Follow-up

Construction of a Plasma Cell for Plasma Acceleration Experiments at PITZ

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Construction of Plasma Cell at PITZ
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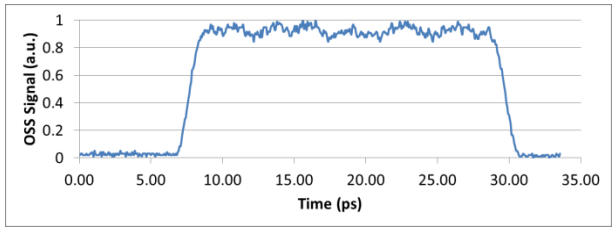
HELMHOLTZ ASSOCIATION

PITZ Photo Injector Test Facility Zeuthen

DESY

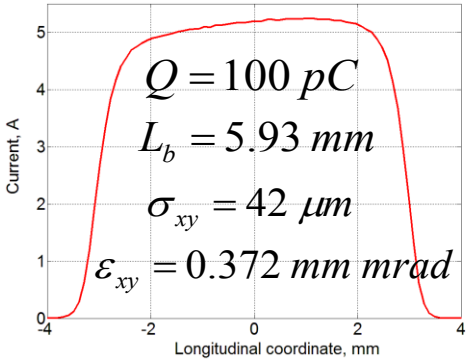
Topic

- LAOLA @ PITZ: Studies for Particle Driven Plasma Acceleration
- **Self-modulation of electron beam** (proof of principle for CERNs AWAKE exp.)
  - use high flexibility of photo cathode laser system:

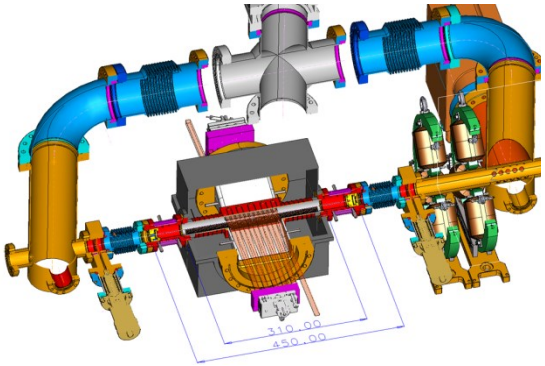


- Example: flat-top e-beam through plasma cell:

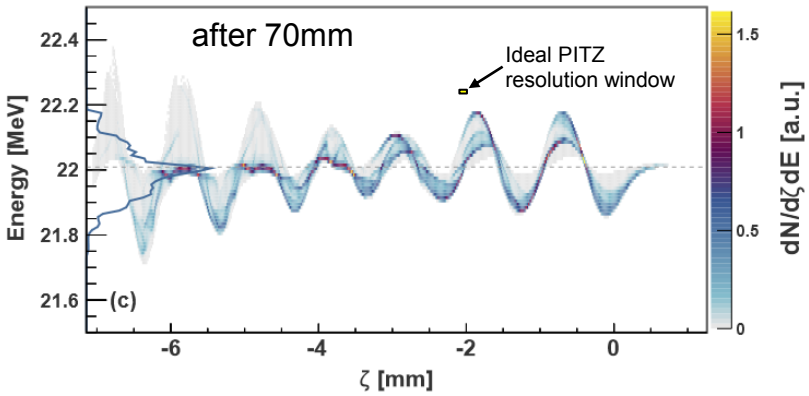
Bunch 6.35m from cathode:



Peak density ≈10^{13} e^-/cm^3

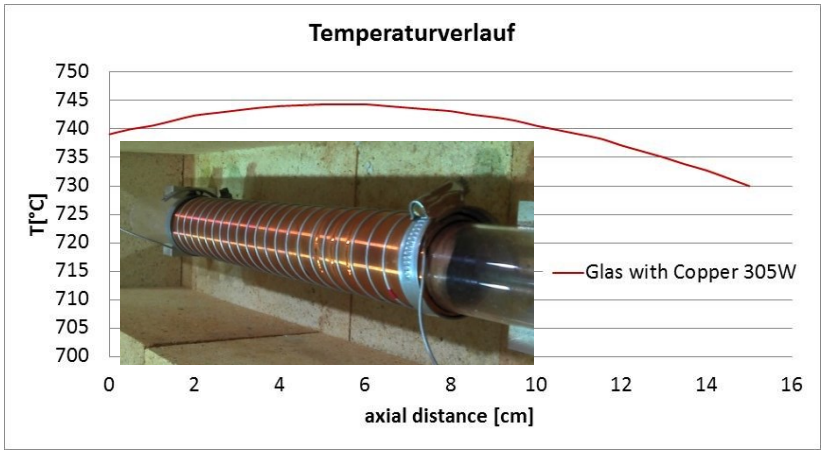


Plasma density ≈10^{15}/cm^3

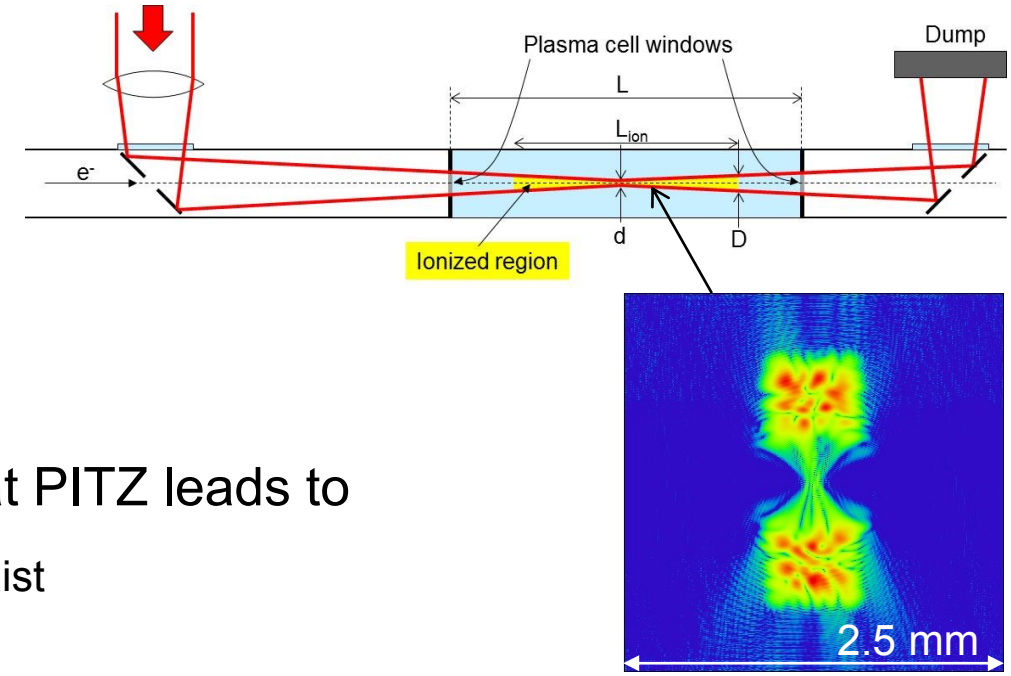


Designing a Plasma Cell for the PITZ Experiment

Heat Pipe Oven Prototype was built



How to ionize the gas?

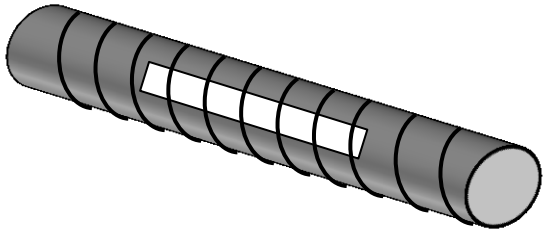


- Problems: Space restrictions at PITZ leads to
  - double cone structure with thin waist
  - strong influence of hole in mirror

- **New idea: modify plasma cell to allow side coupling**

Step 1: Insert Window into Side of Tube

- Problems:

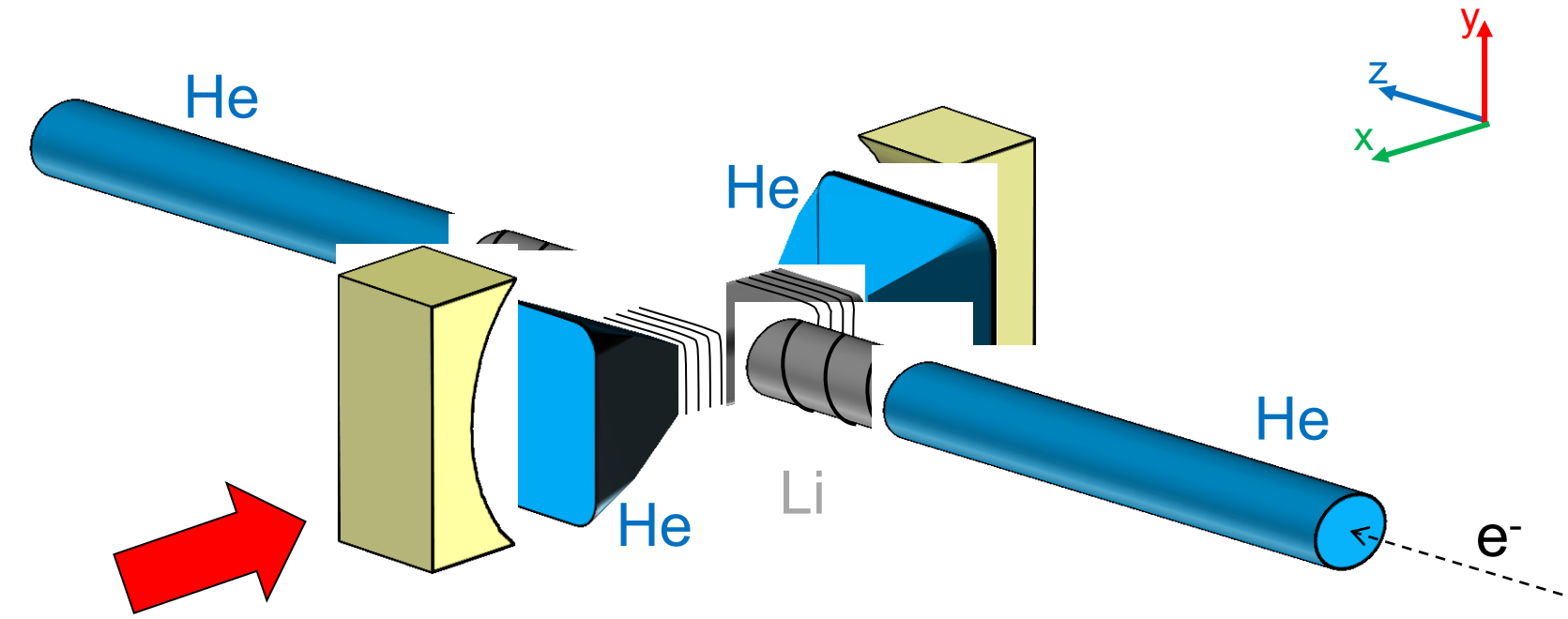


- Heating coil has to be redistributed
  - Cannot go across window
- Hole has to be cut into wick* -> functionality?
  - Flow of liquid Lithium could be disturbed leading to concentration of Lithium in hole area
- Lithium could stick to window, absorb laser energy
  - Calculation: 20nm liquid Lithium thickness is enough to block 90% of laser light

*steel mesh on tube inside to transport liquid Lithium to the tube center

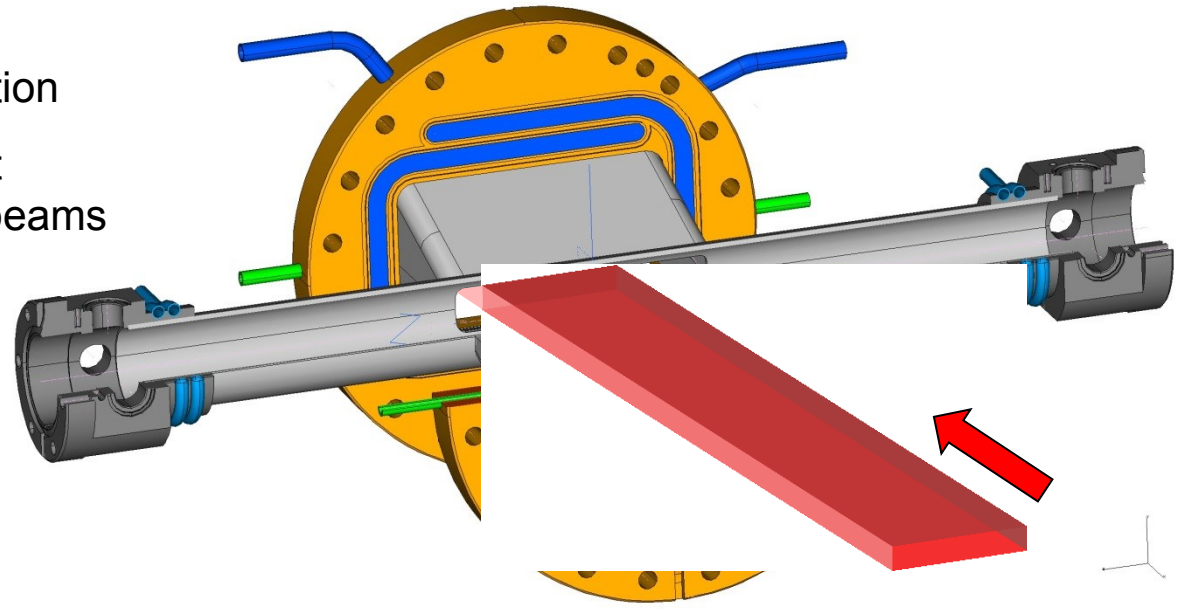
Step 2: Add Helium Buffer Regions

- Prevent Lithium to reach side windows



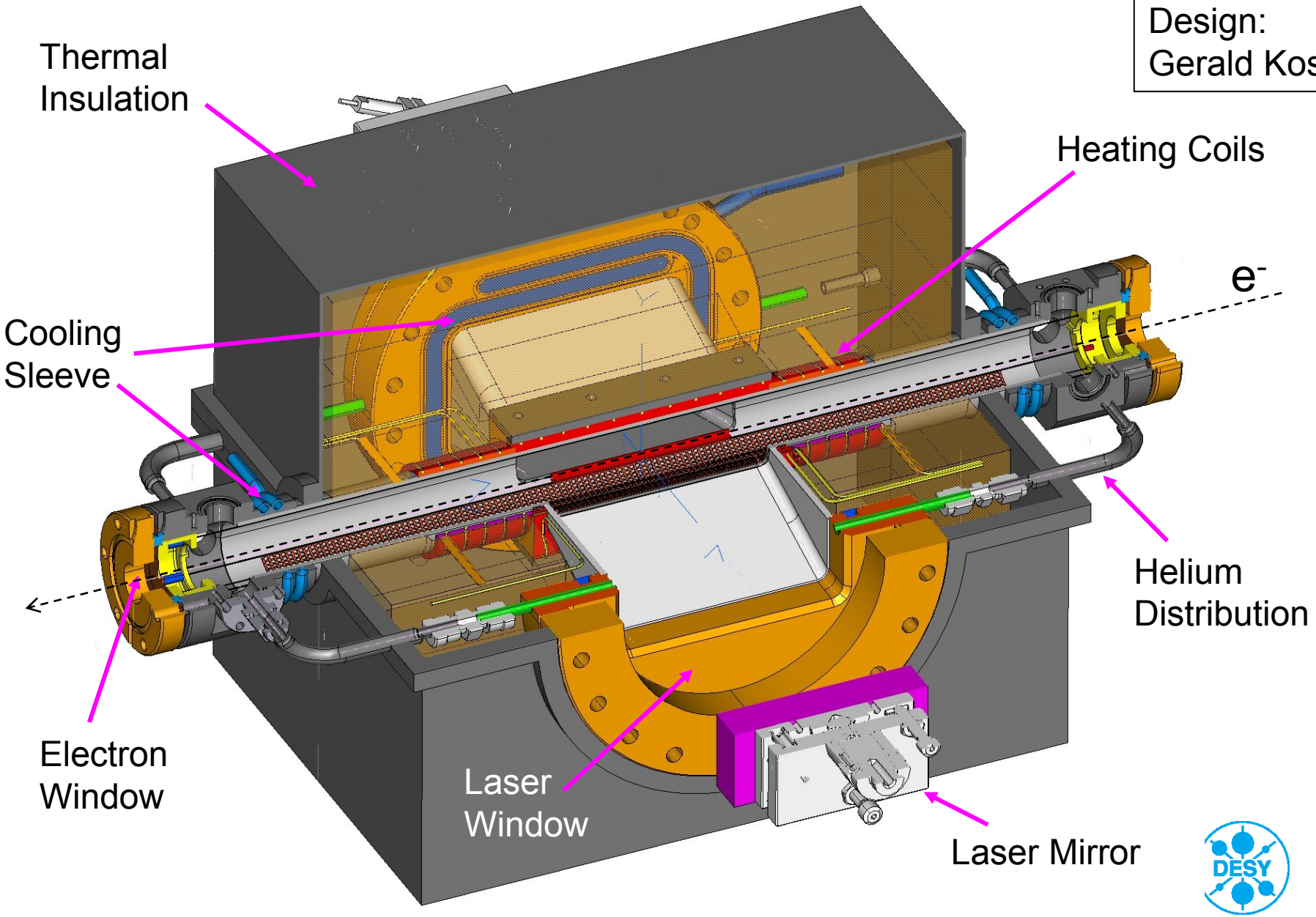
Plasma Ionization Scenario

- Side coupling of ionization laser – here: ArF laser
- Advantages:
  - No additional optical elements in electron beam line up- or downstream of plasma cell
  - Well defined beginning and end of plasma channel
  - Side windows could also be utilized for diagnostics
- Challenges:
  - Complicated construction
  - Non-coaxial alignment of electron and laser beams



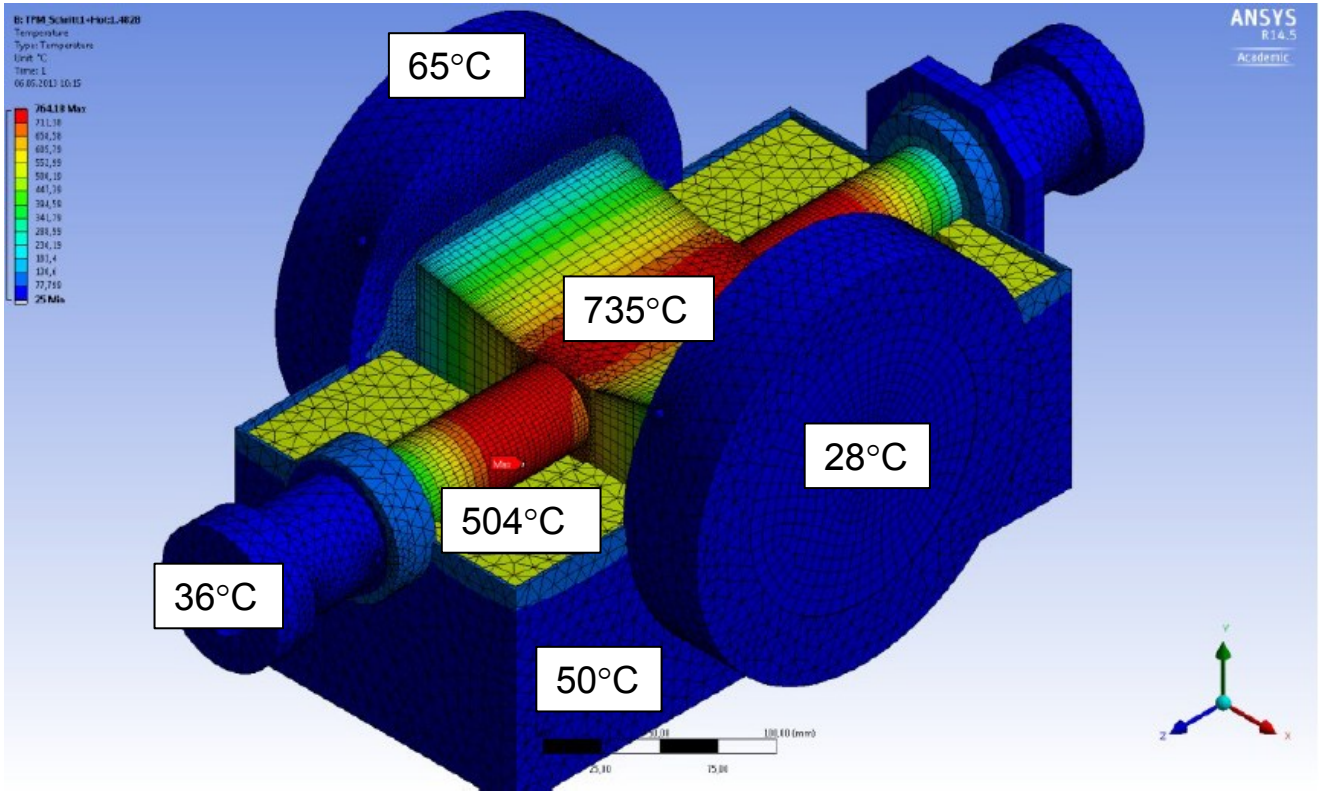
Plasma Cell Design – Currently in Fabrication

Design:
Gerald Koss



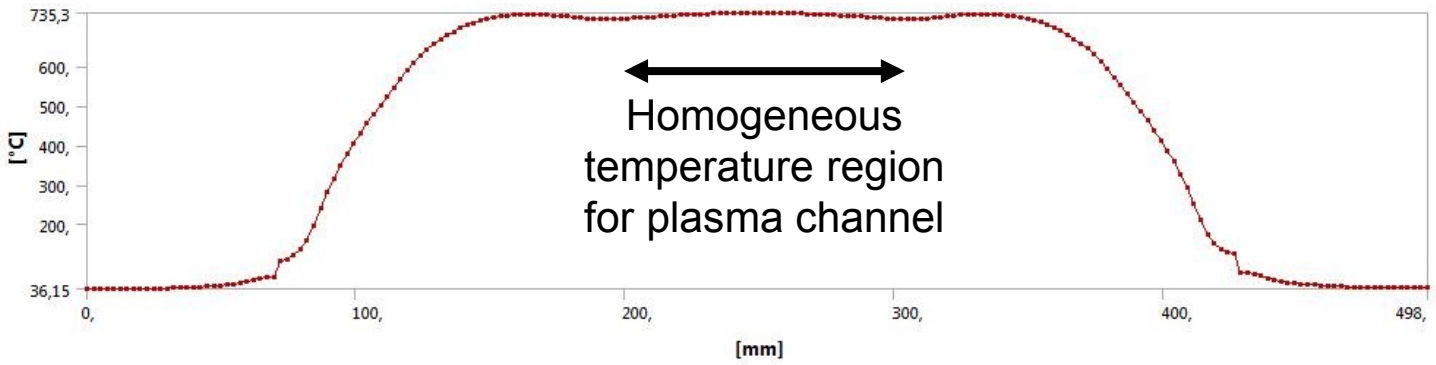
Temperature Simulations of Plasma Cell

- Temperature
  - ANSYS model



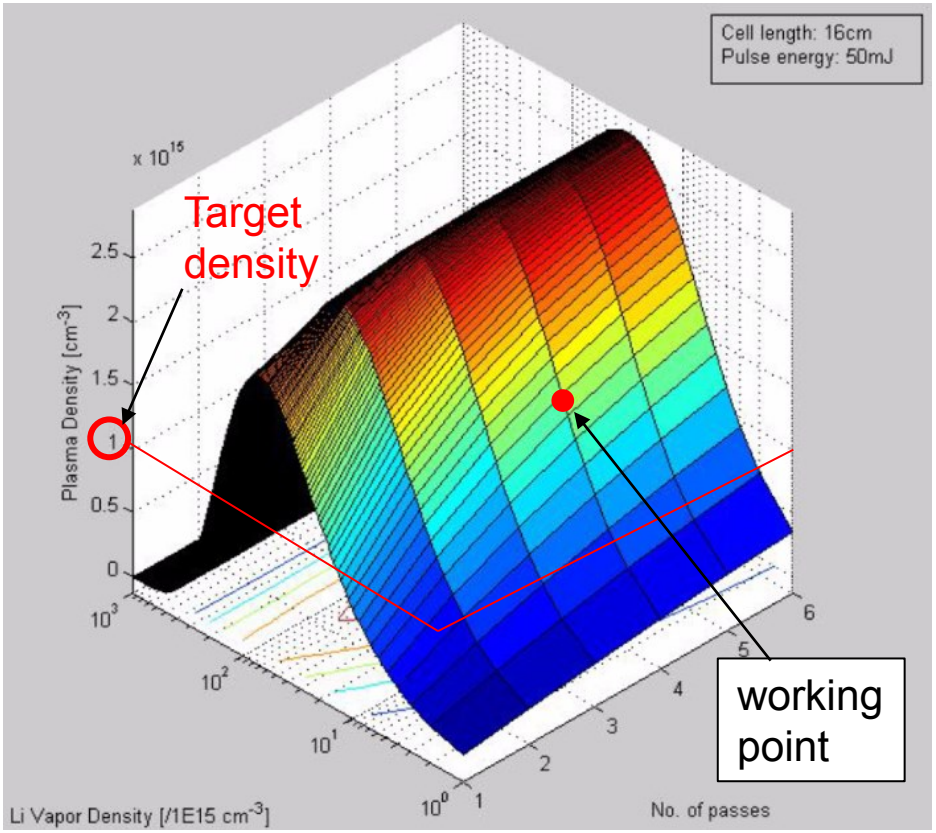
Need 650°C to 700°C for PITZ experiment

- Axial temperature



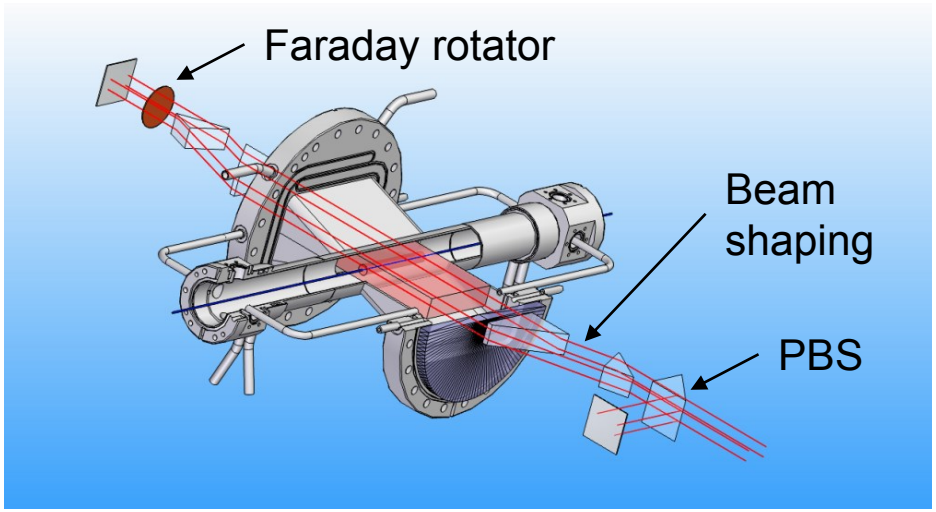
Ionization Optics Simulations of Plasma Cell

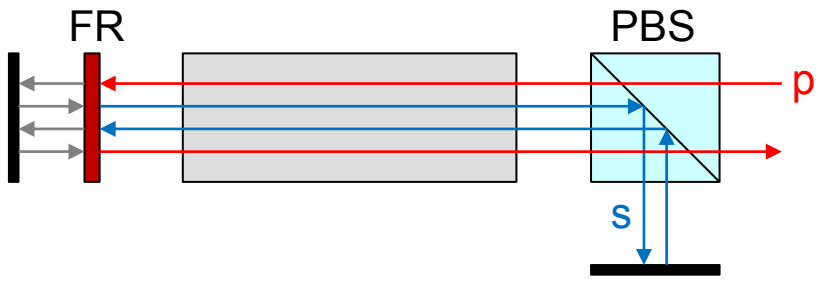
> Plasma density



- A few passes are enough

> Setup





- 4 passes realized utilizing polarization

Summary

- Follow-up: plasma acceleration experiment at PITZ
- Standard design of plasma cell (coaxial coupling of ionization laser) difficult to integrate into PITZ beam line
- **New idea: side coupling of ionization laser – advantages:**
  - No additional optical elements in electron beam line
  - Well defined beginning and end of plasma channel
  - Side windows could also be utilized for diagnostics
- Re-design of plasma cell with helium buffered side windows
  - Construction in mechanical workshop is ongoing
- Temperature distribution and plasma ionization was simulated