Welcome and introduction

Working group on use of novel accelerator tecniques

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Mandate

A mandate for the working group has been defined. See indico page :

https://indico.cern.ch/event/607729/

(go through the mandate)

Plenary meetings at CERN, Fridays 9-11, at a few weeks intervals. Minutes/write up will be provided. Material will be accessible on indico.

Novel Accelerator Techniques (NAT)

Materials with higher damage threshold:
- ✧Dielectrics (~GV/m)
- ✧Plasmas (10-100GV/m or ∞)

Systems powered/driven by:
- ✧Laser pulse(s)*
- ✧Charged particle bunch(es)

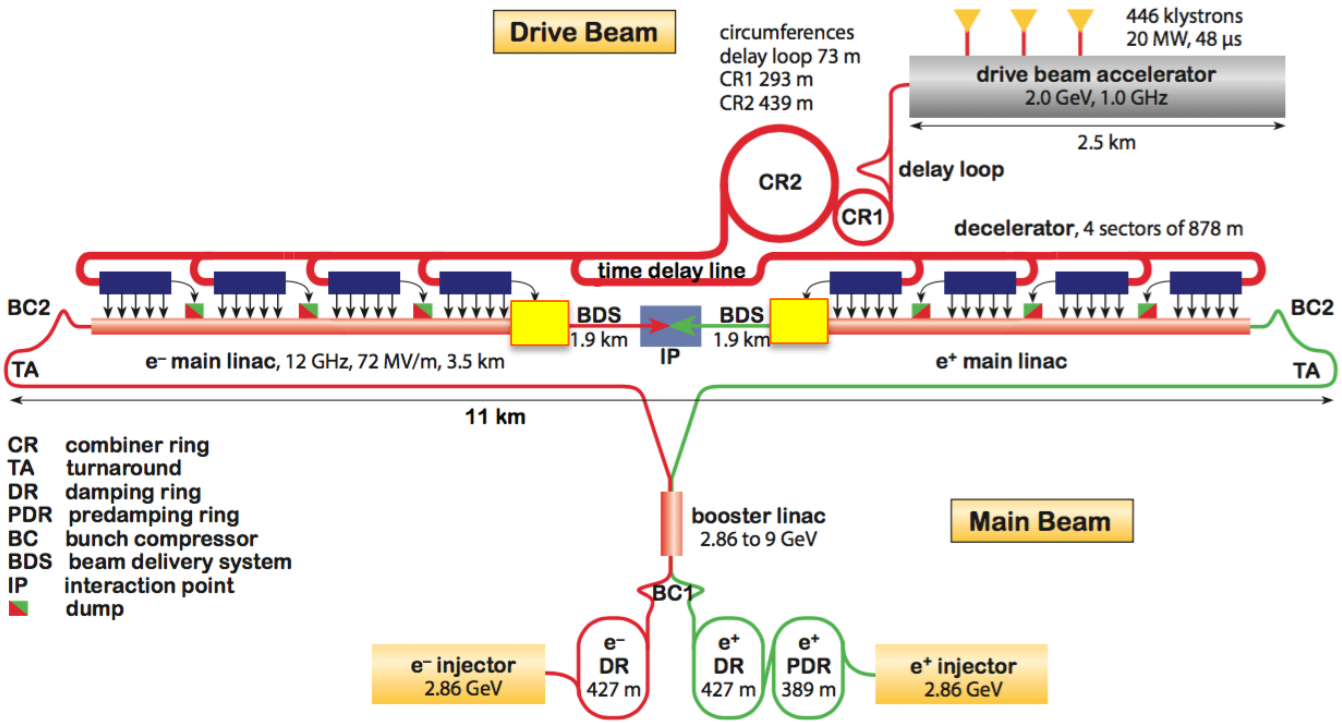
Driver \ Medium	Dielectric	Plasma
Laser Pulse	Dielectric Laser Accelerator DLA	Laser Wakefield Accelerator LWFA
Particle Bunch	Dielectric Wakefield Accelerator DWA	Plasma Wakefield Accelerator PWFA

*do not include laser vacuum/direct acceleration

P. Muggli, EPS-HEP 07/25/2015

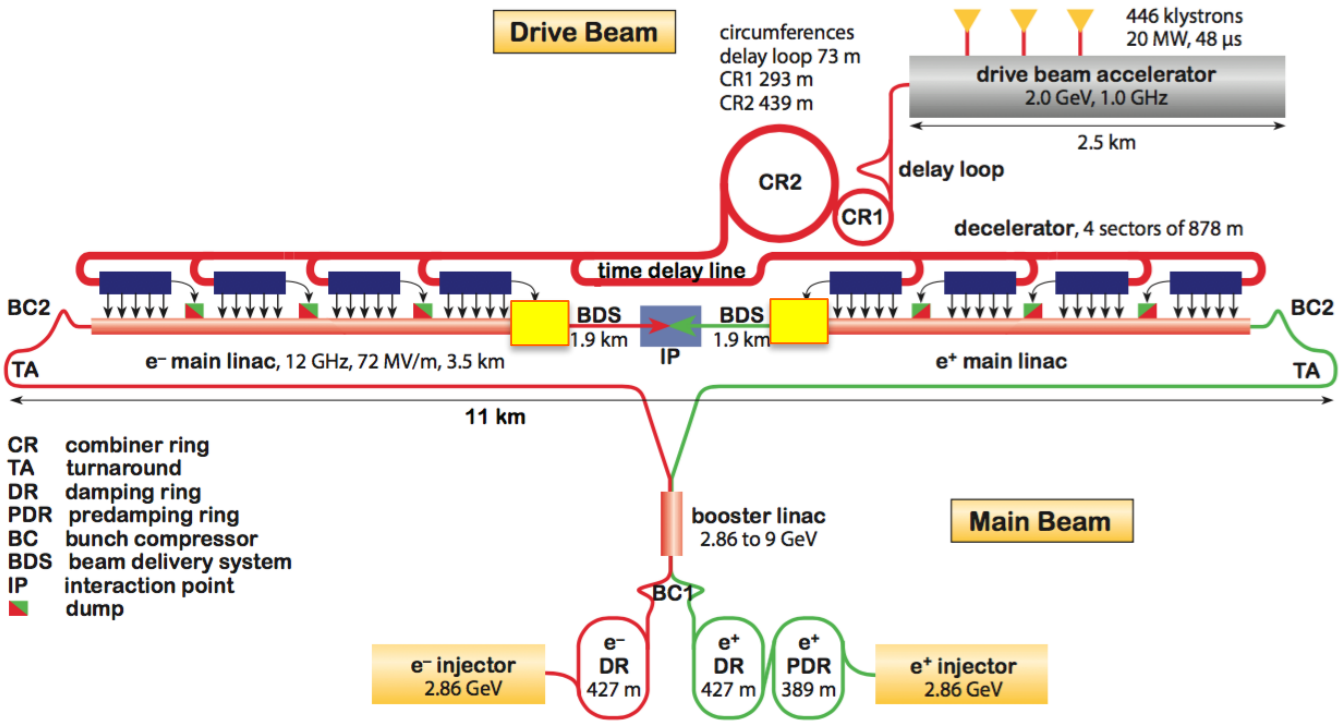
From Patric Muggli

CLIC 380 GeV



The CLIC collaboration, Updated baseline for a staged Compact Linear Collider, arXiv:1608.07537, CERN-2016-004 (2016)

Afterburner: keep all linac, add NAT high-gradient final stage(s)

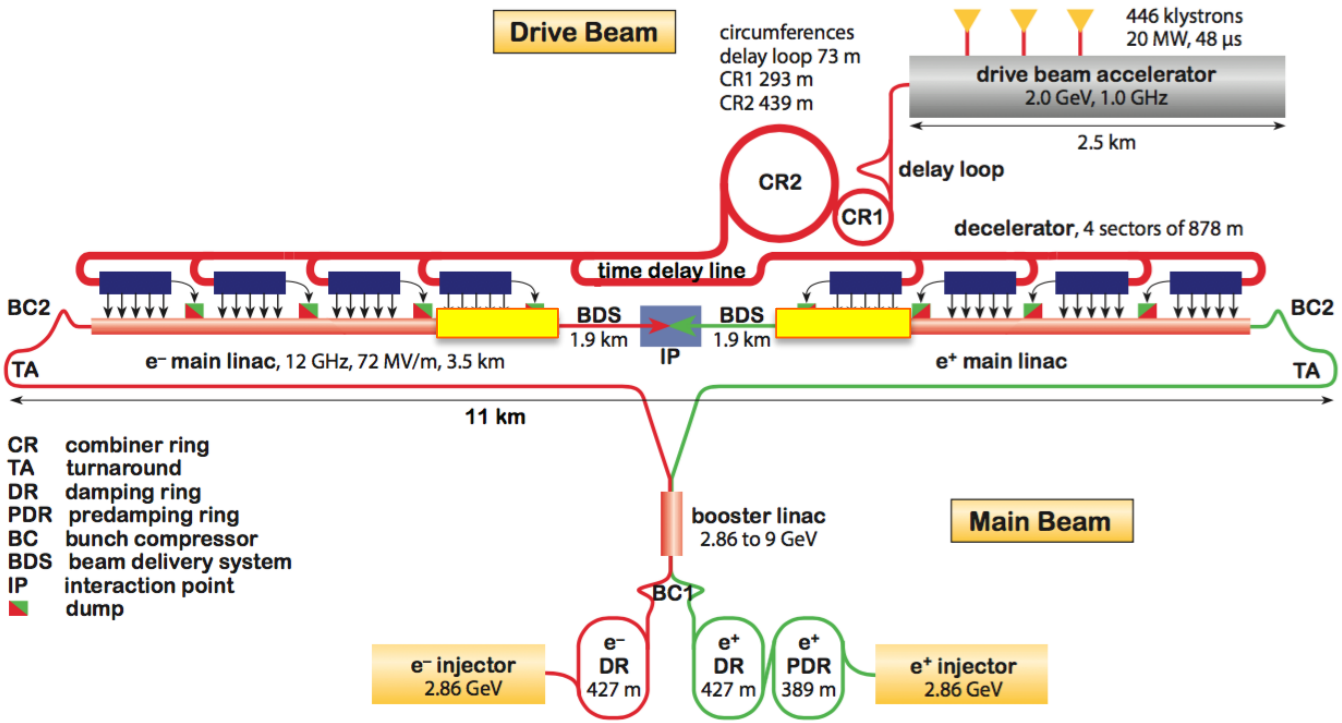


Idea around for some time. Preliminary concepts/considerations :

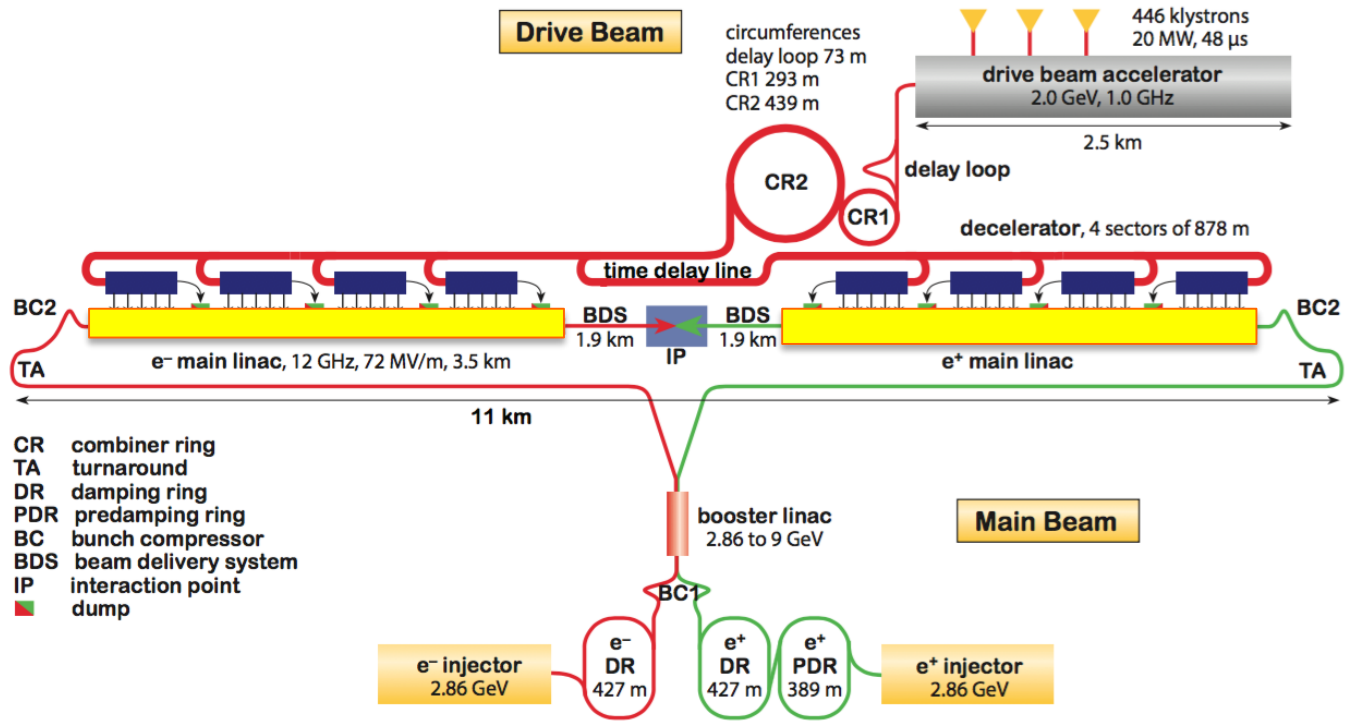
- S. Lee et al., Possibility of a multibunch plasma afterburner for linear colliders, Phys. Rev. ST Accel. Beams **5**, 011001 (2002)
- T. Raubenheimer, An Afterburner at the ILC: The Collider Viewpoint, in Proceedings of the Advanced Accelerator Concepts Workshop (A AC'04), Stony Brook, NY, 2004
- R. Maeda et al., Possibility of a multibunch plasma afterburner for linear colliders, Phys. Rev. ST Accel. Beams **7**, 111301 (2004)

(Bibliography is non-exhaustive)

Afterburner: replace part of linac by NAT - high-gradient at final stage(s)



Linac replacement: replace linac with NAT

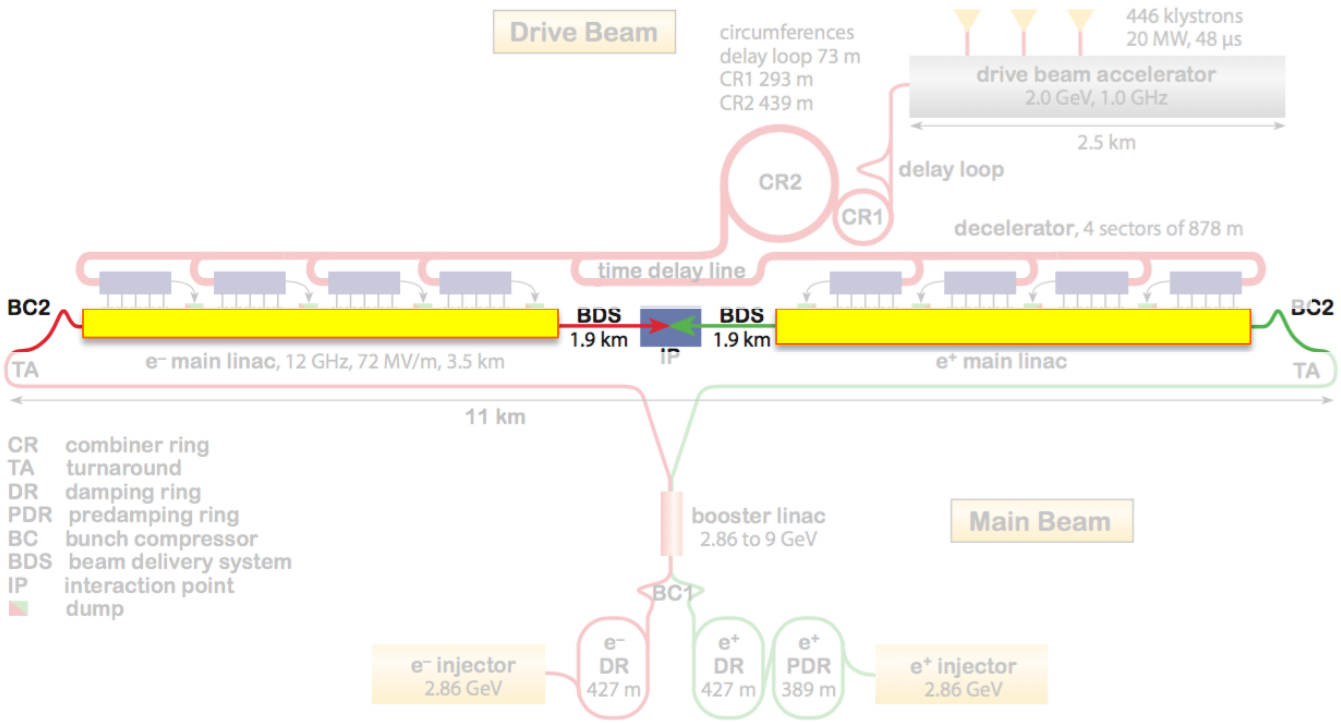


Preliminary concepts/considerations for different technologies :

- A. Seryi et al., A CONCEPT OF PLASMA WAKE FIELD ACCELERATION LINEAR COLLIDER (PWFA-LC), SLAC-PUB-13766
- C. B. Schroeder, E. Esarey and W. P. Leemans, Phys. Rev. ST Accel. Beams 15, 051301 (2012)
- E. Adli et al., A beam driven plasma-wakefield linear collider: from Higgs factory to multi-TeV, SLAC-PUB-15426
- W. Gai et al., CONSIDERATIONS FOR A DIELECTRIC-BASED TWO-BEAM- ACCELERATOR LINEAR COLLIDER,

(Bibliography is non-exhaustive)

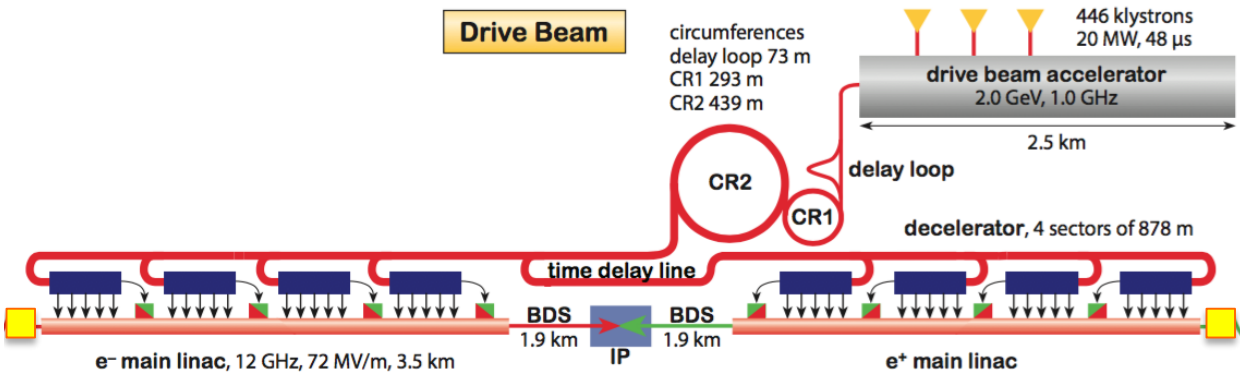
Linac replacement: replace linac with NAT – drive beam schemes and injectors



Optimization for a new two-beam technology may need a new drive beam scheme, and/or new injectors.

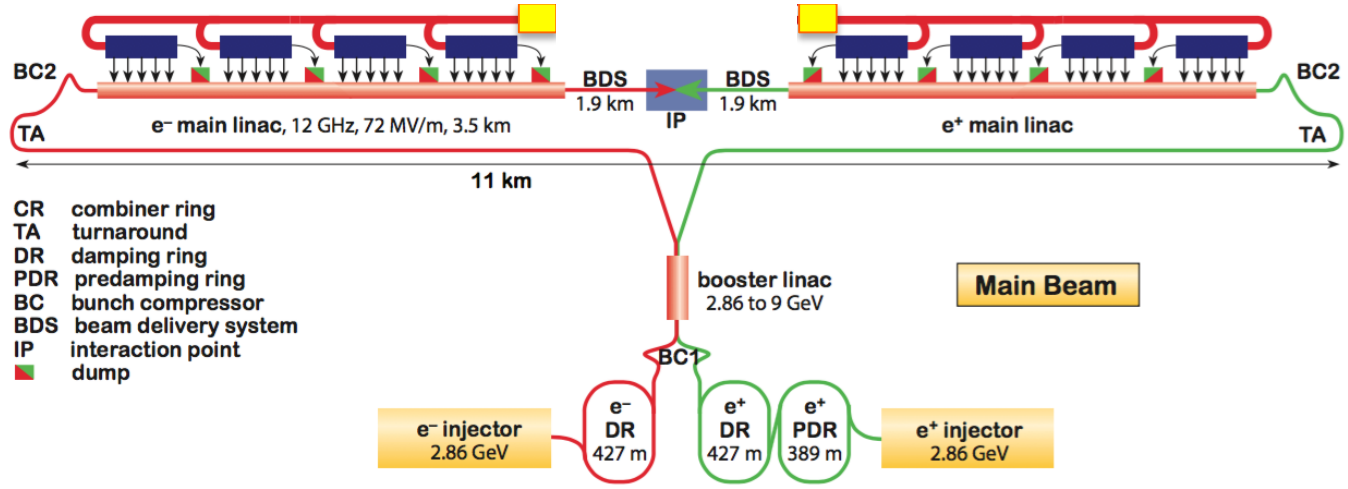
(Bibliography is non-exhaustive)

Injectors: replace injectors, damping rings and/or bunch compressors etc. with NAT



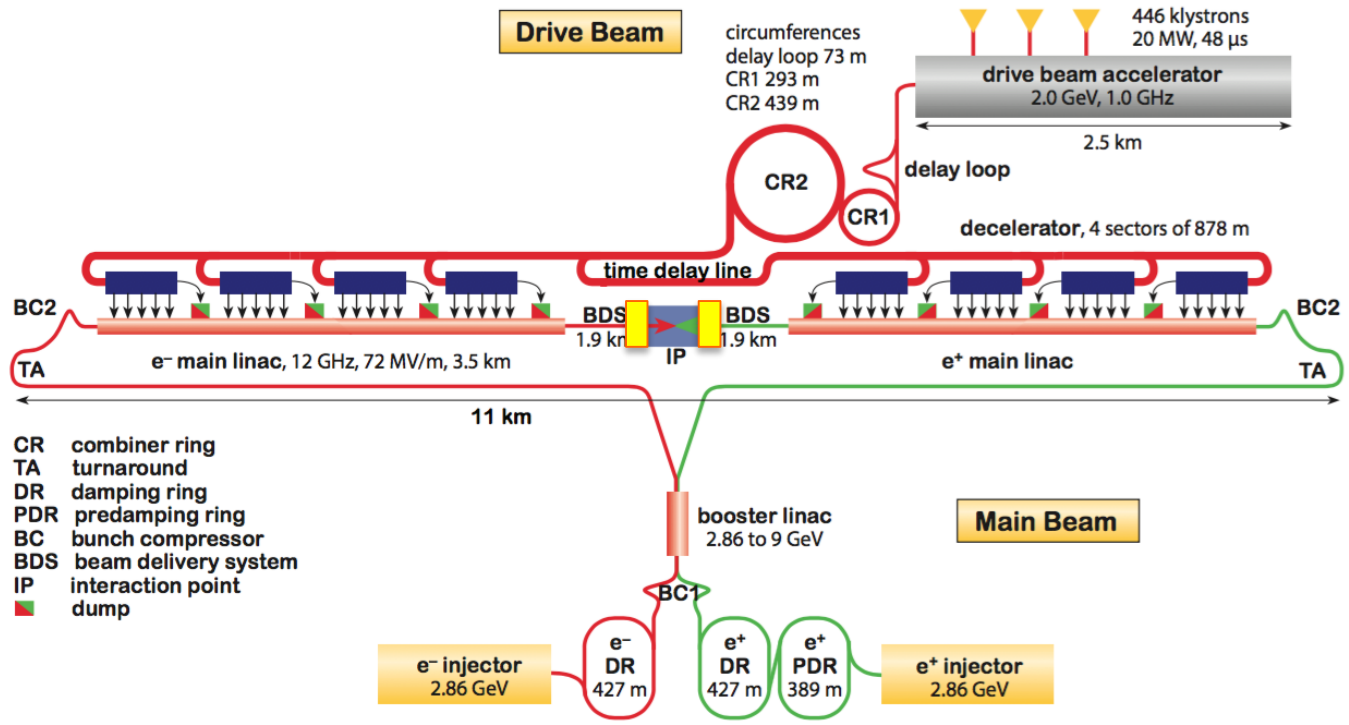
For example, plasmas as injectors (self-injection, ionizaiton injection, Trojan-horse)...
Promise to generate very short bunches (sub 10 um), at several GeV, in a short stage.

Drive beam: generate drive beam with NAT



Not much studies done. Less demands on beam quality; efficiency a key question.

Beam delivery: improve and/or shorten beam delivery system with NAT



For example, plasma lenses for final focusing. Promise for very high focusing gradient, and axially symmetric focusing.

First meeting (today)

Staring point for the study: discuss experience from conventional linear collider design and optimization with respect to luminosity and power. Speaker is Daniel Schulte.

Second meeting (in 5 weeks)

An overview of different NAT will be given. We attempt to have a first discussion on eventual obvious promise and limitations of the technologies with respect to objectives in the mandate. Speaker is Patric Muggli.

A few key metrics

High **gradient** (CLIC 100 MV/m)

Good energy **efficiency** (CLIC 3-7%)

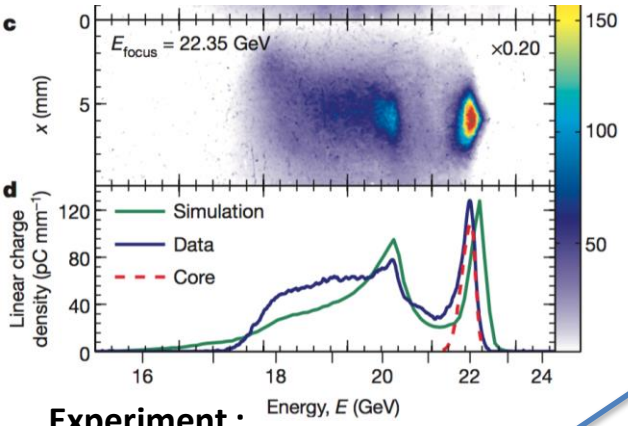
Small **emittance generation** (CLIC $\varepsilon_{N,0}$~10 nm)

Emittance preservation (CLIC ML $\Delta\varepsilon_N$~10 nm)

Low **energy spread** (CLIC 0.3% after ML %)

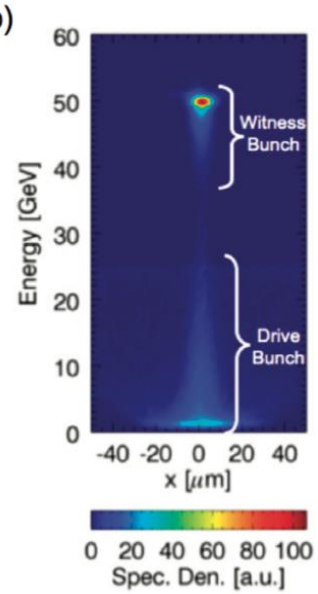
Potential challenge of evaluating NAT

Working group partly stimulated by recent experimental progress in NAT. Although experimental progress is impressive, the technology may be far from its ultimate performance. What should this working group take into account when considering feasibility? **One example** from beam-driven two-bunch PWFA :



Experiment :
two-bunch acceleration, much improved energy spread and efficiency with respect to previous PWFA experiments, but not as good as in PIC simulations. M. Litos et al., Nature **515**, 92–95 (2014)

Simulation :
Two-bunch acceleration, almost full DB depletion, high DB to WB efficiency, emittance preservation at um level, energy spread at %-level. M. Hogan et al., 2010 New J. Phys. **12** 055030 (2010).
However, accurate simulation of nanoscale beams is challenging.



Ultimate performance? :
Assume a performance can be reached only limited by fundamental principles? (Example: multiple scattering). Corresponding tolerances? D. Schulte, Reviews of Accelerator Science and Technology **9** (2017), V. Lebedev, A. Burov, S. Nagaitsev, Reviews of Accelerator Science and Technology **9** (2017)

Technical challenges
Even if the required beam parameters can be achived, there may be significant technical challenges to be addressed, for example linked to high rep. rate.