Neutral-current Drell-Yan measurement at the ATLAS experiment

LIV.DAT project overview

Ricardo González López   Supervised by: Prof. Uta Klein & Dr. Jan Kretzschmar

High-mass Drell-Yan measurement

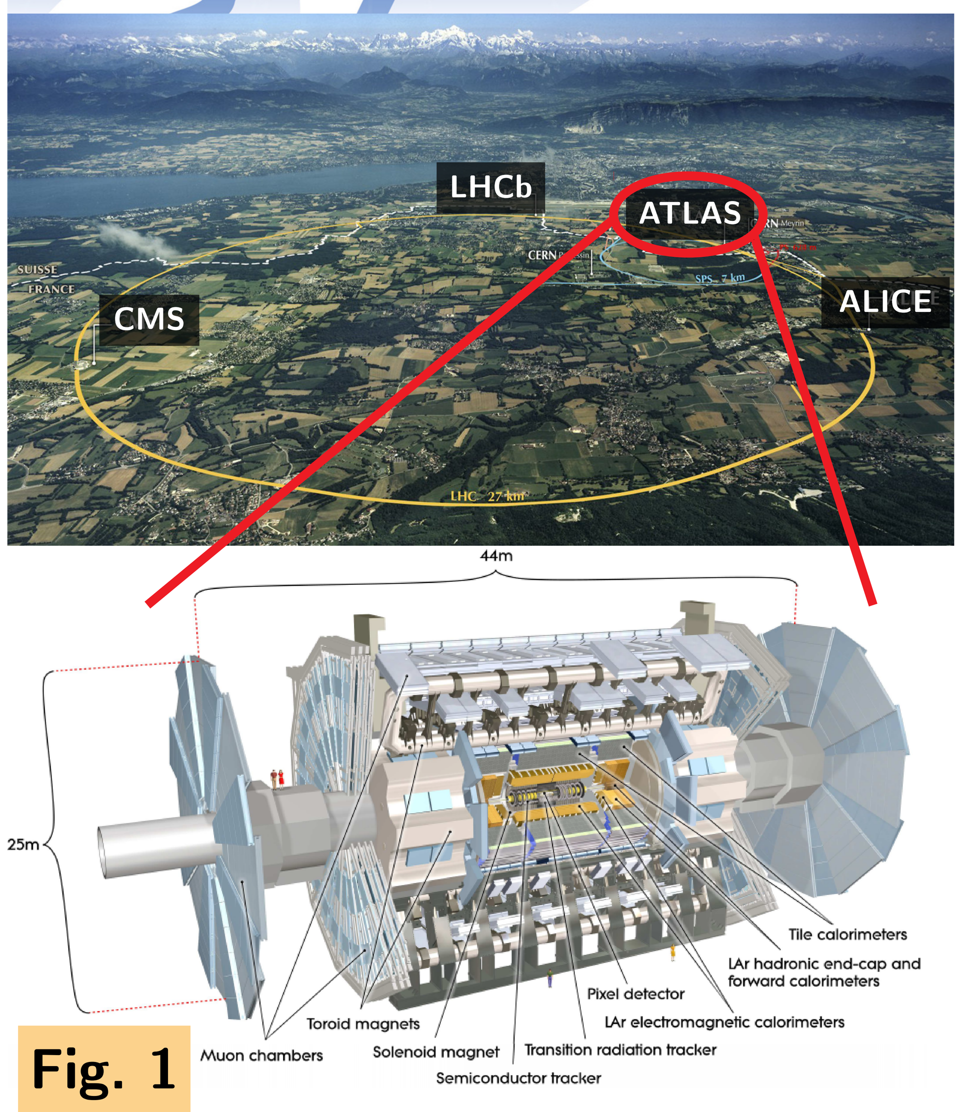


Fig. 1

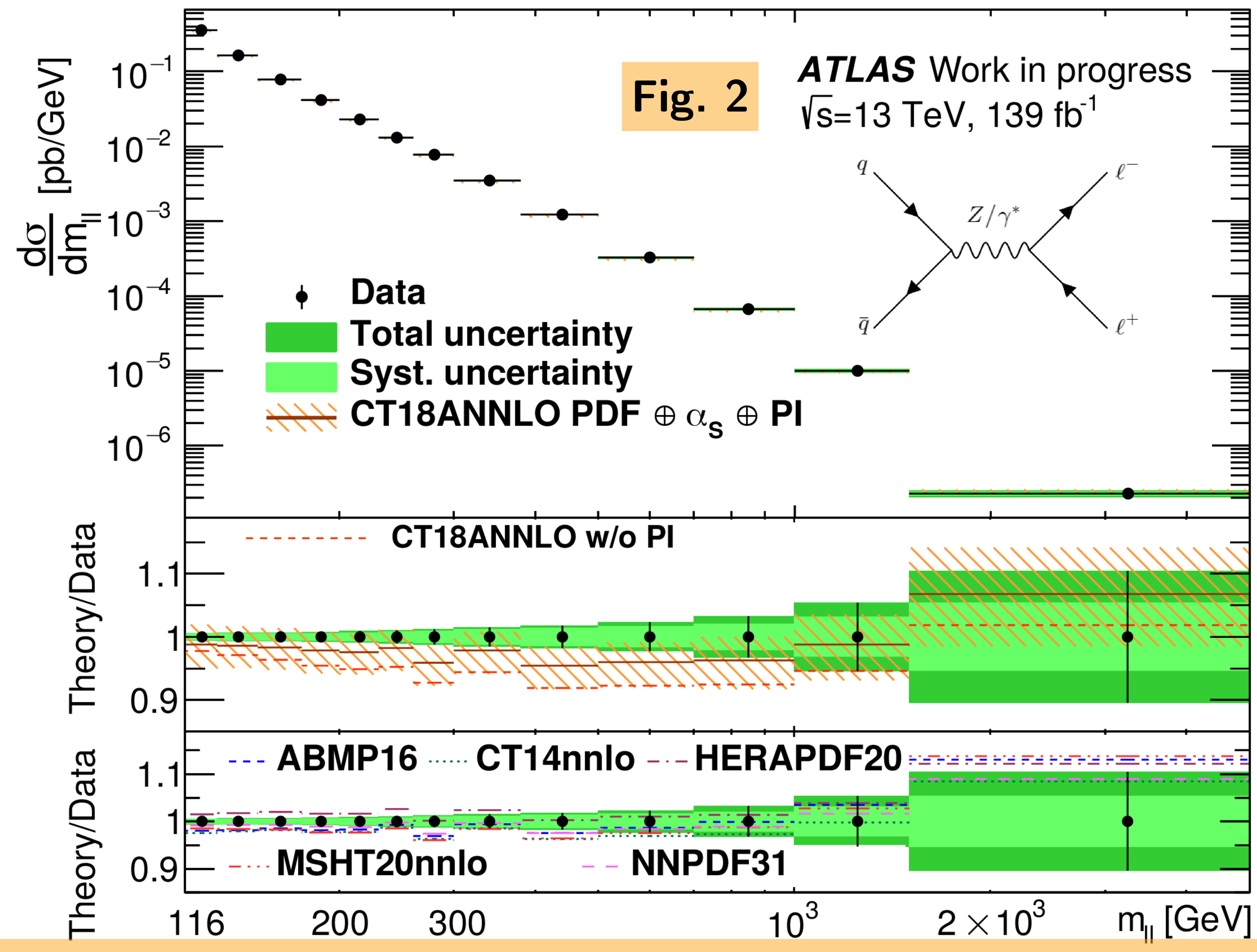
LHC and ATLAS

- The ATLAS detector is one of the general-purpose detectors located at the Large Hadron Collider.
- The LHC accelerates protons to a collision energy of up to 13 TeV → Highest energy achieved ever in a particle collider!
- By observing the products of these collisions we can explore new particles and better understand our known physics.
- The project analyses data collected during the years 2015 and 2018.

Overview of the LHC accelerator complex and the ATLAS detector.

Measurement

- Single- and double-differential production cross section measurements of NCDY, focusing on the high invariant mass regime: m_{ll}>116 GeV
  - **Fig. 2** shows results vs dilepton mass (single-differential), cross section also provided against other kinematic variables.
- Cross section obtained subtracting background events from data and correcting for detector effects using MC (unfolding).
  - Crucial input for PDF and EFT constraints. Lepton flavour universality tests also performed.
- Expected uncertainty at few % level, dominated by systematic sources.

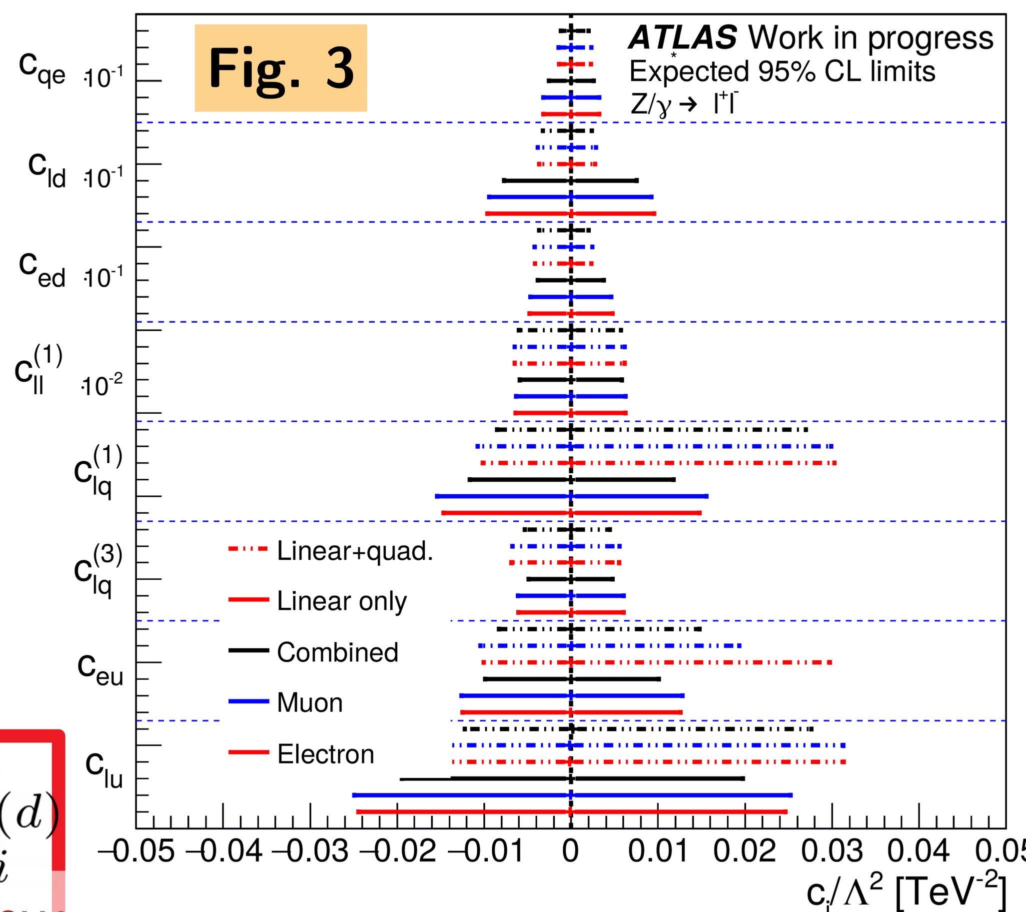


Single differential NCDY cross section measurement ratio to QCD predictions.

SMEFT interpretation

- SM interpreted as the low-energy regime of a more general theory. New physics introduced by higher-dimensional operators (O_i).
- Deviations introduced by the operators are used to set constraints on the Wilson coefficients, c_i (**Fig. 3**).

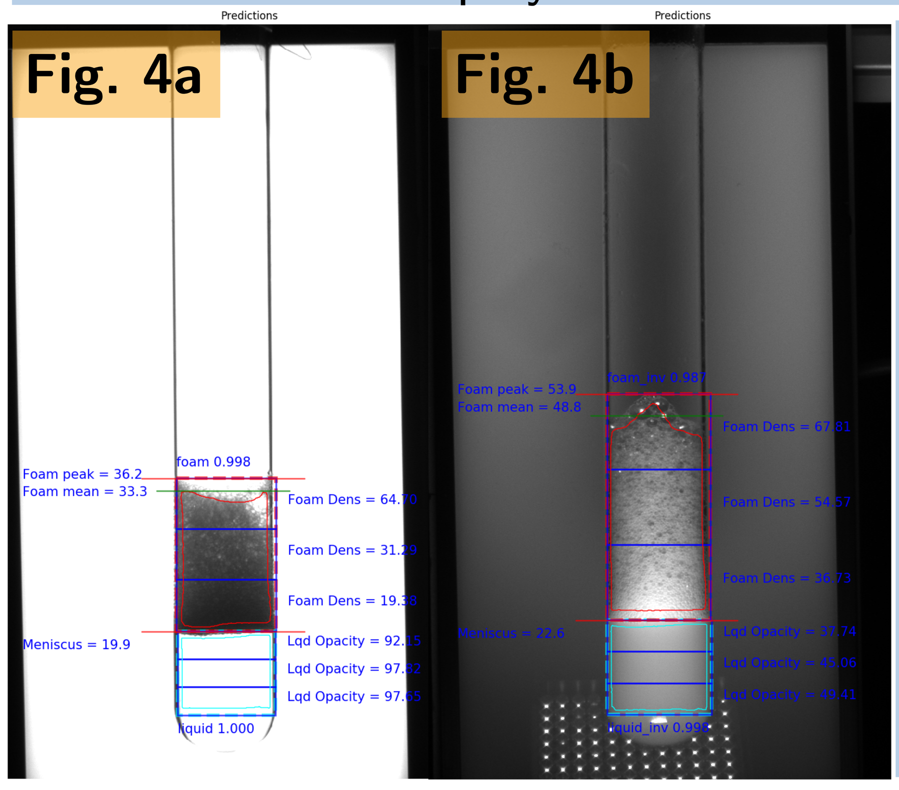
$$\mathcal{L}_{\mathrm{SMEFT}} = \underbrace{\mathcal{L}_{\mathrm{SM}}}_{\text{SM}} + \underbrace{\sum_i \frac{c_i^{(d)}}{\Lambda^{d-4}} \mathcal{O}_i^{(d)}}_{\text{New physics}}$$



Industry placement at Unilever

Project overview

- Worked with Unilever at the Material Innovation Factory to improve automatization of image processing in some of their robots.
- Projects can be tackled using Instance Segmentation, implemented via Mask-RCNN (see Selina Dhinsey's poster for more information!).
  - Algorithm returns class, box and mask for objects recognized in the input image, adapted to work on each robot's output images.
- Project included development, validation and quality control of the new detection algorithms, as well as implementing user's feedback for an easier code deployment.



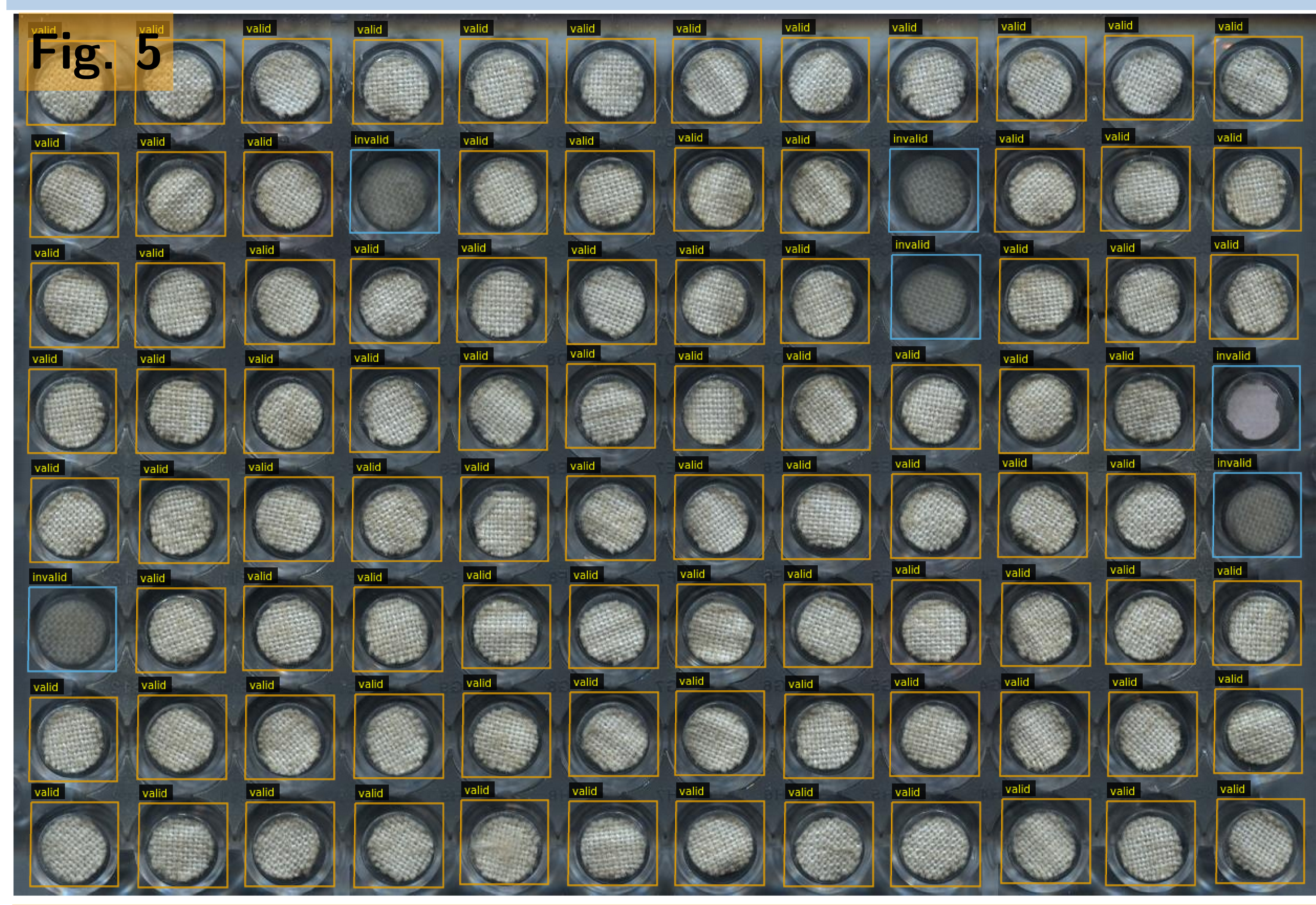
Foam detection

- Developed an algorithm to find foam peak, mean and density.
- Existing algorithm couldn't process backlit images (**Fig. 4b**)
  → key to reduce manual input!
- New algorithm also brings clear criteria for parameter definition, since no human interpretation is needed.

Output of the foam-MRCNN algorithm. **4a**: front-lit **4b**: back-lit images.

Fabric anomaly detection

- The new algorithm finds anomalies in fabric plates: missing, wet, folded or "rogue" pieces of fabric (**Fig 5**).
- No existing automated detection, each picture needs to be manually inspected to ensure study is not affected.
  → Human intervention reduced by >80%!



(Top) Output of MRCNN detection of fabric anomalies.
(Right) Example of fabric anomalies across different studies.

Further training

Outreach

- Accelerators for Science and Society Symposium: *Find the Higgs*
  - Outreach activity demonstrating the ATLAS event filtering.
- Liv@CERN Summer School
  - Directed a particle physics summer school for high-school students.

Learning

- Took part in data science modules at UoL and LJMU.
- Attended STFC Data Intensive Science Schools (Edinburgh, Liverpool).

Hardware

Actively involved in the data analysis of test-beams for the future ATLAS inner-tracker upgrade. Took part in data-taking campaigns at DESY (Hamburg), as well as the Inner Tracker Pixel market survey.