Parameters of Laser-Plasma Accelerators

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Outline

- Laser-Plasma Acceleration: a promising scheme
- Laser-Plasma Acceleration with Self-Injection
  - Basics
  - Experimental results
- ELectron Injector for Compact Staged High Energy Accelerator (ELISA)
- Conclusion and Perspectives

Laser-Plasma Acceleration: a promising scheme

- **RF technology limitation**
  - **E < 50 MV/m**
  - **B < 10 T**
  - **Synchrotron radiation**

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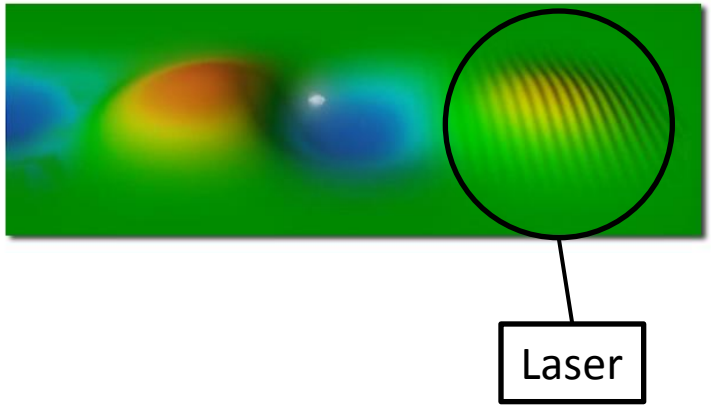

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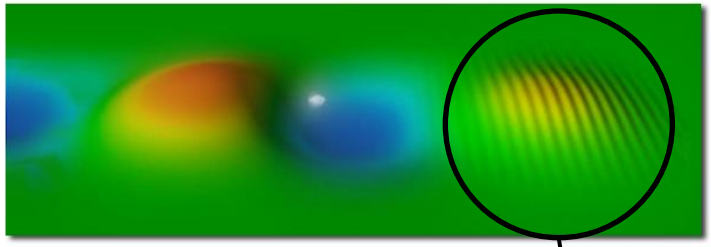

Laser

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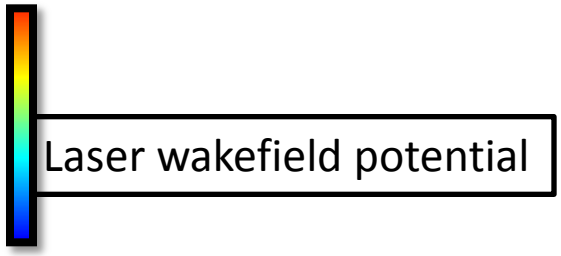

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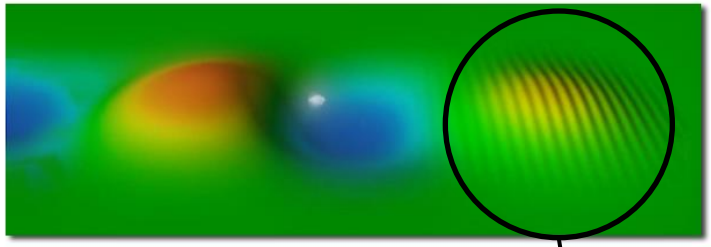

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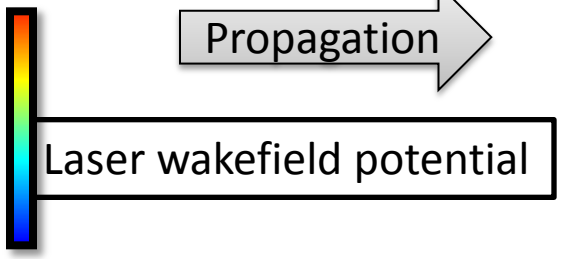

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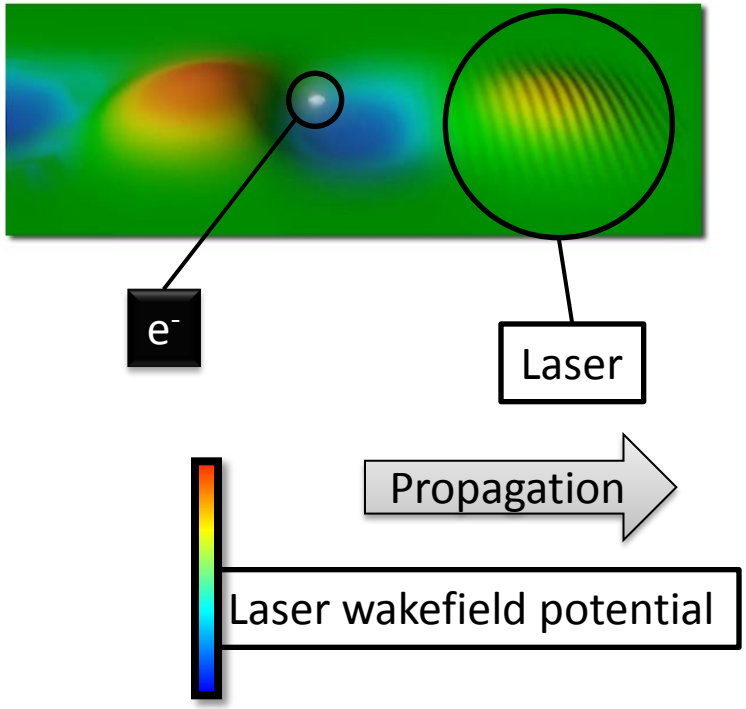

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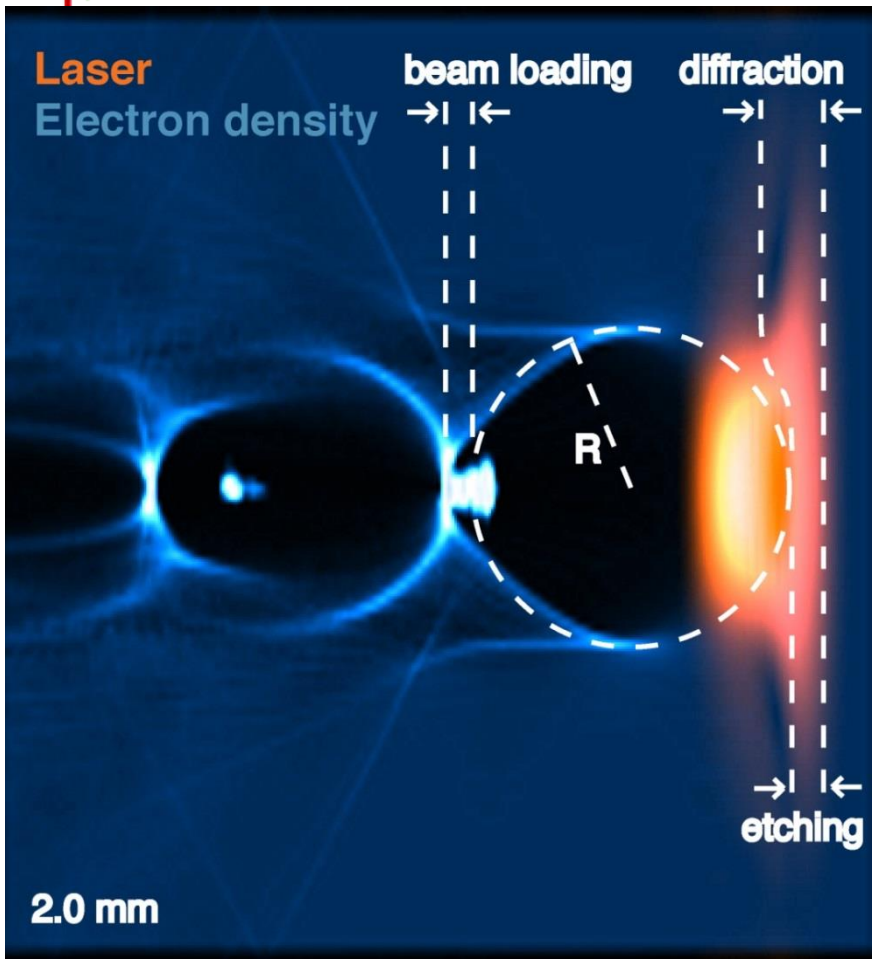
V.S

- **LPA properties**
  - **E ~ 1-100 GV/m,**

  Compact linear accelerator
  - **Non-linear regime:**

  High gradients and self-injection

Non-Linear Regime / Self-Injection



- Compression and self-focusing of the pulse
- Expulsion of e^-: creation of a bubble composed of ions
- e^- self-injected at the back of the bubble by accelerating and focusing fields
- *Beam loading* : Tail of bubbles modified by injected e^-
- Generation of betatron radiation

W. Lu *et al.*, Physical Review Special Topics – Accelerators and beams **10**, 061301 (2007)

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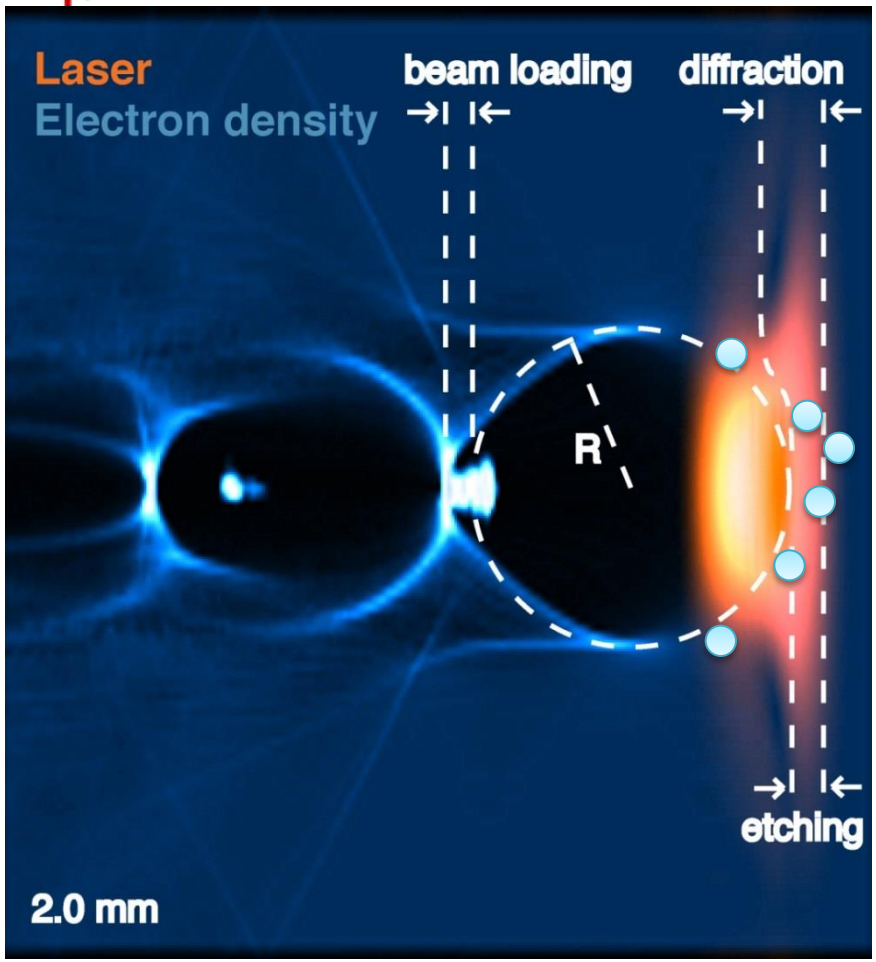

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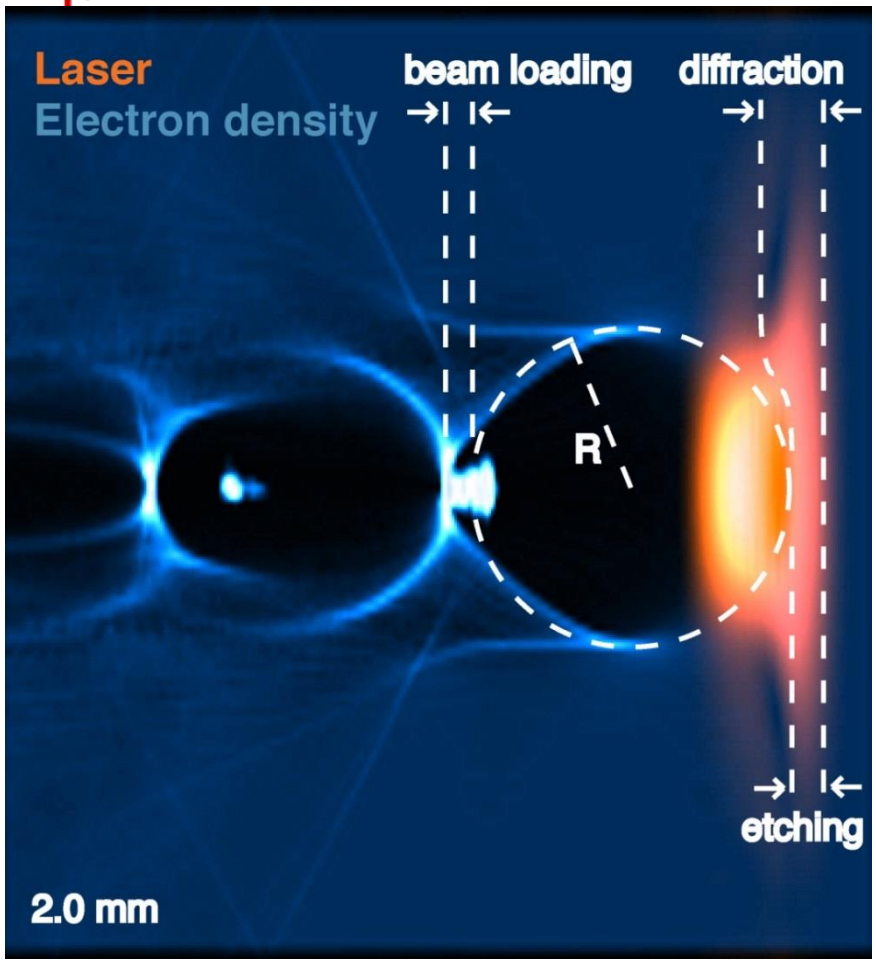

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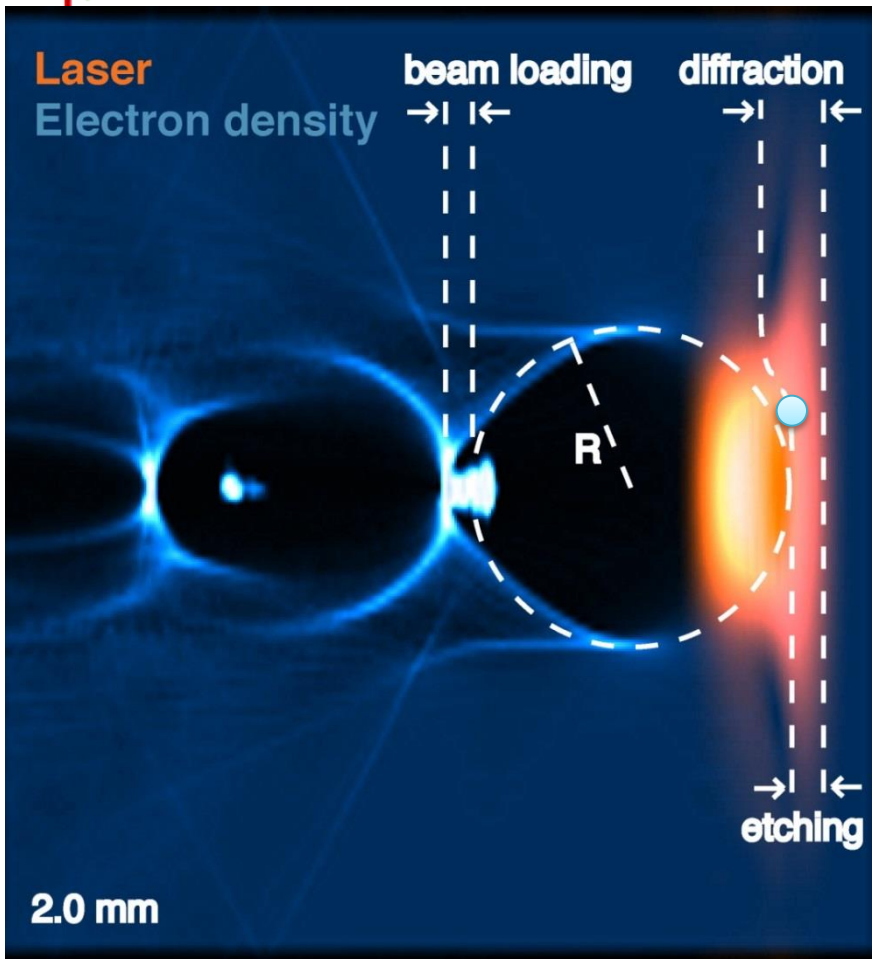

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Self-Injection in Capillary Tubes

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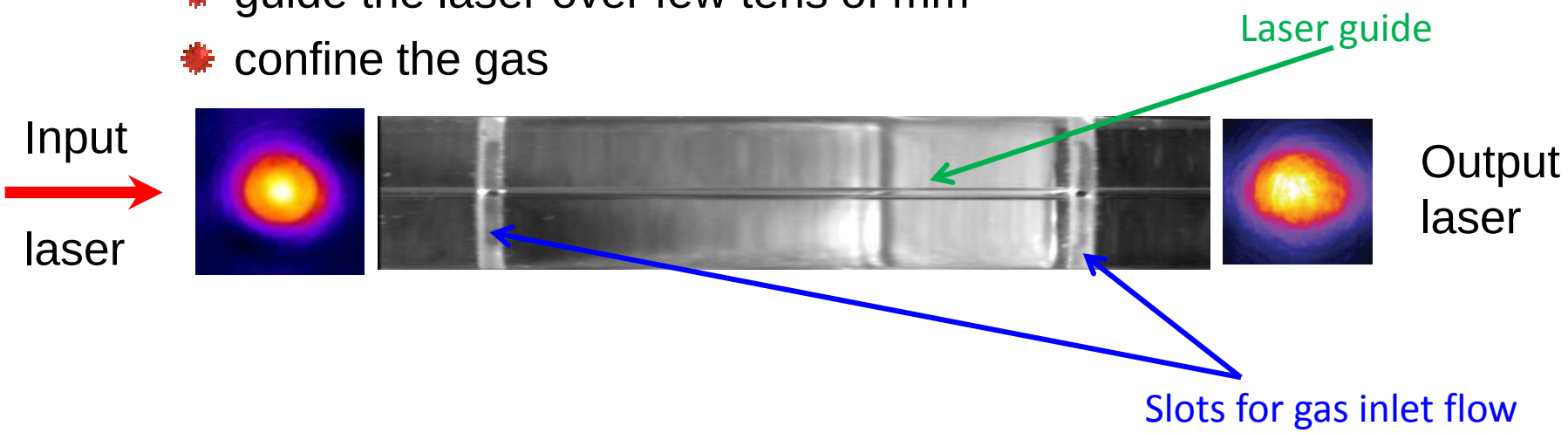

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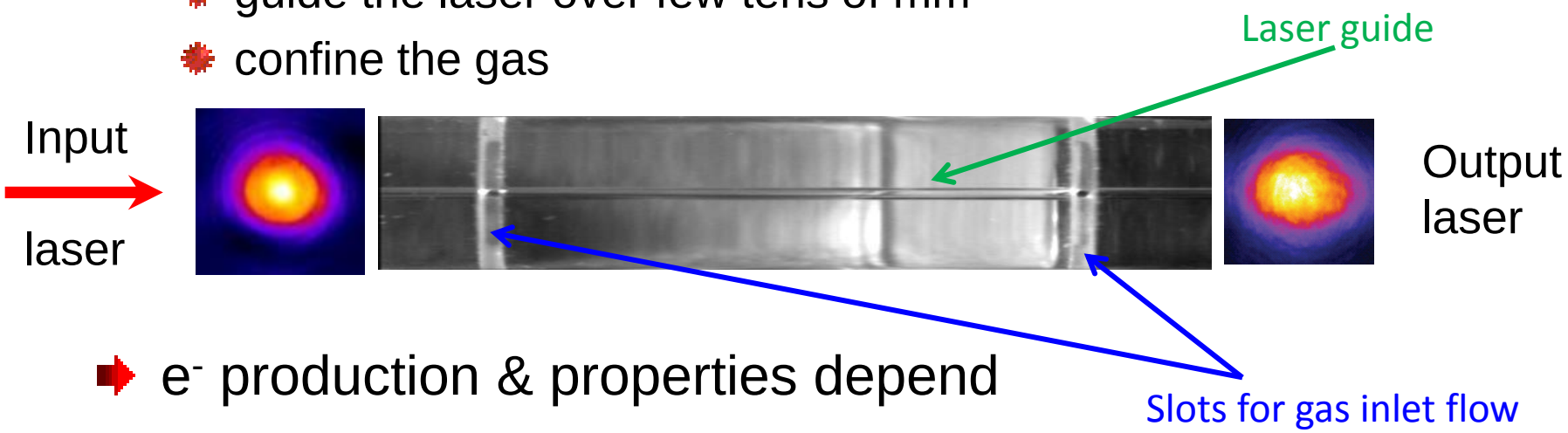
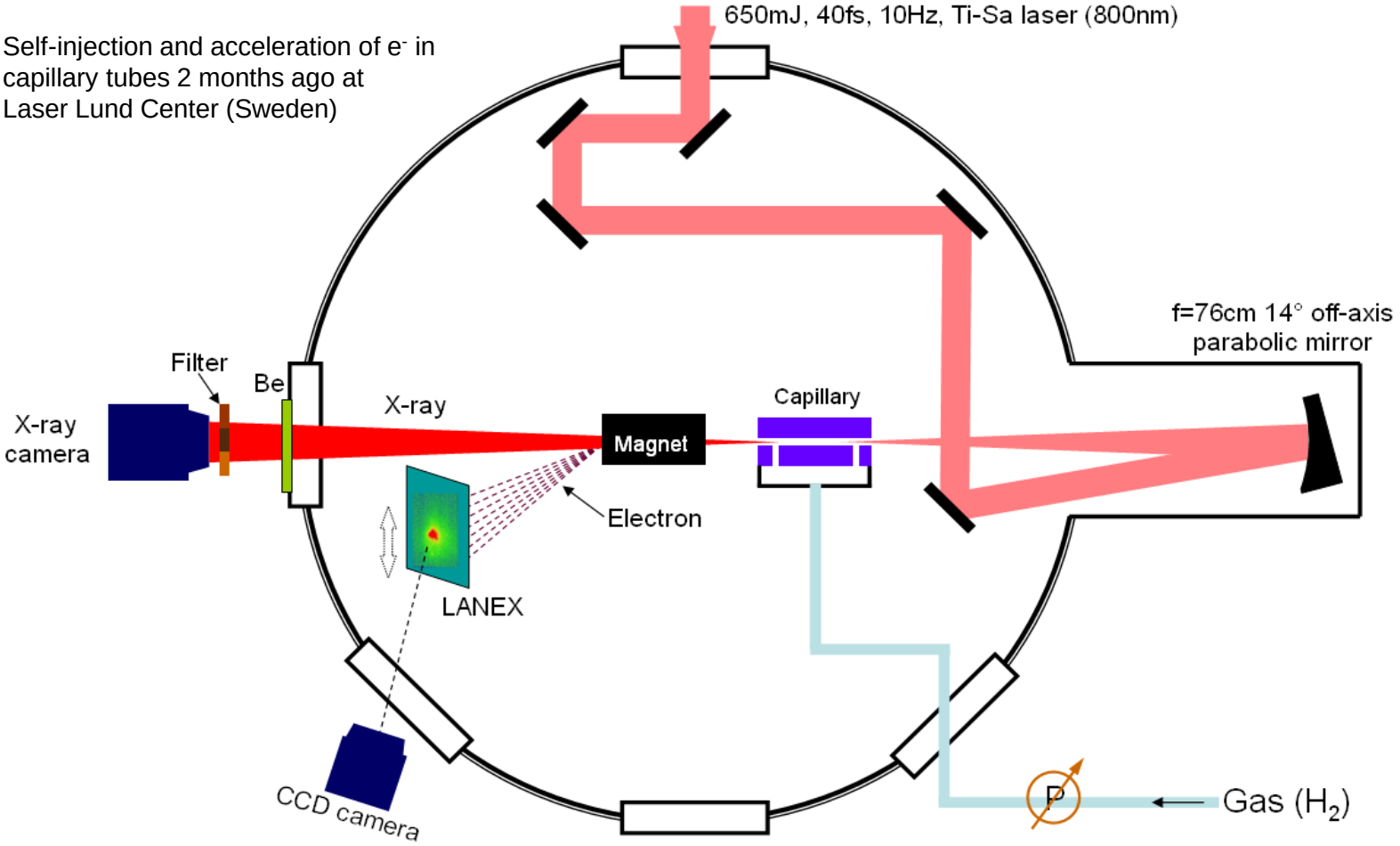


- e^- production & properties depend on plasma parameters.
- Capillary parameters:
  - Diameter: 76 - 254 µm
  - Length: 8 - 30 mm
  - Gas: pure H_2 or with impurities at a few 100 mbar

Typical experimental Set-up

Self-injection and acceleration of e^- in capillary tubes 2 months ago at Laser Lund Center (Sweden)



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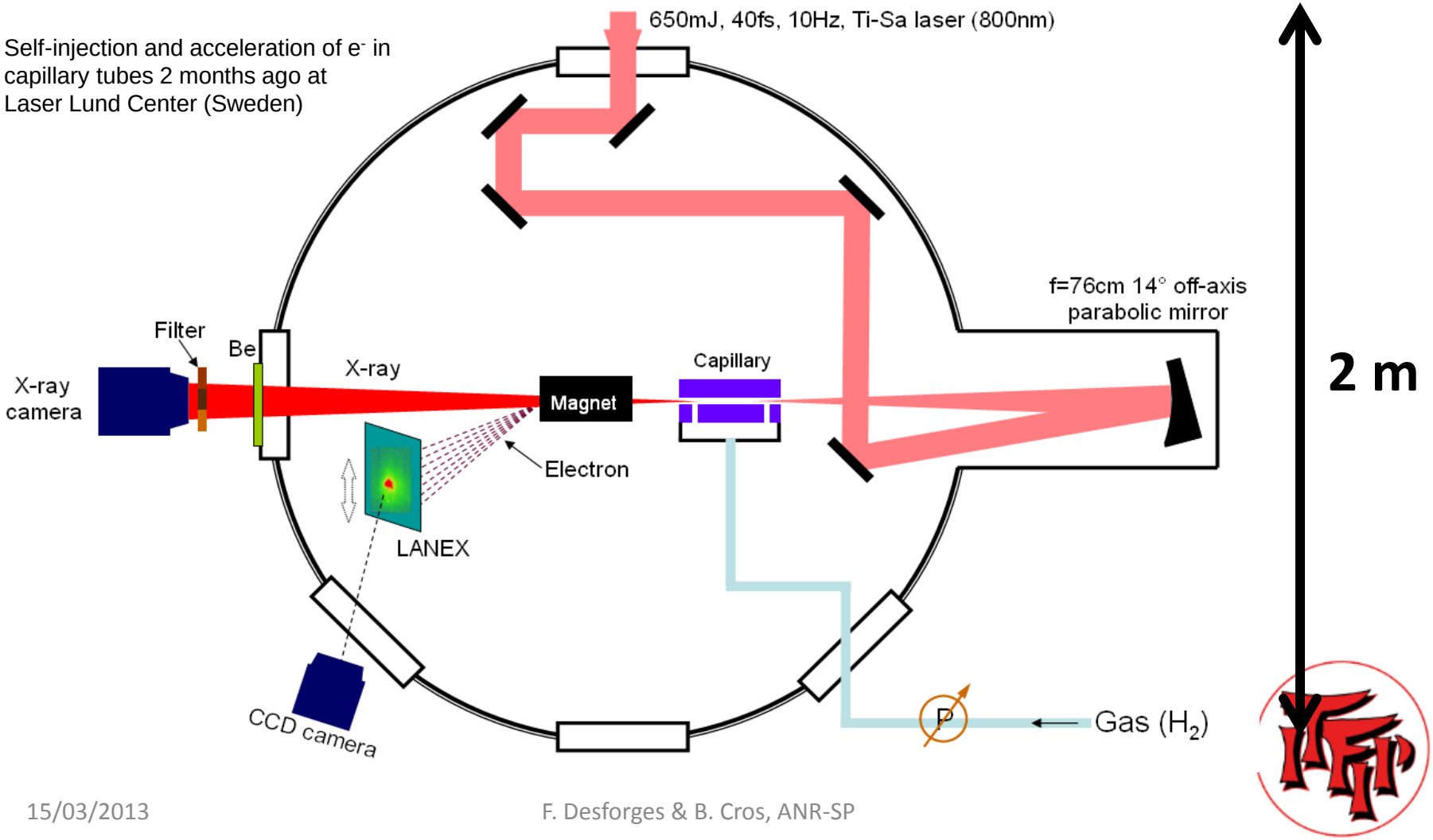
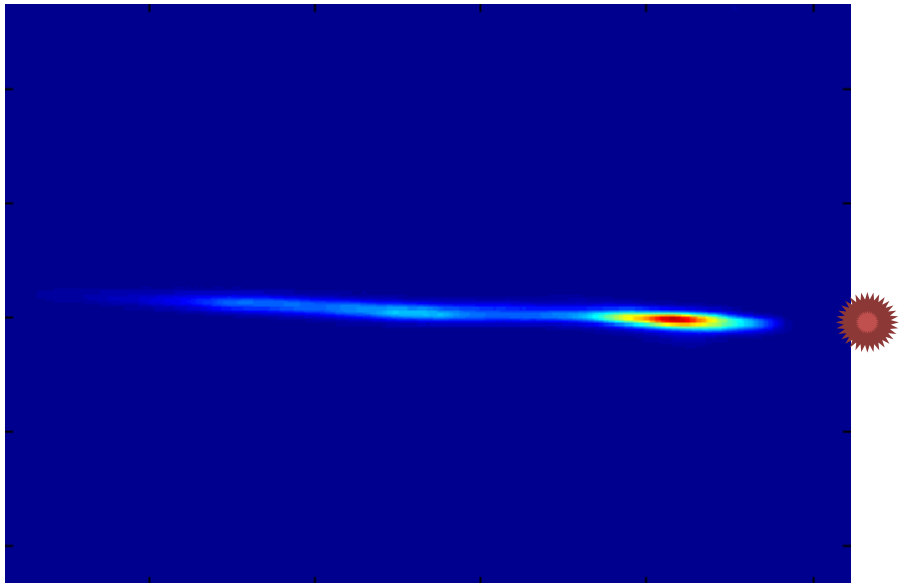


Electron Spectrum and Type of Analysis Performed



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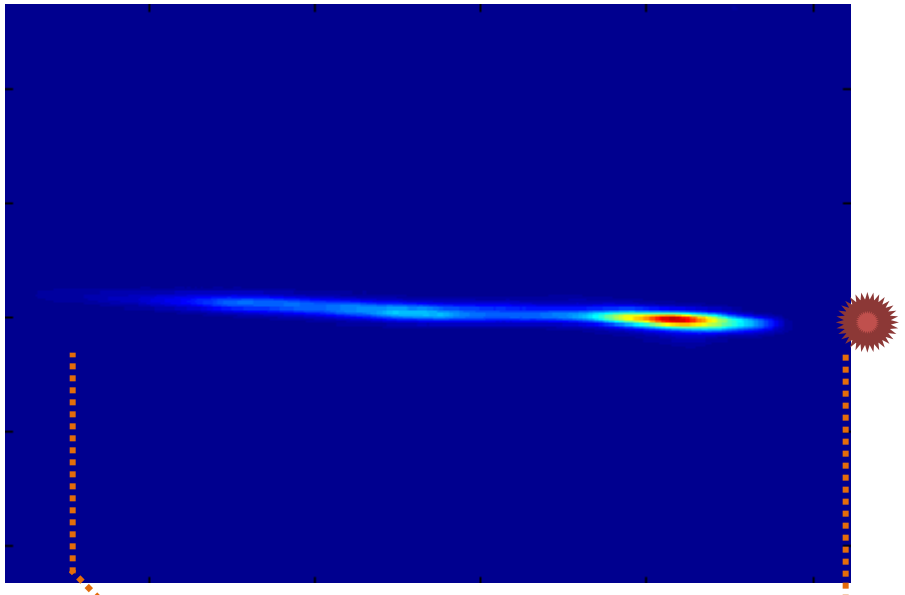

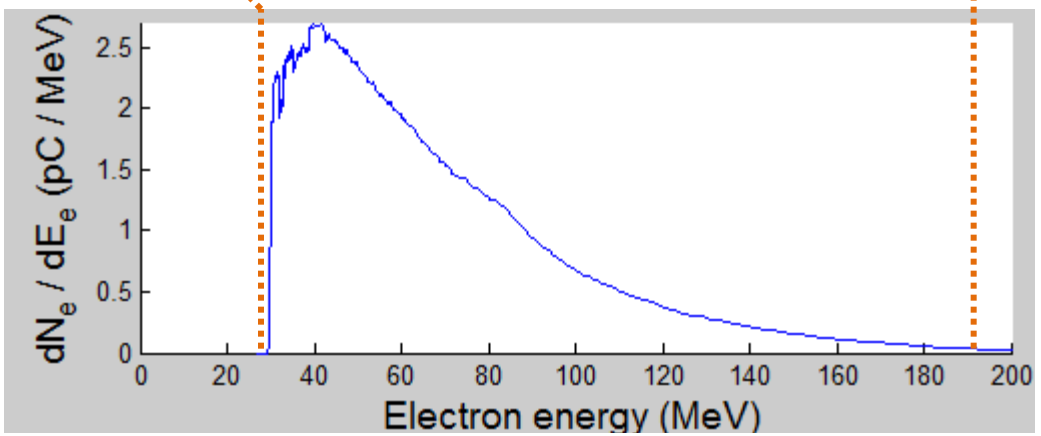

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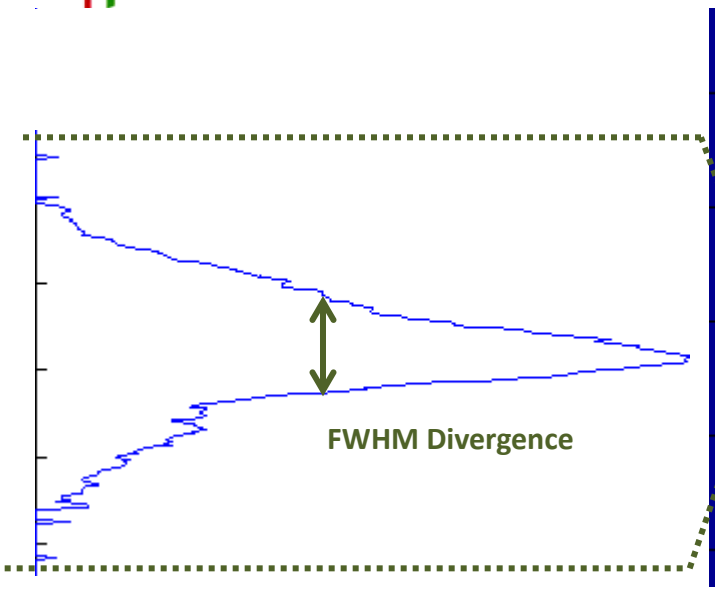
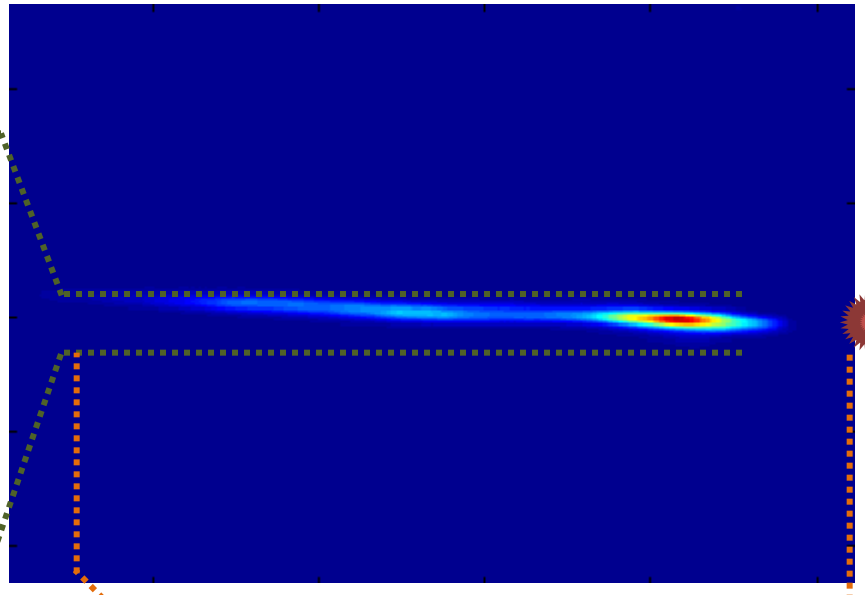
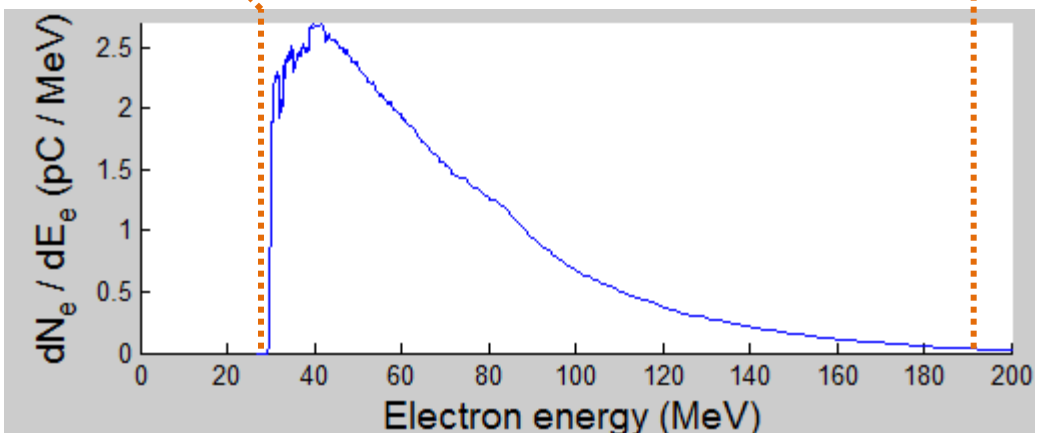
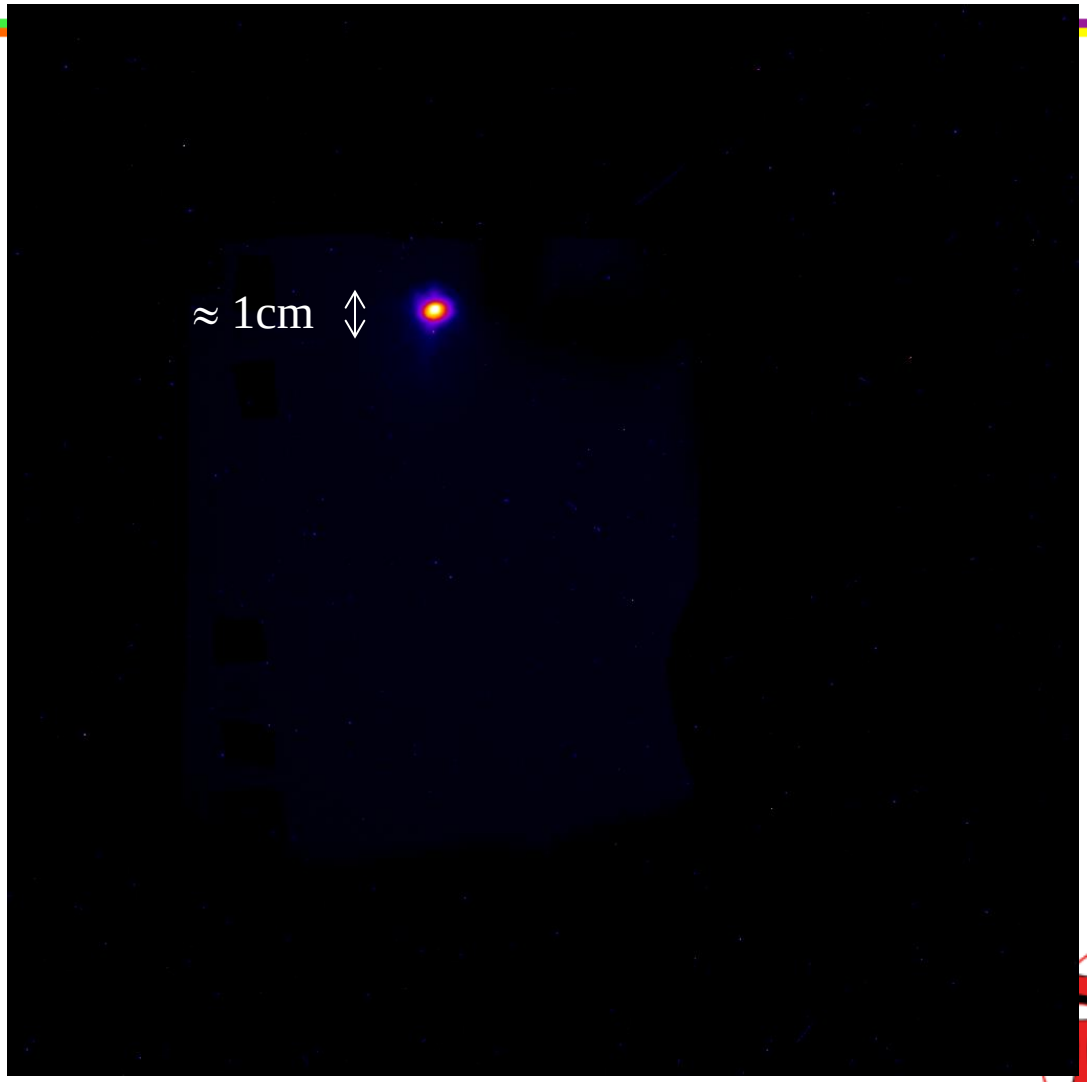






Electron Beam Pointing Stability

- Preliminary study of 15 shots
- After ≈ 40 cm propagation in vacuum



Alternative Mechanism for e^- Injection

- With available parameters,

self-injection leads to

broad e^- energy spectra

- Alternative mechanism for e^- injection

is necessary to reduce injection phase space and to provide high charge beam

ELectron Injector for Compact Staged High Energy Accelerator (ELISA)

- Aims of this project:
  - Decoupling of injection and acceleration in order to have more control on e^- beam properties.
  - Ionization injection instead of self-injection.

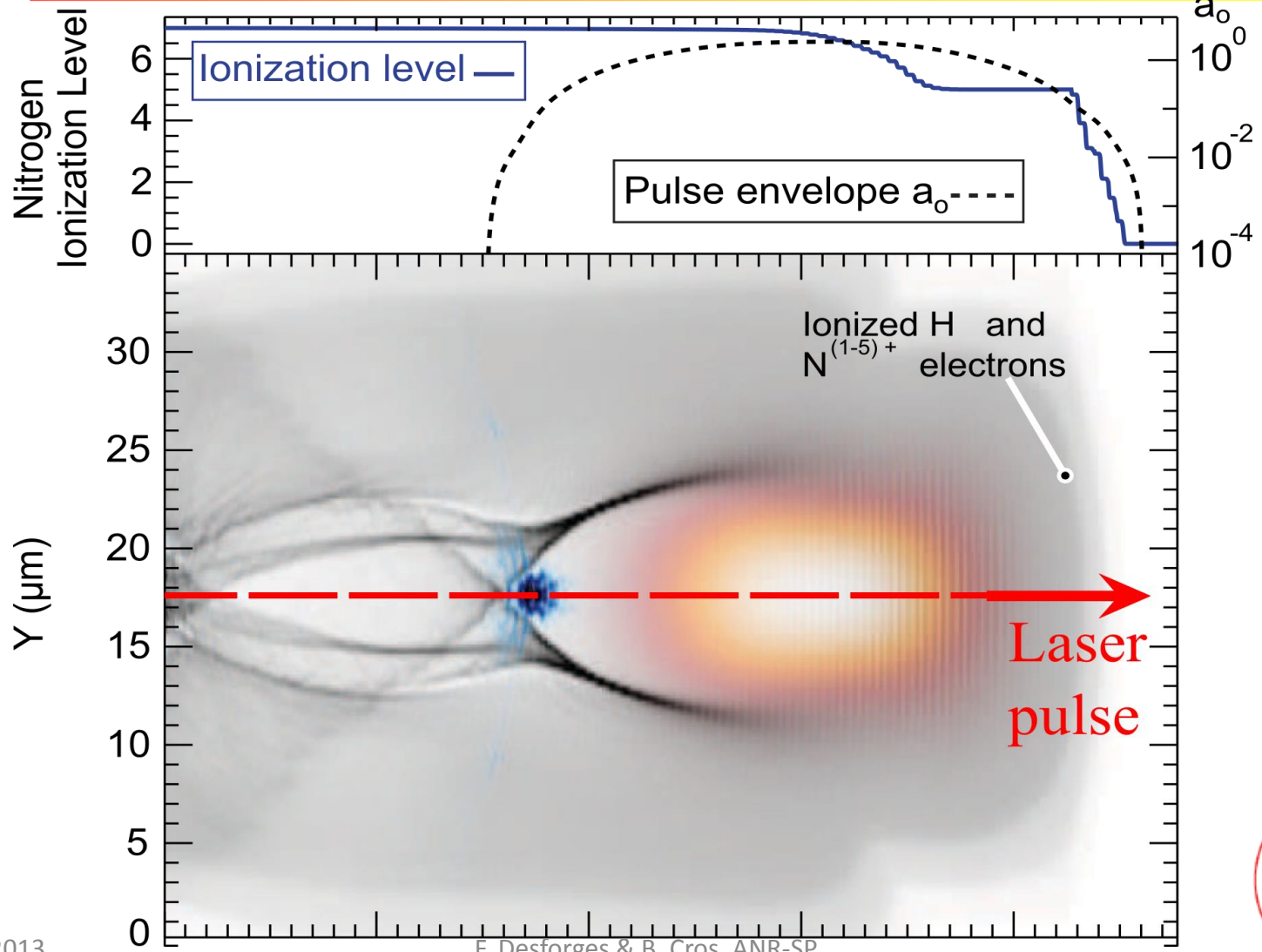
- Physical principle of Ionization injection:

  Ionization and trapping of plasma e^-

  by tunneling photo-ionization

  at laser peak intensity

Physical principle of Ionization Injection



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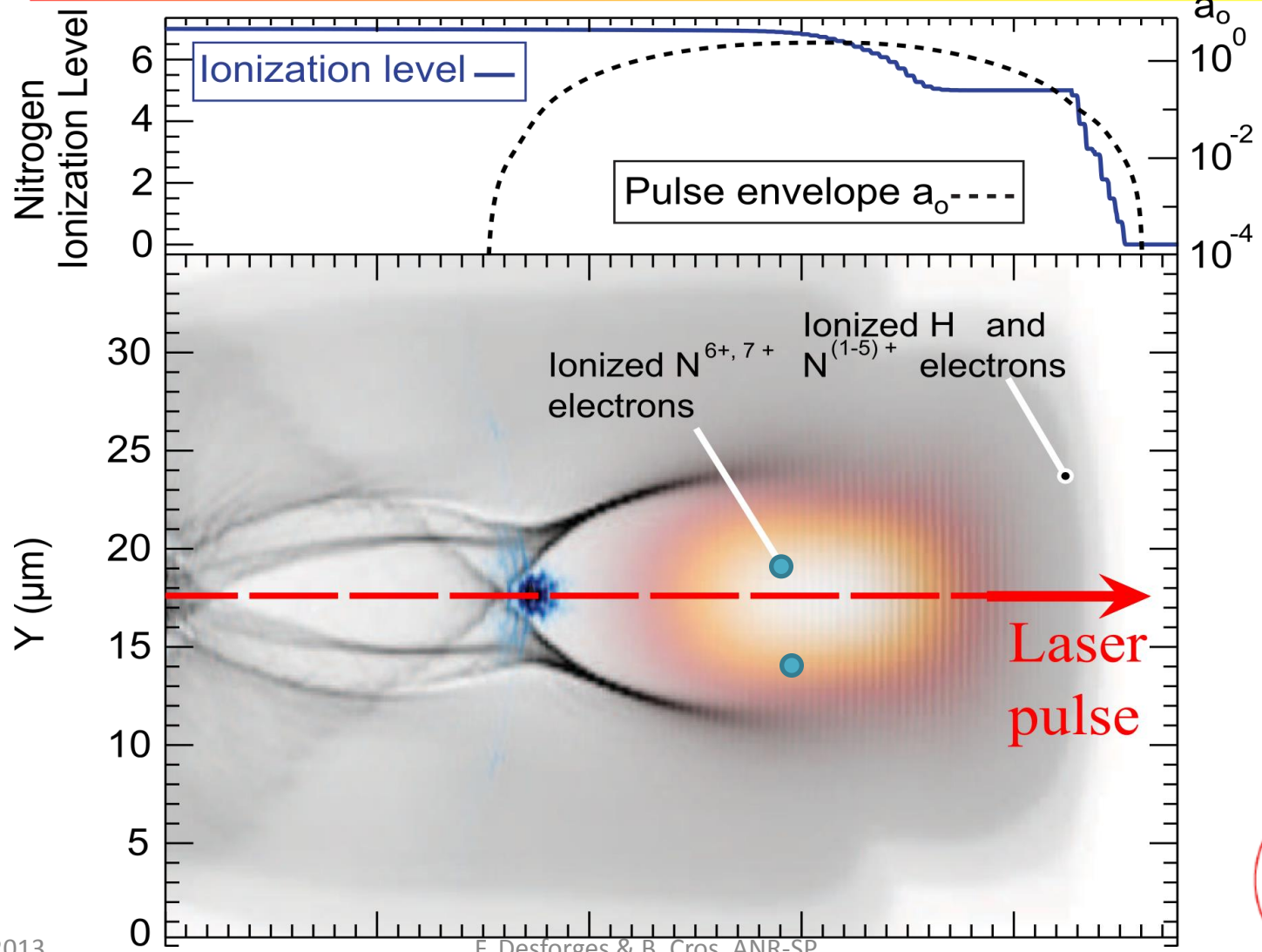

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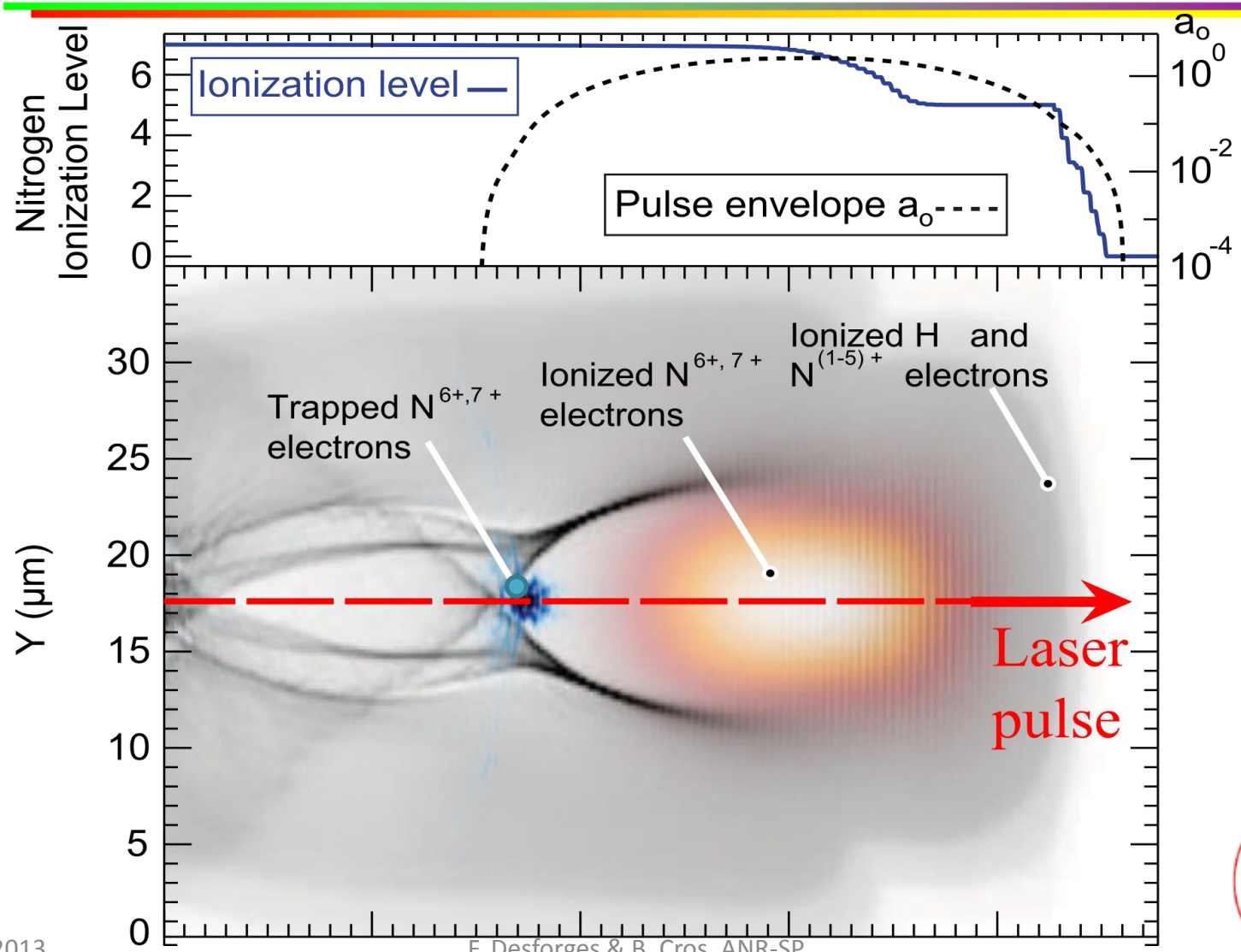

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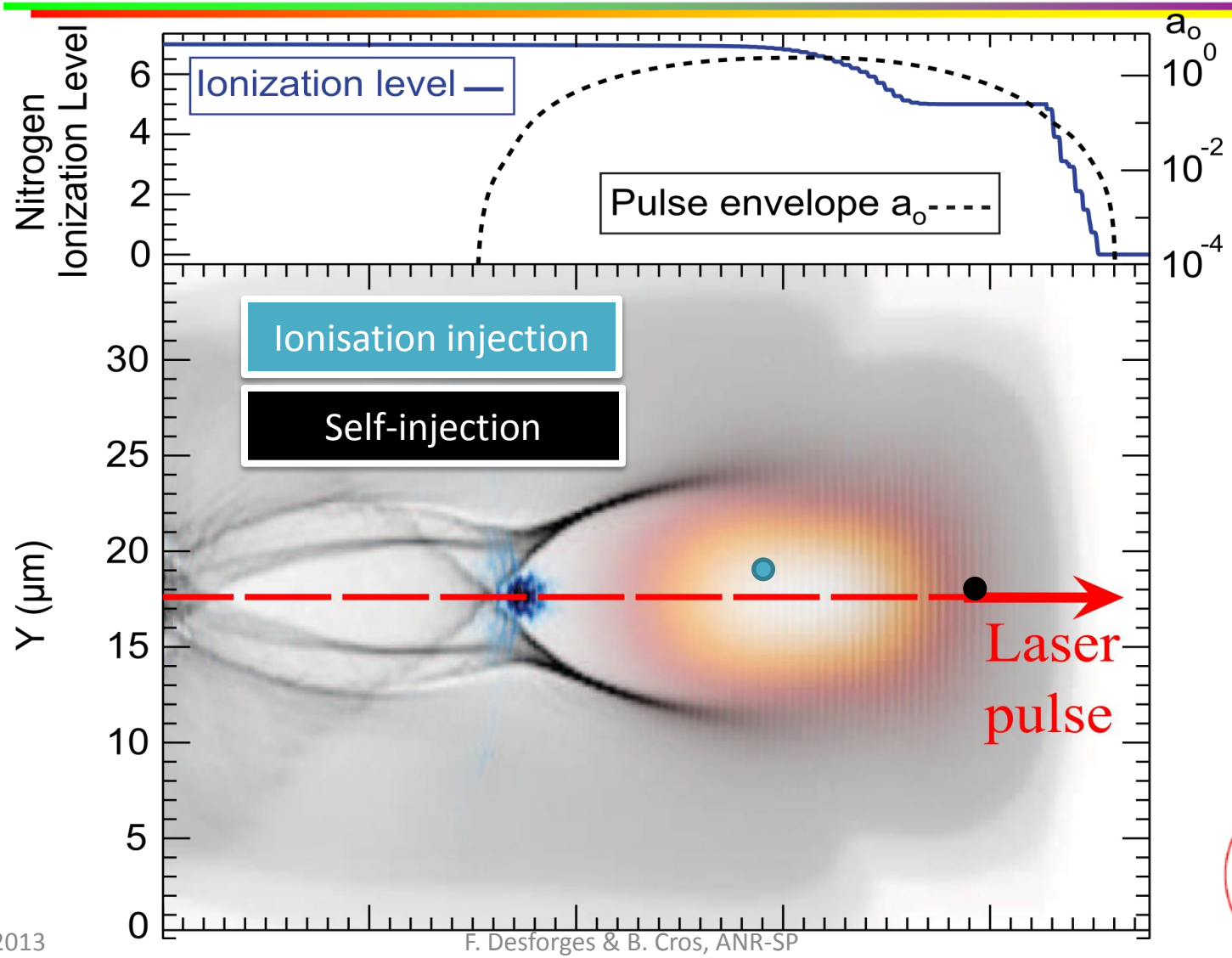

Expected Parameters for ELISA

Simulation publication on ionization injection:

M. Chen, *et al.* Physics of Plasmas, 19(3) :033101, 2012

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Experimental State-of-the-Art

E ~ 50 MeV and dE / E ~ %

Q ~ 10 – 100 pC

Δt ~ 30 fs

θ ~ 1 – 10 mrad

Summary and Perspectives

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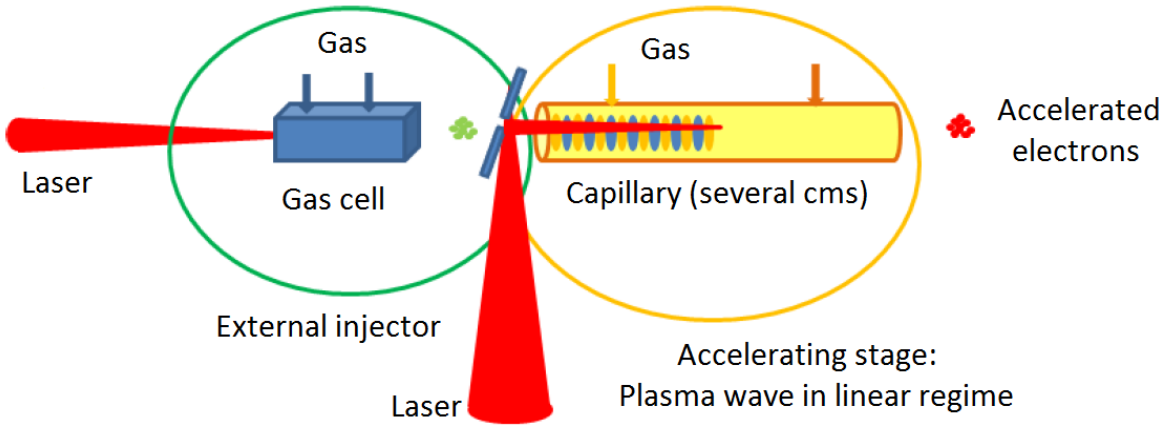

Thank you for your attention

Is there any questions?