Institute for Theoretical Particle Physics and Cosmology | RWTH AACHEN UNIVERSITY

CRC annual meeting 2023

B3b: Anomaly searches in jet physics

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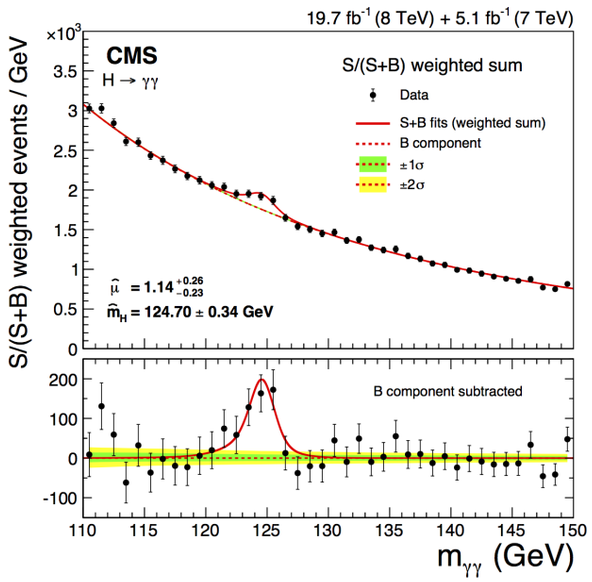
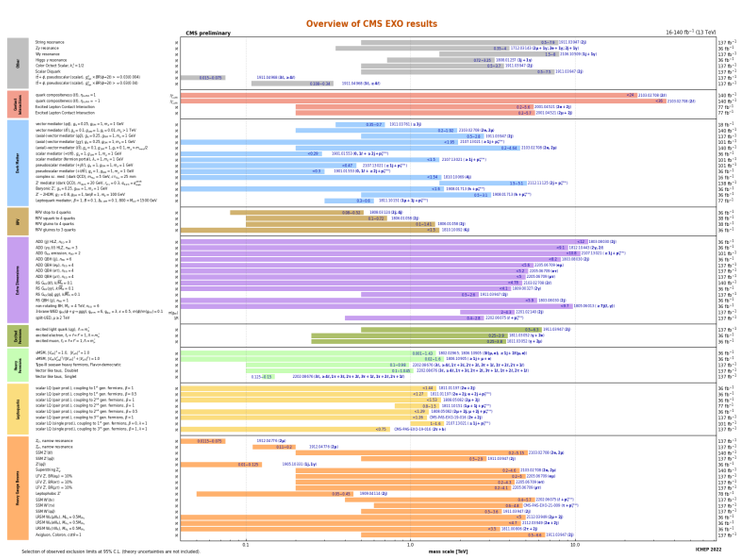
Humberto Reyes, Anja Butter, Barry Dillon, Claudius Krause, Alexander Mück, Alessandro Morandini, Marie Hein, Peter Sorrenson, Lorenz Vogel, Friedrich Feiden, Tanmoy Modak,...

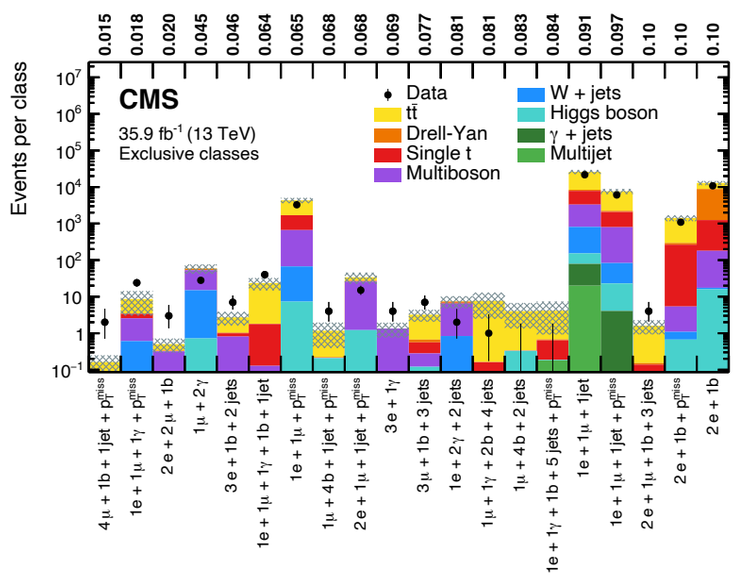
	1: Precision physics	**2**: Effective theories	**3**: Models of New Physics
A: Higgs Physics	Higgs boson production in the SM	Higgs- and SM Effective Field Theory, unitarisation	Extended Higgs sectors, simplified models
B: Top, QCD, Electroweak Physics, DM	Top quark and gauge boson production, physics of jets	Effective field theories for QCD and top quark physics at colliders	Dark sectors, anomaly searches
C: Flavour Physics	Inclusive processes and $B - \bar{B}$ mixing	Exclusive processes and hadronic matrix elements	New sources of flavour and CP violation

BSM searches



B3b





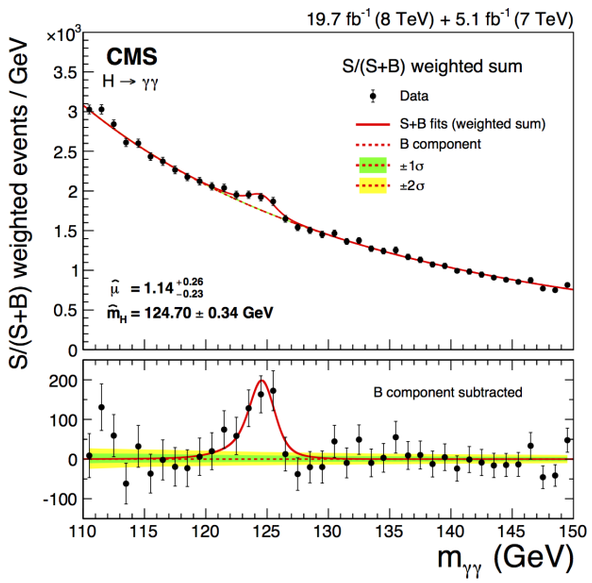
Background model independence

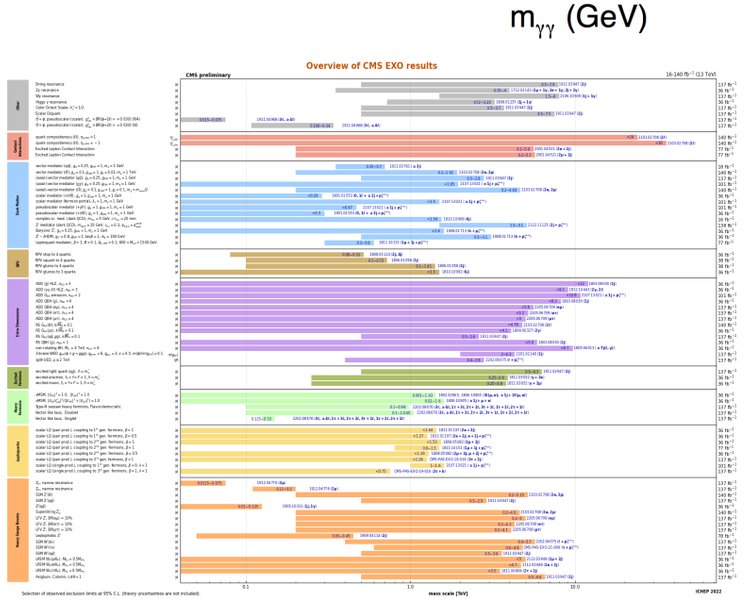
Signal model independence

cf. Karagiorgi, Kasieczka, Kravitz, Nachman, Shih, arXiv:2112.03769 [hep-ph]

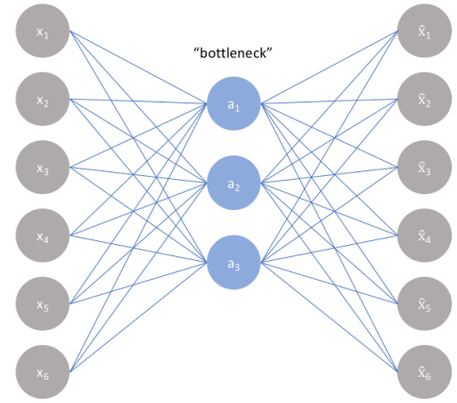
BSM searches

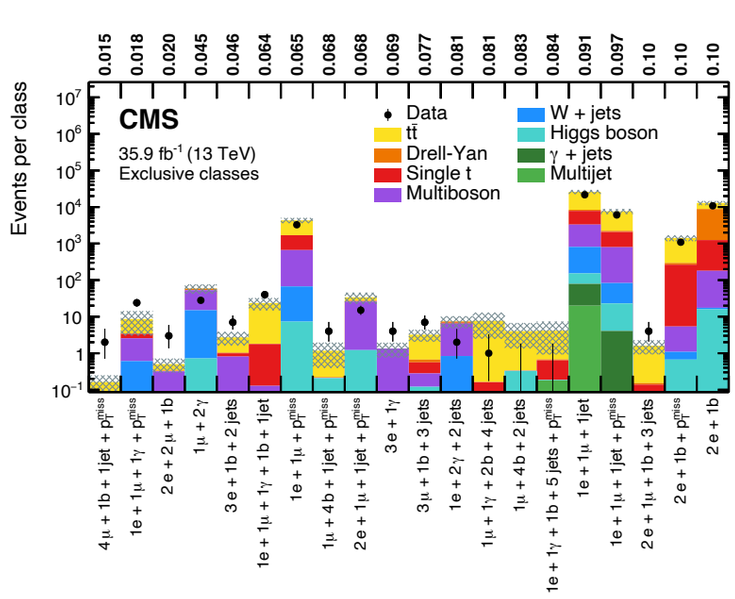
Background model independence





Machine learning





Signal model independence

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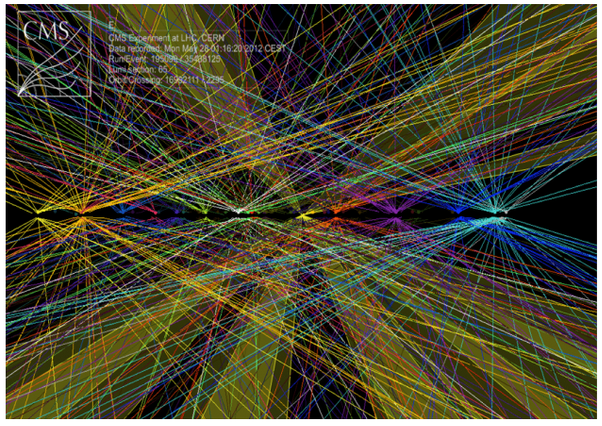
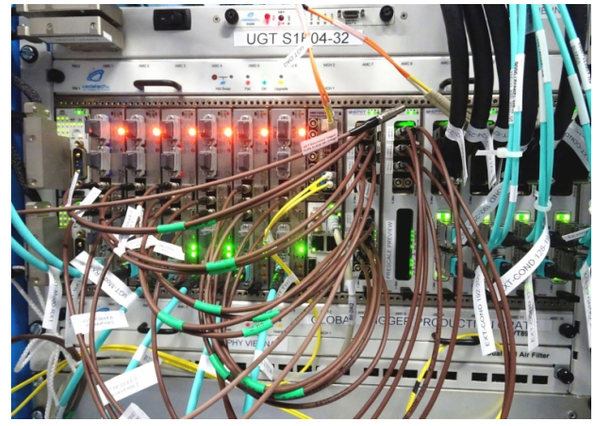
Trigger challenges

Collisions



40M events/sec

Level 1 trigger

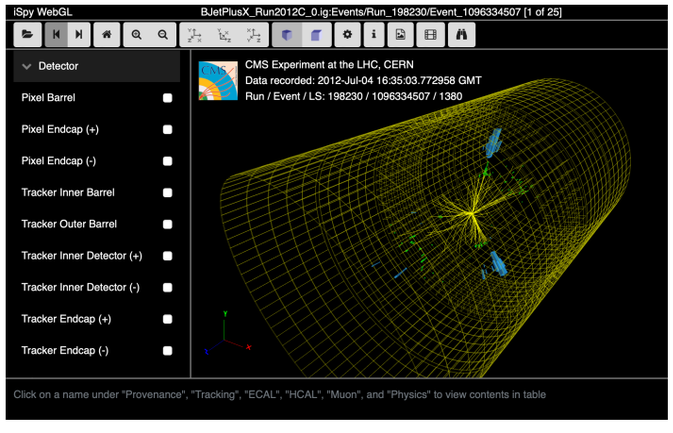


100k events/sec

High-level trigger

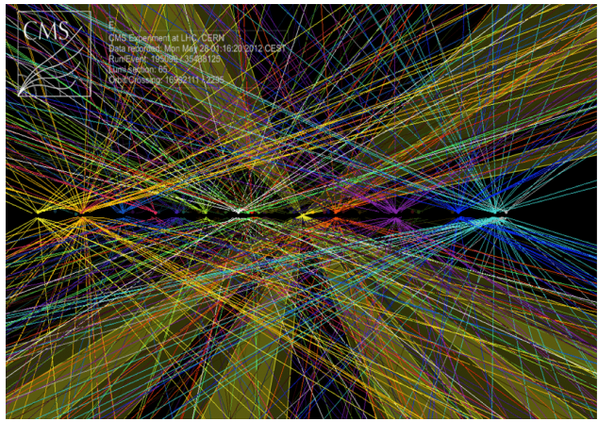
1k events/sec

Data analysis

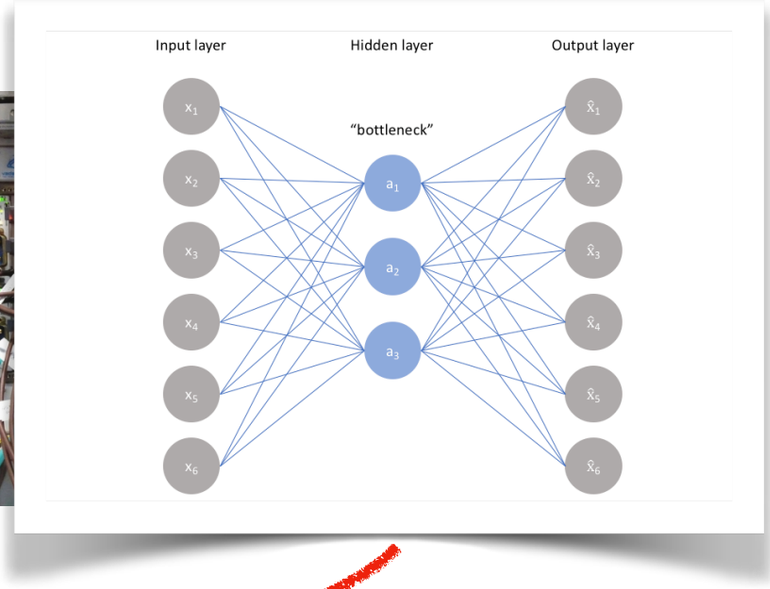


Trigger challenges

Collisions



40M events/sec



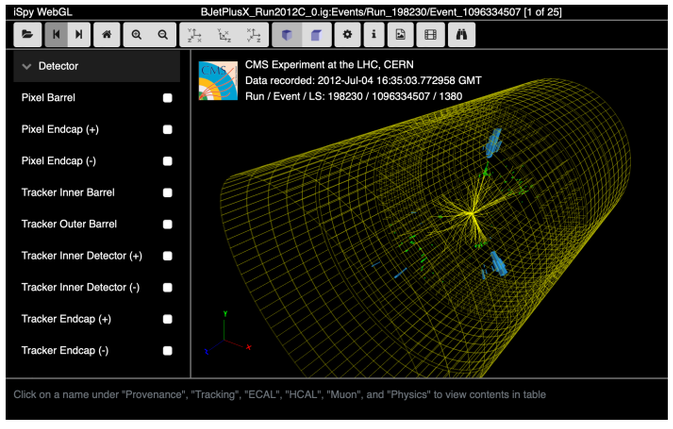
100k events/sec

New physics?

High-level trigger

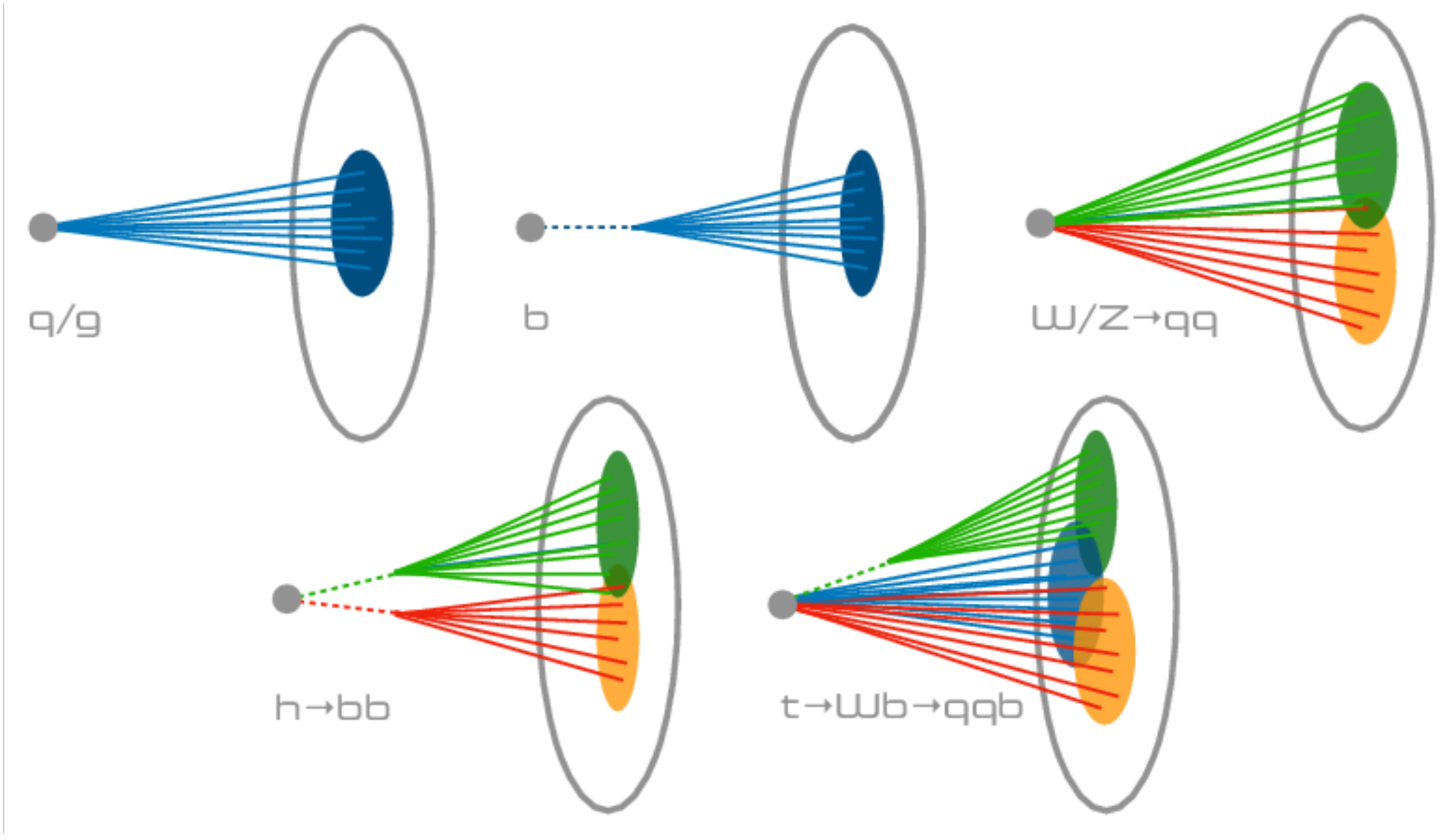
1k events/sec

Data analysis



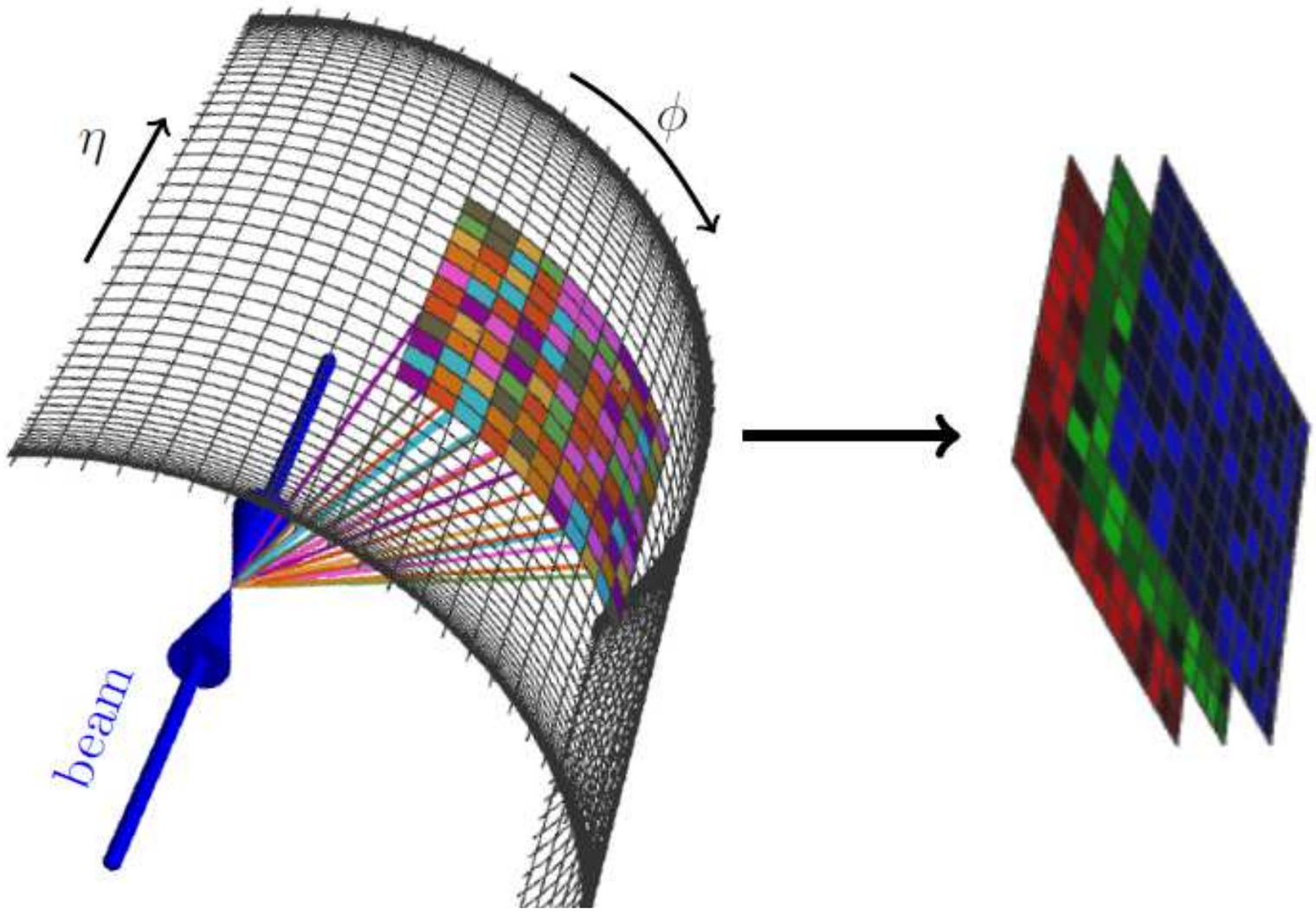
Anomaly detection data challenge: https://mpp-hep.github.io/ADC2021/

Anomaly searches in *jet physics*



Moreno et al., Phys. Rev. D 102, 012010 (2020)

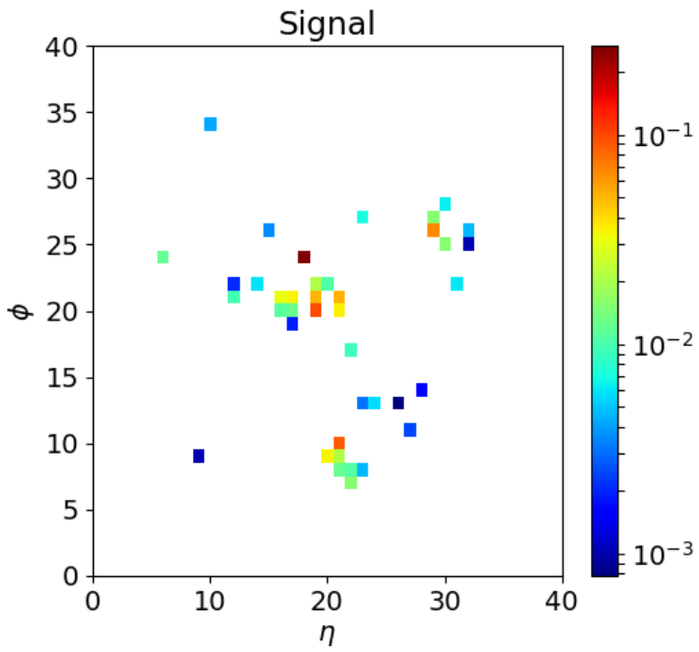
Representing jets



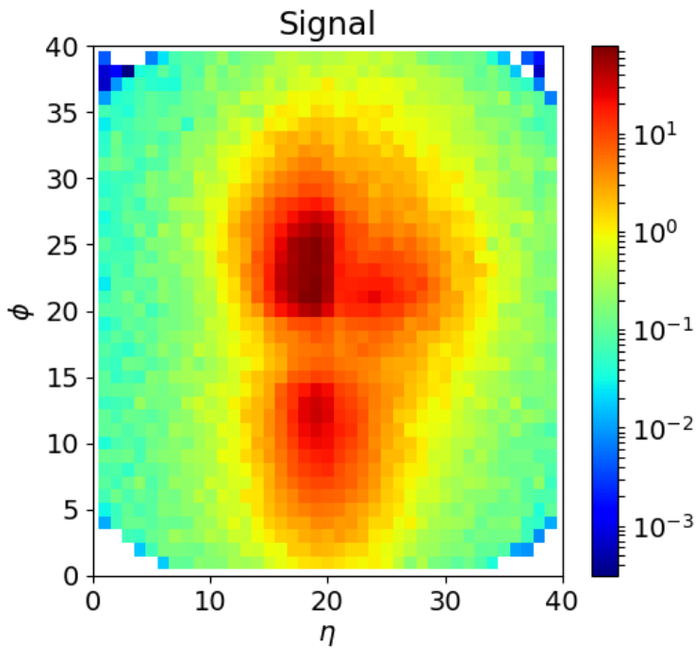
See e.g. Cogan et al., JHEP 02 (2015) 118, de Oliveira et al., JHEP 07 (2016) 069, Komiske, et al., JHEP 01 (2017)110

The data: jets

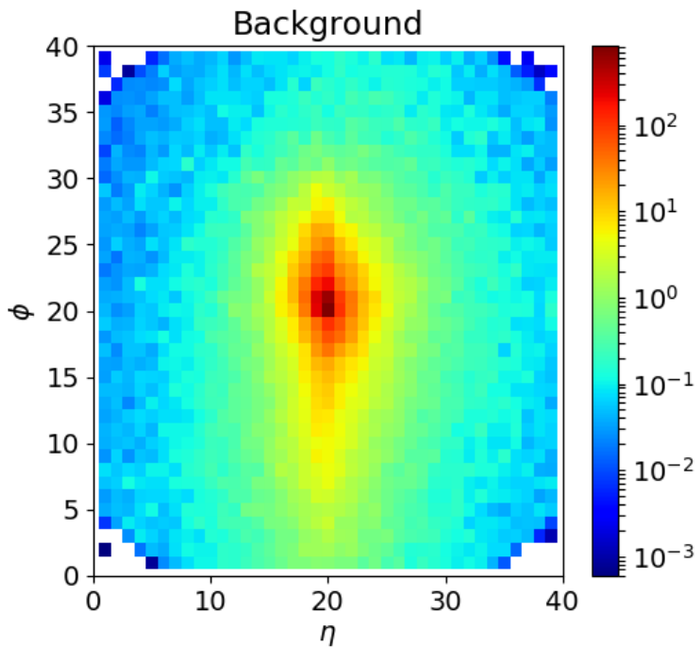
Typical single top-jet



Average top-jet

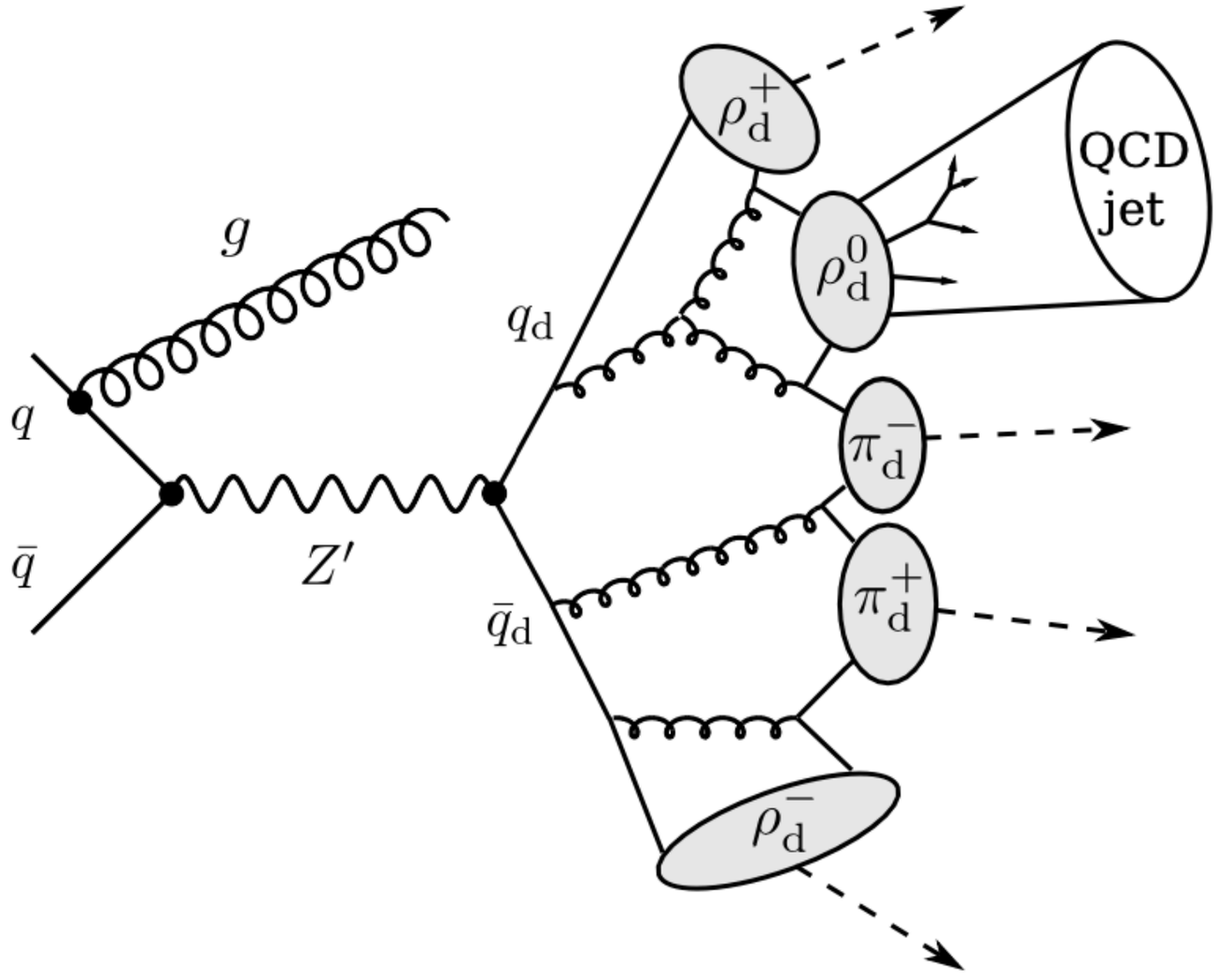


Average QCD-jet



Kasieczka, Plehn et al., SciPost Phys. 7, 014 (2019)

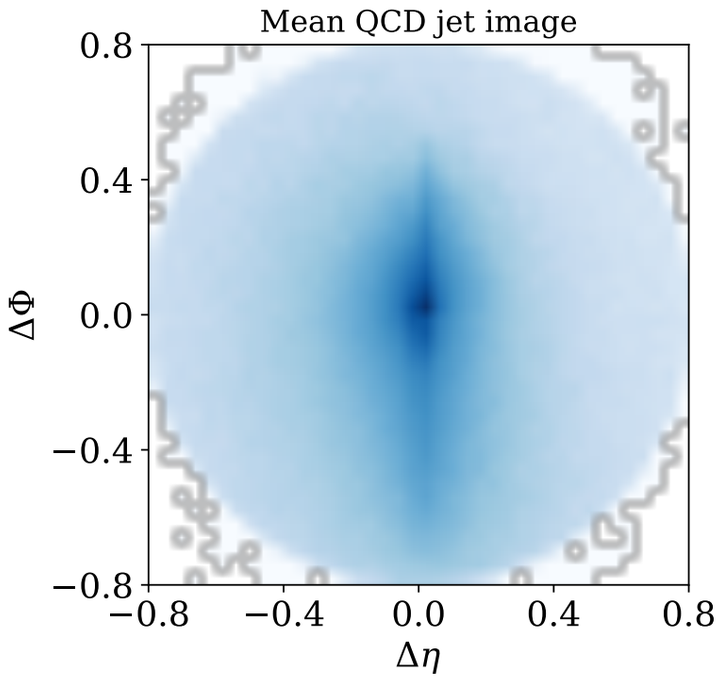
The challenging test case: dark showers



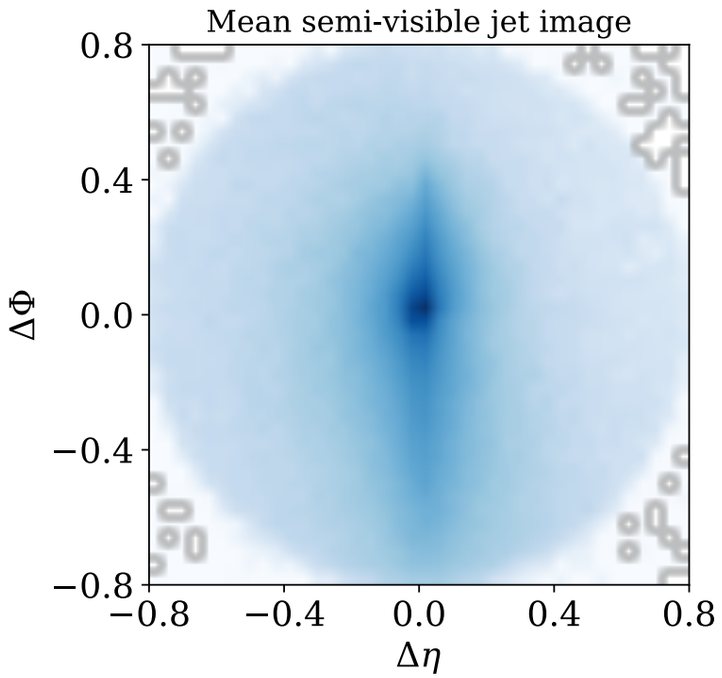
Bernreuther, Kahlhoefer, Krämer, Tunney, P3H-19-019, JHEP 01 (2020) 162

The test case: dark showers

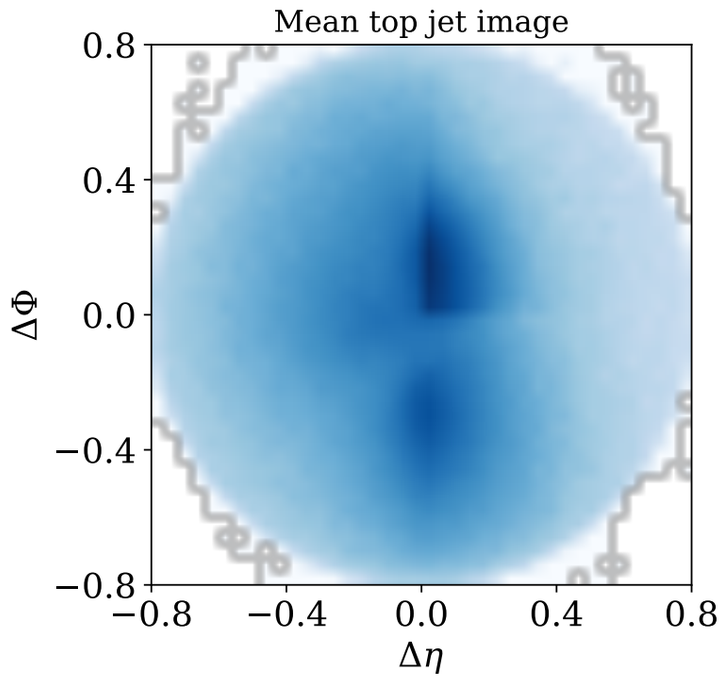
Average QCD-jet



Average dark shower



Average top-jet



Bernreuther, Finke, Kahlhoefer, Krämer, Mück, SciPost Phys. 10, 046 (2021)

B3b: preliminary work and project plan

- QCD or What?
  Heimel, Kasieczka, Plehn, Thompson, SciPost Phys. 6, 030 (2019)
- Better Latent Spaces for Better Autoencoders
  Dillon, Plehn, Sauer, Sorrenson, SciPost Phys. 11, 061 (2021)
- Autoencoders for unsupervised anomaly detection in high energy physics
  Finke, Krämer, Morandini, Mück, Oleksiyuk, JHEP 06 (2021) 161
- Unsupervised hadronic SUEP at the LHC
  Barron, Curtin, Kasieczka, Plehn, Spourdalakis, JHEP 12 (2021) 129
- Boosting mono-jet searches with model-agnostic machine learning
  Finke, Krämer, Lipp, Mück, JHEP 08 (2022) 015
- Symmetries, Safety, and Self-Supervision
  Dillon, Kasieczka, Olischlager, Plehn, Sorrenson, Vogel, SciPost Phys. 12 (2022) 6, 188
- What's Anomalous in LHC Jets?
  Buss, Dillon, Finke, Krämer, Morandini, Mück, Oleksiyuk, Plehn, e-Print: 2202.00686 [hep-ph]
- A Normalized Autoencoder for LHC Triggers
  Dillon, Favaro, Plehn, Sorrenson, Krämer, e-Print: 2206.14225 [hep-ph]
- Anomalies, Representations, and Self-Supervision,
  Dillon, Favaro, Feiden, Modak, Plehn, e-Print: 2301.04660 [hep-ph]

B3b: preliminary work and project plan

- WA1: Density-based and latent-space anomaly searches
- WA2: Anomaly scores with error bars
- WA3: Supervised and weakly supervised anomaly detection
- WA4: Benchmarking with physics problems
- WA5: Applications beyond LHC