NSTX

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Advances in Fast 2-D Camera Data Handling and Analysis on NSTX

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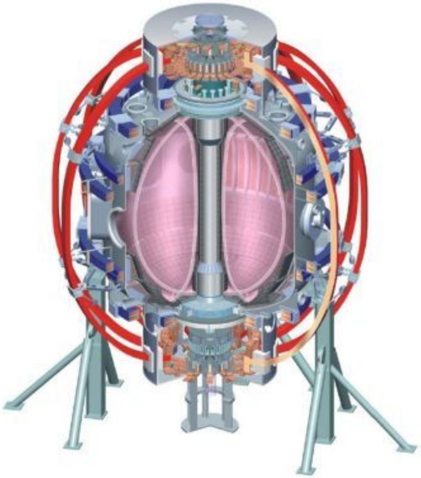

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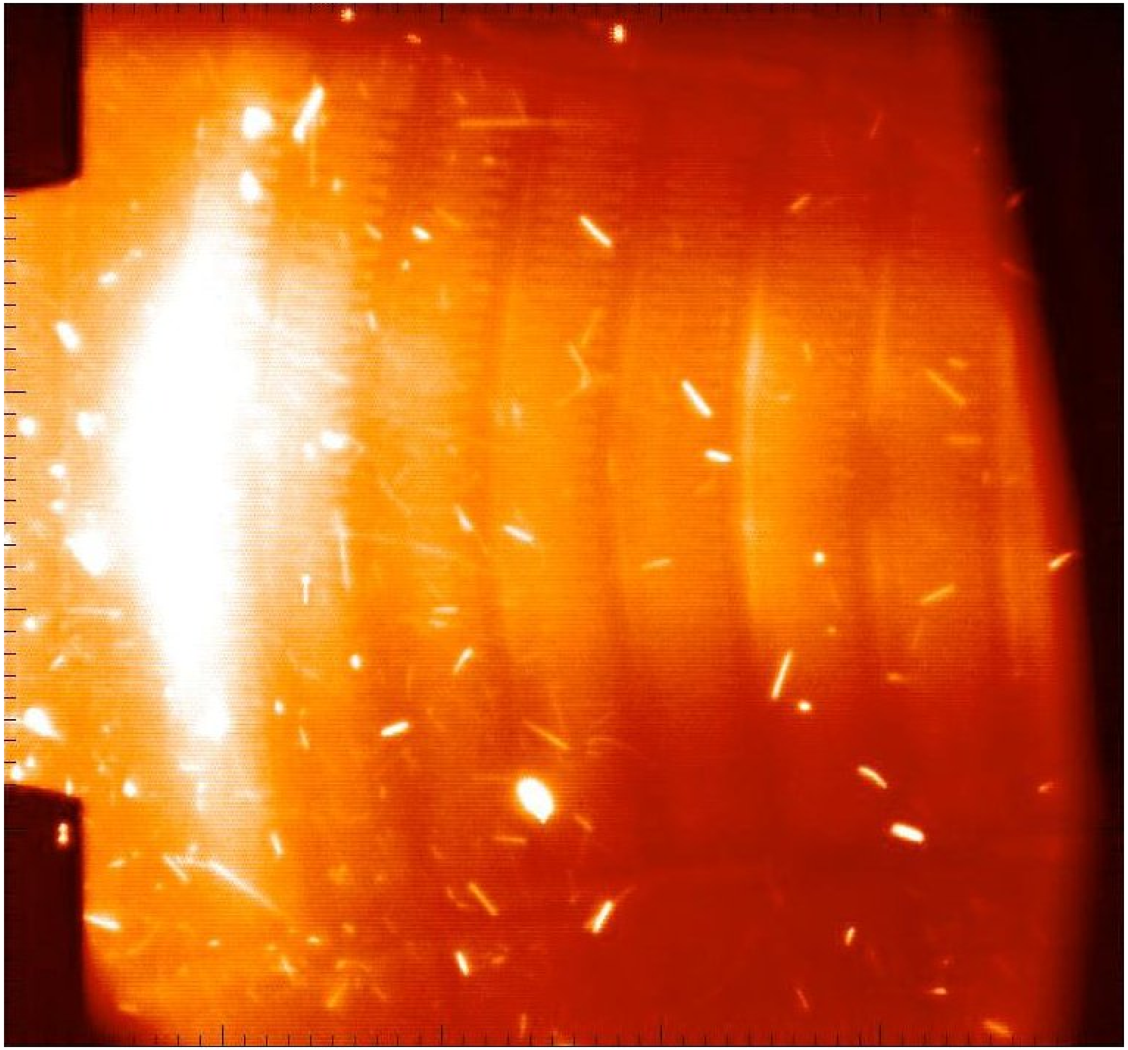
Abstract

The use of fast 2-D cameras on NSTX continues to grow. There are at least 6 cameras that can take up to 1-2 GBs of data apiece during each plasma shot on the National Spherical Torus Experiment (NSTX). Efficient storage and retrieval of this data remains a challenge. Performance comparisons are presented for reading data stored in MDSplus, using both compressed data and segmented records. Encouragingly, fast 2-D camera data provides considerable insight into plasma complexities, such as small scale turbulence and particle transport. As an example of new uses, dual cameras looking at the same region of the plasma from different angles can provide trajectories of identifiable features in three dimensions. A laboratory test of this system is presented, as well as corresponding data from an NSTX plasma where glowing dust particles can be seen to move in interesting paths.

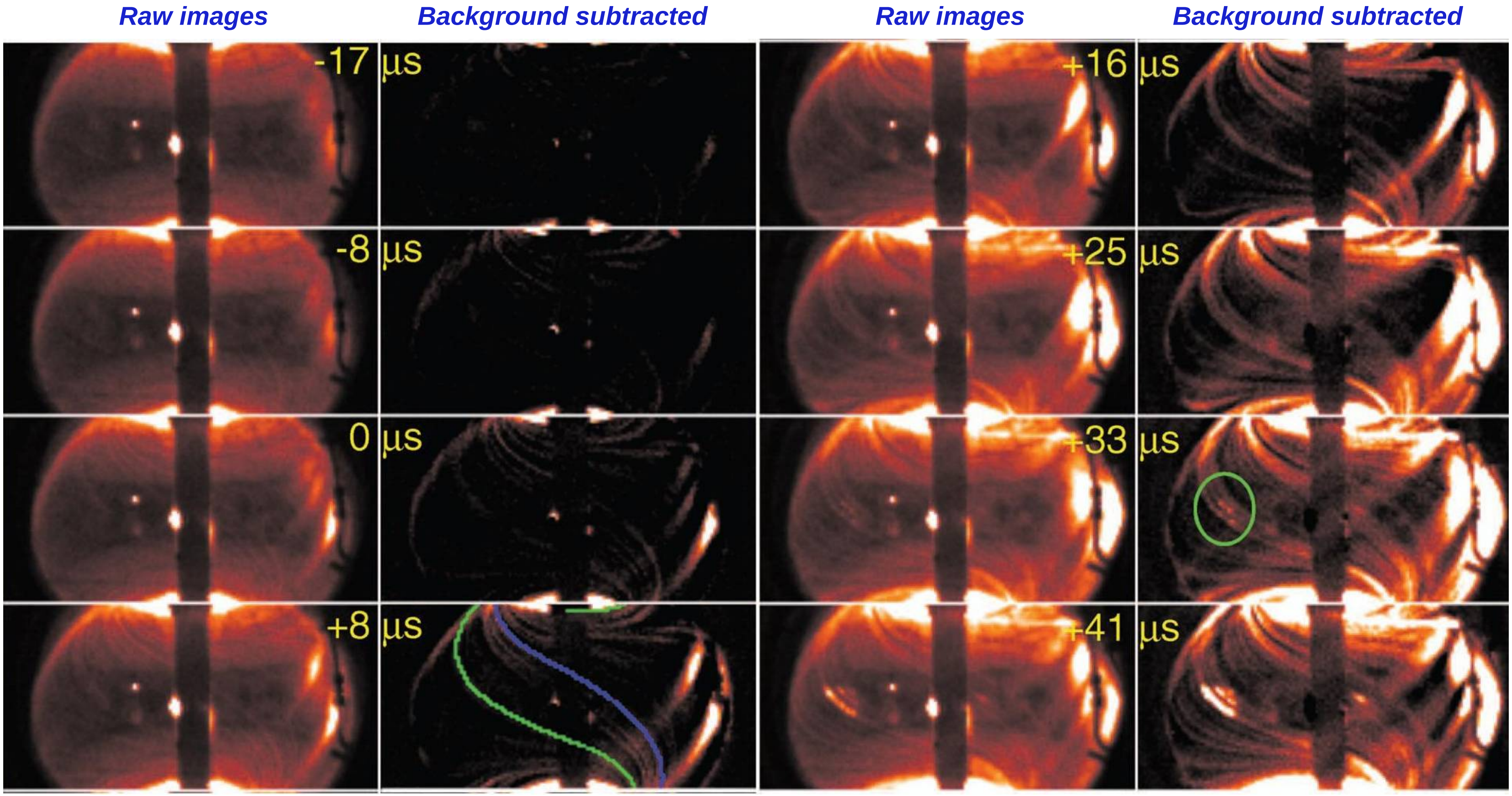
Fast 2-D Cameras on NSTX can record:

- Global plasma shape and position
- Edge turbulence in gas puffs
- The propagation of ELMs and MARFEs
- Heat loading on plasma facing components
- Dust tracking
- Fast Lost Ion pitch angle and gyroradius

Dust in NSTX after a disruption



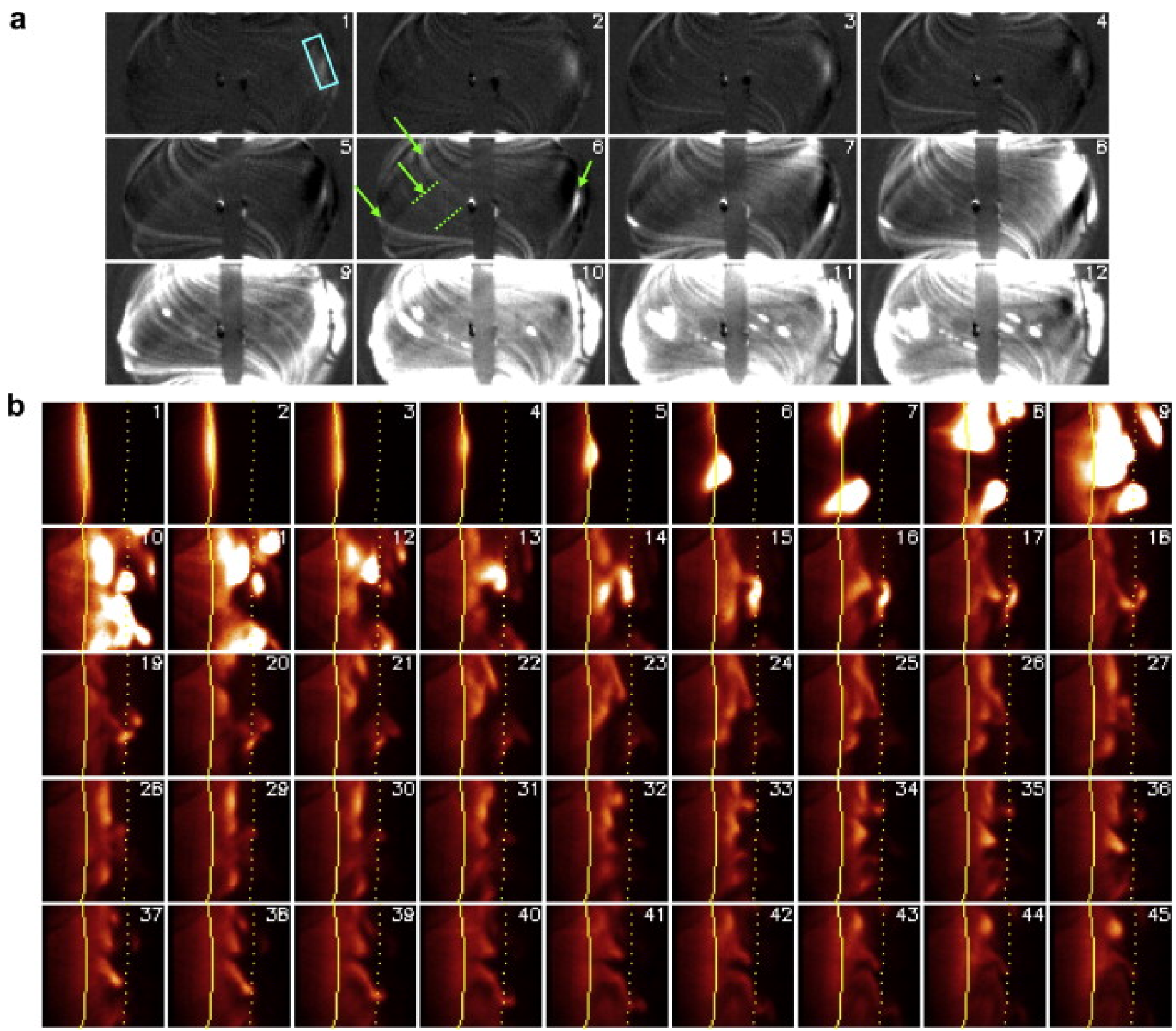
ELM formation with and without background subtraction



- *Helical formation of ELMs are more clear in enhanced images*
- *Note the enhanced visibility of structure in green circle*

(R. Maqueda, et al, Phys. Plasmas 16, 056117 (2009))

Filament structure in Type III ELM



•*R. Maqueda*, *doi:10.1016/j.jnucmat.2009.01.222*

Phantom 7 Fast Camera on NSTX

NSTX Fast 2-D Camera Specs

Camera type	Typical MB/shot	Max MB/shot	Min Rate (KHz)	Min Rate Resol.	Max Rate (KHz)	Max Rate Resol.	Bits
Phantom 7.3 (2@)	350	3500	6.6	800x600	190	32x32	14
Phantom 7.1	350	3500	4.8	800x600	150	32x32	12
Photron Fastcam	750	1500	2.0	1024x1024	120	128x16	10
Miro 2	50	2000	1.2	800x600	111	32x16	12
Phantom 4.2	1000	3500	2.1	512x512	90	32x32	8
S.B. Focalplane	50	64	1.6	128x128	6	96x32	14

NSTX Computing Environment

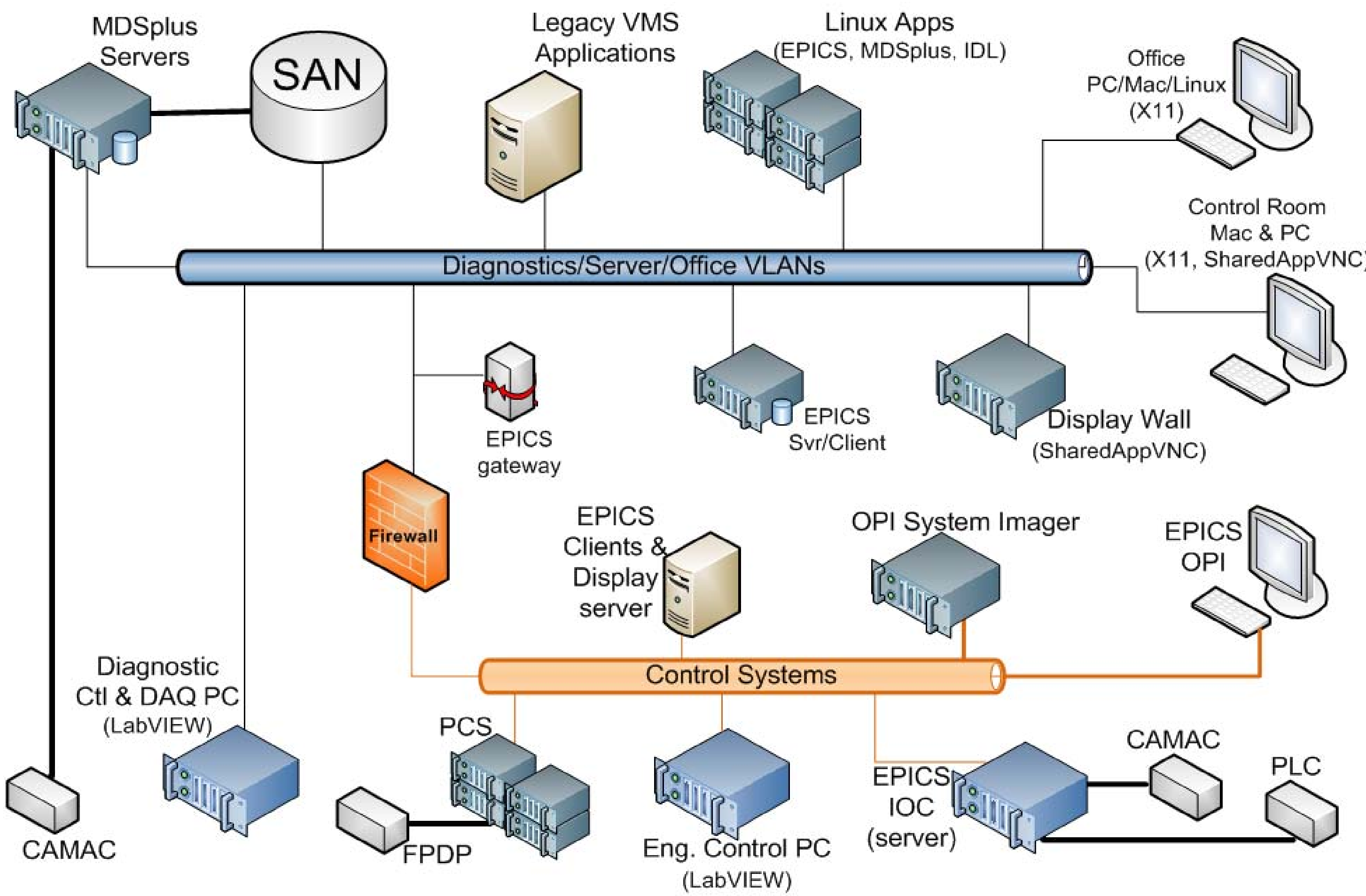
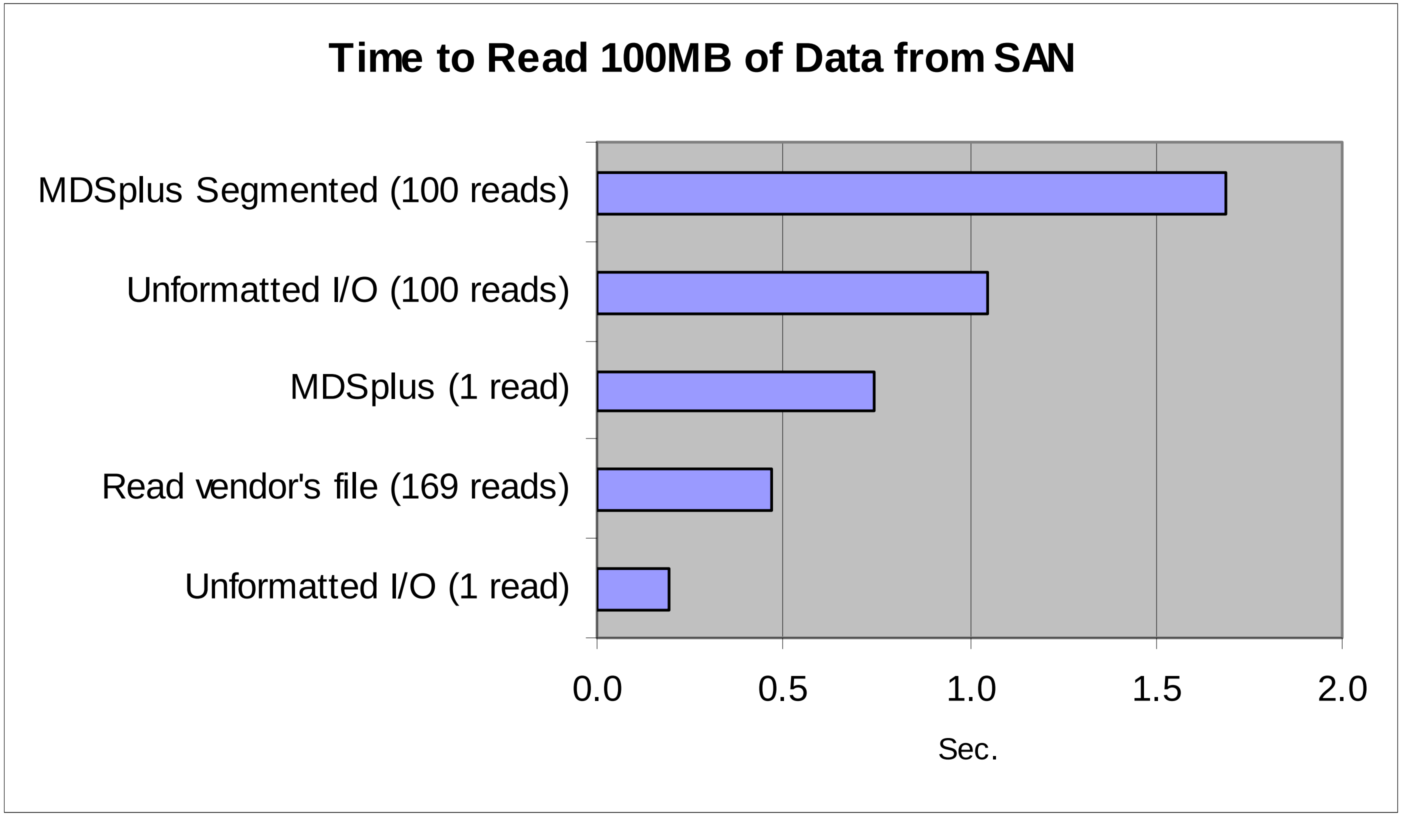


Fig. 1 Simplified depiction of NSTX Computing system The diagram indicates the principal scientific software that runs on the computer.

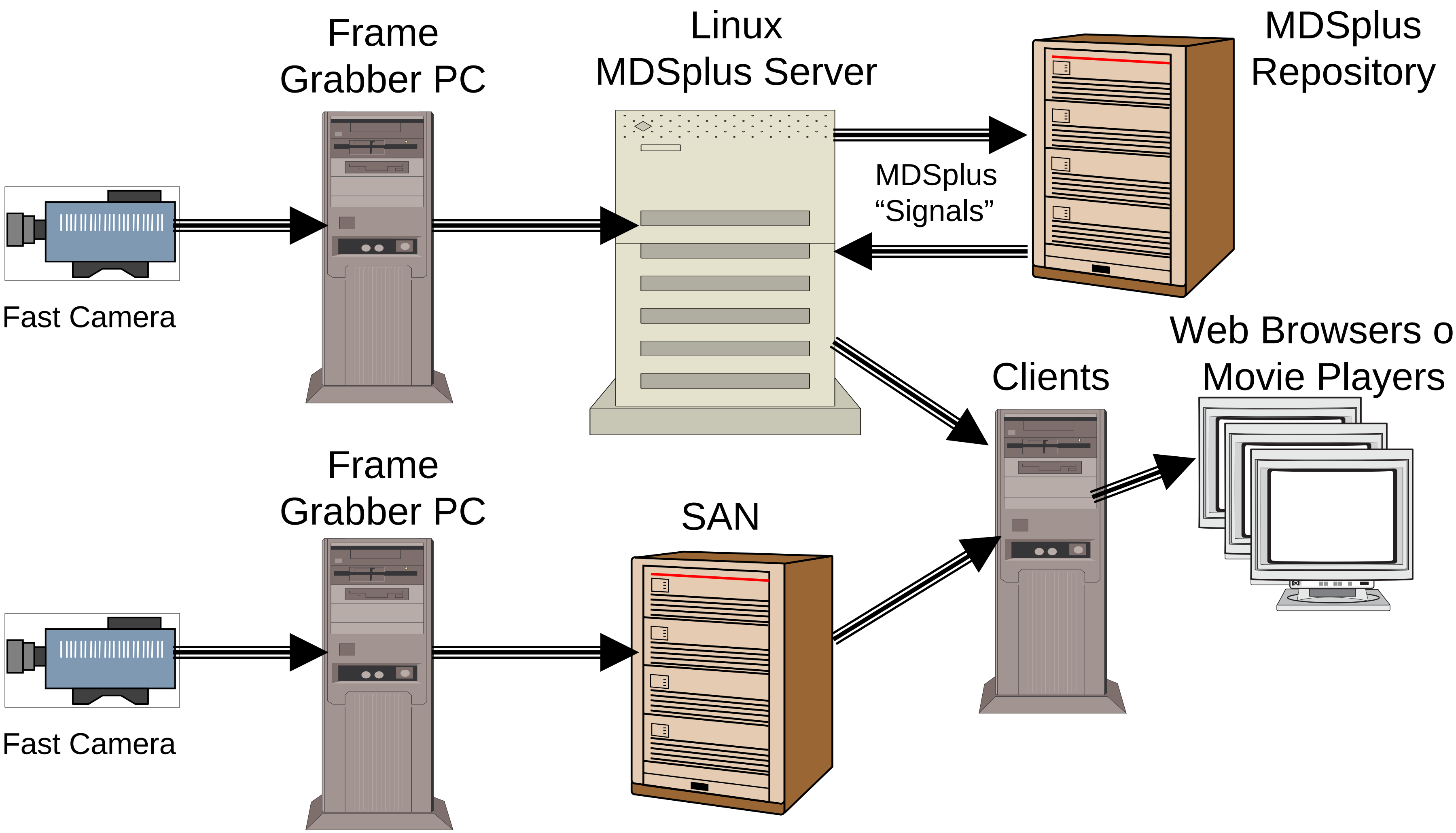
•From P. Sichta, SOFE, 2009

Times to read 100MB of data

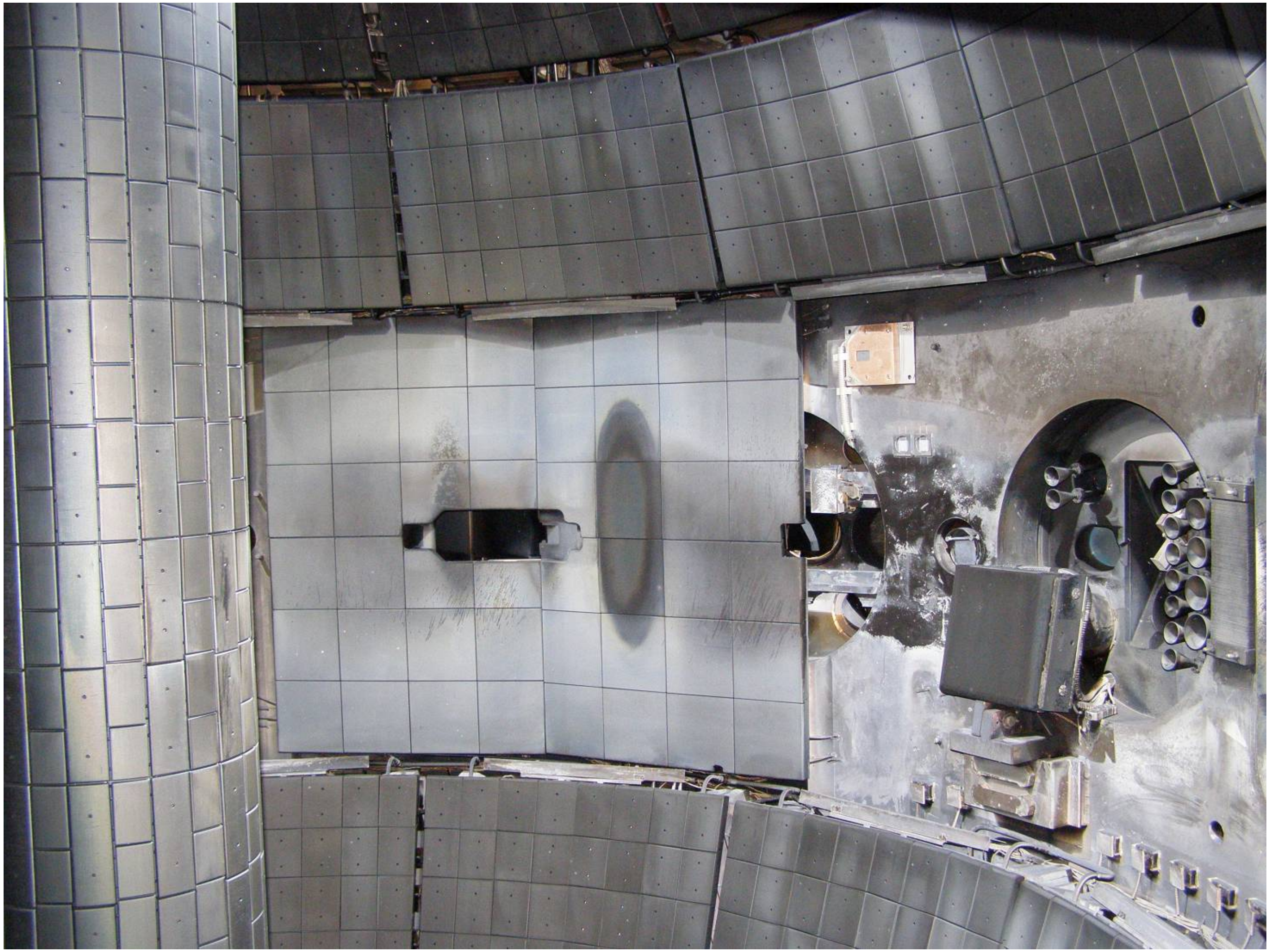


- *Run on an 2.60 GHz, 8-processor Linux computer with 10GB of memory*
- *Writing to SAN disks via 1GB/s fibre channel; no TCP/IP connections involved*
- *All calls from IDL; "reads" means calls to read routines.*

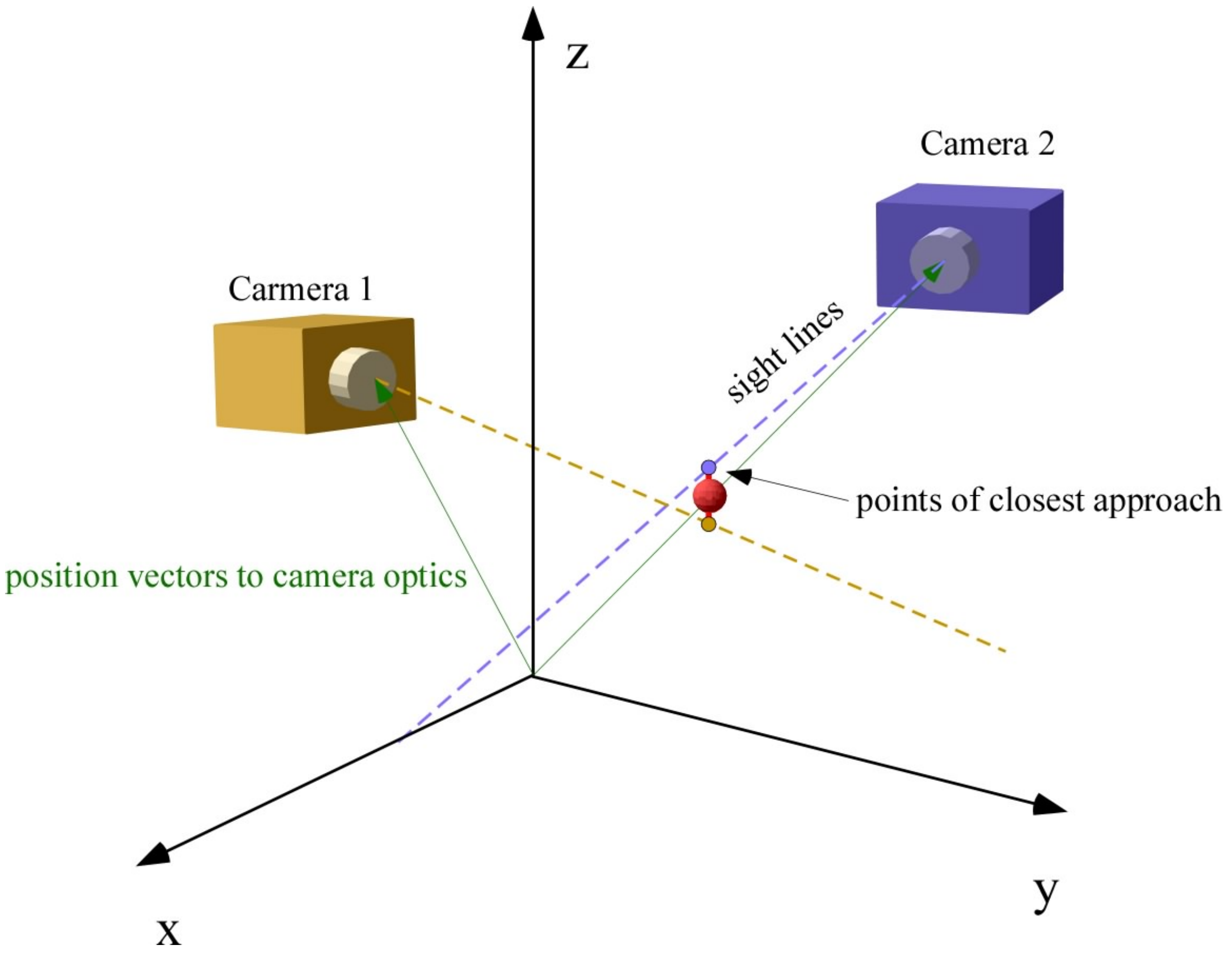
Fast 2-D Camera Data Acquisition
(some stored in MDSplus and some left as files)



Well-lit view of NSTX interior from camera port

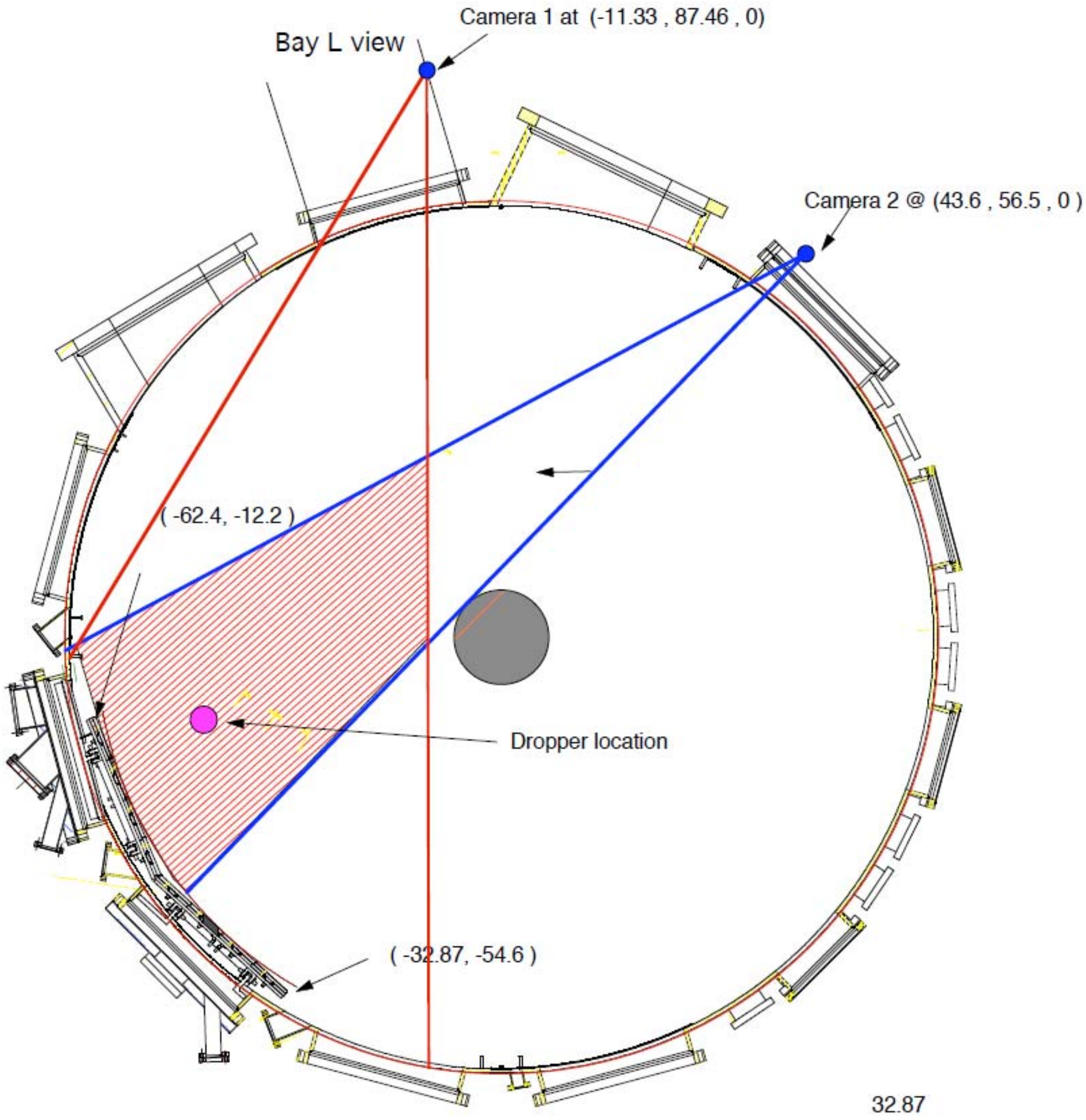


2 Cameras can be used to compute 3-D position

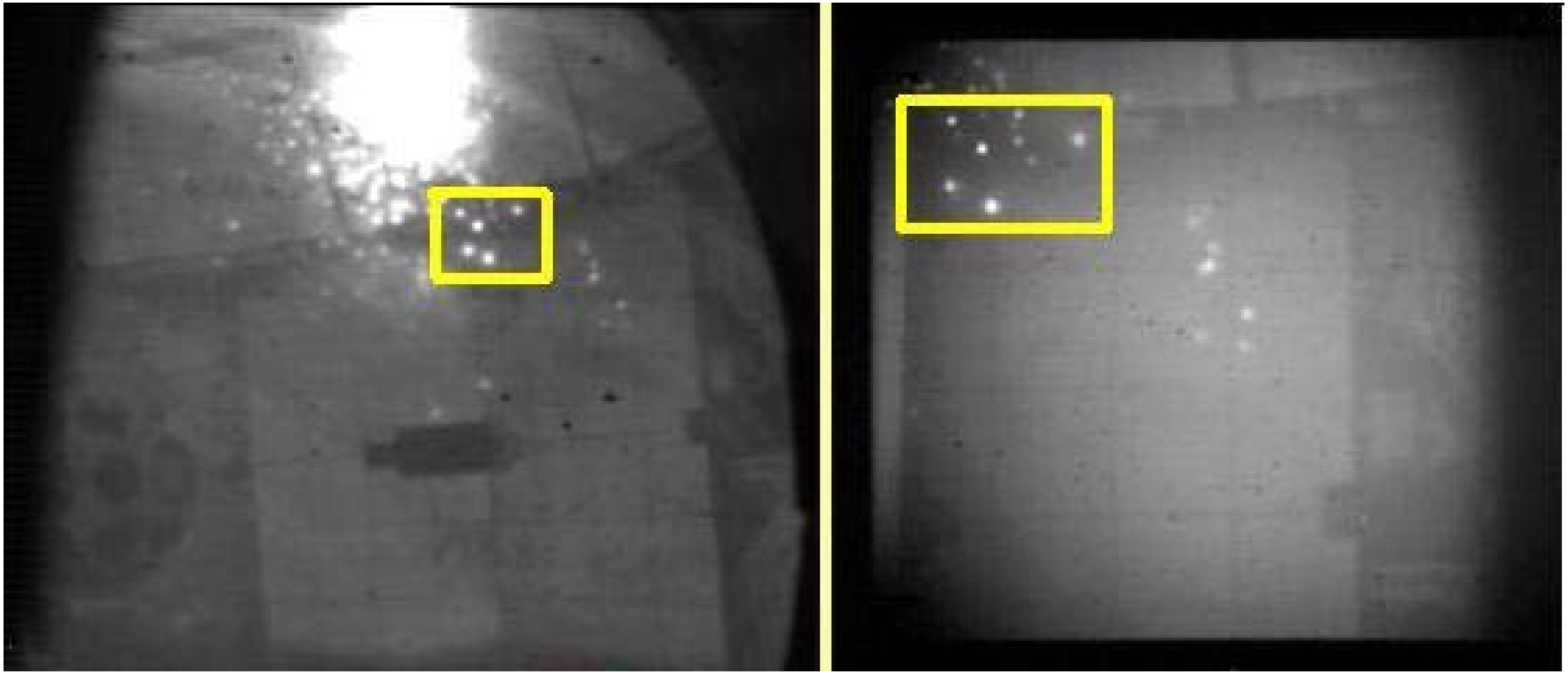


•*From W.U. Boeglin, A.L. Roquemore, R. Maqueda, Rev. of Sci. Instrum. 79 10F334 (OCT 2008).*

Views of 2 Fast Cameras on NSTX



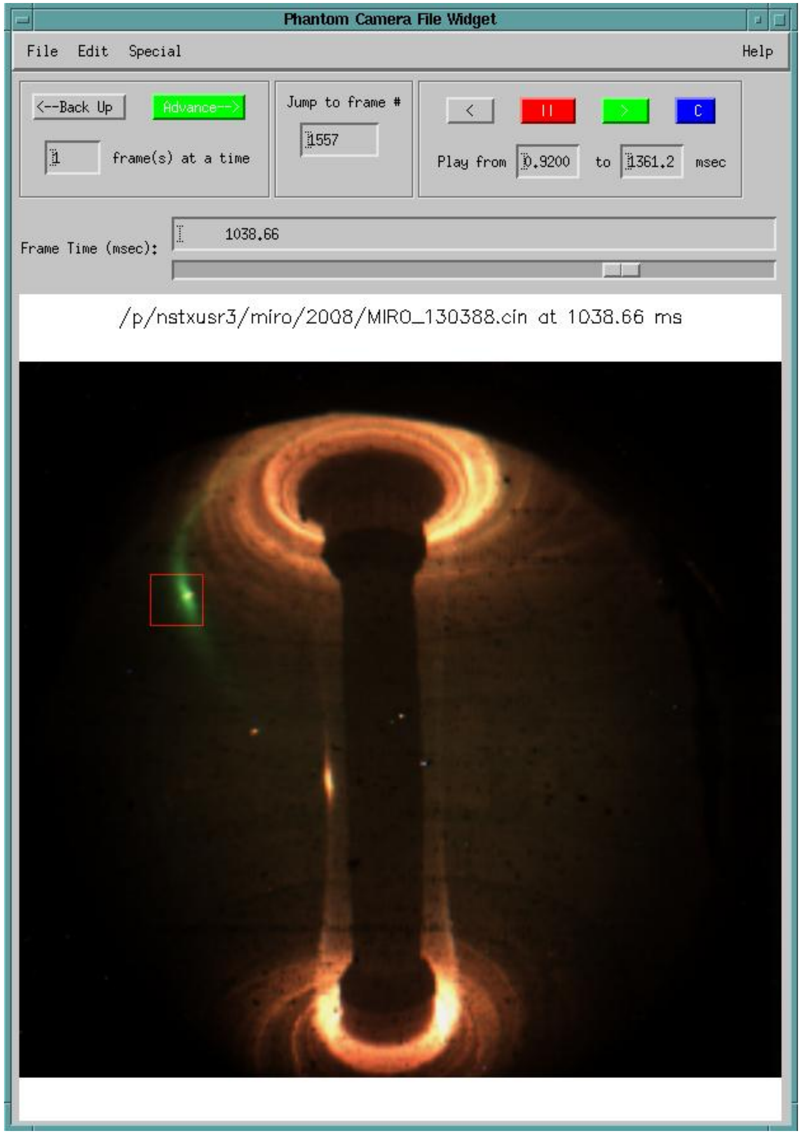
Lithium Dust viewed from 2 cameras



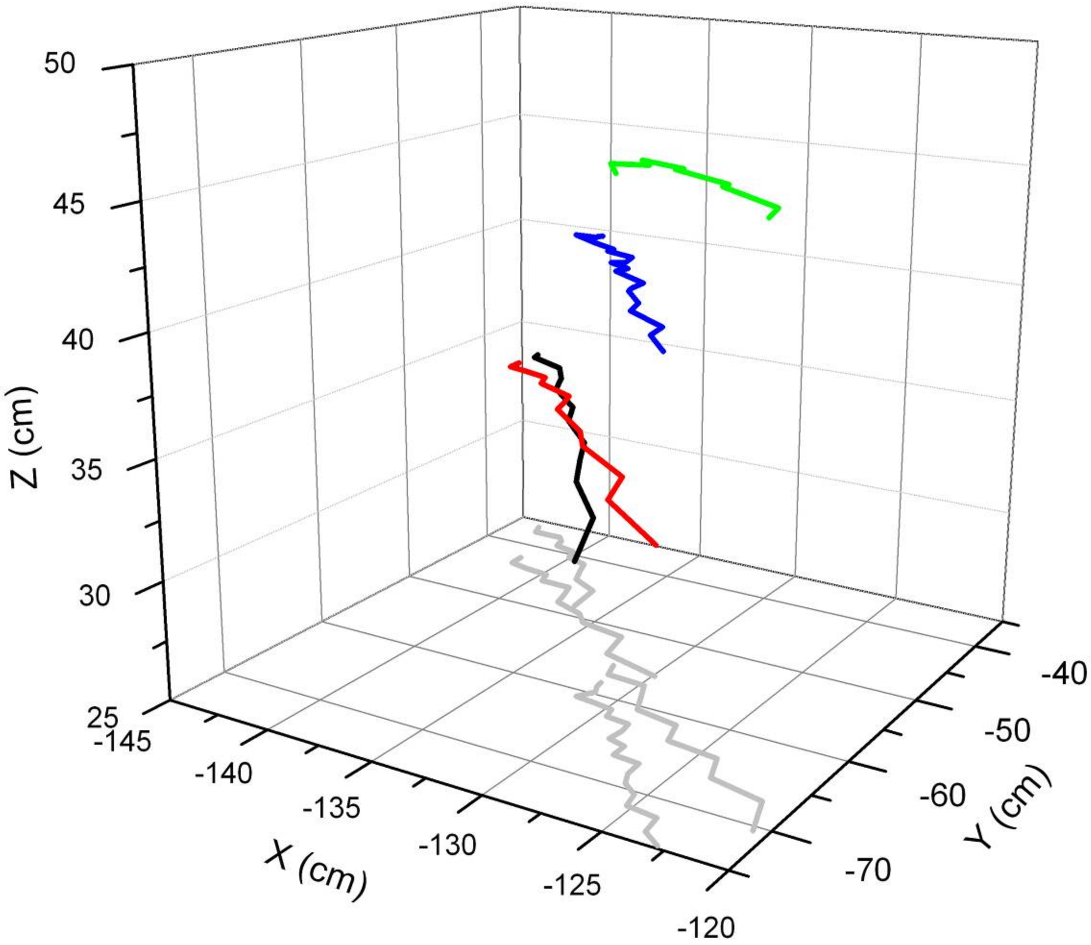
•**The squares enclose the same regions in both views**

(NSTX shot 130377, 722msec)

IDL application for displaying Fast Camera output and for tracking particle positions

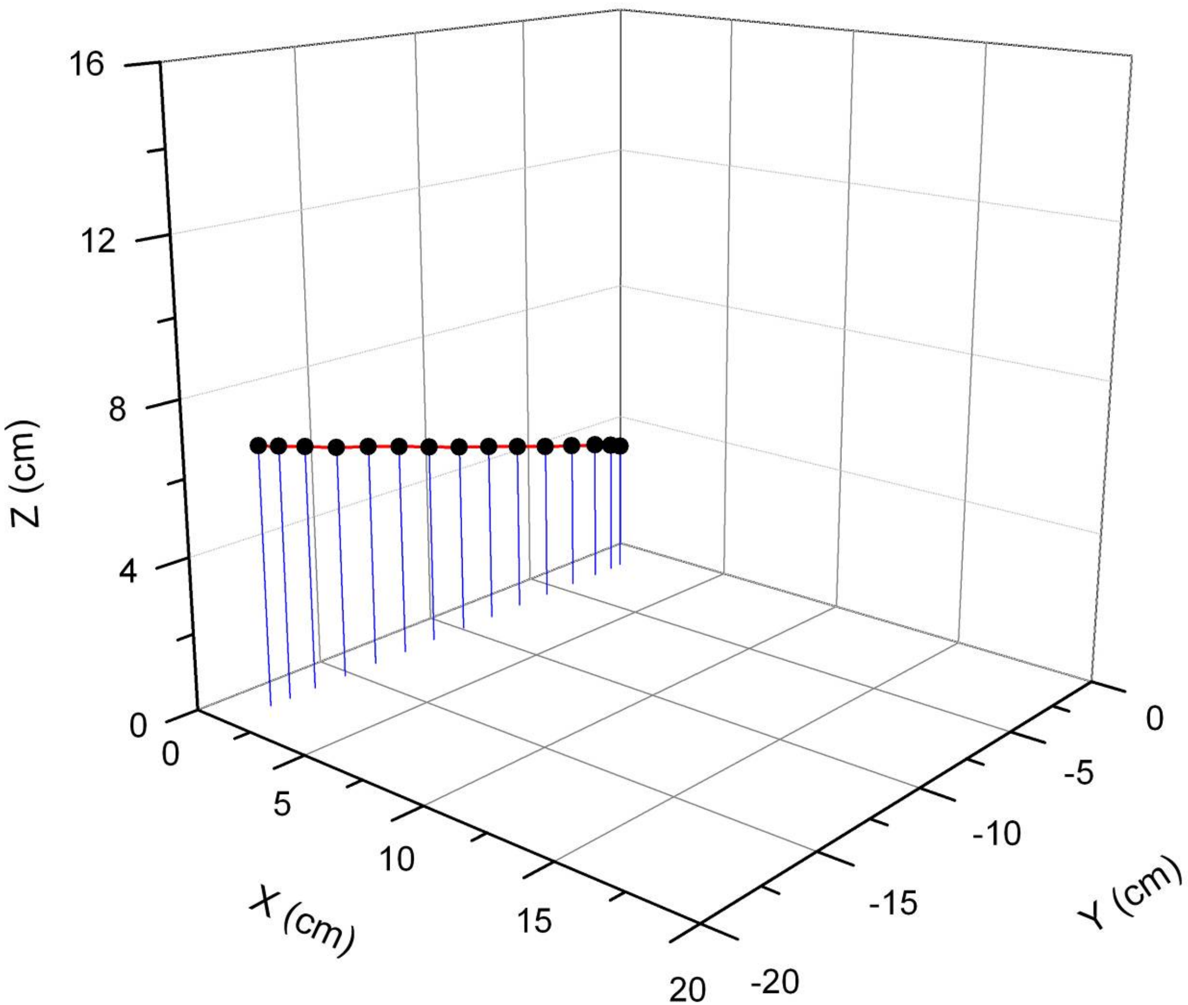


Calculated dust particle positions plotted in 3-D



Setup to capture data from 2 cameras to validate 3-D position calculations

Calculations are validated for ball rolled against wall



Summary

- Fast 2-D cameras are <u>excellent sources of information</u> for operating a fusion experiment and for understanding important internal processes in plasmas.
- <u>Data loads</u> can easily be several times the size of all other pulse-data combined on NSTX.
- Fast Camera data is a challenging to acquire, store, and retrieve efficiently, as well as for developing new analysis methods.
- Improvements to widely-used data storage standards, such as compression methods optimized for plasma video data, would be cost effective.

•This work was supported by DOE Contract DE-AC02-09CH11466.

References

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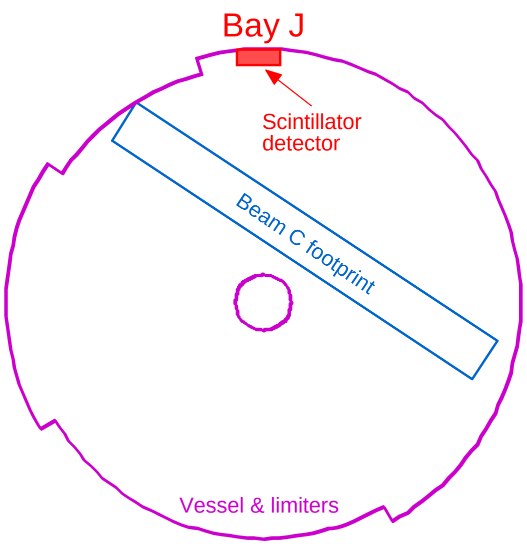
Backup Slides follow

MDSplus Nodes for Fast 2-D Camera Data

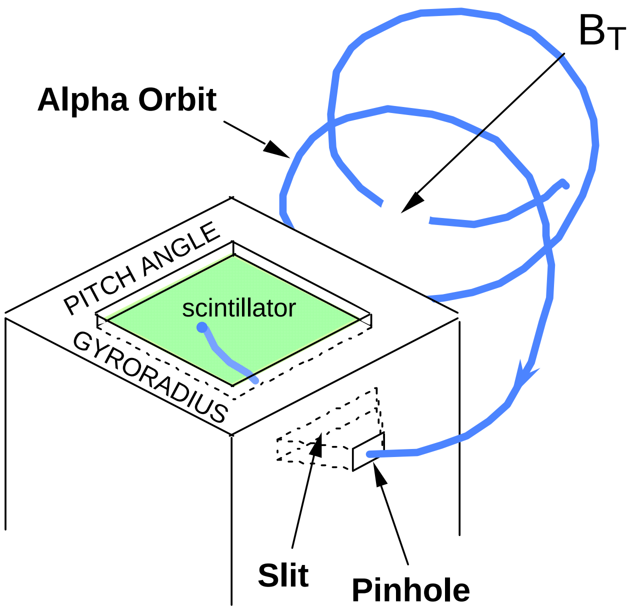
Required:	Frames	Signal	3-D Signal [x,y,t] with axes and units specified
	Frame_rate	Numeric	(int) frames per second
	Exposure	Numeric	(float) seconds shutter open for a frame
	Xpixels	Numeric	(int) # of horizontal pixels
	Ypixels	Numeric	(int) # of vertical pixels
	Nframes	Numeric	(int) # of frames
	Description	Text	text describing diagnostic, location, etc.
	Camera_type	Text	text with camera type, e.g., "Phantom 7.3"
	Cognizant	Text	Person who knows about this system
If Relevant:	Trigger_time	Numeric	(float) seconds after T0 when capture triggered
	Filter	Text	description of filter in place
	Gain	Numeric	(float) # to divide into values
	Offset	Numeric	(float) # to subtract from values
	Npretrigger	Numeric	(int) # of frames taken before trigger
	VersionInfo	Text	desciption of any version information
	Dark_image	Numeric	a 2-D array (or pointer) for background subtraction
	Gamma	Numeric	(float) gamma correction (between 0.0-1.0)
	Thumbnails	Signal	3-D signal of reduced size and/or rate

Scintillator beam ion loss probe is magnetic spectrometer

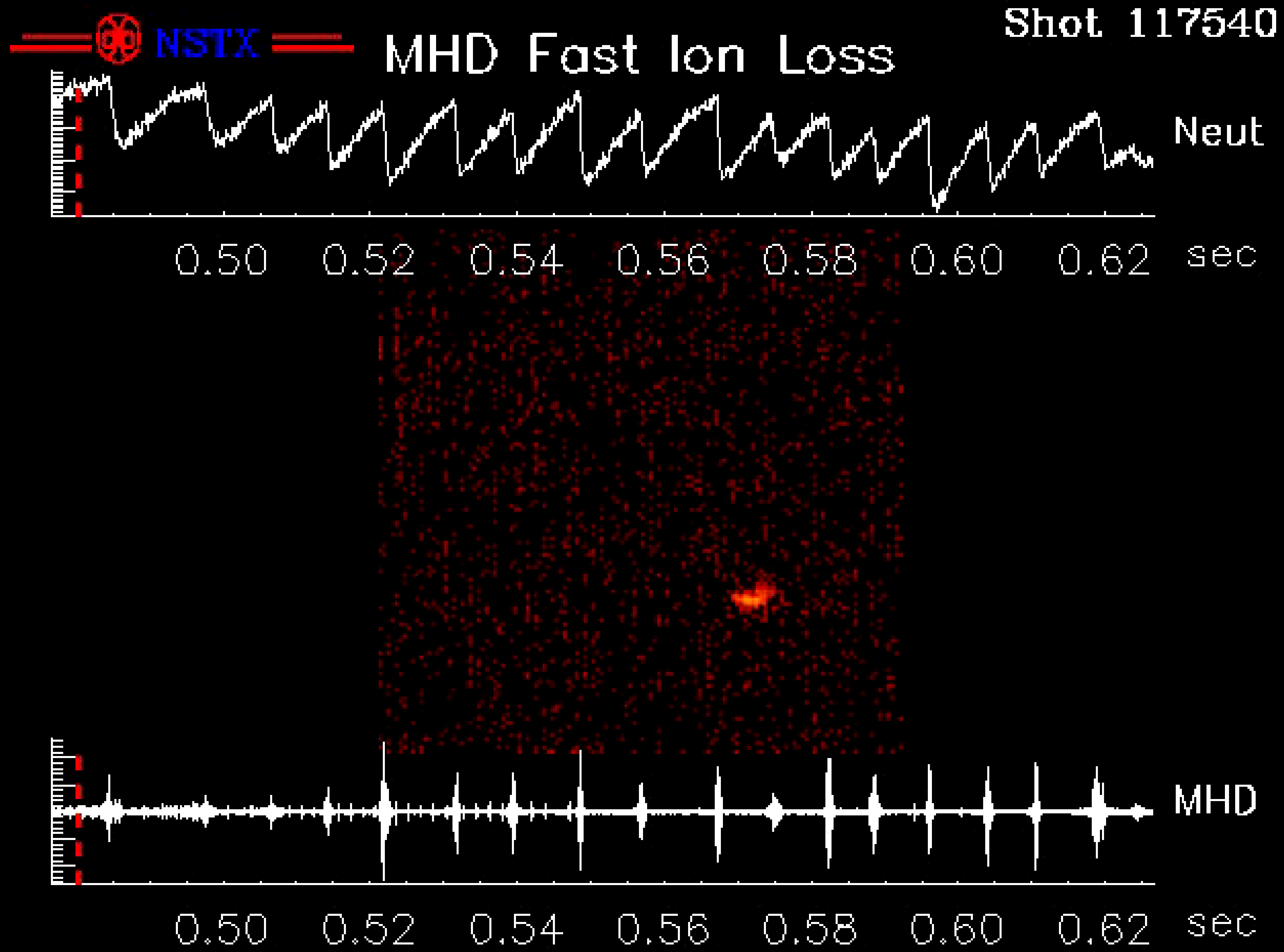
- Combination of B and aperture geometry disperse different pitch angles and energies on scintillator plate



NSTX Midplane



Scintillator detector: principle of operation



NSTX
MHD Fast Ion Loss
Shot 117540
Neut
0.50 0.52 0.54 0.56 0.58 0.60 0.62 sec
MHD
0.50 0.52 0.54 0.56 0.58 0.60 0.62 sec