5th Workshop on High p-T Physics at LHC 2010

Underlying Event Studies for LHC Energies

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Outline

0. Motivation

I. Definition for Underlying Event

- The CDF method
- SB – a new method for UE studies

II. Test SB method by jets & hadron correlation

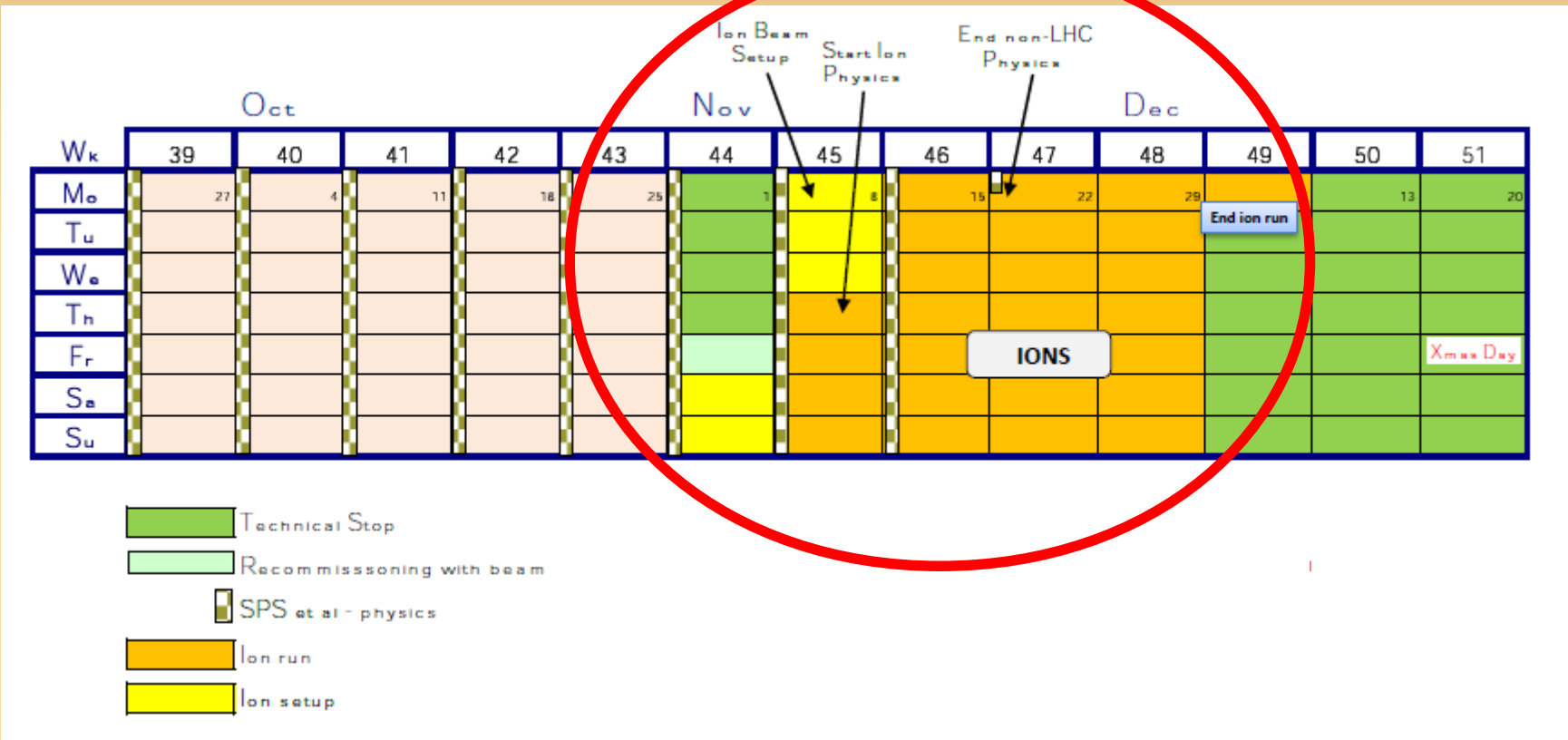
- Underlying Event analysis with jets
- Hadron correlation with 'set-selections'
- π, K and p-triggered correlations

III. Summary & Outlook

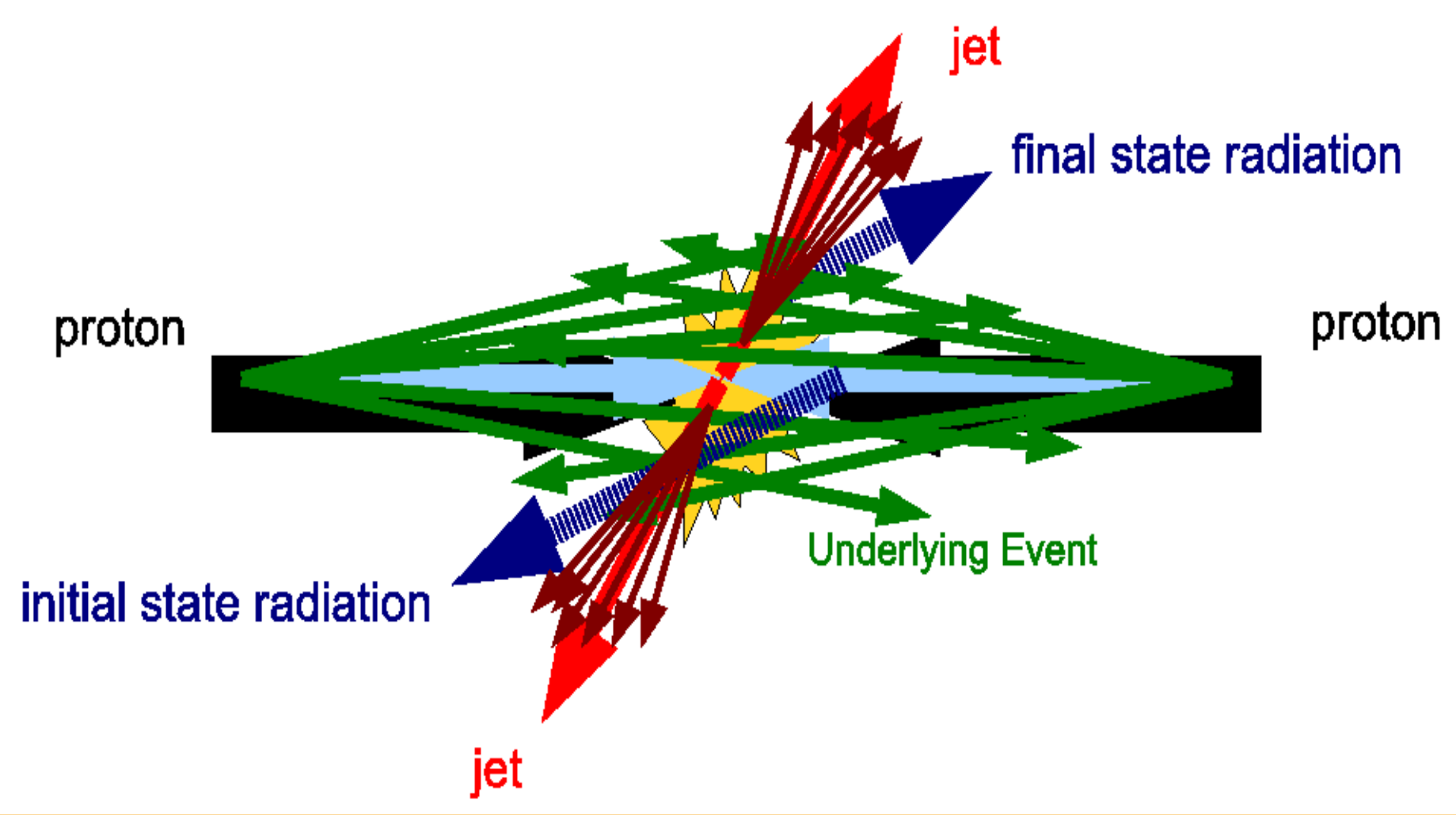
Refs.: AG Agócs, P Lévai: PoS EPS-HEP 2009 472
AG Agócs, GGB, P Lévai: Proc. for HQ2010

0. Motivation

- What should be more motivative than this...?



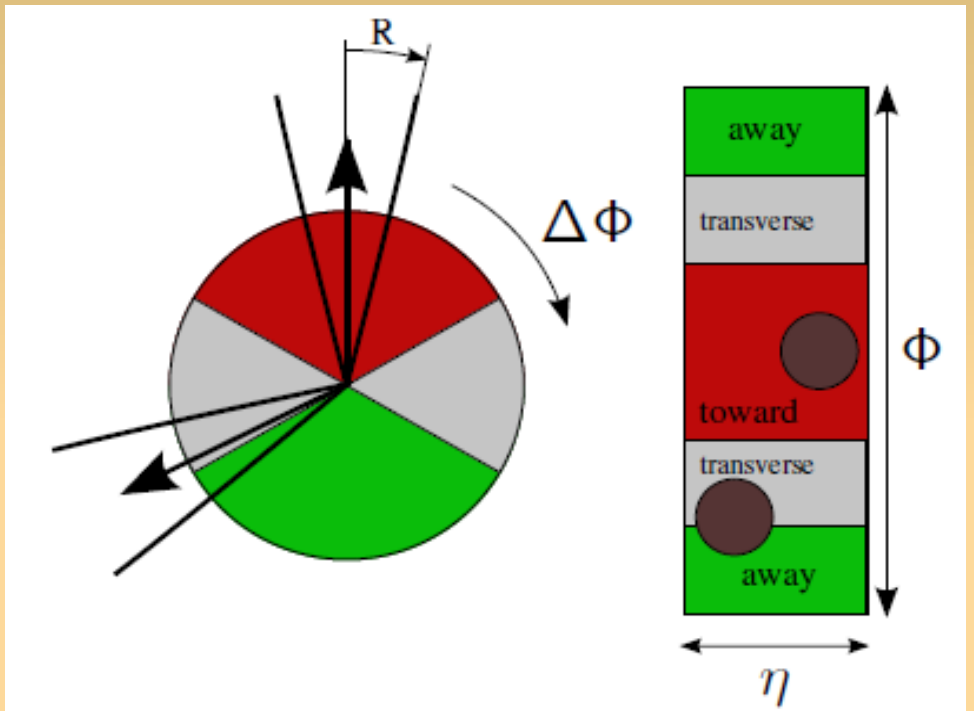
I. The Underlying Event



Definition of Underlying Event

CDF definition of UE

- Developed to subtract the UE as a background.
- There is no dependence contrary to the cone-like shape of jets.
- “The transverse region is perpendicular to the plane of the hard 2->2 scattering and is very sensitive to the UE component of the QCD MC models.”



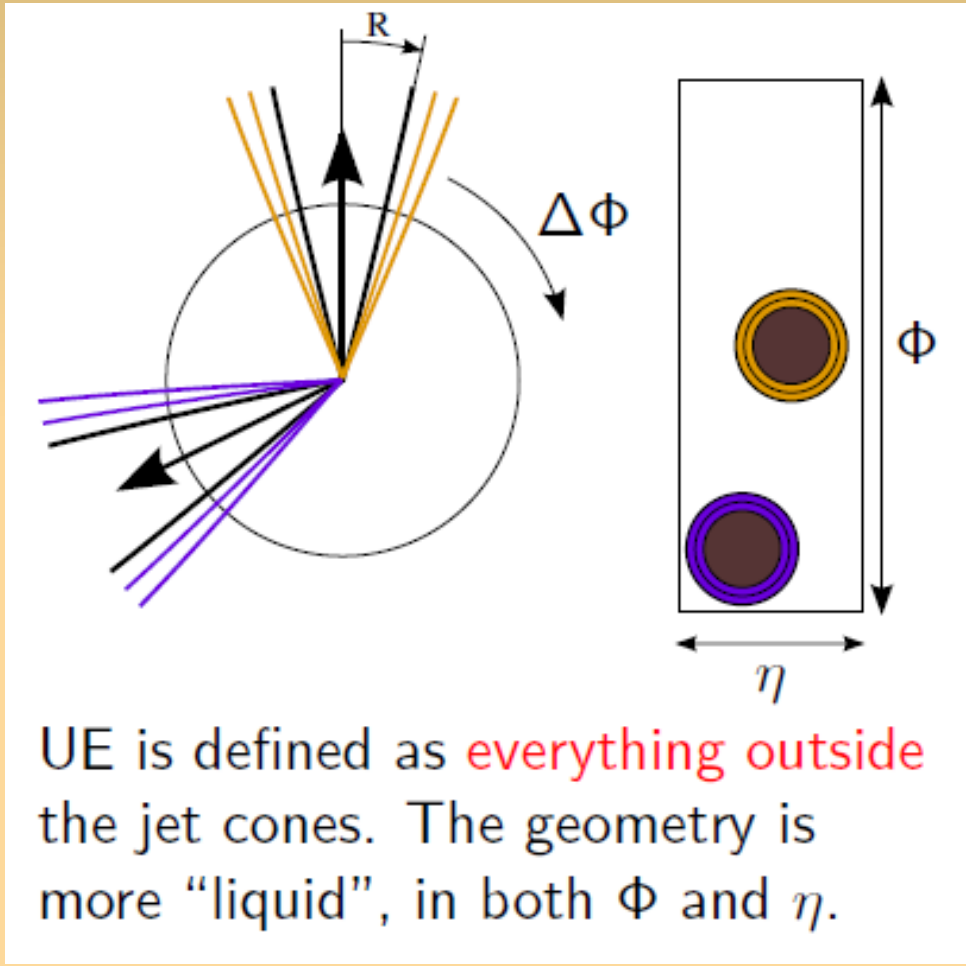
The geometry used by the CDF collaboration. The transverse region is fixed $60° < |\Delta\Phi| < 120°$.

CDF Col.: PRD65 092002

Generalization of UE

A new method for UE

- Based on surrounding cones, ring-shaped subregions can be defined: Surrounding Belts (SB) of the UE. They grasp the border region between the UE and jets.
- Inner and outer SB, for both near-side and away-side jets.



AGA & PL: PoS EPS-HEP 2009 472

Comparison of CDF & SB UE

- Common
  - Similar for back-to-back di-hadron corr.
  - Test areas are fix in both cases.
  - SB is generalization of CDF, so a huge size SB looks CDF-like.
  - Even small statistic is enough to evaluate.
- Differences
  - SB can handle 2 -> 3 and good for *n*-jets.
  - Depends on jet cone size (or jet finder alg.).
  - Taking more SBs leads to differential test of UE properties.
  - Requires higher statistic (in SBs).

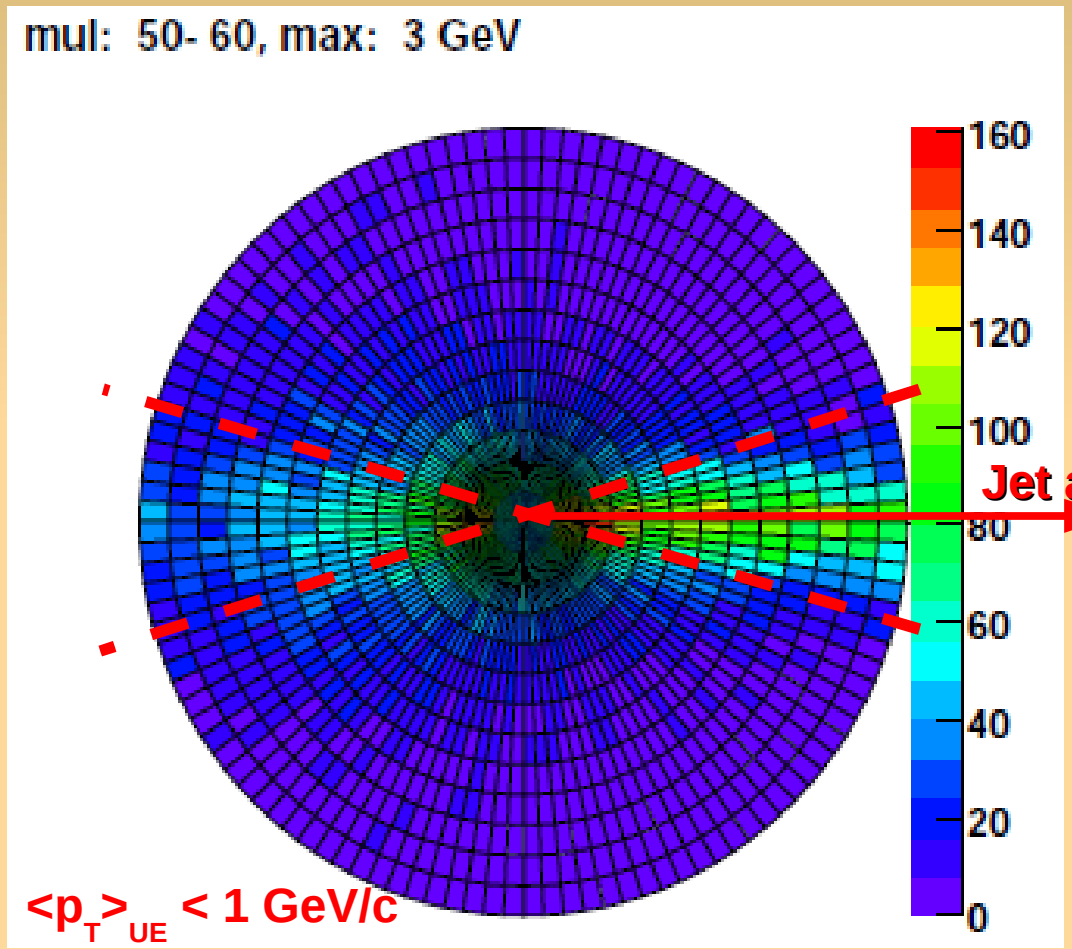
II. Test SB method by jets and hadron-hadron correlation

Geometrical structure of UE

Proton-proton @ 14 TeV

- Analysis:
  - 100 k PYTHIA 6.4 CSC
  - UA1 jet finder, R=0.7
  - Q > 100 GeV/c
  - P_T < 3 GeV/c
  - **SB: δR=0.1**

- Polar plot for charged hadron p_T-distribution with:
  - Intermediate multiplicity: 50 < N_{ch} < 60



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Geometrical structure of UE

Proton-proton @ 14 TeV

- Analysis:
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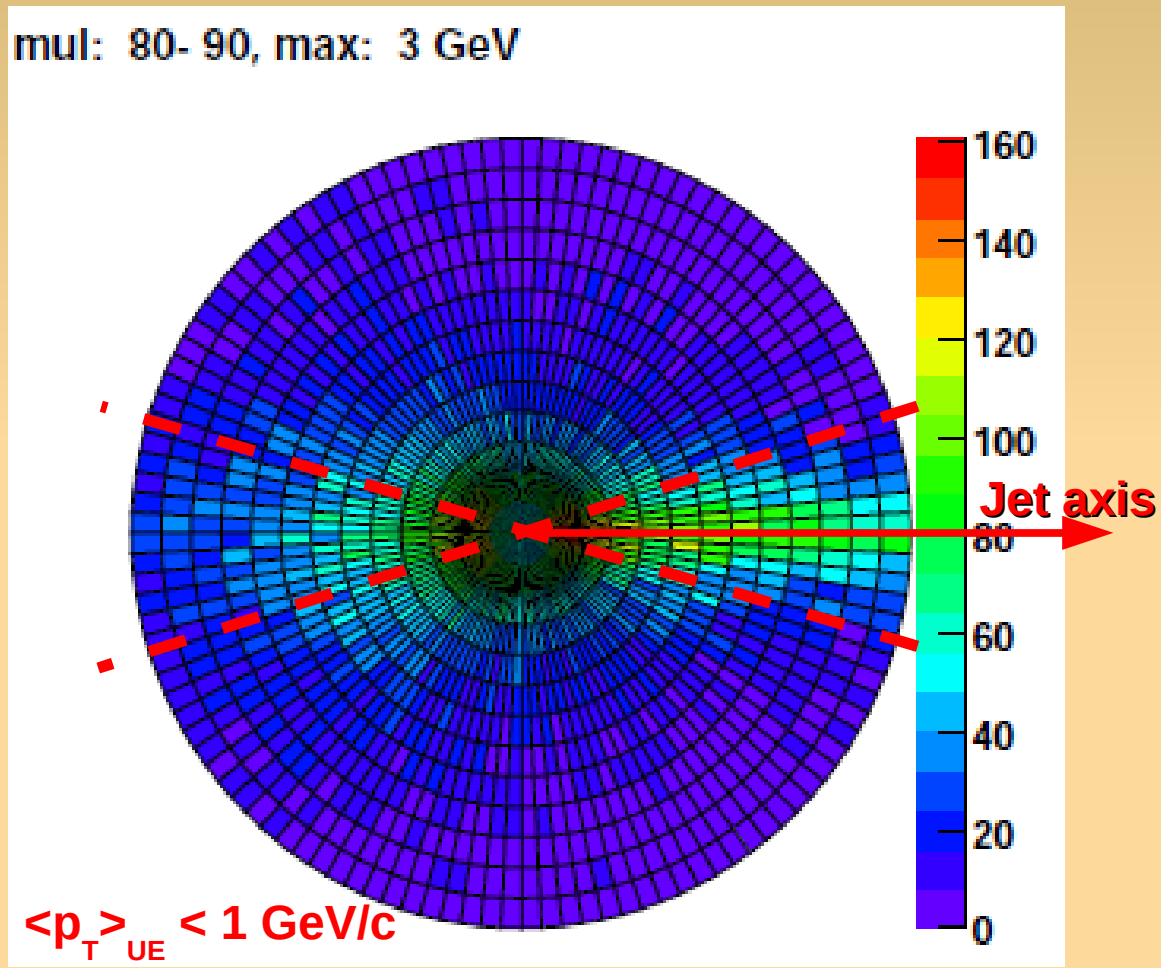
  - UA1 jet finder, R=0.7
  - Q > 100 GeV/c
  - P_T < 3 GeV/c
  - **SB: δR=0.1**

- Polar plot for charged hadron p_T-distribution with:

  - High multiplicity: $80 < N_{ch} < 90$



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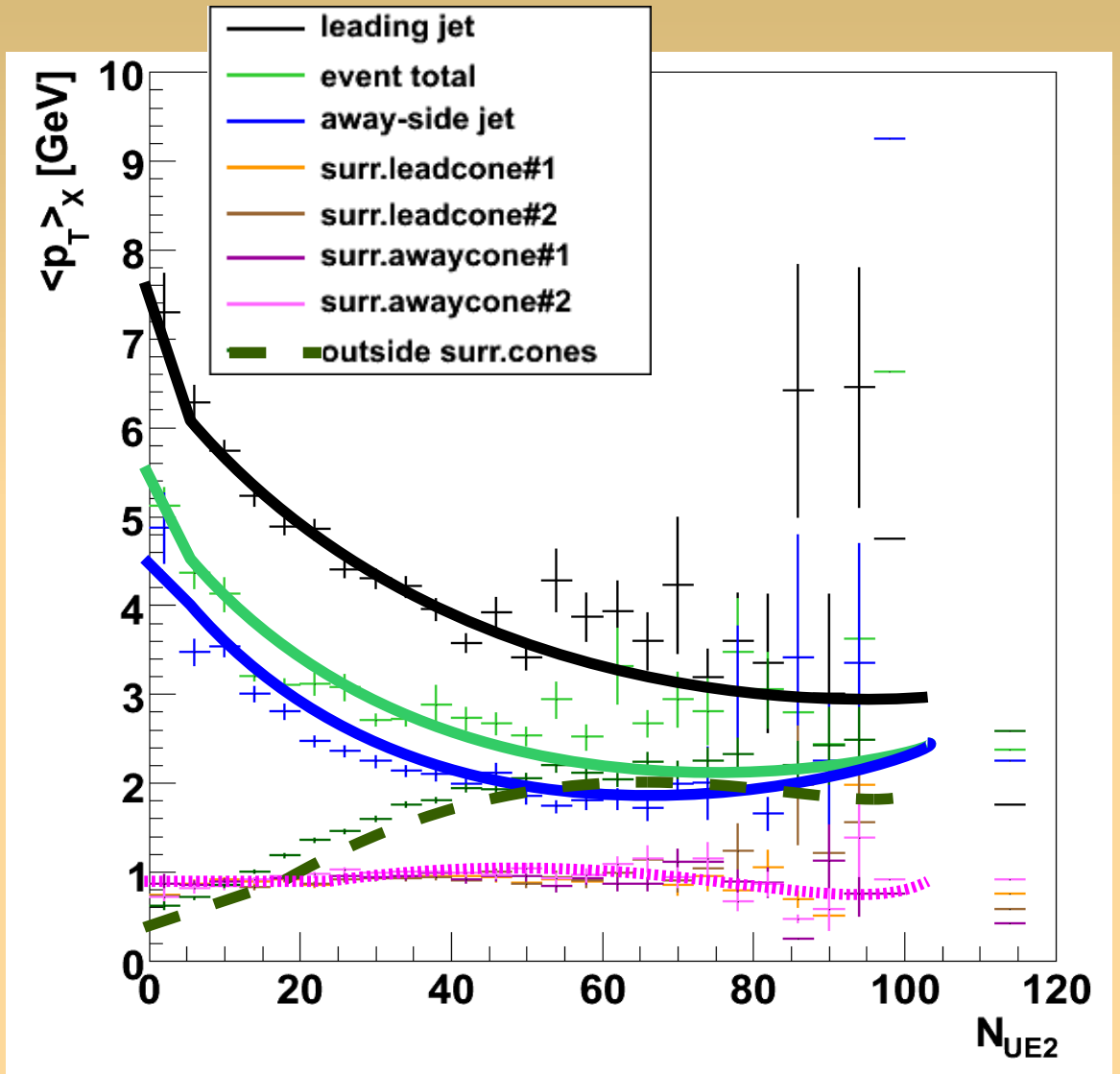
UE study with mean-p_T vs. N_{UE2}

Proton-proton @ 14 TeV

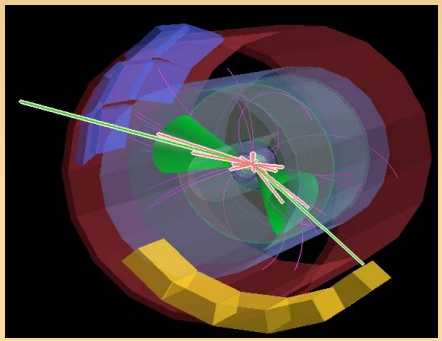
- Jets:
  - Leading & Away side jets has high-<p_T> & low-N_{UE}
- Sorrounding Belts:
  - Independent, constant <p_T>= 1 GeV/c
- The newly defined UE:
  - <p_T> increasing with larger N_{UE2}



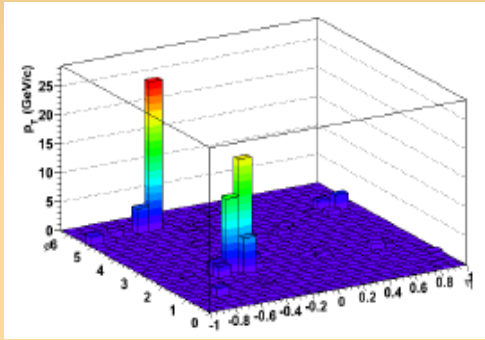
From jets to di-hadron correlation

High-p_T tests:

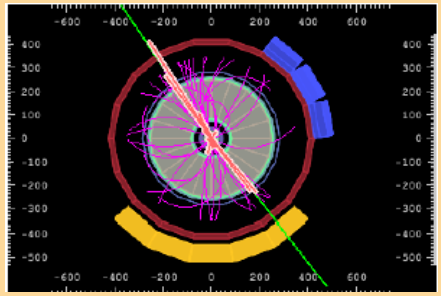
- Jets: full geometry reconstruction



Jet analysis



- Hadron-hadron correlation (Φ direction)



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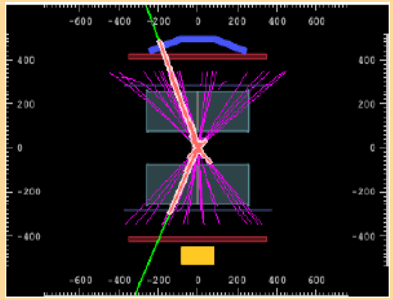
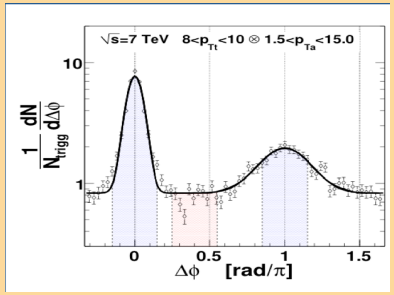
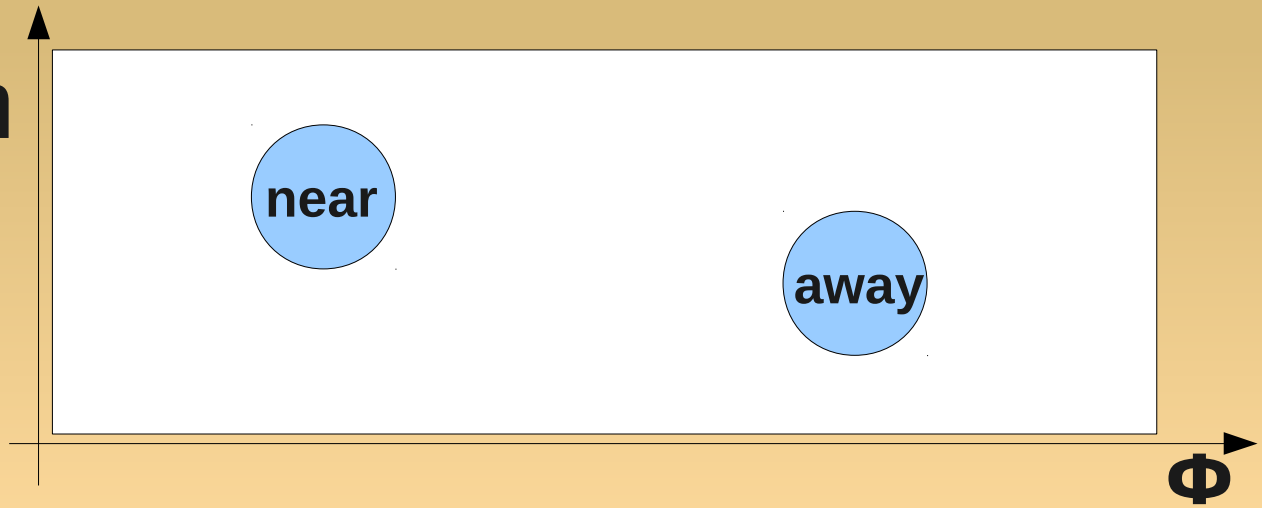


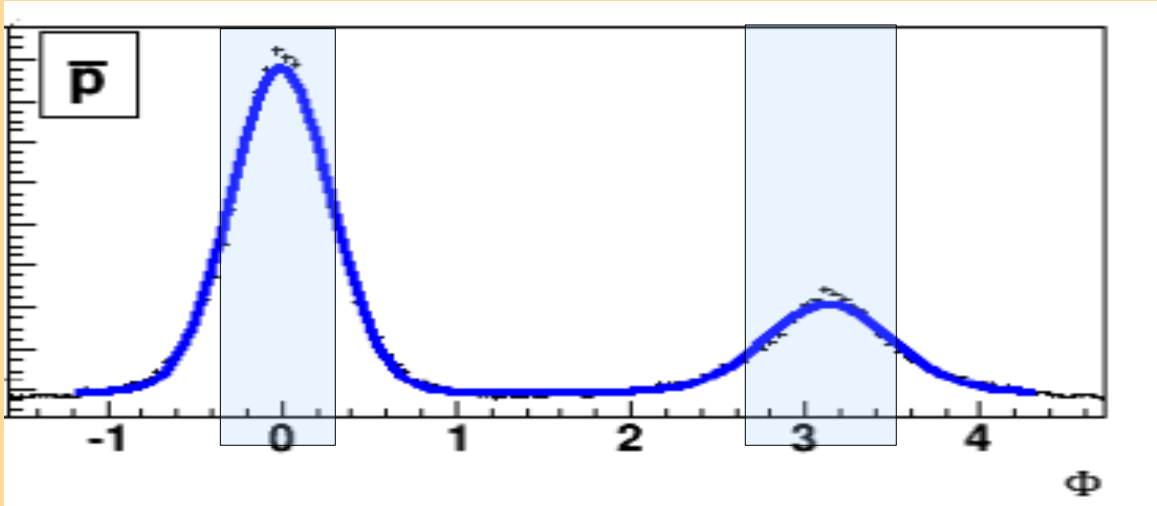
$$d\eta$$



Simplify: jet → di-hadron correlation

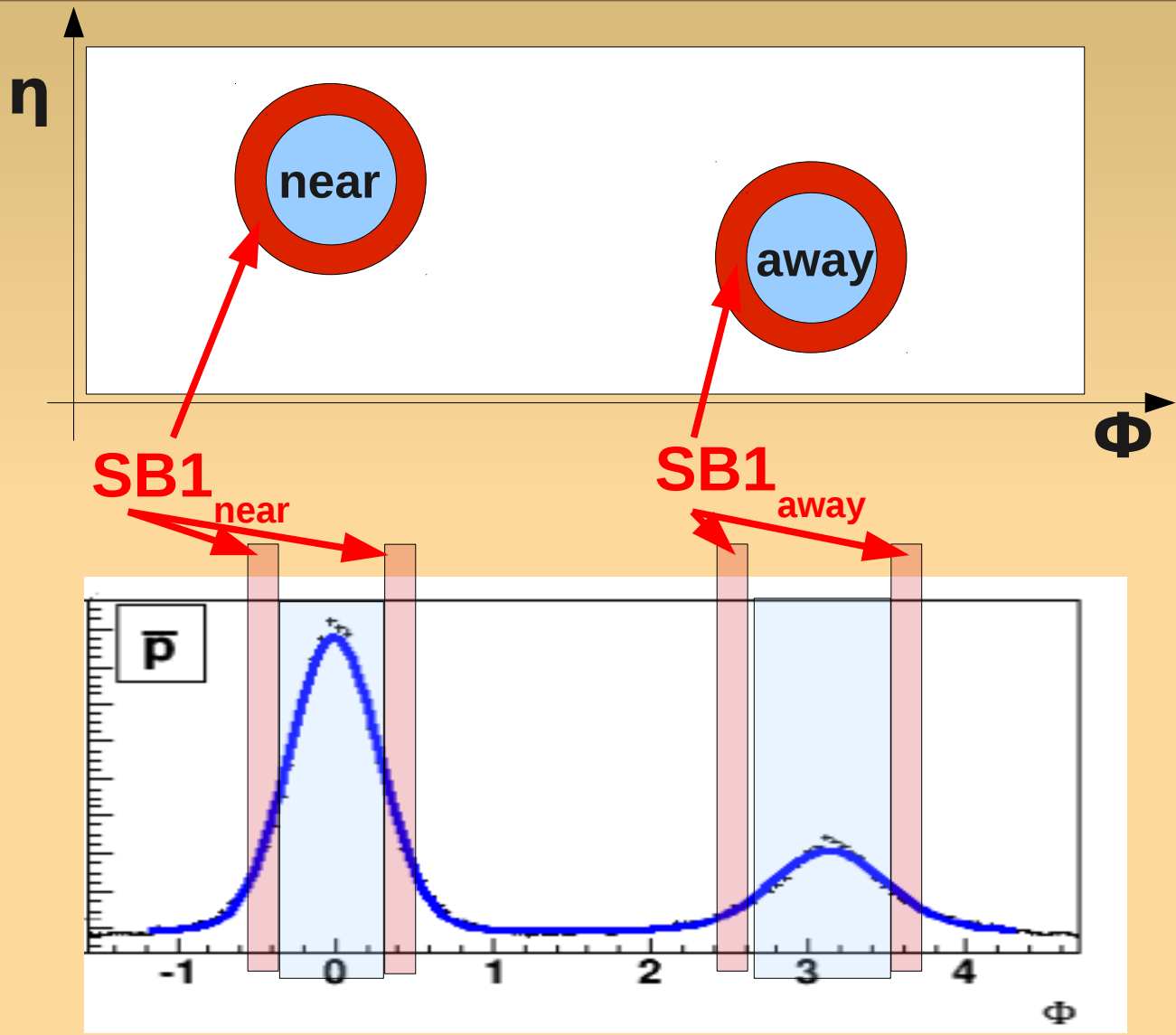
- Assume to have identified jets or 'jet-like' objects at near side and away side.





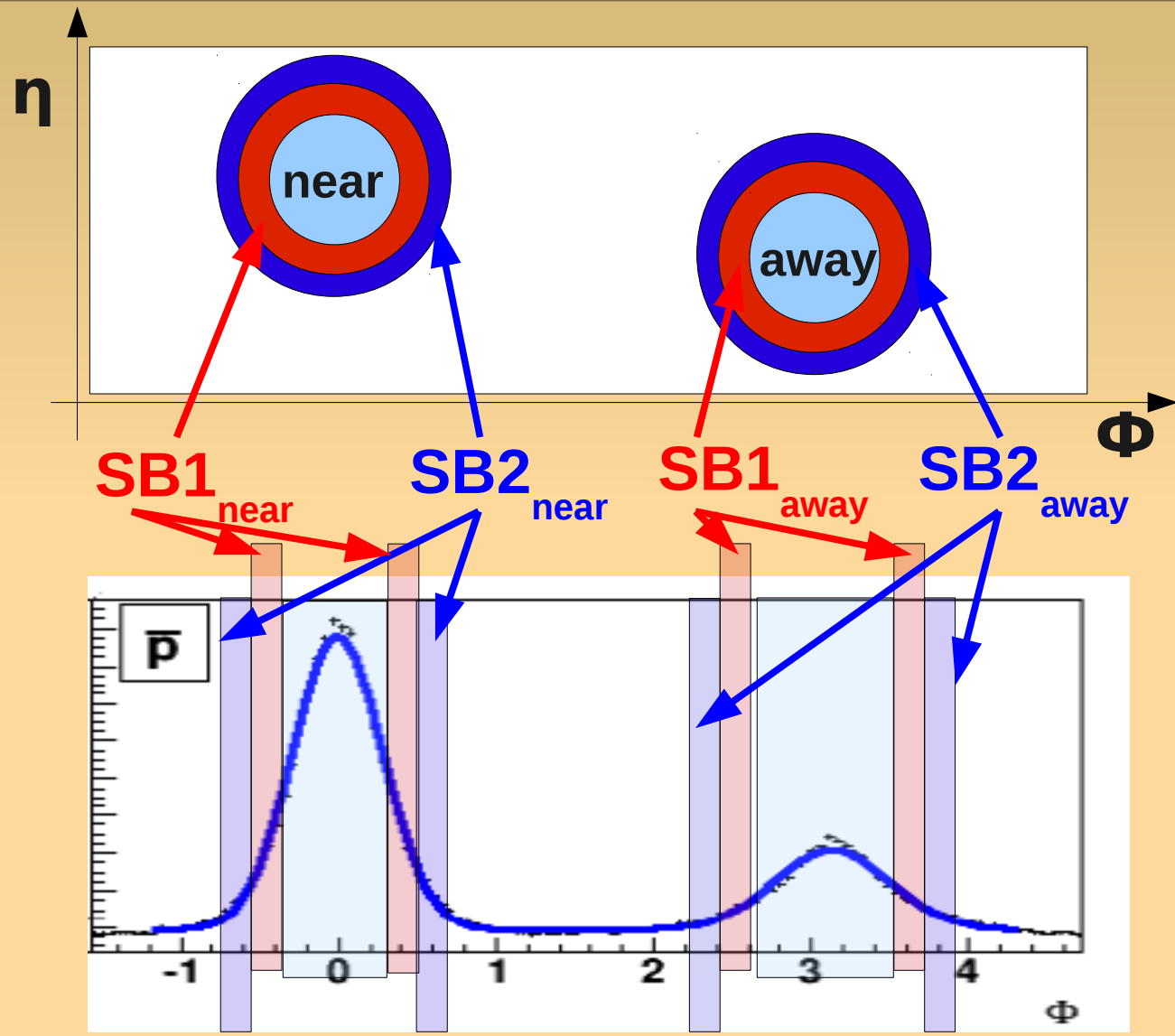
Defining Surrounding Belts (SB1)

- Assume to have identified jets or 'jet-like' objects at near side and away side.
- Define the projection of 1st surrounding cone (SC1) minus jet cone ⇉ Result: surrounding belt (SB1) on the near and away side (width: δΦ).



Defining Surrounding Belts (SB2)

- Assume to have identified jets or 'jet-like' objects at near side and away side.
- Define the projection of 1st surrounding cone (SC1) minus jet cone ⇉ Result: surrounding belt (SB1) on the near and away side (width: δΦ).
- Define a 2nd cone (SC2), then substract SC1 ⇉ Result: SB2 on the near and away side (chosen width: δΦ).



Physical observables for SBs

SB studies are similar to CDF UE:

- p_T spectra for the SB
- Multiplicity in each SB
- Mean p_T for inner and outer SB
- PID-triggered study

Comparison between SBs can be make also:

- Ratio of SB's p_T-spectra
- Jet-side effects, jet enviroment studies, etc.

Technical details of the simulation

The events are generated

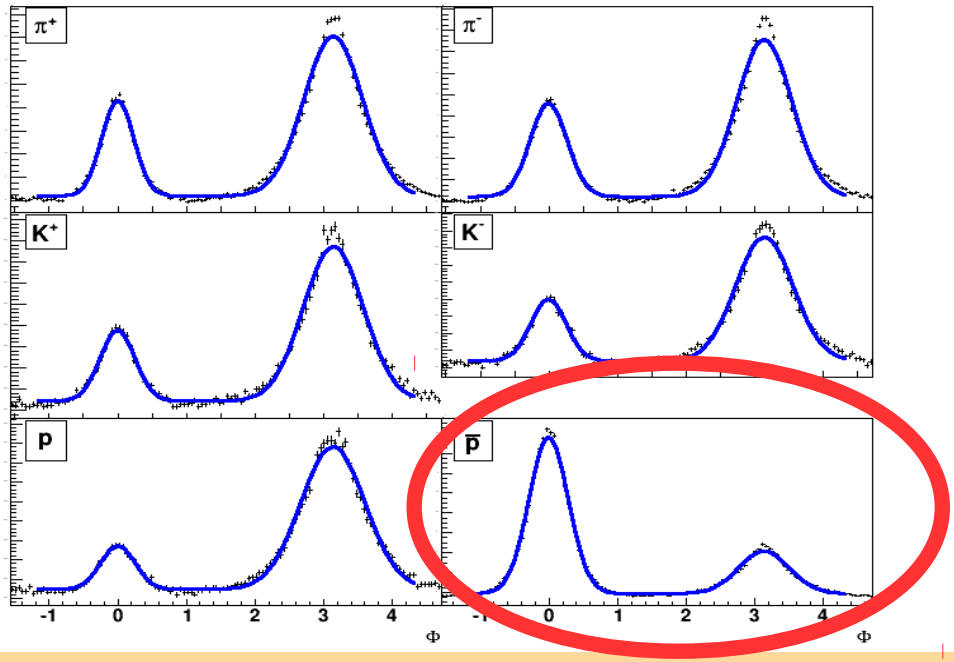
- PYTHIA 6.4 ATLAS-CSC tune

For hadron correlation studies we use

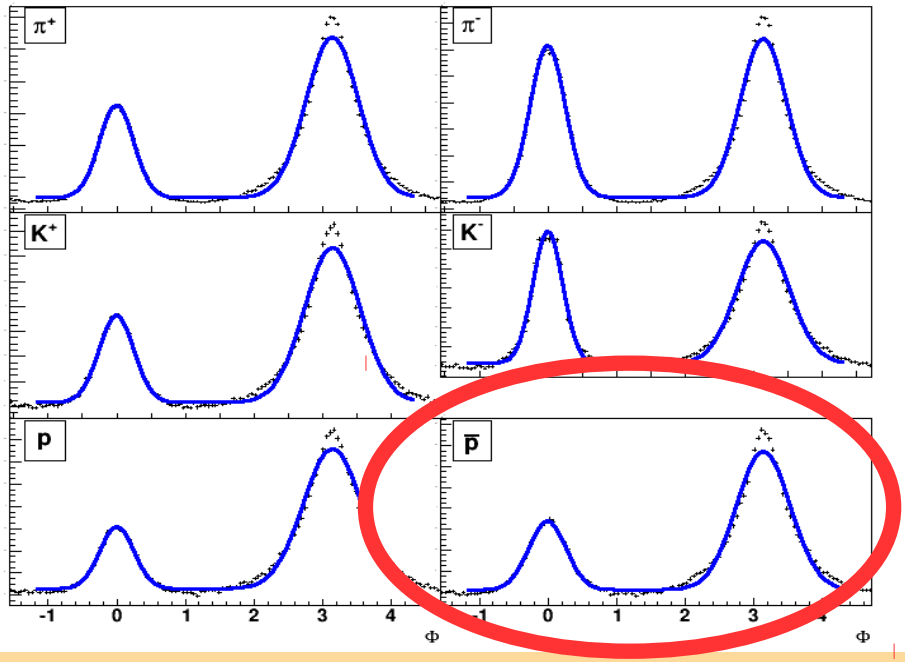
- Minimum-bias events, |η| < 0.35
- 100M events @ $\sqrt{s}=200$ GeV
- 100M events @ $\sqrt{s}=2.36$ TeV
- 45M events @ $\sqrt{s}=7$ TeV

PID-triggered angular correlations

Proton triggered angular corr.



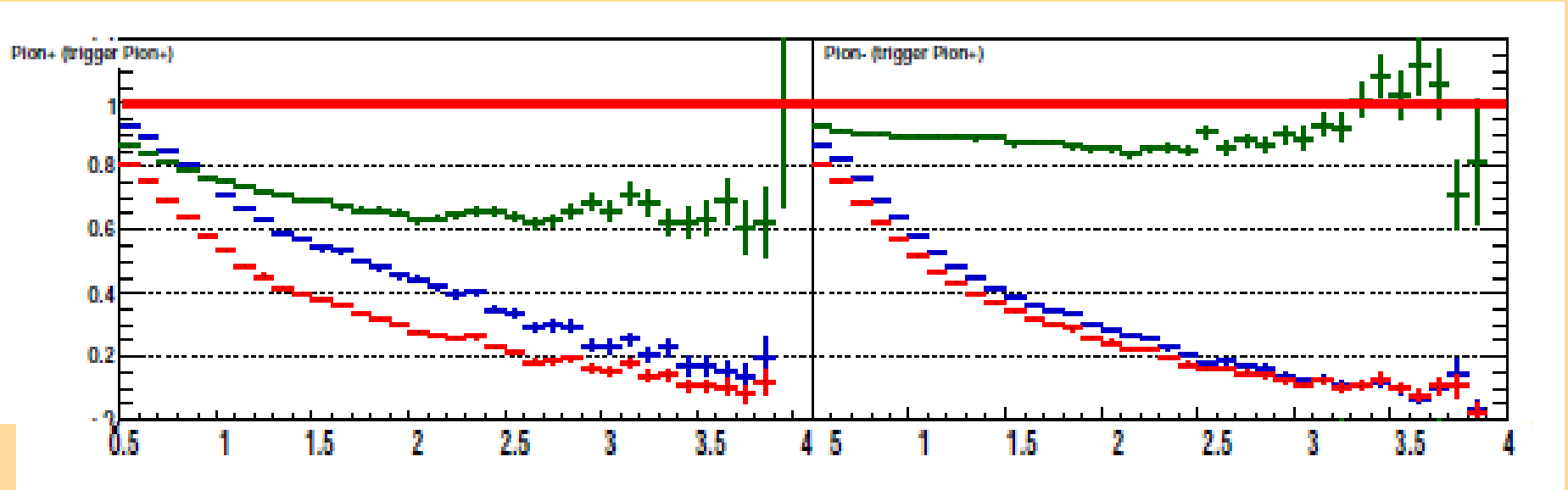
Pion+ triggered angular corr.



- PID triggered angular correlations @ 7TeV pp
- Trigger in p_T [2 GeV/c ; 4 GeV/c]
- Hadron flavor dependence is seen.

Ratios of p_T spectra π-triggered π

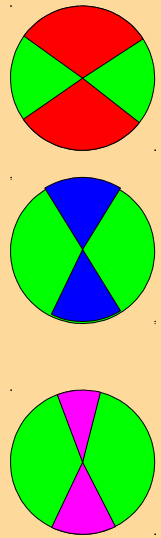
- Near side spectra / UE
- Away side spectra / UE
- Near / Away side spectra



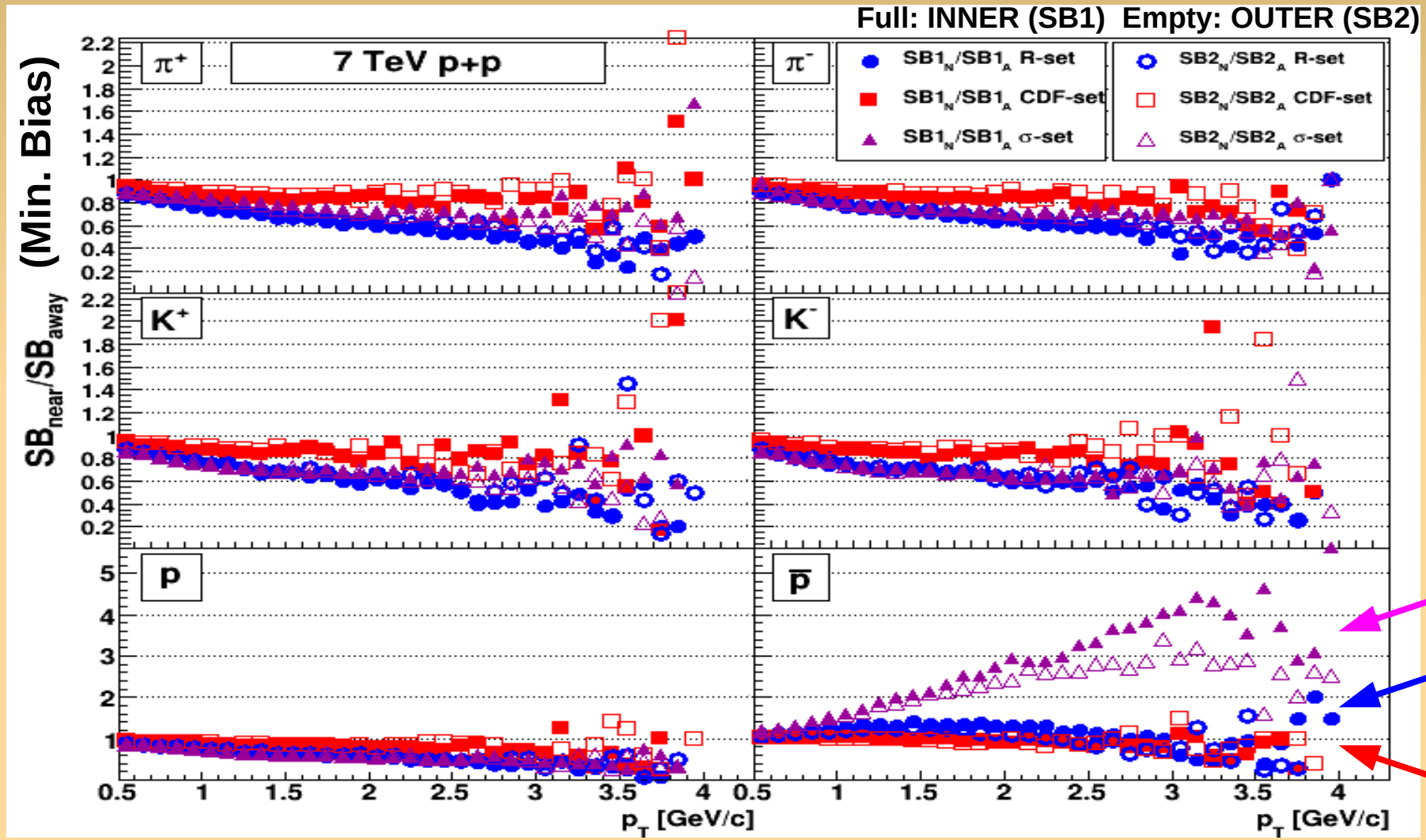
Selections for SB with size-vary

- Based on definitions of SB1 & SB2, we defined 3 'sets' testing UE via the new SB method.

Selection	SB angle	$R_{effective}$ $R_{effective}=\sqrt{\Delta\Phi^2+\Delta\eta^2}$	Belt width $\delta\Phi_{SB}$ & δR
CDF-set	120°	2.3	6° & 0.1
R-set	60°	1.3	6° & 0.1
σ-set	σ_{near} = 16° σ_{away} = 19°	R_{near} = 0.75 R_{away} = 0.77	6° & 0.1



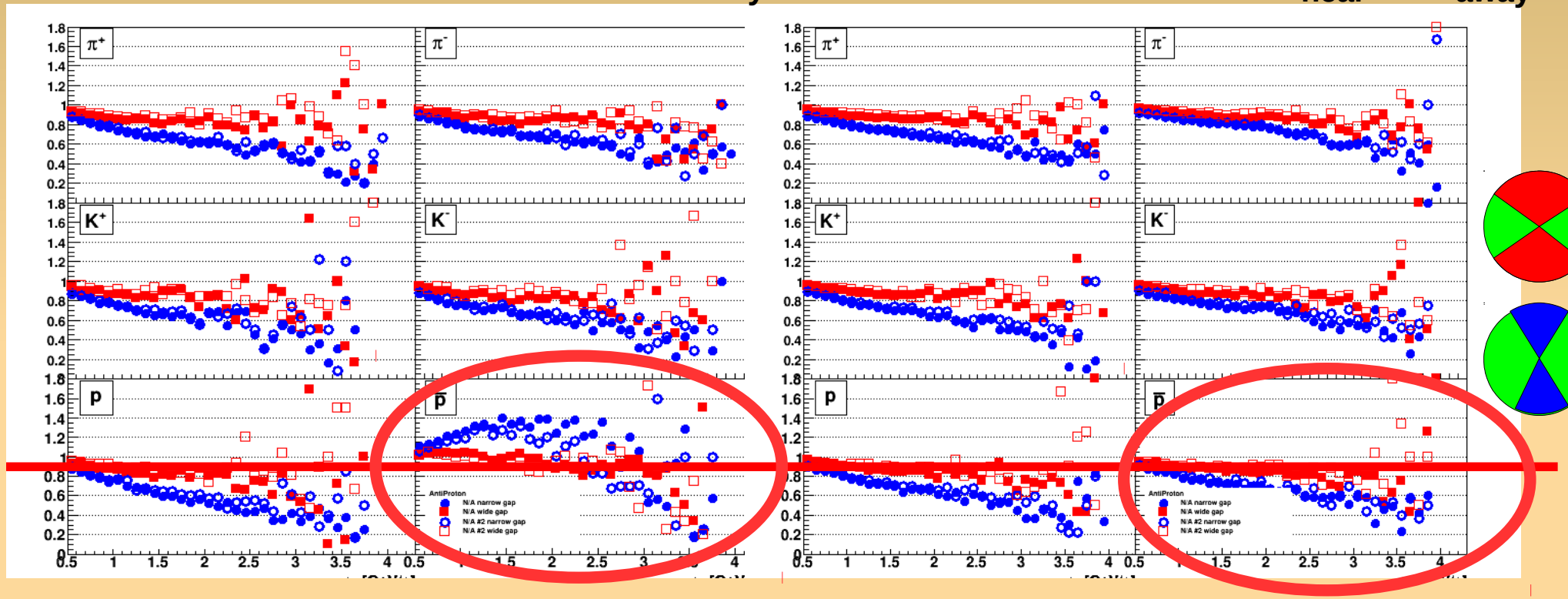
Results on p-triggered SB_{near}/SB_{away}



AGA, GGB, PL.: Proc. for HQ2010

Comparing p- and π-triggered cases

Proton triggered SB_{near}/SB_{away} **Pion+ triggered SB_{near}/SB_{away}**



PID triggered SB_{near} / SB_{away} spectra ratios

- Quantum numbers are conserved (C, I, S, B)
- Strong effect on baryon number, B (and S also)
- HMPID or VHMPID may measure this, using PID

III. Summary & Outlook

- UE defined by the Surrounding Belt :
  - Similar like CDF UE, but more physical observables.
  - In case of hadron-hadron correlation in pp SB1 and SB2 are similar.
  - Triggered hadron-hadron correlation, led to test e.g.: baryon/anti-baryon or strangeness balance.
- Outlook:
  - More detailed study with jets (different algorithms)
  - Similar analysis on PbPb is ongoing (UE modification)
  - Simulations for using PID detector capabilities

BACKUP SLIDES

An ancient red pottery story

No, it's not workin'!

...wait for a new tune...

...go to PYTHIA and tell 'er!

An ancient red pottery story

No, it's not workin'!

...wait for a new tune...

...go to PYTHIA and tell 'er!

You know me... I'm an oracle!

You are not forTUNE teller!

Angular and p_T distribution

- New method in pp collisions at 2.36 TeV:
  - Angular (Φ) and p_T distributions
  - Clear back-to-back structure is seen
  - Particles, hadrons
  - Bayesian on high p_T s in given bins