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# Status of ALCPG Simulation & Reconstruction for the LOI

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# LOI Simulation Requirements

- Characterize subdetector performance.
  - Single particle response can be used to demonstrate energy and position resolution, etc.
  - Very detailed geometric description and detector response can be modeled.
- Demonstrate physics capabilities of the combined detector.
  - Canonical Benchmark physics reactions defined.
  - Large statistics for both signal and background drive alternate, simplified detector response approach.

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# Outline

- Event Samples
  - subdetector performance characterization
  - LOI physics benchmarking
- Detector Response simulation
- Event Reconstruction

# Detector characterization

- For each detector, run neutral single particles to determine calorimeter sampling fractions:
  - $n, \bar{n}, K^0_L$ , gamma, 10k events per run
    - $E = 1, 2, 5, 10, 20, 50, 100$  GeV
    - $\theta = 90, 100, 110, 120, 130, 140, 150, 160, 170$
- Single charged particles for tracking characterization and calorimeter shower/track association
  - $\mu^{+/-}, \pi^{+/-}, \rho, K^{+/-}$
- Composite single particles:  $\pi^0, \tau, \rho, \psi, K^0_S$ , etc.
- Single quarks (u,d,s) and  $Z^0(\rightarrow uds)$  at fixed angles and energies
- Dijet (uds) events at 100, 200, 500, 1000 GeV cms
- $ZZ(\rightarrow q\bar{q}\nu\bar{\nu}$  and  $\rightarrow q\bar{q}q\bar{q})$ ,  $ZZ\nu\bar{\nu}$ ,  $WW\nu\bar{\nu}$ ,  $Zh(q\bar{q}q\bar{q}, q\bar{q}\tau\tau, q\bar{q}\mu\mu)$ , tt, etc.
- Web accessible <http://www.lcsim.org/datasets/ftp.html>

# ILC500 Standard Model Sample

- 500 fb<sup>-1</sup> sample generated at 500GeV cms with 80% e<sup>-</sup>, 30% e<sup>+</sup> polarizations, randomly mixed events from highly weighted processes,
  - [ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI\\_SM\\_Sample/stdhep/](ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI_SM_Sample/stdhep/)
  - Roughly 7.2 million events.
    - 2453865 +80e<sup>-</sup> -30e<sup>+</sup>
    - 4737499 -80e<sup>-</sup> +30e<sup>+</sup>
  - Split into files containing 1,000 events each.

# ILC500 $\tau^+\tau^-$ Sample

- Samples generated at 500GeV cms with 80%  $e^-$ , 30%  $e^+$  polarizations, randomly mixed events from very highly weighted processes,
  - [ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI\\_tautau/stdhep/](ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI_tautau/stdhep/)
  - ~1 million events (SLAC)
    - Some issues with polarization
  - ~2.2 million events (DESY)
    - 1010385 +80e- -30e+
    - 1148162 -80e- +30e+
  - Split into files containing 1,000 events each.

# ILC500 tt Sample

- Two samples generated at 500GeV cms with 80%  $e^-$ , 30%  $e^+$  polarizations, randomly mixed events from very highly weighted six-fermion final-state processes containing  $b\bar{b}$ ,
  - [ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI\\_sixfermion/mtop174.0/stdhep/](ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI_sixfermion/mtop174.0/stdhep/)
  - [ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI\\_sixfermion/mtop173.5/stdhep](ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC500/LOI_sixfermion/mtop173.5/stdhep/)
  - ~2 X 1.1 million events
    - 351861 +80e- -30e+
    - 757724 -80e- +30e+
  - Split into files containing 1,000 events each.

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# ILC500 SUSY Sample

- Most of the whizard files have been generated
  - Some problems at DESY generating events.
- “Derived” files (i.e. randomly mixed events with 80%  $e^-$ , 30%  $e^+$  polarizations) not yet created.

# ILC500 Backgrounds

- $\gamma\gamma \rightarrow$  hadrons

- 241232 events

- <ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/backgrounds/gghad/stdhep/whizard/>

- $\gamma\gamma \rightarrow \mu\mu$  ( $p_T > 115$  MeV)

- 433931 events

- <ftp://ftp-lcd.slac.stanford.edu/ilc/ILC500/backgrounds/ggmumu/stdhep/whizard/>

- GuineaPig pairs

- ~1500 bunch crossings

- <ftp://ftp-lcd.slac.stanford.edu/lcd/ILC/ILC500/backgrounds/pairs/stdhep/>

# ILC250 Standard Model Sample

- 250 fb<sup>-1</sup> sample generated at 250GeV cms with 80% e<sup>-</sup>, 30% e<sup>+</sup> polarizations, randomly mixed events from highly weighted processes,
  - [ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC250/LOI\\_SM\\_Sample/stdhep/](ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC250/LOI_SM_Sample/stdhep/)
  - Roughly 7.9 million events
    - 2904045 +80e<sup>-</sup> -30e<sup>+</sup>
    - 4972958 -80e<sup>-</sup> +30e<sup>+</sup>
  - Split into files containing 1,000 events each.

# ILC250 Higgs Signal Sample

- 4 X 250 fb<sup>-1</sup> samples generated at 250GeV cms with 80% e<sup>-</sup>, 30% e<sup>+</sup> polarizations, randomly mixed events from unweighted higgs processes.
  - [ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC250/LOI\\_higgs/stdhep/](ftp://ftp-lcd.slac.stanford.edu/ilc2/ILC250/LOI_higgs/stdhep/)
  - Roughly 260,000 events
    - 25677 +80e<sup>-</sup> -30e<sup>+</sup>
    - 39893 -80e<sup>-</sup> +30e<sup>+</sup>
  - Split into files containing 1,000 events each.

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# Detector Response Simulation

- The detector being modeled is sid02.
  - See plenary talk by [M. Breidenbach](#).
  - Many other variants studied as part of the (ongoing) optimization process.
    - See talk by [M. Stanitzki](#).
- Using slic version [v2r5p3](#).
- Geant4 9.1 patch 2.
- LCPhys physics list.

# Full Simulation Status ILC500

- LOI\_SM\_Sample
  - Processed primarily at FNAL on the Fermigrid system.
  - ~40 seconds / event
  - All files processed.
- LOI\_tautau
  - Processed at SLAC.
  - ~25 seconds / event
  - All files processed.
- LOI\_sixfermion\_ (mtop173.5, mtop174.0)
  - Processed at SLAC (174) and RAL (173.5).
  - ~50 seconds / event
  - All files processed.

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# Full Simulation Status ILC250

- LOI\_SM\_Sample
  - ❑ Processed at SLAC.
  - ❑ ~20 seconds / event
  - ❑ All files processed.
- LOI\_higgs
  - ❑ Processed at SLAC.
  - ❑ ~25 seconds / event
  - ❑ All files processed.

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# Event Reconstruction

- Using org.lcsim production release 1.4.
- Reconstruction strictly defined as creation of “primitive” ReconstructedParticle objects, viz.
- Full track finding.
  - see talk by [R. Partridge](#).
- Full Calorimeter analysis and track-cluster association.
  - see talks by [R. Cassell](#), [M. Charles](#) & [T. Kim](#).
- Jet-finding, flavor-tagging, mass fitting, etc. will be done as part of analysis.
  - See talk by [T. Barklow](#).

# Reconstruction Status ILC500

- LOI\_SM\_Sample
  - Processed primarily at FNAL on the Fermigrid system.
  - ~10 seconds / event
  - All files processed.
- LOI\_tautau
  - Processed at SLAC.
  - ~5 seconds / event
  - All files processed.
- LOI\_sixfermion\_ (m<sub>top</sub>173.5, m<sub>top</sub>174.0)
  - Processed at SLAC and RAL.
  - ~60 seconds / event
  - All files processed.

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# Reconstruction Status ILC250

- LOI\_SM\_Sample
  - ❑ Processed at SLAC.
  - ❑ ~8 seconds / event
  - ❑ All files processed.
- LOI\_higgs
  - ❑ Processed at SLAC.
  - ❑ ~20 seconds / event
  - ❑ All files processed.

# Benchmarking Sim & Reco Summary\*

Process	Gen	Sim	Reco
500_SM	7.2 M	✓	✓
500_top	2.2 M	✓	✓
500_tau	3.2 M	✓	✓
500_SUSY	-**	✗	✗
500_bckgrnd	~700 k	✓	✓
500_pairs	1500	✗***	✗
250_SM	7.9 M	✓	✓
250_higgs	~250 k	✓	✓

\* Have not completed QA for all events/files to account for crashes, etc.

\*\* Most whizard events have been generated, awaiting mixing.

\*\*\* Will use different field map to accurately track far-forward particles.

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# Sim & Reco Summary

- The detector design, simulation and reconstruction versions are frozen for the LOI.
  - sid02, slic v2r5p3, org.lcsim v1.4
- Many millions of single particle and diagnostic physics signals available.
- Over 20 million benchmark physics events generated, simulated and passed through the reconstruction.
- The data samples described here represent the starting point for the subdetector performance characterization and the physics benchmarking.
  - Much work remains to be done.

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# Acknowledgements

- Would like to acknowledge the time and effort contributed by the developers in making this possible.
  - Thanks and farewell to Mat Charles.
- Thanks to SLAC SCCS, FNAL FermiGrid and RAL for providing computing resources to-date.
- Identified additional resources in the UK (Tier 1 allocation) and France to support analyses.

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# Backup

# Whizard SM Sample

- Generate an inclusive set of MC events with all SM processes.
- WHIZARD Monte Carlo used to generate all 0,2,4,6-fermion and t quark dominated 8-fermion processes.
- 100%  $e^-$  and  $e^+$  polarization used in generation. Arbitrary electron, positron polarization simulated by properly combining data sets.
- Fully fragmented MC data sets are produced. PYTHIA is used for final state QED & QCD parton showering, fragmentation, particle decay.
- **Events are weighted!**

# Standard Model Sample

- Full  $2ab^{-1}$  SM sample available via ftp from SLAC.
- Each file corresponds to a particular initial  $e^-/e^+$  polarization and final state.
  - cumbersome to work with for end user
    - Have to mix polarizations by hand
    - Each file contains only processes of one type, so need to run over complete data set (thousands of files) to get faithful subset.
- $500\text{ fb}^{-1}$  sample of these events generated with 80%  $e^-$ , 30%  $e^+$  polarizations, randomly mixed events from all processes.
  - Roughly 400 million events