Search for the H → ττ → 2l 4ν decay in the Vector Boson Fusion production channel with the ATLAS detector

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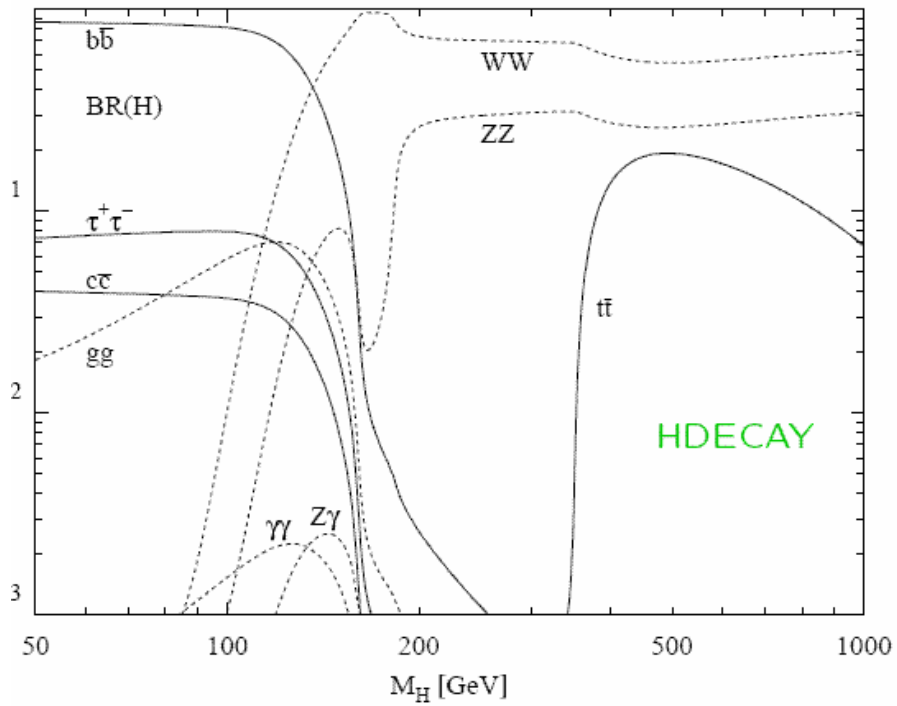
Talk outline

- Signal and background processes
- ATLAS detector
- The analysis procedure
- Results & Conclusions

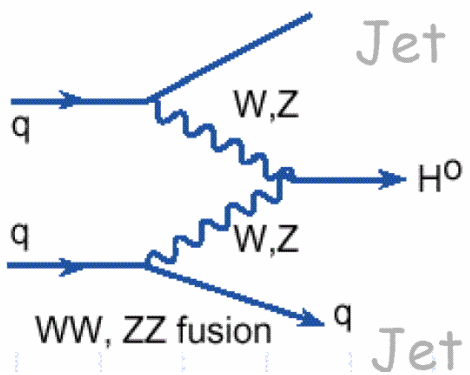
Higgs production and decay at LHC

Present theoretical and experimental bounds: M_H>114.4GeV (LEP), M_H<700GeV (theory). Fit of the electroweak observables: M_H<186GeV (at 95% CL)



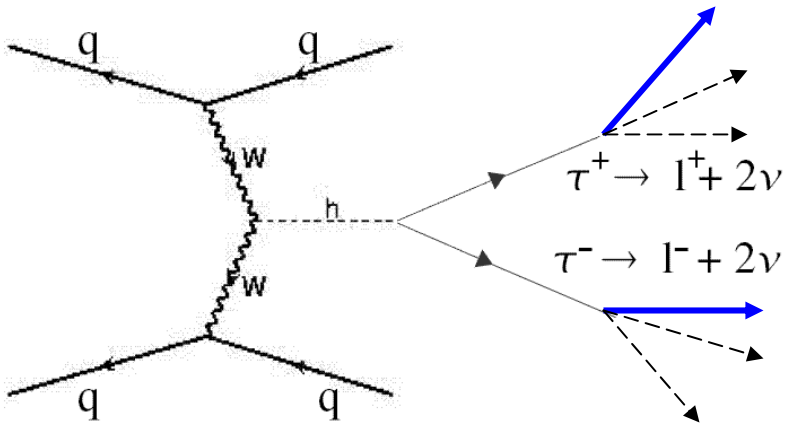
H → ττ : one of the most frequent decay modes for m_H<130GeV

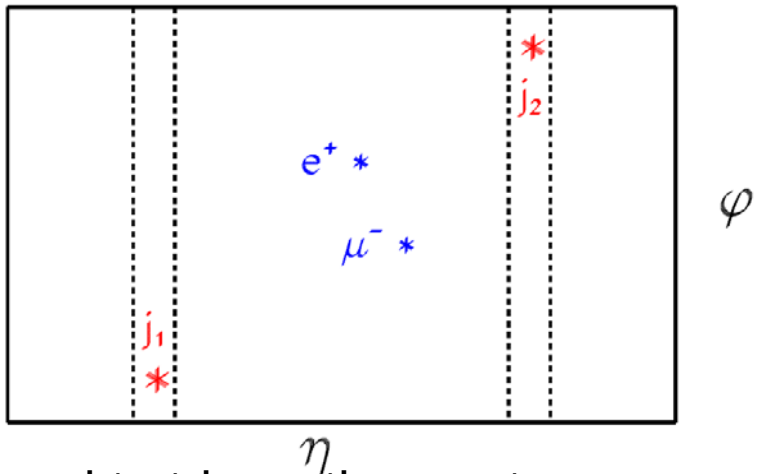
It is observable only in the vector boson fusion production channel



The two additional forward jets are needed to suppress the background

VBF H → ττ → 2l 4ν signal and backgrounds



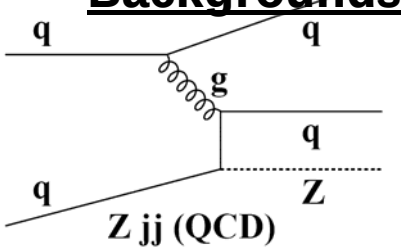


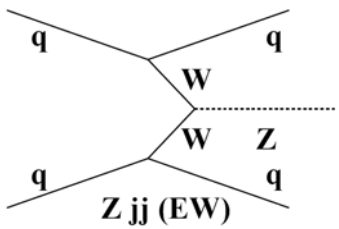
Two leptons in the cental region that can be used to trigger the event

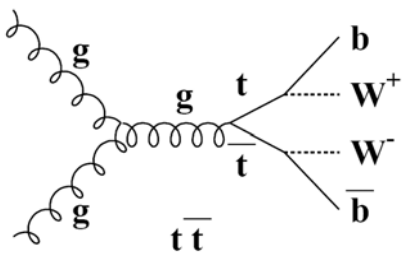
Two forward jets that can be used to tag the event

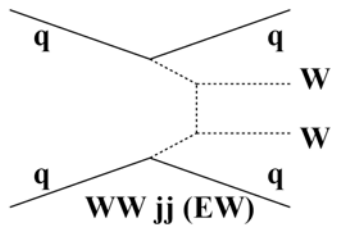
Missing Pt , Little jet activity in the cental region

Backgrounds







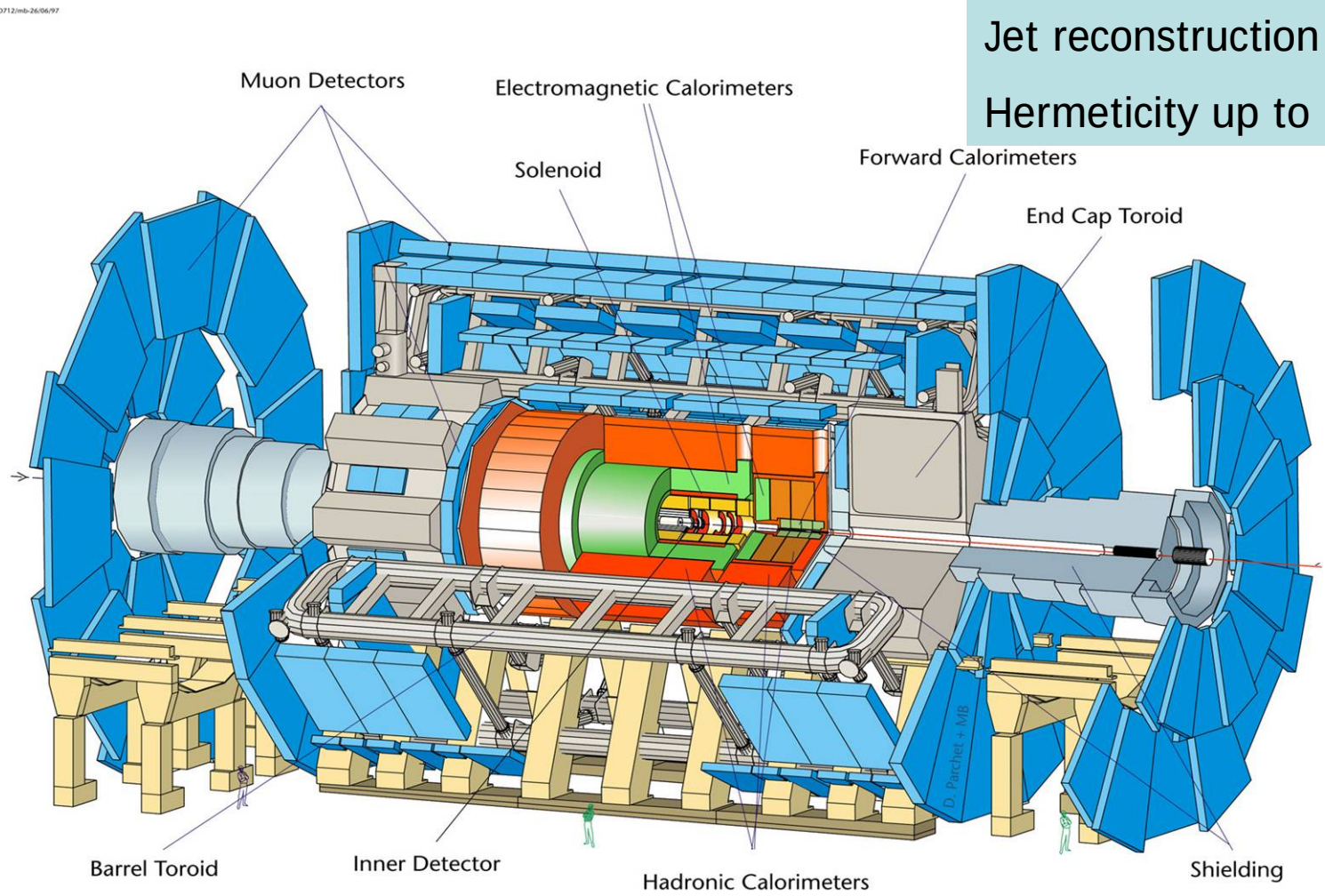


ATLAS detector

Lepton trigger and reconstruction capability up to $|\eta|<2.5$

Jet reconstruction up to $|\eta|<5$

Hermeticity up to $|\eta|<5$



Samples used

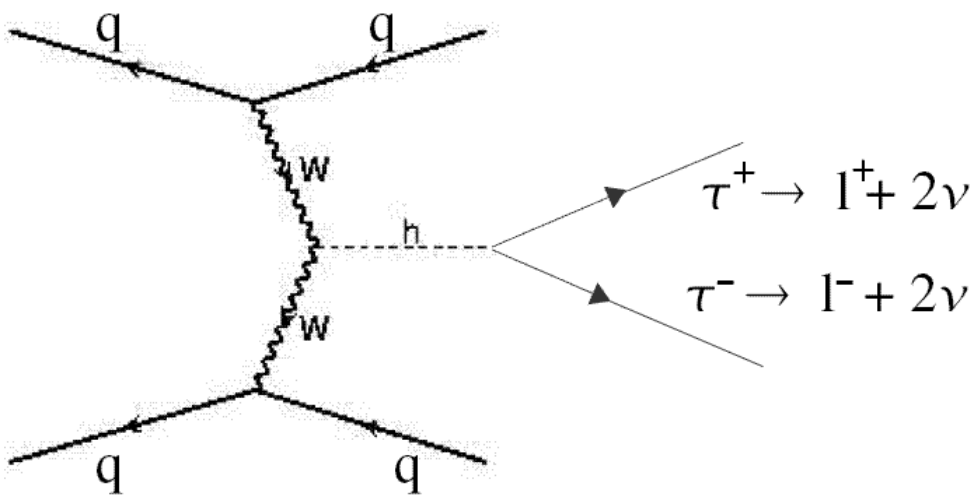
Process	Generator used	Cross section x Branching Ratio	Events expected at 30 fb^{-1}	Events produced
Fast simulation				
H(100)	Pythia	49.3fb	1479	100K
H(115)	Pythia	42.8fb	1223	100K
H(120)	Pythia	36.3fb	1090	100K
H(140)	Pythia	16.4fb	493	100K
$t\bar{t}$, W->leptons	Pythia	52pb	1.5M	16M
WW+jets, W->leptons	Pythia	7pb	200K	7M
Z+jets, Z-> $\tau\tau$->leptons	Pythia	1332pb	39M	38.1M
Z+jets, Z->ee,$\mu\mu$	Pythia	21490pb	640M	18.2M
Full Simulation				
H(120)	Pythia	36.3fb	1090	7K

Cross section for Higgs production and decay channels from ATL-COM-PHYS-2005-005 (using HDECAY, VV2H)

Number of produced background events similar to the statistics expected at 30 fb^{-1} .

Full simulation uses the ATLAS release 10.0.1 “Rome production”.

Event selection

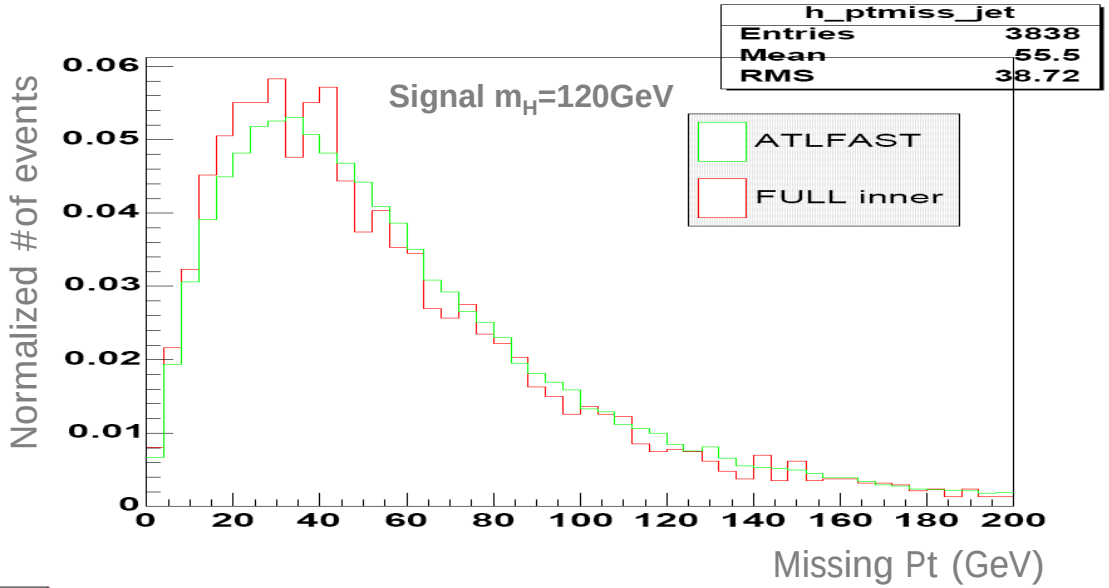


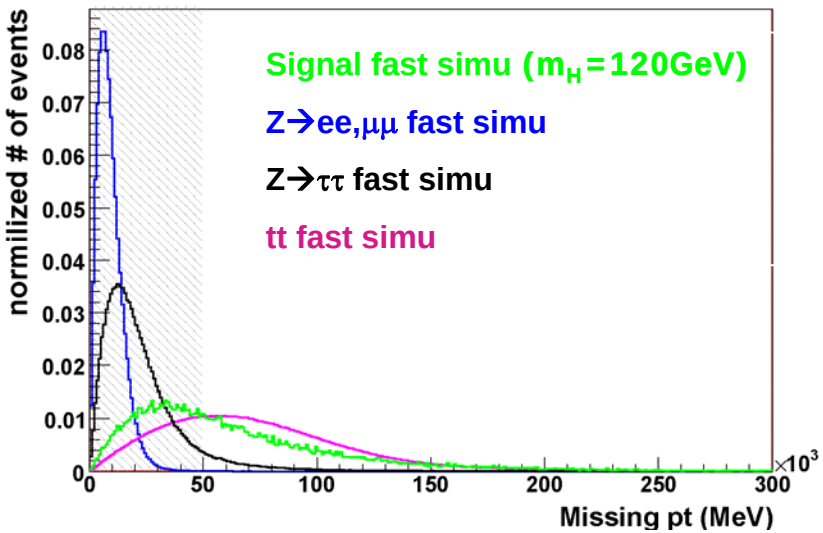
- Kinematical cuts
  - $P_{T\mu}$>20GeV $|\eta_\mu|$<2.5 or
  - P_{Te}>25GeV $|\eta_e|$<2.5 or
  - $P_{Te1,e2}$>15GeV, $|\eta_e|$<2.5 or
  - $P_{T\mu1,\mu2}$>10GeV, $|\eta_\mu|$<2.5 or
  - $P_{T\mu}$>10GeV,P_{Te}>15GeV , $|\eta_{e,\mu}|$<2.5
- $N_{lepton} \geq 2$, $N_{jet} \geq 2$
- Missing pt > 50GeV
- Collinear approximation for calculating τ momenta
- Jet properties
  - leading jet pt > 50GeV, subleading jet pt > 20GeV
  - Jets emitted in opposite directions
  - No jets in the central jet region
- Lepton pair between jet pair

Values of cuts in this analysis according to ATL-COM-PHYS-2002-009
First goal of this analysis to reproduce the results in the new version of software

Missing pt

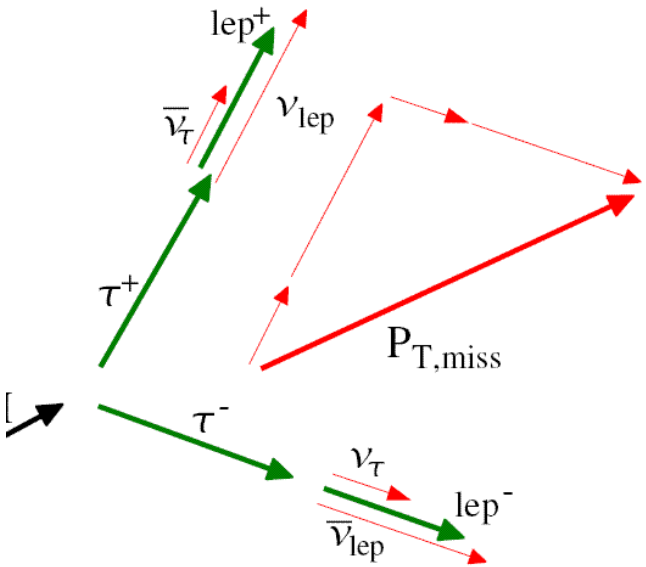
- 4 neutrinos result in a large missing Pt .
- This can be used for suppressing the Z→μ,e background

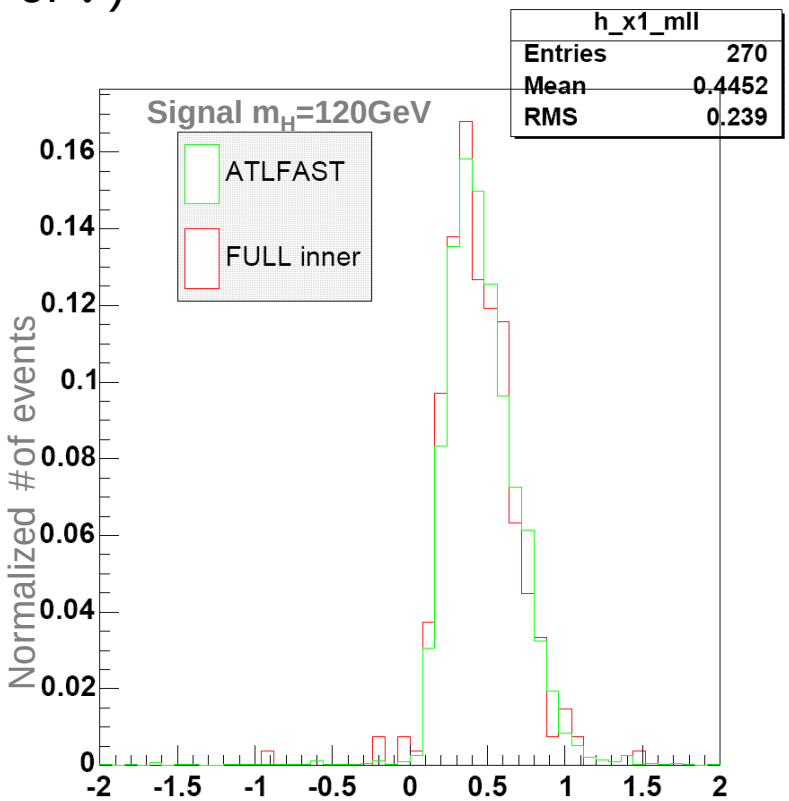


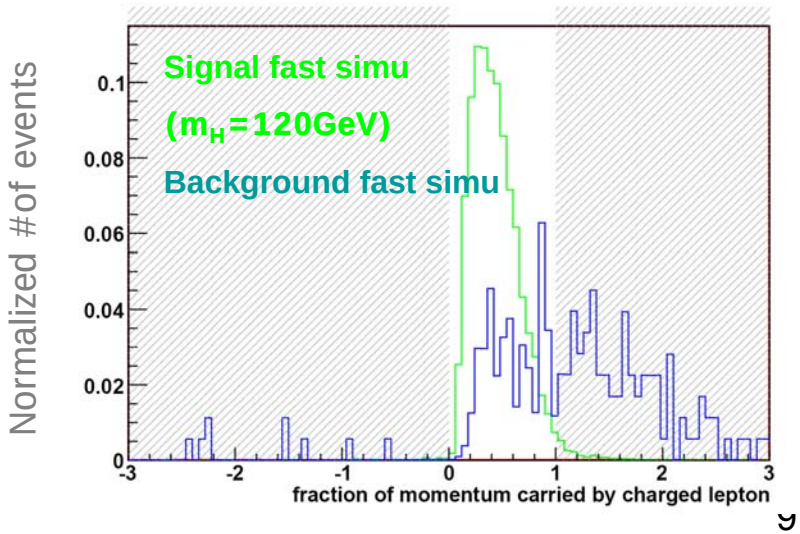


Collinear approximation

We calculate the τ momentum from the measured vectors of lepton momentum and missing energy by using the collinear approximation (leptons emitted in direction of τ)

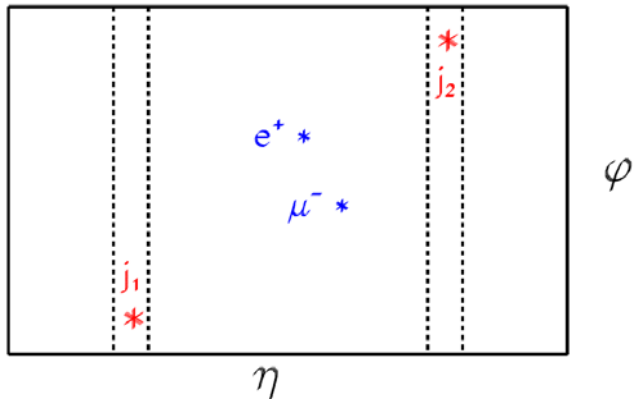


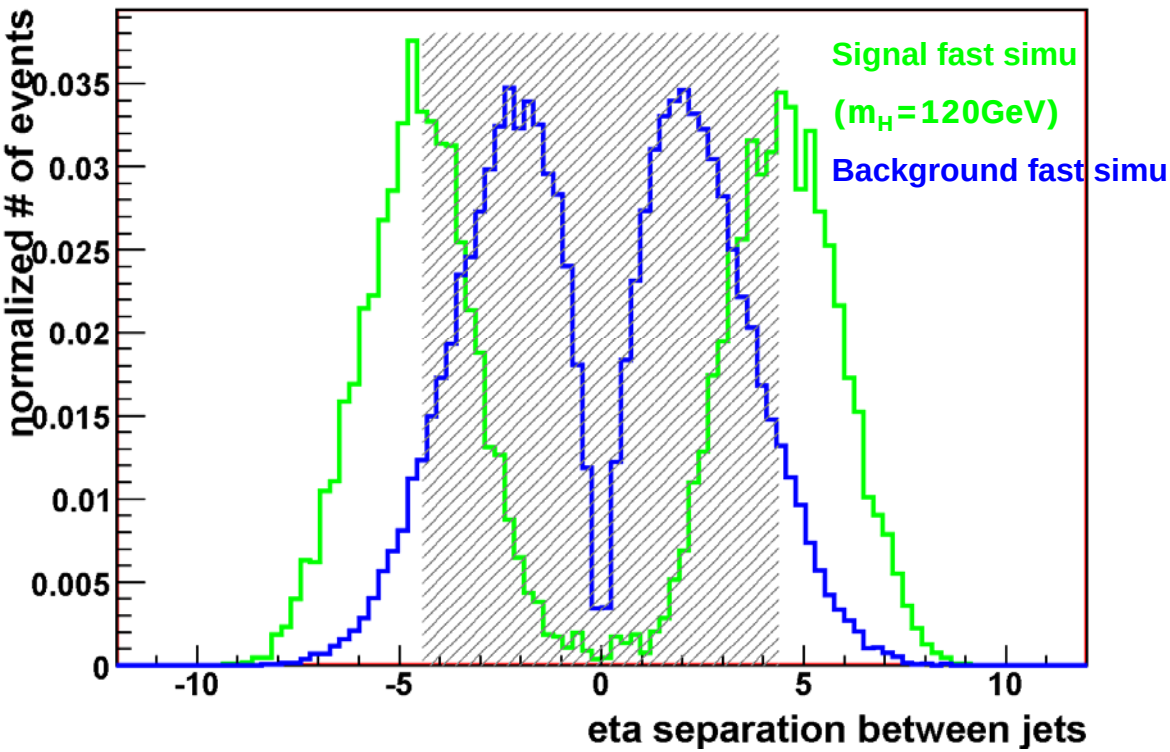




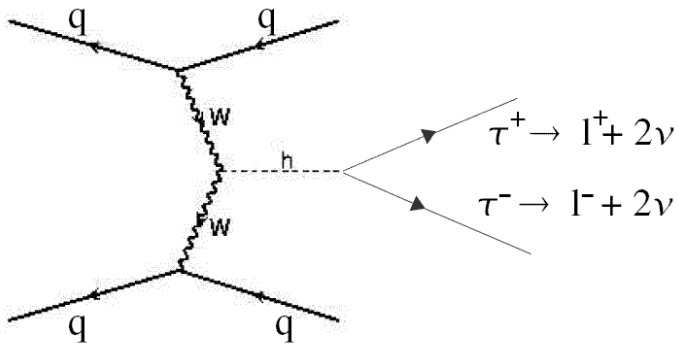
Jet separation in η

Constrain for the fact that the signal jets should exist in the forward region and not in the central part of the detector as opposed to all the background

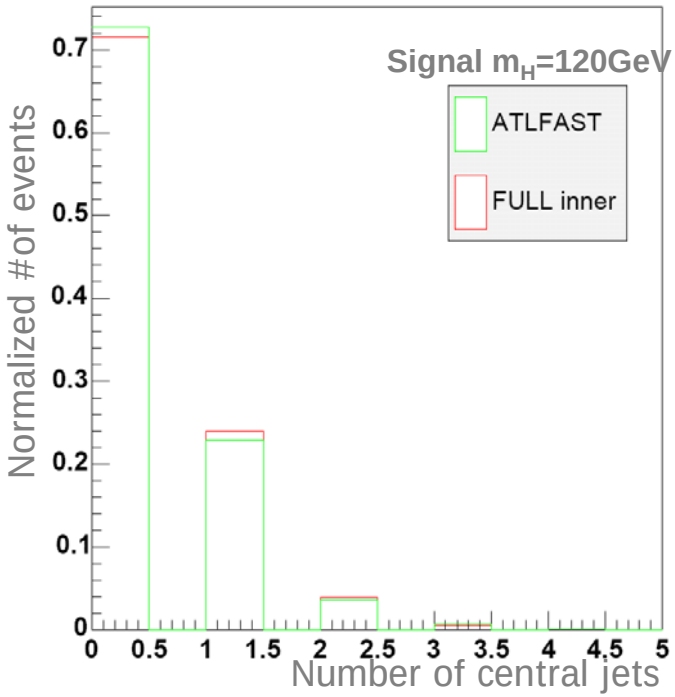


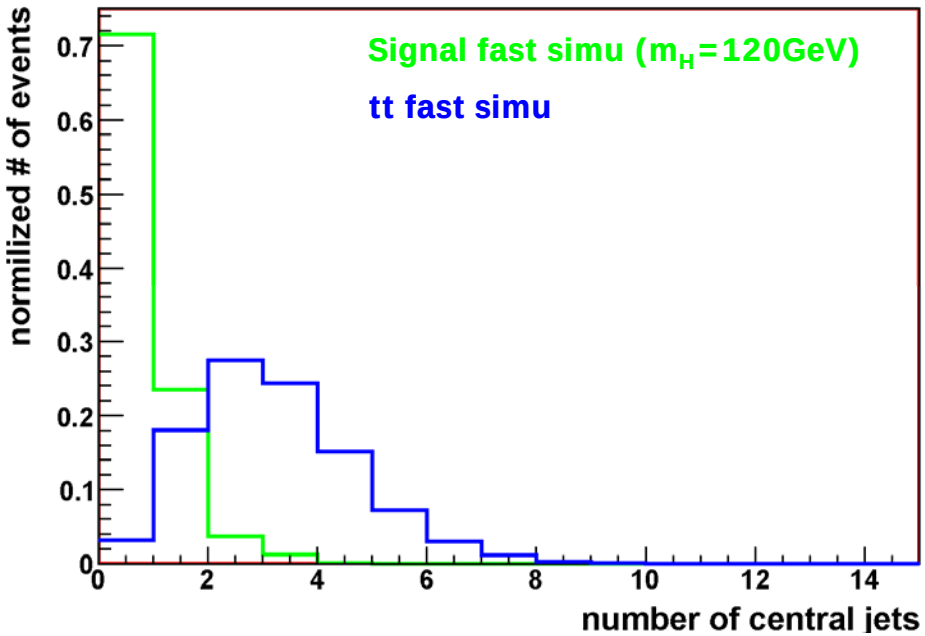


Central jet veto



- The absence of color flow between the forward scattered quarks results in the absence of additional jets in the central detector area.
- This can be used to discriminate the signal against backgrounds with central jet activity (like $t\bar{t}$ production)

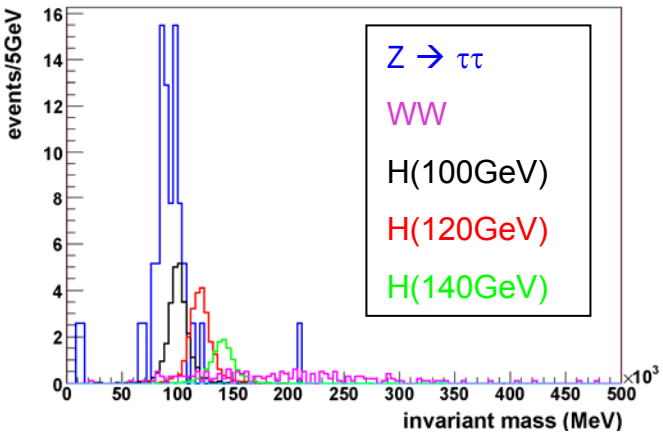


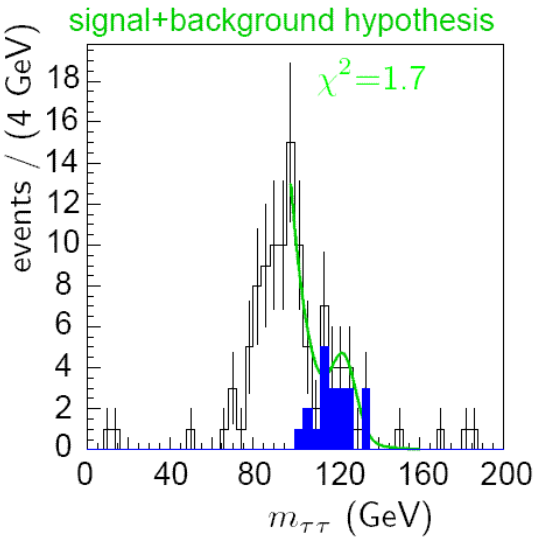


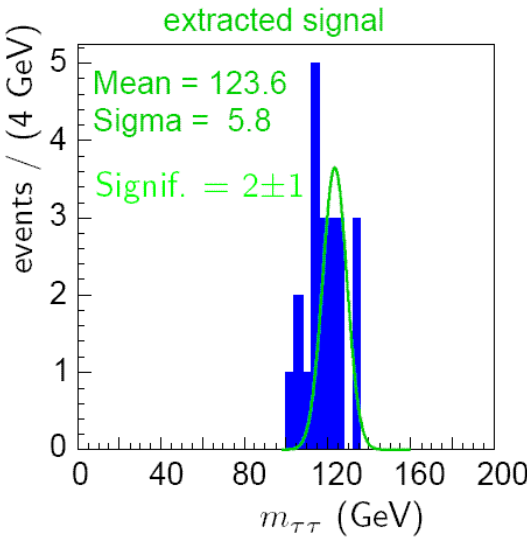
How many events do we expect for 30fb^{-1} after each cut

	H(120)	Z->ττ->2leptons	Z->ee,μμ	$t\bar{t}$	WW
Trigger cuts	661	3267220	171948000	1136850	138573
Lepton Pt	398	790614	39337100	575572	22755
Mising Pt	208	57591	11760	389904	8779
Charge cut	140	34597	8926	327247	7615
Delta phi	132	30910	7049	255086	6202
Collinear approximation	120	27307	850	39333	308
Lepton Delta r	111	24629	354	16566	115
Jet pt and eta	94	14674	177	15112	68
Different hemisphere	81	7409	141	9075	30
Jet separation in η	46	1289	35	1599	4
Jet invariant mass	39	699	-	1028	2
Non central jets	30	253	-	44	-
Jet distance in ϕ	25	183	-	37	-
Leptons between jets	22	103	-	16	-
Total number of events	22	103	0	16	0
Total efficiency	0.020	2.6e-6	0	1.0e-5	0

Invariant mass of ττ pair







	Mass window	N_{signal}	N_{back}	s/√(s+b)		S of fit		s/√(s+b) (previous analysis)
H(100)	[90,115]	22	57	2.4				-
H(120)	[110,135]	19	8	3.6		2±1		3.1
H(140)	[130,155]	9	6	2.3				1.9

Conclusions

- Analysis done with most recent version of fast simulation.
- Signal samples verified by the full simulation.
- Expected signal significance at $30fb^{-1}$ for Higgs mass of 120GeV, S= 3.6 (3.1 from previous analysis)
- Next steps:
  - Include the EW backgrounds.
  - Optimize the cuts further.
  - Production of background samples in full simulation.
  - Include hadronic tau decays.