

N.Vranješ Institute of Physics Belgrade

Gravity: New ideas for unsolved problems (In honour of 67th birthday of Milutin Blagojević) September 12-14, 2011, Divčibare, Serbia

Outlook

- A brief overview of some of the results for BSM searches with ATLAS detector
- Constrained by AR x T x P

AR = ATLAS Rules \rightarrow only public results meaning restricted to up to 1.6 fb⁻¹ T = time \rightarrow for the presentation and for preparation P = personal \rightarrow personal scientific capacity (don't really know all the details esp. theorem

theoretical ones)

- No comparison with CMS (but results similar)
- Will not go into the details mainly on experimental chalenges, event selections, systematic uncertainties, or statistical formalisms... This is of course HUGE amount of work done by the physicists in the collaboration, so please consult the papers and notes.
- Topics covered:
- SUSY with Missing Transverse Energy (MET) signatures
- Heavy Resonances
- Strong Gravity Searches
- MSSM Higgs

https://twiki.cern.ch/twiki/bin/view/AtlasPublic

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Physics WGs B Physics Top Physics Standard Model Higgs Susy Exotics Heavy Ions Monte Carlo Combined Performance Detector Systems, Luminosity and Data Taking, including Event Displays Other Public Documents	NEW ATLAS results for the 201 cummer conferences, EPS-HEP (Grenoble) and Lee This is the central ATLAS results page. It is intended for physicists who are looking for docu from LHC collision data are made available via three routes: publications, listed under the filt preliminary results. Approved event displays are also available. Links to results pages with protes may be available, these typically describe either technical work not related to collision notes may be available, these typically describe either technical work not related to collision Publications of the ATLAS collaboration Physics Groups Combined Summary Plots Detector Systems, Luminosity and Data Taking, including Event Displays Other Public Documents & Information Further information, links	Deton-Photon (Mumbal) NEW Imentation on ATLAS physics, detector and combined performance results. ATLAS results rst sub-heading; performance plots; and conference (CONF) notes, which describe erformance plots and CONF notes are given in the tables below. In addition, public PUB data performance, or studies of the physics capabilities of ATLAS using simulation. PUB ~15 BSM papers, also look at ATLAS <i>Preliminary</i> results in form of CONF notes	5
Physics PUB Notes	Publications of the ATLAS collaboration		
Physics Notes Technical Design Report	The following publications have a full-ATLAS author list. See also: List / 🔂 RSS from	CDS.	
	Title	Links Remarks Group	(
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Non-SUSY: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults Higgs: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HiggsPublicResults

ATLAS data taking in 2011

- pp collisions at 7 TeV
- LHC performance extremely well
 - peak lumi 2.96 x 103
 - max 100 /pb/day (>2 times the whole 2010!)
 - 2.9/fb delivered (~3 times 2011 target)
- ATLAS data taking efficiency 95% Relative fraction of good quality data: 90-100%, depending on detector subsystem.
- 50 ns bunch spacing (25 ns designed).
 6 collisions /crossing (average).
- Substantial in-time and out-of-time pileup. Much effort on understanding impact on detector performance with data and simulation.



https://twiki.cern.ch/twiki/bin/view/AtlasPublic/LuminosityPublicResults#2011_pp_Collisions



0.05% pT (GeV) ⊕ 1%

Hadronic calorimeter: $|\eta| < 1.7$ Fe/scin@llator 1.3< $|\eta| < 4.9$ Cu/ W-Lar; σ /Ejet= 50%/VE \oplus 3%

Muon Spectrometer: $|\eta| < 2.7$ Air-core toroids and gas-based muon chambers $\sigma/p_T = 2\% @ 50$ GeV to 10% @ 1TeV (ID+MS)

EM Calorimeter: $|\eta| < 3.2$ Pb-Lar Accordion $\sigma/E=10\% \ VE\oplus 0.7\%$

BSM, why we need it?

- Standard Model is a (very) effective theory that breaks down at a certain scale (hopefully TeV scale). But:
 - → Hierarchy: quadratic divergence of the Higgs mass, extremely fine-tuned
 - \rightarrow What is the underlying nature of EWSB?
- Dark Matter
- \rightarrow what is it? cannot be explained by SM
- Neutrinos have mass
- \rightarrow where are the right-handed neutrinos?
- BSM models attempt to solve the SM limitations



Models VS Experimental Signatures

- Many extensions of the SM have been developed over the past decades:
- Supersymmetry
- Extra-Dimensions
- Technicolor(s)
- Little Higgs
- No Higgs
- GUT
- Hidden Valley
- Leptoquarks
- Compositeness
- 4th generation (t', b')
- LRSM, heavy neutrino²
- etc...

1 jet + MET jets + MET 1 lepton + MET Same-sign di-lepton Dilepton resonance Diphoton resonance Diphoton + MET Multileptons Lepton-jet resonance Lepton-photon resonance Gamma-jet resonance Diboson resonance Z+MET W/Z+Gamma resonance Top-antitop resonance Slow-moving particles Long-lived particles Top-antitop production Lepton-Jets Microscopic blackholes Dijet resonance

 Experimental point of view: concentrate on signatures, studied with benchmark models!!

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• This would become important if/when significant deviations(s) from SM found.



SUSY - a brief overview

- Extension of SM solves many theoretical problems
- Each SM particle has a partner which differs by 1/2 unit of spin
- SUSY is a broken symmetry, to avoid fine-tuning masses ~<1 TeV
- The minimal extension of the SM (MSSM) introduces ~105 new parameters. Adopt some models (e.g. mSUGRA, CMMSM, GMSB...) or phenomenological assumptions to reduce this number of free handles.



SUSY analyses



- LSP decays often little or no missing momentum
- Strongly interacting particles with high cross sections
- Can exploit invariant mass constraint and LSP decay properties in general

Trying to cover all possibilities in a model independent way: in/exclusive searches needed



Paul D. Jackson - SUSY

strengths some particles can be long-lived

- Slow moving "heavy muon" (sleptons etc)
- Hadronize into R-hadrons (g/t/b)
- Stop late decays (gluino, anything?)
- Decays in detector (slepton/chargino)

Distinctive, low-background signatures usually requiring ESD-level info and dedicated searches



Thanks to P.D. Jeckson for the slide

SUSY analyses



Signatures



- O lepton: squarks and gluionos dominate
- Lepton(s) + Jets + MET: lower BR, but complementary
- 3rd generation (b/t), in cascade, direct production >1 /fb of data
- Photon(s) + MET \rightarrow GMSB

Jets + MET ("0 lepton")

$$\begin{split} \tilde{q} &
ightarrow q \, \tilde{\chi}_1^0 \ \tilde{g} &
ightarrow q q \, \tilde{\chi}_1^0 \end{split}$$

- Typical SUSY (ala CMSSM/mSUGRA)
- Cut on MET and Meff
- No resonance peak, Meff sensitive to SUSY scale
- Good understanding of SM background, esp. multijet production
- Cut and count: No excess above SM



95 % CL Limits on squark/gluino masses from 0-lepton analysis

- Simplified models
- Experimentalists-like plot (more intuitive)
- Squark-gluino mass plain, in which all other SUSY particles (except for the lightest) neutralino are set beyond the reach of the LHC
- Exclude squarks/glionos of ~1 TeV mass.
- Huge jump wrt 2010 result (cf. arXiv:1102.5290)



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95 % CL Limits on squark/gluino masses from 0-lepton analysis

- Exclusion curves for MSUGRA/CMMSM models
- Theorists-like plot (with limits on the formalism)
- "Theorists seek to combine many constraints"
- Here an example of exclusion curves in (m₀, m₁₂) plane

 NB: Limits from Tevatron and LEP generated with different parameter choices.



 m_0 universal scalar mass, $m_{_{12}}$ universal gaugino mass, A_0 universal trilinear scalar coupling, tan β the ratio of vev of the two Higgs fields, μ sign of Higgsino mass par.

Jets + MET + 1,2 Lepton

- Leptons arise from slepton or charginos or W/Z decays
- Due to smaller Branching Ratio, less stringent limits than fully hadronic but complementary.
- Look for 1, 2 (same-sign or opposite sign) or more leptons.
- Flavor subtraction selects flavor-correlated decays.
- Can also look explicitly for heavy boson decay.



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What if gluinos decay preferably to 3rd generation(?)

Consider several pheno.
 scenarii, such as:

Assume m(gluino) > m(stop) > m(neutr.) > m(lsp) $g \rightarrow$ stop+top ; stop \rightarrow b+LSP

→ Complex final states with lepton(s) and b-jets → Limit on gluino mass: m(gluino) > 500 GeV at 95% C.L.

- Also gluino-gluino production followed by decay through off-shell stop:
 g → stop top → ttbar+LSP
- Good performance of b-tagging required



Diphotons + MET (+ Jets)



No excess found in this spectra.

- Gluinos and neutralinos mass limits m>560 GeV
- 1/R <961 GeV

 Unlike mSUGRA, in GMSB SUSY is broken at the TeV scale in a hidden sector, and is propagated to the MSSM vaia gauge and gaugino interactions with MSSM particles.

- Gauge-Mediated SUSY Breaking:
- \rightarrow LSP = Gravitino
- \rightarrow NLSP = Neutralino (and Chargino)
- \rightarrow NLSP \rightarrow LSP + Photon or W or Z

 Inclusive search, jets may be present, bit not required in the selection

- Interpretation also in the context of UED
- Each SM particle has *n* KK excitations with *n*=1 accessible at the LHC KK produced in pairs and decay in cascade to excited photon with subsequent decay $\gamma^* \rightarrow \gamma + G$, with G escaping detector

Heavy resonances

Lepton + X , X= another lepton or a neutrino



Dijet resonances



- Excited quarks, strong gravity, contact interaction
- Look for resonance above phenomenological fit of the data
- Probe quark structure at 4 TeV

Highest mass jj event



M(jj) ~ 4 TeV (impressive) MissingEt ~100 GeV

Strong Gravity

Search for monojets

Large Extra-D (ADD):
 → Brings the Plank scale down to the TeV scale:

 $M_{Pl}^2 \sim M_D^{2+n} R^n$

- → Graviton escapes detector Also Split SUSY
- KK massive graviton modes, produced in association with a jet
- Challenge:
 - \rightarrow Instrumental background
 - \rightarrow Understanding Z(\rightarrow vv) + jets
- M_D excluded in range
 1.8 TeV-2.3 TeV, n=2-4



Contact interactions

 Phenomena BSM such as LED (in ADD model), or quark/lepton compositeness may be described as a four-fermion contact interaction

- Analogue to Fermi theory of β decay
- Experimentally interesting: no resonance peak, rather continuous change in shape. Good understanding of performance of very high-pt leptons
- ∧ > 4.9(4.5) TeV excluded for constructive(destructive) interference



Inevitable black holes

- Microscopic black-holes decaying through Hawking radiation
- Large uncertainty on models due to our ignorance of quantum gravity
- Semi-classical models only for m(B.H.) >> m(threshold)
- m(B.H.) >> m(threshold)
 A safe bet: decay is democratic and isotropic. Likely large multiplicity of particles → look or (many) jets and leptons at high mass
- Inclusive search: sum energy of all objects (e, μ, jets)
- → Can also select peculiar events, e.g. same-sign dilepton with very large track multiplicity
- No deviation from SM



NTracks

Non-SM Higgs

$MSSM \ H/A \to \tau\tau$



MMC $m_{\tau\tau}$ [GeV] • Candidates for A/H/h->tautau decays are selected in the four final states eµ, ehad, µhad and hadhad.

• No evidence for a Higgs boson signal is observed. Exclusion limits on both the cross section for the production of a generic Higgs boson as a function of its mass and on MSSM Higgs boson production A/H/h as a function of m_A and tan β , are derived.

Regions of parameters space beyond the existing limits from LEP and Tevatron.

Charged Higgs



- Charged Higgs in jj chanel studied.
- Assuming 100% BR to charm-strange pairs
- Limits are comparable to the results from the Tevatron.



ATLAS Searches* - 95% CL Lower Limits (Status: SUSY 2011)

Mass scale [TeV]

MSUCRA/CMSSM : 0-loo + i's + F					
MSUCRA/CMSSM : 0-lep + js + $E_{T,miss}$ MSUCRA/CMSSM : 1-lop + i's + E	L=1.04 fb (2011) [Preliminary]	and Gev q - g mass	•		
MSUGRA/CMSSM : multiiote + E	L=1.04 fb (2011) [Preliminary]	\tilde{a} mass $(for m(\tilde{a}) = 2m(\tilde{a}))$	ATLAS		
Simply mode (light \overline{v}^0) : 0 log + i's + E	L=1.34 fb (2011) [Preliminary]	$\tilde{a} = \tilde{a} mass$	Preliminary		
Simpl. mod. (light χ_0): 0-lep + js + $E_{T,miss}$	L=1.04 fb ⁻¹ (2011) [Preliminary]	1.0/s lev q - g Illass	,		
Simpl. mod. (light χ_0): 0-lep + js + $E_{T,miss}$	L=1.04 fb (2011) [Preliminary]		ſ		
Simpl. mod. (light χ_1): U-lep + J s + $E_{T,miss}$	L=1.04 fb (2011) [Preliminary]	$\tilde{a} m \sigma w$ $\tilde{a} m \sigma c$ (for $m(\tilde{b}) < 600 \text{ GoV})$	$Ldt = (0.031 - 1.60) \text{ fb}^{-1}$		
Simpl. mod. (light χ_{i}): 0-lep + b-jets + j s + $E_{T,miss}$	L=0.83 fb (2011) [ATLAS-CONF-2011-098]	\tilde{g} mass (for $m(\tilde{g}) < 80$ GeV)	J,		
Simpl. mod. $(g \rightarrow tt\chi)$: 1-lep + b-jets + js + $E_{T,miss}$	L=1.03 fb (2011) [Preliminary]	sto gev g mass (ioi $m(\chi_1) < 80 \text{ GeV}$)	√s = 7 TeV		
Pheno-MSSM (light χ): 2-lep SS + $E_{T,miss}$	L=35 pb * (2010) [arXiv:1103.6214]	eso Gev q mass	_		
Pheno-MSSIM (light χ_1): 2-lep US + $E_{T,miss}$	L=35 pb ^{-*} (2010) [arXiv:1103.6208]	$\tilde{g}_{ssgev} = q \operatorname{mass}^{(0)} (q \operatorname{mass}^{\pm}) m(\tilde{g}^{\pm}) (q \operatorname{mass}^{\pm}) (q mass$	(0) > 1(0)		
Simpl. mod. ($g \rightarrow qq\chi$): 1-lep + J s + $E_{T,miss}$	L=1.04 fb ⁻⁺ (2011) [Preliminary] 200 GeV	χ mass (for m(g) < 600 GeV, (m(χ) - m(χ)) / (m(g) - m())	()) > (/2)		
$G(MGB)$ (GG(M) + S(H)p). Hodel : $H + E_{T,miss}$	L=1.07 fb ⁻⁺ (2011) [Preliminary]	776 GeV g mass (for $m(bino) > 50 GeV$)			
GMSB : stable ₹	L=37 pb ^{-*} (2010) [arXiv:1106.4495β GeV τ Mi	ass			
Stable massive particles : R-hadrons	L=34 pb ⁻¹ (2010) [arXiv:1103.1984]	562 GeV g mass			
Stable massive particles : R-hadrons	L=34 pb ⁻¹ (2010) [arXiv:1103.1984]	294 GeV D mass			
Stable massive particles : R-hadrons	L=34 pb ⁻¹ (2010) [arXiv:1103.1984]	sog Gev I mass			
Hypercolour scalar gluons : 4 jets, $m_{\parallel} \approx m_{\rm kl}$	L=34 pb ⁻¹ (2010) [Preliminary] 185 GeV	sgluon mass (excl: $m_{sg} < 100 \text{ GeV}, m_{sg} = 140 \pm 3 \text{ GeV}$)			
RPV (λ_{311} =0.01, λ_{312} =0.01) : high-mass eµ	.L=0.87 fb ⁻¹ (2011) [Preliminary]	440 GeV V _τ mass			
Large ED (ADD) : monojet	L=1.00 fb ⁻¹ (2011) [ATLAS-CONF-2011-096]	3.2 τev M _D (δ=2)			
$OED: \gamma\gamma + E_{T,miss}$	L=1.07 fb ⁻¹ (2011) [Preliminary]	1.22 Tev Compact. scale 1/R			
RS with $k/M_{\rm Pl} = 0.1$: diphoton, $m_{\gamma\gamma}$	L=36 pb ⁻¹ (2010) [ATLAS-CONF-2011-044]	920 Gev Graviton mass			
RS with $k/M_{Pl} = 0.1$: dilepton, $m_{ee/\mu\mu}$	L=1.08-1.21 fb ⁻¹ (2011) [arXiv:1108.1582] 1.63 TeV Graviton mass				
RS with g_{qqgKK} / $g_s = -0.20$: $H_T + E_{T,miss}$	L=1.04 fb ⁻¹ (2011) [Preliminary]	840 GeV KK gluon mass			
Quantum black hole (QBH) : m_{dijet} , $F(\chi)$	L=36 pb ⁻¹ (2010) [arXiv:1103.3864]	3.67 TeV M _D (δ=6)			
QBH : High-mass σ_{t+x}	L=33 pb ⁻¹ (2010) [ATLAS-CONF-2011-070]	2.35 TeV M _D			
ADD BH $(M_{th}/M_D=3)$: multijet $\Sigma p_T, N_{jets}$	L=35 pb ⁻¹ (2010) [ATLAS-CONF-2011-068]	1.37 TeV M _D (δ=6)			
ADD BH $(M_{th}/M_{D}=3)$: SS dimuon $N_{ch, part}$	L=31 pb-1 (2010) [ATLAS-CONF-2011-065]	1.20 TeV M _D (δ=6)			
qqqq contact interaction : $F_{\chi}(m_{\text{dijet}})$	L=36 pb ⁻¹ (2010) [arXiv:1103.3864 (Bayesian limit	t)] 6.7 TeV	Λ		
qqμμ contact interaction : m	L=42 pb ⁻¹ (2010) [arXiv:1104.4398]	4.9 TeV A			
SSM : m _{ee/µµ}	L=1.08-1.21 fb ⁻¹ (2011) [arXiv:1108.1582]	1.83 TeV Z' MASS			
SSM : <i>m</i> _{T,e(µ}	L=1.04 fb ⁻¹ (2011) [arXiv:1108.1316]	2.15 TeV W' mass			
Scalar LQ pairs (β =1) : kin. vars. in eejj, evjj	L=35 pb ⁻¹ (2010) [arXiv:1104.4481]	376 Gev 1 ^{at} gen. LQ mass			
Scalar LQ pairs (β=1) : kin. vars. in μμjj, μνjj	L=35 pb ⁻¹ (2010) [arXiv:1104.4481]	422 GeV 2 nd gen. LQ mass			
4^m generation : coll. mass in $Q_{\overline{A}} \rightarrow WqWq$	L=37 pb ⁻¹ (2010) [ATLAS-CONF-2011-022]	270 GeV Q ₄ mass			
4 [™] generation : d ₁ d ₄ → WtŴt (2-lep SS)	L=34 pb ⁻¹ (2010) [arXiv:1108.0368]	290 GeV d ₄ mass			
$T\overline{T}_{4th case} \rightarrow t\overline{t} + A_0 A_0^+$: 1-lep + jets + $E_{T miss}$	L=1.04 fb ⁻¹ (2011) [Preliminary]	420 GeV T mass			
Major. neutr. (LRSM, no mixing) : 2-lep + jets	L=34 pb ⁻¹ (2010) [ATLAS-CONF-2011-115]	780 GeV N mass (m(W P) = 1 TeV)			
Major. neutr. (LRSM, no mixing) : 2-lep + jets	L=34 pb ⁻¹ (2010) [ATLAS-CONF-2011-115]	1.350 TeV W _R mass (230 < m(N) < 7	700 GeV)		
H_{L}^{EE} (DY prod., BR($H_{L}^{\text{EE}} \rightarrow \mu\mu$)=1): $m_{\mu\nu}$ (like size)	L=1.6 fb ⁻¹ (2011) [Preliminary]	375 GeV H ^{±±} mass			
Excited quarks : m _{dilet}	L=0.81 fb ⁻¹ (2011) [ATLAS-CONF-2011-095]	2.91 TeV q* mass			
Axigluons : m _{dijet}	L=0.81 fb ⁻¹ (2011) [ATLAS-CONF-2011-095]	3.21 TeV Axigluon ma	ass		
Color octet scalar : m	L=0.81 fb ⁻¹ (2011) [ATLAS-CONF-2011-095]	1.91 Tev Scalar resonance m	ass		
	10 ⁻¹	1	10		

*Only a selection of the available results leading to mass limits shown

SUSY

Extra dimensions

LQ Z' / W'Ct. I.

Other

ATLAS Searches* - 95% CL Lower Limits (Status: SUSY 2011)



*Only a selection of the available results leading to mass limits

ATLAS Searches* - 95% CL Lower Limits (Status: SUSY 2011)

Mass scale [TeV]



*Only a selection of the available results leading to mass limits shown

Few general and personal comments

SUSY in its most-hoped-for-incarnation on pressure (life support some say)
 → Of course ATLAS will continue looking and increasing the reach

- What if SUSY were hiding? (e.g. no Missing ET)
 → "Split", "low-MET", "squashed", "mashed?"
 → Even if very soft cascade at tree level, Initial State Radiation still creates MET, but this needs to be studied further
- With >1 fb-1, other SUSY production mechanisms open up → exclusive chargino/neutralino and 3rd generation production

 Experimental challenges as we enter further the Multi-TeV: understanding very energetic leptons and jets...

- However, this is only the beginning.
- The moto of this conference is "New Ideas for (old) unsolved problems". So, this is also fun time for theorists and phenomenologists for new ideas: maybe something is missed in the LHC data!

THANK YOU!

Backup



Supersymmetry

- Extension of the Poincaré algebra
- Fermion ↔ Boson symmetry
- Solves many problems of the SM, esp. stabilizes Higgs sector
- If R-parity (R = (-1)^{3(B-L)+2s}) is conserved, Lightest SUSY Particle (LSP) is an excellent Dark Matter candidate
- Phenomenology is very diverse





Wjj a la Tevatron

ATLAS-CONF-2011-097



J.Ellis Supersymmetric Models to Study

• Gravity-mediated:		• Other SUSY 🛛 models:		
– NUHM2		- (Gauge-mediated	
• as below, $m_{hu} \neq m_{hd}$	stu	died ¹	Anomaly-mediated	
– NUHM1 – in g	lobal	fits I	Mixed modulus-anomaly-	
• as below, common $m_h \neq m_0$		1	nediated	
- CMSSM	diad	— I	Phenomenological 19-	
• $m_0, m_{1/2}, \tan \beta (B_0), A_0$ in globa	fits	1	parameter MSSM	
– VCMSSM		[–	NMSSM	
• as above, & $A_0 = B_0 + m_0$ Som		Le	ess studied in global fits	
– mSUGRA Glob	1	Ifm	dal has N paramatars	
• as above, & $m_{3/2} = m_0$	II model has in parameters,			
- RPV CMSSM		^{^{2N} po}	ints, e.g., 10 ⁸ in CMSSM	



J.Ellis

Sustainable Benchmarks

- Many models:
 - CMSSM, NUHM1, RPV-CMSSM, mGMSB, mAMSB, MM-AMSB and pMSSM
- Benchmark planes, lines & points, e.g., CMSSM
 - Varied signatures
 - Similar along lines
 - Move to next point
 if/as needed

AbdusSalam, Allanach, Dreiner, Ellis, Heinemeyer, Krämer, Mangano, Olive, Rogerson, Roszkowski, Weiglein



MSSM Higgs(es)

- MSSM Higgs sector
 - 5 bosons h/H/A, H+, H-
 - Higgs sector: determined by two parameters; at tree level: tan β and m_A (or m_{H+})
- Major production modes:
 - h/H/A: gg-fusion, b-associated
 - Light H+: top quark decays
 - [Heavy H+: gg/gb-fusion]
- Dominant decay modes
 - h/H/A $\rightarrow \tau \tau$
 - H+ $\rightarrow \tau \nu$, for small tan β : H⁺ \rightarrow cs



MSSM H/A $\rightarrow \tau\tau$

- In MSSM the decay of neutral Higgs(es) to tau-lepton pairs strongly enhanced for large regions of the parameter space: → H/A/h→ττ is one of the most
 * TOTOTOTOT promising channels for Higgs searches at the LHC
- Production: $gg \rightarrow A/H/h$ and associated bbA/H/h
- Study the final states:
 - H→eµ4ν
 - − H→eτ_{had}3ν, μτ_{had}3ν
 - $H \rightarrow \tau_{had} \tau_{had} 2\nu$
- Event selection: ask high-p_T, isolated leptons, large E_t^{miss}, good quality high-pT hadronic taus
 - More sophisticated method than the collinear approximation to evaluate the $m_{\tau\tau}$ mass is used for $l\tau_{had}$ final states





 $gg \rightarrow b\bar{b}H$

b-jets, 0 lepton, 0.83/fb

