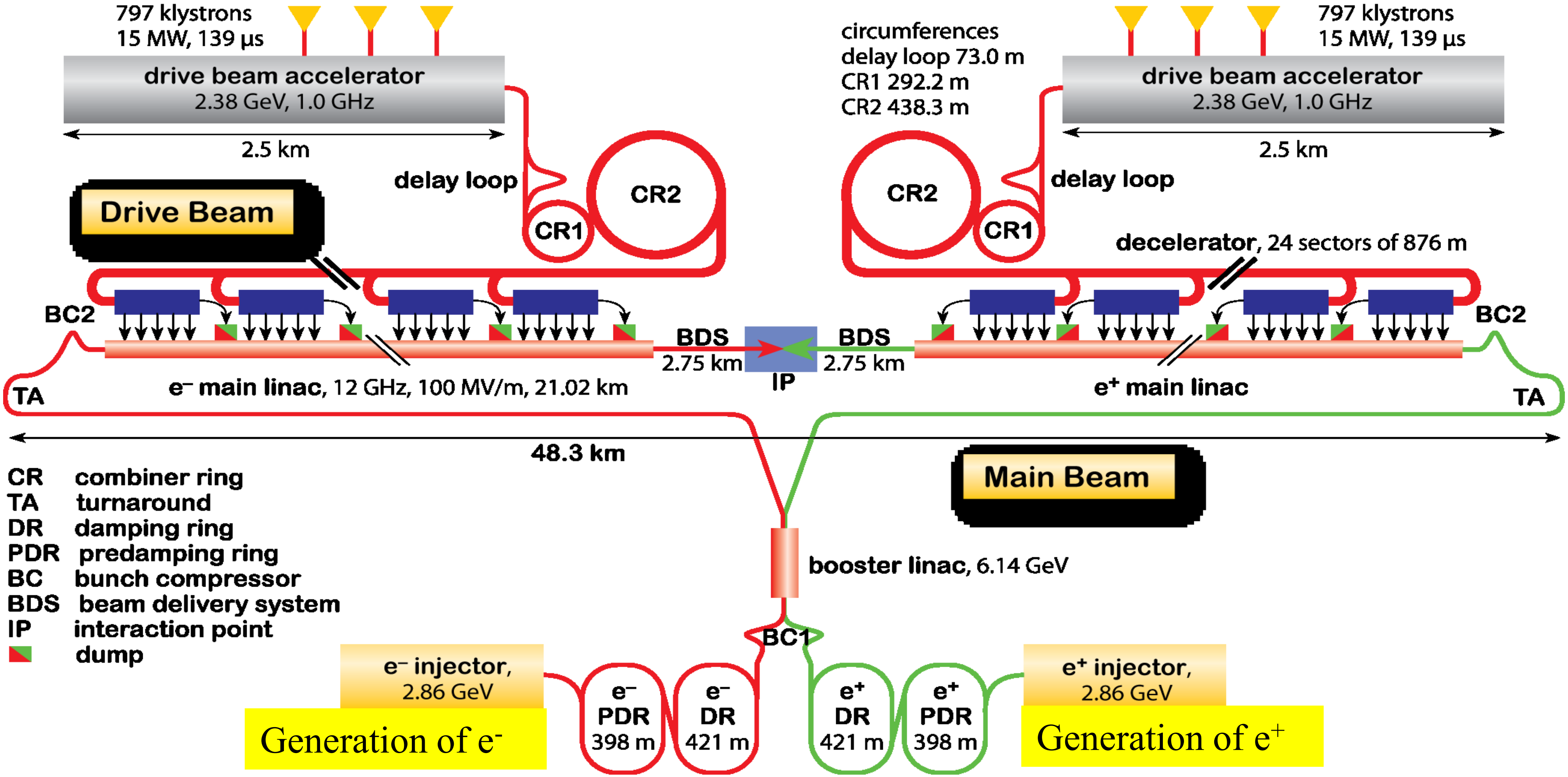
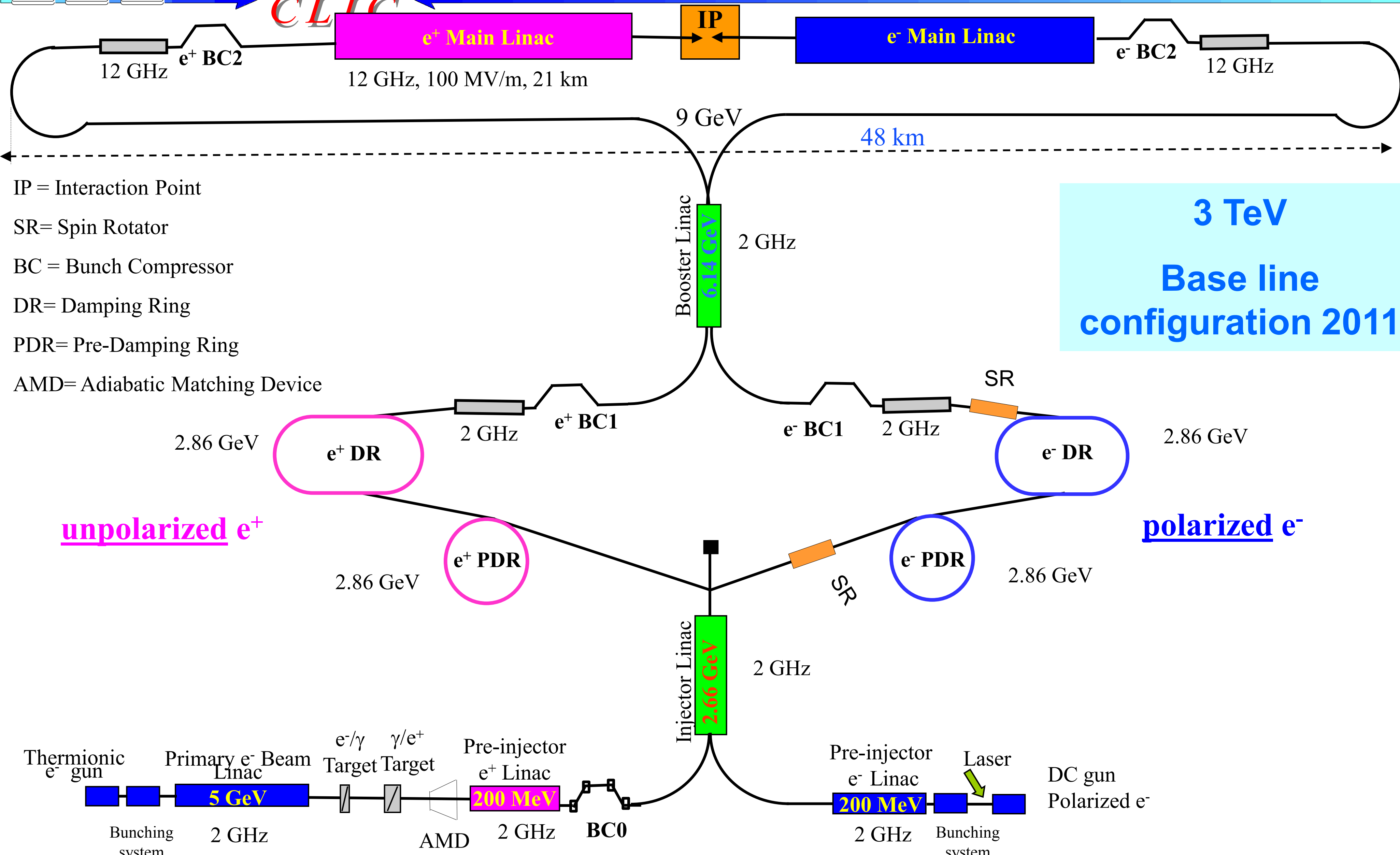
CLIC e^+ status

Louis Rinolfi

General CLIC layout for 3 TeV



CLIC Main Beam Injector Complex



IP = Interaction Point

SR= Spin Rotator

BC = Bunch Compressor

DR= Damping Ring

PDR= Pre-Damping Ring

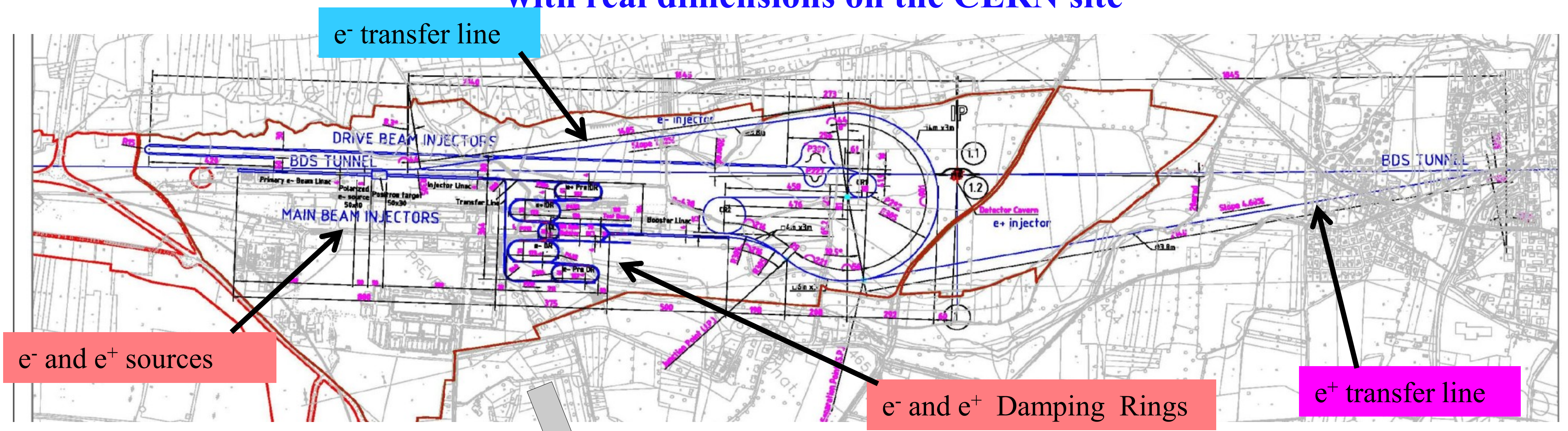
AMD= Adiabatic Matching Device

3 TeV

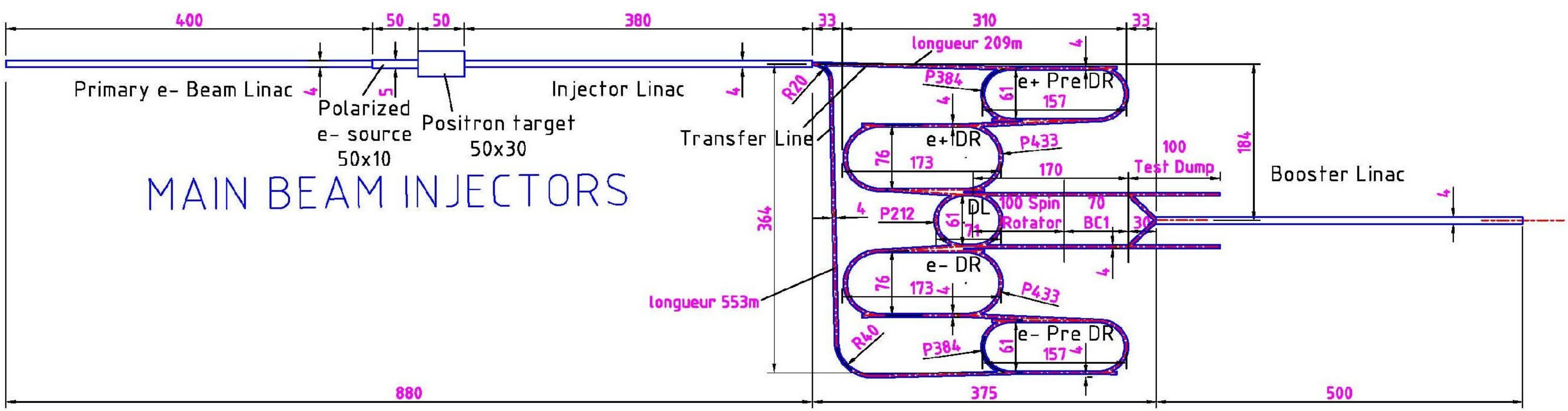
Base line configuration 2011

CLIC Main Beam Injector complex

with real dimensions on the CERN site



Zoom

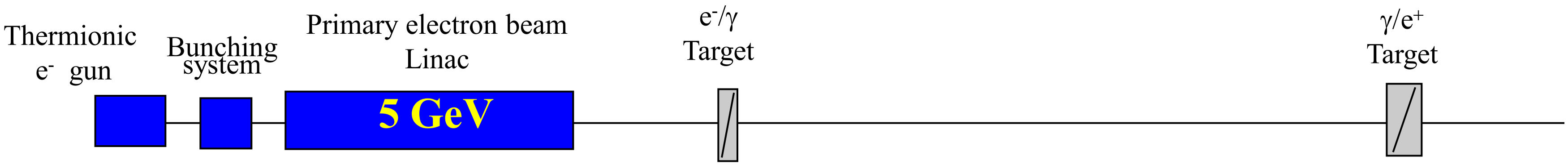


Flux of e^+

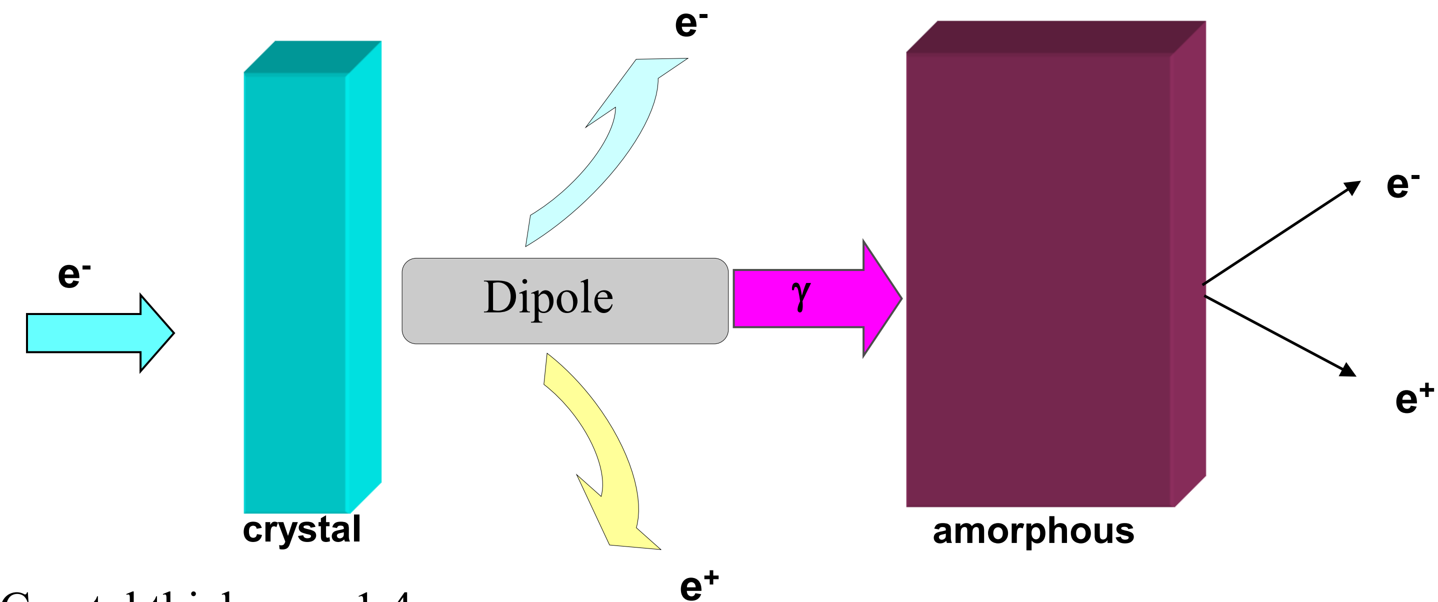
	SLC (California)	CLIC (3 TeV)	CLIC (0.5 TeV)	ILC (RDR)	LHeC (CERN)
Energy	1.19 GeV	2.86 GeV	2.86 GeV	5 GeV	140 GeV
e^+/ bunch (at IP)	40×10^9	3.7×10^9	7.4×10^9	20×10^9	1.6×10^9
e^+/ bunch (after capture)	50×10^9	7×10^9	14×10^9	30×10^9	1.8×10^9
Bunches / macropulse	1	312	354	2625	100 000
Macropulse Rep. Rate (Hz)	120	50	50	5	10
Number bunches / s	120	156 000	177 000	13125	20×10^6
e^+ / second $\times 10^{14}$	**0.06**	**1.1**	**2.5**	**3.9**	**18**

CLIC hybrid targets

e^+ source parameters for the baseline



$3.1\ 10^{12}$ e⁻/train



Crystal thickness: 1.4 mm

Oriented along the <111> axis

Distance (crystal-amorphous) d = 2 m

Amorphous thickness e =10 mm

G4FOT : a new code

O. Dadoun / LAL

- FOT is a code developed by X. Artru (IPN Lyon) in the years 80's
  - Conversion in C^{++} and implementation in GEANT.
  - FOT simulates coherent and incoherent Bremsstrahlung radiations as well as Kumakhov radiation in channelling condition.
  - GEANT 4 simulates pair creation and incoherent Bremsstrahlung (+ usual G4 processes).

- Comparison have been done with V. M. Strakhovenko simulation (BINP)
- A difference between 10 to 20% , has been estimated, depending on the incident energy.
- LAL is studying the origin of this small discrepancy.

. G4FOT allows to simulate the production of photons from the crystal target, the production of positrons from the amorphous target and the capture downstream the amorphous target.

With G4FOT code, the e^+ yield, from hybrid target, can be simulated with one single program.

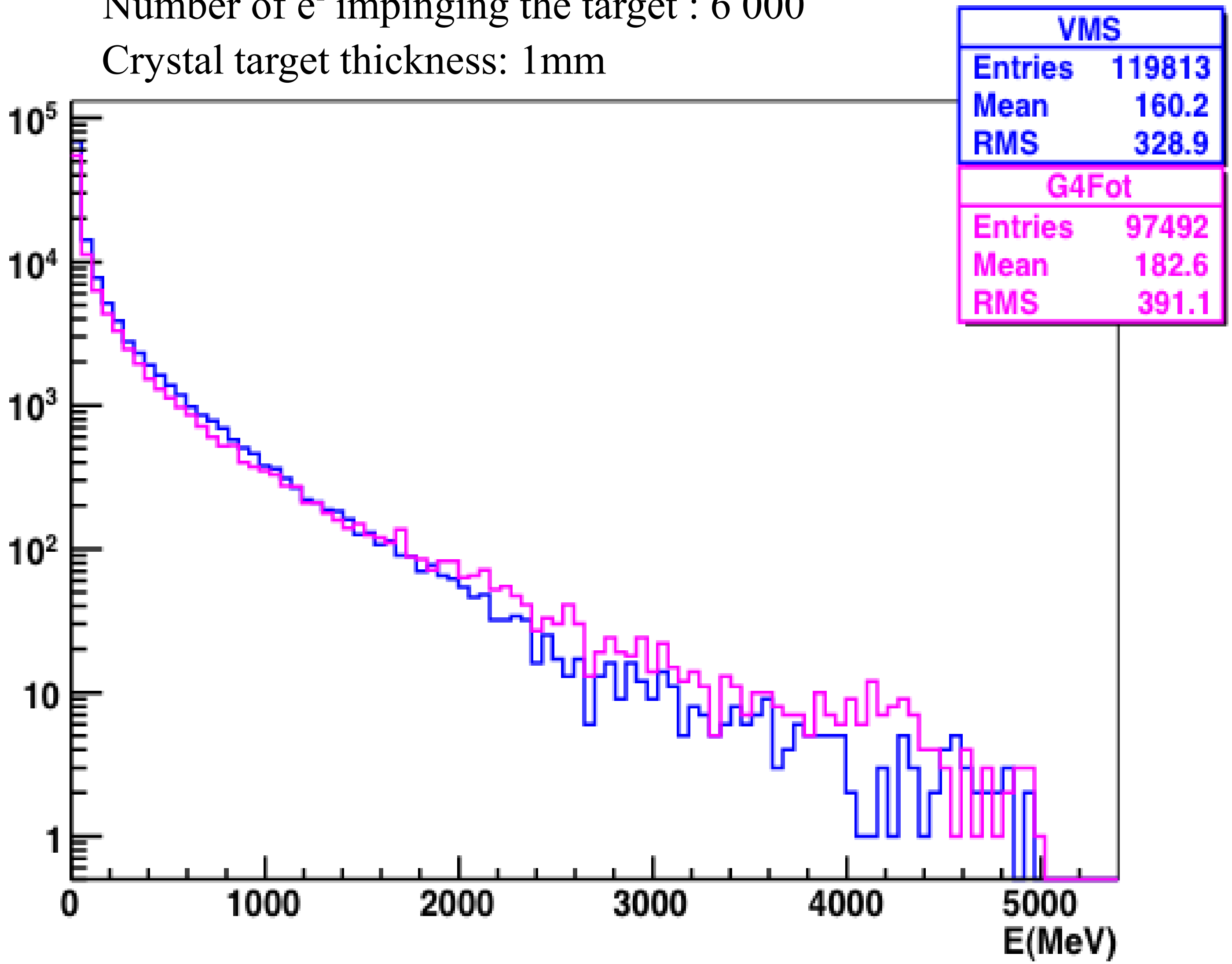
Comparison of the 2 codes

Energy of e^- impinging the crystal target: 5 GeV

Number of e^- impinging the target : 6 000

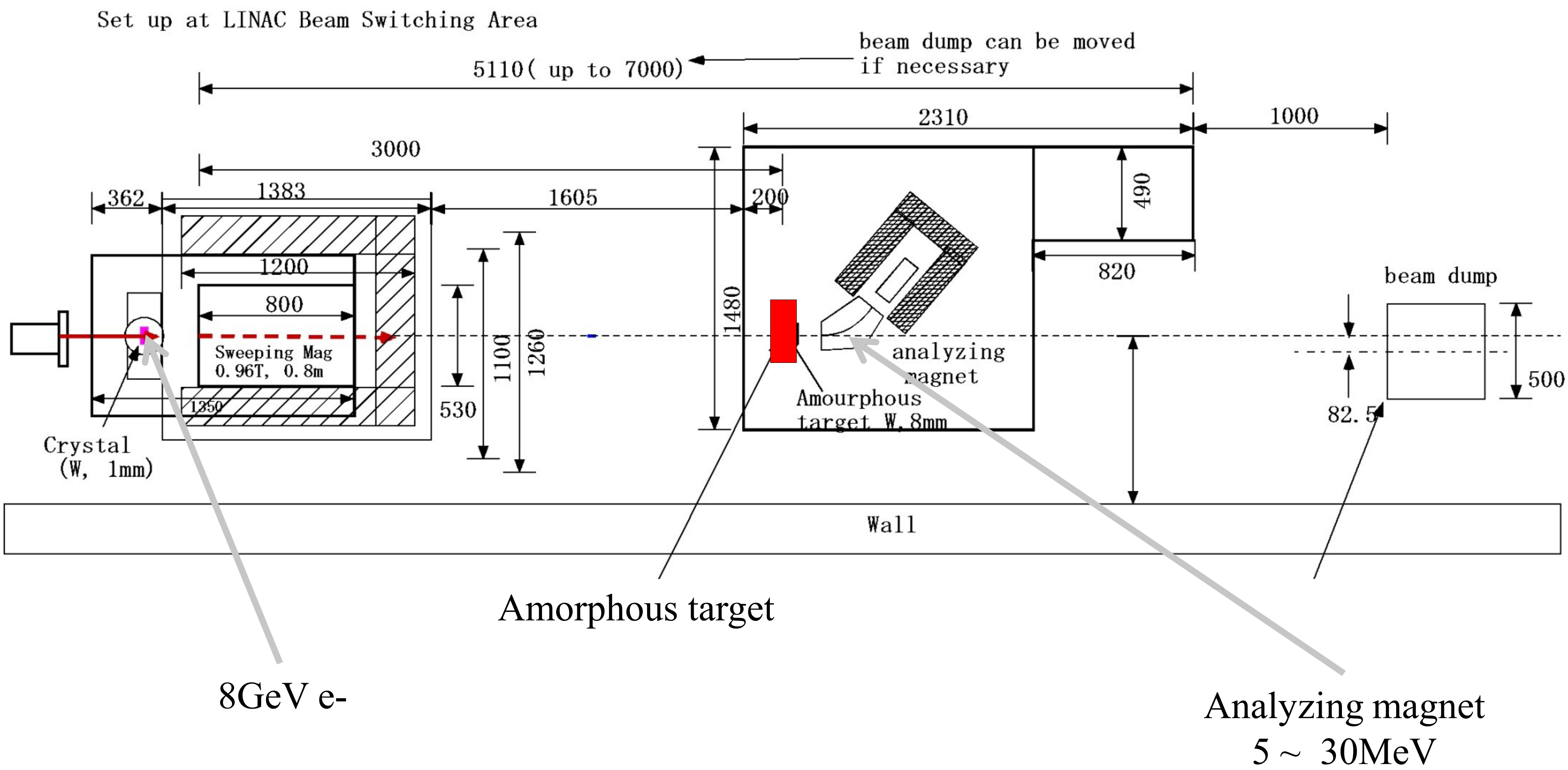
Crystal target thickness: 1mm

Number of photons at the exit of the crystal target



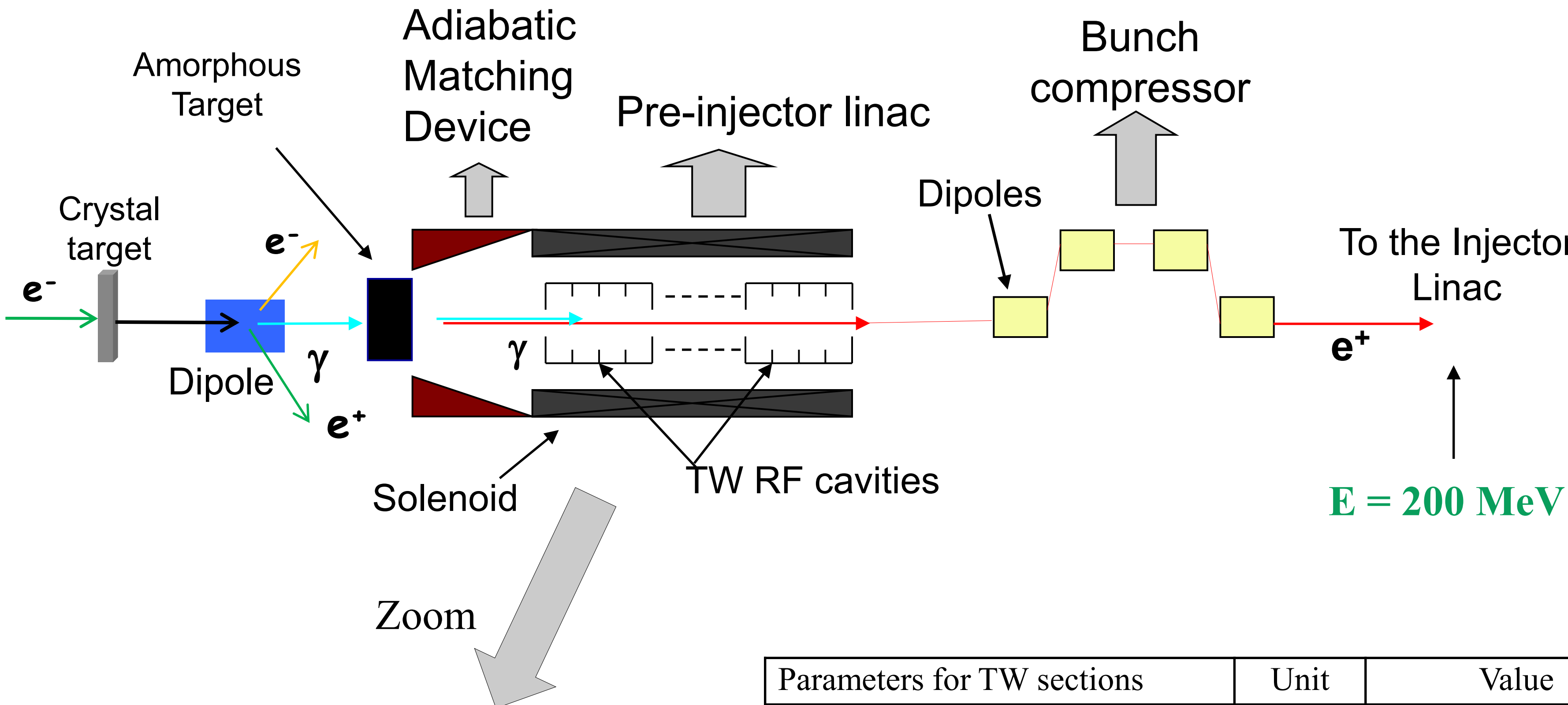
KEKB experiments with hybrid targets

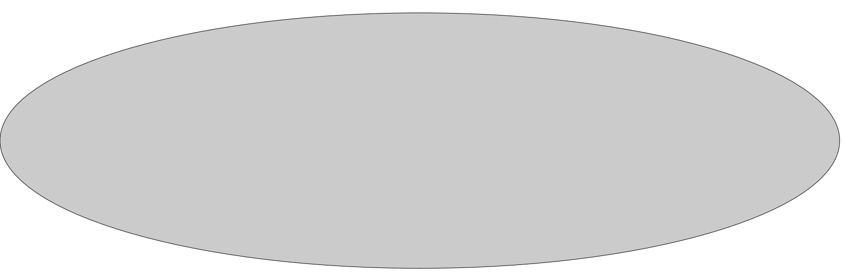
T. Takahashi / Hiroshima Uni.



This experiment will be very useful as test bench to cross-check G4FOT simulations and experimental data

CLIC Pre-Injector e⁺ Linac layout





Parameters for TW sections	Unit	Value
Length	m	4.36
Frequency	GHz	2
Nb of cells		84 + 2 couplers
Phase advance per cell		$2/3\pi$
Maximum Axial Electric Field	MV/m	15
Cell length	m	0.0499

CLIC Pre-Injector e^+ Linac results

F. Poirier / LAL

Mode	Pre-Injector length (m)	Total yield	Efficiency	RMS bunch length (mm)	Mean Energy (MeV)	FWHM energy (MeV)	σ_x (mm)	$\sigma_{x'}$ (mrad)
Accelerating	18.12	0.9	0.77	9.54	191.8	10	8.06	2.86
Decelerating	22.63	0.95	0.89	4.37	197.5	4.5	7.83	2.86

Total yield = N_{e+} (@ 200 MeV) / N_{e-} (@ 5 GeV)

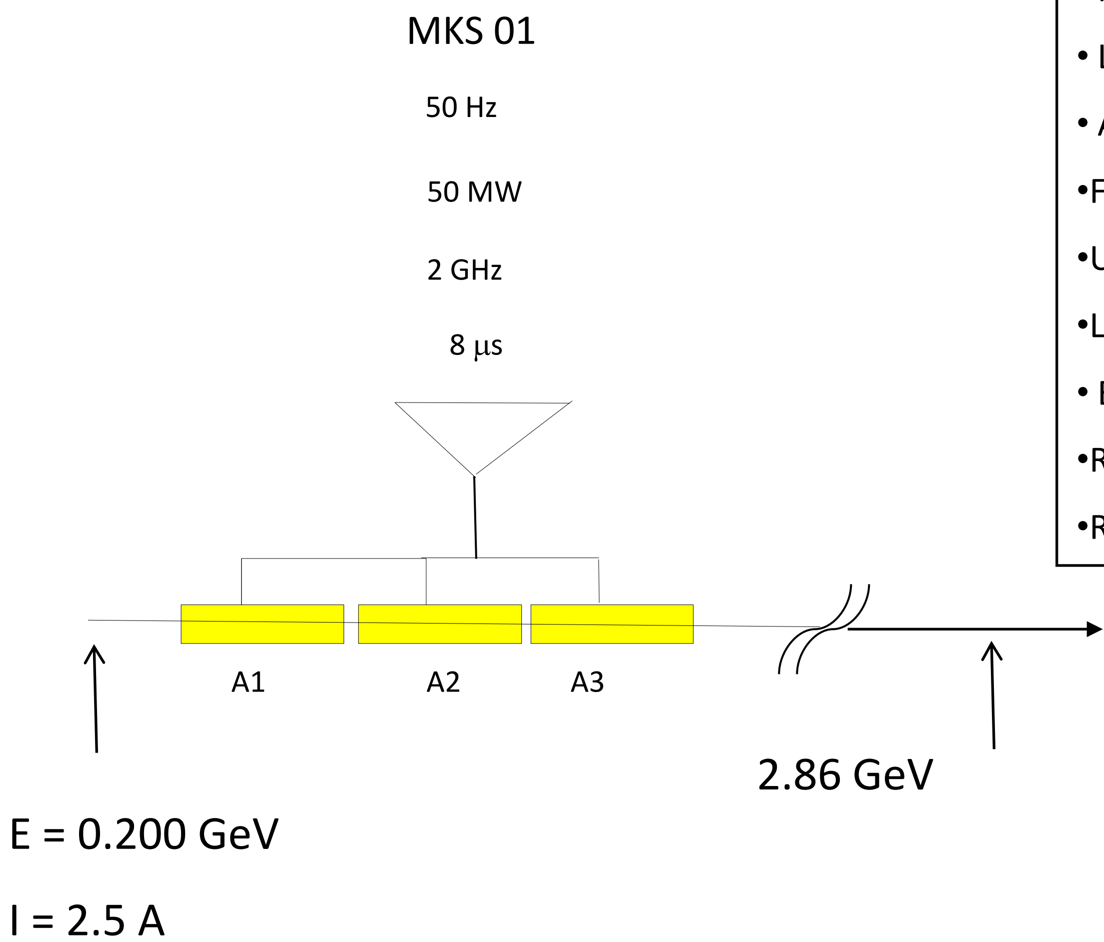
Efficiency = N_{e+} (assuming 1.2% PDR acceptance) / N_{e-} (@ 5 GeV)

The decelerating mode in the Pre-Injector Linac improves the e^+ performance and the efficiency

CLIC Injector e⁺ Linac

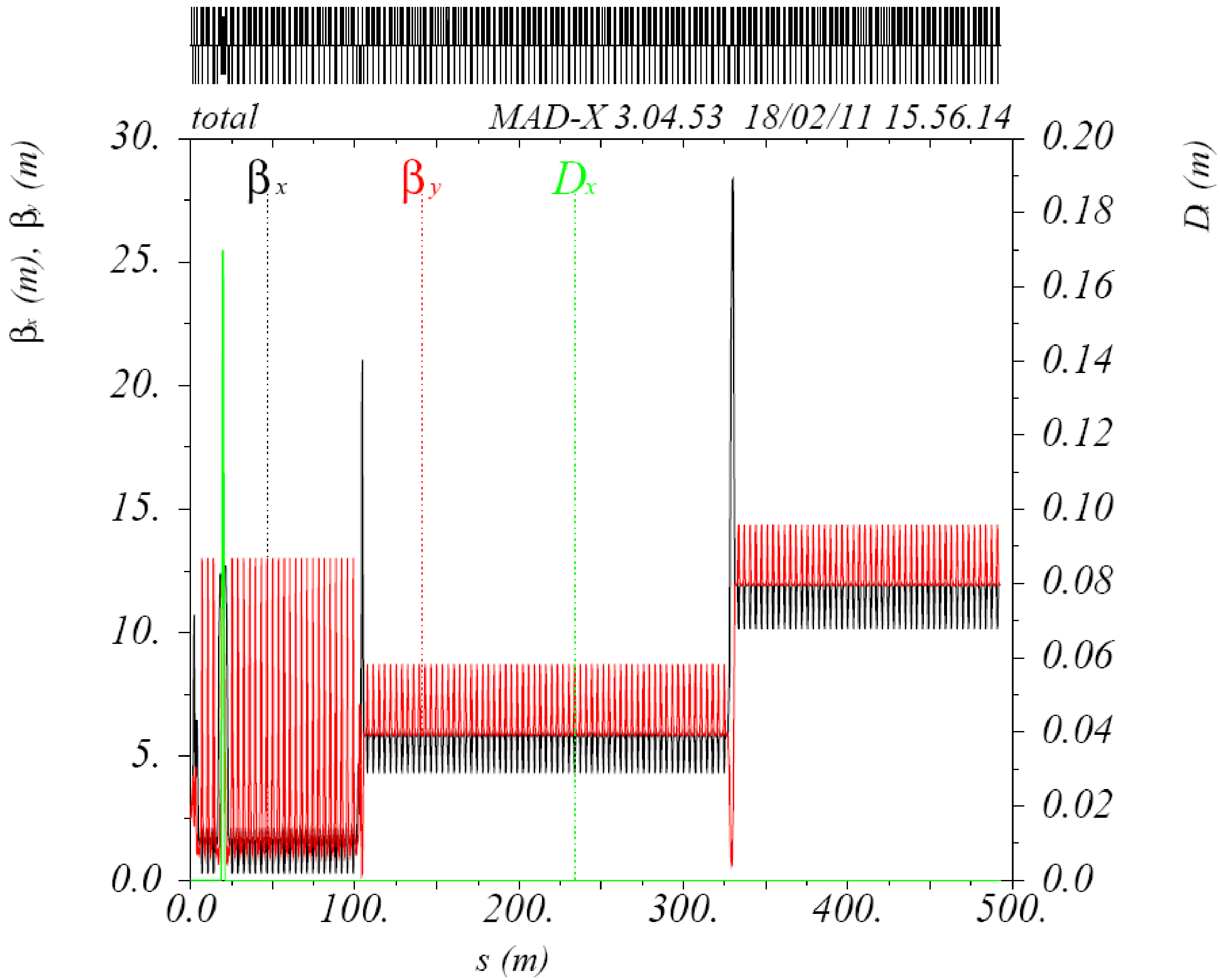
An RF module:

- Number of cavities: $N = 3$
- Length: $L = 1.5$ m
- Aperture radius: $\langle r \rangle = 17$ mm
- Filling time: $t_f = 389$ ns
- Unloaded gradient: $E_z = 27$ MV/m
- Loaded gradient: $E_z = 15$ MV/m
- Energy gain/module: $\Delta E = 67.5$ MeV
- RF frequency: $f = 2$ GHz
- Repetition frequency $F = 50$ Hz



Beam optics for the CLIC Injector Linac

A. Vivoli / CERN



3 sections with triplets

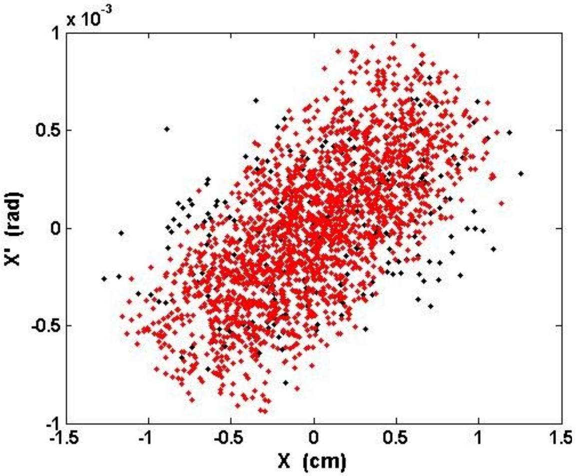
129 RF structures

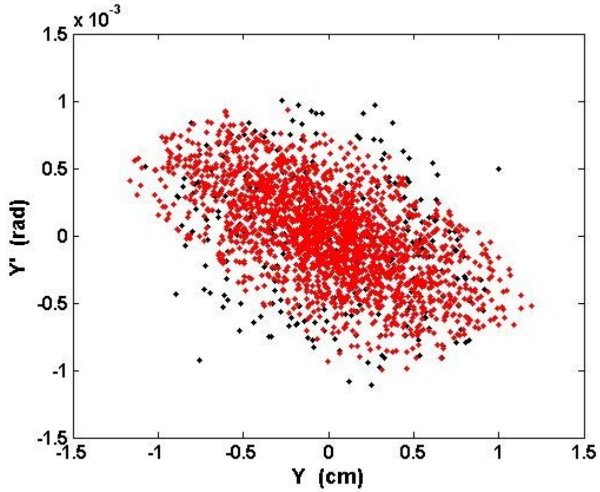
411 quadrupoles

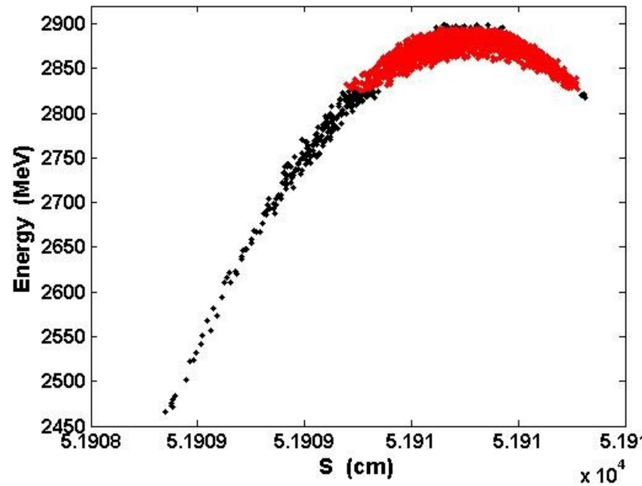
Simulation results for CLIC Injector Linac

Black distribution = end of Injector Linac

Red distribution = captured inside the PDR





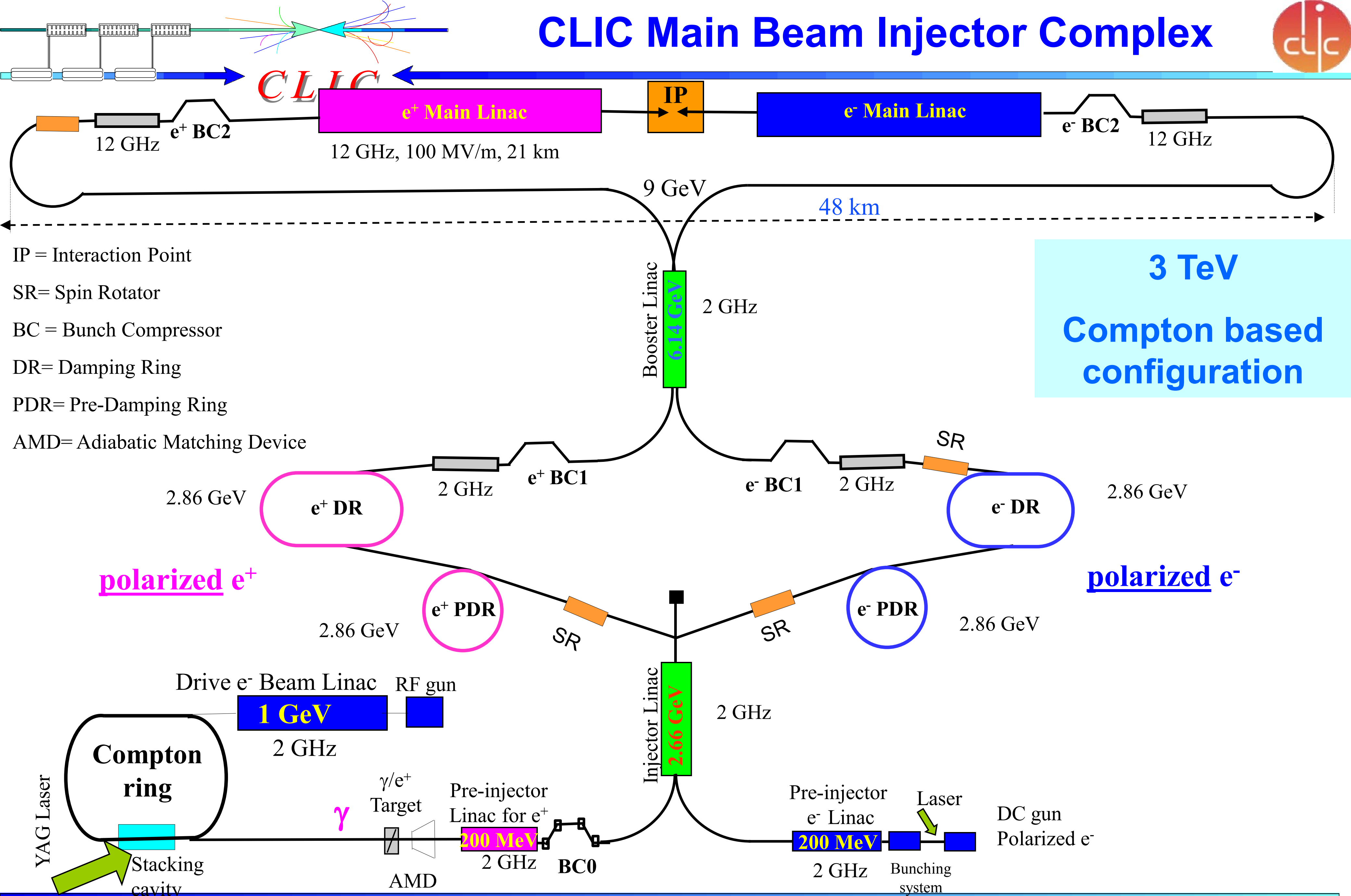


Simulation s	s cm	N. e^+	Yield e^+/e^-	$\gamma\varepsilon_x$ π mm mrad	$\gamma\varepsilon_y$ π mm mrad	<E> MeV	σ_E MeV	σ_z mm	ε_z π cm MeV
Oct. 2010	43480	4204	0.70	7685	8105	2825.4	126.3	5.4	61.6
March 2011	51910	2338	0.39	7071	7577	2859.4	46.7	3.3	23.1

e^+ in PDR (October 2010): Yield e^+/e^- =0.45

e^+ in PDR (March 2011): Yield e^+/e^- =0.35

CLIC Main Beam Injector Complex



Compton ring as polarized e^+ source

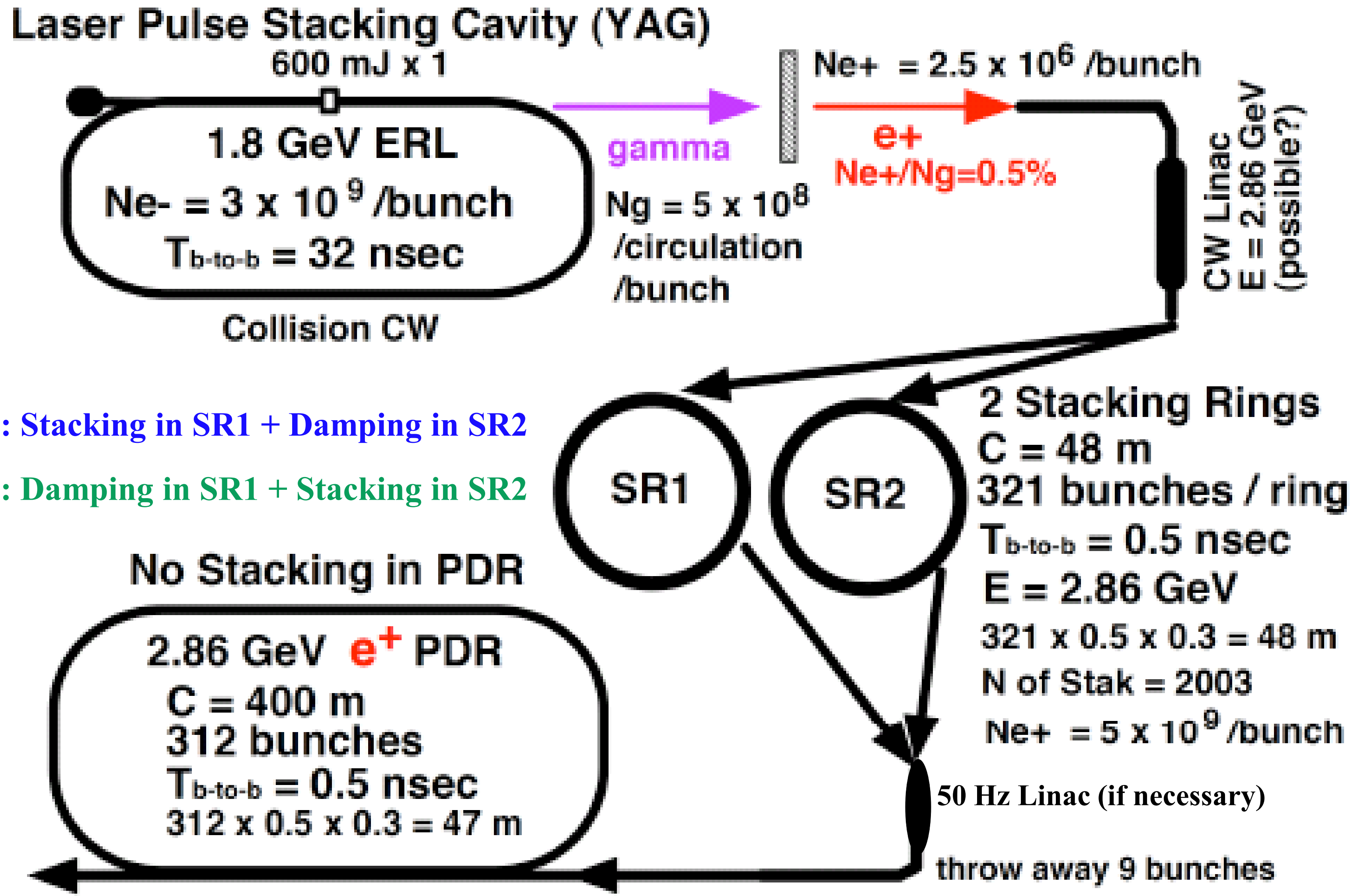
Compton ring is very attractive for the CLIC polarized positron sources:

1) no modification in the Main Linac
2) no modification of the Main Beam Injector complex apart to install a new ring
3) could work in parallel with the existing conventional hybrid targets

BUT it needs:

- a Compton ring design (high beam current, double chicane, high RF voltage,…)
- a strong R&D on laser (laser energy, laser pattern,…)
- a careful optimization of the optical cavity and IP (beam size, stability,…)
- a high stacking efficiency
- a new design of the Pre-Damping (momentum compaction, RF voltage, damping times, dynamic aperture,…)

ERL + 2 SR as e^+ source



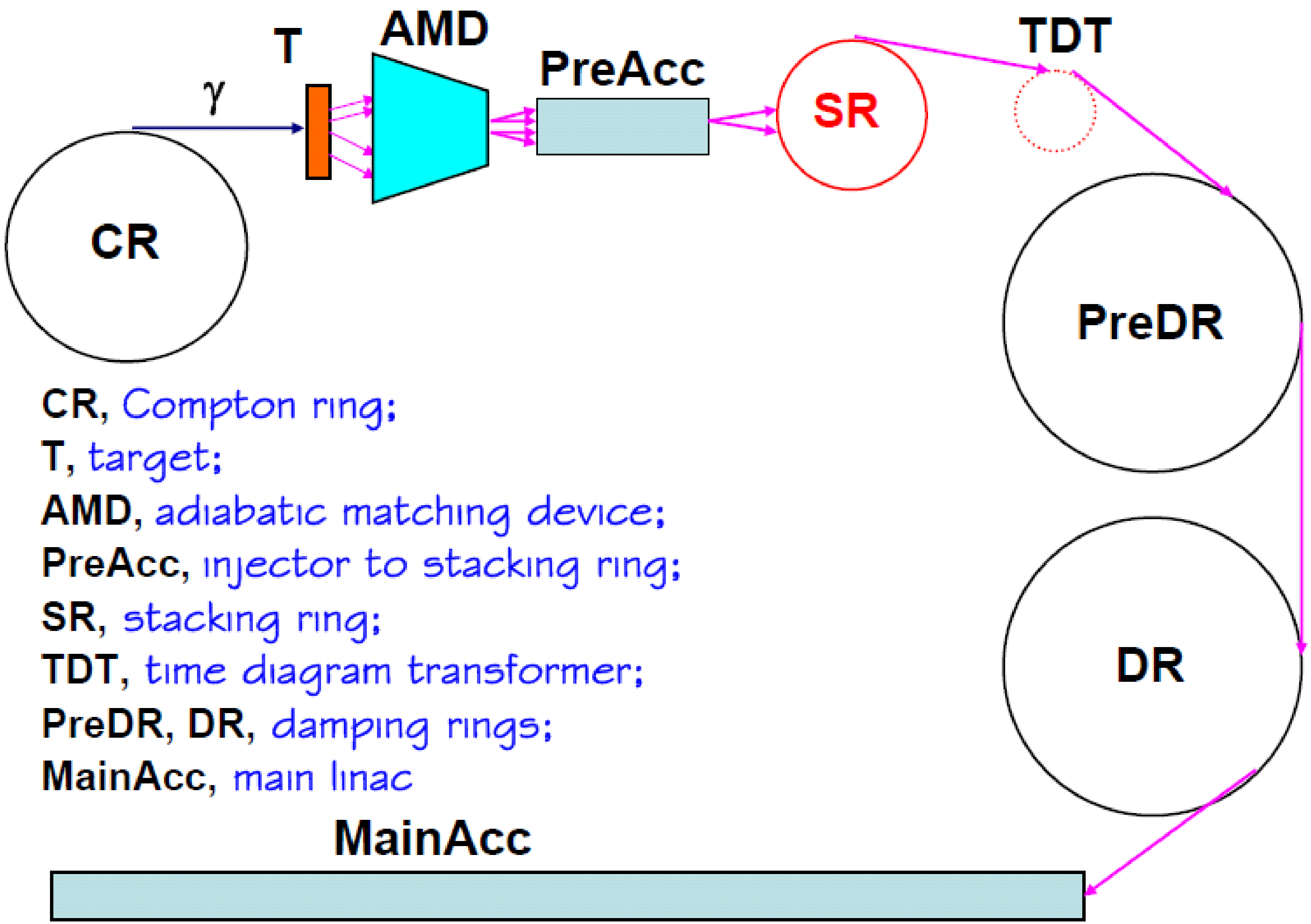
Cycle 1: Stacking in SR1 + Damping in SR2

Cycle 2: Damping in SR1 + Stacking in SR2

T. Omori and

CR + SR + TDT as e^+ source

P. Gladkikh / NSC-KIPT



CR, Compton ring;
T, target;
AMD, adiabatic matching device;
PreAcc, injector to stacking ring;
SR, stacking ring;
TDT, time diagram transformer;
PreDR, DR, damping rings;
MainAcc, main linac

CLIC polarized e^+ beam studies

Collaborations are ongoing with the following institutes:

Compton ring: KEK - NSC/KIPT/Karkhov

ERL: KEK - LAL

Compton Linac: BNL

Undulator: ANL - DESY – CI – Lancaster Uni.

CERN acknowledges them strongly

Summary

1) The unpolarized e^+ source is based on hybrid targets, using channeling. Further studies are ongoing with simulations (G4FOT, GEANT4, FLUKA,…) The beam power deposition in the targets remains a critical issue related to the target breakdown.

2) Test facilities should be implemented. The KEKB experiment is an important step forward for the behavior of e^+ sources.

3) The polarized e^+ sources are under study for several configurations. For all of them, strong R&D program is mandatory for future linear colliders.

Acknowledgements

Thank you for contributions and discussions:

X. Artru, I. Bailey, E. Bulyak, I. Chaikovska, R. Chehab, J. Clarke, O. Dadoun, E. Eroglu, W. Gai, P. Gladkikh, T. Kamitani, A. Latina, W. Liu, T. Omori, J. Osborne, F. Poirier, T. Takahashi, J. Urakawa, A. Variola, A. Vivoli, C. Xu, V. Yakimenko, L. Zang, F. Zimmermann.

15 Institutes: ANL, BNL, BINP, CERN, Cockcroft Institute, DESY, Hiroshima University, IHEP, IPNL, KEK, LAL, Lancaster University, NSC-KIPT, SLAC, Uludag University