Studies for H-> $\gamma\gamma$

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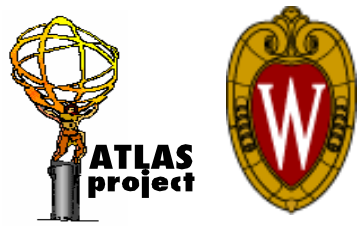


Higgs WG meeting 25/02/04

Outline

- Strategy for H->γγ
- MC for Irreducible background
  - ResBos vs. PYTHIA
  - ResBos vs. HERWIG
  - ResBos vs. MADGRAPHII
- Combination H->γγ and H->γγ + jet
- Status of γ/jet Separation
- Outlook and Future Plans

Strategy for H-> γγ Analysis

- **Combined H→ γγ and H→ γγ + jet analyses**
  - H+1jet analysis takes up only 1/10 of the gg H signal.
    - This fraction may be reduced by tightening the cut on $M_{J\gamma\gamma}$.
  - An optimization procedure needs to be applied:
    - Maximize combined significance of "untagged" analysis (with $M_{\gamma\gamma}$ and $P_{T\gamma\gamma}$ as discriminating variables) with H+1jet analysis by varying P_{TJ} and $M_{J\gamma\gamma}$
- **It is best to have a description of inclusive and H+jet analyses in one MC**
  - This has been achieved for signal (MC@NLO)
  - Results on MC for irreducible background are shown today

ResBos vs. Pythia

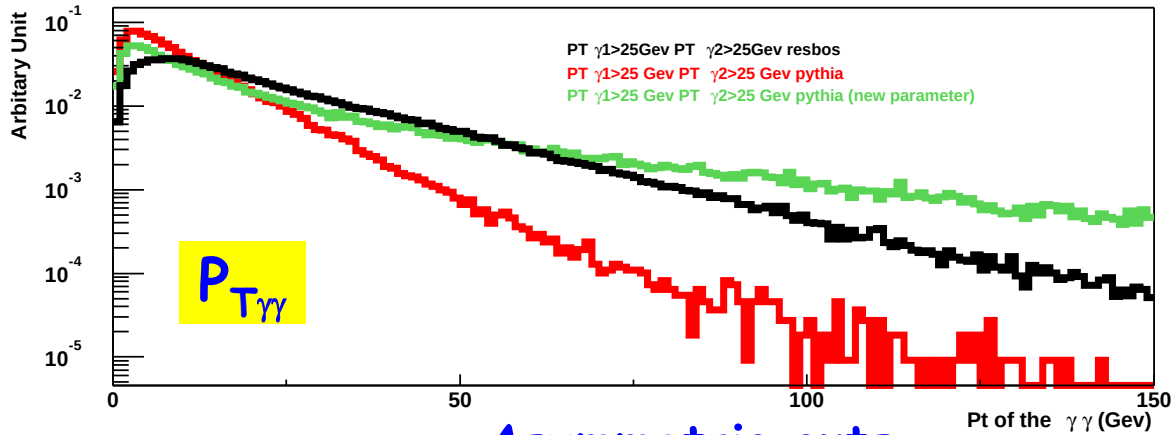
- $P_{T\gamma\gamma}$: Resbos is compared with nominal Pythia and Pythia with MSTP(68)=2

ResBos

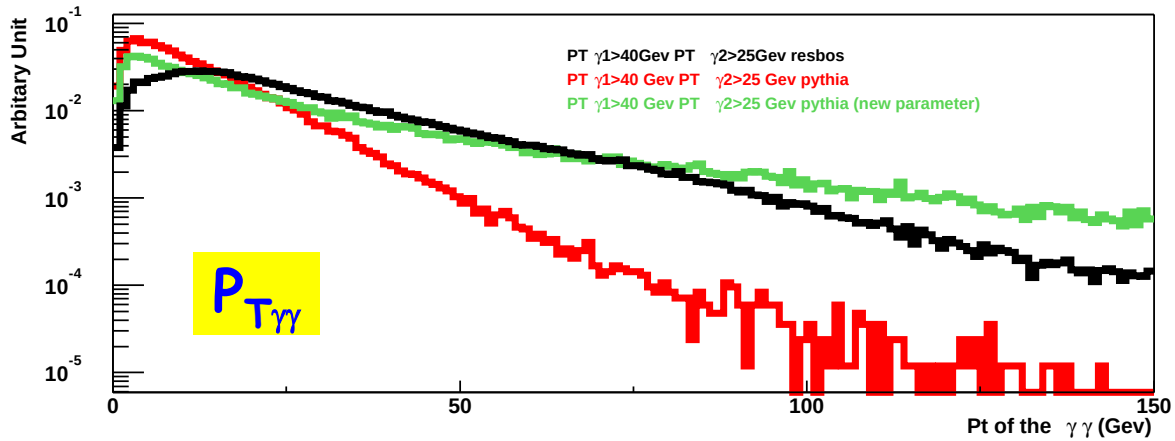
Pythia (Nominal)

Pythia (MSTP(68)=2)

Symmetric cuts



Asymmetric cuts



ResBos vs. Pythia (cont)

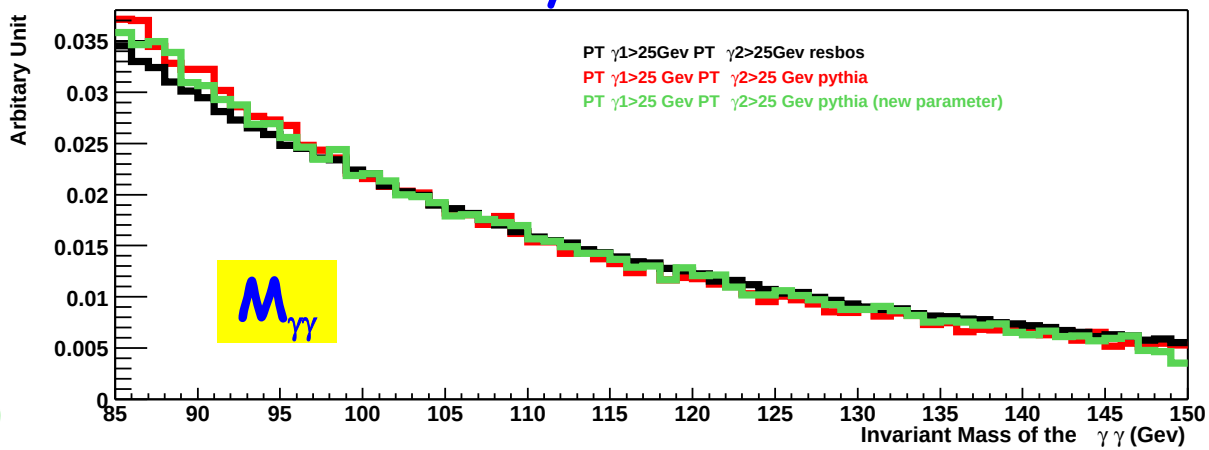
- $M_{\gamma\gamma}$: Resbos is compared with nominal Pythia and Pythia with MSTP(68)=2

ResBos

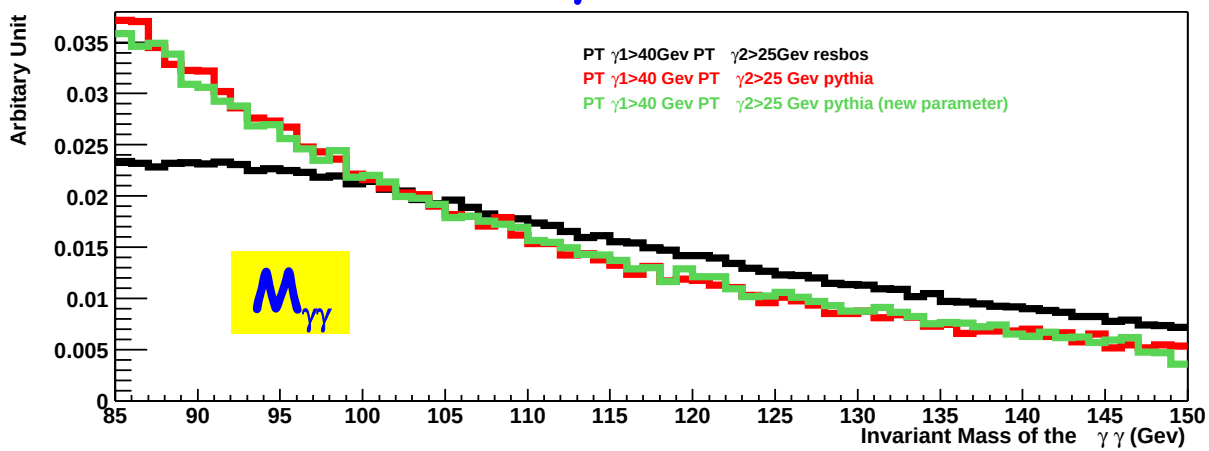
Pythia (Nominal)

Pythia (MSTP(68)=2)

Symmetric cuts

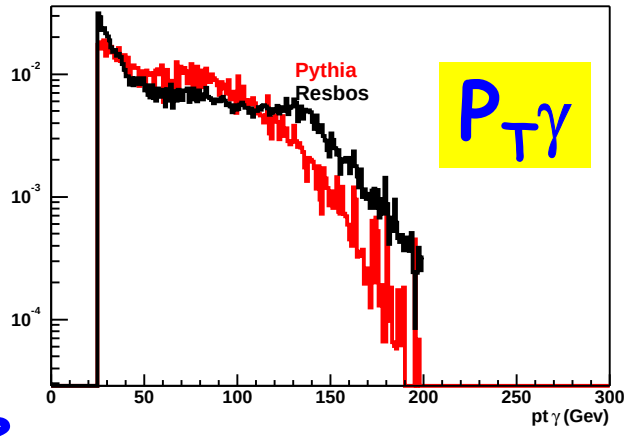


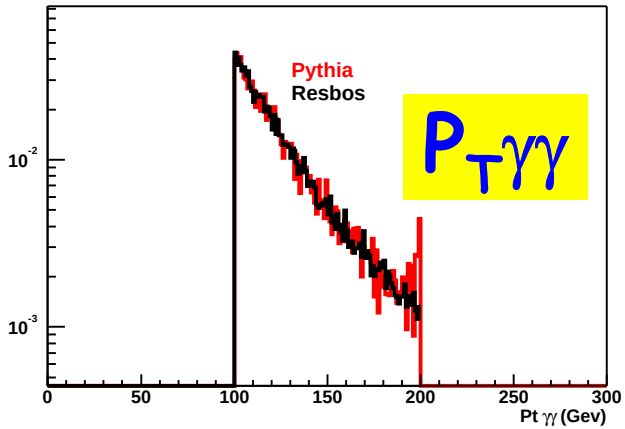
Asymmetric cuts

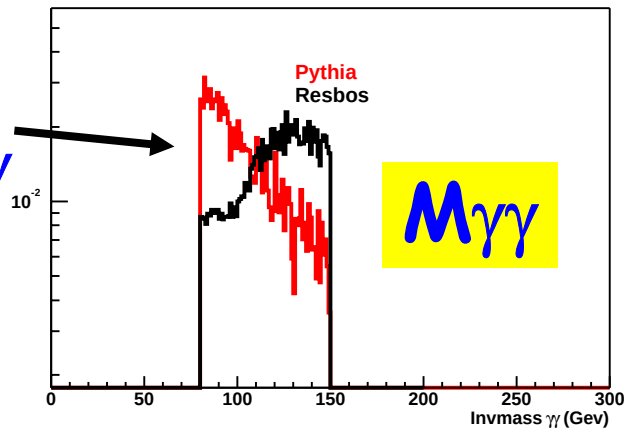


ResBos vs. Pythia (cont)

- However, strong differences in $\gamma\gamma$ spectrum for events with large transverse momentum after re-weighting $P_T\gamma\gamma$ spectrum

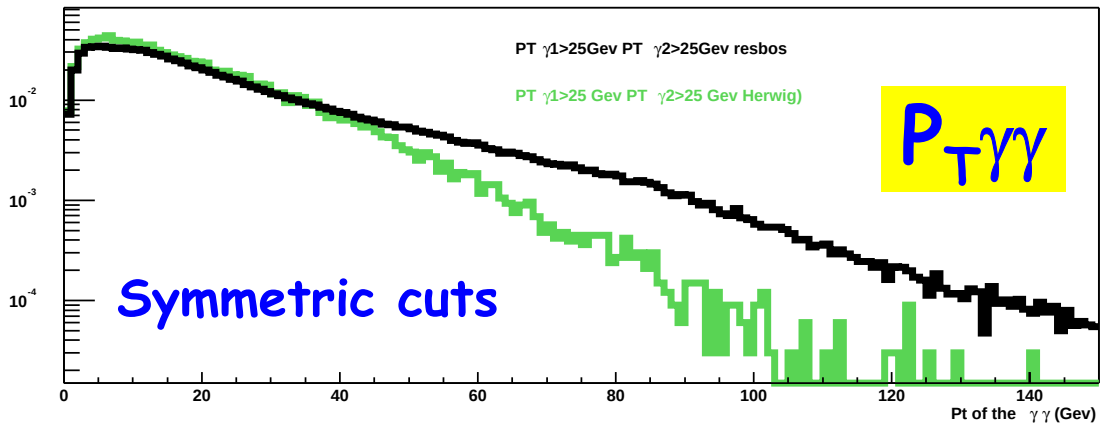


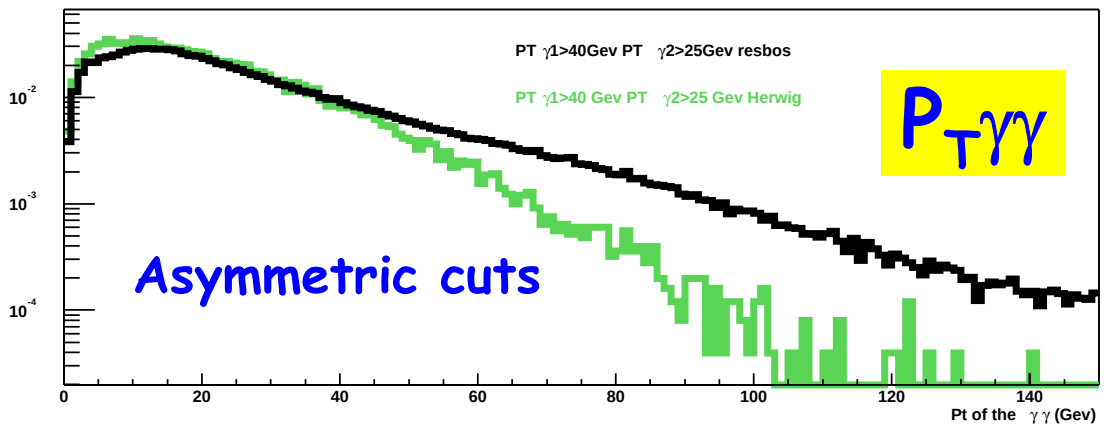




ResBos vs. HERWIG (cont)

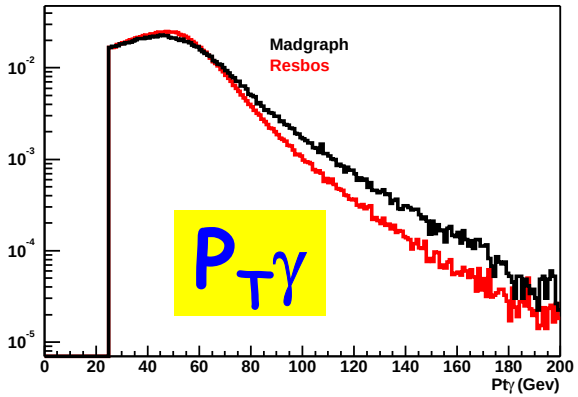
- HERWIG does remarkably well at low-medium P_T. It is expected to fail at high P_T

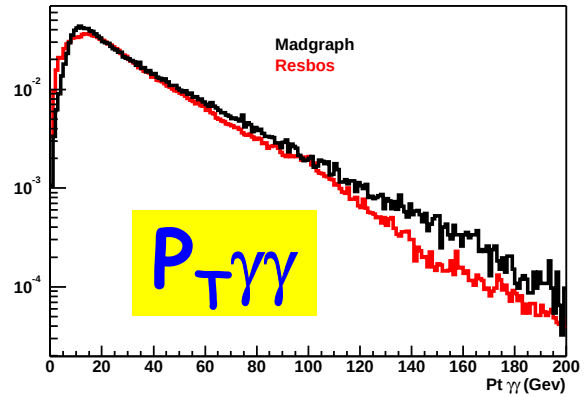


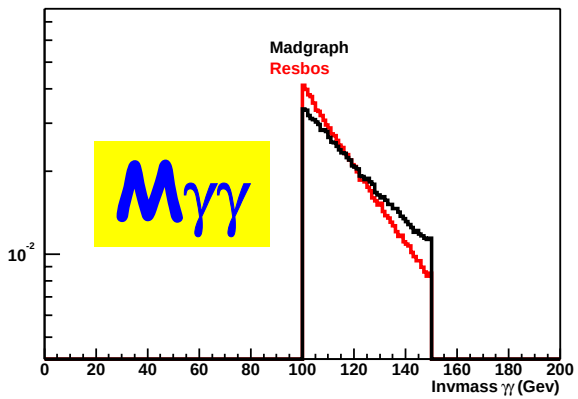


ResBos vs. MadGraphII

- Finally tried with tree ME $\gamma\gamma j$ from MadGraphII interfaced with HERWIG. Placed a low cut on the P_T of the QCD parton (8 GeV)

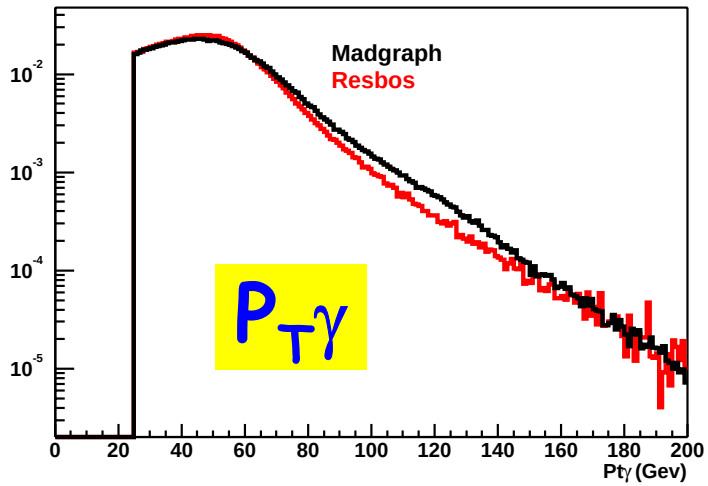


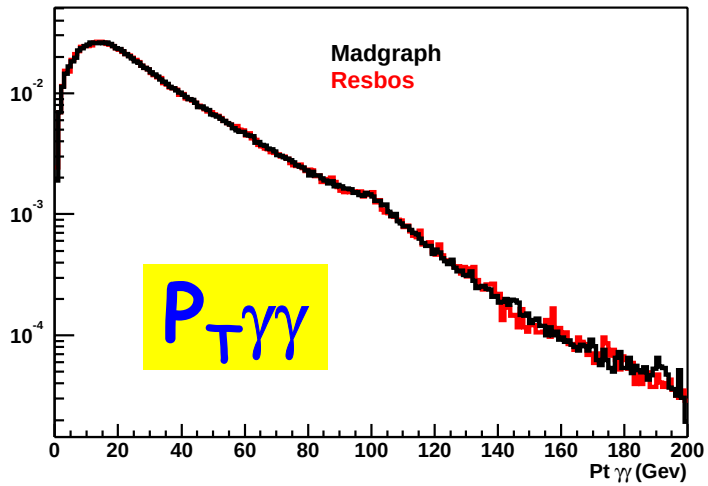


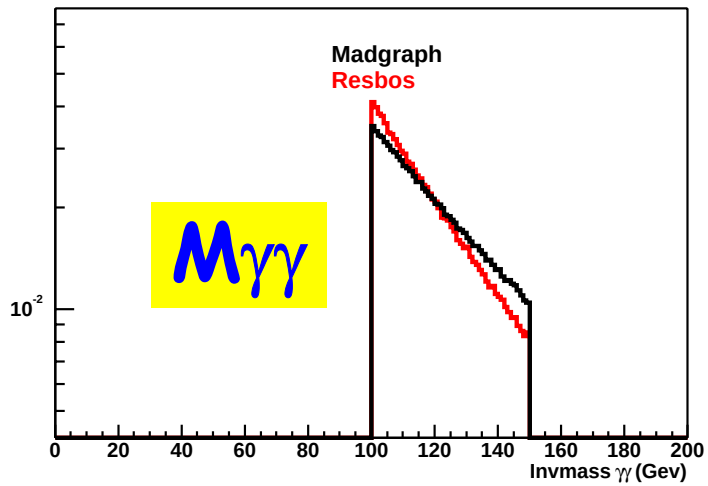


- Before re-weighting

ResBos vs. MadGraphII (cont)

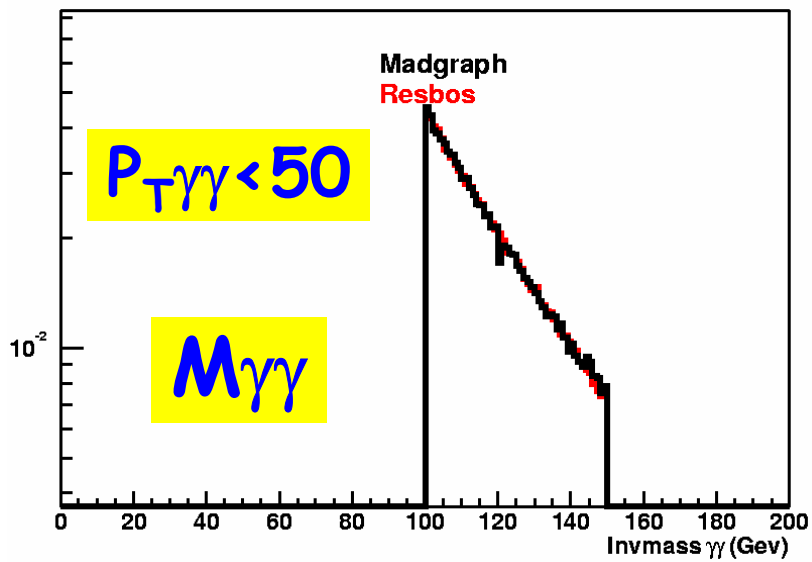


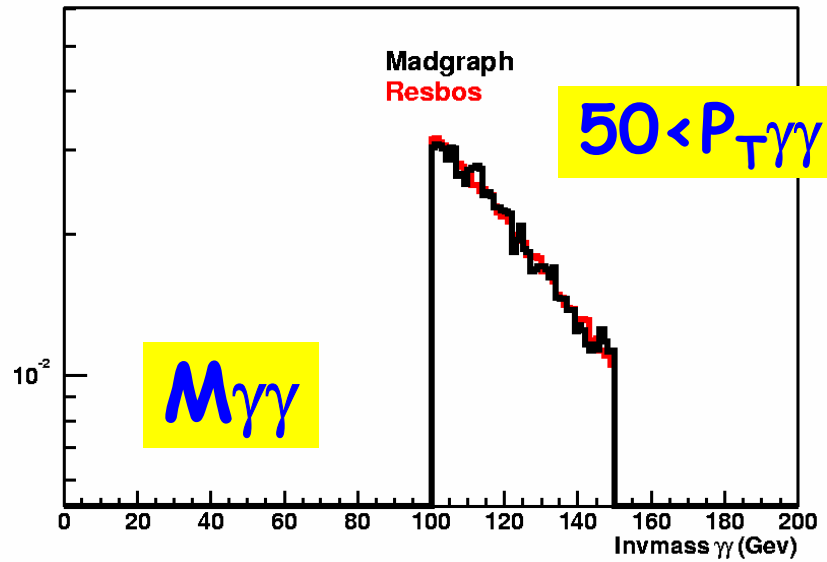


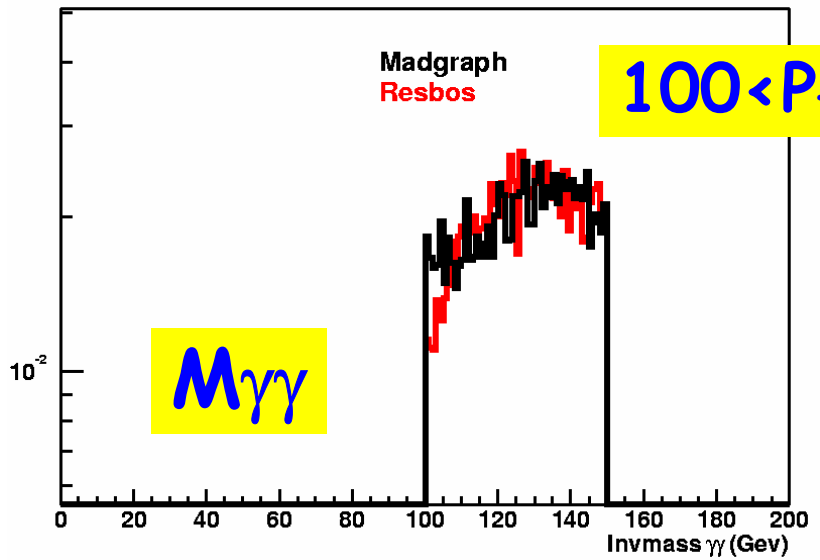


- After re-weighting in $P_T\gamma\gamma$ some discrepancies in Mγγ remain
- Will re-weight Mγγ distribution as well

ResBos vs. MadGraphII (cont)



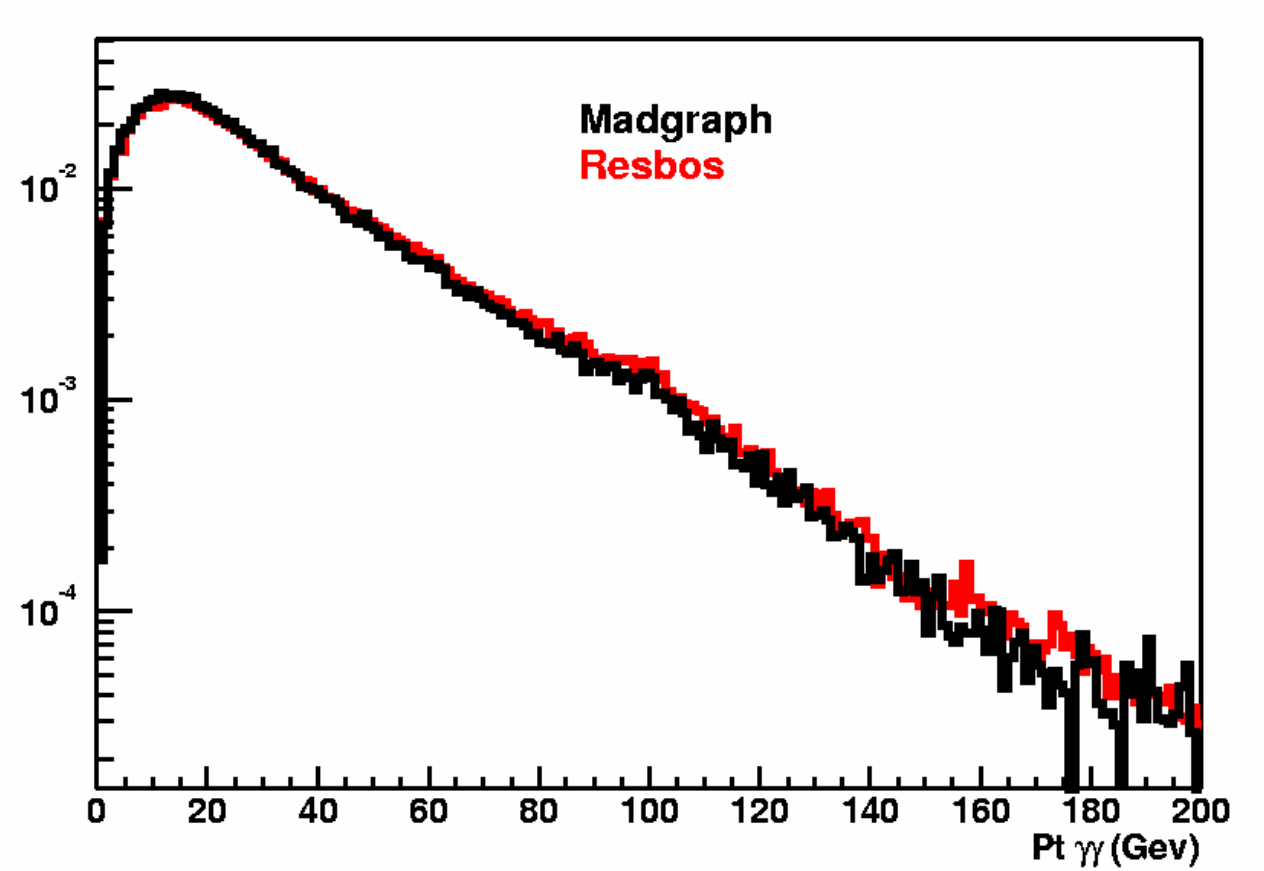




- $M\gamma\gamma$ is re-weighted for $P_T\gamma\gamma < 100$ GeV. For $P_T\gamma\gamma > 100$ GeV, no need to re-weight

ResBos vs. MadGraphII (cont)

- After re-weighting $M_{\gamma\gamma}$ the $P_T{}_{\gamma\gamma}$ spectrum does not change significantly. Now we can move on!!!



Combined Analysis

- Combined analysis with MC@NLO (gg->H), PYTHIA (VBF H) and MadGraphII (irreducible background)
  - Use NLO cross sections for signal and irreducible background
  - For the time being will use earlier studies for contribution from reducible background:
    - TDR for inclusive and "untagged" analyses
    - Wisconsin's results for H->$\gamma\gamma$ + jet (HWG 01/12/03)
- Add $P_T\gamma\gamma$ and $M_J\gamma\gamma$ (when appropriate) as discriminating variables using NN's (think of it as a likelihood method)
  - Use M$\gamma\gamma$ and $P_T\gamma\gamma$ for inclusive and "untagged" samples
  - Use M$\gamma\gamma$, $P_T\gamma\gamma$ and $M_J\gamma\gamma$ for tagged sample

Combined Analysis (cont)

- Analysis for M_H=120 GeV and 10 fb^{-1}

Analysis	Significance (σ)	Improvement (%)
Inclusive with simple counting	2.8	-
Inclusive with $M\gamma\gamma$ as discrim.	2.96	5.7
Inclusive with $M\gamma\gamma$ and $P_T\gamma\gamma$ as discriminating variables	3.44	23
Tagged with $M\gamma\gamma$, $P_T\gamma\gamma$ and $M_J\gamma\gamma$ as discriminating variables	3.28	-
"Untagged" with $M\gamma\gamma$ and $P_T\gamma\gamma$	2.64	-
Tagged and Untagged combined	4.2	46

Combined Analysis (cont)

- These results do not take account for the systematic error on the background normalization
  - Inclusive analysis displays S/B=3.7%. In order for this analysis to reach a 5σ effect with 20 fb^{-1} one needs to control systematic error on background normalization to ~0.3 0.5%
  - Need to assess the combined analysis and systematic errors on the basis of full simulation
- Further suppression of reducible background may increase significance of combined analysis by ~10-15%

Status of γ/jet Separation

- Impact of jj reducible background has been studied with DC1 samples
- Interested in evaluating impact of γj reducible background
  - It is relevant to evaluate differences in rejection patterns between quark and gluon initiated jets, as indicated by Orsay
  - Generated, simulated and reconstructed with Pythia γg and γq final states
    - Interesting to look at γg final state, which yields a sample of gluon initiated jets

Status of γ/jet Separation (cont)

- **Reconstruction performed with Off-Line Release 7.0.2**
  - **Samples with P_{Tg} , P_{Tq} >20 GeV**
    - No Noise
      - higgs.002655.bg_gamma_g.dc1.recon.001._0000.root (776K events)
    - With Noise and LVL1 simulation
      - higgs.002655.bg_gamma_g.dc1.recon.003._0000.root (776K events)
  - **Samples with P_{Tg} , P_{Tq} >30 GeV**
    - No Noise
      - higgs.002680.bg_gamma30_g.dc1.recon.001._0000.root (241K events)
    - With Noise and LVL1 simulation
      - higgs.002680.bg_gamma30_g.dc1.recon.003._0000.root (241K events)

Status of γ/jet Separation (cont)

- **Very PRELIMINARY results using fully simulated and ATLFAST jets for gluon jets (using γg ME, no noise)**
  - Very few EM clusters survive- >huge rejection factor for gluon jets (>10000). Need to understand this

Jet Samples		Initial Number of Jets within acceptance and not photons	Number of Jets matching EM clusters	Number of EM Clusters After Cuts				Rejection
				LVL1	Hadronic	2nd Sampling	1st Sampling	
Reconstructed Jets	20-25 GeV	364836	55524	n/a	150	22	15	24322 (6280)
	30-35GeV	50972	11907	n/a	16	4	3	16990 (9810)
AtlFastB Jets	20-25 GeV	97133	29612	n/a	125	9	3	32378 (18693)
	30-35GeV	20704	7708	n/a	11	1	1	20704 (Huge!!)

Outlook

- Managed to get a MC to describe the P_T spectrum of irreducible $\gamma\gamma$ background
  - Tree- level $\gamma\gamma$j ME based MC (MadGraphII) with 8 GeV cut on QCD parton P_T seems to reproduce well kinematics given by ResBos
- Combined $H\rightarrow \gamma\gamma$ and $H\rightarrow \gamma\gamma$ + jet analysis increases significance by ~45% w.r.t. to baseline inclusive one
  - Addition to inclusive analysis of $M\gamma\gamma$, $P_T\gamma\gamma$ as discriminators enhances significance by ~20 25%
- Need to assess combined $H\rightarrow \gamma\gamma$ and $H\rightarrow \gamma\gamma$ + jet analysis with full simulation
- Very preliminary results on gluon jet rejection yield a very large suppression (>10000)