Nils T. Basse, C. Kissing, R. Bini, M. Seeger, P. Stoller, T. Votteler and B. Wüthrich

Measurement of 3D turbulent mixing in a small-scale circuit breaker model

ABB Corporate Research Center, Baden-Dättwil, Switzerland

XVIII GD, Greifswald, Germany, 2010

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Outline

- How does a self-blast gas circuit breaker work?

- Earlier studies and open questions

- Optical setup and test device

- Discharges

- Shadowgraphy movies

- Streamlines from velocimetry

- Conclusions and outlook

How does a self-blast gas circuit breaker work?
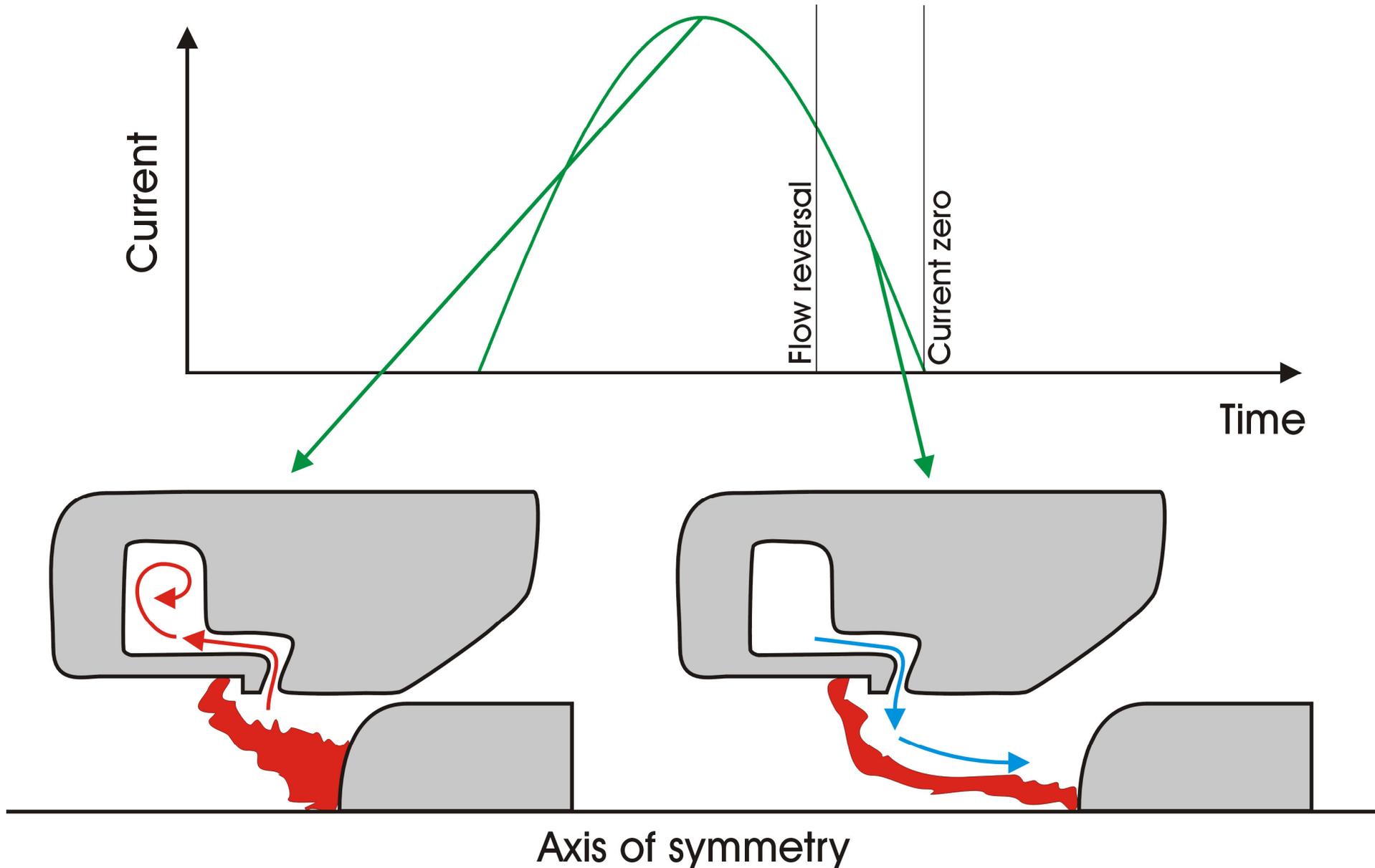
Earlier studies and open questions

- Mixing in 2D slab geometries:

  - R.Bini et al.,"Measured and simulated SF6 mixing behaviour", GD 2010 (A2 Monday 3:00 pm)

  - R.Bini et al., "Arc-induced turbulent mixing in a volume filled with SF6", submitted to J.Phys.D: Appl. Phys. 2010

  - N.P.T.Basse et al., "Measured turbulent mixing in a small-scale circuit breaker model", Applied Optics 2009

- Open questions:

  - Diagnostics: Can we use Fresnel lenses?

  - Mixing: What changes from 2D to 3D?

Optical setup

- 18 µs between frames, 1 µs exposure time

- 128 (width) × 256 (height) pixels
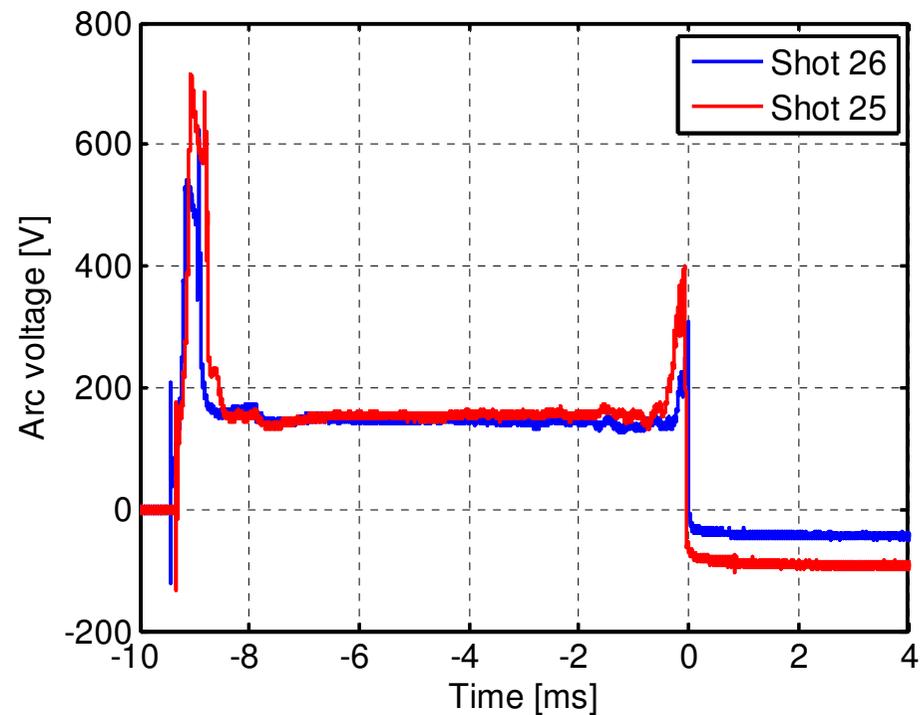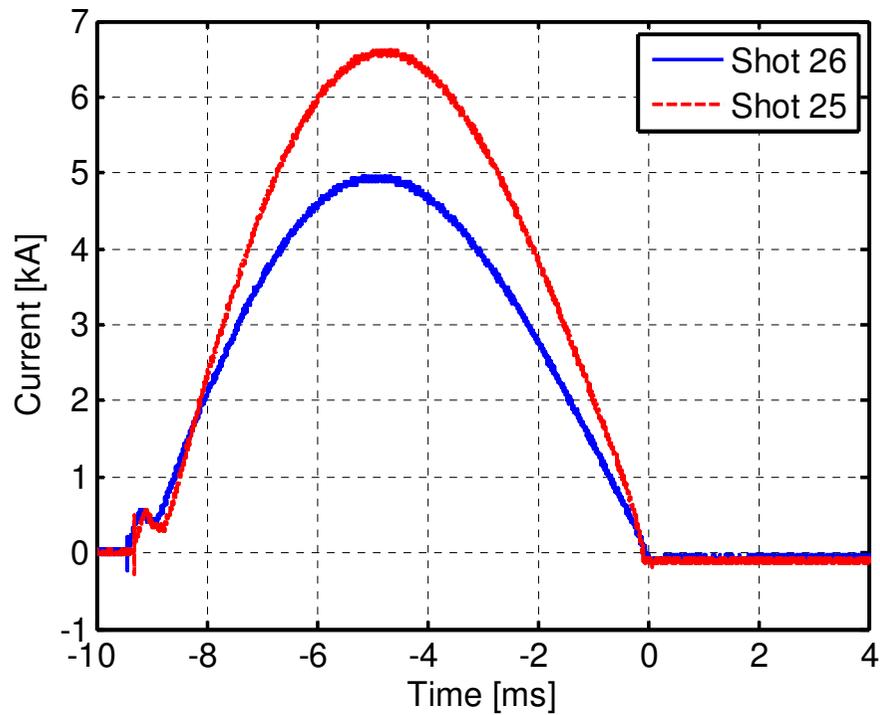
- 1 pixel = 0.6 mm
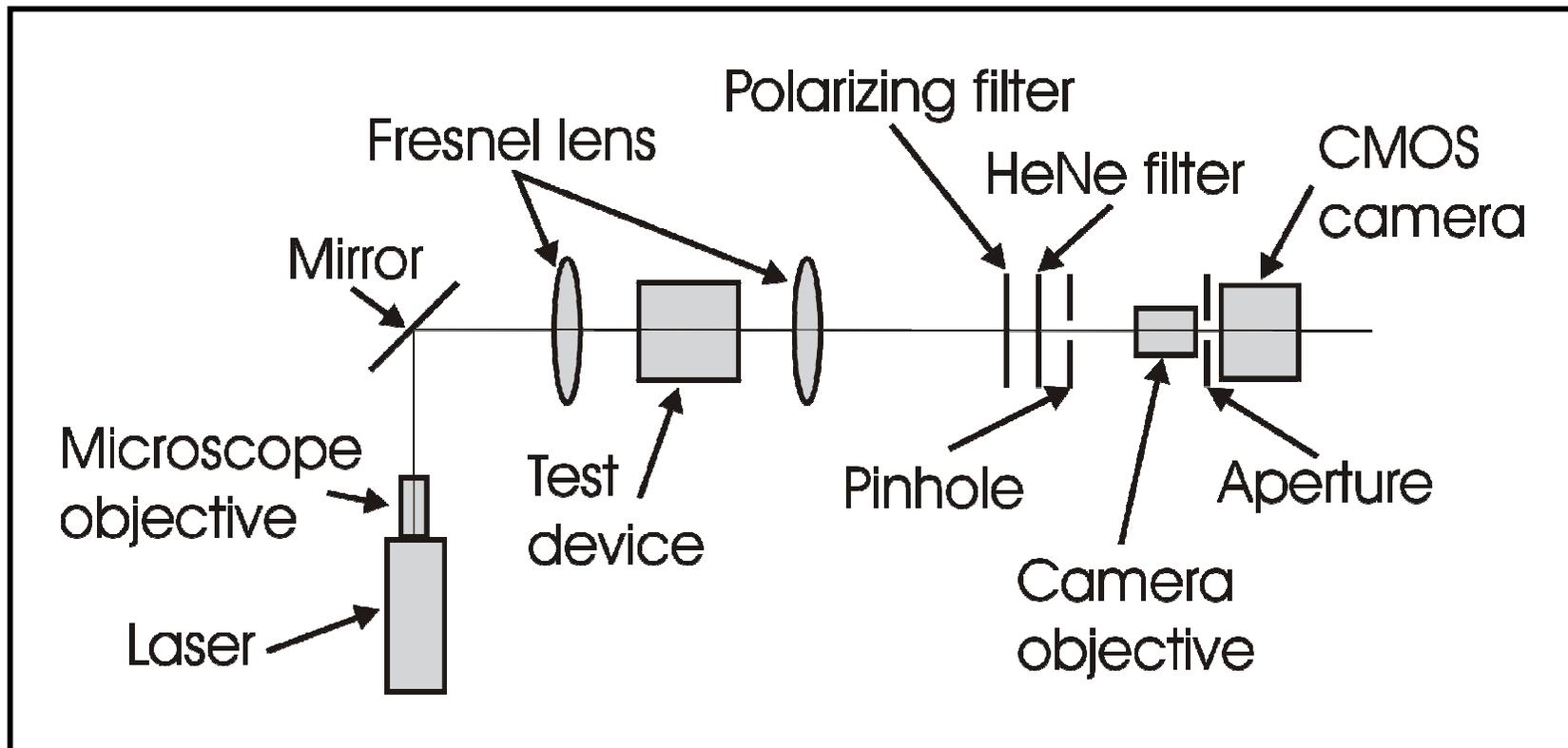
Test device

- Left: Picture of experimental setup

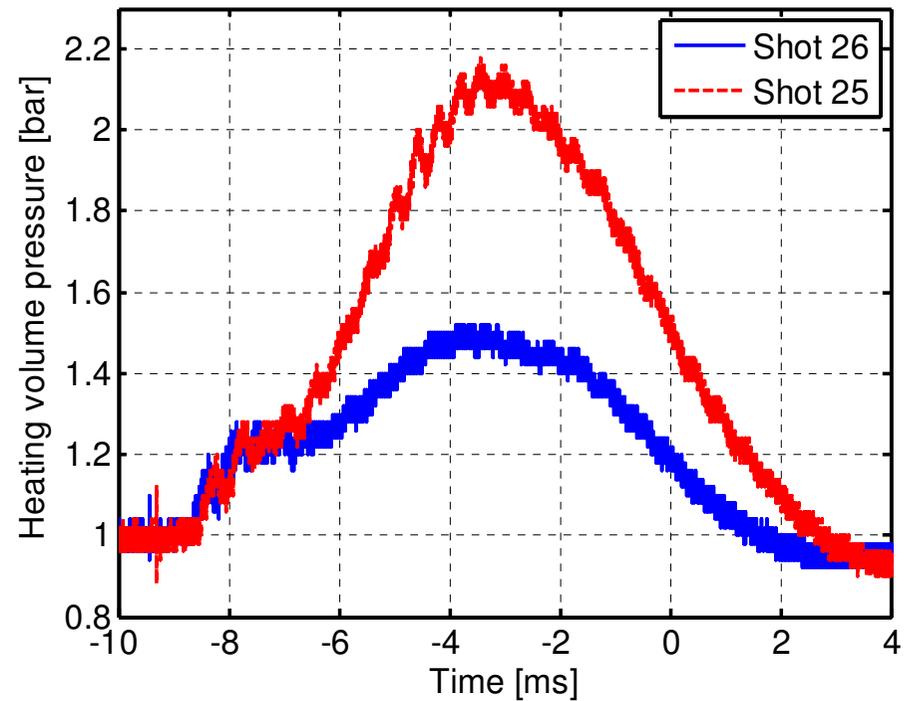- Right: Sketch of heating volume cuboid
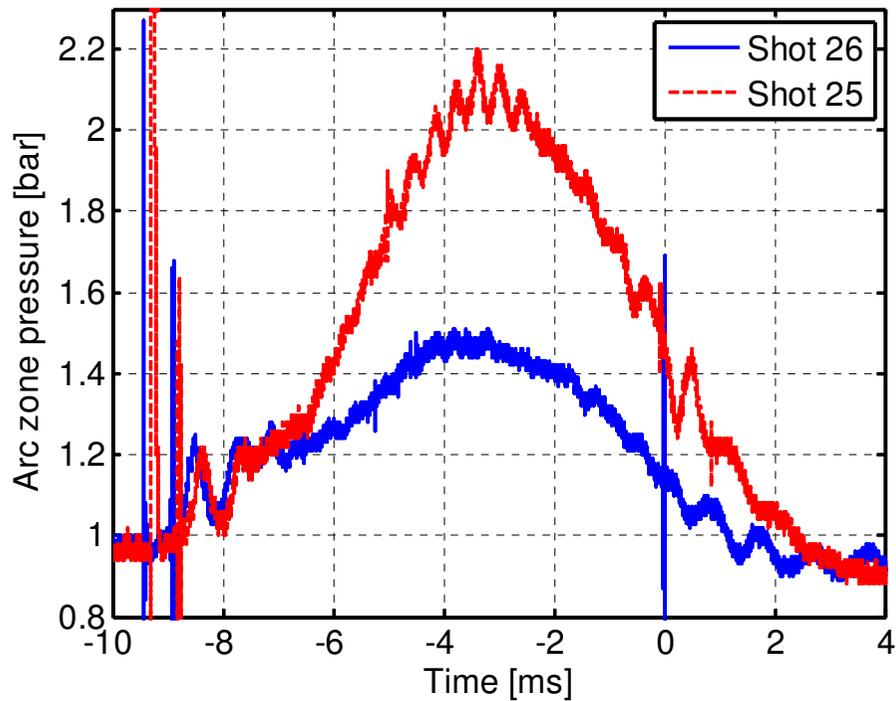

Current path

Heating volume
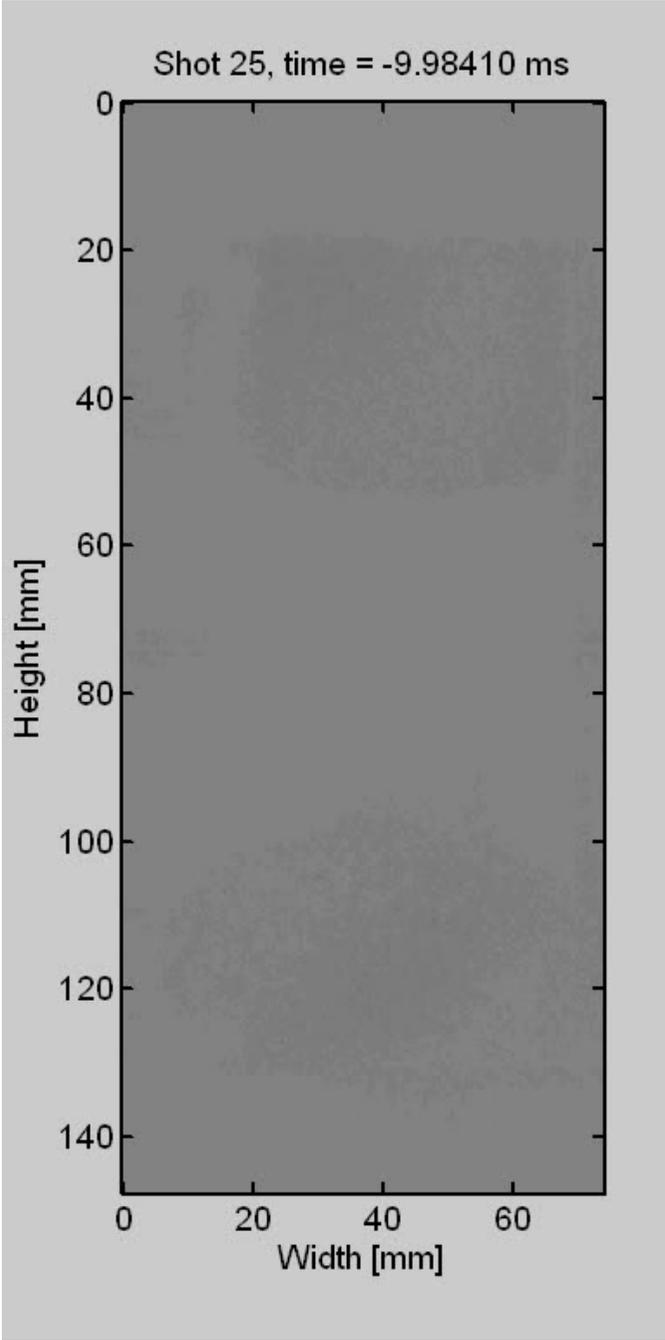
Arc zone

50.4 mm
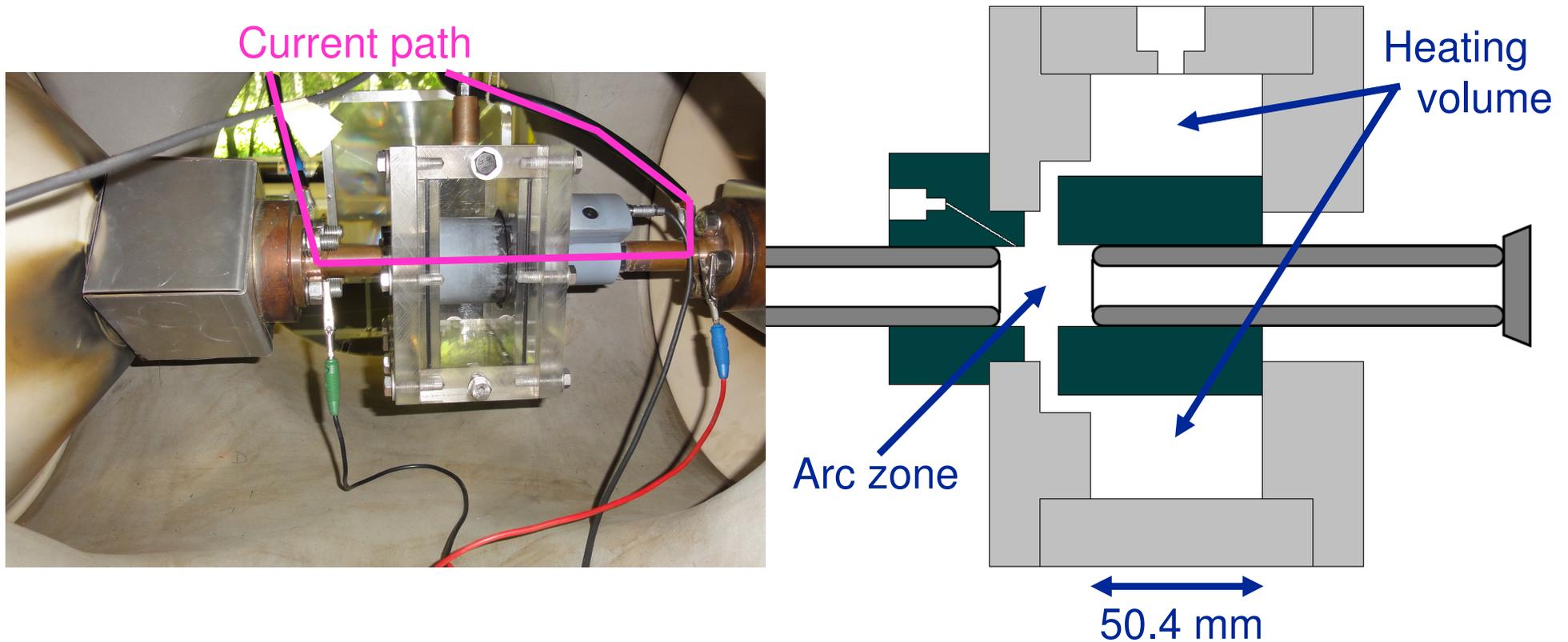
Discharges

- Left: Current
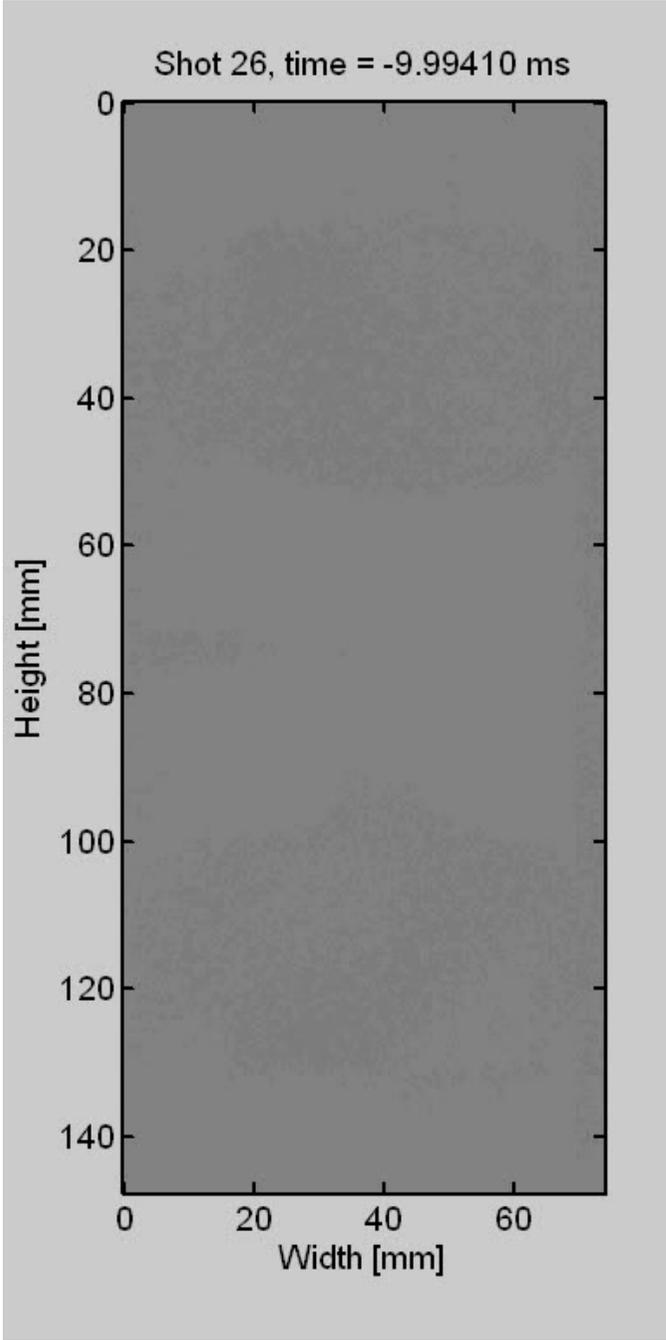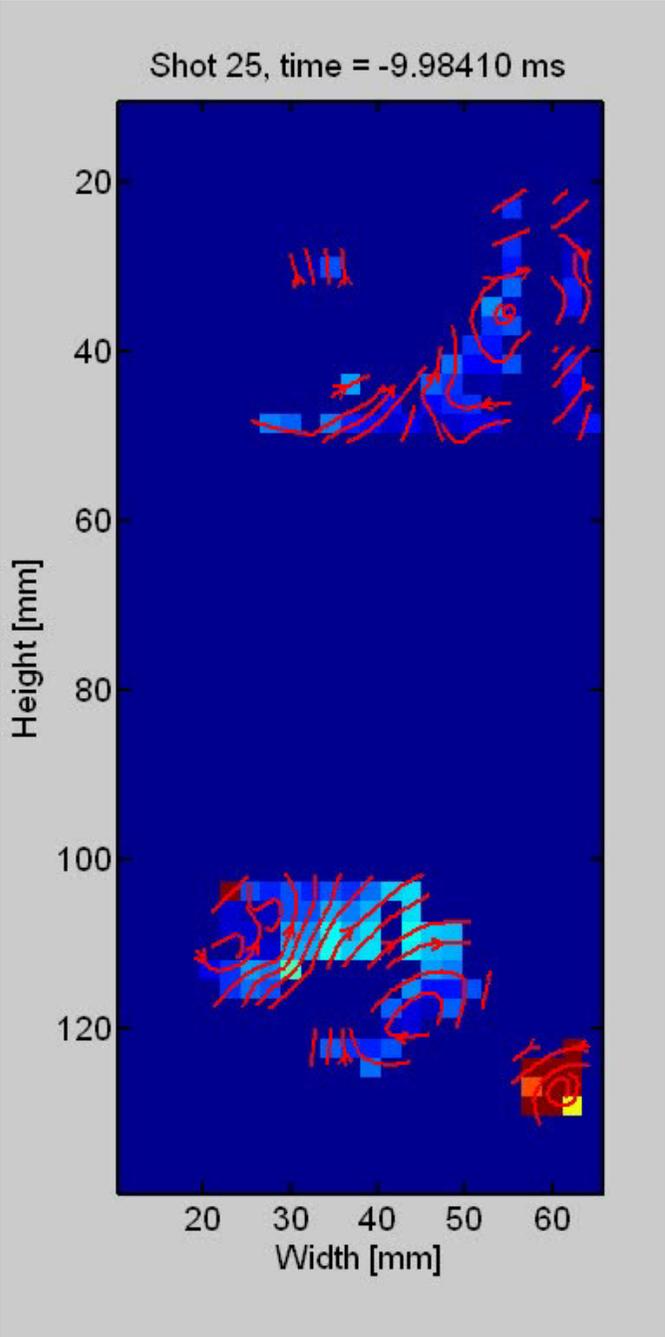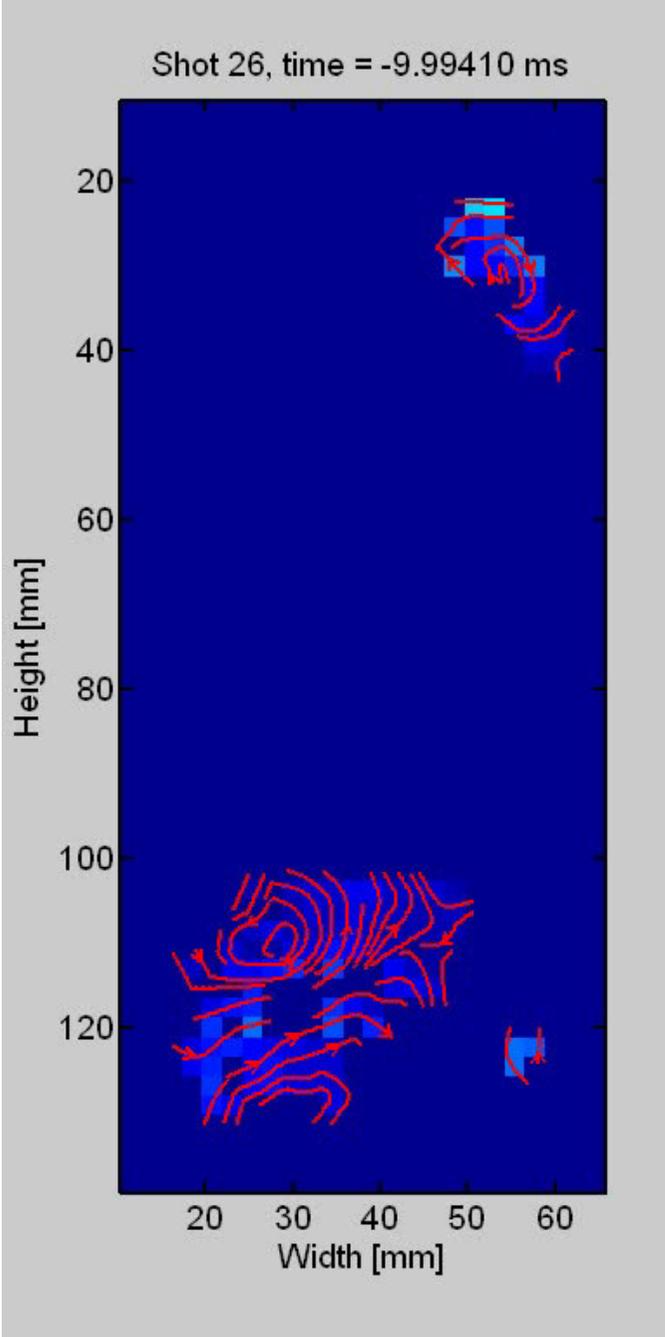
- Right: Arc voltage

Discharges

- Left: Arc zone pressure

- Right: Heating volume pressure
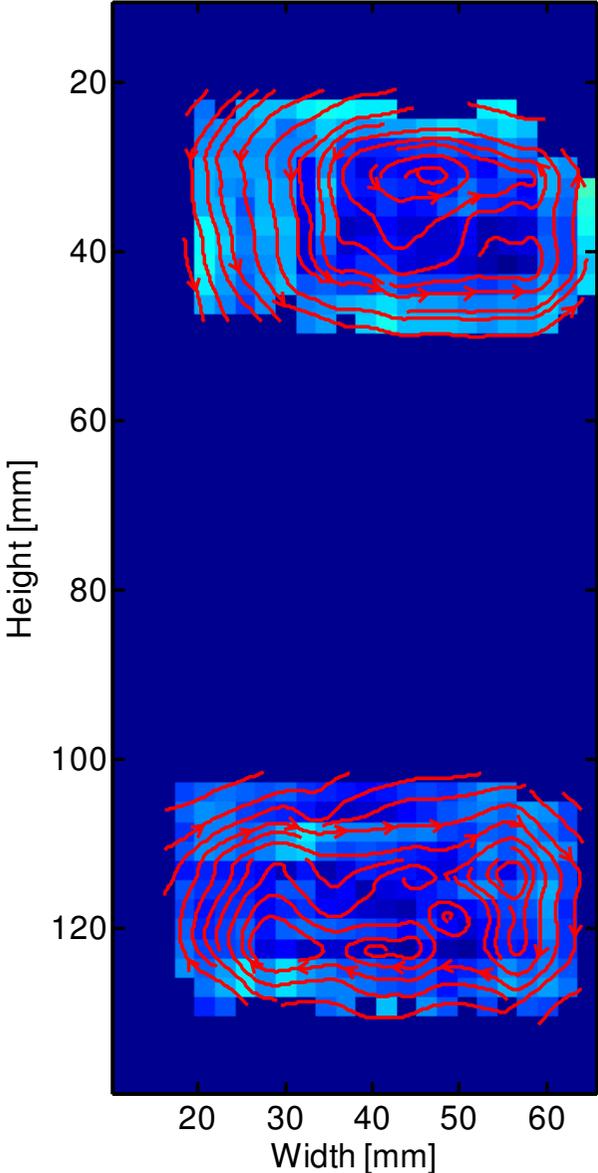
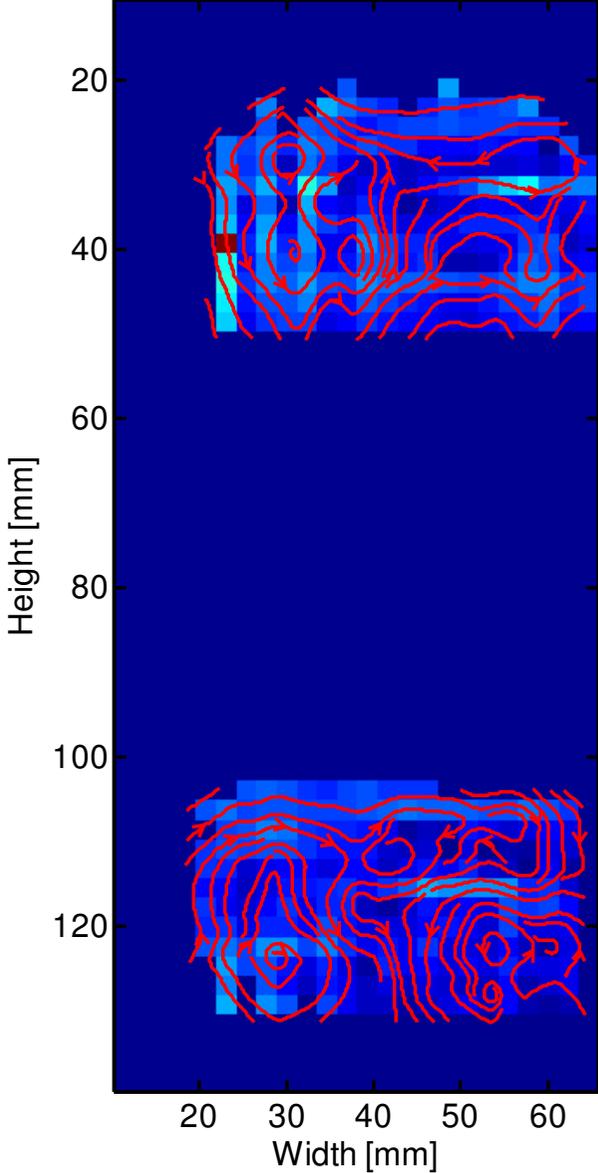# Shadowgraphy movies

Streamlines from velocimetry

Streamlines at CZ

Shot 26, time = -0.00400 ms Shot 25, time = -0.01200 ms

Conclusions

- 3D mixing experiments have been done in air at 1 bar

- It is possible to perform velocimetry on images recorded with Fresnel lenses

- Mixing pattern at CZ:

    - Low current: One vortex

    - High current: Several vortices

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Outlook

- Future work:

  - Diagnostics:

    - Phase-contrast imaging to (i) increase sensitivity and (ii) measure absolute density

    - Use high quality optical components to optimise images

  - Test devices:

    - Heating volume cuboid, fixed contacts (ignition wire):

      - Asymmetries (current path, manufacturing inaccuracies etc.)

      - Other gases, fill pressures, arcing times, geometries

      - Christopher Kissing: RFH Köln, M.Sc. Thesis work

    - Heating volume cylinder, moving contacts:

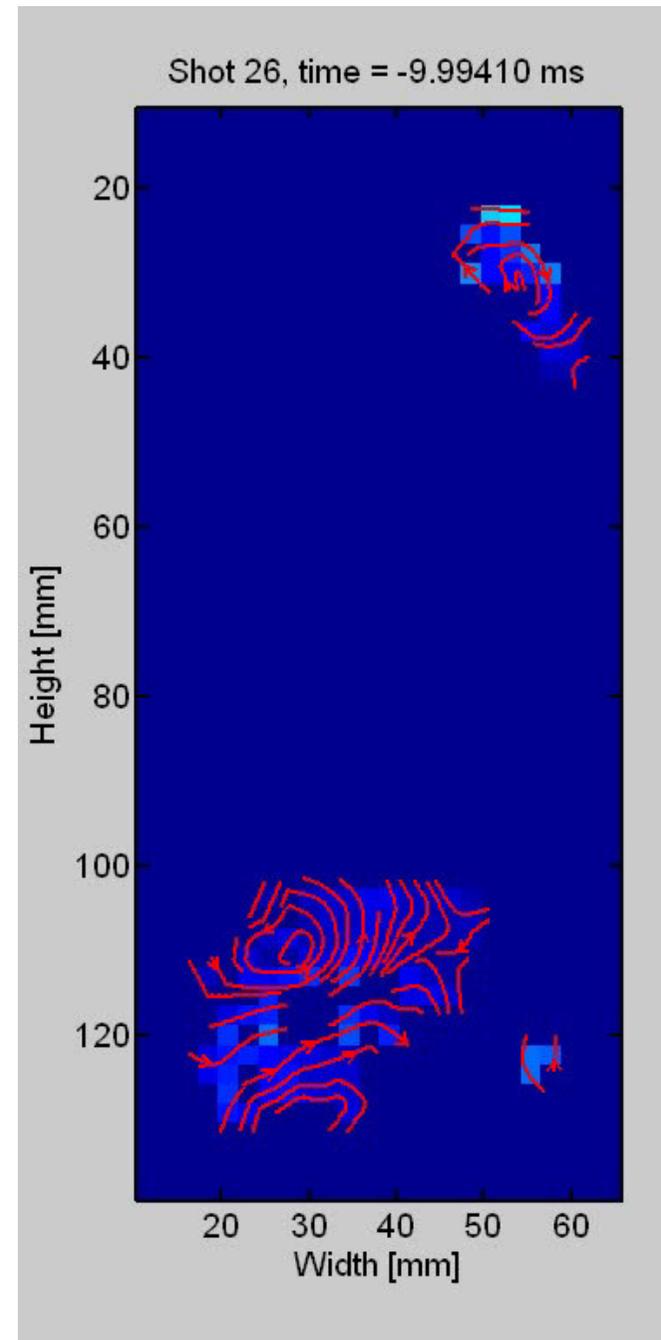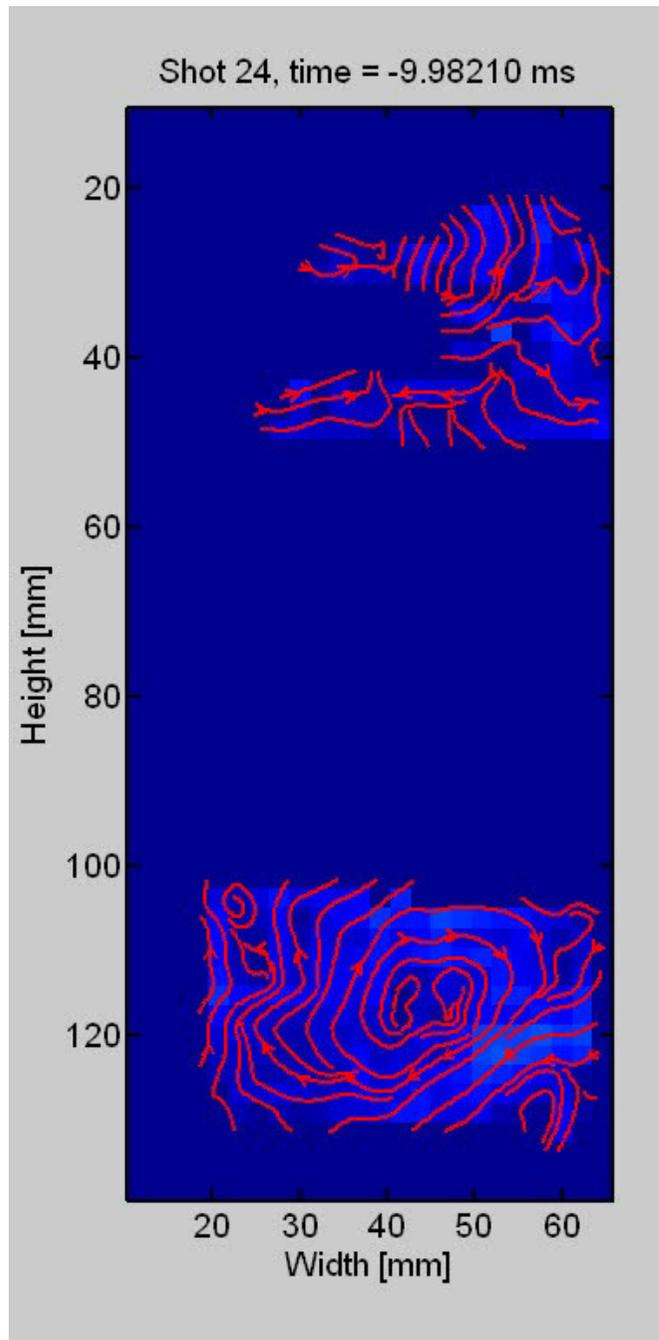   - Roger Wiget: ETH Zürich, M.Sc. Thesis work

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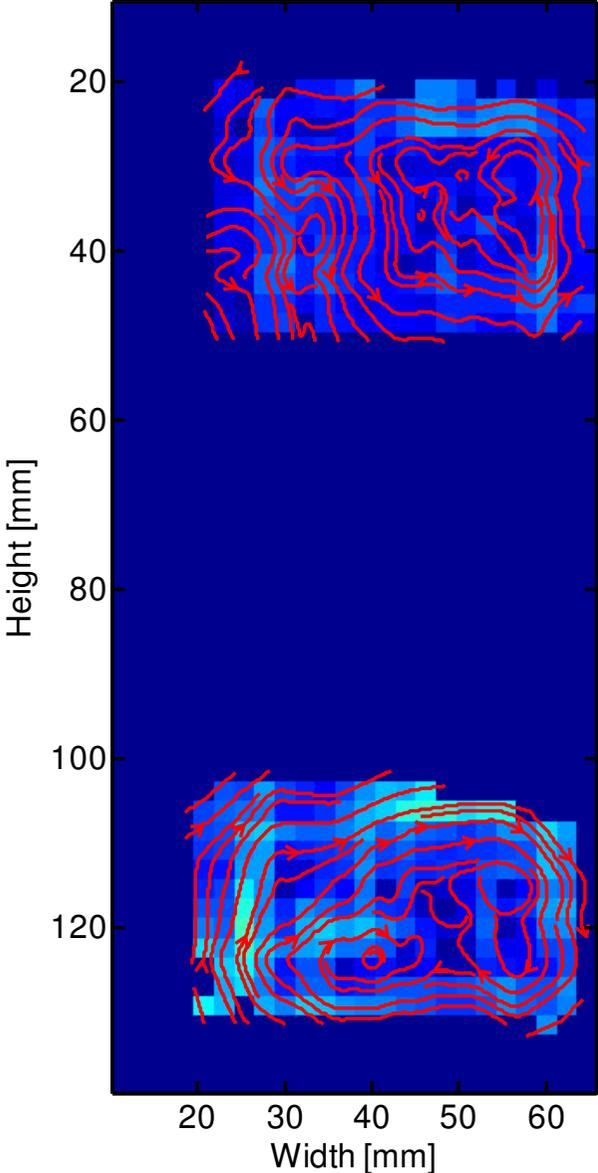for a better world™

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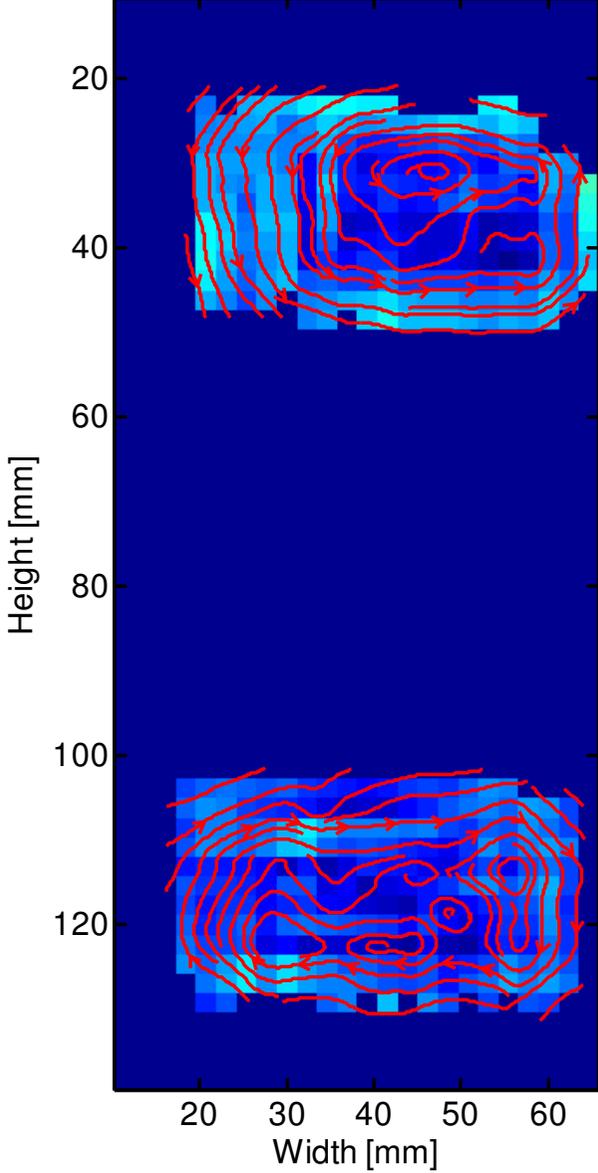# Repeat shots: Low current movies
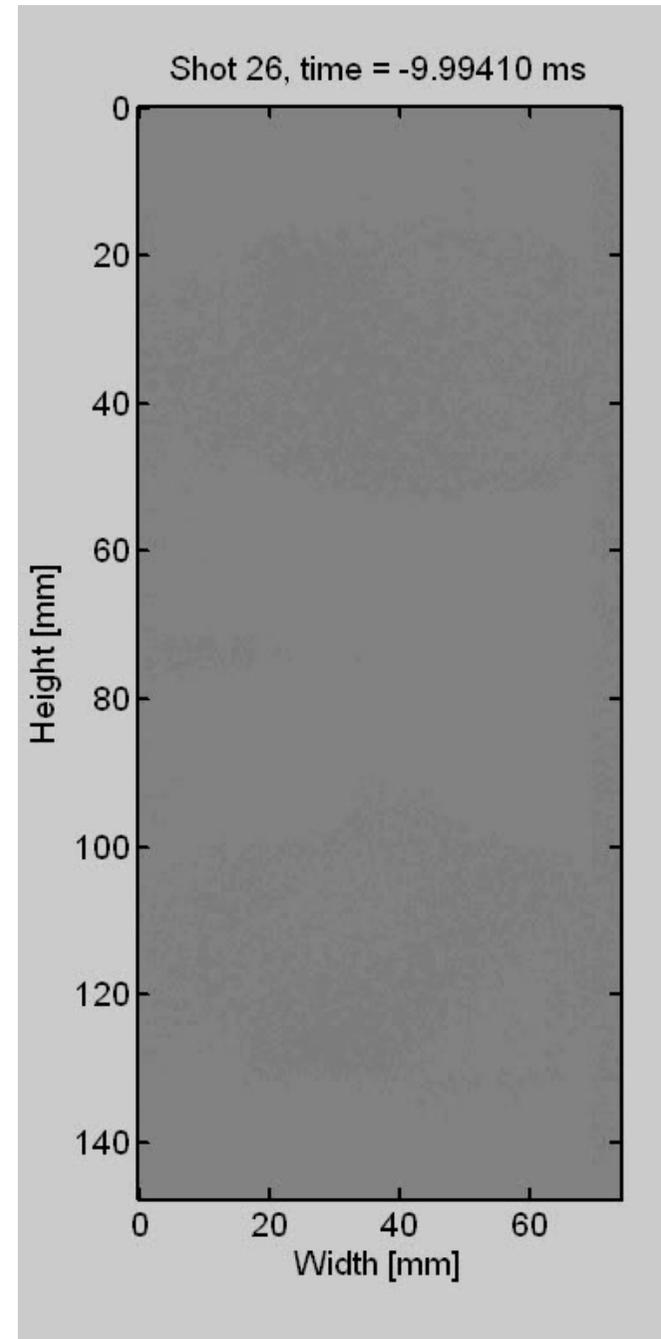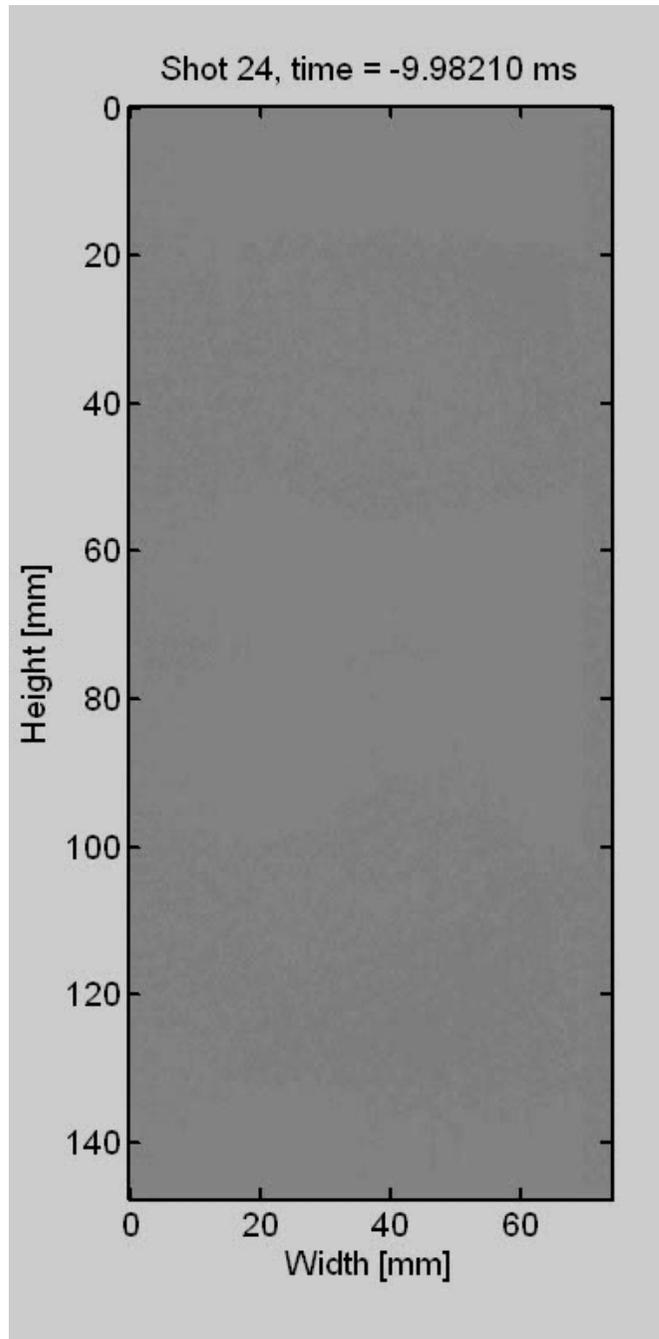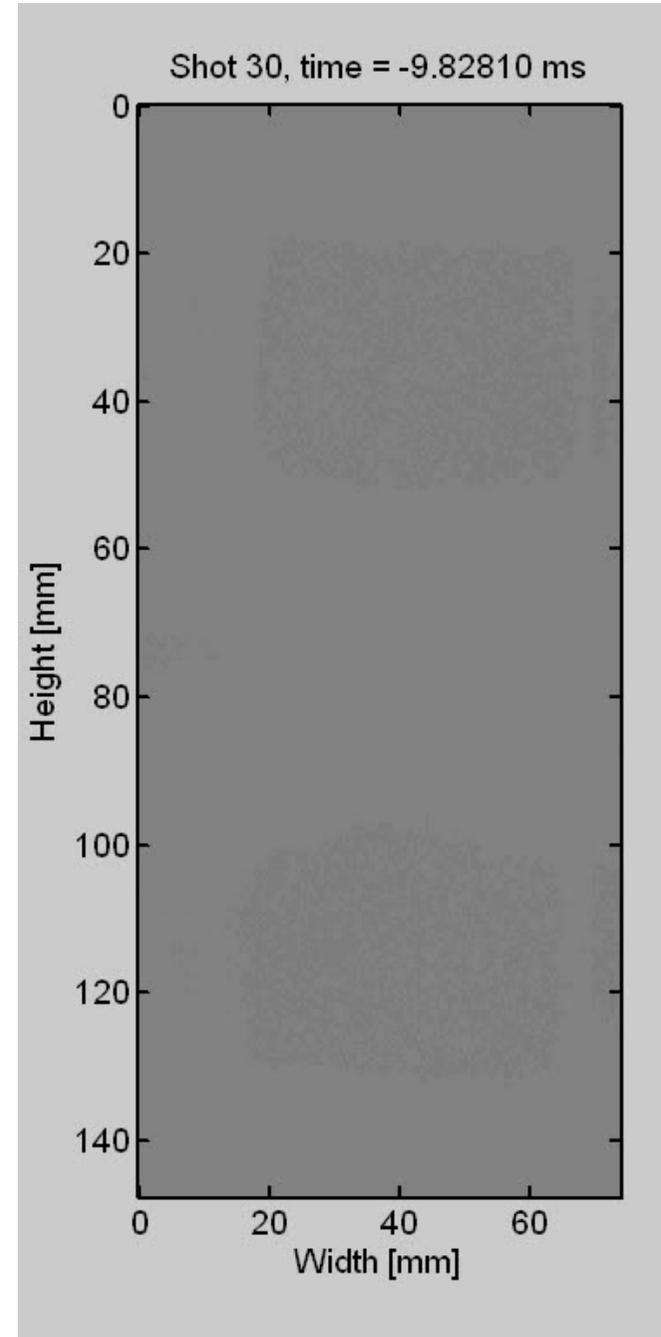
Repeat shots: Low current streamlines
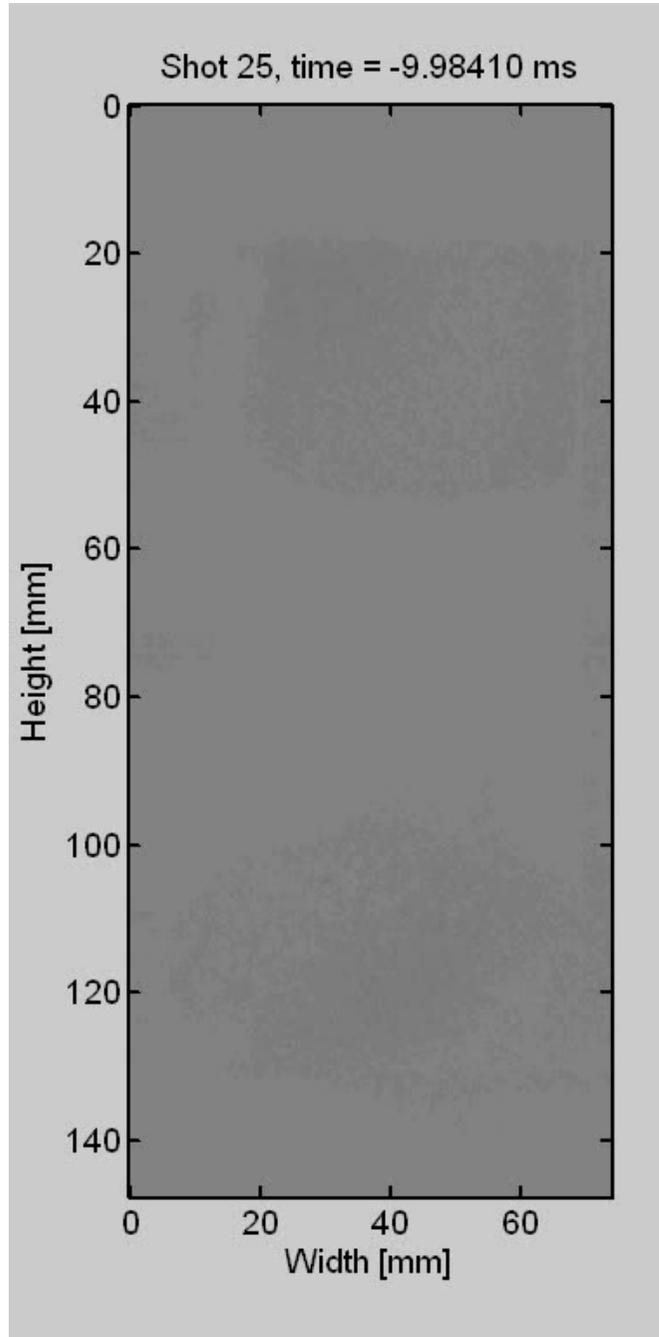
Low current streamlines at CZ

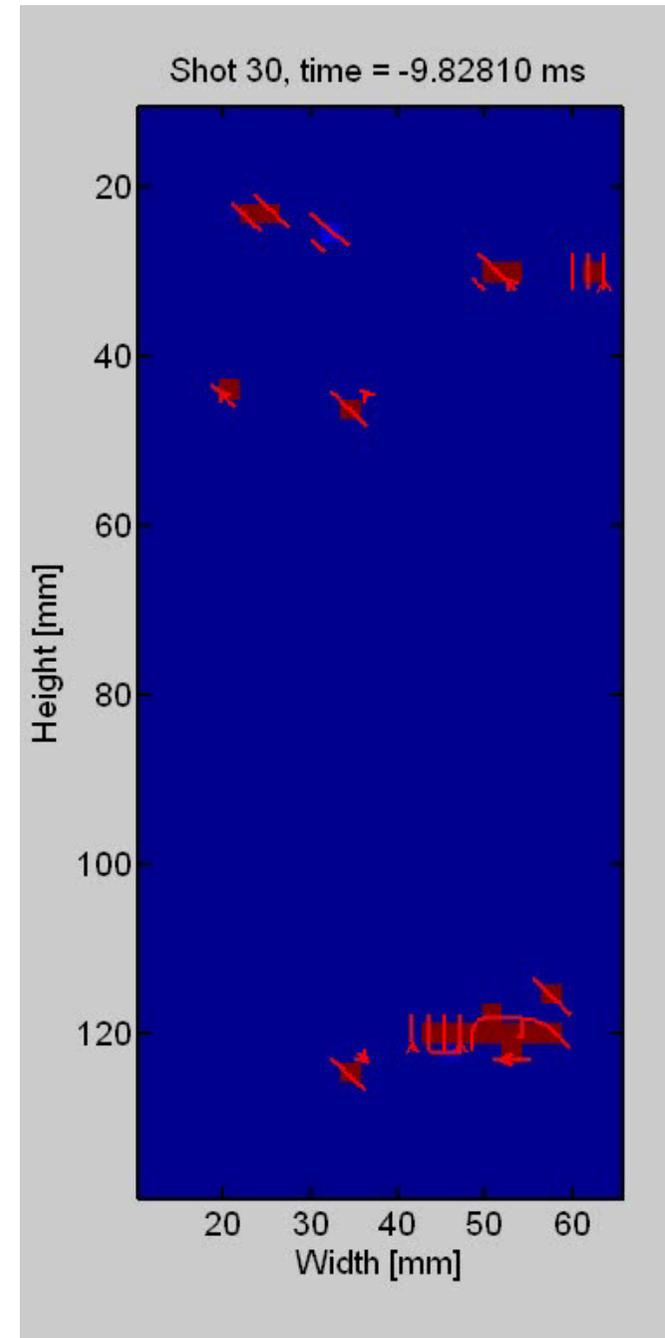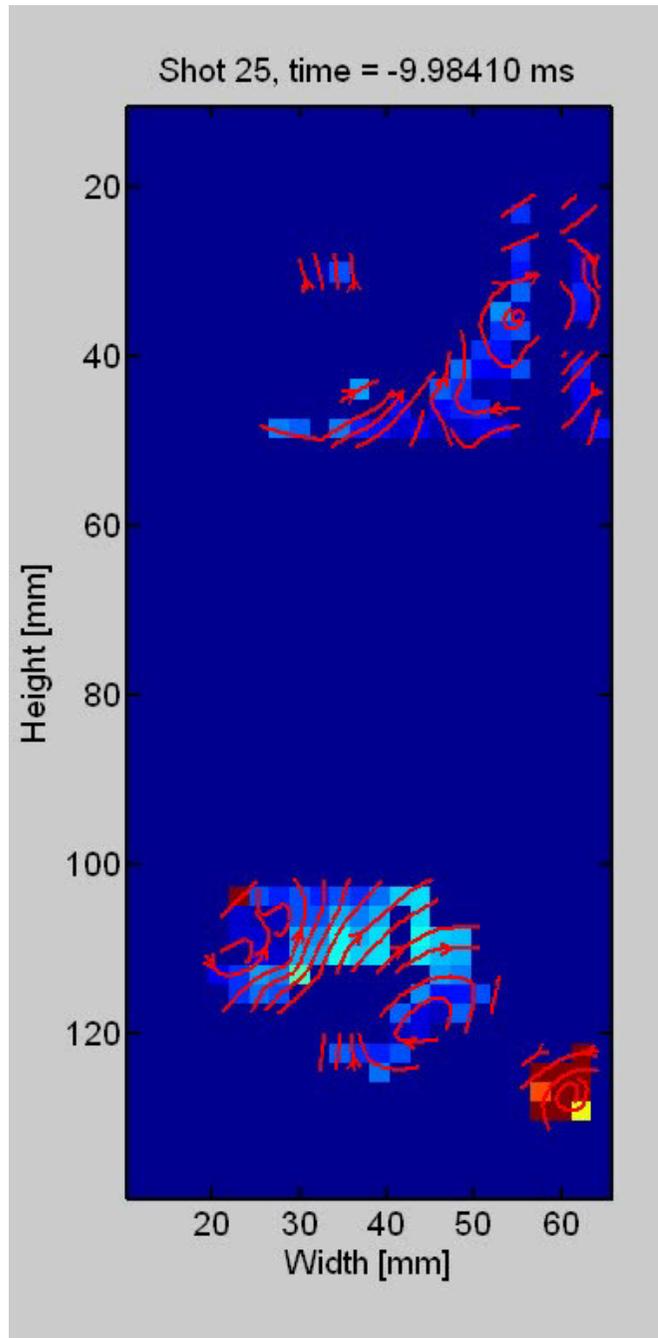Shot 24, time = -0.01000 ms

Shot 26, time = -0.00400 ms
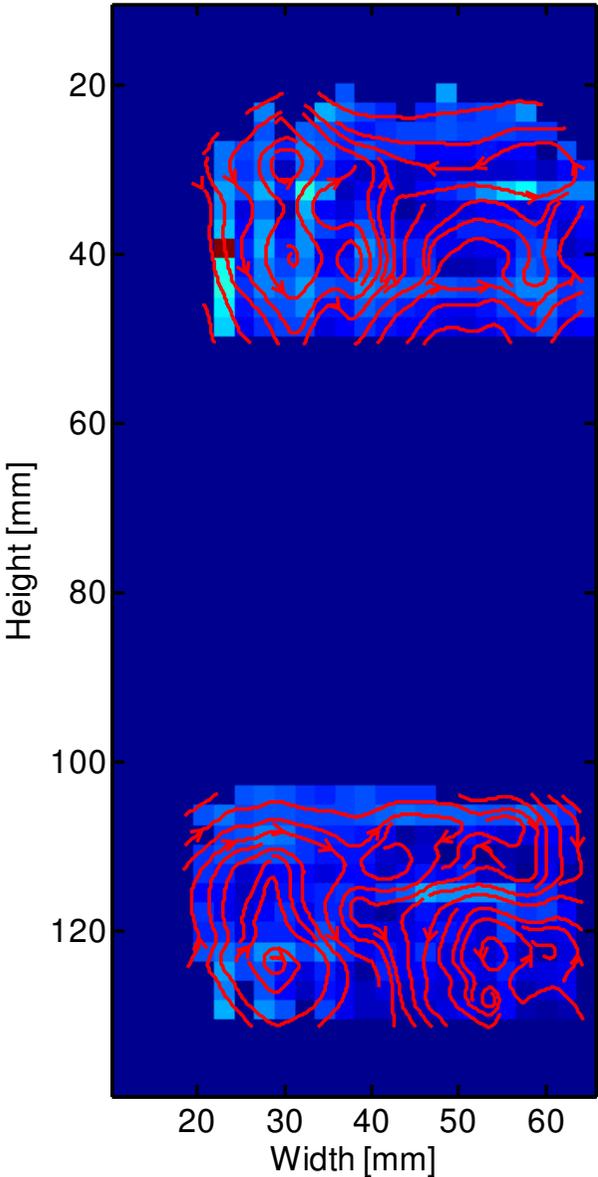
Repeat shots: High current movies

Repeat shots: High current streamlines

High current streamlines at CZ

Shot 25, time = -0.01200 ms

Shot 30, time = 0.00000 ms