The CO2DGM for CO_2 – Breathing Thrusters

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Electric **P**ropulsion **I**nnovation & **C**ompetitiveness
EPIC Workshop, 15 -17 October 2018

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Abstract (1/2)

♣ **CO2DGM is a Detailed Global Model of plasma generated from a gas constituted initially by CO_2**
The effective plasma composition depends on various imposed conditions, e.g. form factor / pressure / absorbed power

CO2DGM is used here to support various types of Electric Thruster (ET) technology, allowing for :

- **Thruster characterization**
- **Functioning description** and **optimization**
- **Optical Emission Spectroscopy (OES) diagnostics**

With **CO2DGM** the plasma components constitution of CO_2 fed **ETs** and their spectra are obtained. The ability of **CO2DGM** to characterize and to diagnose electric thrusters is illustrated.

Abstract (2/2)

** LMO / HMO In Situ Resources Utilization (ISRU) ETs fed by Mars Atmosphere components **

- Plasma Component Composition (**PCC**) results
- Functioning Diagrams (**FD**) results
- Theoretical intensities of **O I** & **II** atomic lines **(OES)**

Characterization / diagnostics of CO_2 fed ETs in a **large domain** of plasma conditions are addressed

One of the **CO2DGM** assets is the calculation of the spectral lines intensities.

For **OES** diagnostics **calculated intensities** of the spectral lines must be compared with the **experimental** ones from the ET plasma.

Summary of Presentation

1. INTRODUCTION including References

2. DENSITIES OF SPECIES
   based on PCC and conjugate diagrams

3. IONIZATION PERCENTAGE
   based on FD diagrams

4. OES PLASMA DIAGNOSTICS
   based on THEORETICAL OXYGEN I & II SPECTRA

5. CONCLUSIONS

1. Introduction (1/2)

♣ Our **CO2DGM** constitutes a tool in support of **CO2 fed** electric thrusters of various types

♣ **ISRU** technology is specifically addressed by adapting accordingly the input parameters

♣ We approach **OES** diagnostics of **CO2 fed** devices

1. Introduction (2/2)

1. Katsonis, K. & Berenguer, Ch. (**2014**). Characterization of Low Pressure **CO_2** Plasma in Space. ESA 6th RHTG Works., St. Andrews, UK

2. Berenguer, Ch. & Katsonis, K. (**2014**). Global Modeling of **CO_2** Discharges with Aerospace Applications. Advances in Aerospace Engineering. Vol. 2014, Article ID **847097**

3. Katsonis, K., Berenguer, Ch., Gonzalez del Amo, J. & Stavrinidis, C. (**2016**). **CO_2 / N_2** Breathing Electric Thrusters for LMOs, Space Prop. Conf., Paper ID SP2016_**3124972** Rome, Italy

4. Berenguer, Ch. & Katsonis, K. (**2016**). A **Detailed Global Model** for Characterization of **CO_2** Fed Electric Thrusters, Imperial Journal of Interdisciplinary Research **2**, 1708

5. Katsonis, K. & Berenguer, Ch. (**2016**). Study of **CO2** Plasma of Interest to Space Applications Based on a **Detailed Global Model**, 7th ESA RHTG Workshop, November 2016, Stuttgart, Germany

6. Katsonis, K. & Berenguer, Ch. (**2018**). Characterization and Optical Diagnostics of CO2 Fed Electric Thrusters by Using a Detailed Global Model, 6th Space Prop. Conf., Paper ID SP2018_00237, Seville, Spain; Summary presentation in Poster.

7. Katsonis, K. & Berenguer, Ch., ISRU based electric propulsion, ResearchGate Project

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2. DENSITY OF SPECIES,

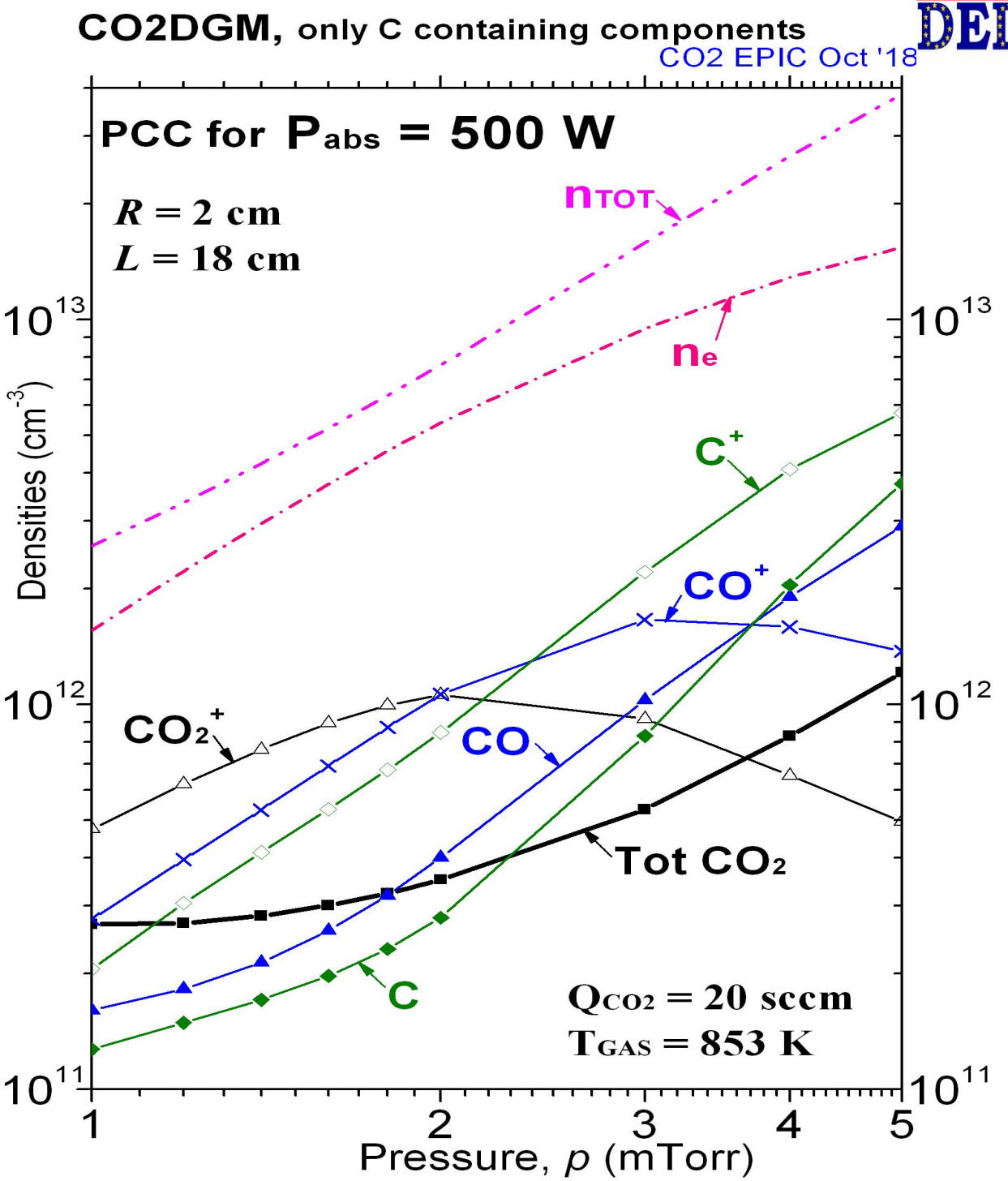
PCC

Fig. 1.

Pressure dependent PCC for P_{abs} = 500 W

CO2 feeding of 20 sccm

Only C containing components shown



DEDALOS

2. DENSITY OF SPECIES,

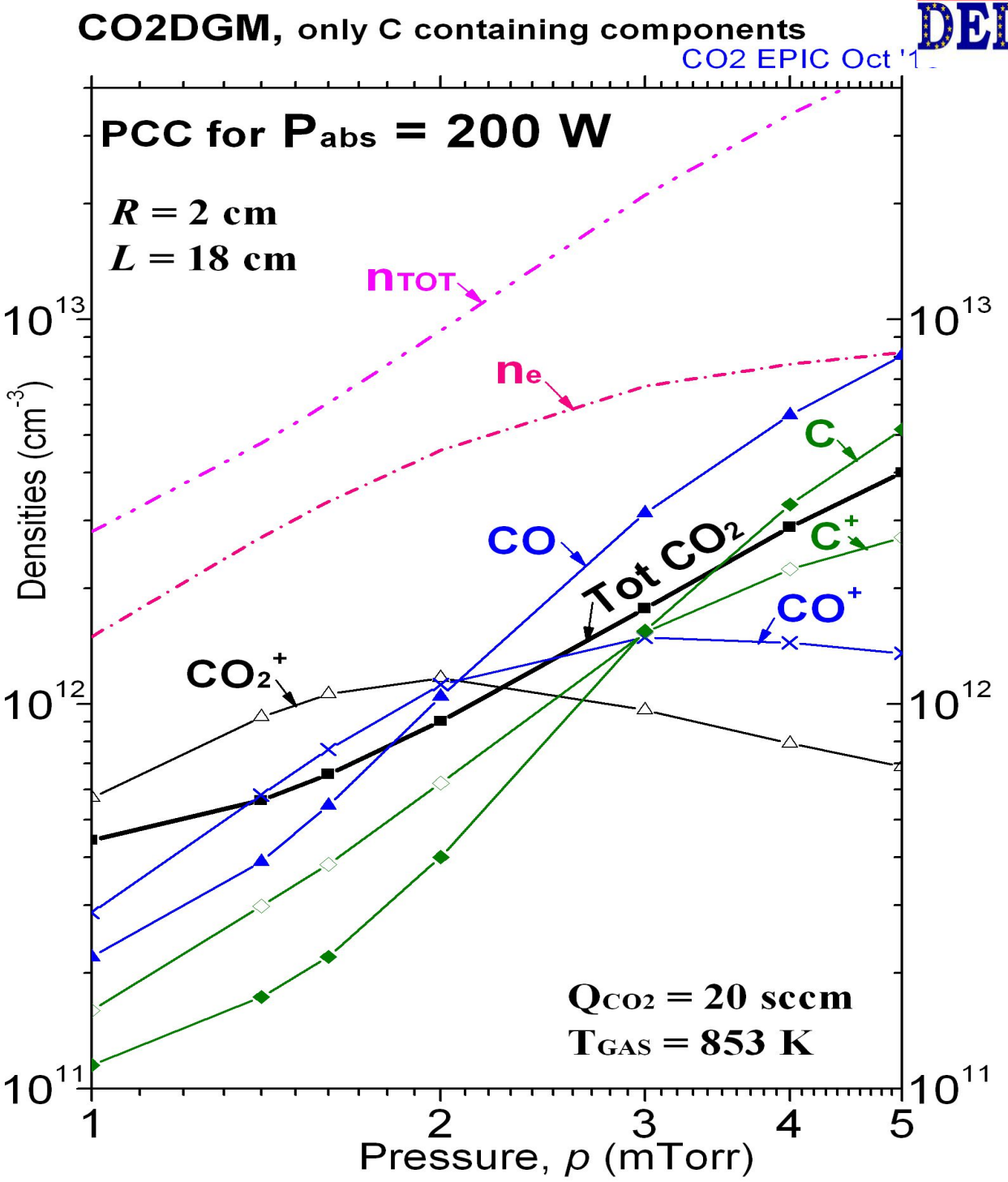
PCC

Fig. 2.

Pressure dependent PCC for P_{abs} = 200 W

CO_2 *feeding of 20 sccm*

Only **C** *containing components shown*



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2. DENSITY OF SPECIES,

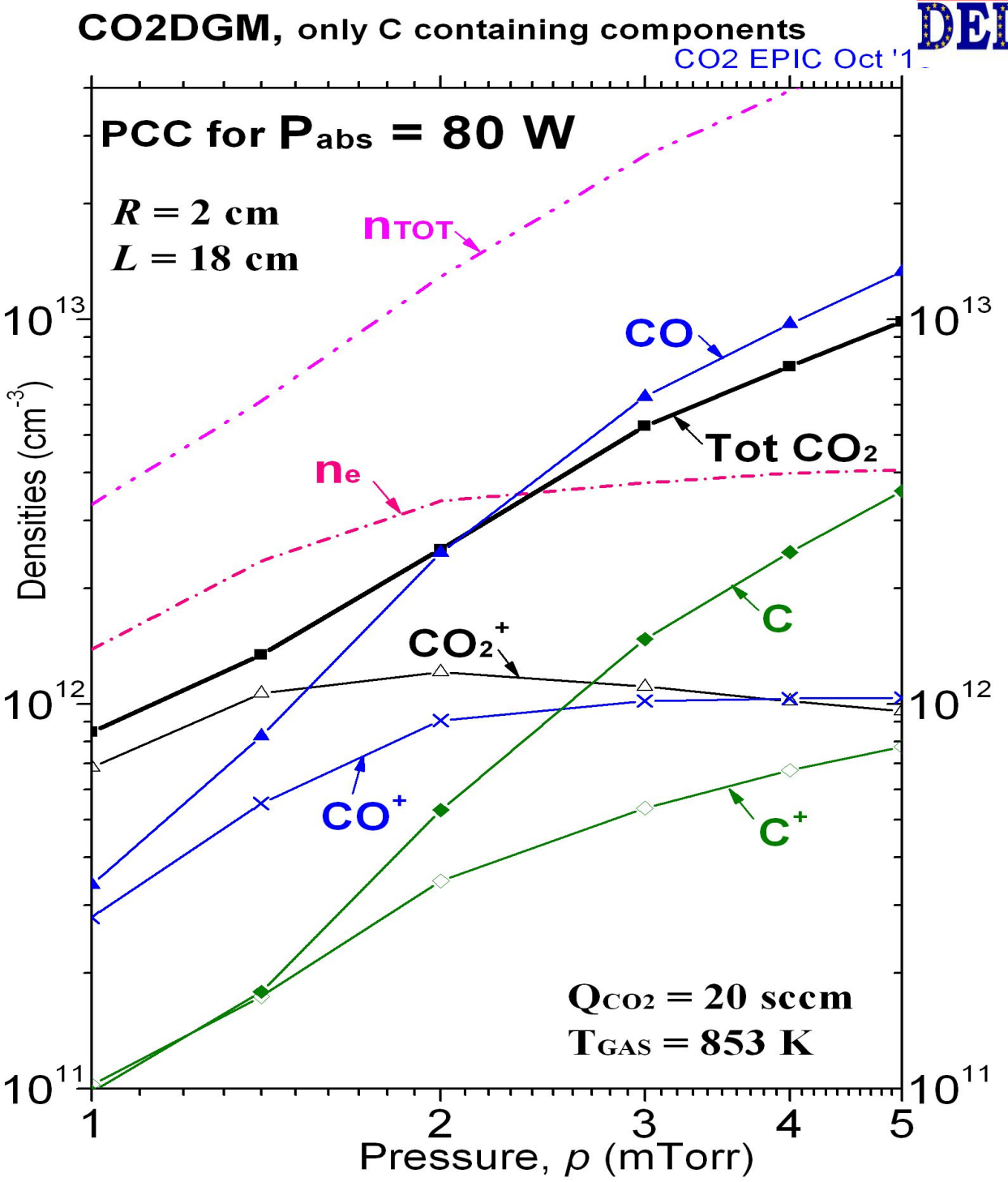
PCC

Fig. 3.

Pressure dependent PCC for P_{abs} = 80 W

CO_2 *feeding of 20 sccm*

Only **C** *containing components shown*



DEDALOS

2. DENSITY OF SPECIES,

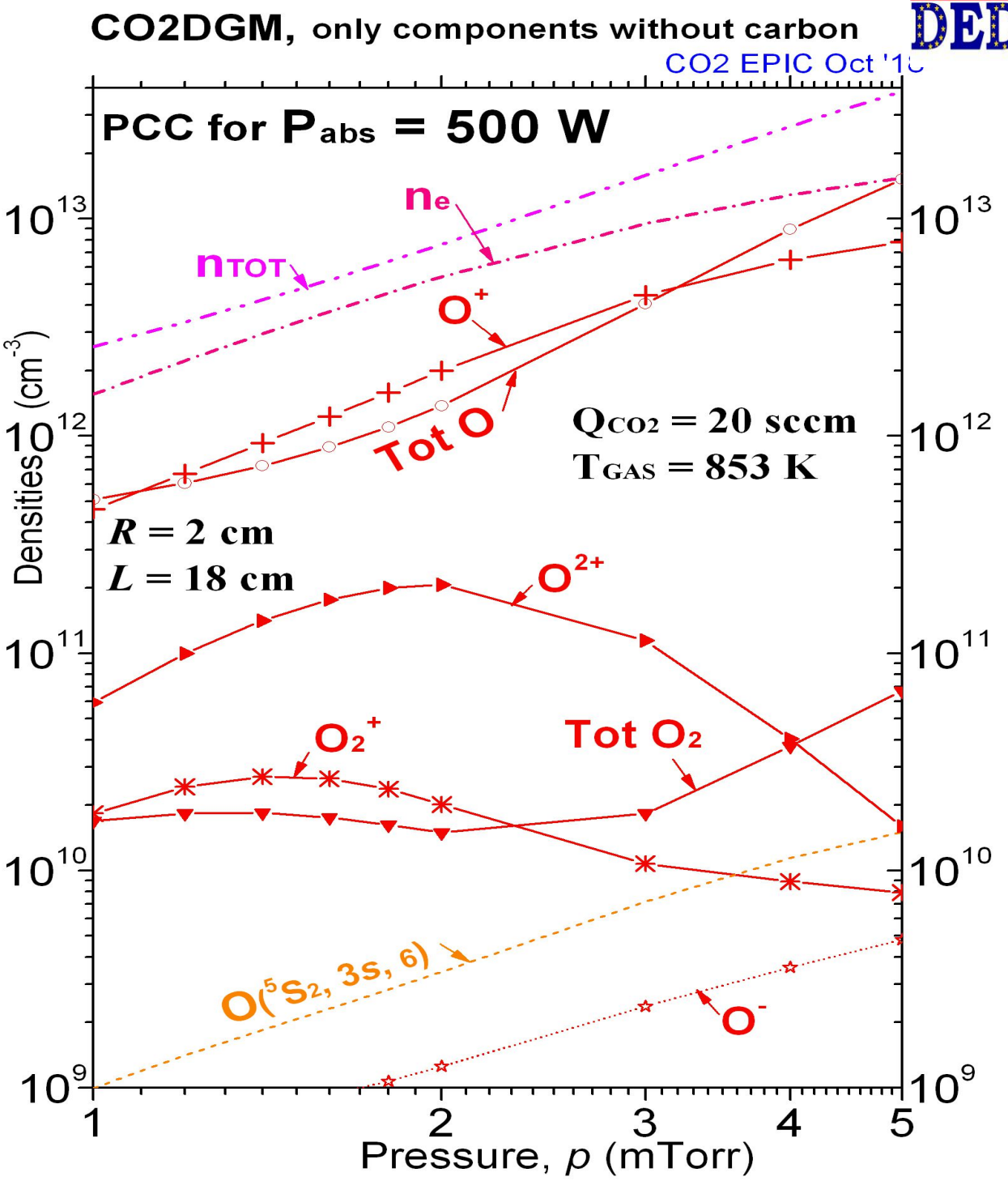
PCC

Fig. 4.

Pressure dependent PCC for P_{abs} = 500 W

CO2 *feeding of 20 sccm*

Only components without ***C*** *shown*



DEDALOS

2. DENSITY OF SPECIES,

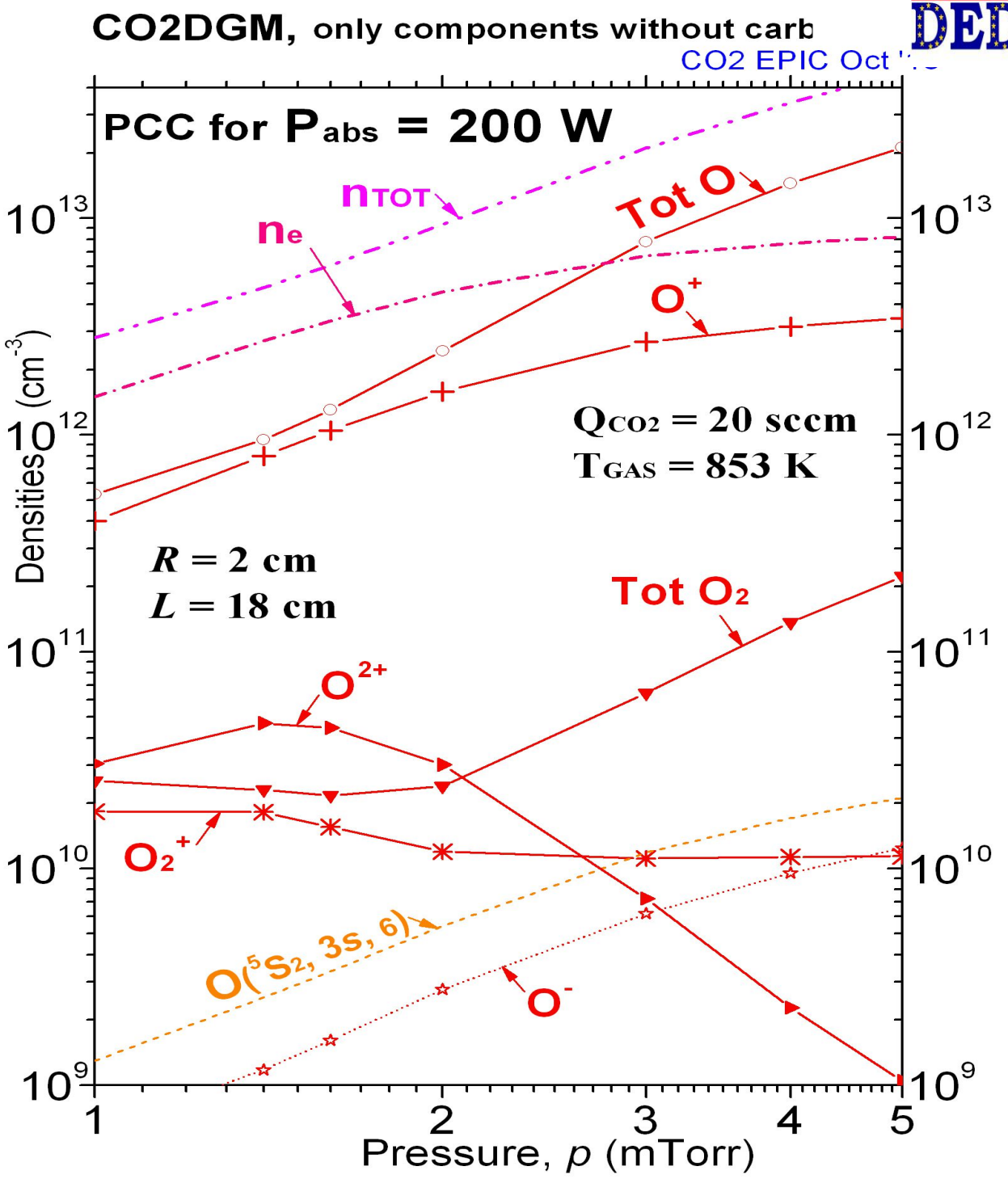
PCC

Fig. 5.

Pressure dependent PCC for P_{abs} = 200 W

CO2 *feeding of 20 sccm*

Only components without ***C*** *shown*



DEDALOS

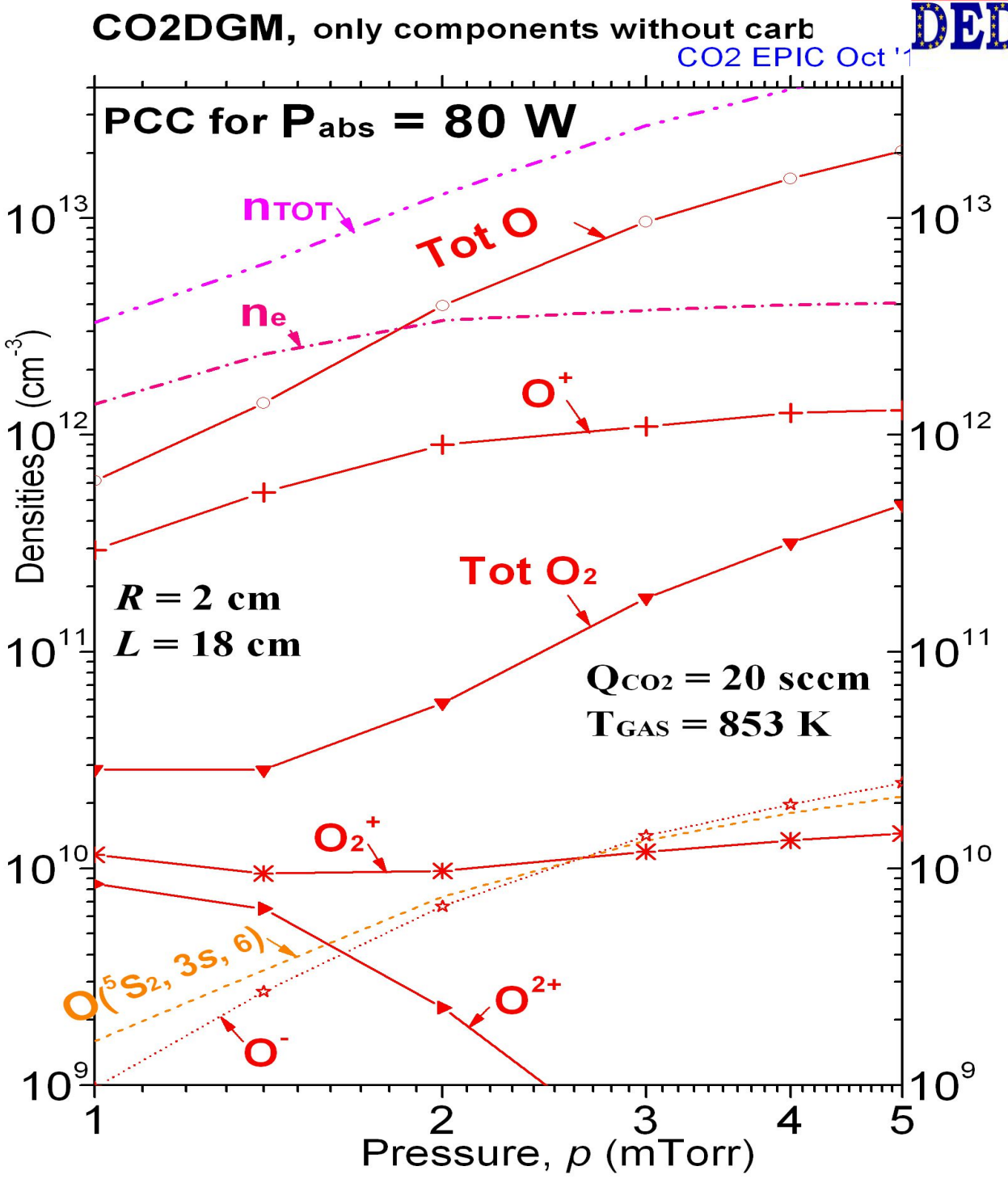
2. DENSITY OF SPECIES, PCC

Fig. 6.

Pressure dependent PCC for P_{abs} = 80 W

CO_2 *feeding of 20 sccm*

Only components without **C** *shown*



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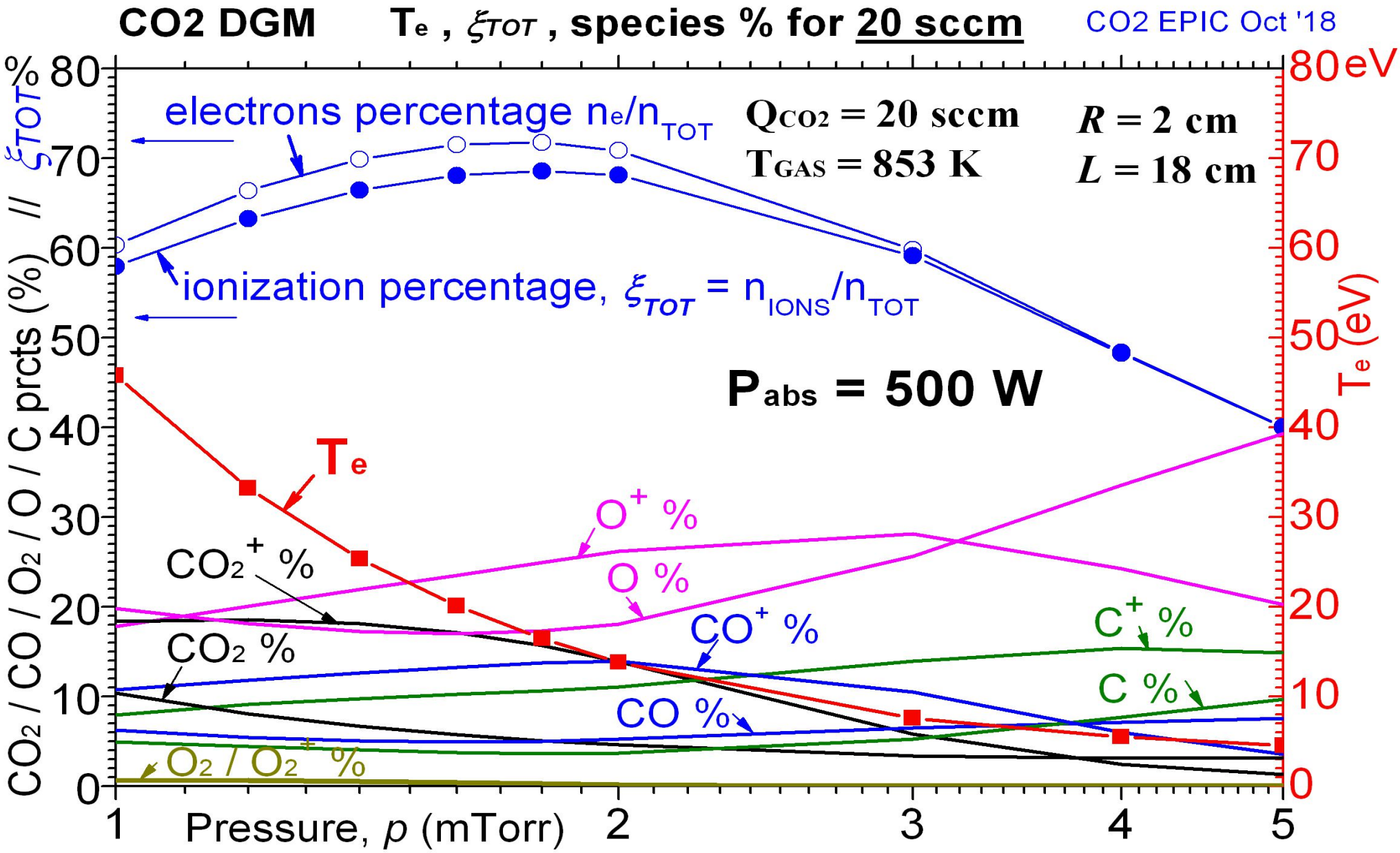
2. DENSITY OF SPECIES PCC

Fig. 7. Conjugate of Figs. 1 & 4



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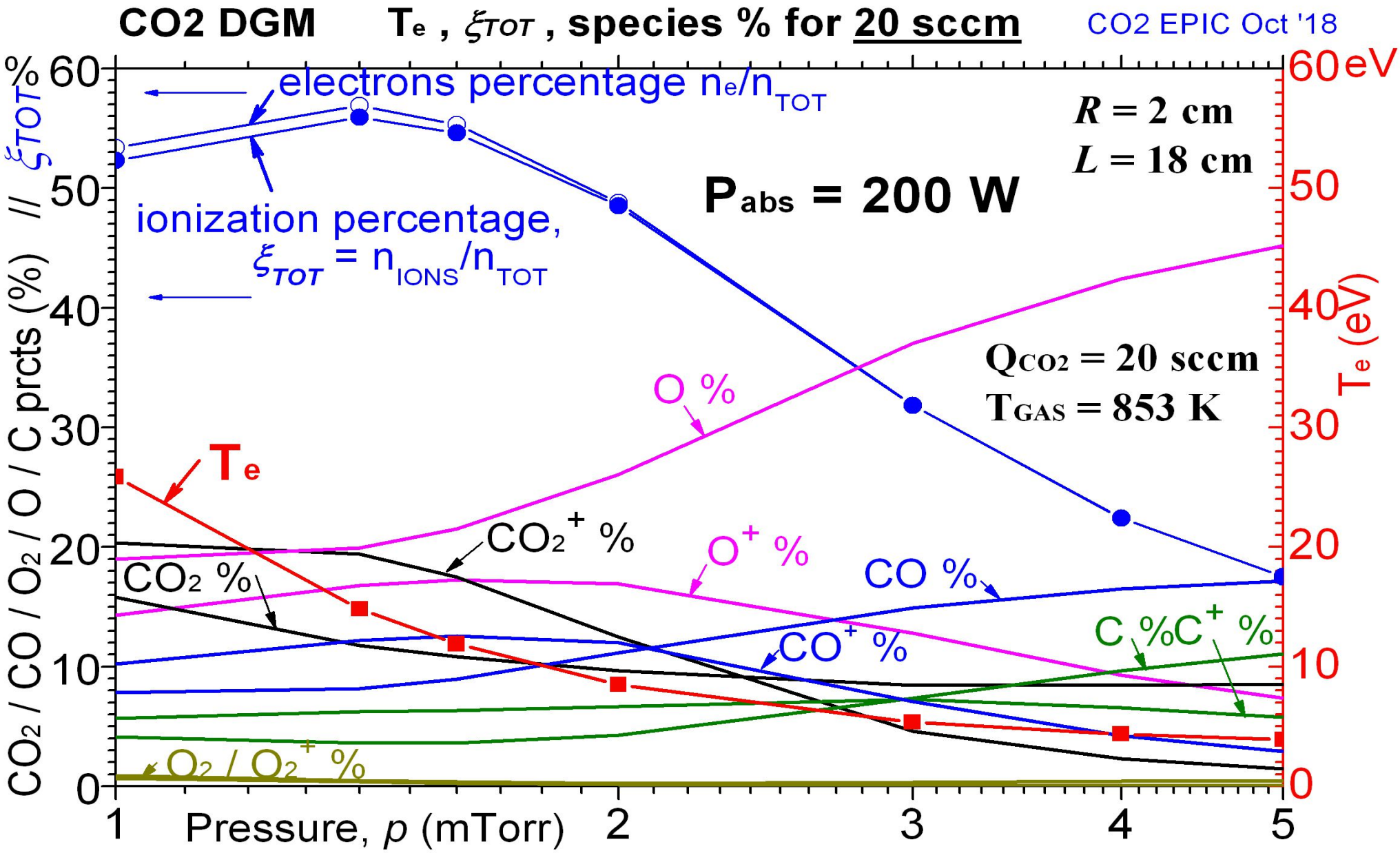
2. DENSITY OF SPECIES PCC

Fig. 8. Conjugate of Figs. 2 & 5



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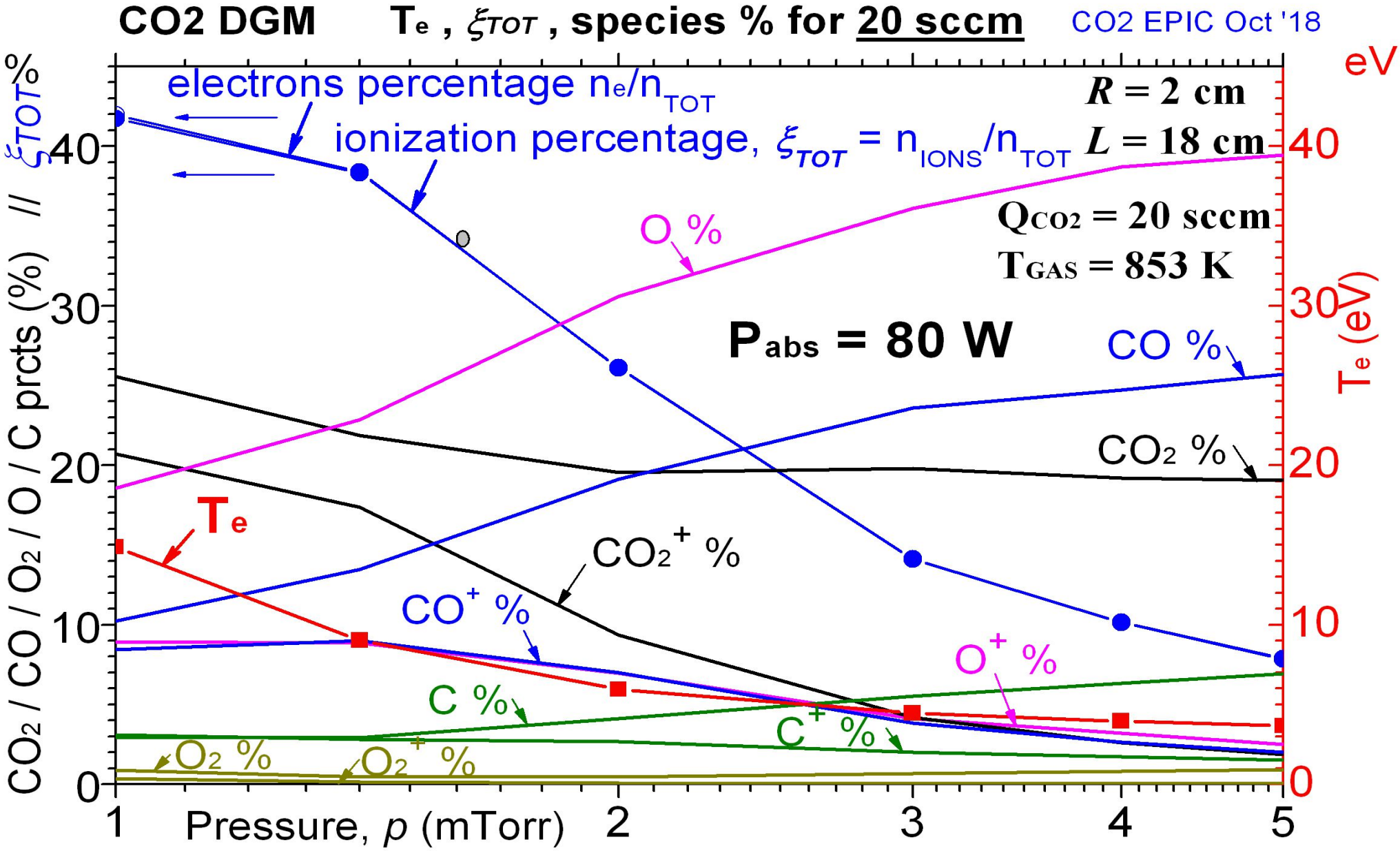
2. DENSITY OF SPECIES PCC

Fig. 9. Conjugate of Figs. 3 & 6



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3. IONIZATION PERCENTAGE

FD

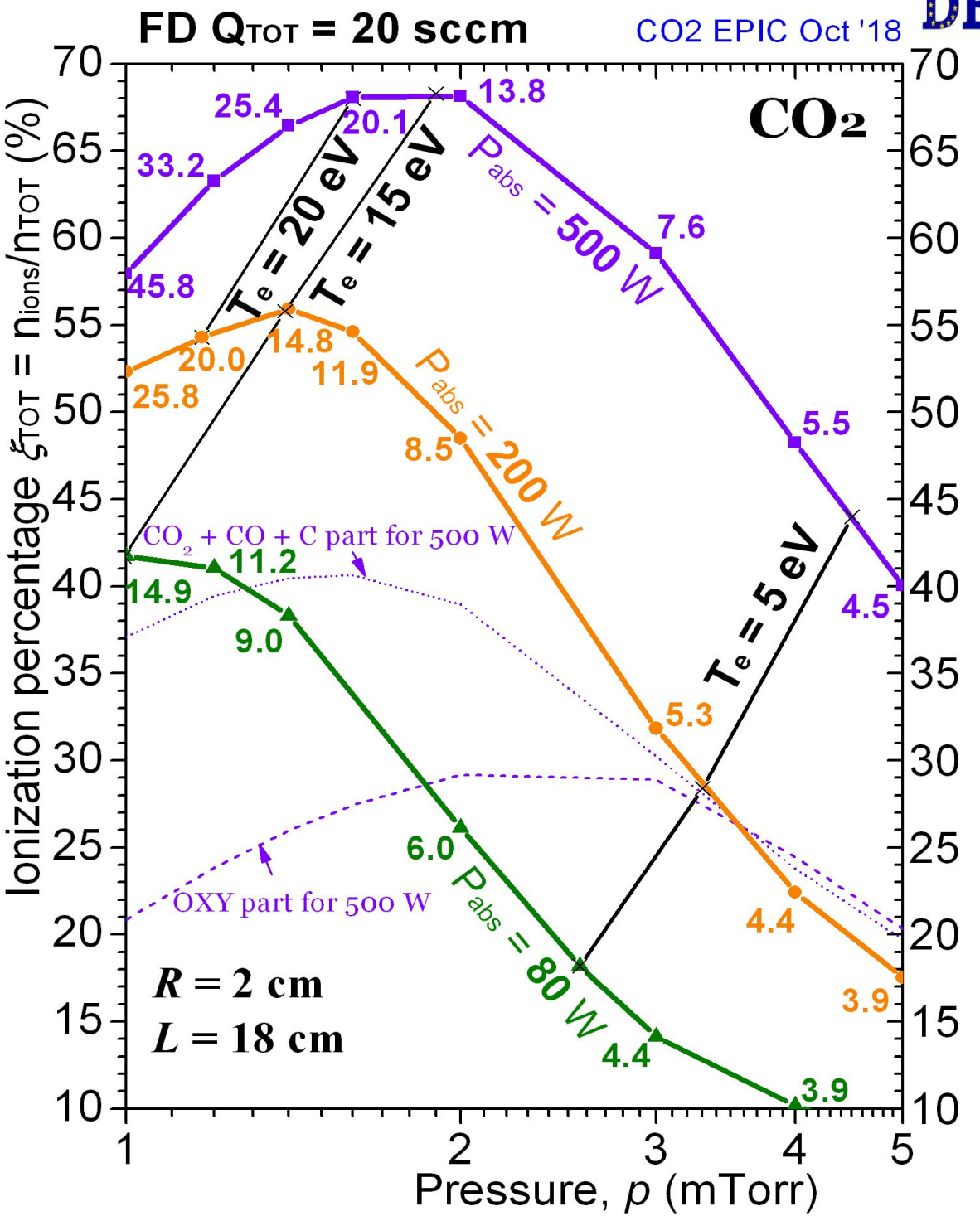
Fig. 10.

FD for
p *values from*
1 mTorr up to
5 mTorr

T_e *of* 5 - 20 eV

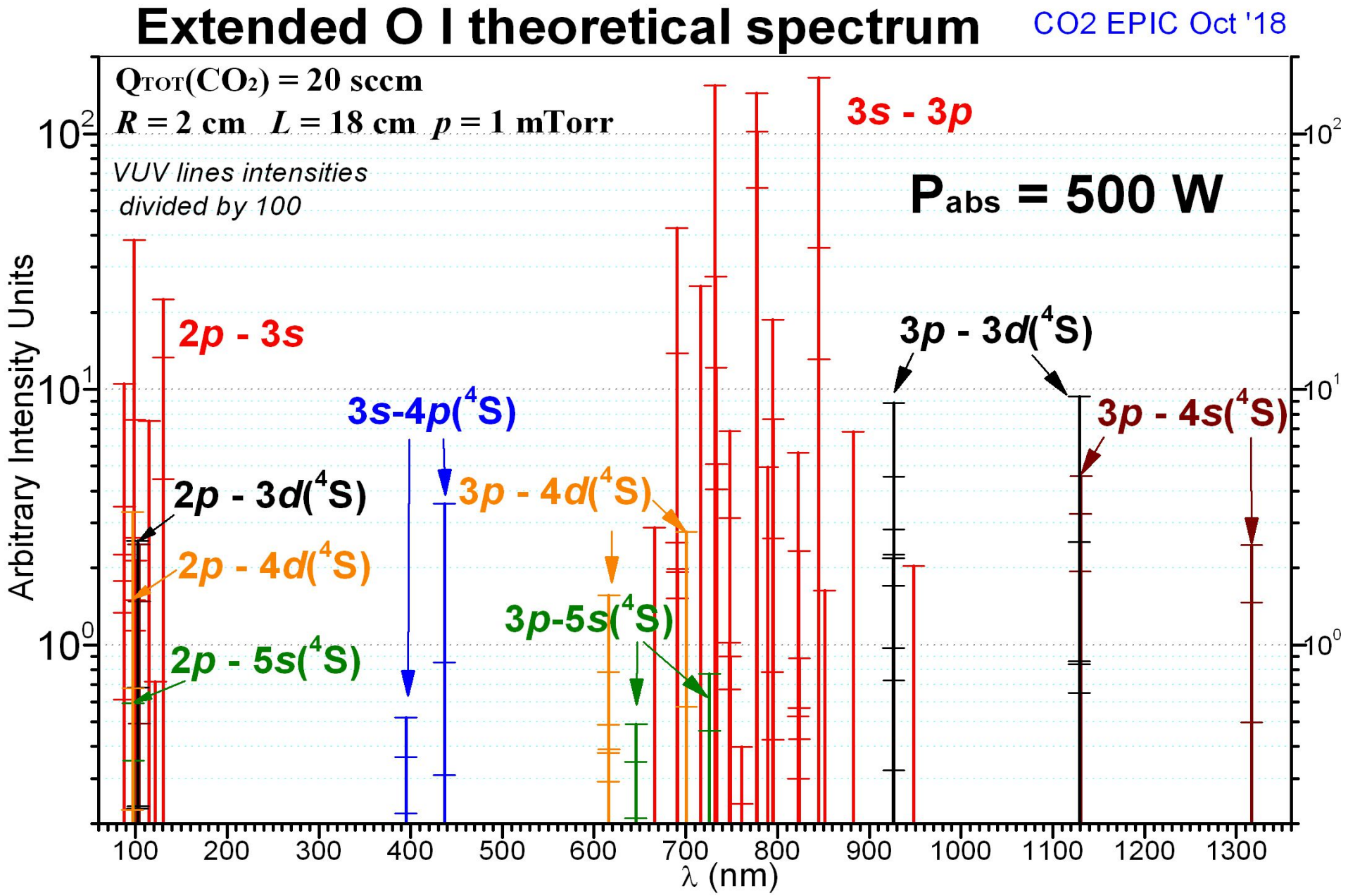
P_{abs} *of 80 W*
- 500 W

20 sccm ***CO2***
feed



4. OXYGEN I SPECTRUM (Theoretical)

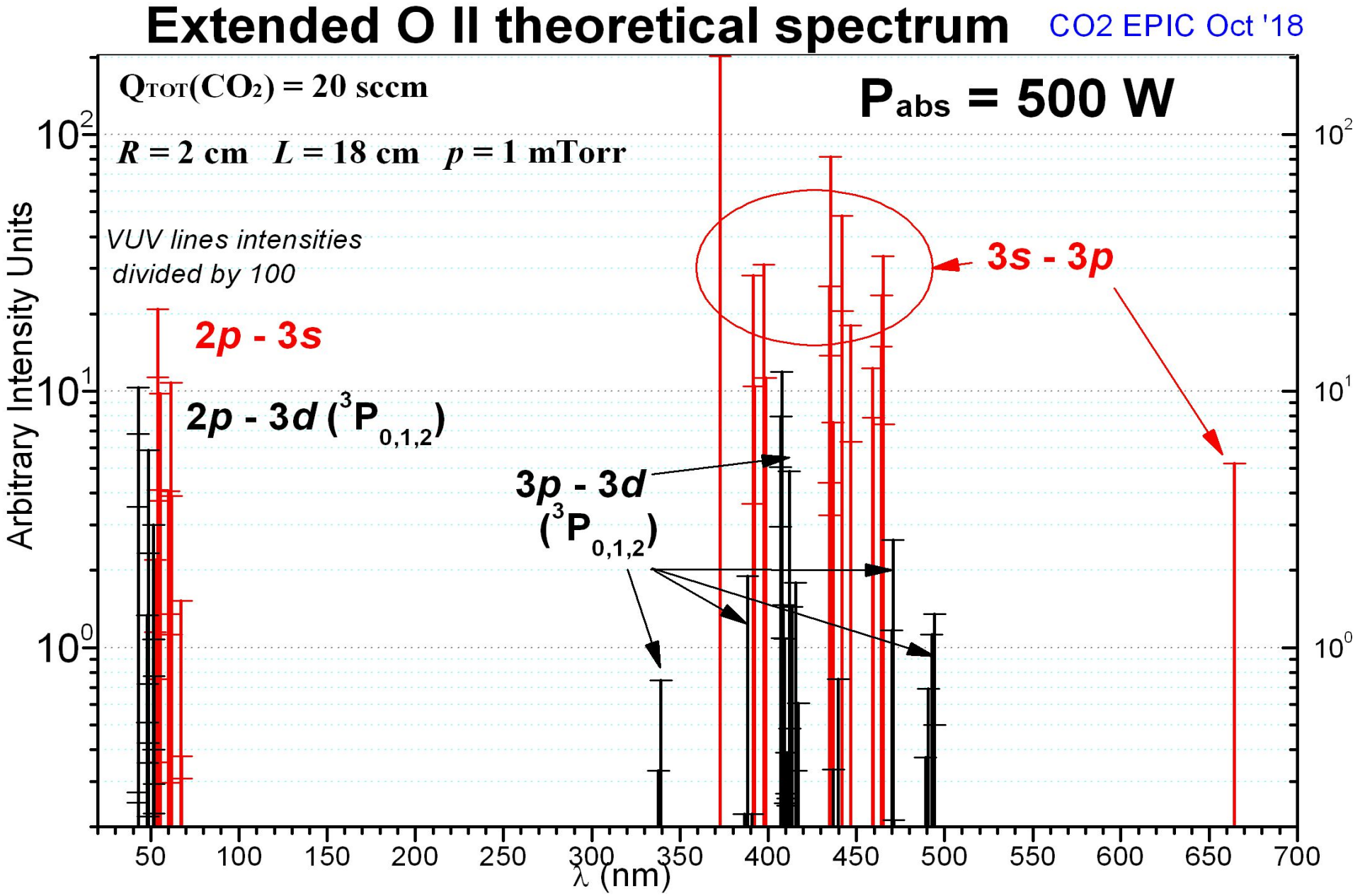
Fig. 11. O I lines in a large spectral region



4. OXYGEN II SPECTRUM (Theoretical)

DEDALOS

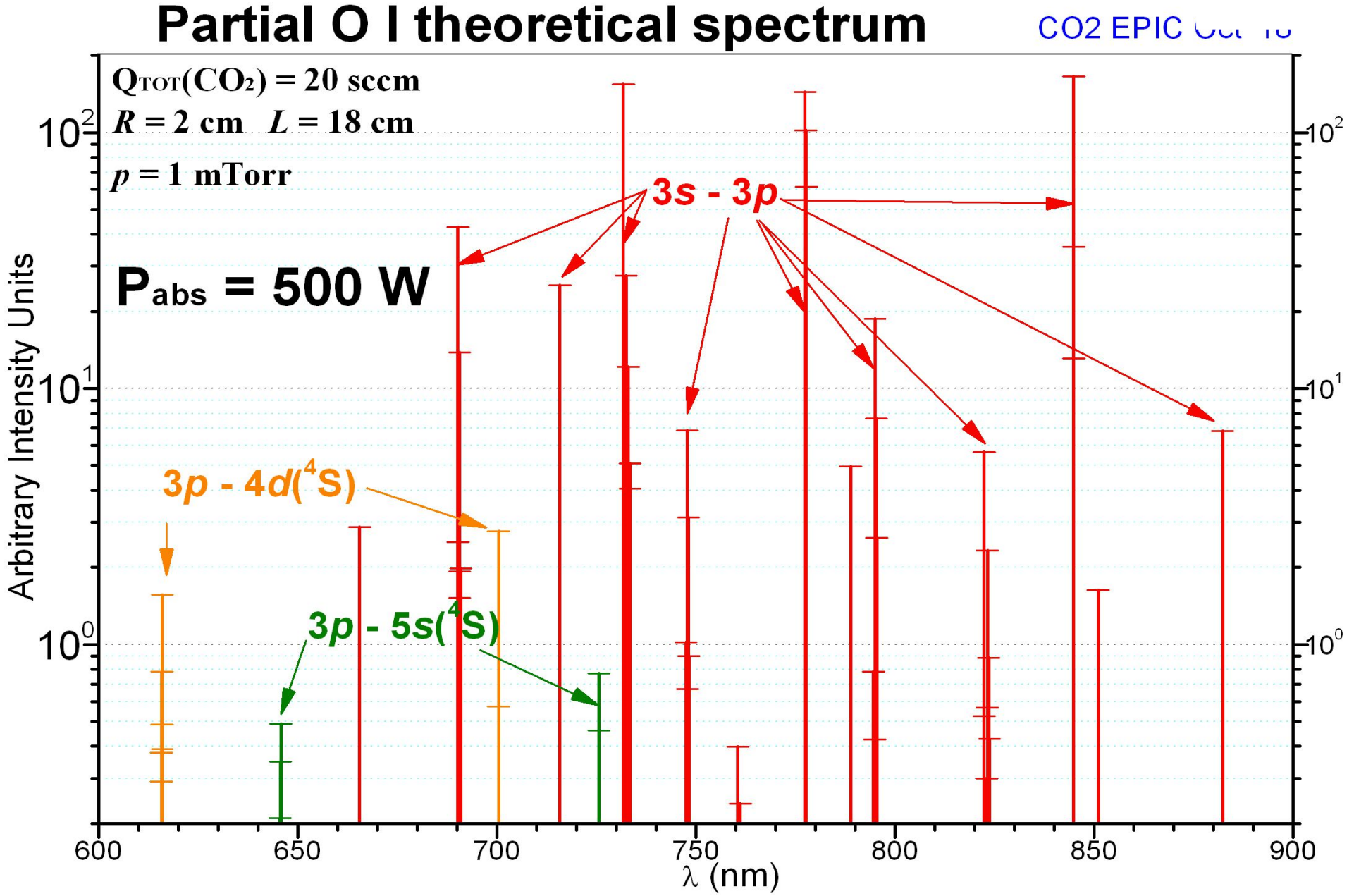
Fig. 12. O II spectrum, VUV, UV & visible regions



4. OXYGEN I SPECTRUM (Theoretical)

DEDALOS

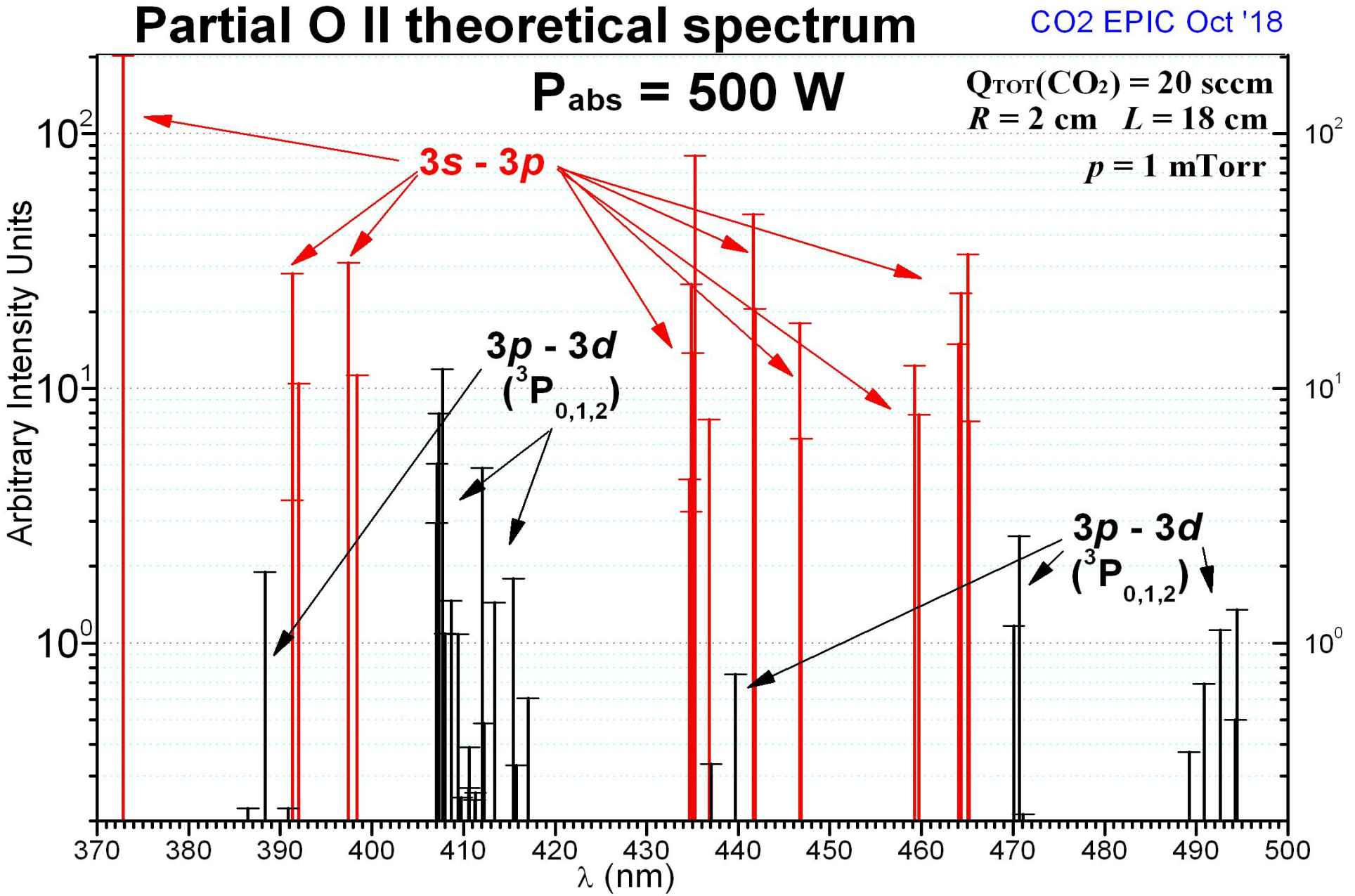
Fig. 13. O I lines in the spectral region 600 – 900 nm



4. OXYGEN II SPECTRUM (Theoretical)

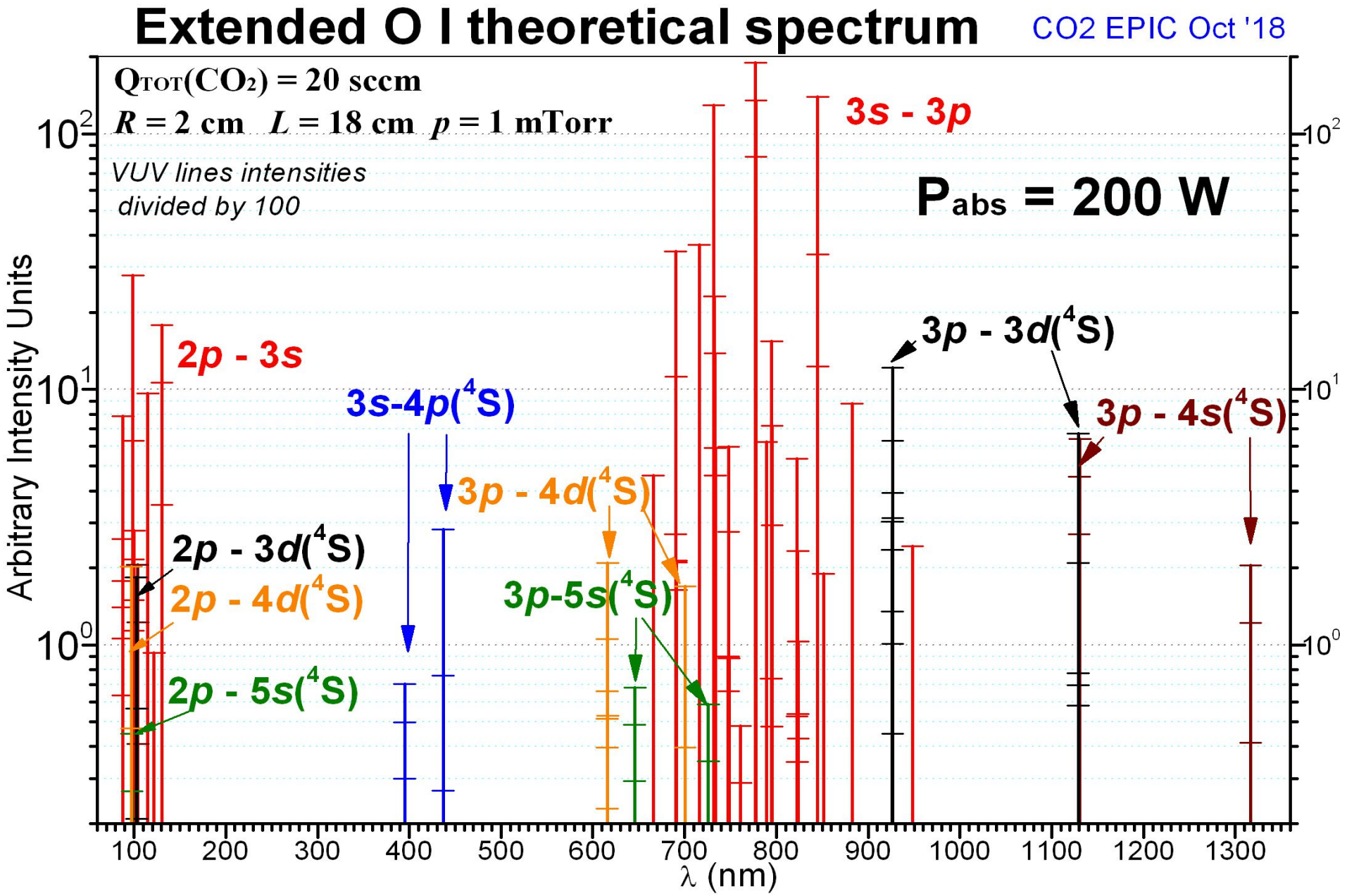
DEDALOS

Fig. 14. O II lines in the spectral region 370 – 500 nm



4. OXYGEN I SPECTRUM (Theoretical)

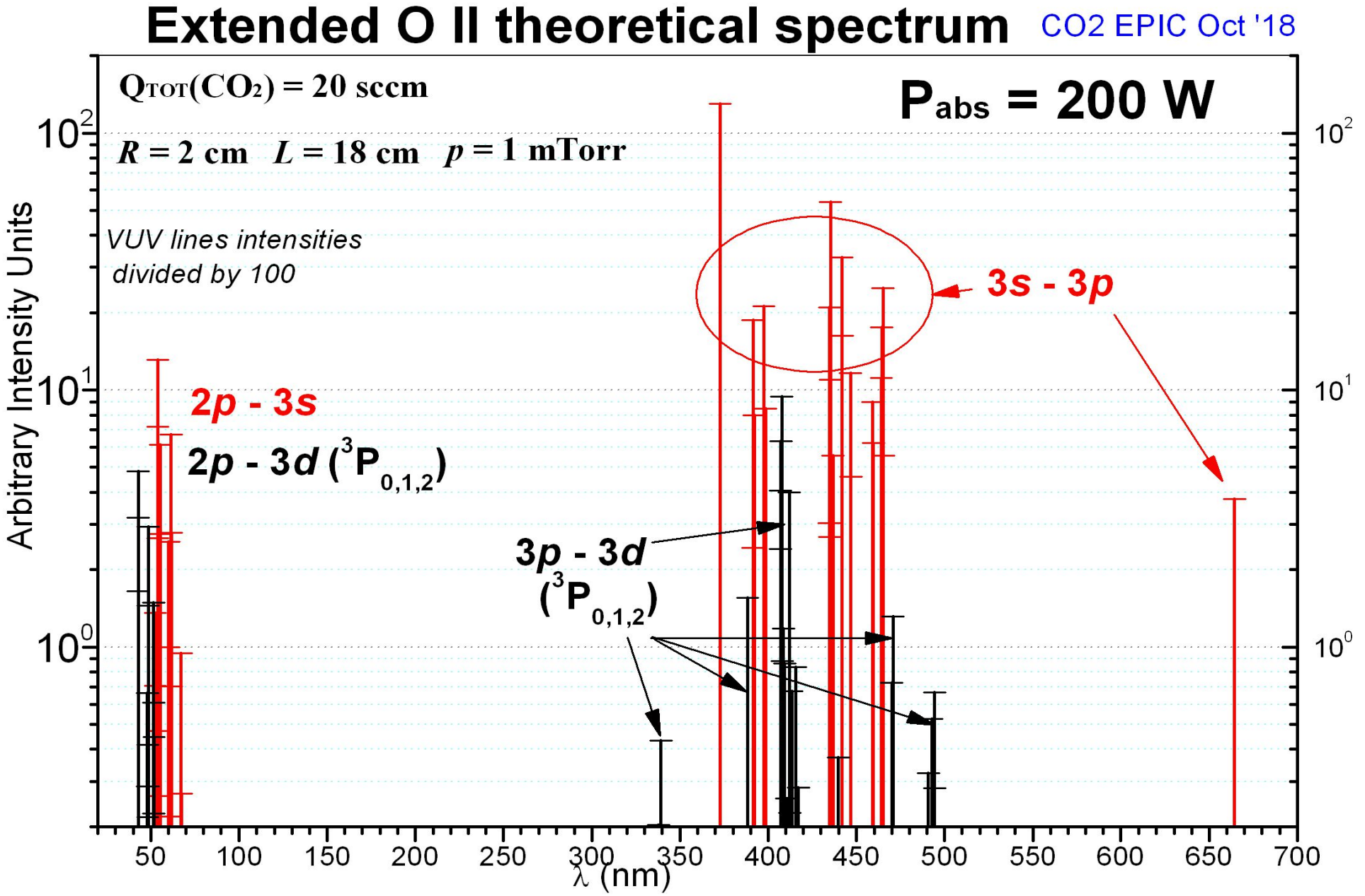
Fig. 15. O I lines in a large spectral region



4. OXYGEN II SPECTRUM (Theoretical)

DEDALOS

Fig. 16. O II spectrum, VUV, UV & visible regions



5. CONCLUSIONS

We conclude that **CO2DGM** contributes efficiently to theoretical characterization and diagnostics of ETs fed by **CO_2** by using **PCC** and **FD** diagrams and theoretical spectra.

Various absorbed power values have been addressed for 20 sccm of **CO_2** flow rate and a form factor of R = 2 cm, L = 18 cm.

Work presented here extends in a lower P_{abs} domain the work presented recently in Seville [6].

Thank you for your attention