initial studies for JET UNDERLYING EVENT with EMCal

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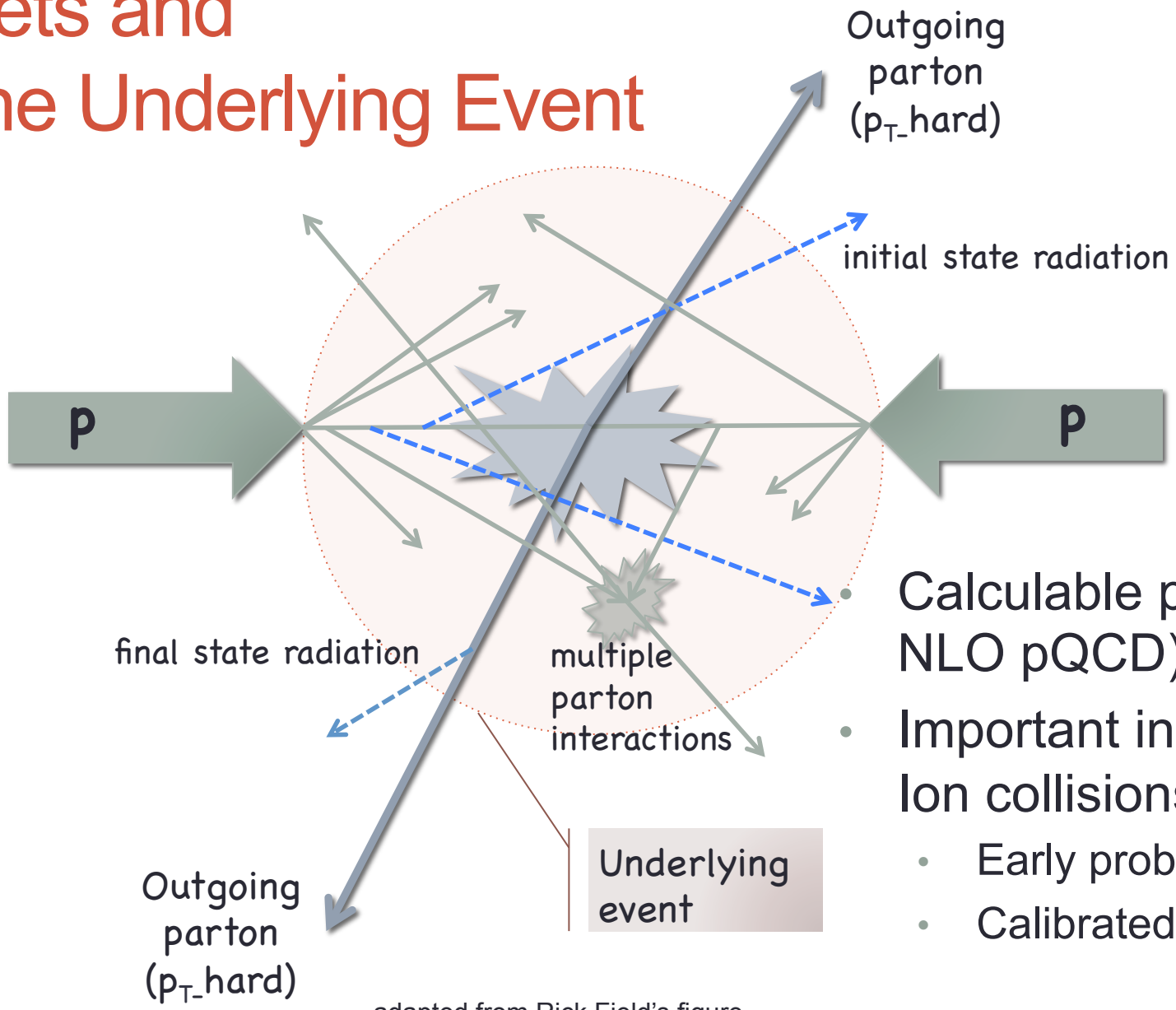
For the ALICE Collaboration

Hot Quarks 2012 ◆ Guanica, Puerto Rico

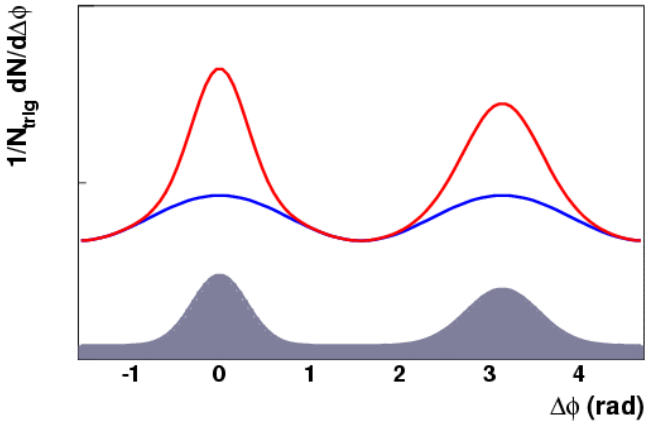
Jets and the Underlying Event



adapted from Rick Field's figure

- Calculable probe (via NLO pQCD)
- Important in Heavy Ion collisions:
  - Early probe
  - Calibrated probe

Jets in the Medium

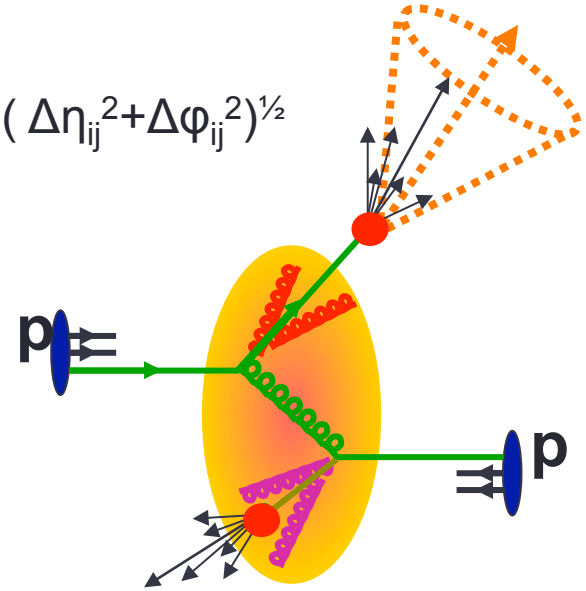


1. Characterizing jets statistically, via azimuthal correlations (10+ years)
   - Need to know the underlying background well: flow, random background:

$$C(\Delta\phi) = A_0 \exp\left(-\frac{\Delta\phi^2}{2\sigma_0^2}\right) + A_\pi \exp\left(-\frac{(\Delta\phi-\pi)^2}{2\sigma_\pi^2}\right) + B\left[1 + 2v_2^{trig} v_2^{as} \cos(2\Delta\phi)\right]$$

2. Full jet reconstruction using clusterization algorithms (eg, the FASTJET package):
   - Need to know the underlying event characteristics: *energy* and *number density* to subtract the underlying event energy from the energy of the jet

$$\Delta R_{ij} = (\Delta\eta_{ij}^2 + \Delta\varphi_{ij}^2)^{1/2}$$



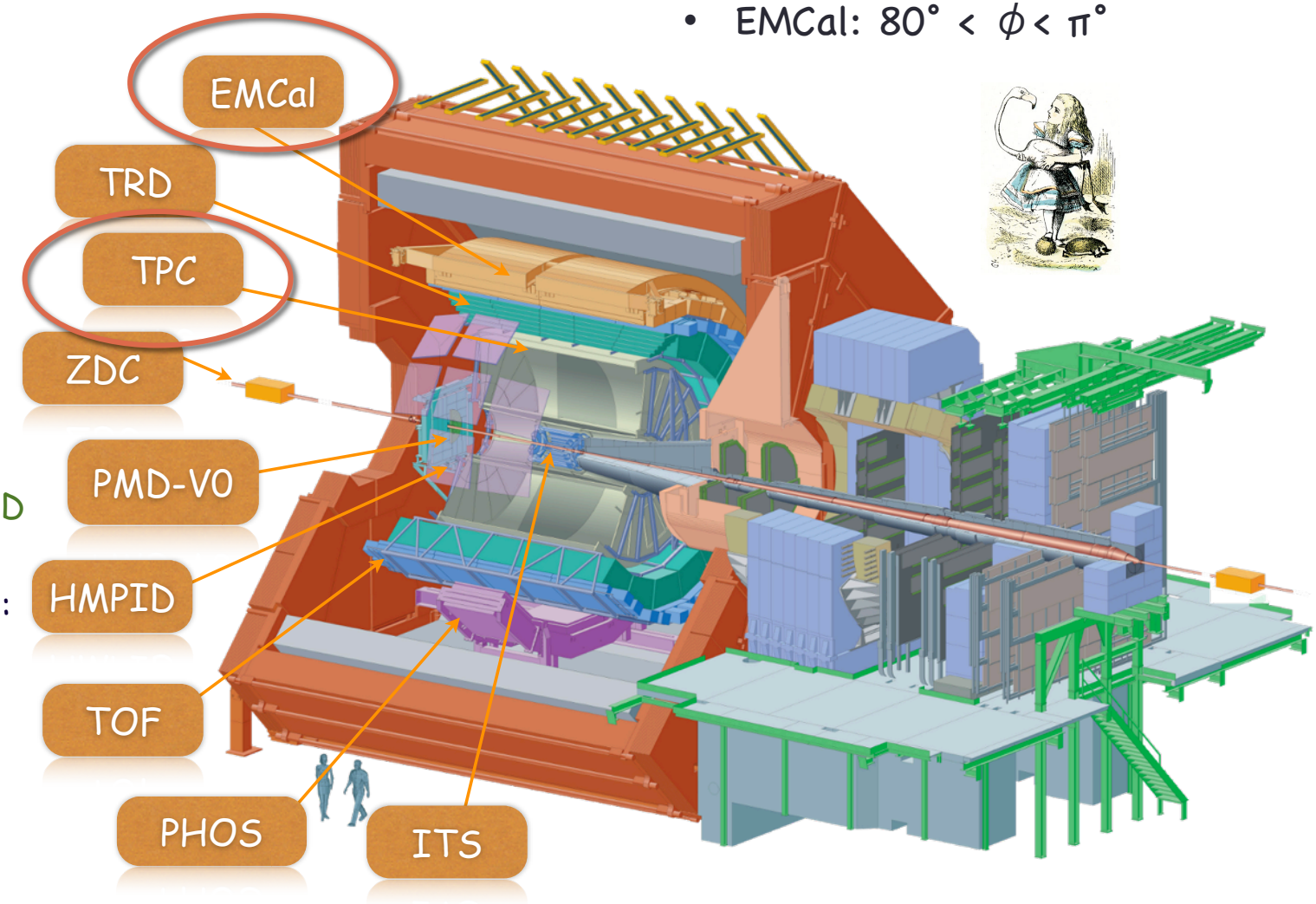
$$p_{Tjet}\ (true) = [p_{Tjet}\ (measured) - p_T(underlying\ event)]/R_{jet}$$

The ALICE detectors

Detector coverage in azimuth:
TPC: $|\phi| < 360°$
- EMCal: $80° < \phi < \pi°$

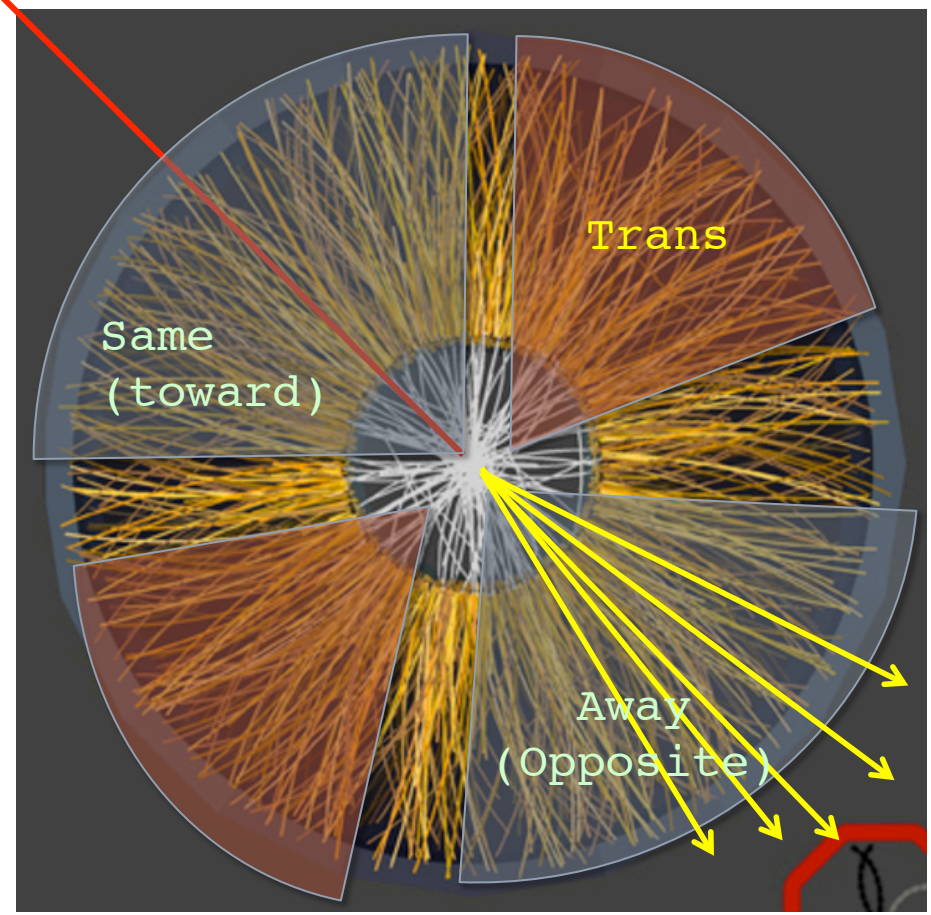
- Triggering:
  - ZDC
  - V0A & V0C coincidences
  - Silicon Pixel Detector, SPD

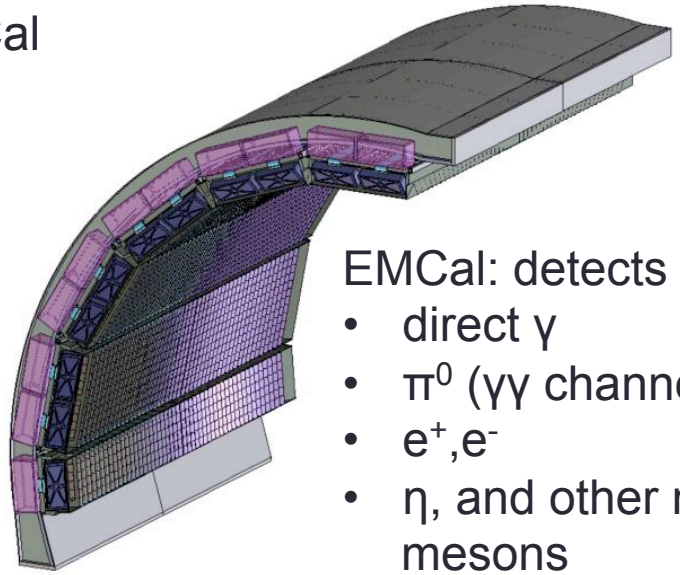
(two middle layers of Silicon: three hits min)

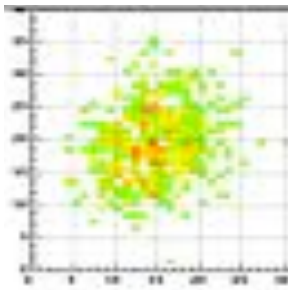


TPC & the EMCal

- Charged particles: tracks from the TPC
- Neutral particles: energy lost in the EMCal







EMCal: detects
- direct γ
- π^0 (γγ channel)
- e^+,e^-
- η, and other neutral mesons

Analysis:
- Energy deposited in towers, towers are clusterized;
- Energy used to calculate neutral particle density

Jet axis: defined in terms of the highest p_T track (p_T >1 GeV/c) : Leading Track (LT)

EMC: Geometric arrangement

- $|\eta| < 0.65$ for all tracks & clusters
- $1.4 < |\phi| < \pi$

  :: EMCal (same-region)
- $0 < |\phi| < -1.74$

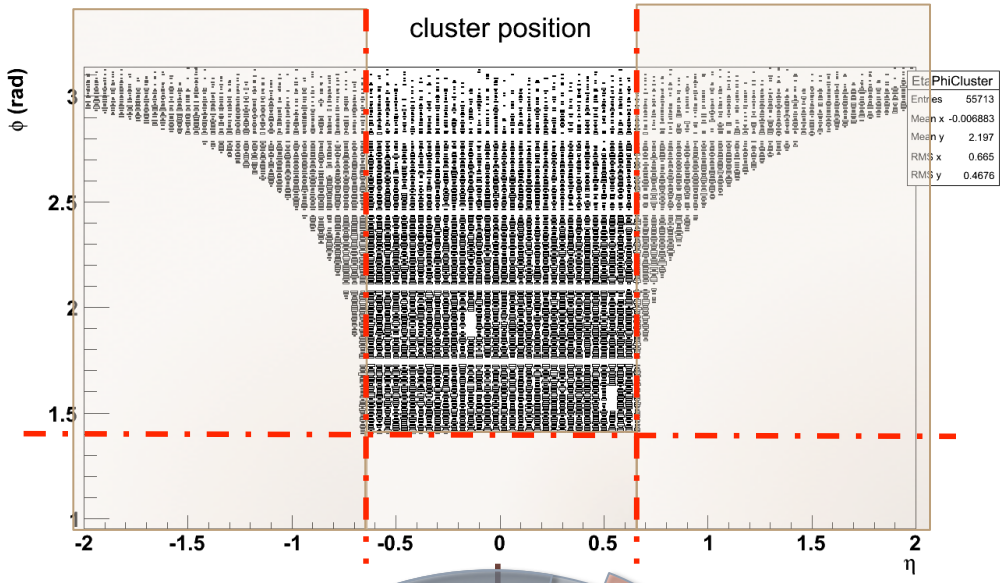
  :: Opposite
- $1.7 < |\phi| < 0$ && $-2.84 < |\phi| - 1.74$

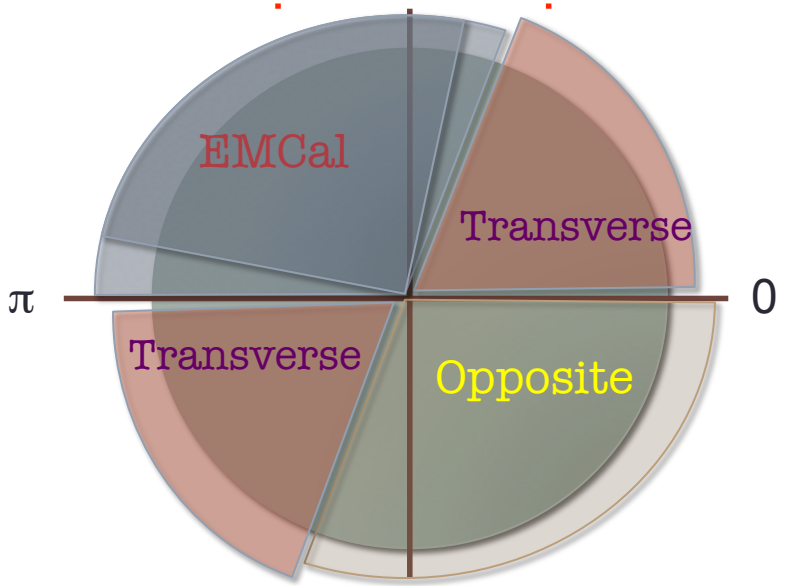
  : Transverse
- EMC Total usable area:

$1.74 \text{ rad} \times 430 \text{ cm} \times 600 \text{ cm}$

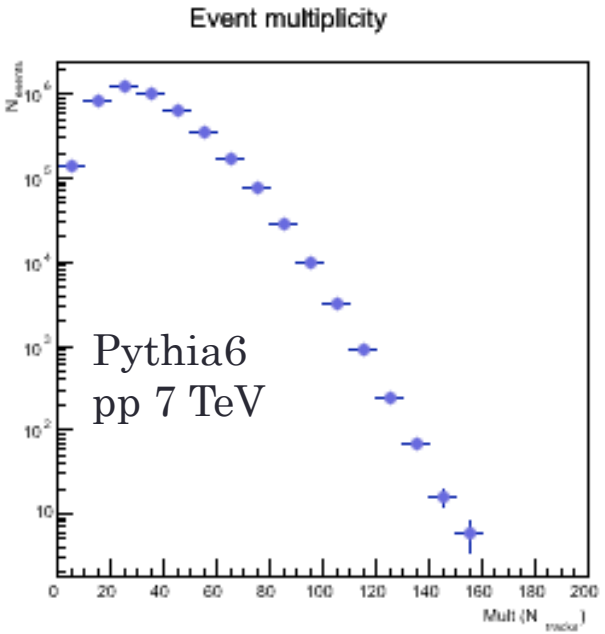
$= 44.9 \text{ m}^2$

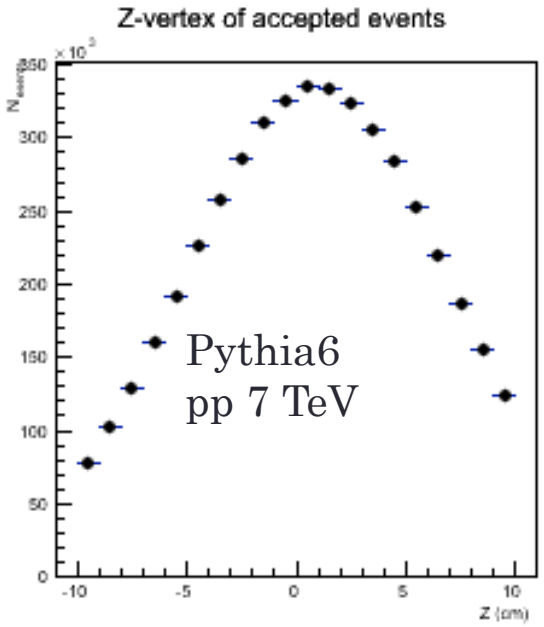
- To prevent spill-over in transverse: cut the EMCal edges by 0.3 rad

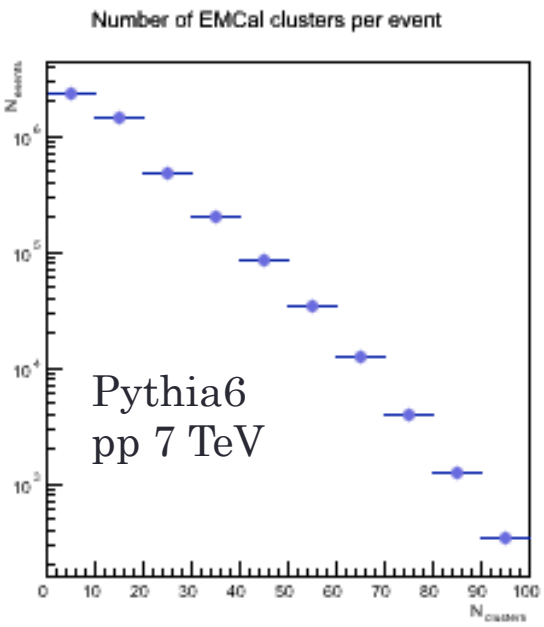




EMCal Data







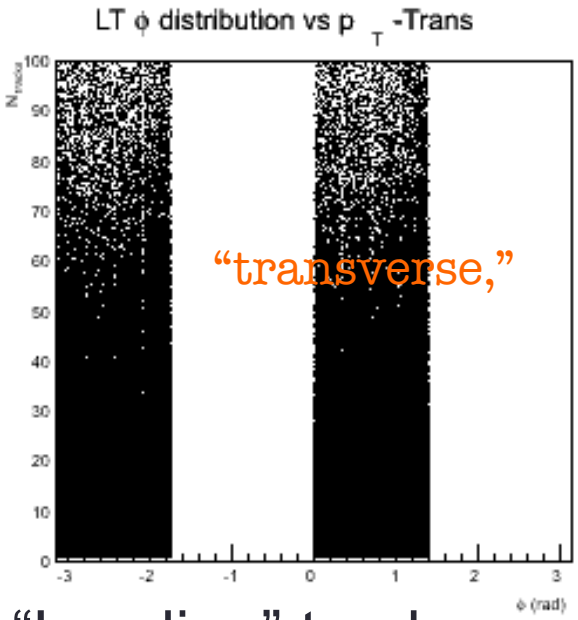
PYTHIA-6 pp 7 TeV simulation with embedded di-jets in ALICE detector

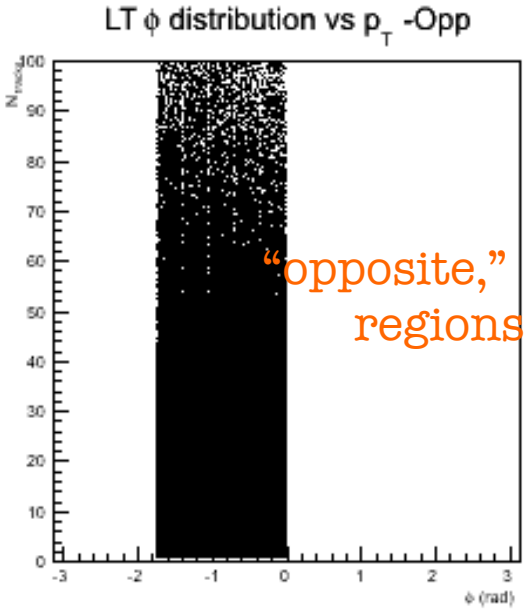
- 4.5M events with a valid leading track and EMCal energy deposits
- Minimum Bias events

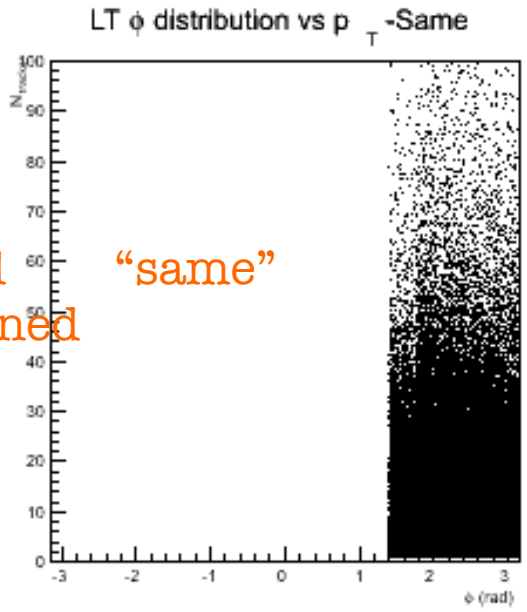
|z-vertex| < 10 cm, as is standard for the physics selection

Cluster selection: $E_{cluster} > 300$ MeV & $E_{cluster} > 1$ GeV
Upper $E_{cluster}$ cut-off: 5.5 GeV
Leading track selection: $p_{T(LT)} > 1$ GeV/c

Highest p_T TPC track (LT) distributions

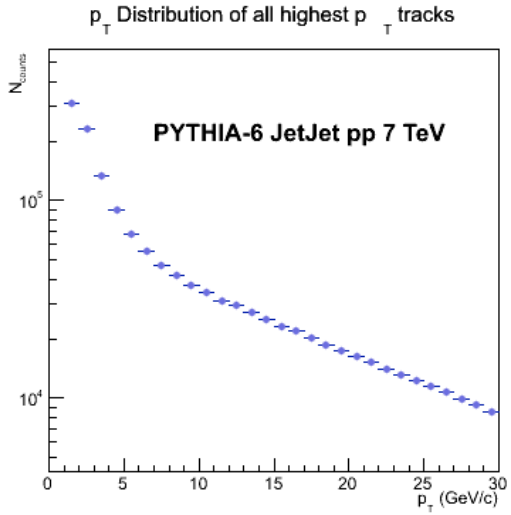






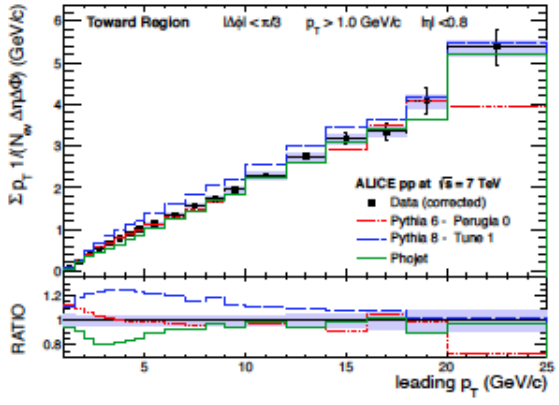
"transverse," "opposite," and "same" regions defined

- "Leading" tracks:
  - identified as primary (i.e., originate at event vertex)
  - ITS+TPC points used
  - Clusters matching TPC tracks excluded from density calculation
  - Assumed to approximate jet axis

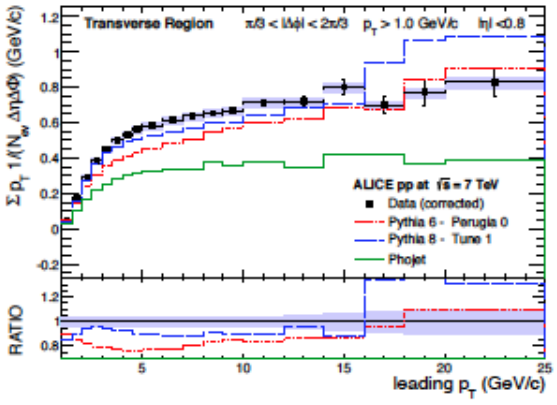


Underlying event with Charged tracks :: energy density

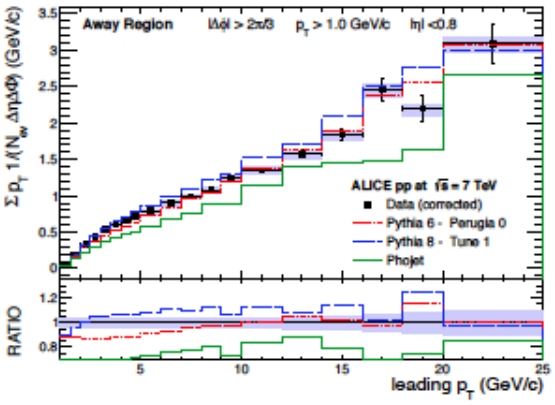
Alice Collaboration, JHEP 07 (2012) 116



toward (same)



transverse

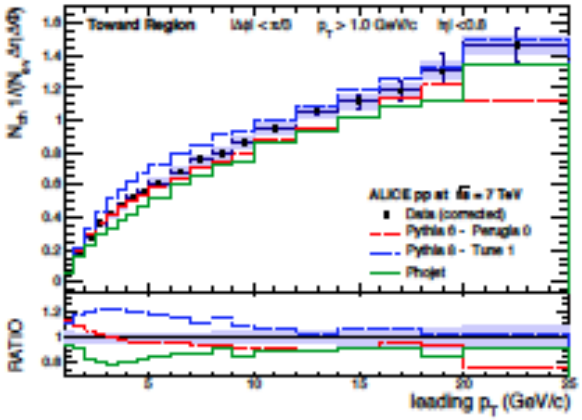


away (opposite)

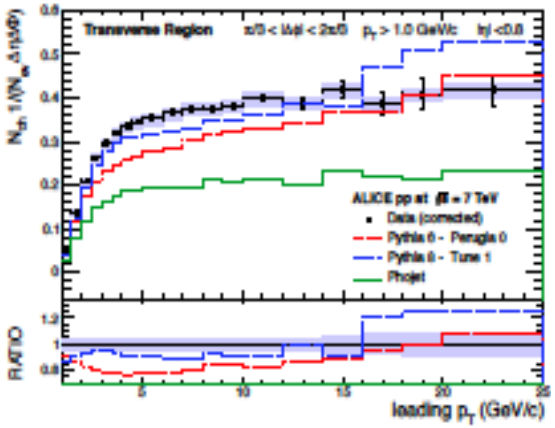
- Data to simulation comparison
- Wider η acceptance: $|\eta| < 0.8$
- Toward & Away regions similar increase pattern
- Transverse region energy-density seems to flatten above $p_T > 5$ GeV/c

Underlying event with Charged tracks :: number density

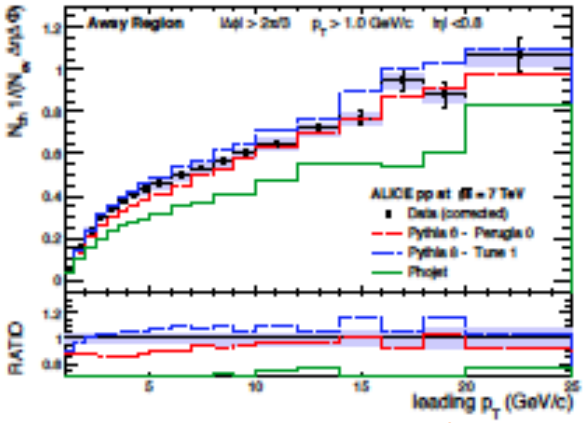
Alice Collaboration, JHEP 07 (2012) 116



toward (same)



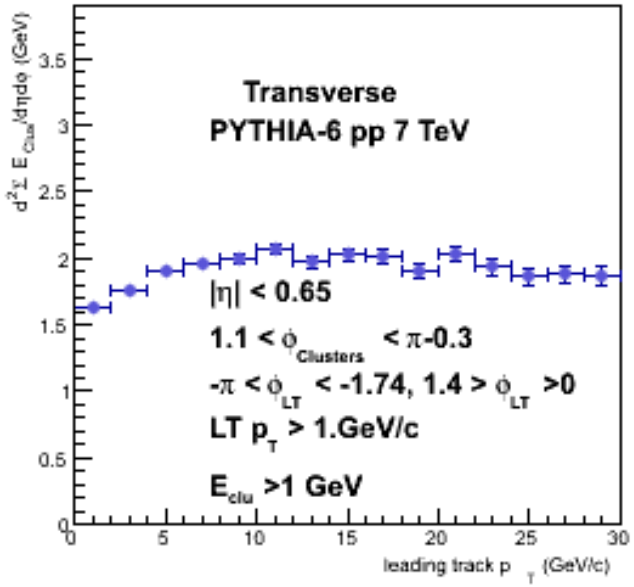
transverse

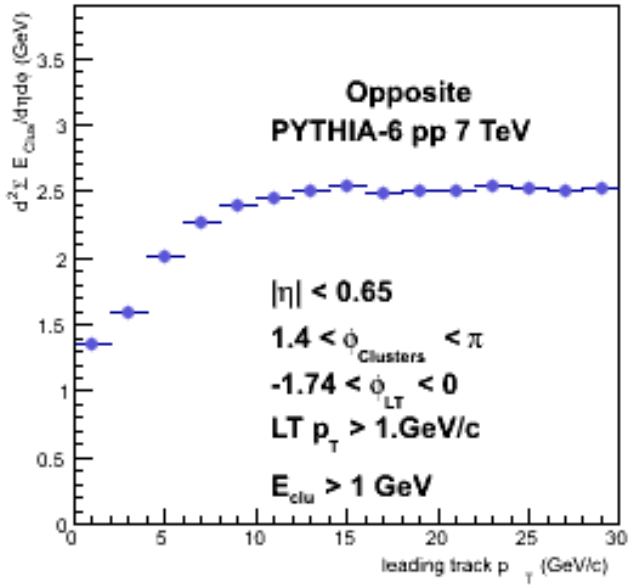


away (opposite)

- Data to simulation comparison:
  - good agreement in toward and away region with Pythia-6 Tune1
- Wider η acceptance: $|\eta| < 0.8$
- Toward & Away regions similar increase pattern
- Transverse region number-density also seems to flatten above $p_T > 5$ GeV/c

$E_{cluster}$ > 1 GeV distributions (Energy density)

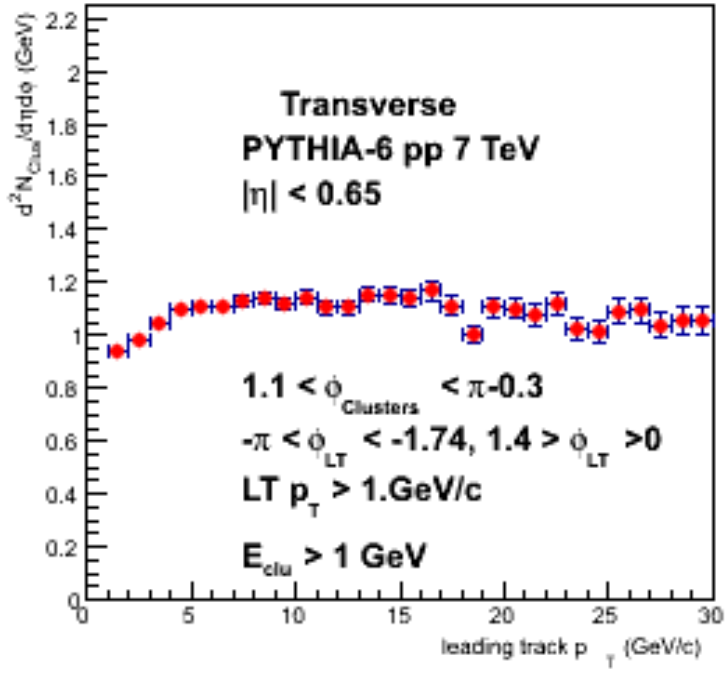


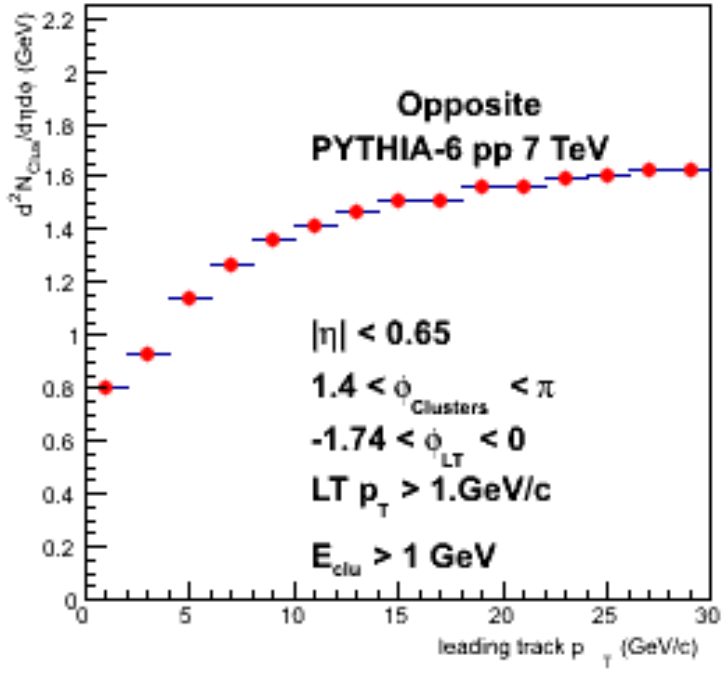


- *Transverse*: energy-density is almost independent of the LT momentum
- *Away* (opposite): energy-density rises more slowly and levels off more slowly then that for charged tracks only

uncorrected, detector level

$E_{cluster}$ > 1 GeV distributions (Number density)

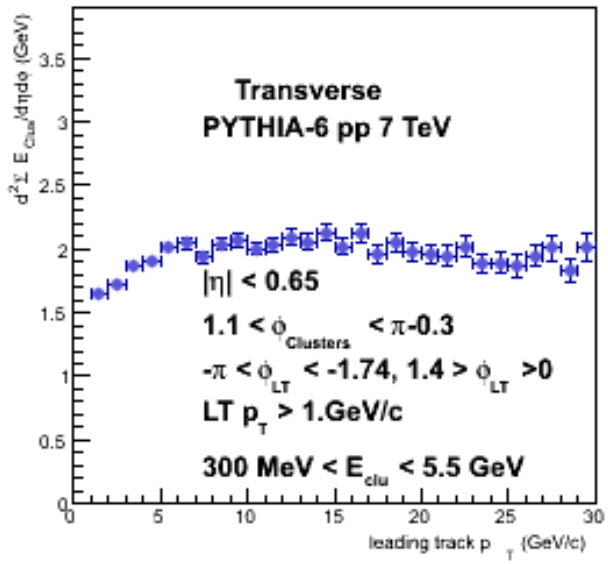


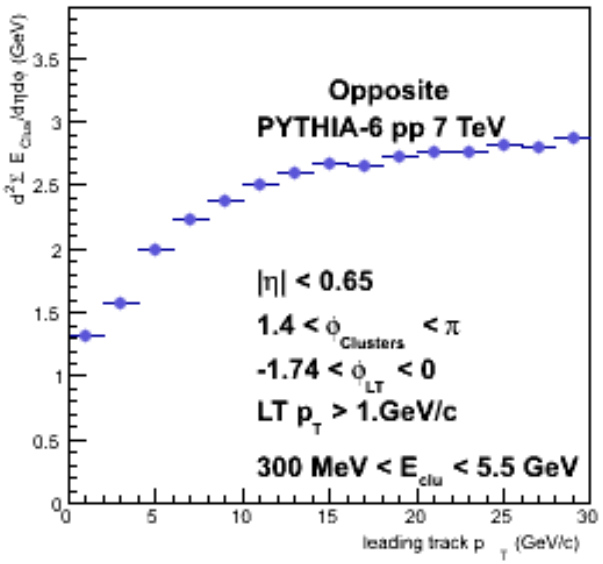


- *Transverse* energy density distribution is flatter;
- *Away (Opposite)* side might not flatten, or flattens later

uncorrected, detector level

$0.3 < E_{cluster} < 5.5$ GeV distributions (Energy density)

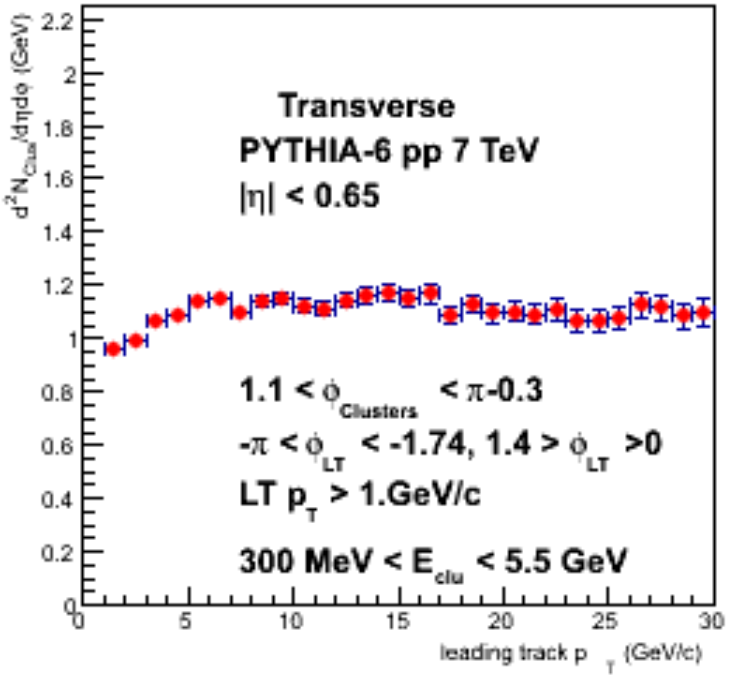


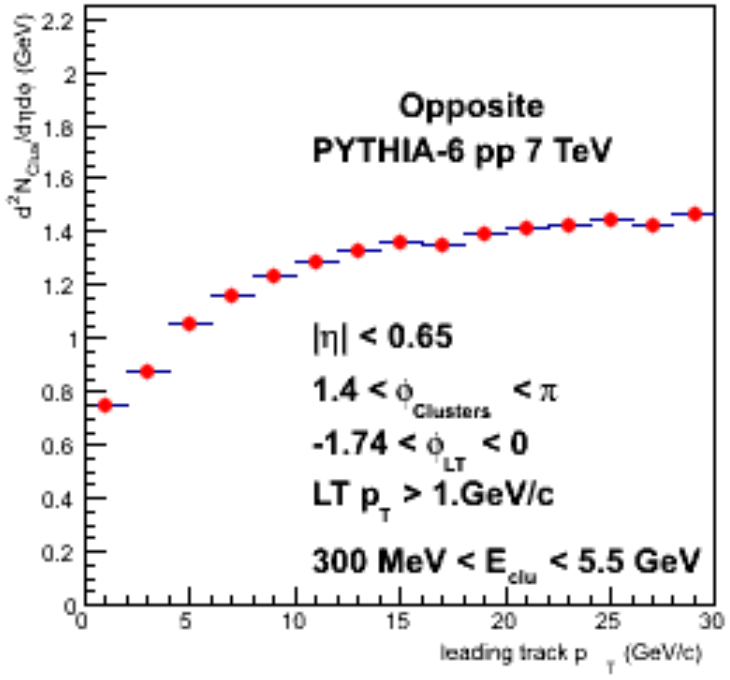


- Energy range chosen to highlight the low-energy clusters
- Trend similar to the previously observed: flat Trans & rising Opp
- Energy density values are similar to wider cluster selection

uncorrected, detector level

$0.3 < E_{cluster} < 5.5$ GeV distributions





- Trends again repeat those of energy-density
- Flat on the transverse side, increasing on the away (opposite) side. Transverse side levels off at the same level as the wider distribution.

uncorrected, detector level

Conclusions /Outlook

- Preliminary study; complimentary analysis to published charged track data
- EMCal: providing the necessary handle on the neutral part of the underlying event
- The density of the transverse and the opposite region to the LT is similar for charged and neutral energy distributions
- Further detailed studies necessary and are under way with real ALICE data
  - Detailed same-side measurements;
  - Real data