Photon collimator design studies

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- ILC positron source unit
- Energy deposition in the collimators
- TDR parameter table with different collimator settings
- Dynamic evolution in the collimator
- Collimator cooling (average temperature)
- Conclusion





ILC positron source unit



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Energy deposition in the collimators (high lumi)

drive beam 250GeV e⁻ , $P_{e+}=50\%$







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250

300

350

3. collimator

z [cm]

200

0.05

100

150

TDR parameter table with different collimator settings

e- drive beam energy (GeV) Farameter Effective undulator field S_{00} Colspan="2">Colspan="2"Colspa="2"Colspan="2"Colspan="2"Colspan="2"Colspan="2"Colspan=	Photon Collimator P	arameters	5		· · · · · · · · · · · · · · · · · · ·		L upgrade	1				Pyr. C	Ti	Fe (ST70)	W (annealed)	W26Re (hardened)
150 175 250 250 Effective undulator field B_{md} T 0.86 0.86 Effective undulator field B_{md} T 0.86 0.86 Colspan="2">Effective undulator field B_{md} T 0.86 0.86 Colspan="2">Colspan="2">Parter Brance Brance, Rengel, 64.8 and MPa 40 40 40 60 Active undulator length L_{md} m 23.1 196.0 70.0 70.0 Photons per bunch train n_{pd} (rrain mode) MParter Brance Brance, Rengel, 64.8 and MPa MParter Brance Brance, Rengel, 64.8 and MPa Solution colspan="2">Colspan="2">Active undulator length MParter Brance Brance, Rengel, 64.8 and MPa MParter Brance Brance, Rengel, 64.8 anded, 60.00 Colspon <th< td=""><td></td><td></td><td></td><td>e- drive</td><td>beam ener</td><td>rgy (GeV)</td><td></td><td></td><td>Fatique Temper</td><td>ature : (Ansys) T</td><td>°C</td><td>900</td><td>600</td><td>130</td><td>185</td><td>500</td></th<>				e- drive	beam ener	rgy (GeV)			Fatique Temper	ature : (Ansys) T	°C	900	600	130	185	500
Effective undulator field B_{max} T 0.86 0.86 Active undulator field B_{max} T 0.86 K=0.92 K=0.92 Active undulator length L_{max} m 231.0 196.0 70.0 70.0 Photons per bunch train $n_{p,h}/Tatin$ 110 3.6 7.2 E_P . Patinger Vaid Strength: 0.6.8,with NP, 36 350 230 440 600 Average photon port $P_{photons}$ kW 985 113.8 83.1 166.2 Abs.ph. power in Titarget B_{max} T_{max} 0.85 50.3 50.3 Politinator r=2.0 / Pyr. C P_{max} M_{3} 3.2 1.9 3.7 collimator r=2.0 / Pyr. C P_{max} M_{3} 3.5 50.3 50.3 collimator r=2.0 / Pyr. C P_{max} M_{3} 3.3 7.9 15.8 collimator r=2.0 / Pyr. C P_{max} M_{3} 3.3 7.9 15.8 collimator r=2.0 / Pyr. C P_{max} M_{2} M_{2	Parameter			150	175	250	250	—	Fatique Energ	y : (Ansys)E _{fatique}	J/g	753	314	58	24	64
K=0.92 K=0.92 K=0.92 Active undulator length L_{wod} m 231.0 196.0 70.0 70.0 Active undulator length L_{wod} m 231.0 196.0 70.0 70.0 Average photon power N N 8 35.5 50.0 440 600 Average photon power $P_{phannarre}$ kW 98.5 113.8 166.2 72 Absph power in collim $P_{willmarre}$ kW 48.1 66.7 43.7 87.3 64.1 61.6 61.3 63.3 72 Collimator r=2.0 / Pyr. C $P_{will<00}$ 55.3 58.5 50.3 50.3 50.3 50.3 c, '' $r_{trife} \approx 2.0 [g^*KJ]$ collimator r=2.0 / Pyr. C $P_{will<00}$ 13 13 5 10 collimator r=1.4 / Pyr. C $P_{will<00}$ 13 11 22 30 32 10 0.4 0.7 collimator r=1.4 / Pyr. C $P_{will<00}$ 13 11 22 30 32 10 0.1 0.2 0.4 0.7 0.6 <td>Effective undulator field</td> <td>B und</td> <td>Т</td> <td></td> <td>0,86</td> <td></td> <td>0,86</td> <td>Fat</td> <td>ique Yield Strengt</td> <td>h : (Ansys)P_{fatique}</td> <td>M Pa</td> <td>40</td> <td>340</td> <td>280</td> <td>440</td> <td>600</td>	Effective undulator field	B und	Т		0,86		0,86	Fat	ique Yield Strengt	h : (Ansys)P _{fatique}	M Pa	40	340	280	440	600
Active undulator length L_{und} m 231,0 196,0 70,0 70,0 Photons per bunch train $p_{p,k}/radin \times 10^{-5}$ 11,8 10,0 3,6 7,2 Abas ph power in collim $p_{p,k}/radin \times 10^{-5}$ 11,8 83,1 166,2 Abas ph power in collim $P_{p,km}$ kW 48,1 68,7 43,7 87,3 Abs ph power in Titarget E_{war} J/g 61 61 31 63 Abs ph power in Titarget E_{war} J/g 1177 144 36 72 collimator r=2.0 / Pyr. C E_{war} J/g 16 18 6 11 collimator r=2.0 / Fi E_{war} J/g 16 18 6 11 collimator r=2.0 / Fi E_{war} J/g 16 18 6 11 collimator r=2.0 / Fi E_{war} J/g 13 13 5 10 collimator r=2.0 / Fi E_{war} J/g 13 11 22 collimator r=1.0 / Fi E_{war} J/g 13 11 22 collimator r=1.4 / Fi E_{war} J/g 13 11 22 collimator r=1.4 / Fi E_{war} J/g 13 11 22 collimator r=1.4 / Fi E_{war} J/g 13 11 22 collimator r=1.0 / Pyr. C E_{war} J/g 13 11 22 collimator r=1.0 / Pyr. C E_{war} J/g 13 11 22 collimator r=1.4 / Fi E_{war} J/g 13 11 22 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,4 collimator r=1.0 / Pyr. C P kW 0,1 0,2 coclimator r=1.0 / Pyr. C P kW 0,2 0,4 collimator r=1.0 / Pyr. C P kW 0,1 0,2 coclimator r=1.0 / Fe P kW 0,1 0,2 coclimator r=1.0 / Fe P kW 0,1 0,2 co					K=0.92		K=0.92		-							
Photons per bunch train $n_{ph}/train \times 10^{13}$ 11,8 10,0 3,6 7,2 Average photon power in the train online $n_{phi}/train \times 10^{13}$ 11,8 10,0 3,6 7,2 Percent the two power in the train the two provides the train train the train t	Active undulator length	L und	m	231,0	196,0	70,0	70,0	Exp	p. Fatique Yield Si	trength : 0.4 R _{max}	M Pa	36	356	280	440	600
Average photon power P_{phone} $kW = 98.5$ 113.8 83.1 166.2 Abs.ph. power in collim. $P_{rotinater}$ $kW = 48.1$ $68.7 = 43.7 = 87.3$ 20 $P_{rotinator} kW = 48.1$ $68.7 = 43.7 = 87.3$ 20 $P_{rotinator} kW = 48.1$ $68.7 = 43.7 = 87.3$ 20 $P_{rotinator} kW = 48.3 = 3.2 = 1.9 = 3.7$ Collimator ratios $r = mm = 2.0$ $1.4 = 1.0 = 1.0$ collimator $r=2.0$ / Pyr. C E_{max} $J/g = 177$ $144 = 36 = 72$ collimator $r=2.0$ / Pyr. C P $kW = 0.8 = 0.2 = 0.4$ collimator $r=2.0$ / Pir $C = P$ $kW = 0.8 = 0.2 = 0.4$ collimator $r=2.0$ / Fi P $kW = 0.2 = 0.3 = 0.4 = 0.7$ collimator $r=2.0$ / Fi P $kW = 0.2 = 0.3 = 0.4 = 0.7$ collimator $r=2.0$ / Fi P $kW = 0.2 = 0.3 = 0.4 = 0.7$ collimator $r=1.4$ / Pyr. C P $kW = 0.2 = 0.3 = 0.4 = 0.7$ collimator $r=1.4$ / Pyr. C P $kW = 0.2 = 0.3 = 0.4 = 0.7$ collimator $r=1.4$ / Pyr. C P $kW = 0.2 = 0.3 = 0.2 = 0.6$ collimator $r=1.4$ / Fi P $kW = 0.2 = 0.3 = 0.2 = 0.6$ collimator $r=1.4$ / Fi P $kW = 0.2 = 0.3 = 0.2 = 0.6 =$	Photons per bunch train	n _{ph} / train	×10 ¹⁵	11,8	10,0	3,6	7,2		Exp. Yield Streng	th : R _{max} / R _{elastic}	м Ра	90	890 / 820	/00 / 340	1100 / 800	1500 / 1200
Abs.ph. power in collim. $P_{collimator}$ kW 48,1 68,7 43,7 87,3 PEDD Ti target E_{max} $1/g$ 61 61 31 63, Abs.ph. power in Ti target P_{max} kW 43,3 3,2 1,9 3,7 Collimator radius r mm 2,0 1,4 1,0 1,0 Positron Polarization P_{*} % 55,3 58,5 50,3 50,3 collimator P_{*} 0/9, C P_{x} C E_{max} $1/g$ 16 18 6 11 collimator P_{*} 0/9, C P_{x} C P kW 44,3 36,3 7,9 15,8 collimator P_{*} 0/9, C P kW 44,3 36,3 7,9 15,8 collimator P_{*} 0/1 E_{max} $1/g$ 16 18 6 11 collimator P_{*} 0/1 E_{max} $1/g$ 13 13 5 10 collimator P_{*} 0/1 P_{x} C P kW 0,2 0,3 0,1 0,2 collimator P_{*} 0/1 P_{x} C P kW 0,2 0,3 0,1 0,2 collimator P_{*} 0/1 P_{x} C P kW 0,2 0,3 0,1 0,2 collimator P_{*} 0/9 P_{x} C P_{x} kW 0,2 0,3 0,1 0,2 collimator P_{*} 0/9 P_{x} C P_{x} kW 0,2 0,3 0,1 0,2 collimator P_{*} 0/9 P_{x} C P_{x} kW 0,2 0,3 0,1 0,2 collimator P_{*} 0/9 P_{x} C P_{x} P_{x} 0,9 0,6 1,2 collimator P_{*} 0/9 P_{x} C P_{x} P_{x} 0,9 0,6 1,2 collimator P_{*} 0/2 P_{x} C P_{x} P_{x} 0,9 0,6 1,2 collimator P_{*} 0/2 P_{x} C P_{x} P_{x} 0,2 0,1 0,2 collimator P_{*} 0/2 P_{x} P_{x} 0,2 0,1 0,2 collimator P_{*} 0/2 P_{x} P_{x} P_{x} 0,2 0,1 0,2 collimator P_{*} 0/2 P_{x} P	Average photon power	P photon	kW	98,5	113,8	83,1	166,2									
PEDD Ti target E_{max} Jg 61 61 31 63 Abs.ph.power in Ti target P_{sarger} kW 4,3 3,2 1,9 3,7 Collimator r=0./ Pyr. C E_{max} Jg 177 144 36 72 collimator r=0./ Pyr. C E_{max} Jg 177 144 36 72 collimator r=0./ Pyr. C E_{max} Jg 16 18 6 11 collimator r=0./ Pyr. C P kW 0,8 0,8 0,2 0,4 collimator r=0./ Pyr. C P kW 0,2 0,3 0,1 0,2 coolimator r=0./ Pyr. C P kW 0,2 0,3 0,1 0,2 coolimator r=1.4 / Pyr. C P kW 0,2 0,3 0,1 0,2 coolimator r=1.4 / Pyr. C P kW 0,2 0,6 1,2 collimator r=1.4 / Pyr. C P kW 0,2 0,1 0,2 coolimator r=1.4 / Fi P kW 0,2 0,1 0,2 coolimator r=1.4 / Fi P kW 0,2 0,1 0,2 coolimator r=1.0 / Pyr. C P kW 1,2 2,4 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 coolimator r=1.0 / Pyr. C P kW 0,1 3,26 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,1 0,2 collimator r=1.0 / Pyr. C P	Abs.ph. power in collim.	P collimator	kW	48,1	68,7	43,7	87,3							_1		
Abs ph. power in Ti target P_{target} kW 4,3 3,2 1,9 3,7 Collimator radius r mm 2,0 1,4 1,0 1,0 Positron Polarization P_+ % 55,3 58,5 50,3 50,3 collimator $r=2.0$ / Pyr. C P_{target} kW 44,8 36,3 7,9 15,8 collimator $r=2.0$ / Ti P_{target} kW 0,8 0,8 0,2 0,4 collimator $r=2.0$ / Ti P_{target} kW 0,8 0,8 0,2 0,4 collimator $r=2.0$ / Fe P_{target} kW 0,2 0,3 0,1 0,2 coolimator $r=2.0$ / Fe P_{target} kW 2,3 19 0,4 0,7 collimator $r=1.4$ / Pyr. C P_{target} kW 2,5 12,9 25,8 collimator $r=1.4$ / Pyr. C P_{target} kW 2,9 0,6 1,2 collimator $r=1.4$ / Fe P_{target} kW 0,2 0,1 0,2 collimator $r=1.0$ / Fe P_{target} kW 0,2 0,4 collimator $r=1.0$ / Fe P_{target} kW 0,1 0,2 collimator $r=1.0$ / Fe P_{target} kW 0,1 10,2 collimator $r=1.0$ / Fe P_{target} kW 0,1 1,8 3,6 collimator $r=1.0$ / Fe $P_{$	PEDD Ti target	E max	J/g	61	61	31	63				Δ	T = E,	nax * C	v'		
Collimator radius r mm 2,0 1,4 1,0 1,0 Pesitron Polarization P_+ % 553 58.5 50,3 50,3 collimator r=2.0 / Pyr, C E_{max} J/g 177 144 36 72 collimator r=2.0 / Pyr, C P kW 44,8 36,3 7,9 15,8 collimator r=2.0 / Fi E_{max} J/g 16 18 6 11 collimator r=2.0 / Fi E_{max} J/g 16 18 6 11 collimator r=2.0 / Fe E_{max} J/g 13 13 5 10 collimator r=2.0 / Fe P kW 0,2 0,3 0,1 0,2 coolimg / Cu P kW 2,3 1-0 0,4 0,7 collimator r=1.4 / Pyr, C P kW 2,3 1-0 0,4 0,7 collimator r=1.4 / Fi E_{max} J/g 18 13 73 14.0 collimator r=1.4 / Fi E_{max} J/g 13 11 122 collimator r=1.4 / Fe E_{max} J/g 13 11 122 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 collimator r=1.0 / Fyr, C P kW 2,4 1,2 2,4 collimator r=1.0 / Fyr, C P kW 0,2 0,1 0,2 collimator r=1.0 / Fyr, C P kW 0,2 0,1 0,2 collimator r=1.0 / Ti P kW 0,2 0,1 0,2 collimator r=1.0 / Ti P kW 0,2 0,1 0,2 collimator r=1.0 / Ti P kW 0,2 0,1 0,2 collimator r=1.0 / Fyr, C P kW 1,8 3,6	Abs.ph. power in Ti target	P target	kW	4,3	3,2	1,9	3,7									
Positron Polarization P_+ 9% 55.3 58.5 50.3 50.3 72 collimator r=2.0 / Pyr. C E_{max} $J'g$ 177 144 35 72 collimator r=2.0 / Fi E_{max} $J'g$ 16 18 6 11 collimator r=2.0 / Fi E_{max} $J'g$ 16 18 6 11 collimator r=2.0 / Fi P kW 0.8 0.8 0.2 0.4 collimator r=2.0 / Fe E_{max} $J'g$ 13 13 5 10 collimator r=2.0 / Fe E_{max} $J'g$ 13 13 5 10 collimator r=2.0 / Fe E_{max} $J'g$ 18 18 73 146 collimator r=1.4 / Pyr. C P kW 0.9 0.6 1.2 collimator r=1.4 / Fi E_{max} $J'g$ 18 18 73 146 collimator r=1.4 / Fi E_{max} $J'g$ 18 18 73 146 collimator r=1.4 / Fi E_{max} $J'g$ 18 18 73 146 collimator r=1.4 / Fi E_{max} $J'g$ 18 18 73 146 collimator r=1.4 / Fi E_{max} $J'g$ 18 18 73 146 collimator r=1.4 / Fi E_{max} $J'g$ 18 18 0.9 0.6 1.2 collimator r=1.4 / Fe E_{max} $J'g$ 18 18 0.9 0.6 1.2 collimator r=1.4 / Fe E_{max} $J'g$ 18 18 0.9 0.6 1.2 collimator r=1.4 / Fe E_{max} $J'g$ 18 18 0.9 0.6 1.2 collimator r=1.4 / Fi E_{max} $J'g$ 18 18 0.9 0.6 1.2 collimator r=1.0 / Pyr. C E_{max} $J'g$ 18 18 0.0 0.2 0.1 0.2 collimator r=1.0 / Pyr. C E_{max} $J'g$ 19 19 0.0 0.2 0.1 0.2 collimator r=1.0 / Pyr. C E_{max} $J'g$ 9 19 collimator r=1.0 / Pyr. C E_{max} $J'g$ 9 19 collimator r=1.0 / Fe P kW 0.0 0.2 0.4 collimator r=1.0 / Fe P kW 0.0 0.2 0.4 collimator r=1.0 / Fe P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C E_{max} $J'g$ 0.9 19 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator r=0 0 / Pyr. C P kW 0.0 0.1 0.2 collimator	Collimator radius	r	mm	2,0	1,4	1,0	1,0				c -1	1	~ 12	[a*K/.[]		
	Positron Polarization	P +	%	55,3	58.5	50,3	50,3				••	Carbon	~ 1.2	[g 100]		
collimator r=2.0 / Pyr. C P kW $\frac{443}{2}$ 36,3 7,9 15,8 collimator r=2.0/Ti E_{max} J/g 16 18 6 11 collimator r=2.0/Ti P kW 0,8 0,8 0,2 0,4 collimator r=2.0/Fe P kW 0,2 0,3 0,1 0,2 cooling/Cu P kW 2,3 19 0,4 0,7 collimator r=1.4 / Pyr. C E_{max} J/g 183 73 1146 collimator r=1.4 / Pyr. C P kW 25,9 12,9 25,8 collimator r=1.4 / Ti E_{max} J/g 22 30 32 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 cooling/Cu P kW 2,4 1,2 2,4 coolimator r=1.0 / Pyr. C P kW 2,4 1,2 2,4 coolimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 coolimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 coolimator r=1.0 / Fe E_{max} J/g 13 13 26 collimator r=1.0 / Fe E_{max} J/g 13 3,26 collimator r=1.0 / Fe E_{max} J/g 9 13 2,27 coolimator r=1.0 / Fe E_{max} J/g 9 13 2,6 collimator r=1.0 / Fe E_{max} J/g 9 19 19 collimator r=1.0 / Fe E_{max} J/g 0 0,2 collimator r=1.0 / Fe E_{max} J/g 0 0,2 collimator r=1.0 / Fe E_{max} J/g 0 0,2 collimator r=1.0 / Fe E_{max} J/g 0 0,2 c	collimator r=2.0 / Pyr. C	E _{max}	J/g	177	144	36	72				-					
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	collimator r=2.0 / Pyr. C	Р	kW	44,8	36,3	7,9	15,8				c,	Ti,Fe 🧍	ਝ 2.0 [g*K/J]		
collimator r=2.0 / Ti P kW 0,8 0,8 0,2 0,4 collimator r=2.0 / Fe E_{max} J/g 13 13 5 10 collimator r=2.0 / Fe P kW 0,2 0,3 0,1 0,2 cooling / Cu P kW 2,3 10 0,4 0,7 collimator r=1.4 / Pyr. C E_{max} J/g 183 73 144 collimator r=1.4 / Pyr. C P kW 2,5 12,9 25,8 collimator r=1.4 / Ti E_{max} J/g 22 30 32 collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 cooling / Cu P kW 0,2 0,1 0,2 cooling tor r=1.0 / Pyr. C P kW 0,2 0,1 0,2 cooling tor r=1.0 / Pyr. C P kW 0,0 0,1 0,2 cooling tor r=1.0 / Fe E_{max} J/g 9 19 collimator r=0 1,0 Fe E_{max} J/g 9 19 collimator r=0 0,0 Fe E_{max} J/g	collimator r=2.0 / Ti	E max	J/g	16	18	6	11									
collimator r=2.0 / Fe E_{max} J/g 13 13 5 10 collimator r=2.0 / Fe P kW 0,2 0,3 0,1 0,2 cooling / Cu P kW 2,3 10 0,4 0,7 collimator r=1.4 / Pyr. C E_{max} J/g 183 73 146 collimator r=1.4 / Pyr. C P kW 2,3 10 0,4 0,7 collimator r=1.4 / Pyr. C P kW 2,3 10 0,4 0,7 collimator r=1.4 / Ti E_{max} J/g 22,3 0 32 collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 2,4 1,2 2,4 collimator r=1.0 / Pyr. C P kW 10,2 0,1 0,2 collimator r=1.0 / Fe E_{max} J/g 13 26 collimator r=1.0 / Fe E_{max} J/g 13 26 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe P kW 0,0,1 0,2 collimator r=1.0 / Fe P kW 10,0,1 0,2 collimator r=0.0 Fe P kW 10,0,	collimator r=2.0 / Ti	Р	kW	0,8	0,8	0,2	0,4									
collimator r=2.0 / Fe P kW 0,2 0,3 0,1 0,2 collimator r=2.0 / Fe P kW 2,3 19 0,4 0,7 collimator r=1.4 / Pyr. C E_{max} J/g 183 73 146 collimator r=1.4 / Ti E_{max} J/g 22 30 32 collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C P kW 0,2 0,1 0,2 collimator r=1.0 / Fe E_{max} J/g 13 26 collimator r=1.0 / Fe E_{max} J/g 13 26 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe E_{max} J/g 9 10 collimator r=1.0 / Fe E_{max} J/g 9 10 collimator r=1.0 / Fe E_{max} J/g 0,1 0,2 collimator r=1.0 / Fe E_{max} J/g	collimator r=2.0 / Fe	E _{max}	J/g	13	13	5	10						2500-0			I / au7
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	collimator r=2.0 / Fe	Р	kW	0,2	0,3	0,1	0,2	0.4		ар	erture -	- 2.0 MM,	200GeV			J 7 CM3
collimator r=1.4 / Pyr. C E_{max} J/g 183 73 146 collimator r=1.4 / Pyr. C P kW 25,9 12,9 25,8 collimator r=1.4 / Ti E_{max} J/g 22 30 32 collimator r=1.4 / Ti P kW 0,9 0,6 1,2 collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 collimator r=1.0 / Pyr. C E_{max} J/g 82 163 collimator r=1.0 / Pyr. C P kW 17,9 35,8 collimator r=1.0 / Fe E_{max} J/g 13 26 collimator r=1.0 / Fe E_{max} J/g 99 19 collimator r=1.0 / Fe F_{max} J/g 99 19 collimator r=1.0 / Fe P kW 0,1 0,2 coolim / Cu P kW 1,8 3,6	cooling / Cu	Р	kW	2,3	1,0	0,4	0,7	\ ***								
collimator r=1.4 / Pyr. C P kW $\overline{25,9}$ $12,9$ $25,8$ collimator r=1.4 / Ti E_{max} J/g 22 30 32 collimator r=1.4 / Ti P kW $0,9$ $0,6$ $1,2$ collimator r=1.4 / Ti P kW $0,9$ $0,6$ $1,2$ collimator r=1.4 / Fe P kW $0,2$ $0,1$ $0,2$ collimator r=1.4 / Fe P kW $0,2$ $0,1$ $0,2$ collimator r=1.0 / Pyr. C E_{max} J/g 13 26 collimator r=1.0 / Pyr. C P kW $0,2$ $0,4$ collimator r=1.0 / Pyr. C P kW $0,2$ $0,4$ collimator r=1.0 / Fe E_{max} J/g 13 26 collimator r=1.0 / Fe E_{max} J/g 9 19 $0,1$ $0,2$ collimator r=1.0 / Fe P kW $0,1$ $0,2$ $2,3$ $-3,0$ -280 -260 -240 -220 -200 -180 -160 -320	collimator r=1.4 / Pyr. C	E _{max}	J/g		183	73	146	0,35	- 15.8	kW		1. A				
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	collimator r=1.4 / Pyr. C	Р	kW		25,9	12,9	25,8									100
collimator r=1.4 / TiPkW0,90,61,2collimator r=1.4 / Fe E_{max} J/g131122collimator r=1.4 / FePkW0,20,10,2collimator r=1.4 / FePkW0,20,10,2collimator r=1.0 / Pyr. C E_{max} J/g82163collimator r=1.0 / Pyr. CPkW0,20,4collimator r=1.0 / Pyr. CPkW0,20,4collimator r=1.0 / Ti E_{max} J/g1326collimator r=1.0 / TiPkW0,20,4collimator r=1.0 / Fe E_{max} J/g919collimator r=1.0 / FePkW0,10,2collimator	collimator r=1.4 / Ti	E max	J/g		22	30	32	0.3	70 1	C					Fe	
collimator r=1.4 / Fe E_{max} J/g 13 11 22 collimator r=1.4 / Fe P kW 0,2 0,1 0,2 cooling / Cu P kW 0,2 0,1 0,2 cooling / Cu P kW 2,4 1,2 2,4 collimator r=1.0 / Pyr. C E_{max} J/g 82 163 collimator r=1.0 / Pyr. C P kW 0,2 0,4 collimator r=1.0 / Ti E_{max} J/g 13 26 collimator r=1.0 / Ti P kW 0,2 0,4 collimator r=1.0 / Fe E_{max} J/g 13 26 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe P kW 0,1 0,2 0,4 collimator r=1.0 / Fe P kW 0,1 0,2 0,4 0,1 0,2 collimator r=1.0 / Fe P kW 0,1 0,2 0,1 0,2 20 -300 -280 -260 -240 -20 <th< td=""><td>collimator r=1.4 / Ti</td><td>Р</td><td>kW</td><td></td><td>0,9</td><td>0,6</td><td>1,2</td><td>0.25</td><td>[[2]]</td><td>g</td><td></td><td></td><td>新海山</td><td></td><td></td><td>10</td></th<>	collimator r=1.4 / Ti	Р	kW		0,9	0,6	1,2	0.25	[[2]]	g			新海 山			10
collimator r=1.4 / FePkW0,20,10,2collimator r=1.0 / Pyr. CPkW2,41,22,4collimator r=1.0 / Pyr. CPkW17,935,8collimator r=1.0 / Ti E_{max} J/g1326collimator r=1.0 / TiPkW0,20,4collimator r=1.0 / Fe E_{max} J/g919collimator r=1.0 / FePkW0,10,2collimator r=1.0 / FePkW <th< td=""><td>collimator r=1.4 / Fe</td><td>E_{max}</td><td>J/g</td><td></td><td>13</td><td>11</td><td>22</td><td>0.20</td><td>Contraction of the second</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	collimator r=1.4 / Fe	E _{max}	J/g		13	11	22	0.20	Contraction of the second							
cooling / Cu P kW 2,4 1,2 2,4 collimator r=1.0 / Pyr. C E_{max} J/g 82 163 collimator r=1.0 / Pyr. C P kW 17,9 35,8 collimator r=1.0 / Ti E_{max} J/g 13 26 collimator r=1.0 / Ti E_{max} J/g 0,2 0,4 collimator r=1.0 / Ti P kW 0,2 0,4 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe P kW 0,1 0,2 cooling / Cu P kW 0,1 0,2 26 -260 -240 -220 -200 -180 -160 -260 -260 -240 -220 -200 -180 -160 -260	collimator r=1.4 / Fe	Р	kW		0,2	0,1	0,2	ۍ <u>گ</u>	·	and the second	a la companya da companya d					1
collimator r=1.0 / Pyr. C E_{max} J/g 82 163 collimator r=1.0 / Pyr. C P kW 17,9 35,8 collimator r=1.0 / Pyr. C P kW 0,2 0,4 collimator r=1.0 / Ti E_{max} J/g 13 26 collimator r=1.0 / Ti P kW 0,2 0,4 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe P kW 0,1 0,2 cooling / Cu P kW 0,1 0,2 x_{20}	cooling / Cu	Р	kW		2,4	1,2	2,4	د م 15								
collimator r=1.0 / Pyr. C P kW In the second	collimator r=1.0 / Pyr. C	E _{max}	J/g			82	163	0,15	Γ			_] ***
collimator r=1.0 / Ti E_{max} J/g 13 26 collimator r=1.0 / Ti P kW 0,2 0,4 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe P kW 0,1 0,2 collimator r=1.0 / Fe P kW 0,1 0,2 cooling / Cu P kW 1,8 3,6	collimator r=1.0 / Pyr. C	Р	kW			17,9	35,8	0,1	. -	1.	coll	imat	or			4
collimator r=1.0 / Ti P kW 0,2 0,4 collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe P kW 0,1 0,2 cooling / Cu P kW 1,8 3,6	collimator r=1.0 / Ti	E _{max}	J/g			13	26									
collimator r=1.0 / Fe E_{max} J/g 9 19 collimator r=1.0 / Fe P kW 0,1 0,2 cooling / Cu P kW 1,8 3,6	collimator r=1.0 / Ti	Р	kW			0,2	0,4	0,05	' F							1
collimator r=1.0 / Fe P kW 0,1 0,2 -320 -300 -280 -240 -220 -200 -180 -160 cooling / Cu P kW 1,8 3,6 z [cm]	collimator r=1.0 / Fe	E max	J/g			9	19	ń								J
cooling / Cu <i>P</i> kW 1,8 3,6 z [cm]	collimator r=1.0 / Fe	Р	kW			0,1	0,2	-	-320 -300	-280 -260) -24	40 -22	20 -20	00 -180	-160	
	cooling / Cu	Р	kW			1,8	3,6				;	z [cm]				





TDR parameter table with different collimator settings

Photon Collimator P	arameters	S				L upgrade					Pyr. C	Ti	Fe (ST70)	W (annealed)	W26Re (hardened)	
			e- drive	beam ene	rgy (GeV)			Fatique Temper	ature : (Ansys) T	°C	900	600	130	185	500	
Parameter			150	175	250	250		Fatique Energ	y : (Ansys)E _{fatique}	J/g	753	314	58	24	64	
Effective undulator field	B und	Т		0,86		0,86	Fati	que Yield Strengt	h : (Ansys)P _{fatique}	M Pa	40	340	280	440	600	
				K=0.92		K=0.92	_	E (1 10 110		MD	24	254	200	440	<u> </u>	
Active undulator length	L und	m	231,0	196,0	70,0	70,0	Exp	. Fallque Hela S Even Vield Strave	trength : 0.4 K max	M Pa	30	300 / 900	280	1100 / 200	1500 / 1200	
Photons per bunch train	n _{ph} / train	$\times 10^{15}$	11,8	10,0	3,6	7,2		Lxp. Tiela Streng	IN . IC max / IC elastic	NI F d	90	890 / 820	7007 540	1100 / 800	1500 / 1200	
Average photon power	P photon	kW	98,5	113,8	83,1	166,2										
Abs.ph. power in collim.	P collimator	kW	48,1	68,7	43,7	87,3							-1			
PEDD Ti target	E _{max}	J/g	61	61	31	63				Δ	r = E,	nax * 🤇	2 _v '			
Abs.ph. power in Ti target	P target	kW	4,3	3,2	1,9	3,7										
Collimator radius	r	mm	2,0	1,4	1,0	1,0				c -1	~ .	~ 1 3	[a*K/.[]			
Positron Polarization	P +	%	55,3	58.5	50,3	50,3				••	Carbon	~	. [g 100]			
collimator r=2.0 / Pyr. C	E _{max}	J/g	177	144	36	72				-						
collimator r=2.0 / Pyr. C	Р	kW	44,8	36,3	7,9	15,8				c,''	Ti,Fe 6	≈ 2.0 ['g*K/J]			
collimator r=2.0 / Ti	E max	J/g	16	18	6	11										
collimator r=2.0 / Ti	Р	kW	0,8	0,8	0,2	0,4										
collimator r=2.0 / Fe	E _{max}	J/g	13	13	5	10										
collimator r=2.0 / Fe	Р	kW	0,2	0,3	0,1	0,2	0.4		ар	erture =	: 1.4 mm,	250GeV			J / cm3	
cooling / Cu	Р	kW	2,3	1,9	0,4	0,7	0.4									
collimator r=1.4 / Pyr. C	E _{max}	J/g		183	73	146	0,35	25.8	kW							
collimator r=1.4 / Pyr. C	Р	kW		25,9	12,9	25,8						Carl 2			100	
collimator r=1.4 / Ti	E _{max}	J/g		22	30	32	0.3		C					i Fe		
collimator r=1.4 / Ti	Р	kW		0,9	0,6	1,2	0.25								10	
collimator r=1.4 / Fe	E _{max}	J/g		13	11	22	0,25									
collimator r=1.4 / Fe	Р	kW		0,2	0,1	0,2	<u>ت</u> 0,2	146	l/a				No.		1	
cooling / Cu	Р	kW		2,4	1,2	2,4	<u>د</u>	State of the second	0/9	A STATE	(Carlored					
collimator r=1.0 / Pyr. C	E _{max}	J/g			82	163	0,15					Ball Control of Contro				
collimator r=1.0 / Pyr. C	Р	kW			17,9	35,8	0.1	-	_						-	
collimator r=1.0 / Ti	E max	J/g			13	26				2. CO	ollim	ator				
collimator r=1.0 / Ti	Р	kW			0,2	0,4	0,05	F							1	
collimator r=1.0 / Fe	E _{max}	J/g			9	19	Ó								J	
collimator r=1.0 / Fe	Р	kW			0,1	0,2	-	-140 -120	-100 -80	-60	-40	-20	0	20 40		
cooling / Cu	Р	kW			1,8	3,6				2	z [cm]					



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TDR parameter table with different collimator settings

Photon Collimator P	arameters	5				L upgrade					Pyr. C	Ti	Fe (ST70)	W (annealed)	W26Re (hardened)
			e- drive	beam ener	rgy (GeV)			Fatique Temper	ature : (Ansys) T	°C	900	600	130	185	500
Parameter			150	175	250	250		Fatique Energ	v : (Ansys)E _{fatique}	J/g	753	314	58	24	64
Effective undulator field	B und	Т		0,86		0,86	Fa	tique Yield Strengtl	h : (Ansys)P _{fatique}	M Pa	40	340	280	440	600
				K=0.92		K=0.92		- Entine Vield C		MD-	26	256	200	440	600
Active undulator length	L und	m	231,0	196,0	70,0	70,0	EX	p. Fatique Field St Fron Viold Strong	rengin : 0.4 K _{max}	M Pa	30	300 / 820	280	1100 / 800	1500 / 1200
Photons per bunch train	n _{ph} / train	$ imes 10^{15}$	11,8	10,0	3,6	7,2		Exp. Tield Strengt	n . 10 max / 10 elastic	WIId	30	8907 820	1007 540	1100 / 800	15007 1200
Average photon power	P photon	kW	98,5	113,8	83,1	166,2									
Abs.ph. power in collim.	P collimator	kW	48,1	68,7	43,7	87,3							-1		
PEDD Ti target	E _{max}	J/g	61	61	31	63				⊿7	r = E,	nax * 🤇			
Abs.ph. power in Ti target	P target	kW	4,3	3,2	1,9	3,7									
Collimator radius	r	mm	2,0	1,4	1,0	1,0				c -1	~ .	~ 12	[a*K/.[]	1	
Positron Polarization	P +	%	55,3	58.5	50,3	50,3				••	Carbon	~	. [g 100]		
collimator r=2.0 / Pyr. C	E _{max}	J/g	177	144	36	72				-					
collimator r=2.0 / Pyr. C	Р	kW	44,8	36,3	7,9	15,8				c , ''	Ti,Fe 6	s 2.0 ['g*K/J]		
collimator r=2.0 / Ti	E max	J/g	16	18	6	11									
collimator r=2.0 / Ti	Р	kW	0,8	0,8	0,2	0,4									
collimator r=2.0 / Fe	E _{max}	J/g	13	13	5	10									
collimator r=2.0 / Fe	Р	kW	0,2	0,3	0,1	0,2			api	erture =	1.0 mm,	250GeV			J/cm3
cooling / Cu	Р	kW	2,3	1,9	0,4	0,7	0 .	4							
collimator r=1.4 / Pyr. C	E _{max}	J/g		183	73	146	0.3	5 35.8	kW						
collimator r=1.4 / Pyr. C	Р	kW		25,9	12,9	25,8									100
collimator r=1.4 / Ti	E _{max}	J/g		22	30	32	٥.	3 -	A MARKEN AND AND						100
collimator r=1.4 / Ti	Р	kW		0,9	0,6	1,2	1		et respective	C					
collimator r=1.4 / Fe	E max	J/g		13	11	22	0.2	5							
collimator r=1.4 / Fe	Р	kW		0,2	0,1	0,2	<u>ل</u> ة 0	2 -							1
cooling / Cu	Р	kW		2,4	1,2	2,4	<u>د</u>		NAMES OF STREET					31.51	
collimator r=1.0 / Pyr. C	E _{max}	J/g			82	163 🖌	0.1	° <u>– 163 </u>	J/g						~+1
collimator r=1.0 / Pyr. C	Р	kW			17,9	35,8	0.	1 -				B ^A ARDANA	and the second second		
collimator r=1.0 / Ti	E _{max}	J/g			13	26			~						
collimator r=1.0 / Ti	Р	kW			0,2	0,4	0.0	5 -	3	. CO	IIIma	ator		-	
collimator r=1.0 / Fe	E _{max}	J/g			9	19									
collimator r=1.0 / Fe	Р	kW			0,1	0,2		100	150	200	2	250	300	350	
cooling / Cu	Р	kW			1,8	3,6				z	[cm]				



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Dynamic evolution in the 1. collimator (high lumi)





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Collimator cooling (average temperature)



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Cooling and temperature (high lumi)

drive beam 250GeV e^- , $P_{e+}=50\%$

Carbon	average T [°C]	ΔT peak [K]	∆E peak [J/g]	fatigue Energy [J/g]
1. collimator	43	86	72	750
2. collimator	54	174	146	750
3. collimator	46	194	163	

Titanium	average T [°C]	ΔT peak [K]	ΔE peak [J/g]	fatigue Energy [J/g]
1. collimator	67	21	11	250
2. collimator	123	61	32	350
3. collimator	132	50	26	

Iron (St70)	average T [°C]	ΔT peak [K]	ΔE peak [J/g]	fatigue Energy [J/g]
1. collimator	30	22	10	50
2. collimator	31	49	22	50
3. collimator	32	42	19	





Cooling and temperature

drive beam 175GeV e^- , $P_{e+}=59\%$

Carbon	average T [°C]	ΔT peak [K]	ΔE peak [J/g]	fatigue Energy [J/g]
1. collimator	70	172	144	750
2. collimator	54	219	183	750

Titanium	average T [°C]	ΔT peak [K]	ΔE peak [J/g]	fatigue Energy [J/g]
1. collimator	113	34	18	250
2. collimator	98	42	22	350

Iron (St70)	average T [°C]	ΔT peak [K]	ΔE peak [J/g]	fatigue Energy [J/g]
1. collimator	34	29	13	50
2. collimator	32	29	13	50





Cooling and temperature

drive beam 150GeV e^- , $P_{e+}=55\%$

Carbon	average T [°C]	ΔT peak [K]	∆E peak [J/g]	fatigue Energy [J/g]
1. collimator	81	140	177	750

Titanium	average T [°C]	ΔT peak [K]	ΔE peak [J/g]	fatigue Energy [J/g]
1. collimator	113	31	16	350

Iron (St70)	average T [°C]	ΔT peak [K]	ΔE peak [J/g]	fatigue Energy [J/g]
1. collimator	30	29	13	50





Conclusion

- The collimator design achieved the fatigue stress limits of the materials for the proposed parameter sets (including safety factors)

- Dynamical calculations for the collimator shows not critical behavior

- Collimator cooling should be not difficult for this introduced design

to do: a material test experiment at a suitable accelerator have to be performed to verify (fatigue) stress limits with realistic beam conditions





Material data

element x ₀ [<i>cm</i>]	E [GPa]	ν	$\rho\left[rac{g}{cm^3} ight]$	$\alpha\left[\frac{10-5}{\kappa}\right]$	$C_{V}\left[\frac{J}{kg\ K}\right]$	$\lambda\left[\frac{W}{m K}\right]$
Au 0.34	81	0.42	19.3	1.43	128	320
Ag 0.85	83	0.38	10.5	1.97	234	430
Cu 1.42	117	0.34	8.3	1.65	385	400
W 0.35	406	0.28	19.3	0.45	138	170
Fe 1.76	196	0.30	7.9	1.22	449	80
Ti 3.59	114	0.34	4.4	0.9	580	7-22
C 18.84	20	0	2.2	0.05 - 0.6	837	350





Collimator cooling (average temperature)

<u>Reynolds number</u>







F.Staufenbiel / ECFA-LC2013 / 29.05.2013