Laser Wakefield Accelerators - a status report

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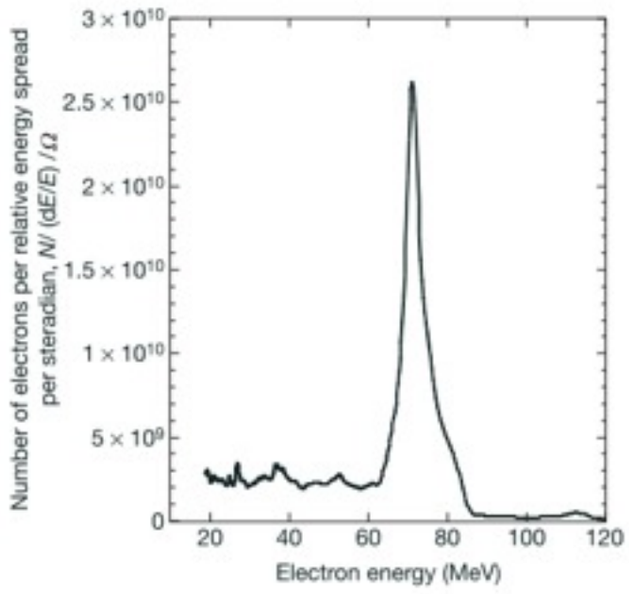
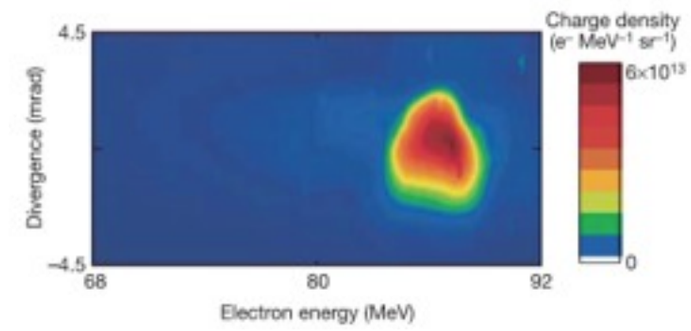
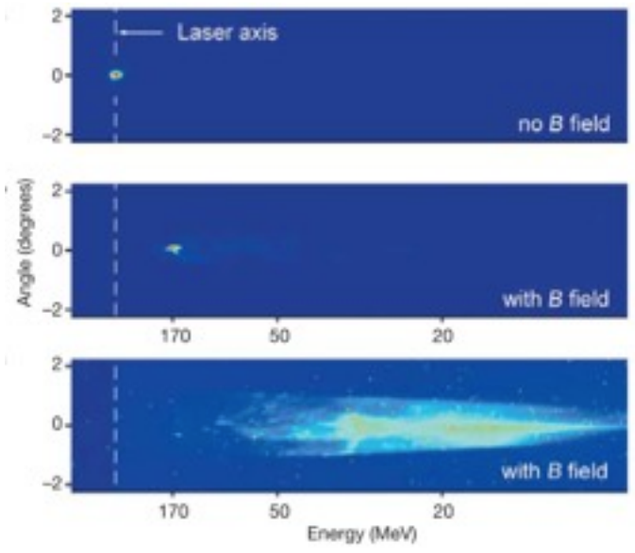
quasi-monoenergetic beams







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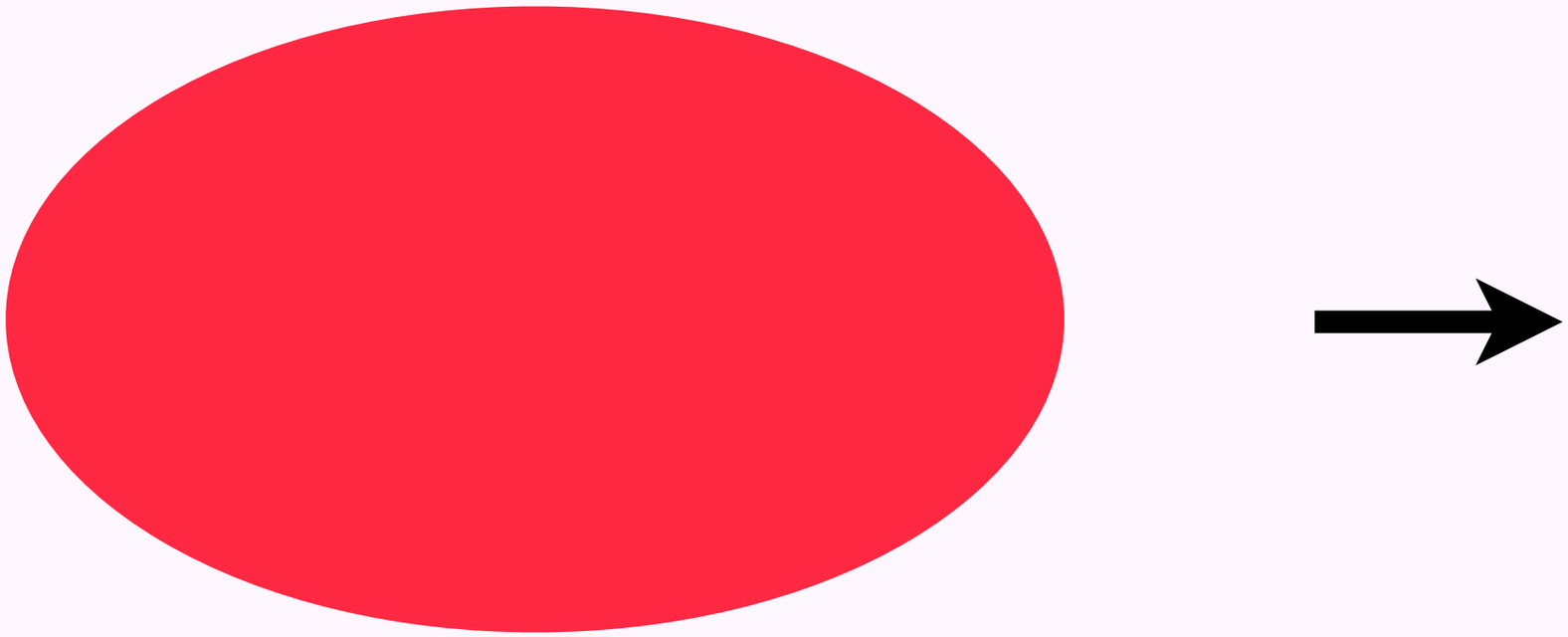
“bubble” plasma wave



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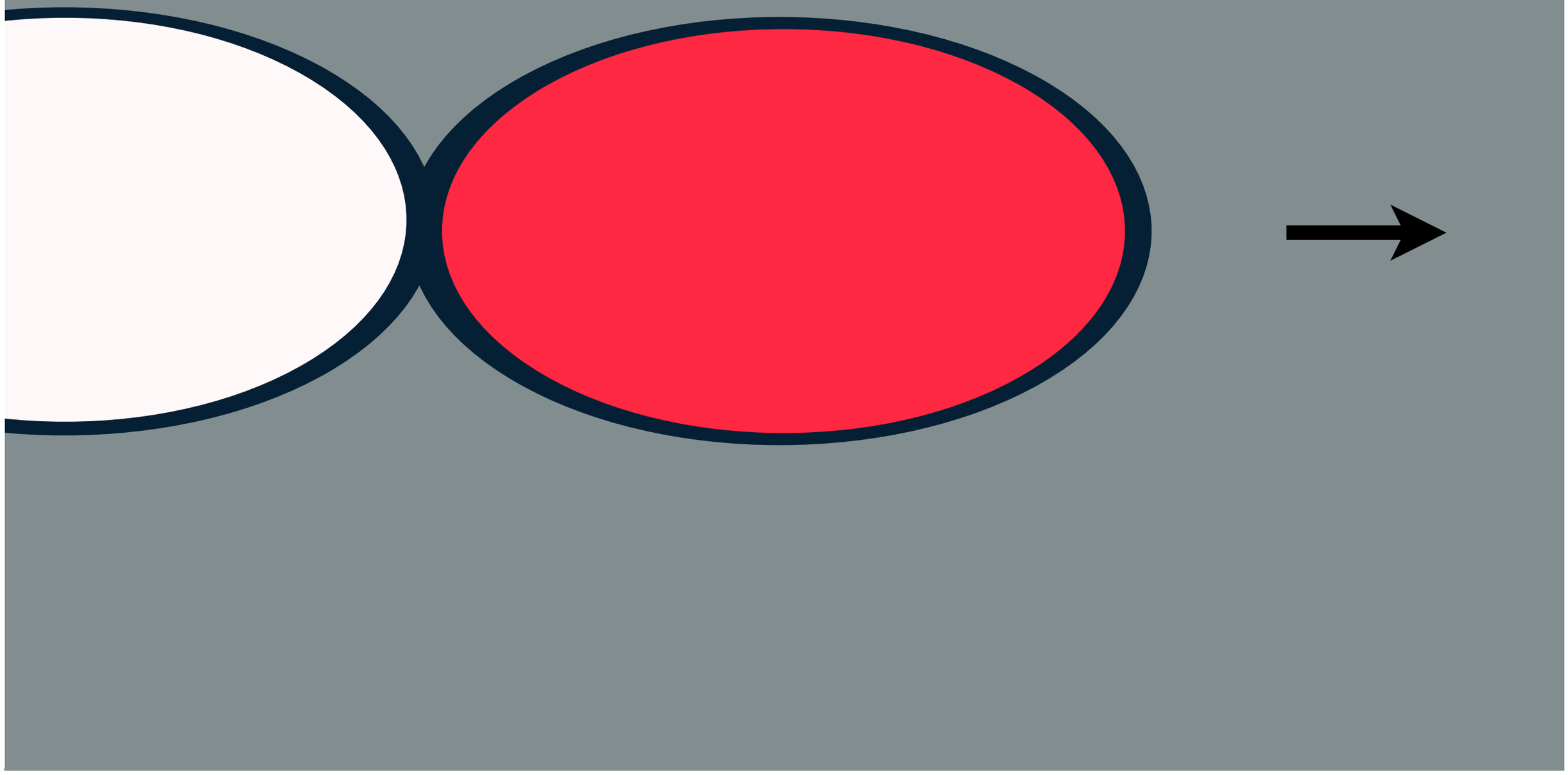

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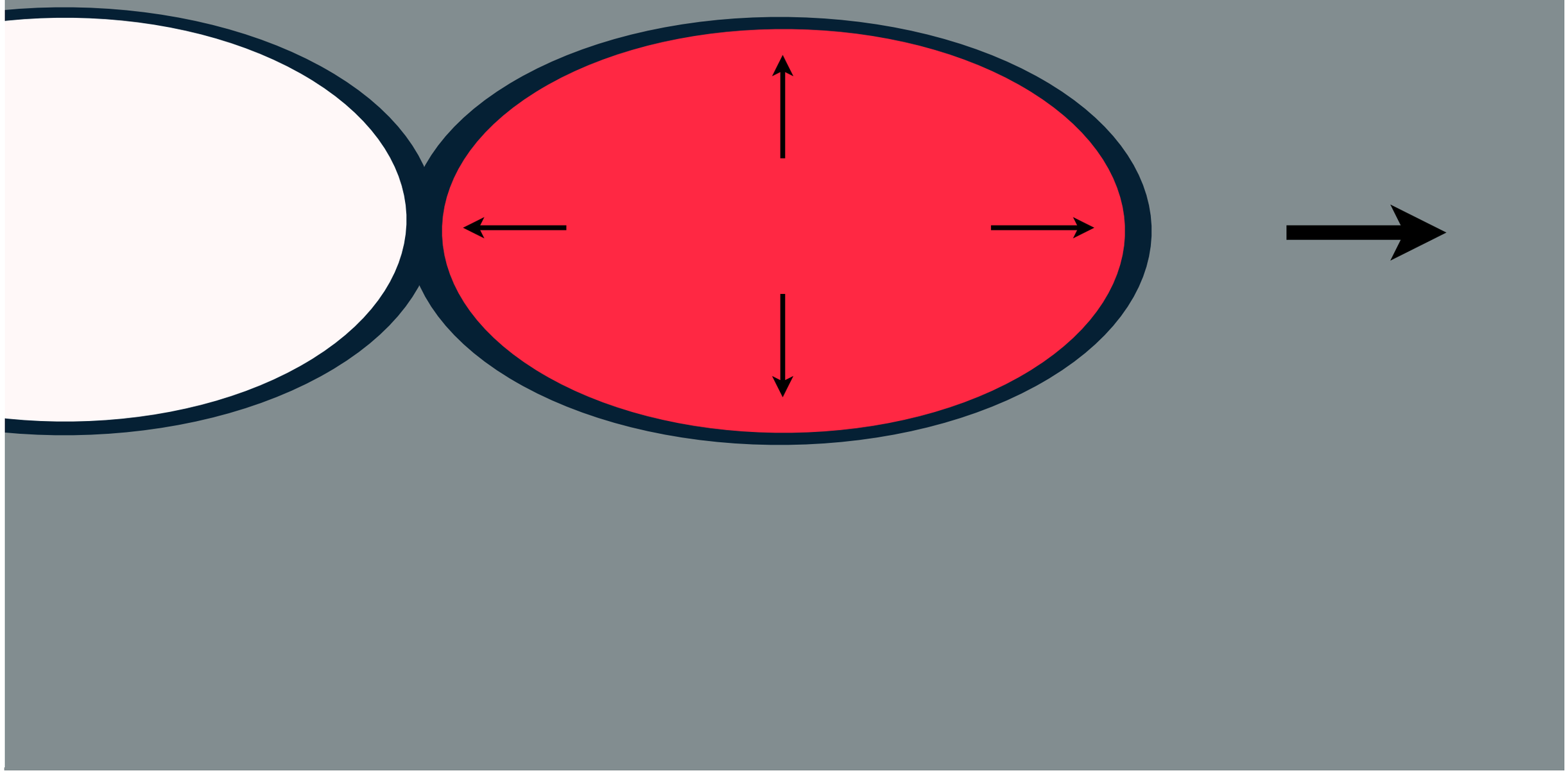

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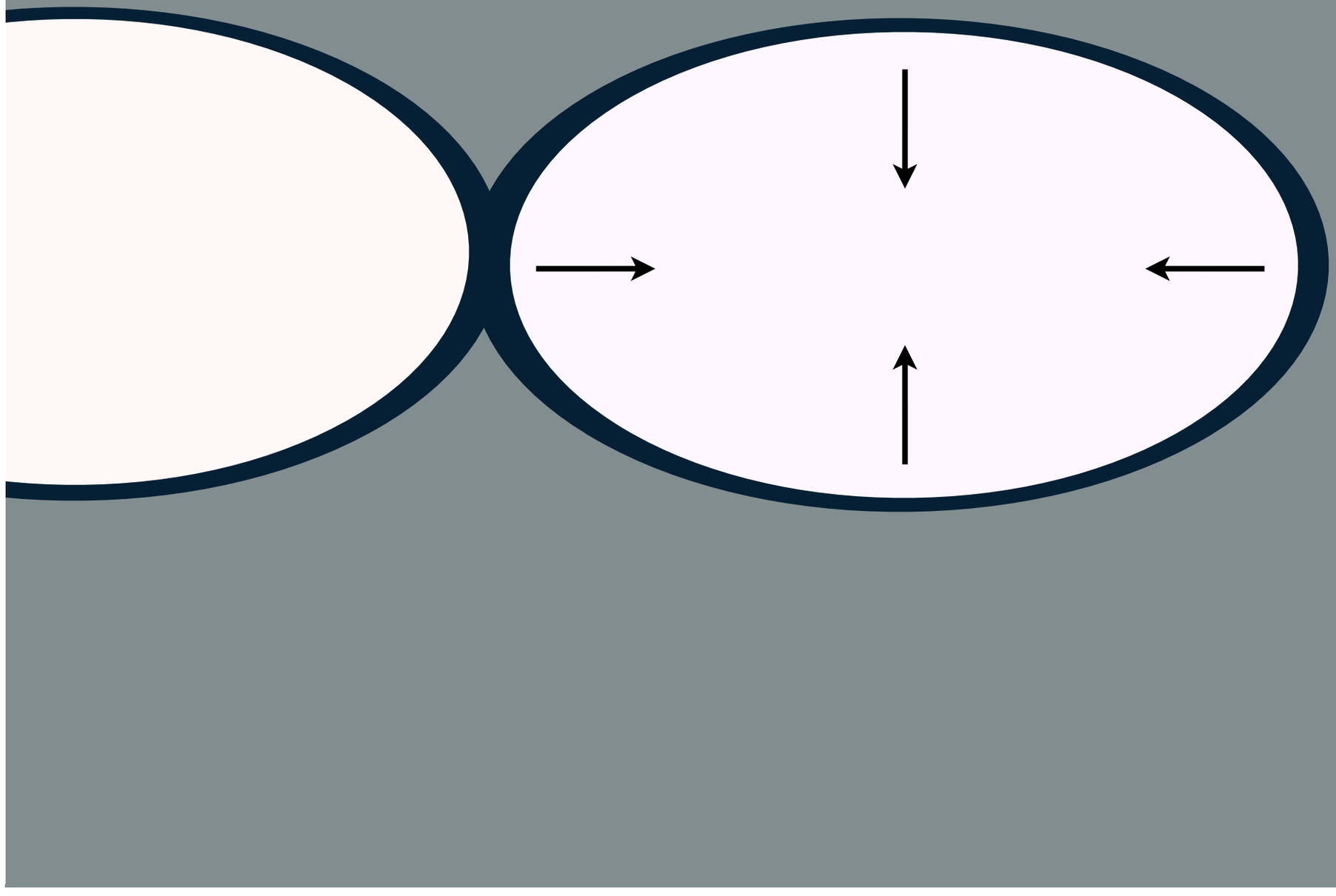

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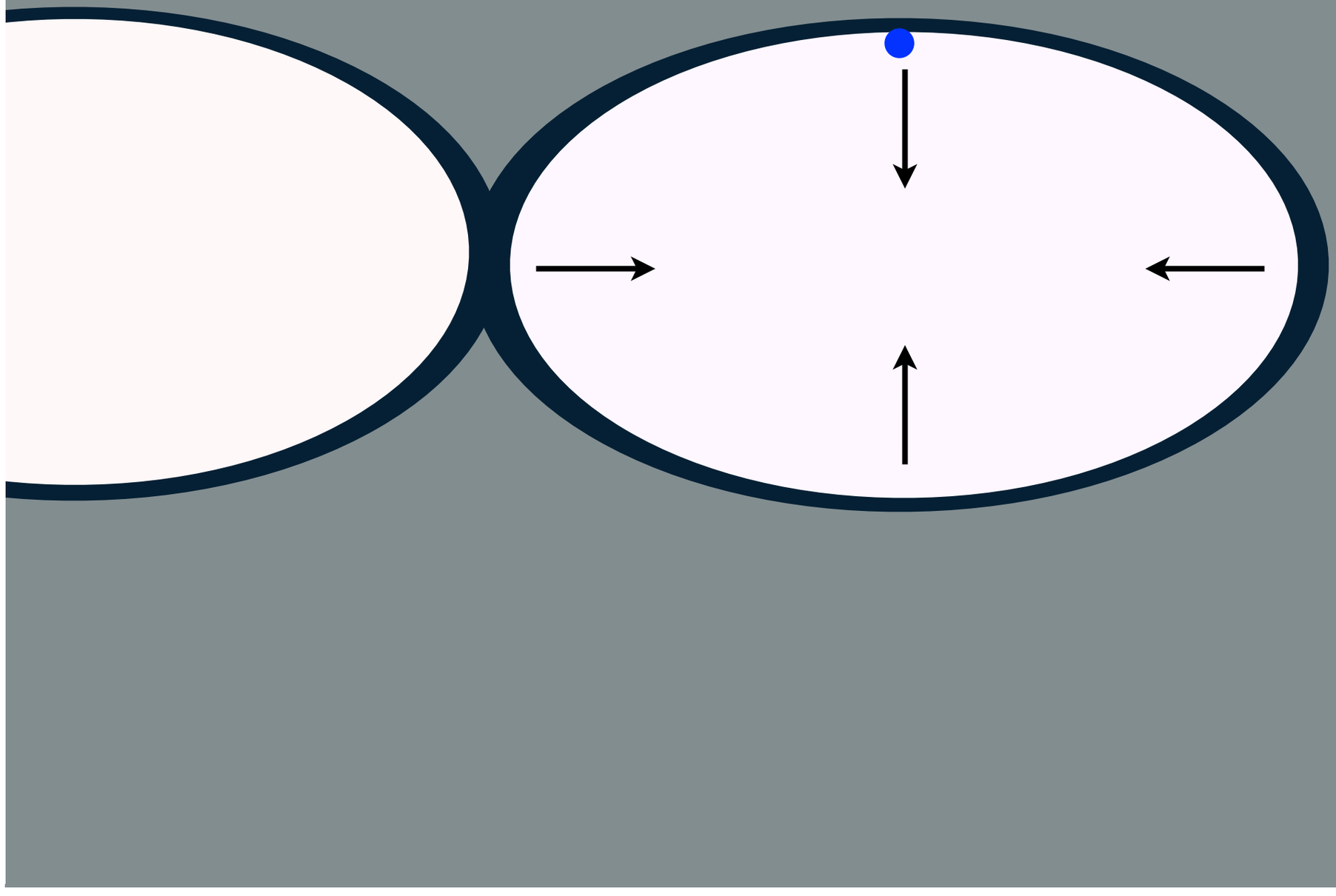

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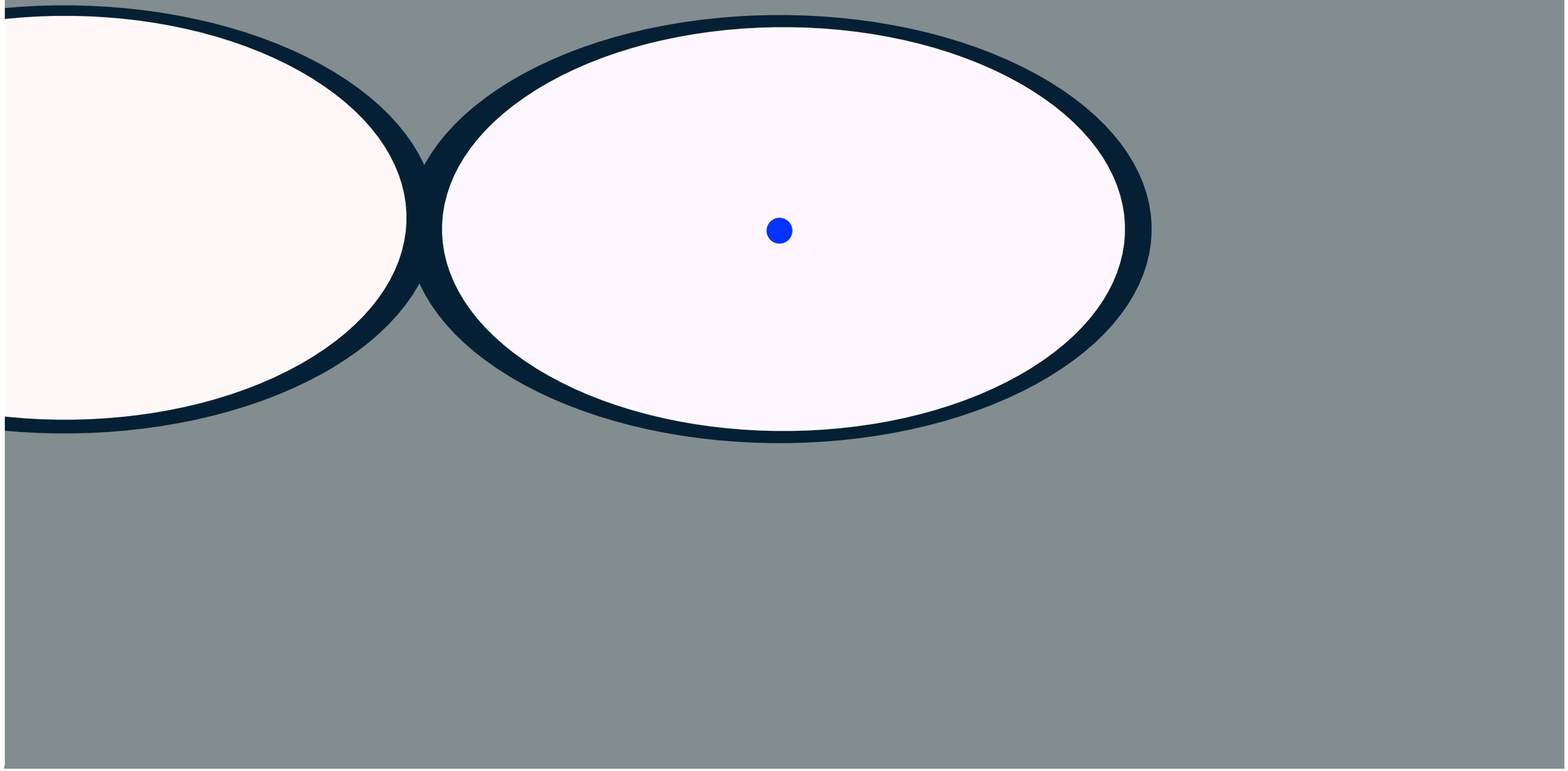

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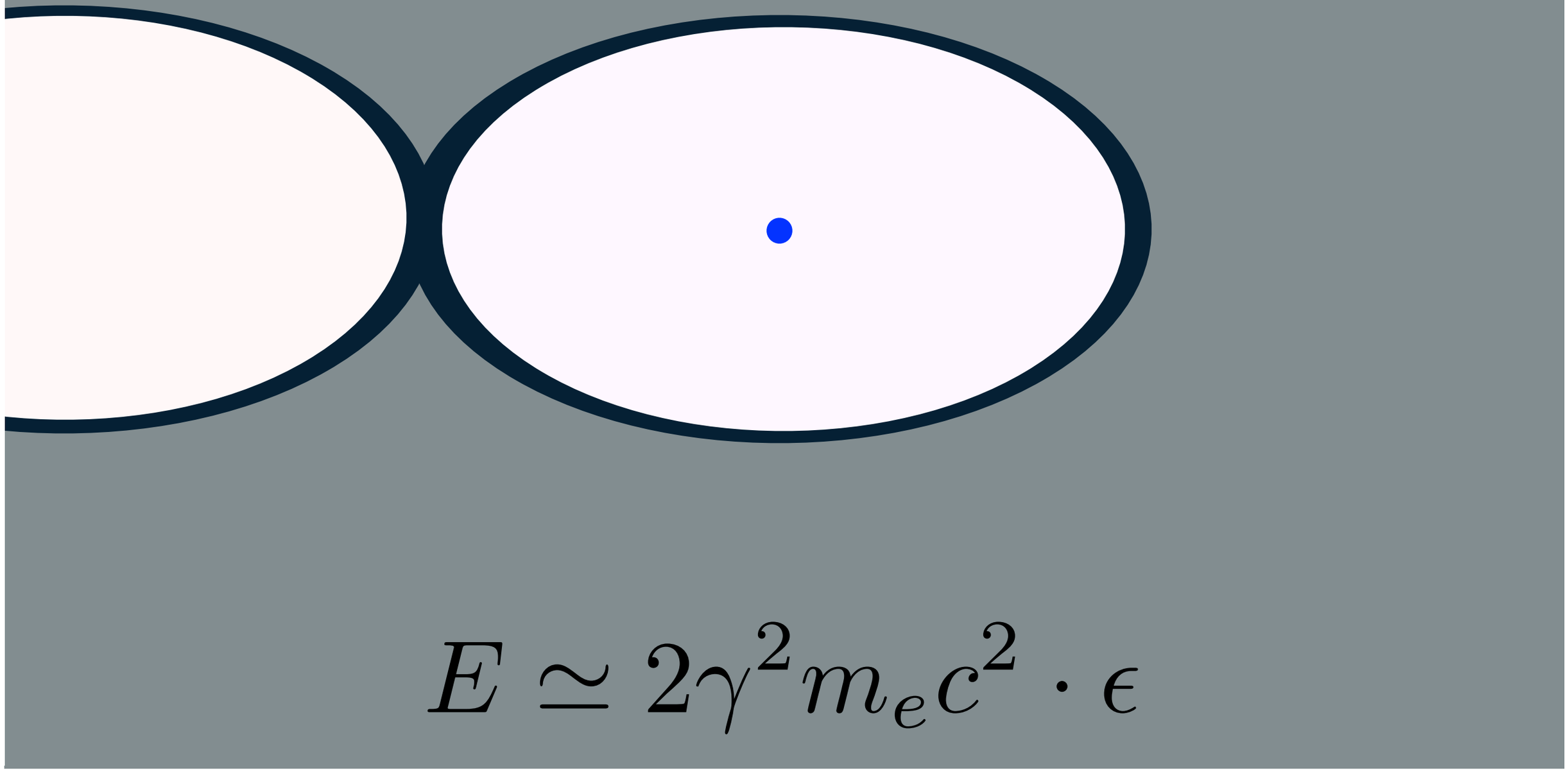
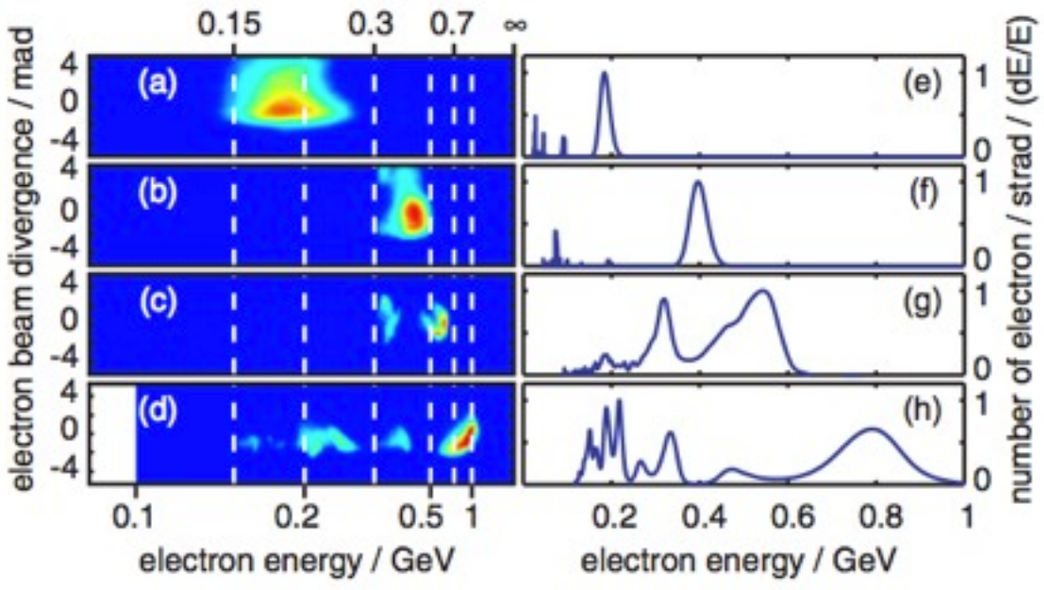
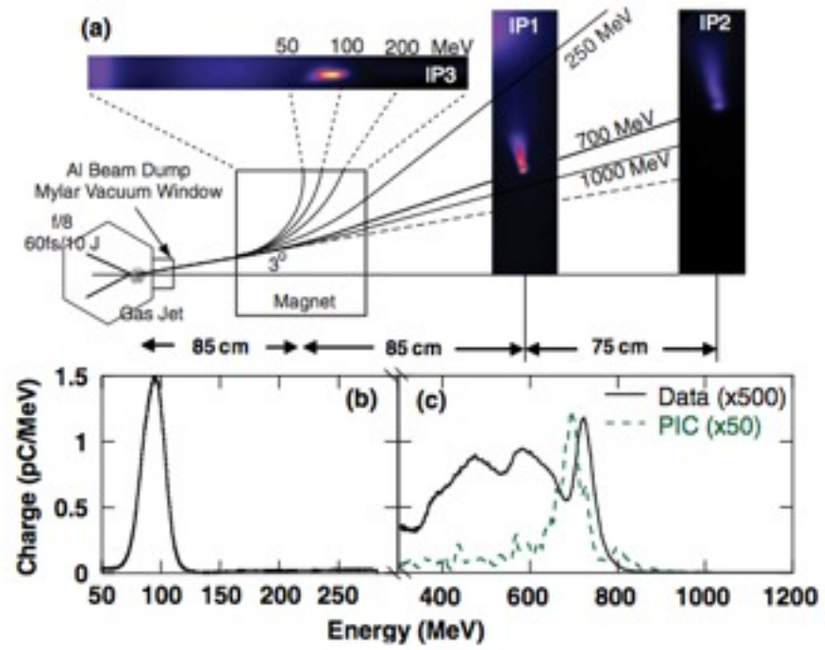
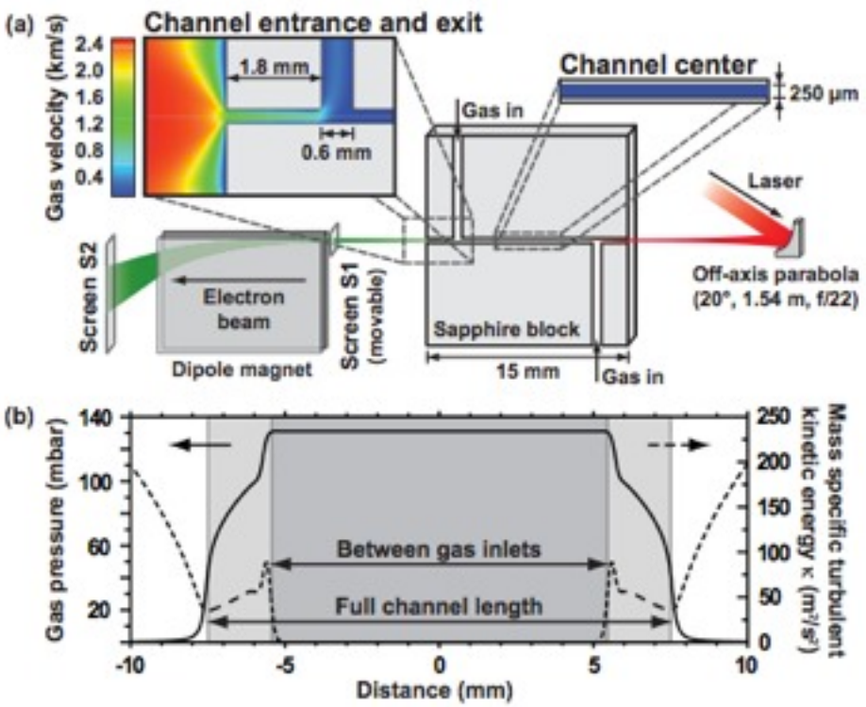


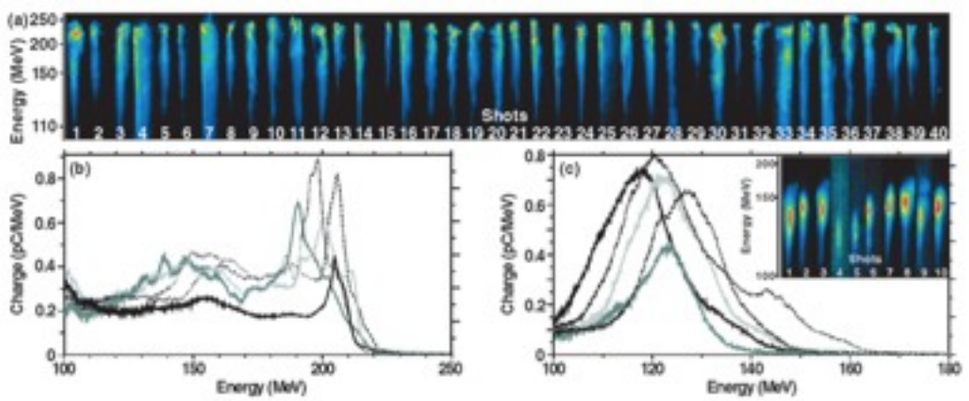
$$E \simeq 2\gamma^2 m_e c^2 \cdot \epsilon$$

GeV self guided acceleration









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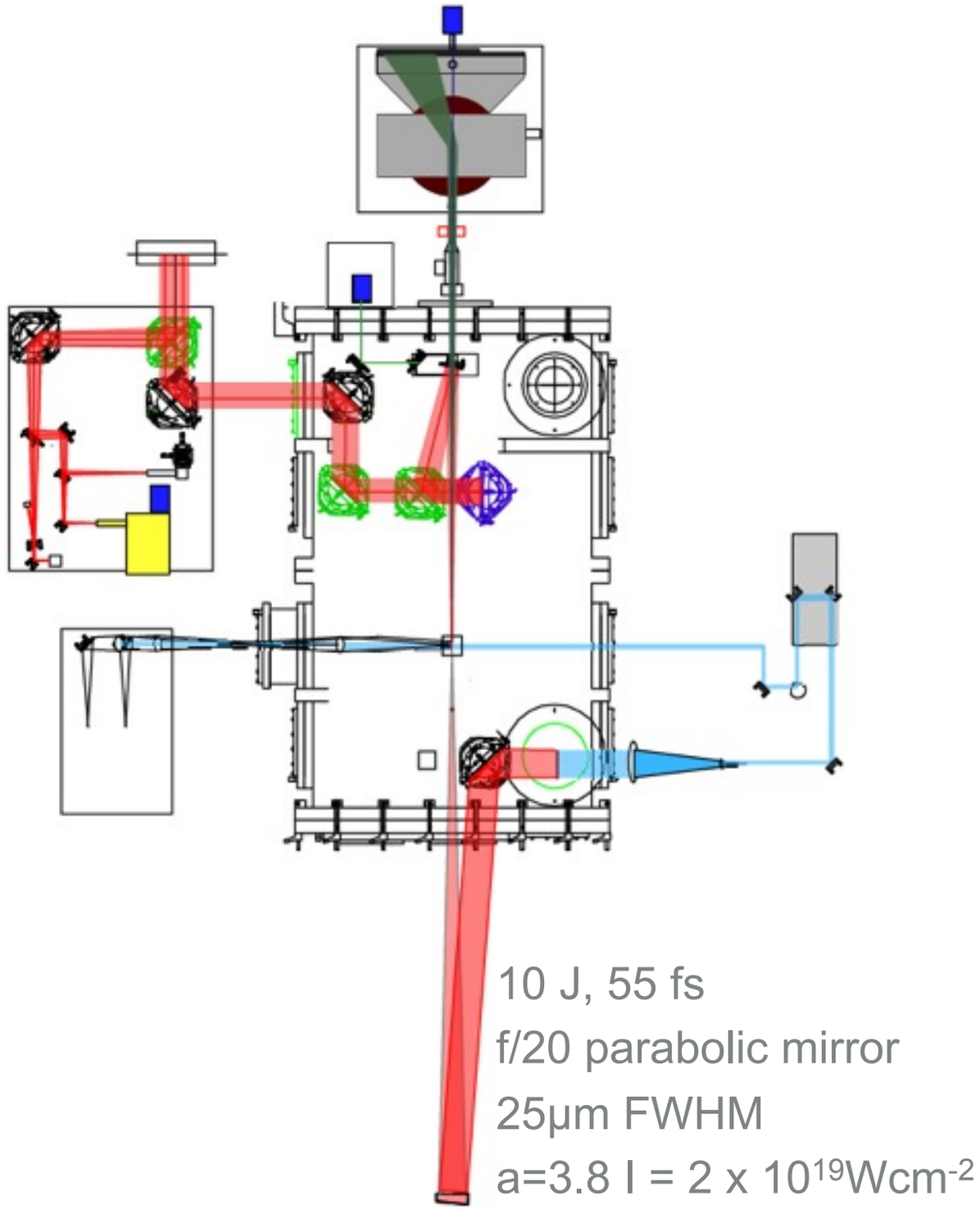
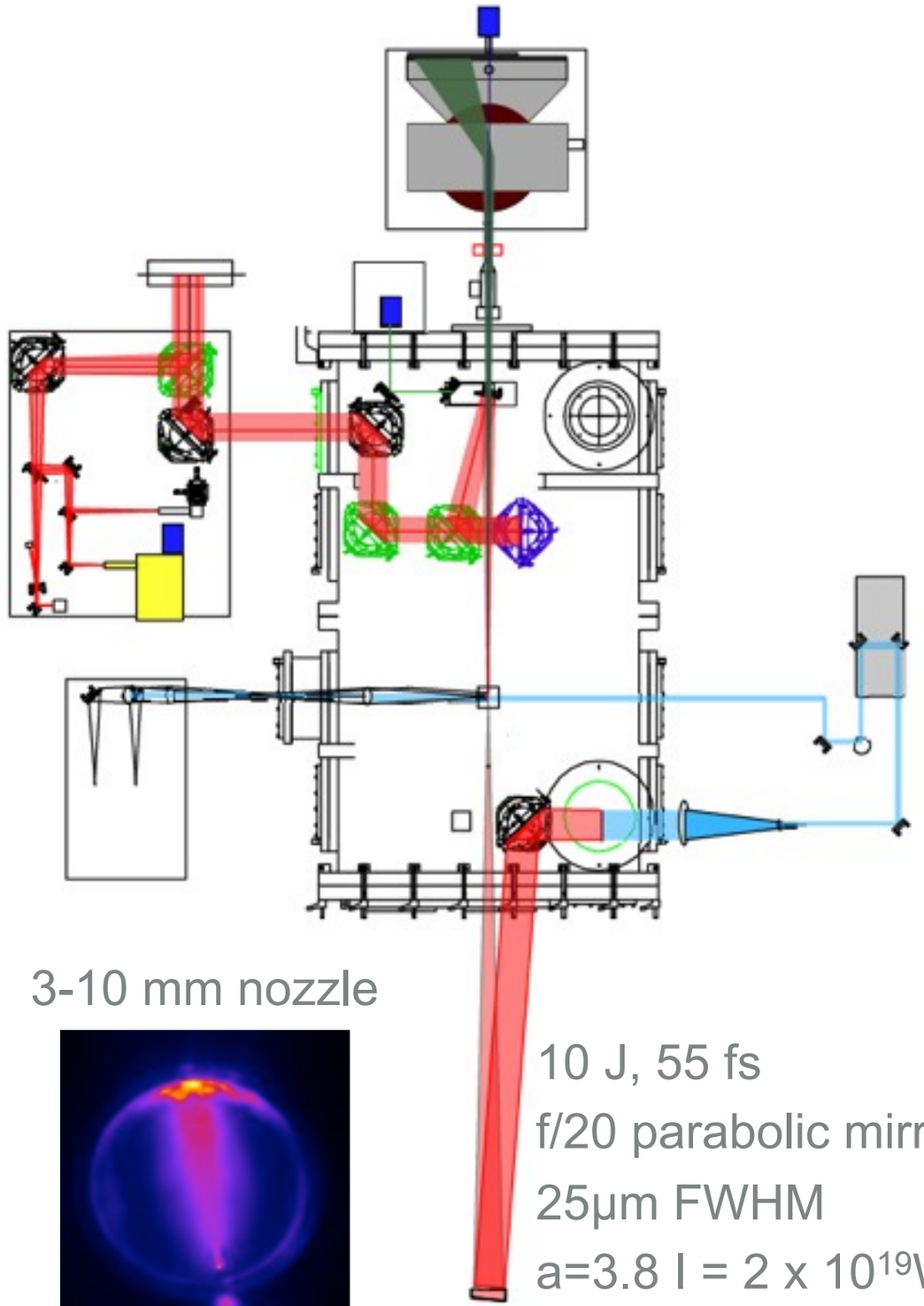
Gemini 2008 - Setup and Diagnostics



10 J, 55 fs
f/20 parabolic mirror
25μm FWHM
$a=3.8\ I = 2 \times 10^{19} Wcm^{-2}$

Gemini 2008 - Setup and Diagnostics



3-10 mm nozzle

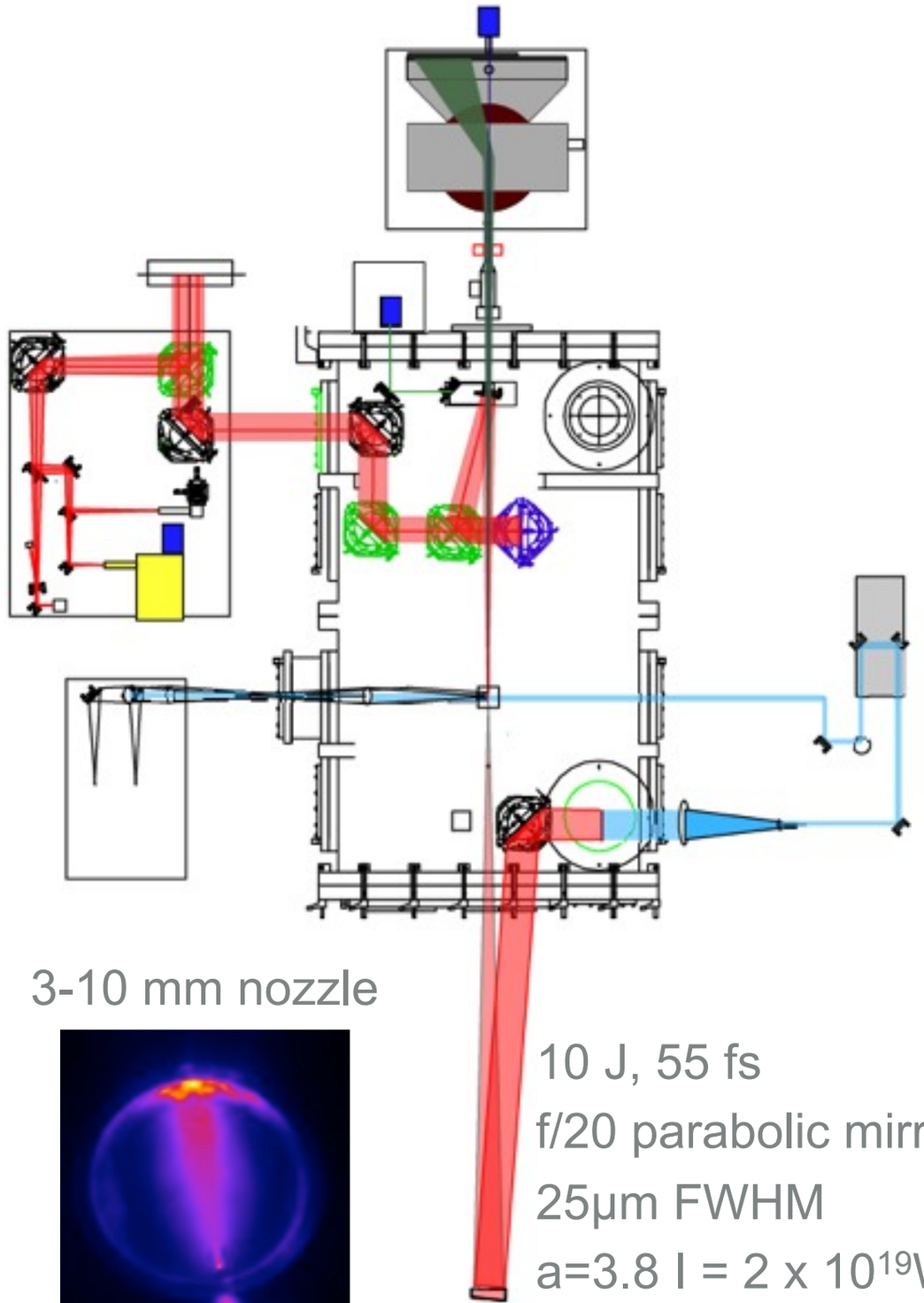
10 J, 55 fs

f/20 parabolic mirror

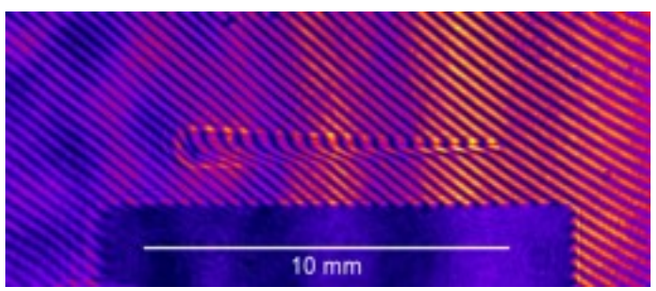
25μm FWHM

$a=3.8\ I = 2 \times 10^{19} Wcm^{-2}$

Gemini 2008 - Setup and Diagnostics



centimetre scale channel



3-10 mm nozzle

10 J, 55 fs

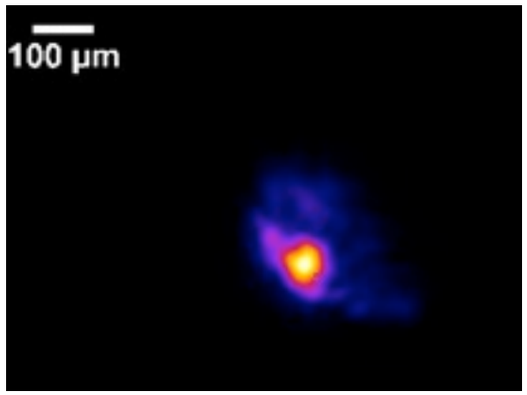
f/20 parabolic mirror

25μm FWHM

$a=3.8\ I = 2 \times 10^{19} Wcm^{-2}$

Gemini 2008 - Setup and Diagnostics

Self-guiding >10mm



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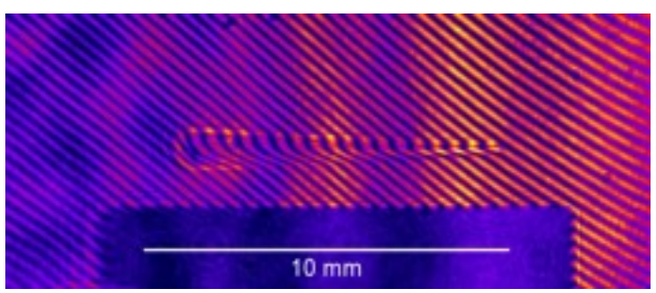

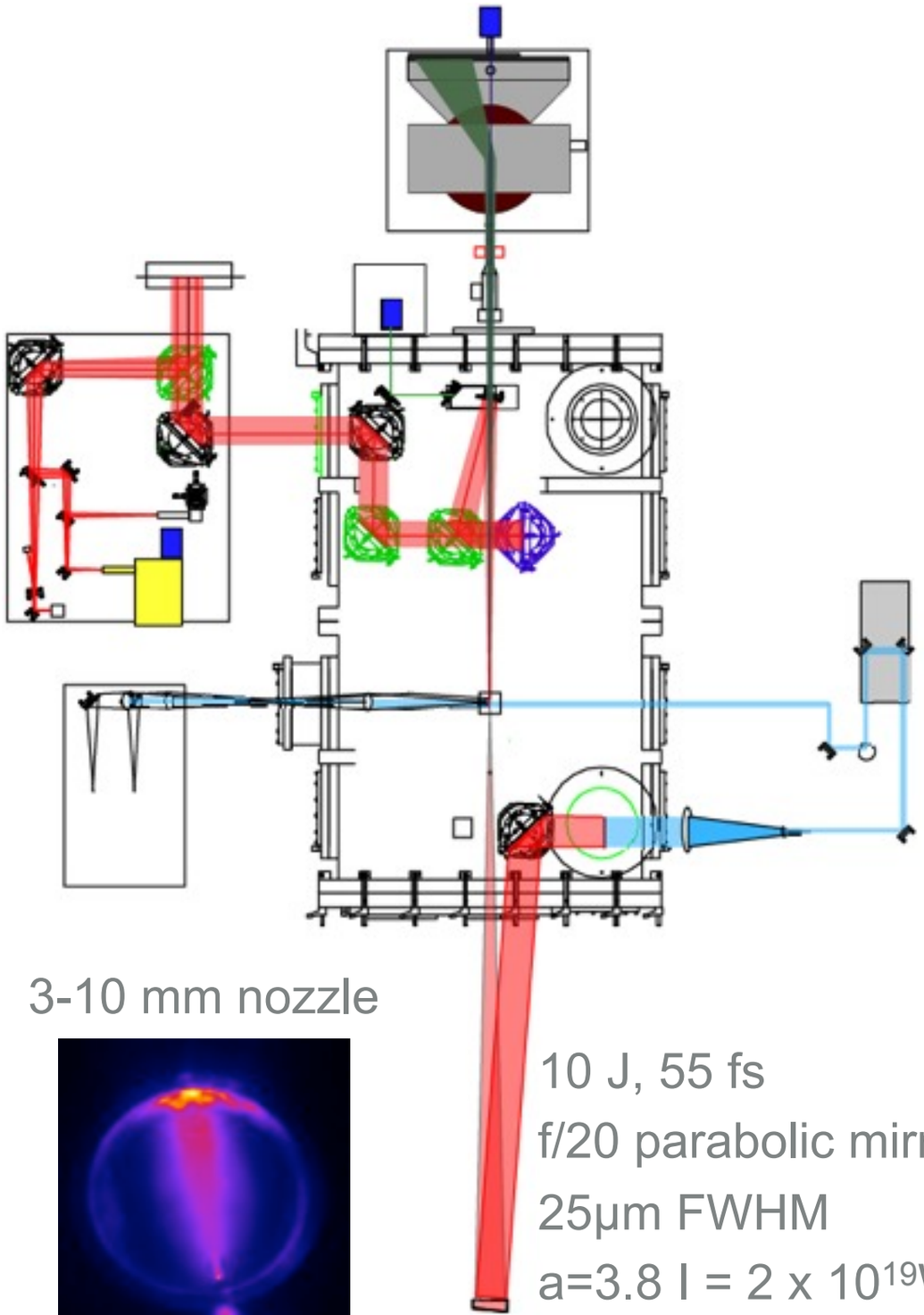

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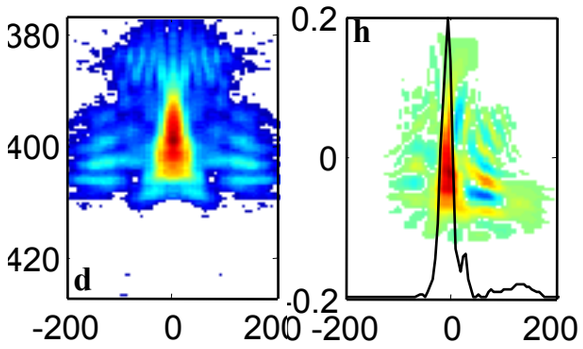
Gemini 2008 - Setup and Diagnostics

Self-compression <20fs



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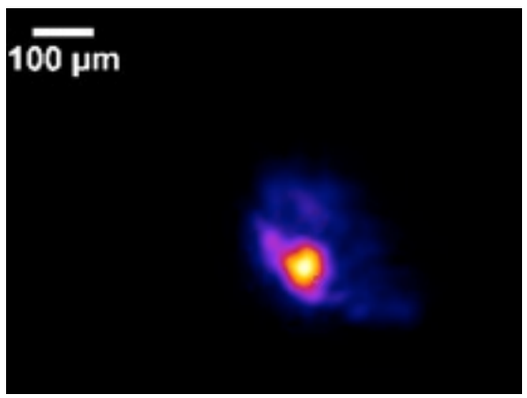
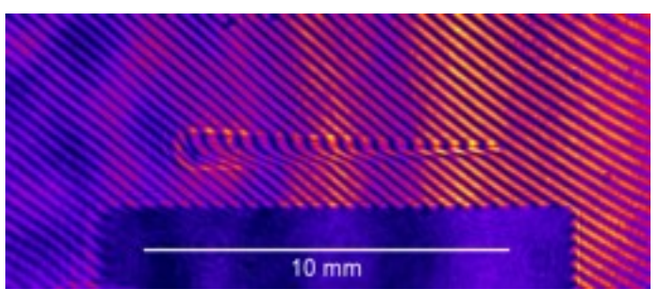
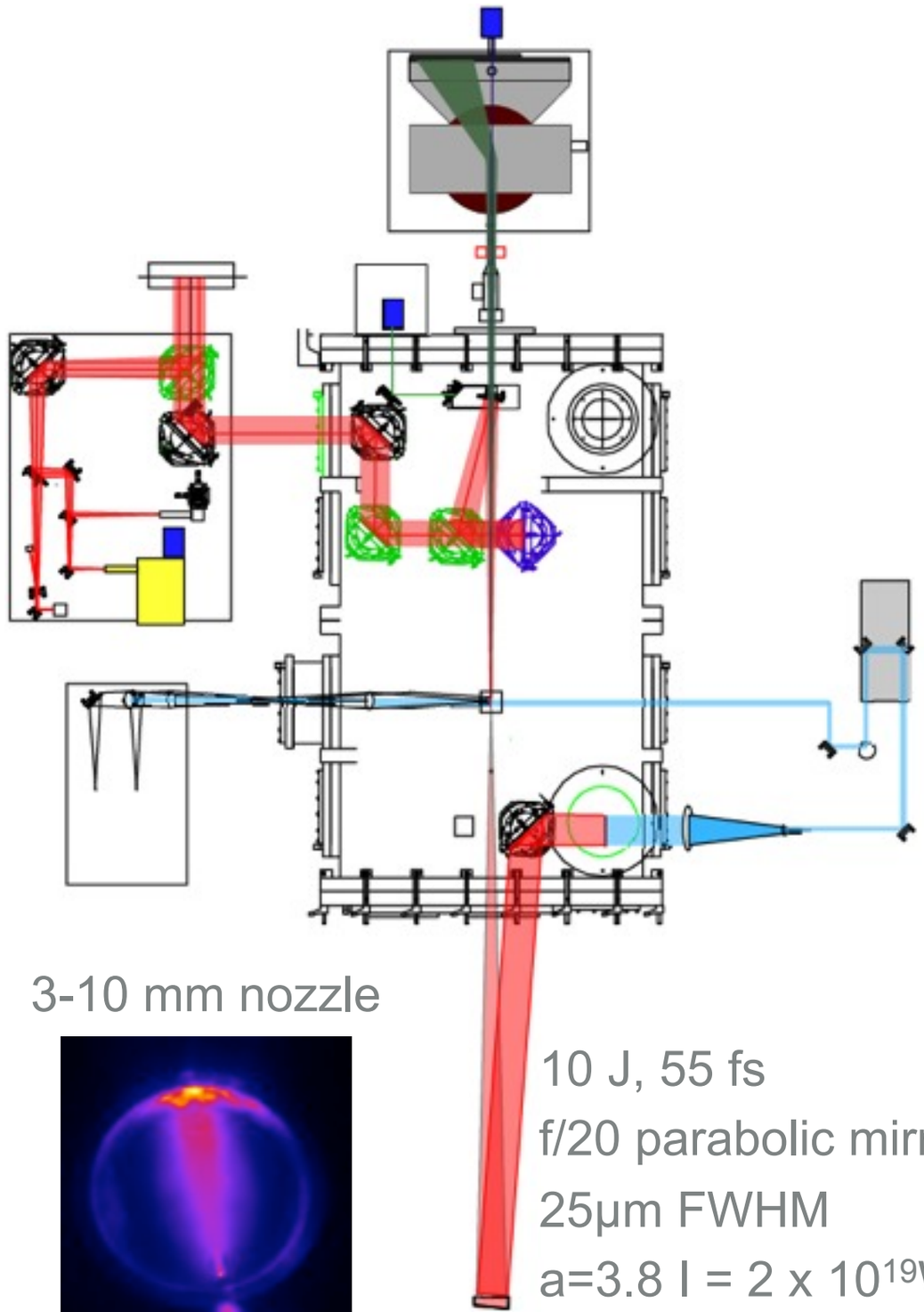


centimetre scale channel





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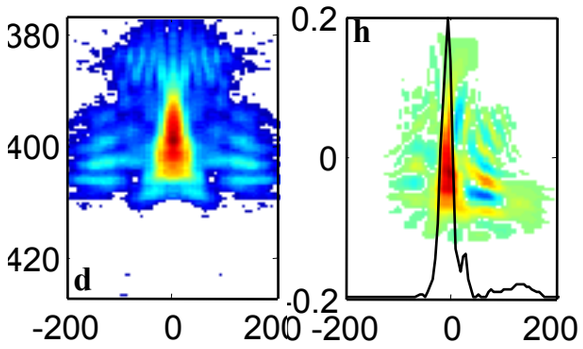

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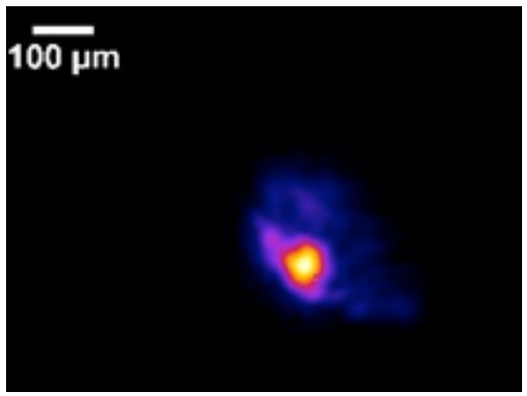
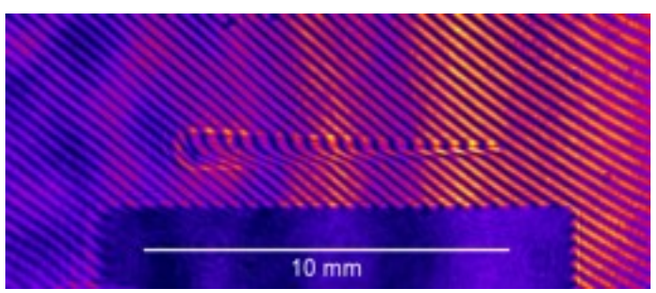
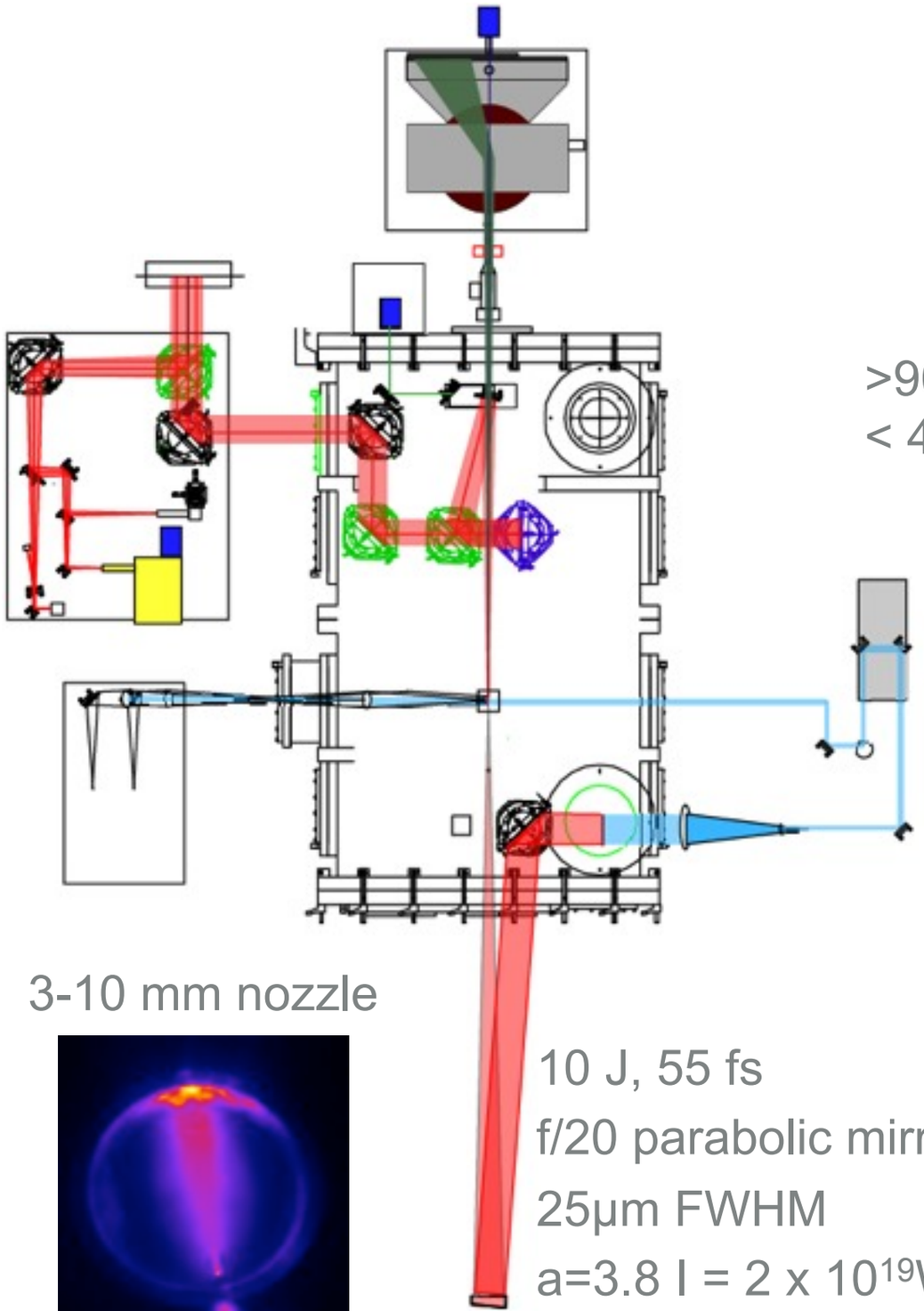


centimetre scale channel





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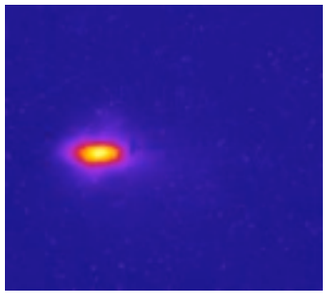

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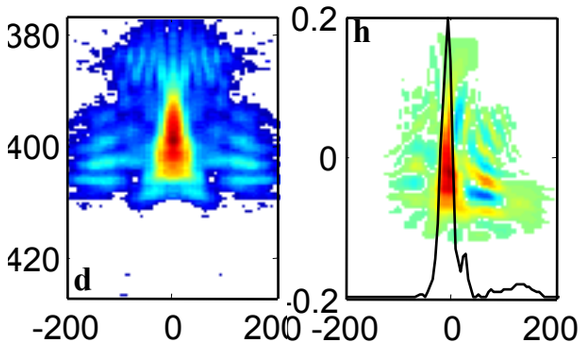

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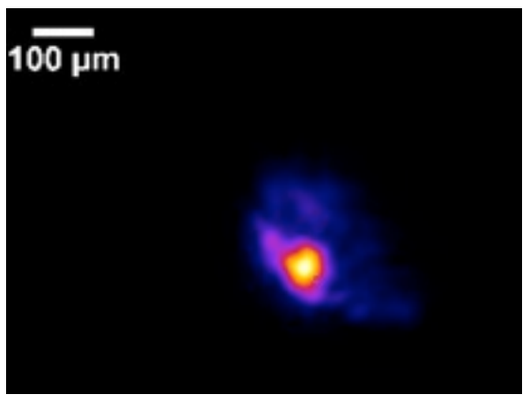

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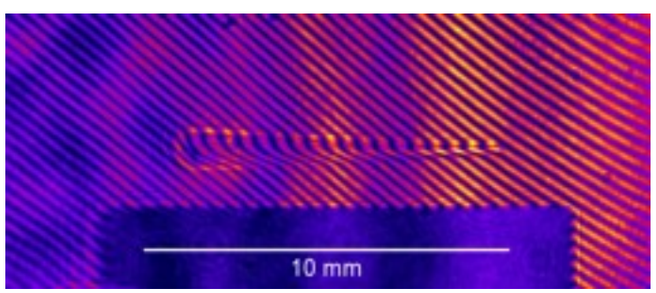

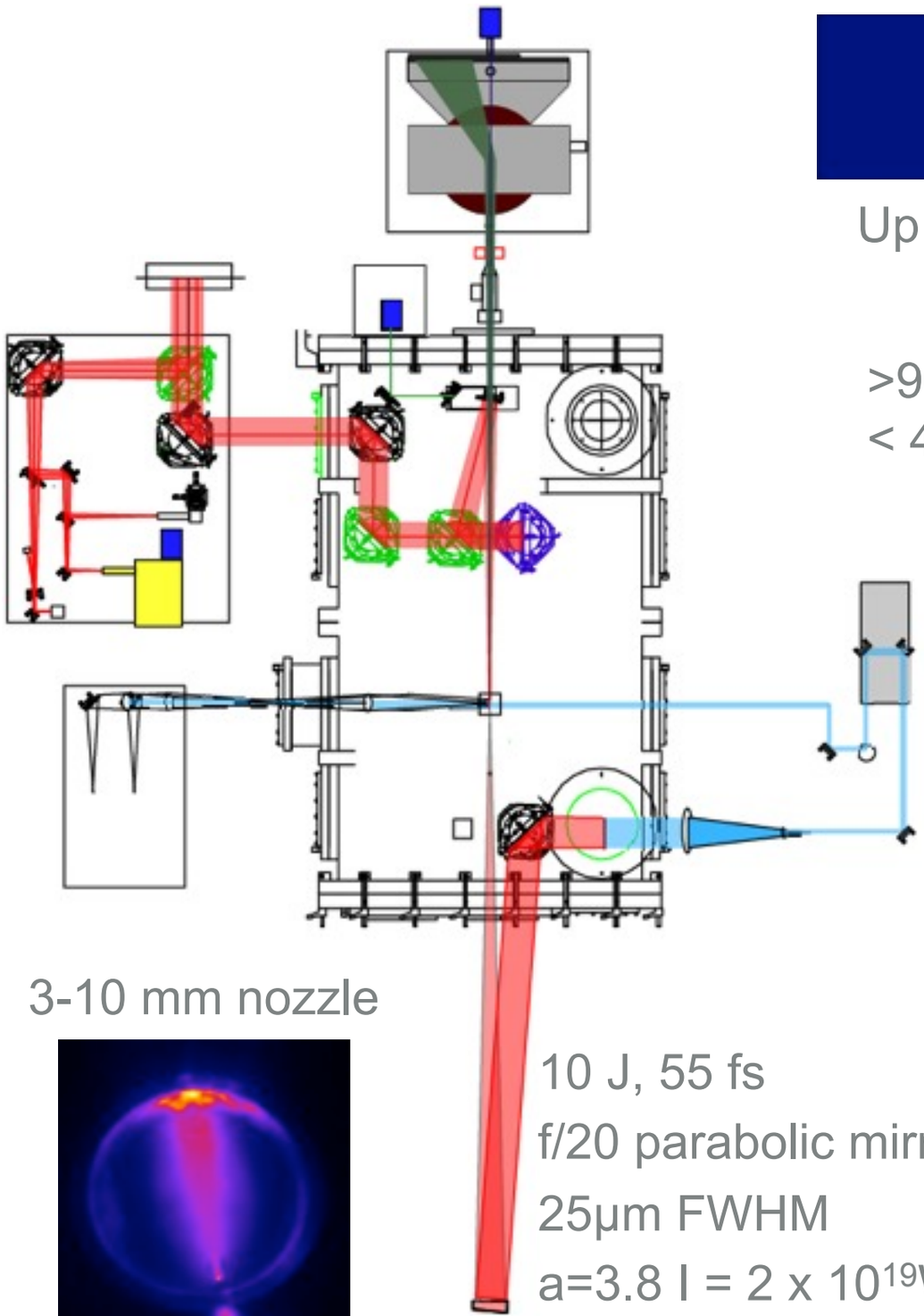

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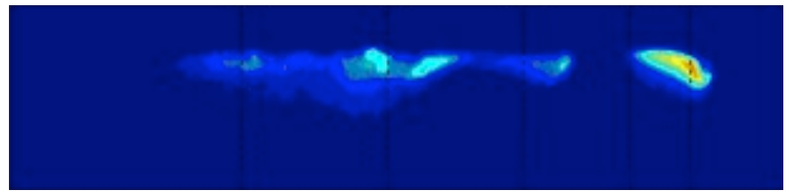

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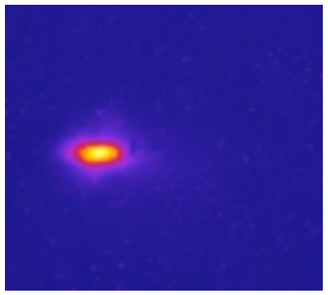

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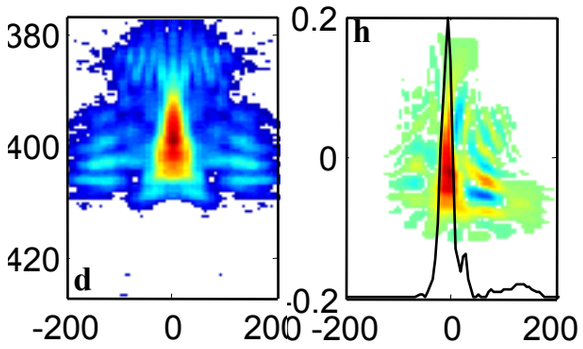

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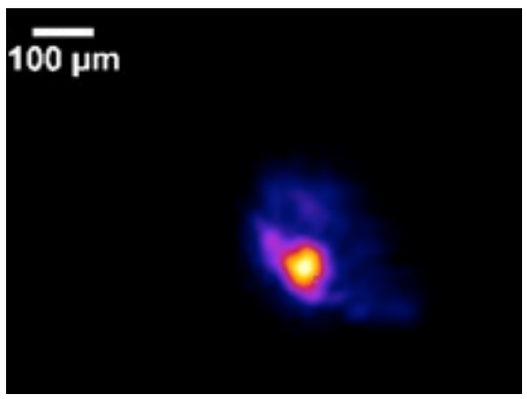
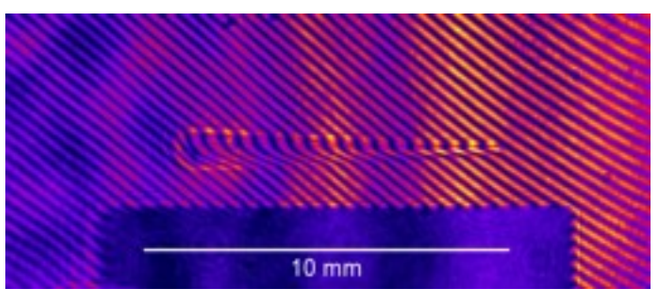
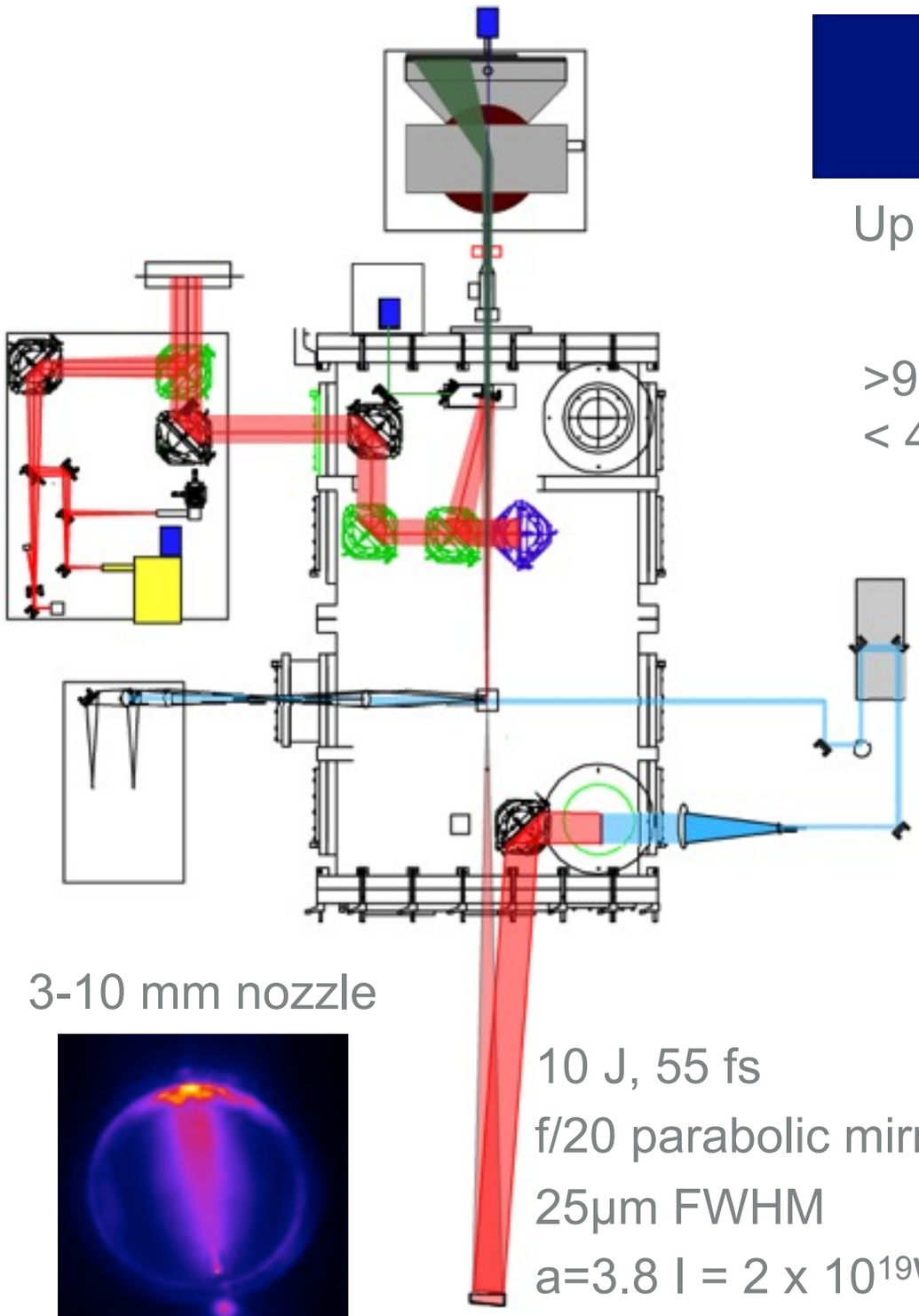


centimetre scale channel





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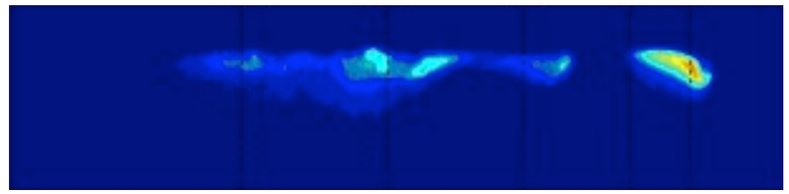

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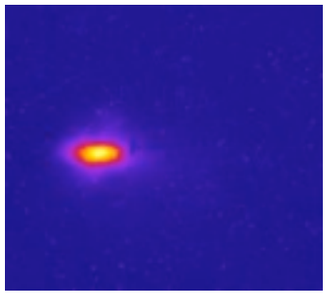
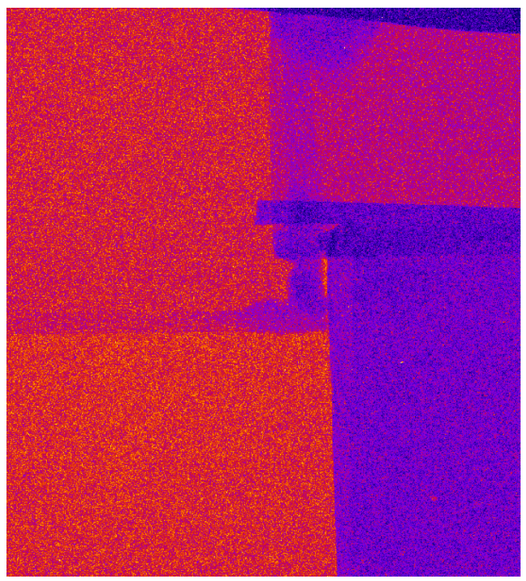


bright x-rays



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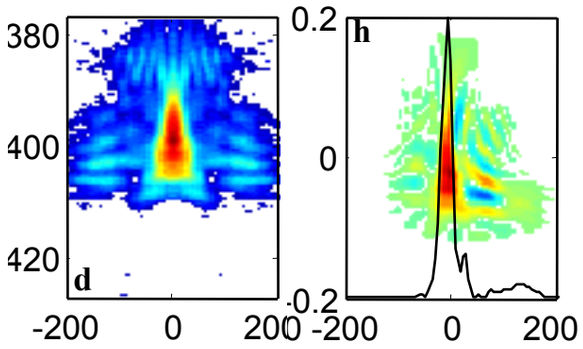

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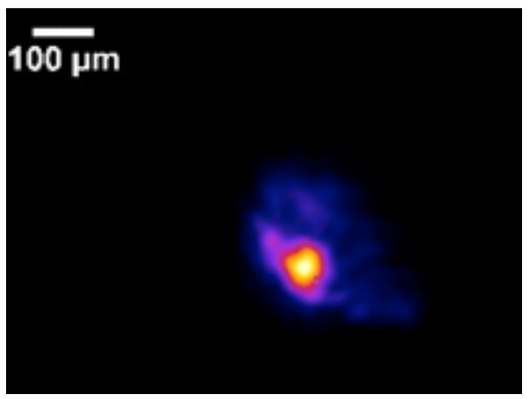
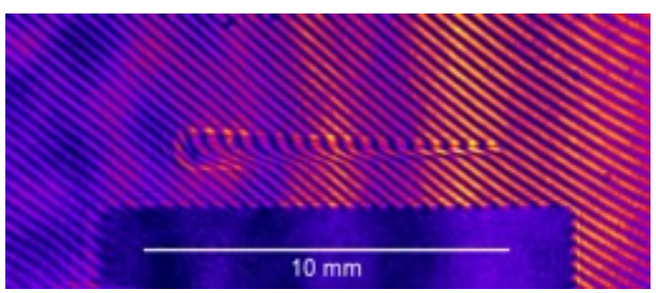
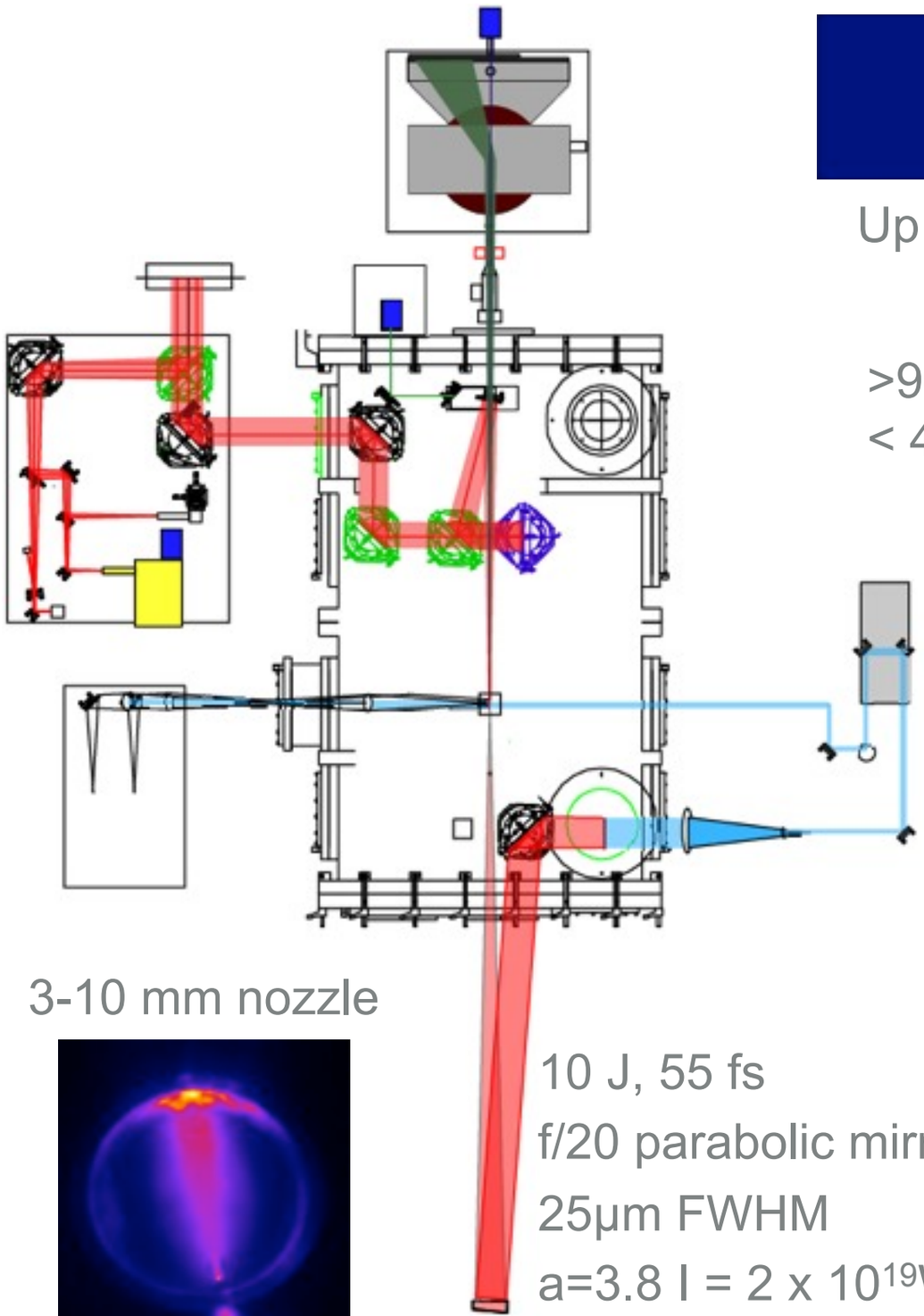


centimetre scale channel





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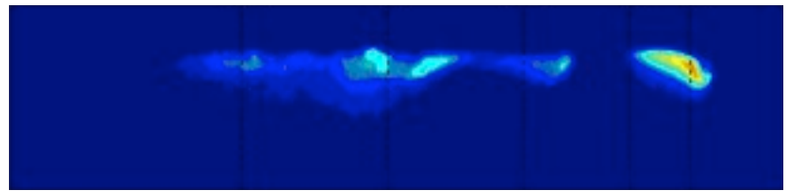

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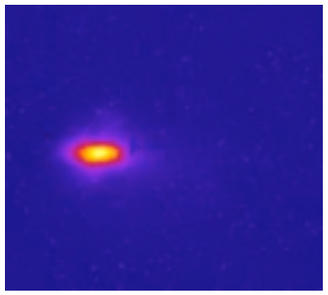

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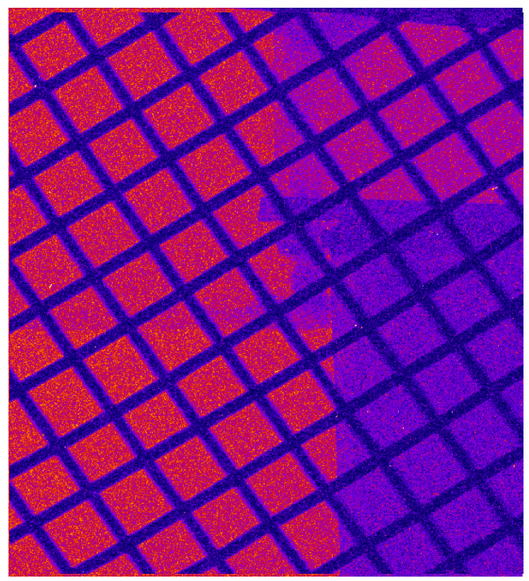
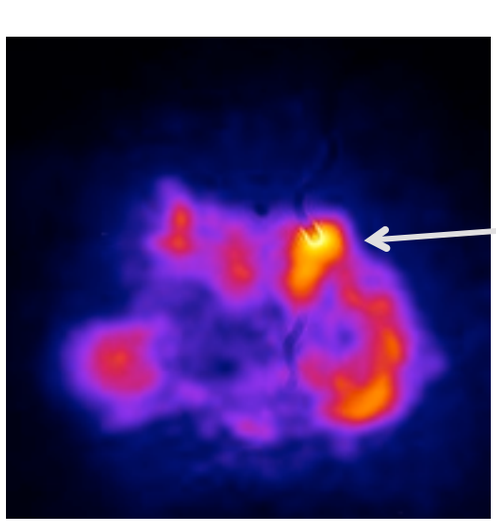
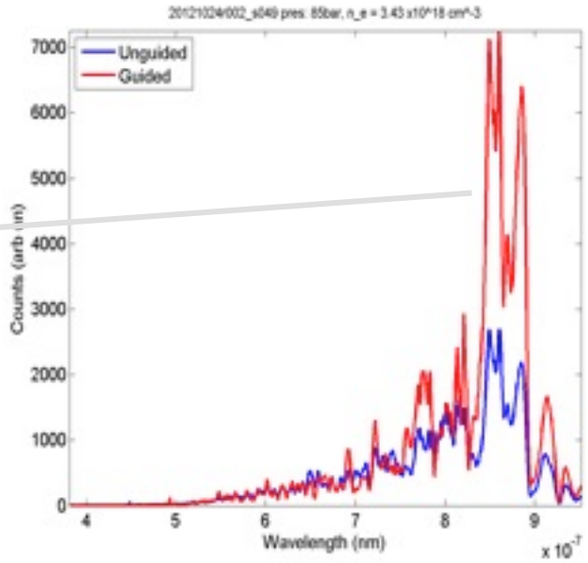


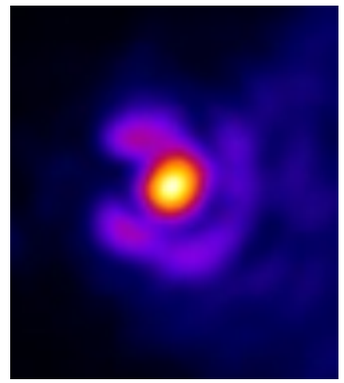
Spatially resolved spectrum measurement of guided laser filament

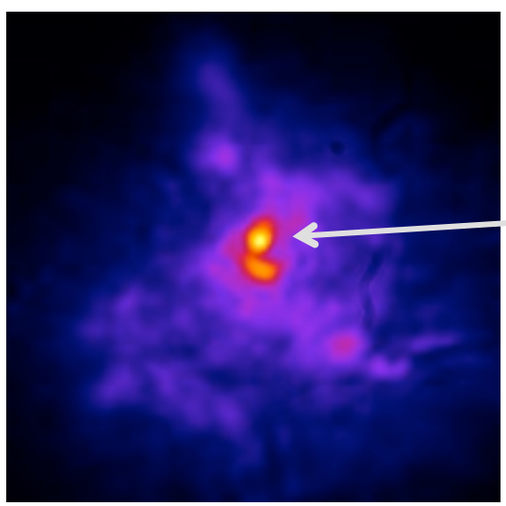
Redshift of the entire pulse spectrum in the guided filament

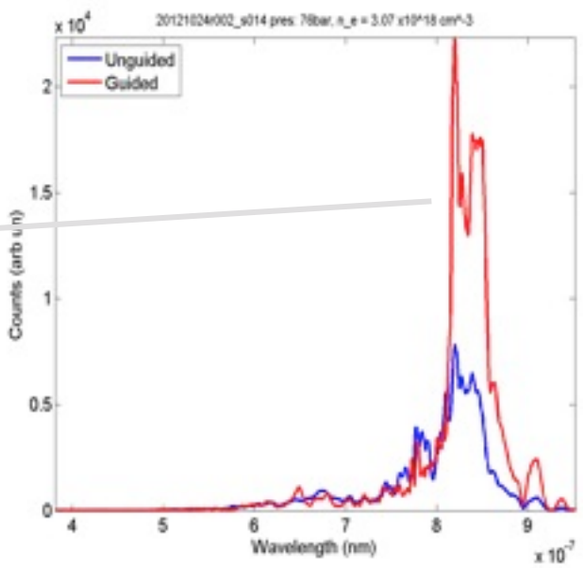


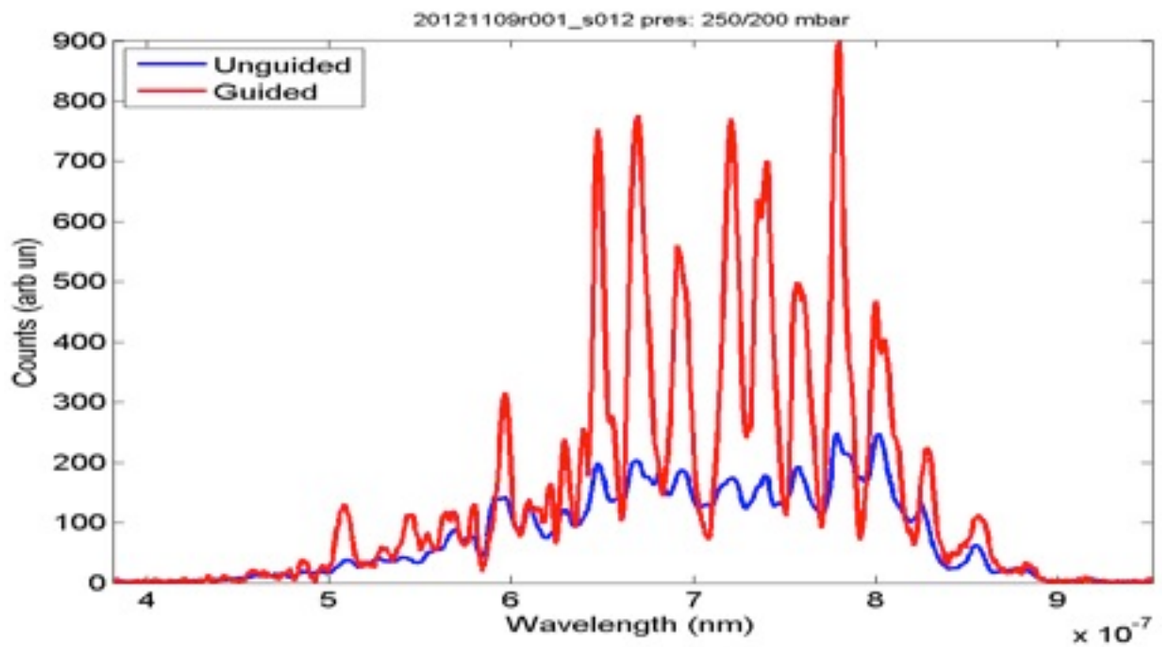


Guiding over 4 cm of plasma (tens of z_R)









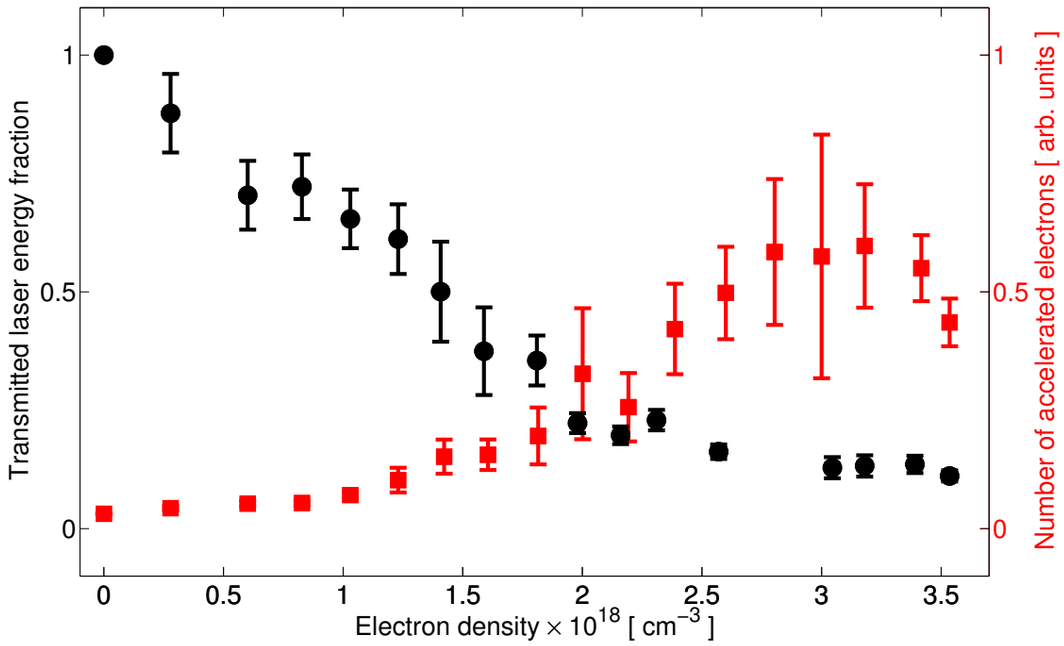
John Adams Institute for Accelerator Science

Imperial College London

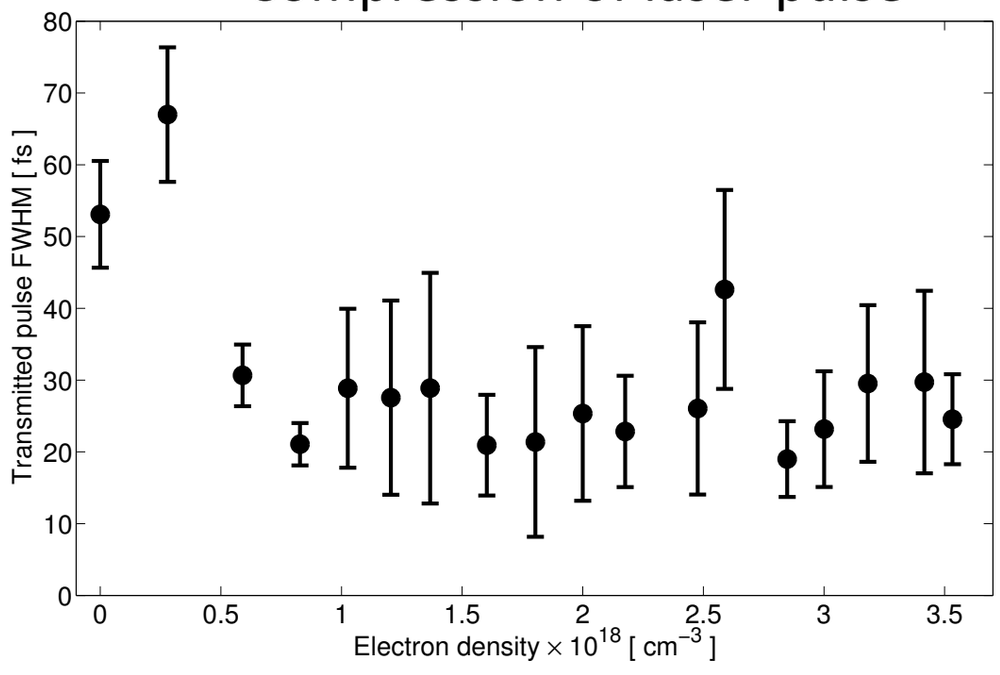
UNIVERSITY OF OXFORD

Royal Holloway University of London

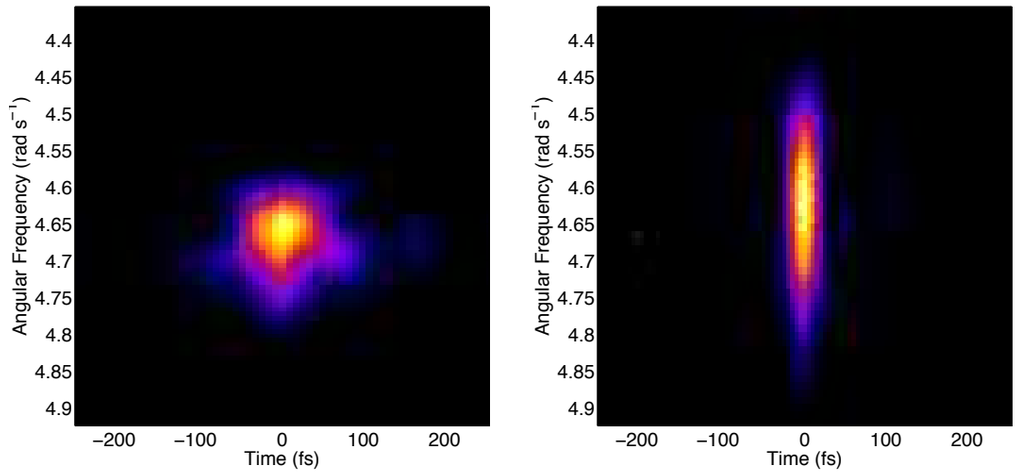
Depletion of laser energy



Compression of laser pulse

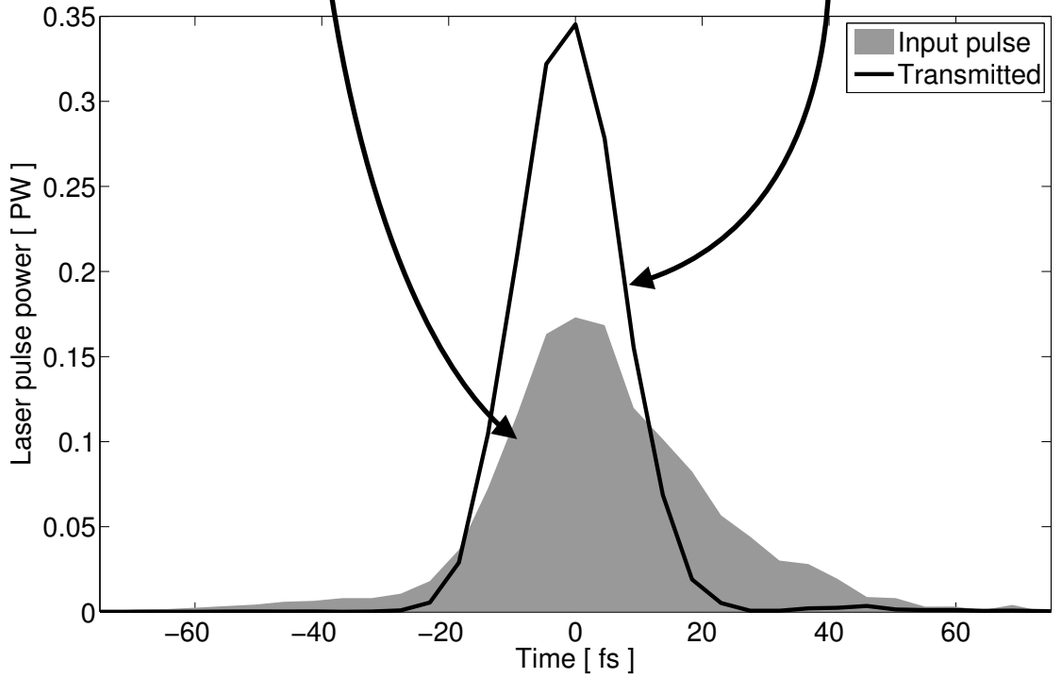


FROG measures laser pulse shape

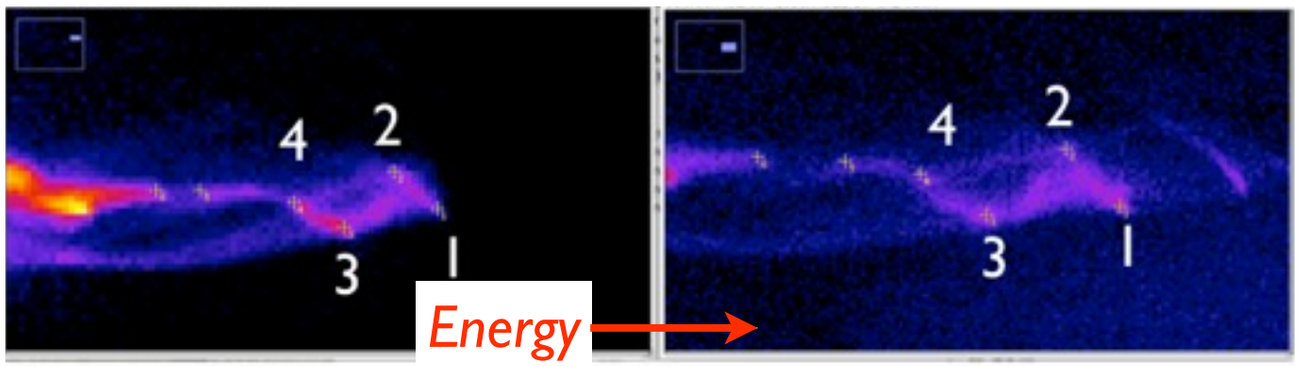


Input pulse

After 15 mm of $n_e = 8 \times 10^{17}$ cm^{-3}



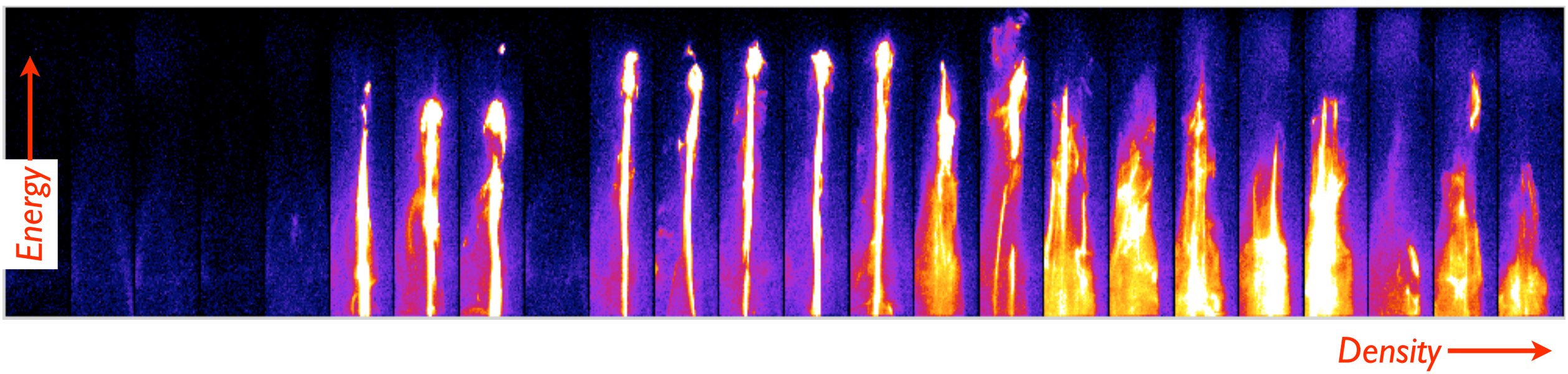
latest Gemini GeV self guided acceleration



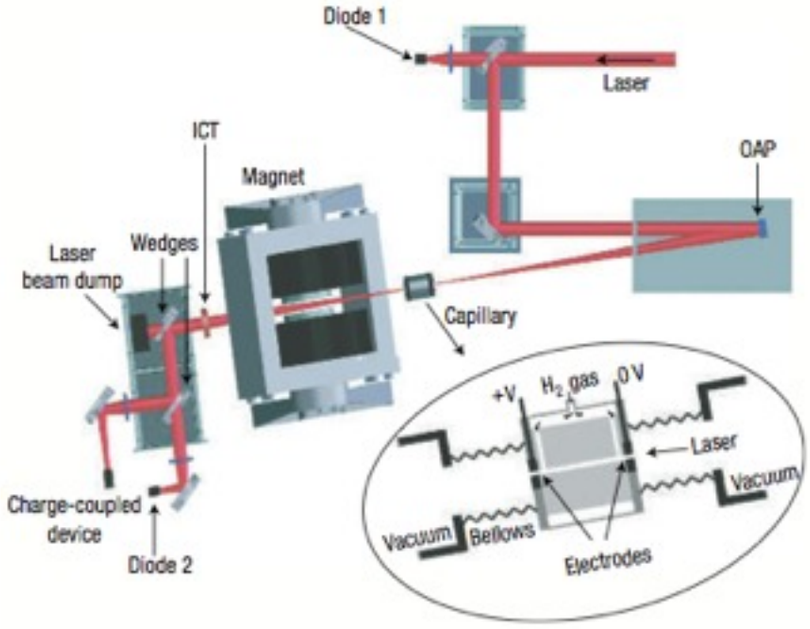
Point	Energy [MeV]	Pointing Angle [rad]
1	1336	-0.003
2	1275	-0.002
3	1156	-0.002
4	1086	-0.001

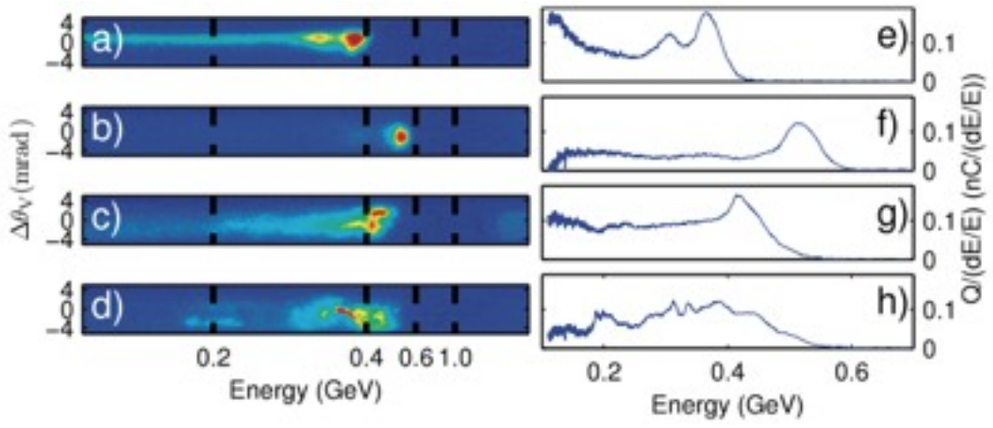
Energies observed > 1.3 GeV
Typical charge > 100 pC @ > 0.5 GeV

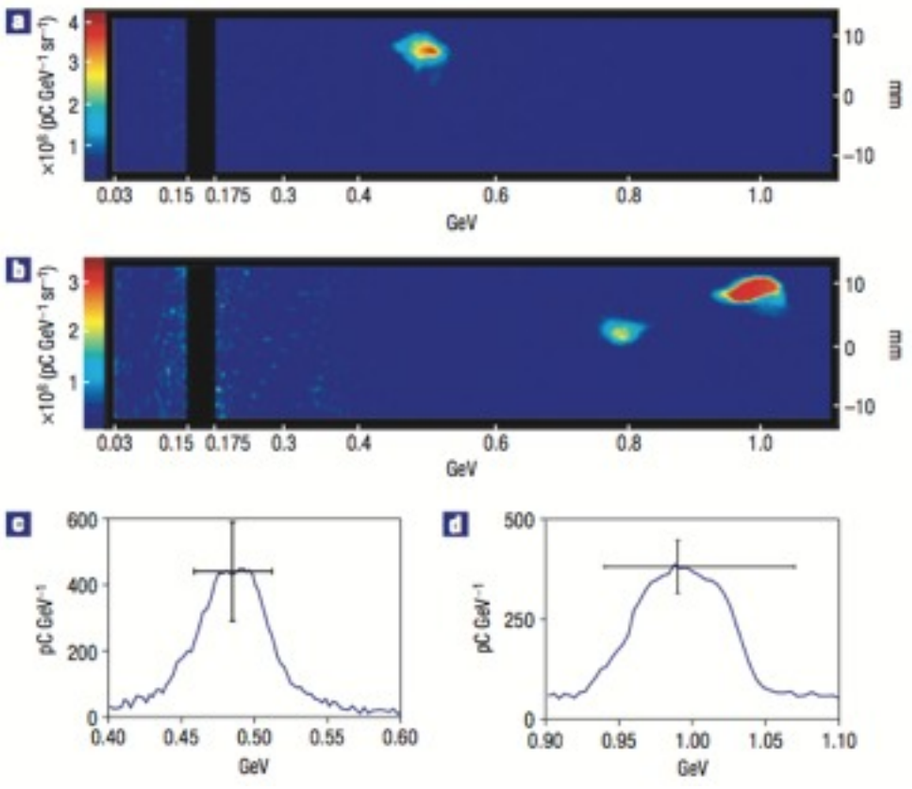
Change in behaviour of electron beam with increasing density

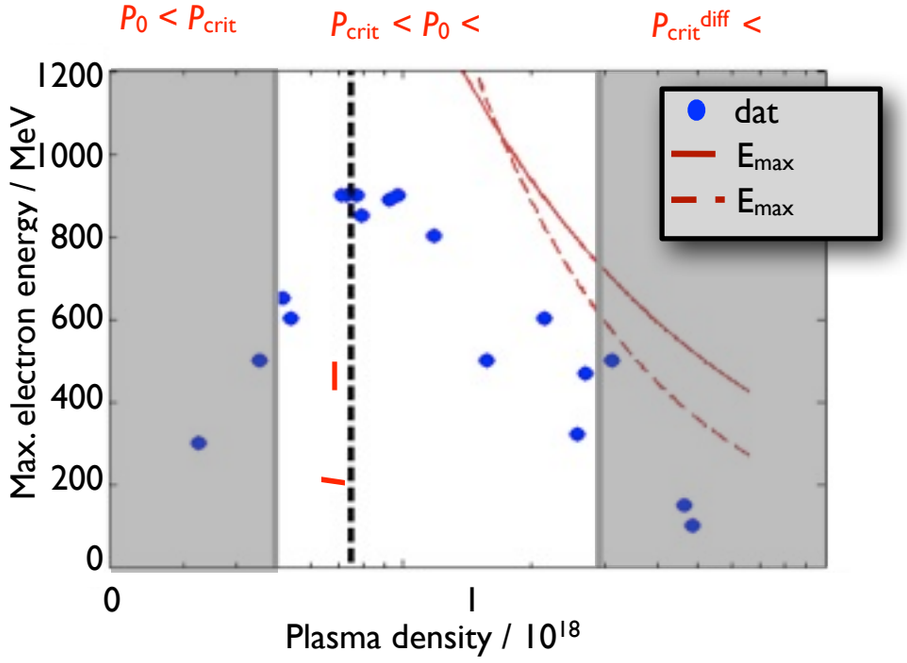


GeV channel guided acceleration







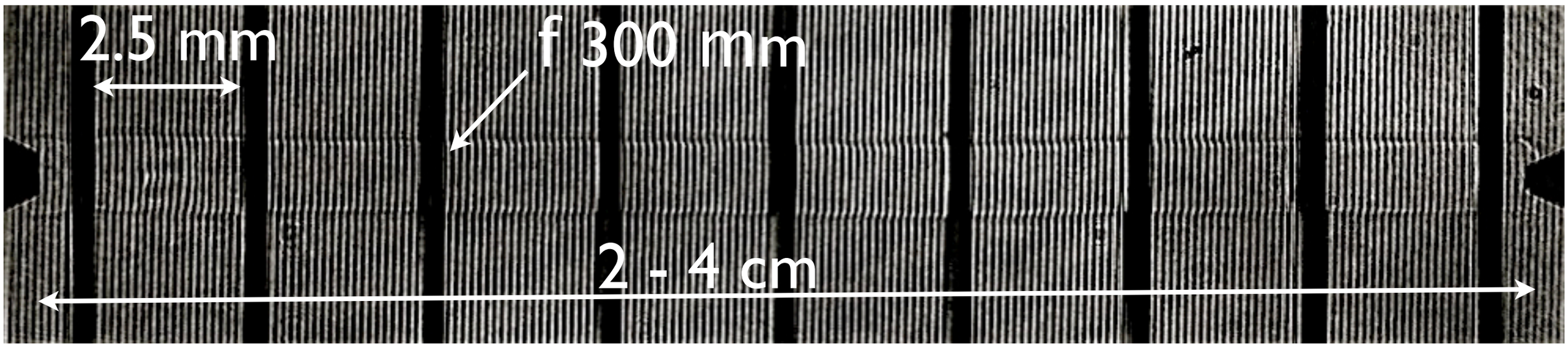


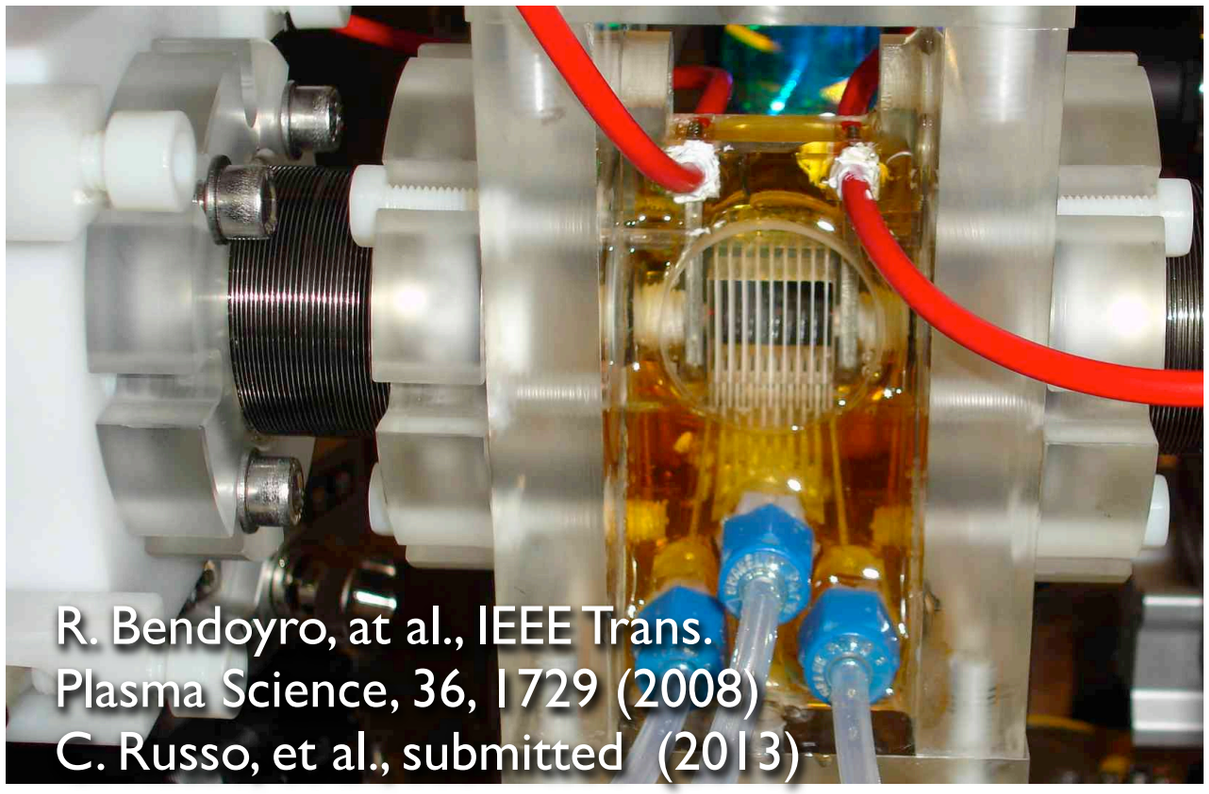
Gonsalves, A J, T P Rowlands-Rees, B H P Broks, J J A M van der Mullen, and S M Hooker. "Transverse Interferometry of a Hydrogen-filled Capillary Discharge Waveguide." *Physical Review Letters* 98, no. 2 (January 2007).

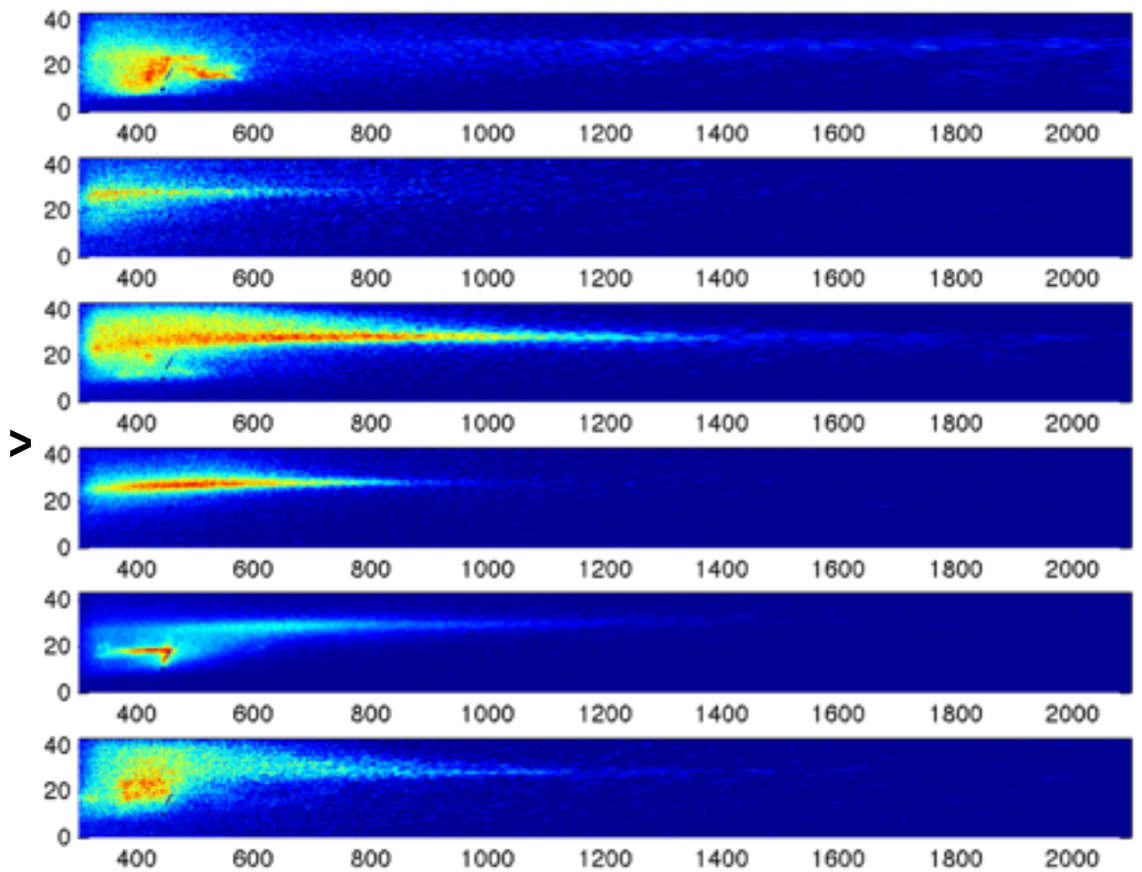
Leemans, W P, B Nagler, A J Gonsalves, Cs. Toth, K Nakamura, C G R Geddes, E Esarey, C B Schroeder, and S M Hooker. "GeV Electron Beams from a Centimetre-scale Accelerator." *Nature Physics* 2, no. 10 (October 2006): 696–699.

Ibbotson, T P A, N Bourgeois, T P Rowlands-Rees, L S Caballero, S I Bajlekov, P A Walker, S Kneip, et al. "Investigation of the Role of Plasma Channels as Waveguides for Laser-wakefield Accelerators." *New Journal of Physics* 12 (2010): 045008.

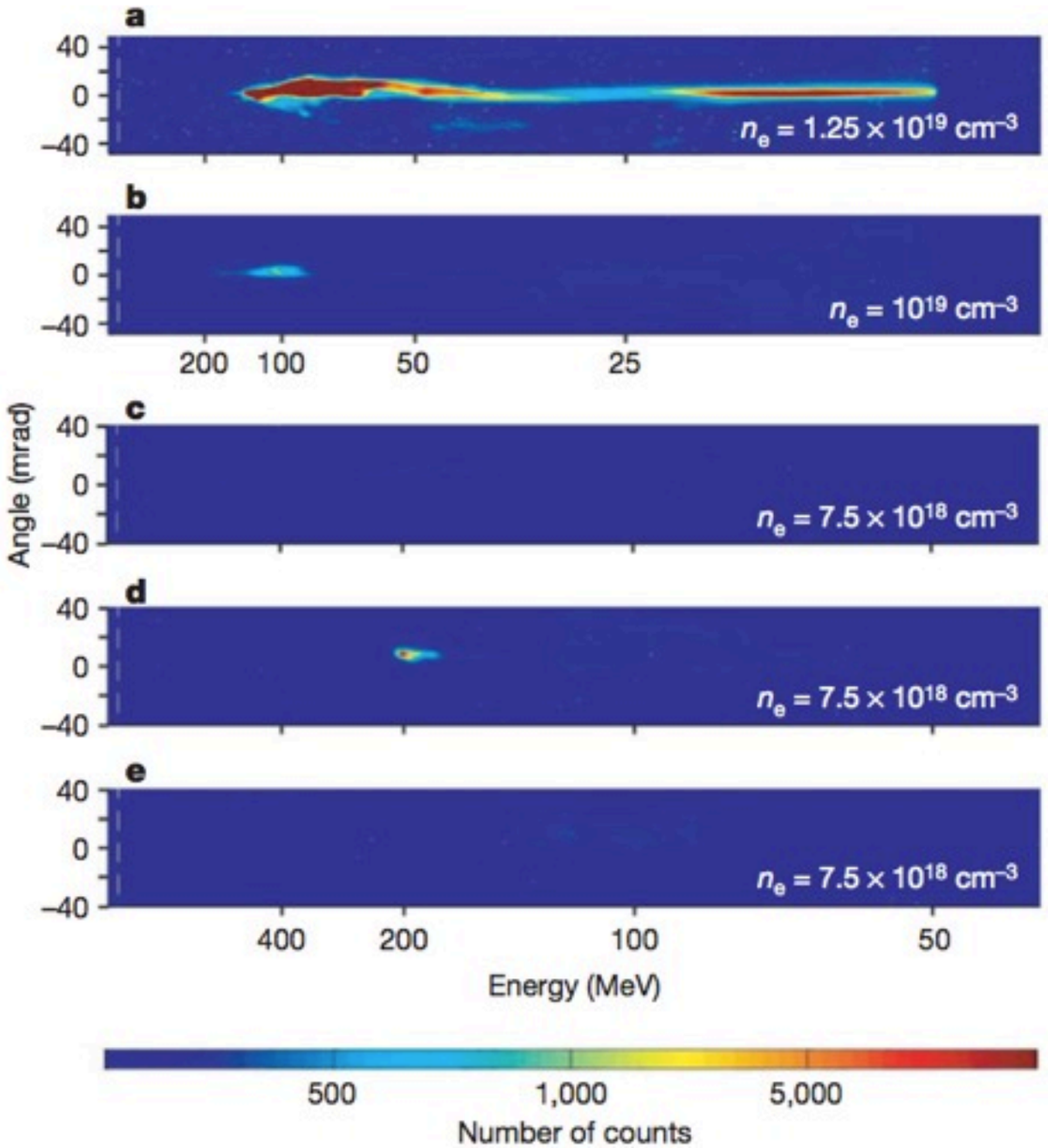
latest Gemini GeV channel guided acceleration

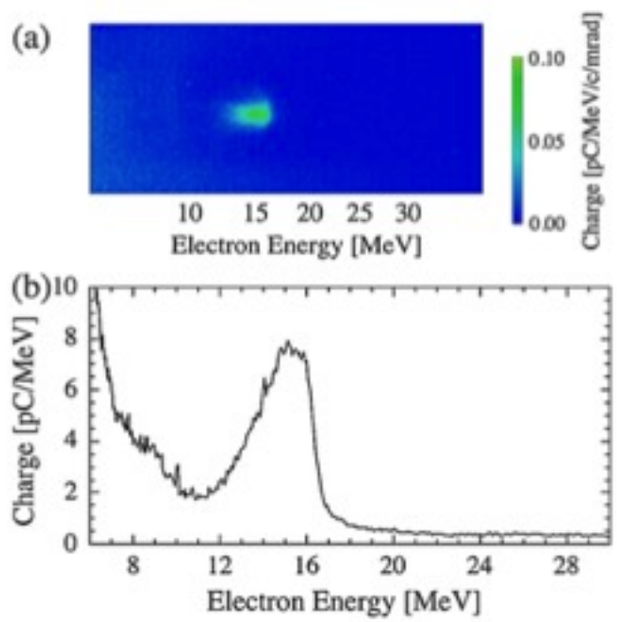


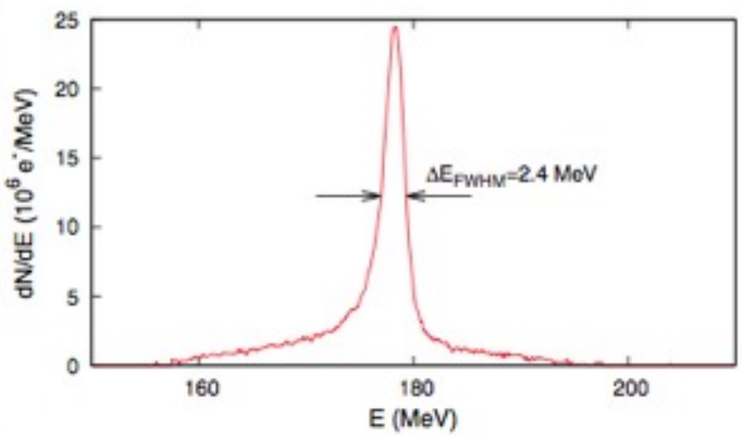




optically induced injection







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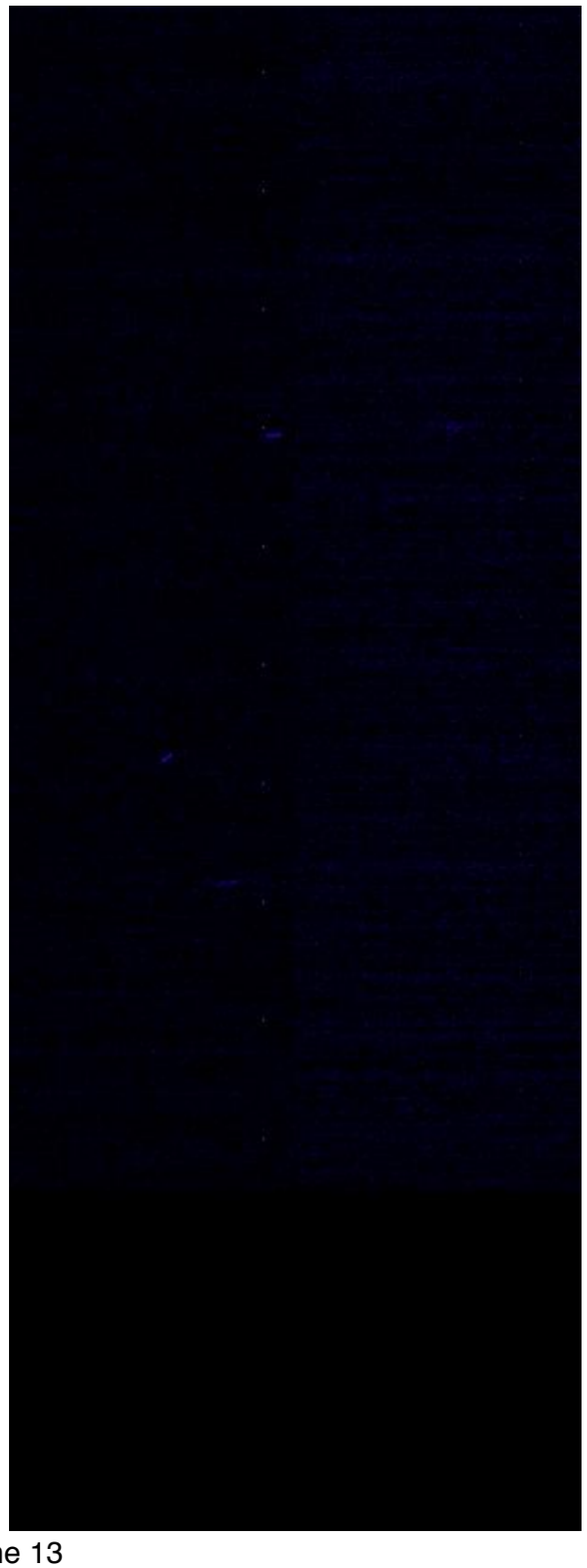
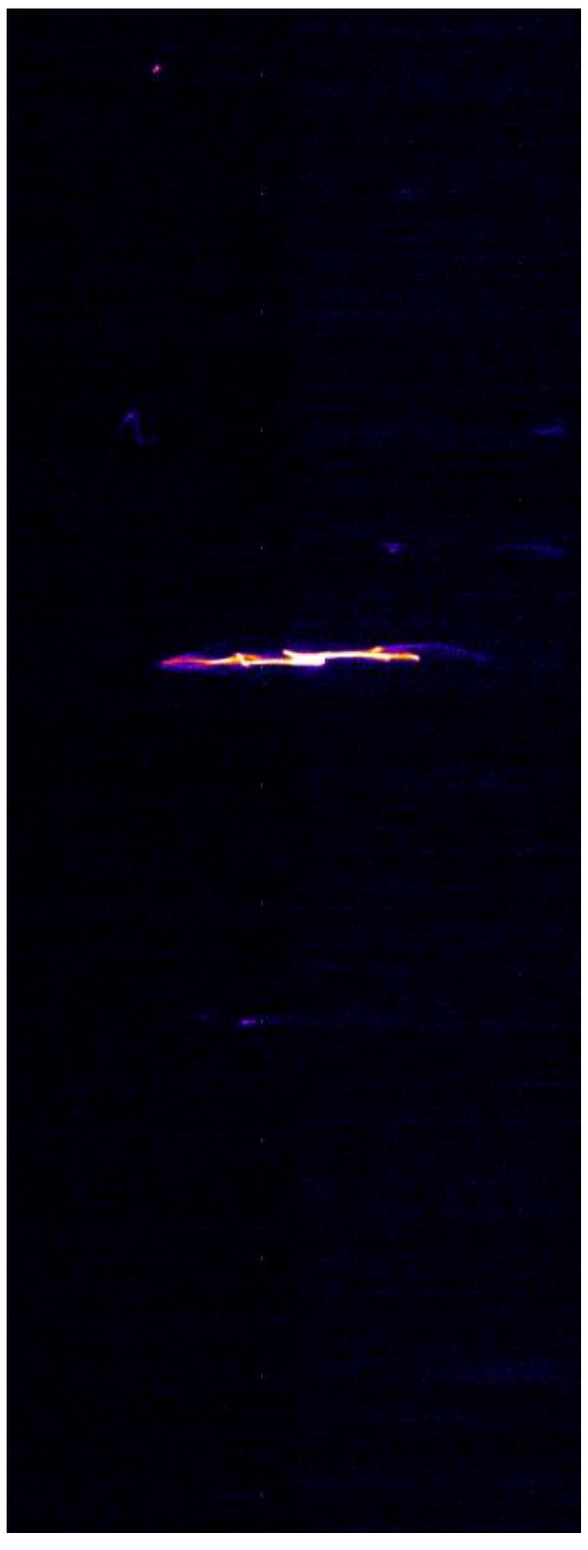
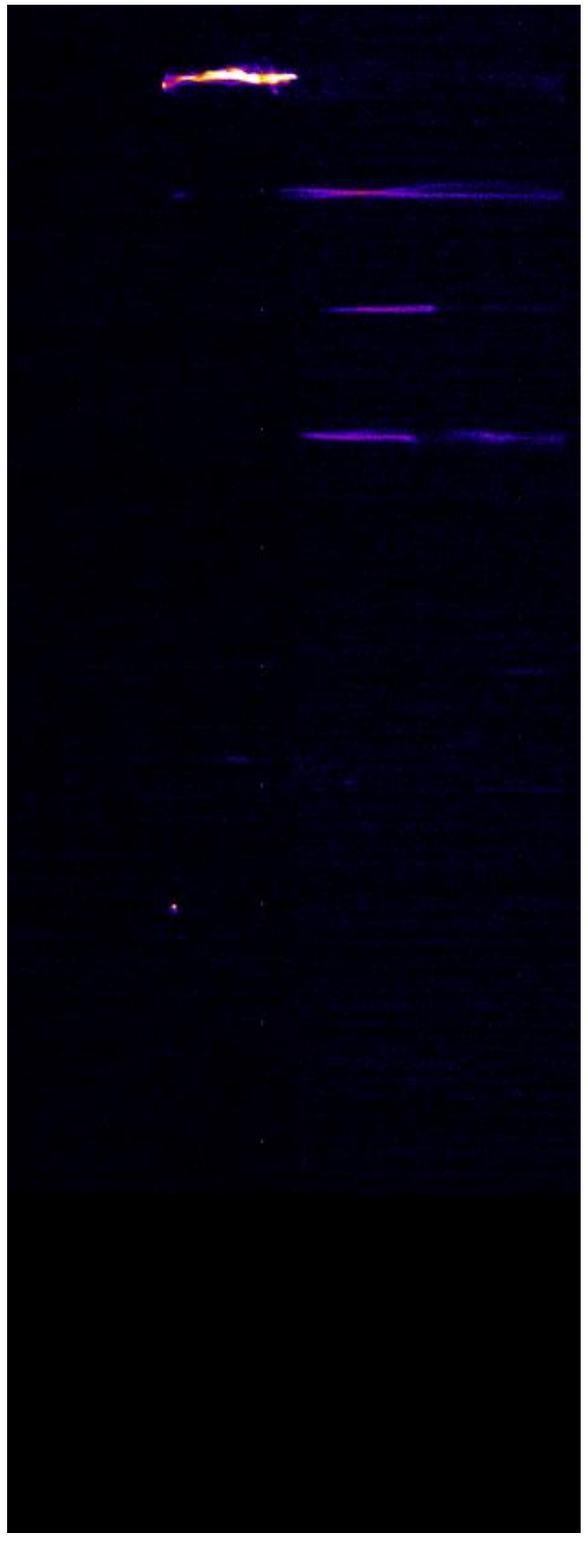
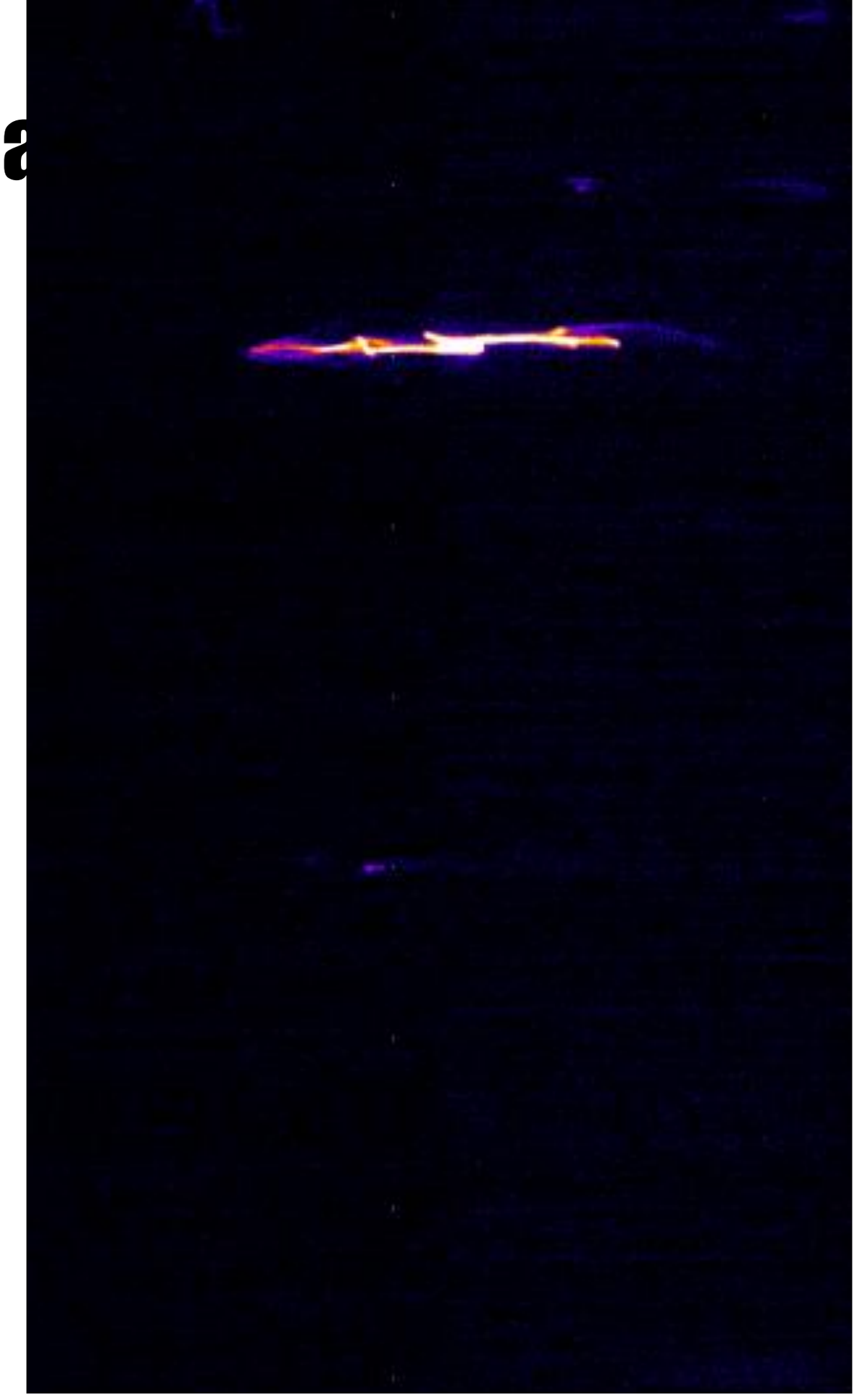
optically induced injection - Gemini

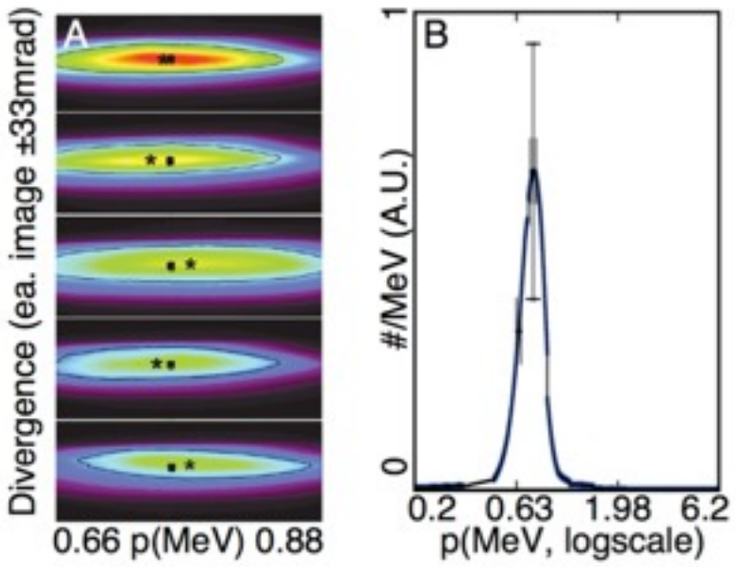
50um early	T_0	50um late
		

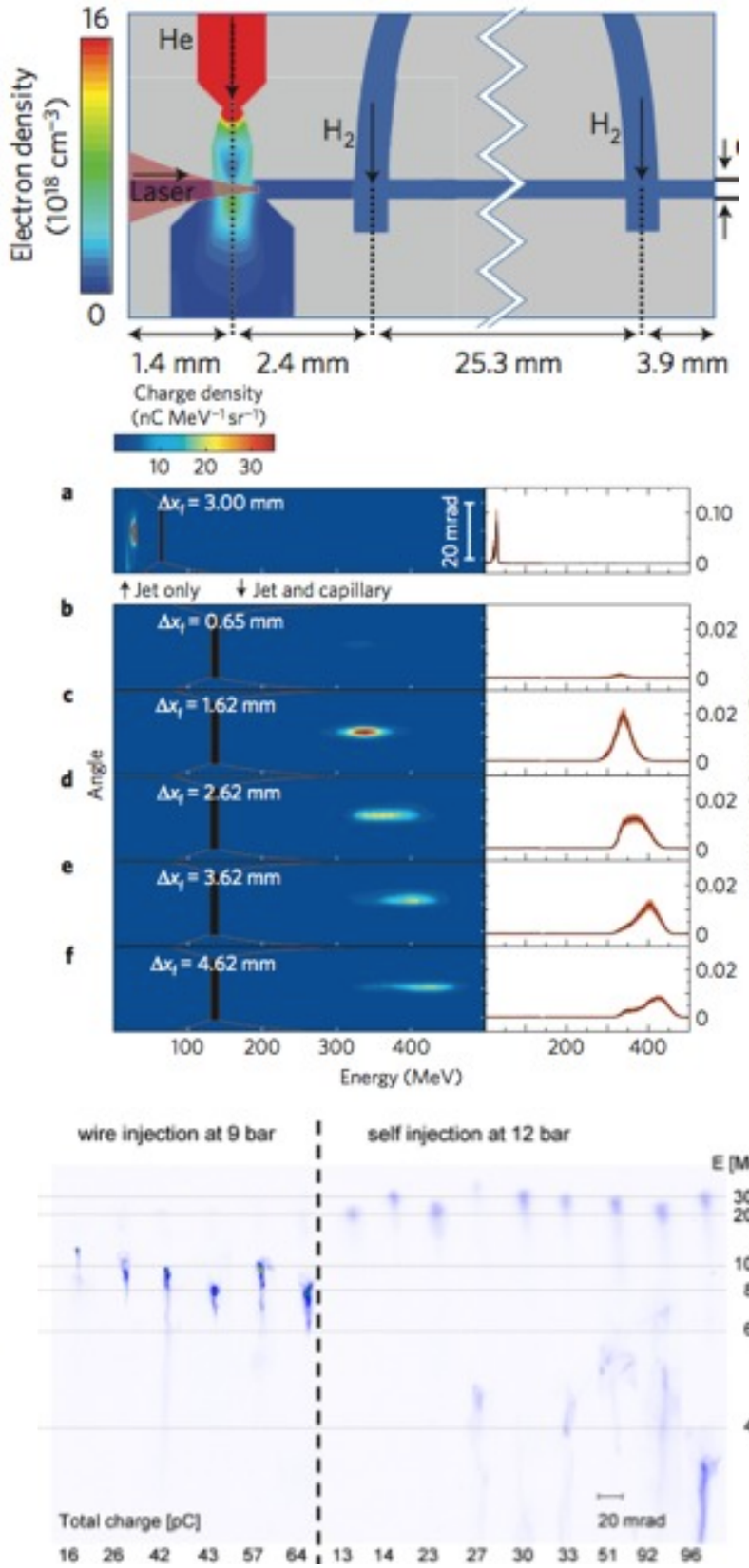
optica

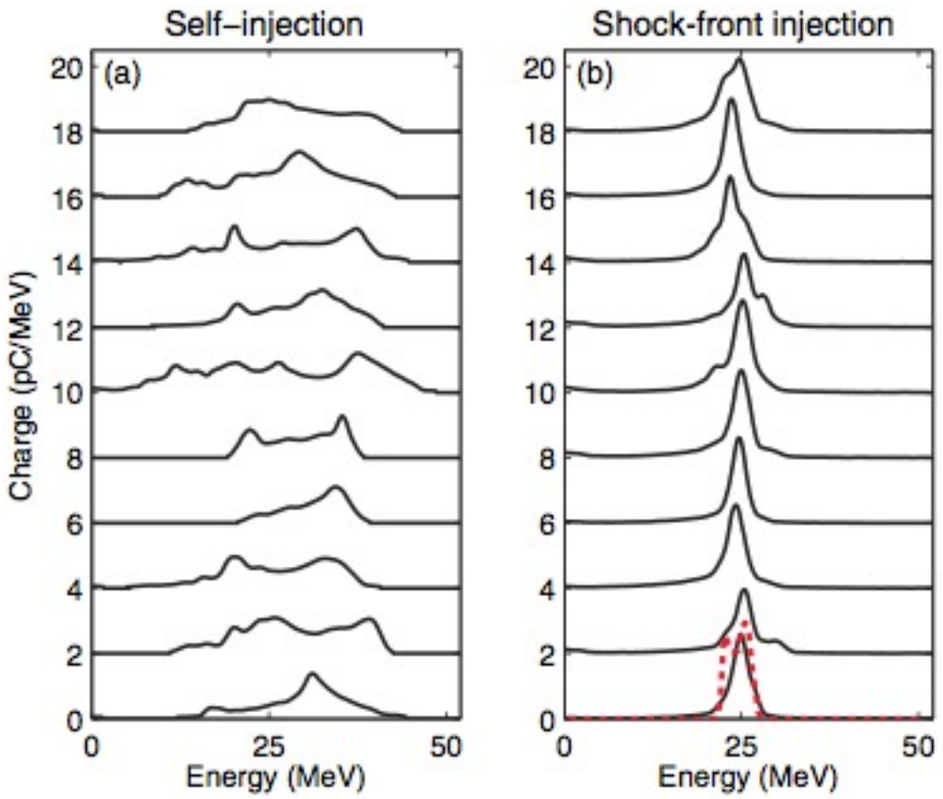


Gemi

density modulation injection







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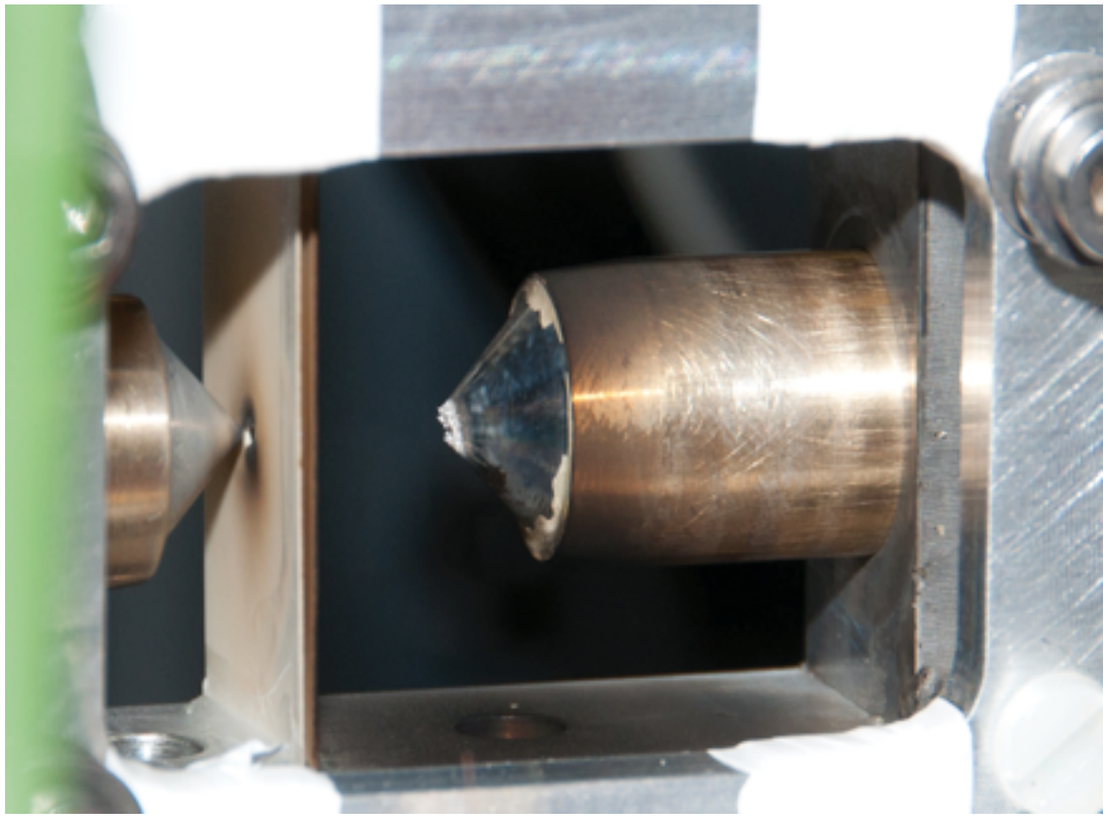
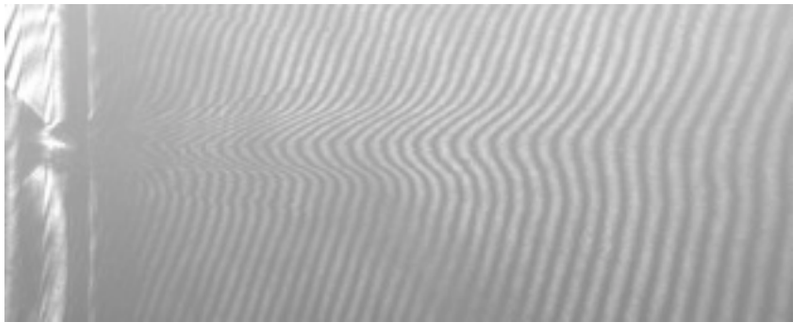
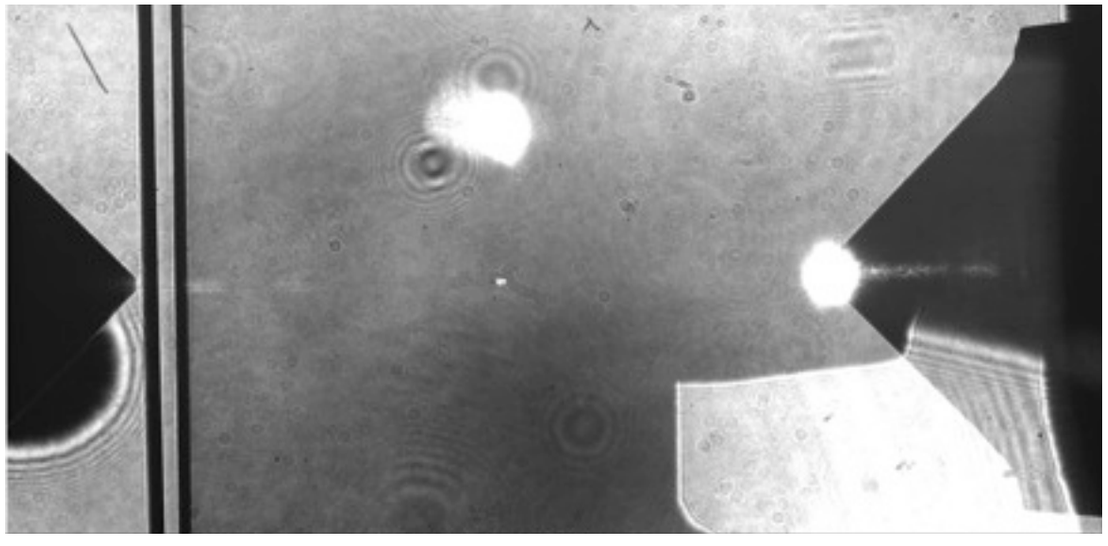
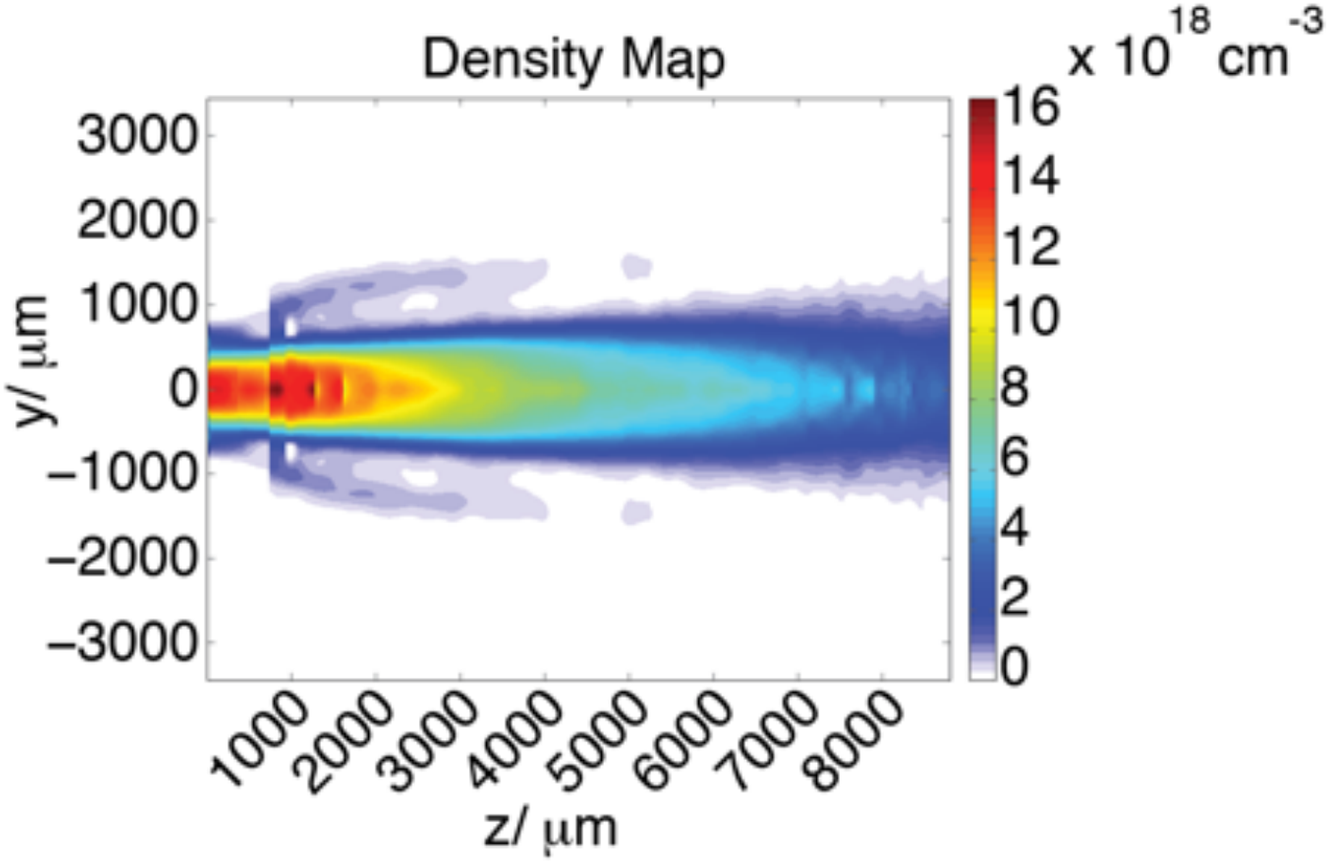
gas cell development









latest Gemini density modulation injection

gas cell with density step

first subcell density 1.2×10^{19} cm^{-3}

remaining cell 3.4×10^{18} cm^{-3}

laser energy ~ 4.3 - 4.9 J

a_0 ~ 1.6

charge 50 - 250 pC

energy 300 MeV - 650 MeV

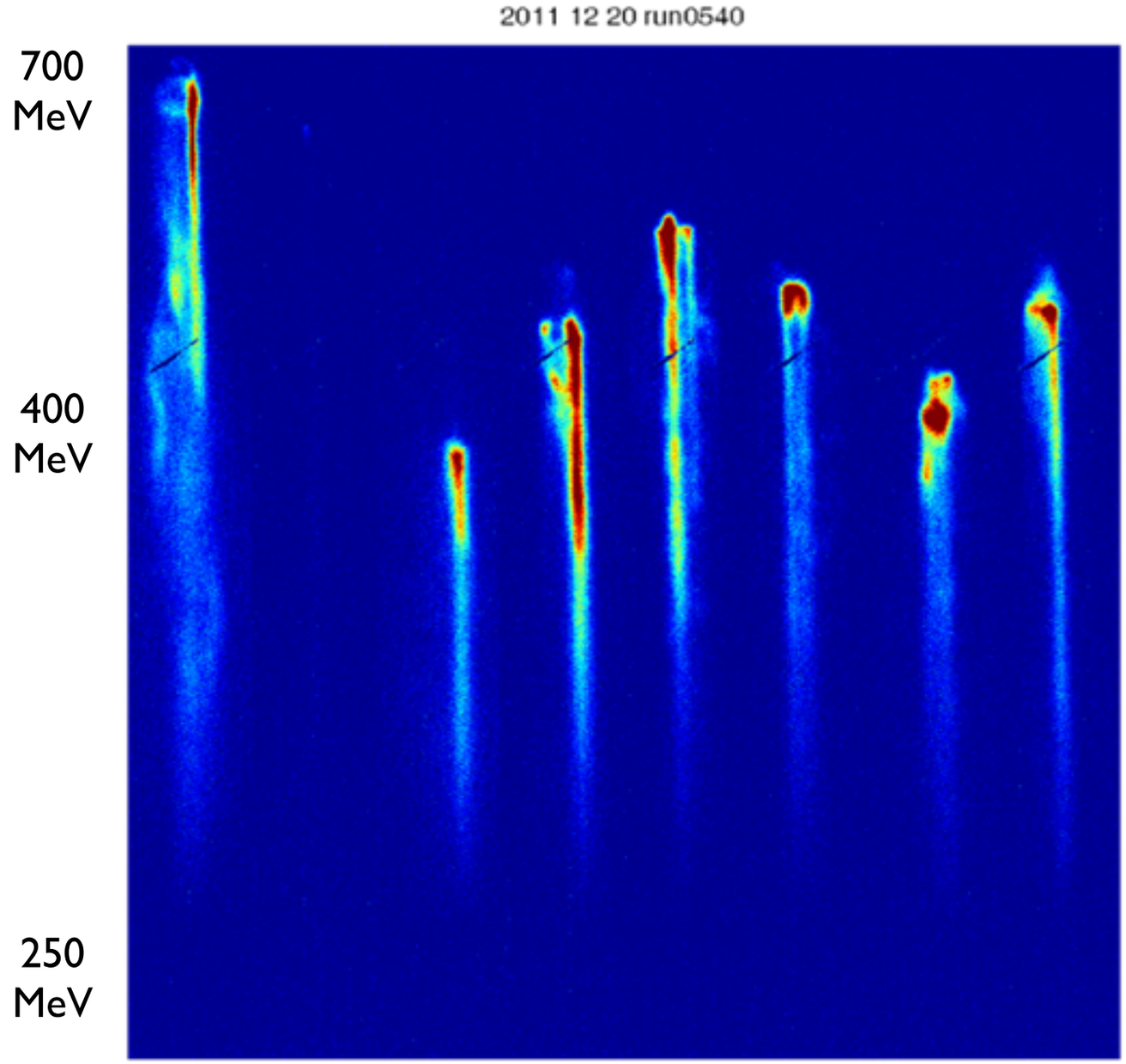
beam diameter ~ 1.3 mm

divergence ~ 2 mrad

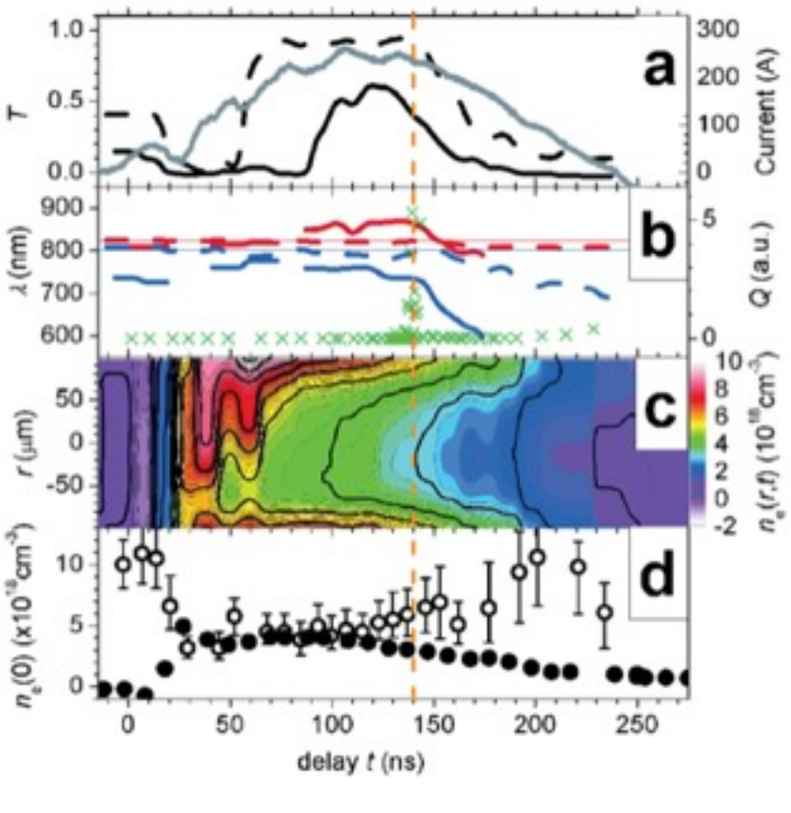
pointing ~ 8-10 mrad

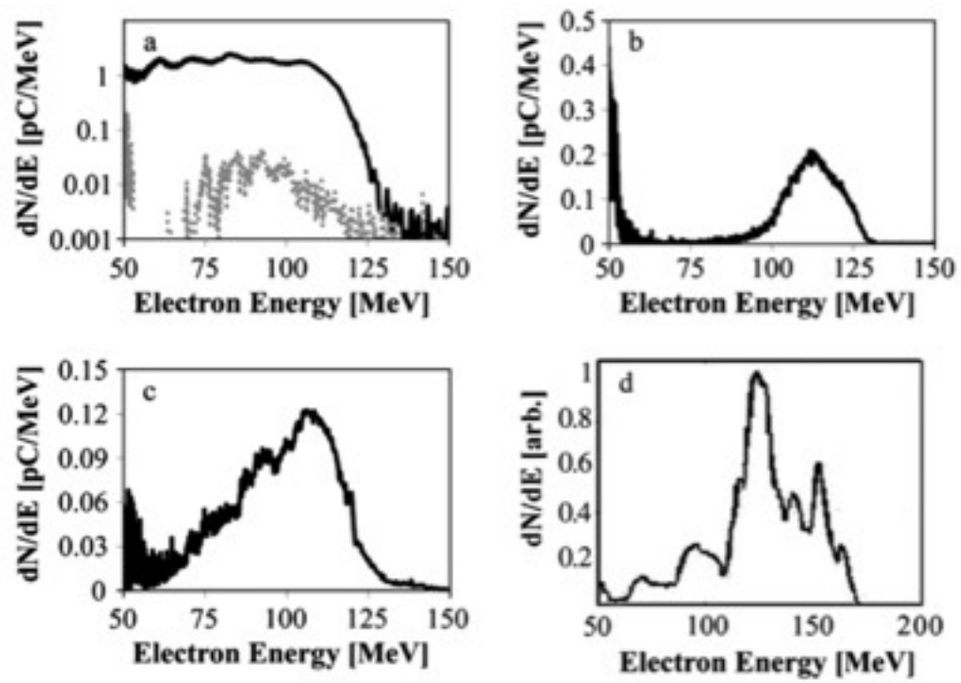
minimum energy spread 8 MeV/460MeV

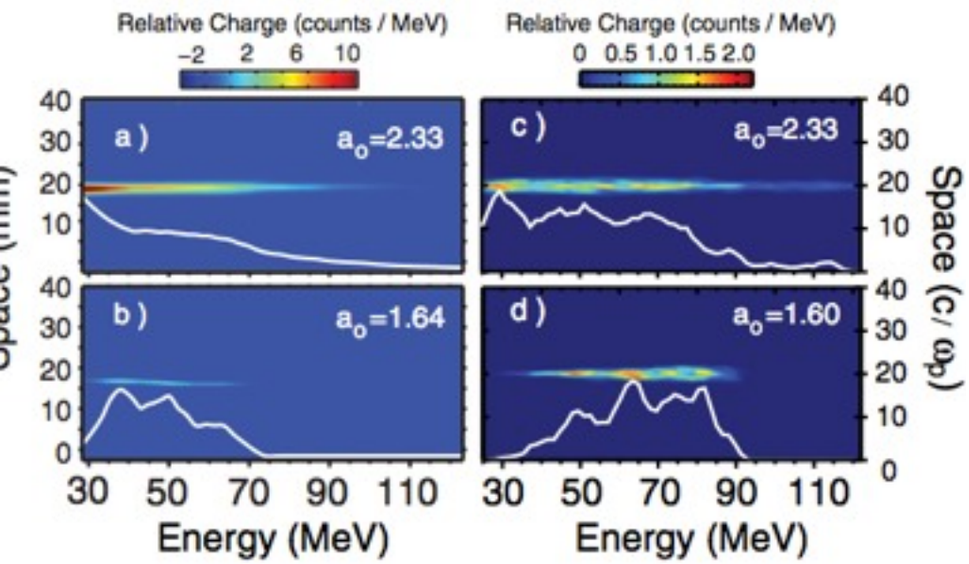
< 2% (main spot on last shot on image)

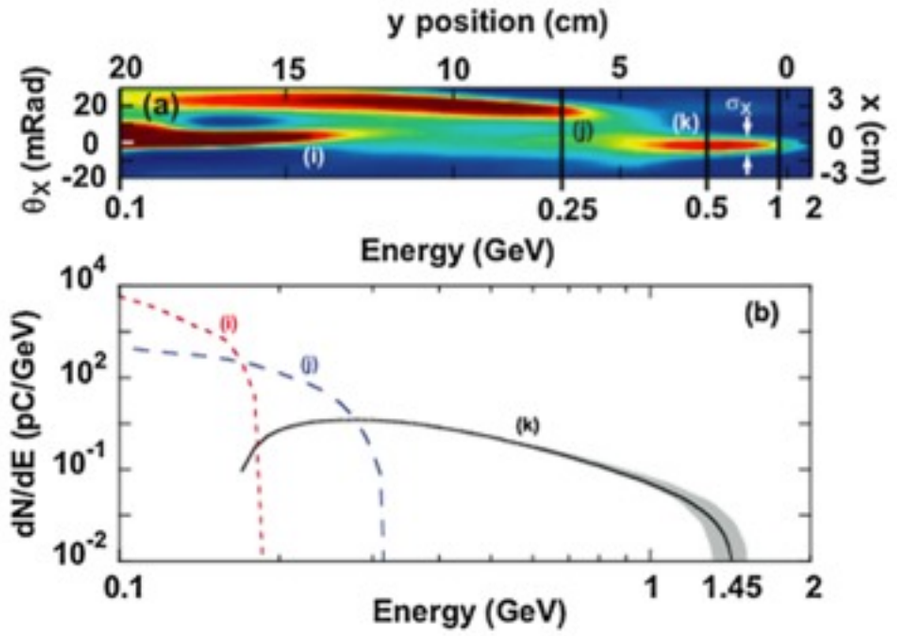


ionisation injection









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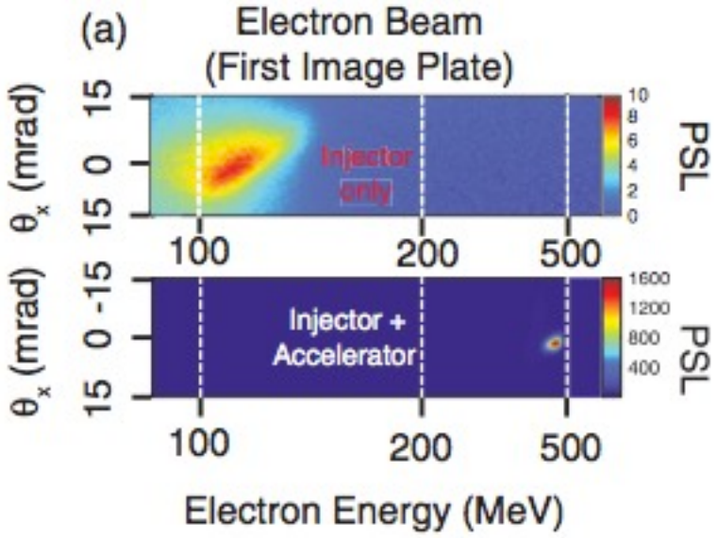
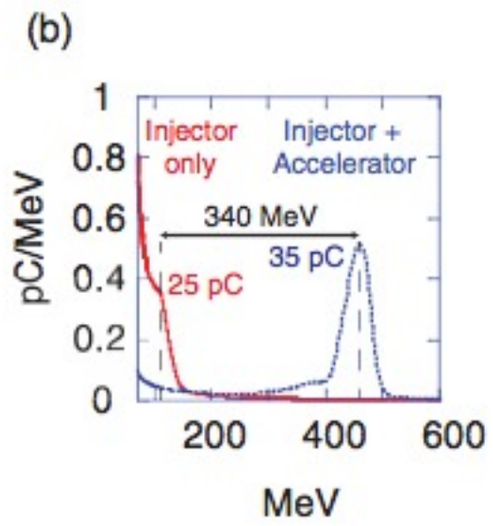
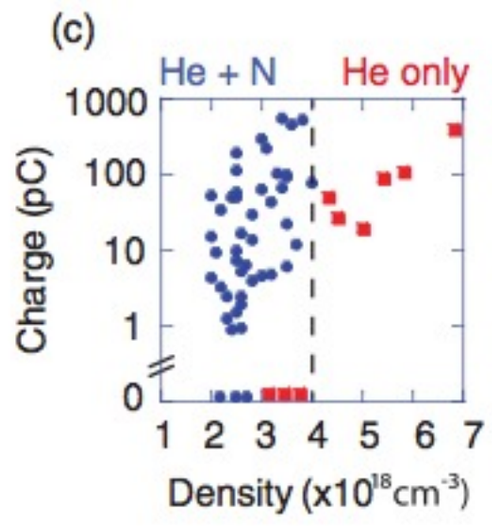
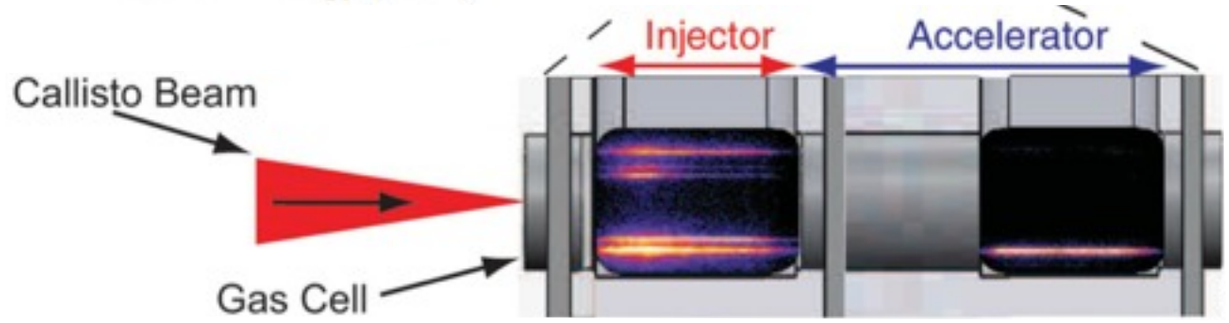
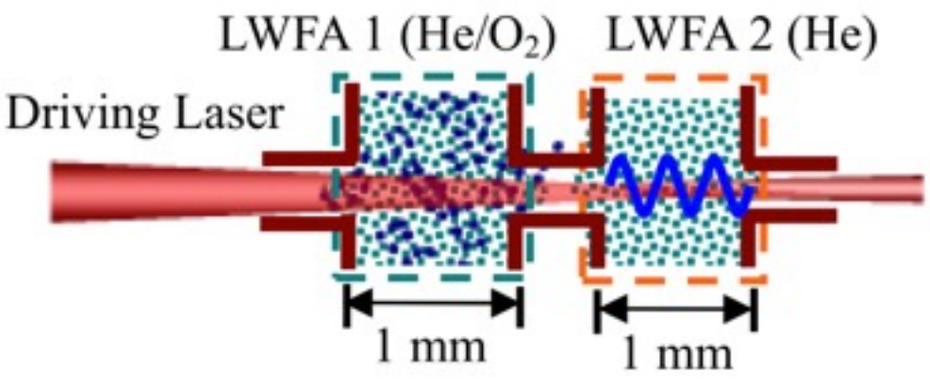
ionisation injection - staged

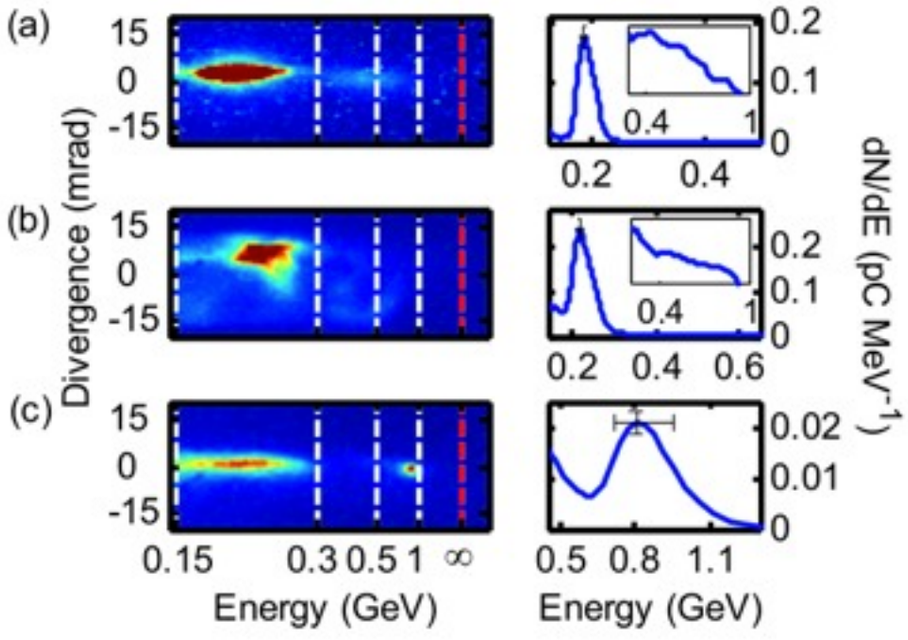












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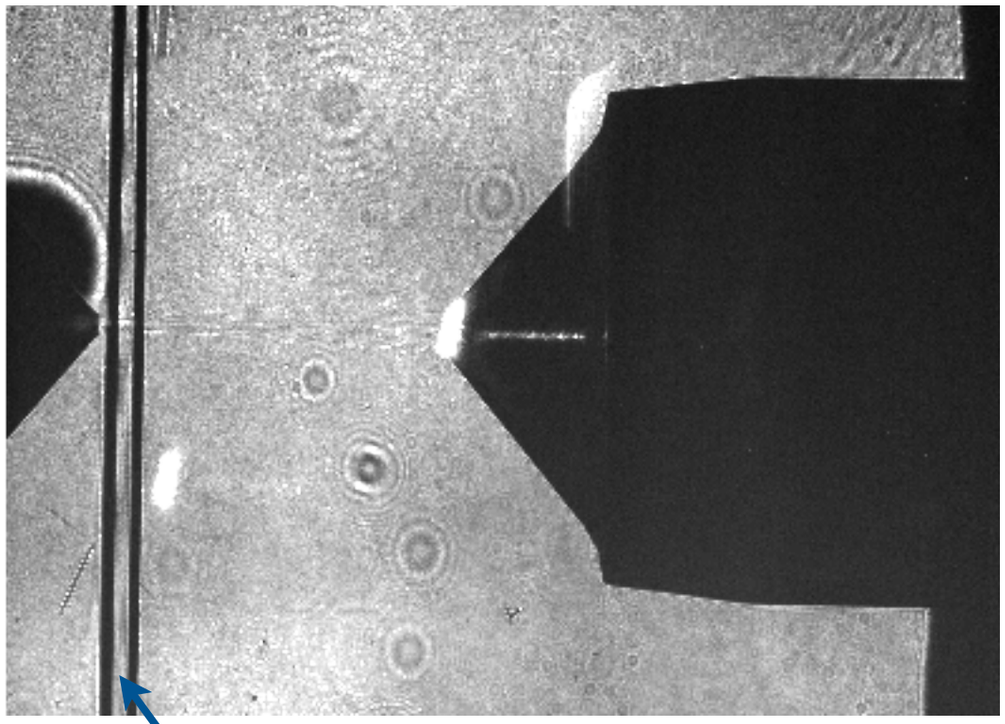
latest Gemini ionisation injection

Gas cell



He He

He + 5% N2

Laser energy = 12.6

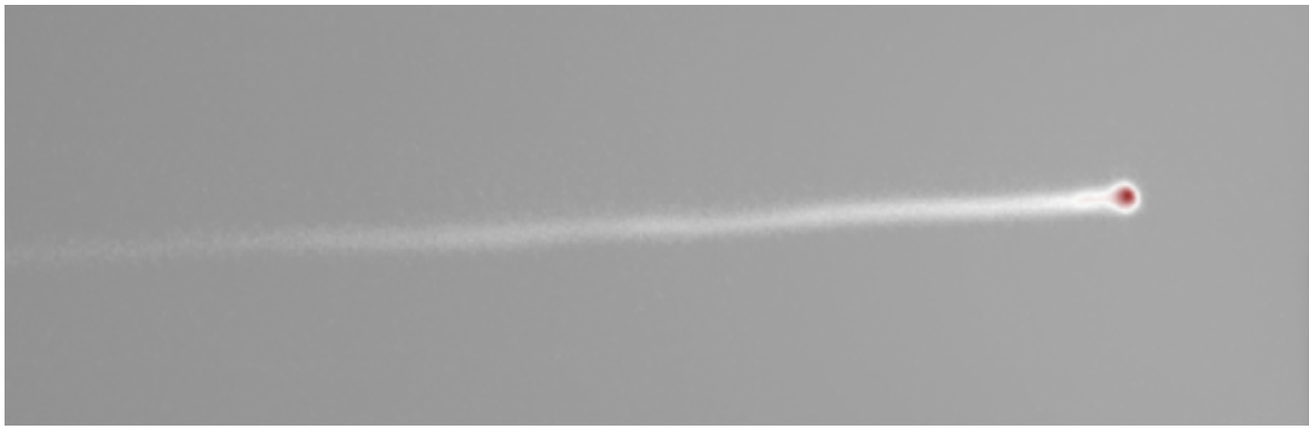
τ = 45 fs

w_0 = 16.6 um

a_0 = 4.0

n_e=1.6×10^{18} cm^{-3}

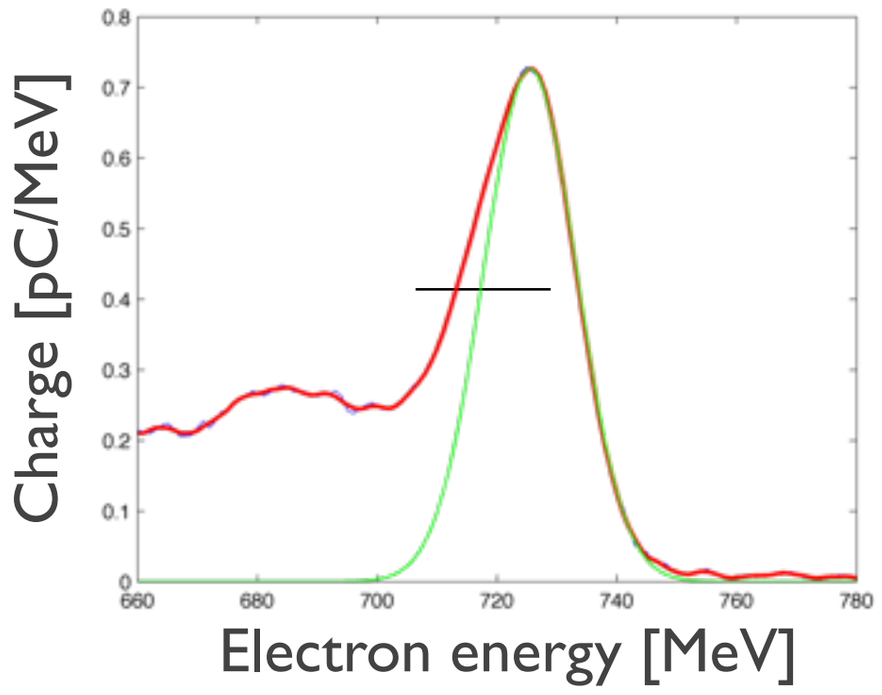
e-spectrometer screen



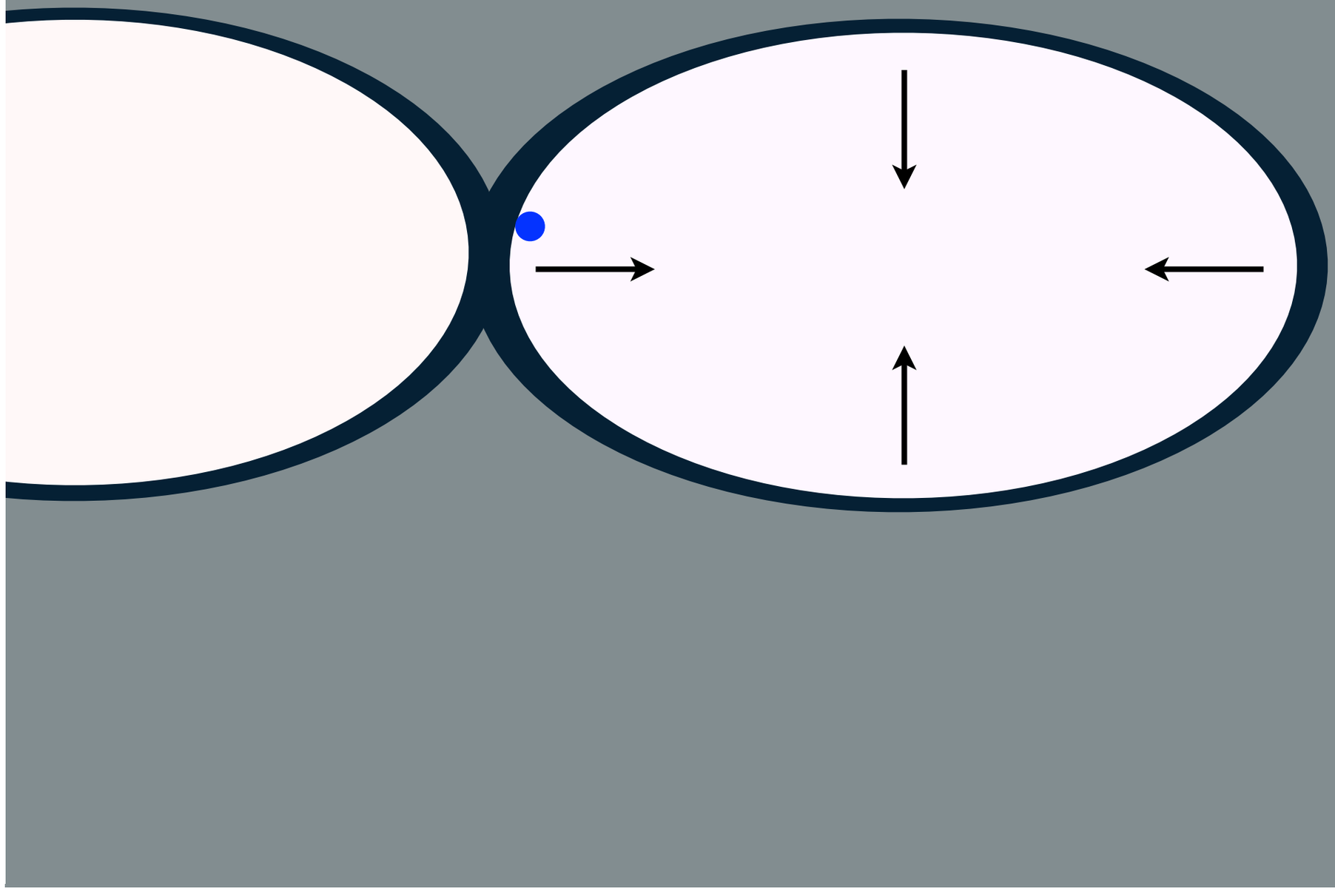
E_e= 726 MeV

ΔE = 3.0%

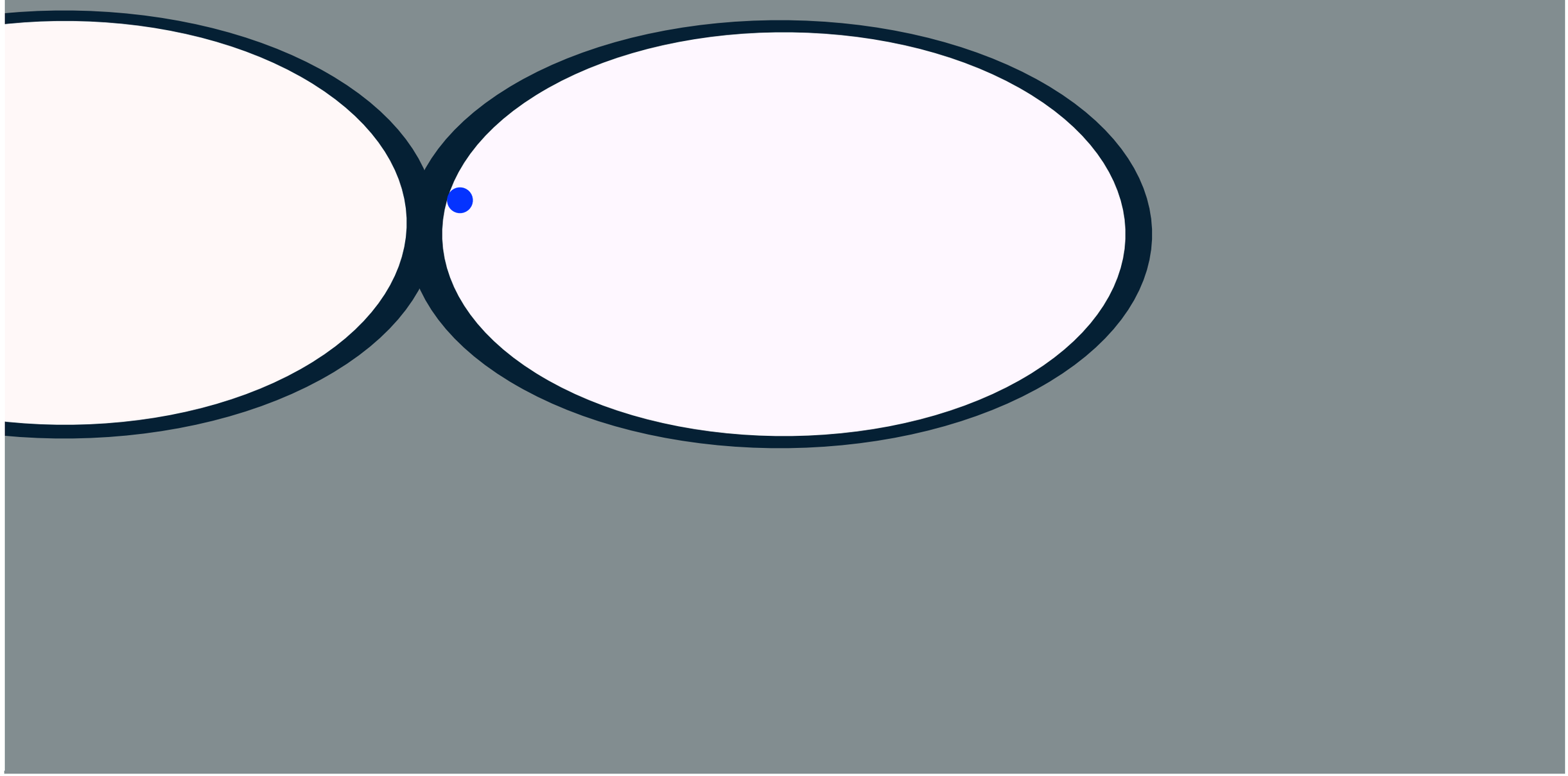
Charge ≈ 17 pC



acceleration



acceleration



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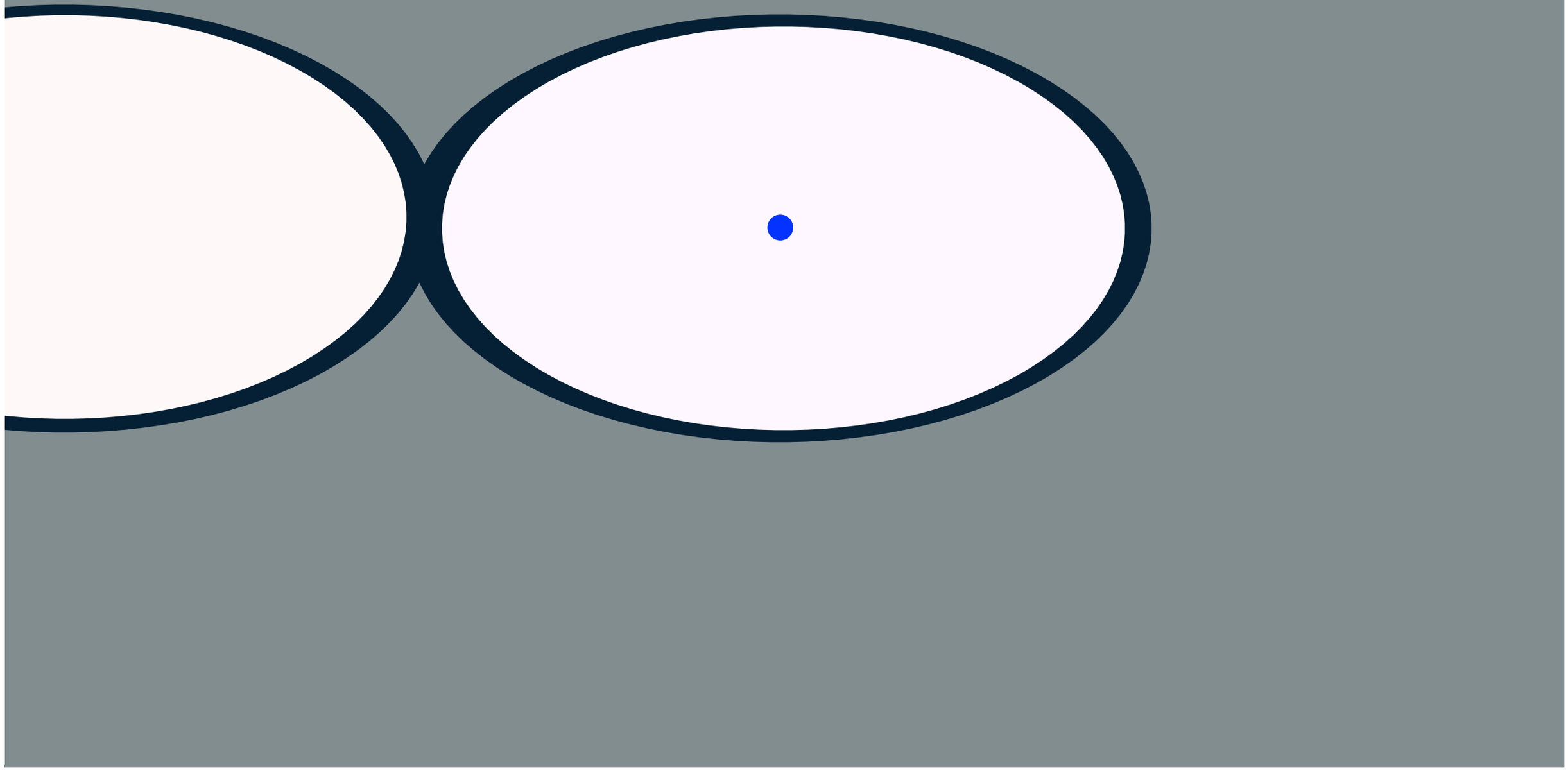

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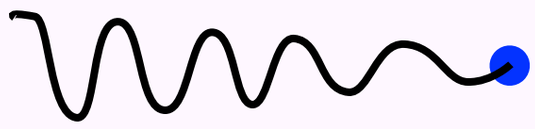
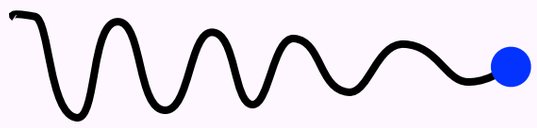


radiation



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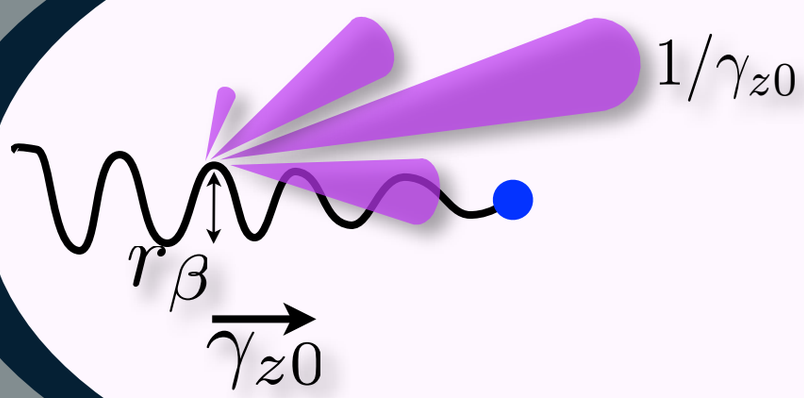

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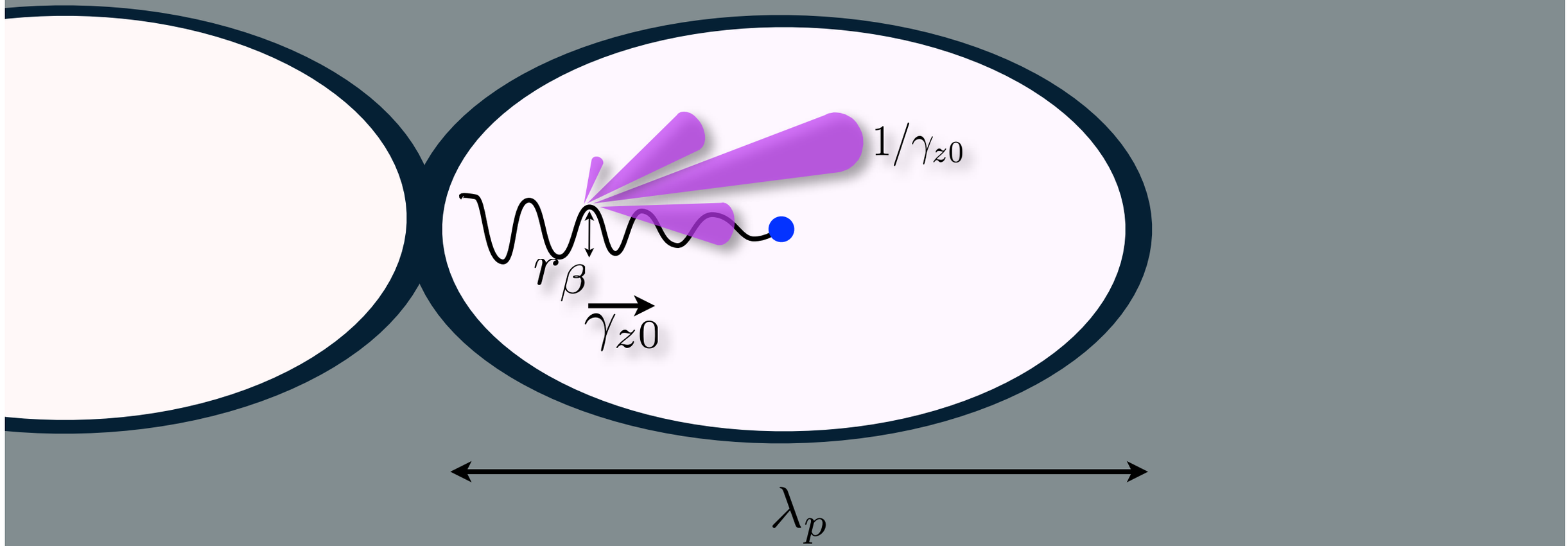


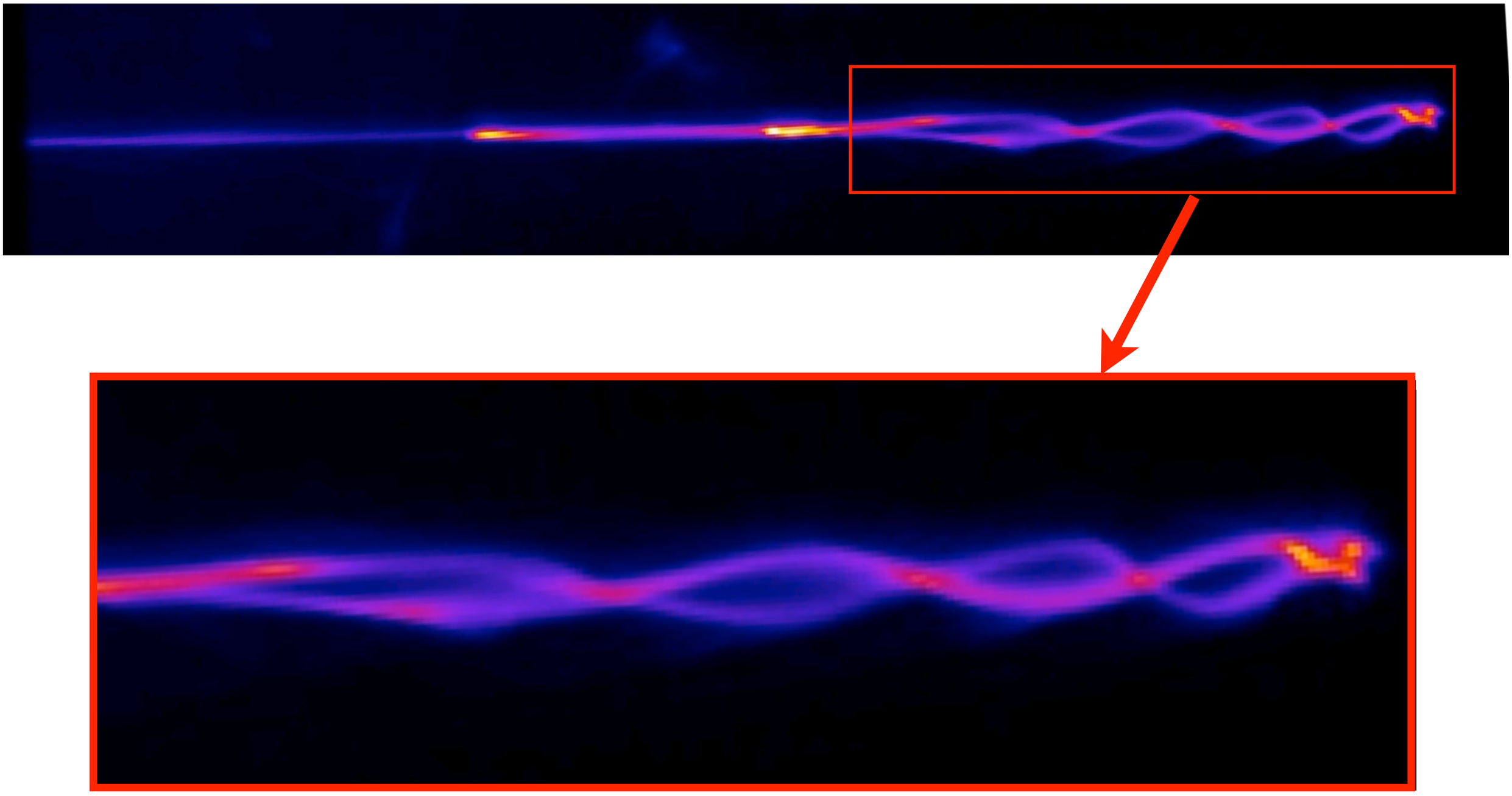
$$P_s = \frac{e^2 c}{3}\gamma_{z0}^2 k_\beta^2 a_\beta^2$$

$$a_\beta = \gamma_{z0} r_\beta k_\beta$$

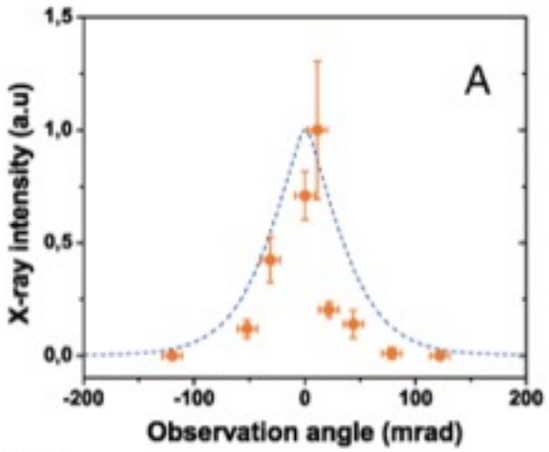
$$\omega_c = 3\gamma^3 \omega_\beta^2 r_\beta / c$$

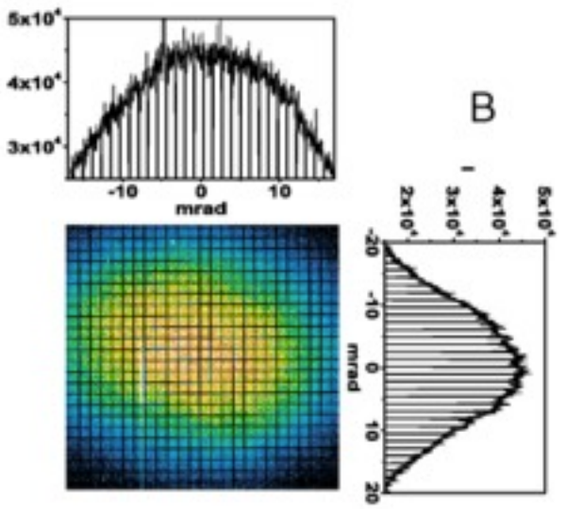
E Esarey PRE **65**, 056505 (2002)

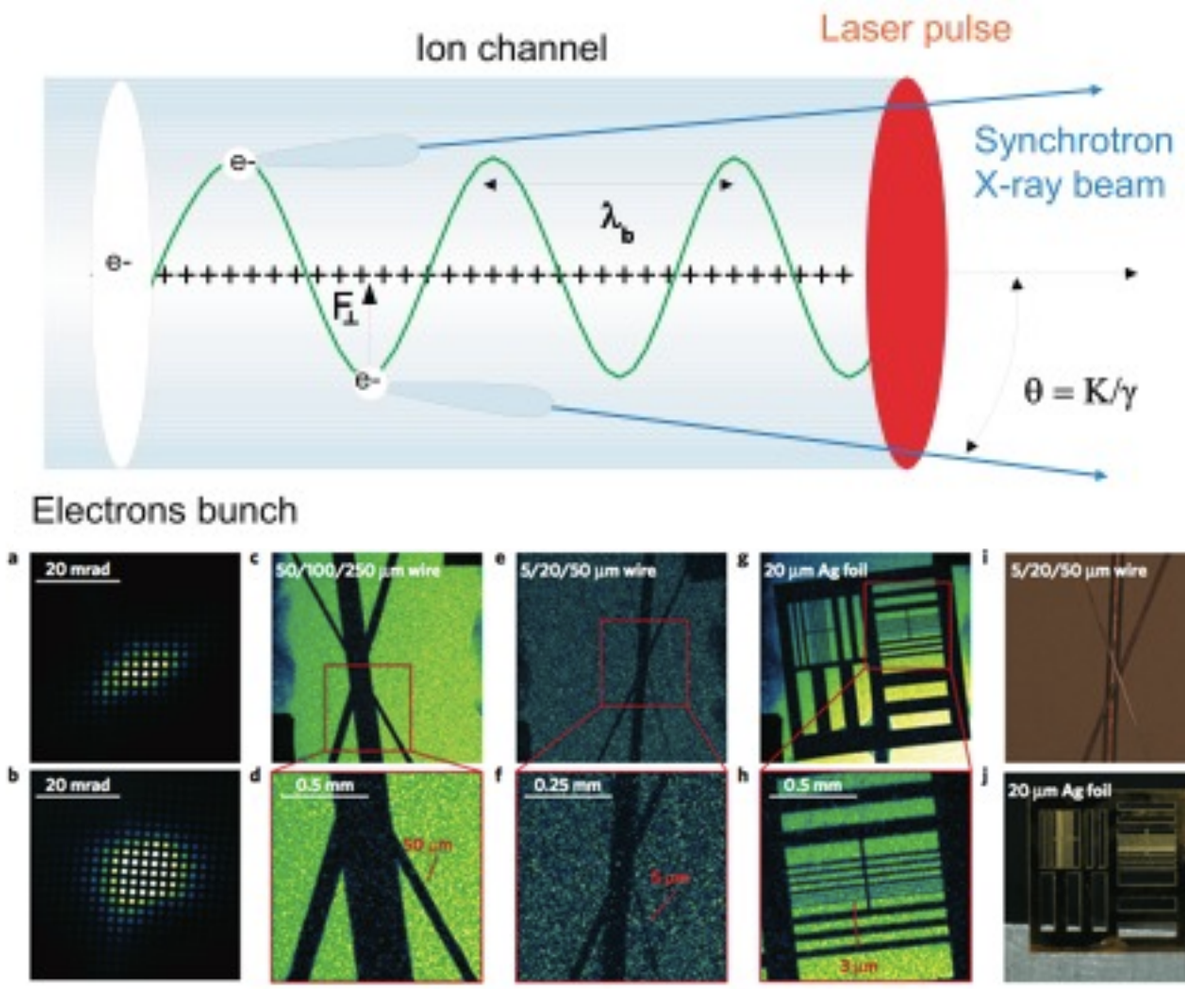
Betatron Oscillations directly observed

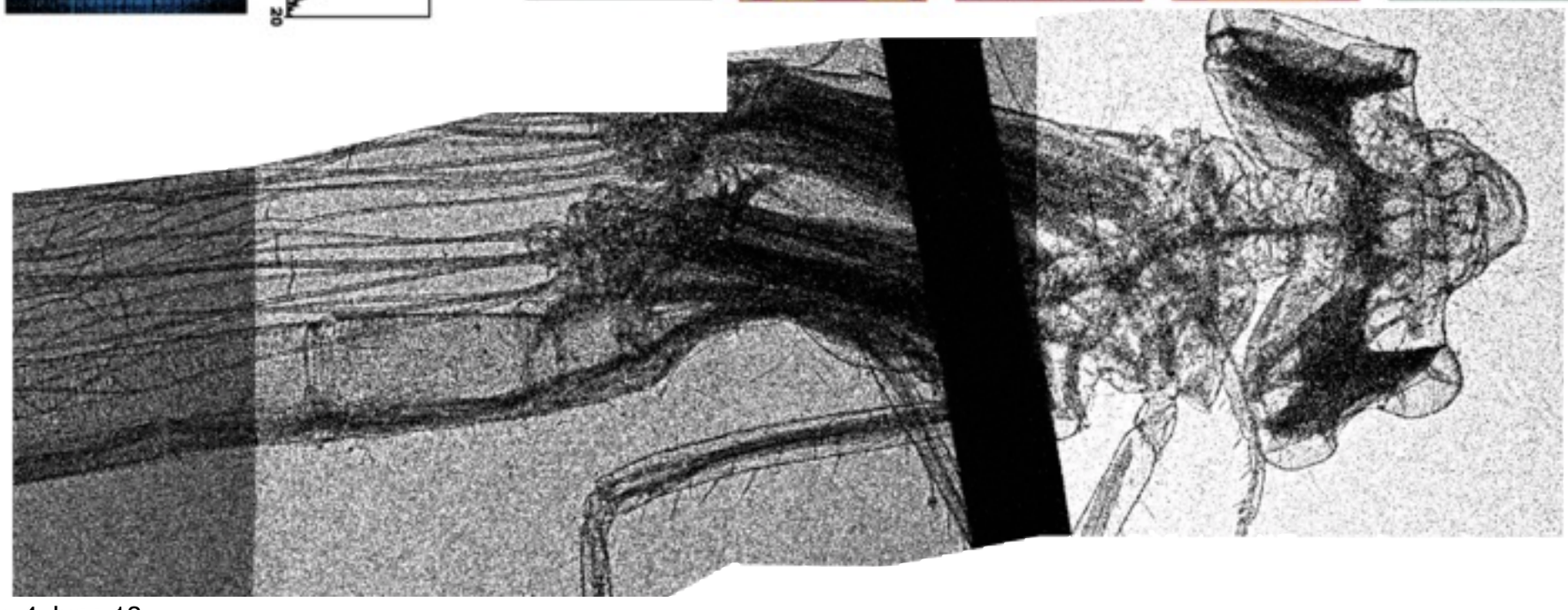


betatron radiation









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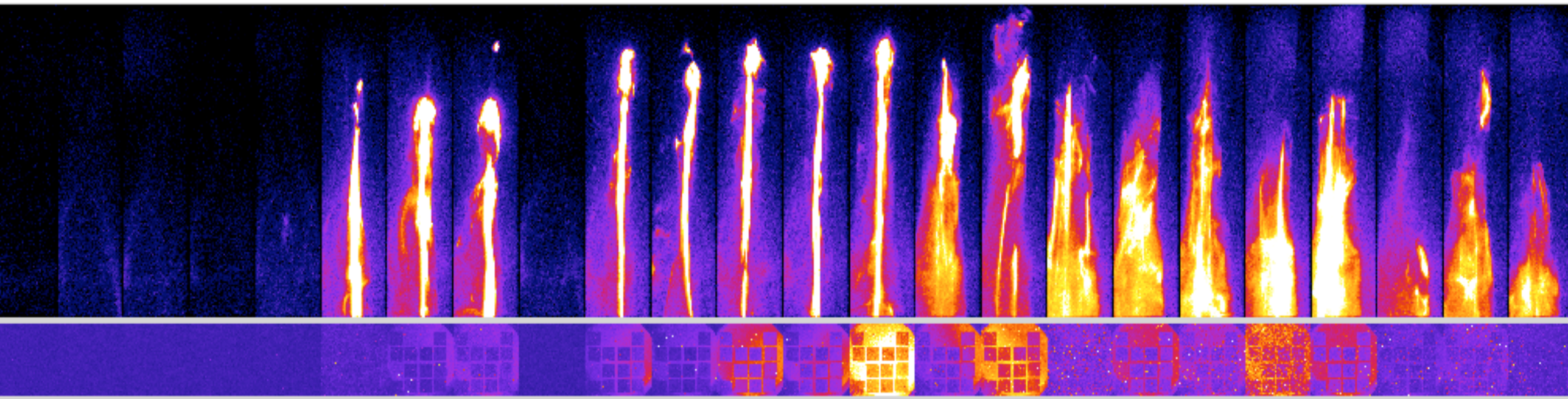
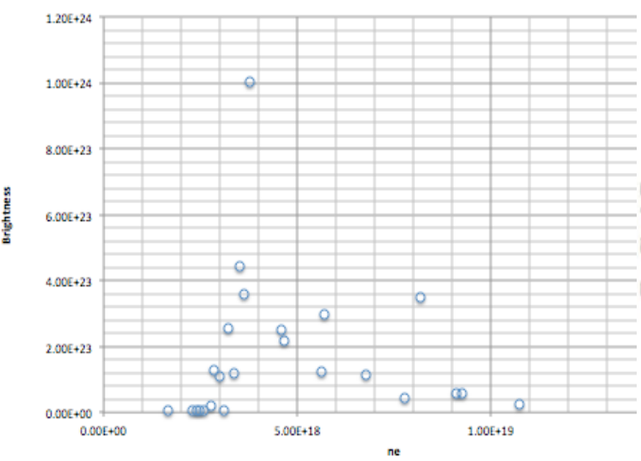
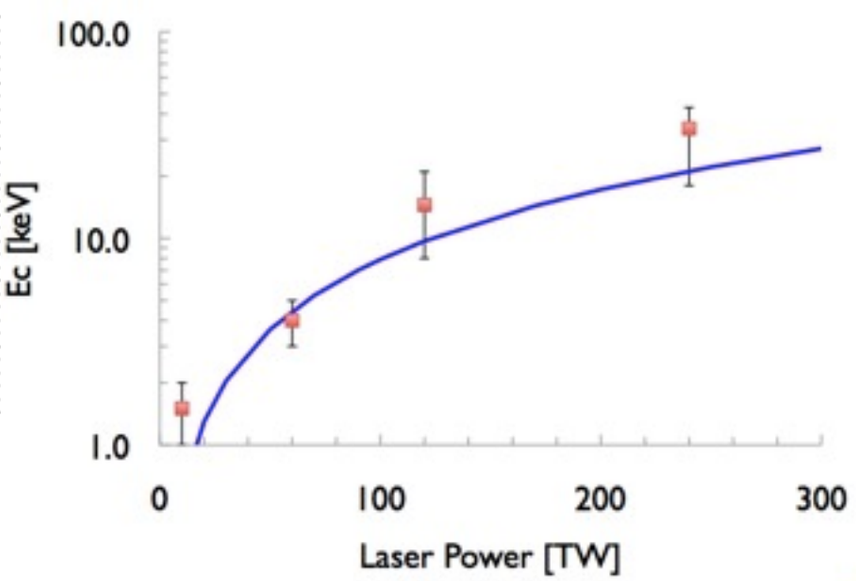
latest Gemini betatron results

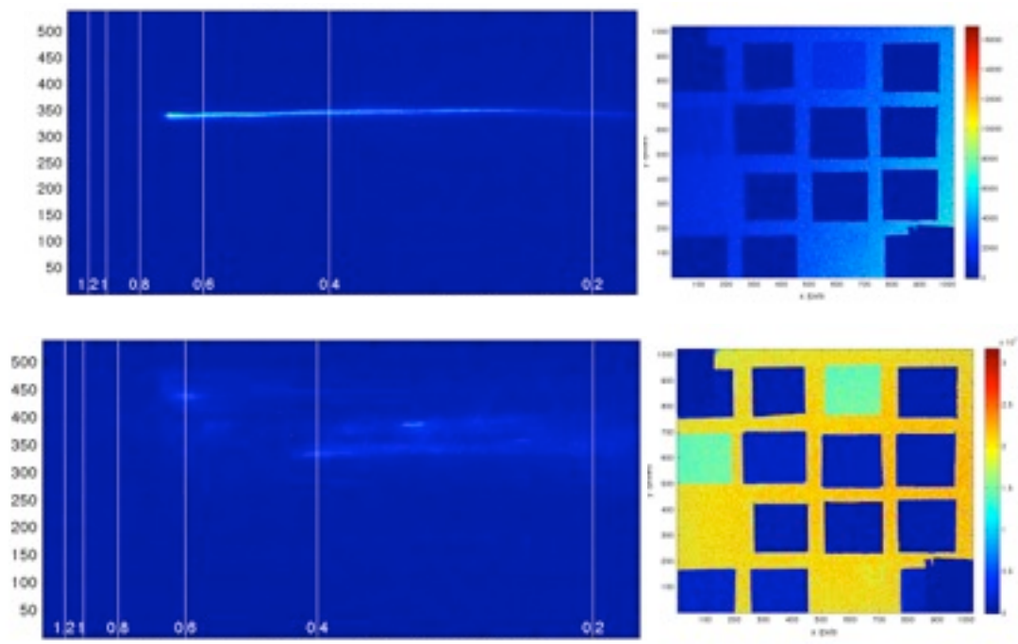






Electron Energy

X-ray filter pack image



- acheta domestica (house cricket)

Conclusions...

Laser and Plasma Accelerator Workshop 2013

Conclusions...

Fort Aguada, Goa, India
2nd-6th September 2013

www.lpaw.net

Laser and Plasma Accelerator Workshop 2013

Conclusions... to be made here

Fort Aguada, Goa, India
2nd-6th September 2013

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