Towards High Brightness from Plasmon-Enhanced Photoemitters

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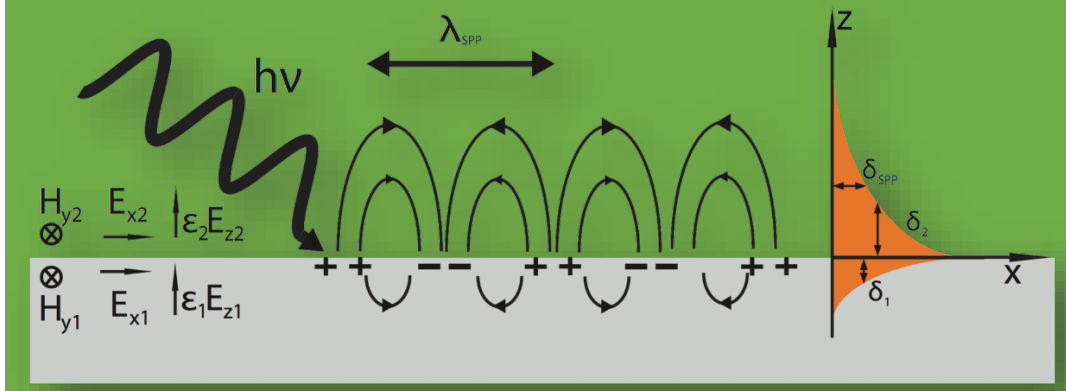
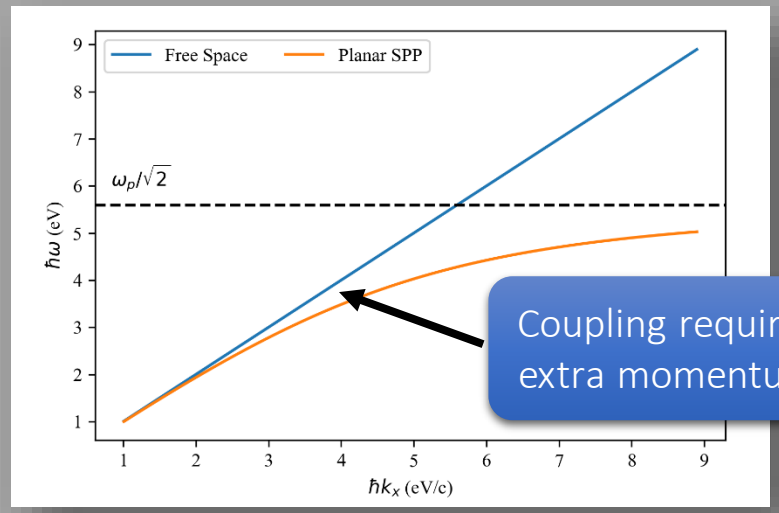
Focusing to Combine Benefit of Tip and Flat Emitters

Surface Plasmon-Polariton



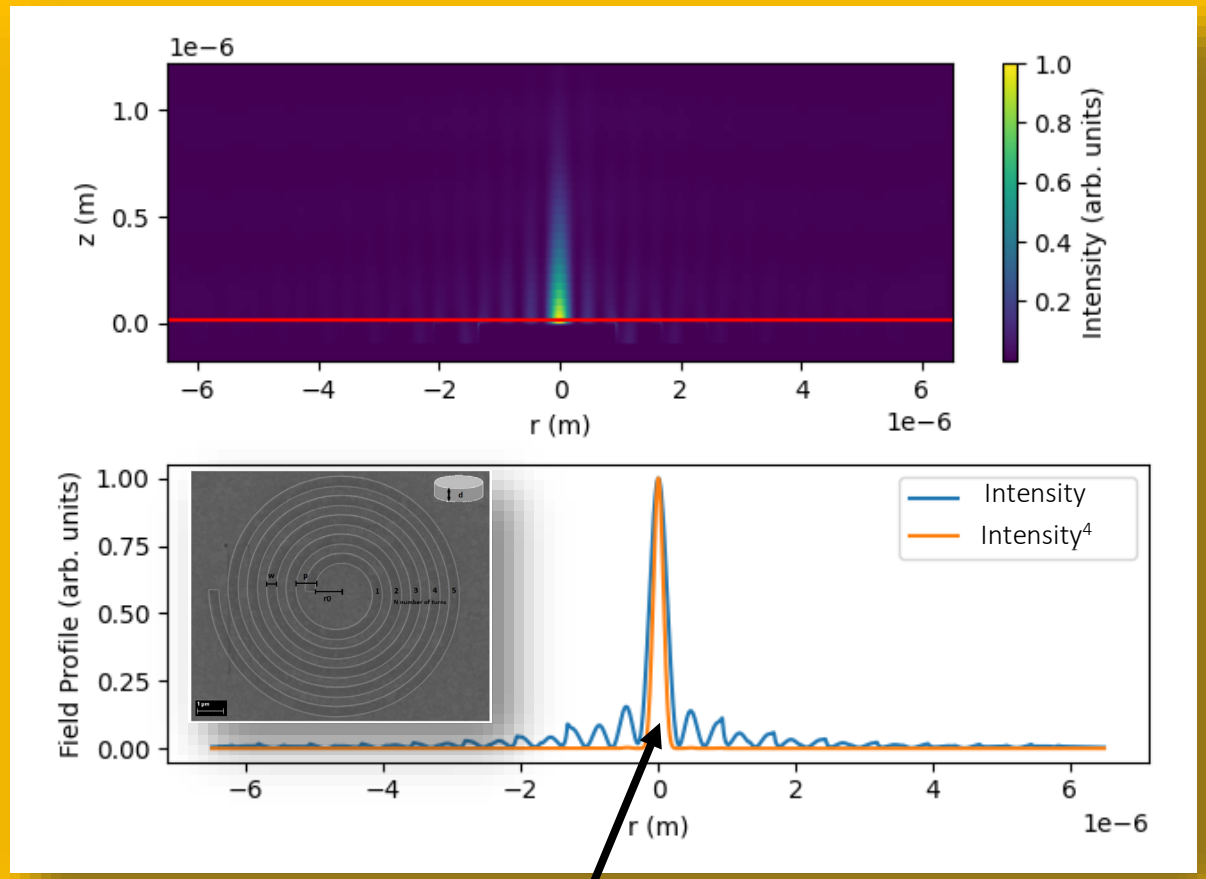
Wikimedia - Anil Thilsted

Dispersion to Right of Light Line



Coupling requires extra momentum

Plasmonic Lens for Sub-Wavelength Emission on Flat Surface

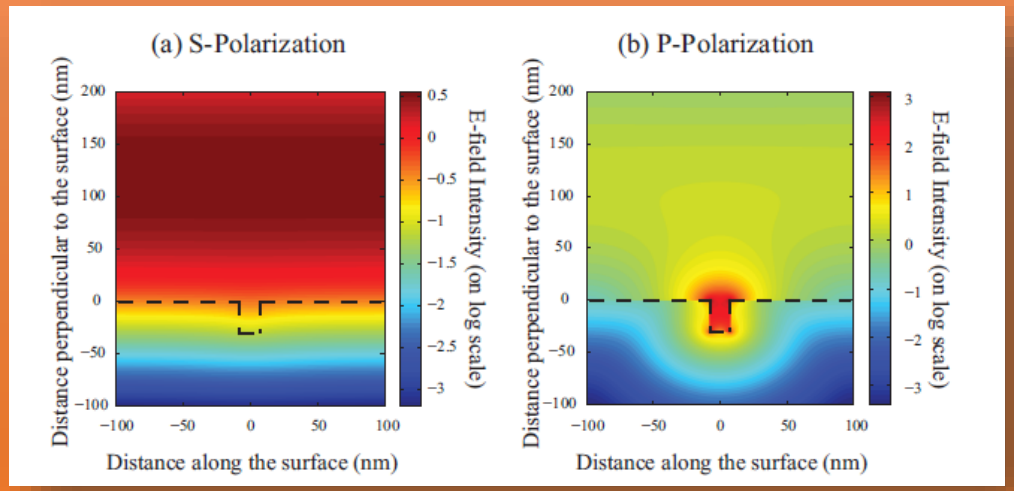


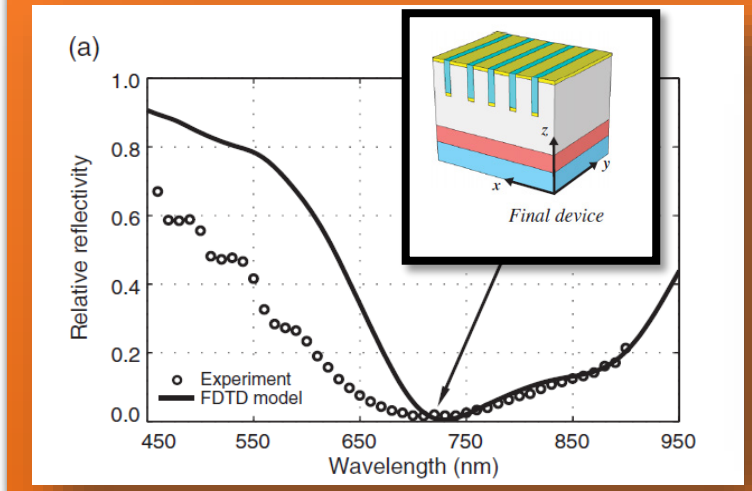
Durham, D. B., Riminucci, F., Ciabattini, F., Mostacci, A., Minor, A. M., Cabrini, S., & Filippetto, D. (2019. *PRA*, *12*(5), 054057.

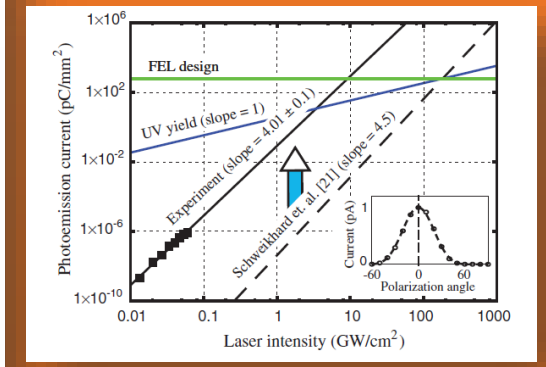
Non-linear photoemission shrinks source size further (estimate ~150nm with practical structures)

Plasmonic Cathodes Improve Nonlinear Yield

Nanogrooves Increase Intensity and Enhance Yield by 10^6

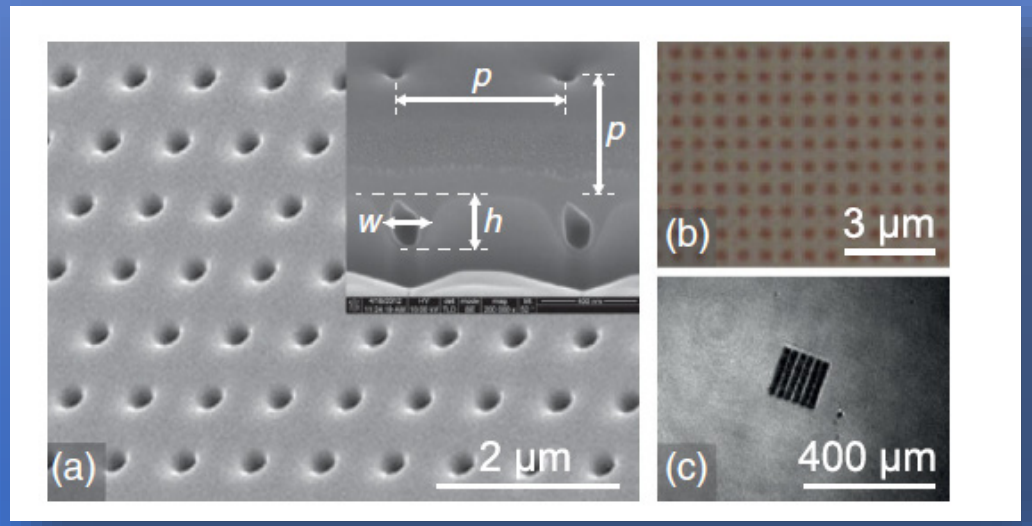






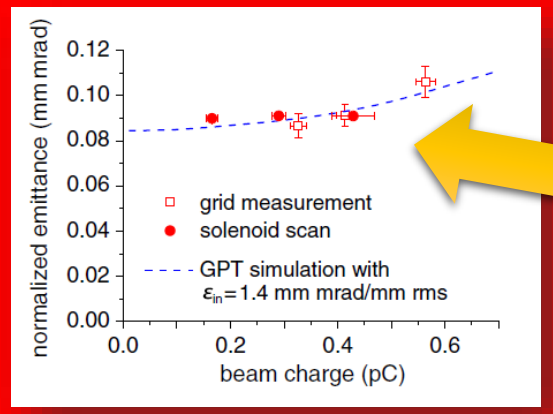
Polyakov, A., et al. (2013). *PRL*, *110*(7), 076802.

2D Grid Shows Similar Improvements



Li, R. K., et al. (2013). *PRL*, *110*(7), 074801.

First Emittance Measurements from 2D Grid



Roughness inflates MTE to 1eV

High-Q Nanogrooves Are First Stop in Campaign

Template Stripping Fabrication

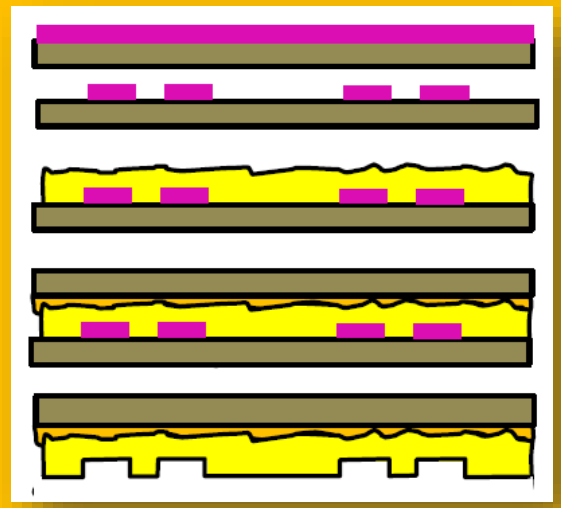
Deposit e-beam resist

Expose Pattern

Evaporate Gold

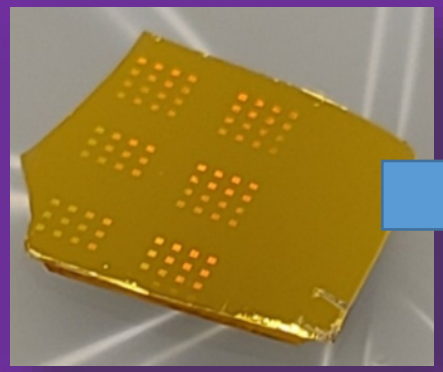
Attach to Substrate with Epoxy

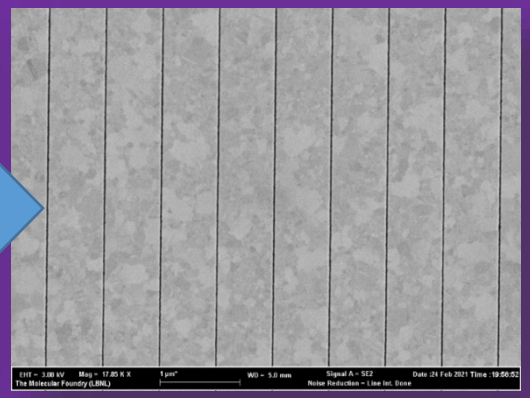
Peel off of Template



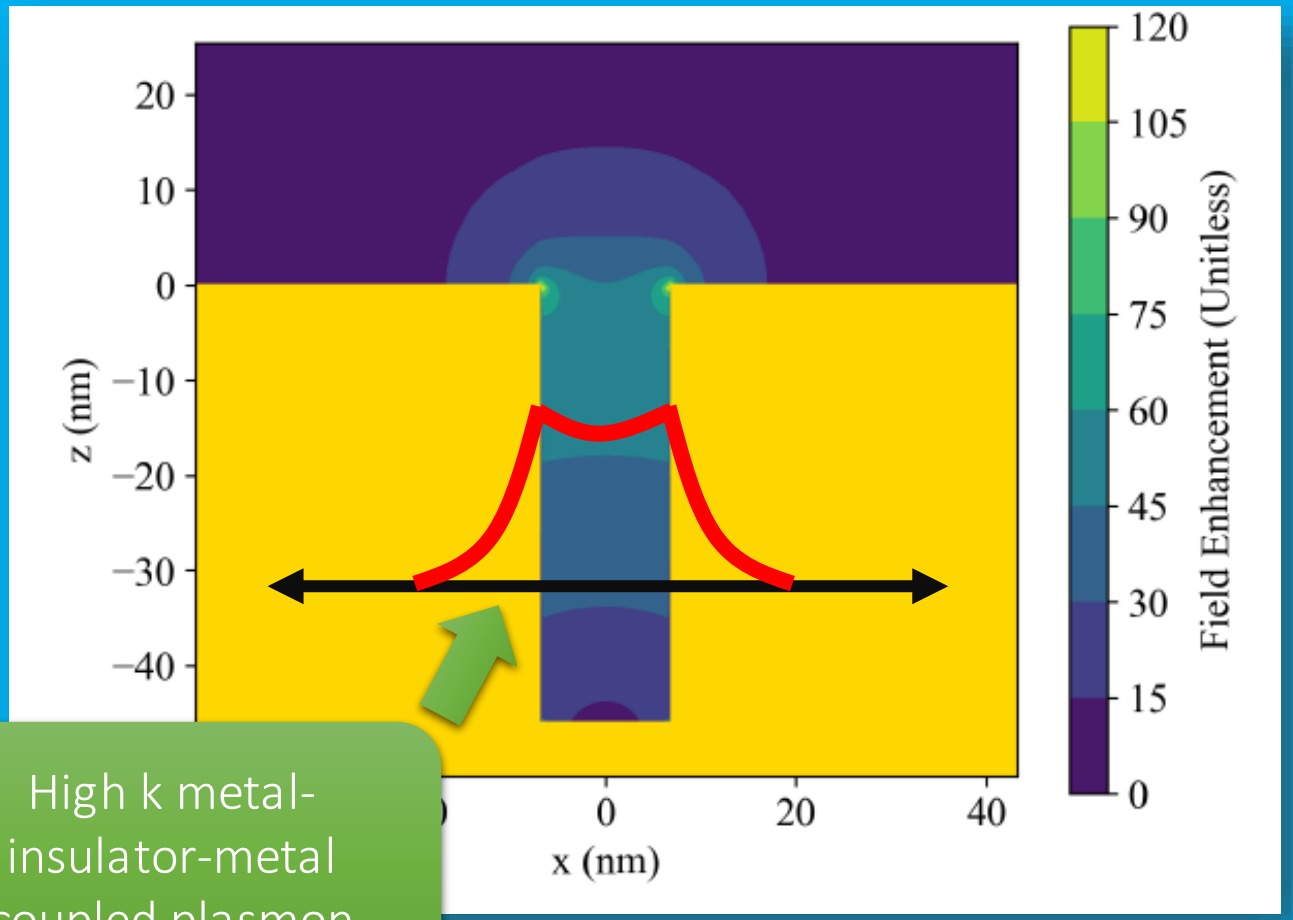
Filippetto, D. (2018, October). Photocathode Physics for Photoinjectors, New Mexico.

Fabricated Cathode



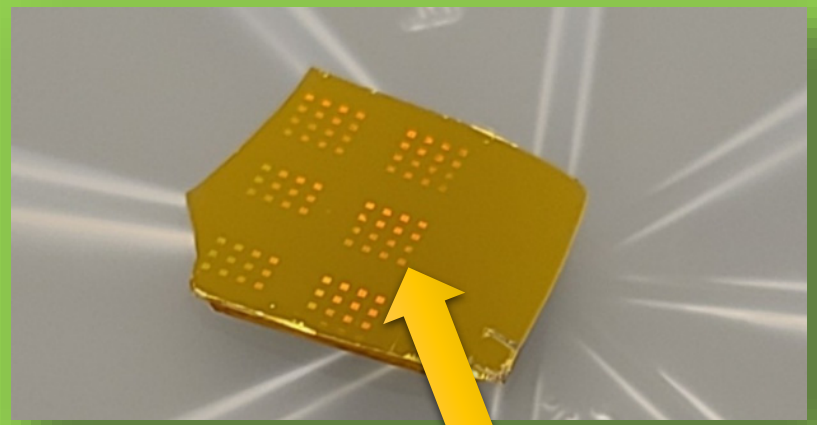


High Field Enhancement from Short λ Plasmon

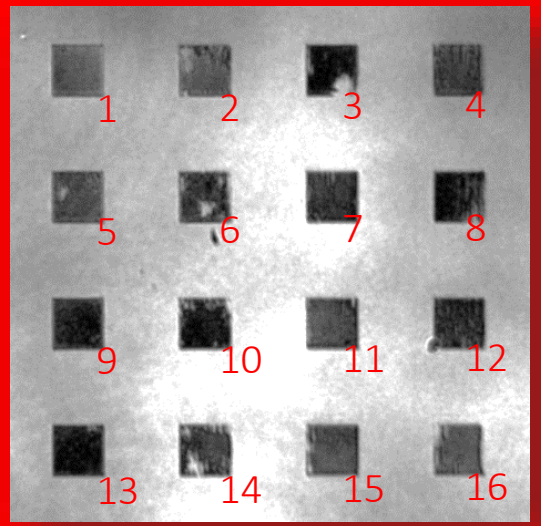


High k metal-insulator-metal coupled plasmon

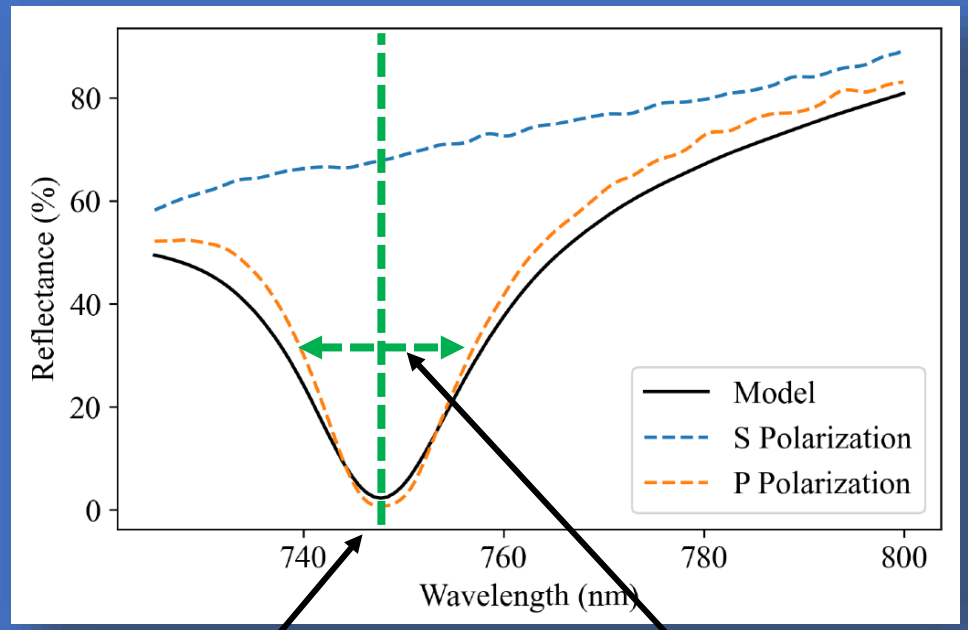
Optical Properties Match Expectations

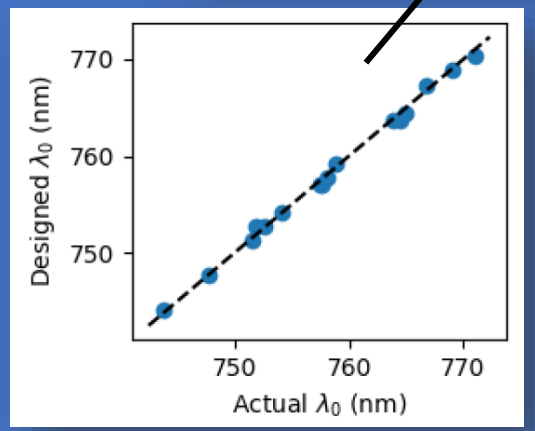


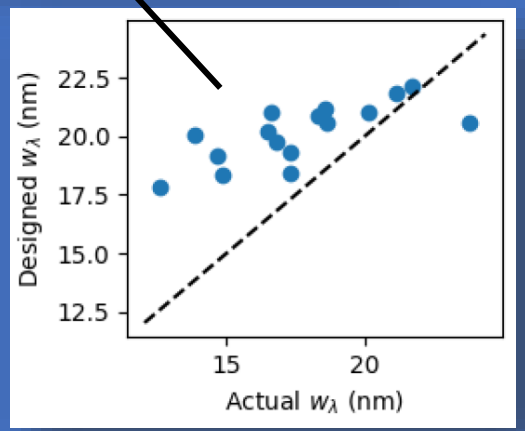
Reflection Mode Imaging



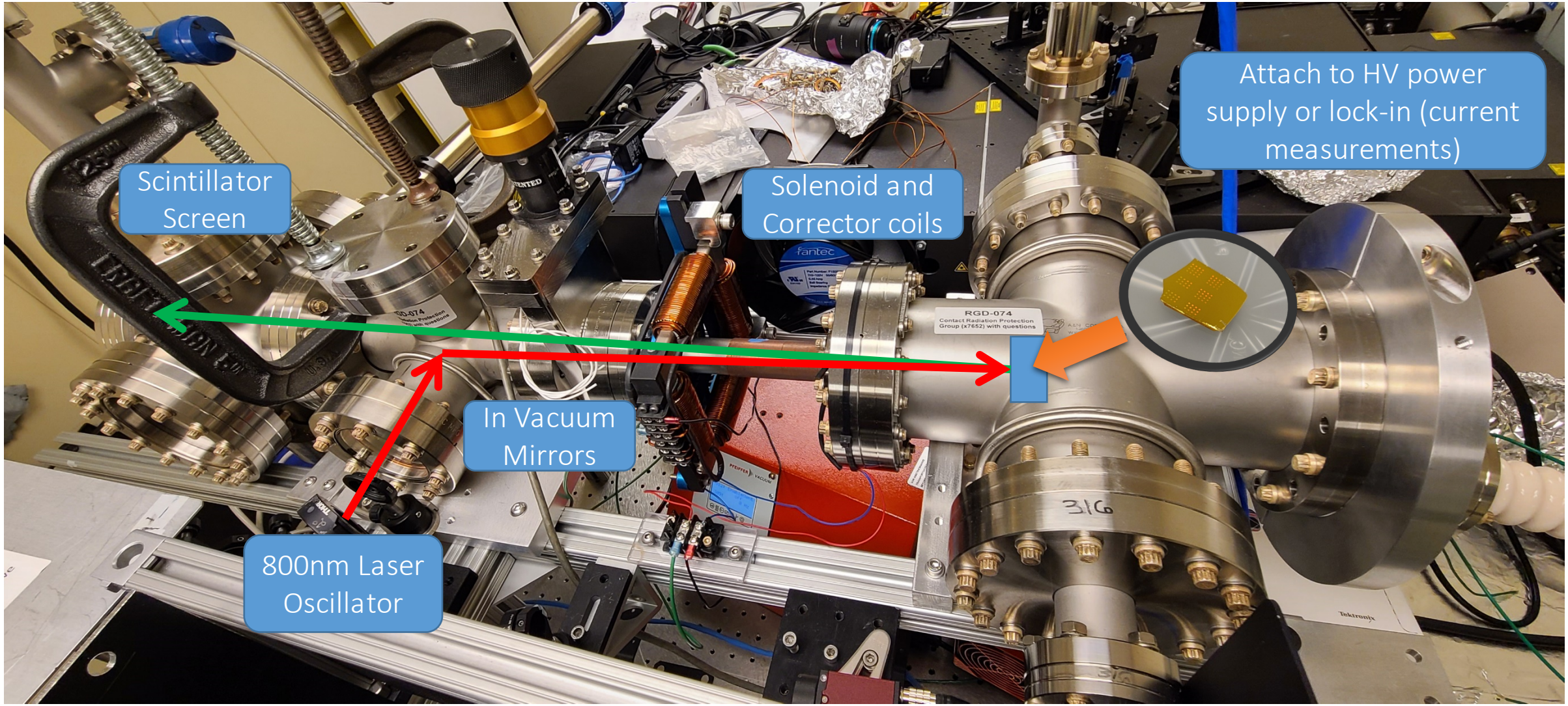
Reflection Spectroscopy





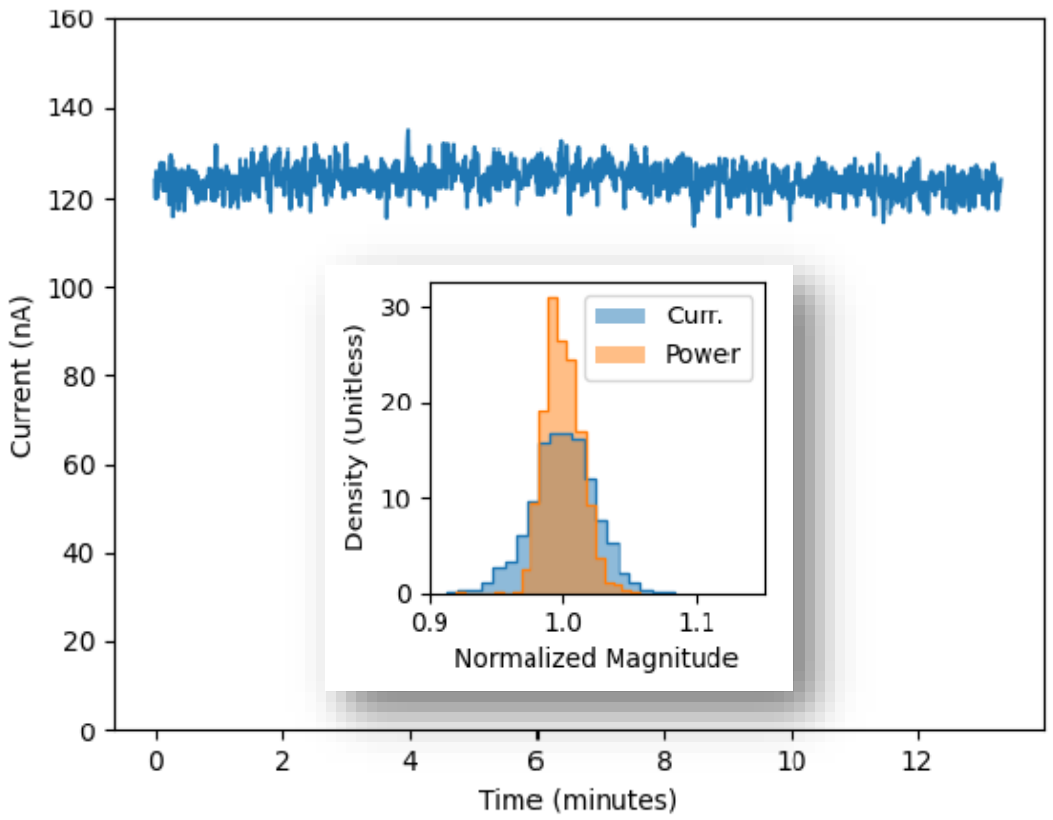


Low Voltage Gun is Used for Current / Emittance

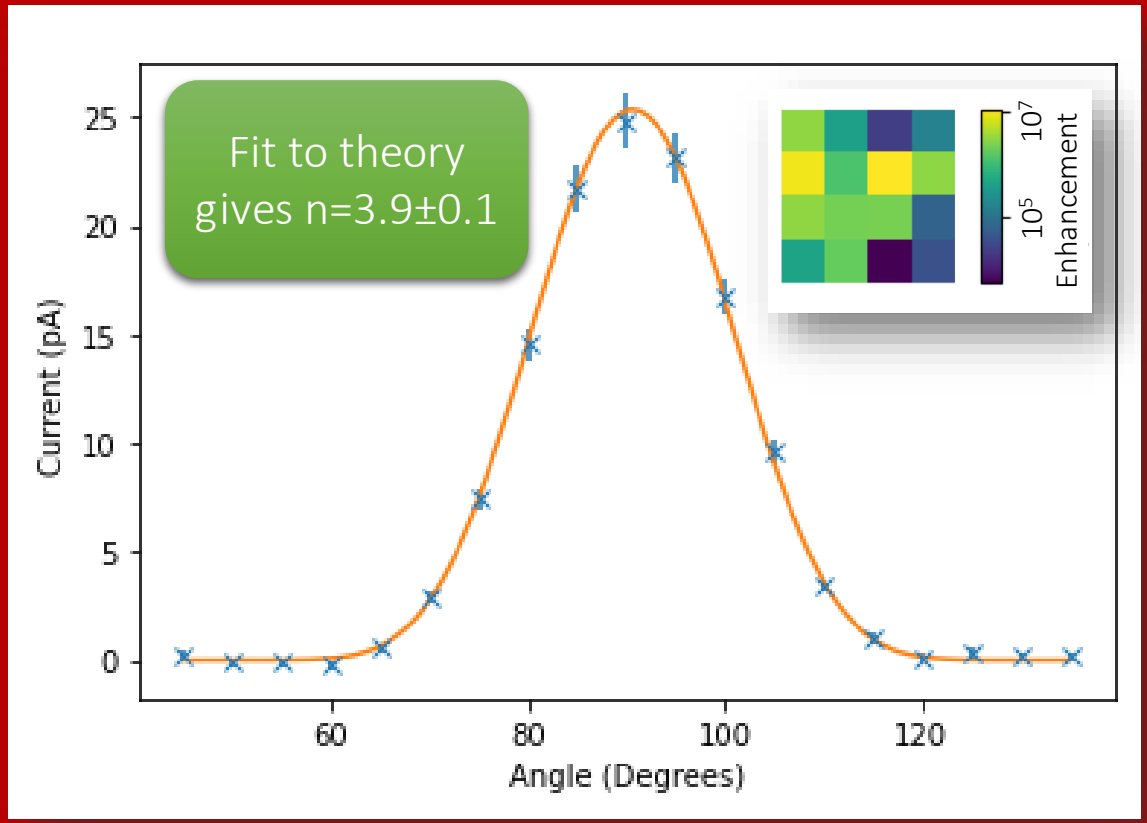


Current Measurements are Stable and Match Theory

Stable Emission and No Damage at ~1 GW/cm^2 Intensities

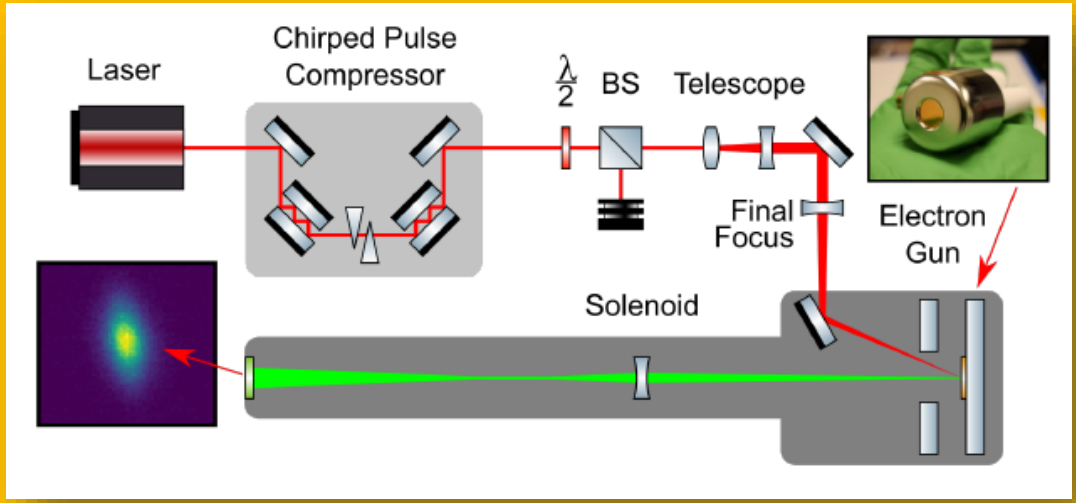


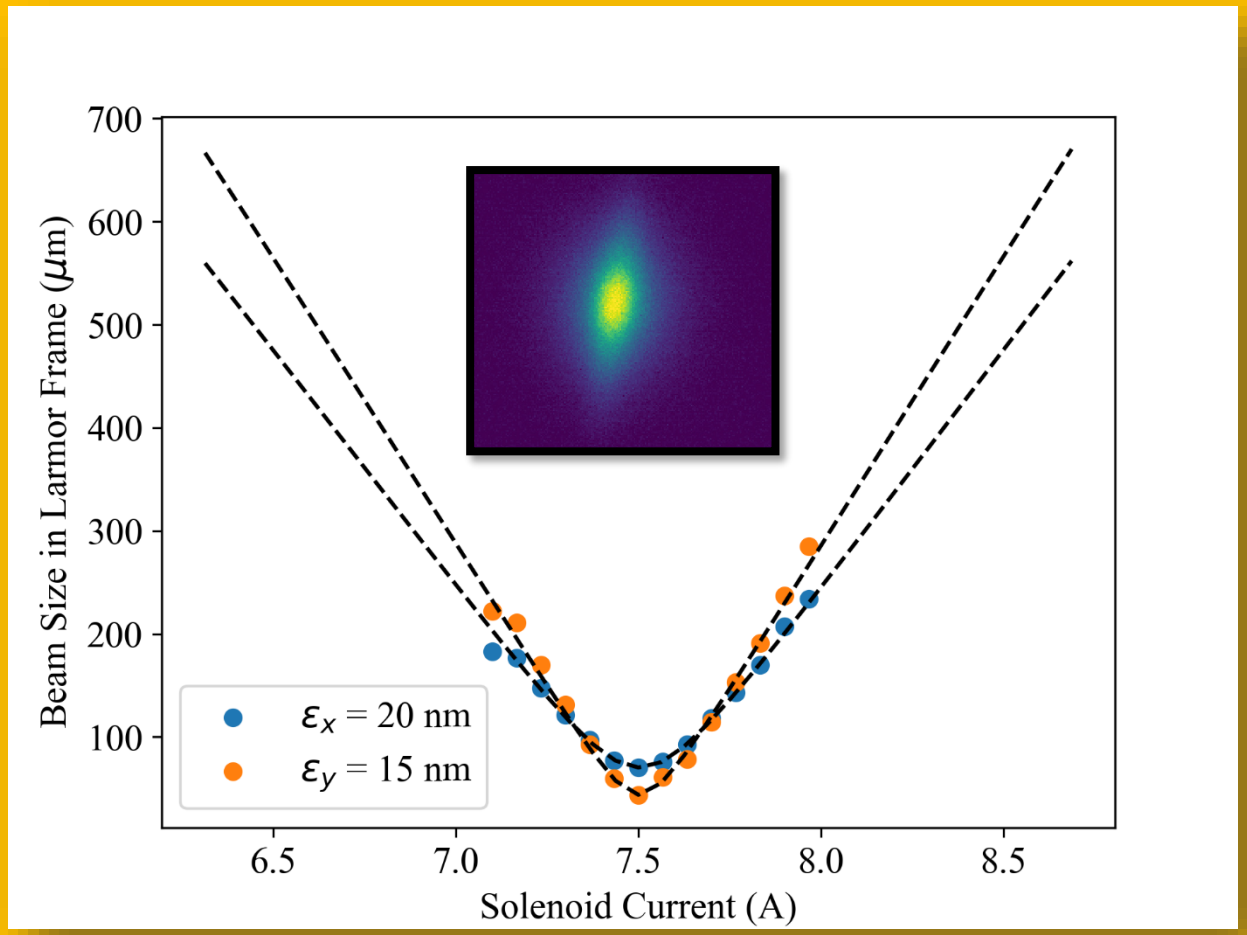
Polarization Dependence Indicates Plasmonic Enhancement



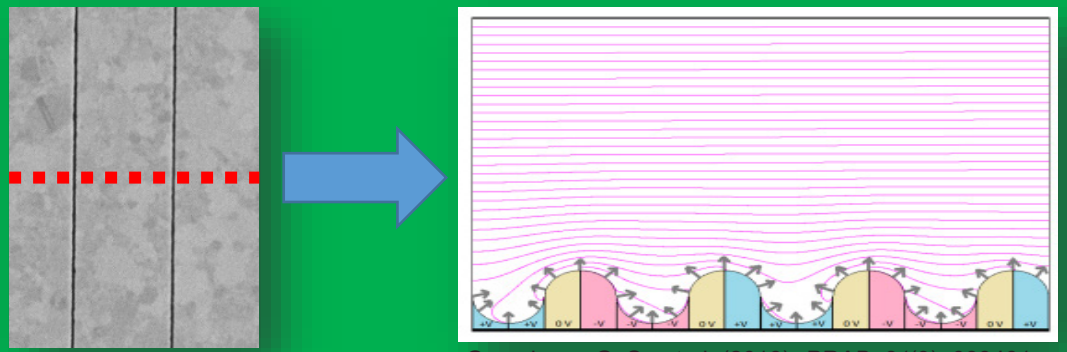
Thermal Emittance of Nanopatterned Cathode

Strong Emittance Asymmetry





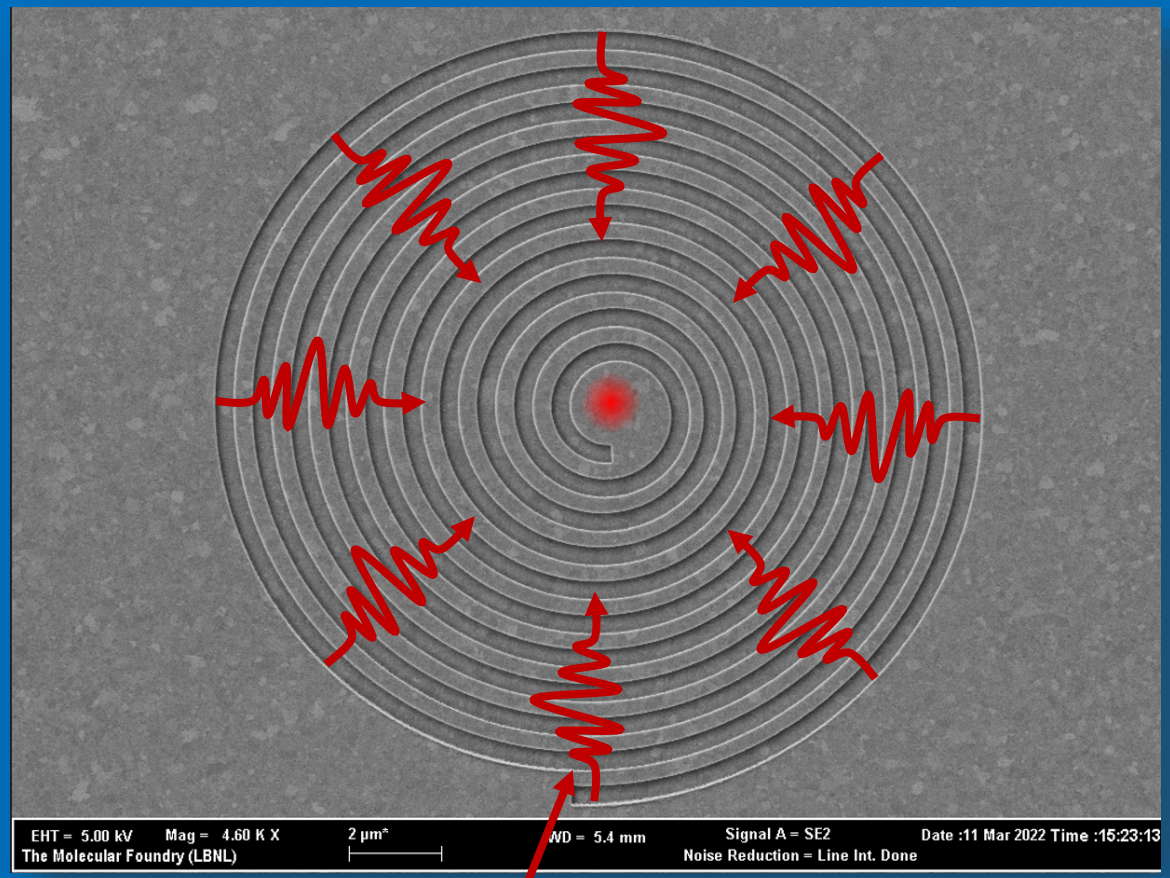
Surface Roughness offers Explanation



Gevorkyan, G. S., et al. (2018). *PRAB*, *21*(9), 093401.

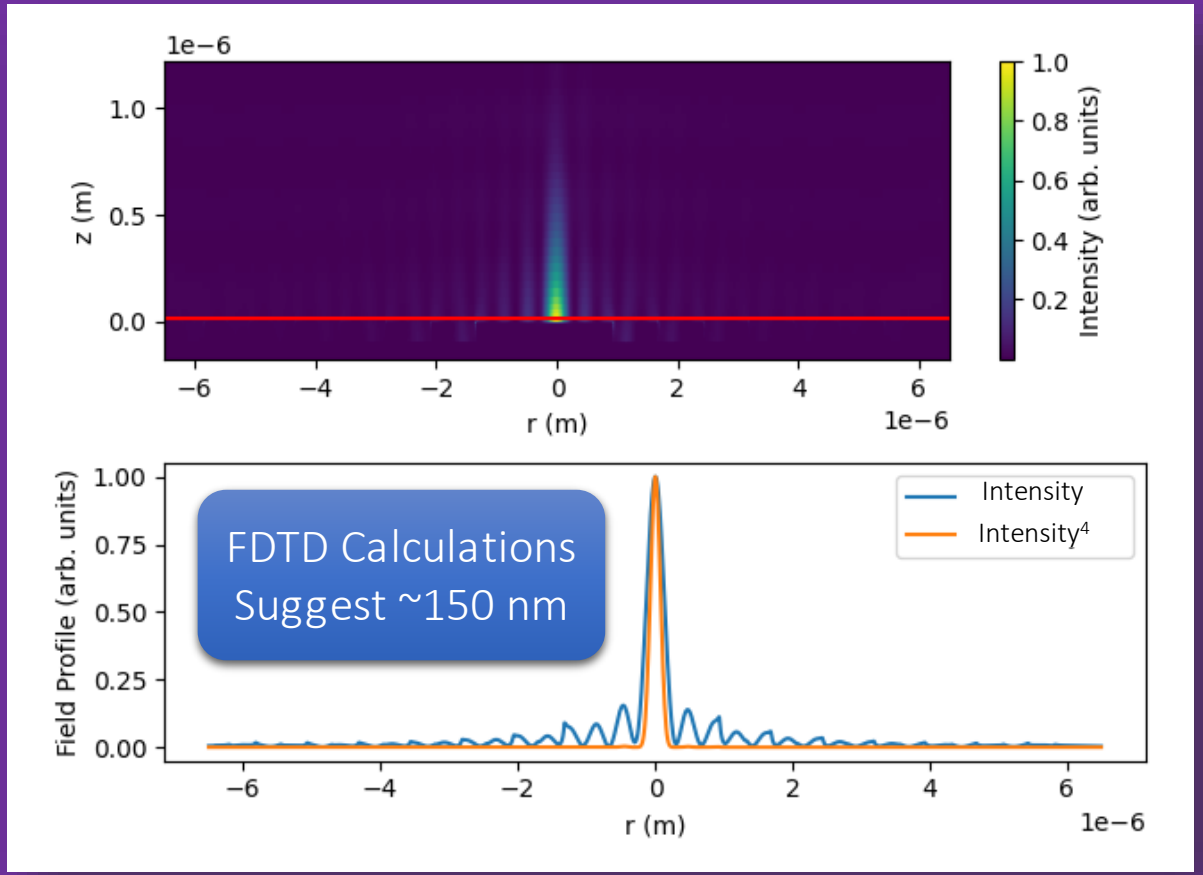
Spiral Nanolens for Small Source Sizes

For circularly polarized light, spiral structure ensures plasmons arrive in-phase at center



Trench Spacing = Plasmon Wavelength

Nonlinearity further shrinks small source size due to diffractive lens



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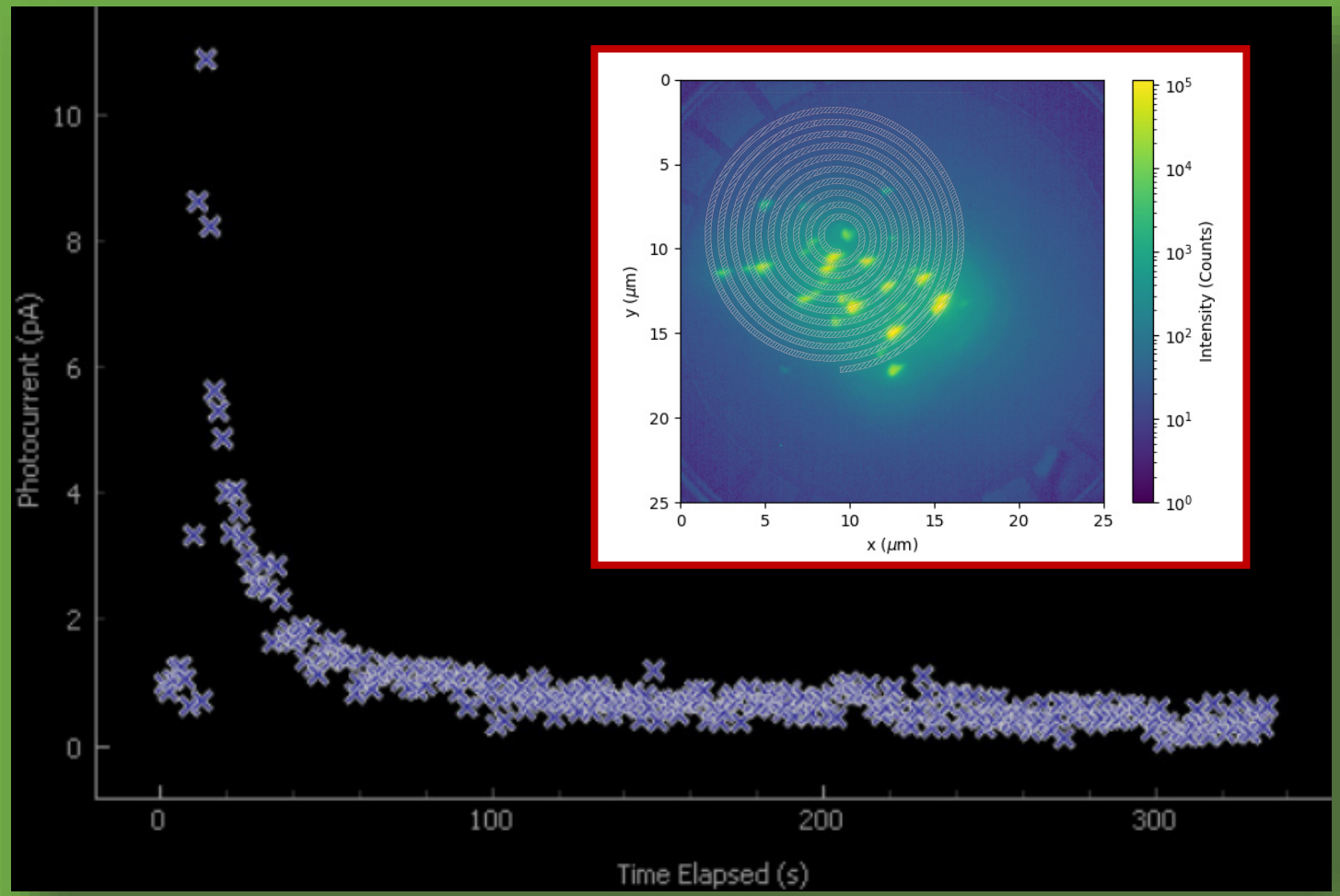
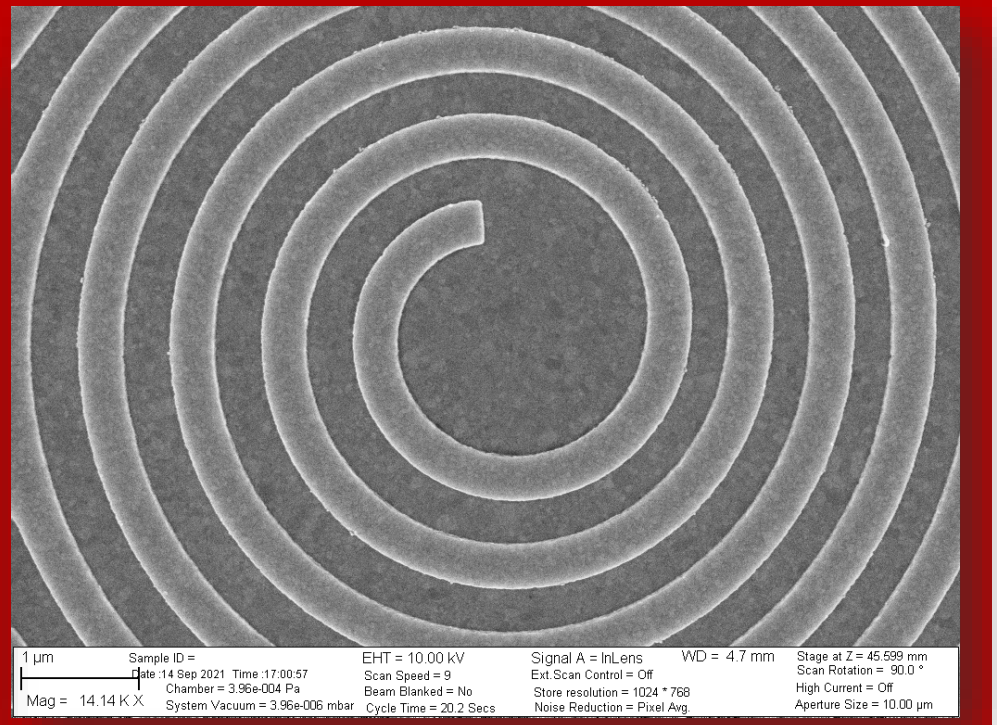
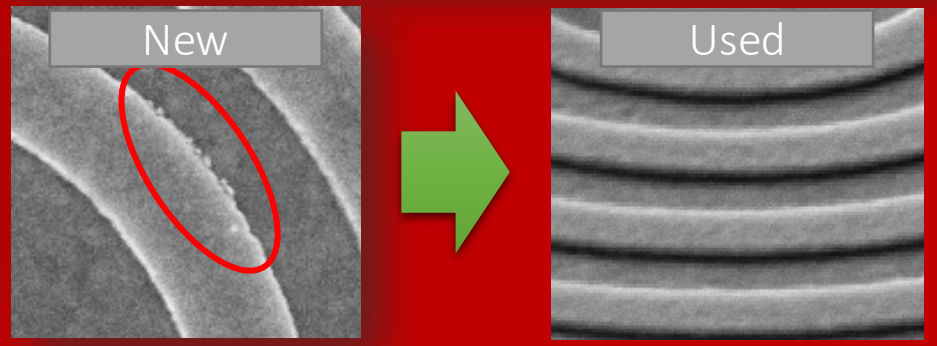
Measurements Limited by Power and “Hot Spots”

“Spikey” Current Behavior & Hotspots



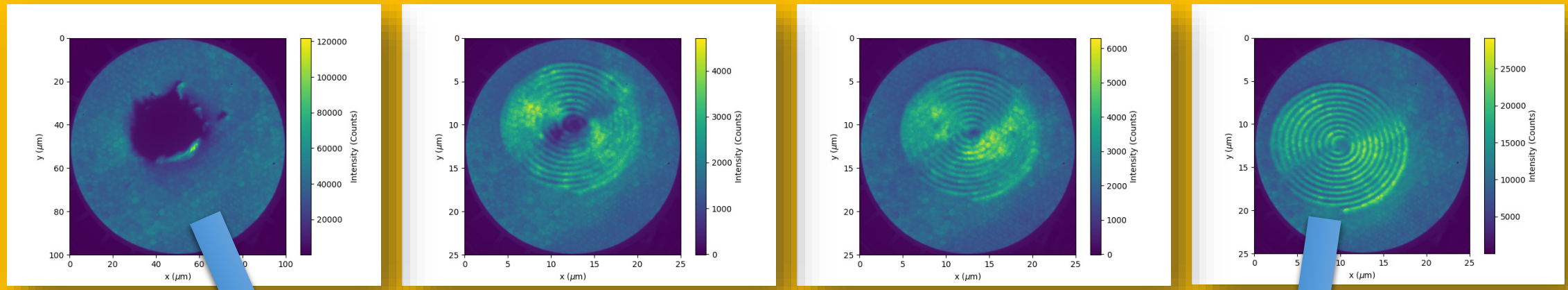
Rough Edges and “Self Cleaning”

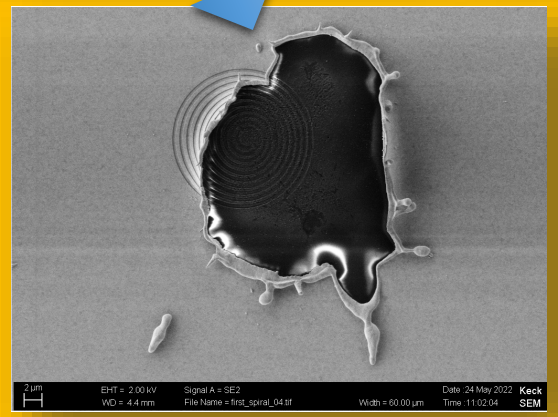




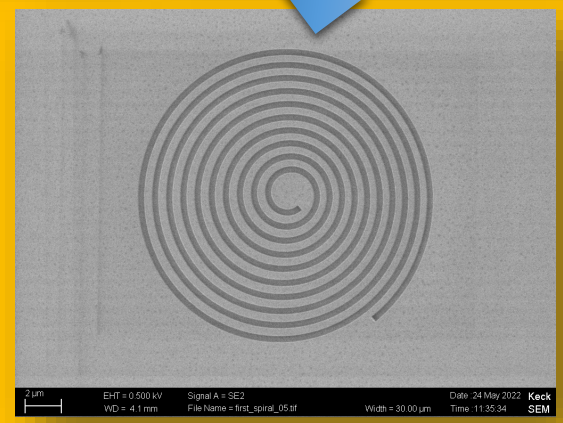
PEEM Images Show Field Enhancement?

Ultrafast laser damage occurs predominantly at center of structure indicating possible lensing effects.

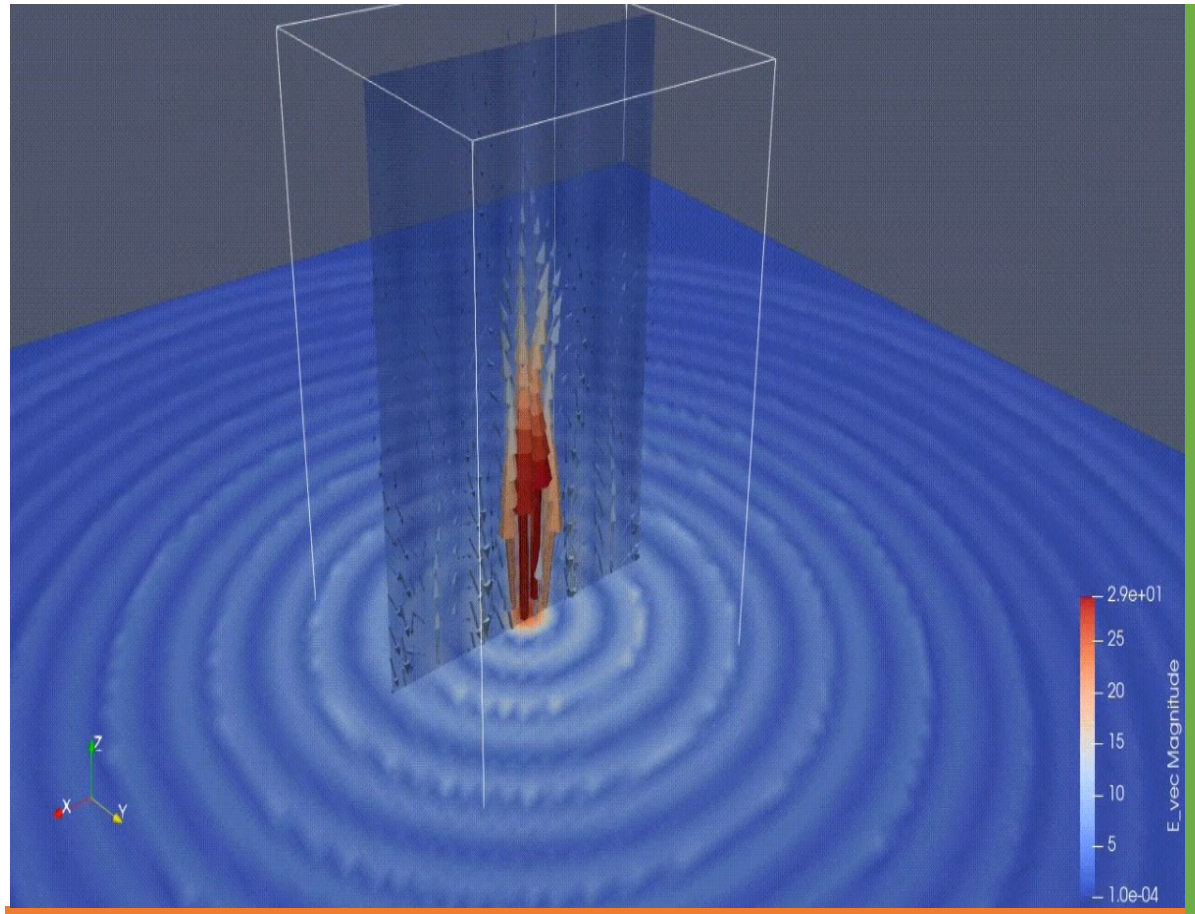




Decreasing Laser Power

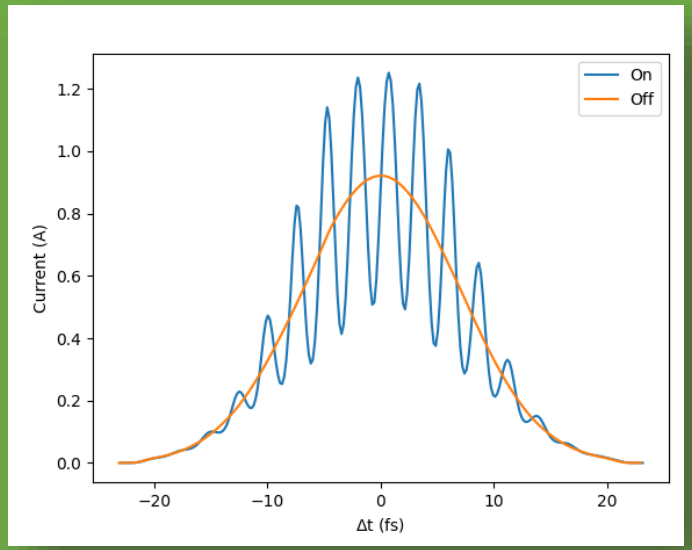


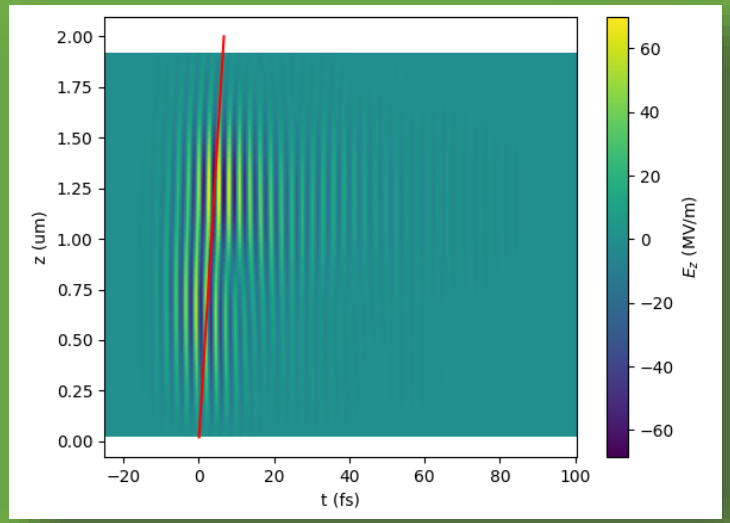
Future Prospects for All Optical Beam Control



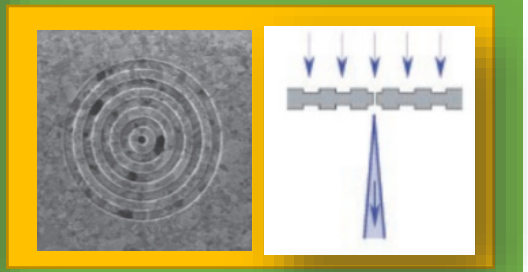
Fields from FDTD Code → Augment to Time Domain with Free Space Maxwell Eqn Solution → Custom Element in 3D Particle Tracking Code (GPT)

Laser phase dressing with prospects for attosecond science





Energy gain realized through plasmonic structure



Nanoscale Emitters Team and Collaborators

Nano-structured photocathodes group

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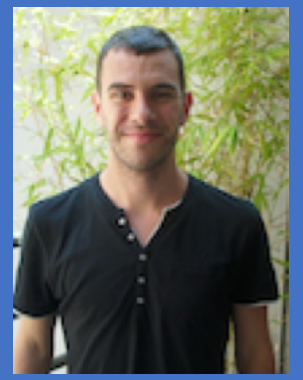
Dan Durham (LBNL)

Andrew Minor (LBNL, UCB)

Chris Pierce (Cornell)

Nanofab



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Cornell Collaborators

Ivan Bazarov

Jared Maxson

PEEM Collaborators

Siddharth Karkare

Alimohammed Kachwala

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Thank you for Listening!