Search for $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^0 \rightarrow 1\ \ell^{\pm} +\ h(b\bar{b}) + \not{E}_T$ with ATLAS at LHC Run2

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PESBLADe Project, June 22 2016

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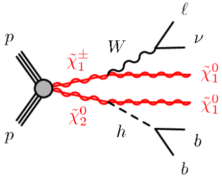
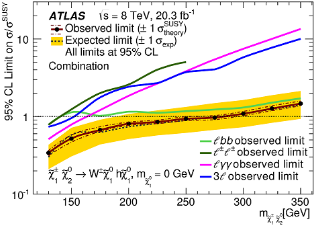
- Looking for $\tilde{\chi}_1^{\pm}\ \tilde{\chi}_2^0 \longrightarrow 1\ \ell^{\pm} + h(b\bar{b}) + \not{E}_T$ at LHC Run2 with ATLAS.



- Past: Run1 ($\sqrt{s}$=8TeV, L= 20 fb^{-1}):
  - 1^{st} analyses using the Higgs boson to search for SUSY.
  - Exclusion limit at 95% C.L.
  $m_{\tilde{\chi}_1^{\pm},\tilde{\chi}_2^0} > 250$ GeV, $m_{\tilde{\chi}_1^0}$=0 GeV, Ref



- Near future: Run2 ($\sqrt{s}$=13 TeV, L= 100 fb^{-1}):
  - Enhance the search sensitivity.

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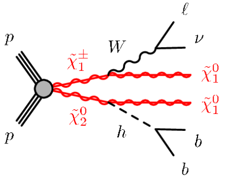

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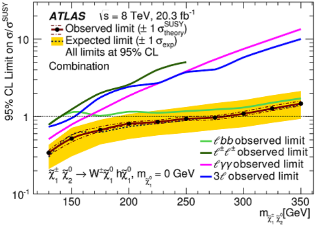
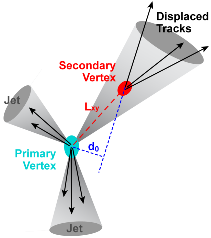


- Near future: Run2 ($\sqrt{s}$=13 TeV, L= 100 fb^{-1}):
  -Enhance the search sensitivity.

- Timing: Starting: Sep 2016
  Goal: Preliminary results conf winter 2017,
  Publication after summer 2017 conf

- b-tagging plays crucial role because of the 2 b-jets in the final state.

- b-taggers distinguish b jet from light and c jets
  - Rely on B-hadron properties (lifetime, mass)
  - Based on jets associated tracks properties. More details



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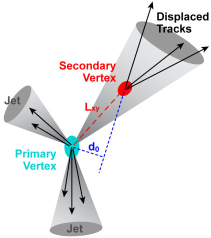
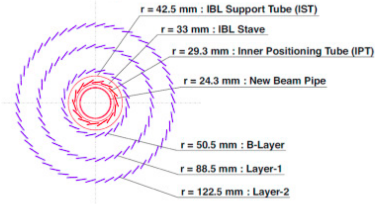
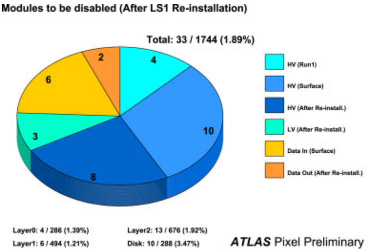


- The tracker (pixel of Si) is the most important for b-tag
- However, pixel modules can turn inactive for several reasons.





- I'm studying the impact on b-tagging of:
  - Varying the fraction of inactive modules in pixel layers
  - Modifying the minimal pixel Time over Threshold:

  ToT $\propto$ deposited charge in Si. More about ToT

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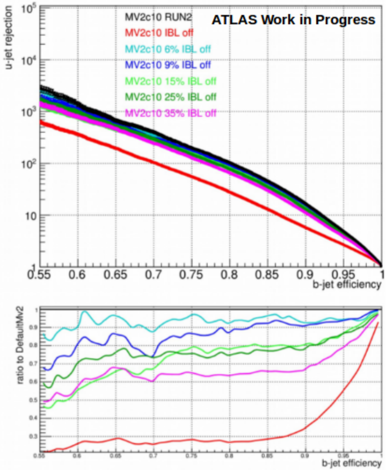


- Status: More results
  - Simulation & analysis setup in place
  - More configurations will be studied
- Goal: ATLAS internal note for Sep 2016.

Suspect3 a SUSY spectrum calculator

- Authors: - Fortran: A. Djouadi, J-L Kneur, G. Moultaka.
  - C++: Michael Ughetto, Dirk Zerwas.
- Aim:
  - Computes pMSSM spectrum for SUSY breaking models mSUGRA, AMSB and GMSB.
  - Implements the radiative corrections at full one loop for the masses and the dominant **two loops for the Higgs** .
- Input: SLHA file containing
  - SM inputs (M_Z, M_{top}^{pole}, $\alpha(M_Z)$, $\alpha_s(M_Z)$,...)
  - Boundary conditions of the SUSY breaking model.

Pheno part

- Add the 125 GeV Higgs boson mass as input to Suspect 3
  - while in the present version it is calculated as output
- Benefit for all SUSY analyses:
  - Facilates pMSSM scans by avoiding large number of incompatible models.
- Task: Look for free parameters in the Higgs and stop sectors (i.e.: μ, A_t, $\tan\beta$) computable for a **known Higgs boson mass**.

- Reminder of the simple approximation for the Higgs mass radiative corrections (RC)

$$m_h^2 = m_h^{2,tree} + \frac{3g_2^2 m_t^4}{8\pi^2 m_w^2 sin^2(\beta)} \left[ln\left(\frac{m_{\tilde{t}_1} m_{\tilde{t}_2}}{m_t^2}\right) + \frac{X_t^2}{2M_s^2} - \frac{X_t^4}{12M_s^4}\right]$$

With $X_t = A_t - \mu cot(\beta)$

$M_s^2 = \sqrt{m_Q^2 m_{t_R}^2 + m_t^2(m_Q^2 + m_{t_R}^2) + m_t^4}$

$m_{\tilde{t}_1} m_{\tilde{t}_2} = \sqrt{M_s^4 - 4m_t^2 X_t^2}$

- Possible inversions:

125 Higgs boson mass $\xrightarrow{1} A_t$

$\xrightarrow{2} \mu$

$\xrightarrow{3} tan\beta$

$\xrightarrow{4} m_{H_u}^2, m_{H_d}^2$

- Example: A_t computation:
  - Input: $\tan(\beta)$, μ, $m^2_{H_u}$, $m^2_{H_d}$
  - Procedure: $m_A \rightarrow \ m_H^{tree} \rightarrow$ RC, Quadratic equation in X_t^2
    $\rightarrow$ multiple A_t solutions
- Technical difficulties:
  - Multiple solutions: Constraints to reject unwanted solutions
  - Convergence of the iterative procedure
- Status: First code version with the 4 inversions working well and in validation.
- Future work: Replace RC with the full one loop for the masses and the dominant **two loops for the Higgs** relation.

Input	Output
type of inversion =1	A_t
m_H exp = 125 GeV	
m_{top} =173 GeV	
m_W =80.1 GeV	
m_Z =90.1 GeV	
m_{t_R} = 2000 GeV	-2004.48 correct value relative deviation=0.24%
m_Q = 2000 GeV	2204.48 unwanted value
g_c = 0.64	
$\tan(\beta)$ = 10	
μ = 1000	
sign of $\mu = +1$	
$m^2_{H_u}$ = -984135 GeV	
$m^2_{H_d}$ =-1.01164e+06 GeV	

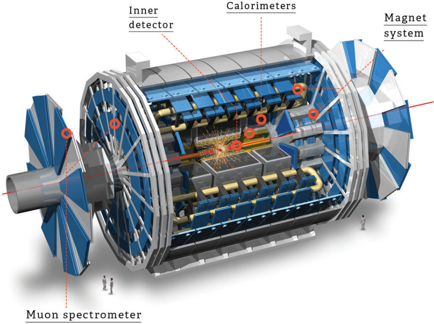
Thank you for your attention!

LHC and ATLAS

- Physics Goals: Precise tests of the SM and searche for New physics (SUSY, Extra Dimensions,..)
- Proton-proton collision
- Run 1: $\sqrt{s}$=8(7) TeV in 2012(2011)
  $\int Ldt \sim 20(5)$ fb^{-}1, **Higgs boson found !!!**
- Run 2: $\sqrt{s}$=13 TeV in 2015→2018
  $\int Ldt \sim 100$ fb^{-}1

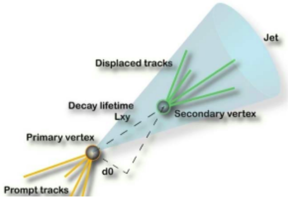
LHC and ATLAS

- Inner Detector (tracker): The most important for b-tag
  as we need accurate tracking and vertiexing
  $\sigma(d_0)$= 35μm for typical trk with p_T=5 GeV
- Calorimeter: Reconstruct amd measure energy of photons, electrons and jets composed of electromagnetic and hadronic calorimeters
- Muon spectrometer: Reconstruct muon tracks and measures their momentum



Basics of b-tagging

- The **B-hadron properties** utilised by spatial b-taggers (i.e.: IP3D, SV):
  - Hard fragmentation of b quarks ($x_B \sim 70\%$)
  - long lifetime($\sim$ 1.5ps)
  leading to a flight length (few mm)
  $\Rightarrow$ displaced secondary vertex



- Tracks from B−hadron decay at the SV are characterised by large impact parameters (IP)
- The IP (d_0, z_0) is the distance from the point of closest approach of the track to the PV.
- Other ATLAS b-taggers: the multivariate Mv2c10
  - It combines the output of the simple taggers (IP3D, SV, ..)

- The Pixel detector measure the Time-over-Threshold (ToT):
  - the time in which the signal is abovethreshold.
  - In units of bunch crossings (BC), i.e. 25 ns
- ToT is proportional to the deposited charge.

$$ToT = A\frac{Q + E}{Q + C}$$

- A, E and C are calibrated for each FE.
- RUN1 calibration ToT@mip30 =19000e
- The threshold represents the efficency to have a hit from charged particle
  - it corresponds to 3500e $\Rightarrow$ hits with time $<$ threshold is not read.

- b-tagger performances for different fraction of pixel inactive modules and minimal ToT values