ID: 3210

Ion Doppler Spectroscopy on the SUNIST-2

M.H. YANG[1], J.R. WANG[1], Y.P. QIN[1], B.B. WANG[2], S.Z. WANG[1], Y. TAN[2], and R. CHEN[1]

[1]Startorus Fusion, Xi'an, China

[2]Department of Engineering Physics, Tsinghua University, Beijing, China

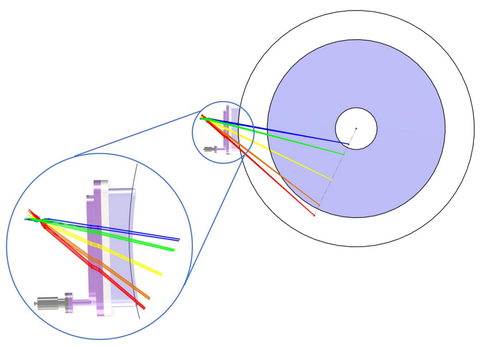
Email: yangmenghua@startorus.cn

ABSTRACT

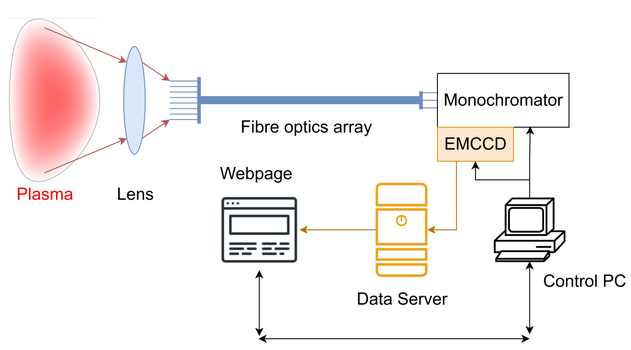
- Innovative Ion Doppler Spectroscopy (IDS) system with high spatial (22 mm radial) and temporal (2 ms) resolution across the entire midplane.
- Spectrum at specific points can be directly obtained in engineering, rather than being inferred from line-integrated measurements.
- Correction method based on an improved Richardson-Lucy iterative deconvolution algorithm for the complex instrument function, with typical fitting errors within 3%.

SYSTEM SETUP

- Large aperture aspheric lens group (f = 35 mm, F = 1.4, with a filter diameter of 67 mm)
- Optical center is 1301 mm from the measurement plane, with respective near and far depth of field (DOF) being 20 mm and 30 mm
- Monochromator with 3 slits(f = 0.67 m, F = 4.7, 1800 g/mm)
- 1024 x 1024 EMCCD. each with a size of 13 μm x 13 μm, 0.008 nm/pixel

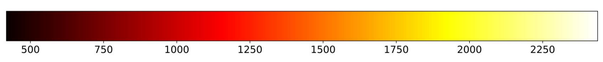


Optical arrangement



Schematic view

Three slits for 12ch x 3



CHALLENGES AND SOLUTIONS

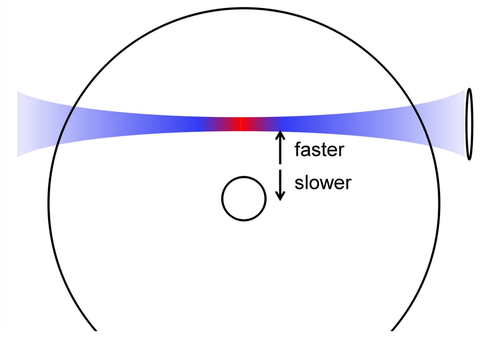
DESIGN OF THE MEASUREMENT POINTS

Optical measurements are inherently path-integrated **in physics**:

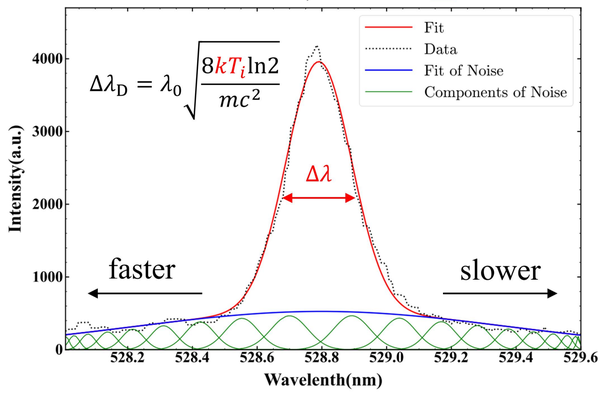
- Complicates the reconstruction of the light at a point;
- Results in challenges related to tomography and reconstruction errors.

The integral of the weight among the path remain the same:

$$\int \varepsilon_{i\perp}\, dl = \int \varepsilon_{j\perp}\, dl$$



Effective measuring range



Separated Doppler spectra (exaggerated)

Optical measurements can be located on points **in engineering**:

- Separating components from different regions using the frequency shift due to plasma rotation;
- Gaussian-like beam collection offers a wider range of rotational velocity distribution compared to parallel beam collection.

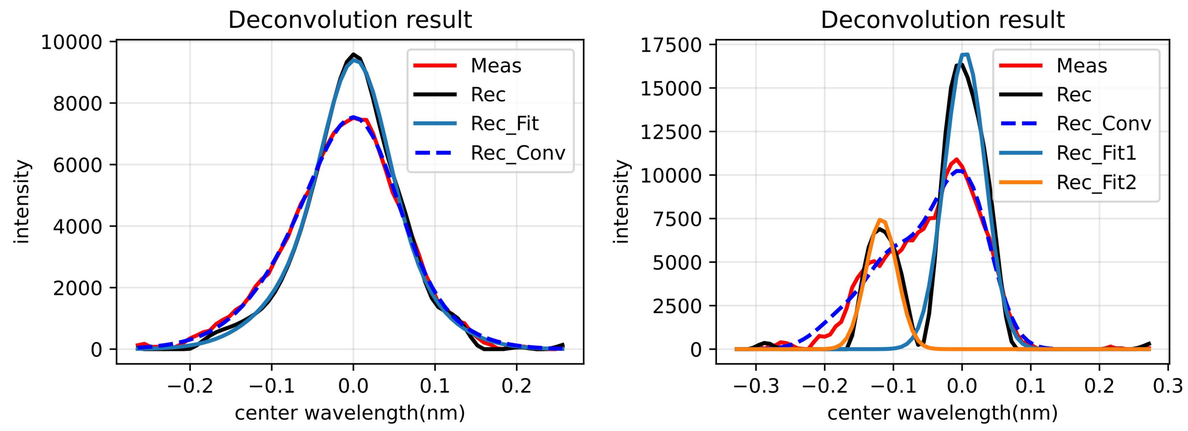
CHALLENGES AND SOLUTIONS

COMPLEX INSTRUMENT FUNCTIONS CORRECTION

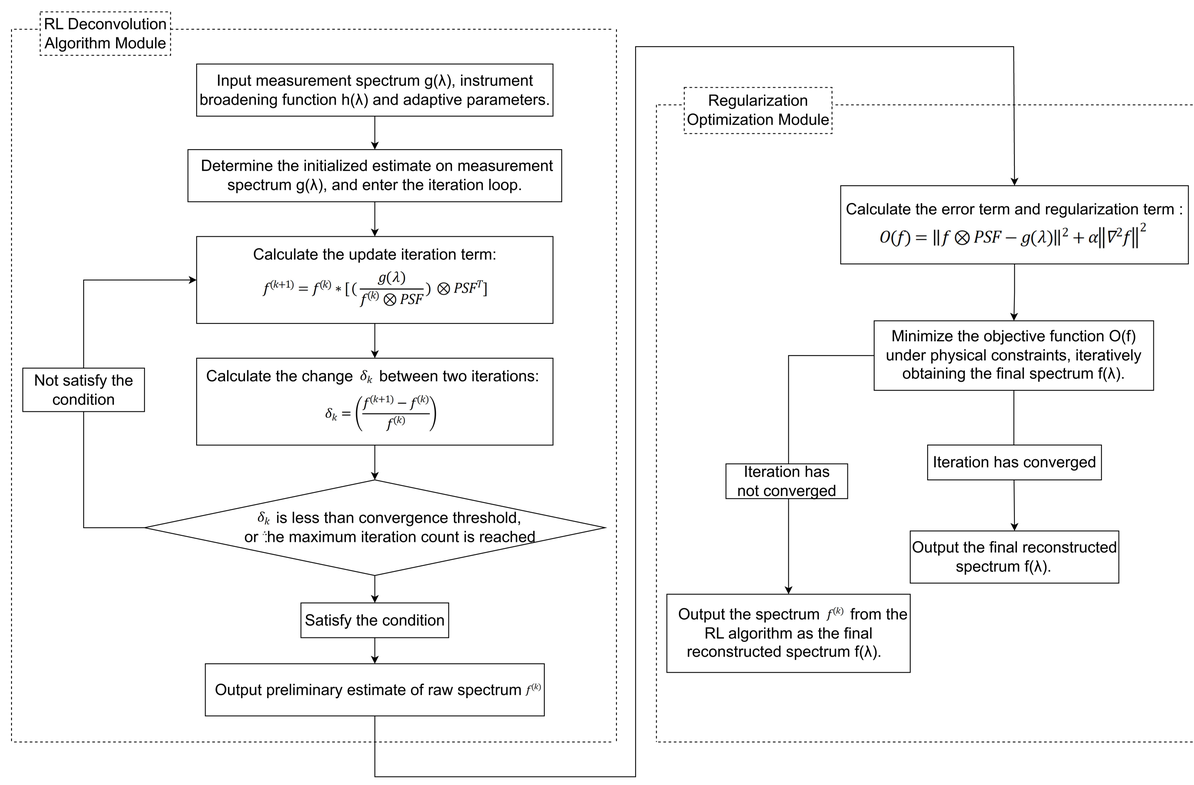
Measured spectral lines can deviate from the Gaussian assumption due to complex effects, result in an overestimation of ion temperatures and failed fitting by distortion.

- unidirectional asymmetric tails
- other spectral lines from impurities
- high-energy radiations...

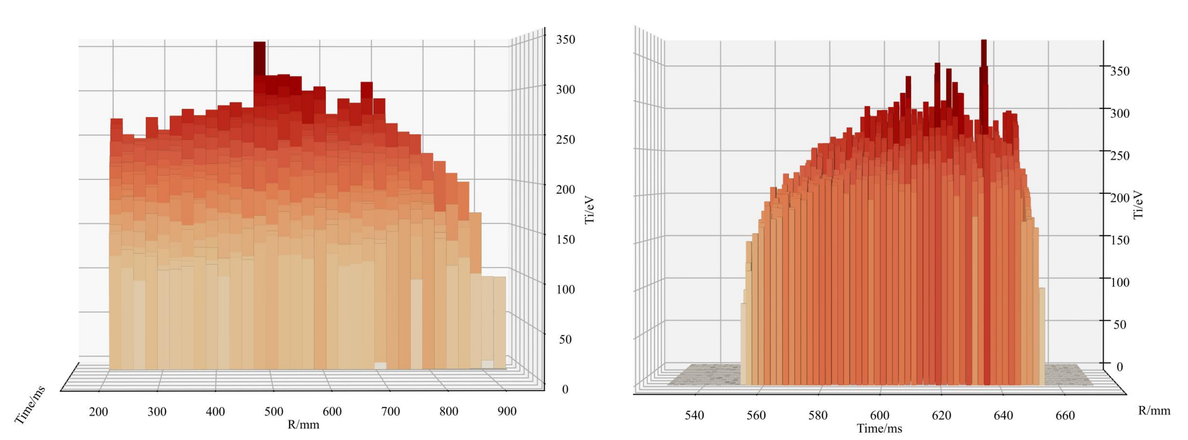
Instrument function correction method based on an improved Richardson-Lucy iterative deconvolution algorithm have been developed. Fitting errors within 5% and 15% in different situation.



Comparison of measured and deconvoluted results



OUTCOME AND CONCLUSION



Time evolution of the ion temperature radial profile

- Developed a novel IDS system to measure specific points and to address the complex instrument functions in spectral line measurements.
- Provides multi-channel ion temperature radial profiles and their temporal evolution with fitting errors within 5% typically.
- Proposed a correction method to suppress light contribution out of DOF.