

- Requirements for positron beam
- Reference Parameters:

## Undulator

- parameters
- Undulator Impacts on Drive Beam

## Target

- Target Energy Deposition

## OMD:

- Flux Concentrator Capturing

## Transport lines

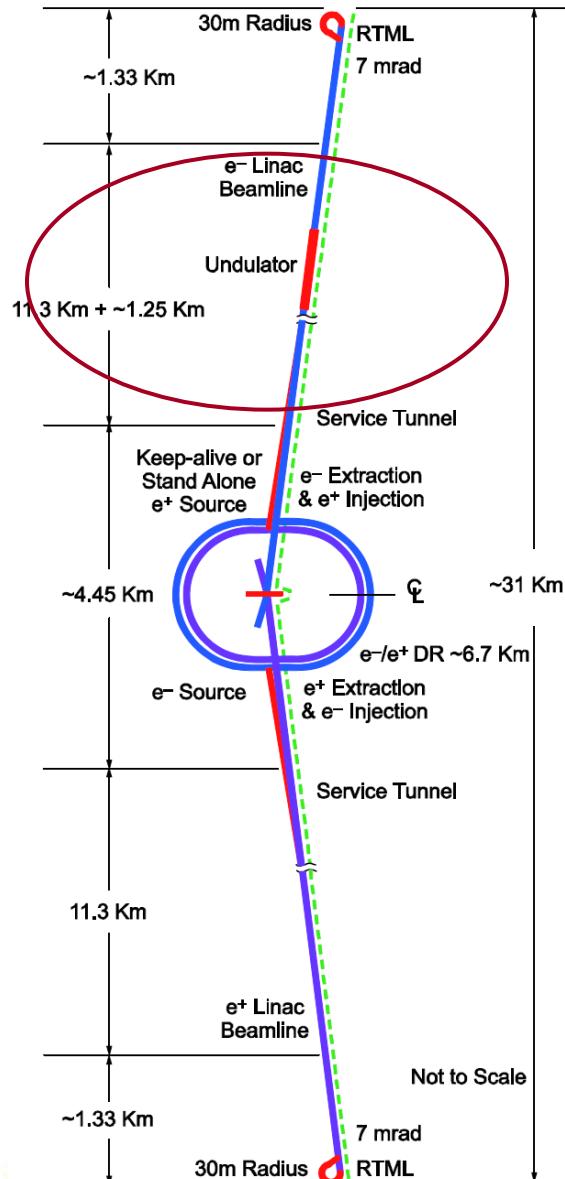
## Booster

## Spin rotation, Energy Compression

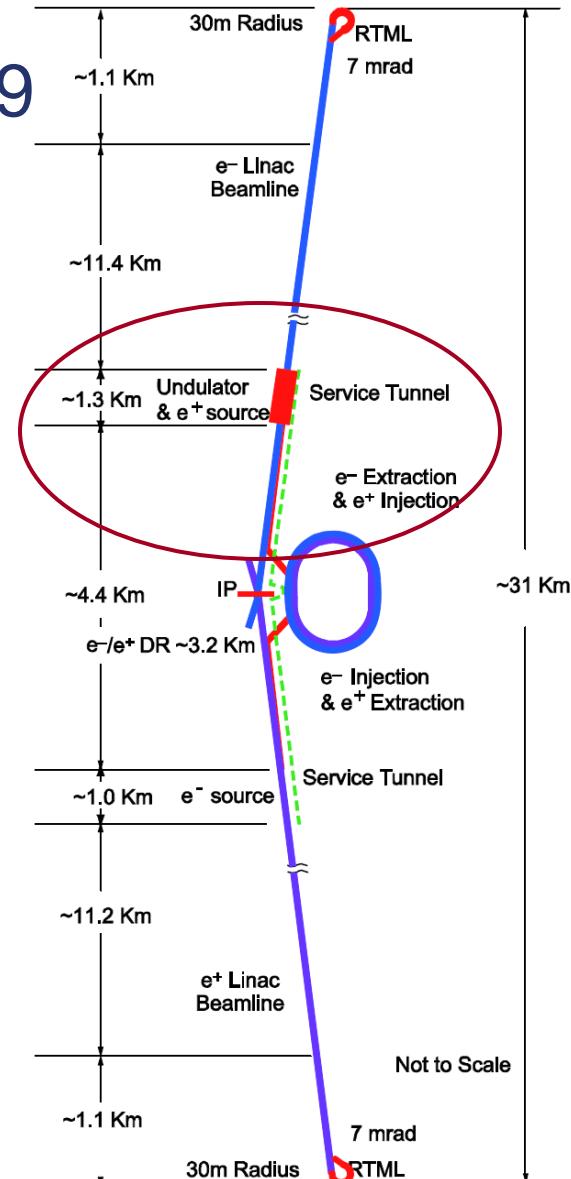
- Path toward higher polarizations
  - Photon collimators
- Remarks on TeV upgrade

## ILC e+ source location

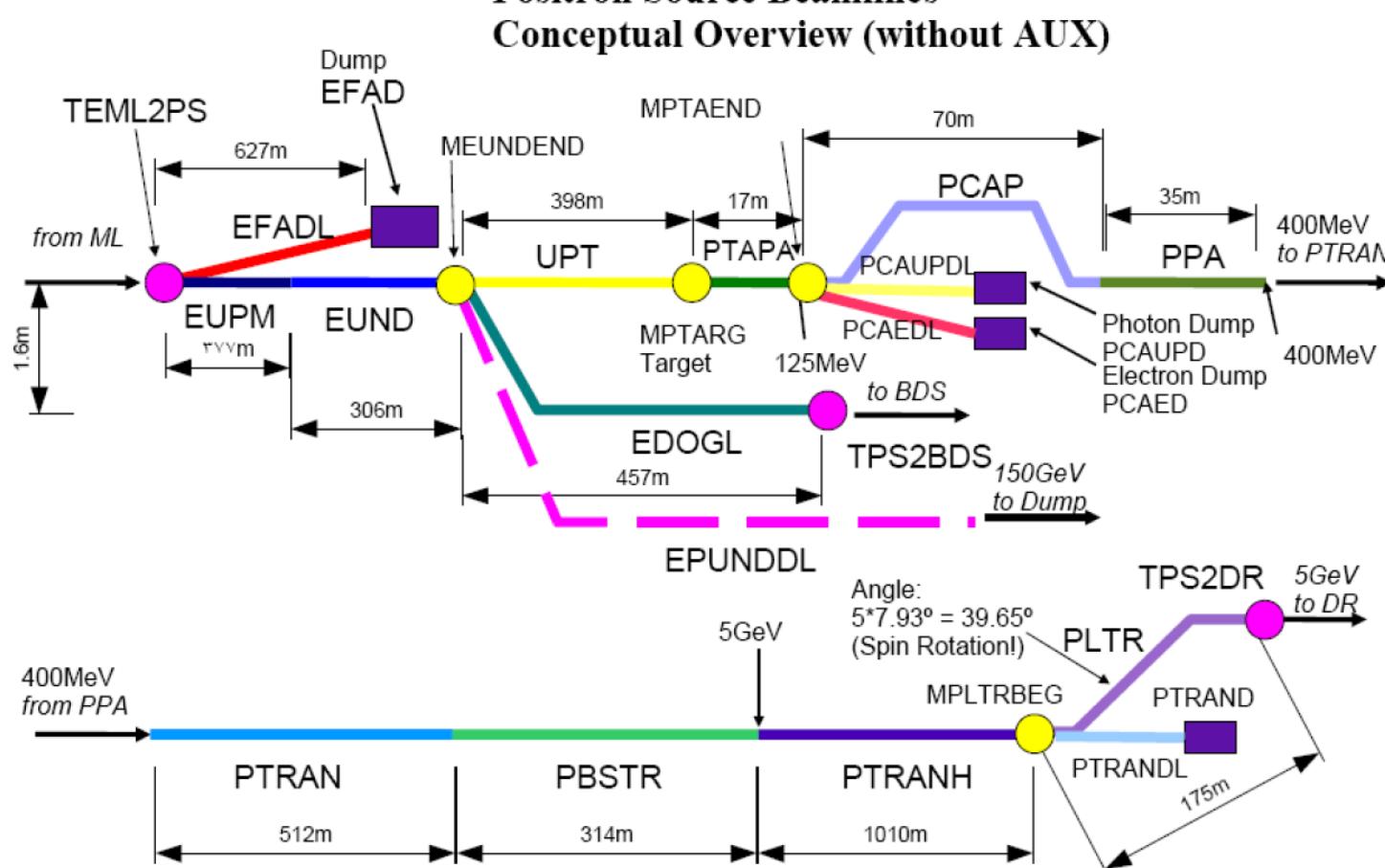
RDR:



SB2009



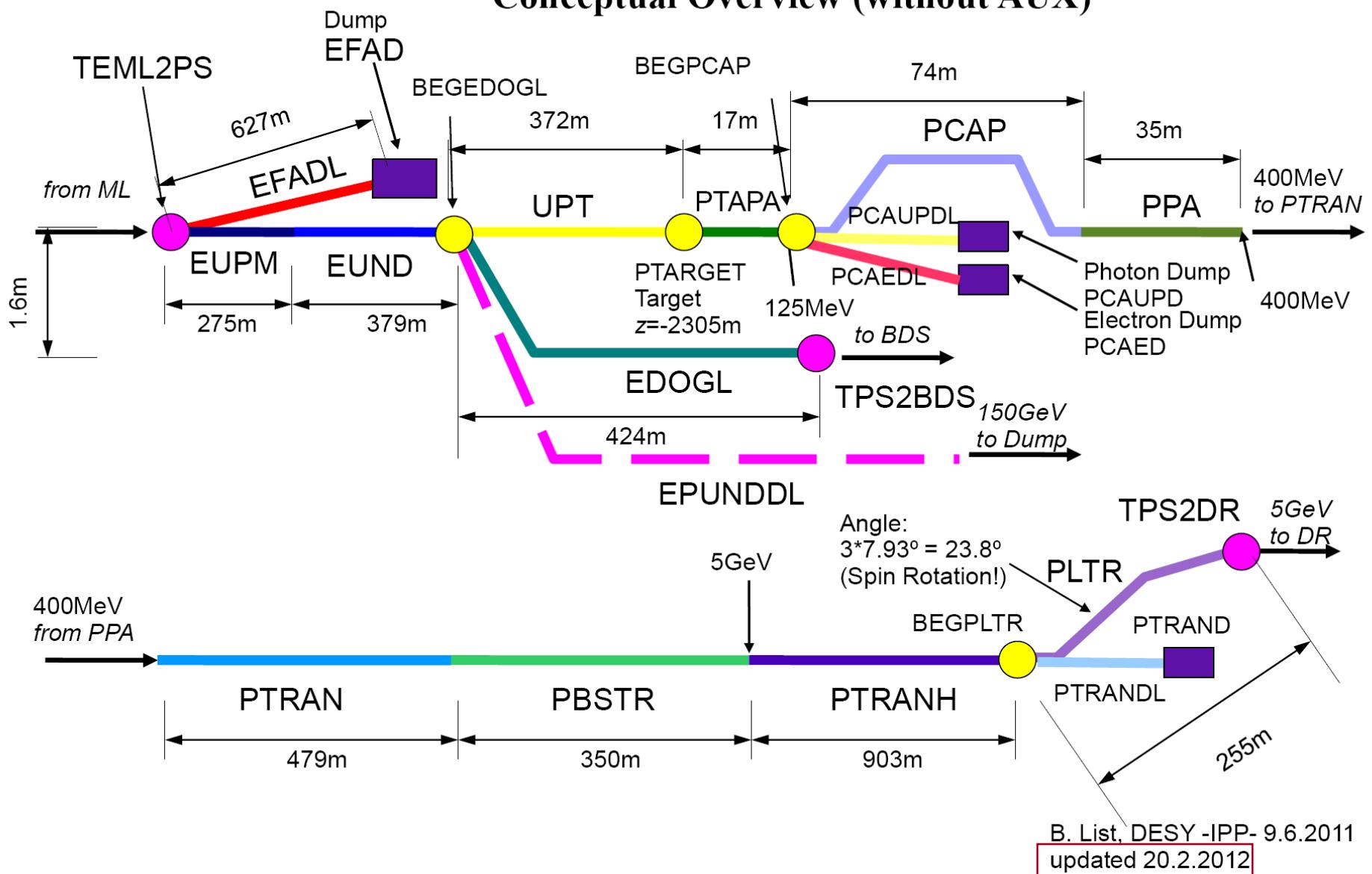
# e+ Beamlne Summary



B. List, DESY -IPP- 9.6.2011

EDMS: D\*0959325

# Positron Source Beamlines Conceptual Overview (without AUX)



# e+ Source Requirements

Parameter	Centre-of-mass energy $E_{\text{cm}}$ (GeV)					$L$ upgrade	$E_{\text{cm}}$ upgrade
	200	230	250	350	500	500	1000
Pulse repetition rate	Hz			5		5	4
Number of bunches	$n_b$			1312		2625	2450
Positron bunch population	$N_+$	$\times 10^{10}$		2		2	1,74
Positron Polarization	$P_+$	%	31	31	31	30	29
Over-production margin (yield*)				50%		50%	50%
Energy to DR		GeV		5		5	5
DR transverse acceptance $\gamma(A_x + A_y)$		m		0,07		0,07	0,07
DR relative energy acceptance	$\pm$			1,0%		1,0%	1,0%
Positron bunch separation	$\Delta t_b$	ns		554		366	366
Positron bunch separation $\times f_{\text{RF}}$	$\Delta t_b f_{\text{RF}}$			720		476	476
Positron beam pulse length	$t_b$	$\mu\text{s}$		727		961	897
Positron pulse current	$I_{\text{beam}}$	$\text{mA}$		5,8		8,8	7,6

Electron Beam Parameters	Ecm (GeV)						
	200	230	250	350	500	500 L upgrade	1000
e- linac pulse rate (Hz)	10		5	5	5	5	4
Drive beam energy (GeV)	150		175	250	250	250	500
Number of bunches per pulse	1312				2625	2450	
Electron bunch population ( $\times 10^{10}$ )	2				2	1.74	
<b>Nominal 5Hz mode</b>							
Beam energy (GeV)			178	253	253	503	
<b>10Hz alternate pulse mode</b>							
Beam energy for e+ prod.(GeV)	150						
Beam energy for lumi (GeV)	101	117	127				
Av. power e+ prod. dumped (MW)	3.1						
e- beam bunch separation (ns)	554				366	366	
e- beam pulse length ( $\mu$ s)	727				961	897	
e- pulse current (mA)	5.8				8.8	7.6	
Horizontal emittance $\gamma \varepsilon_x$ ( $\mu$ m)	??		10		10	10	
vertical emittance $\gamma \varepsilon_y$ ( $\mu$ m)	??		35		35	30	

	units	RDR	SB2009
e+ per bunch at IP		$2 \times 10^{10}$	1 to $2 \times 10^{10}$
Bunches per pulse		2525	1312
Normalized horizontal emittance @ IP	mm-mr	10	10
Normalized vertical emittance @ IP	mm-mr	0.04	0.035
Energy e- beam	GeV	150	125(150)-250
Undulator period	cm		1.15
Undulator strength			0.92
Active undulator length	m	147	Max. 231
Field on axis	T		0.86
Beam aperture	mm		5.85
Photon energy (1 <sup>st</sup> harm. cutoff)	MeV	10.06	28 (@250 GeV)
Photon beam power	kW	131	Max. 102 (at 150 GeV)
Distance undulator center to target	m		500

# Undulator Parameters

Problem of SB2009 undulator parameters: Low e+ polarization (22%) without photon collimator

- Reduced B field (smaller K value) for higher  $E_{\text{cms}}$  values keeping yield and undulator length unchanged
- Lower K value → e+ polarization is increased without adding a photon collimator:
  - Higher order harmonics are reduced
    - less higher order photons produced
    - higher polarization
- 30% polarization without photon collimator
- $E_{\text{cms}}$  below 350 ⇔ 10 Hz option to fulfill requirements

# Undulator parameters EDMS

Parameter	Ecm (GeV)							
	200	230	250	350	500	1000		
e+ production pulse rate (Hz)	5				4			
Drive beam energy (GeV)	150		175		250	500		
Number of bunches per pulse	1312				2450			
Number of e+ per bunch ( $\times 10^{10}$ )	2				1.74			
1 <sup>st</sup> harmonic energy (MeV)	10.1		16.2		42.8	27.6		
Half opening angle of $\gamma$ beam (mr)	3.4		2.9		2.0	1.02		
Active length of undulator(m)	147				132			
Undulator K value	0.92		0.75		0.45	1		
Undulator B field (T)	0.86		0.698		0.42	0.25		
Undulator period length, $\lambda_u$ (cm)	1.15				4.3			
Drive beam energy loss (GeV)	3.0		2.6		2.6	2.4		
$\gamma$ beam power (kW)	63.1		54.7		41.7 ?	65.5		

Not yet considered in detail: alignment tolerances, BPM resolution

# Undulator

Basic undulator module parameters		TeV upgr.	
Cryomodule length	4,116	??	m
Effective magnet length	3,5	??	m
Undulator period	11,5	43	mm
Max. undulator Strength (K)	0,92	1	
Max. field on axis	0,86	0,25	T
Max. required current	??	??	A
Beam aperture	5,85	??	mm
Total active undulator length	220,5	m	Check!
Lattice (Layout) parameters			
Quadrupole spacing	14,538	m	
Quadrupole strength	0,06378	$m^{-1}$	
Quadrupole length	1	m	
Phase advance per cell	45	deg	
Cell length	29,075	m	
Maximum $\beta$ function	46,93	m	
Number of quadrupoles	22		
Total lattice length	305,291	m	
Total active und. Length	220,5	m	

# e- energy spread and emittance growth

- induced energy depends on beam energy AND also on the initial energy spread
  - For higher beam energy more energy will be lost into photons  
→ higher energy spread induced.**
  - higher initial energy spread will induce less energy spread for the same beam energy.**

Gai et al, PAC09 Proceedings

Fixed undulator length scenario		GeV	200	230	250	350	500	L500	1000
Effective undulator length	$L_{und}$	m	147	147	147	147	147	147	132
Effective undulator field	$B_{und}$	T	0,86	0,86	0,86	0,698	0,42	0,42	0,249
undulator period length	? $u$	cm	1,15	1,15	1,15	1,15	1,15	1,15	4,3
Electron energy loss in undulator (e+ prod.)	$\square E_{und}$	GeV	3,0	3,0	3,0		2,6	2,6	2,4
Electron energy loss in undulator (lumi prod.)	$\square E_{und}$	GeV	1,3	1,8	2,1				2,4
Rel. energy spread induced by und.(assumed initial 0.3%)			0,087	0,100	0,112	0,118	0,089	0,089	0,068
Total energy spread (assumed 0.3% initial)			0,312	0,316	0,320	0,322	0,313	0,313	0,308
Rel. energy spread induced by und.(assumed initial 0.2%)			0,092	0,112	0,117	0,116	0,097	0,097	0,066
Total energy spread (assumed 0.2% initial)			0,220	0,229	0,232	0,231	0,222	0,222	0,211
Rel. energy spread induced by und.(assumed initial 0.1%)			0,098	0,111	0,120	0,120	0,102	0,102	0,070
Total energy spread (assumed 0.1% initial)			0,140	0,149	0,156	0,156	0,143	0,143	0,122
Rel. energy spread induced by und.(assumed initial 0%)	$\square(\square E/E\%)$		0,098	0,113	0,123	0,122	0,103	0,103	0,071
Emittance growth	$\square H$	nm	-0,4	-0,6	-0,7	-0,55	-0,4	-0,4	-0,19
Tolerance on beam jitter	$\square_y$					0,1	0,1		??
10Hz e+ prod beam trajectory tolerance			??	??	??				

# Target parameters

Basic target parameters	
Target material	Ti-6%Al-4%V
Target mat. radiation length	35 mm
Target thickness	14 mm
Target thickness / X0	0,4
Target wheel diameter	1 m
Target wheel rotation speed	100 m/s
Target angular rotation	2000 RPM
Photon drift distance	400 m

Estimated target lifetime: 1 year (see also B.D.Wirth, Calculation of Radiation Damage in ILC Targets, UCB-NE-5114, Nov 2007)

# Target parameters

		Centre-of-mass energy $E_{\text{cm}}$ (GeV)					$L$ upgrade		$E_{\text{cm}}$ upgrade
Parameter		200	230	250	350	500	500		1000
Positron pulse production rate	Hz	5	5	5	5	5	5		4
Electron beam energy (e+ prod.)	GeV	150	150	150	178	253	253		503
Number of electron bunches	$n_b$	1312	1312	1312	1312	1312	2625		2450
Electron bunch population	$N_+$ $\times 10^{10}$	2	2	2	2	2	2		1,74
Photon energy (first harmonic)	MeV	10,1	10,1	10,1	16,2	42,8	42,8		27,6
Photon opening angle ( $=1/g$ )	mr	3,4	3,4	3,4	2,9	2,0	2,0		1,02
Concentrator capture device									
<i>Fixed undulator length scenario</i>									
Undulator length	$L_{\text{und}}$ m	147	147	147	147	147	147		132
Required undulator field	$B$ T	0,86	0,86	0,86	0,698	0,42	0,42		0,25
undulator period length	/ $u$ cm	1,15	1,15	1,15	1,15	1,15	1,15		4,3
undulator $K$	$K$				0,75	0,45	0,45		1,0
Average photon power on target	kW	91	100	107	107	79	79		65,46
Incident photon energy per bunch	J	9,6	9,6	9,6	8,1	6,0	6,0		6,67
Energy deposition per bunch (e+ prod.)	J	0,72	0,72	0,72	0,59	0,31	0,31		0,29
Relative energy deposition	%	7%	7%	7%	7,20%	5%	5%		4,40%
Photon rms spot size on target	mm	1,4	1,4	1,4	1,2	0,8	0,8		0,7
Peak energy density in target	J/cm <sup>3</sup>	232,5	232,5	232,5	295,3	304,3	456,4		475
	J/g	51,7	51,7	51,7	65,6	67,5	101,3		105,4

# Target stress

- Energy deposition below fatigue stress limit (=340MPa)

		Pyr. C	Ti	Fe (ST70)	W(annealed)	W(hardened)
<i>Fatigue Temperature : (Ansys) T</i>	deg C	900	600	80	180	274
<i>Fatigue Energy : (Ansys) E<sub>fatigue</sub></i>	J/g	753,3	314	35,92	23,04	35,072
<i>Fatigue Yield Strength : (Ansys) P<sub>fatigue</sub></i>	M Pa	40	340	150	320	480

- Andriy's studies (see also his talk at BTR Oct. 2011)
  - For 350Gev and 500GeV below fatigue limit (~120 – 160MPa)
  - Lumi upgrade for 500 GeV → closer to this faigue stress limit
  - Polarization upgrade ...
  - Not included: eddy currents, mechanical load ⇔ additional stress
- Pressure wave studies in target and collimator material are ongoing (DESY, Uni HH)
- **Rotating vacuum seals test → Jeff's talk**

# Equivalent Stress

D: Explicit Dynamics 2

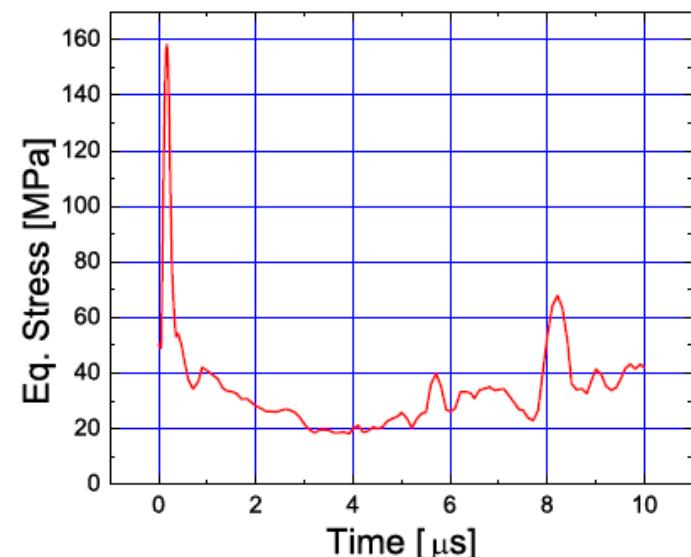
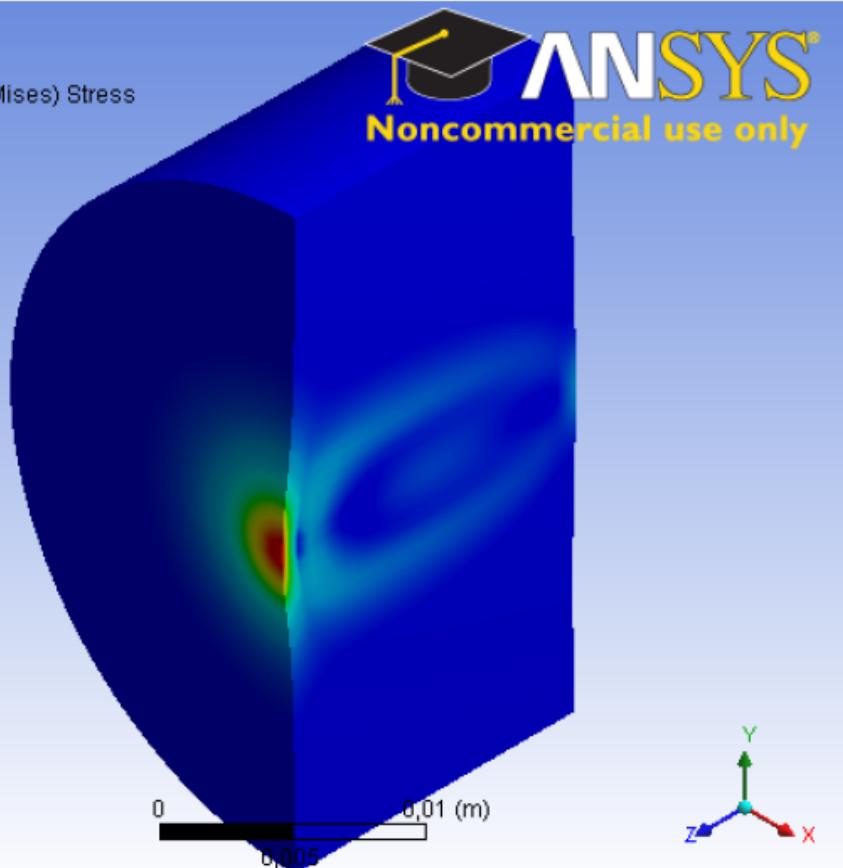
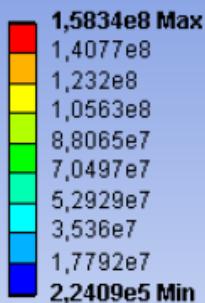
Equivalent Stress

Type: Equivalent (von-Mises) Stress

Unit: Pa

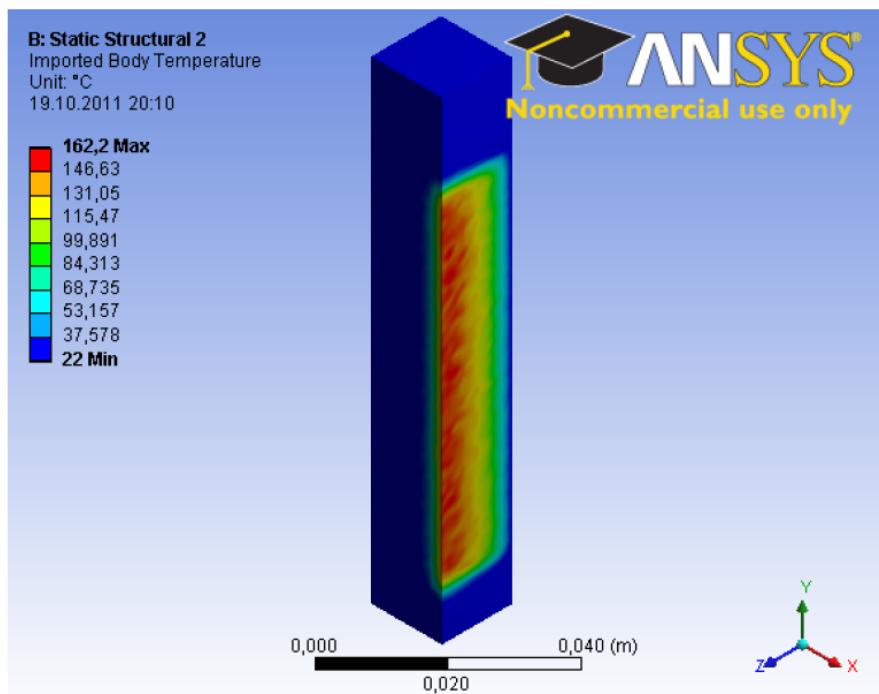
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20.10.2011 20:08

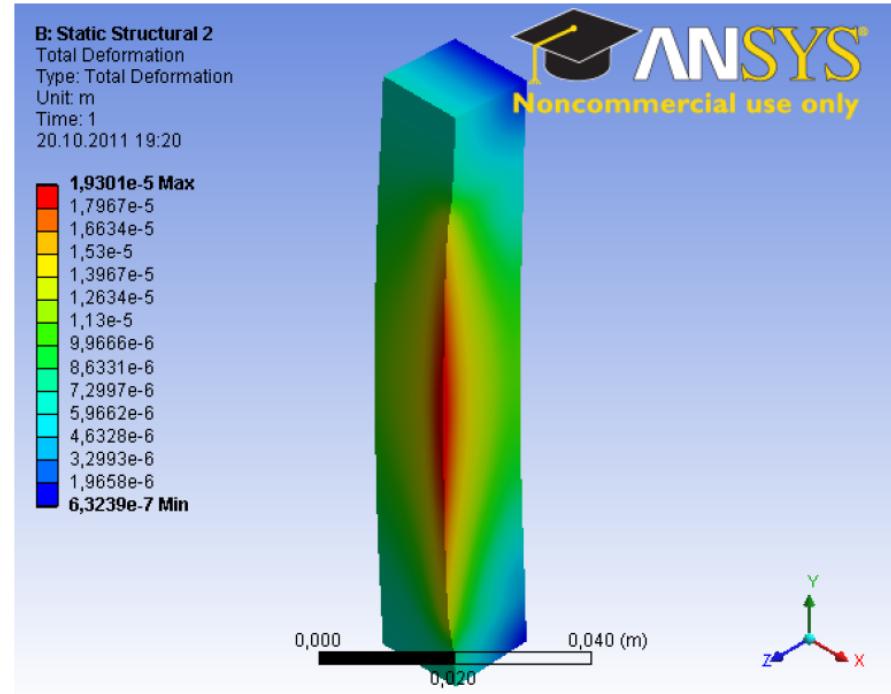


# (Static) Temperature and Deformation in Rotated Target

Temperature Distribution in Target



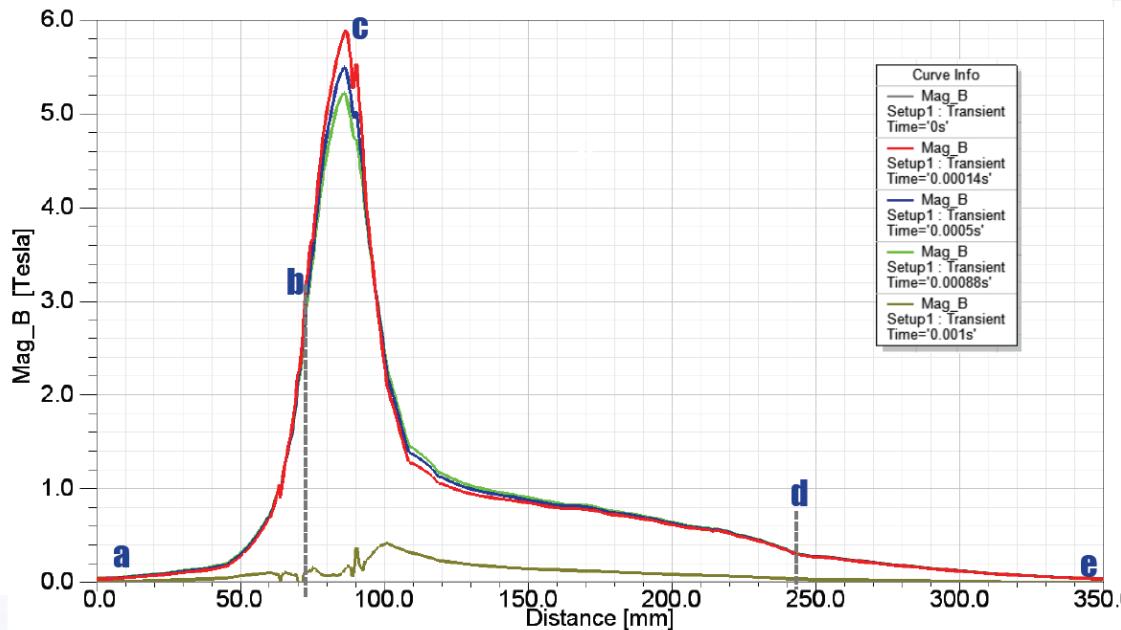
Total Deformation



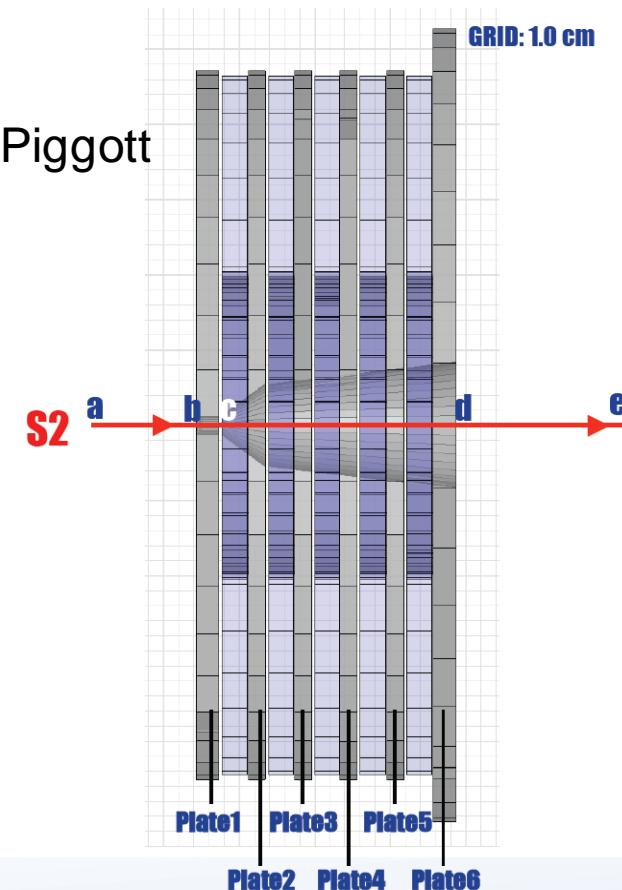
# Pulsed Flux Concentrator

- Capture efficiency:
  - QWT:  $Y \approx 15\%$
  - FC:  $Y \approx 25\%$
- Pulsing the exterior coil enhances the magnetic field in the center.
  - Needs  $\sim 1\text{ms}$  pulse width flattop
  - FC development at LLNL → see Jeff's talk

**|B| along S2 for the case of with Shaping Plates at various times**

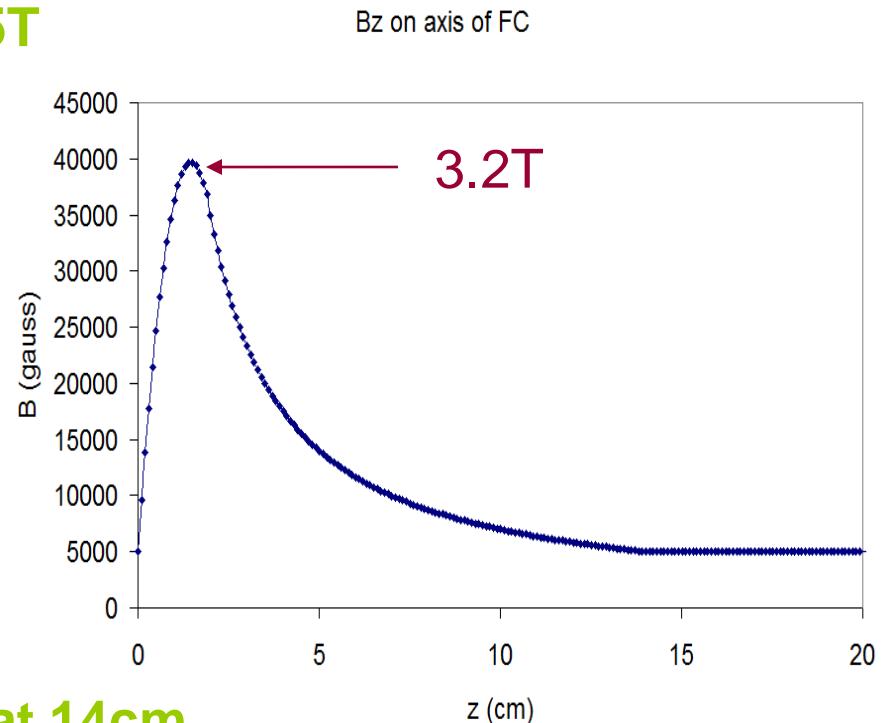


J. Gronberg, T. Piggott

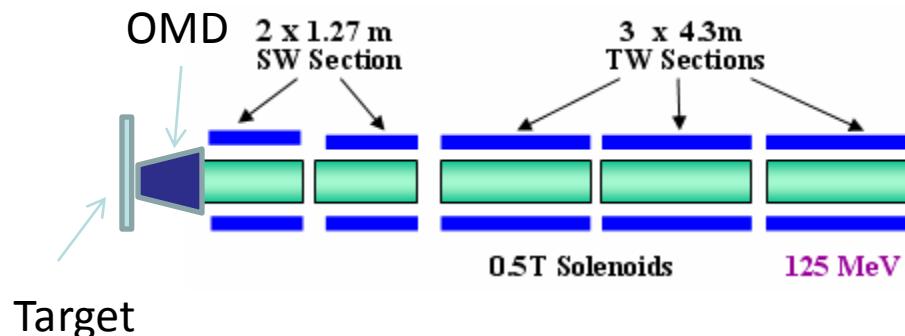


- Length (target to SW RF): 14cm
- Field:

- Field starts target surface: 0.5T
- Ramps up to peak field: 3.2T
- Adiabatic decrease from 3T to 0.5T at z=14cm



- Accelerating structure starts at 14cm
  - RF parameters used in simulation:
    - aperture diameter: 5cm
    - gradient: 12.5MV/m
    - background B field: 0.5T



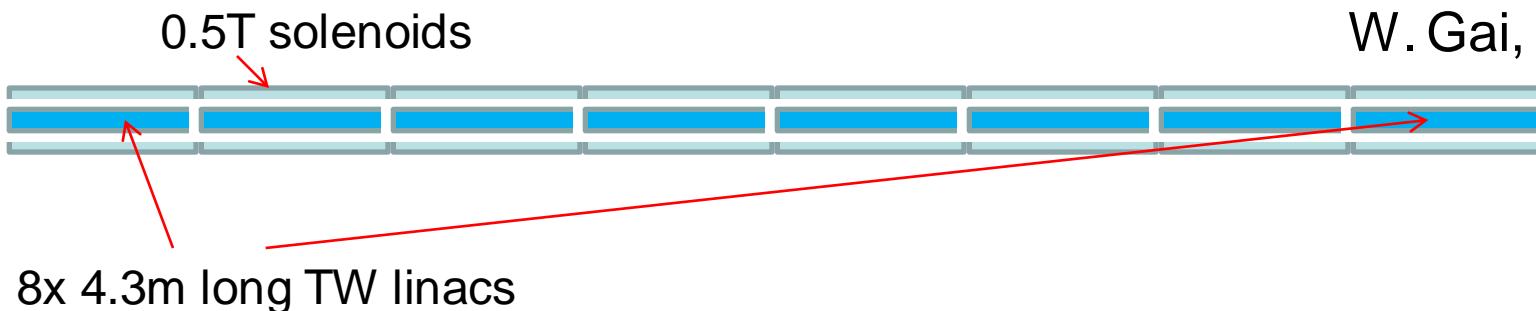
- OMD:
  - Flux concentrator: Physical length ~14cm, With ~0.5T on target surface, and decay adiabatically from 3.5T at 2cm from target down into the 0.5T background solenoid field at 14cm.
  - QWT: Physical length ~20cm, peak field ~1T.
- Standing wave linac: 11 cells,  $\pi$  mode, 15MV/m, length 1.27m each, total numbers: 2
- Traveling wave linac: 50 cells,  $3\pi/4$  mode, 8MV/m, 4.3m long each, total numbers: 3

## RF Parameters(Parameters of the linacs been designed and fabricated at SLAC)

<b>SW structures:</b>	Structure Type	Simple $\pi$ Mode		
	<b>C e l l N u m b e r</b>	1 1		
	<b>A p e r t u r e 2 a</b>	6 0 m m		
	<b>Q</b>	2 9 7 0 0		
	<b>S h u n t i m p e d a n c e r</b>	3 4 . 3 M $\Omega$ /m		
	<b>E 0 (8.6 M W input)</b>	1 5 . 2 M V/m		
	<b>S t r u c t u r e L e n g t h</b>	1 . 2 7 m		
<b>N u m b e r o f S W l i n a c s :</b>	2			
<b>Travelling wave structures:</b>	Structure Type	TW $3\pi/4$ Mode		
	<b>C e l l N u m b e r</b>	5 0		
	<b>A p e r t u r e 2 a</b>	4 6 m m		
	<b>A t t e n u a t i o n <math>\tau</math></b>	0 , 9 8		
	<b>Q</b>	2 4 8 4 2 - 2 1 6 7 6		
	<b>G r o u p v e l o c i t y V g/c</b>	0 . 6 2 % - 0 . 1 4 %		
	<b>S h u n t i m p e d a n c e r</b>	4 8 . 6 0 - 3 9 . 4 5 M $\Omega$ /m		
	<b>F i l l i n g t i m e T f</b>	5 . 3 $\mu$ s		
	<b>P o w e r D i s s i p a t i o n</b>	8 . 2 k W /m		
	<b>E 0 (8.6 M W input)</b>	8 . 0 M V/m		
	<b>S t r u c t u r e L e n g t h</b>	4 . 3 m		
<b>N u m b e r o f T W s t r u c t u r e s :</b>	3			

# 400MeV preaccelerator (PPA)

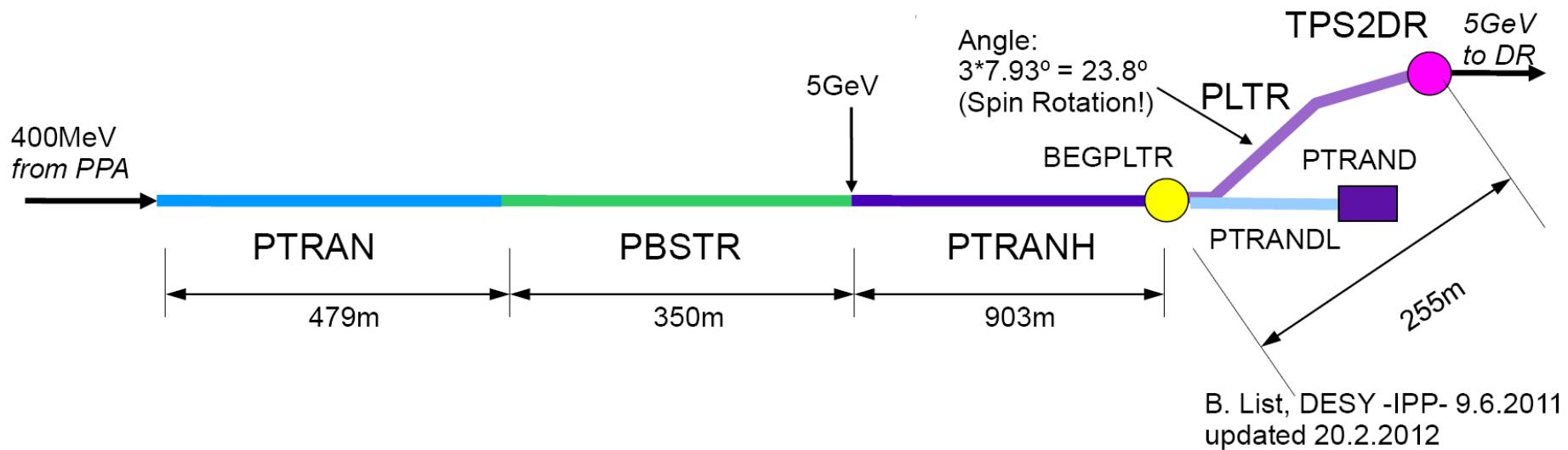
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Parameter	Symbol	Unit	Value
Initial energy		MeV	125
Initial emittance	$e_x$	$\mu\text{m}$	32,3
Initial emittance	$e_y$	$\mu\text{m}$	26,6
Initial normalized emittance	$e_{nx}$	mm	7,9
Initial normalized emittance	$e_{ny}$	mm	6,5
Initial energy spread		%	5,3
Final energy		MeV	400
Final emittance	$e_x$	$\mu\text{m}$	8,2
Final emittance	$e_y$	$\mu\text{m}$	8,9
Final normalized emittance	$e_{nx}$	mm	6,4
Final normalized emittance	$e_{ny}$	mm	7,0
Final energy spread		%	2,97

numbers are results  
without any positron  
collimation to cleanup  
the e+ beam

# Transport lines



Matching section

## PTRAN



FODO lattice with earth bend every 16.8m to match to the earth curvature

**PTRANH:** Simple FODO lattice to transport the beam to PLTR

# 5 GeV Booster (PBSTR)

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Matching  
section

Matching to PTRANH

PBSTR1:  
400MEV TO  
1082.5649MEV

PBSTR2:  
1082.5649MEV TO  
2507.0321 MeV

PBSTR3:  
2507.0321 MeV  
to 5GeV

		Baseline	L upgr.
Initial energy	GeV	0,4	0,4
Initial emittance	nm	9936,1	
Initial normalized emittance	μm	7778	
Initial energy spread	%	2,97	
Initial bunch length	mm	<20	
Final energy	GeV	5,00	5,00
Final emittance	nm	794,9	
Final normalized emittance	μm	7778	
Final energy spread	%	4,40	
Final bunch length	mm	20	
Beam Current (nom)	mA	5,8	8,8
Beam Current (with overhead)	mA	8,7	13,1

# 5 GeV Booster (PBSTR)

Matching  
section

Matching to PTRANH

W. Gai, W. Liu



PBSTR1:  
400MEV TO  
1082.5649MEV

PBSTR2:  
1082.5649MEV TO  
2507.0321 MeV

PBSTR3:  
2507.0321 MeV  
to 5GeV

		Baseline	L upgrade		
Initial energy	GeV	0,4	0,4		
Initial emittance	nm	9936,1			
Initial normalized emittance	μm	7778		from prim. Reqs. (DR acceptance / 9)	
Initial energy spread	%	2,97			This number depends on the collimation in PCAP. It can be higher
Initial bunch length	mm	<20		find out!	The actual number depends on the collimation in PCAP. But it needs to be smaller than the final bunch length 20mm hard edge.
Final energy	GeV	5,00	5,00	from RDR lattice	
Final emittance	nm	794,9			
Final normalized emittance	μm	7778		from prim. requirements	
Final energy spread	%	4,40		fulfills DR acceptance requirements	This is the number that can be compressed down to damping ring acceptance with the current PLTR energy compressor
Final bunch length	mm	20		find out! Does this fulfill DR acceptance requirements?	This is a hard edge bunch length. It depends on the PBSTR RF phase setting. With a wrong RF phase setting, the same bunch length will not be acceptable to the damping ring
Beam Current (nom)	mA	5,8	8,8	from prim. requirements	
Beam Current (with overhead)	mA	8,7	13,1	from prim. requirements	

# 5 GeV Booster (PBSTR)

Matching  
section

Matching to PTRANH

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PBSTR1:  
400MEV TO  
1082.5649MEV

PBSTR2:  
1082.5649MEV TO  
2507.0321 MeV

PBSTR3:  
2507.0321 MeV  
to 5GeV

Section 1:							
Energy after section 1	GeV	1,08	1,08	RDR lattice: 1.083GeV			
Cryomodules C4Q4			6				
Number of cavities			24	RDR lattice has 23 units with 1 cav+1Q in section 1			
RF phase	deg	0	0	check!			
RF voltage per cavity	MV	28,46	28,46				
Beam loading	MV/m	0,00	0,00				
Gradient	MV/m	27,4	27,4	RDR lattice has 22.5 MV/m			
Power to beam	MW	5,9	9,0				
Klystrons		1	1				
Power per klystron	MW	5,9	9,0				
Cavities per klystron		24	24				

The RF phase number might need to have ~15 degree off the crest to produce the longitudinal phase space distribution suitable for PLTR phase space manipulation and energy compression

# 5 GeV Booster (PBSTR)

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Matching  
section

Matching to PTRANH



PBSTR1:  
400MEV TO  
1082.5649MEV

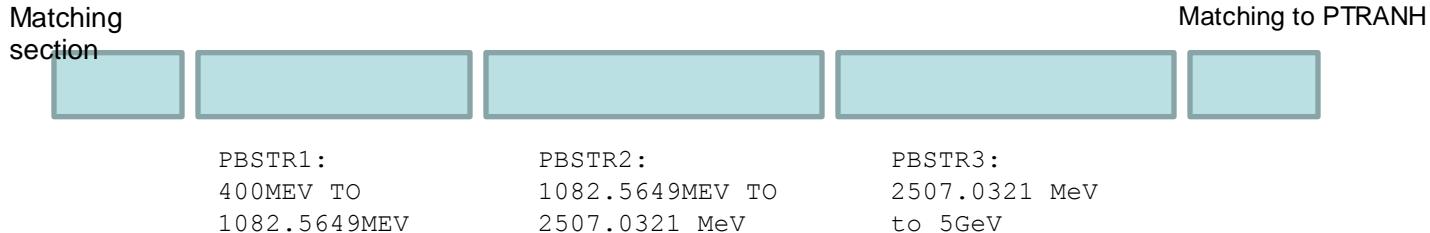
PBSTR2:  
1082.5649MEV TO  
2507.0321 MeV

PBSTR3:  
2507.0321 MeV  
to 5GeV

Section 2:				
Energy after section 1	GeV	2,63	2,63	RDR lattice has 2.507GeV
Cryomodules C8Q2		8		RDR lattice has 13 units with 4 cavities + 1 Q
Cavities		64		RDR lattice has 13x4=52 cavities
RF phase	deg	0	0	check!
RF voltage per cavity	MV	24,09	24,09	
Beam loading	MV/m	0,00	0,00	
Gradient	MV/m	23,2	23,2	
Power to beam	MV	13,4	20,2	
Klystrons		2	4	
Power per klystron	MW	6,7	5,1	
Cavities per klystron		32	16	

# 5 GeV Booster (PBSTR)

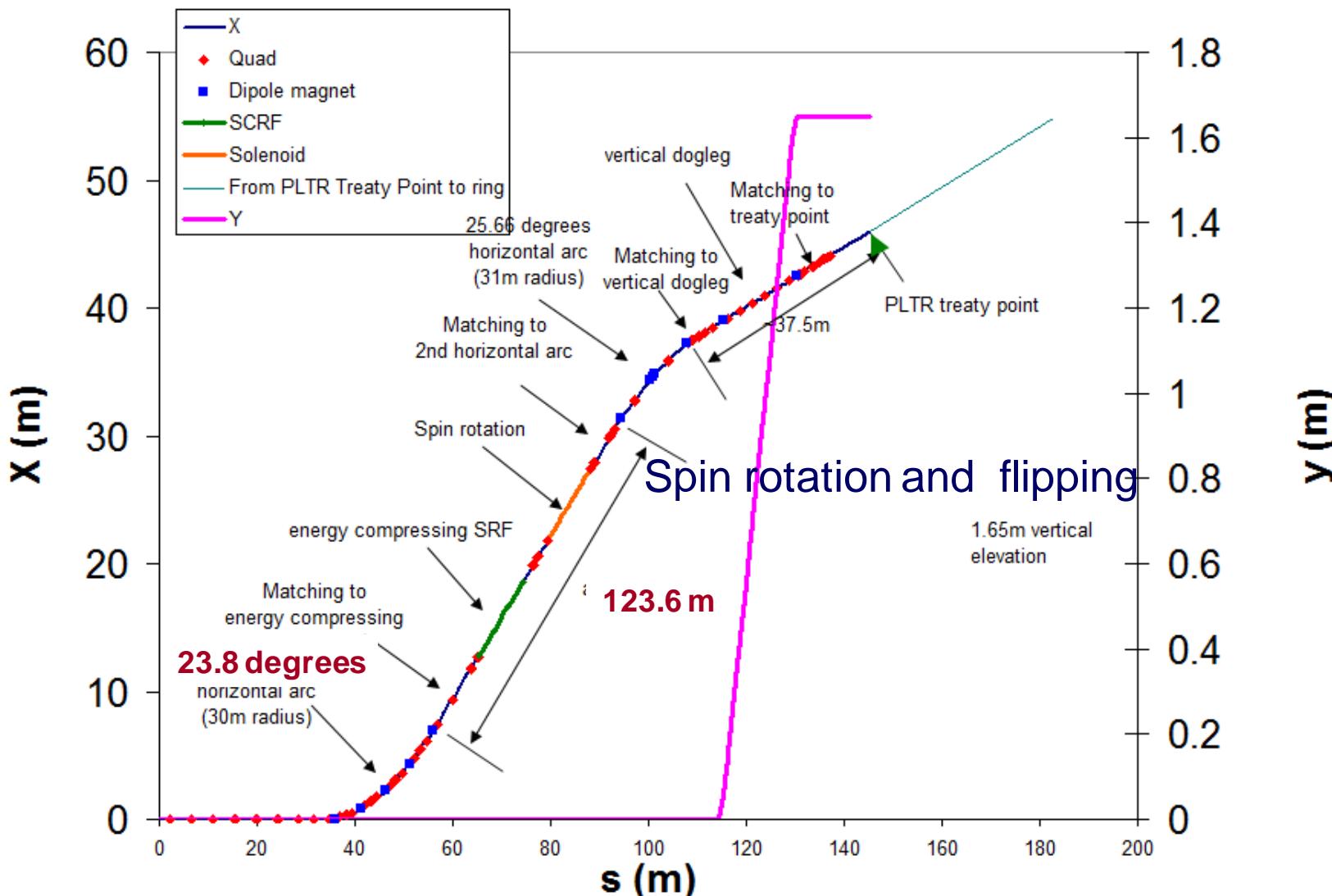
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Section 3:			
Energy after section 3	GeV	5,00	5,00
Cryomodules C8Q1		12	RDR lattice has 9 (with Q at end!)
Cavities		96	RDR has 72
RF phase	deg	0	0 <b>check!</b>
RF voltage per cavity	MV	24,74	24,74
Beam loading	MV/m	0,00	0,00
Gradient	MV/m	23,8	23,8
Power to beam	MV	20,6	31,2
Klystrons		3	4
Power per klystron	MW	6,9	7,8
Cavities per klystron		32	24
Total			
Number of cryomodules		26	

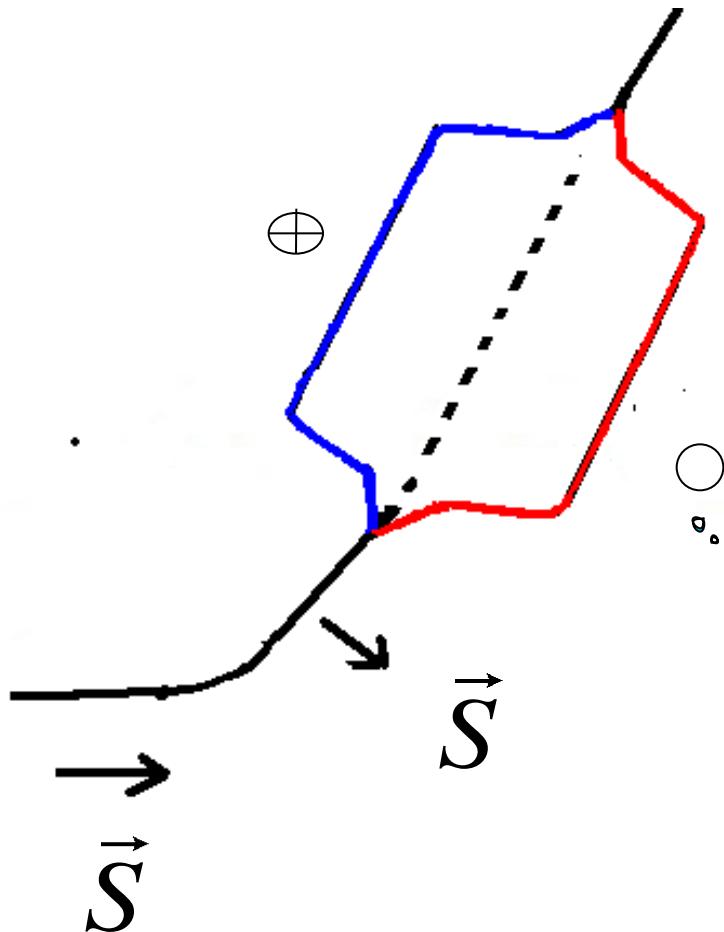
- Extract positrons from PBSTR and PTRANH
- Rotate spin to the vertical (+flipping)
- to match the longitudinal beam size to the DR acceptance  $\Leftrightarrow$  Energy compression
- Inject to DR (treaty point)
- Spin flipper:
  - Flipping the helicity as fast as for electrons
    - Flipper consisting of 2 parallel lines with solenoids to rotate the spin to  $\uparrow$  and  $\downarrow$
    - A kicker magnet will switch the beam to either solenoid
    - see Larisa's talk for details direction
- Solenoid Parameters:
  - So far, we used  $B=3.16\text{ T}$ ;  $L=8.3\text{ m}$
  - Now:  $B=5.24\text{ T} \rightarrow L = 2 \times 2.5\text{ m}$ 
    - Spin rotation design has to be redone

## PLTR floor map (Oct. 2011)



# Modification of bend and straight section

L. Malysheva

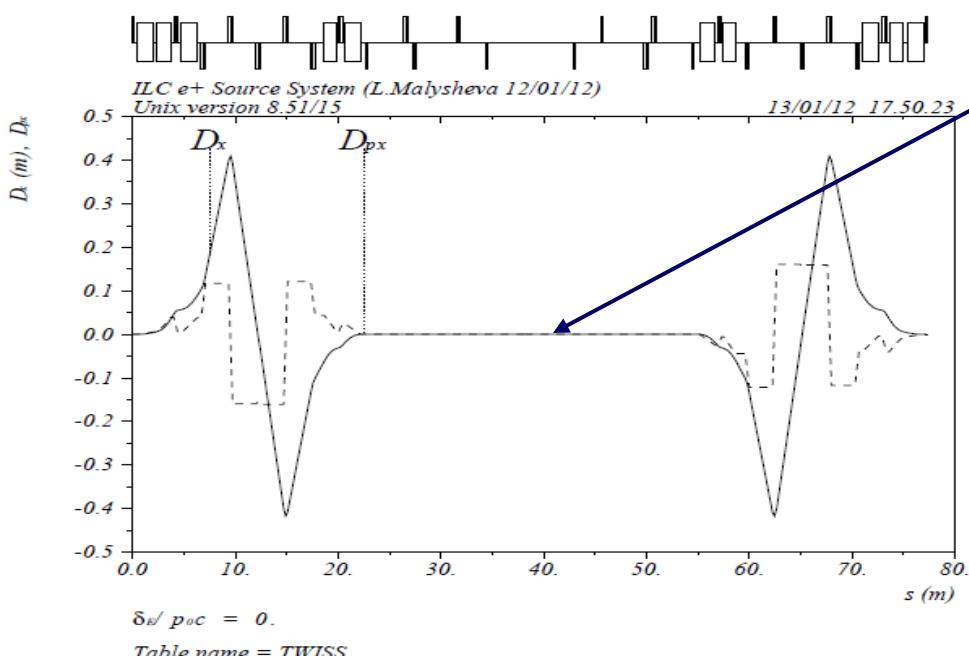
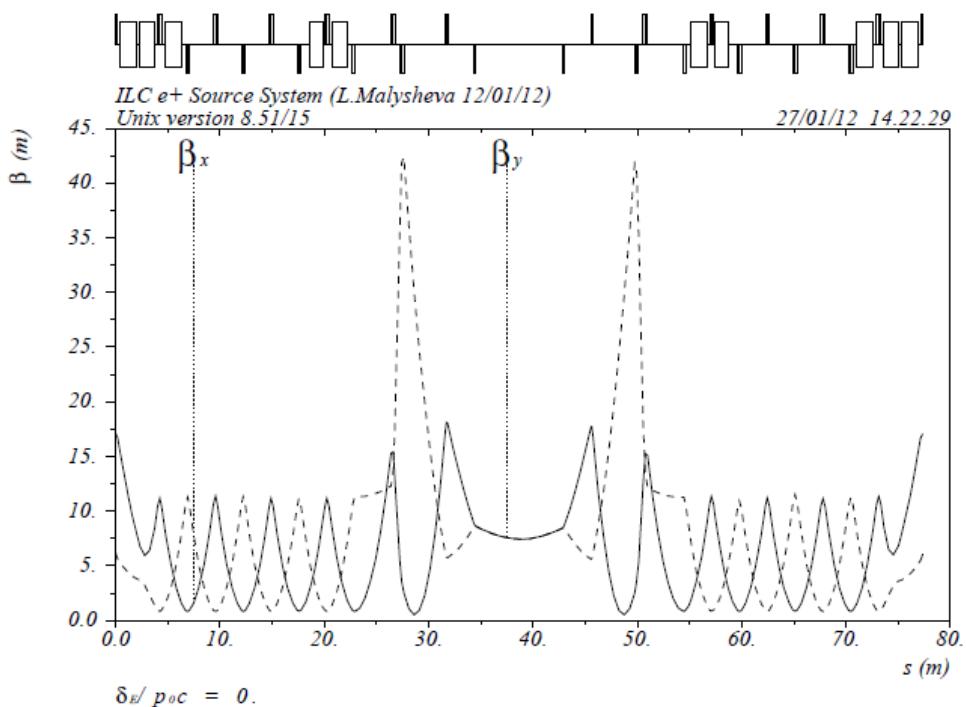


- New arc ( $23.795^0$  orbital  
 $=3*90^0$  spin )
- Length of section for rotation and flipping is now increased to 123.595m
- 2 parallel lines with opposite polarities (2m separation)  
→ opposite solenoid fields
- merger line to recombine

# Lattice version

L. Malysheva

$\beta$  function and dispersion  
of rotation and flipping system  
(March 2011)



NO Dispersion

More details and future plan  
in Larisa's talk

## Arc Parameters

# PLTR Parameters

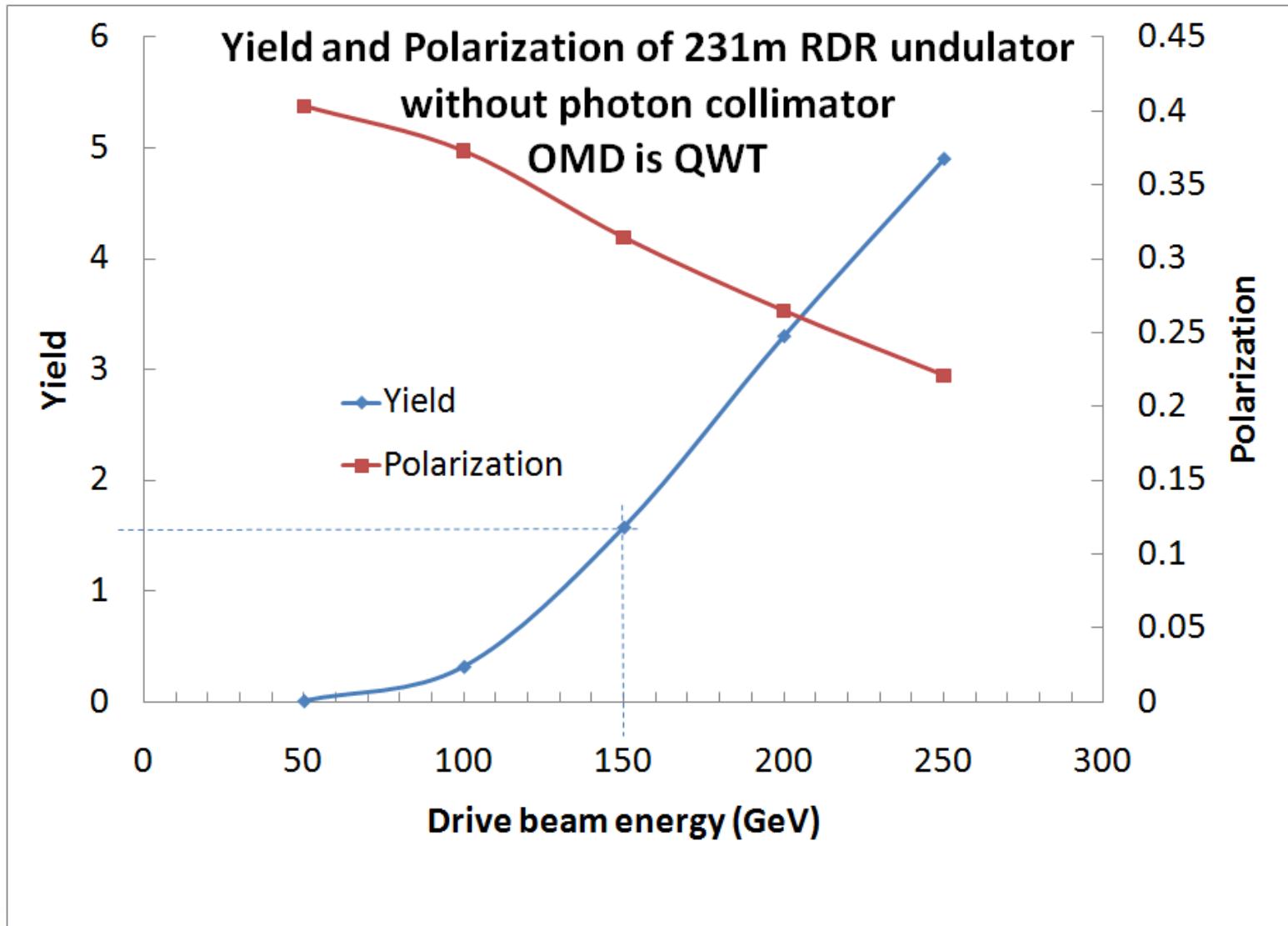
W. Gai, W. Liu

Parameter	Symbol	Unit	Value
Initial energy		GeV	5
Spin Rotation Angle in Arc		degrees	270,0
Arc Bending Angle		degrees	23,80
R56 of Arc	$R_{56}$	m	-0,65
			was 86cm in RDR (SLAC-PUB-12239)
			This R56 is the net of both R56 a chicane at the end of PTRANH and the 1st arc in PLTR.

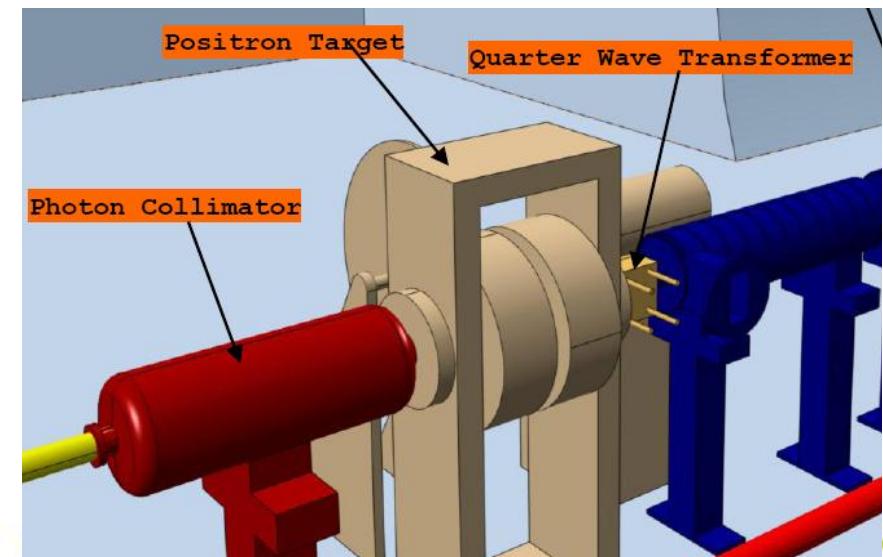
## Energy Compressor Parameters

Parameter	Symbol	Unit	Value	
Initial energy		GeV	5	
Initial emittance		$\mu\text{m}$	794,9	
Initial normalized emittance		mm	7,8	
				This is the hard edge energy spread that can be compressed down to damping ring acceptance with the current compressor setting
Initial energy spread		%	4,40	???
Initial bunch length		mm	20	???
RF Voltage		MV	225	C9Q0 cryomodule with 25MV in each cavity
Final energy		GeV	5	
Final emittance x	$ex$	$\mu\text{m}$	1,45	
Final normalized emittance x	$enx$	mm	16,8	
Final emittance y	$ey$	$\mu\text{m}$	1,45	
Final normalized emittance y	$eny$	mm	14,2	
Final energy spread (RMS)		%	0,59	???
Final bunch length		mm	19,0	???

# Positron Polarization



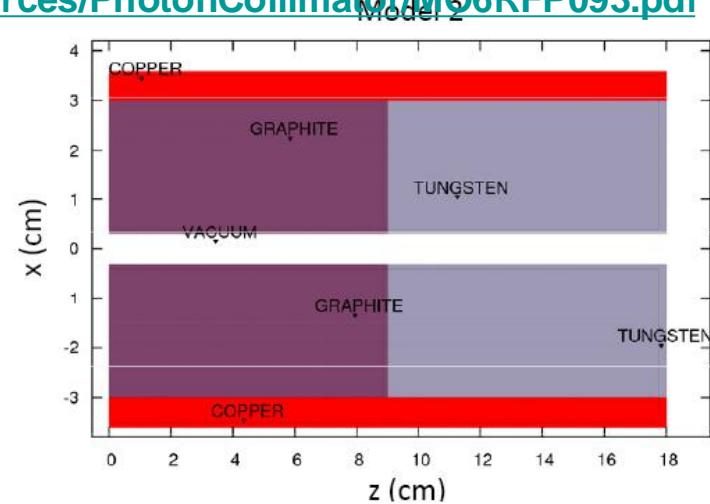
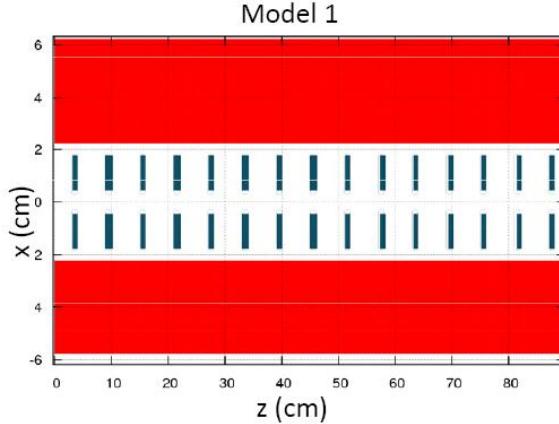
- Most sensitive parameter: Transverse photon distribution:
  - Photon Collimation would eliminate unwanted off axis photons that have low polarization.
  - drive beam energy and undulator K value also influence the collimator parameters (collimator iris, energy deposition and PEDD in collimator and target)
  - EDMS:  
**Collimator list is not yet filled and released**



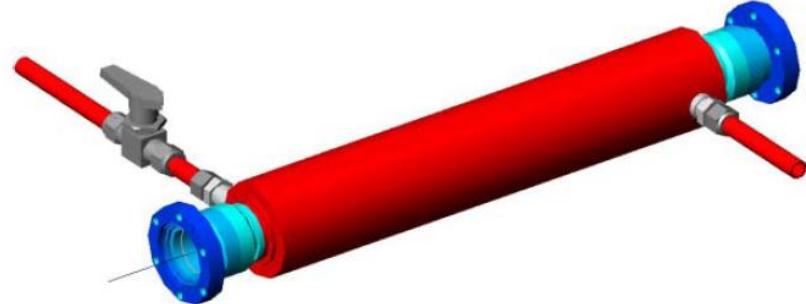
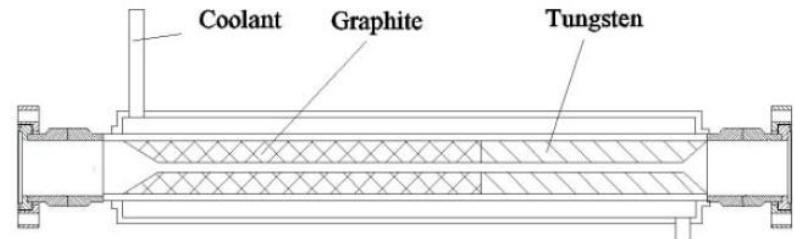
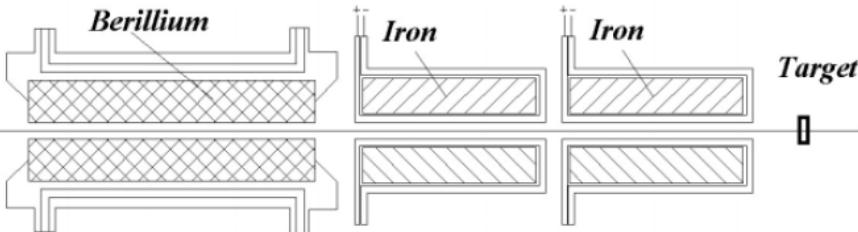
# Collimator Designs

- Bailey, Wolski, Zang:

<http://www.ippp.dur.ac.uk/export/sites/IPPP/LCsources/PhotonCollimator/MO6RFP093.pdf>



- Mikhailichenko: <http://accelconf.web.cern.ch/accelconf/e06/PAPERS/MOPLS105.PDF>



# Photon Collimator

- Recommendation from ILC positron source meeting in Durham (2009) was to include a tungsten/graphite collimator of radius 2mm.
- Since undulator is now at end of the linac, the iris must be smaller than for the 150GeV drive-beam-option to achieve higher polarization  
→Heat load and PEDD increase
- Using only graphite and tungsten would increase the length substantially, fatigue stress for W above limit
- Idea: multistage collimator (see Staufenbiel et al, arXiv/1202.5987)

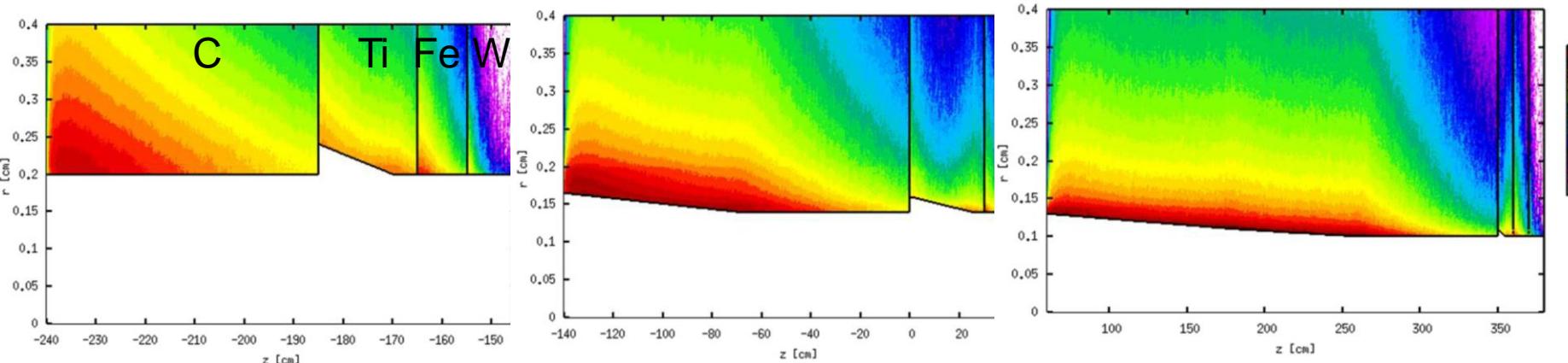


See also Friedrich's talk

Iris: 2mm

1.4mm

1mm



arXiv/1202.5987

- Depending on drive beam energy, for  $K=0.92$ 
  - $P = 55\%$  ( $r = 2\text{mm}$ ) for  $E_{\text{drive}} = 150\text{GeV}$
  - $P = 59\%$  ( $r = 2\text{mm} + 1.4\text{mm}$ ) for  $E_{\text{drive}} = 175\text{GeV}$
  - $P = 50\%$  ( $r = 2\text{mm} + 1.4\text{mm} + 1\text{mm}$ ) for  $E_{\text{drive}} = 250\text{GeV}$
- polarization can be achieved.
- Optimization of  $P$ :  $Y$ ,  $K$ , undulator length, stress
- PEDD and heat load on material safely below fatigue stress
- for high  $P$  up to  $\sim 55\%$  of  $\gamma$  beam power dumped into collimator
- Heat dissipation into collimator material  $\Leftrightarrow$  cooling

	Centre-of-mass energy (GeV)			
Parameter	≤250	350	500	1000
$\lambda_u$ (cm)	1.15			4.3
K	0.92		1	2
Polarization(%)	55	59	50	42
R=2mm (C) E <sub>max</sub> (J/g)	154	139	38	
(Ti)	41	37	10	
(Fe)	23	24	8	
(W)	4	4	2	
R=1.8mm (C) E <sub>max</sub> (J/g)				113
(Ti)				22
(Fe)				118
(W)				3
R=1.4mm (C) E <sub>max</sub> (J/g)		129	54	
(Ti)		16	10	
(Fe)		12	8	
(W)		2	1	
R=1.2mm (C) E <sub>max</sub> (J/g)				193
(Ti)				33
(Fe)				26
(W)				4
R=1.0 (0.8)mm -0.5 (1)TeV (C) E <sub>max</sub>			60	297
(Ti)			10	40
(Fe)			8	32
(W)			2	4

# Collimator Cooling

- Heat dissipation in collimator

- In equilibrium:

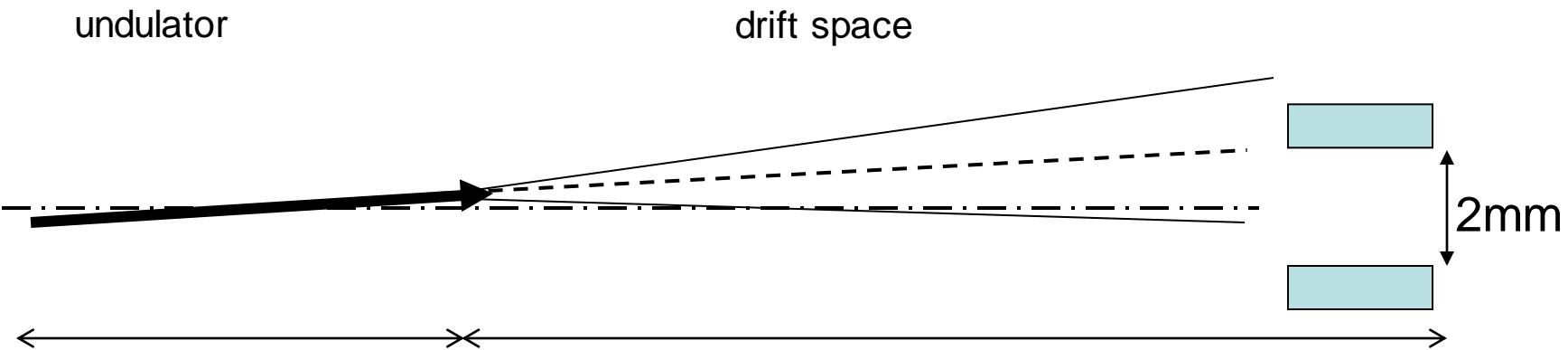
$$\frac{dQ}{dt} = \frac{2\pi z \cdot \lambda \cdot \Delta T}{\ln(r/r_0)}$$

- $r_0$  is inner radius of cylinder
    - $z$  is length of cylinder

- with heat transition coefficient  $1\text{ kW}/(\text{m}^2\text{K})$  outer surface temperature is kept at  $\sim 40^\circ\text{C}$ (?)
    - more details in Staufenbiel et al, arXiv/1202.5987 (POSIPOL11 proceedings)

# Alignment tolerances & polarization

- So far, considerations for ideal case, but have to take into account misalignments, jitter, etc.
- RDR alignment tolerances:
  - ~10  $\mu\text{m}$  in BDS
  - ~100  $\mu\text{m}$  in ML
- Misalignment tolerances in undulator ?
  - Not yet studied in detail
- Angular misalignment between undulator and collimator:

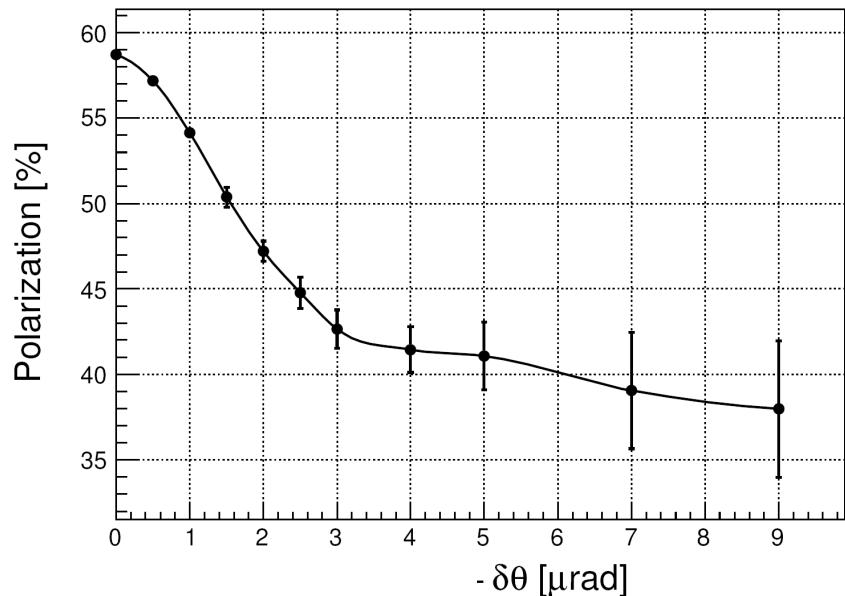
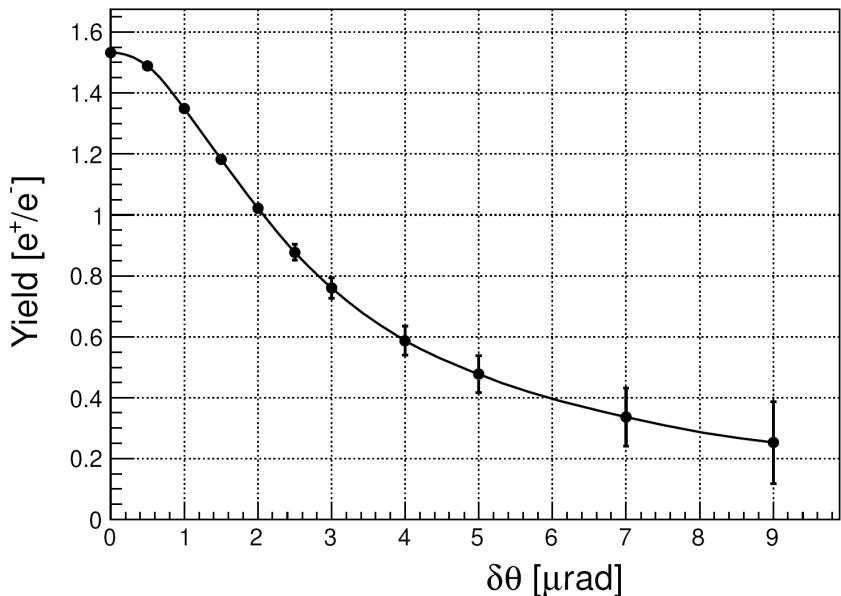


Angular misalignment could change average of e+ polarization.  
Is this effect negligible?

# Misalignment of Undulator Modules: Impact on Yield and Polarization

Baseline undulator at **250 GeV** with collimator (aperture radius = **0.7 mm**)

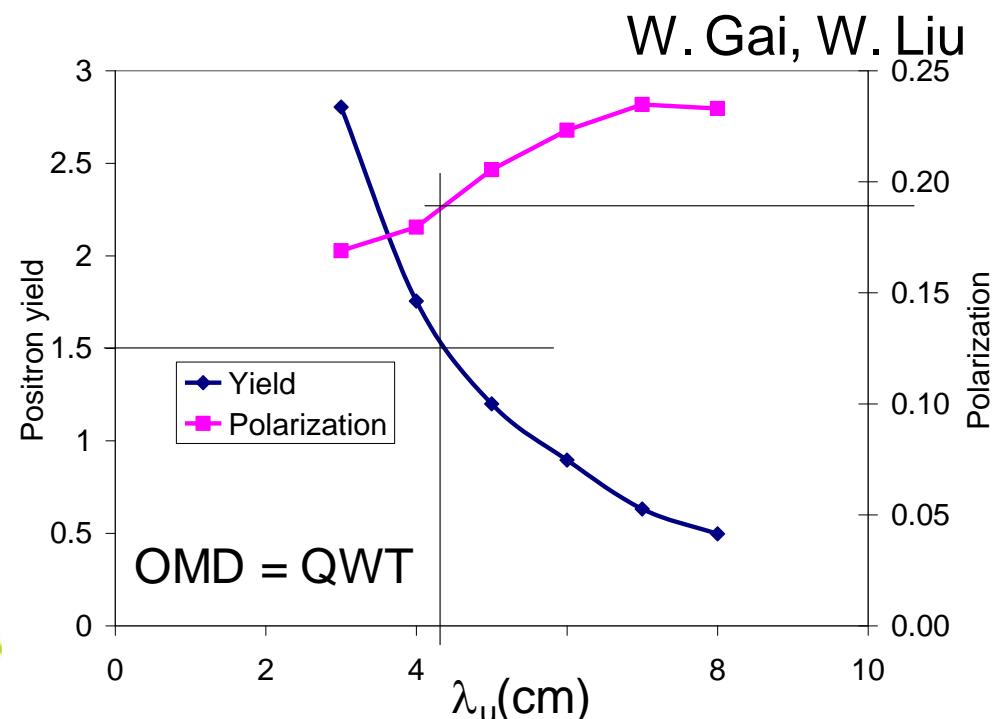
- undulator modules have been randomly shifted
- every module has additionally to the position offset also random angle (positions and angles are “not correlated”/independent)



- Misalignment of undulator effects  $Y$  and  $P$  significantly!
- How big realistic undulator misalignments could be?**
- Should misalignments be included in EDMS source parameters table?

# TeV upgrade scenarios

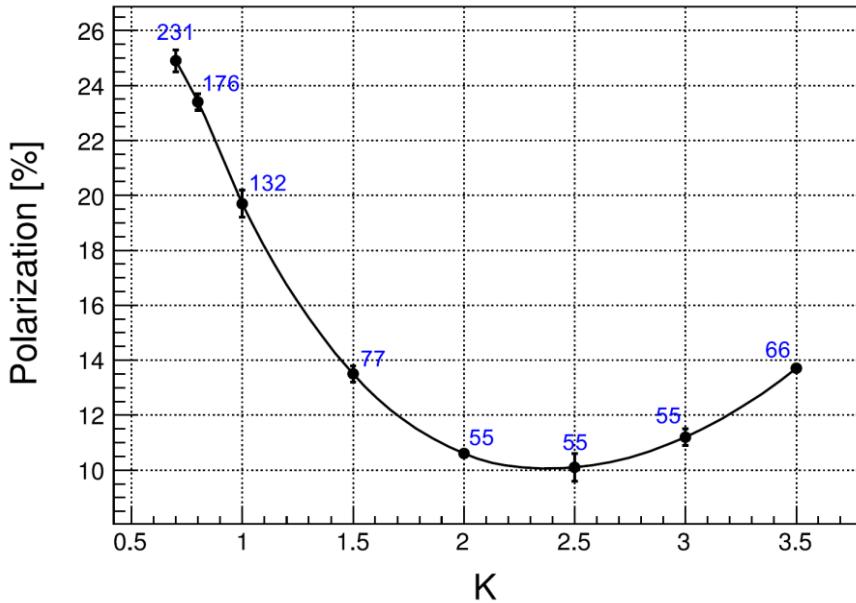
- Goal
  - A reasonable scheme for the 1 TeV option without major impact on the ILC configuration.
- Assumptions
  - Drive beam energy: 500 GeV
  - Target: 0.4 X0 Ti
  - Drift from end of undulator to target: 400m
  - OMD: FC
- Approach (Wei and Wanmin)
  - Longer undulator period,  $\lambda_u = 4.3\text{cm}$
  - $K = 1$  ( $B = 0.25\text{T}$ )
  - $P = 20\%$  ☹
  - Polarization upgrade requires very small collimator iris  
→ see Friedrich's talk



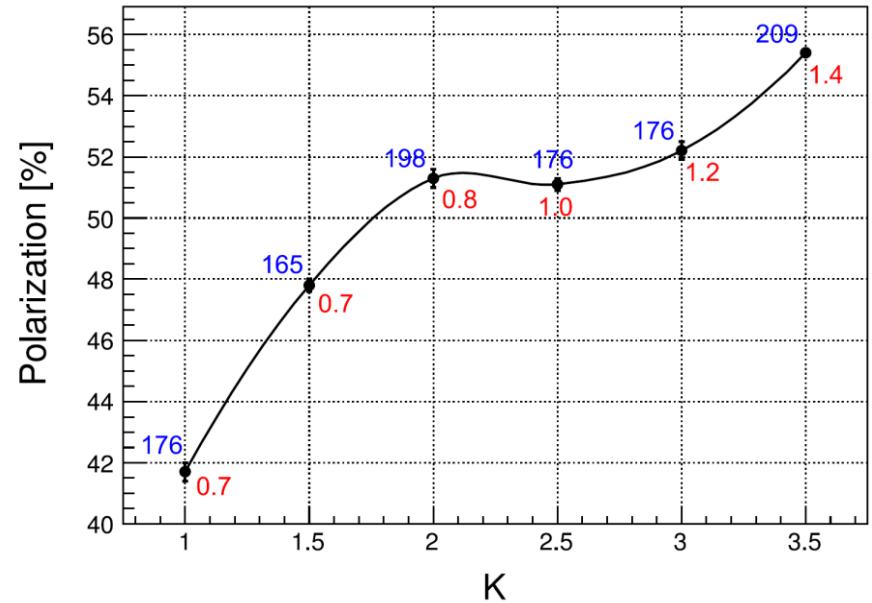
# Polarization vs K

Yield  $\gtrsim 1.5$

*without* Photon Collimator



*with* Photon Collimator



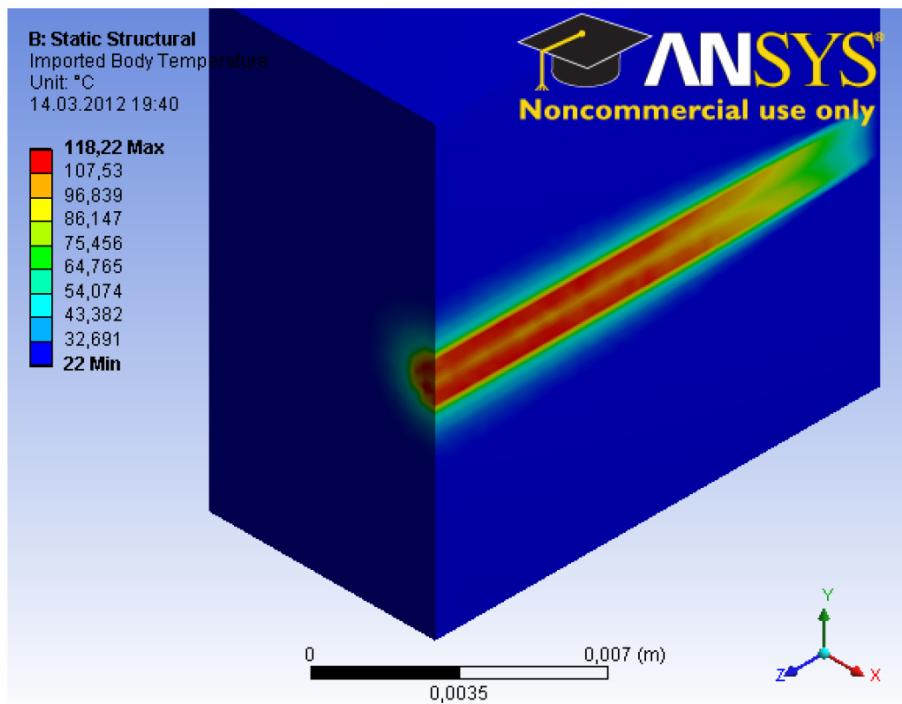
blue numbers – required active undulator length [m]

red numbers – collimator radius [mm]

- ▶ Highest polarization of source without collimator is 25%
- ▶ What is highest  $K$  or  $B$ -field of undulator with 4.3 cm period?

# Temperature Map

500 GeV  $e^-$ ,  $K = 2.0$ ,  $\lambda = 4.3$  cm,  
 $L_u = 198$  m,  $R_{col} = 0.8$  mm,  
39.4 bunches



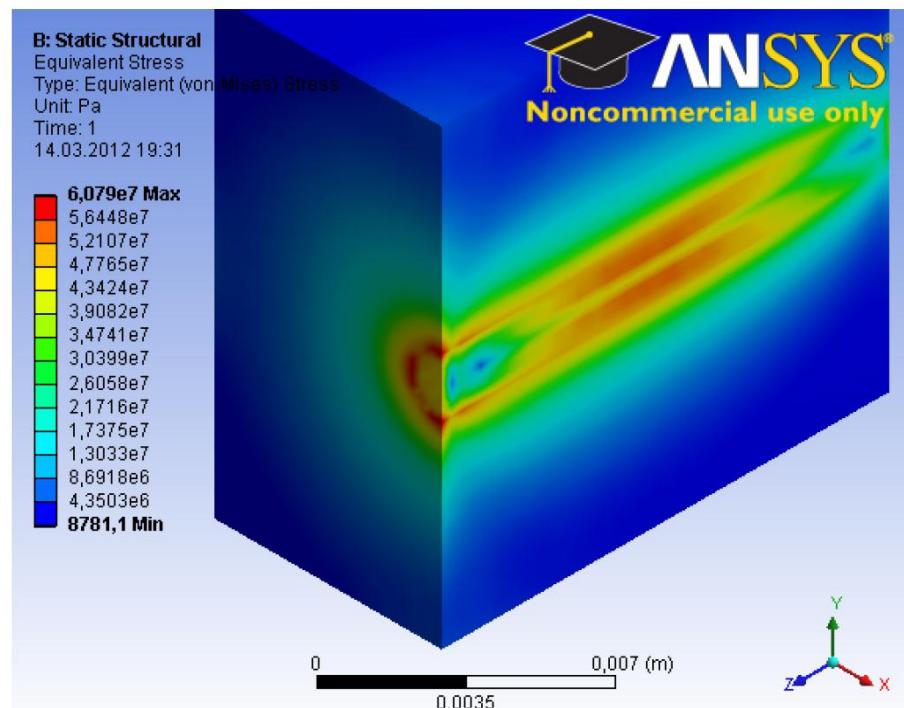
$$\delta T_{max} = 96 \text{ } ^\circ\text{C/pulse}$$

# Static Stress

at the end of pulse ( $t = 0$ )

A. Ushakov

500 GeV  $e^-$



$$\sigma_{max} = 61 \text{ MPa}$$

## Concerns:

1. higher K implies higher E loss in of drive beam
  2. Higher energy deposition in undulator ?  
→ Should be checked
- Jim Clarke:
    - No problem to built undulator with 4.3cm and K=2
    - Energy deposition in undulator shouldn't be serious problem if corresponding collimators are implemented in undulator

To have reasonable polarization for physics, the 1TeV parameters should be reconsidered

# Still missing in EDMS

- PCAP ?
- Collimator table has to be added
- Auxiliary Source
- Beam Dumps (Do the dumps belong to our list?)
- Radiation Aspects (remote handling, shielding,...) → see Xuejun Jia's talk
- Estimated lifetime of components?
- Treaty points?

# Summary

## Status in EDMS

- Undulator:
  - Ok; new improved parameter consideration for 1TeV?
- Collimator – to be added
  - We have to agree the final design
  - Problem: heat load and radiation aspects (remote handling)
- Target – so far ok
  - Vacuum seal tests
  - Shock wave studies
  - Remote handling – update?
- OMD – so far ok
  - FC design  $\Leftrightarrow$  LLNL
- Accelerating structures - ok
- Spin rotation and helicity reversal – to be included
- TeV upgrade – needs still some work (20% polarization ?!)
- Radiation aspects, remote handling – to be done/added
- Dumps ?? Are the RDR dumps sufficient?