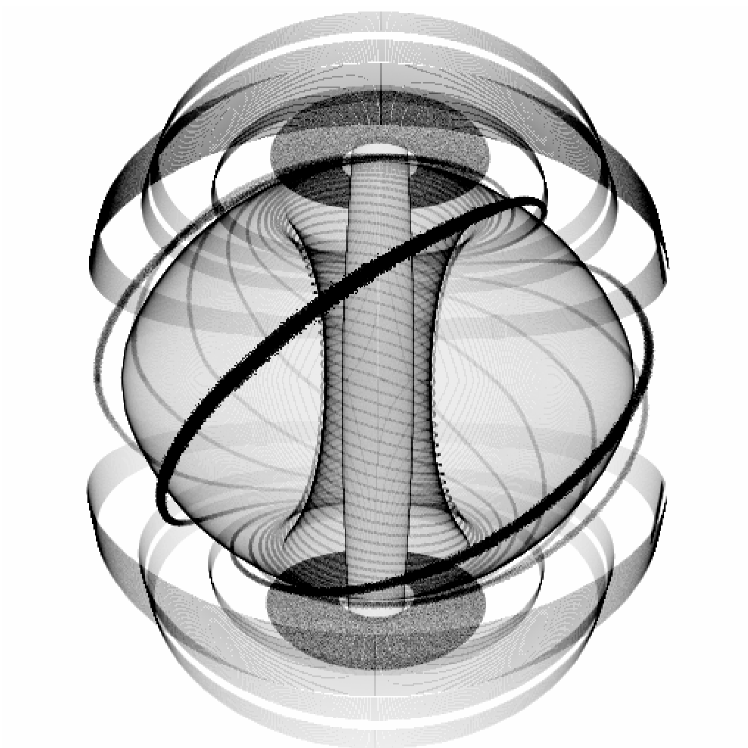
PPPL 22 Feb 2006

MAST Update

Brian Lloyd
For the MAST Team



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MAST Status

Engineering Break started 11 Nov 2005

- completed on schedule
- operations resumed early Feb

Sliding joint maintenance

- Inspection of upper sliding joints showed some wear
- All 24 upper joints were refurbished
  - initial resistance measurements good

Mini vacuum break

- Minor flange changes, window changes etc.
- Completed and pumped down before Christmas
- Base pressure ~ 2 x 10^{-8} mbar
- Extensive He g.d.c. and conditioning discharges; no high temp. bake
- Ohmic H-modes established prior to boronisation

Vacuum break activities

Removed tangential SXR (Sector 2)

Installed compact NPA adaptor and gate valve (Sector 4)

Installed two new filaments for breakdown (Sector 10)

Replaced viewing windows on Sector 11 and Sector 12 (DIVCAM)

Replaced (cleaned) CXRS windows (Sector 7 & 9)

Removed Fast Ion Gauge and installed gate valve (Sector 9)

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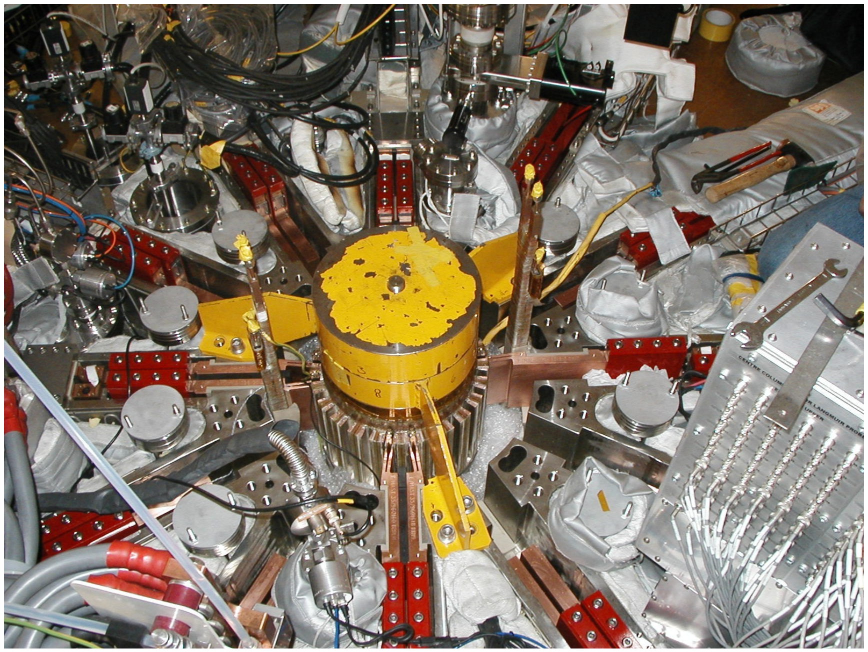
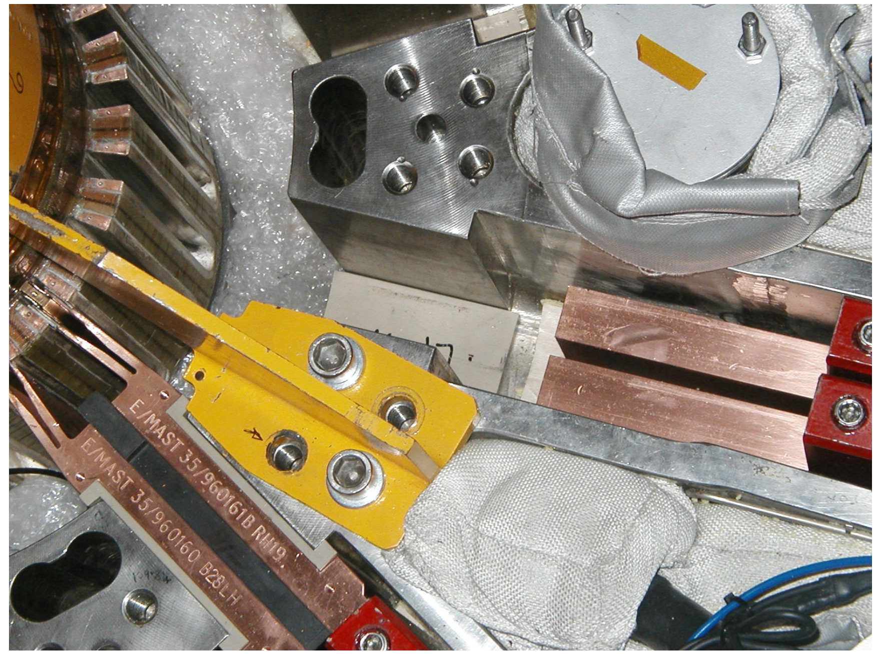
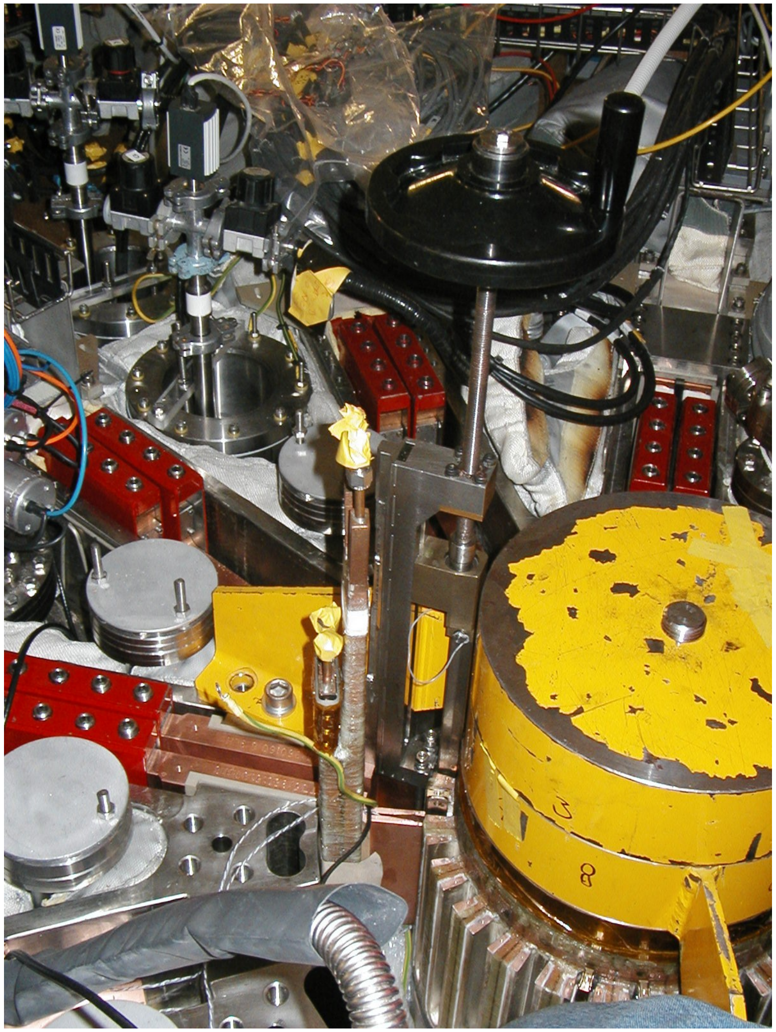
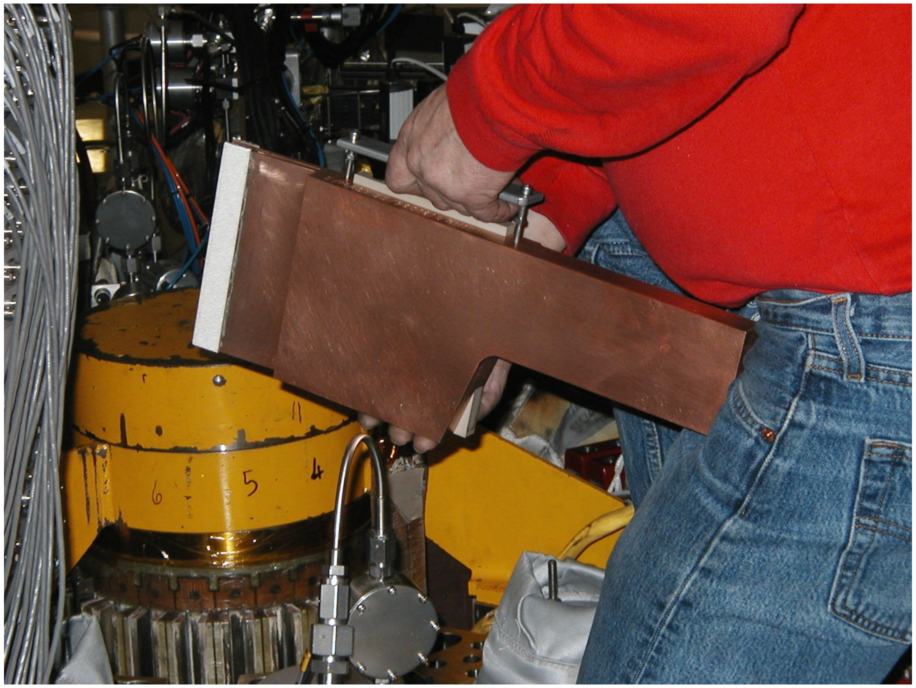
Sliding joint maintenance





Sliding joint maintenance





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MFPS fault

Power supply for P5 vertical field coils (650V, 18kA)

Failure of bolted power connection on 14 Feb between two aluminium heat sinks

Power arc engulfed two p.c.b.s used for thyrister firing

Resulting high voltages transmitted back to control cubicle

Damage assessment still ongoing but replacement of components well underway

Expect at least 3 week delay to programme

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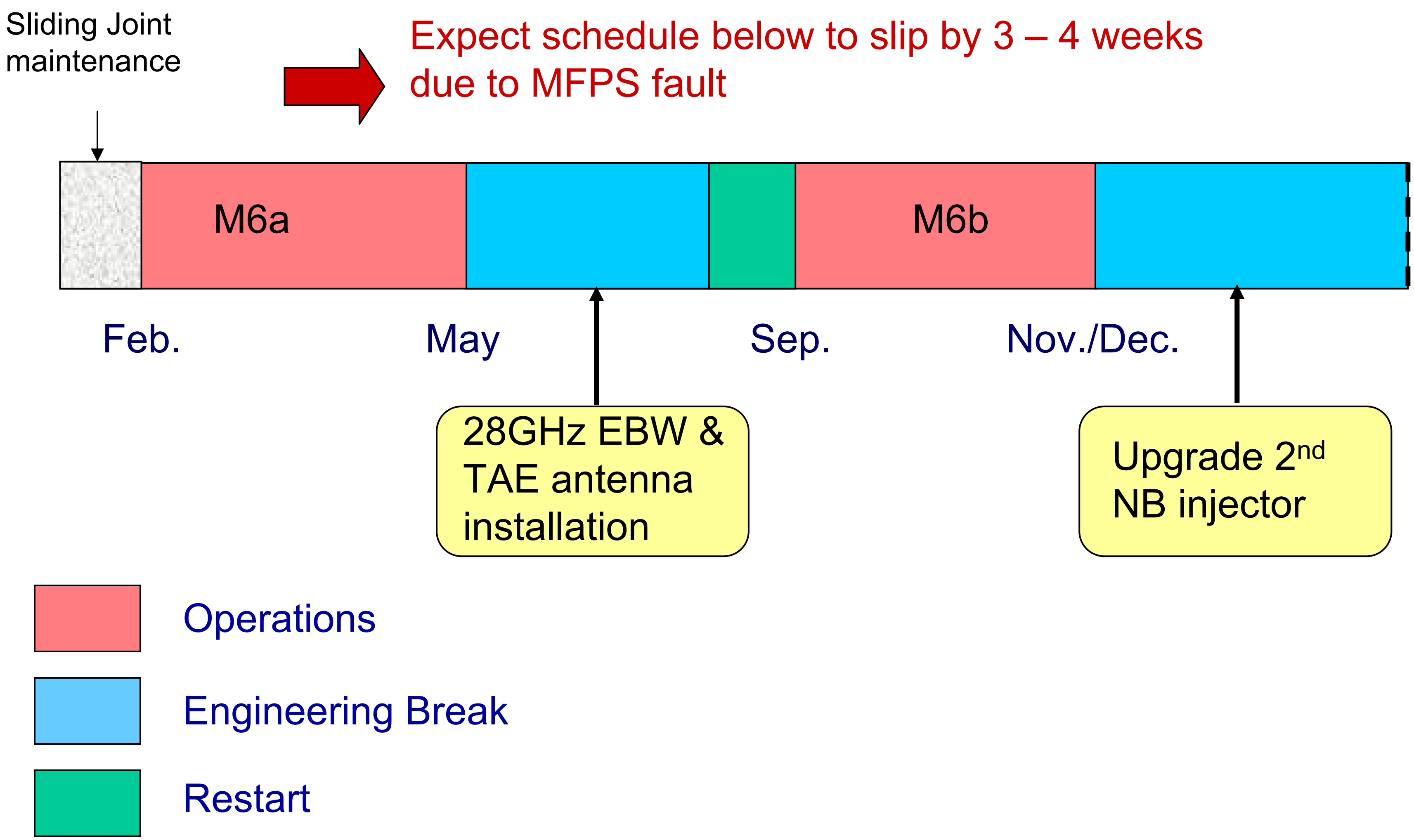
Operating Schedule 2006



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New capabilities: Plant & Operations

- New long pulse NBI
  JET PINI source, 2.5 MW for up to 5s, beam notching.

- Active TAE antenna
  3 coils in 2006 (12 planned)
  designed for high current (possible ELM control capability)

- 28 GHz EBW start-up system
  $\leq$ 200 kW for 40 ms

- Improved control capabilities
  Optical feedback of outer radius
  Improved active vertical feedback
  Density feedback
  Commissioning of rtEFIT

NBI Status

SW NBI – ORNL source
- OK. Readily operated at ~ 2MW after engineering break

S NBI – nearing the finishing line after major delays due mainly to problems upgrading the old power supplies.
3 power supply issues were outstanding at the beginning of the year (linked to arc notcher, HV regulator, crowbar stack)
- ‘arc notcher’ and crowbar stack now commissioned
- HV regulator problem (protection circuitry) resolved, just need to test at full voltage
- about to do PINI breakdown simulation tests then ready to apply HV to source and extract beam
- barring further problems expect high power operation into plasma in April

Plan to procure two new power supply systems for NBI

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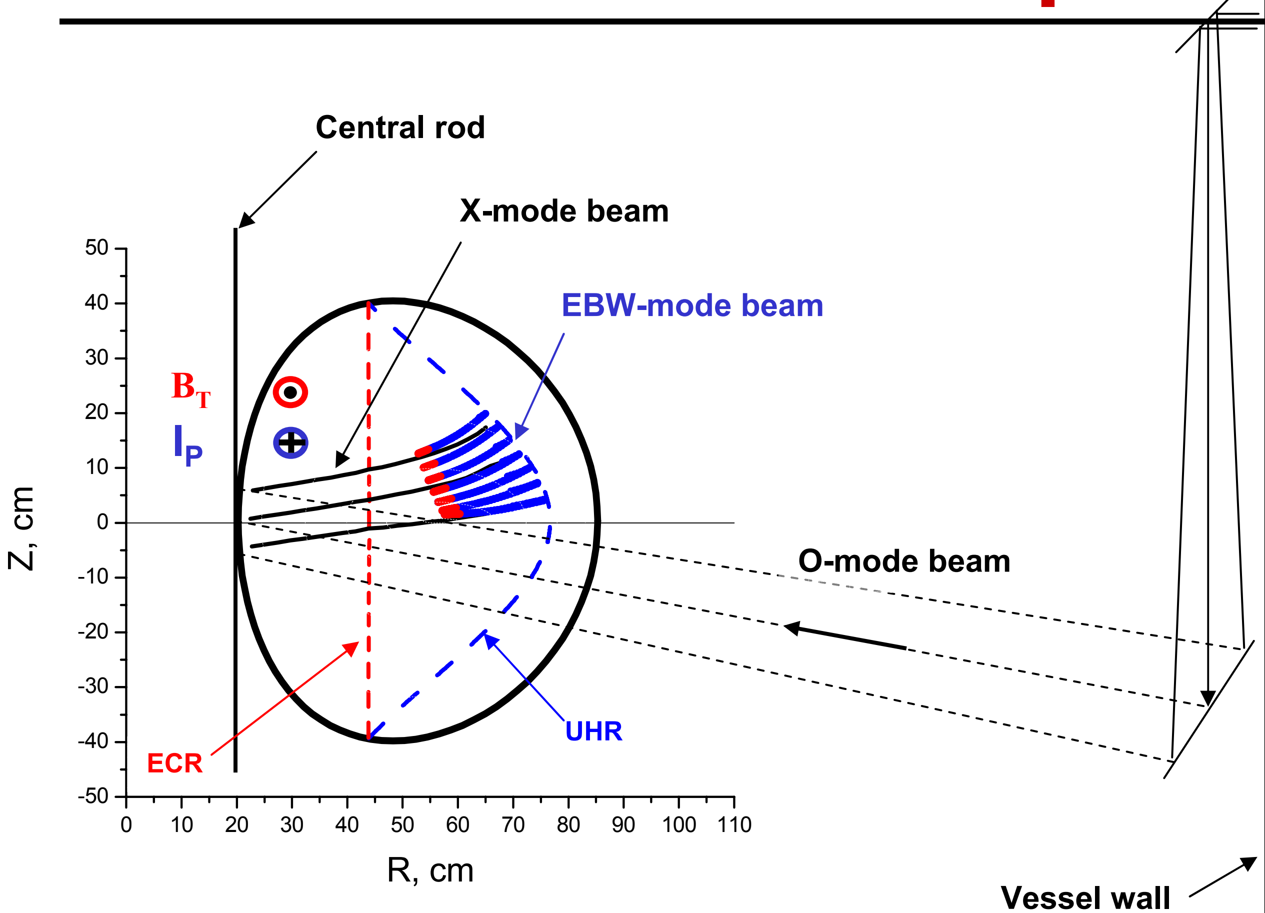
EBW CD Start-up Scenario



28GHz antenna in test area

Implementing 28GHz start-up system
Centre column tile modified to act as polarizer/reflector

Vladimir Shevchenko

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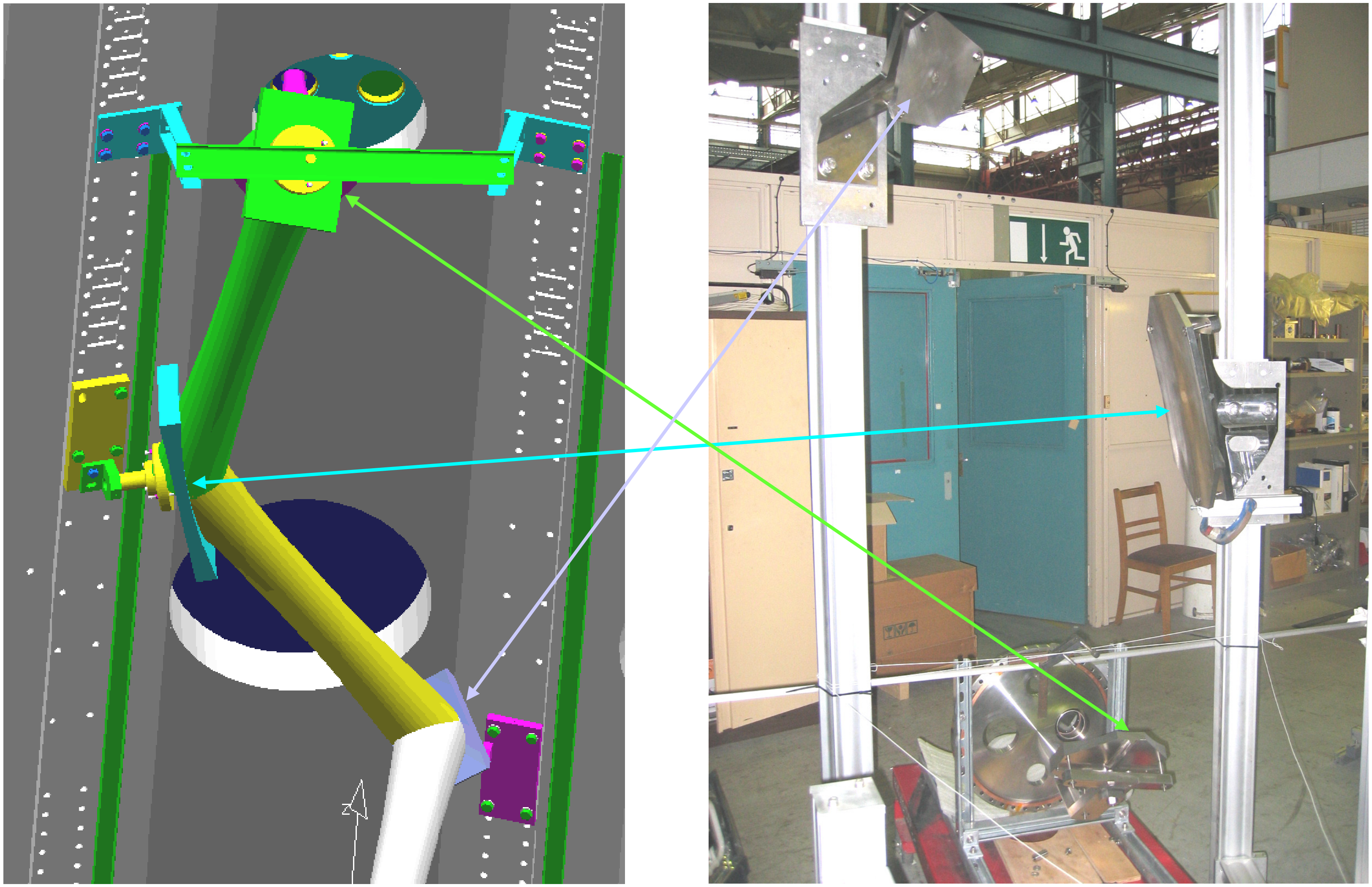
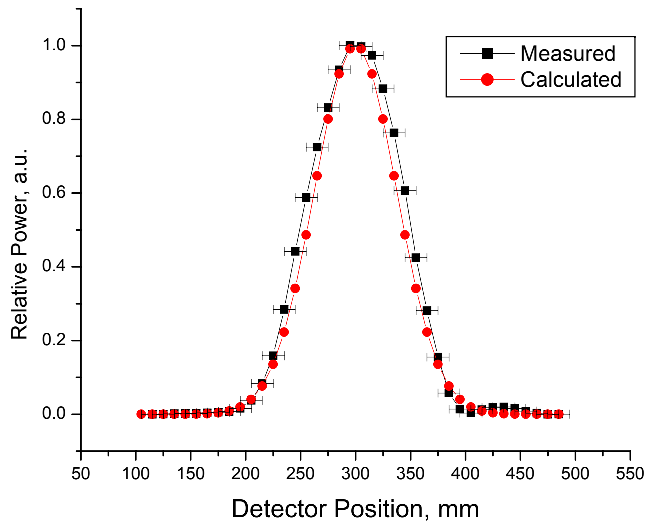
28 GHz Antenna Assembly in RF Test Area



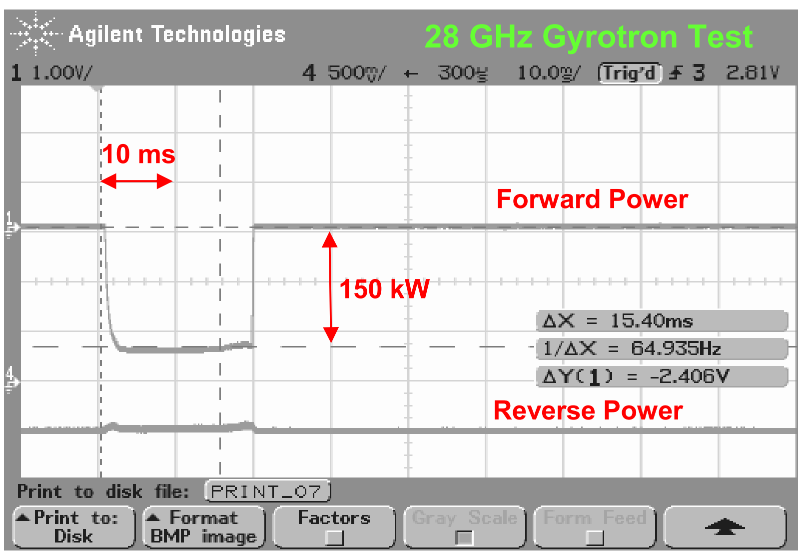
In-vessel mirrors of the 28 GHz launcher

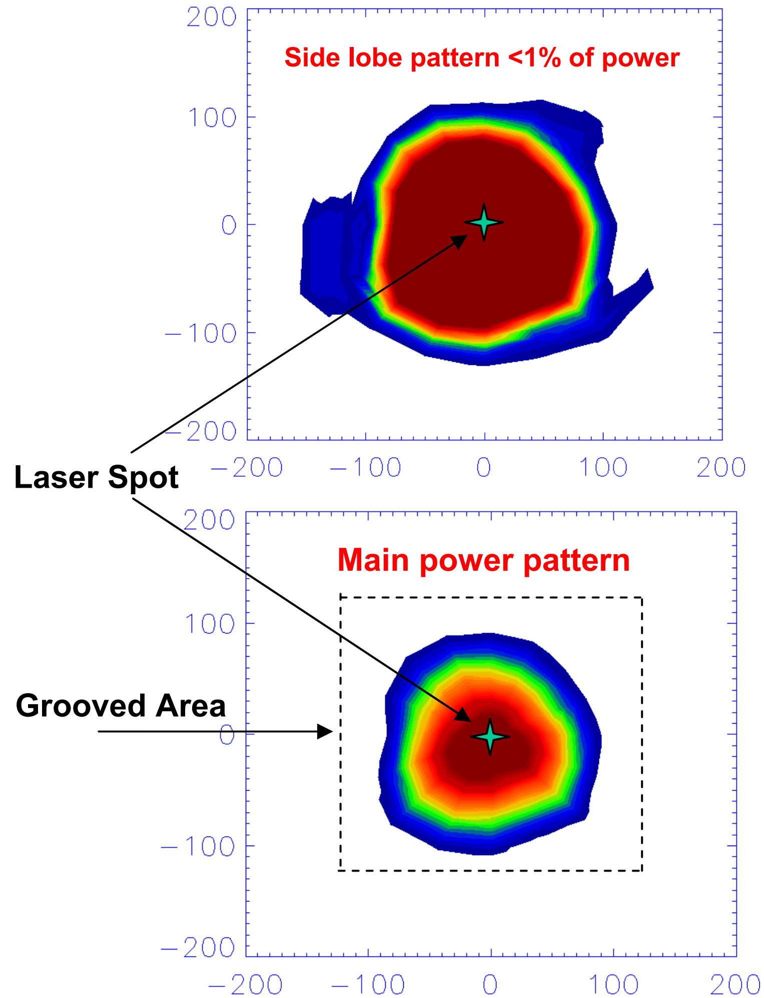
Mock-up assembly of the launcher (upside-down)

28 GHz Test Results



Beam cross-section (low power) measured at the central rod in comparison with quasioptical model





RF beam pattern in millimetres measured at the central rod in comparison with the grooved mirror area

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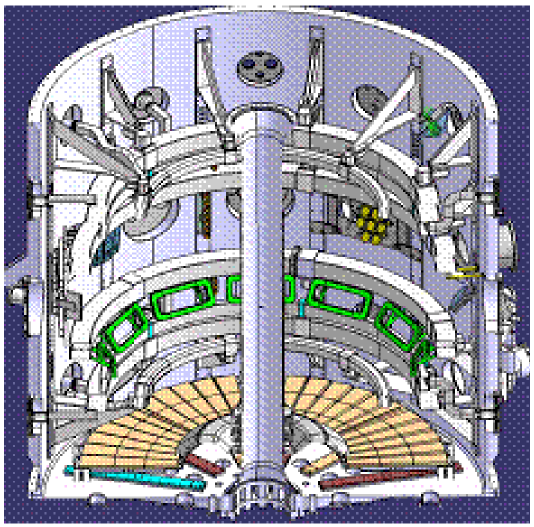
(P_{max} = 169kW for 10ms into calorimeter; max. pulse length 40ms))

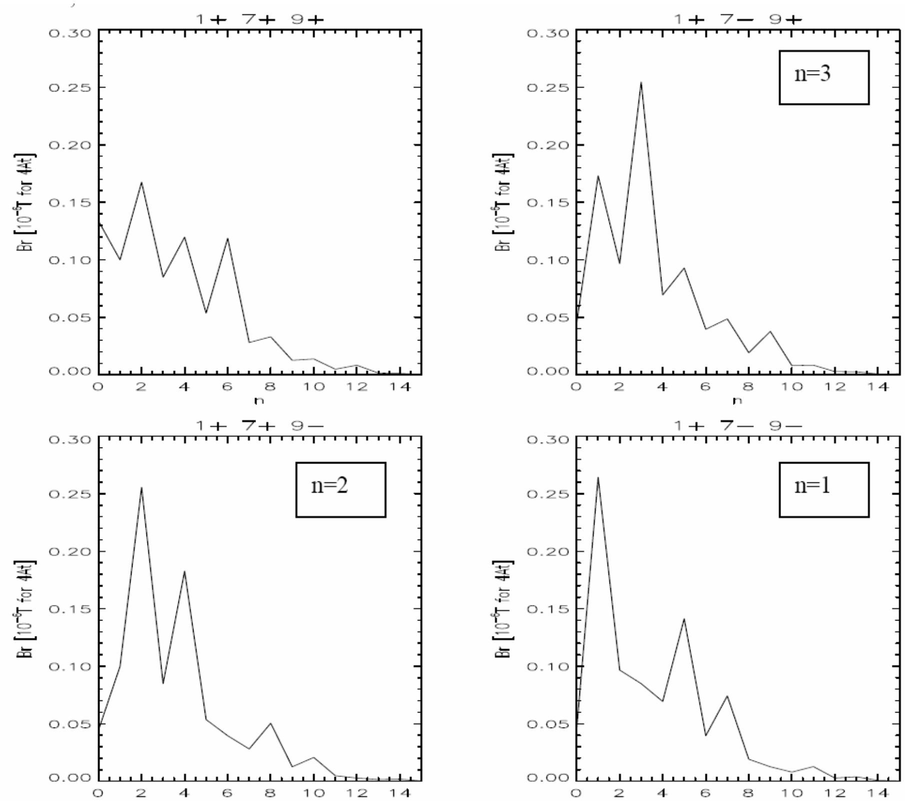
Active TAE antenna

- 12 x 4-turn coils (3 coils will be installed at first stage)
- Frequency range: 0 – 0.5MHz
- Maximum current: 1kA



TAE antenna in MAST

Spectrum produced by different combinations of 3 coils



- Unique measurements of TAE mode damping in the presence of super-Alfvénic NBI
- Study of AEs over a broad range of β-values
- Antenna design allows edge *n* = *3* perturbation for ELM mitigation

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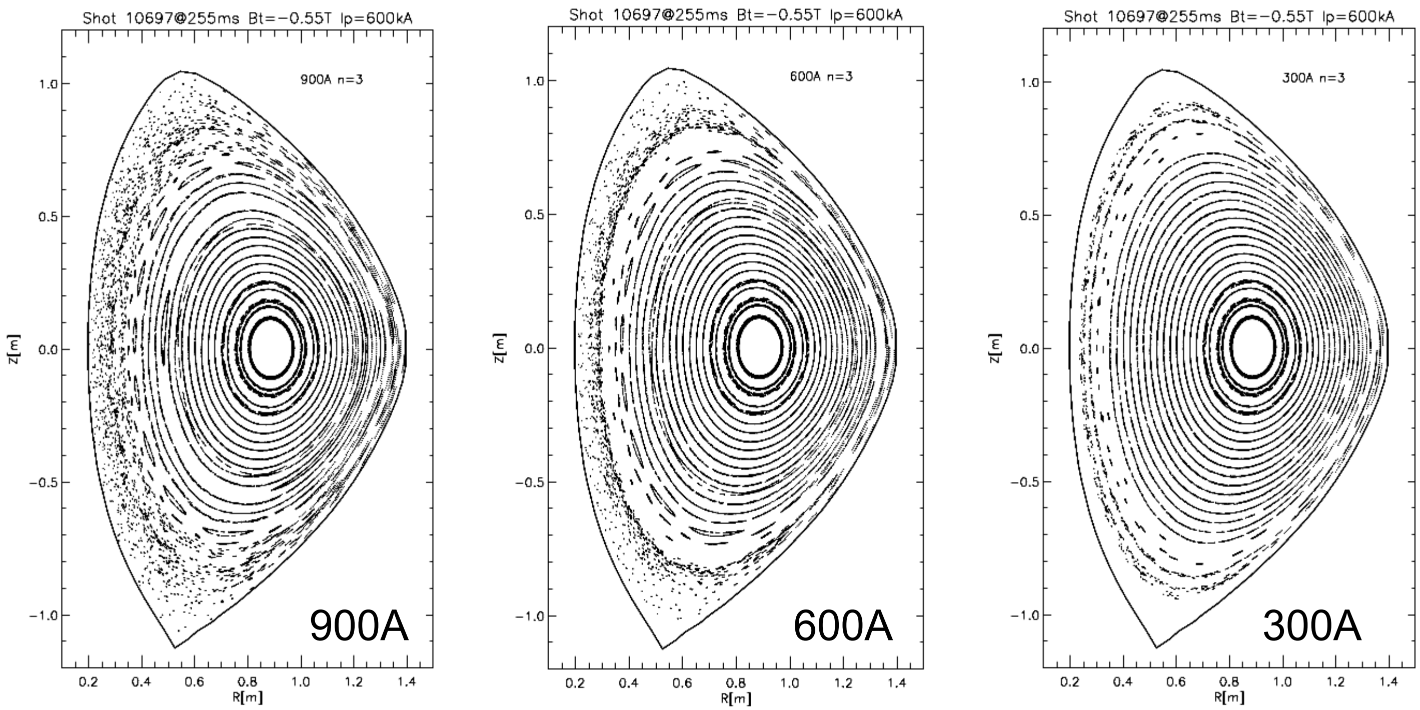
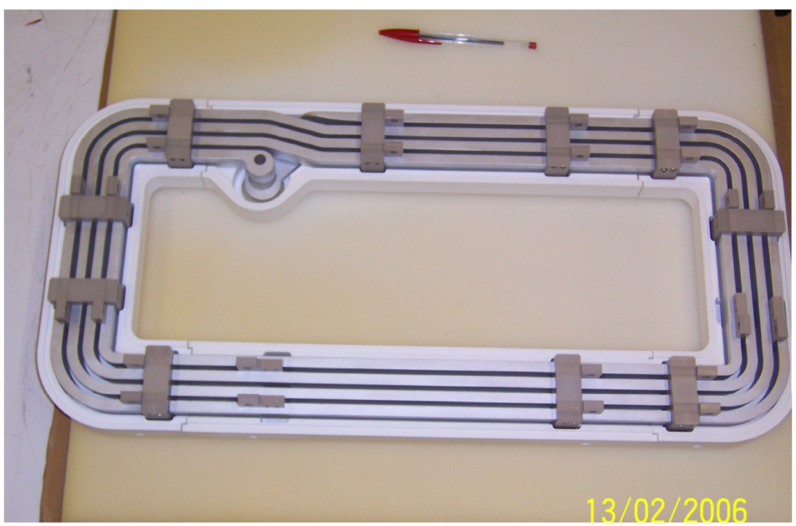
Edge ergodisation





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New capabilities: Diagnostics

- CXRS improvements
  New CCD camera & spectrometer (224 chords) commissioned in 2005
  64 toroidal + 32 poloidal views per beam + background chords
- Edge Thomson scattering improvements
  16 additional edge channels (Nd:YAG) + lower T_e measurement capability (Ruby)
- Edge Doppler spectroscopy (semi active on He II)
  New edge poloidal and toroidal views (up to 120 chords), $\Delta R \leq 4$ mm … 7 mm
- Multi-wavelength narrow bandwidth 2D imaging systems
  BES; Divertor camera (DIVCAM)
- New edge probes commissioned Oct 2005
  Gundestrup probe (able to distinguish || and ⊥ SOL flows); materials probe
- Prototype MSE system
  2(16) chords
- Tilted spinning mirror EBW emission
  Angular distribution of EBW emission, multiple frequencies.

+ …………………

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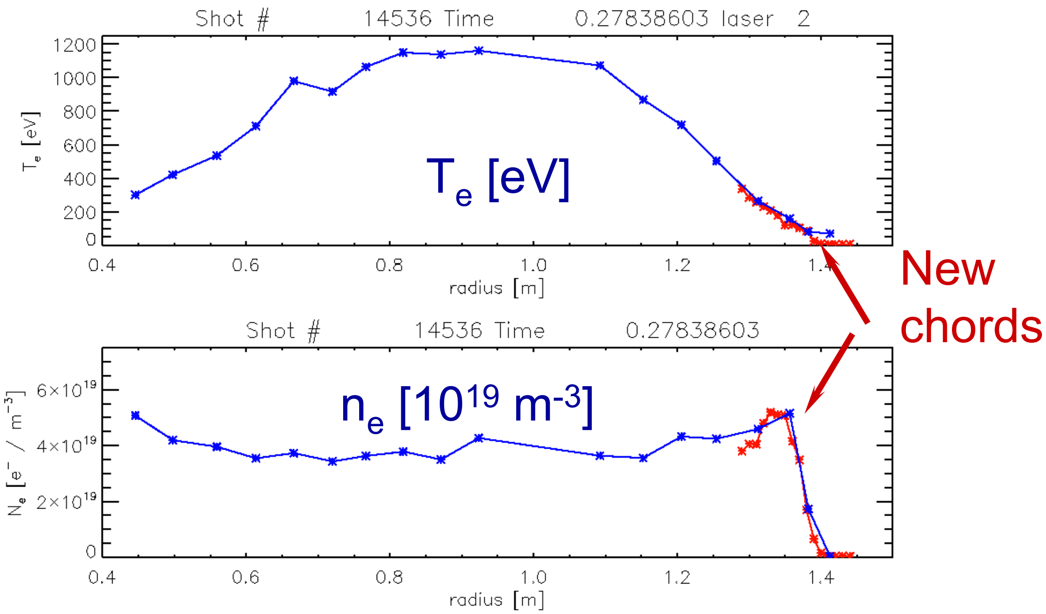
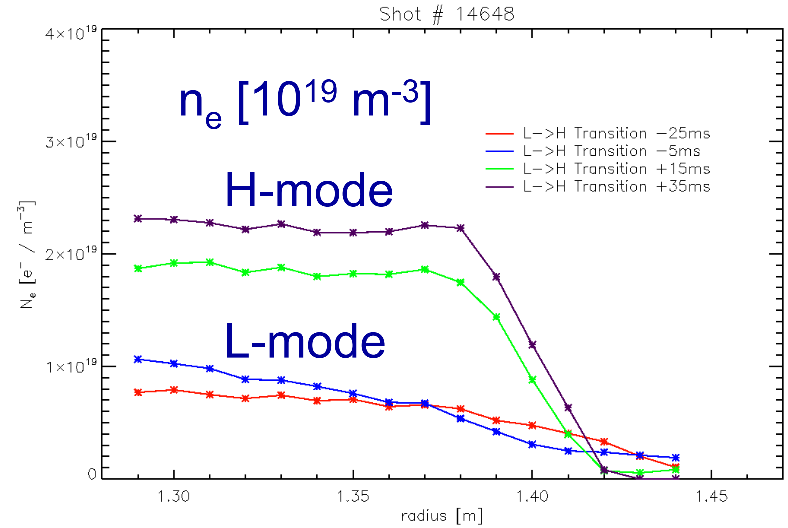
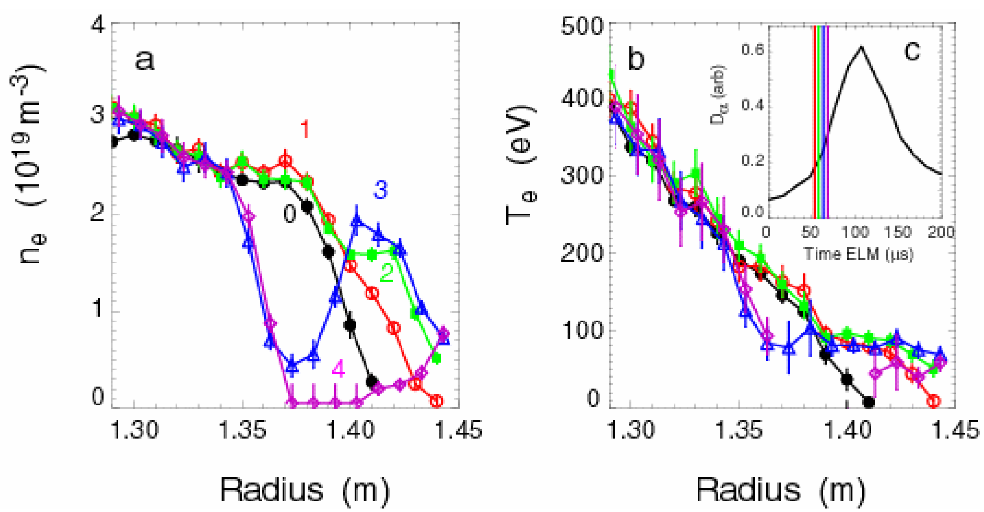
Nd:YAG Edge Thomson Scattering





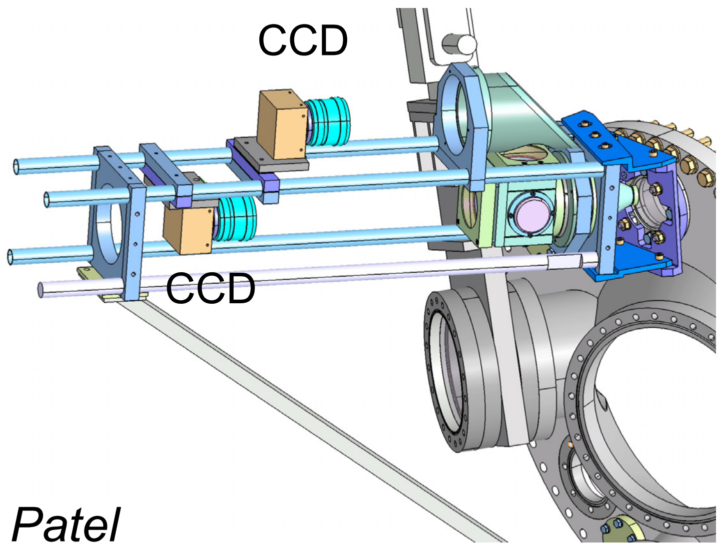


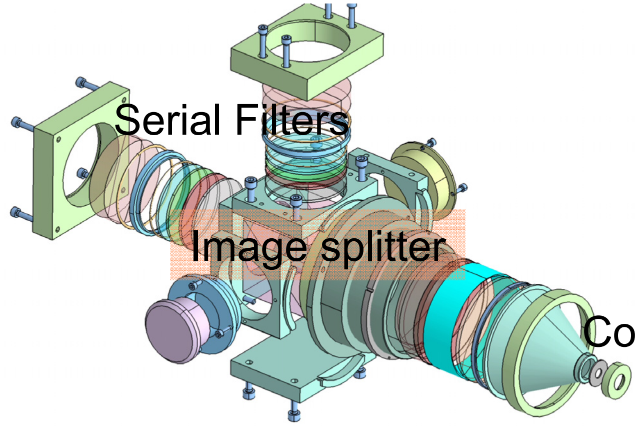
- 4 Lasers at 50 Hz ($\Delta t = 5$ ms)
  - Independent timing of lasers ($\Delta t \geq 5\mu s$)
- 16 spatial channels ($\Delta R \approx 1$ cm)

RGB system (2D imaging - 6 spectral bandpass)

Geometry: full plasma (50° FOV), off equator plane – both beams spatially resolved. VGA resolution (320x240, 320x480, 320x240) @ 210Hz

Channel #	Spectral band pass	Measurements	Parameter
1	BES (D_α 6588.5/30Å 40-75kV)	SW beam emission	SW BE (path,z,t)
2/3	blue/green channel	2xBremsstrahlung	Z_{eff}
1	D_α(6561/10Å)	edge D_α	2D LCFS
		SS beam emission	SS BE (path,z,t)
		(SW beam halo intensity)	
2	CVI(5297/25Å)	C CXRS	C density
3	HeII(4690.5/25Å)	He CXRS	He density





Ash Patel

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Compact NPA

On loan from IPP Greifswald

Basic parameters of CNPA-W

Energy range	0.8-80 keV (H), 0.8-40 keV (D)
Size	169 × 302 × 326 mm
Weight	42.5 kg
Stripping	Carbon foil (100 Angstrom)
Acceleration of secondary ions	+ 5 kV
Permanent magnets	NdFeB, B_r ~ 1 T
Number of energy channels	14 × 2 rows
Purpose	Measurements of thermal and suprathermal CX-fluxes (H and D – simultaneously)

Mikhail Turnyanskiy

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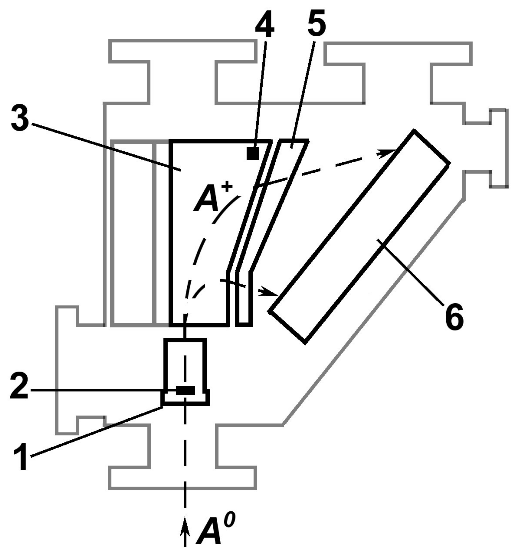
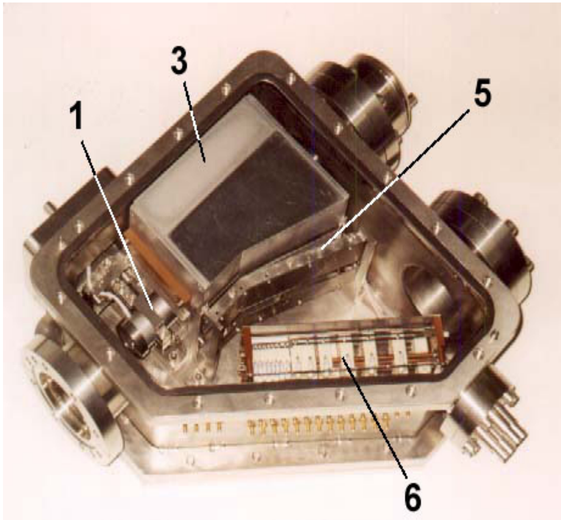
CNPA for Wendelstein 7X stellarator (CNPA-W)

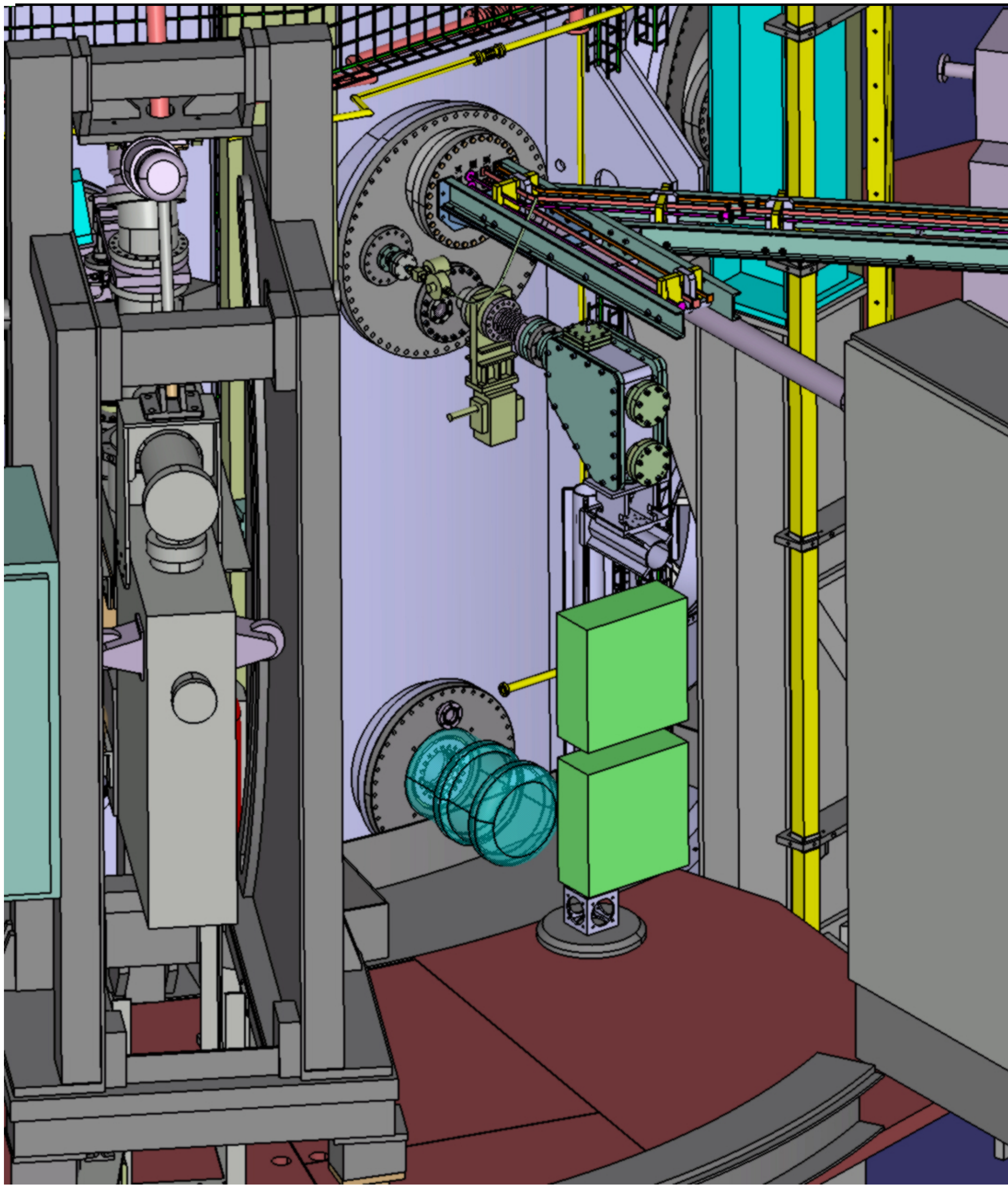




(1) acceleration/stripping unit
(2) stripping foil
(3) analysing magnet

(4) Hall probe
(5) analysing electrostatic condenser
(6) detector array

CNPA on MAST



- Both CNPA and PPPL NPA are present and data will be compared
- Planned to be installed this year
- Ongoing project

Contacts:

- Dr. M. Turnyanskiy (Culham)
- Dr. Wolfgang Schneider
 Max-Planck-Institut für
Plasmaphysik, Greifswald

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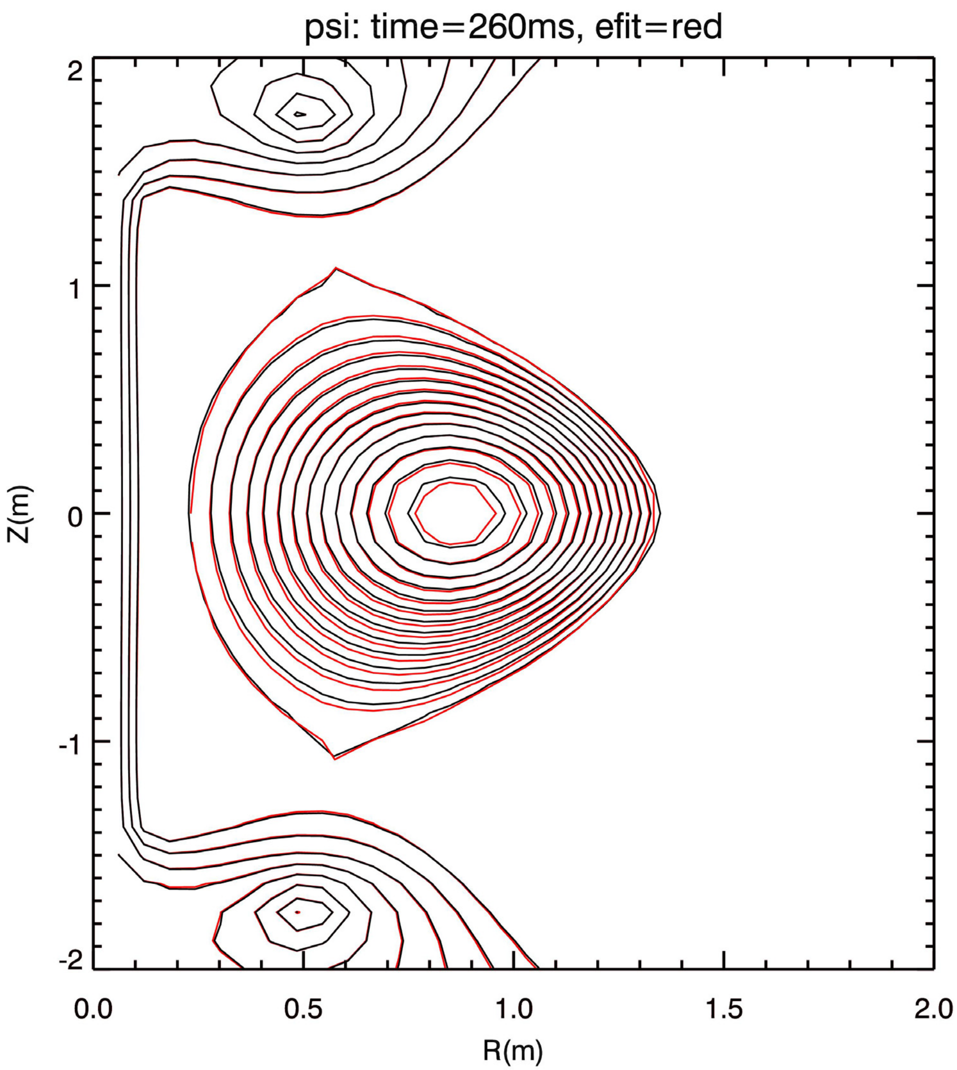
Port of Realtime EFIT to MAST



- The port of GA's Realtime EFIT algorithms to MAST Plasma Control System (PCS) is going well. This will improve plasma shape control on MAST.
- The rtefit algorithm, a realtime version of standard EFIT, now runs in simulation mode both offline and on the PCS hardware.
- Agreement between EFIT and Realtime EFIT results in simulation tests is good, as this overplot of positive flux on the computation grid shows.
- An improved wall model is being developed.

John Storrs, Graham McArdle

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IDAM

IDAM (Integrated Data Access Management) was designed to:

• Overcome some limitations in the capability of MAST's IDA data archive system

• Add additional meta data associated with diagnostics and models

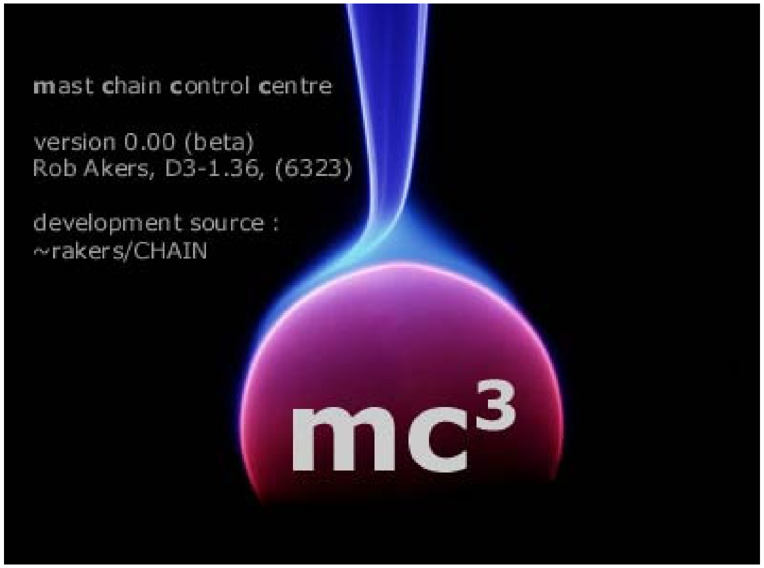
• Enable read access to local and remote heterogeneous data sources, e.g. IDA, netCDF, PPF, JPF, MDS+,…, through a single, unified data access standard.

• Access both legacy data and data in modern data storage formats: Only Meta data is stored in the IDAM Database, not experimental or modelling data.

• Standardise (look & feel, data structures) how data are accessed in IDL, Fortran, C, …

• Integrate Diagnostic Web Page generation with Diagnostic Meta Data

The MAST Chain Control Centre – mc3



Rob Akers

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Philosophy….

Raw data are currently processed within the MAST Scheduler (equivalent to JET Chain 1). Codes like TRANSP, however, require "data preparation", e.g. density and temperature "profiles", an electron source from gas fuelling, Z_{eff} etc. In the past, data have been processed via a linear chain of operations. Due to "dependencies in the data" and "diagnostics niggles", a more flexible approach is required. For example, fitting the electron density profile requires knowledge of Z_{eff} in order to account for in out asymmetry, however obtaining Zeff from Bremsstrahlung requires a density profile, and fitting the density needs an equilibrium, but the Equilibrium depends on the plasma rotation etc. etc.

A new platform is being built which fits around the various chain modules (which can still be run via a script in the scheduler) but which offers added flexibility and improved data quality:

1. The user can move to and fro through the "chain", modifying fits, rejecting bad data etc. with immediate auto fitting of the data and propagation of the data through the chain.
2. Improved data visualisation allows the user/diagnostic RO to immediately see the consequences of having modified their data - say for example the stiffness of fit to the Te profile of one time slice and therefore to understand the implications of changing their part of the chain.
3. The code allows the user to save the data preparation as a "project" for a given shot.
4. Data are lifted from IDAM, allowing calibration offsets, machine and diagnostic geometry/configuration to all be handled from 1 source.
5. The code is designed to be intuitive and easy to use and will be used to prepare data for all our big numerical models – hence data consistency across analyses. In particular, the code is designed to enable all users to use the same tool for preparing data rather than developing their own favourite little IDL codes.

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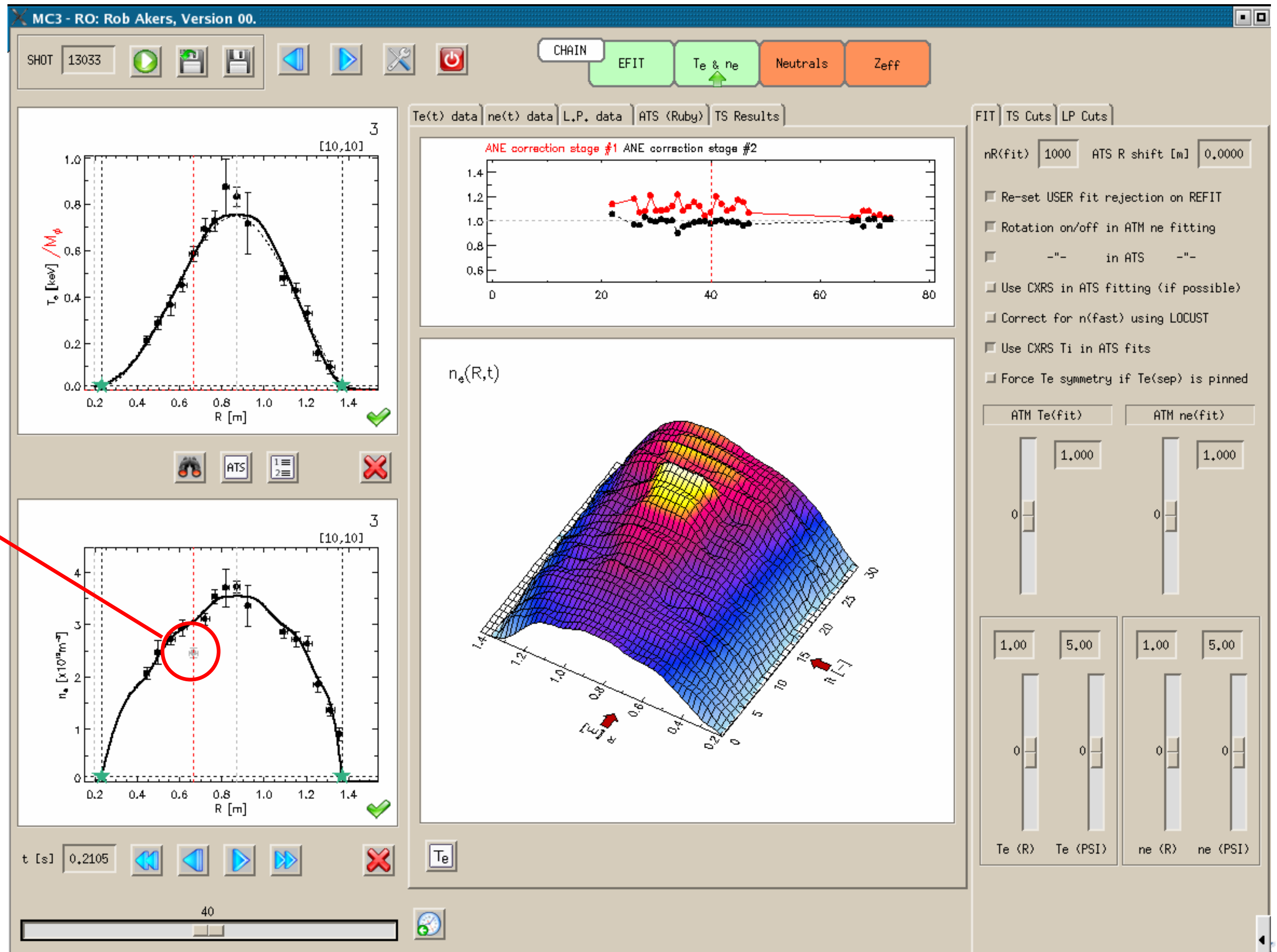
3 Examples….
Example 1: Spurious Nd-YAG TS points.

User can "reject point" and immediately examine consequences for profile, for Zeff, or even equilibrium once EFIT is bolted in.



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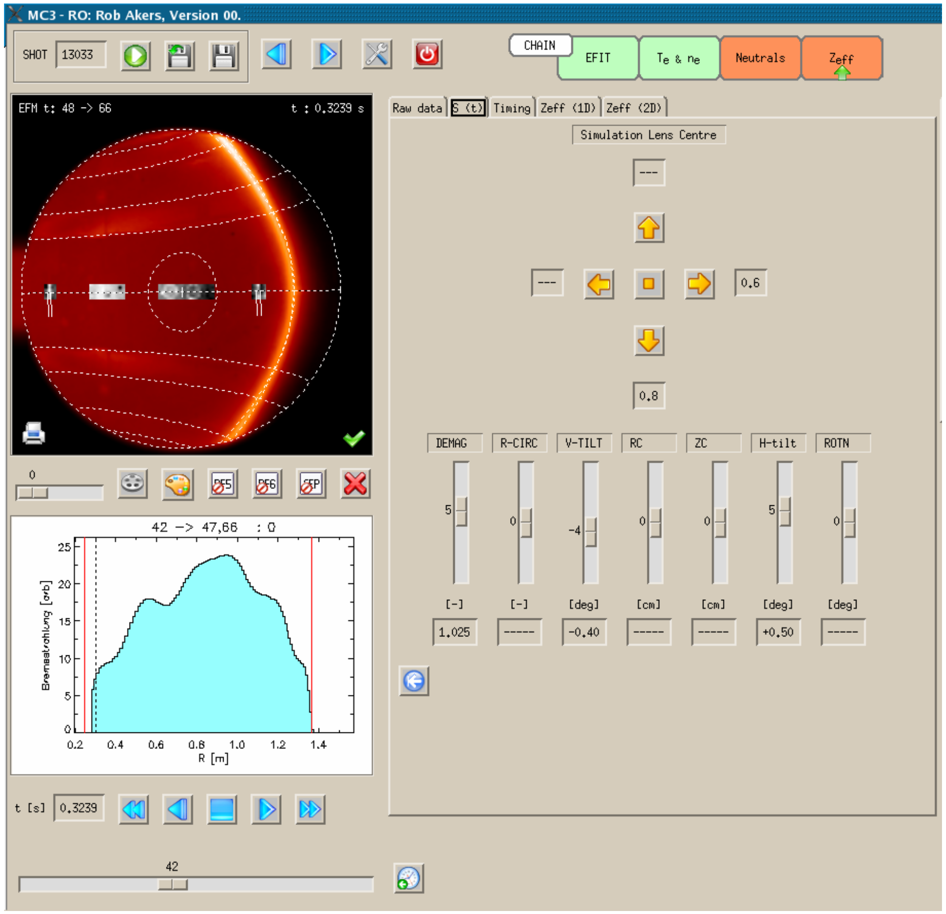
Examples 2: Z_{eff} geometry.

Many of the 2D imaging systems are “moved” around the machine from campaign to campaign.
In addition, systematic errors arise due to cameras being knocked etc. (very crowded imaging port).
A system is available for correcting the spatial calibration of the cameras. ZEBRA is now bolted in,
HSV and RGB will be next (the former for checking that EFIT is doing a good job at the separatrix
Reconstruction – if you look closely you can see the EFIT separatrix on the image below.



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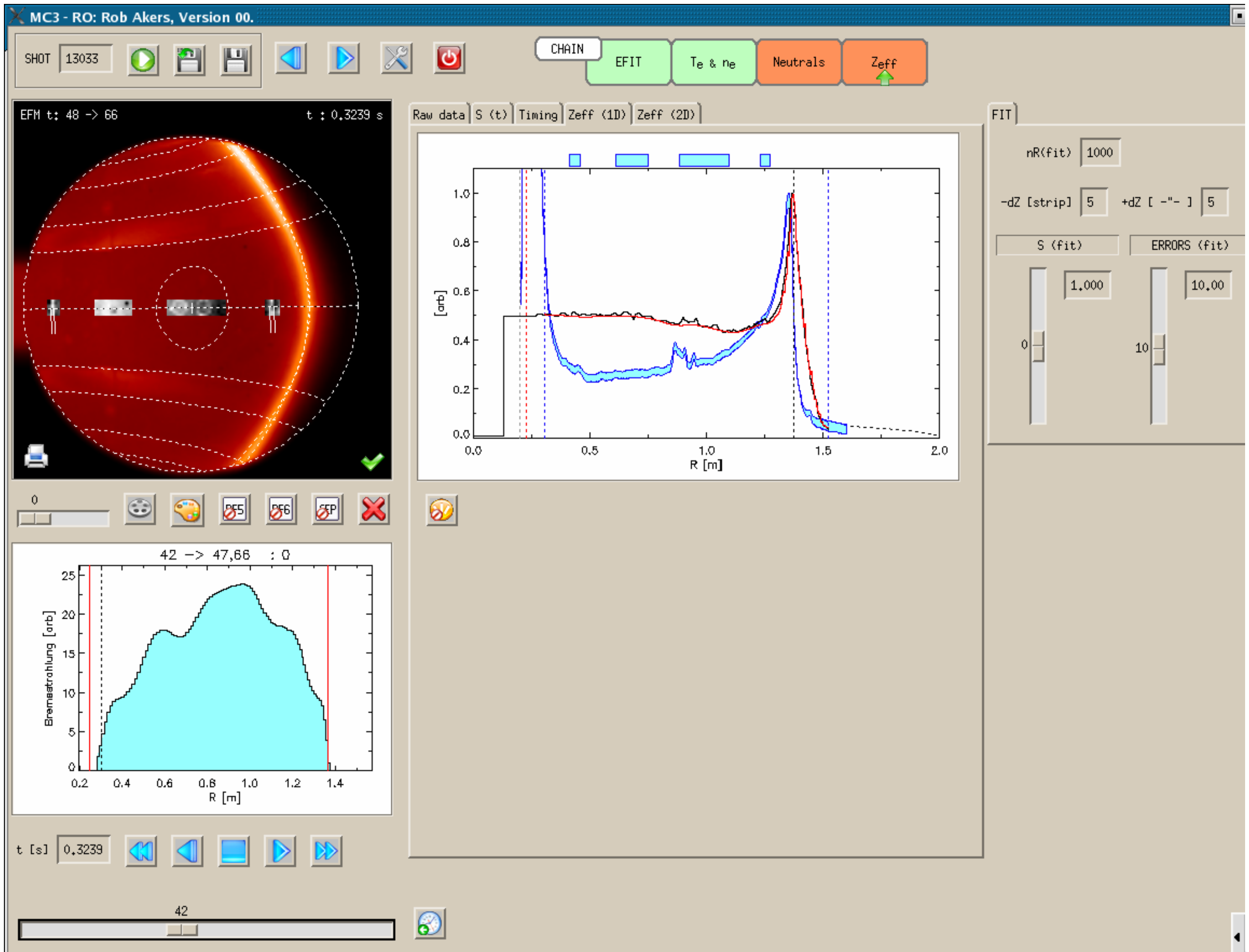
Examples 3: Z_{eff} “reflection control”.

Having 2D Bremsstrahlung images is essential for assessing the effect of vessel Reflections. Here the user can select, modify and remove “reflection” zones which are handled Differently in the fitting and inversion (via Abel, SVD, MAXENT etc.)



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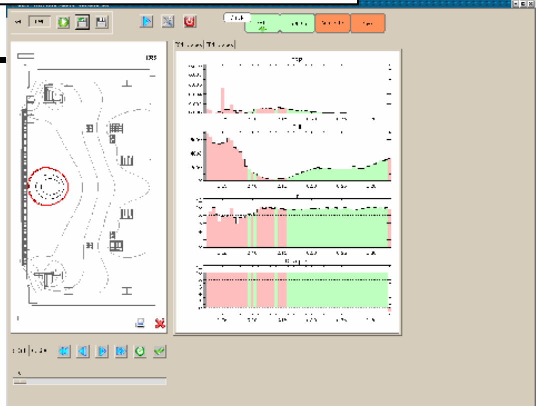
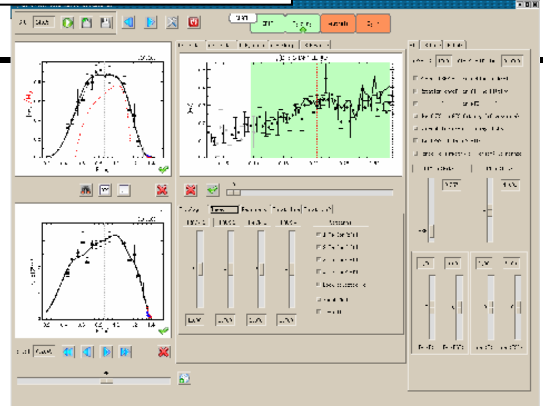
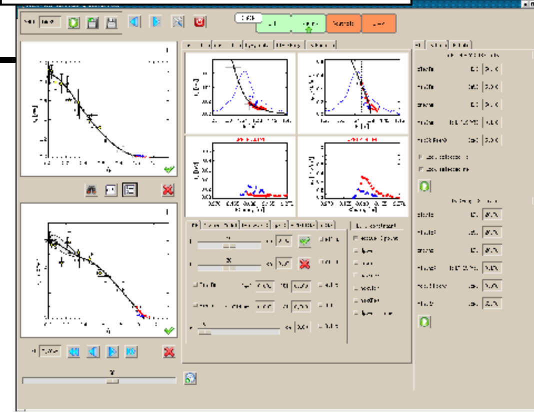
Equilibrium control



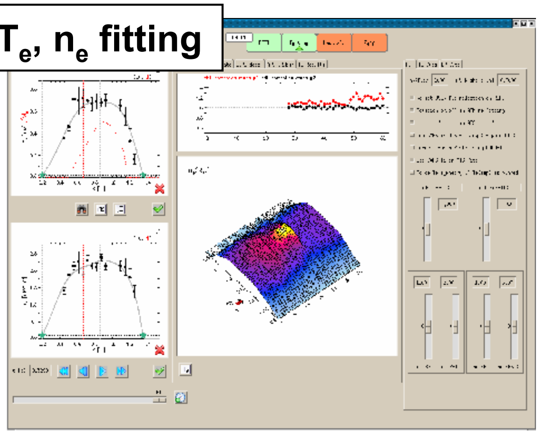
Raw TS control



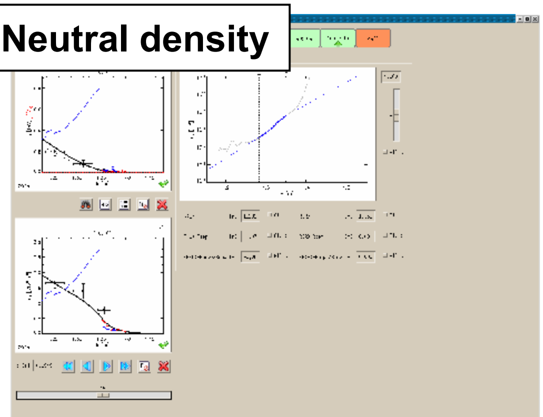
Langmuir probe data



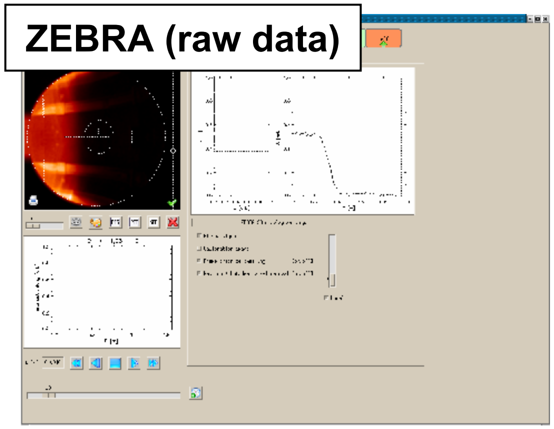
T_e, n_e fitting



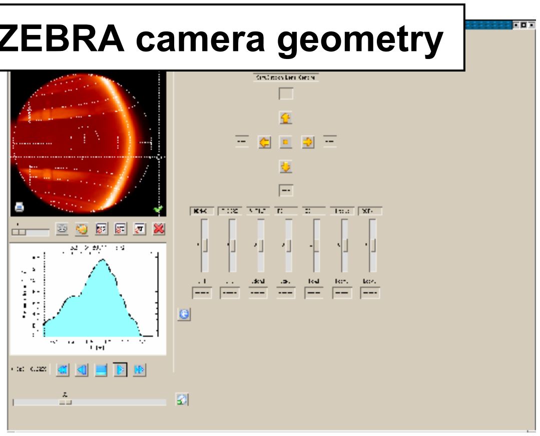
Neutral density



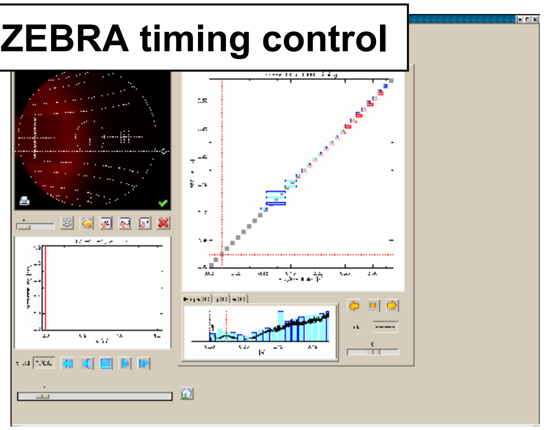
ZEBRA (raw data)



ZEBRA camera geometry



ZEBRA timing control



Selection of screenshots from the New MAST Chain Control Centre

A new tool for pre-processing TRANSP data, allowing “free data flow” (maintaining dependencies), rather than simply using the CHAIN (MAST Scheduler).

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Main campaign thrusts for M6

	Driver(s)
Performance Optimisation	Hendrik Meyer/Geoff Cunningham
Confinement & Transport	Martin Valovic/Anthony Field
Plasma Exhaust	Glenn Counsell/Andrew Kirk
Stability	Mikhail Gryaznevich/Tim Hender
Heating, current drive & start-up	Mikhail Tournianski/Alan Sykes/ Vladimir Shevchenko

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Key elements of the programme

❑ Performance Optimisation

- optimize sustained H-mode performance at high power and high plasma current.
- investigate routes towards high fusion gain $G=\beta_N H_{89} / q_{95}^2$ and CTF/STPP relevant regimes
- develop H-mode with sustainable ELMs at low collisionality

❑ Confinement & transport studies

- extend confinement database to higher P, I_p; confinement scaling (β, ν^*, ε …)
- associated transport studies, modelling & analysis (TRANSP, GS2, CENTORI…)
- plasma rotation & momentum transport
- particle transport incl. pellet injection studies.

❑ Stability

- fast particle instabilities (e.g. TAE damping exploiting new TAE antenna)
- high beta studies (incl. NTM physics, beta limit studies & effects of wall)
- complete locked mode threshold studies (e.g. aspect ratio scaling)

❑ Exhaust & edge physics

- pedestal & ELM studies at higher power (exploiting improved edge TS)
- SOL transport and flows
- disruption studies

❑ Heating, current drive & Start-up

- NBCD studies including off-axis CD (started in 2005)
- Non-solenoid start-up and current ramp up
- electron Bernstein wave studies (heating, start-up, emission studies)

IEA-ITPA Co-ordinated Experiments

2006

	Proposal
CDB-2	Confinement scaling in ELMy H-modes: β degradation
CDB-6	Improving the condition of global DBs: low A
CDB-9	Density profiles at low collisionality
TP-5	QH/QDB studies
TP-6.1	Scaling of spontaneous rotation with no external momentum input
TP-6.3	NBI-driven momentum transport study
TP-8.1	NSTX/MAST ITB similarity experiment
TP-9	H-mode aspect ratio comparison
PEP-6	Pedestal structure and ELM stability in DN
PEP-9	NSTX/MAST/DIII-D pedestal similarity
PEP-10	The radial efflux at the mid-plane and the structure of ELM
PEP-16	C-Mod/NSTX/MAST small ELM regime comparison
DSOL-3	Scaling of radial transport
DSOL-4	Comparison of disruption energy balance in similar discharges and disruption heat flux profile characterisation.
MDC-4	Neoclassical tearing mode physics - aspect ratio comparison
MDC-6	Low beta error field experiments
MDC-9	Fast ion re-distribution by beam-driven Alfven modes and excitation threshold for Alfven cascades
MDC-10	Measurement of damping rate of intermediate toroidal mode number Alfven eigenmodes

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MAST Results Review/Research Forum

Wed/Thu 22-23 March 2006
St. John's College,
Oxford University

Follow-up discussions/Visit to facilities etc
Fri 24 March 2006
Culham Science Centre

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