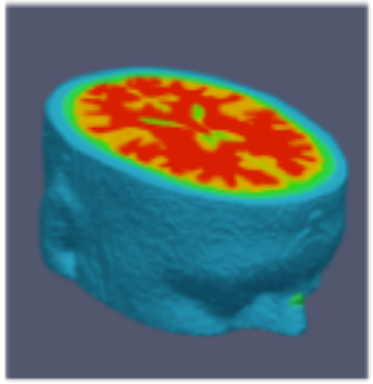
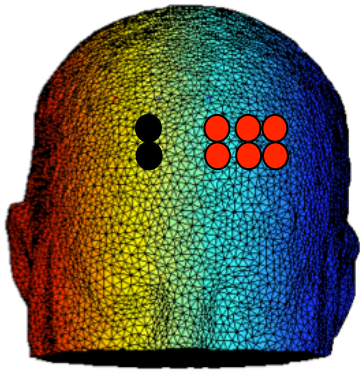
Human Head Models

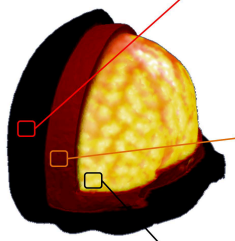
Basic Spectroscopy to study brain oxygenation

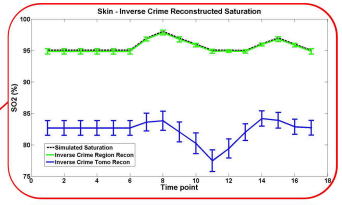
Aims of this session

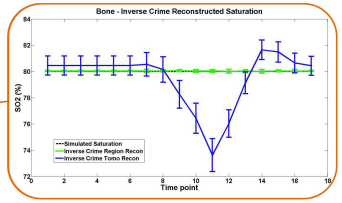
- To use a multi-layered model of the human head
- Model data based on changes in oxygen saturation (SO2) of the brain
- Calculate the Jacobian (mapping function) to allow recovery of SO2 from boundary data

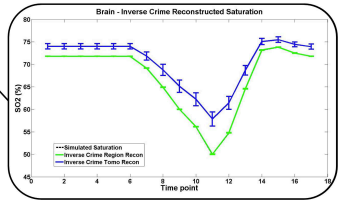






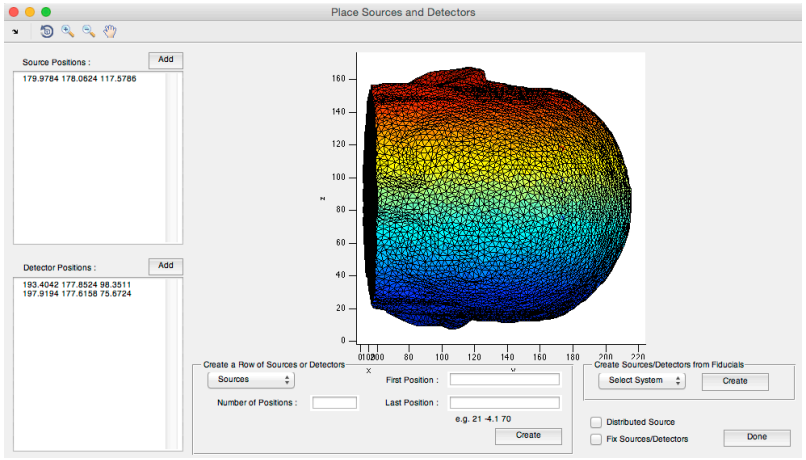




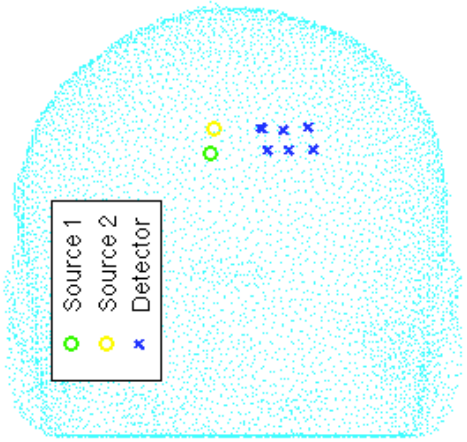


What will you do?

- Either create your own mesh from a pre-segmented scan in NIRFAST

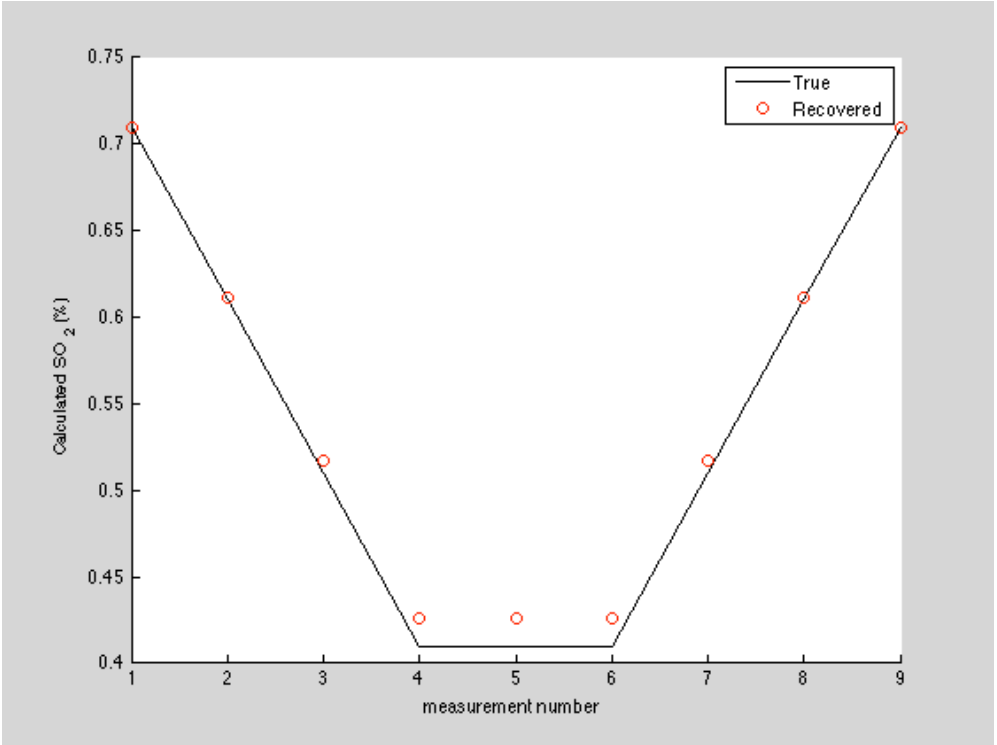


- Or just use a mesh already created



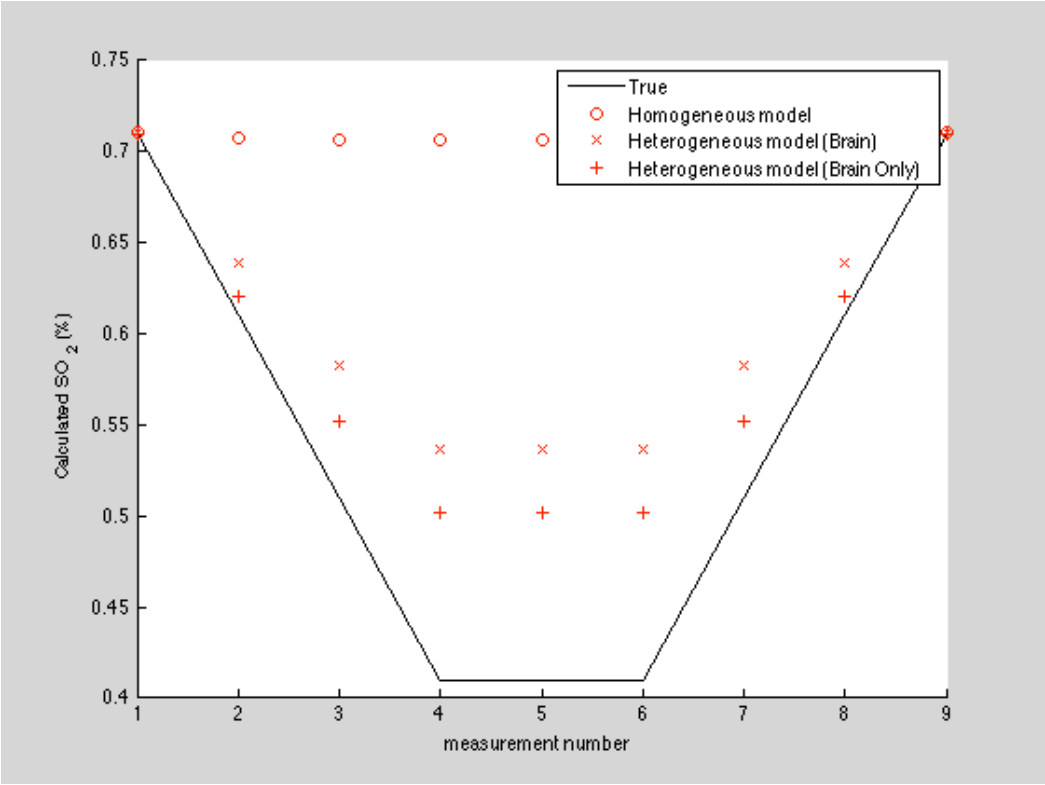
What will you do?

- Either assume a homogeneous head:
  - Model boundary data for a set of oxygen saturations
  - Recover oxygen saturation for the 'whole' head



What will you do?

- OR assume a layered head:
  - Model boundary data for a set of oxygen saturations for ‘brain’
  - Recover oxygen saturation for the ‘whole’ head or the ‘brain only’.



Outline of Tasks

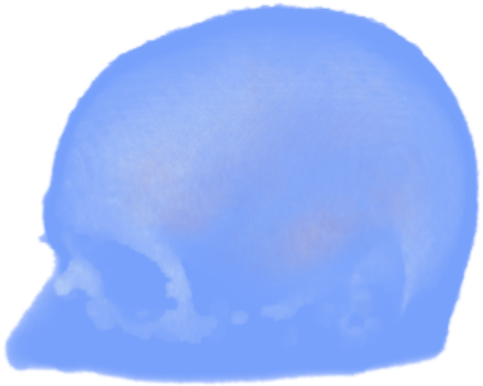
- Create 3D model of a layered head
- Place source/detector positions
- Assign optical properties
- Model forward simulated data
- Recover parameters using basic spectrocopy

3D model of Layered Head

- The ICBM152 atlas has been used with SPM to segment 5 different tissue types:

	Skin	Skull	CSF	White matter	Grey matter
Region Label	1	2	3	4	5

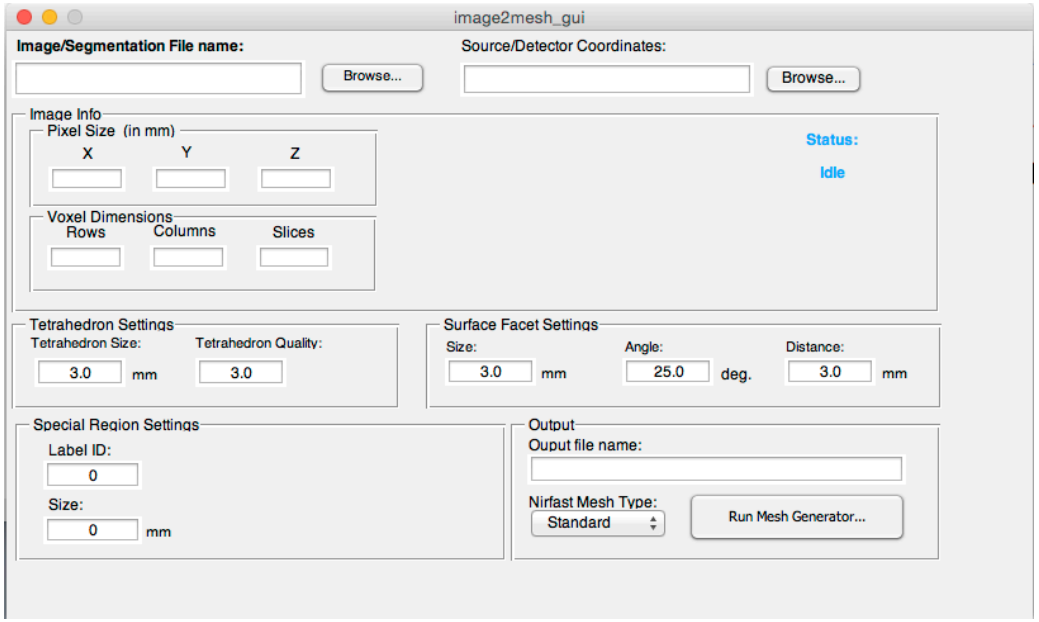
- This is provided to you as an mha file, head.mha



Creating 3D mesh

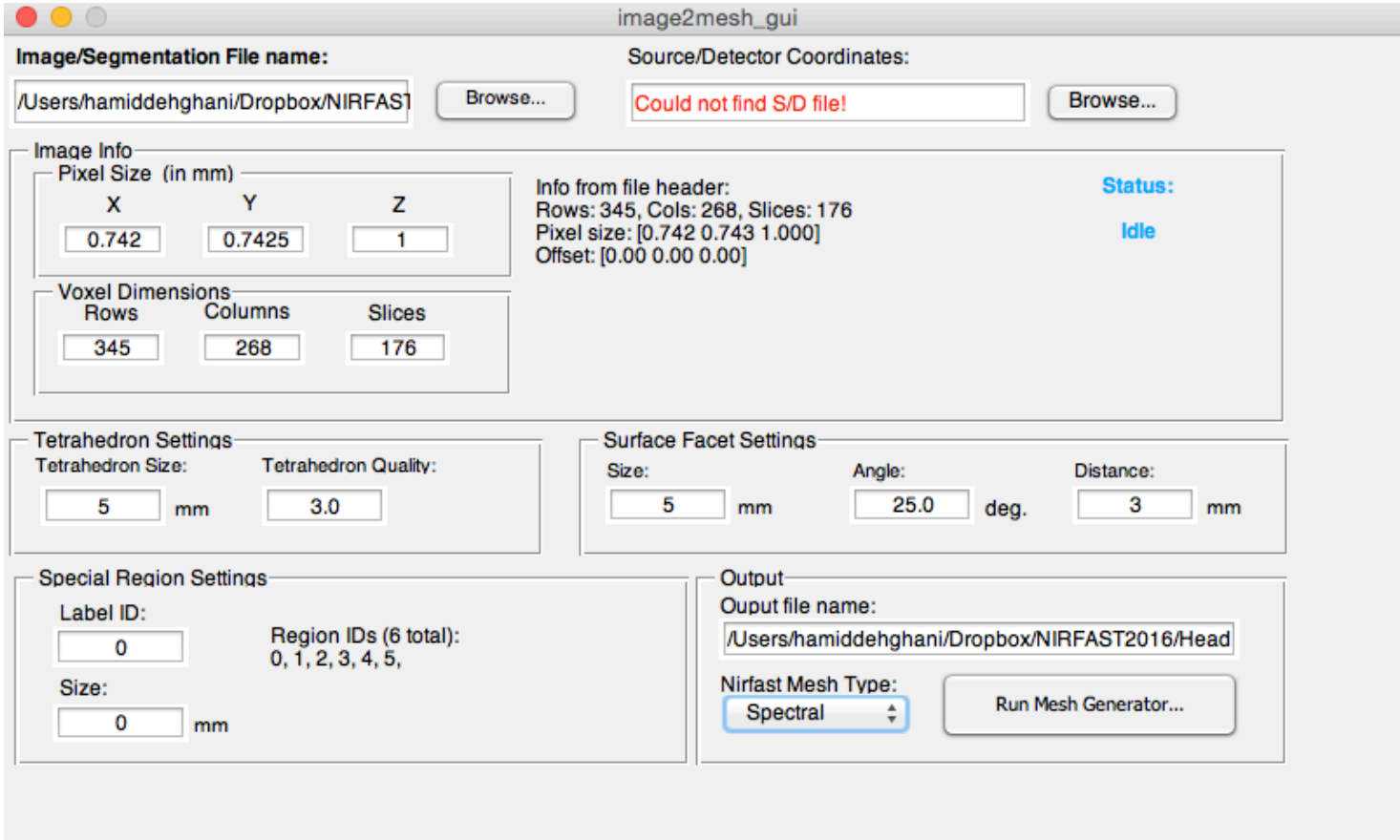
- We will use NIRFAST directly to read the mha file and create a 3D mesh and place source/ detector locations:
- In MATLAB use command

image2mesh_gui



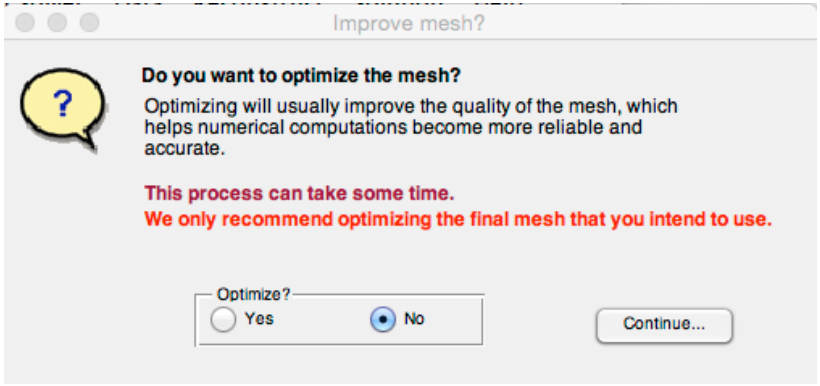
Creating 3D mesh

1. Load up mha file
2. Ignore source / detector coordinates (will do later)
3. Set mesh size (5)
4. Choose spectral
5. Run the generator



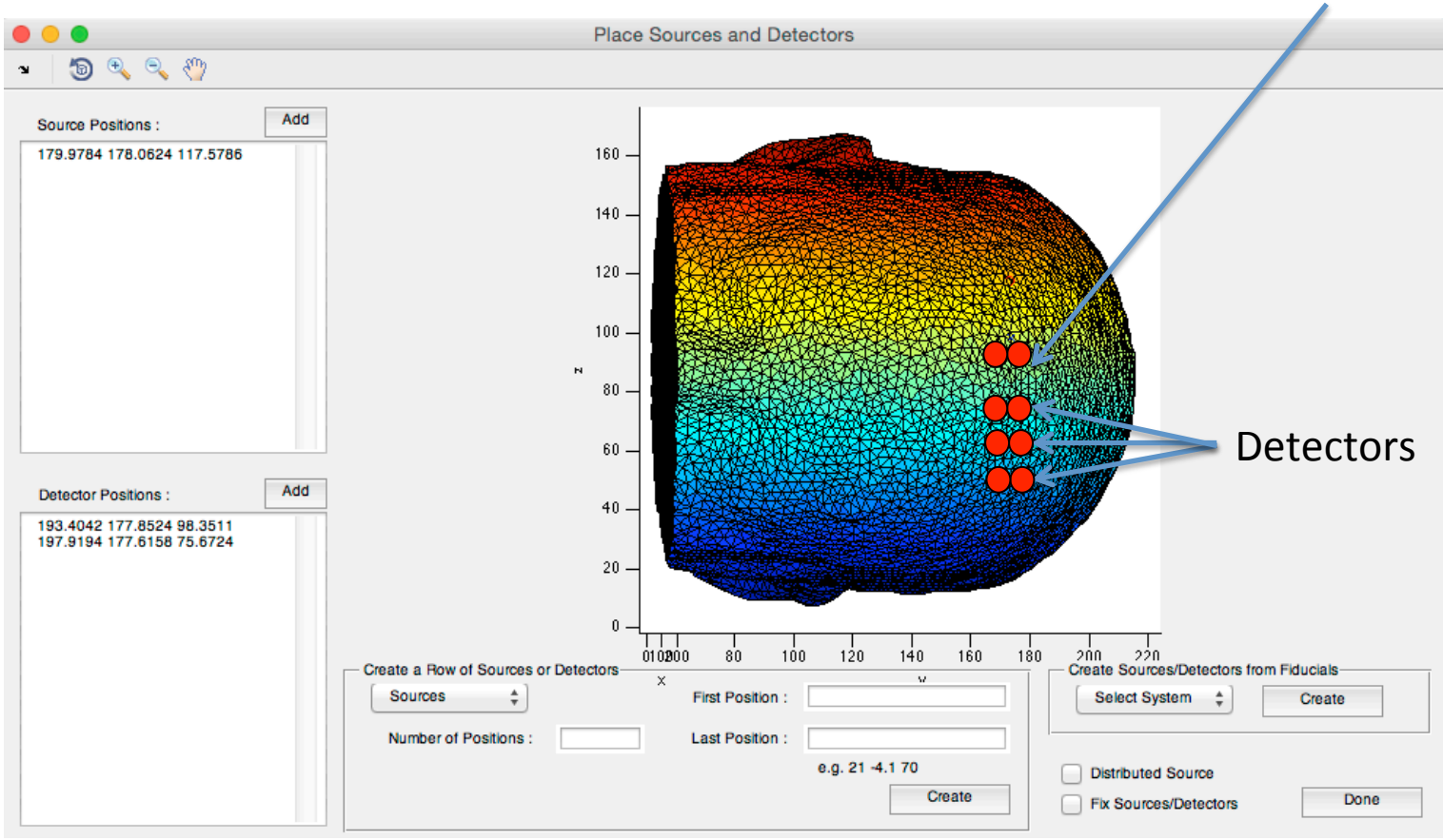
Creating 3D Mesh

- State No, and continue



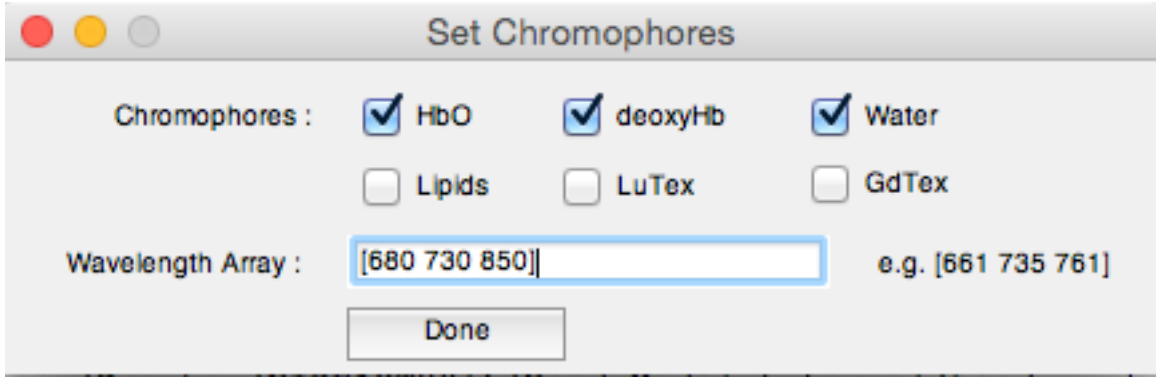
Creating 3D mesh

- Click Add for source and then on TWO single locations for source
- Click Add for Detector and then on SIX locations for detectors
- Hit Done



Creating 3D Mesh

- Set wavelengths of choice as [680 730 850]



Close all menus.

Mesh properties

- Type mesh in MATLAB
- This shows all properties
- To save mesh

save_mesh(mesh,'filename');

- To load a pre-made mesh

mesh = load_mesh('filename');

```
>> mesh

mesh =

              name: [1x78 char]
             nodes: [43410x3 double]
            bndvtx: [43410x1 double]
              type: 'spec'
    chromscattlist: {5x1 cell}
                sa: [43410x1 double]
                sp: [43410x1 double]
              conc: [43410x3 double]
                wv: [3x1 double]
            excoef: [3x3 double]
          elements: [243418x4 double]
         dimension: 3
            region: [43410x1 double]
            source: [1x1 struct]
              meas: [1x1 struct]
              link: [2x5 double]
                ri: [43410x1 double]
                 c: [43410x1 double]
               ksi: [43410x1 double]
      element_area: [243418x1 double]
           support: [43410x1 double]
```

Optical properties

- We will next set optical properties for different tissue types.
- Remember, this is a ‘spectral’ mesh, so rather than stating absorption and scatter for a given wavelength, we will set concentration of oxy and deoxy haemoglobin, water fraction as well as scatter amplitude and power. See NIRFAST paper for details

Set optical properties

	Skin	Bone	CSF	White Matter	Grey matter
HbT (mM)	0.06	0.049	0.001	0.076	0.076
So2 (%)	75	80	90	71	71
Water (fraction)	0.5	0.15	0.99	0.78	0.78
Scatter Amplitude	2	1.4	0.5	0.76	0.76
Scatter Power	0.5	1.4	0.2	0.54	0.54

Note, these are only based part on literature…you can just use your preferred values

Now follow scripts

- To generate the data and look at parameter recover, you will next follow two different scripts:
- head_mesh_script_homogeneous.m
  - In this example, we will assume a homogenous head
- head_mesh_script_layered.m
  - In this example, we will model a multi-layered head