Photon purity measurement at the early data in ATLAS

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High-p_T photons will be one of the "key" signals for discoveries at the LHC, e.g. for search of Higgs boson and SUSY. In order to discover new particle, an excellent understanding of photon measurement using direct photon processes (the Compton process qg→ γ q, the annihilation process qq→ γ g) is required at the early data collected at ATLAS detector.

Photon measurement is not so easy due to backgrounds which come from QCD jets. In ATLAS, we have some sophisticated algorithm of photon identification using information of calorimeter cluster, and information of track especially for converted photons. However, fake photons can't be rejected completely because most of them originate from isolated π^0 in jet. Furthermore, 70% of fakes have π^0 with 80% of jet energy. So its electromagnetic contribution will be large in the calorimeter like real photon. Estimation of fake photons is absolutely requisite in real data.

Table. 1

Signal	Background	Fake photon species	Expected rejection from MC study
Higgs → $\gamma\gamma$	Direct photon	Mostly quarks	~2000-3000
Direct photon (qg→ γ q,qq→ γ g)	Di-jet	Mostly gluons	~15000-30000

Table1 shows summary of relation between signal and fake processes. Our interested prompt-photon processes are the processes which are Higgs decays to two photons and direct photon process. Background is direct photon against the Higgs decay and di-jet against direct photon. The species of fake photon from the two kinds of backgrounds processes are different. For direct photon process, they are originated mostly from quark jets because the Compton process (qg→ γ q) dominates at photon energy region below 100GeV, where is interesting energy region for discoveries of new physics. On the other hand, fake photons in case of di-jet process mostly come from gluon jets because of a large contribution of gluon at the initial states in proton-proton collision like LHC. As shown at Table1, rejection factor of two kinds of fake species are large different. It is affected by broad gluon fragmentation. Cross section of multi-QCD jets is quite huge compared to that of direct photons by factor 10^3~10^4. Though jet rejection factor to photon is small by 10^3~10^4 according to MC study, amount of fake photons will be same order as real photons in fact.

I worked for algorithm for photon conversion recovery on Combined Test beam (CTB) data for a half of my contract. Now I am studying estimation of photon purity using converted photon events on direct photon events at making use of my experience on CTB. About 35% of photon would be converted to e^+e^- by the material of inner detector, which is one radiation length in front of LAr detector and then 82% of conversions can be reconstructed using the inner detector. There are conversions from real and fake photons mixing in real data. So we can express F_{conv}^{Data} which is fraction of reconstructed conversions for photons determined by real data as below,

$$F_{conv}^{data} = \frac{a F_{conv}^{signal} + b F_{conv}^{BG}}{a+b} \quad , a+b=1$$

where F_{conv}^{signal} and F_{conv}^{BG} are fractions of reconstructed conversions for signal and fake photons estimated in MC, respectively. a and b are photon purity and fake rate. In addition, photon conversion can be promising to use for γ/π^0 separation with comparison of its reconstructed energy (E) and its reconstructed momentum (p). p/E is ~1.0 for real photon and less than 1.0 for fake photon as shown in Figure 1.

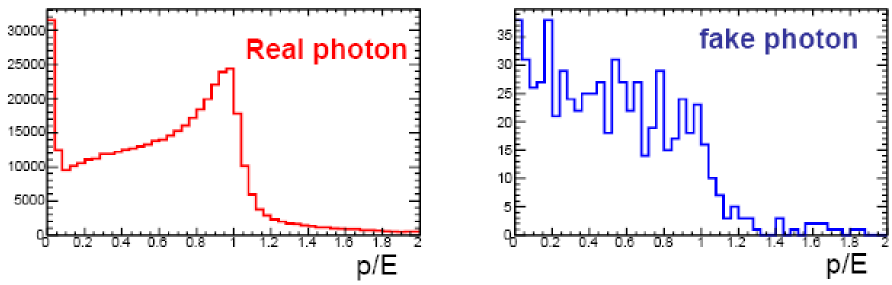

Figure 1

Fake photons originated from two kinds of QCD jets, which originate from quark or gluon. Table2 shows fraction of reconstructed conversions for each photon species.

Table 2

Photon species	Fraction of reconstructed conversions
Real photon	26.9 ± 0.03%
Fake from quark jet	31.8 ± 1.0%
Fake from gluon jet	34.5 ± 1.6%

We can expect 47% for fake photons if one trust 27% is for real photons, however the fractions for fake photons are quite small by 13~15% than the expectation. Track reconstruction of electron pairs from converted photons in jets is not so easy compared to clean prompt-photon. Tracking efficiency is ~90 % for prompt photons. On the other hand, it becomes lower ~70% for events with one conversion in π^0 and ~50% for events with multi conversions in π^0.

By termination of my contract, I would like to establish this algorithm to measure photon purity as a tool.

References:

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5. Tracking performance for electrons and photons in the combined test beam / Kataoka M presented at ATLAS Week on 14 Feb 2008.

6. For mis-alignment issue with Beam-Chamber / M.Kataoka presented at CTB Analysis Meeting on 24 Jan 2008.

7. Short report for new G4 in ID / M. Kataoka presented at CTB Analysis Meeting on 24 Jan 2008.