GDE Global Program

Marc Ross for:
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GDE Project Managers

Risk Reduction (Cost, schedule, technical)
and
Cost Reduction through R&D and design work

Global Design Effort Technical Design Phase Goal:

- **Develop an 'ILC Project Proposal' by mid-2012**
  - A complete and updated technical description
  - Results from critical R&D programs
  - One or more models for a Project Implementation Plan that include in-kind contribution schemes
  - An updated and robust VALUE estimate and construction schedule

- **TD Phase 1 (July 2010)**
  - Critical R & D
  - Potential for cost reduction
  - Re-baseline to prepare for technical design
  - Updated VALUE estimate and schedule
  - Project Implementation Plan

2008/2009: The R&D Plan

- **Goals, Resources and Schedule for the Global Program**
  - [Release 3, 02/2009]
- **Supporting documents:**
  - [Minimum Machine]
  - [Plug Compatibility]

ILC Research and Development Plan for the Technical Design Phase

Release 3

February 2009

ILC Global Design Effort

Director: Barry Barish

Prepared by the Technical Design Phase Project Management

Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

TD Phase 1 Schedule

Published in:

ILC Research and Development Plan for the Technical Design Phase

Release 3, June 2009
(next release 6 months)

Describe the global context for these activities

Show that the ART program supports and is consistent with GDE TDP1 plan

Value engineering

Value engineering

Global Project Plan

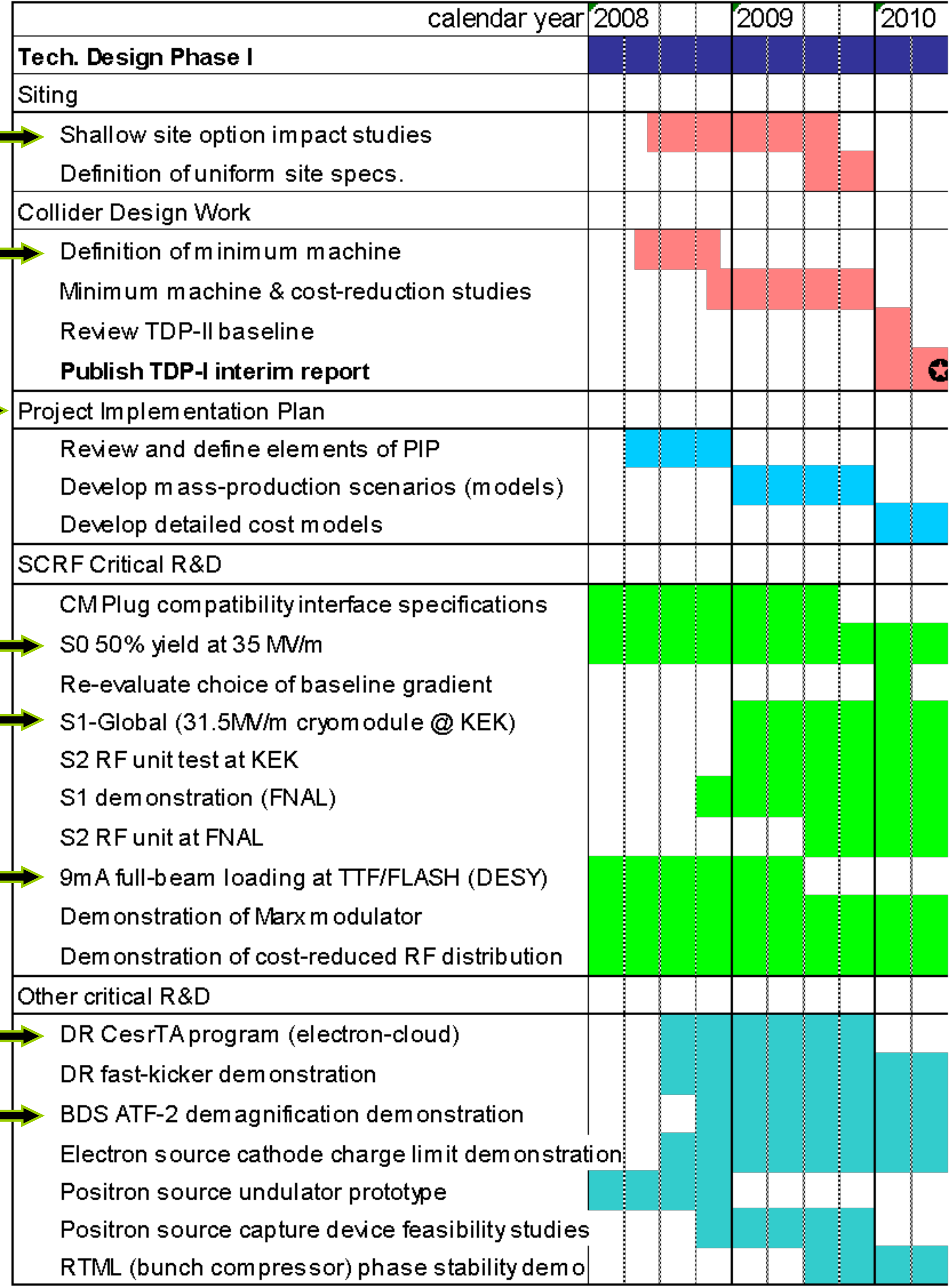
High Gradient

Cryomodule test

SCRF Linac test

Electron Cloud

Precision beam control



High Gradient:

Motivation:

- large potential impact on the cost of the ILC.
- RDR gradient choice is 35 MV/m in vertical test
- *present average: <u>33 MV/m</u>*

- **Limitations:**
  - Fabrication:
    - Equator electron beam welding (EBW)
    - Done in industry
  - Surface processing - Field emission
    - Clean room practice
    - High purity water rinse
    - Chemical process and rinse
    - Testing infrastructure
    - Done at institutions

Cavity R&D: To do →

- **Focus on the fabrication process,**
  - specially on EBW and understand the reasons for defects observed near the heat affected zone,
- **Widely adopt high-resolution optical inspection system**
  - Directly to cavity fabricators/manufacturers, and
  - Accumulate more inspection data and which can be shared by the cavity communities for quick feedback to fabrication process,
- **Boost laboratory-industry cooperation**
  - fair contribution and fair benefit/return, between laboratories and industries,
  - Leading to technology transfer, leveraged on laboratories contribution and effort.

Guidance and Advice from TESLA Technology Collaboration (TTC)

- TTC: derived from the TESLA Collaboration
  - Credited with TESLA SRF design
- Active across a broad set of SCRF topics

Proposal for an R&D Plan towards better Understanding of the Electropolishing of Niobium Cavities

P. Kneisel, K. Saito, D. Reschke
Jan. 17, 2006

Final Surface Preparation for Superconducting Cavities

An attempt to describe an optimized procedure

Reply to the

Request for Consultancy from TTC

raised by

the ILC R&D Board Task Force on High Gradients (S0/S1)

Cryomodule Test – checking global ‘plug compatibility’

Goal:

- R&D on the Cryomodule facilitates the development of a detailed ILC Project Implementation Plan
  - including an achievable project schedule and plan for competitive industrialization in all regions.
- assume ILC will require a flexible design *based on modular sub-components*.

Strategy:

- provide framework for technical and industrial development
  - Specify engineering interfaces between Cryomodule sub-components
    - and if possible within them

Plan:

- assemble and test a high-performance (31.5 MV/m average) cryomodule at KEK using components from each region (TDP 1)
  - 2 cavities from US, 2 from EU, 4 from Asia
- complements US CM efforts

Plug-compatibility: Summary

- **Plug Compatibility is**
  - a means to allow continued innovation from existing and new(!) collaborators while acknowledging the work is part of a larger effort.
  - a way to segregate work such that efforts on components and systems can proceed in parallel
  - a means in the longer term to be more efficient in infrastructure usage
- **Plug Compatibility does**
  - have an initial setup cost
  - impose some minimal boundary conditions, though strong efforts are made to keep them as minimal as possible

How we may prepare for Industrialization and cost reduction?

- **Re-visit previous effort, and update the cost-estimate for production**
  - Understand the cost estimate in RDR
    - mainly based on TESLA design work at ~ 10 years ago and the subsequent experience,
  - Reflect recent R&D experience with laboratories and industries,
- **Encourage R&D Facilities for industrialization**
  - To Learn cost-effective manufacturing, quality control and cost-reduction in cooperation with industries,
    - It is important to facilitate them at major SCRF laboratories and extend the experiences at various laboratories (DESY, Jlab, Cornell and others),
- **Reflect the R&D progress for cost-reduction**
    - Main effort for Baseline >> Forming, EBW, assembly work …
    - Alternate effort with limited scale>> large-grain, seamless, or …

SCRF Linac Systems Test

Goal:

- Demonstrate precision accelerator control in nominal ILC conditions
  - high gradient, full beam loading: 31MV/m, 9 mA, 5Hz
  - Achieve nominal performance specifications in realistic conditions → energy spread, stability etc
- Test higher order mode absorbers, cryo system, instrumentation…

Strategy:

- DESY – FLASH/TTF is the *only* suitable test facility available during TDP1
  - scale, beam parameters, instrumentation etc
  - testing also supports ongoing DESY projects / programs

Status:

- DESY – led, KEK, FNAL team started March 2008
- To be complete by March 2009.

ILC Linac Demonstration →

- **R and D Plan (2009):**
- "The effort to realize a cryomodule-string test in each region is highly encouraged as an important milestone for anticipated regional centres for the ILC construction period."
- **Demonstration will be done at the DESY-based main linac beam test facility TTF2/FLASH**
- **Nominal ILC performance –**
  - Reduced gradient → (see upcoming talk)
- **The highest priority goal:**
  - **to demonstrate beam phase and energy stability at nominal current**
    - **(includes bunch-to-bunch energy difference and pulse to pulse energy stability)**
- **Fermilab / KEK SCRF linacs ~ 2011**

A string test in each region:

- **Complementary testing:**
  - Each region must develop industry and must develop 'ownership' of this critical technology
  - including the cryomodules, beam generation and handling and the RF power source and distribution systems.
- **No one system will represent the baseline reference design RF unit design, *exactly, within the TD Phase time scale.***
  - due to institutional commitments to support parallel projects and also to conventional facilities limitations
  - Limitations:

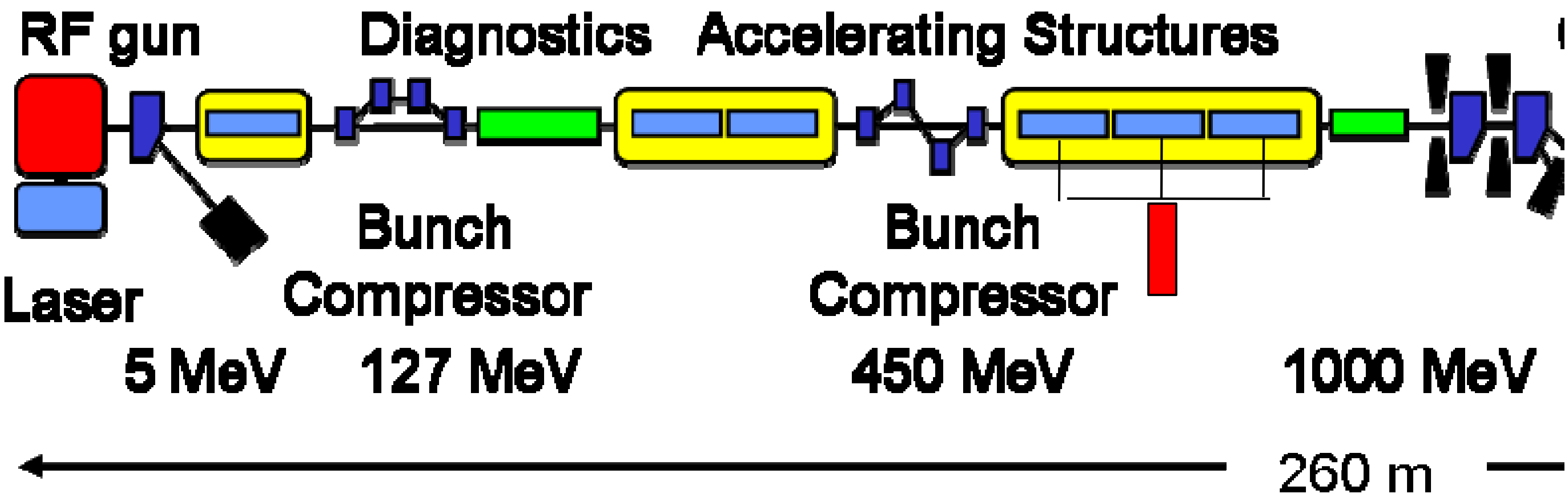
Fermilab:	KEK:	DESY:
Beam format	number of CM	gradient.

- **Strategy must account for infrastructure limitations and construction schedules at each of the three main linac test facilities under development.**

SCRF Test Linac Goals:

- **In addition, to be done at the above facilities:**
- **Secondary goals - impact on cost:**
  - demonstrate operation of RF-unit,
  - determine power overhead
  - measure dark current and x-ray emission
  - heating from higher order modes
- **Finally - understanding main linac subsystem performance.**
  - fault recognition and recovery procedures;
  - cavity quench rates and coupler breakdowns,
  - testing component reliability,
  - long term testing of cryomodule
  - tunnel mock up

XFEL vs. FLASH experiment



		XFEL X-Ray Free-Electron Laser	ilc	FLASH design	FLASH experiment
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

Accelerator Test Facilities

- **CesrTA - Control and mitigation of electron cloud effects**
  - Global collaboration led by Cornell:
    - KEK: support for wiggler vacuum chamber, implementation of beam size monitors
    - CERN & Fermilab: integration with proton accelerator electron cloud R & D
  - Strategy:
    - Test: vacuum chamber coatings, design, instrumentation and surface modeling
    - Test: beam dynamics simulations

- **ATF / ATF2 – control and monitoring of precision beams**
  - Global Collaboration led by KEK and SLAC:
    - Based loosely on the ATF collaboration MOU
    - Strong participation from all regions; a rough model of an in-kind ILC-like project
  - Strategy:
    - Test demagnification optics, tuning process and instrumentation with the ultra-low emittance ATF beam
      - (2 pm-rad vertical normalized emittance)

Test Facility Milestones

STF & ILCTA-NML	Cavity-string test within one cryomodule (S1 and S1-global)	2010
	Cryomodule-string test with one RF Unit with beam (S2)	2012
Electron cloud mitigation studies:		
CESR-TA	Re-configuration (re-build) of CESR as low-emittance e-cloud test facility. First measurements of e-cloud build-up using instrumented sections in dipoles and drifts sections (large emittance).	2008
	Achieve lower emittance beams. Measurements of e-cloud build up in wiggler chambers.	2009
	Characterisation of e-cloud build-up and instability thresholds as a function of low vertical emittance (≤20 pm)	2010

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Electron Cloud R & D

- **By mid-2010, CesrTA will have studied:**
  - Coated vacuum chambers → several coatings
  - Electrodes
  - Grooved vacuum chambers
  - (and ‘bare’ chambers’ as control)

- **Cloud density measurements:**
  - Electron analyzers
  - Tune measurements
- **Low emittance tuning**
- **Comprehensive program, includes simulation activities**
  - adequately supported

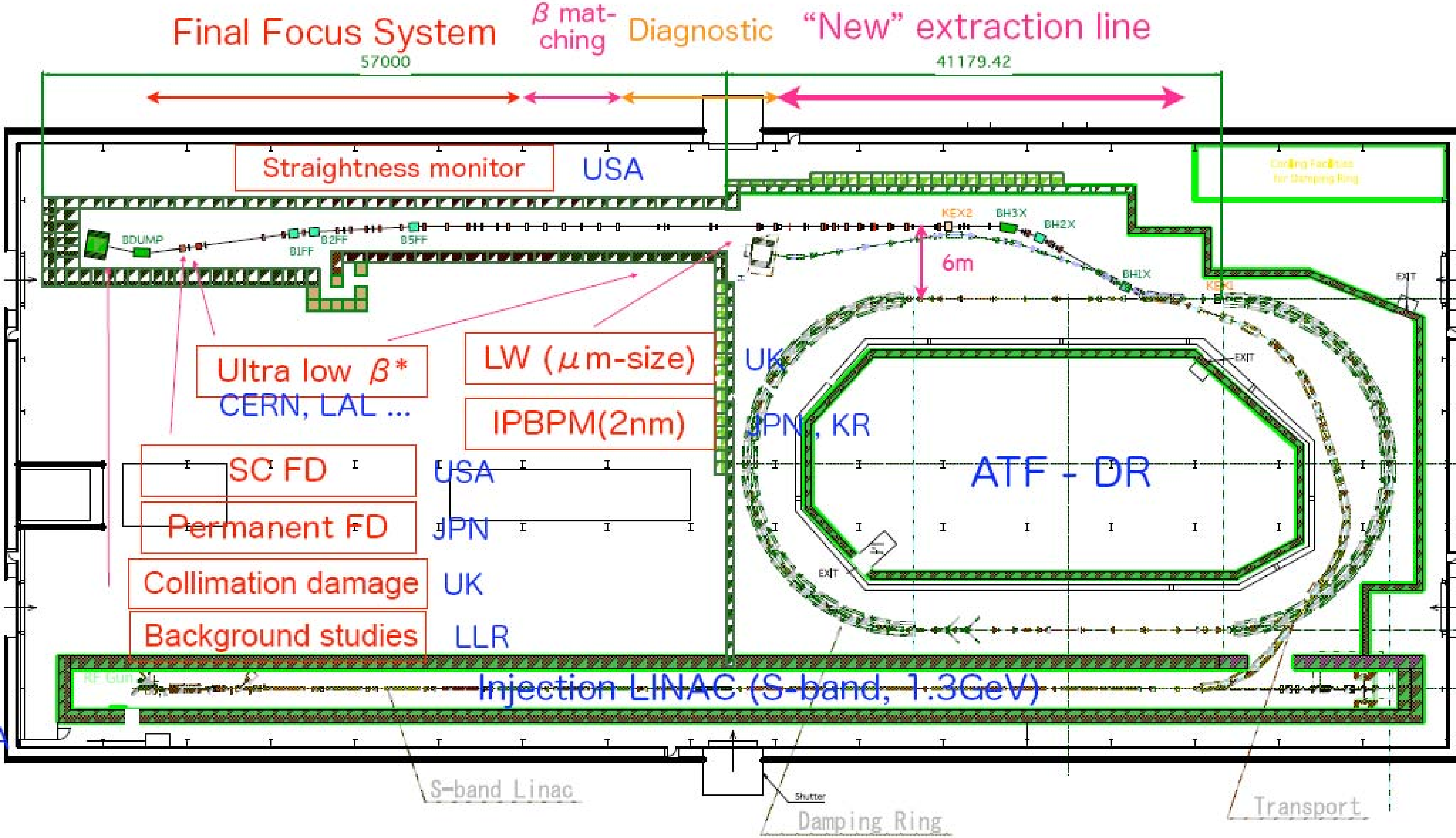
Damping Ring and Beam Delivery

- **→ the ATF / ATF2 Program:**
  - Overall Goals;
  - Demonstration of focusing and stability;
  - Demonstration of ultra-low emittance
- **A fundamentally *international / inter-regional* collaboration**

- **Commissioning started 2009**
- **Beam tuning / beam optics studies underway**

ATF2 beam line and planned/proposed R&Ds

2008 - 2010 - 2012 - 2014



Conventional Facilities and Siting

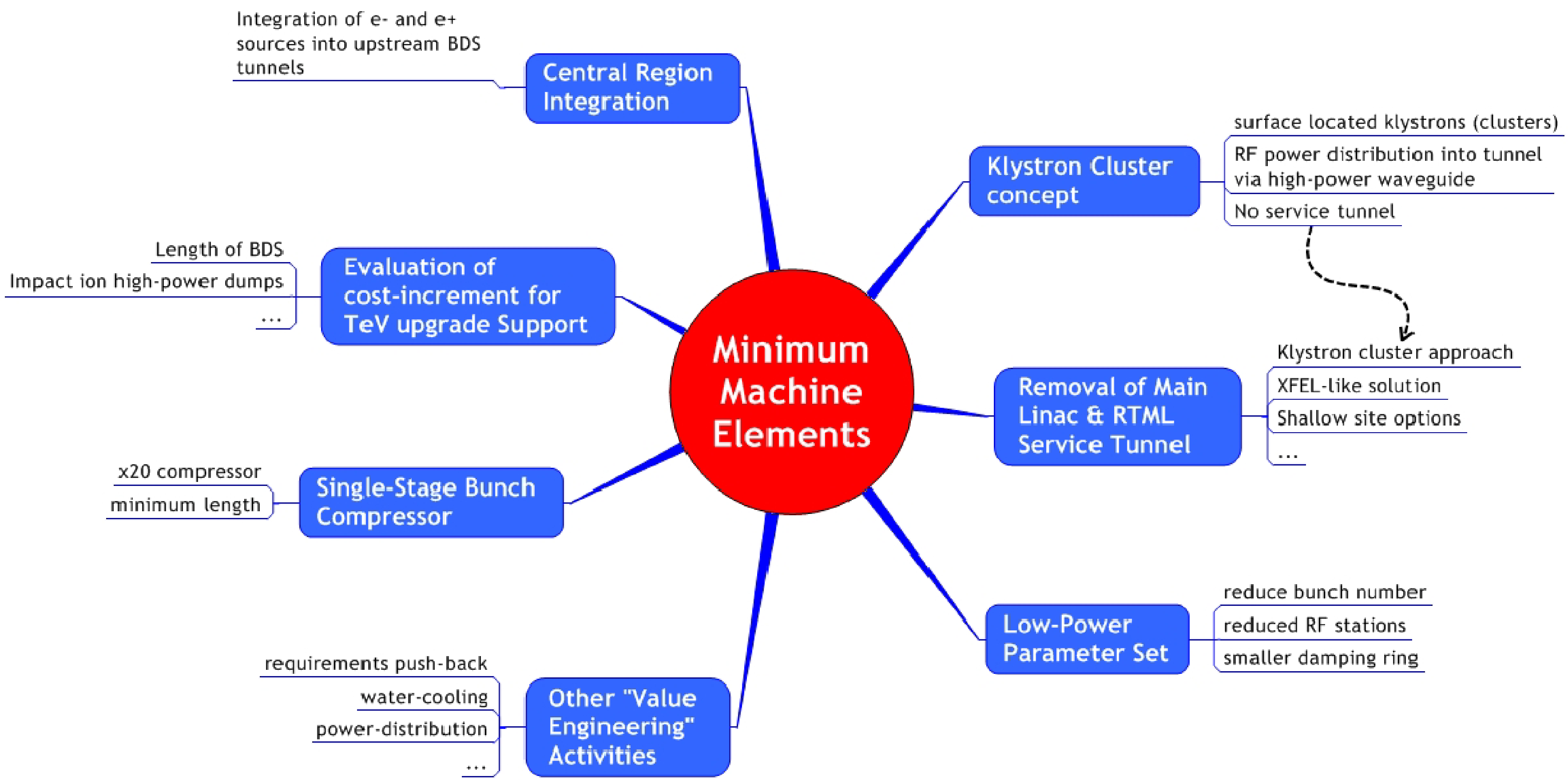
- **Purpose of CF / S effort in TDP:**
  - CF (utilities) effort cost driver, schedule driver
    - Can be challenging (e.g. J-Parc, Numi, …)
  - Fundamentally technical and political – more so than any other single project component
    - *Flexibility* should be a consideration in criteria development process
  - Development of *site-specific technical criteria* in order aid preparation of ‘hosting bids’
- **Basic focus of our Accelerator Design and Integration Activity**
  - Iterating CFS design (‘value engineering’)
  - Many aspects of this machine are unusual →
    - e.g. underground utility usage
  - Balance between generic design development and consideration of specific site details

Site Specific vs *Generic* Design

- **Reference Design is based on a generic twin – tunnel topology →**
  - adapted to sample sites - one in each region: Fermilab, CERN, Japan
  - 2007 Value estimate based on *average*
  - Topology-related cost differences between regions ~ small
- **NOT an optimized, site-specific adaptation of Technical systems**
  - Power / water, High level RF distribution, cryogenics → these were *NOT* adapted in Reference Design to suit each of the 3 sample sites
    - A common 'generic' design for the above chosen / costed for RDR

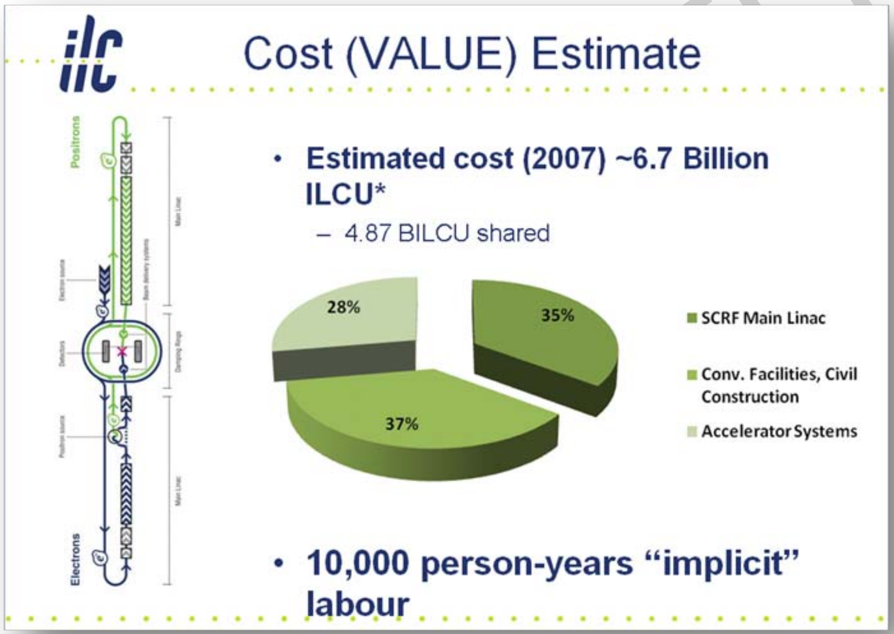
"Minimum Machine" →

Design and Integration Studies: toward a Re-Baseline in 2010 which will be the basis of TDP2 Engineering Design and Costing



Cost Decrements (Rough Estimates)

- **Main Linac (total)** **~ 300 MILCU**
- **Low-Power option** **~ 400 MILCU**
- **Central injector Integration** **~ 100 MILCU**
- **Single-stage compressor** **~ 100 MILCU**



- VERY preliminary: better estimates will be made (end 2009)
  - But still based/scaled from RDR value estimate
- Elements *not* independent! Careful of potential double counting!
- **Cost vs Performance vs Risk**: important information for making informed decisions in 2010

Organization and Review Process

	Technical Area		
	1. Superconducting RF Technology	2. Conventional Facilities & Siting and Global Systems	3. Accelerator Systems
Technical Area Groups	1.1 Cavity 1.2 Cavity-Integration 1.3 Cryomodules 1.4 Cryogenics 1.5 High Level RF 1.6 Main Linac Integration	2.1 Civil Engineering and Services 2.2 Conventional Facilities Process Management 2.3 Controls	3.1 Electron Source 3.2 Positron Source 3.3 Damping Ring 3.4 Ring To Main Linac 3.5 Beam Delivery Systems 3.6 Simulations

- **Reviews by:**
  - Project Advisory Committee
    - J. – E. Augustin, Chair
    - reports to ILCSC
    - October 19-20, 2008 – May 9-10, 2009
  - Accelerator Advisory Panel
    - Bill Willis, Chair
    - reports to Project Director, Barry Barish
    - April 2009

Resource Issues for TDP-2

- **Best knowledge of ILC resource base in given in R&D Plan tables**
- **In many cases numbers are inclusive and reflect our ‘in-kind’ R&D contributions philosophy**
- **This is OK for current TDP-1 activities**
  - Important to keep as large as possible R&D community linked to ILC GDE effort
  - Critical-path activities are covered (S0, e-cloud etc.)
- **CFS may be notable exception**

FTE Summary

- **Snapshot of our resource tables**
  - As of Release 3
  - Will be updated in July
- **“In-kind” R&D contributions**
  - No direct control in many cases
  - (ART an exception)
- **Typical per year total:**
  - SCRF 155
  - AS 73
  - CFS 4
- **CFS sub-critical**
  - Note does not include controls/LLRF

ART contribution to GDE

- **is consistent and significant**
  - But not dominant, overall

- **Gradient →**
  - approaching 35 MV/m
- **Cryomodule test →**
  - ‘CM2’ and Global cryomodule
- **Cryomodule ‘string test’**
- **Electron cloud**
- **Beam Delivery – precision beam handling**
- **CF & S – value engineering**
- **Accelerator Design**

The GDE TDP Program:

- **Has a broad inter-regional basis**
- **Is based on a multi-lateral collaboration**
  - Not centralized
- **Relies on ‘in-kind’ R & D contributions from partner labs and regions**
  - ILC project-specific
  - Other project-specific
  - Generic R & D
- **Has adequate resources for TDP1**
- **TDP2 planning now underway**