Activities in Durham

SHERPA development: Gurpreet Chahal Singh, Frank Krauss, Daniel Reichelt, Marek Schönherr

PhD students: Sofie Erner, Lois Flower, Parisa Gregg, Edwin Herrera-Chacon, Peter Meinzinger, Joseph Walker

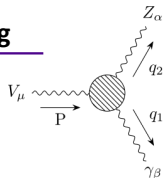**Periphery:** Anke Biekötter, Wan-Li Ju

Associated: Chris Gütschow

Sofie Nordahl Erner

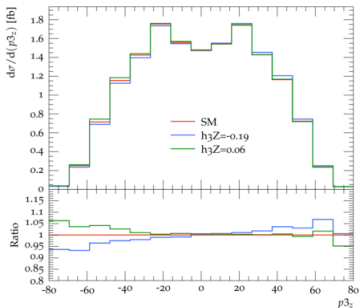## Anomalous Triple Gauge Boson Coupling

- Couplings: Z Z γ and Z γ γ

Process: $e^+ e^- \to \mu^+ \mu^- \gamma$

- BSM matrix amplitude squared found to contain terms not present in SM

 - Terms proportional to the z component of the outgoing momenta

- Results:

  - Vertical shift in cross-section for h_i^γ

  - Forwards-backwards asymmetry for h_i^Z
  - Most significant difference for h_3^Z and h_3^γ

p3: momentum of one of the outgoing muons

Lois Flower

- full QED emissions in CSS (including same-sign dipoles)
- bugfix to running α in $\alpha(m_Z^2)$ scheme (meaningful default scale, allow for running to start at arbitrary scales)
- To do: fix spectator choice issues, implement normalised κ_{ik} factors for photon splitters
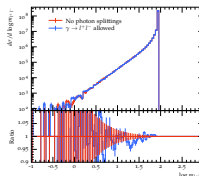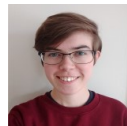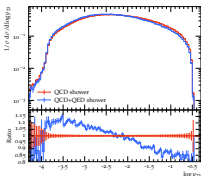
- `PhotonSplitter` within YFS
- One-step shower with $\gamma \rightarrow e^+ e^-$ and $\gamma \rightarrow \mu^+ \mu^-$ splitting functions
- Simultaneous evolution of all splitters, (reconstructed) k_T-ordered
- To do: fix problems with massive $(m > m_e)$ spectators, implement virtuality ordering

Research Topic: Issues In $|V_{ub}|$ and $|V_{cb}|$ Determinations

Working on the HADRONS++ module, implementing form factors in the current for two pseudoscalars, for Tau Decays, such as:

Edwin Herrera

- Pion Vector Form Factor in Resonance Chiral Theory (https://arxiv.org/abs/1902.02273 by Sergi Gonzalez-Solis, Pablo Roig)

- Pion Vector Form Factor based on Gounaris-Sakurai parametrization (Phys. Rev. Lett. 21, 244 – Published 22 July 1968).

Next steps: To compare the Form Factors implemented.
To add more Form Factors to the current for three pseudoscalars.

Peter Meinzinger

Photoproduction in SHERPA

Physical picture

- electromagnetic interaction in low-virtuality regime
- emission of real collinear photons approximated by Weizsäcker-Williams formula + implementation of photon PDFs + LO calculation

Further plans

- validate against HERA
- extend to quasi-real photon $Q^2 \neq 0$
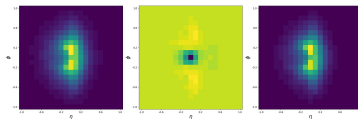- validate against HERA
- implement multiple interaction

Cross section vs $\bar{E}_T$ for all x_γ^+, x_γ^-
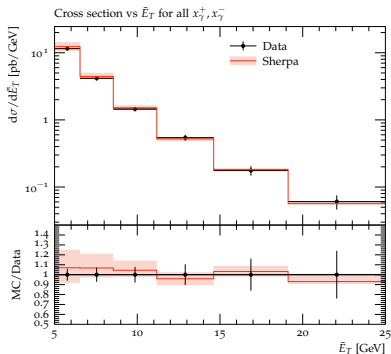
Joseph Walker
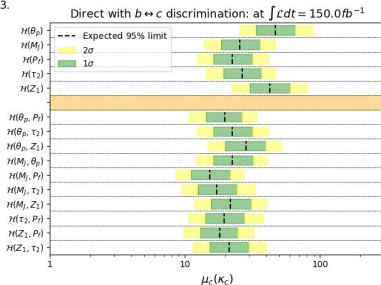Constraining the Yukawa-Charm Coupling
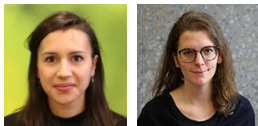

Goal: More tightly constrain κ_c

How: Utilising a range of machine learning tools and data representations including jet images, particle flows and jet features.

κ_c is determined at 95% confidence over a selection of fat jet feature distributions.

3.

Direct with $b \leftrightarrow c$ discrimination: at $\int \mathcal{L} dt = 150.0 fb^{-1}$

$\mathcal{H}(\theta_p)$
$\mathcal{H}(M_j)$
$\mathcal{H}(P_t)$
$\mathcal{H}(\tau_2)$
$\mathcal{H}(Z_1)$

$\mathcal{H}(\theta_p, P_t)$
$\mathcal{H}(\theta_p, \tau_2)$
$\mathcal{H}(\theta_p, Z_1)$
$\mathcal{H}(M_j, \theta_p)$
$\mathcal{H}(M_j, P_t)$
$\mathcal{H}(M_j, \tau_2)$
$\mathcal{H}(M_j, Z_1)$
$\mathcal{H}(\tau_2, P_t)$
$\mathcal{H}(Z_1, P_t)$
$\mathcal{H}(Z_1, \tau_2)$

- - - Expected 95% limit
2σ
1σ

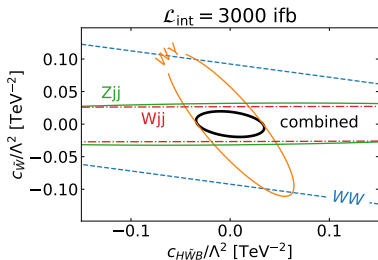$\mu_c(\kappa_c)$

Parisa Gregg, Anke Biekötter

Constraining NP coefficients

- fixed handful of SMEFT issues in SHERPA-2.2
  $\rightarrow$ now usable for everything with SM/MSSM colour structures
  $\rightarrow$ propagator mass shifts still missing
- AGCs through dedicated UFO model

arXiv:2003.06379,2102.01115

$\mathcal{L}_{\text{int}} = 3000$ ifb

**Gurpreet Singh Chahal,** postdoctoral research associate

- **Sherpa**
  - Developing tunes for Sherpa 2.2.11 (Hadronisation) and Sherpa 3.0 (Hadronisation + colour reconnection model)
  - Sherpa 3.0 Tuning plots: https://www.ippp.dur.ac.uk/~gchahal/tune/rivet-css-cr-on-2vs3-4Jan/
  - Tune development for colour reconnection ON vs OFF is in final stages for CSS vs Dire
    - To be published soon!
  - Next plan is to develop underlying event tunes
- **CMS Collaboration**
  - Convenor of CMS MC Generator Modelling group (9/2020 - present)
    - Responsible of CMS Sherpa interface and providing user support to CMS analysts
   - Sherpa code profiling for memory optimisation

Wan-Li Ju
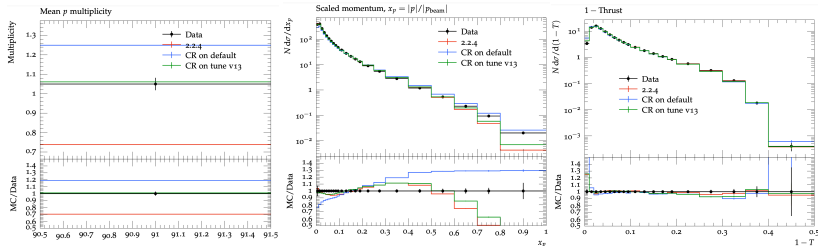
N³LL+N²LO QCD small-q_T resummation for $W^{\pm}$ and Z

- using SCET, incl. singlet ctrs.
- fully diff. in lepton kins.
- multidifferential cross sections and ratios
- pronounced effect on $\mathcal{R}_{W/Z}$ from differing fid. phase spaces, boson masses, spin structures, PDFs

Next developments

- extend to different processes
- extend to N$^\times$LL QED
- fully incorporate in SHERPA

arXiv:2106.11260
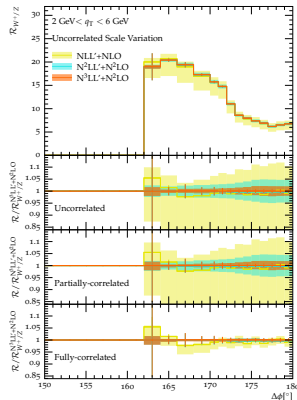
Daniel Reichelt

- soft gluon resummation + parton showers
- recent results:
  - jet substructure Z+jet and dijets

    Caletti, Fedkevych, Marzani, Reichelt, Schumann '21

    Caletti, Fedkevych, Marzani, Reichelt '21

    Reichelt, Caletti, Fedkevych, Marzani, Schumann '21
  - soft-drop grooming for event shapes

    Baron, Reichelt, Schumann, Schwanemann, Theeuwes '20
- plans:
  - additional applications jet substructure / event shape resummation
  - shower benchmarks
  - DIS developments $\Rightarrow$ towards EIC phenomenology

Chris Gütschow

SHERPA performance

- 0.5 FTE swiftHEP PDRA @ UCL (incl. 3 RSE months @ UCL)
- mostly (but not exclusively) dedicated to SHERPA performance improvements
- optimise performance for large ATLAS/CMS samples
- code analysis and structural improvements
- HDF5 read-in