Peter Skands (Monash University)

# Status of the MCPlots Project

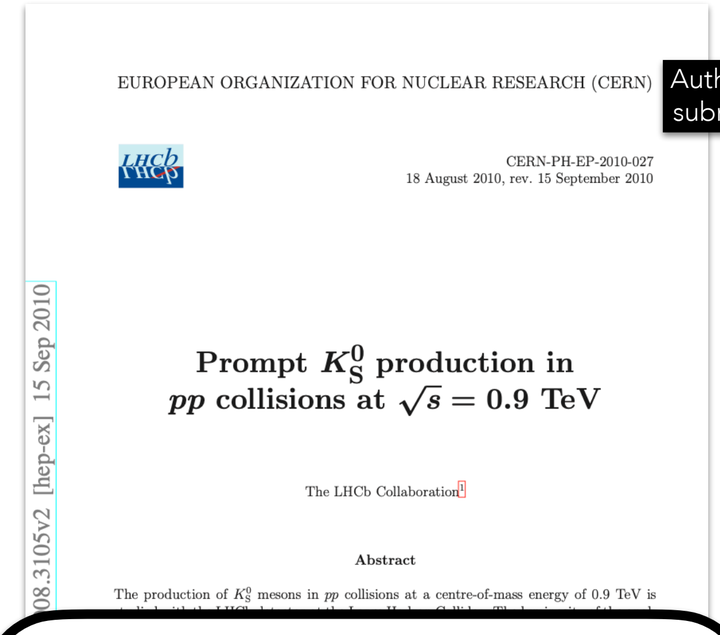

http://mcplots.cern.ch

A. Karneyeu et al., *Eur.Phys.J.C* 74 (2014) 2714

Monash-Warwick Particle Physics Meeting **March 2023**

# From Data Analysis ➟ Validation of (current & future) MC Event Generators

## Experimental Measurement



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN-PH-EP-2010-027
18 August 2010, rev. 15 September 2010

[hep-ex] 15 Sep 2010
08.3105v2

**Prompt $K^0_S$ production in $pp$ collisions at $\sqrt{s} = 0.9$ TeV**

The LHCb Collaboration[1]

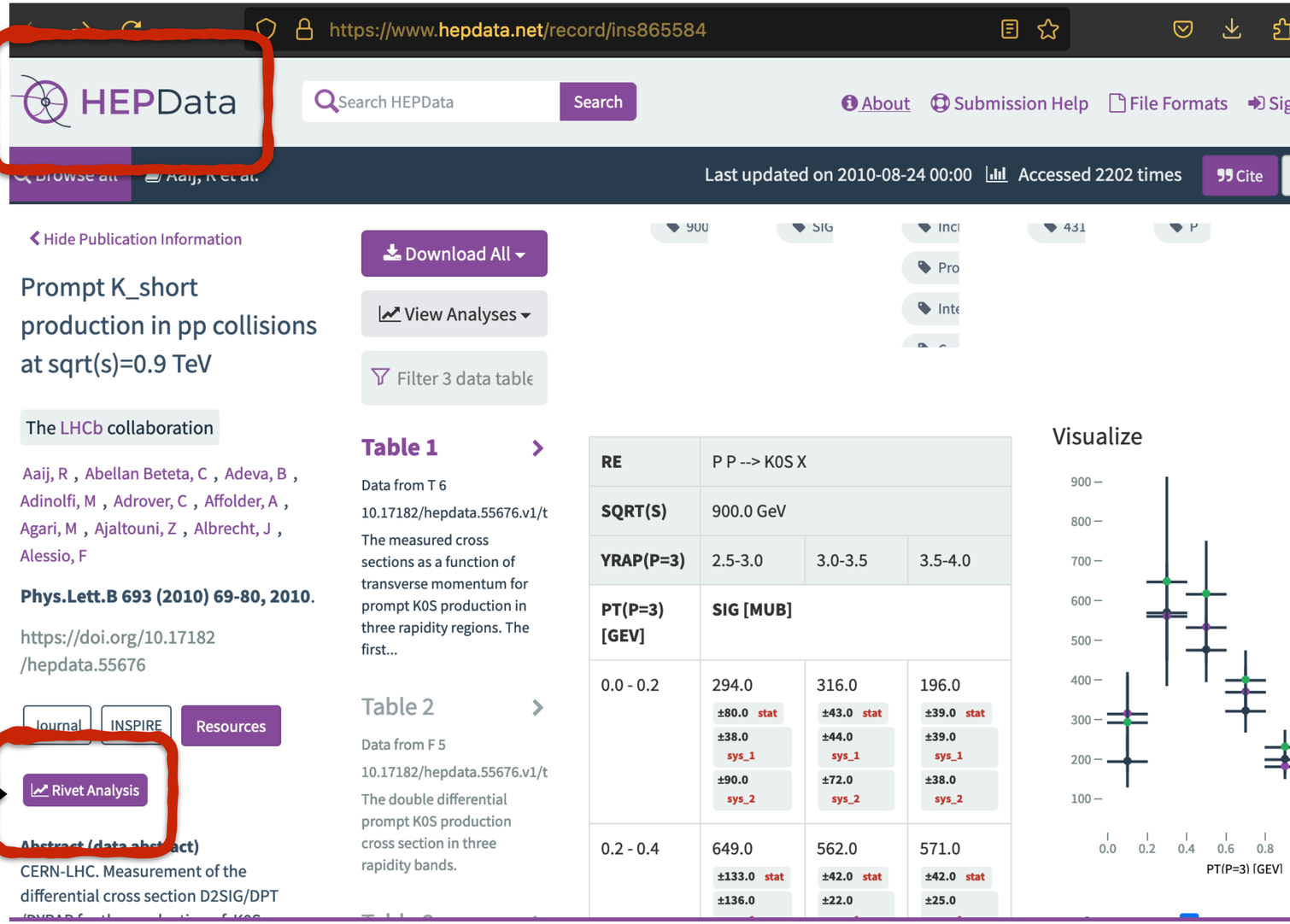
**Abstract**

The production of $K^0_S$ mesons in $pp$ collisions at a centre-of-mass energy of 0.9 TeV is

Authors prepare & submit records to:

## Data Preservation (for HEP): HEPData

(HEPData is funded by the UK STFC and is based at the IPPP at Durham U.)




**How to compare (unambiguously and exactly) to event generators?**

*(e.g., to validate future ones)*

Need **Analysis Preservation** too

Authors prepare & submit **code** to:

## Analysis Preservation (for HEP): Rivet

(Rivet is developed by the CEDAR project, also based in the UK)

# Some years after the org measurement paper …

**Measurement archived in HEPData + analysis code archived in Rivet:**

Easy to run any (salient) MC generator → make comparison plots

Rivet itself contains some nice functionality to assist with this

**Still involves non-trivial effort and time:**

(Installing Rivet + relevant event generators + learning how to use them.)

Setting up (and verifying) run cards for the processes in question

Defining phase-space windows for efficient (but still full-coverage) event generation

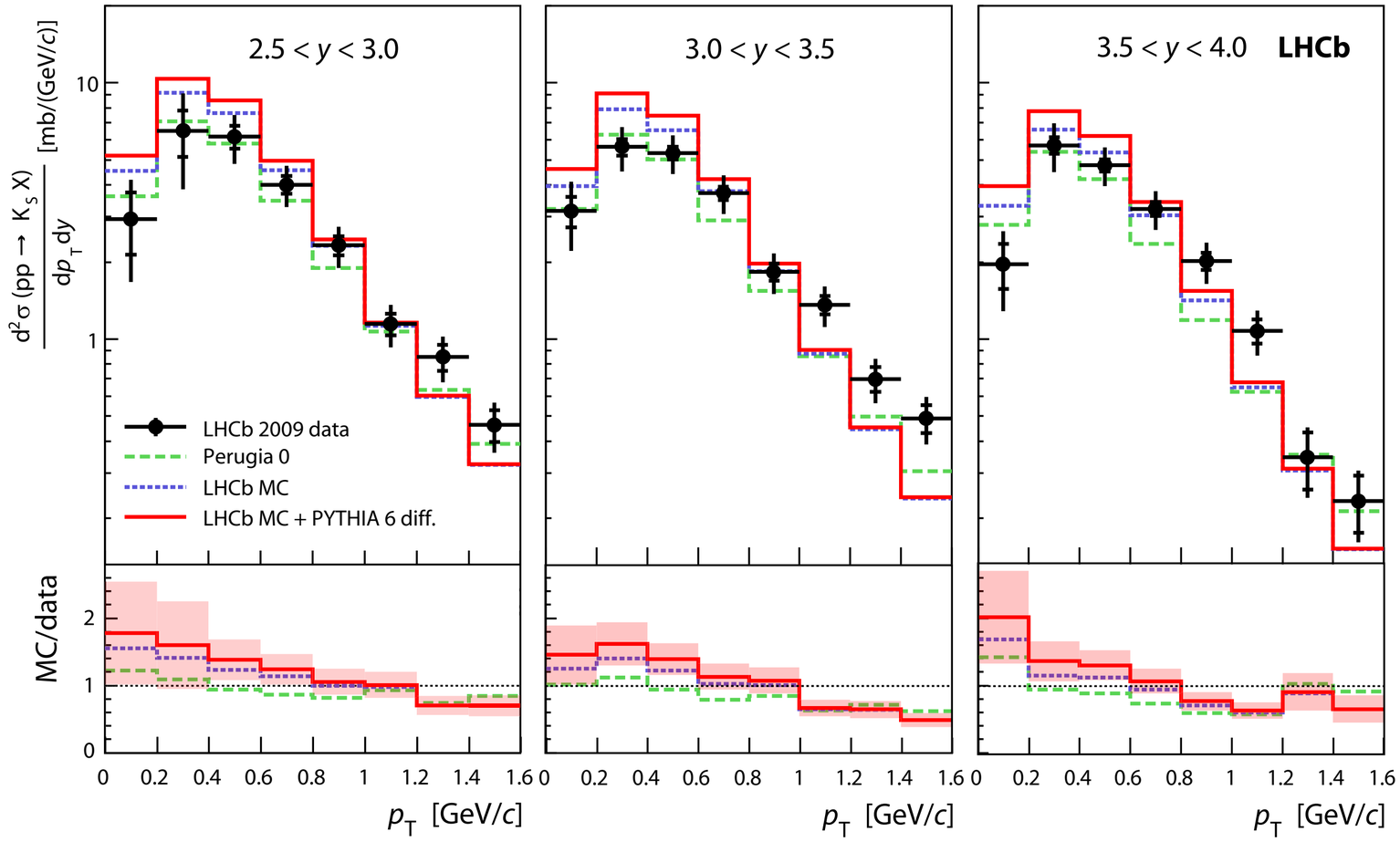
Generating sufficient events (sometimes many millions)

**Possible ✅**

**But not quick!**

No “instant feedback” (eg within a single talk or physics discussion)

# When showing plots from the original paper:




*"Yes but this has been corrected in version X of that generator"*

*"But this other tune or MC that you didn't compare to does better"*

*"Does the model shown there also describe correctly this **other** important observable?"*

…

Instant answers would be convenient for faster & better informed discussions!

# LHC@home/Test4Theory

**2010: Cool idea from LHC@home volunteer-cloud developers**

Embed physics applications in a Virtual Machine (CernVM)

➤ controlled standard environment for physics application, independent of host OS

**They approached CERN Theory Group: could we propose a test application?**

PYTHIA: simple to build (no external libs), small footprint, …

In-principle interested in massive validations; had no own/dedicated theory cluster

Representative of typical scientific-software "problem":

No native Windows support, nor much interest (or manpower) to develop that

We are a small group of physicists; our main (only) goal = physics research

**Virtualisation factorised the problem**

Physics application just saw a (configurable) standard Linux environment (now CentOS)

**Became the Test4Theory project, the world's first virtual volunteer cloud**

Volunteers can join at lhc@home/Test4Theory — Let idle machines run T4T jobs

# LHC@home/Test4Theory ➠ MCPlots

## LHC@Home/Test4Theory

Continuously runs lots of event generators, versions, and tunes, through **Rivet**

Normally in batches of 100k events

Results are accumulated and stored in a database.

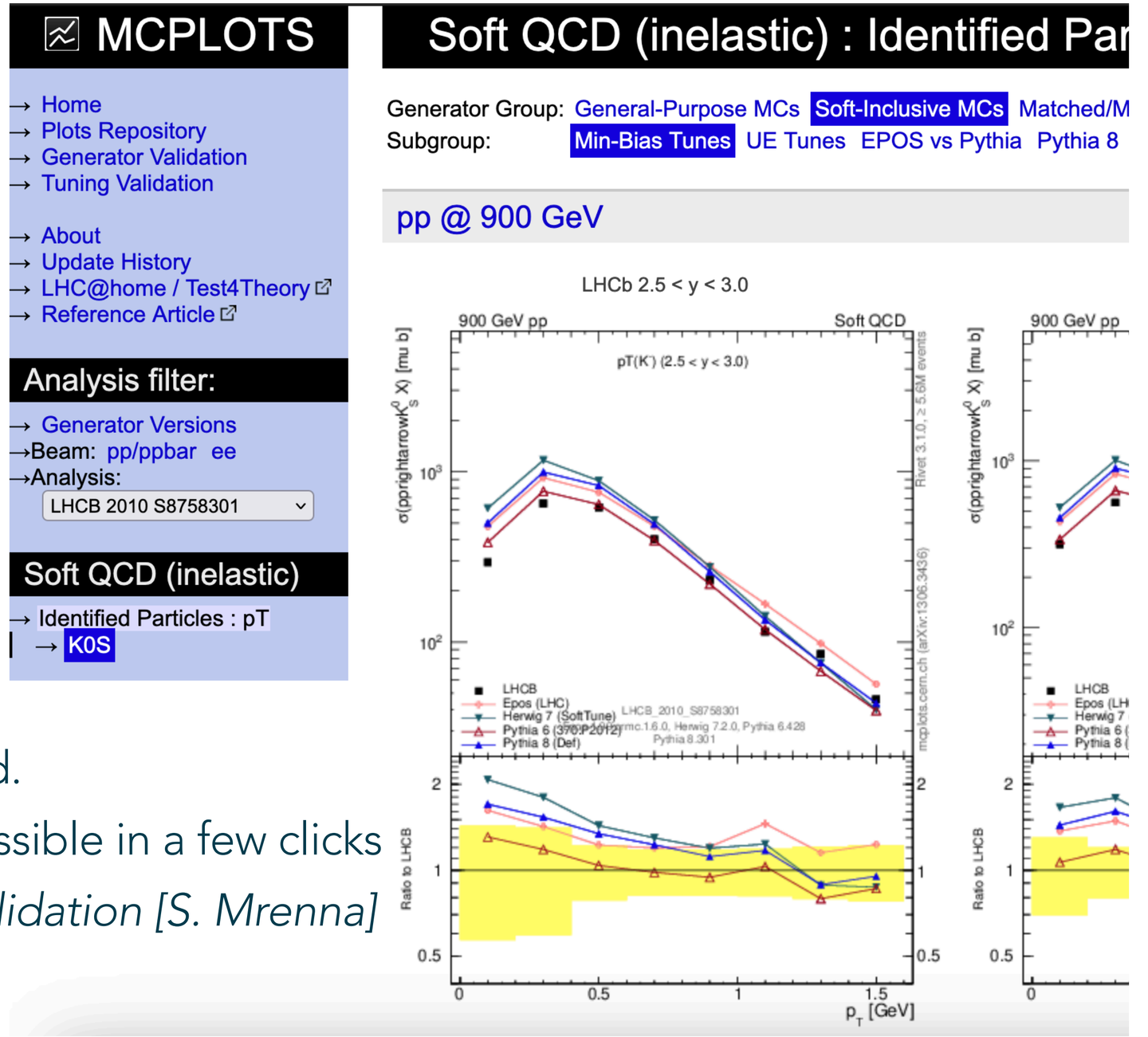
(Automated ~ zero manpower)

## Accessed by a web server: mcplots.cern.ch

Plots generated (& cached) on-demand.

**Hundreds of thousands of plots** accessible in a few clicks

*~ The "Library of Congress" for MC validation [S. Mrenna]*




Published in A. Karneyeu et al., *Eur.Phys.J.C* 74 (2014) 2714

# (Dedicated views to check for changes between versions and/or tunes)

"Average" $X^2$; plans to change to median to be less affected by outliers

Can be done for each tune of each generator, and/or for each version

Main quantities are clickable, for further levels of detail → comparison plots

**Versions:** ☑ 8.301 ☑ 8.244 ☐ 8.243 ☐ 8.240 ☐ 8.235 ☐ 8.230 ☐ 8.226 ☐ 8.212 ☐ 8.210 ☐ 8.209 ☐ 8.205 ☐ 8.201
☑ 8.186 ☐ 8.183 ☐ 8.180 ☐ 8.176 ☐ 8.170 ☐ 8.165 ☐ 8.150 ☑ 8.135 ☐ 8.130.p1 ☐ 8.108.p1

Display

## Process Summary

(click on numbers to see individual observables)

| <$\chi^2$> incl. 5% "theory uncertainty" on all points | min | best | min | best | min | best | min |
|---|---|---|---|---|---|---|---|
| | 8.301 | <Δ> | 8.244 | <Δ> | 8.186 | <Δ> | 8.135 |
| | max | worst | max | worst | max | worst | max |
| ee → γ*/Z (hadronic) | 0 | -0.17 | 0.0000026 | -6.6 | 0.00078 | -1.7 | 0.000045 |
| | 2.2 | 0 | 2.2 | 0 | 2.2 | -0.60 | 2.8 |
| | 220 | +0.26 | 220 | +3.4 | 220 | +2.1 | 220 |
| pp/ppbar → $b\bar{b}$ | 2.6 | -3.3 | 2.6 | +2.4 | 0.20 | -36 | 0.95 |
| | 28 | 0 | 28 | +8.0 | 20 | -6.0 | 26 |
| | 170 | +0.51 | 170 | +43 | 130 | -0.75 | 160 |

# LHC@home Current Status


**SixTrack:** beam dynamics simulations for LHC

**Test4Theory:** MC event-generator validation.
Computational back end for mcplots.cern.ch

\+ **Atlas@home, CMS@home, Beauty**

## Fully integrated with and supported by CERN IT infrastructure

Periodical checkpoint meetings which I attend (chair: N. Høimyr, CERN IT)

## Provides total computing power equivalent to ~500 kCHF / year

I only see the ones connected to Test4Theory: few hundred to few thousand cores

➤ Over 5 *trillion* events in its lifetime

Atlas@home has simulated 1.2 billion events ~ **4% of all ATLAS simulation**

About half of that is backfill from otherwise idle ATLAS grid nodes

Quite a substantial contribution for a single entity!

# MCPlots: Current Status and Plans

## 2022: 6 months of development funded by LHC Physics Centre at CERN

Main collaborator: **Natalia Korneeva**

Extensive sets of 13-TeV analyses added, plus many historical ones

Better automation (e.g., extracting more info from Rivet, more systematic approach to settings generator phase-space cuts)

➤ **Less effort to maintain and update**

+ POWHEG-Box added for hard processes (via LCG LHCb installation!)

No process for Dijets? See `/cvmfs/sft.cern.ch/lcg/releases/LCG_96/MCGenerators/powheg-box-v2/r3043.lhcb/x86_64-centos7-gcc8-opt/bin/`

## 2023: write a paper + update visual layout

Current ~ nineties-look ➤ more modern "cleaner" web design proposed by **NK**

## Question: no dedicated validation of B decays - How does EVTGEN do it?

Interest in MWA generally in PYTHIA+EVTGEN validation?

Rivet analyses + PYTHIA+EVTGEN ➤ MCPlots for B decays?