Parameters of Linac-Ring LHeC

LHC Design Meeting
2 March 2010, 11.25-11.45

Frank Zimmermann

parameter	symbol	nom.	nom.*	ult.	β*=30 cm, HI	β*=30,cm , CC	β*=14, cm HI	β*=14 cm, CC	LPA – 25	LPA – 50
transverse emittance	ε [μm]	3.75	3.75	3.75	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**	**3.75**
protons per bunch	N_b [10^{11}]	1.15	1.7	1.7	**2.3**	**1.6**	**2.3**	**1.6**	**2.6**	**4.2**
bunch spacing	Δt [ns]	25	50	25	**25**	**25**	**25**	**25**	**25**	**50**
beam current	I [A]	0.58	0.43	0.86	**1.16**	**0.81**	**1.16**	**0.81**	**1.32**	**1.06**
longitudinal profile		Gauss	Gauss	Gauss	**Gauss**	**Gauss**	**Gauss**	**Gauss**	**Flat**	**Flat**
rms bunch length	σ_z [cm]	7.55	7.55	7.55	**7.55**	**7.55**	**7.55**	**7.55**	**11.8**	**11.8**
beta* at IP1&5	β∗ [m]	0.55	0.55	0.5	**0.30**	**0.30**	**0.14**	**0.14**	**0.50**	**0.25**
full crossing angle	θ_c [μrad]	285	285	315	**348**	**(348)**	**[illegible]**	**(509)**	**339**	**381**
Piwinski parameter	$\phi=\theta_c\sigma_z/(2*\sigma_x*)$	0.65	0.65	0.75	**1.1**	**0.0**	**2.3**	**0.0**	**2.0**	**2.0**
tune shift	ΔQ_{tot}	0.009	0.0136	0.009	**0.01**	**0.01**	**0.006**	**0.01**	**0.01**	**0.01**
peak luminosity	L [10^{34} cm^{-2}s^{-1}]	1	1.1	2.3	**5.9**	**4.0**	**7.5**	**7.9**	**4.0**	**7.4**
peak events per #ing		19	40	44	**[illegible]**	**76**	**142**	**150**	**75**	**280**
initial lumi lifetime	τ_L [h]	23	16	15	**7.7**	**7.8**	**6.0**	**4.0**	**12.4**	**5.3**
effective luminosity ($T_{turnaround}$=10 h)	L_{eff}[10^{34} cm^{-2}s^{-1}]	0.45	0.43	0.90	**1.8**	**1.2**	**2.0**	**1.7**	**1.5**	**1.9**
	$T_{run,opt}$ [h]	21.5	17.7	17.2	**12.4**	**12.5**	**11.0**	**8.9**	**16.0**	**10.5**
effective luminosity ($T_{turnaround}$=2 h)	L_{eff}[10^{34} cm^{-2}s^{-1}]	0.67	0.68	1.41	**3.2**	**2.2**	**3.8**	**3.5**	**2.4**	**3.6**
	$T_{run,opt}$ [h]	9.6	7.9	7.7	**5.5**	**5.6**	**4.9**	**4.0**	**7.2**	**4.7**
e-c heat SEY=1.3	P_{ec} [W/m]	0.4	0.1	0.6	**1.3**	**0.7**	**1.3**	**0.7**	**1.4**	**0.8**
SR heat 4.6-20 K	P_{SR} [W/m]	0.17	0.13	0.25	**0.34**	**0.24**	**0.34**	**0.24**	**0.38**	**0.31**
image current heat	P_{IC} [W/m]	0.15	0.17	0.33	**0.60**	**0.29**	**0.60**	**0.29**	**0.39**	**0.51**
gas-s. 100 h τ_b	P_{gas} [W/m]	0.04	0.03	0.06	**0.08**	**0.05**	**0.08**	**0.05**	**0.09**	**0.07**
luminous region	σ_l [cm]	4.5	4.5	4.3	**3.7**	**5.3**	**2.2**	**5.3**	**5.2**	**3.8**
annual luminosity	L_{int}[fb^{-1}]	57	56	116	**245**	**169**	**286**	**253**	**198**	**274**

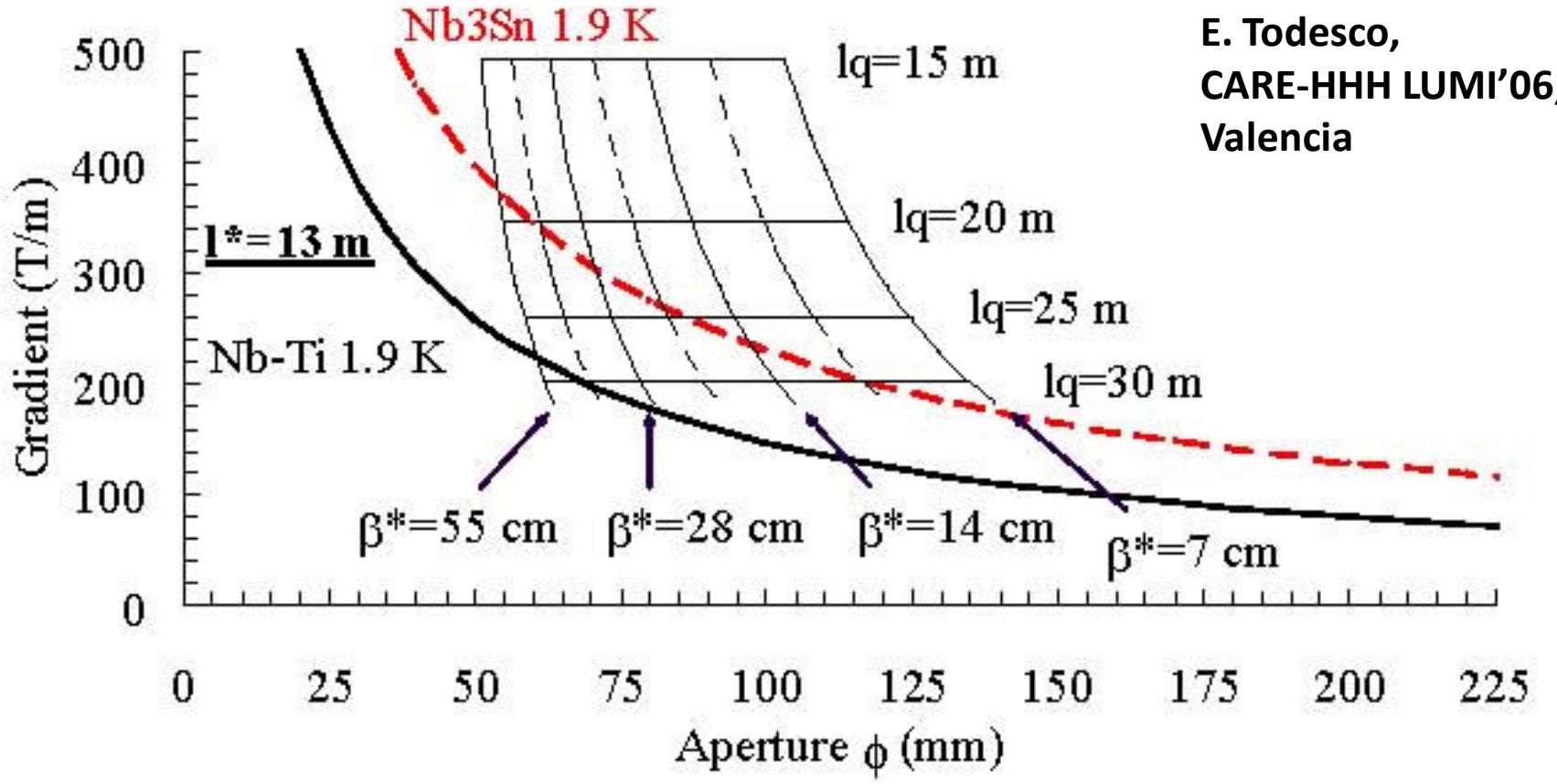
proton parameters	symbol	nominal	nominal*	LPA – 50
transverse emittance	ε [μm]	3.75	3.75	**3.75**
protons per bunch	N_b [10^{11}]	1.15	1.7	**4.2**
bunch spacing	Δt [ns]	25	**50**	**50**
beam current	I [A]	0.58	**0.43**	**1.06**
longitudinal profile		Gauss	Gauss	**Flat**
rms bunch length	σ_z [cm]	7.55	7.55	**11.8**
beta* at LH IP1 & 5	β^* [m]	0.55	0.55	**0.25**
beta* at LHeC IP	β^* [m]	0.10	0.10	**0.10**
full crossing angle	θ_c [μrad]	0	0	**0**
Piwinski parameter	$\phi=\theta_c\sigma_z/(2*\sigma_x^*)$	0.65	0.65	**2.0**
tune shift	ΔQ_{tot}	0.009	**0.0136**	**0.01**
peak luminosity	L [10^{34} cm^{-2}s^{-1}]	1	**1.1**	**7.4**
peak events per #ing (pp)		19	**40**	**280**
initial lumi lifetime (pp)	τ_L [h]	23	16	**5.3**
e-c heat SEY=1.3	P [W/m]	0.4	**0.1**	**0.8**
SR heat 4.6-20 K	P_{SR} [W/m]	0.17	0.13	**0.31**
image current heat	P_{IC} [W/m]	0.15	0.17	**0.51**
gas-s. 100 h τ_b	P_{gas} [W/m]	0.04	0.03	**0.07**
annual luminosity (pp)	L_{int}[fb^{-1}]	57	56	**274**

electron parameters	cheap	high-lumi	high-energy
e- energy [GeV]	60	60	140
luminosity [10^{32} $cm^{-2}s^{-1}$]	1.4	11.2	0.6
e- polarization	90%	90%	90%
bunch population [10^{9}]	4.9	2.0	2.0
bunch length [μm]	300	300	300
bunch interval [ns]	50	50	50
norm. emittance [μm]	50	50	100
average current [mA]	0.8	6.6 (η=90%)	0.33
repetition rate [Hz]	10	cw	10
beam pulse length [ms]	5	N/A	5
cryo power [MW]	1.5	21	6.7
total wall plug power [MW]	100	100	100

"nom.*" assumed; luminosity would be 33% lower for nominal, 2.35x higher for LPA-50

concerning β^*

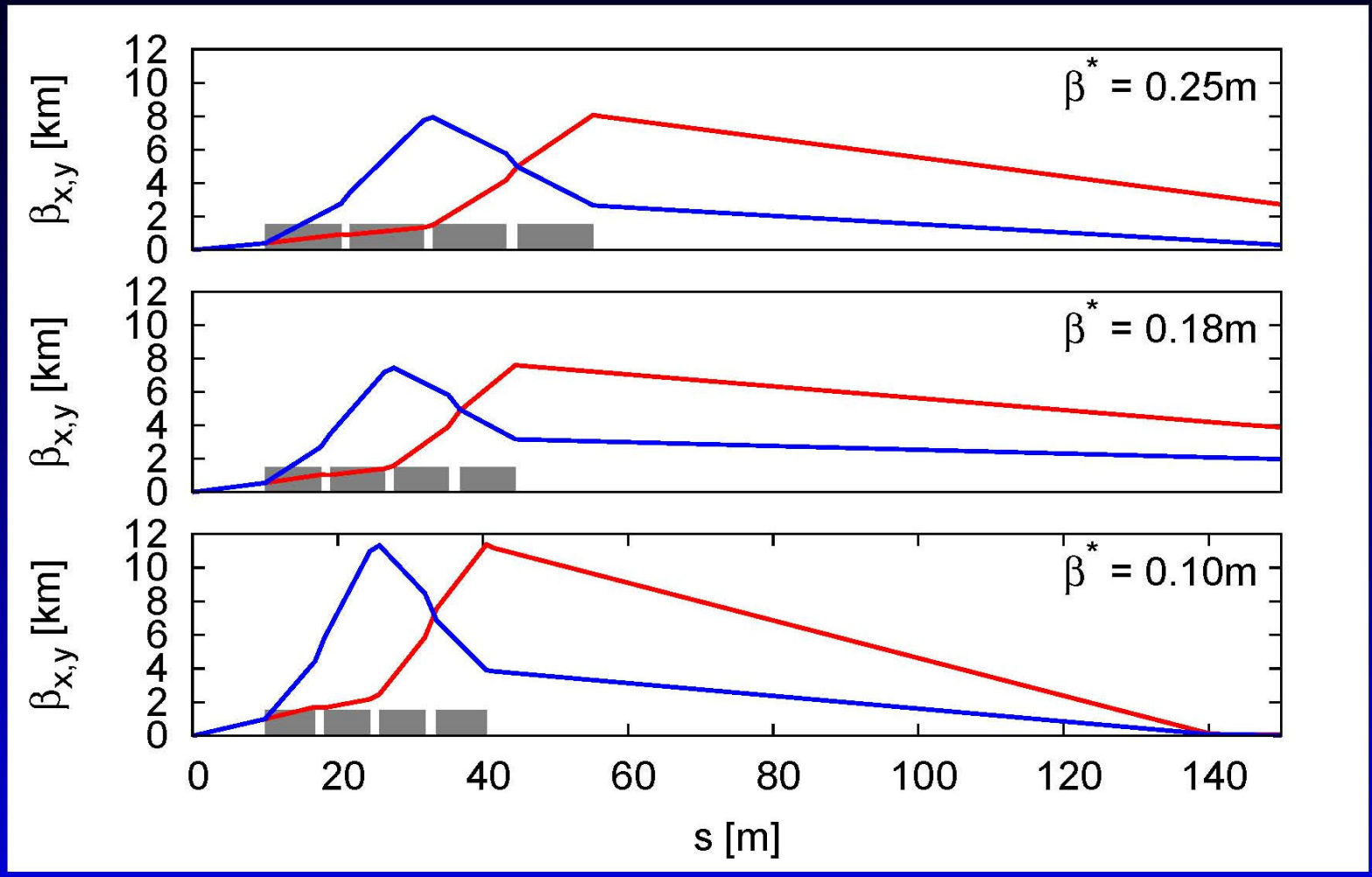
- optics solution from Rogelio Tomas exists for β^*=10 cm, l^*=10 m, and single beam
- earlier scaling law from Ezio Todesco demonstrated β^*=11 cm with both beams squeezed, l^*=13 m, and Nb_3Sn magnets
- we only need to squeeze one beam, and l^* is even shorter than Ezio's
- local chromatic correction desirable, to be studied



E. Todesco, CARE-HHH LUMI'06, Valencia

$\beta^* = 11$ cm at $l^* = 13$ m with 2 beams - confirmed at HHH-2008

Proton triplet options (L*=10m) I



Rogelio Tomas, Divonne 2009

Proton triplet options (L*=10m) II

	Q_1			Q_2			
β^*	Aper	Grad	B_p	Aper	Grad	B_p	ξ
[m]	[mm]	[T/m]	[T]	[mm]	[T/m]	[T]	
0.25	23	176.7	4.0	32	115.0	3.7	635
0.18	23	264.5	6.0	32	180.0	5.7	660
0.10	26	318.6	8.4	36	250.0	9.1	1250

Aperture = 11σ + 10mm

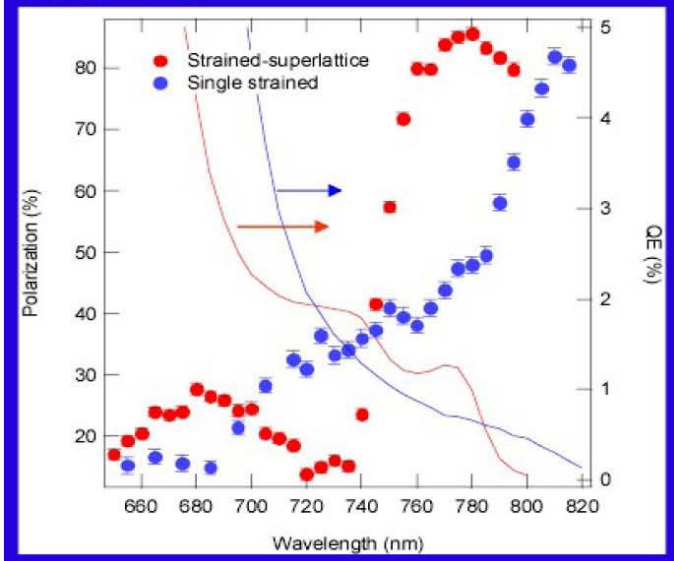
$\beta^* = 0.18$m seems feasible today

$\beta^* = 0.1$m reachable with new technologies (Nb_3Sn, NbAl, ?) and some chromaticity correction scheme.

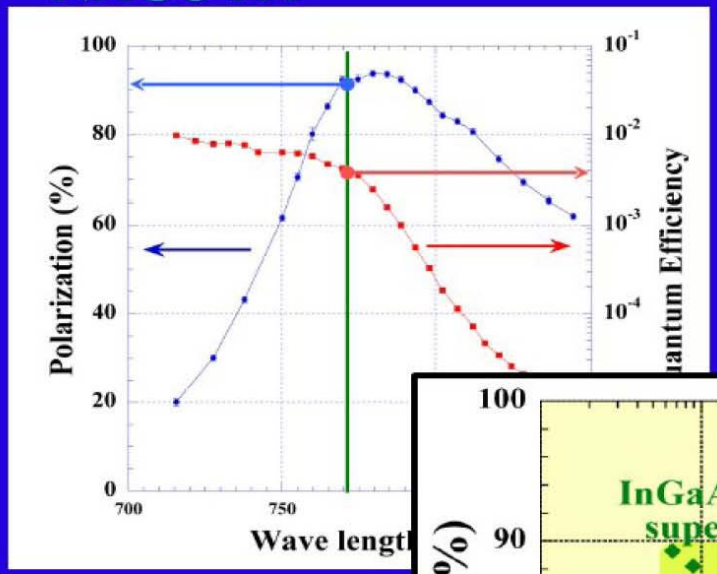
Rogelio Tomas, Divonne 2009

Performance of GaAs/GaAsP superlattice

SLAC



NAGOYA



By N. Yamamoto
(Nagoya Univ.)

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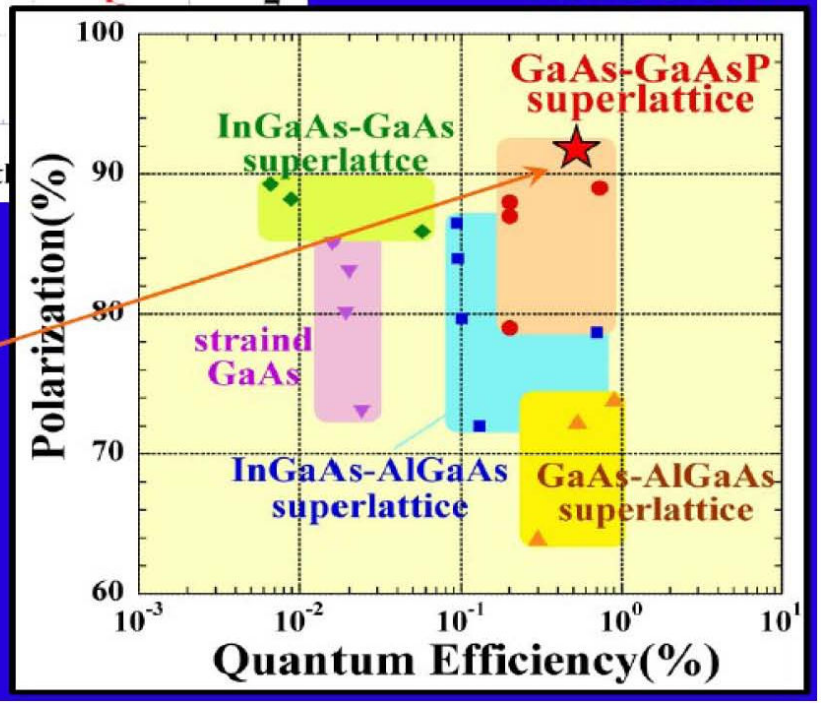

GaAs-GaAsP superlattice shows
the best performance !

@778nm

Polarization ~ 90%
Q.E. ~ 0.5%

M. Kuriki

high polarization → low quantum efficiency? not always