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Edge Characterization Experiment

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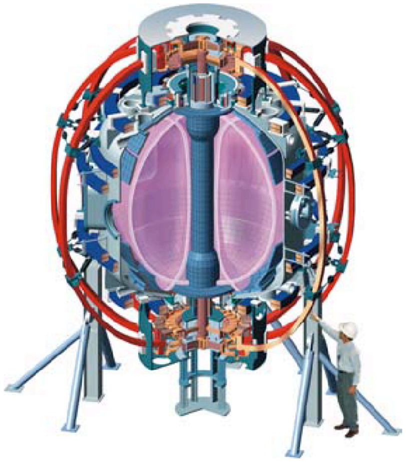
for the Boundary Physics Group



NSTX Research Results Review
Princeton Plasma Physics Laboratory
Princeton, NJ
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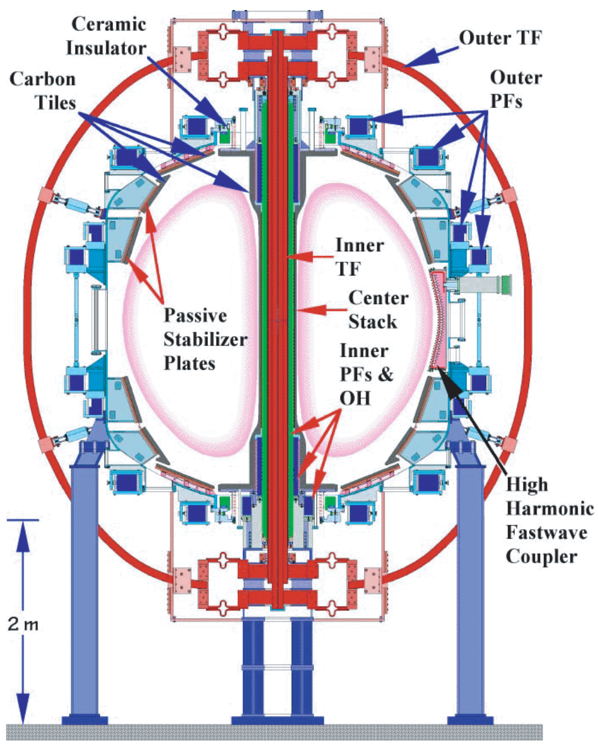
Edge Characterization Experiment

A first systematic survey of the dependence of the edge conditions on heating power, shape, and density was conducted in NSTX. The approach taken was to use newly installed diagnostics:

- *4-channel divertor bolometer array*
- *divertor infrared camera*
- *spatially resolved divertor*
- *D_α camera*
- *edge reciprocating probe.*

Changes were made in the plasma operating conditions that induced changes the plasma edge characteristics, core fueling, impurity transport, and the power flow to the divertor To date, the different edge conditions were observed by inducing a L-mode to H-mode comparison, changing the divertor configuration [lower single null (LSN) vs double-null (DND)] and conducting a NBI power scan in H-mode.

Good diagnostic access to NSTX, a spherical tokamak



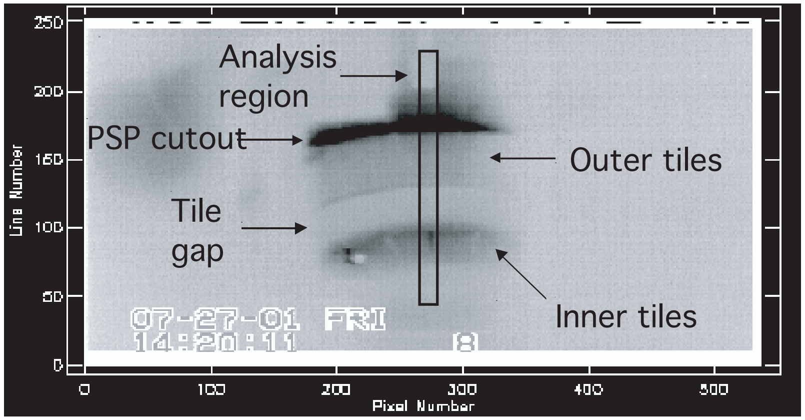
- *Open divertor configuration*
- *Allows viewing from midplane and between plate structures*

IRTV camera installed on NSTX

measures the rise in tile surface temperature from which the heat flux is derived.

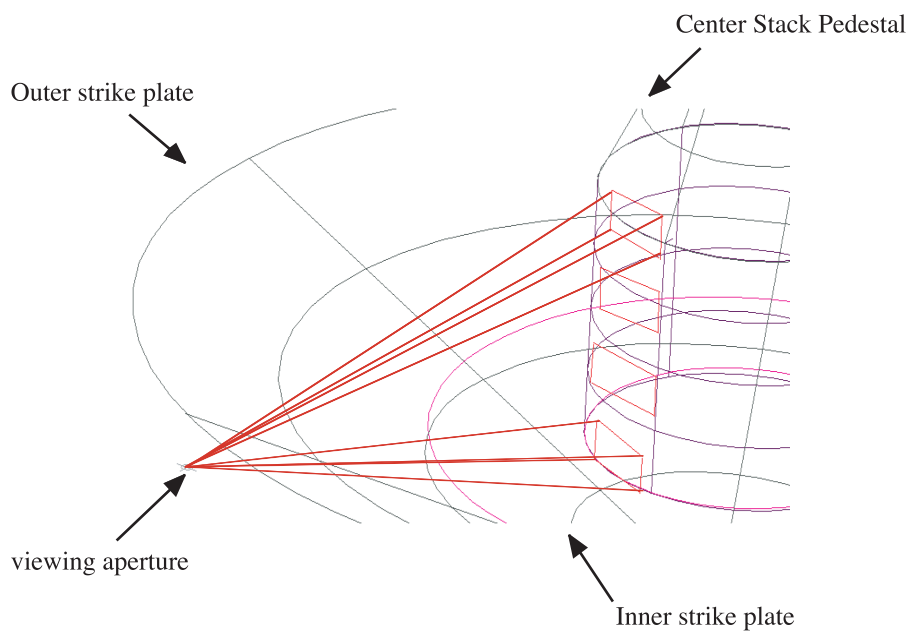
IR camera view allows radial profile measurements

IR camera: 7-13 mm range, 30 Hz,
25ms thermal e-folding time,



IR intensity
(inv.)

4 channel divertor bolometer array installed on NSTX

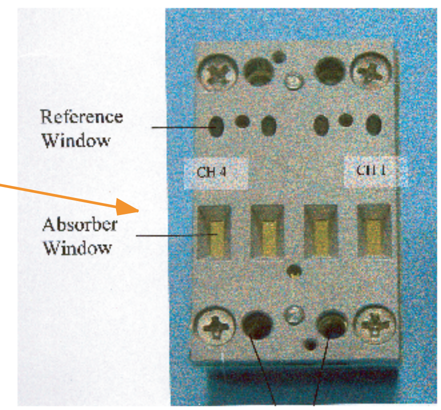


viewing chords 3D view

- *Prototype for 12-16 channel system; similar to that used on JT-60 and ASDEX.*
- *4 μm gold foil on 20 μm mica substrate, able to tolerate 160°C*
- *Cooling time constant is .15 sec, both a direct heat sensor and an integrator*
- *Array is water cooled to prevent overheating during bakeout; normal operation is at room temperature*
- *Highly sensitive -- 1 mW/cm^2 noise limit, measured 1,000 mW /cm^2 on NSTX, but noise pickup is quite high -- grounding reworked for previous run*

Bolometer has gold foil face, reflects above .5 μm

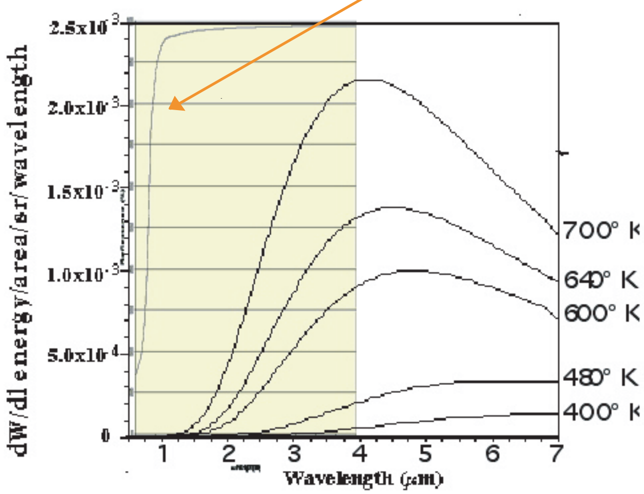
Divertor bolometer sensor



Gold foil sensors

Tile blackbody radiation > 1 μm

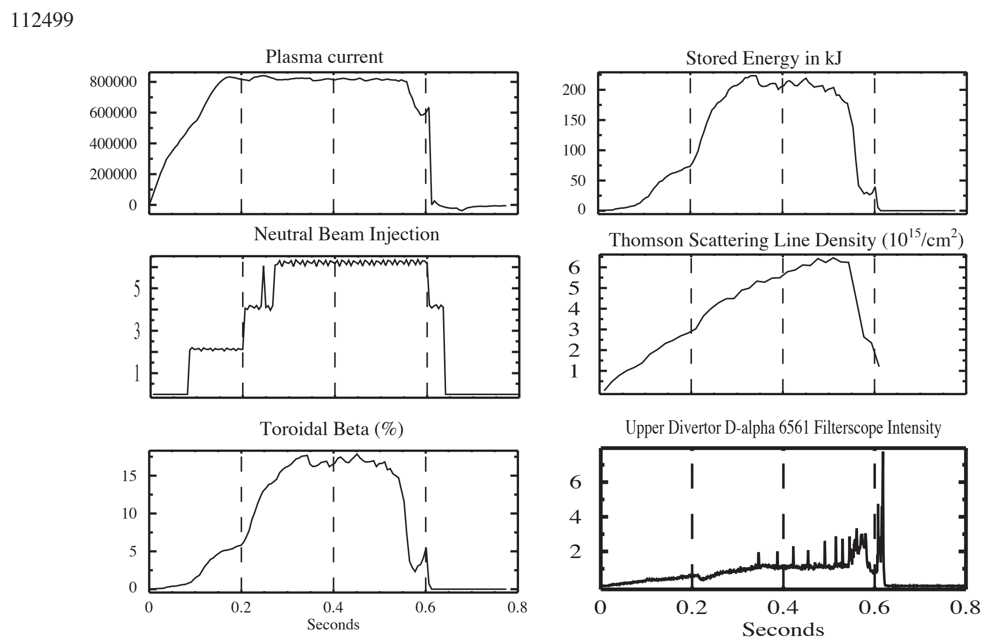
Reflectivity of polished gold



- *All the IR emitted from the tiles is above 1 micron*
- *The emission is reflected by the gold foil, so the tile is considered to be entirely reflected*

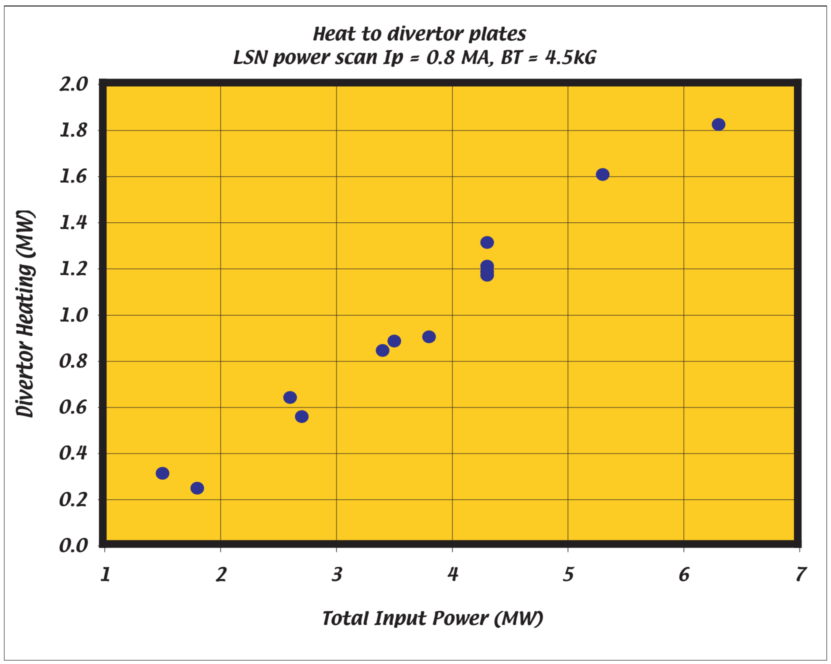
Power Scan Performed in H-mode

NSTX

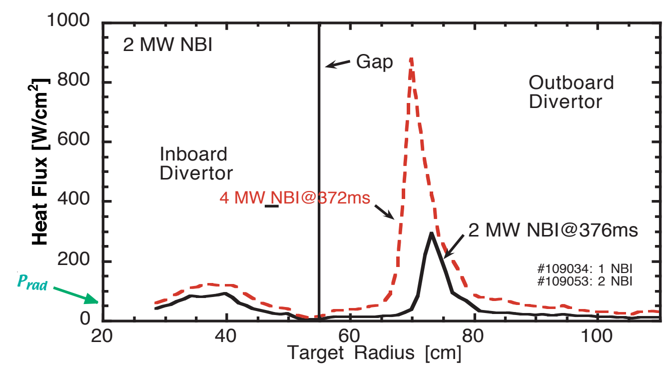


- H-mode is most common NSTX operation
- Shots at Ip = 0.8 MA, free of giant ELM's
- Magnetic field at 4.5 kG to avoid limits
- Between shot GDC for density control
- H-mode transitions reproducible at .22 s
- H-mode duration typically .15 - .2 s

Heat Flow to the Divertor Plates

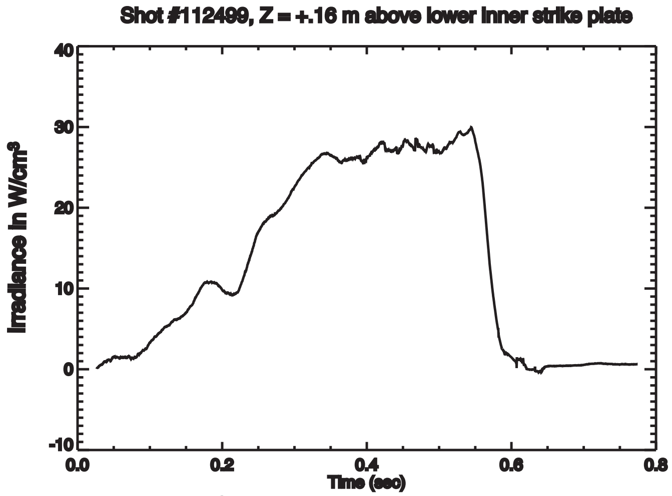


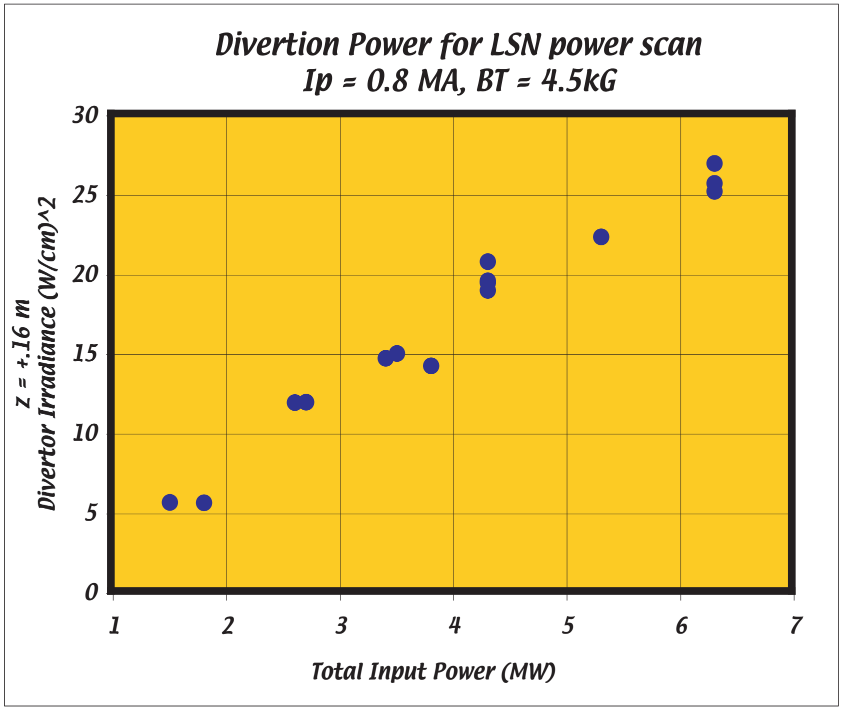
- Primary heat loss mechanism, heat on divertor plates scales linearly with input power
- Ratio of outer to inner heat flow is about 1:3



- Previous power scans showed strong outboard heating
- For newer scans, heat flux is down by about 25%

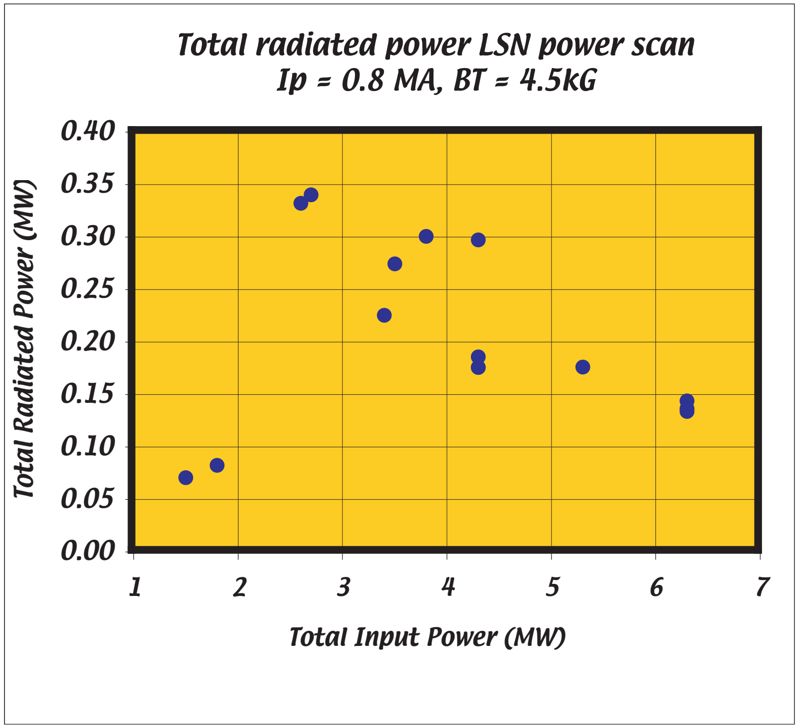
Radiated Power from the Divertor

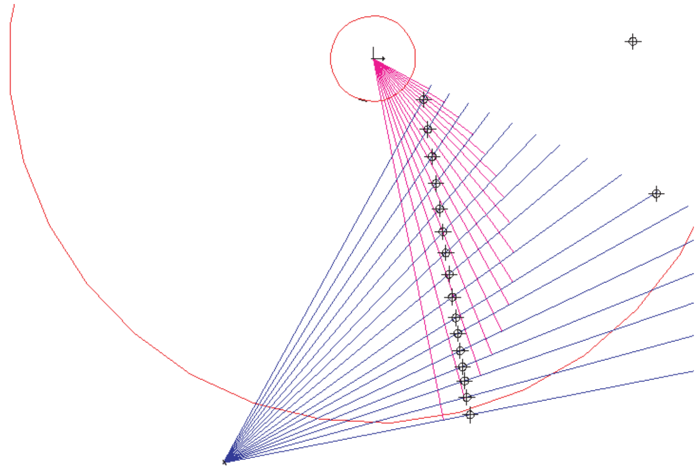




- *20 W/cm^2 is about 25% of the heat flux to the inner divertor plate*
- *It is 20 times less than the heat flux to the outer divertor plate*
- *To obtain a radiated power from the divertor, emission was assumed to originate at the outer strike plate at R = 0.65 m*

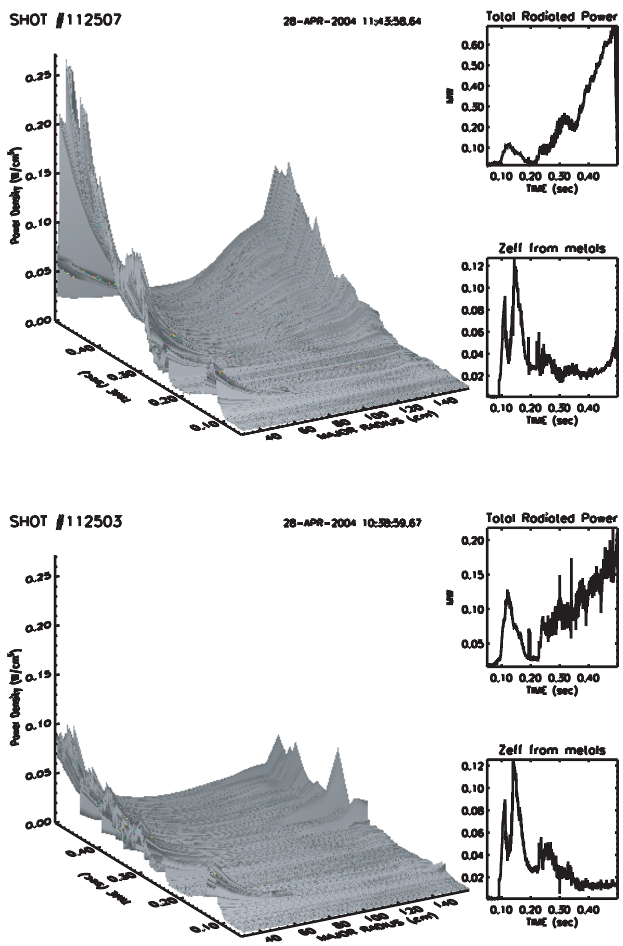
Radiated Power from the Core

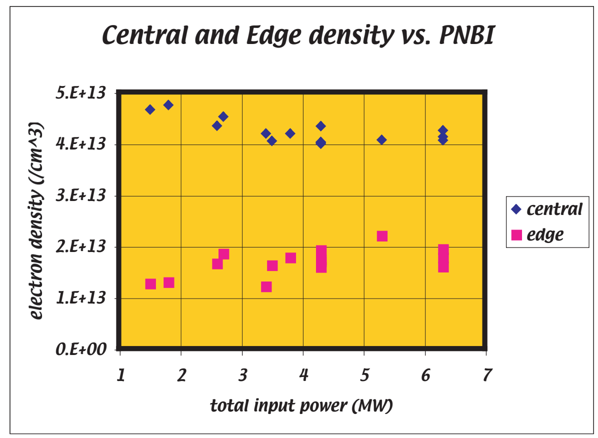




- 16 channel system tangential bolometer array uses AXUV diodes
- Radiated power is very low particularly at high injected power and ranges from 3% to 17% of input power
- For all these shots, profile is very hollow
- For low edge density of $10^{13}/cm^3$, carbon concentration required to emit even this much radiation is about 10%.

Why does the core radiated power decrease with input power?





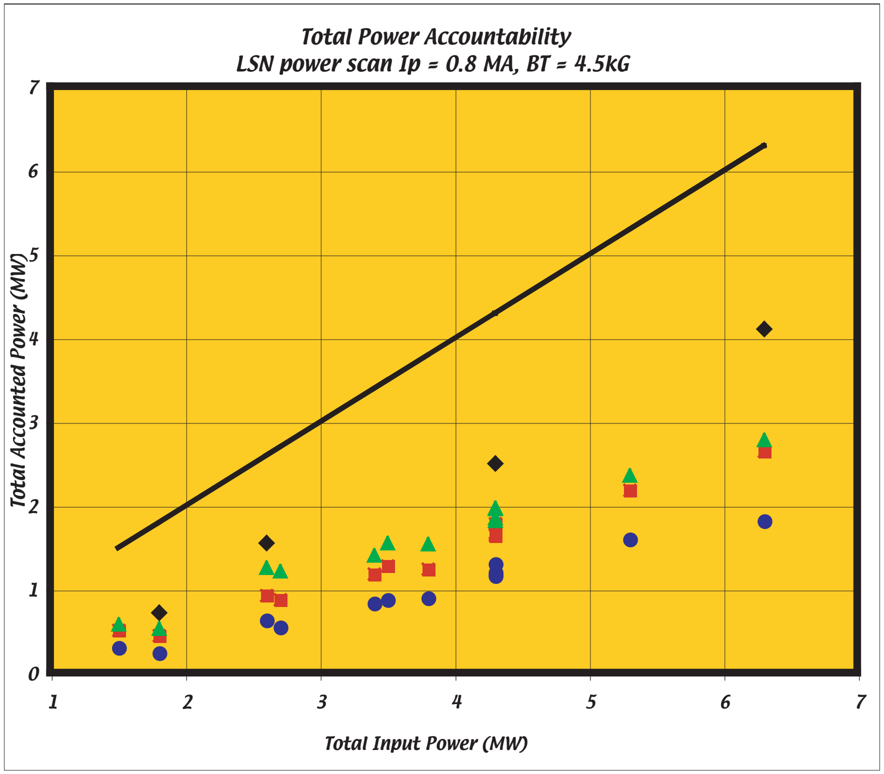
- Some of it is a density effect -- central n_e drops from 4.8 to 4 x 10^{13} cm^{-3}
- Some of it is variability in plasma/conditioning
- First discharge has an input power of 3.5 MW and an equivalent C concentation of 36% at edge; second discharge has 6.3 MW injected and 16% carbon at edge

Fast Ion Losses Calculated by TRANSP

shot	input pwr	shine thru	fast CX	orbit loss
112500	6 MW	100 kW	420 kW	800 kW
112505	4.2 MW	70 kW	220 kW	250 kW
112508	2.2 MW	30 kW	55 kW	210 kW
112510	1.8 MW	25 kW	15 kW	150 kW

For all the runs, Z_{eff} set to 1.5

Total Power Accountability



Legend: fast ions Prad core Prad divertor Heat to plates

- About 60% the input power is accounted for.
- About 20% of power is from fast ion losses -- prompt CX, bad orbits, and shine through.
- About 30% of the input power is incident on the divertor plates
- About 10% is radiated in the core or in the divertor
- Remainder of the power is likely to be found in the upper divertor region.
- Z-position of upper X-point indicates there may be a flow of power (from EFIT reconstruction)