ILD for the International Linear Collider

ILD Concept Group
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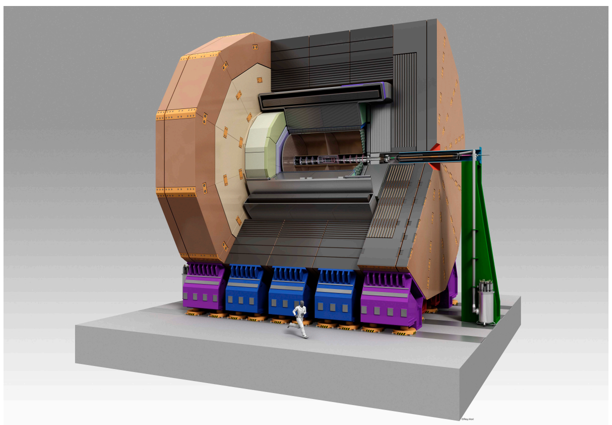


Fig. 1. Artist's view of the ILD detector.

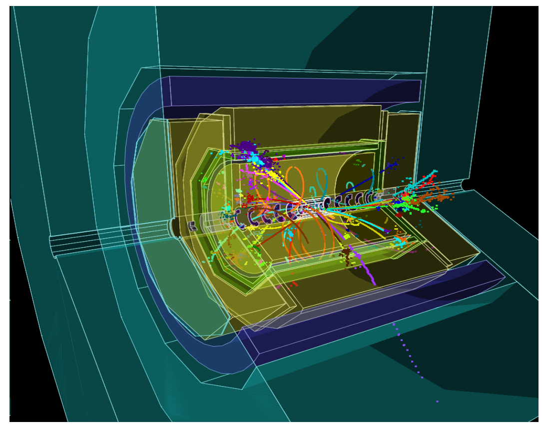


Fig. 2. Simulated $t\bar{t}$ event at 500 GeV.

I. Introduction

The International Linear Collider (ILC) is a proposed e^+e^--collider for centre-of-mass energies of 250-500 GeV with an upgrade path towards 1 TeV [1]. The Japanese High-Energy Physics community has proposed a possible site for the ILC in the Kitakami mountain range in northern Honshu. The International Large Detector (ILD) is a detector concept that has been proposed for the ILC [2], [3]. The ILD design has been optimised with a clear view on precision. It follows the paradigm of particle flow that has shown to deliver the best overall event reconstruction.

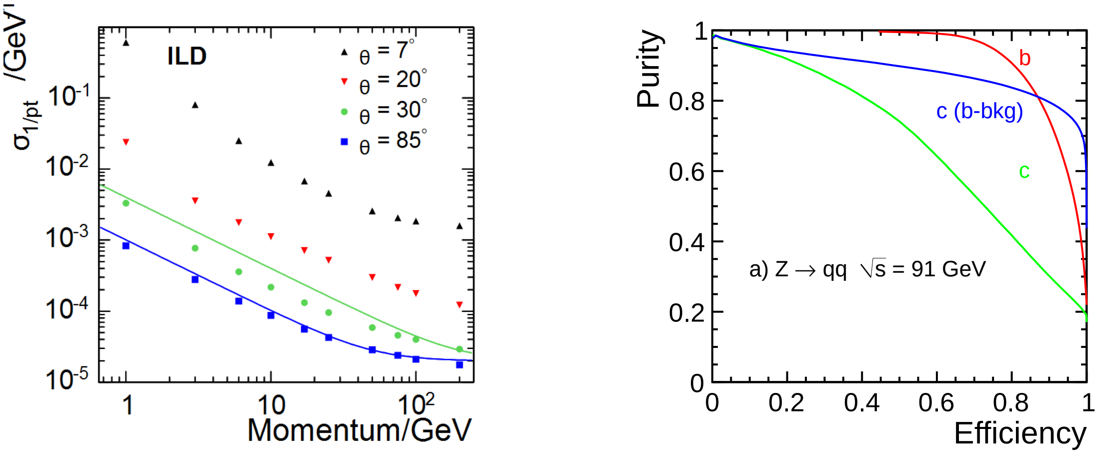
The particle flow concept foresees to reconstruct all particles in an event, charged and neutral, individually combining information from tracking and calorimetry. This requires excellent spatial resolution for all detector systems. A highly granular calorimeter system is combined with a precise and efficient tracking system that allows for excellent momentum resolution and provides identification of secondary vertices. Hermeticity of the detector down to very low polar angles (below 5 mrad) ensures large reach in searches for new phenomena. Figure 1 shows an artist's view of the ILD detector. Figure 2 shows an $t\bar{t}$ event at 500 GeV that has been simulated and reconstructed with the full ILD software chain.

II. ILD Layout and Performance

ILD has been designed as a multi-purpose detector. A high precision vertex detector is followed by a combined tracking system with silicon trackers and a time projection chamber. A highly granular calorimeter system surrounds the tracking system, dedicated forward calorimeters guarantee hermeticity to lowest polar angles. The full system is enclosed in a solenoid coil that provides a nominal magnetic field of 3.5 T and an instrumented iron return yoke.

The silicon part of the tracking system comprises a multi-layer pixel vertex detector (VTX) that aims for point resolutions below 3μm and provides excellent capabilities for the identification of secondary vertices from b and c decays. An intermediate silicon strip detector (SIT) provides additional high-precision space points. The prominent detector of the tracking system is the large Time Projection Chamber (TPC) that provides up to 224 space points per track and aims for a resolution of 100 μm along the full drift length. The TPC is optimised for minimal material in the field cage and the end-plates and allows for dE/dx based particle identification. An outer silicon tracker (SET) provides additional space points and connects the tracking system with the calorimeters. Figure 3 shows the momentum resolution and the flavour tagging performance of the ILD tracking system.

A highly segmented electromagnetic calorimeter (ECAL) with a tungsten absorber provides up to 30 samples in depth and small transverse cell sizes. Either silicon diodes or scintillator strips are considered for the sensitive areas. The also highly segmented hadronic calorimeter (HCAL) uses a steel absorber and provides up to 48 samples in depth. Two options for the sensitive areas are under study, one using scintillator tiles of 3×3 cm^2 with an analogue readout, the other using



(a) Momentum resolution.

(b) Flavour tagging performance.

Fig. 3. ILD tracking system performance.

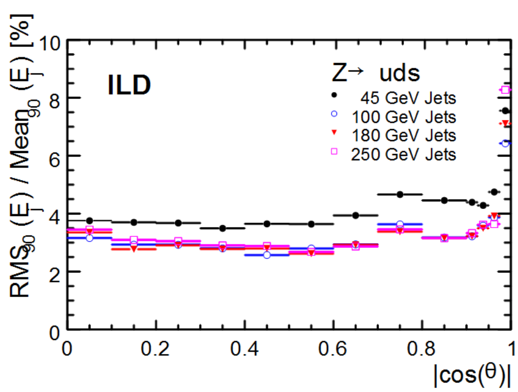


Fig. 4. Jet energy resolution achieved in ILD full detector simulations with particle flow algorithms.

a gas-based system with 1×1 cm^2 cells and a semi-digital readout. The high granularity of the calorimeter system is a pre-requisite for the application of particle flow algorithms to ILD.

III. Particle Flow Performance

The particle flow concept used for ILD is based on the philosophy to reconstruct all particles in a event, especially in multi-jet topologies, using the most precise detector element [4]. At ILC energies, typical events are hadronic final states from Z and W particles. The composition of the jets is typically so that 60% of the final state particles are charged, around 30% are photons and around 10% are neutral long lived hadrons. The charged particles are best reconstructed using the tracking system where the momentum resolution is much better than the energy resolution of the calorimeters. The theoretical best total jet energy resolution is then given by:

$$\sigma^2(E_{jet}) = \omega_{tr}\sigma_{tr}^2 + \omega_\gamma\sigma_\gamma^2 + \omega_{h^0}\sigma_{h^0}^2$$

where ω_i are the relative weights of the jet compositions for charged particles (tr), photons (γ) and neutral hadrons (h^0) and σ_i are the corresponding detector resolutions. In reality, this ideal resolution is deteriorated by many effects. The biggest ones stem from confusion, where the proper assignment of tracks and calorimeter clusters is not perfect so that contributions from charged particles are added to the neutral energies and vice versa. This is even more difficult when realistic detectors with dead zones, realistic acceptances and assumptions about resolution errors are taken into account. It is a major milestone in the detector developments for the ILC, that realistic detector simulation models that have been benchmarked with prototypes at test beam experiments have been used to develop and challenge the particle flow algorithms [5]. The ILD simulations show (Figure 4) that jet energy resolutions of $\sigma_E/E \sim 3-4\%$ at multi jet events at 500 GeV collision energies are realistic. That would be sufficient, to e.g. separate the hadronic decays from Ws and Zs.

IV. Conclusion

The International Large Detector is a proposed detector concept for the future International Linear Collider. The detector design is optimised for particle flow based reconstruction using sub-detector components of unprecedented precision. Technological prototypes of the major sub-detectors have proven the design philosophy of this advanced detector concept.

References

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