

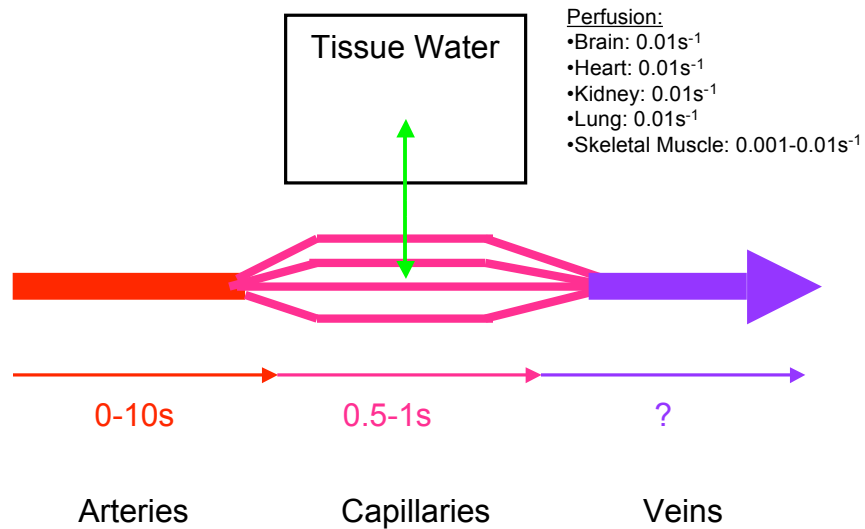
# Bioengineering 208 Magnetic Resonance Imaging

Winter 2007  
Lecture 8

- Arterial Spin Labeling
  - ASL Basics
  - ASL for fMRI
  - Velocity Selective ASL
  - Vessel Encoded ASL

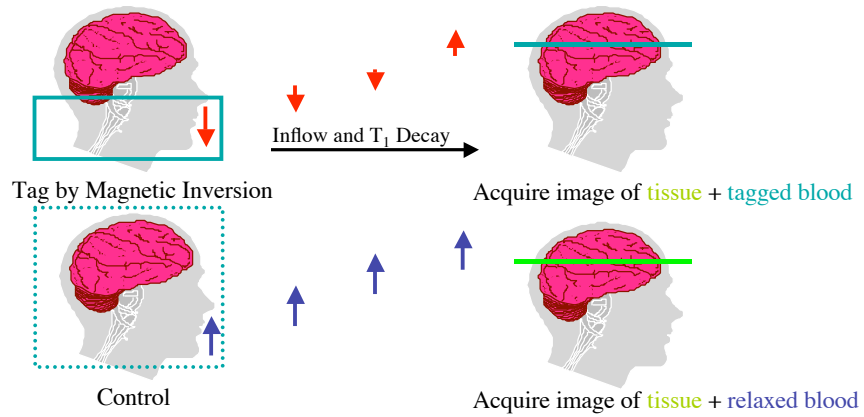
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## Blood Water Dynamics



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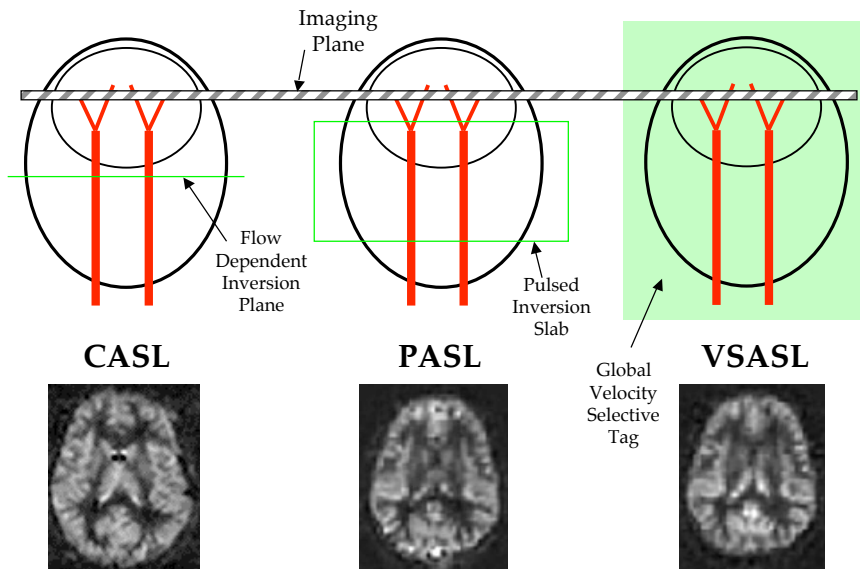
# Arterial Spin Labeling



$$\text{ASL Signal} = \text{Control} - \text{Tag} \propto \text{CBF}$$

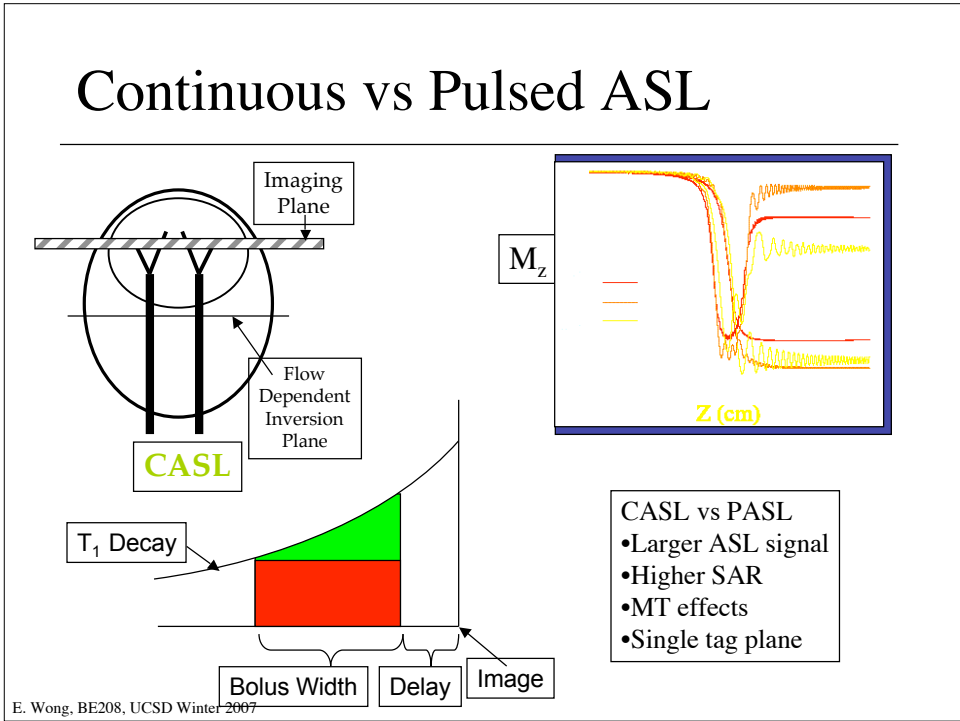
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# Types of ASL

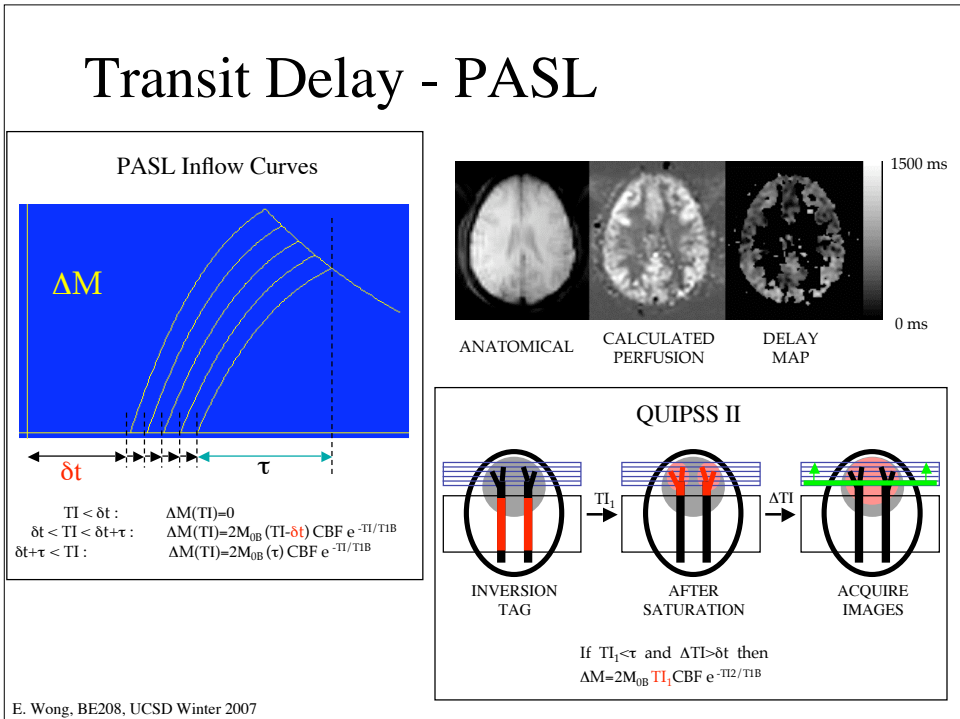


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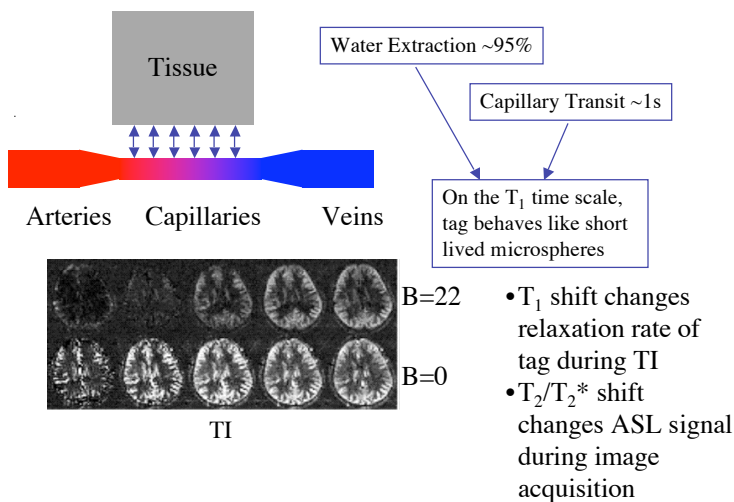
# Continuous vs Pulsed ASL



# Transit Delay - PASL

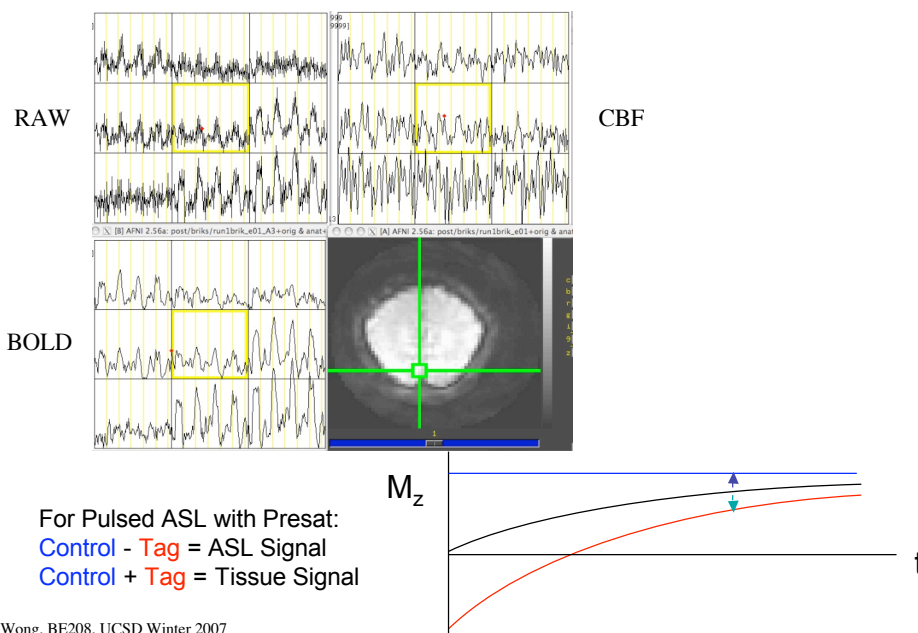


# Water Exchange



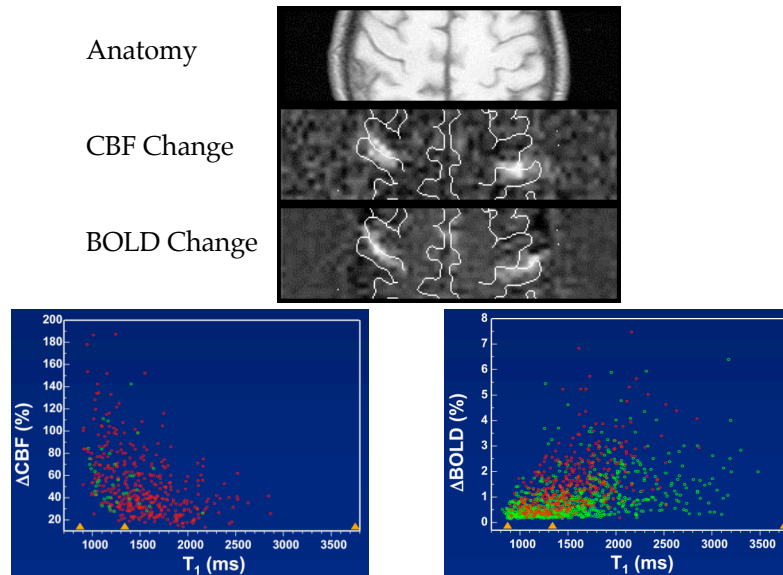
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# CBF and BOLD Time Series



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## Simultaneous Flow and BOLD fMRI



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## Transit Delays in Diagnostic ASL

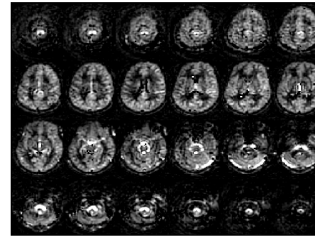
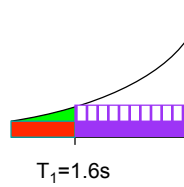
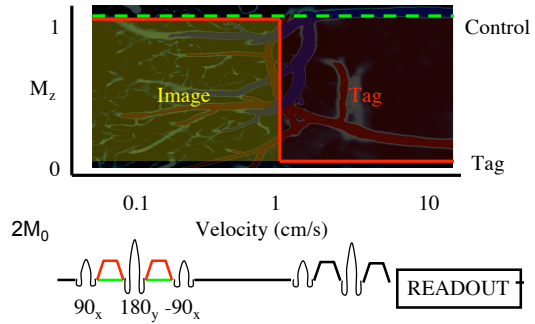
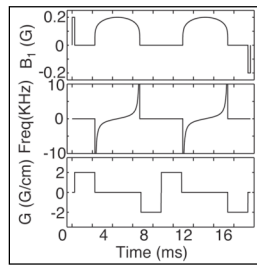
- Problem:
  - Long transit delays (delay  $\gg T_1$ ) limit the diagnostic potential of ASL in some disease states
- Solution:
  - Apply tag pulses that are not spatially selective but velocity selective



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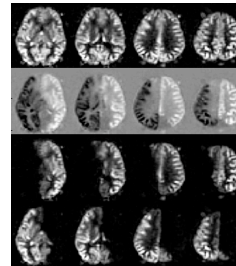
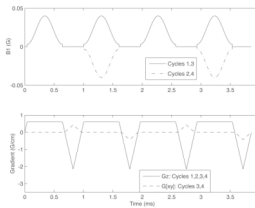
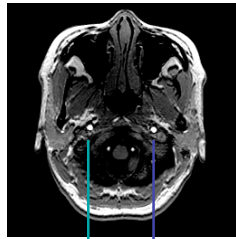
# Velocity Selective ASL

- Tagging based purely on velocity
- Tag has no spatial selectivity
- Transit delay eliminated

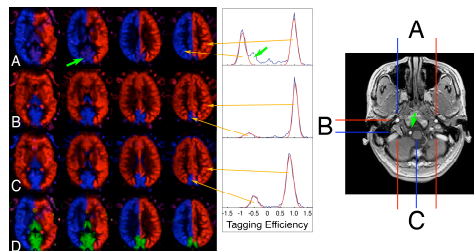


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# Vessel Encoded Pseudo-Continuous ASL

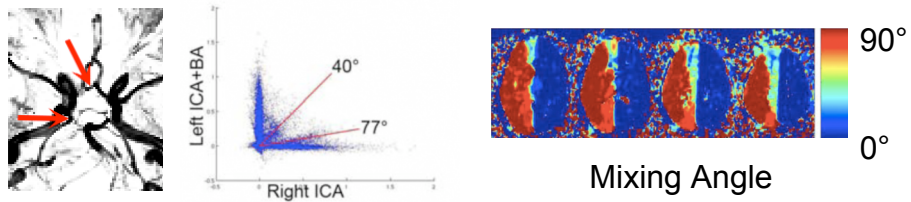


$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} -1 & 1 & -1 & 1 \\ 1 & -1 & -1 & 1 \\ -1 & -1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} R \\ L \\ B \\ S \end{bmatrix}$$

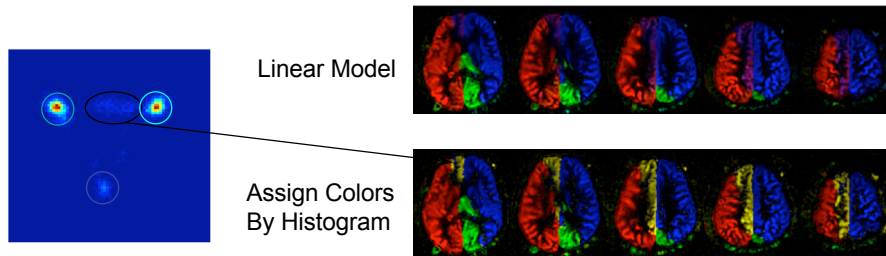


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# Vascular Mixing



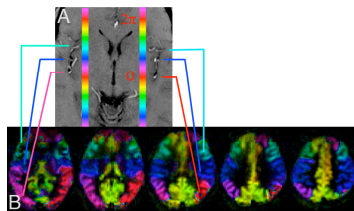
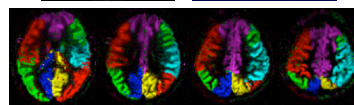
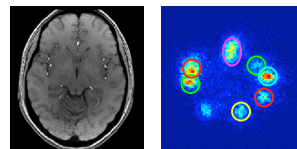
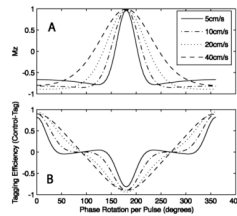
Akash Kansagra



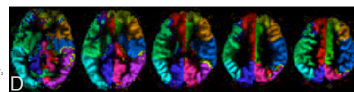
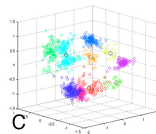
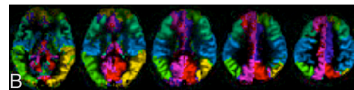
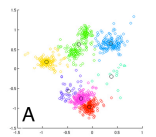
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# Vessel Encoded ASL

- Explicit identification of territories with probabilities
- Nonlinear encoding
- Vascular Source Imaging



sin/cos modulation



Multi-dimensional clustering

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