Probing Strongly Interacting Matter with the ALICE Detector

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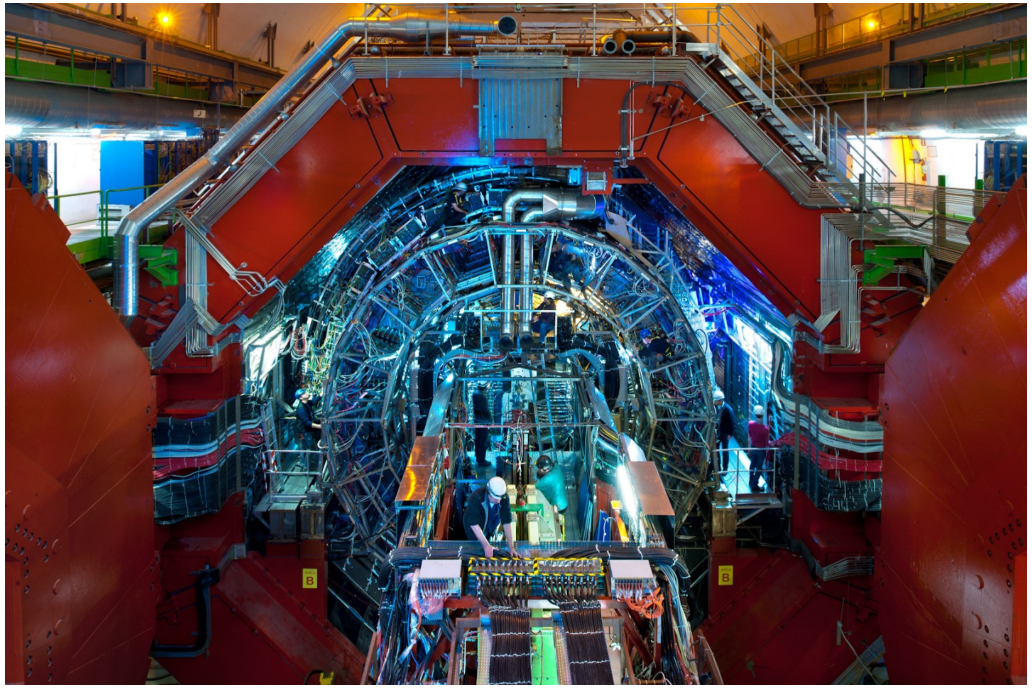
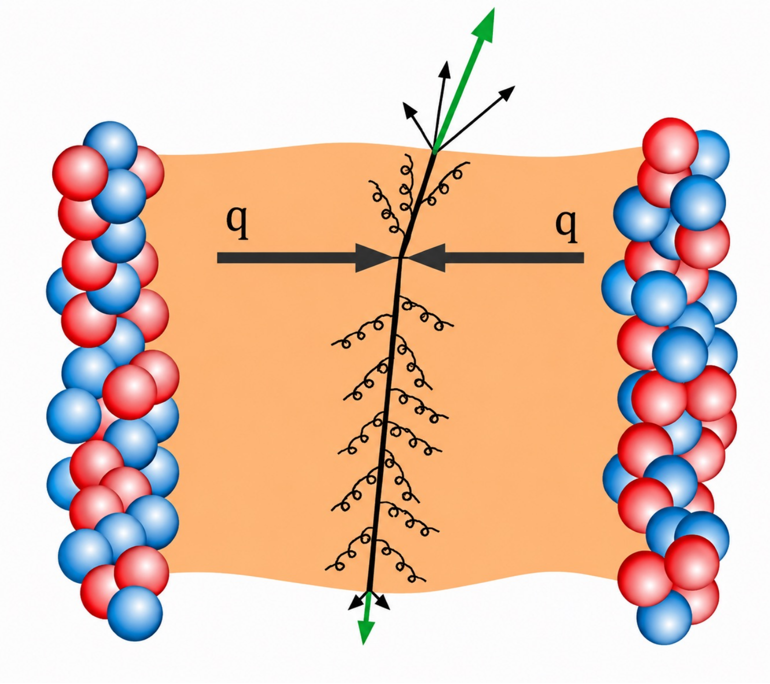
A Large Ion Collider Experiment

ALICE

- LHC Detector specialised for study of heavy-ion collisions
- ALICE primarily studies the Quark-Gluon Plasma (QGP) formed when partons are subject to extreme energy densities
- Quarks and gluons produced in hard scattering processes (jets, heavy quarks) interact with QGP across its evolution which makes them ideal to study QGP properties

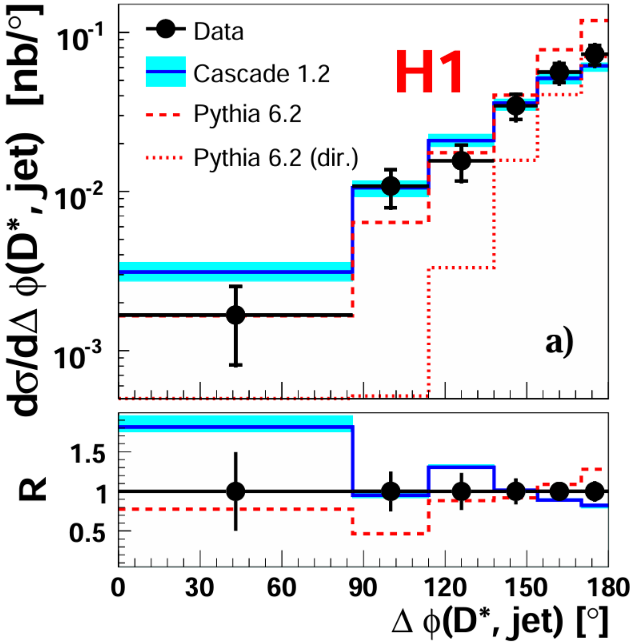


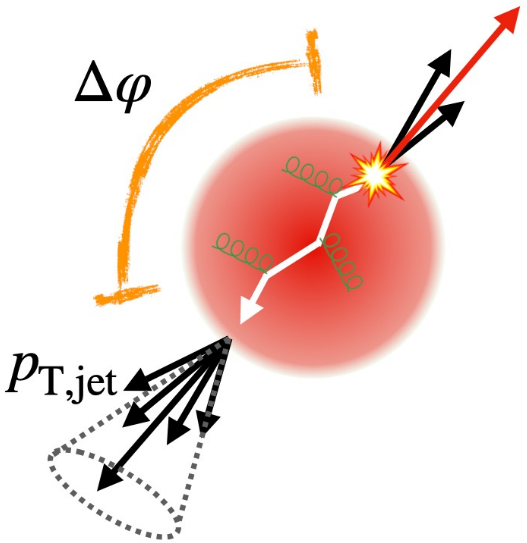


Analysis: D^0+jet Correlations in pp at $\sqrt{13.6}$ TeV

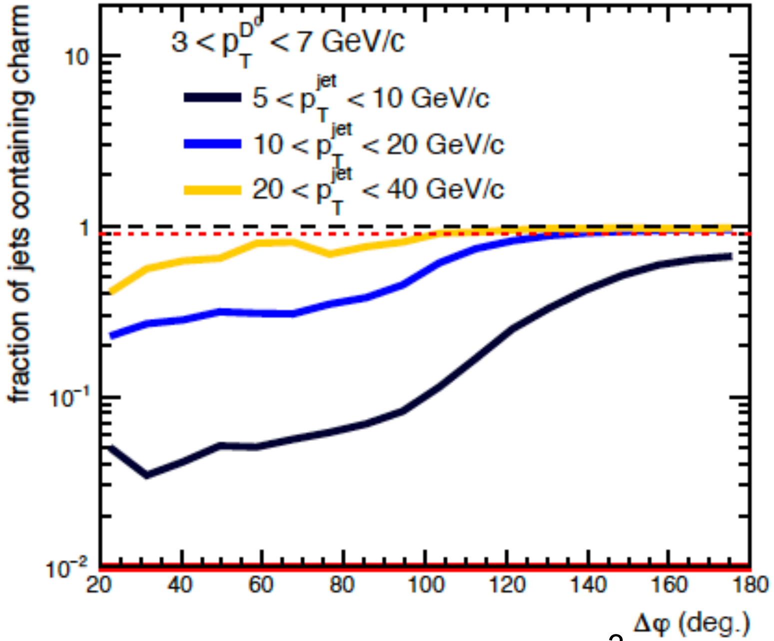
- Charm correlation studies probe …
  - QCD charm production mechanisms in pp
    - Leading order processes
    - Gluon splitting
  - Heavy quark transport properties of QGP in Pb-Pb
    - Medium-induced decorrelation
    - Quenching
- D^0+jet proxy for $D^0\overline{D^0}$ correlations
- Measure yields of charged jets recoiling from D^0s, as a function of the D^0 p_T, jet p_T and azimuthal correlation

H1 paper γp: D* + other jet



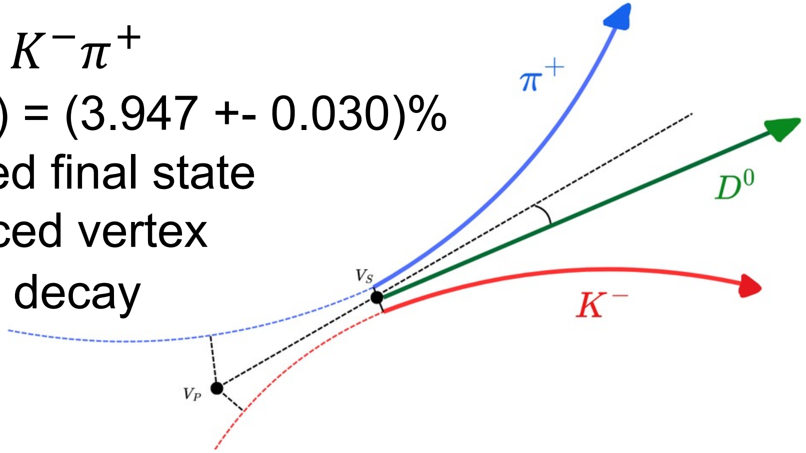


JETSCAPE MC

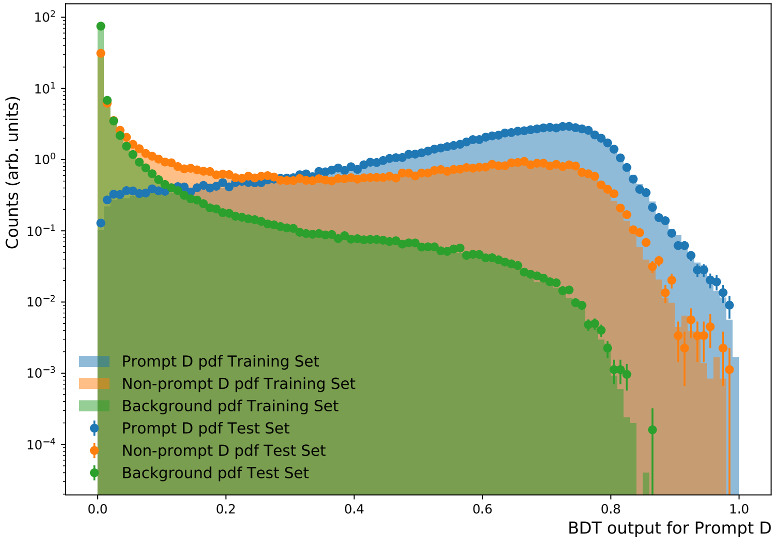


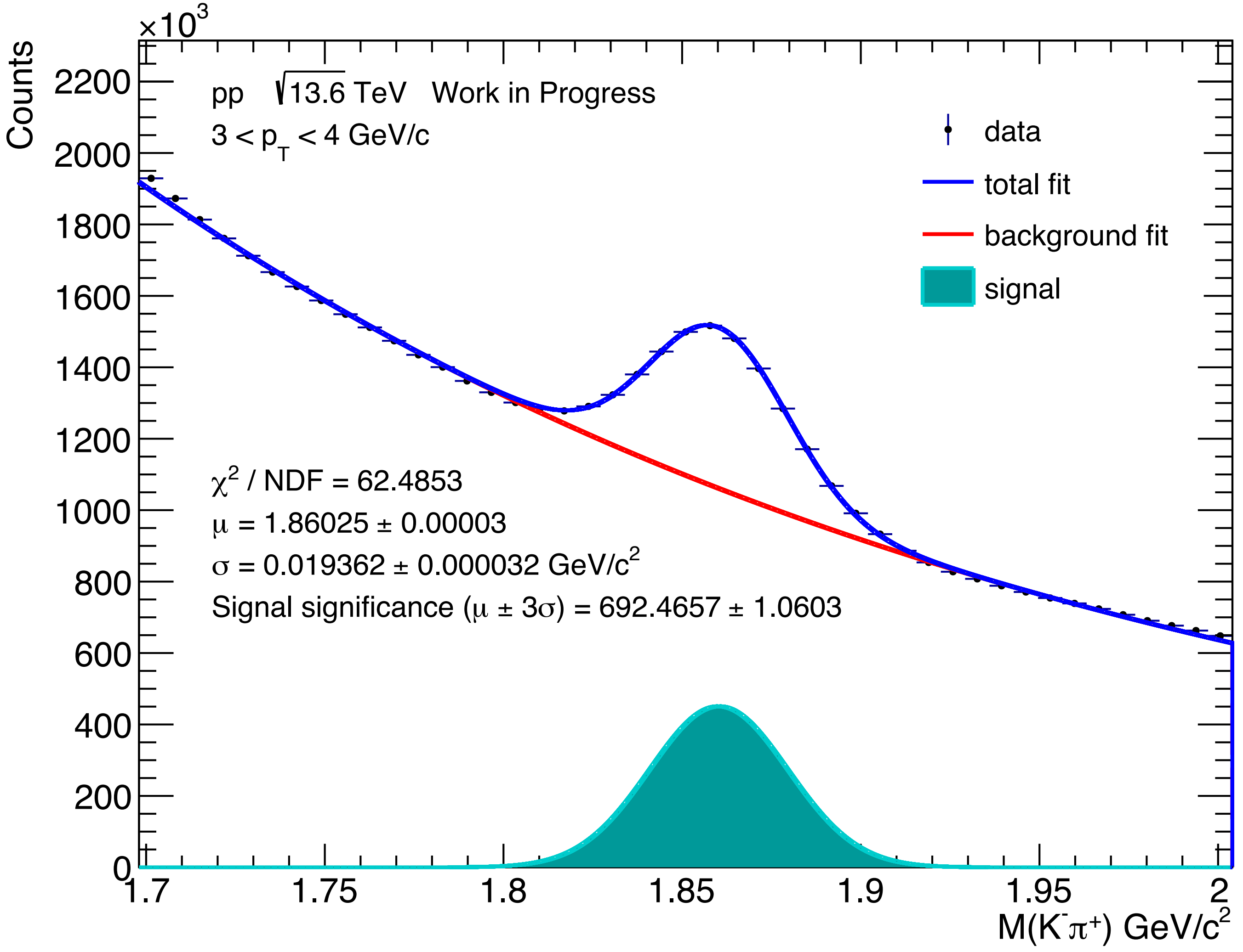
D^0 Reconstruction + Selection

- $D^0(c\bar{u}) \rightarrow K^-\pi^+$
  - BR(D^0) = (3.947 +- 0.030)%
  - Charged final state
  - Displaced vertex
  - 2-body decay



- D^0 Candidates identified using multiclass Boosted Decision Trees





- Gaussian + exponential fit to invariant mass

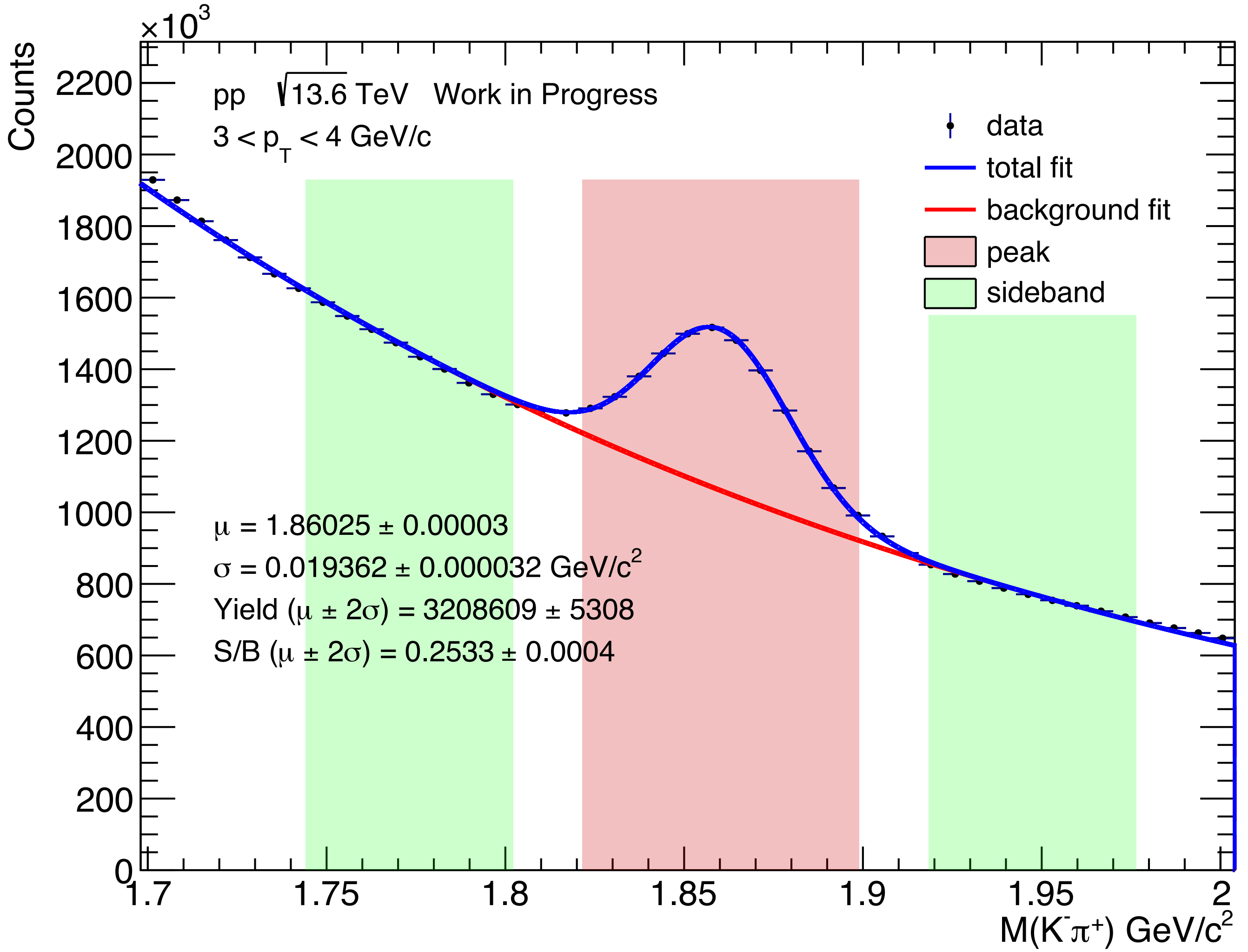
Sideband Subtraction

- Disentangle signal D^0s from peak region
- Subtract background contribution in recoiling jet distributions

- PR: $|m_{inv} - m_{fit}| < 2\sigma$
- SB: $4\sigma < \left|m_{inv} - m_{fit}\right| < 6\sigma$

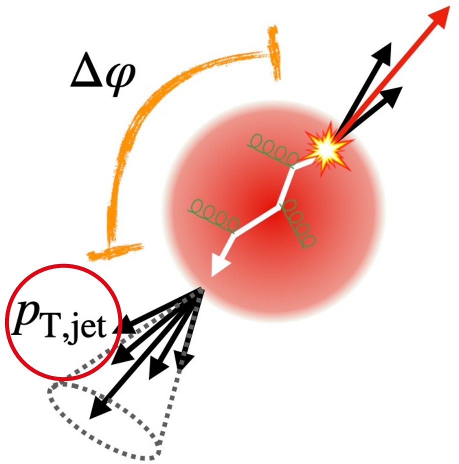
For a given jet observable X:

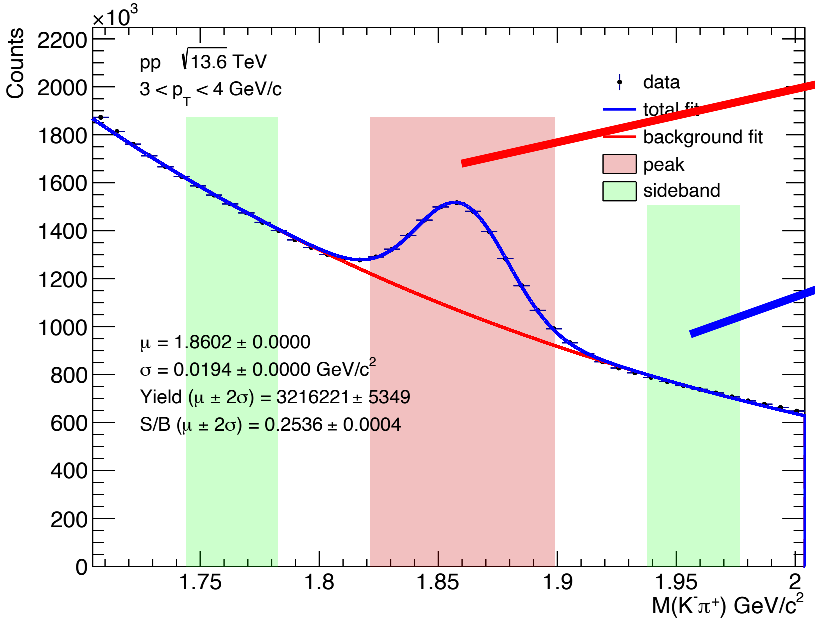
$$X^{raw} = X^{PR} - \frac{N_{bkg}^{PR}}{N_{tot}^{SB}} X^{SB}$$

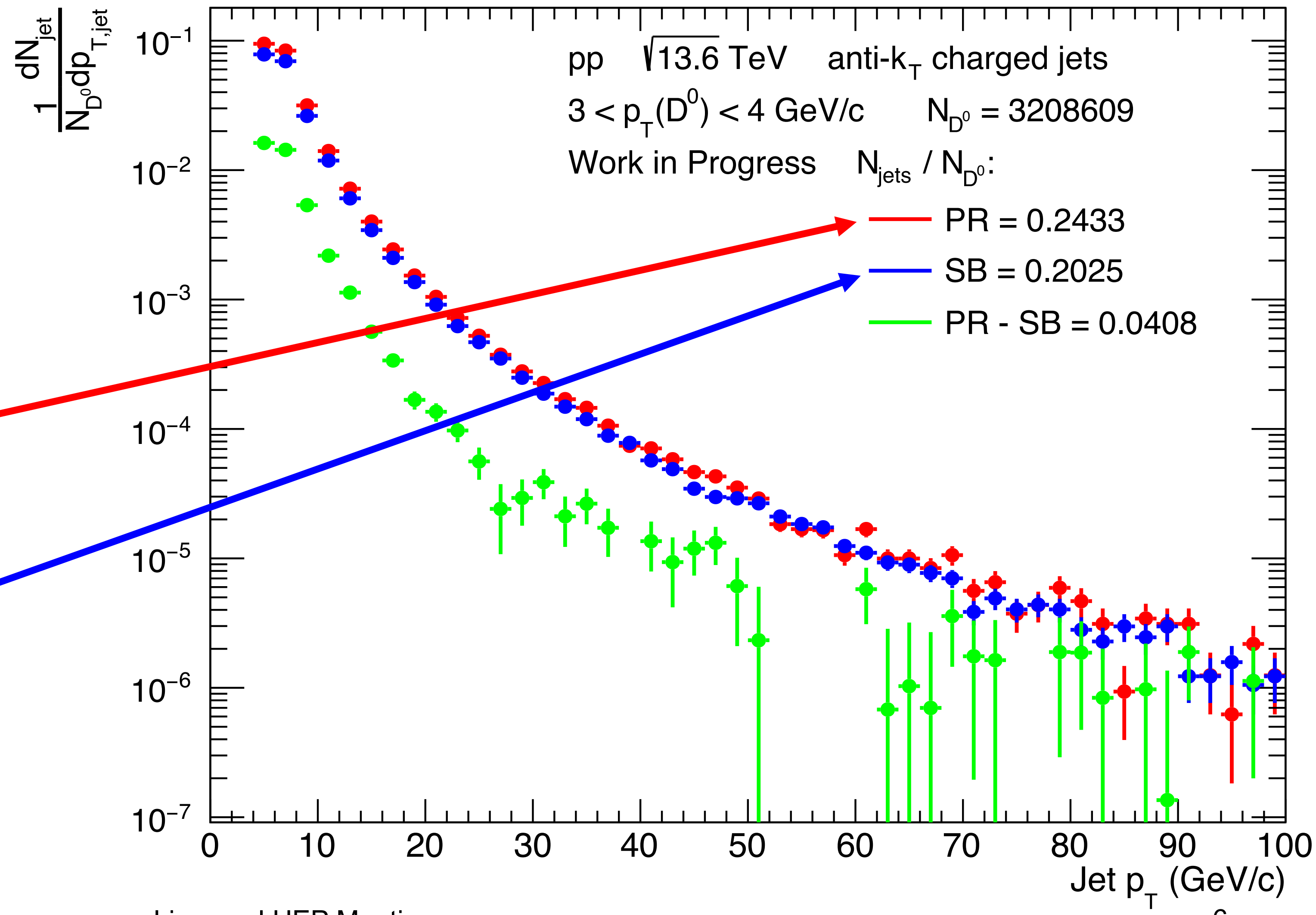


Recoiling Jet p_T Distribution

$3 < D^0\ p_T < 4$ GeV



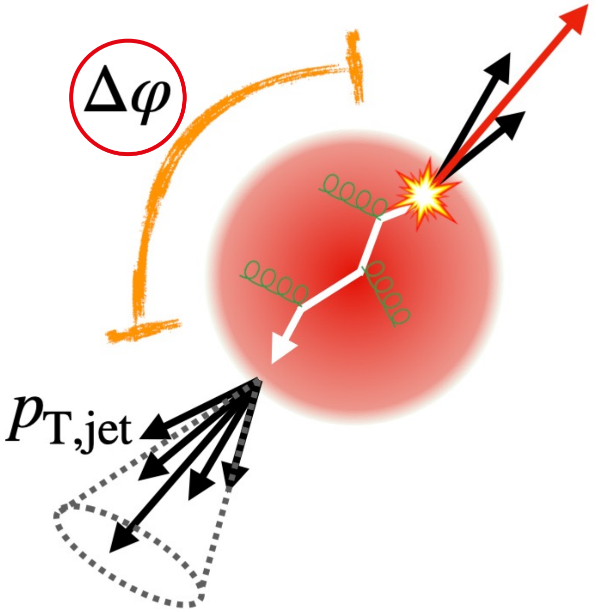


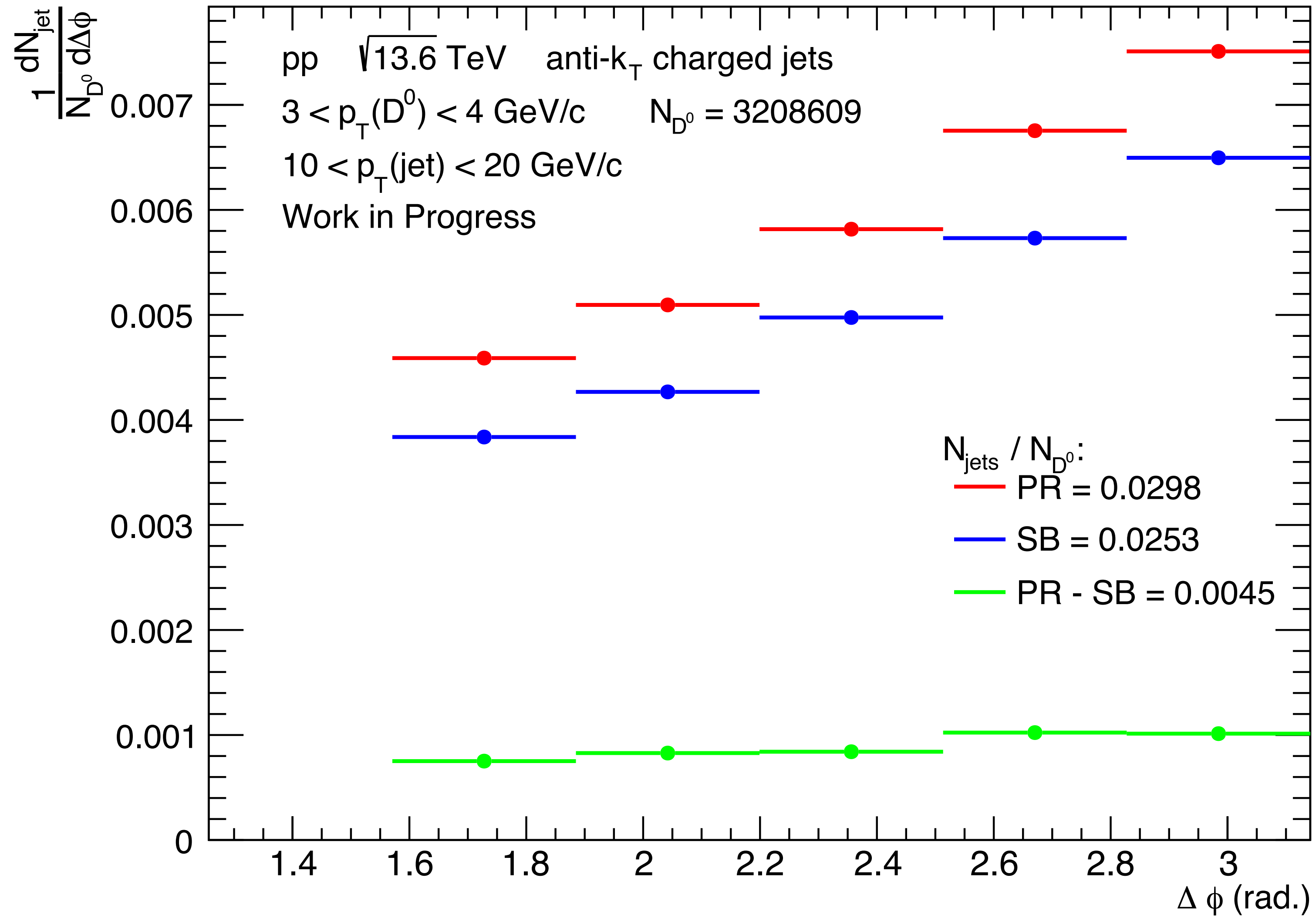


D^0+jet Azimuthal Correlation Distribution

$3 < D^0\ p_T < 4$ GeV

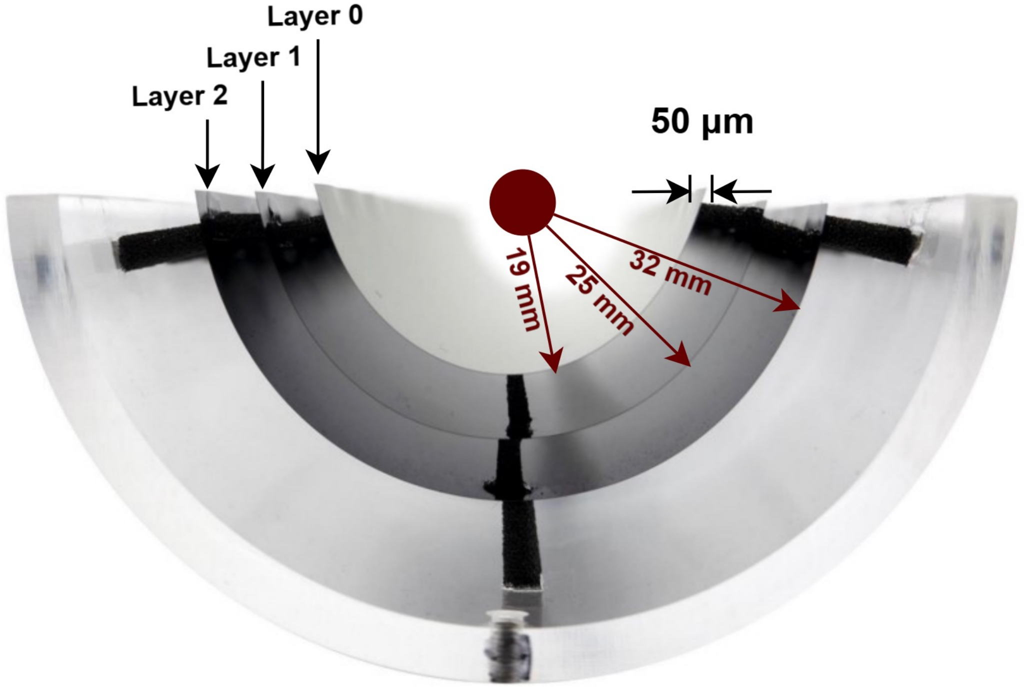
$10 < \text{jet}\ p_T < 20$ GeV

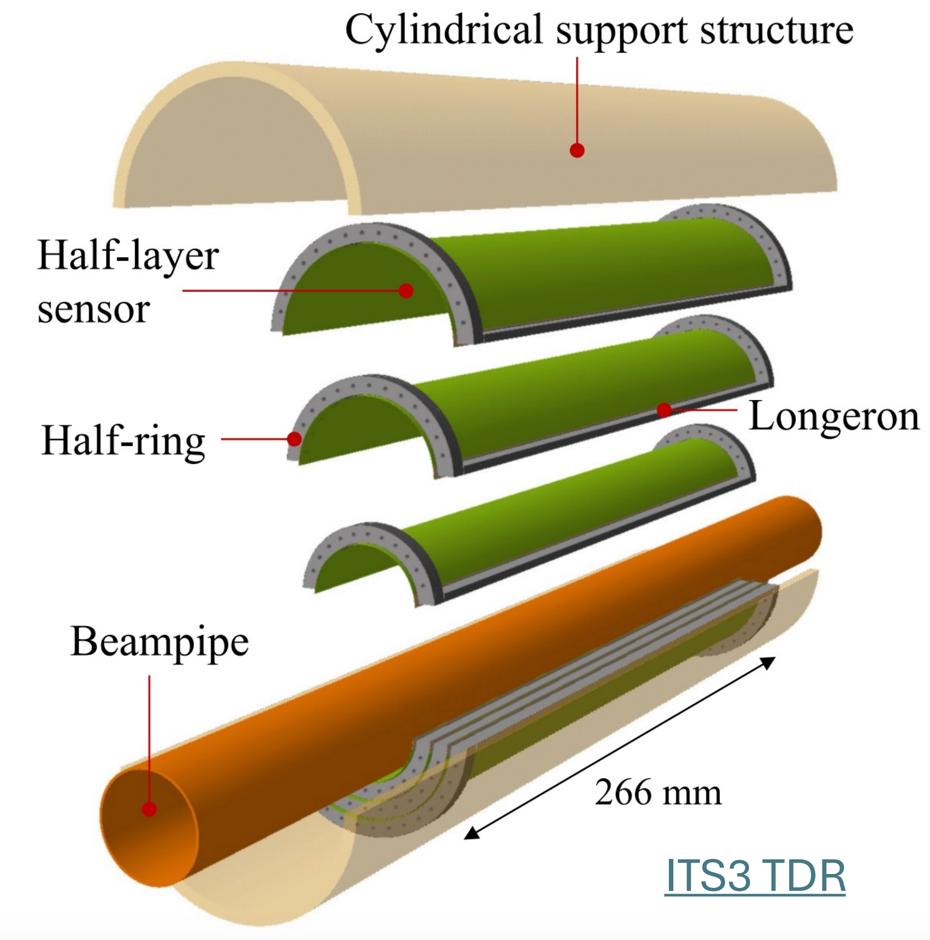




ALICE ITS3

- Inner tracker upgrade for LHC Run 4
- MOSAIX (MOnolithic Stitched Active pIXel sensor)
- Goal: improve vertexing and tracking performance

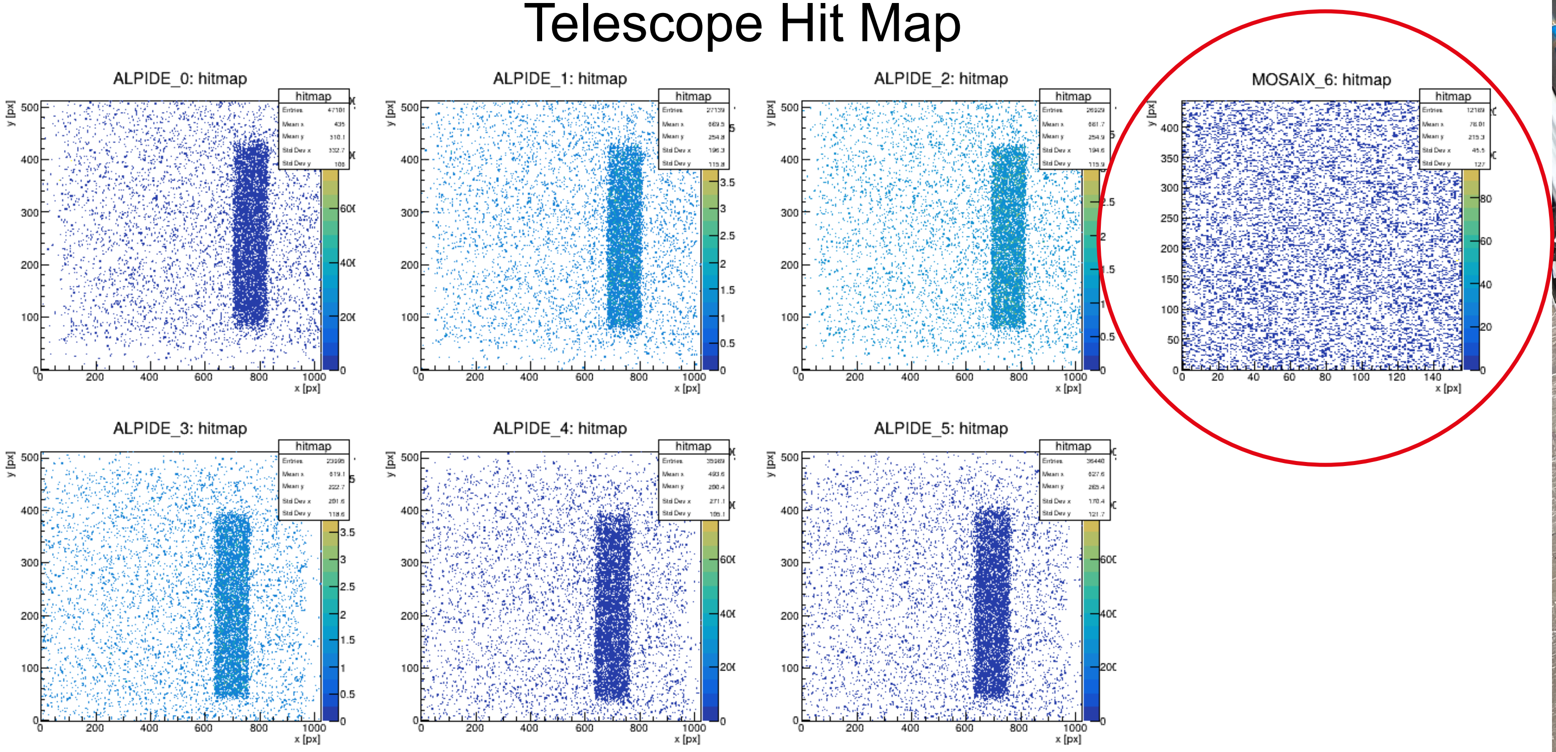


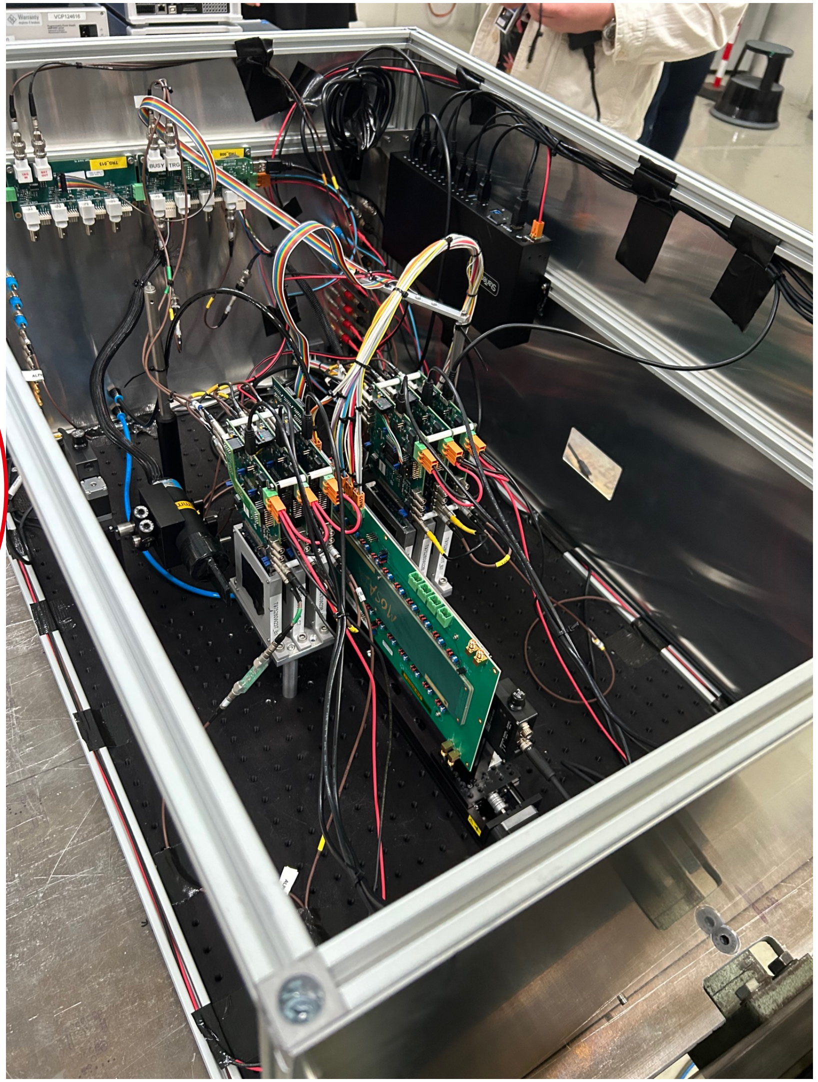


Test Beams

- First TB conducted at CERN's Proton Synchrotron
- Telescope: MOSAIX, 6 ALPIDE chips, 2 scintillators
- Successfully measured hits on MOSAIX for first time

Telescope Hit Map





Future Work - ALICE

Analysis

- Optimise invariant mass fit by modelling combinatorial and correlated backgrounds separately
- Correct raw jet distributions via unfolding
- Explore prompt / non prompt D^0 selection for charm / beauty separation
- Explore tagging jets for charm content using ML

Service Task

- Contribute to future MOSAIX test beams

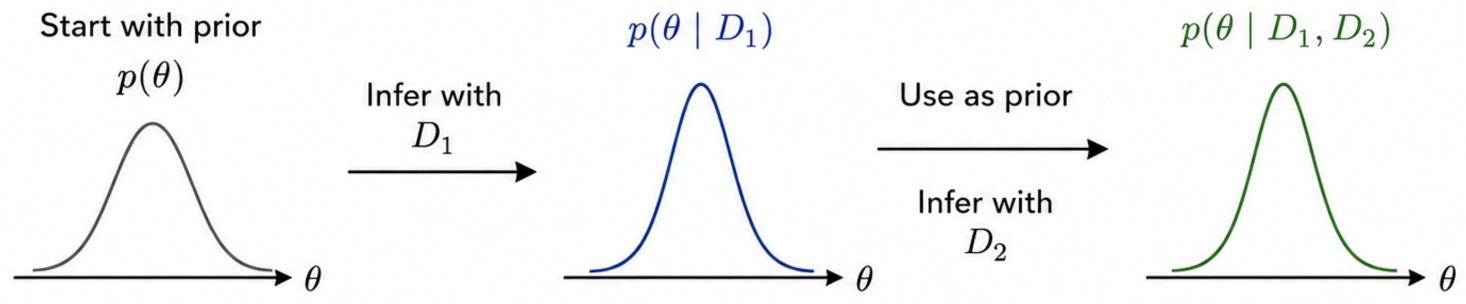
Future Work - JETSCAPE

- MC framework for simulating heavy-ion collisions

- Model used to constrain QGP properties via rigorous data-theory comparison using Bayesian Inference

$$P(\theta|D) = \frac{P(D|\theta)P(\theta)}{P(D)}$$

- Develop framework for prior sampling for sequential Bayesian Inference
  - Normalising flow: algorithm for simplifying complex probability distributions by transforming them into a simple base (Gaussian) distribution



Back Up

BDT training

- Multiclass: prompt, non-prompt, background

- BDT training variables:
  - Decay length
  - Decay length XY
  - χ^2 PCA
  - $\cos(\theta_P)$
  - Impact parameter product
  - N σ TPC TOF Pi exp Pi
  - N σ TPC TOF Ka exp

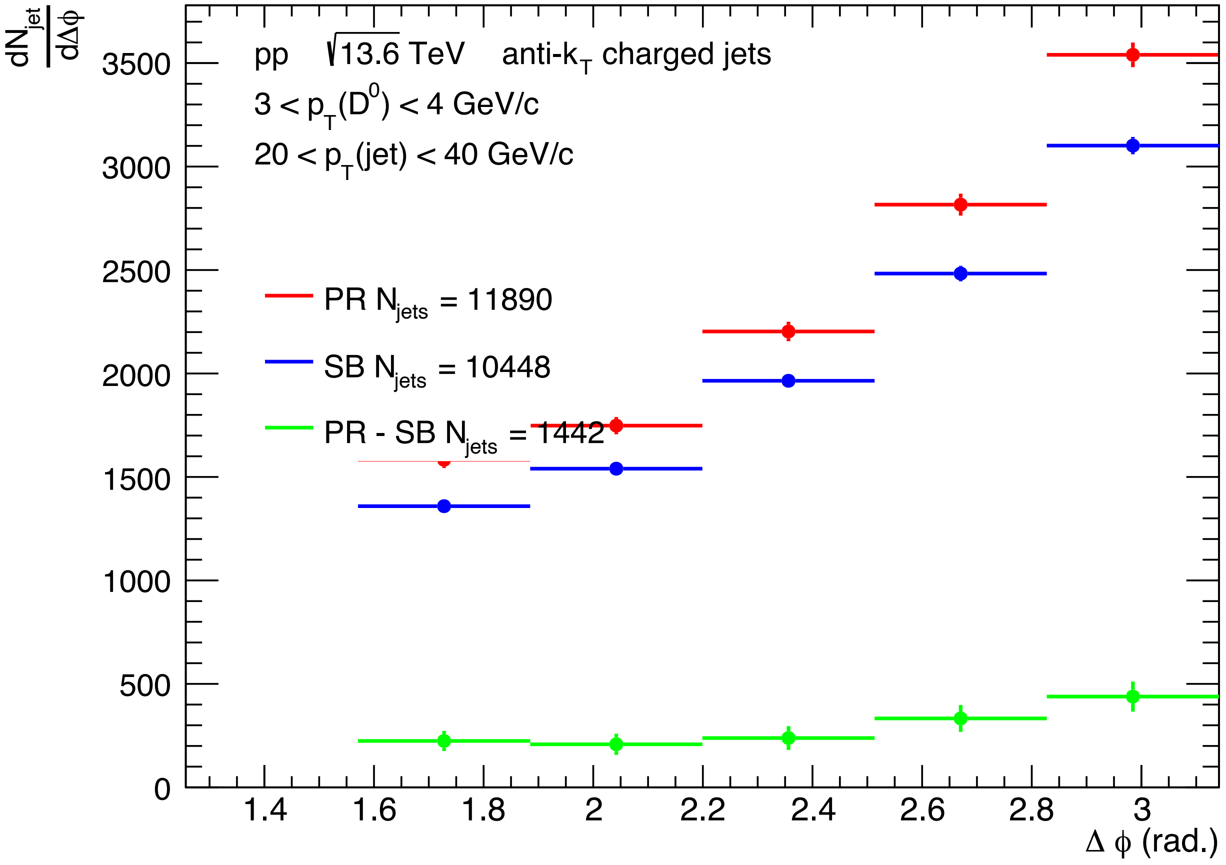
- Separate BDT trained for D^0 p_T range:
  - 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 8-10, 10-12, 12-16, 16-24 GeV

- Background score cut on pre-optimised values

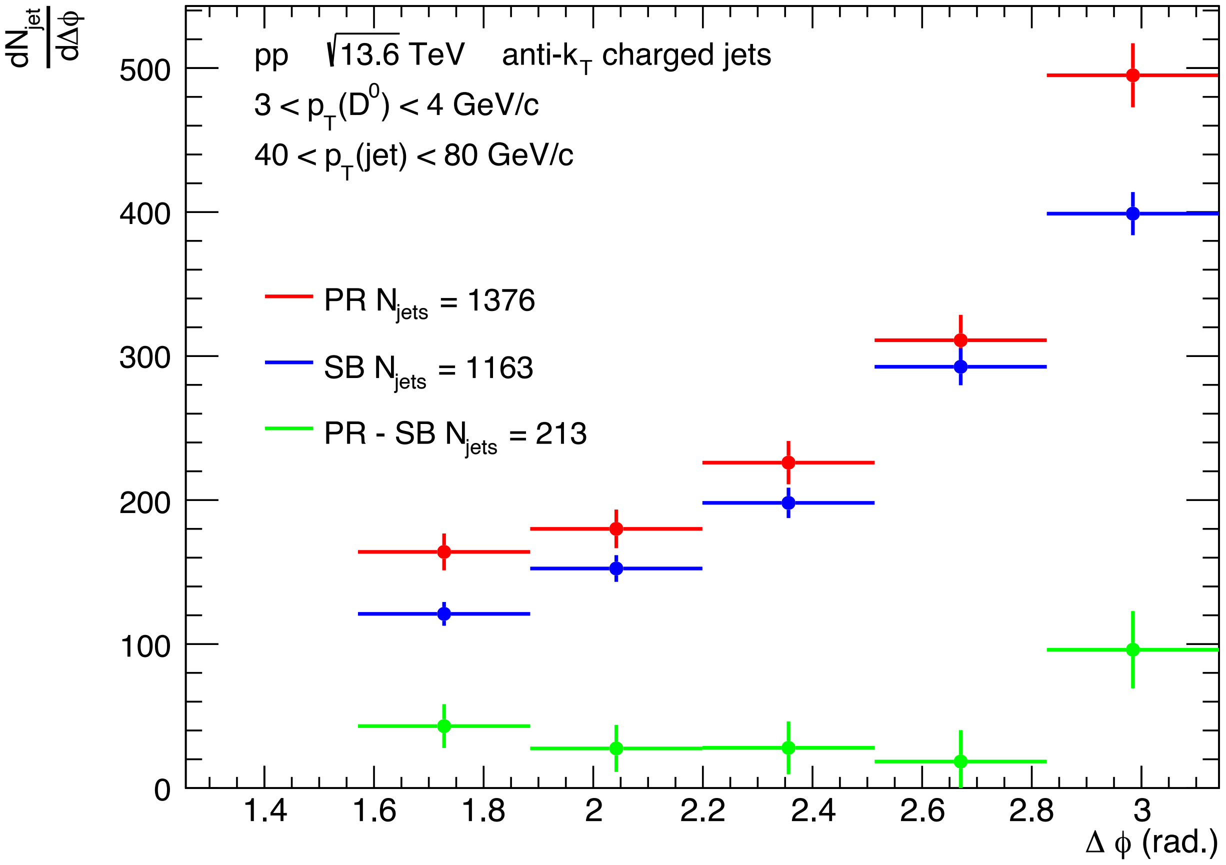
D^0+jet Azimuthal Correlation Distribution

$3 < D^0\ p_T < 4$ GeV/c

$20 <$ jet $p_T < 40$ GeV/c

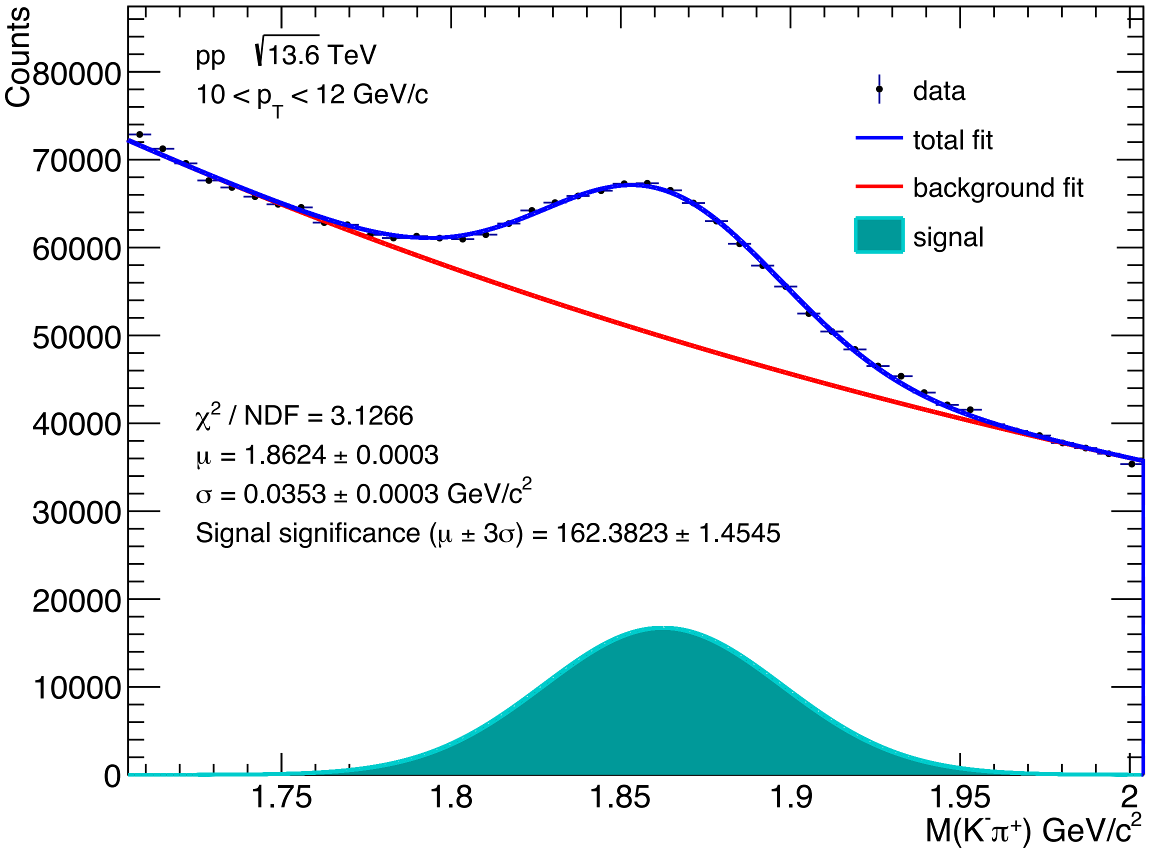


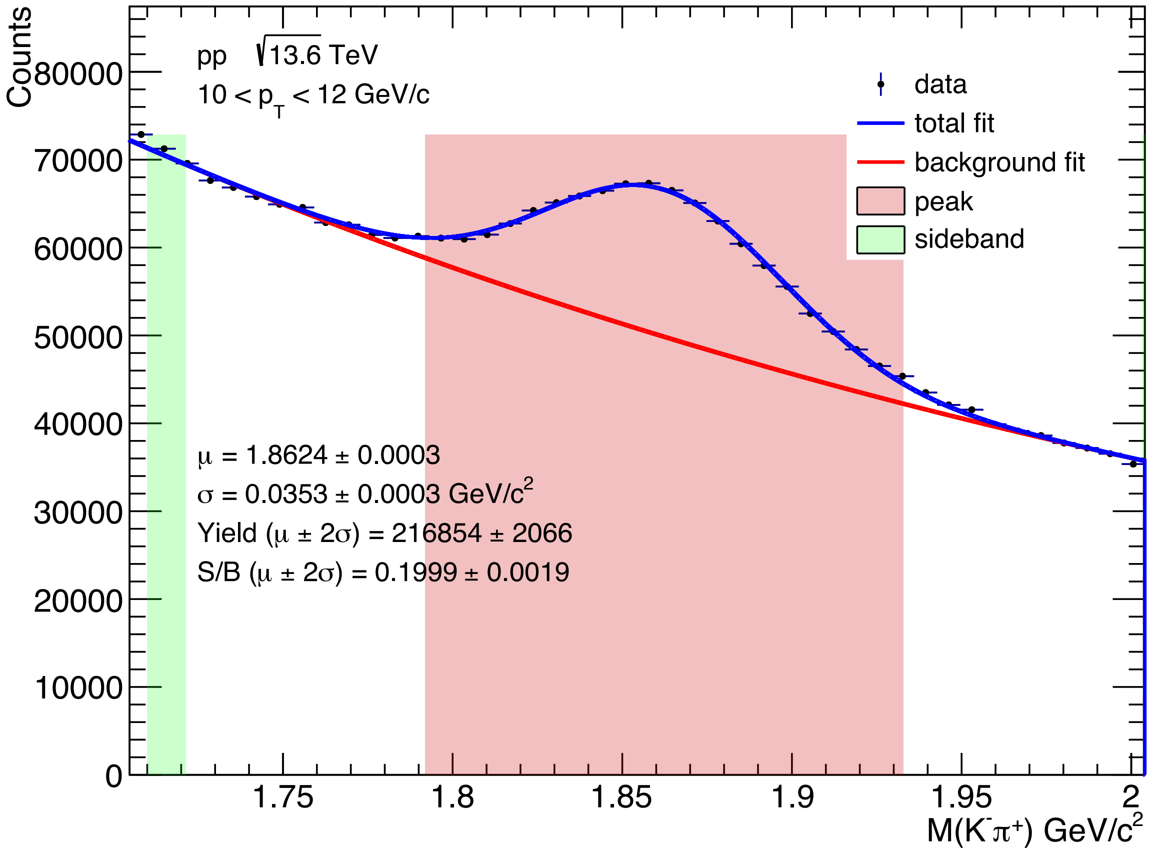
$40 <$ jet $p_T < 80$ GeV/c



Invariant Mass

10 < $D^0\ p_T$ < 12 GeV/c

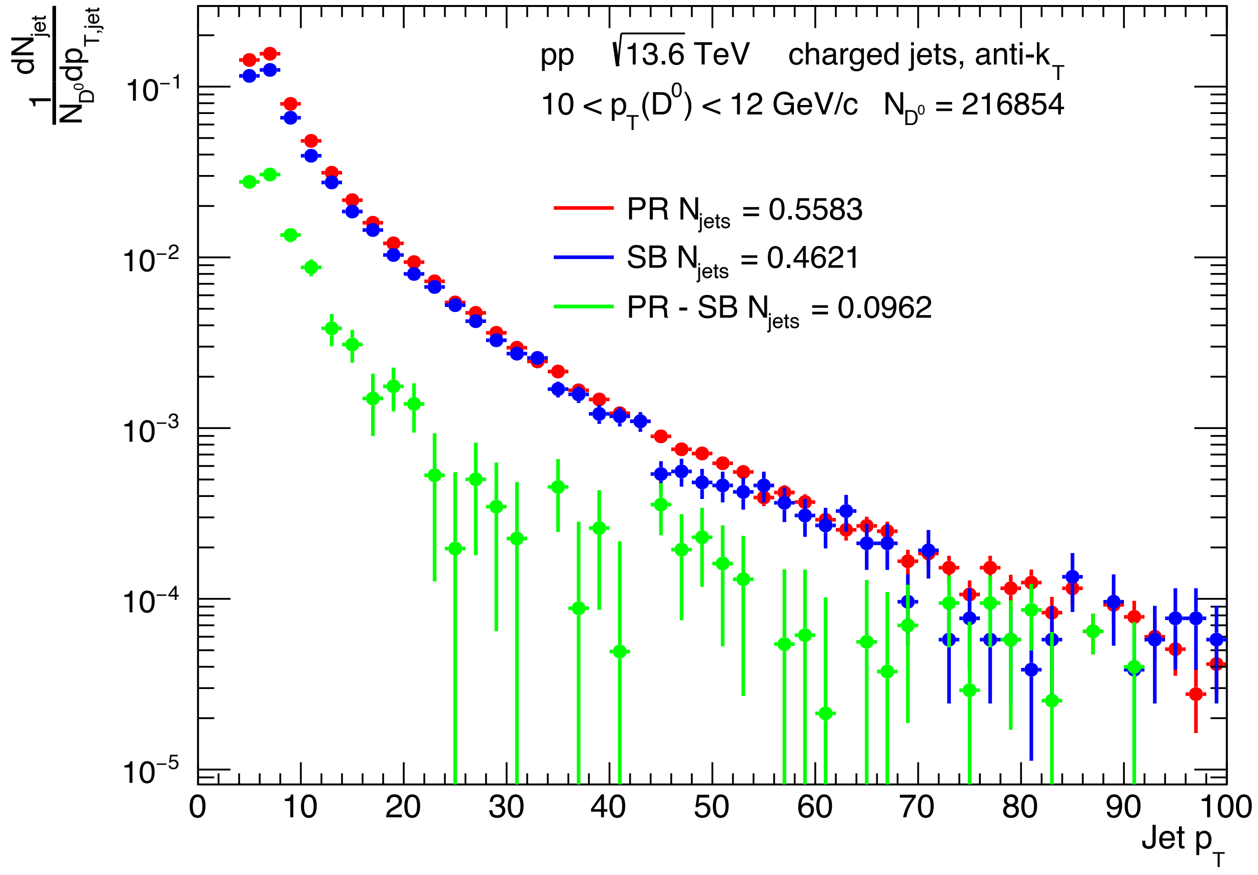


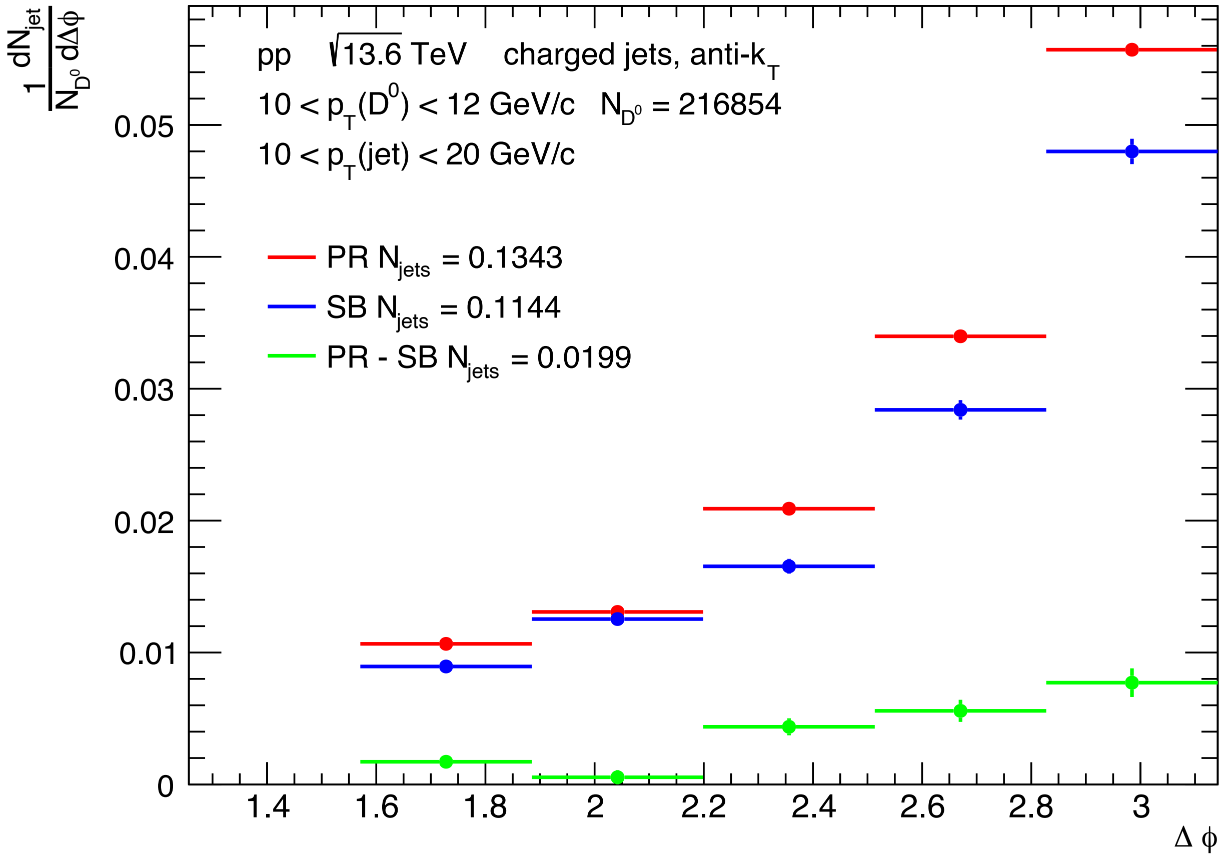


Jet p_T & D^0+jet Azimuthal Correlation Distributions

$10 < D^0\ p_T < 12$ GeV/c

$10 < \text{jet}\ p_T < 20$ GeV/c

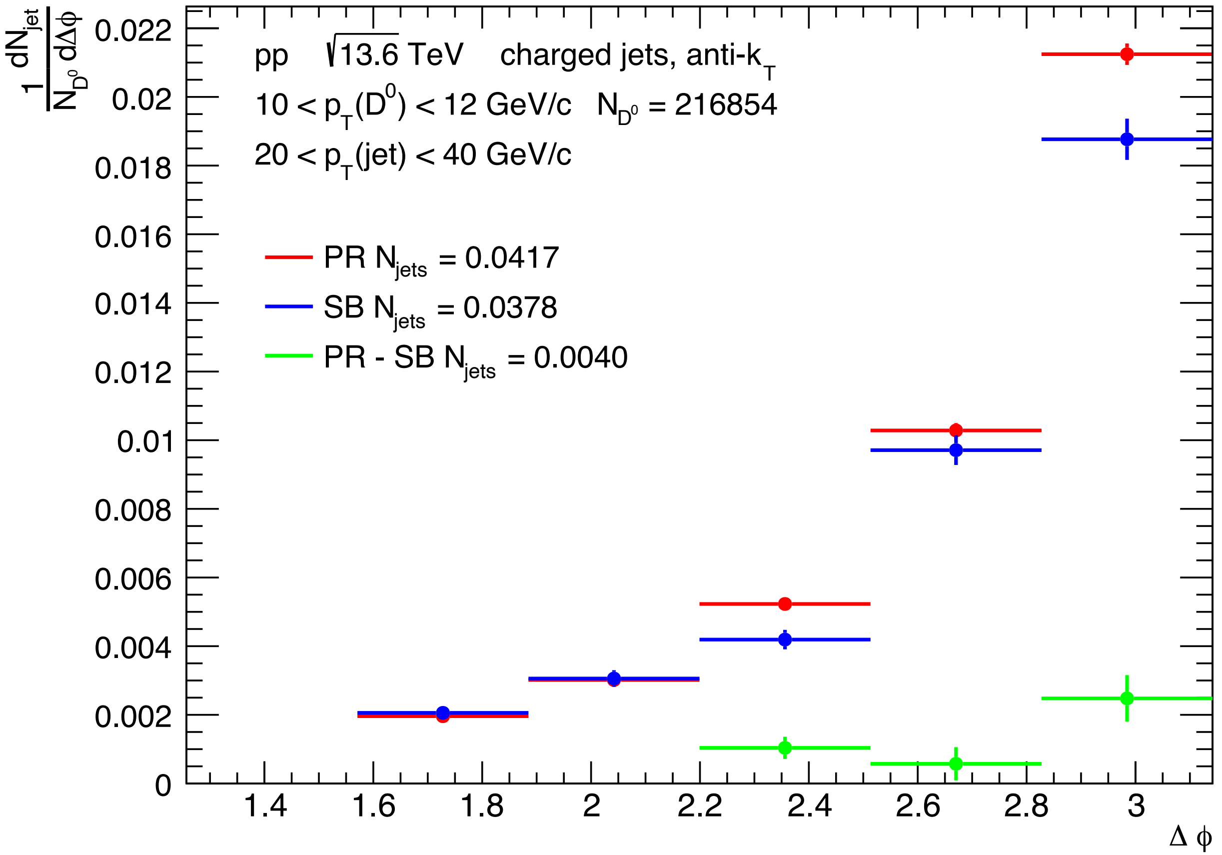




D^0+jet Azimuthal Correlation Distributions

10 < D^0 p_T < 12 GeV/c

20 < jet p_T < 40 GeV/c



40 < jet p_T < 80 GeV/c