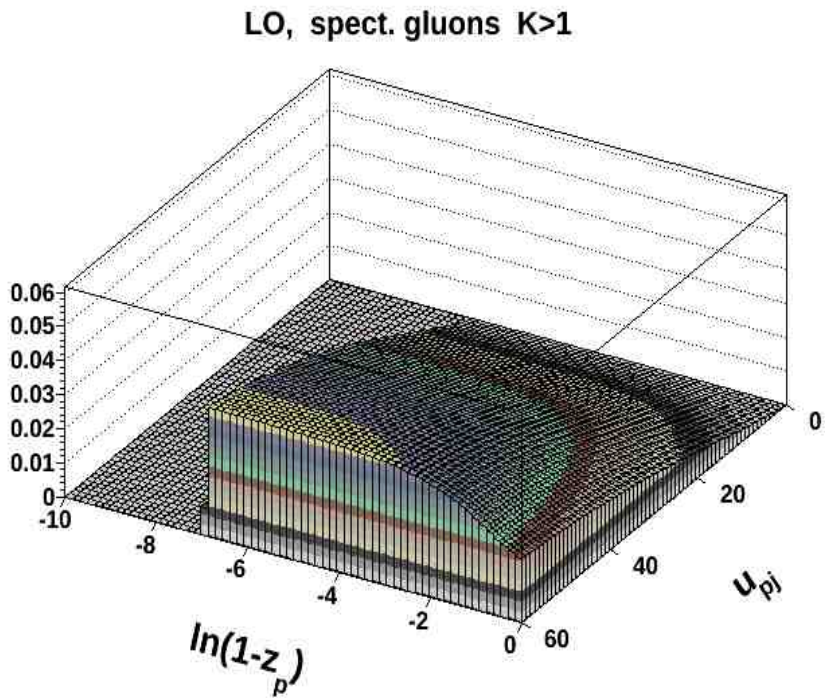
NLO nonzero ONLY if both 1 and 2 in the upper left corner



New method: reduce the sum over spectator gluons just to 1 or 2 terms, which ones?

Inclusive LO distr. of gluons split into the one with max. kT and the rest

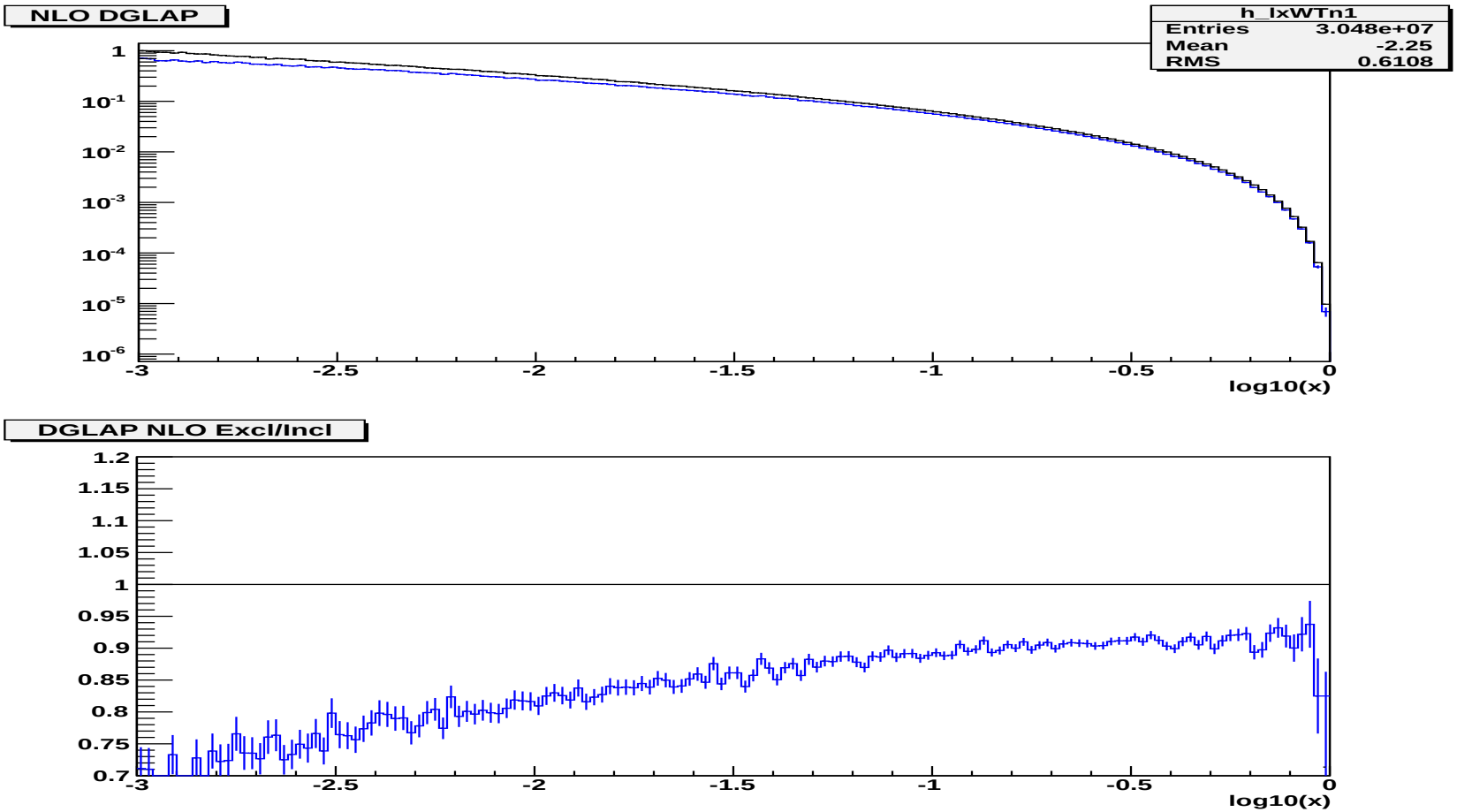




LO distribution of the hardest kT spectator gluon approximates the total distribution in small corner where NLO is non-zero.

NEW test for NLO-corrected ladder

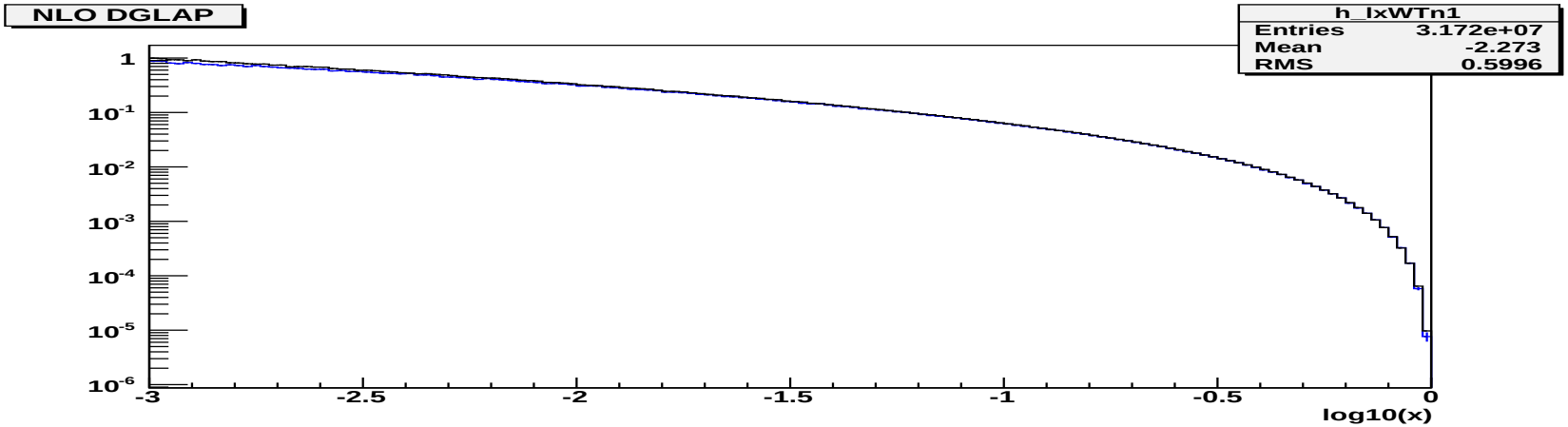
PRELIMINARY!!! May 2012: single contrib. from gluon with max. kT

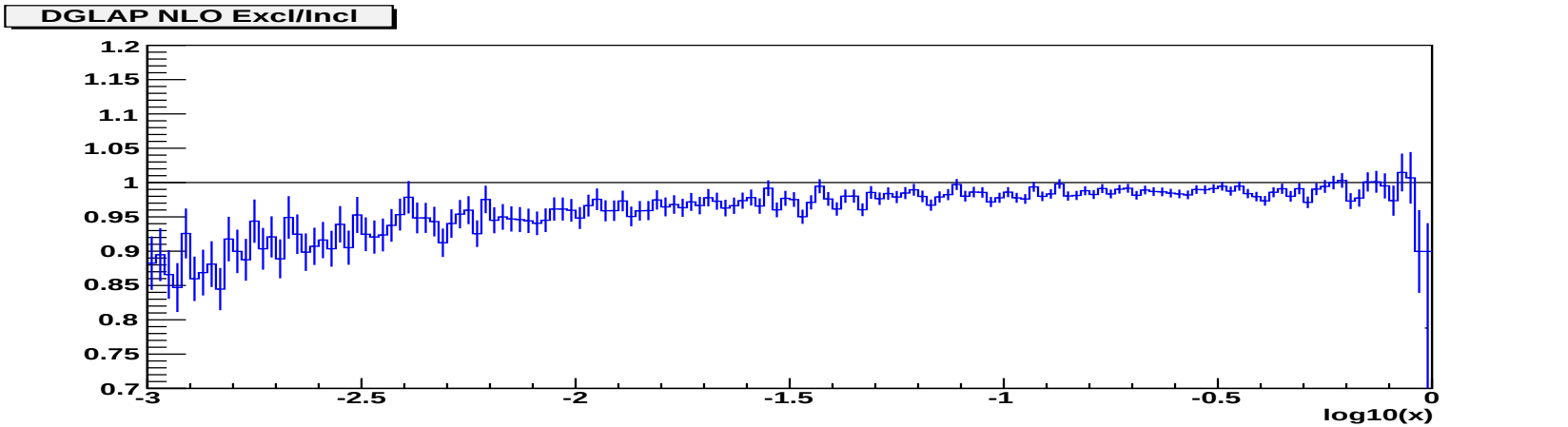


This difference $\sim$ 30% is formally the NNLO/NLO class. (30M evts)

NEW test for NLO-corrected ladder

PRELIMINARY!!! May 2012: contrib. from 2 gluon with max. kT





The difference is acceptable but still $\sim$ 10% (formally N3LO/NLO).

Summary

- Parton shower MC implementing complete NLO DGLAP in the ladders in exclusive form is feasible and we are now optimizing the algorithm.
- Long term: NLO ladder + NNLO hard process, but LO ladder + NLO hard proc. to be optimized first.
- Most likely application: high quality QCD+EW+QED MC with hard process like $W/Z/H$ boson production.
- Potential gains from new QCD methods are:
  – reducing uncertainties due to distributions of partons in hadrons (PDFs, parton luminosities etc.)
  – easier implementation of NLO and NNLO corrections to hard process due to elimination of “trivial” (albeit numerically sizeable) soft gluon corrections
  – better environment for low x resummation (BFKL, CCFM) and heavy quark masses.