Progress Toward the International Linear Collider

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Marc Ross (FNAL)
Akira Yamamoto (KEK)

For the Global Design Effort

PAC’09 – Vancouver – 8.05.2009
The Global Design Effort*

3 Regions 16 Countries 76 Institutes

*Based on known participation and received expressions of interest

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14 Technical Area Groups coordinating the global effort
TD Phase 1 & 2: The R&D Plan

- Stated TDP Goals:
  - Updated ILC design
  - Results of critical risk-mitigating R&D
  - Updated VALUE estimate and schedule
  - Project Implementation Plan
TD Phase Stated Priorities (R&D Plan)

Risk Mitigating R&D
- SCRF Technology (e.g. gradient)
- Damping ring electron cloud
- ...

Beam Test Facilities
- ATF / ATF 2 (KEK)
- CesrTA (Cornell)
- TTF/FLASH (DESY)
- ...

Machine Design / Cost
- CFS / Value Engineering
- Accelerator Design & Integration
Global SCRF Technology

Implicit but critical GDE goal:

Promote development of 1.3GHz nine-cell expertise & infrastructure in all three regions

Major progress in infrastructure development in all three regions
Global SCRF Technology: ASIA

KEK, Japan
Global SCRF Technology: AMERICAS

FNAL, ANL
SLAC
Cornell
JLAB
KEK, Japan

NML Facility

1st U.S. built ILC/PX Cryomodule
Superconducting RF Technology

Critical R&D

35 MV/m Gradient Yield in 9-cell cavities

31.5 MV/m average gradient in a cryomodule

Linac "String Test"
SCRF Priority R&D: Gradient

- Gradient: single biggest cost driver

- RDR baseline:
  - $\geq 35 \text{ MV/m}$ vertical (acceptance) test
  - $\geq 31.5 \text{ MV/m}$ average operational gradient

- Proof of principle of gradient achieved
  - Many single-cells
  - Tens of 9-cells
  - Operational acceleration demonstrated (TTF/FLASH)

- GDE Focus on mass-production yield and cost
  - TDP-1 goal: *process yield* 50%
  - TDP-2 goal: *production yield* 90%
Progress Towards High-Gradient Yield

Recent DESY/JLab “production” series.

Total 39 cavities (08/09)

Mostly result of first cold-test (few cases second-test)

Field Emission greatly reduced (rinses) → identified RDR barrier

Baseline gradient re-evaluation (TDP1) expected to be based on sample of >60 cavities

Current status: 50% yield at ~ 33 MV/m; (80% >25MV/m)
Superconducting RF Technology

Critical R&D

35 MV/m Gradient Yield in 9-cell cavities

31.5 MV/m average gradient in a cryomodule

Linac "String Test"
S1-Global Collaboration

Complementary activity to regional cryomodule development

FNAL

DESY

INFN Milan

KEK, Japan

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Critical R&D

35 MV/m Gradient Yield in 9-cell cavities

31.5 MV/m average gradient in a cryomodule

Linac "String Test"
SRF Test Facilities

NML facility
Under construction
first beam 2010
ILC RF unit test ~2012

TTF/FLASH
~1 GeV
ILC-like beam
ILC RF unit
(* lower gradient)

STF (phase I & II)
Under construction
first beam 2011
ILC RF unit test by 2013

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A string test in each region

- **Complementary testing:**
  - Each region must develop industry and must develop ‘ownership’ of this critical technology

- **No one system will exactly represent the baseline reference design RF unit design (before 2012)**
  - **FNAL:** beam format [under review]
  - **KEK:** number of cryomodules [1 (of 3) by end 2012]
  - **DESY:** gradient [~27MV/m average over 3 cryomodules]

- **Strategy must account for infrastructure limitations and construction schedules at each of the three main linac test facilities under development.**
9mA Experiments in TTF/FLASH

RF gun
Laser
5 MeV

Diagnostics
Compressor
127 MeV

Accelerating Structures
Compressor
Bunch
450 MeV

260 m

<table>
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<tr>
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<th>XFEL</th>
<th>iLC</th>
<th>FLASH design</th>
<th>FLASH experiment</th>
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<td>2625</td>
<td>7200*</td>
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<td>mA</td>
<td>5</td>
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9mA Experiments in TTF/FLASH

RF gun  Diagnostics  Accelerating Structures
Laser  Compress  Bunch  Bunch
  5 MeV  12 GeV  300 MeV  1000 MeV

260 m

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ILC-like RF unit arrangement
FLASH Gradient limits

E_{acc} [MV/m]

module

ACC1     ACC2     ACC3     ACC4     ACC5     ACC6

cavity

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Denis Kostin, MHF-si, DESY
# Global Plan for SCRF R&D

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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<tr>
<td>Technical Design Phase</td>
<td>TDP-1</td>
<td>TDP-2</td>
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<tr>
<td>Cavity Gradient R&amp;D to reach 35 MV/m</td>
<td>Process Yield &gt; 50%</td>
<td>Production Yield &gt;90%</td>
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<td></td>
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<tr>
<td>Cavity-string test: with 1 cryomodule</td>
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<td></td>
<td>Global collab. For &lt;31.5 MV/m&gt;</td>
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<tr>
<td>System Test with beam 1 RF-unit (3-module)</td>
<td>FLASH (DESY)</td>
<td>STF2 (KEK) NML (FNAL)</td>
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Superconducting RF Technology

Critical R&D

Engineering Design Industrialisation Mass-Production

35 MV/m Gradient Yield in 9-cell cavities

31.5 MV/m average gradient in a cryomodule

Linac "String Test"

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Cavity: Plug-compatible Interface

- Allow innovative R&D to continue
  - e.g. novel cavity shapes
- Allow quasi-independent regional development of cost-effective manufacture
- Set boundary conditions and maintain focus

Component interfaces are reduced to the minimum necessary to allow for system assembly

Rapid transition from R&D to construction project
Toward Industrialization

- Global status of Industries
  - Research Instruments and Zanon in Europe
  - AES, Niowave, PAVAC in Americas
  - MHI in Asia

<table>
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<tr>
<th>Project Scope</th>
<th>Cost</th>
<th>Time</th>
<th>Output</th>
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<tr>
<td>Euro XFEL</td>
<td>~800</td>
<td>2 years</td>
<td>~1 cavity / day</td>
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<tr>
<td>Project X</td>
<td>~400</td>
<td>3 years</td>
<td>~2 cavities / week</td>
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<tr>
<td>ILC</td>
<td>~15,500</td>
<td>4 years</td>
<td>~20 cavities / day</td>
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<tr>
<td>(~3 regions)</td>
<td></td>
<td></td>
<td>~7 cavities / day</td>
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- Industrial Capacity: status and scope
  - No company currently has required ILC capacity
  - Understand what is needed (and cost) by 2012
Industrialization and cost reduction

- Re-visit previous effort, and update the cost-estimate for production
  - Review the RDR cost estimate (based on TESLA)
  - Include recent R&D experience (industry/lab)

- Encourage R&D Facilities for industrialization
  - Develop cost-effective manufacturing, quality control and cost-reduction in cooperation with industry

- Reflect the R&D progress for cost-reduction
  - Baseline ⇒ Forming, EBW, assembly work...
ILC: more than just SCRF

Sources
- Positron production
- Polarised electrons
- ...

Damping Rings
- Electron cloud
- Fast kickers
- Low emittance tuning
- ...

Beam Deliver System / MDI
- Optics / demagnification
- FD design
- Stability & feedbacks
- Detector integration
- ...

Beam Test Facilities

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(Non-SRF) Beam Test Facilities

- ATF & ATF2 (KEK)
  - Ultra-low emittance
  - Final Focus optics
  - KEK, Japan

- CesrTA (Cornell)
  - Electron cloud
  - Low emittance

- INFN Frascati

- DAΦNE (INFN Frascati)
  - Kicker development
  - Electron cloud
Example: e-cloud & CesrTA (Cornell)

- **e-cloud**: high-priority risk mitigating R&D

- Cornell SLAC KEK INFN...

- CesrTA: dedicated test facility to
  - Test e-cloud suppression techniques
  - Benchmark and develop theoretical understanding (codes)
  - Develop low-emittance tuning techniques

Sample 1: Radial outside
Sample 2: 45° from radial outside

L3 Experimental Region

Ion Detector (ERL)

PEP II Chicane

SEY Station

EC VC

West

East

Configured for In Situ SEY Measurements

Sample
Example: ATF & ATF2 (KEK)

ATF2 (Final Focus)
- Demonstration of demagnification / compact optics
- Vibration stabilisation
- Instrumentation

ATF (Damping Ring)
- Demonstration of ultra-low emittance (2pm) and its stability
- Fast kicker (beam) tests

From QD20X to the dump

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Integration & Design Activities

Cost (VALUE) Estimate

- Estimated cost (2007) ~6.7 Billion ILCU*
  - 4.87 BILCU shared

- 10,000 person-years “implicit” labour
Integration & Design Activities

- Primary TD Phase Deliverable:
  - Updated design
  - Updated VALUE estimate

- RDR sound base-line
  - Mature, but
  - Conservative

- Use ‘additional’ time to look at options
  - Cost not performance driven
  - CFS cost-driver ⇒ reduce underground volume

Cost (VALUE) Estimate

- Estimated cost (2007) ~6.7 Billion ILCU
  - 4.87 BILCU shared

- 10,000 person-years “implicit” labour
Cost-Driver Design Studies

- Single Tunnel Configuration(s)
- Reduced Beam Power
  - less RF,
  - smaller DR
- Central Injector Housing Integration
  - Sources sharing tunnel with BDS
- CFS: Value Engineering

10-15% TPC
Novel RF Distribution Concepts

2x35 klystrons housed in surface building.
350MW feeds via 0.5m diameter circular waveguide

DRFS (KEK)

Klystron Cluster (SLAC)

Single Tunnel Solutions
Linac Tunnel configurations – 3 of 7 under study
Summary 1/2

- Plans for extended Technical Design Phase now established

- Significant progress on all identified priority R&D
  - Despite 2008 funding crises

- Primary focus maintained on SCRF
  - Cost driver
  - Development in all three regions
  - On-track
    - Significant progress on gradient yield
    - S1-global programme: high-gradient CM and plug compatibility demonstration
    - No full “ILC-spec” string test within TDR time-scale
Summary 2/2

- Major Beam Test Facility addressing (non-SCRF) risk mitigating R&D
  - CesrTA – e-cloud
  - ATF2 BDS/MDI issues
  - ...

- Design and integration activities (including CFS) focusing on updating baseline for TD Phase 2
  - Site variants being studied

We intend to be ready for LHC results in 2012

Thank you for your attention