ILD for the International Linear Collider

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Abstract: The International Large Detector (ILD) is a detector concept for the International Linear Collider (ILC). Its design is optimised for particle flow calorimetry with high granularity calorimeters to perform high precision studies on Higgs and top as well as new particles and new phenomena. The overall layout, sub-detector technologies, expected performance, and recent progress of the ILD are presented.

1. International Linear Collider (ILC) [1]
- Future e+e− linear collider
  \( E_{\text{cm}}=300-500\text{GeV} \) (with upgrade path to 1TeV)
- Tuneable beam energy/polarisation
- Site candidate: Kitakami in Japan
- Two detector concepts based on particle flow calorimetry [2]
  - International Large Detector (ILD)
  - Silicon Detector (SID)

2. ILD
- Detector layout
  - Vertex detector
  - Silicon pixel
  - \( d_{\text{gap}}=5\mu\text{m} \)
  - Tracking
  - Inner and outer silicon layers
  - TPC central tracker
  - High resolution, low mass, dE/dx particle ID
  - \( o(1/pT)=2\times10^{-5} \text{ GeV}^{-1} \)
- Calorimeters
  - High granularity for particle flow calorimetry
  - Unprecedented jet energy resolution: 3-4% multi-jet events at 300GeV

3. Design Concept and Technologies
- Particle Flow Calorimetry [3,4]
  - Measurements with best suited detector depending on particle type
  - Charged particles with tracker (average energy fraction: 64%)
  - Photons with ECAL (average energy fraction: 25%)
  - Neutral hadrons with HCAL (average energy fraction: 11%)
  - Reconstruction of four-vectors of all visible particles in a jet requires
  - Highly granular calorimeters
  - High precision tracker

4. R&D Highlights
- TPC
  - Gating GEM under development to mitigate positive ion back-flow which can cause field distortion
  - Successfully tested in test beam in 2016 at DESY
  - Achieved electron transmission eff. >90% with rather small effect on resolution

- Calorimeter
  - Si-W ECAL
  - 7 layers prototype successfully tested in DESY beam
  - 20 layers in 2018
  - AHCAL
  - Large prototype with full layers (>40 layers) under construction
  - Full-size area prototype to be tested for mechanical structure study
  - SDHCAL:
    - Working with 1m² prototype already
    - Even larger prototype under construction

- New Simulation Framework
  - Recently migrated to DD4hep [5]
  - DD4hep generic detector description toolkit for high energy physics experiments
  - Hybrid simulation for HCAL
    - Two types of sensitive layers (RPC and scintillator) coexist for performance comparison with the same MC events.
    - N.B. simulation purpose only
    - Large-scale MC production this year

5. Further Optimisation of Detector Design
- Optimisation of detector design based on two geometry models
  - Large (ILD-L)
    - Same as used in previous detailed baseline design (DBD) in 2012 [2]
  - Small (ILD-S)
    - Same length, but with smaller radius and higher B field
  - Comparative studies in terms of
    - Physics performance
    - Cost

6. Summary and Outlook
- ILD is a detector concept for future linear collider ILC with excellent jet energy resolution based on FPA.
- Good progress in sub-detector R&D, development of simulation tools and physics performance studies.
- Two detector models (large and small) defined to further optimise the overall design.
- ILD moves forward to be ready for “green-light” of ILC.

References