Studies of photon-jet correlation in ALICE experiment at the LHC

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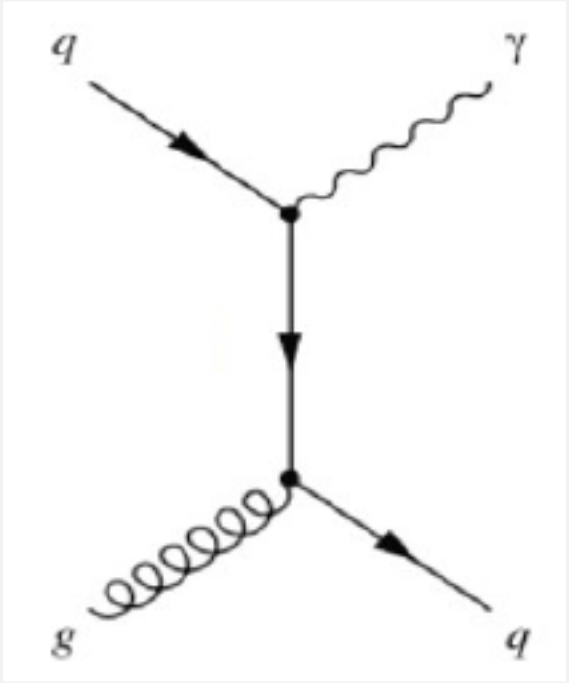
Motivation

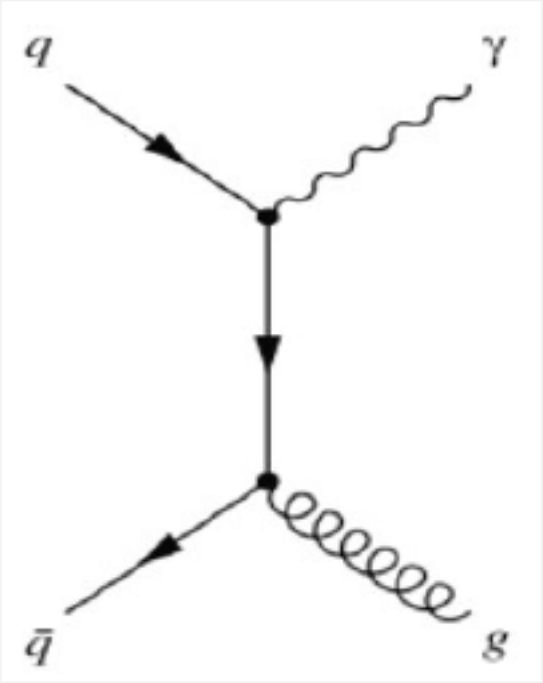
- Main goal: preliminary studies of feasibility of using photon-jet correlated events in further analysis of jets (in ALICE Run 2)
- Measurement of parton to jet fragmentation function can be done via studies of the back-to-back photon and jet events
- Photons are ideal probes for jet energy - they are colorless
- Photon-jet correlated events are approximately 100 times less frequent in comparison to jet-jet events

Photon – jet prodcution mechanisms:

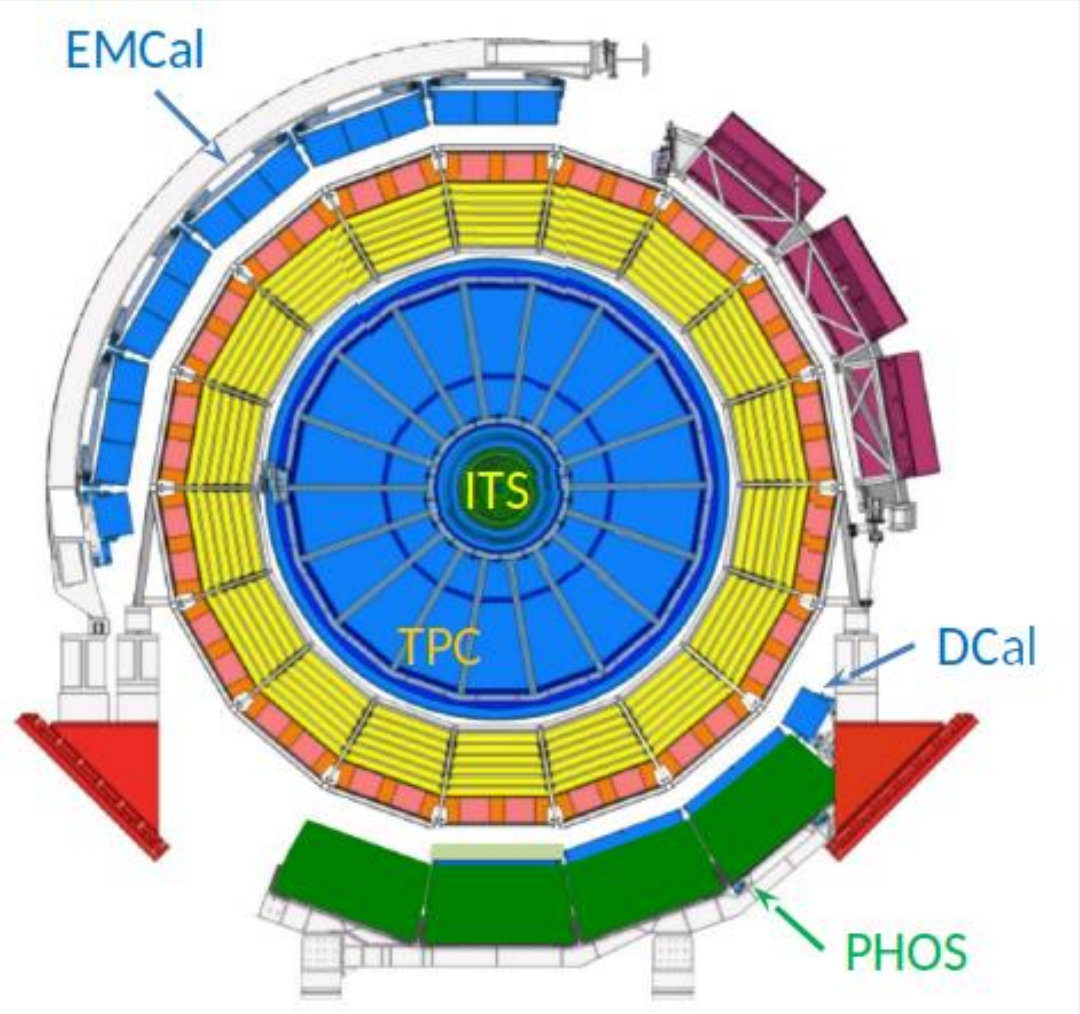
Compton scattering



Annihilation



ALICE detector



TPC
- Large volume gaseous detector with Multi Wire Proportional Chamber readout,
- Acceptance: $\Delta\varphi = 2\pi$, $|\eta|<0.9$.

ITS
- Silicon detector with 2 layers of pixels (SPD), 2 layers of strips (SSD) and 2 layers of drift detector (SDD),
- Acceptance: $\Delta\varphi = 2\pi$, $|\eta|<0.9$.

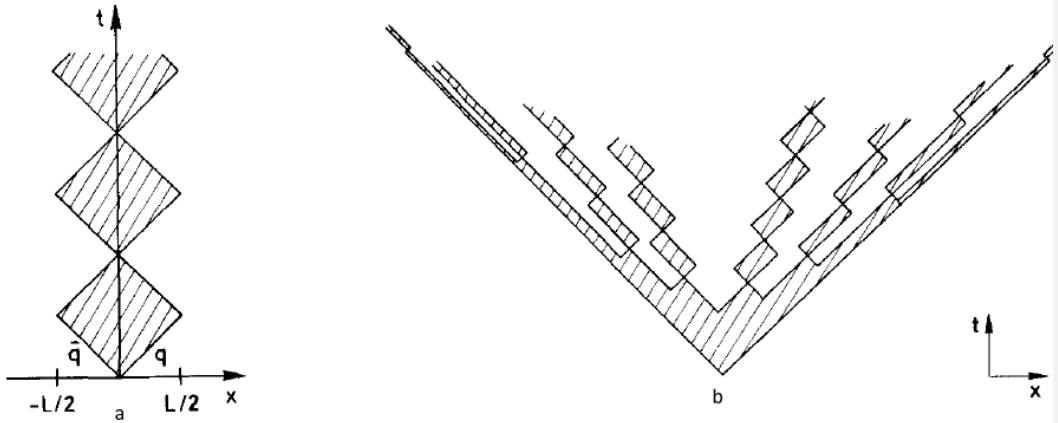
PHOS
- High granularity PbWO4 crystal scintillator based photon spectrometer,
- 3.5 super-modules,
- Acceptance: $250° < \varphi < 320°$ ($\Delta\varphi = 70°$), $|\eta| < 0.12$.

EMCal
- Lead scintillator shashlik, large acceptance electromagnetic calorimeter,
- 12 super-modules ($10 + 2 \times 1/3$),
- Acceptance: $80° < \varphi < 187°$ ($\Delta\varphi = 107°$), $|\eta| < 0.7$.

DCal
- EMCal extension, same technology,
- 8 super-modules ($6 \times 2/3 + 2 \times 1/3$),
- Acceptance: $260° < \varphi < 327°$ ($\Delta\varphi = 67°$), $0.22<|\eta|<0.7$.

Methods

- Monte Carlo Generators:
- PYTHIA: Successor to JETSET (begun in 1978). Originated in hadronization studies: Lund String



- Charged jets are made of charged particles only, full jets are made of other particles as well (except ν, n, K_l^0)
- We look at 1/10 of typical statistic due to time constraints
- Jet clusterization algorithm: FastJet library:
  - Anti-k_t jet algorithm:
    - Sequential recombination algorithm like k_t and Cambridge/Aachen algorithm
    - Distance measures given by:

$$d_{ij} = \min\left(\frac{1}{p_{ti}^2}, \frac{1}{p_{tj}^2}\right)\Delta R_{ij}^2/R^2$$

$$d_{iB} = \frac{1}{p_{ti}^2}$$

,where R – resolution parameter (cone radius)

Cuts

All simulations are generated with $\sqrt{s} = 13\ TeV$
For p-p collsions

- We only consider events with exactly one γ and at least one jet
- γ is isolated

Charged jets:
- γ registered in EMCal, DCal or PHOS:

EMCal: 80° < φ < 187° (Δφ = 107°), $|\eta| < 0.7$
Dcal: 260 ° < φ < 327 ° (Δφ = 67 °), $0.22 < |\eta| < 0.7$
PHOS: 250°< φ < 320° (Δφ = 70°), $|\eta| < 0.12$

- Jets registered in ITS or TCP:

ITS: Δφ = 2π, $|\eta| < 0.9$
TPC: Δφ = 2π, $|\eta| < 0.9$

Full jets:
- γ registered in DCal or PHOS

Dcal: 260 ° < φ < 327 ° (Δφ = 67 °), $0.22 < |\eta| < 0.7$
PHOS: 250°< φ < 320° (Δφ = 70°), $|\eta| < 0.12$

- Jets registered in EMCal acceptance, registered in ITS, TCP:

EMCal: 80° < φ < 187° (Δφ = 107°), $|\eta| < 0.9 \pm R$
ITS: Δφ = 2π, $|\eta| < 0.9$
TPC: Δφ = 2π, $|\eta| < 0.9$

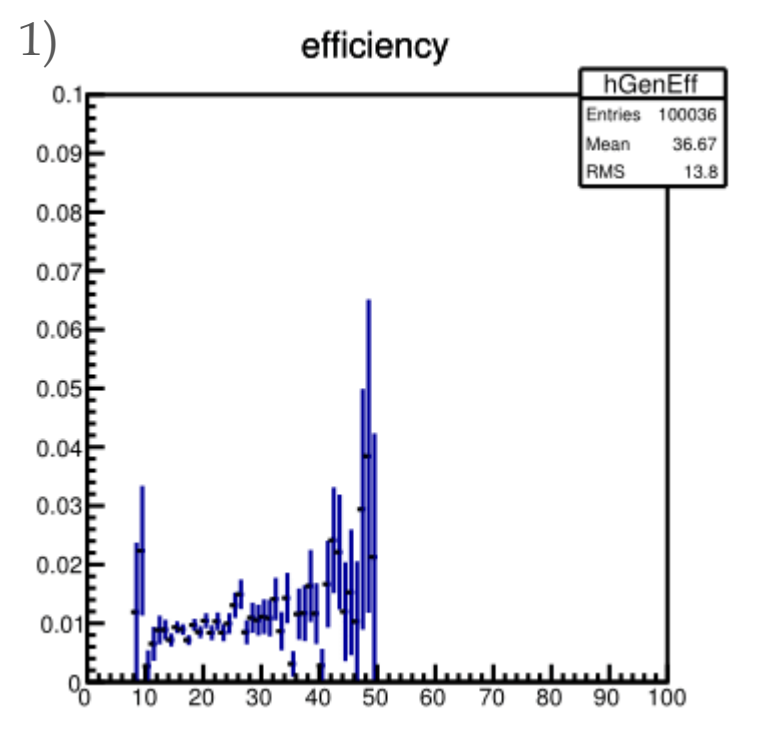
	Full Jet								**Charged Jet**							
R [rad]	0.3				0.5				0.3				0.5			
$p_{T\ min}$, $p_{T\ max}$ [GeV]	20-40		30-50		20-40		30-50		20-40		30-50		20-40		30-50	
$p_{T\ min}$ [GeV]	0.15	0.5	0.15	0.5	0.15	0.5	0.15	0.5	0.15	0.5	0.15	0.5	0.15	0.5	0.15	0.5

Results

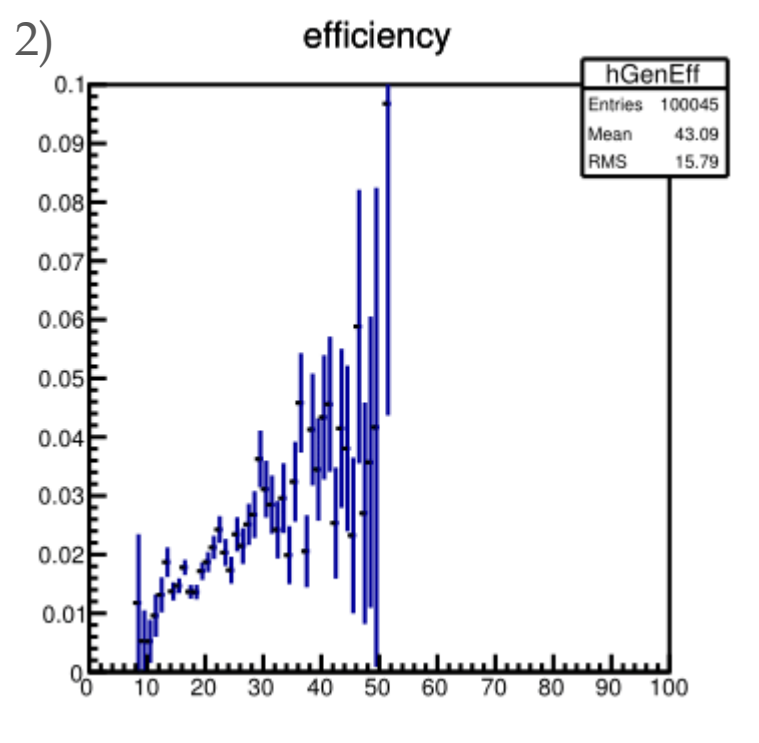
Observables and basic characteristics:

- $\Delta\varphi = \varphi^{jet} - \varphi^{\gamma}$
- $\Delta\eta = \eta^{jet} - \eta^{\gamma}$
- Efficiency of finding γ
- For selected (correlated) events:
  - $p_T^{jet}\ vs\ p_T^{\gamma}$
  - $p_T^{ratio}\ vs\ p_T^{\gamma},\ p_T^{ratio} = {p_T^{jet}}/{p_T^{\gamma}}$
- Number of jets before and after cuts
- $\eta^{jet}\ vs\ \varphi^{jet}$
- $\eta^{\gamma}\ vs\ \varphi^{\gamma}$

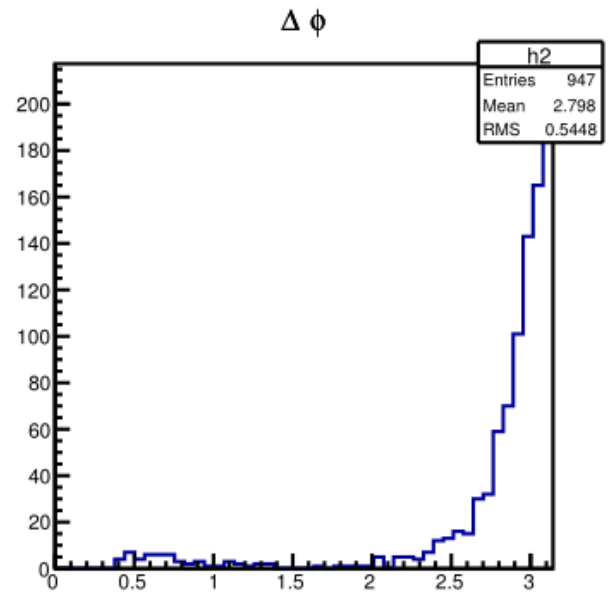
1)

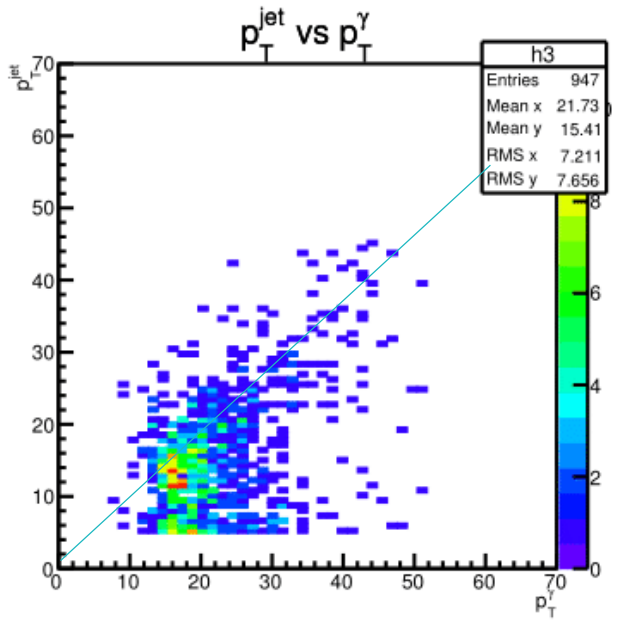


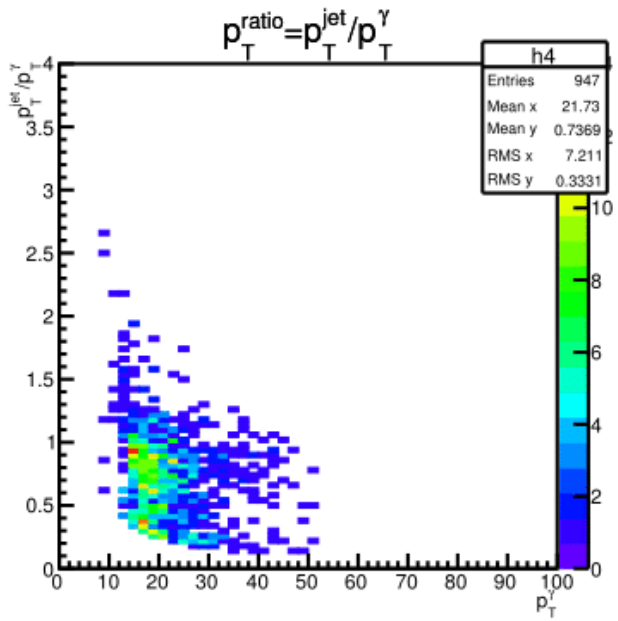
2)



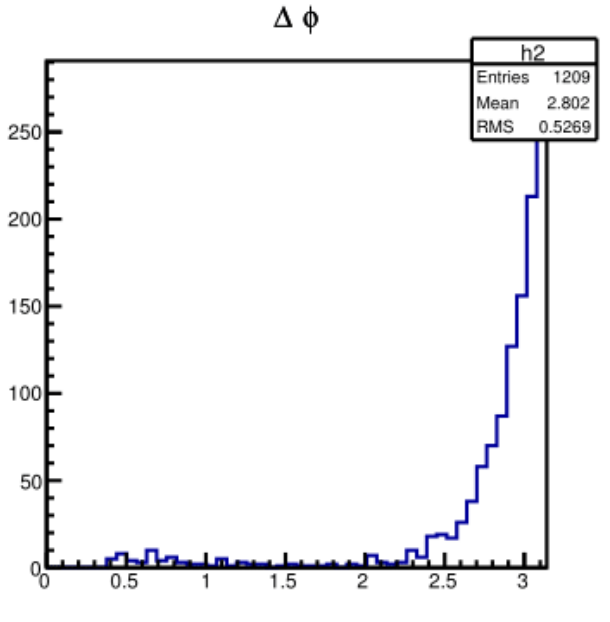
Comparison of efficiency of finding γ in full jets (1) and charged jets (2)

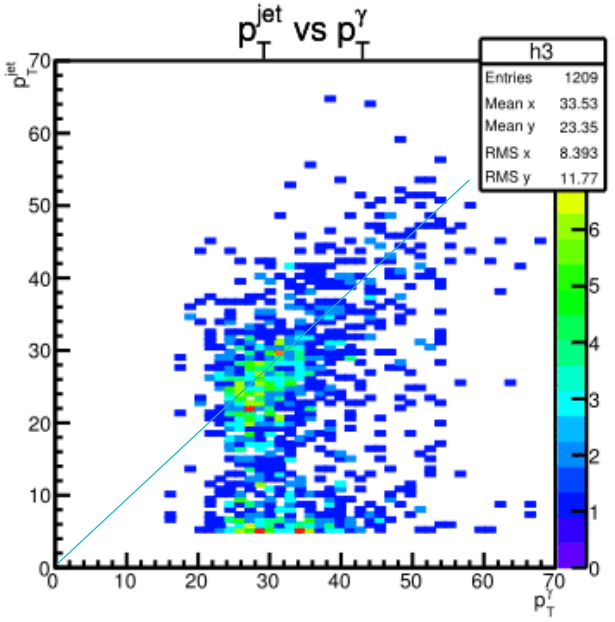


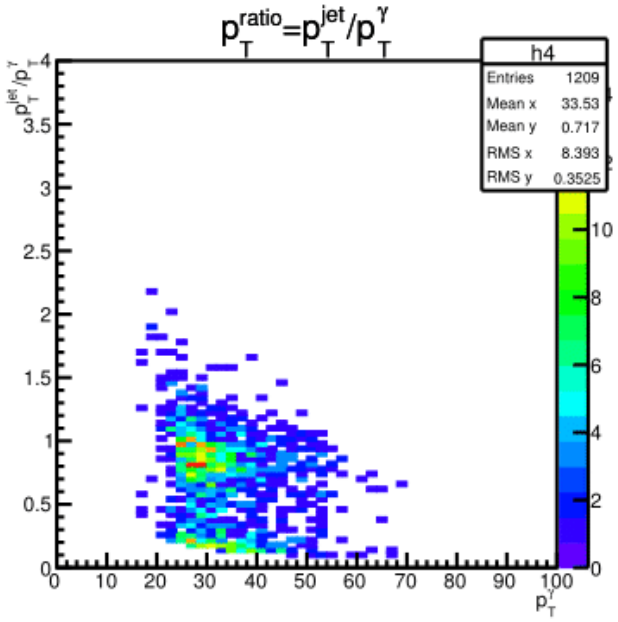




Full Jet
p_t : 20 – 40 GeV

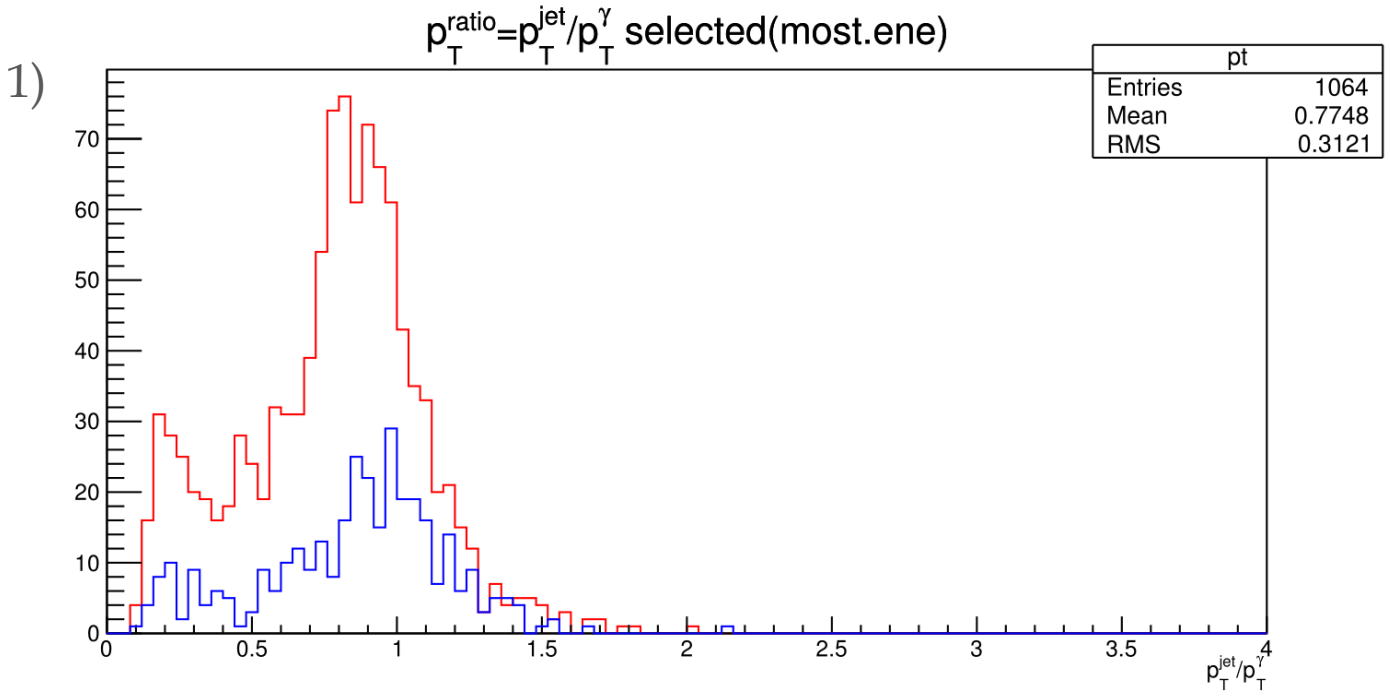






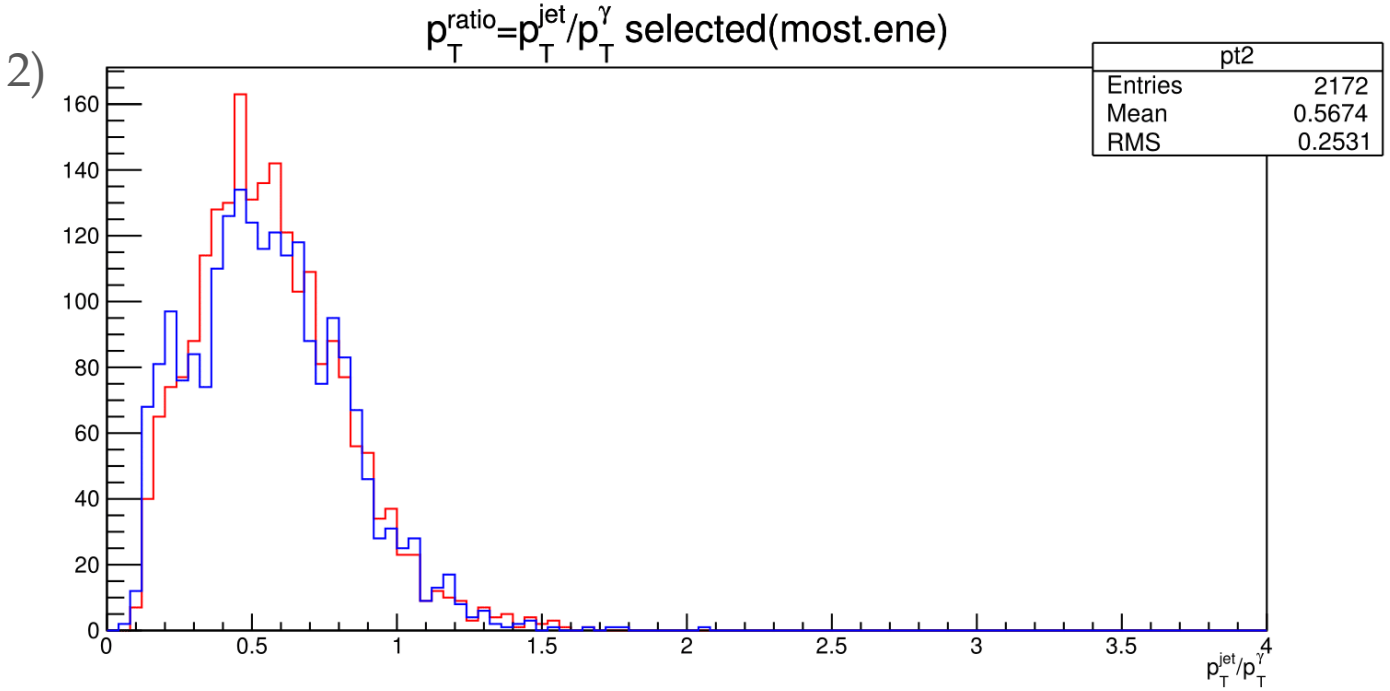
Full Jet
p_t : 30 – 50 GeV

1)



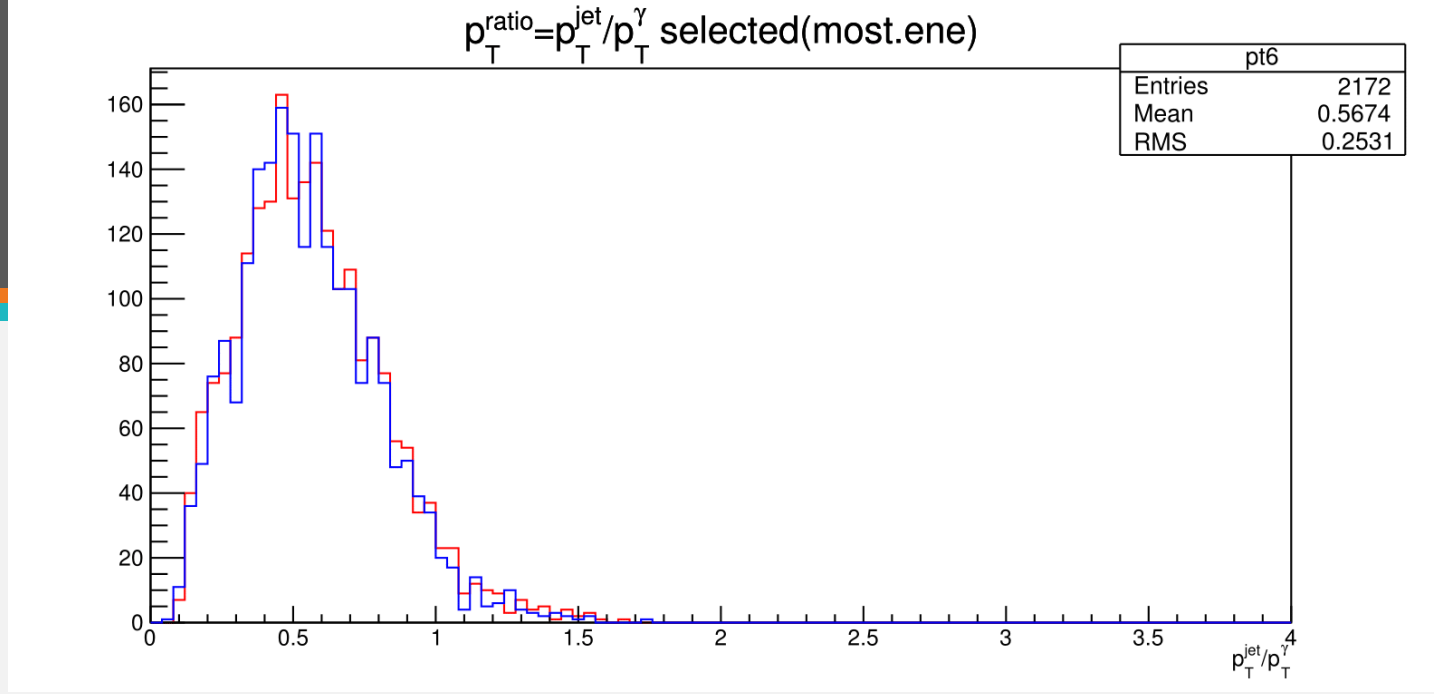
Full Jets
100 000 events
p_t min, max: 20-40
p_t cut= 0.15 GeV
Blue: R = 0.5
Red: R = 0.3

2)

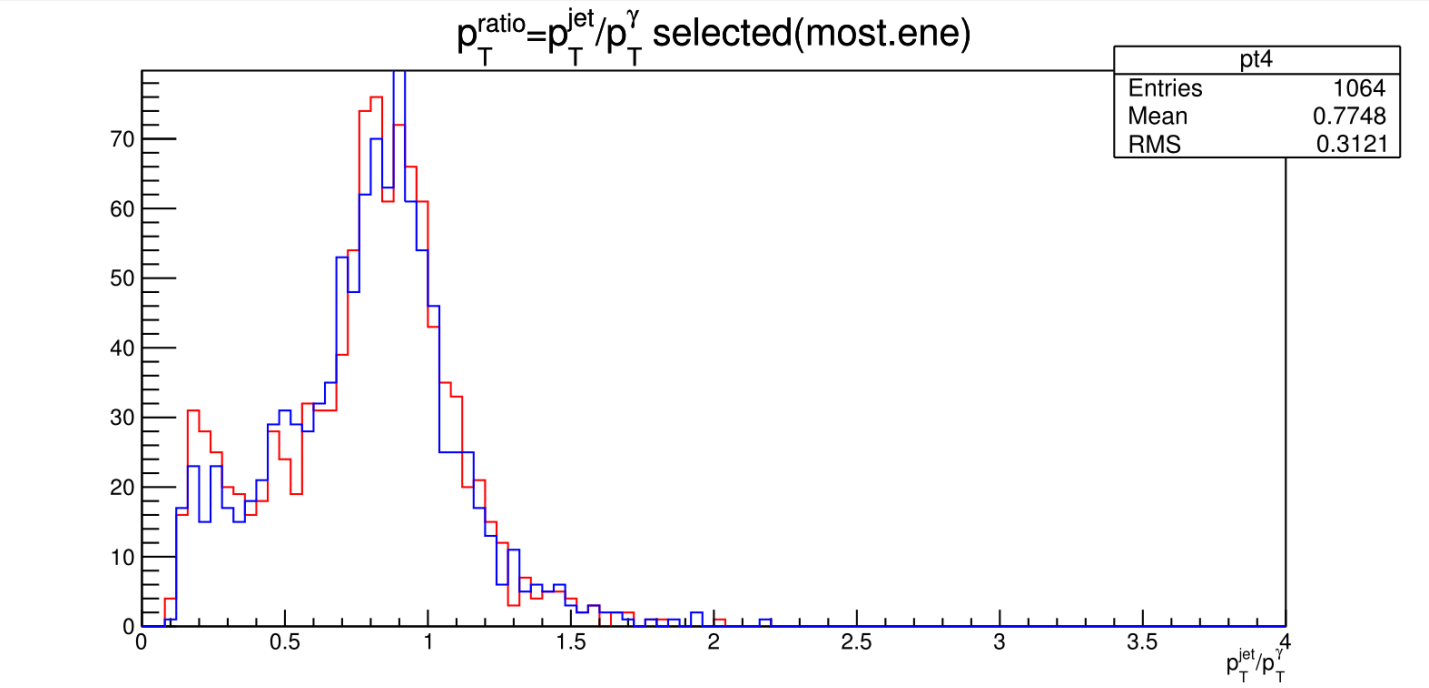


Charged Jets
100 000 events
p_t min, max: 20-40
p_t cut= 0.15 GeV
Blue: R = 0.5
Red: R = 0.3

Charged Jets
100 000 events
p_t min, max: 20-40
R = 0.3
Blue: p_t cut = 0.5 GeV
Red: p_t cut = 0.15 GeV



Full Jets
100 000 events
p_t min, max: 20-40
R = 0.3
Blue: p_t cut = 0.5 GeV
Red: p_t cut = 0.15 GeV



Summary

- Studies of gamma jet events were carried out
- Smaller statistics for full jet in comparison to charged jets were observed
- Linear correlation between p_t and γ energy was seen
- Analysis of jet selection criteria needed
- Next step: Fragmentation function and jet – γ ratio studies

Acknowledgments

- Anti k_T algorithm: Matteo Cacciari, Gavin P. Salam, Gregory Soyez (2012). *Fast Jet user manual*. Eur. Phys. J. C (2012) 72:1896.
- Graphics and photos: ALICE collaboration, press materials