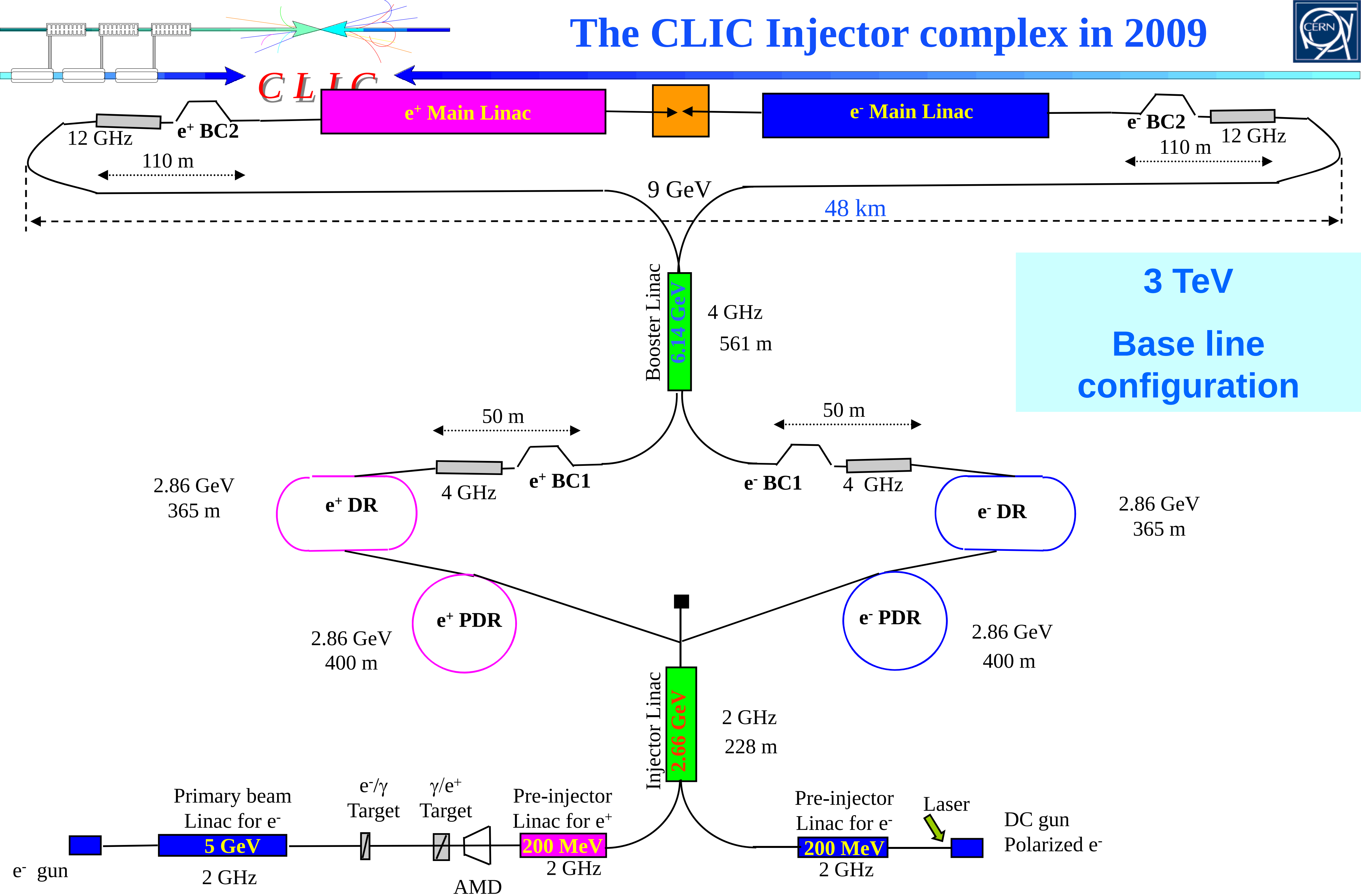
Capture and acceleration study for the CLIC e^+ source

L. Rinolfi

With contributions from

R. Chehab, P. Lepercq, V. Strakhovenko, A. Variola, A. Vivoli

The CLIC Injector complex in 2009



3 TeV

Base line configuration

Estimation of transport efficiency for e^+ beam

	# of bunches per pulse	# of positrons per bunch	# of positrons per pulse	Total charge (nC)	Current (A)
Exit of BC2 = Entrance of Main Linac (9 GeV)	312	4×10^9	1.24×10^{12}	200	1.3
At exit Pre- Damping ring (2.424 GeV)	312	4.4×10^9	1.37×10^{12}	220	1.4
At exit Injector Linac (2.424 GeV)	312	6.4×10^9	2×10^{12}	319	2
At exit Pre- Injector Linac (200 MeV)	312	6.7×10^9	2.1×10^{12}	334	2.1

Assuming ~ 90 % efficiency between the PDR and the Main Linac

Assuming ~ 70 % capture efficiency in the PDR => **this efficiency would be improved**

Assuming ~ 95 % efficiency between the Pre-Injector and the Injector Linac

Primary electron beam

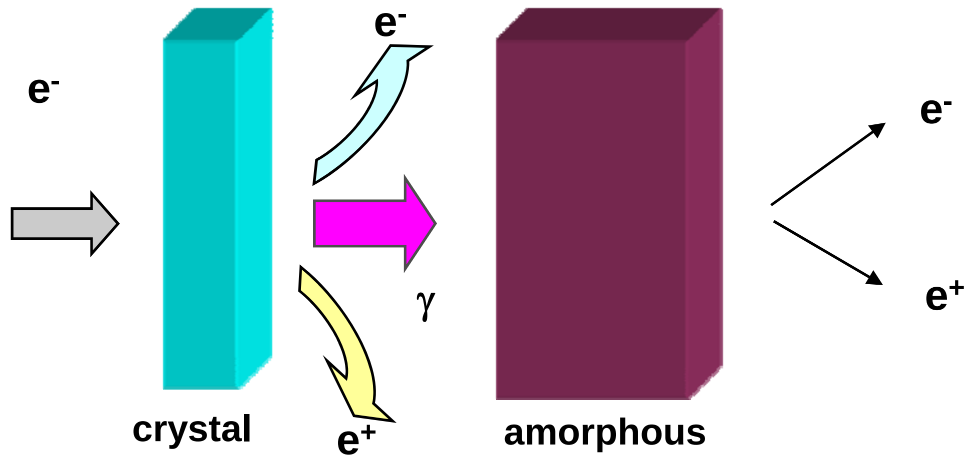
Parameter	Unit	CLIC
Primary e⁻ Beam		
Energy	GeV	5
N e⁻ /bunch	10^9	7.5
N bunches / pulse	-	312
N e⁻ / pulse	10^{12}	2.34
Pulse length	ns	156
Repetition frequency	Hz	50
Beam power	kW	94
Beam radius (rms)	mm	2.5
Bunch length (rms)	mm	0.3

Electron beam parameters on the crystal target

The bunch charge is based on yield of 0.9 e^+/e^-.

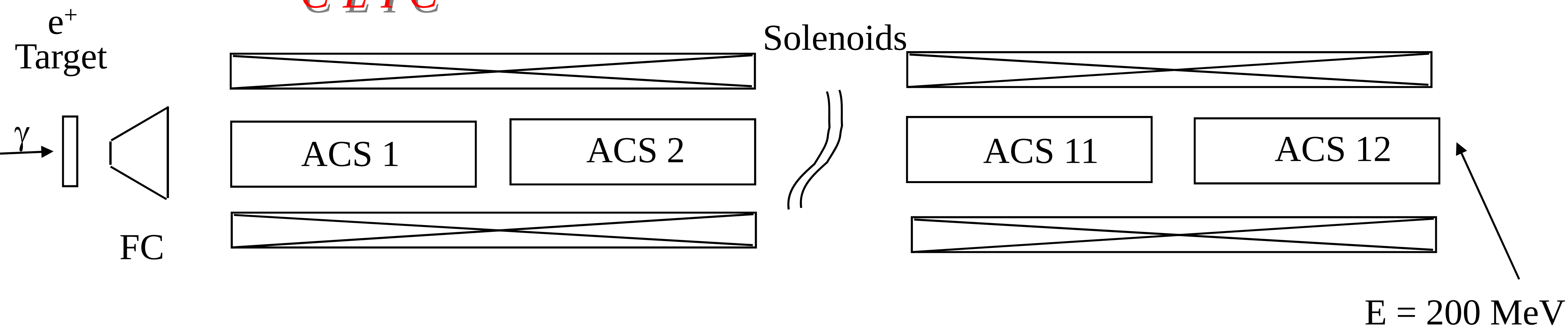
CLIC e^+ targets

Crystal e+ source : a 1.4 mm thick W crystal oriented along <111> axis



Parameter	Unit		
Target		Crystal	Amorphous
Material		W	W
Length	mm	1.4	10
Beam power deposited	kW	0.2	7.5
Deposited P / Beam Power	%	0.2	8
Energy lost per volume	10^9 GeV/mm^3	0.8	1.9
Peak energy deposition density (PEDD)	J/g	6.8	15.5

Pre-Injector Linac for e^+



PARMELA simulations

Accelerating Structures (ACS):

$G \cong 10$ MV/m   L = 1.8 m   Radius = 0.018 m   f = 2 GHz

ASTRA simulations

Accelerating Structures (ACS):

$G \cong 10$ MV/m   L = 3 x 0.60 m   Radius = 0.020 m   f = 2 GHz

Adiabatic Matching Device for e^+

		(A)	(B)	(C)
Magnetic field for FC	T	7	6	6
FC length	m	0.21	0.50	0.20
Solenoid magnetic field	T	0.5	0.5	0.5
Pre-accelerator length	m	15	30	35
Cavities frequency	GHz	1.5 Scaled from LIL	2 Scaled from CTF3	2 P. Lepercq design (LAL)
Accelerating electric field	MV/m	25	10	10

(A) CLIC parameters in CLIC Note 465

(B) (B) PARMELA simulations

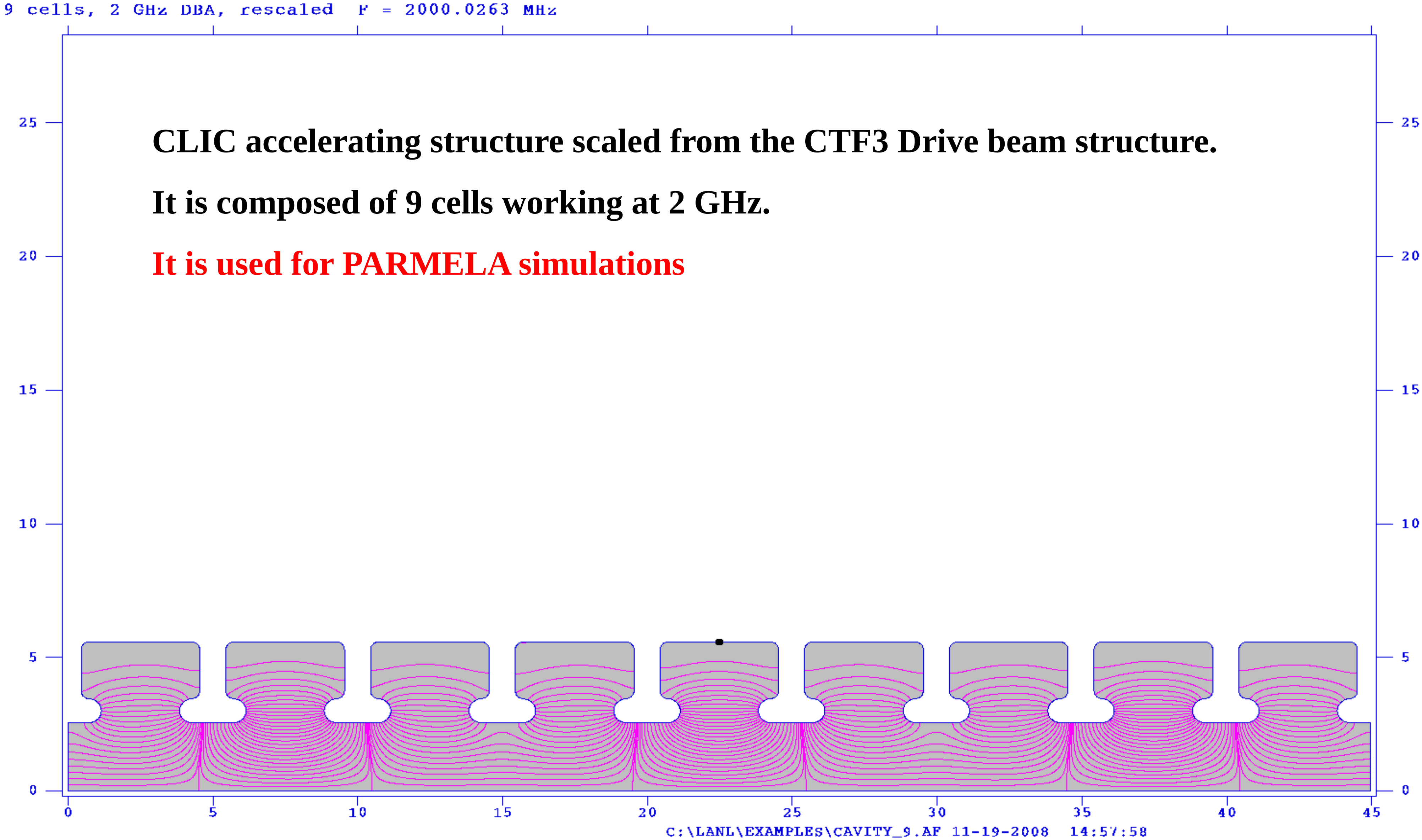
(C) ASTRA simulations

SUPERFISH simulations

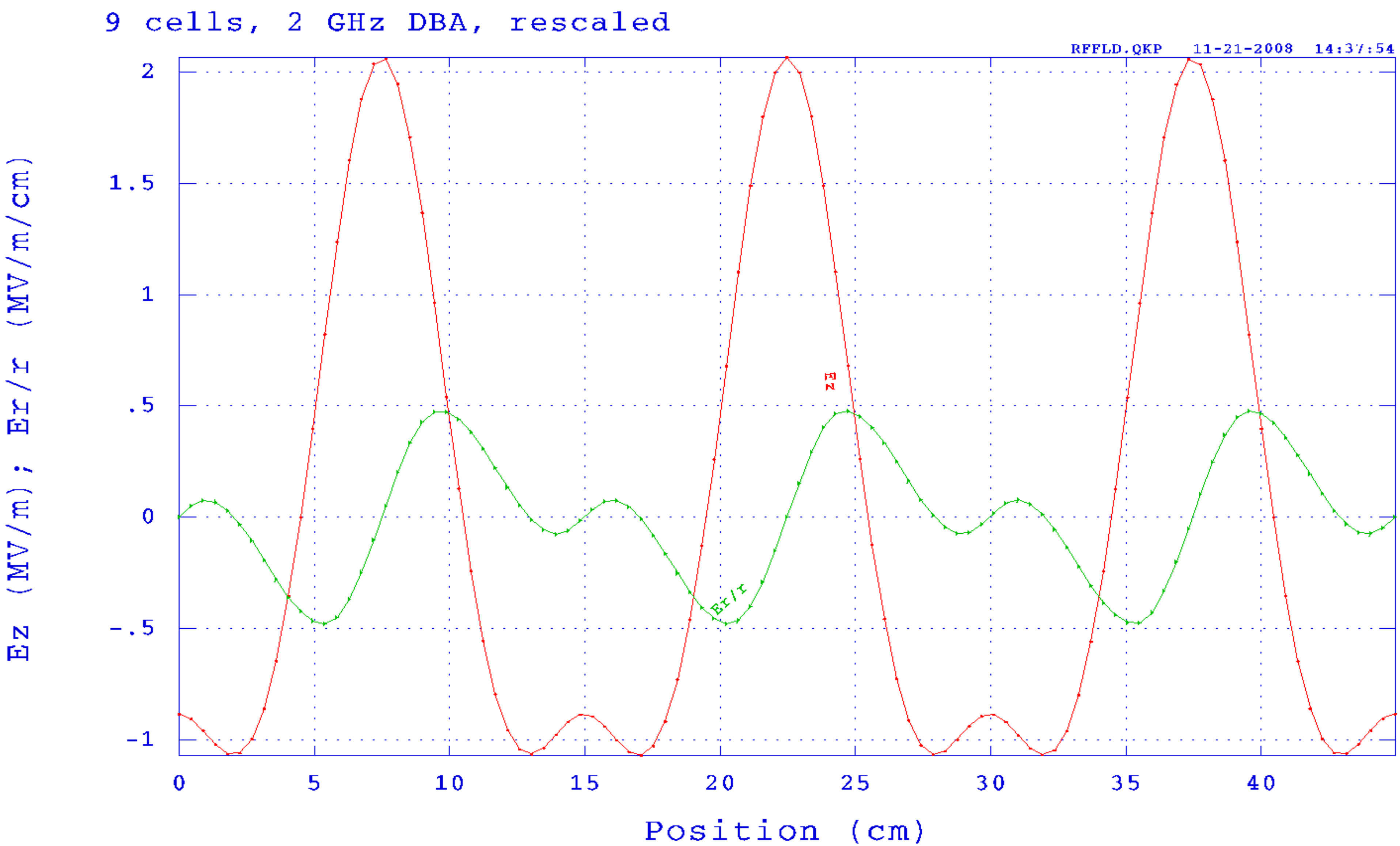
CLIC accelerating structure scaled from the CTF3 Drive beam structure.

It is composed of 9 cells working at 2 GHz.

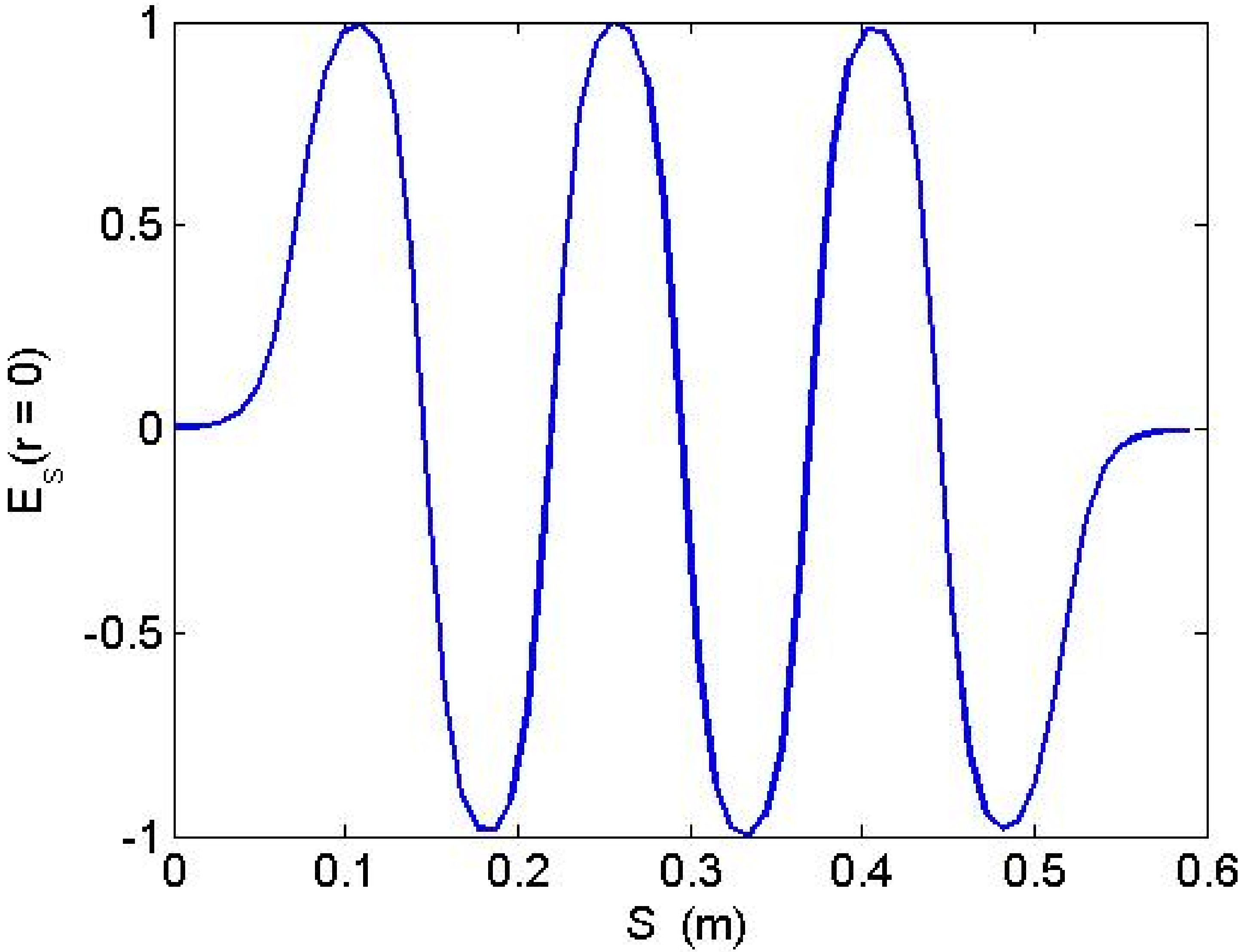
It is used for PARMELA simulations



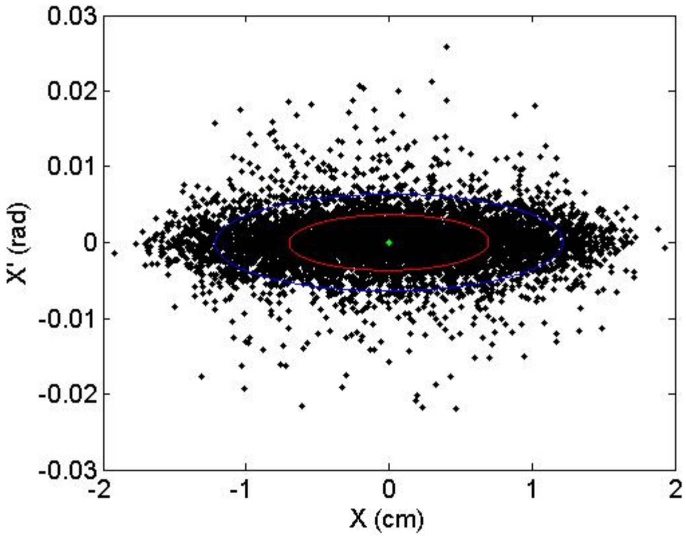
Electric field used for PARMELA simulations

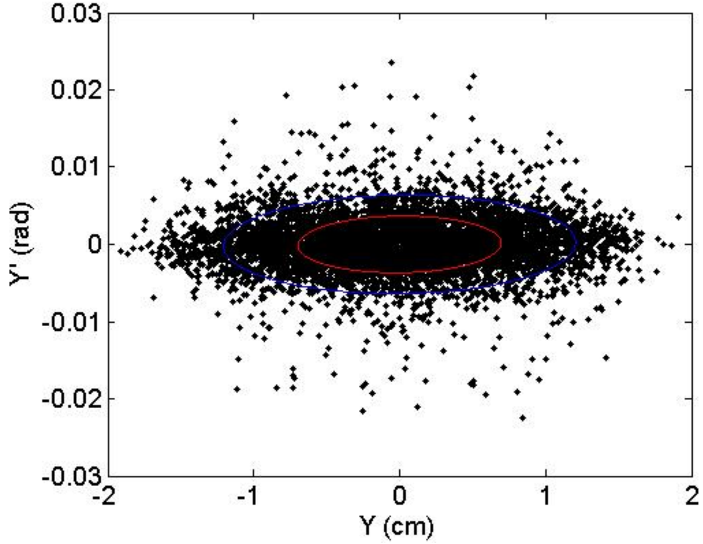


Electric field used for ASTRA simulations

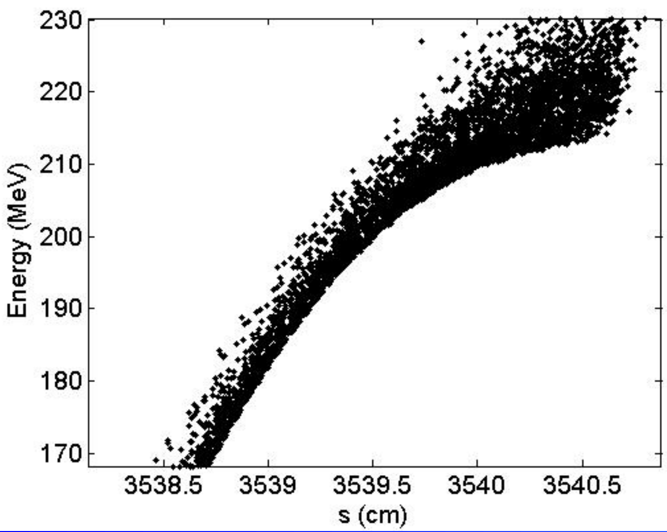


Results of ASTRA simulations @ 200 MeV



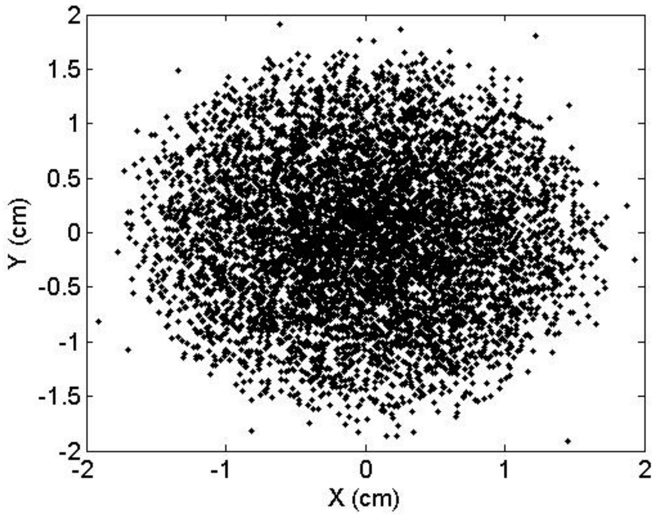


Transverse phase spaces



Longitudinal phase space

Physical space



CLIC beams parameters for e^+

At the exit of Injector Linac

		PARMELA	ASTRA
E	MeV	200	200
n_{e-}	-	6000	6000
n_{e+}	-	4838	6246
Yield (n_{e+} / n_{e-})	-	0.80	1.04
$\gamma\varepsilon_{x,y}$	mm.mrad	6500	10020
$\gamma\varepsilon_z$	10^{-4} eV.s	6.15	7.1
σ_z	mm	9.5	9.9
σ_E	MeV	20	22
N_{e+} / *bunch @ 200 MeV (Requested today)*	10^9	6.7	6.7
N_{e-} / *bunch @ 5 GeV (Primary beam on target)*	10^9	8.4	6.4

Summary

1) Parameters for RF cavities working at 2 GHz are defined.

2) Simulations of e^+ capture and acceleration up to 200 MeV performed with PARMELA and ASTRA.

3) Previous parameters defined for the e^+ target are consistent with the results of the present simulations.

4) Simulations are on going up to 2.86 GeV (entrance of the Pre-Damping Ring).

5) The goal is optimize the e^+ beam parameters at 2.86 GeV in order to increase the injection efficiency into the ring.

6) A crucial study for e^+ source remains to be done for CLIC-500 GeV where the bunch charge is doubled