Americas Region Civil Design

Tom Lackowski

Civil Design Criteria

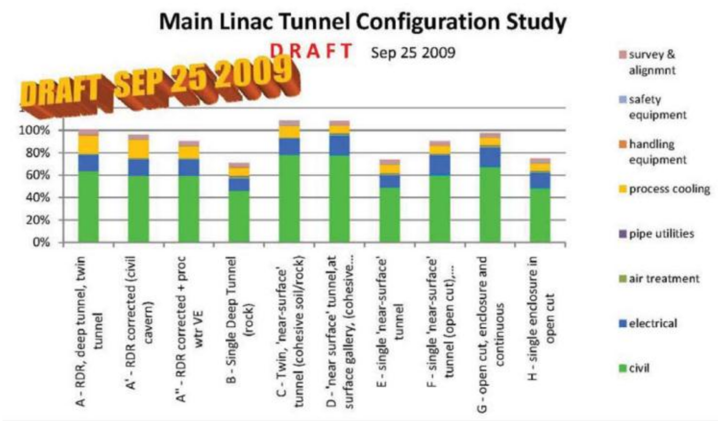
- Requirements for the Civil Design was derived by two major methods
  - **Desktop Studies**
    - These studies used experts in various fields to establish scope of construction that is not derived directly from technical requirements. In general this firmed up elements of the RDR that were based on soft requirements or Engineering Judgments
  - **Area System and Technical Requirements**
    - This information both informal and formal came from Area System leaders, project technical experts, and project management. Many of these requirements have recently been formalized and posted in EDMS by Benno

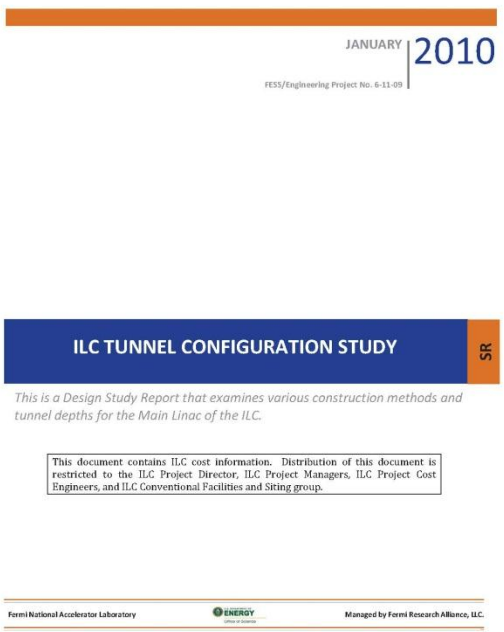
Desktop Studies (since RDR)

– Configuration Study

- Examined various options including cut and cover, soft ground tunneling and deep rock excavation.
- Provided support that a single, deep tunnel, is optimized for an Americas Sample Site

	A	B	C	D	E	F	G	H
	DEEP		NEAR SURFACE					
	Twin Deep Tunnels	Single Deep Tunnel	Twin Near Surfce Tunnels	Near Surface Tunnel, At Surface Gallery	Single Near Surface Tunnel	Enclosure in Open Cut, Cont. Gallery	Enclosure & Cont. Gallery in Open Cut	Enclosure in Open Cut
EXCAVATION	TBM	TBM	TMB	TBM & OPEN CUT	TBM	OPEN CUT	OPEN CUT	OPEN CUT
No. of TUNNELS	TWO-TUNNEL	ONE-TUNNEL	TWO-TUNNEL	TWO-TUNNEL	ONE-TUNNEL	ONE-TUNNEL	TWO-TUNNEL	ONE-TUNNEL
SHAFT SOIL	VARIES	VARIES	VARIES	VARIES	Soft/SURRY	NA	NA	NA
TUNNEL SOIL	ROCK	ROCK	COHESIVE SOIL OR ROCK	COHESIVE SOIL - LOW PERMEABILITY	SATURATED SAND & GRAVEL	SOILS VARIES	SOILS VARIES	SOILS VARIES
SERVICE SPACE	SECOND TUNNEL	SURFACE BUILDINGS	SECOND TUNNEL	CONTINOUS SERVICE GALLERY	AT CAMPUSES	CONTINOUS SERVICE GALLERY	CONTINOUS SERVICE GALLERY	AT CAMPUSES
ILC Technology	DISTRIBUTED RF	CLUSTERED RF	DISTRIBUTED RF	DISTRIBUTED RF	CLUSTERED RF	DISTRIBUTED RF	DISTRIBUTED RF	CLUSTERED RF
SIMILAIR TO	RDR SAMPLE SITES	RDR & CLIC	RDR	DUBNA ILC	XFEL	PROJECT X	PROJECT X	
ACCESS	VERTICAL SHAFT	VERTICAL SHAFT	VERTICAL SHAFT	VERTICAL SHAFT	VERTICAL SHAFT	HATCH	HATCH	HATCH





Life Safety Studies

– Life Safety Studies

- First study provided an analysis and recommendations based on an Americas fire safety code for underground construction
- Second study performed computerized smoke migration analysis, confirming that the NFPA code provisions are appropriate.

FIRE AND EGRESS ANALYSIS FOR THE
INTERNATIONAL LINEAR COLLIDER
(DRAFT)

Prepared for

Fermilab
Kirk Road & Pine Street
P.O. Box 500
Batavia, IL 60510

Prepared by

HUGHES ASSOCIATES, INC.
FIRE SCIENCE & ENGINEERING

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Baltimore, MD 21227-1652
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December 9, 2011

Rev 0

LIFE SAFETY/FIRE PROTECTION ANALYSYS

for

THE INTERNATIONAL LINEAR COLLIDER
Single Deep or Near Surface Tunnel Options

Prepared by

HUGHES ASSOCIATES, INC
FIRE PROTECTION ENGINEERS
CODE CONSULTANTS

September 18, 2009
Revised May 21, 2010

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– Surface Feature Study programmed shaft campus and buildings

- Provided a rational basis for the campus buildings and site (quantities for estimate)

Building	Dims (m) L	Dims (m) W	Dims (m) H		Area (m^2)	Area (sf)	Enclosed Volume (m^3)
RF Unit Bldg	52.50	45.00	varies		2,362.50	25,429.74	15,946.88
RF Bldg Fan-house (x2)	7.00	7.00	3.80		98.00	1,054.86	372.40
Surface Process Cooling DI Plant	40.00	15.00	4.50		600.00	6,458.35	2,700.00
Cryogenic Plant Bldg	37.00	22.50	12.00		* 2,358.50	* 25,386.68	9,990.00
Shaft Access Building	33.59	25.00	12.00		839.73	9,038.72	10,076.70
Fan House	25.00	11.41	12.00		285.25	3,070.41	3,423.00
Support	18.10	11.50	4.00		208.15	2,240.51	832.60
Admin	18.10	11.50	4.00		208.15	2,240.51	832.60
Workshop	20.00	15.00	10.00		300.00	3,229.17	3,000.00
Loading Bay	45.00	20.00	12.00		900.00	9,687.52	10,800.00
Cooling Tower Enclosure	23.33	16.97	n/a		395.87	4,261.15	N/A
Transformer Enclosure	29.44	23.33	n/a		686.96	7,394.42	N/A
Retention Pond	30.00	15.00	1.74		450.00	4,843.76	783.00
TOTALS					9,693.11	104,335.80	58,757.18

*Area includes space for 15 helium storage tanks and 2 liquid nitrogen storage tanks

– Tunnel Cross Section Configuration Study

- Examined tunnel inverts, tunnel linings, utility and technical equipment support anchorage

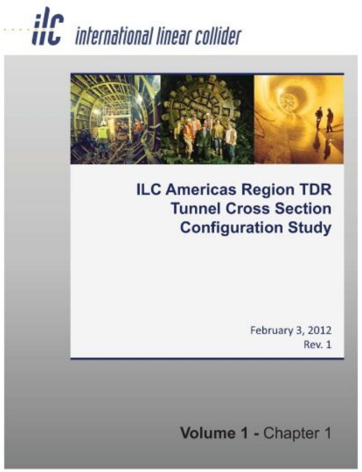


Table 6-6: Estimated Costs Per Foot (September 2011) for Installation of Supports for Physics Equipment and Associated Electrical and Mechanical Utilities

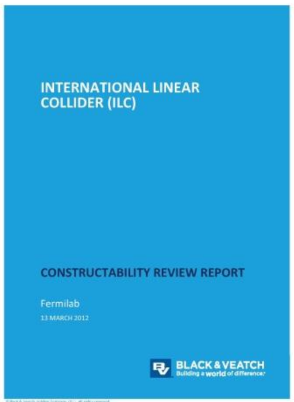
Liner Alternative	Liner Type Description	Type of Anchors	Anchorage Material Cost/Foot	Anchor to Substrate Cost/Foot	Channel or Rib Installation Cost/Foot	Total Cost/Foot	**Comments** (Attaching utility assumed to be same cost for all alternatives not included.)
A, B, C, D, E	Bare/shotcrete, CIP concrete, precast, or thin liner (installed after final liner placed)	Spacing as required by each utility	$39.01	$25.71	$25.71	$90.43	Relatively high, as required for installation of each utility, 10 anchors per hour. Install channel for each utility, 10 connections per hour.
A, B	Shotcrete embedment	Rolled channel every 10 ft. (216 degrees)	$72.38	$33.30	$17.28	$122.96	Channel erected first, then embedded prior to shotcrete.
A, B	Bare rock/shotcrete, or shotcrete embedment	Rolled channel every 10 ft. (180 degrees)	$54.90	$27.75	$14.39	$97.04	Channel erected first, then embedded prior to shotcrete.
A, B, C	Bare rock/shotcrete, CIP	Rolled channel every 10 ft. (240 degrees)	$73.20	$37.00	$19.19	$129.39	Install anchors every 10 in., erect rolled channel after CIP, shotcrete, or bare
D, E	Precast concrete or possible with thin liner	Embedded rolled channel every 10 ft.	$72.57	0	$2.80	$75.37	Relatively low installation costs, channels embedded at segment plant. Structural concerns to embed rolled channel in thin segment.
A, B, C	WT4x5 with anchor studs at 8 in., painted, custom attached connects	Set every 10 ft.	$65.26	$8.83	$10.36	$84.45	Rib installed, connection by welding fastener to rib, for quick connect to utility, plus paint, and studs every 8 in.
A, B, C	WT4x7.5 with anchor studs at 8 in., painted, custom attached connects	Set every 10 ft.	$85.38	$8.83	$10.36	$104.57	Rib installed, connection by welding fastener to rib, for quick connect to utility
	WF4x13, painted, custom attached connects, flange on back side does not require welded studs	Set every 10 ft.	$110.98	0	$18.55	$129.53	Rib installed, connection by welding fastener to rib, for quick connect to utility, no studs required as flange is embedded in shotcrete or concrete

Table 9-1: Summary Comparison of Alternative Liner Systems

Alternative	Description	Excavated Diameter	Tunnel Boring Machine Type	Cost	Schedule
A	4 in. of shotcrete springline and above, as per RDR	5.5	Main Beam	Middle	Shortest
B	20% of shotcrete volume 2 to 4 in. as required	5.4	Main Beam	Lowest	Shortest
C	CIP Liner	5.7	Main Beam	2nd Lowest	Middle
D	PCS Liner	5.91	Double Shield	Highest	Longest
E	Thin, Lightweight Segmented Panel (Hybrid) Liner	5.53	Main Beam	2nd Highest	Slightly Longer than A and B

– Constructability Study

- Proposed locations for TBM heading starts, TBM vs. drill and blast, schedule (advancement rate) , muck handling, water treatment and tunnel lining.



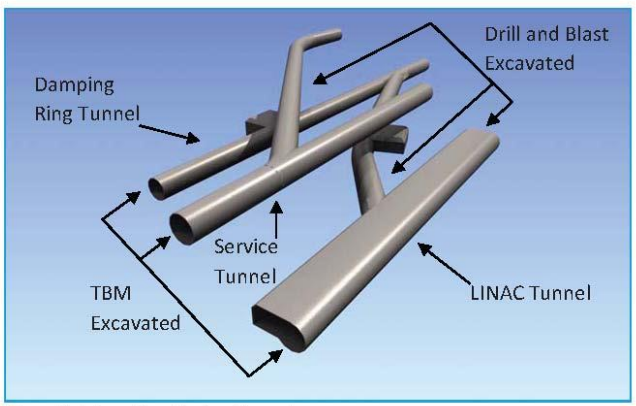


Figure 3. Interaction Region Tunnels

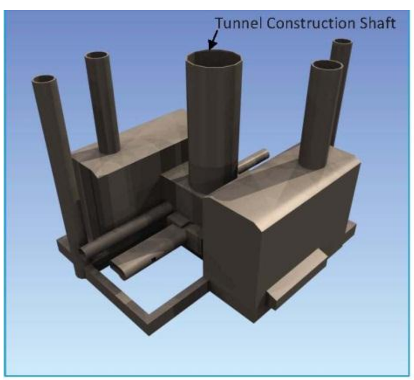


Figure 6. Center shaft at Interaction Region cavern will accommodate mining of LINAC tunnels during cavern construction

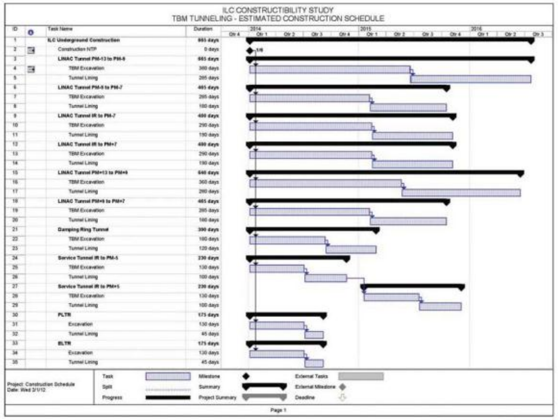


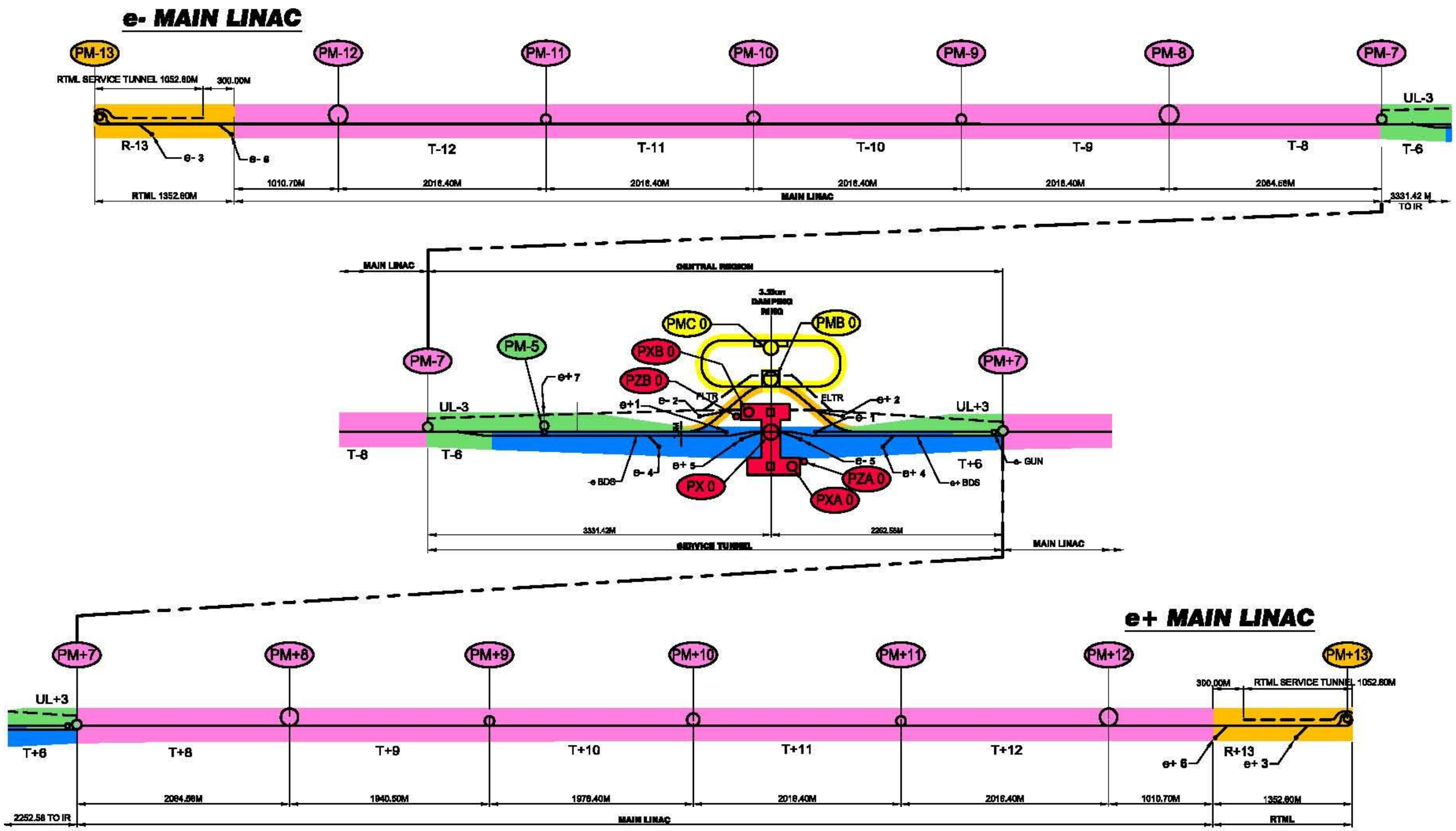
Figure 1. TBM Tunneling Schedule

Table of Contents

Technical Requirements

- Technical requirement inputs have been an ongoing pursuit since Snowmass 2004
  - **Main source of input have been the Area System leaders and Technical Area Leaders; tempered by Project Management**
  - **We know, or think we know, all of the major technical requirements that translate into space requirements which drive the costs.**

Key Plan



SHAFTS AND CAVERNS

NAME Ø M	PM-13	PM-12	PM-11	PM-10	PM-9	PM-8	PM-7	PM-5	PXB-0	PZB-0	PXA-0	PZA-0	PXA-0	PMB-0	PMC-0	PM+7	PM+8	PM+9	PM+10	PM+11	PM+12	PM-13
	6	14	6	9	6	14	6	4	8	6	16	6	8	9	9	6	14	6	9	6	14	6
CAVERN (W x L x H)m	10 x 10 x 5.3	10 x 52 x 5.3	10 x 10 x 5.3	10 x 52 x 5.3	10 x 25 x 5.3	10 x 52 x 5.3	10 x 25 x 5.3	TARGET ENCLOSURE	IR HALL					10 x 20 x 7	16.5 X 220 x7	10 x 25 x 5.3	10 x 52 x 5.3	10 x 25 x 5.3	10 x 52 x 5.3	10 x 10 x 5.3	10 x 52 x 5.3	10 x 10 x 5.3

TUNNELS WIDTH (M)

AREA SYSTEM	e- INJECT. BDS & SERVICE	D.R.	MAIN LINAC BEAM	RTML PLTR & ELTR	e+ INJECT. BDS & SERVICE
AMERICA-width M	4.5 SER. TUNNEL+ 4.5 x 4.5 W / WIDENED AREAS	5.5 -	5.0	4.5 SER. TUNNEL+ 4.5 x 4.5 W / WIDENED AREAS	4.5 SER. TUNNEL+ 5.0 W/ WIDENED AREAS
EUROPE-width M	-	-	-	-	-
ASIA-width M					

DUMPS

MPD	e-1	SC TUNE UP DUMP	311 KW**	MPD	e+1	SC TUNE UP DUMP	311 KW**
MPD	e-2	EDRX TUNE UP DUMP	220 KW	MPD	e+2	PDRX TUNE UP DUMP	220 KW
MPD	e-3	RTML TUNE UP DUMP	220 KW	MPD	e+3	RTML TUNE UP DUMP	220 KW
HPD	e-4	BDS TUNE UP DUMP	18 MW	HPD	e+4	BDS TUNE UP DUMP	18 MW
HPD	e-5	PRIMARY e-DUMP	18 MW*	HPD	e+5	PRIMARY e+DUMP	18 MW*
MPD	e-6	RTML TUNE UP DUMP	220 KW	MPD	e+6	RTML TUNE UP DUMP	220 KW
				MPD	e+7	TARGET DUMP	200 KW*

LEGEND
(HPD) HIGH POWER BEAM DUMP
(MPD) MID POWER BEAM DUMP
* INDICATES NON-STOP DUMP (ALWAYS ON)
** INDICATES 45KW ALWAYS ON

DETECTORS HALL

POINT	PXA 0 PXB 0
VOLUME	14,000 CM

MUON WALL WIDENINGS

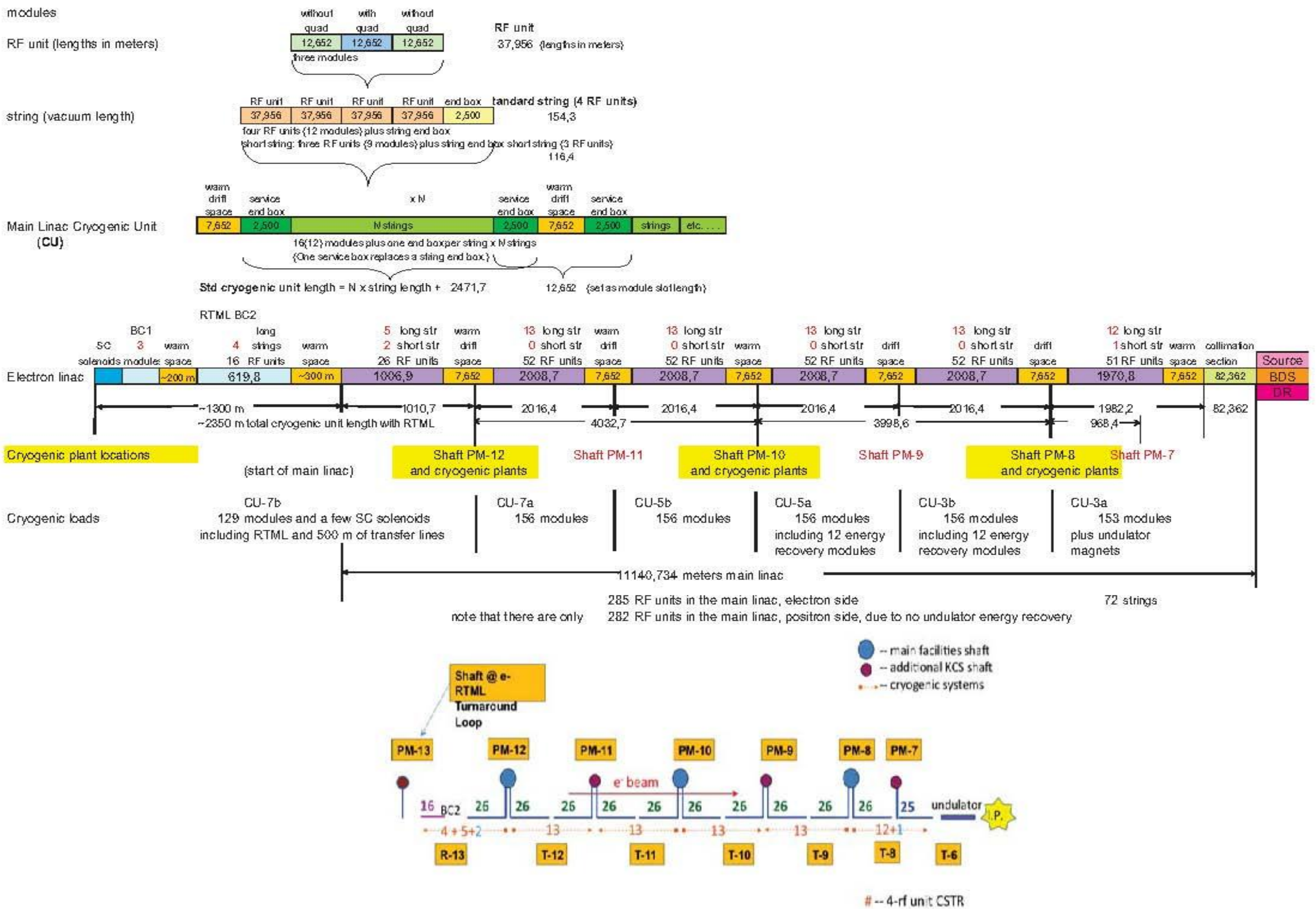
POINT	BDS [illegible]
(L x W x H)m	25 x 7 x 6 +15 x 7 x 6

BEAM ABORT CAVERNS

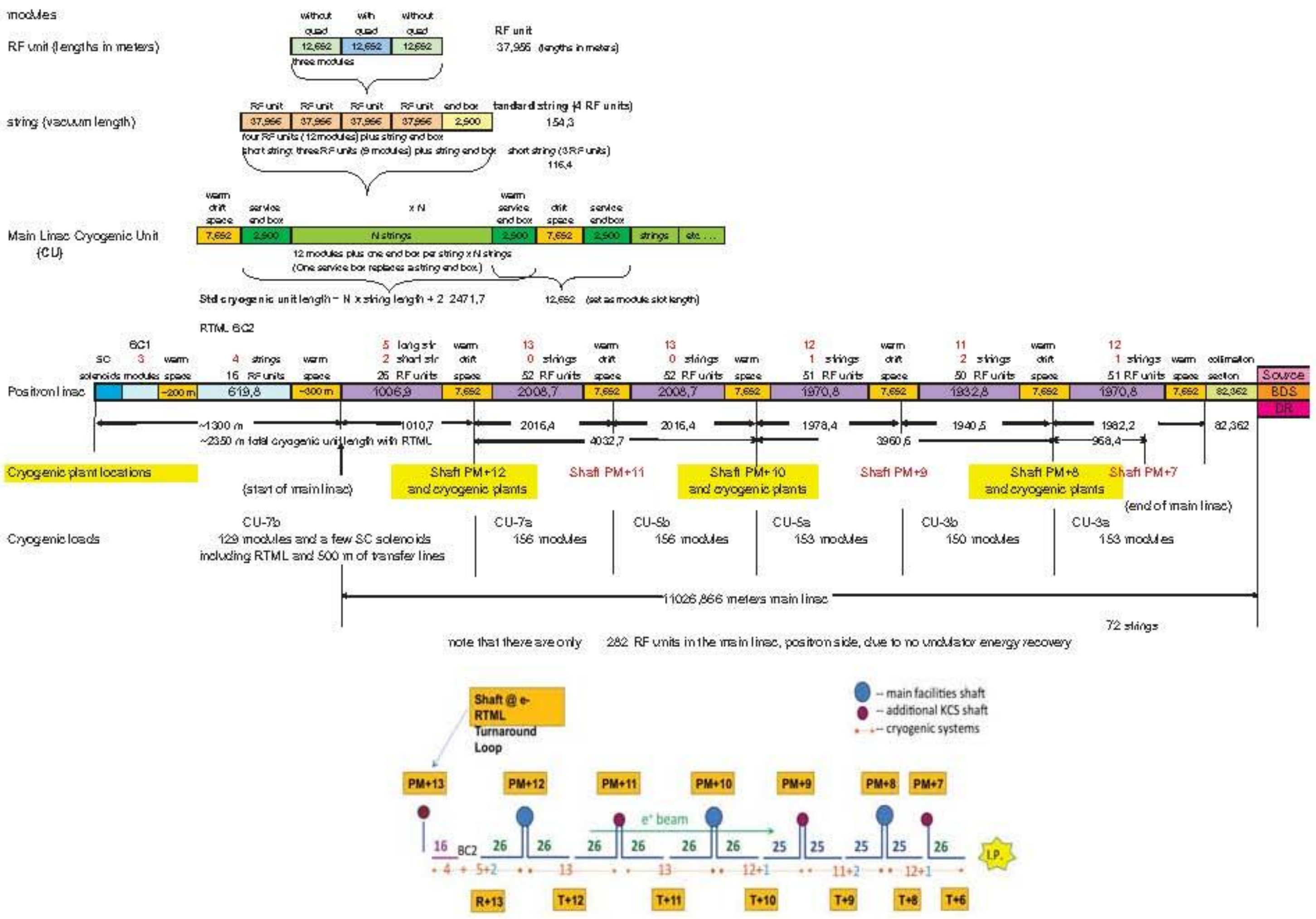
POINT	SOURCES e-1	RTML e-2, e-3, e-4, e-5, e+1, e+2, e+3 & e+4	ML e+5	BDS e-6, e-7, e+6 & e+7
(L x W x H)m	WITHIN TUNNEL	10 x 32 x 7	20 x 9 x 15	20 x 42 x 8

LEGEND
INDICATES SHAFTS FOR KLYCLUSTER TECHNOLOGY ONLY
RTML
ML
SOURCES
DR
BDS
DETECTOR AREA
TIMING

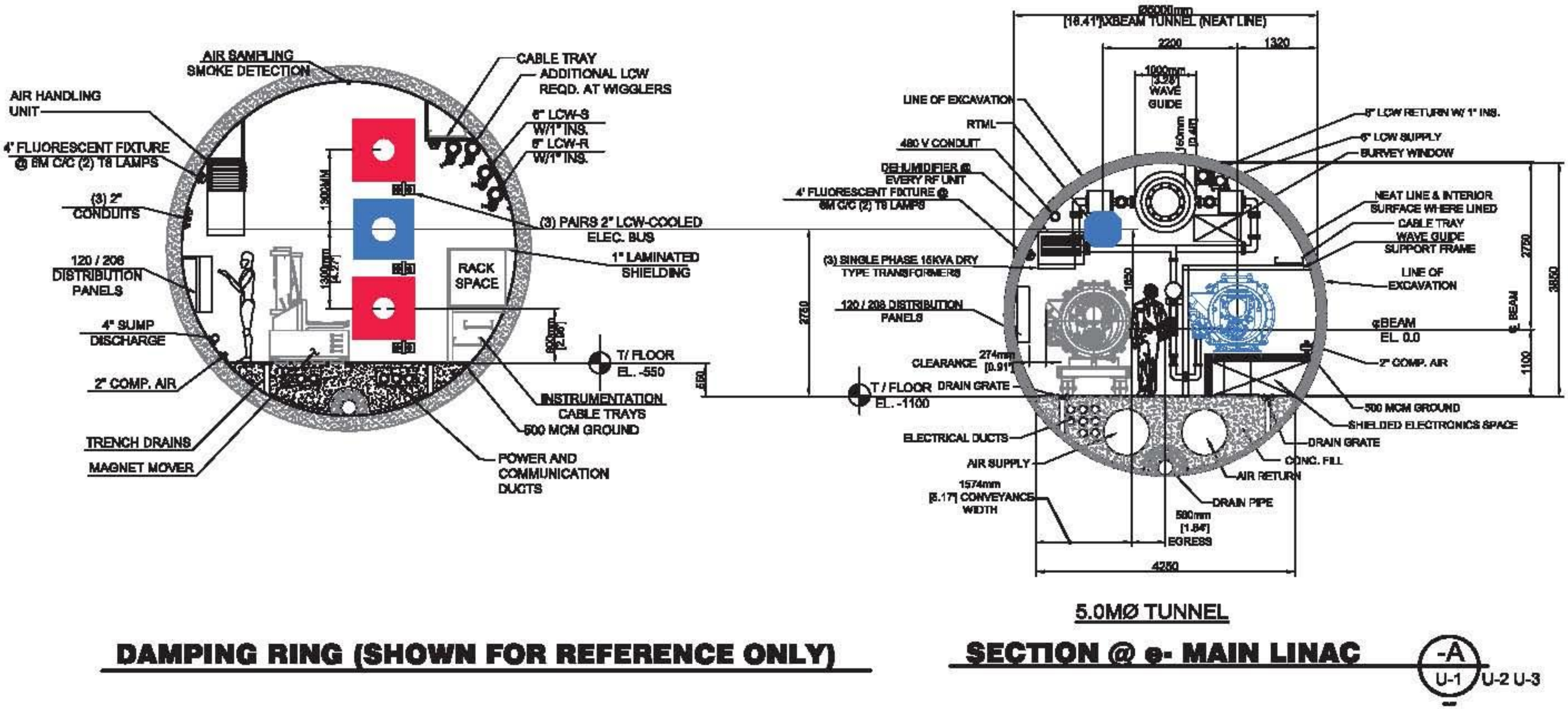
1. CAVERN DIMENSIONS ARE BASED ON THE AMERICAS GEOLOGIC CONDITIONS.



modules
RF unit (lengths in meters)
without quad
with quad
without quad
12,652
12,652
12,652
three modules
RF unit
37,956 (lengths in meters)
string (vacuum length)
RF unit
RF unit
RF unit
RF unit
end box
37,956
37,956
37,956
37,956
2,500
tandard string (4 RF units)
154,3
four RF units (12 modules) plus string end box
short string: three RF units (9 modules) plus string end box
short string (3 RF units)
116,4
Main Linac Cryogenic Unit
(CU)
warm drift space
service end box
x N
service end box
warm drift space
service end box
7,652
2,500
N strings
2,500
7,652
2,500
strings
etc. . . .
16(12) modules plus one end box per string x N strings
(One service box replaces a string end box)
Std cryogenic unit length = N x string length + 2471,7
12,652 (set as module slot length)
RTML BC2
BC1
SC solenoids
3 modules
warm space
long
4 strings
16 RF units
warm space
5 long str
2 short str
26 RF units
warm drift space
13 long str
0 short str
52 RF units
warm drift space
13 long str
0 short str
52 RF units
warm space
13 long str
0 short str
52 RF units
drift space
13 long str
0 short str
52 RF units
drift space
12 long str
1 short str
51 RF units
warm space
collimation section
Electron linac
~200 m
619,8
~300 m
1006,9
7,652
2008,7
7,652
2008,7
7,652
2008,7
7,652
2008,7
7,652
1970,8
7,652
82,362
Source
BDS
DR
~1300 m
1010,7
2016,4
2016,4
2016,4
2016,4
1982,2
82,362
~2350 m total cryogenic unit length with RTML
4032,7
3998,6
968,4
Cryogenic plant locations
(start of main linac)
Shaft PM-12 and cryogenic plants
Shaft PM-11
Shaft PM-10 and cryogenic plants
Shaft PM-9
Shaft PM-8 and cryogenic plants
Shaft PM-7
Cryogenic loads
CU-7b
129 modules and a few SC solenoids including RTML and 500 m of transfer lines
CU-7a
156 modules
CU-5b
156 modules
CU-5a
156 modules including 12 energy recovery modules
CU-3b
156 modules including 12 energy recovery modules
CU-3a
153 modules plus undulator magnets
11140,734 meters main linac
note that there are only
285 RF units in the main linac, electron side
282 RF units in the main linac, positron side, due to no undulator energy recovery
72 strings
-- main facilities shaft
-- additional KCS shaft
-- cryogenic systems
Shaft @ e- RTML Turnaround Loop
PM-13
PM-12
PM-11
PM-10
PM-9
PM-8
PM-7
e- beam
16
BC2
25
26
25
26
26
26
25
26
26
26
25
undulator
I.P.
4 + 5+2
13
13
13
13
12+1
R-13
T-12
T-11
T-10
T-9
T-8
T-6
-- 4-rf unit CSTR


modules
RF unit (lengths in meters)
RF unit
37,956 (lengths in meters)
string (vacuum length)
standard string (4 RF units)
154,3
short string (3 RF units)
116,4
Main Linac Cryogenic Unit (CU)
Std cryogenic unit length = N x string length + 2 2471,7
Positron linac
~1300 m
~2350 m total cryogenic unit length with RTML
Cryogenic plant locations
(start of main linac)
Shaft PM+12 and cryogenic plants
Shaft PM+11
Shaft PM+10 and cryogenic plants
Shaft PM+9
Shaft PM+8 and cryogenic plants
Shaft PM+7
(end of main linac)
Cryogenic loads
CU-7b
129 modules and a few SC solenoids including RTML and 500 m of transfer lines
CU-7a
156 modules
CU-5b
156 modules
CU-5a
153 modules
CU-3b
150 modules
CU-3a
153 modules
11026,866 meters main linac
72 strings
note that there are only 282 RF units in the main linac, positron side, due to no undulator energy recovery
Source
BDS
DR
Shaft @ e- RTML Turnaround Loop
– main facilities shaft
– additional KCS shaft
– cryogenic systems
PM+13
PM+12
PM+11
PM+10
PM+9
PM+8
PM+7
e+ beam
R+13
T+12
T+11
T+10
T+9
T+8
T+6

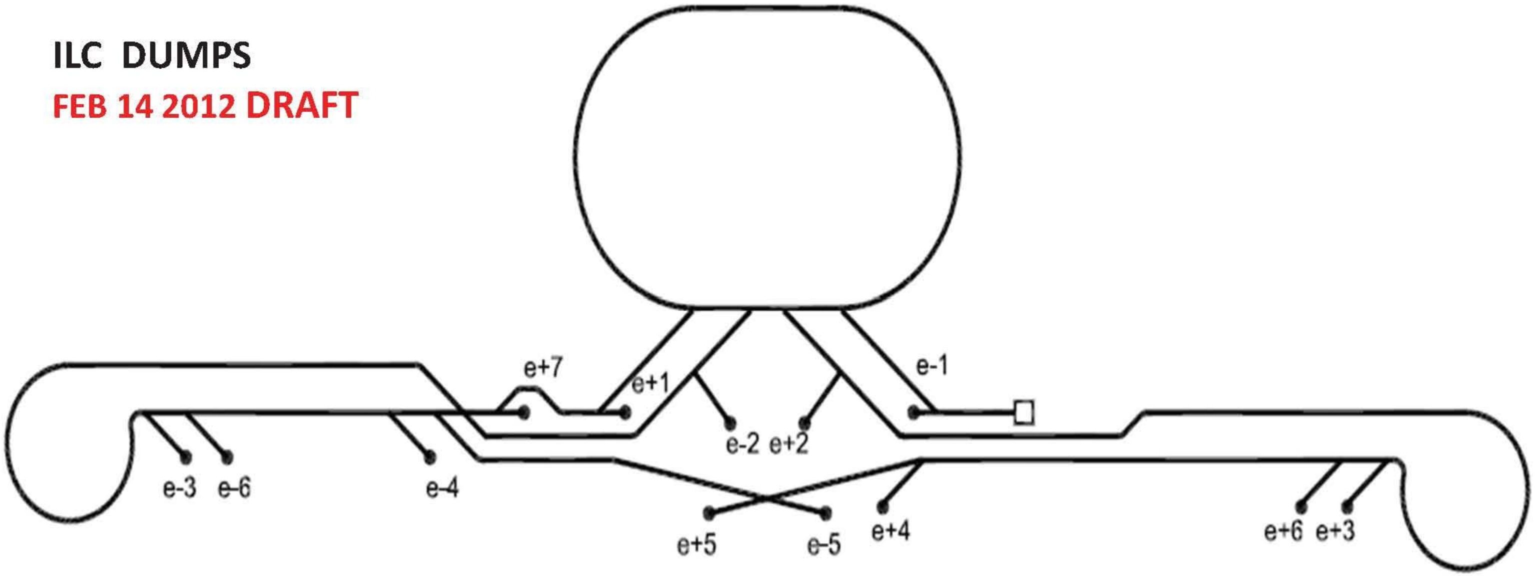
- Major Cross Sections



Dumps

ILC DUMPS

FEB 14 2012 DRAFT



MPD	e-1	SC TUNE UP DUMP	311 KW**		MPD	e+1	SC TUNE UP DUMP	311 KW**
MPD	e-2	EDRX TUNE UP DUMP	220 KW		MPD	e+2	PDRX TUNE UP DUMP	220 KW
MPD	e-3	RTML TUNE UP DUMP	220 KW		MPD	e+3	RTML TUNE UP DUMP	220 KW
HPD	e-4	BDS TUNE UP DUMP	18 MW		HPD	e+4	BDS TUNE UP DUMP	18 MW
HPD	e-5	PRIMARY e-DUMP	18 MW*		HPD	e+5	PRIMARY e+DUMP	18 MW*
MPD	e-6	RTML TUNE UP DUMP	220 KW		MPD	e+6	RTML TUNE UP DUMP	220 KW
					MPD	e+7	TARGET DUMP	200 KW*
MPD	*=HIGH POWER DUMPs (1e-; 2e+; 6 RTML)*				** = indicate non-stop dump (always on)*			
HPD	*=MEDIUM POWER DUMPs (4 BDS)*				***= indicate 45KW always on*			

Page 2

Laser Equipment

Current understanding is that the lasers will be placed in the service tunnel with no increase in the tunnel width. Exception is the e-source lasers, requiring an alcove

FEB 14 2012 ILC LASER EQUIPMENT ENCLOSURES

Notes *from meeting with Marc, Tomski, Vic & Emil on Nov 30 2011 @ Fermilab*

Total ***24*** Laser rooms

1) Use FNAL NML laser room as basis for size/cost; Size of one NML laser room (**670 SF**)
2) Use FNAL NML laser room as basis for criteria except **no** minimum humidity requirement
3) each NML Laser Room HVAC Load = 15 KW
4) ignore the additional load w.r.t to the total thermal load for now
5)Adjust the SF to linear layout of tunnel (same sf)
6) The central region laser rooms will be contained in the service tunnels with no additional excavation
7) The RTML laser rooms near PM+12 &PM-12 shafts will require additional excavated space

TAG #	AREA SYSTEM	PHYSICAL LOCATION (side of the tunnel)	SPECIFIC LOCATION	marked-up Dwg Sht #
INSTRUMENTATION LASER (17 qty)				
IL-RT-1	RTML	electron side	Near Shaft cavern PM-12	
IL-RT-2	RTML	electron side	Near Shaft cavern PM-12	
IL-RT-3	RTML	electron side	at LTR service tunnel	
IL-RT+1	RTML	positron side	Near Shaft cavern PM+12	
IL-RT+2	RTML	positron side	Near Shaft cavern PM+12	
IL-RT+3	RTML	positron side	at LTR service tunnel	
IL-DR	DR	damping ring	Shaft PMB-0 Lower Cavern	
IL-ML-1	ML	electron side	at Service tunnel at end of ML	
IL-ML+1	ML	positron side	at Service tunnel at end of ML	
IL-BDS-1	BDS	electron side	at Service Tunnel before 5 GeV	Sht U-7
IL-BDS+1	BDS	positron side	at Service Tunnel before 5 GeV	Sht U-13
IL-e-1	e- SOURCE	electron side	at Svc tunnel as you go into LTR	
IL-e+1	e+ SOURCE	positron side	at Svc tunnel as you go into LTR	
IL-e+2	e+ SOURCE	electron side	at Svc Tunnel after 400 MeV NC	Sht U-6
IL-e+3	e+ SOURCE	electron side	near where old 18MW dump used to be	
IL-e+4	e+ SOURCE	electron side	at Svc tunnel near "IL-ML-1"	Sht U-13
IL-e+5	e+ SOURCE	electron side	at Svc tunnel near Target	
POLARIMETER LASER (4 qty)				
PL-1	BDS	positron side	at Svc Tunnel right after LTR (towards IR)	
PL-2	BDS	positron side	at Svc Tunnel near	Sht U-13
PL+1	BDS	electron side	at Svc Tunnel right after LTR (towards IR)	
PL+2	BDS	electron side		Sht U-13
SOURCE LASER (3 qty)				
SL-1	e- SOURCE	positron side	at Svc Tunnel at e-source gun	
SL-2	e- SOURCE	positron side	*double this per John Sheppard*	
SL+1	e+ SOURCE	electron side	at Svc tunnel near Auxiliary Source	Sht U-5

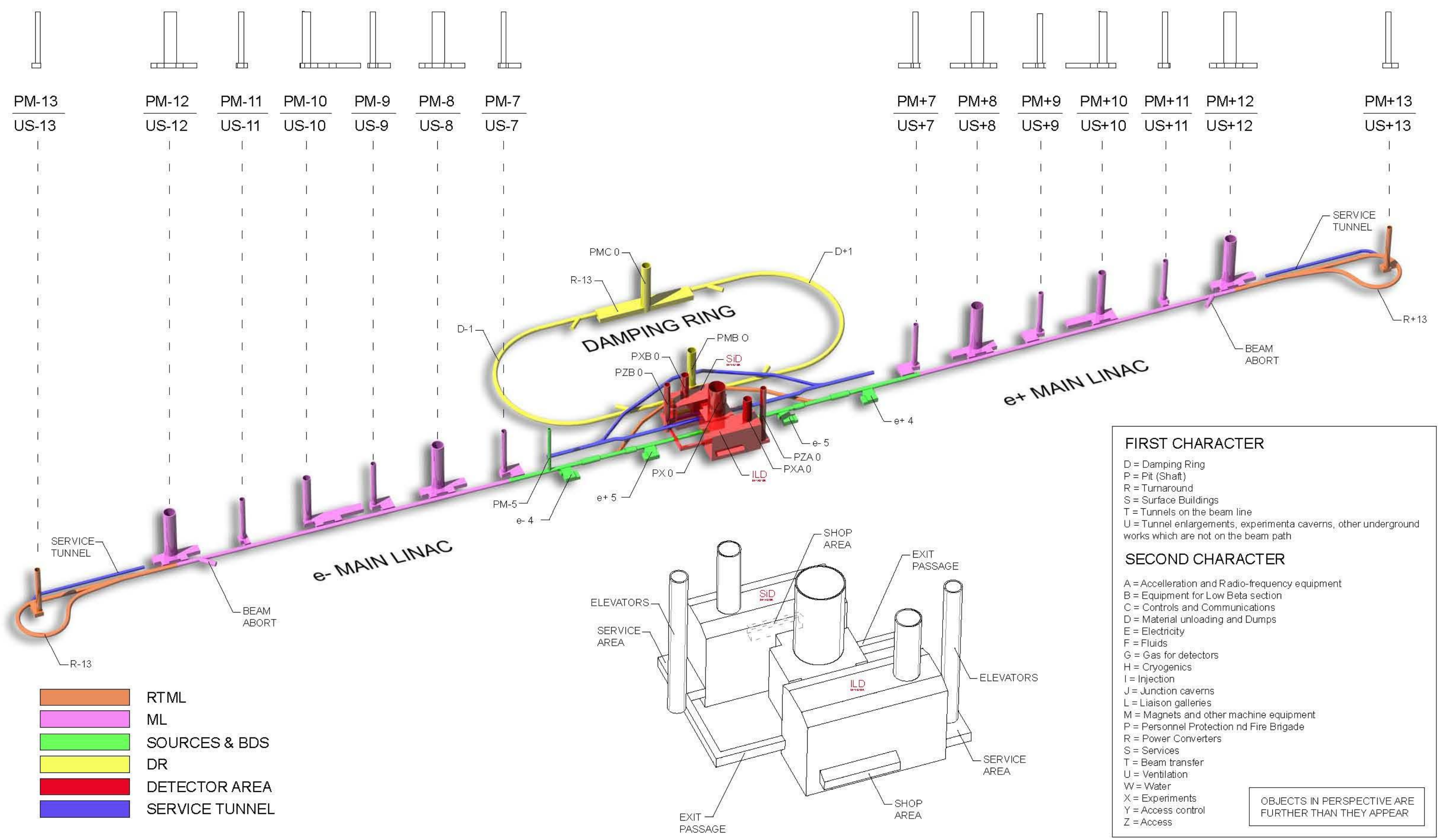
Beamlines

- All beamlines have been generated from geometry files (downloaded from EDMS), derived from lattices except for the Main Linac.
  - **Ends of the Main Linac per, Tom Petersons layout, coincided with the end of the scripts. The length of the Main Linac fell within a fraction of a millimeter between the RTML warm section and the central region beam.**
  - **Except for the Damping Rings all of the geometry files were imputed from a common point; 0,0,0. Damping Rings were generated from Geometry File placed into position from Mark Palmers geometry description.**

- Geometry files include line segments for Dumps/Aborts.
- Last files inserted into drawing middle of last week. It took about two weeks time to get all of the files inserted into AutoCad.

- Extents of Service Tunnel
- Penetrations between Beamline and Service Tunnels
- Dimensions of ~300kw dumps alcoves

ilc international linear collider // HOLABIRD & ROOT // ILC NAMING CONVENTION // KLYCLUSTER AMERICAS REGION // DRAFT // 03-19-2012



What needs to be done

- We have the beamlines drawn, now we need to build the walls around the beamline so that quantity take offs can be accomplished.
  - **The cad files are used to make area and volume rock excavation quantity take off**
  - **Other drawings such as sections sheets, plan details, arrow diagrams …. that are not used for estimate will follow at a lower priority.**