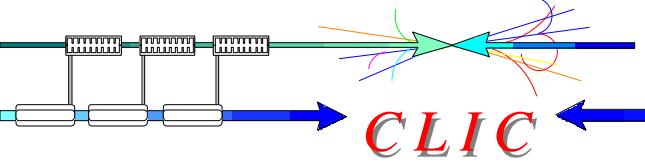
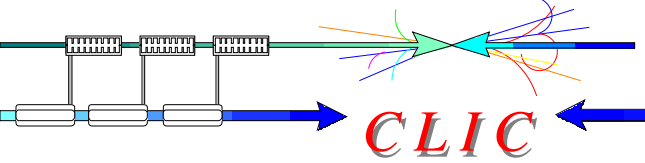


Positron source for CLIC using hybrid targets

L. Rinolfi

Thanks to:

X. Artru, R. Chehab, O. Dadoun, E. Eroglu, T. Kamitani, M. Kuriki, P. Lepercq, T. Omori, F. Poirier, V. Strakhovenko, T. Takahashi, J. Urakawa, A. Variola, A. Vivoli



CLIC Main Beam e^+ generation

CLIC Main Beams generation: 4 studies are ongoing to produce $e^+$with the requested parameters at the entrance of the Pre-Damping Ring (PDR):

1) Baseline configuration:

3 TeV (c.m.) : *7.6x10⁹* e^+/bunch (Oct. 2009) Pulse of 156 ns long with 312 bunches

2) Double charge configuration:

500 GeV (c.m.): *15.2x10⁹* e^+/bunch. Pulse of 177 ns long with 354 bunches

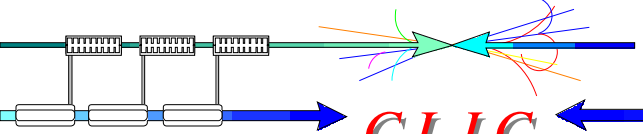
3) Polarized positron configuration:

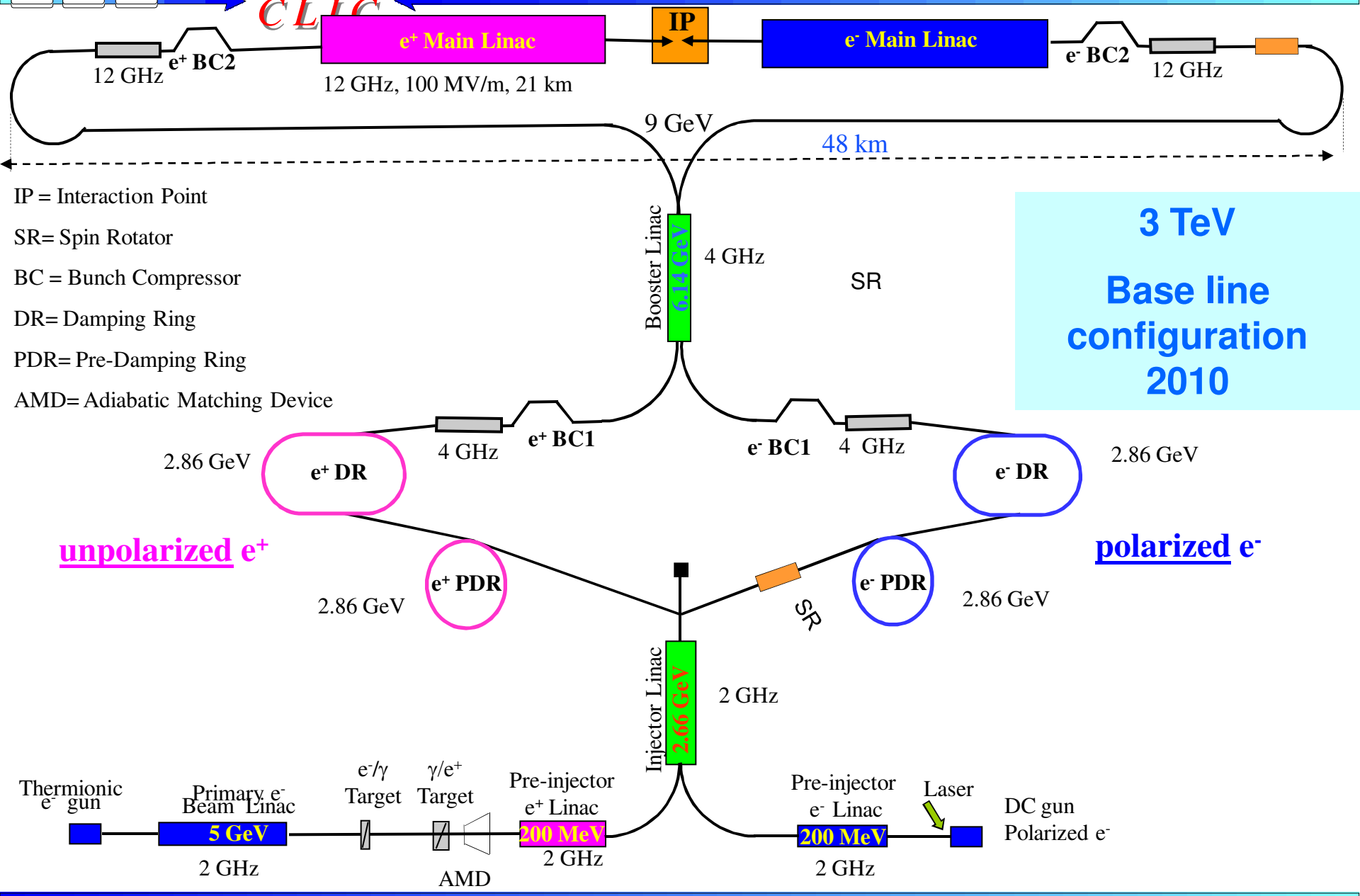
3 TeV (c.m.) - polarized e^+ with same parameters as for the baseline

4) Low energy configuration (< 3 TeV):

4.1) Unpolarized e^+ with the highest repetition frequency
4.2) unpolarized e^+ with half the baseline charge but 800 bunches

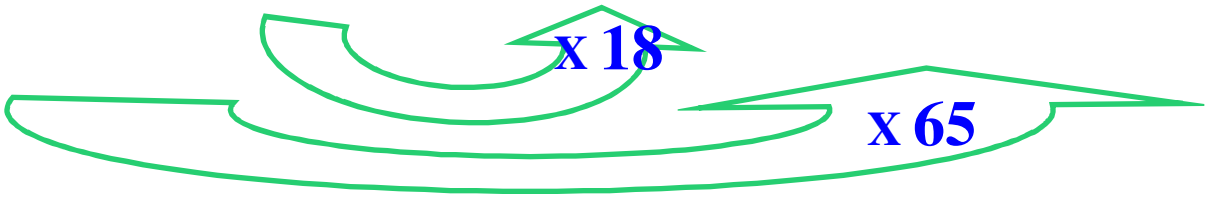
CLIC Main Beam Injector Complex



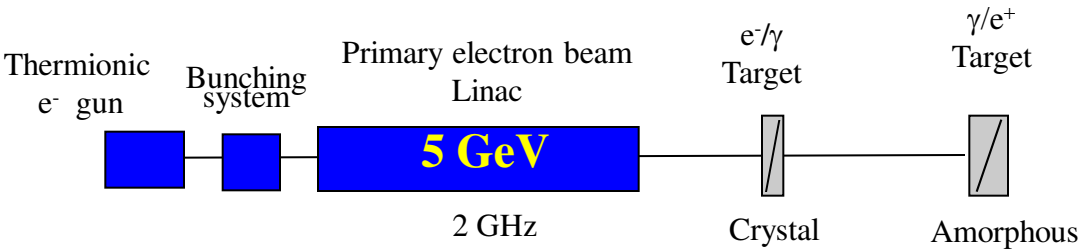


Flux of e^+

	SLC	CLIC (3 TeV)	ILC (RDR)	LHeC
Energy	1.19 GeV	2.86 GeV	5 GeV	100 GeV
e^+/ bunch	50×10^9	7.6×10^9	30×10^9	15×10^9
Bunches / macropulse	1	312	2625	20833
Macropulse Rep. Rate.	120	50	5	10
e^+ / second	0.06×10^{14}	1.1×10^{14}	3.9×10^{14}	31×10^{14}



Primary Electron Beam Linac



Parameter for 3 TeV	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

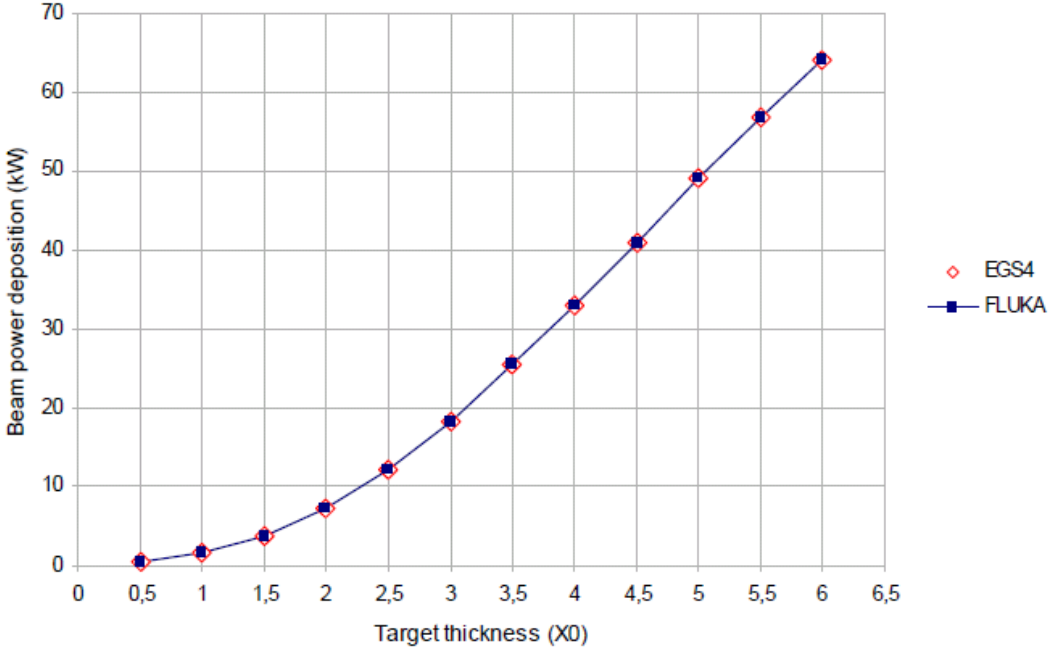
October 2009

With a yield of 1 e^+/e^- at 200 MeV , the requested charge is 7.5 x10^9 e^-/bunch on the target.

Simulations for a W target

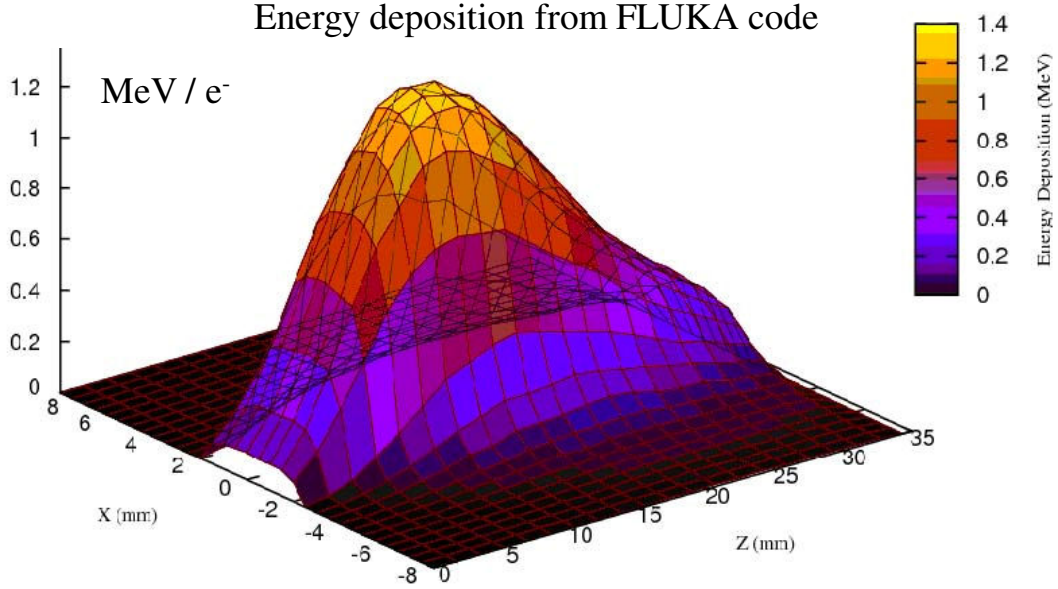
EGS4: T. Kamitani / KEK

FLUKA: E. Eroglu / Uludag University



Excellent agreement
between EGS4 and FLUKA

Energy deposition from FLUKA code



<u>Amorphous W target (CLIC Note 465):</u>

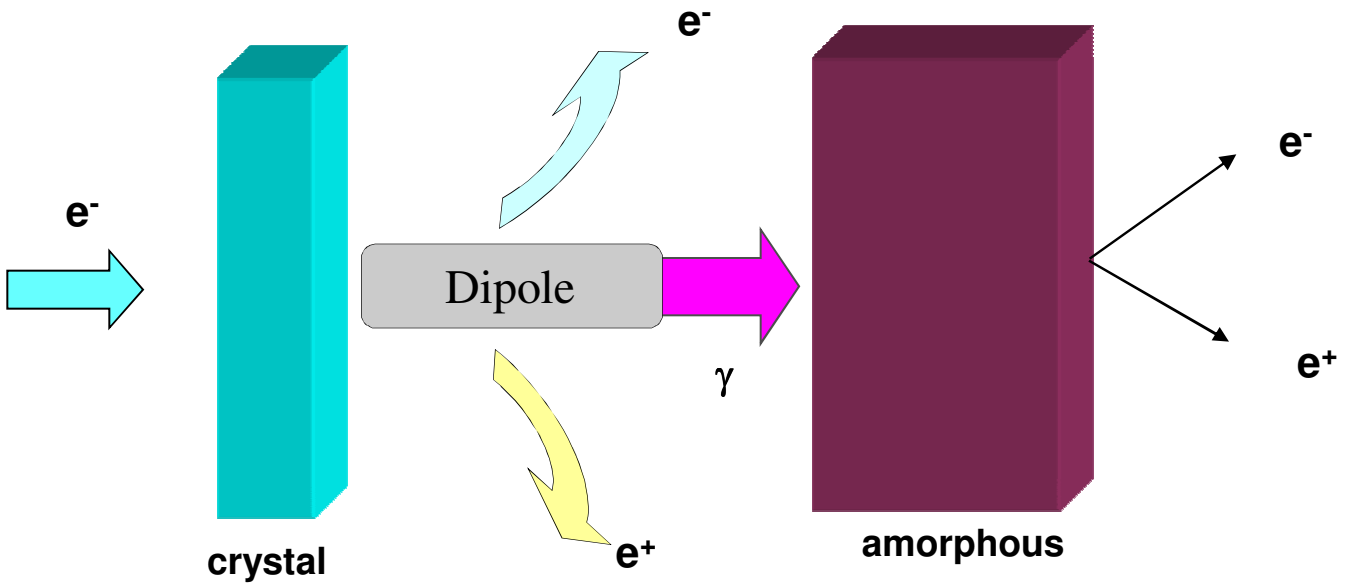
Electron beam energy: 2 GeV

Charge: 2×10^{12} e^-/pulse

Repetition frequency: 200 Hz

Concept of hybrid targets

R. Chehab, V. Strakhovenko, A. Variola

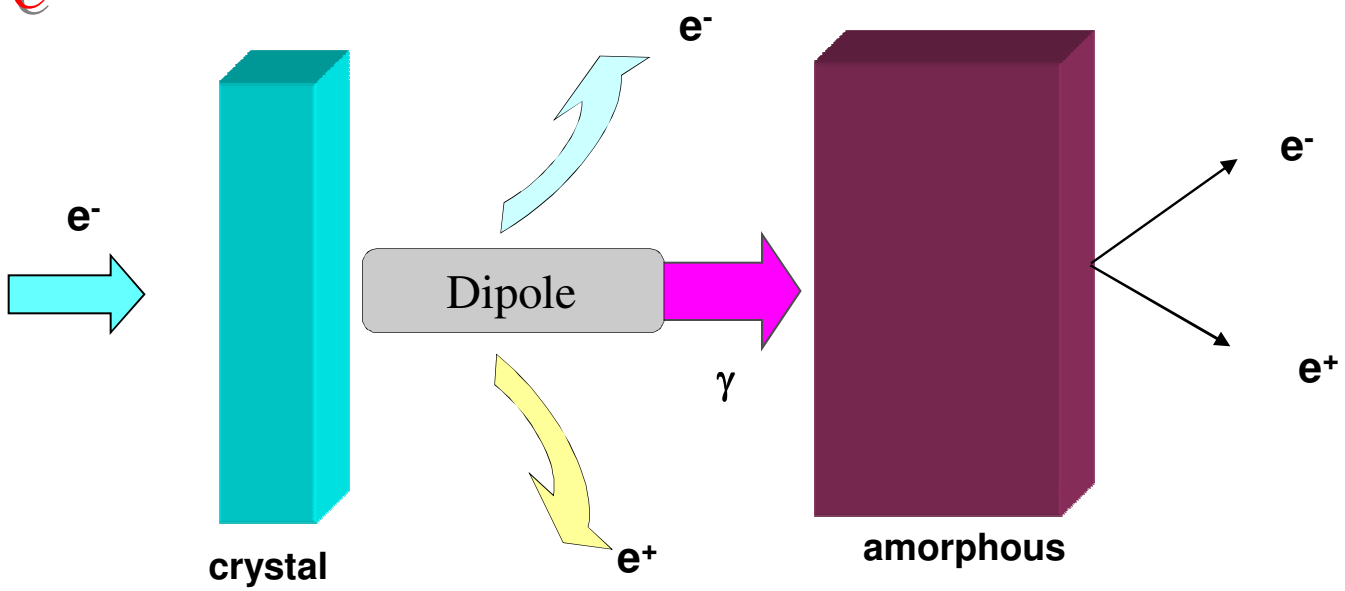


Parameters for CLIC hybrid targets

Primary electron beam Linac

5 GeV

2.34 10^{12} e^-/train



Crystal thickness: 1.4 mm

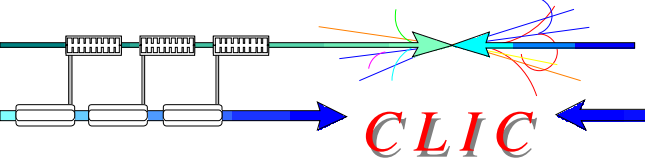
Oriented along the <111> axis

Distance (crystal-amorphous):

2m < d < 3 m

Amorphous thickness:

6 mm < e < 10 mm



CLIC target simulations results

Possible parameters for the CLIC amorphous target

Crystal-amorphous ↓ Amorphous

Distance (m)	Thickness (mm)	Yield (e+/e-)	Power (kW)	PEDD (GeV/cm^3/e$^-$)	PEDD (J/g/train)
2	6	1.76	3.85	0.83	16.1
3	6	1.66	3.65	0.64	12.4
2	8	1.91	6.55	1	19.4
3	8	1.81	6.20	0.78	15.1
2	10	1.97	9.80	1.14	22.14
3	10	1.83	9.25	0.89	17.29

« Study of an hybrid positron source using channeling for CLIC » by O. Dadoun et al., CLIC Note 808

Adiabatic Matching Device (AMD)

The characteristic are:

- Geometrical acceptance:
  $(R_0)_{max} = a.[Bs/Bo]^{1/2}$
- Transverse momentum
  $(p_T)_{max} = e[BoBs]^{1/2}a$

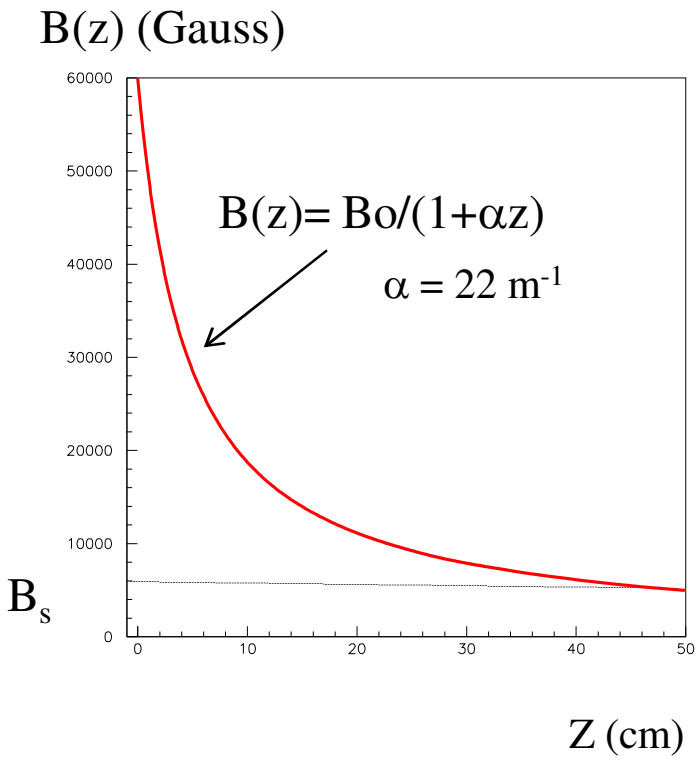
if target immersed in the B field

a = aperture radius = 20 mm

$B_0 = 6$ T

$B_s = 0.5$ T

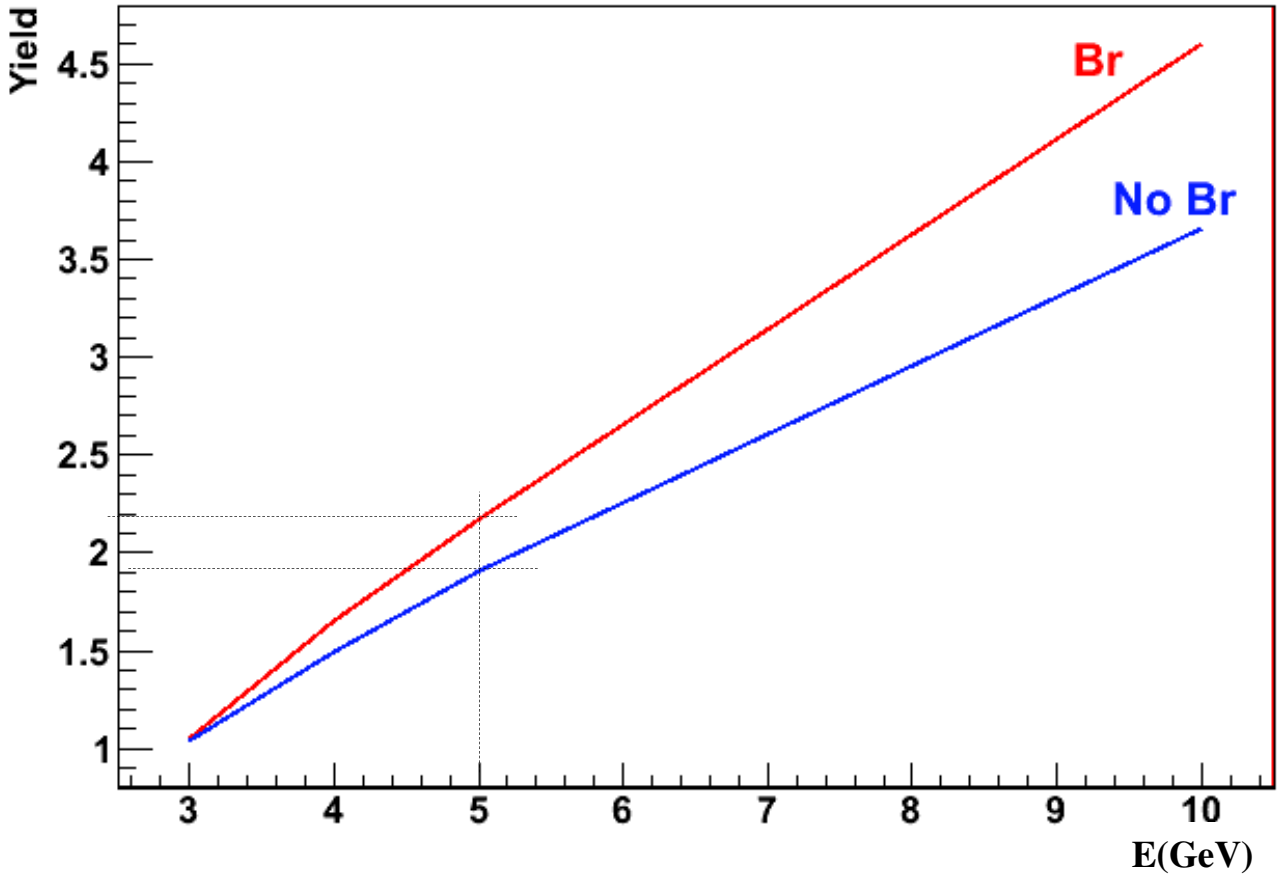
20 cm < L < 50 cm



e^+ yield at AMD

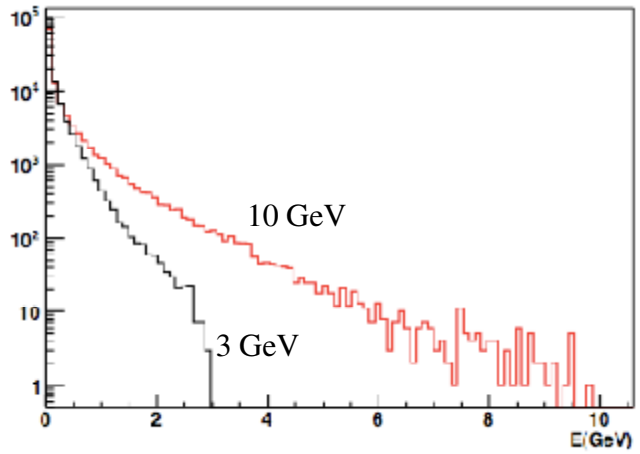
O. Dadoun / LAL

Effect of the radial magnetic field at the exit of the AMD with GEANT4



Positron beam distributions

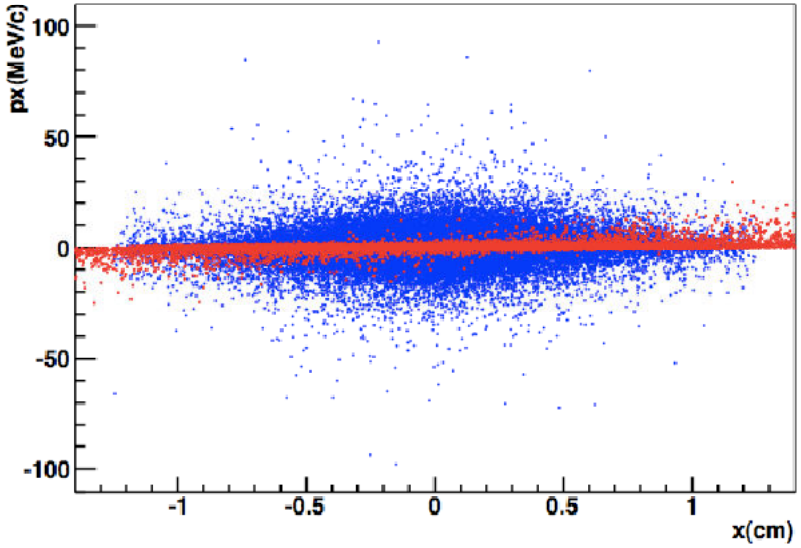
O. Dadoun / LAL



Positron distribution at the amorphous target exit for 2 different primary electron beam energy

Most of e^+ are below 100 MeV

The field law: $B(z) = Bo/(1+\alpha z)$
is introduced in GEANT4 and the accepted e^+ yield is calculated at the AMD exit

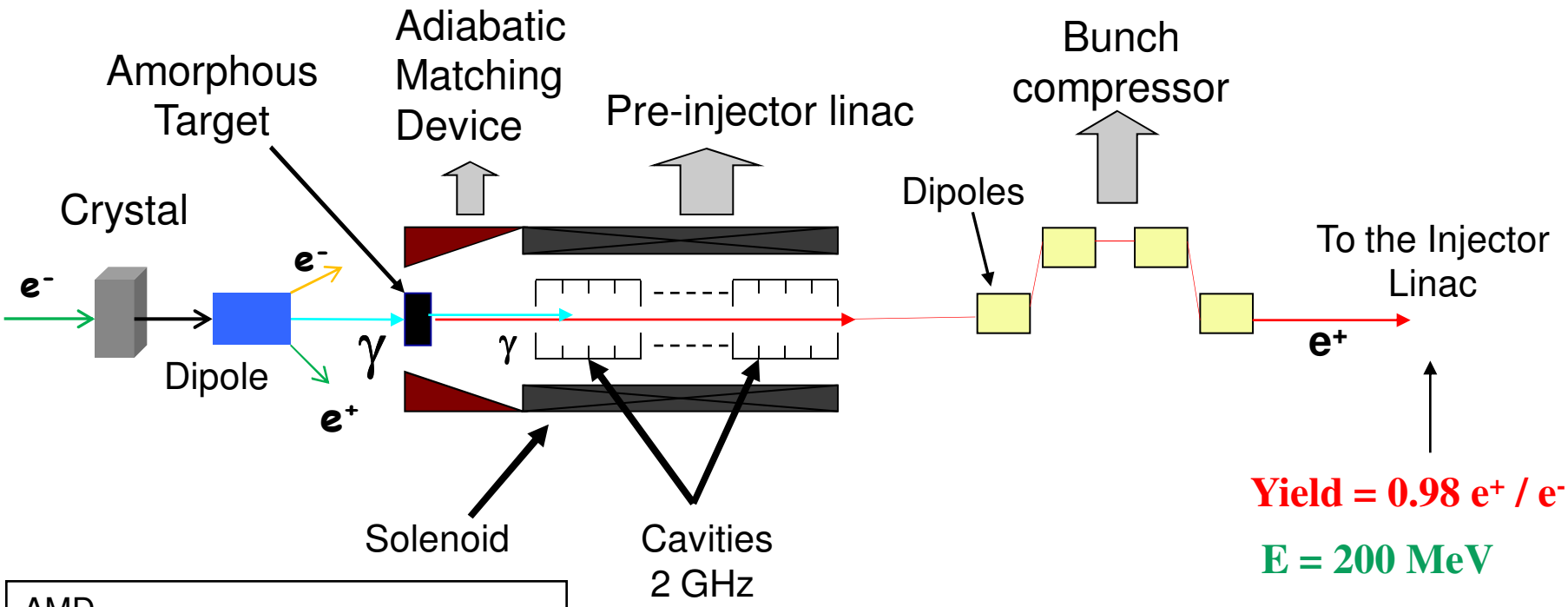


Transverse emittances

Blue = upstream AMD

Red = downstream AMD

CLIC Pre-Injector e+ Linac



AMD

• Length :	L = 20 cm
• Magnetic Filed:	B = 6 - 0.5 T
• Final Aperture:	r = 2 cm

SOLENOID

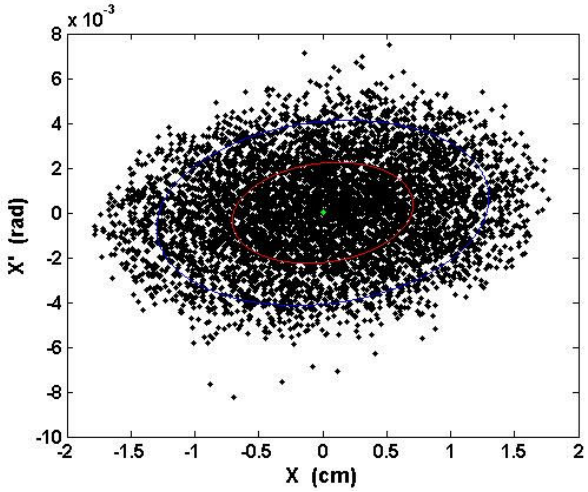
• Length :	L = 41.3 m
• Magnetic Filed:	B = 0.5 T

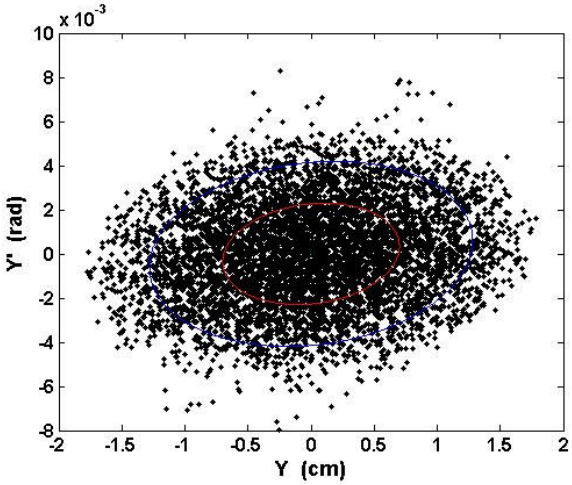
Accelerating cavities:

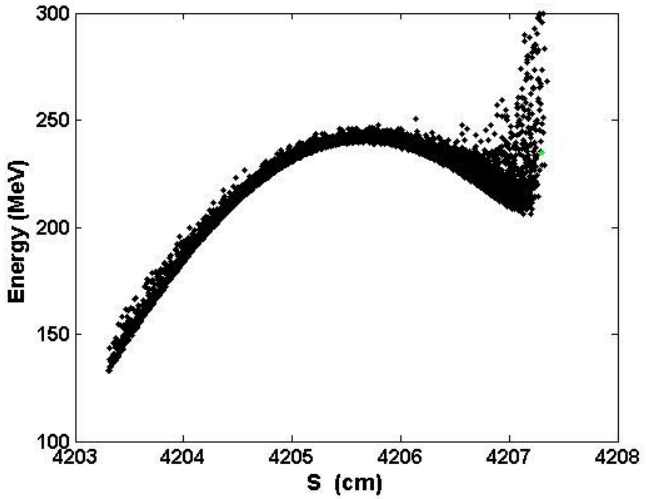
• Number of cavities:	N = 21
• Length:	L = 1.8 m
• Aperture radius:	r = 20 mm
• Energy Gain:	ΔE = 9 MeV
• Average Gradient:	E_z (r=0) = 5 MV/m
• Frequency:	f = 2 GHz

Pre-Injector Linac results

A. Vivoli / CERN





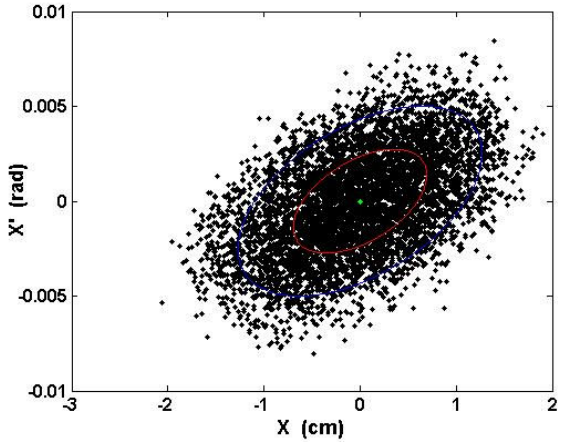


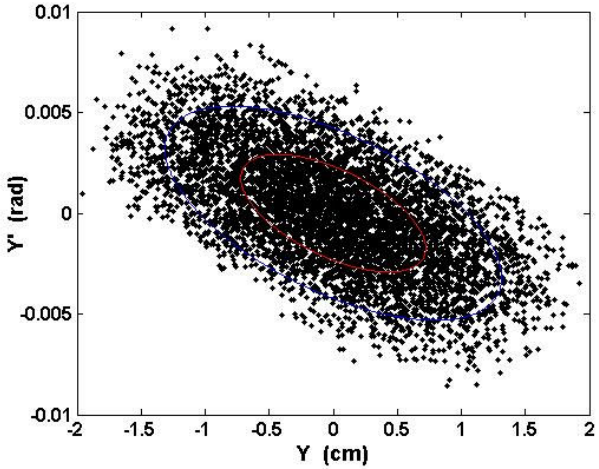
Beam Parameters

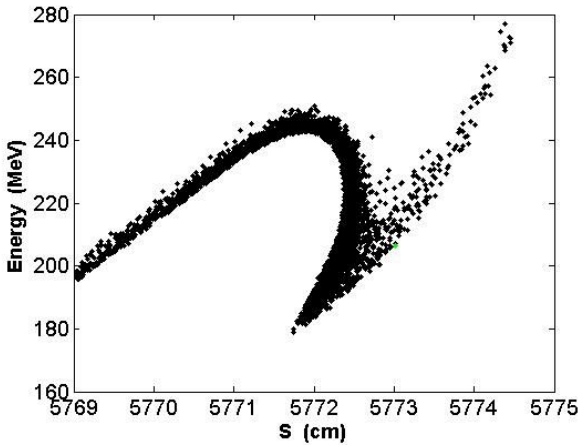
distance from amorphous target			rms transverse emittances		mean energy	energy spread	rms bunch length	
s cm	N. **e⁺**	Yield **e⁺/e⁻**	$\gamma\varepsilon_x$ π mm mrad	$\gamma\varepsilon_y$ π mm mrad	**<E>** MeV	σ_E MeV	σ_z mm	ε_z π cm MeV
4206	6218	1.036	7020	7099	228.1	36.5	9.9	33.5

Bunch compressor results

A. Vivoli / CERN





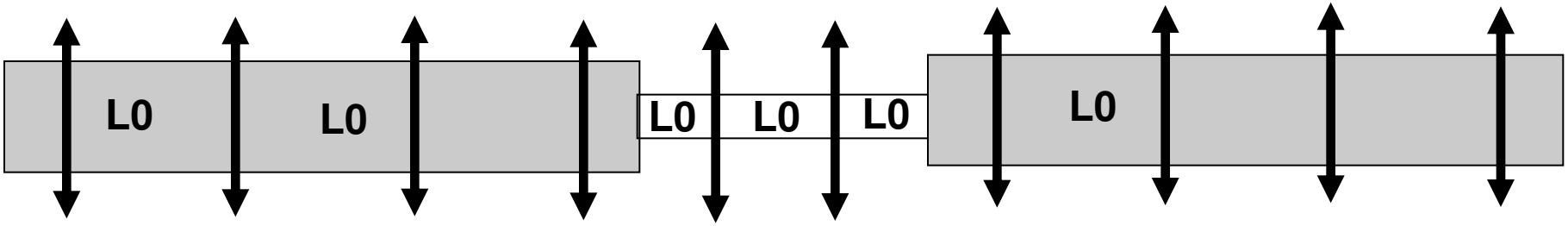


Beam Parameters

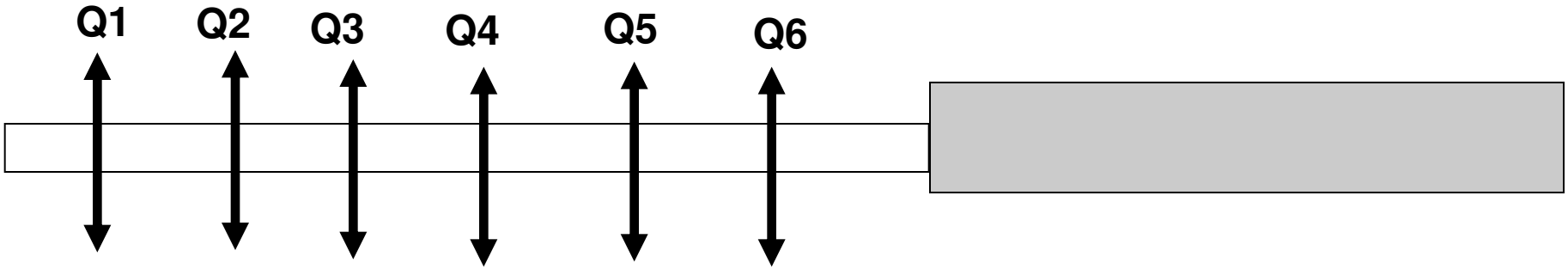
s cm	N. e^+	Yield e^+/e^-	$\gamma\varepsilon_x$ π mm mrad	$\gamma\varepsilon_y$ π mm mrad	<E> MeV	σ_E MeV	σ_z mm	ε_z π cm MeV
5772	5899	0.983	7131	7267	221.8	17.8	7.4	13.3

Injector Linac

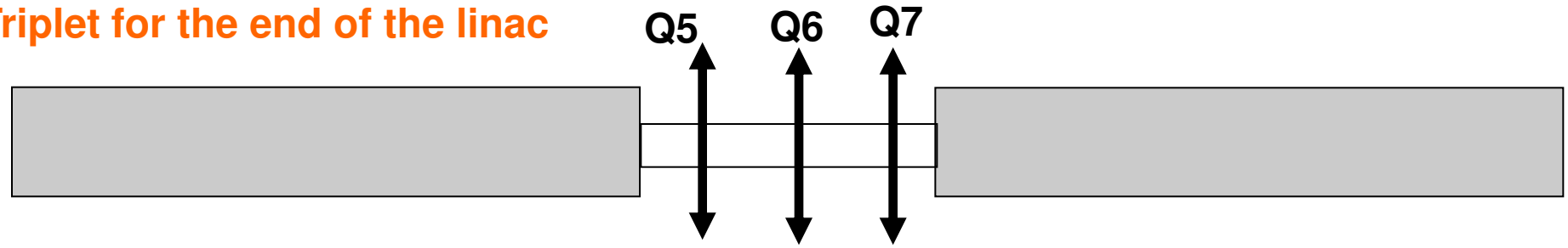
F0DO lattice at the beginning

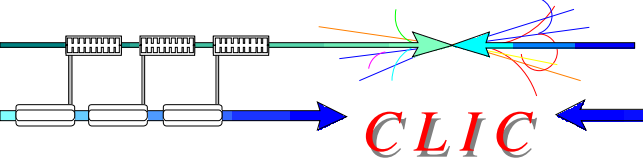


Matching from FODO to Triplet



Triplet for the end of the linac





CLIC Injector Linac parameters

RF structures	Unit	
Frequency	GHz	1.9992
Accelerating field	MV/m	14.6
Length	m	3.9
Energy gain	MeV	57
Aperture radius	mm	30
Number	-	47
Repetition frequency	Hz	50

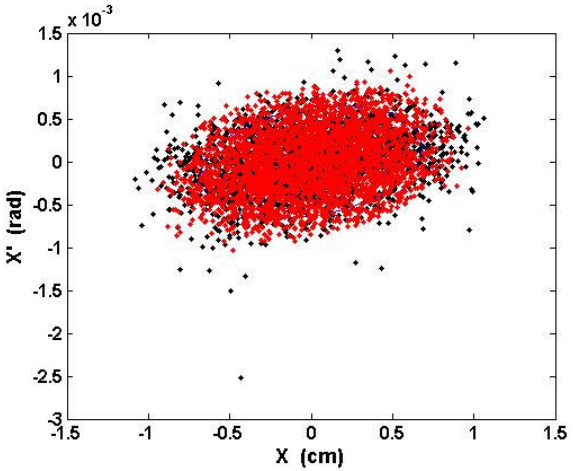
Quadrupoles	Unit	
Length	m	0.4
Gradient	T/m	$0.4 < G < 12$
Aperture radius	mm	50 and 200
Number	-	192

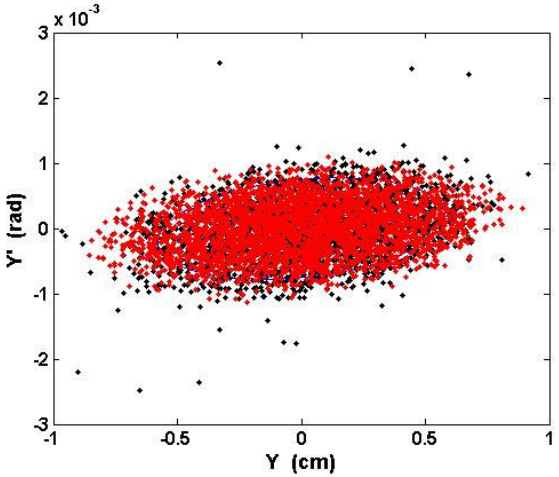
Injector Linac results

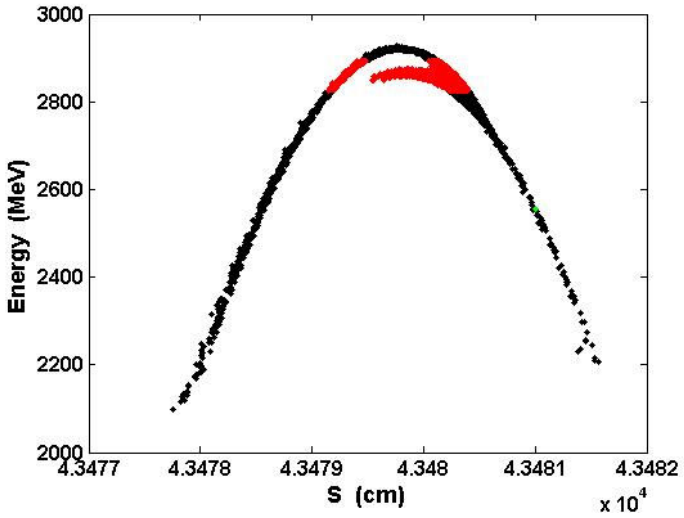
A. Vivoli / CERN

Black distribution = end of Injector Linac

Red distribution = captured inside the PDR







s cm	N. e^+	Yield e^+/e^-	$\gamma\varepsilon_x$ π mm mrad	$\gamma\varepsilon_y$ π mm mrad	<E> MeV	σ_E MeV	σ_z mm	ε_z π cm MeV
43480	5615	0.936	7250	7282	2822.9	112.8	5.3	55.0

CLIC e^+ yield at Pre-Damping Ring

PDR design is done for transverse acceptances A = 7000 mm.mrad (H = V = 6 σ)

=> Allows a good capture efficiency for the transverse planes (see plots)

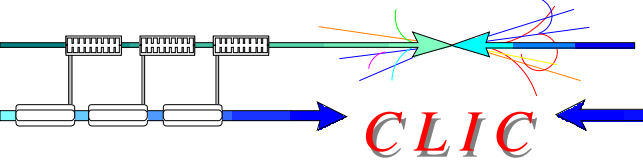
Present design →

Energy acceptance (%)	Yield (e^+ / e^-)
± 1.2	0.525
± 2	0.75
± 3	0.83

With the present parameters, the yield for the capture e^+ inside the PDR is 0.525:

⇒ Primary electron beam charge becomes $4.6 \times 10^9 / 0.525 = 8.76\ 10^9$ e^- / bunch

⇒ PEDD becomes 22.14 x 8.76 / 7.5 = 26 J/g (< 35 J/g)

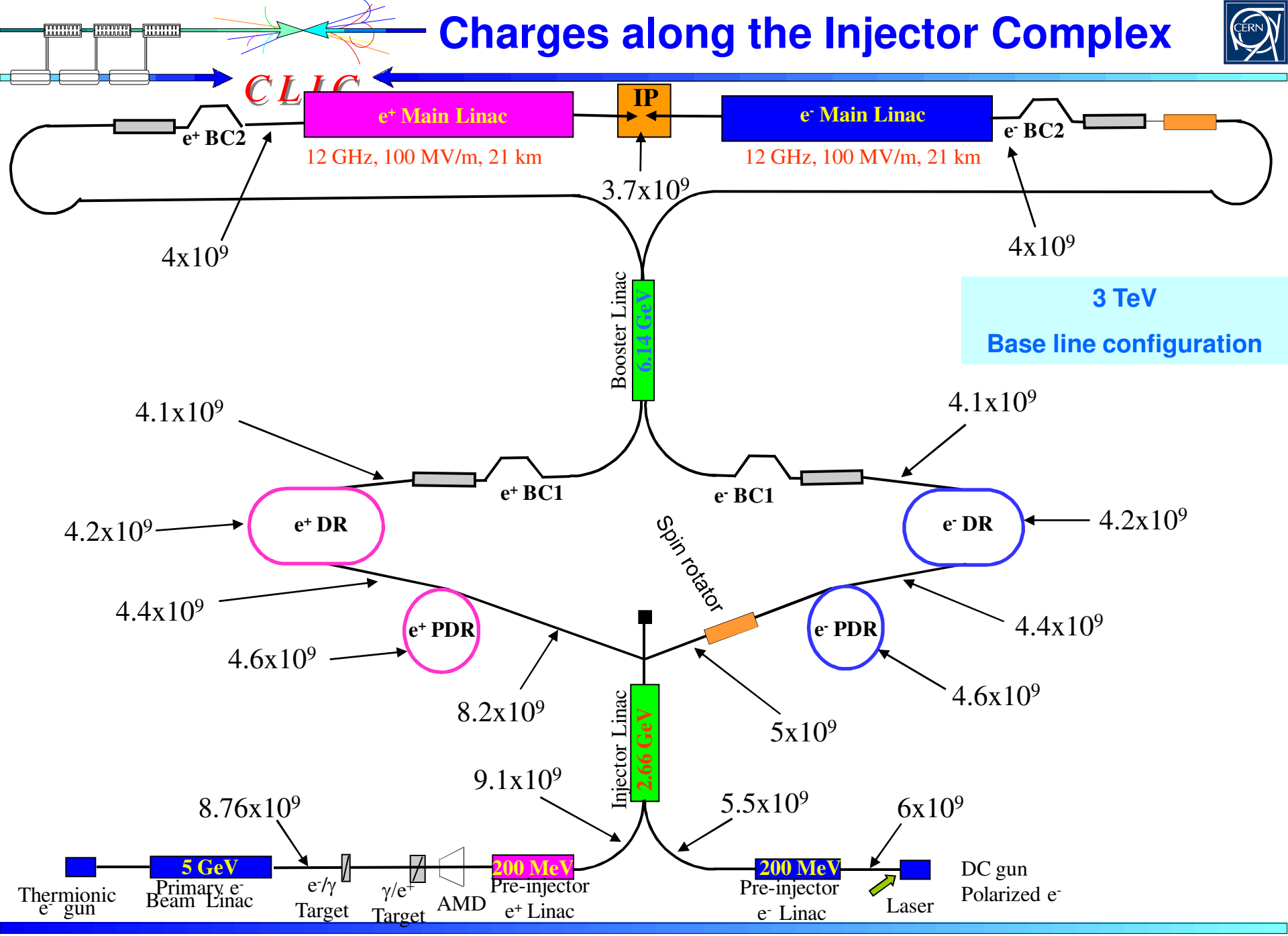


Yield and charge of e^+ beam

Based on the latest simulations, the yield and the charge have been revised along the Main Beam Injector Complex,

Values along the Main Beam Injector Complex	Yield e^+ / e^-	# of e^+ per bunch	# of e^+ per pulse	Total charge (nC)	Current (A)
Entrance Main Linac (9 GeV)	0.457	4×10^9	1.2×10^{12}	200	1.2
Entrance of the RTML (2.8 GeV)	0.468	4.1×10^9	1.3×10^{12}	204	1.3
Captured into PDR (2.8 GeV)	0.525	4.6×10^9	1.4×10^{12}	228	1.4
Entrance of PDR (2.8 GeV)	0.936	8.2×10^9	2.6×10^{12}	409	2.6
Entrance of Injector Linac (200 MeV)	1.04	9.1×10^9	3.2×10^{12}	526	3.3
Primary electron beam (5 GeV)		8.76×10^9	2.7×10^{12}	437	2.8

Charges along the Injector Complex

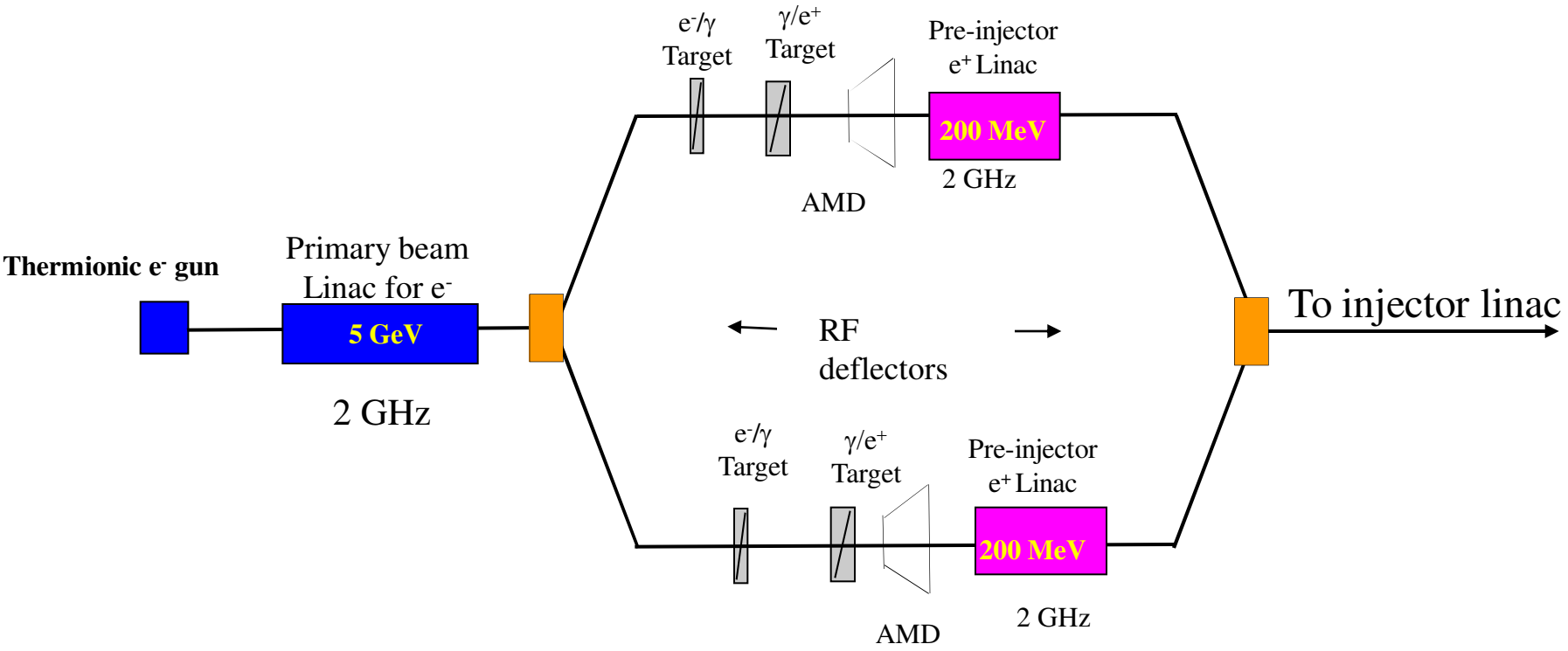


CLIC e+ source for 500 GeV

Double charge / bunch => Double Peak Energy Deposition Density inside the target

=> very close to the breakdown limit (35 J/g)

=> Double target station



Collaborations

for the CLIC Main Beam Generation studies

Alphabetic order for countries

Countries	Institutes	Collaborators	Subject
France	LAL	I. Chaikovska, O. Dadoun, F. Poirier, A. Variola	e^+ studies
France	IPNL	X. Artru, R. Chehab, M. Chevallier	Channeling / e^+ studies
Japan	Hiroshima Uni.	M. Kuriki, T. Takahashi	Experiments at KEKB
Japan	KEK	T. Kamitani, T. Omori, J. Urakawa	e^+ studies
Russia	BINP	V. Strakhovenko	Channeling / e^+ studies
Turkey	Uludag University	E. Eroglu, A. Kenan Çiftçi, E. Pilicer, I.Tapan	FLUKA simulations
Ukraine	Kharkov Institute	E. Bulyak, P. Gladkikh	Compton Rings
United Kingdom	Cockcroft Institute	I. Bailey, J. Clarke, L. Zang	Undulator e^+ studies
USA	ANL	W. Gai, W. Liu	Undulator e^+ studies
USA	BNL	I. Pogorelski, V. Yakimenko	Compton Linac
USA	JLAB	M.Poelker	DC gun for polarized e-
USA	SLAC	A. Brachmann, T. Maryama, J. Sheppard, F. Zhou	Polarized e- sources

Summary

- The CLIC positron source for the 3 TeV baseline configuration assumes hybrid targets and will be described into the CDR.

- The source provides unpolarized e^+ with the requested performance.

- For 0.5 TeV (double charge) configuration, double target positron station is implemented in order to avoid the issues related to the target breakdown.

- Issues related to targets need experimental tests.

- Issues related to radioactivity need crucial investigations.

- Future studies are ongoing to improve the e^+ yield at 200 MeV and at 2.86 GeV and to increase the PDR acceptance.