Tuning of the g→bb splitting and treatment of correlated systematic uncertainties in Professor

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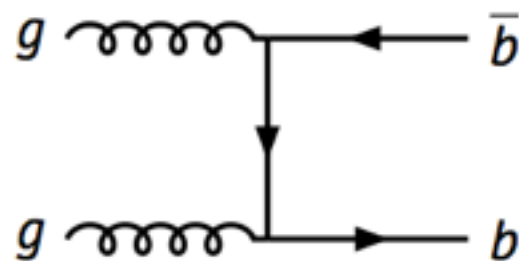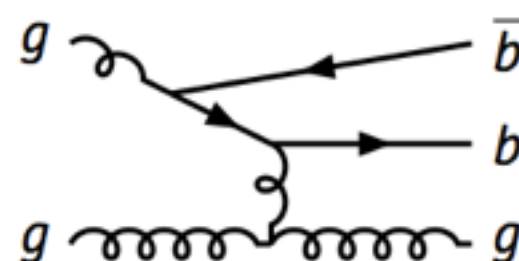Albert Ludwigs Universität Freiburg

Introduction

- Professor is the standard tool to MC tuning

- With the wealth of statistics available at LHC many measurements are already systematics limited, even more so in Run2

- Having the possibility to correctly treat the bin-by-bin correlations among uncertainties becomes crucial

  ▷ Especially for uncertainties like b-tagging or JES

- The rate of gluon splitting to HF quarks is used as a case study:

  ▷ Crucial as background to Higgs and NP searches

  ▷ Significant theoretical uncertainties in the predictions of collinear b-quarks

- Goal of producing a Pythia tune (hopefully also Sherpa and Herwig++) to all sensitive measurements of LEP, Tevatron and LHC
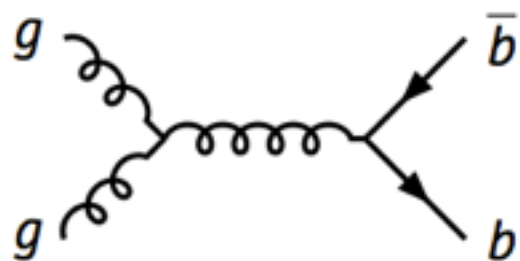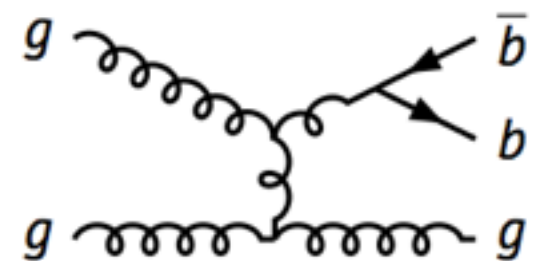
Flavour creation (s- and t-channel)   Flavour excitation   Gluon splitting

Professor in a Nutshell

■ How does Professor works:

▷ Sample N parameter points from the *n*-dimensional space

▷ Run generator and produce RIVET histograms

▷ For each bin *b* in each distribution, use the N points to fit an interpolating function (2nd or 3rd degree polynomial) using singular value decomposition

▷ Construct the overall $\chi^2 = \sum_{bins} \frac{(interpolation - data)^2}{error^2}$

▷ Find the minima with numerical minimisation (Minuit)

■ Already possible to include sys. correlations in the Professor chi2

■ Discussion ongoing on the best way to provide this information:

● Probably will neglect correlations among different histograms or experiments

● Need to have a correlation matrix for each uncertainty for which correlations are to be included

● How should that be provided to HepData? (as of now it would have to be a text file)

Professor

~~Rivet 2.0~~ histogramming upgrade

► We *finally* released Rivet 2.0.0!

► Major effort to move from 1.x to 2.x series: the entire histogram system was replaced with a new interface: *YODA*

► YODA: **http://yoda.hepforge.org**

- Completely new histo library.
- Fast binning, with gaps and easy irregular binning.
- Stores all 2nd order weighted moments: $(\sum w, \sum w^2, \sum wx, \sum wx^2, \sum wxy, \ldots)$ for each bin: *full run combination*
- Natural/default inclusion of overflows and negative weights.
- Lots more features! Pleasant to use, and more data types being added.

► All 250+ analyses had to be migrated and numerically validated…

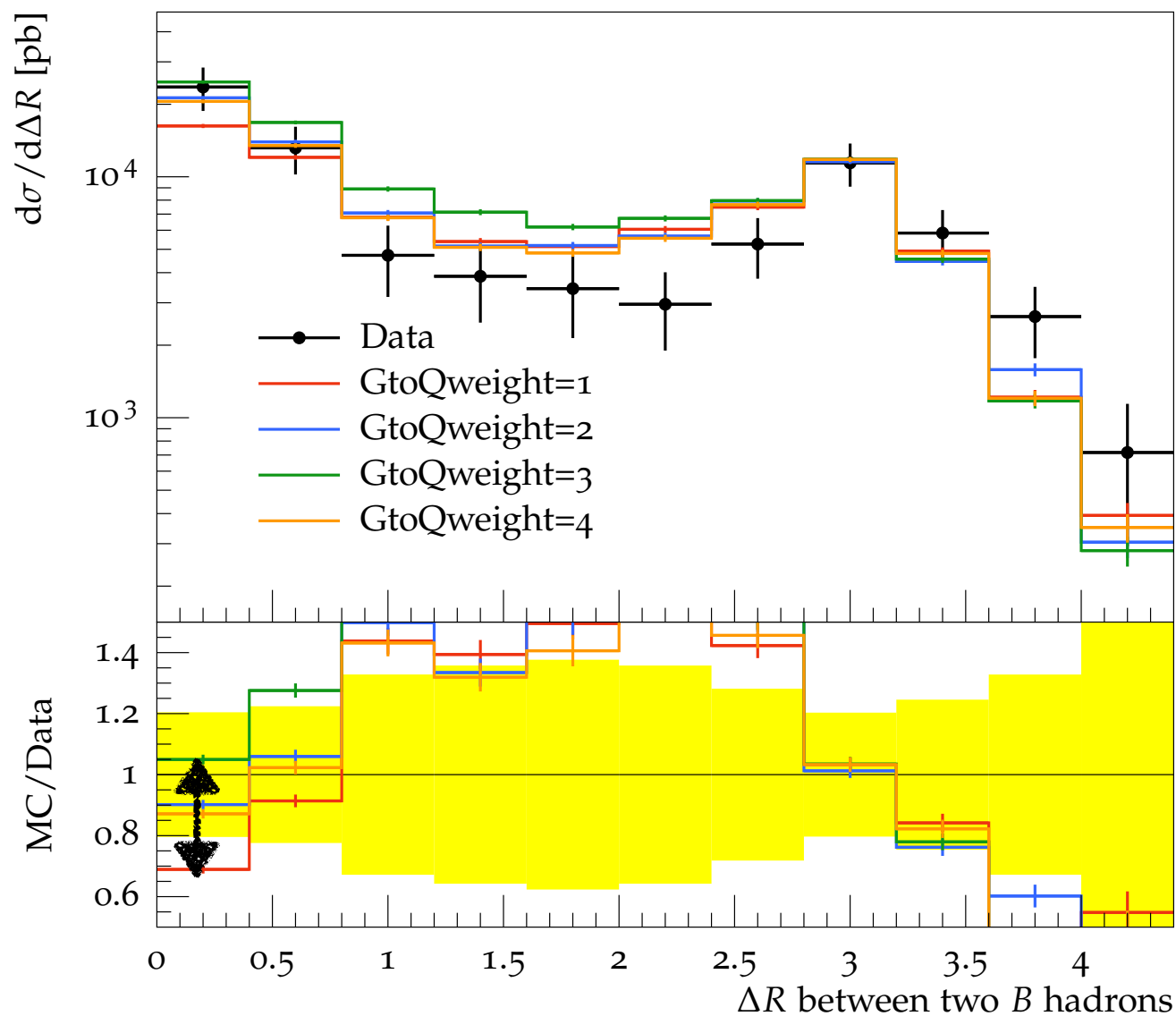Will soon be released in a new Professor development version

Gluon splitting to HF quarks

■ Parton Showers introduced several option to control gluon splitting:

   ▷ In Pythia 8.165 can weight the g->qqbar branching

   ▷ Sherpa allows the gbb coupling to be either k_T and m_{bb}

   ▷ Herwig++ ?

■ Looking into as many measurements as possible

   ☐ LEP measurements of g->bb and g->cc (a single number per experiment)

   ☑ arXiv:9905024 - D0 b-bbar cross-section and angular correlations

   ☑ arXiv:1102.3194 - CMS B-hadron correlations

   ☑ arXiv:1109.6833 - ATLAS dijet cross-section of b-jets, 36 pb^{-1}

   ☐ arXiv:1310.1349 - CMS Z+bb (not in HepData, contacted authors)

   ☑ ATLAS Z+bb (RIVET routine available, soon to be released)

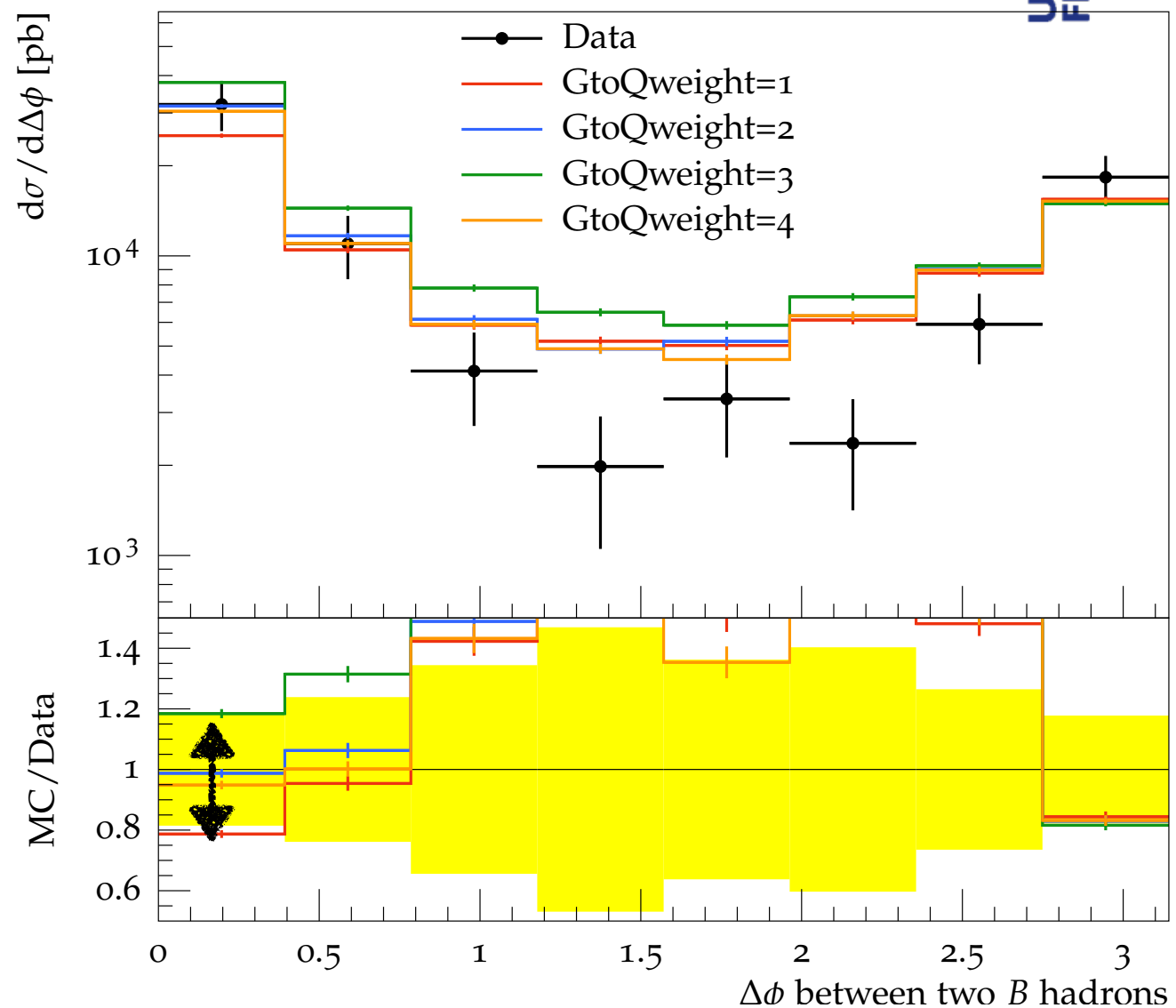   ☑ ATLAS dijet cross-section of b-jets, 4.7 fb^{-1}

CMS B-HADRON CORRELATIONS
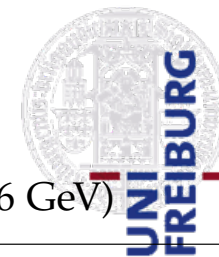
$B\bar{B}$ production cross-section (leading jet $p_\perp > 56$ GeV)

$B\bar{B}$ production cross-section (leading jet $p_\perp > 56$ GeV)

- Data
- GtoQweight=1
- GtoQweight=2
- GtoQweight=3
- GtoQweight=4

ΔR between two B hadrons

$\Delta \phi$ between two B hadrons

- Clear effect at small angular separation of the *b*s, where the gluon splitting process is expected to dominate, although all weighting choices are within uncertainties

- Similar conclusions for the other analyses, hopefully the ones yet to be released will provide more sensitivity

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