ILC – Towards the Straw-man baseline 2009

E. Elsen

Contribution to SOCLE Meeting, Saclay, Nov 9, 2009

Disclaimer

- This is the attempt of a summary of the current developments towards the modifications of the Reference Design Report (RDR) issued in 2007

- Status is as of ALCPG 2009

- I have not attended the Albuquerque meeting myself

  - Material drawn from the slides presented there
    B. Barish, M. Ross, **N. Walker**, A. Yamamoto and the many experts who contributed

Design Considerations for the ILC

Towards a new baseline for TDP2:
an open discussion with the Detector & Physics Community

Overview

- History & Rationale
- Straw-man Baseline 2009 Working Assumptions
- Primary Focus & Issues
- Upgrades & Physics Scope Impact
- Process towards a new Baseline: Next Steps

The R&D plan of the GDE

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

ILC Research and Development Plan for the Technical Design Phase

Release 3

February 2009

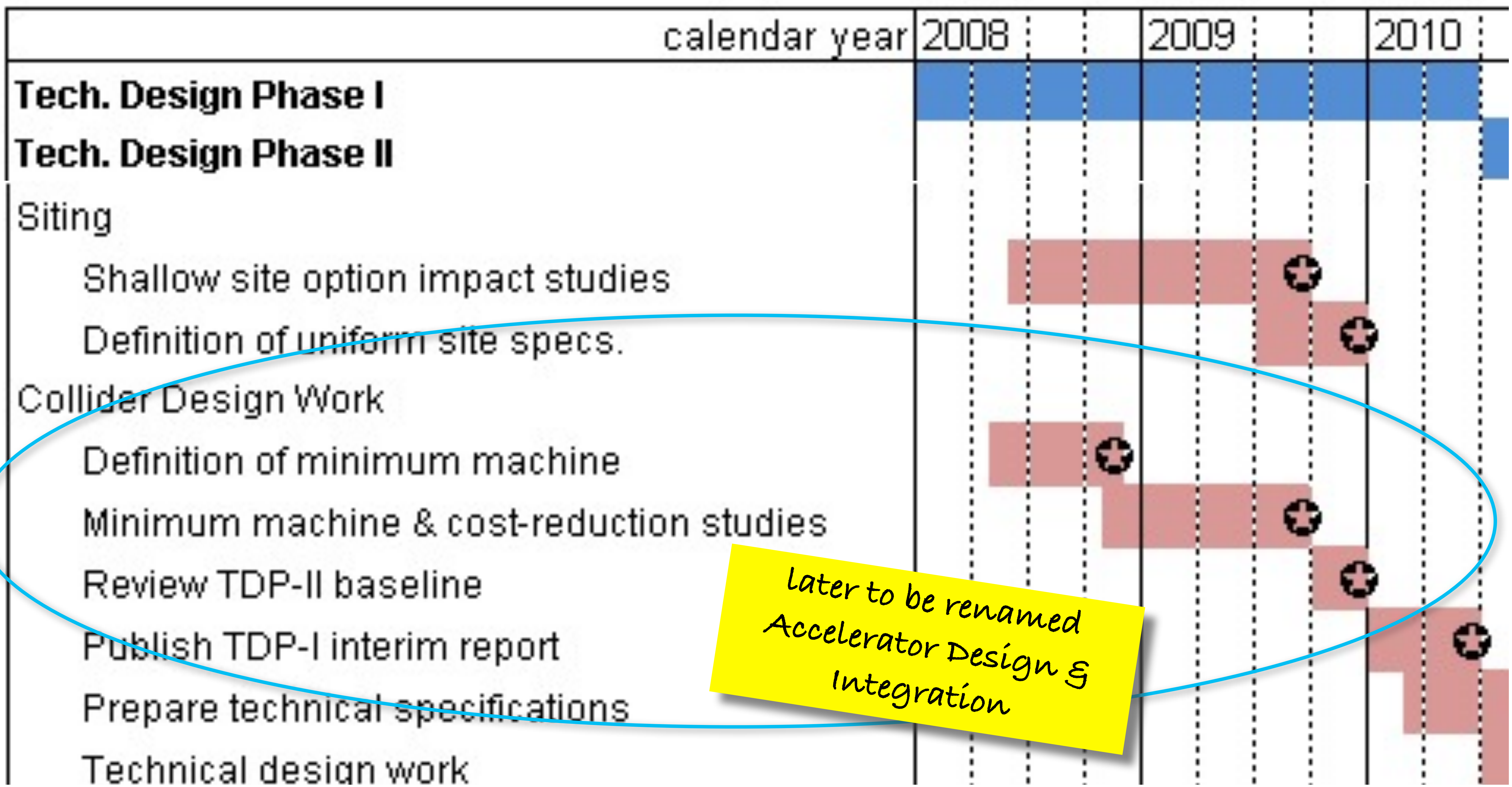
ILC Global Design Effort

Director: Barry Barish

Prepared by the Technical Design Phase Project Management

Project Managers: Marc Ross, Nick Walker, Akira Yamamoto

TDP R&D Plan



calendar year
2008
2009
2010
Tech. Design Phase I
Tech. Design Phase II
Siting
Shallow site option impact studies
Definition of uniform site specs.
Collider Design Work
Definition of minimum machine
Minimum machine & cost-reduction studies
Review TDP-II baseline
Publish TDP-I interim report
Prepare technical specifications
Technical design work
later to be renamed Accelerator Design & Integration

Rationale

- Cost constraint in TDR
  - Updated cost estimate in 2012 ≤6.7 BILCU
  - Need margin against possible increased component costs
- Process forces critical review of RDR design
  - Errors and design issues identified
  - Iteration and refinement of design
  - More critical attention on difficult issues
- Balance for risk mitigating R&D
  - Majority of global resources focused in R&D
  - Important to prepare / re-focus project-orientated activities for TDP-2
  - Need for design options and flexibility
  - Unknown site location

Expectation of Exercise:

- ✴**Robust**
- ✴**Mature**
- ✴**Defendable**

design

Basically a better design.

History (Review)

- DESY EC 01.2008
  - Cost reduction endorsed/encouraged as one of the themes of TDR Plan
- Sendai 03.2008
  - Cost reduction studies WG
- Dubna 06.2008
  - Review of Cost Reduction proposals (new ideas).
  - Single tunnel central theme
  - Consolidation of “Minimum Machine” elements.
- KEK EC 08.2008
  - EC endorses Minimum Machine elements
- PAC Paris 10.2008
  - Minimum Machine elements reviewed.
  - Focus on ‘simplification’ not cost saving.
- LCWS Chicago 11.2008
  - Discussions on Minimum Machine (clarification)
- TILC09 Tsukuba 04.2009
  - AAP review, including ‘minimum machine’
  - Renamed as AD&I
- DESY AD&I 05.2009
  - Formation of AD&I group
  - Project Management proposal SB2009 Working Assumptions
  - Action items
- ALCPG ‘09 Albuquerque 09.2009
  - Following slides

Initial Documentation

Start

ILC Minimum Machine Study Proposal

January 2009

Prepared by the Technical Design Phase Project Management

Editors:
Chris Adolphsen (SLAC)
Jim Clarke (STFC Daresbury Lab.)
Kiyoshi Kubo (KEK)
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Ewan Paterson (SLAC)
Marc Ross(FNAL)
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Working assumptions

Summary report of the first meeting on Accelerator Design & Integration 28-29th May, DESY

5th June, 2009

Editors:
Ewan Paterson (SLAC)
Marc Ross(FNAL)
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ILC-EDMS ID: D*879845

Contains proposed parameters tables

Straw-man Baseline Proposal

- A Main Linac length consistent with an optimal choice of average accelerating gradient
  - RDR: 31.5 MV/m, to be re-evaluated
- Single-tunnel solution for the Main Linacs and Ring-toMain-linac section (RTML), with two possible variants for the HLRF
  - Klystron cluster scheme
  - DRFS scheme
- Undulator-based e^+ source located at the end of the electron Main Linac (250 GeV)
  - Capture device: Quarter-wave transformer

Straw-man Baseline Proposal (cont'd)

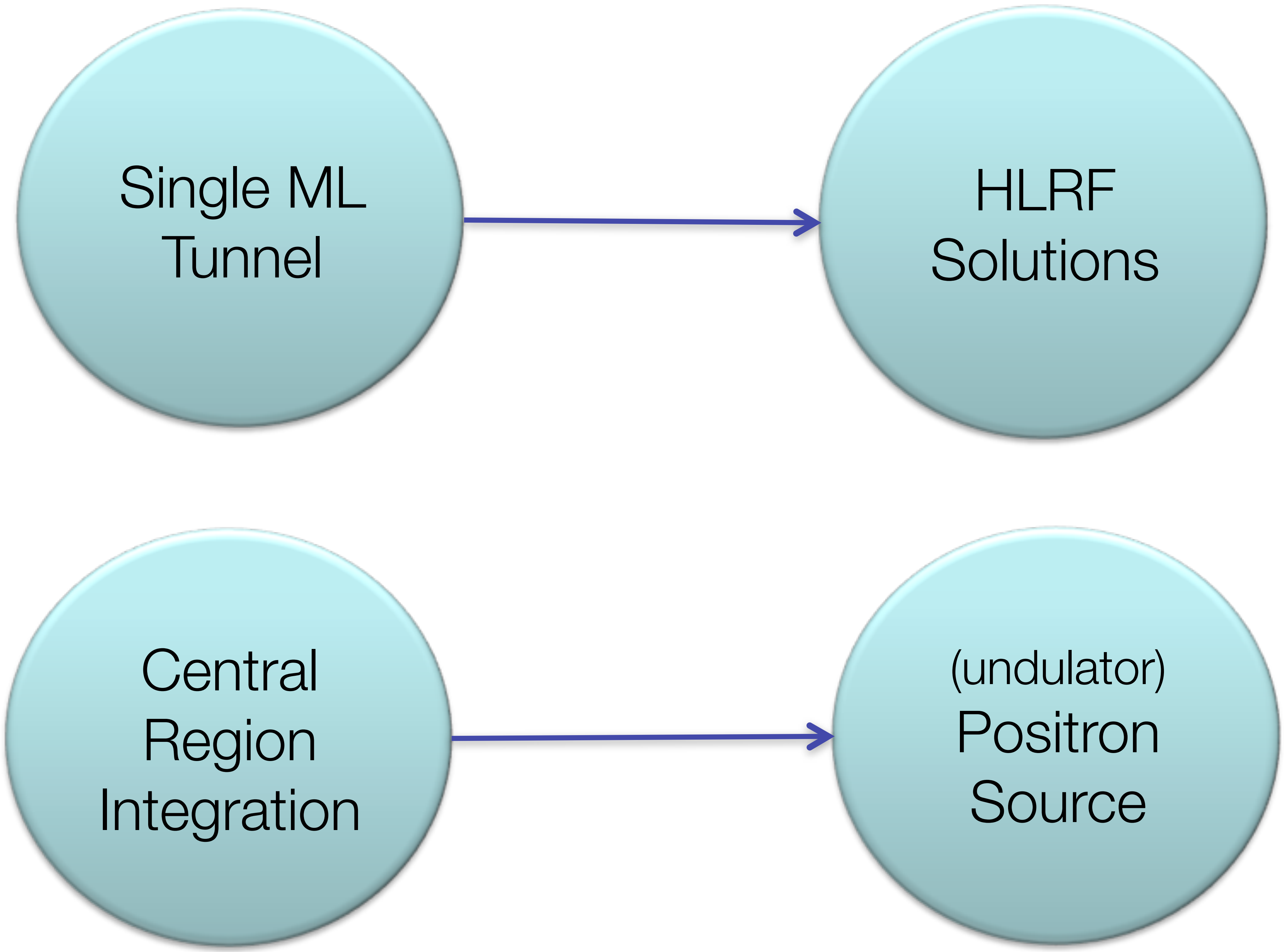
- Reduced parameter set (with respect to the RDR)
  - n_b = 1312 (so-called “Low Power”)
- Approx. 3.2 km circumference damping rings at 5 GeV
  - 6 mm bunch length
- Single-stage bunch compressor
  - compression factor of 20
- Integration of the e^+ and e^- sources into a common *central region beam tunnel*, together with the BDS.

		RDR	SB2009	
Beam and RF Parameters				
No. of bunches		2625	1312	
Bunch spacing	ns	370	740	
beam current	mA	9.0	4.5	
Avg. beam power (250 GeV)	MW	10.8	5.4	
Accelerating gradient	MV/m	31.5	31.5	
P_{fwd} / cavity (matched)	kW	294	147	
Q_{ext} (matched)		3×10^6	6×10^6	
t_{fill}	ms	0.62	1.13	
RF pulse length	ms	1.6	2.0	
RF to beam efficiency	%	61	44	
IP Parameters				
Norm. horizontal emittance	mm.mr	10	10	
Norm. vertical emittance	mm.mr	0.040	0.035	
bunch length	mm	0.3	0.3	
horizontal β^*	mm	20	11	
horizontal beam size	nm	640	470	
			no trav. focus	with trav. focus
vertical β^*	mm	0.40	0.48	0.2
vertical beam size	nm	5.7	5.8	3.8
D_y		19	25	21
dE_{BS}/E	%	2	4	3.6
Avg. P_{BS}	kW	260	200	194
Luminosity	$cm^{-2}s^{-1}$	2×10^{34}	1.5×10^{34}	2×10^{34}

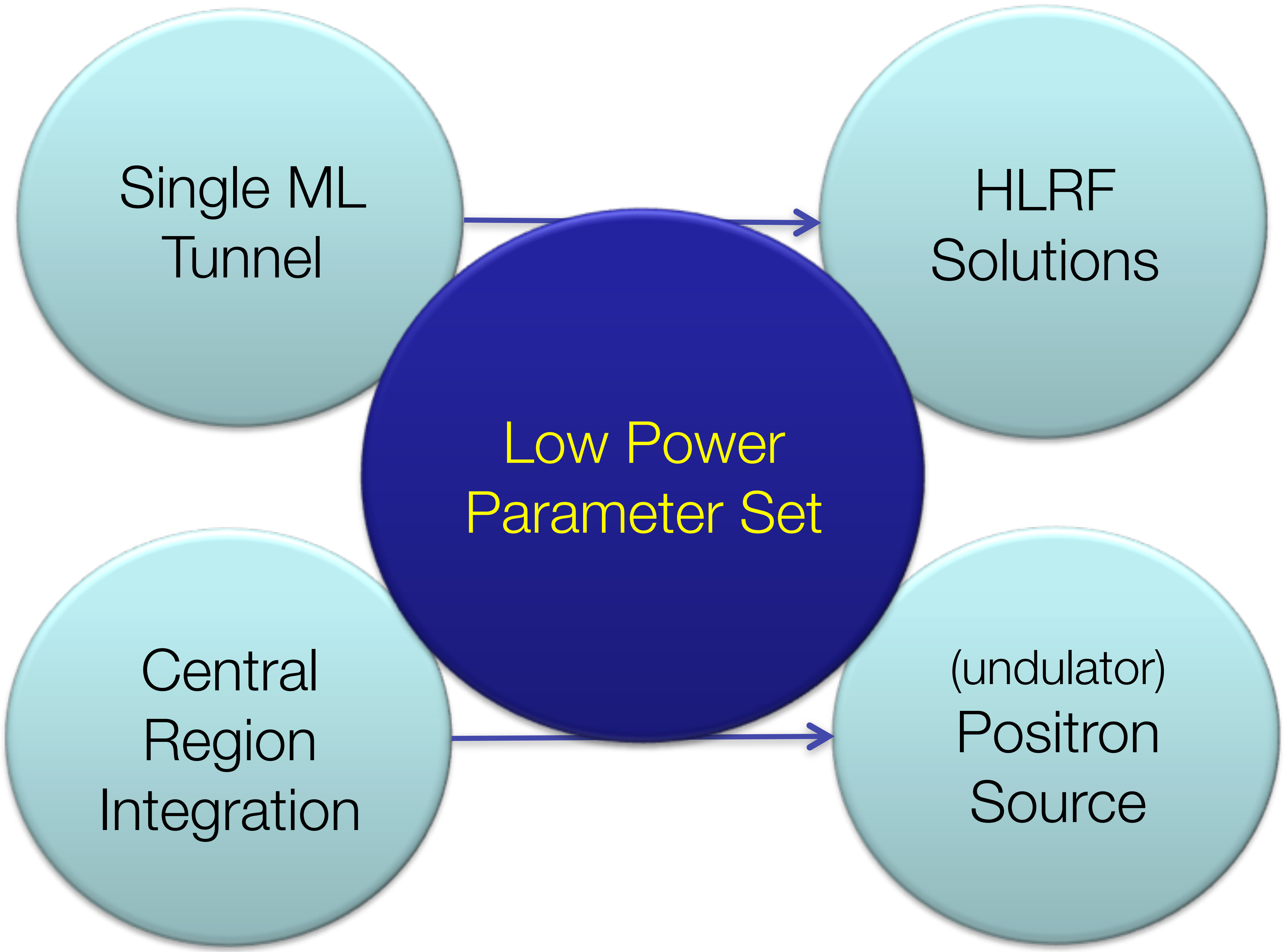
CFS: Primary Cost Driver

- Assumed primary advantage of SB2009 options is reduced CFS scope
  - Underground tunnel / volume
  - Reduced cooling requirements
- Focus of 2009 activities is to assess impact on CFS solutions
  - Removed, added, modified
- SB2009 reduces underground tunnel length by ~27 km

Primary Issues



Primary Issues



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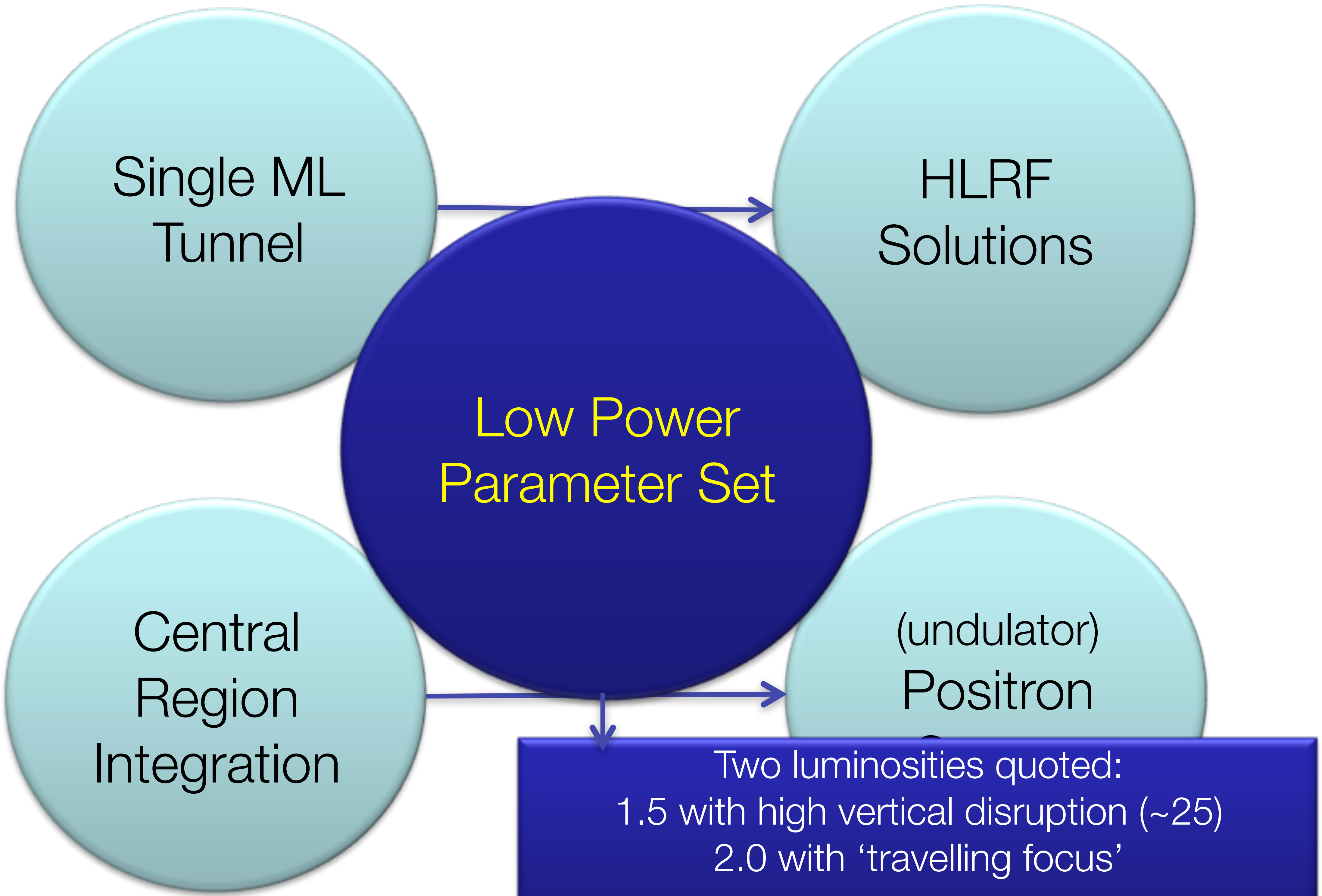

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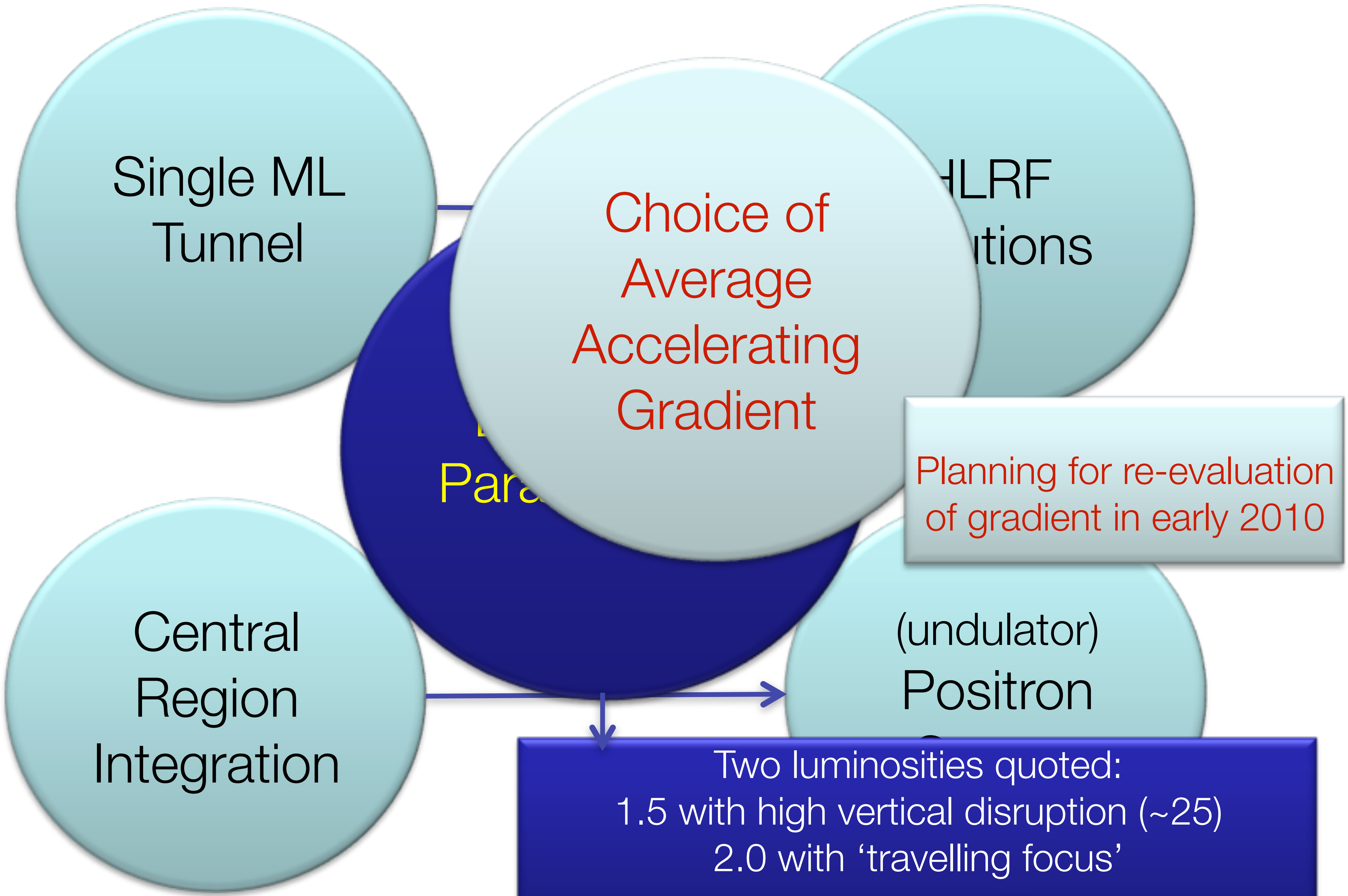
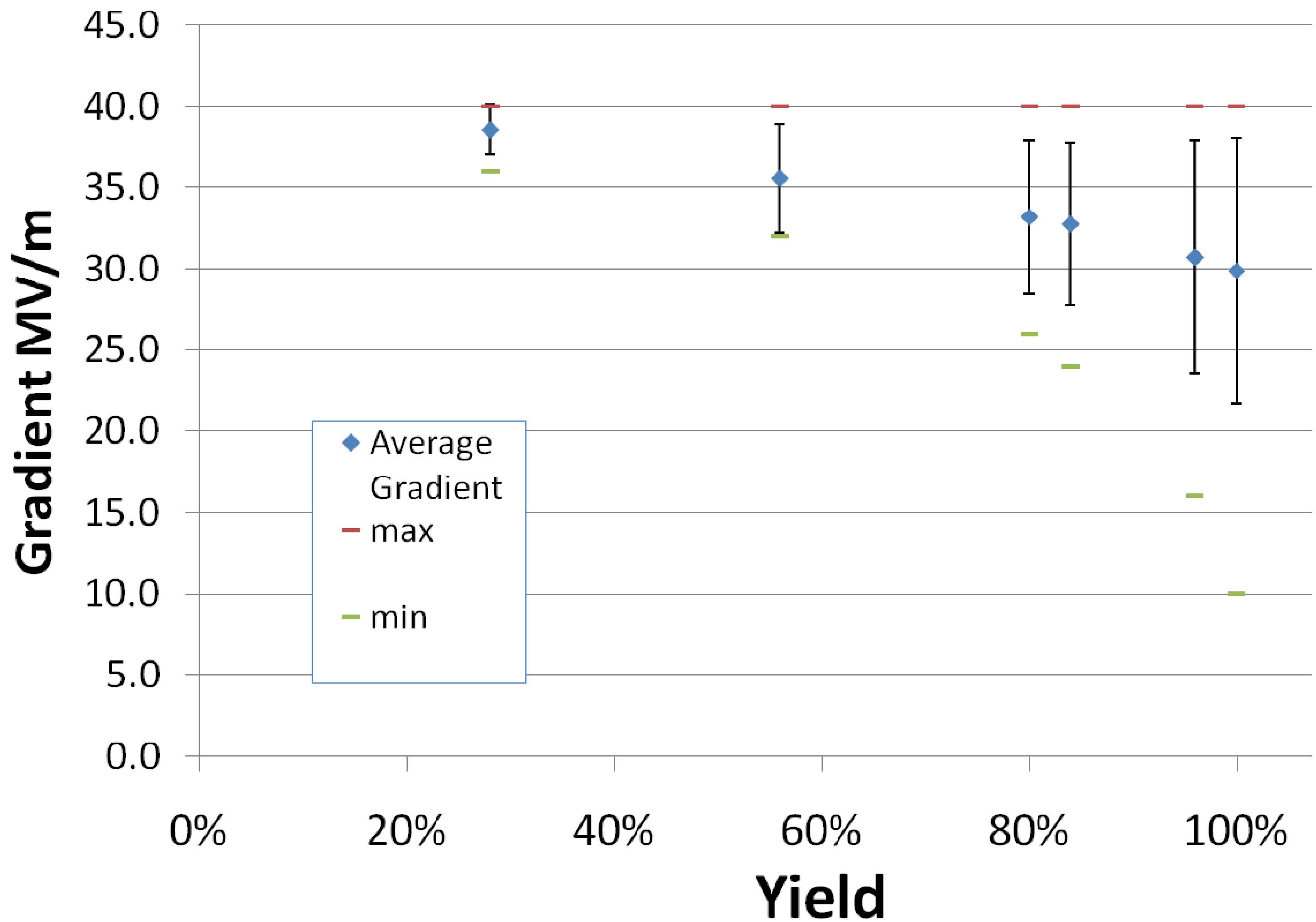


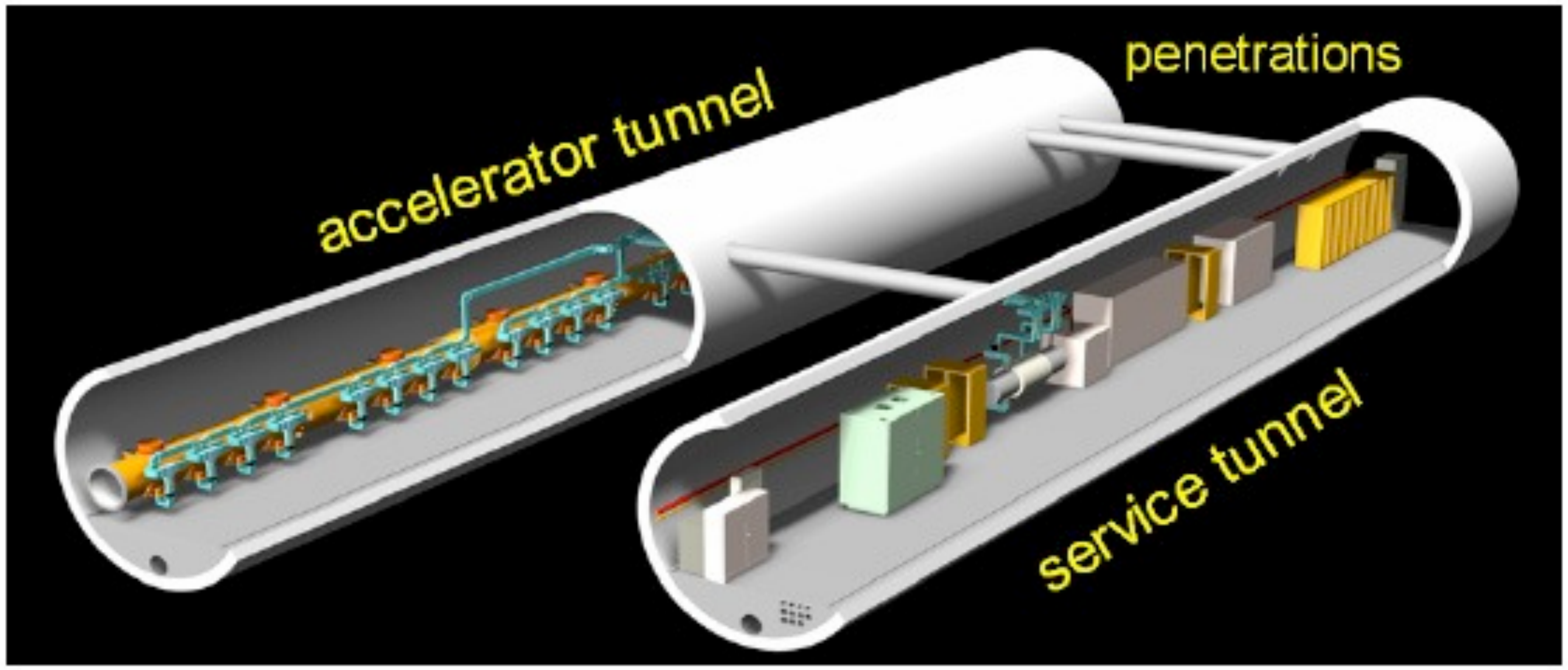
Accelerating Gradient

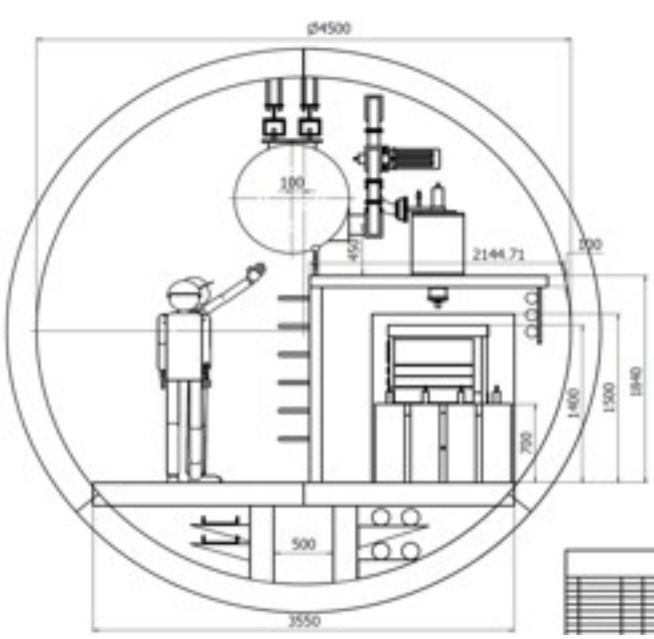
- Parameter with largest cost-leverage
  - Major focus of global R&D effort (‘S0’)
- On-going database effort to evaluate ‘yield’
  - Cost implications
- For TDP-2 baseline, unlikely to change current Working Assumption (31.5 MV/m)
  - Change of gradient at later stage only affects length of linacs
  - At 10% level easily scalable
  - No other subsystems affected
- New approach to ‘yield’ being evaluated, supporting larger spread in cavity performance
  - Average still (currently) 31.5 MV/m
  - Up to 20% spread is probably acceptable

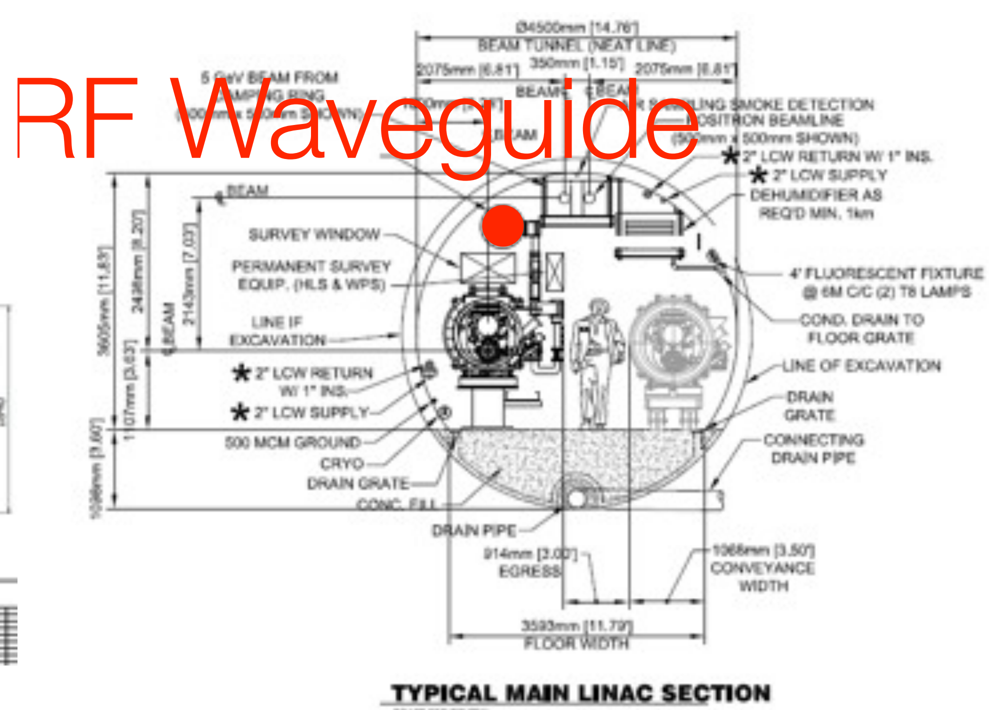
- Allowing for gradient spread
- Additional RF power needed to compensate
- 20% spread seems reasonable

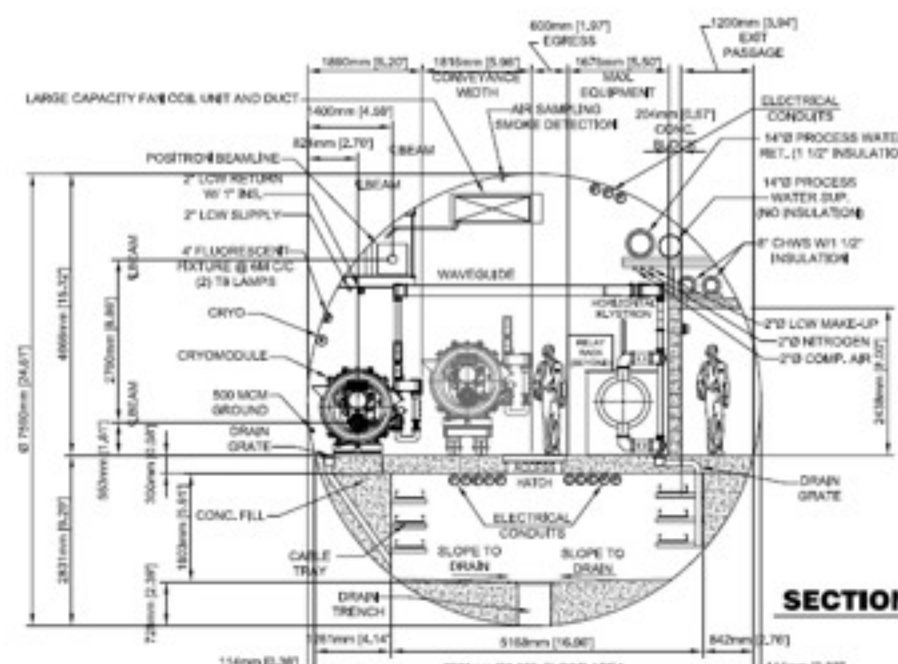


One Tunnel Variants







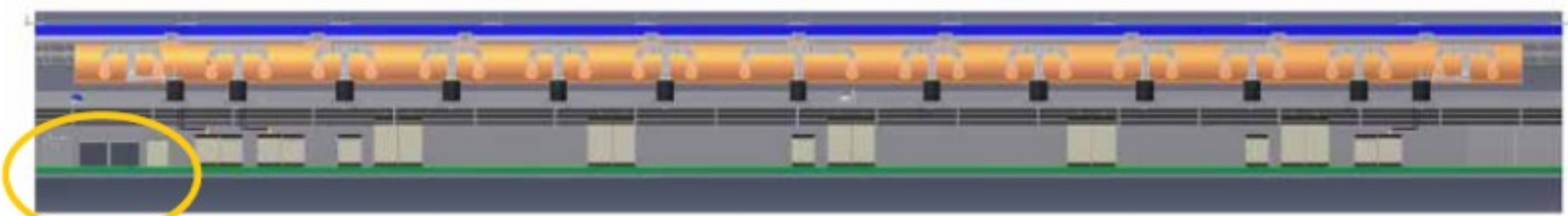


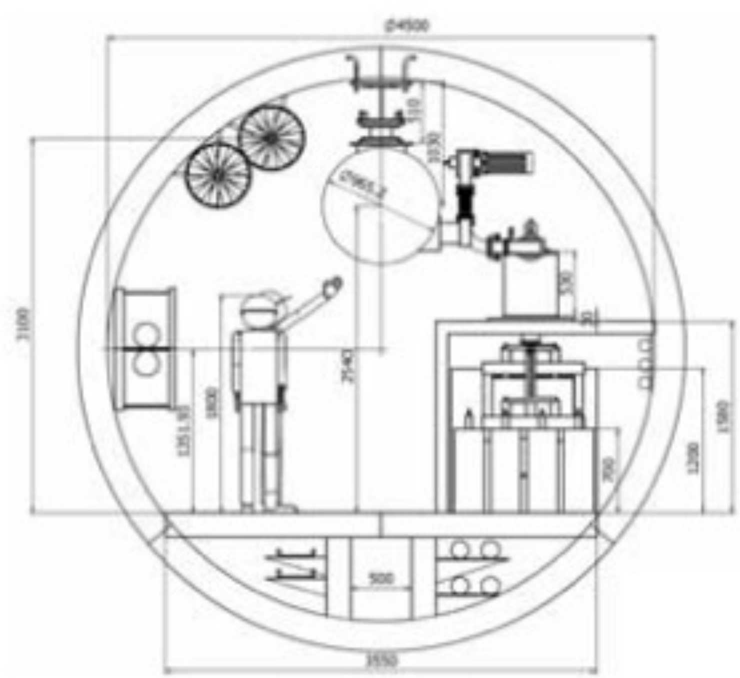
High-Level RF Solution

- Seen as critical component for one-tunnel solution.
- Two solutions:
  - Klystron Cluster concept
    - RDR-like 10 MW Klystrons/modulators on surface
    - Surface building & shafts every ~2 km
    - Novel high-powered RF components (needs R&D)
  - Distributed RF Source
    - Small ~700kW klystrons + modulators in tunnel
    - One klystron per four cavities
    - ~1880 klystrons per linac
    - Challenge is design for manufacture (cost reduction)

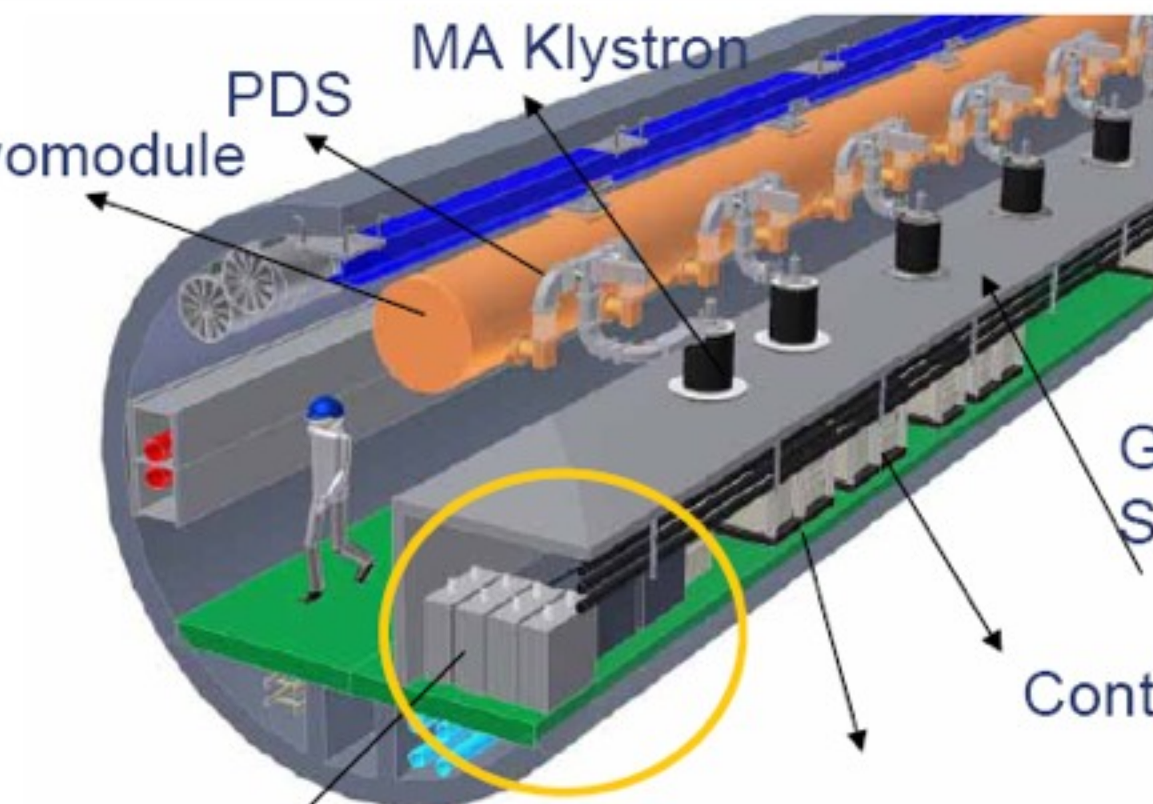
Distributed RF Source

Sketch of 3-Cryo-module unit





Cross Section

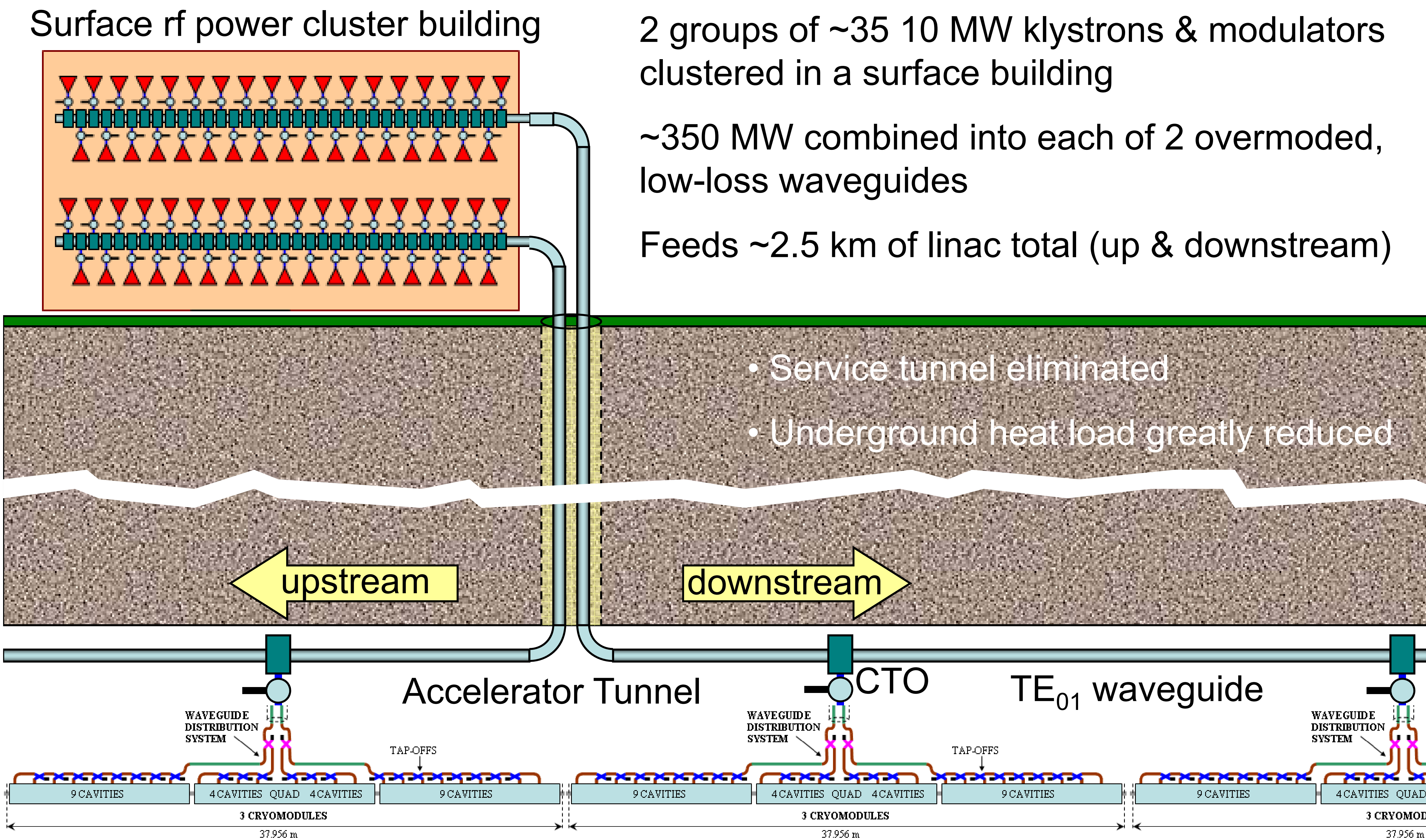


Klystron Cluster Scheme

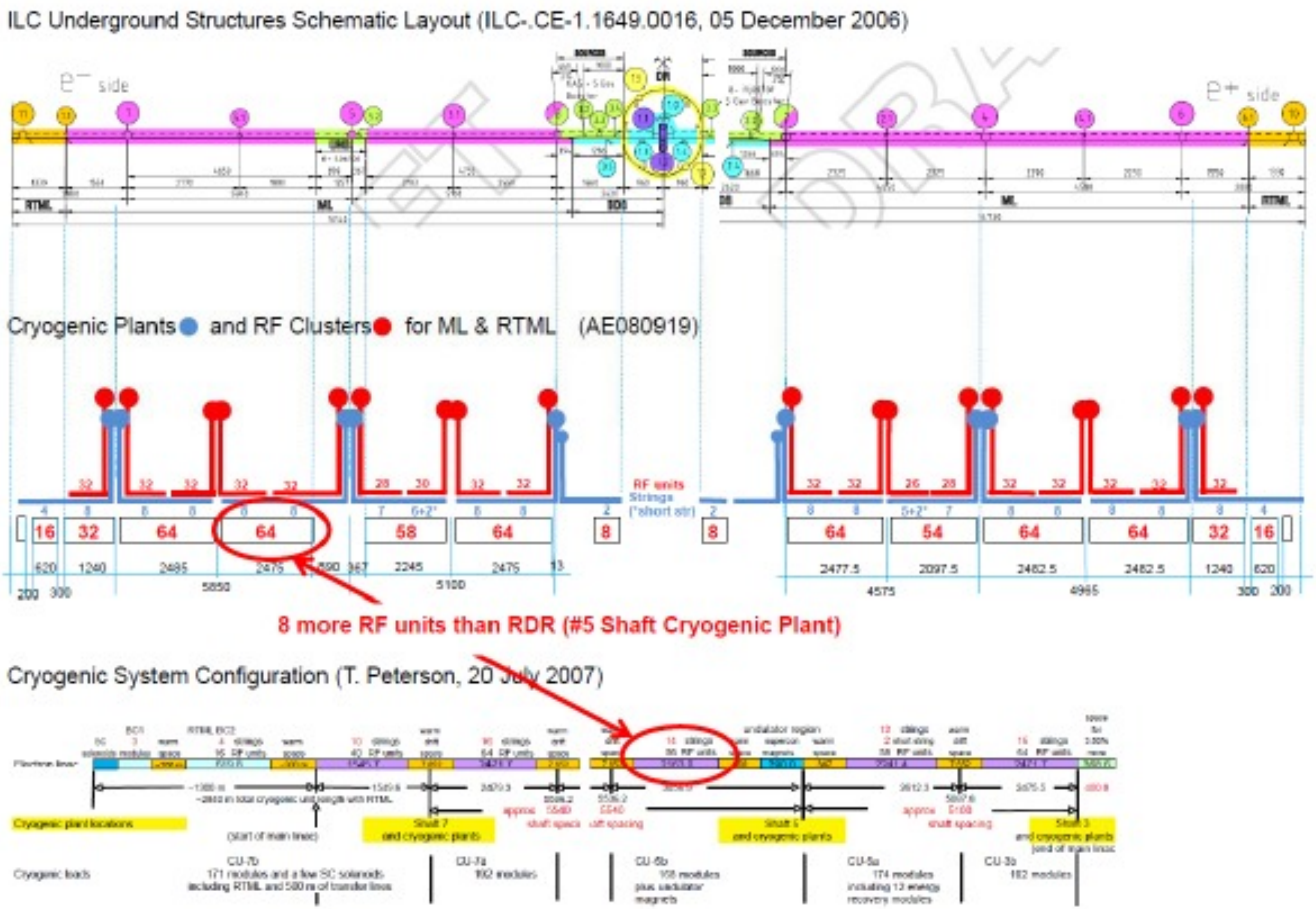
2 groups of ~35 10 MW klystrons & modulators clustered in a surface building

~350 MW combined into each of 2 overmoded, low-loss waveguides

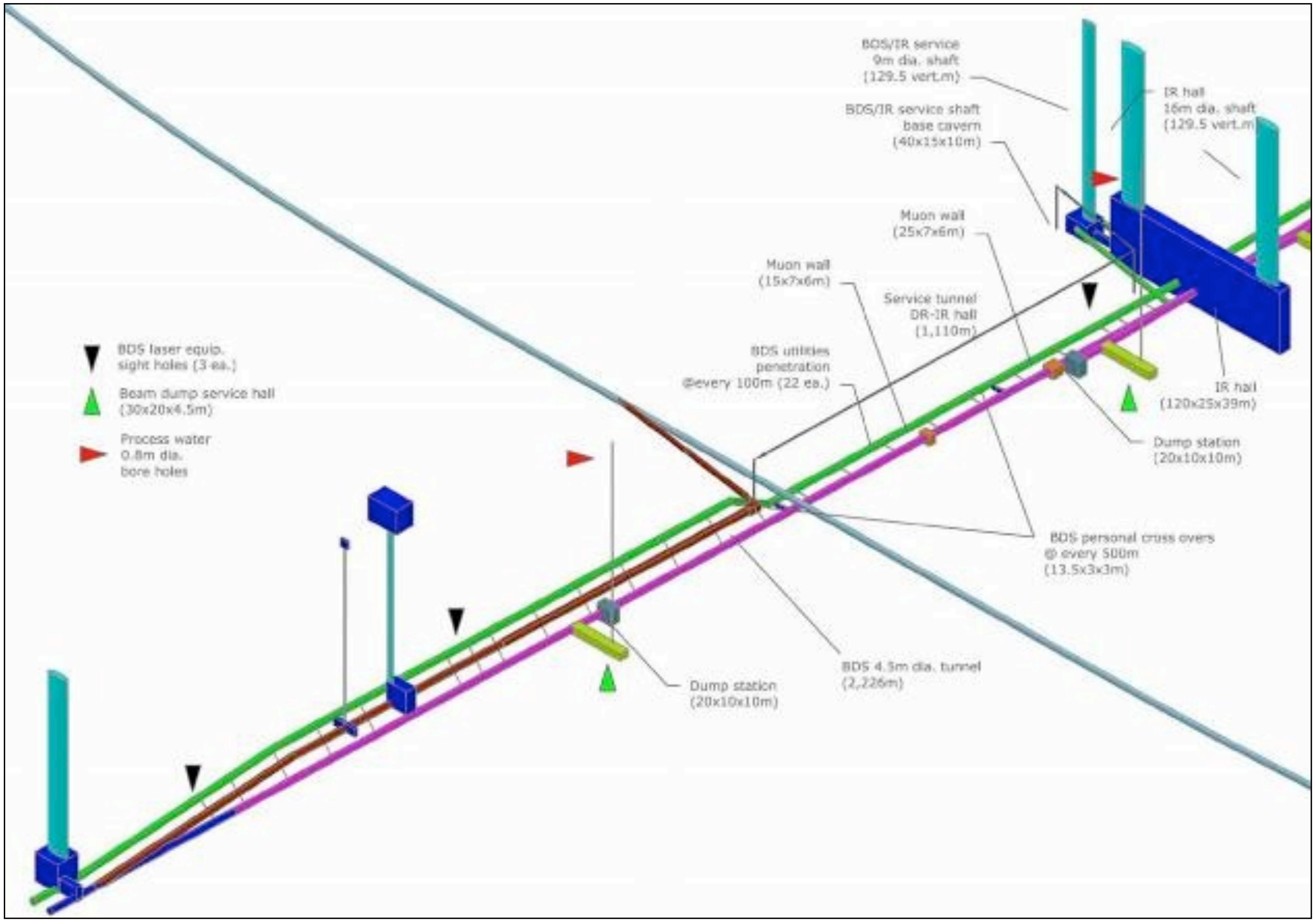
Feeds ~2.5 km of linac total (up & downstream)



Schematic layouts of conventional facilities and RF units



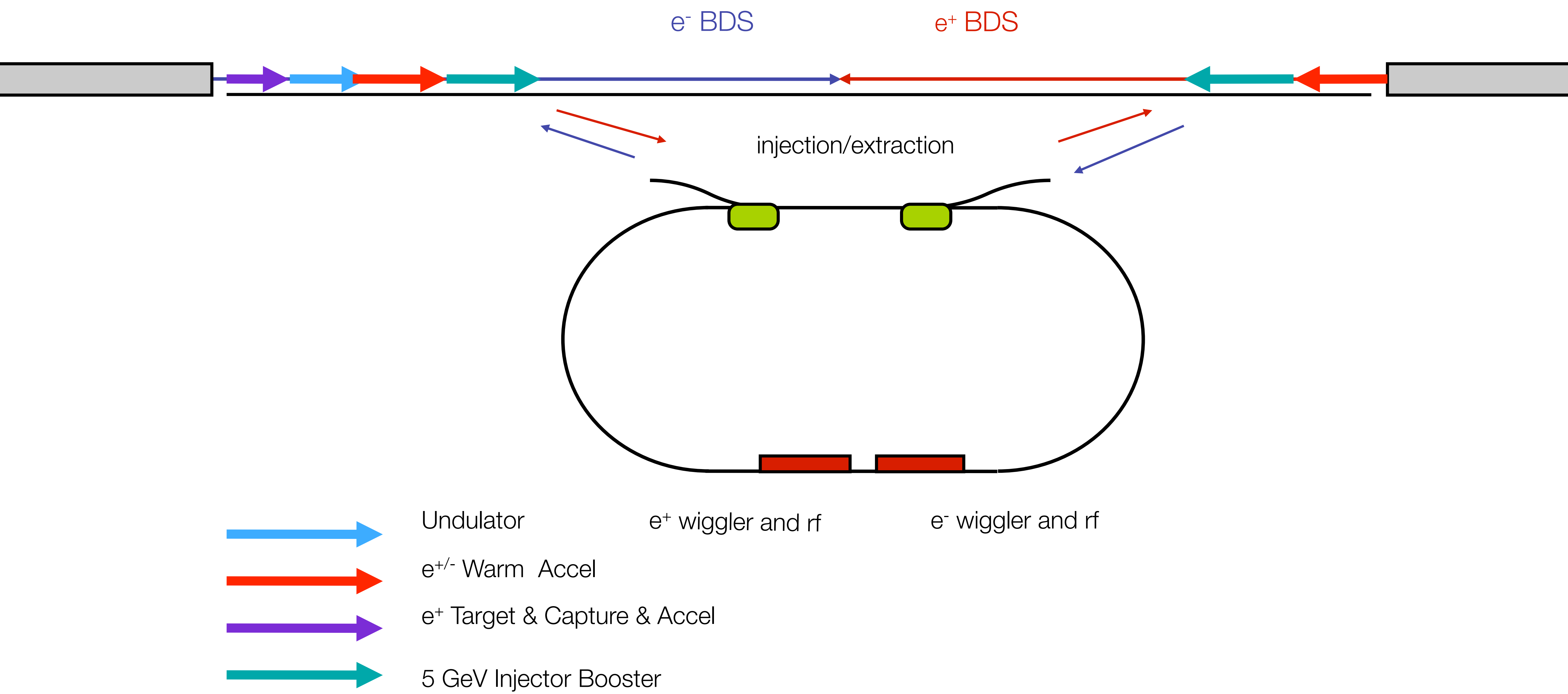
Central Region Integration



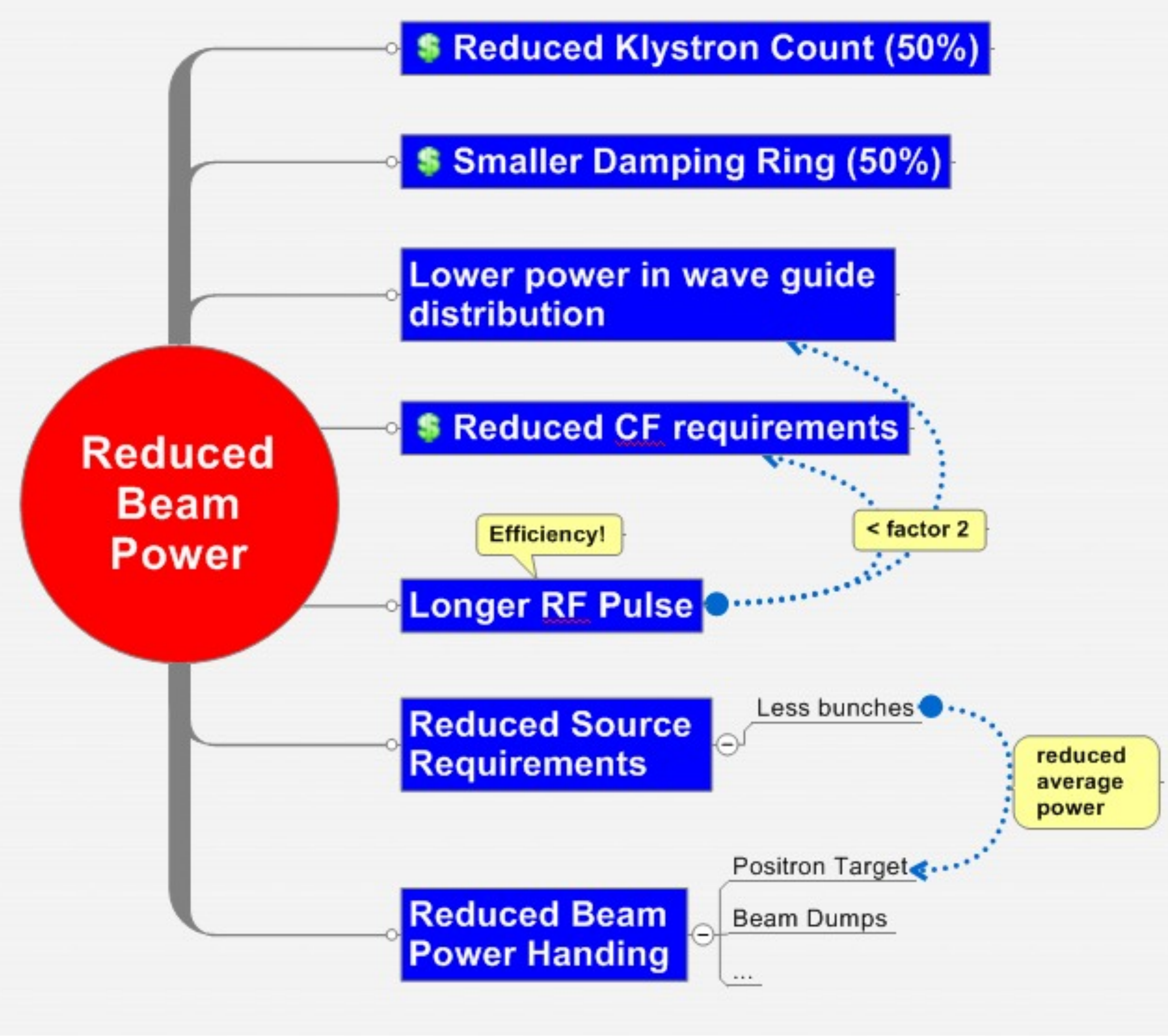
- RDR solution complex (CFS)
- Three tunnel concept
- Looked for consolidated solutions

Central Region Integration

5 GeV Boosters share tunnel with BDS
e^- Gun and injector share tunnel with BDS
Undulator + Aux Injector + e^+ Target-Capture-Accel + Booster share tunnel with BDS
No Keep Alive source and two tunnels, beam + support



Reduced Beam Power



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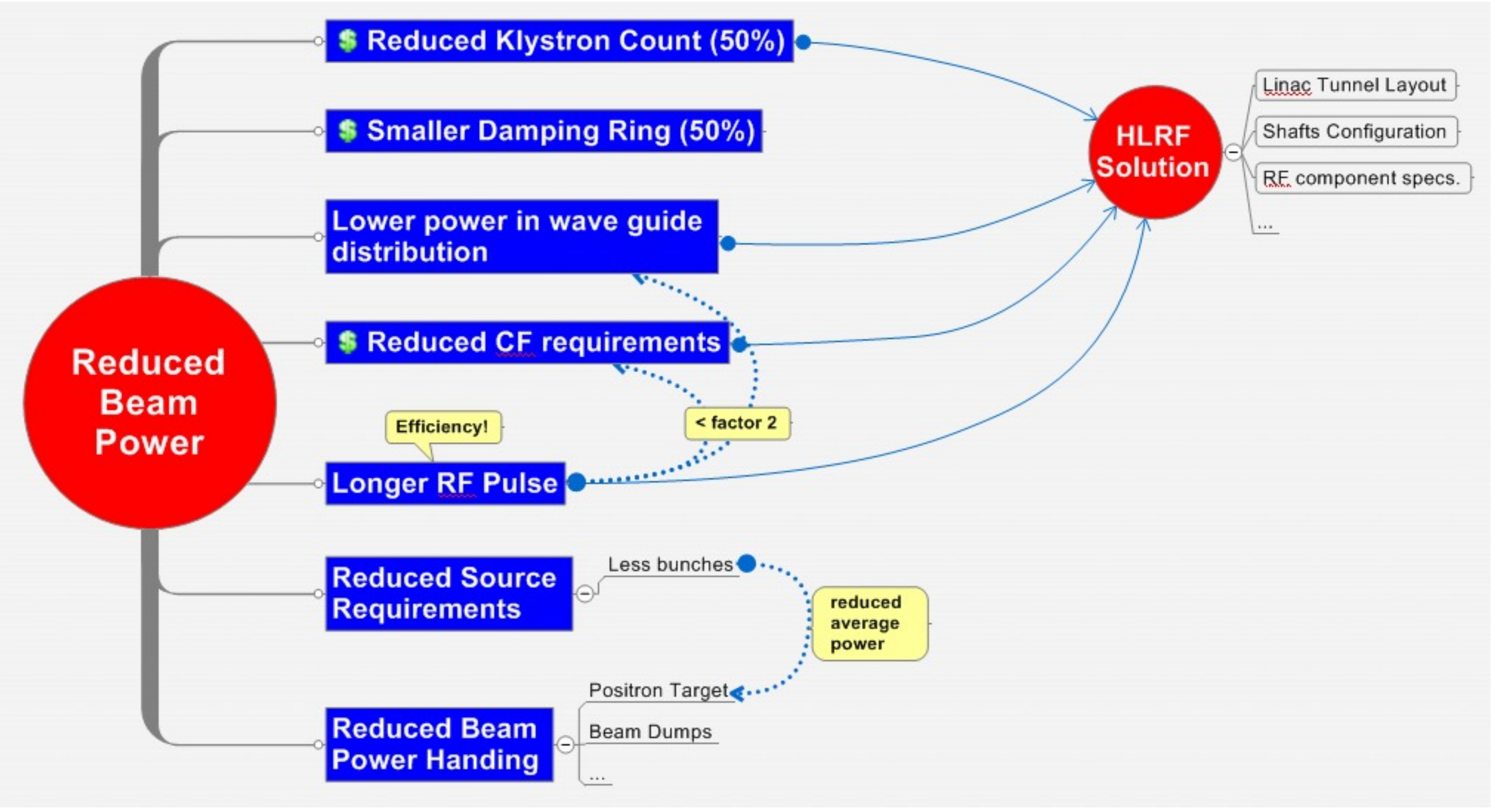

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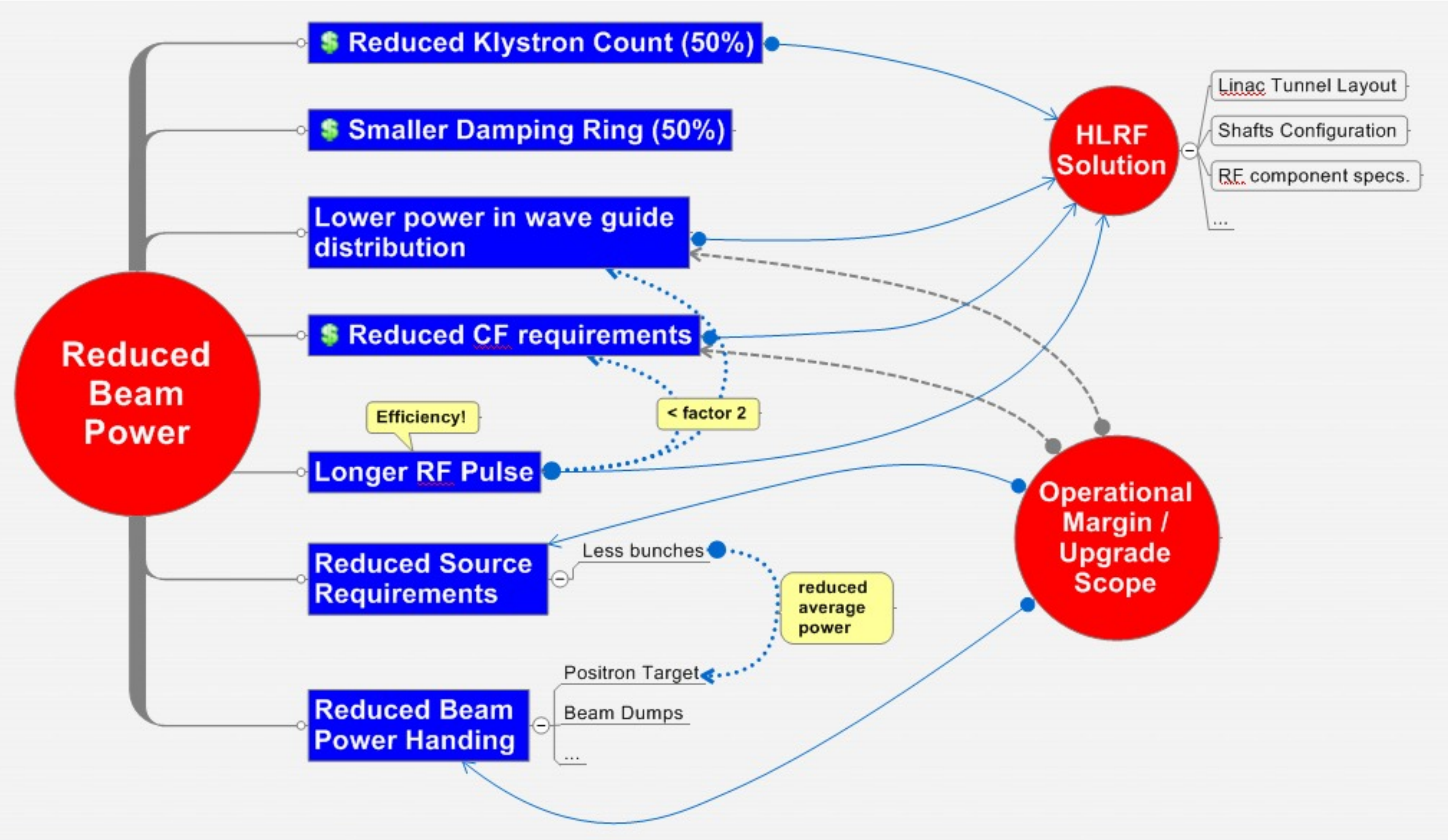


Upgrades &
Physics Scope Impact

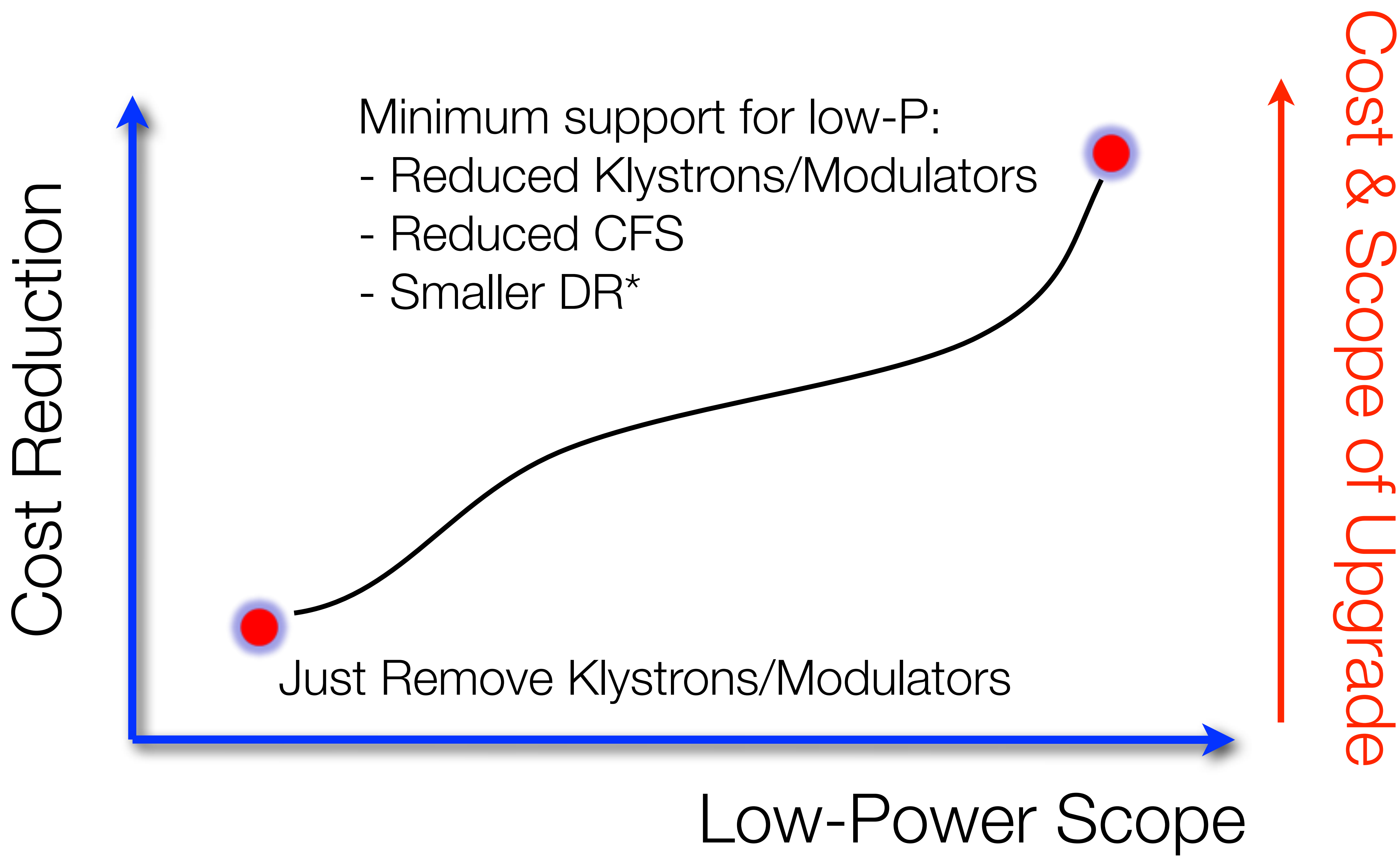
Upgrade Considerations: Energy

- Need to maintain RDR TeV Upgrade capability
  - i.e. build more linac
  - BDS geometry to support 500 GeV beam energy
  - Main (high-power dumps) rated for max. beam power
- Must consider impact on SB2009 of upgrade scenarios (compared to RDR)
  - Example: positron source

Upgrade Considerations: Luminosity

- Reduced power option opens up scope for possible Luminosity Upgrade
- i.e. putting back 30-50% missing klystrons and associated infrastructure
- Potentially up to ×2 increase in L
    - After initial running experience is gained
- Impacts many systems
- Various scenarios can be considered
    - Impacts on upfront cost saving

Low-P: Upgrade Options



Damping Ring Low-P Considerations

- Reduced (÷2) bunch number → Reduction in DR circumference by same fraction
  - Current remains constant
  - Injection/extraction kicker requirements remain the same
  - e-cloud issues remain ~unchanged
- Can we double the number of bunches in a 3.2 km ring?
  - Double current in ring
  - Kicker timing OK (needs R&D, but part of RDR spec.)
  - e-cloud is likely major bottleneck

Positron Source

- SB2009 has e^+ source located at exit of e^- main linac
  - RDR: at 150 GeV beam energy point in e^- main linac
- E_{cm} running below 300 GeV will be affected
  - RDR: decelerate the beam after undulator
  - Not without its own complications
  - SB2009: re-visit solutions proposed by TESLA
  - Double pulsing
- Bypass concepts (probably only for GigaZ)

Three Additional Important Issues

- Availability (single tunnel)
  - Import consideration for single-tunnel solutions
  - Task Force charged with finding HA solutions for proposed single tunnel
    - DRFS & KCS
- Safety Issues (single tunnel)
  - Second important issue for single-tunnel
  - Solutions being investigated
  - Likely differing solutions for each region
- Risk Assessment (general)
  - Important aspect of SB2009 analysis
  - Risk Register will be reviewed and updated
  - Some increased risk expected

Process towards
a Formal Baseline

Next Steps

Next Steps (2009)

- ALCPG'09 meeting focus to consolidate SB2009 Working Assumptions
  - Review action items and outstanding issues from DESY meeting
  - Produce a first-guess estimate of cost increments
  - Begin to prepare Proposal Document
- AD&I meeting 2.-3.12.09 (DESY)
  - 1st draft of Proposal Document
  - Resolve remaining WA issues

} Including designated representatives from Physics & Detector community

- Proposal Document final draft made public 18.12.09
  - Formally to Director/EC
    - Forwarded to AAP for review
  - Entire community for comment/feedback

Next Steps (2010)

- AAP formal review (4.-6.1.2010)

↓ Review/include feedback from AAP and ILC community

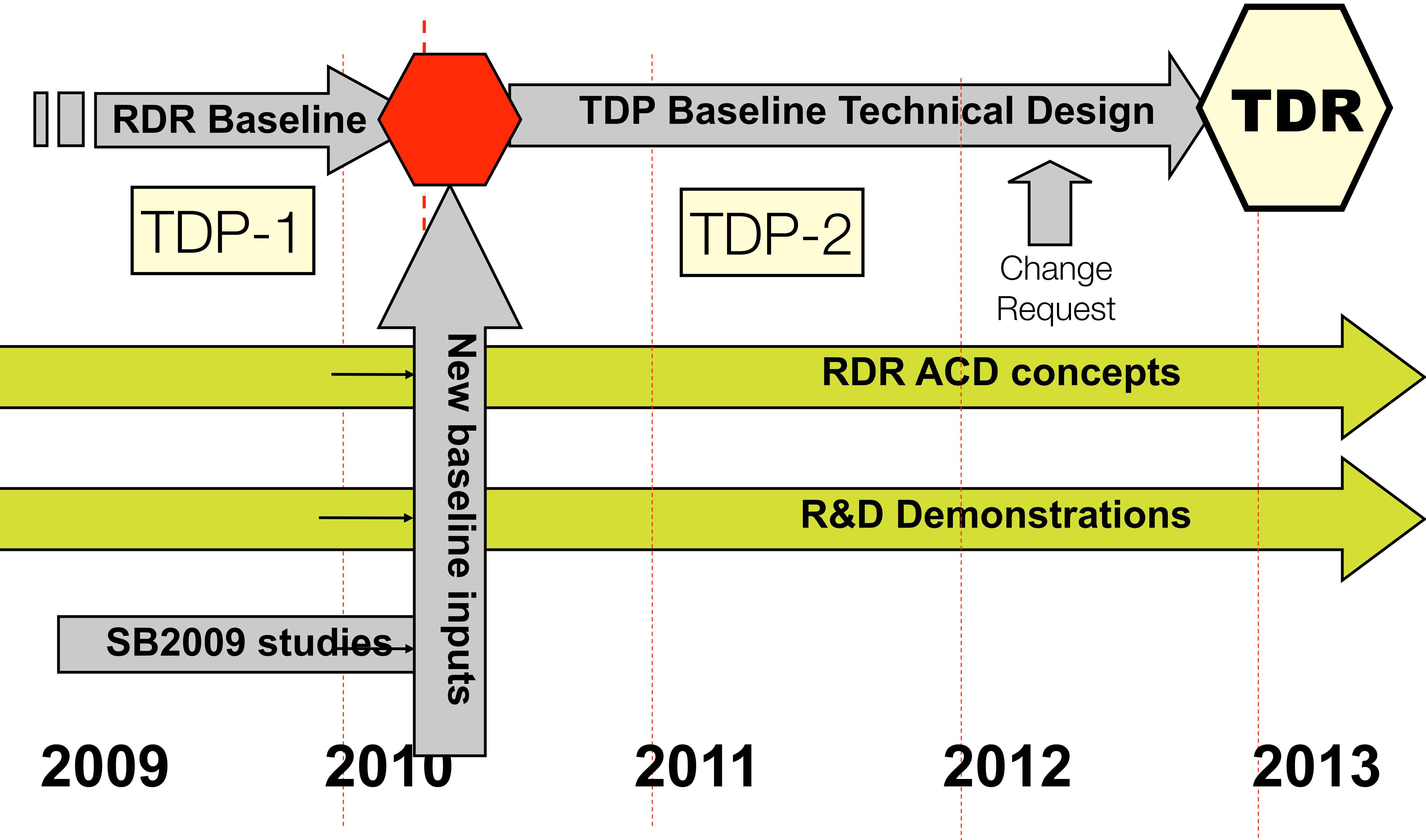
- Final establishment of TDP-2 ILC baseline at LCWS (Beijing, 3.3.2010)

↓ Preparation / planning for TDP-2 activities

- Presentation of new baseline at ICHEPP (Paris, July 2010)

Formal start of TDP-2

Technical Design Phase and Beyond



RDR Guidance for Baseline Definition

Baseline: a forward looking configuration which we are reasonably confident can achieve the required performance and can be used to give a reasonably accurate cost estimate by mid-end 2012 (→ TDR)

Alternate: A technology or concept which may provide a significant cost reduction, increase in performance (or both), but which will not be mature enough to be considered baseline by mid-end 2012

Summary

- AD&I process will lead to a more cost-effective, defendable and complete design
- Cost reduction element is important for
  - Cost constraint (margin for cost update)
  - Defendability
- Baseline proposal document to be submitted end of this year
- Formal acceptance as new baseline at LCWS (Beijing March 2010)
- Comments welcome!