LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

# Photon-Photon Scattering at CALA

Leonard Doyle, Timo Pohle, Fabian Schütze, Pooyan Khademi,

Prof. Jörg Schreiber, Dr. Felix Karbstein, Prof. Matt Zepf

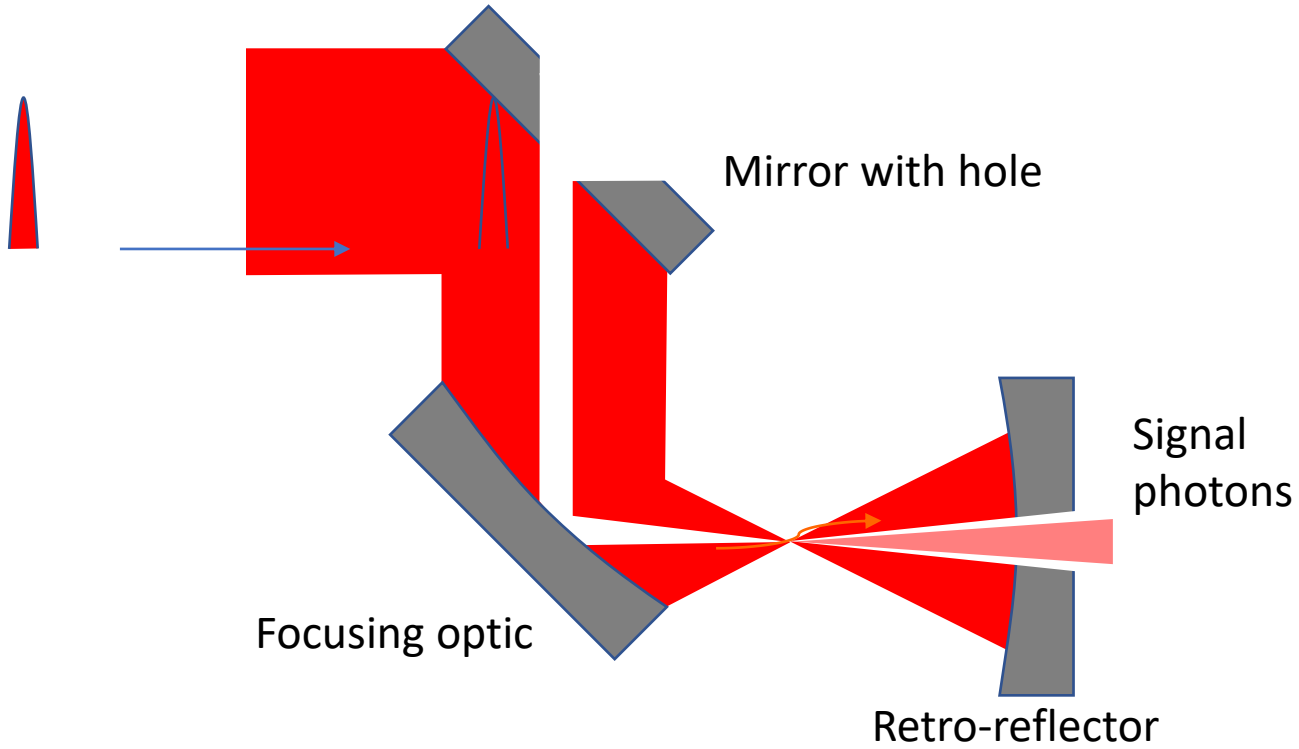
HI JENA Helmholtz Institute Jena

CALA

# Photon-Photon Scattering at CALA



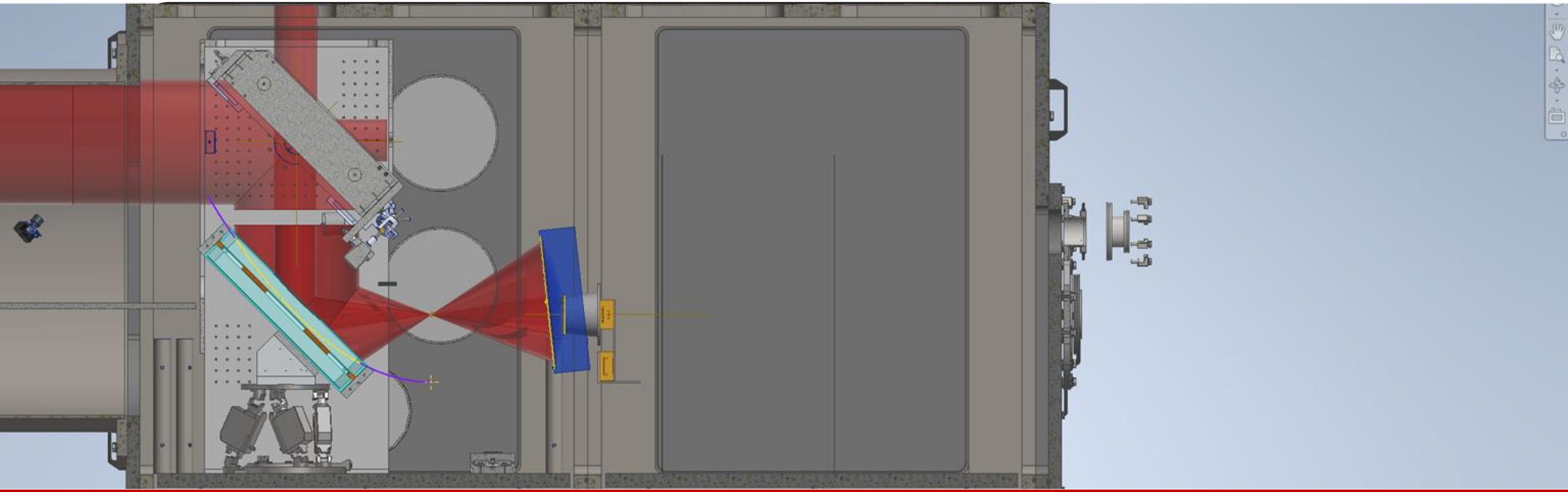
- Head-on collision of two pulses
  - double pulse
  - Retro-reflector
- Signal photons in beam shadow
  - Collection optic in forward direction
- Expected numbers
  - Laser pulses 25J, 30fs each
  - Photons signal (in 30fs) = $\mathcal{O}(3)$
  - Photons rest gas (in ~100s fs?) = $\mathcal{O}(10-100)$
  - Photons static background (in 0.5ns) = $\mathcal{O}(1000-10000)$



# CALA Setup



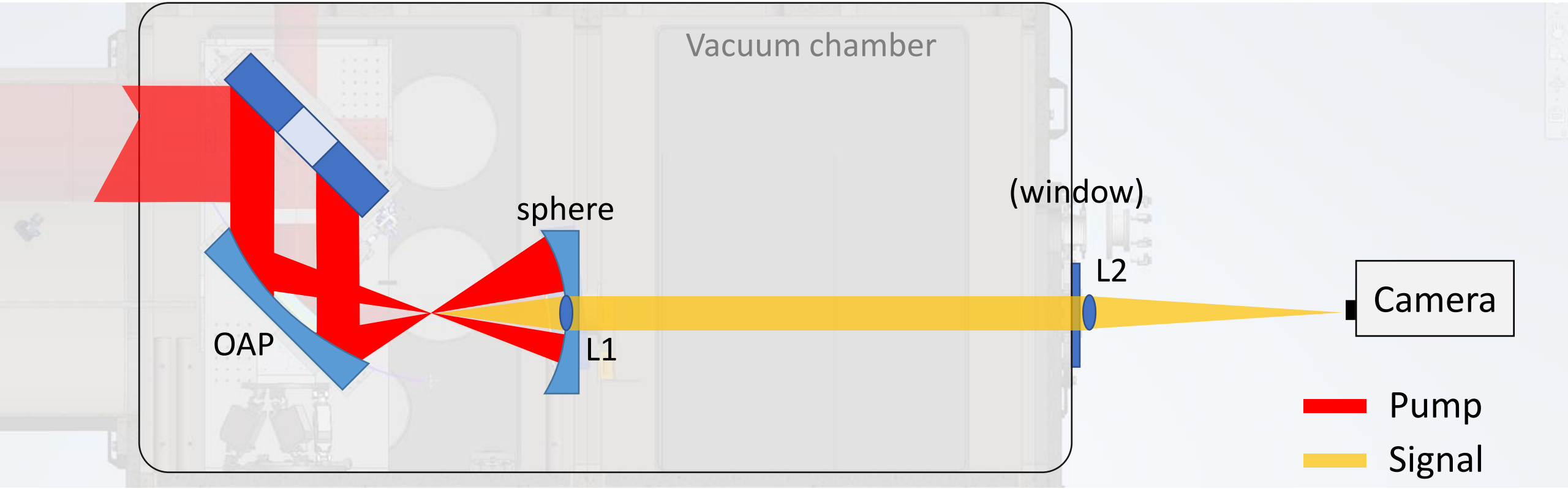
- Components installed except retro-flecting spherical mirror
- → can measure expected background, but not real signal



# CALA Setup



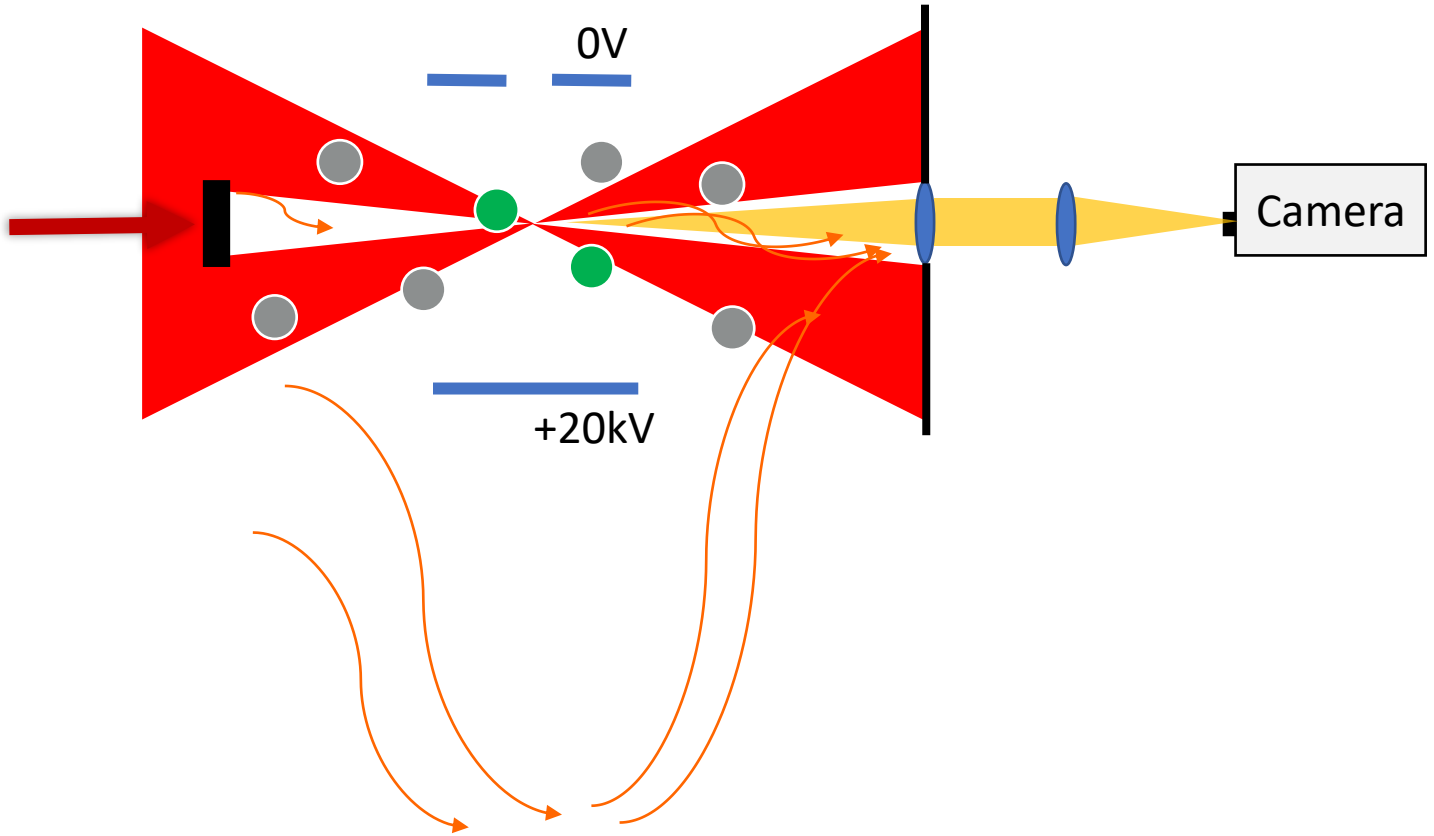
- Components installed except retro-flecting spherical mirror
- → can measure expected background, but not real signal



# Noise Contributions



- Static scatter from parts
  - exclude by arrival time
  - suppress by blocking paths
  - check for imaging paths
- Diffraction
  - no issue so far
- Scattering from residual gas
  - close in origin and arrival time
  - **investigated HV „cleaner“**
    - can be used as particle monitor



Q3 (22) | Q4 | Q1 (23) | Q2 | Q3 | Q4 | Q1 (24) | Q2 | Q3 | Q4 | Q1 (25) | Q2 | Q3 | Q4

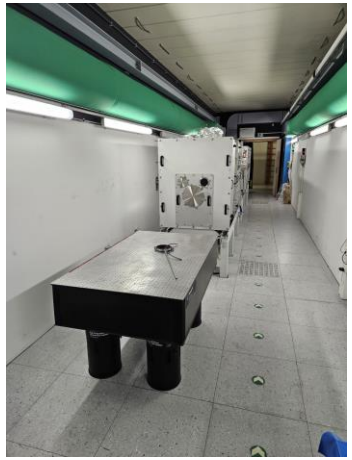
24.06.2023
FIRST ATLAS LIGHT

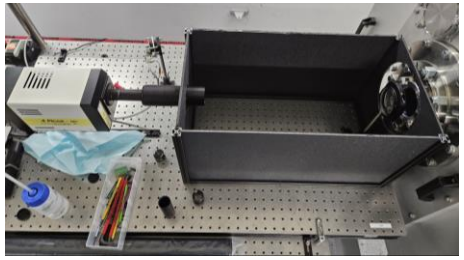
13.07.2023
FIRST SHADOW LIGHT

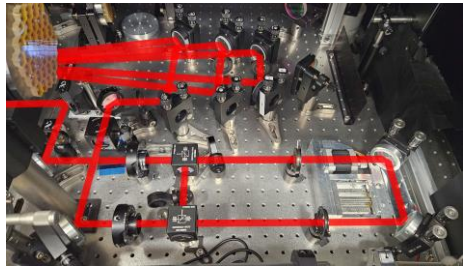
08.01.2024
Order of Sphere

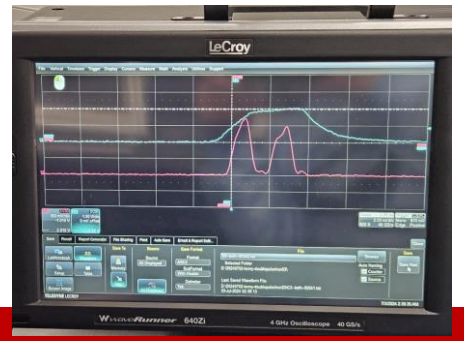
05.07.2024
FIRST DOUBLE SHADOW Exp

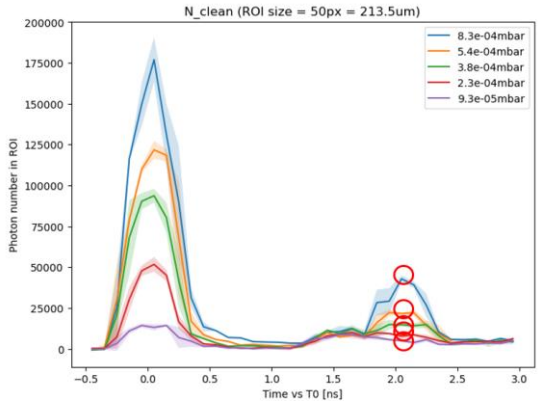
27.02.2025
DOUBLE SHADOW Exp









# Summary



- Photon-photon scattering setup at CALA
  - Background measurements encouraging
  - first double pulse collision experiments possible soon
- Short-term goals
  - improve detection (polarization flip, sensitivity, forward+backward direction)
  - rest gas particle detection
- Mid-term goals
  - investigate $2\omega$ option
- Long-term goals
  - investigate third beam

Acknowledgements
- HI Jena: Matt Zepf, Felix Karbstein, Pooyan Khademi, Fabian Schütze, Peter Hilz, Holger Gies, …
- LMU: AG Schreiber, AG Karsch, AG Thirolf
- This work has been funded by the Deutsche Forschungsgemeinschaft (DFG) under Grant No. 416702141 within the Research Unit FOR2783

# Backup

# Residual gas



- Neutral: Rayleigh scattering
  - Not significant
- Ionized: Thomson scattering off electron
  - Ionization potentials $\ll 10^{20} W/cm^2$
  - Ionization volume $> cm^3$
  - → studied in detail
- Nonlinear $\chi^{(3)}$ → localized to focus volume, density reduced as we will see

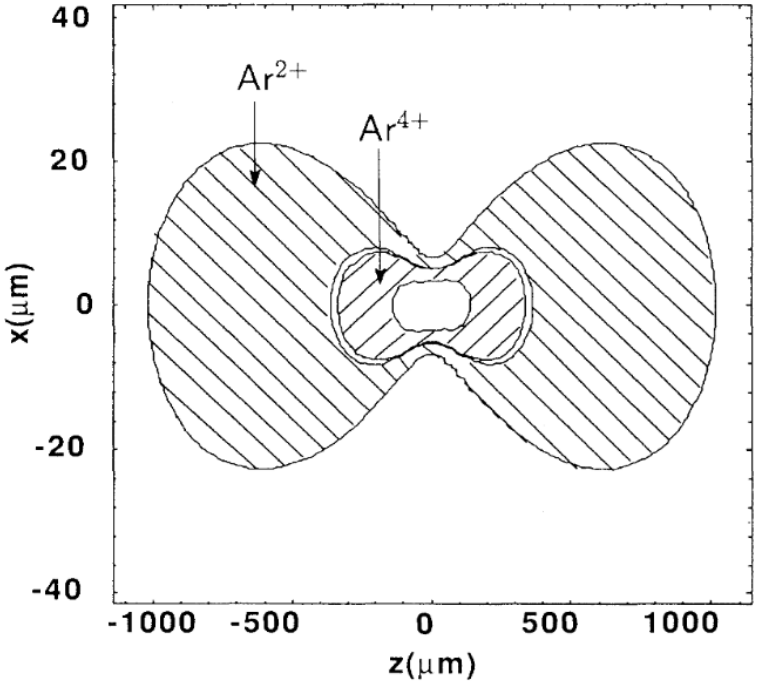


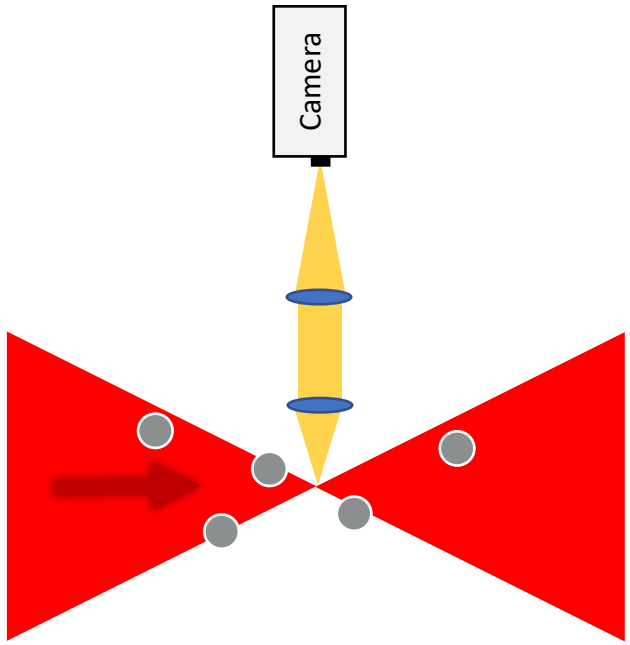

FIG. 4. The spatial distributions for $Ar^{2+}$ and $Ar^{4+}$ produced in a Gaussian beam with peak intensity of $10^{17}$ W/cm$^2$. The focus is for an $f$ number of 5. The ions fall within borders defined by the threshold and saturation isointensity contours.

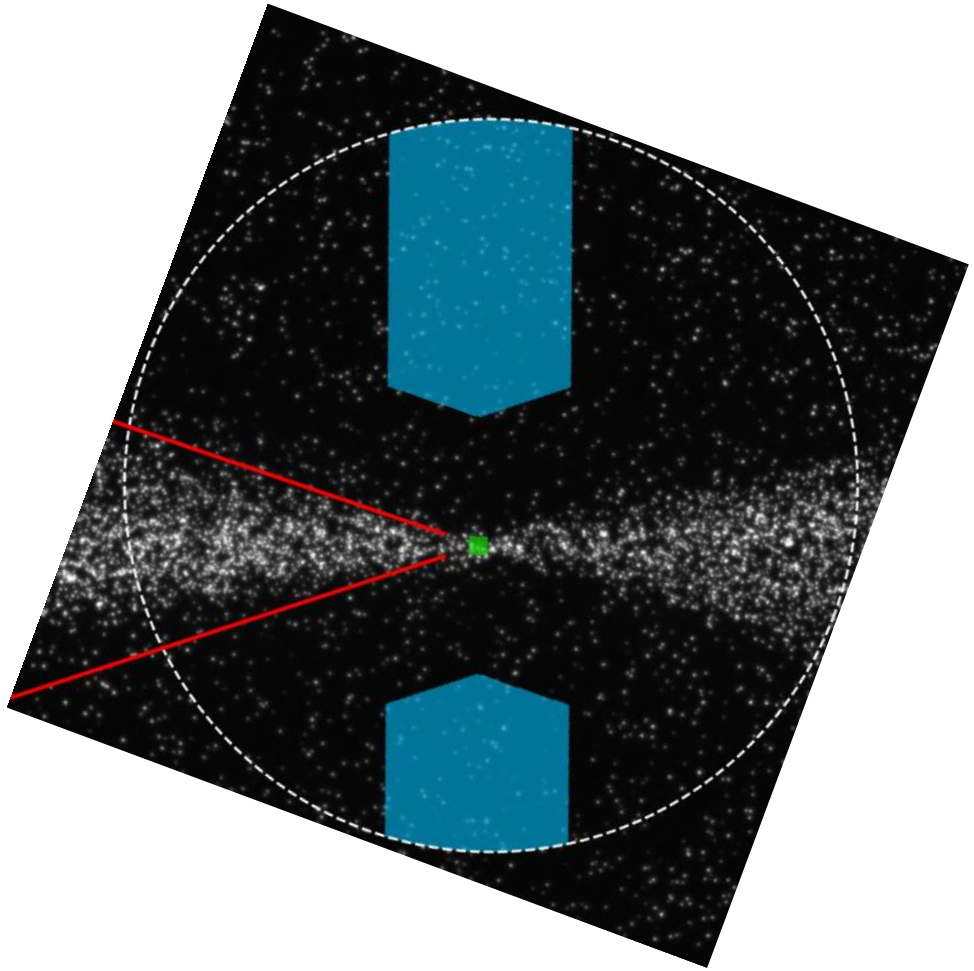
Chang, B., Bolton, P.R. and Fittinghoff, D.N. (1993) 'Closed-form solutions for the production of ions in the collisionless ionization of gases by intense lasers', *Physical Review A*, 47(5), pp. 4193–4203. Available at: https://doi.org/10.1103/PhysRevA.47.4193.

# Residual gas



- Single beam, $\theta_{obs} = 90°$
- $< 200mJ, 24fs$
- $10^{-5} \rightarrow 1mbar$



1. Doyle, L. *et al.* (2022) 'Experimental estimates of the photon background in a potential light-by-light scattering study', *New Journal of Physics*, 24(2), p. 025003. Available at: https://doi.org/10.1088/1367-2630/ac4ad3.