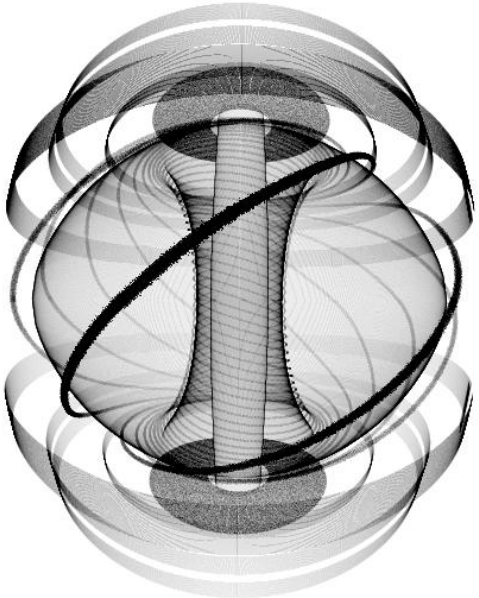
Beam Emission Analysis on MAST

Absolute impurity density measurements



Stuart Henderson

L. Garzotti, M. O'Mullane, A. Patel and H. P. Summers

Talk Overview

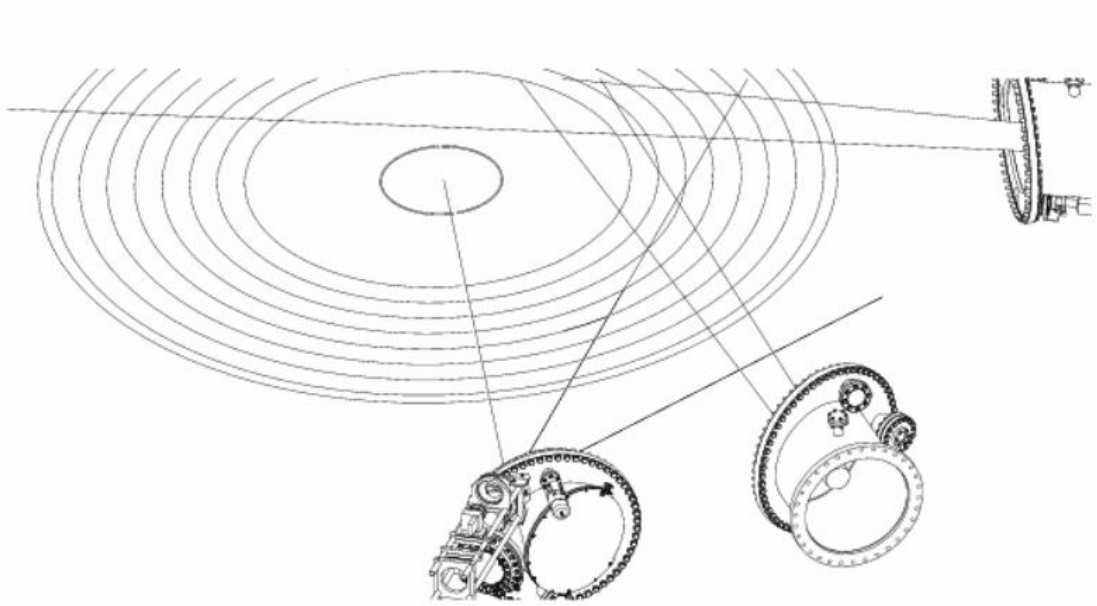
Diagnostic Introduction
(*RGB: 2D Camera Imaging*)

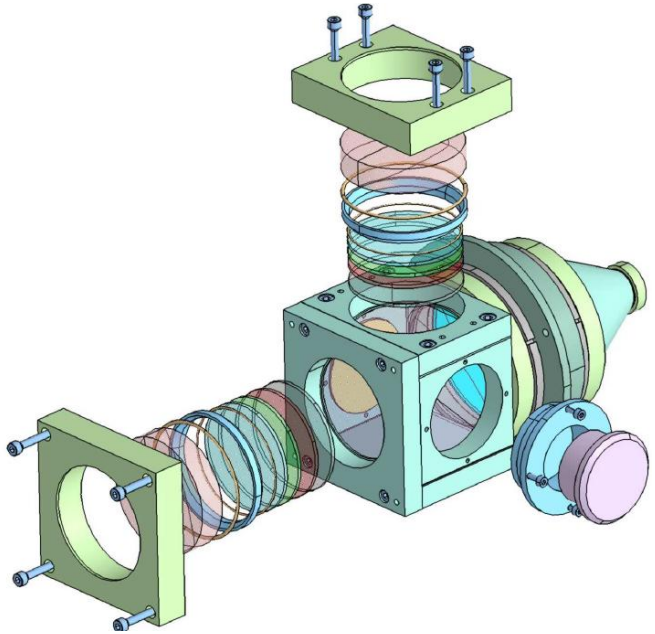
Neutral Beam Model
(*ADAS adf21,adf22: Compare beam emission model/RGB*)

Charge exchange emission
(*RGB He^{2+} and C^{6+} channels, ADAS adf12 files*)

Impurity Profiles + Transport

Diagnostic



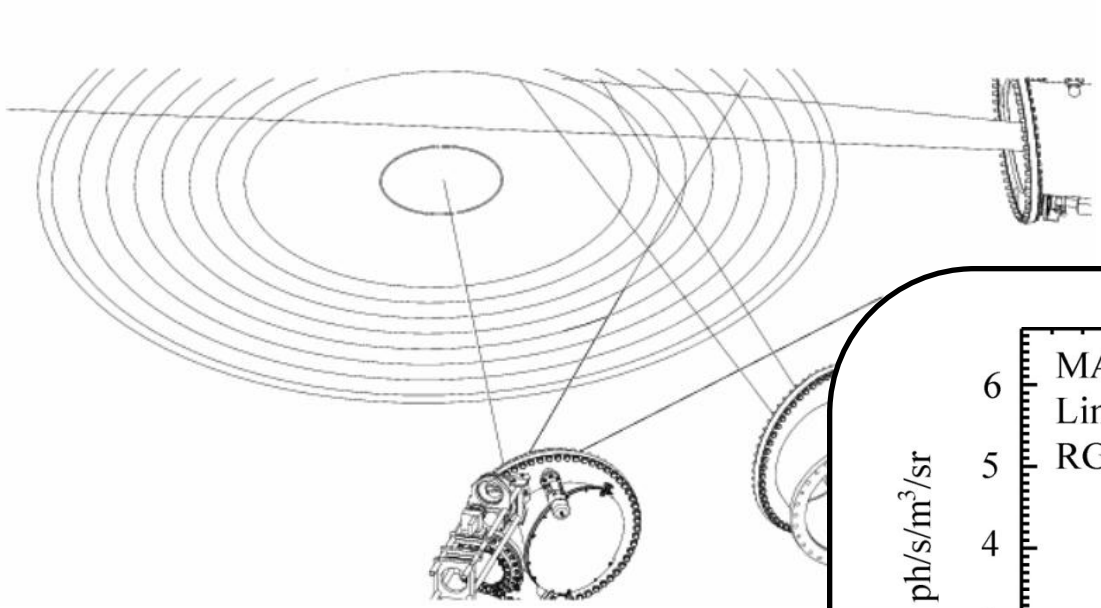


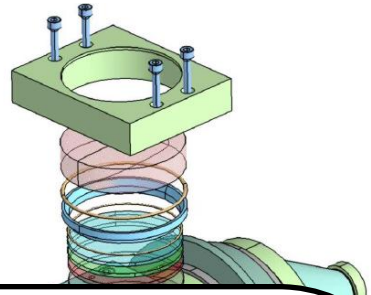
VGA / 200 Hz / 6 Colours Simultaneously

	Channel 1			Channel 2		
	Red	Green	Blue	Red	Green	Blue
Emission	D_α	C^{5+}	He^+	BE	Brem	Brem
Wavelength / nm	656.1	529.5	468.9	660	561.9	457.2

A. Patel *et al*, RSI, in preparation

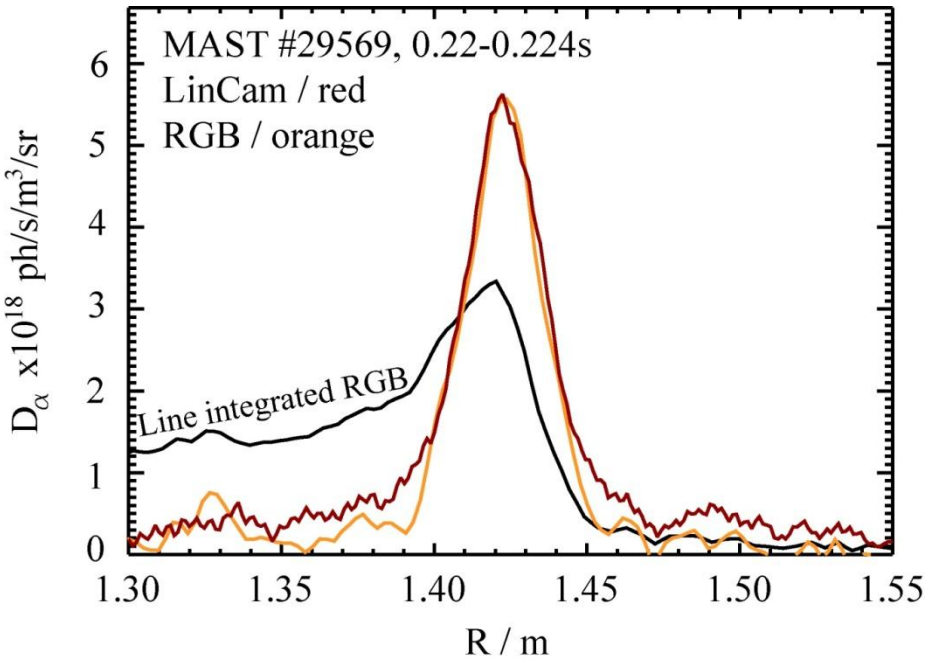
Diagnostic





VGA / 200 Hz / 6

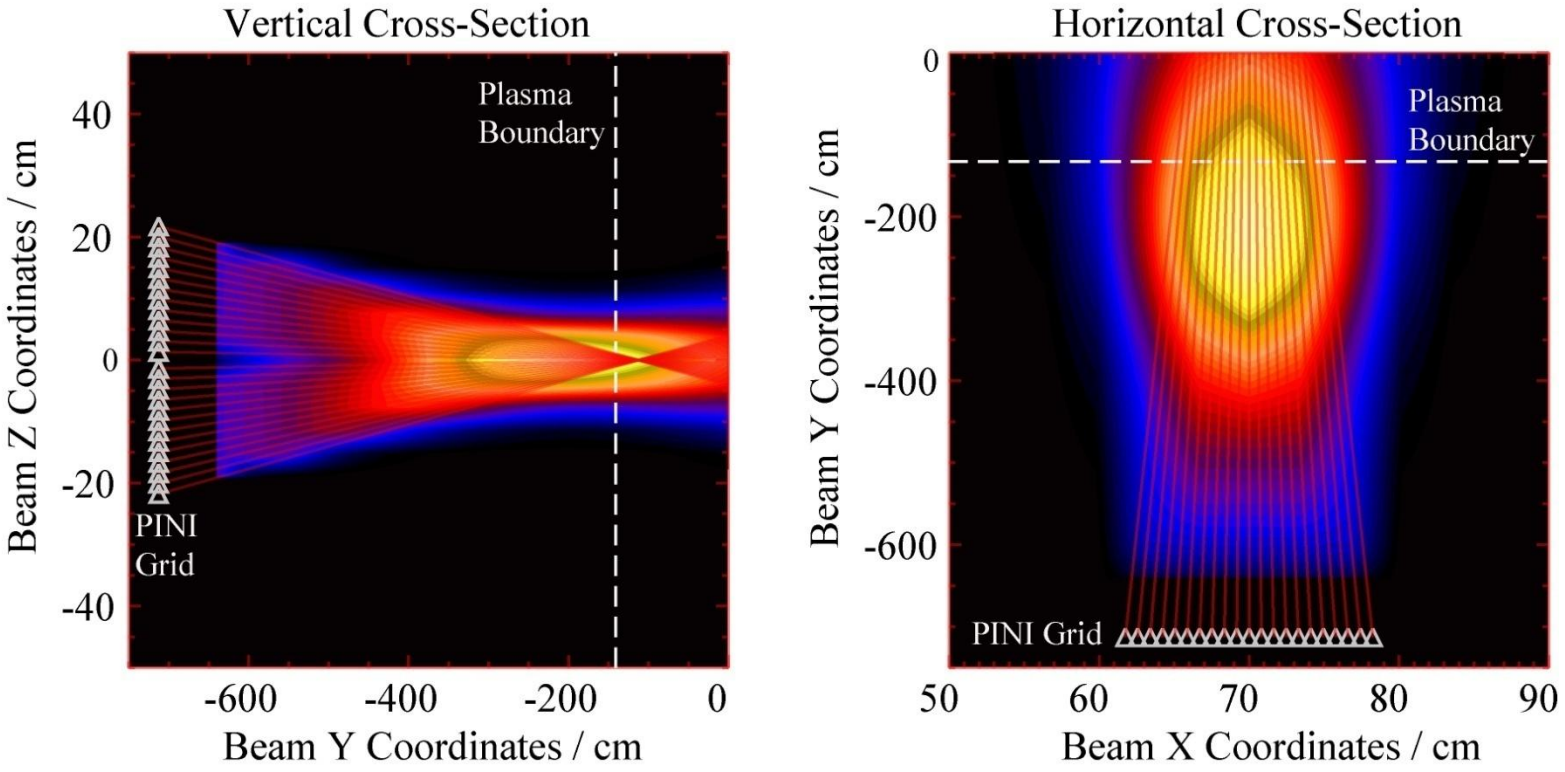
	Cl
	Red
Emission	D_α
Wavelength / nm	656.1



- D_α measurements agree with calibrated LinCam results on MAST

A. Patel *et al*, RSI, in preparation

Beam Model: Shape



Total density

Normalised over beamlets

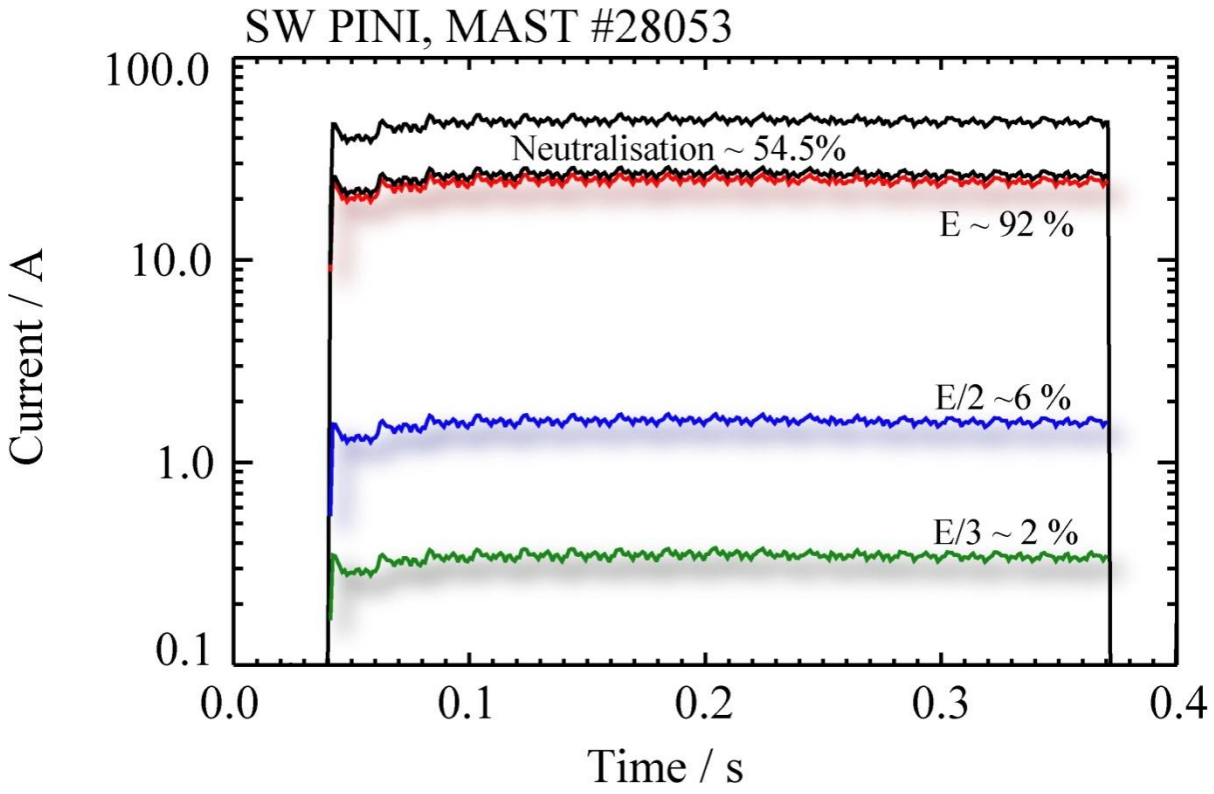
Stopping Coefficient

$$n_b = \sum_{i=1}^{n} \frac{j_i^0}{2\pi \int_0^{\pi/2} e^{-(\theta/\alpha)^2} \sin\theta d\theta} e^{-(\theta_i/\alpha)^2} \frac{\cos\theta_i}{r_i^2} \Lambda_i$$

Normalised over Ω

Gaussian distribution

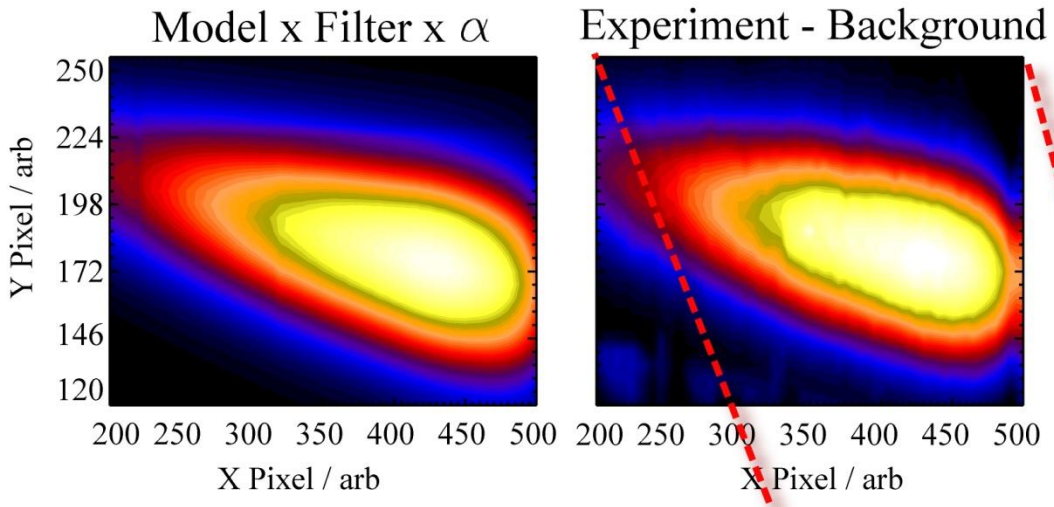
Beam Measurements

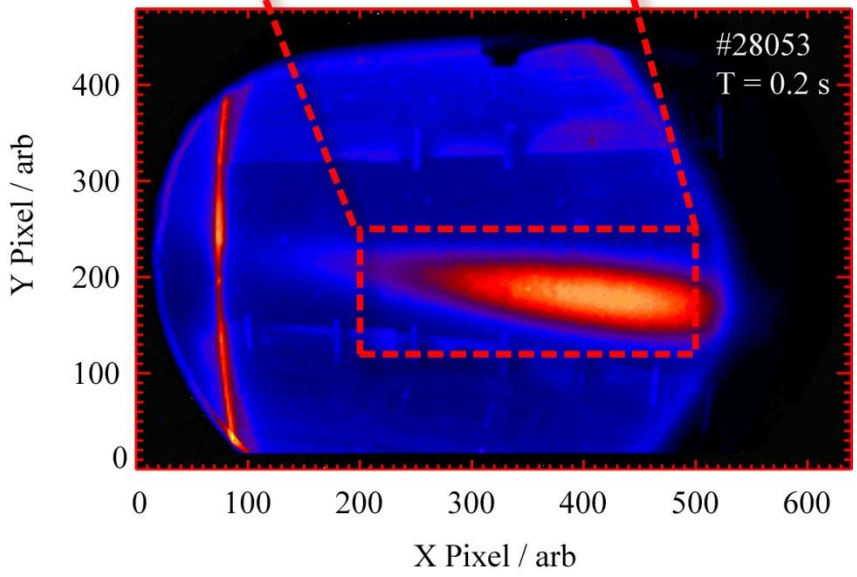


$$j_i^0 = \frac{I}{ev_D}$$

- PINI converts 54.5% energetic ions into neutrals
- Supercusp configuration
- Beam voltage 65 keV
- Total injected power of 1.5 MW
- Deuterium beam (amu = 2)

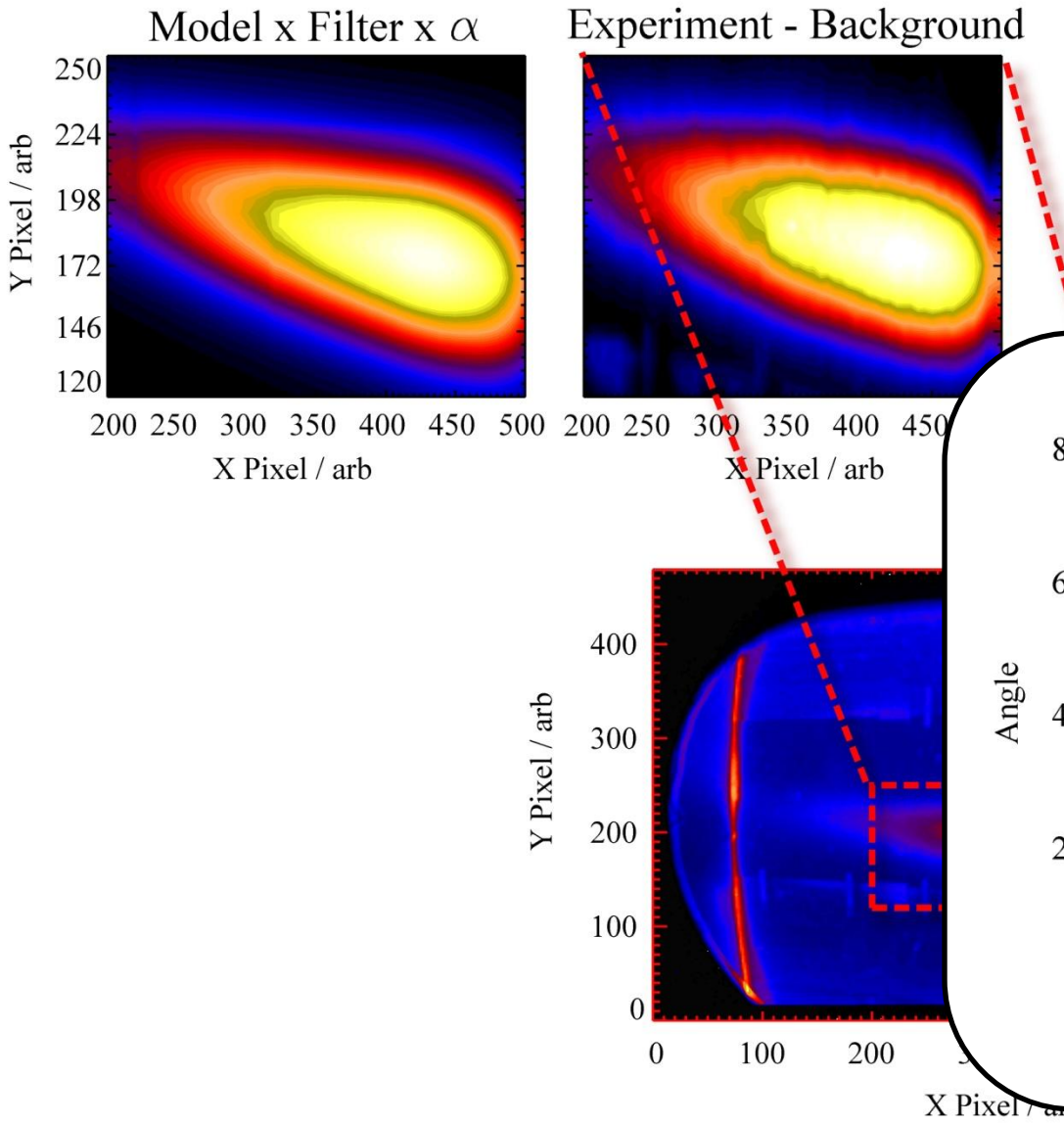
Plasma Beam Emission





- Zoomed in view of SW beam
- Model multiplied by filter function and scaling factor

Plasma Beam Emission



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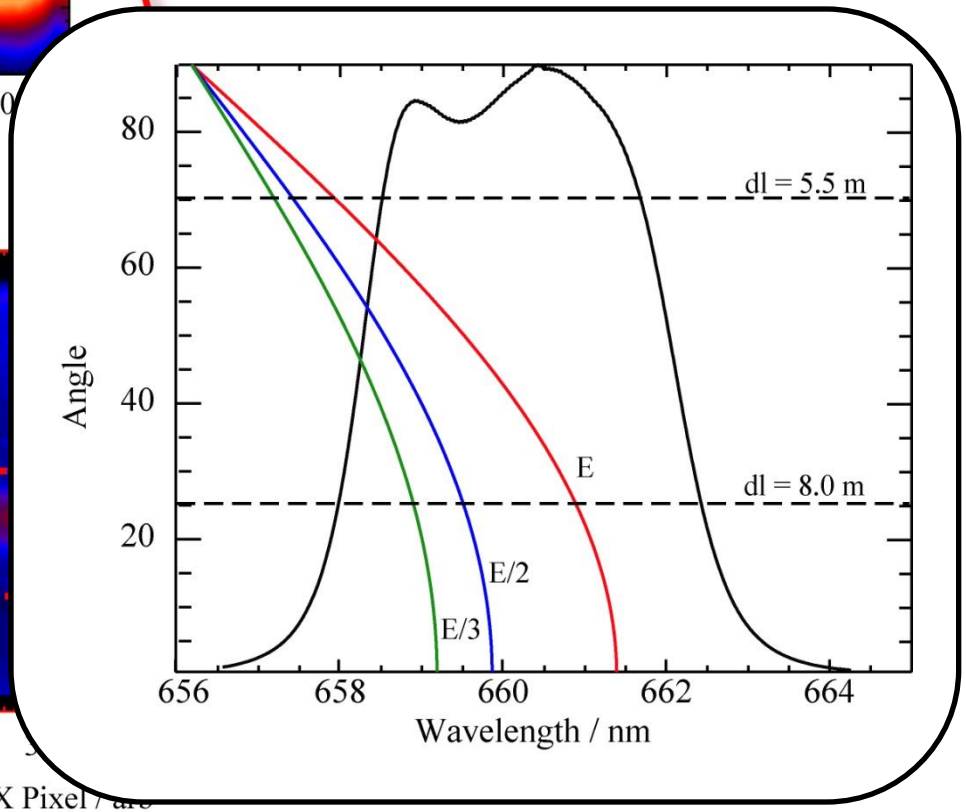
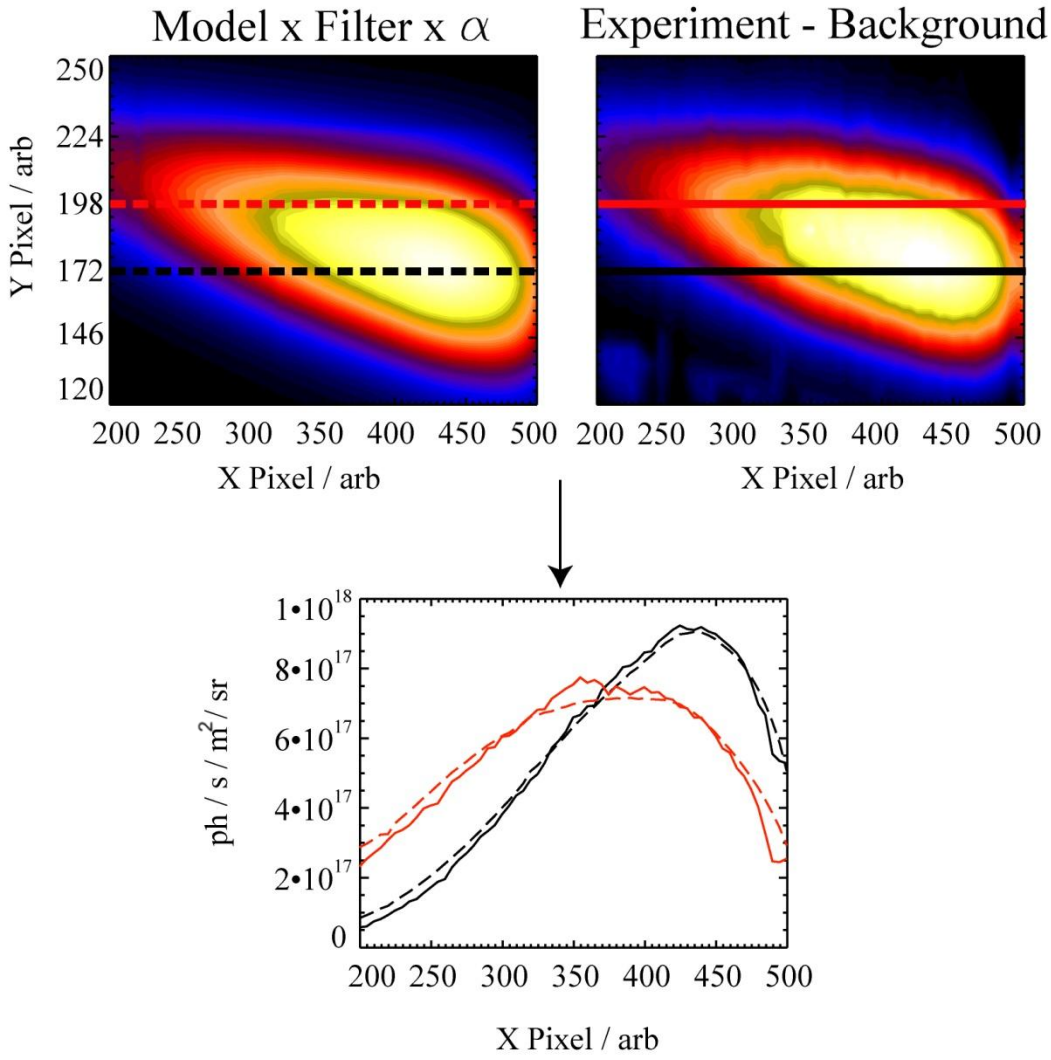
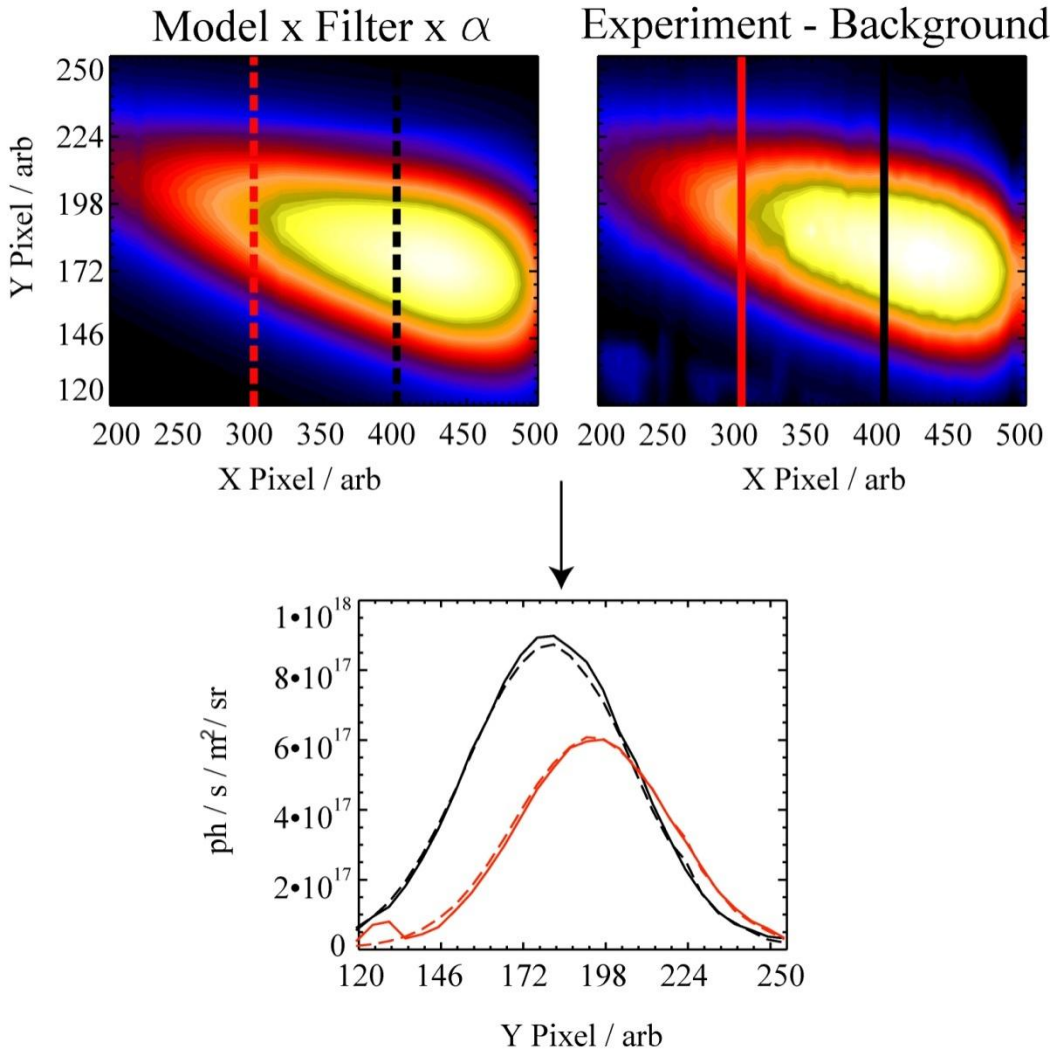


Plasma Beam Emission



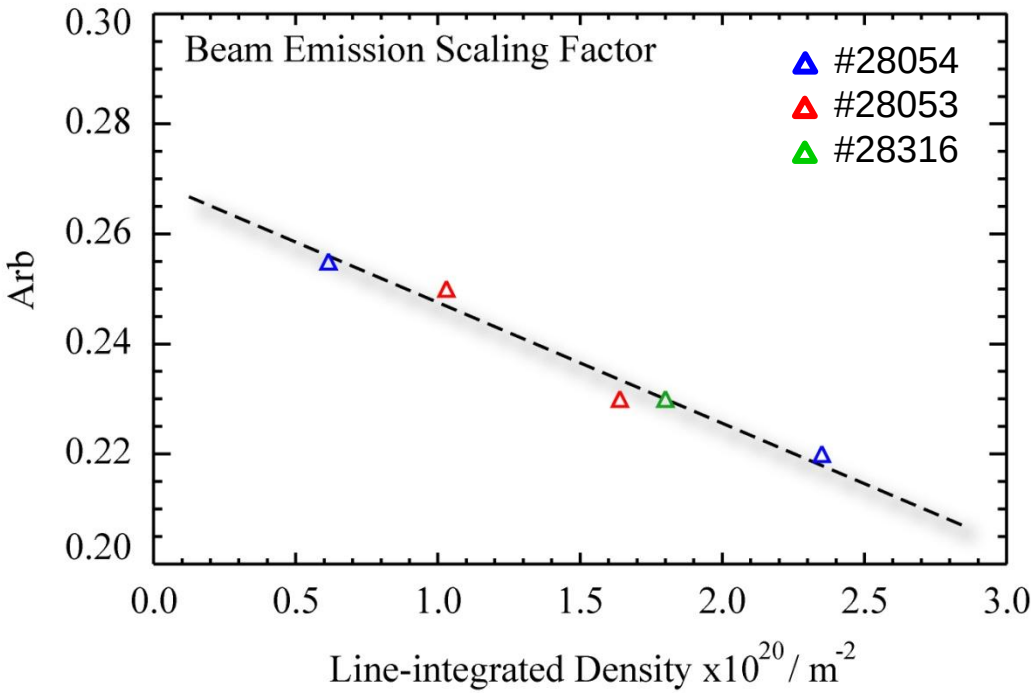
- Zoomed in view of SW beam
- Model multiplied by filter function and scaling factor
- Two horizontal (down-stream) comparisons
- Shape determined largely by stopping coefficient
  - ADAS adf21 ‘09

Plasma Beam Emission



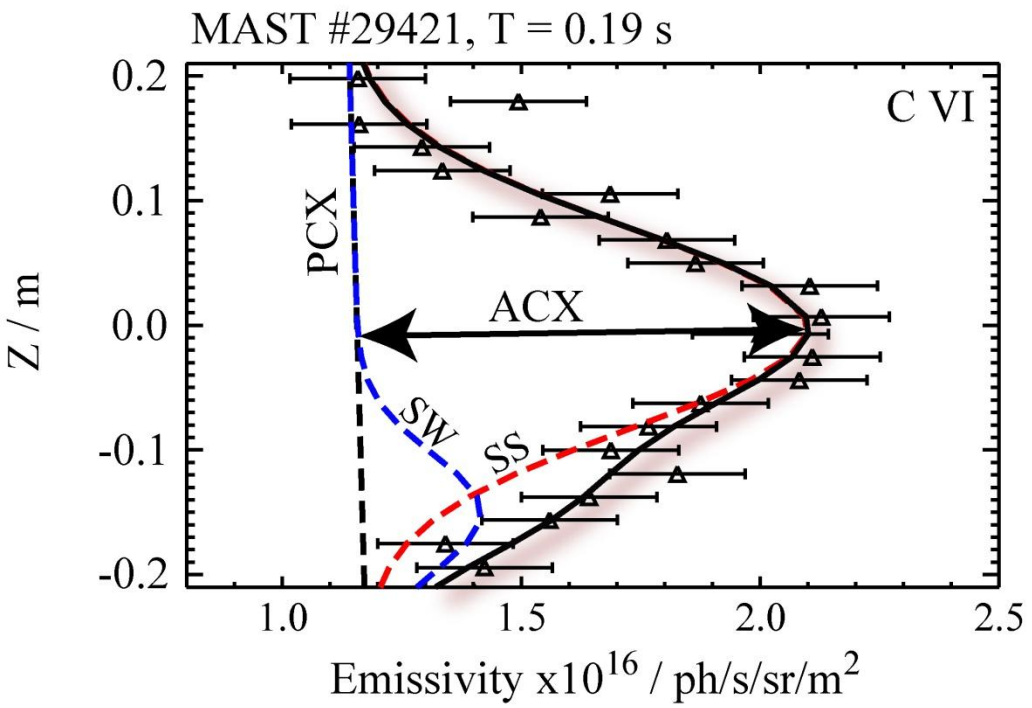
- Zoomed in view of SW beam
- Model multiplied by filter function and scaling factor
- Two vertical (Z) comparisons
- Shape determined mainly by beam focussing and divergence
  - astigmatic focus, 1/e ~ 0.6°

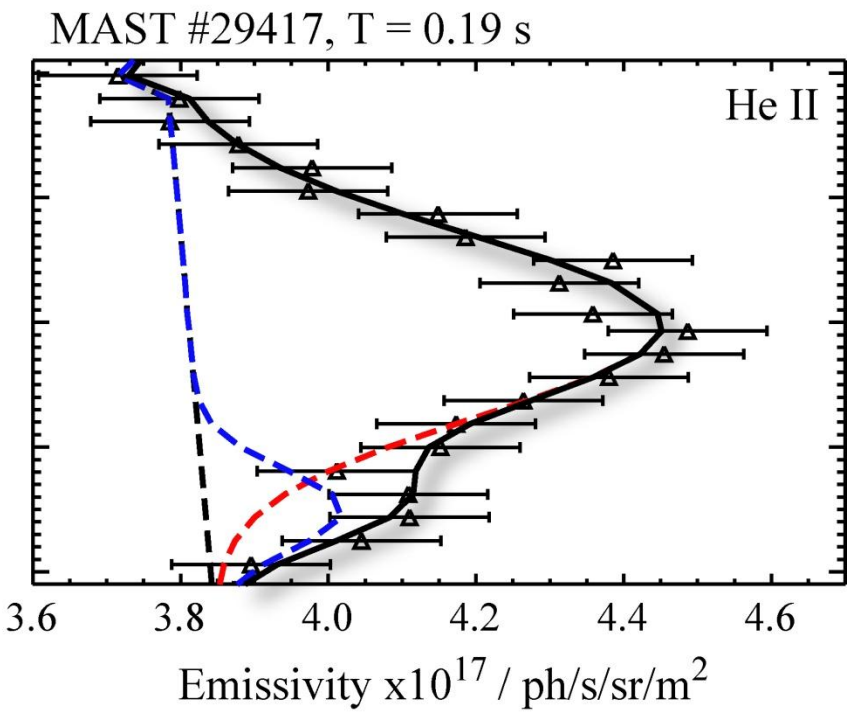
Model Scaling Parameter



- Experiment is ~75% less model
- Small trend of scaling observed as a function of density
- Unclear if scaling due to atomic cross-sections or beam model
- Possibly both?

Charge Exchange Emission

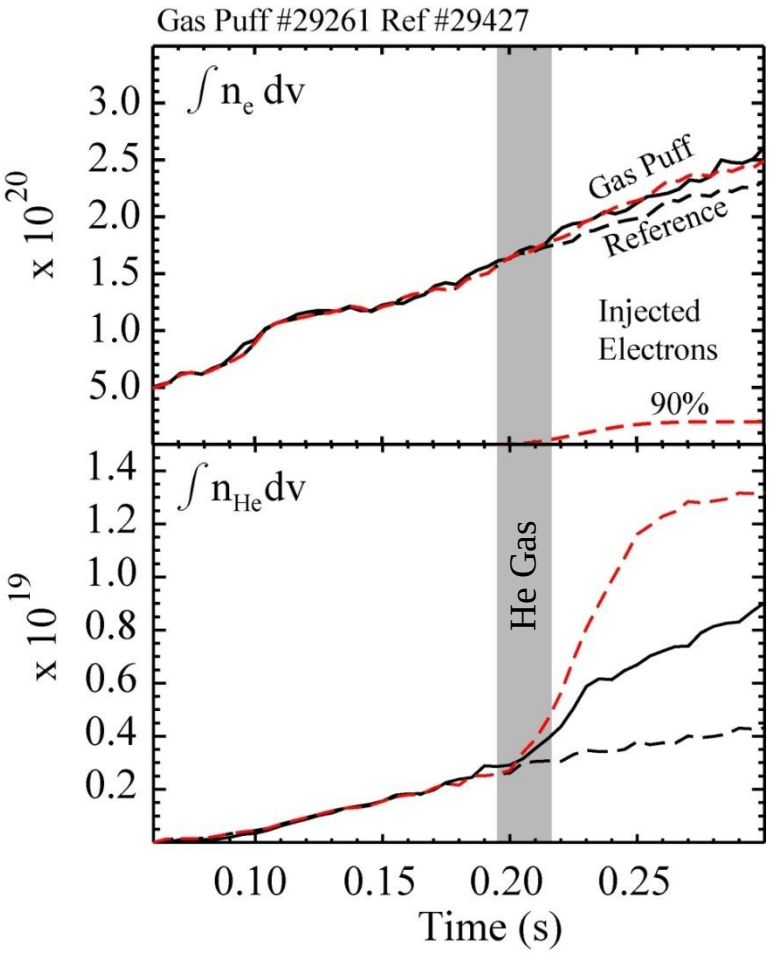


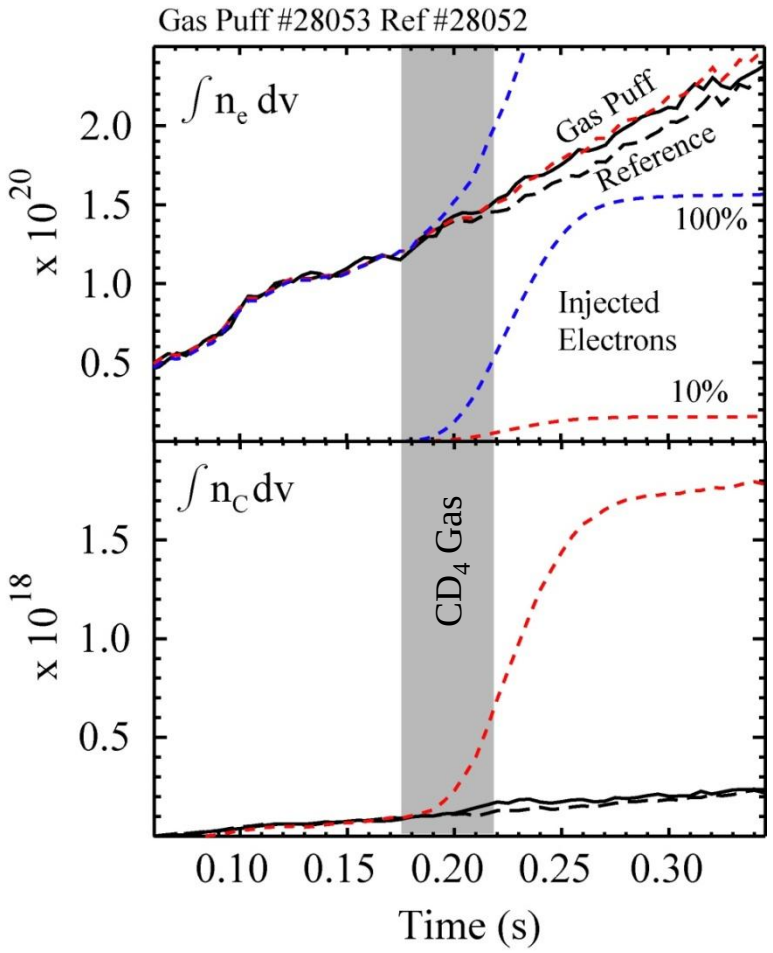


Systematic Errors

- Non-local emission from plume ions – Will cause an increase in density within r/a < 0.3
- CX emission from beam halo – small error (< 15 %) due to dominant E/1 beam energy

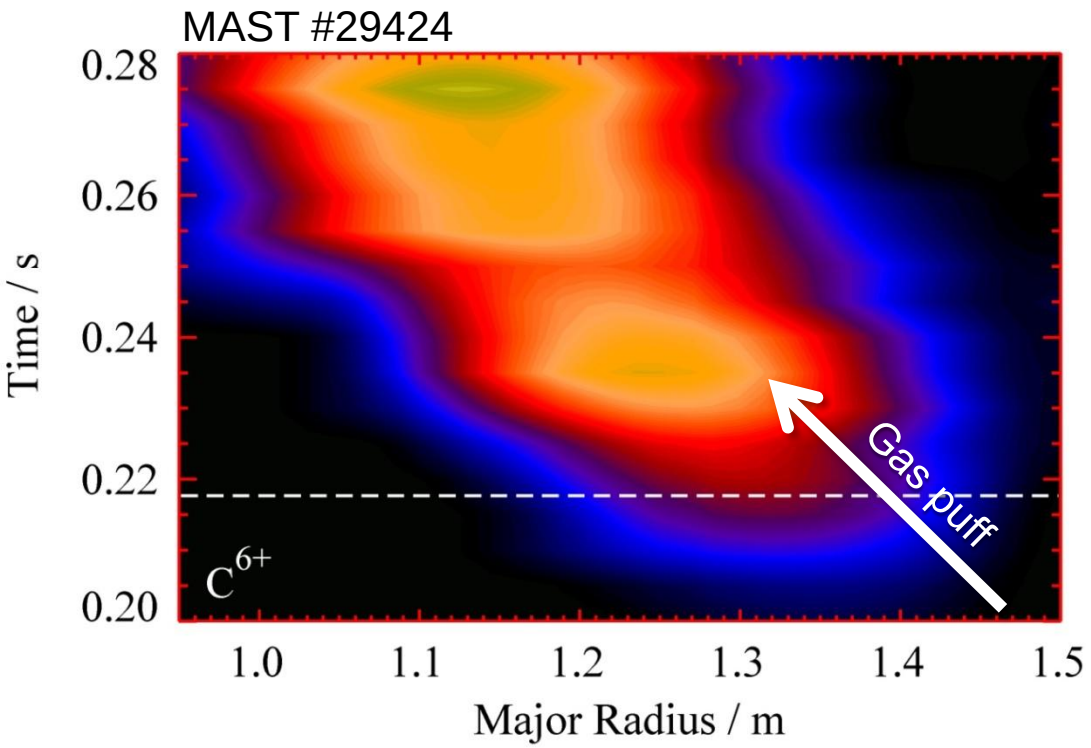
Density Measurements





- Helium measurements suggest impurity densities under-dense by < *x*1.5
- Effective CX emission coefficients or beam model?

Impurity Transport



- Beam shape most important for transport measurements
- Clear evolution of C VI after methane gas puff

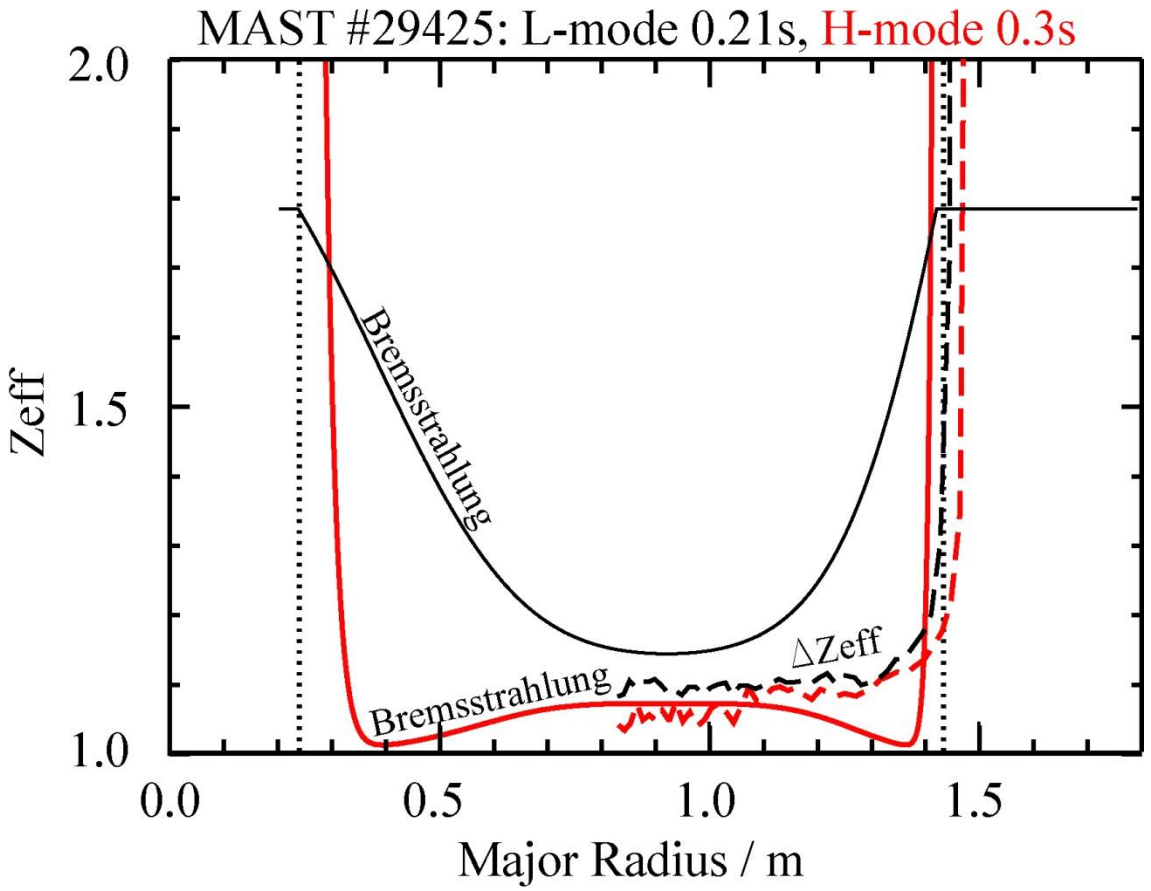
- Initial analysis suggests TEMs dominate an inward pinch in L-mode ($1.25 < R < 1.4$)
- Switching to H-mode reduces the anomalous pinch causing density ‘ears’ to form
- Scans of safety factor (q) imply more impurities reach the core at high-q

Conclusions

- 2D camera imaging 6 channels simultaneously on MAST
  - Matches D_α with different diagnostic
- Beam model used reproduces the experimentally measured beam shape both horizontally and vertically
  - Accurate beam focus and divergence and beam stopping coefficients
- Scaling factor to match absolute beam emission
  - Unclear if cross-section or beam model error
- Accurate picture of the low-Z impurity transport on MAST

Thank you for listening

Appendix: ΔZ_{eff} Profiles



- ΔZ_{eff} profiles compared to Abel inverted Bremsstrahlung Z_{eff}
- Profiles agree in H-mode however $\Delta Z_{eff} < Z_{eff}$ in L-mode
- Possible indication that impurity profiles are under-dense

Appendix: Beam Halo

- The halo population are neutrals at thermal energy created by CX between beam neutrals and plasma ions

  – halo population ≈ beam population
  – cross section for CX into excited states drops rapidly with energy