Fast Probe Results

By
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For the UCSD and NSTX Teams

Acknowledge contributions/discussions with P. Diamond and S. Krashenninikov

Relevance of ST Edge and Edge Turbulence Studies

•Edge Transport is linked to Global Confinement

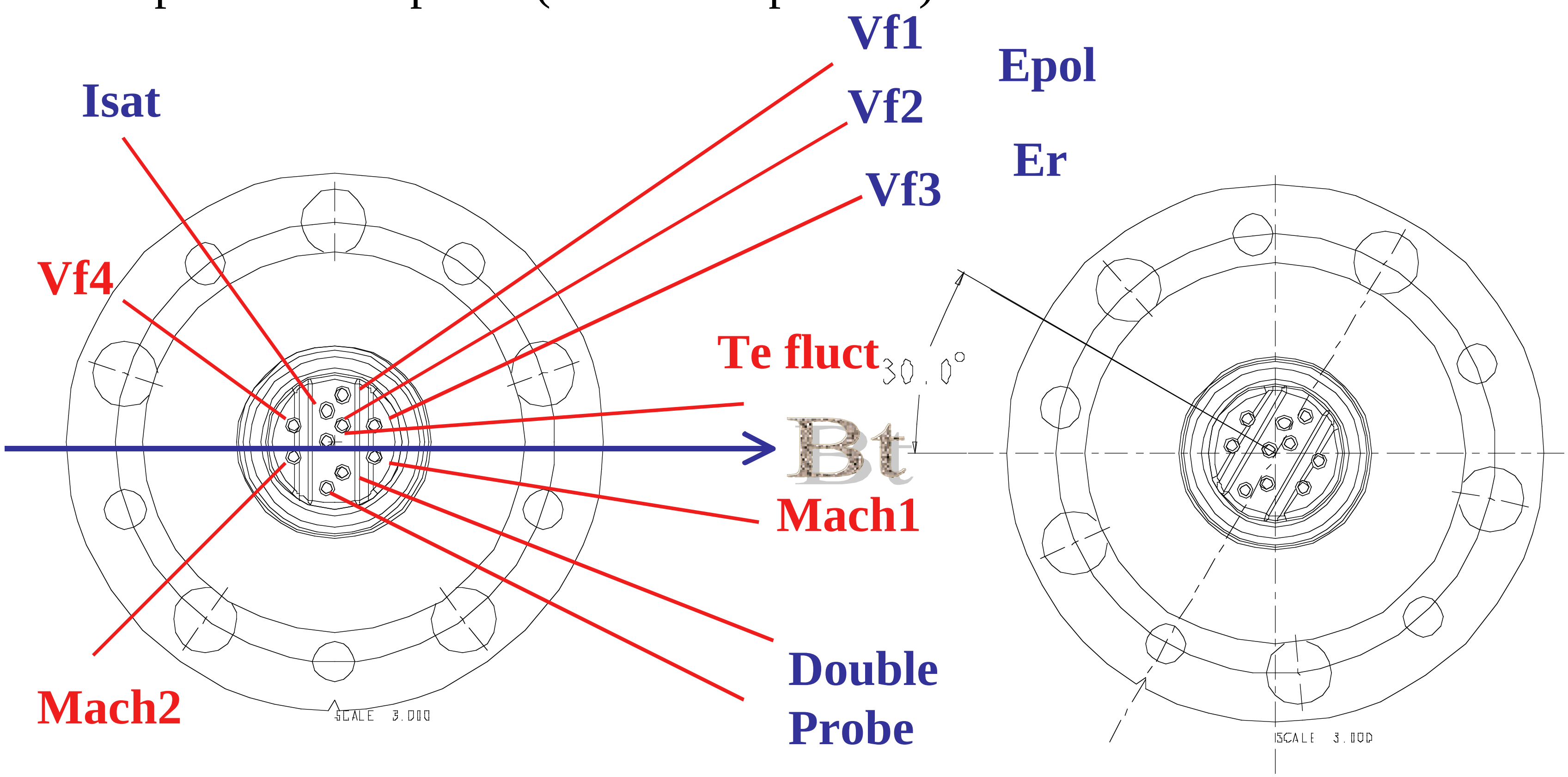
•Current Drive coupling/physics depends on edge profiles

•ST probably has finite beta effects (E-M fluctuations, magnetic flutter induced transport) that grant characterizing (T&T and basic physics)

•Bursty Edge Transport is important in tokamaks (ST?)

Existing Probe Head has 10 Tips

- Tips in blue will be active on day one, the rest implemented as upgrades (if funded)
- Fluctuations to 1 MHz
- Two Vf tips used for Epol (and fluctuations)
- Two Vf tips used as Er (and fluctuations) >> Reynolds Stress
- One tip as Isat >> ne
- Two tips as double probe (Te and Ne profiles)



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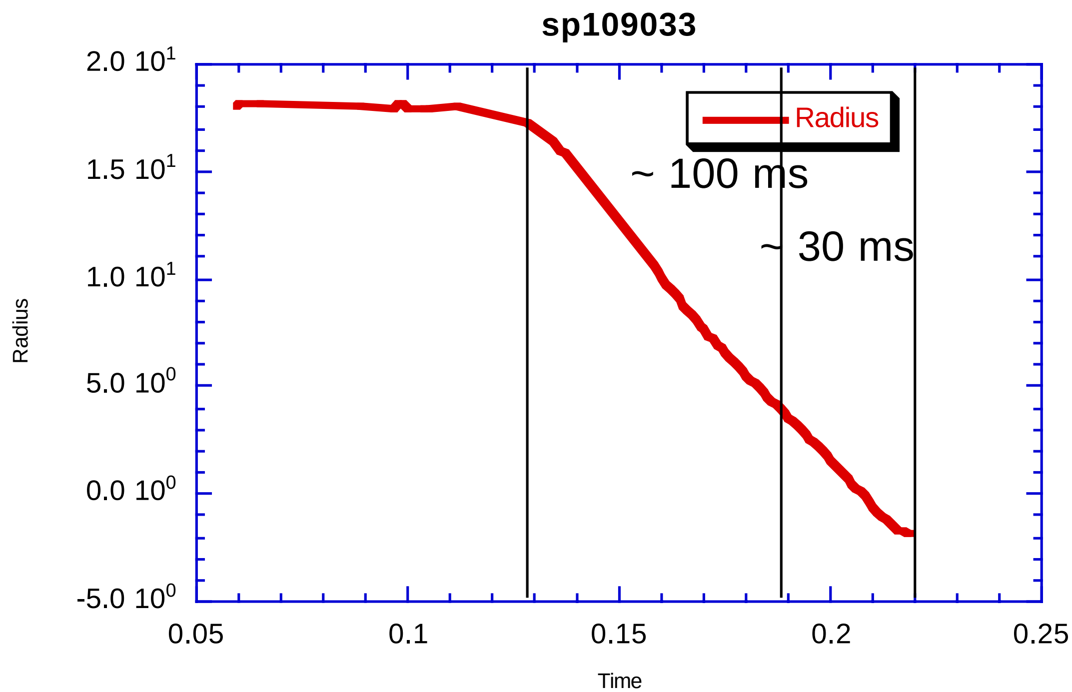
Results: Data Taken at High Spatial and Temporal Resolution



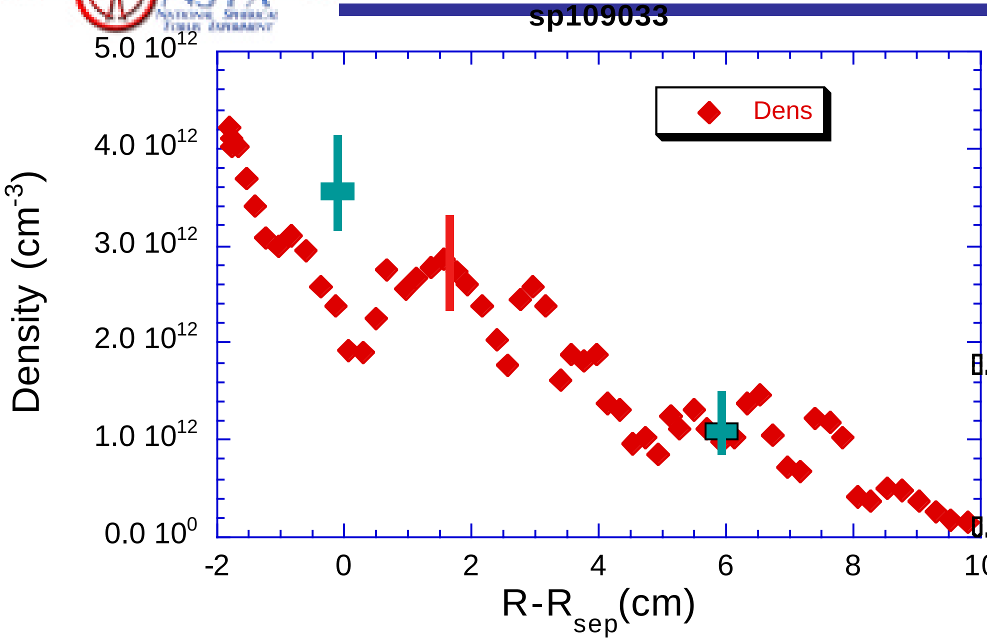
Insertion completed in 100 ms. ~30 ms in plasma

Time resolution for Te and Ne is 1 ms

Time resolution for fluctuations is 1 micro sec

Spatial resolution is 1.5-2 mm (tip size + probe motion)

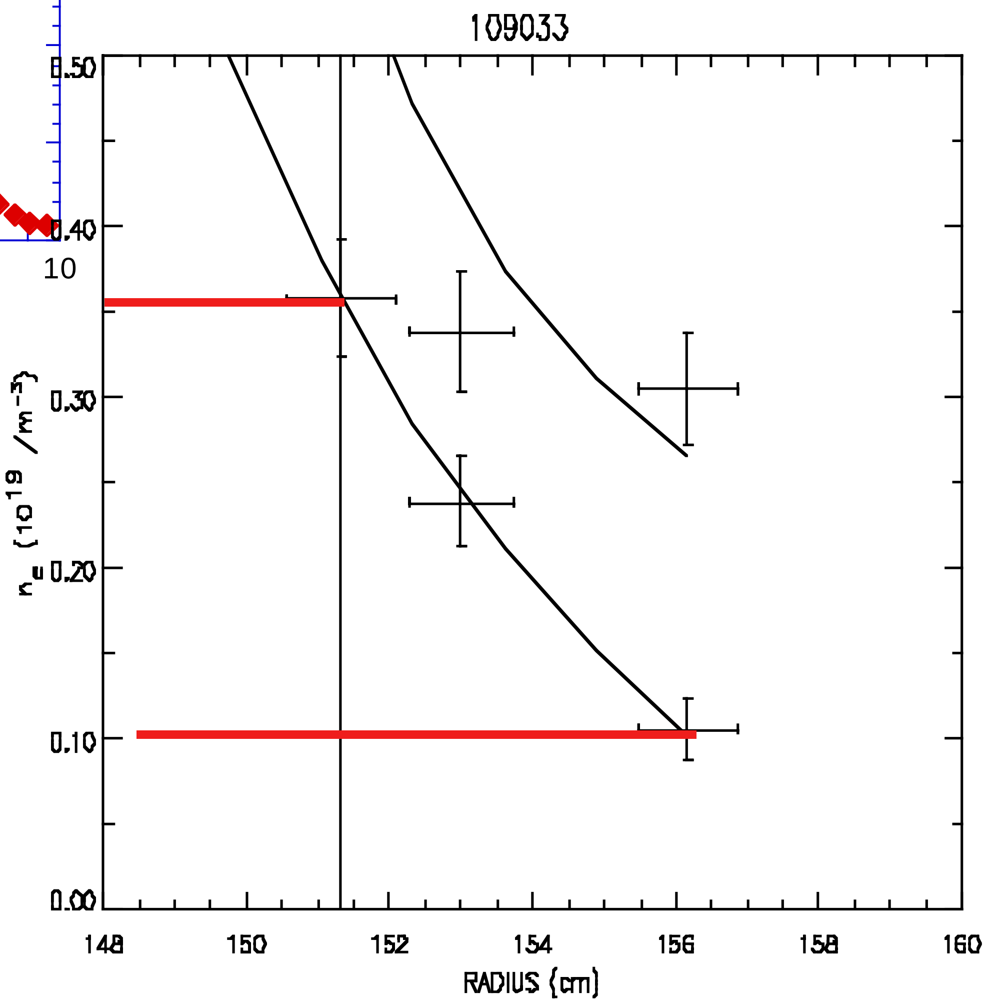
Results: Density Comparison with TS, L-mode

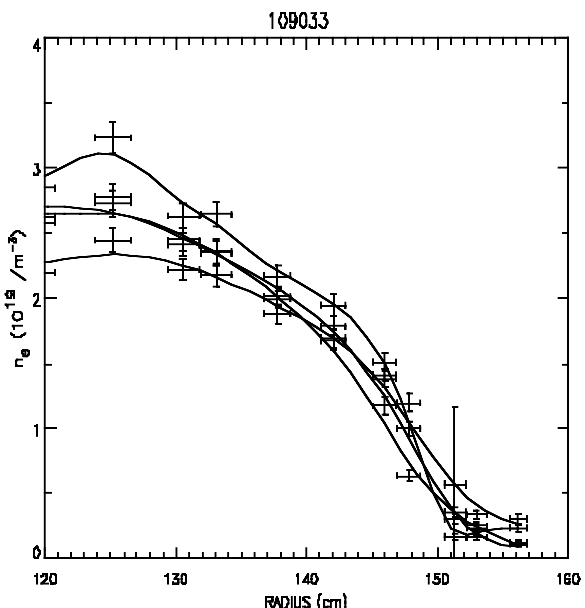


Rsep=1.5-1.51 m

Probe position within 0.15”

One measurement per ms





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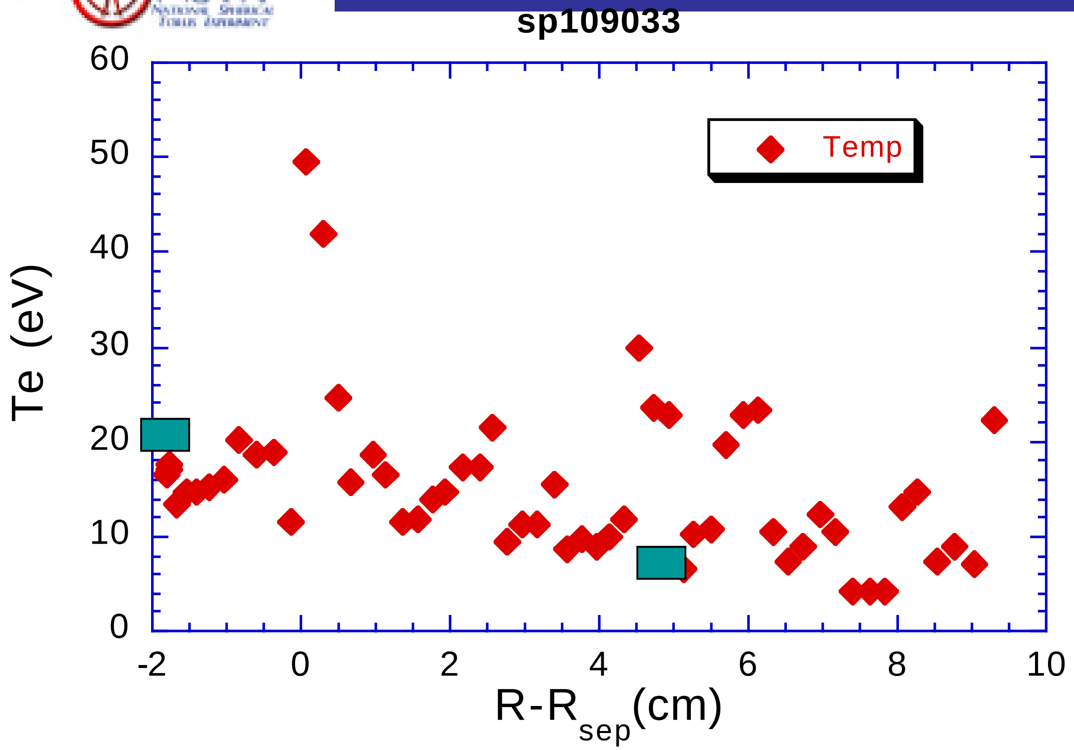
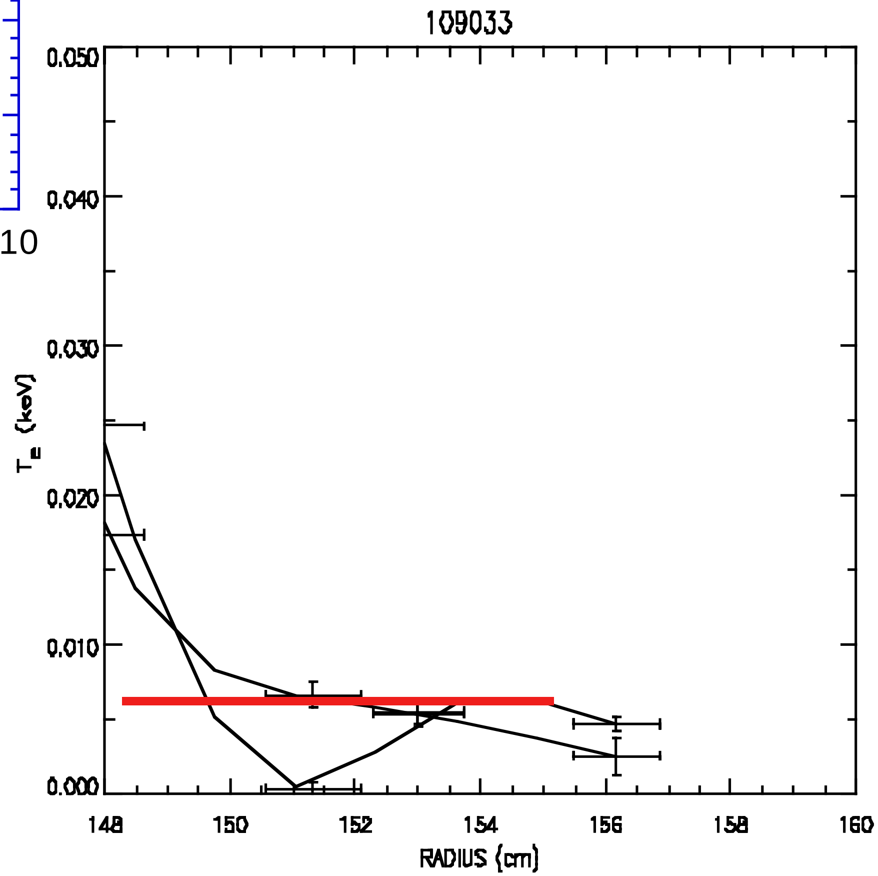
Results: Temperature Comparison with TS, L-mode





Probe measurements in reasonable
agreement with TS, specially if
fluctuations are considered

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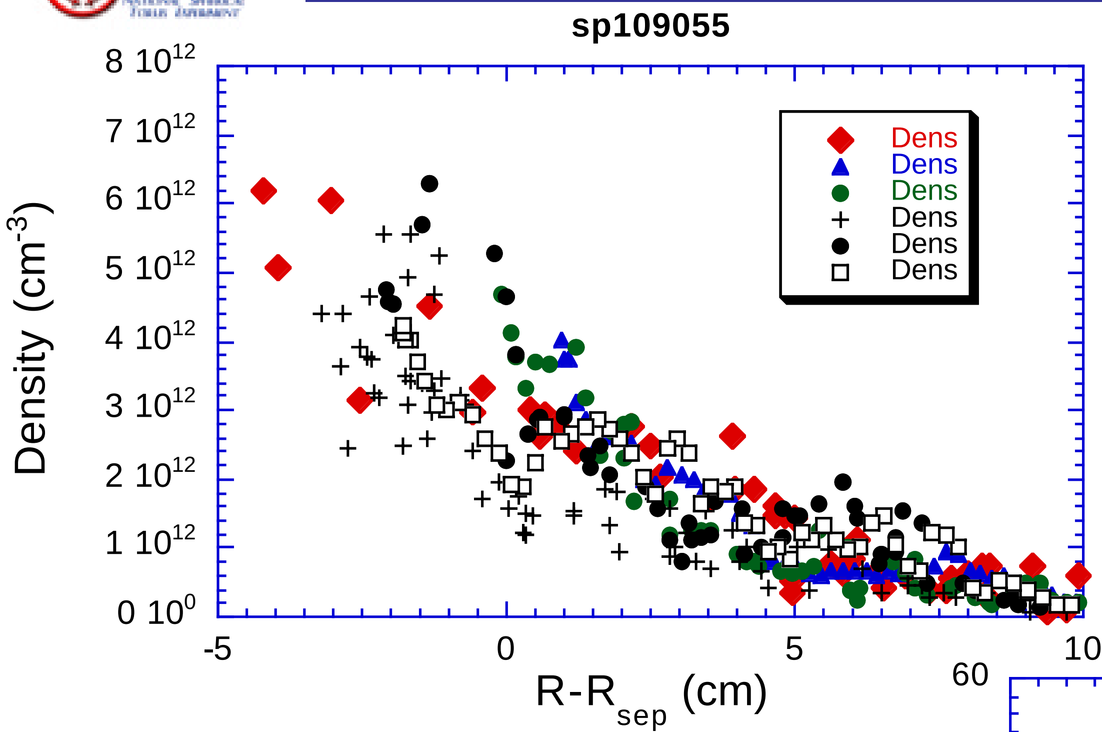
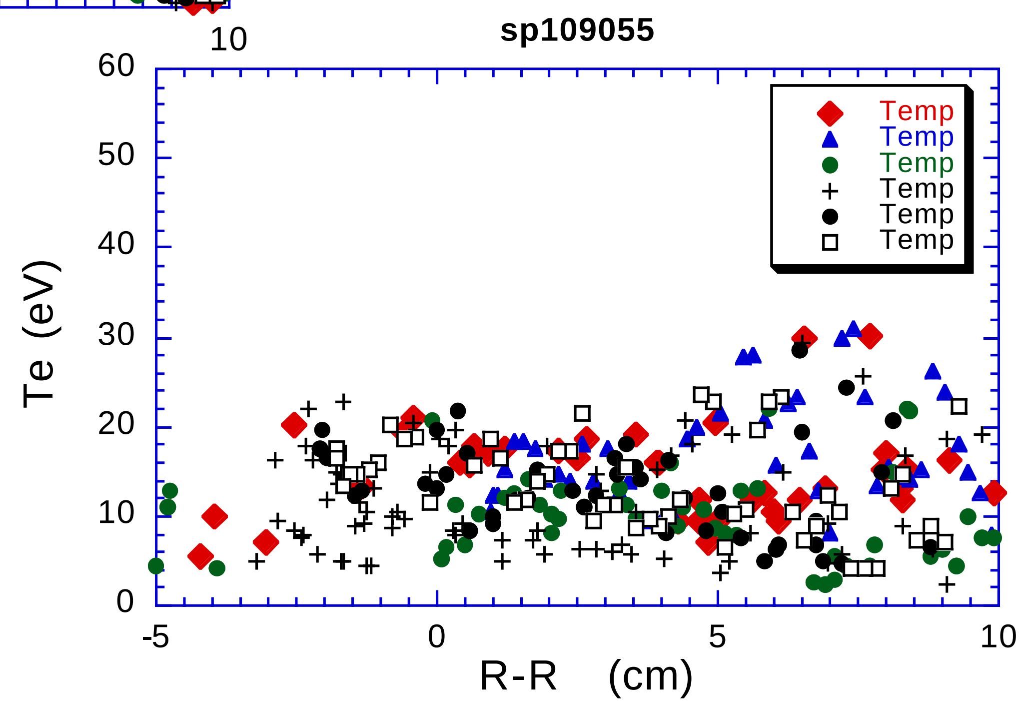
Results: Overview Edge Profile Characteristics



λ_n = 4 cm I.e. Quite long!

λ_T = flat!!



Ne at LCFS ~ 3-4 E12 cm-3

Te at LCFS ~ 20 eV !!

LSN Plasmas

Ne~1-2 E

109032-109062

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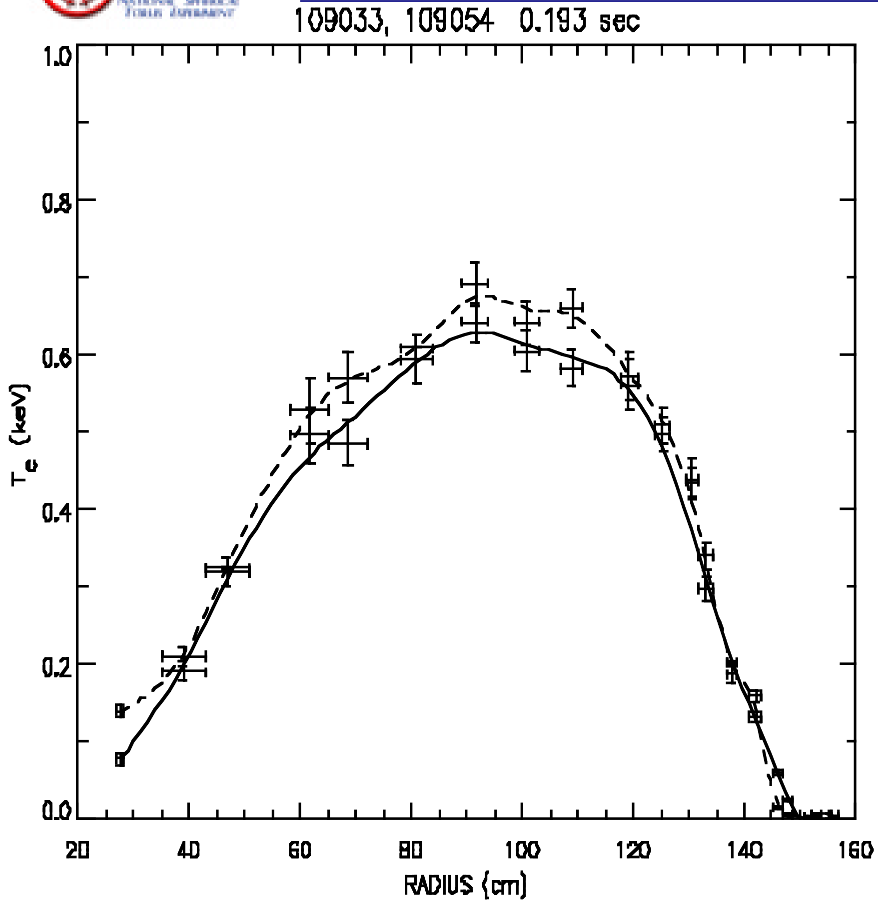
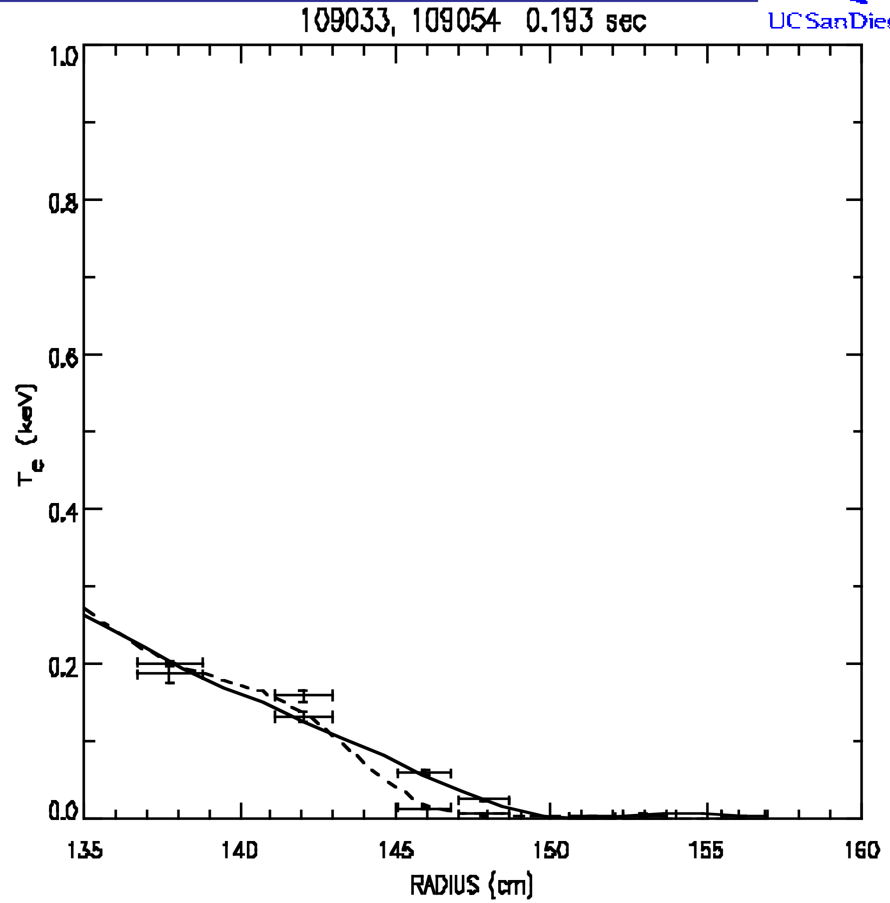
Te LCFS characteristics quite different from DIII-D





100 eV point seems to be located at R~144-145 cm

LCFS at ~150 cm

H-mode pedestal at R~144-145 cm

5cm inside nominal LCFS!!

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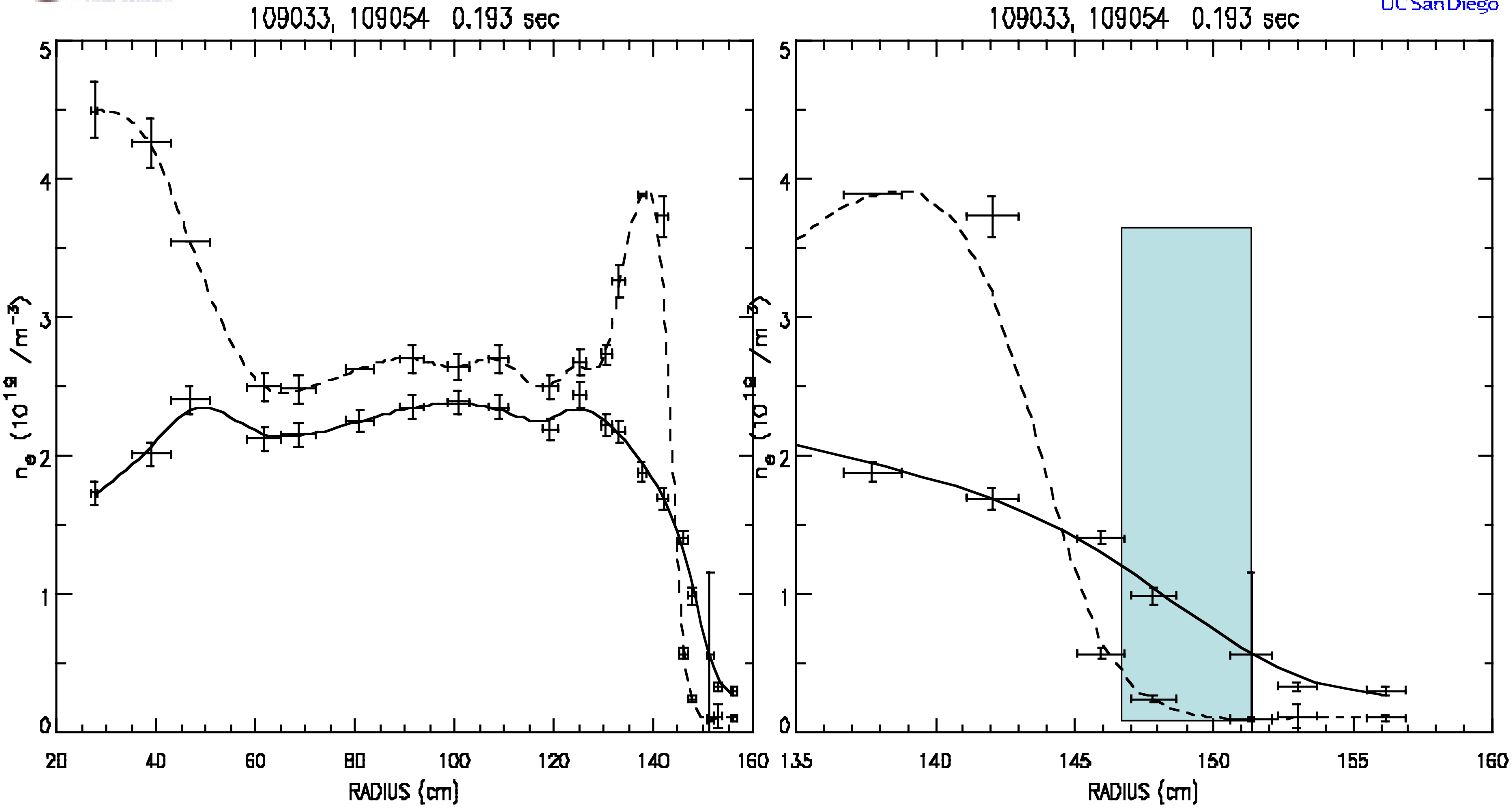
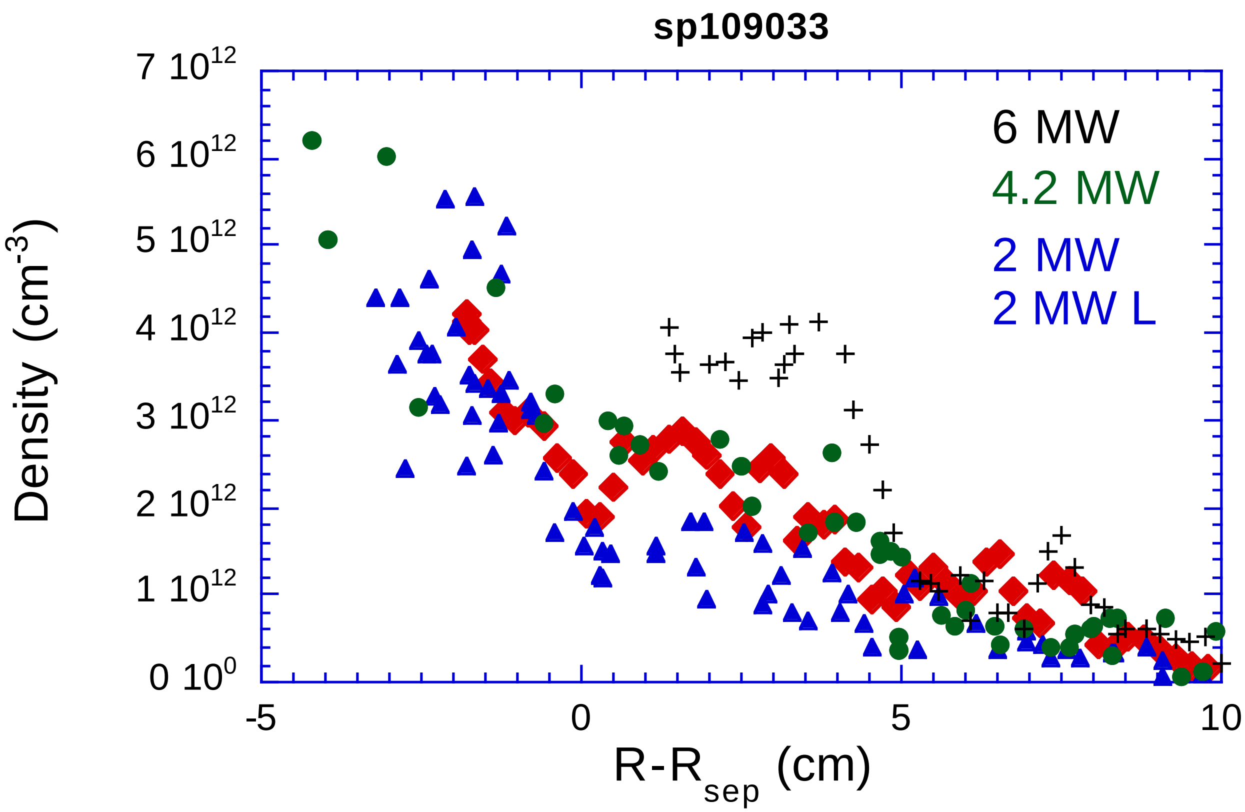
H-mode Ne pedestal Far Inside

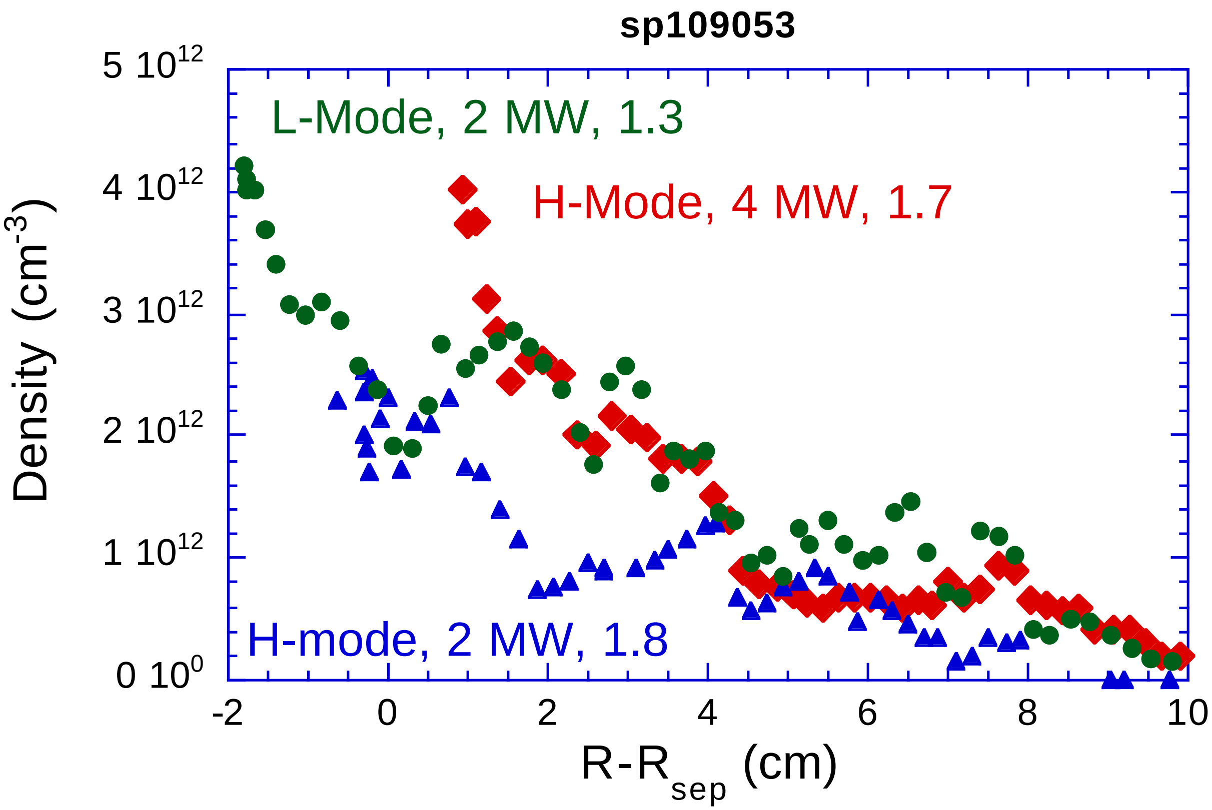


In agreement with probe data

Density Profiles: Decay Length Robust



- Except highest power case, no drastic difference in profile decay lengths (~4 cm) between various powers, at nearly same density



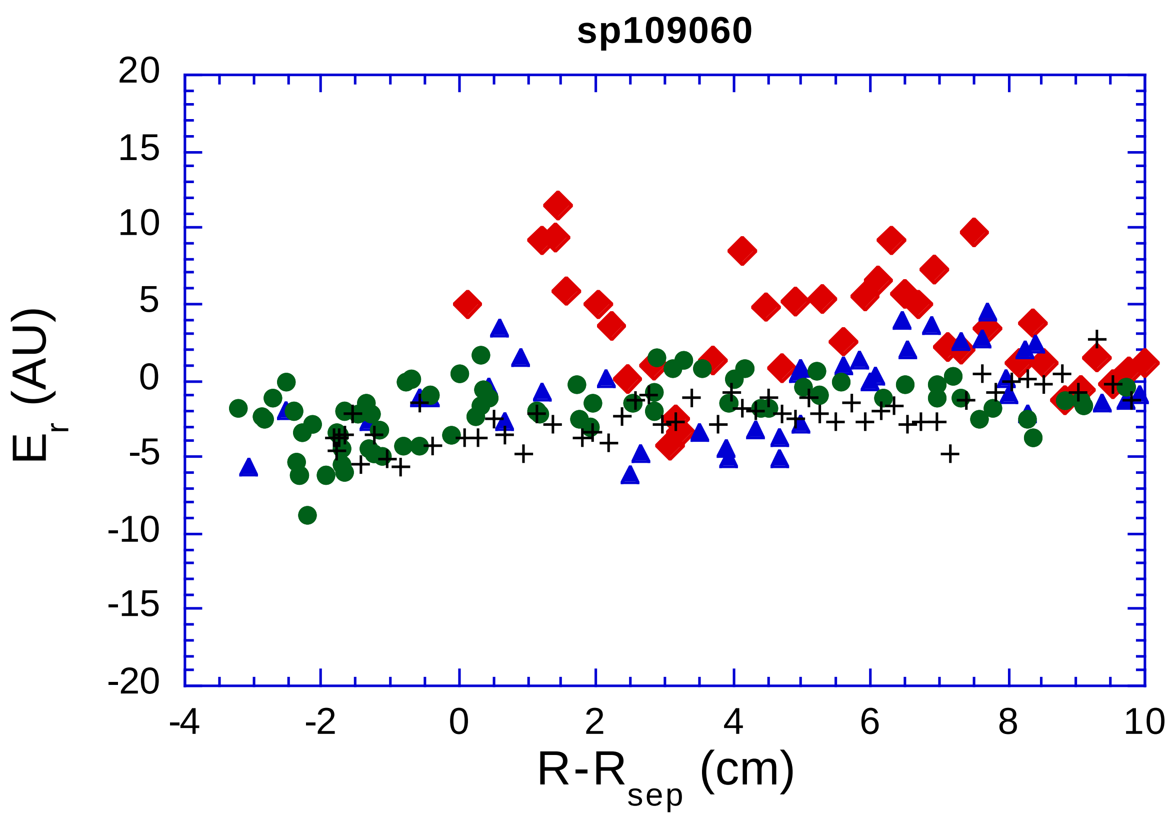
Within the limited shot space, density and power were varied. So scaling is inconclusive

So far:

λ_n decreases in H mode with power 4>2 cm

Will obtain wider operating space in the future and produce scalings

Potential Well Absent in Explored Radii



- Shear Layer NOT found within 4-5 cm inside nominal LCFS
- Transport barrier further inside or physics is quite different

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Profile Conclusions

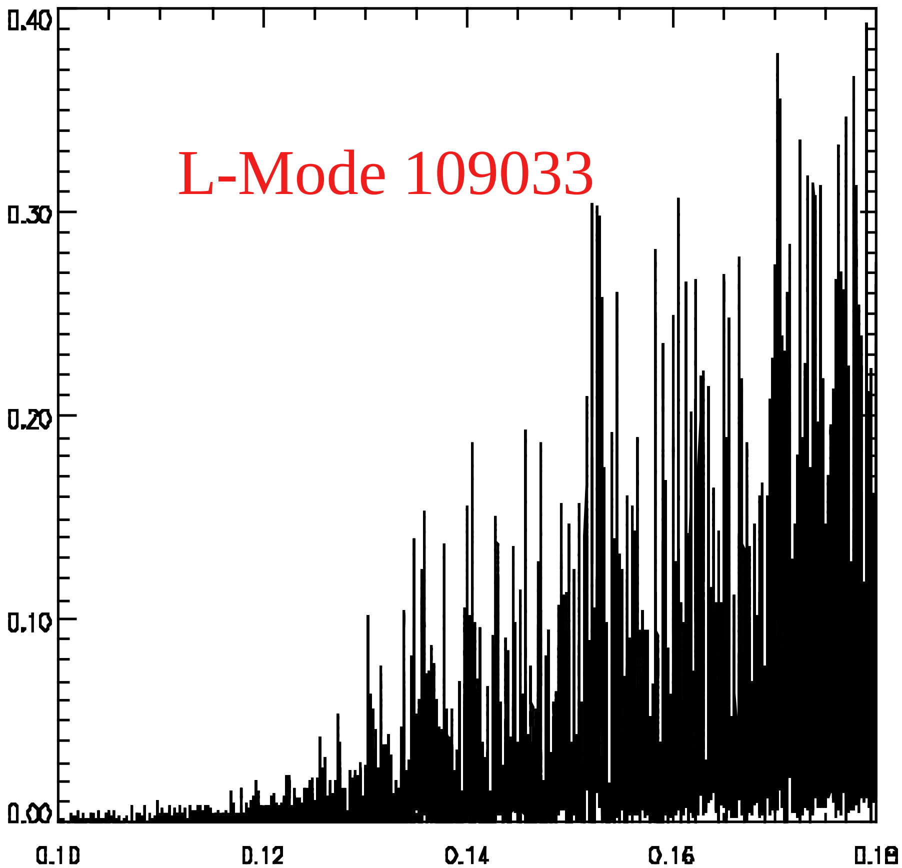
Edge/SOL profiles available with high spatial (2-2.5 mm) resolution
- Limited to 1086xx, 1089xx, 109032-109062
- Fully calibrated data for 109032-xxx062

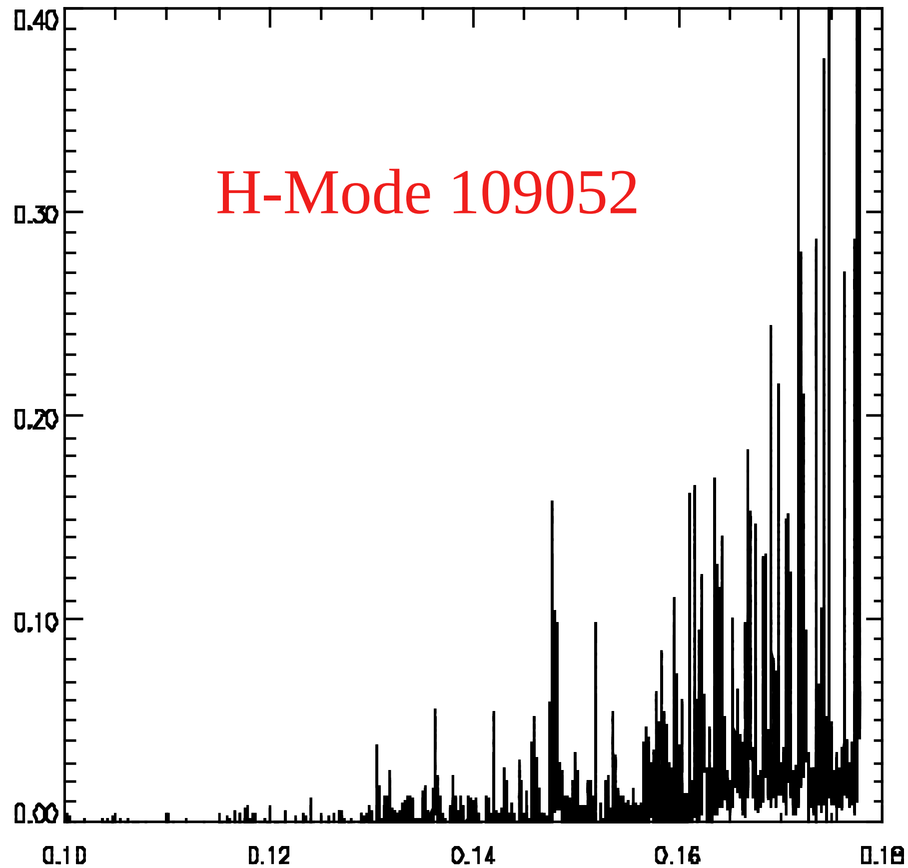
NSTX profiles seem different from larger aspect ratio devices
- Te profile in the edge/SOL is flat at low value
- Ne profile has a very long decay length
- Er profile does not show a potential well in H-mode shots

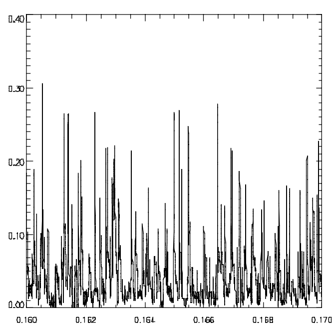
It looks as if the “traditional” edge is further inside
- Do we have a radiating boundary? MARFE?
- Is the LCFS where we think it is?

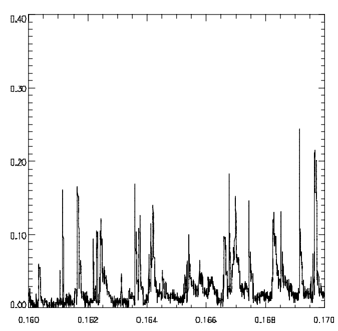
How do flat Te profiles are maintained?
- Do we have (more) anomalous radial transport? (intermittency)
- CAN’T quantify without fast Te measurement (need inc. funding)

Intermittency (Radial Convective Transport) Lower in H-Mode









Intermittency is very strong in NSTX!

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Future Work and Goals

System is fully calibrated and compares well with Thomson

Data obtained in L and H-mode. SOL length scales with power. Ongoing

Many puzzles need addressing

Features usually associated with the LCFS are not present in NSTX, such as a potential well, steep H-mode profiles, etc Ongoing

Intermittency is quite strong in NSTX (very strong radial transport?)

Need to quantify electrostatic turbulence and Intermittency (enough to explain strong transport?) Codes just ported!

Need to quantify electromagnetic components of transport

Upgraded head to be designed and built FY03 (funding on its way)

Relevant Physical Quantities

Particle Flux

$$\tilde{\mathbf{A}}_{\perp} = -\frac{\langle \tilde{n}\nabla\tilde{\phi}\rangle \times \overline{\mathbf{B}}}{B^2} - \frac{\overline{n}\langle \tilde{v}_{\parallel}\tilde{\mathbf{B}}\rangle}{\overline{B}}$$

Reynolds Stress (neglecting ion pressure fluctuations)

$$\vec{\mathbf{r}} = m\overline{n}\left\langle \left(-\frac{\nabla\tilde{\phi}\times\overline{\mathbf{B}}}{B^2}\right)\left(-\frac{\nabla\tilde{\phi}\times\overline{\mathbf{B}}}{B^2}\right)\right\rangle$$

Heat Flux

$$\tilde{\mathbf{Q}} \equiv \frac{3}{2}\left[\frac{\langle \tilde{p}\tilde{\mathbf{E}}\rangle \times \overline{\mathbf{B}}}{B^2} + \frac{\langle \tilde{q}_{\parallel}\tilde{\mathbf{B}}\rangle}{\overline{B}}\right]$$

Parallel Current Flux

$$\tilde{\mathbf{A}}_{J_{\parallel}} = -\frac{\langle \tilde{j}_{\parallel}\nabla\tilde{\phi}\rangle \times \overline{\mathbf{B}}}{B^2} + \frac{\langle \tilde{p}_{\parallel}\tilde{\mathbf{B}}_r\rangle}{\overline{B}}$$

Helicity Flux

$$\tilde{\mathbf{A}}_{K} = \langle \tilde{\phi}\tilde{\mathbf{B}}_{\perp}\rangle$$

New Issues

- Intermittency in the edge/SOL
- Reynolds Stress studies & turbulent energy cascade in 2-D Plasmas (Especially During L-H Transitions)
- Probe/gas puff imaging comparisons
- Finite Beta effects on transport
  - Coupling between density and magnetic fluctuations (ala Drift-Alfven waves)
  - Magnetic Reynolds Stress v. Electrostatic Reynolds Stress