The RDR Companion Document

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Oxford University

http://www.linearcollider.org/rdrcompanion/

Outline

- The charge for the ‘companion document’
- The committee
- Drafting process
- Tour of the report
- Next steps

The Charge

The Reference Design Report will contain a technical description of the ILC baseline and the Detector Report the technical concepts for the detectors, as well as preliminary costing.

This companion volume is intended for a broader audience of interested outsiders, policy makers …

… an attractive and informative document.

Such a document will play an extremely important role in communicating our project plans to a broad audience that must become convinced to support our ambitions.

The Committee

- Jonathan Bagger
- Ties Behnke
- Philip Burrows
- Jinhyuk Choi
- Elizabeth Clements
- Jean-Pierre Delahaye
- Chris Damerell
- Jie Gao
- David Harris
- Rolf Heuer
- JoAnne Hewett
- Young-Kee Kim
- Joe Lykken
- Youhei Morita
- Hitoshi Murayama
- Won Namkung
- Perrine Royole-Degieux
- Nobu Toge
- Nick Walker
- Barbara Warmbein
- John Womersley

Committee representation

- The three regions
- Experimentalists / theorists
- Particle / machine physicists
- Physicists / communicators

Editorial Team

Editorial Team

Editorial Team

Grumpy old man

Up to the neck in it …

Drafting process

- 1st meeting Valencia November 22: draft outline
- Phone meeting December 14: review material
- Meeting Daresbury January 11: finalise material
- Revision and editing within committee
- Final draft 'Word' version January 31
- Draft 'laid-out' version February 1
- Reviewed by Executive Committee February 3

Drafting process

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Example of layout

The major challenges

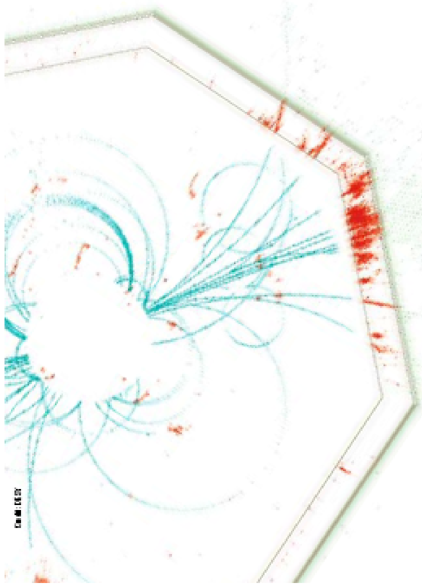
Energy

The energy scales we will probe with the ILC are far beyond anything electron-positron colliders have ever achieved. To attain the beam energy of up to 250 GeV per particle, adding up to 500 GeV per collision, would require 167 billion standard AA batteries placed end to end.

Superconducting radio-frequency technology

A charged particle can only be accelerated by an electric field. To provide the necessary acceleration we will use superconducting niobium radio-frequency (RF) cavities. The accelerating electric field is established by supplying RF energy pulses to the cavities, which are immersed in liquid helium at a temperature of -271°C. The cavities sit inside vessels surrounded by thermal shields and an outer tank – a cryostat – to insulate them from the exterior, which will be 300 degrees hotter.

As many as 8000 cavities per linac, each roughly a metre long, and placed end-to-end in cryomodules, will drive the electrons and positrons forward with an accelerating gradient of more than 30 million volts per metre. The higher this gradient, the shorter, and hence cheaper, the ILC can be made.



Luminosity

In order to make discoveries, we require large amounts of high-quality data. The more often electrons and positrons collide and annihilate, the larger the amount of interesting data that will be produced. This requires a high luminosity, or rate of collisions per cross-sectional area. The ILC requirement of luminosity in excess of 10^{34} electron-positron crossings per square centimetre per second represents a major design challenge.

We can achieve this high luminosity by cramming as many electrons and positrons as possible into the smallest beams we can make, and ensuring that the beams collide. In practice this means squeezing more than 10 billion electrons and positrons into beams roughly five nanometres tall by 500 nanometres wide, and then steering the bunches into collision using advanced feedback systems.

The particle detectors

The particle detectors will literally provide the centrepiece of the ILC. The detectors will enclose the collision point where electrons and positrons annihilate, and they will yield the clues that will allow us to unravel the Quantum Universe. Twelve metres long, high and wide to contain all components, cables and a powerful magnet, they will be as big as a three-storey building and weigh several thousand tons.

Employing state-of-the-art components, the detectors will record every collision that takes place and each particle that gets produced. Millions of electronics channels will be needed to record the precious information and ensure that nothing is missed.

Armed with this information, we will be able to reconstruct every collision and look at each such "event" to understand what happened. This analysis will allow us to find those events that contain dark matter particles, the Higgs boson, superparticles – or completely unanticipated things – and study them in great detail. We intend to use the ILC detectors to measure collisions more precisely than ever before.

The vertex detector

At the heart of the massive ILC detector system, the vertex detector, a compact tracking device about the size of a wine bottle surrounds the interaction region. Consisting of cylinders of silicon detectors, this high-tech device contains about a billion pixels in total – equivalent to hundreds of the finest digital cameras. It works just like a 3D camera or microscope because it measures the tracks of outgoing particles with micron precision. A few of the colliding particles might contain exotic heavy quarks, which live for a billionth of a second before they decay to familiar forms of matter. These quarks reveal themselves by decaying at "vertices" very near the collision point. The exotic quarks, made visible by the vertex detector, are pointers to new physics.

The 1-metre long superconducting cavities are made from pure niobium, treated and tested by scientists to ensure high-performance capabilities for accelerating particles.

Superconducting niobium cavities

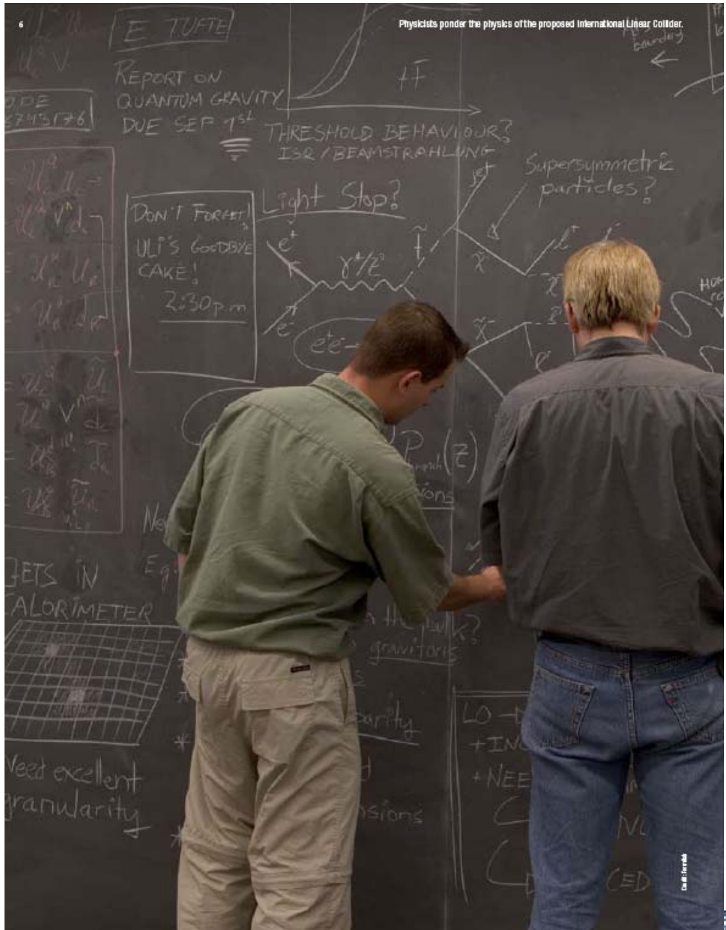
How do superconducting cavities work? A voltage generator fills each hollow structure with an electric field. The voltage of the field changes with a certain frequency: a radio frequency, or RF. Charged particles feel the force of the electric field and accelerate. Build the cavity out of superconductor, such as niobium, and chill it to near absolute zero and you have a "superconducting RF cavity." They conduct electric current with no loss of energy, which means that almost all the electrical energy goes into accelerating the beam, rather than into heating up the accelerating structures themselves.

Designing and building the optimal cavity is not simple. The 1-metre long cavities are made from nine smooth cells, polished to provide micron-level surface quality, and free of impurities. Significant surface blemishes, or dust, could cause them to lose their superconductivity without sustaining the electric field needed to accelerate particles. A series of detailed chemical treatments and processes literally make the cavities sparkle.

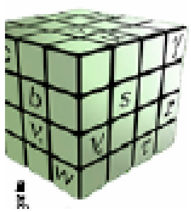
Document outline

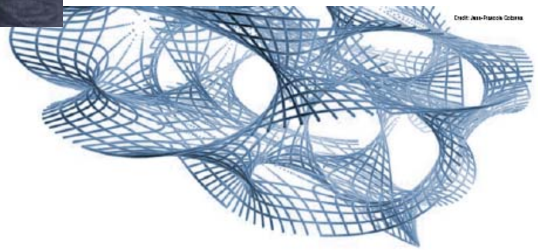
- Introduction (1 paragraph)
- The Quantum Universe (6 pages)
- ILC: The Machine for the Future (8 pages)
- A Global Project (6 pages)
- The Road Ahead (3 pages)

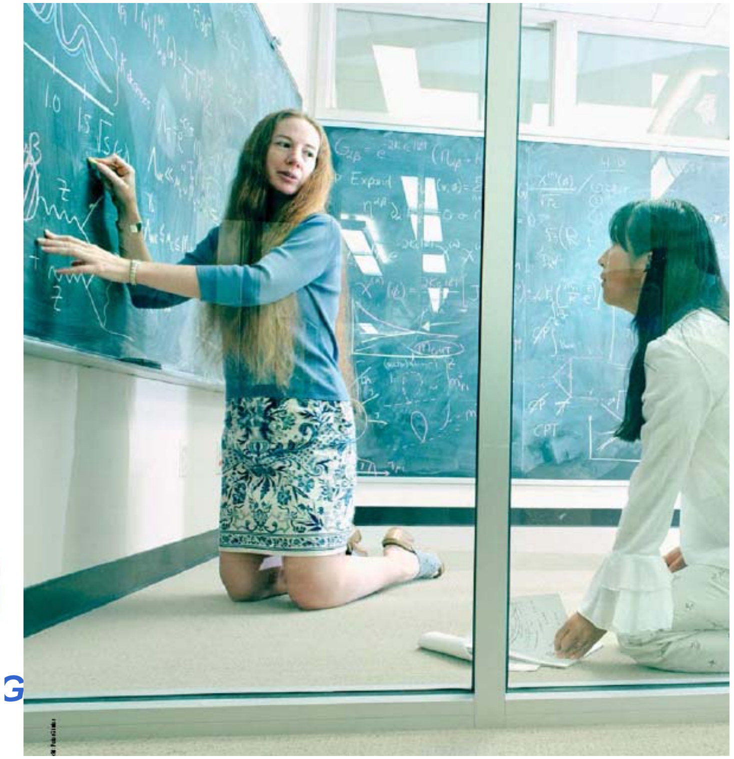
The Quantum Universe



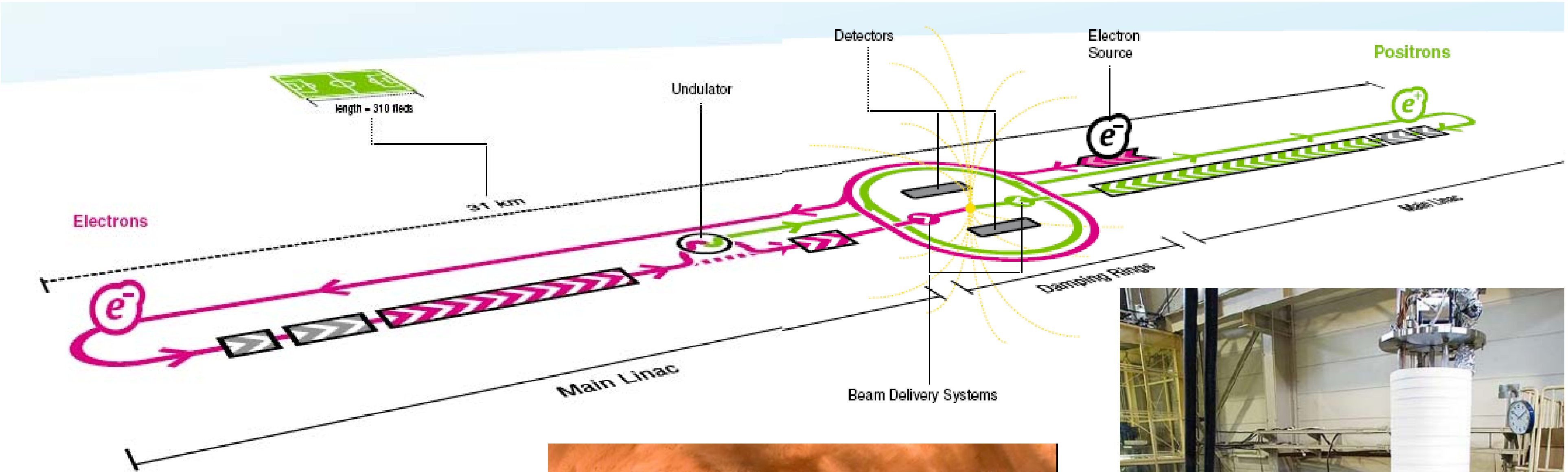
- Gateways to the Quantum Universe
- Secrets of the Terascale
- The Higgs Boson
- Revealing the Ultimate: extra dimensions
- Shedding light on dark matter
- A parallel superworld
- A telescope to the unknown







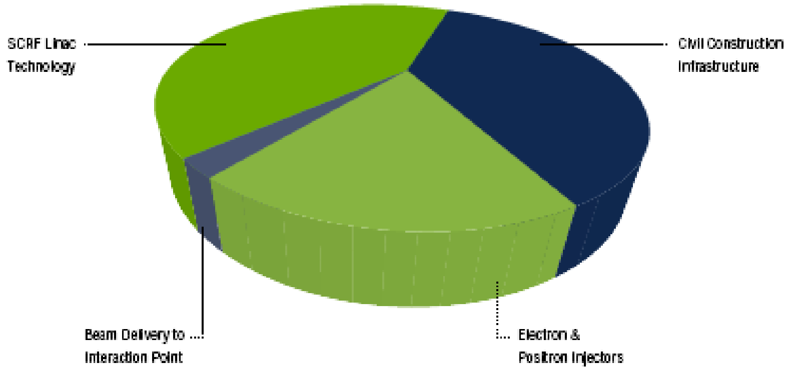
ILC: The Machine for the future

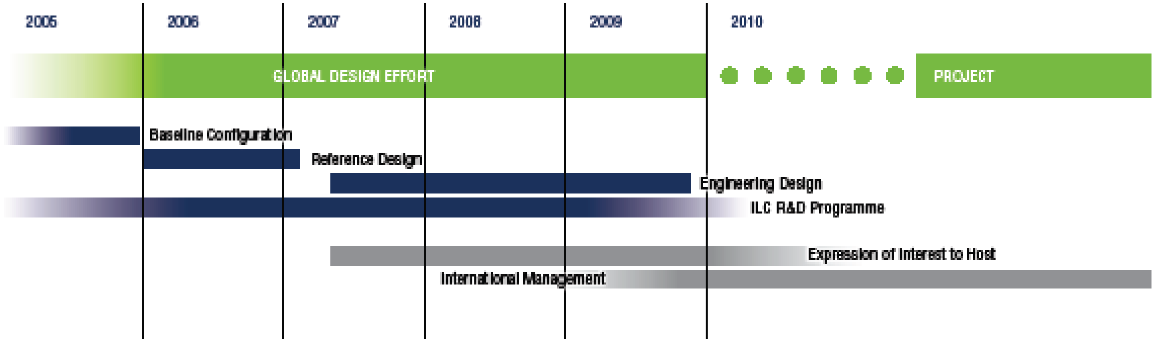


- Creating the right tool
- ILC step-by-step guide
- The major challenges:
  - Energy
  - Superconducting RF
  - Luminosity
  - The detectors

A Global Project

- Global Design Effort
- Site considerations
- Estimate for the ILC machine
- The next steps





The Road Ahead

- The ‘I’ in ILC
- Industrialisation
- Training the next generation

Feedback from Executive Committee

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- **'Awesome!' (Nick Walker)**

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- **‘there are a residual number of typos, infelicities etc - e.g. no hyphen is necessary between adverbs and adjectival nouns or adjectives - of course hyphens are optional and there is nothing to stop one inserting hyphens all over the shop but in my view they should be limited to where they are necessary.’ (Brian Foster)**

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  ‘Google gives the frequency of "electron volt" as 3 times that of electronvolt and that is certainly an underestimate as a lot of the "electronvolt" references are website etc names...’

Caveats

- **Document is far from perfect – never will be**
- **n physicists --> n**2 opinions**
- **Balance presentation taking regional concerns into account**
- **Some compromises were made in order to make ideas clear and simple**
- **In order to meet schedule not all comments addressed**
- **The document is a DRAFT, like RDR, and will be revised**

Thanks

- **Document put together in 2 months!**
- **Many contributors heavily committed to other ILC work**
- **Input from other community members**
- **This is OUR document:**

please read it and send us your input!

Next Steps

- Draft document formally released tomorrow
- Hard copies available for ILCSC and the press
- pdf file available on www

    http://www.linearcollider.org/rdrcompanion/

- We will collect comments + suggestions
- There will be a revised version:

    improve layout, better graphics, images …

  to come out along with the final RDR + DCR