MCPLOTS status and plans

A. Karneyeu[1], N. Korneeva[2], P. Skands[2]

[1] University of Notre Dame
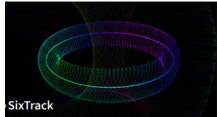[2] Monash University

LHC MC WG meeting
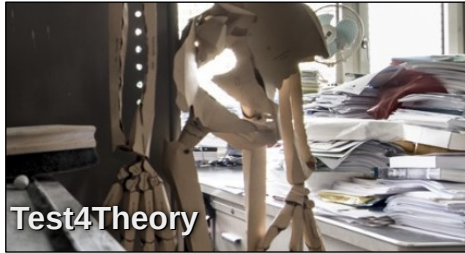14 November 2024

MCPLOTS : overview

2004

Birth of the LHC@home : an outreach event for CERN's 50th anniversary
SixTrack simulation of beam dynamics runs on Windows/OSX/Linux

2010

Start of the Test4Theory/MCPLOTS project being the first using virtualization (CernVM).
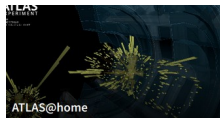
Basic idea : test virtual LHC@home with real scientific applications (Pythia and eventually other HEP MC generators)

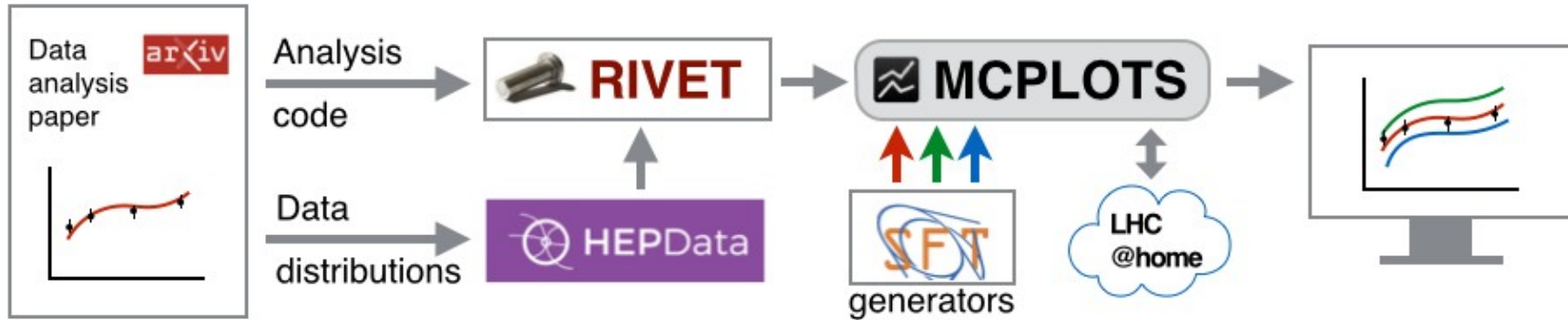Addition of Rivet brought in the **validation** aspect

2016

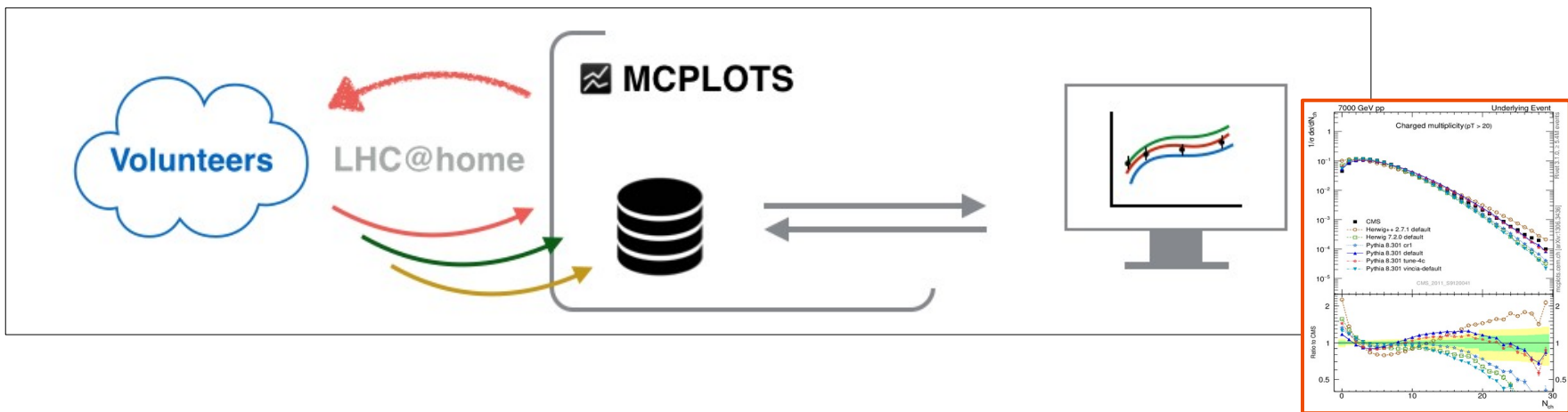Main CERN experiments joined the platform
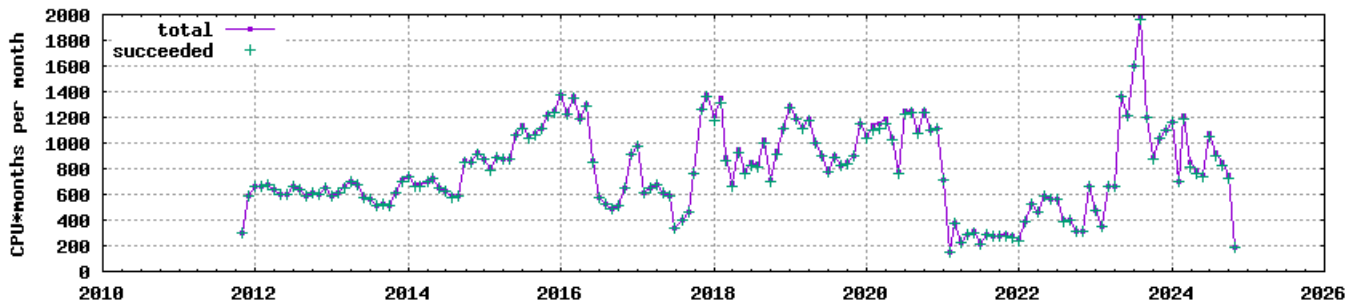
MCPLOTS : overview

https://mcplots.cern.ch/

https://rivet.hepforge.org/   https://ep-dep-sft.web.cern.ch/

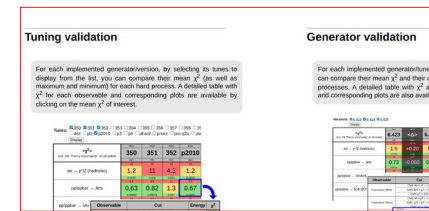https://www.hepdata.net/   https://lhcathome.web.cern.ch/
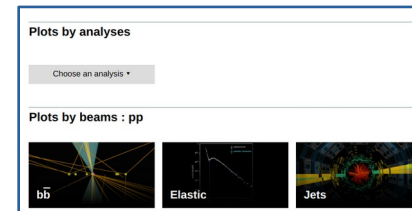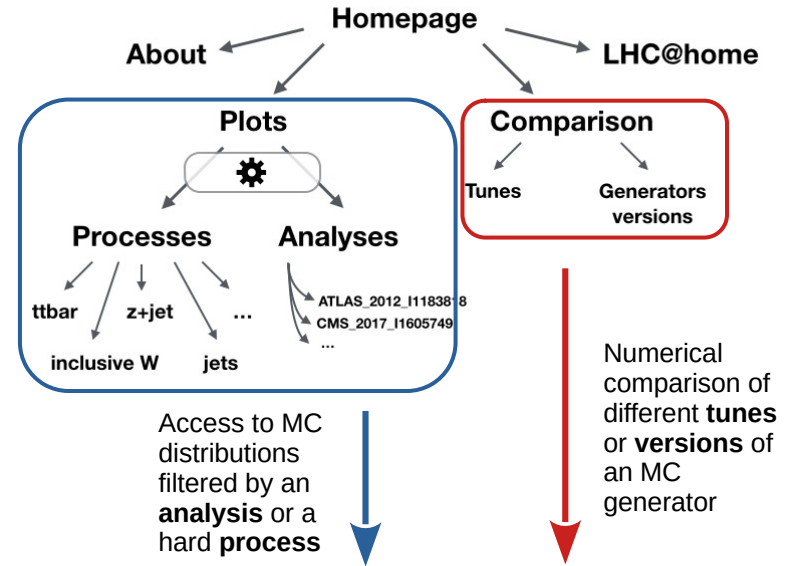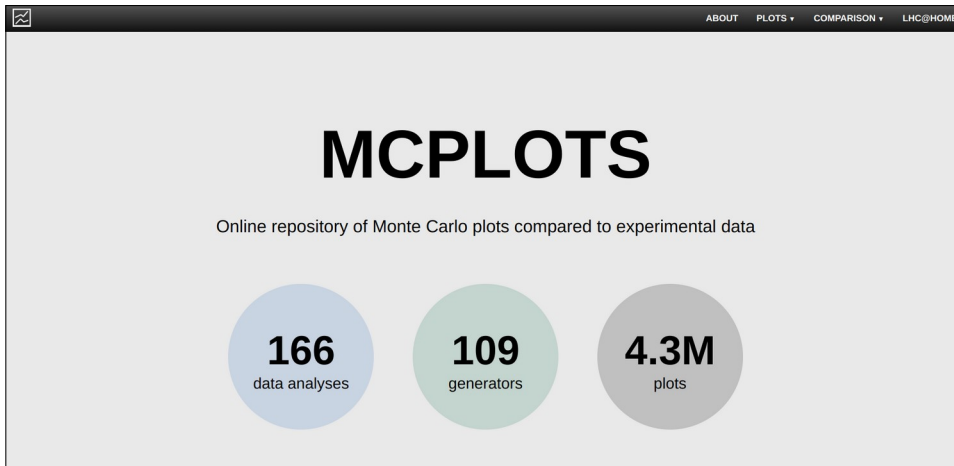
MCPLOTS workflow

CPU resources accessed by the Test4Theory project (monthly averaged)

Key numbers :
~800 volunteers
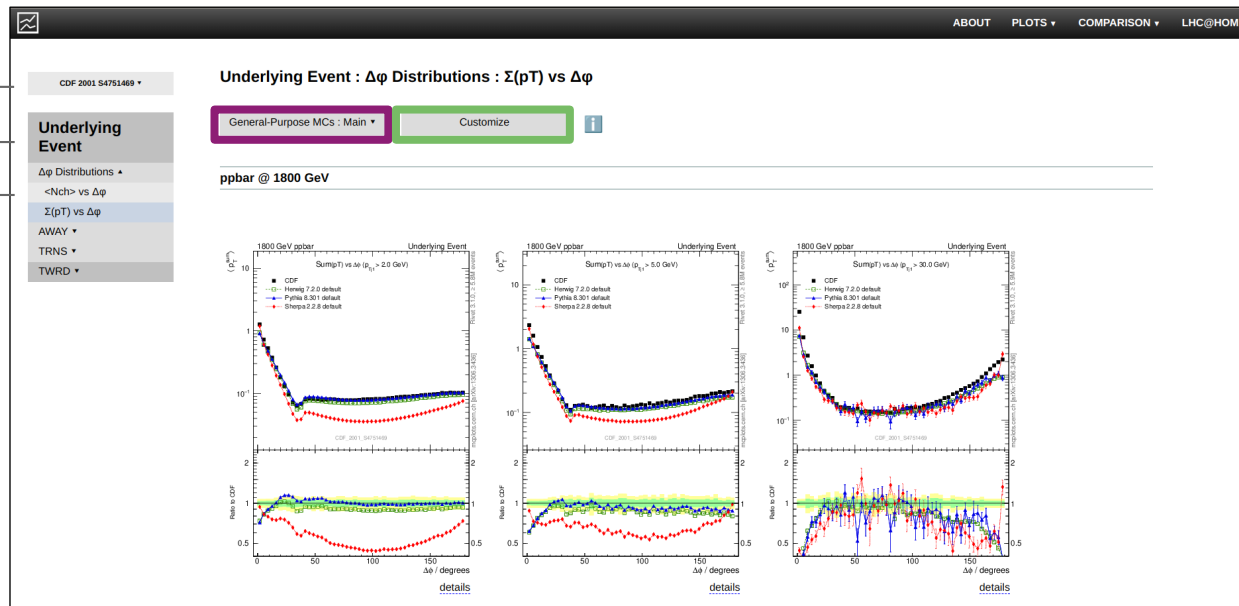~10^9 events per day

Website

Website : plots

Analysis filter (if used)

Hard process

Individual distributions

Possibility to choose what to plot either from **a pre-defined preset** or from **all MCs**

Website : comparison

Generator (tune) name

Available versions to compare

χ² for individual observables

Number of distributions used to calculate <χ²>

Current status

Always shown on the main page :

166 data analyses   **109** generators   **4.3M** plots
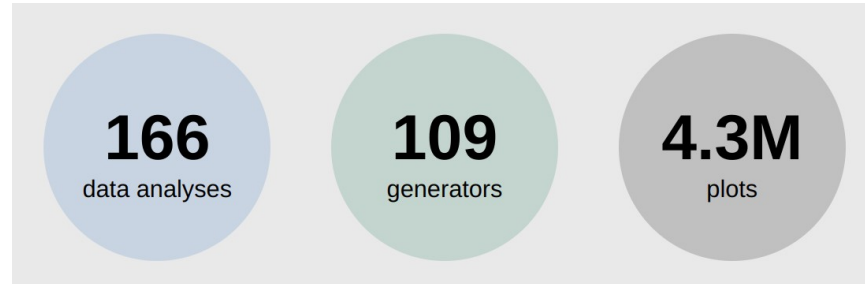
Implemented generators : Alpgen, Epos, Herwig++ and Herwig7, MadGraph, Powheg-Box, Pythia6 and Pythia8, Sherpa, Vincia

1065 generator-version-tune combinations

166 data analyses with **5016 data distributions** implemented so far refer mostly to the *ee* and *pp* HEP collider experiments: ATLAS, CMS, D0 etc. Recently added: *PbPb.*

The repository is continously filled and the **source code** of the project is available :

https://gitlab.cern.ch/MCPLOTS/mcplots

MCPLOTS paper : Event-Generator Validation with MCPLOTS and LHC@home

https://doi.org/10.1140/epjp/s13360-024-05353-2

MCPLOTS production cycle

Fix mc configurations to be used and start the production

Initial accumulation of statistics   *2-3 weeks*

Update the website with new plots

Calculation of χ^2 values   *3 days*

Accumulation of statistics and development stage

Implementation of   new Rivet routines   *several months*
                     new generators/versions/tunes

. . .

Express productions
of custom distributions

Switch to the latest Rivet version
Fix the updates

Fix mc configurations to be used and start a new production

MCPLOTS production cycle

Express production

- main production is on hold
- only relevant tasks are distributed to volunteers
- **first results in 24 hours**
- after collecting sufficient statistics, it is switched back to the main production

In the last few months, there have been three of such express productions :

These express results are on
https://mcplots-dev.cern.ch/

1. Variations of Powheg-Box/Pythia matching parameters
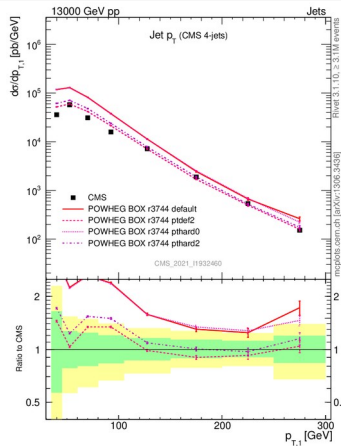
2. Variations of Herwig matching schemes
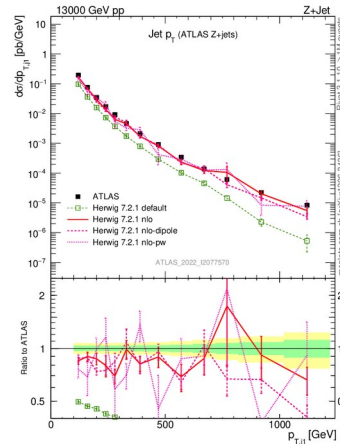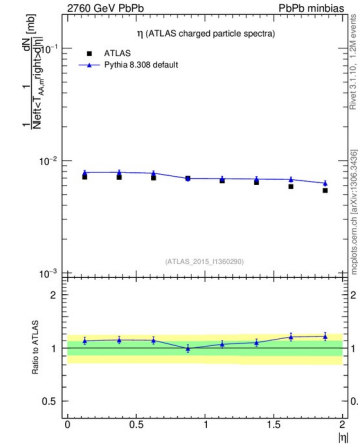
3. Heavy ion runs

Development

Recent updates
Rivet to **4.0.x**
YODA to **2.0.x**

MCPLOTS major update
corresponding change in the data storage
format and data merging in MCPLOTS

Profits from this update and using Rivet native histogram merging :

Fill in the high-pt tails of distributions

400 K events
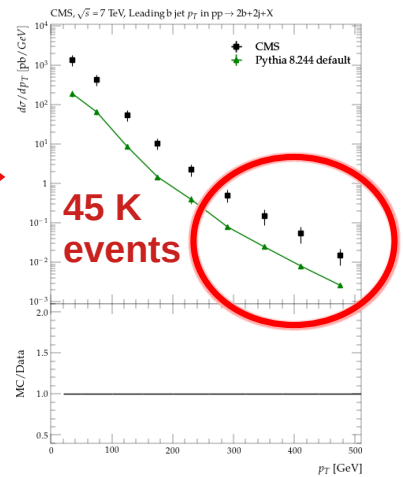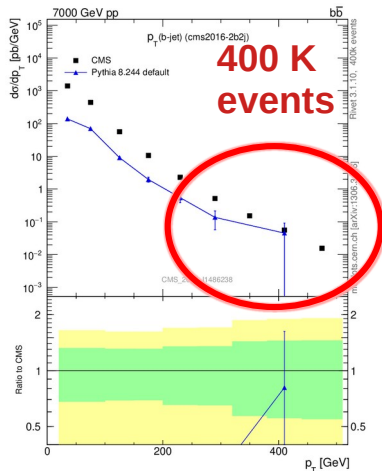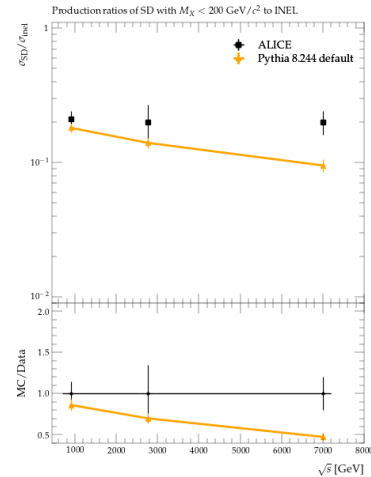
45 K events

Leading b-jet pT distribution

√s distributions

SD to INEL as a function of ECM

HI RAA distributions

11

Development

- **Usual development tasks** : implementation of new analyses, new generator versions etc.
- Work on **automation of adding new generators/generator versions** for quicker validation : in collaboration with the SFT team
- Improving the **website** validation pages
- Increasing **statistics** :

  update from 05/2024

- New data analyses have been implemented
- Number of **plots** are increased by **more than 4x**

Plan to **remove** some outdated versions/tunes to increase statistics in distributions of interest

Example :
Pythia 6
6 versions: 6.428, 6.427, 6.426, 6.425, 6.424, 6.423.
58 tunes: 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356...

Summary

➢ MCPLOTS : MC validation resource based on volunteer computing

➢ CPU power: LHC@home

➢ Website: https://mcplots.cern.ch/

➢ Continuous development of the project to add more features and improve the accuracy of comparison of MC generators with data

➢ Fast validation including   sample generation

production of plots with Rivet

χ^2 calculation

BACKUP

Database

Information about the distributions

[id]	[fname]	[type]	[prc]	[obs]	[tune]	[exp]	[ref]	[hid]	[beam]	[Ecm]	[cuts]	[gen]	[ver]
90	dat/CDF_2005 _S6217184-ppbar -1960/jets-js_int -cdf3-037-d07-x01 -y01/pythia8 -8.244-tune-2m.dat	mc	jets	js_int	tune-2m	CDF	CDF_2005 _S6217184	d07 -x01 -y01	ppbar	1960	cdf3 -037	pythia8	8.244
91	dat/CDF_2005 _S6217184-ppbar -1960/jets-js_int -cdf3-037-d07-x01 -y01/CDF_2005 _S6217184.dat	data	jets	js_int		CDF	CDF_2005 _S6217184	d07 -x01 -y01	ppbar	1960	cdf3 -037		

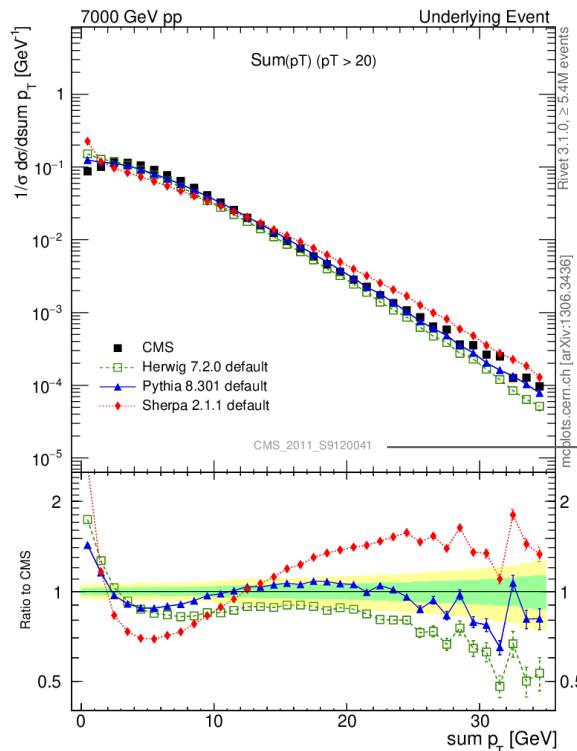The website operates with queries to this table

Website : plots

Beam parameters

Hard process

RIVET version and
# of MC events

Generator-version-tune
for each MC curve

RIVET reference

7000 GeV pp   Underlying Event

Sum(pT) (pT > 20)

$1/\sigma \, d\sigma/dsum \, p_T \, [GeV^{-1}]$

CMS
Herwig 7.2.0 default
Pythia 8.301 default
Sherpa 2.1.1 default

CMS_2011_S9120041

Rivet 3.1.0, ≥ 5.4M events

mcplots.cern.ch [arXiv:1306.3436]

Ratio to CMS

sum p_T [GeV]

details
Download as: .pdf .eps .png .script.tgz #
CMS experiment: data | article paper
Herwig 7 (Def): data |generator card
Pythia 8 (Def): data |generator card
Sherpa (Def): data |generator card

Plot in higher resolution
Data distribution and article paper

Steering files and results
for each MC curve

16

Paper

The first paper was published ~10 year ago :
MCPLOTS: a particle physics resource based on volunteer computing
https://doi.org/10.1140/epjc/s10052-014-2714-9

The second one : **January 2024**
Event-Generator Validation with MCPLOTS and LHC@home
https://doi.org/10.1140/epjp/s13360-024-05353-2

- Full description of the updated repository and database structure

- Comprehensive user's guide (the website functionality)

- Developer's guide : how to implement

  ➔ a new data analysis
  ➔ a new generator (version)
  ➔ a new generator tune

- Phase-space cuts discussion