EUROfusion

Negative triangularity edge modelling with SOLEDGE2D-EIRENE

Paola Muscente
Paolo Innocente

CONSORZIO RFX
Ricerca Formazione Innovazione

UNIVERSITÀ DEGLI STUDI DI PADOVA

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Aim

Context: explain the effects of negative triangularity on plasma performance

Final aims: use **interpretive** and **predictive** tools based on first-principles simulations to understand the properties of NT in heat, particles and momentum **transport in the SOL**

→ **SOLEDGE3X**: first-principles code from the combination of SOLEDGE2D-EIRENE and the turbulence code TOKAM3X, which solves drift-reduced Braginskii equations for multi-species

Aim of preliminary studies: understand feature of edge transport in NT configuration with respect to the PT one

→ **SOLEDGE2D-EIREN**E: a fluid-Monte Carlo edge transport code, which requires certain empirical input parameters (e.g. cross-field diffusivities), which are be found by modelling experiments

Strategy

- Study how power and particle exhaust differ between **diverted L-mode** pulses with different triangularity (*on-going*)
- Compare the edge transport in **NT configuration** with respect to the one in the **PT configuration in H-mode** (TCV, AUG)

On going study

Modelling discharges in the standard single null magnetic divertor configuration with fixed lower triangularity (δ_{bottom}=+0.5)
but **different upper triangularity**, from δ_{up}=-0.26 to δ_{up}=+0.45

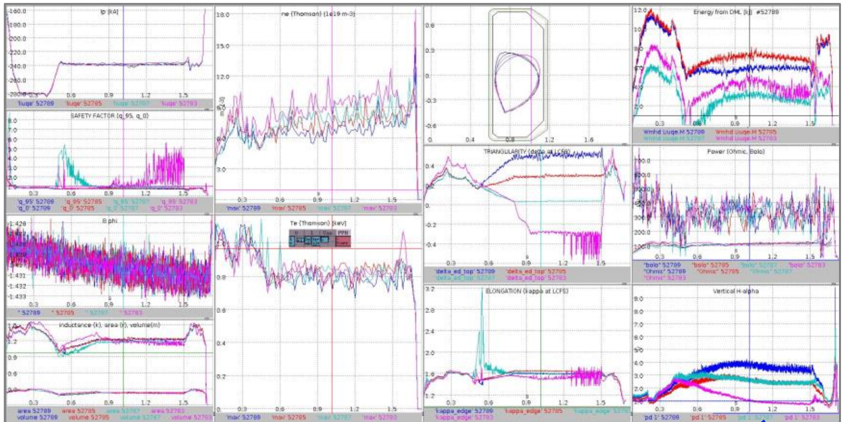
Discharges chosen:
→ are ohmically heated, L-mode deuterium plasmas attached conditions (T_{target} >10eV)
→ have **reliable measurements** on the mid-plane (TS), at strike points (LP, IR) and have also bolometry data → allow good validation of the modelling
→ were used previously to study the heat flux decay length (*), allowing us to compare the results of these simulations with this previous analysis

Strategy

- Collection and analysis of experimental data ✓
- Mesh generation ✓
- Start from pure Deuterium condition and use ad hoc transport parameter profiles to reproduce better the experimental data first for the positive triangularity case ✓
- Same but for other cases (on-going)
    → We aspect to have first indications about transport behavior/differences
- Introduce Carbon impurity to describe radiation and energy flow

(*)M Faitsch et al., 2018 Plasma Phys. Control. Fusion 60 045010

Overview of the discharges



H-alpha emission decreases with NT

We aspect:

→ lower particle transport

→ Lower $J_{sat,i}$ from LP at the strike points

Common features of shots at t chosen						
Ip [kA]	**B_phi [T m]**	**Te [keV]**	**Ohmic power [kW]**	**Area**	**Volume**	**q95/q0**
-240	-1,43	0,8	300	0,22	1,2	3/1,5

Powers						
Prad tot [kW]	**Prad core [kW]**	**Prad ext [kW]**	**Prad private [kW]**	**P ohm [kW]**	**P input (without C) [kW]**	**P input (with C) [kW]**
105	32	60	8	300	195	268
116	37	65	11,5	300	184	263
112	39	60	11,5	300	188	261
109	46	53	9	300	191	254

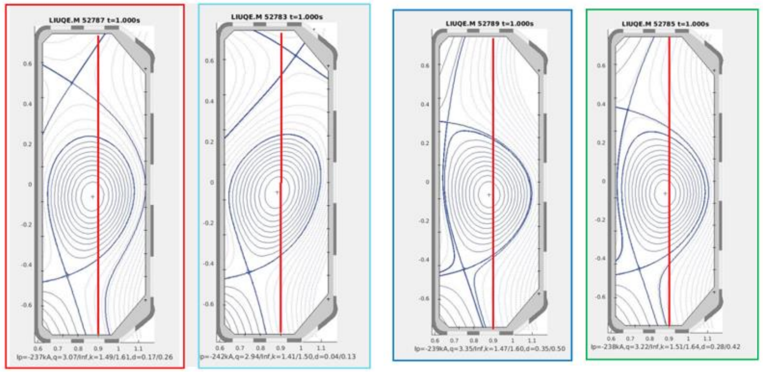
Features of interest					
Pulse #	**δ up**	**n_e [x10^{19} m^{-3}]**	**κ**	**Gas puffing [x10^{20} D2/s]**	**Grazing angle**
52789	+0,45	6,5	1,59	6	4,18
52785	+0,28	7,2	1,64	3	3,85
52787	+0,04	8,0	1,59	3	3,85
52783	- 0,28	9,4	1,5	0,5	4,33

Experimental data analysis

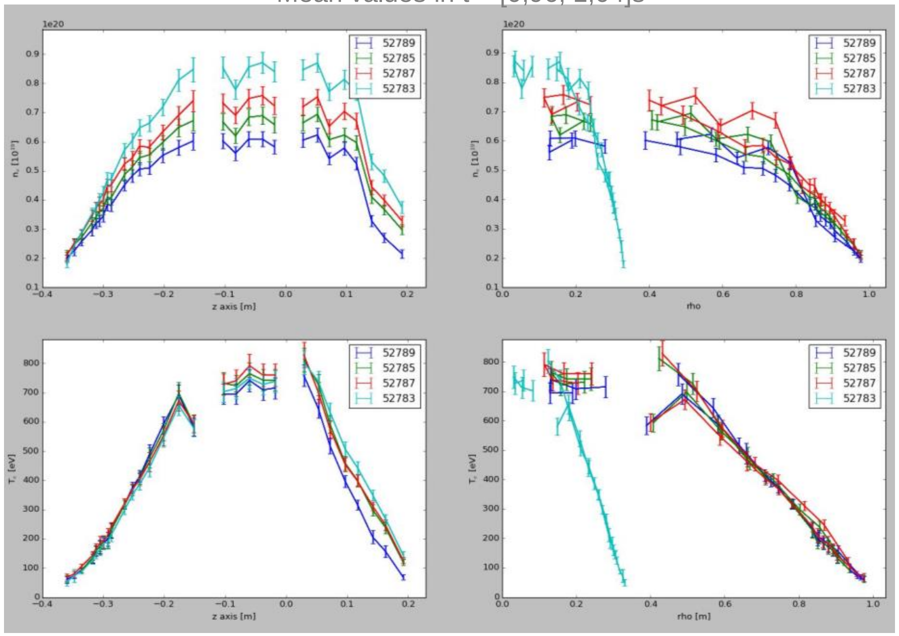
Thomson scattering

Langmuir probes

Thomson scattering profiles along los



Thomson scattering data: electron temperature and electron density profiles
Mean values in t = [0,96; 1,04]s



Differences in density profiles
→ Change in particle transport ?

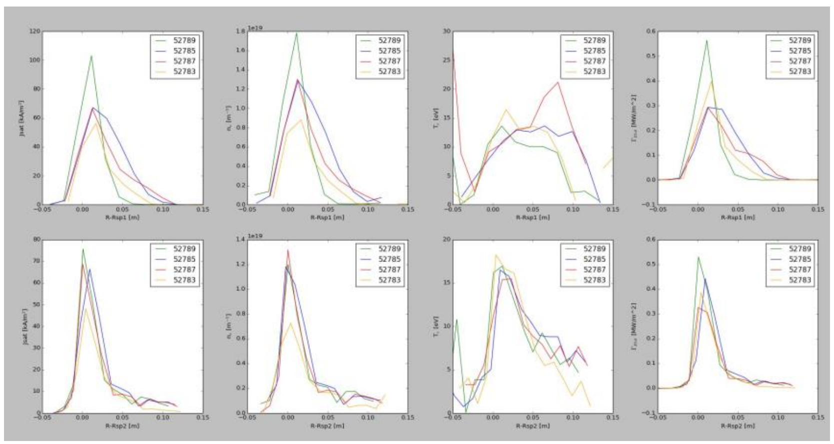
No differences in temperature around the separatrix
→ No chage in energy transport ?

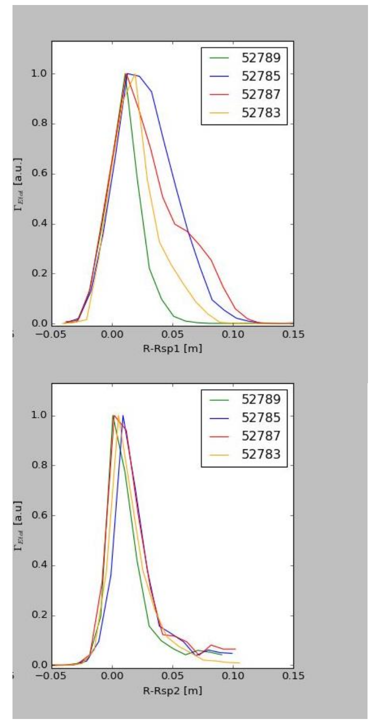
Langmuir probes data

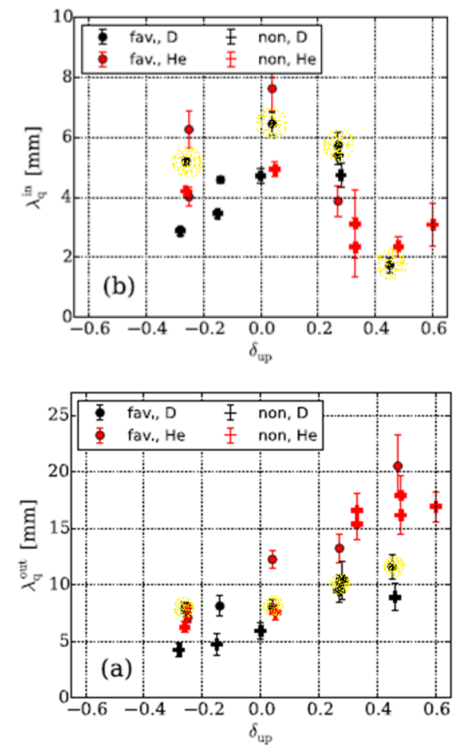
Heat flux normalized
with respect to max

Heat decay length
Faitsch's results

Langmuir probes data round inner and outer strike points
Mean values in t = [0,96; 1,04]s







No particular trends in heat flux profiles
No match with heat decay length → next step: include IR analysis

About the $J_{sat,i}$ trend that we aspected from H-alpha observation

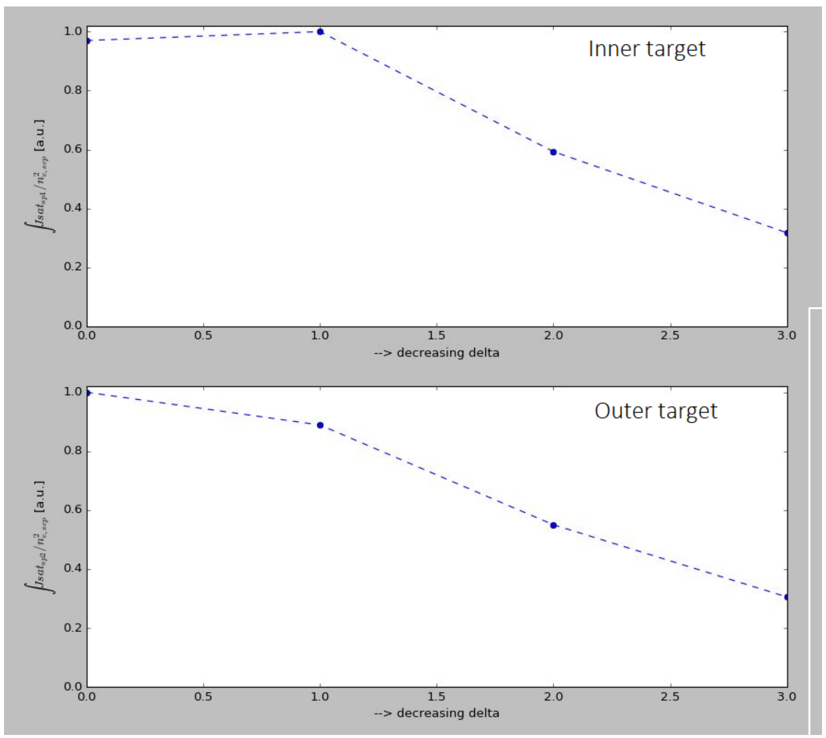
In order to exclude the n_e dependency:

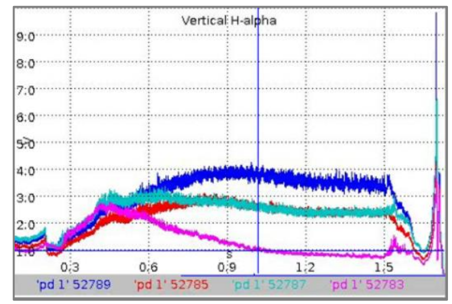
- LP: $J_{sat,i} \div n_t\sqrt{T_t}$
- 2-point model in high-recycling regime (10eV < Ttarget < 20ev): $n_t \div n_{upstream}^3$ and $T_t \div 1/n_u^2$

  → $\int J_{sat,i} \div n_u^2$

  → $\int J_{sat,i} / n_u^2$ to exclude the dependency on electron density

Integral of Jsat on the square of the electron density at the separatrix





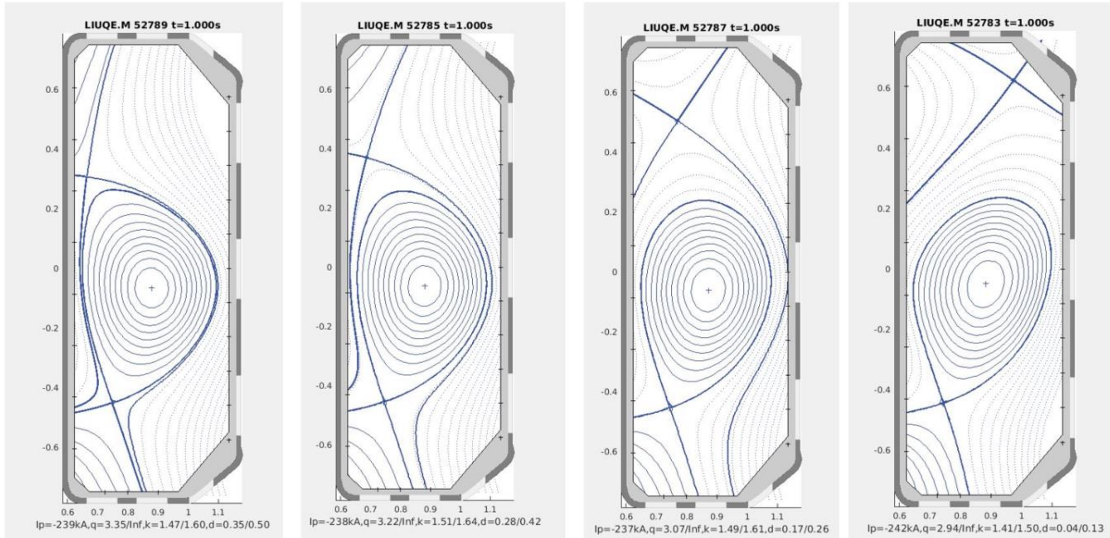
TREND as aspected:
$J_{sat,i}$ decreases with triangularity on both target

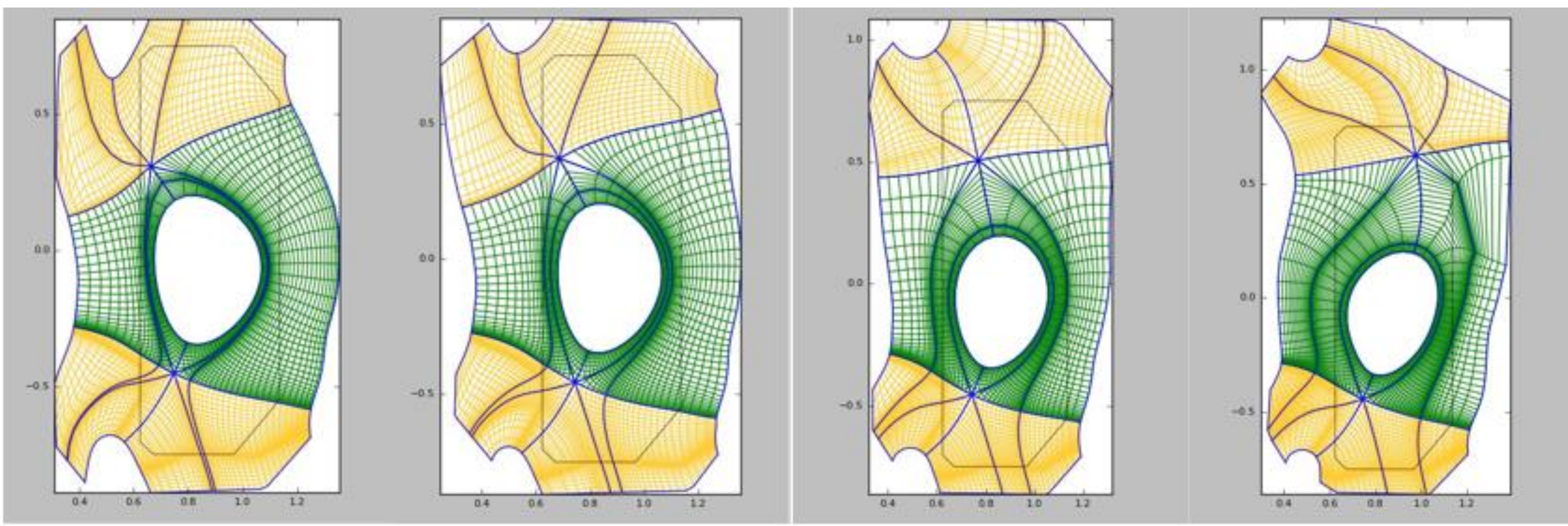
Change in particle transport

We aspect a **decrease in D** transport parameters whilst we aspect no significant changes in energy transport (no difference in T_e from TS data)

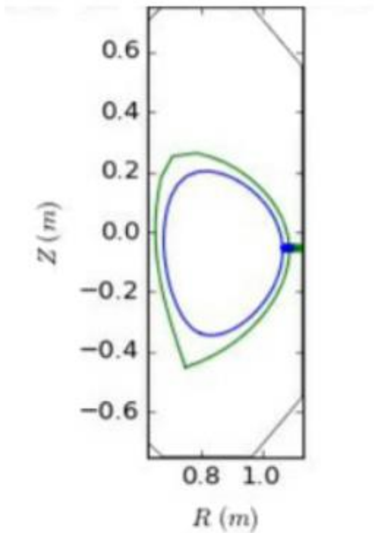
SOLEDGE2D-EIRENE modelling

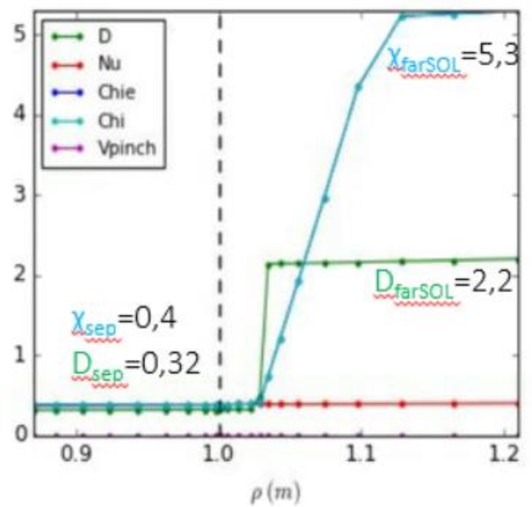
Equilibria from LIUQE and meshes made using SOLEDGE2D

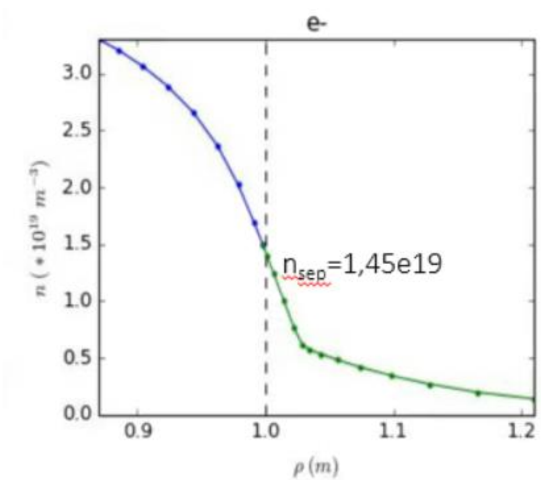


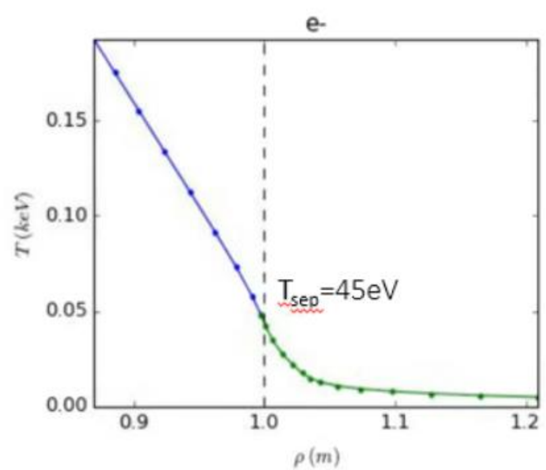


Thomson scattering data and modelling match: mid-outer plane





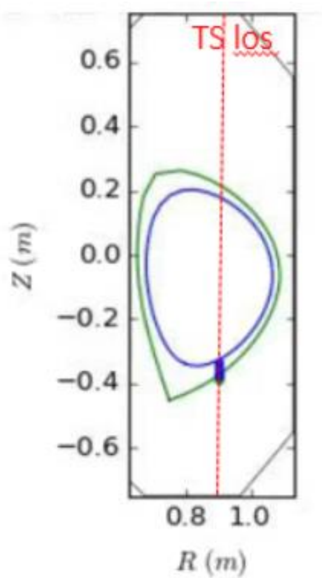


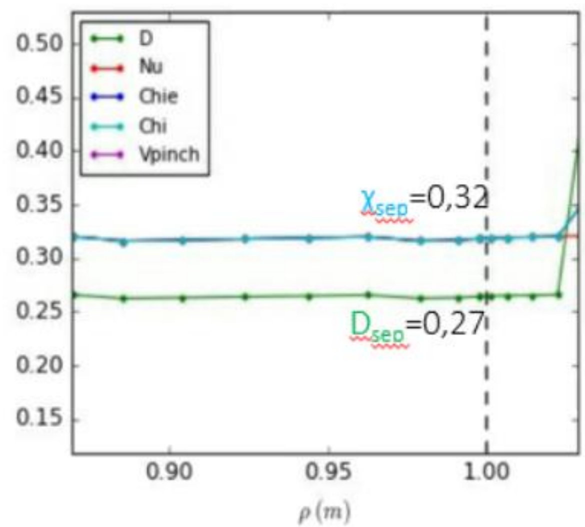


No TS data on the mid-outer plane

Next step→ RPTCV ?

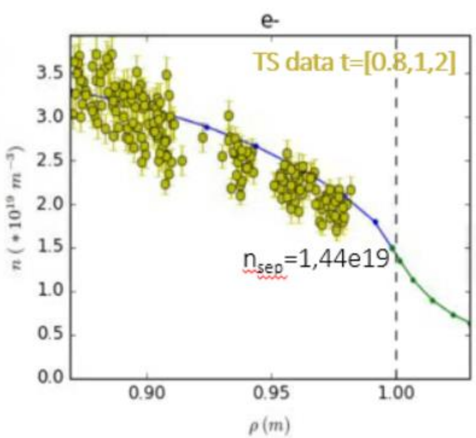
Thomson scattering data and modelling match: on TS los

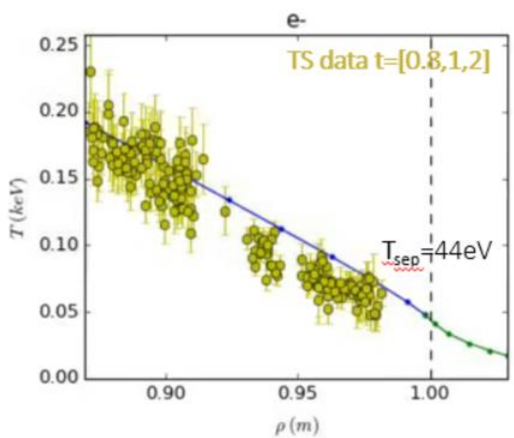




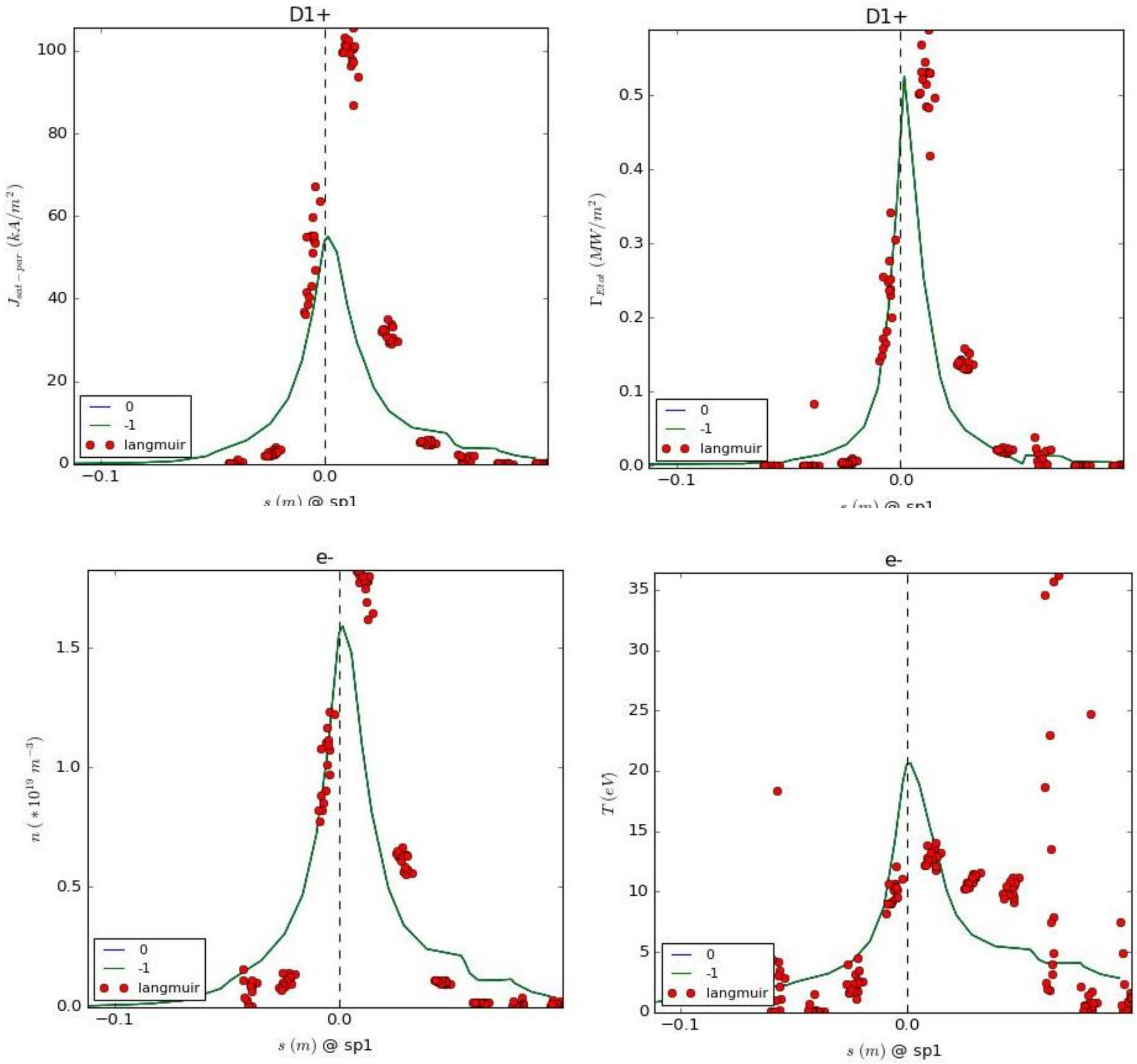
No TS data around the separatrix

On going→ effect of magnetic field ($1/B_t$)



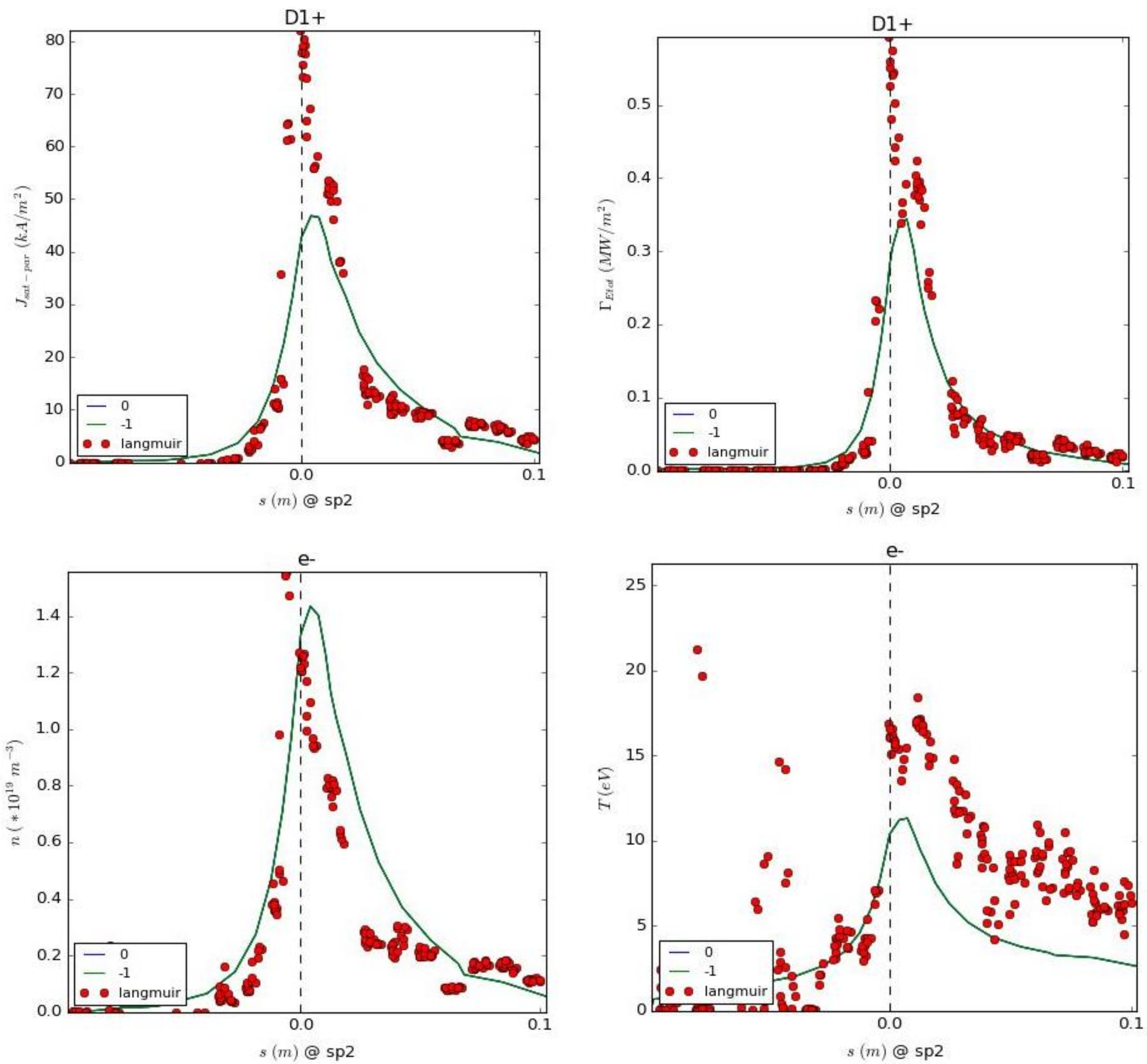


Langmuir probe and simulation match: inner strike point



- J_{sat} low
- Too much narrow heat flux
- Difficult to reproduce T_e profile shape

Langmuir probe and simulation match: outer strike point



- J_{sat} low (as inner)
- Too wide n_e profile
- Difficult to achieve T_e peak shape

What's next in the near future?

- Try to correct the mismatch for the positive case

  → seems not possible

  → Carbon impurity introduction can help ?

- Tuning transport parameters in pure D for other cases in order to reproduce experimental data (first TS, LP)

  → first results seems to indicate a reduction in particle transport

Thanks for your attention