ACCELERATOR ADVISORY PANEL REVIEW

CONVENTIONAL FACILITIES AND SITING GROUP

Single Tunnel CFS Aspects
Cooling and AC Power Aspects

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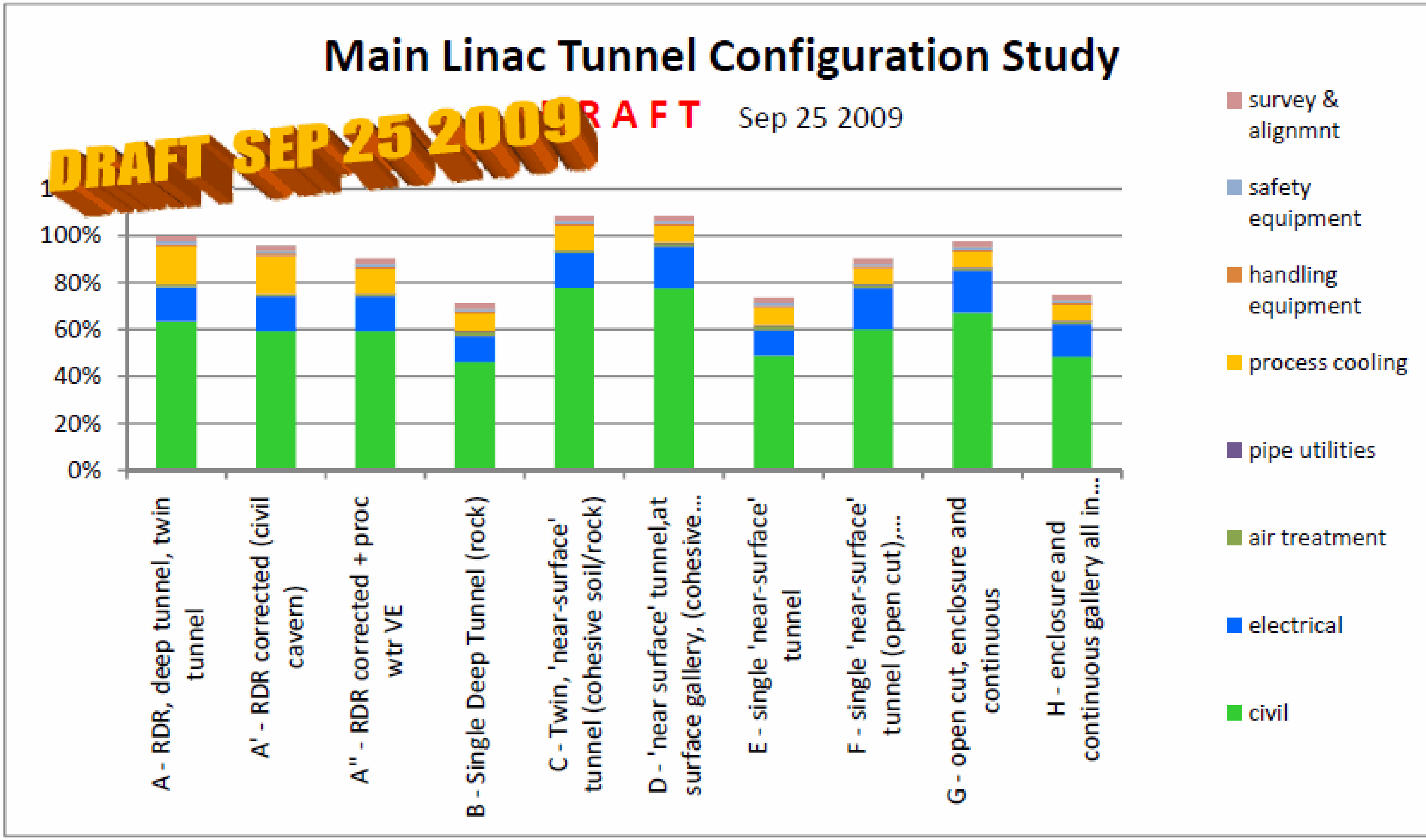
Overview

- Response to AAP Review at TILC'09
- Single Tunnel CFS Aspects
    - SB 2009 Working Assumptions 1, 2a & 2b
- Cooling and AC Power Requirements
    - VE Study Conclusions
    - SB 2009 Working Assumptions 3 – 7
- Clarification of CFS Cost Estimate
- Summary

Response to AAP Review at TILC'09

The AAP encourages the CFS groups to continue their efforts to explore the various tunnel configurations with a uniform approach and common methodology

- *The Consultant Effort to Review Alternative Tunnel Configurations was Completed in September 2009*
- *Seven Alternative Tunnel Configurations were Studied and Cost Estimates Developed for the ILC Main Linacs*
- *The RDR Deep Twin Tunnel Configuration was Used as the Basis of Comparison*
  - ***Single Deep Tunnel in Rock With Clustered Surface Buildings (B)***
  - ***Twin Near Surface Tunnels in Cohesive Soils or Rock with Clustered Surface Buildings(C)***
  - ***Near Surface Tunnel with Continuous At Surface Gallery in Cohesive Soil with Low Permeability (D)***
  - ***Single Near Surface Tunnel with Clustered Surface Buildings (E)***
  - ***Single Near Surface Tunnel (Open Cut) with Continuous Gallery (F)***
  - ***Open Cut Enclosure and Continuous At Surface Gallery (G)***
  - ***Open Cut Enclosure with Clustered Surface Buildings (H)***


Main Linac Tunnel Configuration Study
DRAFT SEP 25 2009
DRAFT Sep 25 2009
100%
80%
60%
40%
20%
0%
A - RDR, deep tunnel, twin tunnel
A' - RDR corrected (civil cavern)
A'' - RDR corrected + proc wtr VE
B - Single Deep Tunnel (rock)
C - Twin, 'near-surface' tunnel (cohesive soil/rock)
D - 'near surface' tunnel,at surface gallery, (cohesive...
E - single 'near-surface' tunnel
F - single 'near-surface' tunnel (open cut),...
G - open cut, enclosure and continuous
H - enclosure and continuous gallery all in...
survey & alignmnt
safety equipment
handling equipment
process cooling
pipe utilities
air treatment
electrical
civil

Response to AAP Review at TILC'09

Technical designs of configurations such as RF power distribution and the treatment of operational reliability (downtime for klystron replacement etc.), safety and radiation aspects should be handled in a consistent and transparent manner. Each configuration should be subject to an in-depth risk analysis that includes consideration of the operation and maintenance aspects

- ***The CFS Group Reviewed both the Klystron Cluster and DRFS RF Power Distribution Alternatives as Part of the SB 2009 Process***
- ***The Asian Region Site Conditions Favored the DRFS Alternative***
- ***The European Region Site Conditions Favored the Klystron Cluster Alternative***
- ***The Americas Region Site Conditions Allow the Use of Either RF Distribution System***
- ***The CFS Group has Incorporated Safety and Radiation Considerations into All of the Regional CFS RF Studies***

Response to AAP Review at TILC'09

Installation and Maintenance Aspects

- The Current 2D CFS Machine and Enclosure Drawing Does Reflect and Initial Consideration for Aisle Spacing and Continuity to Accommodate Installation and Maintenance of Beamline Components
- It is Not Comprehensive in Nature
- No Work on Installation Issues has been Completed by the CFS Group Since Before 2008
- A Separate Study for Both Installation and Maintenance Issues Needs to be Conducted to Identify Problem Areas and Develop Further Criteria for Tunnel and Enclosure Adjustments to Accommodate Installation and Operational Considerations
- CFS Can Help in this Effort, But Resources will be Required and Technical Systems Must Take the Lead in this Effort

Response to AAP Review at TILC'09

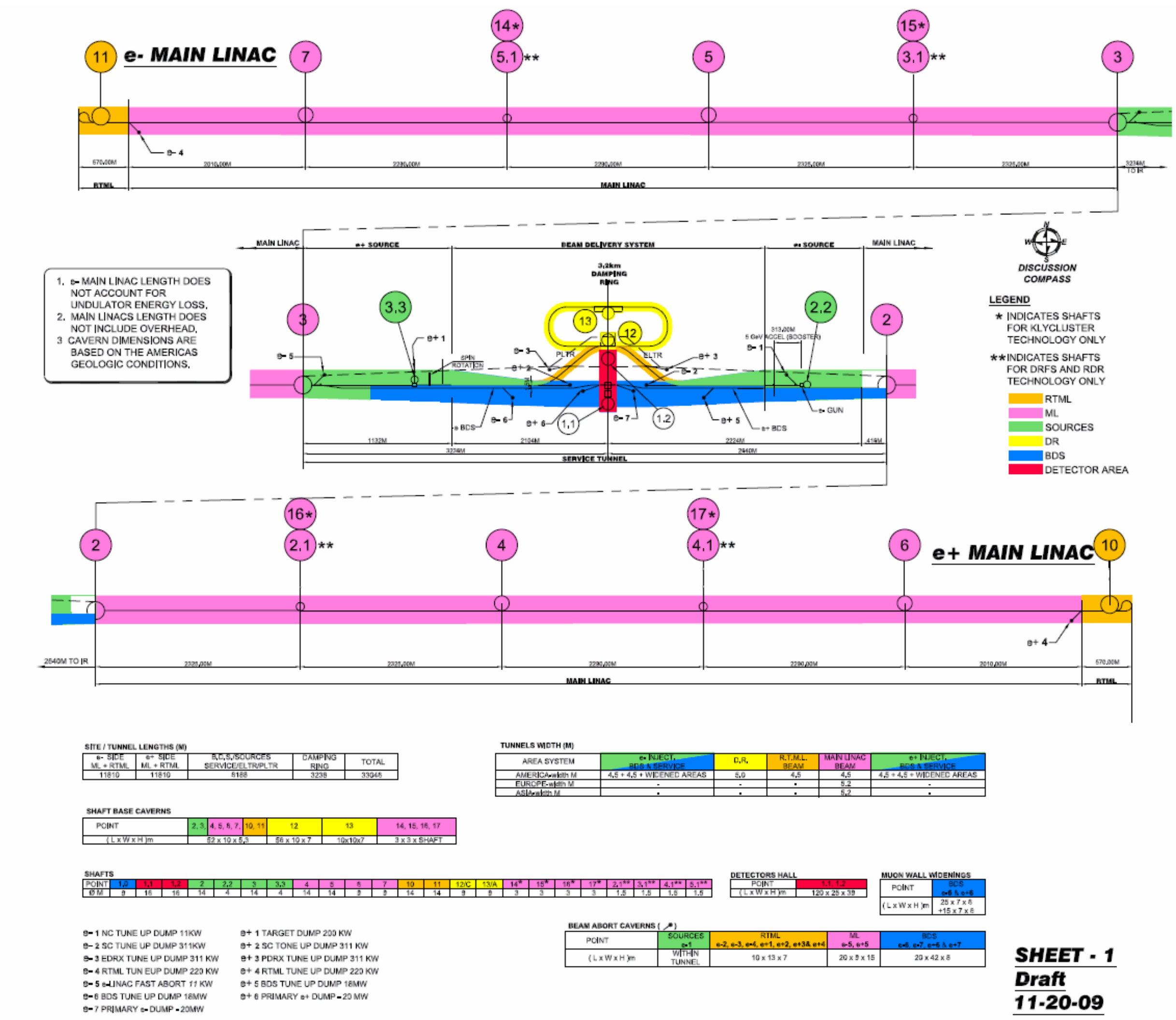
The AAP encourages further exchange between the various area groups. In many cases, guidance from the project managers is necessary for systematic application across the project. For these CFS efforts to be most useful, it is important to define clearly the main assumptions and technical choices

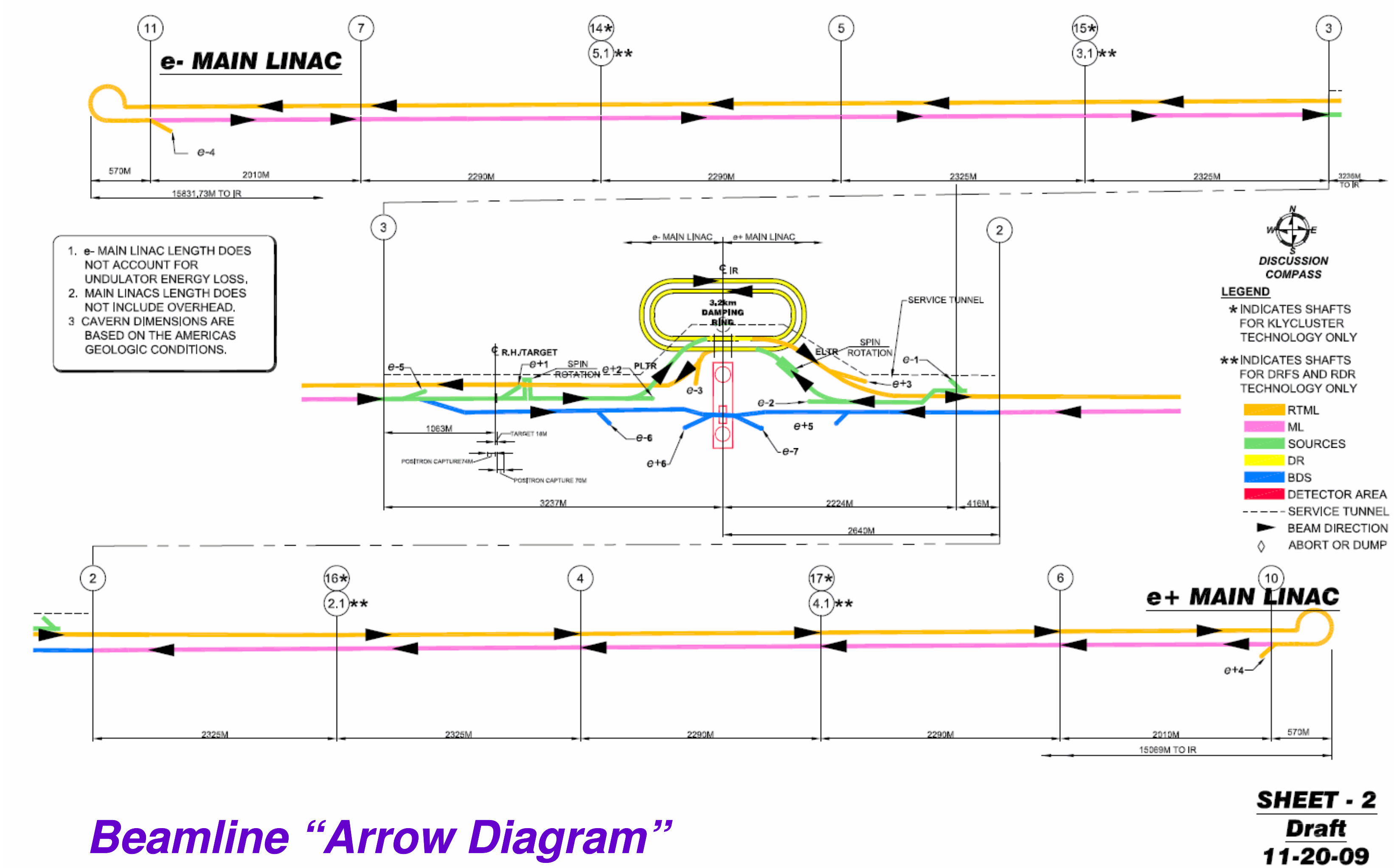
- ***Since the Previous AD&I Meeting in May, 2009 the CFS Group has had Several Direct Meetings with the Various Area System Groups***
  - ***CFS Weekly Video/Webex Meetings were Devoted to Specific Area Systems with AS Representatives***
  - ***A CFS 2-Day Workshop was Held at SLAC in July, 2009***
  - ***A Second CFS 2-Day Workshop was Held at the Daresbury Laboratory in September, 2009***
  - ***Both CFS Workshops Allotted Time for Each Area System with Direct and/or Webex Participation with AS Representatives***
- ***From These Meetings Criteria were Developed for the Layout of Each Area System and Combined into a Single Complete Machine Layout Which did Undergo Several Iterations***

Response to AAP Review at TILC'09

- Norbert Collomb was the Main CFS Point of Contact to Collect and Combine all of the Area System Technical Criteria into a Complete Beam Layout
- After Several iterations a Complete Technical Beamline Layout was Established in Mid-October, 2009
- This Layout was Used by the CFS Group at FNAL to Develop the Final 2D Layout for the Tunnels and Enclosures to Match the Technical Beamline Layout
- These Drawings Were Posted on the EDMS System in Mid-November, 2009
- These 2D Drawings are the Basis for the On-Going 3D Drawing Effort

CFS Overall Machine Layout Drawing



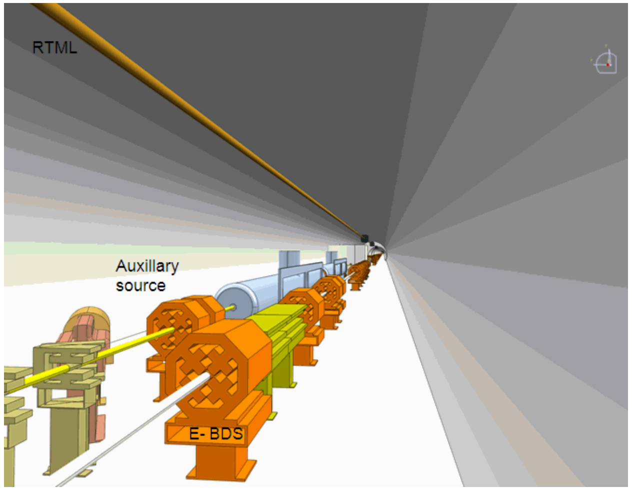


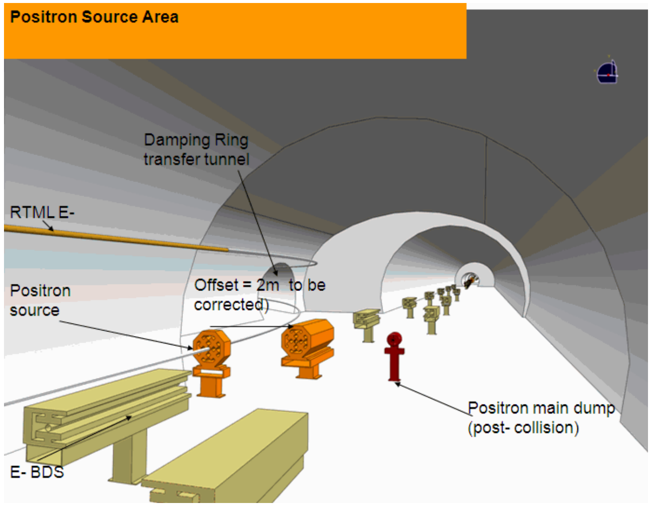
Beamline "Arrow Diagram"

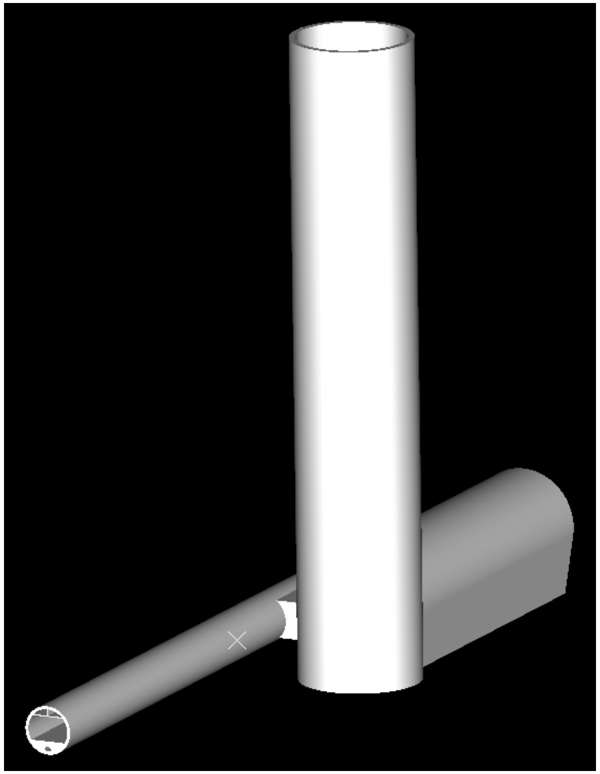
Response to AAP Review at TILC'09

The AAP is impressed by the progress of the 3d tool integration. The tools are recognized as an important aid in understanding critical aspects of a chosen layout, where the benefits from the resource-intensive implementation efforts may be justified.

- *The 2D Machine Layout Drawing is the Basis for the 3D CFS Enclosure Drawing that is Being Developed by the CFS Effort at CERN Using the European Cavern Configuration (More to Come on This Issue)*
- *The 2D Machine Layout Drawing is also the Basis for the 3D Support Utility Drawings that are Being Developed by the CFS Effort at FNAL (M+W Zander)*
- *3D Drawings are Being Forwarded to DESY for Inclusion into the Complete ILC 3D Model as They Progress*
- *Currently the Focus of the 3D Effort are Two 100m Sections of the Machine Layout as a Starting Point*

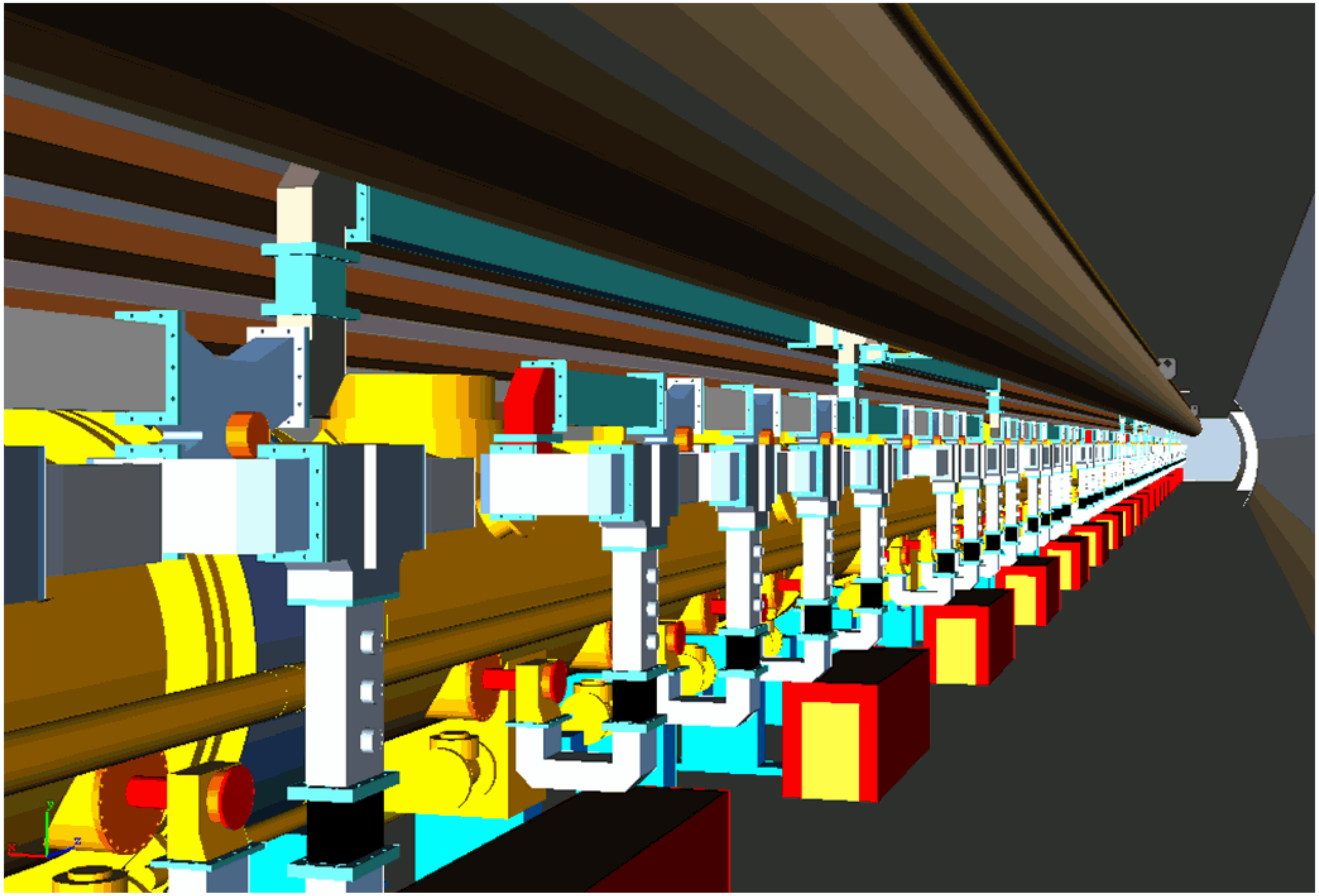






European CFS Group 3D Drawing Examples

DESY 3D Drawing Example



DESY 3D Drawing Example

Regional Impact on the 3D Drawing Effort

- The Asian Region has Focused on the Distributed RF System While the Americas and European Regions have Focused on the Klystron Cluster RF System
- The Asian and European Regions Use 5.2 m Main Linac Tunnel Diameter and the Americas Region Uses a 4.5 m Main Linac Tunnel Diameter
- The European CFS Group is Developing a 3D Enclosure Model Based on the 5.2 m Tunnel
- The Americas Region is Developing a 3D Mechanical Support Model Initially for a 4.5 m Tunnel which has to be Redrawn to a 5.2 m Tunnel so it Fits into the Overall DESY 3D Model
- It is Likely that Each Region will Develop a Separate 3D Model During the TDP II Effort
- This will Require an Increased Level of Resources

Single Tunnel CFS Aspects

SB 2009
WA 1

- *Variation in the Nominal Accelerating Gradient Can Easily be Evaluated as a Linear Function of Overall Main Linac Tunnel Length*

SB 2009
WA 2a & 2b

- *The Asian Solution Uses a 5.2 m Main Linac Diameter for the Distributed RF System and the Klystron Cluster RF System*
- *The Americas Solution Uses a 4.5 m Main Linac Tunnel Diameter for the Klystron Cluster RF System and has Taken the Asian Configuration (5.2 m Main Linac Tunnel Diameter) for the Distributed RF System*
- *The European Region Uses a 5.2 m Tunnel Diameter for the Klystron Cluster RF Systems and the Distributed RF System*
- *It Should be Noted that Each Region is Concentrating It's Design Efforts on a Regional Preference for RF System*

Regional Impacts for the CFS Effort

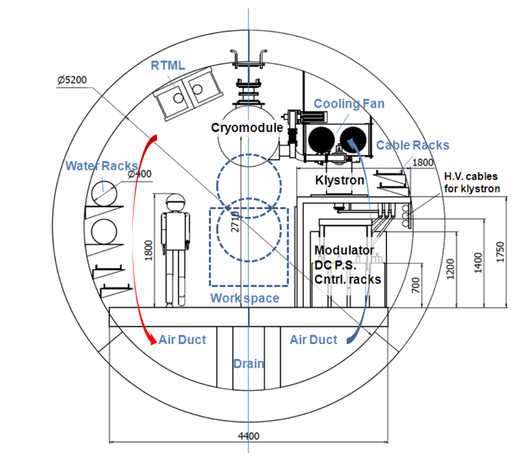
- *Asian Region*
  - *Design Focus is on Distributed RF System*
  - *Physical Size of DRFS Components*
  - *Supply and Exhaust Duct Size w/Respect to the Compartmentalized Approach to Life Safety and Egress Issues*
  - *Cavern and Enclosure Shape Due to Geologic Conditions (Ceiling Profiles are Elliptical in Shape)*
  - *Optimization of Horizontal Access Tunnels May Result in a Limited Parallel Egress Tunnel in Portions of the Main Linac*

Regional Impacts for the CFS Effort

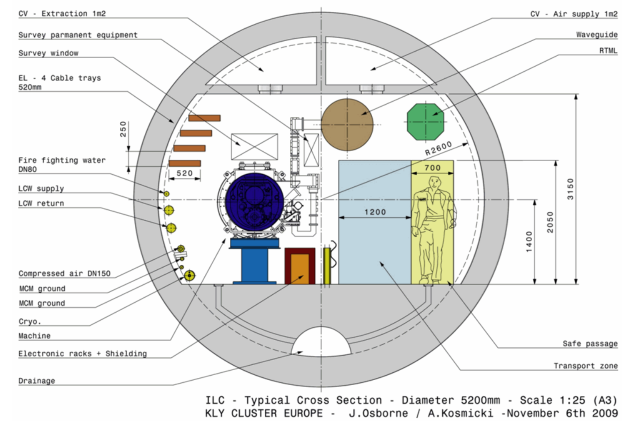
- **Americas Region**
  - ***Either RF System Can Be Used, However the Current Design Focus is on the Klystron Cluster RF System Which Can Fit into a 4.5 m Tunnel***
  - ***The Americas Region has Currently Adopted the Asian Solution for the Distributed RF System Which Requires a 5.2 m Tunnel . This Solution has not yet been Optimized in the Americas Region***
  - ***Most Klystron Cluster RF Equipment is Located on the Surface***
  - ***Life Safety and Egress Requirements do not Require Tunnel Compartmentalization and Consequently Large Air Supply and Exhaust Ducts are not Required***
  - ***Cavern and Enclosure Shape Due to Geologic Conditions (Ceiling Profiles are Relatively Horizontal in Shape)***

Regional Impacts for the CFS Effort

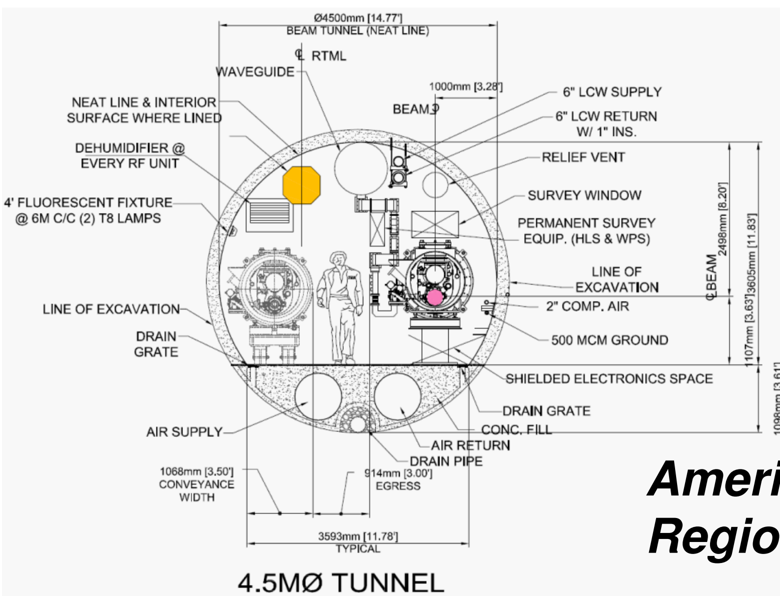
- European Region
  - Focus is on the Klystron Cluster RF System (Geology is not Conducive to Ceiling Mounted Loads)
  - Most Klystron Cluster RF Equipment is Located on the Surface
  - Supply and Exhaust Duct Size w/Respect to the Compartmentalized Approach to Life Safety and Egress Issues Requires the 5.2 m Tunnel Diameter
  - Cavern and Enclosure Shape Due to Geologic Conditions (Ceiling Profiles are Semicircular in Shape)



Asian Region

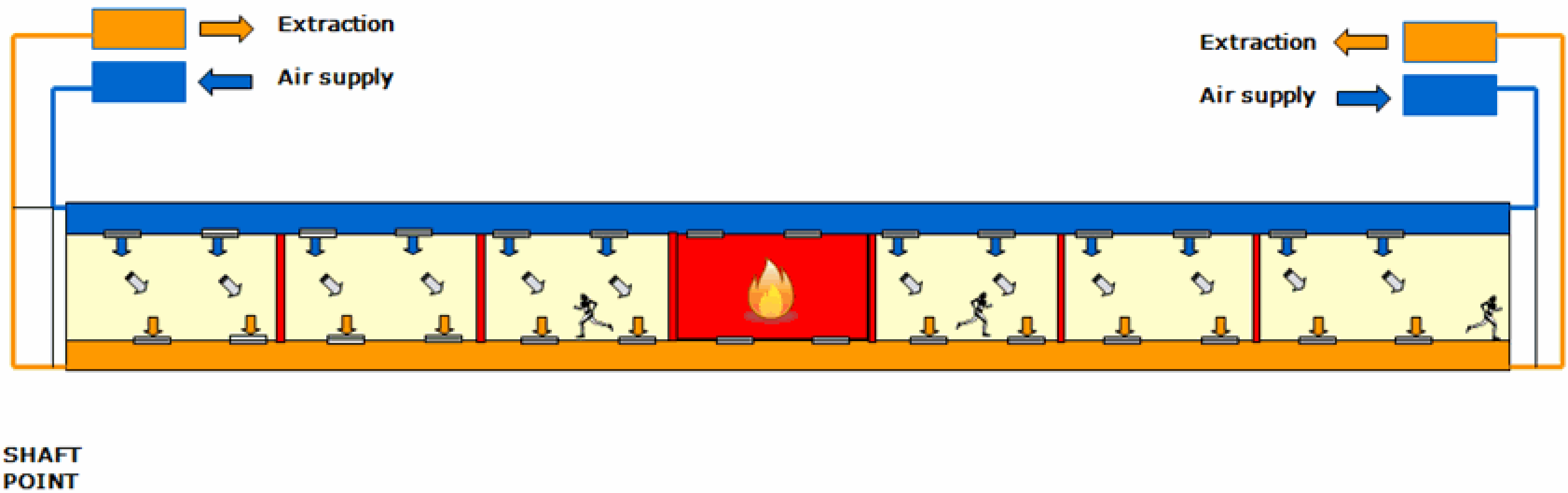


European Region



Americas Region

Regional Tunnel Comparison



- Control of the pressure from both ends of a sector.
- Control of the pressure (overpressure or underpressure in each area).
- Fire detection per sector compatible to fire fighting via water mist.

Schematic Diagram of Asian and European Compartmentalization Concept

CFS Figures of Merit

- These are Salient Features of the CFS Underground Construction
- Comparison is Between the RDR Design and the Americas Klystron Cluster Single Tunnel Configuration
- Also Indicated are the Differences Associated with the Revised Central Machine Region

DRAFT Dec 28 2009		CFS FIGURES OF MERIT		
		RDR & A"	SB2009 -KCS	Units
SHAFTS				
	Shaft 16m dia 130m depth	2	2	each
	Shaft 14m dia 130m depth	6	6	each
	Shaft 9m dia 130m depth	5	5	each
	Shaft 4m dia 130m depth	2	2	each
	Shaft 3m dia 130m depth	0	4	each
	Shaft 1.5m dia 130m depth	6	6	each
	Shaft <1m dia 130m depth	8	6	each
TBM TUNNELS				
	TBM tunnel 4.5m (Sources, BDS, RTML)	20,636	12,683	lineal meter
	TBM tunnel 4.5m (Main Linac)	45,002	22,480	lineal meter
	TBM DR tunnel 5m	6,689	3,238	lineal meter
DRILL AND BLAST				
	Tunnel Widening	**19,720**	**37,498**	**cubic meter**
	Tail Tunnel (at RTML)	14,746	10,670	cubic meter
	All Beam Dumps (Qty Dump Hall) ** [Qty Dump Service Hall]	32,190 (12) [6]	23,946 (6)* [4]	cubic meter
	Rad Hot Cavern (KAS & Undulator)	12,600	0	cubic meter
	personnel xover & passgway	16,633	4,141	cubic meter
	Moveable shield doors	7,009	7,009	cubic meter
	Muon Wall Alcove	3,360	3,360	cubic meter
	Shaft Base Caverns	41,122	23,888	cubic meter
	Alcoves/Refuge Areas (Damping Ring)	1,104	1,274	cubic meter
	Alcove/Refuge Areas (Main Linac)	0	5,100	cubic meter
	IR Hall	116,167	116,167	cubic meter
	IR Steel Track Plates	640,000	640,000	Kg
	penetrations	2,410	254	each
SURFACE STRUCTURES		**52,689**	**67,623**	square meter

*Total beam dump =13. Six requre specific tunnel widening

** Dump service hall is the equipment area adjacent to the main dump enclosure

TUNNEL WIDENINGS breakdown DRAFT Dec 28 2009		RDR & A"	SB2009 -KCS	Units
	e- source widenings	0	5,305	cubic meter
	e+ source widenings	0	16,633	cubic meter
	ELTR	0	7,780	cubic meter
	PLTR	0	7,780	cubic meter
	e- BDS widening	2,916	0	cubic meter
	e+ BDS widening	2,916	0	cubic meter
	e+ undulator widening	11,059	0	cubic meter
	e+ Keep Alive widening	619	0	cubic meter
	e-source beam tunnel connect to DR	1,105	0	cubic meter
	e+ source beam tunnel connect to DR	1,105	0	cubic meter
		19,720	37,498	

Details of Tunnel Widening

- e- and e+ Sources and ELTR and PLTR are New Required Enclosures
- All Other LIne Items Listed No Longer Require Distinct Tunnels and Are Now Incorporated into Other Widened Enclosure Areas
- Although the Drill and Blast Tunnel Widening Requirements have Increased, Approximately 8 km of 4.5 m Diameter Tunnel have been Eliminated (Not Including the Damping Ring)

Cooling Requirements – Basis

- SB 2009 WA 3 - 7 were Combined into a Single CFS Evaluation of the Revised Central Region Layout
- The Basis of the CFS Examination of the SB 2009 Working Assumptions, with Respect to Process Cooling , Incorporated the Increased ΔT Criteria Developed During the Value Engineering Review of the RDR Process Cooling System Design
- The Americas Version of the Klystron Cluster RF System has been the Basis of Analysis with Respect to Process Cooling at this Point
- The Asian Region has Also Completed Preliminary Studies of the DRFS System with Respect to Process Cooling

Cooling Requirements - Pros and Cons

- *The Klystron Cluster RF System has Approximately the Same Heat Loads as the RDR, However Since Most of the Heat Producing Equipment is Clustered and On the Surface, the Cooling Solution is Greatly Simplified*
- *Access to Equipment is Basically the Same for Both the RDR and the Klystron Cluster Configurations*
- *The Revised Central Region Layout Now has More Than One Set of Equipment in a Single Enclosure*
  - ***This Preliminary Review Uses the Most Stringent Temperature Requirements to Govern the Analysis of Cooling Loads***
  - ***Revisiting the Various Area System Requirements will be Necessary Before a Final Optimized Solution can be Determined***
- *The Reduction in the Damping Ring Length and Associated Components has Reduced the Cooling Requirements by ~40%*

Thermal Load in MW

RDR 2006

	LCW	Air/Chw	Total
e-sources	2.88	1.42	**4.3**
e+sources	17.48	5.33	**22.8**
DR	17.68	1.85	**19.5**
RTML	9.25	1.34	**10.6**
Main Linac	56	21.1	**77.1**
BDS	10.29	0.98	**11.3**
Dumps (wtr)	36	0	**36**
	Total including dump		**182**
	Total excluding dump		*146*

SB2009 (w KlyCluster)full power

	LCW	Air/Chw	Total
e-sources	2.88	1.42	**4.3**
e+sources	13.11	4.00	**17.1**
DR	6.84	1.61	**8.4**
RTML	6.97	2.10	**9.1**
Main Linac	62.72	5.6 *	**68.3** *
BDS	9.65	0.62	**10.3**
Dumps (wtr)	36	0	**36**
	Total including dump		**154**
	Total excluding dump		*118*

SB2009 (w KlyCluster) Low Power

	LCW	Air/Chw	Total
e-sources	2.88	1.42	**4.3**
e+sources	13.11	4.00	**17.1**
DR	6.84	1.61	**8.4**
RTML	6.97	2.10	**9.1**
Main Linac	31.36	2.8 **	**34.2 ** **
BDS	9.65	0.62	**10.3**
Dumps (wtr)	36	0	**36**
	Total including dump		**119**
	Total excluding dump		*83*

* heat load to air in the surface is ignored (cooled by ventilation) & no heat load to air in the tunnel

** ML heat load assume reduced by 50% for low power

Thermal Load Summary

- ***Major Value of the Klystron Cluster is the Reduction of Heat Loading in the Main Linac Tunnel***
- ***Surface Equipment can be Efficiently Air Cooled***
- ***BDS Must be Sized for Eventual Upgrade to 1 Tev***

AC Power Requirements - Basis and Pros and Cons

- The Americas Version of the Klystron Cluster RF System has been the Basis of Analysis with Respect to the Electrical Distribution and Power Requirements to This Point
- The Klystron Cluster has Approximately the Same Electrical Loads as the RDR, However More Clustered Equipment Provides Initial Capital Savings Due to Larger and Centralized Transformers and Distribution Conductor Size
- SB 2009 Low Power Option has Only a Minor Effect on the Electrical System Since High Power Capacity will Eventually be Needed
- If Only Low Power Equipment is Installed Initially, the Cost and Downtime Required to Completely Replace the Initially Installed Equipment Far Outweighs the Initial High Power Capital Cost

Electrical Power in MW DRAFT Dec 29 2009

RDR							
Area System	RF Power	Conventional Power				Emerg Power	Total
		Conv	NC Magnets	Water Systems	Cryo		
e-sources	1.05	1.19	0.73	1.27	0.46	0.06	4.764
e+sources	4.11	7.32	8.9	1.27	0.46	0.21	22.27
DR	14	1.71	7.92	0.67	1.76	0.23	26.29
RTML	7.14	3.78	4.74	1.34	0	0.15	17.15
Main Linac	75.72	13.54	0.78	9.86	33.9	0.404	134.21
BDS	0	1.11	2.57	3.51	0.33	0.2	7.72
Dumps	0	3.83	0	0	0	0.12	3.95
TOTALS	102.0	32.5	25.6	17.9	36.9	1.4	216.3

SB2009 (KlyCluster) Full Power							
Area System	RF Power	Conventional Power				Emerg Power	Total
		Conv	NC Magnets	Water Systems	Cryo		
e-sources	1.05	1.19	0.73	1.27	0.46	0.06	4.76
e+sources	3.08	5.49	6.68	0.95	0.46	0.16	16.82
DR	6.05	0.74	3.42	0.29	1.76	0.10	12.36
RTML	6.12	3.24	4.06	1.15	0	0.13	14.70
Main Linac	75.72	8.12	0.78	8.87	33	0.4	126.90
BDS	0	1.01	2.34	3.20	0.33	0.18	7.07
Dumps	0	3.83	0	0	0	0.12	3.95
TOTALS	92.0	23.6	18.0	15.7	36.0	1.1	186.6

SB2009 (KlyCluster) Low Power							
Area System	RF Power	Conventional Power				Emerg Power	Total
		Conv	NC Magnets	Water Systems	Cryo		
e-sources	1.05	1.19	0.73	1.27	0.46	0.06	4.76
e+sources	3.08	5.49	6.68	0.95	0.46	0.16	16.82
DR	6.05	0.74	3.42	0.29	1.76	0.10	12.36
RTML	6.12	3.24	4.06	1.15	0.00	0.13	14.70
Main Linac	37.86	8.12	0.78	4.44	33	0.4	84.60
BDS	0.00	1.01	2.34	3.20	0.33	0.18	7.07
Dumps	0	3.83	0	0	0	0.12	3.95
TOTALS	54.2	23.6	18.0	11.3	36.0	1.1	144.3

AC Power Requirements

- *Values Shown Reflect Only the Klystron Cluster RF Alternative at this Time and Represent Only Loads and Not Installed Power Required*
- *The DRFS System will be Reviewed by the CFS Group as Part of TDP II*
- *Transformer and Conductor Sizing is not Linear but Rather a Step Function*

DRAFT Dec 29 2009

Total Thermal Load in MW

	RDR 2006	SB2009 KCS Full Power	SB2009 KCS Low Power
e-sources	4.3	4.3	4.3
e+sources	22.8	17.1	17.1
DR	19.5	8.4	8.4
RTML	10.6	9.1	9.1
Main Linac	77.1	68.3	34.2
BDS	11.3	10.3	10.3
Dumps (wtr)	36.0	36.0	36.0
TOTAL	**181.6**	**153.5**	**119.4**

Total Electrical Load in MW

	RDR 2006	SB2009 KCS Full Power	SB2009 KCS Low Power
e-sources	4.76	4.76	4.76
e+sources	22.27	16.82	16.82
DR	26.29	12.36	12.36
RTML	17.15	14.70	14.70
Main Linac	134.21	126.90	84.60
BDS	7.72	7.07	7.07
Dumps (wtr)	3.95	3.95	3.95
TOTAL	**216.3**	**186.6**	**144.3**

Summary of Thermal and Electrical Loads

Status of CFS Cost Estimates

- The Americas Region has Developed the Following Cost Estimates and Provided Them to the Cost Group:
  - Full Cost Estimate Based on the Machine Layout Developed and the Current AD&I Machine Layout Drawings
  - Main Linac Klystron Cluster High Power Option
  - Main Linac Klystron Cluster Low Power Option
  - Main Linac DRFS High Power Option
  - Main Linac DRFS Low Power Option
  - Main Linac Tunnel Alternative Study
- All of These Cost Estimates are Based on the Current Technical Beamline Layout and the Current 2D CFS Enclosure Layout Posted on the EDMS System
- The Asian Region has Developed a Preliminary Cost Estimate for the DRFS High Power Option
- The European Region will Begin to Develop Cost Estimates as Resources Become Available

Regional CFS Cost Estimates

- The RDR had Three Distinct CFS Cost Estimates, One for Each Region
- Civil Construction Portion of Each CFS RDR Cost Estimate was Developed Independently in Each Region
- All Other Parts of the CFS RDR Cost Estimates were Developed in One Region and Used by All Three Regions
- As CFS Design Maturity and Level of Detail Increases, the Distinctions of the Regional Designs Become More Apparent
- This is Likely to Preclude Any Common CFS Cost Estimating and Require Complete Independent CFS Cost Estimates in TDP II
- This will Also Require an Increased Level of Resources

Summary

- The CFS Group has Completed a Comprehensive Interaction with the Various Area Systems in Order to Develop a Complete Machine and Enclosure Layout for the ILC
- Cost Information Reflecting the SB 2009 Working Assumptions has been Provided to Peter Garbincius and the Cost Group
- Both the Machine Layout Drawings and Cost Information have been Iterated Several Times to Correct Discrepancies
- Some Issues Remain to be Resolved Prior to the Start of the CFS TDP II Process
  - SB 2009 Proposal Document/New Baseline
  - Compensation for Undulator Energy Loss
  - Main Linac Energy Overhead
  - Revisit area Systems Cooling Requirements
- Resources, as Always, will have to be Carefully Assigned to Maximize the TDP II Effort