

04/11/2022

# Physics Goals of Run2(c)

**Patric Muggli**

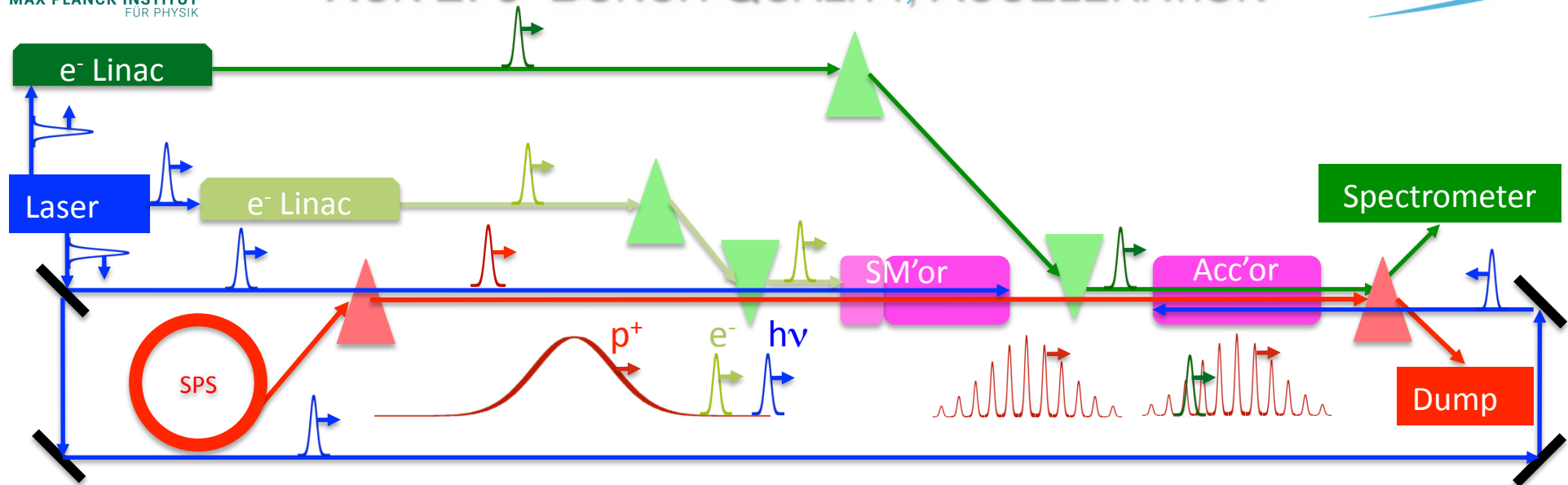
*Max Planck Institute for Physics*  
Munich

[muggli@mpp.mpg.de](mailto:muggli@mpp.mpg.de)

<https://www.mpp.mpg.de/~muggli>

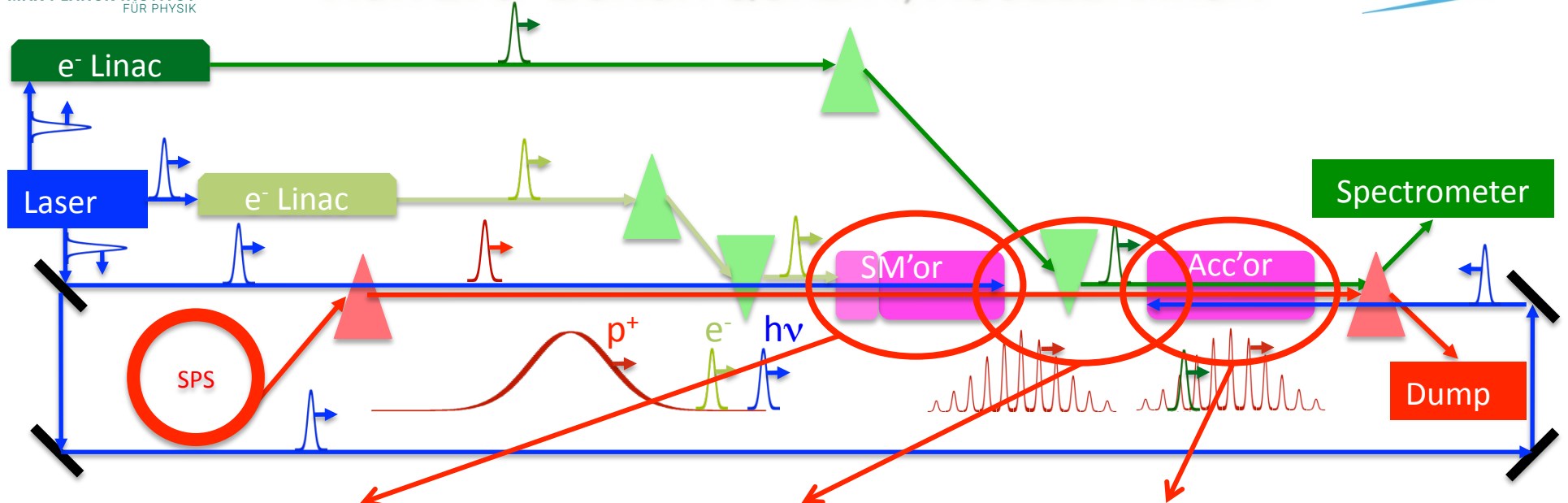


# RUN 2: $e^-$ BUNCH QUALITY, ACCELERATION



- ◇ Separate self-modulation and acceleration
- ◇ Two plasmas

# RUN 2: $e^-$ BUNCH QUALITY, ACCELERATION



### Self-Modulator, Run 2a,b:

- ✧  $e^-$  bunch seeding of SM
- ✧ Plasma density step

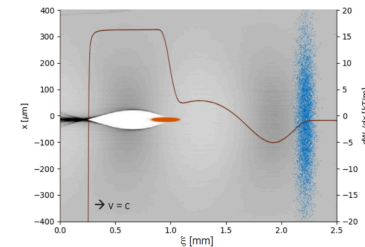
### $e^-$ external injection, Runs 2 c,d:

- ✧ On-axis injection
- ✧ Bunch quality
- ✧ Plasma source for  $\gg$ GeV scale

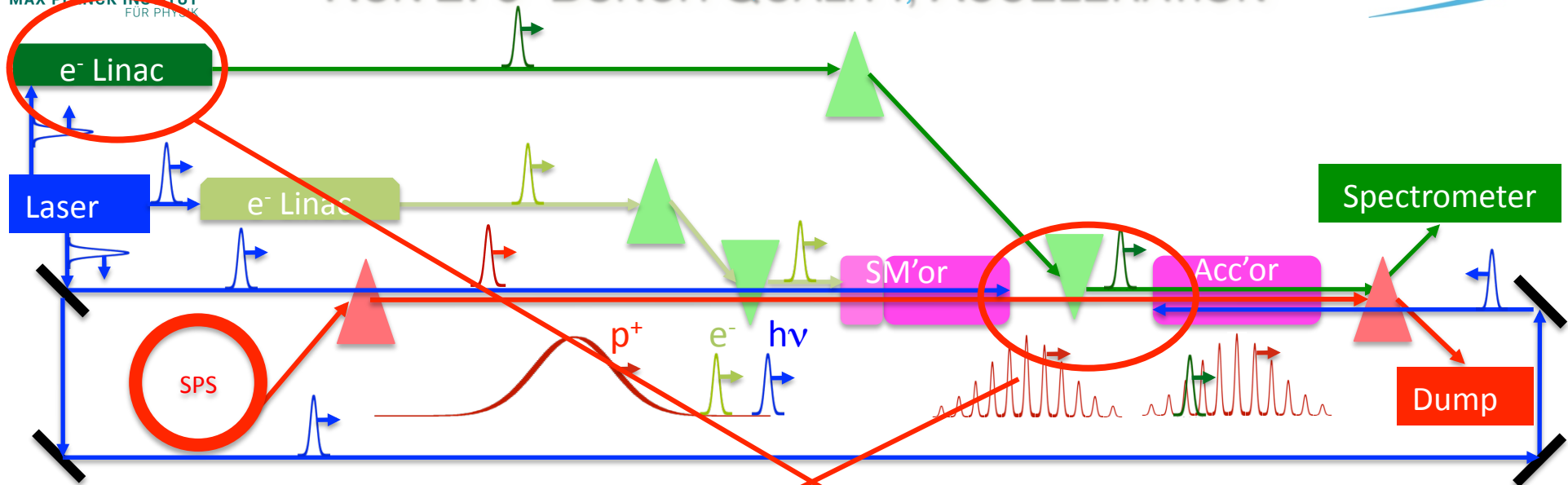
### Accelerator:

- ✧ Blow-out
- ✧ Beam loading
- ✧ Beam matching

✧ Bunch quality



# RUN 2: e<sup>-</sup> BUNCH QUALITY, ACCELERATION



### Self-Modulator, Run 2a,b:

- ✧ e<sup>-</sup> bunch seeding of SM
- ✧ Plasma density step

### e<sup>-</sup> external injection, Runs 2 c,d:

- ✧ On-axis injection
- ✧ Bunch quality

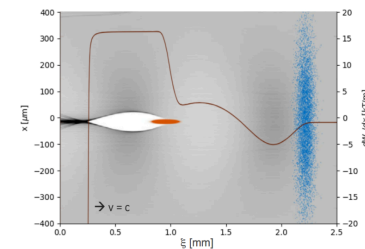
### Accelerator:

- ✧ Blow-out
- ✧ Beam loading
- ✧ Beam matching

✧ Bunch quality

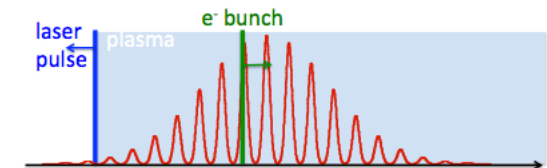
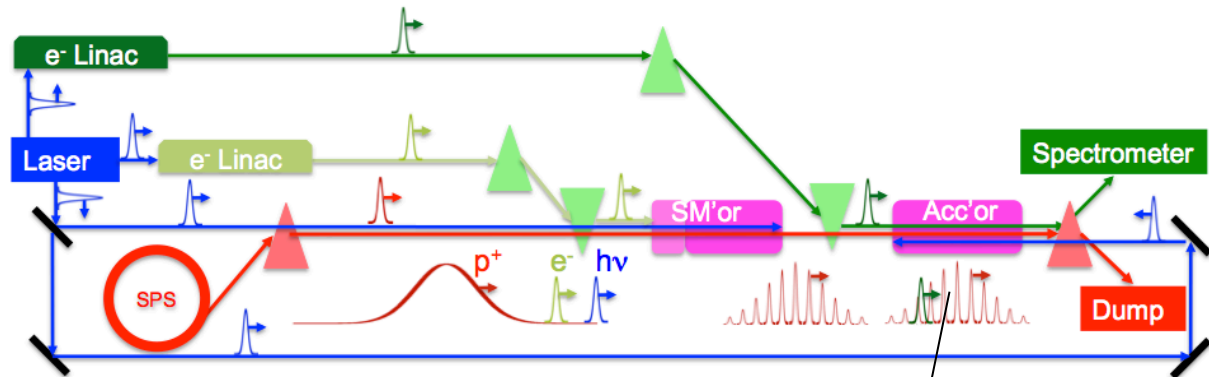
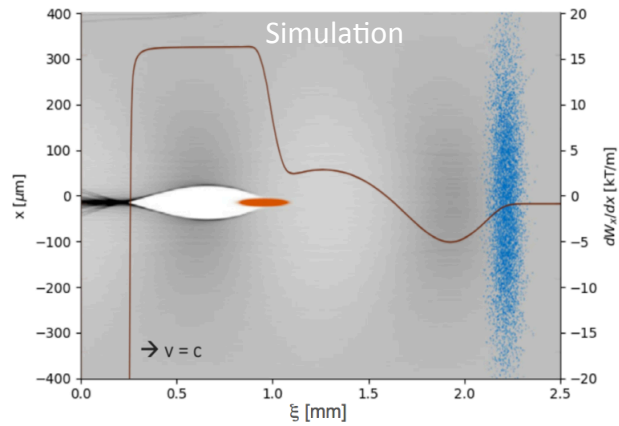
### Current plan:

- ✧ S-band/X-band RF-photo injector: Steffen's talk
- ✧ e-line: Vittorio's talk



# e<sup>-</sup> EXTERNAL INJECTION

V. K. Berglyd Olsen, PR- AB 21, 011301 (2018)

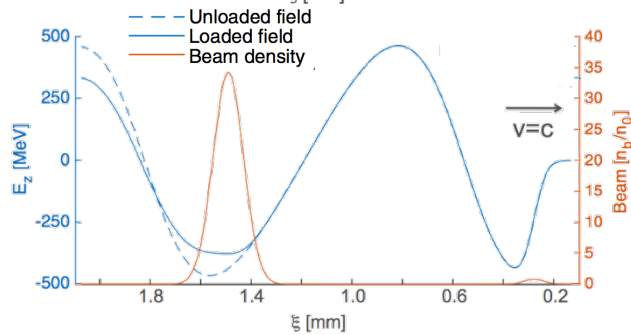
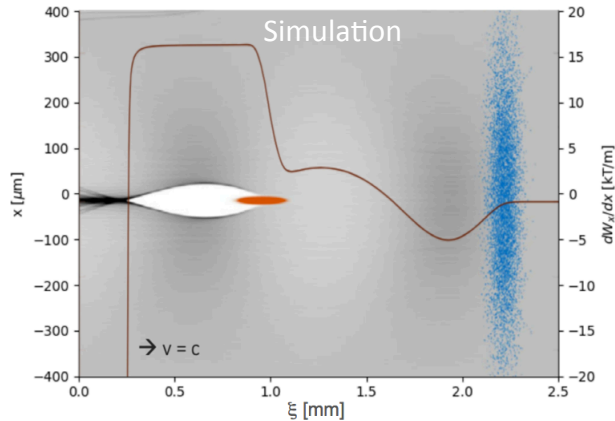


- ✧ Two plasmas
- ✧ Separate self-modulation and acceleration
- ✧ External injection of e<sup>-</sup> bunch

# e<sup>-</sup> EXTERNAL INJECTION

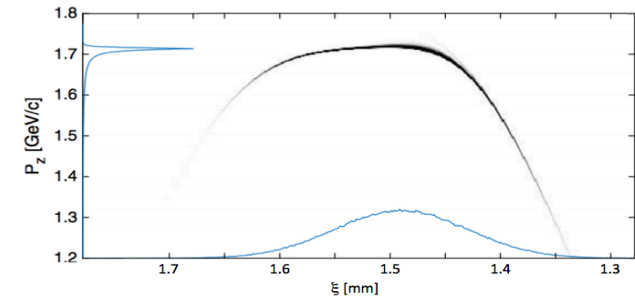
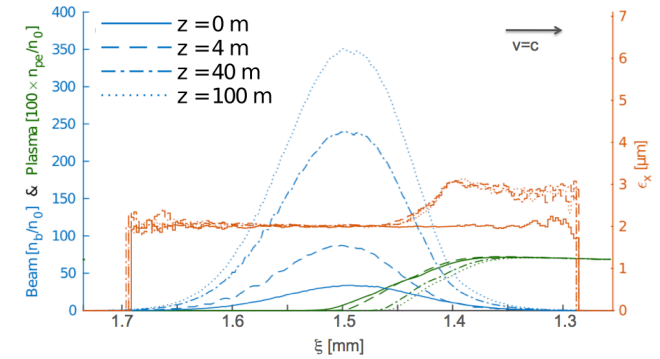


V. K. Berglyd Olsen, PR- AB 21, 011301 (2018)



Blow-out  
+  
Beam loading  
+  
Matching  
=

Bunch quality:  
 $\epsilon_N \sim \text{mm-mrad}$   
 $\Delta E/E \sim \%$   
 $Q \sim 70 \text{pC (of 100pC)}$

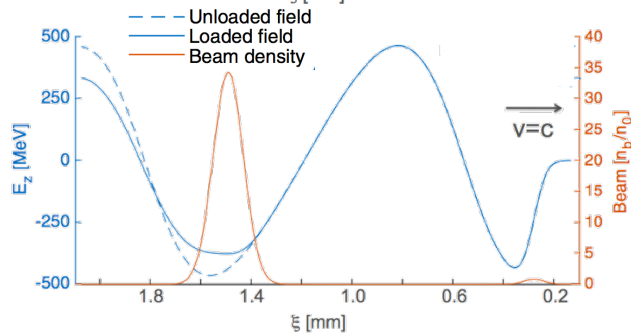
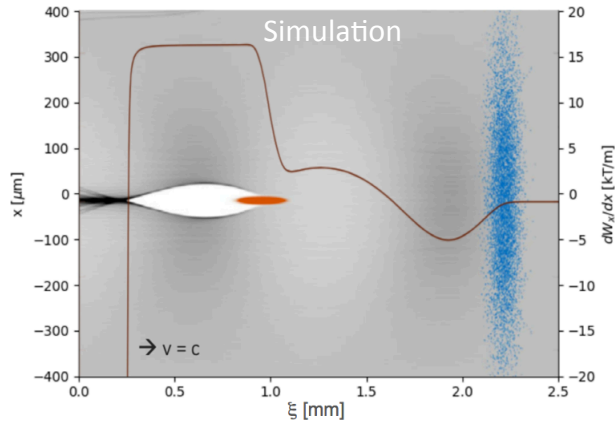


$E_0$	218 MeV	} $\frac{\gamma n_{e0} \sigma_{r,match}^4}{\epsilon_N^2} = \frac{2\epsilon_0 m_e c^2}{e^2}$	
$\gamma$	427		
$Q$	100 pC		
$\epsilon_N$	2 mm-mrad		
$n_{e0}$	$7 \times 10^{14} \text{ cm}^{-3}$		
		$\sigma_{r0,match}$	5.25 $\mu\text{m}$
		$\beta_{0,match}$	5.9 mm
		$n_b/n_{e0}$	$\cong 35$

# e<sup>-</sup> EXTERNAL INJECTION

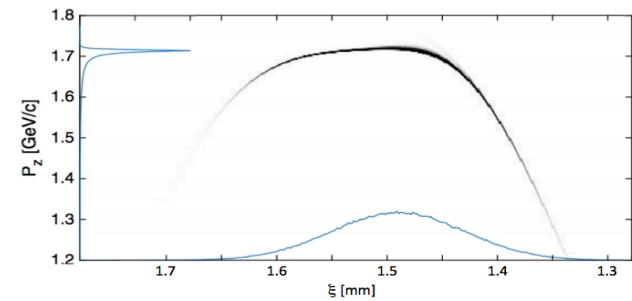
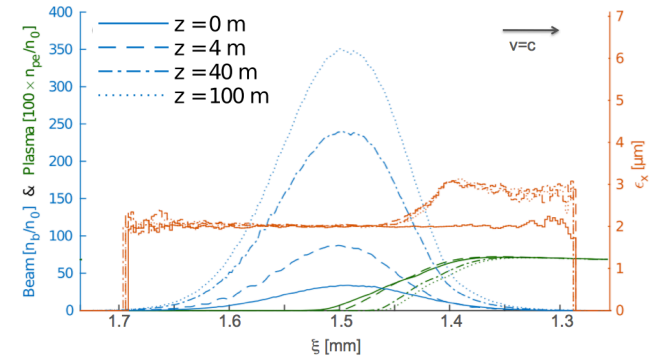


V. K. Berglyd Olsen, PR- AB 21, 011301 (2018)



Blow-out  
+  
Beam loading  
+  
Matching  
=

Bunch quality:  
 $\epsilon_N \sim \text{mm-mrad}$   
 $\Delta E/E \sim \%$   
 $Q \sim 70\text{pC}$  (of 100pC)



$E_0$	218 MeV	} $\frac{\gamma n_{e0} \sigma_{r,match}^4}{\epsilon_N^2} = \frac{2\epsilon_0 m_e c^2}{e^2}$	
$\gamma$	427		
$Q$	100 pC		
$\epsilon_N$	2 mm-mrad		
$n_{e0}$	$7 \times 10^{14} \text{ cm}^{-3}$		
		$\sigma_{r0,match}$	5.25 $\mu\text{m}$
		$\beta_{0,match}$	5.9 mm
		$n_b/n_{e0}$	$\cong 35$

## Challenges:

- ✧ e<sup>-</sup> transport, e<sup>-</sup>-p<sup>+</sup> alignment ( $\leq 10\mu\text{m}$ )
- ✧ e<sup>-</sup> bunch parameters
- ✧ John's talk for the latest results and option ...

# e<sup>-</sup> EXTERNAL INJECTOR



## Goals:

- ✧ On-axis external e-injection
- ✧ Multi-GeV energy gain
- ✧ e-bunch quality, sufficient for HEP applications

## The e-bunch must:

Blow-out  
+  
Beam load  
+  
Be matched  
=  
Bunch quality:  
 $\epsilon_N \sim \text{mm-mrad}$   
 $\Delta E/E \sim \%$   
 $Q \sim 400 \text{pC}$

## Some Run 2c global parameters:

Plasma density  $(1-10) \times 10^{14} / \text{cc}$

### e-injection:

$E_0 = 150 \text{MeV}$   
 $\sigma_t = 200 \text{fs}$   
 $\sigma_0 = 5.75 \text{mm}$  (before scattering)  
 Position pointing jitter  $< \sigma_0$   
 Angle pointing jitter  $< \epsilon / \gamma \sigma_0$   
 $\epsilon_N = 2 \text{mm-mrad}$  (before scattering)  
 $\beta_0 = 5 \text{mm}$  (before scattering)  
 $Q_{\text{in}} = 0-1 \text{nC}$   
 Laser pulse - e-bunch jitter  $< 100 \text{fs}$

### e<sup>-</sup> out:

$E = 150 \text{MeV}-10 \text{GeV}$   
 $\epsilon_N = 2-100 \text{mm-mrad}$   
 $Q_{\text{out}} = Q_{\text{in}}$

## Unique opportunity:

- ✧ Very compact 150MeV LWFA injector
- ✧ Are the parameters possible?
- ✧ Not an experiment on top of an experiment
- ✧ Injector only or injector + transfer line?
- ✧ Important to know ...



Thank you to my collaborators



Thank you!

<http://www.mpp.mpg.de/~muggli>

muggli@mpp.mpg.de