Ricerca di supersimmetria in eventi caratterizzati da due fotoni e momento trasverso mancante in collisioni *pp* con il rivelatore ATLAS

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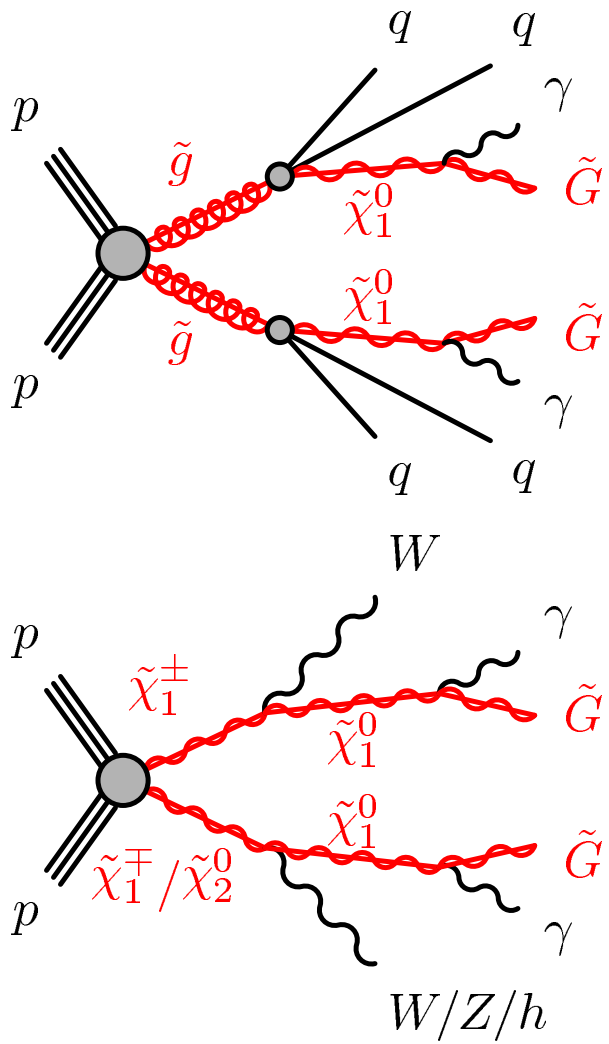
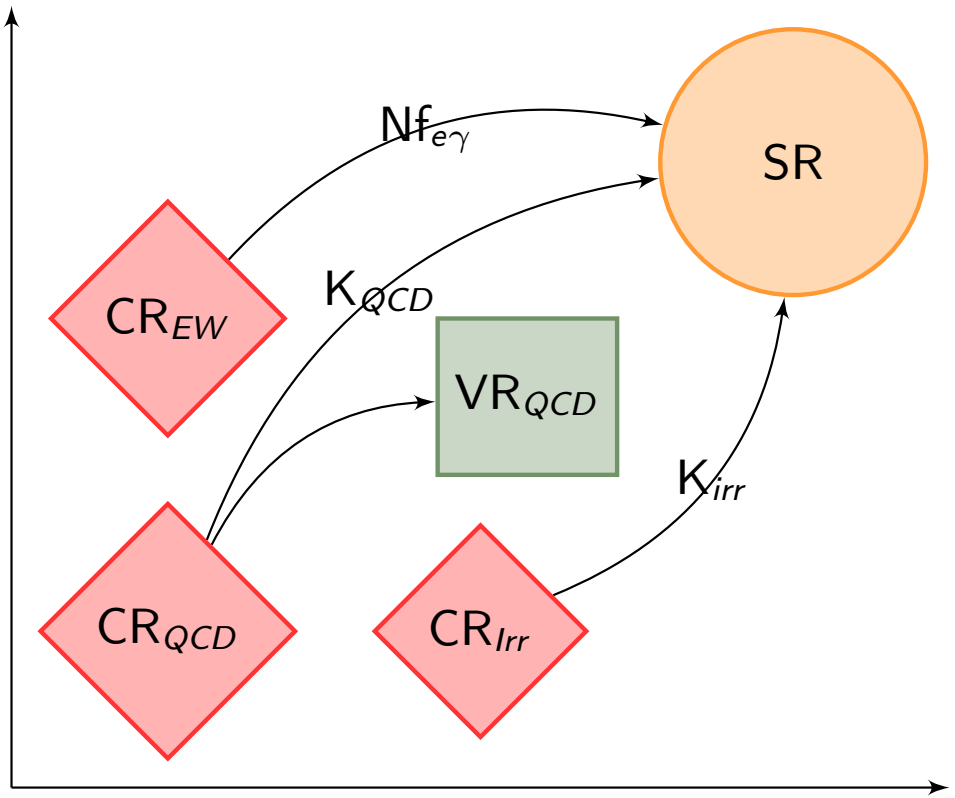
Signal processes

- 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 $\tilde{\chi}_1^0 \to \tilde{G}\gamma$ ($c\tau < 0.1$ mm)



Data and Analysis strategy

- RUN1 data: $\sqrt{s} = 8$ TeV and $L = 20.3$ fb^{-1}
- 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

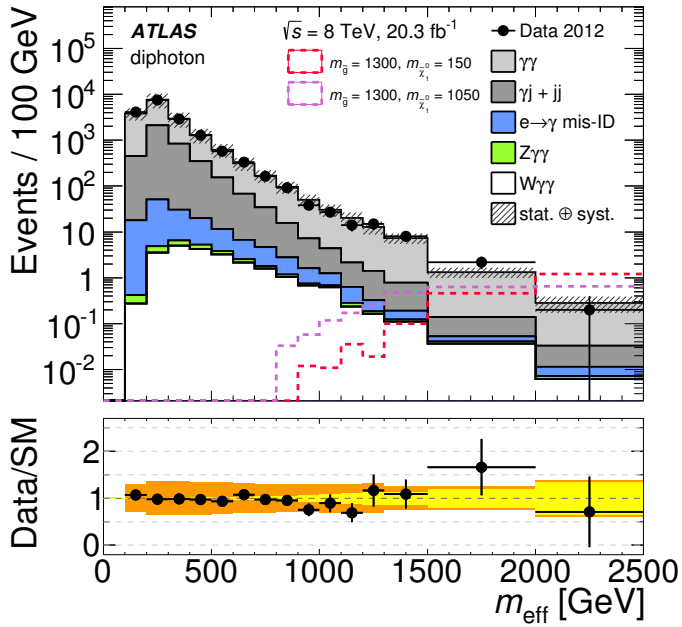


Event selection and Signal Regions

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

→ Inclusive signature: no explicit requests on jets, leptons

- Four Signal Regions optimised:
  - Two for strong production (SH, SL)
    - m($\tilde{g}, \tilde{\chi}_1^0$)(1300, 1050) GeV and (1300, 150) 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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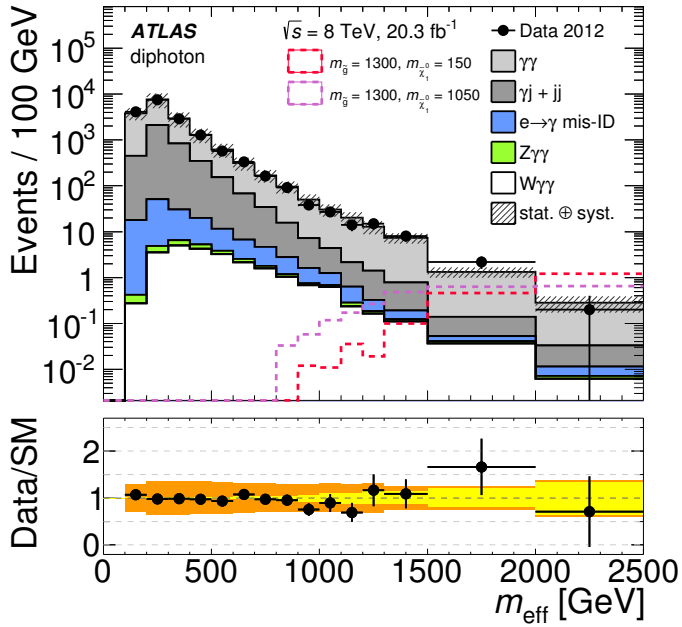

Signal Region BWH	$SR^{\gamma\gamma}_{S-L}$	$SR^{\gamma\gamma}_{S-H}$	$SR^{\gamma\gamma}_{W-L}$	
No. photons (E_T [GeV])	> 1 (> 75)	> 1 (> 75)	> 1 (> 75)	> 1 (> 75)
E_T^{miss} [GeV]	> 150	> 250	> 150	> 200
H_T [GeV]	–	–	> 600	> 400
m_{eff} [GeV]	> 1800	> 1500	–	–
$\Delta\phi_{min}$(jet, E_T^{miss}) (No. leading jets)	> 0.5 (2)	> 0.5 (2)	> 0.5 (2)	> 0.5 (2)
$\Delta\phi_{min}(\gamma, E_T^{miss})$	–	> 0.5	–	> 0.5

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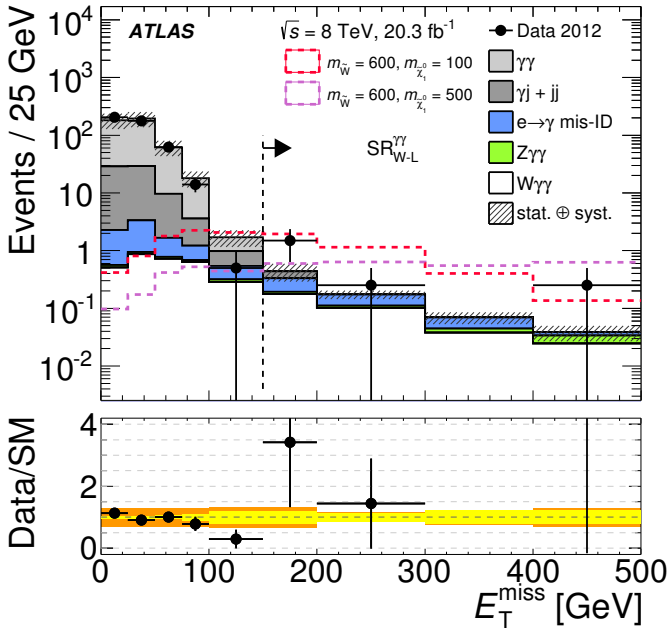

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$\Delta\phi_{min}(\gamma, E_T^{miss})$	–	> 0.5	–	> 0.5

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QCD Background

- QCD background:
  - Instrumental E_T^{miss}
  - SM $\gamma\gamma$, γ+jet
- QCD sample:
  - $\gamma\gamma$: di-photon MC sample $\rightarrow$ 75%
  - γ+jet: pseudo-photon control sample $\rightarrow$ 25%
    - one tight photon and one pseudo-photon (loose and fail fracs1 and weta1 tight request)
    - weak isolation (20 GeV)
    - leptons veto $\rightarrow$ avoid W events
- Control Region: scale factor in region $0 < E_T^{miss} < 60$ GeV tight-tight photon and H_T, m_{eff}, $\Delta\phi(\gamma, E_T^{Miss})$, $\Delta\phi(jet, E_T^{Miss})$ request
- Validation Region: side-bands $100 < E_T^{miss} < 150$ GeV in bins of 300 GeV in H_T
- Systematic uncertainties:
  - varying the relative contribution $\gamma\gamma$-QCD control sample

Signal Regions	$SR^{\gamma\gamma}_{S-L}$	$SR^{\gamma\gamma}_{S-H}$	$SR^{\gamma\gamma}_{W-L}$	$SR^{\gamma\gamma}_{W-H}$
QCD	$0.00^{+0.24}_{-0.00}$	$0.00^{+0.24}_{-0.00}$	$0.32^{+0.45}_{-0.32}$	$0.22^{+0.33}_{-0.22}$

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EW Background

- 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:
  - tag-and-probe method using $Z \rightarrow ee$
  - request tag electron (25<p$_T$<50 GeV and Tight++) and search for an electron/photon (p$_T$>50 GeV)
  - evaluate scale factor $f = \frac{N_{e\gamma}}{N_{ee}}$
    - scale factor depends on the amount of material in front of the calorimeter

    $\rightarrow$ for five η bins $(-2.47, -1.52], (-1.37, -0.6], (-0.6, 0.6), [0.6, 1.37), [1.52, 2.47)$
- Control Region: electron-photon control sample with the request of a tight photon and a tight electron with $p_T > 75$ GeV
- Systematic uncertainties:
  - varying the fitting window of Z peak
  - varying the p$_T$ request for the probe

Signal Regions	$SR^{\gamma\gamma}_{S-L}$	$SR^{\gamma\gamma}_{S-H}$	$SR^{\gamma\gamma}_{W-L}$	$SR^{\gamma\gamma}_{W-H}$
EW	0.02 ± 0.02	0.0 ± 0.0	0.64 ± 0.27	0.13 ± 0.08

Irreducible Background

- Z+$\gamma\gamma$ (Z$\rightarrow \nu\nu$)
  - Sherpa cross section (10.1 fb) rescaled to MadGraph at NLO (2.8 LO, K-factor 2)
- W+$\gamma\gamma$ (W$\rightarrow e\nu$)
  - Normalized in Control Region:
    - 50<E_T^{miss}<150 GeV
    - photon wiht p_T>50 GeV
    - $p_T^{\gamma\gamma\ell}$>100 GeV

Signal Regions	$SR^{\gamma\gamma}_{S-L}$	$SR^{\gamma\gamma}_{S-H}$	$SR^{\gamma\gamma}_{W-L}$	$SR^{\gamma\gamma}_{W-H}$
$(W \rightarrow \ell\nu)\gamma\gamma$	0.04 ± 0.02	0.05 ± 0.04	1.01 ± 0.62	0.53 ± 0.34
$(Z \rightarrow \nu\nu)\gamma\gamma$	0.00 ± 0.00	0.01 ± 0.01	0.07 ± 0.04	0.13 ± 0.07

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Irreducible Background

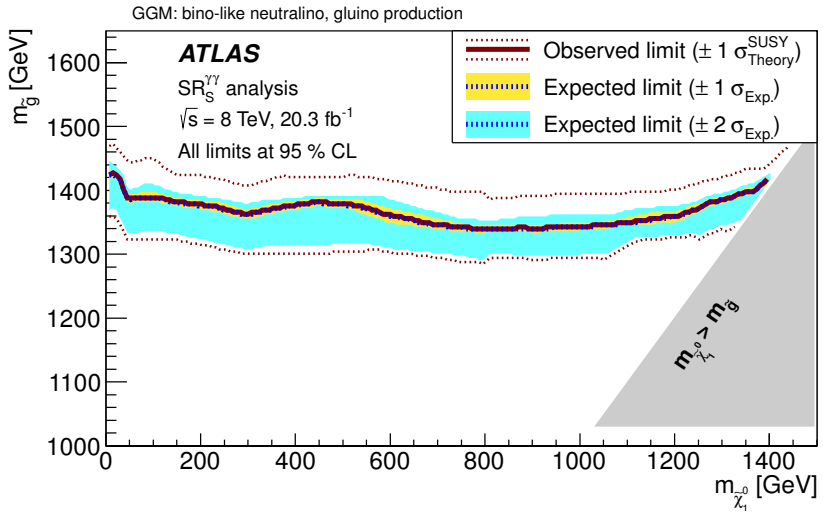
- Z+$\gamma\gamma$ (Z$\rightarrow \nu\nu$)
  - Sherpa cross section (10.1 fb) rescaled to MadGraph at NLO (2.8 LO, K-factor 2)
- W+$\gamma\gamma$ (W$\rightarrow e\nu$)
  - Normalized in Control Region:
    - 50<E_T^{miss}<150 GeV
    - photon wiht p_T>50 GeV
    - $p_T^{\gamma\gamma\ell}$>100 GeV

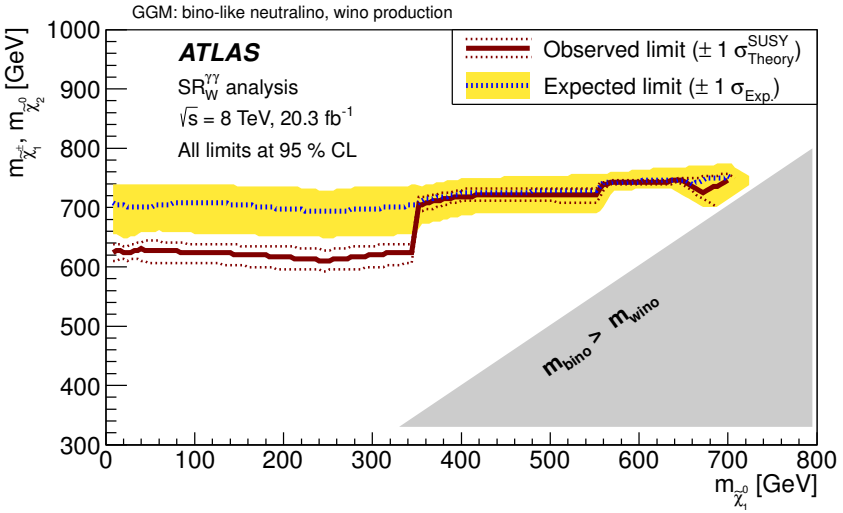
Signal Regions	$SR^{\gamma\gamma}_{S-L}$	$SR^{\gamma\gamma}_{S-H}$	$SR^{\gamma\gamma}_{W-L}$	$SR^{\gamma\gamma}_{W-H}$
Expected background events	$0.06^{+0.24}_{-0.03}$	$0.06^{+0.24}_{-0.04}$	$2.04^{+0.82}_{-0.75}$	$1.01^{+0.48}_{-0.42}$
QCD	$0.00^{+0.24}_{-0.00}$	$0.00^{+0.24}_{-0.00}$	$0.32^{+0.45}_{-0.32}$	$0.22^{+0.33}_{-0.22}$
EW	0.02 ± 0.02	0.0 ± 0.0	0.64 ± 0.27	0.13 ± 0.08
$(W \rightarrow \ell\nu)\gamma\gamma$	0.04 ± 0.02	0.05 ± 0.04	1.01 ± 0.62	0.53 ± 0.34
$(Z \rightarrow \nu\nu)\gamma\gamma$	0.00 ± 0.00	0.01 ± 0.01	0.07 ± 0.04	0.13 ± 0.07

Results

Signal region	N_{obs}	$N_{\text{exp}}^{\text{SM}}$	S_{obs}^{95}	$\langle\epsilon\sigma\rangle_{\text{obs}}^{95}$[fb]
$\text{SR}_{\text{S-L}}^{\gamma\gamma}$	0	$0.06^{+0.24}_{-0.03}$	3.0	0.15
$\text{SR}_{\text{S-H}}^{\gamma\gamma}$	0	$0.06^{+0.24}_{-0.04}$	3.0	0.15
$\text{SR}_{\text{W-L}}^{\gamma\gamma}$	5	$2.04^{+0.82}_{-0.75}$	8.2	0.41
$\text{SR}_{\text{W-H}}^{\gamma\gamma}$	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_{Theory}^{SUSY})
  - $m_{(\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0)}$ at 590 GeV (at -1σ_{Theory}^{SUSY})





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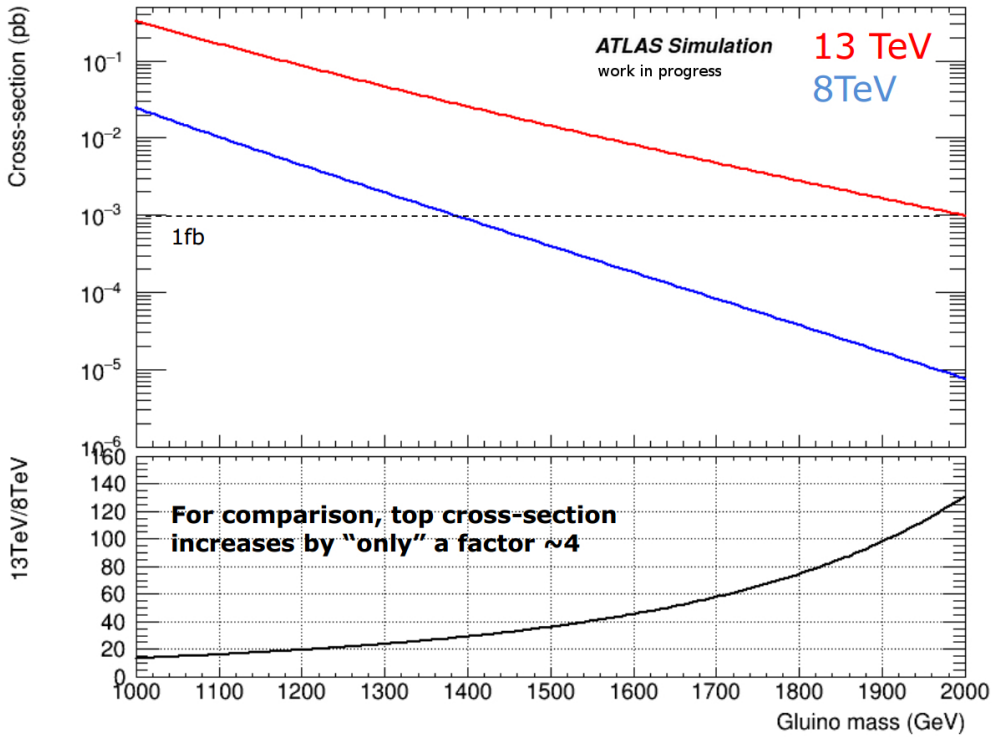
Run2 Prospect



- 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