Further LP Analysis for Cryopump Calculations:
Electron temperature in the far-SOL and Particle flux scaling with Ip

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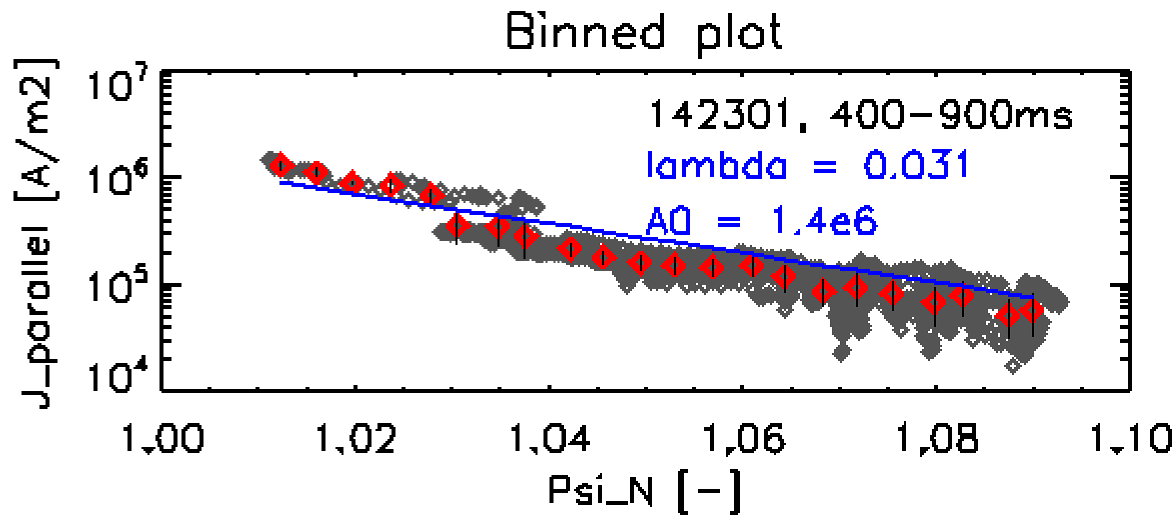
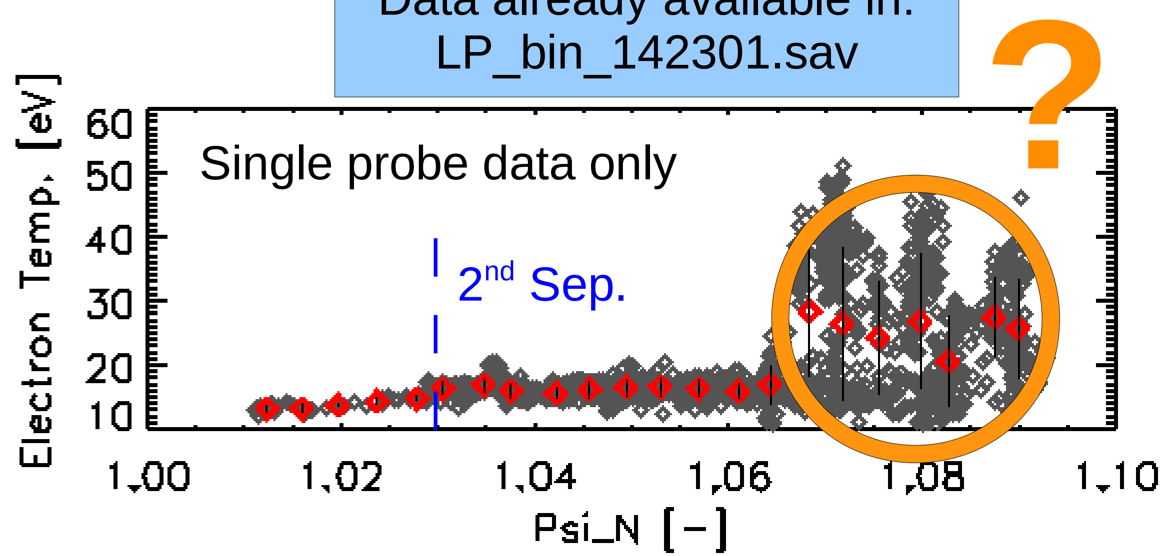
Question: What is correct Te on "model" cryo shot 142301?

- Single probe analysis sent previously contains T_e array data
  - Te calculated from classical interpretation
  - This typically **over-estimates** Te if non-Maxwellian populations are present
  - Classical interpretation may be ok in low density regions
- Shows large scatter after PsiN~1.065
  - Are these T_e calculations real?

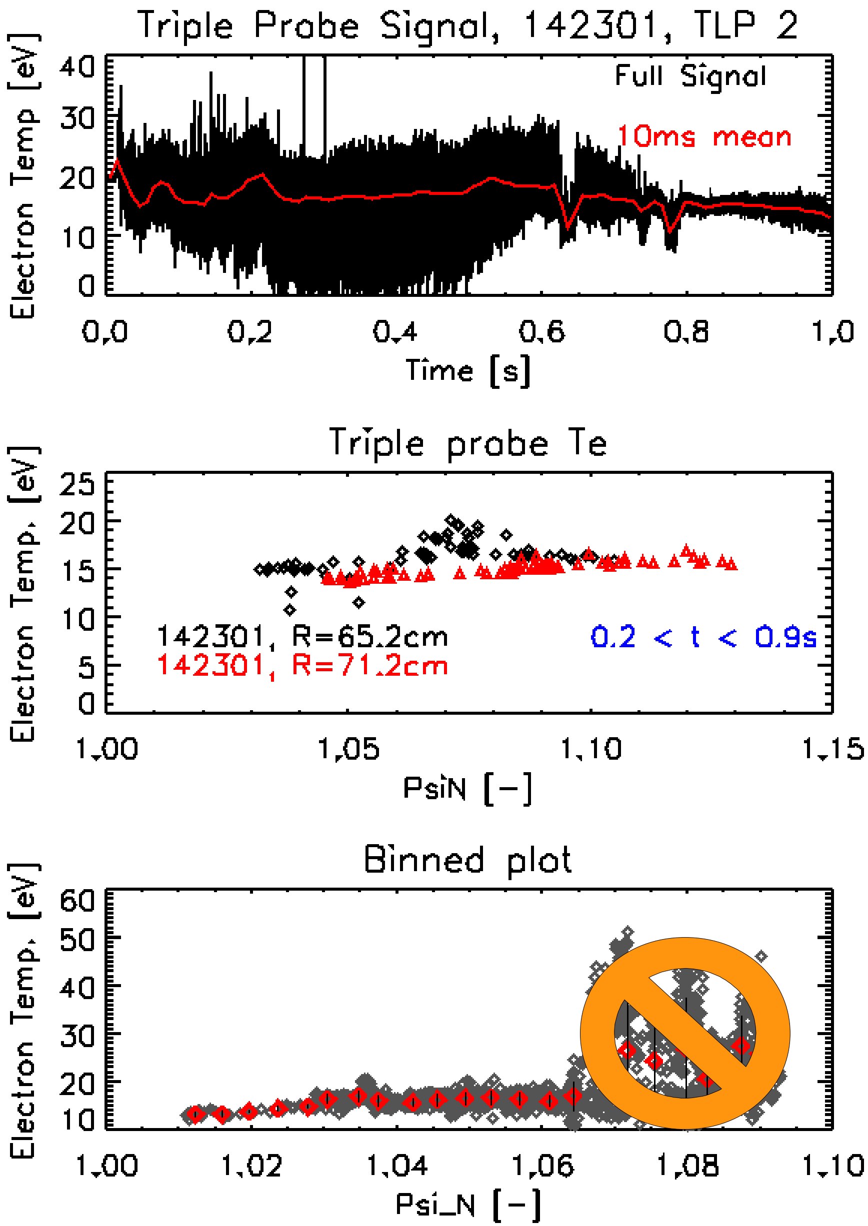


Data already available in:
LP_bin_142301.sav



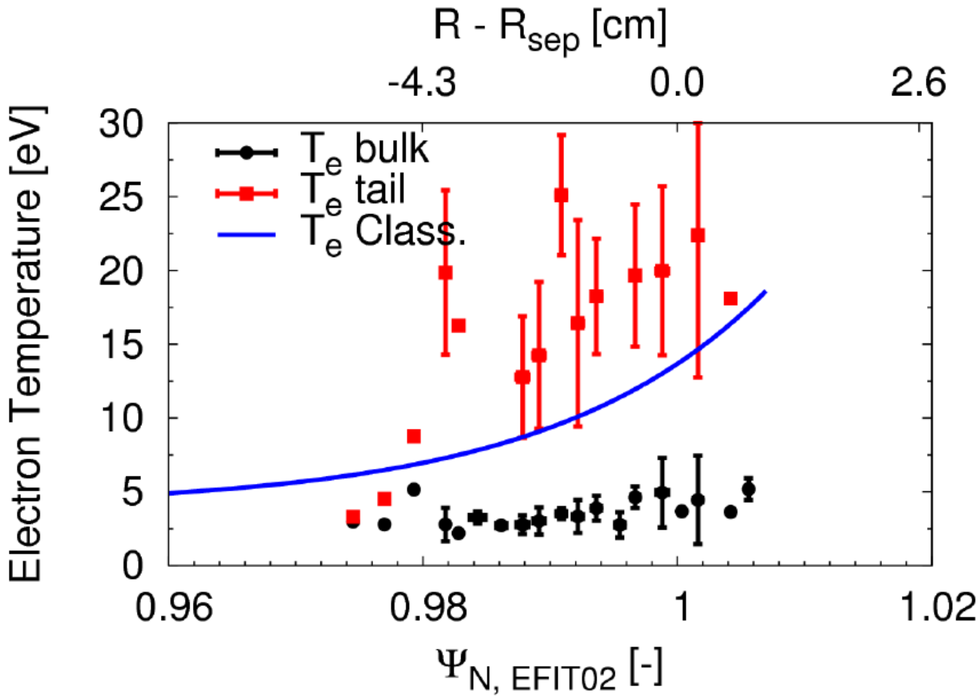
Estimate for classical Te is ~15eV for the far-SOL

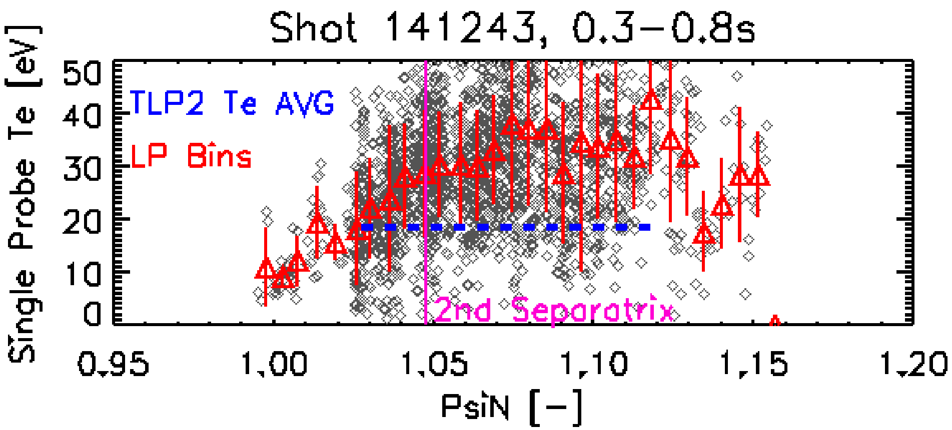
- Triple probe Te indicates flat profile at 15eV from 1.04<PsiN<1.13
- Corresponds to single probe Te in non-turbulent portion of discharge
  - Large scatter in single probe data beyond PsiN~1.065 is probably due to fluctuations
- Still based on classical interpretation, but should provide upper-bound for simulations
- Jpara calculation not as affected as Te, can use previous relation
- Consistent with J. Canik calculations reported to date



Temperature near the strike-point not flat as in far-SOL

- Analysis of LLD discharges indicated temperature increase moving outboard of strike-point (from 2-5eV for the data range obtained here)
- Similar temperature rise exhibited in XP1043 discharges (at least, comparing classical analyses)

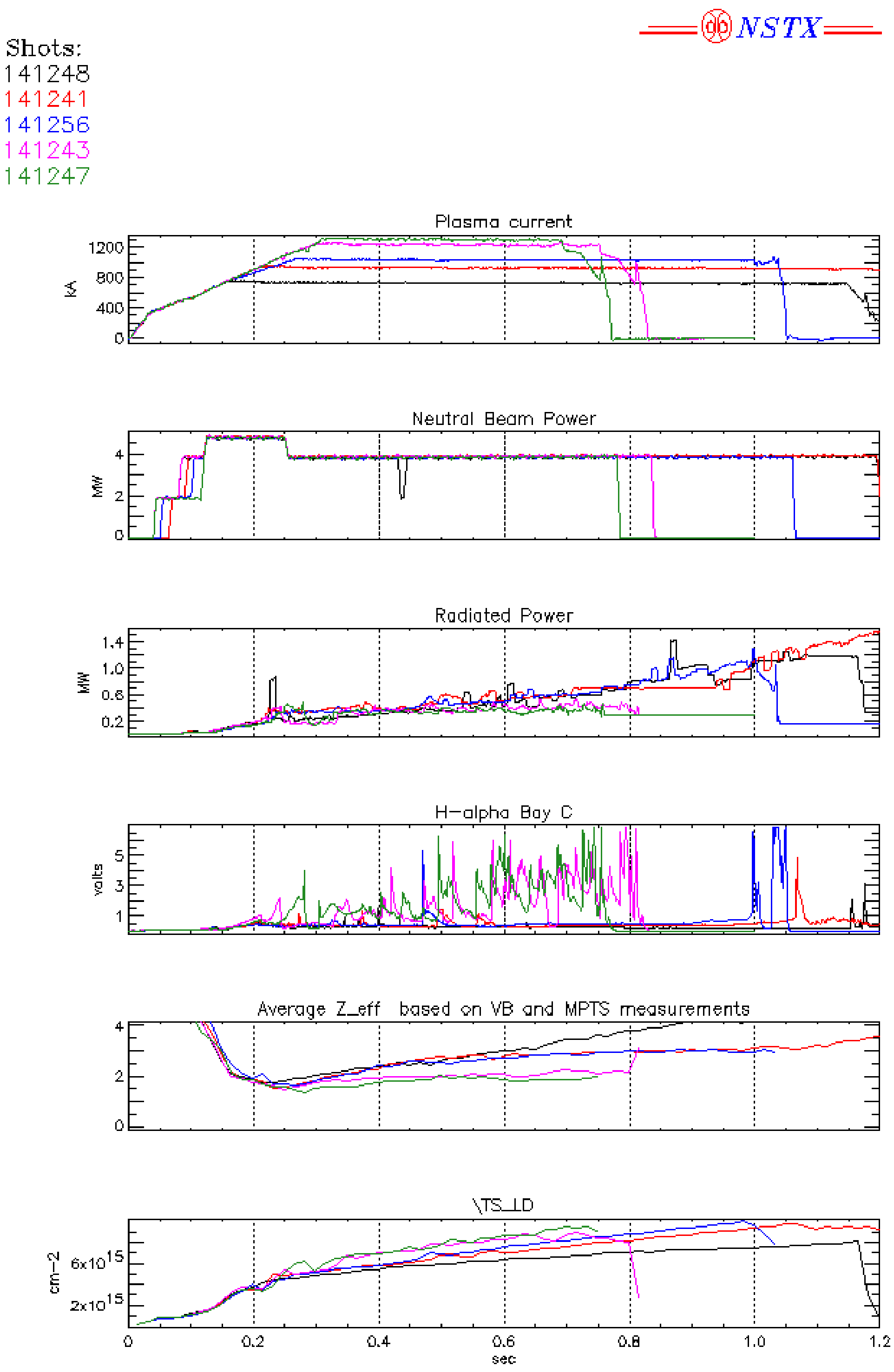




Particle Flux Scaling with Ip

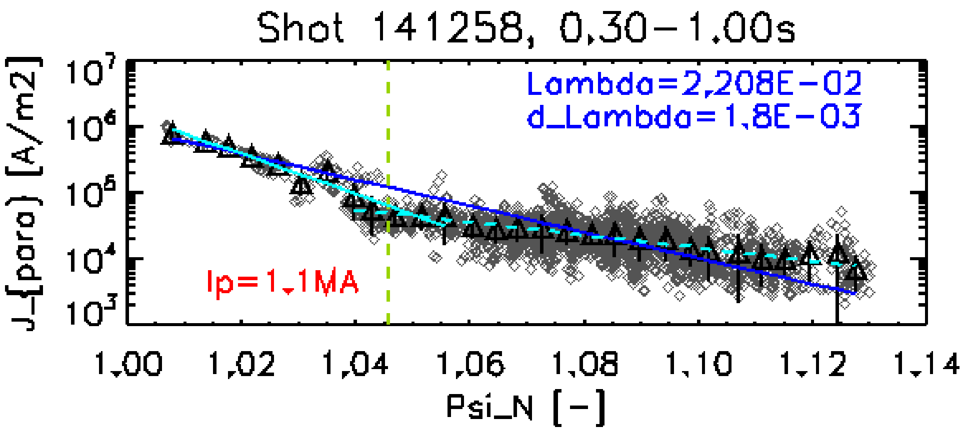
Typical shot parameters

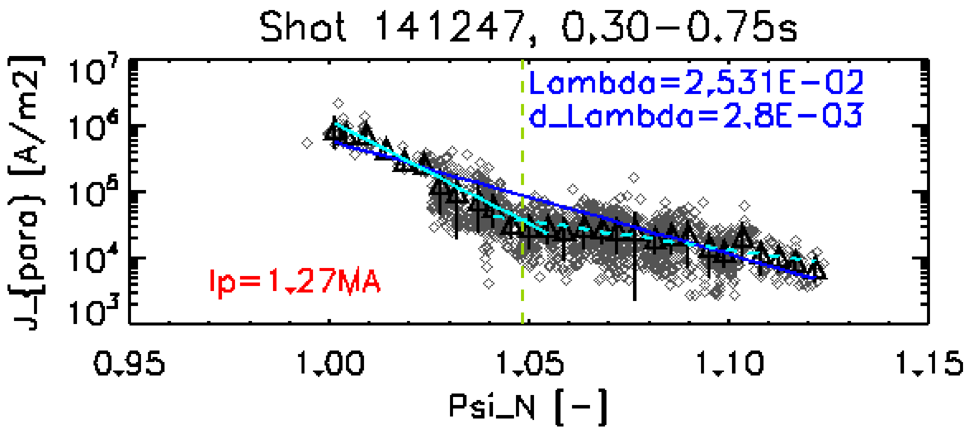
- Set of shots taken from XP1043 (Ip scan)
- High-triangularity discharges
- Particle profile obtained during “natural” strike-point motion during discharge
- Useful time period determined by flat-top time
- dr-sep ~ -0.01



LP-based particle flux analysis

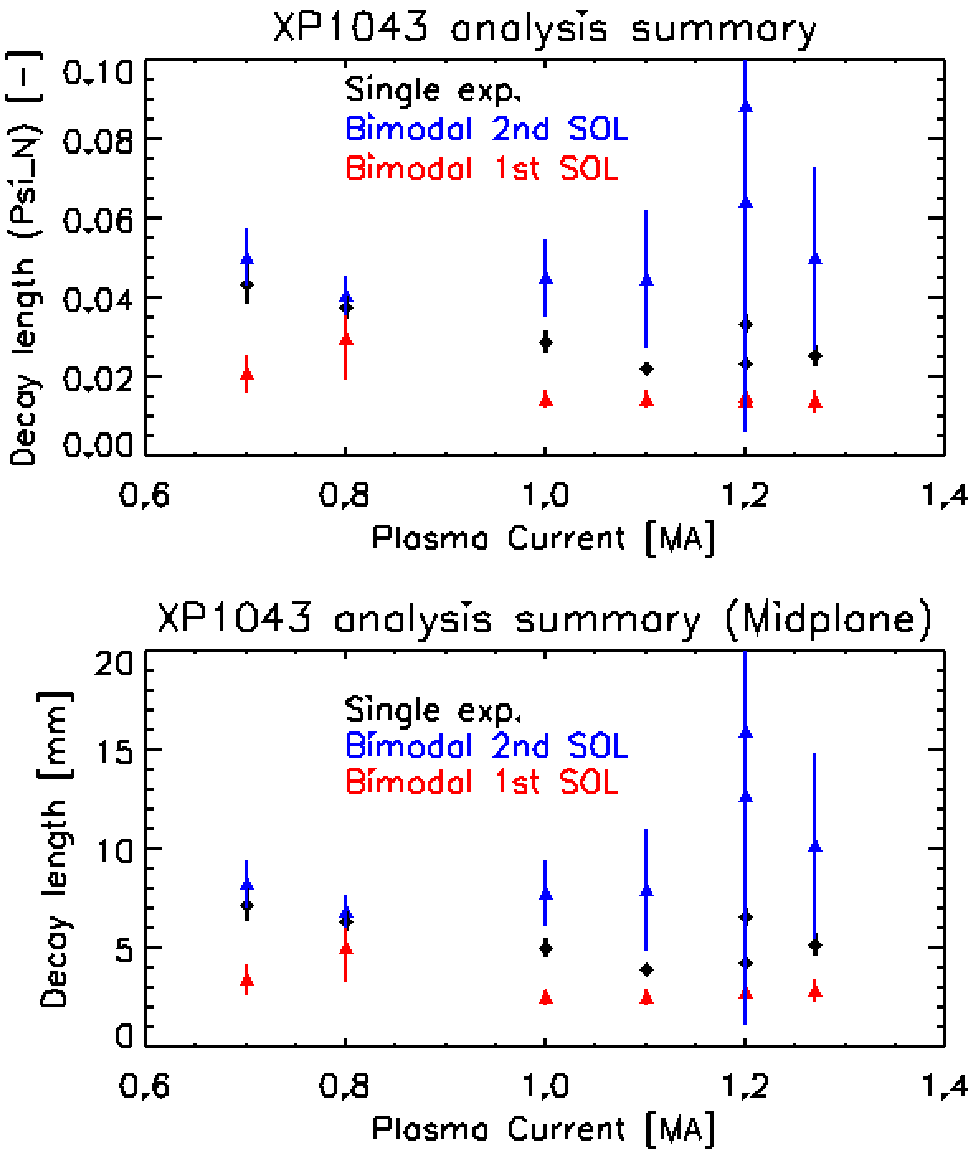
- Parallel particle flux extracted from all available probes and aggregated (gray pts.)
- Binned and averaged (black pts. with std. dev.)
- Exponential fit applied
  - SOL profile suggesting bi-modal profile
  - For now, break in profile defined by EFIT 2nd Xpt PsiN location





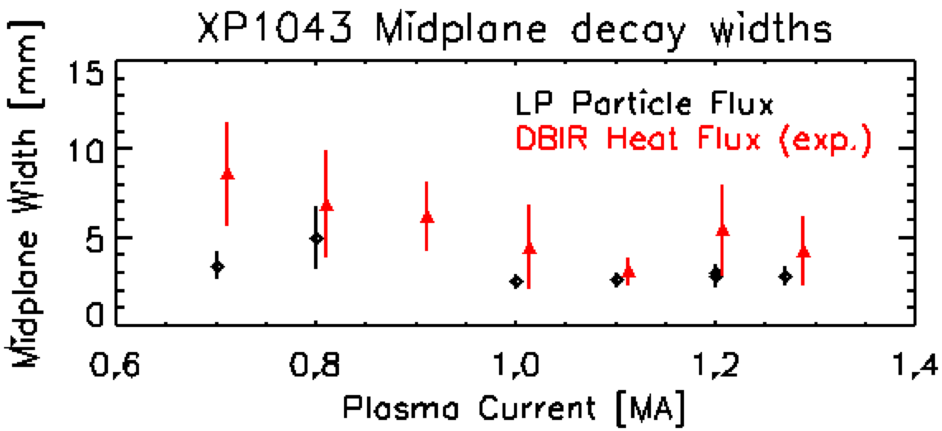
Different decay length behavior between near- and far-SOL

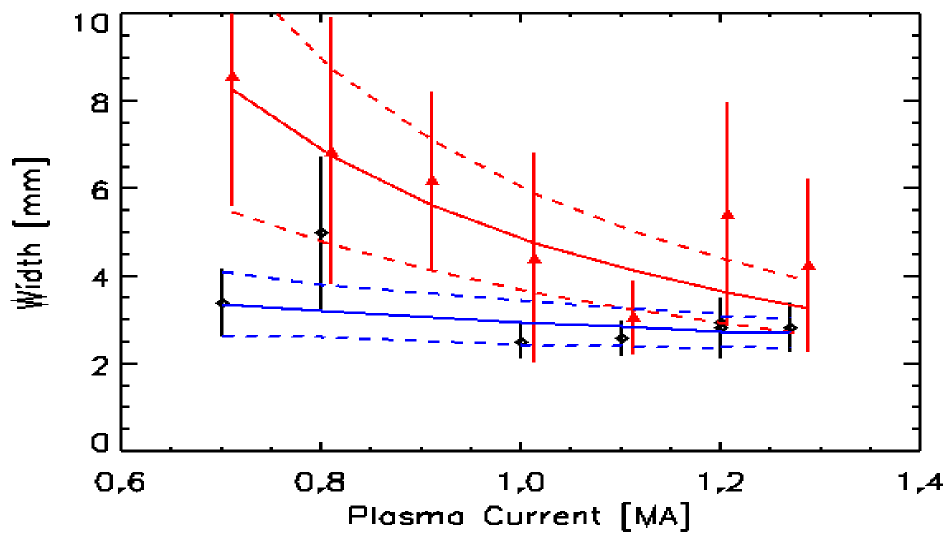
- Fits performed in Psi_N coordinates
- Mapping to mid-plane provides comparison with IR heat flux widths
- Obtain typical values of 2-5mm for the primary SOL
- Secondary SOL decay length seems to **grow** with Ip
- Long “tail” often observed in IR measurements – probe indicates actual particle flux involved, not purely radiative heating of PFCs



Power law indicates inverse square-root dependence on Ip (or weaker)

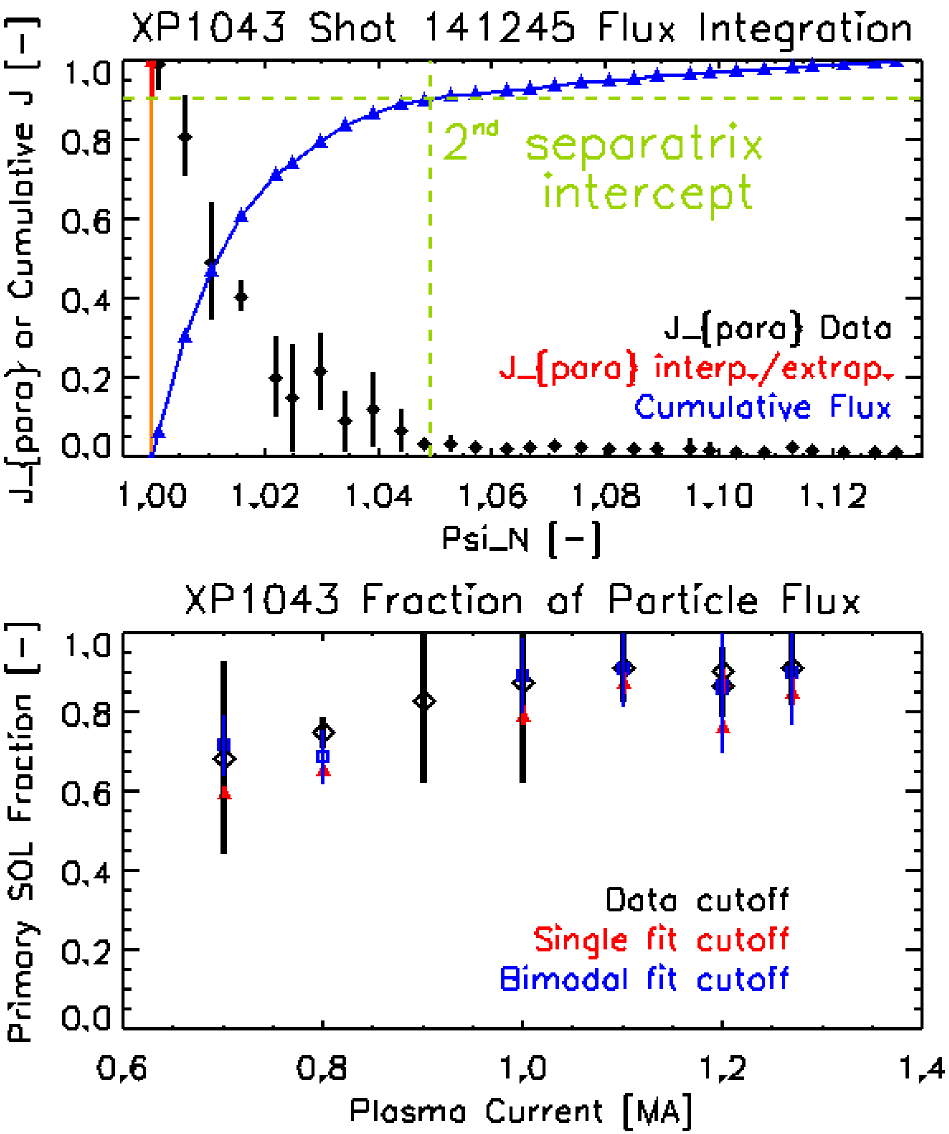
- At low-Ip, particle flux is narrower than shot-averaged heat flux width, possibly converging at high-Ip
  - Variation in IR data over entire shot (std. dev. shown)
- Power-law fit applied to primary SOL data
  - b~(-0.4) with -0.2>b>-0.5 confidence interval
  - Converging toward same answer at higher Ip (~1.7-2.3mm at 2MA)
- Comparing 150mg Li only





Most of the SOL particle flux is located close to the separatrix

- Integrate entire flux captured by the probe array to get a sense of the fraction contained in the 1st or 2nd SOL
  - If no data available right at Psi_N=1.0, interpolation or extrapolation used
  - Extrapolations are given large uncertainty for a conservative estimate
  - Multiple calculation methods used with similar results
- For Ip>1MA, roughly 90% of the SOL flux is in the primary SOL



Discussion of Results

- Flat Te profile in far-SOL is consistent with analysis already presented by J. Canik to date
- Te near the strike-point, however, is not flat (decreases near S.P.)
- For a given heat flux profile (q), lowering T increases particle flux
- Exacerbates localization of **particle flux** at the strike-point
- SOLPS runs should probably include variable Te near the strike-point
- Fate of recycled particles *at strike-point* (and inboard) requires 2D fluid analysis

$$q(x) \propto n_e(x) T_e(x)^{3/2} \propto A e^{-x/\lambda}$$

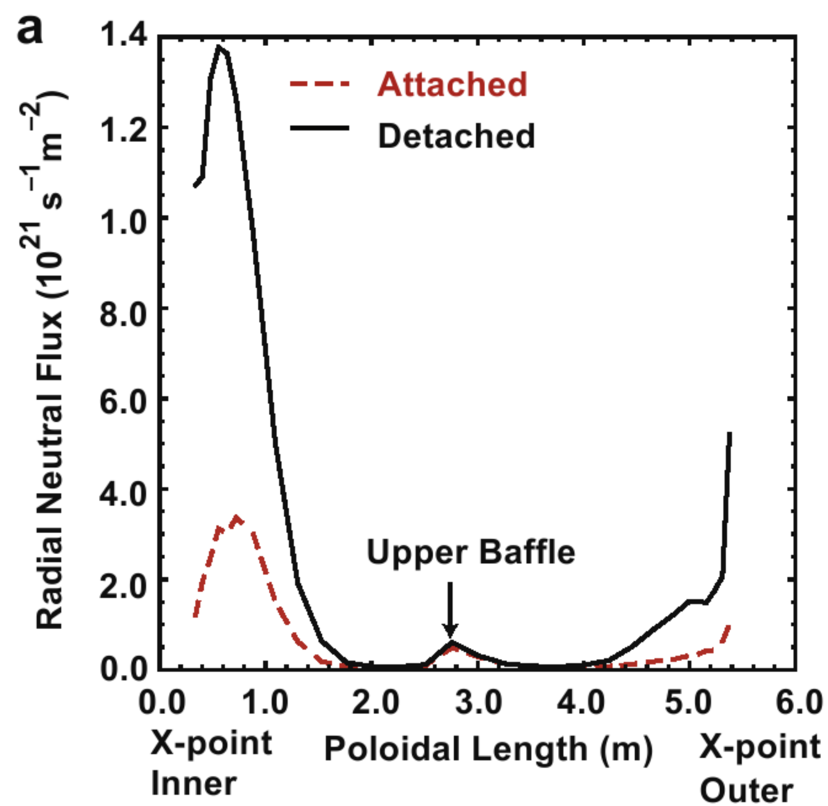
$$\Gamma(x) \propto n_e(x) T_e(x)^{1/2}$$

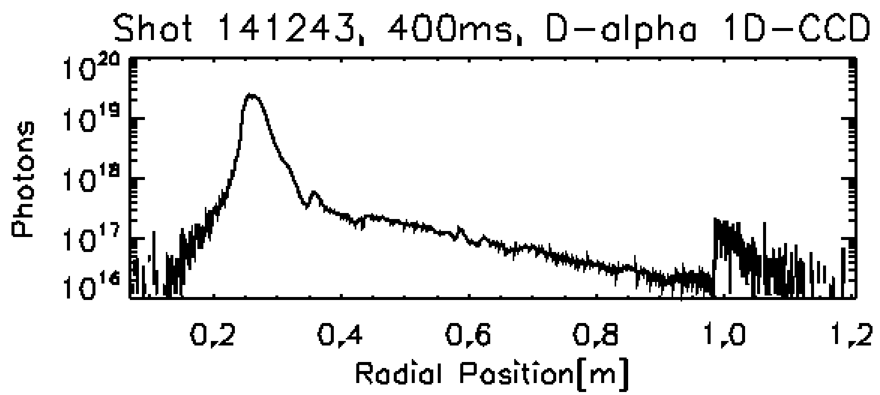
$$1 = \frac{q_1(x)}{q_2(x)} \propto \frac{[\Gamma_1(x) T_{e,1}(x)]}{[\Gamma_1(x) T_{e,2}(x)]}$$

$$\frac{\Gamma_1}{\Gamma_2} \propto \frac{T_{e,2}}{T_{e,1}} \ at\ constant\ q$$

DIII-D Fueling and NSTX D-alpha

- Leonard 2009 PSI result of UEDGE-DEGAS2 interpretative modeling figure shown at right
  - Indicates most of the pedestal fueling is from the *inboard* side
  - Pedestal fueling even more dominated by inboard when it is detached
- D-alpha profile in NSTX indicates large emission from inboard and X-point
- If both machines have similar poloidal fueling, then cryo implementation may work despite potential inboard fueling dominance



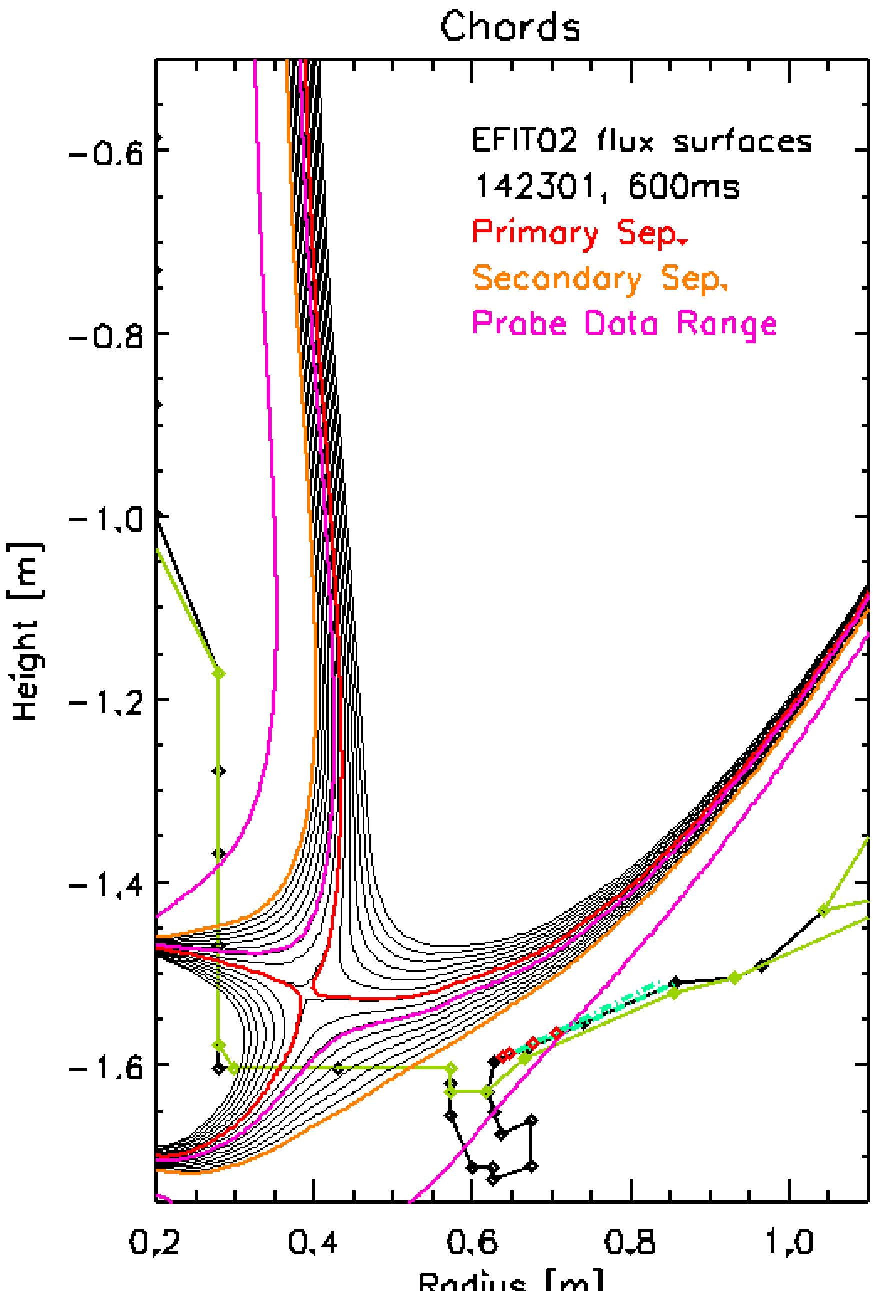


Comparison with DIII-D poloidal fueling profile provides confidence in cryo-pump scoping studies

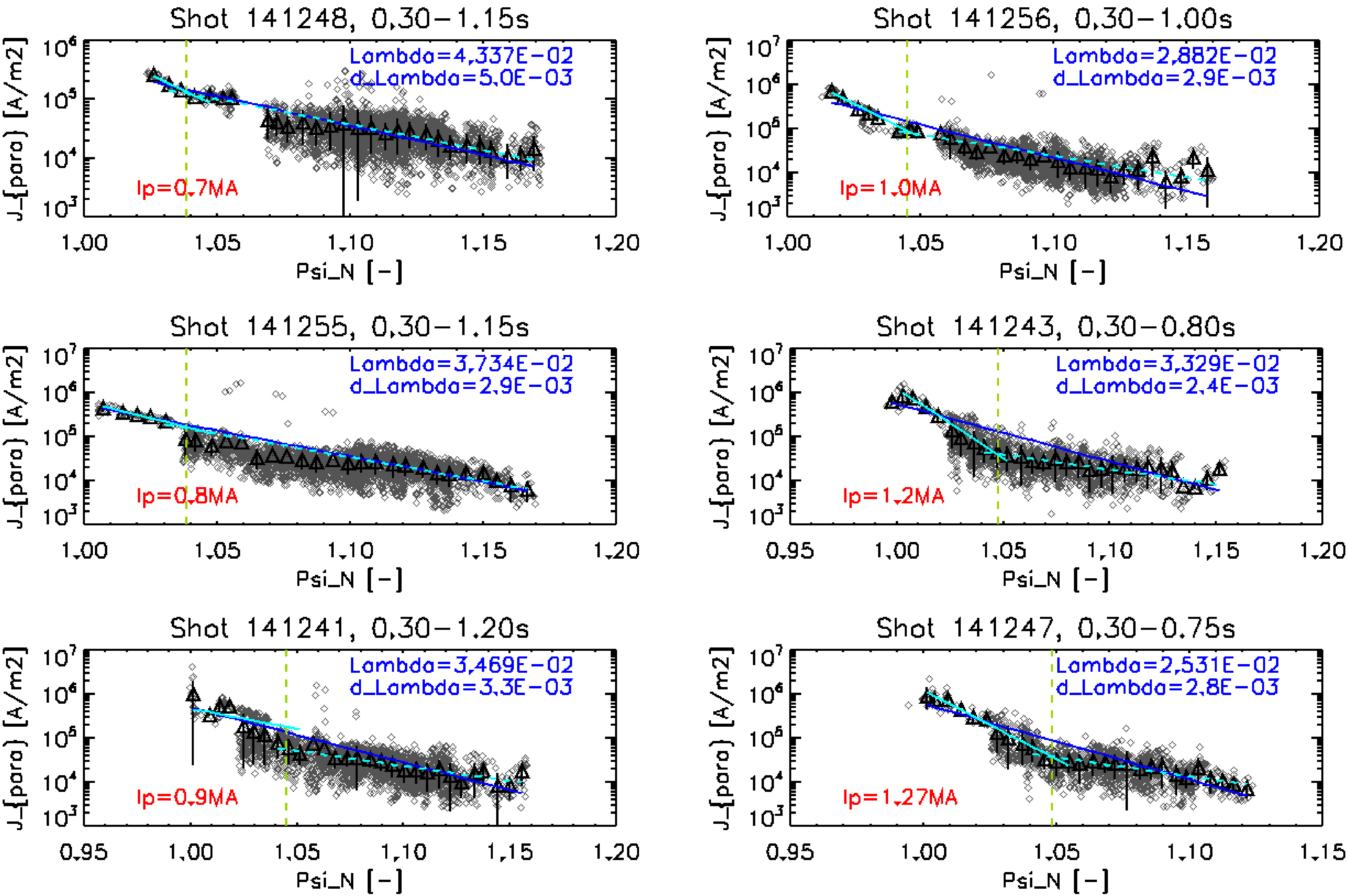
- May be possible to constrain an OEDGE solution with available data
- Seems the D-alpha 1D-CCD array inboard strike-point not saturated for at least some of the XP 1043 shots
- Have probe data for outboard strike point and some (not much) data on the inboard
- Would provide a model solution in NSTX discharges for comparison to NSTX-U simulations (OEDGE/SOLPS/UEDGE comparison)

End

Flux surface locations reference

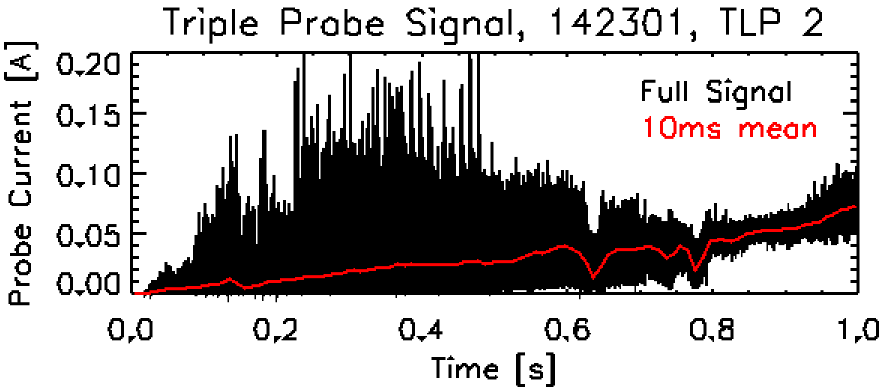


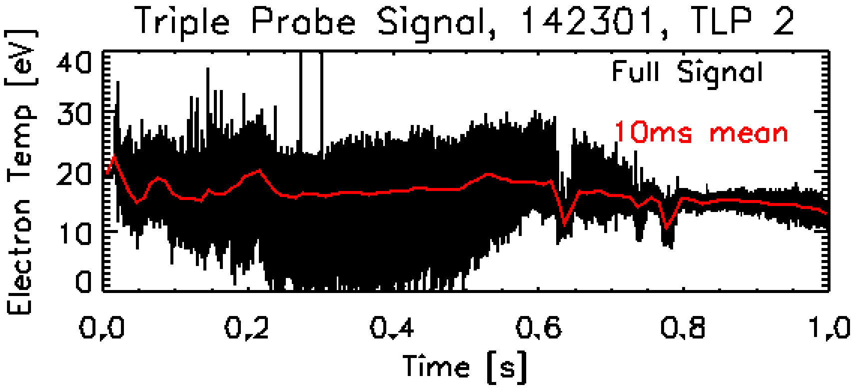
Data Fits (1.1MA on slide 3)



Turbulence is common problem for single probe interpretation

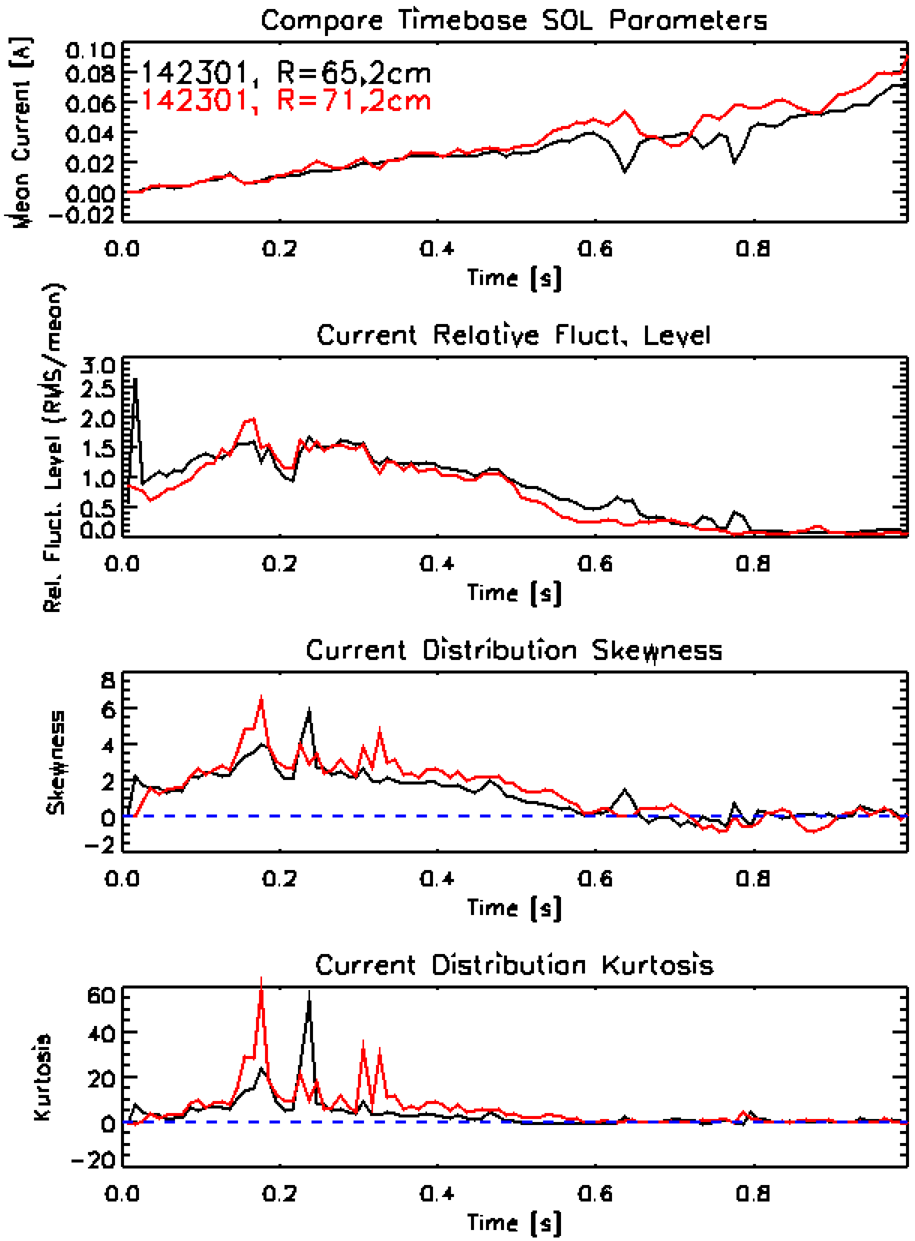
- Triple probes utilize constant bias to capture transients
  - Provide equivalent Te calculation as classical analysis
  - See Jaworski, RSI, 2010 for more detail
- Strong fluctuations seen on probes for this discharge (probe at 66cm)
  - Fluctuations decrease to smaller levels after 0.6s
  - Is this intrinsic to plasma or temporal evolution?





Comparison of two probes shows similar evolution in time

- Two TLPs compared at different radii
  - Fluctuations analyzed within 10ms moving window
  - RMS, skew, kurtosis calculated for all data within 10ms window (2500 data points ea.)
- Similar evolution found for both locations



Comparison on magnetic surfaces indicates temporal effect, not position

- PsiN calculated for both probes from EFIT02
- Change in relative fluctuation level is shifted for both probes
  - Indicates it occurs at the same time, as opposed to same magnetic surface
- D-alpha filterscope seems also to show change in temporal characteristics
  - Fluctuations strong around 0.4s
  - Similar to behavior seen on TLPs