b/c Separation and Tau Tagging, Charged Particle Momentum Measurements, V0 Reconstruction, and Identification of Stable Charged Particles

Tomáš Laštovička, University of Oxford

2009 Linear Collider Workshop of the Americas

Albuquerque, NM

Presentations and Speakers

- ZHH analysis with ILD *(Yosuke Takubo)*
- ZH → ννH with ILD *(Kohei Yoshida)*
- Tau-pair analysis in the ILD detector *(Taikan Suehara)*
- SiD benchmarking analyses with b/c tagging *(Tomáš Laštovička)*

- Lepton jets at High Energy Colliders *(Liantao Wang)*
- Studies for the SiD Letter of Intent, H → μμ *(Jan Strube)*
- Studies for the ILD Letter of Intent *(Hengne Li)*
- Stable Charged Particle Identification Signatures *(John Hauptman)*
- Momentum Precision and Non-Prompt Track Reconstruction in SiD *(Bruce Schumm)*

FLAVOUR TAG ANALYSES

Higgs Branching Ratios

- Summary given by Yosuke Takubo on yesterday's plenary.
  - Higgs branching ratio is proportional to particle masses.
  - Essential to confirm Higgs mechanism experimentally.
  - Results have substantially changed since LoI (analysis improvement/debugging/…)

LOI

	ILD	SiD
• $ZH \rightarrow \nu\nu cc$:	13.8%	10.3%
• $ZH \rightarrow qqcc$:	30.0%	5.8%
• $ZH \rightarrow llcc$:	28.0%	
• $ZH \rightarrow qq\mu\mu$:		1.1σ

ALCPG09

	ILD	SiD
• $ZH \rightarrow \nu\nu cc$:	13.8%	11.6%
• $ZH \rightarrow qqcc$:	16.6%	8.8%
• $ZH \rightarrow llcc$:	20.8%	
• $ZH \rightarrow qq\mu\mu$:		1.1σ

Higgs Branching Ratios

- ILD/SiD results consistent for ZH → vvcC .
- There is a factor of two difference in ZH → qQcC
  - Still to be understood.
  - It was a factor of 5 in LoIs…
  - ILD: significant improvement due to better cuts
  - SiD: code and calculation fixes

Top Mass and Asymmetry Measurements

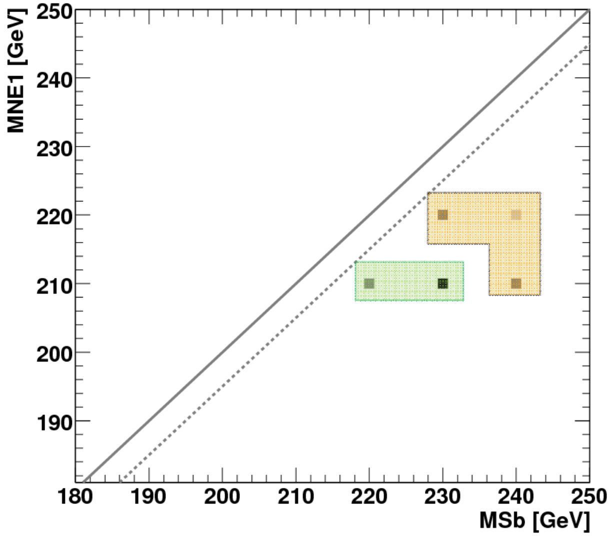
- Assuming $\sqrt{s}$ = 500GeV and 500 fb^{-1} luminosity:

	$\Delta M_t\,(MeV)$	$\Delta\sigma_{t\bar{t}}\,/\,\sigma_{t\bar{t}}$	$\Delta A_{FB}(t\bar{t})$
4th	59	–	–
ILD	40	0.0040	0.008
SiD	45	0.0045	0.008

- Cross section: ~0.4 – 0.5% (statistical precision)
- Asymmetry addressed by both ILD/SiD
  – Quark charge measurement studied in detail in the SiD collaboration.
  – Precision of about 0.008 reached for A_{fb}

Sbottom Production at the ILC

- Cosmology motivated scenario.
  - virtually impossible for the LHC.
- Very challenging measurement:
  - Due to very soft jets tagging/jet finding breaks down.
  - Large two-photon and γe background.
  - Studied by SiD in 5 mass-points in (M_{sb},M_{ne}) space.
- This measurement is @
  - 95% confidence level for all studied points
  - >4 std deviations for the “bulk part” (green)



Tau Pair Analyses

- Decay modes of 250 GeV tau leptons can be identified with efficiencies and purities in the 90% range.

		ILD			SiD	
Mode		Eff	Purity		Eff	Purity
$e\nu\nu$		0.989	0.989		0.991	0.977
$\mu\nu\nu$		0.988	0.993		0.993	0.989
$\pi\nu$		0.960	0.895		0.933	0.917
$\rho\nu$		0.916	0.886		0.790	0.874
$a_1\nu$ 1-prong		0.675	0.734		0.732	0.621
$a_1\nu$ 3-prong		0.911	0.889		0.914	0.905

- Tau polarization measured with an uncertainty of 0.7%.

			$P(e^+,e^-)=(+30\%,-80\%)$			$P(e^+,e^-)=(-30\%,+80\%)$	
	$\Delta\sigma_{\tau\tau}/\sigma_{\tau\tau}$		$\Delta A_{FB}(\tau^+\tau^-)$	ΔP_τ		$\Delta A_{FB}(\tau^+\tau^-)$	ΔP_τ
ILD	0.0029		0.0025	0.0066		–	0.0079
SiD	0.0028		0.0015	0.0065		0.0017	0.0072

Higgs Self-coupling Analysis

- Both concepts have problems to achieve reasonable precision
  - Analyses not included in LoIs
  - Major degradation due to
    1) FSR – compared to Tesla TDR
    2) Full simulation/reconstruction/tagging

- In this respect studies for TeV LC were mentioned.
  - Namely for CLIC.

CHARGED PARTICLE MOMENTUM MEASUREMENTS, V0 RECONSTRUCTION AND IDENTIFICATION OF STABLE CHARGED PARTICLES

Stable Charged Particle Identification in 4th

- DREAM data
  - Very high efficiency and purity of track-particle identification.
  - Dual readout, both scintillation and Čerenkov fibers.
- Impressive capabilities
  - Many particle ID measurements,
  - including handles on all fundamental partons.

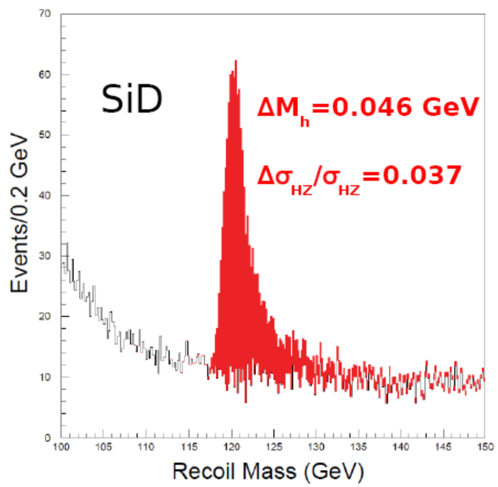
- *Leptons: e, mu, tau & neutrino (by subtraction)*
- *Quarks: uds & t → Wb (by reconstruction)*
- *Bosons: W, Z, and gamma*
- *Hadrons: pi-zero (by mass), charged pi, K, p (by dE/dx)*

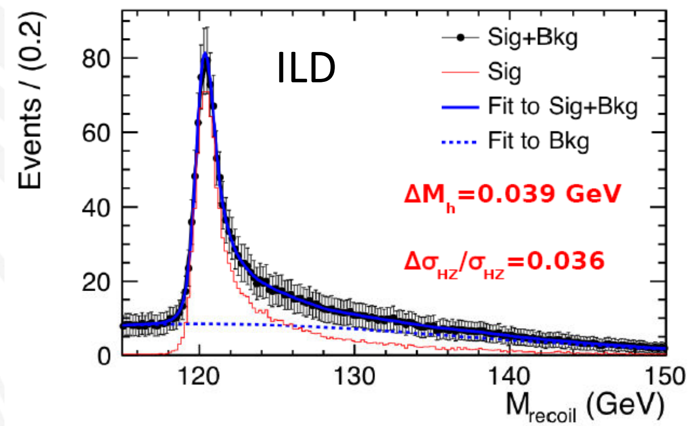
GeV Dark Sector

- Excesses in cosmic-ray electron and positron.
  - Dark matter annihilation may be a possible source of the excess...
  - ...and it can have self-interactions mediated by GeV dark sector states
- Searches for “dark photon” γ’
  - Decays into leptons, kaons, pions, …
- Lepton jets
  - Clear signature, highly collimated lepton pairs.
- Unexplored region.

Higgs Recoil Mass Measurement

- Very precise in the muon channel (less in the electron channel, bremsstrahlung)





- Bremsstrahlung recovery successfully applied.
- Higgs mass measurement sensitive to beam parameters.
- No studies of systematic errors (limited time&manpower)
  - Common for most of analyses presented…

Last but not Least

- $Z \rightarrow \nu\nu + H \rightarrow \mu^{+}\mu^{-}$
  - Despite a clear signal it is a very challenging analysis; matured since LoI.
  - Random Forest Classifier used instead of simple box cuts (SiD)

- Momentum Resolution and Non-Prompt Track Reconstruction
  - Better ILD recoil mass is not due to curvature reconstruction.
  - In terms of σ_p/p @ p_T = 100 GeV: LCDTRK (0.28%), Residuals(0.39%)
  - SiD LoI (0.33%) from single muon fits.

Summary

Impressive amount of work done to benchmark all three detector concepts.

Capabilities to perform required measurements demonstrated.

New ideas and some outstanding results presented.