



Sherpa and the QED parton shower

RadioMonteCarLow2 Working Group Meeting

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General methods and features

- Full NLO EW fixed-order integration/event generation for any SM process schönherr '17
- Catani-Seymour subtraction
- Can be combined with electron structure function for ${\rm e^+e^-}$



Preliminary

- Pion XS in F×sQED at LO (+ IS YFS)
- In future: NLO corrections to pions
- Validate pion form factor implementation(s)
- In future: sQED in automated ME generators \rightarrow matched parton shower?

Hadronic Vacuum Polarisation

• Jegerlehner parametrisation implemented privately & validated

- Decay tables for au and $\mathcal{O}(200)$ hadrons Siegert, Laubrich Diploma Theses
- pprox 2600 decay channels
- Accounts for $D-\bar{D},\,B-\bar{B},\,B_s-\bar{B}_s$ mixing, off-shell decays, form-factors
- New decay channels can be added dynamically
- QED corrections applied to these using YFS
- $\bullet\,$ Including exact NLO QED for B decays $\,$ Bernlochner, Schönherr '10 $\,$





Alan Price

Soft photon resummation

- Photon radiation from initial and final states through YFS Krauss, Price, Schönherr '22
- Also for polarised initial states MEs available through Amegic++
- Advantage: no negative weights
- Upcoming: YFS-based subtraction scheme
- See Alan's talk



 γ energy validation at LEP

CPU performance: we are working on this!



Parton shower methods

- Photon radiation (and optionally charged particle production) from all external legs
- QCD shower paradigm: evolution outwards from amplitude
- Allows for equal treatment of ISR, FSR and interference
- Separate ISR and FSR fully implemented and validated



Preliminary

10x more stats for interference

Automated NLO parton shower matching

- QED extension of MC@NLO method Frixione, Webber '02
- Correct XS and IR-safe observables to O(α), further radiative corrections in shower approximation
- Treatment of Born photons not implemented yet



TBP: Flower, Schönherr '25

Conclusions

In the future, we hope to have...

- Full YFS@NLO+EEX framework for precision low-energy (+NNLO?)
- QED parton shower for $\mathrm{e^+e^-}$ and automated NLO matching
- On-the-fly uncertainty estimates for parametric uncertainties
- Low-energy hadronic physics improvements
 - Pion form factor in different approaches help from Liverpool experts
 - Hadronic VP improvements
 - Treatment of radiation off pions and NLO corrections parton shower approach?

Download and manual sherpa-team.gitlab.io



Thanks for listening!

Backup: on-the-fly variations

- More flexibility in form factor and HVP choices
- Capture HVP and form factor uncertainties without re-running
- On-the-fly variations Bothmann, Schönherr, Schumann '16



• No progress on this to report

Backup: Developments in high-energy $\mathrm{e^+e^-}$

- Automated EW Sudakov corrections Bothmann, Napoletano '20
- Cross sections for polarised intermediate EW bosons Hoppe, Schönherr, Siegert '23
- Combined QED ISR (YFS+EEX) with QCD FSR (MEPs@NLO and Mc@NLO)
- New NLL QCD parton shower: ALARIC Herren et al. '21
- Photoproduction at NLO Höche, Krauss, Meinzinger
 ²³
 - Single or double
 - Resolved or direct



Bothmann et al. '21