Novel Installation of Fast Cameras at Tokamak GOLEM

32nd SYMPOSIUM ON FUSION TECHNOLOGY
SEPTEMBER 18-23, 2022 • Dubrovnik, Croatia

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Abstract

Tomographic inversion of radiation [1] determines spatial distribution of **tokamak plasma radiation** sources using line integrated plasma **projections data**. For measurements of the projections, **fast visible radiation matrix cameras** became broadly applied on tokamaks in recent past [2]. The **tokamak GOLEM** of the Czech Technical University in Prague strives to implement up-to-date diagnostics with enhanced temporal and spatial resolution. Therefore, a novel diagnostic system of two crossed monochrome cameras (vertical and horizontal) was integrated into the GOLEM diagnostics. In this study the progress in solving specific challenges of the ill-conditioned tomographic inversion via the algorithm [3] optimisation and testing for tokamak GOLEM will be presented together with the first tomographic results.

Tokamak GOLEM & Visible Cameras

The tokamak **GOLEM** is located at the Faculty of Nuclear Physics an Physical Engineering (Czech Technical University in Prague)
Minor & Major radius = 0.085 & 0.4 m
Discharge duration ~ 5 ms

Monochrome cameras Photron FASTCAM Mini UX 50 with Maximum Frame Rate of 160,000 fps (1280 × 8 pixels) in 12-bit ADC dynamic range.
Pixel size = 10 µm × 10 µm
Frame Rate = 40,000 fps (1280 × 56 pixels) [4]

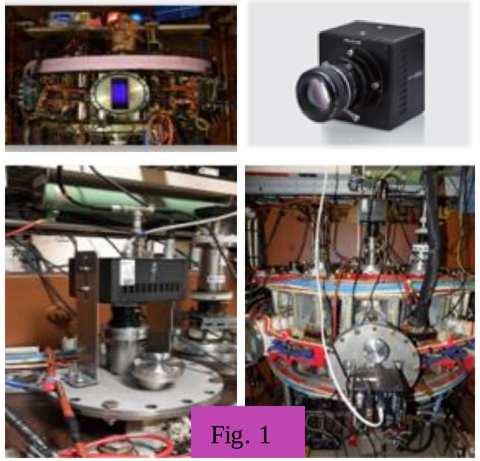


Fig. 1

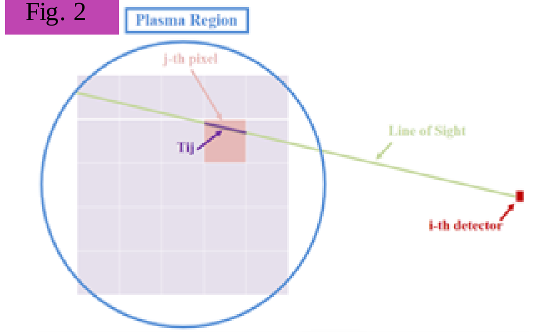
Tomographic Inversion

Tomographic inversion of radiation determines spatial distribution of **tokamak plasma radiation** sources using line integrated plasma **projections data**. In this method the plasma region observed by the detector pinhole camera is discretized into N plasma pixels as shown in Fig. 2. The small pinhole consists of a fan of narrow cones that, cconsidering smooth variation of the emission function over the view cone, provides the Line Of Sight (LOS) approximation in which each pinhole cone approximated by a single LOS. The line integrated measurements f_i of the detector **i** relates to all g_js corresponding emissivity in **j**-th plasma pixel along the respective LOS as follows:

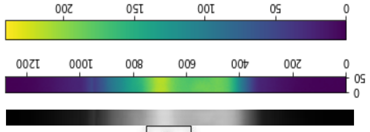
$f_i = \Sigma_j T_{ij} \cdot g_j$,

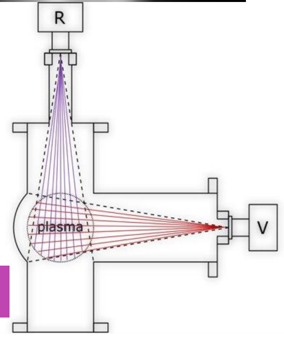
T_{ij} = the length of the **i**-th LOS in the **j**-th plasma pixel. The equation will be inverted to reconstruct the two dimensional (2D) emissivity function **g(x,y)** of the plasma region observed by detectors. The reconstruction result is optimized by using Minimum Fisher Regularisation (MFR) [1,3].

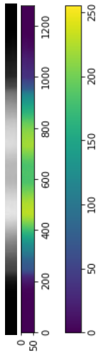
Fig. 2



The Radial camera image







The vertical camera image

Fig. 3

Fig 3: Schematic figure of Poloidal GOLEM tokamak cross section (plasma vacuum vessel) with the geometry of the lines of sight of two Vertical (V) and Radial (R) fast visible cameras in respectively red and purple.

Results

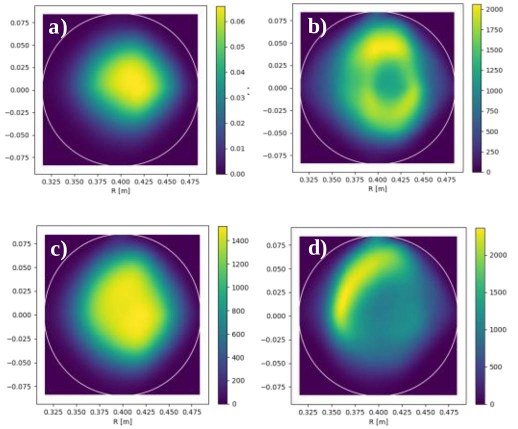


Fig. 4

Fig. 4: The figure shows the reconstructed plasma emissivity profiles at several times with frame numbers a) 158, b) 208, c) 308 and d) 408. Figure b) displays expected hollow profile.

References

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