Jet Analysis at ALICE

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The workshop for ALICE upgrades by Asian countries (11/07/'09)

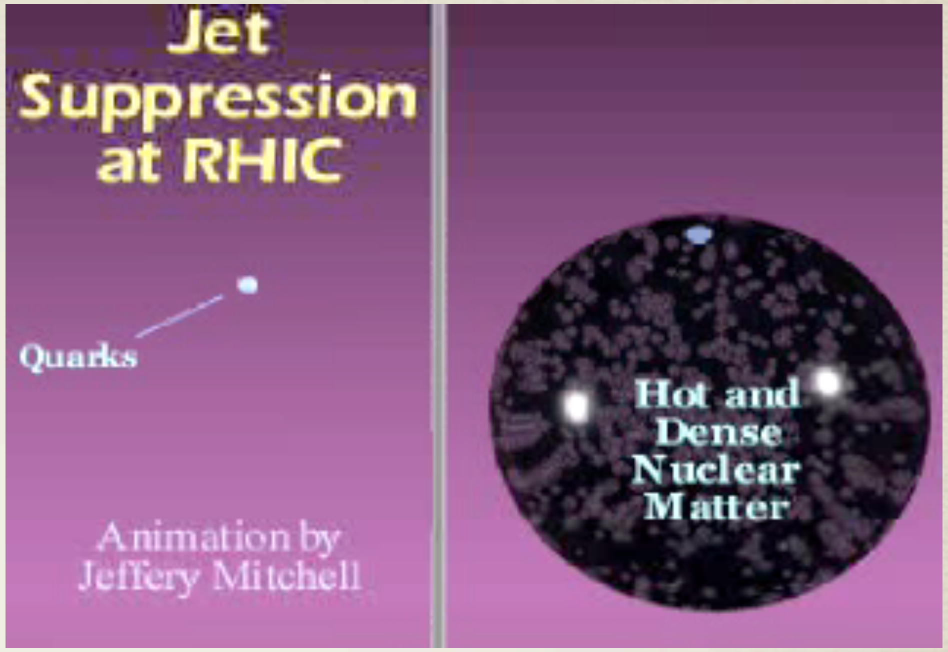
Outline

* Motivation
* Jet study at ALICE with PYTHIA
  * Jet Annual Yield at ALICE in 5.5TeV PbPb collisions
  * Capability of Quark/Gluon Jet separation in 14TeV pp collisions
* Summary & Outlook

Jet Physics at ALICE

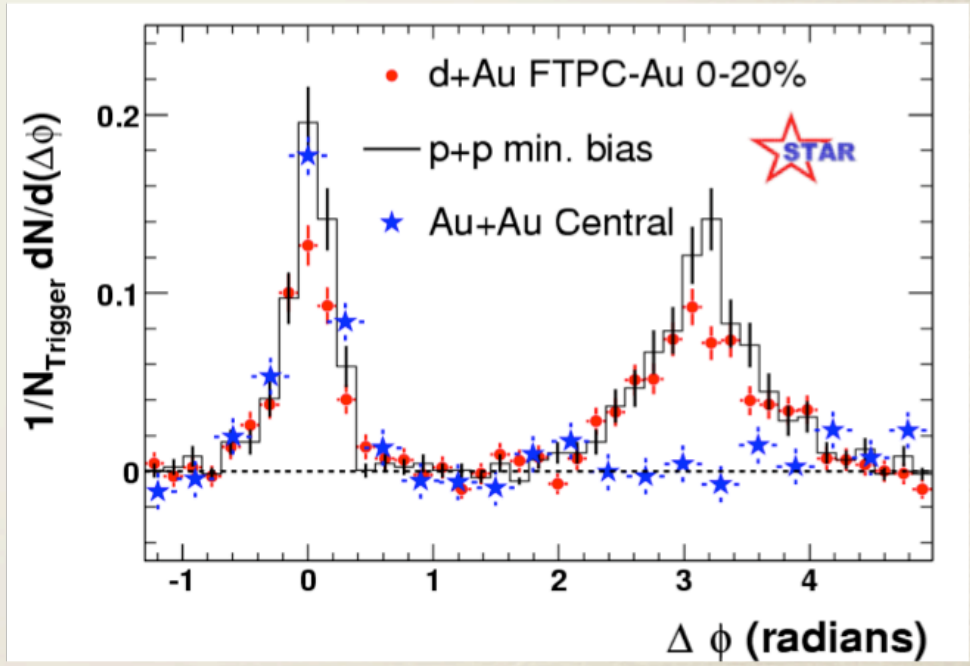
Jet quenching

- Energy loss of hard-scattered parton in QGP
- Information of parton’s behavior in QGP



What is expected in ALICE?

- The highest energy experiment in the world !
- ⇒Produced higher energy jets
- ⇒Possibility of more accurate jet analysis



Jet is an important tool to understand parton’s behavior in QGP

Motivation

* Jet is an important tool to understand parton's behavior in QGP
* ->Inclusive-Jet, Di-Jet, γ -Jet analysis

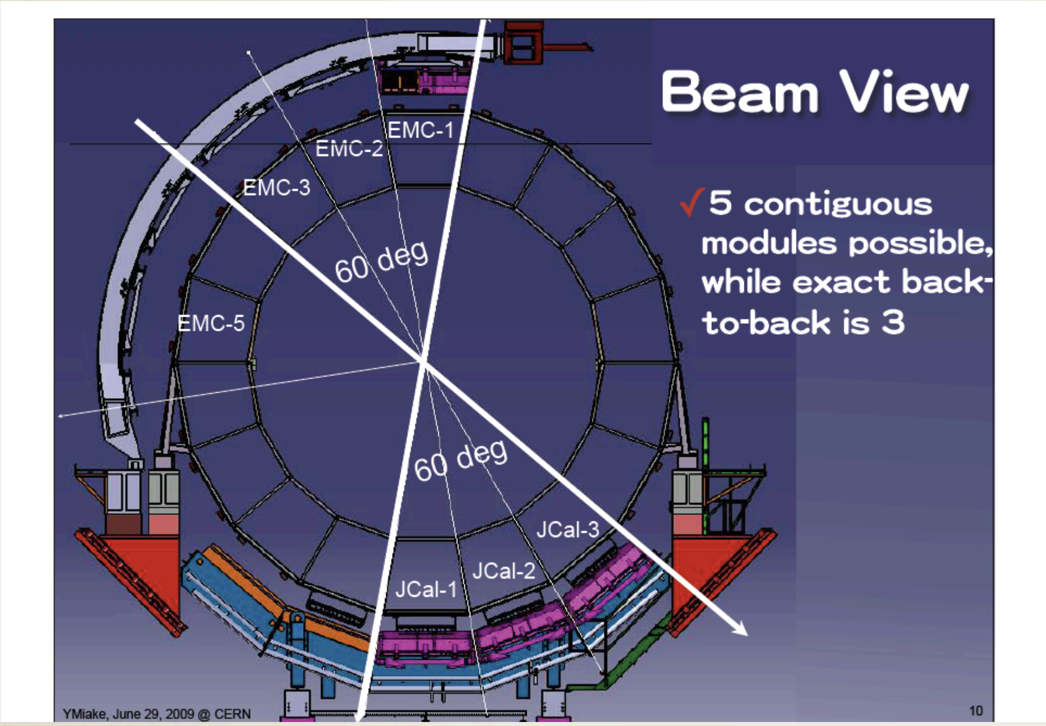
* Evaluation of the upper limit of the jet energy we can measure in ALICE
  * ALICE-EMCAL + J-Cal
  * Rate calculation of inclusive-jet & coincidence-jet
    * -> To determine the J-Cal configuration

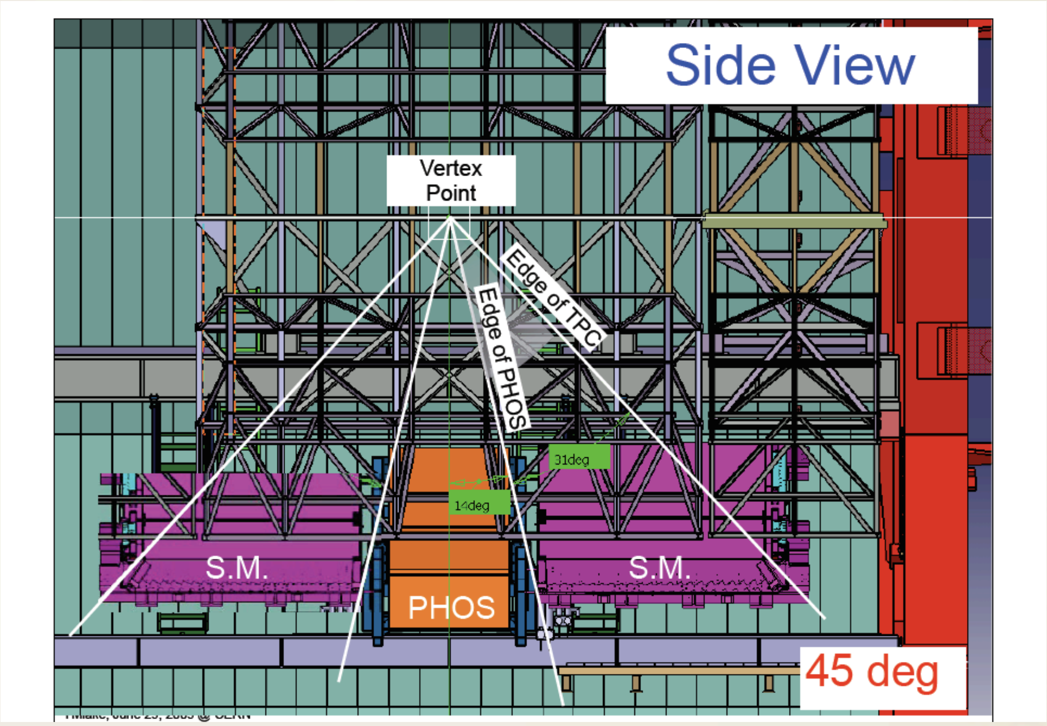
* Simulation of coincidence-jet and Parton-ID
  * Coincidence-jet -> Measurement of energy unbalance
    * Jet tomography
  * Identification of the parton species in γ -Jet/Di-Jet samples
    * Differences of energy loss in QGP b/w quark & gluon
  * Quark/Gluon separation using Jet properties
    * Number of jet constituents
    * Jet broadness
  * Using the simulation data in 14TeV pp collisions as a first step

Jet Annual Yield

Jet-Calorimeter (J-Cal)

- Opposite side calorimeter against ALICE-EMCAL
  - To catch the Di-Jet and γ -Jet
  - Quenching effect -> energy unbalance
- Both side of PHOS

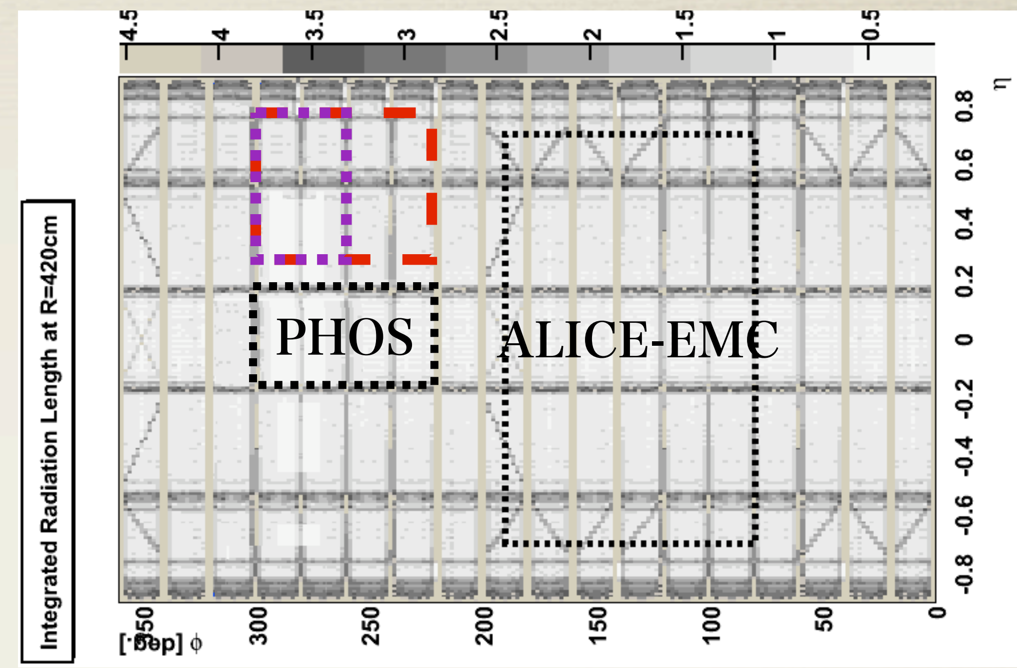


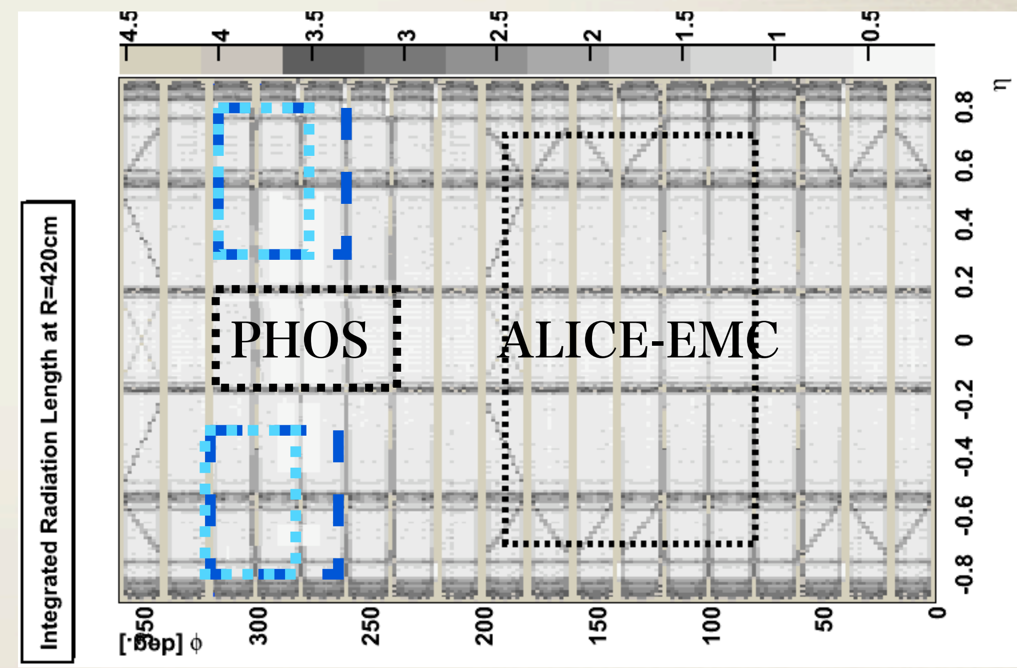


Which configuration of J-Cal is reasonable?

Analysis Condition for Jet Annual Yield

- AliRoot v4-16-Rev-03
  - kPyJets (2->2 jet production)
  - kPyDirectGamma (direct-photon production)
- Jet Reconstruction(ref. talk of T. Horaguchi on Nov. 5)
  - Fastjet(http://www.lpthe.jussieu.fr/~salam/fastjet/)
    - anti-kt algorithm
    - p_T cut of single particles = 0.5GeV/c
    - Using detectable particles in ALICE
- J-Cal (A2, A4, B4, B6) : R=0.2
- EMCAL : R=0.4
- Back-to-Back requirement: $|\varphi 1-\varphi 2|<0.5$[rad]
- Applied the binary scaling to pp 5.5TeV
  - (No quenching effect)

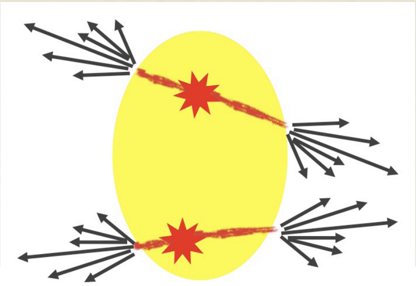


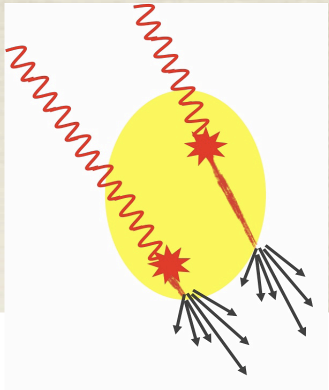


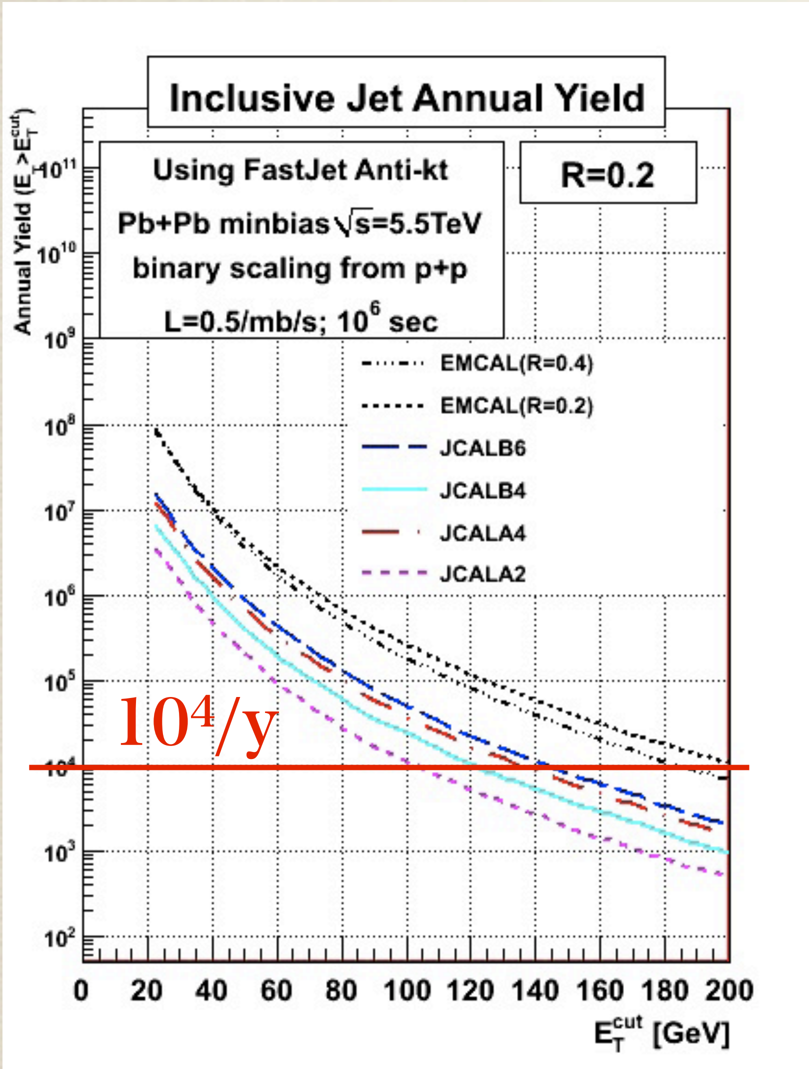
J-Cal acceptance : η - φ plane

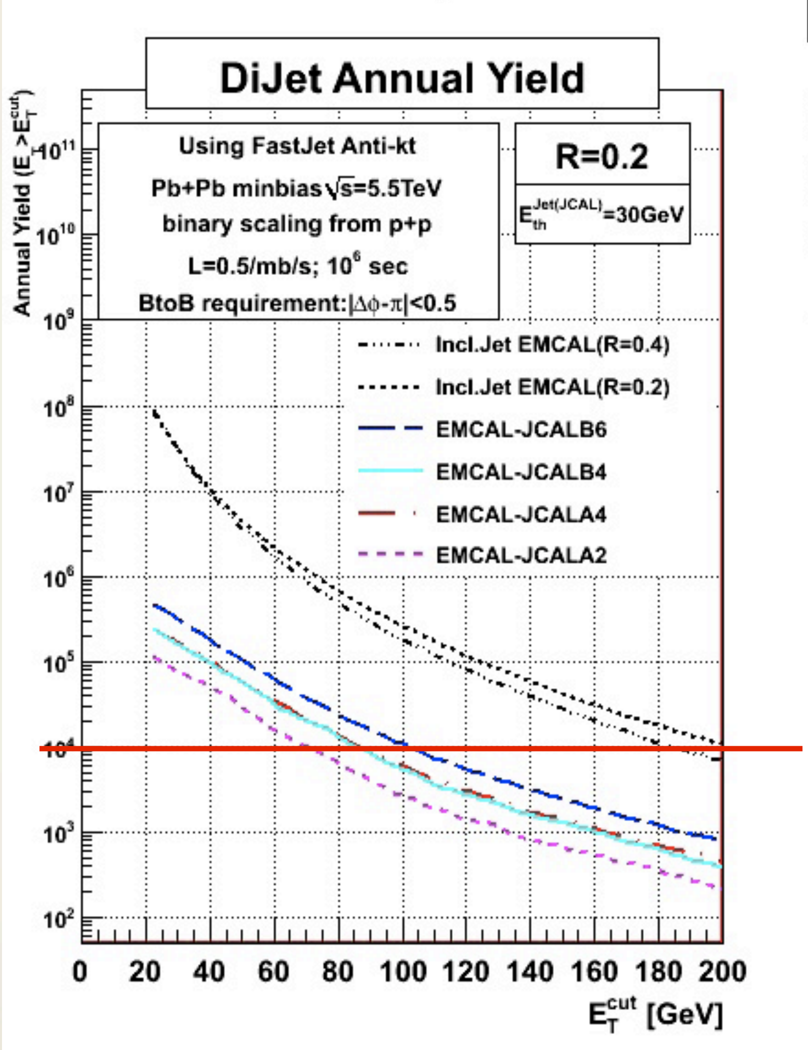
A2
A4
B4
B6

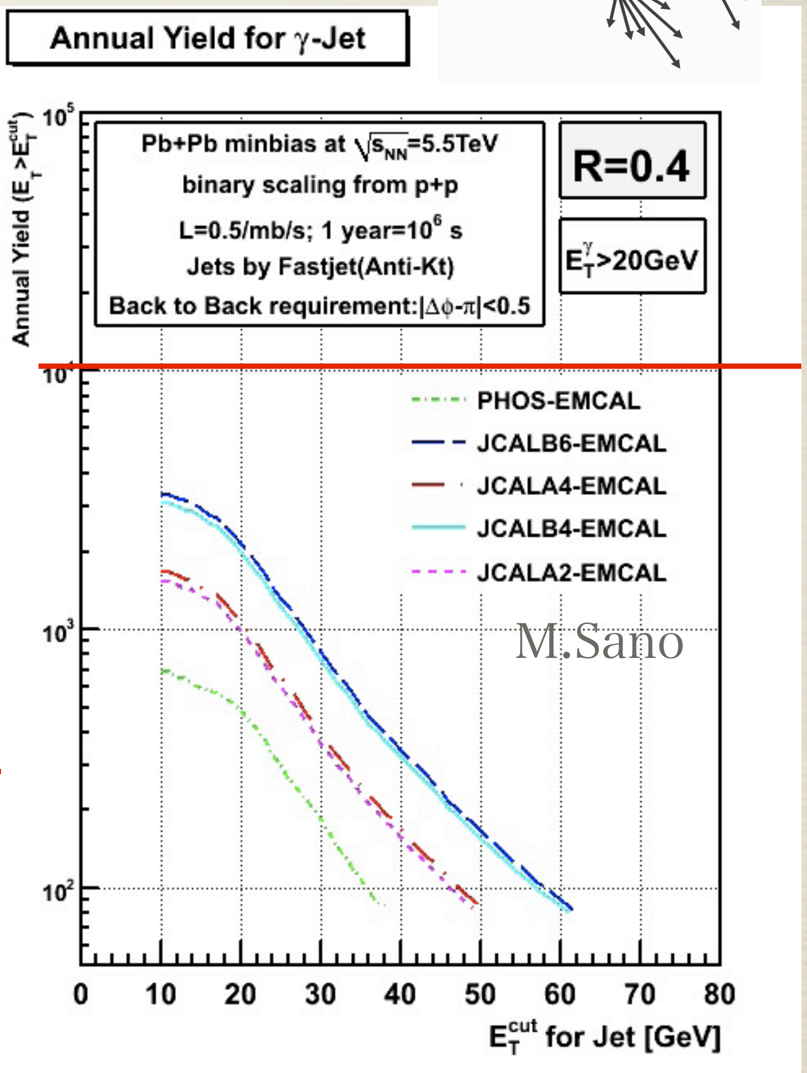
Jet Annual Yield











J-Cal-B6 is reasonable for coincidence-jet measurement !

B6 configuration is approved by ALICE !

Quark/Gluon Jet Separation

Analysis Condition for Quark/Gluon Jet Separation

- AliRoot v4-17-01
  - kPyJets (2->2 jet production)
- Jet Reconstruction (ref. talk of T. Horaguchi on Nov. 5)
  - Fastjet(http://www.lpthe.jussieu.fr/~salam/fastjet/)
    - anti-kt algorithm
    - p_T cut of single particle = 0.5GeV/c
    - Using detectable particles in ALICE
    - R=0.2, 0.4, 0.7
- Jet from initial parton is defined as the largest energy jet in $dR_{parton}<0.5$
  - dR_{parton} is the distance from initial parton
  - $dR_{parton} = \sqrt{((\eta_{jet} - \eta_{parton})^2 + (\varphi_{jet} - \varphi_{parton})^2)}$

Difference b/w Quark & Gluon Jets

* Divide Jets into Gluon/Quark jet sample
  * Number of jet constituents
  * The parameter represent Jet broadness of transverse direction
  * The parameter represent Jet broadness of longitudinal direction

$$s^2 = \frac{\sum\left\{\left(P_{T/L}/2\pi R\right)\cdot R^2\right\}}{\sum\left(P_{T/L}/2\pi R\right)} \qquad R = \sqrt{\left(\eta_{jet} - \eta_{particle}\right)^2 + \left(\phi_{jet} - \phi_{particle}\right)^2}$$

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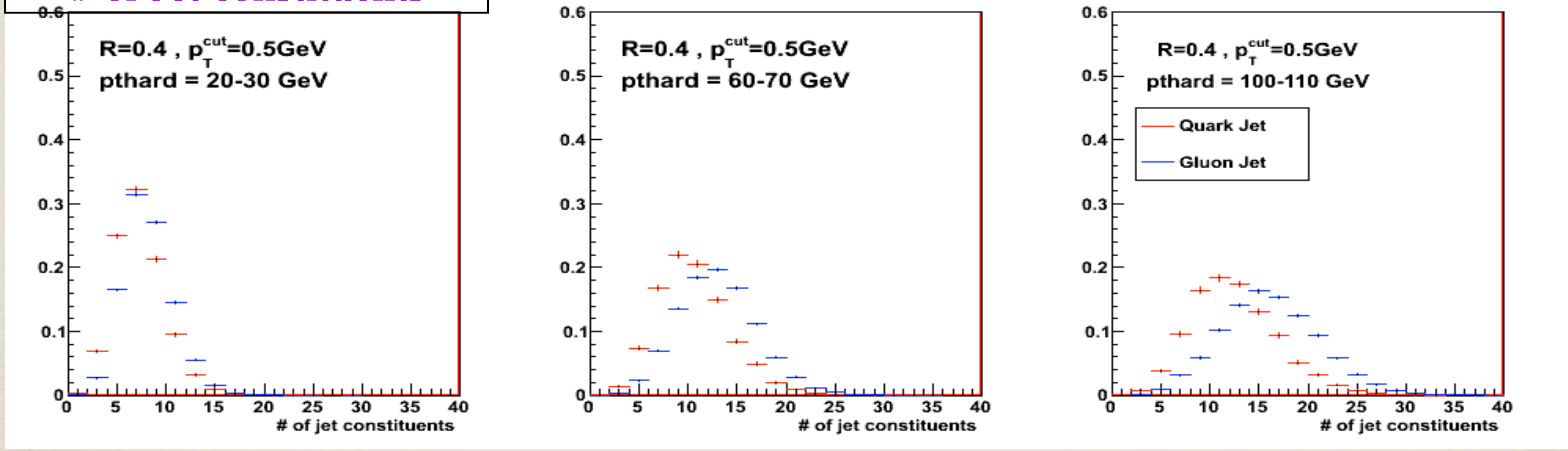
# of Jet constituents



Number of gluon-jet constituents is larger than that of quark-jet.

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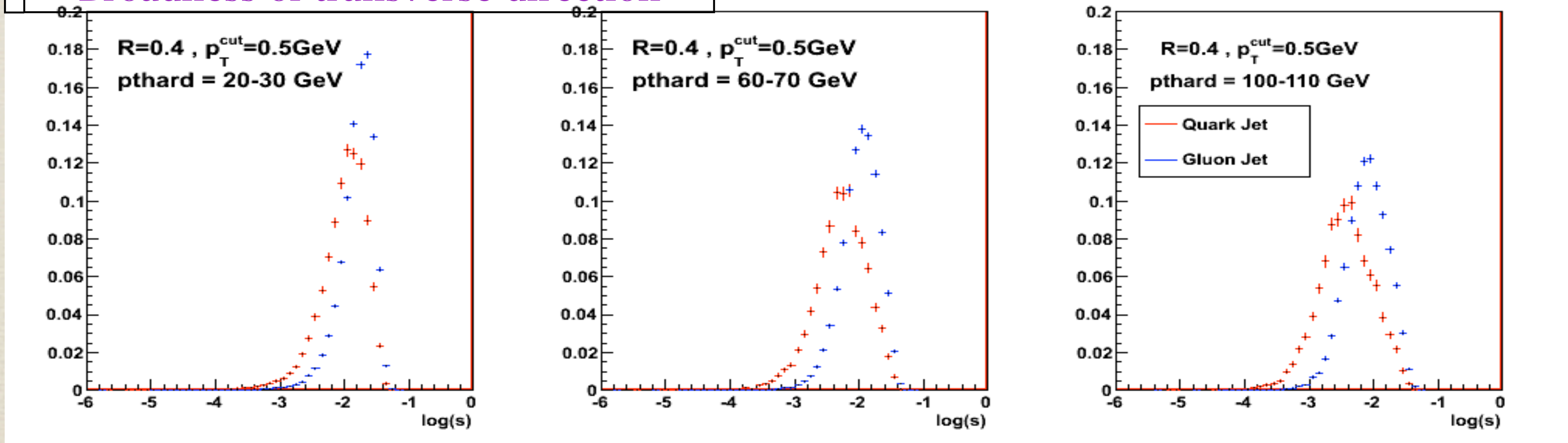
Broadness of transverse direction



Gluon-jet is broader than quark-jet .

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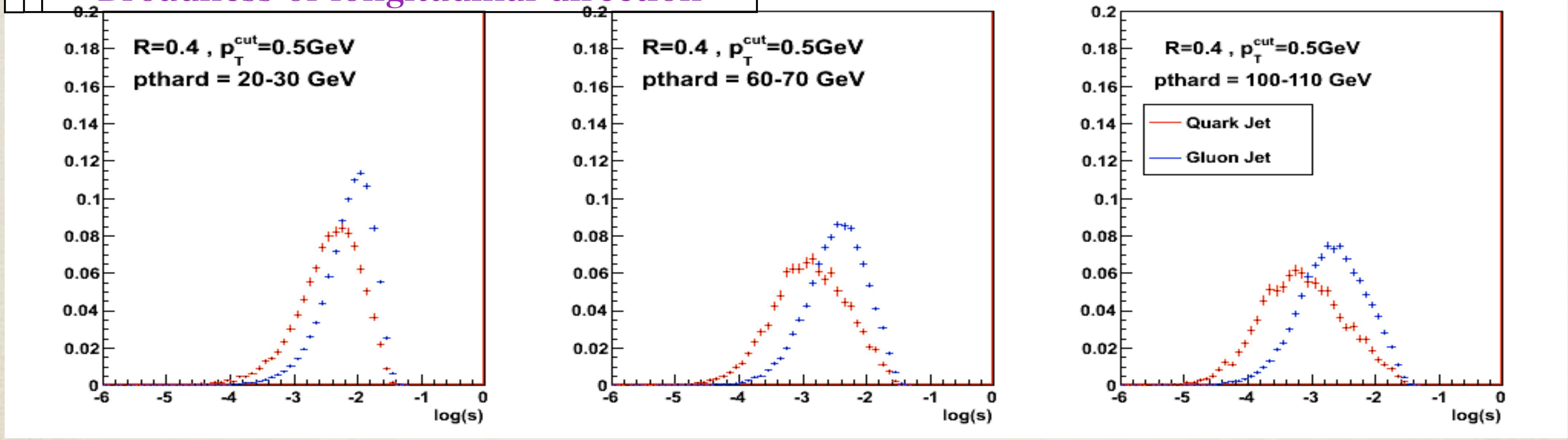
Broadness of longitudinal direction



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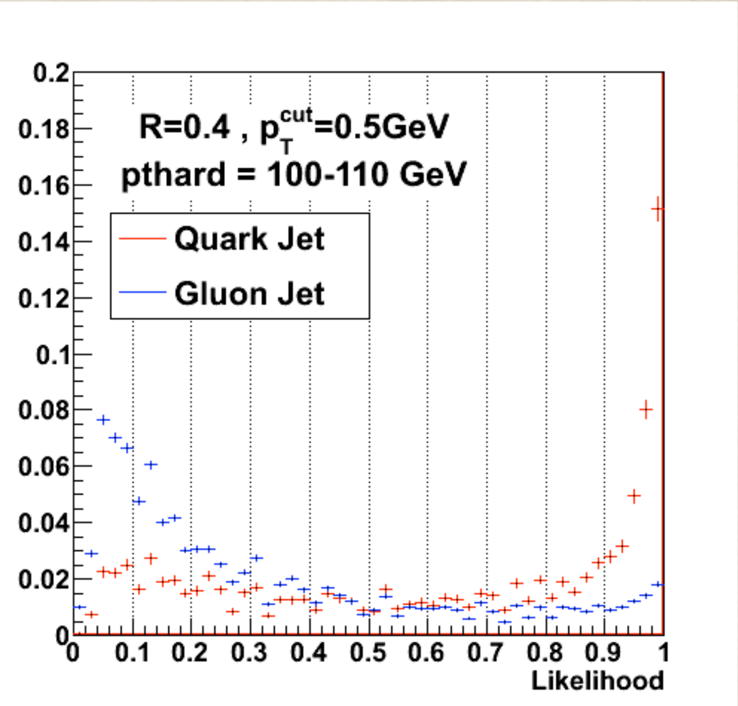
Quark/Gluon Jet Separation

* Quark-jet likelihood
* Remained gluon-jet fraction after quark-jet cut of likelihood



$$likelihood = \frac{P_{quark}}{P_{quark} + P_{gluon}}$$

$$P_{quark} = \prod_{i=1}^{N} P_{quark}^{(i)}$$

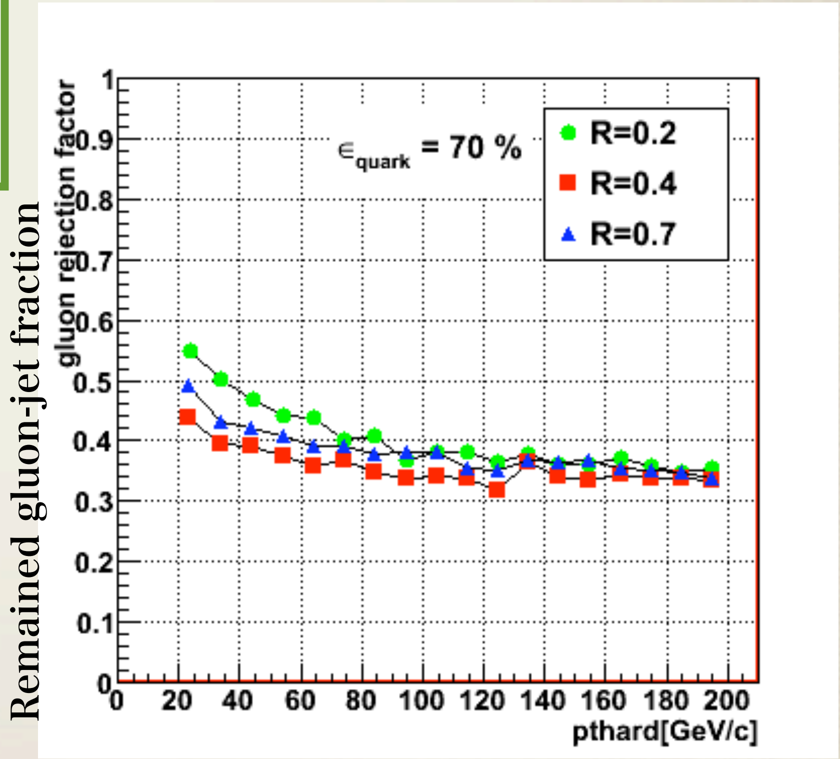
$$P_{gluon} = \prod_{i=1}^{N} P_{gluon}^{(i)}$$

$$\epsilon_{quark} = \int_{L_{\epsilon_{quark}}}^{1} \frac{1}{N_{quark}} \frac{dN_{quark}}{dL} dL$$

$$\epsilon_{gluon} = \int_{L_{\epsilon_{quark}}}^{1} \frac{1}{N_{gluon}} \frac{dN_{gluon}}{dL} dL$$

$P_{quark}^{(i)}, P_{gluon}^{(i)}$: Probability of i'th parameter

L :quark likelihood



Remained gluon-jet fraction = 0.05 (ε_{quark}=30%)

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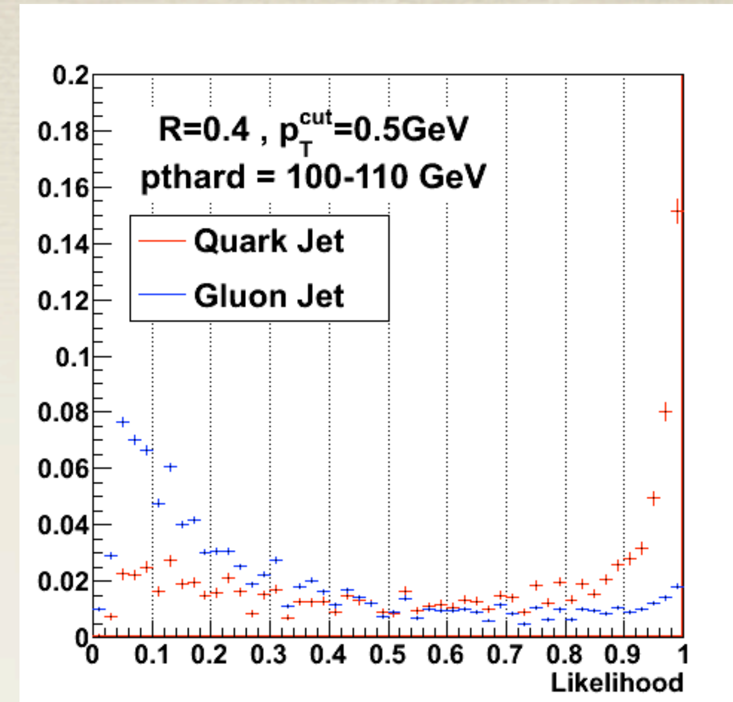

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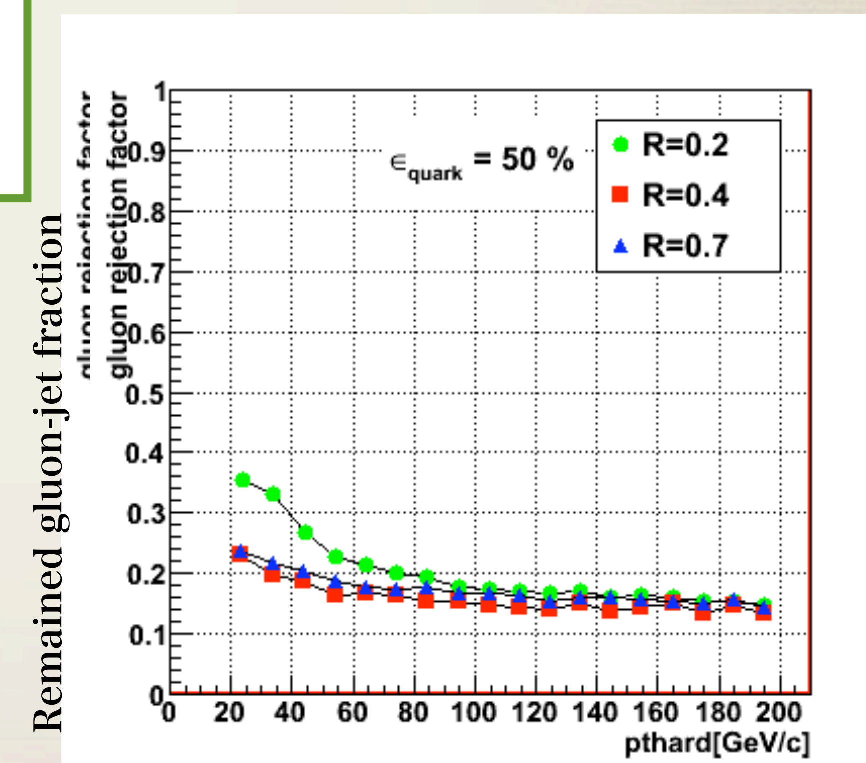

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- Remained gluon-jet fraction after quark-jet cut of likelihood

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$P^{(i)}_{quark}, P^{(i)}_{gluon}$: Probability of i'th parameter

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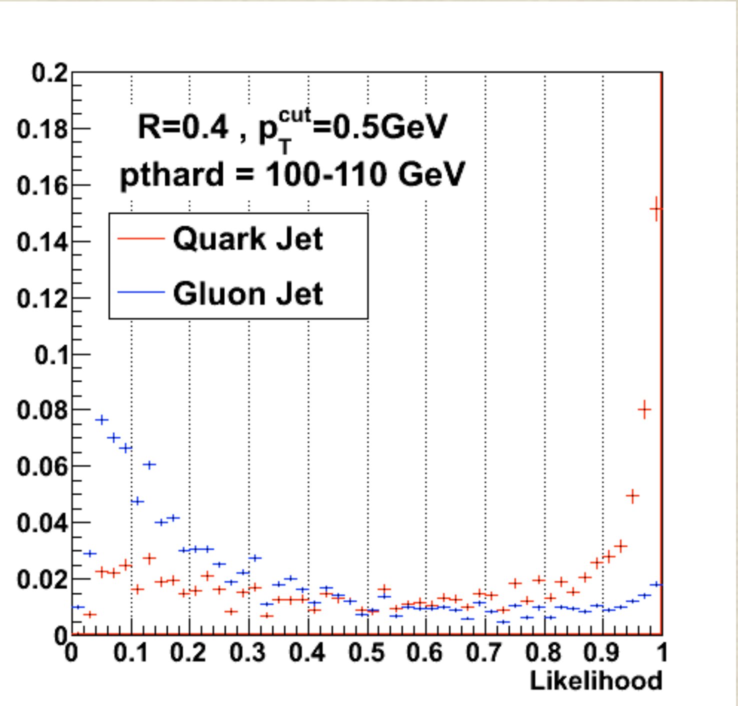

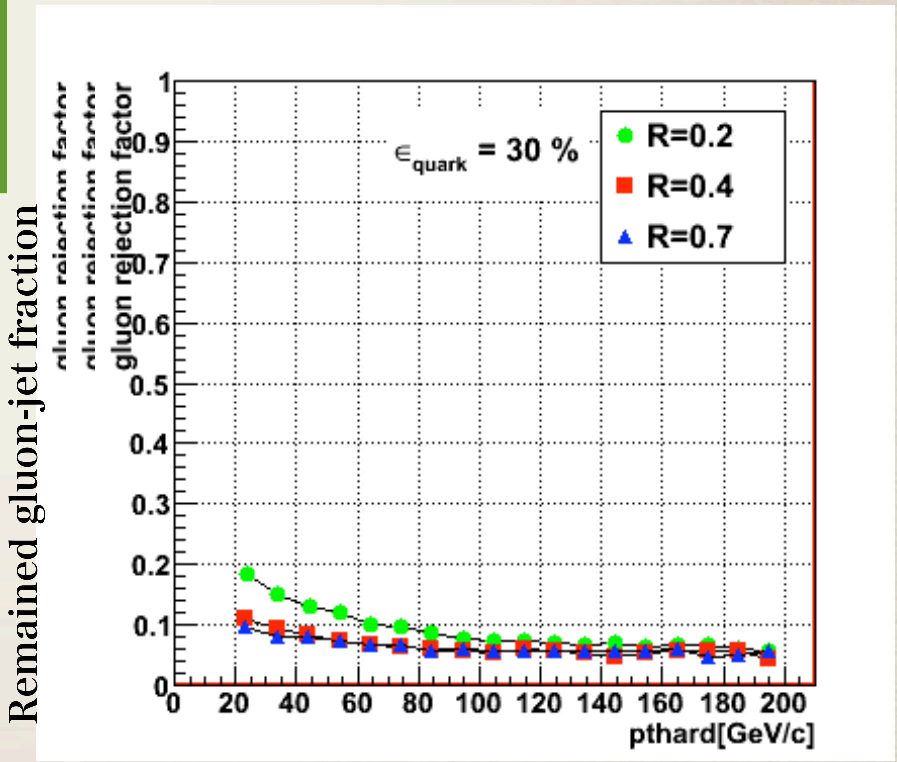

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Summary & Outlook

Summary

* Evaluate Jet Annual Yield at ALICE J-Cal in 5.5TeV PbPb collisions
  * ~100GeV Di-jet measurement is possible !
  * J-Cal-B6 is the best condition, and it have been approved in this October!
* Evaluate capability of quark/gluon jet separation in 14TeV pp collisions
  * Remained gluon-jet fraction after quark-jet cut of likelihood
    * Quark/Gluon Jet separation method

Outlook

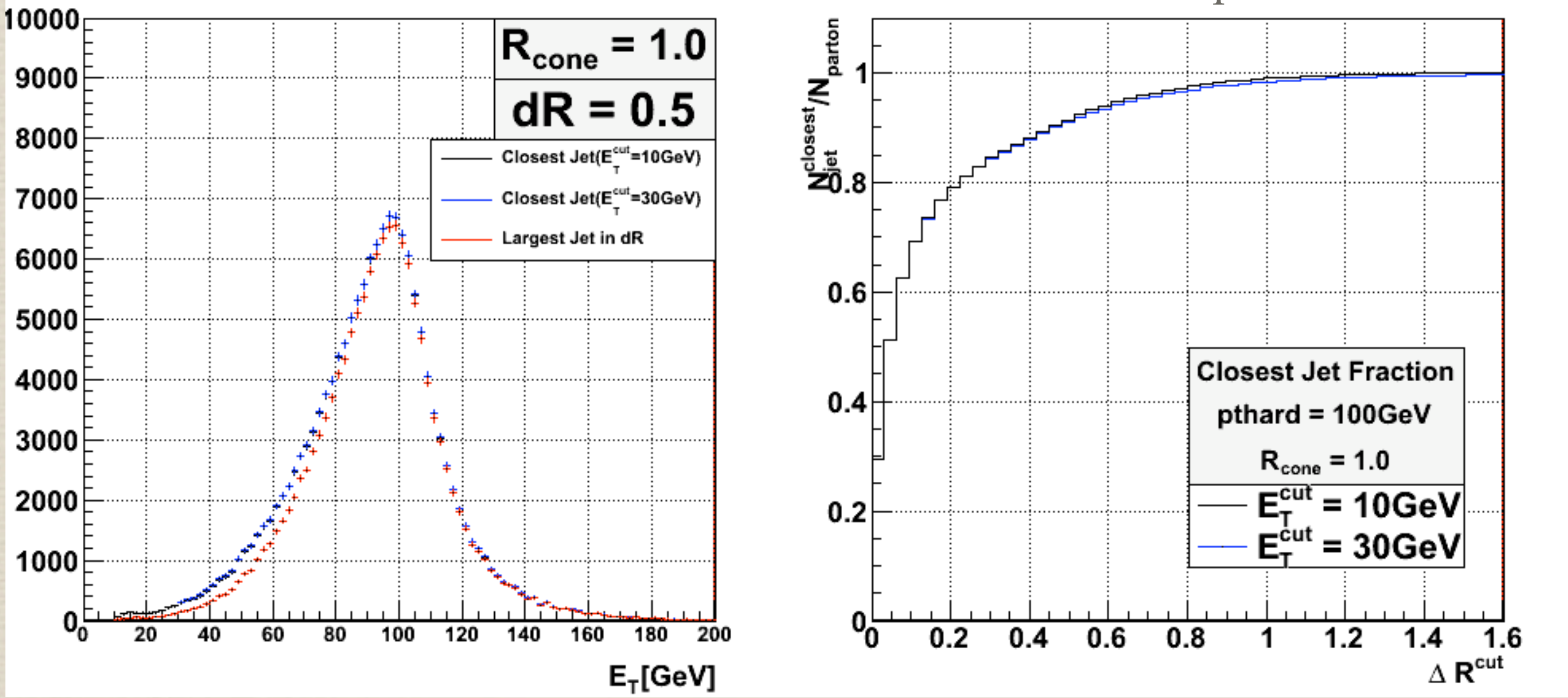
* Analysis in the case of heavy ion collisions
* Same calculation including detector response

Thank You for Listening!

Determination of parton-jet pair

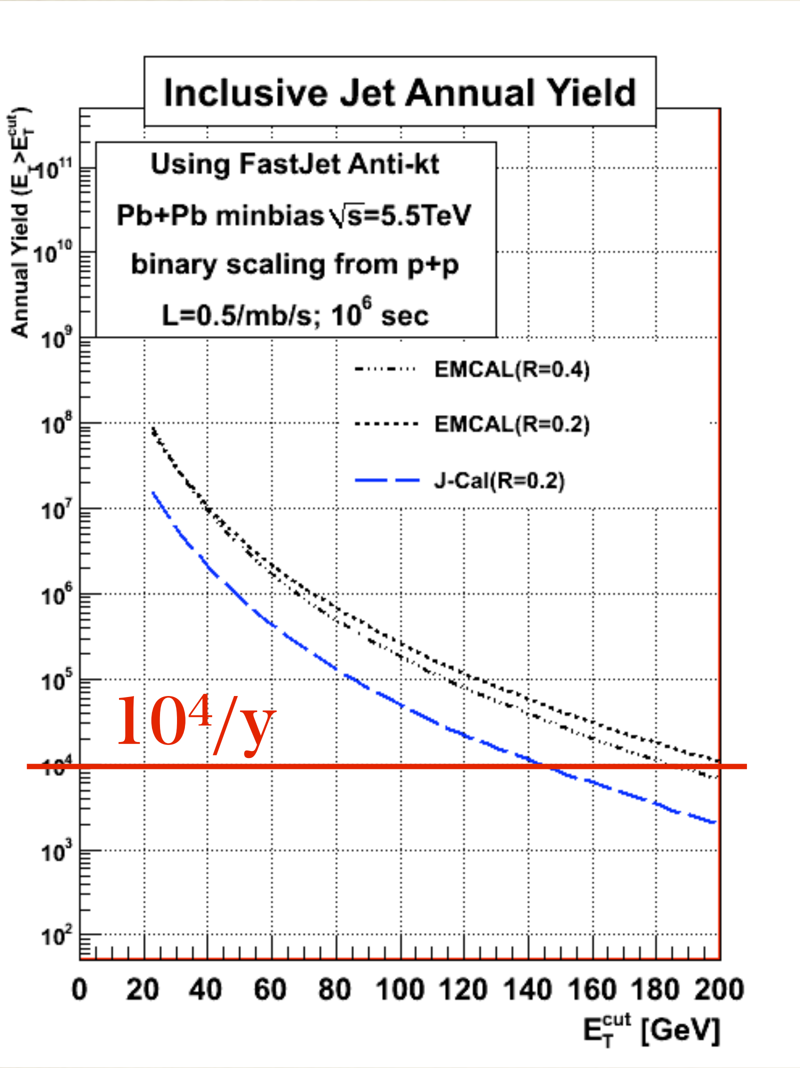
* pair of parton & jet
* $\Delta R \equiv \sqrt{(\Delta \eta^2 + \Delta \varphi^2)}$
* large cone⇒ right amount of jet should be measured
* 3-jet(??→qqg) fraction : 10%

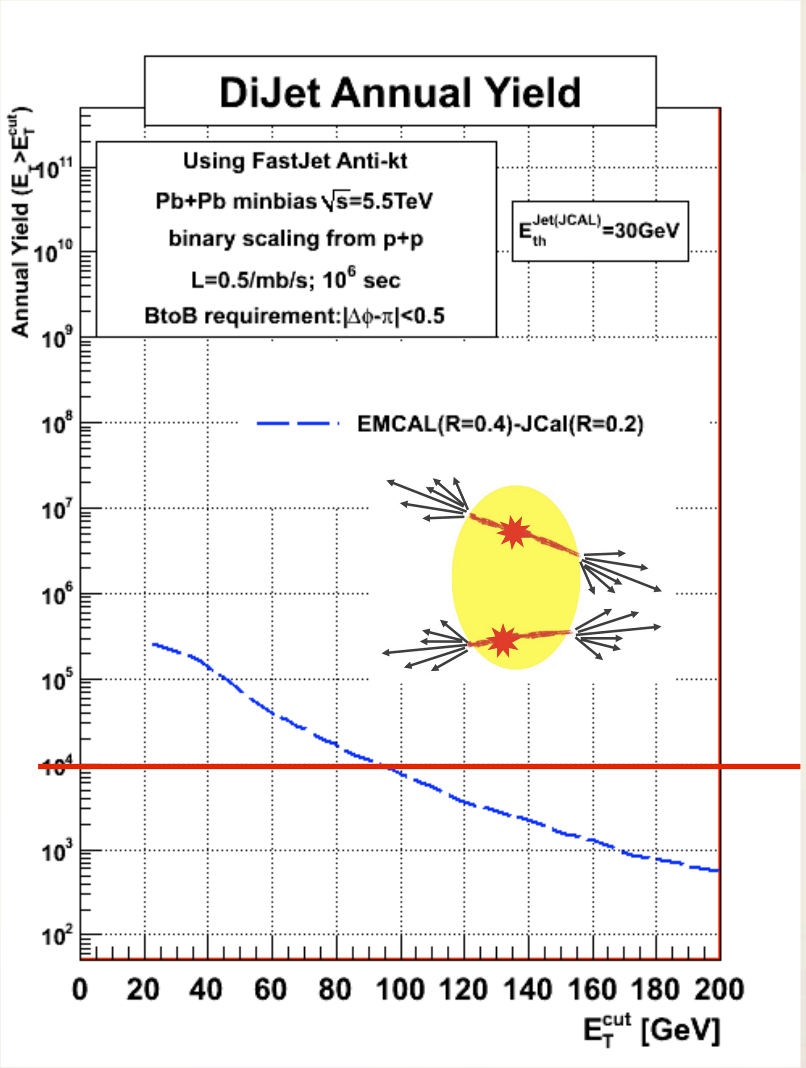
pthard=100GeV

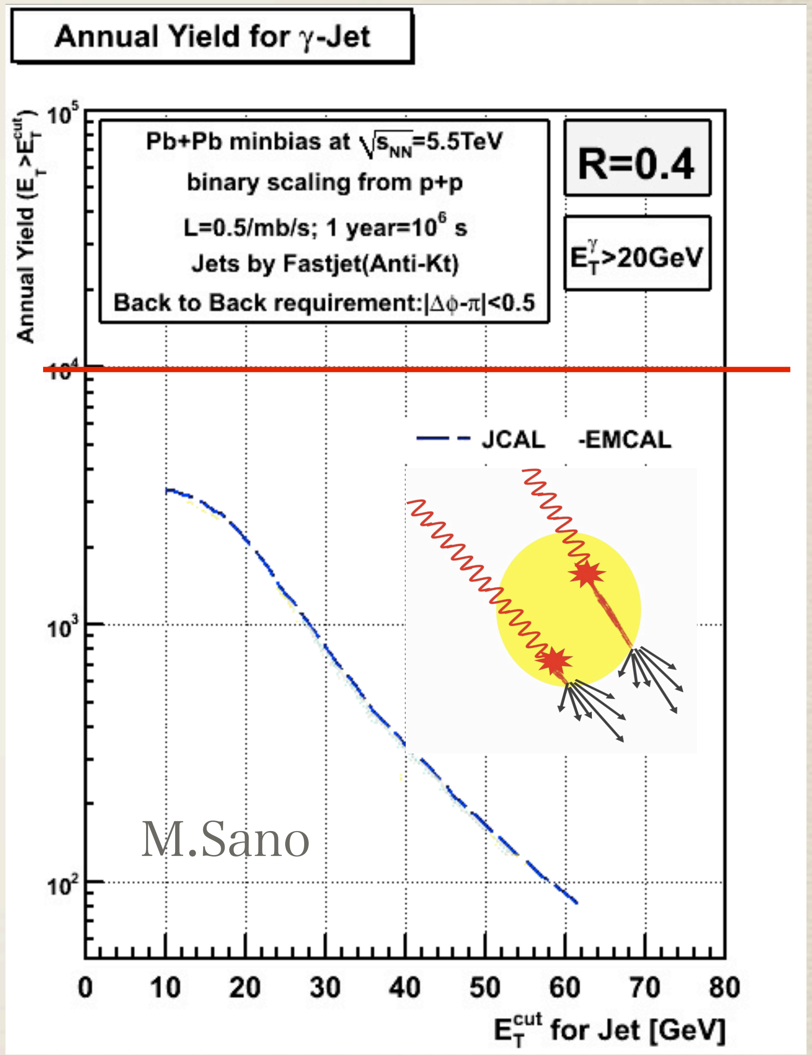


Jet from initial parton is defined
as the largest energy Jet in $dR_{parton}<0.5$

Jet Annual Yield (J-Cal-B6)







Jet-finding algorithm (anti-kt)

- FastJet-anti-kt algorithm
  - calculate d_{ij} and d_{iB} by all particles combination
  - when minimum "d" among them is part of d_{ij}
    - merge particle "i" and "j"
  - when minimum "d" among them is part of d_{iB}
    - that cluster defined as jet
  - repeat until no particle are left

$$d_{ij} = \min(1/k_{ti}^2, 1/k_{tj}^2)\, \Delta R_{ij}^2 / R^2 \,,$$
$$d_{iB} = 1/k_{ti}^2 \,.$$

Quark Likelihood

- likelihood distribution
- high energy jet(pthard>100GeV) has sharper shape