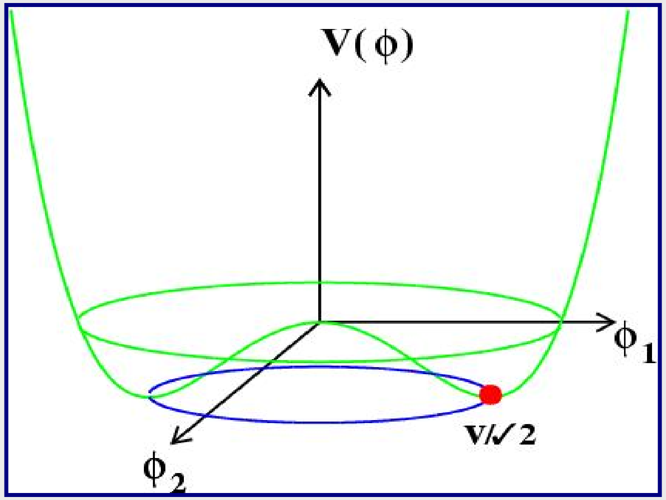
Experimental Summary of Higgs Session

Physics at TeV Colliders

Les Houches, 11-29 June 2007

on behalf of the LH'07 Higgs WG

Convenors: Sally Dawson, Massimiliano Grazzini,
Sasha Nikitenko, Markus Schumacher



Les Houches June 29th 2007

Overview

- ❖ $gg \rightarrow ZZ$ background for $H \rightarrow ZZ$ 4l

- ❖ issues related to vector boson fusion

  - background from double parton scattering
  - jet veto versus track veto
  - event rates from $gg \rightarrow Hjj$ after VBF selction
  - jet veto efficiency for signal from data: $Z(\gamma)jj$ and single top

- ❖ difficult regions in BSM Higgs Models

  e.g. NMSSM or CPX scenario of CPV MSSM

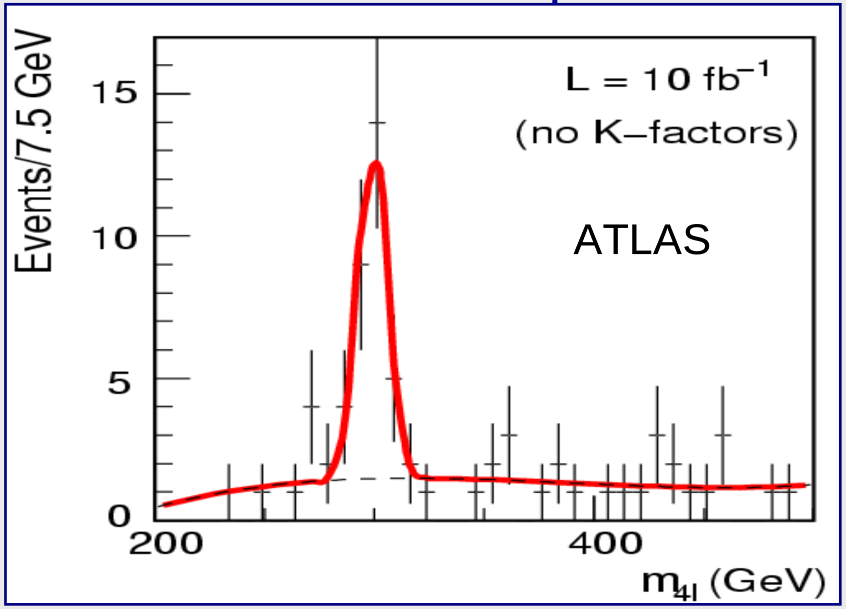
  i) lightest H decoupled from Z/W and t

  → exp study: $tt \rightarrow W+bH-$, $H^- \rightarrow W^-H_1$, $H_1 \rightarrow bb$

  ii) large BR for light H → A A with A→tau tau (bb)

  → exp study: VBF, WH with H→AA→4 tau →2mu 2 had , 4 mu

H→ZZ→ 4 Leptons



dominant background is

irreducible pp→ZZ—4l

so far only: qqbar → ZZ → 4l in MC

(estimate up to now: 30% after cuts)

new: MC generator for gg→ZZ→4l

by Nicolas Kauer

- question: - how much is contribution from gg→ZZ after all cuts?
  - difference in distributions from qqbar and gg e.g. M_{4l} ?

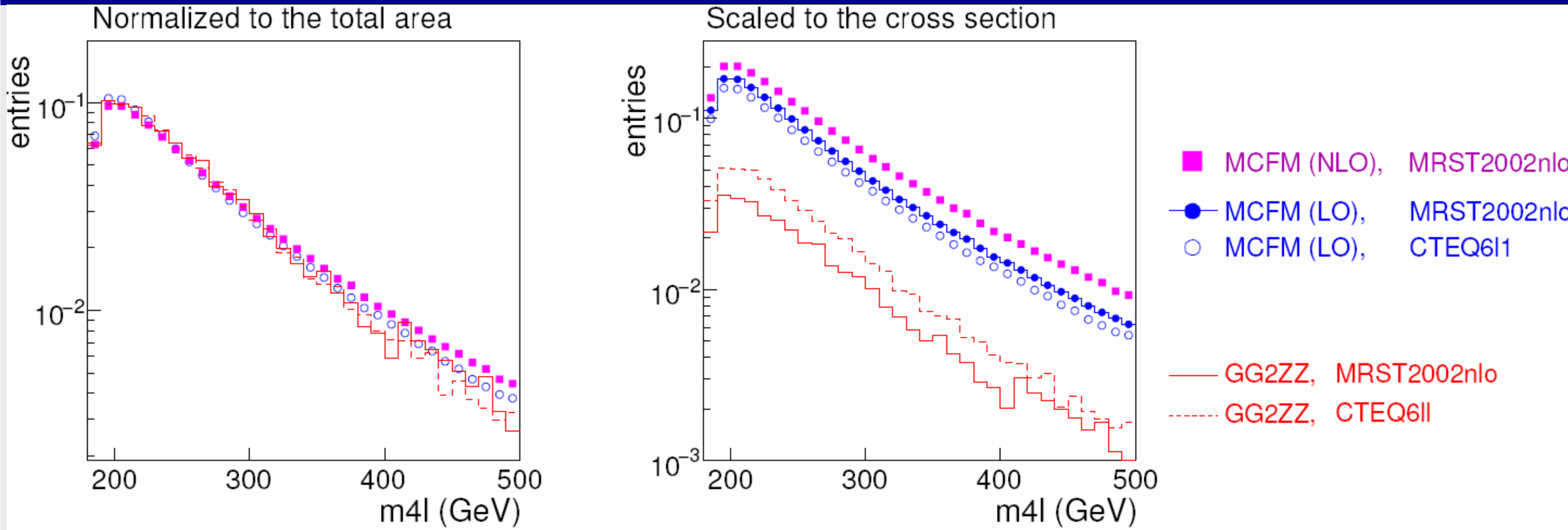
- gg2ZZ-MC: for now includes no „photon“ diagrams

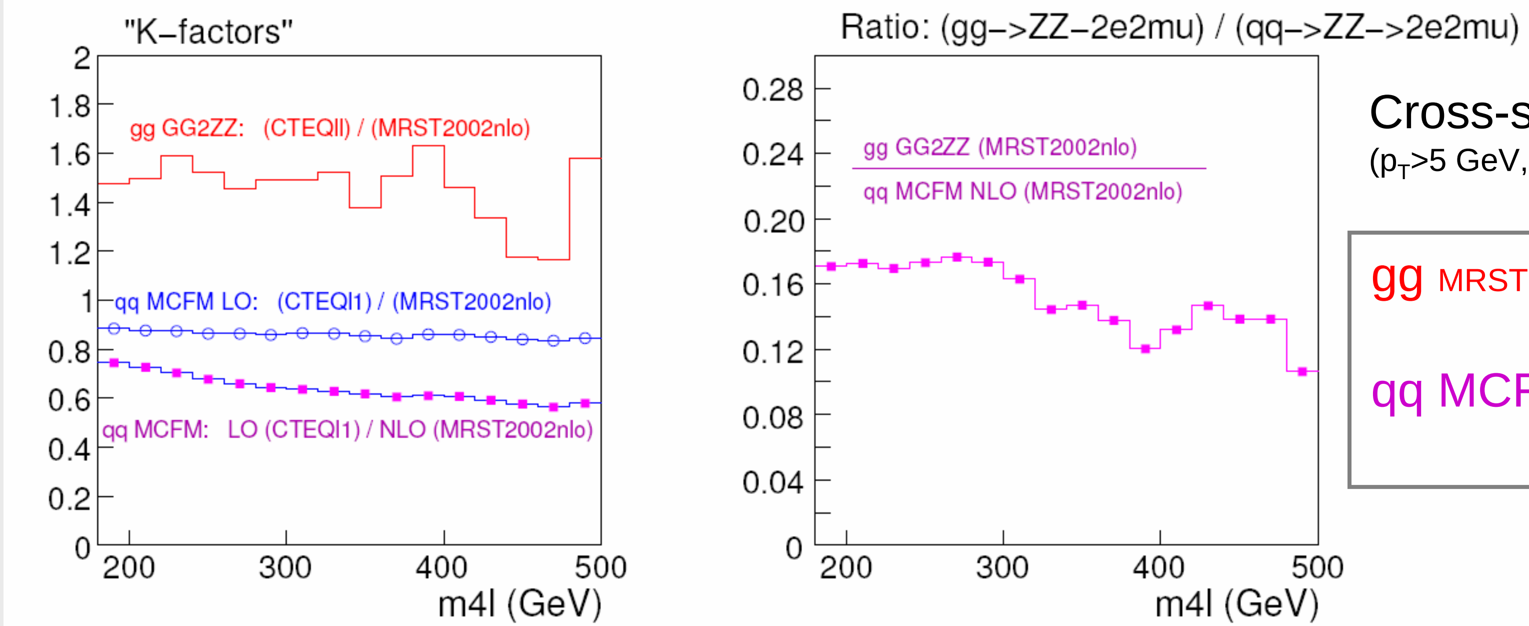
  „interference“ effect for 4 mu / 4 e final states

  → study masses above 180 GeV for 2e2mu final state

Domenico Giordano, Massimiliano Grazzini, Sandra Horvat , Nicolas Kauer

$pp \rightarrow ZZ \rightarrow 4l$ background for $H \rightarrow ZZ \rightarrow 4l$: mass distribution





Cross-sections:

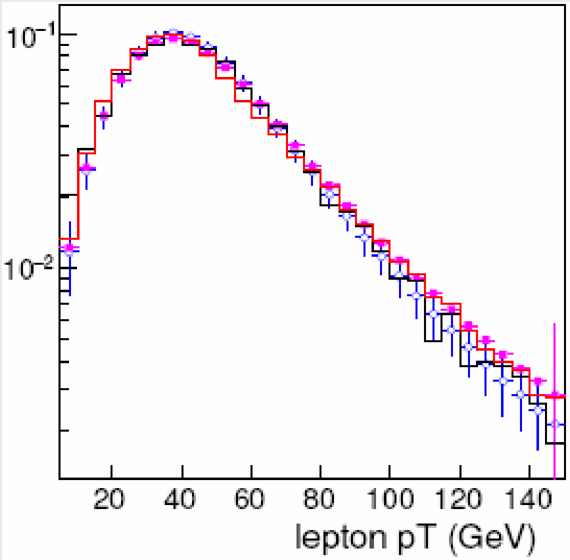
(p_T>5 GeV, $|\eta|$<2.7, m_{ZZ}>180 GeV)

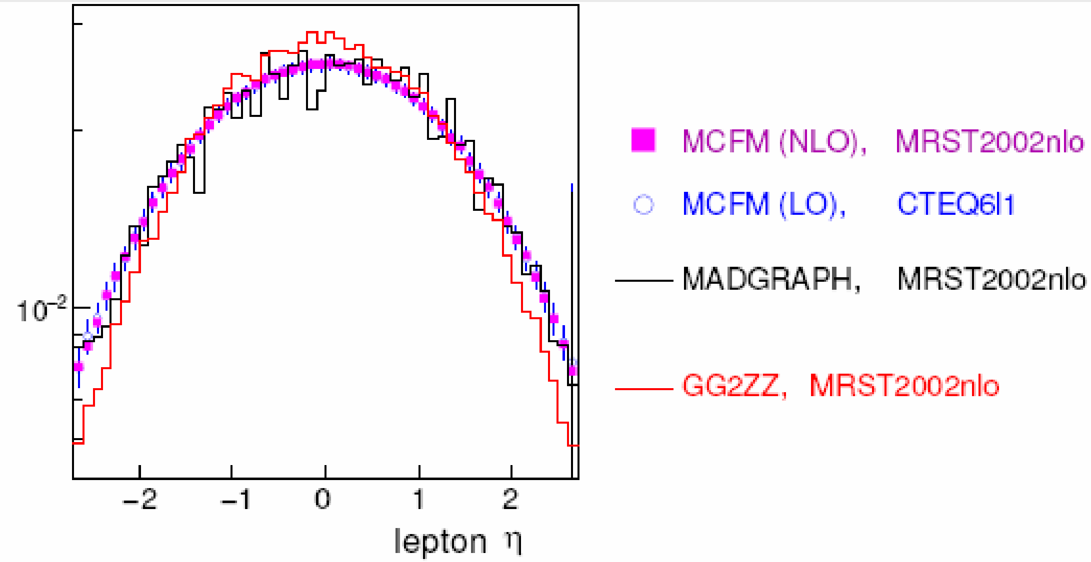
gg MRST2002nlo:
3.69 fb

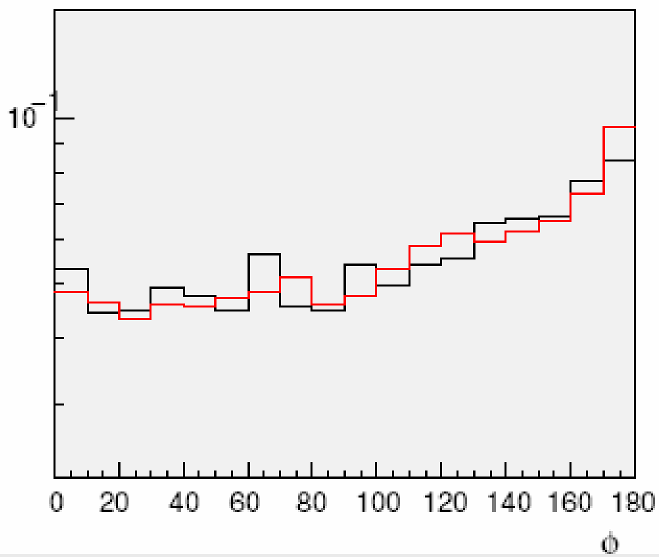
qq MCFM MRST2002nlo:
17.87 fb

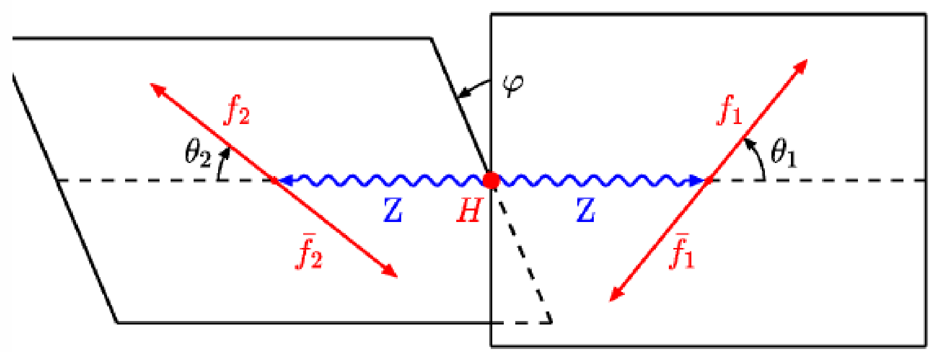
Domenico Giordano, Massimiliano Grazzini, Sandra Horvat , Nicolas Kauer

pp→ZZ→4l background for H→ZZ→4l: lepton distributions







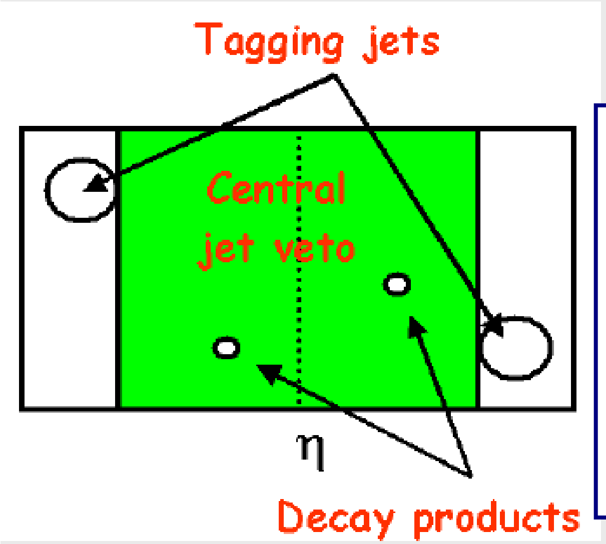


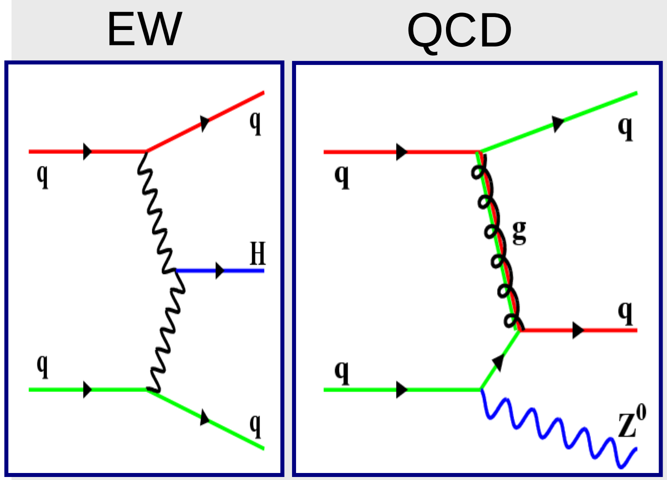
important for CP studies

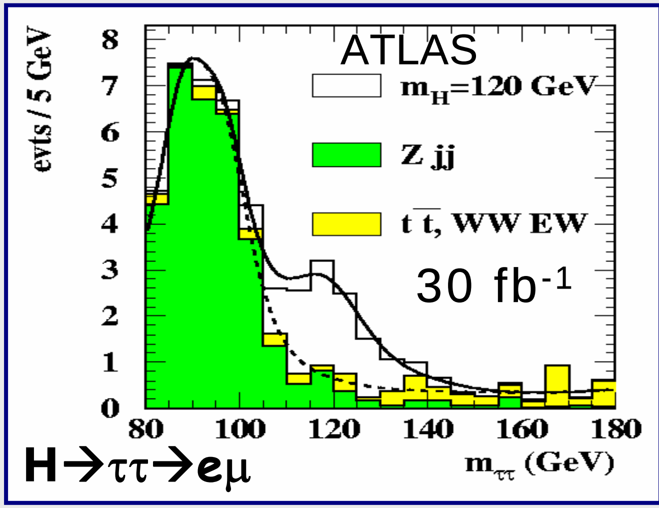
next steps: - apply full selection criteria and use full simulation

- repeat study for low masses with updated code by N. Kauer

Vector boson fusion VBF: pp→qqH, H→tau tau





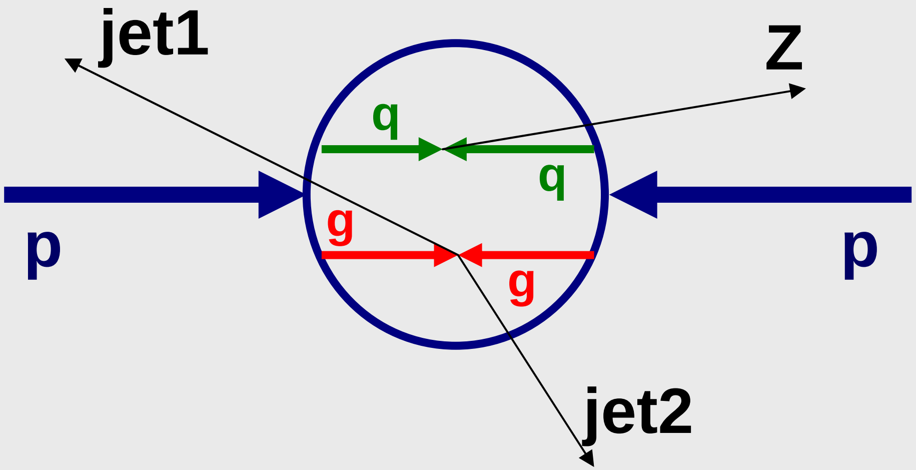


- dominant background still Zjj QCD (factor 4 larger than EW)
- can selection be improved by track veto compared to central jet veto?
- what about bckg. from Drell Yan + dijets via doube parton scattering?

- beyond discovery: signal rate measurement (exclusion limit)

  CP studies, coupling determination need

  - determination of gg→Hjj contribution
  - knowledge of signal efficiency, especially for jet veto



$\sigma^D_{(A,B)} = (m/2)\ \sigma_A \sigma_B / \sigma_{eff}$,

(m=2 for A=Z, B=di-jets) σ_{eff}=14.5 mb
from CDF Phys.Rev. D56 (1997) 3811

Expectations at LHC: σ_{eff} ~ 20 mb
(T. Sjostrand, private communication)

- „rough“ estimate of background contribution

- loose VBF selection: 2 jets in opposite hemishperes, $\Delta\eta$>4.2, M_{JJ}>1TeV

“normal” Z+jets (ALPGEN): σ ~ 770 fb

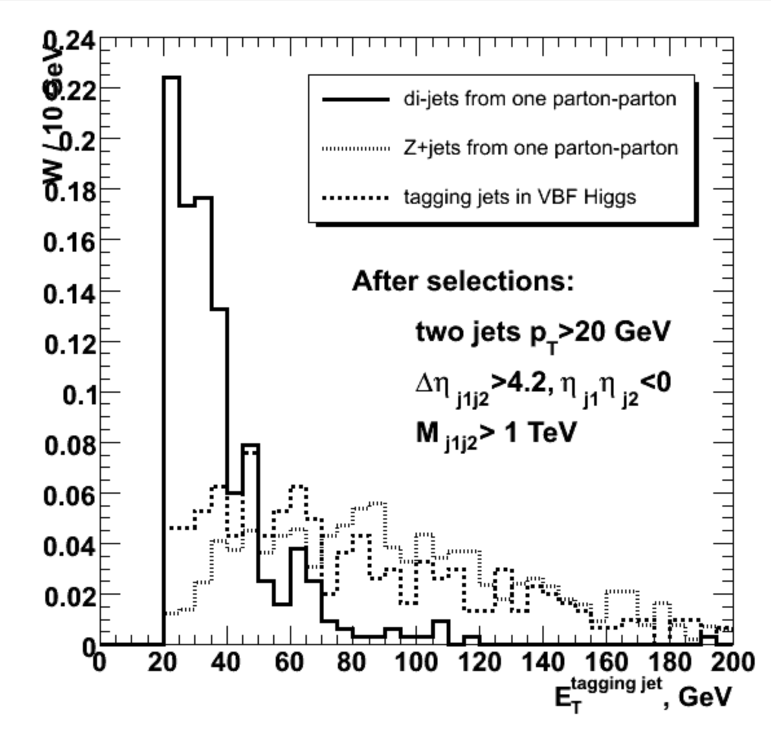
DY: σ ~ 2nb
di-jets (σ_{tot}=100mb): σ~ 1.4mb → σ ~140 fb

- contribution at 20% level → reduce it

- next step: DY+„hard“ UE with PYTHIA following recipe by T. Sjostrand

Supression of Zjj BG from double parton scattering

ET of tagging jets

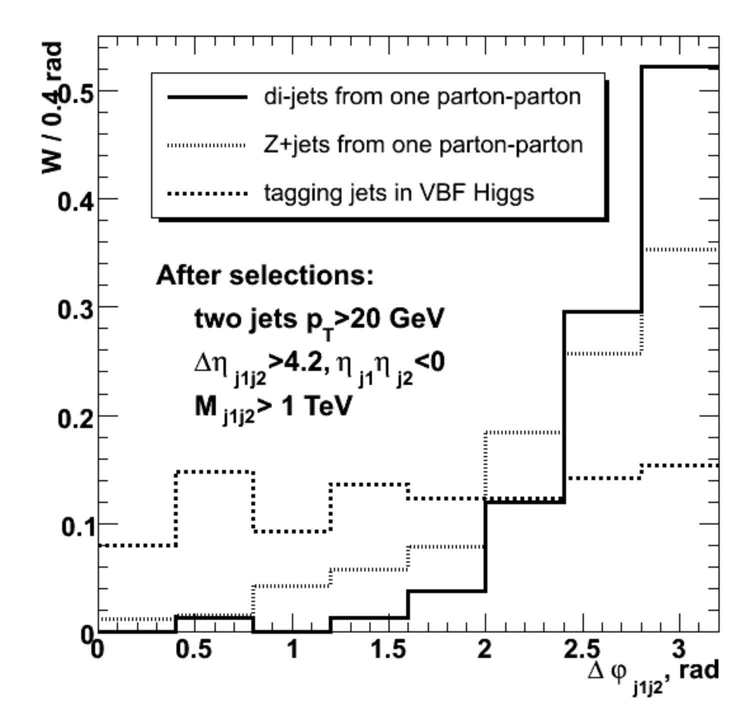


$E_{Tj1,j2}$ > 40 GeV

DPS Z+di-jets: eff. ~ 30%

Signal: eff: ~ 80%

$\Delta\phi_{jj}$ btw. tagging jets



$\Delta\phi_{jj}$ < 2.8

DPS Z+di-jets: eff. ~ 50%

Signal eff. ~ 85%

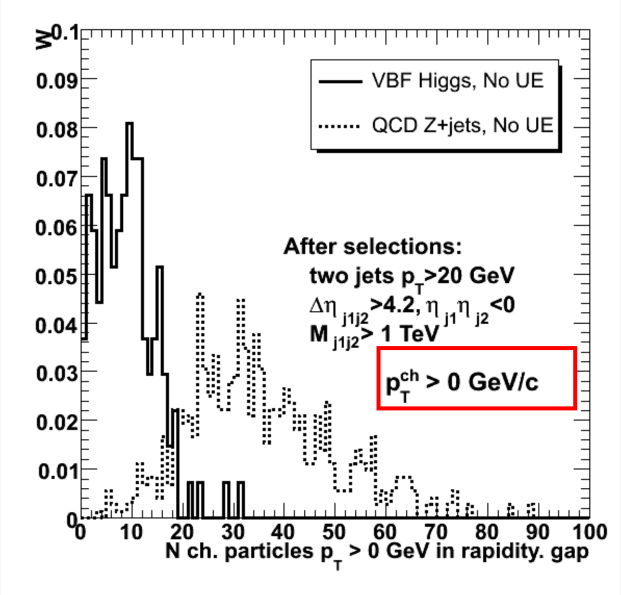
- Conclusion: DPS DY + di-jets bkg. seem no to be a problem
- Next steps: - check DPS Z+j plus di-jets with one lost jet
  - develop method how to estimate it from data

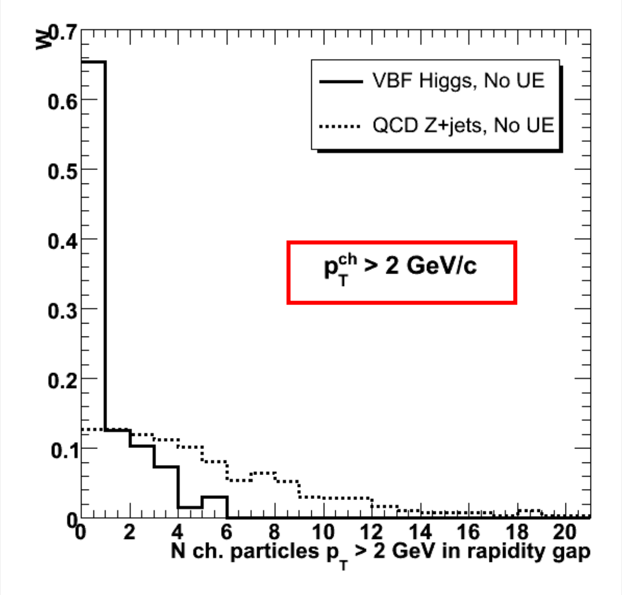
TV idea: count charged particles in rapidity gap: $\eta_{Jmin}+0.5<\eta_{trk}<\eta_{Jmax}-0.5$

PYTHIA hadron level study

without

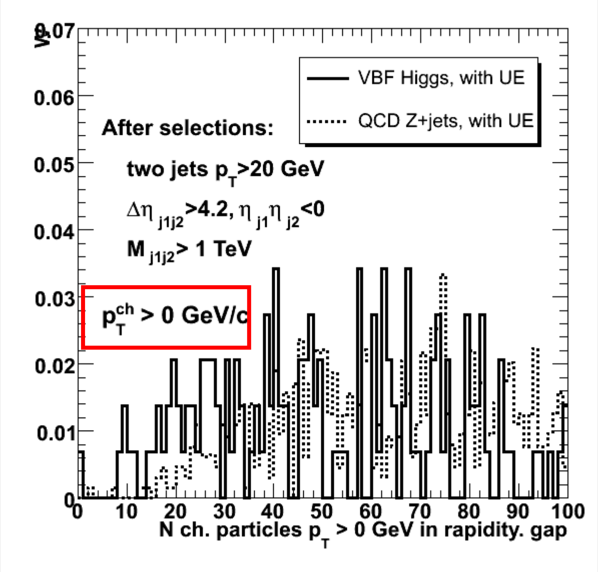
underlying event

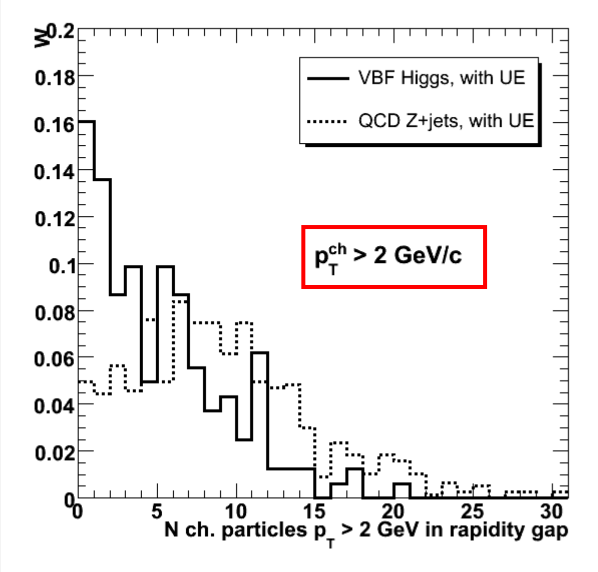




with

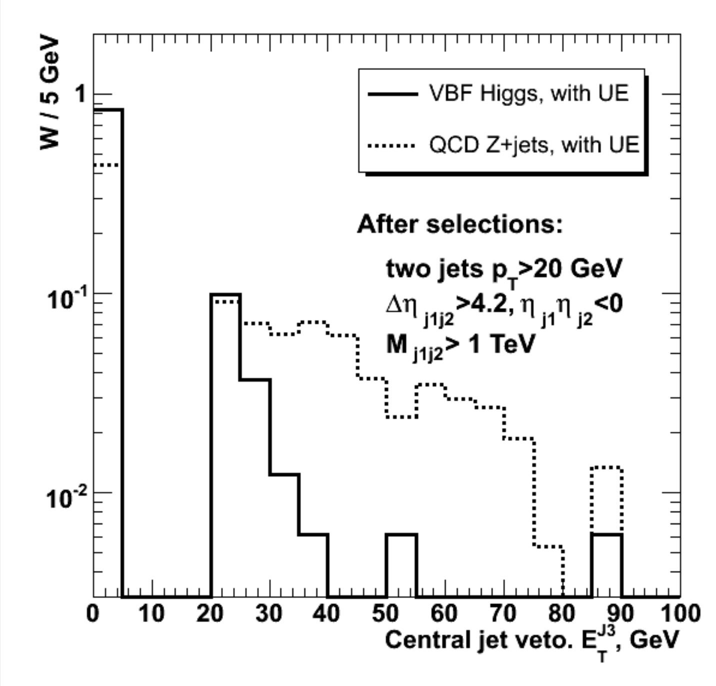
underlying event



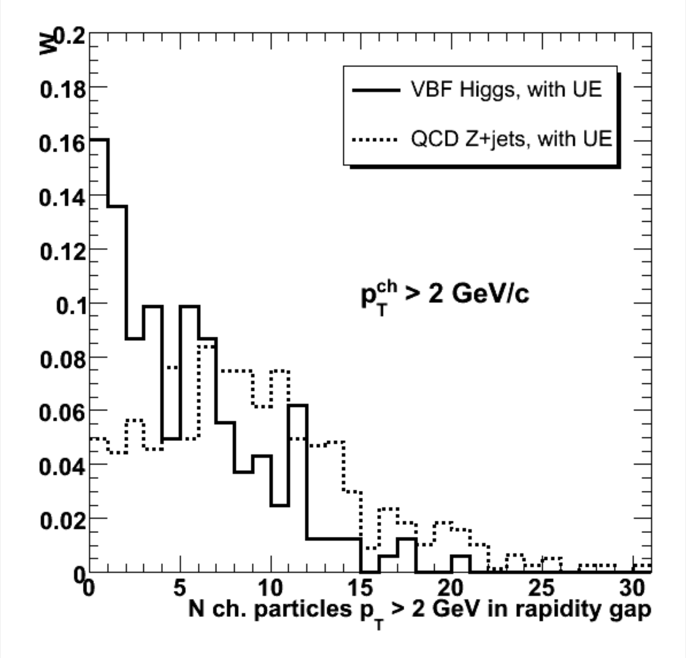


Track veto vs CJV: Comparion of survival probabilities

Jet veto



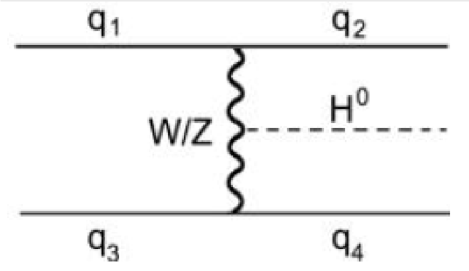
Track veto

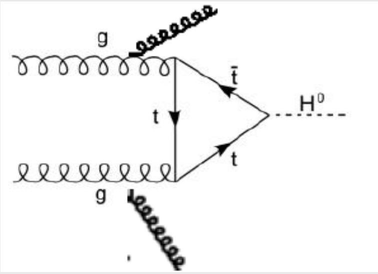


	veto cut	qqH	Z+jets
CJV	E_T^{J3}>20 GeV	0.83 (0.81)	0.44 (0.46)
TCV	N_{trk} > 9	0.80	0.55

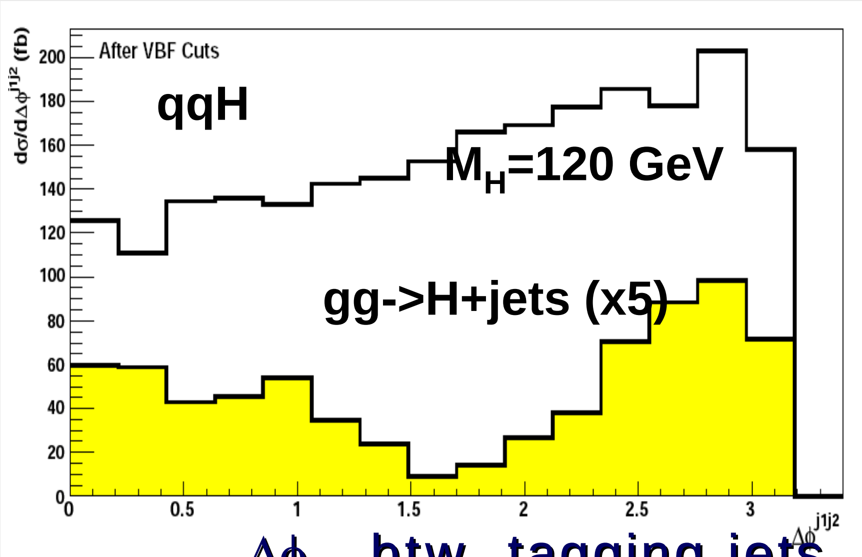
* Numbers in parenthesis from CMS PTDR with full simulation

- similar project in ATLAS started: J. B. De Vivie
- TV seems to be more robust against pile up (primary vertex determination)

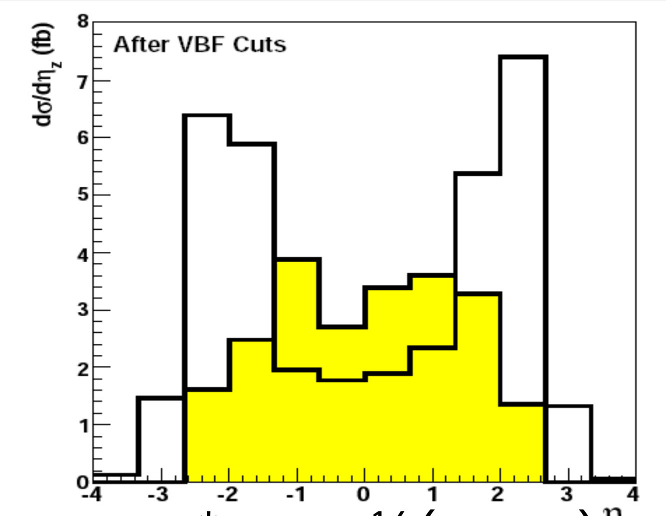




Monica.V. Acosta and S. Nikitenko
gg->H+ up to 4jets with ALPGEN+MLM
qqH with PYTHIA
fast CMS detector simulation



$\Delta\phi_{jj}$ btw. tagging jets



$\eta_3{}^* = \eta_3 - ½(\eta_1+\eta_2)$

- conclusion: gg→Hjj contribution is ~ 4-5 % for M_H=120 GeV after cuts

- next steps: - repeat study at NLO using Campell program for gg→Hjj and VBFNLO (D. Zeppenefeld et al.) for VBF
  - estimating Zjj background from data
  - comparison of Zjj EW and QCD with different MCs

Disentangling Z(γ)jj EW from QCD production

goal: -estimate jet veto efficiency for EW process

- transfer it to VBF Higgs production using theoretical calulcations/ MC generators

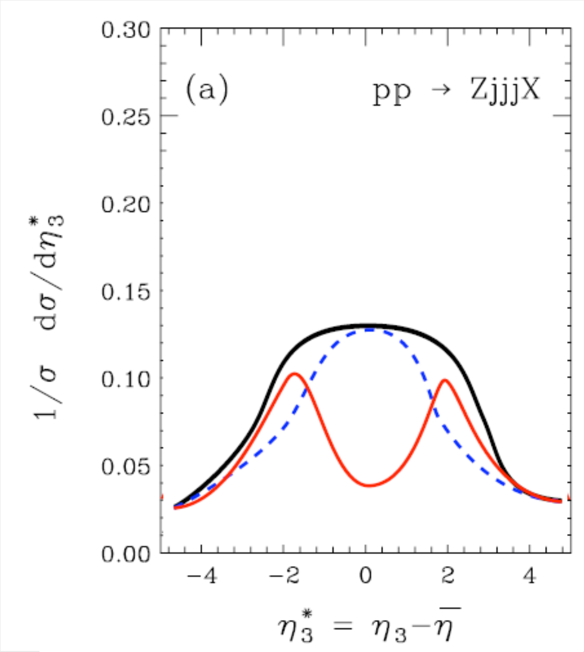
problem: QCD rate large compared to EW rate

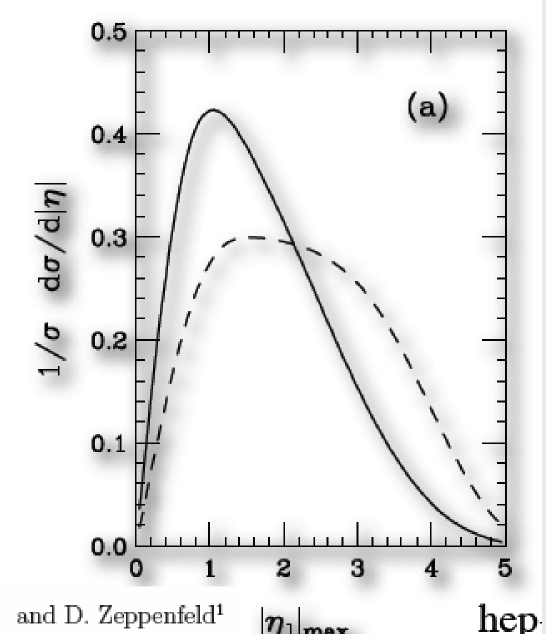
(still factor 10 after basic VF cuts)

idea: look at Z→ee,mumu and unfold 3rd jet distributions using uncorrleated variables (Kyle Cranmer)

maybe: use also photon + jets to do the same

additional issue: photon/jet discrmination

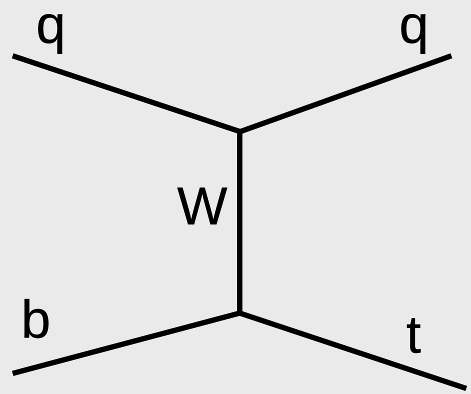




D. Rainwater[1], R. Szalapski[2], and D. Zeppenfeld[1] hep-

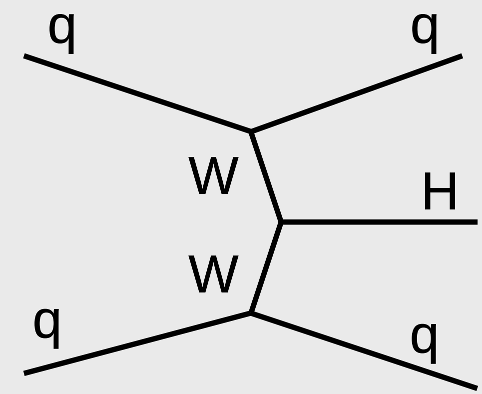
- same colour structure
- similar rapidity gap and radiation pattern after selection cuts?

Dieter Zeppenfeld + MS



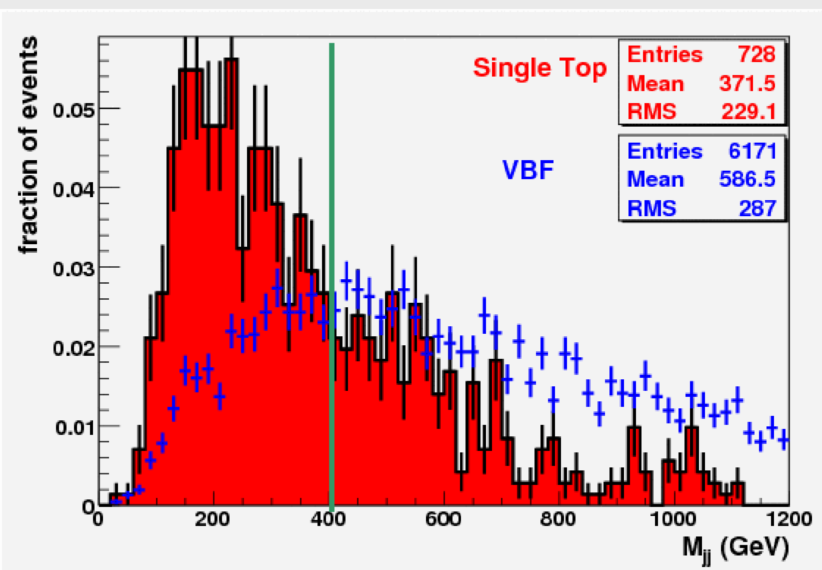
σ(NLO)~50 pb

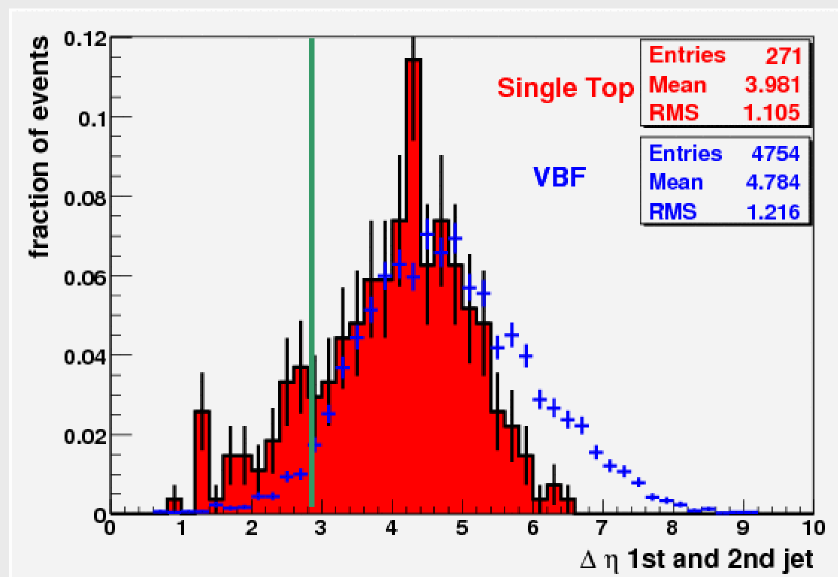
(incl. BR →e,mu)



σ(LO,120GeV)~4.4 pb

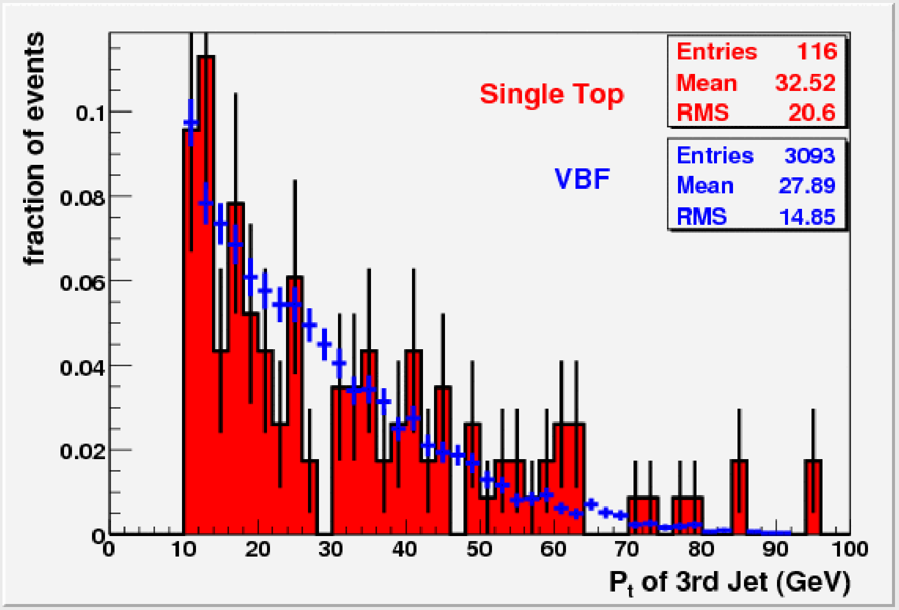
2 tagging jets in opposite hemispheres: (Herwig+Jimmy+ fast detector sim)



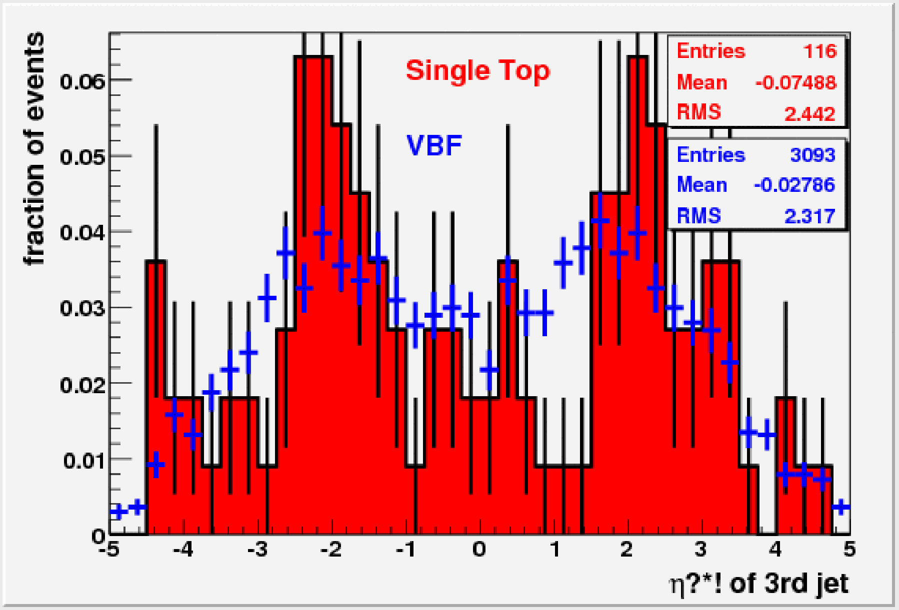


Characteristics of third jet

transverse momentum



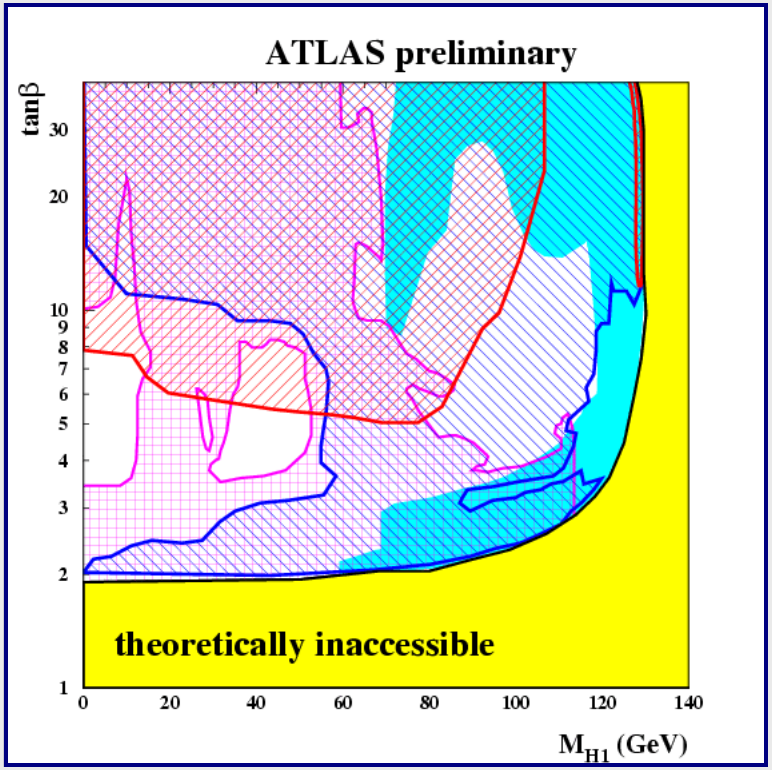
$\eta_3^* = \eta_3 - \frac{1}{2}(\eta_1 + \eta_2)$



- with small statistics no definite conclusions possible!
- at 1st glance: no significant discrepancy btw. single top and VBF

  → not yet completly dismotivated
- next steps: use ME calculations for 3rd jets

Light H1 and Charged Higgs e.g. in CPV MSSM



- uncovered region:

M_{H1}: < 50 GeV, M_{H2}: 105 to 115 GeV
M_{H3}: 140 to 180 GeV, M $_{H+-}$:130 to 170 GeV

- light H1 decouples from W,Z and top

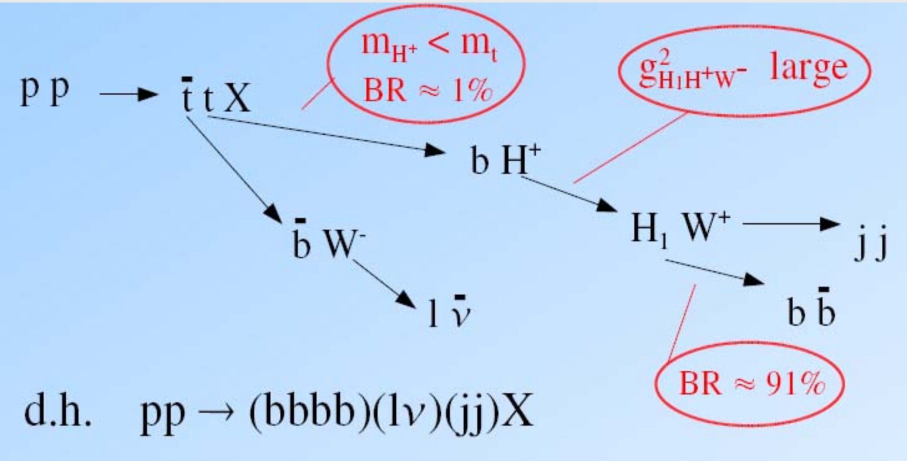
- no sensitive MC study from LHC yet

- most promising channel:

final state: 4b 2j l ν (R. Godbole et al.)

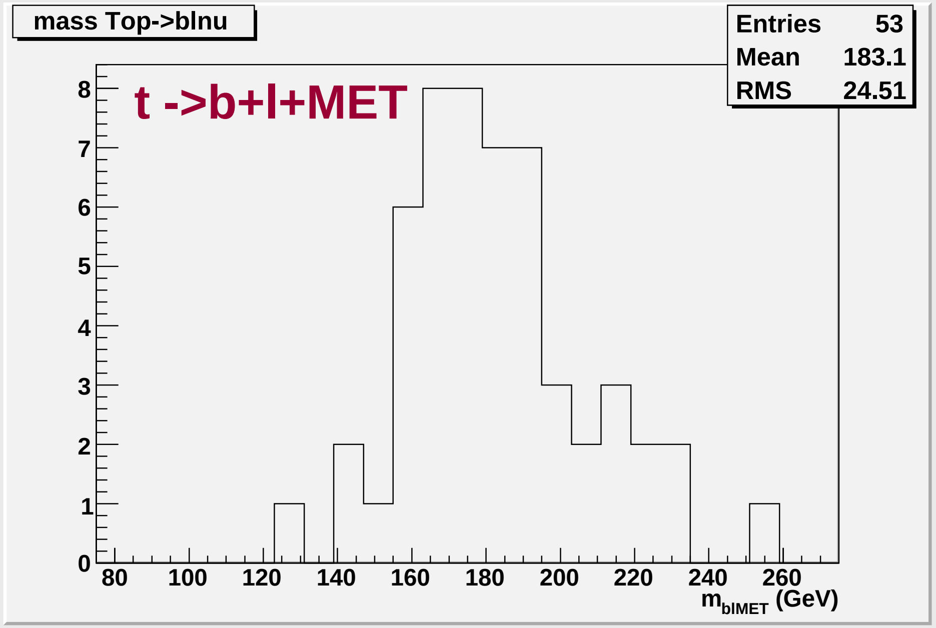
same as ttH, H→bb

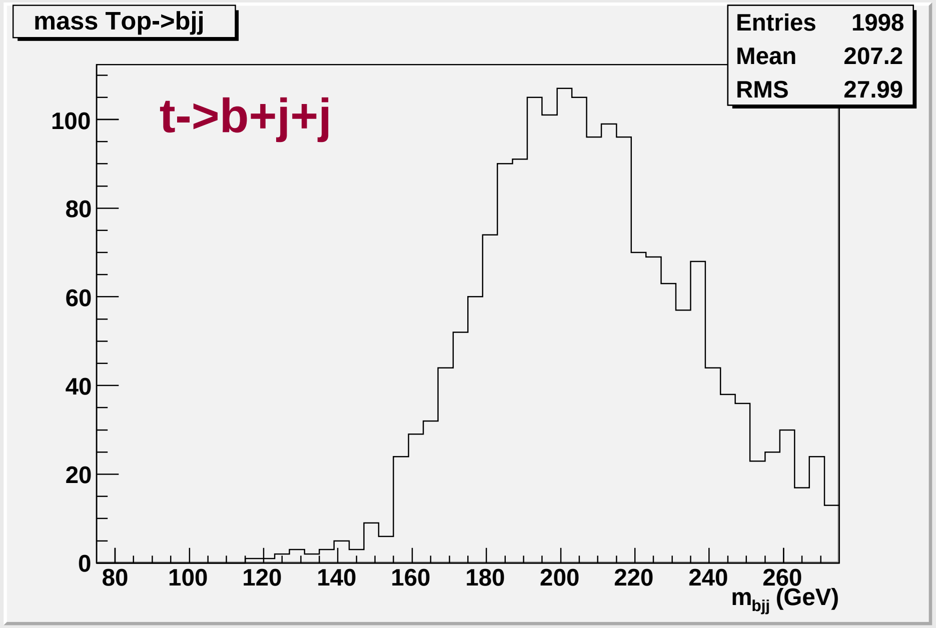
ATLAS fastsim study looks promising



tt→H+bWb,H+→WH1, H1→bb

- Mass resolution studies for signal (Aruna J. Nayak): $M_{H+}=133GeV$, $M_{H1}=51GeV$
- t->Wb from full CMS detector simulation (matching from MC truth)





- combinatorics challenge: how to assign b's and q's to t, H1, H+
- Claire Shepard-T. et al: optimise selection with various methods (cuts, ANN, liklelihood)
- other problem: background estimate from data (as in ttH→bb)

Large BR(H→AA) e.g. in NMSSM (Sami Lethi, Sasha Nikitenko)

- CMS study for VBF→H→AA→4 taus → 2 μ 2 tau-jet 6 ν
- M_H=105GeV, M_A=5.3 GeV with BRs > 90% in NMSSM

  → soft taus and close in phase space from the same A decay
- challenges: - trigger on no isolated muons (→ rate problem)

  - mass reconstruction

- proposal: trigger on same sign non isolated di-muons with pT threshold ~ 5-7 GeV

- rate reduction for gg->bb:

  $R=\sigma(\mu+\mu+OR\mu-\mu-)/\sigma(\mu\mu)$ at p_T> 5 GeV is ~ 4.0 ! evaluated with PYTHIA6.227 need confirmation with full simulation

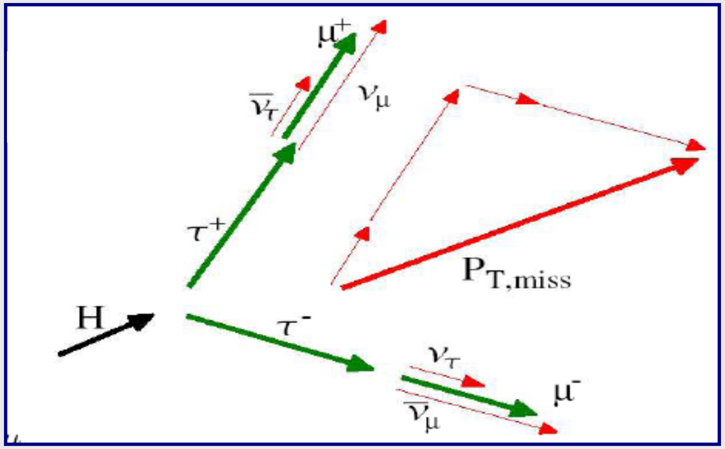
$\mu^-\mu^-j^+j^+ + \mu^+\mu^+j^-j^-$ *topology 107.5 fb*		
	$p_T^\mu > 7$ GeV (iso.)	$p_T^\mu > 10$ GeV (non iso).
Cumulative efficiency		
2 μ, η<2.1	**0.160**	**0.089**
$N_{trk.}$ = 1	**0.056**	**0.031**
$Q_\mu x Q_h$<0	**0.054**	**0.030**
$\sigma_{sel.}$, fb	**5.8 fb**	**3.2 fb**

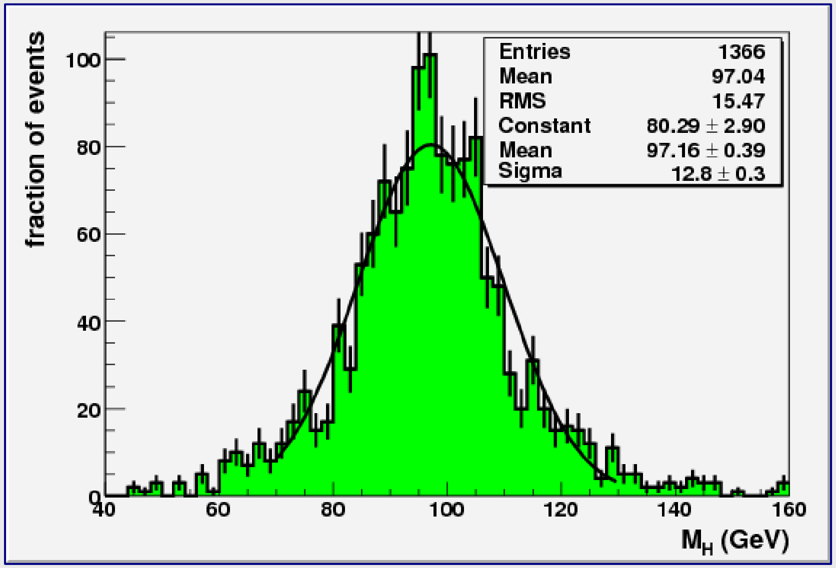
- similar study for WH with same decay chain → avoid trigger problem

VBF H→AA→4 tau→4 mu + 8 neutrinos (Iris Rottländer+MS)

M_H=100 GeV, M_A=10 GeV, generated with PYTHIA + fast detector simulation

- require 3 or 4 muons (1/6 of selected events have 4 muons)
- standard VBF cuts
- collinear approximation for mass reconstruction (2mu and 4 nu follow A)
- signal efficiency: ~ 2.5 to 3 %
- mass resolution 13 GeV





next steps: - background with Madgraph, check trigger availability

Outlook

- several interesting projects just started ... → hope for good proceedings

- in addition to what was shown:

  - angular correlations for rescueing ttH→bb (R.Godbole, A. Djouadi, ...)

  - CP studies in ZZ→4l (R.Godbole,D.Miller,M.Mühlleitner, S.Horvat, S. Nikitenko)

  - discriminating SM, MSSM, NMSSM via ratio of BRs (S. Heinemeyer, MS, ...)

- apologies to people whose contributions and plans I forgot to mention

personal remark:

leave „Les Houches“ how and where it has been for the last 8 years

for me it is the most stimulating workshop I have ever been to