Upgrade to the NSTX Thomson Scattering Diagnostic*

B.P. LeBlanc, D.W. Johnson

Princeton Plasma Physics Laboratory

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MPTS

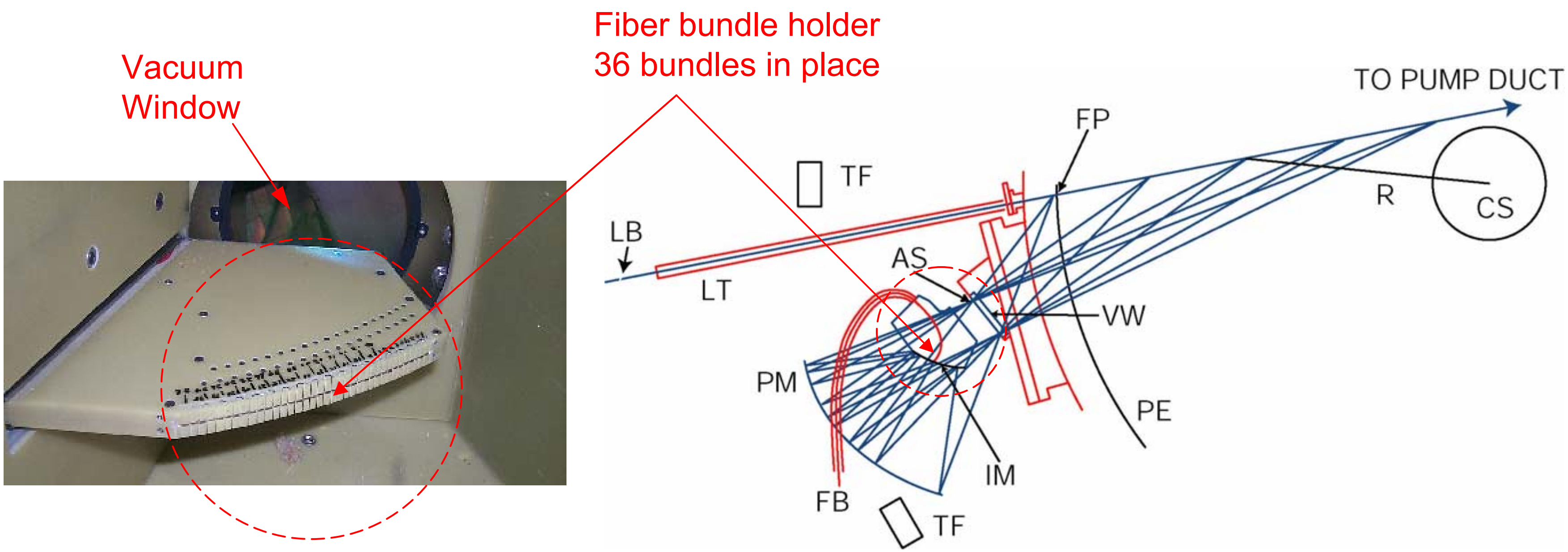
- MPTS is a multi-time multi-spatial point Thomson scattering diagnostic, which routinely provides $T_e(R,t)$ and $n_e(R,t)$.
- *So far two 30-Hz Nd:YAG lasers*
- *36 fiber bundles already viewing plasma*
  - *Output end can be split for improved resolution*
- *Phased implementation*
  - *Phase I 60 Hz 10 channels*
  - *Phase II 60 Hz 20 channels*
  - *Phase III 60 Hz 30 channels ⇦ this poster*

MPTS Laser System

Two 30-Hz Nd:YAG Lasers

1064 nm, 1.6 J/pulse

Collecting Optics



Laser beam (LB), laser tube (LT), TF coil (TF), focal point (FP), primary mirror (PM), aperture stop (AS), image of laser path (IM), fiber bundle (FB), plasma edge (PE), major radius (R), center stack (CS), vacuum window (VW)

Overview of this poster

- 10 polychromators were added to MPTS bringing its capability to 30 spatial channels
  - Special attention was given to improve spatial resolution at the edge of the low-field side
- The new channels are instrumented with
  - A four-wavelength GA filter polychromator
  - EG&G APD's with PPPL preamplifiers
- The new channels took data during most of last NSTX experimental run
- Calibration work is in progress

Implementation of Phase III

- A “tower” houses the new polychromators
- Each polychromator is attached to a movable shelf
- Room temperature ± 1°C
- HV power supply of each APD is compensated for small temperature variation

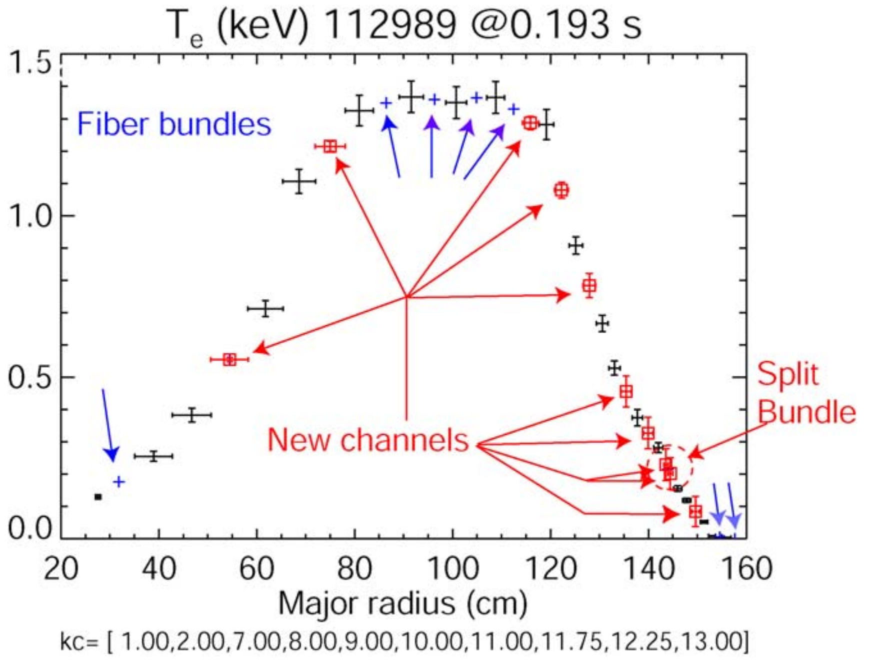
GA Optics & PPPL Electronics

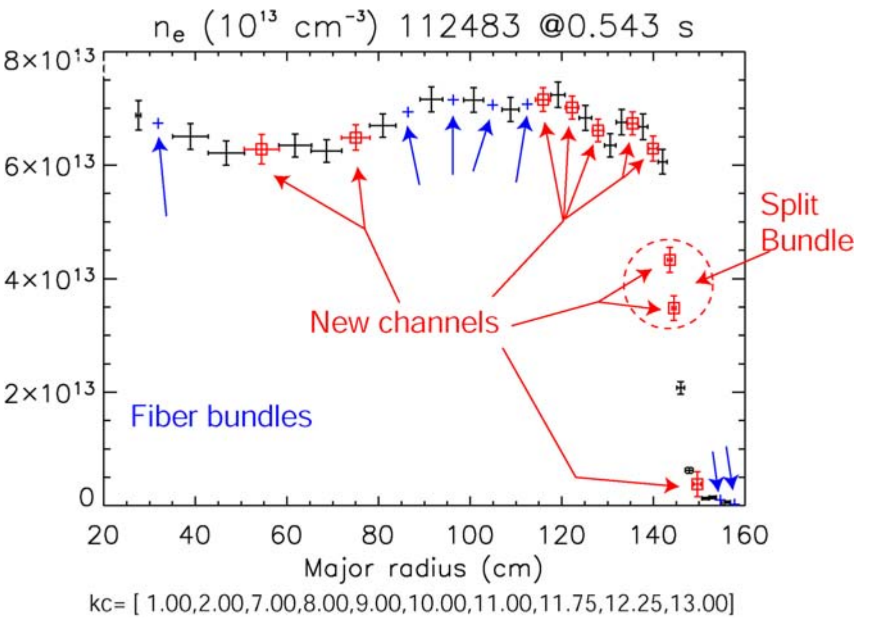
New Radial Channel Allocation

- A collegial decision, mindful of PAC's recommendation
  - Enhance outer edge resolution 8 channels
  - Better inner resolution 2 channels
- Split – for the first time – the output end of a fiber bundle to improve spatial resolution

Location of New Radial Position

Simulated 30-point data overlaid on 20-point system





Split Fiber Bundle for Better Resolution

Fiber bundle #9 was split in two in order to improve spatial resolution at R = 144 cm

Right and below: Photographs of the back illuminated bundle before and after separation

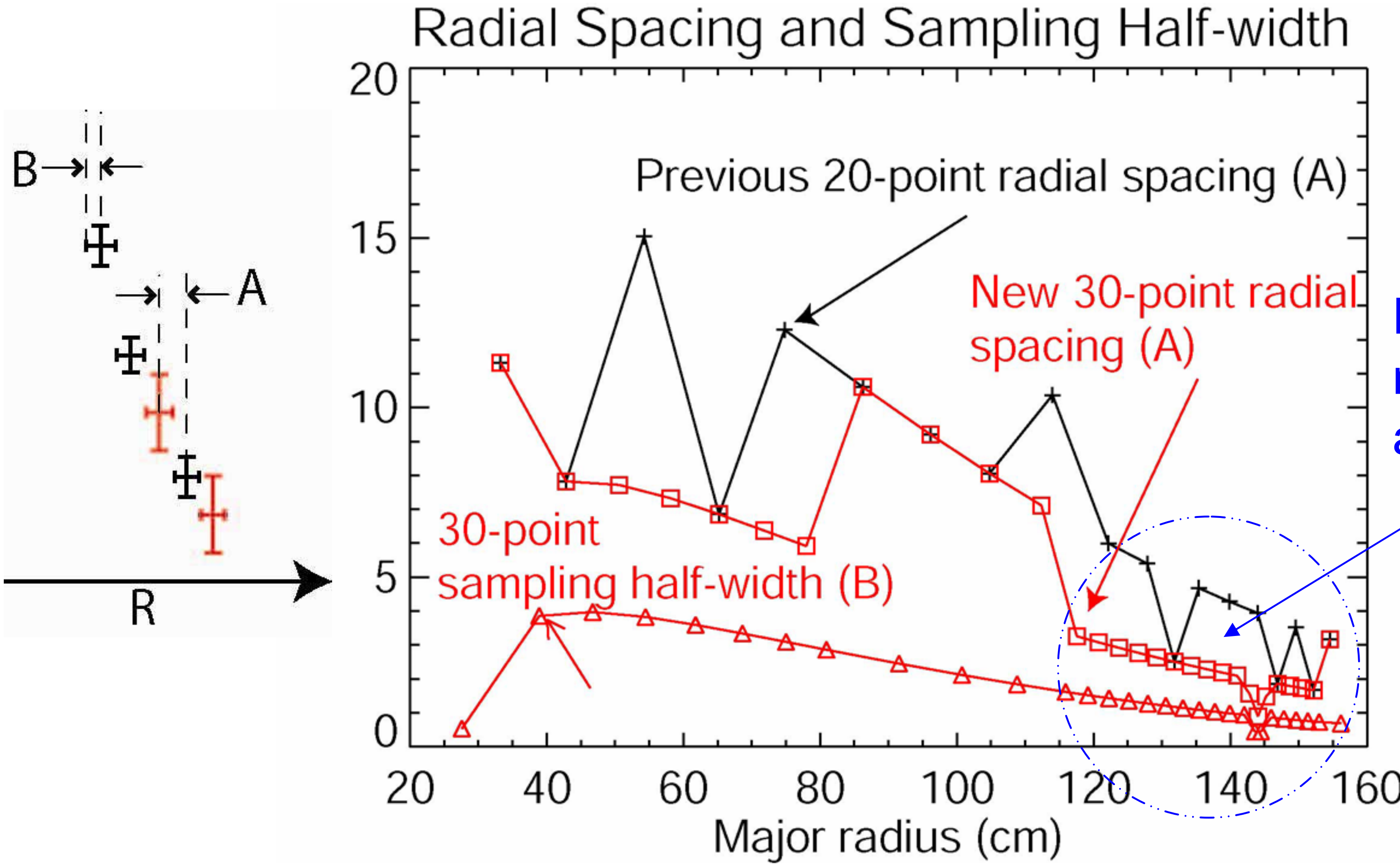
Original bundle
R =144cm±1cm

Inner split bundle
R =143.6cm±0.5cm

Outer split bundle
R =144.5 cm±0.5cm

Spatial Resolution Improvement

30-point spatial resolution is compared to 20-point system



Radial spacing reduced by ½ at outer edge

n_e Profile Calibration

- Phases I and II polychromators have 6 spectral channels, including one at Rayleigh wavelength
  - So far n_e calibration done with Rayleigh scattering
  - But could also be done with Raman scattering
- Phase III polychromators have 4 spectral channels, but none at Rayleigh wavelength
  - n_e profile calibration with Raman scattering
- Since Rayleigh signal is much larger than Raman, need to ascertain extinction ratio of Rayleigh light at Raman spectral location.

1064-nm Extinction Ratio Measurement

NSTX

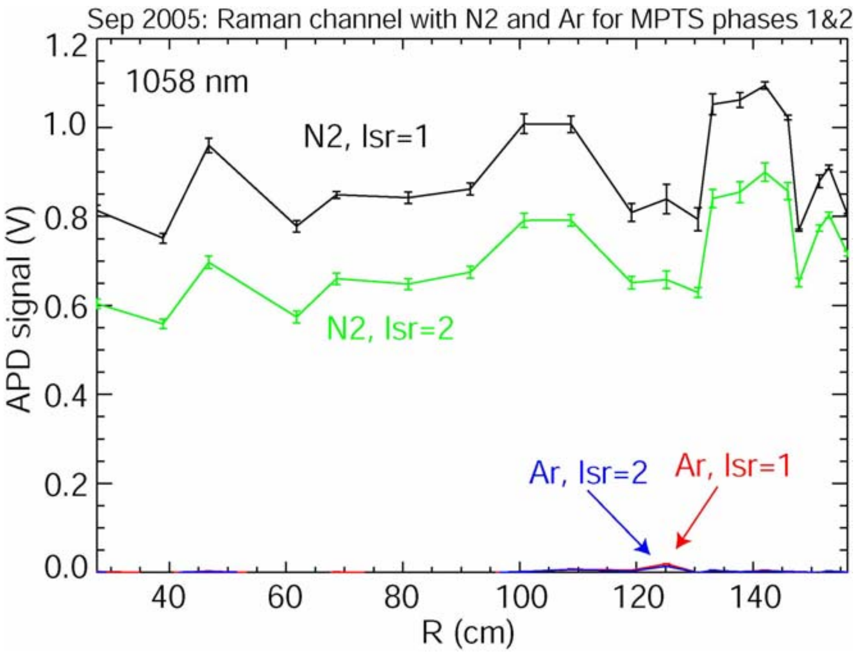
- Do Raman scattering with N_2 at 50 Torr
- Repeat same laser scattering measurement, but with Ar at 50 Torr
- A perfect "Raman" filter should block all Rayleigh radiation, resulting into no laser scattered signal with Ar.

Since the N_2 and Ar Rayleigh cross sections differ by only 12%, and assuming that $P_N \approx P_A$ and that the "Raman" signals are such that $V_N >> V_A$, one can compute a figure of merit, F_{EXT}, for the extinction ratio given by:

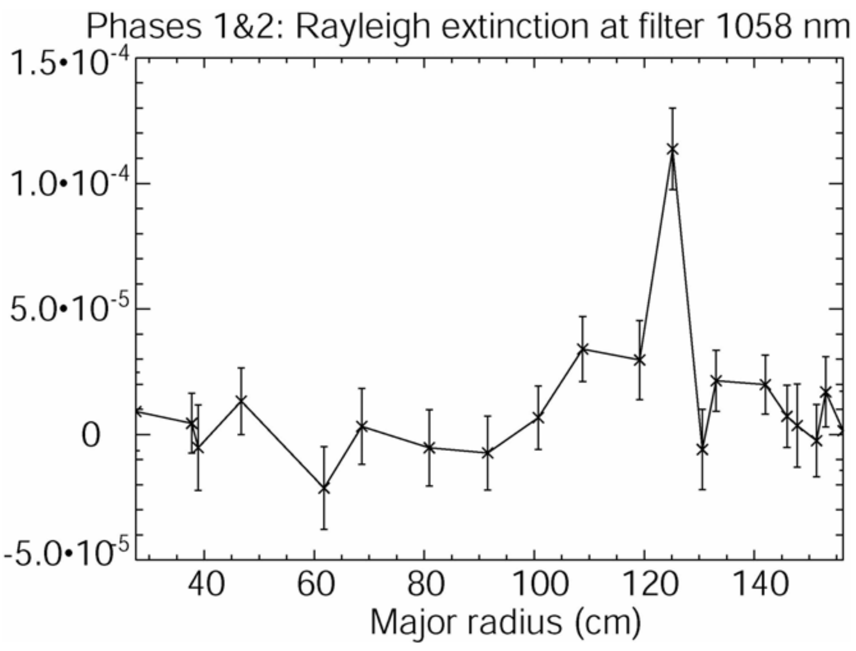
$$F_{EXT} = \frac{\left(\frac{d\sigma}{d\Omega}\right)^N_{RAM}}{\left(\frac{d\sigma}{d\Omega}\right)^A_{RAY}} \frac{P_N}{P_A} \frac{V_A}{V_N}$$

Extinction Ratio for Phases I and II

The 1058-nm blocks well the Rayleigh light



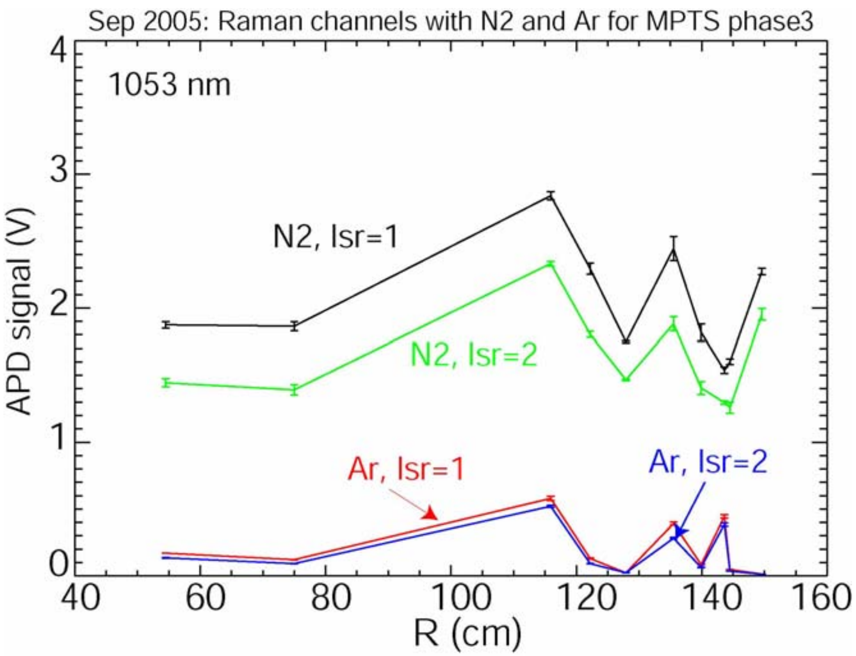
Extinction ratio for 1064-nm light through 1058-nm filter

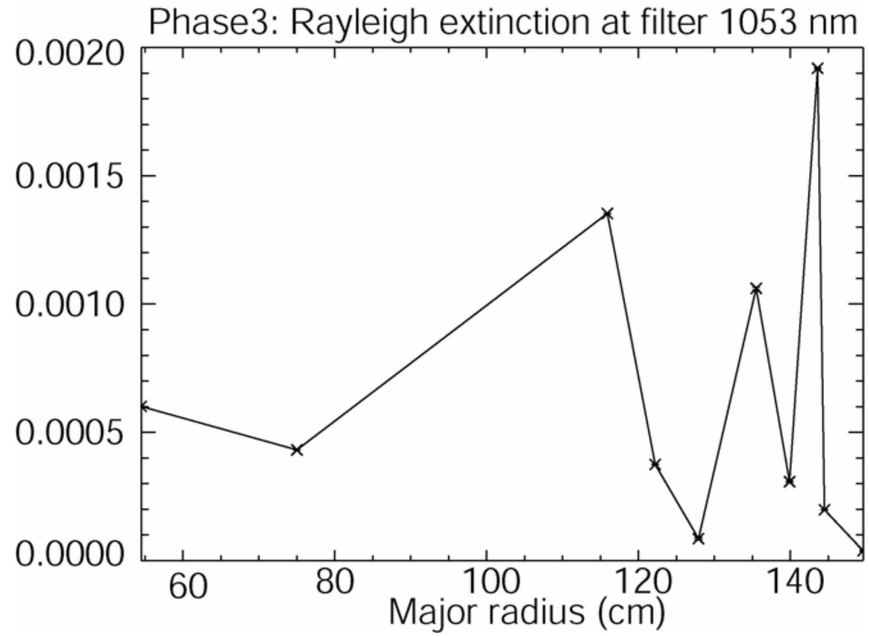


Extinction for Ratio Phase III

Significant amount of Rayleigh light enters the 1053-nm filter

Extinction ratio for 1064-nm light through 1053-nm filter



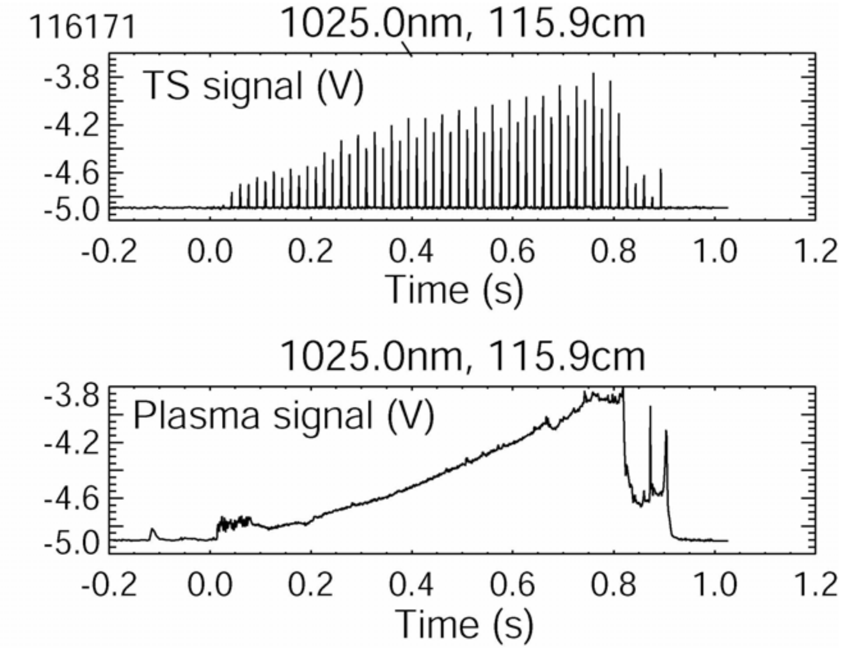


Raman Scattering Calibration

- The filters of phase I and II do a good job at blocking Rayleigh scattering light
- Unfortunately the filters of phase III let a significant amount of Rayleigh radiation enter the Raman spectral channel
  - Special care will have to be taken, where the contribution from Rayleigh scattering will have to be measured and folded in
  - Concern about reproducibility of F_{EXT}
  - Time consuming
  - Stray laser light remains an issue

Raw Data Acquired

- Phase III hardware has acquired data for most of last NSTX experimental run
- Raw data signals
  - *Top*: fast signal (Thomson scattering)
  - *Bottom*: slow signal (plasma light)



Calibration/Work Plan

- Raman/Rayleigh scattering → Raw data acquired
- Wavelength calibration using preamplifier slow output → In progress
- APD gain calibration using preamplifier slow output → Pending
- Fast vs. slow output calibration → Preliminary raw data acquired
- Software modification for Raman density calibration → Work initiated

Ad hoc Calibration

- An ad hoc calibration has been made using ensemble average of the existing 20 channels and assuming that on average the phase-III results can be extrapolated from adjacent channels
- This technique is a temporary expedient and does not replace the ongoing calibration
  - Tendency to overshoot at high Te
  - Soften spatial features

Preliminary Results from Ad Hoc Calibration

New radial points shown in red