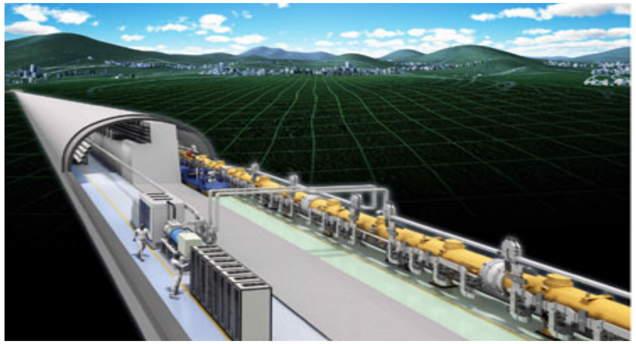

ILC TDR Overview
ILC 技術設計書･概要

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the 1st ILC TDR Verification Working Group
第一回　ILC 技術設計書･ 検証作業部会
30 June, 2014

Outline

- Introduction
- Accelerator R&D: 加速器研究開発
- Accelerator Baseline Design：加速器基本設計
- Detectors ：測定器
- Energy Staging：エネルギー･アップグレード
- Schedule：スケジュール
- Summary

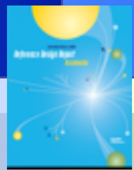
ILC Technical Design Phase

ILC 技術設計段階・期間

1980’ ~ Basic Study

2004

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014



ILC-GDE

LCC

Ref. Design (RDR)

Tech. Design : TDP1

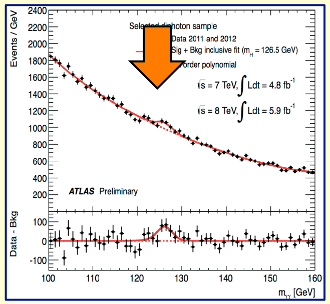
TDP 2

LHC

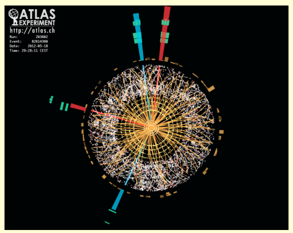
TDR completion

Selection of SC Technology

126 GeV



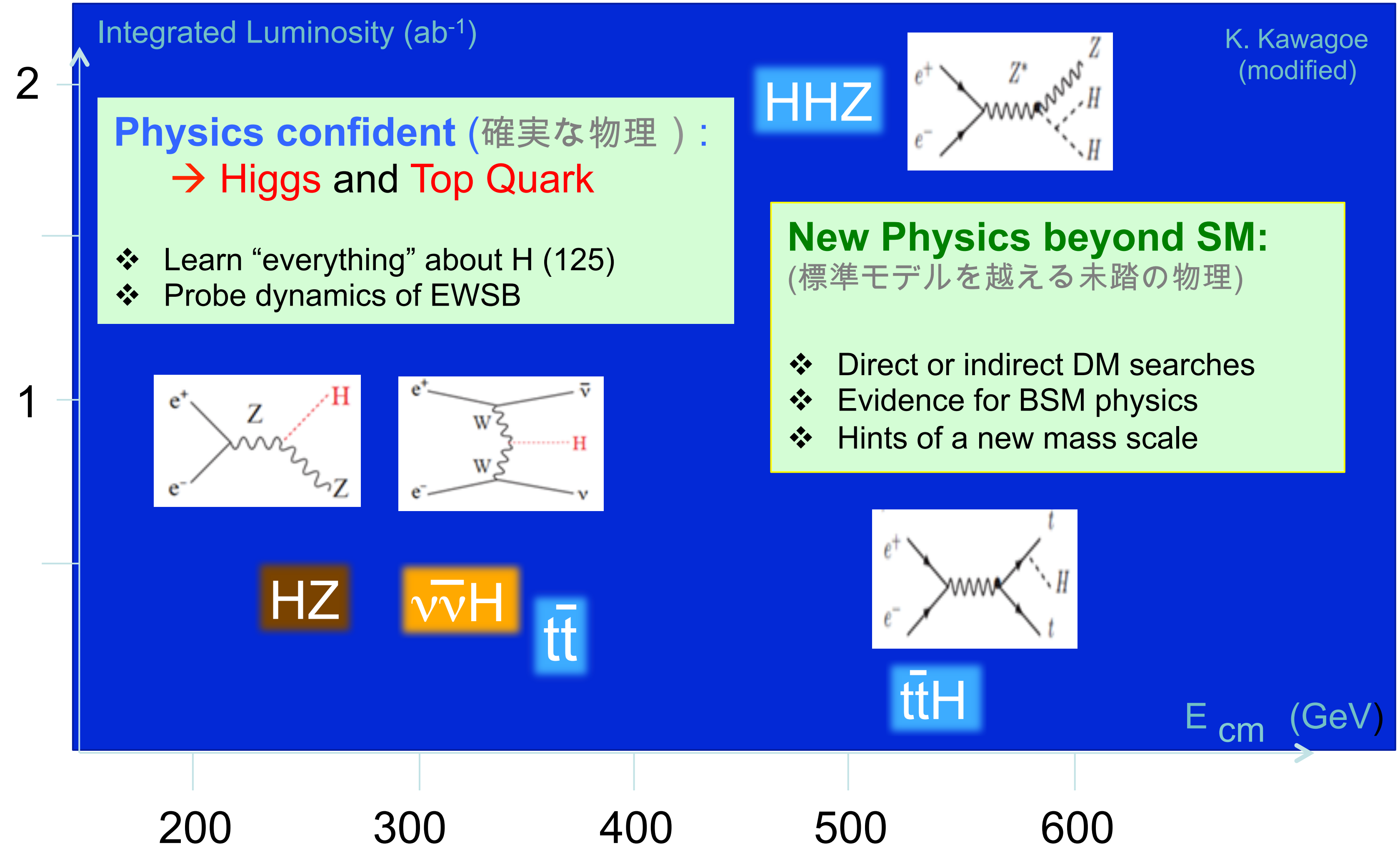
Higgs discovered



Important Energies in ILC

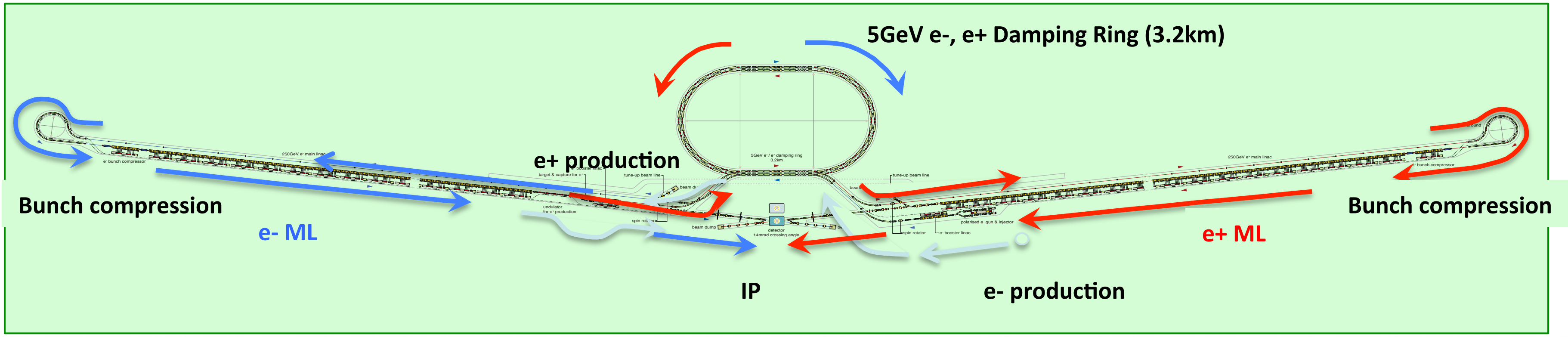
ILCにおける重要な衝突エネルギー

- ❖ Discovery of a 125 GeV Higgs has reinforced the importance of the ILC

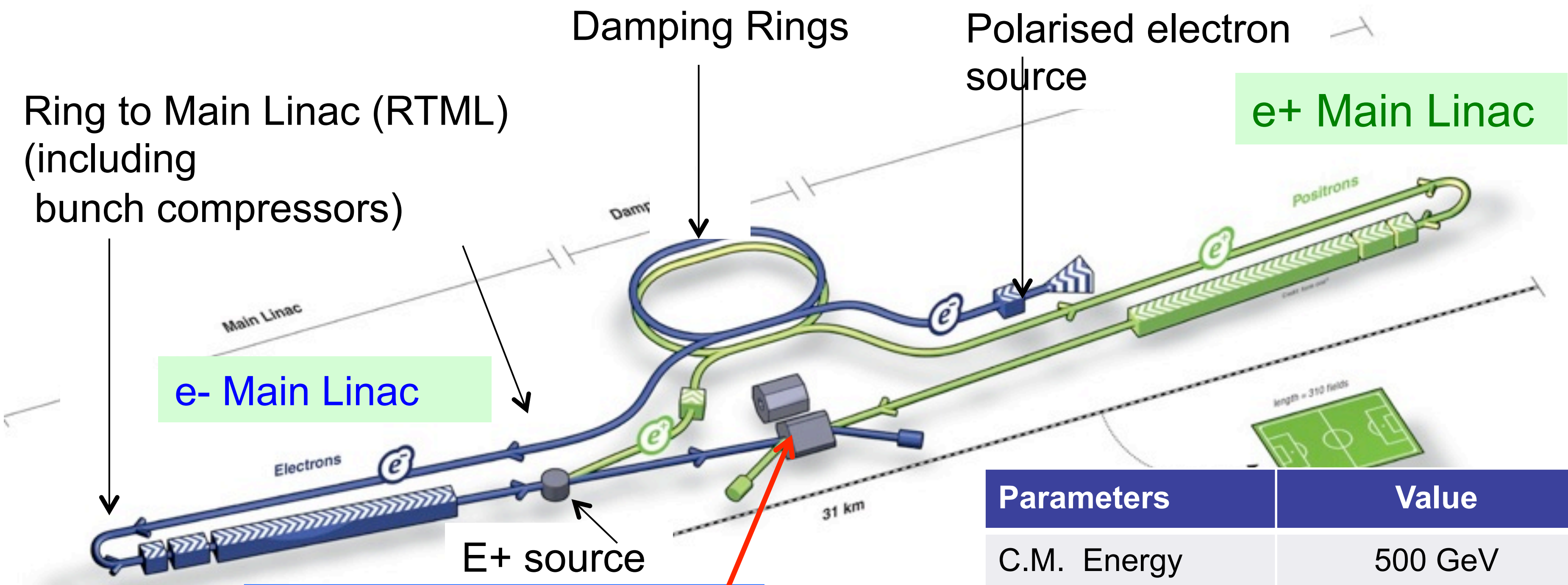


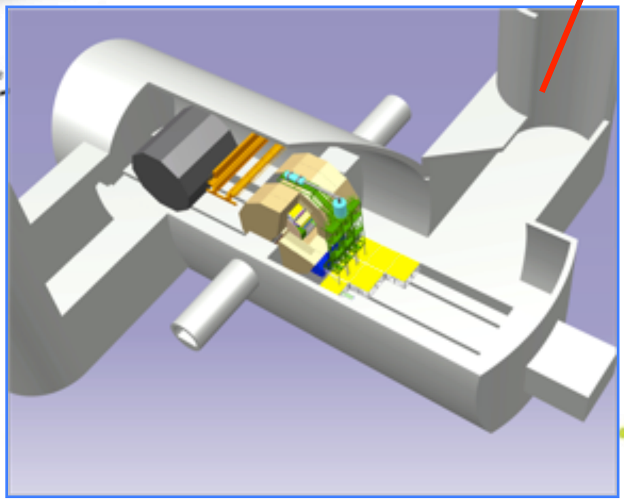
Requirements from Physics
物理実験からの要求

- **Basic requirements （基本要求）：**
  - Luminosity : $\int L dt$ = 500 fb^{-1} in 4 years
  - E_{cm} : **200 – 500 GeV, and the ability to scan**
  - E stability and precision: < 0.1%
  - Electron polarization: > 80%
- **Extend-ability（エネルギー拡張性）：**
  - Energy upgrade: **500 → 1,000 GeV**



ILC TDR Layout



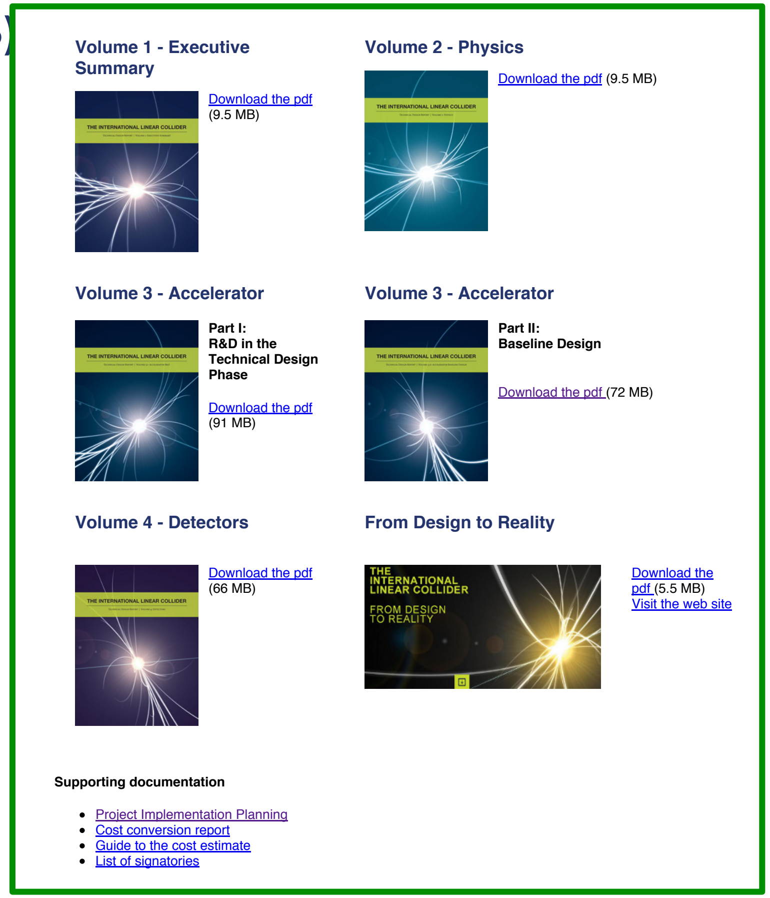


Parameters	Value
C.M. Energy	500 GeV
Peak luminosity	1.8 x10^{34} $cm^{-2}s^{-1}$
Beam Rep. rate	5 Hz
Pulse duration	0.73 ms
Average current	5.8 mA (in pulse)
E gradient in SCRF acc. cavity	31.5 MV/m +/-20% Q_0 = 1E10

Preface: ILC TDR Configuration

TDR の構成

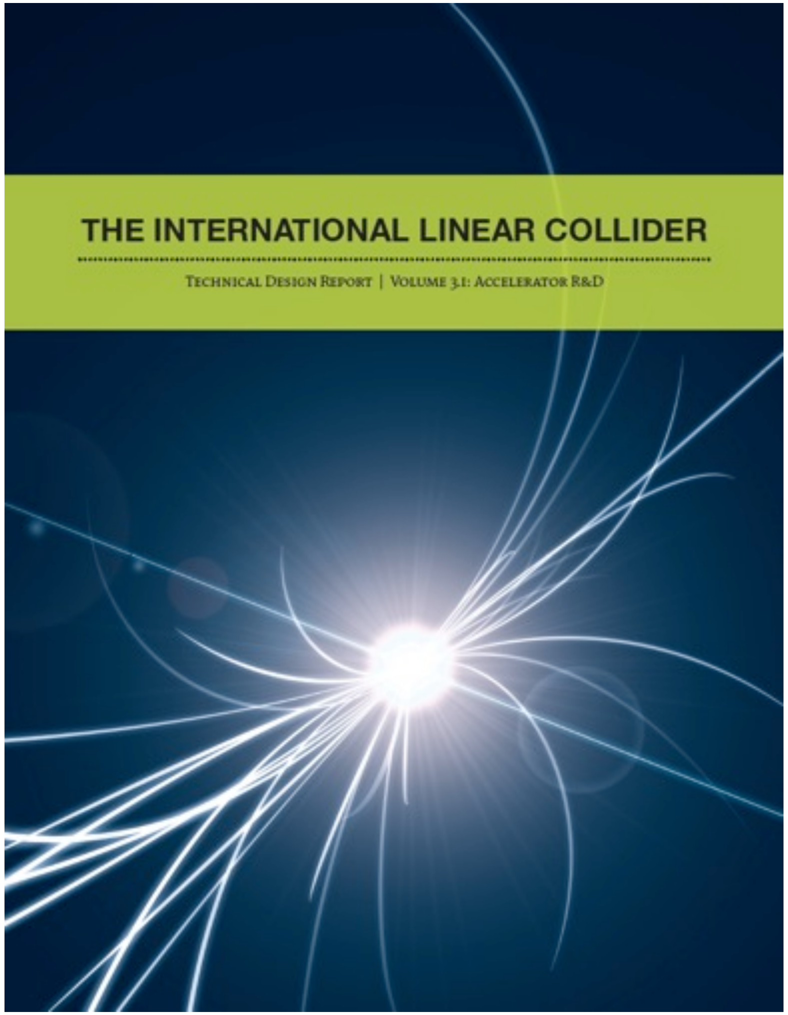
- **ILC Technical Design Report (Published, June, 2013)**
  https://www.linearcollider.org/ILC/Publications/Technical-Design-Report
  – Vol. 1. Executive Summary
  – Vol. 2. Physics
  – **Vol. 3, P1. Accelerator: R&D in the TD Phase**
  – **Vol. 3, P2. Accelerator: Baseline Design**
  – **Vol. 4. Detectors**
  – (+) From Design to Reality
- **TDR Supporting Documents**
  https://www.linearcollider.org/ILC/Publications/Technical-Design-Report
  – Project Implementation Planning
  – Cost Conversion Report
  – Guide to the Cost Estimate
  – List of signatures



- ILC TDR Value Estimate and Schedule (confidential documents)
  – V. 6.0, April 13, 2013.
- Further details in ILC EDMS (confidential documents),

ILC-TDR Vol. 3-I Accelerator R&D

Vol. 3-I, ILC 加速器技術開発



1. Introduction
2. Superconducting RF (SCRF) technology
    1. Cavity field **gradient**
    2. Cavity system test: **S1 Global**
    3. Industrialization **E-XFEL**
    4. …
    5. …

    focused
3. Beam Test Facilities
    1. SCRF, Beam Acceleration: **FLASH, STF,**
    2. Nano-beam handling : **ATF**
    3. E- cloud mitigation: CESR-TA
    4. …
    5. …

    focused
4. Accelerator Systems R&D
5. Conventional Facilities and Siting Studies
6. Post-TDR R&D (to be briefly reported)
    1. **SCRF, ATF, …**

Global Cooperation for Test Facilities

国際協力による加速器試験施設

TTF/FLASH (DESY) ~1 GeV
ILC-like beam   ILC RF unit

STF (KEK) operation/construction
ILC-like Cryomodule test： S1-Gloabal
SRF beam acceleration : QB, STF2

CesrTA (Cornell)
electron cloud
low emittance

DESY

INFN Frascati

KEK, Japan

FNAL

Cornell

DAΦNE (INFN Frascati)
kicker development
electron cloud

ATF & ATF2 (KEK)
ultra-low emittance
Final Focus optics, nano-beam
KEKB electron-cloud

NML/ASTA facility
ILC RF unit test
Full-CM Test,
SRF beam acceleration, soon

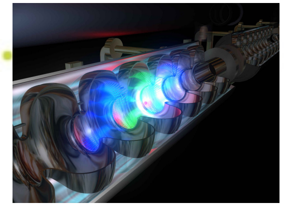
Technical Highlight in TD Phase

技術設計段階での技術開発・ハイライト

- **SCRF Technology（超伝導・ビーム加速技術）**
  - Cavity: High Gradient R&D:
    - 35 MV/m with 50% yield by 2010 , and 90% by 2012 (TDR)
    - Manufacturing with cost effective design
  - Cryomodule performance including HLRF, and LLRF
  - Beam Acceleration
    - 9 mA: FLASH
    - 1 ms: STF2 - Quantum Beam
- **Nano-beam handling （ナノビーム技術）**
  - ILC-like beam acceleration
    - Ultra-low beam emittance: Cesr-TA, ATF
    - Ultra-small beam size at Final Focusing: ATF2

Advantage of Superconducting RF

超伝導RF の特色・利点



- ❖ Ultra-high (Q_0 =10^{10}):
  - small surface resistance → almost zero power (heat) in cavity walls
  - use relatively low-power microwave source to 'charge up' cavity

  (高い高周波電力効率）

- ❖ Long beam pulses (~1 ms)

  → intra-pulse feedback

  （パルス中でのフィードバック制御、可）

- ❖ Larger aperture / smaller beam loss

  → better beam quality with larger aperture - lower wake-fields

  （大口径→少ビームロス）

- ❖ Work necessary on engineering for:
  - Cryomodule (thermal insultation)
  - Cryogenics

    （冷却）
  - Gradient to be further improved

Luminosity:

RF efficiency

RF power / beam current

$$L \propto \frac{\eta P_{RF}}{E_{CM}} \sqrt{\frac{\delta_{BS}}{\varepsilon_y}}$$

Vertical emittance (tiny beams)

- ❖ Luminosity proportional to RF efficiency ILC
  - ❖ (ルミノシティはRF効率に比例):
  - ❖ for given total power (electricity bill !),
  - ❖ ~160MW @ 500GeV
- ❖ Capable of efficiently accelerating high beam currents （大電流）
- ❖ Low impedance aids preservation of high beam quality (low emittance)（良質ビーム）

→ Ideal for Linear Collider

Global Plan for SCRF R&D

超伝導空洞技術開発タイムライン

Year	07	2008	2009	2010	2011	2012
Phase	TDP-1			TDP-2		
Cavity Gradient （電界） test to reach 35 MV/m	→ Yield 50%			→ Yield 90%		
Cavity-string to reach 31.5 MV/m, with one-cryomodule (システム)		Global effort for string assembly and test (DESY, FNAL, INFN, KEK)				
System Test with beam acceleration (ビーム)		FLASH (DESY) , NML/ASTA (FNAL) QB, STF2 (KEK)				
Preparation for Industrialization (工業化)			Production Technology R&D			
Communication with industry （企業との検討:	1st Visit Vendors (2009), Organize Workshop (2010) 2nd visit and communication, Organize 2nd workshop (2011) 3rd communication and study contracted with selected vendors (2011-2012)					

Progress in 1.3 GHz Cavity Production

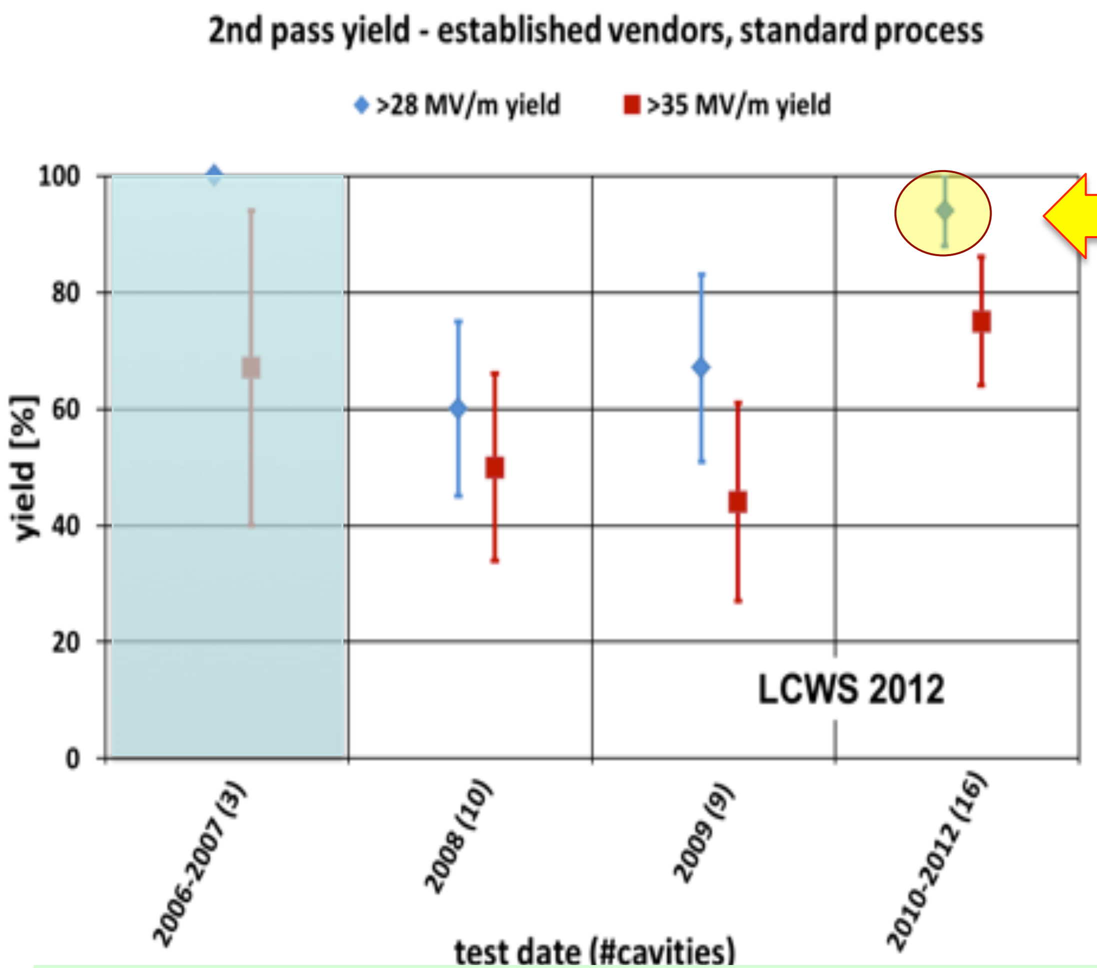
1.3 GHz 超伝導加速空洞製造実績の進展

year	# 9-cell cavities qualified	Capable Lab.	Capable Industry
2006	10	1 DESY	2 ACCEL, ZANON
2011	41	4 DESY, JLAB, FNAL, **KEK**	4 RI, ZANON, AES, MHI,
2012	(45)	5 DESY, JLAB, FNAL, **KEK**, Cornell	5 RI, ZANON, AES, **MHI,** **Hitachi**

- One Lab (2 vendor) in 2006, and 5 Lab (5 vendor) in 2012 may handle to fabricate 35 MV/m at Q= 8E9
- 6年間で、技術を保有する研究所、（製造会社）が1,(2) → 5 機関に、.

Progress in SCRF Cavity Gradient

空洞製造･成功率の向上



電界性能幅+/-20 %→成功率（歩留まり）~10% 向上

Production yield:
94 % at > 35+/-20%
（目標の> 90 % を達成）,

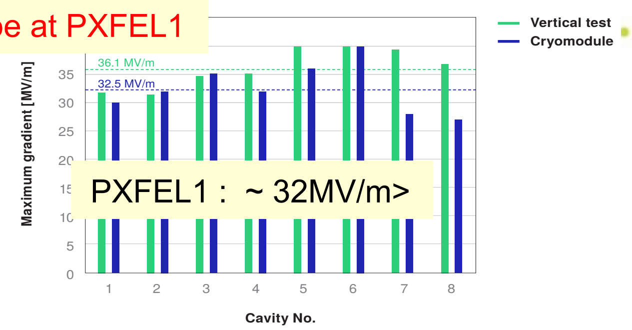
Average gradient:
37.1 MV/m

reached (2012)

Cryomodule System Test
超伝導加速空洞・CMおよびビーム加速実証試験

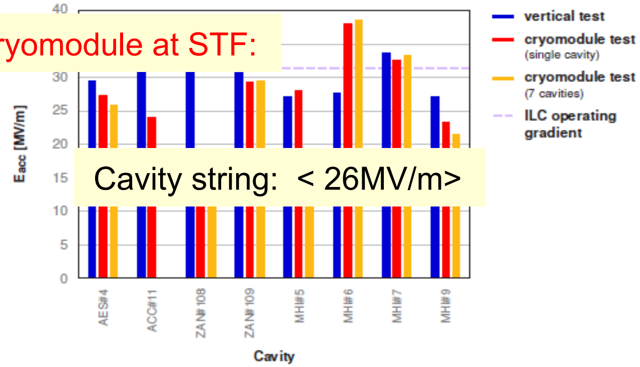
DESY: FLASH

- 1.25 GeV linac (TESLA-Like tech.)
- ILC-like bunch trains:
- 600 ms, 9 mA beam (2009); ← ILC ビーム電流の実証
  800 ms 4.5 mA (2012)
- RF-cryomodule string with beam → PXFEL1 operational at FLASH



KEK: SRF Test Facility (STF/STF2)

- S1-Global: completed (2010)
- Quantum Beam Accelerator (Inverse Laser Compton): 6.7 mA, **1 ms** ← ILC ビームパルス長の実証
- CM1 test with beam (2014 ~2015)
- STF-COI: Facility to demonstrate CM assembly/test in near future



FNAL: NML (New Muon Lab) / ASTA
(Advanced Superconducting Test Accelerator)

- CM1 test complete
- CM2 operation (2013)
- CM2 with beam (soon)