Future High Energy Lepton Accelerators

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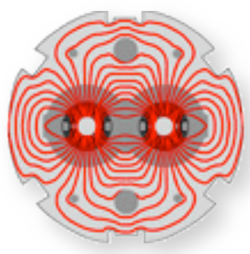
Outline

- Physics motivation
- Present and future high energy colliders
- LHeC
- Plasma Acceleration
- Summary

Physics Motivation

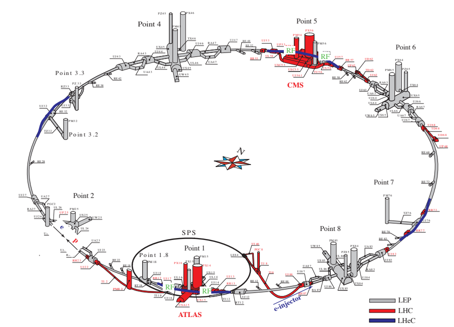
Lepton-Lepton collisions allow most precise studies

Present and Future High Energy Colliders



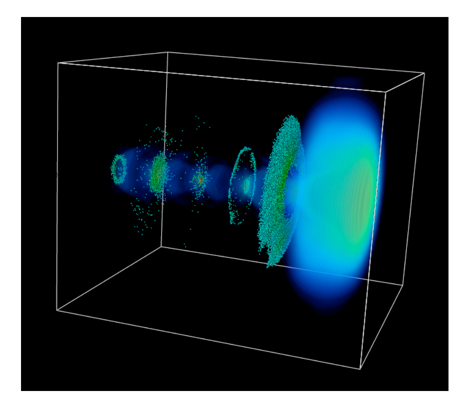
LHC - p-p Collisions

LHeC - e-p Collisions (Miriam)



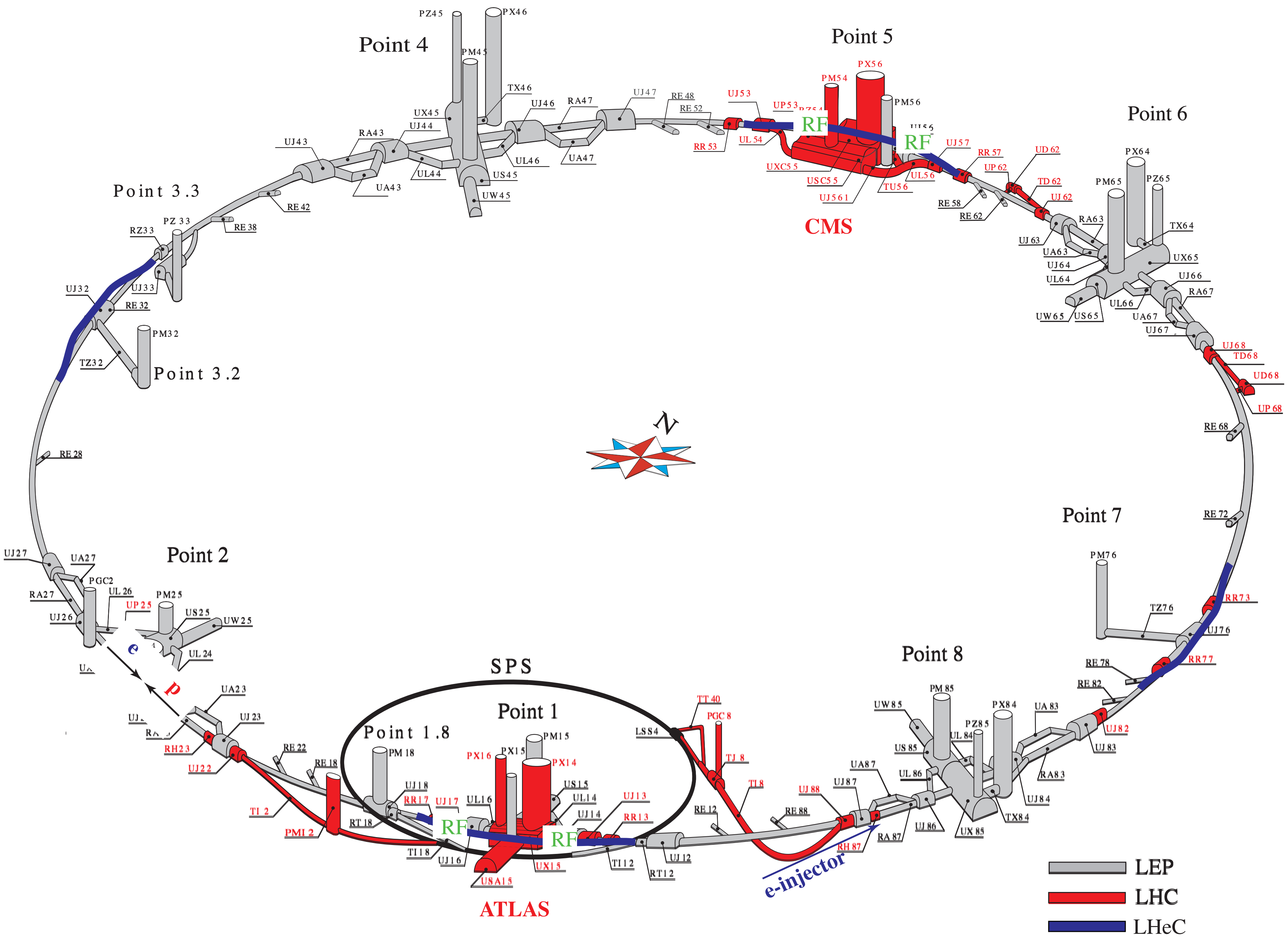
CLIC and ILC - e-e Collisions

PWFA - e-e Collisions (Steffen)



LHeC

Overall Layout and Bypasses



Bypass around IP1 and IP5:

- as short as possible (tunnel cost)
- as close as possible to the LHC in order to match LHC and LHeC circumference
- integration

Parameters 70 GeV

	Protons	Electrons
Number of bunches	2808	
Beam Energy	7 TeV	60 GeV
Number of particles per bunch	1.7×10^{11}	$2.6\ 10^{10}$
Horizontal Beta	180 cm	18.0 cm
Vertical Beta	50 cm	10.0 cm
Normalized Emittance (horizontal)	3.75 µm rad	0.58 mm rad
Normalized Emittance (vertical)	3.75 µm rad	0.29 mm rad
Beam Size (horizontal)	30.0 µm	
Beam Size (vertical)	16.0 µm	
crossing angle	0.93 mrad	
geometric reduction	0,77	
Luminosity	$1.7\ 10^{32}\ cm^{-2}\ s^{-1}$	
total wall plug power		100 MW
Synchrotron radiation	negligible	< 50 MW

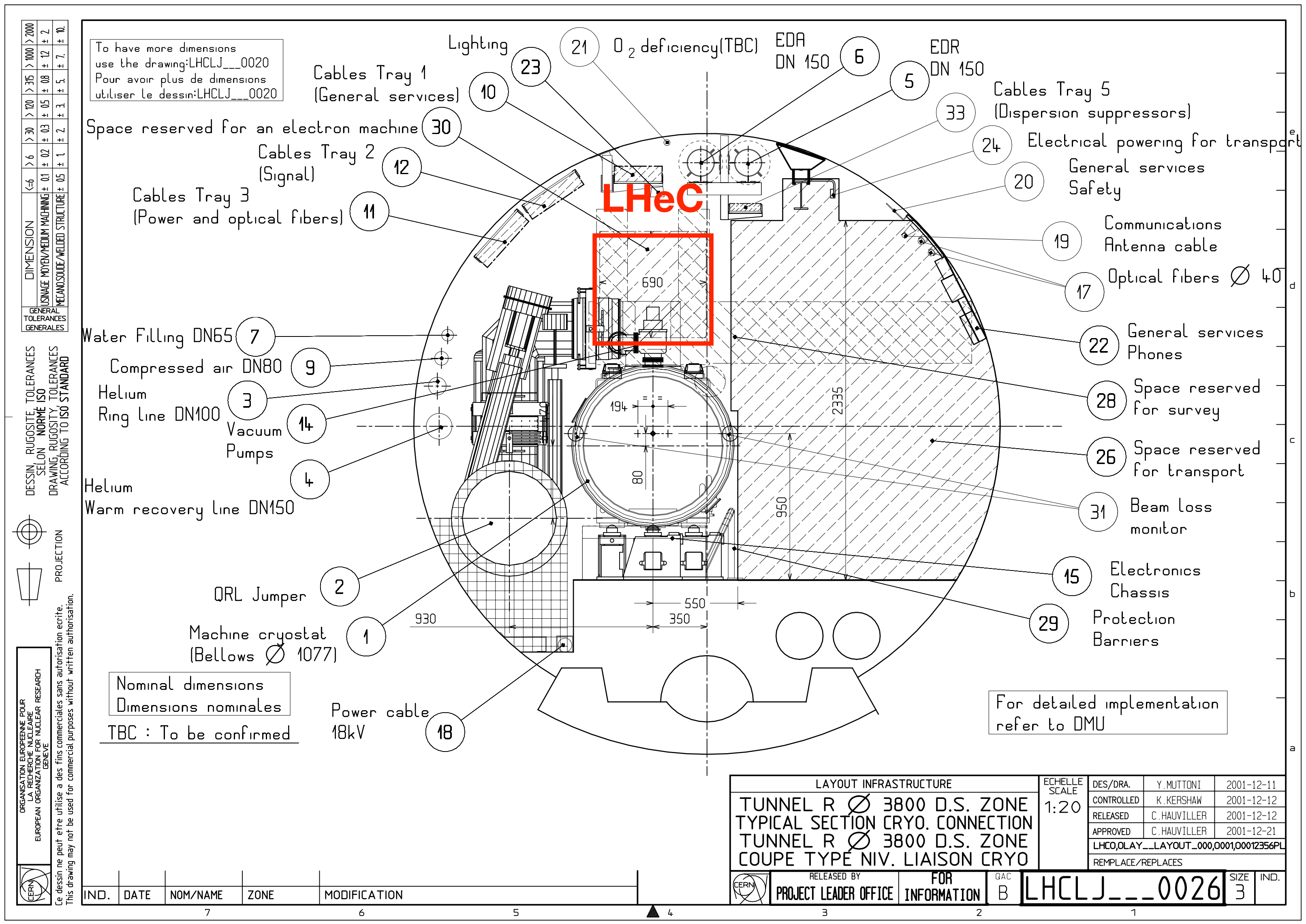
unequal beams:
strong p-beam, weak e-beam

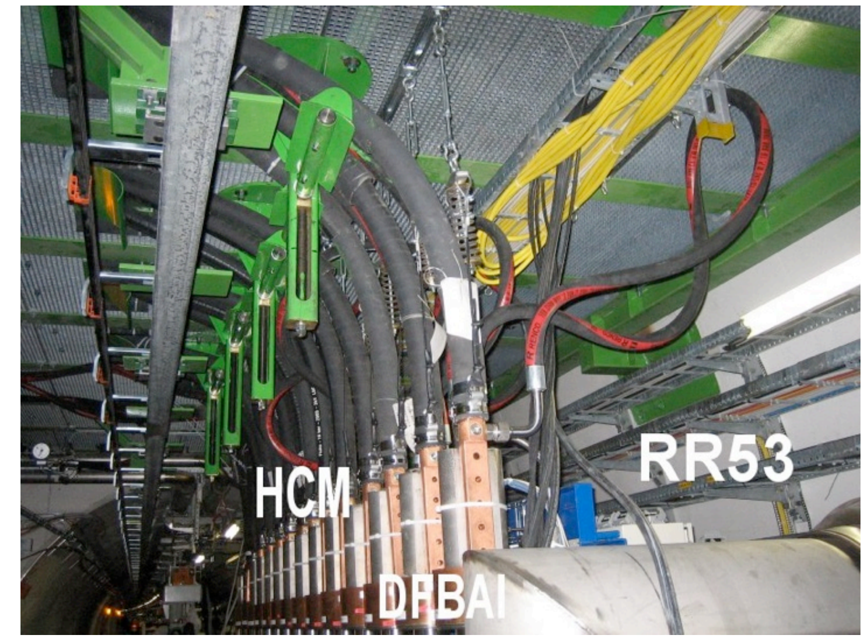
elliptical e-beam must be matched to round p-beam

large crossing angle necessary for beam separation

upper limit for synrad determines the e-beam intensity and with it luminosity

Lattice Design



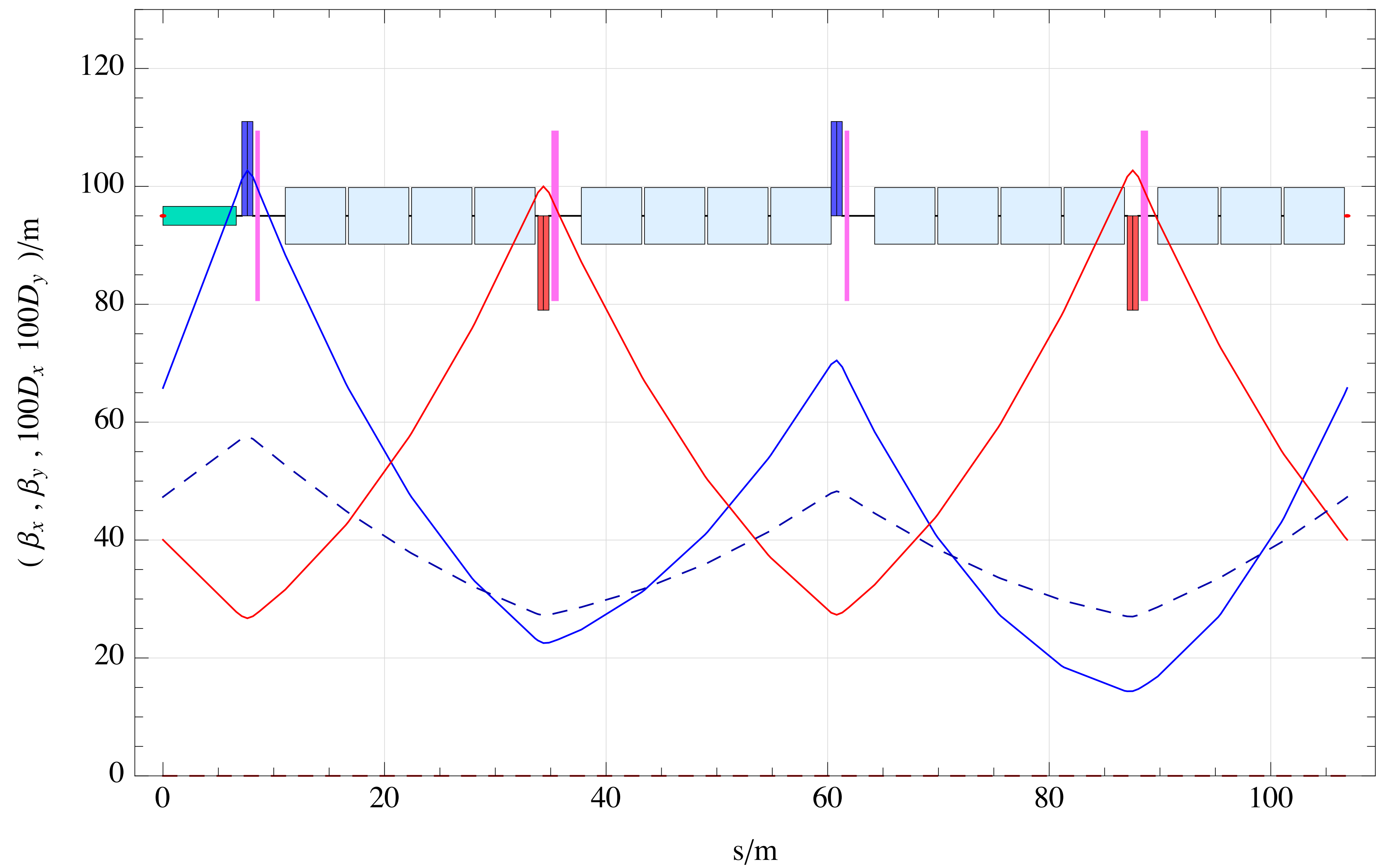


DFBM in the arc

Lattice design is dominated by integration and geometry

Example Arc Cell

Arc: 23 arc cells, L_{cell}=106.9 m



The space blocked by the DFBMs leads to an asymmetric cell design. The resulting asymmetric geometry can only be fit to the symmetric LHC geometry by shortening and moving the dipoles.

PWFA

Plasma Wake Field Accelerator

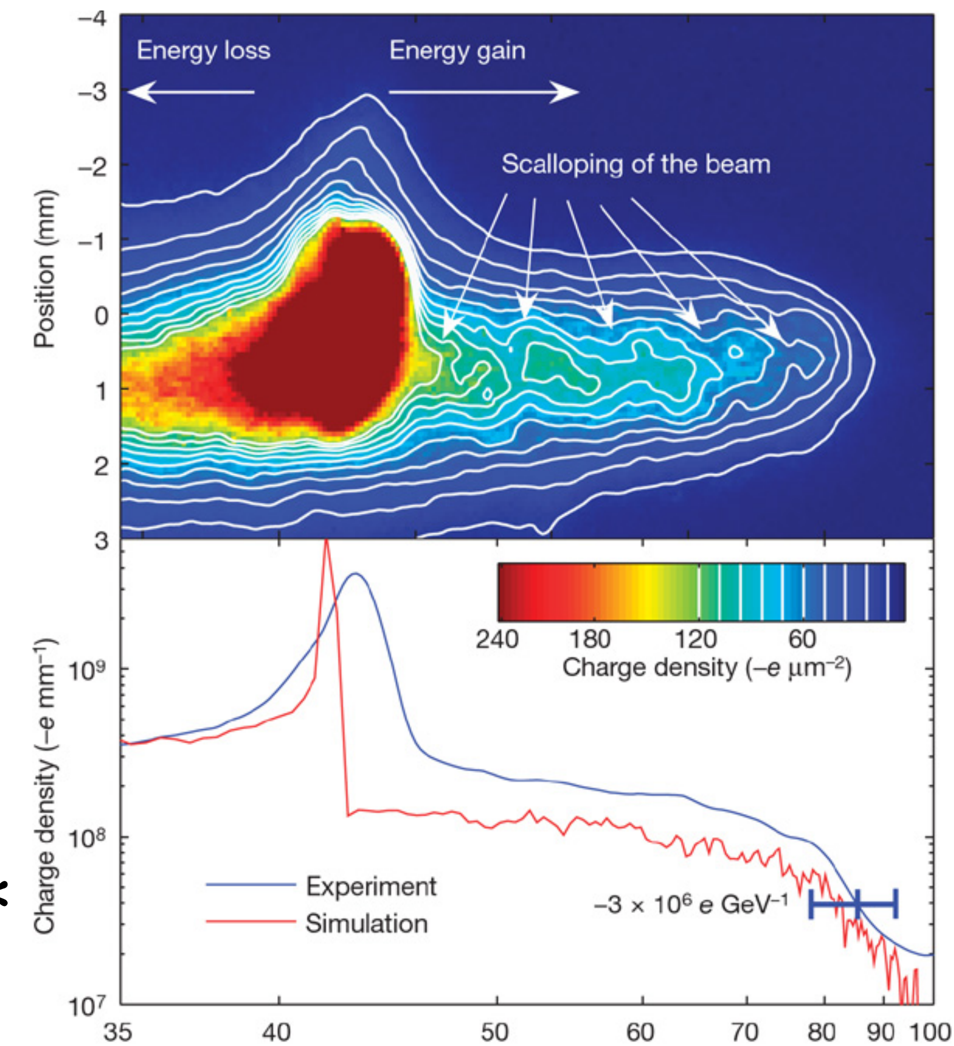
Why use plasmas for electron acceleration?

The gradient in normal Cavities is limited to about 50 MeV/m due to material breakdown.

To reach TeV energies, accelerators have to be very long (see CLIC / ILC) and are therefore very expensive.

A plasma is already completely "destroyed" and can support fields of up to 100 GeV/m.*

Therefore accelerators could be significantly shorter (i.e. cheaper).

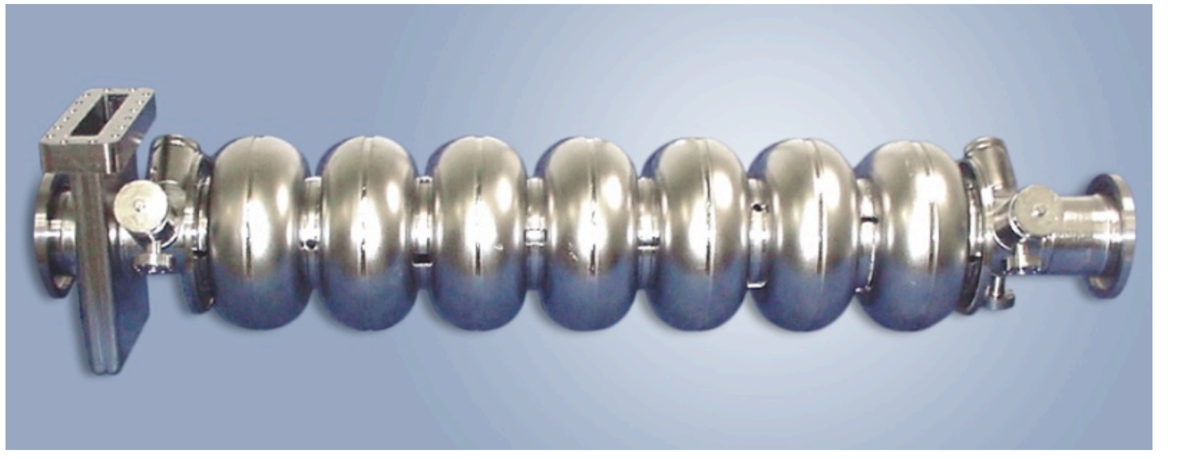


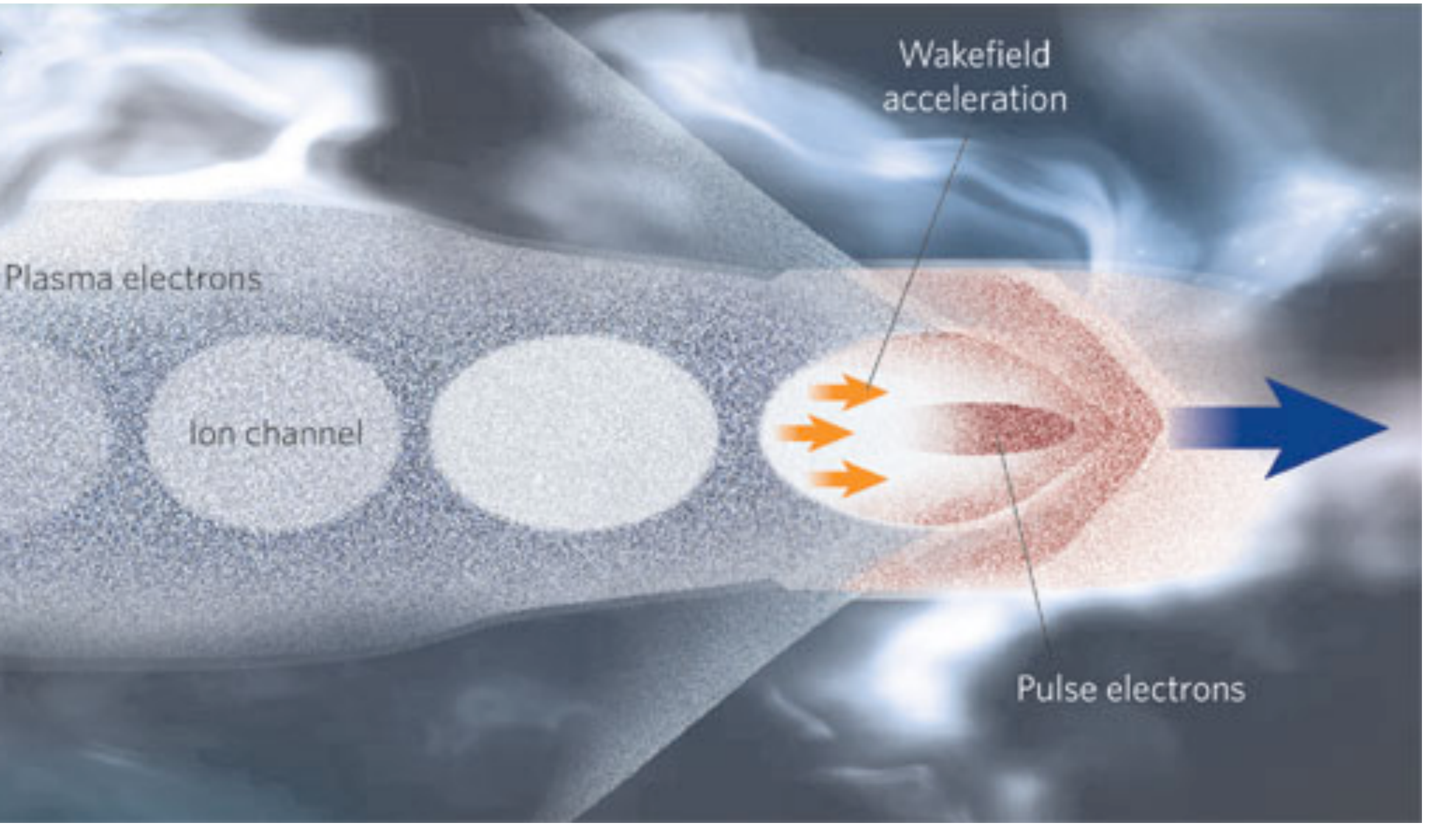
*Blumenfeld 2007, doi: 10.1038/nature05538
Leemans 2006, doi: 10.1038/nphys418;

How do PWFA work?*

*Esarey 1996, doi 10.1109/27.509991

Plasma Wake Field Accelerators (PWFA) work *almost* like normal cavities.





Picture: Bingham 2007, doi:10.1038/445721a

"Bubble regime":

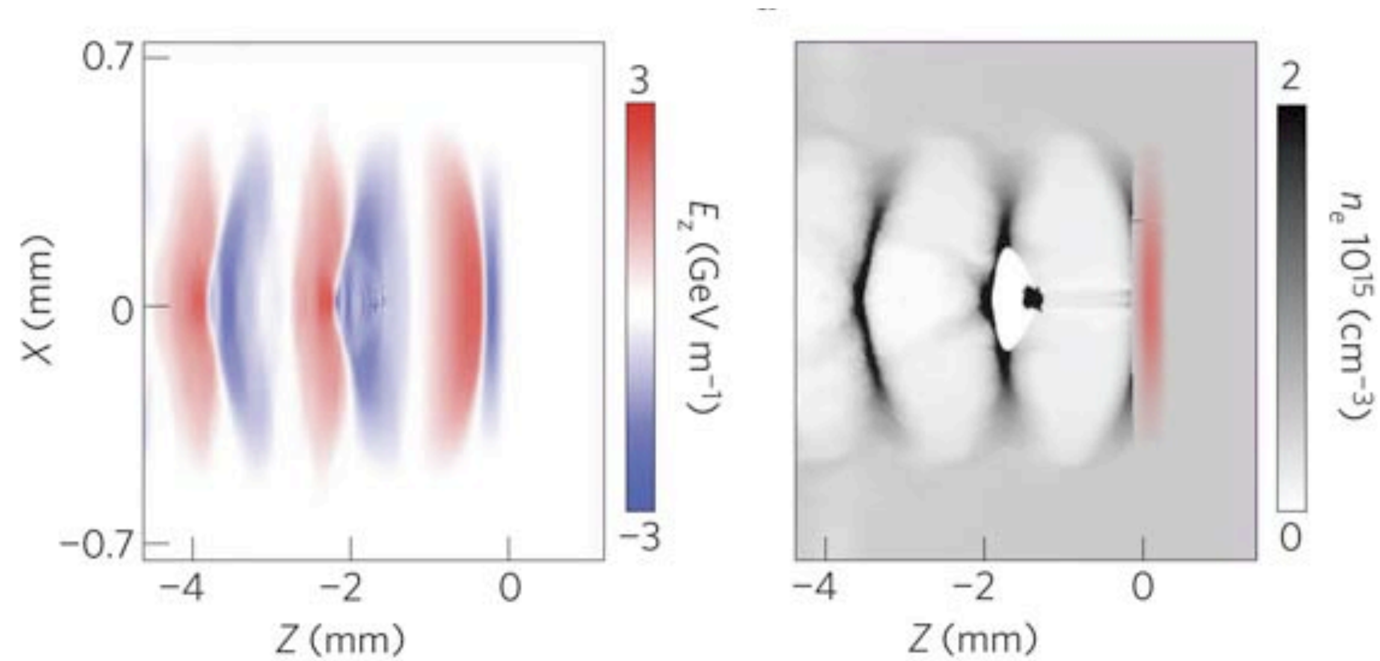
Driver displaces the plasma electrons.

Heavier Ions remain stationary.

Resulting field accelerates particles (normally electrons).

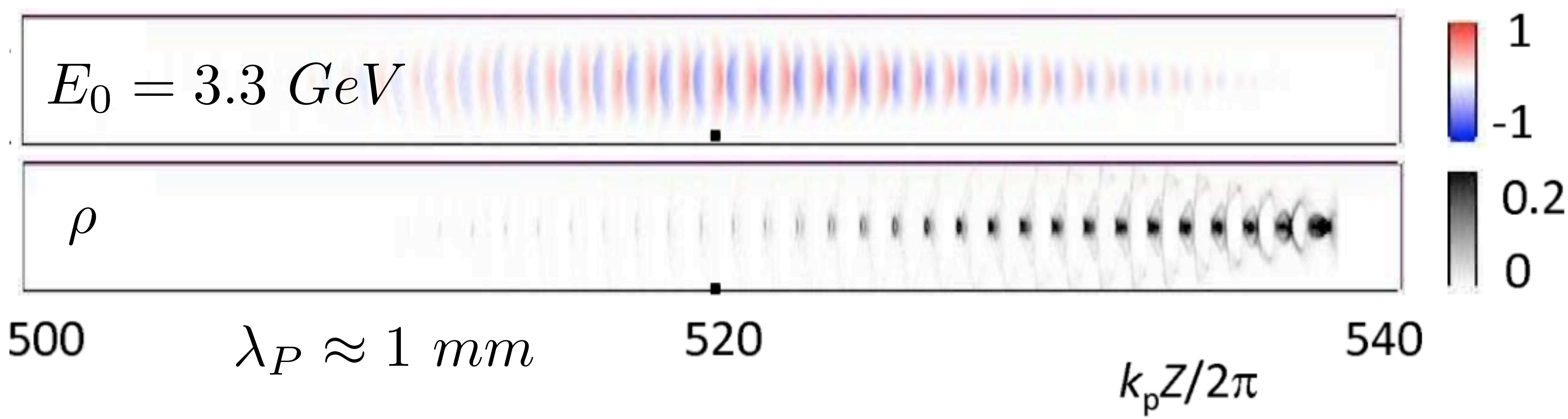
What are we planning at CERN?

- Use protons
  to drive a plasma
- Build proof-of-principle
  experiment at SPS
  (Linear regime)
- Accelerate electrons to TeV



Caldwell 2009, doi: 10.1038/NPHYS1248

Kumar 2010, doi: 10.1103/PhysRevLett.104.255003



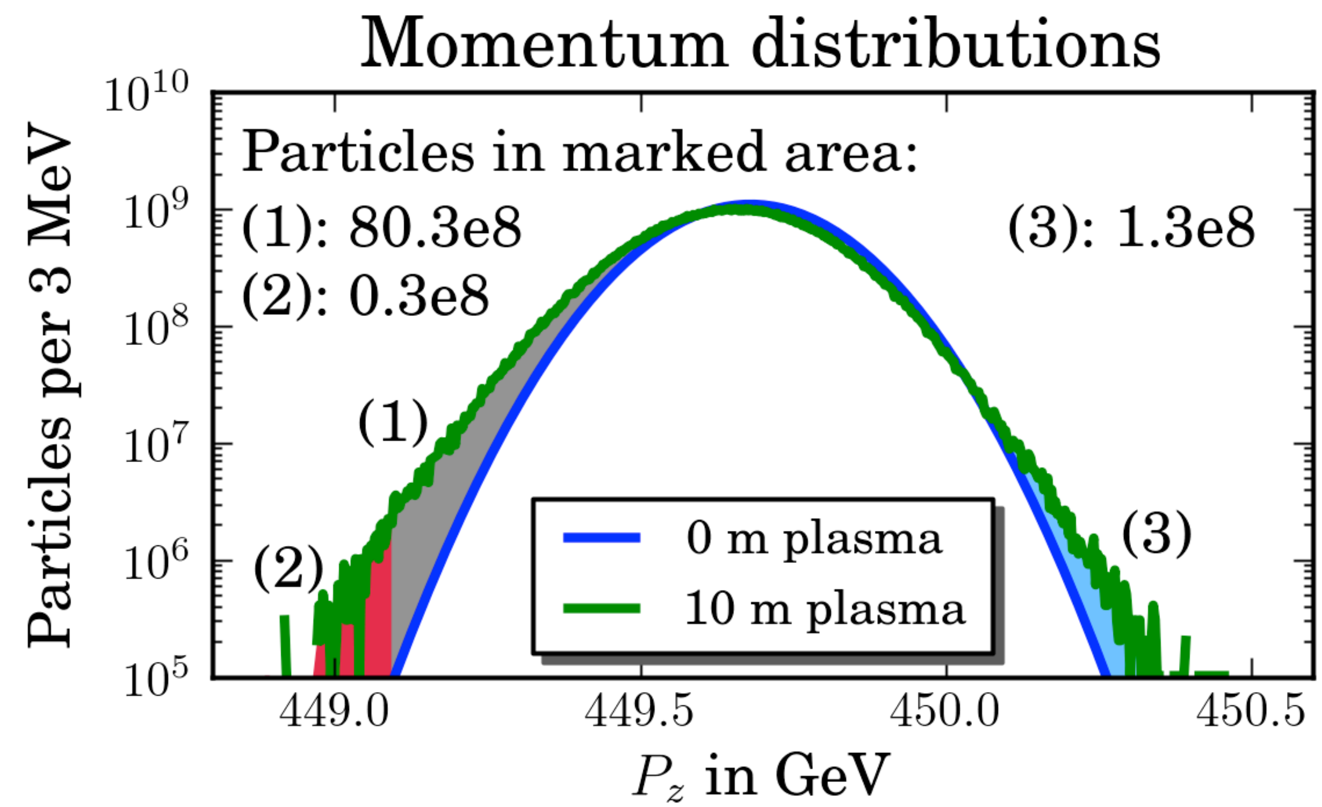
What is my part in this?

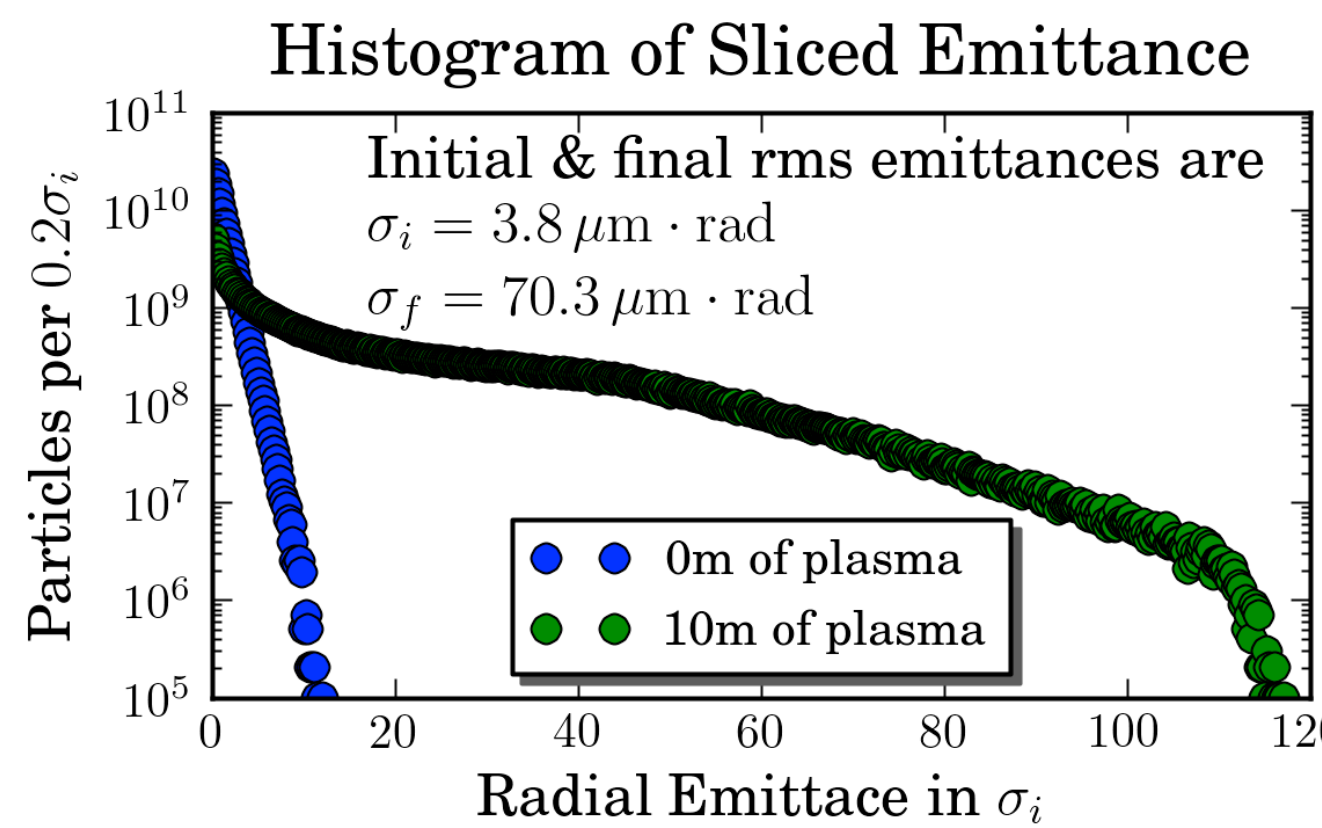
Understand, how a plasma accelerator works in general.

Understand what is different for a positively charged driver.

Optimize the drive beam for the needs of the experiment.

Find a way to measure the parameters of the beam after the plasma cell.





Summary

Summary

- Future high energy physics will require new Lepton accelerators.
- Several possibilities for different time scales are researched at the moment.

Thank you!