Features within sheath accelerated proton beams

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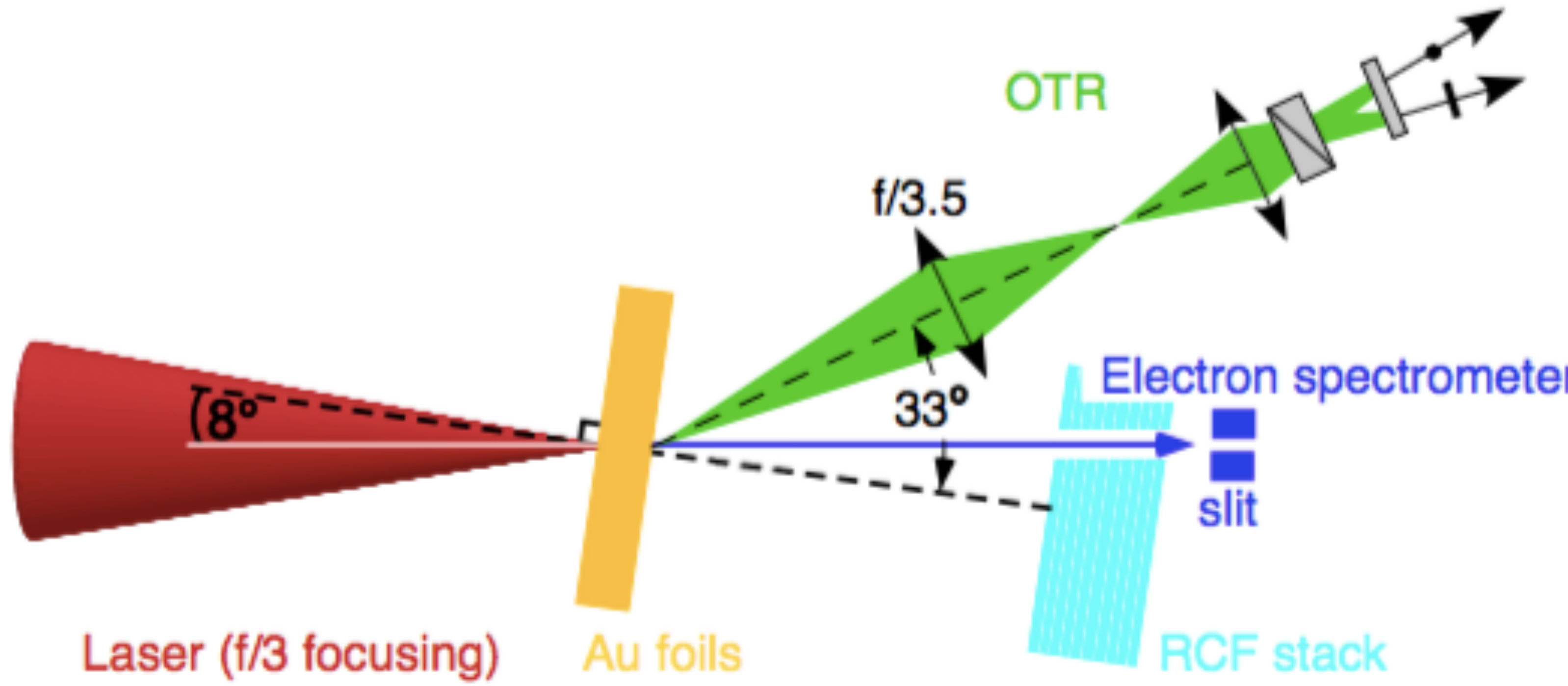
Experimental setup

Aim: Study of **j**x**B** heating using linearly or circularly polarised light at near normal incidence.

- Laser energy ~ 54.8 J
- Laser duration ~ 642 fs
- Focus (FWHM) ~ 9.5 um
- Intensity ~ 8.3 x 10^{19} W/cm^2
- a_0 ~ 8.2
- Incident angle ~ 8 deg
- Contrast ratio ~ 10^6
- Au foils from 10 - 100 um thick



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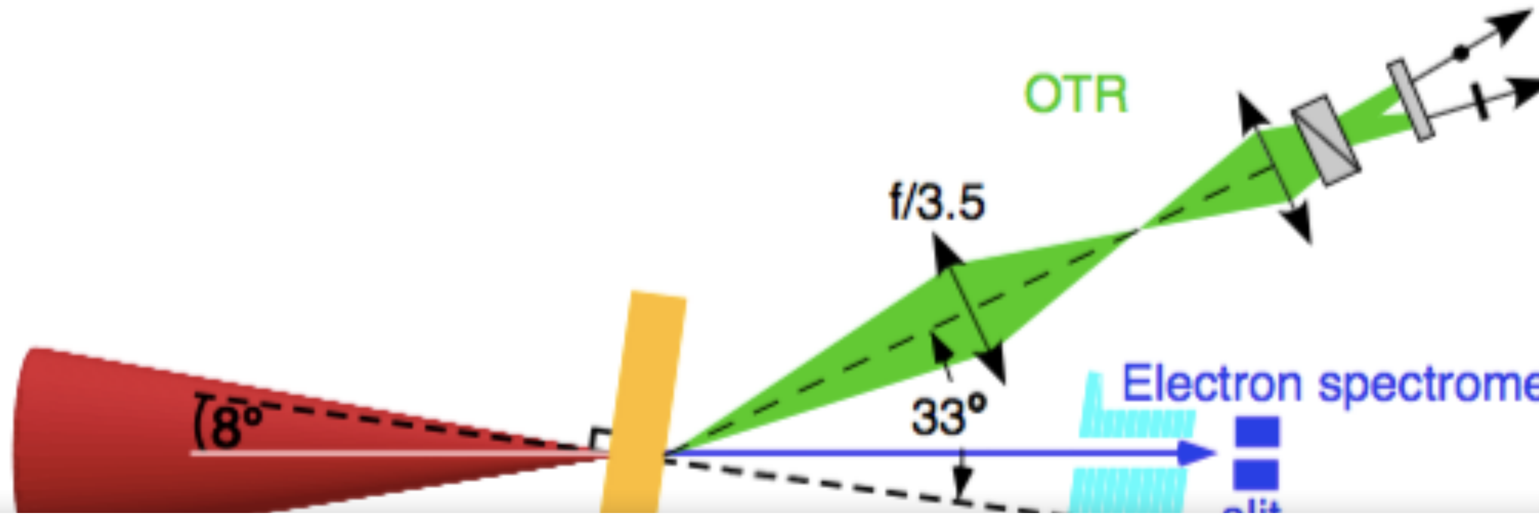

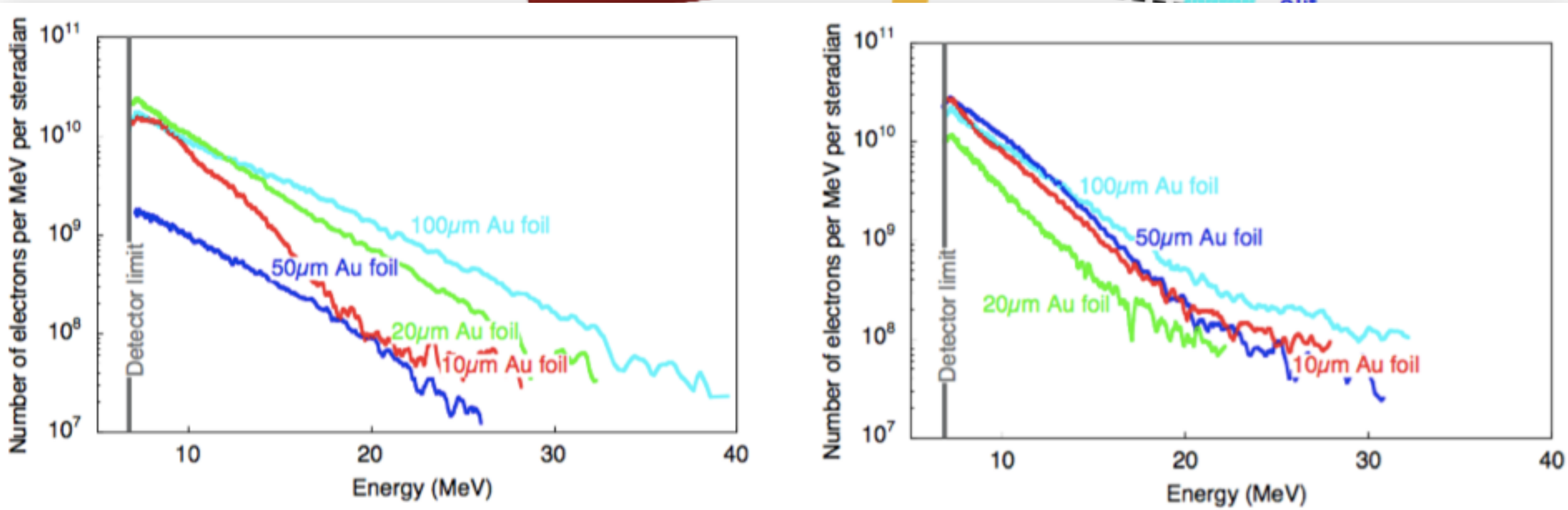

Linearly polarised **Circularly polarised**

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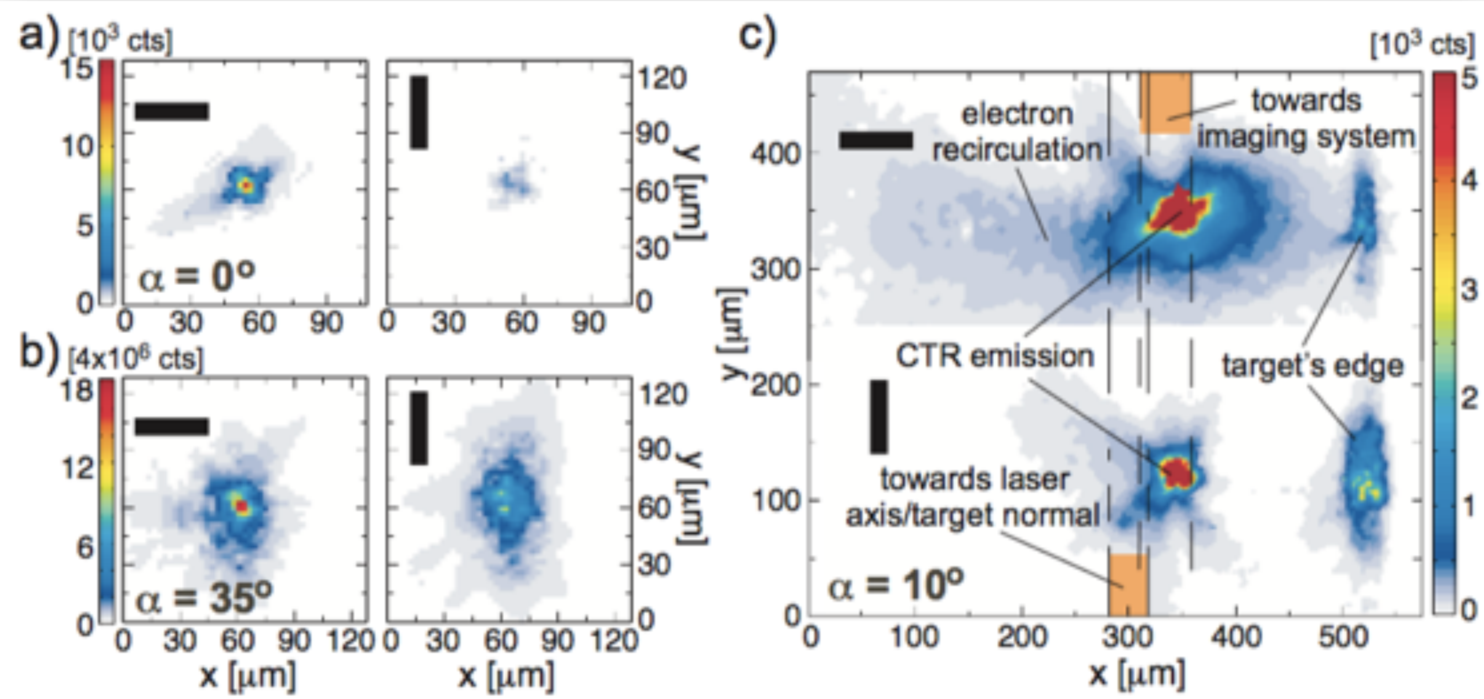
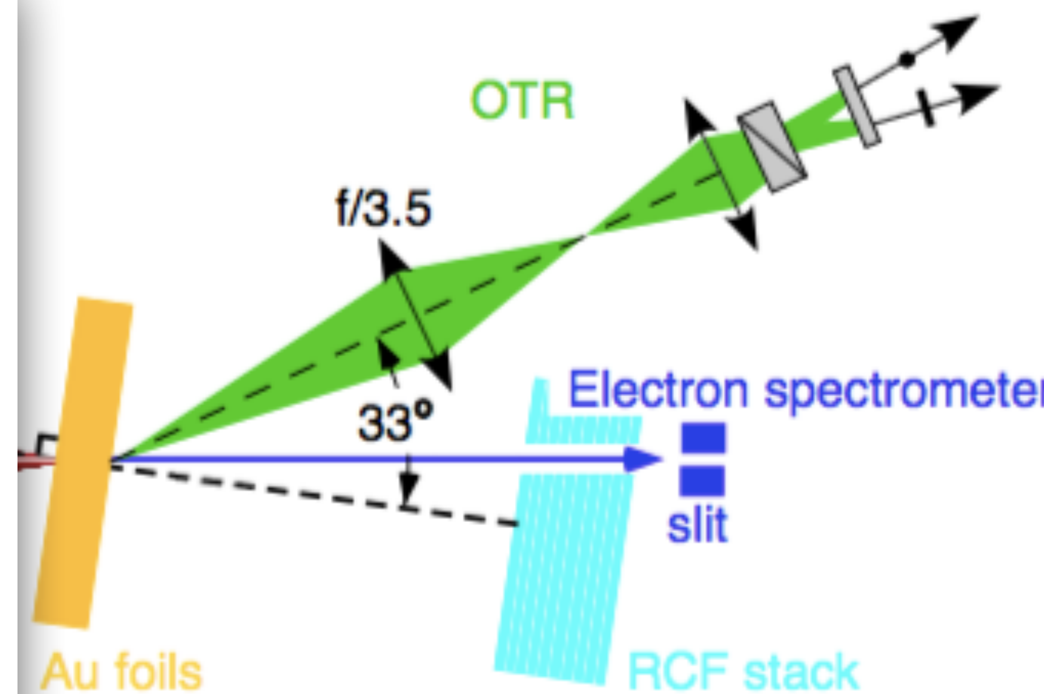


FIGURE 6.7. Polarisation analysed OTR images; LHS horizontal polarisation, RHS vertical polarisation for a) 50 μm foil, b) 35° wedge, c) 10° wedge (here top is horizontal and bottom vertical polarisation). In c), the center is over-exposed to enhance target visibility.



- Contrast ratio ~ 10
- Au foils from 10 - 100 um thick

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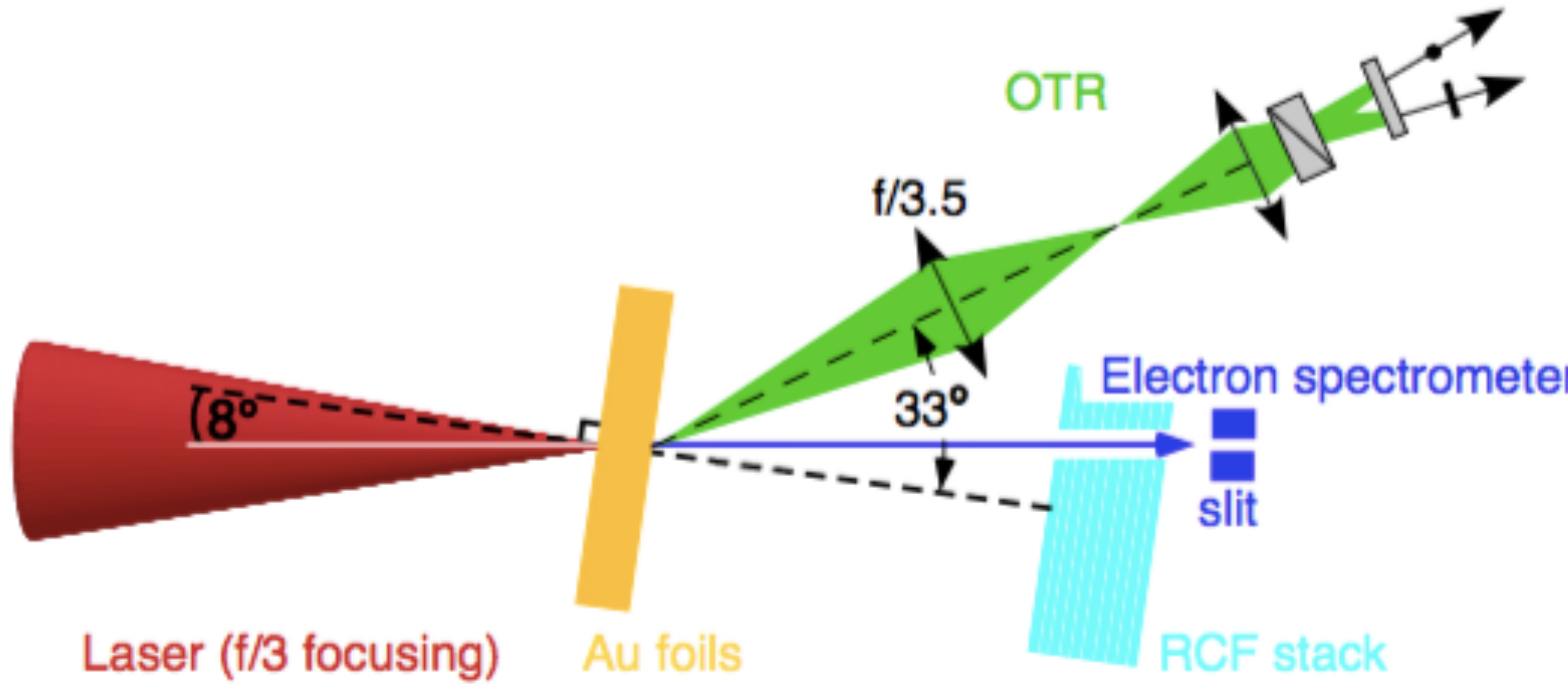
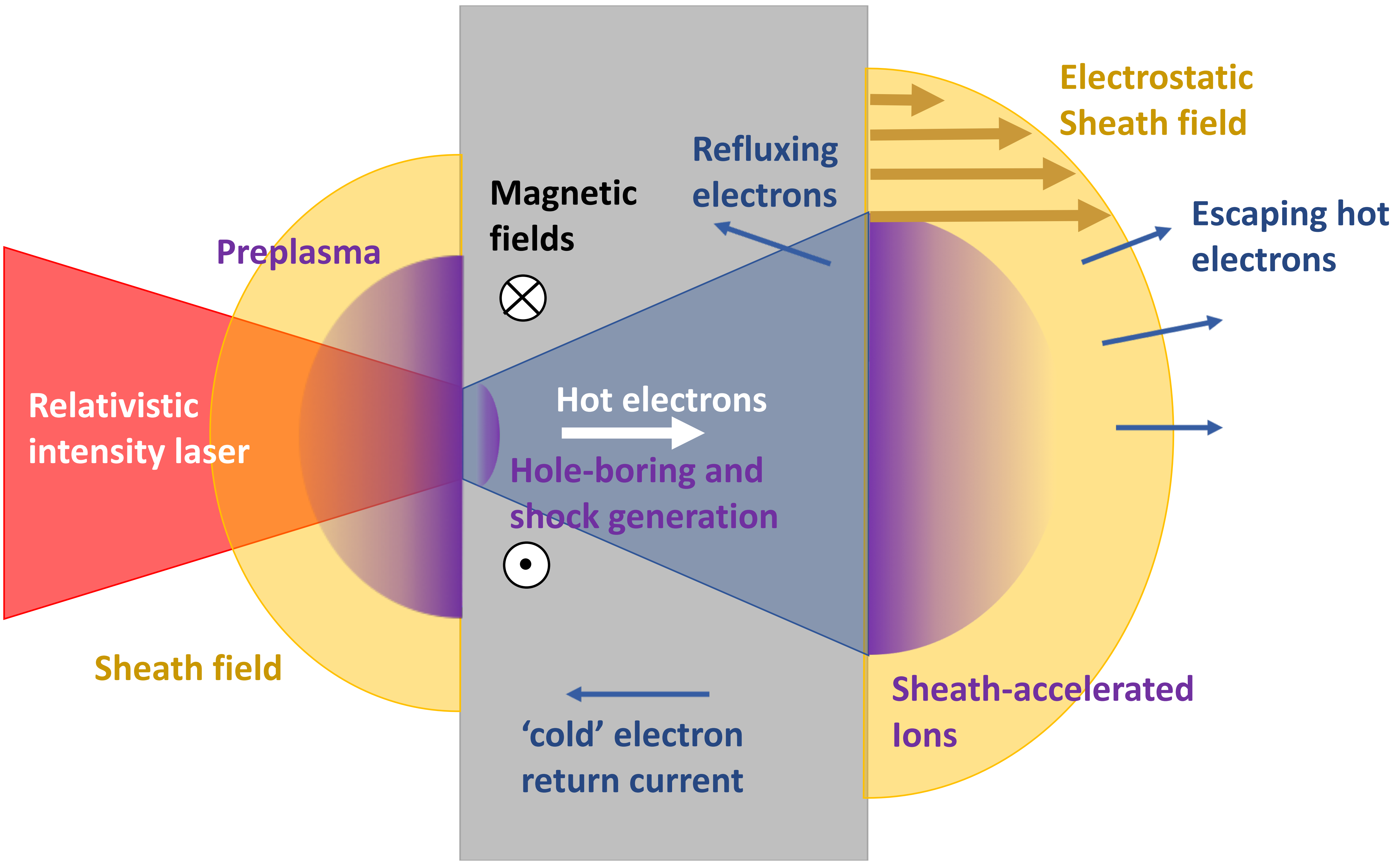
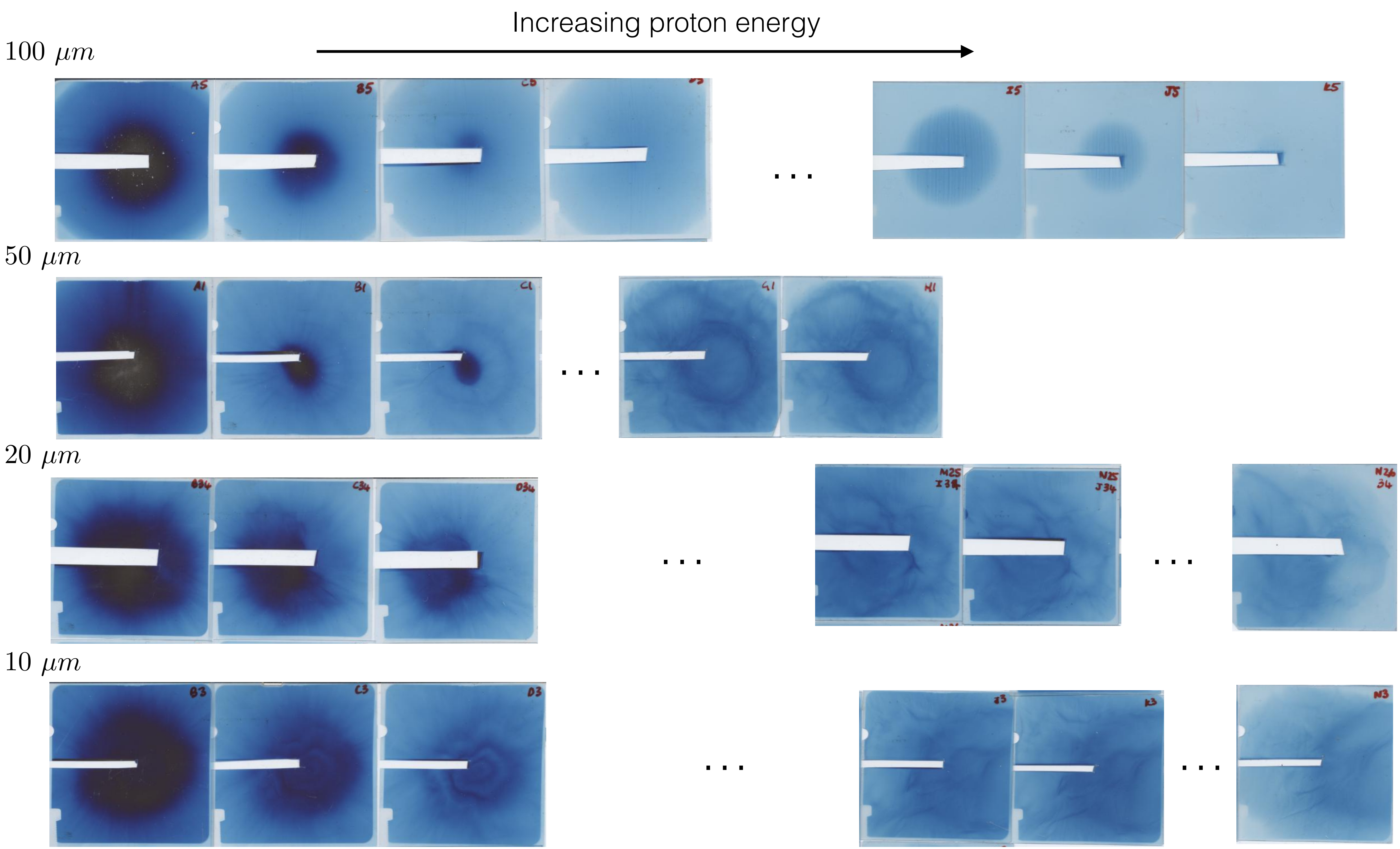


Laser driven ion acceleration from solid targets

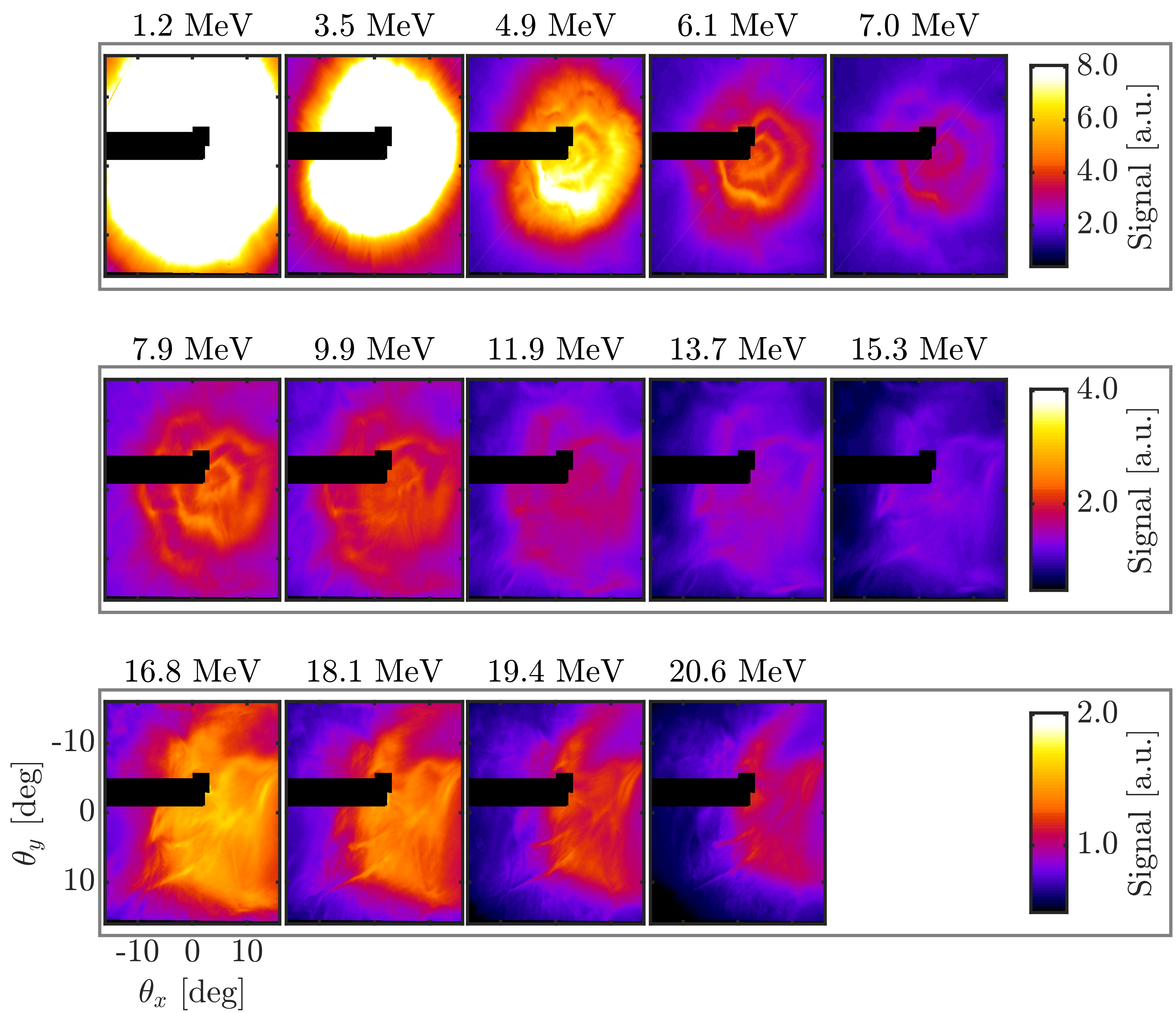


Target thickness scan



More details on the multi-ring-ed structure

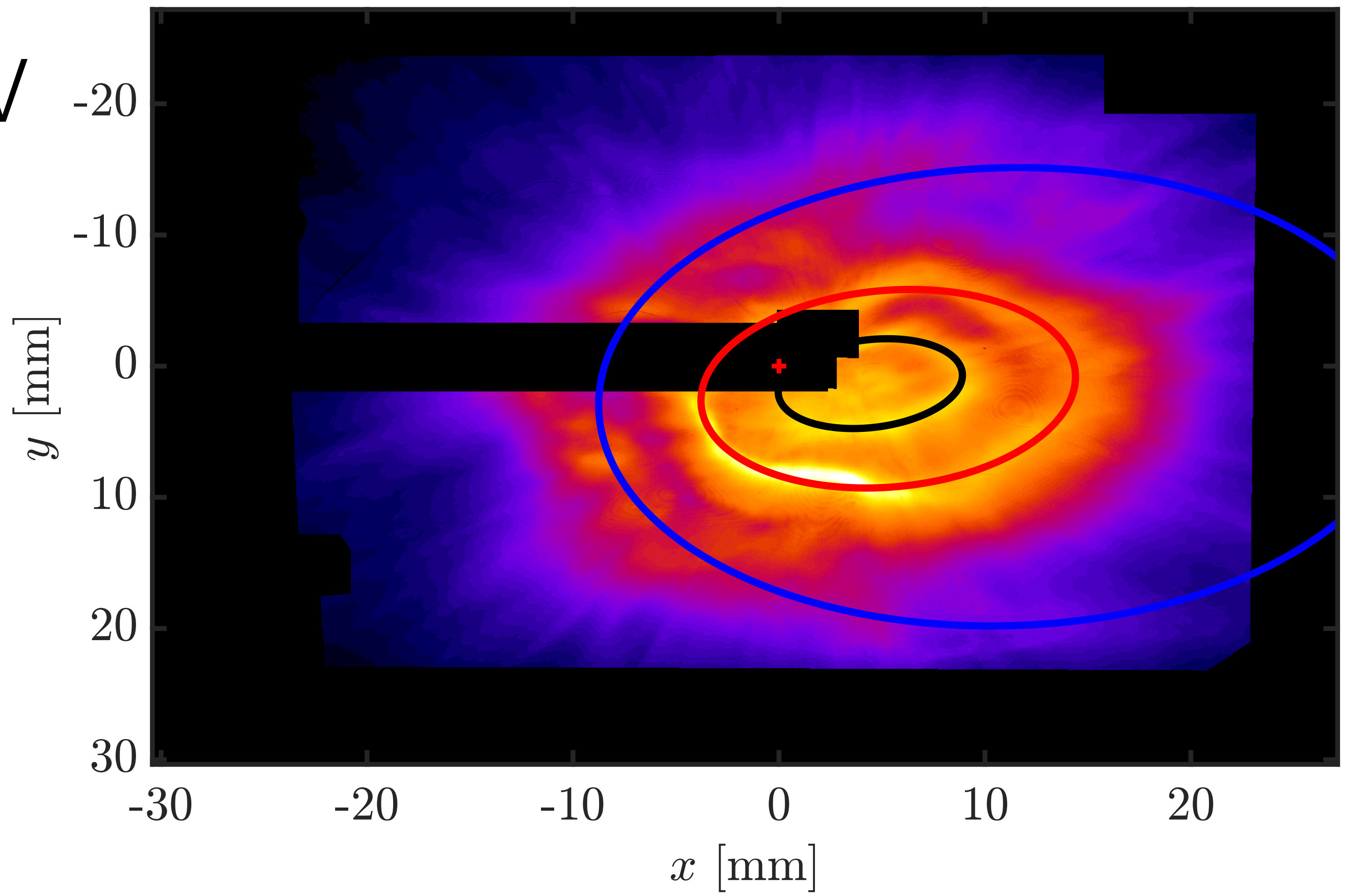
- Rings visible from 3 - 20 MeV
- Roughly concentric, directed around target normal.
- Central ring disappears as energy increases.
- At highest energy only the outer ring remains.



Ring radius and centroid position with energy

- Radius fluctuates slightly with proton energy.
- Centroid of rings drifts away from the laser axis at higher proton energy.

E = 6 MeV



Ring radius and centroid position with energy

- Radius fluctuates slightly with proton energy.
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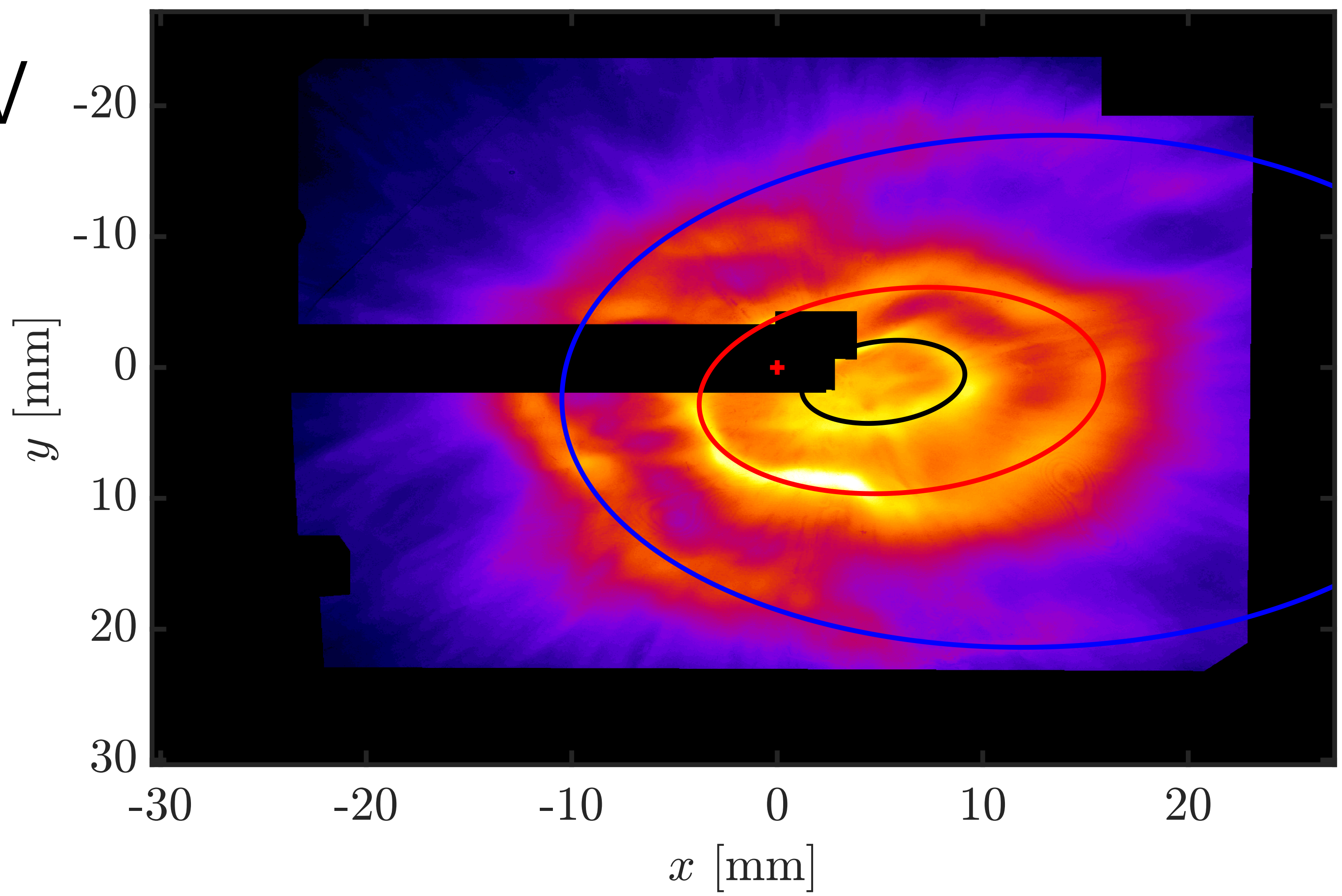
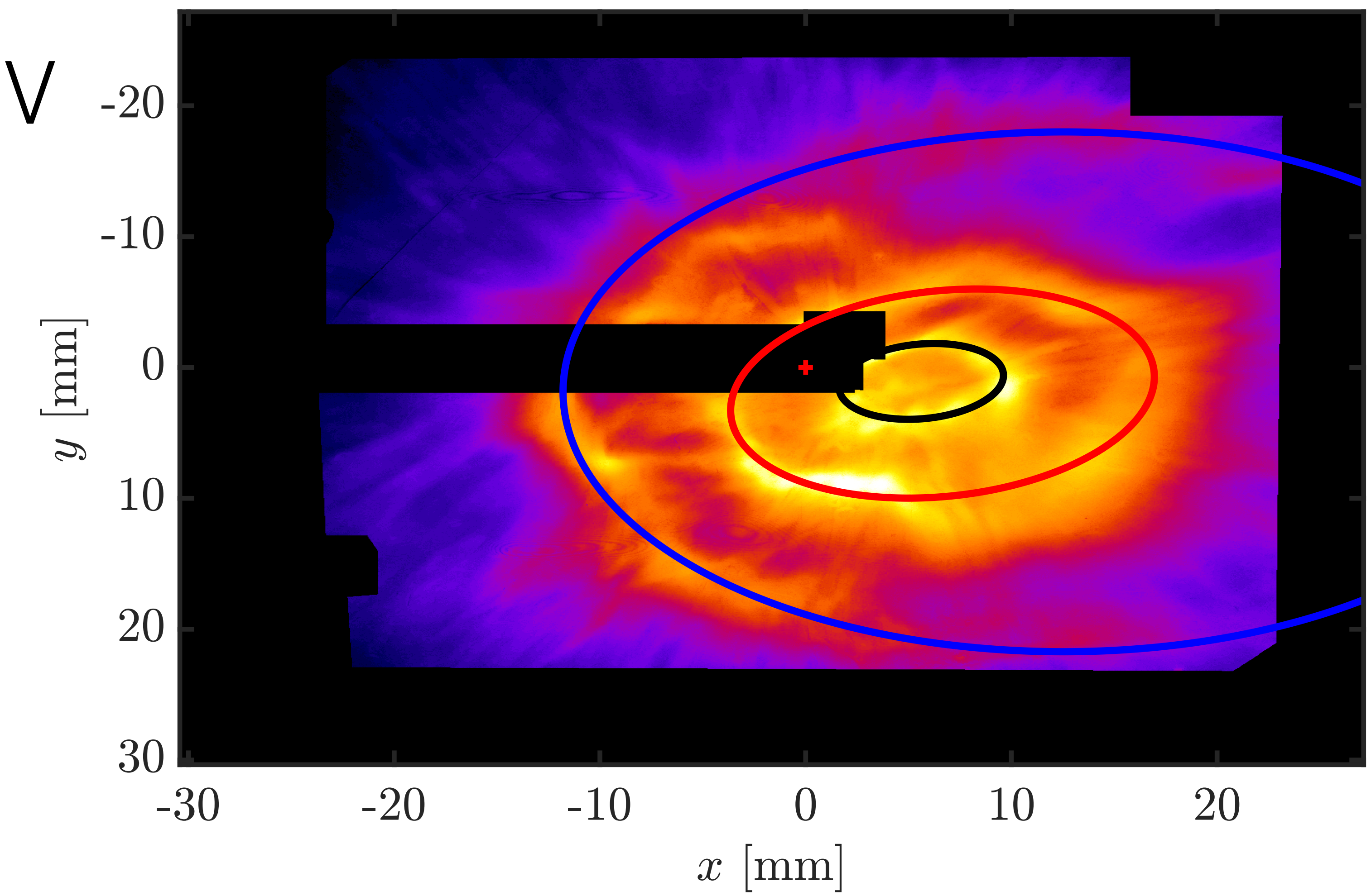
E = 7 MeV



Ring radius and centroid position with energy

- Radius fluctuates slightly with proton energy.
- Centroid of rings drifts away from the laser axis at higher proton energy.

E = 8 MeV



Ring radius and centroid position with energy

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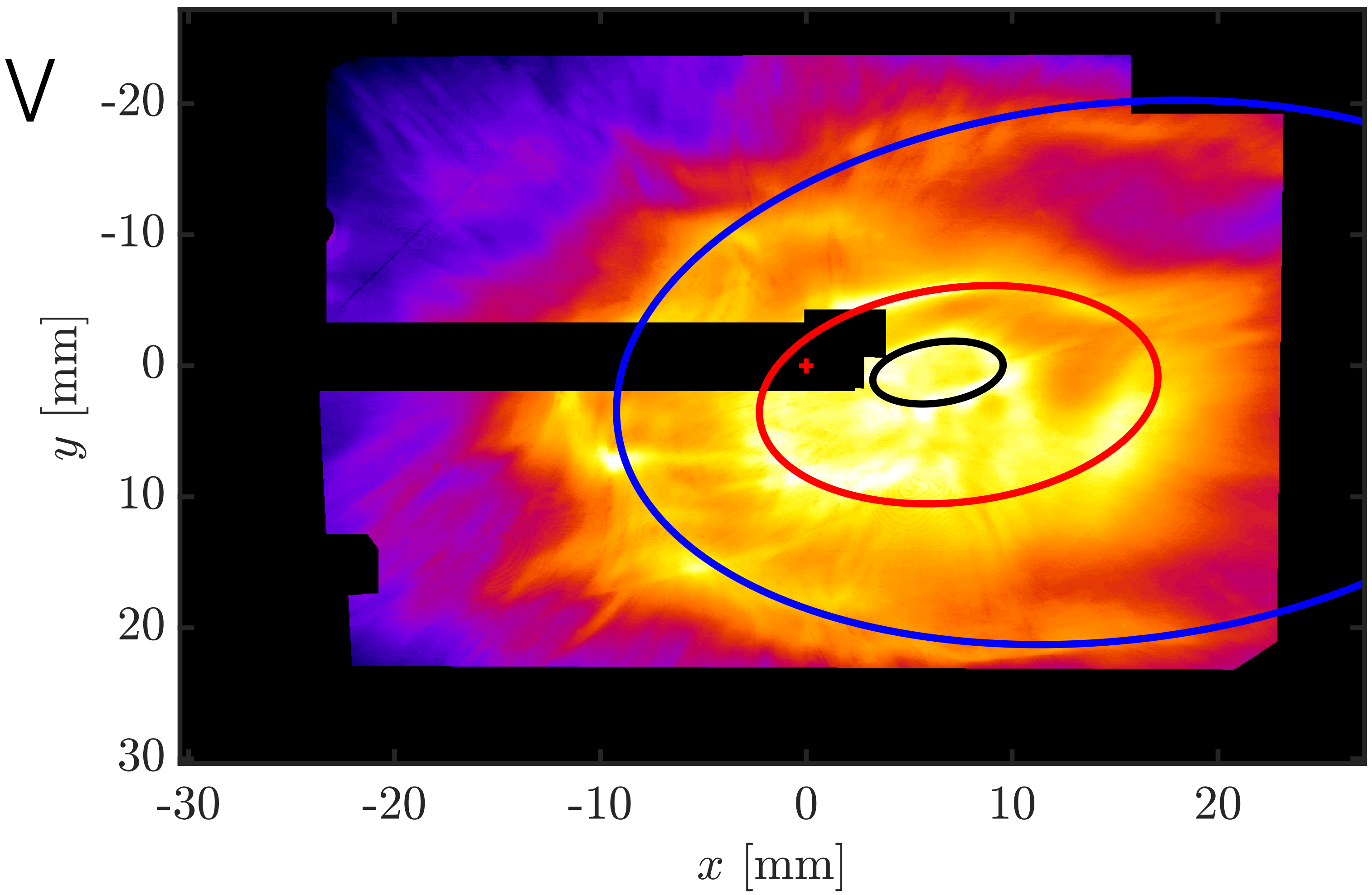
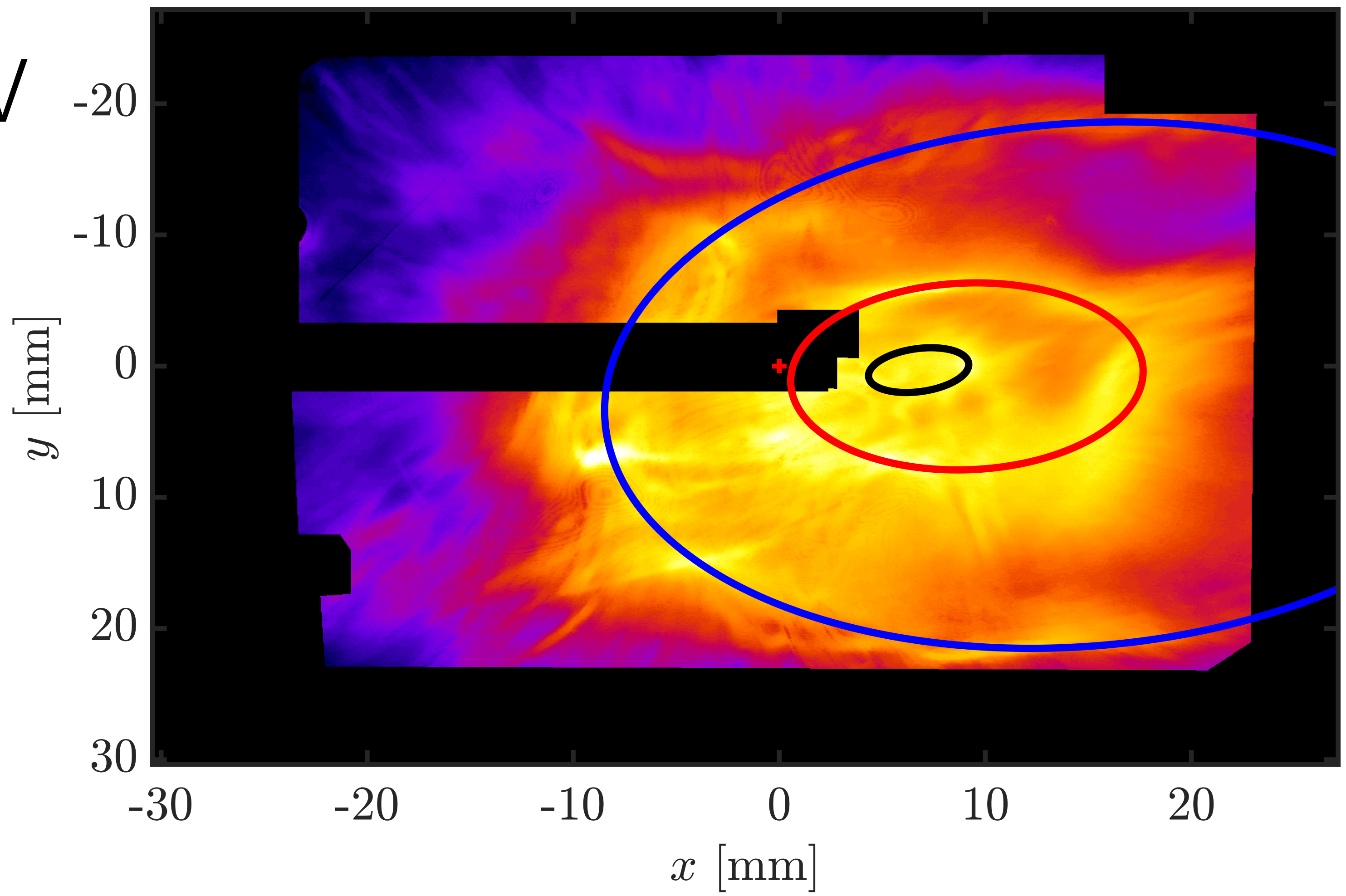
E = 10 MeV



Ring radius and centroid position with energy

- Radius fluctuates slightly with proton energy.
- Centroid of rings drifts away from the laser axis at higher proton energy.

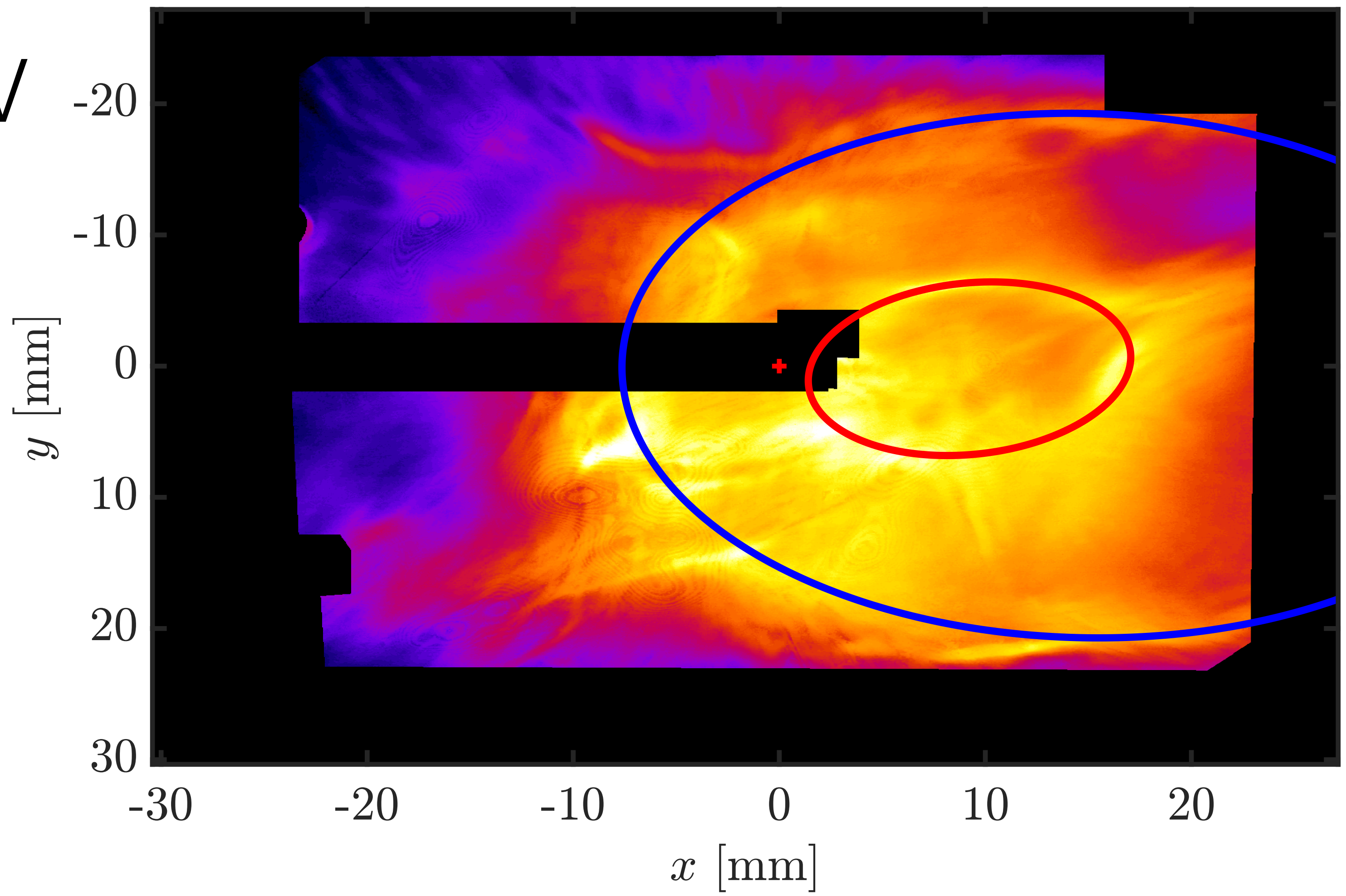
E = 12 MeV



Ring radius and centroid position with energy

- Radius fluctuates slightly with proton energy.
- Centroid of rings drifts away from the laser axis at higher proton energy.

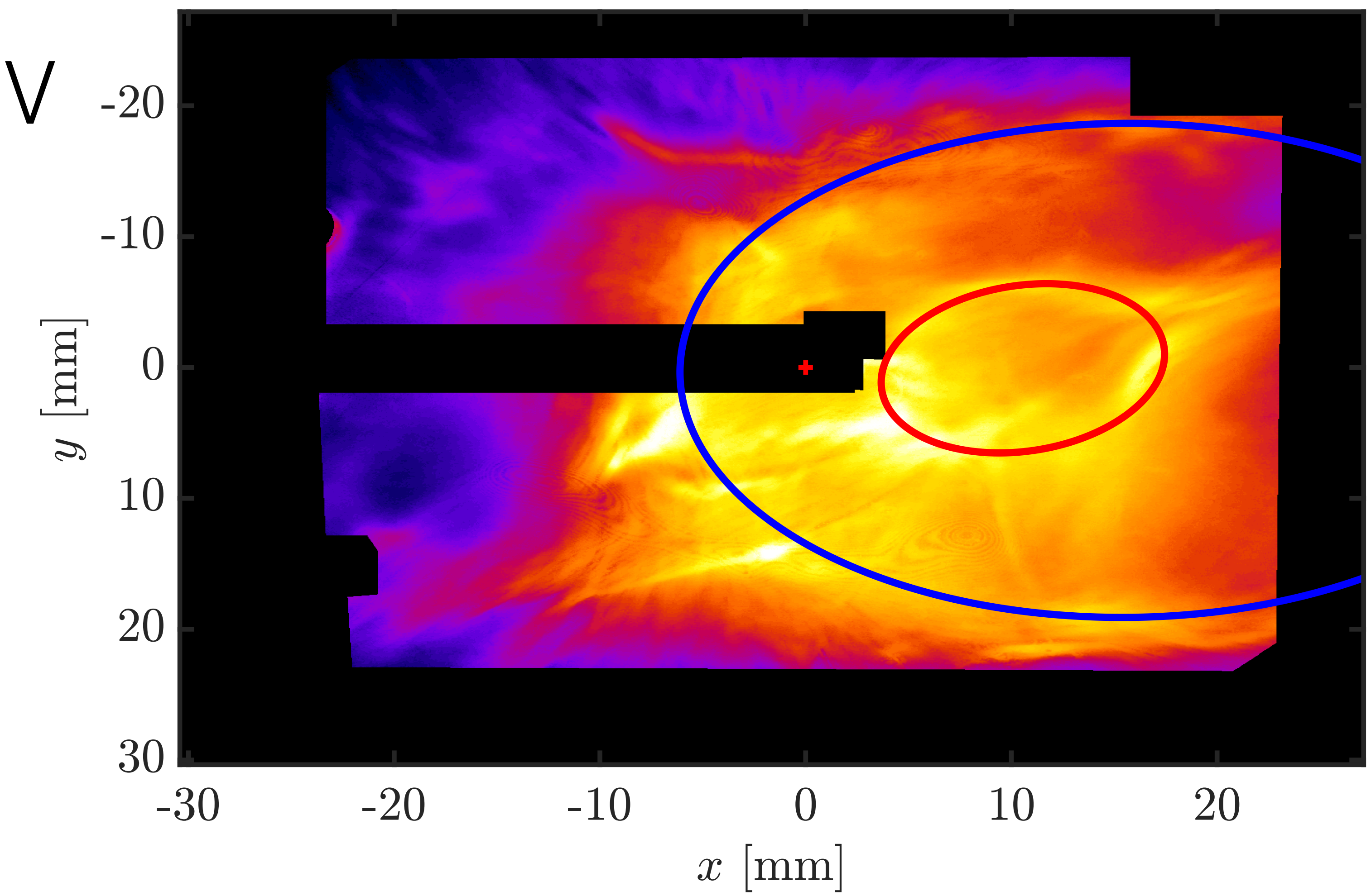
E = 14 MeV



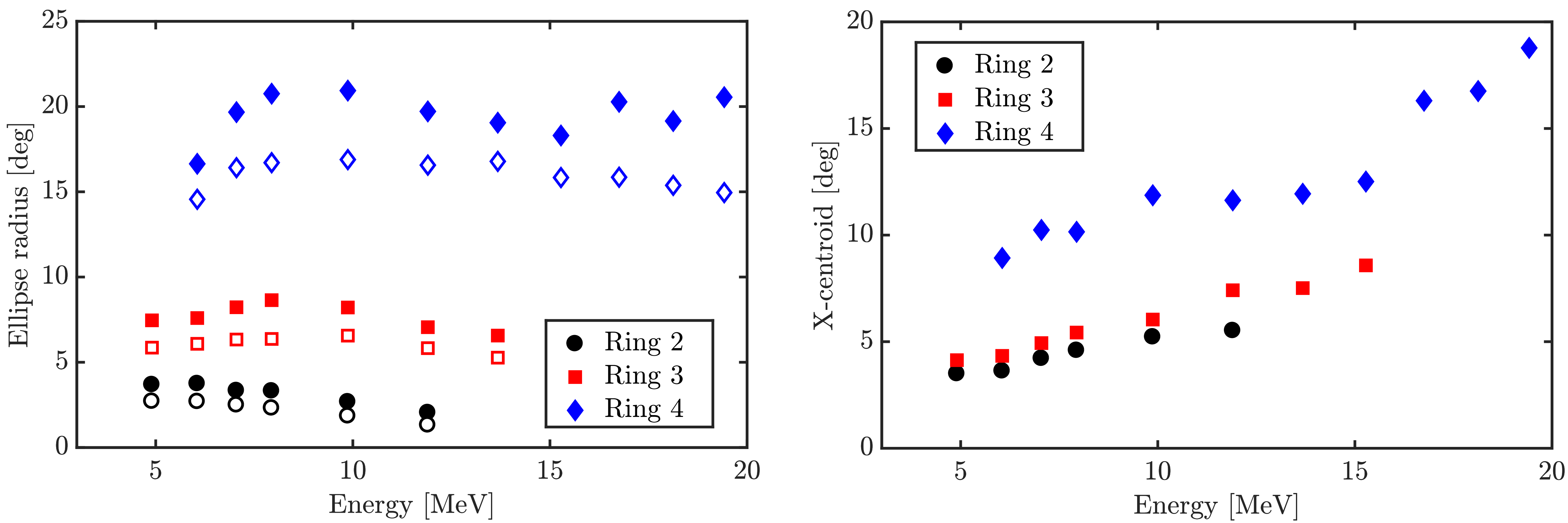
Ring radius and centroid position with energy

- Radius fluctuates slightly with proton energy.
- Centroid of rings drifts away from the laser axis at higher proton energy.

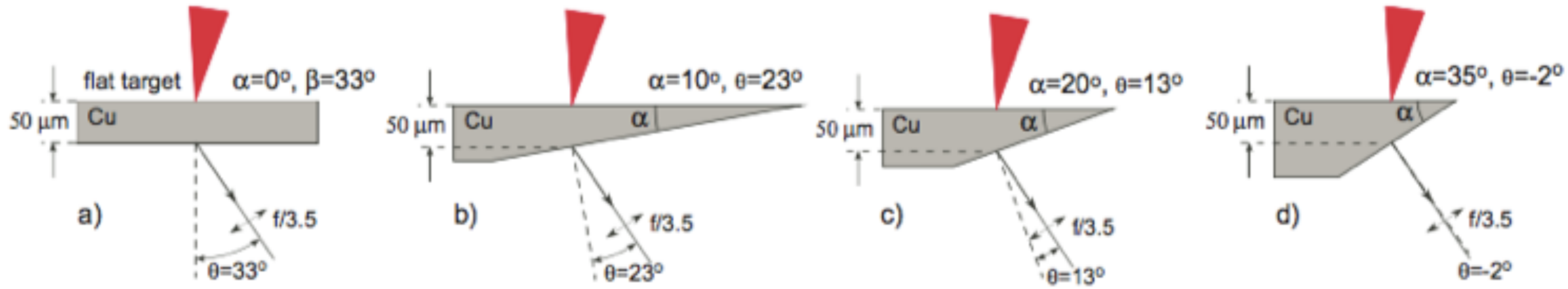
E = 15 MeV

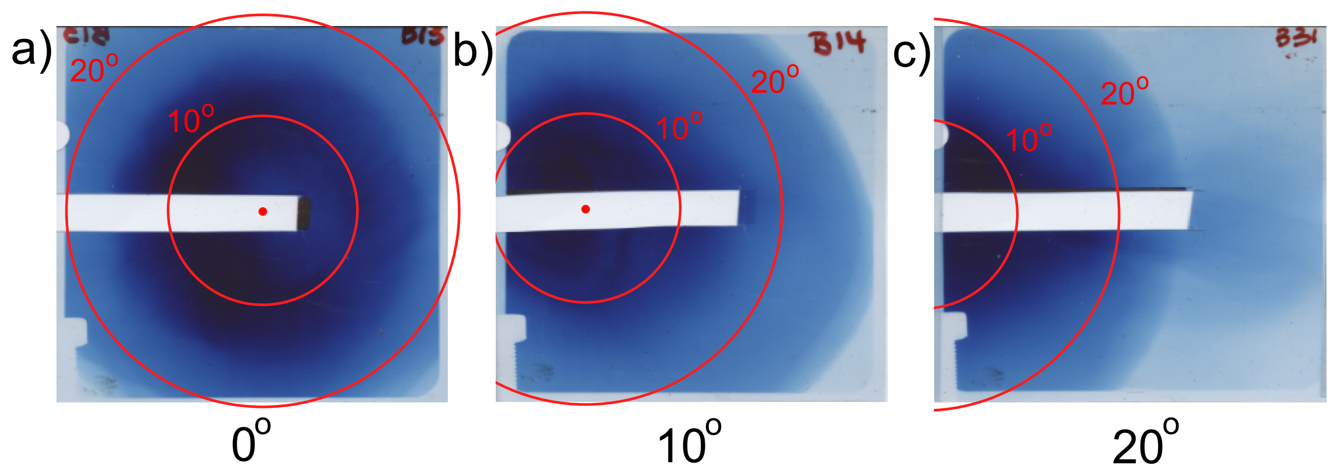


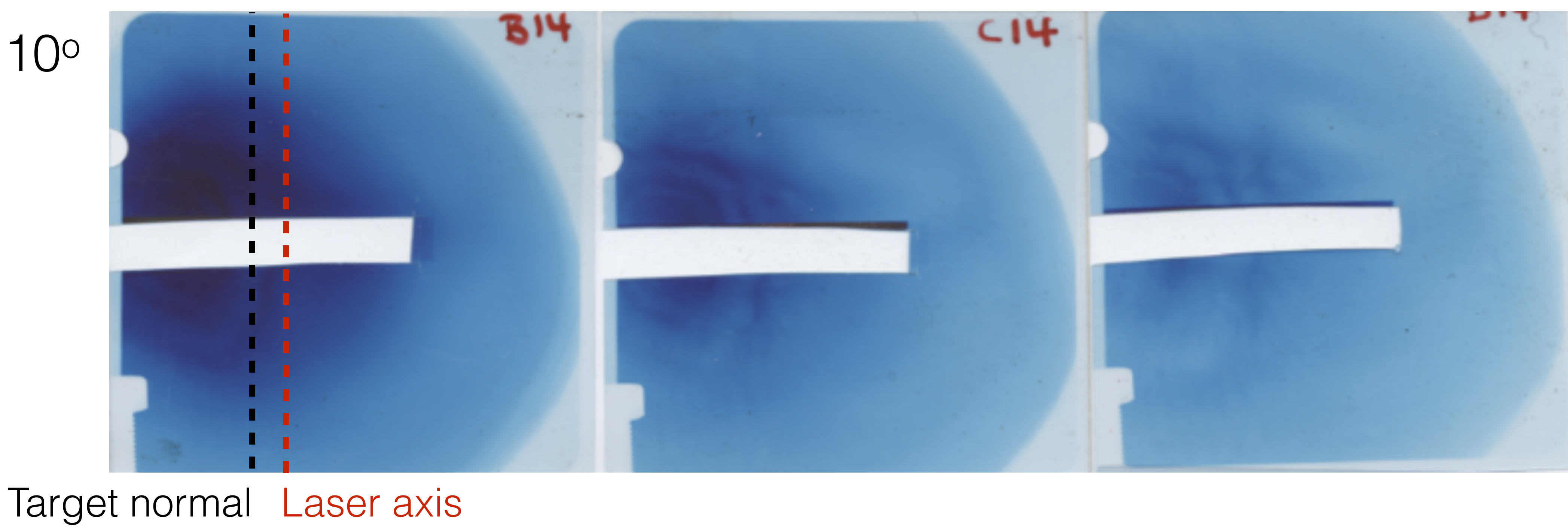
Ring radius and centroid position with energy



Wedged Cu targets imply rear surface proton source







Previous observations of rings

Previous observations of single rings, or rings with a central beam, predominantly attributed to:

- Magnetic fields in the bulk of the target directly influencing protons accelerated from the front surface, or causing hollowing of the electron beam.
- Toroidal magnetic fields in plasma at the rear of the target.
- Filamentation

Clarke et al., PRL, 2000

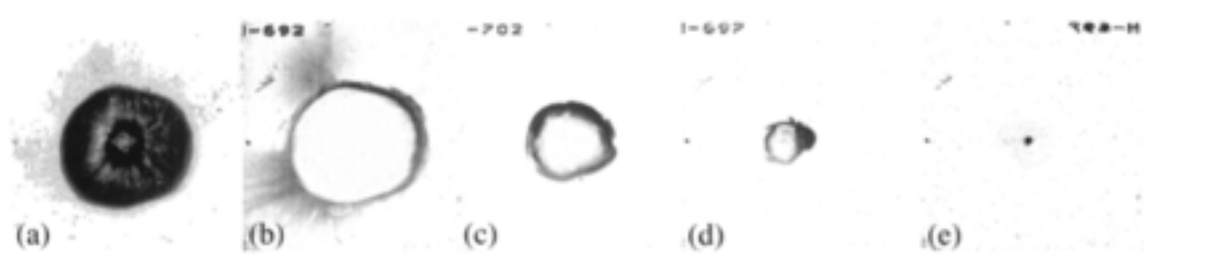
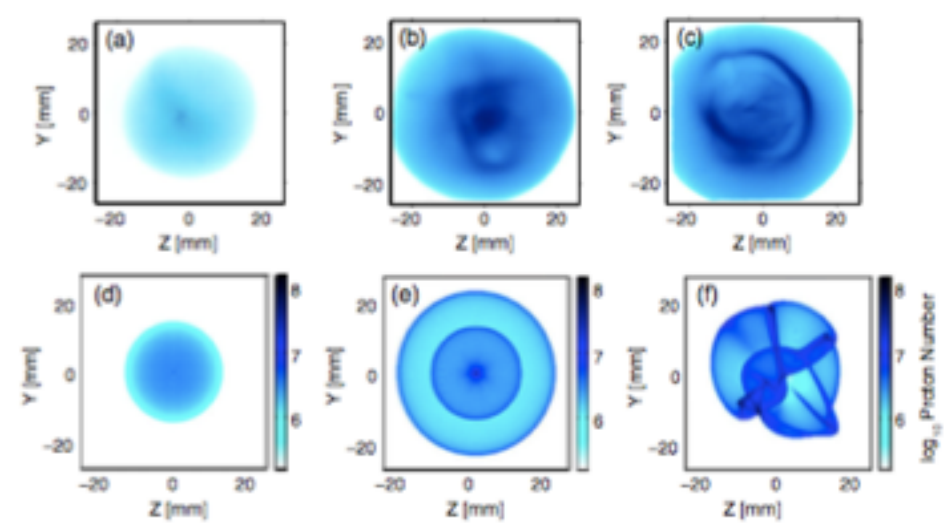


FIG. 1. Ring structure observed on RCF/CR39 "sandwich" track detectors: (a) radiochromic film (front surface); (b) tracks on CR39 from 3 MeV protons; (c) 8.9 MeV, (d) 11.6 MeV, (e) 17.6 MeV protons (track detectors were 5 cm × 5 cm × 0.75 mm thick).

MacLellan et al., PRL, 2013



Electron recirculation modulating the rear surface field?

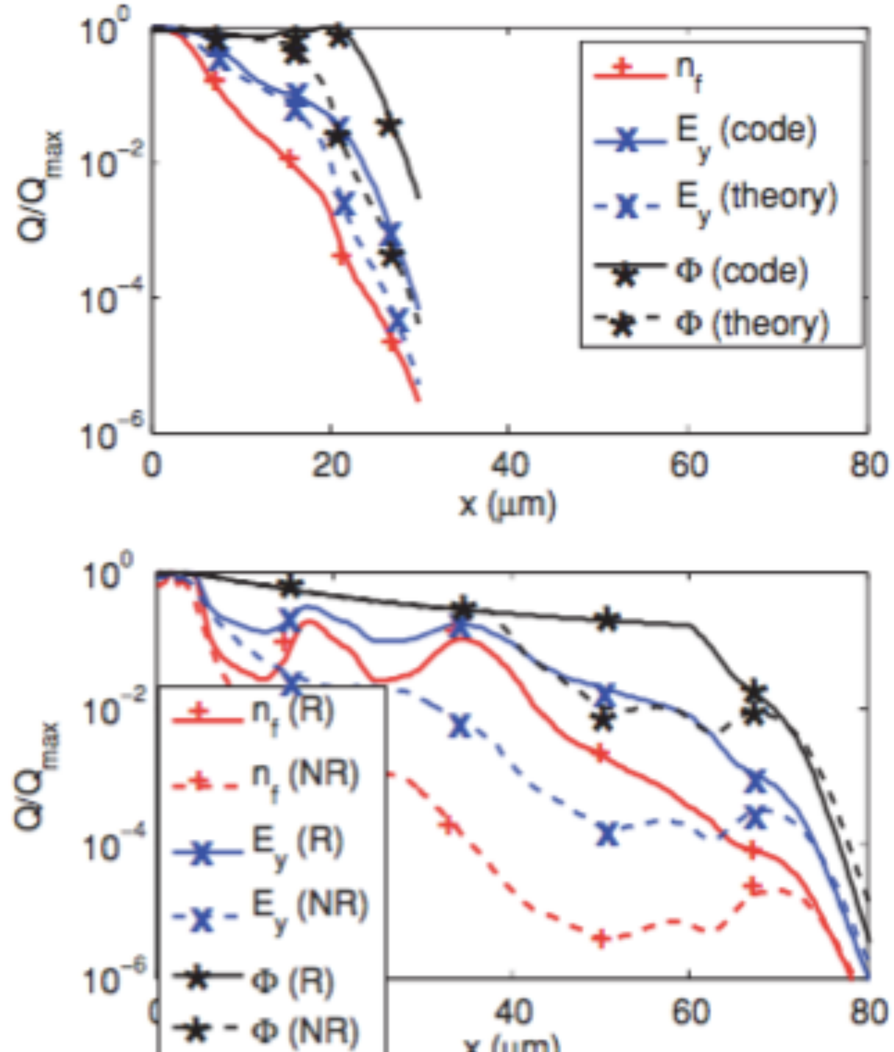


FIG. 4. (Color online) Fast-electron number density just inside and sheath field and potential just outside the target after 100 fs (top). Profiles outside the target constructed from current inside after 285 fs with (R) and without (NR) refluxing (bottom). The peak values are as follows: $n_f^{\text{peak}} = 2.0 \times 10^{27}\ \text{m}^{-3}$, $E_y^{\text{peak}} = 8.1 \times 10^{12}\ \text{V m}^{-1}$, and $\Phi^{\text{peak}} = 3.8$ MeV (top); $n_f^{\text{peak}} = 4.6 \times 10^{27}\ \text{m}^{-3}$ with refluxing and $n_f^{\text{peak}} = 2.4 \times 10^{27}\ \text{m}^{-3}$ without refluxing (bottom). Q/Q_{max} represents the normalized value of a general physical quantity.

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Superluminal sheath-field expansion and fast-electron-beam divergence measurements in laser-solid interactions

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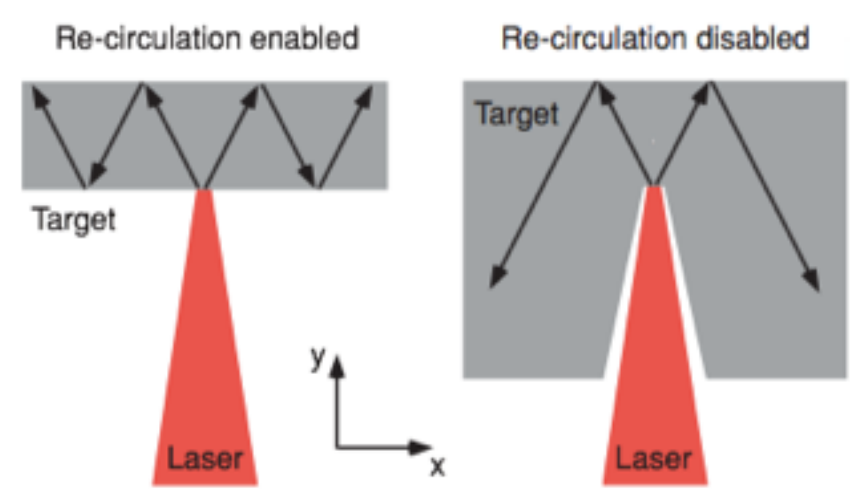
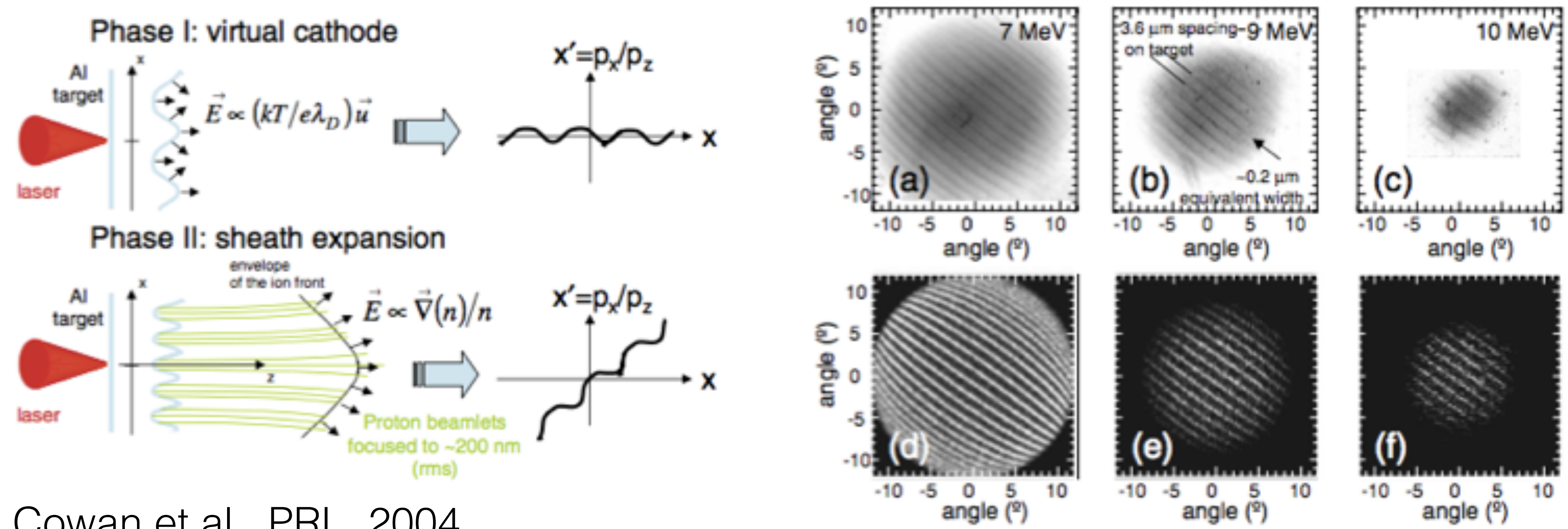
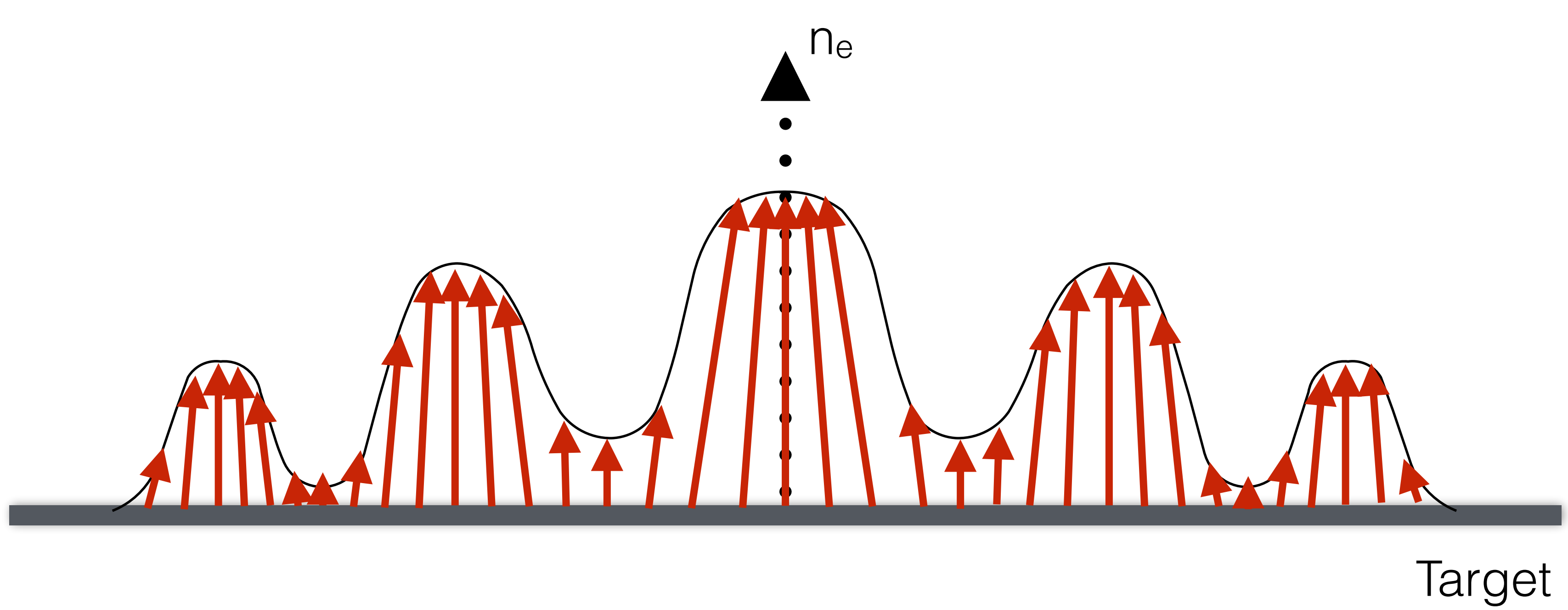


FIG. 1. (Color online) The two types of targets considered in this paper.

How would this modulated electron density affect the proton beam?



Cowan et al., PRL, 2004



- Simulations underway using ZEPHYRS to model evolution of electron density at rear surface for different target thicknesses.

Thank you!