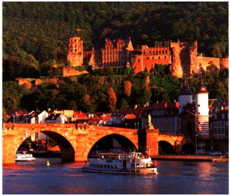
Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

MAX-PLANCK-GESELLSCHAFT

Sandra Horvat for the MPI Group

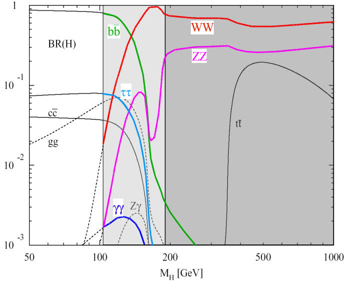
Higgs Activities and Plans at MPI



2^{nd} ATLAS-D Workshop • Heidelberg • 21.-22.09.2006

Overview of the Higgs searches at MPI

M. Spira Fortsch. Phys. 46 (1998)



SM Higgs:

Motivation: cover the whole allowed mass region.

- $(tt, W, VBF)\ H \rightarrow b\bar{b}$
- $VBF\ H \rightarrow \tau\tau \rightarrow (\ell\nu\nu)(anything)$
- $VBF\ H \rightarrow WW \rightarrow (\ell\nu)(anything)$
- $H \rightarrow ZZ^{(*)} \rightarrow (\ell^+\ell^-)(\ell^+\ell^-)$

Neutral MSSM Higgs:

Motivation: expertise in μ- (and τ-) reconstruction.

- $A/H \rightarrow \mu^+\mu^-$
- $A/H \rightarrow \tau^+\tau^- \rightarrow (\ell\nu\nu)(anything)$

Related software development:

- b-jet reconstruction, b-tagging: Neural-Net Tag Combiner
- τ-identification (using TopoClusters): first preliminary results
- forward jet reconstruction (VBF channels): just starting
- jet reconstruction with the first data: to start in Jan 2007

Current status of analyses

	PROCESS	PEOPLE	STATUS	DATA USED
SM	$(tt, W, VBF)H \to b\bar{b}$	S.Kotov, J.Yuan	optimized	FULL/FAST
SM	$(VBF)H \to \tau\tau \to (\ell\nu\nu)(\ell\nu\nu)$	S.Horvat, S.M-Möck, C.Valderanis	optimized	FAST
SM	$(VBF)H \to \tau\tau \to (\ell\nu\nu)(h\nu)$	M.Groh, S.Horvat	first data	
SM	$(VBF)H \to WW \to (\ell\nu)(\ell\nu, h\nu)$	S.Horvat, S.Kaiser, O.Kortner	first data	
SM	$H \to ZZ^{(*)} \to (\ell^+\ell^-)(\ell^+\ell^-)$	N.Benekos, S.Horvat, O.Kortner	optimized	FULL
MSSM	$(bb)A/H \to \mu^+\mu^-$	G.Dedes, S.Horvat	optimized	FULL/FAST
MSSM	$(bb)A/H \to \tau^+\tau^-$	G.Dedes, S.Horvat	first data	

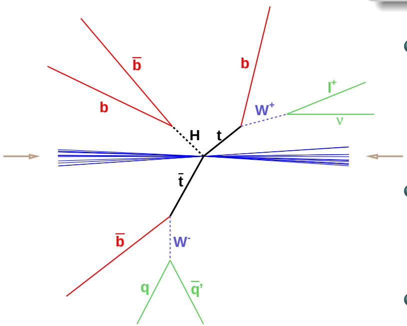
Optimized analyses:

- Cuts optimized for the low-luminosity up to $\mathcal{L}$=30 fb^{-1}.
- Using FAST (Atlfast) and/or
  FULL (V10.0.4, "Rome-Layout") detector simulation.
- All data (before the CSC era) produced privately at MPI and FZK.
- Pile-up, cavern background and misalignment effects still missing, to be done with the CSC data (Dec 2006).

First data:

- Preparation for the studies on the CSC data (V11.0.42, V12.0.2).

$ttH, H \to b\bar{b}$



Neural-Network based analysis (S.Kotov):

- analysis results strongly depend on the jet reconstruction performance
  $\Rightarrow$ using recalibrated Cone4-jets
- NN trained with ATLFAST or FULLY SIM. data, then applied on FULLY SIM. data
- selects the best combination of reconstr. W_{lep} , W_{had} and 4 b-jets

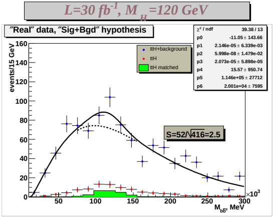
Performance of different jet reconstruction algorithms:

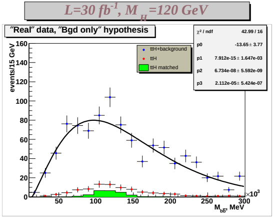
	Particle	$t\bar{t}H$ Cone4	$t\bar{t}H$ Cone7	$t\bar{t}H$ $k_T^{D=0.5}$	$t\bar{t}b\bar{b}$ Cone4	$t\bar{t}b\bar{b}$ Cone7	$t\bar{t}b\bar{b}$ $k_T^{D=0.5}$
Rec. efficiency, %	b-jet	52.2	42.9	49.3	47.1	41.5	45.8
	light jet	72.9	54.4	68.7	76.0	62.1	73.9
Mean $\Delta p_t/p_t$ shift, %	b-jet	-10.5	0.4	-0.4	-9.6	0.9	0.6
	light jet	-8.2	3.4	2.2	-9.0	2.8	1.7

$ttH, H \rightarrow b\bar{b}$: Analysis results

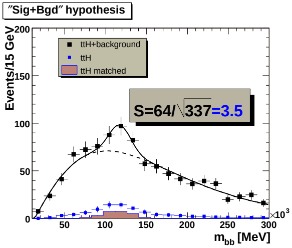
Recent improvement: NN training on the fully simulated data

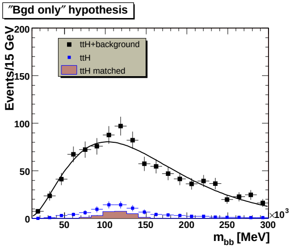
A) using NN-training on ATLFAST data (1M $t\bar{t}H$, 1.8M $t\bar{t}b\bar{b}$)

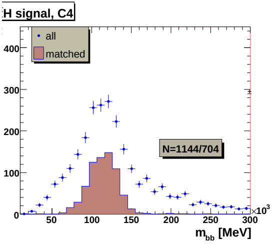




B) using NN-training on FULLY SIM. data (50k $t\bar{t}H$, 150k $t\bar{t}b\bar{b}$)



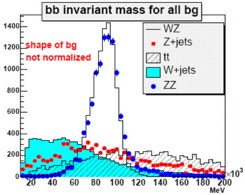


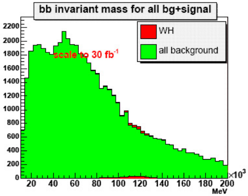


$(W, VBF)H, H \rightarrow b\bar{b}$

ATLFAST studies exploring the feasibility of these searches (J.Yuan).

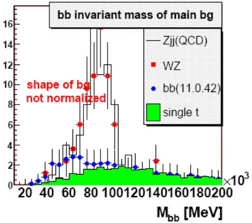
WH channel:

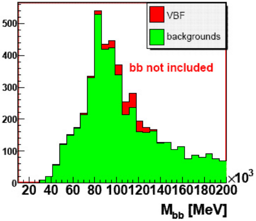




- Dominant bckgr.: $W + jets$
- More realistic b-tagging compared to TDR $\Rightarrow$
  - TDR significance: 2.4
  - New result: 1.1

VBF H channel:

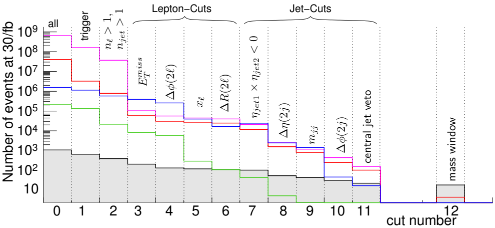


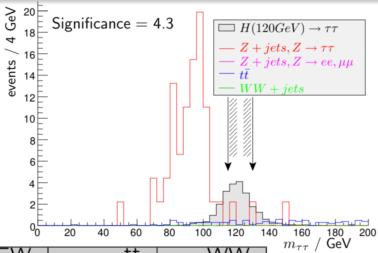


- Without the $b\bar{b}$: Significance $\approx$ 3-4
- $b\bar{b}$-contribution hard to estimate, large statistics needed

VBF $H \to \tau^+\tau^- \to (\ell\nu\nu)(\ell\nu\nu)$: Analysis results

ATLFAST study (M.Groh, C.Valderanis):





	H 120	QCD $Z \to \tau\tau$	QCD $Z \to ee, \mu\mu$	EW $Z \to ll$	tt	WW
all	1089	40 M	645 M	15 M	1,56 M	210.000
$N_l \geq 2$, $N_{Jet} \geq 2$	289	790.464	37 M	965.696	576.198	21.730
$E_T miss$	152	57.573	103.950	67.582	390.324	8.384
x_l	122	27.300	44.586	6.868	39.426	294
$\Delta R(2l)$	114	24.625	39.767	4.407	16.598	110
$\Delta\eta(2j)$	52	1.582	2.489	316	2.468	5
m_{jj}	46	819	1.180	219	1449	2
Jet veto	33	103	159	12	17	0,5
ΔM	15.5	4.4	0.5	0	1.8	0.06

Plans:

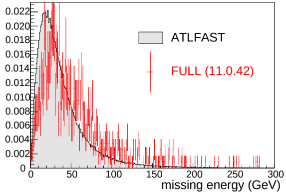
- extend to the lepton-hadron channel
- perform the analysis with the CSC data

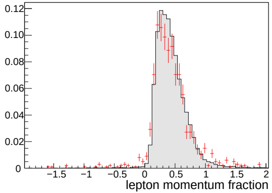
VBF $H \to \tau^+\tau^- \to (\ell\nu\nu)(\ell\nu\nu)$: First CSC data

Contribution to the CSC data production (full sim. with 11.0.42):

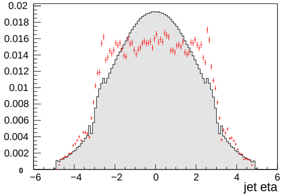
- 8138-8141: $Z \to e^+e^- + n\ jets$, $\sim$ 160k events
- 8150-8153: $Z \to \mu^+\mu^- + n\ jets$, $\sim$ 160k events
- 8162: $Z \to \tau^+\tau^- + 2\ jets$, $\sim$ 30k events (4M ATLFAST)

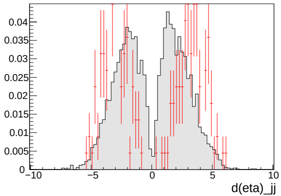
First look at the data (8162), very preliminary:

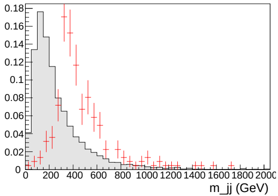




- good agreement for lepton distributions
- discrepancies for the jets

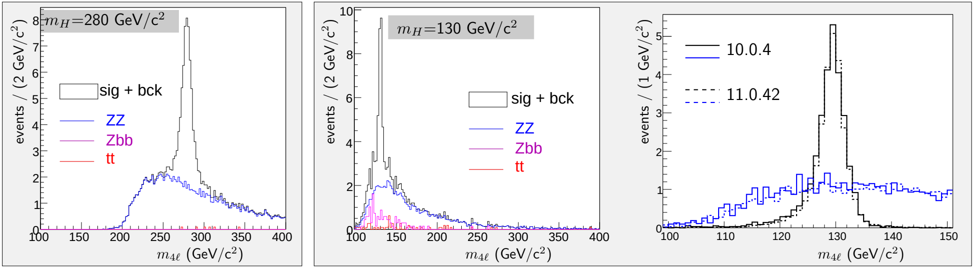






$H \rightarrow ZZ^{(*)} \rightarrow (\ell^+\ell^-)(\ell^+\ell^-)$: Analysis results

Analysis optimized with 10.0.4 data (S.Horvat, O.Kortner):
(afterwards well reproduced on the 11.0.42 CSC data: 5300,5200,5176,5980).

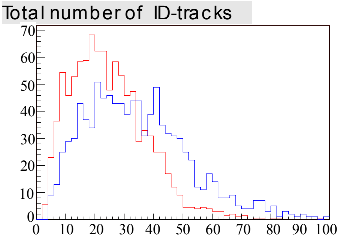


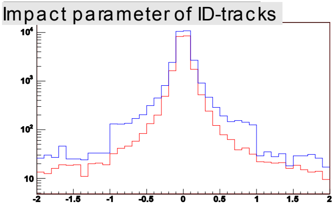
	m_H =130 GeV ($\delta m = \pm 5$ GeV)	m_H =160 GeV ($\delta m = \pm 6$ GeV)	m_H =180 GeV ($\delta m = \pm 7$ GeV)	m_H =280 GeV ($\delta m = \pm 20$ GeV)
N_{signal}	17.2±0.1	20±1	21.4±0.3	49.1±0.1
N_{ZZ}	8.7±0.3	8.8±0.3	21.0±0.5	31.1±0.6
$N_{Zb\bar{b}}$	2±2	2±2	1±1	0±2
$N_{t\bar{t}}$	0±0.4	0±0.4	0.5±0.4	0±0.4
Signif. (no K-fact)	5.0±0.3	5.5±0.5	4.5±0.2	8.7±0.4

$H \to ZZ^{(*)} \to (\mu^+\mu^-)(\mu^+\mu^-)$: Pile-Up Studies

Influence of the pile-up at L=10^{33} (N.Benekos in collaboration with Saclay)

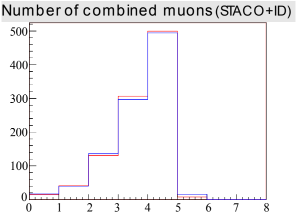
- suppression of the $t\bar{t}$ and $Zb\bar{b}$ background might be affected

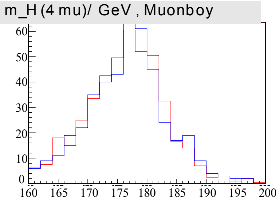




without pile-up
with pile-up

- no influence on the muon reconstruction



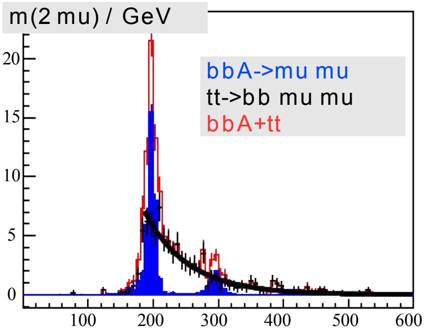


without pile-up
with pile-up

Plans:
develop the tools to identify the tracks from secondary pp-collisions.

$(bb)A/H \to \mu^+\mu^-$: Analysis results

Analysis with ATLFAST and FULL SIM (10.0.4) (G.Dedes, S.Horvat):



Cuts optimized separately for the FAST and the FULL simulation:

	TDR cut	ATLFAST	FULL
E_T^{miss}	20	17	26
p_T^b	–	35	48

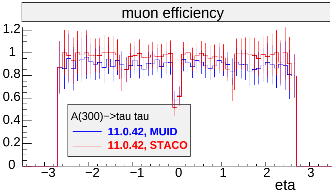
Significance	200 GeV	300 GeV	350 GeV	450 GeV
ATLFAST	6.5	1.9	1.5	0.7
FULL	5.4	1.7	–	0.4

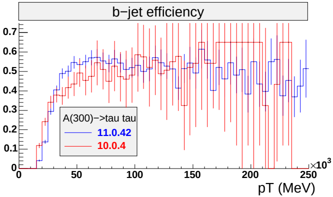
Plans:

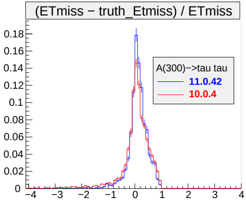
- CSC analysis, combined with the low-mass region (m_A <150 GeV)
- extend to the $A \to \tau\tau$ channel

$(bb)A/H \rightarrow \tau^+\tau^-$: First data

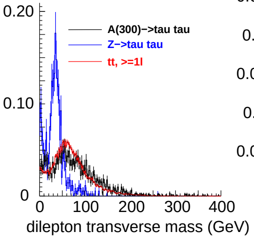
Performance plots, CSC samples 5352, 5200, 5149 (G.Dedes):

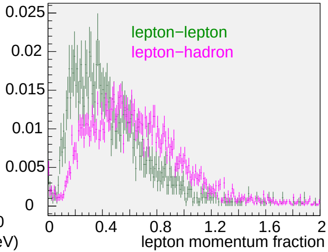


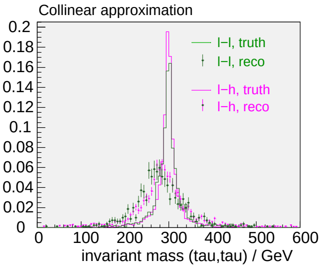




Discriminating variables, invariant mass $m_{\tau\tau}$:



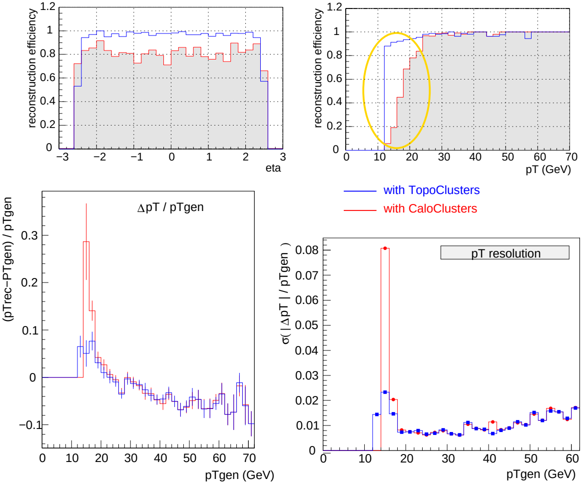




Related software: τ-identification

Exploring TopoClusters as the seeds for τ-reconstruction (M.Groh, S.Horvat):

- work started in collaboration with Freiburg



TopoClusters: possible improvements at low p_T.

To Do List

Commitments to the Higgs Working Group:

Contributions to 6 Higgs CSC notes (editing of the $A/H \to \mu\mu$ note).

$\Downarrow$

- Validation and development of the reconstruction algorithms. (Possible field for the common work within ATLAS-D: organized, systematic evaluation of the reconstruction perform.)

- Preparation of analyses for the CSC data, CSC data prodution.
- Trigger studies.
- Include more realistic detector effects:
  - Pile-up (VBF channels): development of the handling tools.
  - Misalignment, cavern background (particularly for the muons).

- Priority: determination of the background from real data. $\Longrightarrow$

Extracting information from real data

Methods for evaluating the lepton and jet reconstruction performances from the data, using standard candles like $t\bar{t}$ and $Z \rightarrow ee, \mu\mu, \tau\tau, b\bar{b}$.

Measurement of background shapes by means of control samples:

- Control sample selected by relaxing the cuts on certain variables. such to obtain a large background sample
- Ideally, the background shape should not be correlated with the particular variable for which the cut was relaxed.

Calibration with related reference processes.

Example $Z + jets$:

- Information on the pile-up effects contained in angular and rapidity gap distributions of forward jets.
- Reference for the cross-section of the VBF Higgs production (same dependence on the p_T^{jet}-cuts). V.A.Khoze et al., hep-ph/0207365v3