ILC Technical Design Report

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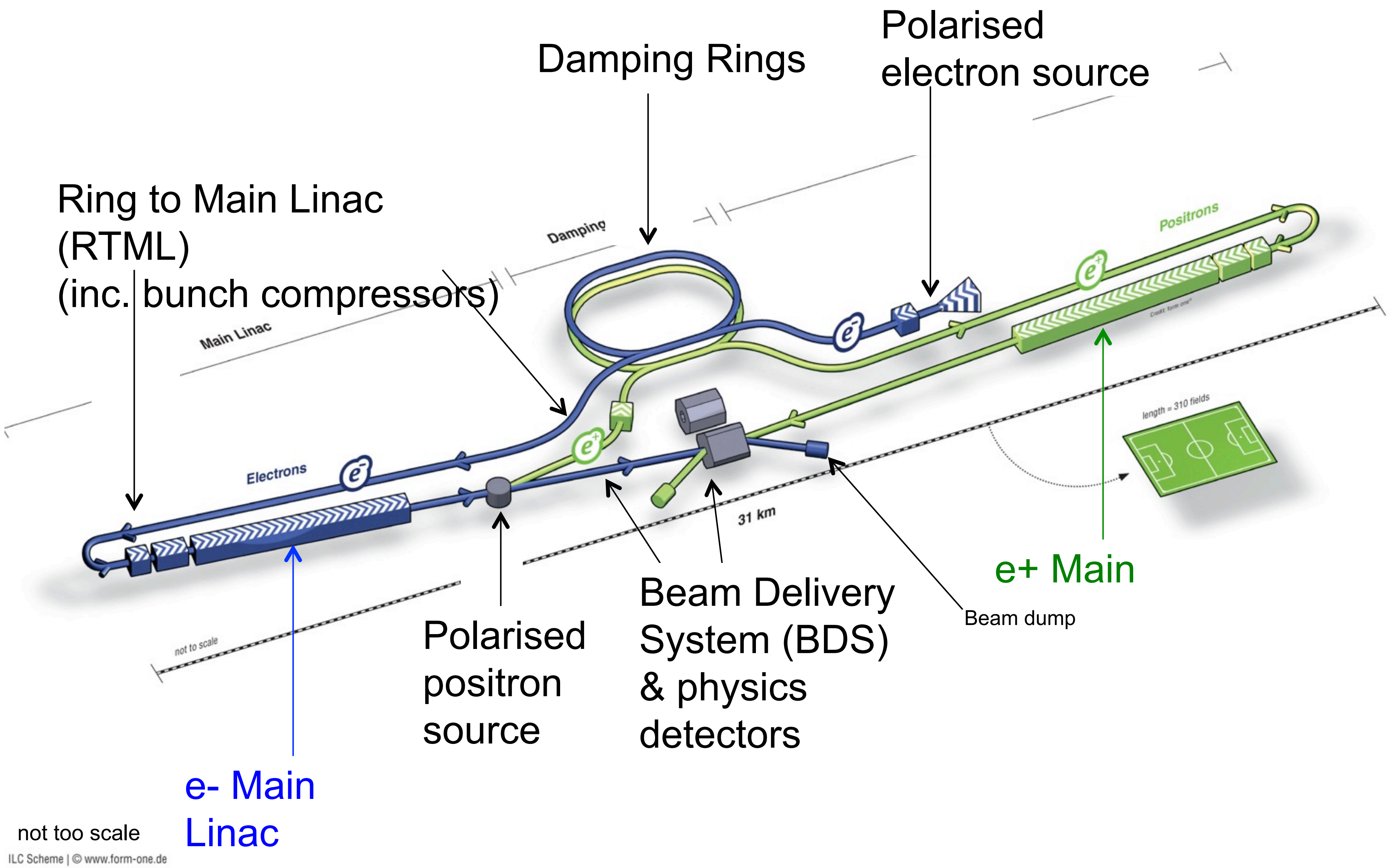
Plenary ECFA CERN 22/11/12

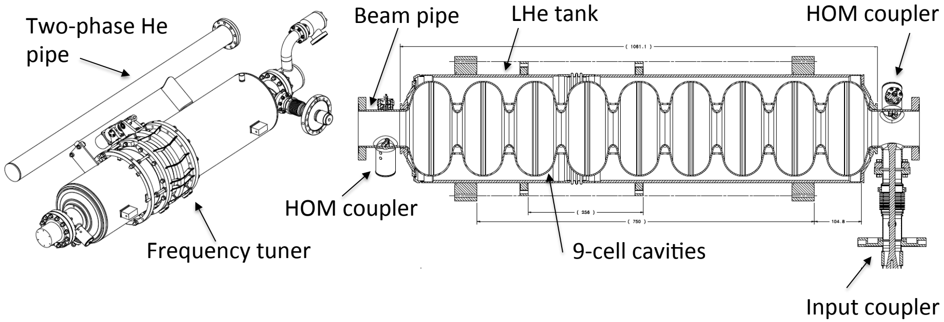
Overview

- Introduction
- The Technical Design Report – Major Achievements
- Developments on ILC Site & Higgs Factory
- Summary & Outlook

ILC Overview



SCRF Linac Technology

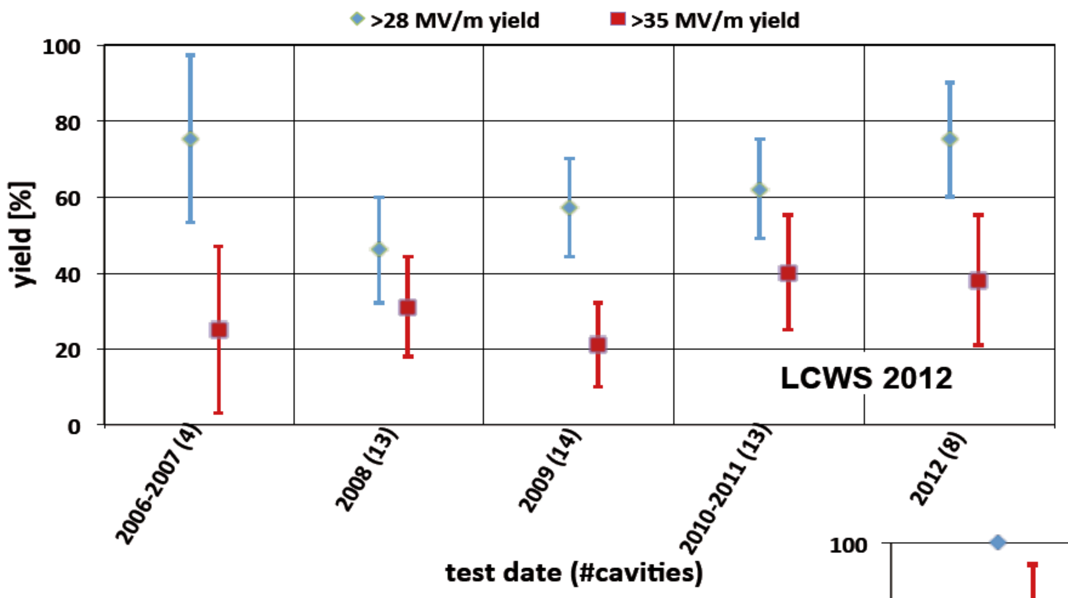


1.3 GHz Nb 9-cellCavities	16,024
Cryomodules	1,855
SC quadrupole pkg	673
10 MW MB Klystrons & modulators	436 / 471 *

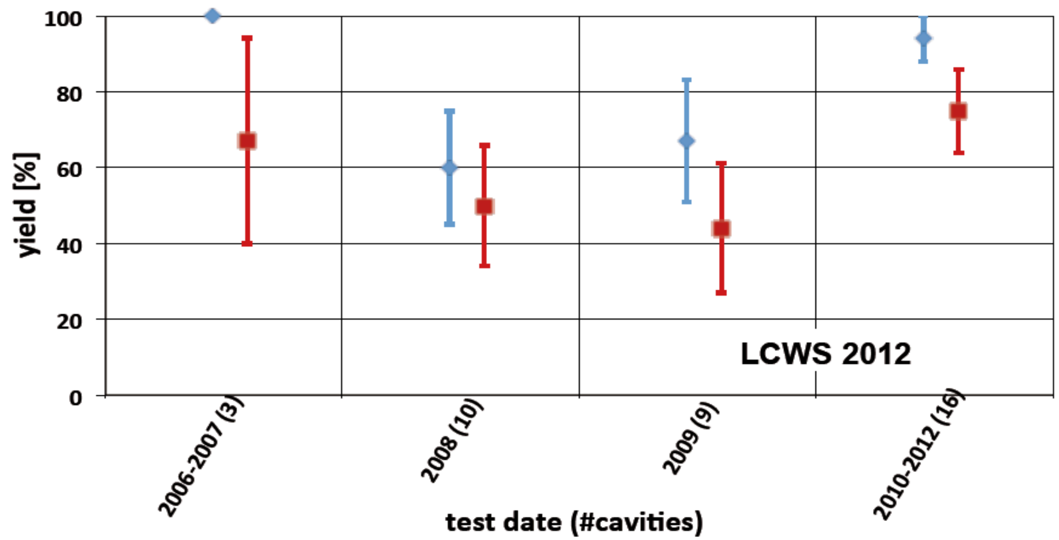
* site dependent

Approximately 20 years of R&D worldwide
→ Mature technology

SCRF Linac Technology

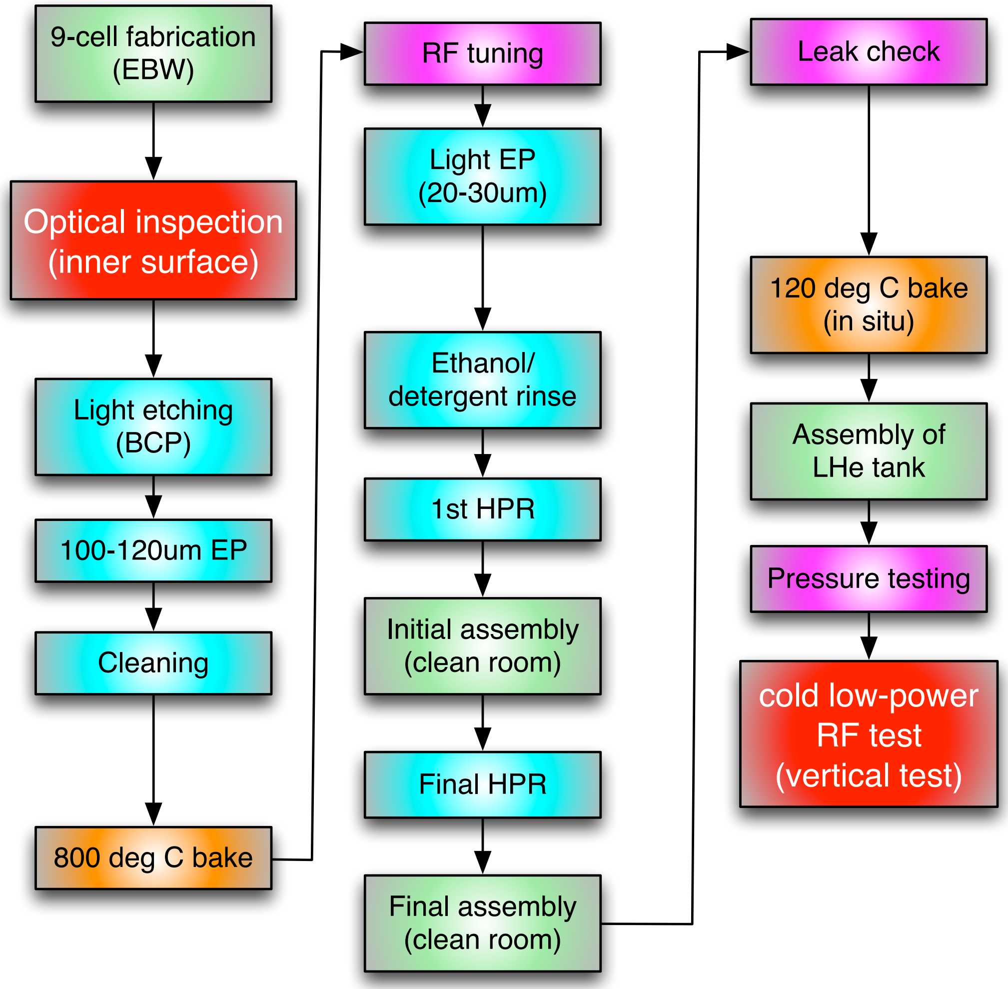


(a) First-pass yield



(b) Second-pass yield

The Path to High Performance



70% yield

>28 MV/m

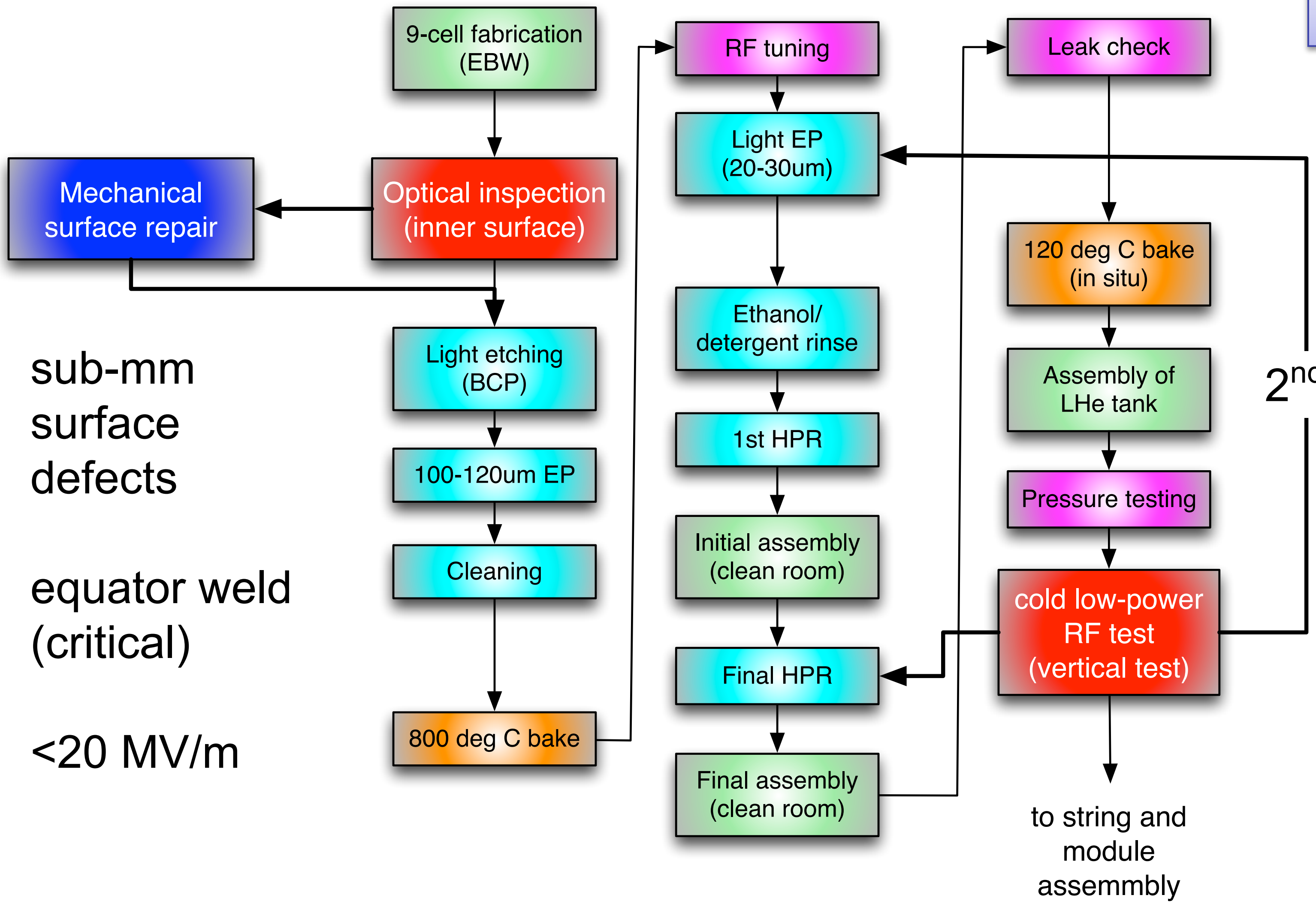
The Path to High Performance

90% yield

sub-mm surface defects

equator weld (critical)

<20 MV/m



Field emission

Thermal breakdown (quench)

<35 MV/m

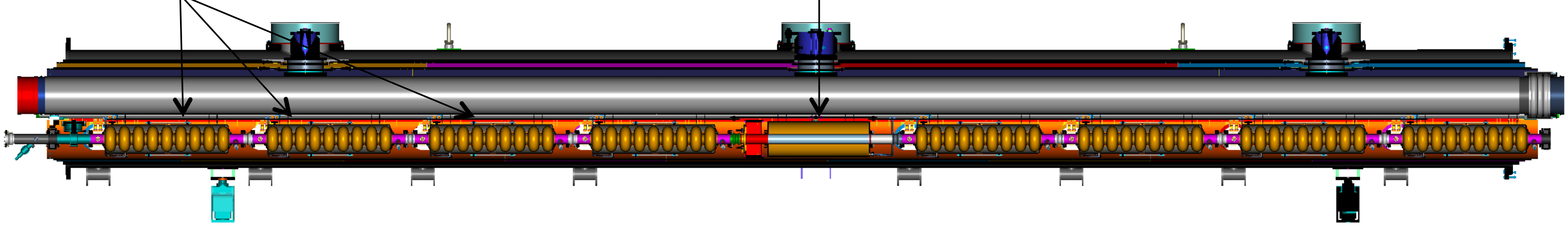
Cryomodule

cavities (8)

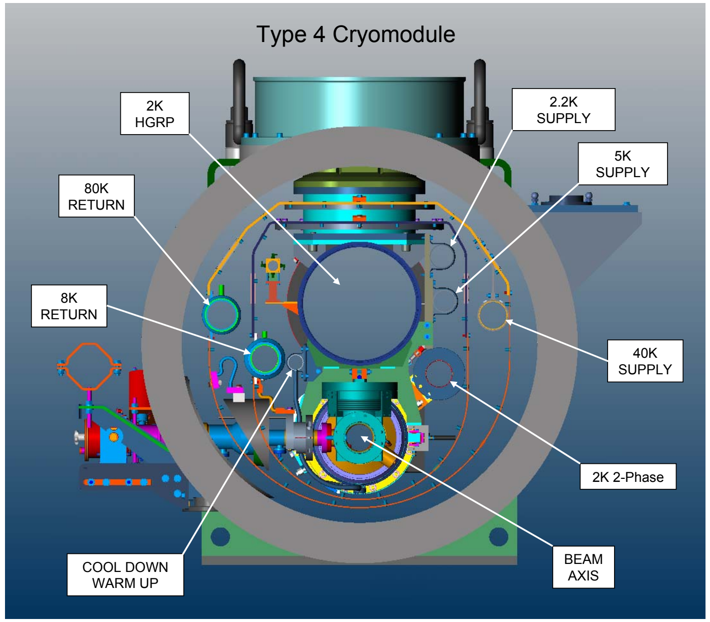
SC quad package

Type-B module

Type-A has 9 cavities and no quadrupole



12.652 m (slot length)



Cryomodule at FLASH

The European XFEL

European XFEL

PXFEL1 - The *Chinese* Module at CMTB

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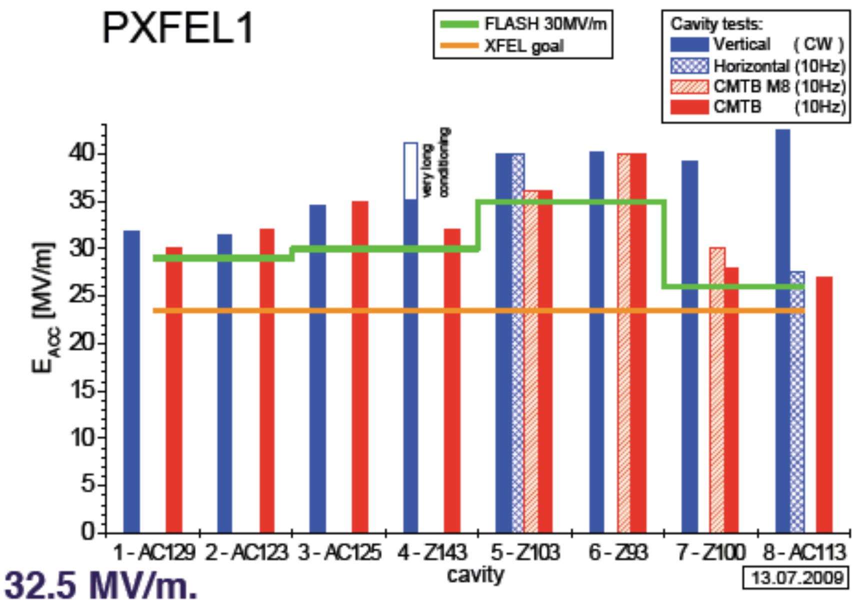


- The accelerator module PXFEL1 was conditioned and tested at the Cryo-Module Test Bench (CMTB).
- The average maximum gradient is **32.5 MV/m.**
- After string and module installation we have seen a **gradient reduction of only 5%.**
- PXFEL1 has been installed at FLASH and **can be operated** there with an average gradient of **30 MV/m.**
- The **XFEL waveguide distribution** is used.

TTC Meeting, Fermilab, April 19/22, 2010
Hans Weise / DESY

FLASH Achievements

High beam power and long bunch-trains *(Sept 2009)*

Metric	ILC Goal	Achieved
Macro-pulse current	9mA	9mA
Bunches per pulse	2400 x 3nC (3MHz)	1800 x 3nC 2400 x 2nC
Cavities operating at high gradients, close to quench	31.5MV/m +/-20%	4 cavities > 30MV/m

Gradient operating margins *(Feb 2012)*

Metric	ILC Goal	Achieved
Cavity gradient flatness (all cavities in vector sum)	2% $\Delta V/V$ (800μs, 5.8mA) (800μs, 9mA)	<0.3% $\Delta V/V$ (800μs, 4.5mA) *First tests of automation for Pk/Ql control*
Gradient operating margin	All cavities operating within 3% of quench limits	Some cavities within ~5% of quench (800us, 4.5mA) *First tests of operations strategies for gradients close to quench*
Energy Stability	0.1% rms at 250GeV	<0.15% p-p (0.4ms) <0.02% rms (5Hz)

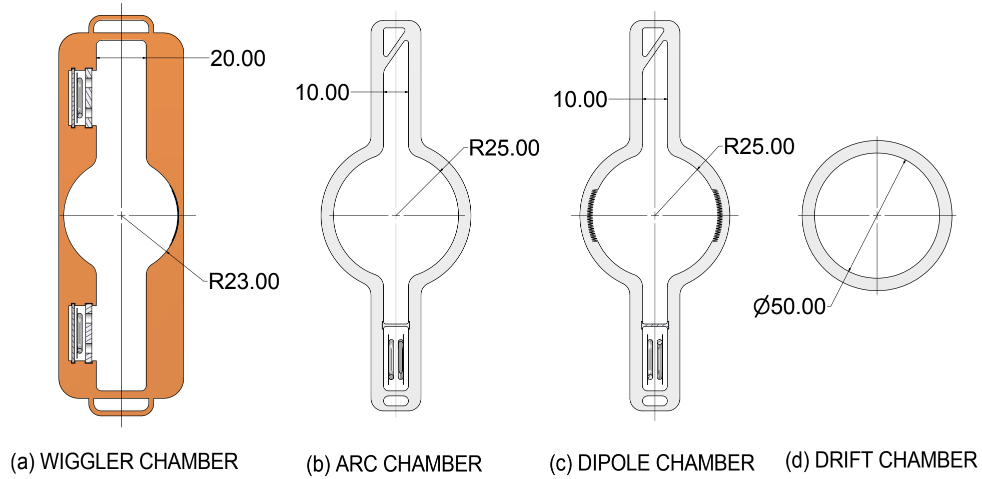
SCRF Linac Technology

Table 2.2. Main achievements of the SCRF R&D effort.

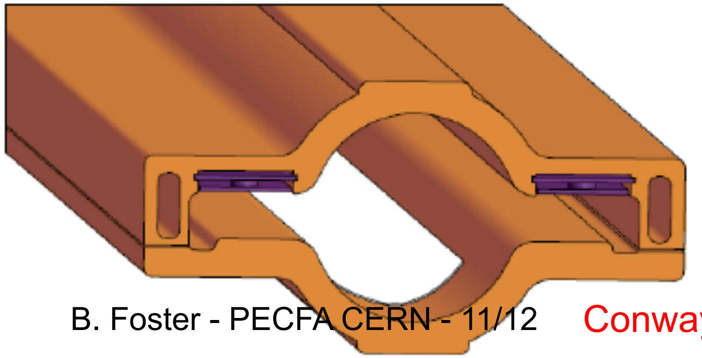
Achievements
Understanding and mitigation of field emission at low gradient.
Establishment of a baseline sequence of cavity fabrication and surface preparation for ILC.
Achievement of a production yield of 94 % at 28 MV/m and of 75 % at 35 MV/m ± 20 %.
Achievement of an average gradient of 37.1 MV/m in the ensemble.
Achievement of an average field gradient of 32 MV/m in a prototype cryomodule for the European XFEL program.
Demonstration of the technical feasibility of assembling ILC cryomodules with global in-kind contributions.

DR: Vacuum (Electron Cloud)

- Reduction of **electron cloud build-up** in e + ring critical for ILC parameters
- Full e-cloud mitigation concepts included into vacuum design
  - CesrTA (and other) R&D results
- Vacuum System Design/Costing
  - **Super-KEK-B VCs in production with similar designs to ILC DR**

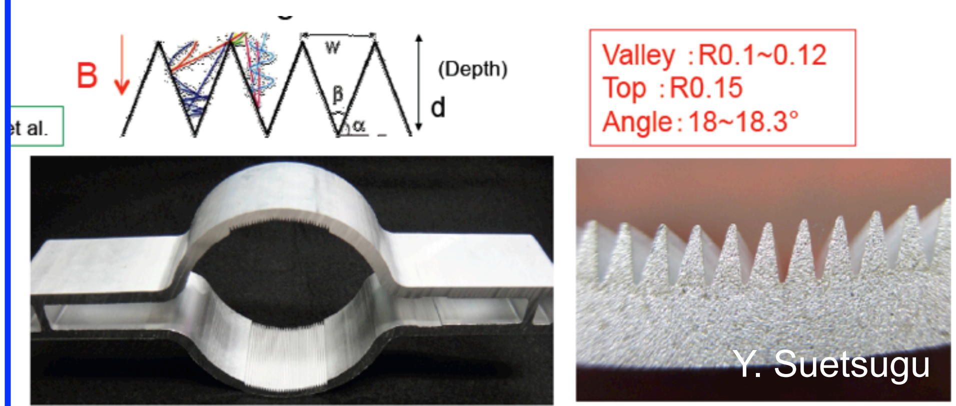


DR Wiggler chamber concept with thermal spray clearing electrode – 1 VC for each wiggler pair.

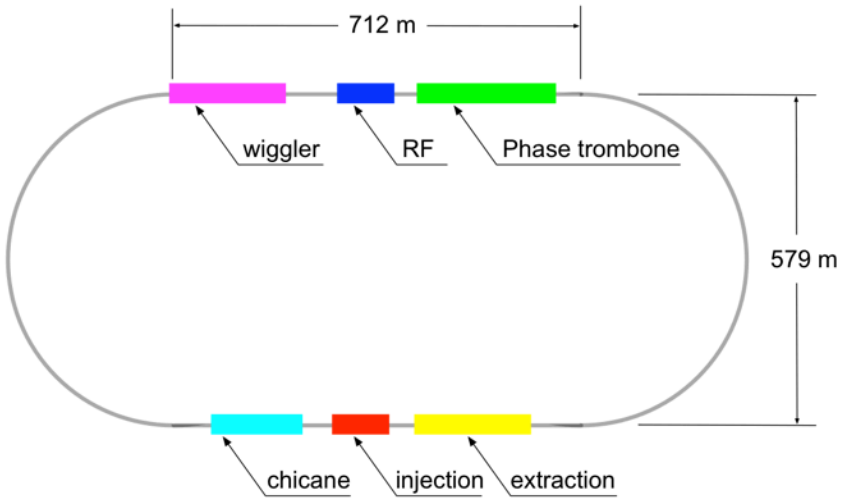


Conway/Li

SuperKEKB Dipole Chamber Extrusion



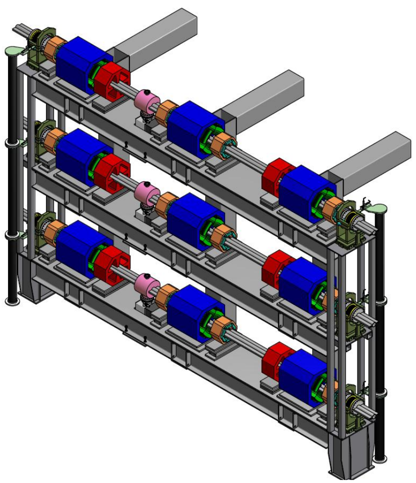
Damping Rings



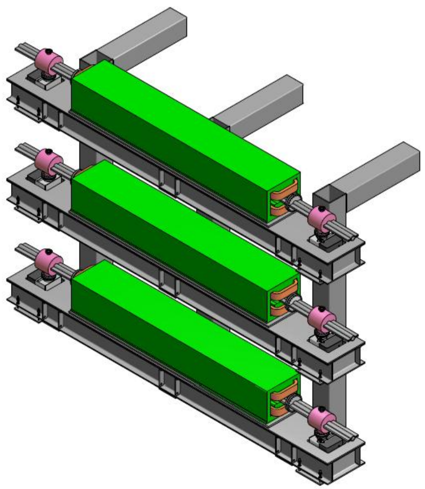
Positron ring (upgrade)

Electron ring (baseline)

Positron ring (baseline)



Arc quadrupole section



Dipole section

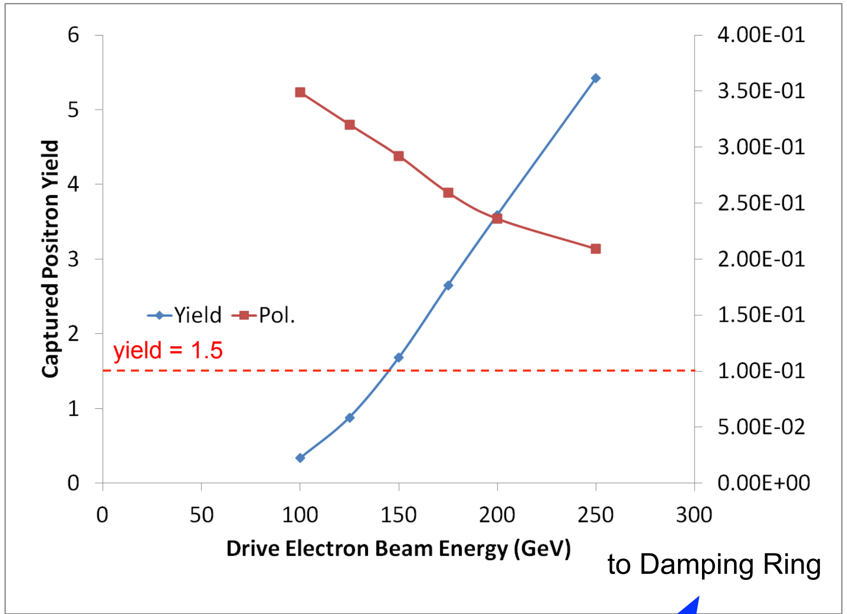
Circumference		3.2	km
Energy		5	GeV
RF frequency		650	MHz
Beam current		390	mA
Store time		200 (100)	ms
Trans. damping time		24 (13)	ms
Extracted emittance	x	5.5	µm
(normalised)	y	20	nm
No. cavities		10 (12)	
Total voltage		14 (22)	MV
RF power / coupler		176 (272)	kW
No.wiggler magnets		54	
Total length wiggler		113	m
Wiggler field		1.5 (2.2)	T
Beam power		1.76 (2.38)	MW

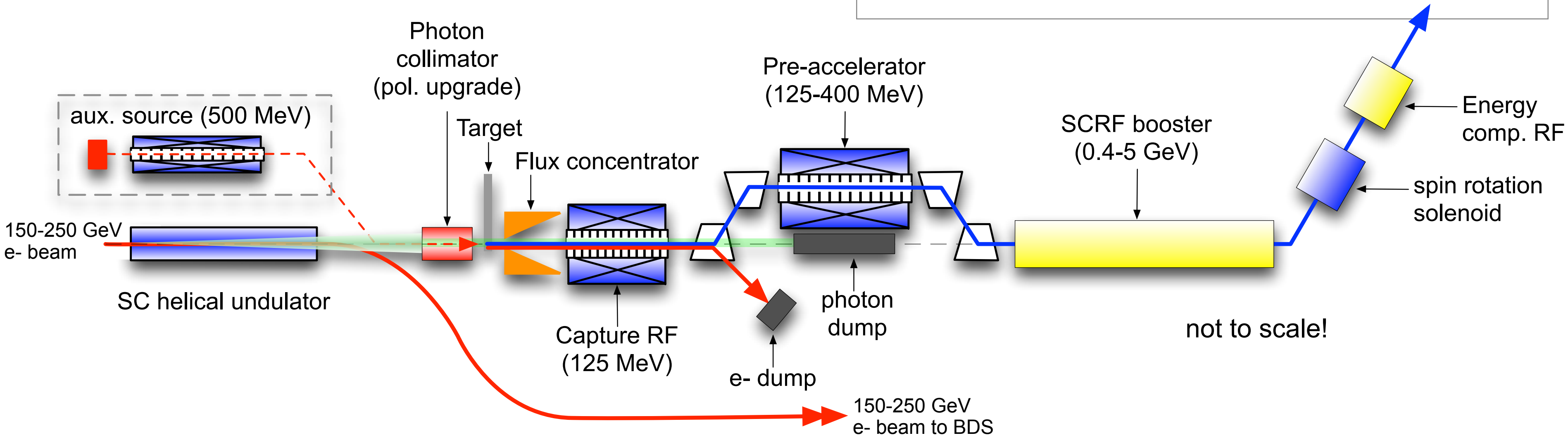
Values in () are for 10-Hz mode

Many similarities to modern 3rd-generation light sources

Positron Source (central region)

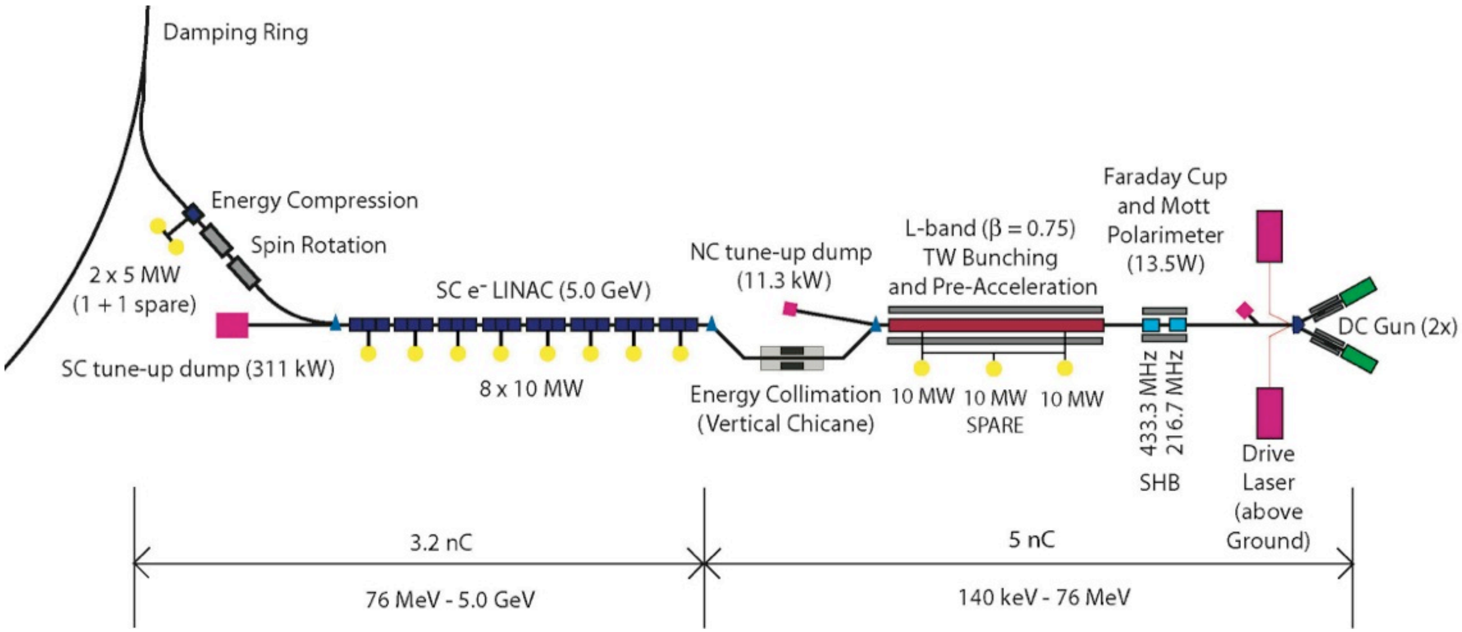
- located at exit of electron Main Linac
- 147m SC helical undulator
- driven by primary electron beam (150-250 GeV)
- produces ~30 MeV photons
- converted in thin target into e^+e^- pairs



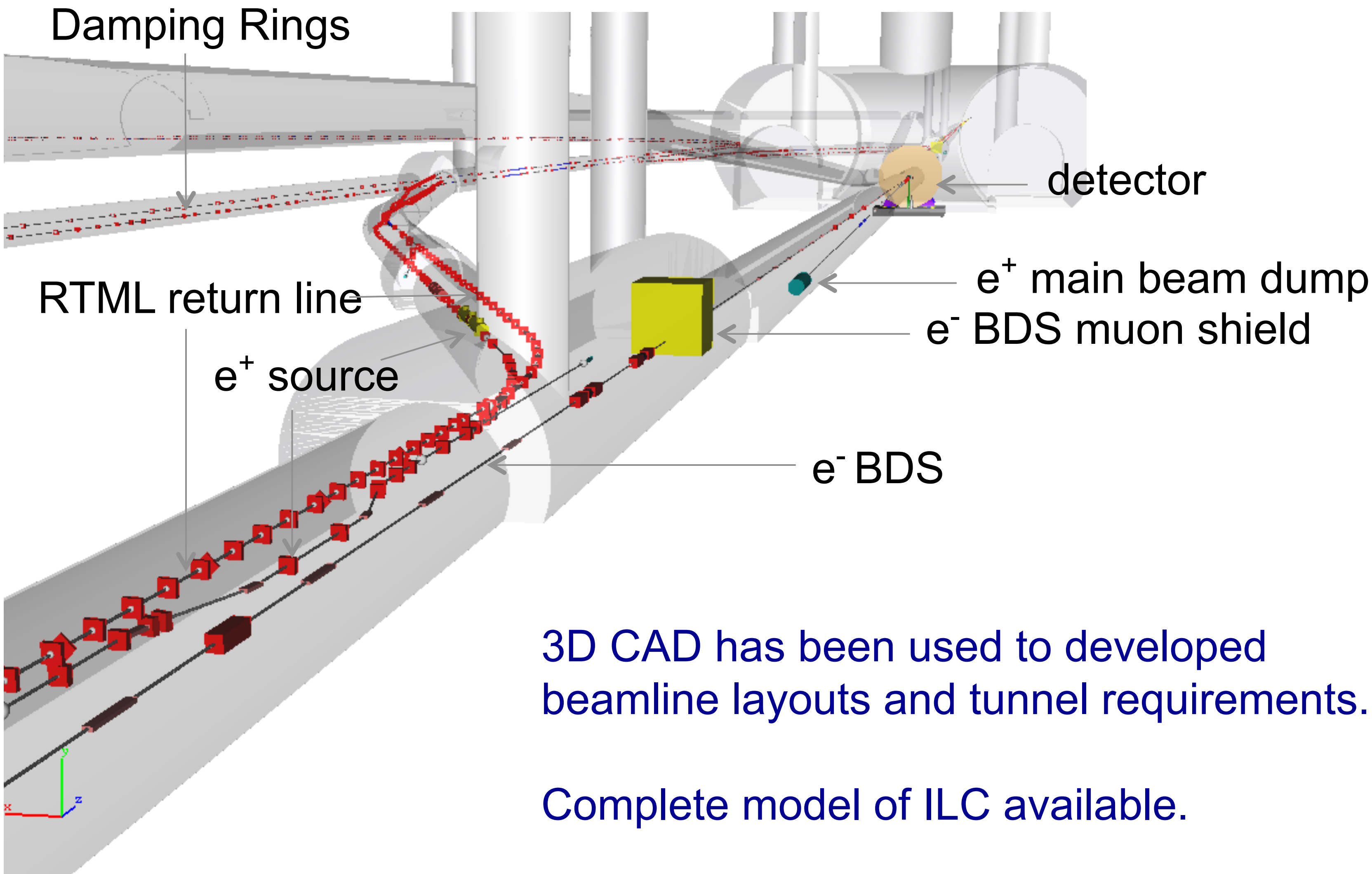


Polarised Electron Source

- Laser-driven photo cathode (GaAs)
- DC gun
- Integrated into common tunnel with positron BDS



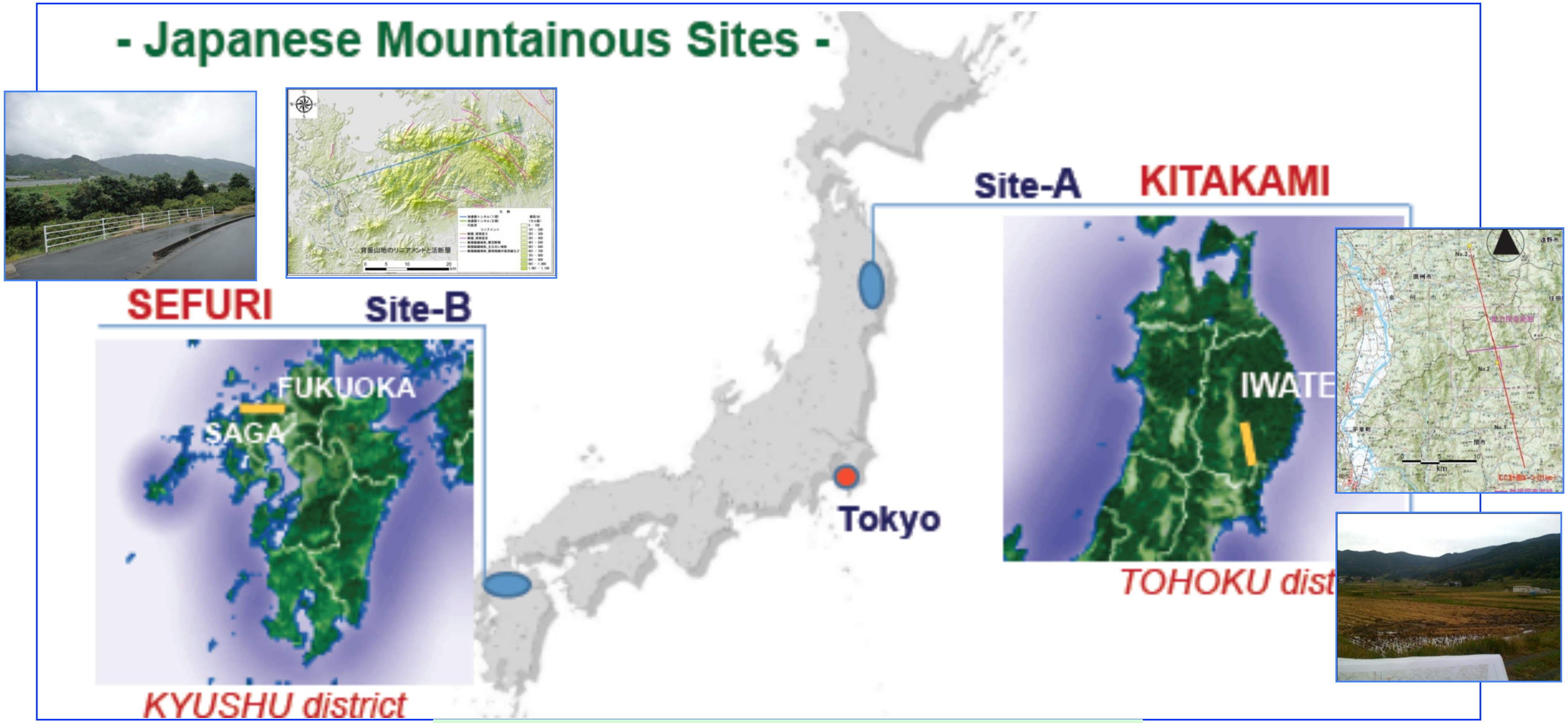
Central Region Integration



3D CAD has been used to developed beamline layouts and tunnel requirements.

Complete model of ILC available.

Japanese Sites



- GDE-CFS group visited two sites, Oct., 2011.
- GDE EC visit in Jan. 2012.

Y. Okada - CPM12 Fermilab

ILC Plan in Japan

(After the discovery of a Higgs-like particle)

- Japanese HEP community proposes to host ILC based on the "staging scenario" to the Japanese Government.
  - ILC starts as a 250GeV Higgs factory, and will evolve to a 500GeV machine.
  - Technical extendability to 1TeV is to be preserved.

- It is assumed that one half of the cost of the 500GeV machine is to be covered by Japanese Government. However, the share has to be referred to inter-governmental negotiation.

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250 GeV CM (first stage)

Relative to TDR 500 GeV baseline

Half linacs solution
G = 31.5 MV/m

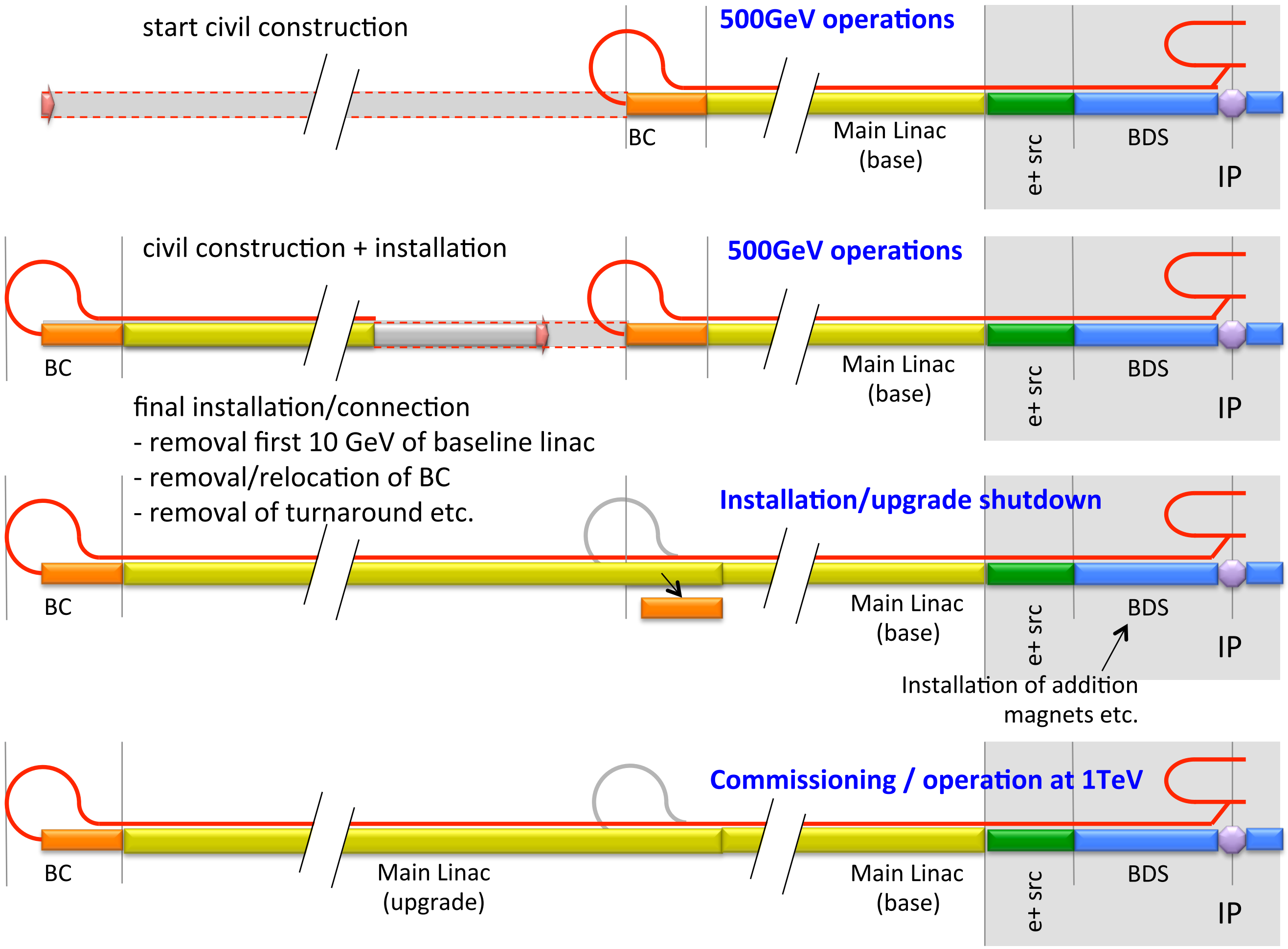
POSITRON linac straightforward
~50% ML linac cost (cryomodules, klystrons, cryo etc.)
~50% ML AC power

ELECTRON linac needs 10Hz mode for e+ production
ΔE = 135 GeV instead of 110 GeV (+25 GeV)
~57% ML linac cost (cryomodules, klystrons etc)

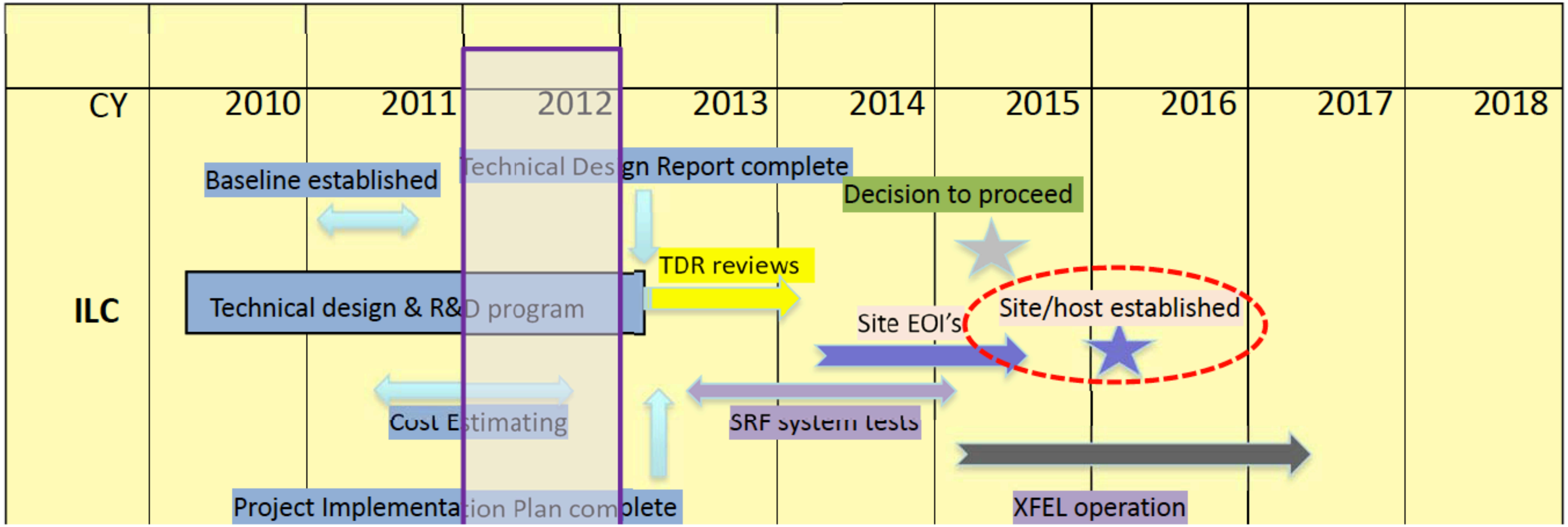
Main Linac infrastructure
Linac components: 50%
Cryogenics: 65%
RF AC power: 80%

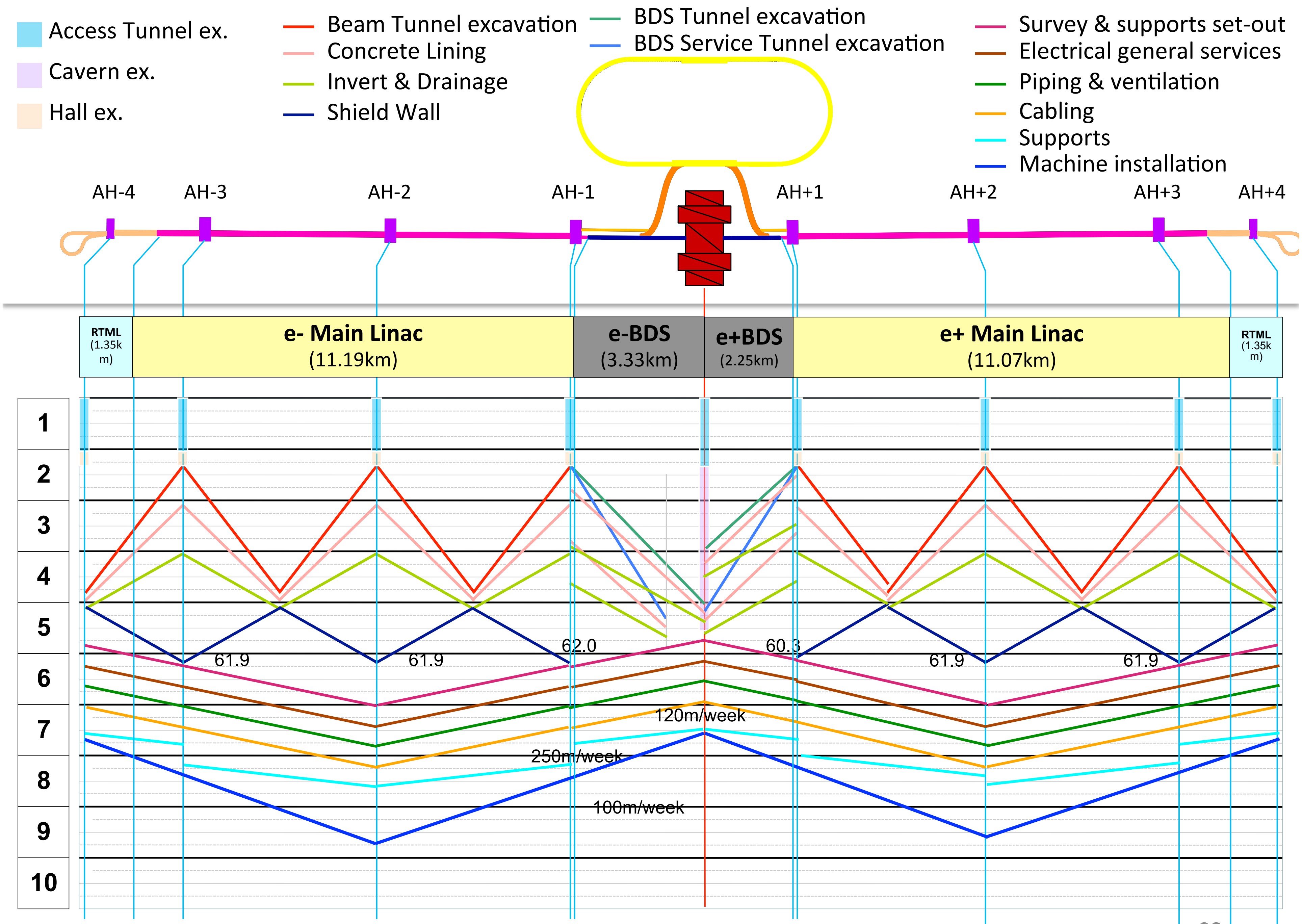
10Hz needs (1/2 linac × 10Hz/5Hz):
- 100% ML AC power
  (1/2 linac × 10Hz/5Hz)
- 80% cryo cost
  (50% static + 100% dynamic)

1 TeV Upgrade



A. Suzuki – IEEE 11/12





Access Tunnel ex.
Cavern ex.
Hall ex.
Beam Tunnel excavation
Concrete Lining
Invert & Drainage
Shield Wall
BDS Tunnel excavation
BDS Service Tunnel excavation
Survey & supports set-out
Electrical general services
Piping & ventilation
Cabling
Supports
Machine installation
AH-4
AH-3
AH-2
AH-1
AH+1
AH+2
AH+3
AH+4
RTML (1.35km)
e- Main Linac (11.19km)
e-BDS (3.33km)
e+BDS (2.25km)
e+ Main Linac (11.07km)
RTML (1.35km)
1
2
3
4
5
6
7
8
9
10
61.9
61.9
62.0
60.3
61.9
61.9
120m/week
250m/week
100m/week
22

Future LC objectives

- Strongly support the Japanese initiative to construct a linear collider as a staged project in Japan.

- Prepare CLIC machine and detectors as an option for a future high-energy linear collider at CERN.

- Further improve collaboration between CLIC and ILC machine experts.

- Move towards a “more normal” structure of collaboration in the detector community to prepare for the construction of two high-performance detectors.

CLIC CDR completed, see talk of Steinar Stapnes (some detector&physics issues in talk of Juan Fuster)

Single slide in talk of Steinar Stapnes

See talk of Juan Fuster concerning LC detector and physics studies – ILC DBD and CLIC CDR

Summary and Outlook

- The TDR of the ILC accelerator has been submitted for peer review. It demonstrates that the ILC can be built tomorrow.
- Completion of the TDR marks the end of the GDE's mandate. The Linear Collider Organisation led by Lyn Evans takes over from February. These milestones will be marked by "The International Linear Collider – A World-wide Event – From Design to Reality" – a rolling event across the 3 regions starting at 5pm local time on June 12th, 2013. The European event will be in the Globe at CERN
- Strong statements of interest to host ILC from the Japanese physics community. Timetable exists for decision to proceed in ~ 2 years. Strong support from Europe, in the European Strategy, and US essential for this initiative to succeed.