ILC Baseline e^+ Source

PosiPol 2006, CERN

J. C. Sheppard, SLAC with M. Kuriki, KEK

April 26, 2006

ILC Baseline e^+ Source Collaborators

ANL, CCLRC, Cornell, DESY,
KEK, LLNL, Liverpool, SLAC

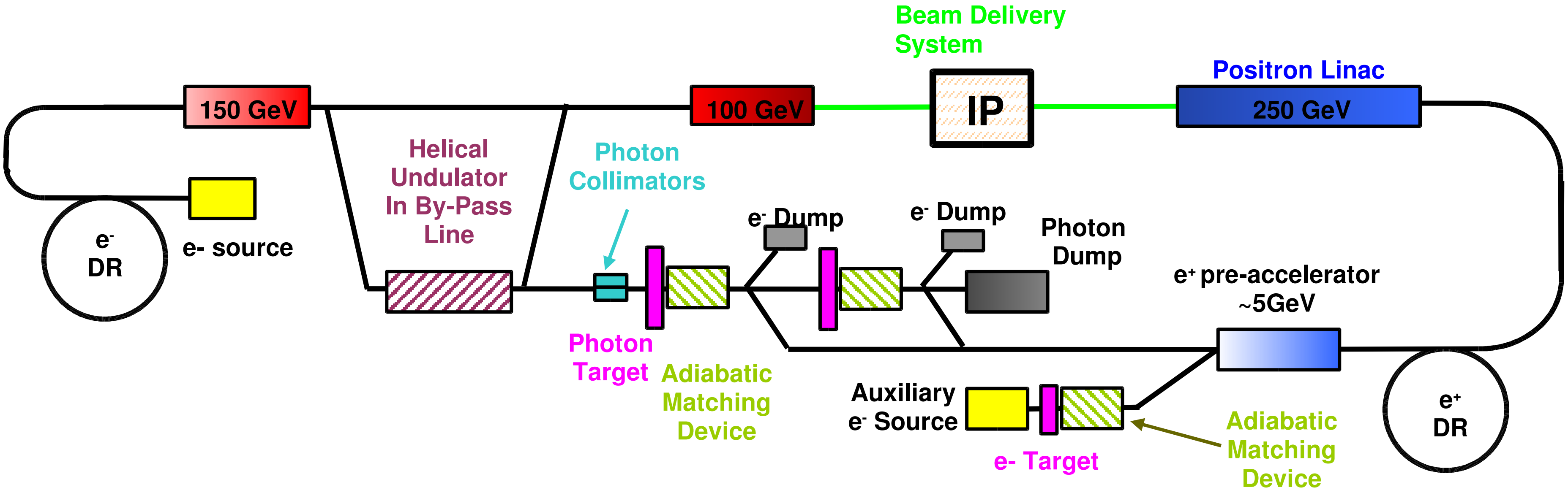
(Cockcroft, LBL)

ILC Baseline e^+ Source Parameters

Positron Beam				
Positron Intensity	2×10^{10}	e+/bunch	N_b	
Number of Bunches	2820	Bunches/train	n_b	
Bunch spacing	310	ns	t_b	
Repetition rate	5	Hz	f_{rep}	
Energy	5000	MeV	E_{e+}	
Beam Power	230	kW	P_{e+}	
Overhead	1.5		F	

Layout of ILC Positron Source

- Photon production at 150 GeV electron energy
- K=1, λ=1 cm, 200 m long helical undulator
- Two e+ production stations including a back up.
- Keep alive auxiliary source is e+ side.



M. Kuriki, KEK

Working Assumptions

2.5 m parallel offset of undulator from electron main linac

Pulsed flux concentrator

TiAlV Target material, ~0.4 rl

200 m long undulator for polarized e+ w/ 50% overhead

400 MeV long-haul transport

Transport channel acceptance: 0.045-0.06 m (DR acceptance: 0.09 m)

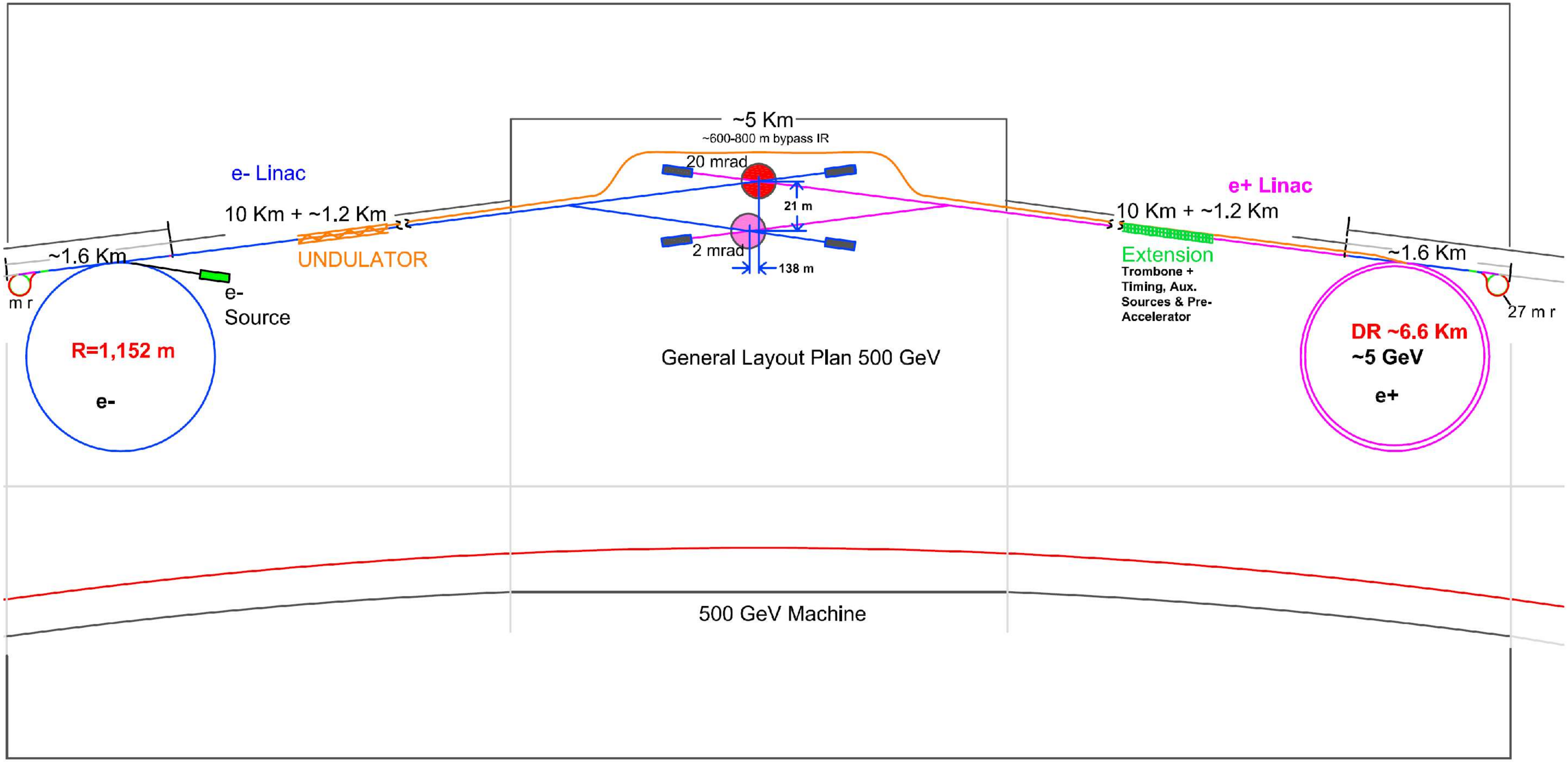
Avoid the IP BDS bypass (~600-800)

500 MeV e- drive, conventional e+ keep alive source, unpolarized e-gun, 4 rl WRe target

Positron Linac timing extension w/Trombones

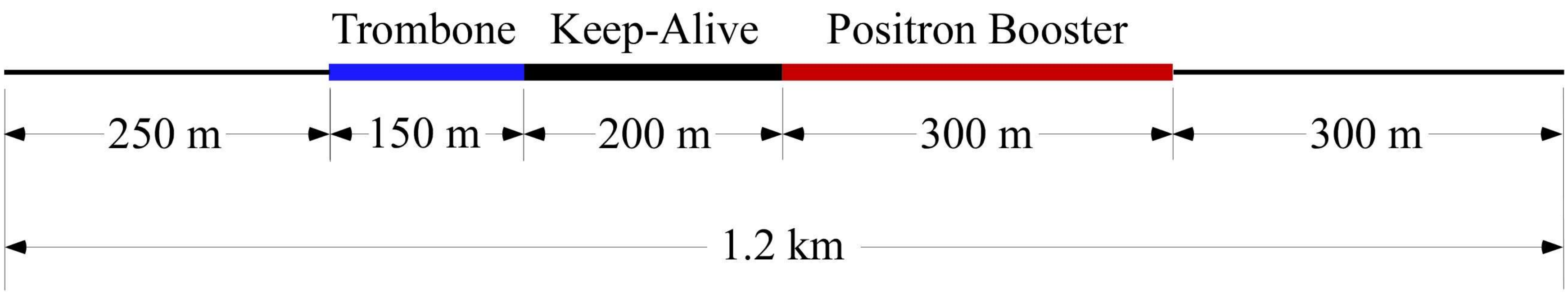
Full power e+ tune up dump at PLTR: 500 kW

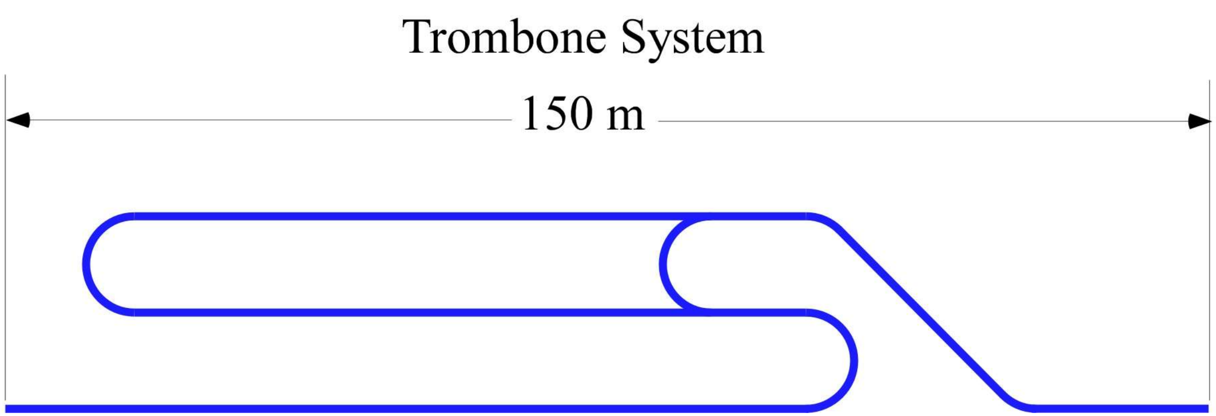
Positron System Site Layout



General Elevation View

Positron Linac Extension





ILC Positron System RDR Interconnects and Responsibilities

Table 1: ILC Interconnects

System	SLAC Person	TG/GG Person	Comments
Magnets	Sheppard	J. Thompkins	Yes
Vacuum	Sheppard	J. Noonan	May be
Linacs	Sheppard	C. Adolphsen, J. Wang	Yes
RF	Sheppard	R. Larsen	Yes
Diagnostics	Bharadwaj	M. Ross	Yes
Controls	Bharadwaj	J. Cawardine	Yes, TG integration
Undulator	Sheppard	J. Clarke, Daresbury	Yes, May 2006 visit
Target	Bharadwaj	LLNL, Liverpool	Yes, weekly meetings
AMD	Bharadwaj	SLAC, LLNL	Yes, weekly meetings
Civil	Bharadwaj	C. Corvin	Yes
Cryo	Sheppard	T. Peterson	Yes, May be
Dumps	Sheppard	Ban	Not really (scale 20 MW dumps)
Accelerator Physics	Sheppard	Schulte, Kubo	Not really (fill in necessary at SLAC)
Radiation Physics	Kuriki	?need to check?	Not really, BDS and Dumps
Installation	Bharadwaj	F. Asiri	Needs RRA definition
Availability	Sheppard	T. Himel	To be added
Remote Handling	JCS/VKB	??????	Not started
Electron Source	Sheppard	A. Brachmann	Yes
Damping Rings	Sheppard	Wolski, et al.	Yes
Beam Delivery	Bharadwaj	A. Seryi	Yes
Main Linacs	Sheppard	C. Adolphsen	Yes
R&D Plan	VB and JCS	various	Needs approval and funding
RDR Text	Bharadwaj	Various	Needs definition
RDR Cost	Sheppard	Various	Needs definition

International Linear Collider

Sources (Accelerator Development: Injector) ILC @ SLAC - Microsoft Internet Explorer

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Address http://www-project.slac.stanford.edu/ilc/acceldev/eplus/pos-rdr.html Go Links

International Linear Collider
at Stanford Linear Accelerator Center

- ILC @ SLAC Home
- Program Office
- ILC Program Description
- Accelerator Design
- Experiments & Prototypes
- Test Facilities
- Documentation
- Past Seminars/Workshops
- International Links

ILC Positron Source : RDR

BCD RDR

Documents/Presentations	FT	Date	Layouts/Parameters/Tables	FT	Date	Estimates/Calculations/Lattices	FT	Date
ILC Pos Source Linac Systems	.doc	29-Mar-06	Overall Layout	.jpg	29-Mar-06	Positron Beam Sizes	.jpg	29-Mar-06
ILC Pos Source Beam Optics	.doc	29-Mar-06	Capture RF (0-125 MeV)	.jpg	29-Mar-06	Positron Beam Stayclears	.jpg	29-Mar-06
ILC Pos Source Beam Dumps	.doc	29-Mar-06	PPA RF (125-400 MeV)	.jpg	29-Mar-06	Positron Betas	.jpg	29-Mar-06
ILC Pos Source Photon Dump	.doc	29-Mar-06	CM1 RF (400-1135 MeV)	.jpg	29-Mar-06	Positron Beam Power	.jpg	29-Mar-06
ILC Pos Source Solenoids	.doc	29-Mar-06	CM2 RF (1135-2605 MeV)	.jpg	29-Mar-06			
ILC Pos System Keep Alive Source	.doc	29-Mar-06	CM3 RF (2605-500 MeV)	.jpg	29-Mar-06			
ILC Pos Source Vacuum Specs	.doc	29-Mar-06	Keep Alive Source	.jpg	29-Mar-06			
ILC Pos Source Undulator MPS	.doc	29-Mar-06	Beam Dump Powers	.xls	29-Mar-06			
30% Positrons	.ppt	29-Mar-06						
Pos Source Instrumentation	.doc	04-Mar-06						

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Helical Undulator: J Clarke et al., Daresbury Laboratory

200 m helical undulator

K=1, λ = 1 cm, id > 6 mm

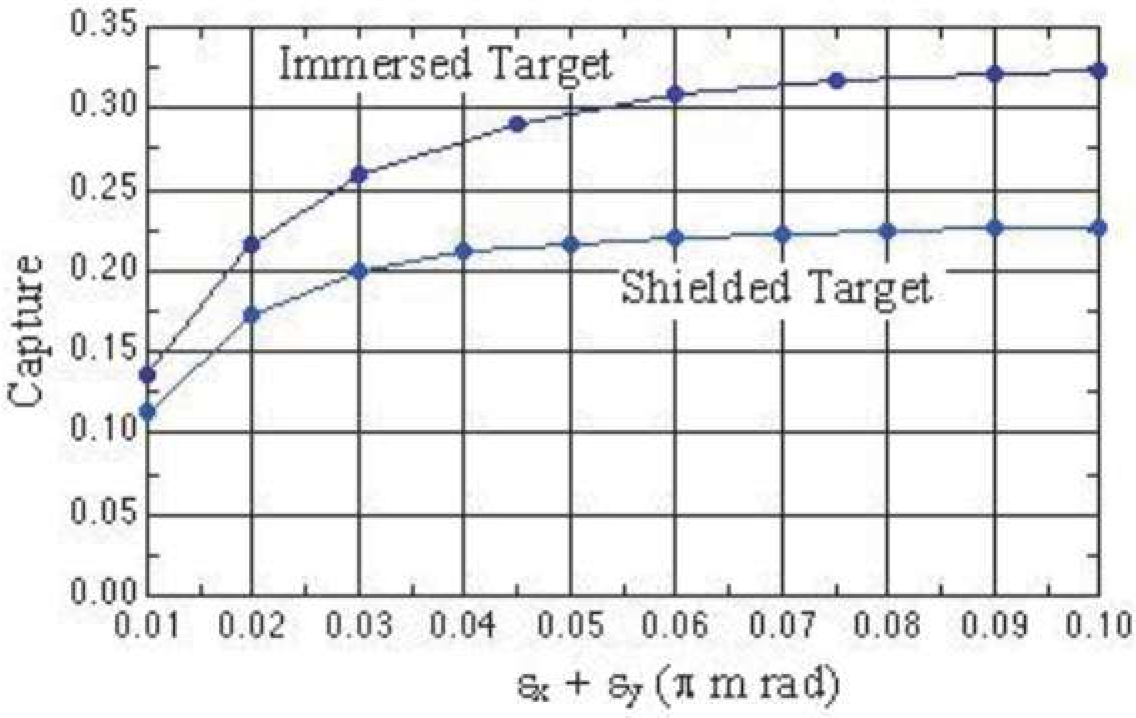
superconducting coil

2-4 m length module

Associated supports and vacuum

NOTE: $L_{und} \propto (150/E[GeV] \times \lambda(cm)/K)^2$

Positron System Optics: Capture



Positron yield at 5 GeV (e+/e+target) for undulator based source with $\Delta E/E \leq 1\%$ for immersed target with B_z= 6T and for shielded target.

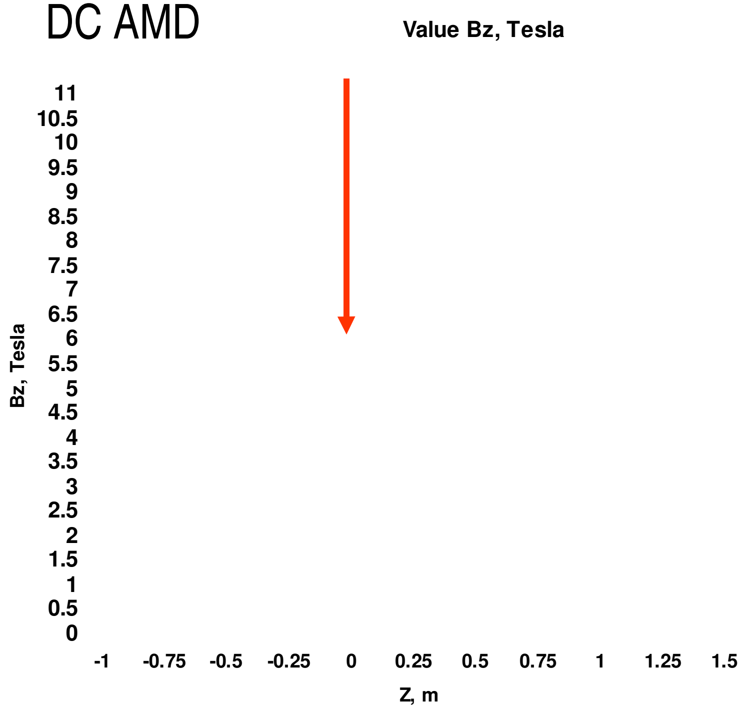
AMD (Flux Concentrator)

Table 2: Nominal AMD Specifications

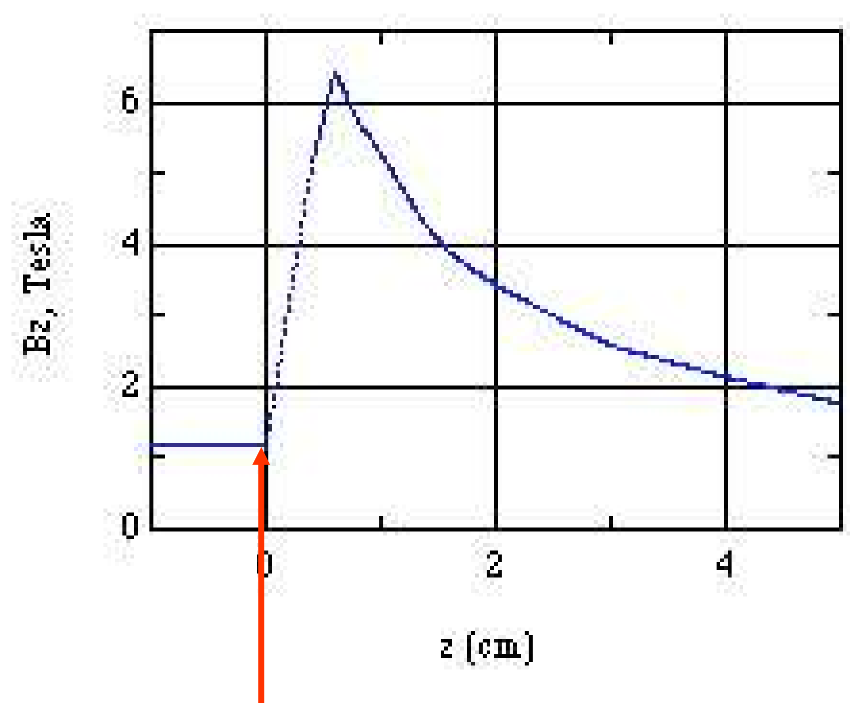
Item	B_0	G	Pulse Length	Rep. Rate
	kG	cm^{-1}	ms	Hz
DC AMD	60	8-80	dc	-
Pulsed AMD	60	60	1.2	5

$B(z)=B_0/(1+z*G)$ for $Z>0$; B_0 is the field at $Z=0$

DC AMD



Pulsed AMD



Pulsed Flux Concentrator, circa 1965: Brechna et al.

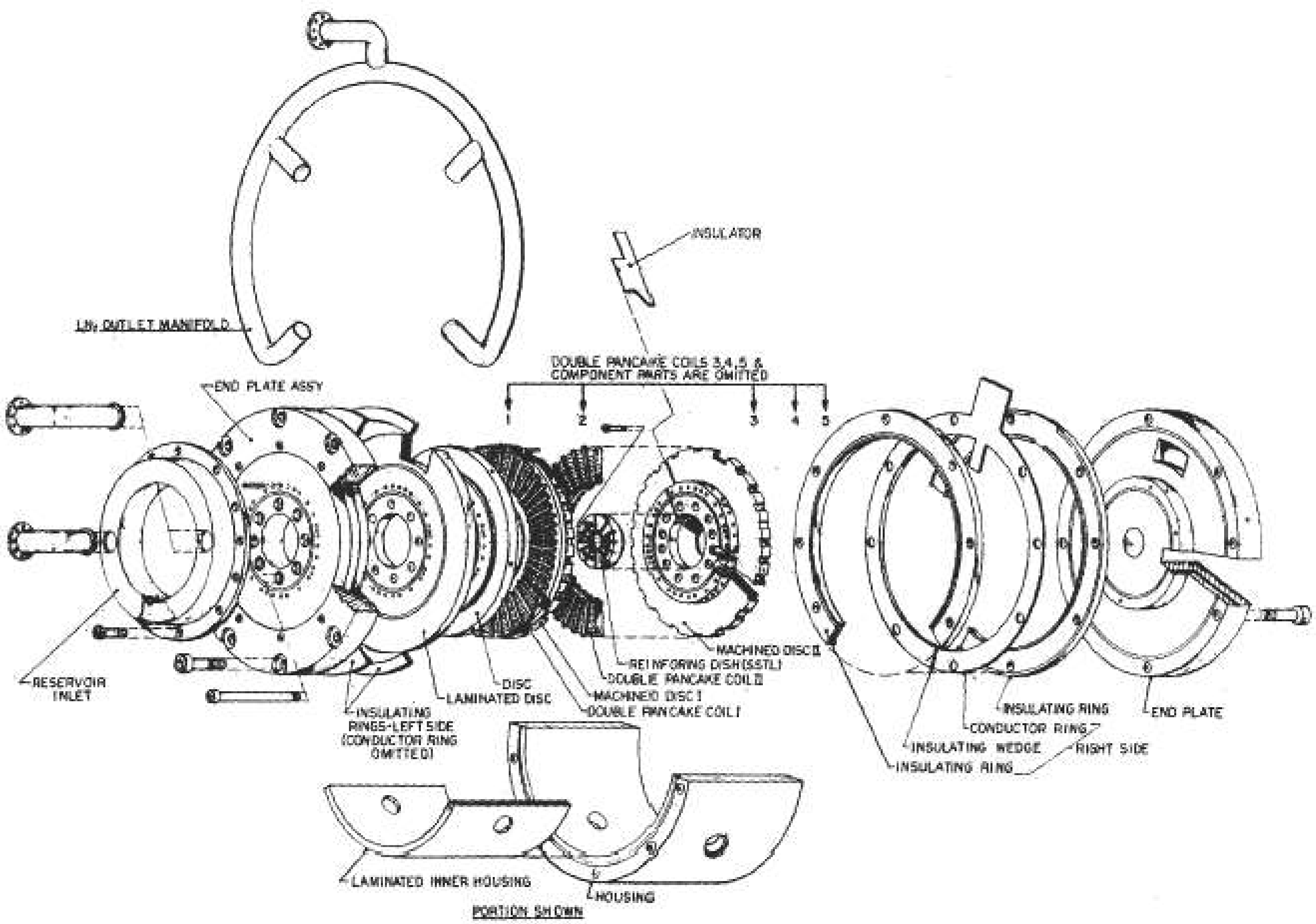
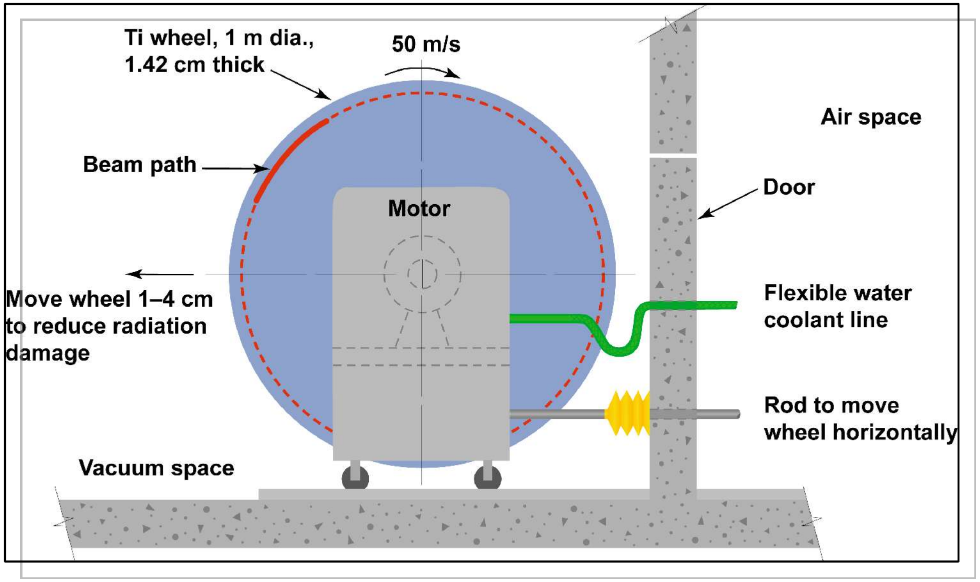


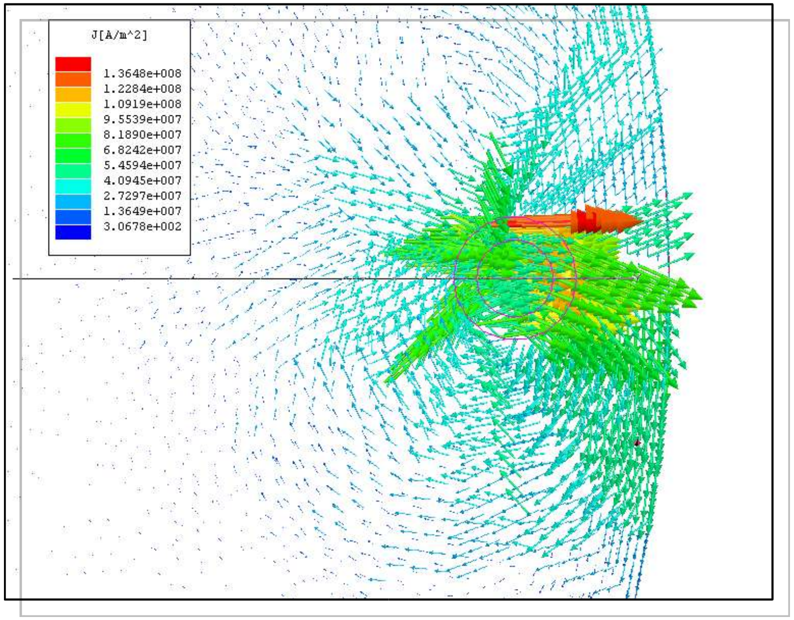
FIG. 5. Exploded view of flux-concentrator assembly.

Positron Target and AMD (J. Gronberg, LLNL)
[Pulsed Flux Concentrator for RDR]

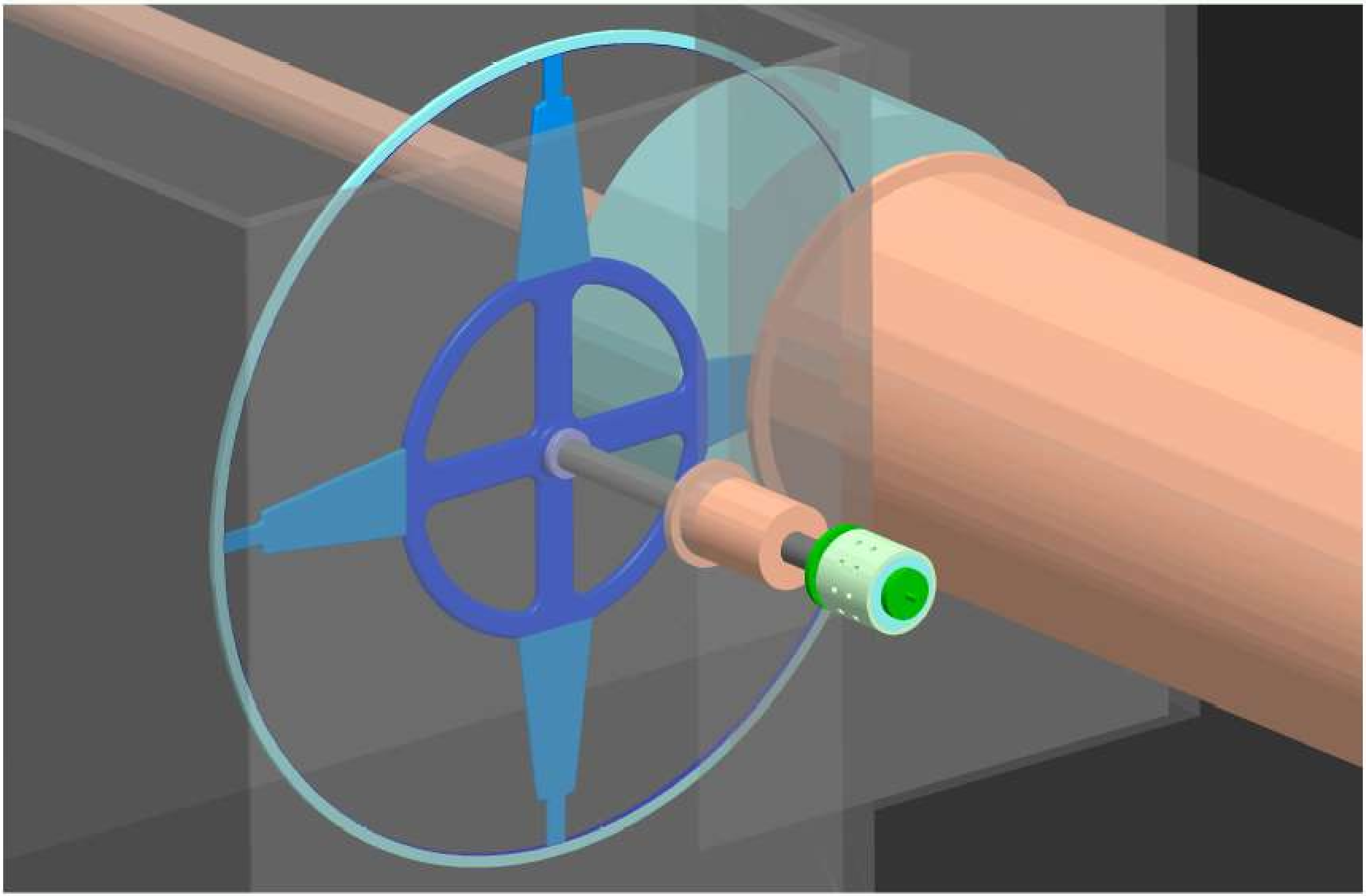
A conceptual design for the positron target



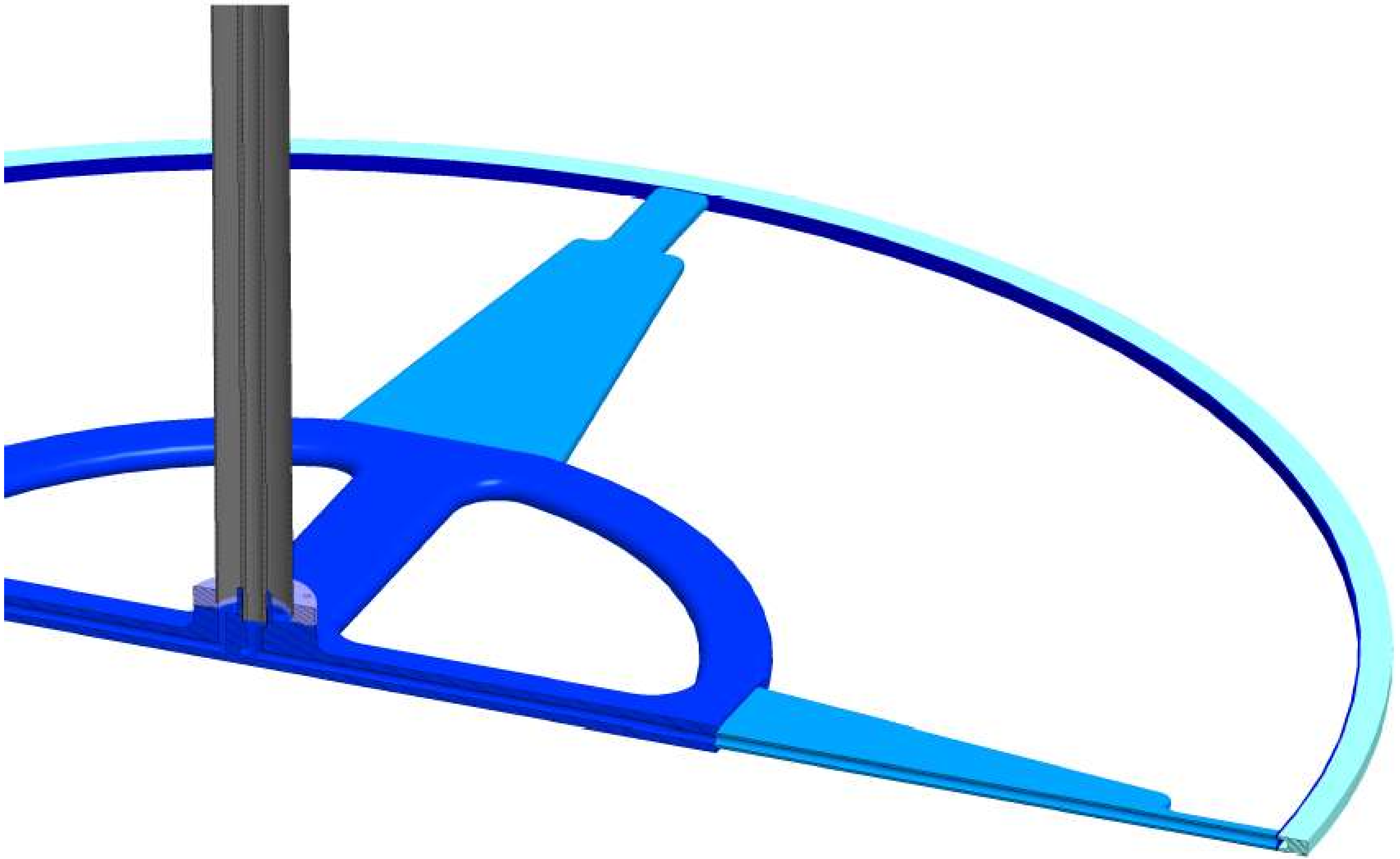
Eddy currents in a spinning metal disc



Positron Target and AMD (Stein, Grtonberg, et al., LLNL)

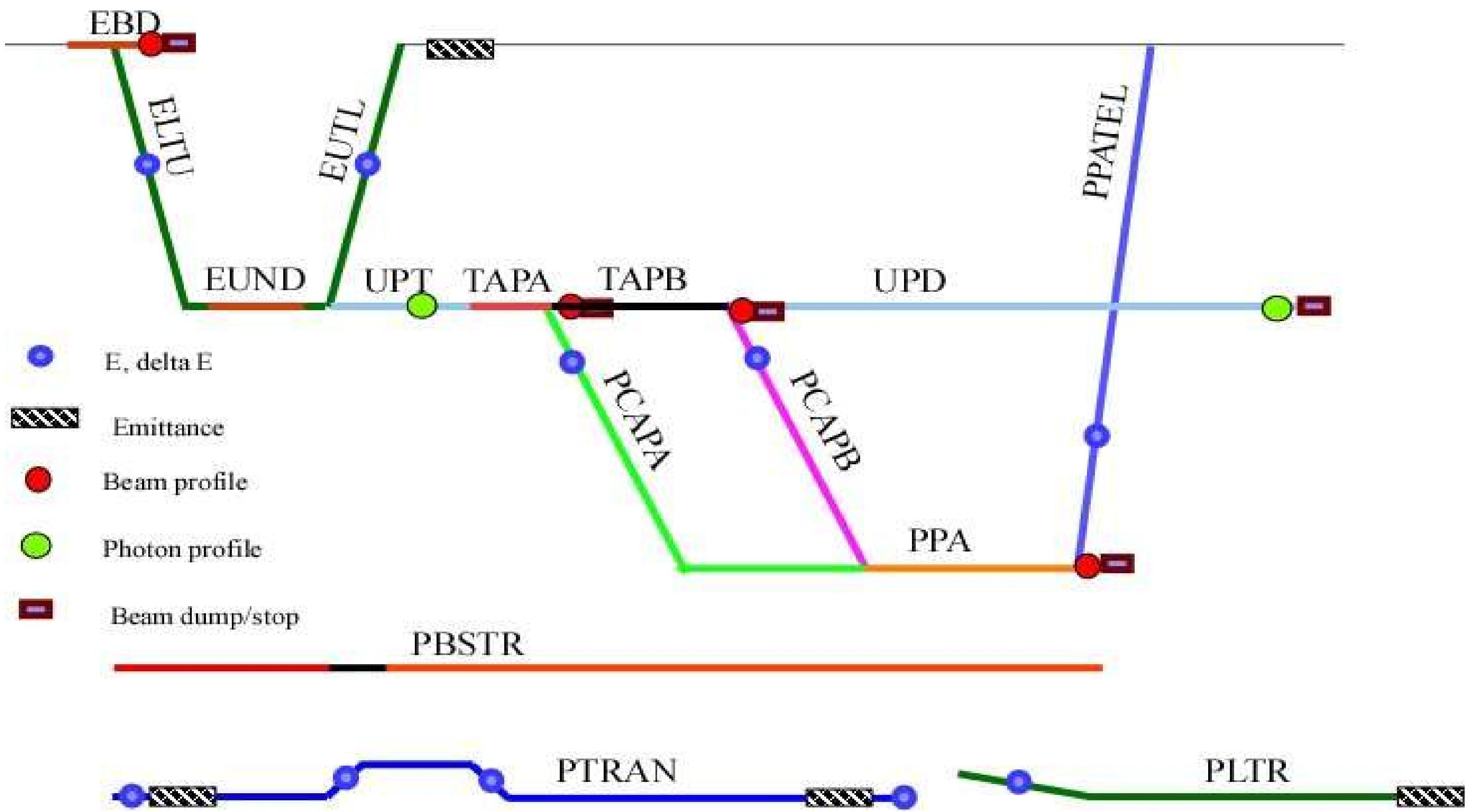


Positron Target and AMD (Stein, Grtonberg, et al., LLNL)



ILC Positron System Beamlines

Beam Diagnostics

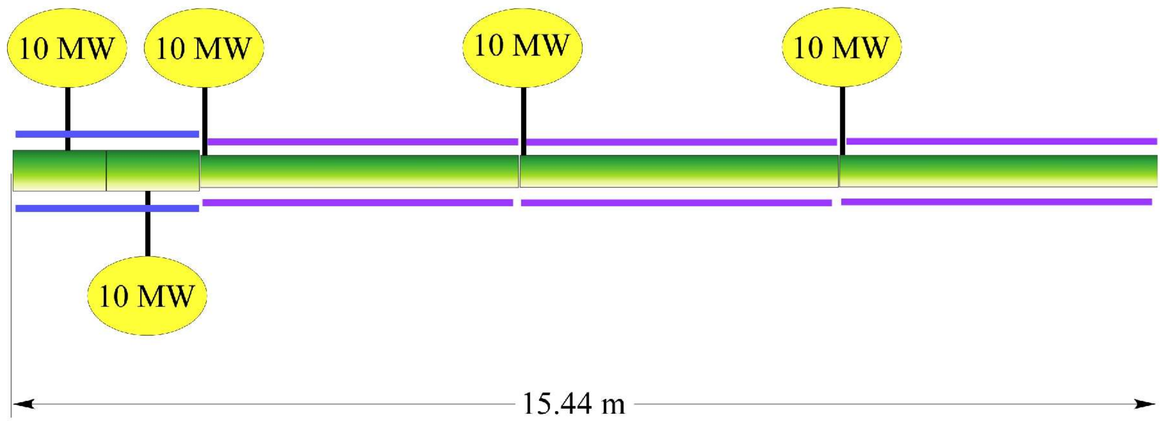


Positron System Magnet List

Table 1: ILC Positron System Optics

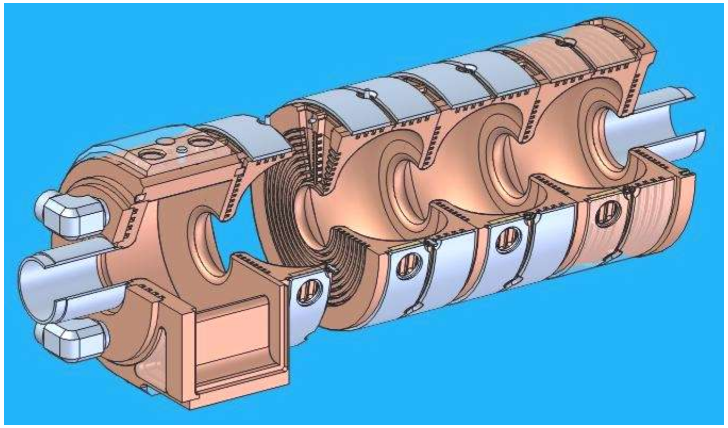
Location	Energy Range	Magnet Type	B-field[(a)]	id	Quad Spacing	Quantity
	MeV		kG	cm	m	
ELinac	150,000	Kicker	0.125	8	2.0(length)	15 (MPS)[(j)]
ELinac	150,000	Septum	4.75	8	5.0(length)	6(MPS)[(k)]
ELTU+EULT	150,000	quadrupole	1000	1	7	85
EUND	150,000	quadrupole	575	1	12.3	20
ELTU+EULT	150,000	dipole	1.6	1	2.25(length)	112
ELTU+EULT	150,000	sextupole	0.1	10	0.035 ($L_{effective}$)	16 (k2=0.6-7 m^{-2})
TAPA+TAPB+KAS	1-38	solenoid	5	36	1.3(length)	6 x1.27 m long[(b)]
TAPA+TAPB+KAS	38-125	solenoid	5	31	4.3(length)	9x4.3 m long[(b)]
PPA	125-400	solenoid	2.5	31	4.3(length)	24x4.3 m long[(b)]
PBSTR	400-1135	quadrupole	8.5-24	7.4	1.95	24 quads in cryostat
PBSTR	1135–2605	quadrupole	6.8-15.6	7.4	6.9	12 quads in cryostat
PBSTR	2605-5000	quadrupole	8.8-16.8	7.4	12.3	12 quads in cryostat
PBSTR	1135, 2605	quadrupole	20	7.4	-	8 quads, matching[(i)]
PTRAN+PPATEL	400	quadrupole	2.0	15.4	8.4	~3000 quads[(c)]
PTRAN+PPATEL	400	dipole	10[(e)]	15.4	0.43 (length)	~6 bends[(c)]
PTRAN+PPATEL	1135	quadrupole	2.0	15.4	23.7	~1000 quads[(c)]
PTRAN+PPATEL	1135	dipole	10[(e)]	15.4	1.2 (length)	~6 bends[(c)]
PCAPA+PCAPB+KAS	125	quadrupole	3.3	15.4	1.6	~61 quads[(d)]
PCAPA+PCAPB+KAS	125	dipole	2[(f)]	15.4	0.26 (length)	8 bends[(d)]
PLTR	5000	quadrupole	40	7.5	6.5	~45 quads[(g)]
PLTR	5000	dipole	2.9	7.5	1.0 (length)	8 bends[(h)]

Proposed NC Positron Capture Accelerator System
0-125 MeV



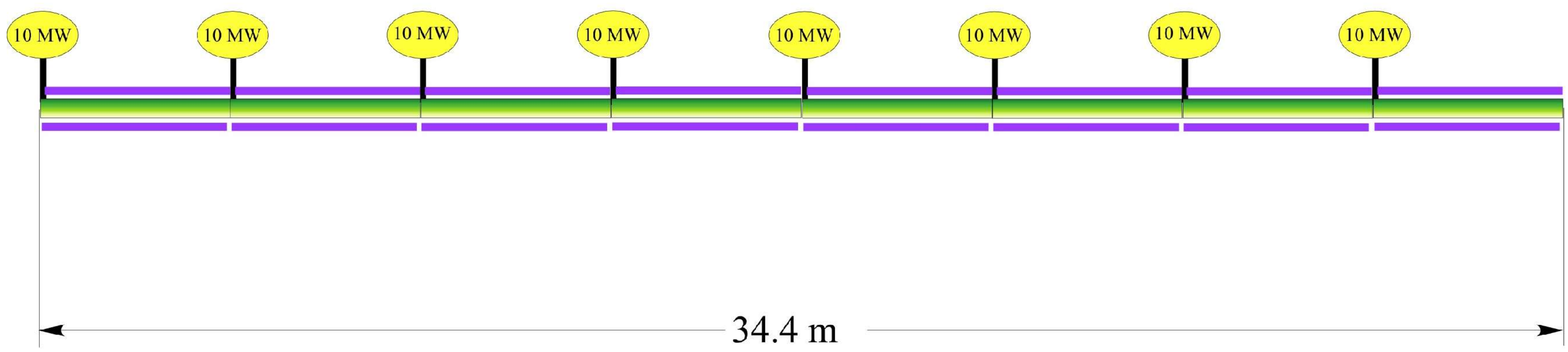
- Goal: Evaluate performance of a 1.3 GHz, NC cavity
- Issues: Significant heating from both rf and particle losses,

  must sustain high surface fields (~ 35 MV/m for 1 msec)



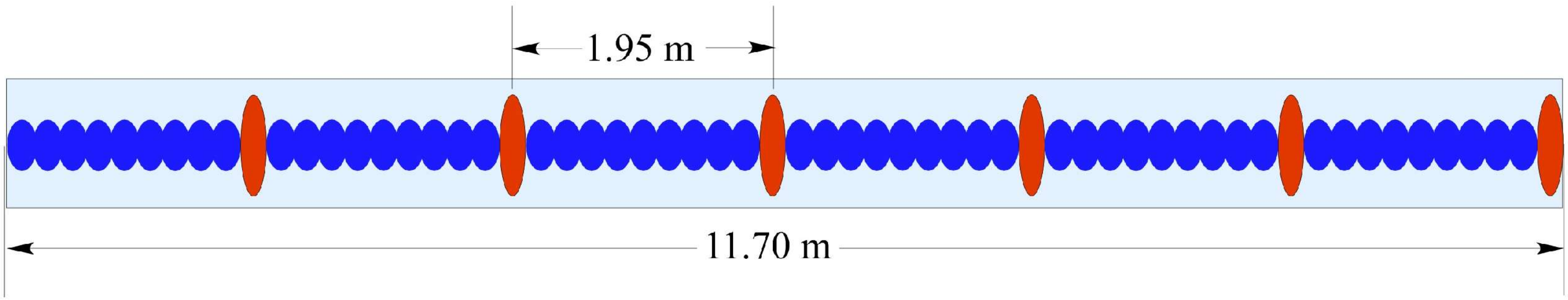
Proposed NC Positron Pre-Accelerator System

125-400 MeV

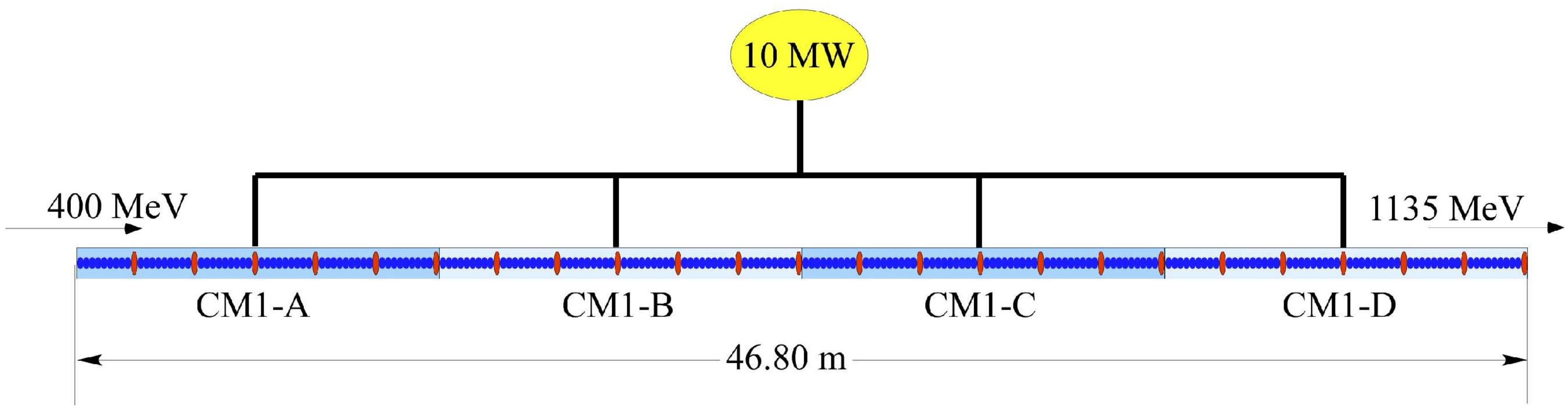


8 x 4.3 m TW Section
8 x 10 MW Klystron
8 x 4.3 m 0.5 T Solenoid
(from J. Wang)

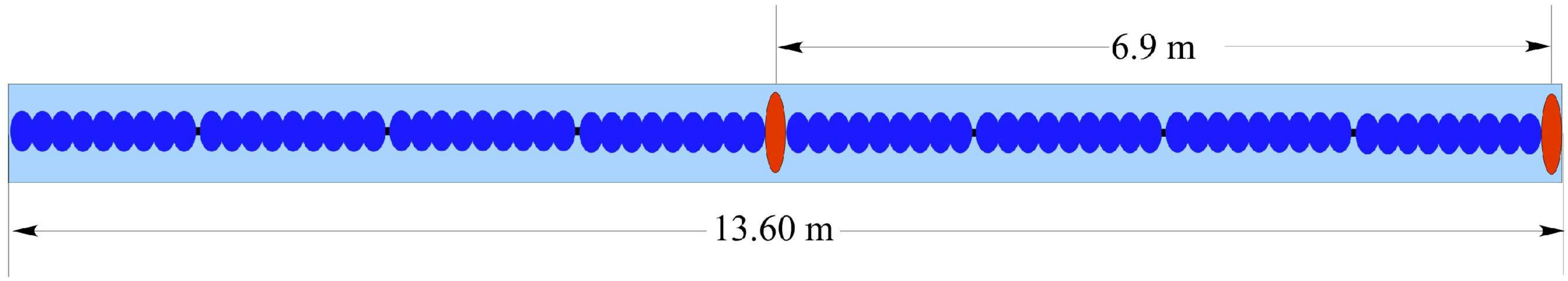
Proposed CM1 SC Accelerator Module for e+ Booster



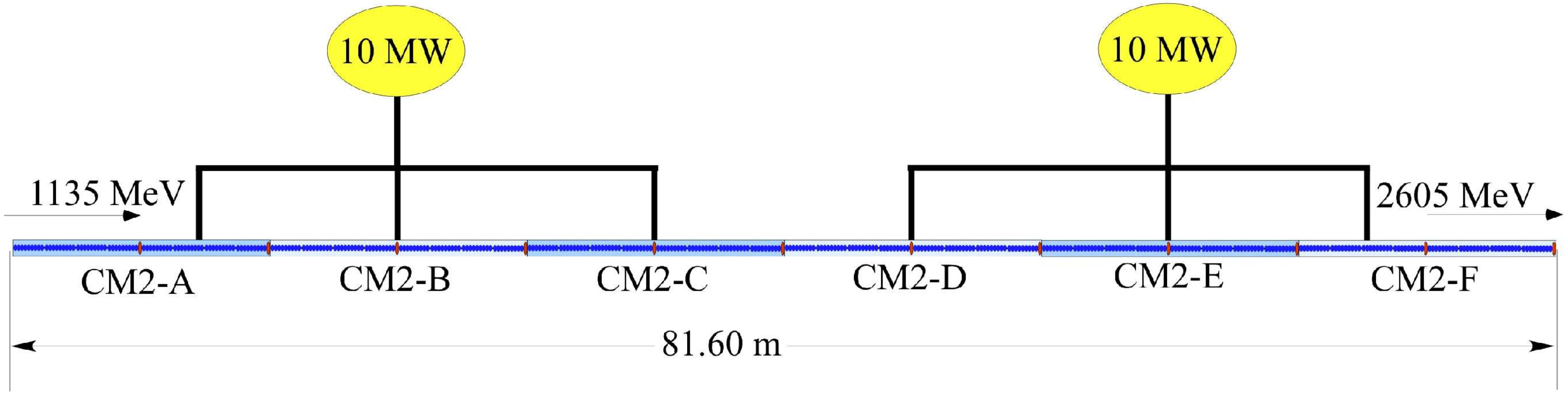
Proposed PBSTR-1: 400-1135 MeV



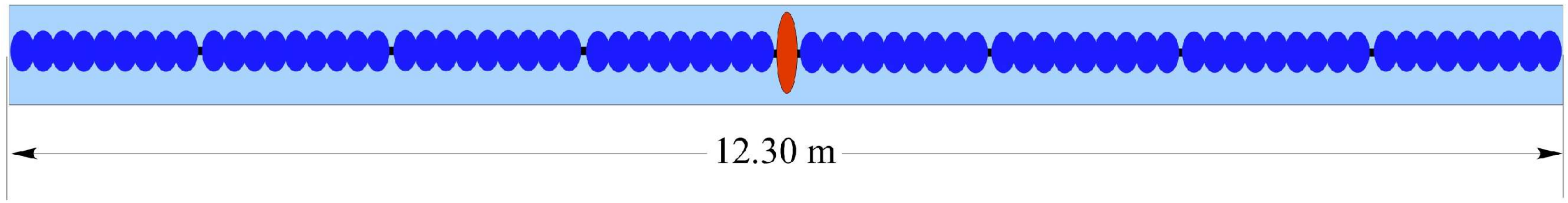
Proposed CM2 SC Accelerator Module for e+ Booster



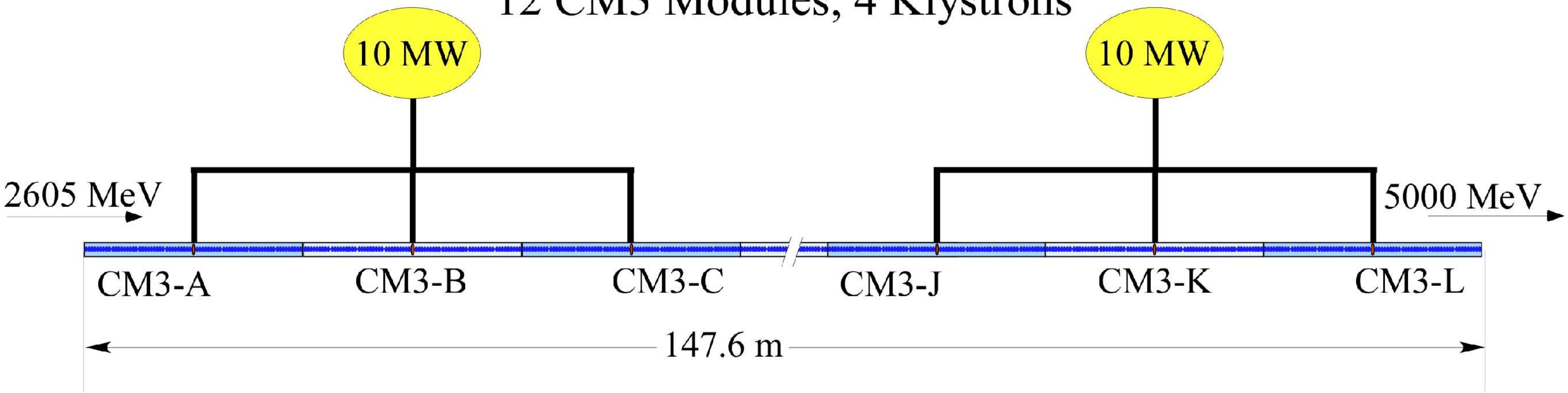
Proposed PBSTR-2: 1135-2605 MeV



Proposed CM3 SC Accelerator Module for e+ Booster



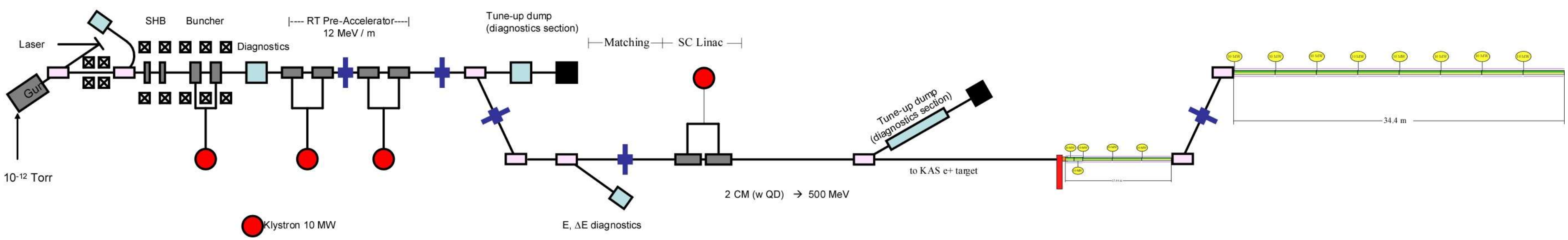
Proposed PBSTR-3: 2605-5000 MeV
12 CM3 Modules, 4 Klystrons



Positron Keep Alive System

Positron Beam				
Positron Intensity	2×10^{9}	e+/bunch	N_b	
Number of Bunches	2820	Bunches/train	n_b	
Bunch spacing	310	ns	t_b	
Repetition rate	5	Hz	f_{rep}	
Energy	5000	MeV	E_{e+}	
Beam Power	23	kW	P_{e+}	
Overhead	1.5		F	
Electron Drive Beam				
Electron Intensity	2×10^{10}	e-/bunch	N_b	
Number of Bunches	2820	Bunches/train	n_b	
Bunch spacing	310	ns	t_b	
Repetition rate	5	Hz	f_{rep}	
Energy	500	MeV	E_{e-}	
Beam Power	23	kW	P_{e-}	
Target System				
Target Material	W23%Re			
Target Thickness	4	r.l.	L_t	
Target Thickness	1.4	cm	L_t	
Peak Energy Deposition	?	J/g		Needs checking
Average Power Deposition	3.5	kW		
Average Energy Absorption	16	%		
Target Diameter	1	m		Needs checking
Target Rotation Speed	1000	rpm		Needs checking
Perimeter Velocity	52	m/s		Needs checking
FC/AMD Field	6	T		

ILC Keep Alive Source, Rev 0.



ILC e+ BCD/RDR Summary

All (?) pieces identified

High Level Parts List Complete

Ongoing R&D:

- Undulator
- Target
- AMDs
- NC RF
- (Remote handling, not started)

Goals

- RDR and Cost Estimate, end of calendar 2006
- TDR w/ key technology demos, end of calendar 2009