Search of supersimmetry signature with photons in the finale state with the ATLAS detector

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Summary

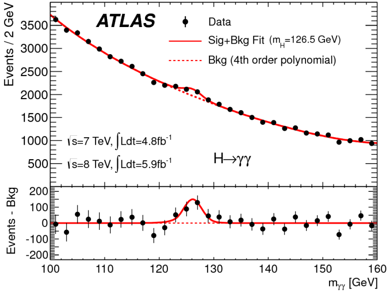
- Introduction
- Photon Physics
- Analysis details
- Previous Results and prospect

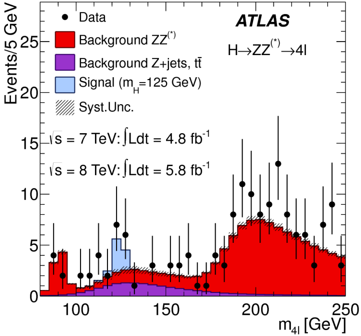
We found the Higgs...

2012 Discover of a particle compatible with the Higgs predicted by the SM (H$\to \gamma\gamma$, H$\to ZZ^* \to 4\ell$)

2013 Run 1 $\sqrt{s} = 8(7)$ TeV and $L = 20.3(4.5)$ fb^{-1}:

- H$\to WW^* \to \ell\nu\ell\nu$, H$\to \tau\tau$
- spin-0 nature
- almost right couplings





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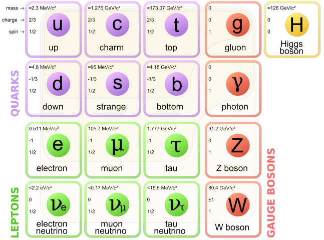
$\rightarrow$ SM: solid and robust theory



...But

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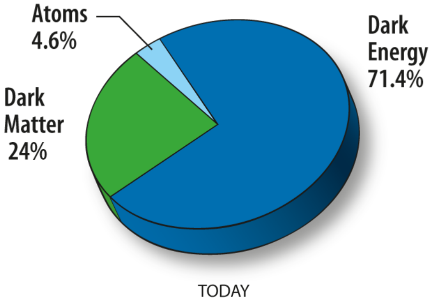
  - Dark matter



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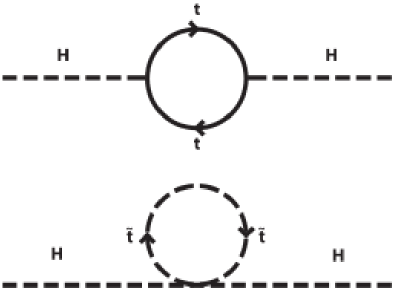

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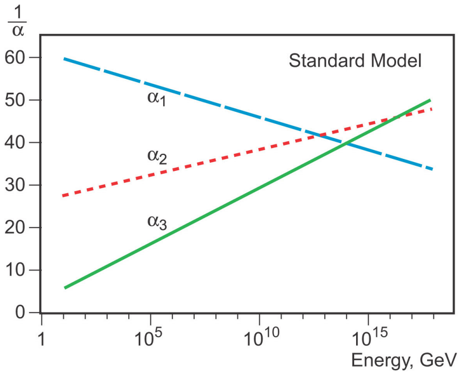

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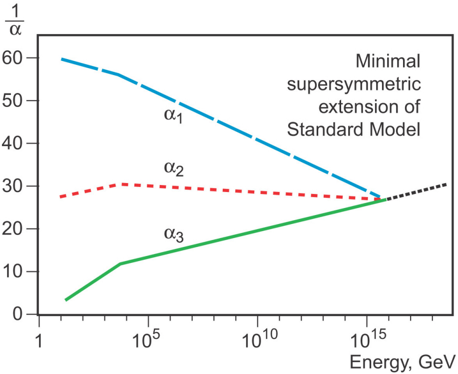

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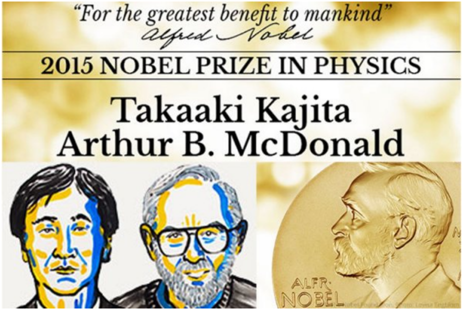

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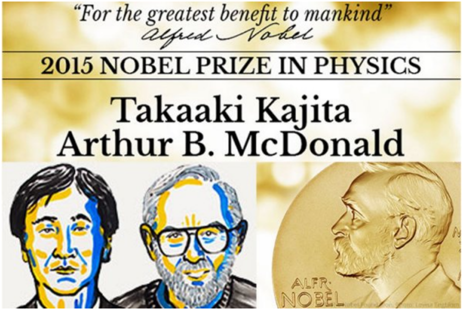

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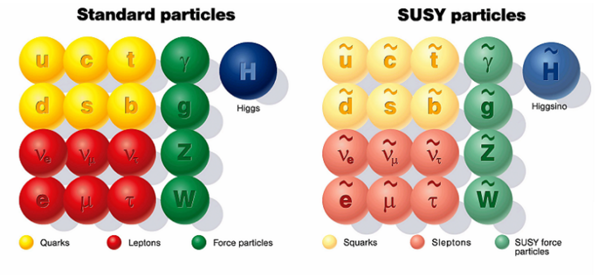
- Critical points for the SM theoretical structure:

- ATLAS RUN 2:
  - $\rightarrow$ stress the SM with precise measurement
  - $\rightarrow$ search for new phenomena: BSM theory



- Supersimmetry:
  - new bosonic field to each SM fermion
  - new fermionic field to each SM gauge boson

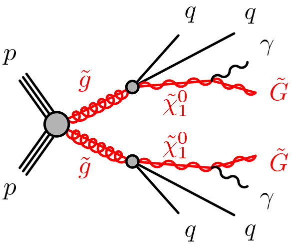
$\rightarrow$ Solve the Higgs/hierarchy problem

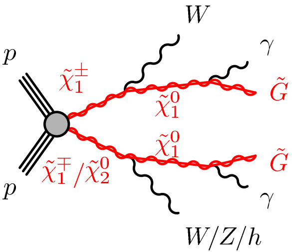
$\rightarrow$ In Susy the unification of the coupling costants is far more precise

$\rightarrow$ Dark matter: LSP SUSY particle (with R-parity conservation)

Signal processes

- Search for a signal from GGM models
  - LSP Gravitino
  - NLSP Neutralino
- Two processes identified with $\gamma\gamma + E_T^{miss}$ final state:
  - Strong production
    - gluinos→Neutralinos (bino-like)+jets→photons+Gravitinos+jets
  - Electroweak production
    - wino triplet→neutralinos+gauge-bosons→photons+Gravitinos
- The mass of the neutralino is treated as a free parameter $m_{\tilde{\chi}_1^0} = (0GeV, m_{\tilde{g}}/m_{(\tilde{\chi}_1^{\pm 1}, \tilde{\chi}_2^0)})$
- Prompt decay $\tilde{\chi}_1^0 \rightarrow \tilde{G}\gamma$ ($c\tau < 0.1$ mm)

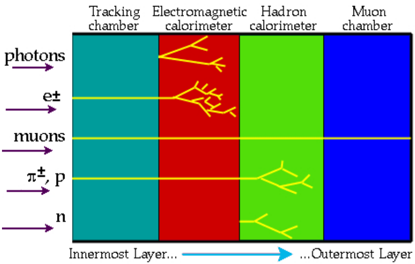


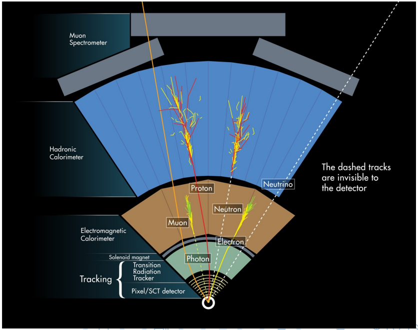


Photon Identification and reconstruction

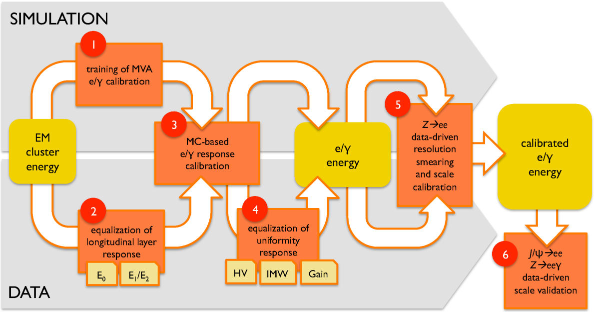
- Photon Reconstruction:
  - Energy deposit in the electromagnetic calorimeter
  - Tracks to determine if the candidate is an electron or converted/unconverted photon
- Photon Identification:
  - Energy leakage in the hadronic calorimeter
  - Shower shapes in the three layer of EM calorimeter
- Isolation: further discrimination between jets and photons: Isolation
  - energy around the candidate in a cone $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$

  $\rightarrow$ jets faking a photons have lots of other particles around it



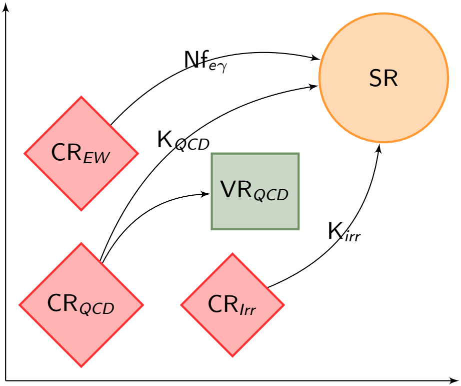


- Goal: $E_{reco} \rightarrow E_{true}$



- My qualification task: training the MVA calibration (1)
  - Monte Carlo based
  - advantages:
    - easiness to derive a new set of correction
    - take into account the correlation between the inputs

- Cut and count analysis:
  - Signal Region optimisation
  - Background evaluation:
    - SM contribution
    - Evaluation in Control Region (orthogonal to SR) with data-driven/MC methods
    - Validation Region
  - Statistical comparison of Expected (bkg) events vs. Observed

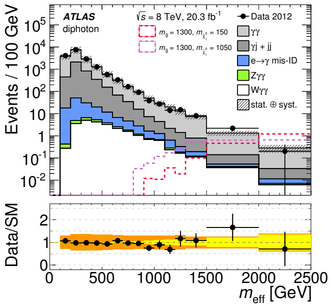


Event selection and Signal Regions

- Event selection:
  - Two tight and isolated photons
  - Event Cleaning (jet cleaning, cosmic muon cleaning)

$\rightarrow$ Inclusive signature: no explicit requests on jets, leptons

- Four Signal Regions optimised:
  - Two for strong production (SH, SL)
    - $m(\tilde{g}, \tilde{\chi}_1^0)$(1500, 1300) GeV and (1500, 100) GeV
  - Two for ew production (WH, WL)
    - $m(\tilde{\chi}_1^{\pm 1}/\tilde{\chi}_2^0, \tilde{\chi}_1^0)$ (600, 500) GeV and (600, 100) GeV.
  - Using variables:
    - p_T^{γ}
    - E_T^{miss}, $\Delta\phi(\gamma, E_T^{miss})$, $\Delta\phi(jet, E_T^{miss})$
    - H_T (=total transverse energy of all visible objects)
    - m_{eff} (scalar sum of H_T and E_T^{miss})



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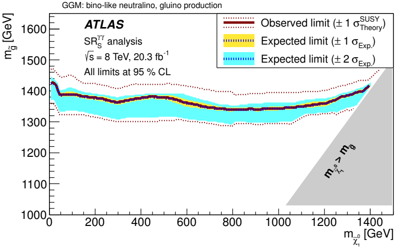
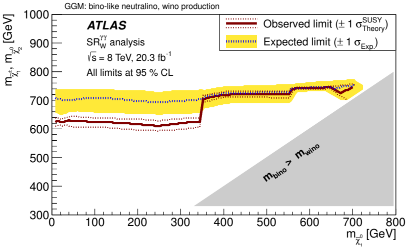
Backgrounds

- QCD background:
  - Instrumental E_T^{miss}
  - SM $\gamma\gamma$, γ+jet
  - QCD sample $\rightarrow$ normalised in a control region at low E_T^{miss}
    - $\gamma\gamma$: di-photon MC sample
    - γ+jet: pseudo-photon control sample
- EW background
  - Genuine E_T^{miss}
  - W+γ (W$\rightarrow$eν), Z+γ (Z$\rightarrow$ $\tau^+\tau^-$), $t\bar{t}$+γ (t $\rightarrow$beν)
  - electron faking photon rate from data
- Irreducible background:
  - Finale state identical to the searched signal
  - Z+$\gamma\gamma$ (Z$\rightarrow$ $\nu\nu$), W+$\gamma\gamma$ (W$\rightarrow$ $e\nu$)
  - Evaluated using MC normalised in a control region

Signal region	N_{obs}	$N_{\mathrm{exp}}^{\mathrm{SM}}$	S_{obs}^{95}	$\langle\epsilon\sigma\rangle_{\mathrm{obs}}^{95}$[fb]
$\mathrm{SR}_{\mathrm{S-L}}^{\gamma\gamma}$	0	$0.06^{+0.24}_{-0.03}$	3.0	0.15
$\mathrm{SR}_{\mathrm{S-H}}^{\gamma\gamma}$	0	$0.06^{+0.24}_{-0.04}$	3.0	0.15
$\mathrm{SR}_{\mathrm{W-L}}^{\gamma\gamma}$	5	$2.04^{+0.82}_{-0.75}$	8.2	0.41
$\mathrm{SR}_{\mathrm{W-H}}^{\gamma\gamma}$	1	$1.01^{+0.48}_{-0.42}$	3.7	0.18

- No statistically significant deviation from the SM is observed
- For each signal region 95% CL upper limit is set on the visible cross section:
  - SL (SH) 0.15 (0.15) fb
  - WL (WH) 0.25 (0.18) fb
- 95% CL lower limits are set on
  - $m_{\tilde{g}}$ at 1290 GeV (at -1σ^{SUSY}_{Theory})
  - $m_{(\tilde{\chi}_1^{\pm 1},\tilde{\chi}_2^0)}$ at 590 GeV (at -1σ^{SUSY}_{Theory})





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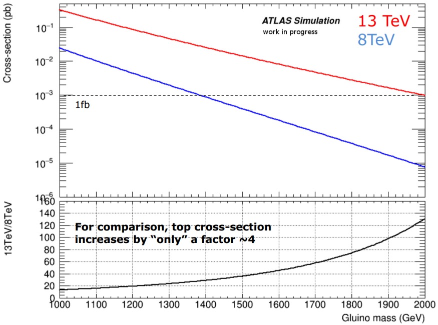
Run 2 Prospect

- Run2:
  - $\sqrt{s} \to 13$ TeV
  - $\int \mathcal{L}dt$ 100 fb^{-1} (expected)



- Considering a single signal point, gluino with mass 1400 GeV, just above the 8 TeV exclusion limit:
  - Signal: $\sigma(13\,TeV)/\sigma(8\,TeV) \sim 30$
  - Background: $\sigma(13\,TeV)/\sigma(8\,TeV) \sim 2-3$
  - $S/\sqrt{B} \sim 20$ times bigger than at 8 TeV (at the same L)
- The sensitivity of the 8 TeV analysis will be reached with L=1-2 fb^{-1} at 13 TeV

Nikola Makovec


Stay tuned!