Where are we with the BCD?

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GDE Meeting

Dec.7.2005, Frascati

Snowmass — Summary of Summary

Strawman BCD

Next Step to RDR

Snowmass Workshop

- 2nd WS following the 1st WS at KEK
- 2 week's WS in parallel with Physics WS
- Participants over 600

- Complete the **BCD** (Baseline Configuration Document) by end of 2005
- BCD describes the **Design Outline**
- Snowmass is the **1st step to BCD**

BCD will contain

- Description of **BC** (Baseline Configuration)

  BC: 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 2006 (RDR)

- and **AC** (Alternative Configuration)

  AC: 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 2006

- together with
  - justification of the choice
  - required R&D listed for both BC and AC

Design Outline

- Basic beam parameters
- Accelerating gradient
- Cavity shape
- Positron generation scheme
- Shape & size of DR
- Number of bunch compressor stages
- Number of main tunnels
- Earth's curvature
- Number of IPs and crossing angle
- Configuration layout of linac, DR, etc.

etc. . . . .

Accelerating Gradient and Cavity Shape

	500GeV stage		2nd stage (1TeV extension)	
	Baseline	Alternative	Baseline	ultimate dream
Acc.Grad. Q_0 (10^{10})	**31.5(35)** 1.0(0.8)	**36(40)** 1.0(0.8)	**36(40)** 1.0(0.8)	
Cavi.shape	TESLA-type	LL/RE super-structure	LL/RE super-structure	single-crystal Nb super-structure

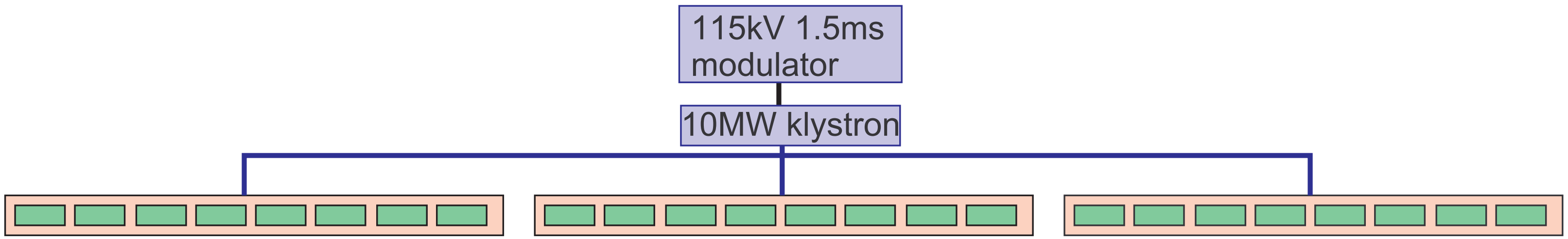
'31.5(35)' means

- Adopt only the cavities over 35MV/m in vertical test (average over $\gtrsim$37MV/m needed, taking into account the production yield)
- Prepare RF and cryo-system for 35MV/m
- but operate at 31.5MV/m
- Tunnel length to be computed using 31.5MV/m

- According to the baseline, the main linac length $\sim$41km for 1TeV
- Adding other components, the tunnel would be nearly 50km long

Main Linac

- Klystron
  - BC: 10MW MBK
  - AC: Sheet beam klystron, etc.
- RF Unit Configuration
  - Bouncer-type modulator
  - 10MW klystron
  - 3 cryomodule, each containing 8 cavities



- Quads: 1 for every 24 cavities is enough
  (Later, decided every 32 cavities)

Positron Source

- BC: Undulator scheme
- AC: Laser-Compton scheme
  with the conventional scheme as 'back-up'

Bunch Compressor

- BC: 2-stage compressor, 1.4km long, with turn-around
- AC:
  - No turn-around
  - 1-stage compressor
  - 2-stage shorter compressor

Back to these problems later.

Parameters

- "Beam and IP parameters" distributed in Feb.2005.
  Nominal, Low Q, Large Y, Low P, High L
- Several possibilities have been pointed out at Snowmass
  - Longer beam/RF pulse with same train charge to reduce RF requirements
  - Smaller number of bunches with higher rep rate
  - Lower charge case, lower than Low Q set.

  etc.
- These require more study and, it was judged there is no compelling reason to change the parameter sets at present.

Beam and IP parameters for 500 GeV cms (Feb.2005)

	Nominal	Low Q	Large Y	Low P	High L
N (10^{10})	2.0	**1.0**	2.0	2.0	2.0
n_b	2820	5640	2820	1330	2820
t_b (ns)	307.7	153.8	307.7	461.5	307.7
I_{ave} (mA)	10.4	10.4	10.4	**6.9**	10.4
Gradient	30.0	30.0	30.0	30.0	30.0
$\gamma\epsilon_x$ (mm·rad)	10	10	12	10	10
$\gamma\epsilon_y$ (mm·rad)	0.04	0.03	**0.08**	0.035	0.03
β_x^* (mm)	21	12	10	10	10
β_y^* (mm)	0.4	0.2	0.4	0.2	0.2
σ_x^* (nm)	655	495	495	452	452
σ_y^* (nm)	5.7	3.5	**8.1**	3.8	3.5
σ_z (μm)	300	150	500	200	150
D_x	0.162	0.0708	0.468	0.226	0.170
D_y	18.5	10.0	28.6	27.0	21.9
Υ_{ave}	0.046	0.061	0.036	0.100	0.133
δ_{BS}	0.022	0.018	0.024	0.057	0.070
n_γ	1.257	0.823	1.664	1.756	1.725
$\mathcal{L}$ 10^{34}	2.03	2.01	2.00	2.05	**4.92**

After Snowmass

- Damping Ring Workshop on Nov.9-11 at CERN,
- task forces (next page),
- and activities of individual groups (incl. node-support team)
- BCD Executive Committee meetings on Sep.22 and Nov.17-18 at SLAC,
- Strawman BCD, now ready at
  `http://www.linearcollider.org/wiki/doku.php?id=bcd:bcd_home`
  All together ~600 pages
- To be finalized here at Frascati to the BCD

Task Forces

- Task forces have been created for the 5 problems for which the Snowmass WS did not come to conclusions or for which some more considerations were thought to be needed.
- They have written 'white papers' by Nov.16

The problems are

- **Positron source**
  (intensity of 'keep-alive source' and location of undulator)
- **Energy upgrade path**
  (1TeV tunnel or 500GeV tunnel in the first stage)
- **Tunnel curvature**
  (laser-straight or kinked or curved along earth's curvature)
- **Number of IPs** (interaction points)
- **Number of tunnels** (2 or 1)

Positron Source

Snowmass

- Chose the undulator scheme as the baseline (this is not an issue for the task force)
- No conclusion on the intensity of 'keep-alive source' (1% ?)
  'keep-alive source': e^+ source by conventional method to keep tuned the e^+ beamline (DR, linac, BDS) when e^- is not available
- Undulator at linac end (500GeV and 1TeV stages)

White paper (the only white paper giving a result different from Snowmass)

- Intensity of 'keep-alive source' $\gtrsim$ 10% (for the BPMs to work)
  This should be possible without excessive cost.
- Undulator at 150GeV (deceleration needed if $E_{CM} < 300$GeV), because the luminosity for 200GeV $< E_{CM} <$ 300GeV is lower if linac end

Strawman BCD adopted this

Energy Upgrade Path

Snowmass and white paper came to the same conclusion

- Build 1TeV tunnel and fill the first half with linac in 500GeV stage. 

But Strawman BCD concluded

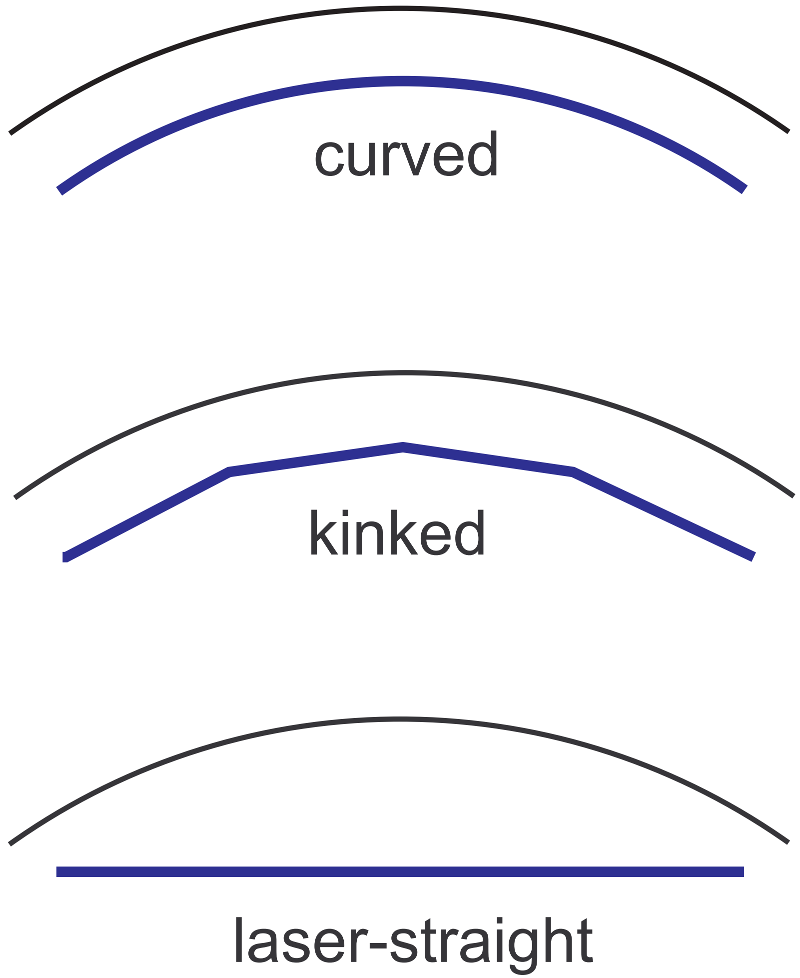
- Build only 500GeV tunnel in 500GeV stage because of lower 1st stage cost. 
  (White paper says 500GeV collider with 1TeV tunnel is 15% more expensive than that with 500GeV tunnel.)

in spite

- The total cost would be a little higher
- Some of the injector lines (turn-around, spin rotator, bunch compressor, undulator?) have to be moved at upgrade
- Shutdown between stage 1 and 2 might be longer

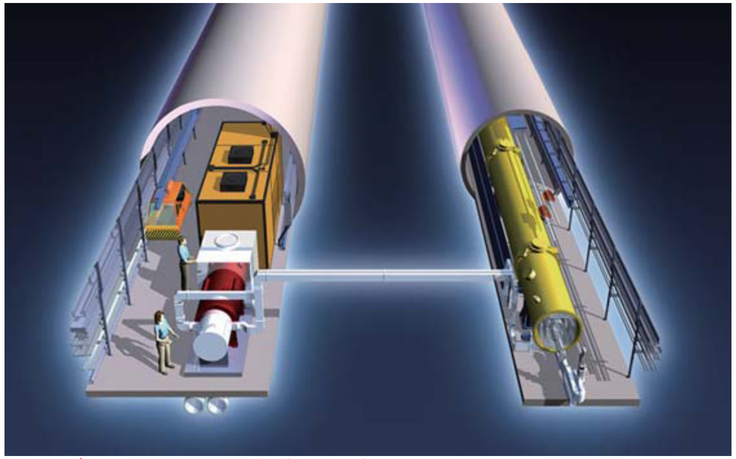
Tunnel Curvature

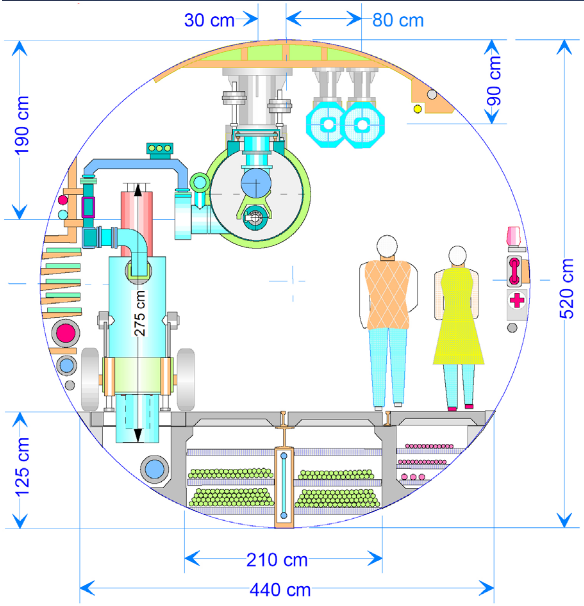
- Snowmass : no consistent conclusion
  - WG1 prefers ‘laser-straight’
  - Cryogenics prefers ‘kinked’ or ‘curved’
- White paper says ‘curved’ is preferred because of lower cost, provided no site constraint.
  - All 3 are feasible after some R&D
    - ⋆ inclined cryogenic system
    - ⋆ beam dynamics in curved/kinked tunnel
  - ‘laser-straight’ requires extra cost for cryogenics system
  - ‘kinked’ requires extra cost for bending sections
- Strawman BCD agrees with ‘curved’



Number of Tunnels

- Both Snowmass and white paper prefer 2 tunnels
  (or 1 tunnel with the power system on (near) the surface)
  - Additional cost only marginal (with same reliability/safety)
  - Easier maintenance
  - Less radiation on power equipments
  - There is still an argument that repair works in the 2nd tunnel may not be allowed during operation. (site dependent?)
- Strawman BCD agrees



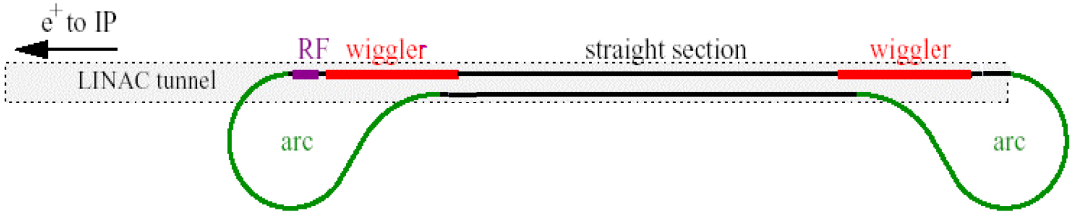


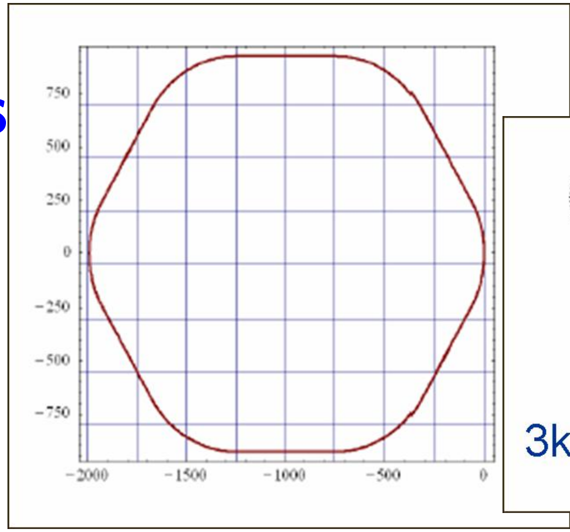
Number of IPs

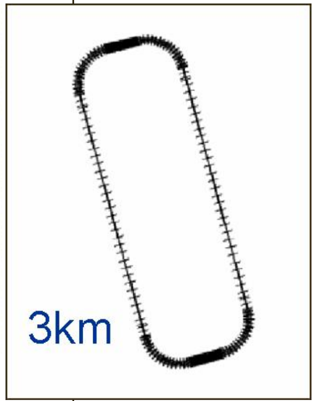
- Both Snowmass and white paper chose 2 IPs + 2 detectors as the baseline.
- White paper says the cost of 2nd IP (beamline + exp.hall) corresponds to the energy 14-19% of 500GeV (change of tunnel cost not included).

  Caveats: Total cost estimation from 3 regions agree well but the cost of individual components scatter in wide ranges.
- This means 405-430 GeV LC with 2IP is comparable in cost with 500GeV LC with 1IP (if I understand correctly)
- Strawman BCD adopts this conclusion
- but we might go to 1IP in the near future so that WG4 must be prepared to respond quickly

Other Issues : Damping Rings







Workshop on Nov.9-11 at CERN

- Over >30 people gathered
- Final summary report DRConfigRecommendSummary.pdf posted yesterday

  http://www.desy.de/ãwolski/ILCDR/DRConfigurationStudy_files/DRConfigRecommendSummary.pdf
- Big, comprehensive report nearly done. (186 pages)

DR Workshop Conclusions

- Chose one 6km ring for e^- and two 6km ring for e^+ , ‘unanimouly’.
- judged from the ranking issues
  - dynamic aperture of 17km dogbone is smaller
  - space-charge with dogbone
  - tunnel layout issue
- kicker technology considered to be feasible (assume feedforward)
- Cost is similar to two 17km dogbone
- More study needed for collective phenomena issues

An example from the *Summary Report*: the Circumference (4)

Issues Ranking

Issue	Significance	Risks			
		3 km	6 km	2×6 km	17 km
Electron cloud (positron ring)	A	4	3	2	2
Kickers	A	3	2	2	2
Acceptance	A	2	1	1	2
Cost	A	1	2	3	3
Ion effects (electron ring)	B	3	2	2	2
Space-charge	B	1	1	1	2
Tunnel layout	B	1	1	1	2
Availability	C	1	1	1	1
Classical collective effects	C	2	2	2	2
Low-emittance tuning	C	2	2	2	2
Polarization	C	1	1	1	1

The significance of each issue and the risk associated with each option are based on results from the configuration studies, which will be presented in the *Detailed Report*.

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- Exec Com accepted the WS conclusion after a long discussion
  - White paper choice does not guarantee Low Q (6000 bunches)
  - Dynamic aperture problem may be cured by longer undulator
  - Collective phenomena more serious especially in 6km e^- ring
  - The selected upgrade path makes the DR-linac interference (commissioning, stray field) inevitable with dogbone
- May be a topic for Frascati and CCB (Change Control Board)

Bunch Compressor

Snowmass

- Recommend 2-stage compressor of 1.4km long as baseline
- 1-stage satisfies only 6mm DR bunch → 300μm linac bunch

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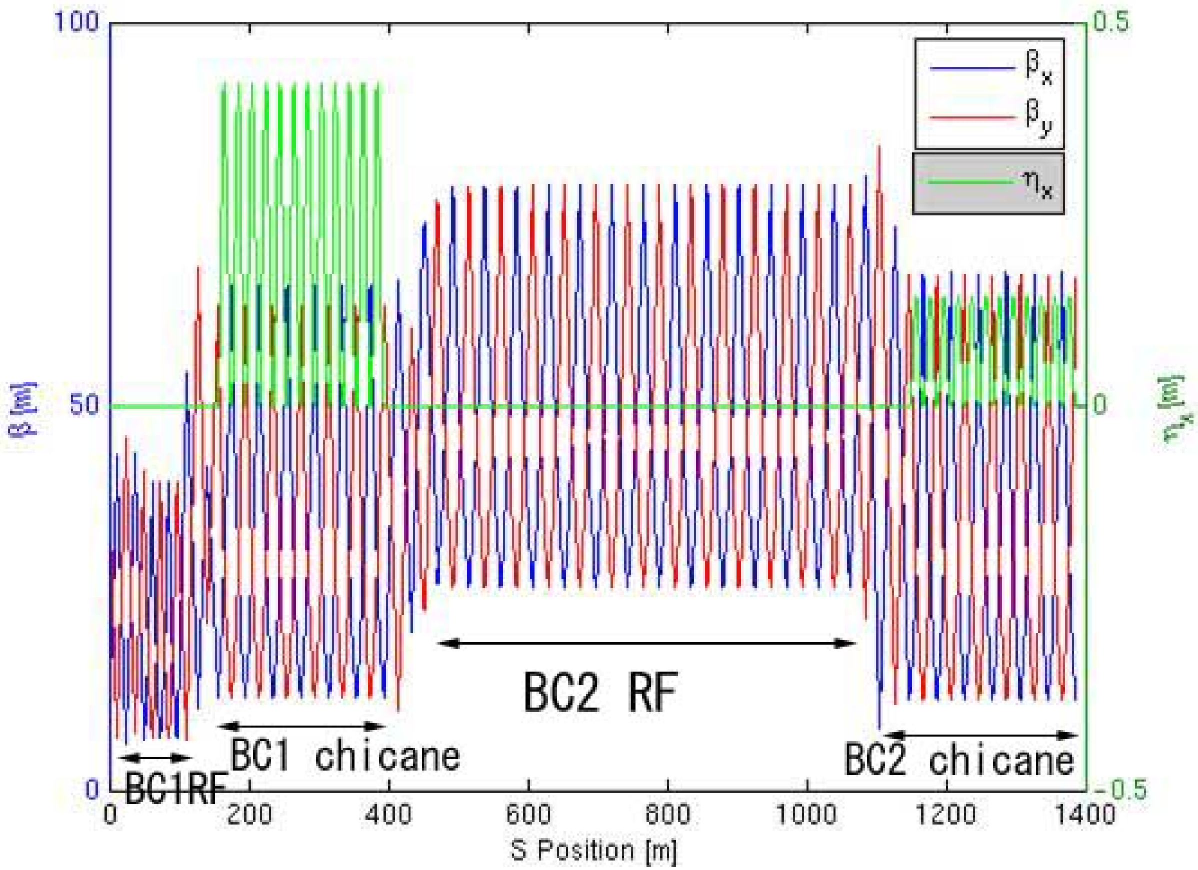
- Accept this
- But ask WG1 to persue shorter 2-stage compressor more intensively



Back to Parameters Again

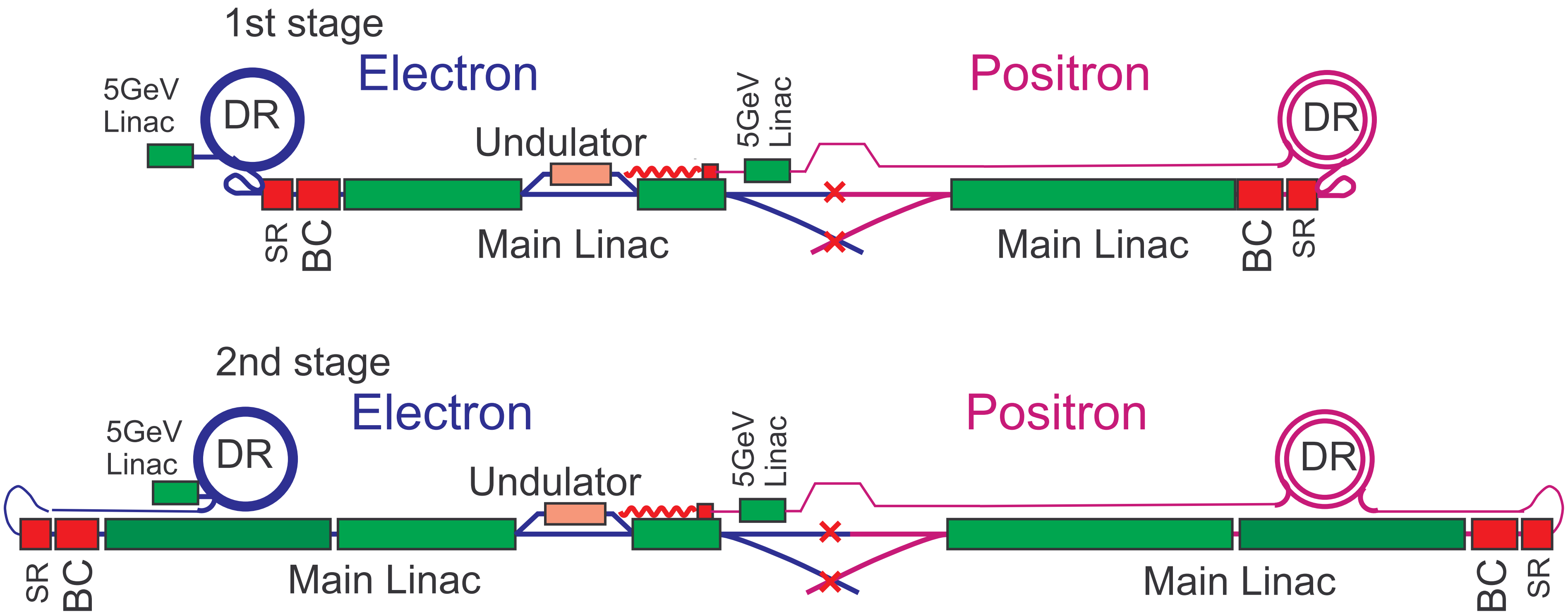
- Tweaking the parameters is anyway needed due to
  - small change of nominal gradient to 30 to 31.5MV/m
  - change of RF unit configuration (which must be consistent with 35MV/m)

  This can be done soon.

- However, more important is whether Low Q set can be retained.
  - 6km e^- DR and 2× 6km e^+ DR do not guarantee ~6000 bunches
  - Bunch compressor might be smaller if $\sigma_z = 150\mu$m is not required.

- This is still an open question.

Strawman BCD Layout



These figures are not intended to define

- Location of 5GeV linacs (e^+ and e^-)
- Location of 2nd stage undulator (must move to 150GeV point?)
- Linac orientation (2 linacs may have an angle)

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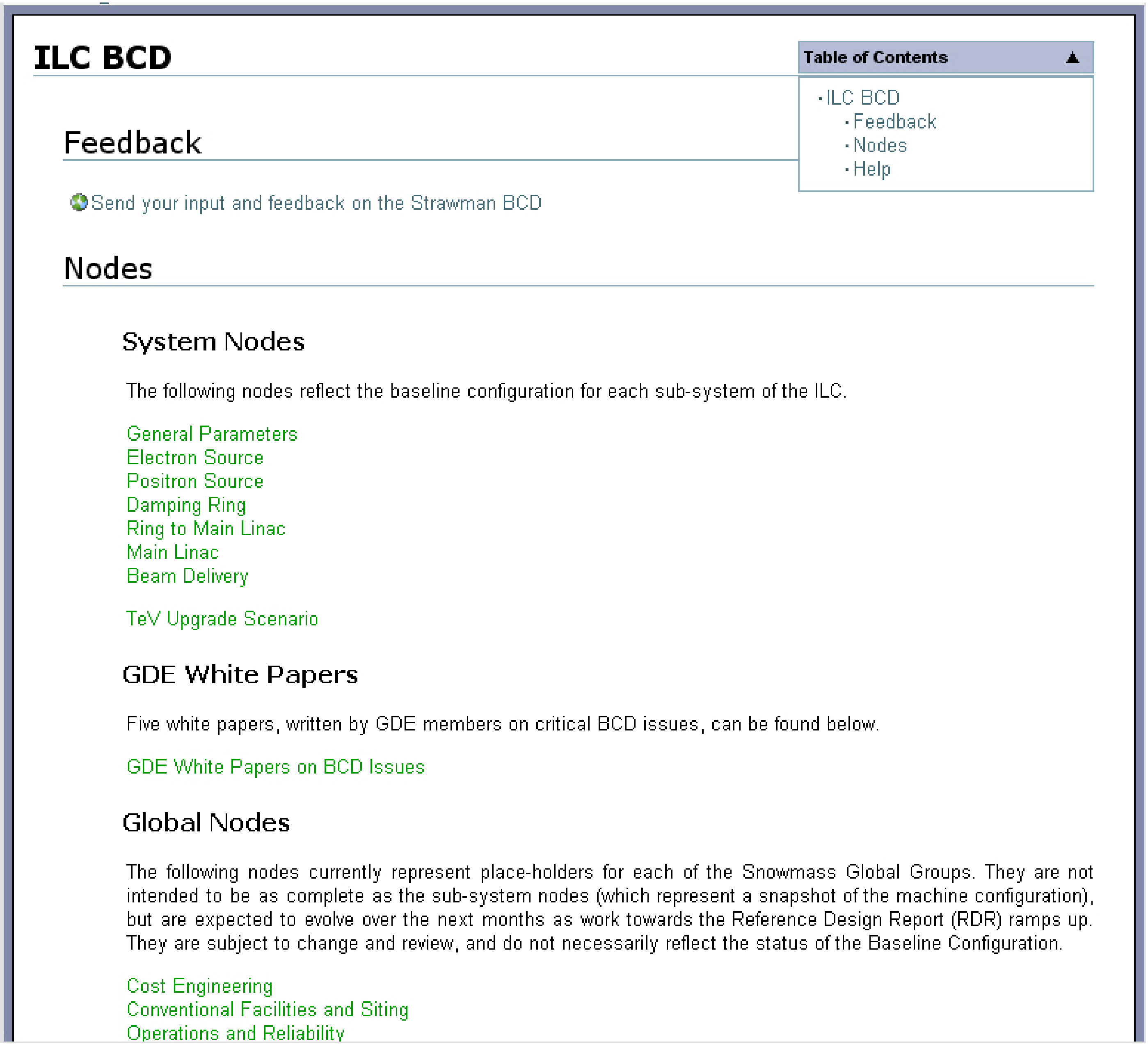
- ~600 pages if printed

Describes

- Choices of baseline and alternatives
- Justification of the choices
- Required R&D



ILC BCD

Table of Contents

Feedback

Send your input and feedback on the Strawman BCD

Nodes

System Nodes

The following nodes reflect the baseline configuration for each sub-system of the ILC.

General Parameters
Electron Source
Positron Source
Damping Ring
Ring to Main Linac
Main Linac
Beam Delivery

TeV Upgrade Scenario

GDE White Papers

Five white papers, written by GDE members on critical BCD issues, can be found below.

GDE White Papers on BCD Issues

Global Nodes

The following nodes currently represent place-holders for each of the Snowmass Global Groups. They are not intended to be as complete as the sub-system nodes (which represent a snapshot of the machine configuration), but are expected to evolve over the next months as work towards the Reference Design Report (RDR) ramps up. They are subject to change and review, and do not necessarily reflect the status of the Baseline Configuration.

Cost Engineering
Conventional Facilities and Siting
Operations and Reliability

Some Issues Yet To Be Decided

- Location of the 5GeV e+ linac
- Number and location of diagnostics sections
- Linac orientation
- Linac BPM resolution

Change of Organization

KEK ILCWS

WG1	Parameters
WG2	Linac
WG3	Injectors
WG4	BDS
WG5	Cavity
WG6	Communication

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Snowmass ILCWS

	WG1 Beam dynamics	WG2 Linac	WG3a Sources	WG3b DR	WG4 BDS	WG5 Cavity	WG6 Communication
GG1 Parameters							
GG2 Instrumentation							
GG3 Operation/Reliability							
GG4 Cost							
GG5 Conv.Facility							
GG6 Physics options							

After Frascati for writing RDR

	e^- source	e^+ source	DR	RTML	Main Linac	BDS
Technical Systems						
Accelerator phys.						
Vacuum						
Magnets						
Cryomodule						
Cavity						
RF Power						
Instrumentation						
Dumps/collimators						
Global Systems						
Commissioning/operation/reliab.						
Control system						
Cryogenics						
CF&S						
Installation						

Plan After Frascati

- Final documentation by end of the year (Christmas)
- Form **CCB** (Change Control Board) $\Rightarrow$ Barry's talk
- Meetings

Mar.9-11.2006	Bangalore
Jul.18-23.2006	Vancouber.
Autumn	somewhere

- RDR by the end of 2006

Finally

- Tremendous work has been done since the ICFA Decision
- After the process
  KEK WS $\Rightarrow$ GDE formation $\Rightarrow$ Snowmass WS $\Rightarrow$ Frascati
  we are now at the first milestone of the Global Design : BCD
- Still lots of work is awaiting
  - Details of everything
  - First cost estimation
- Keep our momentum to the next milestone : RDR