Si Based Detectors for the ILC
Main Trends & Needs

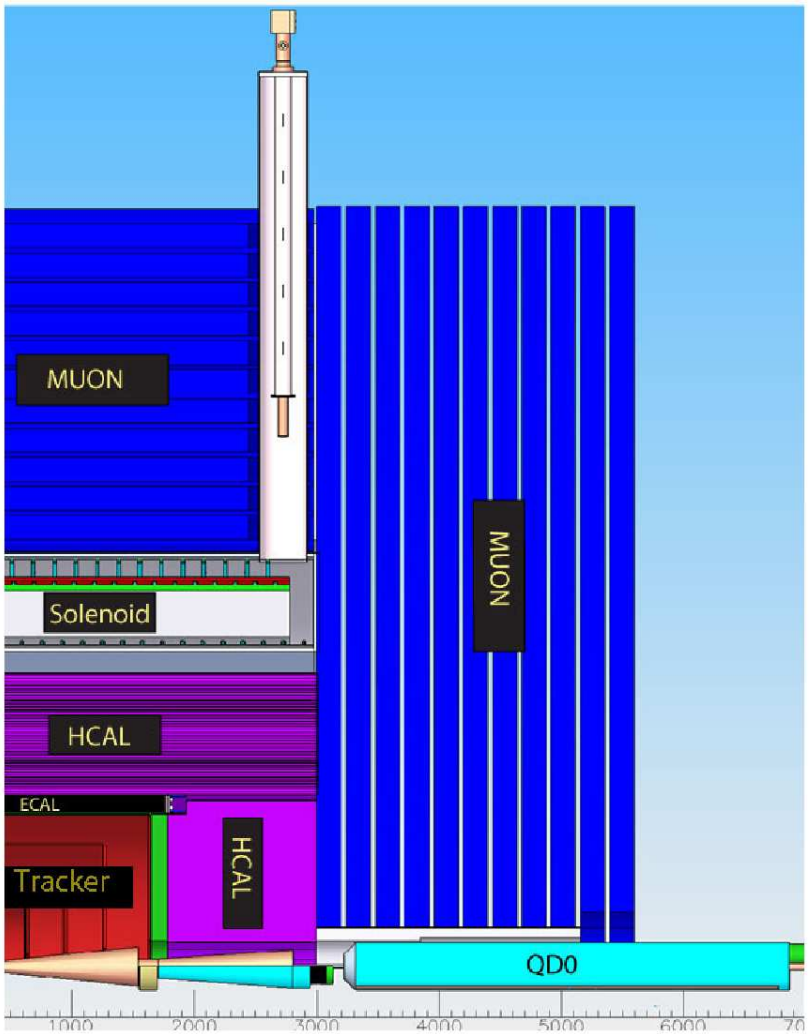
M.Winter / 29th of Novembre 2013

Outline

- *S*ub-systems using Si detectors
- *P*resent limitations & issues
- *E*volution trends & possible goals within upcoming 3-5 years
- *C*onclusions $\longmapsto$ implementation & structure ?

Use of Silicon Detectors

- VERTEX DETECTORS :
  - Flavour tagging: c-tag & jet-flavour most challenging
  - Electric charge of displaced vertices ?
  - Standalone tracking (track seed)
  - **Main limitation :** beam related background $\Rrightarrow$ σ_{sp} vs t_{ro}
- TRACKERS :
  - Soft and shallow angle (low B) particles most challenging
    - track reconstruction efficiency
    - momentum resolution
  - **Major limitation :** nb of points/track due to mat. budget/layer
- EM CALORIMETERS :
  - Jet & di-jet 4-momentum in multi-jet final states
  - Jet separation $\rightarrowtail$ granularity $\Rrightarrow$ large Nb(channels)
  - CPS based option (adaptable pixel grouping on-chip) $\rightarrowtail$ TRACAL ???
  - **Major limitation :** nb of channels & power consumption



The Central Conflict of Vertexing

- A COMPLEX SET OF INTERCORRELATED ISSUES:
  - ✳ **Charged particle sensor technology :**

    highly granular, thin, low power, swift pixel sensors
  - ✳ **Micro-electronics :**

    highly integrated, low power, SEE safe, r.o. μcircuits
  - ✳ **Electronics :**

    high data transfer bandwith (no trigger), some SEE tol.

    low mass power delivery, allowing for power cycling
  - ✳ **Mechanics :**

    rigid, ultra-light, heat but not electrical conductive, mechanical supports, possibly with $C_{\Delta t} \simeq C_{\Delta t}^{Si}$

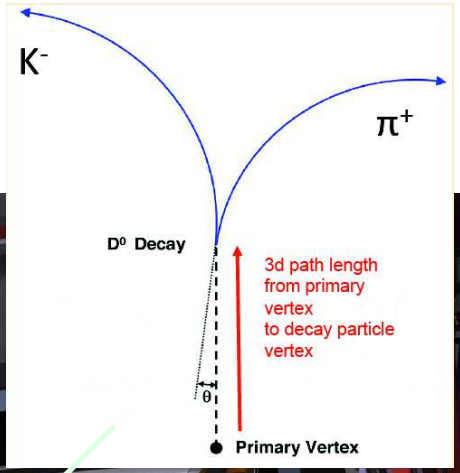
    very low mass, preferably air, cooling system

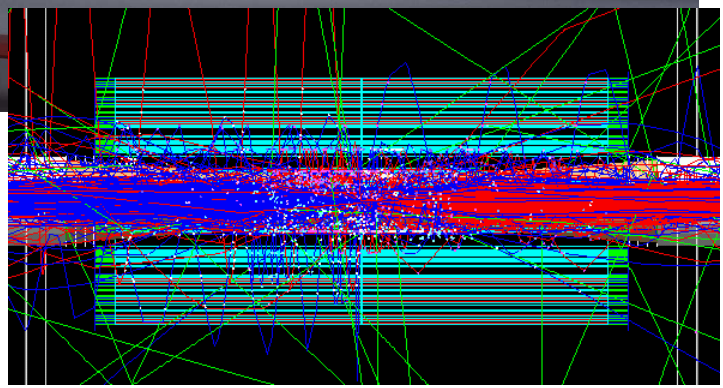
    micron level alignment capability
  - ✳ **EM compliance :**

    power cycling in high B field $\Rrightarrow$ F(Lorentz)

    higher mode beam wakefield disturbance $\Rrightarrow$ pick-up noise
  - ✳ **Radiation load and SEE compliance at T_{room}**

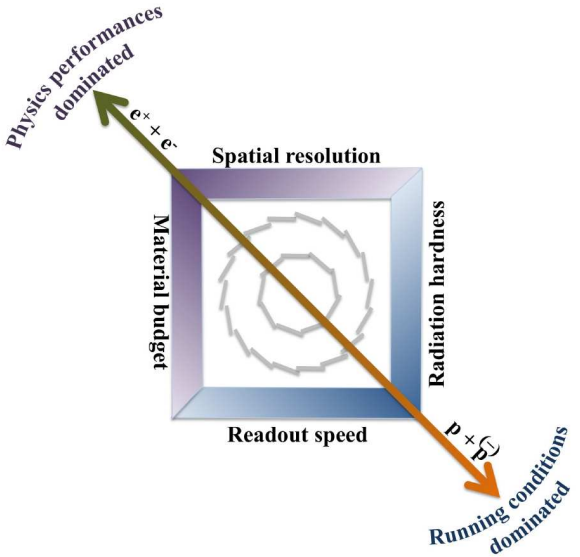
    $\Rrightarrow$ reduced material budget

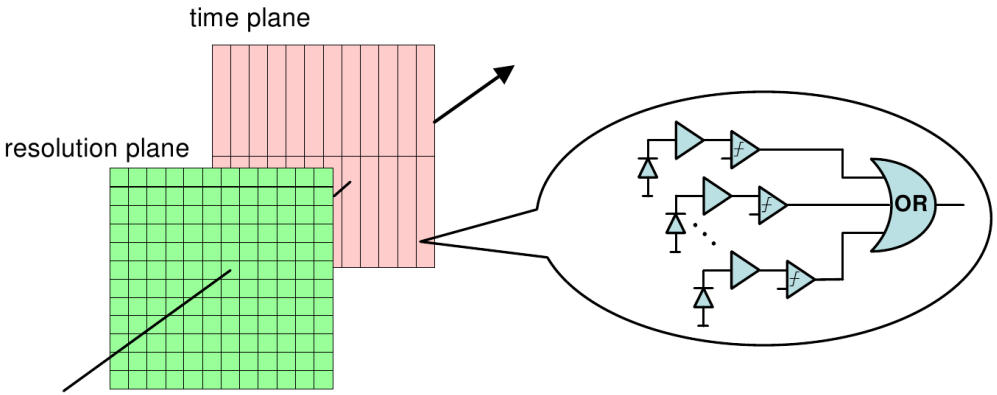


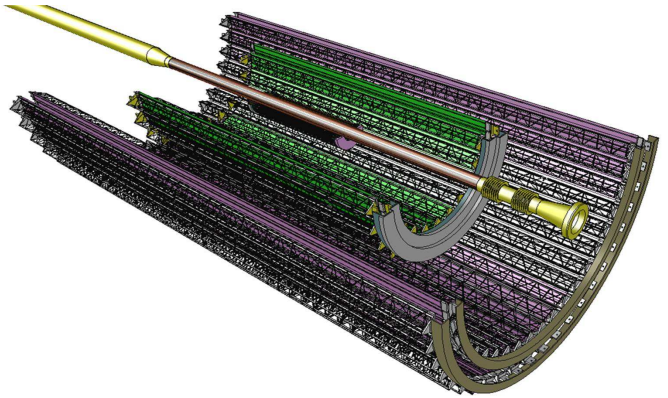


R&D on Silicon Sensors

- R&D DIRECTIONS :
  - faster (low power) high-resolution & thin pixel sensors for continuous read-o
    ⟶ bunch tagging
  - high level signal processing & transfer integrated on small pixels
    ⟶ small feature size, 3DIC, 3DIC-CPS⊕NN, ...
  - fast, coarse resolution, very low power and thin sensors
    adapted to large sensitive areas ⟶ trackers
  - large area pixel sensors : stitching, logical strips







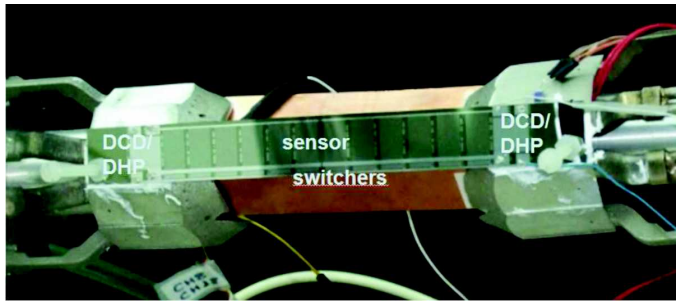
- EXISTING EXPERTISE & INTEREST (TBC)
  - **Pixel technologies :** CPS, DEPFET, 3DIC, ...
  - **Institutes concerned :** in Spain, Germany, France, others ?

R&D on Services and System Integration

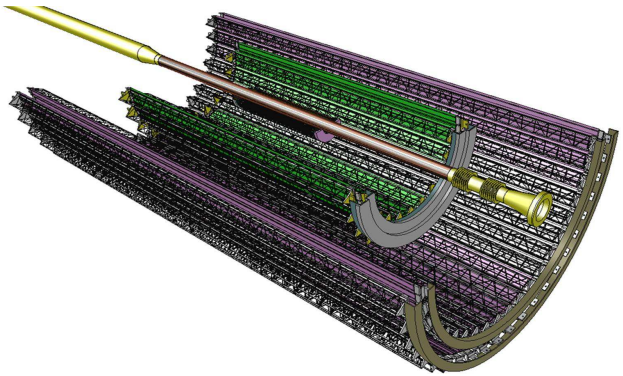
- R&D DIRECTIONS :
  - low mass, high density connections (cf LHCb, ALICE)
  - light, pulsed, power distribution
  - μ-channel cooling
  - ultra-light & fast signal transmission
  - operation of sensors in vacuum (minimise m.s.)
  - micrometric alignment algorithms and systems
  - blue tooth transmission at end of ladder
  - new materials (e.g. graphene)
    - study properties of graphene & multi-layers made of it
    - assess added value of graphene
    - find industrial sources

- EXISTING EXPERTISE & INTEREST (TBC)
  - **Services and Mechanics :**

    ↪ PLUME coll., STAR, Belle-2, ALICE, ...



Belle-2

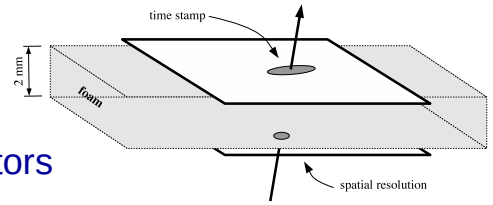


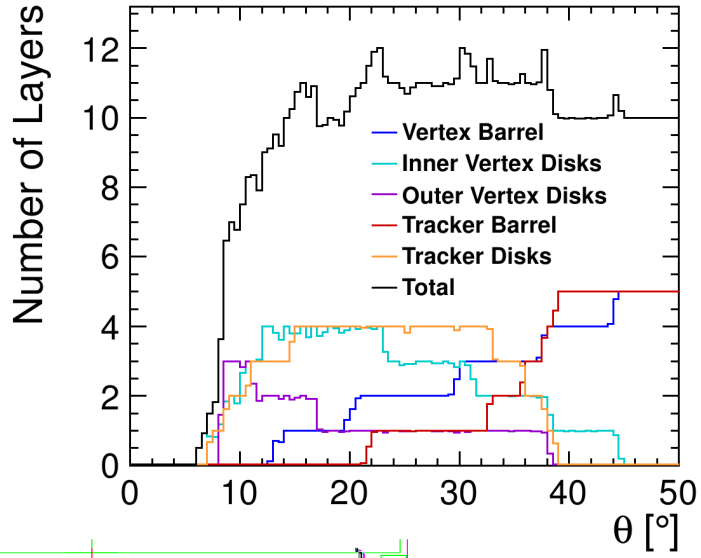
ALICE

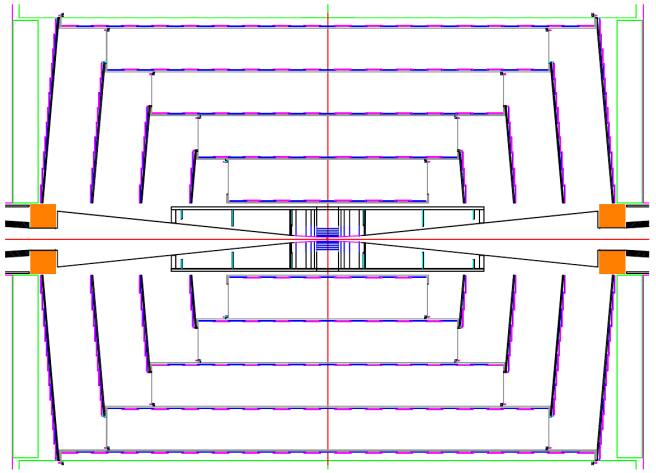
R&D on Pixelated Systems

- DOUBLE-SIDED LADDERS $\rightarrowtail$ MINI-VECTORS :
  - power cycling in high magnetic field
  - complementary optimised sensors : σ_{sp} vs t_{ro}
  - new mechanical supports : foams, graphene ?
  - integrated μ-channel cooling
  - micrometric alignment studies based on mini-vectors
  - application of 2-sided staves to large area detectors

    $\hookrightarrow$ target value O(100 m^2) $\Rightarrow$ genuine R&D



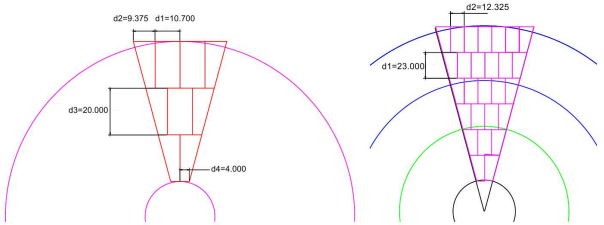




- SINGLE-SIDED LADDERS :
  - thin & flexible sensors wrapped in mylar

    $\hookrightarrow$ target value 0.1 % X_0
  - ultra-light full Si ladders (DEPFET)

- MULTI-LAYER TRACKERS :
  - Intelligent trackers
  - compact, mixed tracking-calorimetric device : TRACAL



SUMMARY

- Numerous R&D directions, strongly driven by fast evolution of industry

  (Si, μ-electronics, materials, frontier technologies)

- Wide coverage of sub-systems $\Rightarrow$ direct impact on phys. performance
  - vertex detectors, trackers, ECAL
  - (small) pixel sensors, services, thermo-mechanics

- EU community has long, appropriate, experience & test infrastructures
  - vertex detectors : CPS, DEPFET
  - trackers : μ-strip end-cap trackers $\rightarrowtail$ pixels
  - ECAL : UK labs

- Several groups active in ILC driven networks, AIDA, ...

- Next step: need to find out which R&D topics/directions are most appropriate