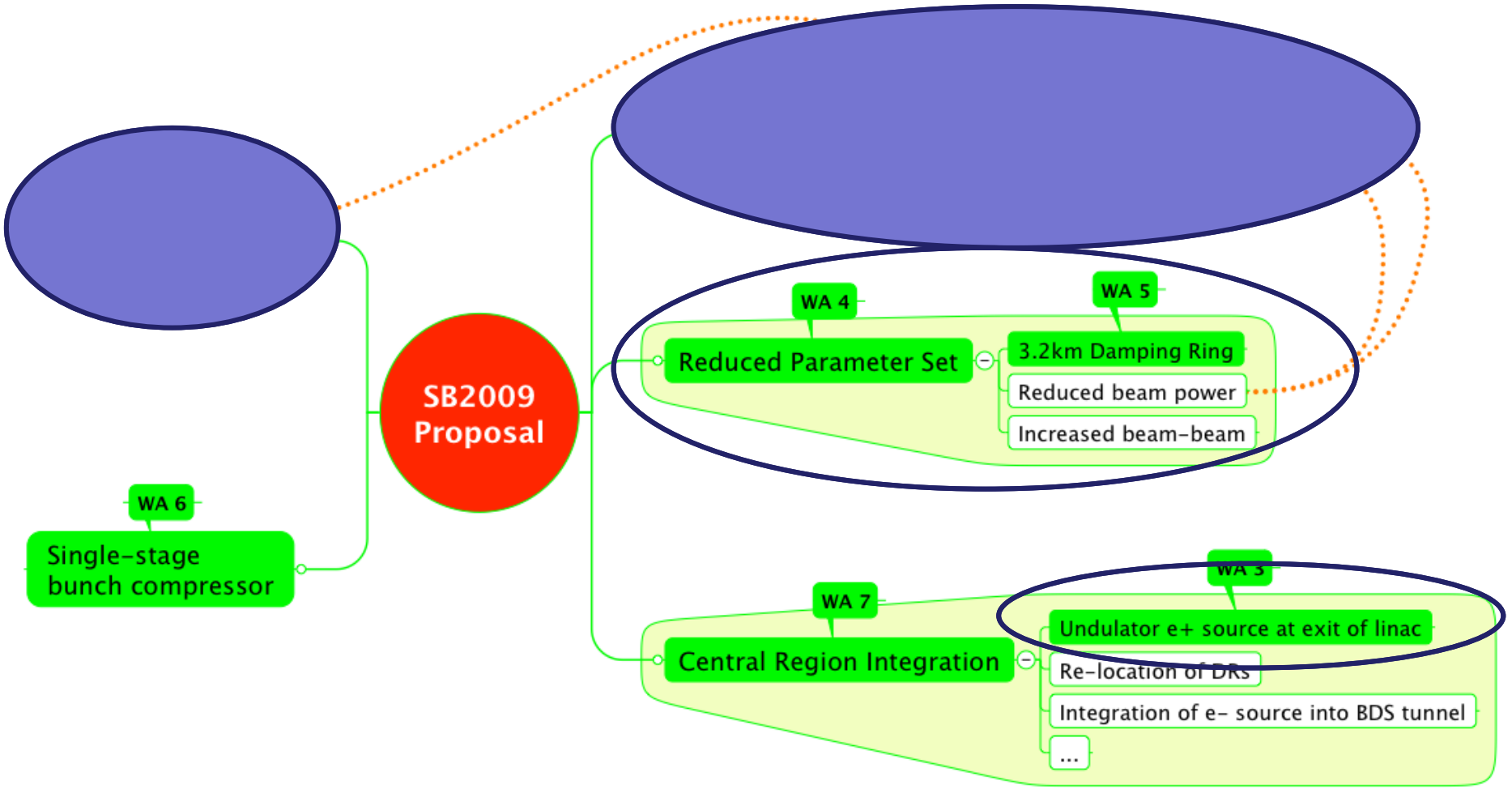
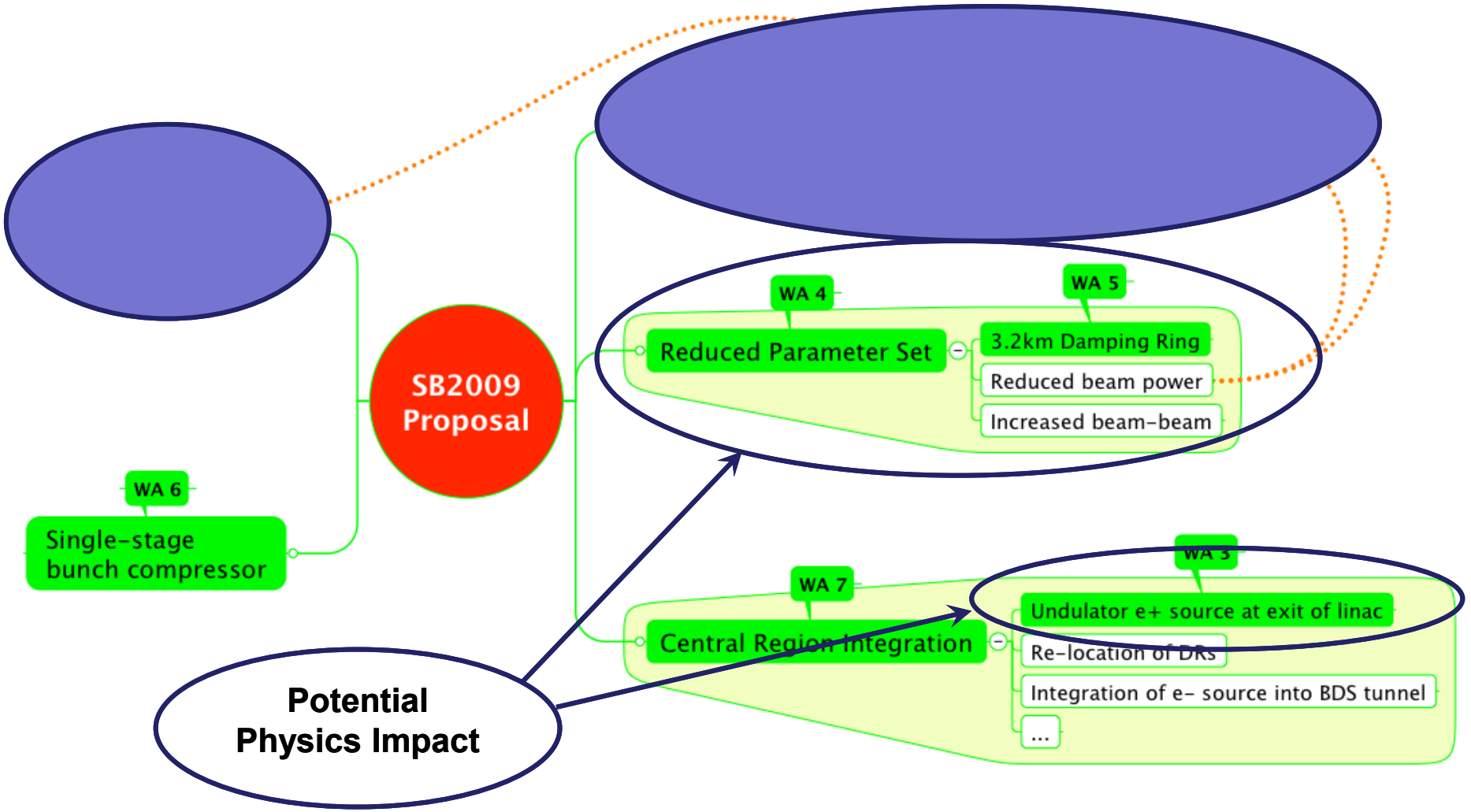
TLCC Themes


SB2009
Proposal
WA 4
Reduced Parameter Set
WA 5
3.2km Damping Ring
Reduced beam power
Increased beam-beam
WA 6
Single-stage
bunch compressor
WA 7
Central Region Integration
Undulator e+ source at exit of linac
Re-location of DRs
Integration of e- source into BDS tunnel
...

TLCC Themes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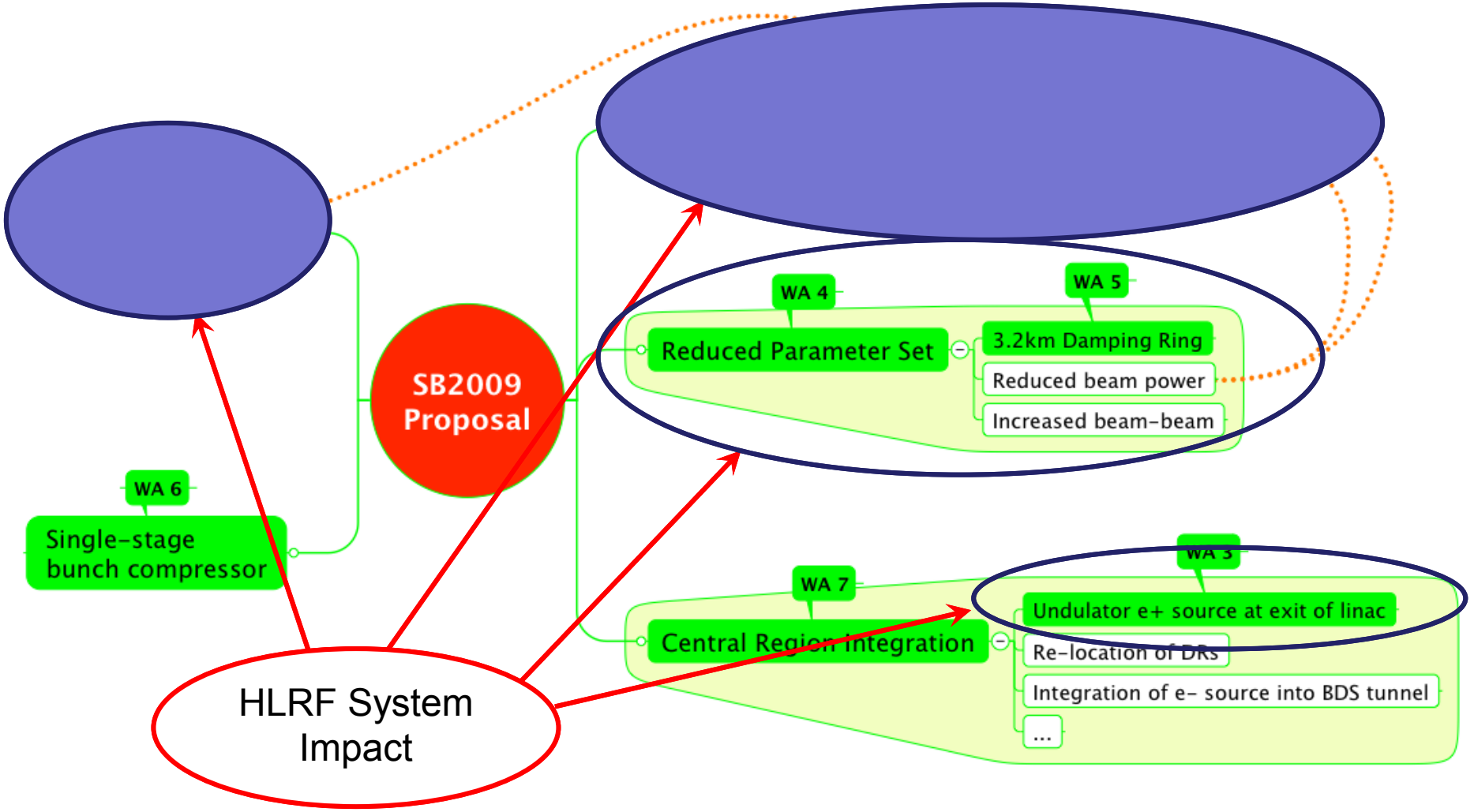
Potential
Physics Impact

TLCC Themes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...
HLRF System
Impact

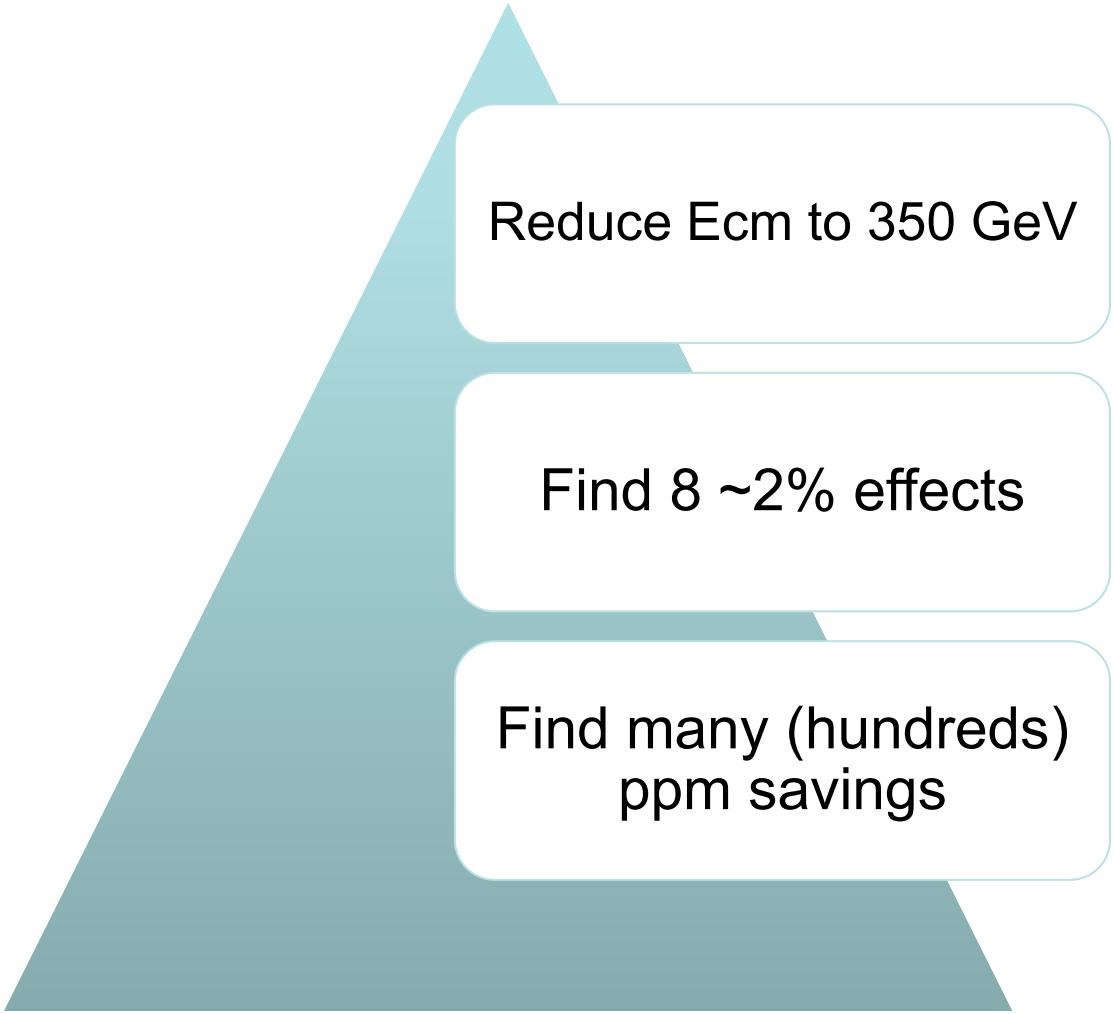
BAW-2 Themes

- **Reduction of # bunches (2625 → 1312)**
  - Reduced beam power → reduced RF
  - Smaller damping rings (6.4 km → 3.2 km)
  - Regain luminosity via stronger focusing at IP
- **Re-location of e+ source to end of Main Linac**
  - Better integration (central camp… higher overhead (at 500 GeV running) ⇒ re… risk
  - Issues of running for Ecm < 300 GeV

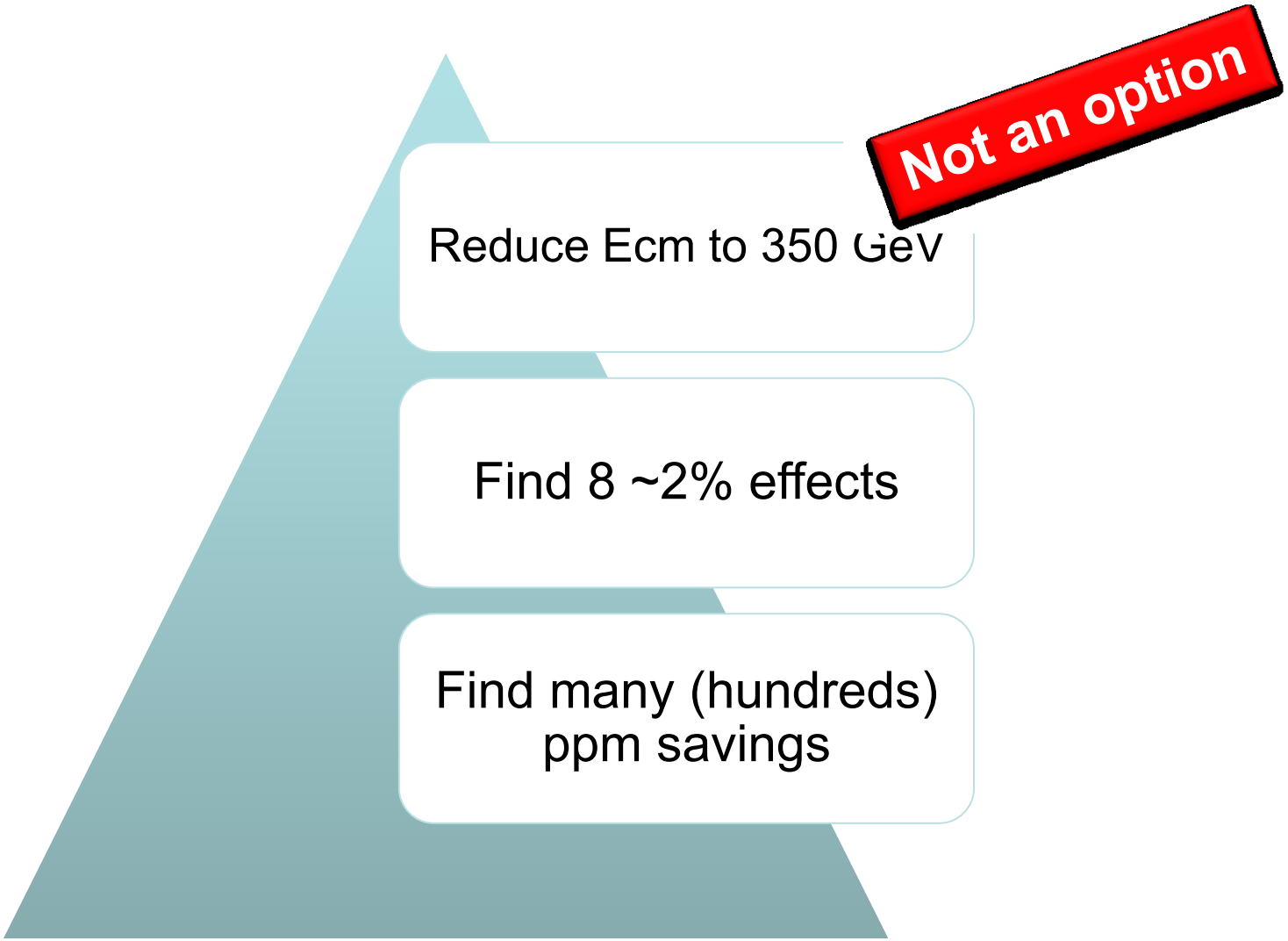
Thursday & Friday

								upgrade
Centre-of-mass energy	E_{cm}	**GeV**	**200**	**230**	**250**	**350**	**500**	**1000**
Luminosity	L	$\times 10^{34}$ cm^{-2}s^{-2}	**0.5**	**0.5**	**0.7**	**0.8**	**1.5**	**2.8**
Luminosity (Travelling Focus)	L_{TF}	$\times 10^{34}$ cm^{-2}s^{-2}	**0.5**		**0.8**	**1.0**	**2.0**	
Number of bunches	n_b		1312	1312	1312	1312	1312	2625
Collision rate	f_{rep}	Hz	5	5	5	5	5	4
Electron linac rate	f_{linac}	Hz	10	10	10	5	5	4
Positron bunch population	N_e	$\times 10^{10}$	2	2	2	2	2	2

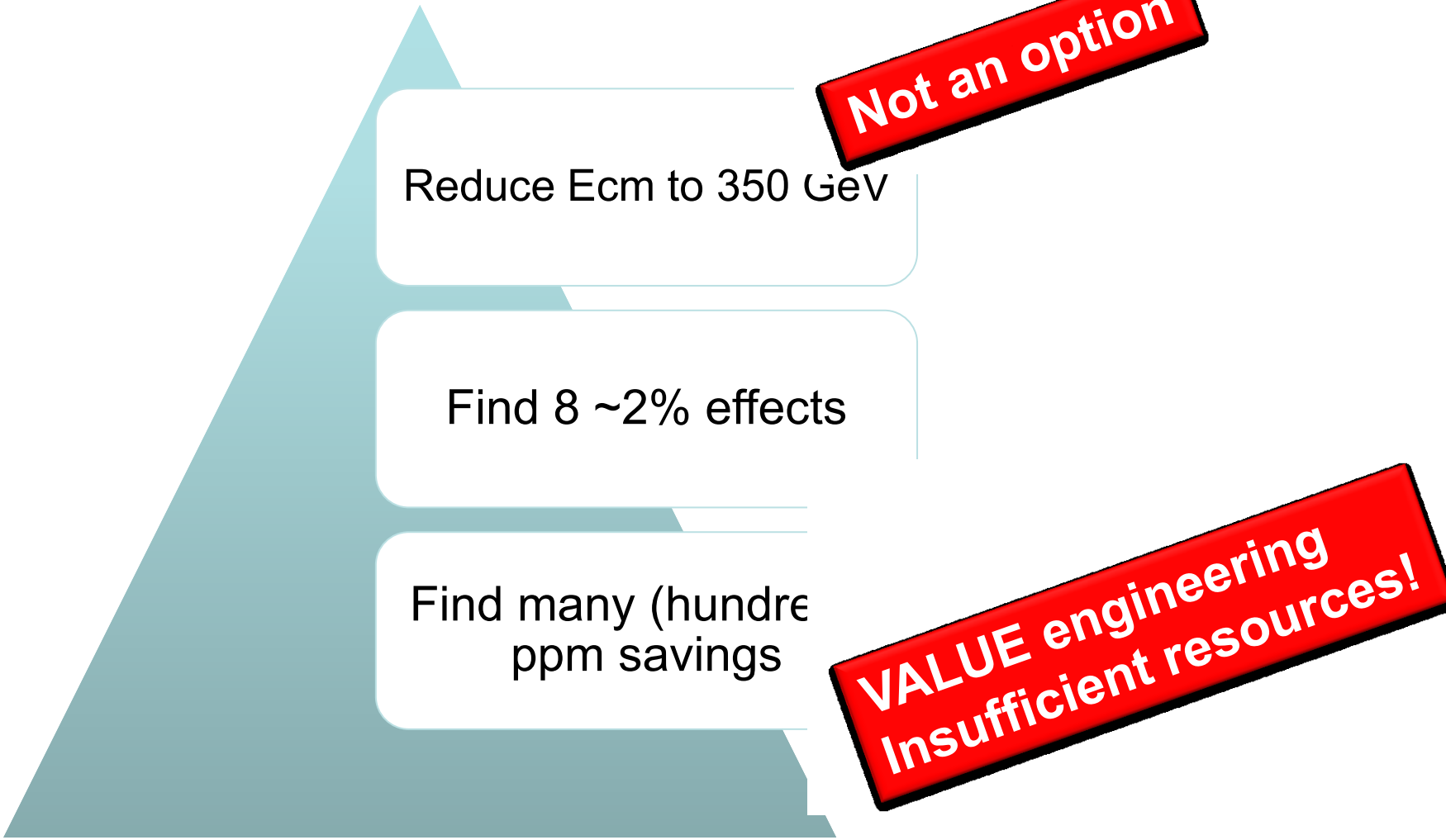
Approach to finding 15%



Approach to finding 15%



Approach to finding 15%



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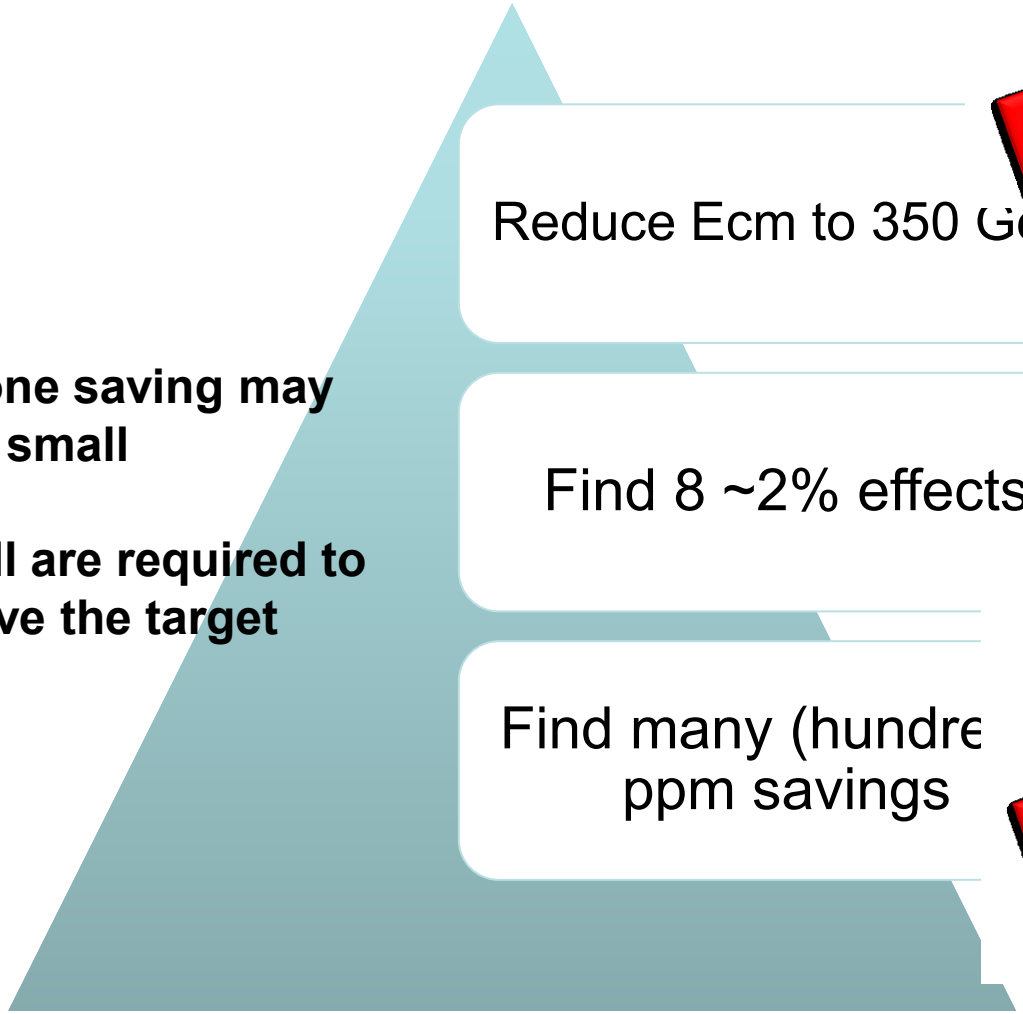


Any one saving may seem small

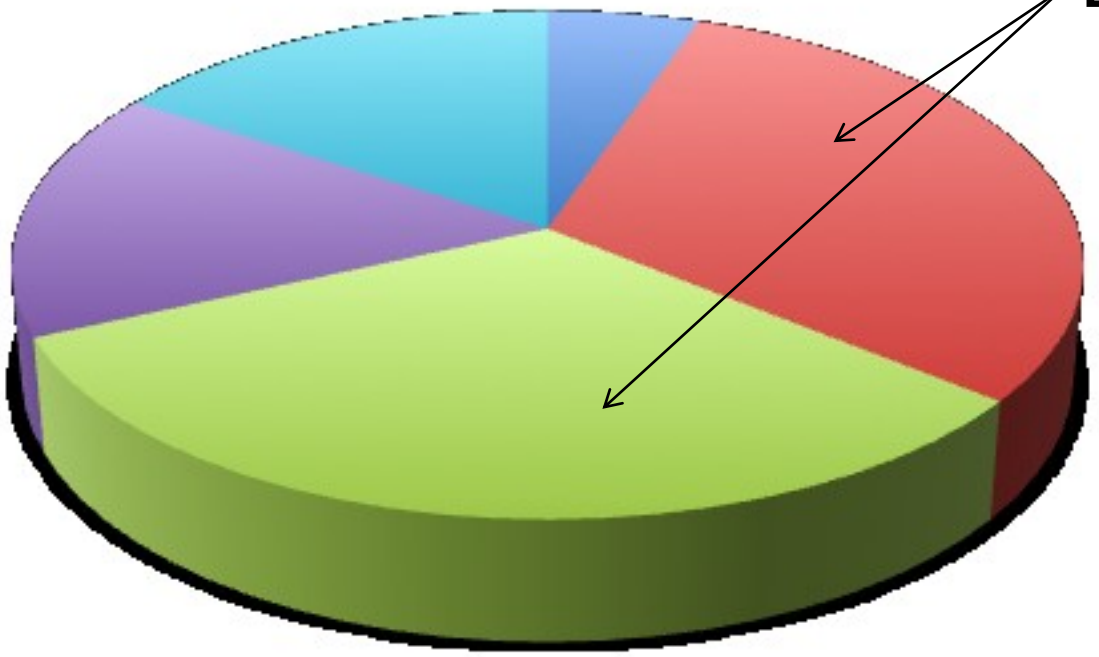
But all are required to achieve the target

Not an option

Adopted approach

VALUE engineering
Insufficient resources!

SB2009 Cost Increments



Low-P largest fraction

single-stage compressor

3.2km DR (low-p)

Reduced RF (low-p)

Central region integration

Single tunnel + HLRF

Total: ~13% RDR Total Project Cost

Costing effort: 2011-2012

- *TDR will reflect SCRF and CFS progress*
  - (beyond RDR 2007)
  - Technical advancement (esp. R & D)
  - Project strategy (design, industrialization, siting)
  - AND COST
- **Balance performance scope and accelerator system design against these cost drivers**
- **Motivation for Cost – Containment**
  - Development of SCRF 2007→
  - Siting 2010 →

Cost Containment Estimated Impact:

- **RDR ML Technical Cost:**
  - 2/3 cold SCRF
  - 1/3 Modulator/infrastructure, Klystron, Power Distribution
    - ½ Modulator
    - ¼ Klystron
    - ¼ PDS
- **Half-Power ~ 16% ML technical reduction**
- **Could offset up to ~25% cold SCRF 'increase'**
- **TDR cost breakdown will differ → 2011**

Scope of Proposal 1/2

1. **A reduction in Main Linac beam current, and therefor beam power, and an associated reduction in the number of klystrons, modulators and power supplies (primary cost saving).**
   - Key conventional facilities support for the full RDR RF power will be installed upfront during construction, in support of future possible upgrade to higher bunch numbers (risk mitigation).

2. **A corresponding reduction in the circumference of the damping rings from 6476 m to 3238 m (i.e. 50%), while maintaining the DR current approximately constant. This includes the associated reduction in DR R approximately 50% (primary cost saving).**

Scope of Proposal 2/2

3. **The reduction in current will be achieved by reducing number of bunches per pulse (n_b) by a factor of two from 2625 to 1312.**
   - increasing the linac bunch spacing

4. **An increase in the DR tunnel diameter to accommodate the possibility of installing a third damping ring (second positron damping ring) at some later date, if required (risk mitigation).**

5. **Adoption of stronger focusing at the interaction point (enhanced beam-beam) – including the possibility of travelling focus – to provide the required luminosity (maintaining performance at higher risk).**

Low Power Parameters

Parameter	unit	RDR (nom.)	TLCC
E_{cm}	GeV	500	500
Rep. rate	Hz	5	5
Q_{bunch}	nC	3.2	3.2
Bunches/pulse		2625	1312
LINAC RF parameters:			
RF pulse length	ms	1.6	KCS: 1.6 DRFS: 2.2
Beam current	mA	9	KCS: 6 DRFS: 4.5
Damping Ring:			
Circumference	m	6476*	3238
Avg. Current	mA	388	390
Damping time	ms	21	24
RF power	MW	3.97	1.76

- Focus on 500 GeV centre-of-mass
  - **Low E_{cm} →cf 'Positron Source Relocation'**
- Different parameters for DRFS and KCS(RDR T.O.).
- 2x3.2km DR with reduced bunch number (@5Hz)

Since RDR / SB2009:

- **Gradient Spread (BAW 1)**
  - RDR design: fixed 31.5 MV/m
  - TDR baseline: 31.5 avg +/- 20%
  - Penalty: Increased HLRF overhead (10 - 15%)
  - (offset by decreased cavity cost; model dependent)
- **Single Tunnel (BAW 1)**
  - Facilitate siting through flexible HLRF technology
  - Penalty: different criteria for CFS / Cryo design
- **Restoration of full beam parameters**
  - Penalty: Identify and reserve space / support equipment needs

HLRF – two technical options

- **Both options subject to R & D; Both to be (hopefully) included in TDR**
- **Different optimum bunch parameters**
  - Both have reduced plug–to-beam efficiency

Key Main Linac HLRF parameters at 500 GeV centre-of-mass (approximate numbers)

Parameter	unit	RDR (nominal)	KCS	DRFS
Beam current	mA	9	6	4.5
Bunch spacing	ns	369	535	738
Beam pulse length	μs	969	702	969
RF fill time	μs	595	862	1190
RF pulse	μs	1564	1564	2159

Damping Ring

(Susanna, Mark and Junji)

Reduce Circumference 2x:

- **Design of 3.2 km DR**
- **(including component counts, cost savings and upgrade path configurations with 2 and 3 rings)**

Evaluate e+ instability thresholds for

- ***increasing the number of bunches at a later stage***
- **Electron cloud issues at 1312 and 2625 bunches**

- **DR cost ~ 10% RDR (1/3 CFS)**
  - Technical cost does not scale → some component counts are fixed

BDS

- **50% reduction P_{beam} ⇒ ×2 L recovery via enhanced beam-beam (BDS)**
  - stronger focusing (tighter tolerances, see below)
  - higher disruption / beamstrahlung etc.
  - travelling focus
  - Collimation depth issues
  - Modular FD concept (for low Ecm running)
- **Cost neutral**
  - travelling focus hardware has negligible cost
- **Concern with operational aspects and tighter tolerances**
  - Collision (luminosity) stability
  - more demands on beam-beam feedback
  - Emittance preservation in RTML, ML and BDS
  - Overall tuning strategies and *integrated* luminosity performance

A higher risk scenario?

Note reduced average beam power reduces risk in many subsystems

Luminosity @ 500 GeV cm

- **TF parameter set is self consistent with 2×10^{34} cm^{-2} s^{-1}**
  - based on 'built-in' TF model in GUINEA PIG

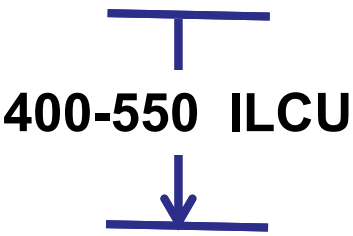
- **Advanced studies have only now just started.**
  - Understanding how to generate the crab-waist
  - Understanding what the realistic impact of this is
  - Closer look at tolerances etc.

started late ☹

- **Achieving and stabilising this 2×10^{34} cm^{-2} s^{-1} under this regime will be very challenging**
  - Top ~30% of the luminosity 'risky'

Luminosity @ 500 GeV cm

- **RDR** 2×10^{34} cm^{-2} s^{-1}
- **50% P_{beam}** 1×10^{34} cm^{-2} s^{-1}
- **High Disruption** 1.5×10^{34} cm^{-2} s^{-1}
- **Travelling Focus** $1.5\text{-}2.0\times10^{34}$ cm^{-2} s^{-1}
- **(Alt. Low-Q** 2.0×10^{34} cm^{-2} s^{-1})



Bunch number "restoration"

- **Important to discuss scenarios for increasing the bunch number 1300→2600**
  - At some later date, after initial construction.

- **Damping Ring:**
  - Additional 3.2km ring for positrons → no parameter changes
  - 2625 bunches in single (existing) electron ring
    - 780 mA avg. current
    - 4.84 MW power
  - Tunnel/alcoves spec'd for 3 stacked rings.

- **HLRF**
  - Add klystrons/modulators/power supplies
  - Scenarios for CFS support
    - what must we invest in up-front to support this

- **Complete studies left for TDP-2**
  - but qualitatively, scenarios need to be discussed at BAW-2

+ / - Reduced Beam Parameters

- **Pro's:**
  - Largest *single-item* cost impact
  - Minimum technical risk for the change itself
  - Manageable restoration path
    - KCS, DRFS, DR
- **Con's:**
  - Luminosity reduction to be compensated in BDS
  - Reduced ML efficiency
  - Significant cost penalty to maintain restoration path
    - DR, CFS

TLCC-3 Proposal Document

- **Authored by PMs**
- **Scope points from slides 12 & 13**
- **More detailed description of technical scope**
  - DR and HLRF parameters
  - Component count tables
- **Issues**
  - Luminosity performance
- **Physics impact (short summary)**
- **Cost Summary**

To be submitted to Director by end of next week