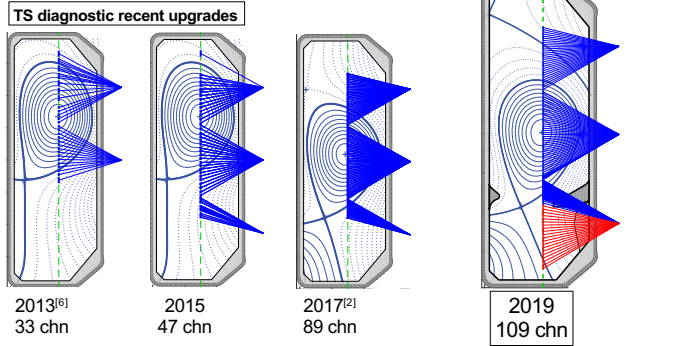


P. Blanchard, Y. Andrebe, H. Arnichand, R. Agnello, S. Antonioni, S. Couturier, J. Decker, T. De Kerchove D'Exaerde, B.P. Duval, I. Furno, P-F. Isoz, P. Lavanchy, X. Llobet, B. Marlétaz, J. Masur and the TCV team

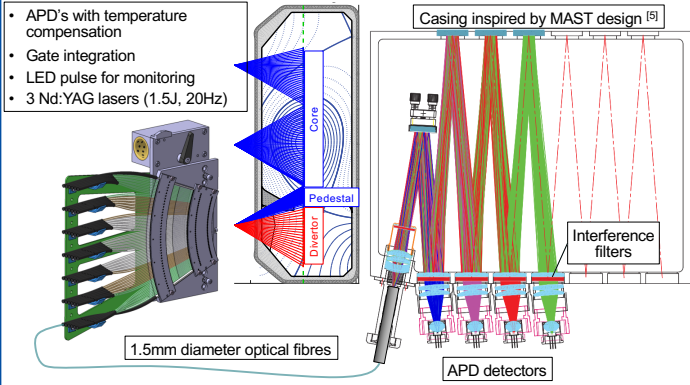
École Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), CH-1015 Lausanne, Switzerland

Thomson scattering Upgrade

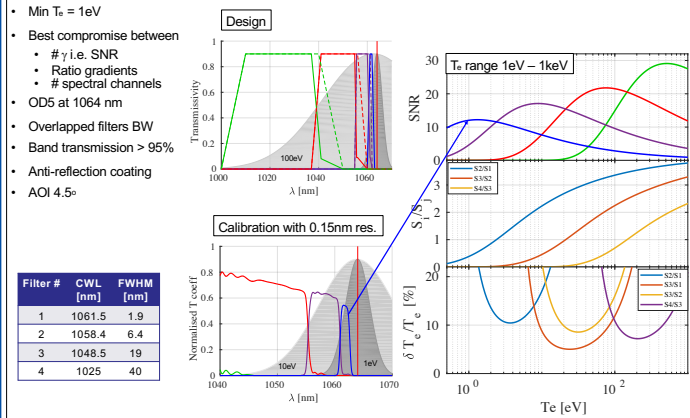


- Project goals**
- Provide T_e and n_e measurements in the new TCV divertor region^[1]
 - Possibility to measure T_e down to **1eV** with $n_e = 1.5 \times 10^{19} \text{ m}^{-3}$
 - Install 20 lines of sight with 16mm spatial resolution along the laser
- Realisation^[3]**
- Design and manufacture of 20 new 4-channel polychromators
 - Installation of 1.5mm diameter glass optical fibres
 - Analysis code adaptation for new channels, especially for rejection criteria (SNR, baseline fluctuation, error bars...)

Overall design

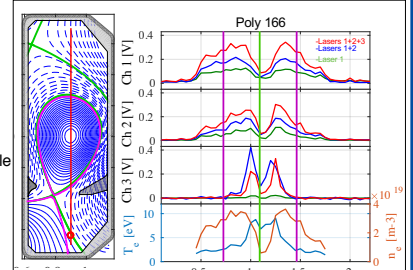


Interference filter design



Preliminary measurements

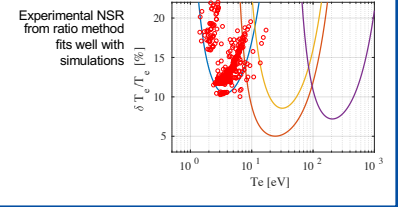
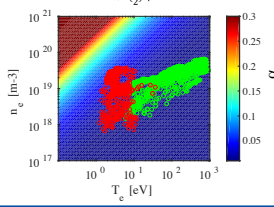
- Upgraded TCV: graphite baffles defining a divertor chamber
- Commissioning Aug. 2019
- No stray light**
- Noise levels ~ 0.4mV
- SNR > 7 for $n_e < 1 \times 10^{19} \text{ m}^{-3}$
- $T_e = 1.4\text{eV}$ for $n_e = 1.5 \times 10^{18} \text{ m}^{-3}$ achievable
- SNR ↑ if laser power or n_e ↑
- Tests on RAID^[4] show good consistency between TS n_e and interferometer for $T_e < 5\text{eV}$



- Divertor leg sweep features clearly visible on raw signals
- Strong coherence between divertor leg position and APD signals
- T_e and n_e measurements consistent

Incoherent regime valid:

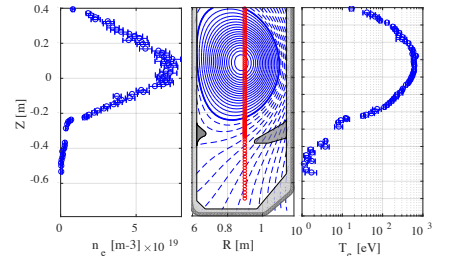
$$\alpha = \frac{\lambda_e}{4\pi \sin(\theta/2)} \sqrt{\frac{e^2 n_e}{\epsilon_0 \epsilon_e}} < 1$$



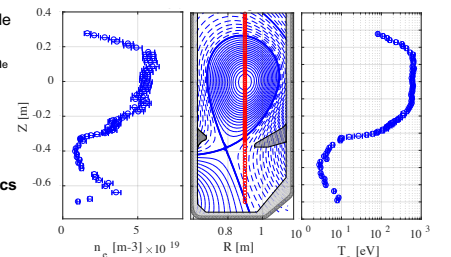
First results from the divertor chamber

- Baffles makes YO-YO shots not possible
- Signals only in chn 1 & 2
- T_e and n_e measurements for $T_e < 1.5\text{eV}$
- TS measurements available well outside the LCFS
- Good consistency between adjacent channels

Limited plasma



Diverted plasma



- T_e and n_e along and well outside the divertor legs
- High correlation between $T_e - n_e$ and divertor leg position
- Same order of magnitude between n_e along the leg and $n_e(0)$
- To become an **essential diagnostic for divertor physics**

Summary and next steps

- TS Upgrade in the framework of the TCV Upgrade completed
- TS measurements for $T_e \geq 1\text{eV}$ and for n_e as low as $1.5 \times 10^{18} \text{ m}^{-3}$ have been obtained successfully
- New TS system to become a key diagnostic for divertor physics on TCV
- Comparisons with other diagnostics needed (RDPA, Langmuir probes, reflectometry...)
- Analysis code optimization ongoing
- Possible next steps: new 2.3J lasers, new divertor TS system with adjustable laser path and collection optics

[1] H. Reimerdes et al Nucl. Mat. and Energy 12 1106 (2017)
[2] J. Hawke et al JINST 12 C12005 (2017)

[3] H. Arnichand et al 2019 JINST 14 C09013
[4] I. Furno et al EPJ Web of Conferences 157 03014 (2017)

[5] R. Scannell et al., Rev. Sci. Instr. 79, 10E730, (2008)
[6] R. Behn et al 1999 RSI 70 768 (1999)