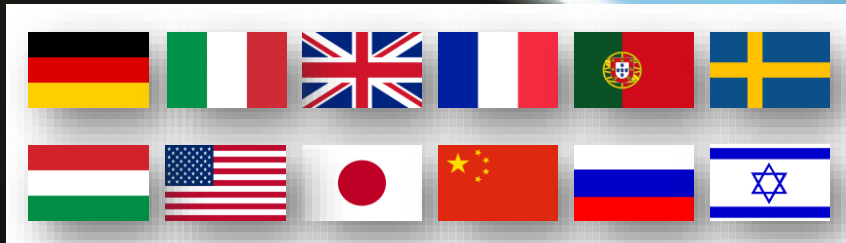


EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS



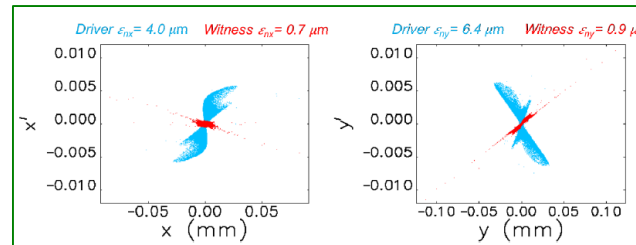
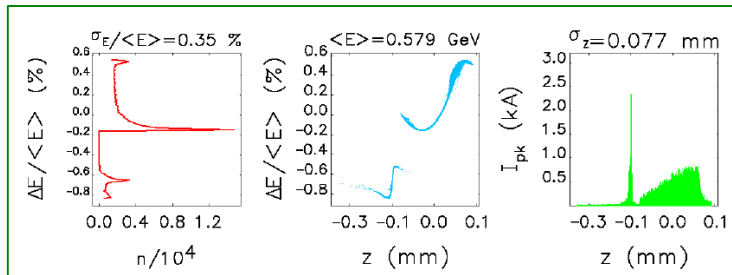
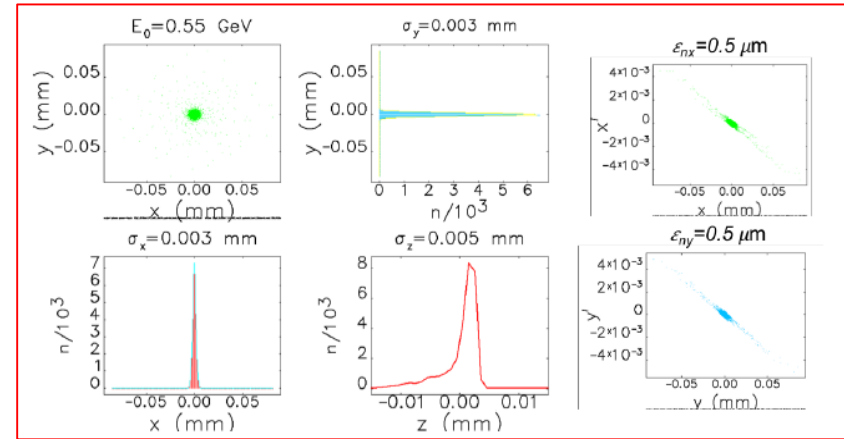
Electron Beam Design and Optimization (WP5)

Antoine Chance on behalf of WP5 collaboration



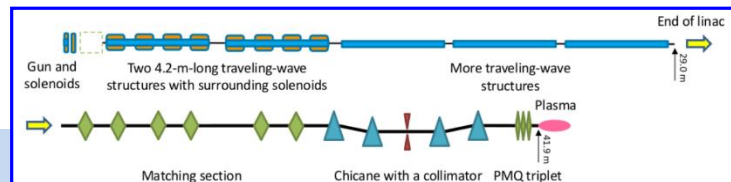
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653782.

- Start-to-End simulations from the cathode to the plasma module
 - Full RF compression for LWFA external injection (INFN)
 - 3 S-band TW sections and X-band booster
 - Full RF compression for PWFA (INFN)
 - 3 S-band TW sections and X-band booster



Transverse phase space at the plasma entrance

- Hybrid compression (DESY)



	Linac exit	Injection point
Energy (MeV)	242.0	240.8
Bunch charge (pC)	50.0	29.8
RMS bunch length (fs)	160.0	7.5
Peak current (kA)	0.13	4.0
Projected ϵ_x / ϵ_y (μm)	0.30 / 0.30	0.81 / 0.46
Slice ϵ_x / ϵ_y (μm)	0.28 / 0.28	0.59 / 0.34
β_x / β_y (mm)		3.1 / 3.0
RMS energy spread (%)	0.50	0.27
Slice RMS energy spread (%)	0.05	0.23

- Creation of a new work package dedicated to diagnostics: WP15.
- Advances on this topic in the WP15 presentation.

Date of document: 12.11.2018

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EuPRAXIA: DELIVERABLE REPORT

Doc. Identifier:
Del 5.1
Date: 27 April, 2018

DELIVERABLE REPORT

EUPRAXIA: DELIVERABLE REPORT

DELIVERABLE: D15 (5.1)

Design report photo-injector

Document identifier:	EuPRAXIA Del 15-5.1
Due date of deliverable:	End of Month April (Month 30)
Report release date:	30/04/2018
Work package:	WP5: Electron Beam Design and Optimization (EBDO)
Lead beneficiary:	INFN
Document status:	Final

Abstract: The final Radio-Frequency (RF) photo-injector design for the EuPRAXIA collaboration is presented in this report based on work of working package 5 members. Both laser driven (LWFA) and particle beam driven (PWFA) external injection cases are explored.

- Close loop with WP2 to get distributions and transport them in transfer lines.
- Theoretical studies have given a recommended strategy for WP2: **Energy spread should be minimized jointly with the Twiss parameter γ_0 at the plasma exit**. The total length and the integrated focusing strength in the transfer line should be minimized also.
- Optimization of the transfer lines to keep the beam quality and to match to second plasma stage (conditions from WP2) or to users (WP6 and WP7).
- First discussions with WP15 (diagnostics) to find the allocated place for diags.



- Low energy spread: only 0.2% 😊
- Low emittance growth 😊.
- 24 pC 😊

Quadrupole	Length	Max Gradient
Permanent	100 mm	660 T/m
Electromagnets	400 mm	88 T/m

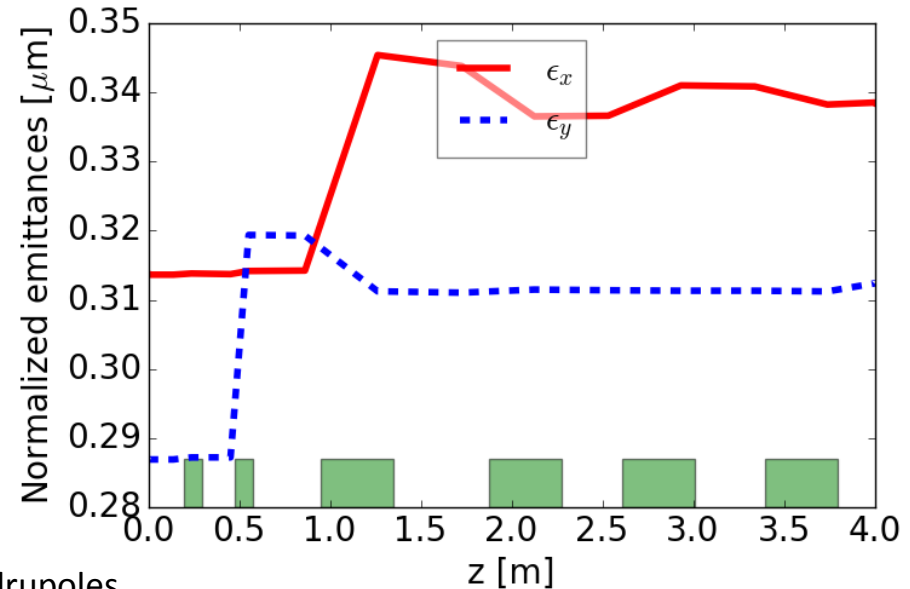
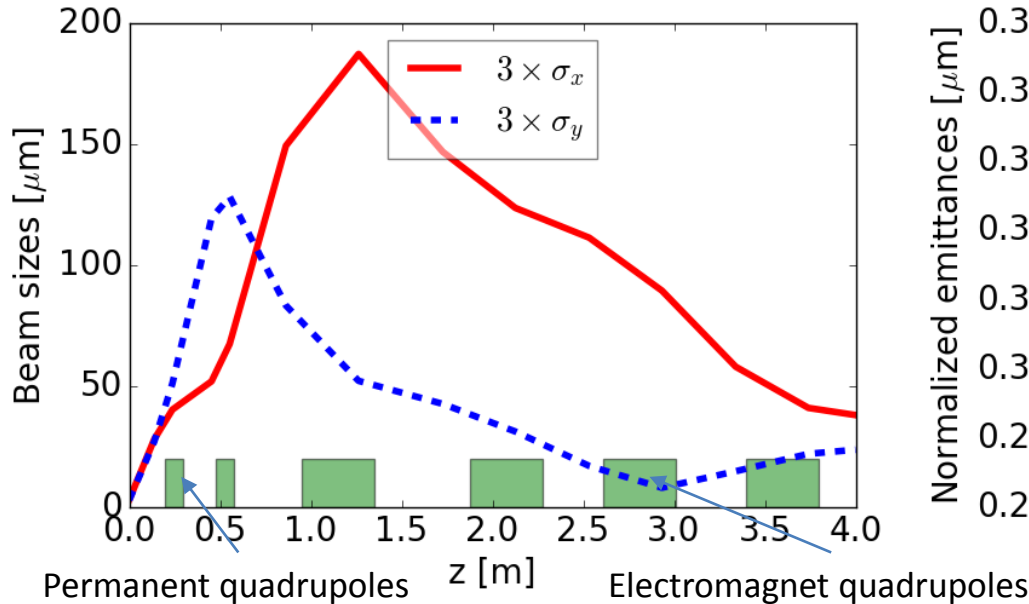
Next steps:

- Allocate some place for diags.
- Laser removal.
- Optimize magnets.

Distribution from A. Rossi

Exit of the 5 GeV LPA

Undulator entrance





Low energy spread: only 0.2% for slice 😊

Low emittance growth 😊.

25 pC 😊

Next steps:

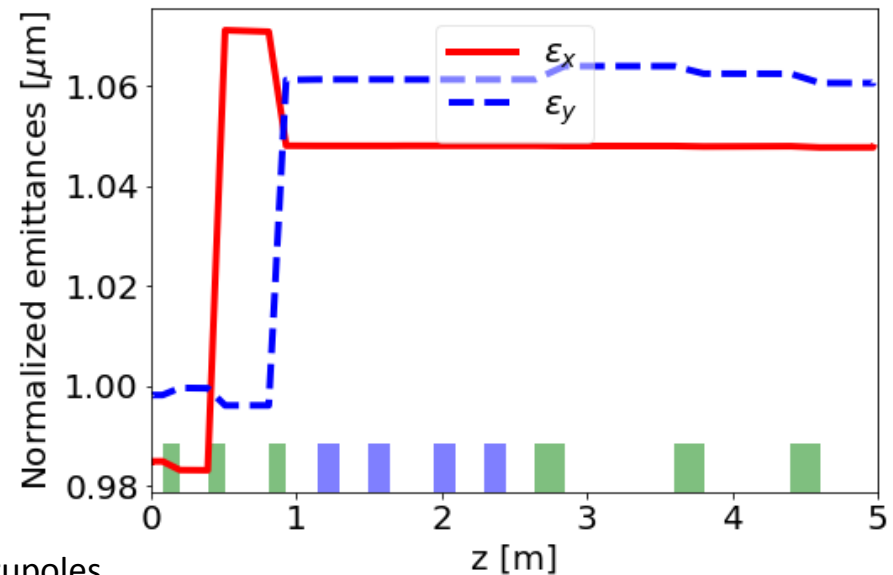
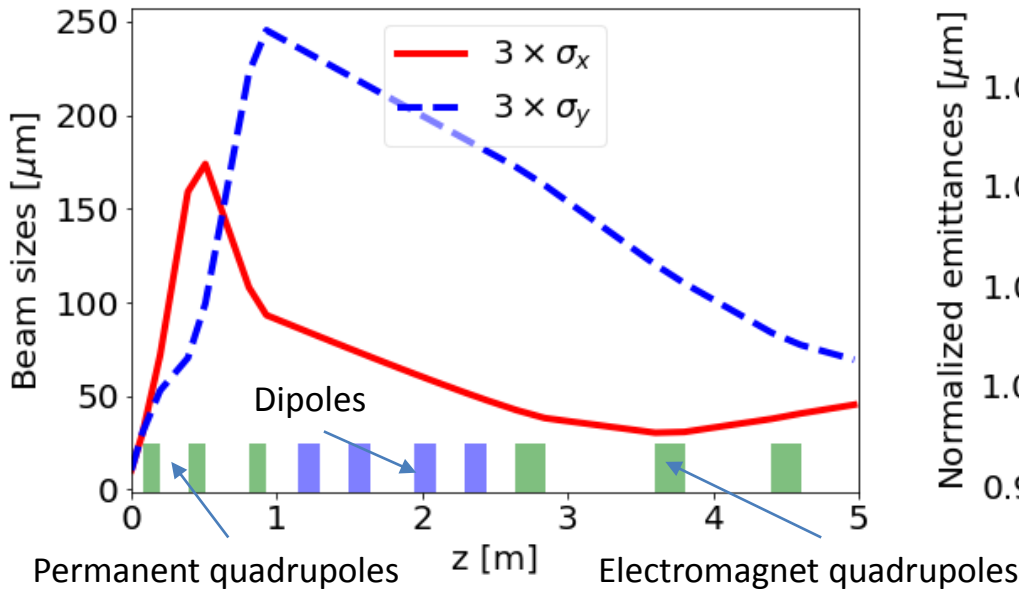
- Allocate some place for diags.
- Laser removal.
- Optimize magnets.

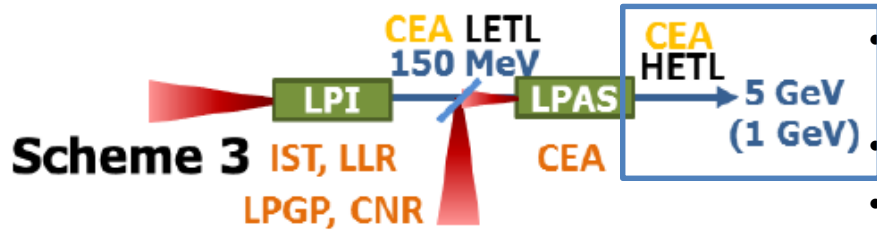
Distribution from X. Li

Quadrupole	Length	Max Gradient*
Permanent	120 mm	570 T/m
Electromagnets	200 mm	23 T/m

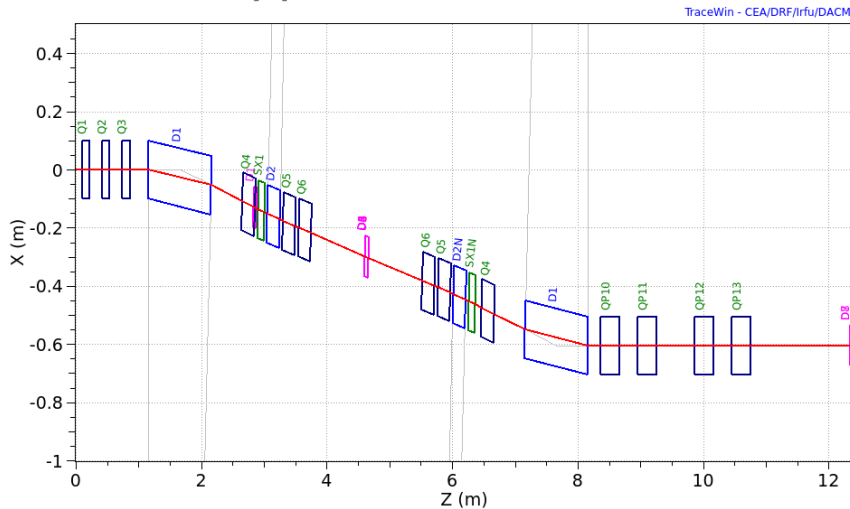
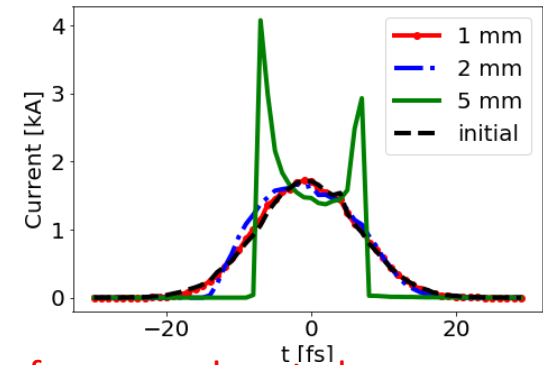
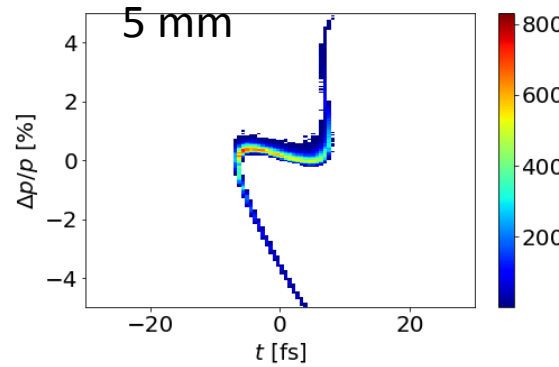
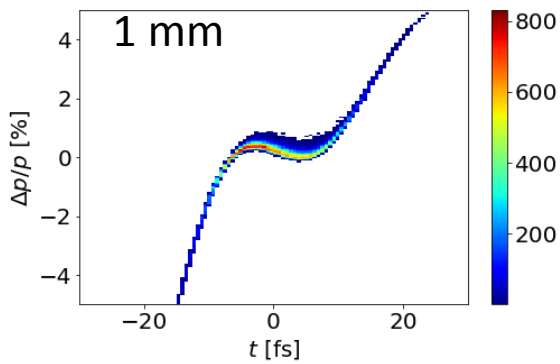
Exit of the 5 GeV LPA

Undulator entrance

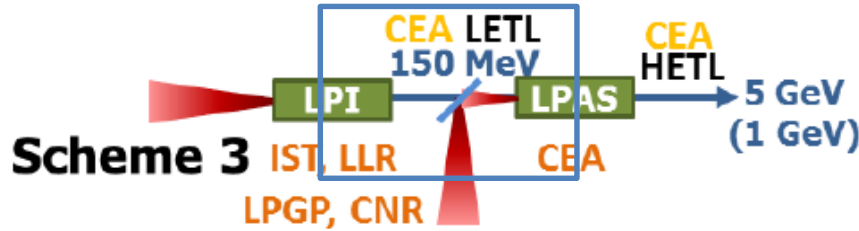




- C-chicane: no bunch lengthening if deflection of a few mm 😊.
- Scaling laws exist 😊
- Small normalized dispersion: small collimation efficiency.
- Next step: Laser removal.



- Dogleg: needs for more place to have a deflection of 600 mm @ 5 GeV (needed to avoid the undulators).
- Large emittance growth: factor 2-3 😞
- Next steps:
 - Scaling laws to optimize the line
 - To improve the beam line



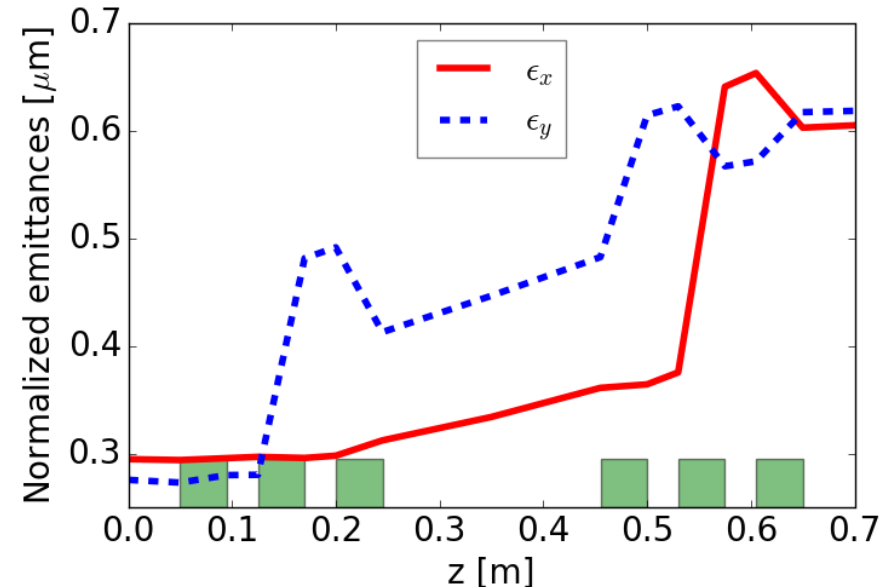
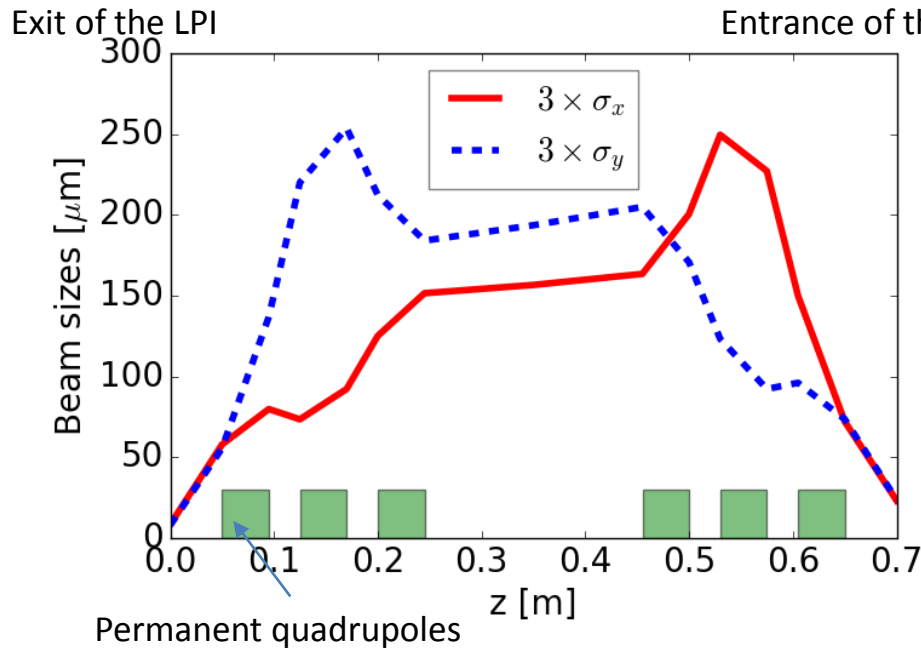
- Space charge included
- Emittance growth within requirements 😊
- 30 pC 😊

Quadrupole	Length	Max Gradient
Permanent	45 mm	211 T/m

Next steps:

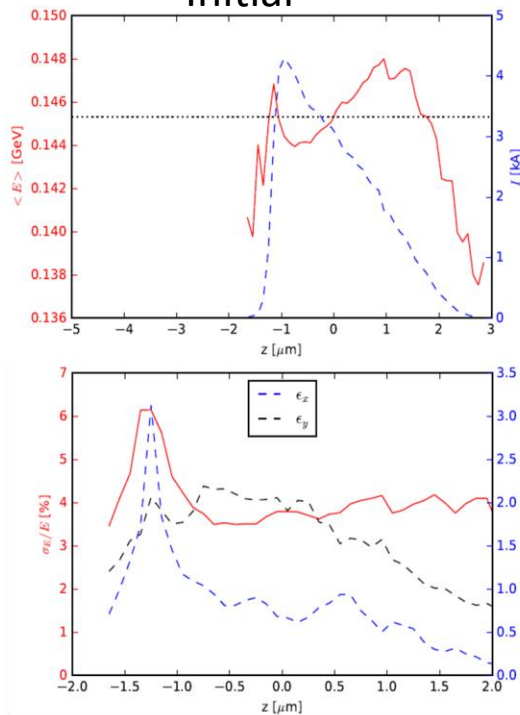
- Allocate some place for diags.
- Laser removal and injection.
- Optimize magnets.

Distribution from P. Tommassini

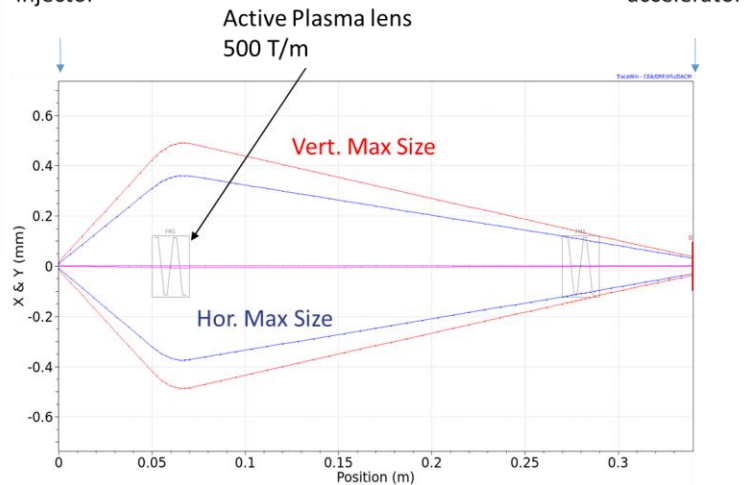


- Plasma lenses are a promising alternative:
 - More compact.
 - Smaller emittance growth (focusing in both planes).
- Next steps:
 - To check that wakefield generated from bunch is negligible
 - To optimize plasma len parameters.

Initial

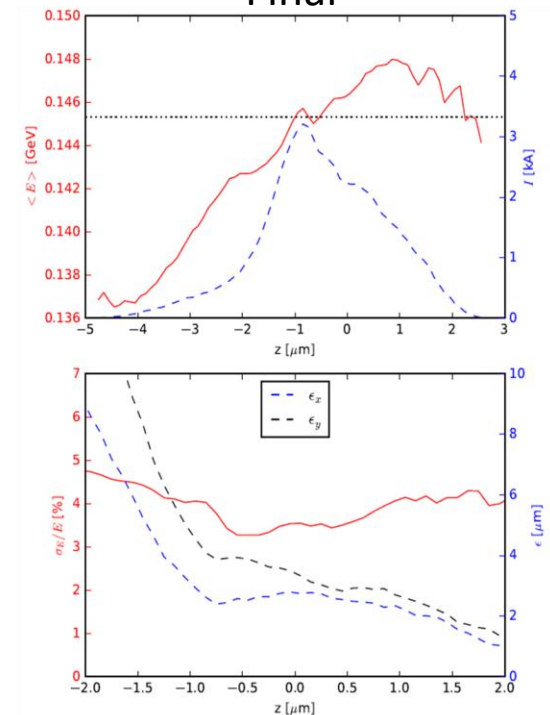


Exit of the plasma injector



Entrance of the plasma accelerator

Final





- Large emittance growth 😊.
- 23 pC 😐
- With collimators in chicane (deflection of 2 mm), driver can be removed (>95% lost)

Quadrupole	Length	Max Gradient
Permanent	100 mm	318 T/m
Electromagnets	100 mm	21 T/m

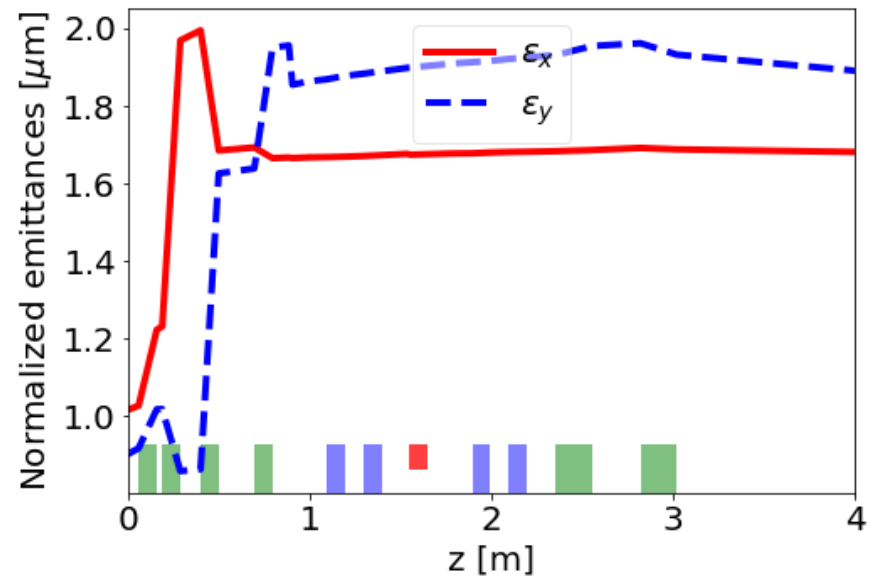
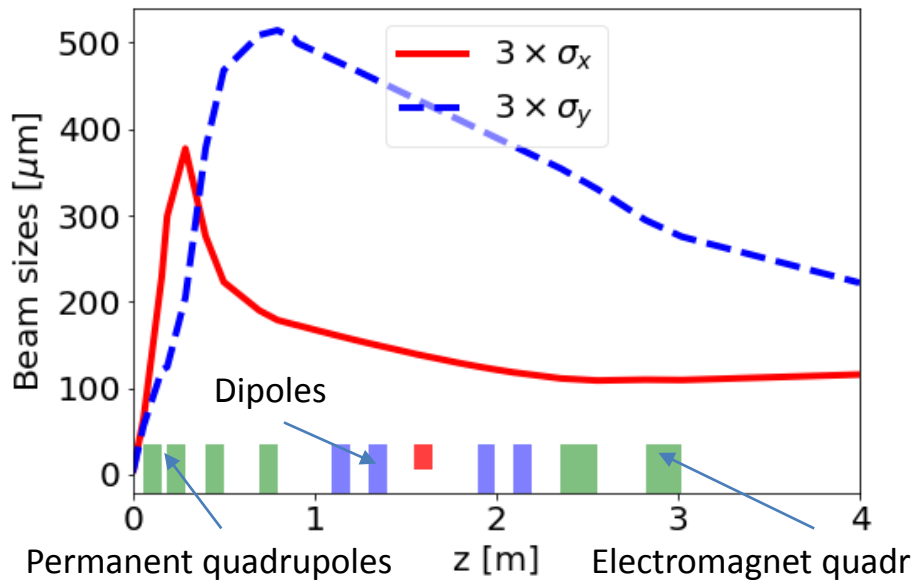
Next steps:

- Allocate some place for diags.
- Laser removal.
- Optimize magnets.

Distribution from Marocchino

Exit of the 1 GeV LPA

Undulator entrance



- Design of the photoinjector exists and in good shape.
- Design of most transfer lines exists.
- Next steps:
 - Design of the left transfer lines (dogleg for WP7).
 - Tolerance studies.
 - Start-to-end simulations (from plasma injector to users).

- Rec19. SAC recommends including the diagnostics for the pre-acceleration injection of the beam in the overall analysis. These diagnostics could be the subject of experimental investigation at one of the two facilities proposed for external injection, at Flash Forward or at SPARC.
 - Dedicated work package WP15.
- Rec20. SAC recommends analysing the expected effects of electron scattering in the gas, the effect on the emittance growth and the resulting dose irradiated.
 - Until now, effort was focused on transporting the beam in the transfer line (emittance growth was non negligible).
 - Several loops occurred between WP5 and WP2: beam distributions have evolved.
 - Not yet studied. Should be done.