Argonne NATIONAL LABORATORY

Direct photon studies at Tier3

S.Chekanov, B.Blair

Jan 19, 2010

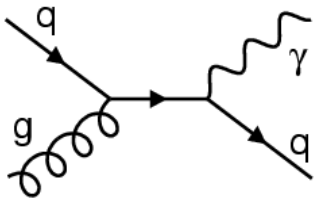
ANL Jamboree

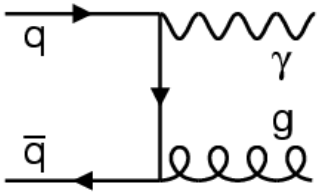
Plan:

- First look at 900 GeV data
- An engine for parallel QCD NLO calculations
- How to analyze data using limited Tier3 resources

Prompt photons in pp collisions

- **LO QCD:**
  - $qg \rightarrow q\gamma$ - "compton-like" process
    - dominant process (~90%)
    - direct sensitivity to gluon
    - similar to ep (resolved photoproduction)
  - $q\bar{q} \rightarrow g\gamma$ - "annihilation" process
    - contribution (~10%)
  - $q\bar{q} \rightarrow \gamma\gamma$ – small (<0.1%)



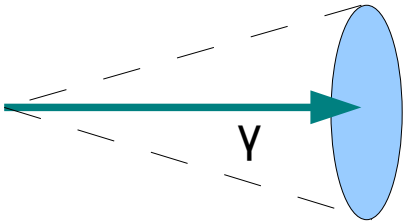


Sensitive probe of:

- gluon density
- NLO QCD calculations
- low x physics. Collinear or kt factorization?

\+ should be understood for new particle searches

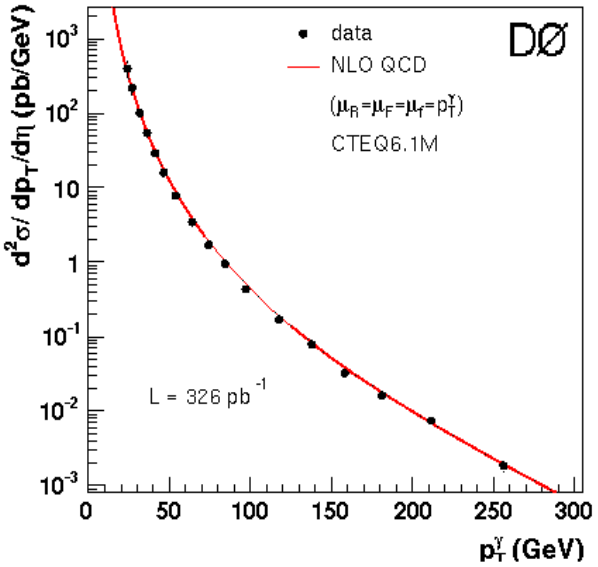
Isolation to reduce photons from π0 /eta:

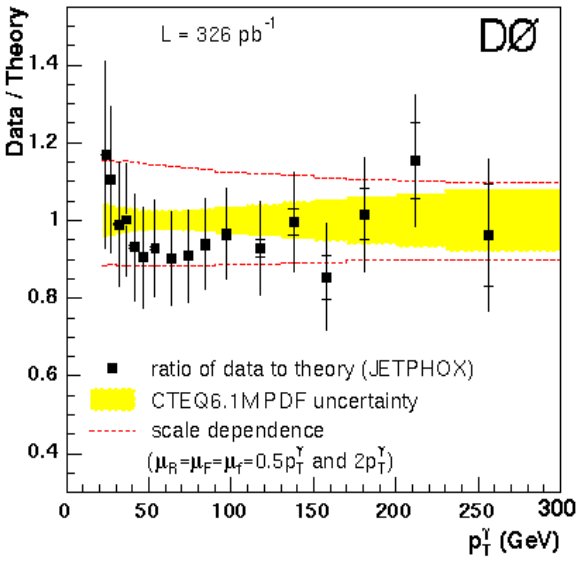


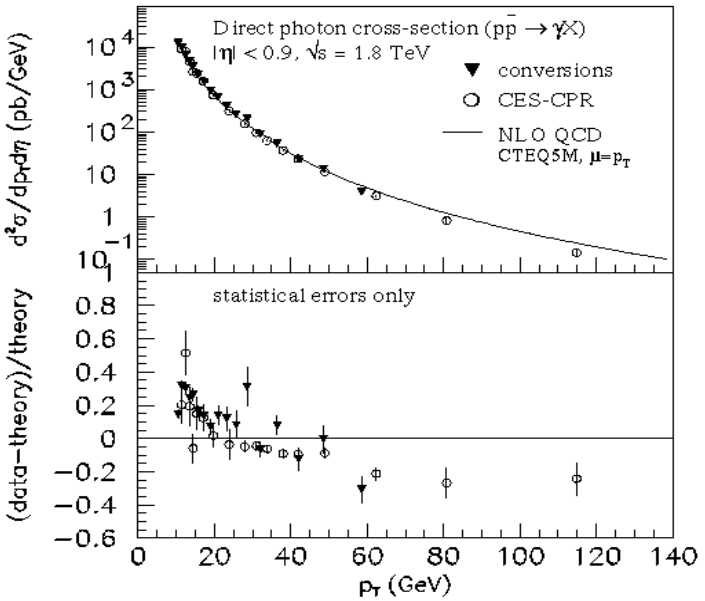
Cone ~ 0.4-0.6 in eta and phi

$P_T(\gamma) > 0.9\ P_T(tot)$

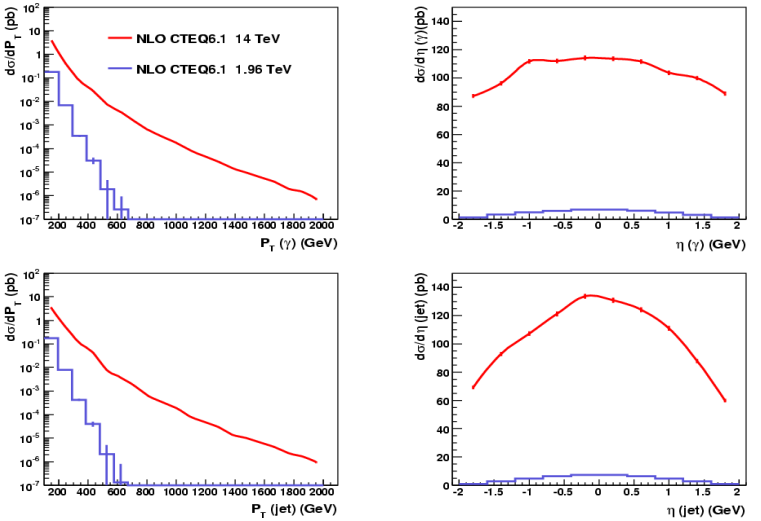
γ cross sections at TEVATRON







- **Large PT:**
  - significant scale and PDF uncertainty!
- **Low PT:**
  - Deviation from NLO?



Blair, R., Chekanov, S., Heinrich, G., Lipatov, A., Zotov, N. ANL-HEP-CP-08-52, IPPP-08-64, DCPT-08-128, Proceedings of the HERA-LHC workshop, 2007-2008, p. 681. hep-ph/0809.0846

Selection cuts

- Good runs 141565, 141707,141746,141748,141811,142166,142191,142193,142195,142383
- *PromptGamma* program for structural ntuples (based on TLorenzVector) from AOD files
  - https://twiki.cern.ch/twiki/bin/view/AtlasProtected/PromptGamma
  - Processed 0.8M events with min pT(gamma)>2 GeV
  - Processing time: 2h on 24 cores using ArCond/Condor
    - http://atlaswww.hep.anl.gov/asc/arcond/
  - 30 MB → 1 min Ntuple processing time
    - Using a similar code as posted for the Jamboree (Advanced level)
- Monte Carlo sample:
  - PYTHIA MinBias sample (no prompt photons)
  - mc09_900GeV.105001.pythia_minbias.recon.ESD.e466_s604_s582_r849
  - 2M processed events stored at ANL (3h using ArCond)

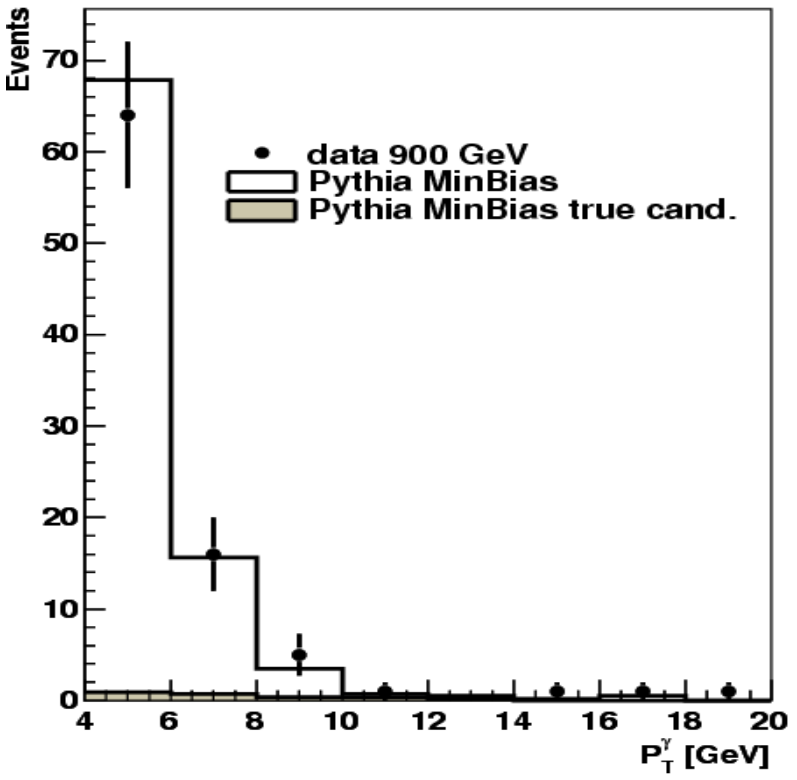
Final event selection:

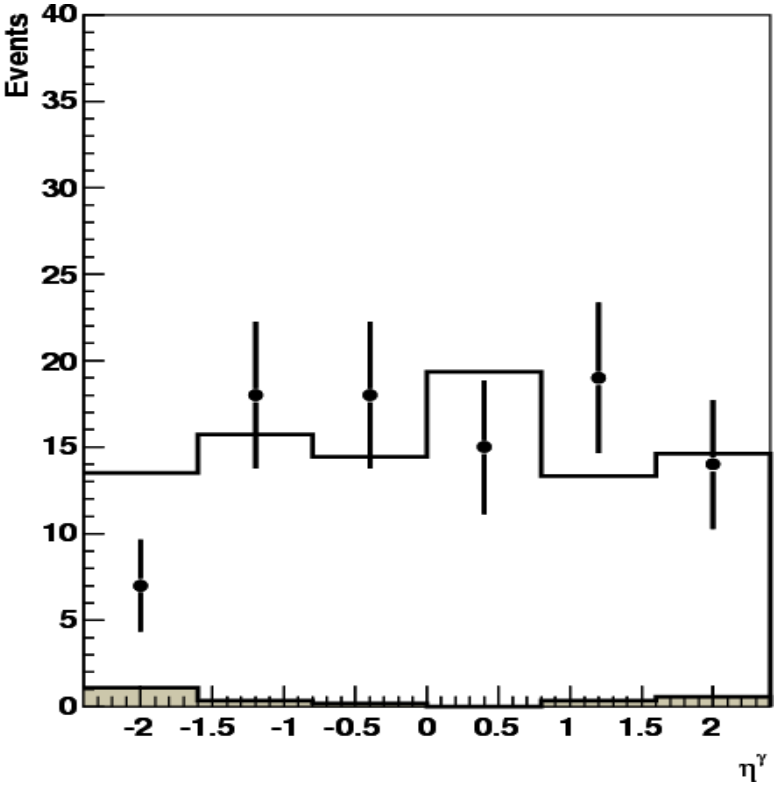
- Photon candidates: pT(γ)>4 GeV, |eta (γ) |<2.37 *(pT cut motivated by HERA articles)*
- IsAuthor==true (standard photons)
- Loose definition (based on isEM)
- Isolation based on the cells (econe40) R=0.4 (ET(cone)/ET(γ) < 0.9)

Data vs Pythia MinBias MC

93 photon candidates

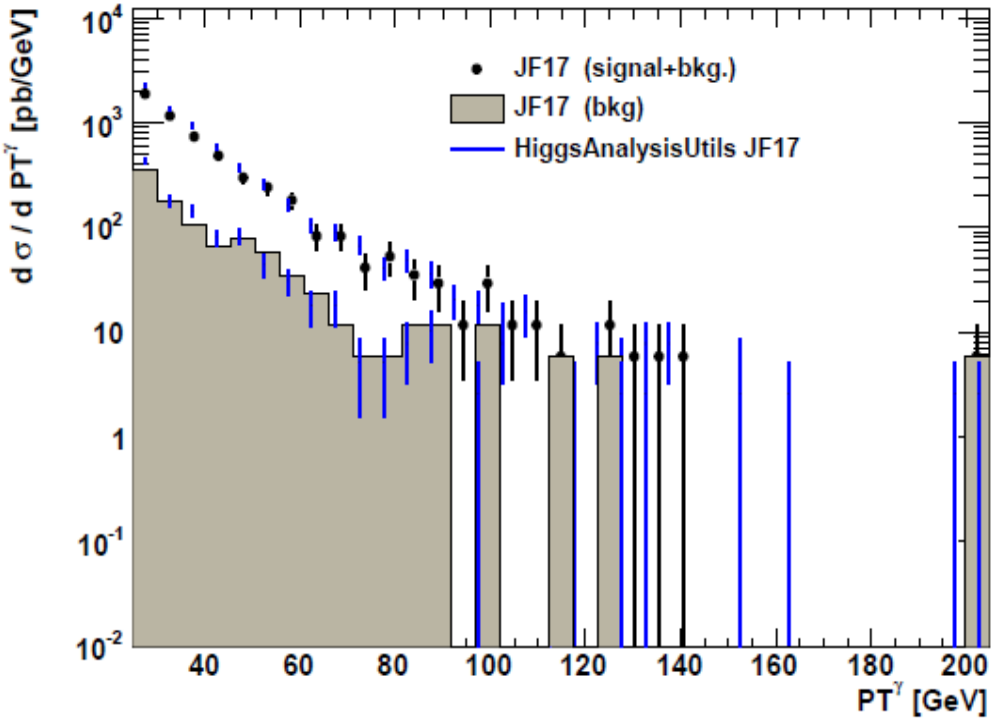
- PYTHIA: 490 photons. 16 comes from q/g lines (signal direct photons) from fragmentation
- MC was generated without the prompt-photon subprocess (MSUB=14,19).
- The expected number of direct photons in MC is at the level 20-40% from the total number of reconstructed photons (expected for ET>20 GeV)
- **Need MC with direct photons included (MSUB=14,19)**





Cuts: Loose photons + cone ET(cone=0.4)/ET(γ) < 0.9. Isolation using cells.

Contribution from hadronic background



For “tight” photons without isolation, 40-60% photons are from hadronic decays

With additional cone isolation, the background can be as low as 14-20% (the cone size 0.4-0.6)

COM-PHYS-2009-158
(R.~Blair, S.C., L.~Price)

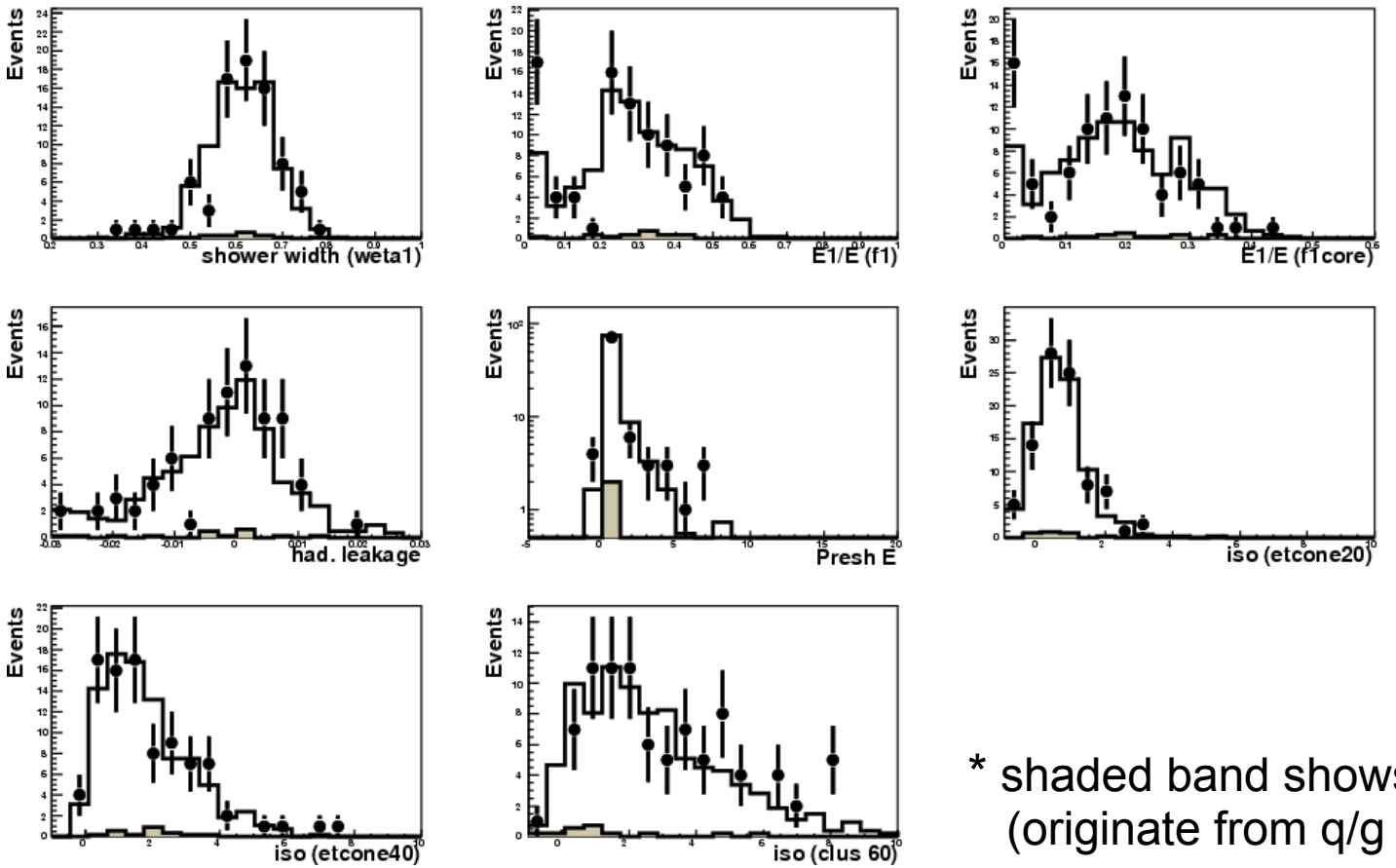
2 strategies:

1) Set the isolation requirements and use tight photons. If efficiencies, purities and PID variables are well understood and systematic is under full control, use a MC-based approach

2) Identify a calorimeter-shape variable(s) to separate background on statistical bases. Works **only** if PID variables are sufficiently distinct for background and MC

- preferred option!

Data vs MC



* shaded band shows signal photons (originate from q/g in fragmentation)

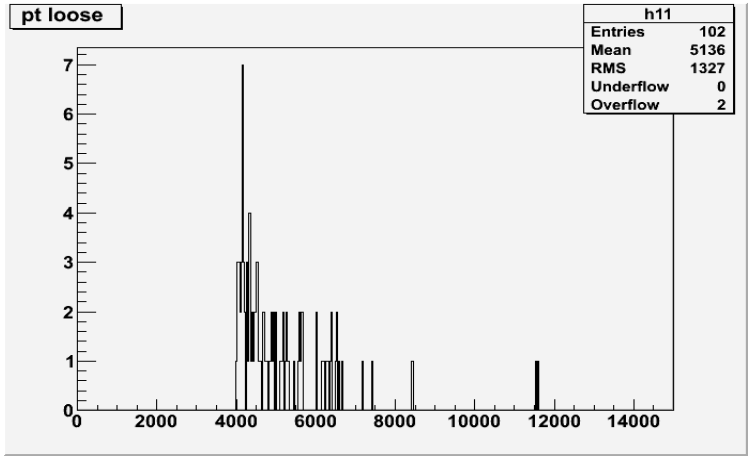
Good agreement →Two conclusions:

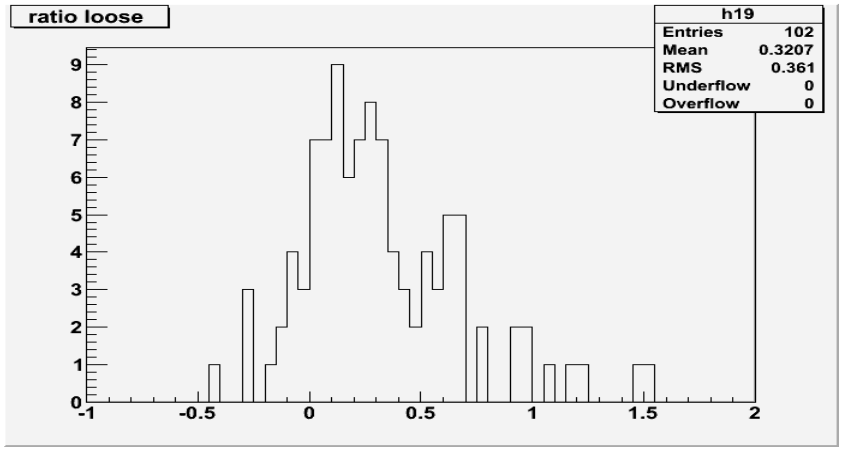
- PID variables for photons cannot disentangle the signal from background even for "loose" photons (isem(egammaPID::PhotonLoose)). Need more statistics?
- Data contain signal photons at much smaller level than the expectation (<20-40%)

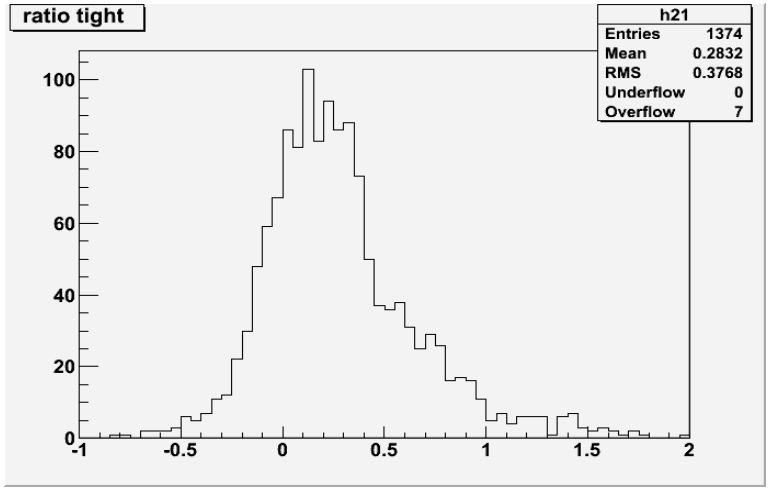
Independent analysis

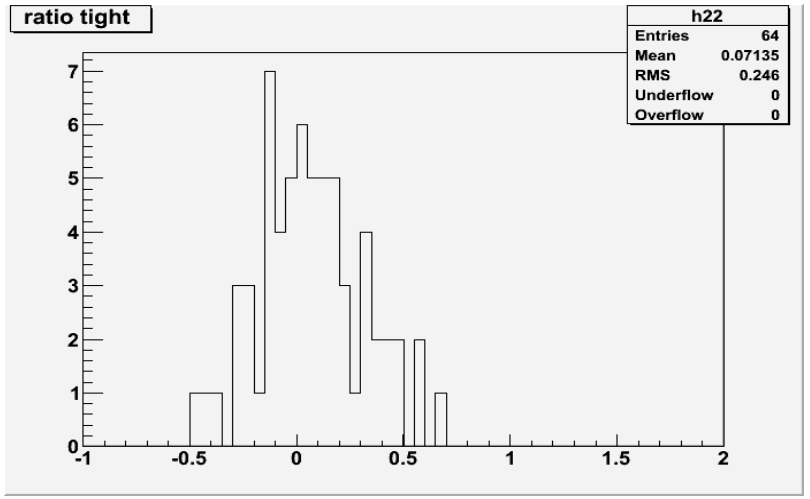
- L.Fayard, H.Abreu, M.Escalier (LAL) joined. Agreement between 2 analyses within 2%
- Agreement for fraction of brems. photons in Monte Carlo

ratio=etcon40/pt



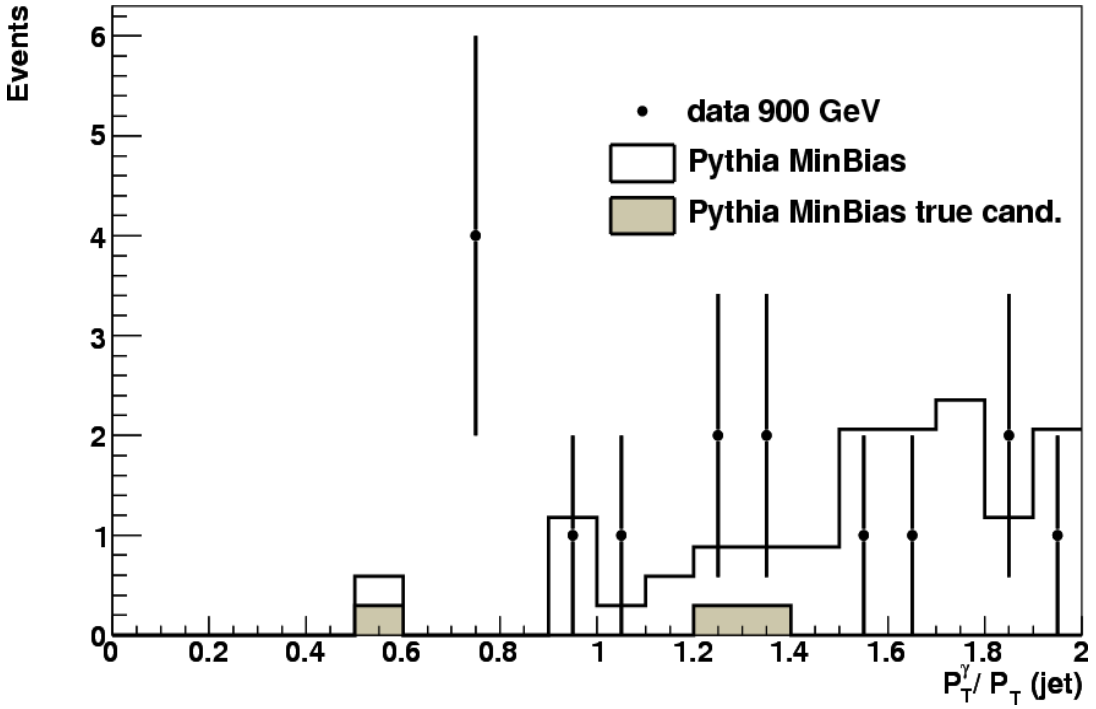






γ+jet candidates

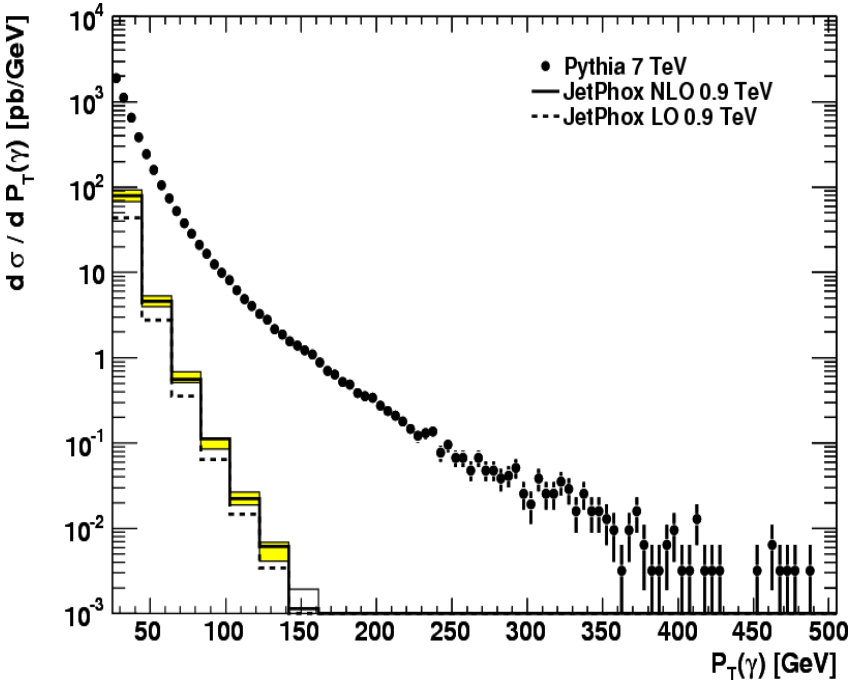
- antiKT jets. pT(jets)>4 GeV, |Eta(jet)|<2.4
- Select events based on the requirement |φ(γ)-φ(jet)|>2.5 (back-to-back)
- Look at pT(γ)/pT(jet)

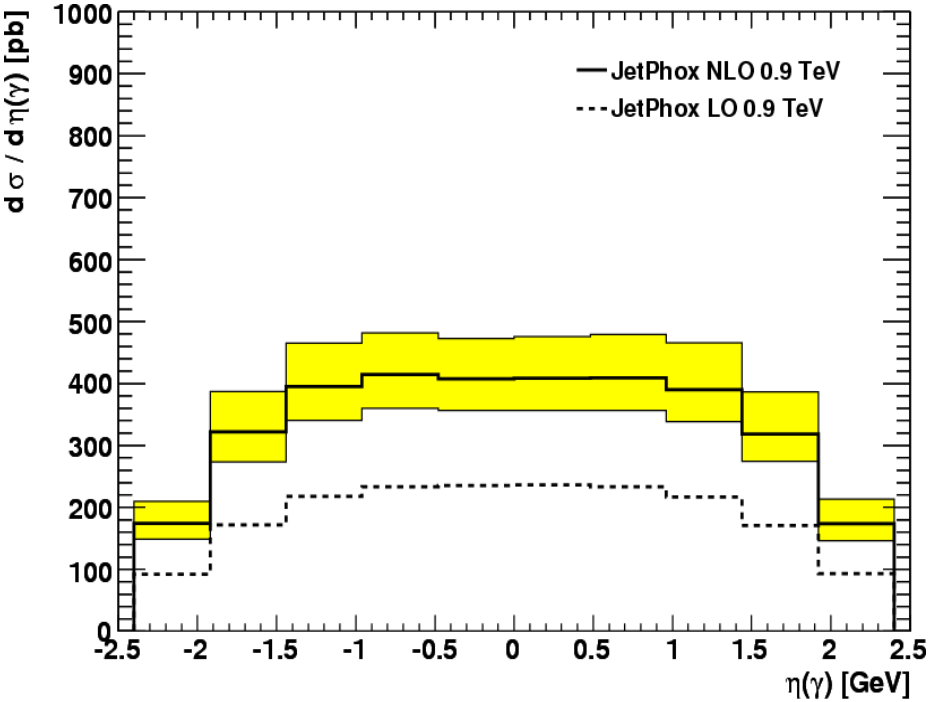


- 22 back-to-back events
- No good balance in pT (too low jet pT?)

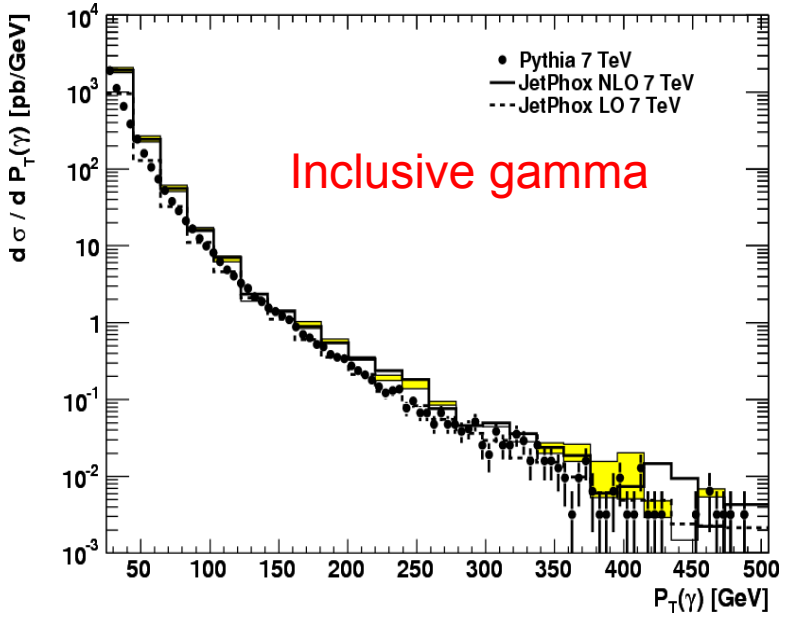
A farm for QCD NLO predictions using multi-core parallel processing

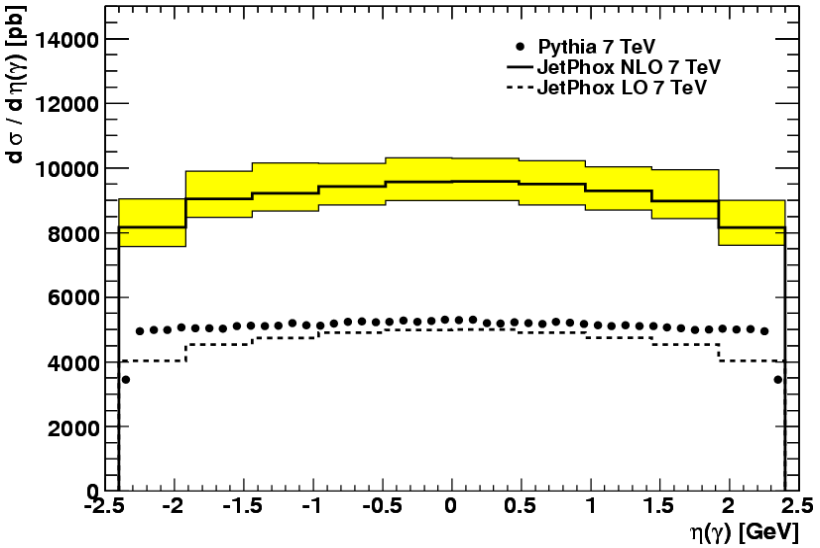
- NLO QCD processing engine was built using the ArCond package for parallel calculations on Tier3 sites http://atlaswww.hep.anl.gov/asc/arcond/
- 3 computers used (24 cores).
- Processing time: ~10h per calculation (3 scale uncertainty, direct+fram. parts)
- Also used for MC truth generation (~2h for 5M events)
- Can provide services for egamma/SM group



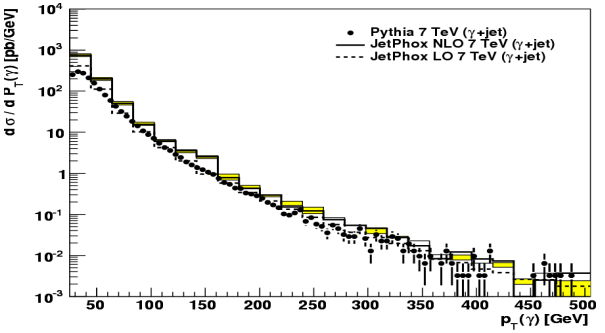


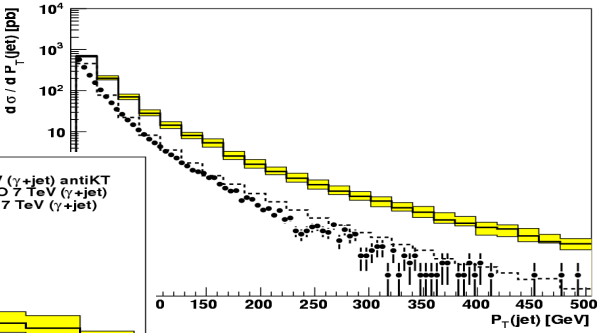
A farm for QCD NLO predictions using multi-core parallel processing

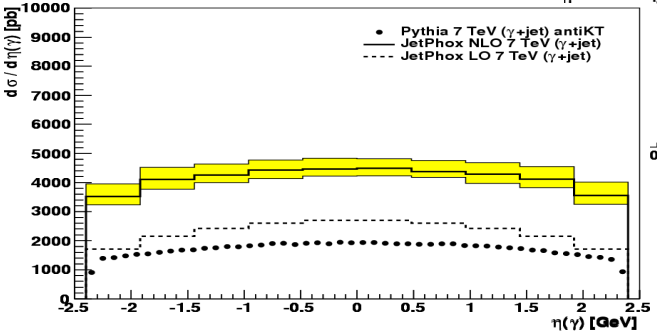


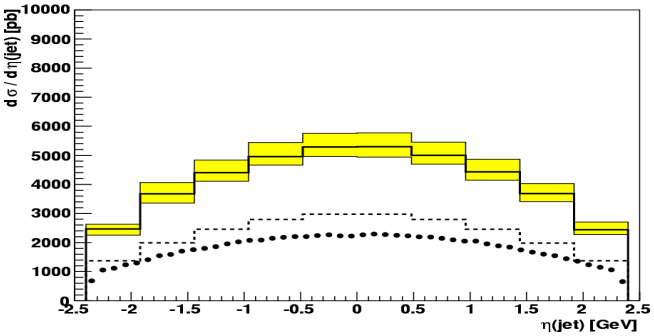


gamma+jet









Data analysis steps

- **Step 1:** Generate ntuples from AOD using PromptGamma + ArCond
  - ~ 2h on 24 cores. PromptGamma located on the SM SVN
- **Step 2:** Read ntuples using C++/ROOT code: 2 min for data/MC runs

- **Method I:**
  - Use a simplified version of PromptGamma (GammaJetExample)
  - Install & run over a small sample of MinBias data
  - Creates a ntuple based on a Lorentz vector class
  - Run over the ntuple using a C++/ROOT program
  - Advantages:
    - easy to add new variable without modifications of C++ code
    - true object oriented approach
    - 100 histograms to look at filled variables
  - Disadvantages: smaller user support
- **Method II**
  - use a C++/ROOT code to run over D3PDs
  - Advantages: Good support
  - Disadvantages:
    - Data not structured (not object oriented!). More difficult to use
    - Any change in D3PD will trigger modifications of C++/ROOT code
    - Takes ~5 min to look at a single branch (on a single core)
    - Some important variables could be missing

Look at the examples for both methods:

- https://atlaswww.hep.anl.gov/twiki/bin/view/Jamborees/Jamboree2010JanPart2