High-mass DY studies at ATLAS and their phenomenological interpretation
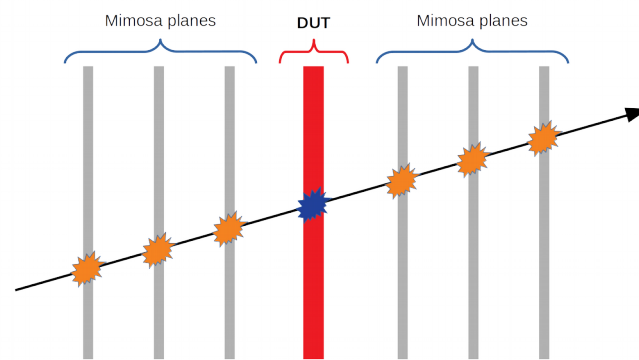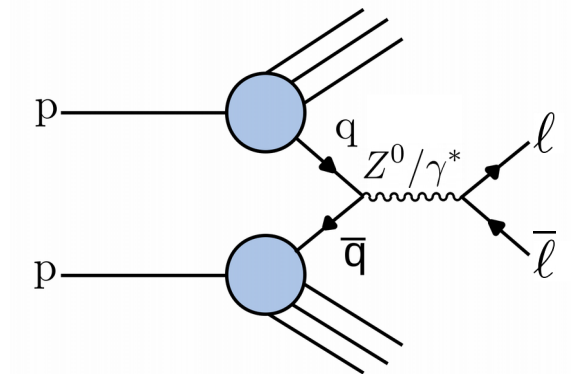
Ricardo González López

Supervised by: Prof. Uta Klein
Dr. Jan Kretzschmar
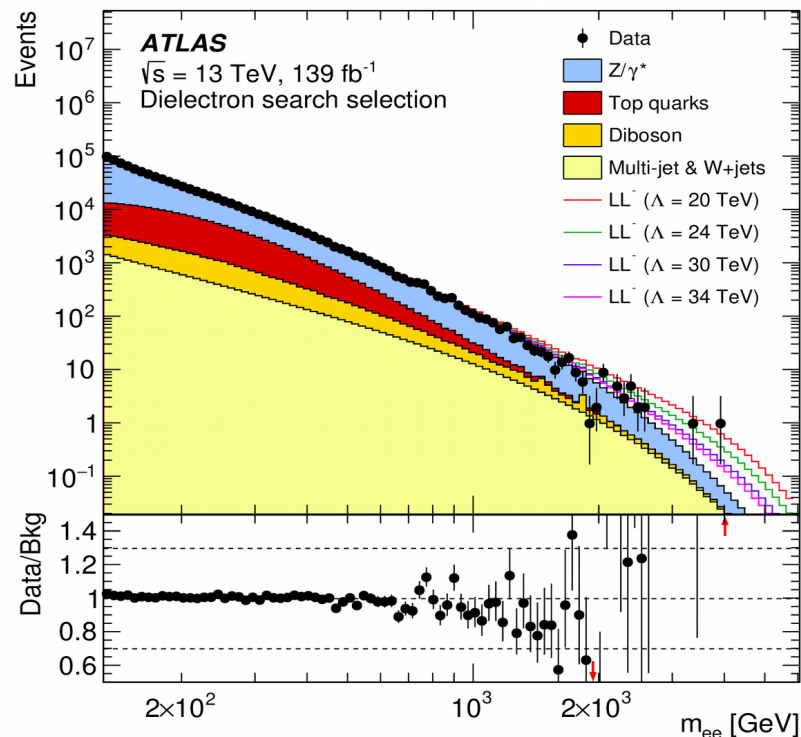
UoL HEP "Christmas" meeting - 28/04/2021

- ATLAS studies in the dilepton final state

  - BSM searches: contact interaction

  - High-mass Drell-Yan measurement

- ATLAS ITk Pixel testbeam data analysis

- Industrial placement at Unilever

# BSM searches in the dilepton final state: contact interaction

$$\mathcal{L} = \frac{g^2}{\Lambda^2} \{ \quad \eta_{LL}(\bar{q}_L \gamma_\mu q_L)(\bar{\ell}_L \gamma_\mu \ell_L) + \eta_{RR}(\bar{q}_R \gamma_\mu q_R)(\bar{\ell}_R \gamma_\mu \ell_R) +$$

$$\eta_{LR}(\bar{q}_L \gamma_\mu q_L)(\bar{\ell}_R \gamma_\mu \ell_R) + \eta_{RL}(\bar{q}_R \gamma_\mu q_R)(\bar{\ell}_L \gamma_\mu \ell_L) \}$$

- Signature is a quark-lepton contact interaction, implying quarks and leptons are composite beyond a given compositeness scale, Λ.

  - The same idea behind Fermi's theory of beta decay. Contact interaction at low energies, W mediates at high energies.

- No significant deviation is observed, but we can set limits on the lowest Λ value compatible with data: $\Lambda > 35.8$ TeV.

- Submitted to arxiv last March, paper published in June.

  - First appearance in an ATLAS paper!

  - Contributed in the estimation of the multijet background → challenging bkg, estimated using data-driven techniques

From JHEP 11 (2020) 005

High-mass Drell Yan measurement

- The analysis aims to measure single ($d\sigma/dm_{ll}$) and double ($d^2\sigma/dm_{ll}d|y_{ll}|$) differential production cross sections of neutral-current DY at $116 < m_{ll} < 5000$ GeV.

- The results are corrected for detector efficiencies and unfolded to particle level.

- High energy probed by this analysis provides a significant input to EFT fits (see following slides).

  – Future plans also include PDF fits.

- Measurement performed in the electron and muon channels, testing the compatibility of both lepton decays and providing the combination of their cross sections.
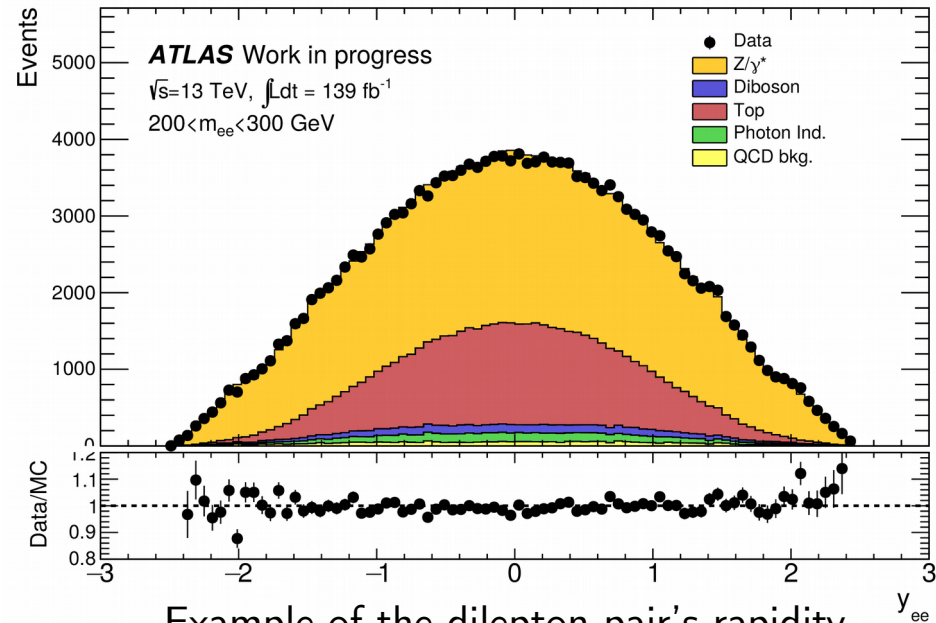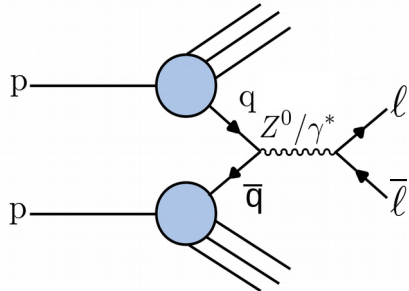
Example of the dilepton pair's rapidity measurement in the mass slice $200 < m_{ee} < 300$ GeV.

The cross section can be extracted by measuring the number of data events recorded and subtracting the other SM backgrounds that decay into a dilepton pair.

- An Effective Field Theory (EFT) approach can be used to set model-independent constraints on BSM physics:

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \sum_{d>4} \mathcal{L}^{(d)} = \underbrace{\mathcal{L}_{\text{SM}}}_{\text{SM}} + \underbrace{\sum_i \frac{c_i^{(d)}}{\Lambda^{d-4}} \mathcal{O}_i^{(d)}}_{\text{New physics}}$$

- New operators alter the cross section, increasing (decreasing) the total cross section when positively (negatively) interfering with the SM processes.

- Limits on c_i/Λ^2 currently set using 1D ($d\sigma/dm_{ll}$) pseudo-data using the expected statistical and systematic uncertainties → Expected limits

- Neutral-current DY offers the potential for leading constraints on 4-fermion operators.
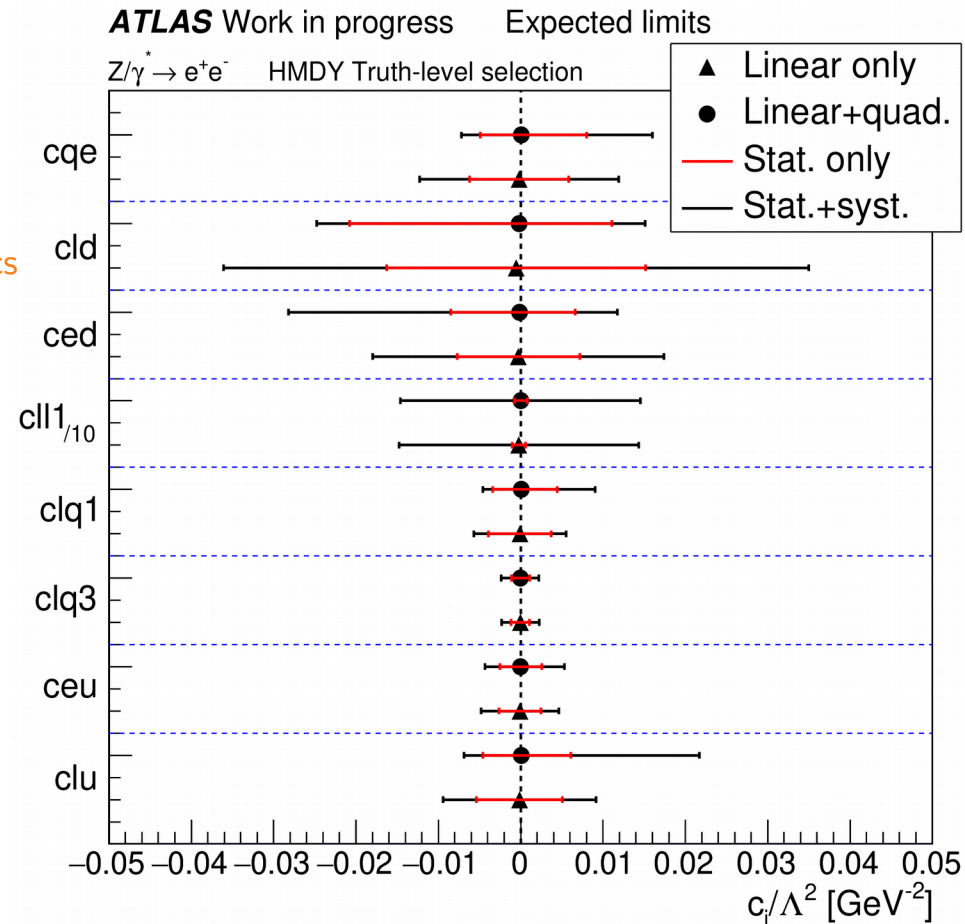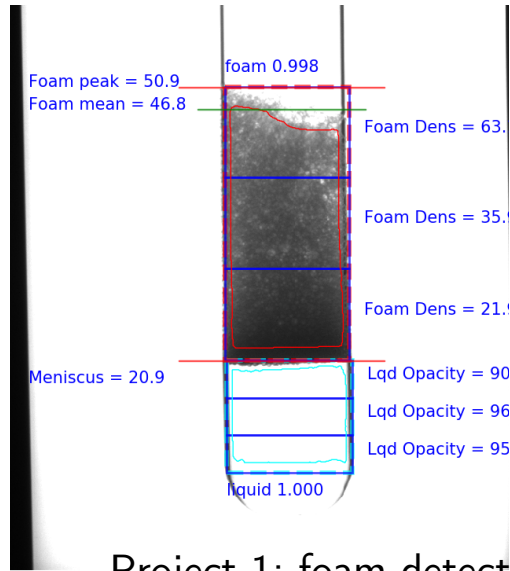
ATLAS ITk Pixel testbeam data analysis

- Working analysing testbeam data, studying prototypes of pixel detectors (RD53A) for the future ATLAS Inner Tracker.

- Contributed to the Market Survey, assessing the quality of the sensors provided by different anonymous vendors.

  - Finished last March my Qualification Task, officially becoming an ATLAS author.

  - MS results were the final input to the detector's Final Design Review, approved last September.

- Also worked establishing UK's analysis framework, used to analyse all data taking campaigns prior to 2020. Aiming to publish the results this year.
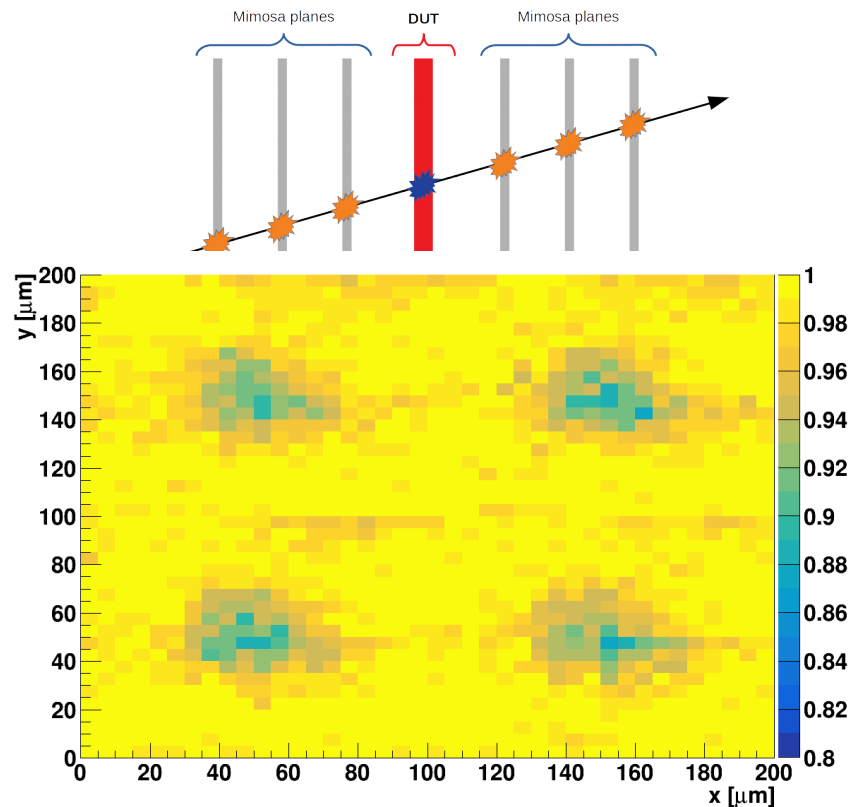
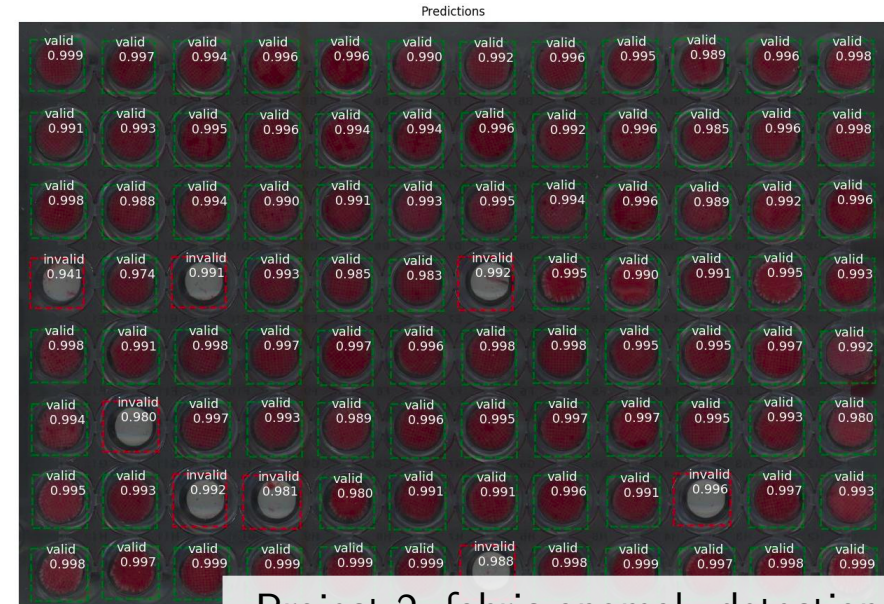Efficiency map of a 4x4 pixel array in one of UK's sensors.

Efficiency drops correspond to voltage bias dots.

Foam peak = 50.9
Foam mean = 46.8
foam 0.998
Foam Dens = 63.
Foam Dens = 35.
Foam Dens = 21.
Meniscus = 20.9
Lqd Opacity = 90
Lqd Opacity = 96
Lqd Opacity = 95
liquid 1.000

Project 1: foam detection

- Part of the Liv.Dat CDT training to get some experience working in different environments and apply our data analysis training.

- Worked with Unilever, at MIF, applying machine learning to some of their robots to reduce the amount of manual input required by the users.

- Using instance segmentation to perform visual inspection, previously carried out by the users.

Predictions

Project 2: fabric anomaly detection

- Two different projects were finished: foam detection and fabric anomaly detection.

- Really good experience: working in a different environment, expand programming skills, develop code for users…

Ricardo González López – Uc

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Summary

- 2020 was a very different year, but thankfully our research wasn't heavily impacted.

- First analysis I worked at was published, aiming to publish our second this year.

- QT finished last March, still working with testbeam team, aiming to publish UK results later this year too.

- Industry placement was a great experience, good chance to experience what's like to work in a different environment and put in practice different skills I learnt through my PhD.

Thanks for your attention!