# NSTX Diagnostic Status

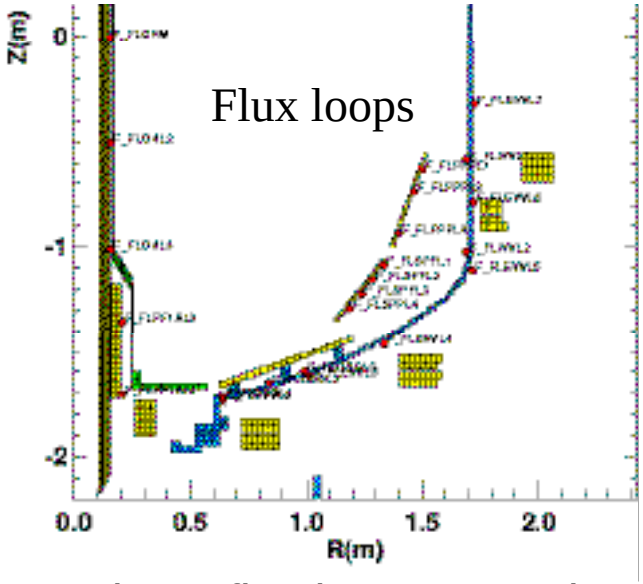
David Johnson
Princeton Plasma Physics Laboratory

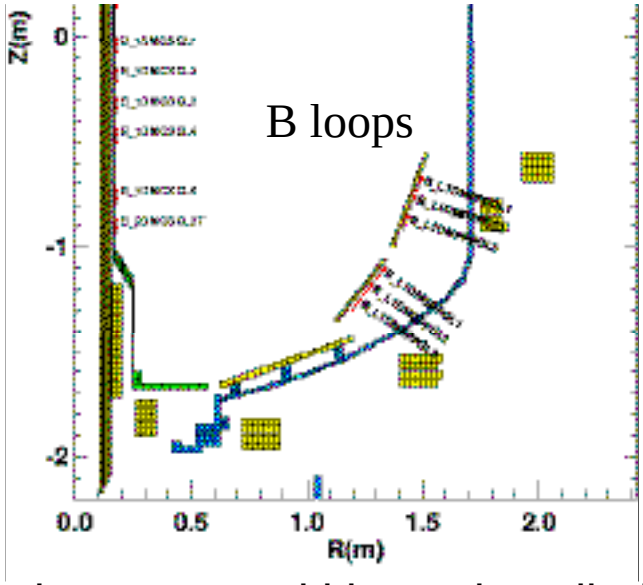
- Survey of existing NSTX diagnostics
  - Status at end of run
  - Problems
  - Outage plans
- Plans for new diagnostics for next run

# NSTX Diagnostics Team

| | |
|---|---|
| • Fusion Physics and Technology | MSE polarimeters |
| • Princeton Scientific Instruments | Fast 2-D x-ray camera |
| • Johns Hopkins University | USXR arrays |
| • University of California, Davis | FIR interferometer/polarimeter |
| • University of California, Los Angeles | Reflectometry |
| • Sandia National Laboratory | Edge coupons |
| • Los Alamos National Laboratory | Fast imaging cameras |
| • Oak Ridge National Laboratory | SOL reflectometer |
| | IR camera, edge spectroscopy |
| • Princeton Plasma Physics Laboratory | Assorted diagnostics |

# Magnetic Sensors Essential in Phase 1

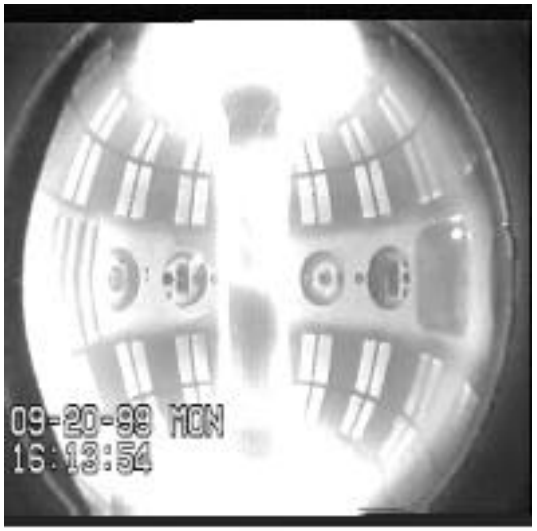



- Presently 64 flux loops, 27 B loops, and 11 Rogowski loops installed
  - Inputs to EFIT, which calculates $I_p$, plasma shape, and position
  - Also inputs to real time digital plasma control system
- Problems with $B_z$: 1) many CS $B_z$ coils shorted to CS, 2) nonlinear response
- Outage plans: 1) repair CS $B_z$ coils 2) replace outer $B_z$ coils ???
  3) add 14 $B_z$ coils in inner and outer divertor tiles
  4) add 12 ex-vessel locked mode loops

# Cameras Have Been Extremely Useful

- One of the most useful diagnostics has been the LANL fast camera (1 kHz)
  - Essential for initial commissioning of coils systems, real time plasma control, CHI, RF systems
  - Also used to view edge turbulence with gas puffer.
- Wide angle slow camera (30 Hz) useful operator aid is shown here.

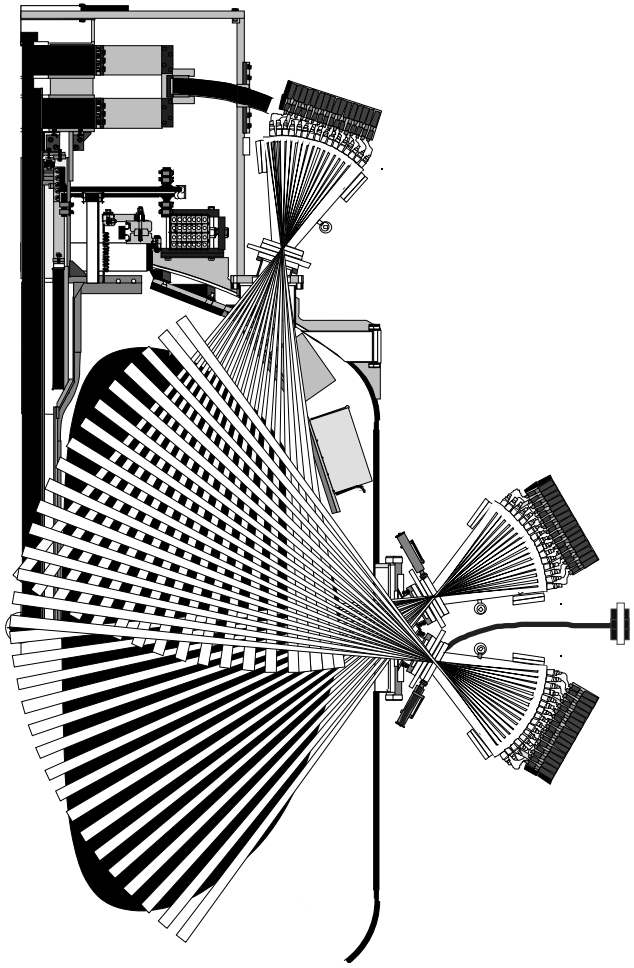



- Outage plans
  - Both cameras need to be relocated, because of port cover changes
  - A wide angle, re-entrant viewing window and shutter are being designed for Bay B, located slightly above the midplane.
  - A narrow angle re-entrant view of edge gas puff is also being designed at Bay B.
  - Also hope to install new IR camera to monitor fast ion loss

# Passive Spectroscopy

- Filterscopes (ORNL) ➡ worked well, will add shutters, more ch.
- Visible (VIPS) spect. ➡ problems with data interface, worked well late in run. Needs minor repair, alignment
- VUV (SPRED) spect.➡ problems with data interface, never worked well, critical problem. Will fix during outage, and align
- 16 ch. tang. bolometer ➡ 12 of 16 channels worked late in run. Need to repair bad channels, calibrate and improve analysis.
- X- ray PHA ➡ Worked late in the run, need to change apertures, filters to increase sensitivity and need to automate drive. May refurbish detectors.
- X-ray crystal spect. ➡ Worked late in the run. Spectral resolution poorer than expected. Will investigate in lab. Need to verify alignment during outage.

# 1-D Soft X-Ray Arrays

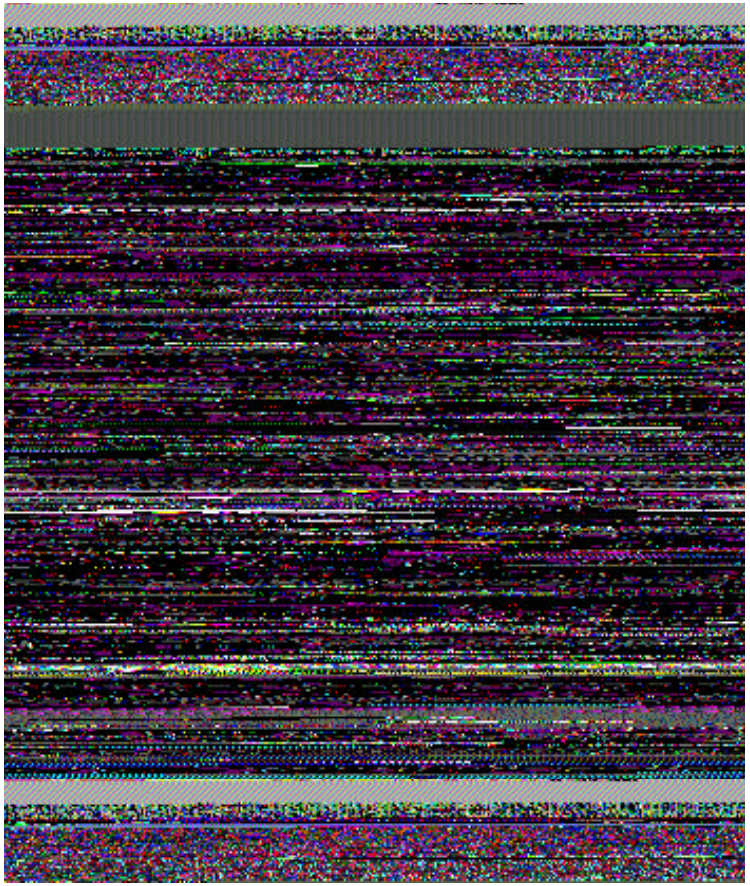


- JHU installed three 16 channel arrays as shown using leftover PPPL surface barrier diodes.
- Able to debug these systems and obtained the most detailed NSTX profile information
  - Observed interesting MHD activity
  - Obtained crude estimate of $T_e$
- During the outage:
  - Will replace detectors with absolutely calibrated AXUV diodes, 0.1 - 10.0 keV, 100 kHz bandwidth
  - Will fabricate fourth array to be installed symmetrically in bottom dome port during run
  - Will permit 2 color estimates of $T_e(R, t)$ and better tomography

# Reflectometry

- For edge and core measurements, 4 pairs of transmit/receive horns covering 12 - 50 GHz installed (UCLA)
  - For this run, one pair used for initial measurements and debugging
  - Experienced problems with sweep
  - During outage, will add more channels, improve analysis
- SOL $n_e$ profiles using horns integrated into RF antenna with a 6-36 GHz system (ORNL)
  - Fast scanning system operational for part of run
  - Initial data useful in assessing RF coupling and EBW mode conversion

UCLA Horn Array



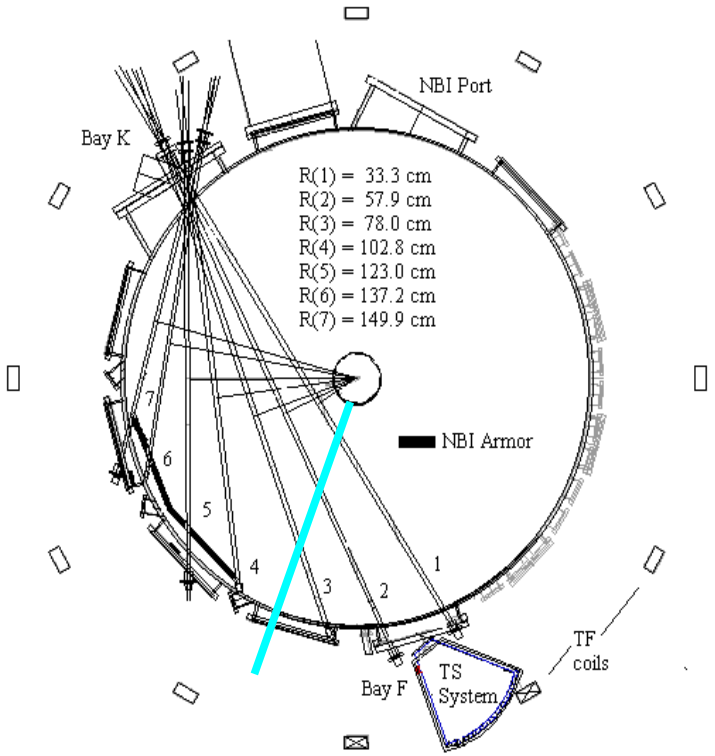
PPPL PRINCETON PLASMA PHYSICS LABORATORY

ornl

UCLA

NSTX

# Interferometry




- For last run used PPPL reflectometer hardware for 2mm interferometer using a radial beam reflecting from CS.
  - Window problem early in run
  - Loss of signal likely due to refraction causes fringe loss ➡ unreliable
- UC Davis will be installing a 3 laser FIR laser system
  - 2 probing lasers with opposite circular polarizations + reference laser
  - Phase shift between signals ➡ $B_T(R,t)$
  - Average plasma induced shift ➡ $n_e(R,t)$
  - Expect large signals 10 - 20 fringes, 10°-15° Faraday rotation in core
  - Sightlines 1 and 2 installed for next run

NSTX

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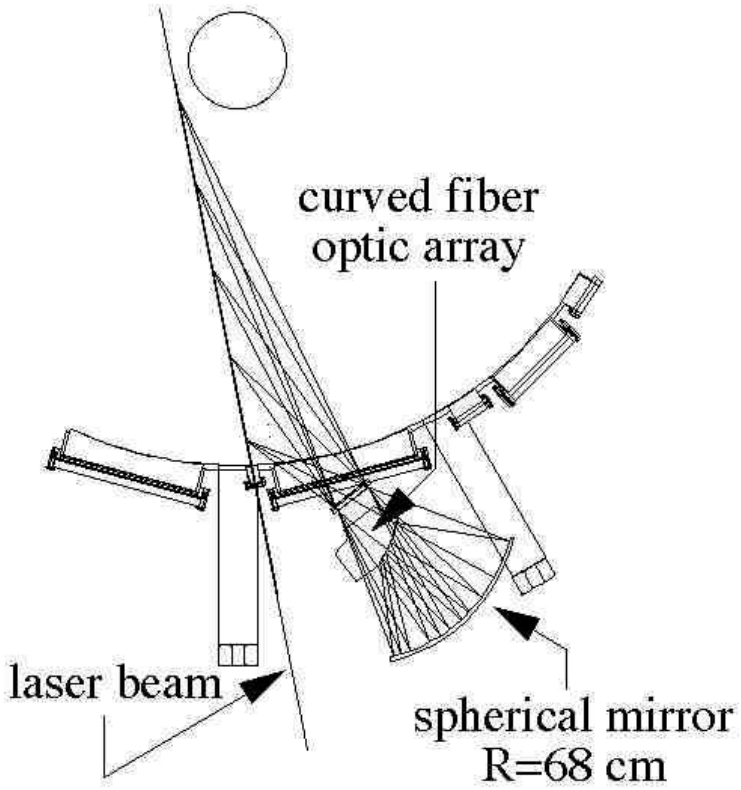
UC Davis

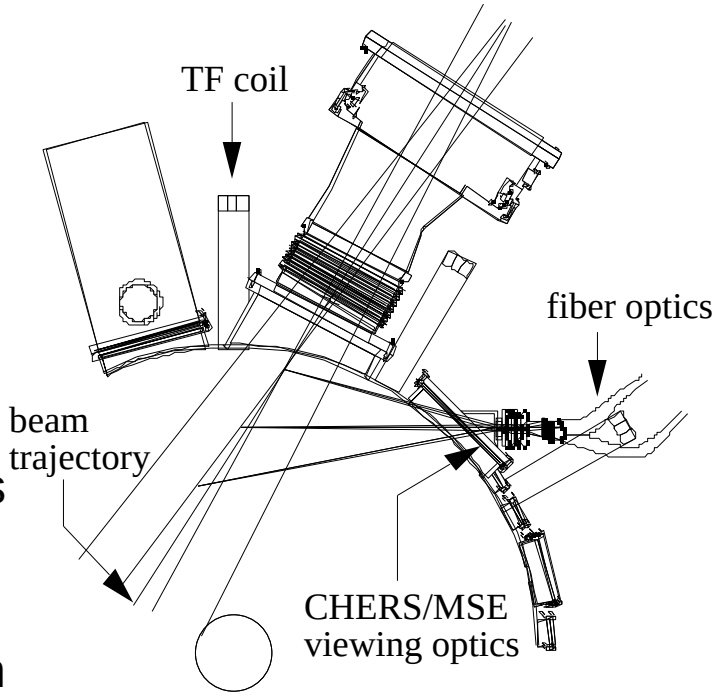
# Multipulse Thomson Scattering

- Designed for 36 spatial channels each with 5 spectral channels
- 1 cm edge resolution, 3 - 5 cm at magnetic axis, 8 - 10 cm on inner edge
- Nd:YAG laser, initially 30 Hz
- Start with polychromators/detectors for 10 spatial channels
  - progressively add spatial channels, lasers
- All laser and collection optics mounted directly to floor or shield wall for stable alignment
- Installation/testing underway
- Initial operation for first plasma of upcoming run.

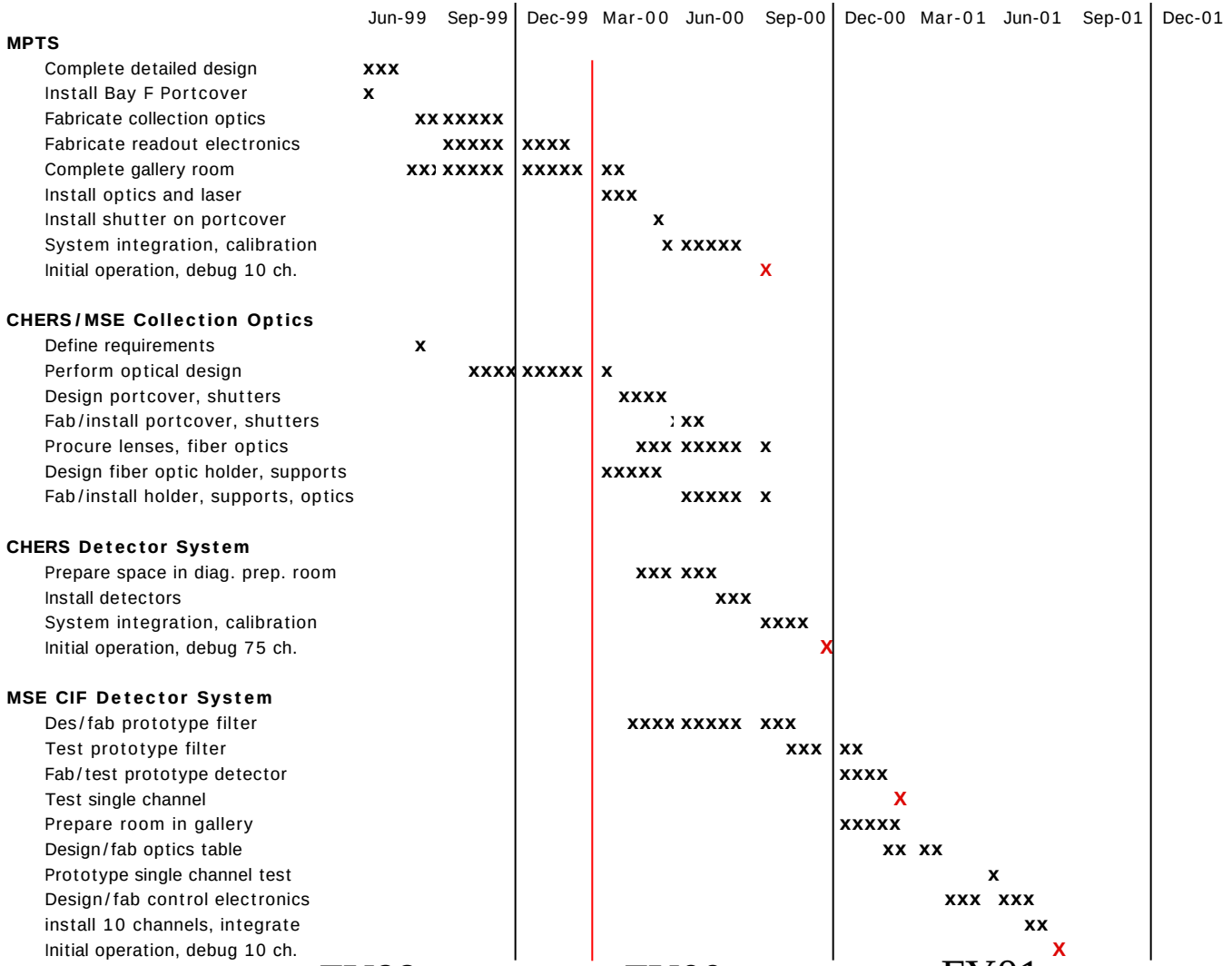


# Beam Spectroscopy

- Toroidal CHERS - $T_i(R,t)$, $v_\varphi(R,t)$ - 9/00
  - Will use high throughput spectrometers and detectors from TFTR $v_\theta$ system
  - ~75 spatial channels
    - 0.5 cm edge resolution, 2.0 cm core
- MSE - $q(R,t))$, $E_r(R,t)$ - 2/01 (FP&T)
  - Reduce geometric broadening by narrowing the viewing aperture in the horizontal direction. Elongate vertically.
  - Develop narrow bandpass, high throughput birefringent filters (0.075nm vs 0.7nm currently)
  - Increase optical throughput of system to compensate for lower polarization fraction (expect $P_f$ ~ 0.4 vs 0.8 current systems)
  - Ultimately 20 ch. - 2.5 cm edge res., 3.0 cm core, start with 10 channels.



# Schedule for Core Profile Diagnostics



# EBW Radiometry Hopeful for $T_e$

- Single channel EBW radiometer installed on NSTX in December 1999, shared view with ORNL reflectometer
- First observation of mode-converted EBW on NSTX in Jan. '00
- Inferred mode conversion efficiency only ~10%, based on PHA $T_e$ and absolute in-situ radiometer calibration
- Low conversion efficiency consistent with preliminary edge density profile results from reflectometer
- Use edge density profiles from reflectometer in MIT EBW code to predict mode conversion efficiency
- Plan to install fast scanning (10-20 kHz), 12-18 GHz, EBW radiometer in June 2000 on dedicated midplane view

# Diagnostic Innovation Opportunities

- $T_e(R,t)$ measurements
  - EBW proof-of-principal will continue on NSTX (PPPL)
- J(R, t), E(R,t), p(R,t) measurements (FP&T)
  - CIF MSE
  - LIF MSE

  } both require considerable new development driven by ST needs
- 2-D fluctuation imaging
  - Imaging of edge gas puff (LANL/PPPL)
  - Fast (500 kHz) tangential x-ray camera (PSI)
  - LIF imaging of edge turbulence (FP&T)
- NSTX will continually encourage diagnostic innovation. Session leaders should identify critical areas for such development.

# Summary

- National team is assembling a broad array of diagnostics for NSTX
- For initial physics run:
  - Diagnostics allowed to commission device, control plasma and obtain crude estimates of core parameters
  - Problems with window coating, Bz coils, interferometer, and UV spectroscopy. Will be addressed during outage.
- During outage will be installing important core profile diagnostics: operational
  - MPTS initial data with 10 spatial channels 7/00
  - CHERS initial data with ~ 75 spatial channels 10/00
  - MSE initial data with 10 spatial channels 3/01
- New techniques to meet special ST measurement needs are under development and show potential, more will be needed.