New Baseline Accelerator

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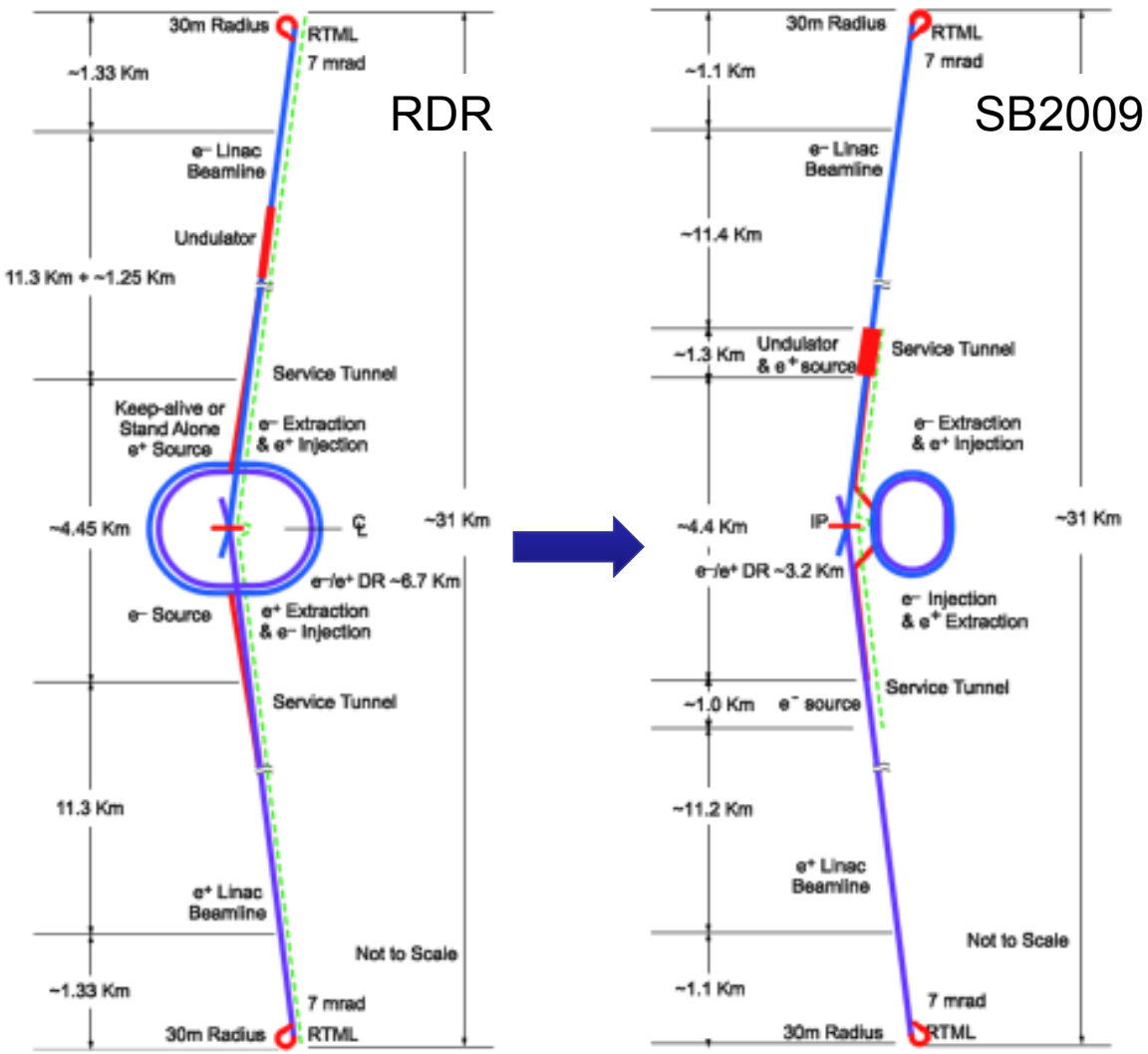
PAC Review – 20.05.2011

Overview

- **Process Overview (recap)**
- **Top-Level Change Control: Baseline Summary**
- **Next-Level Design Development**
  - towards the TDR
- **TeV Upgrade Study**
- **Planning for TDR**

Accelerator Design & Integration



- **2009 Design Studies**
  - on-going
- **Cost Constraint**
  - 'Global' Value Engineering
- **Towards an agreed-upon baseline for the TDR**
  - Top-Level Change Control Process (**TLCC**)
  - Communication with stakeholders (e.g. Physics & Detector groups)

SB2009 Working Assumptions

Seven Working Assumptions put forth in original SB2009 Proposal (Dec. 2009)

1. **31.5 MV/m average accelerating gradient**
2. **Single tunnel for Main Linacs**
3. **Undulator-based e^+ source relocation to end of e^- Main Linac**
4. **Reduced beam-power parameter set**
5. **3.2km circumference Damping Ring**
6. **Singe-stage bunch compressor**
7. **Central region integration**

http://ilc-edmsdirect.desy.de/ilc-edmsdirect/file.jsp?edmsid=*900425

SB2009 Working Assumptions

5 Taken forward as part of Top-Level Change Control process

(Four Themes)

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Possible impact on Physics & Detector

http://ilc-edmsdirect.desy.de/ilc-edmsdirect/file.jsp?edmsid=*900425

TLCC Process

1. Accelerating Gradient
2. Single-tunnel (HLRF)
3. Low-Power Parameter
4. Positron source location

1st BAW
KEK 7-10th Sept. 2010
2nd BAW
SLAC 18-21st Jan. 2011

Proposals submitted to director

Issue Identification

- Planning
- Identify further studies
- Canvas input from stakeholders
- …

Baseline Assessment Workshops

- Face to face meetings
- Open to all stakeholders
- Plenary

Formal Director Approval

- Change evaluation panel
- Chaired by Director

APPROVED

keywords: open, transparent

TLCC Documentation (EDMS)

TLCC-1	Proposal for average accelerating gradient	PDF
TLCC-2	Proposal for Main Linac Single Tunnel	PDF
TLCC-3	Proposal for reduced beam-power parameter set	PDF
TLCC-4	Proposal for relocation of positron source	PDF
CEP-1	Change Evaluation Panal's decision memo on the TLCC proposal on average accelerating gradient and ±20% gradient spread.	PDF
CEP-2	Change Evaluation Panal's decision memo on the TLCC proposal for a single tunnel solution for the Main Linac, with either KCS or DRFS (RDR HLRF Tech. solution as back-up).	PDF
CEP-3	Change Evaluation Panal's decision memo on the TLCC proposal for a single tunnel solution for the Main Linac, with either KCS or DRFS (RDR HLRF Tech. solution as back-up).	PDF
CEP-4	Change Evaluation Panel's decision memo on the TLCC proposal to relocate the positron source to the end of the main electron linac. Includes options for low-energy running based on 10Hz alternate pulse operation.	PDF

Reports to this Committee

For Reference

Nov 2010 Eugene	SB2009 Accelerator update	N. Walker	slides
May 2010 Valencia	SB2009 Accelerator Design & Integration	E. Paterson	slides
Nov 2009 Seoul	Proposed New Baseline Design	E. Paterson	slides
May 2009 Vancouver	Minimum Machine	E. Paterson	slides
October 2008 Paris	Machine Design and Cost-reduction Activities	N. Walker	slides

TLCC-1: Gradient

- **Average accelerating gradient of ≥31.5 MV/m**
  $Q_0 \geq 10^{10}$

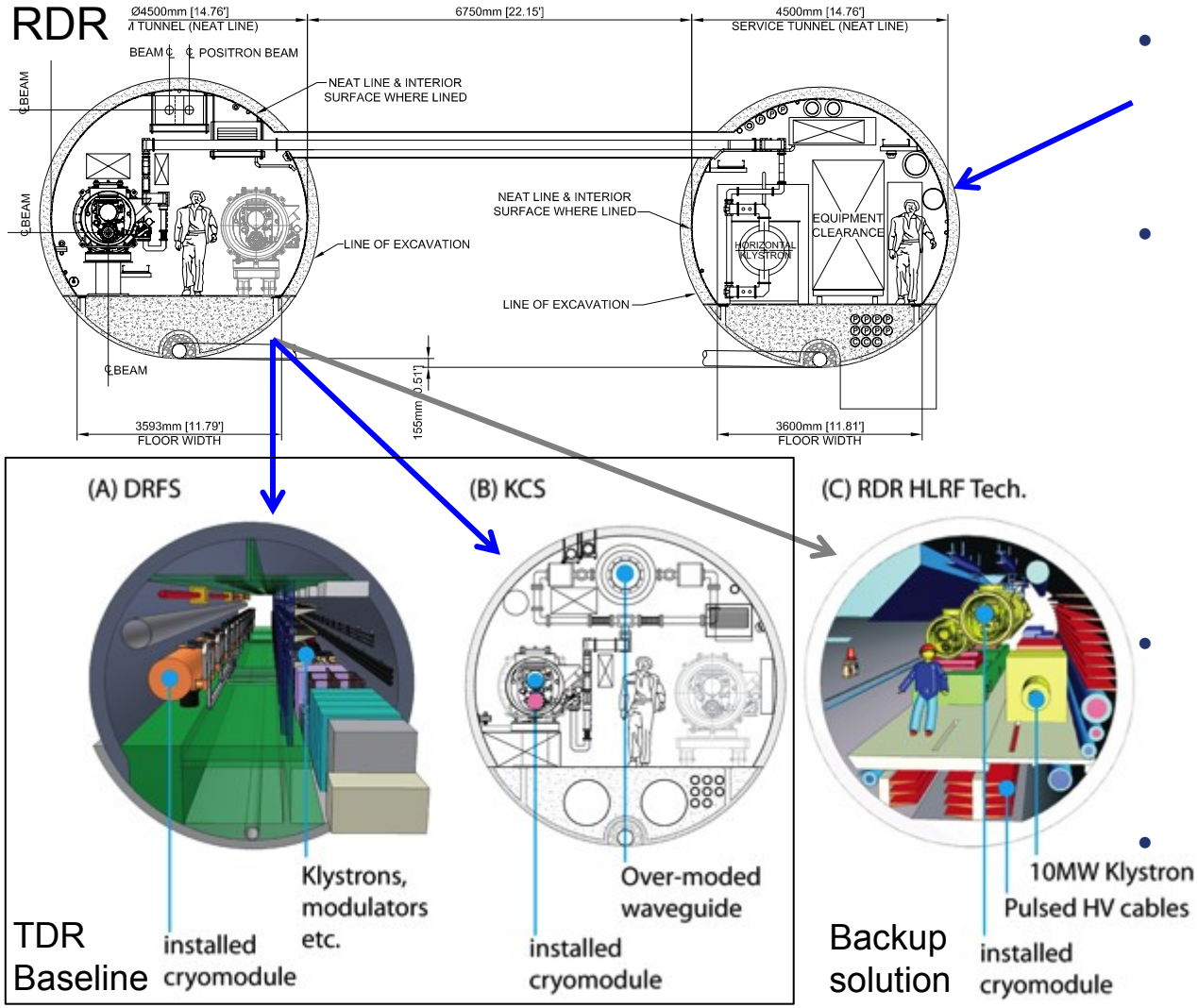
- **≤ ±20% Operational Gradient Spread (new)**
  - Acceptance Test ≥ 0.8×35 = 28 MV/m → **<u>yield improvement</u>**
  - Assumes (some) cavities will achieve 1.2×35 = 42 MV/m
  - 10% margin for assembly degradation, LLRF control etc.
  - 31.5 MV/m avg. E_{acc} in linac ($25 \leq E_{acc} \leq 38$ MV/m)

- **Primary impact on baseline design is RF power capacity**
  - Additional 10-15% required (reduced $\eta_{RF \rightarrow beam}$)
  - Operational challenges for LLRF (→9mA programme)
  - Increased cost, but $(1% E_{acc})/$(1% RF Power) ~ 4

TLCC-1: CEP Observations

- **Acknowledged forward looking goals**
- **Low statistics for production yield**
  - Strategy for demonstrating yield?
  - Reprocessing strategy (cost impact)?
  - What new information from e.g. XFEL production?
- **Cost of additional RF power**
  - Simulations to understand LLRF control issues
- **Maintain flexibility to adapt to evolving high-gradient R&D results**
  - cost advantage of gradient spread is difficult to quantify at this time

TLCC-2 Single Tunnel



- **Removal of ~25 km service tunnel**
  - central region (BDS/sources) retains service tunnel
- **Two variants for RF Power solution**
  - Distributed RF sources (DRFS) (mountainous region)
  - Klystron Cluster Scheme (KCS)
  - "Flat-land" site
  - **Both require R&D**
- **Considerations of**
  - Operations /installation
  - Availability
  - Safety egress
- **Back-up solution**
  - TESLA Tech. option in single tunnel (e.g. XFEL-like)

TLCC-2: CEP Observations

- **Level of design maturity for DRFS/KCS**
  - R&D programmes which go beyond 2012
    - KCS: power distribution system and operational aspects
    - DRFS: design for manufacture (cost)
- **Back-up solutions for RDR-like RF system**
  - Reduce possible options to singe feasible option
  - Feasible (single-tunnel) solution should be identified
- **Crowded tunnel layouts**
  - installation of large number of components etc.
- **Cost saving relative small (~2% TPC)**
  - may be reduced when energy margin/overhead considered in detail

TLCC-3 Low Beam Power

- **Reduce number of bunches per pulse by 50%**
  - 2600 → 1300
- **Allows to**
  - Reduce the circumference of DR from 6.4→3.2 km
  - Reduce the installed RF power by 30-50%*
  - Major cost saving
- **Recover luminosity by more aggressive beam-beam**
  - stronger focusing at IP
  - possibility of using travelling focus scheme
  - Top 30% luminosity is **high-risk** (compared to RDR)
- ***Solutions differ for baseline RF**
  - KCS: 6.0 mA current, 1.6 ms RF pulse
  - DRFS: 4.5 mA current, 2.2 ms RF pulse
- **Recovery (risk mitigation) / upgrade**
  - Restore (install) RF power (modulators/klystrons)
  - Allow possibility to construct a second DR for e+
    - 3rd ring in tunnel

CFS support in baseline to accommodate possible restoration

TLCC-3: CEP Observations

- **Acknowledge large cost saving associated with this approach**
  - Cautionary note on ‘scaled’ approach to cost reduction estimate.

- **Concern over high-risk of enhanced beam-beam**
  - and in particular travelling focus
  - Very tight stability issues and feedback feasibility
    - 0.1 σ_y at IP for few % luminosity loss

TLCC-4: Positron Source Relocation

- **Relocate undulator-based source at end of main electron linac**
  - RDR location: nominal 150 GeV point
- **Rationale:**
  - Consolidation of sources in central “campus” region (environment etc.)
  - Large energy overhead for driving source for E_{cm}>300 GeV
  - No need to decelerate the beam for E_{cm}<300 GeV
  - Further integration with stand-alone conventional source (AUX source) for commissioning/availability.
- **Requires implementation of 10 Hz alternate pulse scheme for E_{cm}<300 GeV**
  - Make use of reduce linac power to have separate pulse to generate positrons
  - Implications for RF sources and Damping Rings
    - cost increase
  - Some additional transfer lines and pulsed-magnet systems required in central region (not incl. in cost estimate)

TLCC-4: CEP Observations

- **Need for better evaluation of cost impact of 10Hz operation (KCS and DRFS)**
- **Need to re-evaluate parameters/solutions for 250-300 GeV**
  - physics driven ← LHC!
- **Issues pertaining to target survivability**
  - choice of magnetic capture device
  - high photon density on target at higher electron energies
- **Better specification of requirements for AUX source**
  - RDR chose 10% of full charge
  - AUX source likely to be lower (requirements?)

CEP Comments (General)

- **Many good and important observations**
- **No surprises – have been discussed several times**
  - CEP provided good summary of important points
- **Several cannot be addressed in detail in the remaining time (to TDR) but**
- **Several of them can and will be returned to during the BTR process (see later)**

Further consolidation of TDR baseline

- **Top-level baseline decisions have now been made**
  - Large ticket items (either cost or performance)
  - Mandatory interaction with Physics & Detector
  - Requiring Director sign-off

- **<u>Many</u> next-level detail decisions still required for TDR baseline**
  - **Many things** have changed/evolved from the RDR
  - Level of complexity and impact varies substantially
  - None are deemed to be as “high-level” as TLCC themes

Further consolidation of TDR baseline

- **Approach: continue successful format of the TLCC-BAW plenary workshops**
  - Baseline Technical Reviews (BTR)
  - Project Manager driven
    - no need for Director sign-off, unless…
  - Accelerator Integration & Design team orientated
  - Maintain strong involvement with **Physics & Detector** groups
  - Generate design documentation (→ILC-EDMS)
    - in preparation for cost estimation
    - in preparation for TDR writing

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   3.2km circumference Damping Ring

6. **Singe-stage bunch compressor (IP bunch length)**
7. **Central region integration (mostly e- source)**

Not considered for TLCC

Will be dealt with during relevant BTRs

[Note that 6 is borderline due to potential physics impact]

Baseline Technical Reviews

Damping Ring	7-8 July 2011	INFN Frascati
Sources, RTML incl. BC, BDS/MDI	24-28 October 2011	DESY
Main Linacs (SCRF)	19-20 January 2012	KEK
CFS/Global	February 2012 TBC	FNAL/CERN

- **Typically 2 days for each accelerator system**
- **Plenary (no parallel sessions)**
- **Open meetings (but working environment)**

Baseline Technical Reviews

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- **Goal: document and sign-off Baseline design elements**
  - Includes review of on-going (and needed) R&D
  - detained design documentation structured into ILC-EDMS WBS
  - cost review
- **Work is on-going via remote conferencing (monthly AD&I meetings)**
  - Workshop is the end result

From 500 to 1000 GeV

<26 km ?
(site length <52 km ?)

1.1 km | <10.8 km ? | 10.8 km | 1.3 km | 2.2 km

bunch comp. | Main Linac | e+ src | BDS | IP

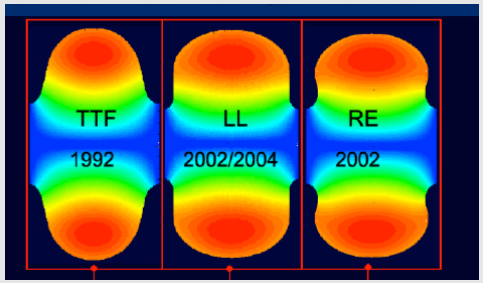
central region

ultra-high gradient R&D
>2012

Main Linac
$\langle G_{cavity} \rangle$ = 31.5 MV/m
G_{eff} ≈ 22.7 MV/m
(fill fact. = 0.72)

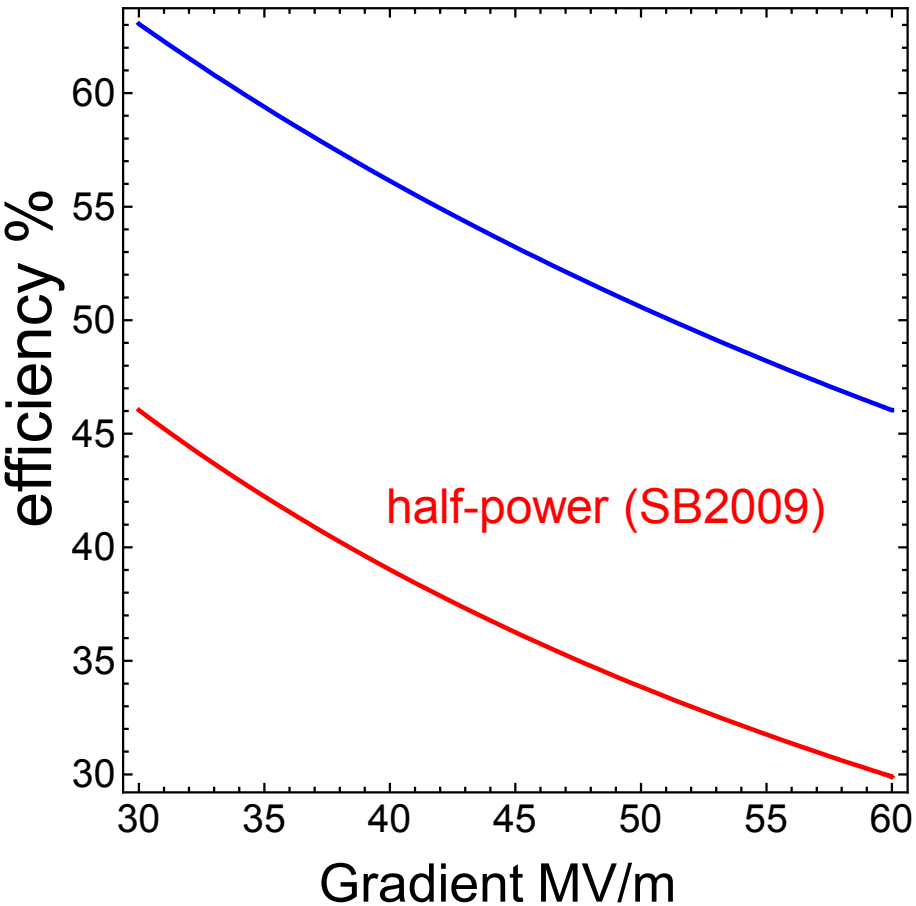
Snowmass 2005 baseline recommendation for TeV upgrade:

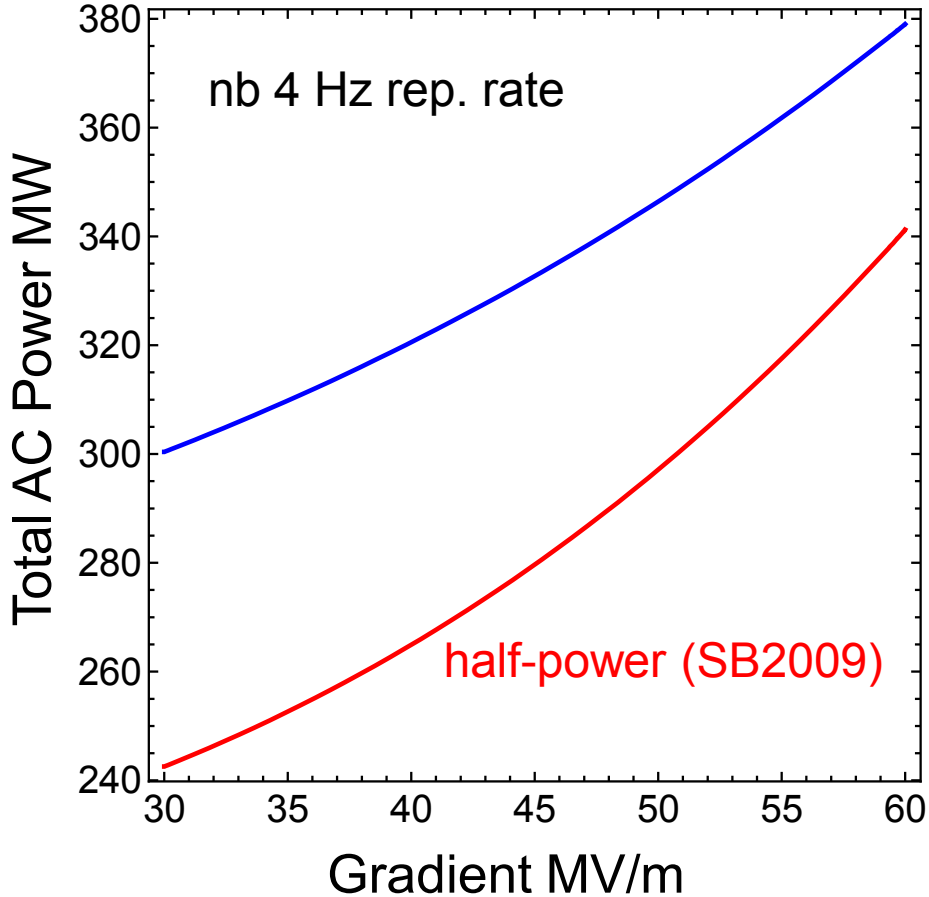
G_{cavity} = 36 MV/m ⇒ 9.6 km
(VT ≥ 40 MV/m)



Based on use of low-loss or re-entrant cavity shapes

Efficiency and Power





Simples scaling – needs more detailed analysis

1 TeV Tentative Parameters

Collision rate	f_{rep}	4	Hz
Number of bunches	n_b	2625	
Bunch population	N_-	2	$\times 10^{10}$
Bunch seperation	Δt_b	356	ns
Pulse current	I_{beam}	9.0	mA
RMS bunch length	σ_z	0.3	mm
RMS energy spread (e-, e+)	$\Delta p/p$	0.105, 0.038	
Polarisation (e^-, e^+)	P_-	80, 22	%
Emittance (linac exit)	$\gamma\varepsilon_{x,y}$	10, 0.035	µm
IP beta function	$\beta_{x,y}$*	30, 0.3	mm
IP RMS beam size	$\sigma_{x,y}$*	554, 3.3	nm
Vertical disruption parameter	D_y	19.2	
Luminosity	$\boldsymbol{L}$	**2.70**	$\times 10^{34}$ **cm^{-2}s^{-1}**
Fraction of luminosity in top 1%	$L_{0.01}/L$	63.5	%
Average energy loss	δE_{BS}	4.9	%
Number of pairs per bunch crossing	N_{pairs}	169	
Total pair energy per bunch crossing	E_{pairs}	1084	TeV

Current "official" parameter set in EDMS*.

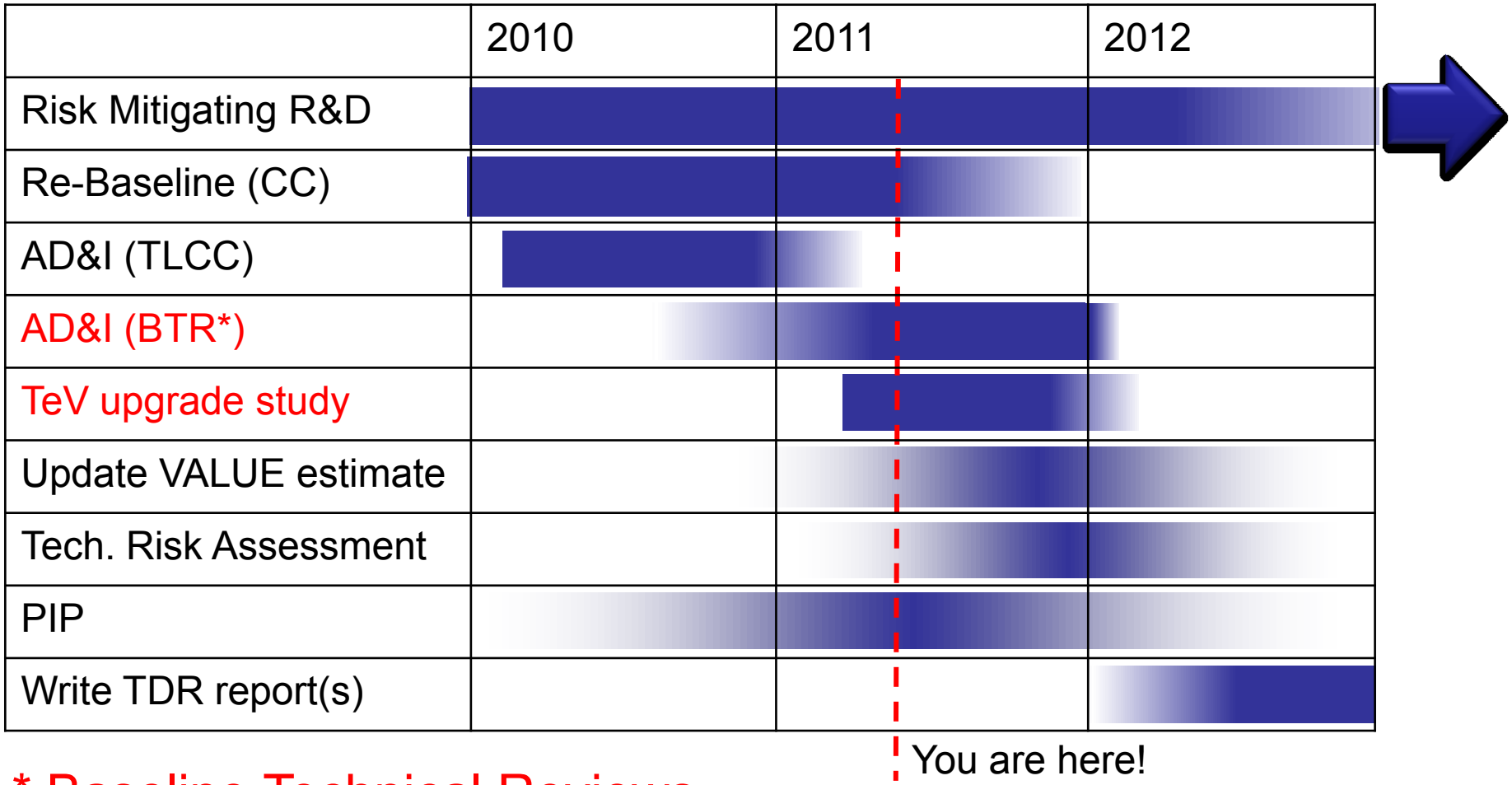
Should still be considered tentative, pending review and further study.

Understanding (and updating) these parameters is our job for the next ~6 months.

negotiation!

* EDMS Doc ID: D*925325
http://ilc-edmsdirect.desy.de/ilc-edmsdirect/file.jsp?edmsid=*925325&fileClass=ExcelShtX

Planning for the TDP 2



* Baseline Technical Reviews

TDP Key Focus (beyond R&D)

SCRF Cost	CFS design & cost	Baseline Design
• mass production models • global distribution	• Design update • Value engineering	• Final design decisions • Documentation • Cost estimate
Highest Priority (new estimate)	High Priority (updated estimate)	RDR update Documentation (scaled estimate)

Resources!

CFS requirements critical input

Summary

- **Four proposed changes to baseline now formally accepted**
  - TLCC process
  - Culmination of 18 months of work
- **AD&I efforts now focused on next-level of baseline detail (→ BTRs)**
  - Comprehensive review of TDR baseline
  - R&D status (TDR relevant)
  - Cost
  - Documentation!
- **TeV upgrade study now gaining momentum**
  - Increasing emphasis ← LHC!