Positron Source Estimate

Peter H. Garbincius

Positron Source Meeting

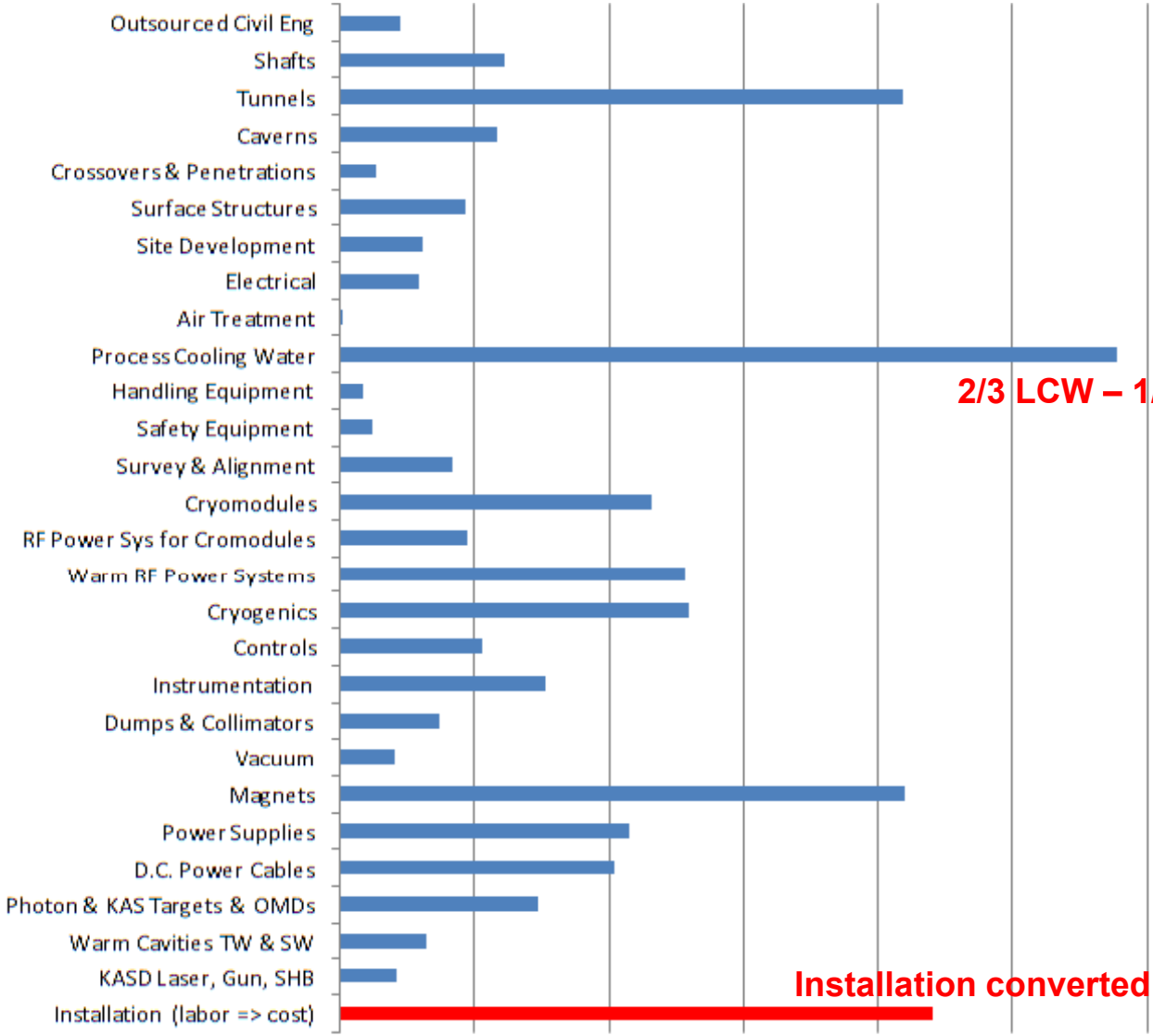
DESY-Zeuthen, Berlin

by WEBEX – April 7, 2008

1. review RDR estimate for the Positron Source
2. follow-up John Sheppard's comments at e+ KOM
3. status and quality of estimate & documentation
4. correspondence on optics questions
5. how do we proceed from here?

filename: PHG_Positron_Source_Estimate_7april08.ppt

Positron Source – 6% of RDR Estimate



2/3 LCW – 1/3 Chilled Water

Installation converted from hrs => ILC U

ILC Positron Systems RDR Costs

J. C. Sheppard

Daresbury, UK

October 8, 2007

Cost Drivers

Civil:	
Und Insert:	yield and capture efficiency
	undulator strength, K^2
	electron emittance dilution
KAS Source:	~14% of total system cost
	~21% of total component cost
	is this needed? why?
	eliminate or defer
Process Water:	what is this and why?
Magnet PS:	PS are x2 cost of magnets
	excessive cable plant

Cost Concerns

Remote handling is not sufficiently accounted in RDR ($$$)

Agreed! If not included in targets, it's not included at all!

Installation is possibly too low, certainly not well understood in terms of full picture (acquisition, inspection, warehousing, checkout,…..) ($$)

Agreed! Installation needs much better understanding.

Civil allocations not well understood (caverns, shafts, timing insert,….) likely more of an accounting issue

Nope: pretty much what Positron Source said it needed!

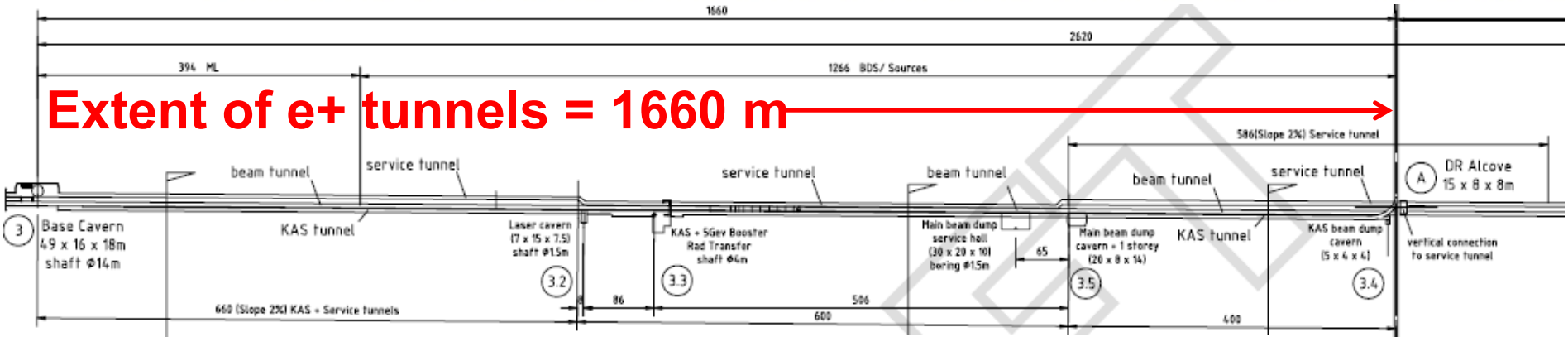
KAS may not be needed but ILC may want something for commissioning, e- on e-, and gamma-gamma

Management decision on whether KAS is needed & current

Question of cryo costs from e- KOM, not sure if this is important or not

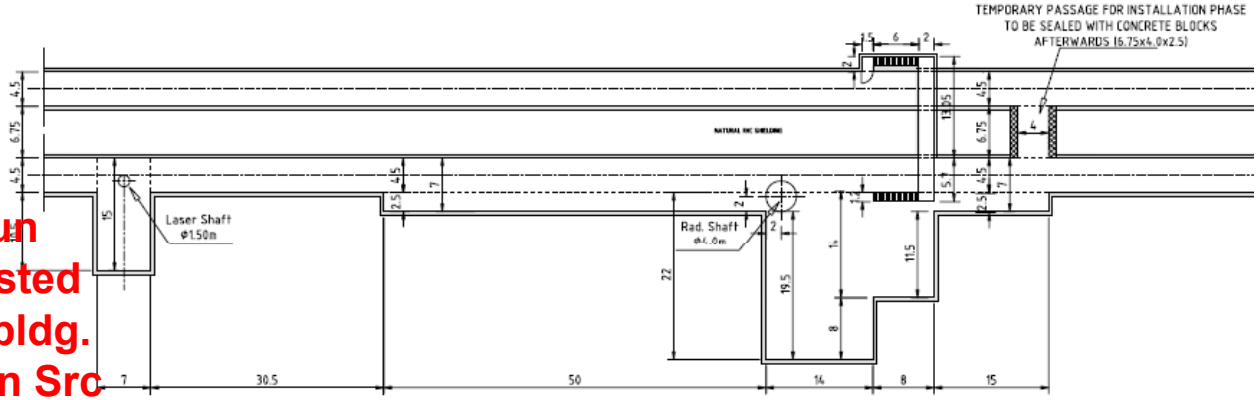
Includes cryo plant costs for operation independent of ML

Positron Source Civil Engineering Layout



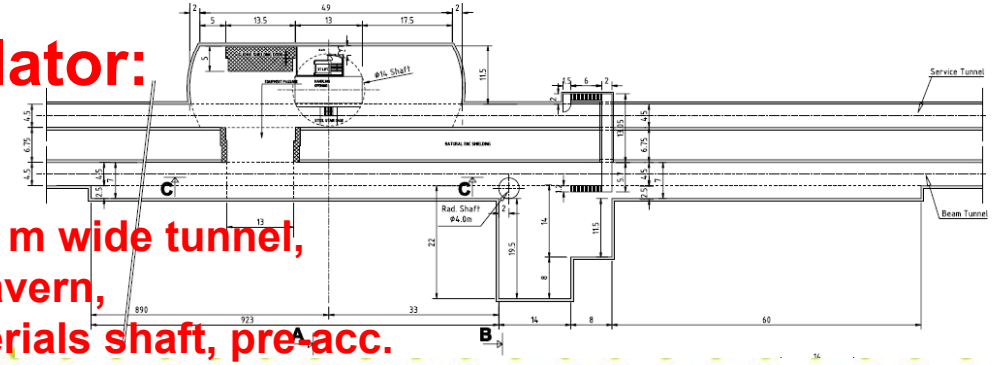
KASD:

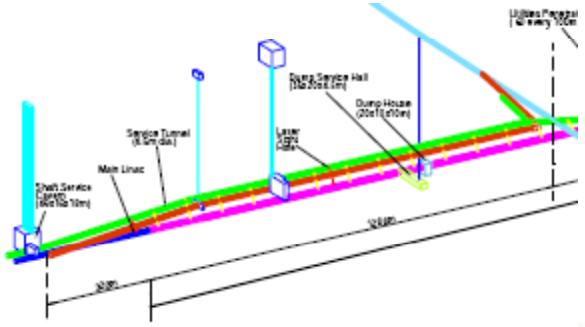
Americas' CF&S est did not include gun cavern, and listed laser shaft & bldg. under Electron Src



Damping Rings

Undulator:





~ 1 km 7 m wide tunnel, target cavern, rad materials shaft, pre-acc.

Positron Source Civil Engineering Costs

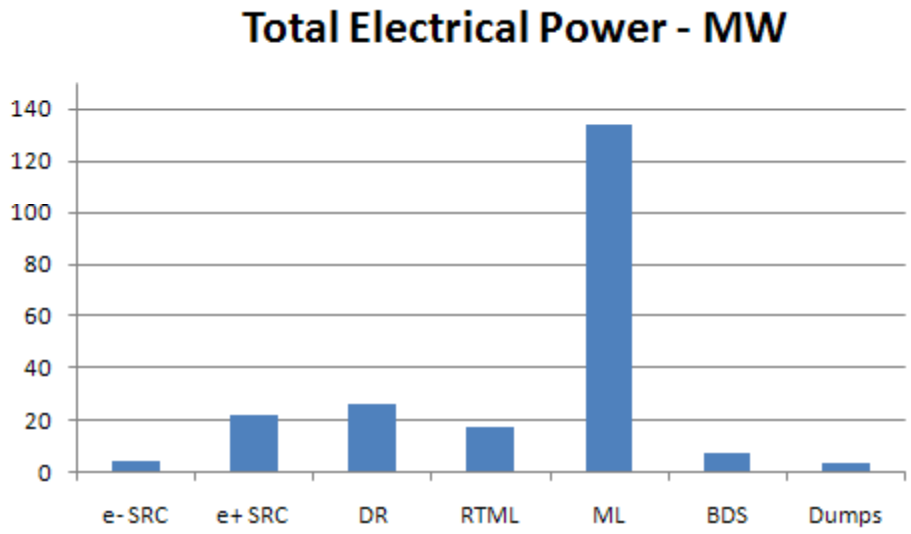
- Driven by ***scope*** – ***who specified/guessed?*** – uses same unit costs
- – no association issues except: escalator, KASD in e- est, laser caverns
- **Undulator System:**
  - Rad material shaft (4 m), Hot Cell Cavern (6.3 K m^3), and Rad Storage Building (800 m^3)
  - Beam and Service tunnel (4.5 m dia) 1,257 m ea.
  - Excavate beam tunnel to 7 m wide – 983 m long
  - Access passage (2), personnel crossovers (2)
- **KAS, 0.4 => 5 GeV e+ linac, and transport to DR:**
  - Rad material shaft (4 m), Hot Cell Cavern (6.3 K m^3), and Rad Storage Building (800 m^3)
  - Beam and Service Tunnel (4.5 m dia) – 1,659 m and 1,610 m (incl. escalator)
  - Excavate beam tunnel to 7 m wide – 55 m long
  - D&B tunnel connection to DR (42 meters => 1,100 m^3)
  - Beam dump cavern (191 m^3) and service cavern (382 m^2)
  - Access passage (26 m), personnel crossovers (2), and WG penetrations (122)

Positron Source Cooling Water Costs

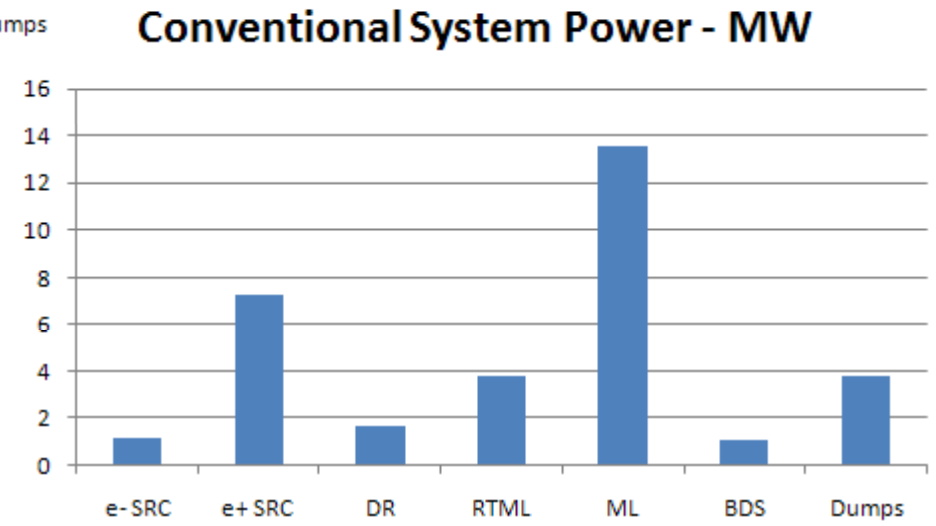
- Driven by loads on LCW & Chilled Water
  - same unit costs as ML – specified by Axel, Vinod, JCS
- Positron Source Quantities:

Electrical Power (MW)	Cooling Systems (MW)
4.11 – RF power	17.48 – LCW & processed
7.32 – conventional	5.33 – Chilled Water
8.90 – RT magnets	22.8 MW total (RDR III-227)
1.27 – water systems	References from Clay Corvin:
0.46 – cryogenics	e-e+ Sources Electrical Demand Rev2 9SEP2006.xls
0.21 – emergency	total_load_nov_27.pdf (accessible via CFS wiki)
22.3 MW total	**electrical is a real can o'worms: death, RIF, etc.** **too complicated to understand in short term!**

Compared to other systems?



As far as I can tell, “conventional” means electronics racks and infrastructure components.



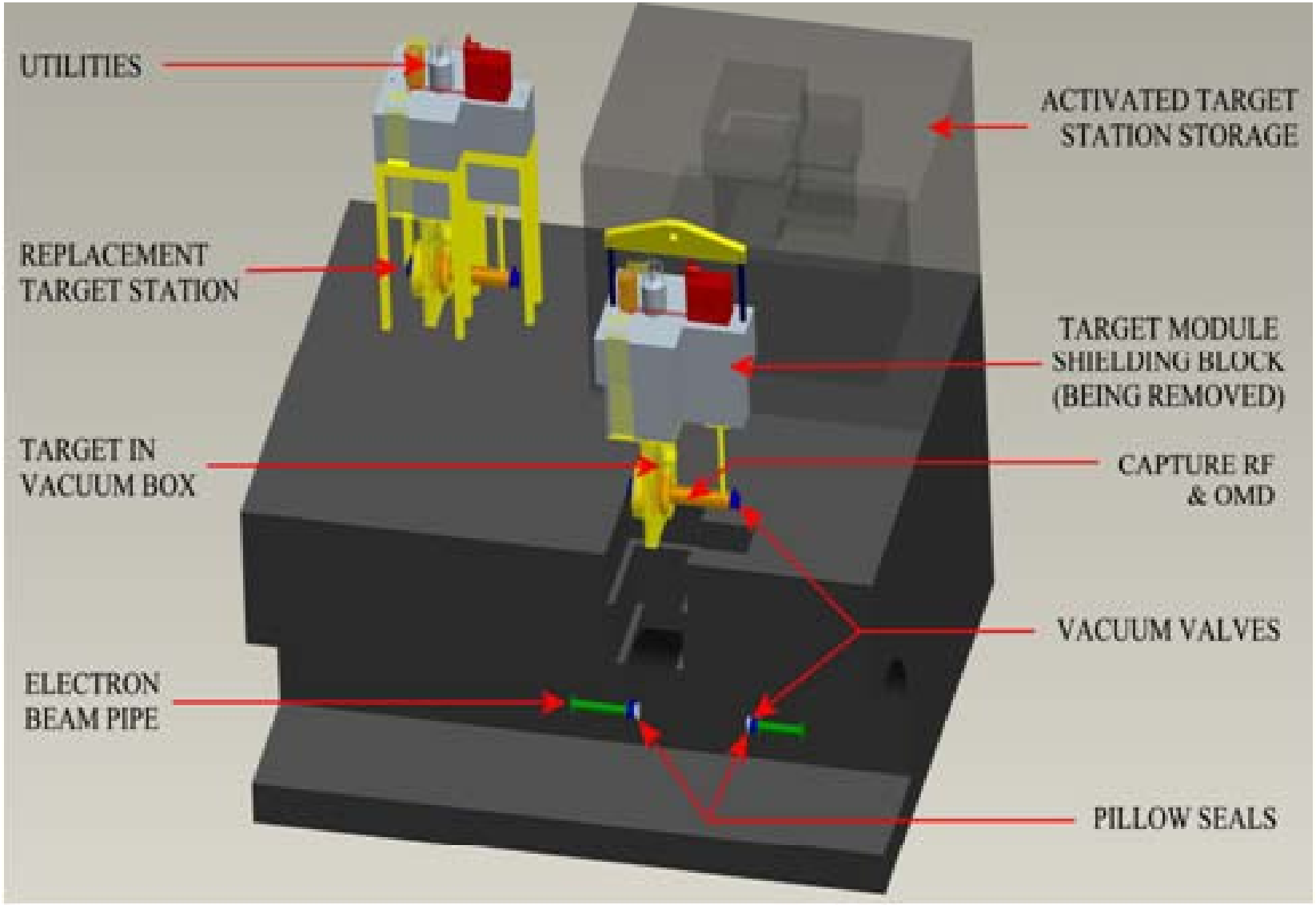
Positron Source Power Supply Costs

- Paul Bellomo's PS est. does not incl undulator
  but Power Supply costs ***are included***
  Jim Clarke's undulator estimate
- Approximate Cost Ratios
  Undulator & PS : Magnets : PS : Cables ::
  :: **0.8** : **1.2** : **1** : **1**
- Paul Bellomo and Cherrill Spencer have
  proposals for PS cost reduction studies
- Cable costs – dependent on routing & hook-up
  does Paul Bellomo have reasonable specs?

Positron Source Cryogenics Costs

- Although this disagrees with the RDR text, Tom Peterson costed a 0.59 MW (@ 300^{o}K) cryogenics plant and accessories to allow operation of KAS, SC linac, spin rotator, and energy compressor independently of ML (same for Electron Source)
- Cryogenics for the undulator is supplied by ML cryogenics system
- The cost of these 0.59 MW plants are estimated from the 4.35 MW plants for Main Linac according to the LHC scaling ~ $Q_{300^{o}K}^{0.6}$
- CF&S doesn't include shafts & caverns for e+ cryo

Target Station/Remote Handling Issues



Quality of the Positron Source Cost Estimate (estimates hidden)

Undulator Source - 05/09/07	# of units	from John Sheppard: Comments	November Notes	PHG comments 1april08 on quality & completeness of RDR Cost Estimate
E+ Source Management				management cost translated
	1	JCS/VB 5% estimate		to labor for RDR estimate
E+ source specific items				
Target	2	TP/VB	1 production target	no details
AMD	2	TP/VB	1 production target	no details
T&A Box	2	TP/VB	1 production target	no details
Undulator	42	JC/YI/JT 12/19/06 update		no details - Undulator est incl PS
E- source specific items				management cost translated
KAS e- source management	5		ab_nov	to labor for RDR estimate
Laser system 1	0.5	AB	ab_nov	no details from Axel B, scale 0.5 for 3rd
Gun 1	0.5	AB	ab_nov	no details from Axel B, scale 0.5 for 3rd
SHB System	2	AB 2/16/07 update, incl PS	ab_nov	no details from Axel B
TW Buncher	0	AB 2/16/07 update	ab_nov	no details from Axel B
CF&S		TS estimate		CF&S estimates here are
e+ civil	1	cc 1/18/07		Americas' estimate. For RDR
Electrical	1			used average of 3 regions' ests.
Air	1			Estimates are based on
Piped Utilities	1			requirements from AS Leaders
Process Water	1			and common unit costs.
Handling Equipment	1			Does not include estimates for CF&S:
Safety Equipment	1			US est for KASD (or e-) DC Gun cavern
Survey and Alignment	1			US CFS est has KASD under e-, not e+
				any est for e+/e- Source Cryo Plants
Installation		TS estimate		Installation $ was converted to labor
Total	993,885.0	fa 1/09/07: listed as labor but includes ~$4M of M&S		No details for e+ Source - needs work!
Instrumentation		TS estimate		
e+specific	1	mw 12/11/06	reduce bpm count	agrees: Sheppart, Wendt, PHG Master
e+Common Hardware	0	mw 12/11/06	pro rated common costs	Instrumentation has good Basis of Est
e-KASD specific	0.25	AB		scaled 0.25 from e- Src instrumenation
e- KASD Common Hardware	0.25	AB		scaled 0.25 from e- Src instrumenation
Cavities		TBD/JW		
SW Section	4	JW (jcs 2/26 cnt update)		I have no details
TW Section	24	JW (jcs 2/26 cnt update)		I have no details
Cryomodules		TS		RDR estimate used scaled-TESLA
12 m Module	26	CA		unit costs (rather than US est) plus
HL RF Dist	0	included in HLRF		some "extras" for custom 8C2Q &
				6C6Q cryomodules - good details
Cryogenics		TS		Tom Peterson estimated 0.59 MW
Sources cryogenic plants	0.5	TP (2/27/07 update)	1/2 of e- + e+ cryo	(at Room Temp) cryo plants for both
Sources cryogenic distribution	0.5	TP (2/27/07 update)	1/2 of e- + e+ cryo	e- and e+/KASD to allow operation
				independent of ML - good details

Quality of the Positron Source Cost Estimate page 2 of 2 (estimates hidden)

Undulator Source - 05/09/07		from John Sheppard		PHG comments 1april08 on quality & completeness of RDR Cost Estimate
	# of units	Comments	November Notes	
Cryogenics		TS		Tom Peterson estimated 0.59 MW
Sources cryogenic plants	0.5	TP (2/27/07 update)	1/2 of e- + e+ cryo	(at Room Temp) cryo plants for both
Sources cryogenic distribution	0.5	TP (2/27/07 update)	1/2 of e- + e+ cryo	e- and e+/KASD to allow operation
				independent of ML - good details
Controls		TS estimate		Good Basis of Estimate for Controls!
Phase and Timing	1	bb 2/7/07 update		OK
Front end Control Sys. Equip.	1	bb 2/7/07 update		OK
LLRF Warm Sations	28	bb (jcs 2/26/07 cnt update)		**est based on 39 e- & e+, should be 3 e- & 28 e+**
LLRF Cold Stations	9	bb (jcs 2/26/07 cnt update)		**est based on 13 e- & e+, should be 10 e- & 9 e+**
				didn't have # LLRF units in Controls est
HLRF		TS estimate		
Warm Sations	28	JW (jcs 2/26/07 cnt update)		**no details on est for warm stations,**
SW HL RF Dist	4	JW/MN (jcs 2/26 cnt update)		**or warm RF distribution**
TW HL RF Dist	24	JW/MN (jcs 2/26 cnt update)		**likewise, not details on HLRF estimate**
Cold Stations	8	RL		Cold Station Est used RF Group est
Energy (Bunch) compressor	1	RL 03/16/07 update		with updated values (+7%)
Magnets		TS estimate	jcs count update	Removed ED&I from Magnet & PS est
Magnets	1	JT/VK 12/19		**JCS gave no details but = MagSys total**
Magnet Power Supplies	1	PB 12/24/06	reduce quads and corr	**JCS gave no details but = PS $ total**
e-Abort kickers and septa	19	includes 87k$ edi	12/24/06 PB update	**JCS gave no details but = MagSys total**
e-Abort kickers and septa PS	0	included in e+ list 12/19/06		**CM SC Quad = TESLA = 59% MagSys**
KASD Magnets	0	included in e+ list 12/19/06	undulator reported above	**PS & Cable ests need optimization**
KASD Magnets PS	0	included in e+ list 12/19/06	**incl undulator PS**	Spin Rotator Solenoid -
pLTR Spin Rotator Solenoids	2			V. Kashikhin estimate based on
pLTR Spin Rotator Solenoid PS	0		2/28/07 jcs confirmed	INP (Troizk) 7 Tesla Solenoids
			Solenoid PS in PB est	**slight inconsistency with DeckFile**
Dumps and Collimators		TS estimate		
Dumps	9	twm/avg unit cost, sum ok	twm cost revision	agrees with Dumps & Collimator Group Est
Ecol	1	twm	twm 12/18/06 updates	but added KASD components at same est
Rcol short	10	twm		
Rcol long	6			
PPS Stopper	2	twm		KASD dumps include:
MPS Stopper	3	twm		2 * 45 KW solid AL block w/cooling
KASD Dumps	3	twm/avg unit cost, sum ok	ab_nov+twm cost rev	& 1 * PPS Stopper with Burn-thru monitor
KASD Rcol	1	twm	ab_nov	
D&C edi	1	k$, twm 12/18/06 update	not in summed costs	removed ED&I from RDR Estimate
Vacuum System		estimate using 24 km est		e+ Source Vacuum Est. by J. Noonan
ELTU	1	jnoonan 7/14; m	jcs reduction	**plenty of detail:** pipes, bellows, crosses,
Undulator	1	estimate using 24 km est	jn update	pumps, pump controllers, gate valves,
UTEL	1	estimate Transport lines	jn 12/06 updates	ritht angle valves, valve interlocks, stands,
UPT	1			gauges, gaskets, cables, bolts, racks, and
PTRAN	1			pump carts
RT RF	1			
Cold Vacuum	1			**used P. Michelato est for CM vacuum**
LTR	1			**which is 45% higher than J. Noonan est**
Misc transport	1			
e+ vacuum edi	1	jn 12/06	not in summed costs	removed ED&I from RDR Estimate
KASD Vacuum	0.25	estimate Transport lines		**scaled 25% from e- Source vacuum**

Correspondence - March 13-17, 2008

- PHG: inconsistency in **PBSTR.xsif** deckfile:
  - PBSTR1 has 23 cavities & 23 quads but RDR estimate has 4 * {6 cavity + 6 quad/corrector} CMs
  - PBSTR2 has 52 cavities & 13 quads, but John S specs were 6 * 8C2Q = 48 cavities and 12 quads!
  - PBSTR3 lists length of 8C1Q CM as 12.3 meters, yet it was standardized as 12.652 m in Summer '06 when we went to 26 cavity RF units. Also this assumes cavity effective length is 1.3 m (not 1.038 m)
- Jim Clarke: differences probably thought not to be important, but should be checked with a physics model

Correspondence - March 13-17, 2008

- PHG: Energy Compressor **RFLTR** in **LTR.xsif** has 2 cavities 1.3 m long at 30 MV/m @ phi = 72/360. two 1.038 m cavities pushes gradient to 37.6 MV/m however, we anticipate one 9C0Q CM here, so plenty of range => 78 MV total voltage

  Any impact due to extra length of CM insert?

  Axel e+ excites all 9 cavities of 9C0Q at 16.6 MV/m @ phi = 72/360 => 155 MV – why 2X different?

- Vladimir Kashikhin verified (31march08) that he estimated $\int B\,dl$ = 26.3 T-m for SC Spin Rotator Solenoids => 2 * 2.5 m * 5.24 Tesla for e- & e+ Src.

- Why does Axel have redundant (2) CMs, RFs, and LLRF stations for e- Energy Compressor, while e+ Energy Compressor has only 1 each?

PTRAN: long 400 MeV/c e^+ drift

- info from deckfiles/pSource/PTRAN.xsif
- length = 5,082 meters
- 707 quadrupoles FODO and Matching

  L = 30 cm, k = 0.568/m^2, G = 0.757 T/m
- 4 dipoles Vertical dogleg

  L = 20 cm, bend = 8.5 mrad, B = 0.0567 T
- 120 earthbends (commented out in pub. version)

  bend = 2.634 μ-rad => $\int B\, dl$ = 3.5 gauss-cm!!!
- avg distance between C/L of quads = 7.2 meters

  all run in series
- Vacuum = 10^{-7}, vacuum cost is $ 496/meter
- Someone asked, “are these requirements are excessive?”

Positron Source Vacuum Costs (2007)

- From John Noonan: (compare to Suetsugu & others?)
- Section Length(m) Pressure Cost/meter
  - ELTU 300 10^{-12} $ 468
  - Undulator 290 10^{-7} $ 610
  - EUTL 300 10^{-12} $ 492
  - UPT 500 10^{-6} $ 395
  - PTRAN 5,000 10^{-7} $ 496
  - LTR 80 $5*10^{-8}$ $ 497
  - Misc. transp. 300 10^{-7} $ 499
  - Warm RF 111 $2*10^{-8}$ $ 462
- CryoModule vacuum estimate (total)
  - Use common Paolo Michelato est (2*12 CM) = $ 595 K
  - Compare to John Noonan est = $ 409 K!

Magnet Info

Magnet Engineering Name (Style)	Revised Count (070419, 070501)
Positron Source System Magnets	
e+ Source Conventional Magnets	
D13L2250	112
D154L400	12
D160L300	840
D40L2000	20
D72L500	8
Q13L1000	85
Q13L500	20
Q160L300V1	612
Q160L300V2	75
Q80L300	48
S13L100	16
S154L300	16
SL310L4300	22
SL360L1300	4
"Gun Solenoids"	10
D35L104	1
Spin Rotator Solenoid SLSCL2500	2
e+ Source Superconducting Magnets	
QSC74L200	23
QSC74L200	12
QSC74L200	10
Undulator Costs (Daresbury)	
Undulator Modules	42
e+ Source Magnet Total	1990
e+ Source Pulsed Magnets	
Abort kicker (2m)	15
Abort septum (10mm thick)	4
e+ Source Magnet Total	19

MagSys Group
John Sheppard

Undulator Source - 05/09/07	
	# of units
Magnets	
Magnets	1
Magnet Power Supplies	1
e-Abort kickers and septa	19
pLTR Spin Rotator Solenoids	2
pLTR Spin Rotator Solenoid PS	0

ILC Positron Source Magnets

Y. Batygin, V. Bharadwaj, Y. Nosochkov, J.C. Sheppard, M. D. Woodley, F. Zhou
Rev. 1: May 18, 2006

obsolete but need something like this for all AS

Table 1 lists the magnet requirements for the ILC positron system optics. The id is the minimum diameter for the solenoids. In the case of quardupoles, dipoles, and sextupoles a 2 mm vacuum chamber wall thickness is assumed. Alignment tolerances: 300 microns, absolute, transverse; field quality: 1% sum over allowed harmonics at 2 cm radius; PS tolerance: 10^{-3} δI/I. Dipole corrector pair for each quadrupole, strength ~50 g-m. BPM for each quadrupole

Table 1: ILC Positron System Magnets

Location	Energy Range	Type	B-field[a]	id	Effective Length[b]	Quantity	Notes
	MeV		kG	cm	m		
ELinac	150,000	Kicker	0.13	4	2.0	15	c
ELinac	150,000	Septum	5	3	5.0	6	d
ELTU+EULT	150,000	quadrupole	1000	1.3	1.0	85	e
EUND	150,000	quadrupole	575	1.3	0.5	20	f
ELTU+EULT	150,000	dipole	1.5	1.3	2.25	112	
ELTU+EULT	150,000	sextupole	7	1.3	0.1	16	
TAPA+TAPB+KAS	1-38	solenoid	5	36	1.3	6	g
TAPA+TAPB+KAS+PPA	38-400	solenoid	5	31	4.3	33	g
PCAPA,B+PPATEL+KAS	125, 400	quadrupole	4-16	15.4	0.3	126	h,i
PCAPA,B+PPATEL+KAS	125, 400	dipole	4	15.4	0.4	14	h
PCAPA,B+PPATEL+KAS	125, 400	sextupole	2.0	15.4	0.3	14	h
Trombone	400	quadrupole	2.5-7	15.4	0.2	33	
Trombone	400	quadrupole	2.0	15.4	0.3	28	
Trombone	400	quadrupole	0.06	13.4	0.26	4	
Trombone	400	quadrupole	25	5.6	0.17	4	
Trombone	400	dipole	1.5-2.3	3	0.3	10	
Trombone	400	dipole	11.4	4	1.6	4	
PBSTR	400	quadrupole	1	7.4	0.2	4	j
PBSTR	400-1135	quadrupole	8-24	7.4	0.2	23	k,l
PBSTR	1135–2605	quadrupole	6-16	7.4	0.2	12	k,m
PBSTR	2605-5000	quadrupole	8-17	7.4	0.2	10	k,n
PTRAN	400, 5000	quadrupole	2.0	15.4	0.3	1662	o,p
PTRAN	400	dipole	2.3	7.2	1.0	8	

Positron Source Magnet & PS notes

- Can't go through all DECKFILES line by line to get magnet inventories. Gotta automate!
- John Sheppard's Magnet Estimates
  - Have no details, just one lot or count plus $ est

	JCS	MagSys
– Conventional Magnets:	total $ =	total $
– Pulsed Magnets:	total $ =	total $
– SC Spin Rotator Solenoids:	$ ≠	$

  use updated V. Kashikhin estimate
  - SC Quads/Corrector packages for Cryomodules

  use scaled-TESLA, note MagSys est. is **70% more**

PS estimate

From Paul Bellomo's

7.7 MByte file!

PS for kickers & septa incl'd in T. Mattison's magnet estimate

PS for undulator incl'd in J. Clarke est

PS for 31KASD NC Quads are not included in est

2143 magnets + undulators

41 magnet strings

1125 Power Supplies

Section	Line	Reference	Poles	Lattice Name	Normal or Superconducting	Magnet Quantity	Unipolar (U) or Bipolar (B)	String (s) or Individually (I) Powered	Single Maximum Volts (40C)	Maximum Amps
e+	ELTU+EULT	V Kashikhin 12-08-06	Dipole	Later	N	112	U	S	4.9	26
e+	PCAPA,B+PPATE	V Kashikhin 12-08-06	Dipole	Later	N	12	U	S	7.96	511
e+	PTRAN	V Kashikhin 12-08-06	Dipole	Later	N	8	U	S	2.6	60
e+	PLTR	V Kashikhin 12-08-06	Dipole	Later	N	20	U	S	12.4	498
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 1	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 2	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 3	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 4	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 5	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 6	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 7	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 8	N	61	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 9	N	62	U	S	3.6	66.0
e+	PTRAN	V Kashikhin 12-08-06	Quadrupole	String 10	N	62	U	S	3.6	66.0
e+	EUND	V Kashikhin 12-08-06	Quadrupole	Later	N	20	U	S	6.0	64.0
e+	ELTU+EULT	V Kashikhin 12-08-06	Quadrupole	String 1	N	43	U	S	9.8	56.0
e+	ELTU+EULT	V Kashikhin 12-08-06	Quadrupole	String 1	N	42	U	S	9.8	56.0
e+	PCAP+PPATE	V Kashikhin 12-08-06	Quadrupole	String 1	N	25	U	S	6.1	393.0
e+	PCAP+PPATE	V Kashikhin 12-08-06	Quadrupole	String 1	N	25	U	S	6.1	393.0
e+	PCAP+PPATE	V Kashikhin 12-08-06	Quadrupole	String 1	N	25	U	S	6.1	393.0
e+	PBSTR	V Kashikhin 12-08-06	Quadrupole	String 1	S	23	U	S	0.0	93.0
e+	PBSTR	V Kashikhin 12-08-06	Quadrupole	String 2	S	12	U	S	0.0	62.0
e+	PBSTR	V Kashikhin 12-08-06	Quadrupole	String 3	S	10	U	S	0.0	66.0
e+	KASD		Quadrupole	String 4	S	6	U	S	0.0	66.0
e+	PTRAN+PLTR	V Kashikhin 12-08-06	Quadrupole	String	N	48	U	S	4.7	299.0
e+	ELTU+EULT	V Kashikhin 12-08-06	Sextupole	Later	N	16	U	I	1.6	50
e+	PCAPA,B+PPATE	V Kashikhin 12-08-06	Sextupole	Later	N	16	U	I	3.72	341
e+	TAP+KAS	V Kashikhin 12-08-06	Solenoid	Later	N	4	U	I	135	500
e+	TAP+PPA+KAS	V Kashikhin 12-08-06	Solenoid	Later	N	22	U	I	415	500
e+	PTRAN	V Kashikhin 12-08-06	Corrector	Later	N	840	B	I	1.8	64
e+	ELINAC	V Kashikhin 12-08-06	Septum	Later	N	4	U	I	Later	Later
e+	ELINAC	V Kashikhin 12-08-06	Kicker	Later	N	15	U	I	Later	Later
e+			Corrector	Later	S	102	B	I	0	20
e+			Undulator	Later	S	27	Later	Later	Later	Later
e+	KASD		Dipole	Gun Bend	N	1	U	I	1.2	3.9
e+	KASD		Dipole	Chicane Bend	N	4	U	S	3	2.5
e+	KASD		Quadrupole		N	31	U	I	Later	Later
e+	KASD		Solenoid	Gun Solenoid	N	10	U	I	39.6	45
e+	KASD		Solenoid	Later	N	2	U	I	415	500
e+	PLTR		Solenoid	Spin Rotator	S	2	U	I	0.0	4000.0
e+	KASD		Corrector		N	31	B	I	1.8	64

Finally

- **This detailed study of the status & quality of the Positron Cost Estimate is a pilot study for all Area Systems**
- **Finally, what work still needs to be done or documented for the Positron Source estimate?**
- **How are/should continuing design changes be correlated with estimate?**
- **How do we work together to accomplish this?**

Further questions – if time

- Is number of magnets reasonable?
  - **Compared to e- source for same regions?**