Jet Fragmentation Properties with CMS Open-Data

- **Saksevul Arias[1], Eleazar Cuautle[2], and Hermes León Vargas[3]**

[1] Centro de Investigación en Computación, Instituto Politécnico Nacional (CIC, IPN)

[2] Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México (ICN, UNAM)

[3] Instituto de Física, Universidad Nacional Autónoma de México (IF, UNAM)

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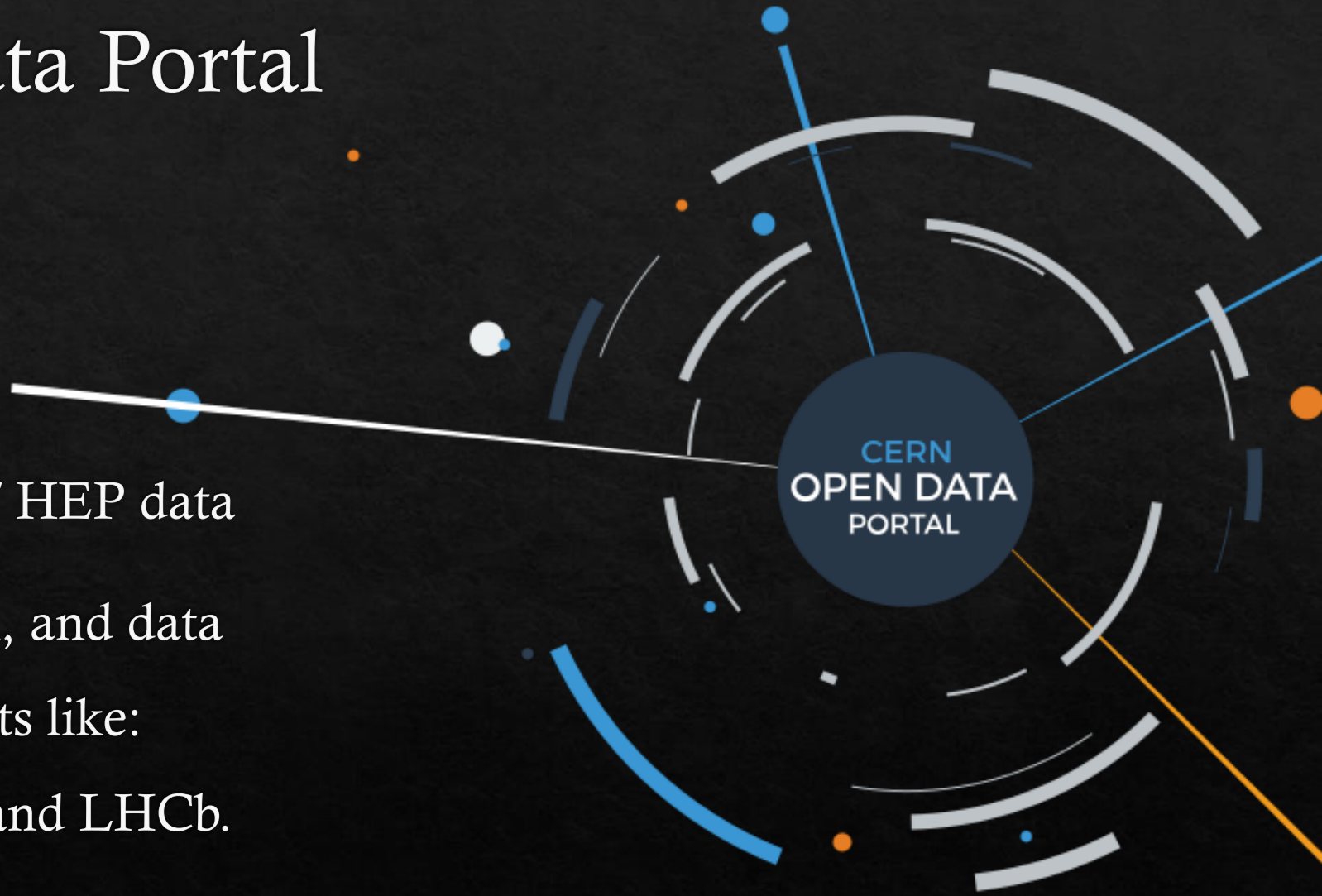
CERN Open-Data Portal

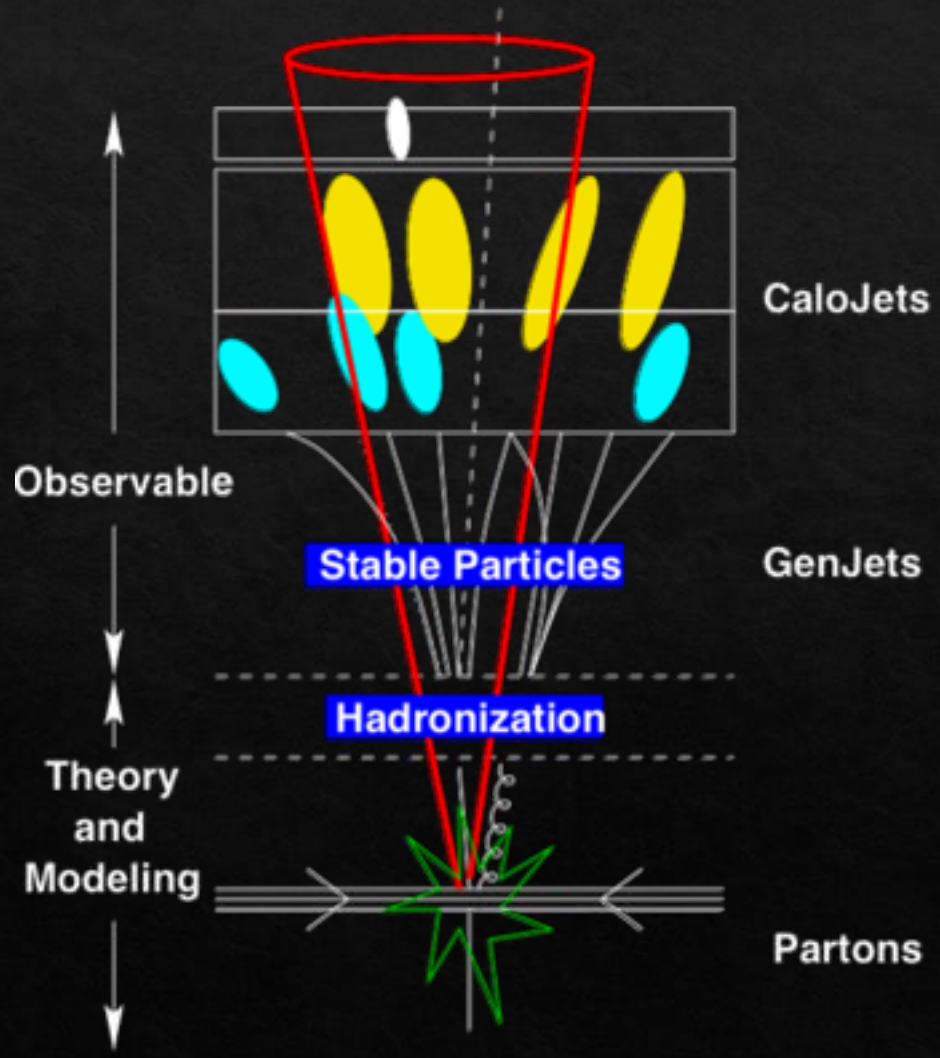
- Access-free portal:

  http://opendata.cern.ch/

- More than 2 petabytes of HEP data
- Software, documentation, and data from different experiments like: ALICE, ATLAS, CMS, and LHCb.



Jets



Jets are **collimated bunches of particles** originated from the hadronization of hard scattered partons produced in hadronic collisions

Jet Restrictions

- Jet radius 0.5
- $E^{Jet} > 120$ GeV
- $|\eta^{Jet}| < 2.1$
- $E^{Ch} > 1.5$ GeV
- $E^{Lep} > 6$ GeV

Data Samples

- CMS Open-Data samples from pp collisions at $\sqrt{s} = 7$ TeV :
  - Jet
  - BTag
  - MinBias
  - MultiJet
- Pythia 8 simulation

Objective

The objective of our study was to explore the data sets and look for differences in the results

Fragmentation Function

- Fraction of jet energy carried by particle type

$$Z = \frac{E^{Part}}{E^{Jet}}$$

- Fragmentation function (FF):

$$F\left(Z, E^{Jet}\right) = \frac{1}{N^{Jet}} \frac{dN_{Ch}}{dZ}$$

Results

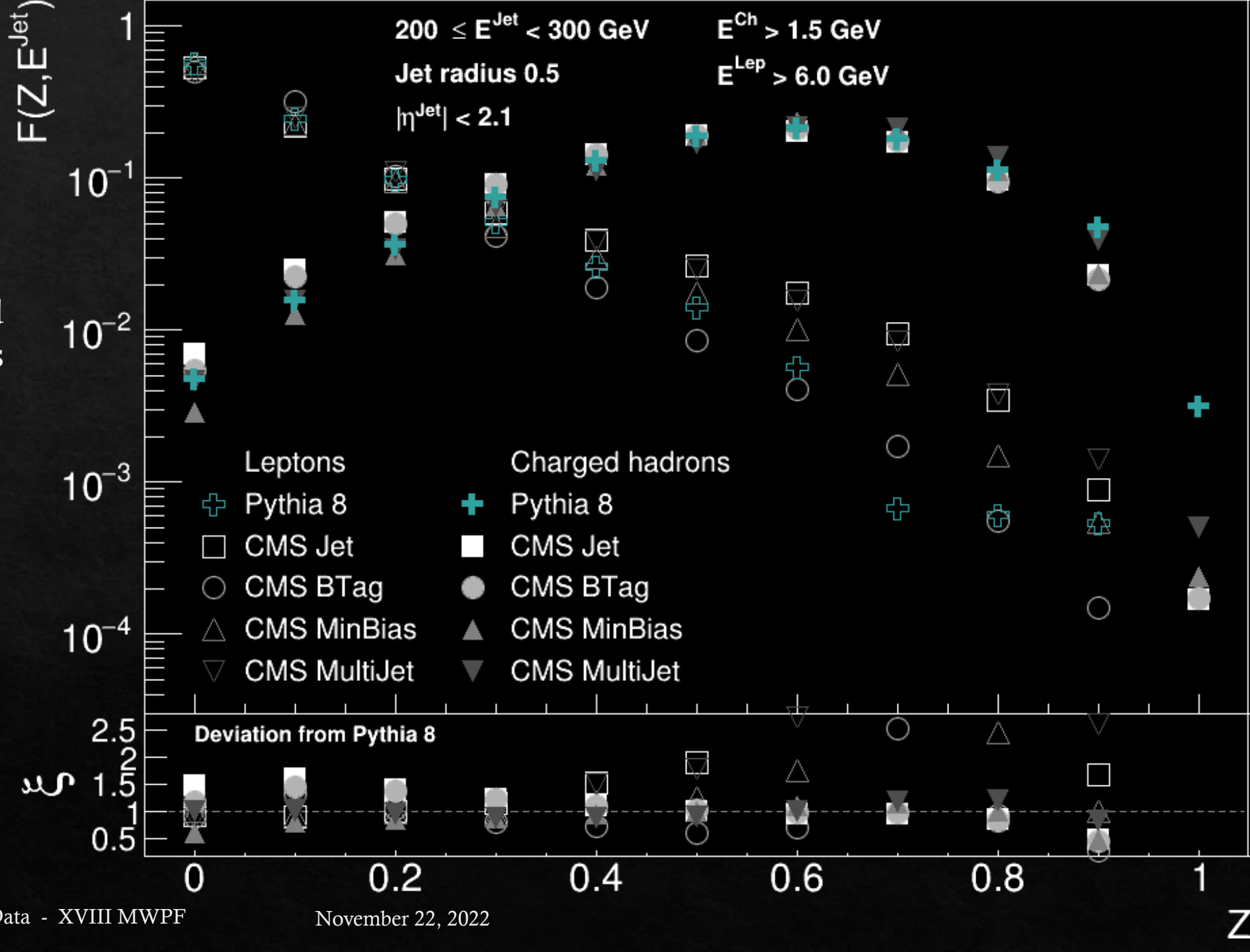
F F

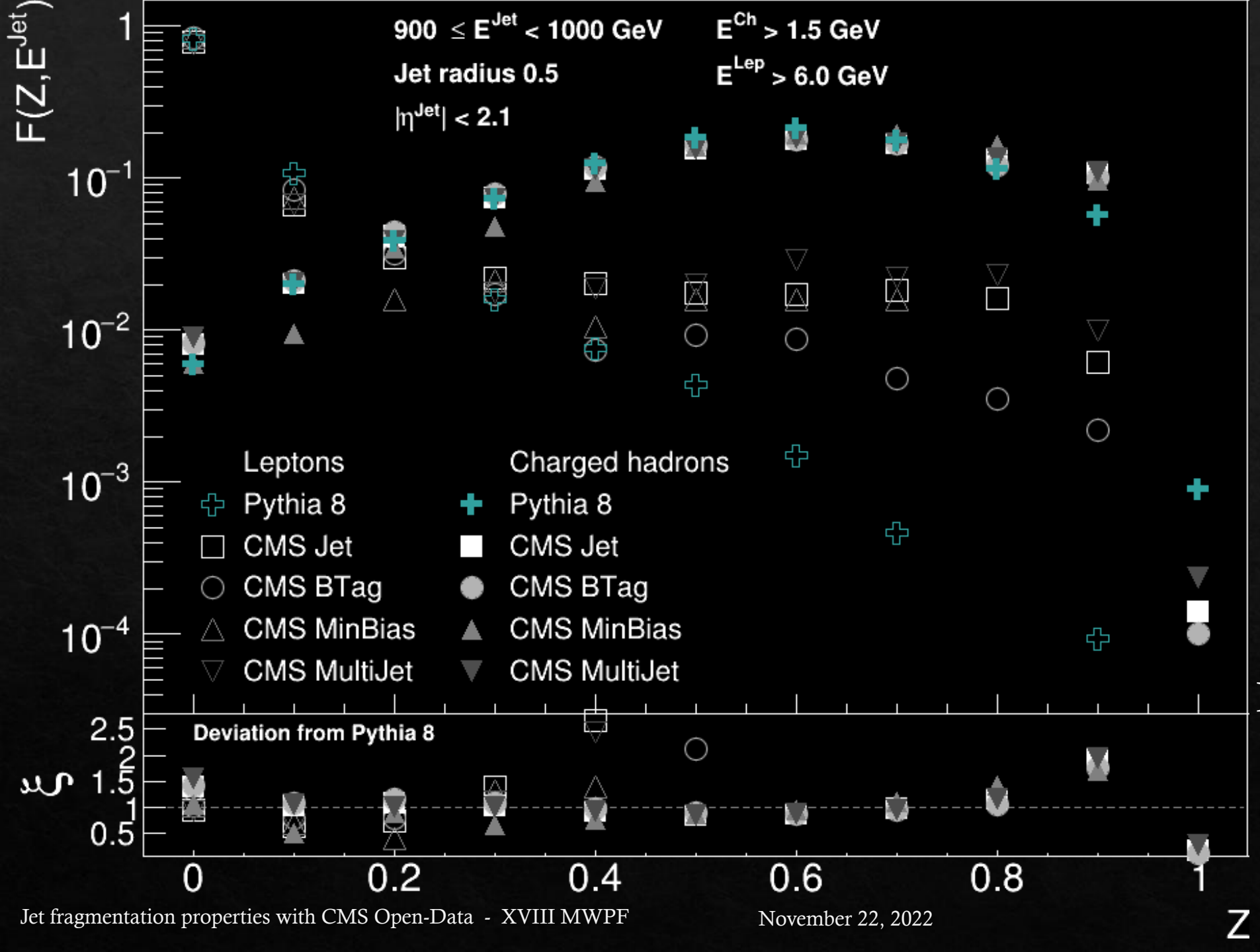
Fragmentation function for charged hadrons and leptons

$200 \leq E^{Jet} < 300GeV$

$$Z = \frac{E^{Part}}{E^{Jet}}$$

$$F\left(Z, E^{Jet}\right) = \frac{1}{N^{Jet}} \frac{dN_{Ch}}{dZ}$$





Fragmentation function for charged hadrons and leptons

$900 \leq E^{Jet} < 1000\text{GeV}$

$$Z = \frac{E^{Part}}{E^{Jet}}$$

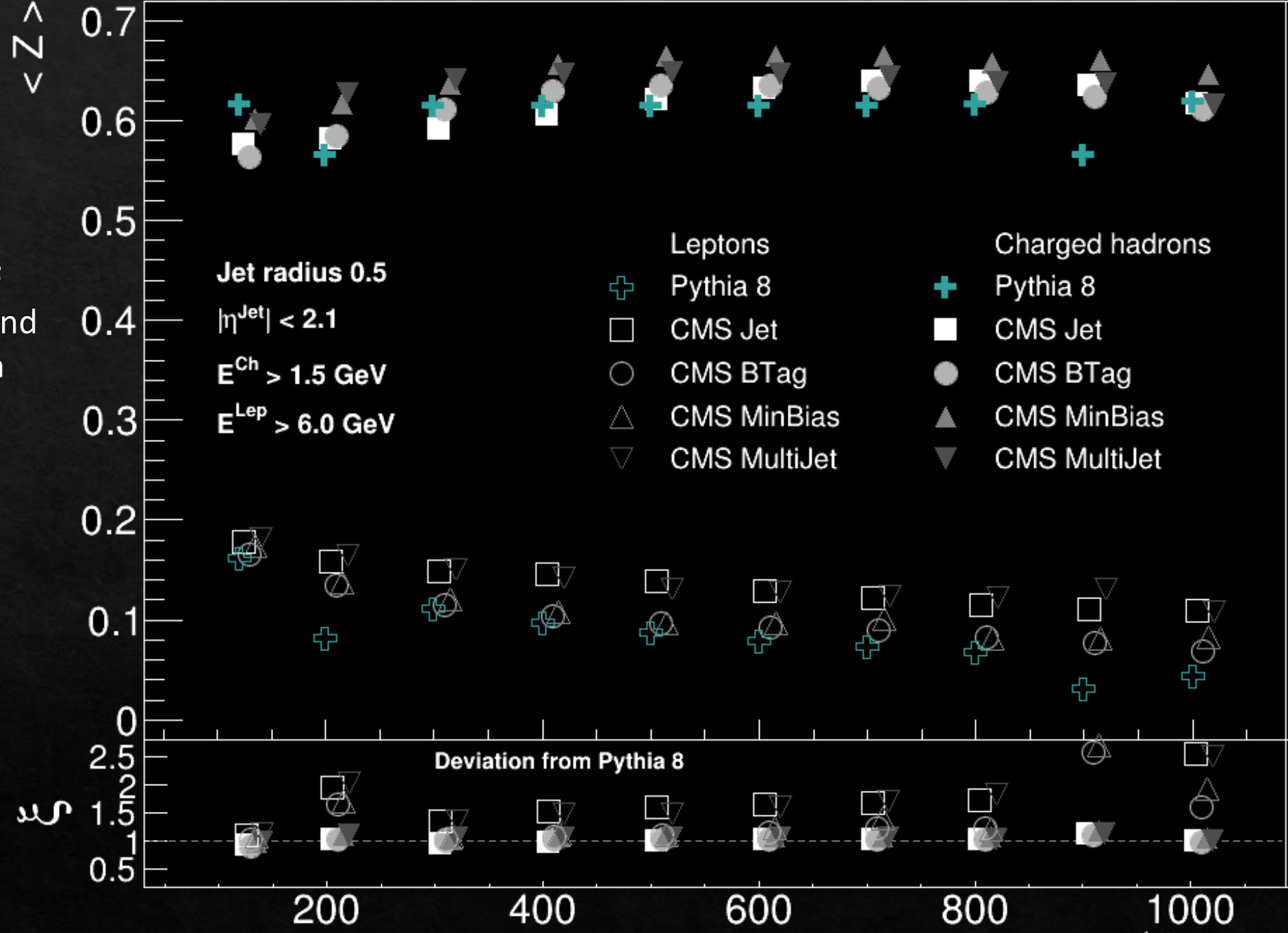
$$F\left(Z, E^{Jet}\right) = \frac{1}{N^{Jet}} \frac{dN_{Ch}}{dZ}$$

Z Mean

Mean value of the **FF** for charged leptons and hadrons as a function of the jet energy

$$Z = \frac{E^{Part}}{E^{Jet}}$$

$$F\left(Z, E^{Jet}\right) = \frac{1}{N^{Jet}} \frac{dN_{Ch}}{dZ}$$



Conclusions

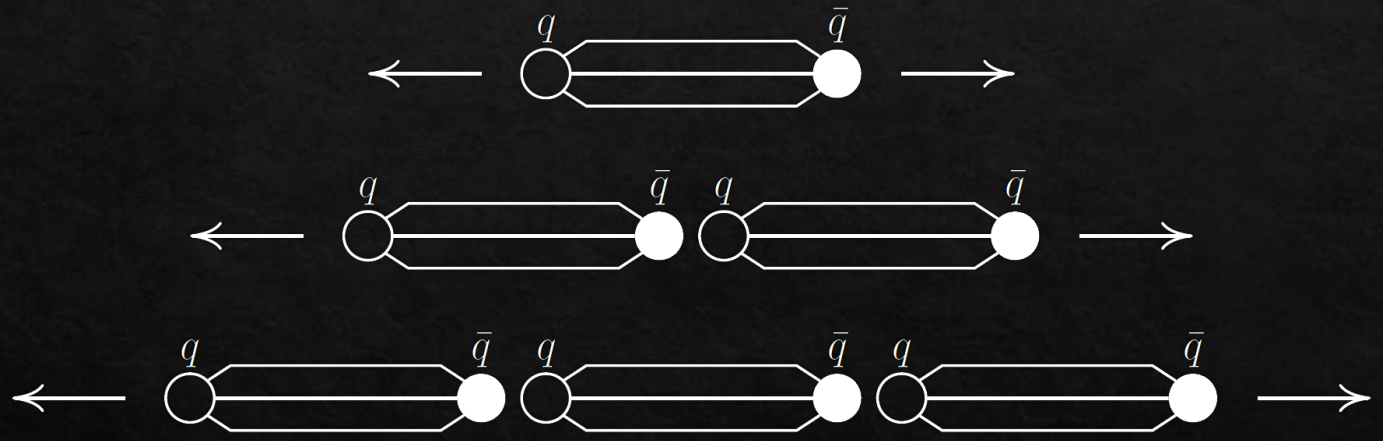
- We analyzed CMS Open-Data to characterize jet properties
  - This analysis does not include corrections by the detector efficiency. Instead, we implemented high energy thresholds
- We studied FF for charged hadrons and leptons
  - For leptons, the FF becomes harder for the high energy range
  - For hadrons, the FF decreases at low and high Z values
  - Our simulation does not describe FF in all Z range
- We characterized FF evolution with the jet energy using $\langle Z \rangle$
  - The most considerable disagreement with simulation is for the case of leptons
  - The $\langle Z \rangle$ value is larger for hadrons than for leptons
- The results show the capability to perform analyses using CMS Open-Data

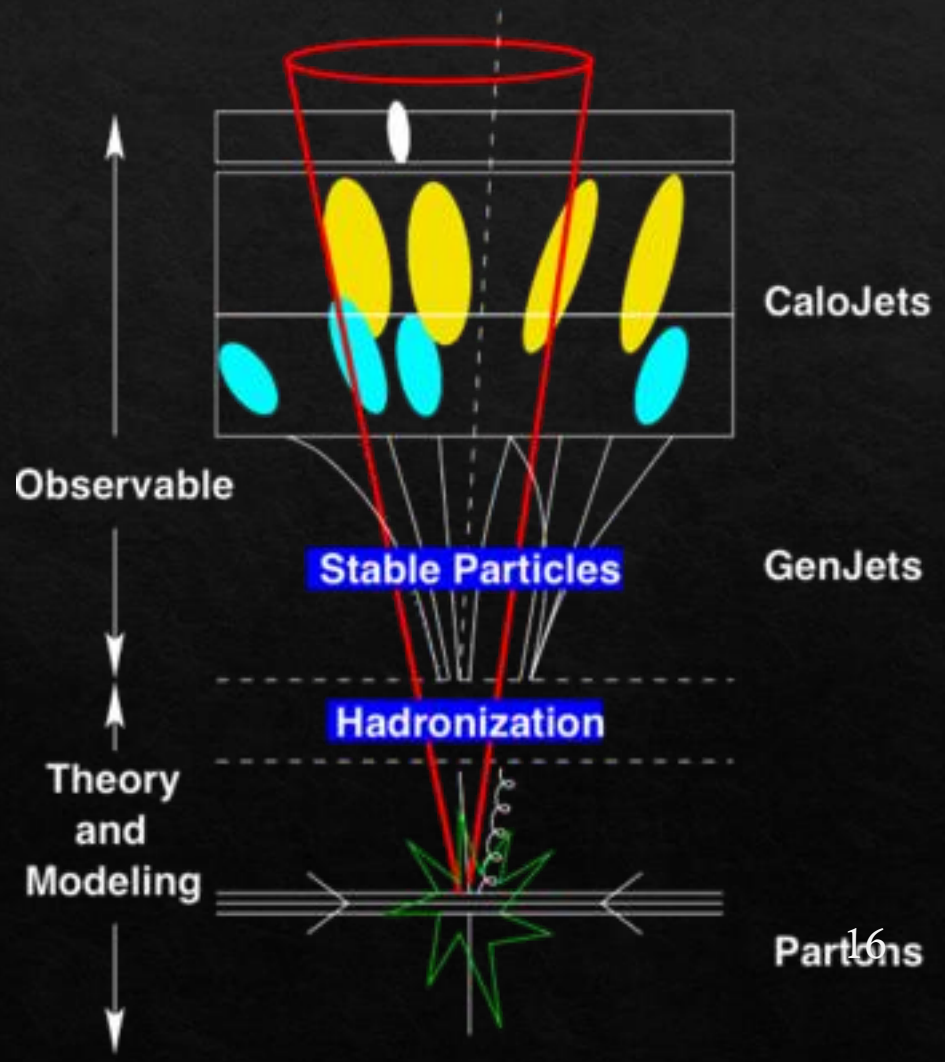
Thank you for your attention!

Any question?

Backup

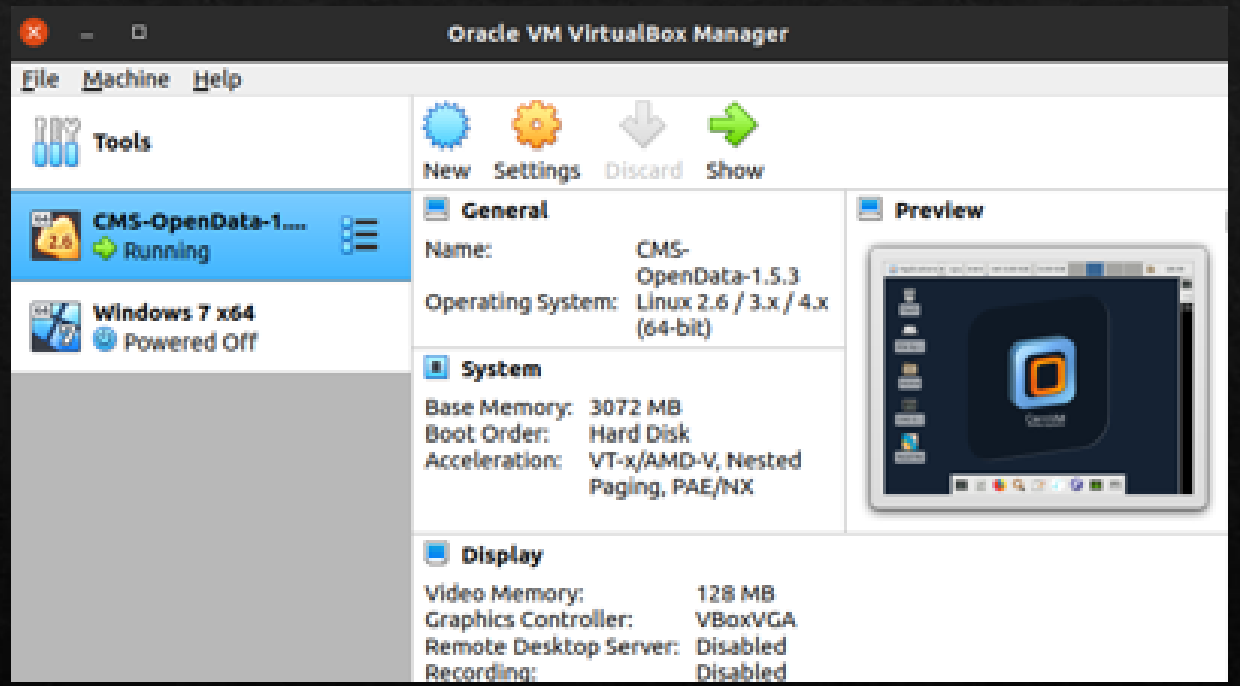
Jets Fragmentation



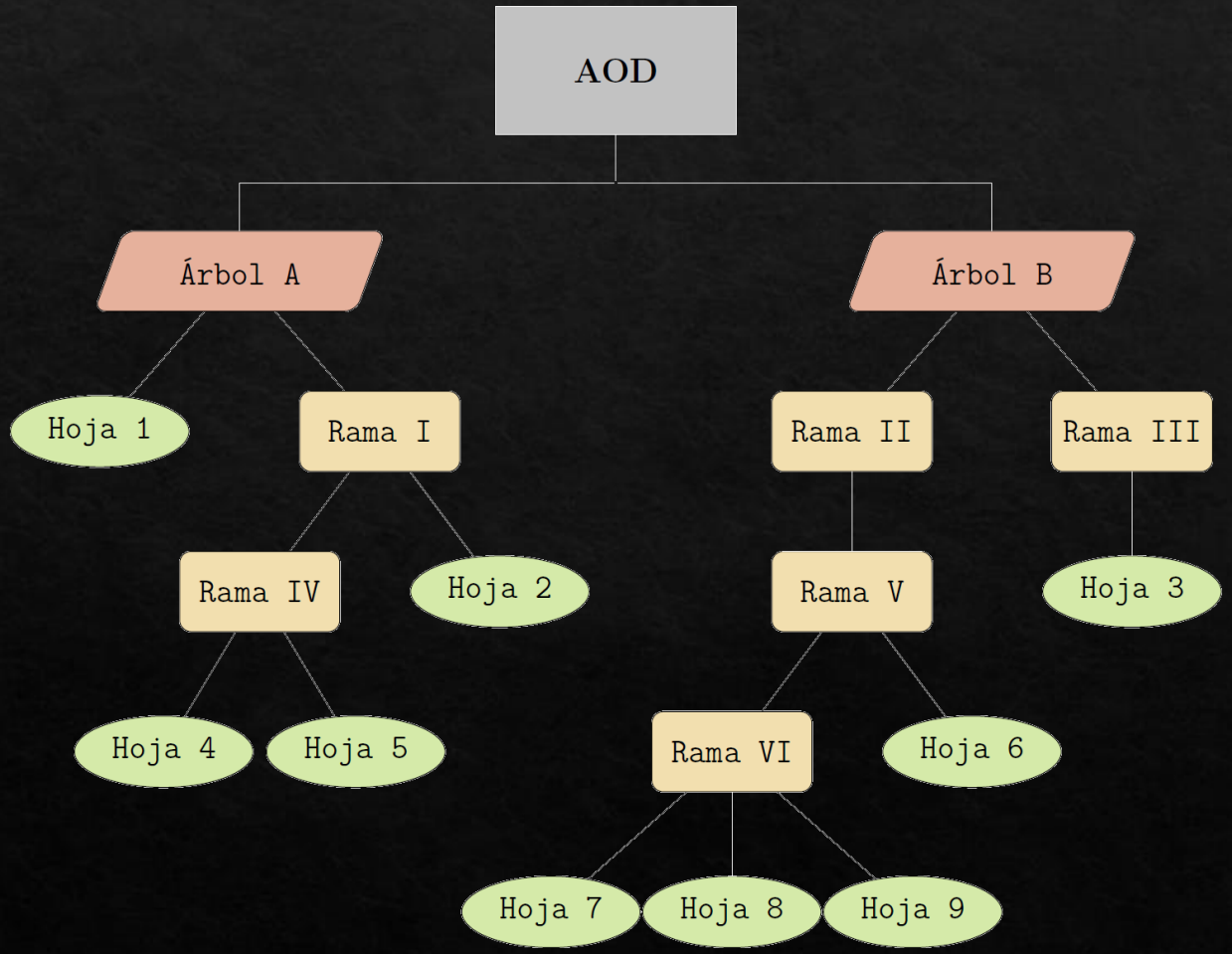


CMS Open-Data Framework

- Even though CMS offers a framework to access and to work with open data, it results unpractical.



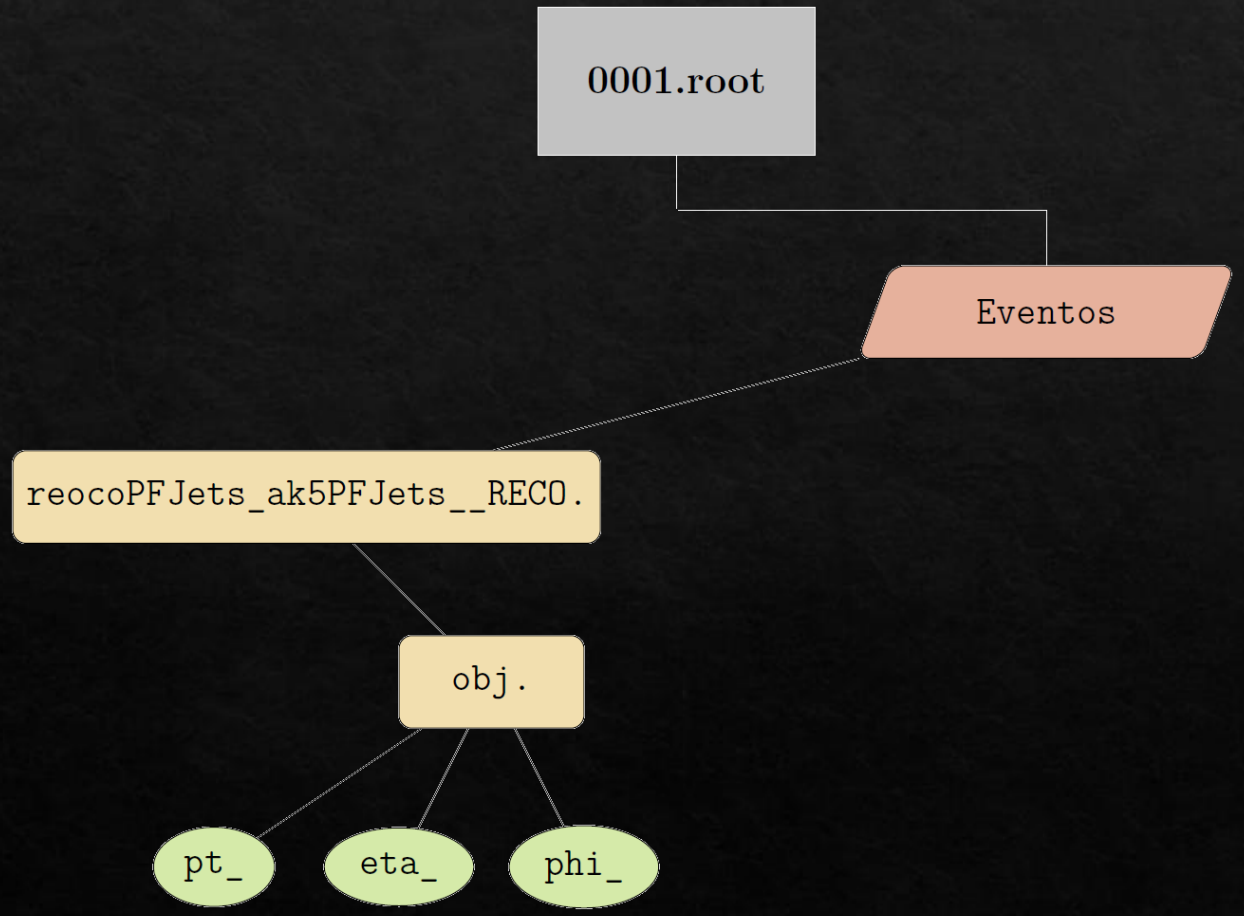
CMS Open-Data



Tree main tires:

- RAW: Electronic signals
- RECO: Reconstructed data
- **ADO**: Distilled version of RECO, meant for its direct use

Jets Branch Structure



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- pt
- eta
- phi
- particle energy
- particle multiplicity

More Jet Restrictions

Neutral Hadron Fraction	< 0.95
Neutral Electromagnetic Fraction	< 0.95
Number of Constituents	> 1
Charged Hadron Fraction	> 0.00
Charged Electromagnetic Fraction	< 0.99
Number of Charged Constituents	> 0

Jet Finding Algorithm

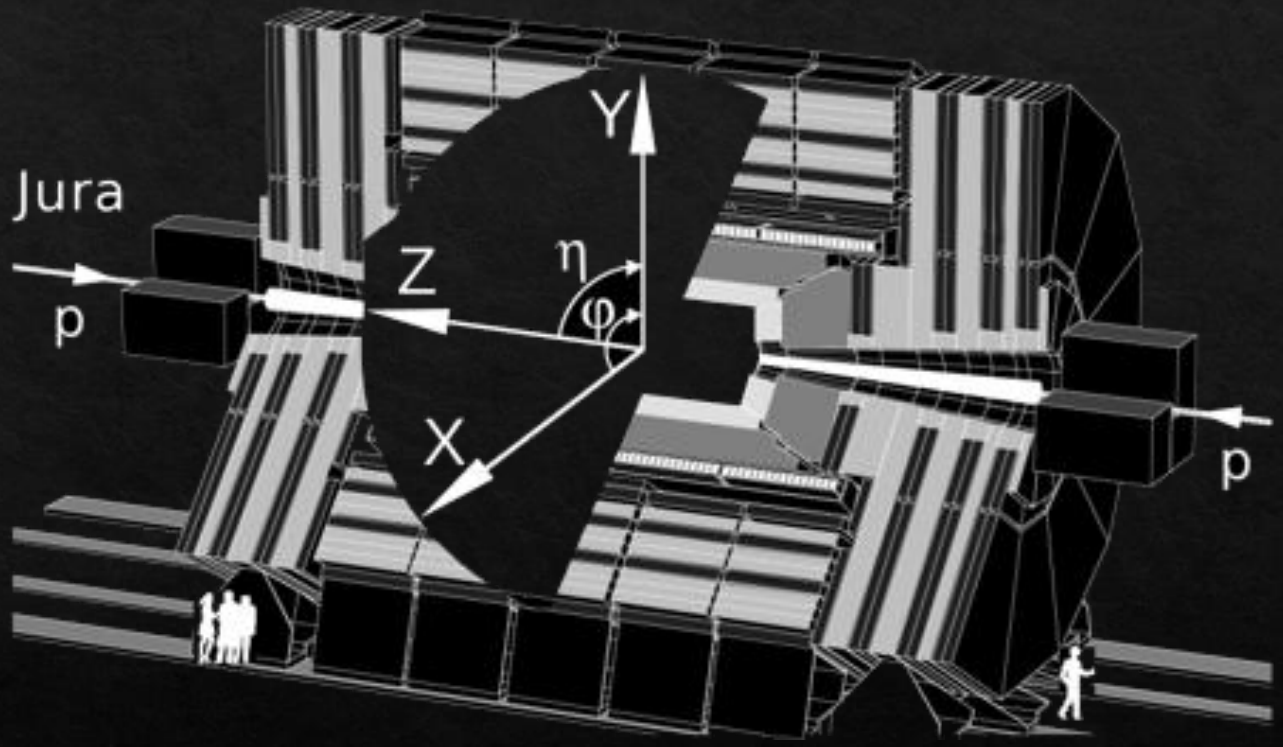
A jet has multiple variables such as:

- Size (radius) R
- Type of input particles
  - For example: Particle-Flow particles, calorimeter signals, etc
- Algorithm used to cluster

$$d_{ij} = \min\left[k_{ti}^{2p}, k_{tj}^{2p}\right]\left(\frac{\Delta_{ij}^2}{R^2}\right)$$

$$\Delta_{ij} = \sqrt{(y_i - y_j)^2 + (\phi_i - \phi_j)^2}$$

CMS Coordinates



Pseudo-rapidity $\eta \equiv -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$

Multiplicity $\langle Mult_{Ch} \rangle$

Average multiplicity of charged hadrons from **CMS Published** data and **Pythia 8 simulation**