UNIVERSITY OF LIVERPOOL

Measurements of jet quenching using hadron-jet observables at ALICE

ALICE

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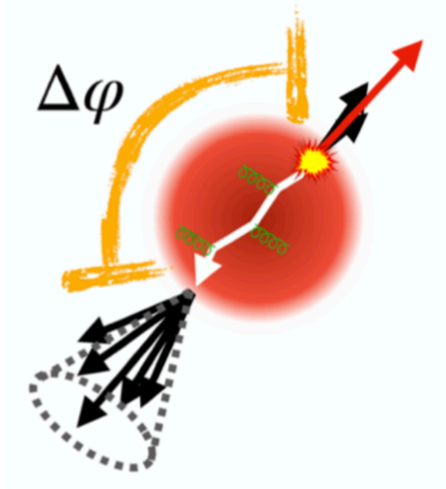
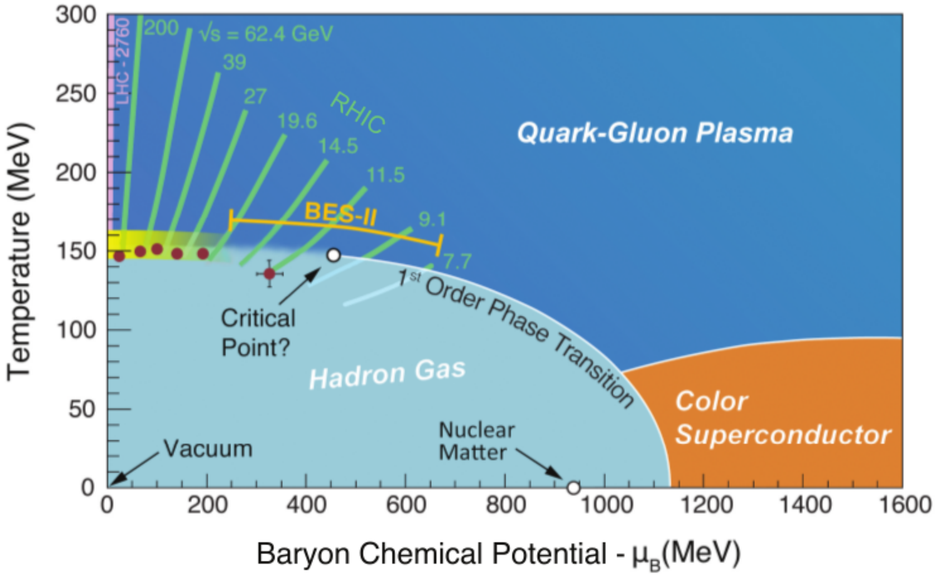
The ALICE Experiment

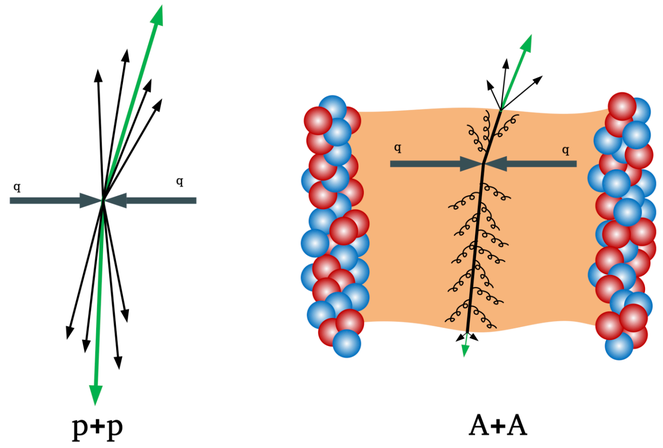
Supervisors: Dr Jaime Norman,
Prof. Marielle Chartier



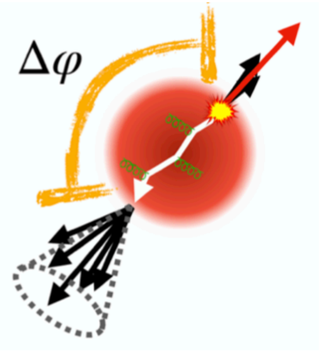
ALICE and Heavy ion collisions

- **A Large Ion Collider Experiment: Investigate the extreme conditions which occur during the collisions of lead ions at relativistic energies**
  - Formation of a Quark-Gluon Plasma - deconfined state of quarks and gluons
- **Jets: Collimated sprays of high energy hadrons from a high-Q^2 scattering**
  - pp: Act as a probe of QCD
  - Pb-Pb: Study how jets interact with the medium
    - **Jet Quenching!**

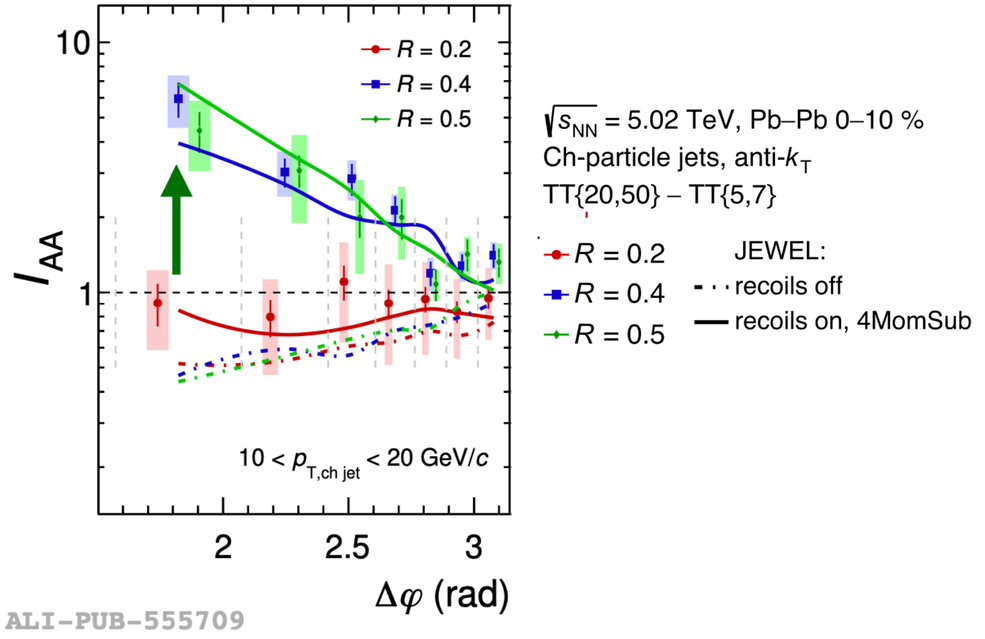




Semi-inclusive hadron-jet measurements



- **We want to explore jet quenching across the full LHC phase space**
  - Specifically low-p_{T} and large R
- **Uncorrelated background is huge in these regions**
  - Solution: Semi-inclusive hadron-jet measurements!
  - Cleanly select events based on high p_T trigger
- **Exciting results from Run 2!**
  - First observation of a low p_T and large angle enhancement in Pb-Pb
- **Open questions:**
  - To what extent is the medium response (e.g. the wake) responsible?
  - Could single hard scatterings still play a role?
- **Motivation → study recoil jet substructure**



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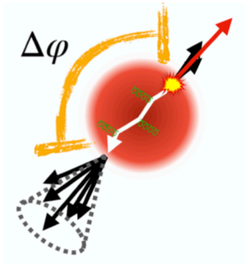
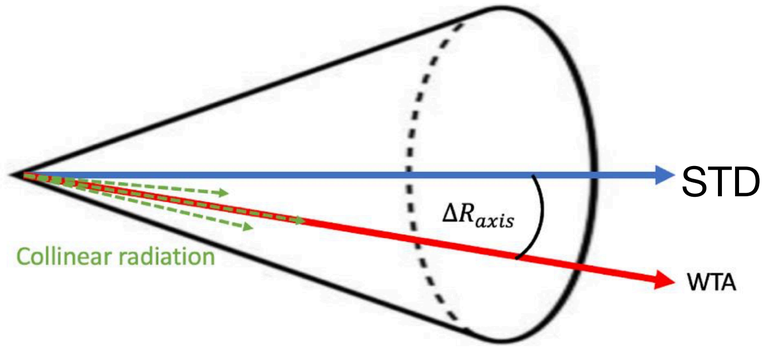
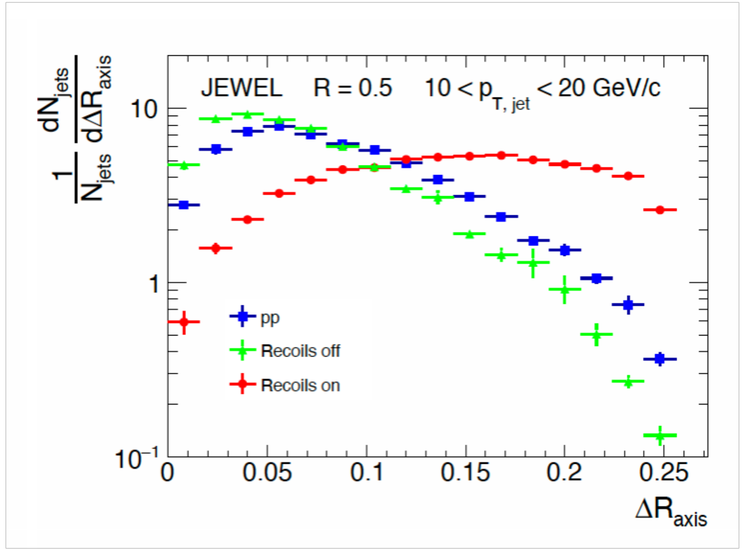
Hadron-jet in Run 3





- **Measure the yield of charged particle jets recoiling from a high-p_{T} hadron as a function of:**
  - The jet transverse momentum ($p_{\mathrm{T,jet}}$)
  - The trigger-jet opening angle ($\Delta\phi$)
  - The Standard Axis - Winner-Takes-All (WTA) axis separation (ΔR)
- **This difference provides a good probe of the soft content of a jet**
  - JEWEL studies suggest that this observable is sensitive to medium response effects
- **Datasets:**
  - pp: 2022 data, 13.6 TeV
  - Pb-Pb: 2023 data, 5.36 TeV

$$\Delta R = \sqrt{(\eta_{SA} - \eta_{WTA})^2 + (\phi_{SA} - \phi_{WTA})^2}$$



Δ_{recoil} - approach to uncorrelated background yield subtraction

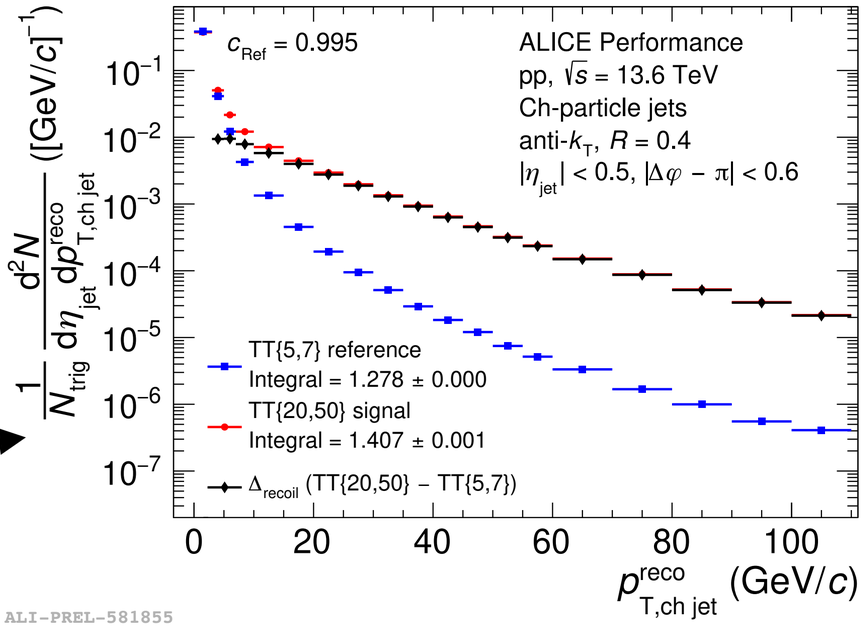
- **Take the difference between two semi inclusive, trigger normalised jet yields: signal and reference**

$$\Delta_{\text{recoil}} = \left.\frac{1}{N_{\text{trig}}}\frac{\mathrm{d}^3 N_{\text{jet}}}{\mathrm{d}p_{\text{T,jet}}^{\text{ch}}\mathrm{d}\Delta\phi\mathrm{d}\Delta R}\right|_{TT_{sig}} - c_{ref}\left.\frac{1}{N_{\text{trig}}}\frac{\mathrm{d}^3 N_{\text{jet}}}{\mathrm{d}p_{\text{T,jet}}^{\text{ch}}\mathrm{d}\Delta\phi\mathrm{d}\Delta R}\right|_{TT_{ref}}$$

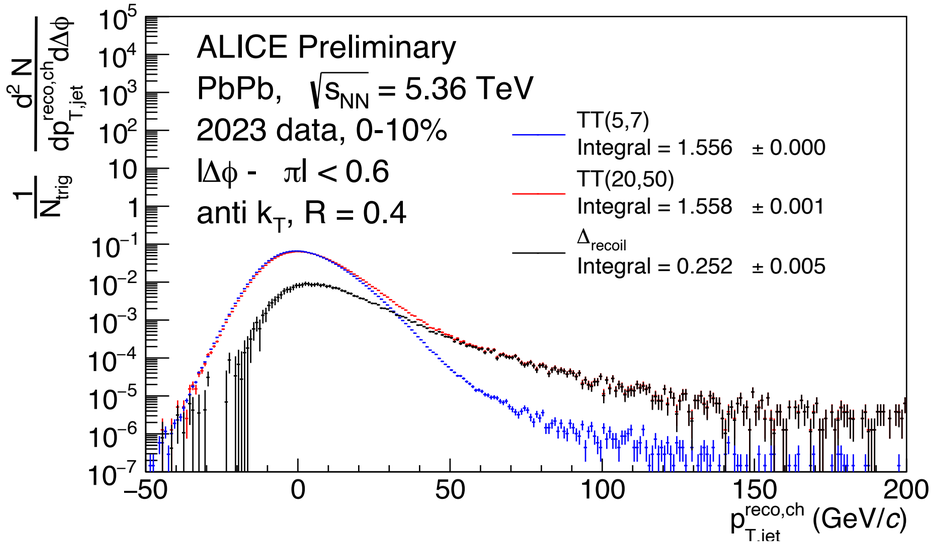
- **Advantages:**
  - Data-driven subtraction of uncorrelated background yield
  - Perturbatively calculable

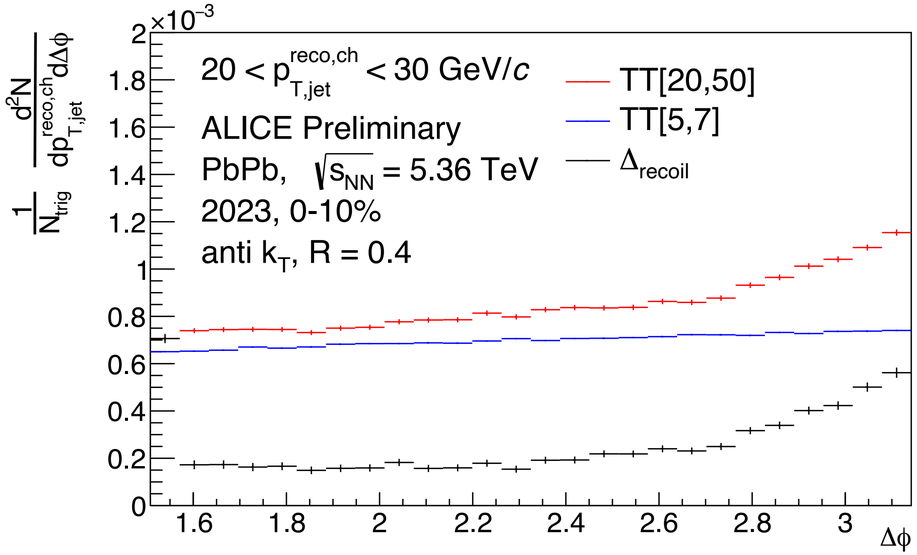
c_{ref}: normalisation factor - derived from data

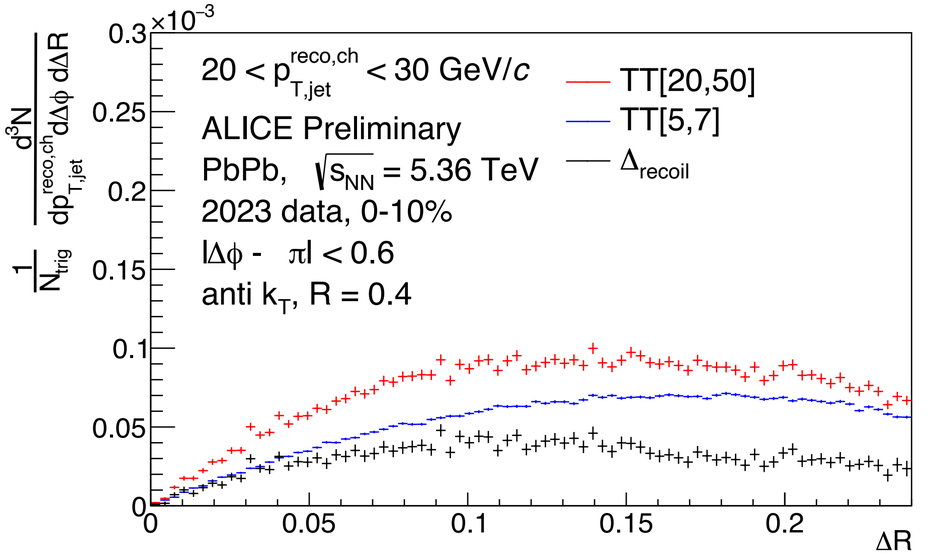
Raw pp data



Raw semi-inclusive hadron+jet yield in Pb-Pb





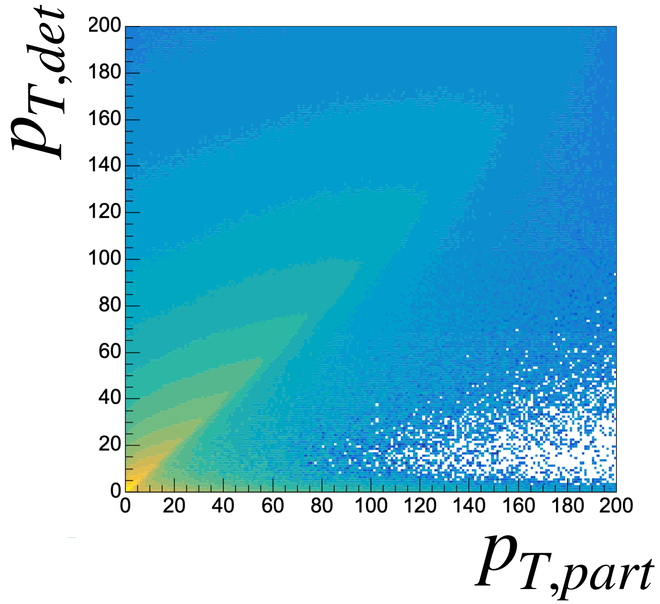


- **Uncorrelated background subtraction working well!**

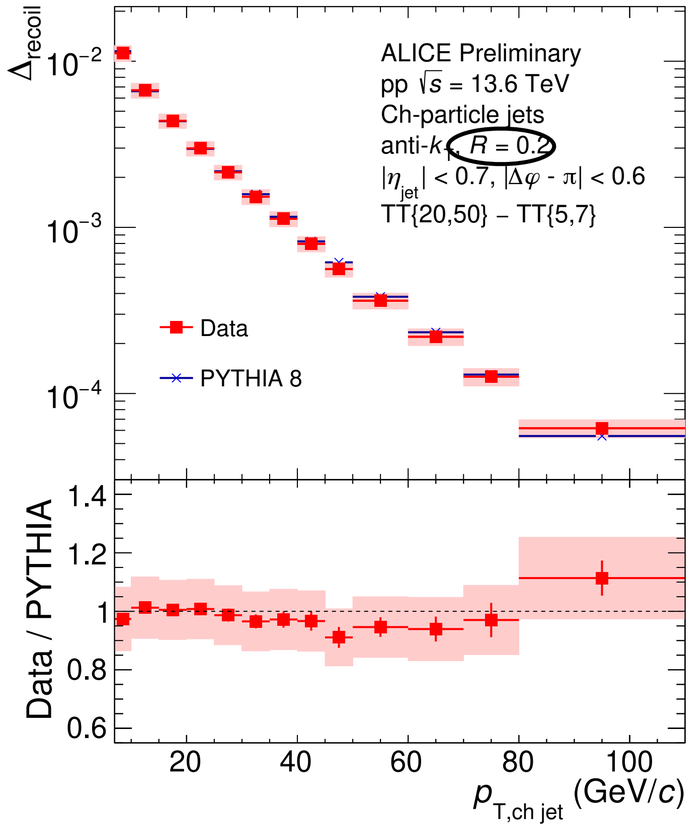
$$\Delta_{\text{recoil}} = \frac{1}{N_{\text{trig}}} \frac{\mathrm{d}^3 N_{\text{jet}}}{\mathrm{d}p_{\text{T,jet}}^{\text{ch}} \mathrm{d}\Delta\phi \mathrm{d}\Delta R}\bigg|_{TT_{sig}} - c_{ref} \frac{1}{N_{\text{trig}}} \frac{\mathrm{d}^3 N_{\text{jet}}}{\mathrm{d}p_{\text{T,jet}}^{\text{ch}} \mathrm{d}\Delta\phi \mathrm{d}\Delta R}\bigg|_{TT_{ref}}$$

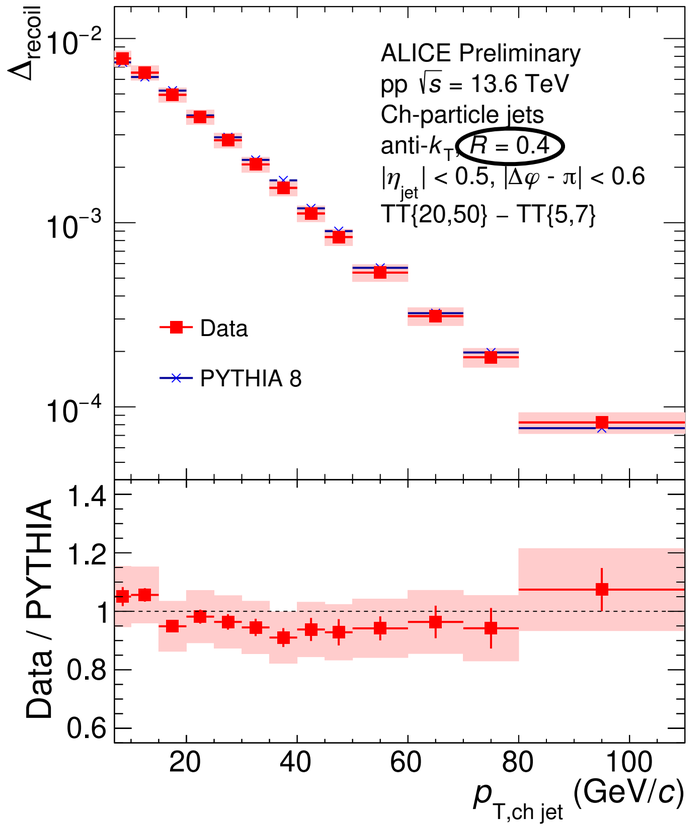
Next steps

- **Raw distributions must be unfolded:**
  - pp - isolate effects from the detector
  - Pb-Pb - isolate effects from the detector and background fluctuations
- **We then calculate systematic uncertainties:**
  - Tracking efficiency
  - Unfolding procedure
  - Reference normalisation
  - …
- **Current status:**
  - Pb-Pb: Work in progress
  - pp: Preliminary results as a function of p_T!



Fully corrected semi-inclusive hadron+jet yield - pp





One of the first jet measurements in Run 3 at ALICE!

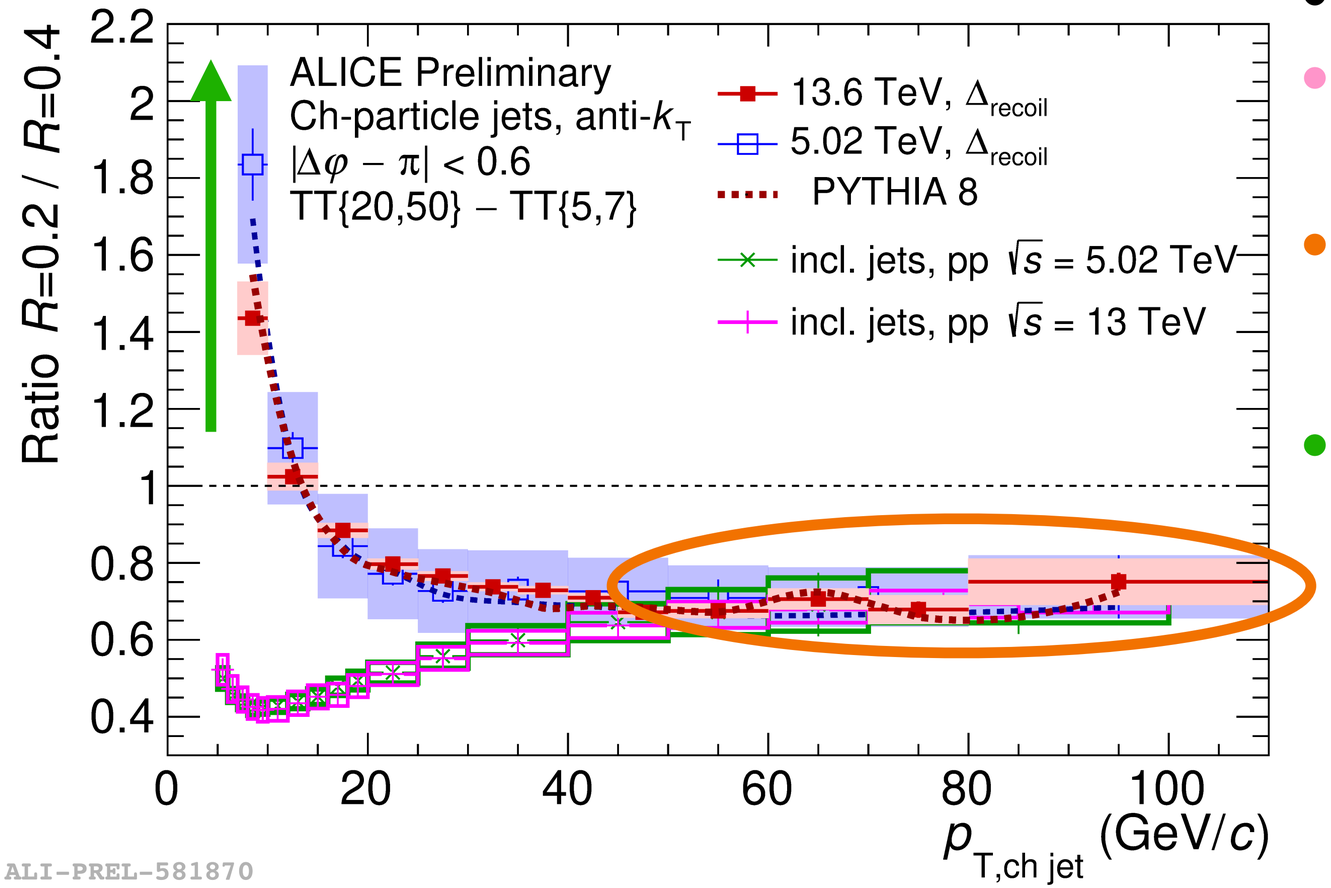
- Measure $\Delta_{\text{recoil}}(p_{\text{T}})$ from 7 GeV/c to 110 GeV/c for $R = 0.2$ and $R = 0.4$

  → **PYTHIA describes the data well within uncertainties**

Fully corrected yield ratio, $(R = 0.2)/(R = 0.4)$ - pp

Robust jet shape observable - precise theory and experiment

pQCD: JHEP 04 (2015) 039



- **Good agreement with Run 2 result**
- **Substantial improvement in the uncertainties with respect to Run 2**
- **Agreement between inclusive jets and semi-inclusive at high p_T**
- **Enhancement in $R = 0.2$ recoil jet yield at low p_T**
  - Bias towards NLO effects when $p_{T,jet} < p_{T,trig}$?
  - Jet splitting?

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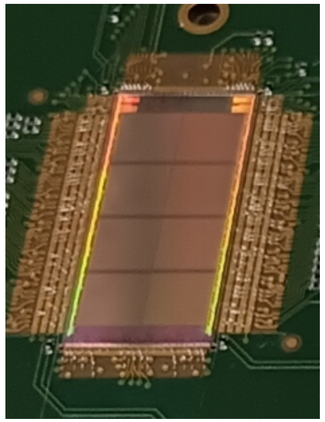
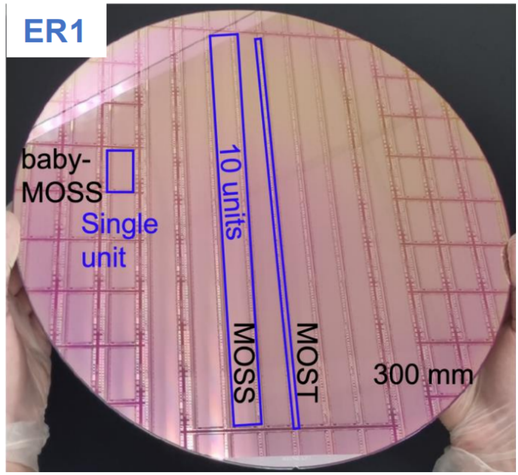
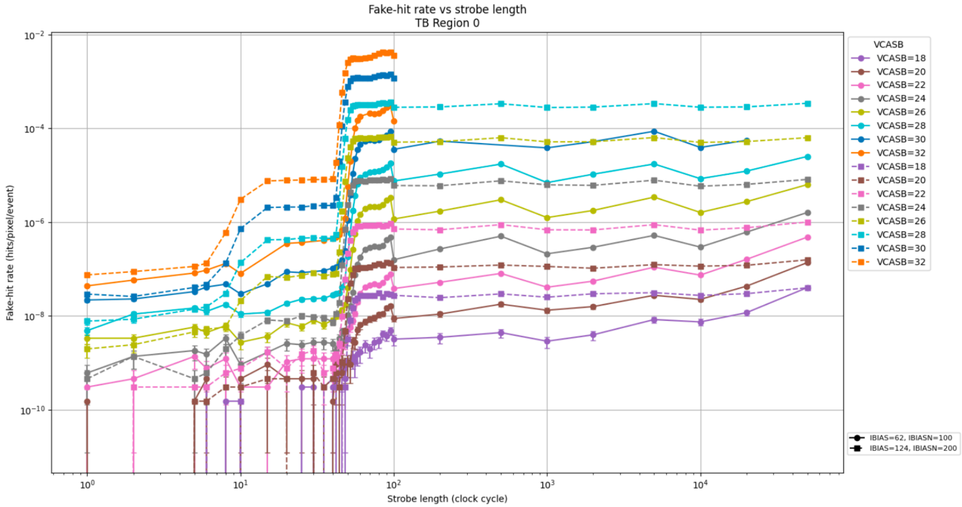
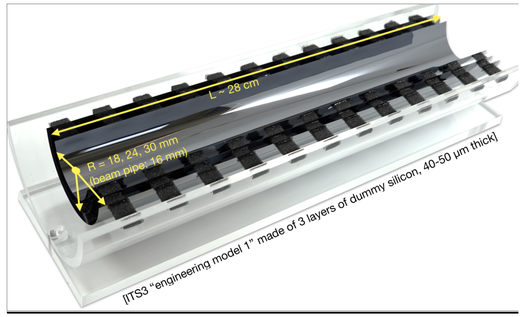
Service task: ITS3 babyMOSS chip testing

- **As part of the next LHC long shutdown (2026-28), the ALICE silicon pixel Inner Tracking System (ITS) will receive it's next upgrade: ITS3**
  - Use of curved pixel sensors for the first truly cylindrical detector geometry
  - Stitching technology used to create wafer-scale sensors: MOSS - the first stitched MAPS in HEP
- **For my service task, I have been testing the single unit of the MOSS prototype called babyMOSS**
  - We have been investigating how the Fake-Hit rate is affected by the Strobe Length, front-end biasing currents and sensor backbias voltages
  - Impedance and power ramp tests to come!









TPSCo 65nm technology

Summary and outlook

- **Good progress towards a measurement of a hadron-jet correlations at ALICE in Run 3**
  - This would be the first measurement of recoil jet substructure - using the ΔR_{axis} observable
- **We have fully corrected results as a function of p_T in pp collisions - including a yield ratio for different jet R**
  - Possible observation of NLO effects when $p_{T,jet} < p_{T,trig}$
- **Aim to finalise pp results over the next few months**
- **In Pb-Pb: additional challenges due to background fluctuations. Framework development for Run 3 data ongoing**
  - Stay tuned!

Work presented at Hard Probes 2024, Nagasaki