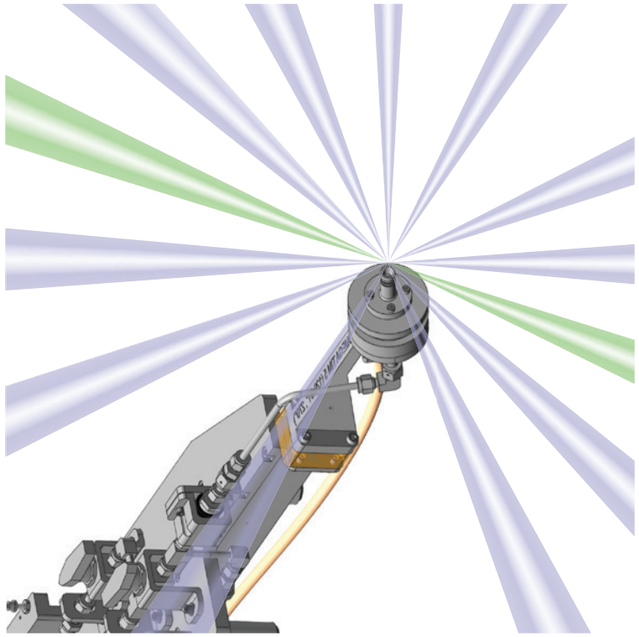
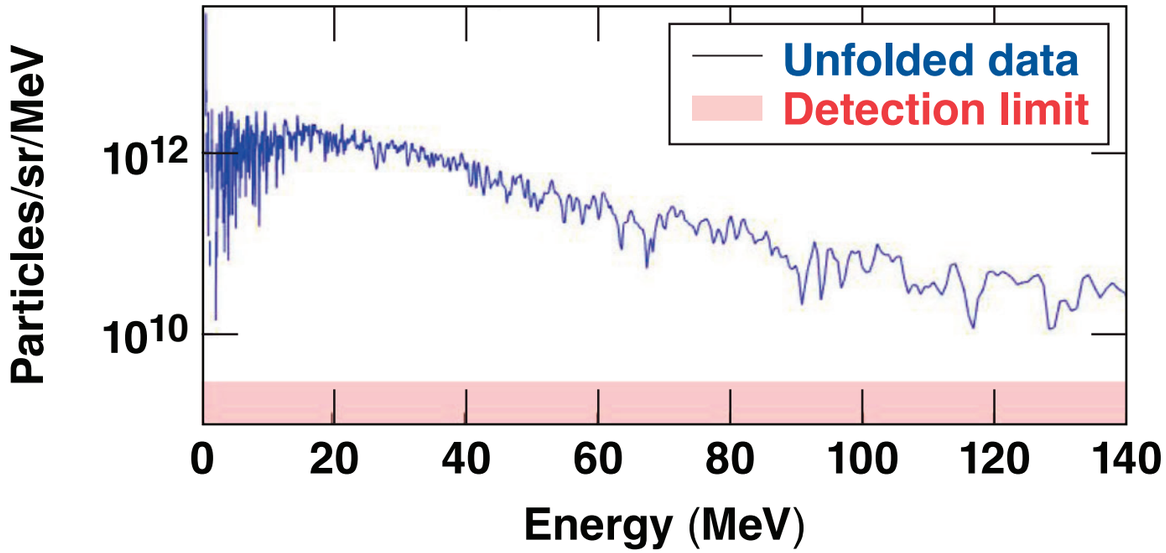
# Laser Wakefield Acceleration Platform for OMEGA EP



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University of Rochester
Laboratory for Laser Energetics

60th Annual Meeting of the
American Physical Society
Division of Plasma Physics
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Summary

# LLE is developing gas-jet capabilities as a platform for advanced radiography sources

- A gas-jet system has been activated for laser wakefield acceleration (LWFA) on OMEGA EP
- Two paths to modified focal geometries are under development
- Preliminary LWFA experiments on OMEGA EP have  produced 100 MeV electron beams

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# Collaborators


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**P. Fan and Y. Lu**

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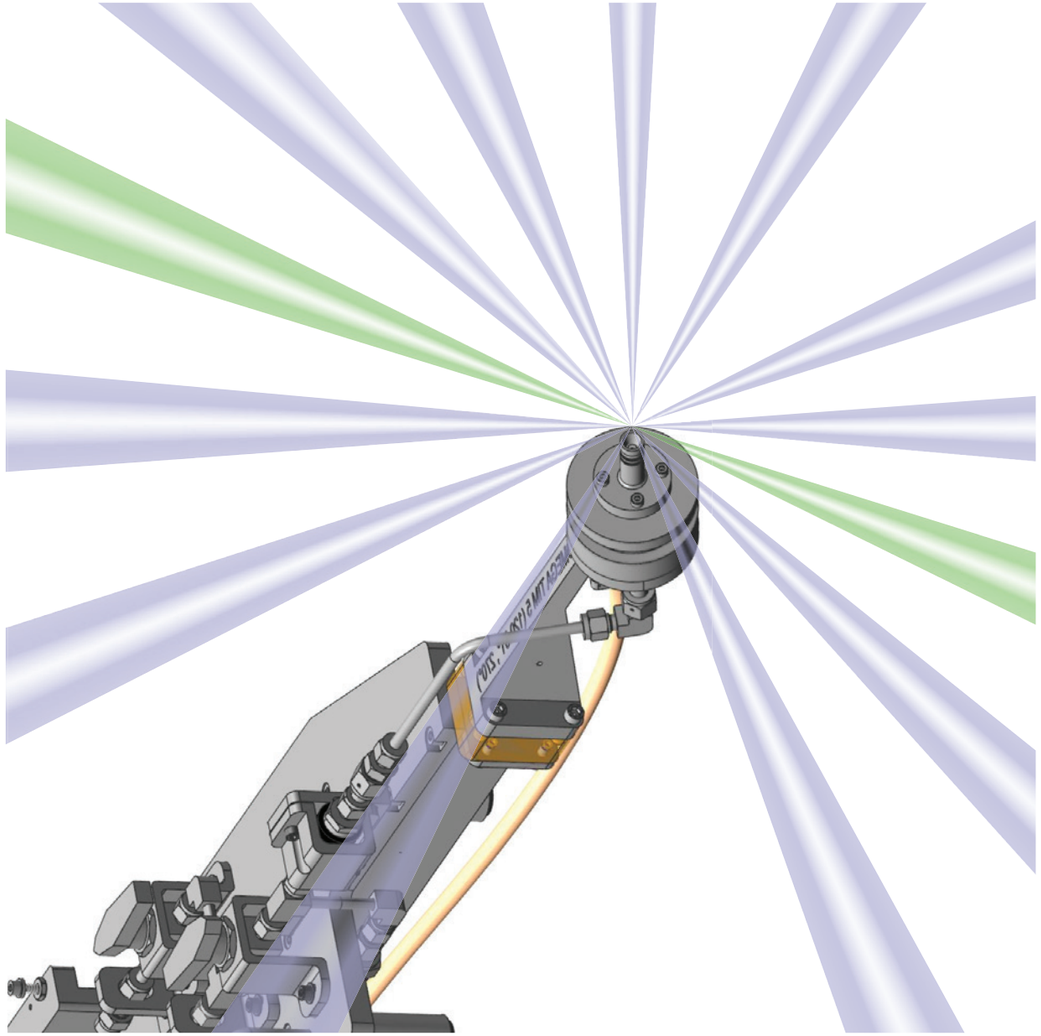
# An ultrafast gas-jet system was developed for use on OMEGA EP

- The gas jet-system was specifically designed to limit gas release in case of failure to protect sensitive electronics in the OMEGA EP compressor
  - maximum gas release in event of total failure: 30 $cm^3$
- The gas-jet valve is fast opening; the gas jet opens and closes in ~100 $\mu$s with a 0.5-Hz repetition rate
- Built by Alameda Applied Sciences Corporation



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# The gas jet has been activated for use on OMEGA and OMEGA EP

| Parameter | Value |
|---|---|
| Systems | OMEGA EP (long* and short** pulse)<br>OMEGA (long† pulse) |
| Mach numbers | 3 to 6 |
| Nozzle diameters | 500 $\mu$m to 10 mm |
| Gas fills | $H_2$, He, $N_2$, Ar, Ne, Kr, Xe, $CO_2$ |
| Fill pressures | Up to 720 psi<br>(Demonstrated densities<br>up to $4 \times 10^{20}$ $cm^{-3}$) |

*PI: D. Haberberger; **PI: J. L. Shaw; †PI: A. Hansen

E27730b

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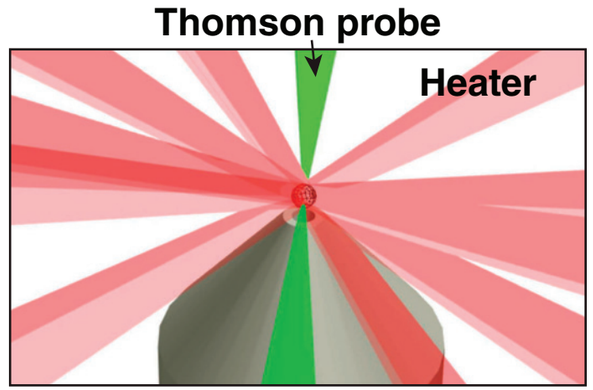


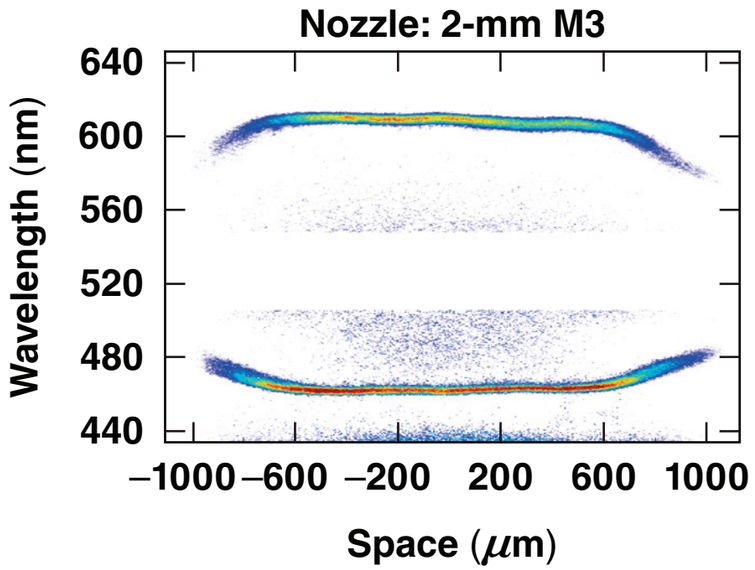


*PI: D. Haberberger; **PI: J. L. Shaw; †PI: A. Hansen

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Path 1

# Apodizer capability is under development to convert OMEGA EP from *f*/2 to longer focal lengths

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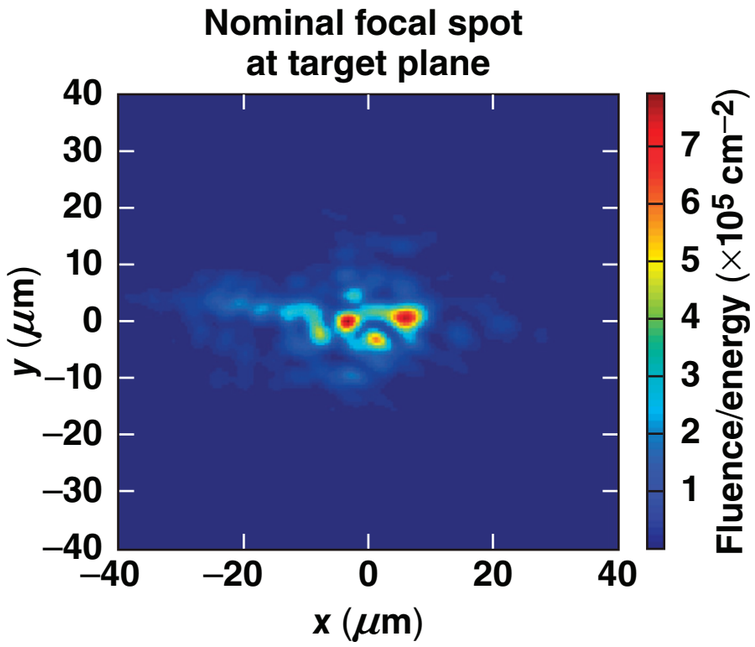
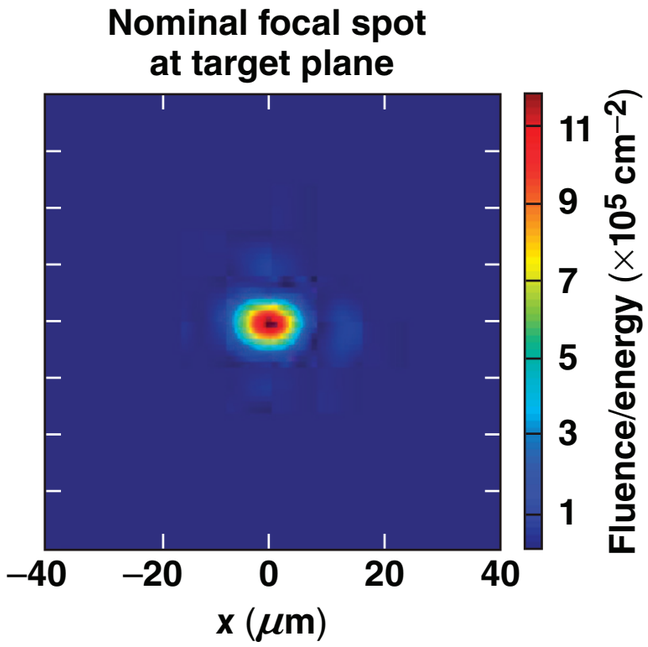
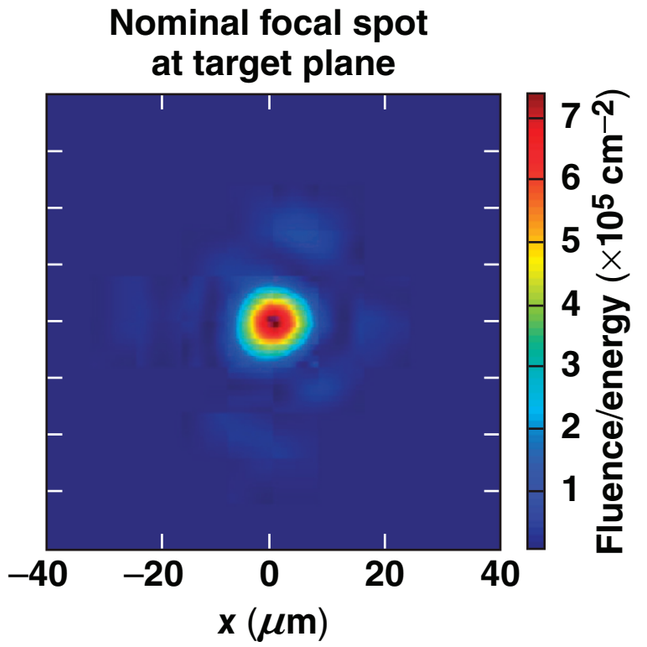
## Standard OMEGA EP *f*/2 focus




## *f*/6 apodizer




## *f*/8 apodizer

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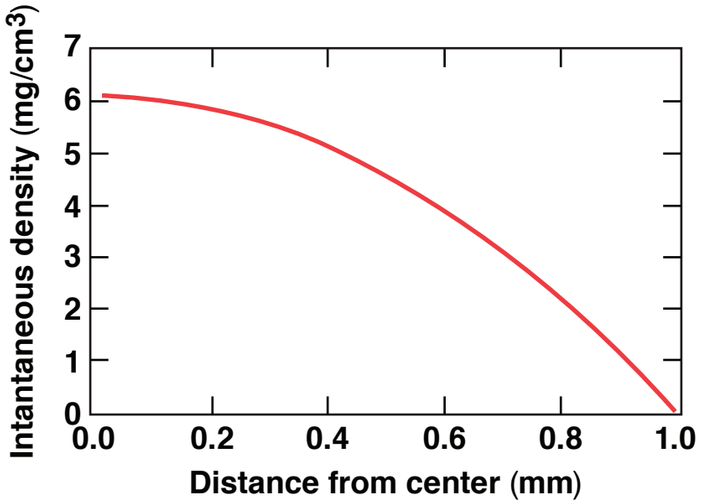
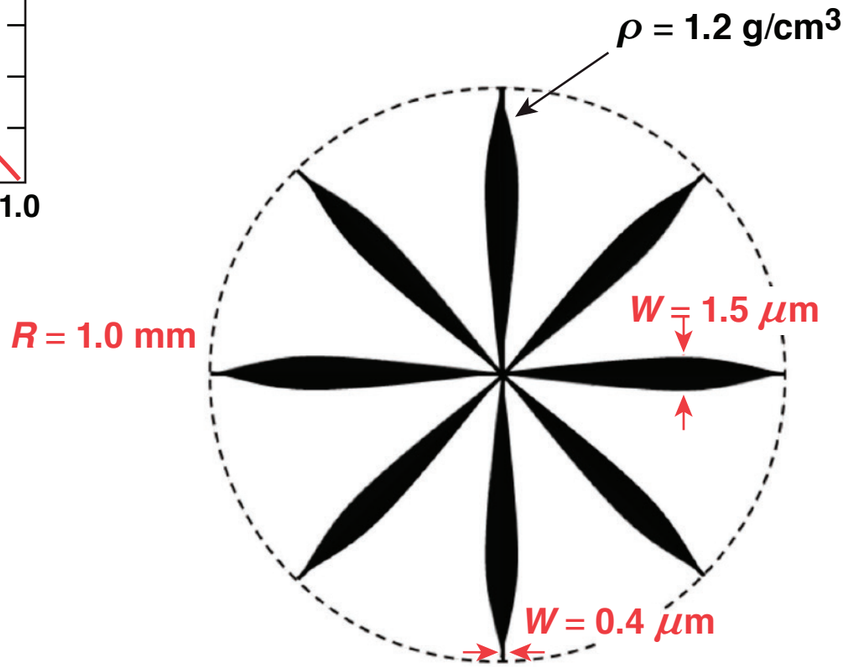
Path 2

# Plasma lenses are also under development to convert OMEGA EP from *f*/2 to longer focal lengths

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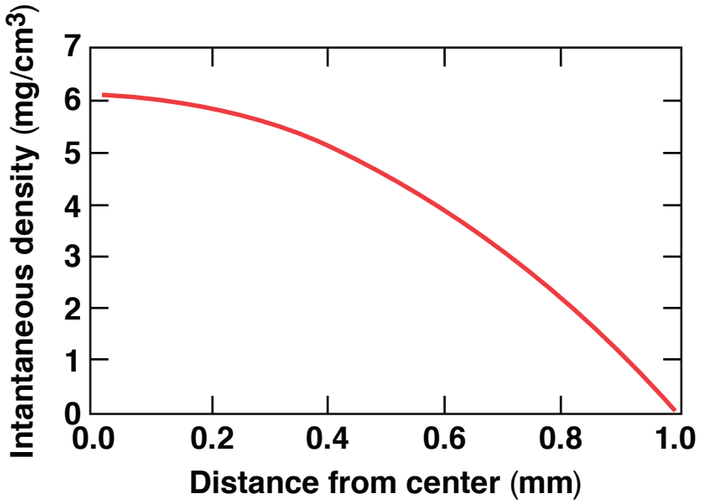
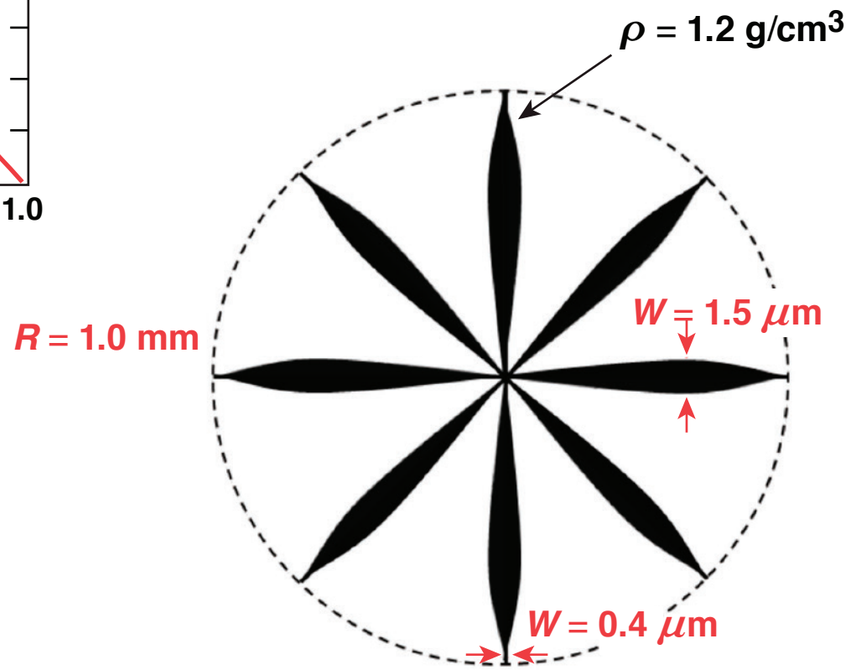
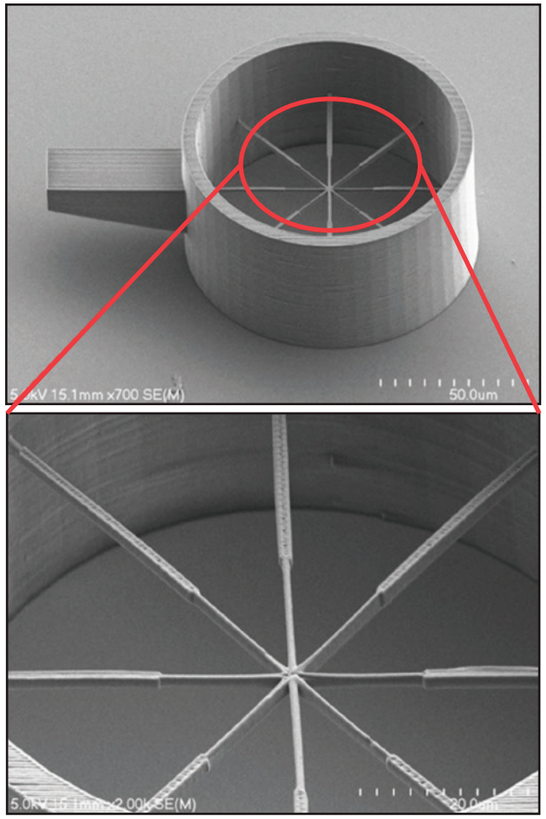


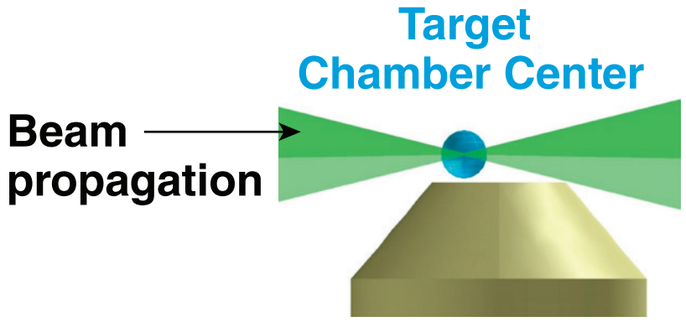



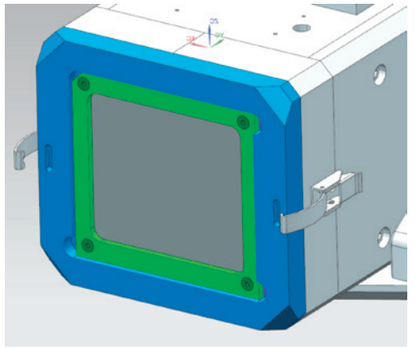
E28129

# Self-modulated laser wakefield accelerator (SMLWFA) experiments with the gas jet were performed on OMEGA EP

| Parameter | Value |
|---|---|
| *f*-number | 6, 8 |
| Pulse length | ~700 fs |
| $a_0$ | 2.6 to 3.2 |
| Nozzle diameter | 4 mm |
| Mach number | 5 |
| Gas | 100% He |
| Density | $1, 3 \times 10^{19}$ cm$^{-3}$ |
| Focal position | 500 $\mu$m |




Modified electron–positron proton spectrometer (EPPS)



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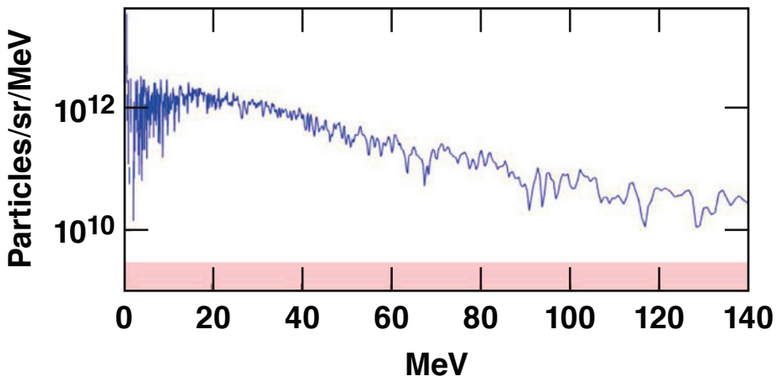
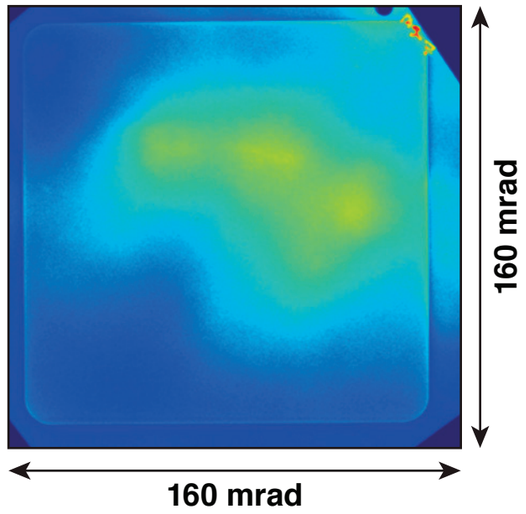
# Preliminary results showed 100-MeV electron beams

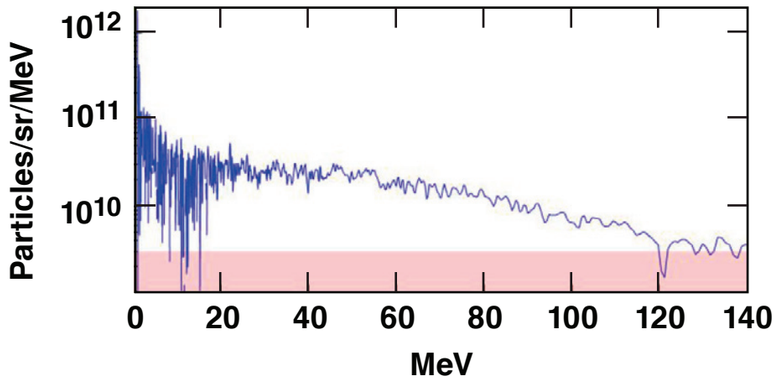
*f*/6, $a_0 = 2.8$, $n_e = 1 \times 10^{19}$ cm$^{-3}$

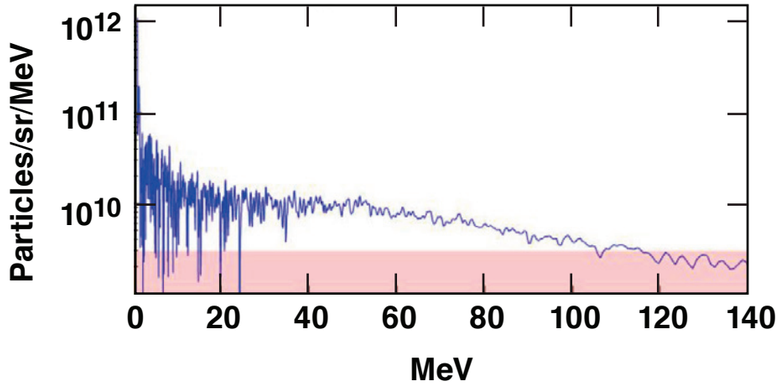







*f*/8, $a_0 = 2.6$ or $3.2$, $n_e = 3 \times 10^{19}$ cm$^{-3}$

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Summary/Conclusions

# LLE is developing gas-jet capabilities as a platform for electron and advanced radiography sources

- A gas-jet system has been activated for laser wakefield acceleration (LWFA) on OMEGA EP
- Two paths to modified focal geometries are under development
- Preliminary LWFA experiments on OMEGA EP have produced 100 MeV electron beams

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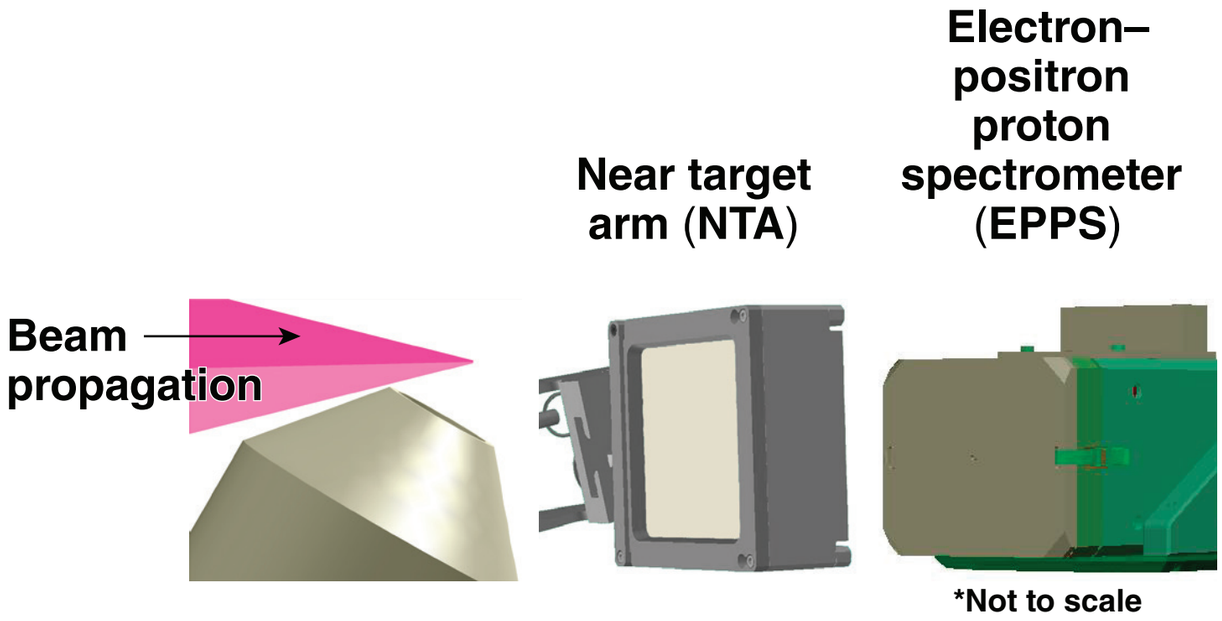
# Acknowledgements


**This material is based upon work supported by the U.S. Department of Energy/National Science Foundation under Award # DE-SC0017950, and by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0001944.**

E27737

# Initial self-modulated laser wakefield accelerator (SMLWFA) experiments with the gas jet were performed on OMEGA EP

| Parameter | Value |
|---|---|
| *f*-number | ~2 |
| Pulse length | 600 to 800 fs |
| Laser energy | 60 J, 300 J |
| $a_0$ | 4, 9.6 |
| Nozzle diameter | 1 mm, 4 mm |
| Mach number | 5 |
| Gas | 95/5 He/$N_2$ or 100% He |
| Fill pressure | 65 to 410 psi |
| Density | $8 \times 10^{18}$ to $3 \times 10^{19}$ $cm^{-3}$ |
| Focal position | –100 to 500 $\mu$m |

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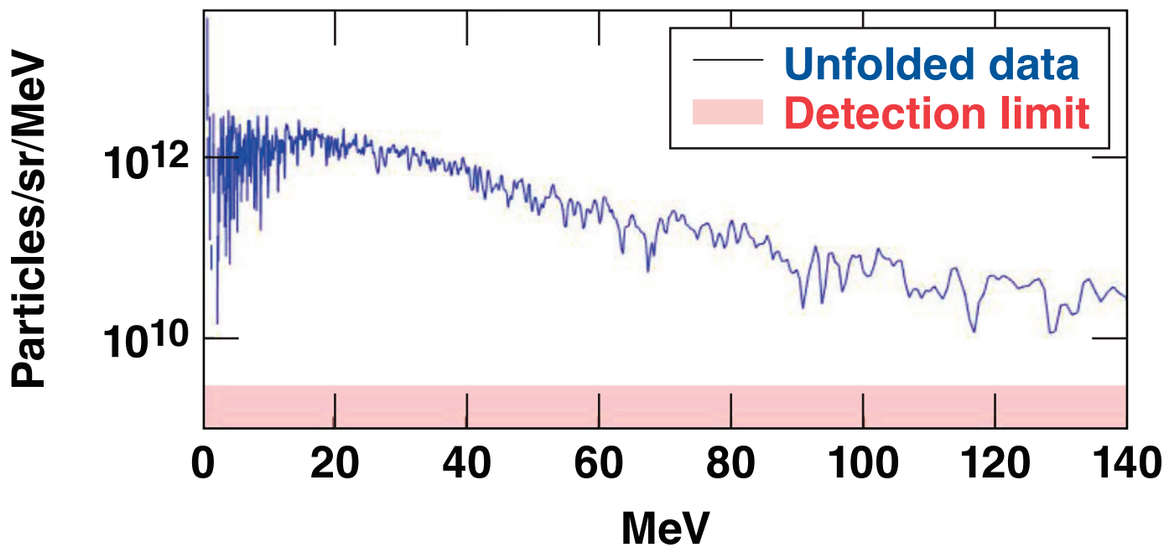
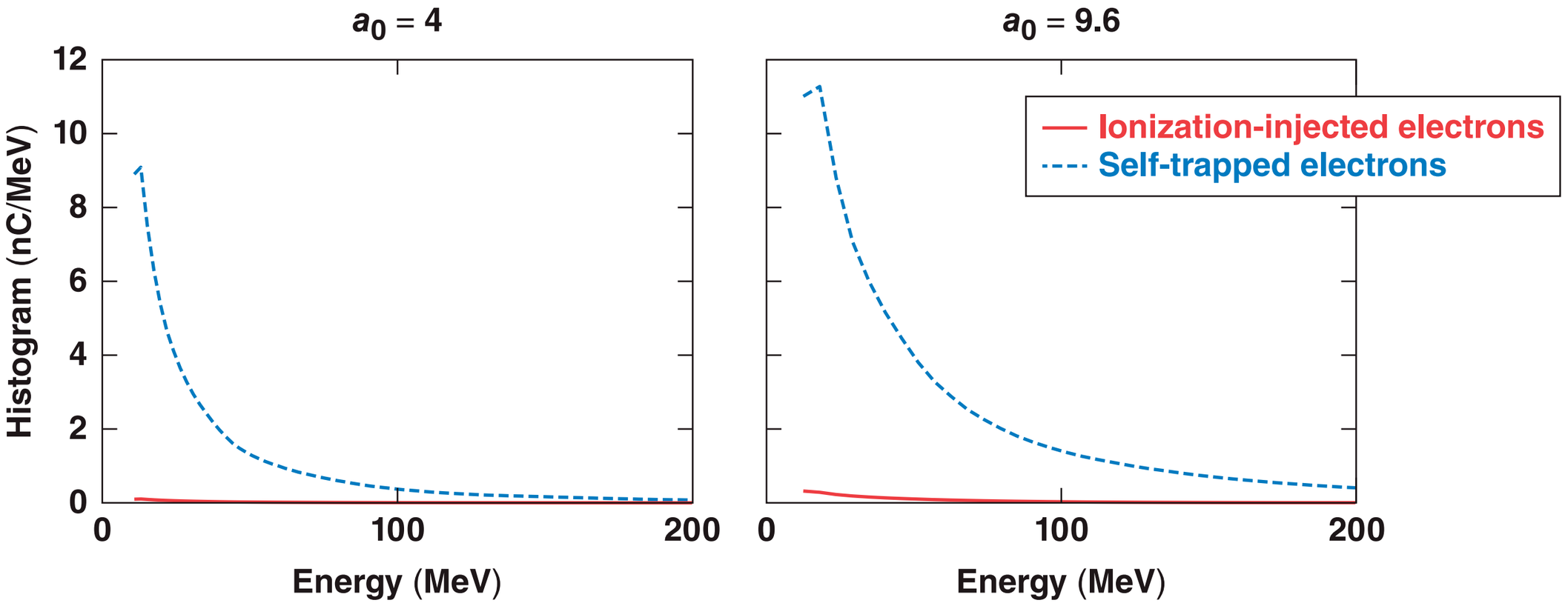
# Initial results showed a significant difference based on shot energy

- For shot energies of 60 J ($a_0 = 4$), no electrons with energies above 1 MeV were produced
- For shot energies of 300 J ($a_0 = 9.6$), electrons were observed
  - cutoff energies of ~8 MeV for 1-mm-diam nozzles
  - cutoff energies of ~14 MeV for 4-mm-diam nozzles




E27717b

# *OSIRIS* simulations were used to investigate the low-electron energies

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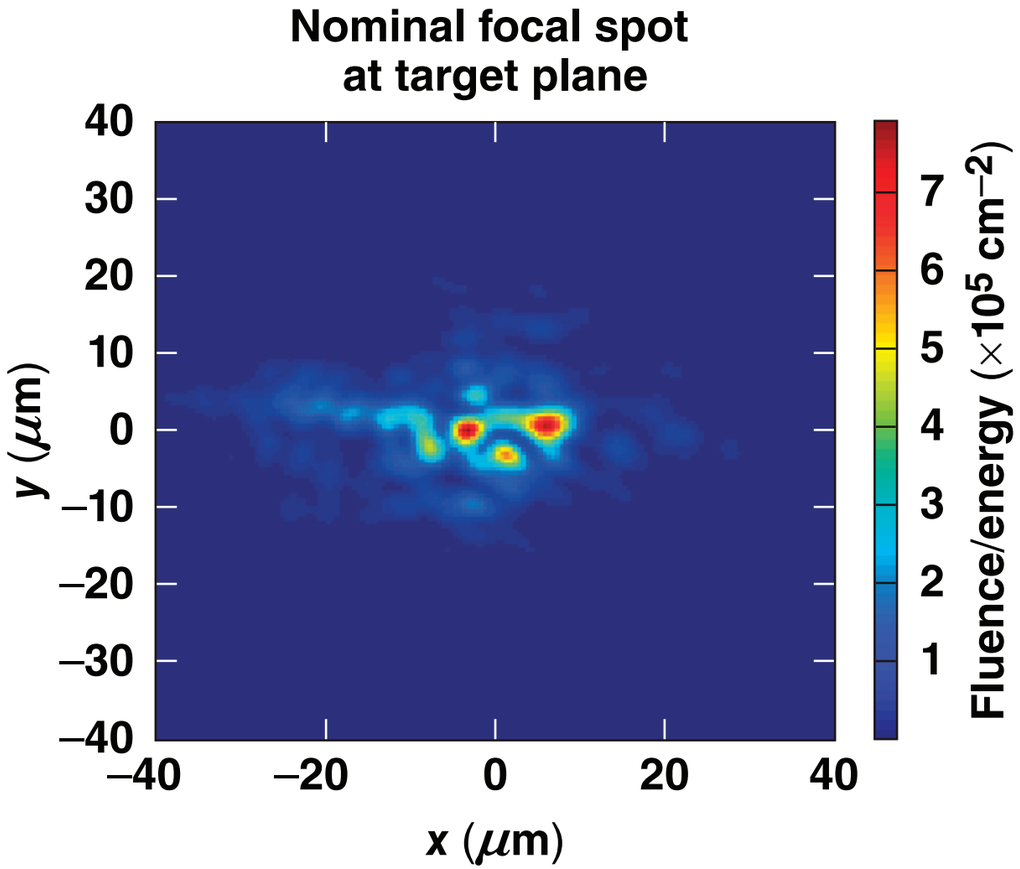
# Focal geometry of OMEGA EP needs to be better modeled in *OSIRIS*

- **OMEGA EP: focal geometry ~*f*/# = 2; the laser spot is not very clean for LWFA applications**
- ***OSIRIS*: focuses to the given laser spot using ideal Gaussian beam**




**The discrepancy between experimental results and simulation likely results from this difference.**

E27733