# Forward Jets in pA at CMS

Saray Arteaga Escatel
On behalf of CMS collaboration

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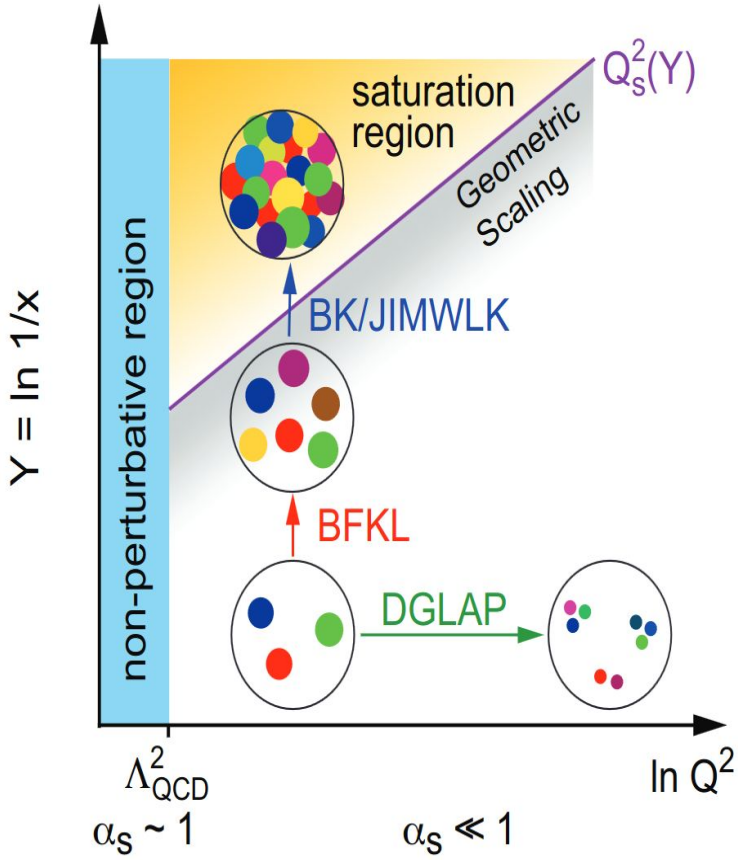
**Forward Physics and QCD at the LHC and EIC**



# Motivation

- Jets in leading order approximation : $x \approx \frac{p_T}{\sqrt{s}} e^{\pm\eta}$
  - forward jets with low $p_T$ offer insights into the parton densities and their evolution at small x.

- Saturation scale in heavy ion larger than single nucleon.
  - $Q^2$ increases as $A^{1/3}$ with respect to proton -> for lead ~ factor 6
  - More accessible experimentally.
  - Jets in the p+Pb data probe the ion parton density at low values of x → therefore sensitive to possible enhanced saturation effects in nuclei.

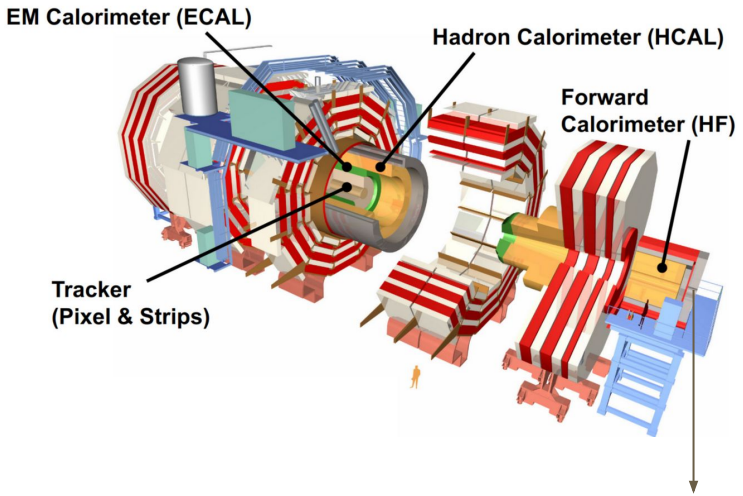


# Forward Calorimeter at CMS

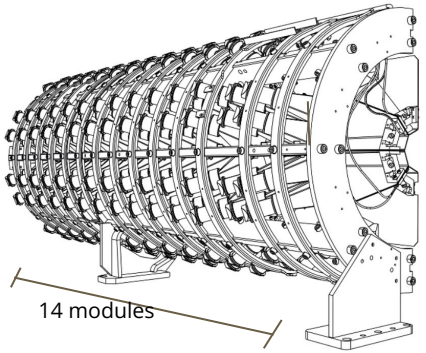
- CASTOR EM-hadronic calorimeter at CMS:
  $-6.6 \leq \eta \leq -5.2$
  - Forward calorimeter at 14 m from interaction point

- CASTOR has no η segmentation. Present energy spectra instead of pt

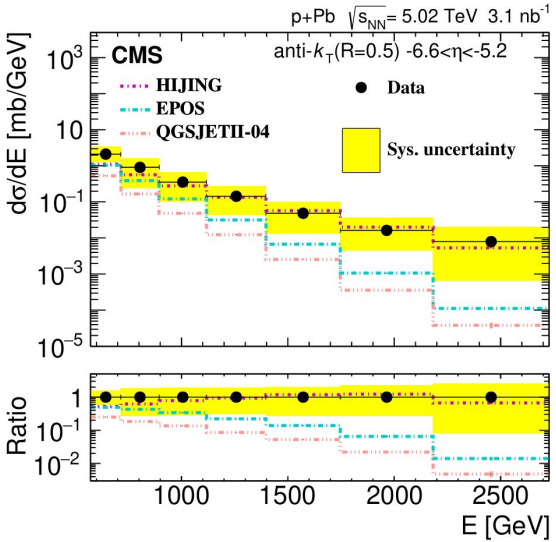
- CASTOR successfully extended acceptance for different measurements:
  - Inelastic and diffractive cross sections
  - Forward energy flow and underlying events
  - Jet spectra

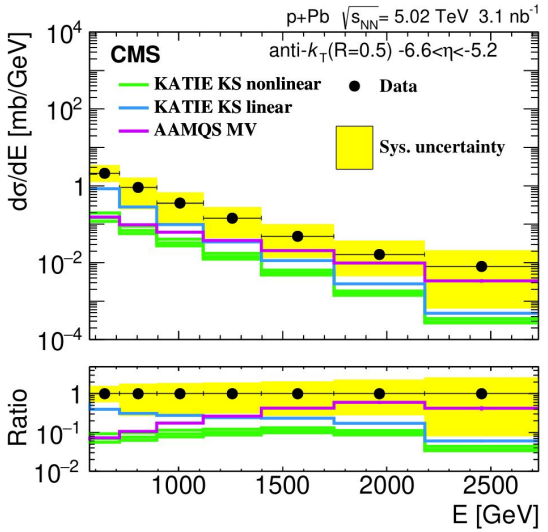



CASTOR



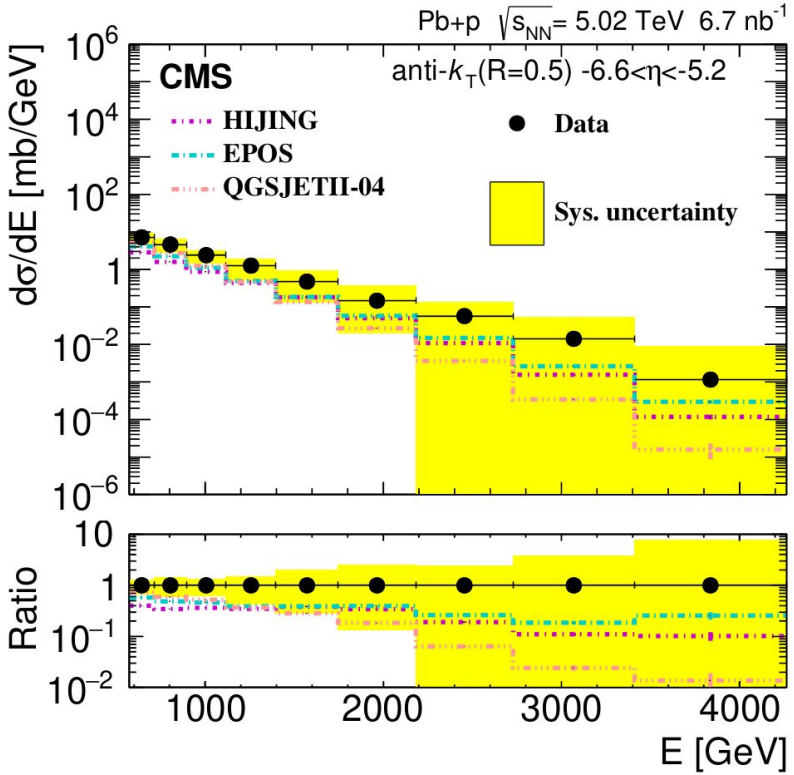
# p+Pb differential jet cross section as a function of jet energy



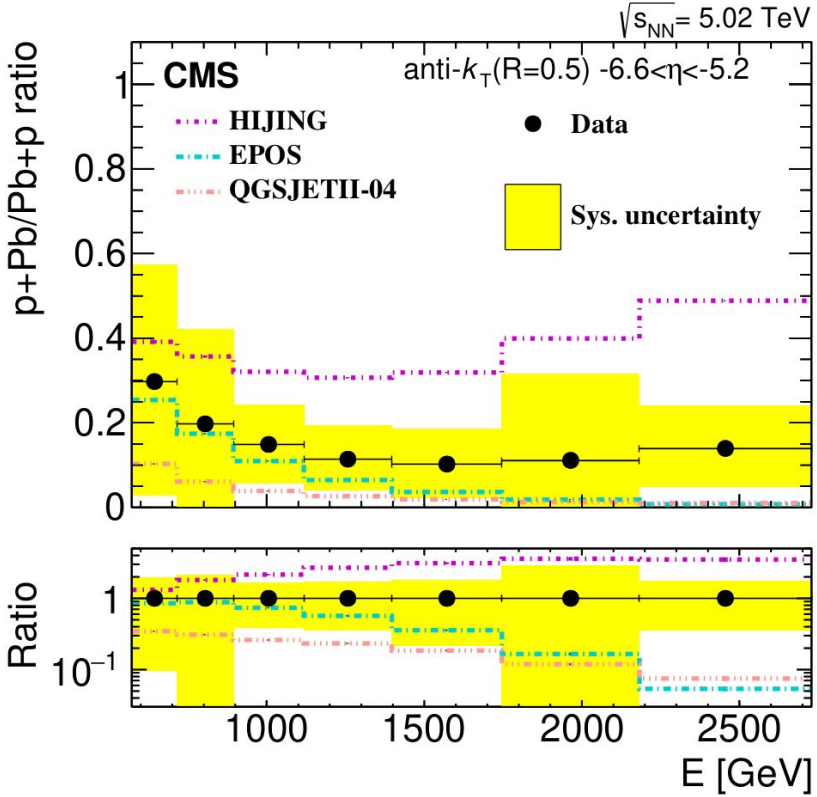

- The predictions of the EPOS-LHC and QGSJETII-04 model differ by more than two orders of magnitude at E = 2.5 TeV.
  - both yield an energy spectrum that is too soft and underestimate the data at high energy.
- HIJING model describes the measured distributions best.
- KATIE-KS predictions differ by an order of magnitude in the low energy region, while converging for the high energies.
- The AAMQS model underestimates the data also in the region most affected by saturation.

# Pb+p differential jet cross section as a function of jet energy




- All models underestimate the data for a few lower energy bins.
- From ~ 1.2 TeV onwards, all models are in agreement with the data within the systematic uncertainty.

# Ratio of the p+Pb to Pb+p cross sections




- p+Pb cross section order of magnitude smaller than Pb+p.
- Ratio is quite flat, substantial uncertainty cancelation occurs.
  → Ratio opportune observable
- HIJING describes shape well but an overall factor ≈ 2 off, due to poor Pb+p description.
- EPOS-LHC model describes the lower energy part of the ratio spectrum well, but fails to describe the shape at high energies.
- QGSJETII-04 underestimates both the shape and normalization of the ratio, which can also be attributed to the poor description of the p+Pb spectrum.

# Summary

- Measurements of the differential inclusive forward jet cross sections in proton-lead collisions at 5.02 TeV have been discussed.
- Overall, none of these saturation models can explain all the features observed in the data.
- Disagreement between the data and the KATIE and AAMQS saturation models is the largest in the region where nonlinear effects are expected to be the strongest.
- Jet spectra in CASTOR in proton lead collisions appears to have good resolution for low-x physics studies.

# Thank you for your attention!