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APPLICATIONS

EuPRAXIA

Laser-plasma injectors in the frame of EuPRAXIA

3rd EAAC, Elba island, 25-29 September 2017

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The EuPRAXIA project

- Design study for an accelerator facility providing 5 GeV electron bunches to two user areas
  - Free electron laser science area
  - High energy physics detector science area

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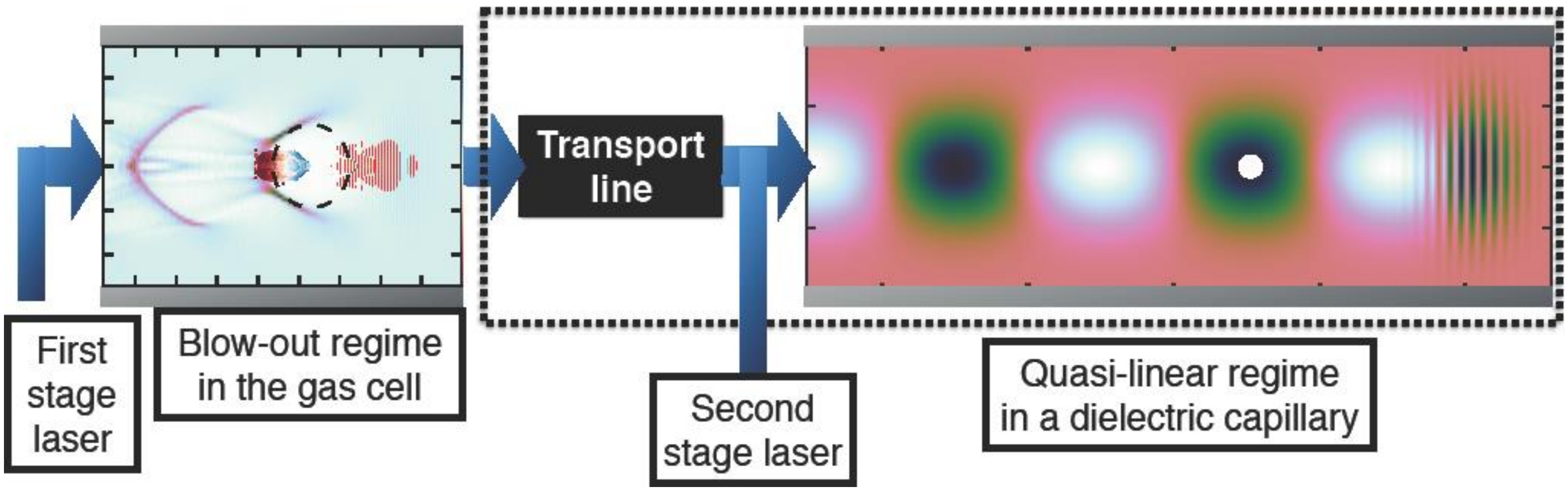

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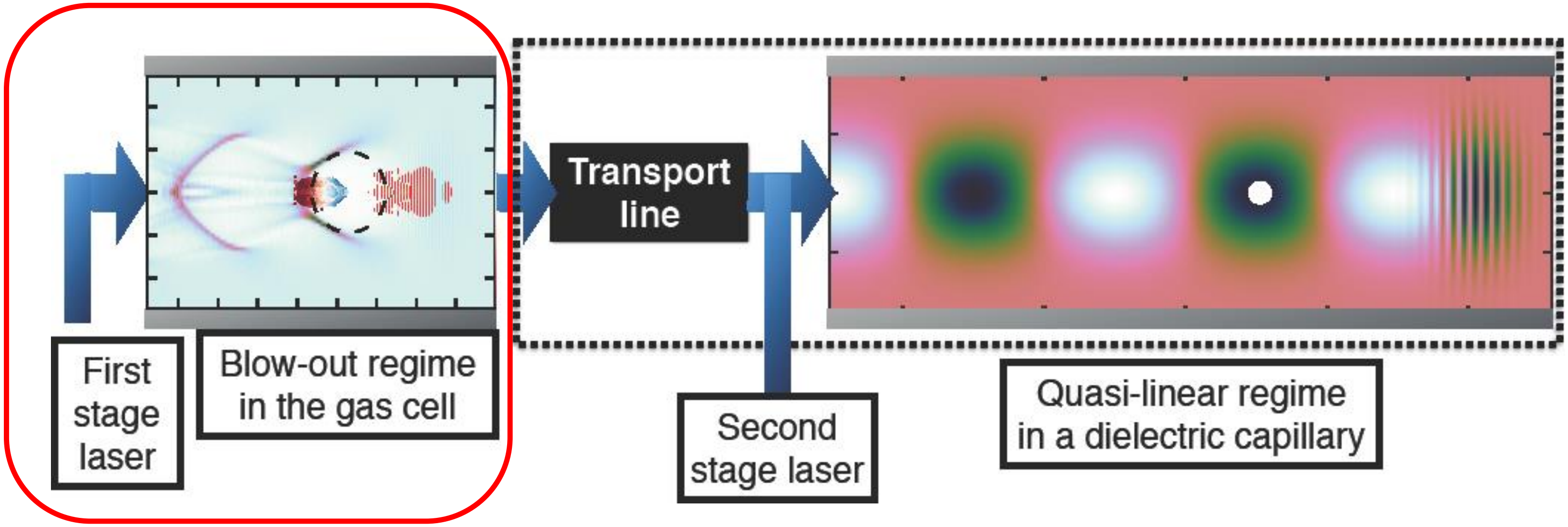

150 MeV Injector – Targeted properties

Quantity	Target value
Energy	150 MeV [100 – 200 MeV]
Charge	100 pC [30 – 100 pC]
Bunch length	5 fs (rms) [3 – 20 fs]
Repetition rate	10 Hz [1 – 100 Hz]
Total energy spread	5 % (rms) [1 – 5 %]
Transverse normalized emittance	1 mm.mrad
Transverse beam size	0.58 µm (rms) [0.5 – 0.71 µm]
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- These target properties are given at the entrance of the second stage

→ Impact of transport on charge, bunch length and spatial properties

150 MeV Injector – Comparative study

- We compared experimental results with electron energy in the range of EuPRAXIA

- We focused on properties that will not be changed or improved during transport :
  - → Energy
  - → Charge
  - → Energy spread

- We looked at four injection schemes :
  - → SI : self-injection
  - → CPI : colliding pulse injection
  - → DGI : density gradient injection
  - → III : ionization-induced injection

150 MeV Injector – State of the Art

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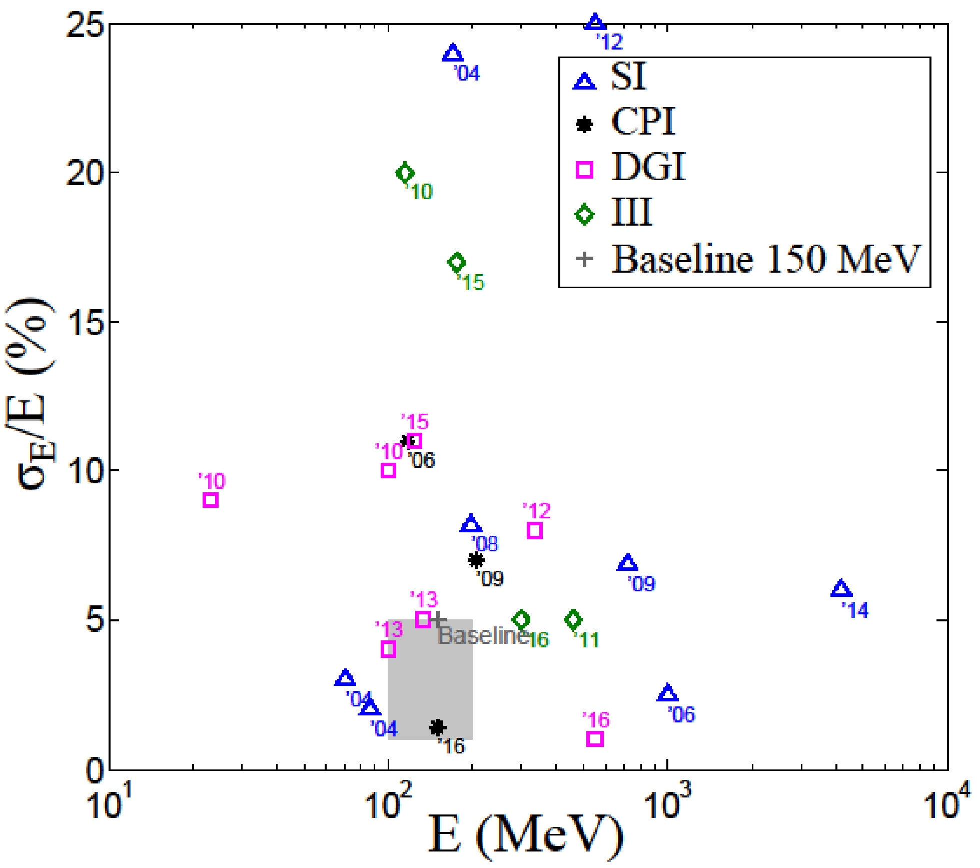

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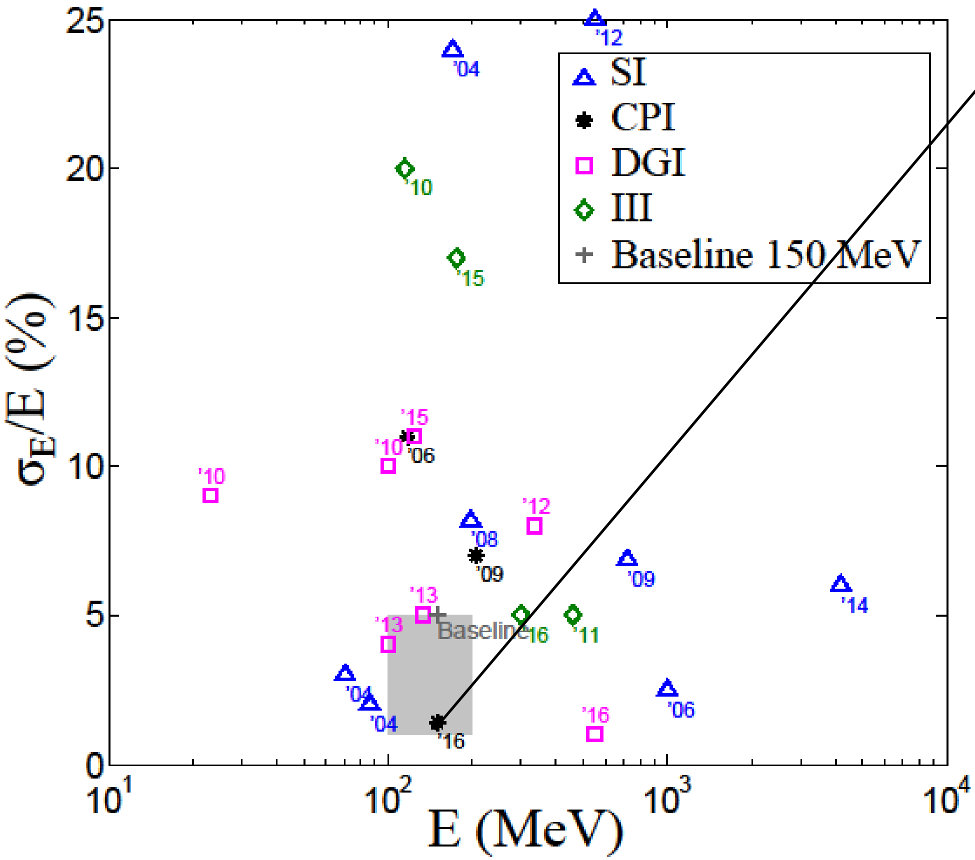
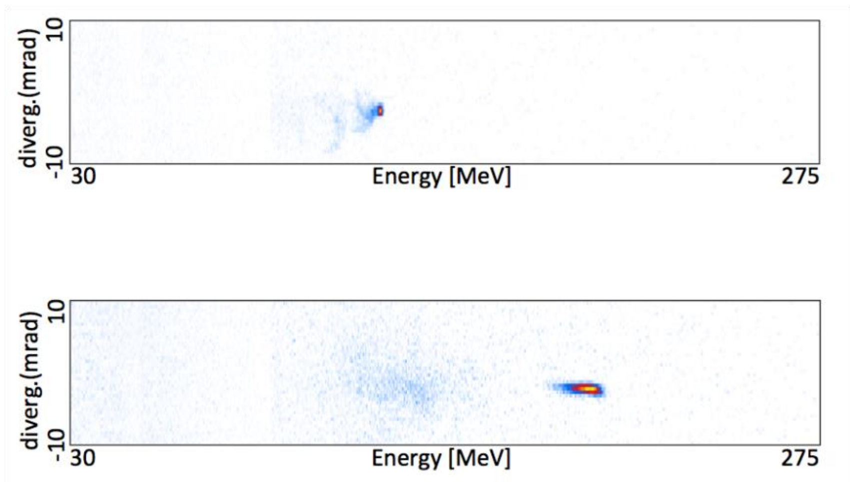


C.G.R. Geddes et al. AIP Conf. Proc. (2016)



- CPI in gas jet
- $a_0 = 1.2$ & 0.6
- $n_e \sim 10^{19}$ cm^{-3}

- $E = 150$ MeV
- $\frac{\sigma_E}{E} = 1.4\ \%$ (fwhm)
- $Q \sim 8$ pC

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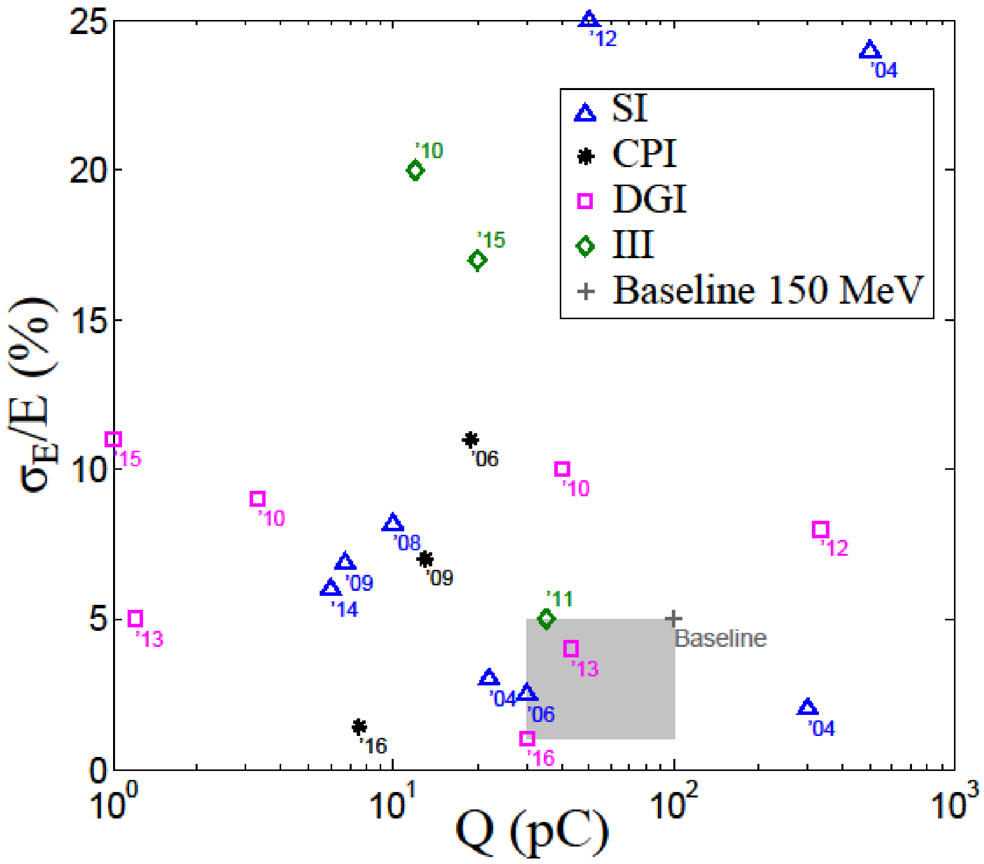

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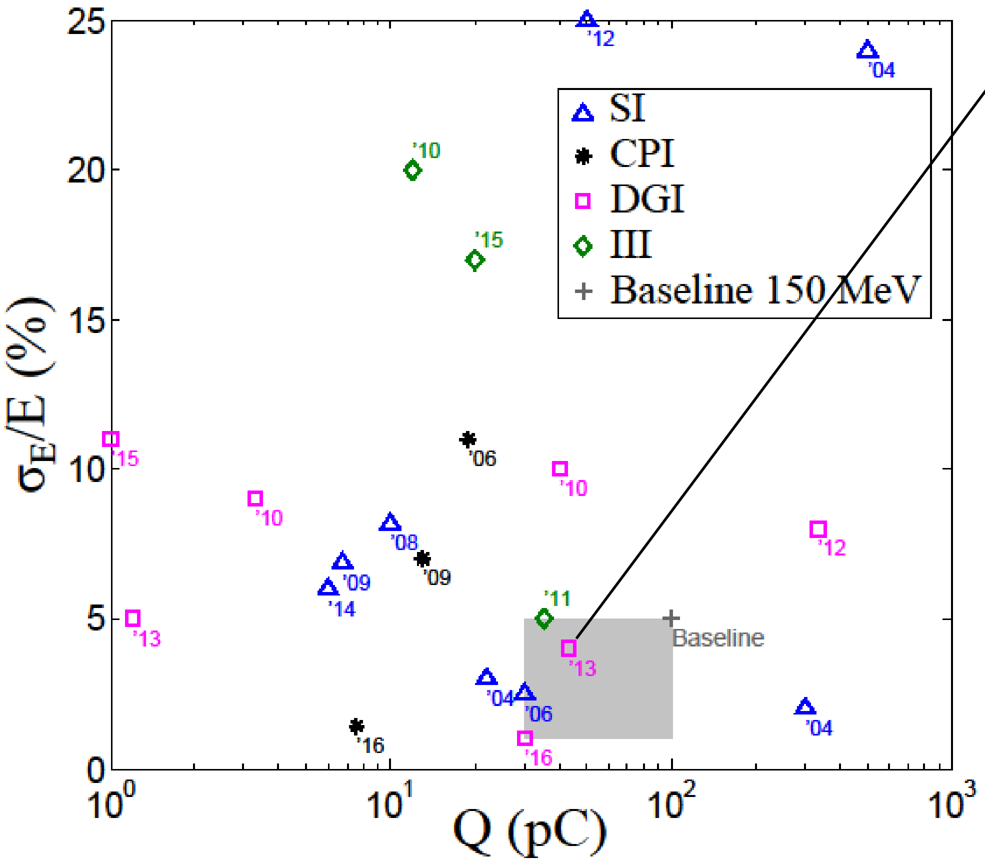
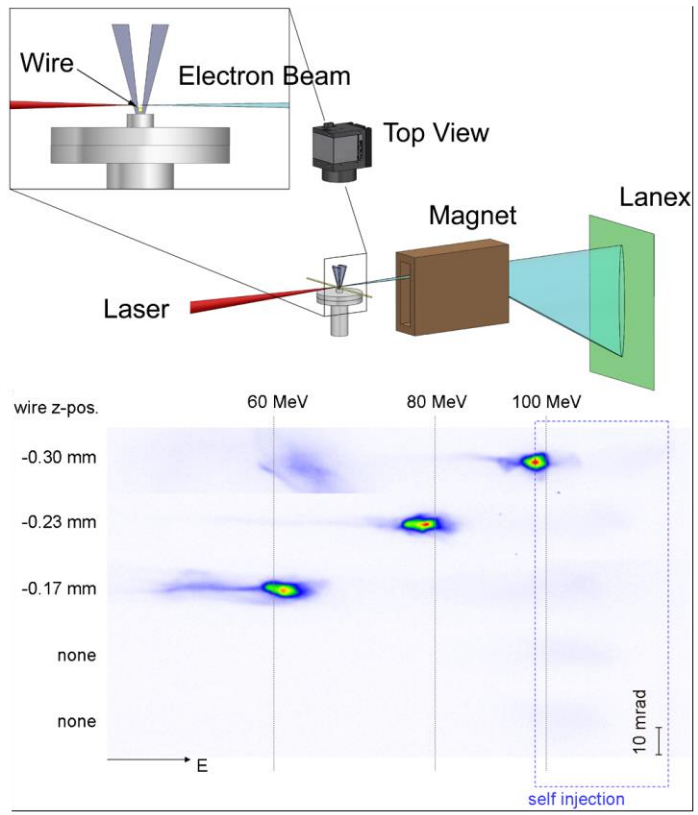


M. Burza et al. PRSTAB (2013)



- DGI in gas jet
- $n_e \sim (6 \rightarrow 3) \times 10^{18}$ cm^{-3}

- $E = 100$ MeV
- $\frac{\sigma_E}{E} = 4$ % (fwhm)
- $Q \sim 43$ pC

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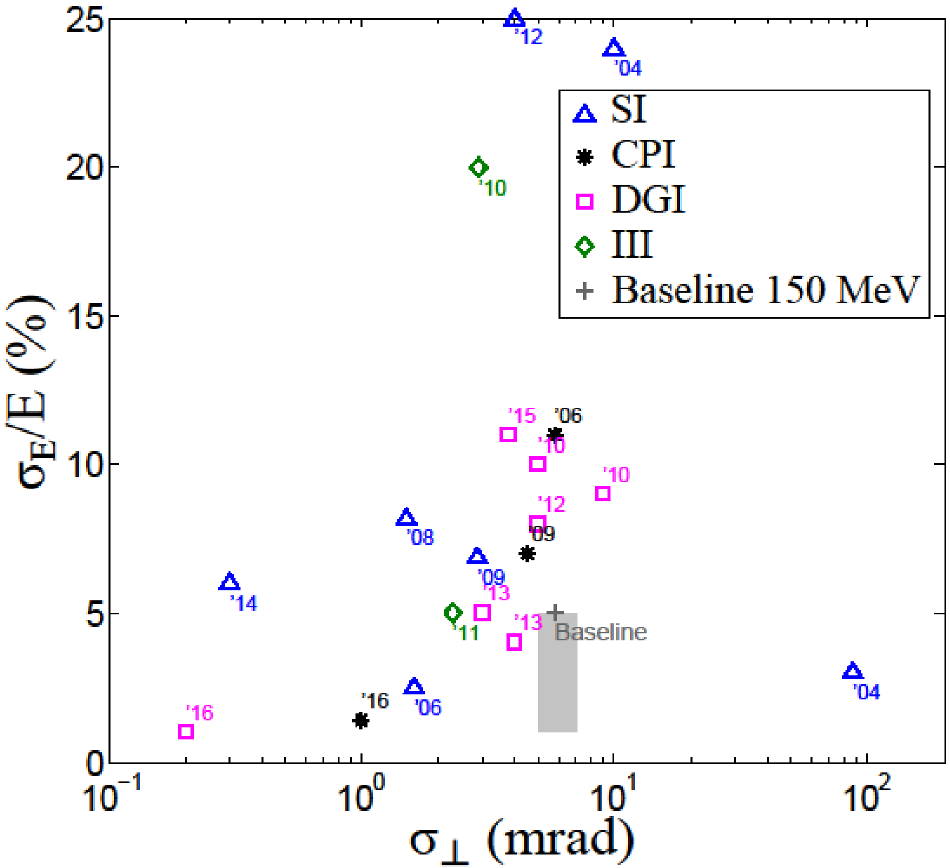

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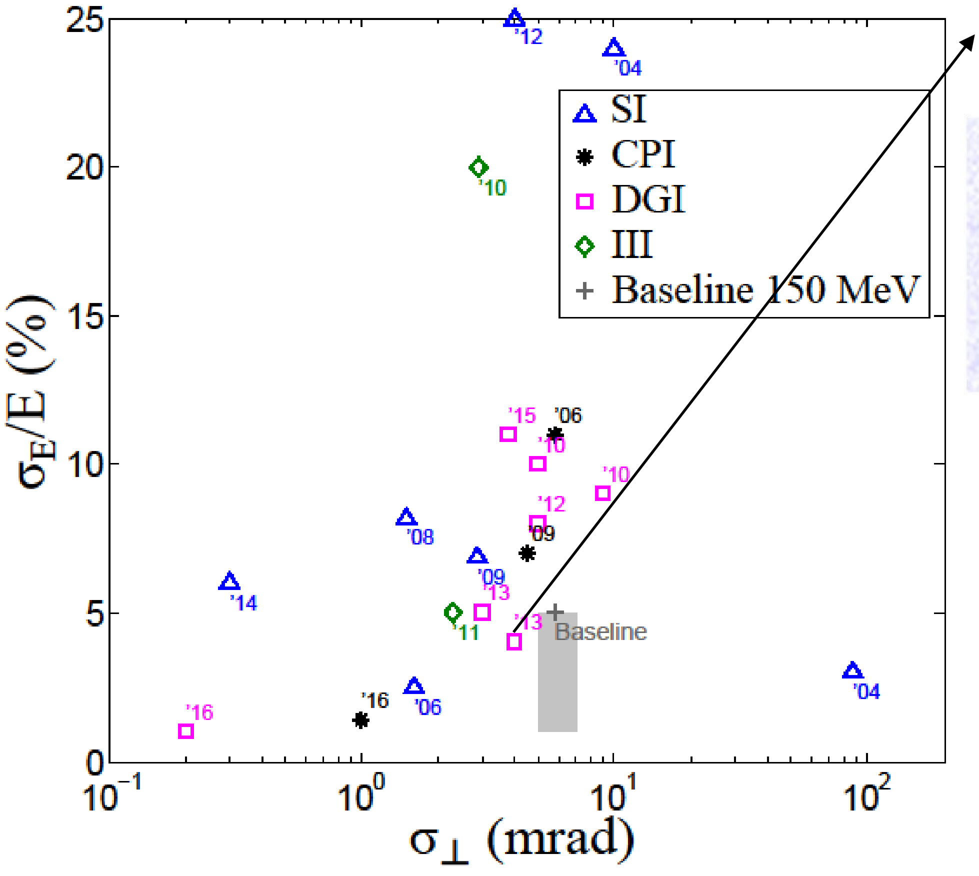

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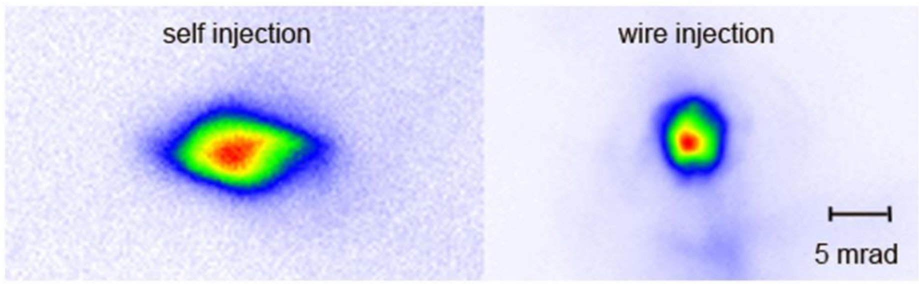

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- $E = 100$ MeV
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- $Q \sim 43$ pC
- $\sigma_\perp = 4$ mrad (fwhm)

150 MeV Injector – Targeted properties

Quantity	Target value	Published results
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Charge	100 pC [30 – 100 pC]	✘
Bunch length	5 fs (rms) [3 – 20 fs]	✔✘
Repetition rate	10 Hz [1 – 100 Hz]	✔
Total energy spread	5 % (rms) [1 – 5 %]	✔
Transverse normalized emittance	1 mm.mrad	✘
Transverse beam size	0.58 µm (rms) [0.5 – 0.71 µm]	✔✘
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Critical issue :

- High charge (100 pC) **combined with** low energy spread (5 % rms) and low emittance (1mm.mrad)

Possible 150 MeV injector

- Published results only partially match EuPRAXIA injector parameters
  → Optimization investigated through simulations

P. Lee PRSTAB (2016)

P. Lee PRSTAB (to be submitted)

  - Ionization induced injection in a gas cell with tuned density profile
  - Density transition injection in a gas jet
  - Self-truncated inonization induced injection in gas jet ?

… in quasi-linear regime

Summary / discussion

- Published experimental results are getting closer to EuPRAXIA target parameters :
  - Energy, energy spread and divergence are already achievable
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- Stability (pointing, charge, energy …) is mandatory for injection into a second plasma stage → more results on stability are needed

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- Stability (pointing, charge, energy …) is mandatory for injection into a second plasma stage → more results on stability are needed

- Transport will have an impact on the stability
  - Up to a factor ~10 in size and pointing stability → A. Maitrallain (to be published)

  - A stable injector producing wider energy distribution but large pC/MeV could also be an option

Horizon 2020

Thank you !