Imaging Science

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Advanced Sensing Laboratory
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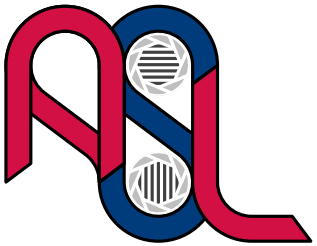

August 6, 2013

Some personal info

- B.S. in Math

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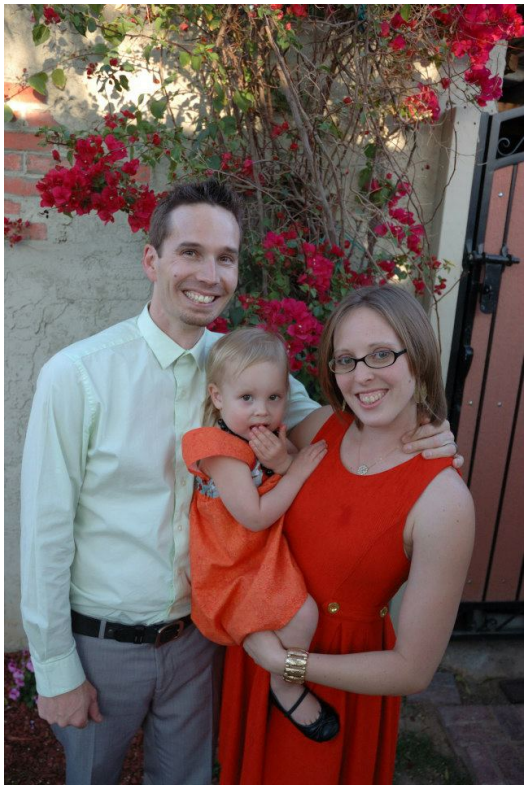
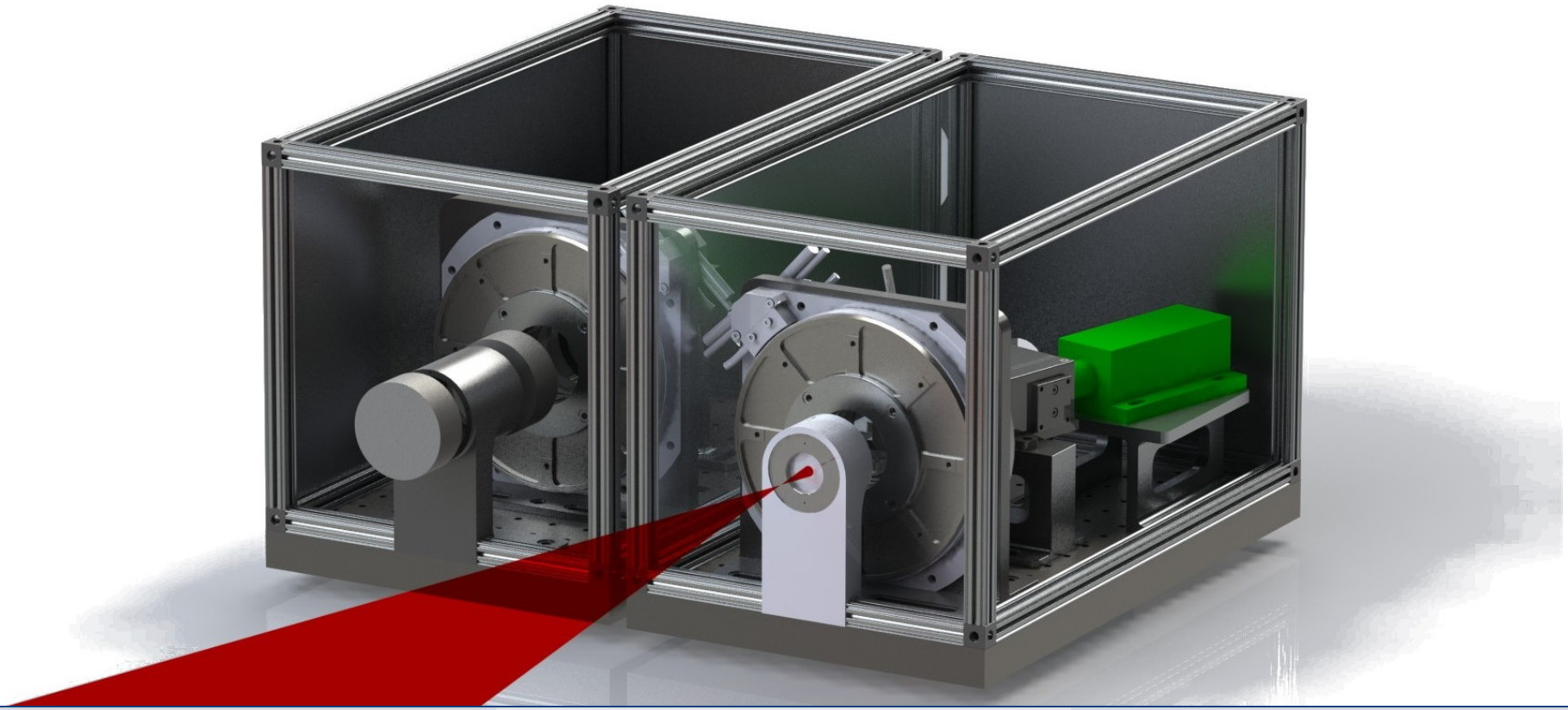
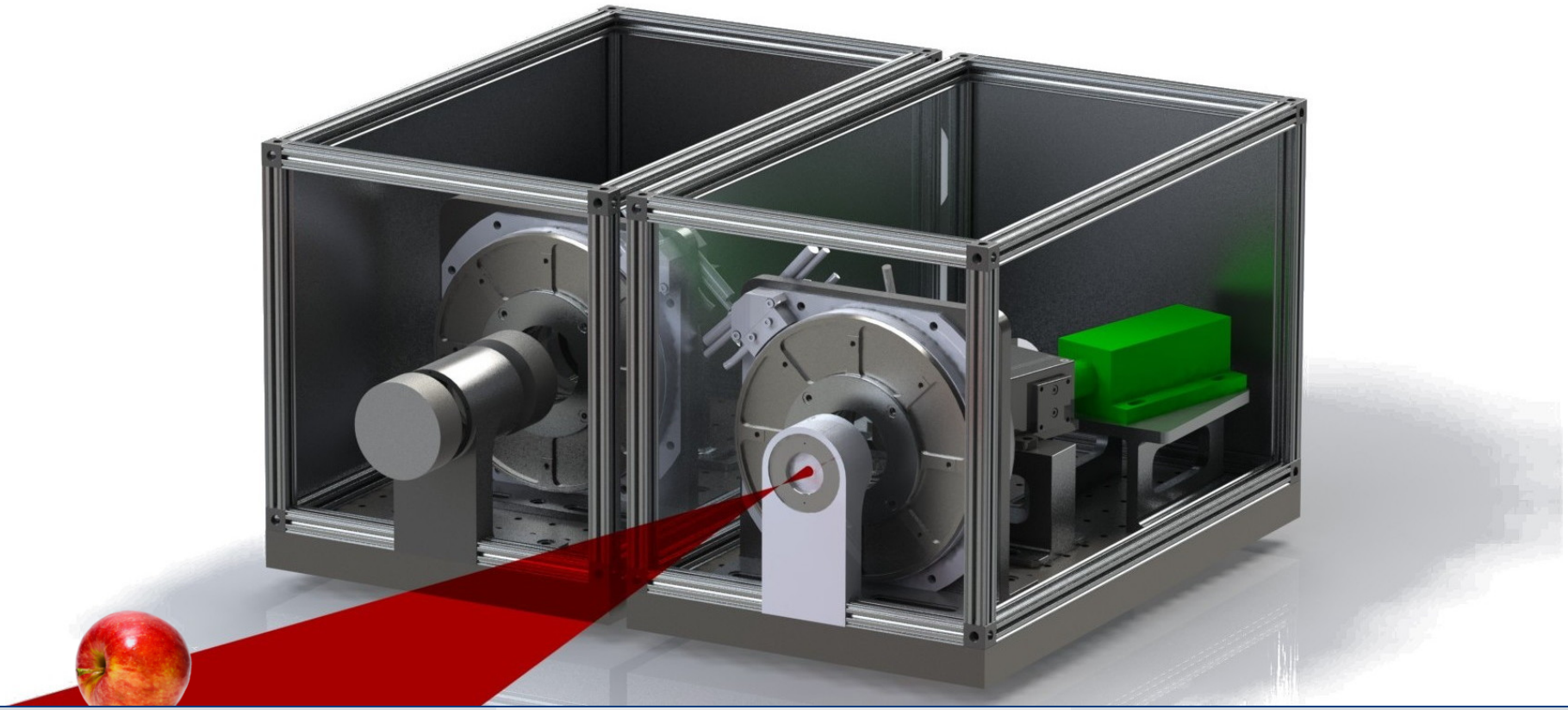


Mathematical model



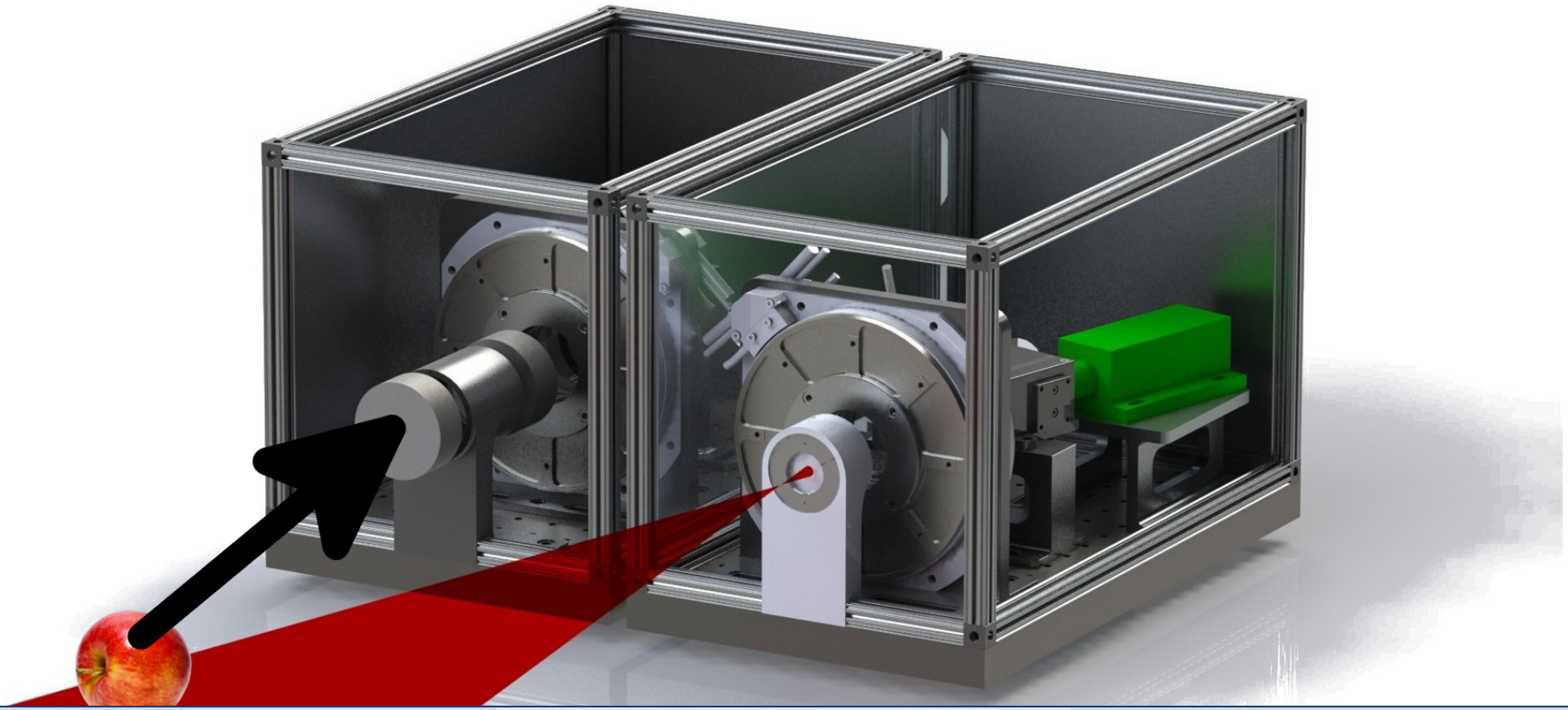
Mathematical model

- Begin with the physics (object)...



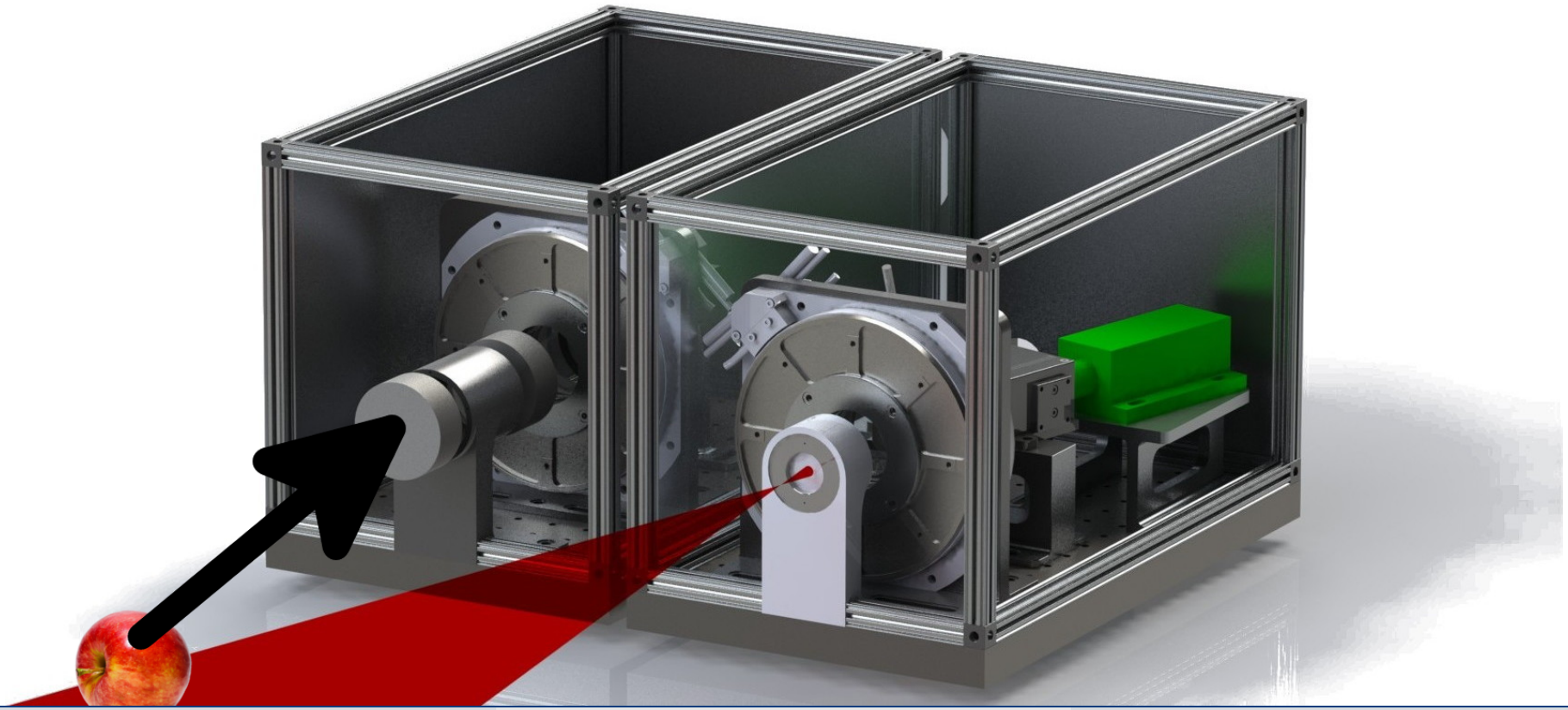
Mathematical model

- Begin with the physics (object)...
- Analyze physical interaction with an instrument to measured data (image)...



Mathematical model

- Begin with the physics (object)...
- Analyze physical interaction with an instrument to measured data (image)...
- Derive a mathematical model from the physics and the physical interaction.



Mathematical model

- Begin with the physics (object)...
- Analyze physical interaction with an instrument to measured data (image)...
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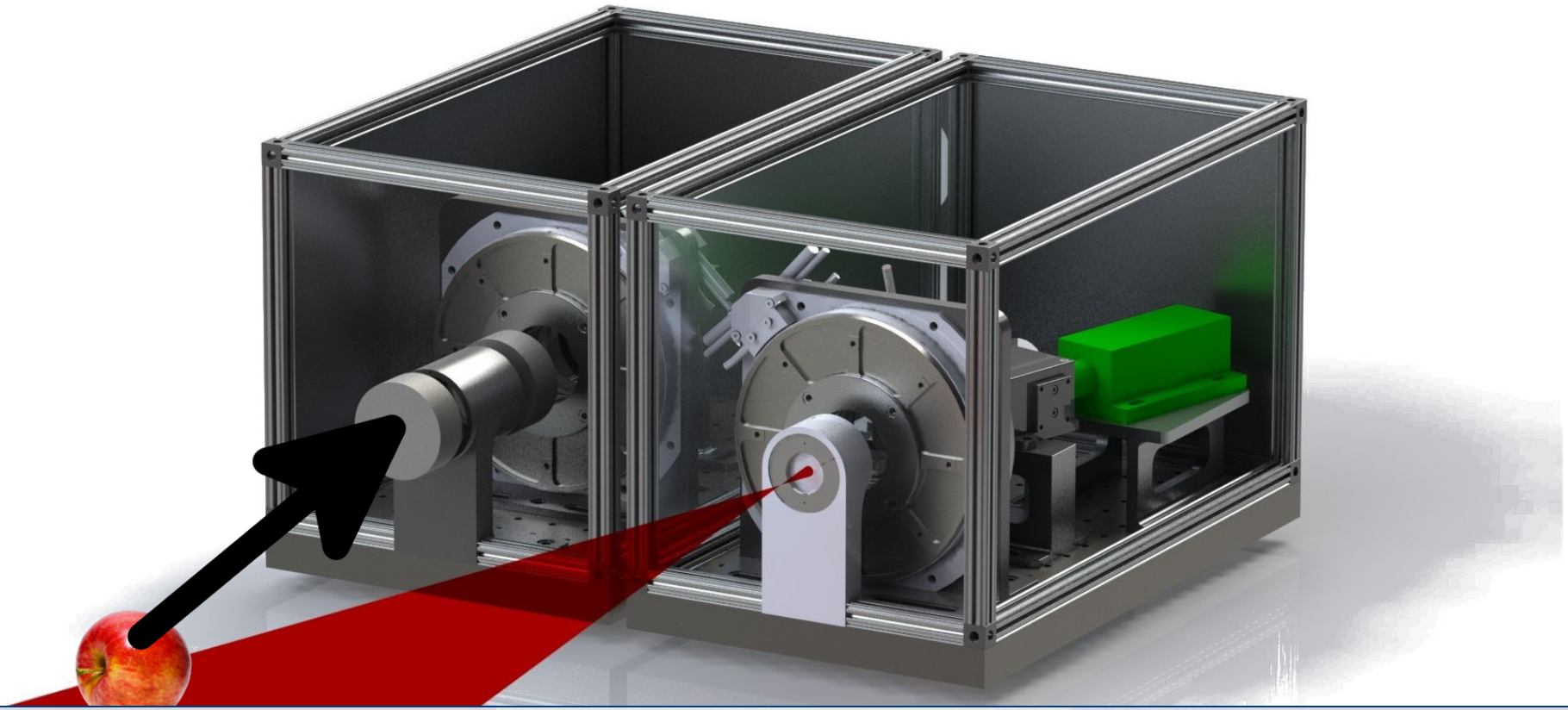
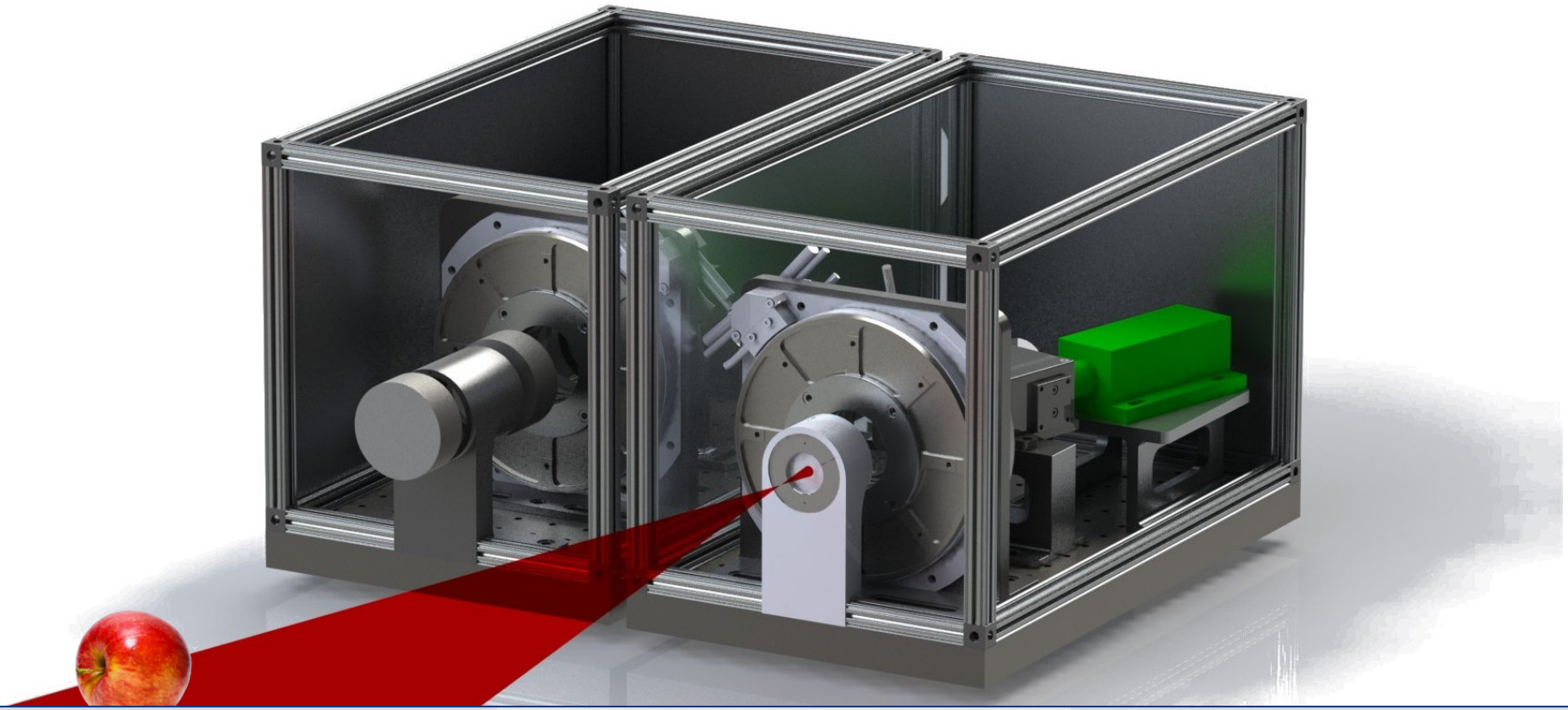
$$\mathbf{g} = \mathcal{H}\mathbf{f}$$

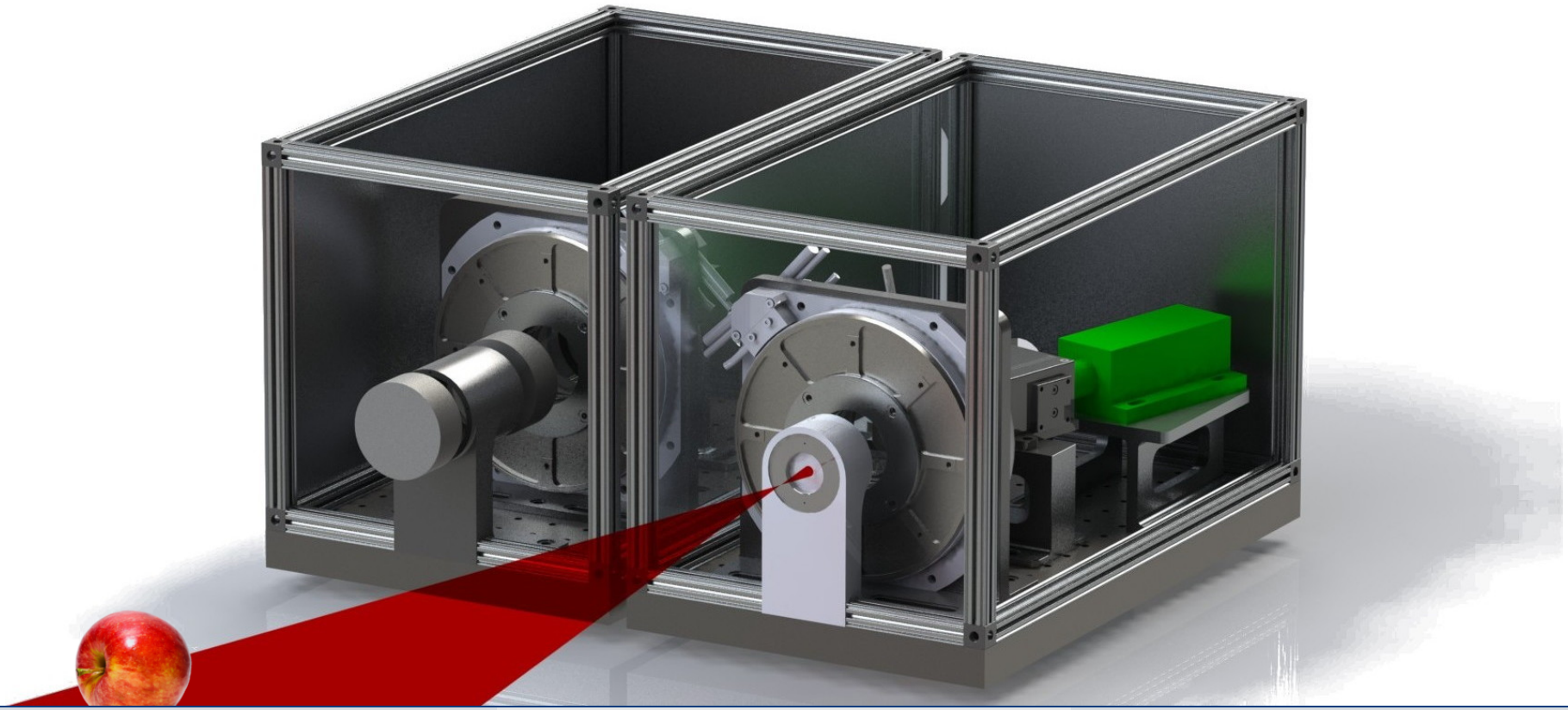


Working backward - inverting the model



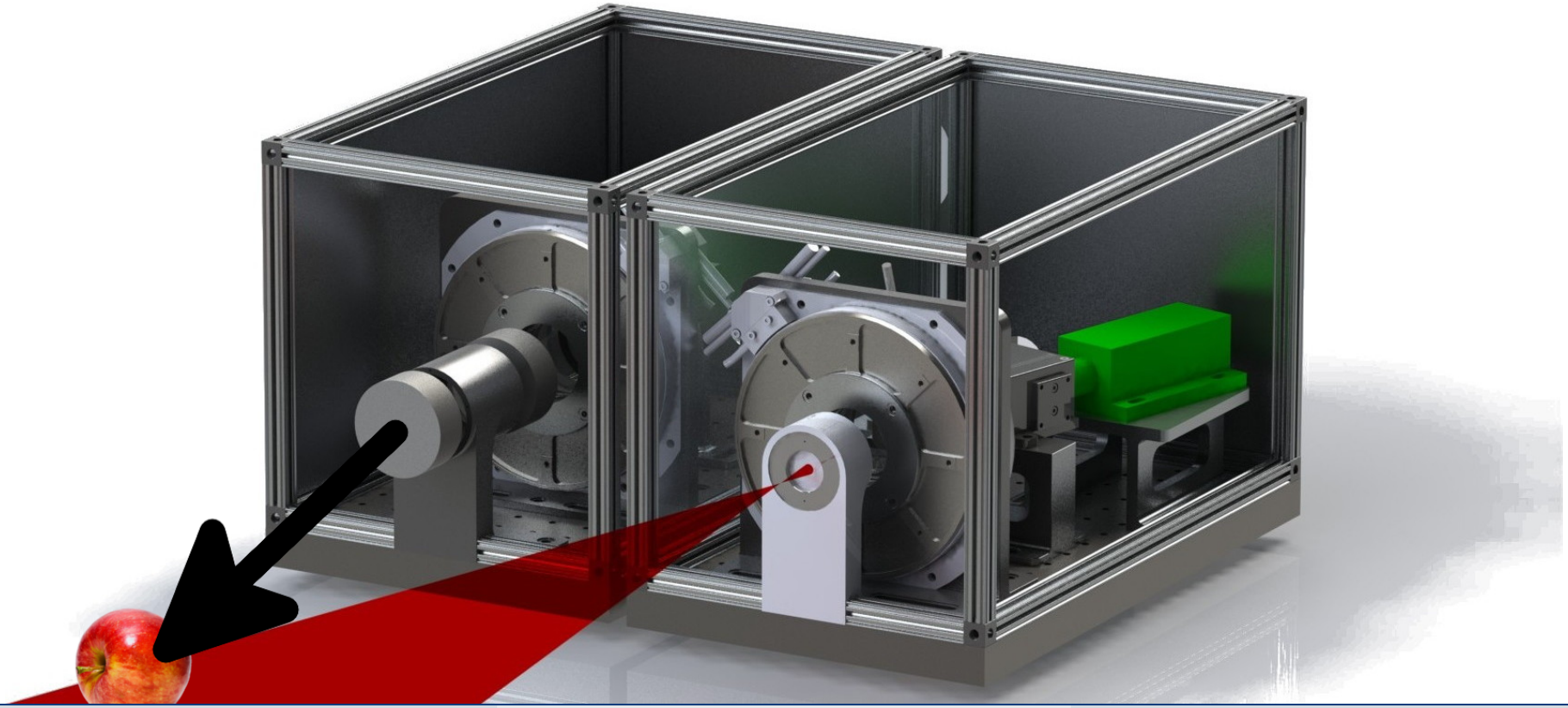
Working backward - inverting the model

- Begin with the model...



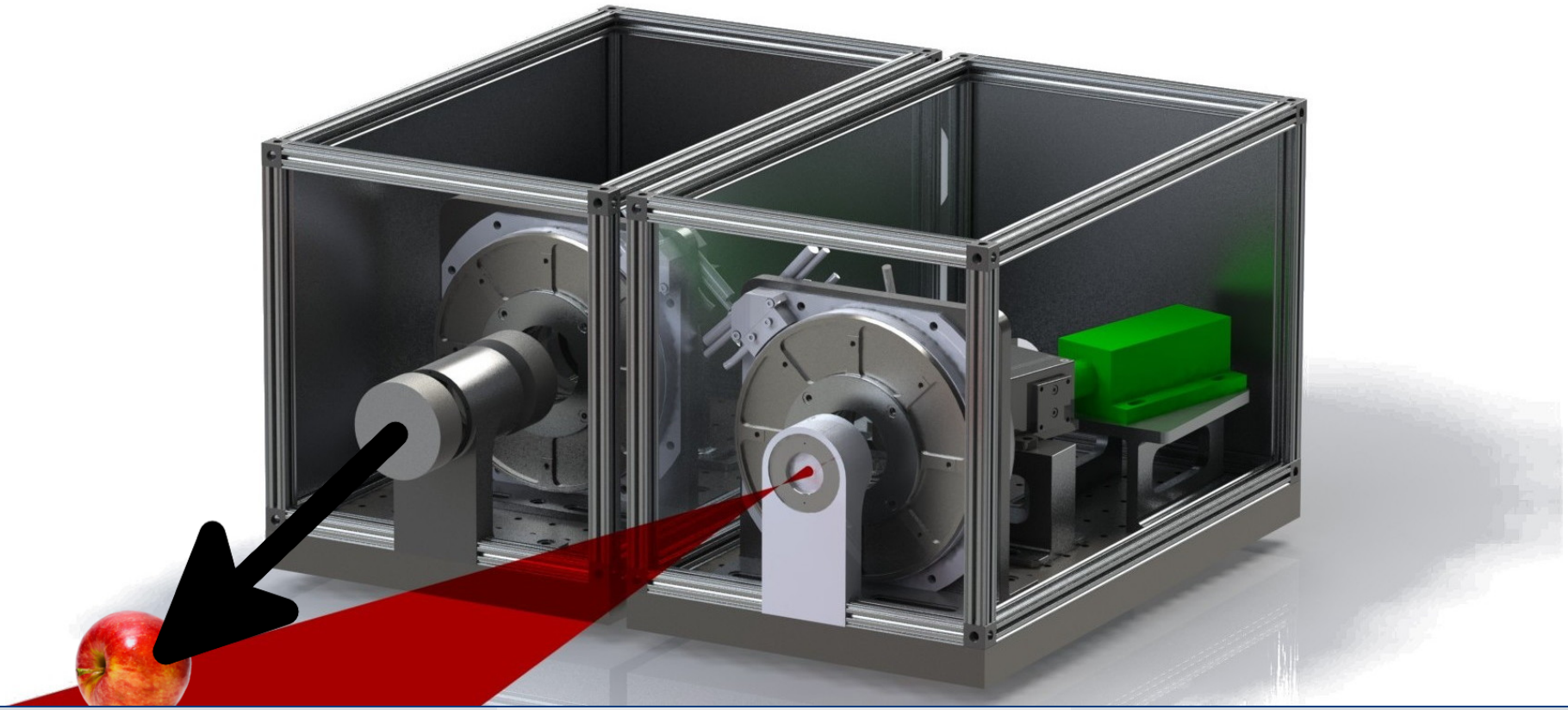
Working backward - inverting the model

- Begin with the model...
- Invert the model (work backwards) to obtain...



Working backward - inverting the model

- Begin with the model...
- Invert the model (work backwards) to obtain...
- An estimation of the physical quantity.



Working backward - inverting the model

- Begin with the model...
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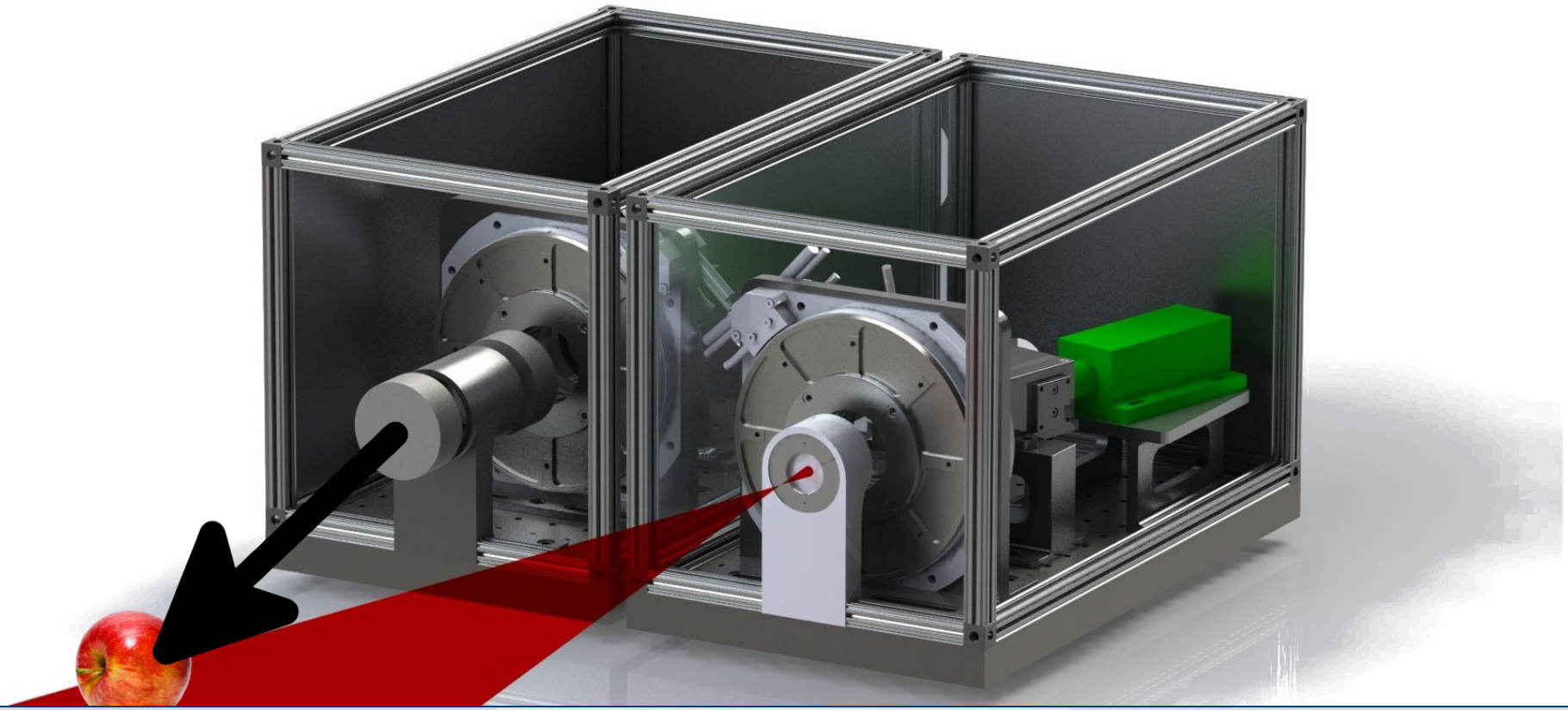
- An estimation of the physical quantity.

$$\mathcal{H}^{-1}\mathbf{g} = \mathbf{f}$$

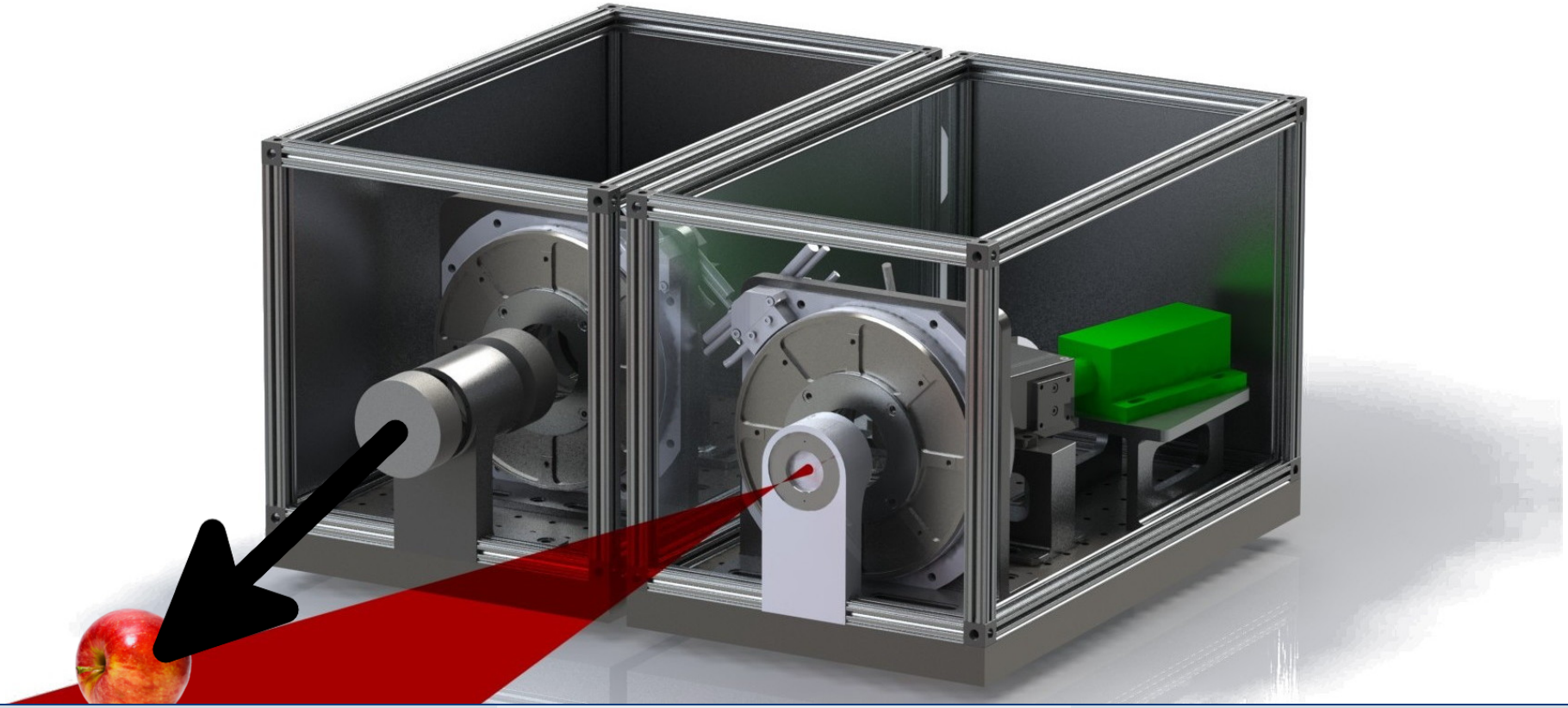


Working backward - inverting the model

- Begin with the model...
- Invert the model (work backwards) to obtain...
- An estimation of the physical quantity.

$$\mathcal{H}^{-1}\mathbf{g} = \mathbf{f}$$

Inverting the model is a subject of an entire mathematical subfield called *Stochastic or statistical estimation theory*.



Example : MRI

- 2003 Nobel prize in medicine awarded to Mansfield and Lauterbur.

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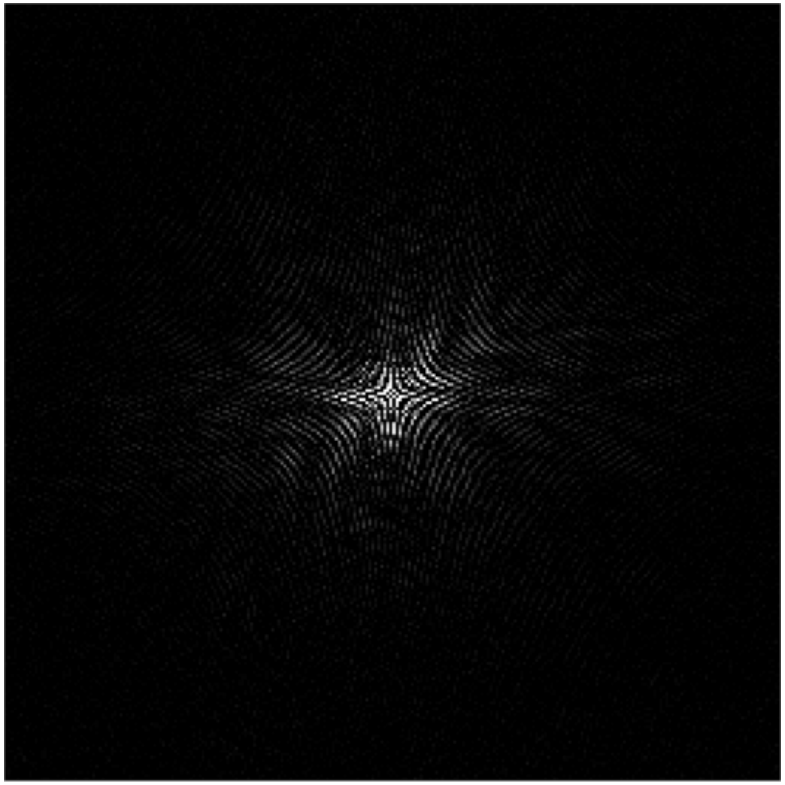


Figure 1: image

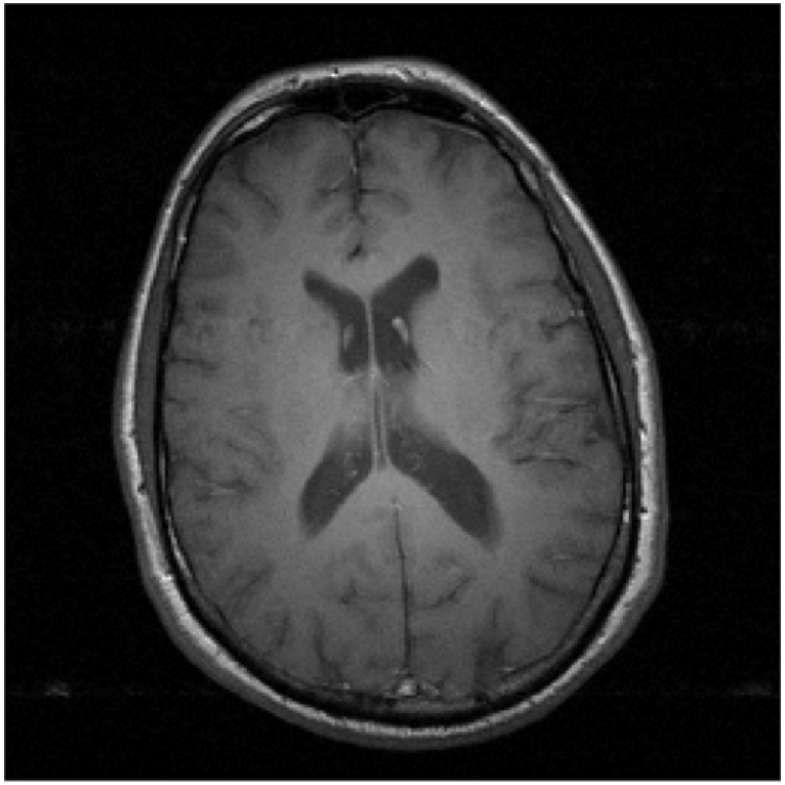
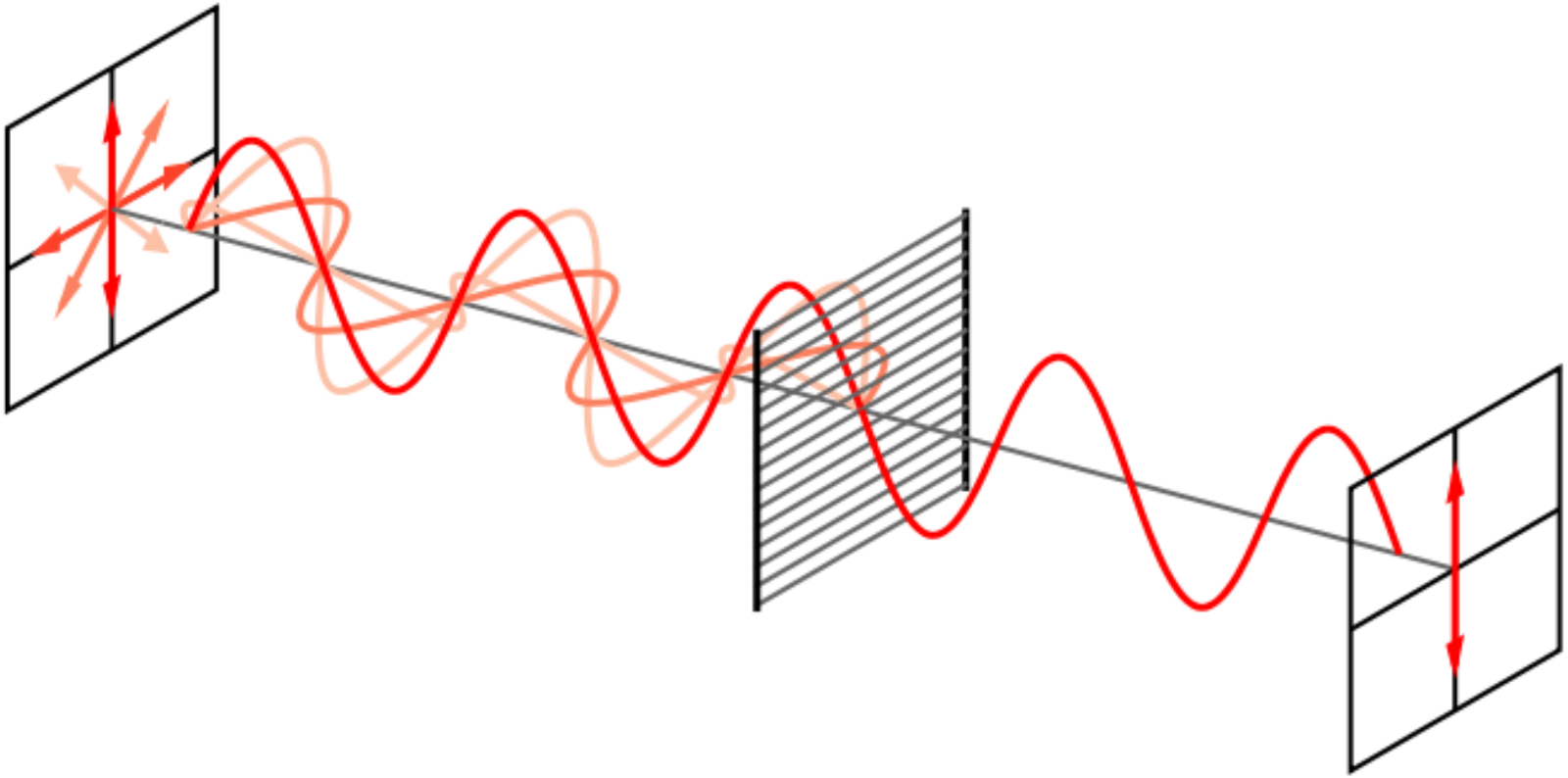


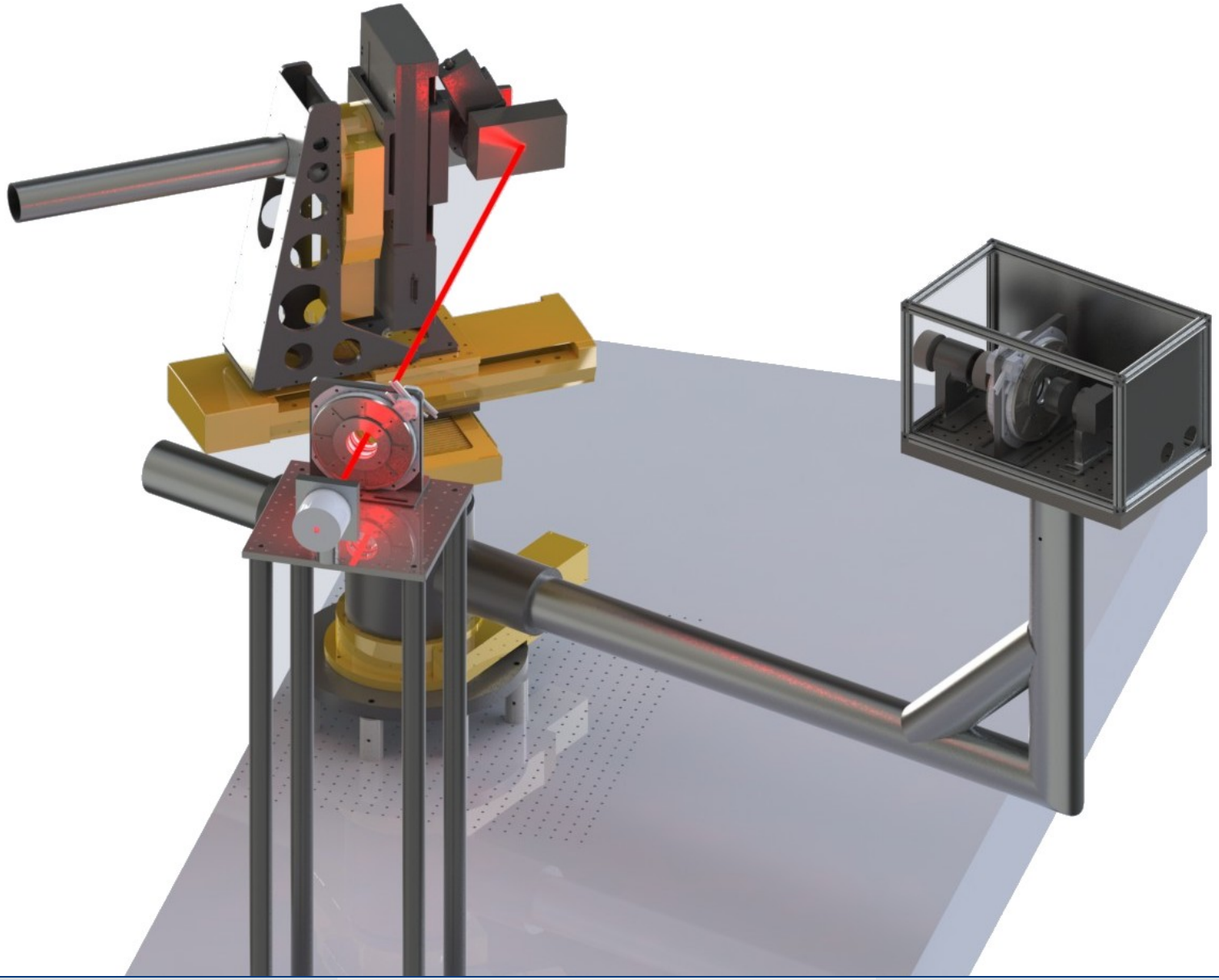
Figure 2: object

Oriented electric field



Electric field is oriented in space.

Polarimetric instrument

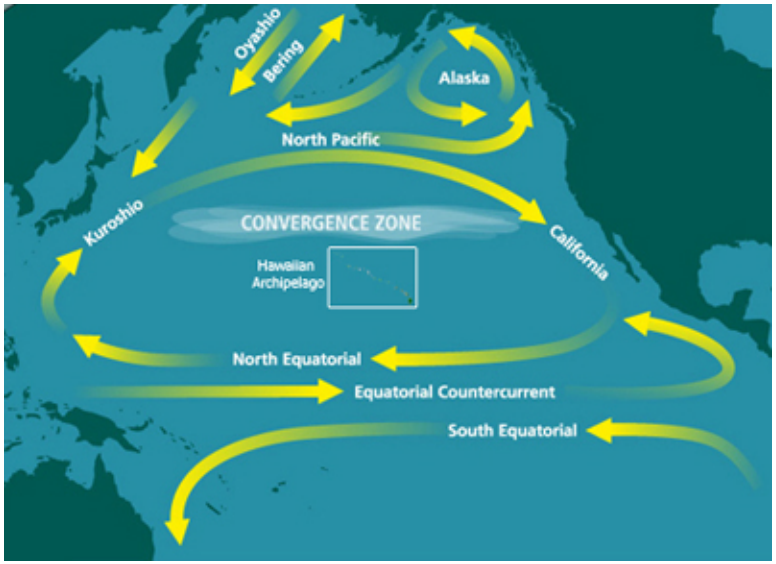


Polarimetric camera equation

$$\sum_{j'} \frac{\ell^2}{\mu_0 \omega_{j'}} \operatorname{Re}\left\{\left[\left(e^{i\boldsymbol{\ell}_{m,n}\cdot\boldsymbol{\kappa}_{j'}}\operatorname{sinc}\left(\frac{\ell\boldsymbol{\kappa}_{j'}}{2\pi}\right) * \mathscr{F}_2\left\{\mathcal{H}^2(\theta_{m,n})\,\tilde{\mathbf{f}}(\mathbf{r},0)\right\}\cdot\tilde{\mathbf{e}}_{j'}\right)k_{z,j'}\right.\right.$$
$$\left.\left. - \left(\left[e^{i\boldsymbol{\ell}_{m,n}\cdot\boldsymbol{\kappa}_{j'}}\operatorname{sinc}\left(\frac{\ell\boldsymbol{\kappa}_{j'}}{2\pi}\right) * \mathscr{F}_2\left\{\mathcal{H}(\theta_{m,n})\,\tilde{\mathbf{f}}(\mathbf{r},0)\right\}\right]\cdot\boldsymbol{\kappa}_{j'}\right)e_{z,j'}\right]\right\}$$
$$+\sum_{j'} \frac{\ell^2}{\mu_0 \omega_{j'}} \operatorname{Re}\left\{\left[\left(e^{-i\boldsymbol{\ell}_{m,n}\cdot\boldsymbol{\kappa}_{j'}}\operatorname{sinc}\left(\frac{\ell\boldsymbol{\kappa}_{j'}}{2\pi}\right) * \mathscr{F}_2\left\{\mathcal{H}^2(\theta_{m,n})\,\tilde{\mathbf{f}}^*(\mathbf{r},0)\right\}\cdot\tilde{\mathbf{e}}_{j'}\right)k_{z,j'}\right.\right.$$
$$\left.\left. - \left(\left[e^{-i\boldsymbol{\ell}_{m,n}\cdot\boldsymbol{\kappa}_{j'}}\operatorname{sinc}\left(\frac{\ell\boldsymbol{\kappa}_{j'}}{2\pi}\right) * \mathscr{F}_2\left\{\mathcal{H}(\theta_{m,n})\,\tilde{\mathbf{f}}^*(\mathbf{r},0)\right\}\right]\cdot\boldsymbol{\kappa}_{j'}\right)e_{z,j'}\right]\right\}$$

Polarimetric instrument application

- Pacific plastic patch.



Polarimetric instrument application

- Pacific plastic patch.
- Plastic quantity completely unknown.