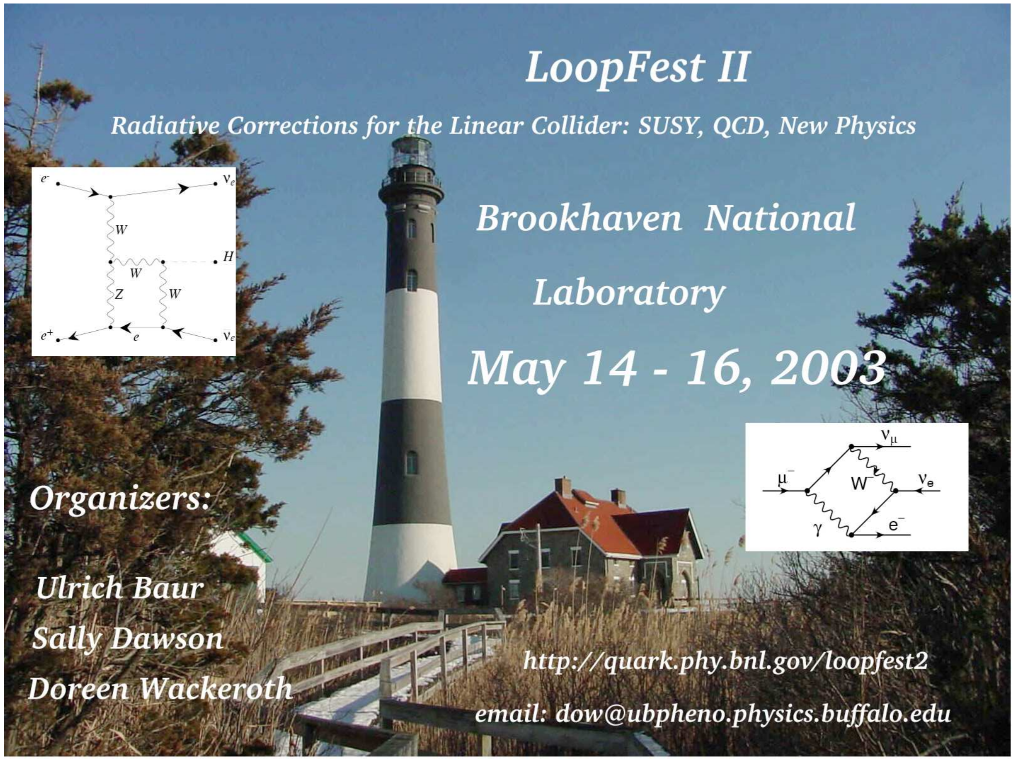
Outlook


LoopFest II
Radiative Corrections for the Linear Collider: SUSY, QCD, New Physics
Brookhaven National
Laboratory
May 14 - 16, 2003
Organizers:
Ulrich Baur
Sally Dawson
Doreen Wackeroth
http://quark.phy.bnl.gov/loopfest2
email: dow@ubpheno.physics.buffalo.edu

Activities worldwide:

The LoopVerein of the ECFA/DESY LC workshop

Conveners:

W.Hollik (MPI Munich), hollik@mppmu.mpg.de

S.Dittmaier (MPI Munich), dittmair@mppmu.mpg.de

web page: http://wwwth.mppmu.mpg.de/members/loopverein/TheLoopVerein.html

For an overview of activities since TESLA TDR see talk by S.Dittmaier.

The Radiative Corrections WG of the American LC Physics Group

Conveners:

U.Baur (SUNY at Buffalo), baur@ubhep.physics.buffalo.edu

S.Dawson (BNL), dawson@quark.phy.bnl.gov

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web page: http://quark.phy.bnl.gov/lcwg

Asia ?

Recent meetings of the LoopVerein/Radiative Corrections WG:

- Arlington LC Workshop at UT at Arlington, Texas (January 9-11, 2003): transparencies available at http://ubpheno.physics.buffalo.edu/ dow/loopverein-texas.html
- ECFA/DESY LC Workshop in Amsterdam (April 1-4, 2003): transparencies available http://www.nikhef.nl/ecfa-desy/start.html
- LoopFest II talks will be posted at http://quark.phy.bnl.gov/loopfest2/program.html

Goals

To meet the theoretical challenges posed by the ultra-high experimental precision of a future e^+e^- Linear Collider. see talk by T.Barklow

Mark Oreglia's talk: We also need to be ready for Tevatron/LHC $\rightarrow$ many talks on non-LC studies.

Examples (see T.Barklow's talk):

$e^+e^- \rightarrow \nu\bar{\nu}H$: SM background: 0.5% TU, signal: 0.15% TU.

TGCs extracted from differential WW cross section: 0.1% TU.

M_W from WW threshold scan: a few MeV TU.

- Assessment of the quality of theoretical predictions for SM processes and for physics beyond the SM in view of the anticipated experimental precision.

  Importance of TUs:

  See, e.g., talks at mini-workshop on *EWK precision data and the Higgs mass* at DESY Zeuthen (Feb. 2003).

  Examples:

EWK $\mathcal{O}(\alpha)$ corrections to $e^+e^- \to \nu\bar{\nu}H$ known. see talk by G.Belanger

EWK $\mathcal{O}(\alpha)$ to $e^+e^- \to WW \to 4f$ known in DPA. see talk by S.Dittmaier

$\to$ Estimate of TU ? (intrinsic, missing higher orders, ...)

TU studied for M_W, TGCs at LEP2 energies using RacoonWW/YFSWW.

$\to$ Corresponding study of TU at the LC ?

- Development of new tools and techniques for calculating precise rates for SM and supersymmetric processes.

  Challenges: more loops, more legs, higher complexity.

  Example: $e^+e^- \to t\bar{t}$

  Well under control at 1-loop.

  Off-shell top pair production (threshold, continuum) ?

  Combination of EWK and QCD corrections ? ("naive" and more sophisticated)

  Multi-loop:

  enormous progress at 2-loop ($2 \to 2$), master integrals, physics results (distributions, IR divergent phase space integration).

see talks by Z.Bern, F.Petriello, A.Ghinculov, W.Kilgore

and beyond: dominant EWK 3-loop to ρ parameter (and μ decay) $\rightarrow$ TU M_W down to 2 MeV.

see talks by J.Kühn, S.Dittmaier

New: planar massless on-shell triple box diagram, V.Smirnov, hep-ph/0305142.

$\rightarrow$ 3-loop virtual corrections to scattering processes ?

Automization:

tree-level (up to $2 \rightarrow 8$), 1-loop (up to $2 \rightarrow 3$), (2-loop, 3-loop) in SM and MSSM (tree-level, 1-loop)

see talks by T.Hahn, T.Kon, A.Ghinculov, E.de Doncker, T.Riemann, J.Kühn

Based on analytically known loop integrals in libraries (e.g. LoopTools).

work in progress:

numerical integration of loop integrals (IR,UV divergences ?) (see also LoopFest I talk by G.Passarino).

Ongoing:

Comparisons with existing calculations, tuned comparisons of MC generators for multi-particle final states (6f, see talk by S.Dittmaier).

$\rightarrow$ Complete $2 \rightarrow 4f$ at 1-loop ?

Leading higher orders, resummation:

see talks by F.Olness, R.Akhoury, D.Pirjol (SCET), V. del Duca (BFKL), J.Blümlein, J.Kühn.

Understand structure of EWK Sudakov-like logs $\alpha log^2(s/M_V^2)$ (factorization properties, exponentation ?). Subleading logs important (alternate signs lead to cancellations). see talk by J.Kühn

$\rightarrow$ Universal treatment of EWK Sudakov logs to improve 1-loop calculations ?

- Interface to and/or implementation in event generators which is crucial for the extraction of precision physics information from data.

  First joint Simulations/LoopVerein session at LCWS2002

  see talks by M.Peskin, K.Ellis

  Reweighting of distributions with K-factors in general not sufficient (e.g. $e^+e^- \rightarrow WW \rightarrow 4f$ at NLO, rapidity distribution in $pp \rightarrow \gamma + X$ at NNLO).

Interface of NLO with general purpose generators (Pythia,Herwig, ...) for e.g. parton showering.

Negative weights ? Double counting (explicit matrix element calculation vs resummation in showers) ?

To fully exploit the potential of a future LC to verify the SM or identify and disentangle signals of physics beyond the SM, theoretical predictions need to be of highest standards.

We are faced with an increased complexity of calculations:

- $2 \to 2$ processes at 2-loop and leading 3-loop.
  Complete electroweak 2-loop calculation?

- $2 \to 4, 6 \ldots$ processes via e.g. $ZH, WW, ZZ, Z\gamma, \gamma\gamma, t\bar{t}, \ldots$ production at complete 1-loop.
  Complete electroweak 1-loop calculation?

- Higher complexity in models beyond the SM, e.g., loop calculations in the MSSM.

  see talks by K.Matchev, H.Logan, S.Su, J.Jang, J.Guasch, A.Freitas.

- Alternative initial states: $\gamma\gamma, \gamma e, e^- e^-$

These calculations pose technical/computational challenges, e.g. when going from $\mathcal{O}(100)$ to $\mathcal{O}$(several 10000) diagrams (more legs, more loops),

and theoretical/conceptual problems:

$\rightarrow$ Gauge-invariant treatment (or consistent perturbative expansion) of unstable particles ? see talk by A.Signer

$\rightarrow$ Treatment of electroweak Sudakov logarithms $(\alpha/\pi \log^2(s/M_V^2))$ (higher orders, resummation) ? see talk by J.Kühn

$\rightarrow$ Renormalization in the MSSM (restoring supersymmetry). see talk by J.Guasch

Providing precise predictions for collider experiments is an active field, producing exciting, new results.

I am looking forward to LoopFest III ...

... and Loops and Legs 2004 (Usedum, April 2004), LCWS 2004 (Paris, April 2004).