



# Jets in ALICE: from global to differential measurements

FCPPL 2014 Mengliang WANG SUBATECH & CCNU



1



# Outline



- Physics motivation
- How to measure jets in ALICE?
  - TPC + EMCal
  - DCal (and its geometry implementation )
- A selection of jet results from ALICE
- Towards more differential measurements: jet fragmentation (My PhD topic: Fragmentation function moments)





### **Physics motivation**





Hard probes are created at early stages of heavy ion collisions. As a consequence, their properties may be modified by the medium, they can be used to measure the property of the QGP:

- study jets in p-p collisions:
  - test of pQCD
  - as a reference to Pb-Pb
- Measure global jet observables (e.g. R<sub>AA</sub>) in Pb-Pb: To extract medium properties like:
  - energy loss
  - path length dependence
  - density of the medium

More differential measurements for a "topological" understanding of the quenching picture.



8 April 2014

Select observables as insensitive as possible to the heavy ion background





# How do we measure jets in ALICE ?



4



8 April 2014

# Measuring jets with ALICE





**Di-jet Calorimeter (DCal) for next RUNs** 



### DCal and its geometry implementation (ALICE service task)



#### DCal:

Sampling electromagnetic calorimeter ("SHASHLIK", Pb – scintillator) Acceptance:  $260^{\circ} < \phi < 327^{\circ}$  $0.22 < |\eta| < 0.7$ Energy resolution :  $11\%/VE \oplus 1.7\%$ 

EMCal + DCal in AliRoot EMCal: 12 Super Modules (SM) (10 + 2\* 1/3 SM)

DCal: 8 Super Modules (6 + 2\* 1/3 SM)

Three versions of geometry have been implemented in AliRoot (older design, this version, possible updates)









# A (small) selection of jet results from ALICE



In the following, we reconstruct jet using Anti- $k_T$  algorithm with R from 0.2 to 0.4



## Full jets in pp 2.76 TeV





PLB 722, 262 2013

Good agreement with NLO pQCD (+ hadronization) and PYTHIA 8



#### Important reference for Pb-Pb analysis

8 April 2014



# Pb-Pb background estimation and fluctuations: charged and neutral



#### Challenge in Pb+Pb: subtract soft background and correct for fluctuations



8 April 2014



# Full jet R<sub>AA</sub>







## Hadron-jet correlations



#### h-jet correlation study



Surface bias effect: trigger hadron close to the surface, so the recoil jet is biased towards higher in-medium path length

For the charge triggered recoil jet:

$$p_{T,jet}^{reco,ch} = p_{T,rec}^{reco,ch} - 
ho A$$



Low  $p_{T,trig}$  (TT[8, 9]) trigger recoil jet spectrum as a reference (dominated by combinatorial jet).

High  $p_{T,trig}$  (TT[20, 50]) trigger recoil jet spectrum mainly from hard (high Q<sup>2</sup>) process (signal).

 $\Delta_{\text{Recoil}}$  is defined as the difference of these two spectra to remove bkg and uncorrelated component.





## Hadron-jet correlations



 $\Delta I_{AA}^{jet}$ , the comparison with pp (MC here), allows to emphasize the quenching.





suppressed than inclusive jets

8 April 2014



# **Jet fragmentation functions**



Towards more differential measurements: study the momentum distribution of tracks in jets



 pp collisions @ 7 TeV: expected evolution with jet p<sub>T</sub> (angular ordering)



These are charged jet results. It is a challenge to do these measurement in Pb-Pb collisions (because of background)





# According to Cacciari et al.\* the fragmentation function moments should be less sensitive to the background fluctuations.

\* reference: arxiv:1209.6086, "Jet fragmentation function moments in heavy ion collisions"



Figures display the model calculations of fragmentation function moments using ATLAS parameters, where M<sub>N</sub> is the N<sup>th</sup> fragmentation function moments:

$$M_N = \frac{1}{N_{\text{jet}}} \int_0^1 z^N \frac{dN_{\text{hadron}}}{dz} dz , \qquad z = \frac{p_T^{\text{hadron}}}{p_T^{\text{jet}}}$$



**Feasibility of such measurement under investigation in ALICE** 8 April 2014





- Jets are measured in ALICE using the TPC (+ ITS) + EMCal (and DCal in future)
  - DCal geometry has been implemented in AliRoot
- In pp collisions: jet spectrum shows agreement with NLO pQCD + hadronization, the fragmentation functions have been measured
- In heavy ion collisions, the background contribution and its fluctuations are playing important roles
- Jet suppression was observed in Pb-Pb collisions ( $R_{AA} < 1$ )
- Hadron-jet correlations less sensitive to background give access to larger R
- <u>My Ph.D. analysis</u>: fragmentation function moments should be less sensitive to background fluctuations. Their measurement is currently under investigation in ALICE



