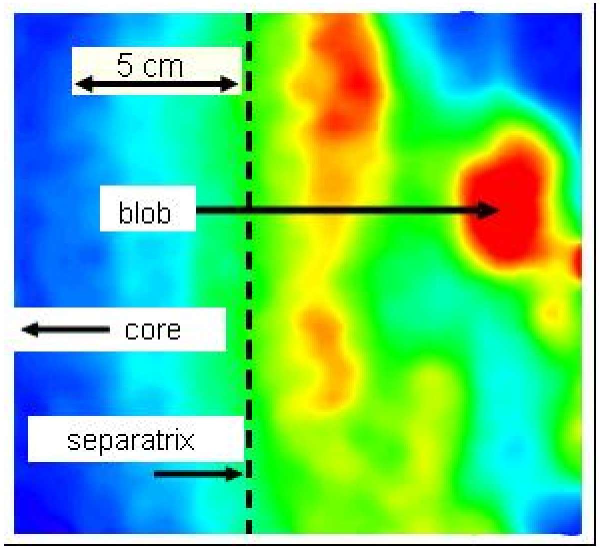
Blob transport theory and GPI imaging analysis

J.R. Myra, D.A. D'Ippolito, D.A. Russell *Lodestar*,
D.P. Stotler, S.J. Zweben, B. P. LeBlanc, J. E. Menard *PPPL*,
R. Maqueda, *Nova Photonics*, J. Boedo, *UCSD*

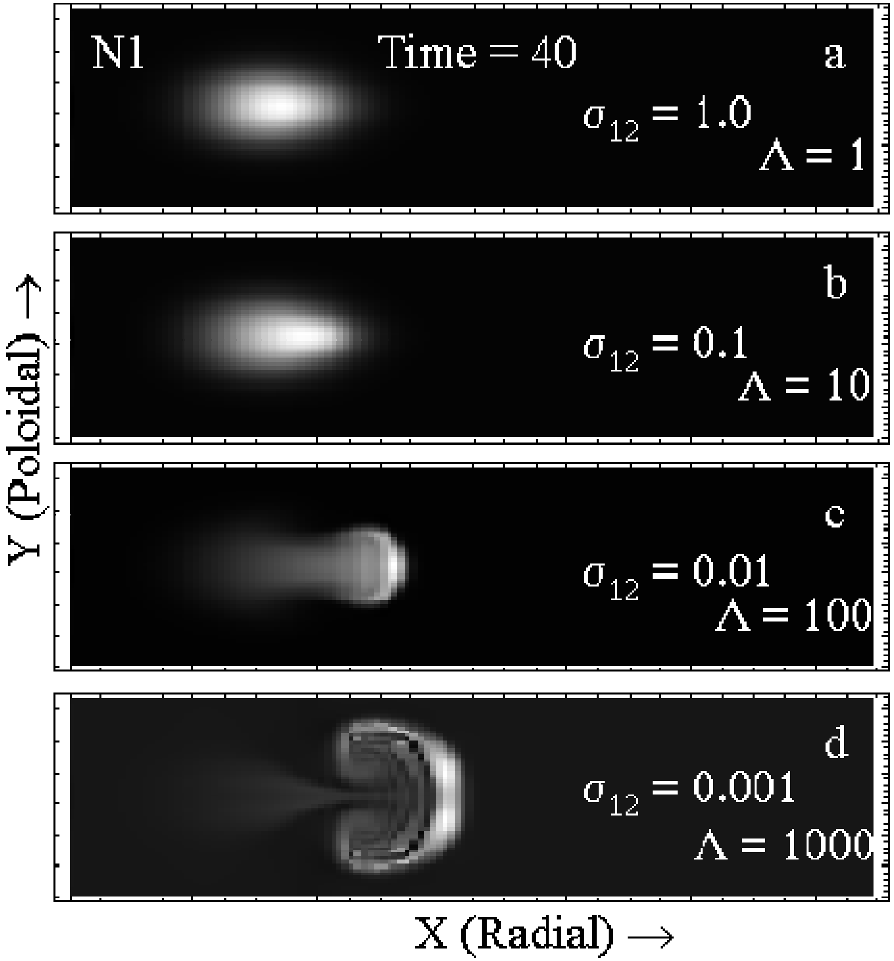


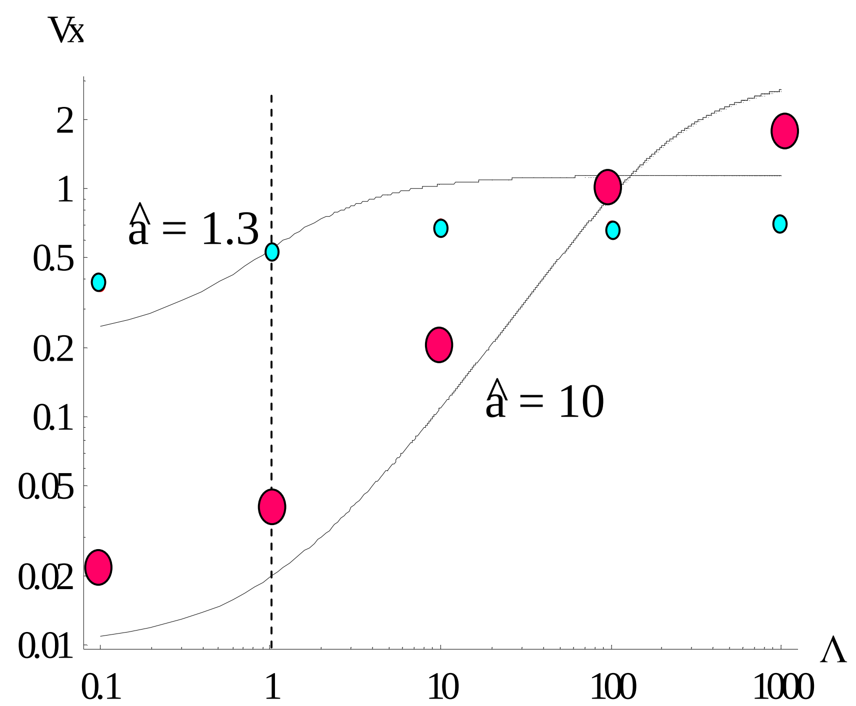
- theory
- contact with experiment
- SOL broadening
- future work

presented at the NSTX Results Review, July 26 - 27, 2006
work supported by DOE grants DE-FG03-02ER54678 and DE-FG02-97ER54392

Theory and simulations show the scaling of blob velocity vs. size ($\hat{a}$) and collisionality regime (Λ)

Myra, Russell, D'Ippolito, Lodestar Report #LRC-06-111, (submitted to Phys. Plasmas)
http://www.lodestar.com/LRCreports/TwoRegionModel_I_blobs.pdf





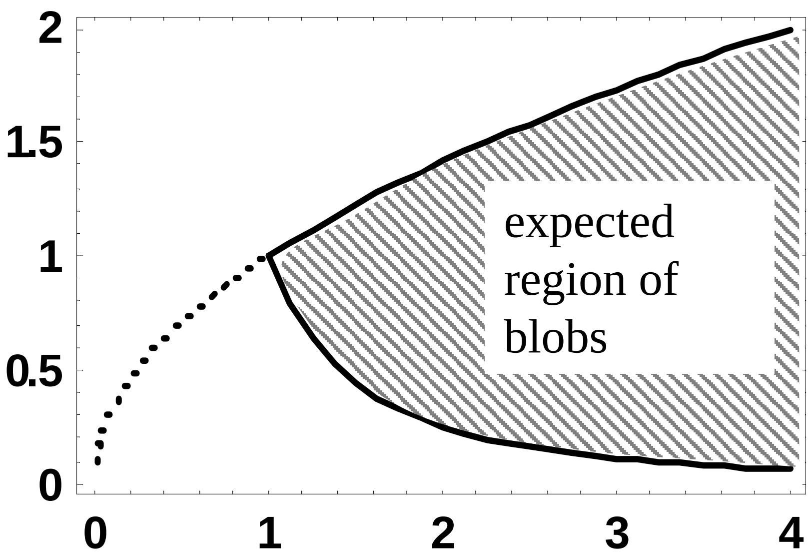
- **blobs speed up with collisionality Λ**
- **for low Λ, small blobs move fastest**
- **for large Λ, large blobs move fastest**

Theory predicts bounds on radial blob velocity

$$\frac{1}{\hat{a}^2} < \frac{v_r}{v_*} < \hat{a}^{1/2}$$

$$\hat{a} = \frac{a_b}{a_*} = \frac{a_b R^{1/5}}{L_\parallel^{2/5} \rho_s^{4/5}} \qquad v_* = c_s \left(\frac{a_*}{R} \right)^{1/2}$$

$$\hat{v} = \frac{v_r}{v_*}$$



$$\hat{a} = \frac{a_b}{a_*}$$

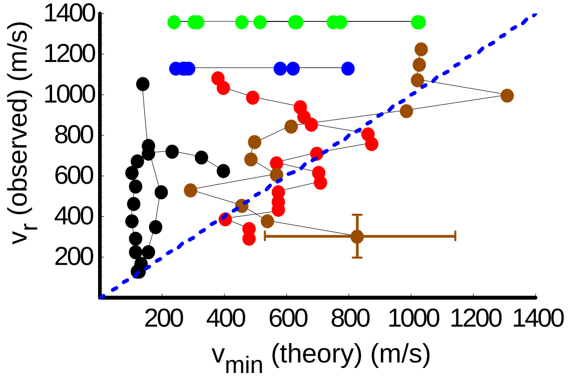
- hidden parameter is collisionality, Λ $\Rightarrow$ parallel structure
  - sheath connected (small Λ) slow
  - disconnected (large Λ) fast

$$\Lambda = \frac{\nu_{ei} L_\parallel}{\Omega_e \rho_s}$$

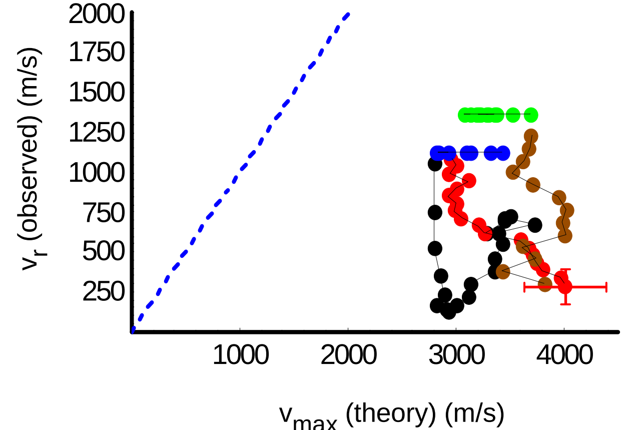
Blob velocity bounds verified from the GPI imaging analysis

Myra, D'Ippolito, Stotler, Zweben, LeBlanc, Menard, Maqueda and Boedo,
Lodestar Report #LRC-06-110, June, 2006, (submitted to Phys. Plasmas)
http://www.lodestar.com/LRCreports/NSTX_blobs_GPI.pdf

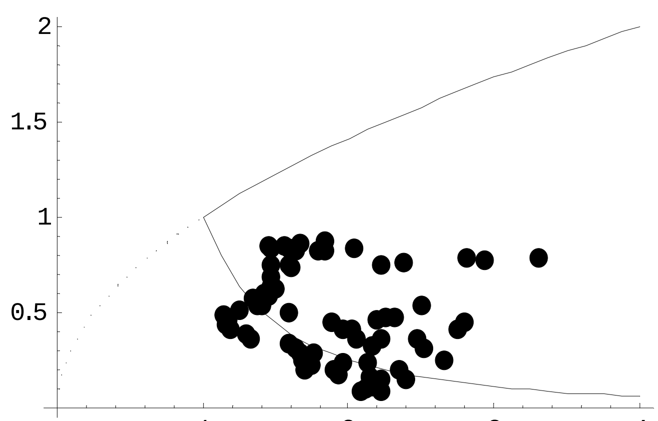
v_r (GPI) vs. v_{min}



v_r (GPI) vs. v_{max}



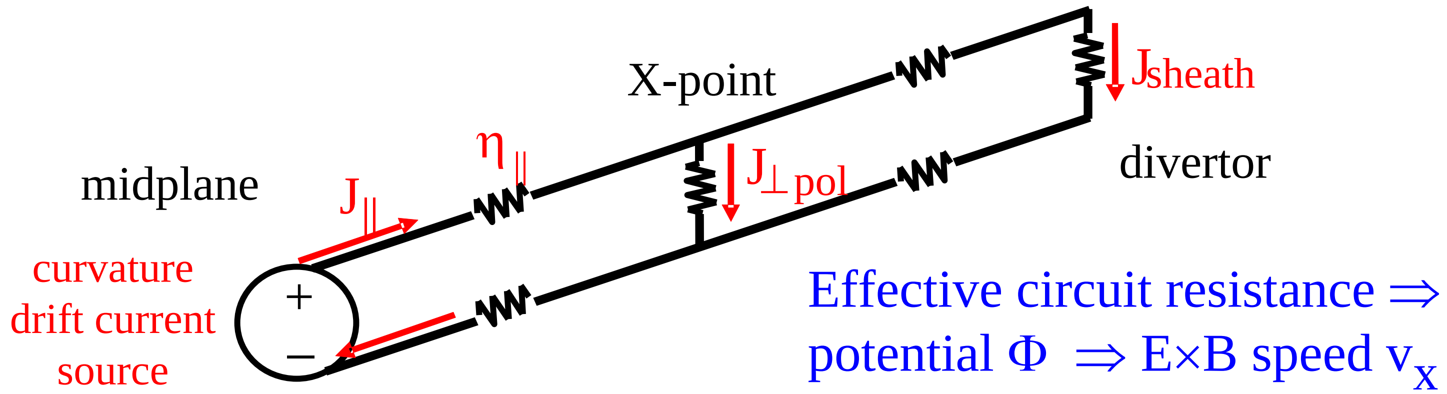
$$\hat{v} = \frac{v_r}{v_*}$$



$$\hat{a} = \frac{a_b}{a_*}$$

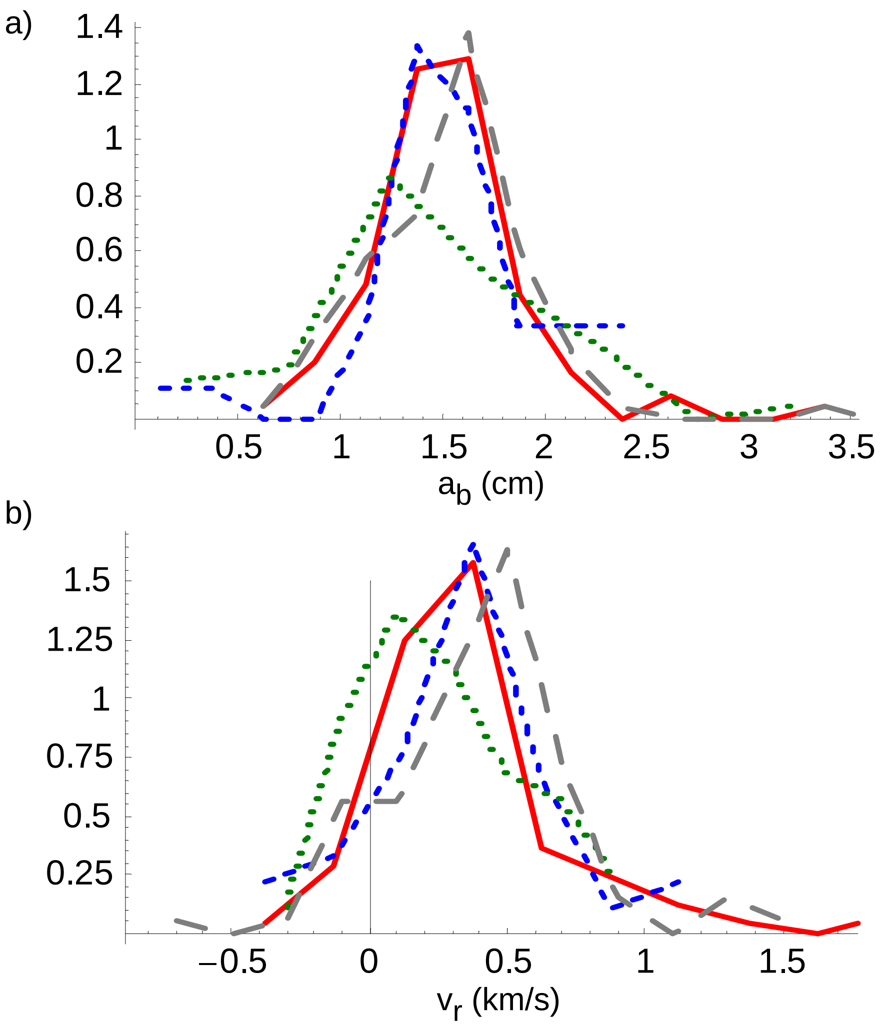
$$\frac{1}{\hat{a}^2} < \frac{v_r}{v_*} < \hat{a}^{1/2}$$

Proposal: increase SOL width by X-point gas puff



- increased parallel resistivity ($\eta_{||} \propto \Lambda$) increases circuit resistance
- current loops are forced to close locally at midplane or at X-point
- blobs disconnect from divertor plate sheaths and move faster
- cold gas puff in X-pt region could accomplish this
  - directly observe v_r increase with GPI
  - should increase SOL width
- disconnection, increased ⊥ thermal flux, related to SOL density limit physics:
  - D.A. D'Ippolito and J.R. Myra, Phys. Plasmas **13**, 062503 (2006).
- electrical disconnection vs. thermal (detachment)

So far, large changes in blob v_r (or a_b) with plasma conditions are not observed



- PDF's of a_b and v_r
- automated blob finder (R. Maqueda) + selection criteria

shot #	conf. mode	edge $\bar{n}_e$ (10^{13} cm−3)	P_{nbi}(MW)	blob activity
112825	L	4.0	0.8	turbulent
112814	L	2.5	0.8	quiescent
112842	H	2.0	0.8	quiescent
112844	L (DX)	3.0	1.7	turbulent

Ideas for future work

- statistics of blob sizes and velocities
  - measure from GPI long movies [R. Maqueda, 10,000 frames]
  - simulation using Lodestar 2D turbulence code [D. Russell, see APS 2006]
- access different collisionality regimes to observe/induce changes in v_r
  - gas puff ?
- fundamental question: what $\perp$ scale size a_b are blob born with ?
  - ρ_s
  - $a_* = L_{\parallel}^{2/5} \rho_s^{4/5} R^{-1/5}$
  - $1/k_y(\gamma_{max})$
  - $a_b(v_{r,max})$
- investigate correspondence rule postulate between linear theory and blobs

$$\gamma \to \frac{v_r}{a_b},\ k_\perp \to \frac{1}{a_b},\ L_n \to a_b$$