Injectors and Damping rings

Working group

Summary

S. Guiducci (INFN), L. Rinolfi (CERN)

Wednesday 17th October

13:40->18:40 Injector & Damping Rings Wkg

(Convener: Susanna Guiducci (*INFN*) , Louis Rinolfi (*CERN*)) (Location: 40-S2-B01_)

13:40	CLIC Injector Complex Review and Status (25')	Louis RINOLFI (*CERN*)
14:05	Discussion (10')	
14:15	Conventional Positron Sources (15')	Robert Chehab (*IPN-LYON-IN2P3)*
14:30	Discussion (10')	
14:40	Beam Dynamics in CLIC Injector Linacs (20')	Arnaud Ferrari (*Uppsala Univ*)
15:00	Discussion (10')	
15:10	Bunch Compressors and Turn Around for CLIC (20')	Frank Stulle (*PSI*)
15:30	Discussion (10')	
15:40	Coffee break	
16:10	Polarized Electrons Source (25')	Matt Poelker (*Jefferson Lab*)
16:35	Discussion (10')	
16:45	Compton Schemes for Polarized e+ (25')	Alessandro Variola (*LAL*)
17:10	Discussion (10')	
17:20	Latest Parameter Changes, Consequences and Issues (15')	Steffen Doebert (*CERN*)
17:35	Discussion (10')	
17:45	General Discussion (25')	

CLIC

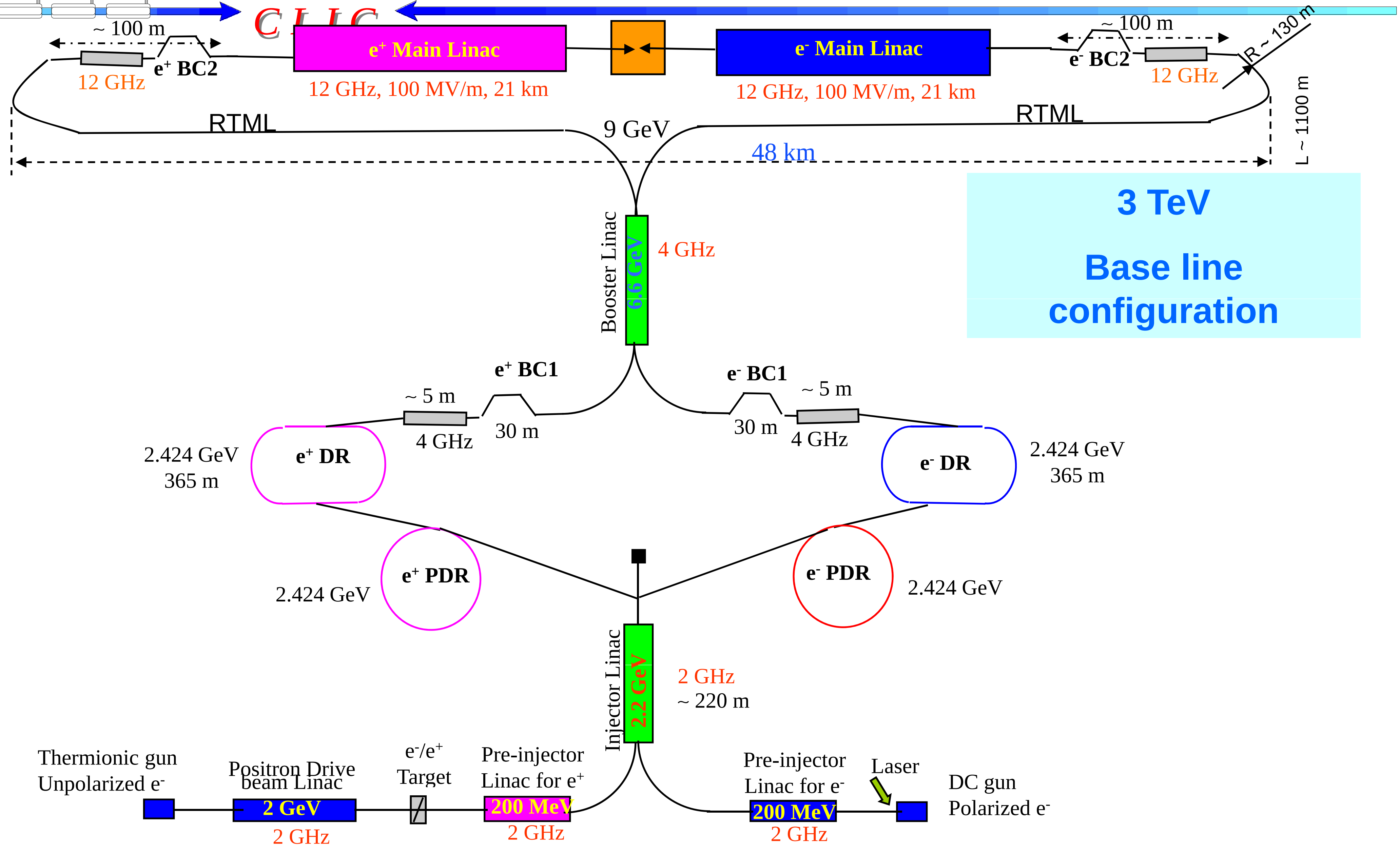
Thursday 18th October

08:45->12:05 Injectors & Damping Rings Wkg

(Convener: Susanna Guiducci (*INFN*) , Louis Rinolfi (*CERN*)) (Location: 513-1-023_)

08:45	CLIC Damping Rings Overview and Open Issues (20')	Yannis Papaphilippou (*CERN*)
09:05	Discussion (10')	
09:15	Status of Studies at BINP for the CLIC DR (20')	Evgeni Levitchev
09:35	Discussion (10')	
09:45	Superconductive Wiggler (20')	Robert Rossmanith (*ANKA*)
10:05	Discussion (10')	
10:15	Coffee break	
10:45	IBS and Polarisation (20')	Frank Zimmermann (*CERN*)
11:05	Discussion (10')	
11:15	Summary of the IBS Workshop at Cockcroft Institute (20')	Michel Martini (*CERN*)
11:35	Discussion (10')	
11:45	Summary of Working Group (15')	Louis RINOLFI (*CERN*) , Susanna Guiducci (*INFN*)

The CLIC Injector complex in October 2007



CLIC Main beam parameters

At the entrance of the Main Linac for e^- and e^+

		NLC (1 TeV)	**CLIC 2007 (October)**
E	GeV	8	9
N	10^9	7.5	3.72 - 4
n_b	-	190	312
Δt_b	ns	1.4	0.5 (6 RF periods)
t_{pulse}	ns	266	156
$\varepsilon_{x,y}$	nm, nm	3300, 30	600, 10
σ_z	µm	90-140	43 - 45
σ_E	%	0.68 (3.2 % FW)	1.5 - 2
f_{rep}	Hz	120	50
P	kW	219	90

CLIC e^- Beam Source Parameters

(October 2007)

Parameter	Symbol	CLIC
Number Electrons per microbunch	N_e	6 x 10^9
Number of microbunches	n_b	312
Width of microbunch	t_b	~ 100 ps
Time between microbunches	Δt_b	500.2 ps
Microbunch rep rate	f_b	1999 MHz
Width of macropulse	T_B	156 ns
Macropulse repetition rate	f_{rep}	50 Hz
Charge per micropulse	C_b	0.96 nC
Charge per macropulse	C_B	300 nC
Average current from gun (C_B x F_B)	I_{ave}	15 uA
Average current macropulse (C_B / T_B)	I_B	1.9 A
Duty Factor w/in macropulse (100ps/500ps)	DF	0.2
Peak current of micropulse (I_B / DF)	I_{peak}	9.6 A

Best surface charge limit @ Nagoya

9.7 A/cm^2 for 780 nm, 30 ps

CLIC current density bigger to these values…something to worry about

=> $J = 12.1$ A/cm^2

CLIC Conventional e^+ source (October 2007)

Parameter	Unit	CLIC
Primary Beam		
Energy (E)	GeV	2
N e^- /bunch (N)	10^9	11
N bunches / pulse	-	312
Pulse length	ns	156
Repetition frequency	Hz	50
Beam power	kW	55
Linac frequency	GHz	2
Beam radius (rms) ($\sigma_{x,y}$)	mm	2
Bunch length (rms) (σ_z)	mm	3

Parameter	Unit	
Target		
Material		$W_{75}Re_{25}$
Length (4 χ_0)	mm	14
Beam power deposited	kW	13.6
Deposited P / Beam Power	%	25
Pulse energy density per area	10^{12} GeV/mm^2	0.54
Energy lost per volume	10^{10} GeV/mm^3	1.0
Peak energy deposition density	J/g	87.5

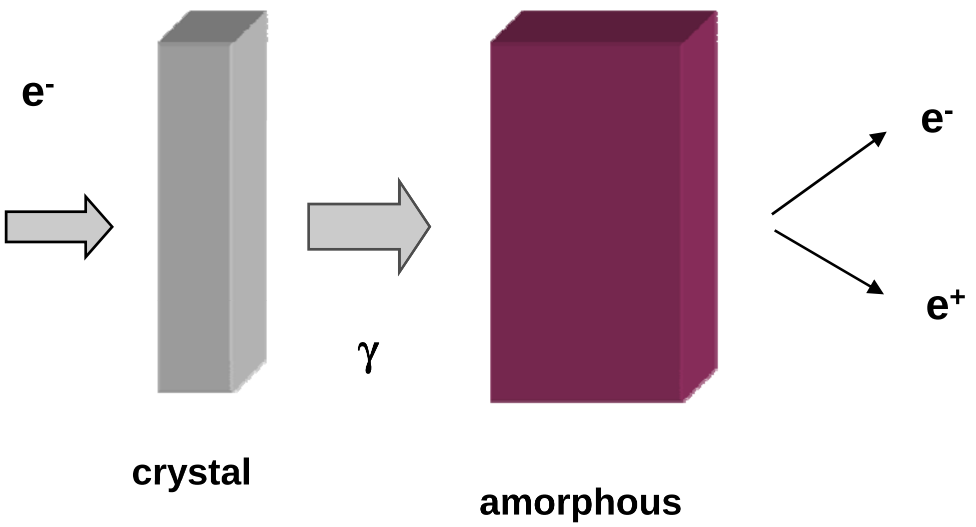
Limit from SLAC target: 35 J/g => a triple target

SOLUTION IS A CRYSTAL POSITRON SOURCE

- A e- beam impinges on the crystal:
  - energy of 5 GeV
  - beam size of 2.5 mm

Yield: 0.9 e^+ / e^-

- A crystal e+ source :
  - a 1.4 mm thick W crystal oriented along <111> axis
  - a 8 mm thick W amorphous disk



- Charged particles are swept off after the crystal:only γ (> 2MeV) impinge on the amorphous target.

- The distance between the 2 targets is 3 meters.

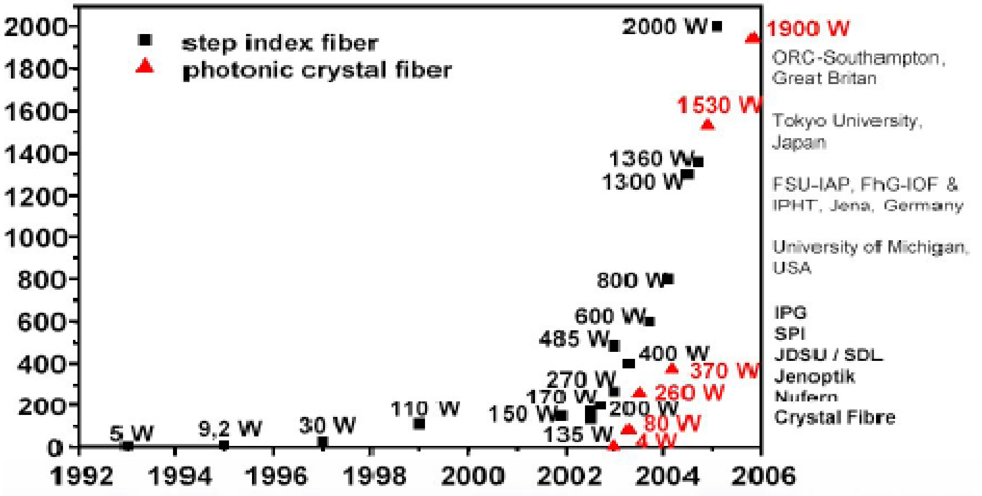
=> A single target station

Compton polarized positron source

EXAMPLE : FIBER LASER

INSTITUT d'OPTIQUE GRADUATE SCHOOL

State of the art



- High average power femtosecond fiber amplifier
  Röser et al., Opt. Lett., vol. 30, no. 20 (2005) Jena group (J. Limpert)
  131 W 220 fs 73 MHz
- High energy femtosecond fiber amplifier
  Liao et al. CLEO 2006 postdeadline CPDB4 Michigan group (A. Galvanauskas)
  500 µJ 520 fs 5 kHz
- Review paper
  Tunnermann et al., Topics in applied physics vol. 96, pp.35-53 (2004)

CW fiber laser output power

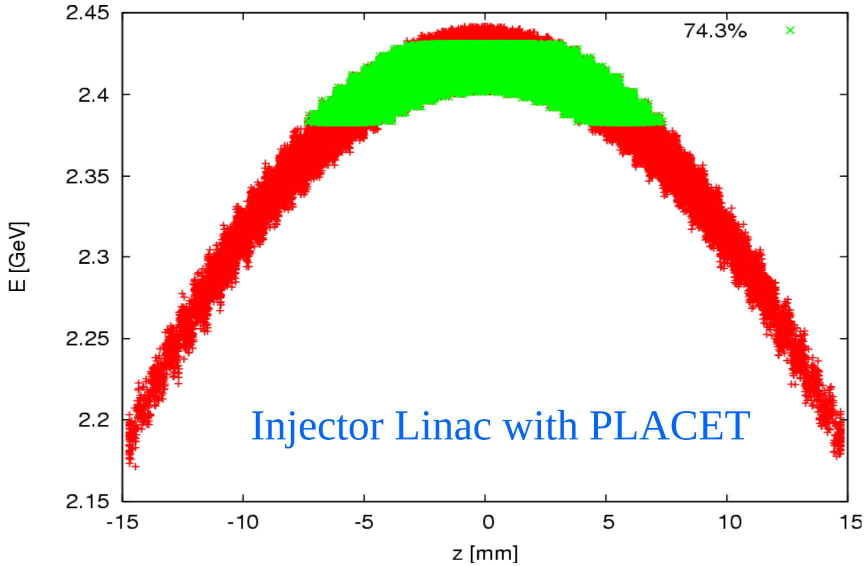
Transverse monomode

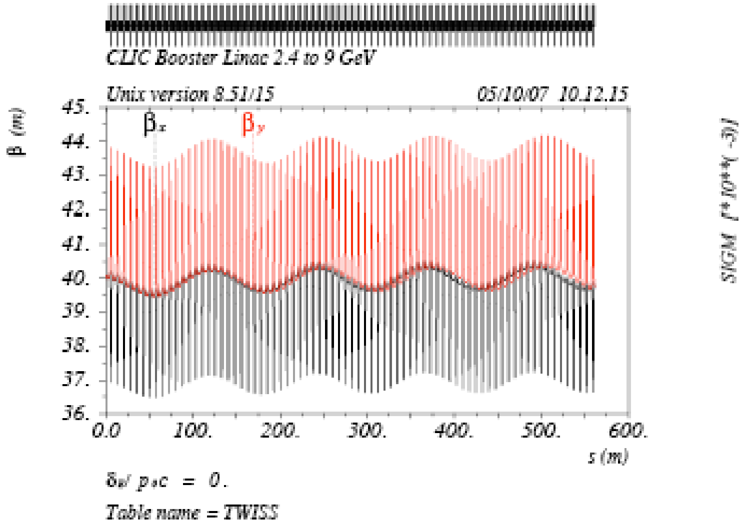
R&D for the kW regime + lock to FP cavity

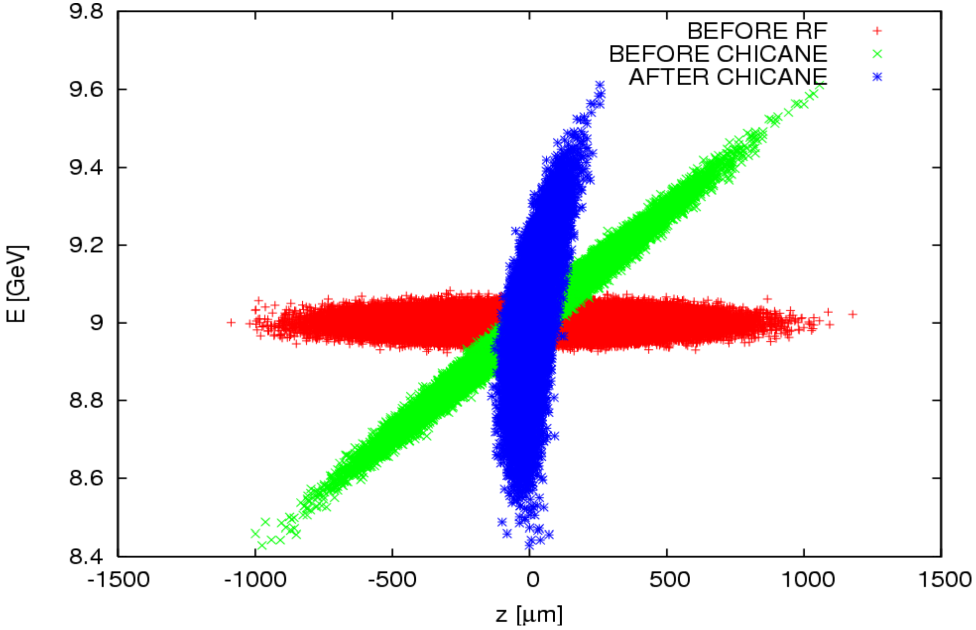
Compton polarized positron source

- Compton Schemes are extremely attractive for the polarized positron sources since they present many advantages on the undulator schemes
- Need of strong R&D on lasers and cavities
- Careful optimization of the interaction point is necessary
- CLIC is a machine that can surely benefit from these schemes.

Linacs and bunch compressors



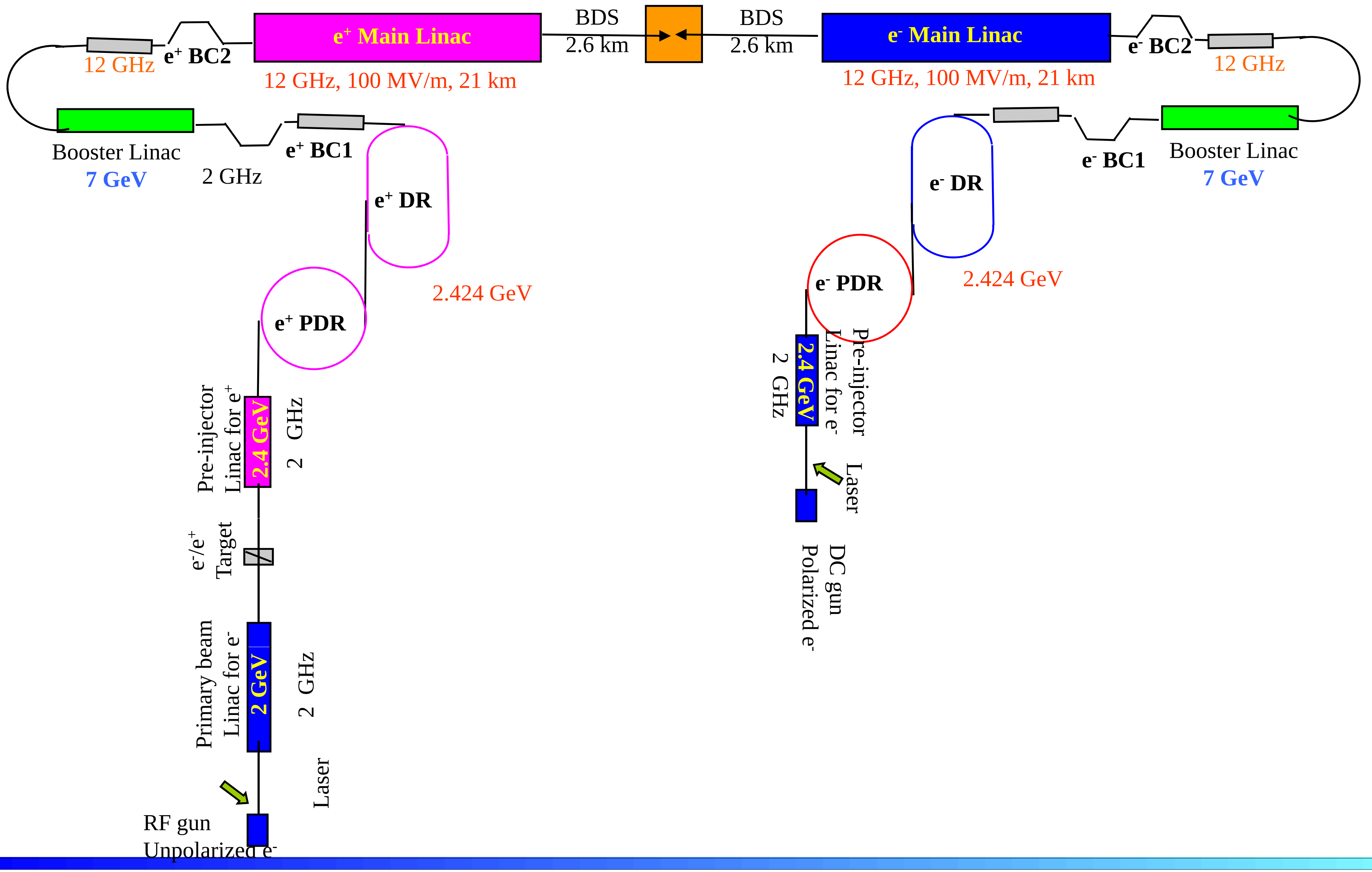




Design done for 1.5 GHz

To be revisited for 2 GHz

Central vs Local Injectors ?



Damping rings

Parameter	Unit	CLIC 2006 Note 627	CLIC 2007 (October)
Energy (E)	GeV	2.424	2.424
No. of particles/bunch (N)	10^9	2.6	4.1
Bunch length (rms) (σ_z)	mm	1.55	1.53
Energy Spread (rms) (σ_E)	%	0.13	0.134
Longitudinal emittance (ε_l)	eV.m	4980	4996
Horizontal emittance ($\gamma\varepsilon_x$)	nm. rad	550 **(450) (*)**	381 **(540) (*)**
Vertical emittance ($\gamma\varepsilon_y$)	nm. rad	3.3 **(3)(*)**	4.1 **(5)(*)**

(*) Goal

- Very challenging since it aims at ultra low transverse and longitudinal emittance
- New regime with respect to operating rings:
  - Wiggler dominated
  - IBS dominated
  - Ultra short bunch distance
    - High RF frequency 2 GHz
    - Ultra short bunch length

Many issues already addressed

- Lattice design and optimization with IBS
- Wiggler parameters optimization
- Present lattice satisfies emittance requirements
- Many beam dynamics studies performed and others are in progress:
  - dynamic aperture, e^- cloud, fast ion, impedance
  - IBS studies: workshop, IBS and polarization, complete Hamiltonian treatment (CI)
- Two different wiggler designs: BINP and ANKA

Concluding remarks

Y. Papaphilippou

- Detailed and robust design of the CLIC damping rings, delivering target emittance with the help of super-conducting wigglers
  - Prototype to be built and tested at ANKA synchrotron
  - Radiation absorption and quench protection
- Areas needing further optimisation and/or detailed studies
  - Pre-damping ring optics design
  - Realistic damping ring cell length and magnet parameters
  - Sextupole optimisation and non-linear dynamics including wiggler field errors
    - Linear and non-linear correction schemes
  - Low emittance tuning and alignment tolerances
  - IBS theory, numerical tools and experimental demonstration of low emittance
  - Collective effects including electron cloud and fast ion instability
    - Detailed vacuum chamber design – impedance budget
  - Injection and extraction elements
  - Design of HOM free high frequency RF cavities
  - Diagnostics and feedback

Summary of the summary

1) A complete review of the Injector complex is necessary.

2) A design of the Pre-dampings is urgently needed (for e^+ and e^-) and many issues for the Damping rings (emittances, IBS,e^- cloud,…) remain to be studied.

3) A review of the options for polarized e^+ strongly recommended.

4) CLIC Lattice repository

http://clicr.web.cern.ch/CLICr/