MPTS Recent and Upcoming Upgrades*

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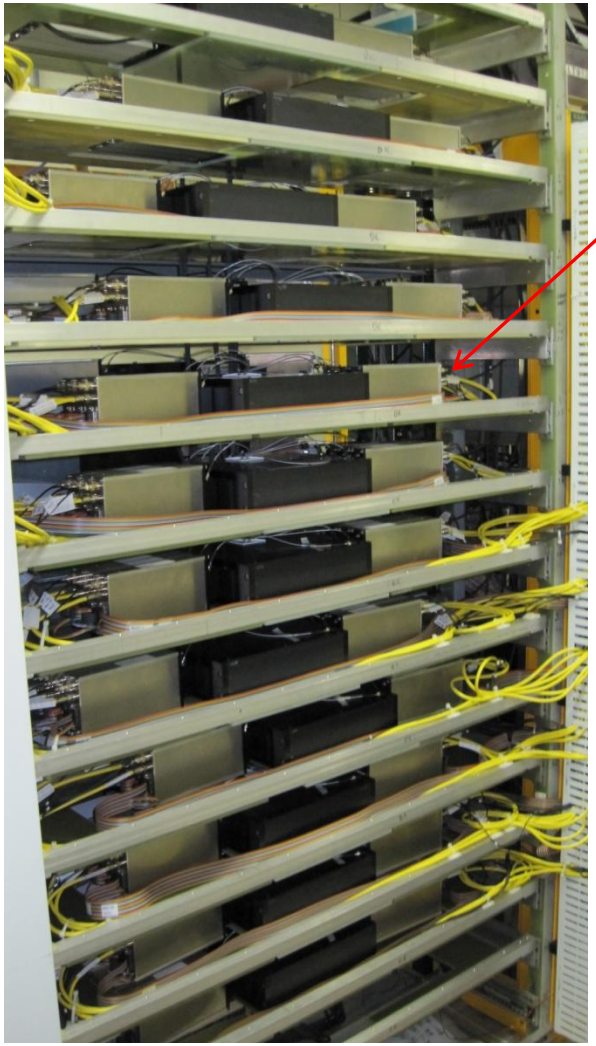
Introduction

- *The title and content of this poster has been modified to reflect the postponement of NSTX operation until completion of the NSTX device Upgrade (NSTXU)*
- The MPTS (Multi-Point Thomson Scattering) underwent a significant upgrade, which was made ready for FY 2011
  - To improve spatial resolution in the pedestal and internal transport barrier (ITB) regions
  - Twelve new channels were added, for a total of 42 radial positions
  - Some of the new channels resulted from splitting the output end of fiber bundles
- NSTXU will have a center stack, B_t, I_p and heating power
  - Re-aiming of the laser beams and re-focussing of the light collection optics
  - NSTXU is expected to reach ≤ Te 10keV

Allocation of 12 new polychromators

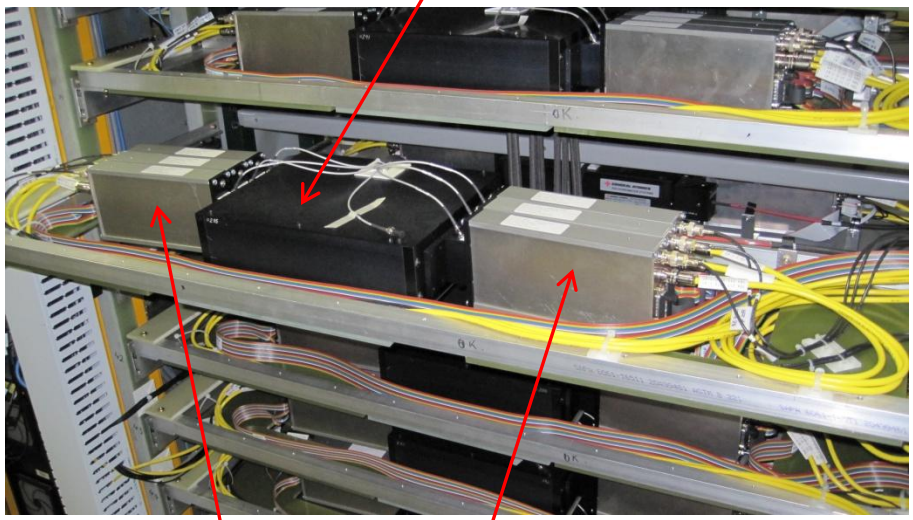
- Inner edge: 1 new polychromator
  - 1 new bundle @31.8 cm (1) new poly(s)
- ITB region: 5 new polychromators
  - 2 new bundles @86.4 and 112.5 cm (2)
  - 3 split bundles [79.5,82.4] (1)
  - [121.5,123.0] (1)
  - [124.5,125.8] cm (1)
- Pedestal: 5 new polychromators
  - 6 split bundles [134.9,136.0] (1)
  - [137.2,138.3] (1)
  - [139.4,140.4] (1)
  - [141.6,142.5] (1)
  - [143.6,144.5] *existing split bundle*
  - [146.4,147.8] cm (1)
- SOL: 1 new polychromator
  - 1 new bundle @154.61cm (1)

Twelve Additional Polychromators Installed for FY 2011



New 12-high polychromator tower

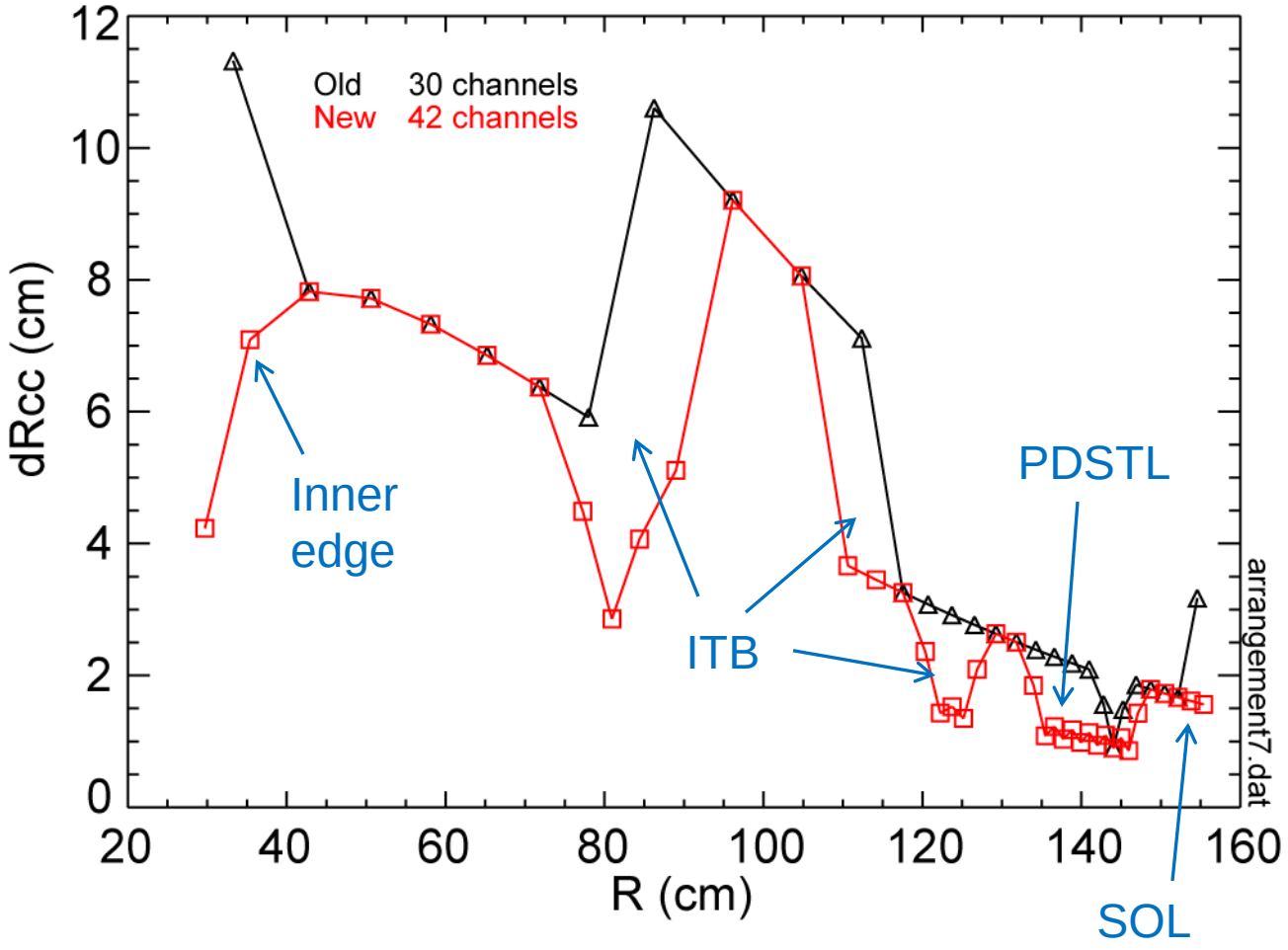
6-filter polychromator



PPPL “low readout noise” preamplifiers

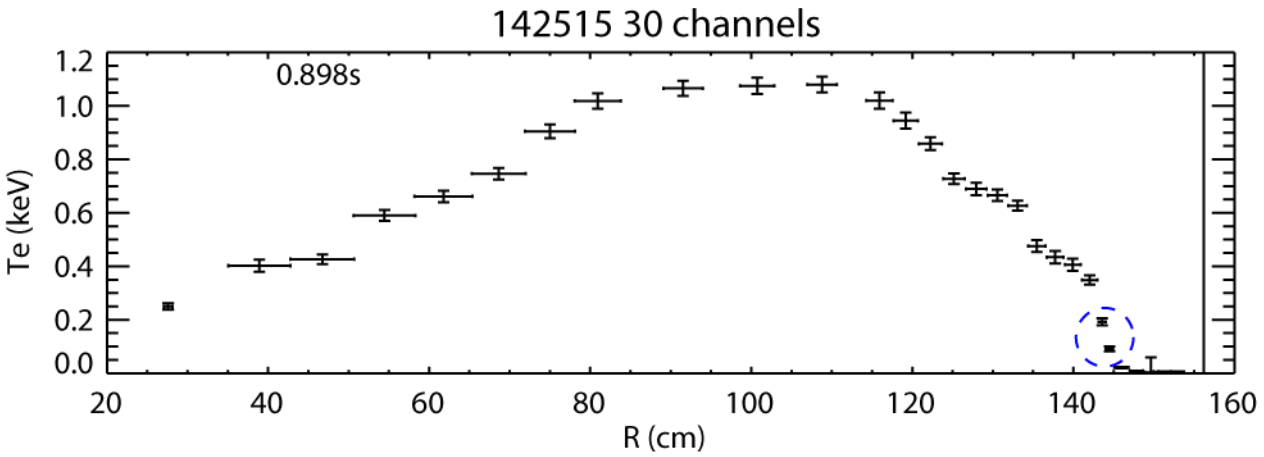
Improved Spatial Resolution

Reduced radial array spacing (dRcc)

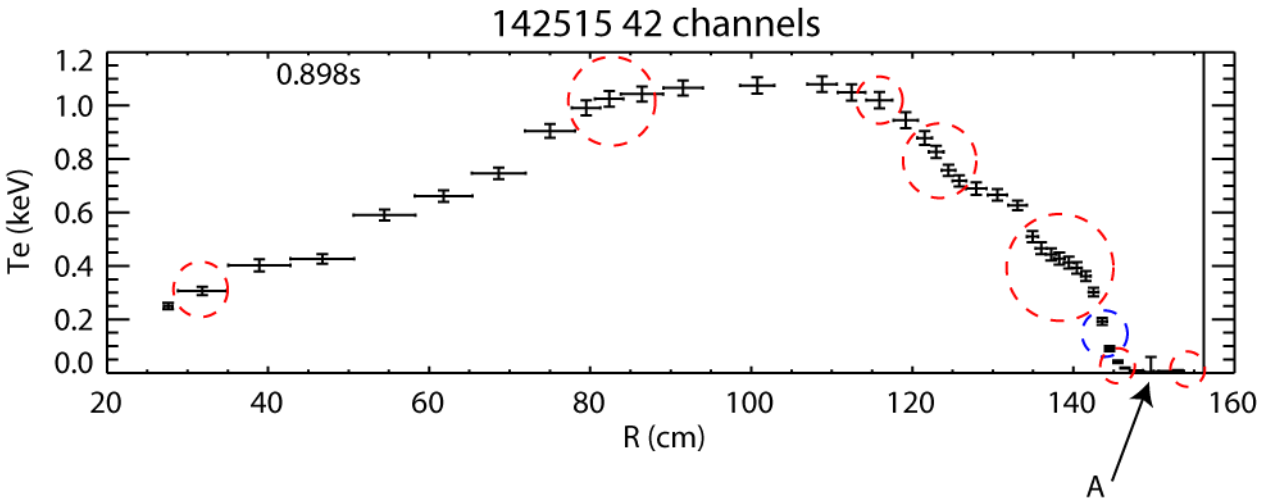


Comparison $T_e(R)$ 32 vs. 42 Channels

Experimental
30-channel data



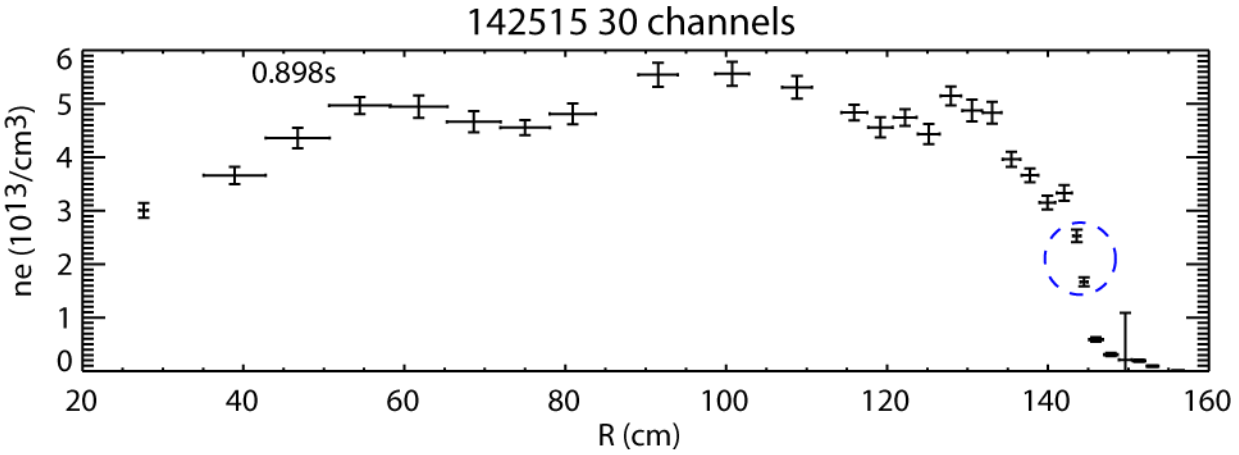
Simulated
42-channel data



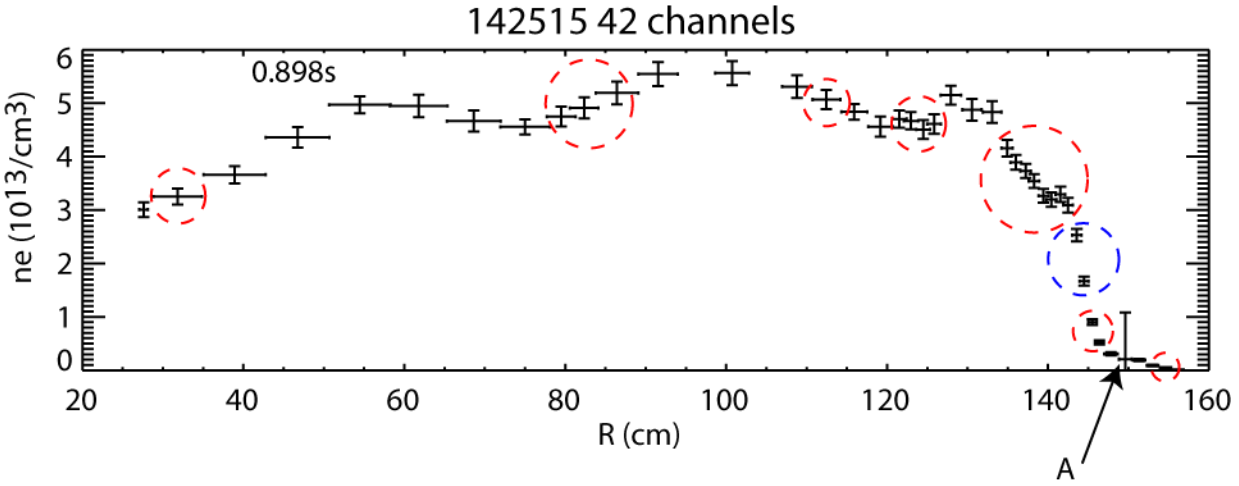
The existing 4-filter polychromator at position “A” has been replaced by one with 6 filters, and should produce smaller error bars – not presently reflected in the above figure.

Comparison $n_e(R)$ 32 vs. 42 Channels

Experimental
30-channel data



Simulated
42-channel data



The existing 4-filter polychromator at position “A” has been replaced by one with 6 filters, and should produce smaller error bars – not presently reflected in the above figure.

Splitting Fiber Bundles

Separation made at output end

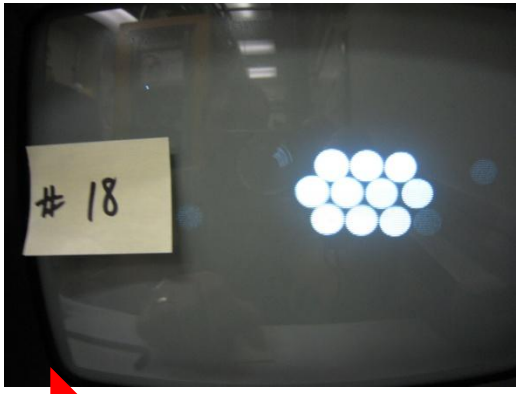
Whole bundle

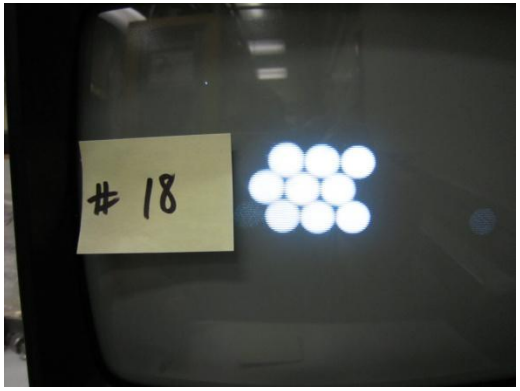
Back illuminated input end

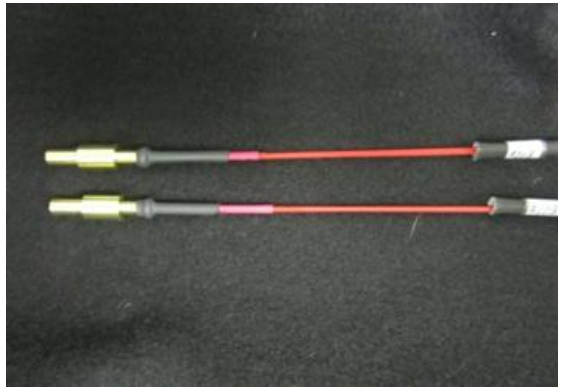
Light output end

Split bundles

Back illuminated input end







Light output end

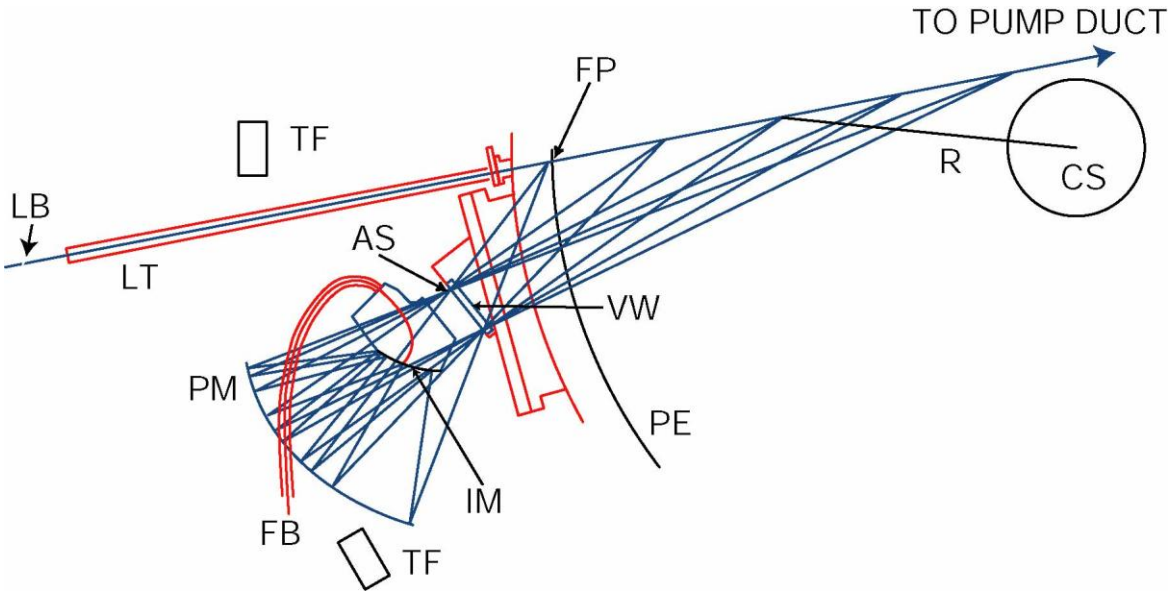
Radial Position Crosstalk

- Crosstalk can occur because of the shallow angles and the finite size of the laser beam
- Original MPTS arrangement provides for inter bundle gaps which preclude radial position crosstalk
- But some level of crosstalk will occur after splitting of fiber bundles output ends into different polychromators

MPTS Collection Optics overview

Back Scattering Configuration

Mirror (PM) optics collect the light scattered along the laser beam (LB) path and focus it at the “image” IM onto 36 fiber bundles

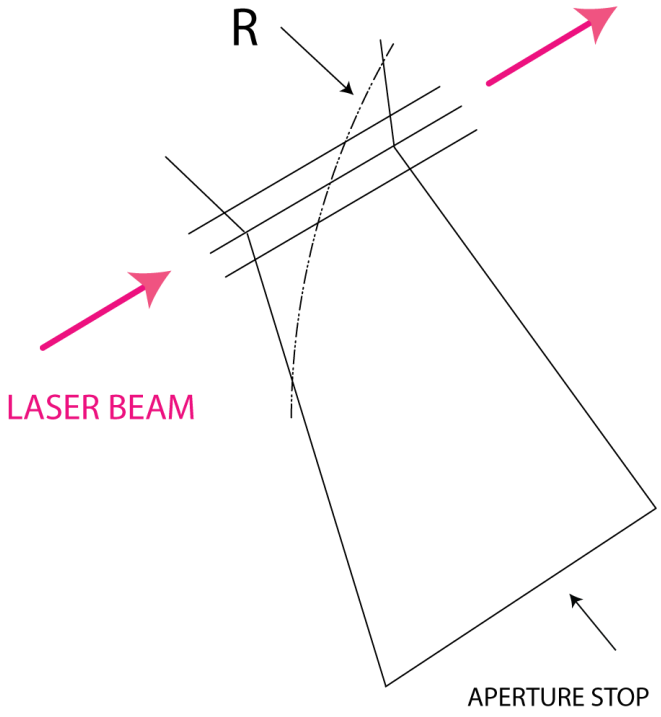


LB: Laser beam; TF: Toroidal Field Coil; PM: Primary mirror; FB: fiber bundles; AS: aperture stop; VW: vacuum window; PE: nominal plasma edge; FP: laser beam focus; R: major radius; CS: Center stack; IM: image

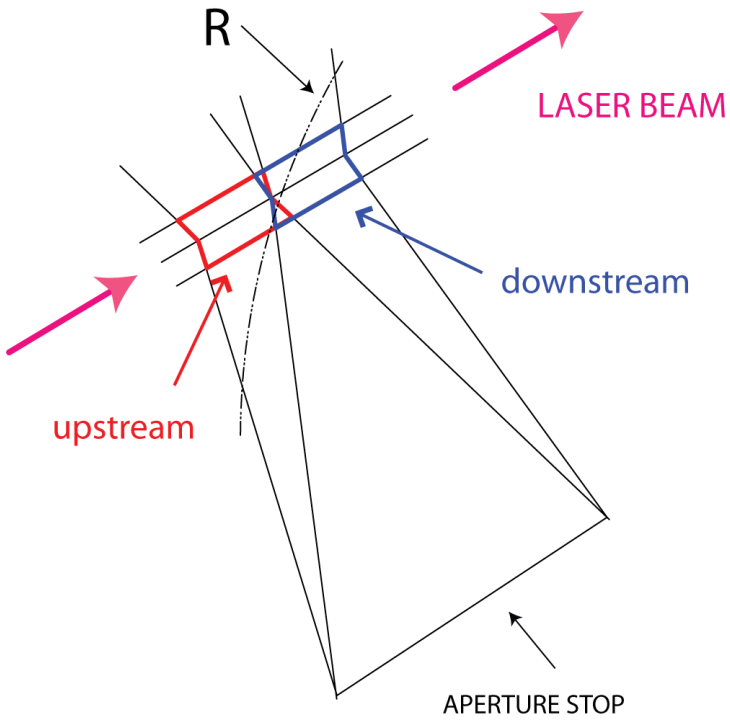
Schematic Illustration of Crosstalk

Crosstalk is caused by (1) overlapping fields of view of the split fiber bundles – red and blue – and (2) same value of the major radius R being observed by both split bundles.

Whole fiber bundle imaged along laser beam path

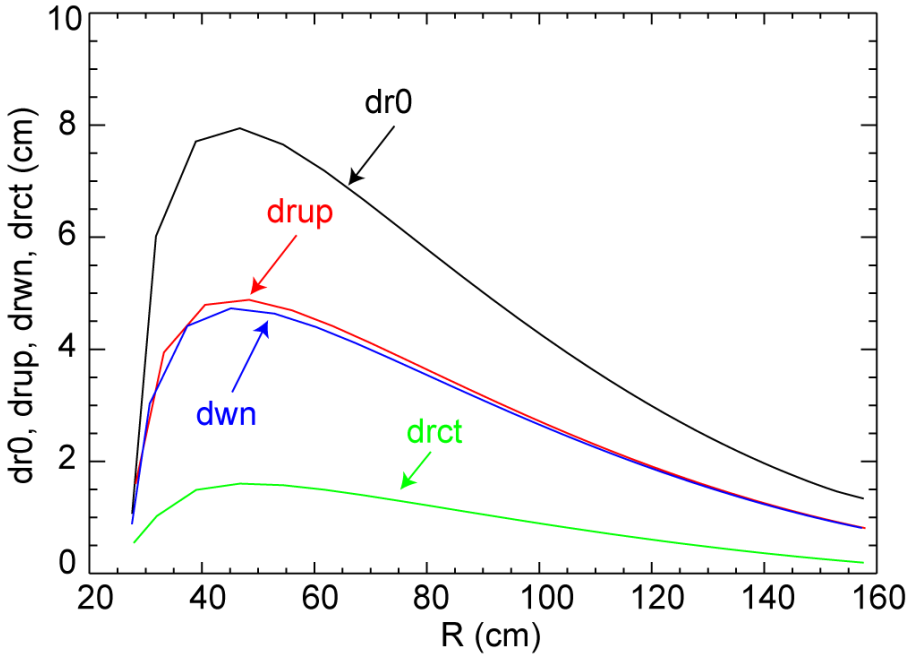


Split fiber bundles – red and blue – imaged along laser beam path



Geometric Crosstalk Evaluation

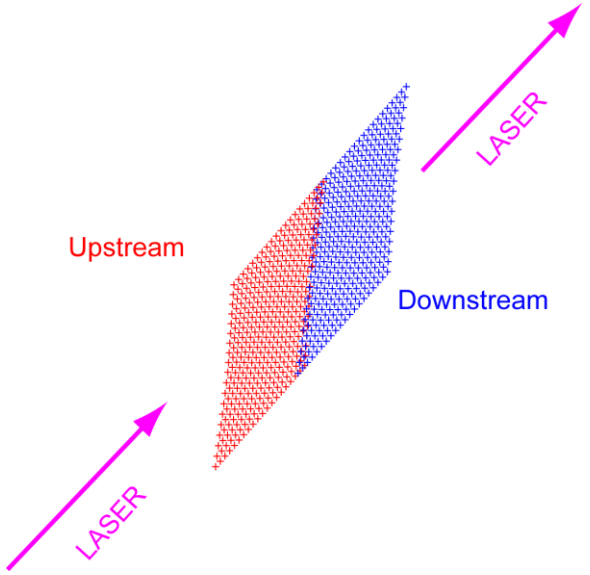
- dr0: major radius span for whole fiber bundles
- Evaluate major radius (R) at the vertices of upstream and downstream sub bundles and compute
  - drup: upstream sub bundle R span
  - drwn: downstream sub fiber bundle R span
  - drct: geometric evaluation of R overlap



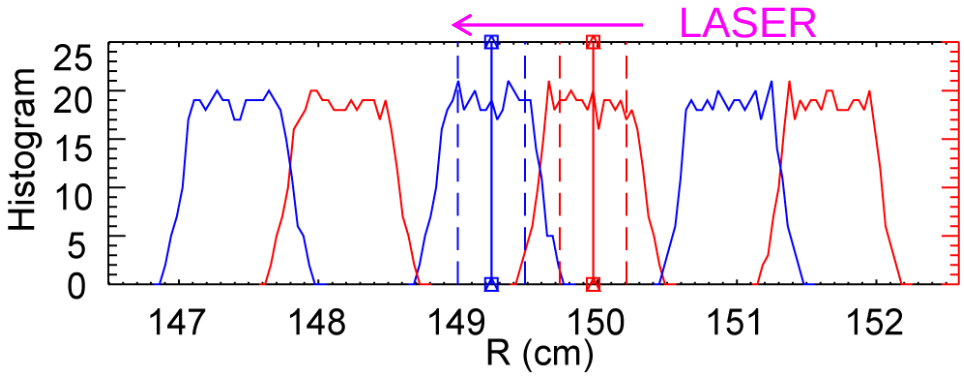
Crosstalk 30% of R span of split bundle

“Statistical” Crosstalk Evaluation

- Statistical analysis based on 800 points per split bundles



- Compute histograms of R corresponding to these points
  - ±1 sigma indicated with vertical dashed lines
  - Crosstalk absent for ±1 sigma



Histograms of R for three consecutive fiber bundles viewing near R=150cm.

MPTS Configuration after FY 2011
12 radial channels upgrade

- Two Nd:YAG lasers, aligned side-by-side on the midplane, with a combined nominal time resolution of 60 Hz
- 32 polychromators with 6 spectral channels
  - 20 existing plus 12 new polychromators
- 10 polychromators with 4 spectral channels
- Total of 42 radial channels
- In-situ viewing window calibration

Base Parameters for NSTX and NSTXU

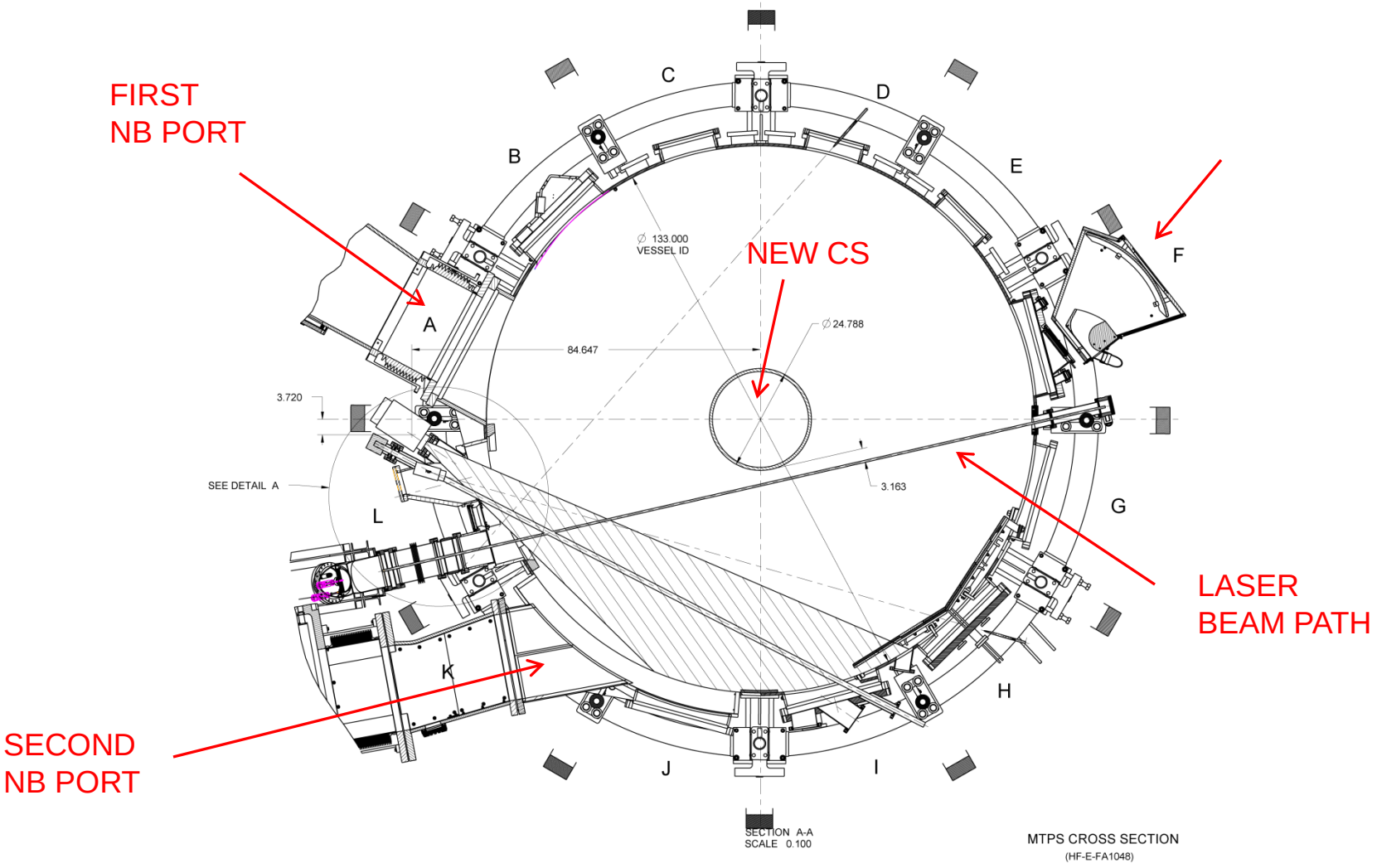
	Base NSTX	NSTX Upgrade
Rgeom (m)	0.854	0.934
a (m)	0.669	0.619
A	1.27	1.50
Ip (MA)	1.0 (1.5)*	2.0
Bt (T)	0.55 (0.6)*	1.0
Tpulse (s)	0.5	5.0
Rate (#/h)	10	5
R0-a (m)	0.185	0.315
Rant+a (m)	1.574	1.574

	Base NSTX	NSTX Upgrade
NBI (MW)	6	12
HHFW (MW)	6	6
Te (keV)		
HHFW	≤ 6.25	≤ 10
NBI (reg. q')	≤ 1.5	≤ 2.5
NBI (rev. q')	≤ 2.5	?
nebar (10^{14}/cm^3)		
NBI (reg. q')	0.6	1.3

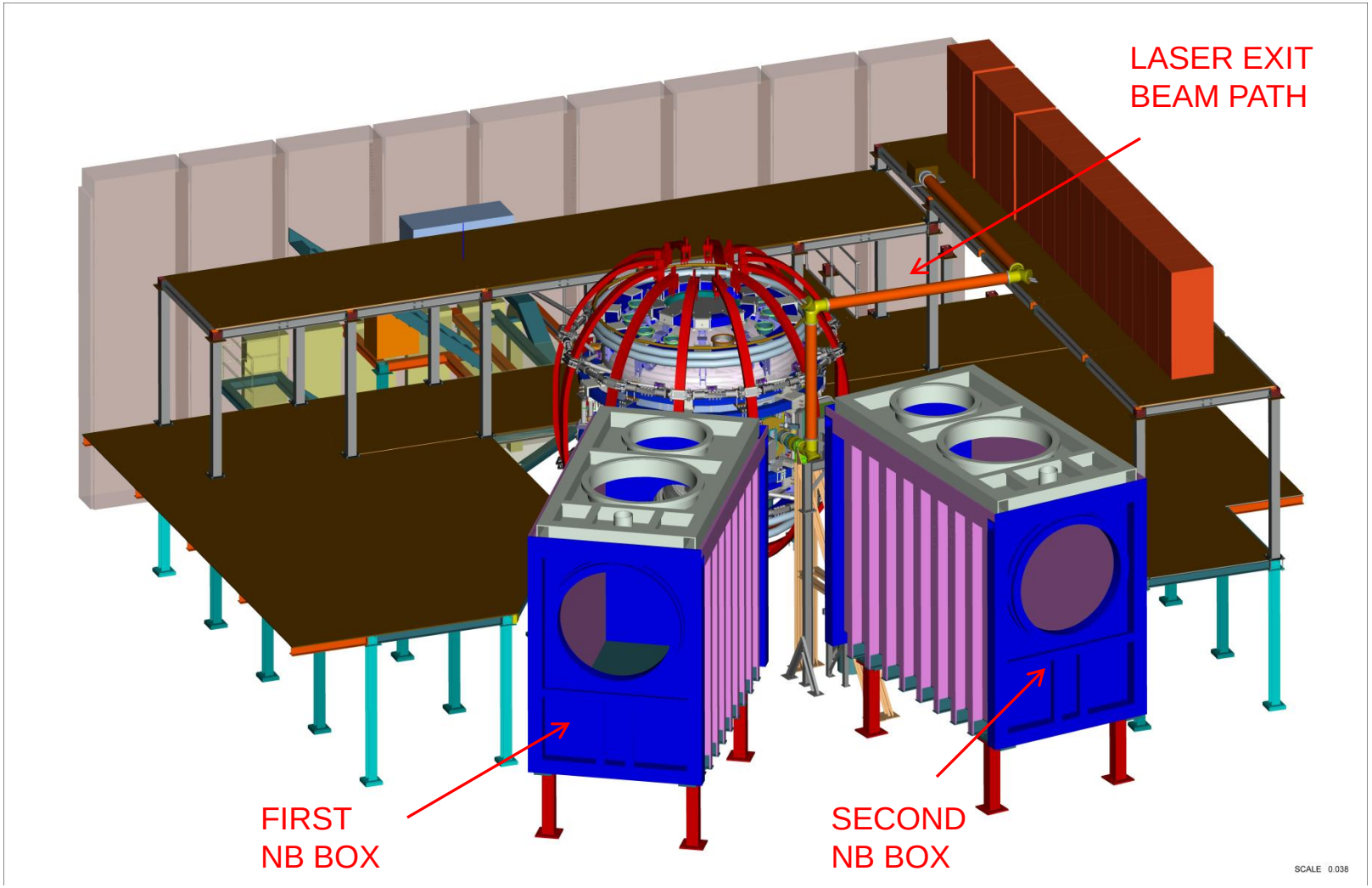
Numbers on the left: C. Neumeyer, *et al.* Symposium on Fusion Energy (SOFE) -- June 1-5, 2009, *Achieved

NSTXU

MPTS laser beam re-aimed away from new CS

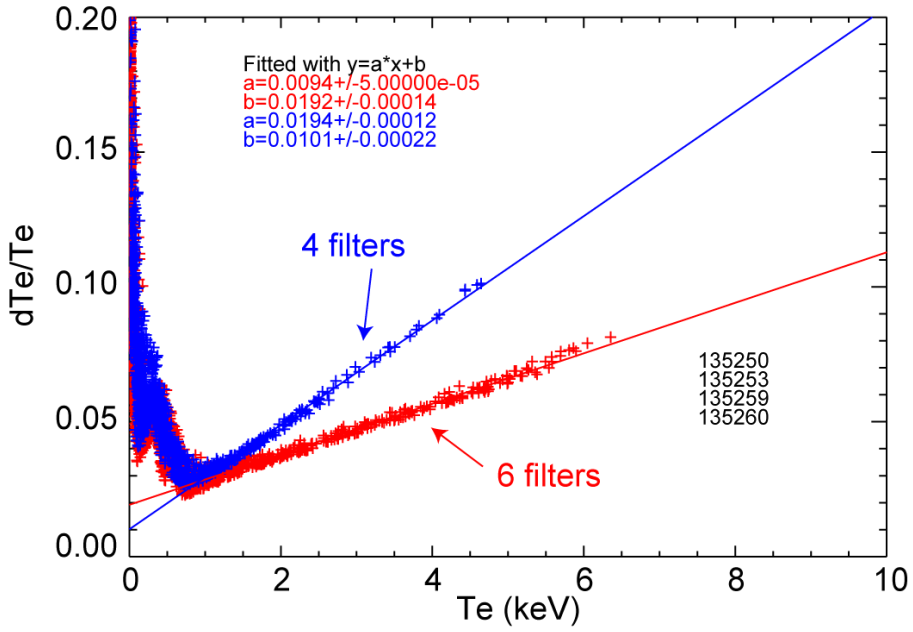


NSTXU Test Cell
Long laser beam path to beam dump



Measurement Precision at Higher Te

- NSTXU may reach Te ≤10 keV during HHFW, *i.e.* 60% higher than measured so far
- Use measured Te ≤6.25keV HHFW plasmas, to extrapolate error at 10keV: ±11% with 6-filter polychromator; ±20% with 4-filter polychromator
- A new 6-filter array could be needed to improve resolution at high Te



Conclusion

- Twelve new 6-filter polychromators have been installed and commissioned for FY2011. They provide improved spatial resolution in the pedestal, and ITB regions. Supplementary channels were added to the SOL and the inner edge as well.
- Crosstalk between sub-bundles
  - Geometric estimate: 30% of R span of split bundle
  - Statistical estimate with 800 points per split bundle

    ±1 sigma of R sampling shows no crosstalk

    ±2 sigmas of R sampling show 25% crosstalk
- Work has started to modify the MPTS diagnostic in order to operate on the NSTXU
  - Re-aim the laser beams and refocus the mirror optics
  - A new 6-filter array could be needed in order to retain accuracy at Te≈10keV