COMETA polarisation study

Kick-off meeting, 27th March 2024

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COMETA

Objectives

Comparison of Monte Carlo codes that are capable of simulating polarised EW bosons as intermediate states:

- ➔ different approaches to define polarised signals (NWA, DPA, ...)
- ➔ LO predictions
- ➔ exact vs approximate NLO QCD corrections (for leptonic decays)
- ➔ (N)LO+PS, LO-merged matched predictions
- ➔ NLO EW corrections
- ➔ NNLO QCD corrections (even if just one group)
- ➔ loop-induced production

Provide to the LHC community:

- ➔ general recommendations on simulation tools
- ➔ reliable estimates of theoretical systematic uncertainties (QCD-scale, ...)

Involve ATLAS/CMS hands-on people:

- ➔ compare with currently used simulation tools & reweighting methods

Contributions

Contacted ~15 people involved in automating polarised-boson production and decay beyond LO

- SHERPA: Mareen Hoppe, Marek Schönherr, Frank Siegert
- POWHEG-BOX: Jakob Linder, Giovanni Pelliccioli, Giulia Zanderighi
- MOCANLO: Ansgar Denner, Giovanni Pelliccioli
- BBMC: Ansgar Denner, Christoph Haitz
- MG5_aMC@NLO: Richard Ruiz, Olivier Mattelaer, Martina Javurkova
- STRIPPER/HighTEA: Rene Poncelet
- Ninh-private: Le Duc Ninh, Thi Nhung Dao

Serious commitment needed!

Monte Carlo tools

- LO: all
- NLO QCD: POWHEG-BOX, MOCANLO, BBMC, STRIPPER/HighTEA, Ninh-private
- multi-jet merging (LO): SHERPA, MG5_aMC@NLO
- NLOPS matching: POWHEG-BOX, SHERPA
- NLO EW: MOCANLO, BBMC, Ninh-private
- loop-ind (LO): MOCANLO, Ninh-private, STRIPPER/HighTEA, MG5_aMC@NLO
- NNLO QCD: STRIPPER/HighTEA

others?

Shall we involve some hands-on people from ATLAS and CMS? Ask ATLAS & CMS contact people whether they can provide samples used in ZZ analyses

- reweighting methods which are still used in polarisation analyses
- MC tools already used in exp. analyses

Choosing a multi-boson process

Targeting an **inclusive-diboson** process would:

- ➔ maximise number of contributing MCs
- ➔ enable calculation of higher orders & PS matching (not available for VBS)
- ➔ match processes measured by ATLAS & CMS: WZ (1902.05759, 2110.11231, 2211.09435, 2402.16365) and ZZ (2310.04350), for WW no polarisation measurement yet

ZZ inclusive production in fully leptonic decay channel, $pp \rightarrow e^+e^-\mu^+\mu^-$, has several advantages:

- ➔ cleanest diboson channel
- ➔ offers numerous polarisation-sensitive observables
- ➔ first measurement exists by ATLAS 2310.04350 (evidence for LL)
- ➔ NLO QCD, NLO EW, PS matching available
- ➔ receive loop-induced contribution

Decisions

- ➔ ZZ production in four-lepton channel
- ➔ polarisation defined in diboson CM frame as default
- ➔ may consider LAB frame as well later (depending on time, motivation etc.)

SM input and setup

All details will be provided asap in a note (dedicated git repository)

- ➔ Five-flavour scheme
- ➔ Massless leptons and quarks
- ➔ Unit CKM matrix
- ➔ Pole masses and widths for W/Z as input to MCs (from on-shell values of the recent PDG review)
- ➔ G_μ scheme for electroweak coupling (G_F , real pole EW-boson masses)
- ➔ MSbar factorisation for PDFs (matches most used LHAPDF sets)
- ➔ PDF set including photons: default will be NNPDF40_qed
- ➔ fiducial setup that mimics as much as possible ATLAS measurement
- ➔ choice of photon recombination (cone/anti-kt dressing, should have small effects)

Decisions

- ➔ make use of a dedicated git repository for collection of results and writing of the note/paper: COMETA public git or a separate one: to be understood
- ➔ observables to study, histogram binning & range: Giovanni and Rene will draft a proposal
- ➔ format for the differential histograms: left bin edge, right bin edge, central value, numerical uncertainty, value for each of 7-point QCD-scale variations

- ➔ PDF uncertainties, different PDF sets: decide later
- ➔ merged & matched predictions, hadronisation & MPI: decide later

Timeline and outcome

- ➔ document with all details (SM parameters, selection cuts, various input, observables and histogram binning) will be circulated in mid April

- ➔ Monthly on-line meetings (next one end of April)
- ➔ First basic comparison amongst codes (LO) should happen quite early (end of May?)
- ➔ Presenting the progress of the comparison at the Toulouse meeting (23-24 Sept.) is a milestone, one entire afternoon will be dedicated to the comparison activities
- ➔ Target a regular article as final document, to be submitted to a peer-reviewed journal, similarly to the VBSCan case
- ➔ Soft deadline for completing work & writing: end of this year? Most likely in Grant Period 2