New participants since last meeting :

Igor Syratchev, CERN
Edda Gschwentdner, CERN
Philpp Roloff, CERN
Bernard Holzer, CERN

Previous meeting (17/2):

Daniel Schulte, Requirements for linear colliders

This meeting:

Patric Muggli, An overview of novel accelerator technologies

Next meeting (21/4):

Philipp Roloff, Physics considerations for multi-TeV collisions (tentative title)

Conclusion

- Our objective
  - Understand the potential to upgrade CLIC (or ILC) with novel technologies to reach multi-TeV energies
- Requires to address the goals
  - Develop credible scenarios/concepts of multi-TeV colliders based on novel technologies
  - Identity the associated feasibility issues
  - Contribute to the specific R&D required to make novel technologies useful for colliders
- Identified some exploration and more detailed work that should be started
  - Significant effort is required
  - Certainly this will become more refined

From Daniel's slides

Luminosity Challenge for Linear Colliders

$$\mathcal{L} \propto H_D \frac{n_\gamma^{\frac{3}{2}}}{\sqrt{\sigma_z}} \frac{1}{\sqrt{\epsilon_y \beta_y}} \frac{R+1}{R} \frac{\eta P_{wall}}{mc^2}$$

Efficiency will limit beam power in plasma-based colliders

- Likely find practical efficiency to be smaller in plasma-based colliders than assumed now

$\Rightarrow$ Have to improve luminosity per beam current

$\Rightarrow$ Could be useful for linear colliders in general, but also means no low-hanging fruit known

$\Rightarrow$ Still have to push efficiency as much as possible

From Daniel's slides

Luminosity Challenge for Linear Colliders

$$\mathcal{L} \propto H_D \frac{n_\gamma^{\frac{3}{2}}}{\sqrt{\sigma_z}} \frac{1}{\sqrt{\epsilon_y \beta_y}} \frac{R+1}{R} \frac{\eta P_{wall}}{mc^2}$$

Reduce the vertical beamsize (betafunction and emittance) as much as possible

Plasma-based linacs might lead to larger energy spreads
$\Rightarrow$ R&D required to get to same beamsizes as with conventional technology
$\Rightarrow$ Or reduce energy spread, if possible

- Smaller emittances needs
  - better emittance preservation in main linac (but more difficult than in LC)
  - better sources
    - e.g. undulator-based damping?

- Smaller betafunction could be achieved using novel beam delivery system design
  - Plasma lenses?
  - Crystals?
  - Electron/proton lenses?
  - RF quadrupoles to correct correlated energy spread?

- Have to keep the tiny beams in collision
  - but high repetition rate would help

From Daniel's slides

Some Tentative Work Steps I

- Derive realistic main linac beam parameters for plasma-based accelerators
  - Develop beam dynamics models
  - Develop a consistent design
  - Solution for positrons?

Quite some work for us
Theory needs to be developed

- Study plasma drivers
  - Develop realistic drive beam concepts
  - Collect information on laser
  - Consider proton driver (help of AWAKE?)

Some work for us

Exploration of information

Exploration of information

- Review dielectric acceleration concept and parameters
  - RF structures
  - Beam parameters
  - Emittances

Exploration of information

Could become important work for us

From Daniel's slides

Some Tentative Work Steps II

- Develop technologies for main linac
  - Stabilisation
  - Timing
  - …

Quite some work for us
Concepts may need to be developed
Input from design required

- Study low emittance sources
  - Pushing emittances further down
  - Novel concepts and technologies

Quite some work for us
Concepts may need to be developed

- Study improved focusing at collision point
  - Novel concepts and technologies

Quite some work for us
Concepts may need to be developed

- Develop alternative overall concepts
  - Asymmetric beams
    - E.g. low energy high-current positron beam in conventional technology, high energy, low-current electron beam in plasma
  - Gamma-gamma option
  - Beamstrahlung suppression

Quite some work for us
Concepts may need to be developed

From Daniel's slides

Beam Stability in Plasma Linac

Highest beam current leads to highest RF to beam efficiency
$\Rightarrow$ Maximise bunch charge
$\Rightarrow$ Minimise bunch distance

Short-range longitudinal wakefields induce energy spread, compensated with RF
$\Rightarrow$ bunch charge defines bunch length $\sigma_z(N,W_L)$

Short-range transverse wakefields can make beam instable
$\Rightarrow$ limits the bunch charge $(W_T\ \sigma_z(N)\ N)$

Transverse long-range wakefield can make the beam instable
$\Rightarrow$ limits the distance between bunches

Beam stability for strongest practical lattice defines beam parameters

Wakefield in LPA is O(10^7) larger than in CLIC
- Require very strong focusing
- But still seems very high wake

CLIC single bunch extracts 0.3% of stored energy in accelerating structure (ignoring losses in copper)
- multi-bunch is key

- Make a realistic estimate for the stable bunch charge in plasma colliders
  - improve wakefield model (actually two-stream model)
- Can one consider multi-bunch operation in plasma?
  - actually this is a principle in AWAKE, but not clear if it works there as well as one would like

From Daniel's slides

Selected Example Main Linac Issues

- Positron acceleration in bubble regime
- Lattice design
  - Main beam focusing has huge impact on beam stability
  - Drive beam/laser in and out
  - Clearly lower drive beam energy would be beneficial
- Two stream instability main beam in plasma (similar to wakefields in CLIC)
- Making a hollow channel (rest gas would be ionised by main beam)
- Channel alignment for hollow channel
  - Similar to structure alignment in CLIC, but likely tolerance very tight
- Drive beam/laser to main beam alignment/jitter stability
- Plasma density stability, in particular with longitudinal profiles
- Heating of the plasma (O(100kW/m))
  - 75% of drive beam power to plasma, 65% from plasma to main beam
- Many more imperfections
  - This has been critical for conventional linear colliders
- ...