W,Z + jets studies at Tevatron relevant to Higgs searches at LHC

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ATLAS project

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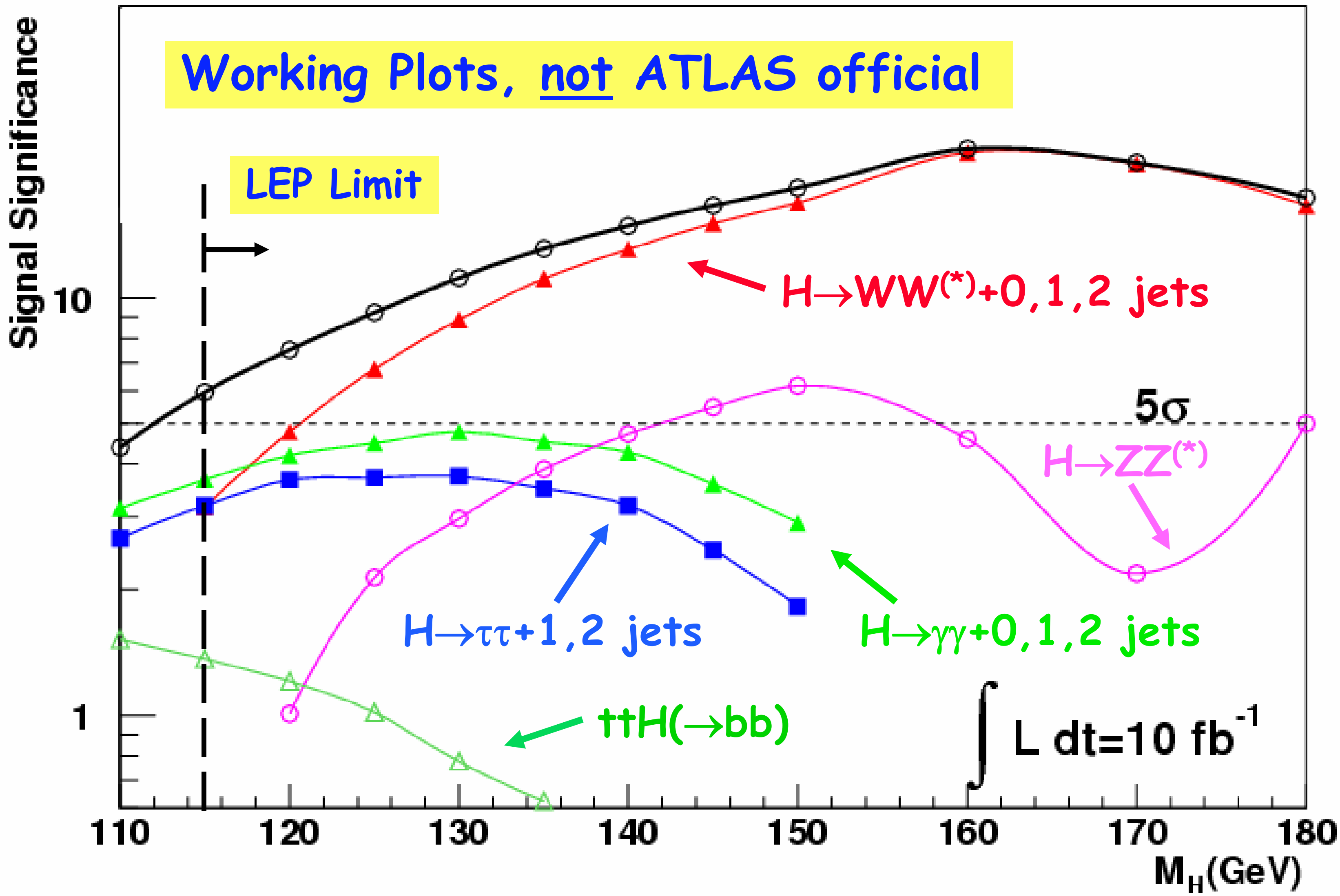
Outline

- Introduction
  - H+jets in Higgs searches at the LHC
  - Considerations on background extraction
- W,Z+jet studies for H+2jets (VBF)
- Z+1jet studies for $\tau\tau$+jet final state
- Jet veto studies for pp->WW+X
- Outlook

Low Mass SM Higgs Potential at LHC



H+jets in Low Mass Higgs Searches at the LHC

- H+jets will play a very important role at the LHC in observing a low mass Higgs
  - These analyses are harder than purely inclusive ones

Relative Sensitivity of H+jets (preliminary)

$H\to\tau\tau$	$H\to\gamma\gamma$	$H\to WW^{(*)}$	$H\to ZZ^{(*)}$
100%	~50%	~50%	~0% (?)

Together with ttH($\to$bb) most important final states close to LEP limit (114 GeV)

On background extraction

- The determination of the SM (mostly QCD) backgrounds associated with jets will rely on LHC data itself
  - Will not rely on a prediction based on extrapolation from Tevatron to LHC
- Control samples in Data are well defined
  - Will require a certain degree of extrapolation from control sample phase space to signal-like region
  - If MC are used for this, extrapolation needs to be validated with Data
  - <u>Tevatron plays a central role in validating MC tools, which will be extensively used at the LHC</u>

On background extraction (cont)

- Take example of H(→ττ)+Jets: Main background Z+jets
  - Can be generalized to rest of final states

Control Sample 1

Z →ee,μμ
Loose cuts on Jets

MC extrap. is validated

Control Sample 3

Z →ee,μμ
Tight cuts on Jets

Replace Z→ ee,μμ by Z→ ττ

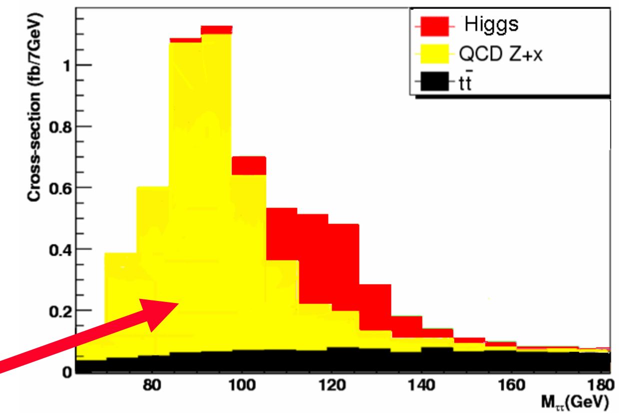
Control Sample 2

Z →ττ
Loose cuts on Jets

MC extrap.

Signal Region

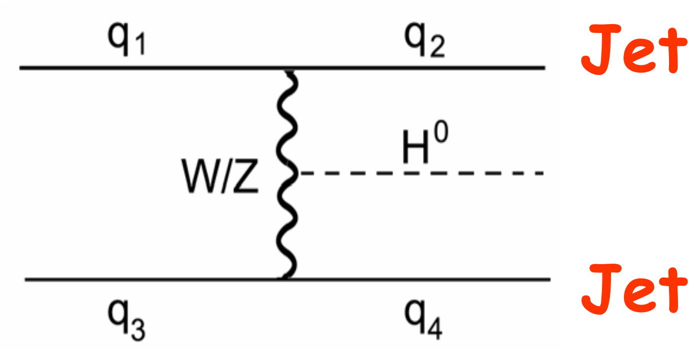
Z →ττ
Tight cuts on Jets



Determine shape of Z →ττ background
Normalization taken from Data in signal—like region

H+2jets (VBF) at the LHC

- D.Zeppenfeld, D.Rainwater, et al. proposed to search for a Low Mass Higgs in association with two jets

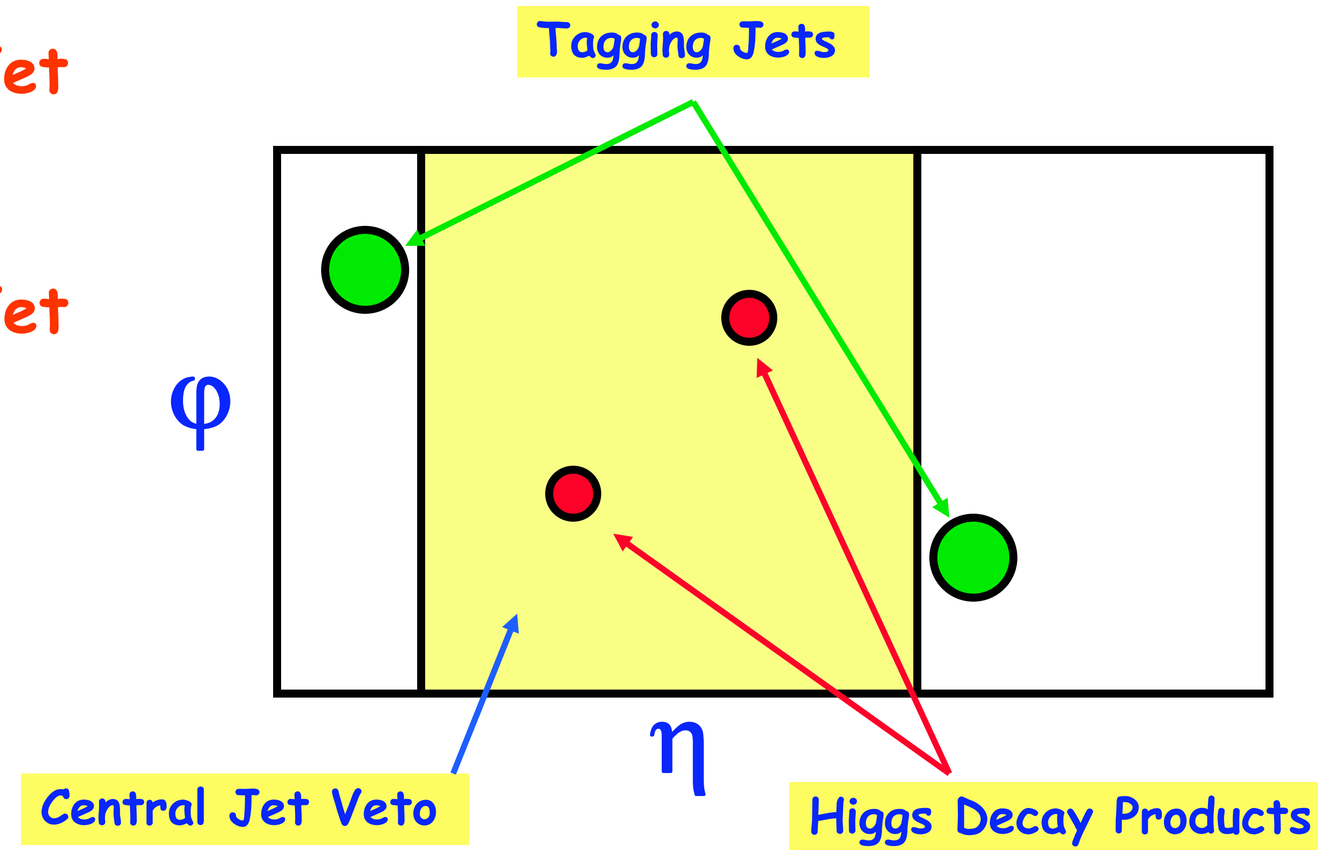


$\eta_{J1} \cdot \eta_{J2} < 0$

$\Delta\eta_{JJ} > 3.5 \div 4$

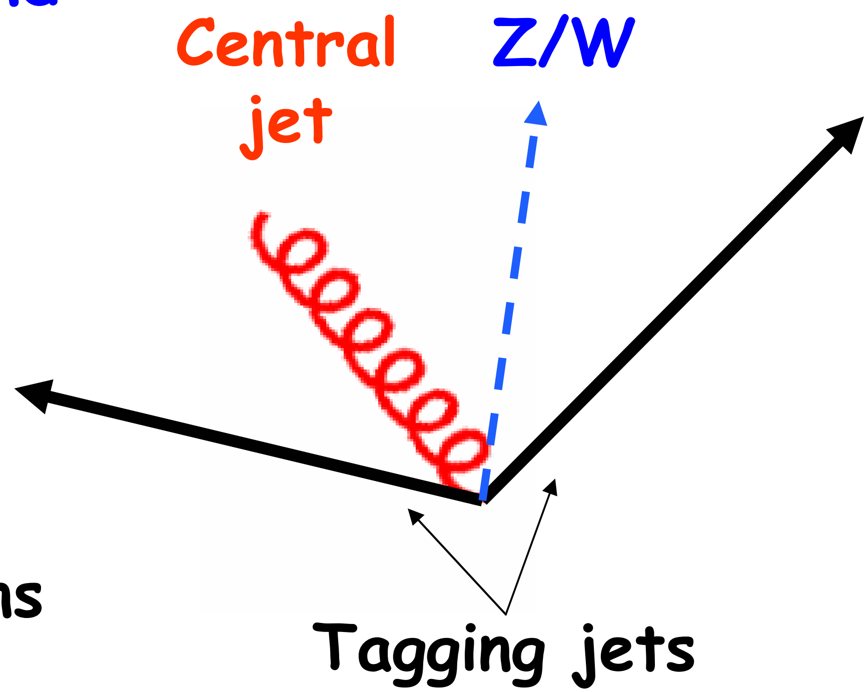
$M_{JJ} > 500 \div 700\mathrm{GeV}$

c.j.v.



H+2jets (VBF) at the LHC (cont)

- Study additional (central) jet production to W + 2 forward and separated jets (tagging jets)
  - Cross-section dependence on separation in pseudorapidity between tagging jets
  - Rate of third jet
  - Angular correlations between tagging jets and central jet
- Comparison with QCD predictions
  - Test interplay between perturbative and parton shower approaches



H+2jets (VBF) at the LHC (cont)

- Effective cross-sections (in pb) evaluated with MadGraphII for the Tevatron
  - Fast simulation with basic detector response (thanks to M.Martinez and Y-K.Kim)

Process	$\eta_{j_1 j_2} > 2$	$\eta_{j_1 j_2} > 2.5$	$\eta_{j_1 j_2} > 3$	$\eta_{j_1 j_2} > 3.5$	$\eta_{j_1 j_2} > 4$
QCD Wjj	7.07	4.29	2.40	1.23	0.56
EW Wjj	0.12	0.07	0.04	0.03	0.01
QCD $Wjjjj$	0.34	0.22	0.13	0.07	0.04

- W+2j and W+4j display large enough cross-section at the Tevatron
  - Very hard to disentangle EW from QCD W/Z production

H(→ττ)+1jet at the LHC

- Tag one semi-central jet, require P_{TH}>100 and M_{HJ}>700 GeV and a loose central jet veto ("top killer")
  - Allow significant contribution from gg->h

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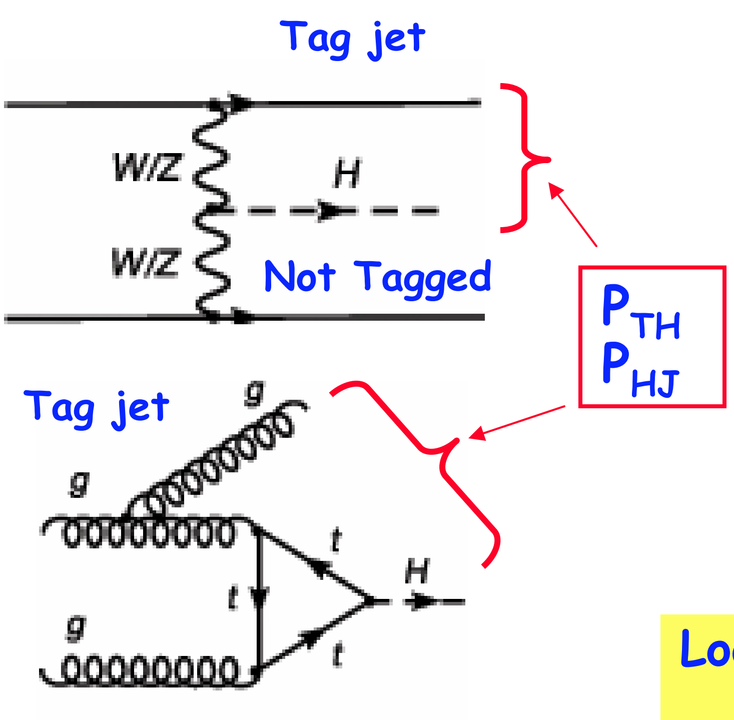
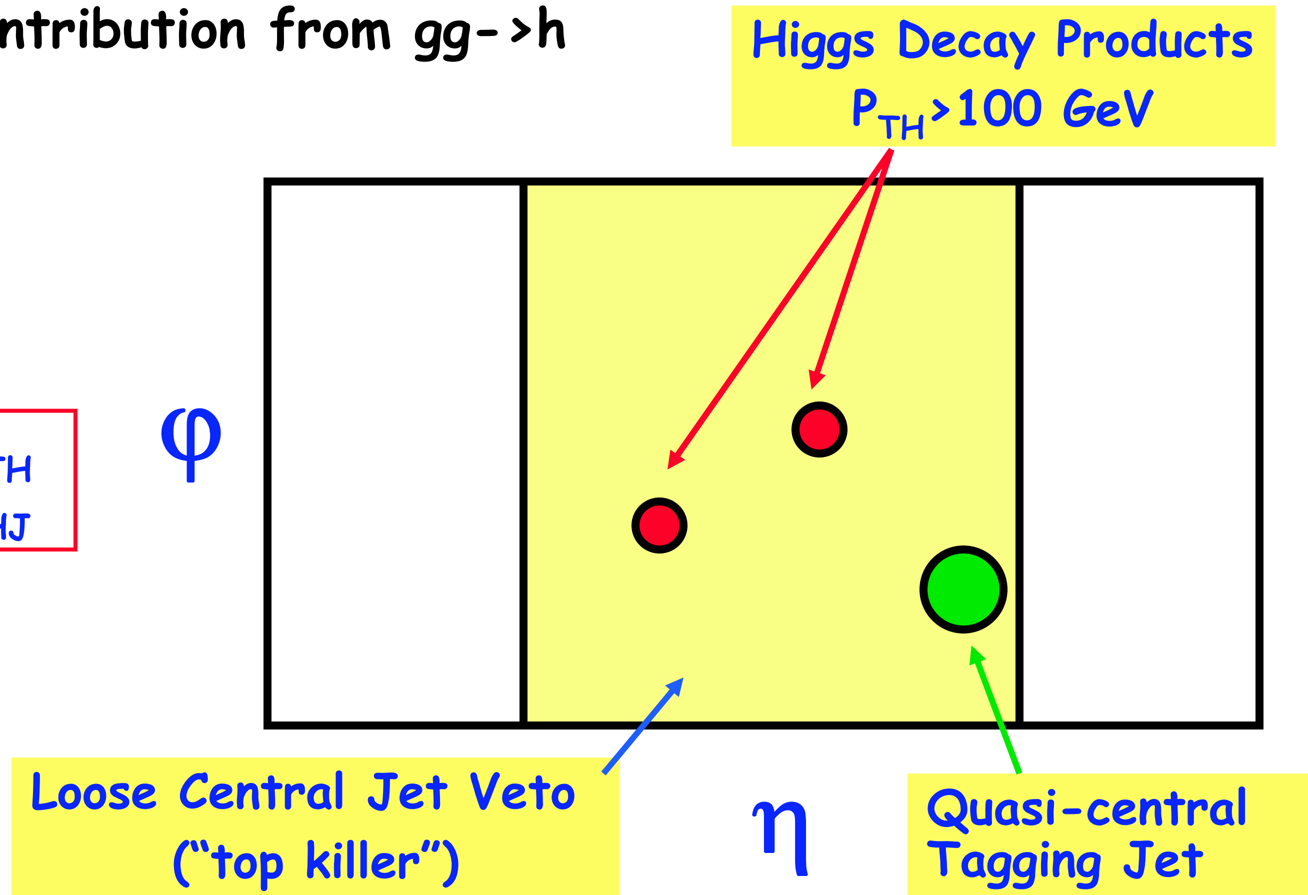
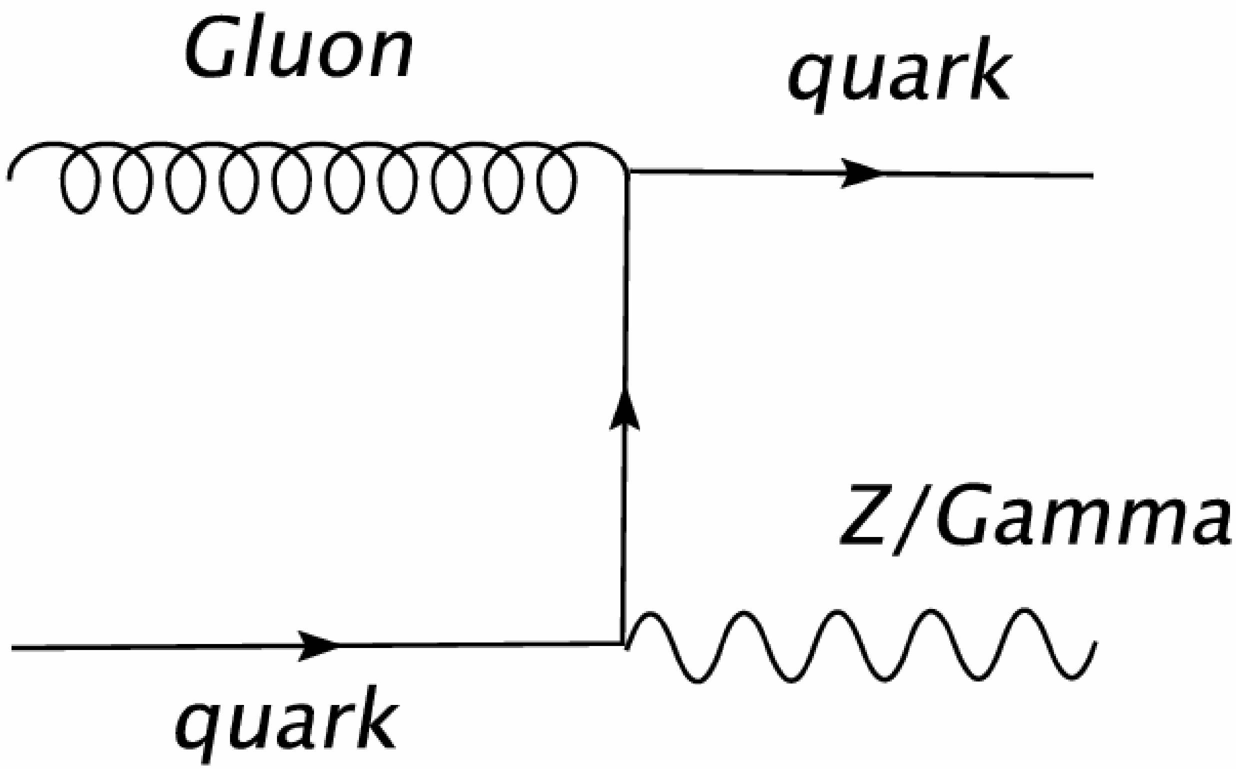
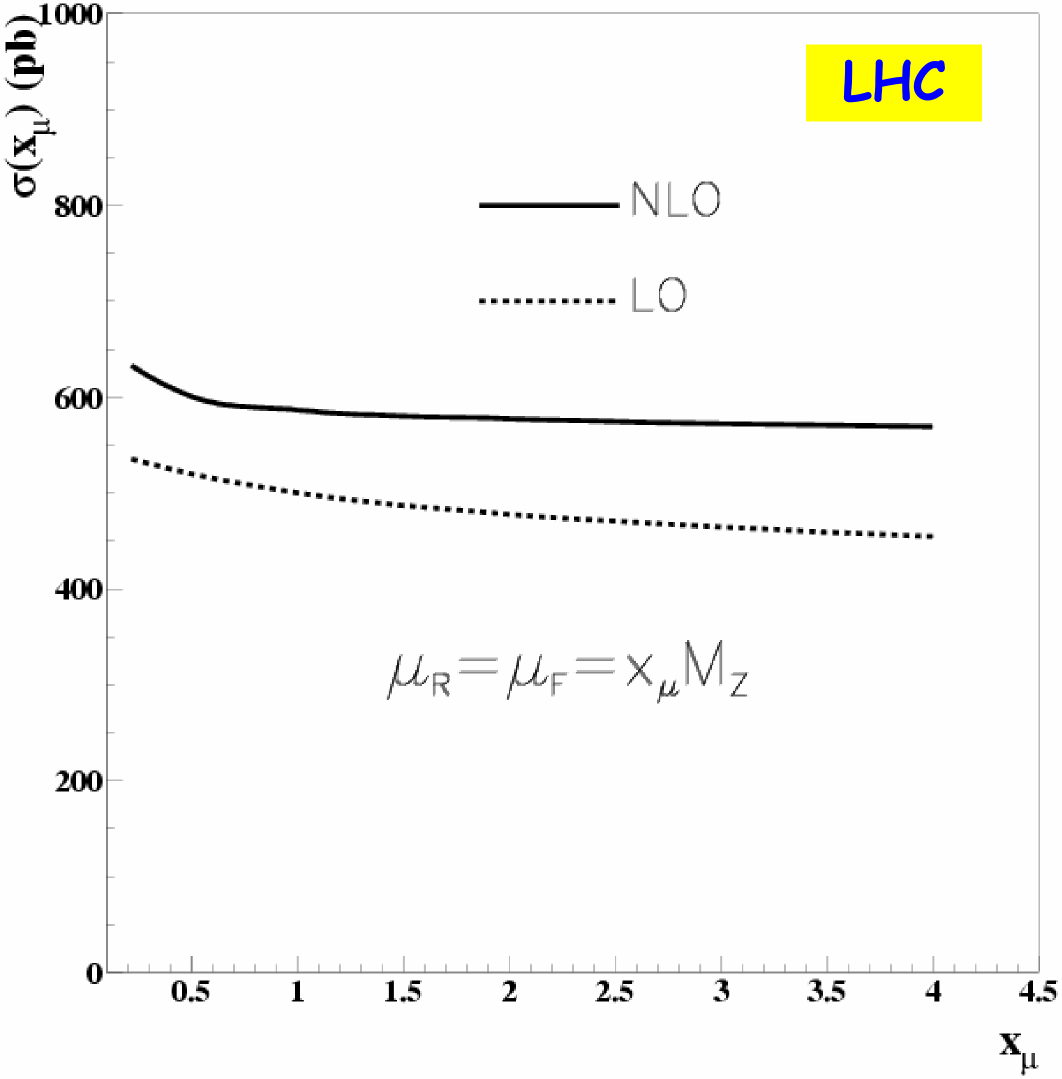




- QCD Z+1j production gives about 50% of background
  - Need to evaluate role of QCD higher order corrections
    - These are not trivial due to specifics of cuts

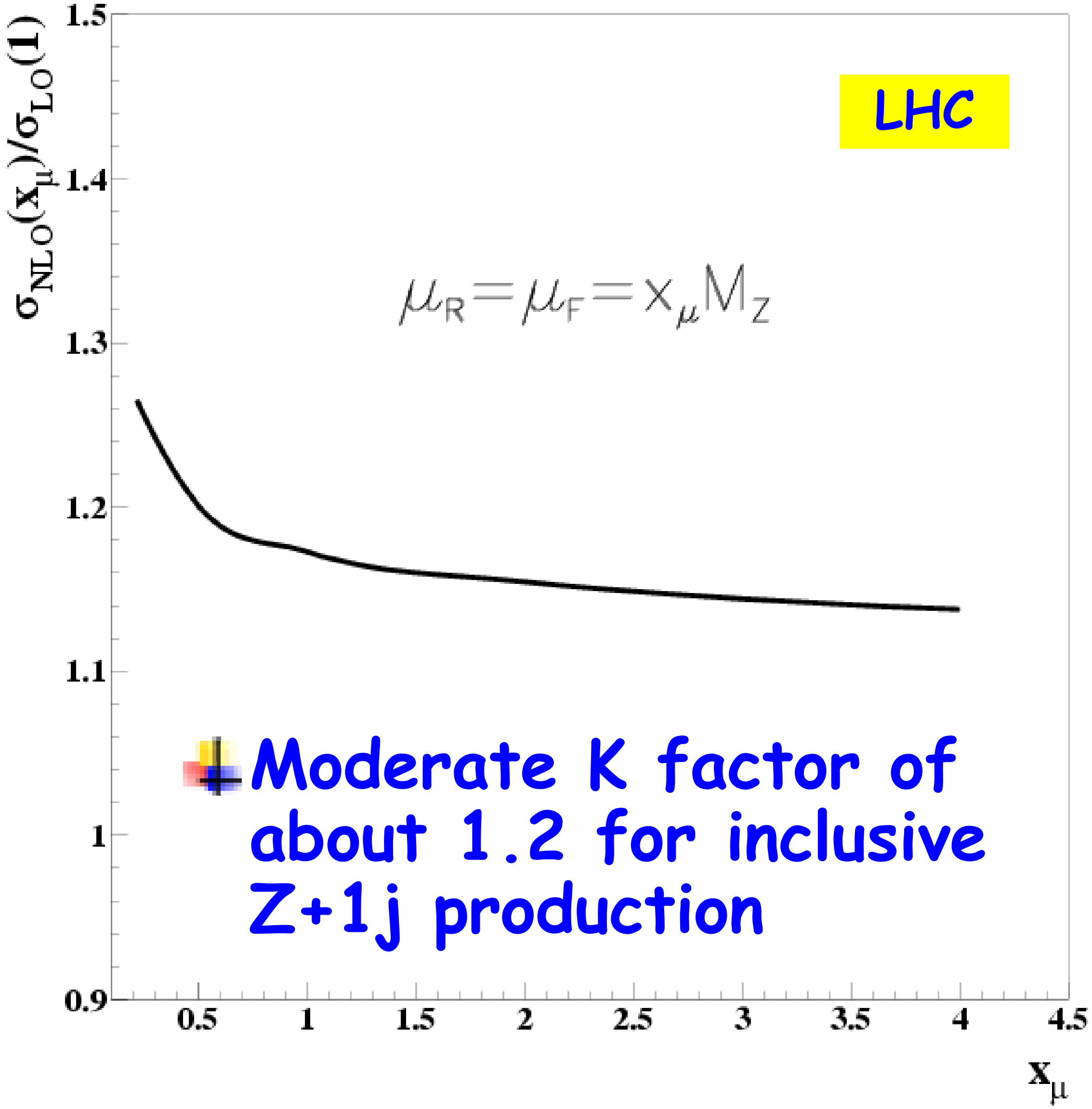


QCD HO Corrections in QCD Z+1jet



MCFM

K Factor



MCFM

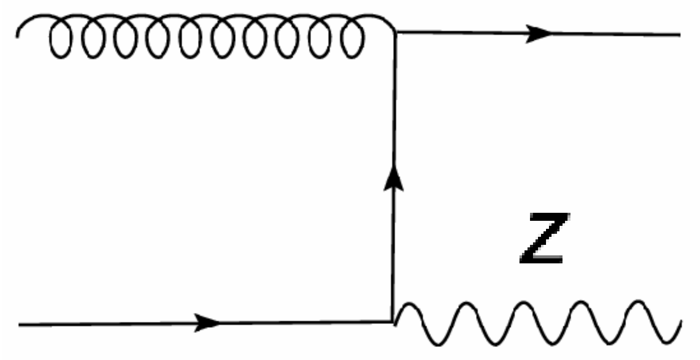
- Moderate K factor of about 1.2 for inclusive Z+1j production

QCD HO Corrections in QCD Z+1jet (Kinematic Effects)

- MC@NLO: Kinematic effects of Higher Order corrections to Z+1j (incorporates LO Z+1j ME) are given by Parton Showers
  - Certain limitations, which are analysis dependent
- SHERPA incorporates consistent matching between multi-parton tree-level ME with Parton showers
  - It gives rates to LO but it is a good tool to address kinematic effects of extra hard gluon radiation in the final state
  - <u>Generate same number of events with Z+1j ME + PS and Z+2j ME + PS with SHERPA</u>

Z+1jet Study with SHERPA

Z+1j ME



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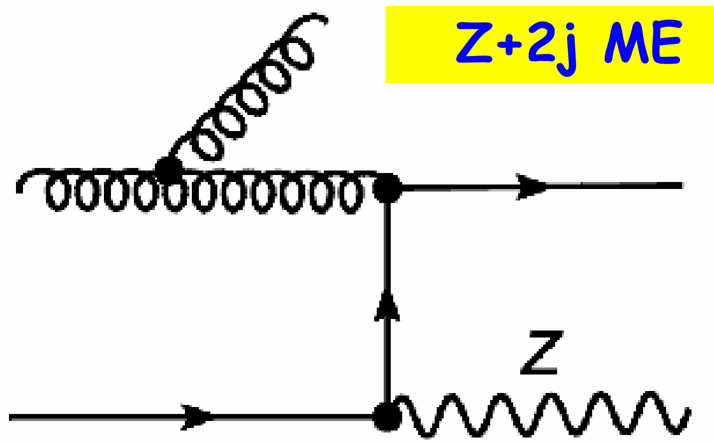
Parton Shower for extra gluon radiation

Z+2j ME



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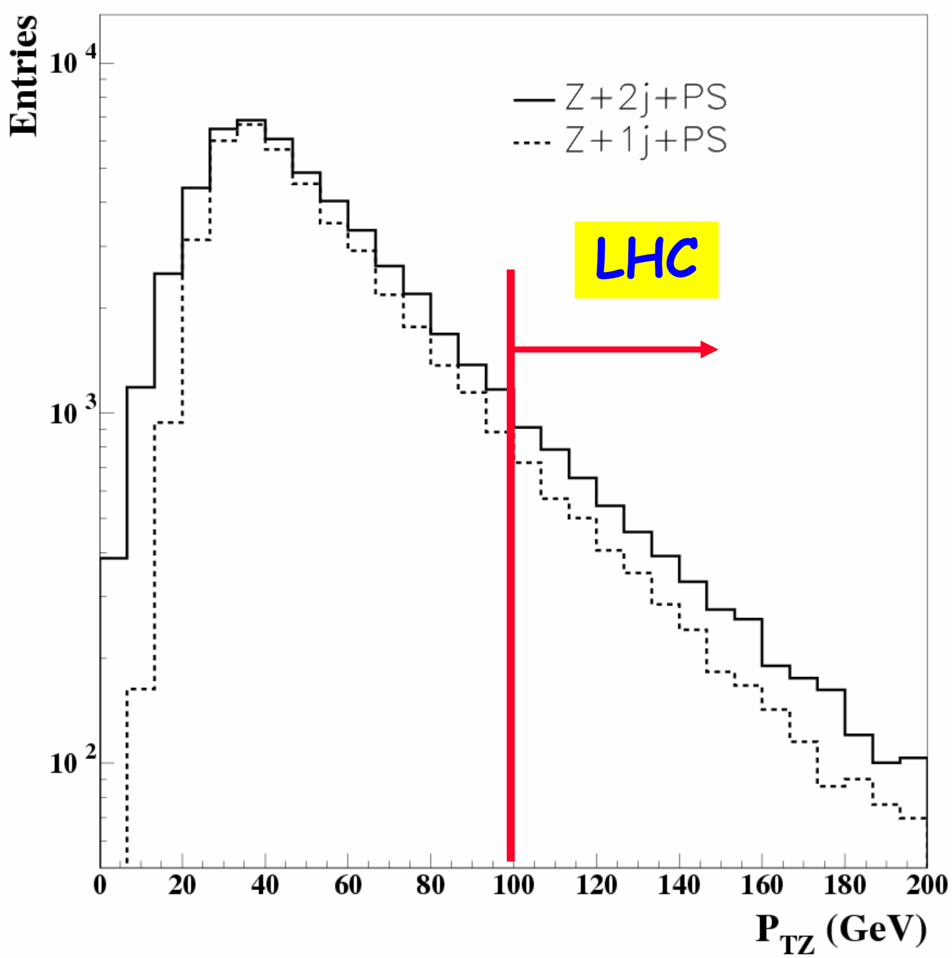
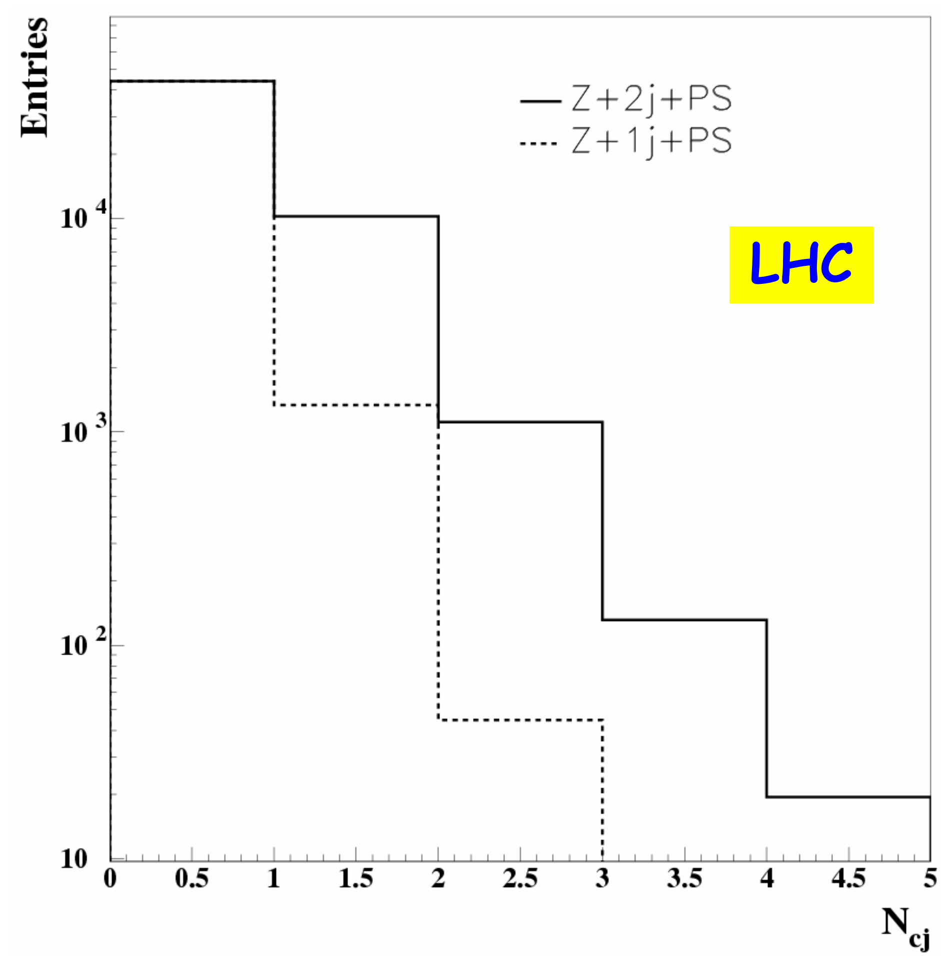
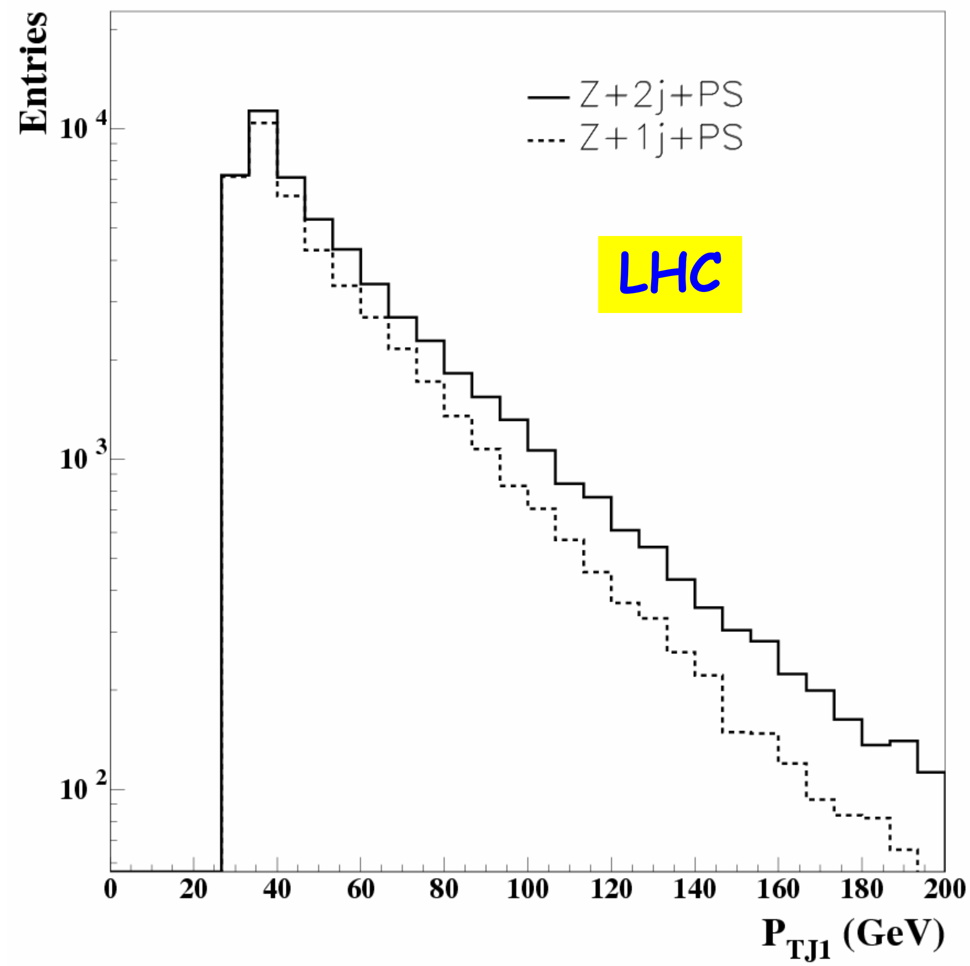
Parton Shower for extra gluon radiation

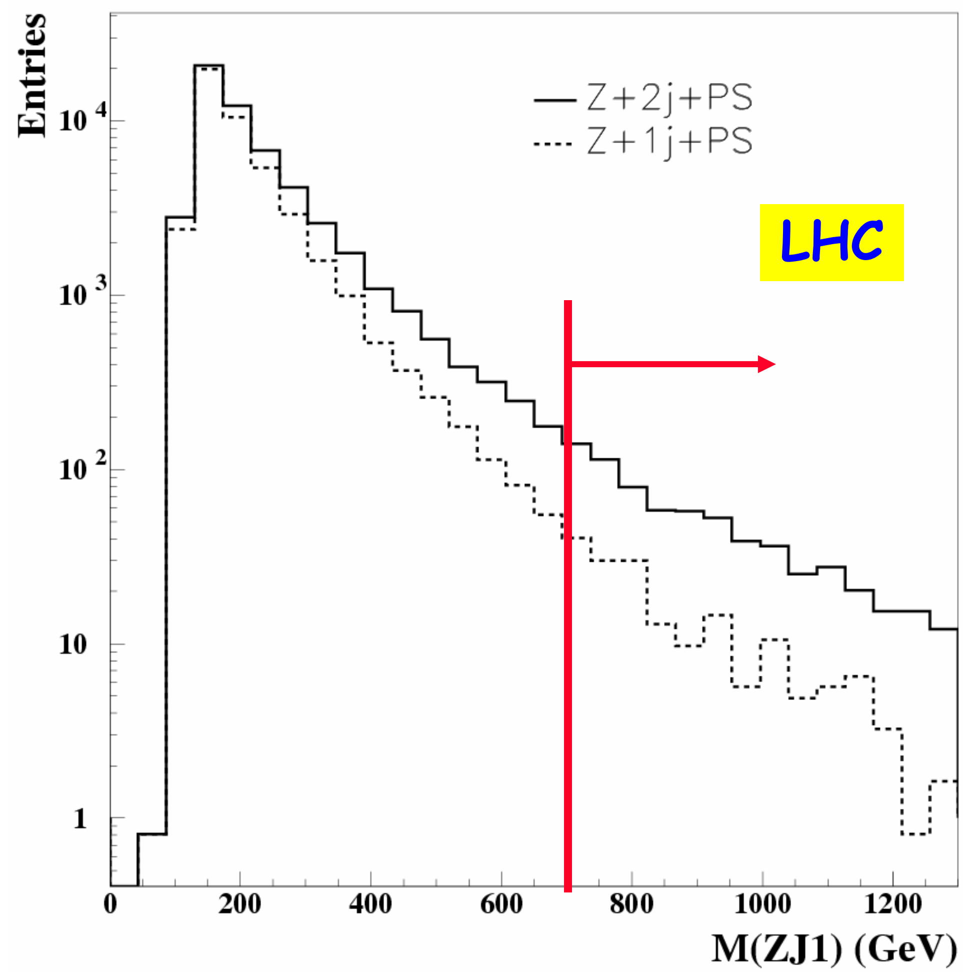
- Require at least one jet with P_T>30 GeV
- To define an extra jet P_T>30 GeV is also required
  - N_{cj} = number of extra jets with $|\eta|<2$



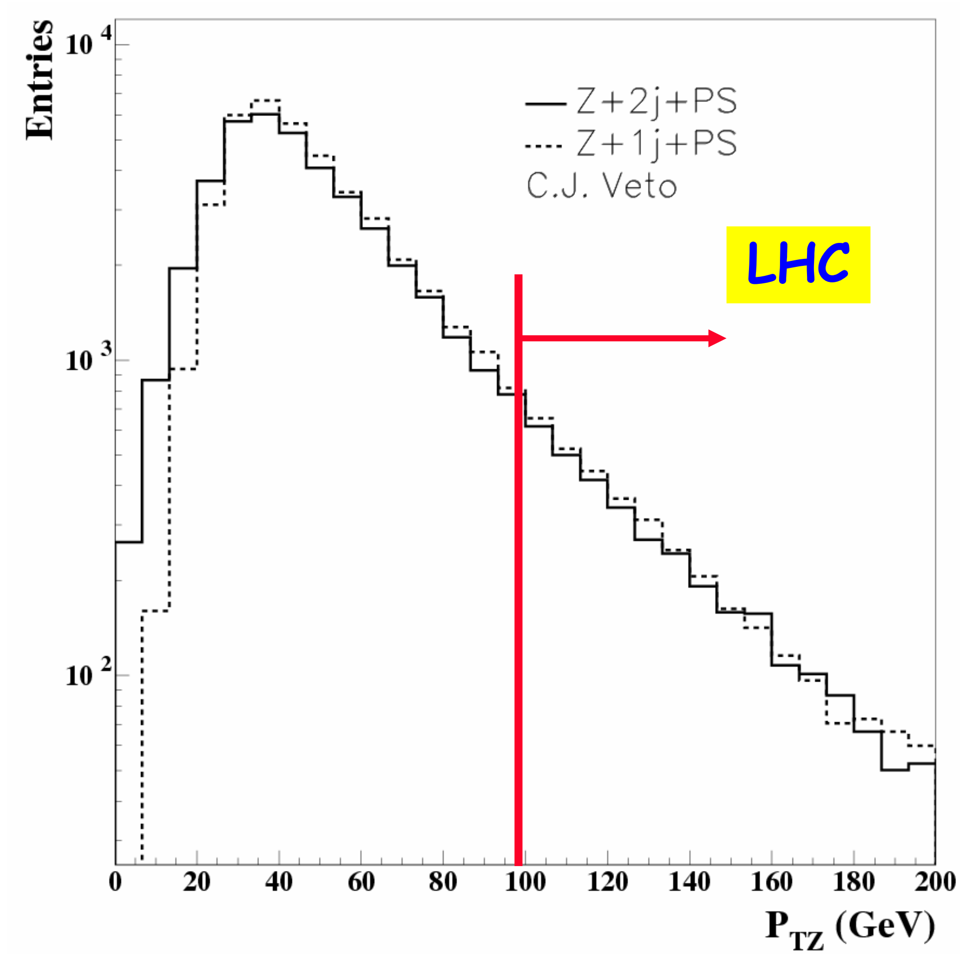


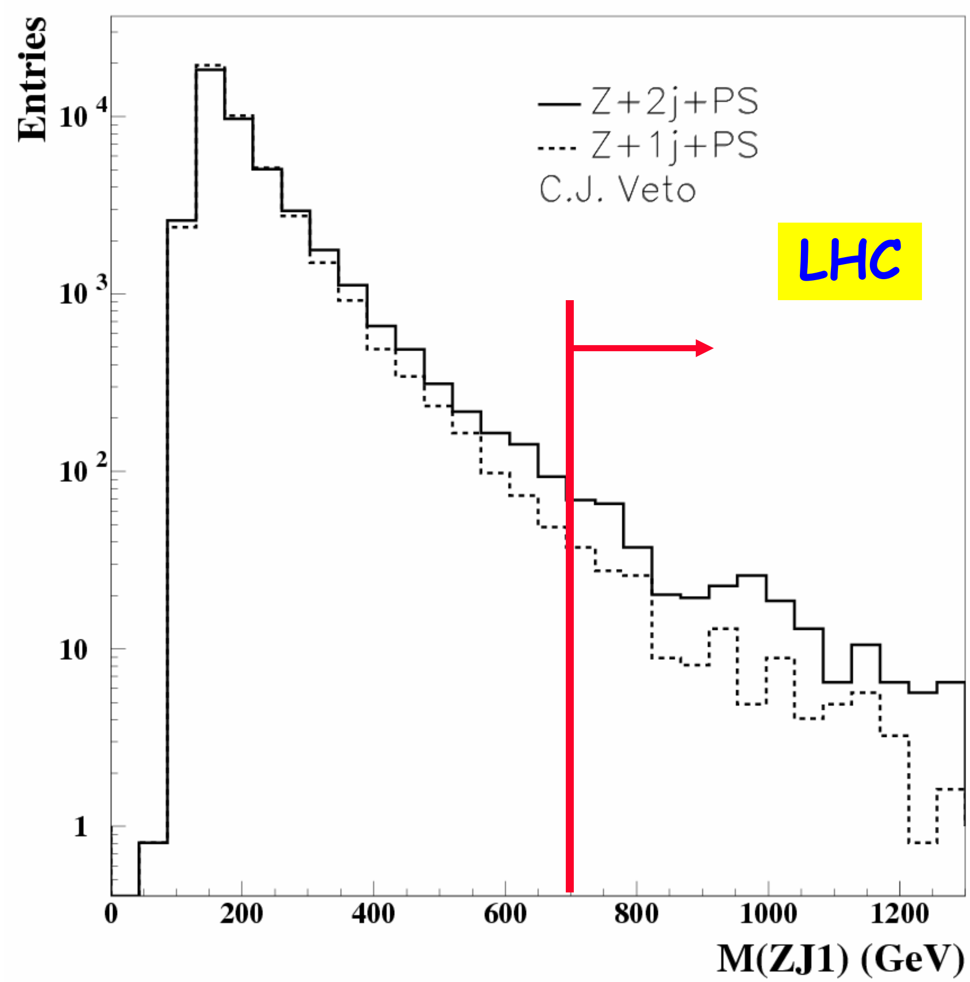
Strong effect on P_T of leading jet and the invariant mass of Z and the leading jet



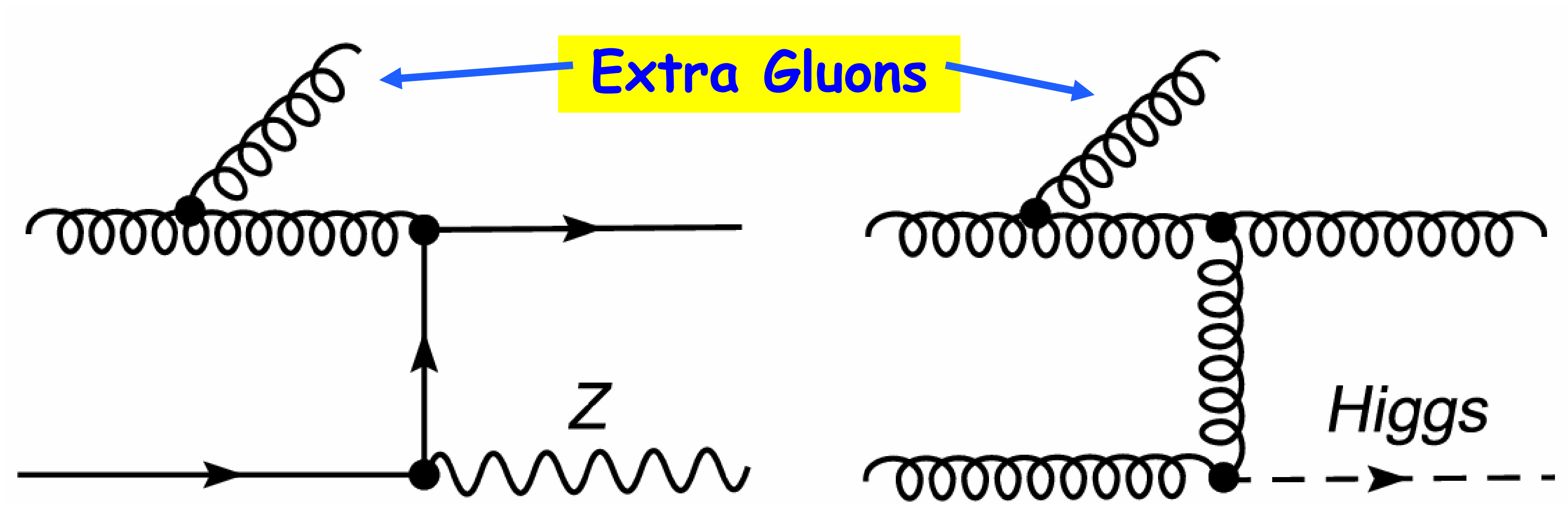


- Central jet veto ("top killer", P_{TJ}<30GeV) significantly reduces effect of higher order corrections
  - With M_{ZJ}>700 GeV Z+1j increases by factor of 2

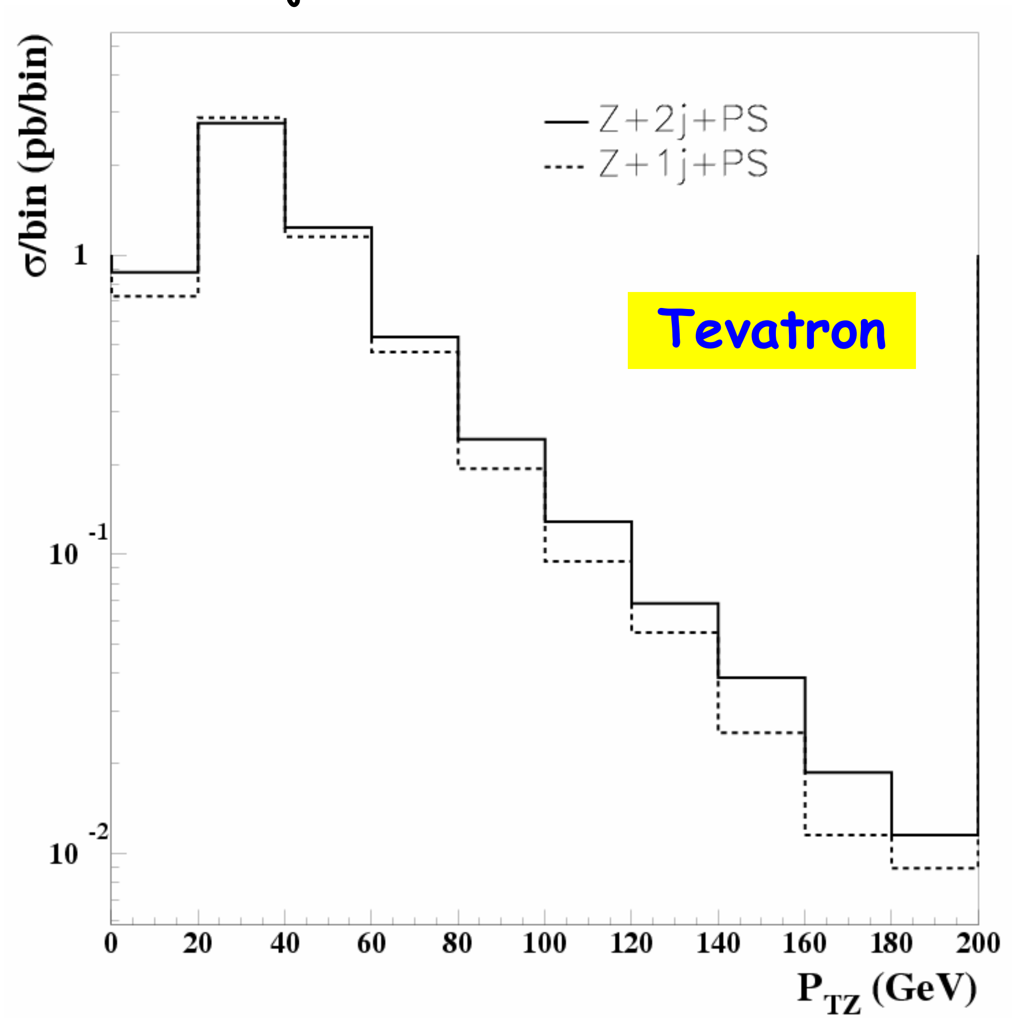


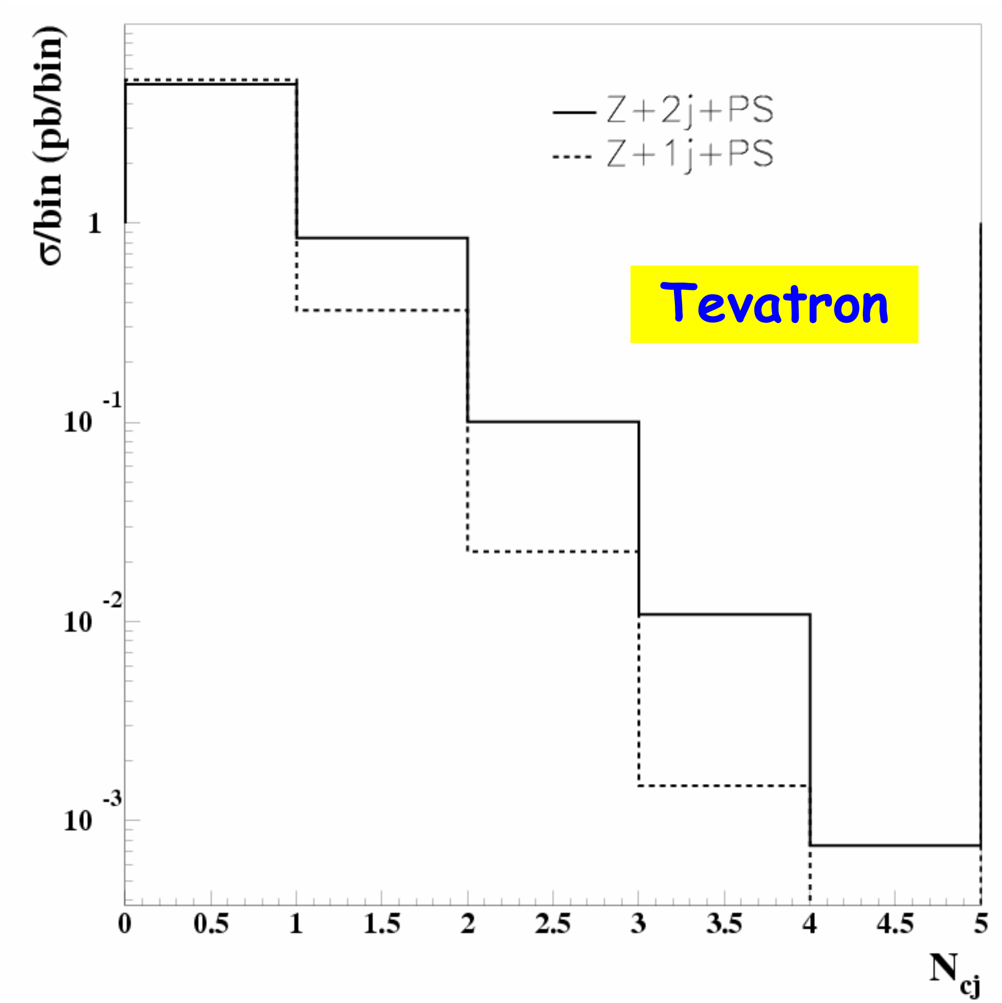


- Enhancement of Z+1j background due to extra gluon radiation may be excellent news to the analysis
- H+1j and Z+1j diagrams bear strong similarities. Expect similar effect on Higgs production.
  - If signal enhancement turns out to be large then it would be a good idea to remove the central jet veto to further improve the signal significance
  - Requires study within SHERPA

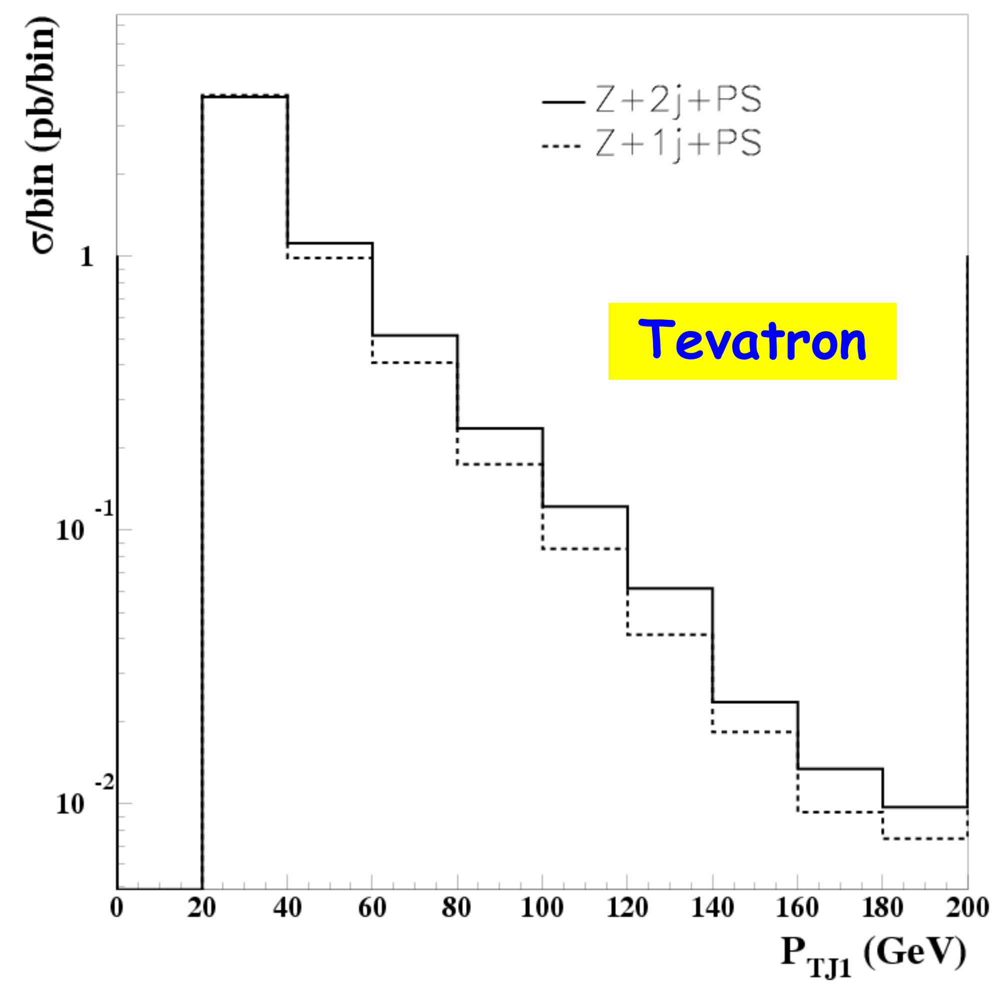


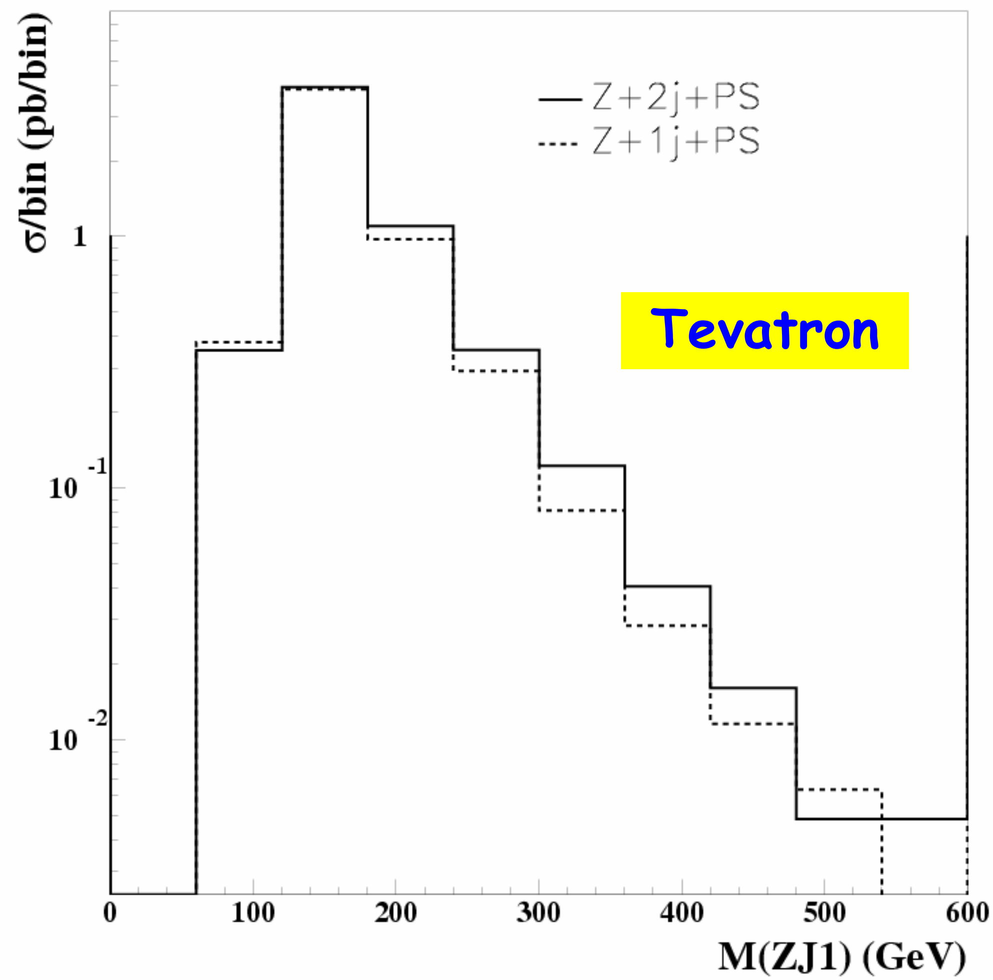
- Require at least one jet with P_T>20 GeV
- To define an extra jet P_T>20 GeV is also required
  - N_{cj} = number of extra jets with $|\eta|$<2





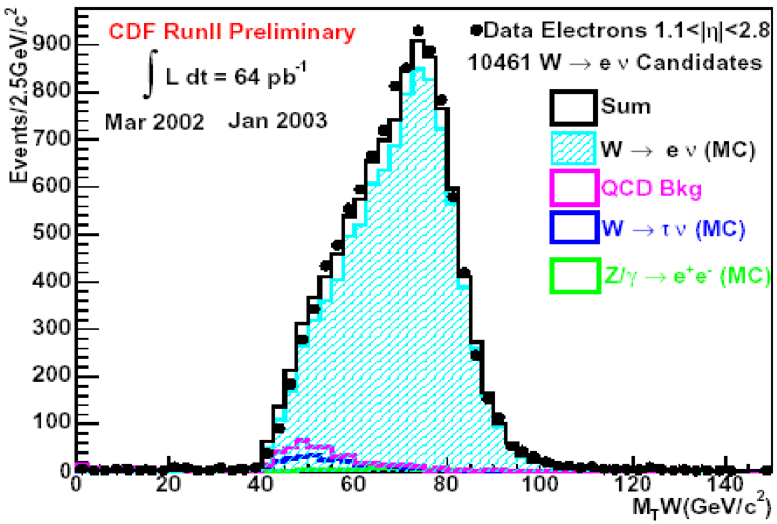
- Cross-section is large enough at the Tevatron to do studies at large P_{TZ}, P_{TJ} and M_{ZJ}
  - About 100-200 fb for P_{TZ}>100 GeV

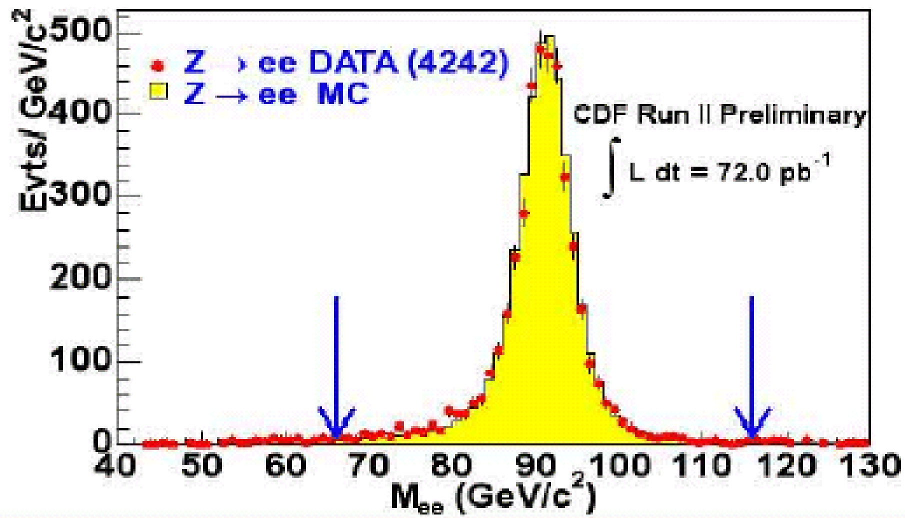




W/Z + jets in CDF

Preliminary, (kindly provided by CDF)





W+jets

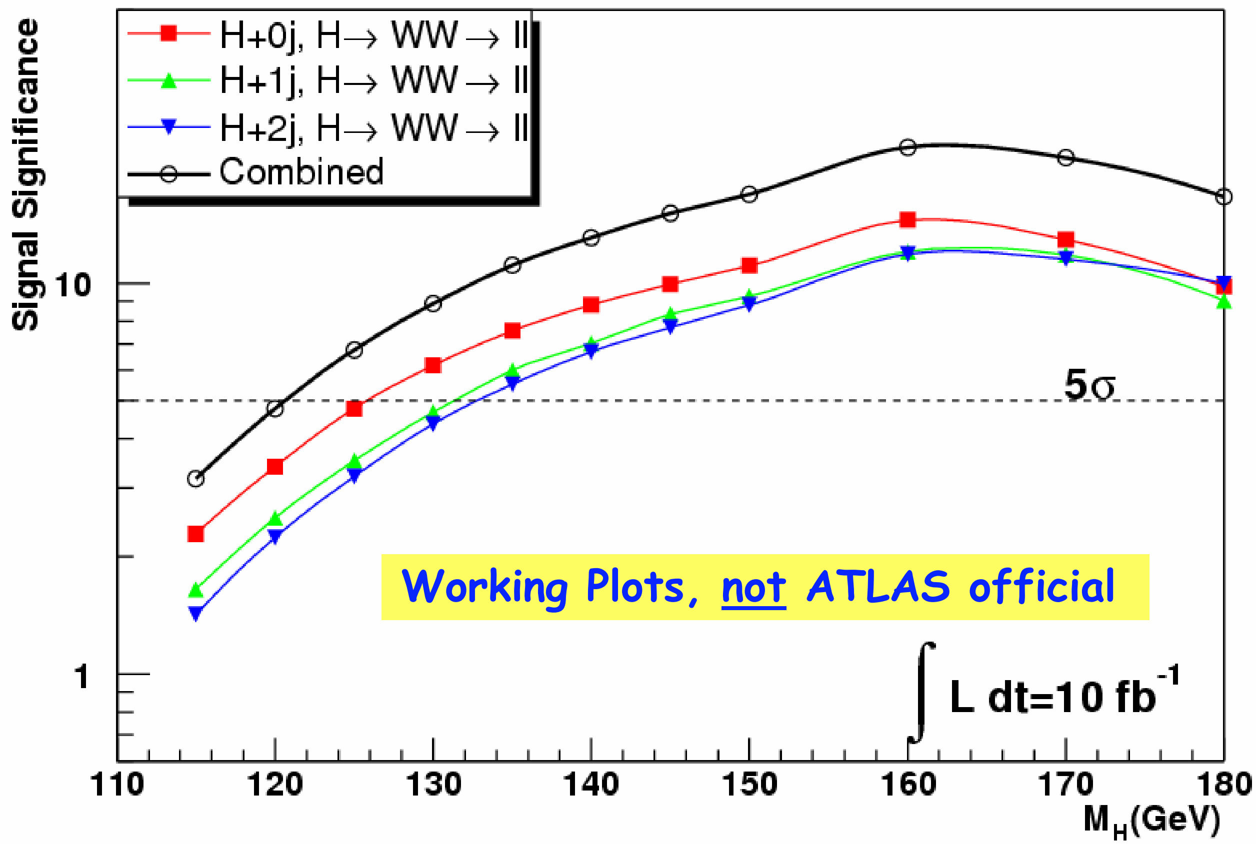
n	≥ 0	≥ 1	≥ 2	≥ 3	≥ 4
N_n	54799	11615	2680	602	145
B_n	1869	951	349	138	55

Z+jets
(central electrons)

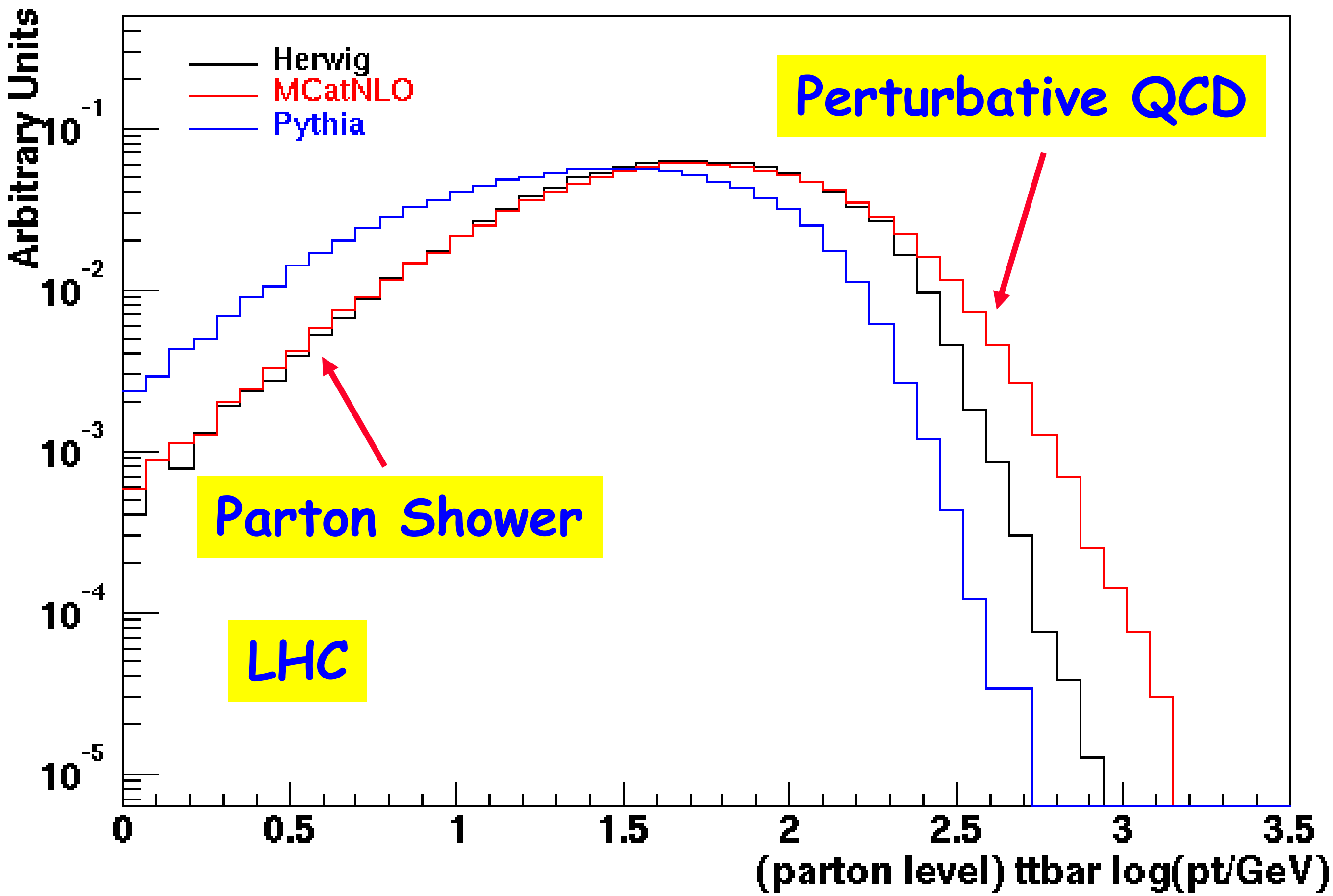
	≥ 0	≥ 1	≥ 2	≥ 3	≥ 4
N_n^{cand}	4232	935	193	40	4
N_n^{bkg}	6,51	8,01	3,82	0,67	0,10
$\epsilon_n(\%)$	80,53	76,66	70,31	69,78	85,76
$A_n(\%)$	10,81	10,13	9,40	9,48	11,70

Jet veto studies for pp→WW+X

- The application of a jet veto in pp→WW+X is fundamental to Low Mass Higgs searches with H→WW→llνν at the LHC
  - MC will be validated with tt, WW samples with $M_{ll} > M_H$, and ZW



- **Different MC's (Pythia and MC@NLO/Herwig) predict very different P_T of tt for LHC. Differences should be visible already at the Tevatron**
  - P_T of tt strongly correlated to jet multiplicity



Outlook

- Higgs associated with jets play a central role in searches for Low Mass Higgs at the LHC
  - Need to extract reliably QCD backgrounds
    - Will rely on LHC data to extract QCD backgrounds
  - Tevatron plays a central role in validating MC tools, which will be extensively used at the LHC
- W/Z associated with jets are produced copiously enough at the Tevatron to study topologies relevant to H+1j and H+2j searches at the LHC
  - Cross-sections for W/Z+1,2,4 jets are large enough to investigate relevant corners of the phase-space
- Jet veto in pp→WW+X is central to Higgs searches with H→WW→llνν at the LHC