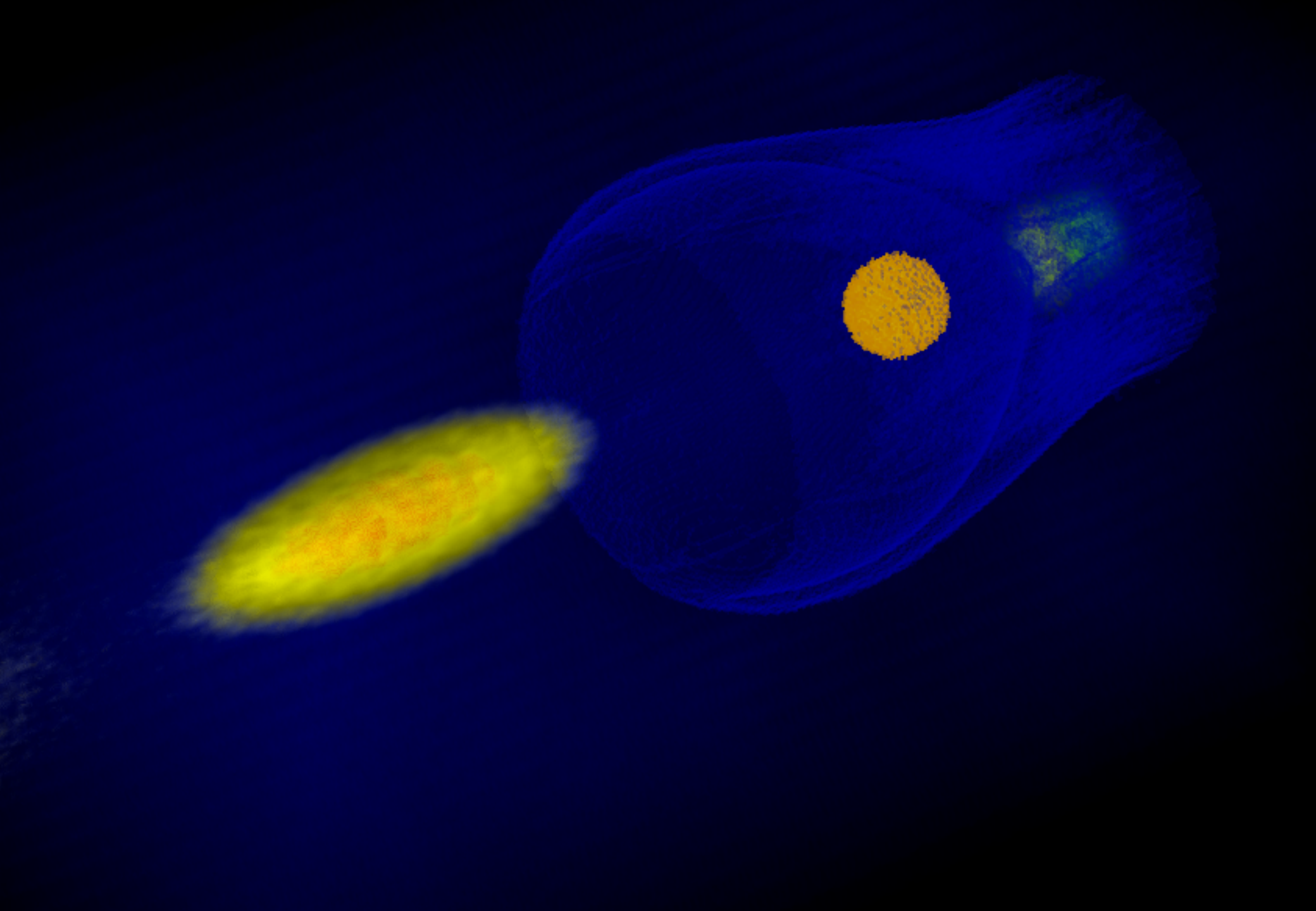
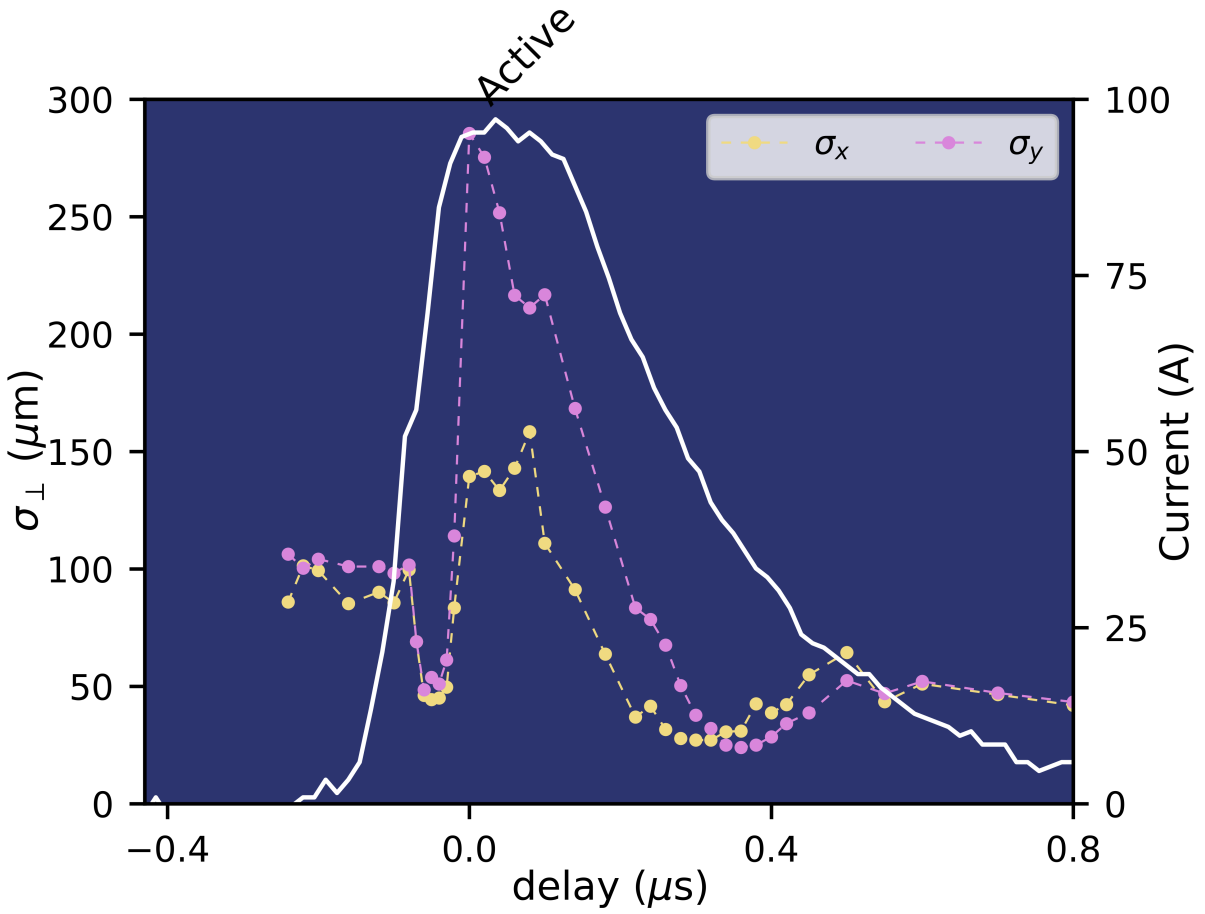


Active Plasma Lens Focusing



Results

R. Pompili, et al. “Applied Physics Letters, vol. 110, no. 10, p. 104101, Mar. 2017.

Sparc_Lab Result

Characterisation of active plasma lens

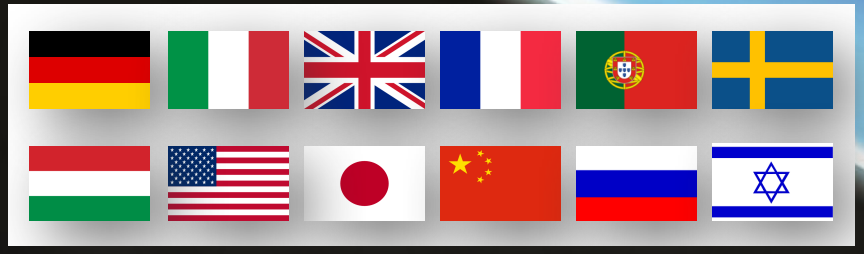
EUROPEAN
PLASMA RESEARCH
ACCELERATOR WITH
EXCELLENCE IN
APPLICATIONS

EuPRAXIA

Active Plasma lens at SPARC_LAB

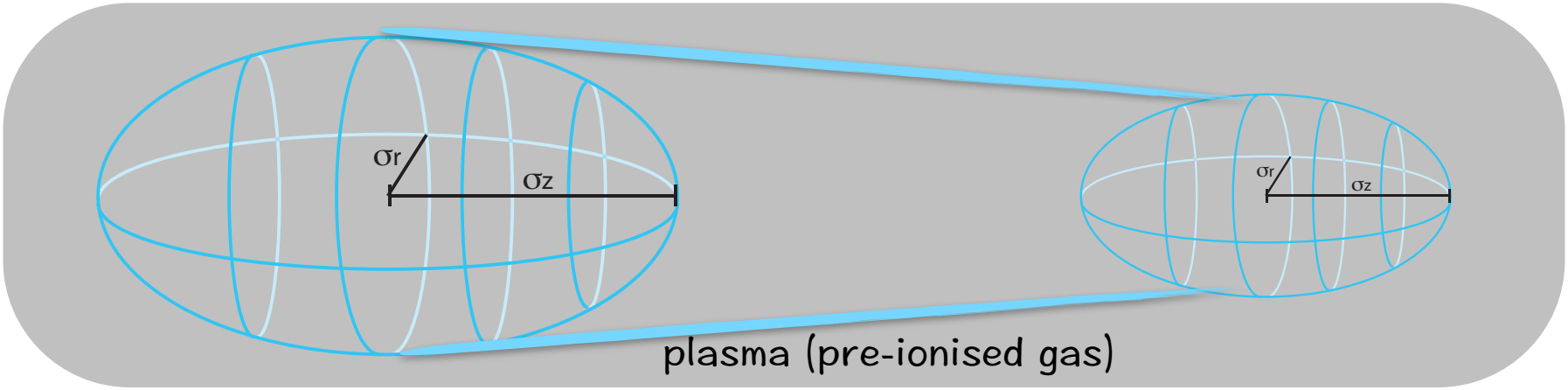
Alberto Marocchino on behalf of the SPARC_LAB collaboration

SPARC_LAB



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

what is a plasma lens?

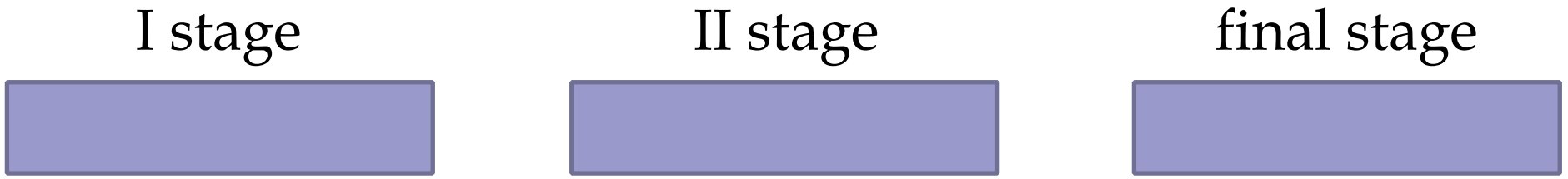


bunch at some z

bunch at some z+Δz

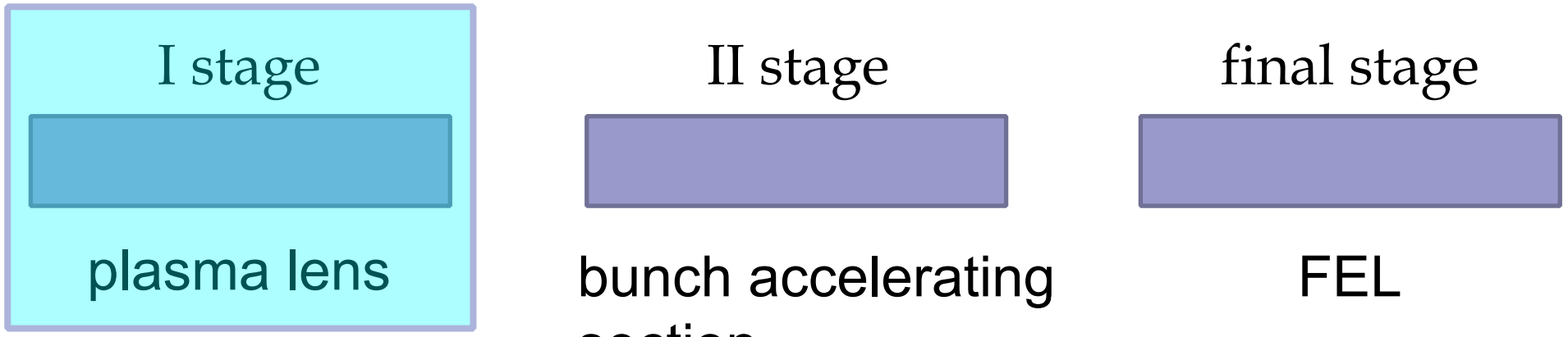
- Transversely Smaller
- Trying to preserve:
  - emittance
  - energy spred

lattice: plasma-lens + FEL layout



- Compress bunch
- accelerate bunch

lattice: plasma-lens + FEL layout



- Compress bunch
- accelerate bunch

electrostatic-active-passive lenses

- **Electrostatic lenses**:
  - focusing is due to: Electrostatic fields in a quasi neutral plasma
  - Field are created by an electron beam travelling through a neutral gas
  - work mainly by: Halsted and Gabor

- **Active lenses**:
  - focusing is due to: 'plasma discharge' background electron motion
  - for large aperture and large gradients
  - for electrons: conditions imply self focusing

- **Passive lenses**:
  - focusing is due to: pre-formed, current-free and neutral plasma
  - firstly studied by: Bennett, Katsouleas
- high focusing gradients (much larger than conventional quadrupole)
- Sym focusing
- compact (~cm)

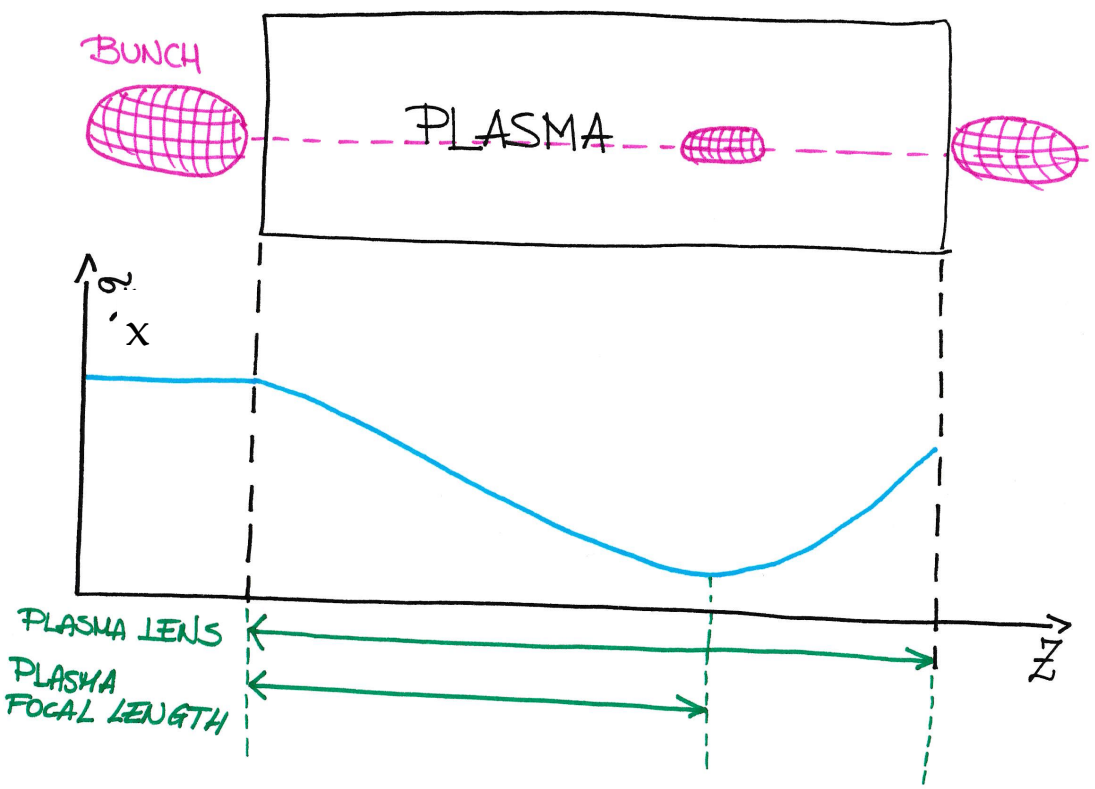
electrostatic-active-passive lenses

- **Electrostatic lenses**:
  - focusing is due to: Electrostatic fields in a quasi neutral plasma
  - Field are created by an electron beam travelling through a neutral gas
- **Active lenses**:
  - focusing is due to: ‘plasma discharge’ background electron motion
  - for large aperture and large gradients
  - for electrons: conditions imply self focusing

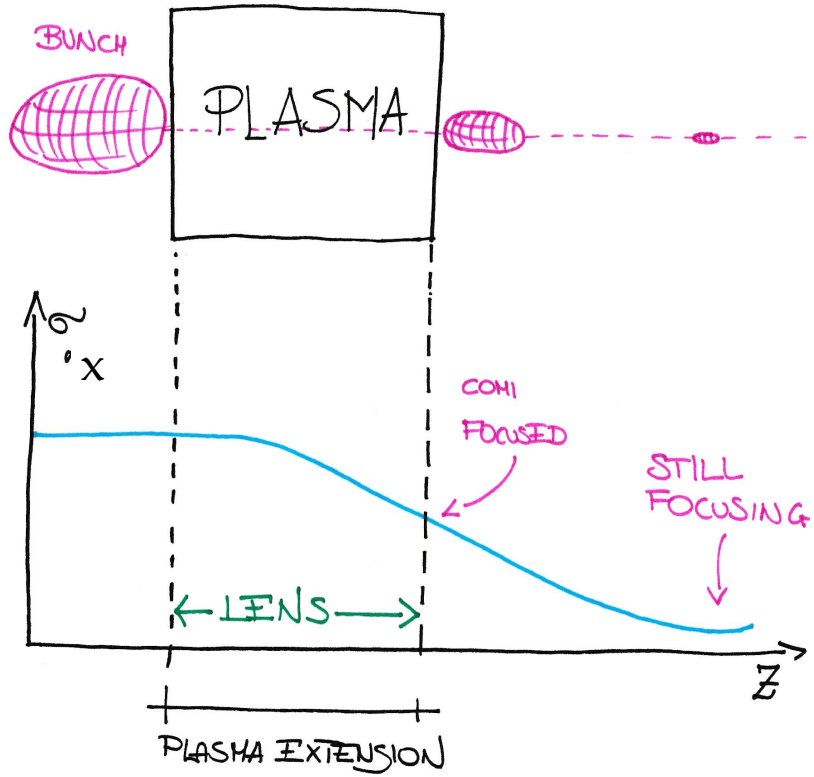
  - Sym focusing
  - compact focusing (quadrupole like)
- **Passive lenses**:
  - focusing is due to: pre-formed, current-free and neutral plasma
  - high focusing gradients (much larger than conventional quadrupole)
  - Sym focusing
  - compact (~cm)

thick-thin lenses

Thick

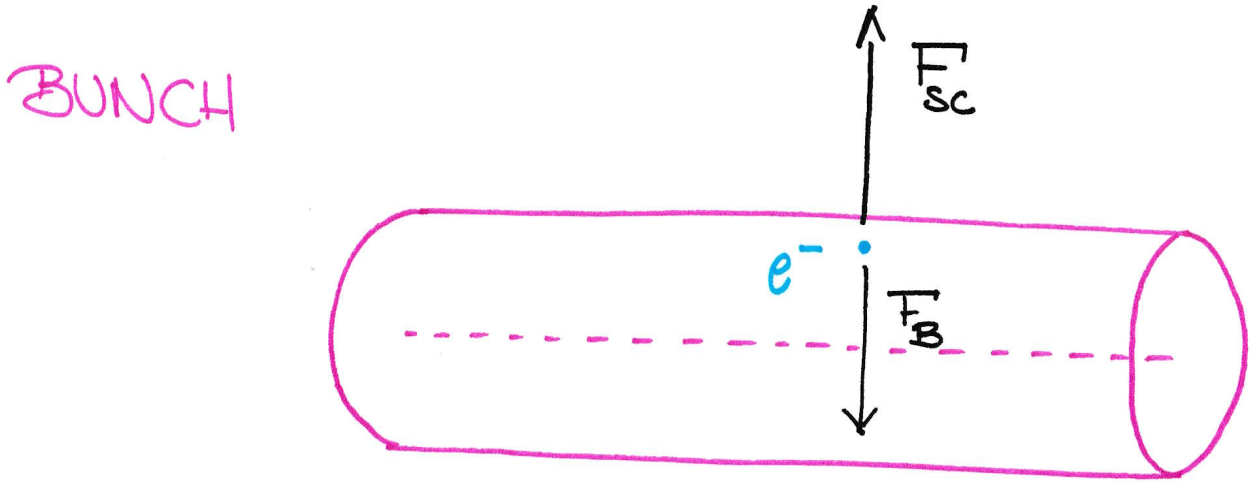


Thin



bunch in vacuum

Simplified-intuitive plasma lens treatment



from GAUSS:

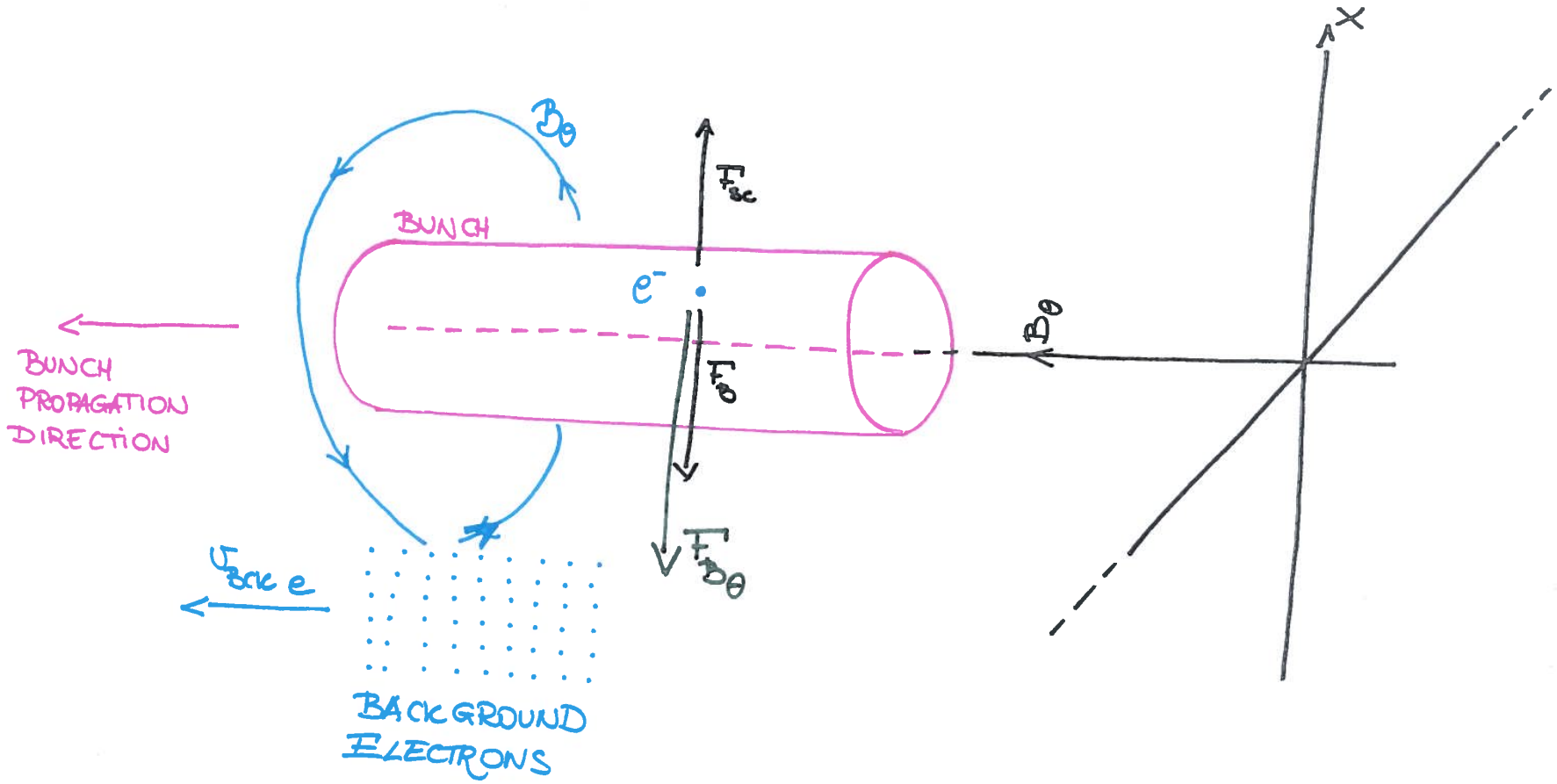
$$\underline{F_{sc}} = 2\pi n_b e^2 r \, \hat{u}_r$$

from AMPERE:

$$\underline{F_B} = -2\pi n_b e^2 \beta^2 r \, \hat{u}_r$$

$$\oplus \quad \underline{F_{tot}} = \frac{2\pi n_b e^2}{\gamma^2} r \, \hat{u}_r$$

active lenses



lattice: plasma-lens + FEL layout

I stage

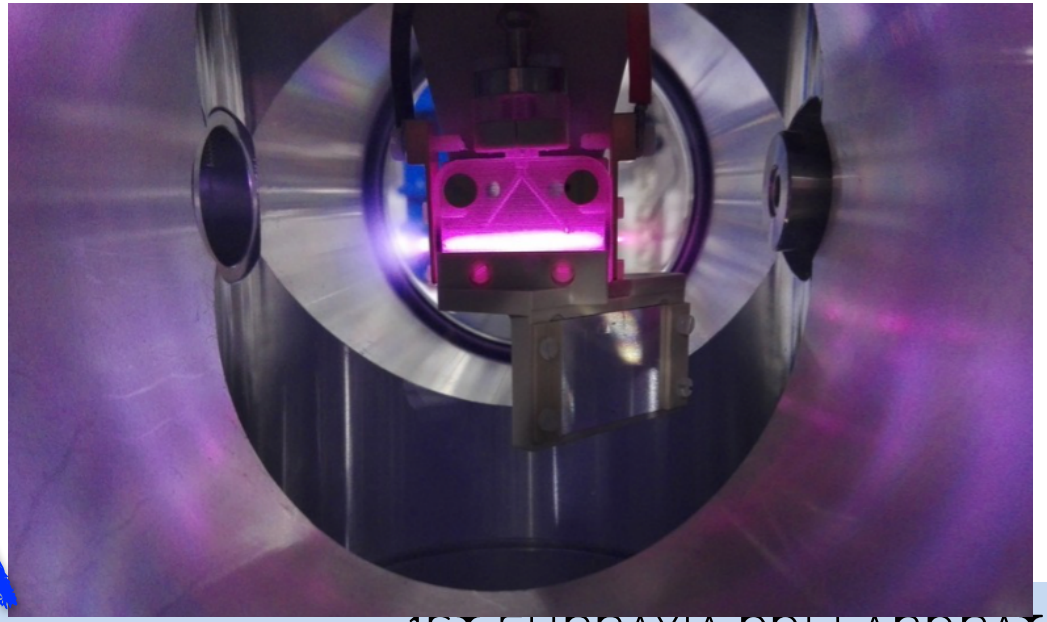
II stage

final stage

plasma lens

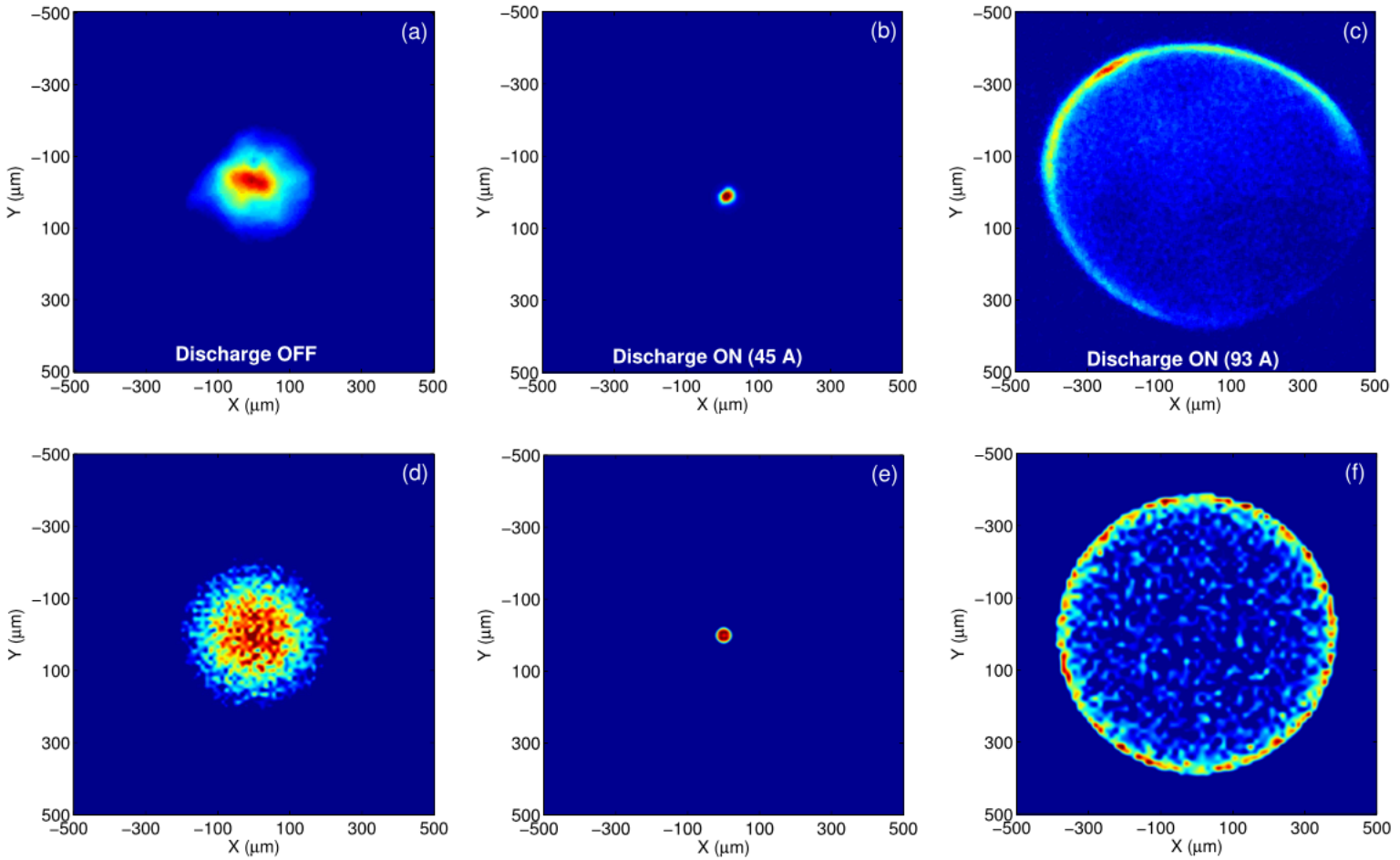
bunch accelerating section

FEL

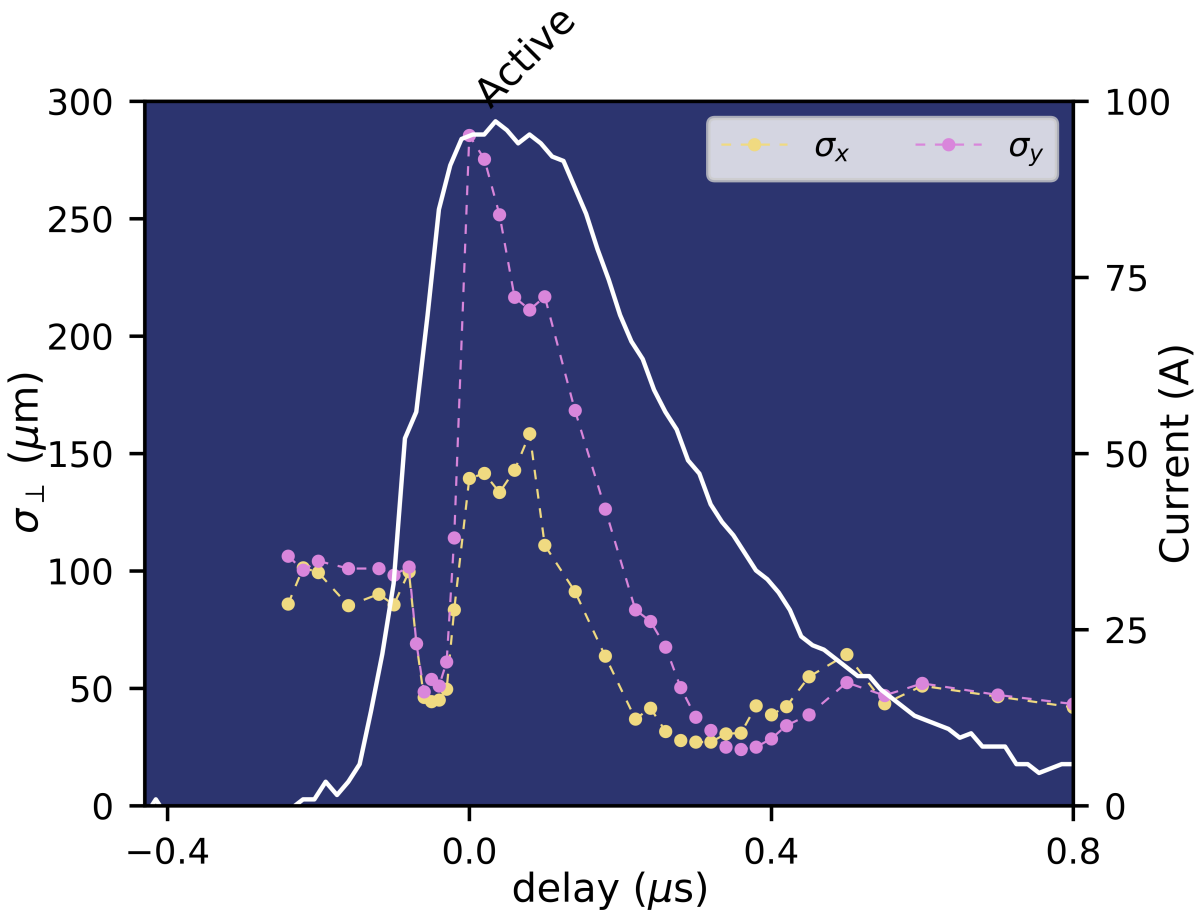


$n_p \sim 10^{16}, 10^{17}$

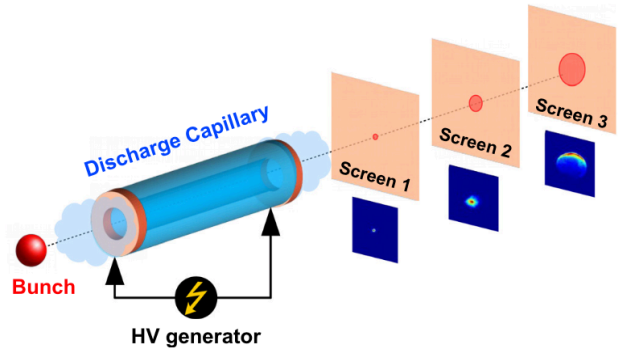
Focusing


(a)
Discharge OFF
(b)
Discharge ON (45 A)
(c)
Discharge ON (93 A)
(d)
(e)
(f)
Y (µm)
X (µm)
−500
−300
−100
100
300
500

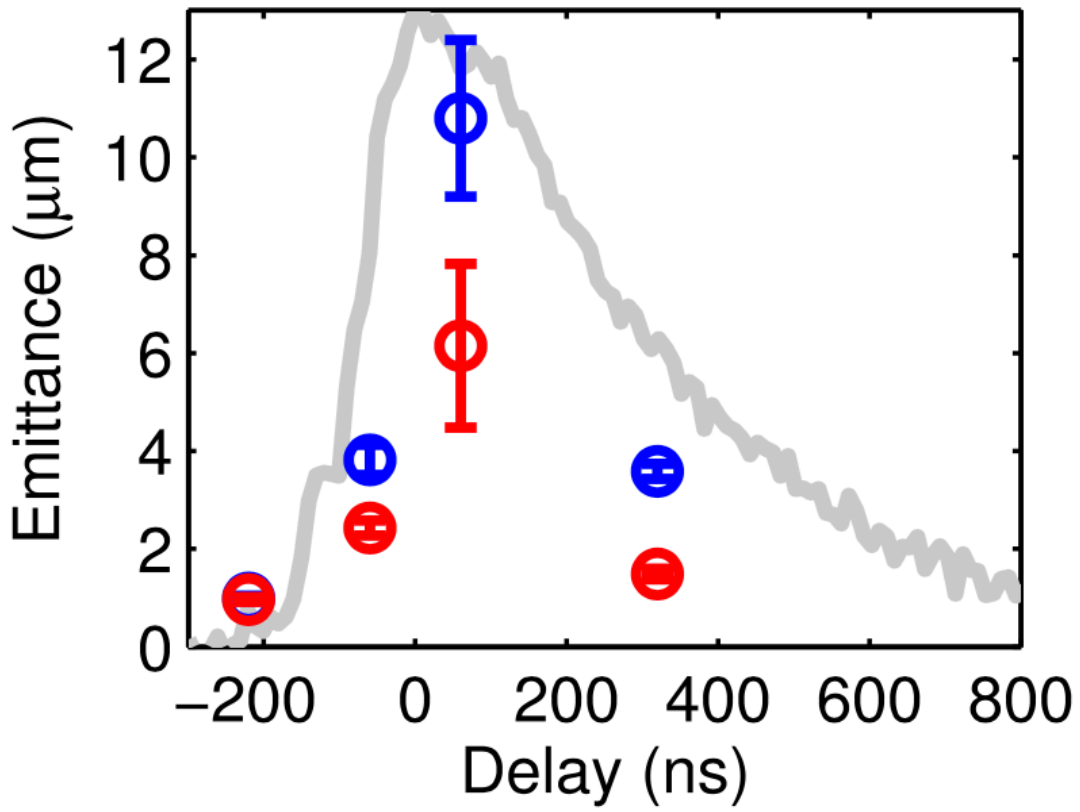
Active Plasma Lens Focusing



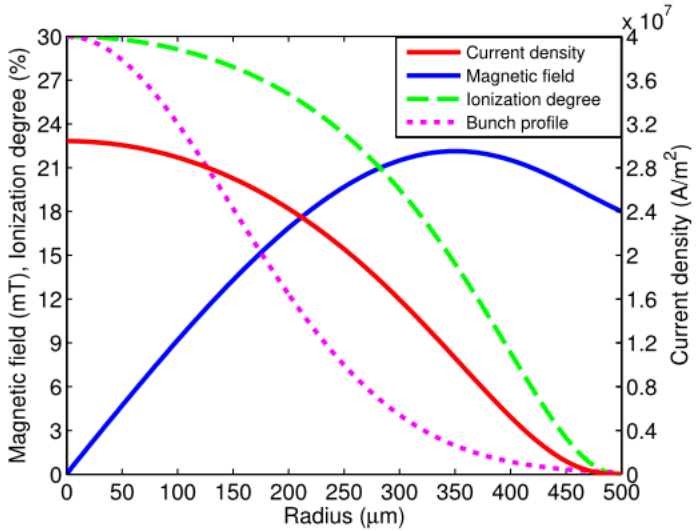
measure

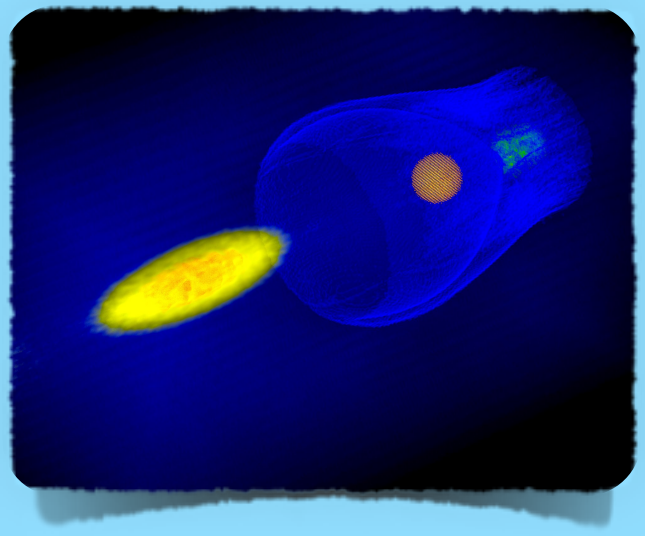


Quality Deterioration



Current Profile

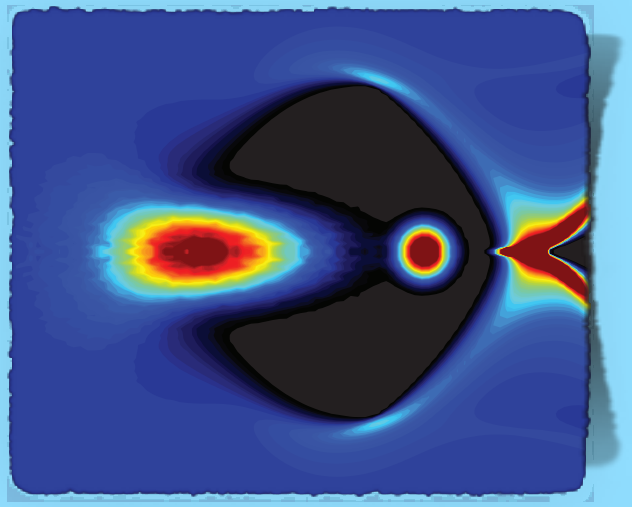




ALaDyn

full PIC code

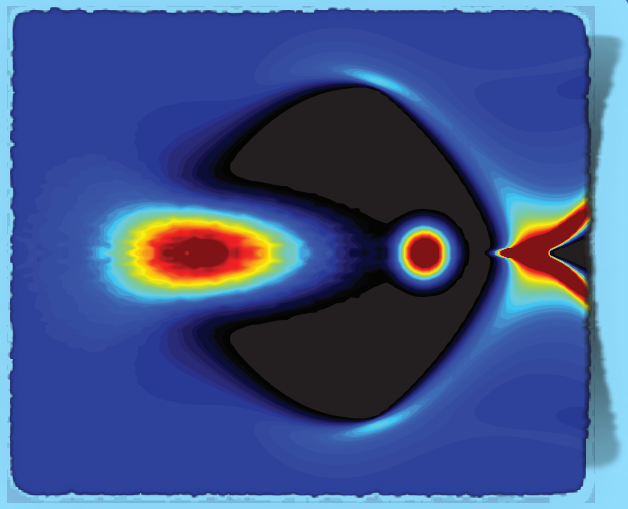
bunch and background
treated with macro-particles



Architect

hybrid code

bunch treated as a PIC
background as a fluid



Architect

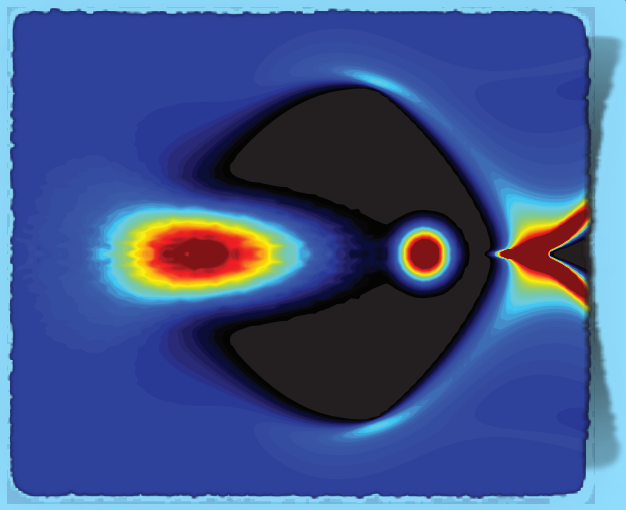
hybrid code

bunch treated as a PIC
background as a fluid

Start-to-end

Start to end simulation for **Direct Comparison with the experiment**

Magnetic field **non-linear** Profile reconstruction



Architect

hybrid code

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