CMS MTD upgrade and the prospects for identified jet substructure measurements for QGP studies

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For the CMS collaboration

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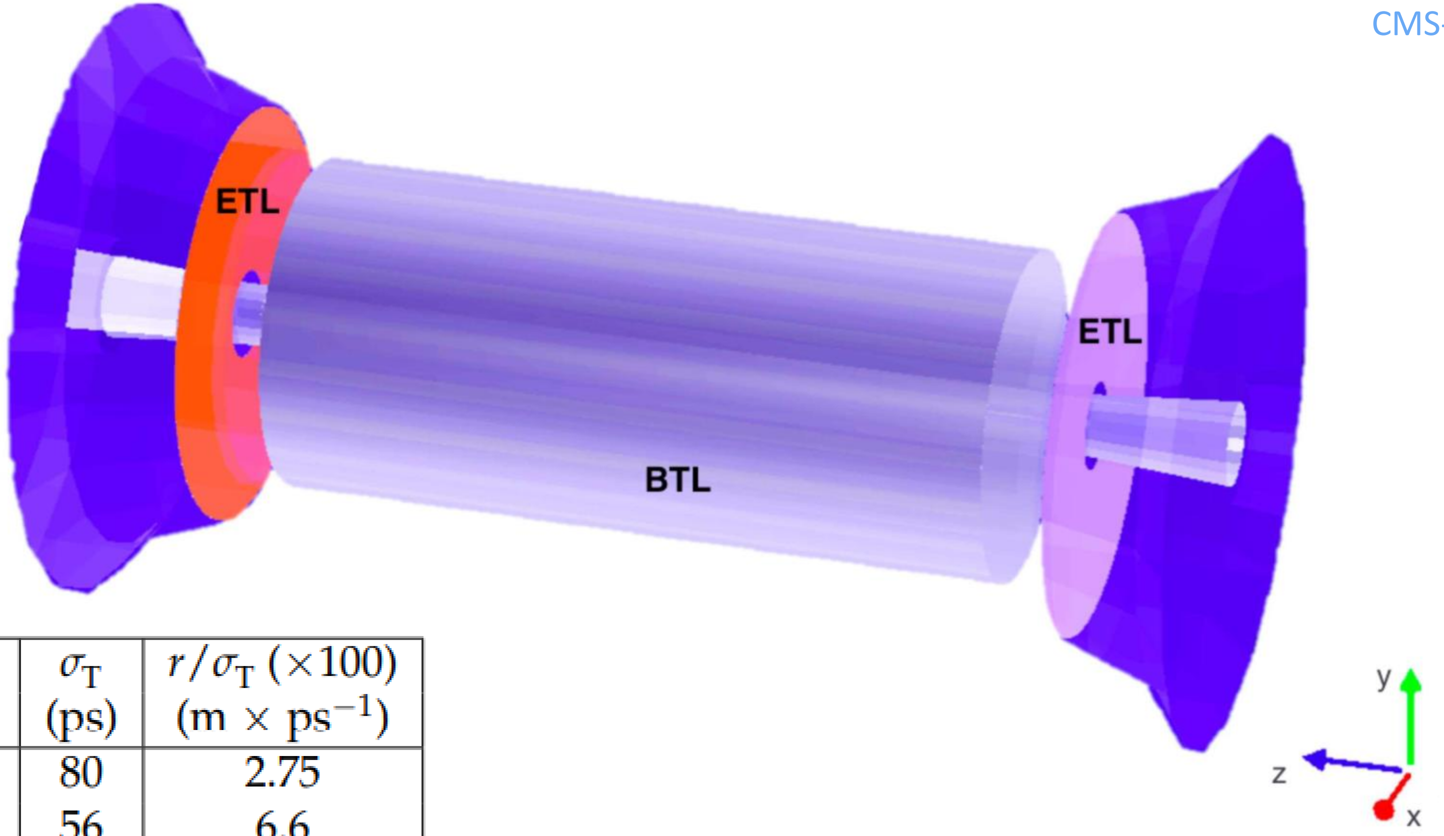
MIP Timing Detector (MTD)

CMS-TDR-020

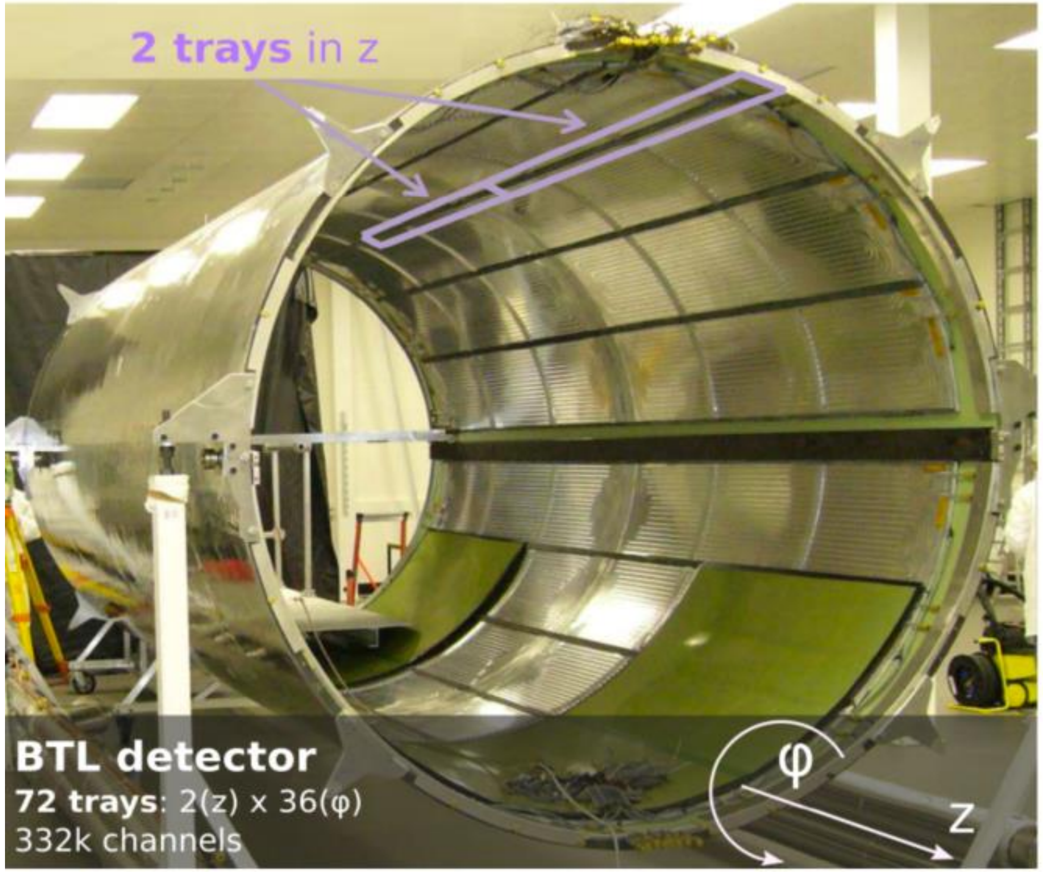


Experiment	r (m)	σ_T (ps)	r/σ_T (×100) (m × ps^{-1})
STAR-TOF	2.2	80	2.75
ALICE-TOF	3.7	56	6.6
CMS-MTD	1.16	30	3.87

- **Record arrival time of minimum ionizing particles with 30 ps precision**
- **Main components: Barrel Timing Layer (BTL) and 2 Endcap Timing Layers (ETL)**

Barrel Timing Layer (BTL)

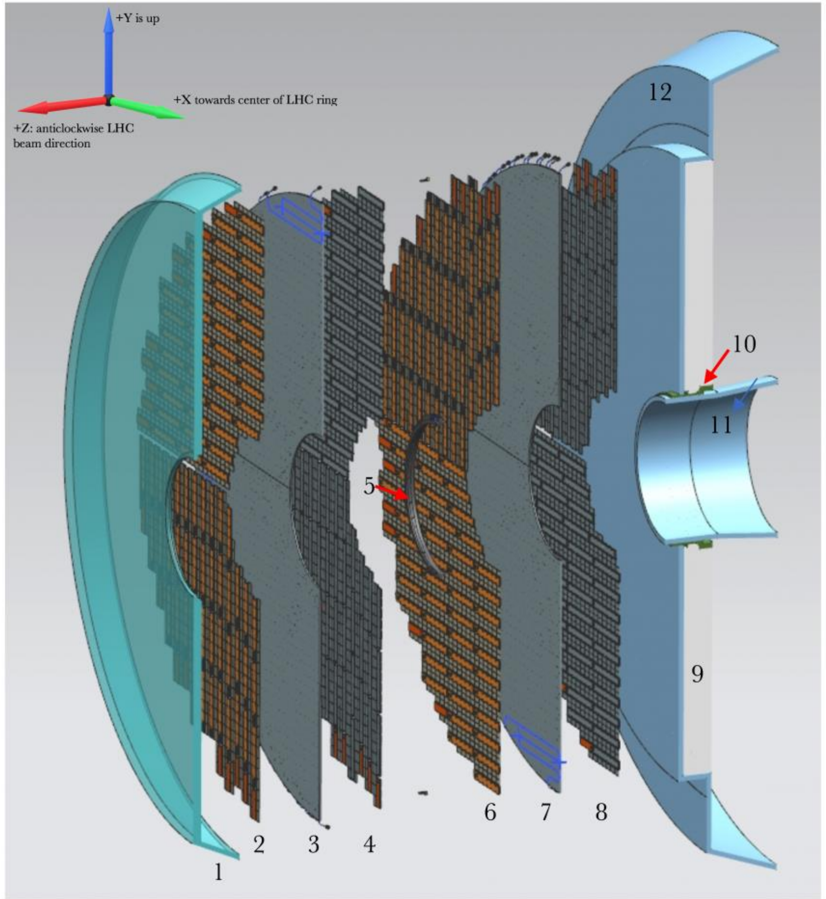
CMS-TDR-19-001



- Inner radius 1148 mm, outer radius 1188 mm, length 5.2 m
- Time resolution of 30-40 ps using LYSO crystals with SiPM read-out
- Covers pseudorapidity region up to $|\eta| < 1.5$

Endcap Timing Layers (ETL)

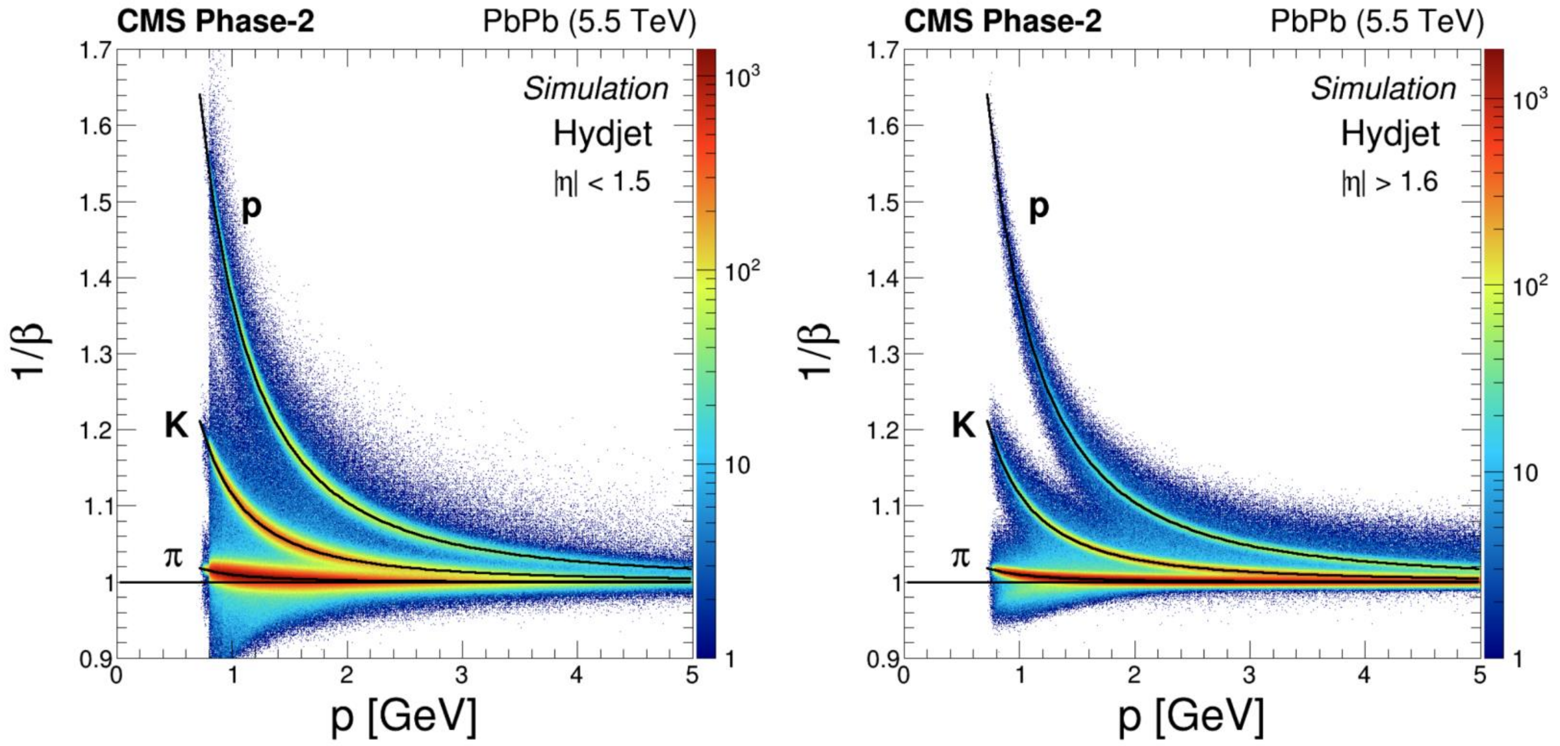
CMS-TDR-19-001



1: ETL Thermal Screen
2: Disk 1, Face 1
3: Disk 1 Support Plate
4: Disk 1, Face 2
5: ETL Mounting Bracket
6: Disk 2, Face 1
7: Disk 2 Support Plate
8: Disk 2, Face 2
9: HGCal Neutron Moderator
10: ETL Support Cone
11: Support cone insulation
12: HGCal Thermal Screen

- **315 < r < 1200 mm, total active sensor area 7.9 m^2**
- **Resolution of about 30 ps and 50 ps at $|\eta| \cong 2.5$ and 3.0**
- **Pseudorapidity acceptance of $1.6 < |\eta| < 3.0$**

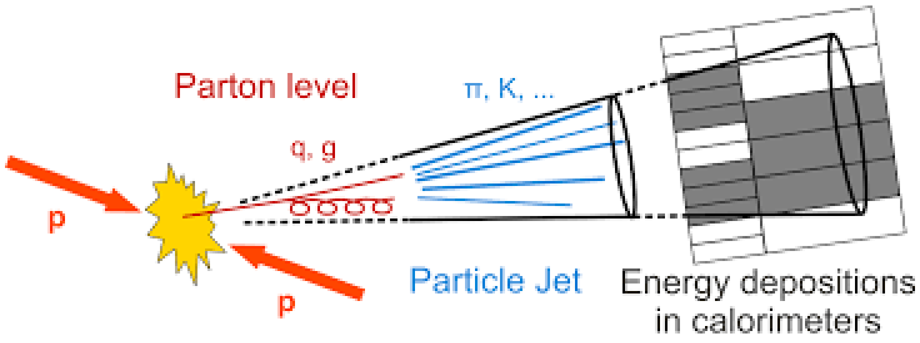
Extensions of physics capability

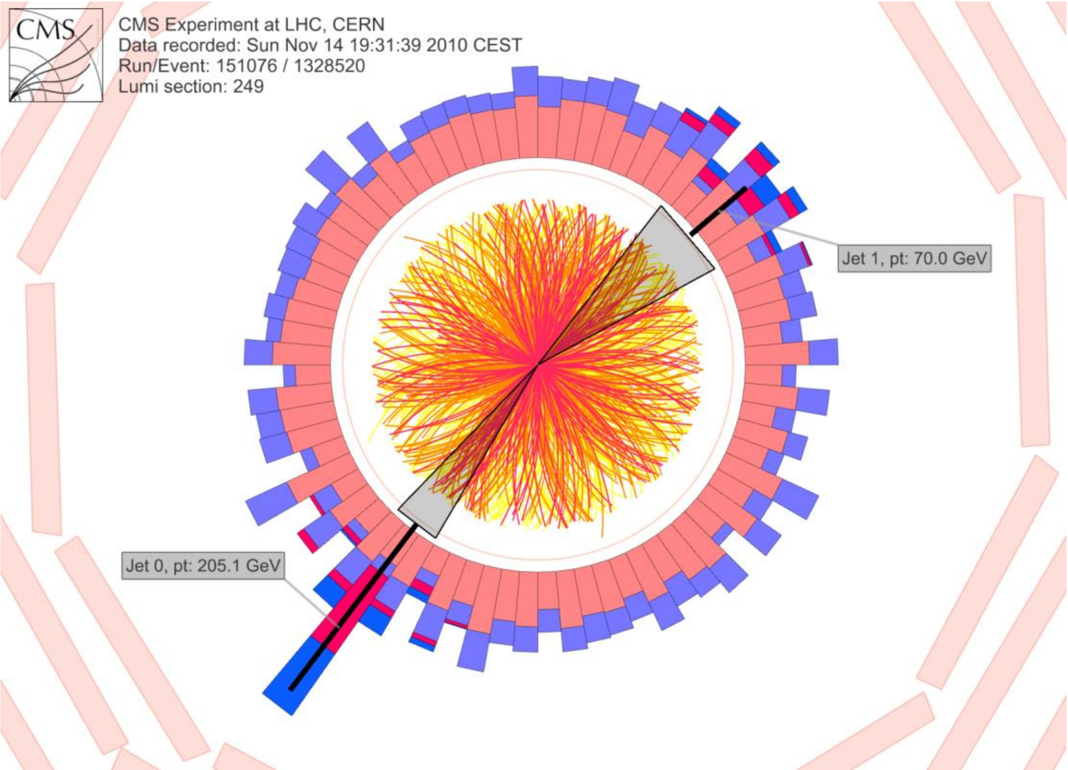


CMS-TDR-020

- **Extends Particle Identification (PID) capability**
- **pp collisions: pile-up mitigation,**
  hadronization/fragmentation studies with PID
- **AA collisions: flavor/color-charge dependence of jet quenching,**
  in-medium fragmentation/ hadronization

Jet Quenching

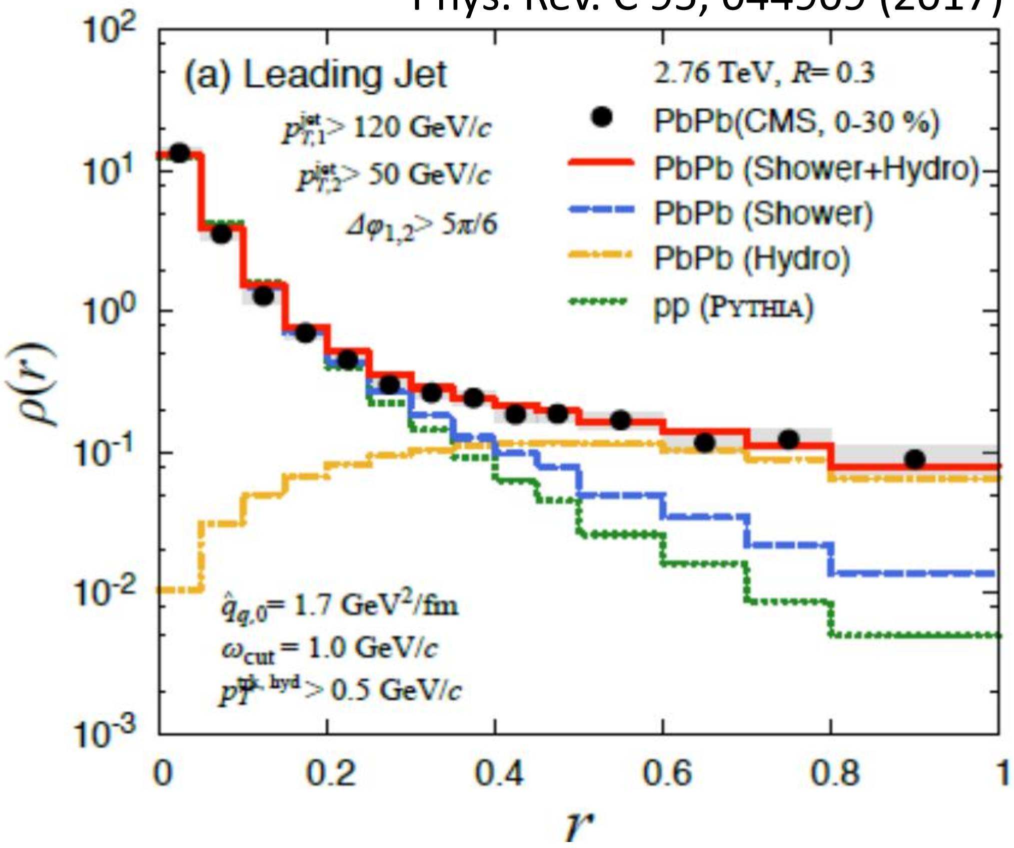




- **Collimated streams of particles produced by fragmentation of hard scattered partons**
- **Jet quenching phenomena is an established signature of Quark-Gluon Plasma (QGP)**
- **Allow probing the properties of QGP and searching for new physics**

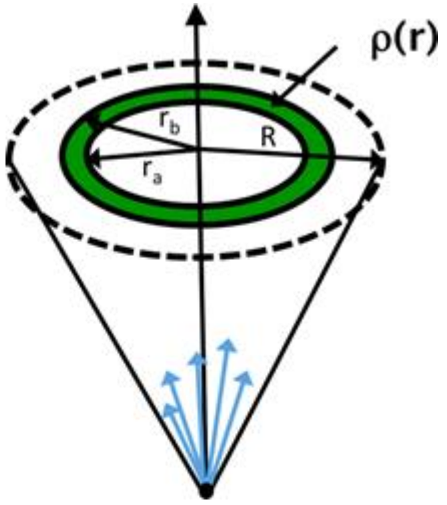
Jet shape modification

Phys. Rev. C 95, 044909 (2017)



Phys. Rev. C 95, 044909 (2017)

$$r = \sqrt{\eta^2 + \phi^2}$$

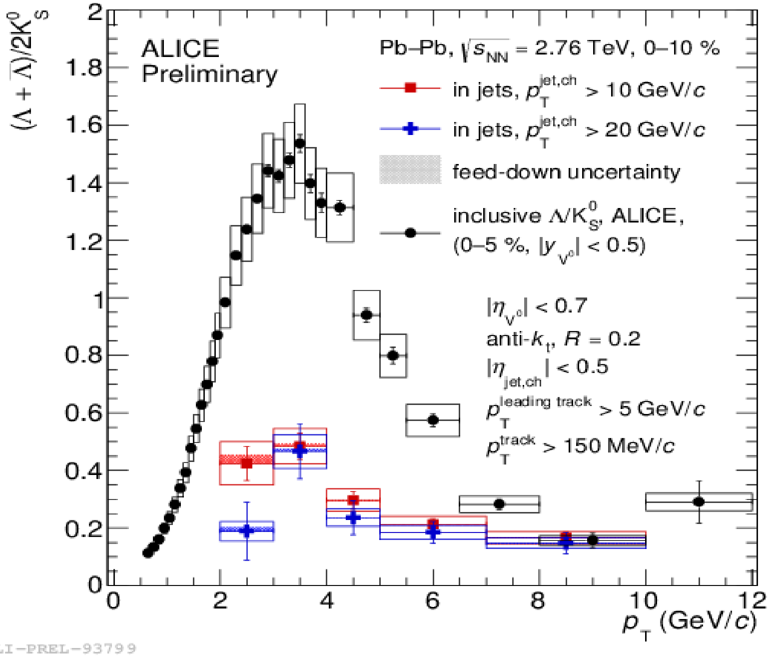


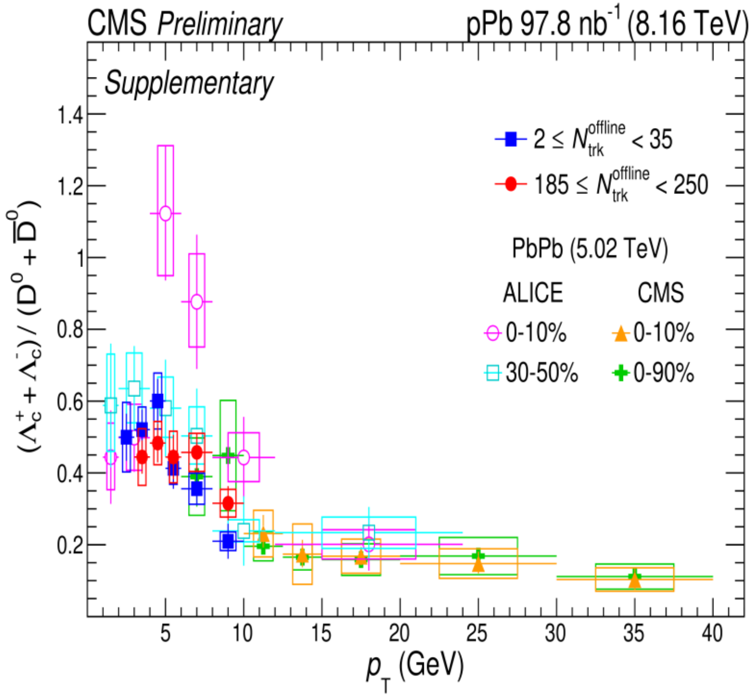
- Jet shape: radial transverse momentum distribution of jet constituents
- QGP effects modify jet shapes, most evidently at large r
- Require large rapidity coverage for $r\sim1$ measurements → ETL

Hadronization in QGP

ALI-PREL-93799

CMS-PAS-HIN-21-016

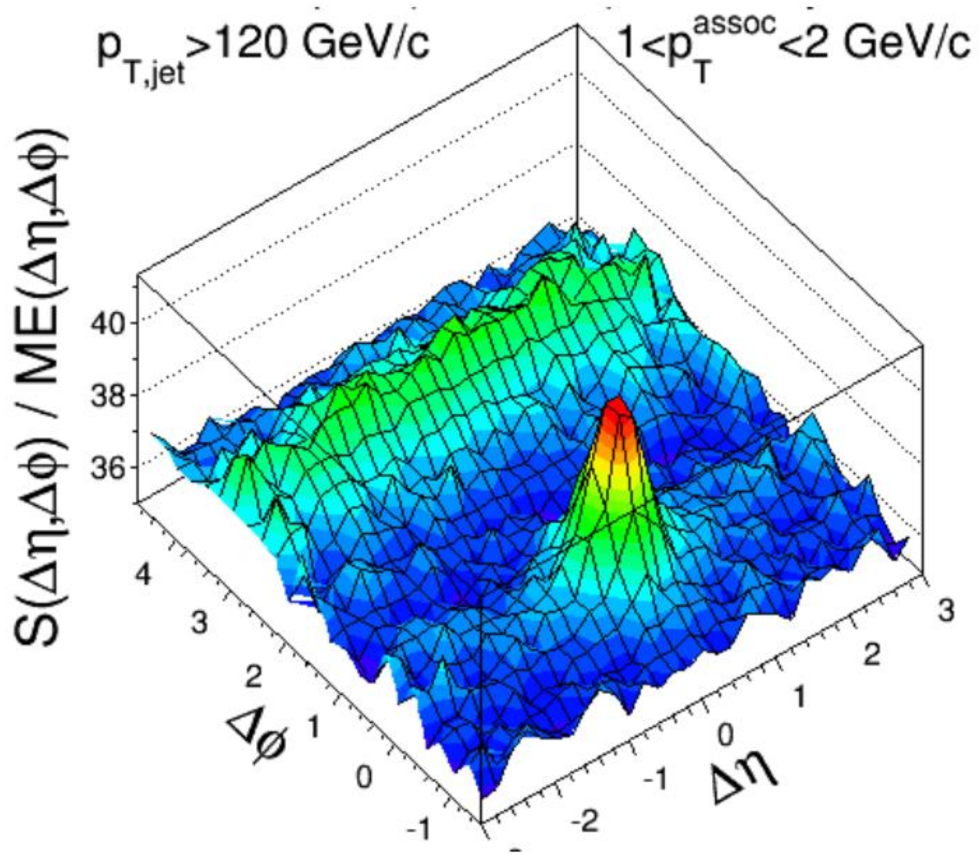




- **Baryon to meson ratios strongly enhanced in QGP**
- **In-cone jet fragmentation shows significantly smaller relative Baryon production**
- **Barion to meson ratios after QGP at large r?**

Jet-track correlations

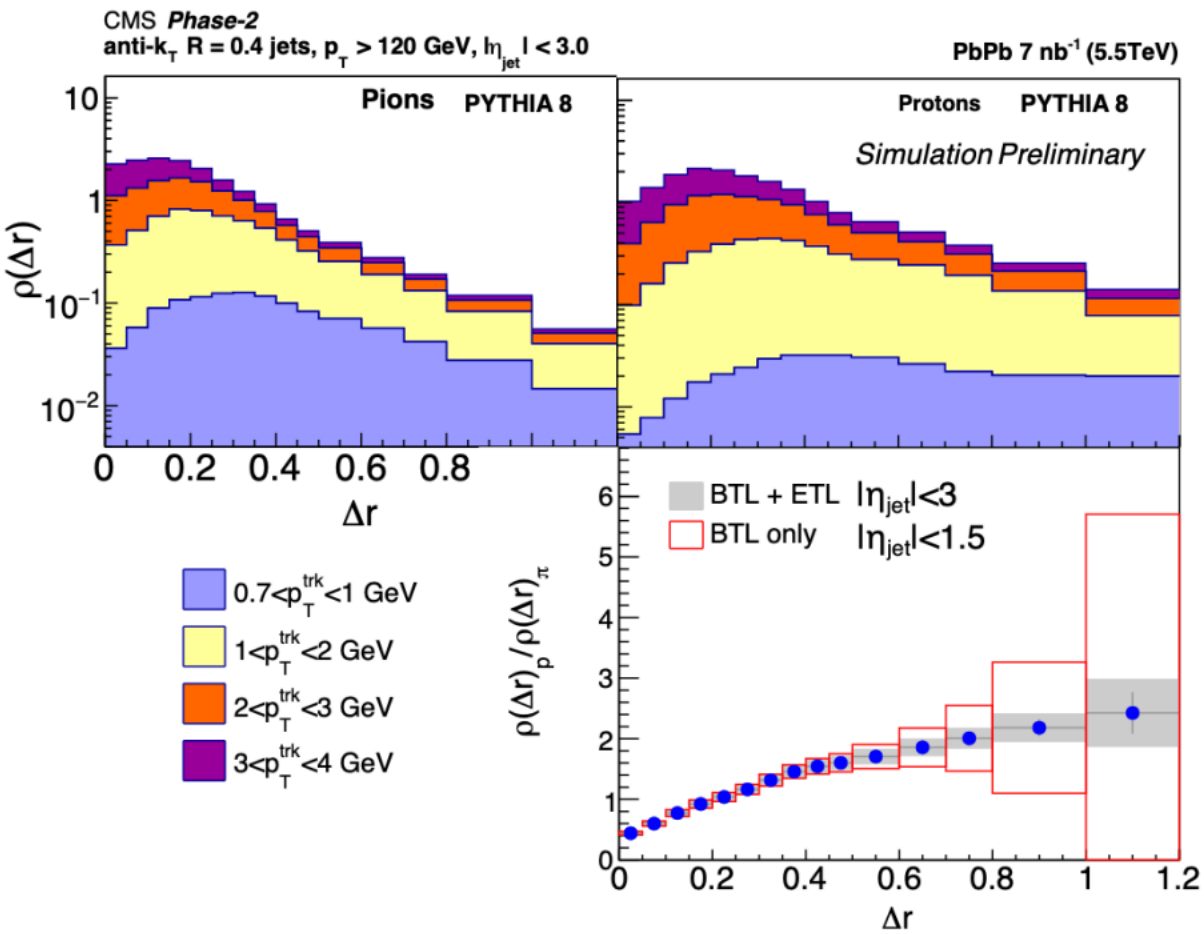
JHEP02(2016)156



- Large background contribution
- Jet peak's range extends to $r \sim 1$
- Background can be isolated at $1.6 < |\eta| < 3.0$

Jet shape measurements with PID

CMS-DP-2021-037

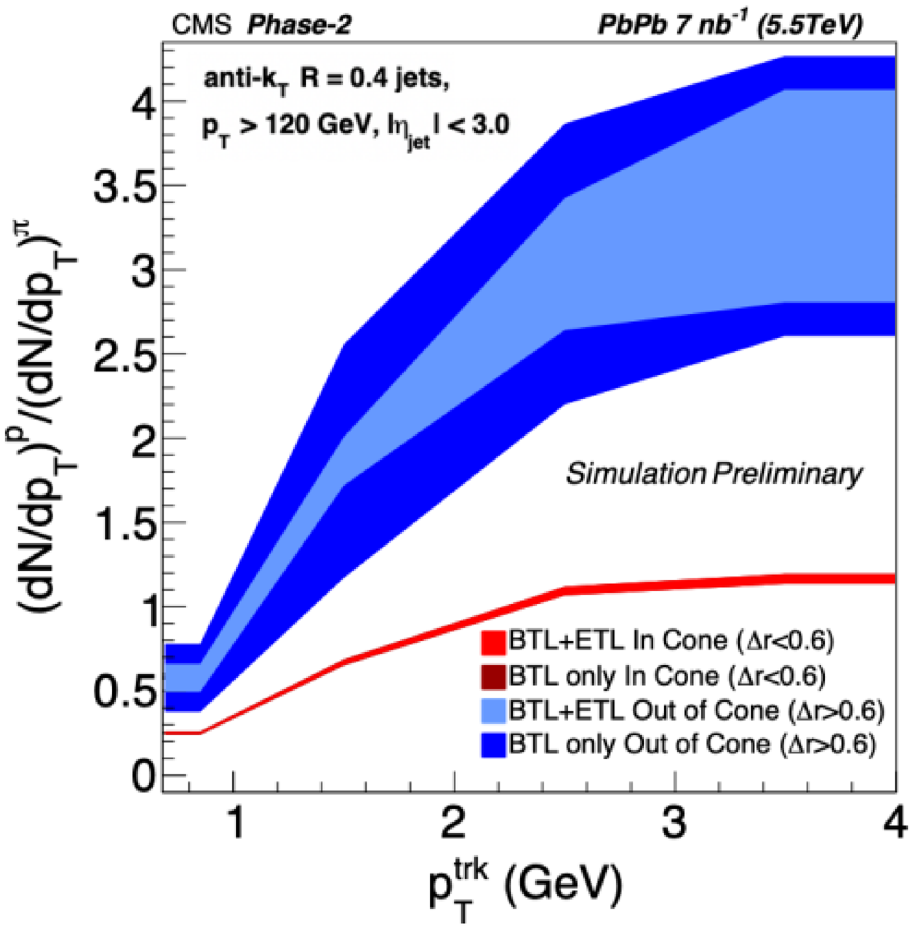


Pythia 8 + Hydjet
PbPb 7 nb^{-1} $(5.5TeV)$

- **MTD allows unique jet shape measurements with PID**
- **Jet shape measurement extended to large r where QGP effects dominate**
- **Significant reduction of projected uncertainties with ETL**

In-Jet Baryon to Meson ratio

CMS-DP-2021-037

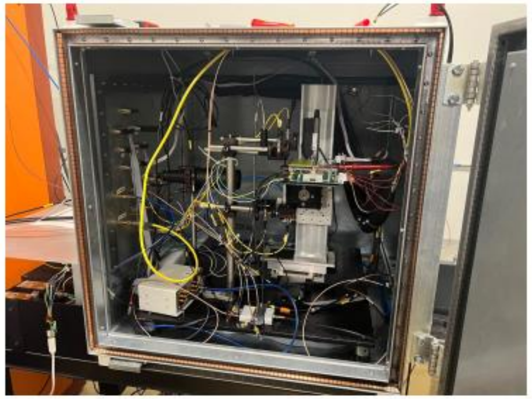


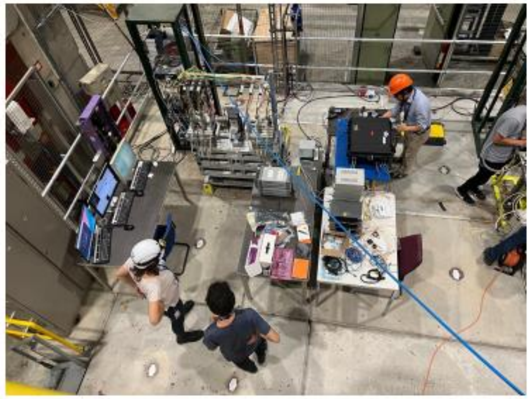
Pythia 8 + Hydjet
PbPb 7 nb^{-1} $(5.5TeV)$

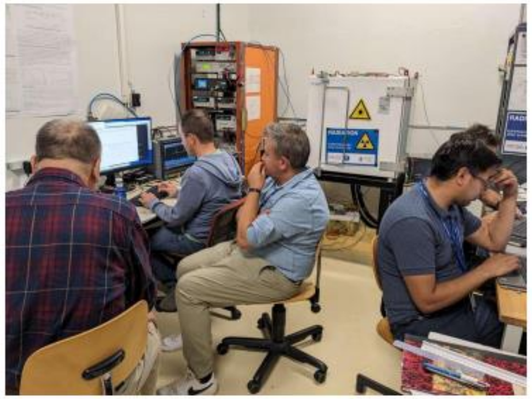
- **Distinguish r integrated in-cone vs out-cone baryon to meson ratios**
- **Projected uncertainties improve with the inclusion of ETL**

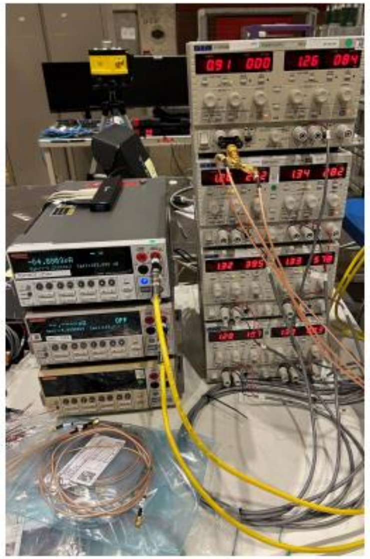
CMS ETL Read-out Chip (ETROC)

From Murtaza Safdari talk at the ETL meeting









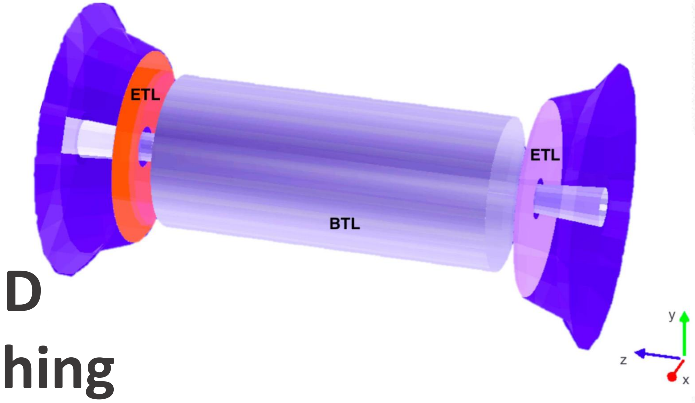
- **International multi-institutional effort: FNAL, SMU, KU, IFCA, UNITO, UIC and others**
- **Successfully developed the ETROC2 telescope at FNAL**
- **Laser tests taken with the ETROC2 at CERN**
- **Test beam data with the ETROC2 chip performed at DESY**

ETROC Testing at UIC

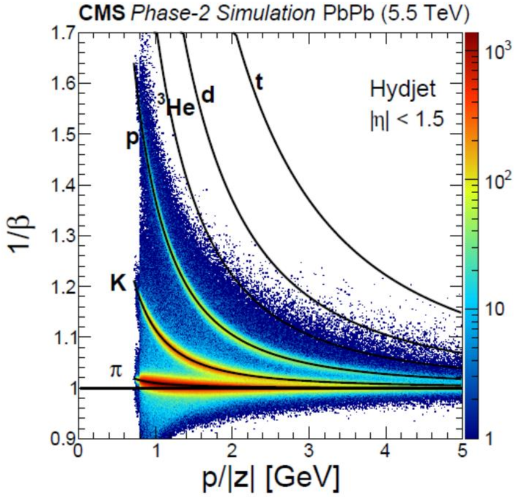
- Time resolution measurements using laser
- **Measuring baseline and noise widths, TOA, TOT, and CAL**
- **Provide temperature dependence of above measurements**

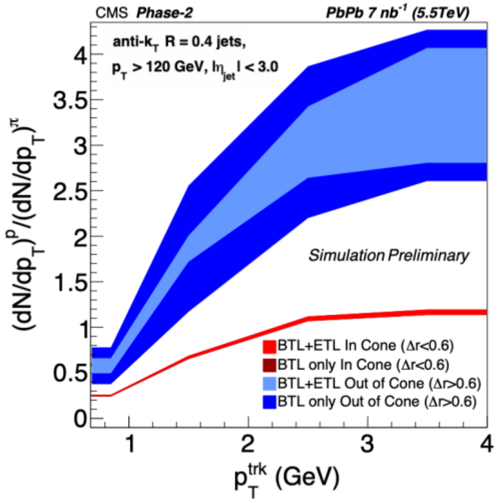
Conclusions

- **Timing precision and PID capabilities**
- **Physics advantages:**
  pile-up mitigation,
  hadronization/fragmentation studies with PID
  flavor/color-charge dependence of jet quenching



- **Enrich jet quenching studies for CMS heavy-ion program to test in-medium hadronization/QGP properties**





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Questions?