PMI-5.2.5-T012
Fast Particle Losses after sawtooth crash

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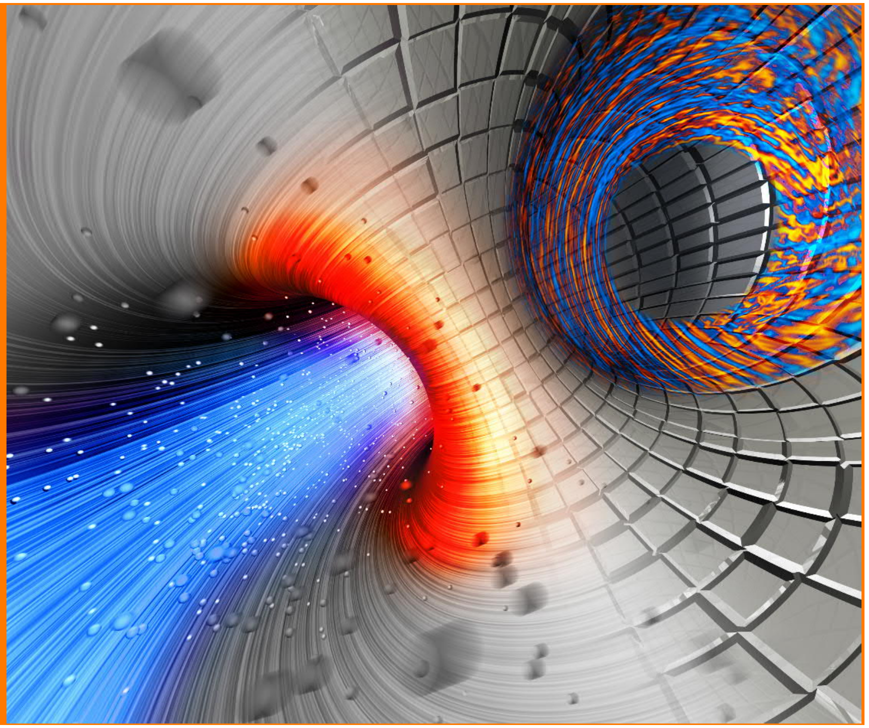


Aim of this task

- ★ EU-DEMO is large, with large plasma wall clearance
  - ➔ alpha losses expected negligible in *MHD-quiescent* plasmas
- ★ EU-DEMO : $q_s(\rho = 0) < 1$
  - ➔ sawtooth crashes to be expected

However, introduce a large sawtooth crash

- ➔ fusion-born alphas ejected towards plasma periphery where MeV-range alphas ought not to exist

➔ estimate the effect of a sawtooth crash on alpha particle losses and power load to the wall

Task Performance – original plan

- ★ The alpha particles distribution after a sawtooth crash to be produced by E. Fable at IPP Garching = input for transport simulations
- ★ The analysis of alpha particle losses after a sawtooth crash will be performed with the code ASCOT
- ★ Results to be compared with the unperturbed case (i.e. when the displacement due to sawtooth crash is not considered).

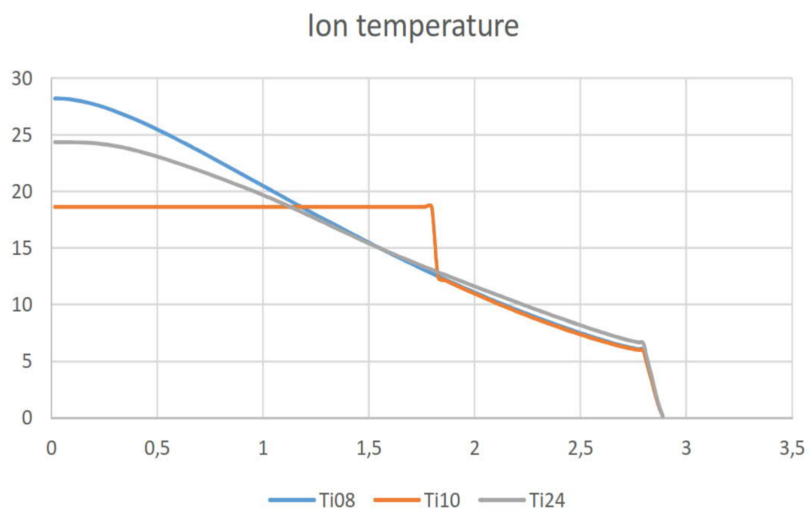
Task Performance – revised plan

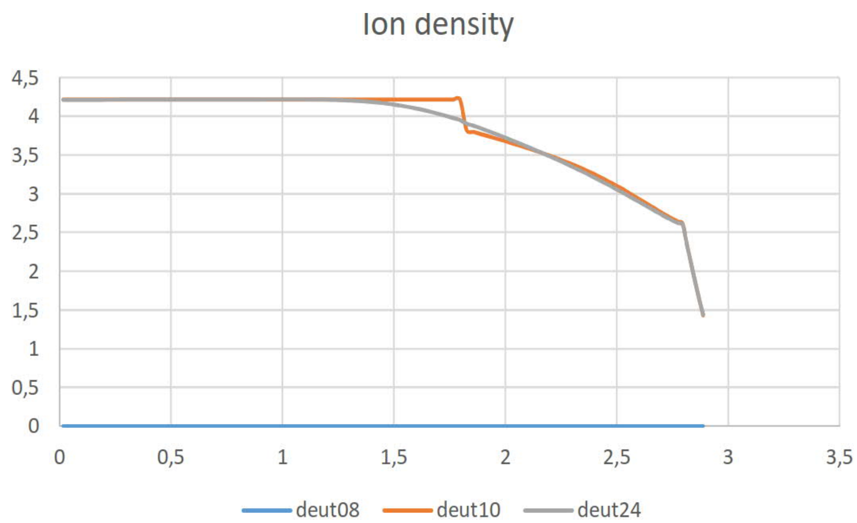
- ★ E. Fable at IPP Garching provides ASCOT group with (at least) two different plasmas:
  - – Equilibrium and kinetic profiles corresponding to pre-sawtooth phase
  - – Equilibrium and kinetic profiles corresponding to post-sawtooth phase
- ★ ASCOT group will
  - – Run the AFSI code to calculate the birth distribution of fusion alphas for both cases
  - – Run the ASCOT code for both cases to determine if the power arriving at the wall will be significantly larger after a sawtooth
  - – Compare the losses between pre- and post-sawtooth phases

Plasma profiles

★ Three extreme profiles chosen for the AFSI-ASCOT analysis:

- a fully relaxed profile (t08),
- profiles just after a sawtooth crash (t10)
- profiles half-way in the recovery phase (t24).





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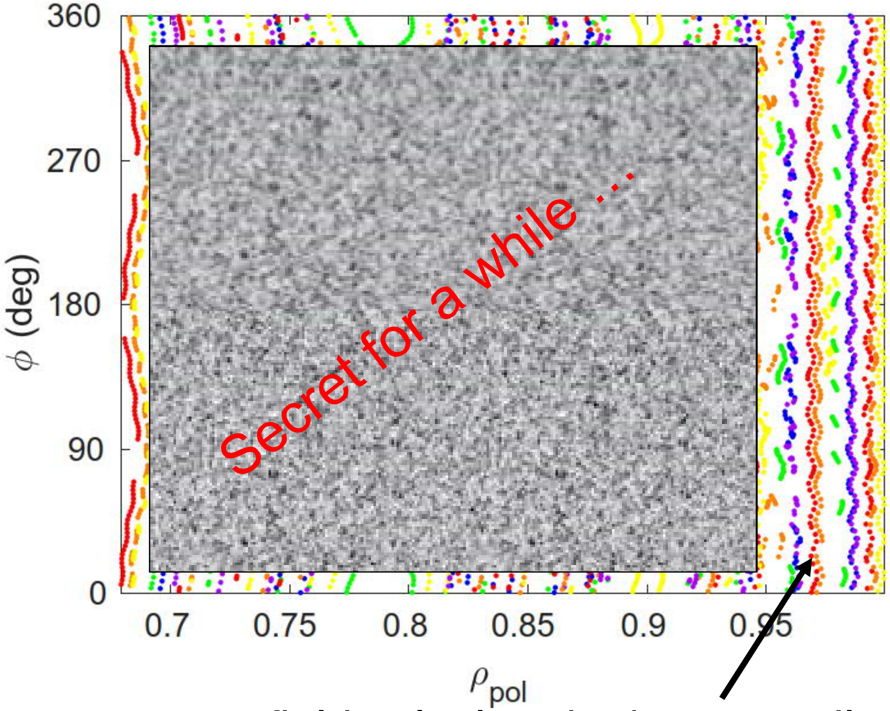
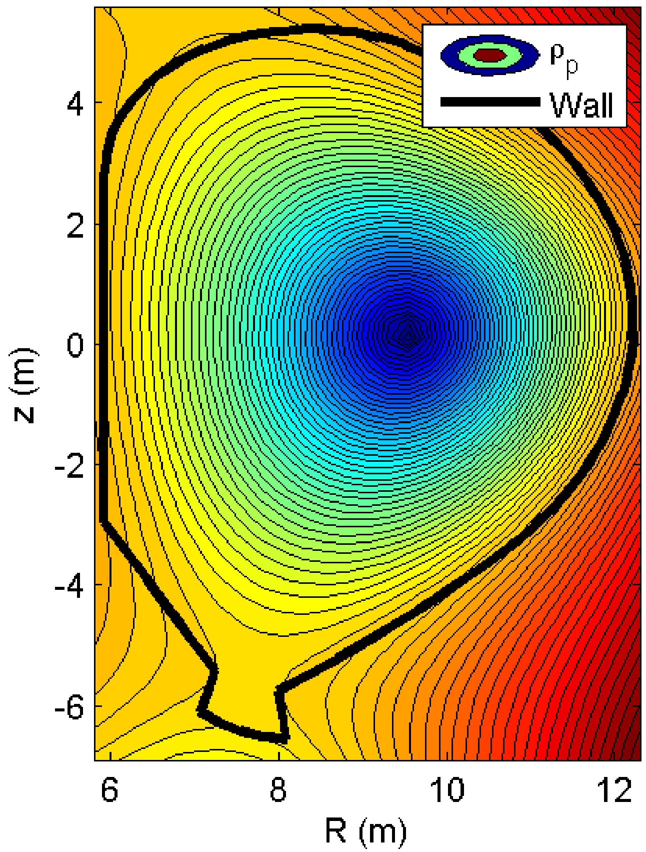
Magnetic geometry



Vacuum field calculated w/ 16 TF coils

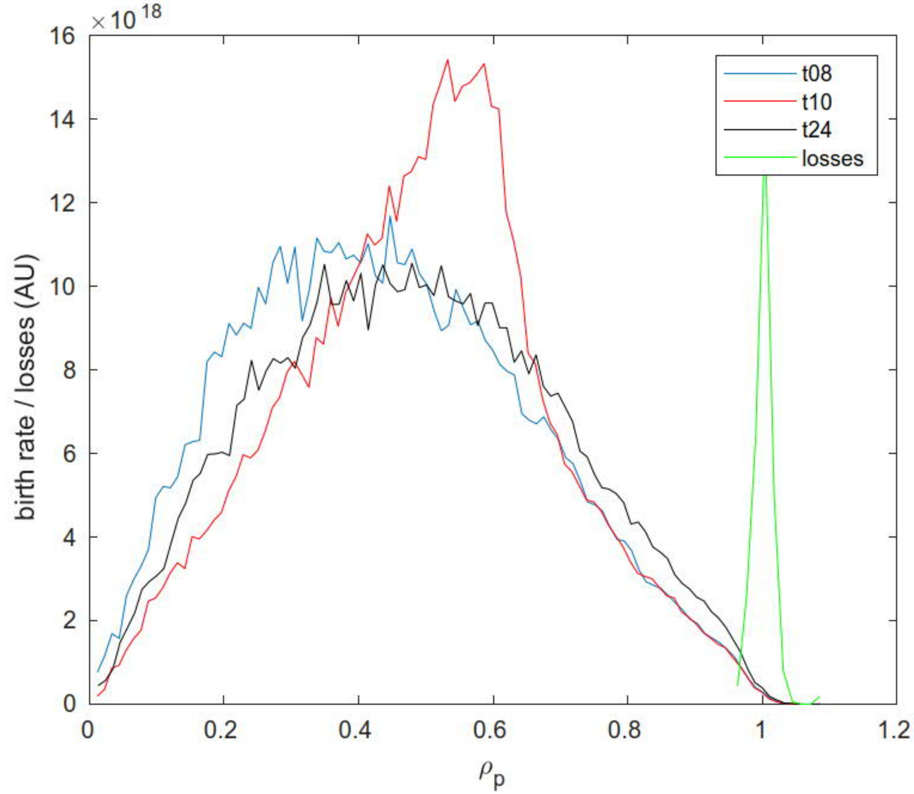
$\Delta_{ripple} \approx$ 15cm



Magnetic equilibrium assumed uncompromised during the ST cycle, $\Delta_{plasma-wall} \approx$ 10cm

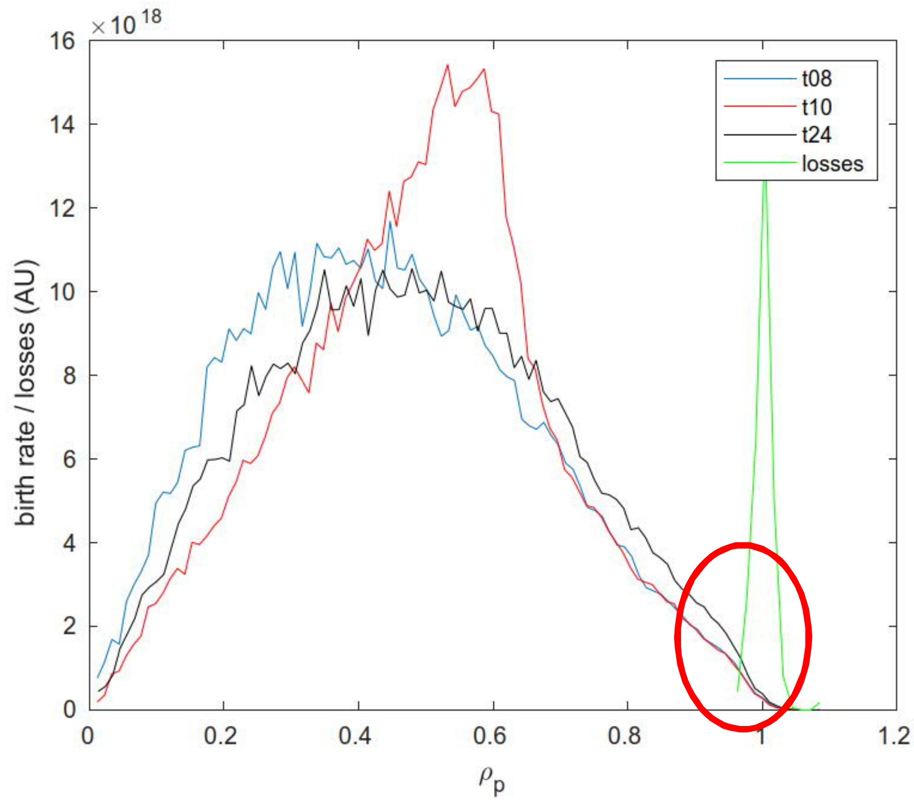
Observations on the profiles

- ★ The radial shift of the high-n, high-T profile is about 50cm: 1.2m -> 1.7m
- ★ Expected:
  - – 'at' sawtooth event (t10), significant increase in alpha production at around the corresponding location, ρ_p ~ 0.6
- ★ Not expected:
  - – Further out, ρ_p > 0.7, the production rate highest in the *recovery* phase (t24) …



ASCOT simulations

- The ST cycle lasts about 100ms -> virgin alphas simulated for 100µs to capture the effect of profile changes only
- Power lost in 100µs:
  - Pre-ST: 160 kW
  - 'at' ST: 130 kW
  - Half-way to recovery: ***200 kW***
- Conclusions:
  - Changes due to ST too deep inside to matter
    - $\rho_L(\alpha) \approx$ 2.5cm
    - Δ_b ≈10cm
    - distance to the separatrix: ~100cm



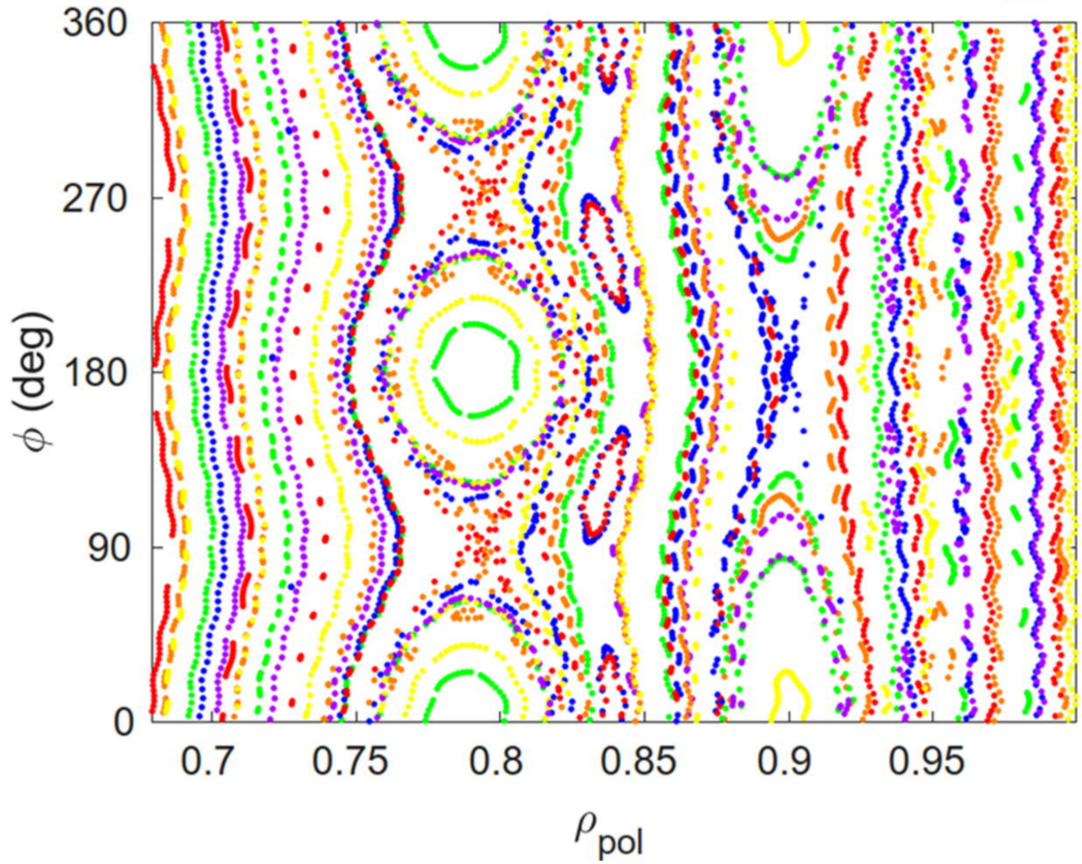
Extension of the work …

Can’t we make the losses any bigger???

Include two NTM islands

- ★ NTMs are expected in any high-performance plasmas
- ★ (3,2) and (2,1) NTM islands included in the recovery phase
- ★ Foreseen transport chain:

  ST -> NTMs -> TF ripple -> wall
- ★ simulation time increased to 5 ms
- ★ Results for 5ms simulations:
  - no NTMs: 310kW
  - w/ two NTM islands: 510kW



Conclusions

★ *Profile changes* across ST crashes are unlikely to lead to significant alpha losses even if reasonably-sized NTM islands are included

★ However …

- only prompt losses of thermonuclear fusion alphas was addressed, i.e.,
  - alphas born due to fast ions from external heating were excluded
  - the alphas in the slowing-down (SD) distribution were excluded
- magnetic equilibrium was assumed unchanged during the sawtooth event
- the parallel electric field related to an ST event was not included

Thank you ☺