Hiding and Finding New Physics in Cosmic Ray Air Showers

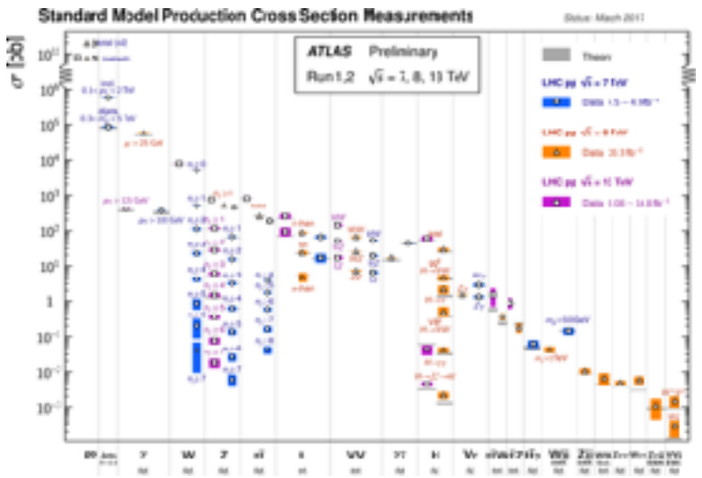
Peter Schichtel

@ Pheno 2017

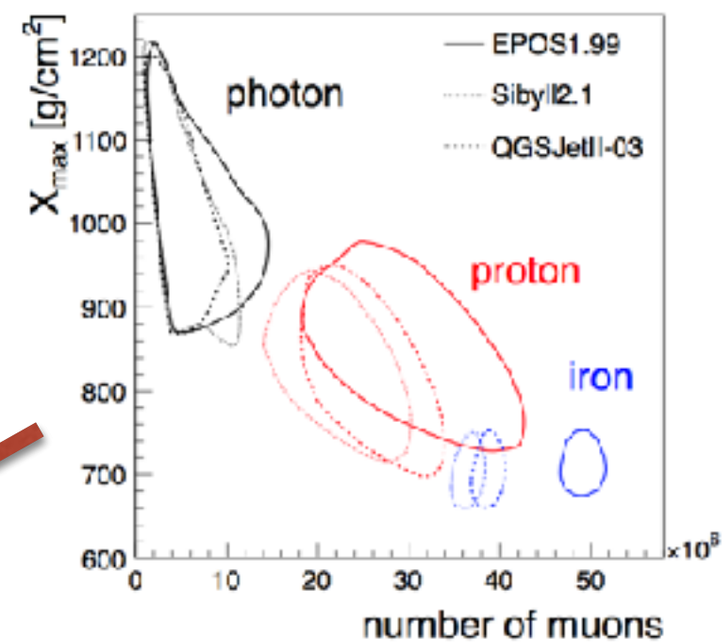
Some Motivation

LHC Run I

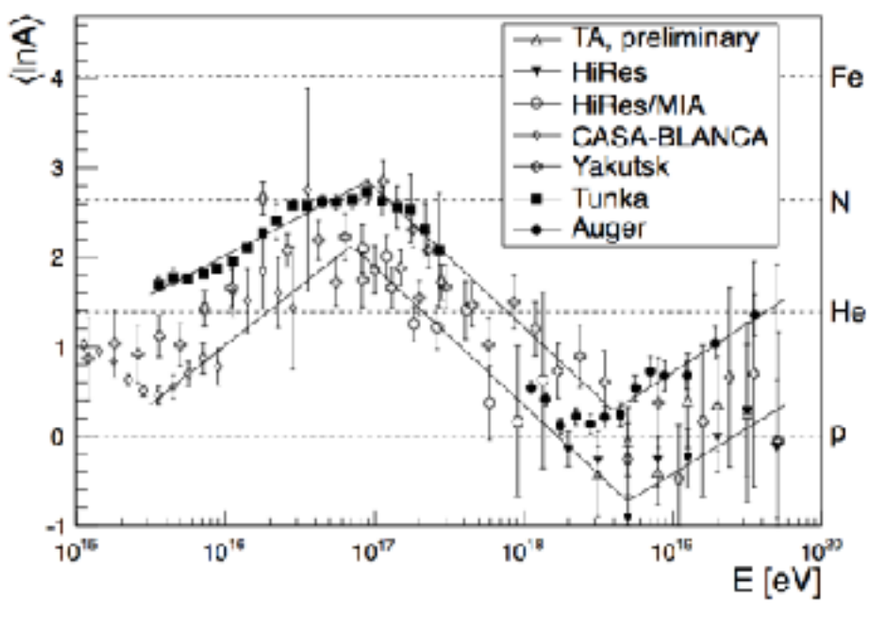
no sign of new physics



Hybrid Observables

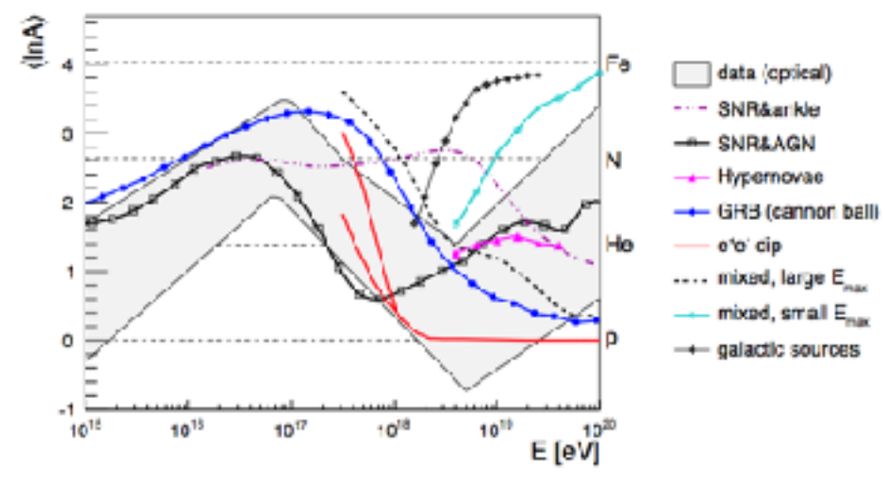


Cosmic ray primaries



(a) QGSJet01

primary source models



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Outline

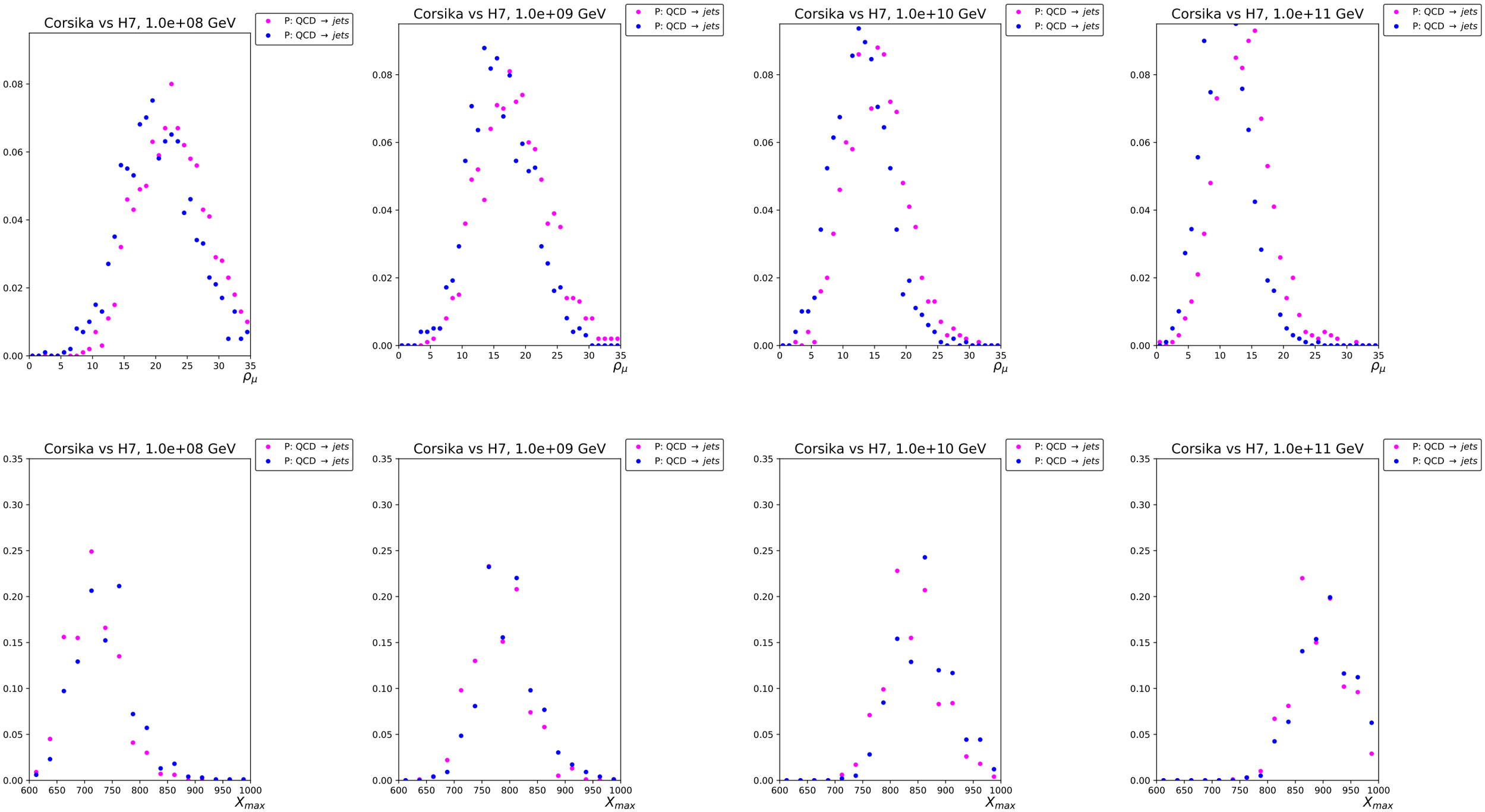
- ✦ some details of the simulation
- ✦ Z' decays (model resonance)
- ✦ Sphalerons (model particle bomb)
- ✦ primary composition

ρ_μ number of muons between 550 and 650 metres shower core distance

$X_{\max}$ atmospheric penetration depth (shower maximum)

for simplicity: fix incident angle

Simulation: modelling the hard interaction



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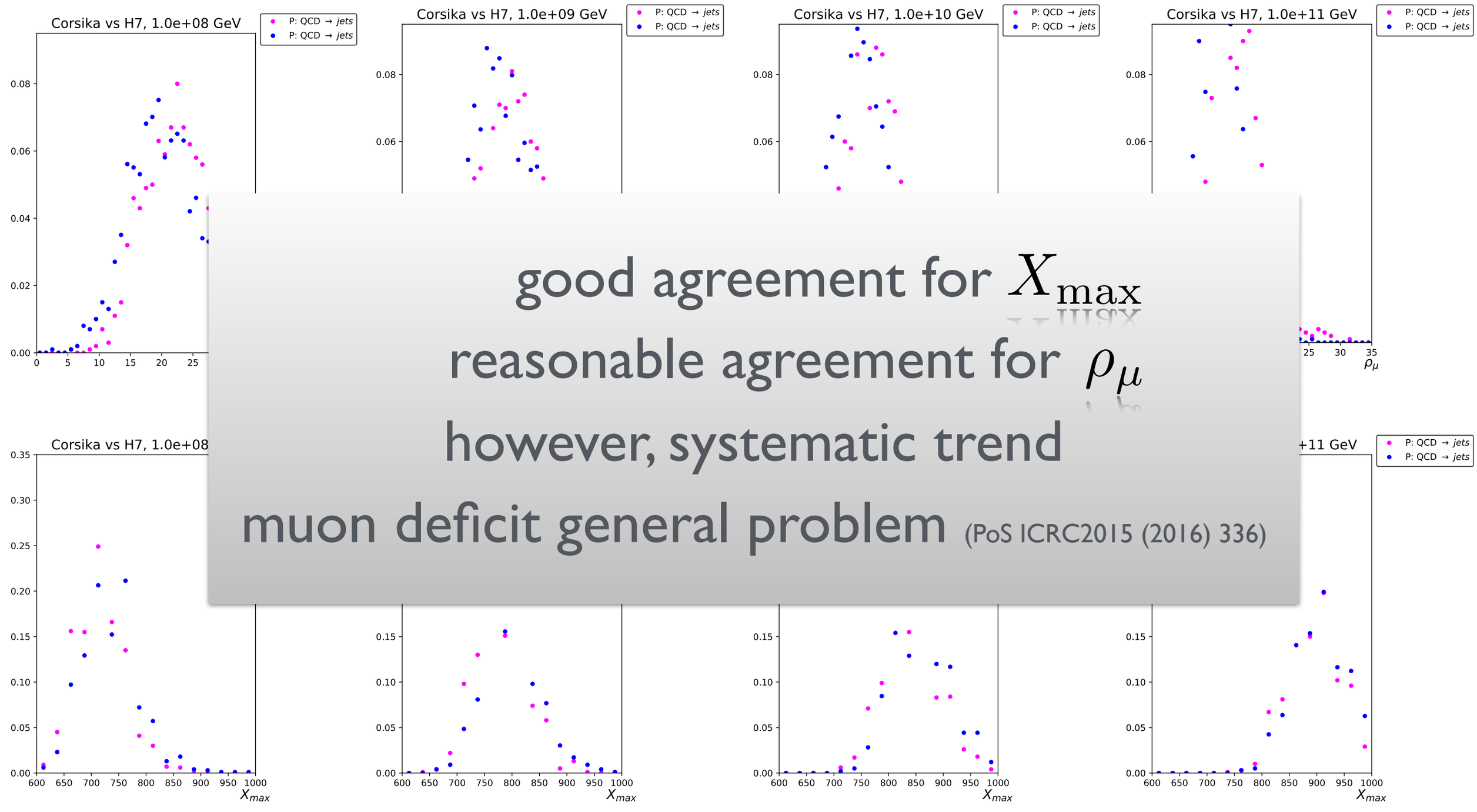


good agreement for $X_{\max}$

reasonable agreement for ρ_μ

however, systematic trend

muon deficit general problem (PoS ICRC2015 (2016) 336)

Simulation: modelling nuclei

what kind of particles are forwarded to corsica air shower

full fragmentation

vs.

daughter nuclei

fragmentation

view nucleus as cloud of nuclei
interact with one proton

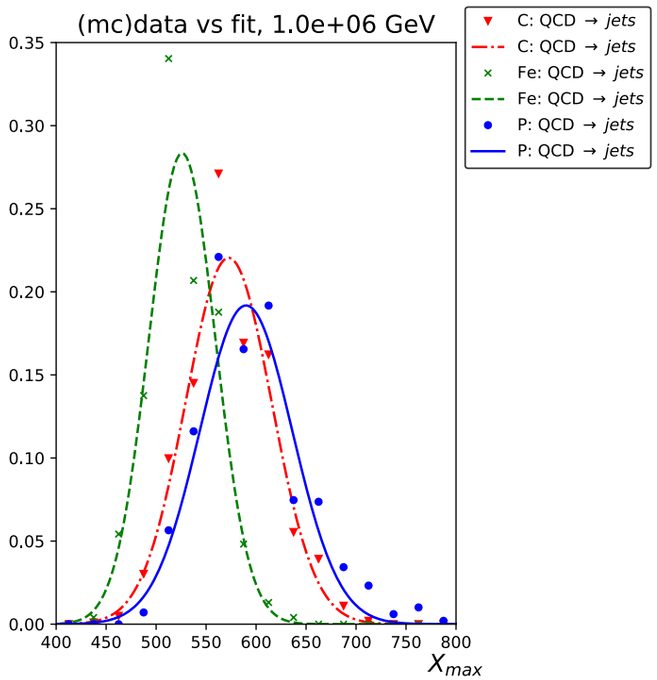
nucleus

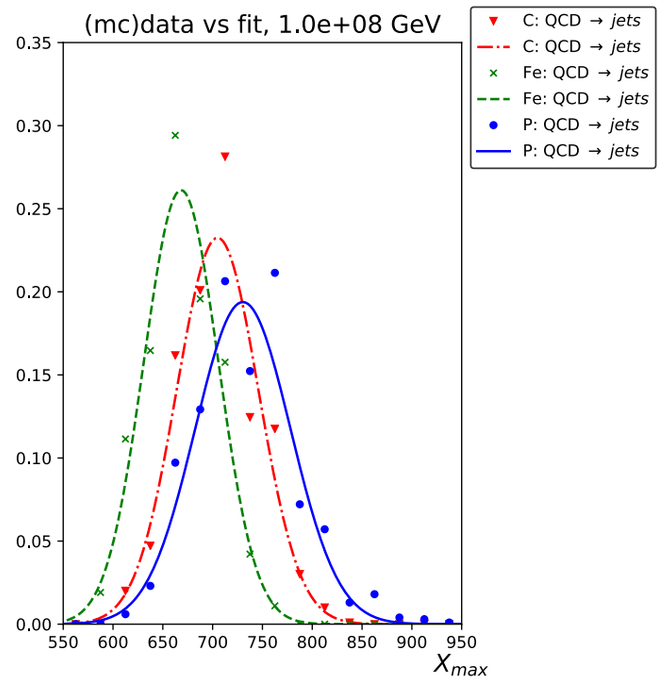
interact with one proton
daughter nucleus remains

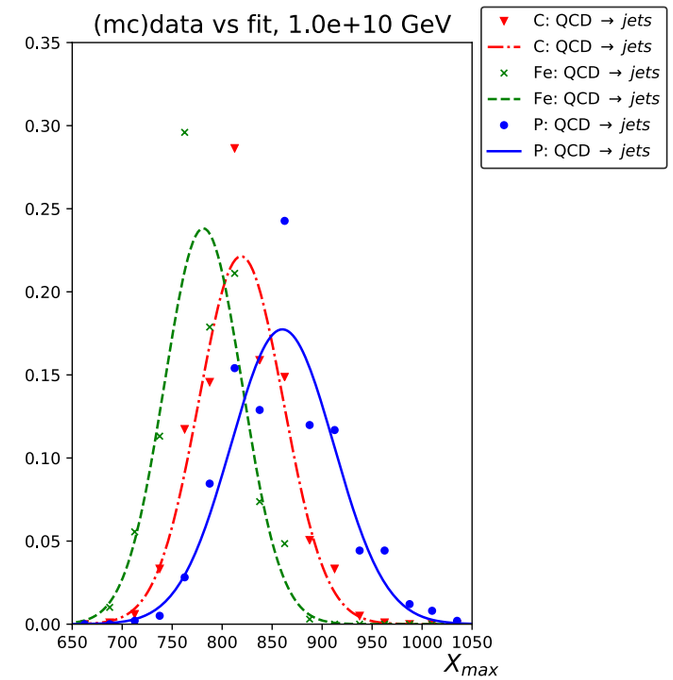
can simulate any physics with any composition

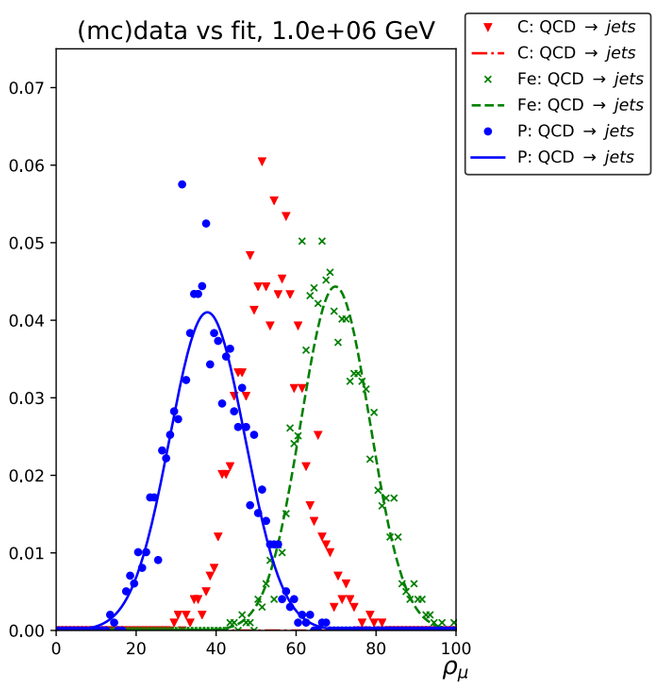
reasonable agreement between two models

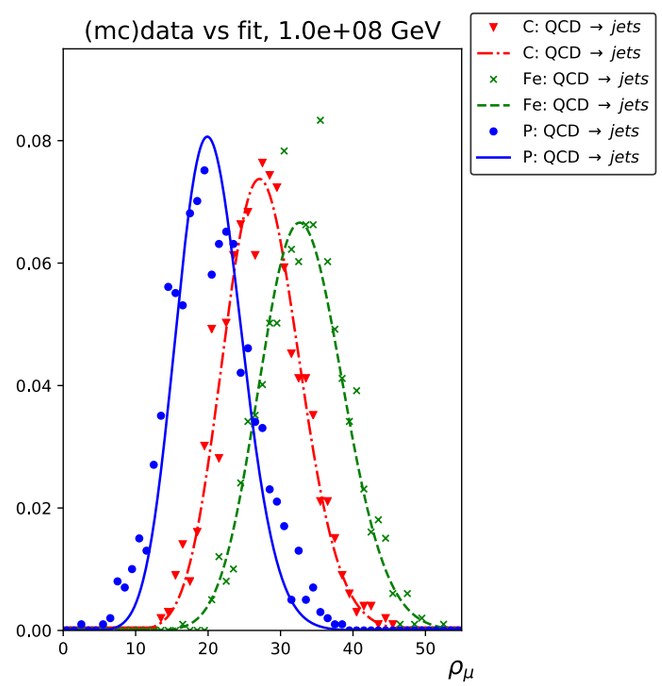
Presentation: what'll you see

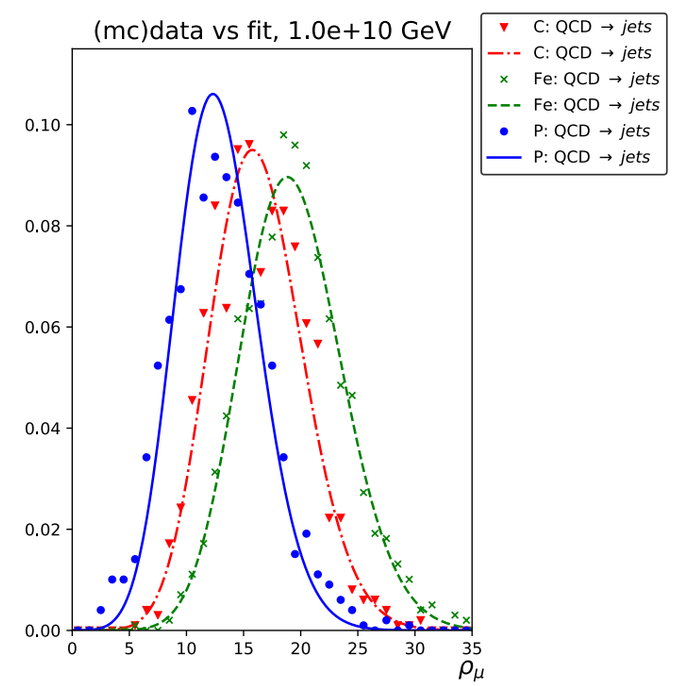












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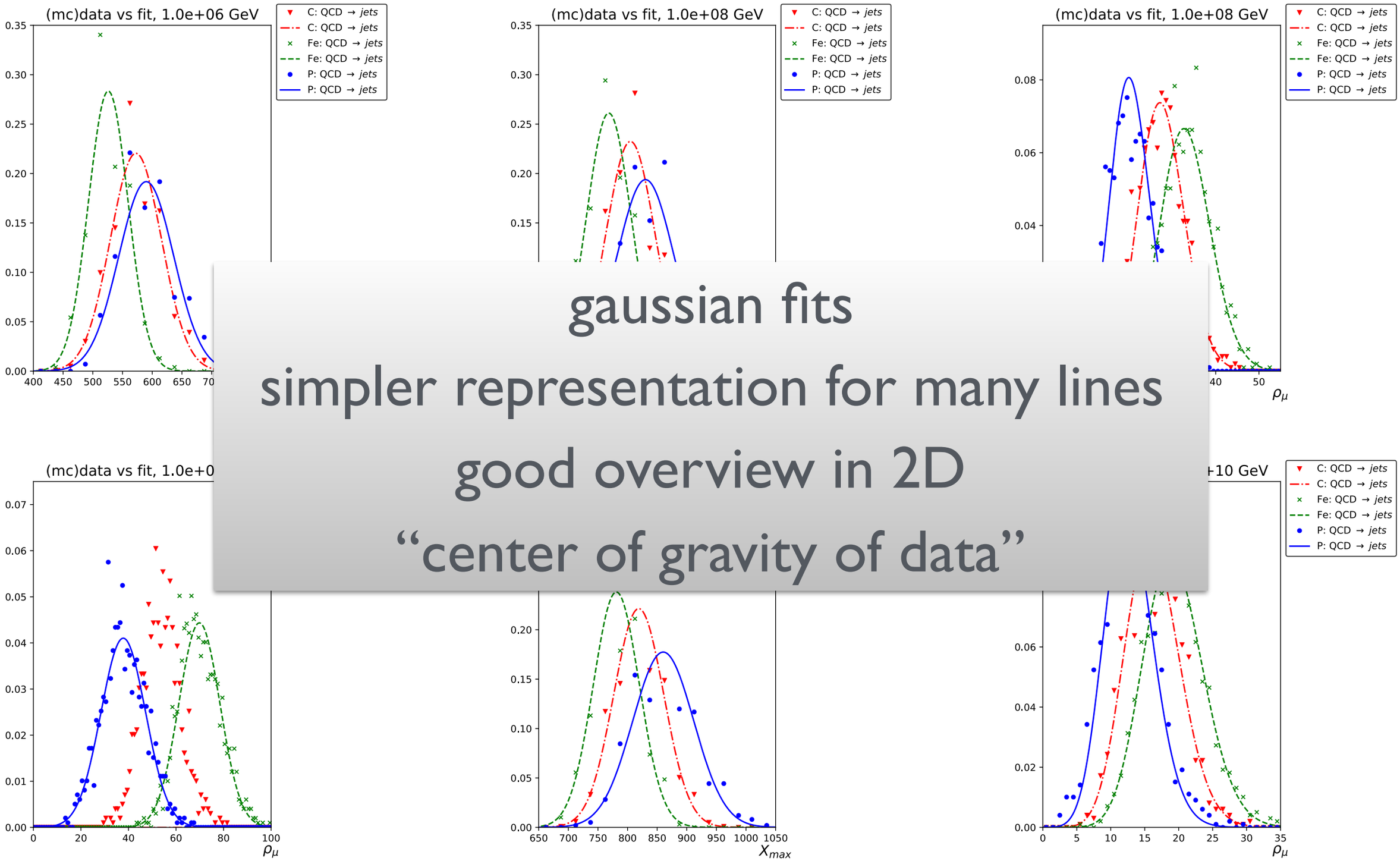


gaussian fits

simpler representation for many lines

good overview in 2D

"center of gravity of data"

Different Z' decay channels

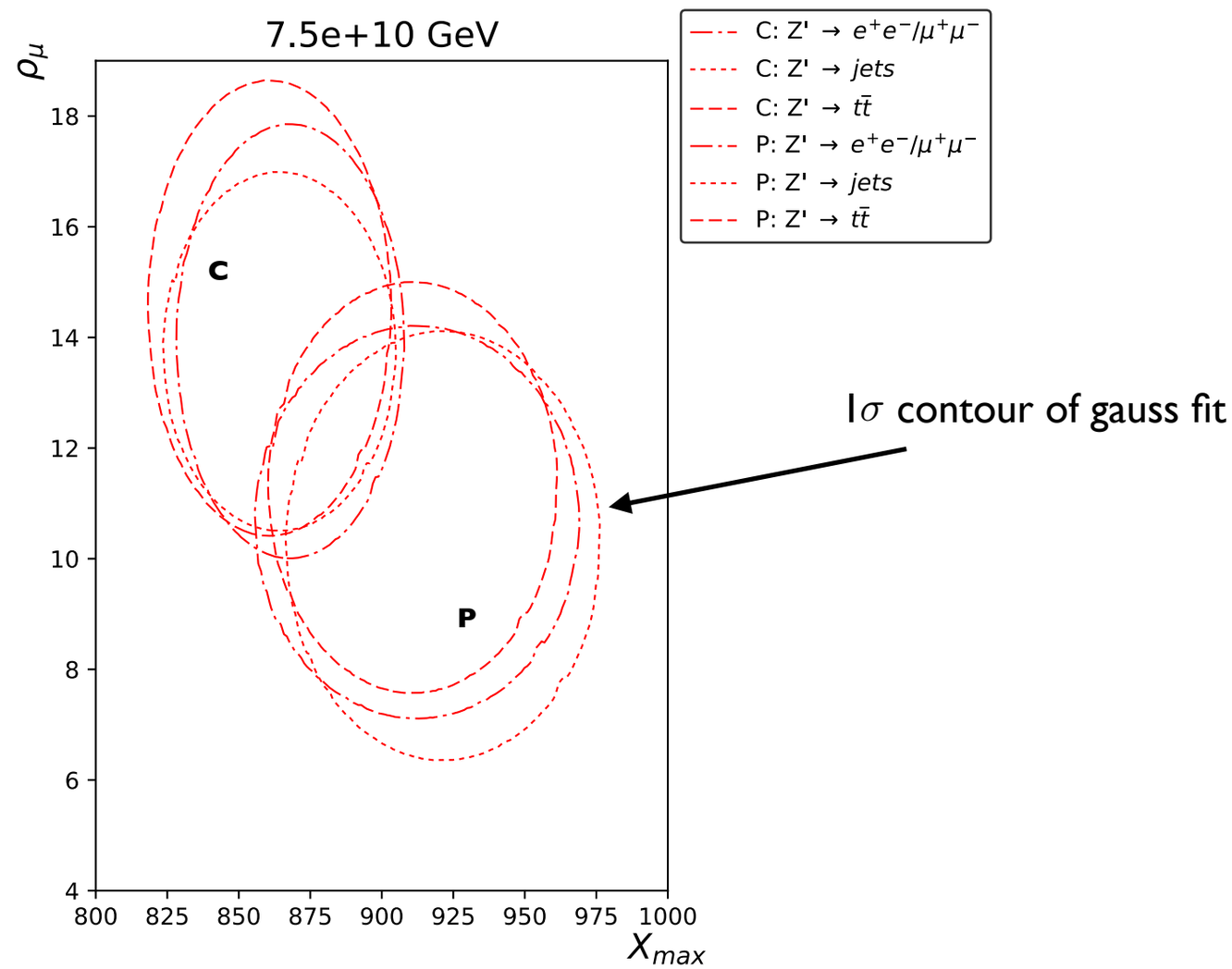
$$E_{\min} \approx \frac{m_{Z'}^2}{4\, m_p^2} = 2.5 \times 10^7\,\mathrm{GeV}$$

however: pdf suppression effects

$$m_{Z'} = 10\,\mathrm{TeV}$$
$$\Gamma_{Z'} = 1\,\mathrm{TeV}$$

Decay modes

- light jets
- charged leptons
- tops
- neutrinos



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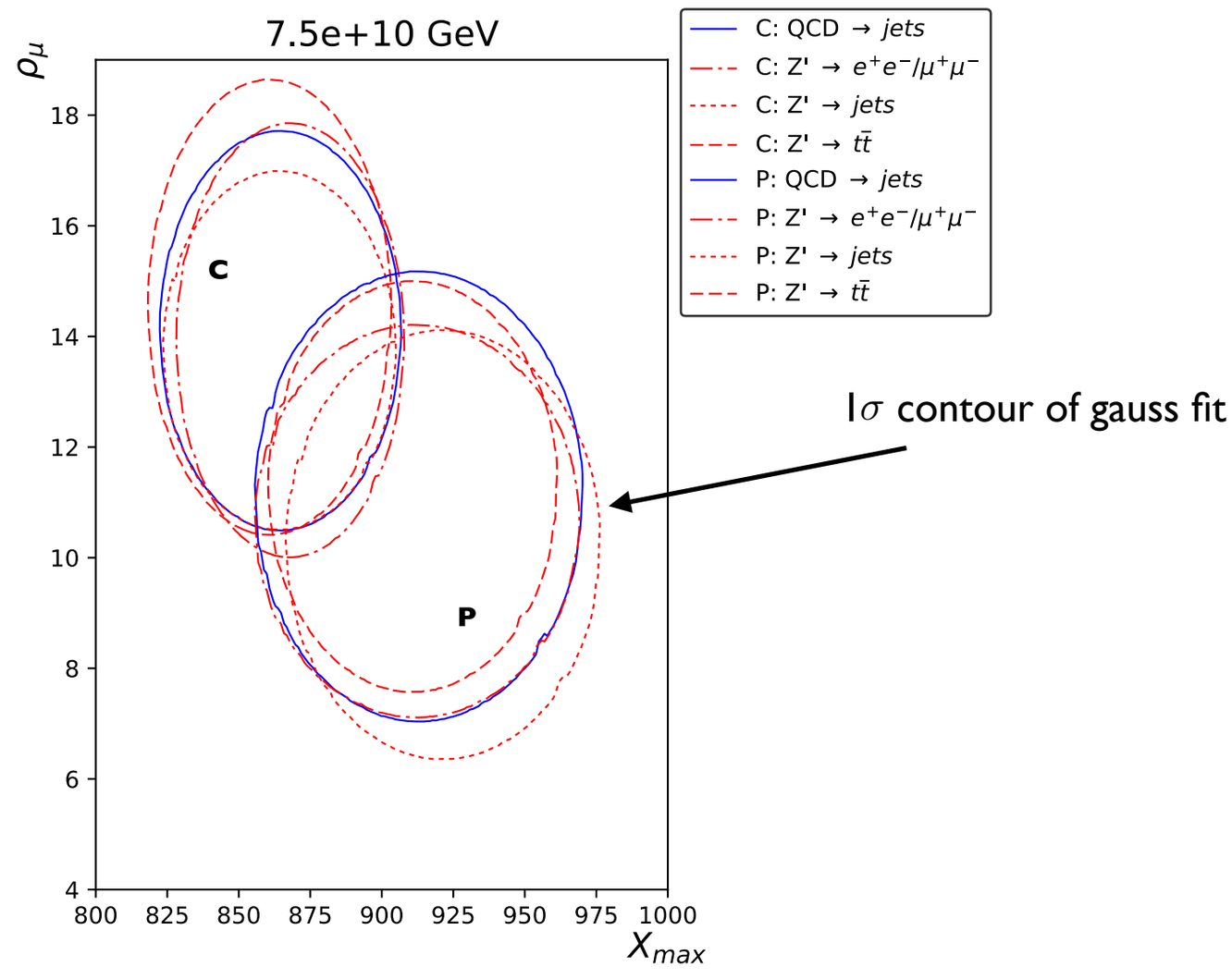

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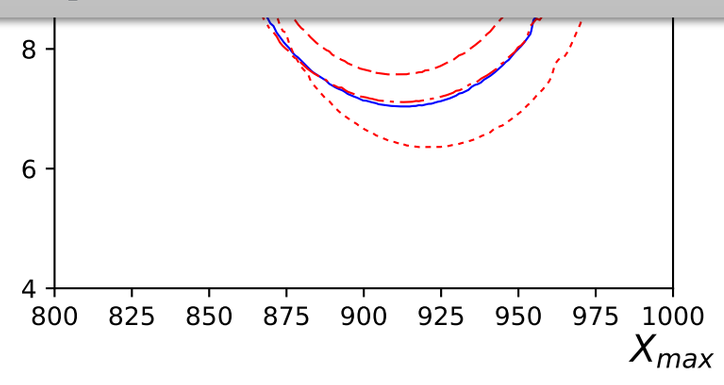
however: pdf effects

Z' decay channels in *principle* distinguishable signal regions may be defined

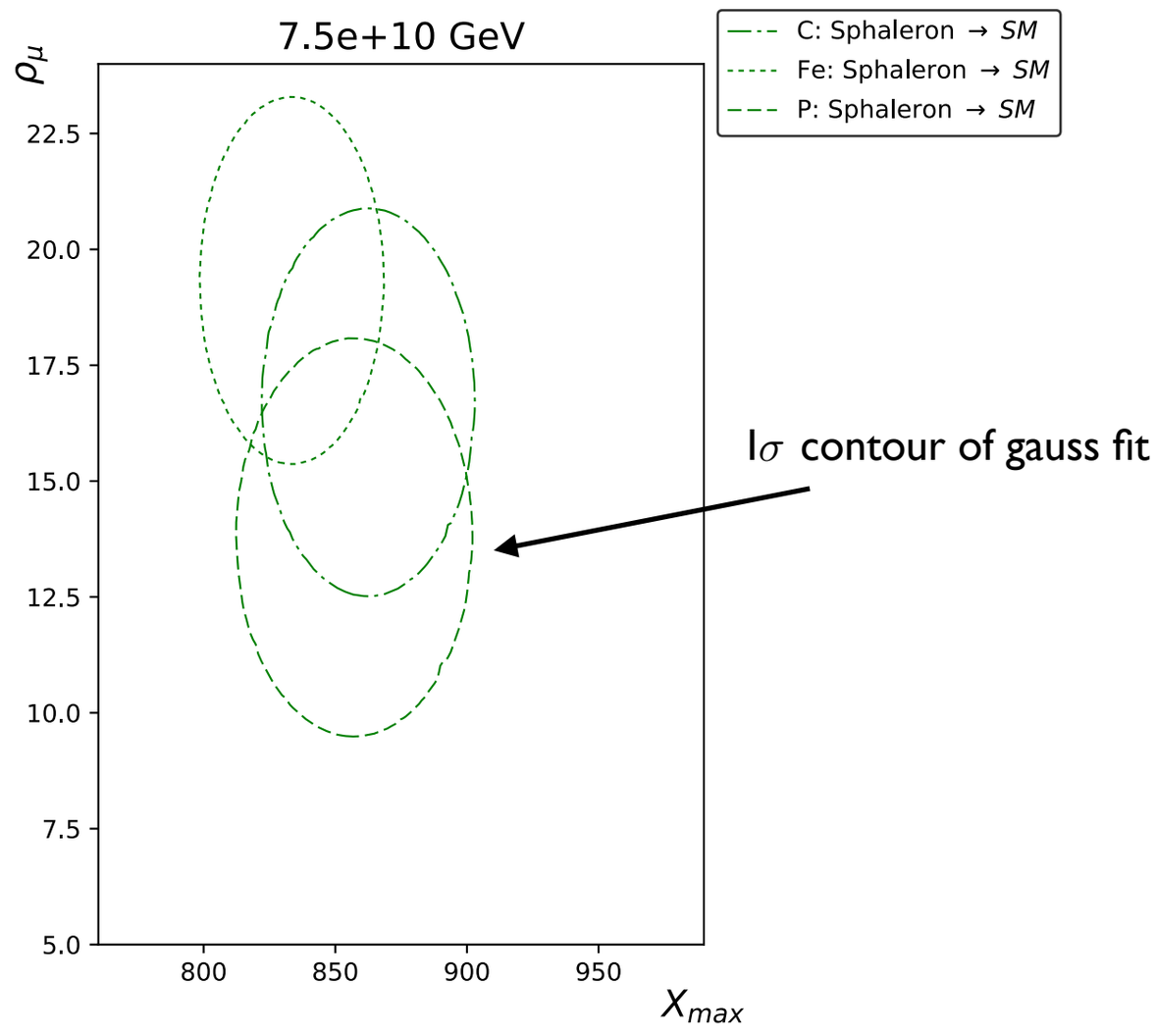
(dependent on decay channel and available statistics)

huge overlap with QCD ➤ hidden primary composition dependent switch on effect

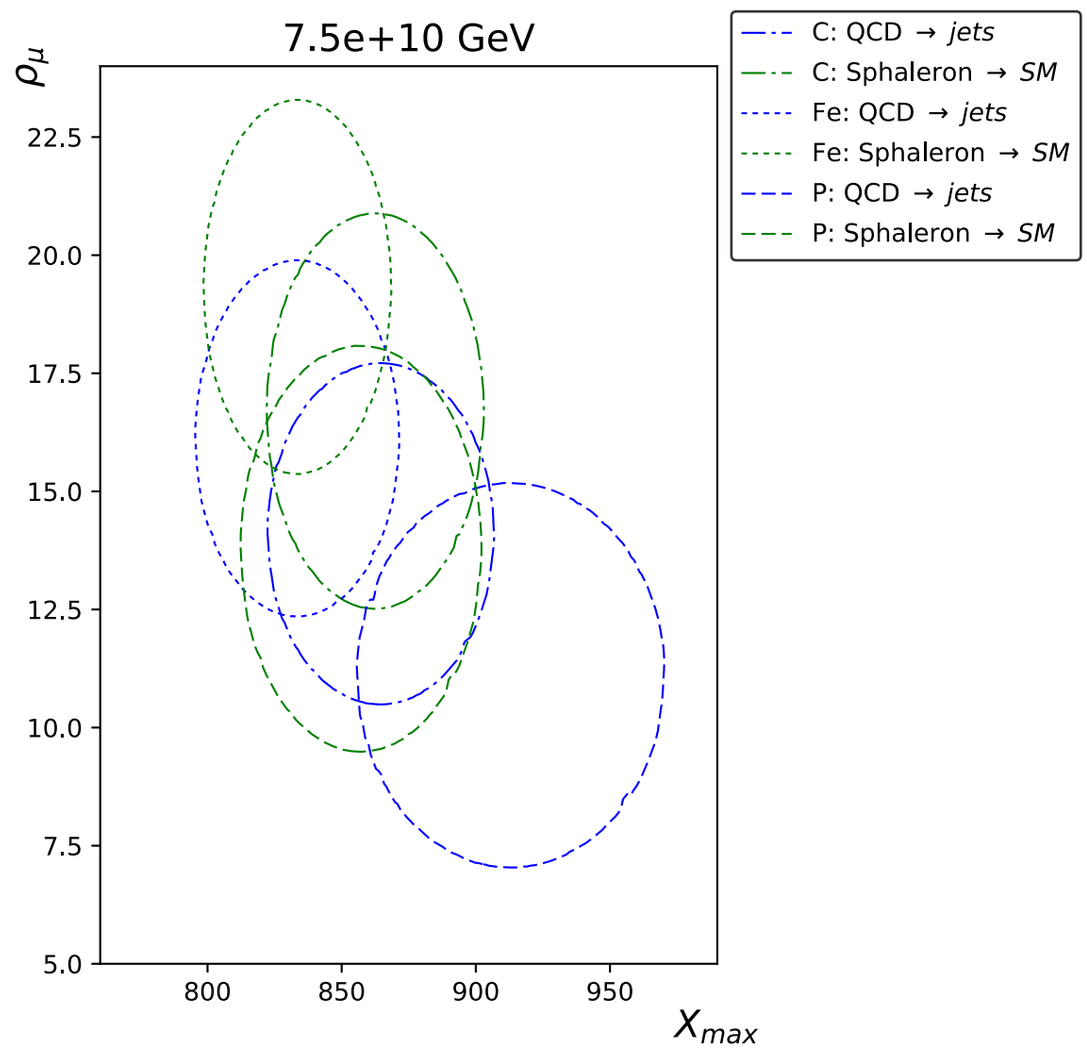
- tops
- neutrinos



Sphalerons


7.5e+10 GeV
ρ_μ
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
800
850
900
950
X_{max}
C: Sphaleron → SM
Fe: Sphaleron → SM
P: Sphaleron → SM
1σ contour of gauss fit

Sphalerons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C: QCD → *jets*
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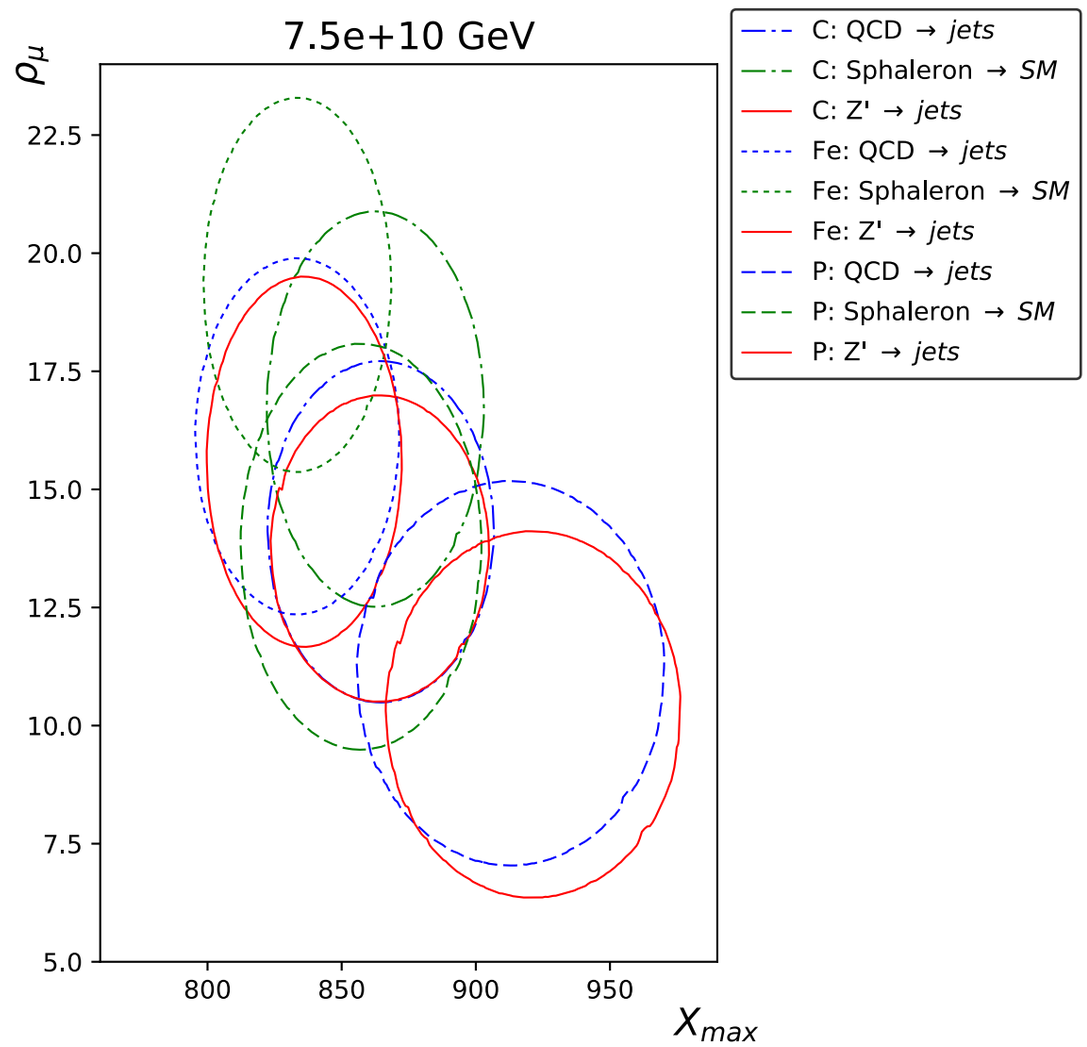
Sphalerons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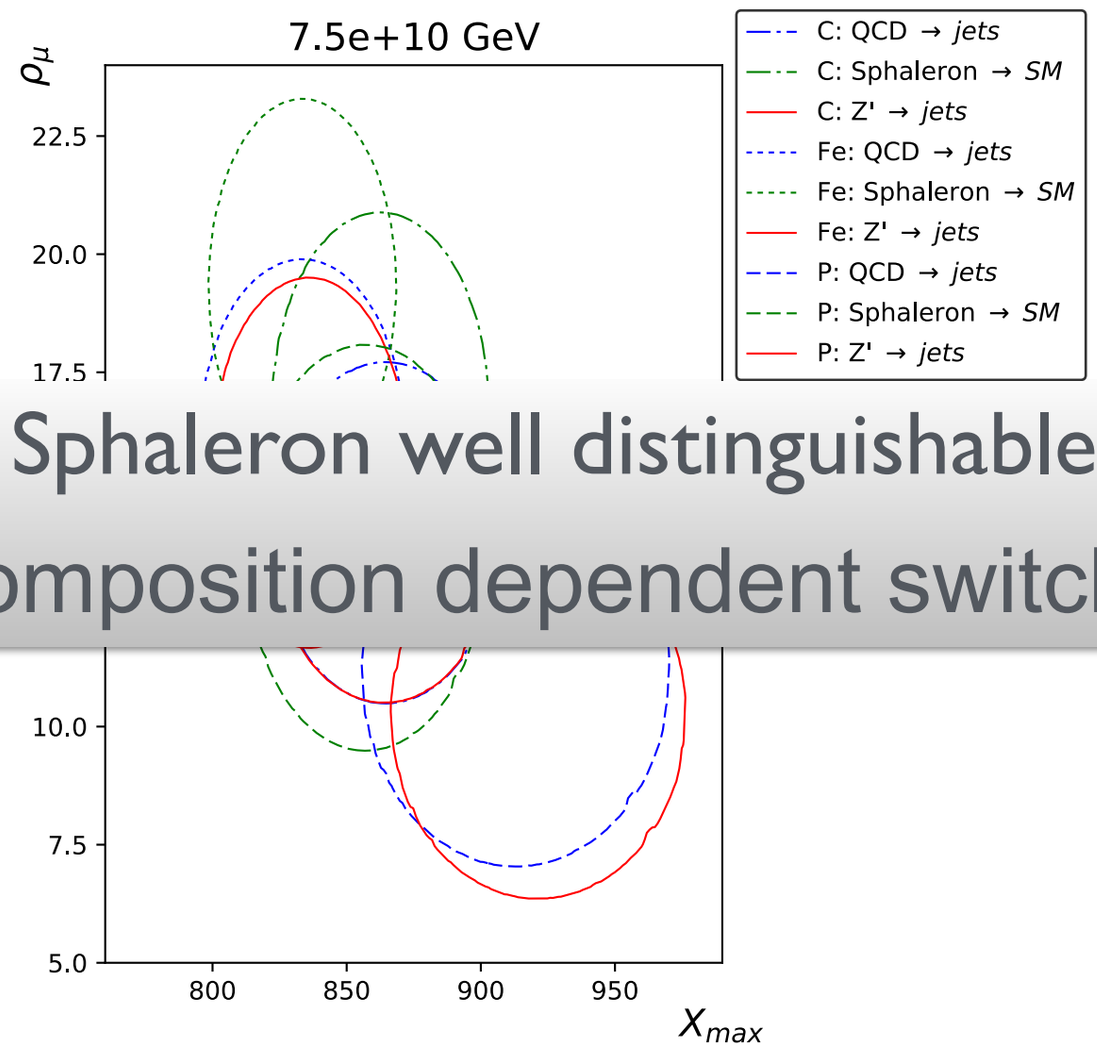
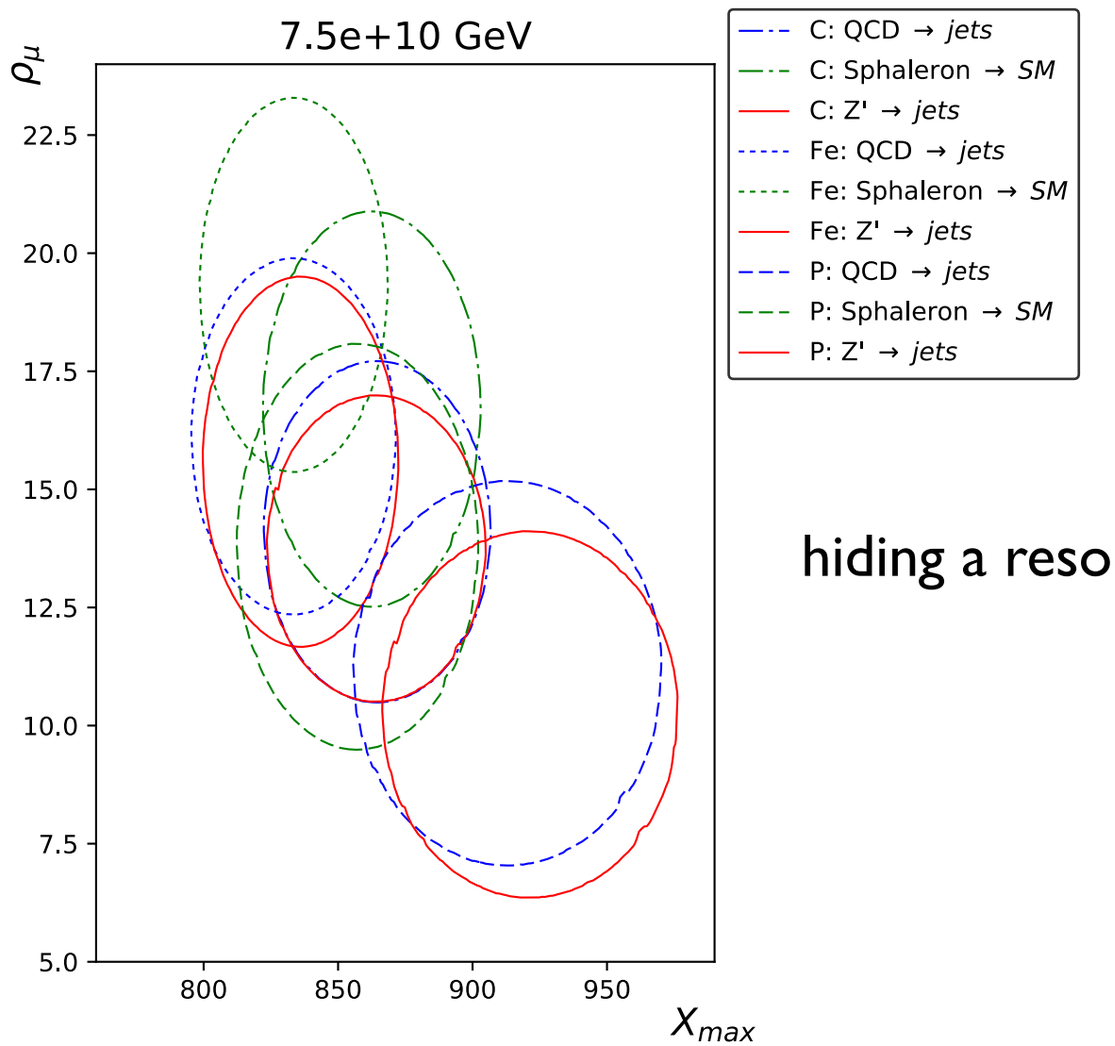
Sphalerons



Sphaleron well distinguishable

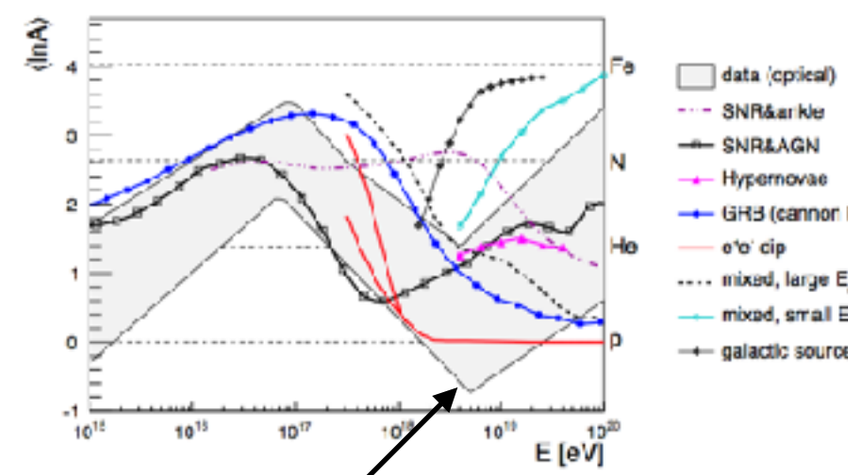
primary composition dependent switch on effect

Conclusion



hiding a resonance?

primary source models



switching on a sphaleron?

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Summary and Outlook

- ✦ simulate new physics in EAS
- ✦ insert BSM into heavy primaries
- ✦ simple resonance not distinguishable
- ✦ high multiplicity decays visible in 2D
- ✦ more structure in 2D not analysed yet