About me

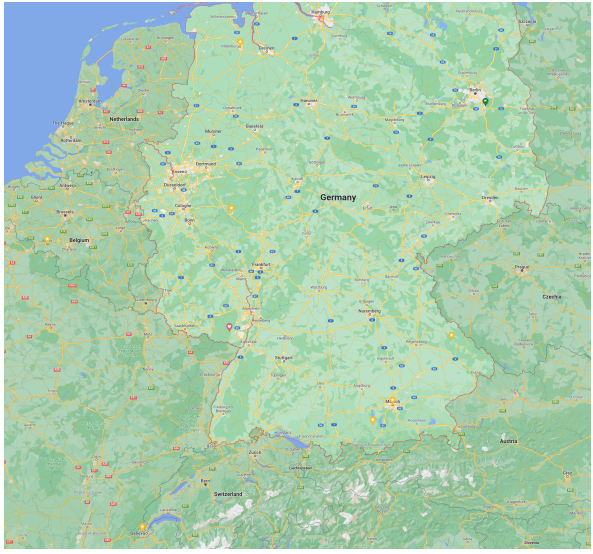
A short self-introduction

Florian Fischer

Gamma Group Meeting, 4. November 2021

Where I come from

Actually hard to tell…let me take you on a little journey



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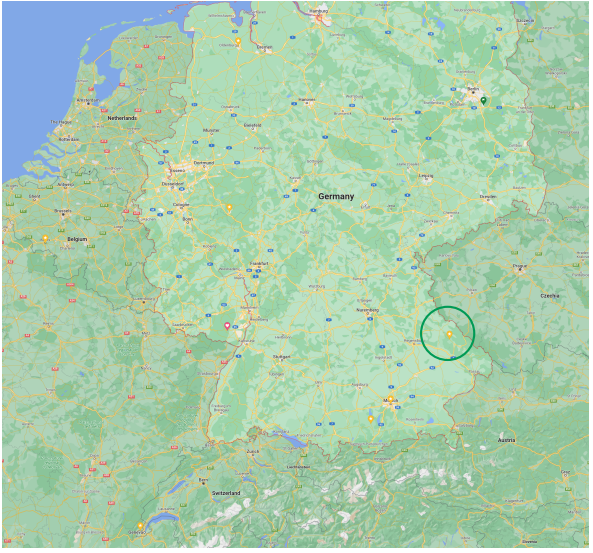

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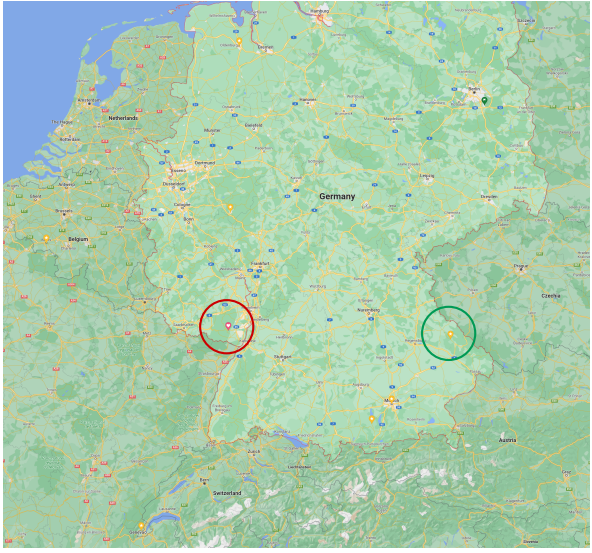

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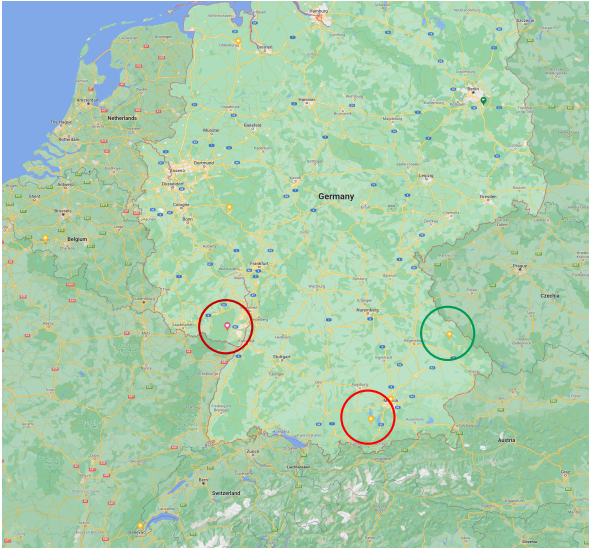

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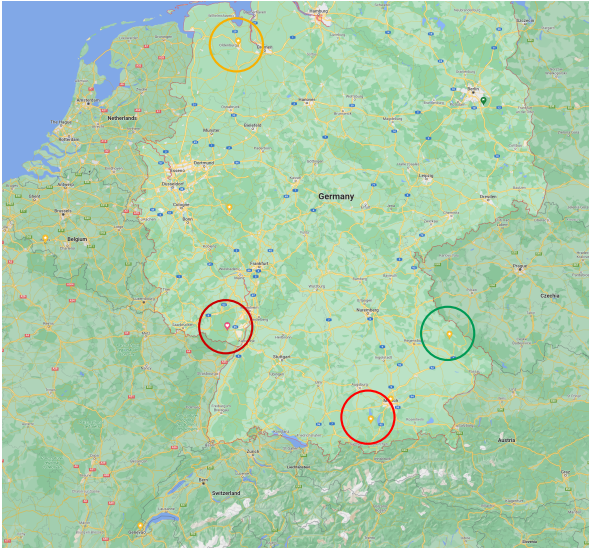

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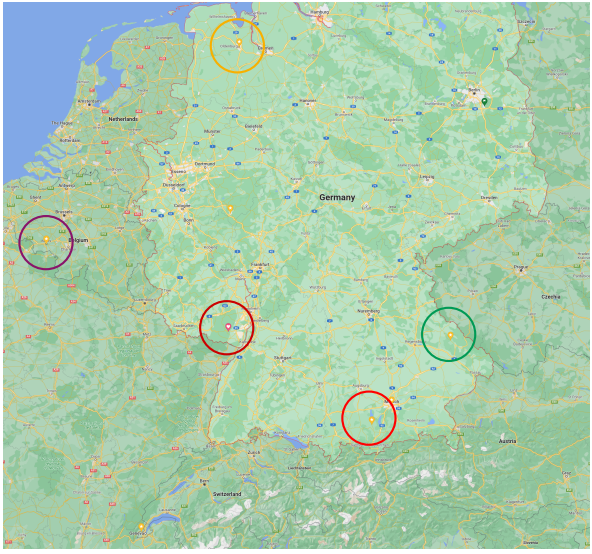

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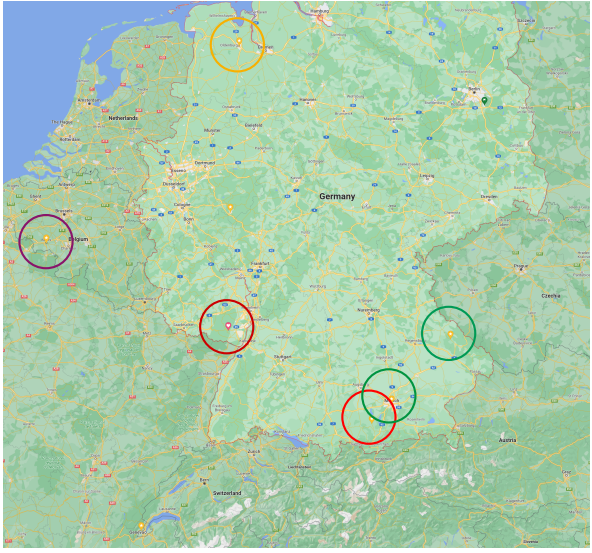

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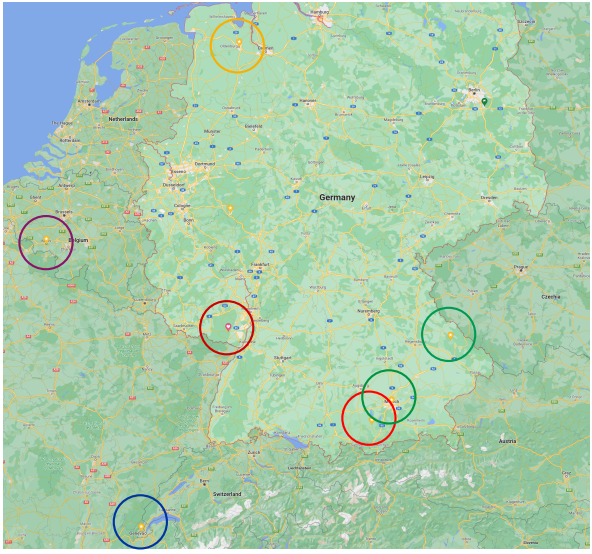

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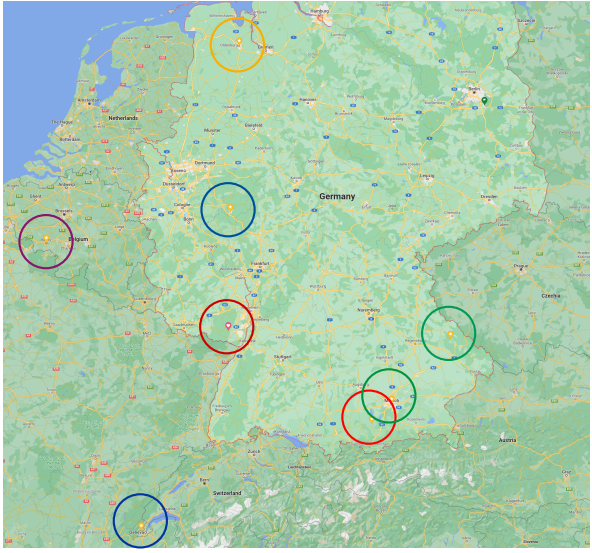

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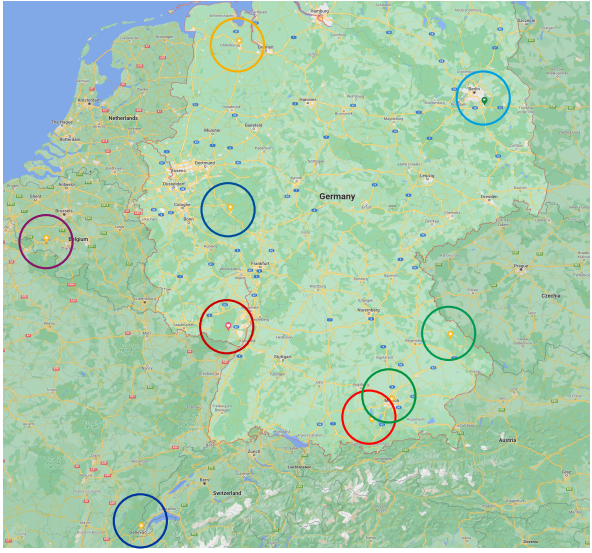
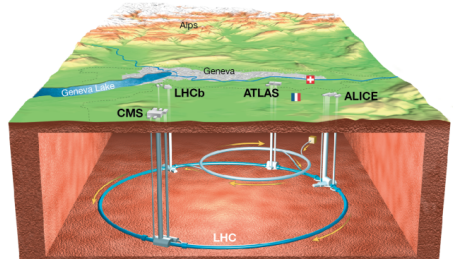


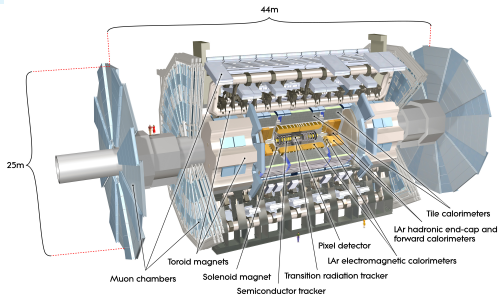
Scientific work

A (very) short overview

Top quark physics with ATLAS @ LHC

- PhD project: $t\bar{t}Z$ cross-section measurement in $2\ell OS$ channel
- Direct I/O testing of ATLAS software and grid infrastructure
- Broad range of outreach activities





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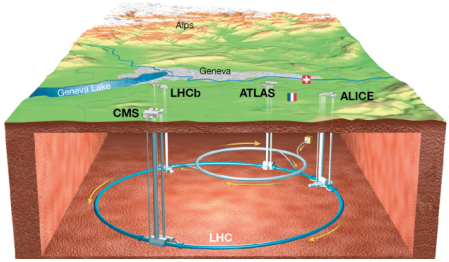
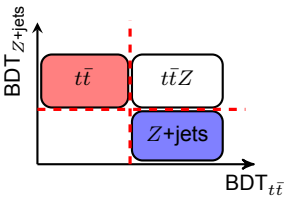
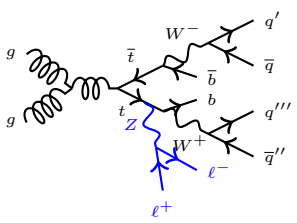
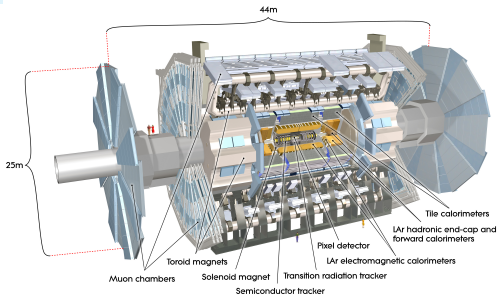


2D-MVA strategy $\rightarrow 5\sigma$







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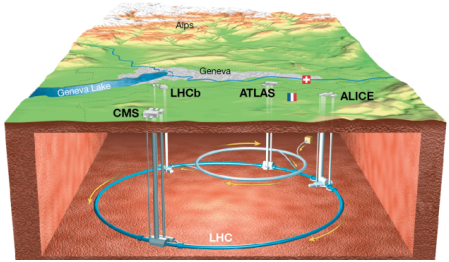

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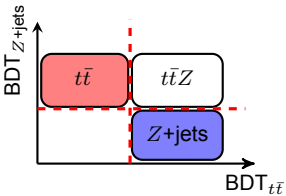
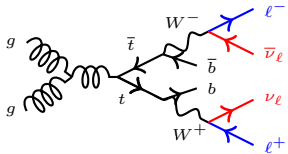
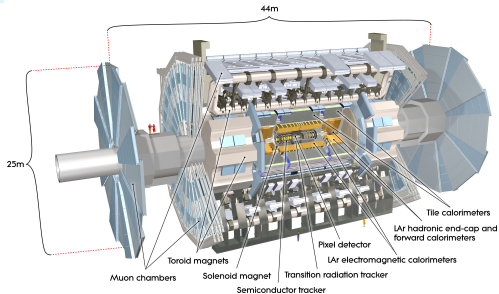


Reconstruction of under-determined $t\bar{t}$ topology





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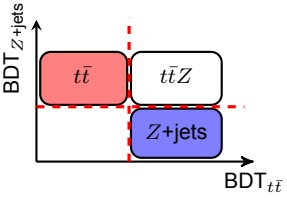

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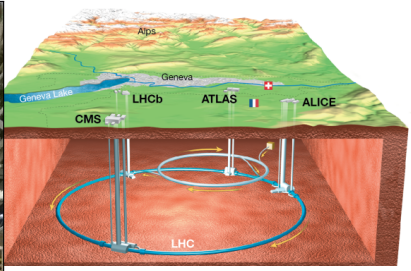
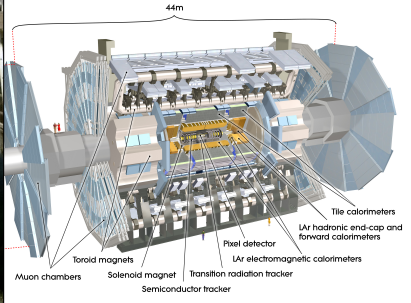
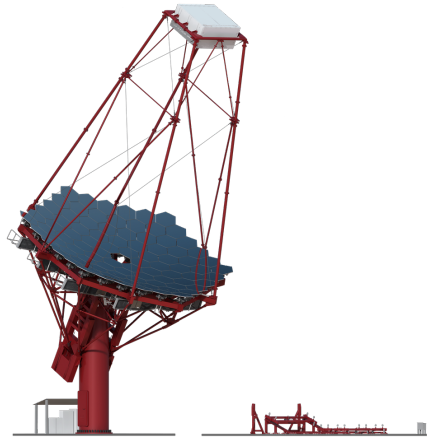




Future engagement @ DESY

- Postdoc in the CTAI group
- Software development and monitoring for MST structure
- Familiarizing with new environment at the moment
- Specific projects not yet defined, will come very soon



Apart from work

Interested in many things

Backup

Scientific work

Overview

Top quark physics with ATLAS @ LHC

- Study on jet energy scale uncertainty for top quark mass measurement
- Production cross-section measurements of $t\bar{t}Z$ and $t\bar{t}t\bar{t}$ events
- Direct I/O testing of ATLAS software and grid infrastructure

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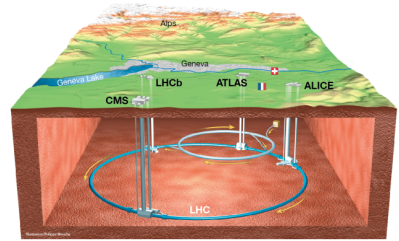

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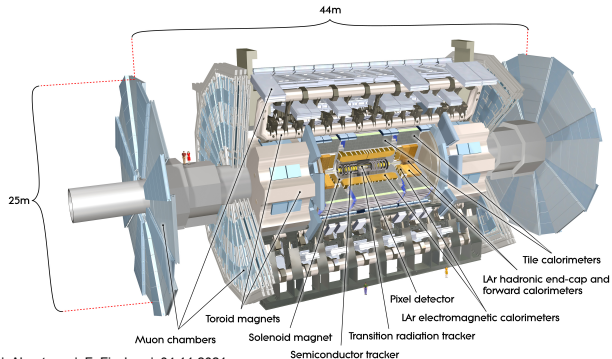
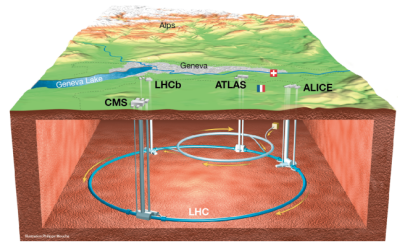
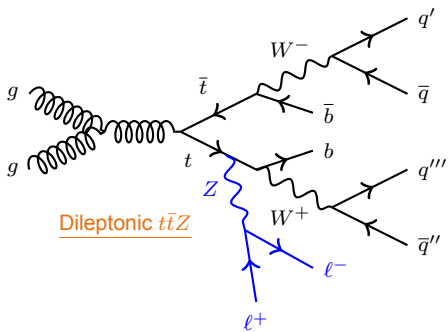




Scientific work

Kinematic reconstruction of incomplete $t\bar{t}$ topology



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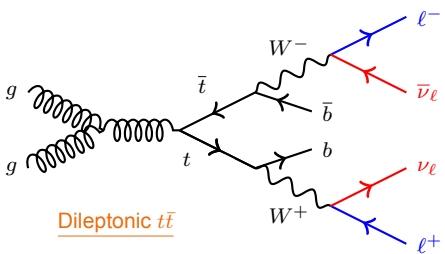

Dileptonic $t\bar{t}$

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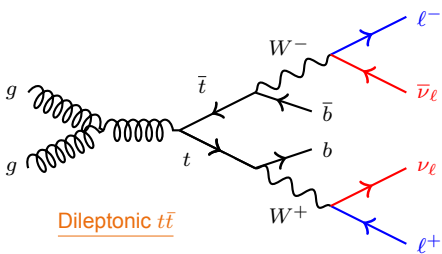

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Challenges @ LHC

- > Neutrinos do not interact with detector
  → Single observable from momentum conservation
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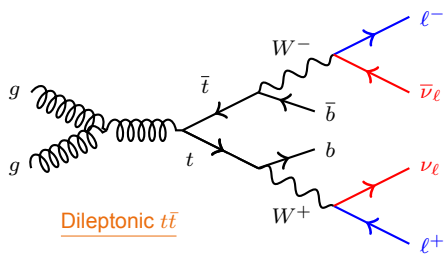

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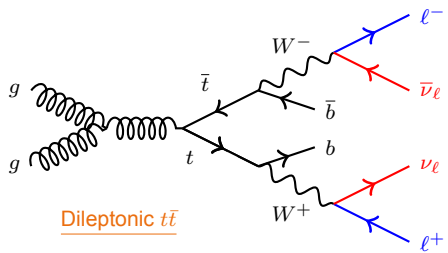

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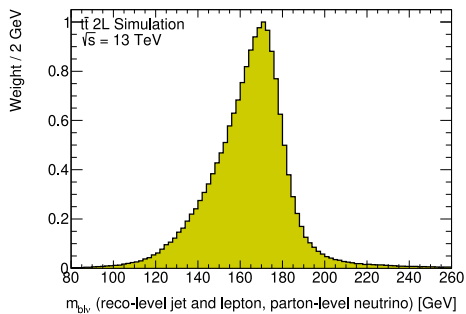

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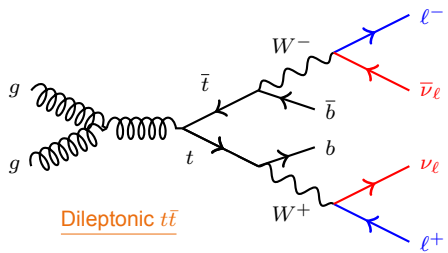

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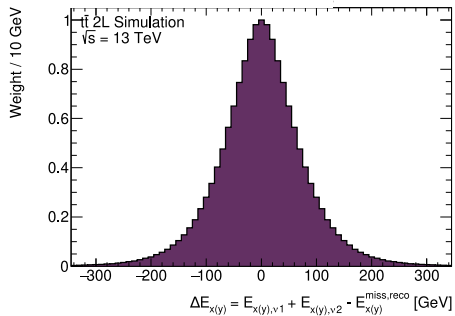

Scientific work

Outreach

LMU

- Open days

Scientific work

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NWTW

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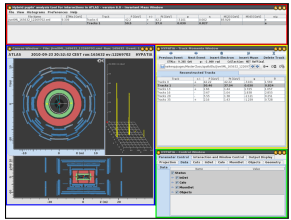

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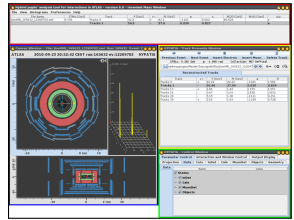

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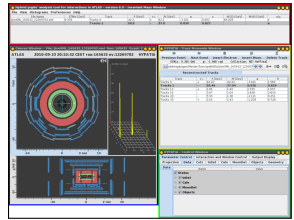
ATLAS

> Underground tours



Top quark pairs in association with a Z boson ($t\bar{t}Z$)

Motivation

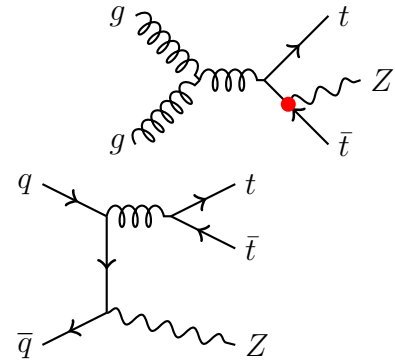
- Sensitive to the t-Z coupling
- Probing the Standard Model (SM)
- → Recent measurements all in agreement with SM:

$\sigma_{t\bar{t}Z} = 1.05 \pm 0.05\,(\text{stat.}) \pm 0.09\,(\text{syst.})$ pb
▸ ATLAS-CONF-2020-028

$\sigma_{t\bar{t}Z} = 0.95 \pm 0.08\,(\text{stat.}) \pm 0.10\,(\text{syst.})$ pb
▸ Phys.Rev.D 99 (2019) 7, 072009

$\sigma_{t\bar{t}Z} = 0.95 \pm 0.05\,(\text{stat.}) \pm 0.06\,(\text{syst.})$ pb
▸ JHEP 03 (2020) 056

- Measurement only at the LHC so far
  - First observation in 2015 ▸ JHEP 01 (2016) 096
- $t\bar{t}Z$ states an important background to other rare processes, e.g.
  - $t\bar{t}H$ measurement
  - $t\bar{t}$ FCNC or SUSY searches



Employed dataset

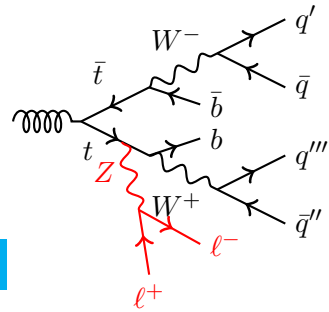
- Full LHC Run 2 pp-collision dataset taken by ATLAS
- $\mathcal{L} = 139\,\text{fb}^{-1}, \sqrt{s} = 13\,\text{TeV}$

The $t\bar{t}Z$ dilepton opposite-sign ($2\ell OS$) channel

$2\ell OS$ channel characteristics

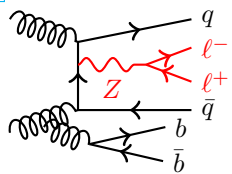
- Fully hadronic $t\bar{t}$ decay
  - High branching fraction
- Leptonic decay of Z boson
  - Clean detector signature

⇒ Full kinematic reconstruction possible



Dominant background processes

Z+jets



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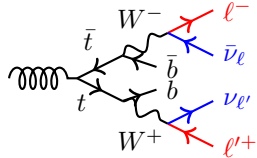


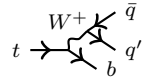
Further backgrounds

- $t\bar{t}X$ $(X = W, H, \gamma)$
- VV, VH $(V = Z, W)$
- tWZ, tZq, Wt

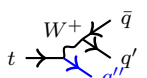
$2\ell OS$ analysis strategy

Targeted phase-space regions

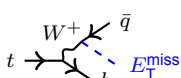
- Z boson identification:
  - $Z \to e^+e^-/\mu^+\mu^-$
  - $|m_{\ell\ell} - m_Z| < 10\,\text{GeV}$
- 3 jet scenarios:



(≥ 6 jets, ≥ 2 b-jets)



(≥ 6 jets, $1b$-jet)



(5 jets, ≥ 2 b-jets)

Data-driven $t\bar{t}$ estimation

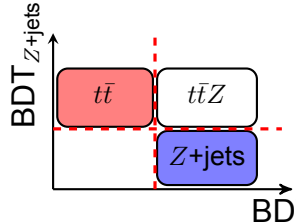
- Modelling of additional jets associated with large systematic uncertainties
- Lepton flavour unversality:

$$N(e^{\pm}\mu^{\mp}) \approx N(e^+e^-) + N(\mu^+\mu^-)$$

- Selected different-flavour data events as a proxy for same-flavour dileptonic $t\bar{t}$
- Correct for remaining tiny non-$t\bar{t}$ contribution & kinematics check

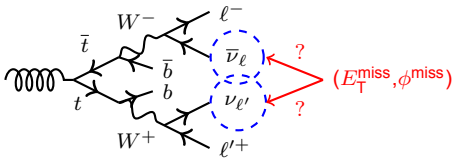
MVA strategy

- Boosted Decision Tree (BDT)
- Separate training against each **dominant background** for each **target region** → **6 individual BDTs**
- 2D-selection via combination of BDT outputs
- Different sets of discriminating variables for given background/target region



Two-neutrino scanning method

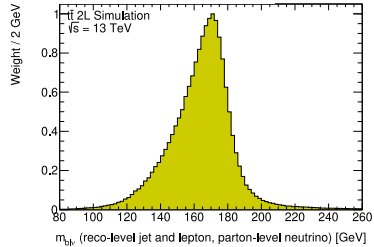
Reconstruction of dileptonic $t\bar{t}$



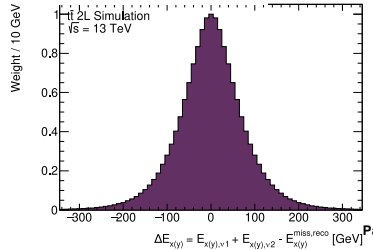
- Deduce neutrino 4-vectors from missing transverse momentum
- Systematic scan of η-ϕ-space
  - Test of different (η, ϕ)-hypotheses
  - Neutrino p_T derived from W mass constraint
  - Reconstruction of $t\bar{t}$ system with the help of leptons and b-tagged jets
- Most probable (η, ϕ)-hypotheses determined via interpolation with truth-matched reference distributions (**top mass**, **ν-energy resolution**)

In collaboration with Tom McCarthy (MPP Munich)

Reconstructed top quark mass

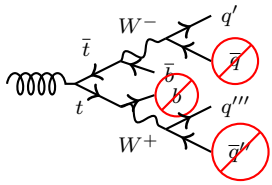


Neutrino energy resolution



Multi-hypothesis hadronic top/W reconstruction

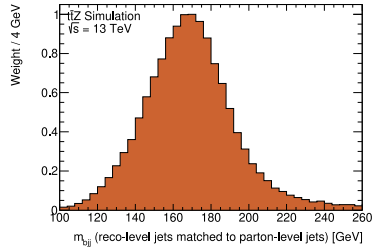
Reconstruction of allhadronic $t\bar{t}$



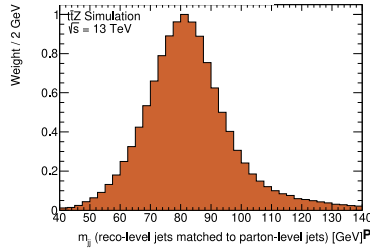
- Finite energy resolution and limited detector coverage
  - Not all $t\bar{t}$-associated jets can be reconstructed
- Five different hypotheses of the number of missing jets:
  $t\bar{t}$, tW, WW, t, W
- Most probable jet-quark assignment determined via interpolation with truth-matched reference distributions
  (**top mass**, **W mass**)
- Reconstruction performed independently for each category

In collaboration with Tom McCarthy (MPP Munich)

Reconstructed top quark mass



Reconstructed W boson mass

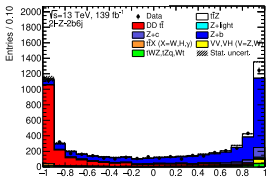


Two-dimensional signal region optimisation

- Training and application
- Combine 1D BDT outputs into 2D-plane
- Select phase-space regions enriched in
  - $t\bar{t}Z$
  - $t\bar{t}$/Z+jets

  events based on the purity of the respective process
- Conceptual model ⇔ reality

$t\bar{t}$ training



Z+jets training