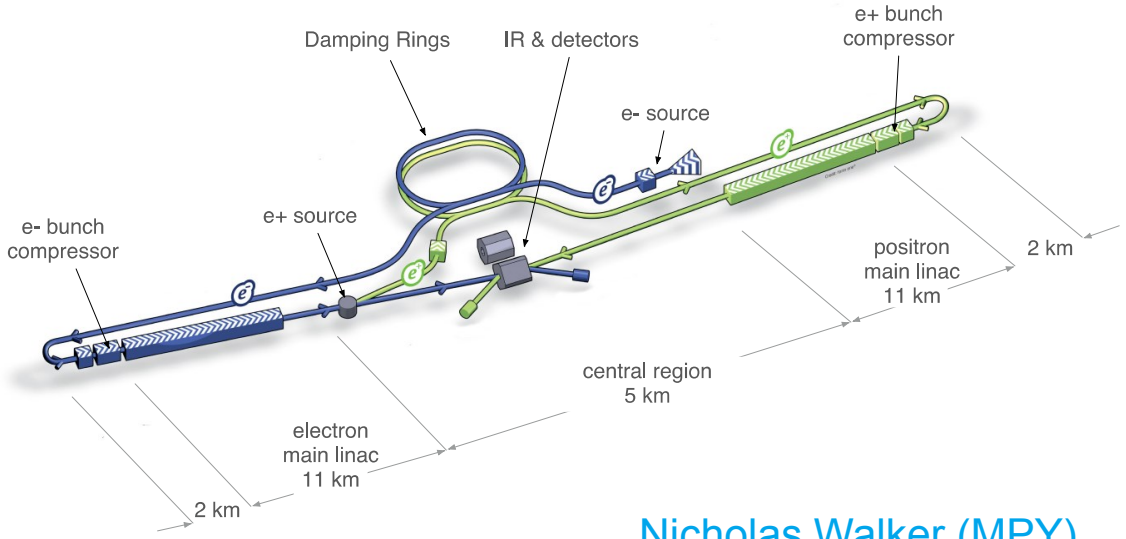
Status and prospects for the International Linear Collider



Nicholas Walker (MPY)

263rd Meeting of the WA

20.08.2013

HELMHOLTZ ASSOCIATION

DESY

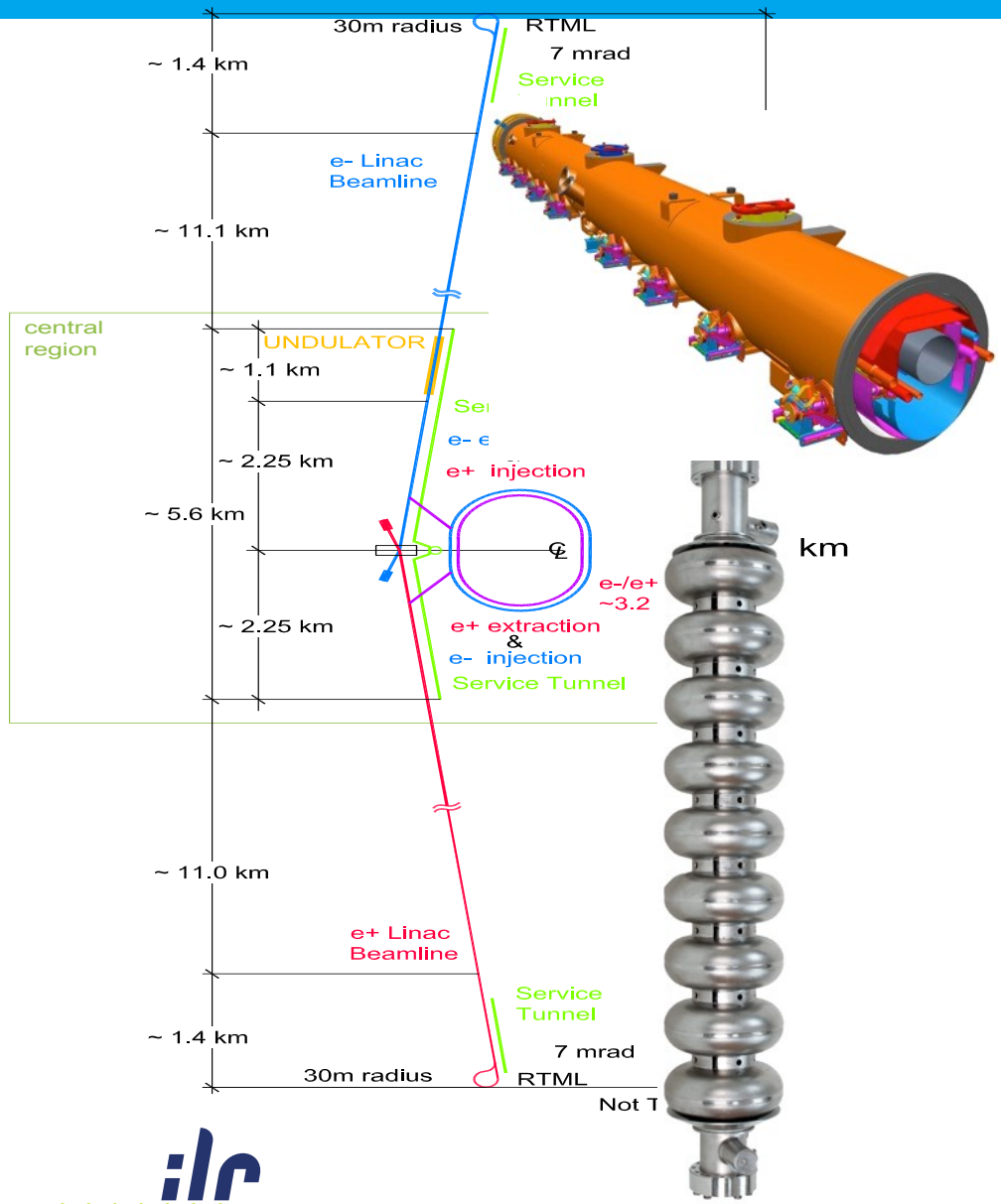
Introduction

- This talk will focus on the ILC machine status, and the situation in Japan.

- Discovery of a light Higgs particle @126 GeV by LHC changed the world physics landscape
  - Japan was waiting for this “signal”
  - EU strategy welcomes ILC in Japan
  - US Snowmass process endorsed ILC in Japan

- I will not discuss physics or detectors
  - Although DESY’s leadership role in these areas is undisputed.

ILC in a Nutshell



- 200-500 GeV E_{cm} e^+e^- collider
  $L \sim 2\times10^{34}\ cm^{-2}s^{-1}$
  - upgrade: ~1 TeV
- SCRF Technology
  - 1.3GHz SCRF with 31.5 MV/m
  - 17,000 cavities
  - 1,700 cryomodules
  - 2×11 km linacs
- Developed as a truly global collaboration
  - **G**lobal **D**esign **E**ffort – **GDE**
  - ~130 institutes
  - http://www.linearcollider.org/ILC

500 GeV Parameters

Physics	Max. E_{cm}	500 GeV
	Luminosity	1.8×10^{34} cm^{-2}s^{-1}
	Polarisation (e-/e+)	80% / 30%
	δ_{BS}	4.5%
Beam (interaction point)	σ_x / σ_y	574 nm / 6 nm
	σ_z	300 μm
	$\gamma\varepsilon_x$ / $\gamma\varepsilon_y$	10 μm / 35 nm
	β_x / β_y	11 mm / 0.48 mm
	bunch charge	2×10^{10}
RF (linac structure)	Number of bunches / pulse	1312
	Bunch spacing	554 ns
	Pulse current	5.8 mA
	Beam pulse length	727 μs
	Pulse repetition rate	5 Hz
Accelerator (general)	Average beam power	10.5 MW (total)
	Total AC power	163 MW
	(linacs AC power	107 MW)

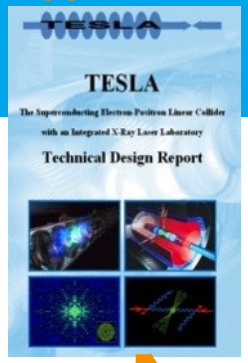
tiny emittances
nano-beams at IP
strong beam-beam

High-power high-current beams.
Long bunch trains.
→ SCRF

ILC History

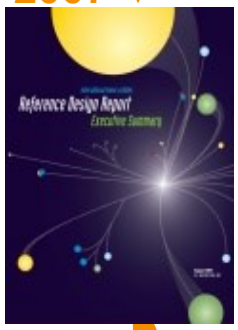
- Pre Global Design Effort
  - 1992 TESLA starts (TTF)
  - 2002 BMBF XFEL decision
  - 2004 ITRP decision
  - 2009 XFEL construction begins
- Since 2005: GDE
  - 2005-2007 Reference Design Report and cost estimate
  - 2008-2012 Technical Design Phase
  - 2012 Technical Design Report and updated cost estimate
- **2013…**
  Linear Collider Collaboration (LCC) and towards Project Realisation (in Japan)

2001

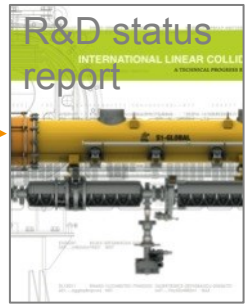


2006

2007



2011



2013

GDE Timeline

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014

LHC physics

GDE

Reference Design Report (RDR)

LCC

Tech. Design Phase (TDP) 1

TDP 2

TDR published

~250 FTE per year (avg)

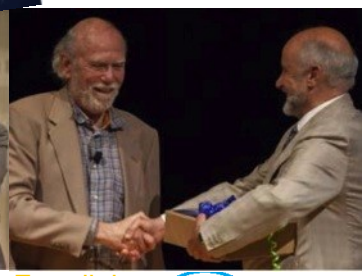
~2,000 MY (→ ~5,000 if pre-GDE included)

~300 M$ globally

Global Event
June 12

Tokyo

CERN



Fermilab

ILC TDR: 2,400 signatories worldwide

Three Projects – One Technology

TESLA Technology

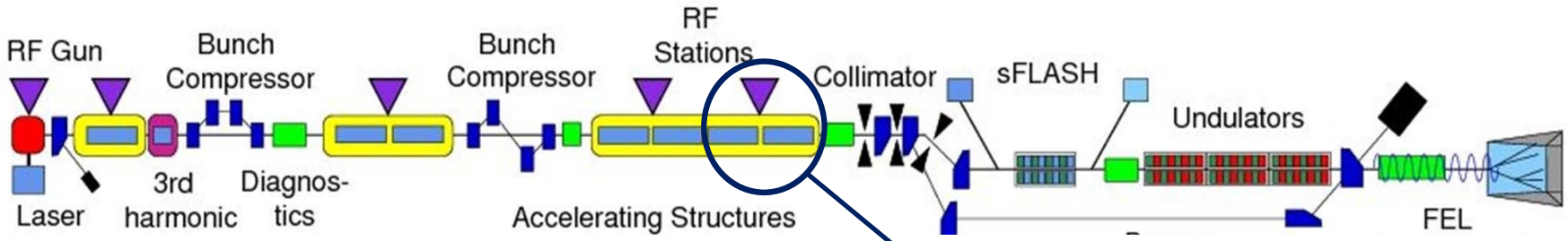
European XFEL

FLASH
Free-electron laser FLASH

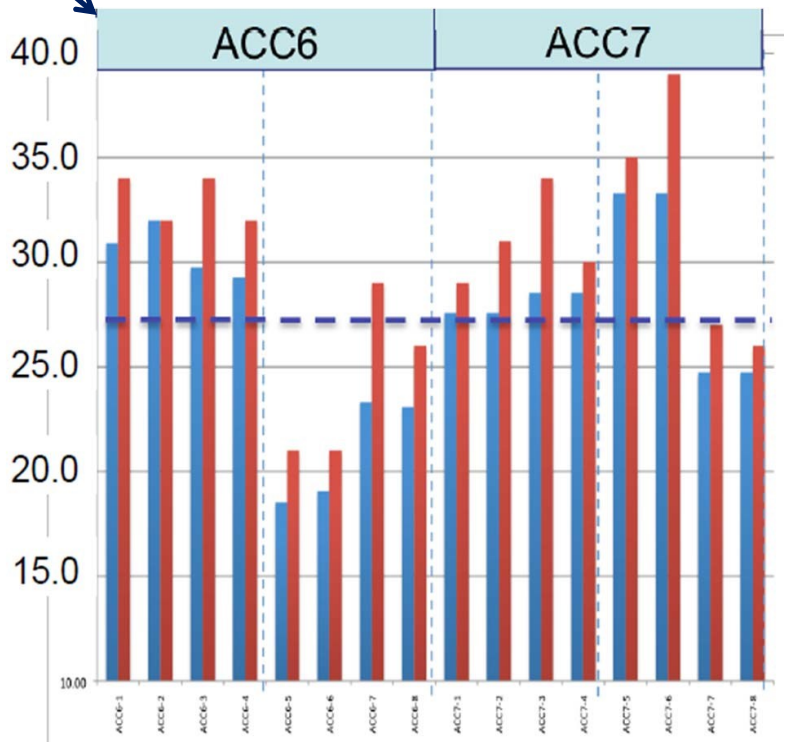
ILC

DESY is **THE world-leading centre** for this technology

FLASH@DESY 9mA Experiment



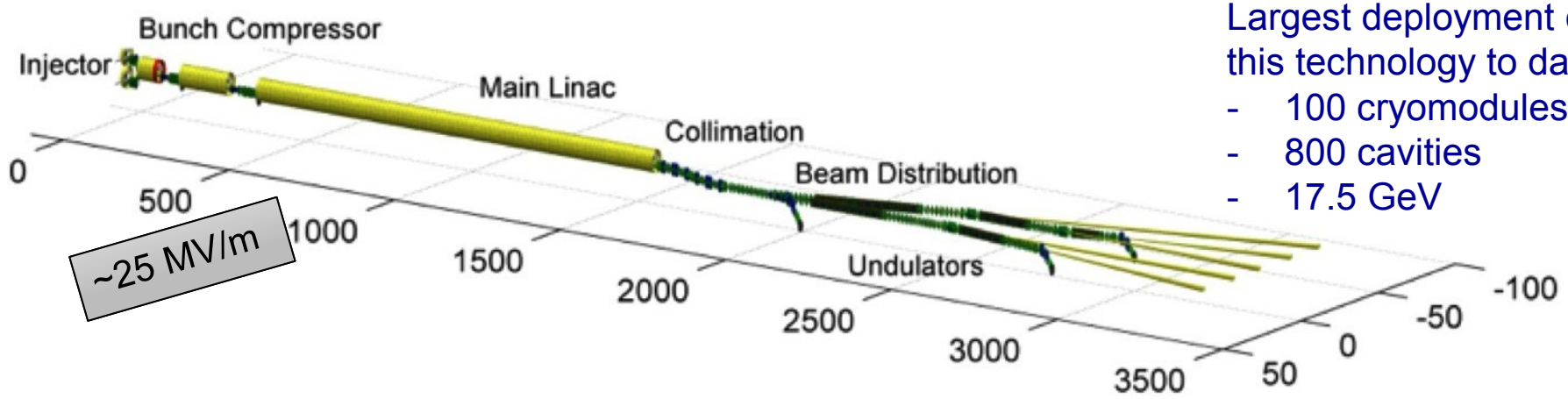
		XFEL	ILC (upg.)	FLASH design	9mA studies
Bunch charge	nC	1	3.2	1	3
# bunches		3250	2625	7200*	2400
Pulse length	μs	650	970	800	800
Current	mA	5	9	9	9



Many basic demonstrations:
- heavy beam loading with long bunch trains
- operation close to quench limits
- klystron overhead etc.

Development (LLRF & controls):
- tuning algorithms
- automation
- quench protection etc.

European XFEL @ DESY

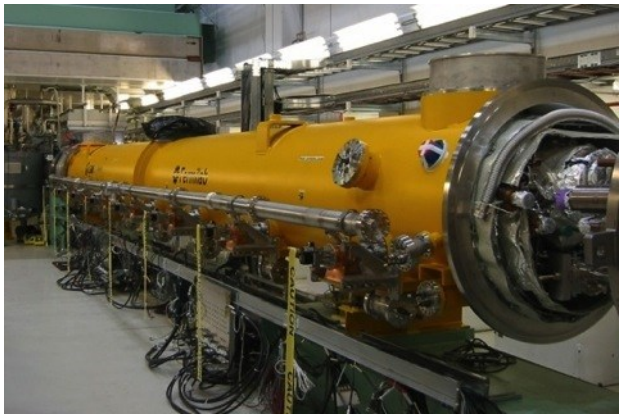


Largest deployment of this technology to date
- 100 cryomodules
- 800 cavities
- 17.5 GeV

Institute	Component Task
CEA Saclay / IRFU, France	Cavity string and module assembly; cold beam position monitors
CNRS / LAL Orsay, France	RF main input coupler incl. RF conditioning
DESY, Germany	Cavities & cryostats; contributions to string & module assembly; coupler interlock; frequency tuner; cold-vacuum system; integration of superconducting magnets; cold beam-position monitors
INFN Milano, Italy	Cavities & cryostats
Soltan Inst., Poland	Higher-order-mode coupler & absorber
CIEMAT, Spain	Superconducting magnets
IFJ PAN Cracow, Poland	RF cavity and cryomodule testing
BINP, Russia	Cold vacuum components

The ultimate '**integrated systems test**' for ILC.

Worldwide Cryomodule Development



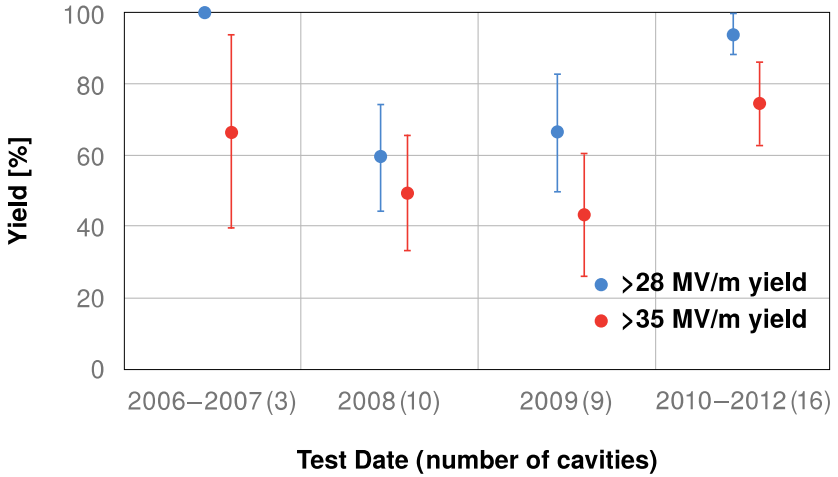
CM1 at FNAL NML module test facility

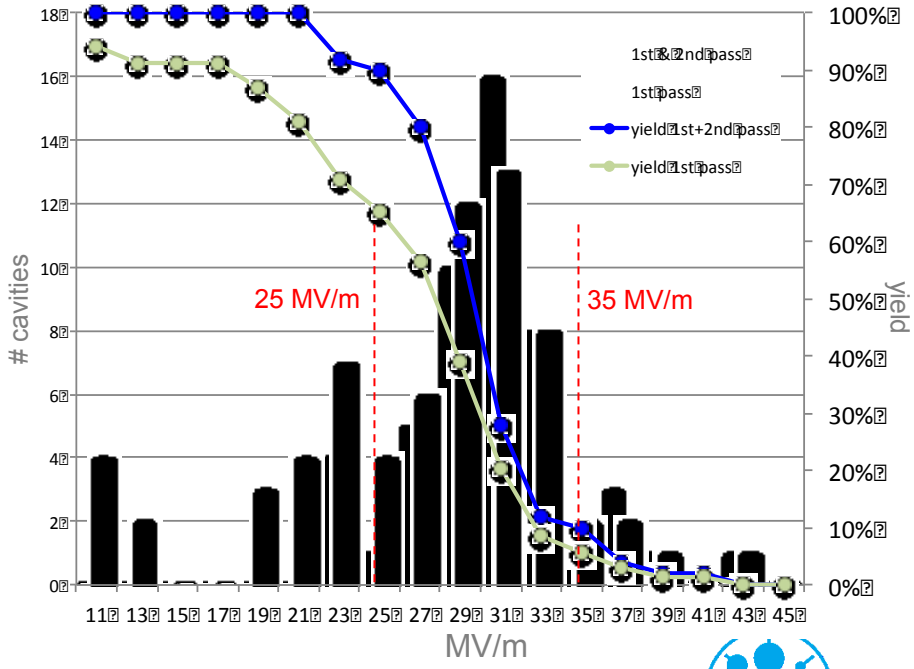
S1 Global at KEK SRF Test Facility (STF)

PXFEL 1 installed at FLASH, DESY, Hamburg
→ now commencing XFEL production

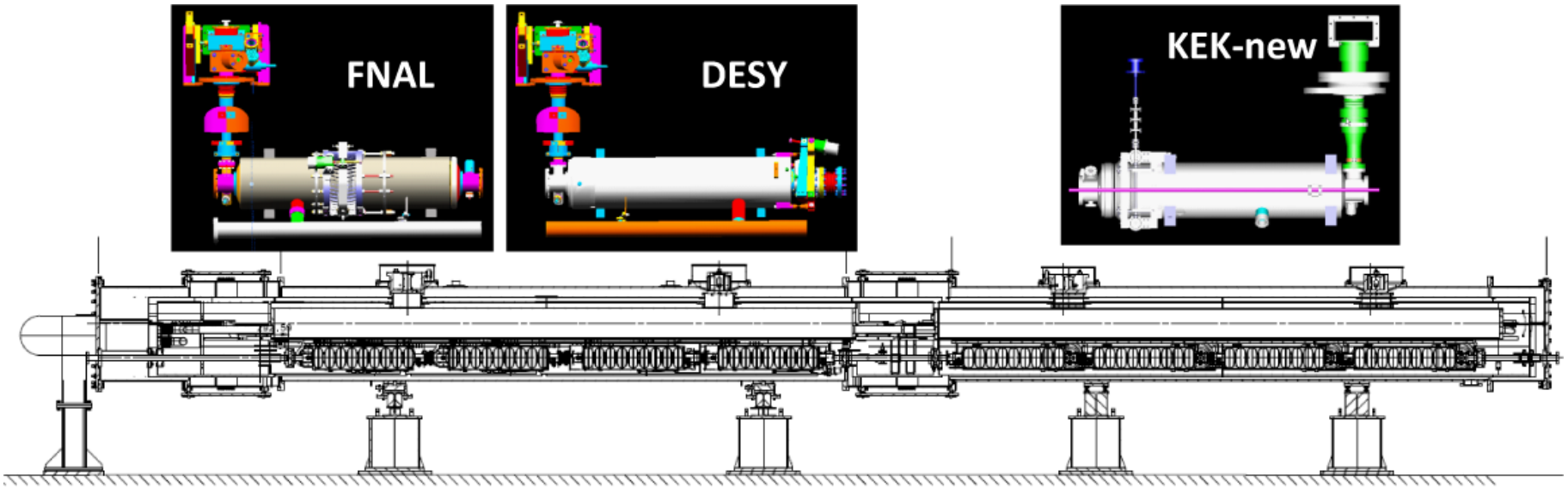
Quest for high gradients

- GDE worldwide R&D effort to establish high-gradient cavity production
- 6 Now qualified cavity vendors
- XFEL (mass) production
  - large (~800) unbiased statistical sample (<10% →)
  - critical for ILC
- ILC-HiGrade programme

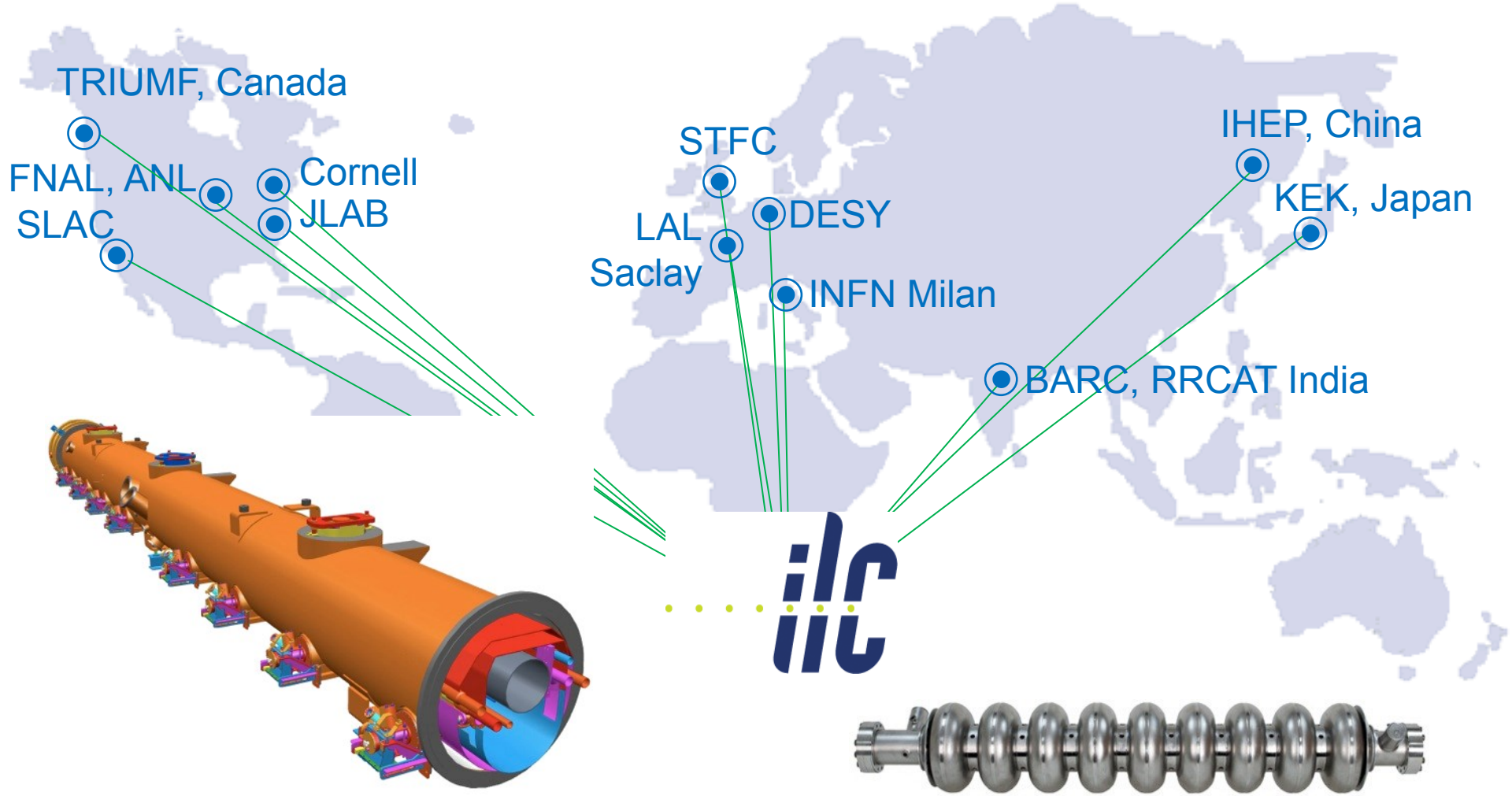




S1-Global @ KEK (2011)



Global SCRF Technology



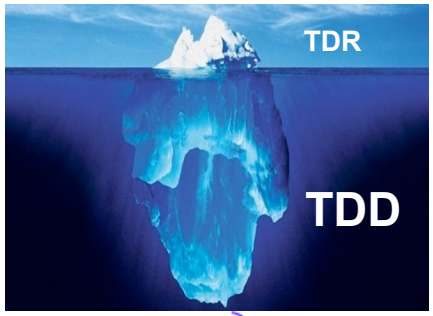
ILC-EDMS and Tech. Design Documentation

TD Phase Deliverables

Technical Design Report (TDR)

Documents primary TDR deliverables
1. Results and status of Risk Mitigating R&D
2. Updated Reference Design
3. Updated VALUE estimate
4. Project Implementation Plan
5. Technical risk assessment and future R&D

Readable
6–9 months to write



Supports

Summarises

Technical Design Documentation (TDD)

Reference Documentation
Structured and linked

Basic design documentation
- Parameter tables
- Requirements
- Specifications
- Design documents
- Drawings (2D)
- CAD-3D models
- ...

Cost information
Schedule
→ ICET

ILC-EDMS

An important DESY contribution

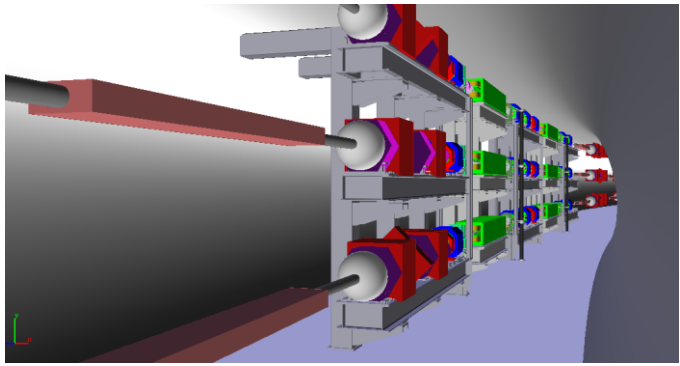
ILC Design Integration (DESY IPP)

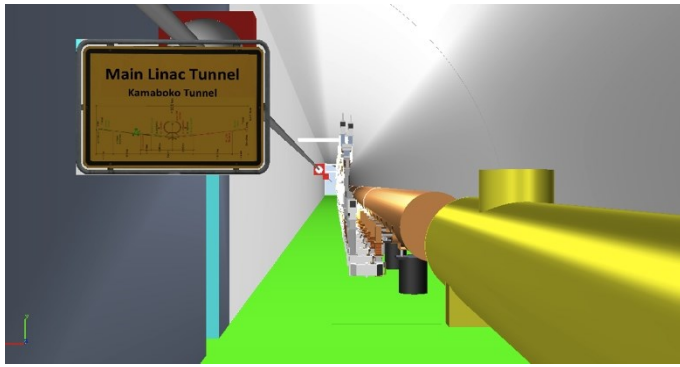
- Complete lattice description of accelerator
- Automated generation of 3D models
- Integration into tunnel / halls
- Integration of more detailed 3D models from many sources worldwide
- All in ILC-EDMS

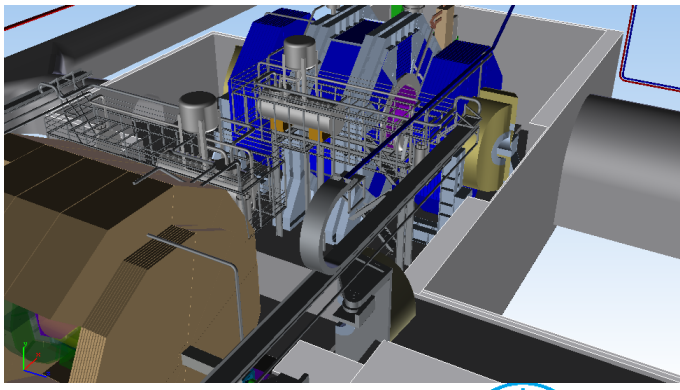
TDD defines the formal technical baseline for ILC

Now under formal change control

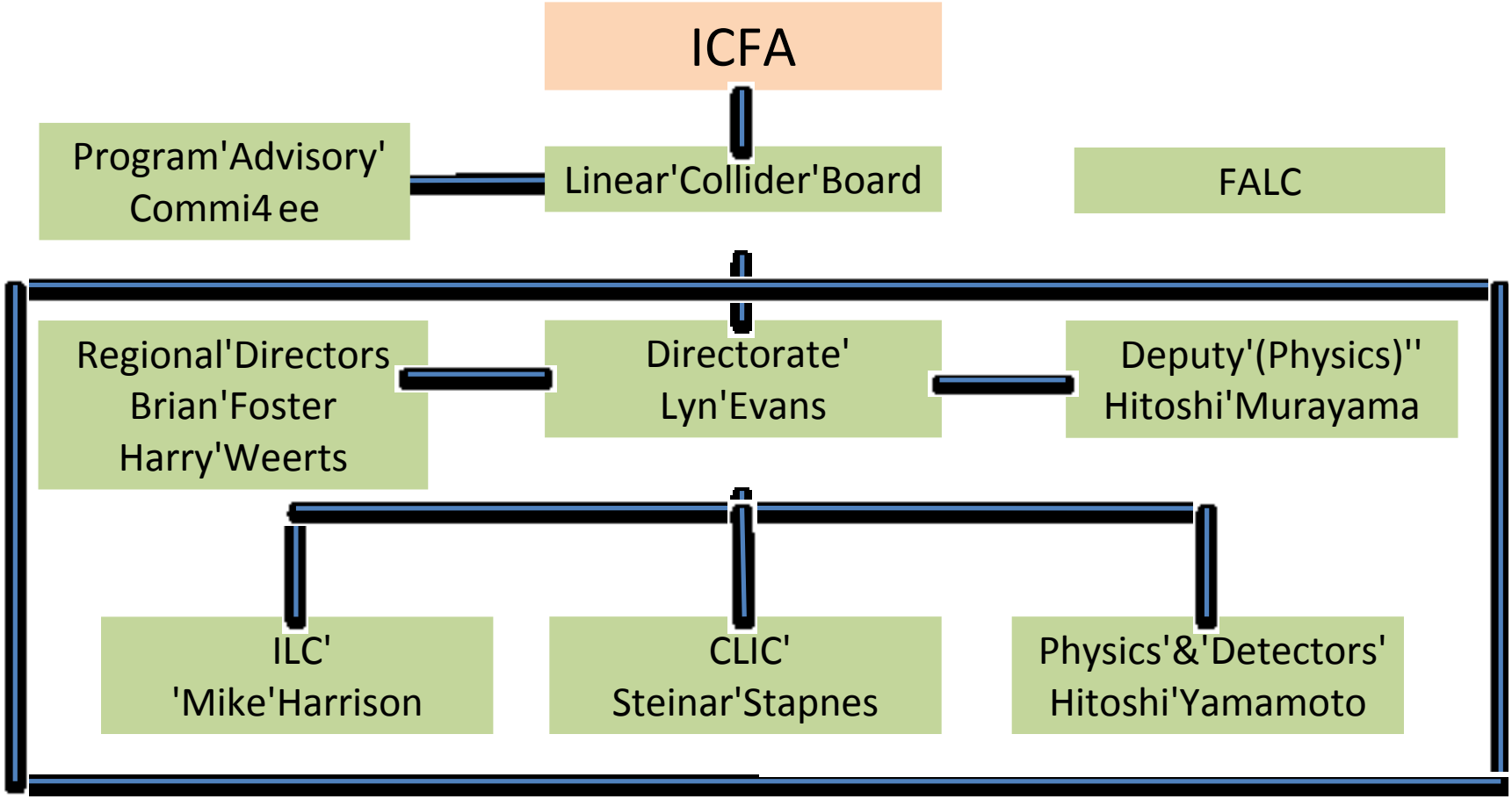
Link to cost estimate (also in ILC-EDMS)



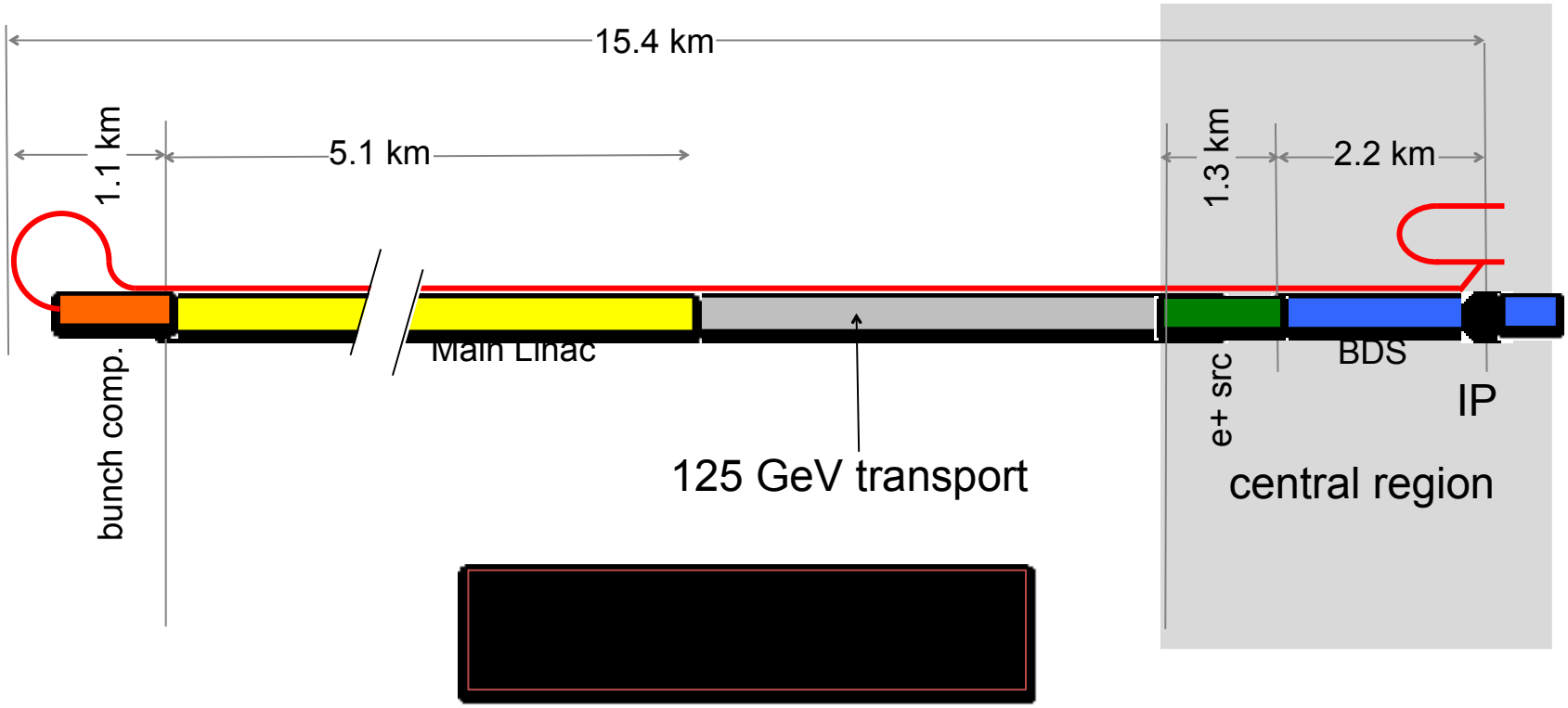




Linear Collider Collaboration



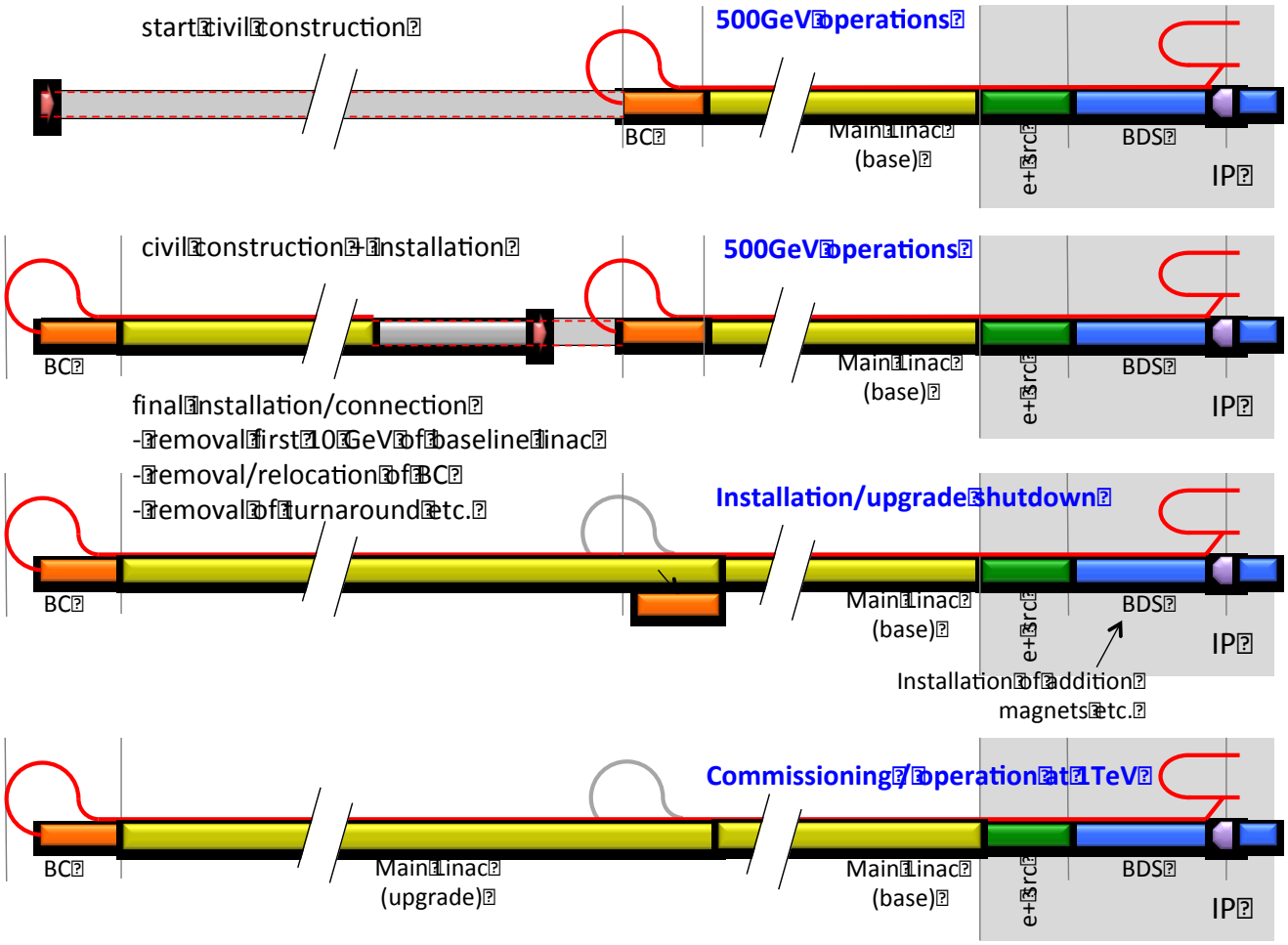
Staged construction: 250 GeV first phase



- Complete civil construction for 500 GeV machine
- Install ~1/2 linacs for fist stage operation (and long transport line)
- Capital savings ~25%
- Adiabatic energy upgrade (lower rate cryomodule production)

Favoured by Japan

250 GeV → 500 GeV → 1 TeV



Upgrade scenario included in TDR.

~50 km machine

Concept: concurrent construction and operation (minimum downtime for physics)

Lumi ~ 3-5×10^{34} $cm^{-2}s^{-1}$

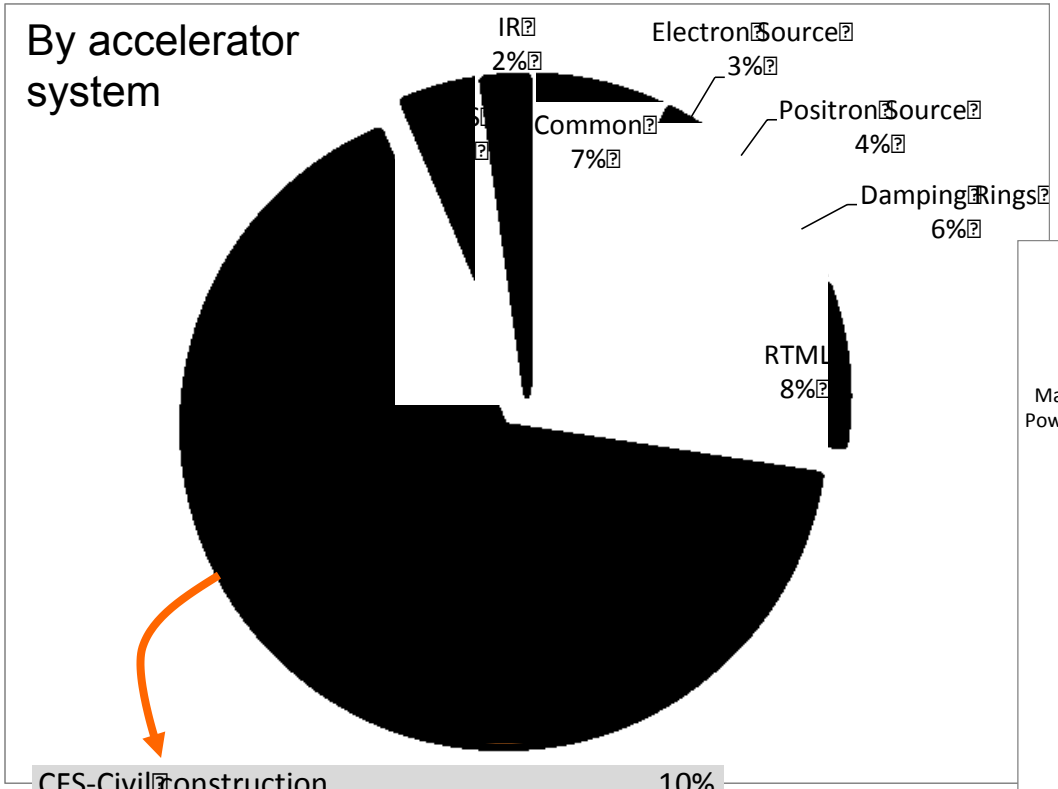
P_{AC} ~ 300 MW (limited)

TDR Value Estimate

7.8 Billion ILCU
22.6 Million person-hours

1 ILCU = 1 US$ Jan 2012

TDR Value Estimate



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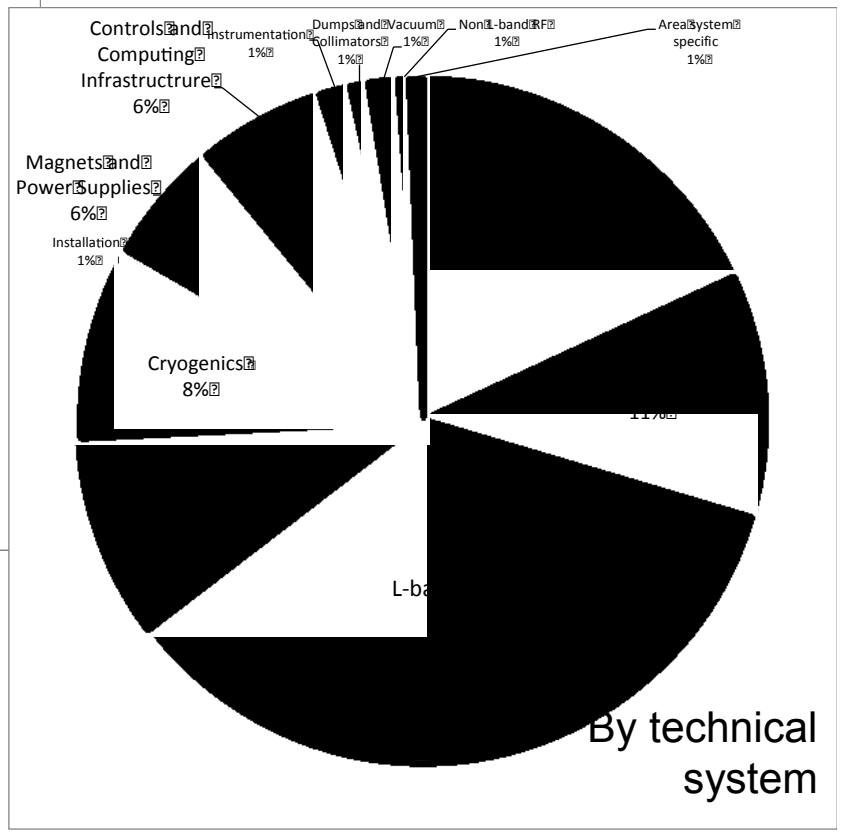


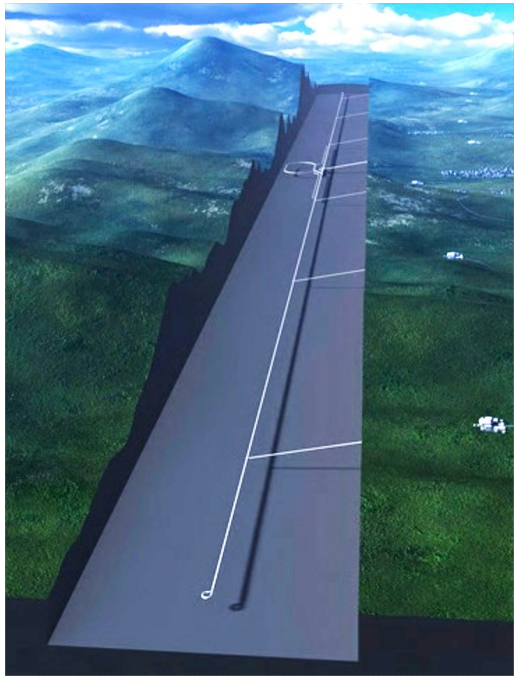
CFS-Civil Construction	10%
CFS-other	6%
L-band Cavities and Cryomodules	32%
L-band HLRF	9%
Cryogenics	7%
Controls	2%
TOTAL Main Linac	**66%**

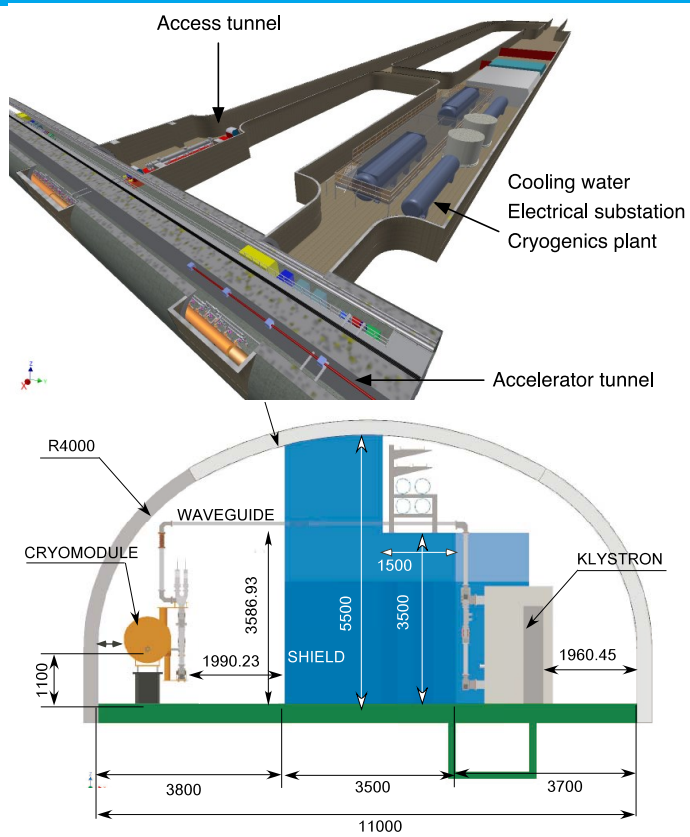
TDR: Japanese site-dependent design

Challenges of a mountainous terrain

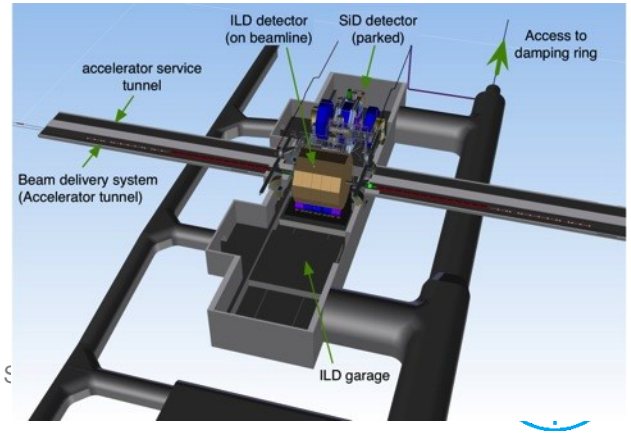
Long horizontal access tunnels (≤ 1 km)

Almost entirely under ground installation





Site-dependent design study will officially start when Japanese candidate site is announced (23.08.13)




©Rey.Hori/KEK

Japanese candidate site






KEK

Kitakami

Sefuri

Kyushu U.
G. Survey.

Tohoku U.
G. Survey

-150m

IWATE

FUKUOKA

SAGA

Nomura Research
Common Subject:
Central Campus

KYUSHU district

TOHOKU district

Competition in Japan between two sites has been intense

Single site will be formally announced on 23.08

Concept of new “Science City” being evaluated.

The road to a Japanese ILC

- March 2013: Formal proposal to Science Council of Japan (SCJ)
  - 100's of proposals across all of science
- May 2013: MEXT requests separate evaluation of ILC
  - sub-panel of SCJ set-up.
- Report expect ~end of August – what we *expect*:
  - science case of ILC 250-500 GeV very good
  - further studies required for practical scope (2-3 years) of hosting an international project.
- In parallel
  - Technical evaluation of two sites by domestic evaluation committee, outcome reviewed and endorsed by international committee (under LCC).
  - Formal announcement 23.08 – start of site dependent design study.

Japanese political support

- Federation of diet members for promotion of the ILC
  - Established in 2008
  - Expanded to a multi-partisan group: now ~150 members
- Association of Corporate Executives
  - Strong statements and endorsements on Japan hosting the ILC
  - Lobbying government to proceed
- Advanced Accelerator Association for promoting science and technology (AAA)
  - Established in 2008
  - Headed by a former CEO of Mitsubishi Heavy Industries: Mr. Nishioka
  - Hitachi, Toshiba, Mitsubishi, etc.
  - ~90 industries + ~30 universities
- Shinzo Abe (PM, Liberal Democratic Party) strong support for ILC
  - Mentions ILC twice in its election manifesto
  - Meeting with Lyn Evens (director LCC)

A European (in-kind) contributions to the ILC machine?

- Cavity & Cryomodule production infrastructure
- XFEL wisdom and know-how (including operations)

XFEL cold-linac consortium
CERN LHC experience

- Large cryogenics systems (XFEL and LHC)
- International project management experience (LHC, XFEL…)
  - **Project tools (ILC-EDMS and beyond)**

CERN, DESY…

- Other (machine) areas
  - **Damping rings**
  - **Beam delivery system**
  - **Sources**
  - **…**

CERN, DESY, UK, Frascati, LAL…

Strong synergy with CLIC

A European (in-kind) contributions to the ILC machine?

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CERN, DESY…

Will require "New Money"

- Other (machine) areas
  - **Damping rings**
  - **Beam delivery system**
  - **Sources**
  - **…**

CERN, DESY, UK, Frascati, LAL…

Strong synergy with CLIC

Next Steps (in Europe)

- (Wait for Japan announcement)

Funding ?

Currently looking to EU for possibilities

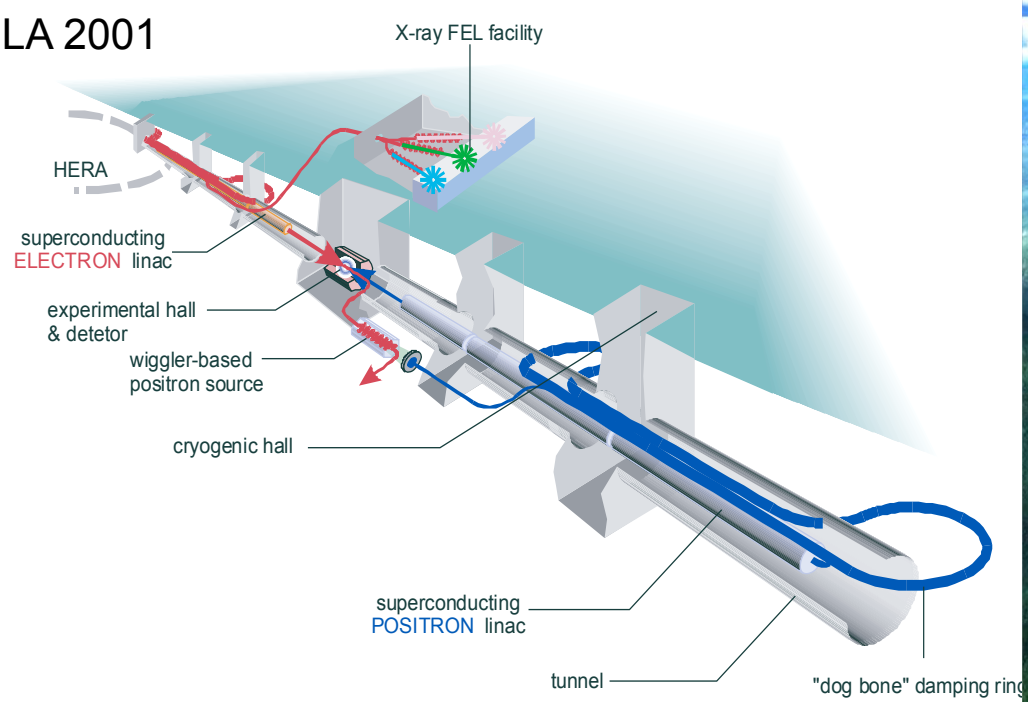
- Form an interim European Design Effort
  - **Establish a post-TDR network**
  - **Site-specific studies**
- Get involved in XFEL construction and commissioning
  - **Important for ILC to maximise knowledge and experience from this unique opportunity**
  - **and help XFEL be a success ☺**
- Begin in-kind contribution and possible project structure studies
  - **IKC in Europe – scenarios, what does it mean? How much will it cost?**
  - **Project structure – how would Europe organise itself as part of the global project?**

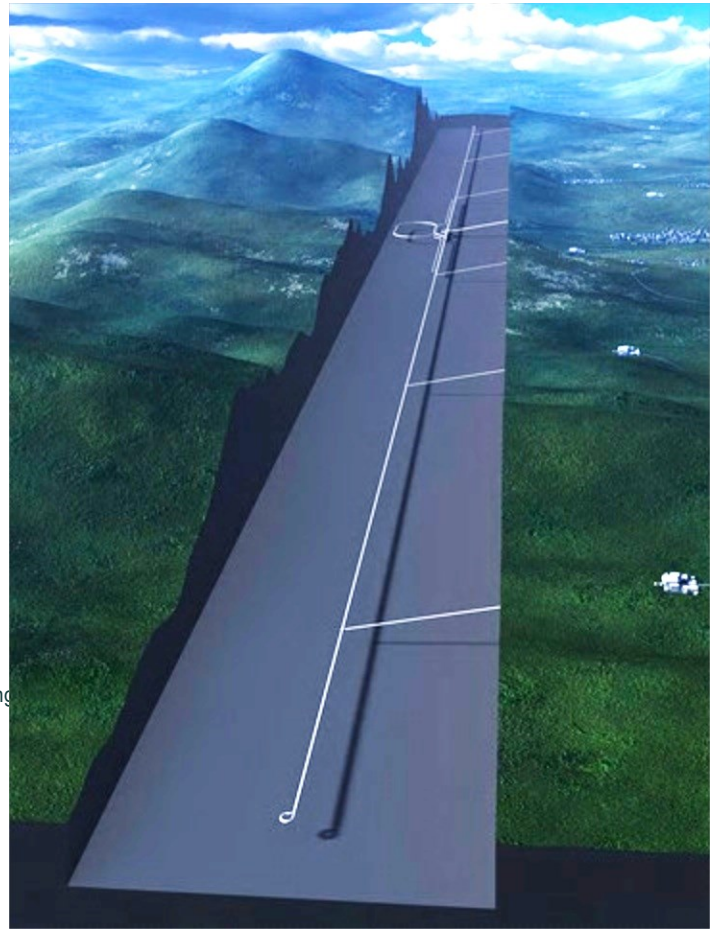
Summary

- Publication of the GDE's ILC TDR has been a major international achievement
  - Built on >20 years of history
  - A major and ready-to-go technical design
- DESY's has contributed enormously
  - Mostly via XFEL and FLASH synergy
  - But also more specific ILC contributions
- Situation in Japan exciting
  - A major science project on the brink of reality
  - But still hard international negotiations ahead (they have started!)
- Single Japanese candidate host site to be announced Friday
  - Beginnings of specific site ILC international design study
- Europe (and DESY) well placed to contribute to the ILC hosted by Japan
  - As part of a European collaboration (probably lead by CERN)
  - More than just cryomodules

From Hamburg to Japan

TESLA 2001





Japan in 2013

It only took ~10 years!

(It may take ~10 more)

But it started here @ DESY ☺