Gaining Analytic Control of Parton Showers

Frank Tackmann

University of California, Berkeley
Lawrence Berkeley National Laboratory

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Work in progress with Christian Bauer

Outline

Possible Improvements from SCET

What is nice about an SCET based description?

- SCET reproduces the parton shower at leading order
- Provides framework for systematic improvements
  - Matching QCD to SCET
  - Subleading logs from running
  - Power corrections
- Gives systematic control of uncertainties

But how can we take advantage of these improvements?

- Matching: in principle possible with existing algorithms
- Power corrections: likely to break probability interpretation
- Subleading logs: definitely break binary structure of parton showers
- How to implement uncertainties?

Practical Limitations

There are also important practical limitations

- Detector simulation is very time consuming, $\mathcal{O}$(minutes/event)
- Disk space is limited, $\mathcal{O}$(MB/event)
- It is very impractical to impossible to
  - Resimulate full event set each time theory makes progress
  - Simulate separate event sets for different parameter sets or different parton shower implementations/schemes

The Idea

We can solve all of these problems (in principle) by proceeding in 3 steps

1. Use existing parton showers to produce events
   - That's the easy part
2. Compute relative probability with which each single event was generated
   - Requires analytic control of what the parton shower is doing
   - Try to keep necessary numerical integrations at a minimum
3. Reweight events according to any desired analytical distribution on *event by event* basis
   - Can take full advantage of SCET improvements (whenever they become available)
   - Can estimate uncertainties from input parameters (α_s, matching scales, ...)
   - Greatly simplifies tuning of parton shower variables (t_{cut}, various schemes)

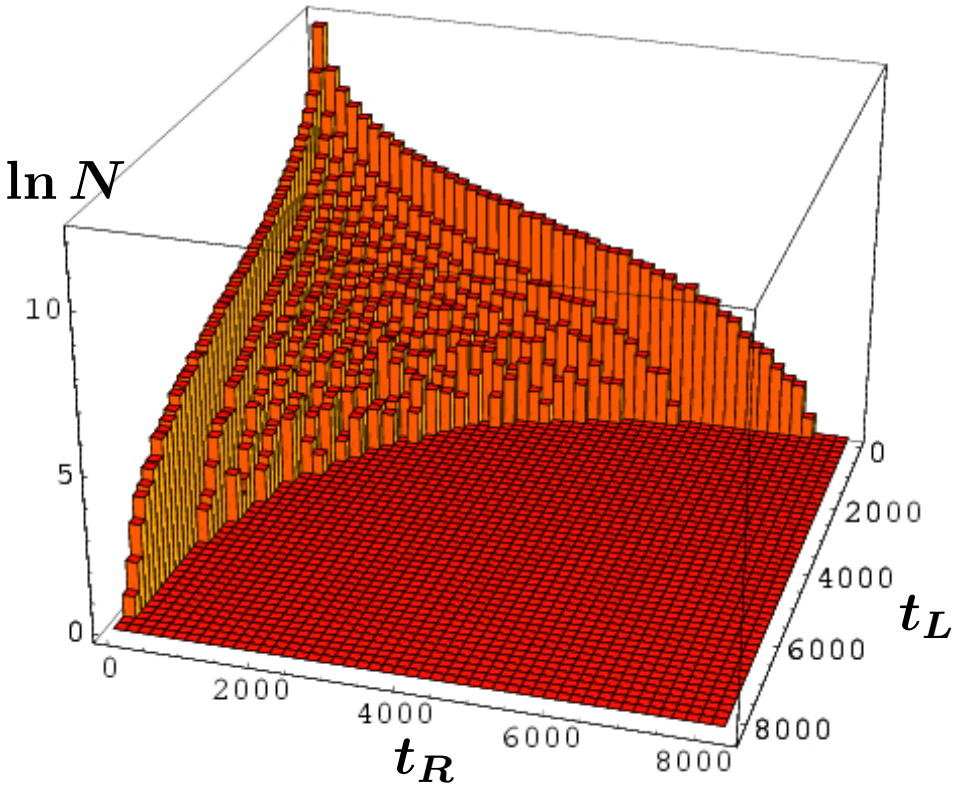
Technical Details ⟶ Blackboard

1. Reweighting
2. Naive parton shower
3. Real-life parton shower
4. Modifications

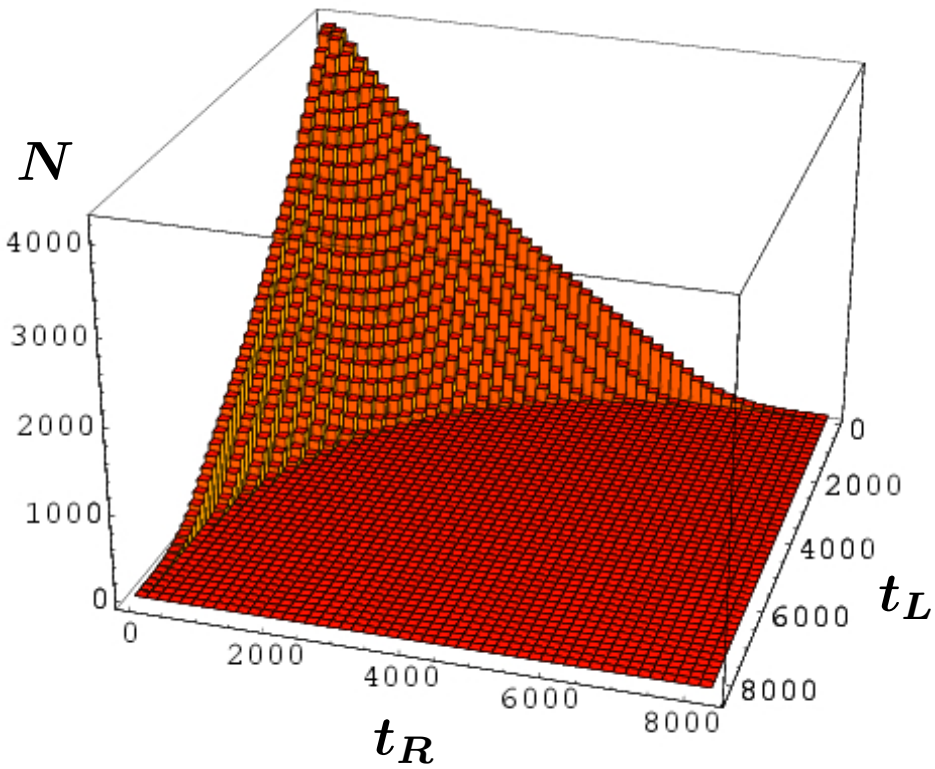
Reweighting to Flat Distribution

- Reweight to flat distribution in $t_{L,R}$ and $z_{L,R}$.

Parton Shower Generated



Theoretical



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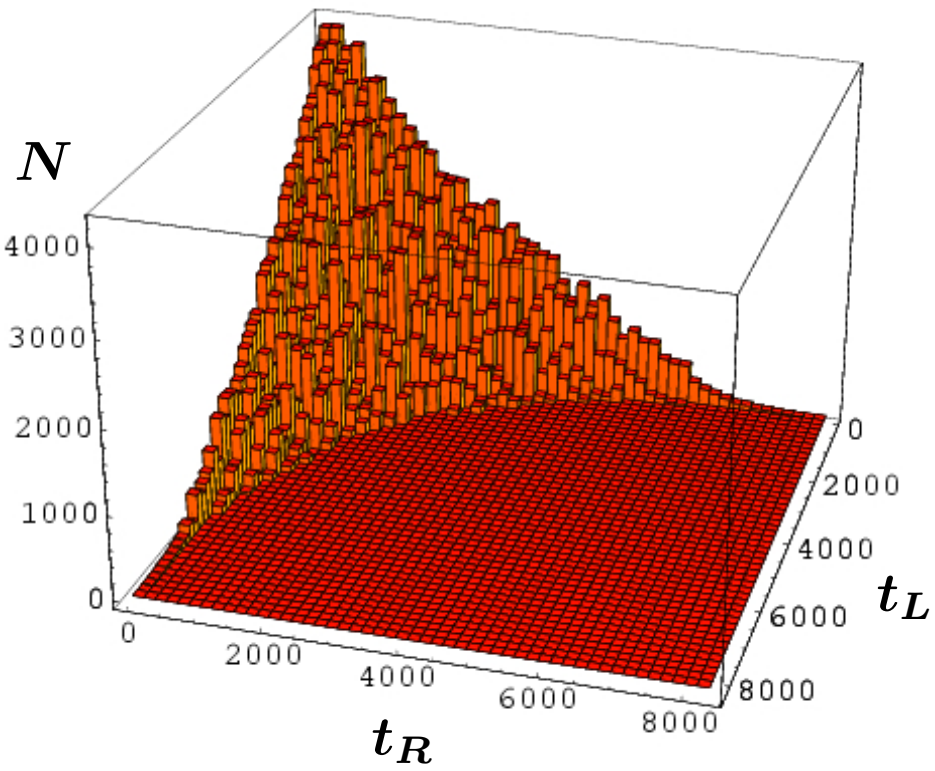
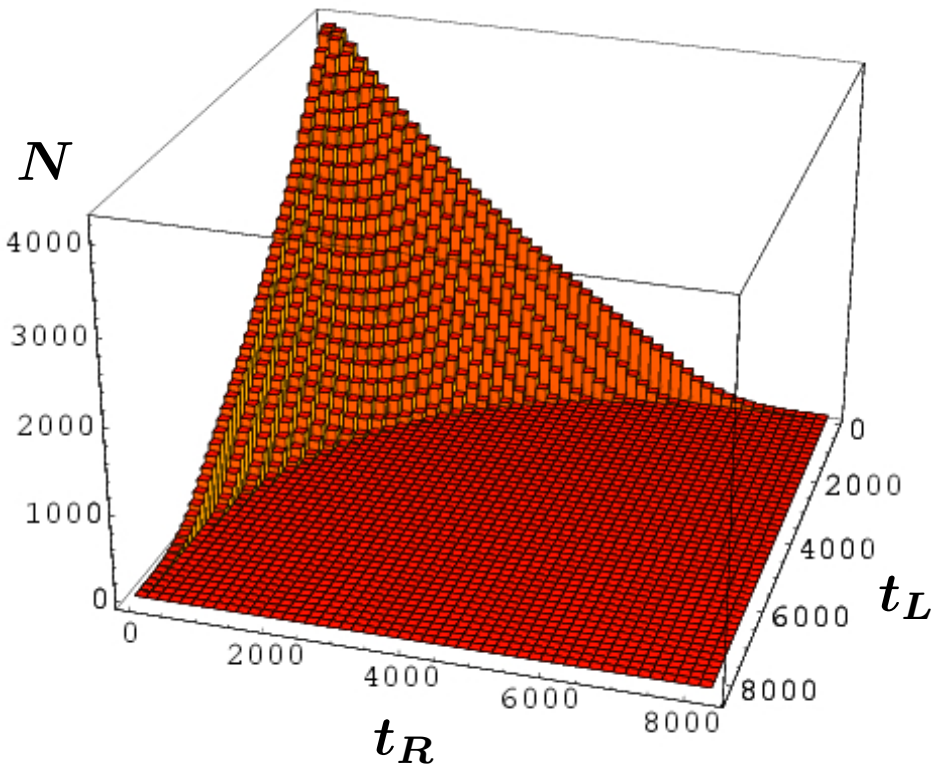
Parton Shower Reweighted



Theoretical



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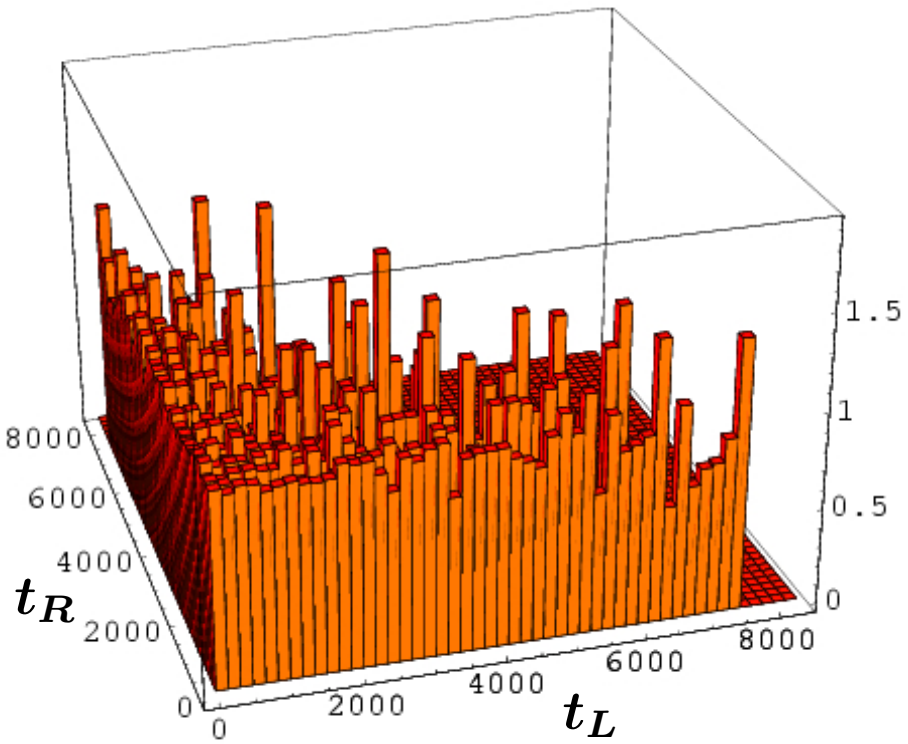
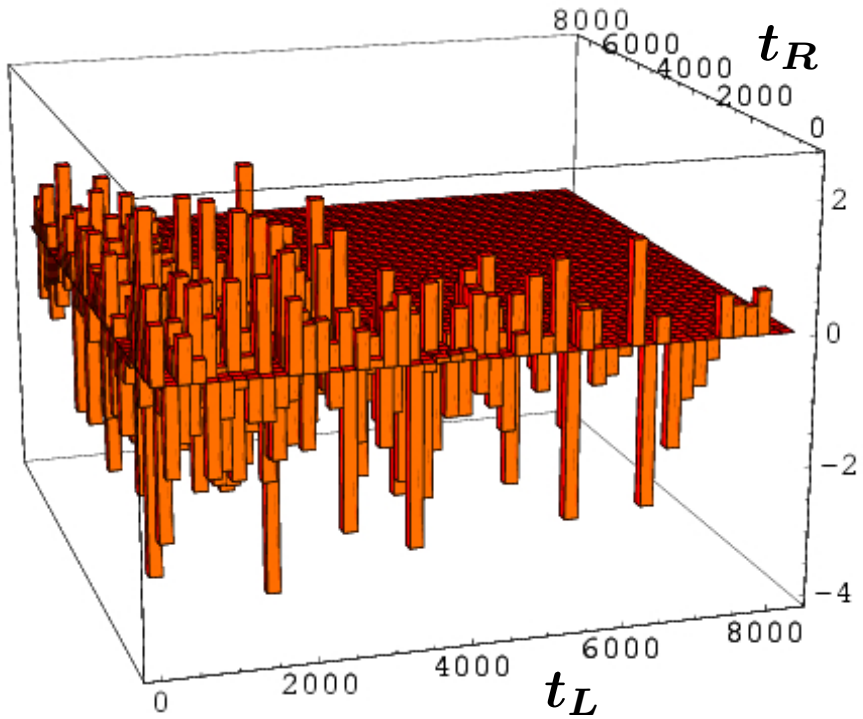
Ratio



Pull Distribution



Conclusions and Outlook

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- Parton shower can be modified to gain analytic control
- Reweighting works for single branches (including quark masses)
- Incorporated modifications into Sherpa

Outlook

- Things to do next
  - Include angular ordering veto and gluon splitting functions
  - Test reweighting on fully showered events
  - Check effect of modifications on observables
- Future plans
  - Concrete applications (SCET, parton shower uncertainties, ...)
  - Convince parton shower people (and experimentalists)
  - General framework

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