11th IAEA Technical Meeting on H-mode Physics and Transport Barriers

The role of MHD in the sustainment of electron internal transport barriers and H-mode in TCV confinement during flat-top eITB plasmas on TCV

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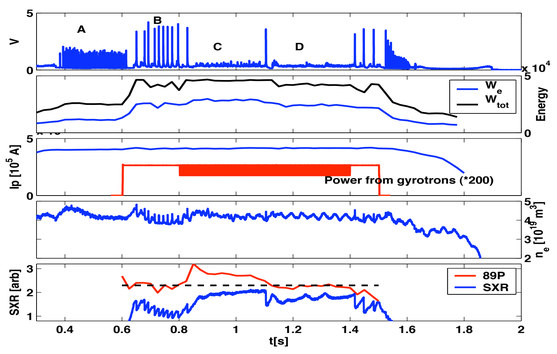
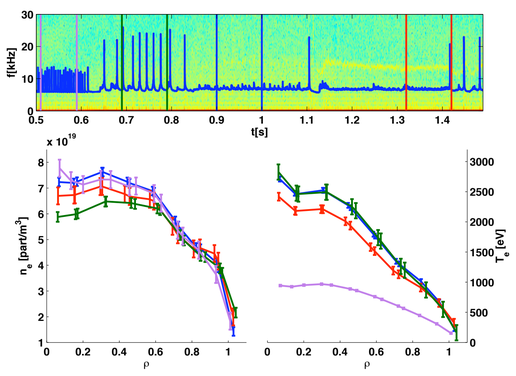
1) Introduction

- Advanced scenarios exhibit improved confinement properties
  - High performance leads plasma close to stability limits
- Quasi-Stationary ELM-Free H-Mode is obtained with vertical X3
  - No density peaking
  - Robust once in place
  - Shaping details as well as pre-QSEFHM MHD could play role in attainment of the regime
- eITBs with and without MHD (ideal and resistive)
  - strong gradients in the region of shear inversion: Infernal limit
  - Major/minor disruptions, q=2 sawteeth, β-collapse displaying the same character
  - NTMs and O-regime observed, stabilization has been used
- Advanced scenarios and confinement properties depend on MHD

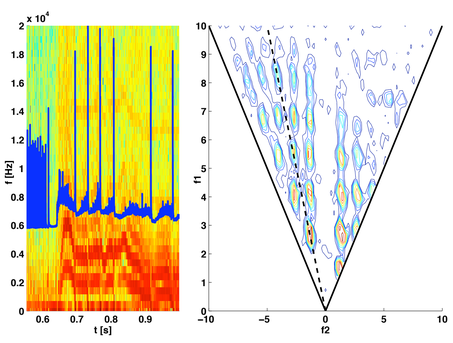
2) QSEFHM



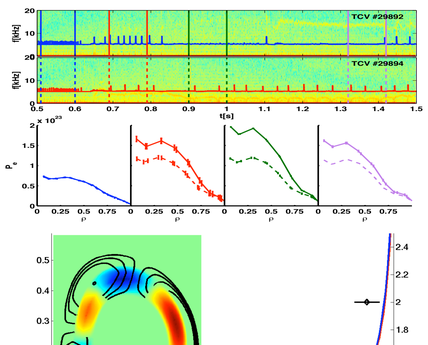
- Transition after X3 heating applied
- Good confinement properties
- high H factor
- no density peaking
- resilient to singular ELMs and NTM



- Best performance during QSEFHM
- ELMy X3 H-Mode same as QSEFHM with small NTM
- Density pedestal similar during all phases
- Needs Edge TS for understanding



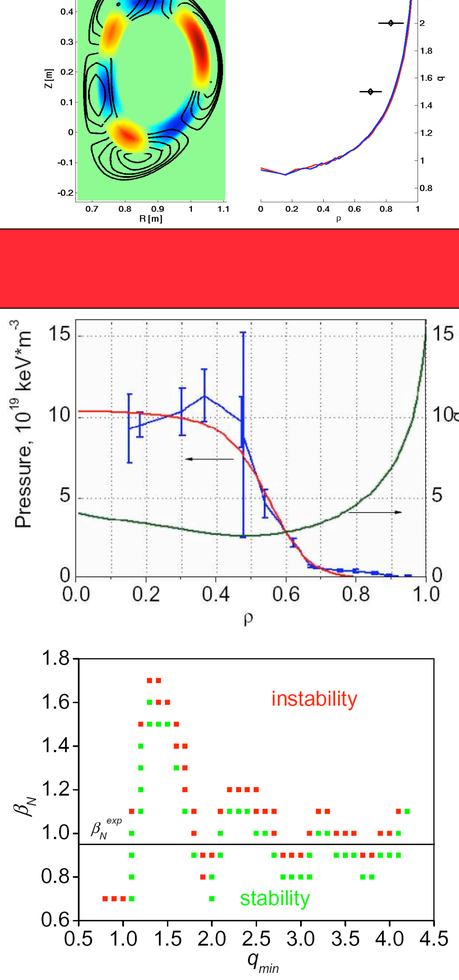
- Early MHD detrimental for scenario attainment
- Details in shaping, current profile, pressure profile important
- 3/2 locked to 2/1, first is dominant
- Current filamnents analysis confirm



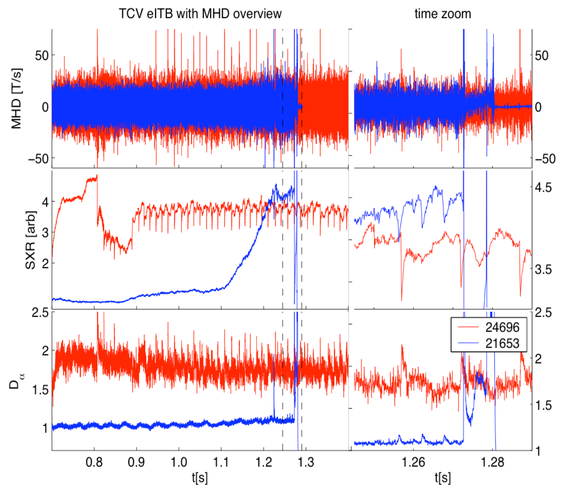
- Add points to q-reconstruction
- Mode effect on confinement

3) eITBs

- Electron internal transport barriers (eITBs) generally obtained with a hollow current density profile.
- Rapid formation ($T<\tau_{eE}$)
- sustained with q and shear profiles completely relaxed
- Can be non-inductively sustained (ECCD) + bootstrap
- eITBs inherent to reverse shear, with steep gradients at q_{min}: INFERNAL modes
- stability limit calculations shows lower βN limit near near low rational qMIN
- CQL3D + KINX for #21655, shows location of q_{min} and proximity to β limit (factor 1.2)

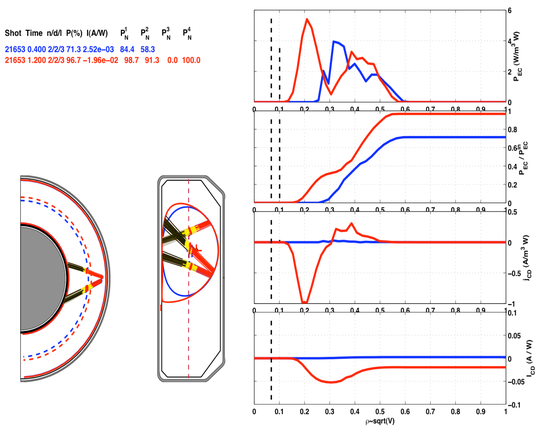


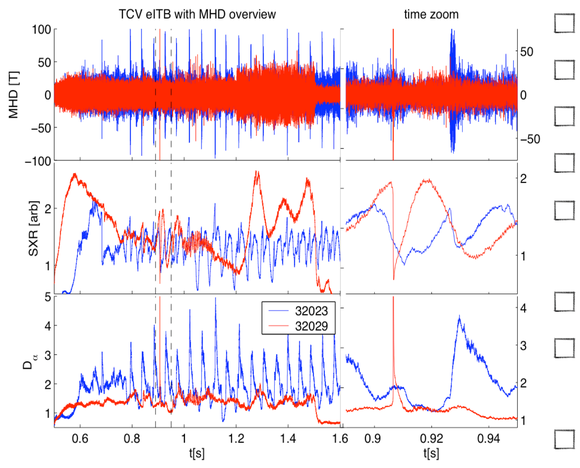
4) Data Analysis



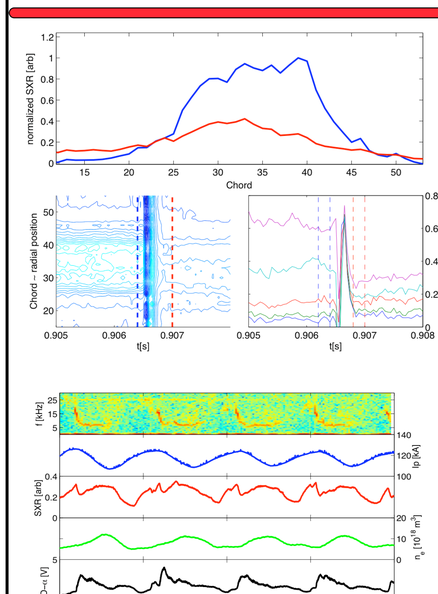
- 21653 [4] bootstrap + ECCD; 3rd gyrotron at t=1.1s
- Current profile reconstructed with CQL3D [4]
- qmin≈2.7 at ρΨ=0.5, where barrier is formed [4]
- m/n=3/1 with 2/1 component
- βN ~ 1 close to ideal stability limit
- ILM like effect on Dα
- Limit for high ∇p in low-shear

- #24696 on-axis counter-ECCD preceded by off-axis ECH
- (Ohmic contribution)
- q=2 sawtooth crash character, aka Periodic Relaxation Oscillations
- Ideal kink-like, dominated by high ∇p in the barrier
- resemble β-collapse in JT-60U



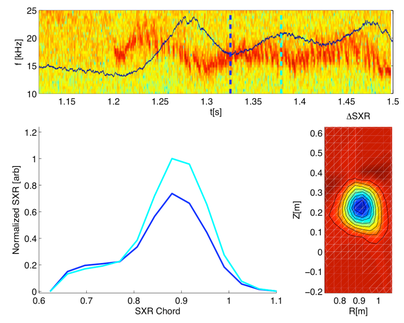


- #32023, small periodic infernal mode
- ideal activity followed by resistive mode
- Fast collapse, accompanied by Dα light
- Ideal mode of main periodicity m/n=2/1
- #32029, minor disruption at t=0.9s during huge O-regime
- barrier lost, due to small infernal modes
- When ideal modes stabilized, t≈1.22s, barrier grows, with resistive MHD
- NTM-like (dw/dt) and bootstrap



- loss of confinement estimated through SXR, 60%
- gradient in the barrier region is lost,
- Particles and heat expulsion, visible in chords outside the core
- q=2 involvement
- KINX and CHEASE --> evidence of plasma close to ideal stability limit at minor disruption

- 32029, dual character: ideal and resistive
- Ideal phase also evident in SXR and Dα
- crashes at top of confinement
- drop in confinement



- Second phase with global O-regime, NTM mode
- confinement drop between hign-low H_{rlw} phases
- NTM with main periodicity m/n=2/1

4) Conclusions and comments

- Advanced scenarios exhibit improved confinement properties
- Transport barriers require high pressure gradients
  - High performance leads plasma close to stability limits
- QSEFHM displays good properties
  - no density peaking, robust
  - MHD can be cause of difficult attainment
- eITBs on TCV with and without MHD
  - Infernal mode inherent due to pressure profile and low shear
  - various ideal-to-resistive MHD ascribable to infernal limit
  - stability windows exist
- More experiments planned for next campaign