**Plasma Radius Measurement Using Schlieren Imaging**

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### Advanced Wakefield Experiment (AWAKE) at CERN

- **Plasma based Acceleration**
  - Proton beam propagates through the Rubidium Plasma
  - Co-propagating laser seeds self-modulation instability (SMI)
  - Generation of the Wakefield
  - Acceleration of injected electrons

### Formation of Micro Bunches through SMI

Formation of Micro Bunches through SMI

- Ionizing laser (blue): Creates Rb plasma in the cell's center
- Imaging laser (red): Transverse image of the plasma column

### Schlieren Imaging

**Basic Principle**
- Blocking of non-deflected rays
- Imaging of deflected rays

**Visualization of Density Perturbations**
Imaging transparent objects by making the strength of bending visible using Schlieren imaging

### Plasma Radius Measurement

**Refractive Index of Rb close to Transition Line D2**

Difference in refractive index determines the strength of bending of the rays

- for vapor
  \[ n(\nu) = \frac{1}{\sqrt{1 + \frac{\nu_f}{\nu_0}}} \]
- for plasma
  \[ n = \sqrt{1 - \frac{c^2}{v^2}} \]

### Schlieren Set Up for Plasma Radius Determination

- Laser wavelength close to transition line D2:
  - refractive index of vapor in the ground state >1 (or <1)
  - refractive index of plasma ~1
  - Plasma column as transparent object with different refractive index
  - Bending of the rays which propagate through the object

### Current Set Up at MPP

- Pump beam: Creating column of excited atoms in the center of the cell
- Imaging beam: Used for Schlieren imaging of the column of excited atoms
- Knife edge: Razor blade as cut off in the focal plane of lens L1