

Parameter Mapping

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Imaging application: parametric mapping

- Fits a model in every image pixel/voxel and produces an image of the model parameter.
- Input: several images acquired with different device settings.
- Output: set of fitted parameters in each pixel.

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MRI

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Diffusion MRI

- Image intensity sensitive to water dispersion
- Water mobility determined by local tissue architecture

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Water diffusion in Brain Tissue

Image from brainmuseum.org

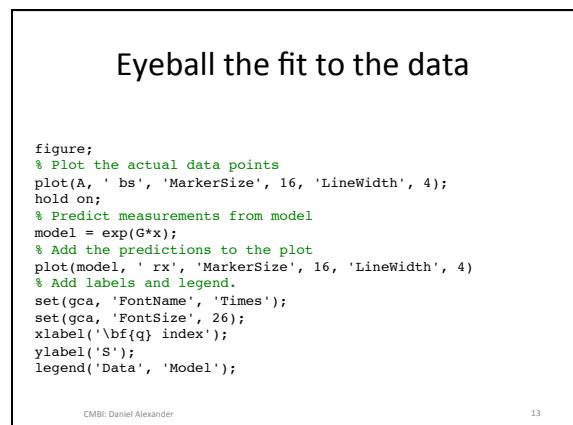
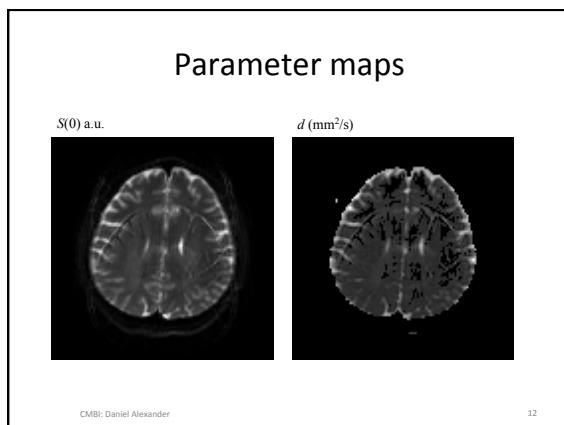
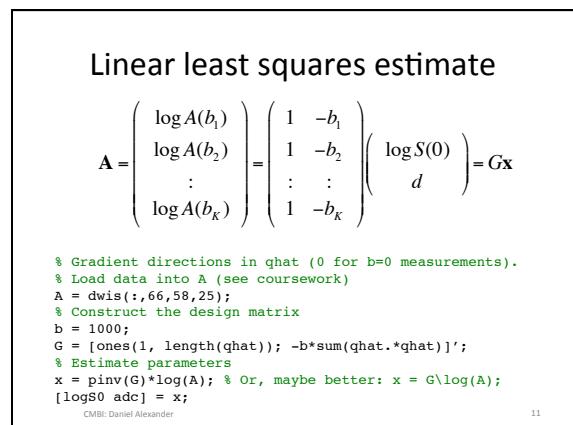
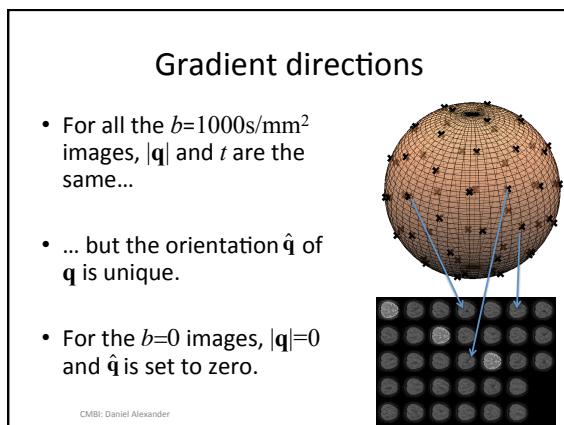
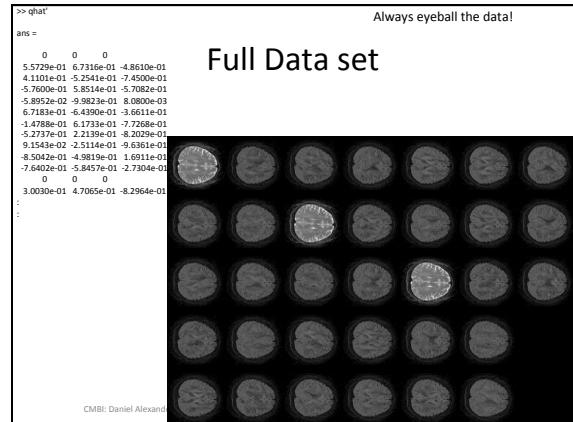
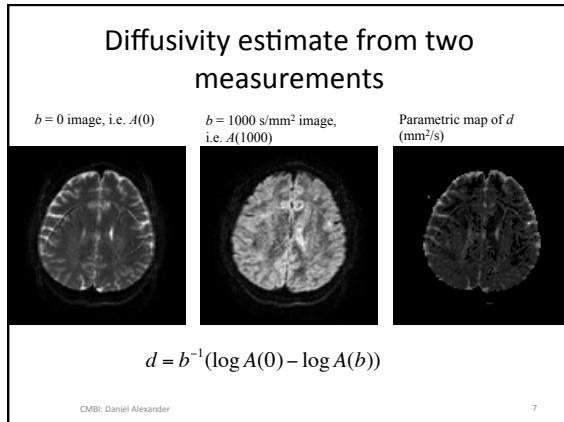
Estimate diffusivity

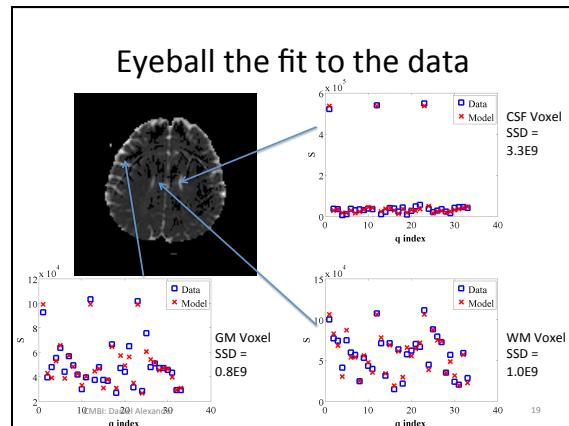
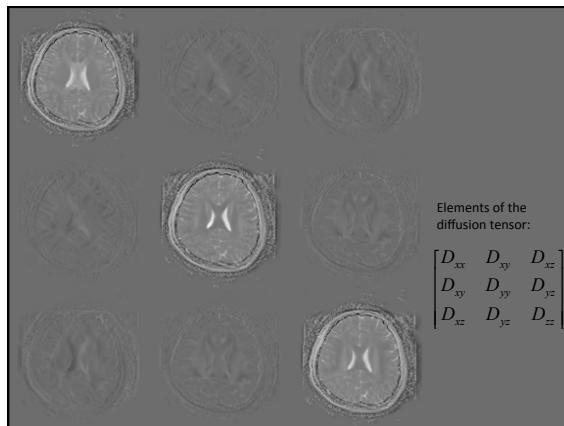
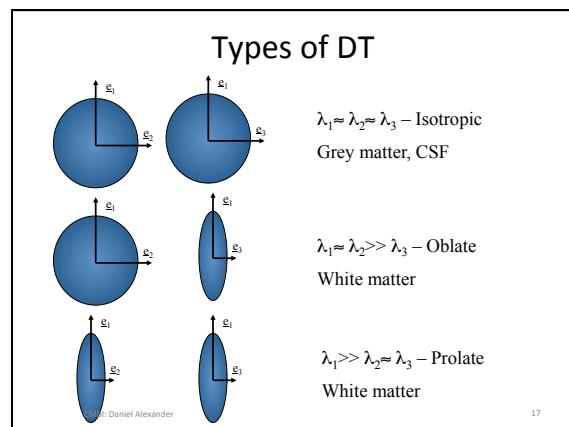
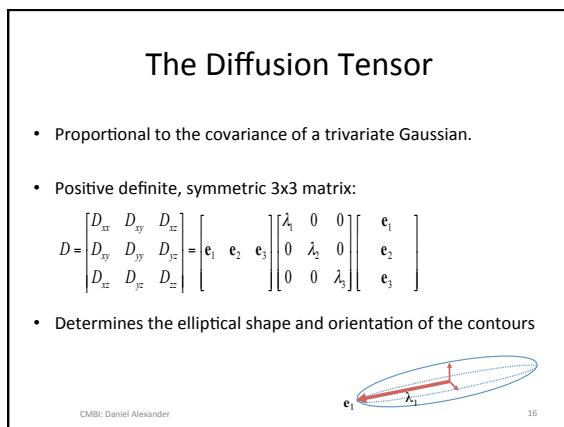
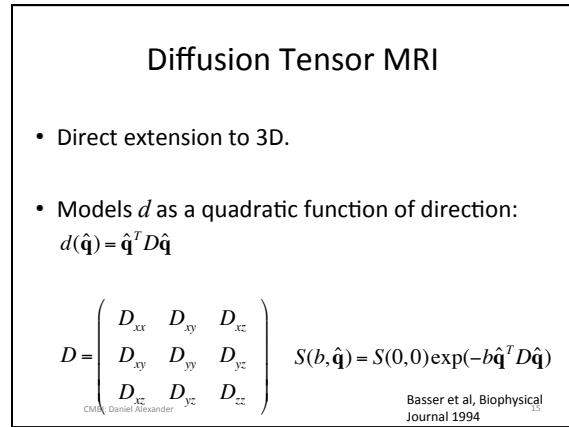
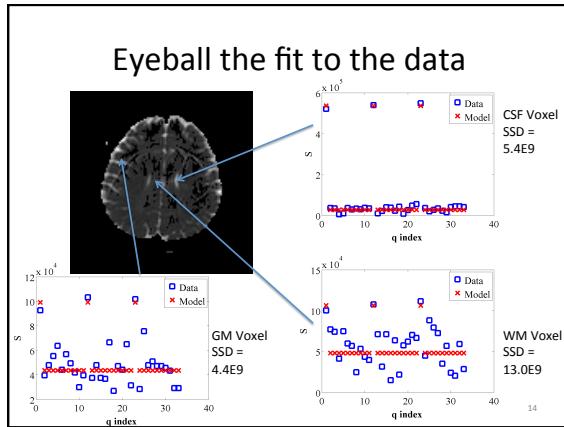
$$b = (\gamma \delta |\mathbf{G}|)^2 (\Delta - \delta/3)$$

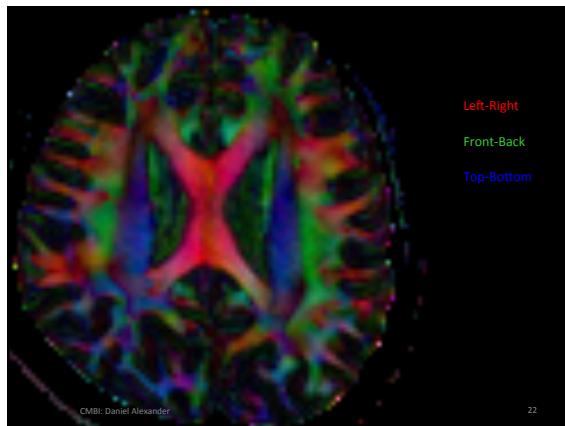
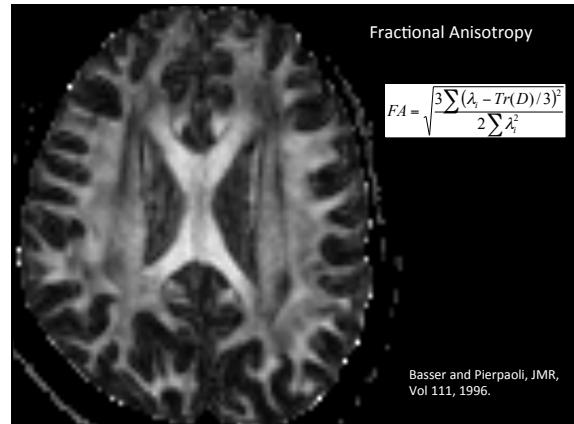
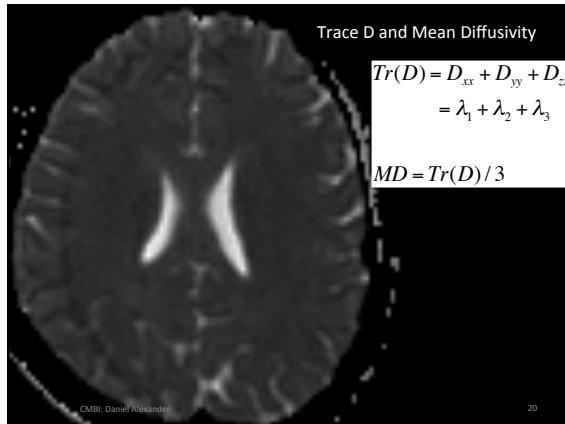
$$b = |\mathbf{q}|^2 t$$

$$S(b) = S(0) \exp(-bd)$$

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Weighted linear least squares

- Any reason to weight different measurements differently?

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Error propagation

- Measurement A has standard deviation σ .
- What is the standard deviation of $f(A)$?

$$\sigma_f = \sigma \frac{\partial f}{\partial S}$$

- Simple version of more general approach called *error propagation*.

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Non-linear DT fit (naïve!!)

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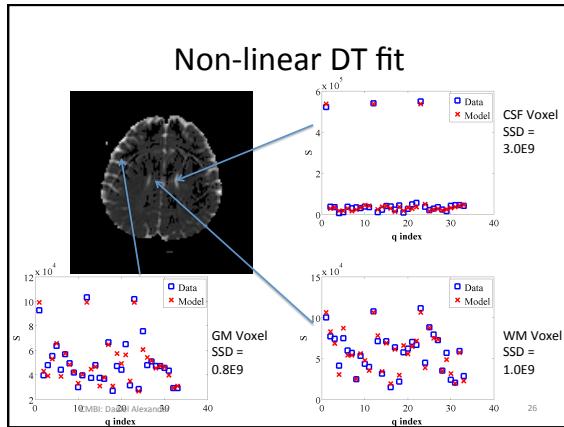
voxdw = dwis(:,66,58,25);
ps = pinv(X)*log(voxdw);
startx = ps;
startx(1) = exp(startx(1));
h = optimset();
[par,RES,EXIT,OUT]=fminunc('DT_SSD',startx,h,voxdw,bvals,qhat);

function [sumRes, resJ] = DT_SSD(x, meas, bvals, qhat)
S0 = x(1);
Dxx=x(2);Dxy=x(3);Dxz=x(4);Dyy=x(5);Dyz=x(6);Dzz=x(7);
D = [[Dxx Dxy Dxz];[Dxy Dyy Dyz];[Dxz Dyz Dzz]];
% The abs is a cheat to add numerical stability.
S = S0*exp(-abs(sum(qhat.*(D*qhat)).*bvals))

sumRes = sum((meas - S').^2);

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Constraints

- The naïve non-linear fit above places no constraints on the elements of D.
- What constraints are appropriate?
- How might we enforce them?

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