Brief recap

Working group on use of novel accelerator techniques

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Previous meeting:

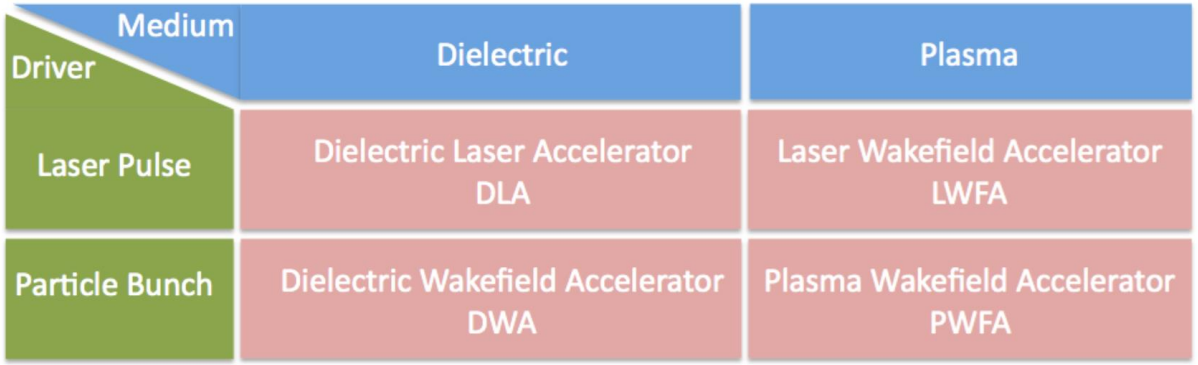
Overview of main novel accelerator techniques, by Patric Muggli.

Materials with higher damage threshold:

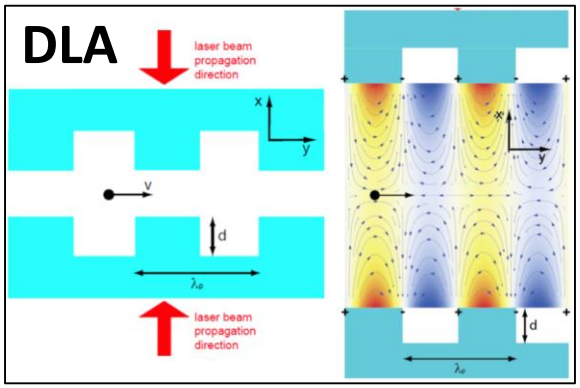
- Dielectrics (~GV/m)
- Plasmas (10-1000GV/m)

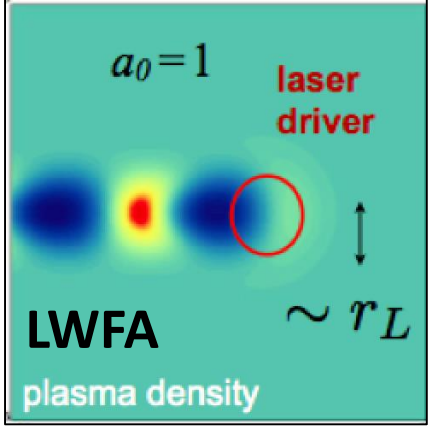
Systems powered/driven by:

- Laser pulse(s)*
- Relativistic, charged particle bunch(es)



*do not include laser vacuum/direct acceleration





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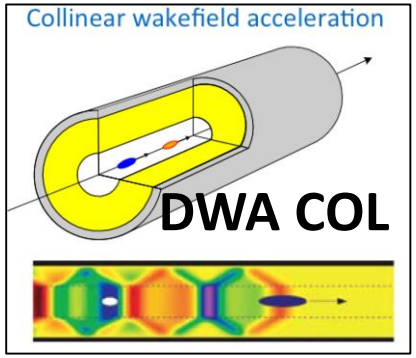
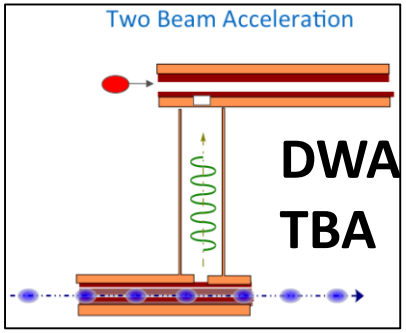
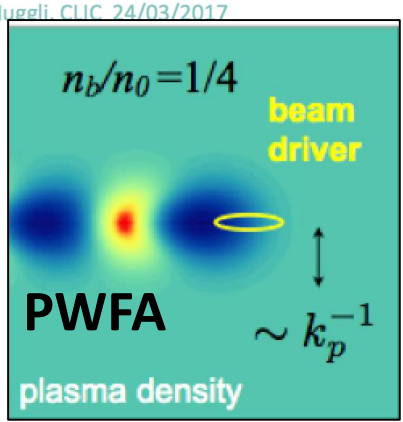
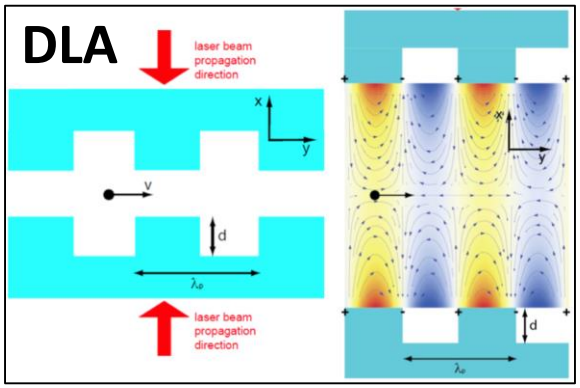
Driver \ Medium	Dielectric	Plasma
Laser Pulse	Dielectric Laser Accelerator DLA	Laser Wakefield Accelerator LWFA
Particle Bunch	Dielectric Wakefield Accelerator DWA	Plasma Wakefield Accelerator PWFA

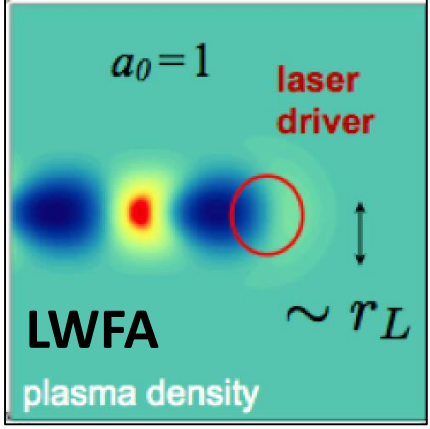
 *do not include laser vacuum/direct acceleration





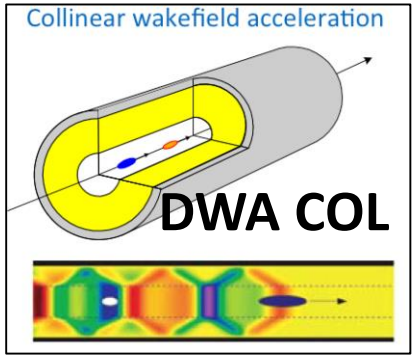


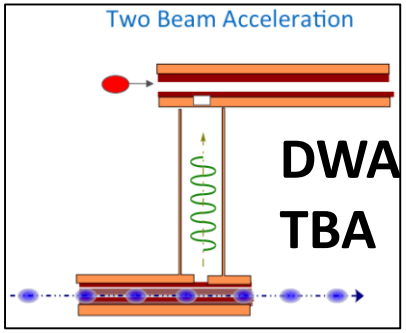


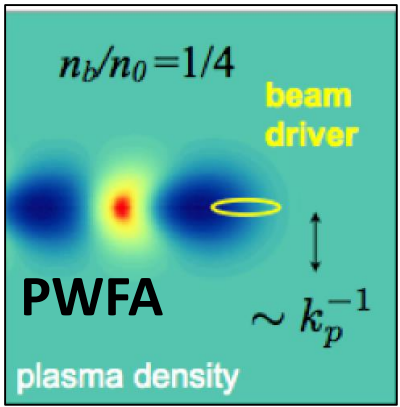


Charge symmetric
- same acceleration mechanism for e- and e+

Charge asymmetric in the non-linear regime (blow-out)
- e-: promise of good emittance preservation during acceleration
- e+: less clear







Mandate :

"Increasing the energy with CLIC technology in stages towards ~3 TeV is possible, beyond this range costs, power and dimensions become prohibiting."

Steinar :

"We are still far from promising +10 TeV as Fabiola ordered - so more meetings will be needed."

NN :

"I am glad that more meetings will allow you to go to higher energies!!"

Thoughts on the way forward

Working group on use of novel accelerator techniques

Actions on two time scales

1) Address open questions, develop credible concepts, optimze for key novel technologies. Longer time scale.

2) Investigate in more detail technology that are close to CLIC technology (wakefield driven dielectrics – "DWA"). Start collaboration on short time scale

(Both points detailed more in what follows)

CLIC: overall parameter optimization

- CLIC overall parameters (frequency, gradient, pulse length, current ...) decided by a global optimization procedure.
- Optimization initially based on luminosity-per-power as criterion (Grudiev et al., EPAC'06, p.1869), later extended with a simple cost model (Grudiev et al., LINAC'08, p. 529). Later further refined.
- Cite from CLIC rebaselining document :

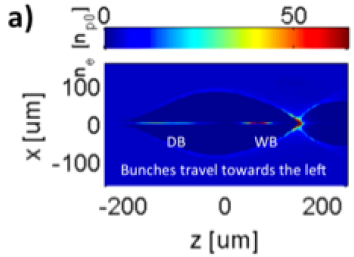
"One of the key elements which has made the overall optimisation of the CLIC accelerator complex possible is the **parameterisation of the full RF properties of the accelerating structures**. "

NAT: overall parameter optimization

The dependencies for novel technologies may be very different**.**
Example dependencies :

* CLIC main linac: increased frequency -> smaller aperture (1/f) -> less charge per bunch -> longer pulses

* PWFA blow-out:



- increased frequency -> smaller aperture k_p^{-1}

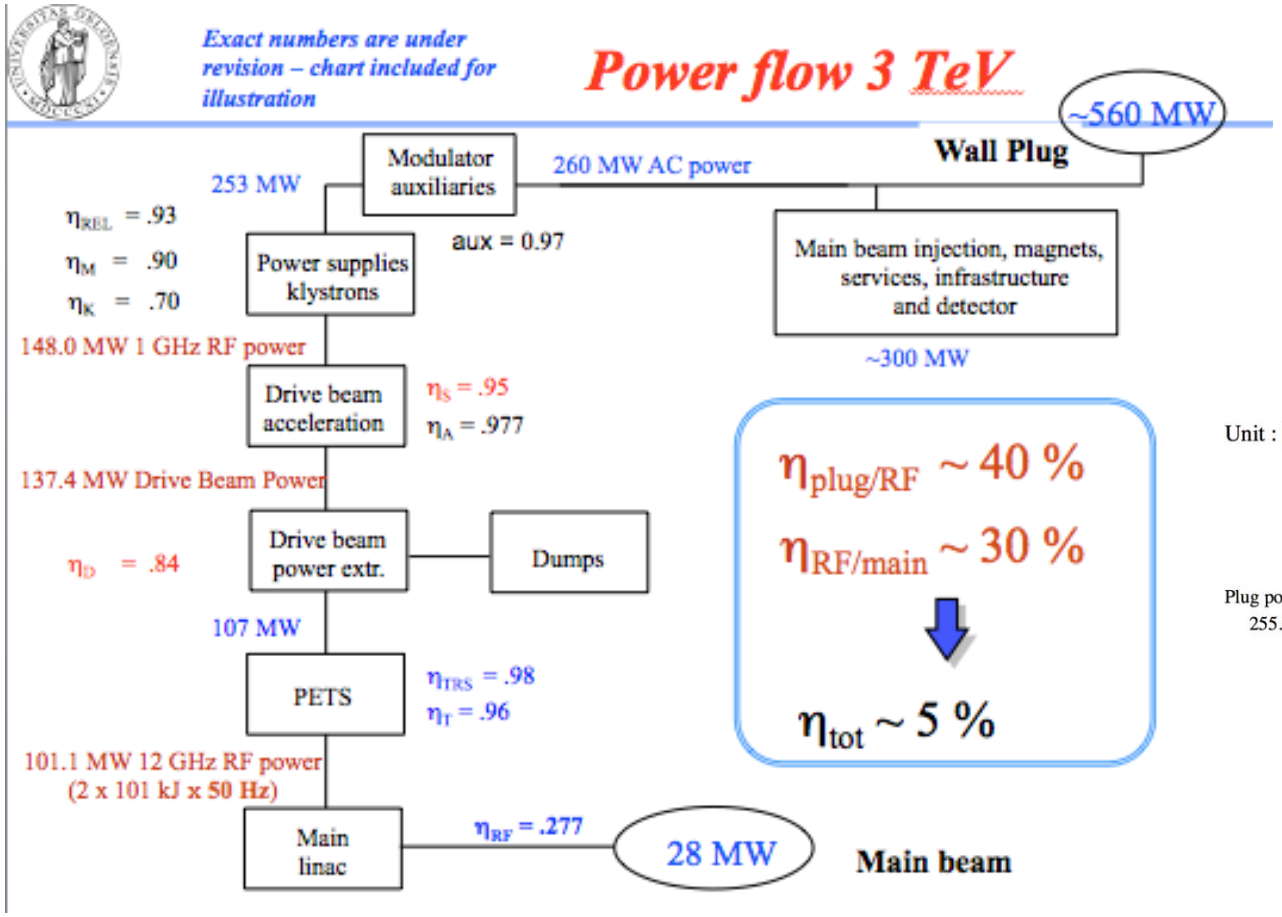
- increased charge per drive bunch -> large bubble size -> increasing aperture (looser tolerances)

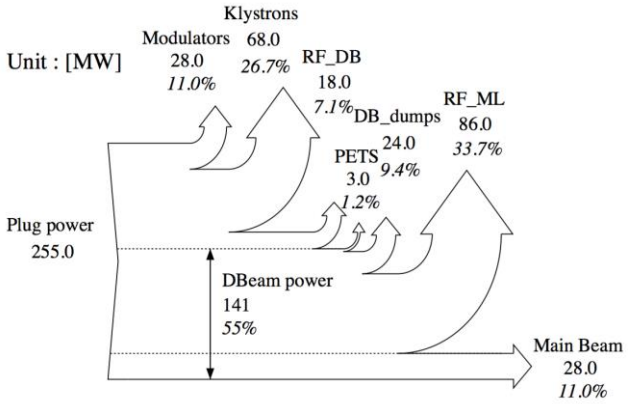
Point is: dependencies for PWFA not clear, and may be different than RF, leading to different scalings.

Need to understand dependencies better in order to optimize parameters for novel technologies. I think this is true for at least PWFA, LWFA and DLA.

CLIC: understanding performance for *single* parameter set

For a given CLIC parameter set, key performance metrics can be calculated.
Example: wallplug-to-beam efficiency (about 10 %).



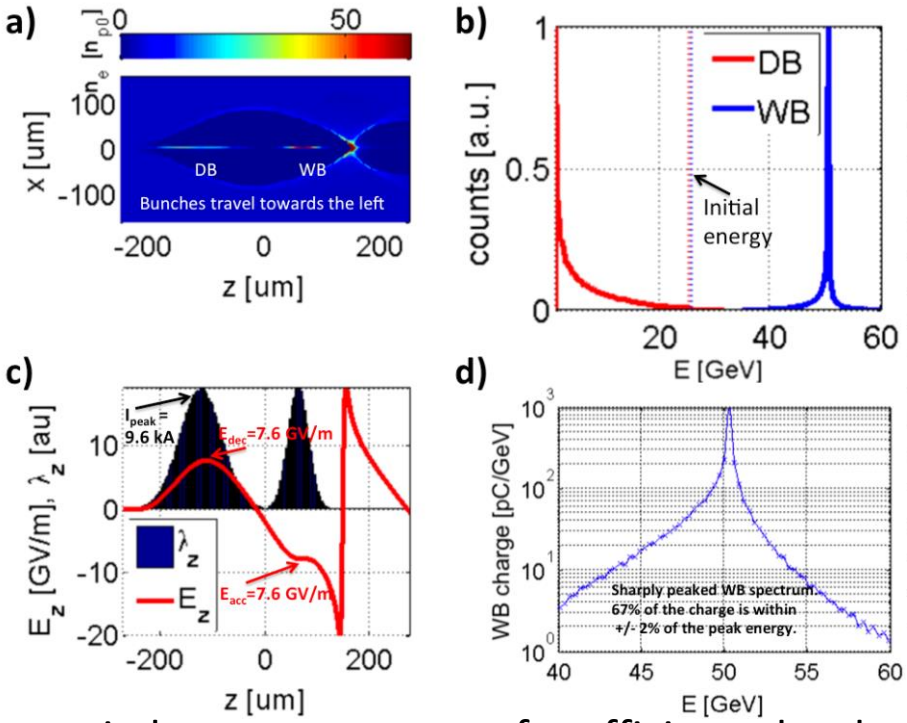


(From CLIC CDR)

NAT: understanding performance for *single* parameter set

We could attempt to estimate efficiencies, as well as beam quality metric, for a given parameter set. Could be an educating exercise, however, large error bars on key numbers.

Example PWFA :



	T=1.5	T=1.0
n_0 $[10^{16}/cm^3]$	2	2
Q_{WB} $[10^{10}e]$	1.0	1.0
T	1.5	1.0
$\sigma_{z,DB}$ $[\mu m]$	40	40
E_d [GV/m]	10	7.6
E_a [GV/m]	15	7.6
$\mathscr{E}_{0,DB}$ [GeV]	17	25
L_{cell} [m]	1.7	3.3
Q_{DB} $[10^{10}e]$	3.0	2.0
$\sigma_{z,WB}$ $[\mu m]$	14	20
Δz_{DW} $[\mu m]$	225	187
$<\sigma_E/\mathscr{E}>_{WB}$	3%	(n/calc)
η_{DW}	50%	50%
$\sigma_{\{x,y\},mat}$ [nm]	{328,51}	{328,51}
$W'_{loss,max}$ [MeV/m]	6.1	6.1
Δr @ 100 MeV/m [um]	1.3	1.3

The drive beam to main beam energy transfer efficiency has been quoted higher than **50%** (based on on-axis 3D PIC simulations, with um-emittance beams) (Adli, Delahaye, Snowmass), or, **significantly lower** (order of magnitude?) , if considering also the transverse wake and/or energy spread (Fermilab, Schulte). **Needs more study.**

Conclusion NAT WG

Seems important to understand main key parameter dependencies. Some may be easily answered by experts outside this WG, some may need work. Perhaps much can be done by theoretical and numerical studies. Perhaps some questions needs experimental studies.

This WG can be helpful *in defining key question* to be answered (by us, by experts or by studies to be defined). A few of these questions are already clear :

* drive-to-witness efficiency PWFA when taking into account transverse wakes and energy spread considerations
* wallplug-to-drive efficiency PWFA (optimal design of PWFA drive beam)
* laser-to-witness efficiency LWFA
* laser-to-witness efficiency DLA
* wallplug-to-laser LWFA and DLA
* transformer ratio for DB schemes
* DWA: see next slide
* etc.

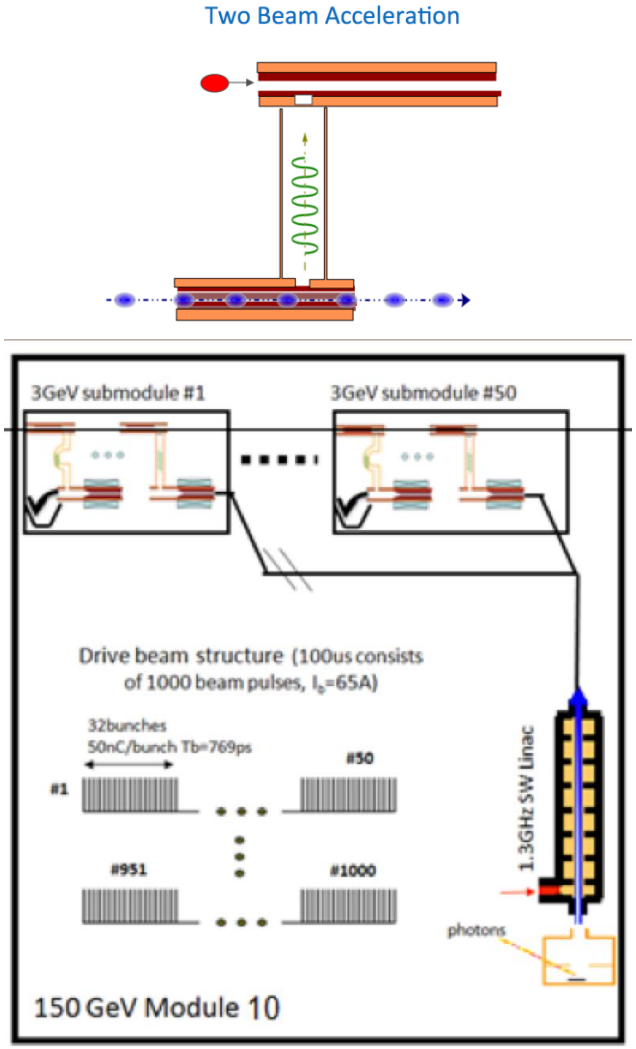
See also Daniel's WG presentations where some questions and ways to address them are already outlined.

In addition similar questions on emittance preservation considerations, especially in plasmas.

Suggestion: write up a document with key questions to be address. Deadline relatively short time scale (2 months?). A draft to be discussed in a future meeting.

Short term goal: study wakefield driven dielectrics (DWA)

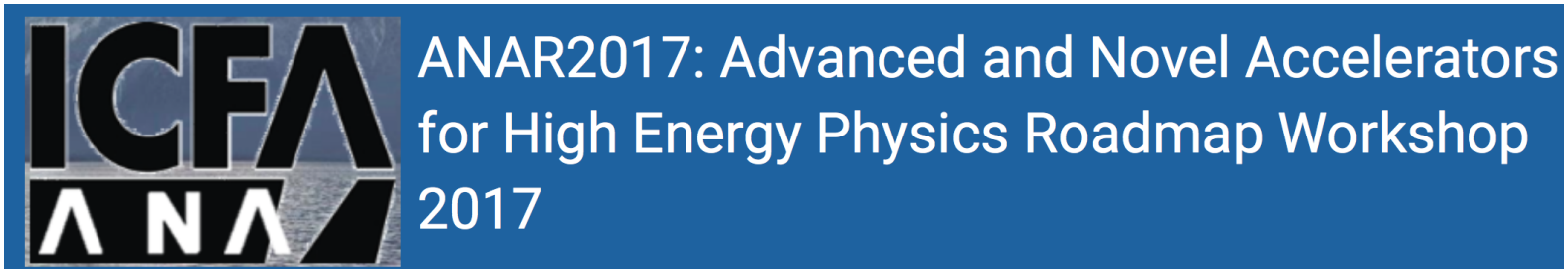
- Substantial experimental activities on DWA on-going at Argonne and other labs.
- Two-beam DWA concept similar to CLIC.
- Technology thus easier to compare head-to-head, to see if CLIC can benefit from dielectrics
- CLIC already contacted Argonne, Interest in collaboration stated from both sides
- The CLIC WG could help guiding the research in order to answer key questions (gradient, BDR, transverse wakes etc.)
- Argonne will present status and plans in one of the next meetings



From John Power (Argonne)

ANAR workshop at CERN

Next week: a good opportunity to work on the list of questions and how to address them, in collaboration with the ANAR workshop "Advanced and Novel Accelerators for High Energy Physics", where many experts in PWFA, LWFA, DLA and DWA will be present.



https://indico.cern.ch/event/569406/

I am not among the organizers, but I believe everyone will be welcome to the plenary sessions in the BE auditorium.