TECHNISCHE UNIVERSITÄT DRESDEN
Fakultät Physik Institut für Kern- und Teilchenphysik

Professur Teilchenphysik

Messungen mit ATLAS & Vorhersagen mit Monte Carlo

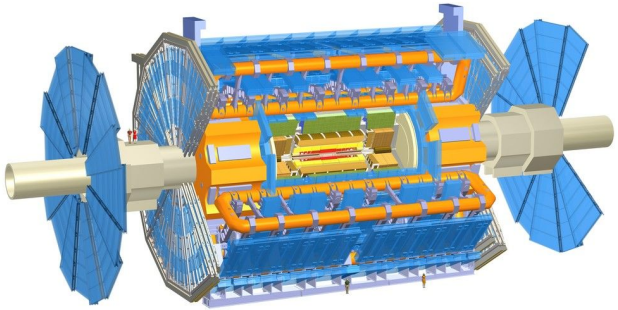
Teilchenphysik-Forschung an der Schnittstelle:

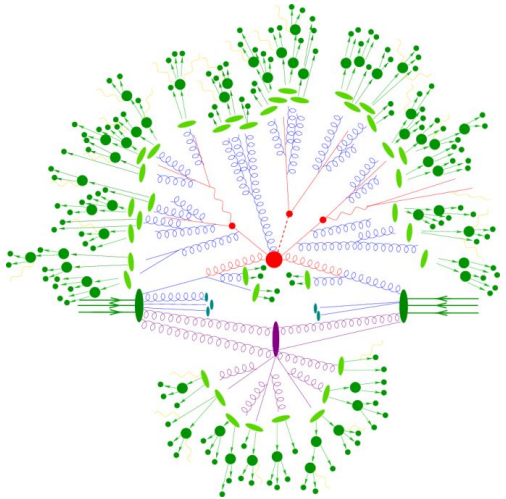
Experiment

Messungen mit dem ATLAS-Detektor am LHC

Theorie

Monte-Carlo-Simulation von Teilchenkollisionen am LHC





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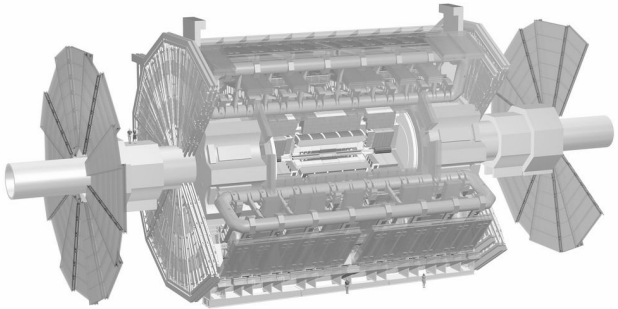
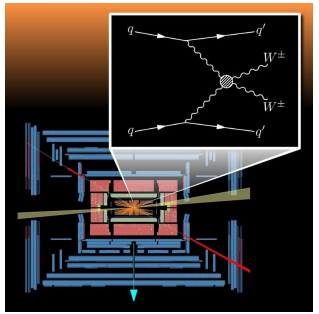
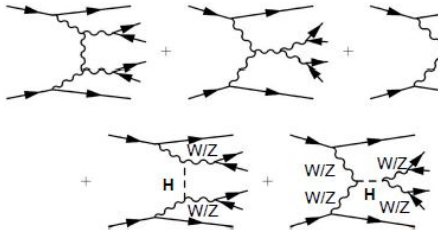


"Das Higgs-Feld als Stoßdämpfer"

- Photonen stoßen nicht zusammen...
  - elektrisch ungeladen
  - Abelsche Eichsymmetrie U(1)
- W- und Z-Bosonen dagegen schon!
  - tragen selbst schwache Ladung
  - Nicht-Abelsche Eichsymmetrie SU(2)
  - Erste Beobachtung in preisgekrönten Dresdner Doktorarbeiten





Der Higgs-Beitrag "dämpft" den Stoß! (→ Unitarität)

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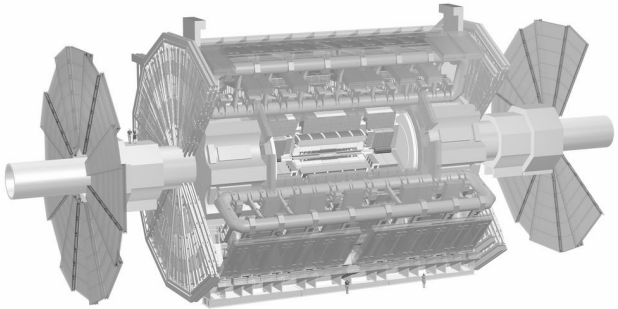
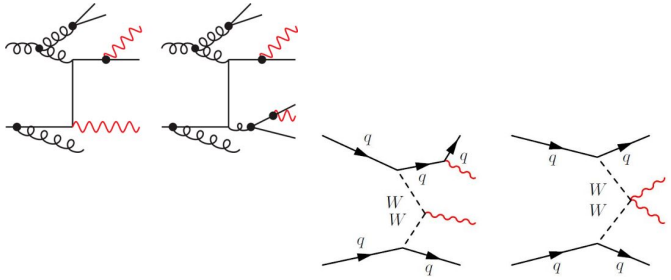
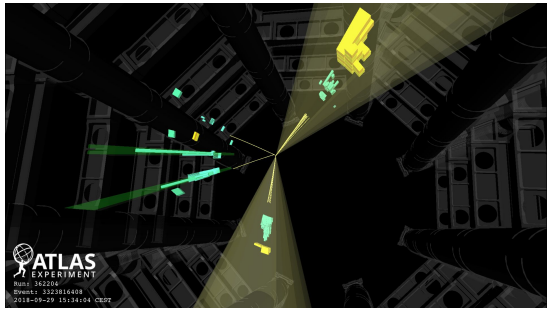
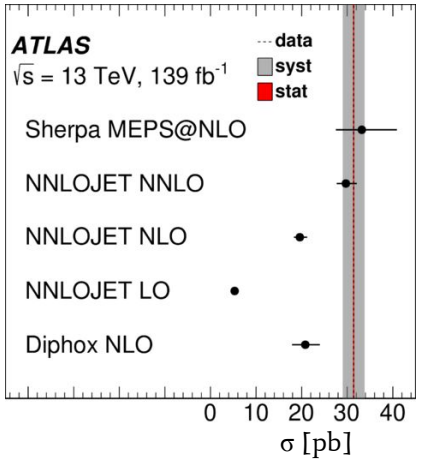


“Mit Photonen die starke Wechselwirkung testen?!?”

- Photonpaare am LHC: Produktion aus Kopplung an Quarks
- QCD-Effekte der Quarks untersuchbar durch viel genauer messbare Photonen!







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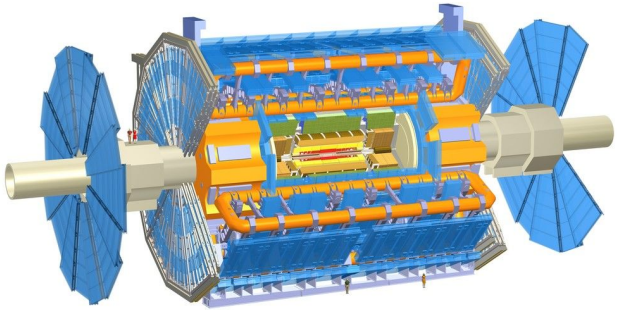
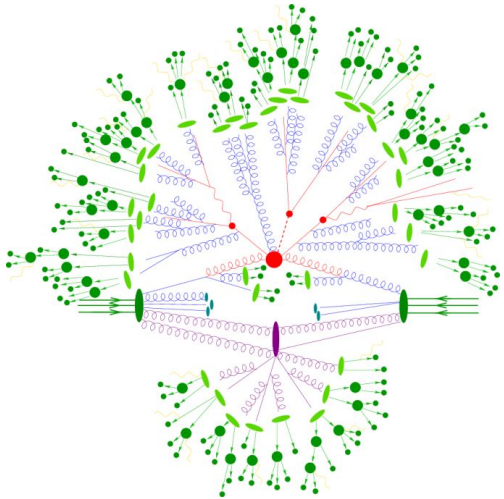
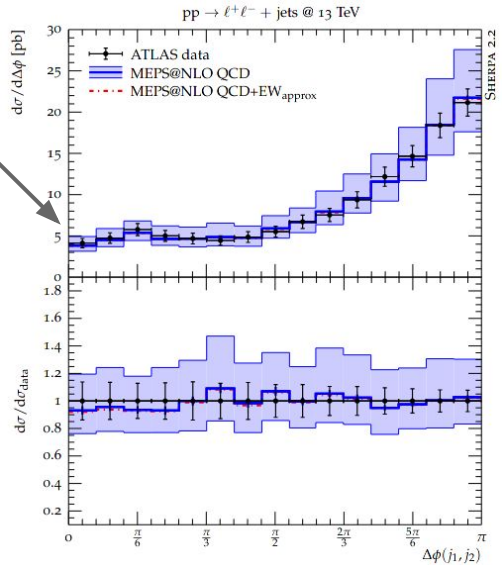




Teilchenphysik-Forschung an der Schnittstelle:

“Alles nur Zufall?
Wie präzise sind LHC-Kollisionen vorhersagbar?”

- Von der Lagrangedichte zum Wirkungsquerschnitt



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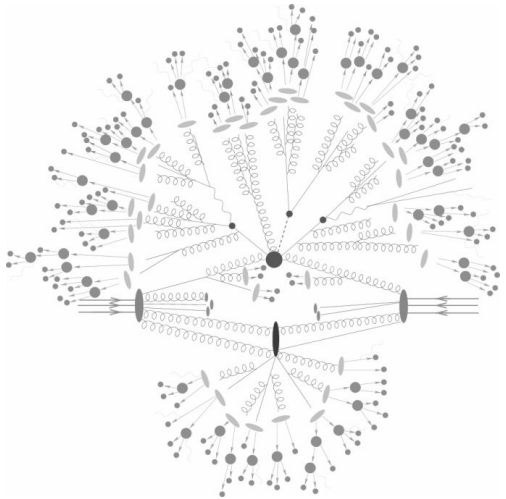

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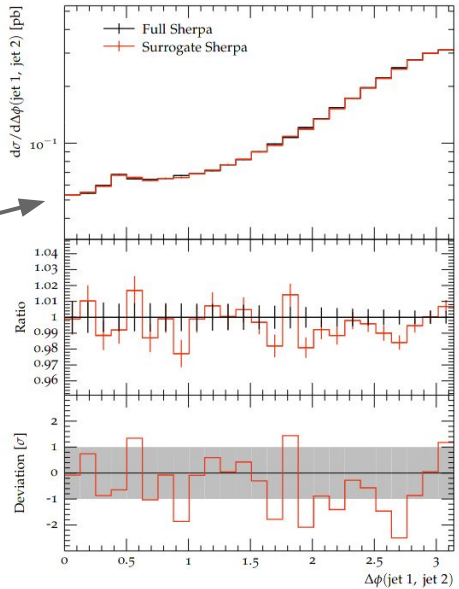
- Von der Lagrangedichte zum Wirkungsquerschnitt
- Numerische Berechnungen, Monte Carlo-Algorithmen, Machine Learning



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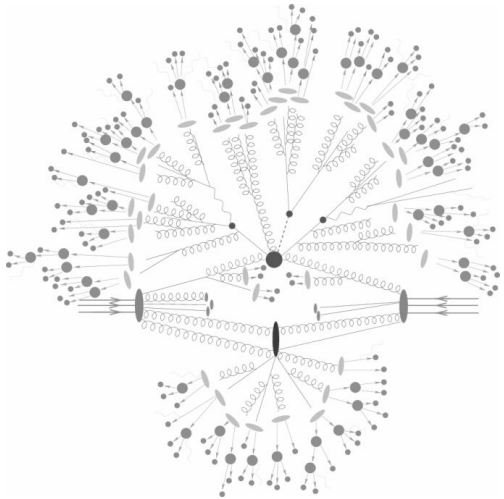
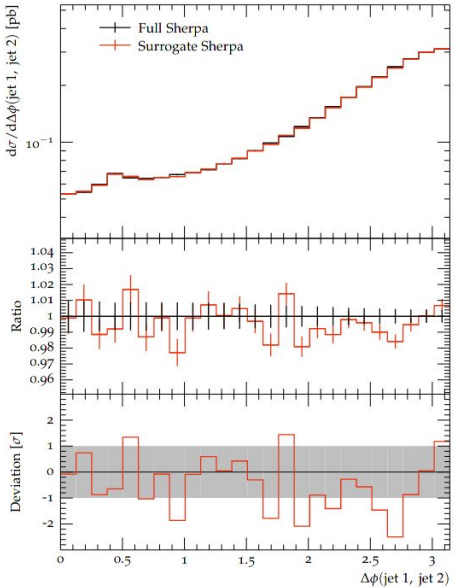


Teilchenphysik-Forschung an der Schnittstelle:

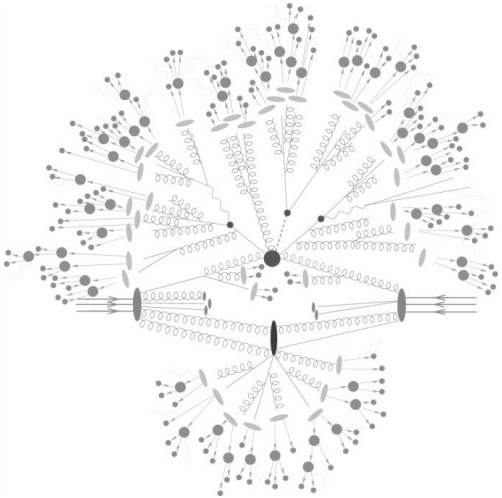
“Alles nur Zufall?
Wie präzise sind LHC-Kollisionen vorhersagbar?”

- Von der Lagrangedichte zum Wirkungsquerschnitt
- Numerische Berechnungen, Monte Carlo-Algorithmen, Machine Learning
- “Sherpa” = eines der häufig genutzten Simulations-Programme am LHC



Theorie

Monte-Carlo-Simulation von Teilchenkollisionen am LHC



Bachelorarbeiten Physik

Bisherige Bachelorarbeiten

- Study of the radiation amplitude zero effect in polarized WZ production with Sherpa
- Neural network optimisation for vector boson polarisation measurements
- EFT effects on the WWyy quartic vertex in EW yyjj production
- Effects from dimension-6 operators in the electroweak production of WZjj in fully leptonic decay models
- Sensitivity study of dim-6 operators in the WZ polarization phase space
- Study of triboson contributions in the context of vector boson scattering
- Study of the neutrino reconstruction in events with a resonance decaying to X→WZ→lvll and the possible dependence with the mass
- Radiation amplitude zero in Wgamma production

Master Forschungsjahr Physik

Bisherige Masterarbeiten Bisherige Diplomarbeiten

- Sensitivity to the H++ resonances predicted by the GM model in the current ssWWjj analysis
- Messung der Vektorboson-Streuung W+W- -> gamma gamma
- Untersuchung von geboosteten Z→ee Zerfällen unter Verwendung von "fetten Elektronen"
- Resonances in WZ production at high pT
- Study of possible signal gain using the new VBF Trigger planned for the Run-3 data
- Photon isolation with particle-flow objects
- Polarization modelling with Sherpa

https://tud.link/49qg

Was kann man neben Teilchenphysik lernen?

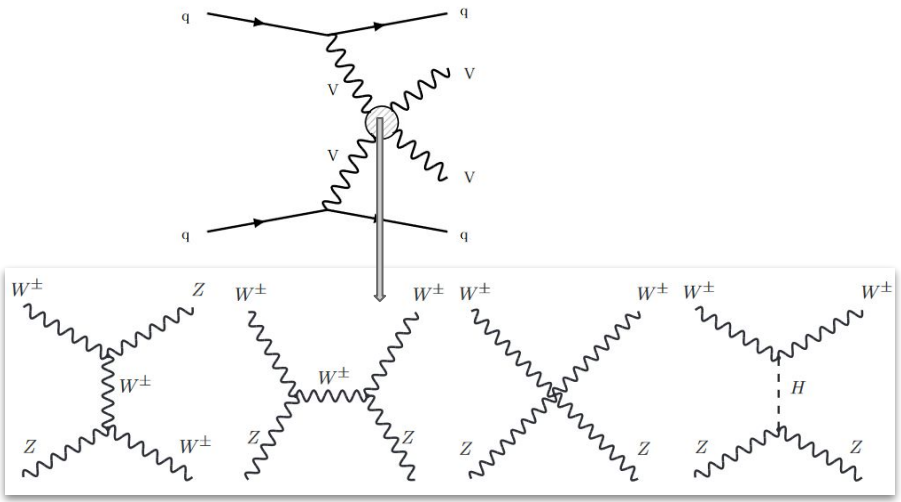
- Computational Physics
- Monte-Carlo-Techniken für hochdimensionale Integration und Simulation
- C++/Python-Programmierung, Software-Entwicklung
- Kollaboration mit internationalen Wissenschaftlern
- Zusammenspiel von Theorie und Experiment in der Physik ...

... und beim Kickern ;-)

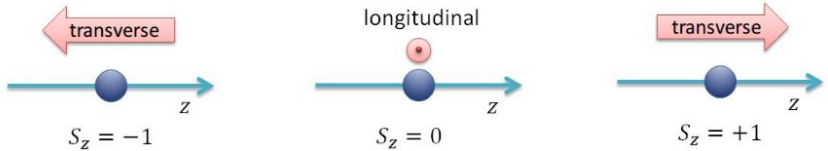
Interesse? Wir freuen uns auf Eure Fragen!

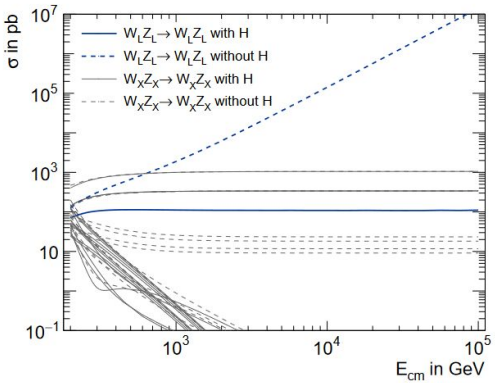
frank.siegert@tu-dresden.de

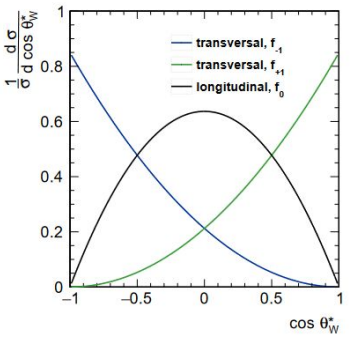
WZ Vector boson scattering



Polarization of vector bosons



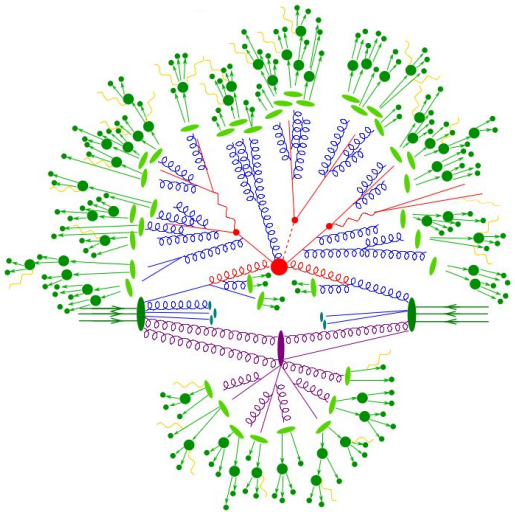




Dimension-6 EFT operators

$$\mathcal{L}_{EFF} = \mathcal{L}_{SM} + \frac{a_5}{\Lambda}\mathcal{O}^{(5)} + \sum_i \frac{a_i}{\Lambda^2}\mathcal{O}_i^{(6)} + \sum_j \frac{a_j}{\Lambda^4}\mathcal{O}_j^{(8)} + \dots$$

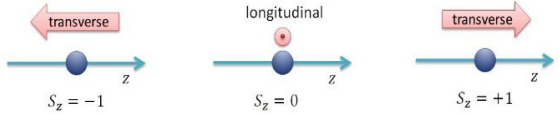
Simulation of polarized cross sections with Sherpa



$$\mathcal{M} = \mathcal{M}_{\mu}^{prod}\left(\frac{i\left(-g^{\mu\nu}+\frac{q^{\mu}q^{\nu}}{m_{\mathrm{VB}}^{2}}\right)}{q^{2}-m_{\mathrm{VB}}^{2}+i\Gamma_{\mathrm{VB}}m_{\mathrm{VB}}}\right)\mathcal{M}_{\nu}^{decay} = \frac{i}{q^{2}-m_{\mathrm{VB}}^{2}+i\Gamma_{\mathrm{VB}}m_{\mathrm{VB}}}\mathcal{M}_{\mu}^{prod}\left(\sum_{\lambda=1}^{4}\varepsilon^{*\mu}(q,\lambda)\varepsilon^{\nu}(q,\lambda)\right)\mathcal{M}_{\nu}^{decay}$$

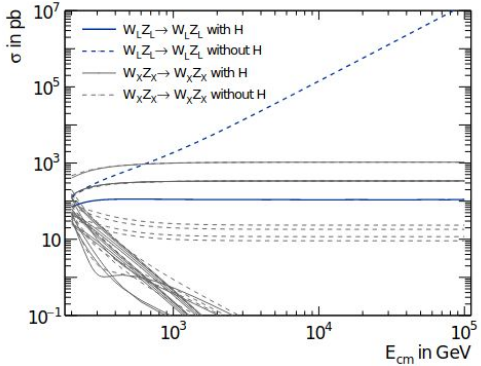
$$\varepsilon_{\pm}^{\mu}(q) = \frac{e^{\mp i\phi}}{\sqrt{2}}(0,\ -\cos\theta\cos\phi \pm i\sin\phi,\ -\cos\theta\sin\phi \mp i\cos\phi,\sin\theta)$$

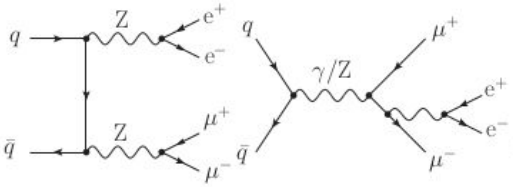
$$\varepsilon_{0}^{\mu}(q) = \frac{q^{0}}{m}\left(\frac{|\vec{q}|}{q^{0}},\cos\phi\sin\theta,\sin\phi\sin\theta,\cos\theta\right)$$

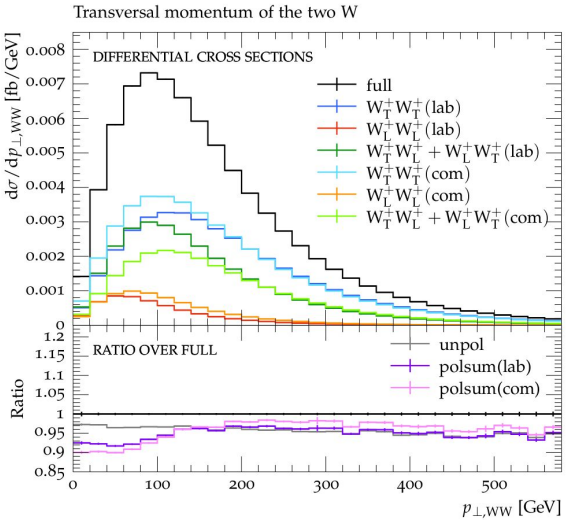


$$h = \frac{\vec{q}\cdot S}{|\vec{q}|}$$

- **Hard interaction**
- **Parton shower**
- **Multiple parton interactions**
- **Hadronisation**
- **Hadron decays**
- **Higher-order QED corrections**







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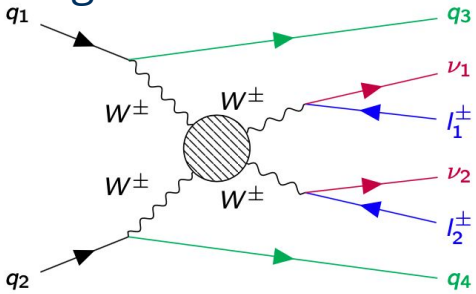
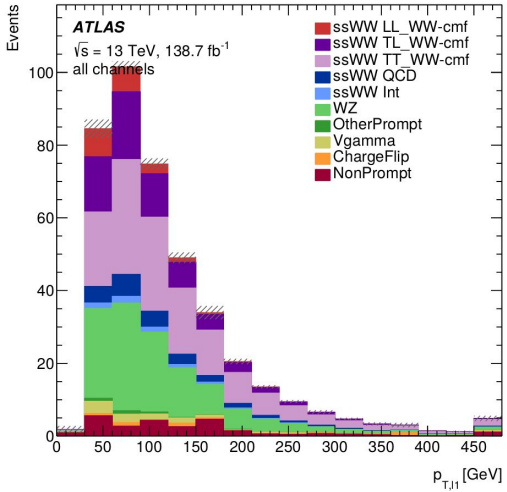
Multi-process classification for vector boson polarization measurements using multi-class neural networks

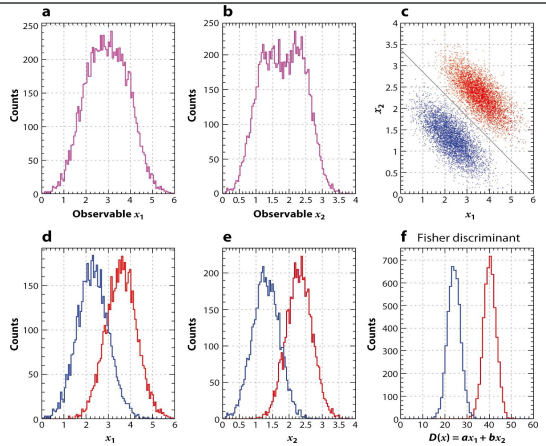
Signal Process



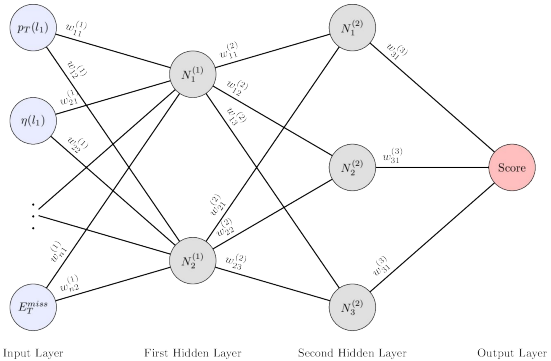
Single Observable



Multivariate Analysis



Multilayer Perceptron



$$N_i^{(l)} = A^{(l)}\left(\sum_j w_{ij}^{(l)} N_j^{(l-1)}\right)$$

Neural Network output