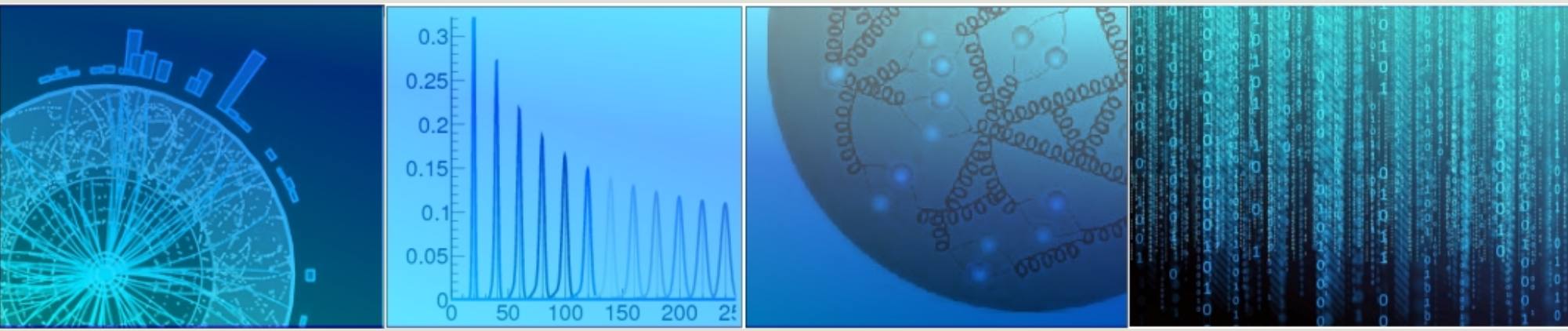
MemTk
Real Experiences, Challenges & Discussion

Data Science @LHC Workshop | CERN · November 10, 2015



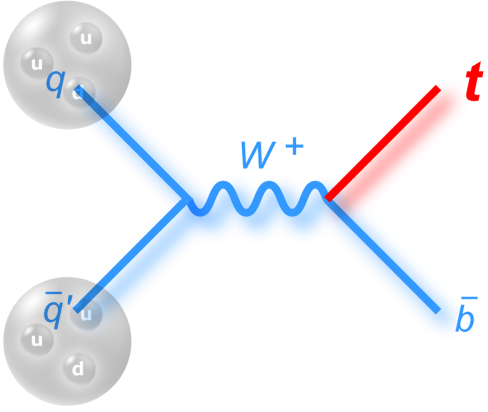
Patrick Rieck · Oliver Maria Kind · Sören Stamm

Institut für Physik
Humboldt-Universität zu Berlin
Germany

Single-Top *s*-Channel Production

Introduction

Motivation:



Feb 2014 | CDF & DØ @1.96 TeV, 9.7/fb
NN, BDT, ME combination ➔ 6.3σ

Dec 2013 | CMS @8 TeV, 19.3/fb
BDT analysis ➔ 0.7σ

Oct 2014 | ATLAS @8 TeV, 20.3/fb
BDT analysis ➔ 1.3σ

First evidence in pp collisions at the LHC ?

Event selection:

- Isolated high-p_t e|μ & 2 b-jets & large $\not{E}_t$
- Main backgrounds: $t\bar{t}$, W+jets, single-top *t*-channel

Single-Top *s*-Channel Production
ME discriminant

- Build ME discriminant for each selected event
  Discriminate *s*-channel against *t*-channel, $t\bar{t}$, W+$b\bar{b}$, W+c + jet, W+jets light-flavour
- Signal probability for given event X:
  (Bayes' theorem)

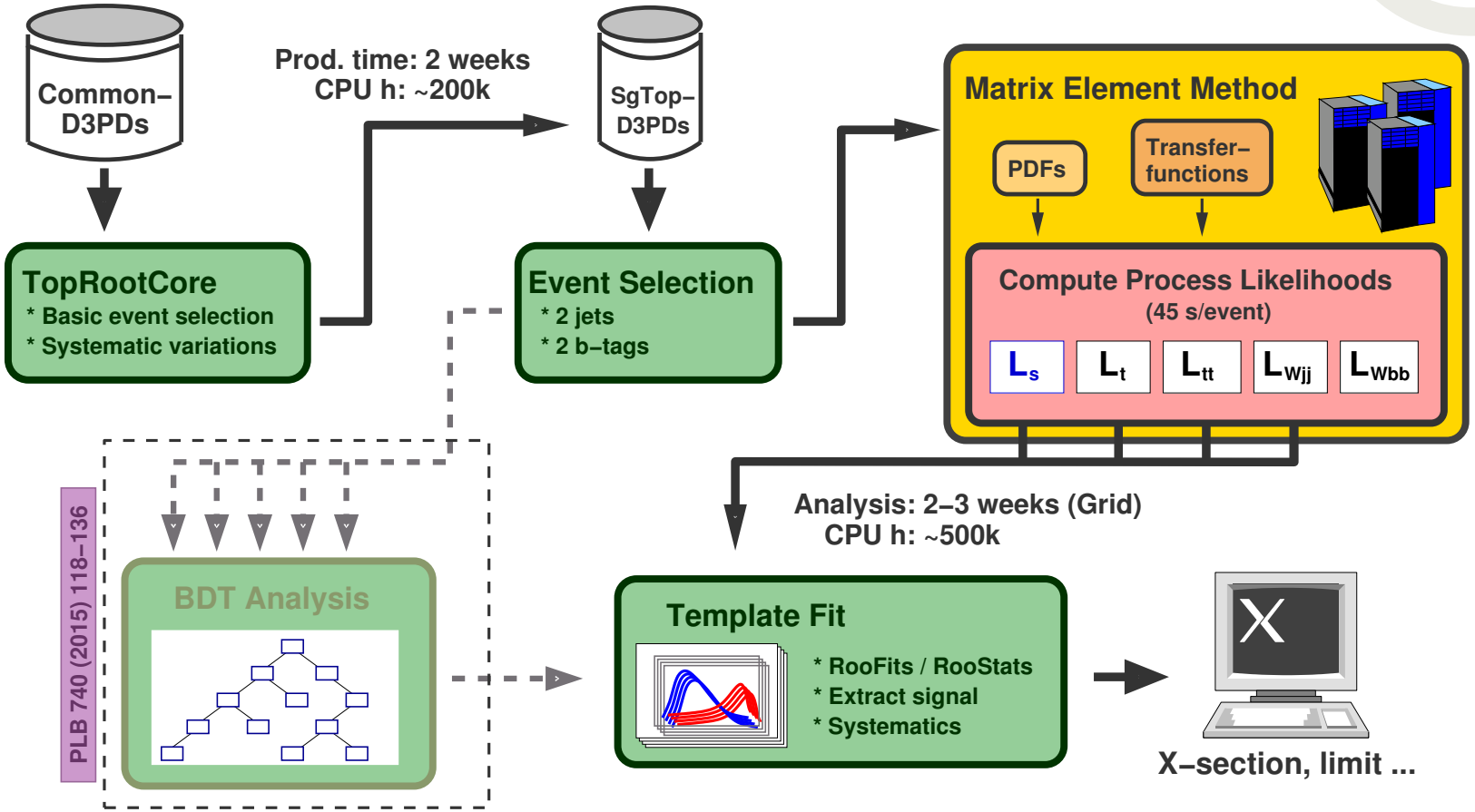
$$P(S|X) = \frac{\sum_S P(S)\mathcal{P}(X|S)}{\sum_S P(S)\mathcal{P}(X|S) + \sum_B P(B)\mathcal{P}(X|B)}$$

- Process likelihoods, $\mathcal{P}(X|H)$:
  - *s*-channel, 2 outgoing partons
  - *s*-channel, 3 outgoing partons
  - *t*-channel (2→3)
  - $t\bar{t}$, single lepton | di-lepton
  - W + 2 outgoing light partons
  - W + $b\bar{b}$
  - W + c + 1 outgoing parton
- P(H): *a priori* probabilities given by relative MC event yields
- Signal shape differs from background shapes

➔ signal extraction: template fit of ME discriminant distributions

Single-Top *s*-Channel Production

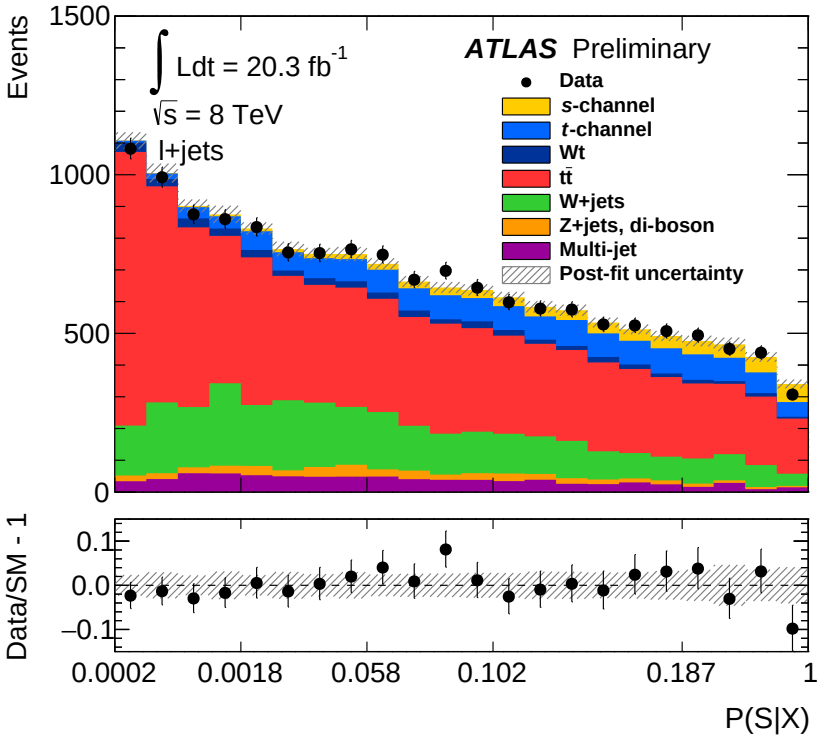
Analysis outline



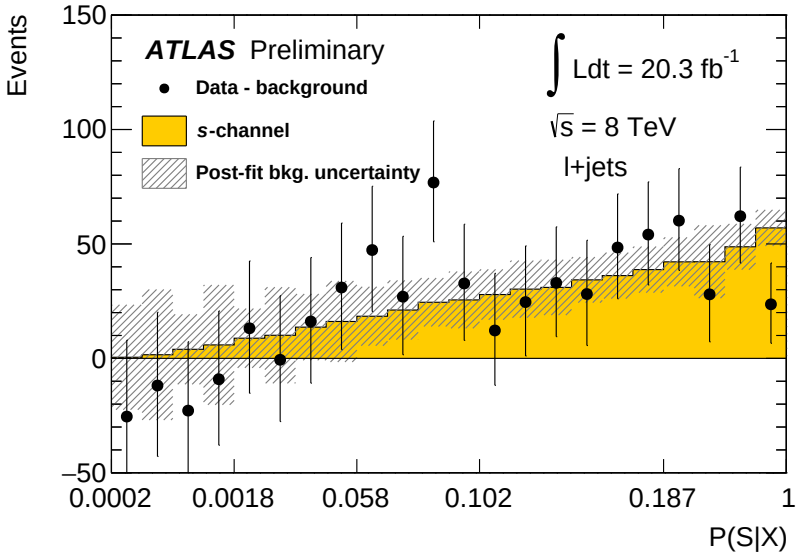
- Compute all event probabilities for all systematics in parallel ➔ GRID
- Total computing time for all processes per event: ~ 45s only
  (Achieved by random number transformations, MC integration optimization, exploiting crossing symmetries, smart caching etc.)
- Analysis can be run on a feasible time scale

Single-Top *s*-Channel Production
Results

Post-fit ME discriminant



ME discriminant, signal only



Cross-section measurement:

$$\sigma_s = 4.8 \pm 1.1(\text{stat.})^{+2.2}_{-2.0}(\text{syst.})\ \text{pb}$$

- Observed significance 3.2σ
- Expected significance 3.9σ

First evidence for single-top *s*-channel production at the LHC

ATLAS-CONF-2015-047

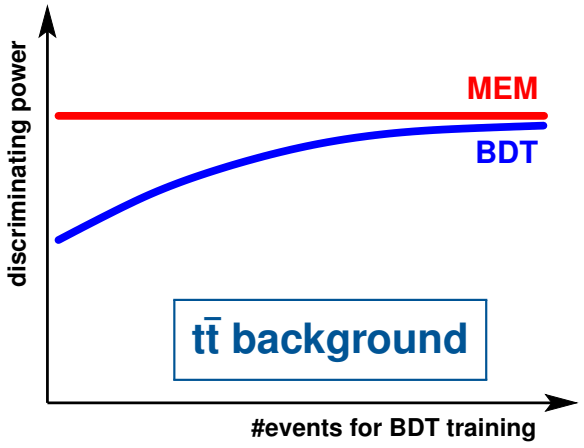
ME vs. BDT Comparison

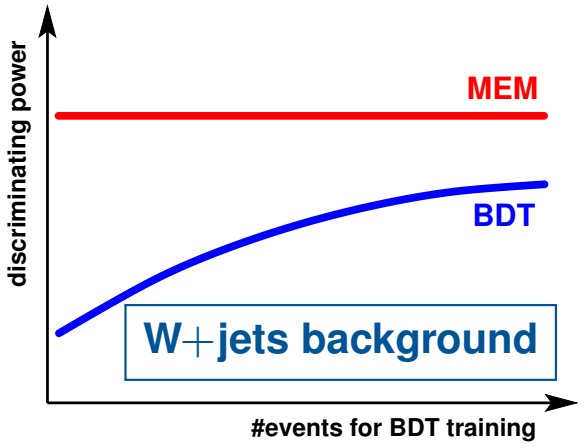
Single-Top *s*-channel analysis

- Performed detailed comparison between (old) BDT and ME analysis
- Partial improvement by better calibration, improved/larger MC samples and improved event selection

MC statistics:

- The BDT suffers from an insufficient number of training events for some of the main backgrounds





MEMTk Fact Sheet

Purpose:

- A C++ package for the computation of ME event likelihoods

Dependencies: ROOT, CUBA, LHAPDF

Input / output: ROOT-based ntuples (generic or user-defined)

Processes:

- Already implemented:
  - single-top: *s*-channel $2\to2|3$, *t*-channel $2\to2|3$
  - $t\bar{t}$: single lepton | di-lepton
  - $W+qq$, $W+qqq$, $W+cq$, $W+\bar{b}$, $W+b\bar{b}q$, $WH\to b\bar{b}$, $WqH\to b\bar{b}$
- Adding more processes possible (not automatized)

Performance:

Per process (depending on precision)	1 – 10 s
For a typical single-top event (7 processes)	40 – 50 s
$20\,\text{fb}^{-1}$ including ~90 systematics	2 weeks

Availability: will be public soon – currently upon request only