The Eindhoven

High-Brightness Electron Source

Program

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1st ELAN Workshop, 4-6 May 2004

‘Physics and Applications of Accelerators’

Research Theme:

‘Generation of ultra-bright femtosecond electron bunches from table-top accelerators’

for application in:

- injection into laser wakefield accelerator
- source of broadband THz Coherent Transition Radiation
- source of Thomson-scattering X-rays
- contribution to X-ray FEL-development

Laser Wakefield Acceleration

External Injection

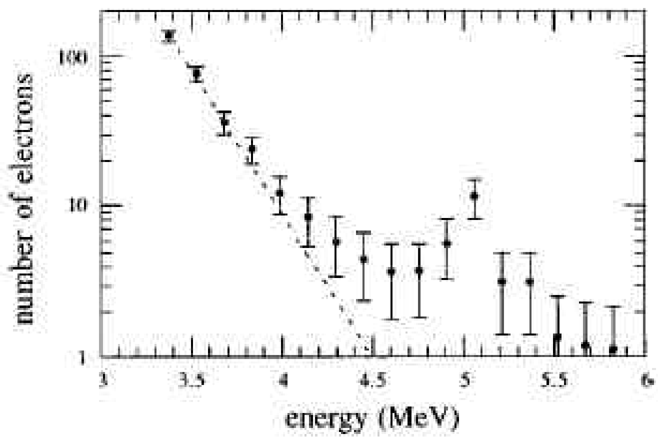
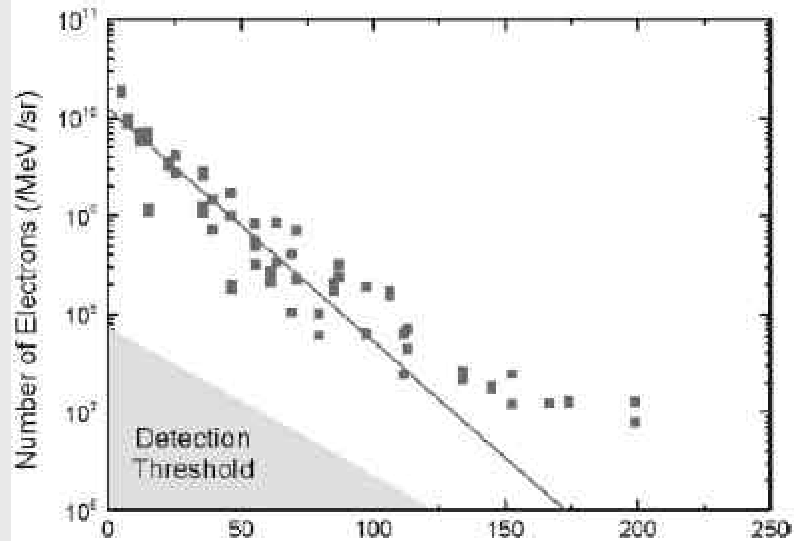


FIG. 9. Electron spectrum of a typical shot. The low energy points are fitted by a decreasing exponential.

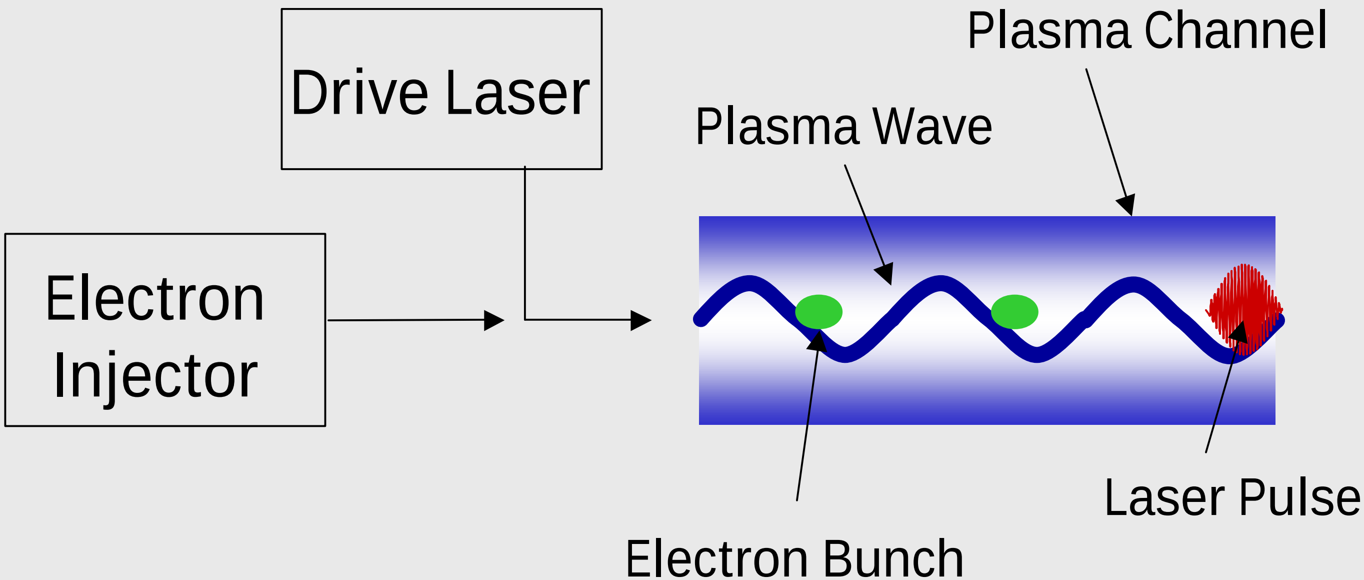
Self Modulated



F. Dorchies et al., Phys. Plasmas 6, 2903-2913 (1999)

S.Fritzler, PRL 92, 165005 (2004)

"Classical" Laser Wakefield Acceleration



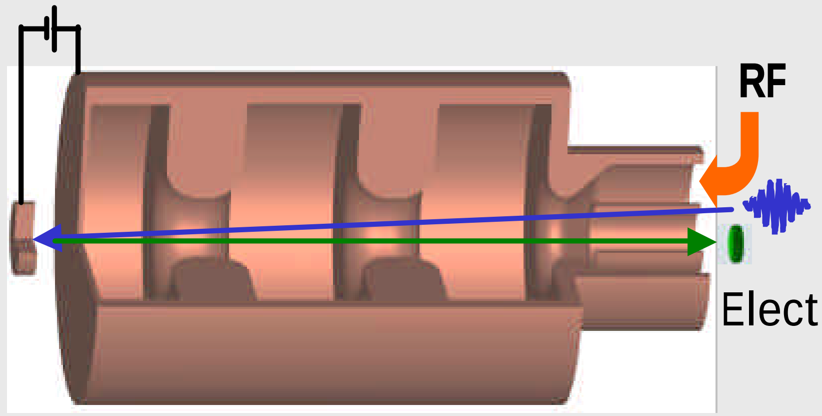
Can we perform a controlled LWFA experiment?

	Available	Foreseeable improvements
High Brightness Injector		
Plasma Waveguide		
Drive Laser		
Expected Results		

DC-RF Photogun

2 MV across 2 mm

Cylindrically symmetric
2½ cell 8 MeV S-band RF booster

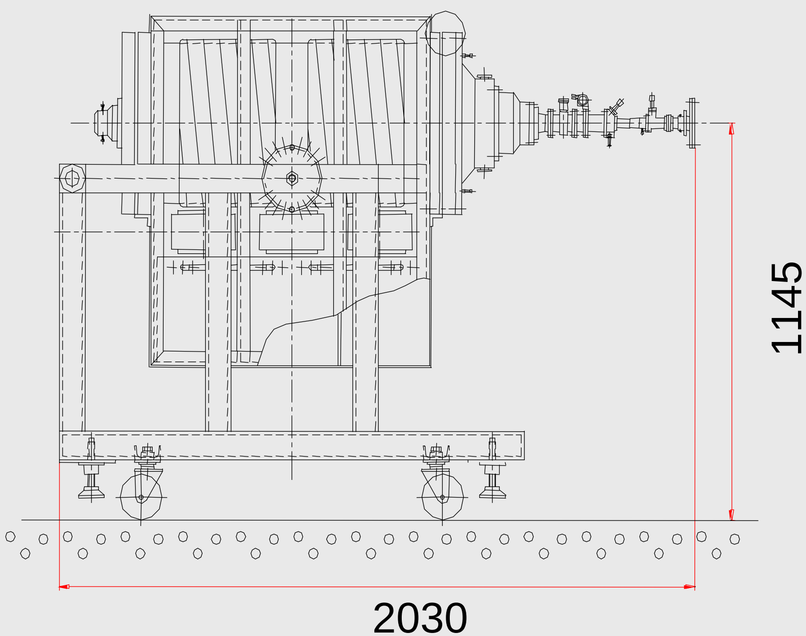


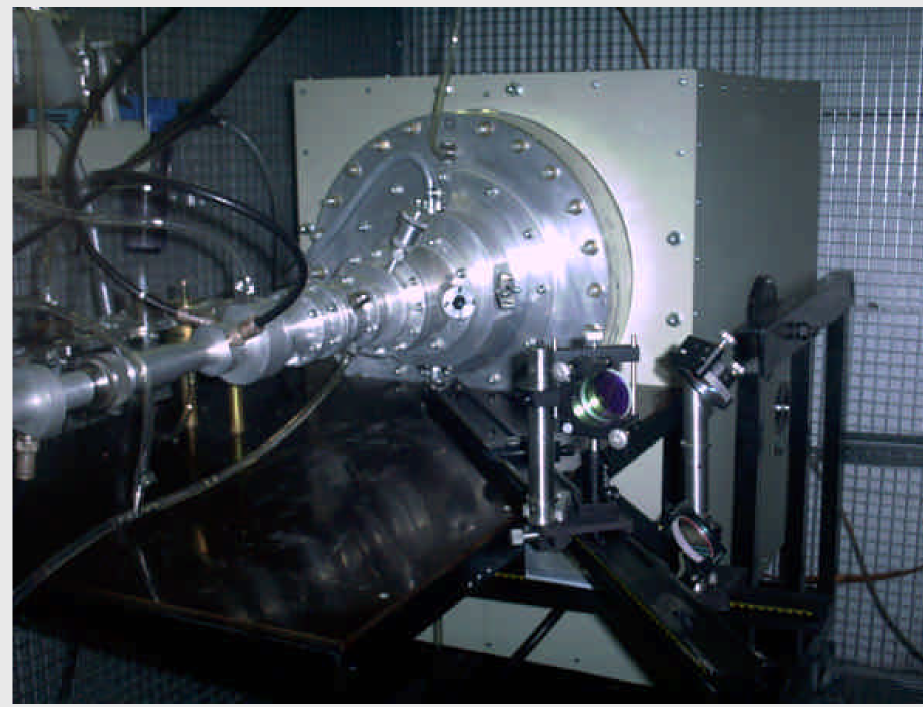
Projected Bunch Parameters:

Energy:	10 MeV
Peak Current:	1 kA
Emittance:	1 mm mrad
Length:	100 fs
Charge:	100 pC

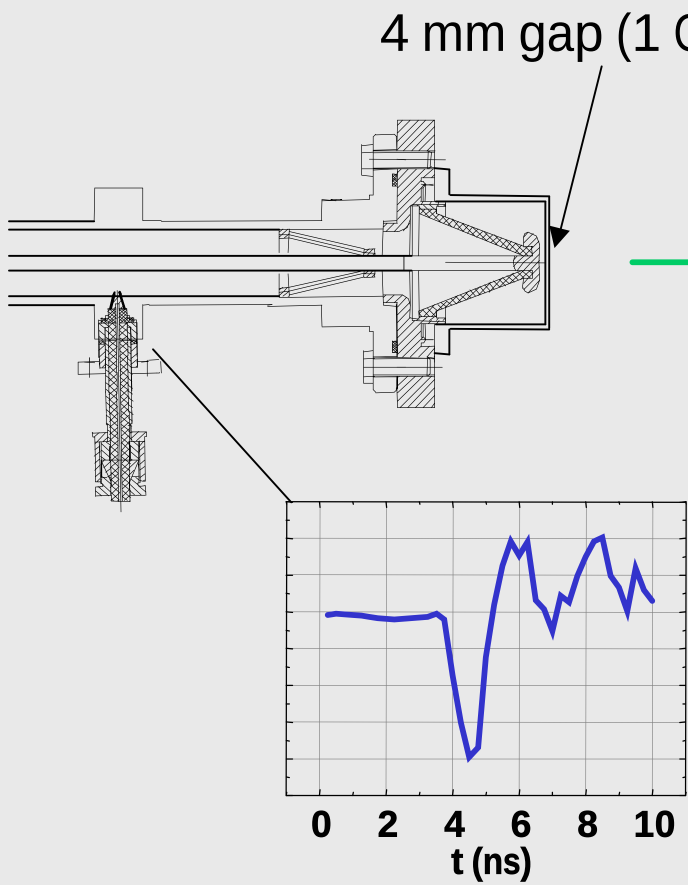
DC gun

2 MV, 1ns pulse





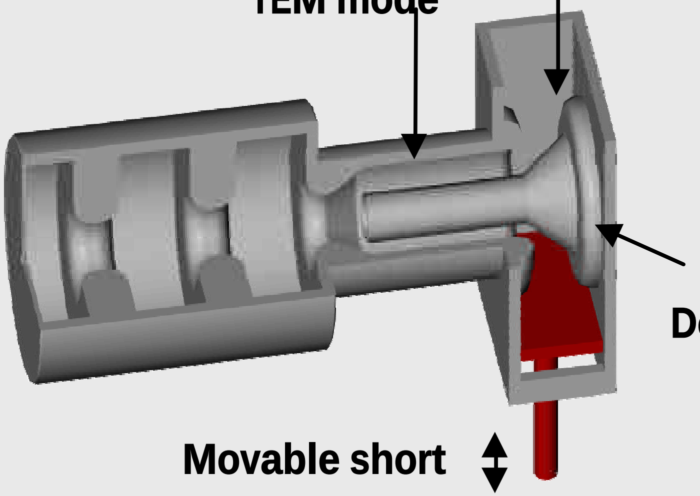
DC gun: Pulse-Forming Line

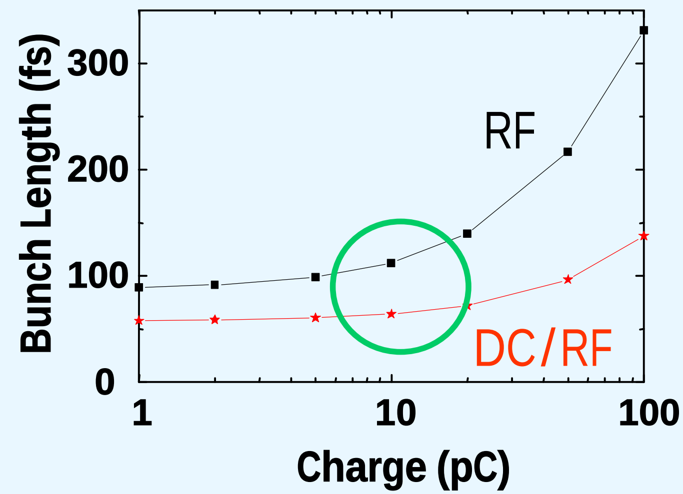


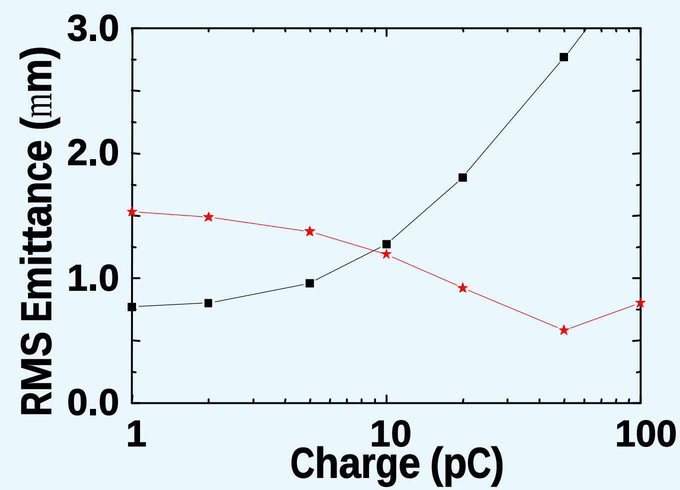
Field emission (3 mm gap):
4 MeV electrons
@ 1.3 GV/m

RF Photogun

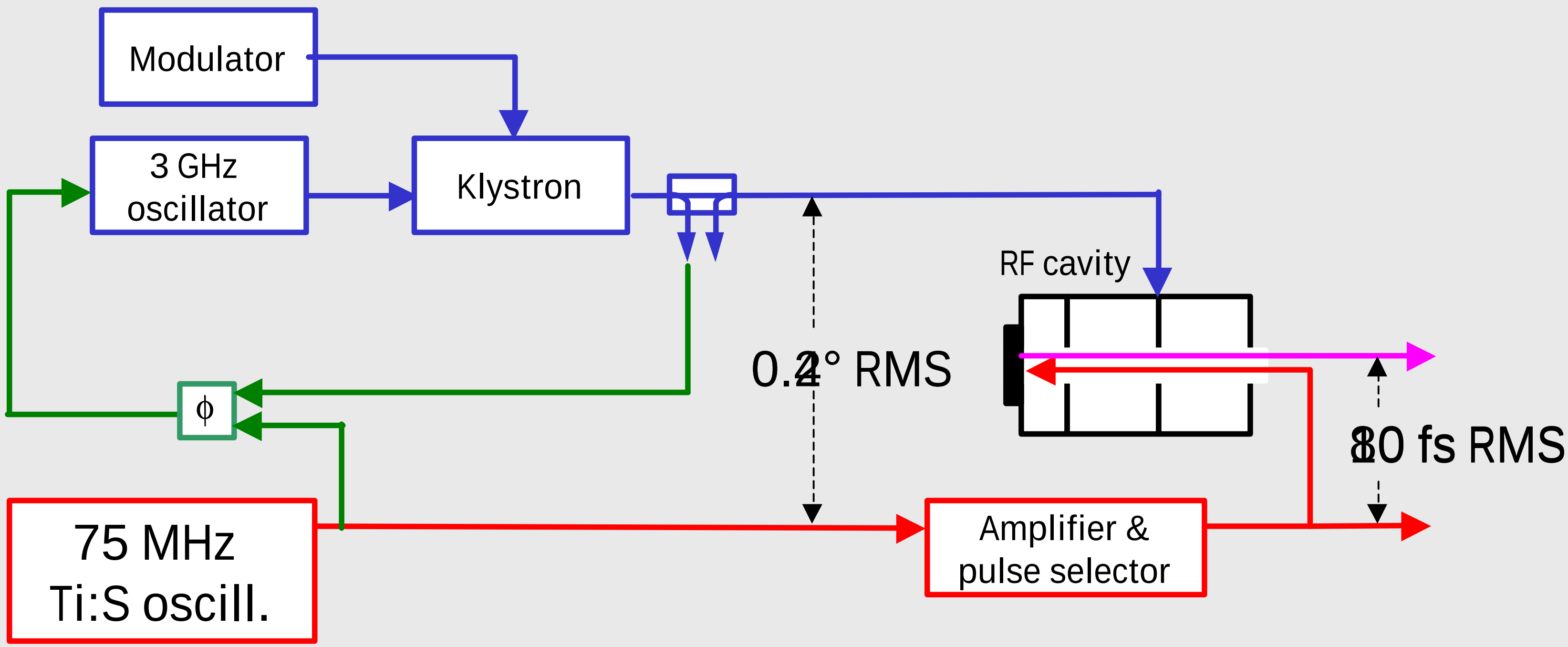
7.5 MeV







Synchronization

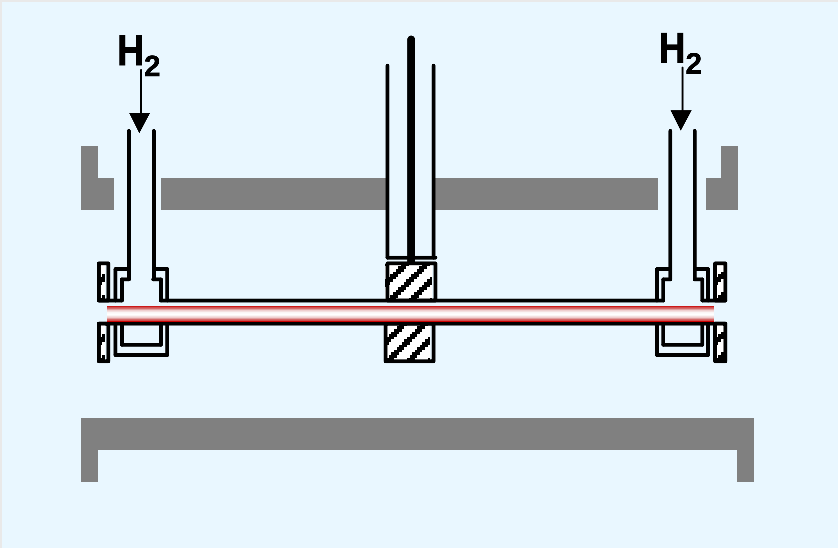


Improvements:

Klystron Power Stability: 0.1% → 0.05%

RF Gun: 2.6 cell → 2.5 cell

Capillary Discharge Waveguide



length: 30-50 mm
diameter: 300 μm

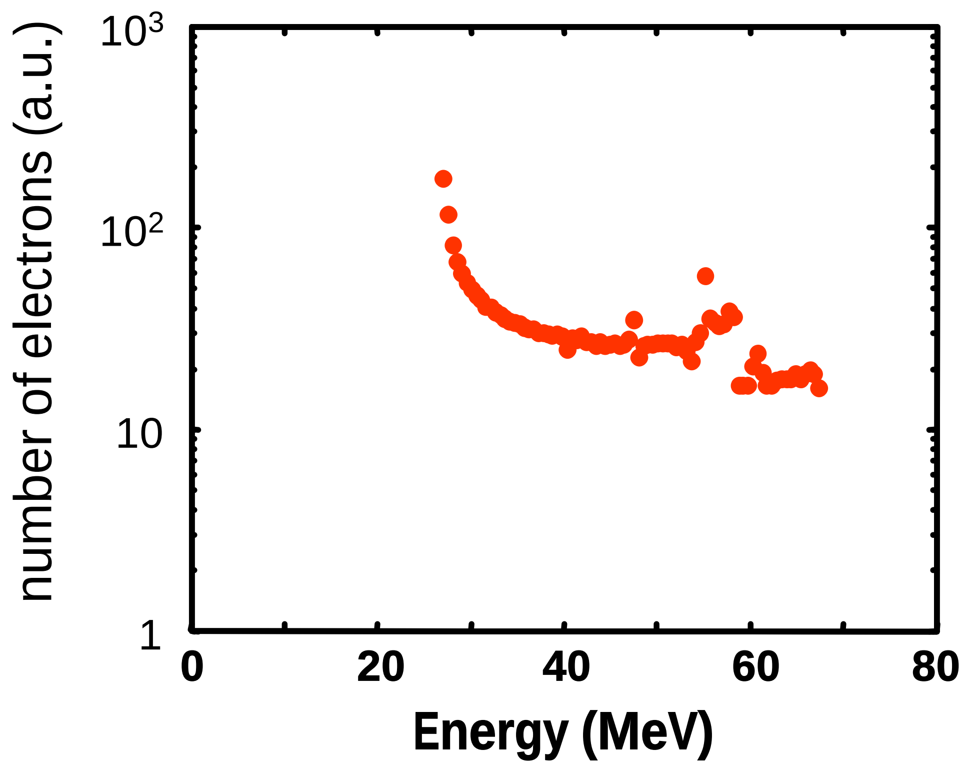
Plasma parameters:
$n_e(0) = 2.7 \times 10^{18}$ cm^{-3}
$\Delta n_e = 1.2 \times 10^{18}$ cm^{-3}

matched spot size: 37.5 μm
plasma wavelength: 25 μm (80 fs)

Spence et al., J. Opt. Soc. Am. B **20, 138-151 (2003)**

Controlled LWFA

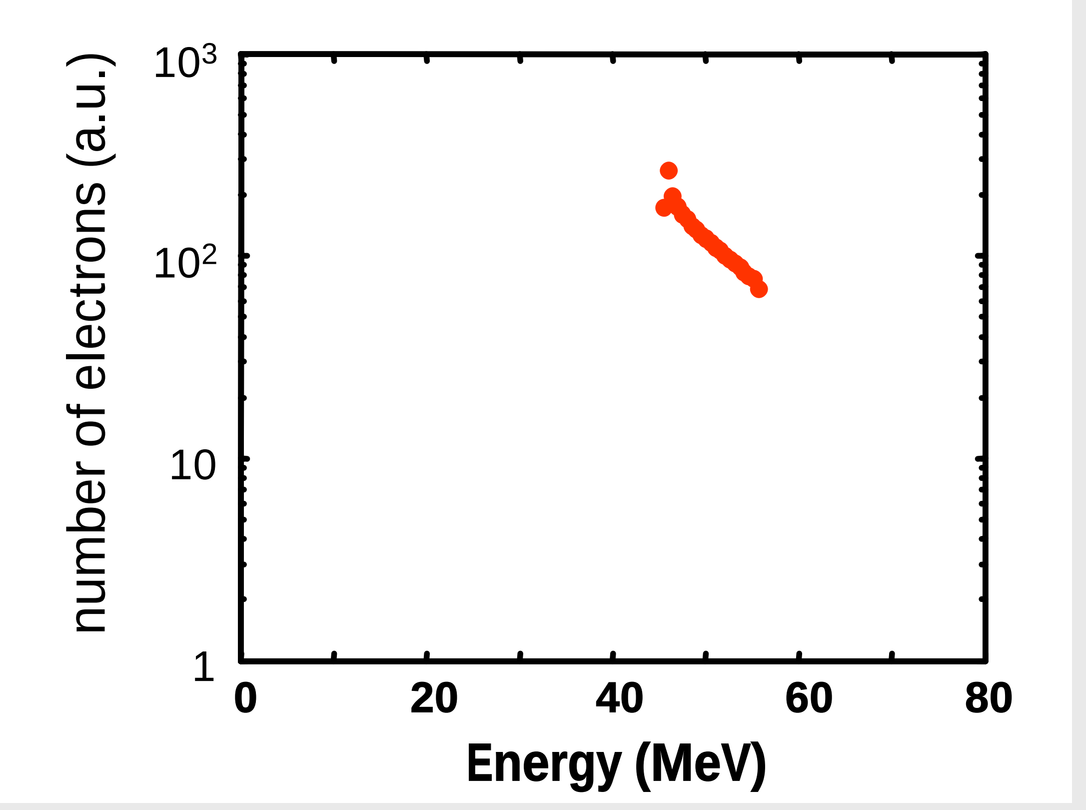
	Available	Foreseeable improvements
High Brightness Injector	**100 fs, 10 pC 7.5 MeV**	
Plasma Waveguide	**2×10^{18} cm^{-3}**	
Drive Laser	**2 TW**	
Expected Results		



Plasma density:	2×10^{18} cm^{-3}	Drive Laser:	2 TW
Channel Length:	1 cm	Injected Bunch:	7.5 MeV, 100 fs

Controlled LWFA

	Available	Foreseeable improvements
High Brightness Injector	100 fs, 10 pC 7.5 MeV	75 fs, 100 pC 9.5 MeV
Plasma Waveguide	$2{\times}10^{18}$ cm^{-3}	$2{\times}10^{17}$ cm^{-3} ?
Drive Laser	2 TW	2 TW
Expected Results	50±20 MeV	



Plasma density:	2×10^{17} cm^{-3}	Drive Laser:	2 TW
Channel Length:	5 cm	Injected Bunch:	9.5 MeV, 75 fs

Controlled LWFA

	Available	Foreseeable improvements
High Brightness Injector	100 fs, 10 pC 7.5 MeV	75 fs, 100 pC 9.5 MeV
Plasma Waveguide	2×10^{18} cm^{-3}	2×10^{17} cm^{-3} ???
Drive Laser	2 TW	2 TW
Expected Results	50±20 MeV	50±5 MeV

Conclusion

We can and will perform a
controlled Laser Wakefield Acceleration experiment