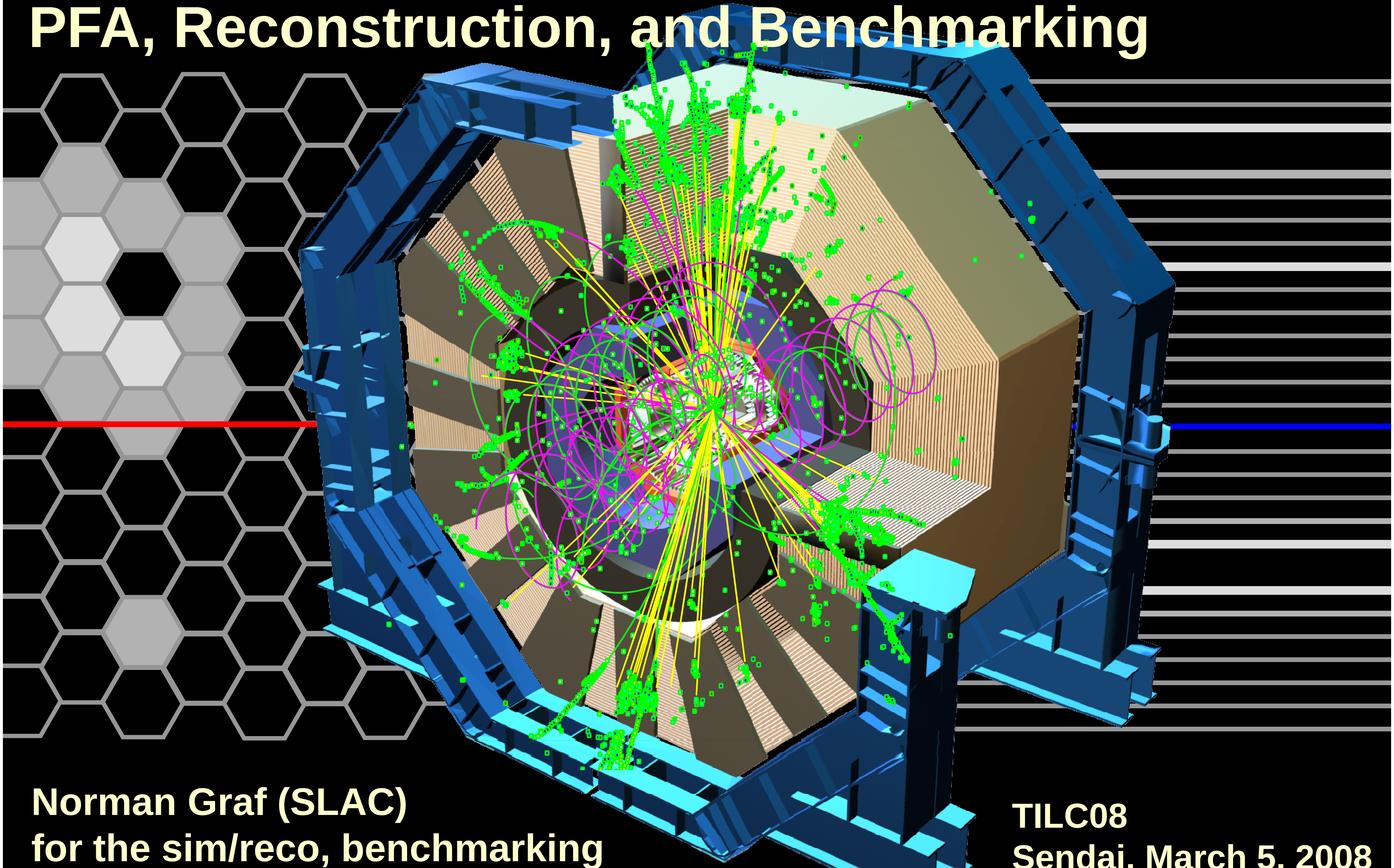
Simulating the Silicon Detector

PFA, Reconstruction, and Benchmarking



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Goals

- Study the physics performance of the silicon detector, particularly the benchmark channels
- Optimize the detector design quantitatively
- Make informed, rational technology choices
- To do these with confidence, we need:
  - Highly efficient, excellent resolution tracking
  - A robust, high-performance PFA
  - Physics analyses

Benchmarking Processes

- Compulsory and additional processes will allow to benchmark subsystems
  - Vertexing
  - Tracking
  - EM and HAD Calorimetry
  - Muon system
  - Forward system
- and to compare SiD to other concepts

Benchmarking Plans, Andrei Nomerotski, 30 Jan 2008

1. $e^+e^- \to Zh, \to \ell^+\ell^- X$, $l = e, \mu$; $m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV	SLAC
2. $e^+e^- \to Zh$, $Z \to q\bar{q}, \nu\bar{\nu}$; $h \to c\bar{c}, \mu^+\mu^-$; $m_h = 120$ GeV at $\sqrt{s}$=0.25 TeV	Michigan/Bristol ?
3. $e^+e^- \to \tau^+\tau^-$, at $\sqrt{s}$=0.5 TeV	Texas A&M ?
4. $e^+e^- \to t\bar{t}$ at $\sqrt{s}$=0.5 TeV	RAL/Oxford
5. $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- / \tilde{\chi}_2^0\tilde{\chi}_2^0 \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ / $ZZ\tilde{\chi}_1^0\tilde{\chi}_1^0$ at $\sqrt{s}$=0.5 TeV	SLAC
6. $e^+e^- \to c\bar{c}, b\bar{b}$, at $\sqrt{s}$=0.5 TeV;	Oxford
7. $e^+e^- \to Zhh$, $m_h = 120$ GeV at $\sqrt{s}$=0.5 TeV;	Oxford
8. $e^+e^- \to \tilde{\tau}_1\tilde{\tau}_1$, at Point 3 at $\sqrt{s}$=0.5 TeV;	Texas A&M/Colorado ? /Montenegro
9. $e^+e^- \to \tilde{t}_1\tilde{t}_1^* \to c\bar{c}\tilde{\chi}_1^0\tilde{\chi}_1^0$, $m_{\tilde{t}_1} = 120$ GeV, $m_{\tilde{\chi}_1^0} = 100$ GeV, at $\sqrt{s}$=0.5 TeV	Lancaster
10. $e^+e^- \to \tilde{b}_1\tilde{b}_1^* \to b\bar{b}\tilde{\chi}_1^0\tilde{\chi}_1^0$, at $\sqrt{s}$=0.5 TeV	Oxford/Montenegro
11. $e^+e^- \to \mu^+\mu^-$, at $\sqrt{s}$=0.5 TeV	SLAC
12. H→ γγ	RAL

Tools for Benchmarking

Java based lcsim.org framework

- lcsim.org FastMC
  - Smeared MC informaiton
- lcsim.org full MC: SLIC
  - GEANT based
- Perfect PFA

- Vertexing / Flavour tagging : LCFI package

- Track reconstruction and Full PFA
  - Many pieces in place, need to be brought together into production reconstruction, optimized, and applied to subdetector optimization.

Analysis Model

- Use FastMC to develop analysis algorithms
- Use full MC and Perfect PFA as intermediate step to develop a realistic analysis

- Use realistic tracking and full PFA for the analysis when ready
  - A drop-in replacement of algorithms

What does Perfect PFA do?

- Tracking
  - Define “trackable” charged particles
  - Smear as in FastMC
  - Full material effects (interactions and decays) before the calorimeter are taken into account in deciding which particles are actually tracked
- Neutrals
  - For all “non-trackable” particles, assign energy deposits in the calorimeters
  - Do neutral particle reconstruction using those deposits using perfect pattern recognition (no confusion term)
  - Use actual detector responses for energy and direction - so most of the nasty nonlinear, nongaussian effects are included

List of existing SiD full PFAs

- Steve Magill: Track following + E/p clustering
- Mat Charles: NonTrivialPFA & ReclusterDTree
- Lei Xia: Density-based clustering.
- NIU/NICADD group: Directed tree clustering

Interaction with other frameworks

- Can also study silicon detector variants using other simulation and reconstruction frameworks.
- Use Mokka to simulate a “SiD-ish” detector, analyze using PandoraPFA.
- See talk by Marcel Stanitzki in the sim/reco session.

Processes for PFA Development

e+e- -> ZZ -> qq + νν @ 500 GeV

- Development of PFAs on ~120 GeV jets – most common ILC jets
- Unambiguous dijet mass allows PFA performance to be evaluated w/o jet combination confusion
- PFA performance at constant mass, different jet E (compare to ZPole)
- dE/E, dθ/θ -> dM/M characterization with jet E

2 jets

e+e- -> ZZ -> qqqq @ 500 GeV

- 4 jets - same jet E, but filling more of detector
- Same PFA performance as above?
- Use for detector parameter evaluations (B-field, IR, granularity, etc.)

4 jets

6 jets

e+e- -> tt @ 500 GeV

- Lower E jets, but 6 – fuller detector

e+e- -> qq @ 500 GeV

- 250 GeV jets – challenge for PFA, not physics

Detector Variants & Event Samples

- A number of variants of the silicon detector have been implemented, varying:
  - ECal inner radius
  - HCal absorber (Fe, W, Cu, Pb), readout (Scint, RPC)
  - BField (5, 4, 3T)
- Response to the canonical event samples has been simulated
- Detector optimization studies could commence immediately.

How to contribute?

- Join the track reconstruction effort.
  - The forward region in particular.
- Join the particle flow effort
  - Templated analysis framework means you can work on individual aspects of the reconstruction
    - muons
    - photons
    - charged hadron shower/track association
    - neutral hadron shower identification
- Join the benchmarking effort
  - Fast MC, and PerfectPFA allow analyses to be developed now, with seamless inclusion of full reconstruction results when they become available.