### iii "Minimum Machine" is code for **Design and Integration Studies** in 2009 toward a Re-Baseline in 2010 which will be the basis of TDP2 Engineering Design and Costing Minimum Machine is shorter Ewan Paterson

GDE

### Some of the topics under study from ilC

**Minimum Machine Definition** 

Release 30.01.09 ILC-EDMS Doc. # 865085



April 2009 AAP Review

- Quick look? Personal opinion JMP
- Update on status of the studies starting clockwise at 1 o'clock (to be adjusted after the prior AAP discussions. I will try not to repeat, too much, of what you have heard earlier-later today.)
- First look at "impact" of some of the proposed topics
- Plans for continuing work in 2009

İİİ.

#### Topics under study which can be implemented almost independent of one another and with little impact on readiness to complete TDP2 on schedule. A QUICK LOOK



April 2009 AAP Review

## Klystron Clusters, DRFS or ?

- Alternative High Level RF Systems have major impact on single tunnel studies.
- The impact depends on site assumptions
- Although R&D will continue on these different approaches, it is unlikely that technical demonstrations will be possible on the rebaseline schedule.
- We will need to make working decisions for the single tunnel studies.

## Klystron Cluster Concept (1)

- Idea has impacts well beyond the RF distribution for main linac.
- With less active high power equipment in the beam tunnel it could have a major impact on single tunnel design studies and discussions on operability and availability.
- Although this concept has been drawn up as Klystron Clusters in surface buildings, it could also be considered as packaged with Cryogenic plants wherever they are located. For example they could be in underground caverns at the end of a few major access shafts.



- Technical issues of flexible control and impact on operation should be resolved as early as possible in the MMS process to determine if there are impacts and or risks other than power handling.
- A demonstration of component capability of handling high power may take longer than the desired re-baseline schedule and a decision may have to be based on incomplete R&D and a judgment of risk-benefits. This is also true with other alternate RF system designs.

### **Removal of Service Tunnel**

- The impact of the removal of the service tunnel has to be re-evaluated using all of the following, the RDR systems, Klystron Clusters and Distributed RF.
- The 3d CAD work will be useful very soon in making more realistic evaluations of tunnel space and installation and personnel egress problems.
- An updated evaluation of availability, using the best and most up-to-date data, should be done for various models and assumptions.
- The removal of service tunnels in the Central Region may have to be considered separately as the optimum layout of injector, DR and BDS systems involve different impacts on operation etc than with the long linac. (see Central Region Integration) There are, however, obvious benefits from having as much common design as possible.

# RDR Baseline Tunnel Layout

Two 4-5 m diameter tunnels spaced by ~7 m.









### XFEL

Similar to RDR with Klystron in beam tunnel And modulator elsewhere

### **KLYSTRON CLUSTER CONCEPT**



IIL

Each tap-off from the main waveguide feeds 10 MW through a high power window and probably a circulator or switch to a local PDS for a 3 cryomodule, 26 cavity RF unit (RDR baseline).

- RF power "piped" into accelerator tunnel every 2.5 km
- Service tunnel eliminated
- Electrical and cooling systems simplified
- Concerns: power handling, LLRF control coarseness

# **First Pass at New Tunnel Layout**



April 2009

UIUNAI DESIGII LIIVIL

## Low Power Parameter Set

- The Low Power Parameter Set (<sup>1</sup>/<sub>2</sub> power using <sup>1</sup>/<sub>2</sub> length bunch train length) has impact on many systems. They are in brief :-
- e- Injector--- Easier on laser/photocathode
- e+ Source----Easier target,/ capture systems
- Damping Rings----Makes ½ circumference DR possible without other negative affects.
- RTML/Bunch Compressor----Increases importance of achieving short (200-300 micron) bunch length over a variety of conditions

## Low Power Parameters (2)

- Main Linac---Reduces by factor of two the required number of RF sources
- BDS--- Requires 200 micron bunch length, or use of Travelling Focus, to maintain design luminosity. First studies are encouraging showing Travelling Focus alleviates these problems.
- Ability to upgrade to higher power via longer bunch train, *if required*, would be dominated by the cost and interference of adding damping rings. (Assuming x2 faster kickers are out of the question)
- How much head room or safety factor do we have in other systems to increase the single bunch current, giving more flexibility in the parameter plane around the low power set?

### Some results from early studies look encouraging. The next three slides show the following:-

- The application of "travelling focus" in the BDS maintains performance of nominal RDR central parameters
- There is an increased sensitivity to beambeam alignment but not extreme
- The proposed Low Power parameters control the backgrounds in detectors.

#### Candidates for new Low P parameter sets

	Nom. RDR	Low P RDR	new Low P	new Low P	new Low P	new Low P		
Case ID	1	2	3	30	4	5		
E CM (GeV)	500	500	500	500	500	500		
Ν	2.0E+10	2.0E+10	2.0E+10	2.0E+10	2.0E+10	2.0E+10		
n <sub>b</sub>	2625	1320	1320	1320	1105	1320		
F (Hz)	5	5	5	5	5	5		
P <sub>b</sub> (MW)	10.5	5.3	5.3	5.3	4.4	5.3		
γε <sub>χ</sub> (m)	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05		
γε <sub>γ</sub> (m)	4.0E-08	3.6E-08	3.6E-08	3.6E-08	3.0E-08	3.0E-08		
β <b>x (m)</b>	2.0E-02	1.1E-02	1.1E-02	1.1E-02	7.0E-03	1.5E-02		
β <b>y (m)</b>	4.0E-04	2.0E-04	2.0E-04	1.0E-04	1.0E-04	1.0E-04		
Travelling focus	No	No	Yes	Yes	Yes	Yes		
Z-distribution *	Gauss	Gauss	Gauss	Flat	Flat	Flat		
σ <sub>x</sub> (m)	6.39E-07	4.74E-07	4.74E-07	4.74E-07	3.78E-07	5.54E-07		
σ <sub>y</sub> (m)	5.7E-09	3.8E-09	3.8E-09	2.7E-09	2.5E-09	2.5E-09		
σ <sub>z</sub> (m)	3.0E-04	2.0E-04	3.0E-04	3.0E-04	5.0E-04	2.0E-04		
Guinea-Pig δE/E	0.023	0.045	0.036	0.036	0.039	0.038		
Guinea-Pig L (cm <sup>-2</sup> s <sup>-1</sup> )	2.02E+34	1.86E+34	1.92E+34	1.98E+34	2.00E+34	2.02E+34		
Guinea-Pig Lumi in 1%	1.50E+34	1.09E+34	1.18E+34	1.17E+34	1.06E+34	1.24E+34		

### Case 3 Low P & offset sensitivity



- Luminosity kept by tighter focusing  $(\beta_y^* < \sigma_z)$  while the moving focus and beam-beam force keep beam focusing each other
- Higher disruption needed, which produces higher sensitivity to offset of the beams
- Operation of intratrain luminosity optimization is more challenging



**Global Design Effort** 

April 2009 AAP Review

18

## Single Stage Bunch Compressors

- The RDR design two stage compressor system was designed to accept very long bunches from the damping rings (≥ 9mm) and compress, with good emittance control, to very short bunches (≤ 200µ) for operation with some parts of the parameter plane including the Low Power.
- The present DR design has shorter bunches (~ 6mm) and it appears possible to achieve adequate compression with a single stage of compression which would be shorter in length and would have fewer active components. A design is under study from the point of view of performance beam dynamics and emittance control.
- This study looks towards a positive outcome and does not interact with other system parameters. However, the RTML beam lines from the DR to the Compressor do interact with other systems and are a very important component in the single tunnel studies and in general in the Central Region Integration.

### Evaluation of cost –increment for TeV Upgrade Support

- This subject covers many topics from site specifications for a longer machine to the luminosity versus energy distribution at the IP as a function of energy.
- For the Minimum Machine Study, the emphasis is on the BDS design. How short can the BDS be and still provide 'acceptable performance' at 1 TeV. (Beamstrahlung and luminosity spectrum?)
- The ILC layout with all sources etc in one central region encourages energy upgrades by simple elongation of the linacs. Can civil construction of linac extensions go along with physics operation? The answer is probably site dependent.





April 2009 AAP Review

### **RDR Central Region**



IIL

## Contents of part of Central Region



## A Compact Central Region (1)

#### <u>Central Region Integration</u>

- This is a simple concept but requires a complex design effort and impact analysis. The general idea is to group all systems except the actual linacs in the central region and minimize the underground housings required to house them. Basic assumptions for the study are that :-
- a) Everything will be in one plane, Inj's,DR, RTML and BDS
- b) The distance from the IP to the linac exit does not have to the same on either side
- c) The 'Keep Alive Source' will be functionally replaced with an 'Auxiliary Source' which is integrated into the E+ Source.
- d) Both E- and E+ sources, including the 5 GeV booster linacs and housings, will be in-line with the Linac and BDS

## A Compact Central Region (2)

- e) The degree of overlap, and therefore savings in tunnel length between the Sources and the BDS has to be studied and considered as a variable.
- f) 3D CAD capability will be available in studying this tunnel sharing from the points of view of feasibility, cost, operability, installation planning and personnel safety.
- g) The TeV upgrade plans (see above) should be an integral part of this study
- h) The final layout should support either 3.2 or 6.4 km circumference damping rings.
- The end result should be a Central Region Layout which does not necessarily have the minimum of underground civil construction or cost but has a more optimized lower cost design than the RDR.

## **3D CAD Integration Team**

 Multi-lab effort to develop a single 3D CAD modeling system which can accept input on lattice designs, equipment models and underground civil construction designs from several labs using different software.

## 3D CAD Collaboration Test Scenario



Access, Analysis and Markup ILC EDMS Anywhere at ILC





Study area refined to 50m either side of Shaft No. 3

#### April 2009 AAP Review

## Potential Impact on Operation

After answering the questions of technical feasibility of tightly coupling everything in the central region. (The Compact Central Region) One must look at

> Availability Looks OK, next topic Impact on installation and repair Part of the 3D CAD study. Could be Achilles heel! Commissioning Still maintains the desirable features that injectors and DR's can be early but with some interference with BDS installation.



### **Zone Zone Interactions**

		ГС		Γ.	· · · · ·	D D	•	<b>- -</b>	D.C.	Γ.	DDC	<b>г</b> 1	•	<b>F</b> . 1		<b>F</b> 0		Γ. (	<b>^</b>			
ILC Zones	<b>i</b>	E- 5	ource	E+ 3	Source	ed R	ings	E- B	05	E+	BD2	E-L	Inac	£+ I	Linac	E- (	.omp	E+ (	comp			
BEAM OF	FIN	BEA	MS P	055	IBLE <b>\</b>	with	auxili	ary e	e+ sou	rce								Rela	ative im	pact of acce	ess to	) zon
E- Source		NO	NO	NO	0K	NO	0K	NO	NO	NO	NO	NO	NO	0K	OK	NO	NO	0K	0K	7		-5
E+ Source	;	0K	0K	NO	NO	NO	NC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0K	0K	7		- 7
D Rings		0K	0K	0K	OK	NO	NC	NO	NC	NO	NC	NO	NC	NO	NC	NO	NC	NO	NO	7		- 7
E- BDS		0K	0K	0K	NC	ЮK	NO	NO	NC	OK	NC	ЮK	NC	0K	NC	NO	NC	0K	NO	2	2	- 7
E+BDS		0K	NO	0K	OK	0K	NO	0K	NO	NO	NO	0K	NO	0K	NO	0K	NO	0K	NO	1		8
E- Linac		0K	0K	0K	OK	0K	OK	NO	NC	OK	OK	NO	NC	0K	OK	NO	NC	0K	OK	3	}	3
E+ Linac		0K	0K	0K	OK	0K	OK	0K	OK	NO	NC	0K	0K	NO	NC	0K	OK	NO	NO	3	}	3
E- Compre	ssor	0K	0K	0K	OK	0K	OK	NO	NC	OK	OK	NO	NC	0K	OK	NO	NO	0K	OK	3	}	3
E+ Compr	essor	0K	0K	0K	OK	0K	OK	0K	OK	NO	NC	0K	OK	NO	NC	0K	OK	NO	NO	3	}	3
I.R.		0K	0K	0K	OK	0K	OK	0K	OK	0K	OK	0K	OK	0K	OK	0K	OK	0K	0K	(	)	0
# of OK's r	max 10	9	8	8	8	8	8	4	3	4	3	5	3	6	4	4	3	7	5			
	Conclude	that o	n aver	age '	with ac	ces	s to a :	zone	, beam	IS Ca	in kept	alive	e in 619	 % of 1	the ILC	l With	CDR	desiç	an and			
													50% in the CCR design									
	The differen		in 4	lan in		n al im		A alari						7								
	ine amere	ence II	es in t	ne Ir	icreasi	ea in	ipact c	00 U U U U	vntime	in t	ne ±+:	ana t	5- BDS	o Zon	es							

### Impact of BDS from RDR



In the RDR, the BDS's together accounted for only 7% of the downtime which overall was 17%. Therefore the impact of the change to the Compact Central Region on overall availability will be small.

However detailed simulations will be done on several "minimum machine" configurations to evaluate the impacts.

ΪĹ

### COST IMPACTS

- The Cost Management Group will evaluate the cost delta's associated with the possible re-baseline topics using the RDR data for the basis of comparison.
- These delta's will be part of the cost/risk evaluation in the re-baseline discussions.
- A 'Bottoms Up' ILC cost estimate will be part of the TDP2 process.

## Cost Decrements (Rough Estimates)

- Main Linac (total)
- Low-Power option
- Central injector Integration
- Single-stage compressor

~ 300 MILCU ~ 400 MILCU ~ 100 MILCU ~ 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

## Proposing the Updated Baseline

- Project Management will drive re-baseline design
- Core "design & integration" team
  - TAG leaders
  - Cost Management Group
  - Few key (specialist) additions

~30 people

- Series of face-to-face meetings foreseen
  - DESY 28-29.05
  - ALCPG GDE meeting (Albuquerque) 29.09-03.10
  - (Possible meeting in early December tbc)
- Produce proposed baseline early 2010
  - Review process  $\rightarrow$  consensus  $\rightarrow$  sign-off
- Mechanisms for transparency and communication during process needs to be defined
  - Particularly true for Physics & Detector groups

# Processes that do not yet have a satisfactory plans defined.

- How do we evaluate impacts on construction, installation and commissioning schedules (and associated costs) when (at least for the latter two) adequate RDR plans did not exist?
- Technical risk tables (from Dec 2007) can be updated and can provide qualitative basis for some comparisons!
- Computer modeling of "Availability" for different assumed baselines can again give only qualitative comparisons.
- As usual nothing will be BLACK or WHITE

#### April 2009 AAP Review

#### **Global Design Effort**

Questions?