Study of di-jet properties in p+p collisions at √s = 7 TeV by the LHC-ALICE experiment

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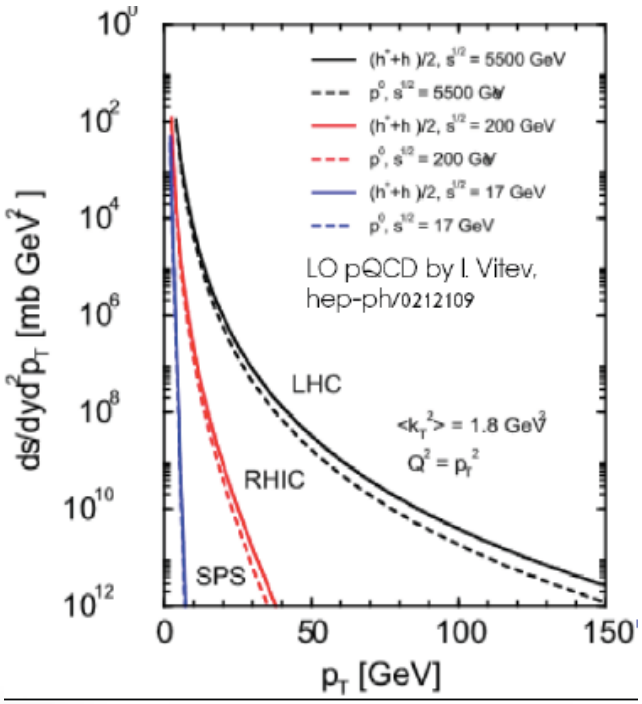
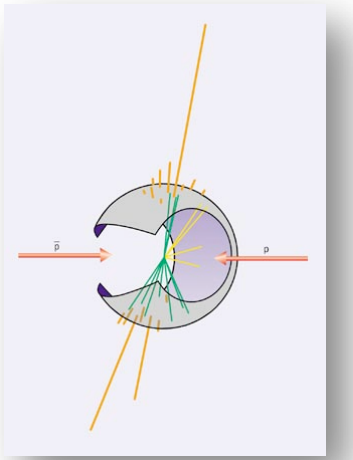
Outline

- Physics motivation
- ALICE experiment and data set
- First look at (di-) jet in p+p $\sqrt{s}$ = 7 TeV in ALICE
- Dijet Calorimeter project
- Summary and outlook

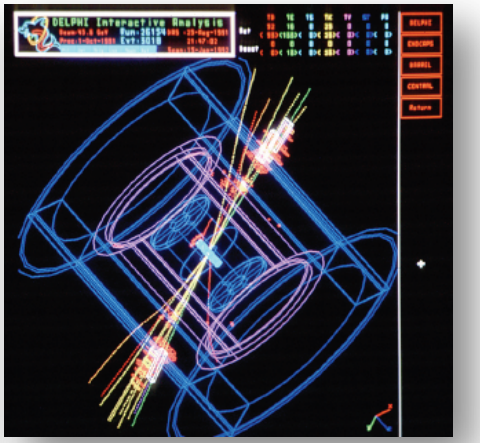
Why jets?

- Jet is a well defined object, and produced by the hard scatting of partons at the initial stage of the collision.
- Studied in many high energy experiments for many years.
- Jet provides a powerful prove to study the hot and dense QCD matter created in high energy heavy ion collisions.
- **At LHC energy, jet production is dominant, compared to that in RHIC.**
- Jet measurements in **p+p** at LHC **provide an important baseline to heavy ion data**, as well as the further understating of QCD.

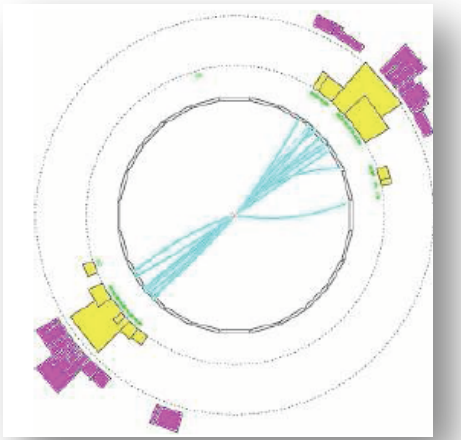




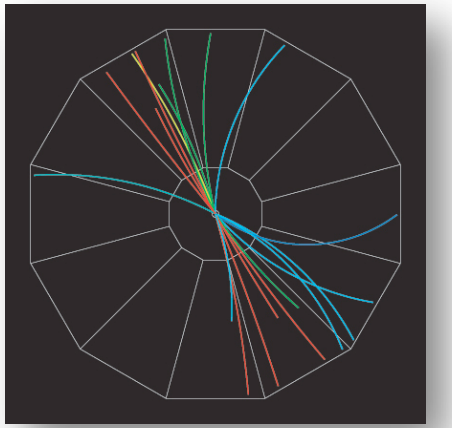
UA2 (1982)



Delphi (1992)



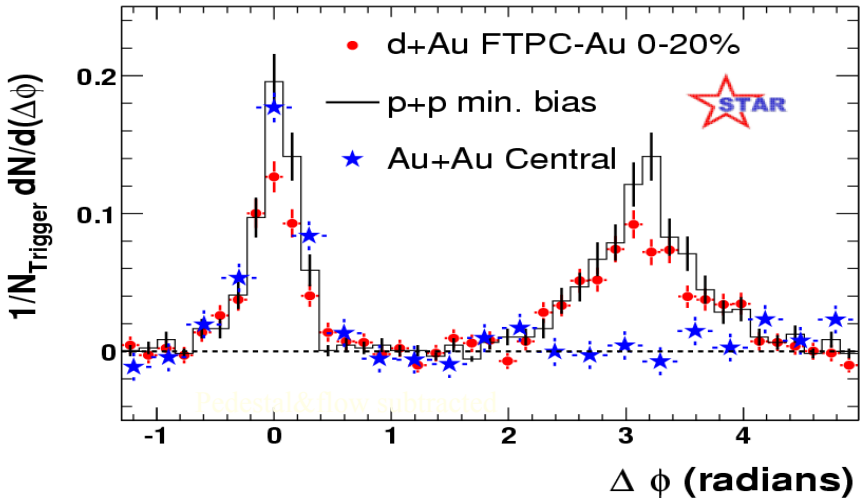
CDF

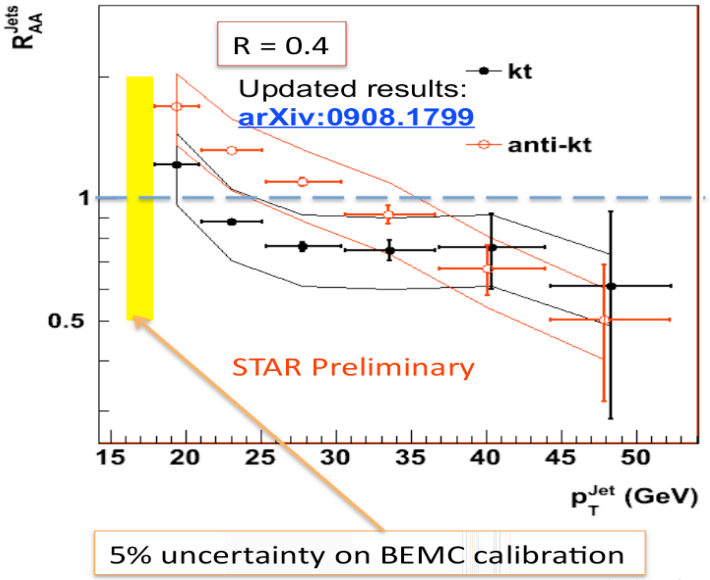


STAR

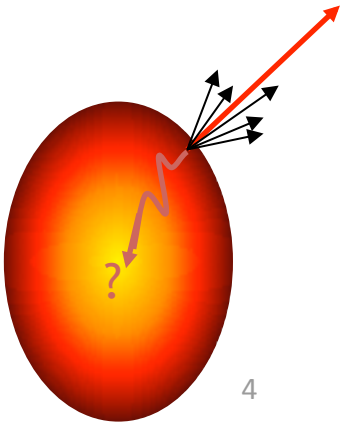
Jet quenching at RHIC

Phys. Rev. Lett. 91, 072304 (2003).



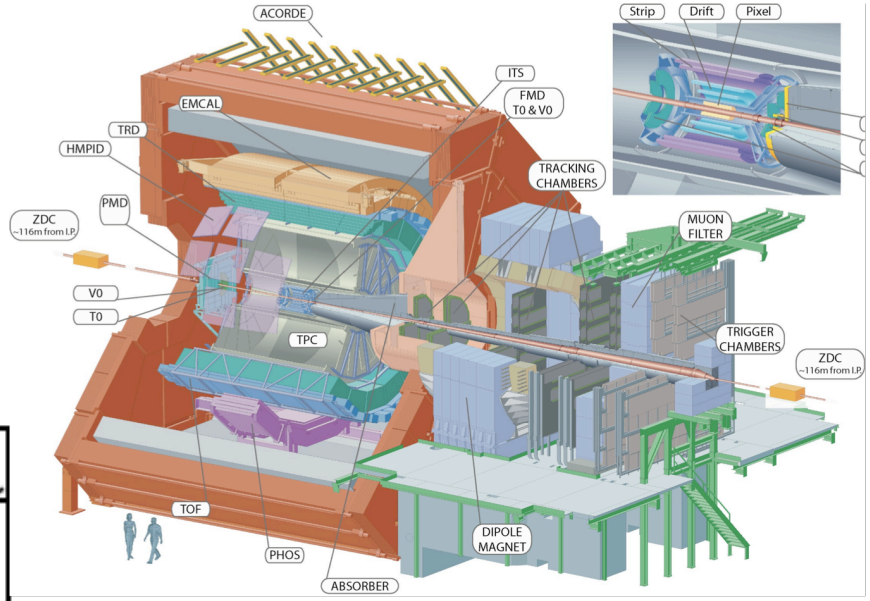


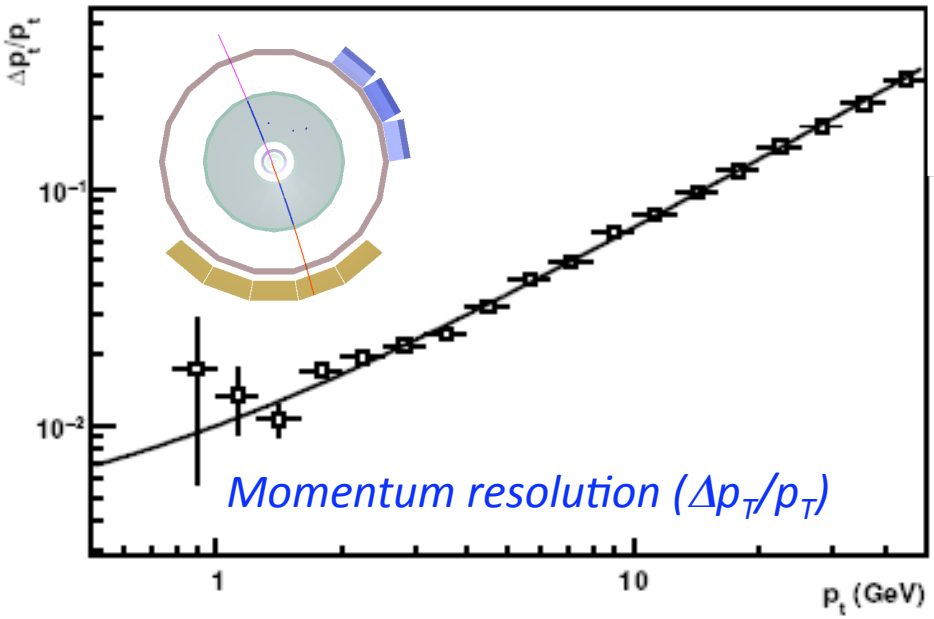
- Disappearance of away-side jet in Au+Au central at RHIC ($\sqrt{s_{NN}}$ = 200 GeV).
- Jet quenching by hot and dense medium.
  - indicating energy density: **$\varepsilon > 100\ \varepsilon_0$**
- First measurement of full jet reconstruction at RHIC (STAR).

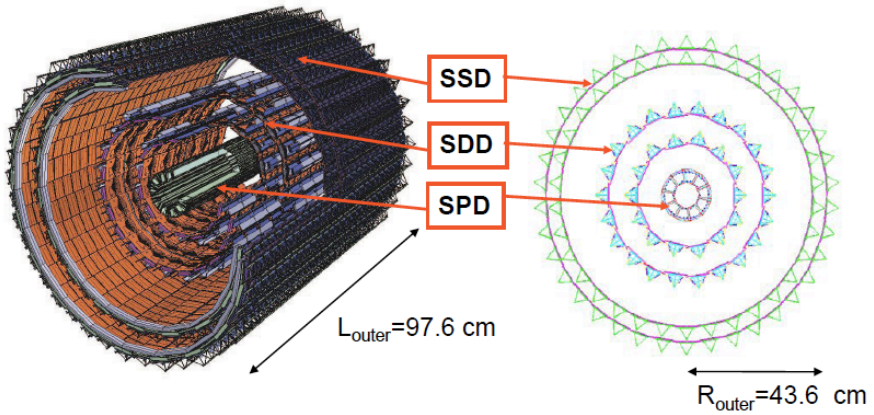


Jet ID using TPC & ITS in ALICE

- **ITS (Inner Tracking System), TPC**
  - Charged particles reconstructed $\Delta\eta$ = 1.8.
  - ITS: $\sigma_{r\phi}$ ~ few 10 um, σ_z~few 100 um (SPD, SDD)
    - SPD: Silicon Pixel
    - SSD: Silicon Strip
    - SDD: Silicon Drift
    - Material budget: ~1% X/X_0 per layer.
  - TPC: Excellent momentum resolution.
    - ~7% at 10 GeV.



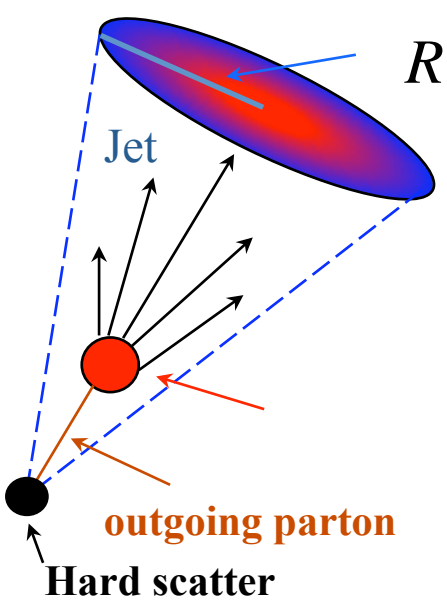




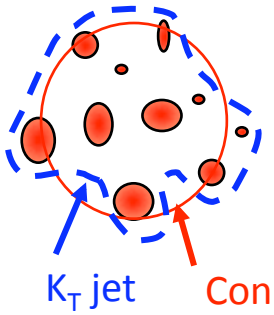
Analyzed data sample

- p+p at √s = 7.0 TeV, reconstructed data from LHC10c and LHC10d periods.
- Minimum bias trigger: 128 M events.
  - eliminating non-physics events, and requiring z-vertex < +- 10 cm.
  - MB trigger: "SPD ***or*** V0-A ***or*** V0-C"
    - at least one charged particle in 8 pseudorapidity units
- η cut:
  - single charged tracks within $|\eta| < 0.9$.
  - jets $|\eta| < 0.5$.

Jet finding algorithms

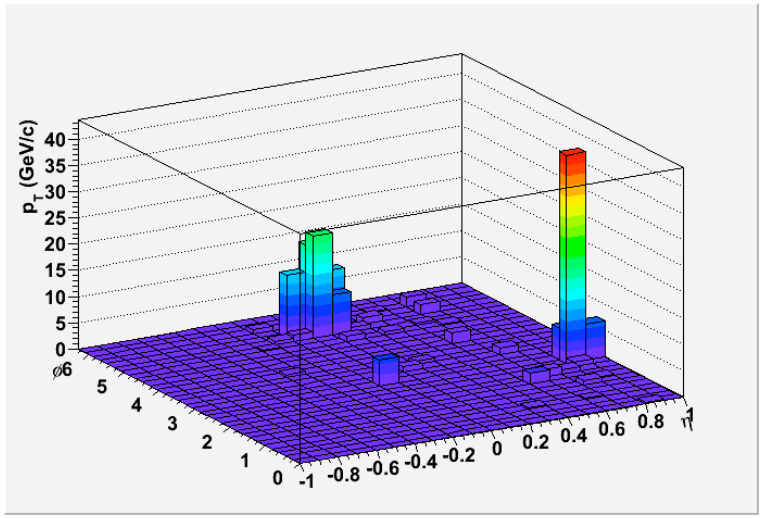


$$R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

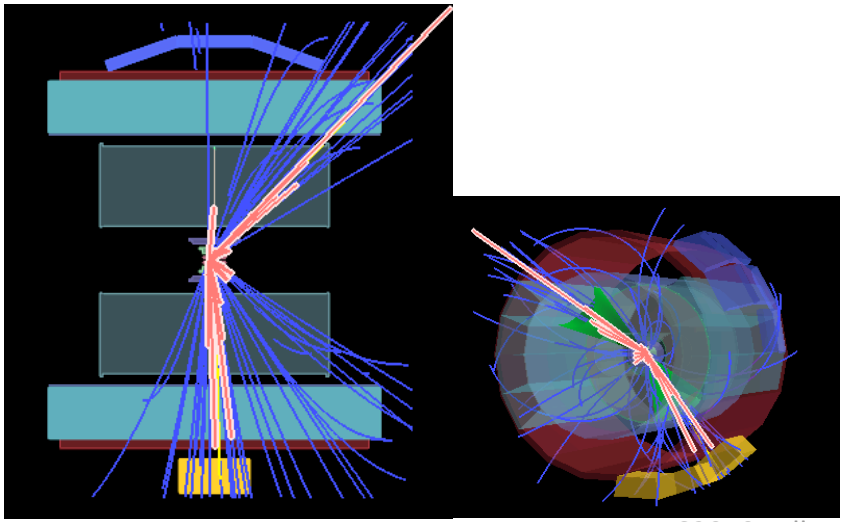


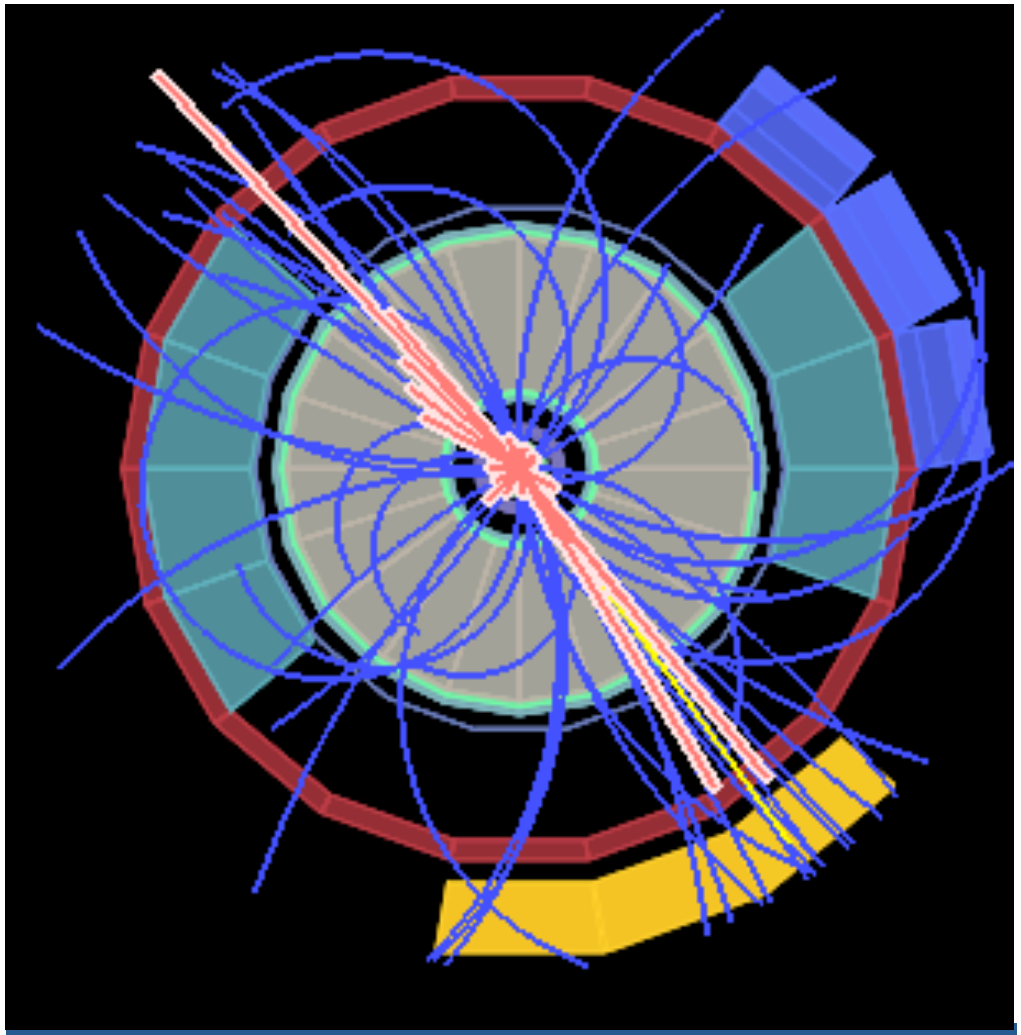
1. Cone algorithm:
   - Simple geometric motivation.
   - Split/merging procedure for overlapping cone.
   - UA1
   - SIS cone
     - Seedless Infrared Safe Cone algorithm
     - insensitive to soft radiation.
2. Sequential recombination algorithm:
   - Cluster pairs of objects close in relative p_T.
   - Define "distance" between pairs.
   - k_T algorithm
     - Starting from low p_T particle.
   - anti-k_T algorithm
     - Starting from high p_T particle.

Dijet event in p+p 7 TeV in ALICE



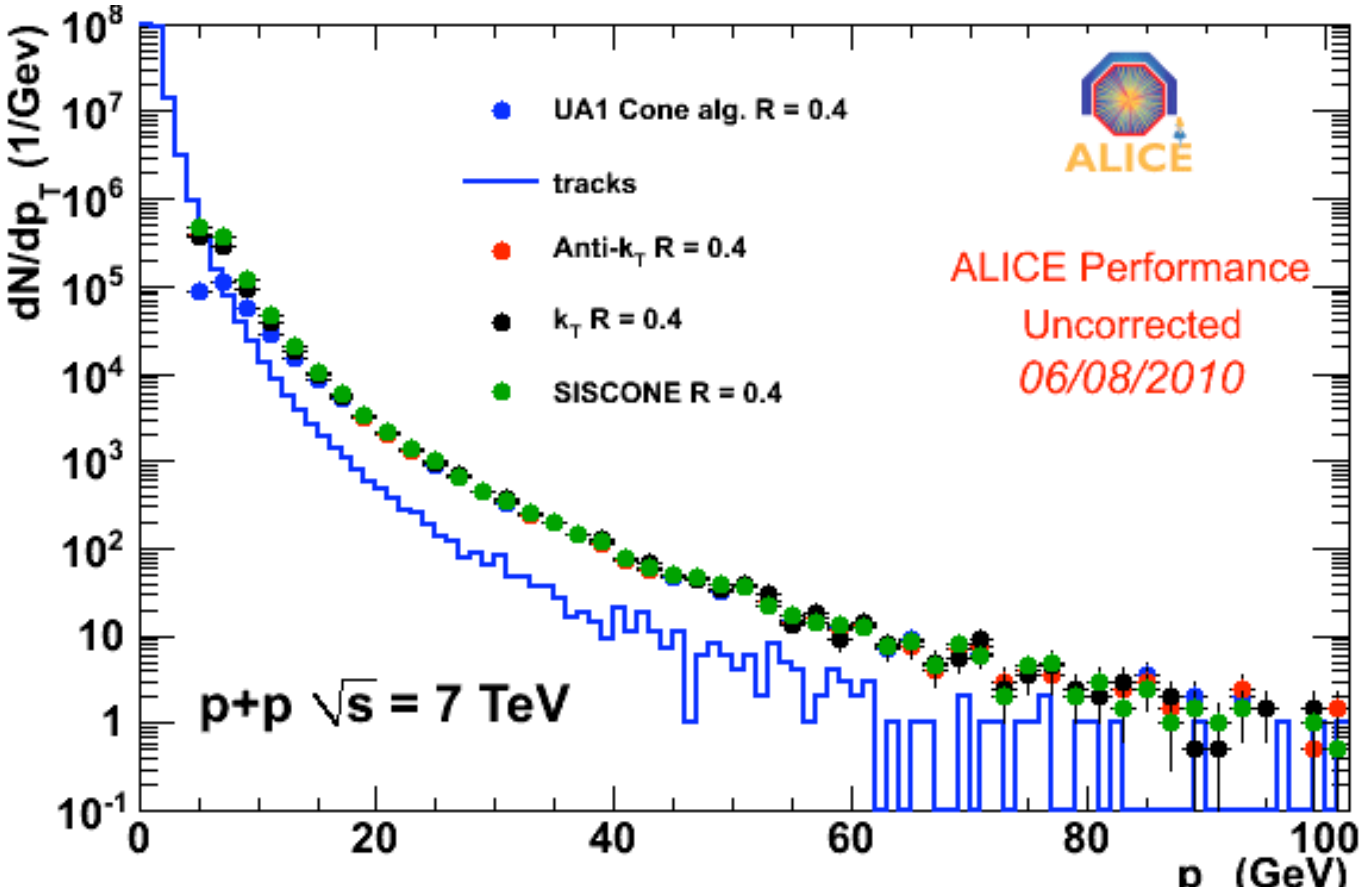
η−ϕ grid





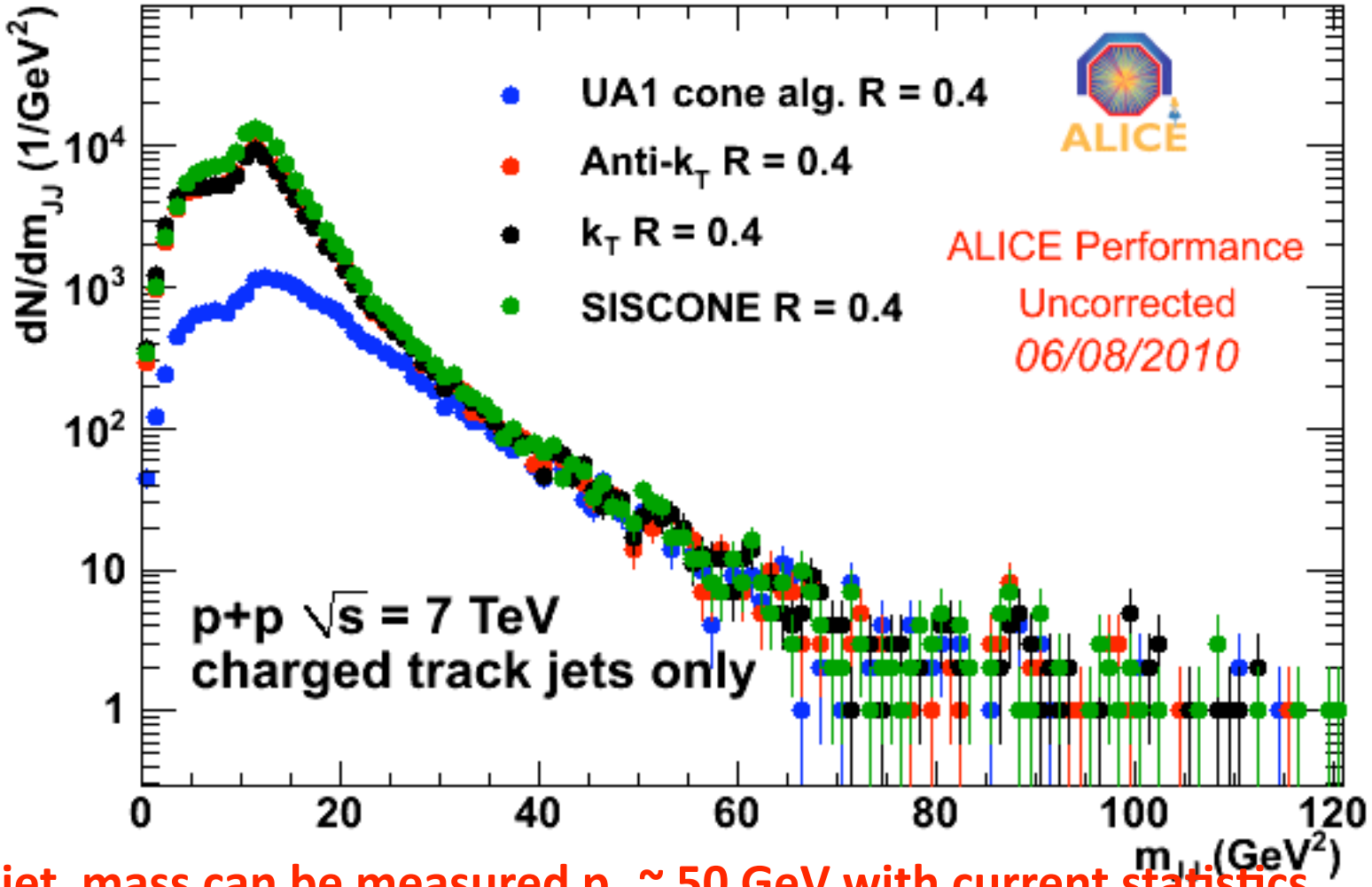
Reconstructed Jets UA1 Cone R = 0.4:
Jet 1: η = 0.02, ϕ = 306°, p_T = 71 GeV, Tracks 15
Jet 2: η = 0.84, ϕ = 132, p_T = 47 GeV, Tracks 9
Δϕ = 174°
Total Tracks 108

(Raw) single jet spectrum in p+p 7 TeV



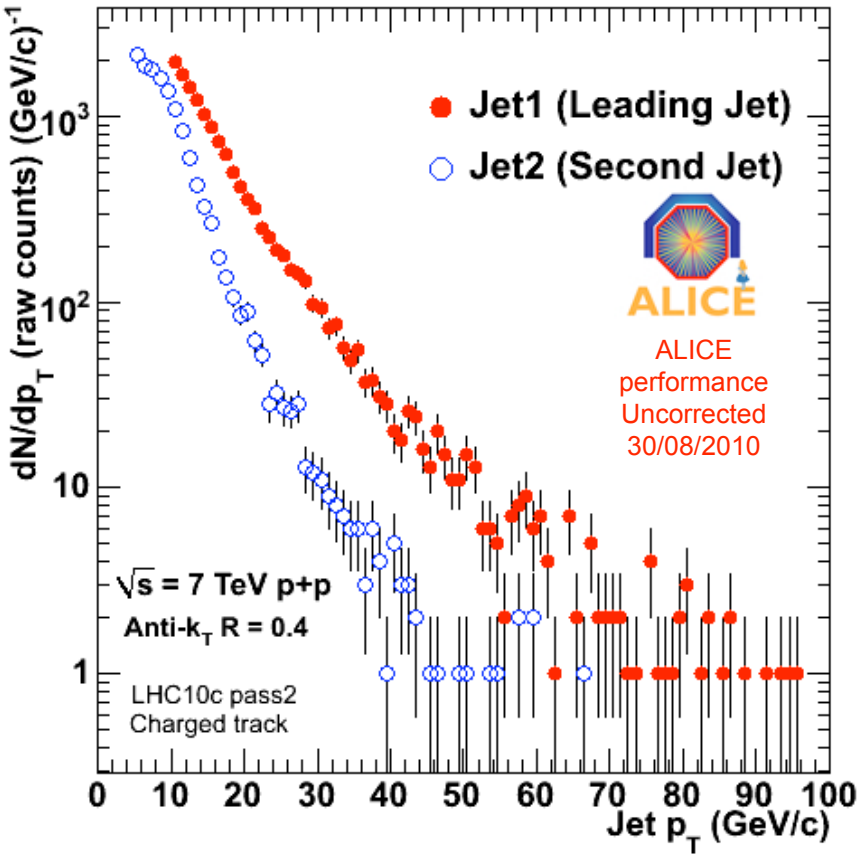
Jet can be measured p_T ~ 70 GeV/c with current statistics.

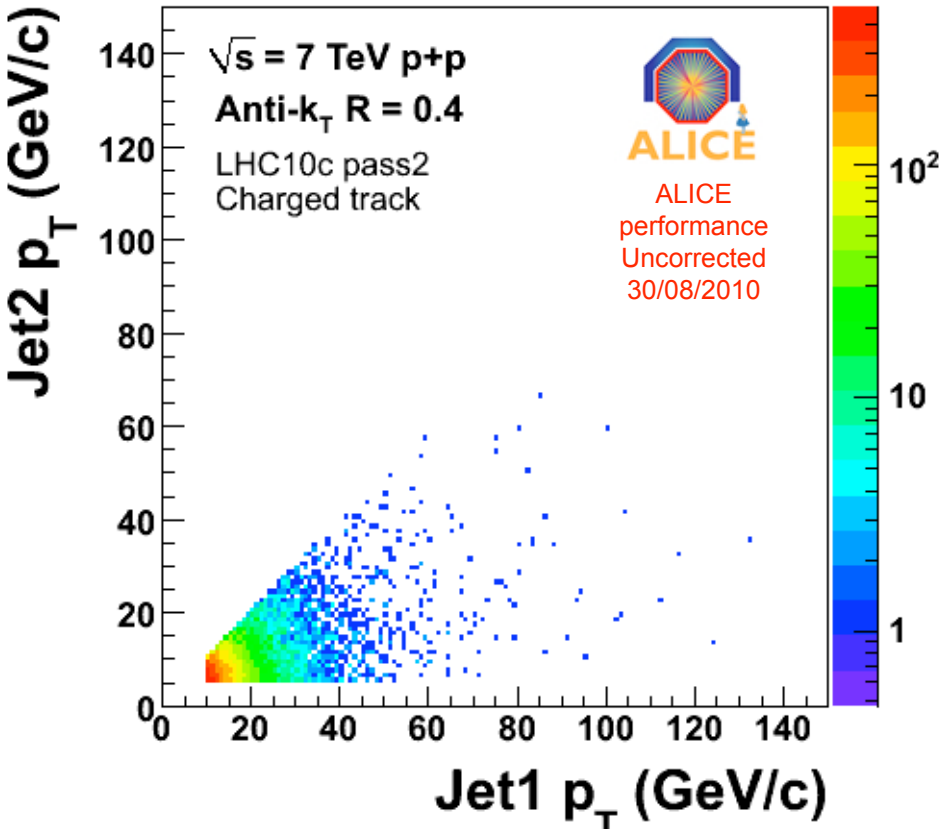
Di-jet invariant mass plot



di-jet mass can be measured p_T ~ 50 GeV with current statistics.

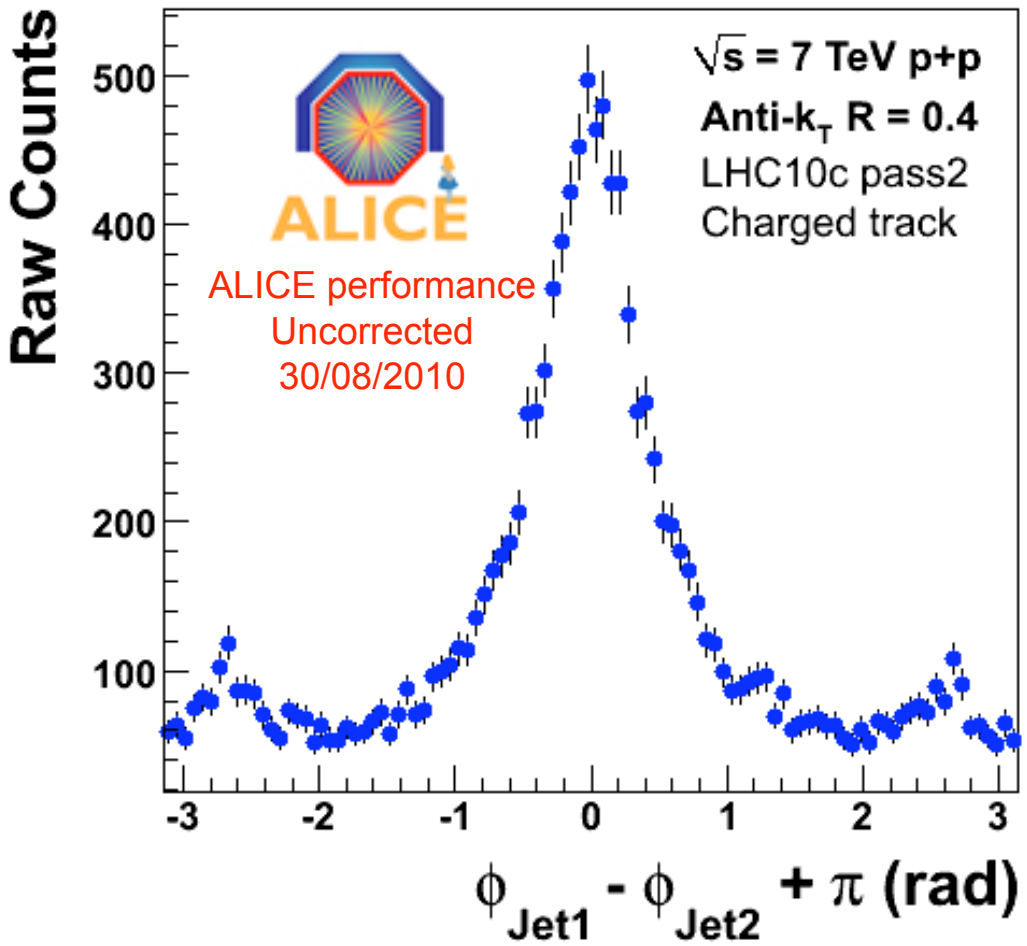
Leading and second jet p_T raw spectrum and correlation (for





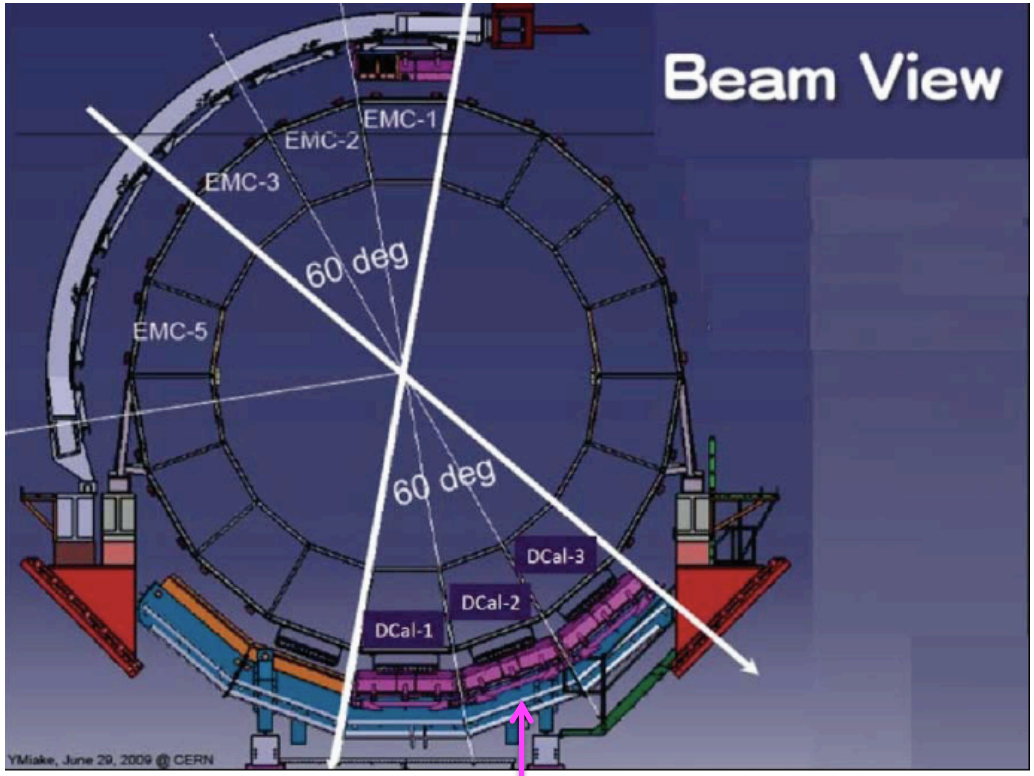
Leading jet p_T spectrum is harder than that for 2nd jet.

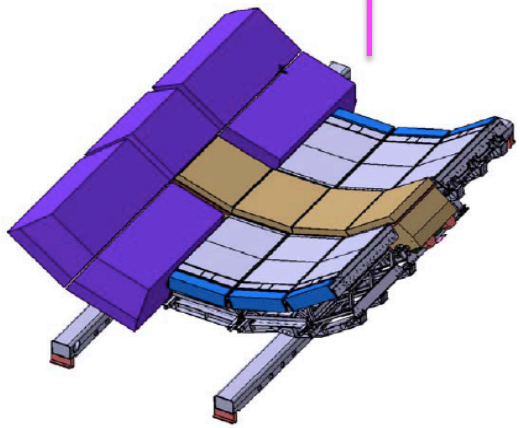
Acoplanarity of jets (Raw)



- Azimuthal angle difference between 1st (leading) jet and 2nd jet.
- leading jet p_T cut: > 10 GeV/c
- Acoplanarity:
  - $\phi_{Jet1} - \phi_{Jet2} + \pi$
- Next step:
  - comparison with model.
  - **Comparison to that in heavy ion**, which will start data taking in Nov. 2010,Pb+Pb 2.76 TeV.

ALICE Dijet Calorimeter (DCal) Project





DCal:

- *Extend the acceptance of EMCal (Pb-Scinti. sampling).*
  - *EMCal: $\Delta\phi = 110°$*
  - *DCal: $\Delta\phi = 60°$ (on opposite side of EMCal)*
  - *$\Delta\eta = 0.7$ for both EMCal and DCal + PHOS*
  - *~10%/√E*
- *Allow back-to-back hadron-jet, di-jet measurements in ALICE, with R = 0.4, up to p_T ~ 150 GeV/c.*
- *Enhance jet, γ trigger capability.*
  - *Catania, CERN, Franscati, Grenoble, INFN, Jyväskylä, Nantes, Stranbourg, **Tsukuba**, ORNL, LBNL, Yale, Huston,LANL, Wuhan*
- ***To be installed in 2012.***

Summary and outlook

- **First look at jet and dijet in p+p 7 TeV in ALICE.**
- Using the 128 M MB statistics, ALICE can measure single jet up to p_T ~ 70 GeV/c, and dijet mass < 50 GeV/c^2.
- **Outlook:**
  - Analyze full statistics data sample (so far, 700 M MB data in p+p 7 TeV as of Sep. 2010).
  - Corrections to the raw (di-) jet spectra.
  - Acoplanarity:
    - Model comparison.
    - > 2 jets study.
  - **Prepare for the first Pb+Pb run ($\sqrt{s_{NN}}$ = 2.76 TeV, Nov. 2010)!**
    - **Any difference in ϕ balance, p_T balance in Pb+Pb compared to p+p?**
  - Use EMCal & PHOS info, to enhance di-jet measurement.