Using Sloppy Models for Low-Emittance Tuning at CESR

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Cornell Laboratory for
Accelerator-based Sciences
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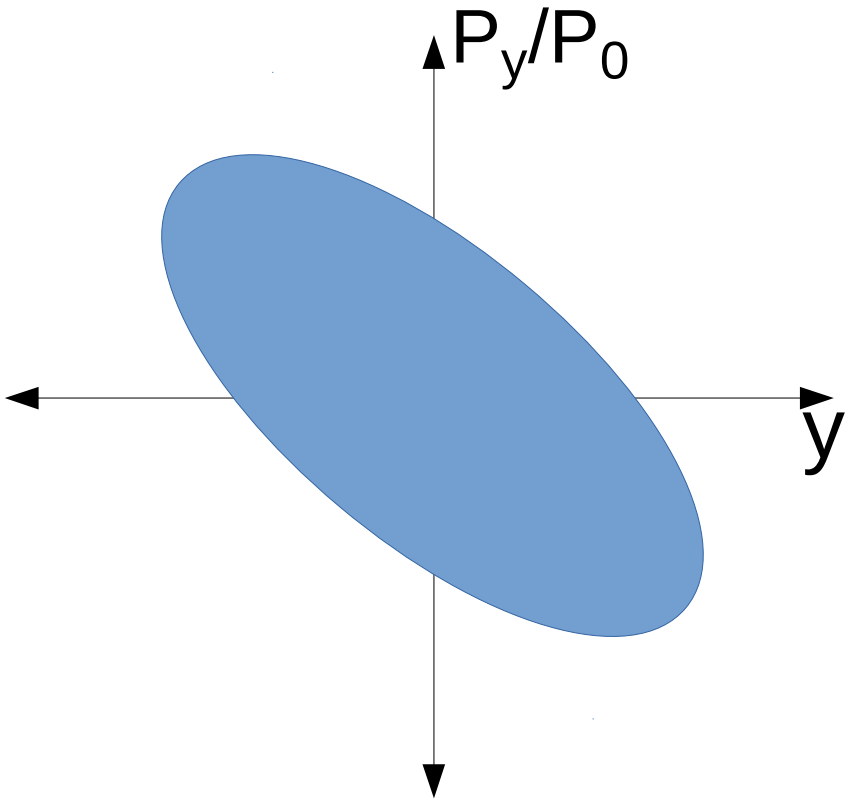
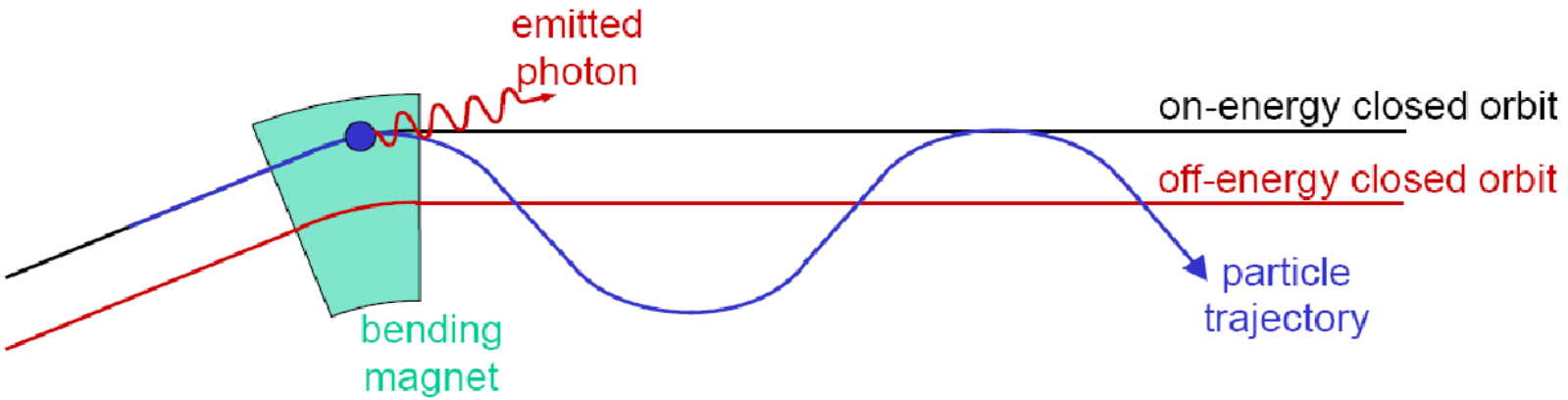
Emittance



Emittance Due to Dispersion



Alex Bogacz, USPAS June, 2016. http://casa.jlab.org/publications/USPAS_Summer_2016.shtml

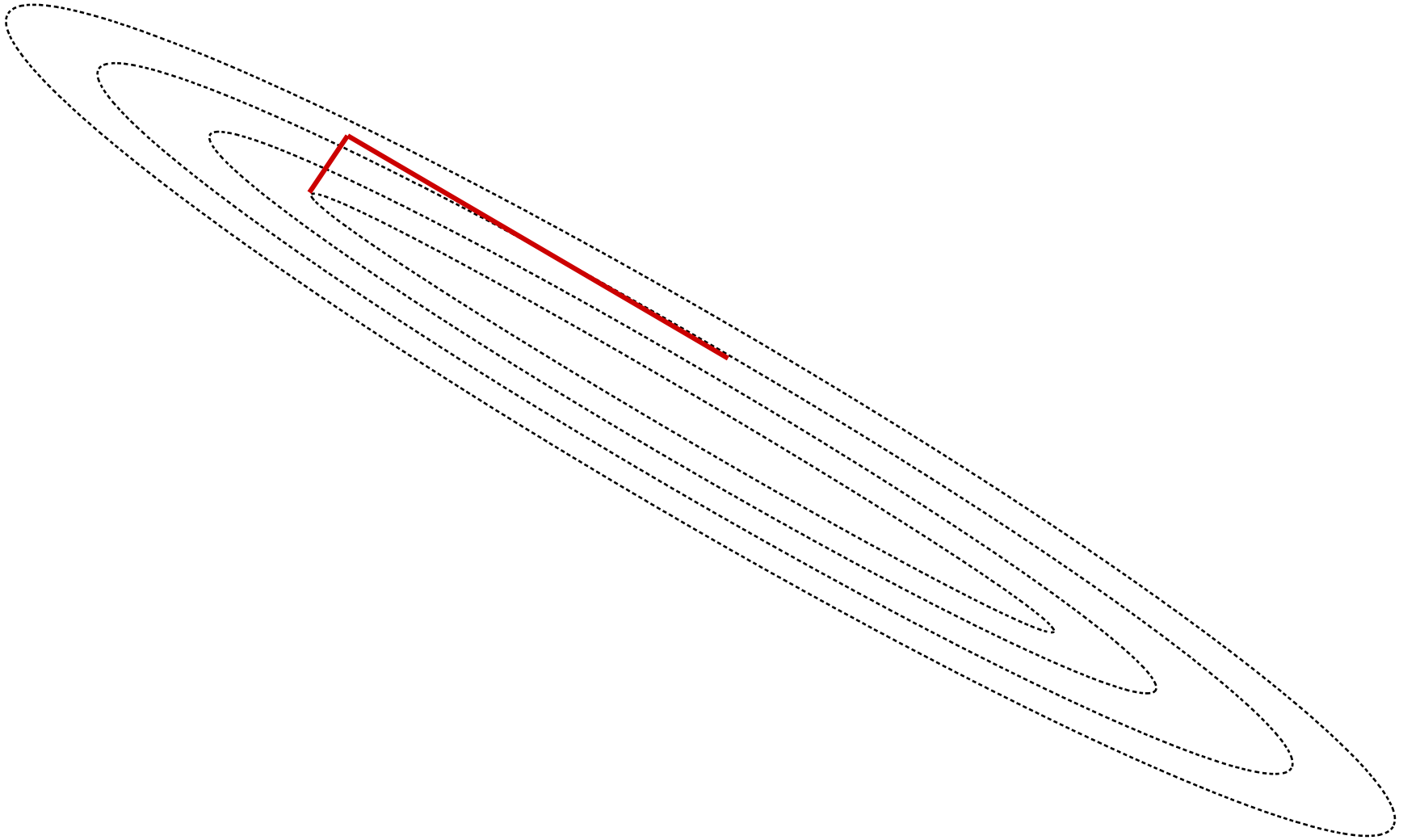
Fix Emittance by Fixing Dispersion

We know how to correct for dipsersion, but have finite dispersion resolution

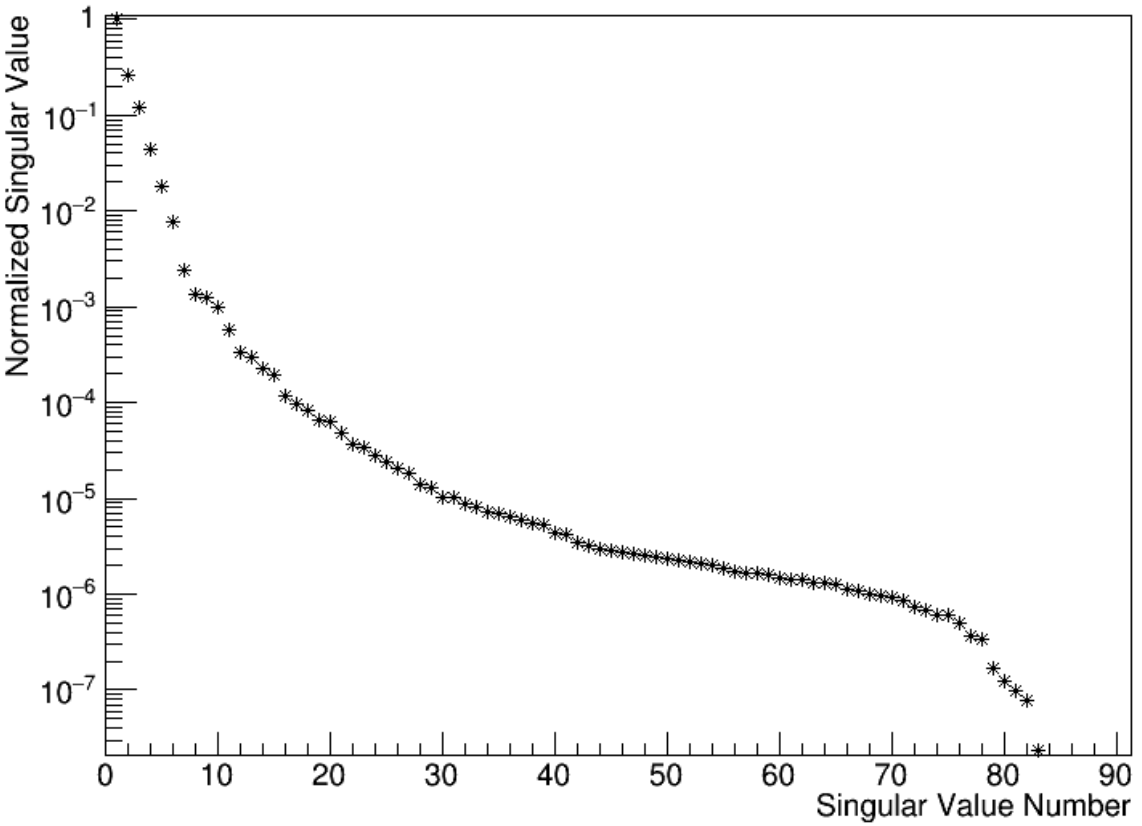
The Problem

- Emittance is a global beam property
- Depends on many parameters
  (83 useful corrector magnets)
- We have one useful measurement (beam size)
- Hard to get gradient

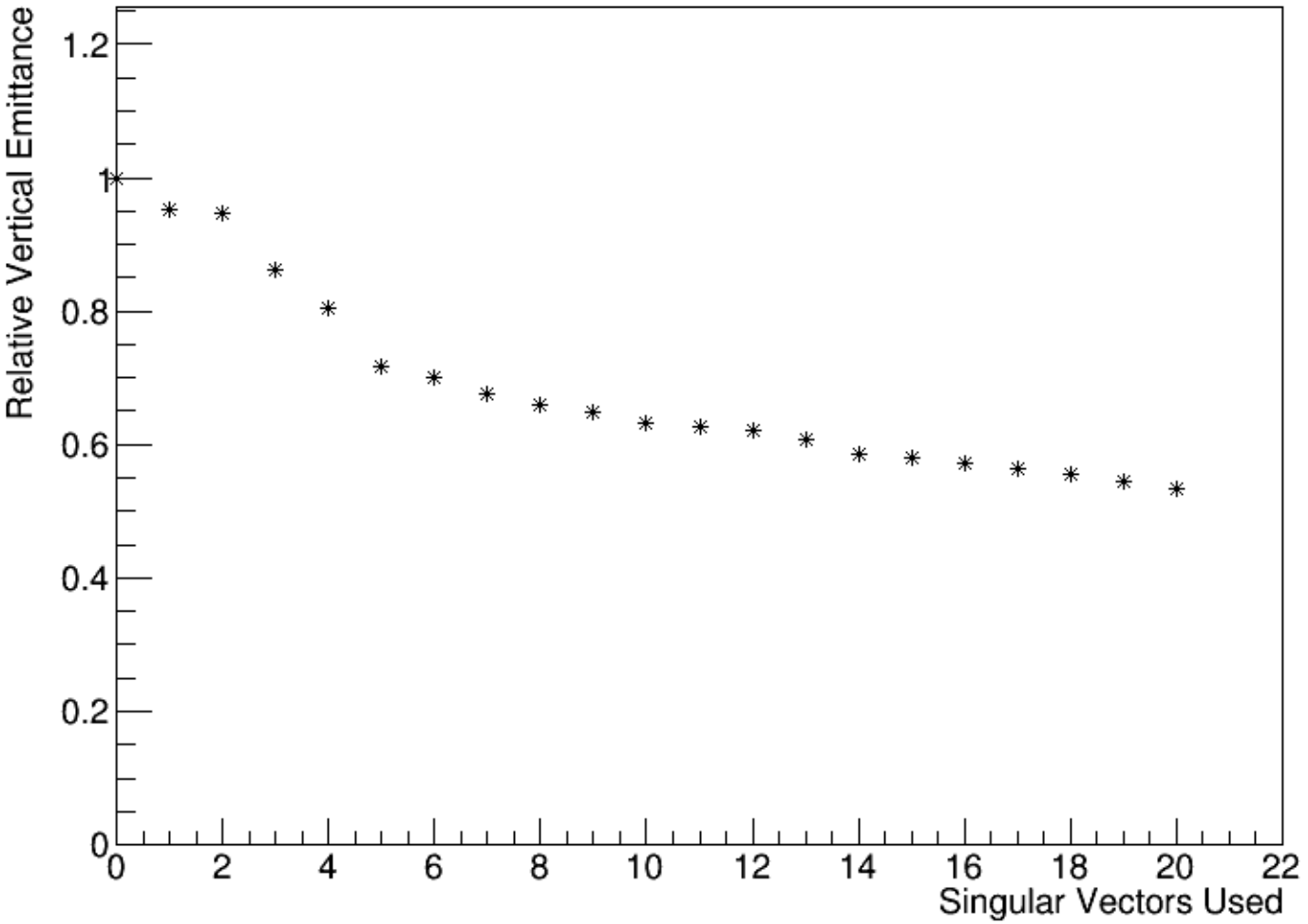
Sloppy Models



Is CESR Sloppy?



Simulation Results



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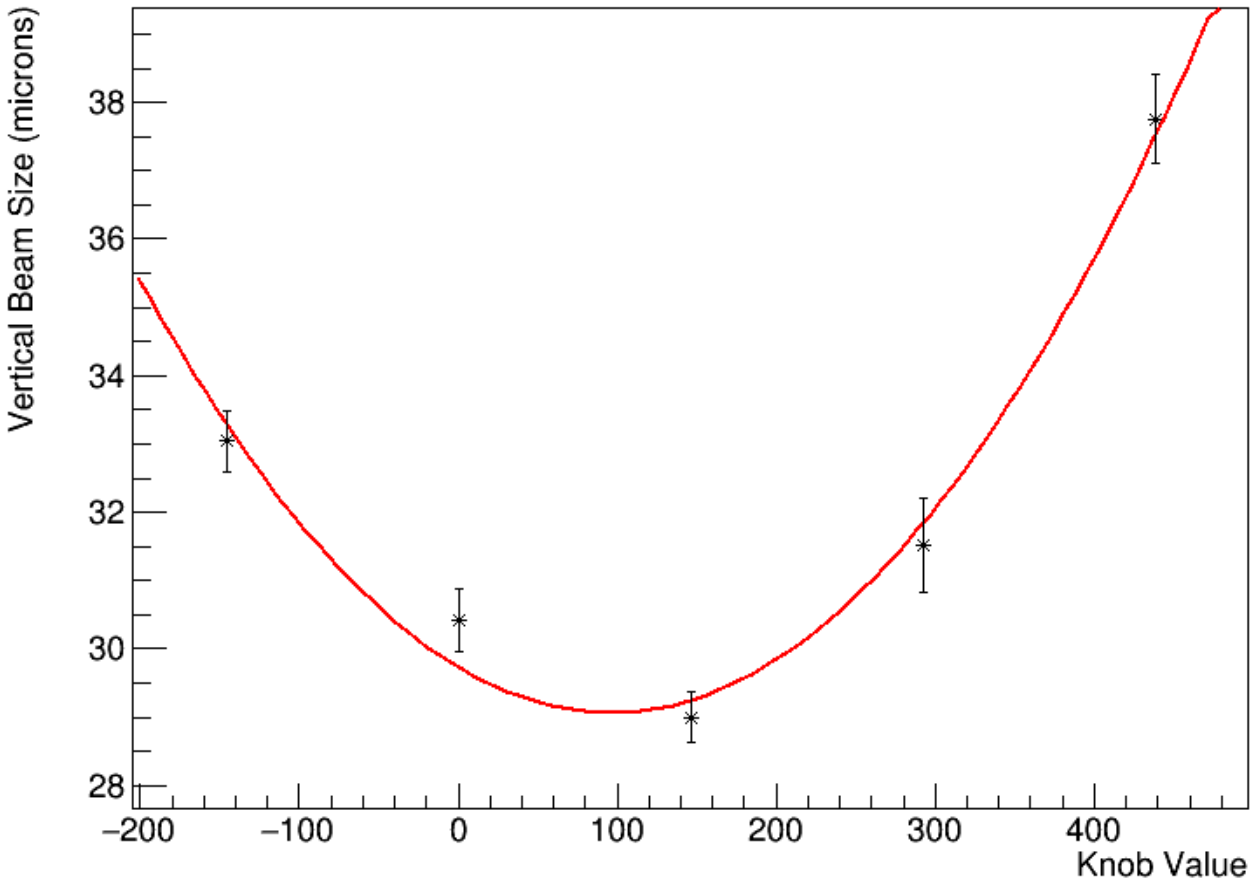
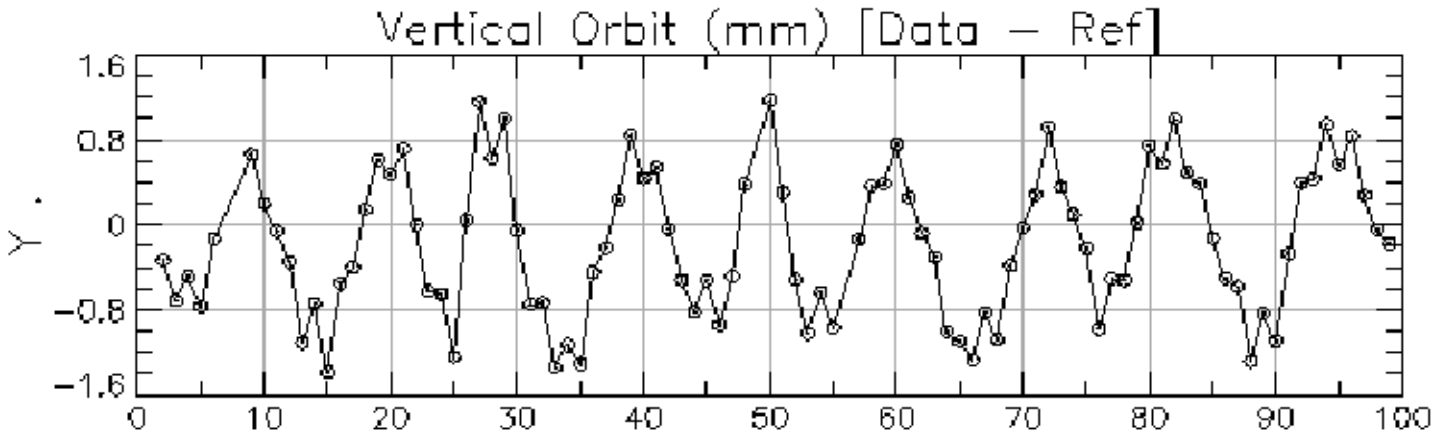
Beam Size Parabola



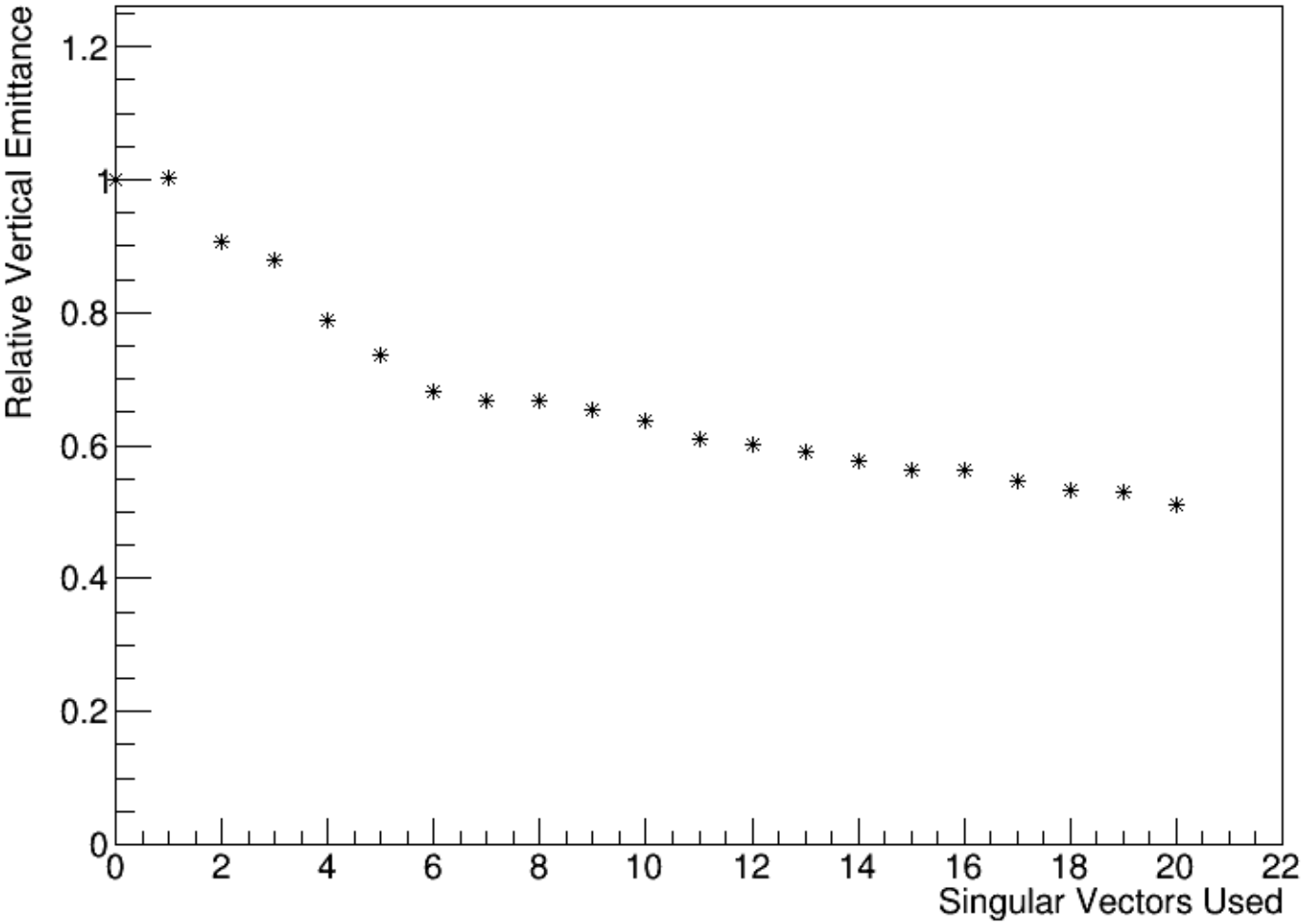
Results

	Beam Size (μm)
Tuned Normally	31.20 ± 0.26
Apply 8 Knobs	28.31 ± 0.20

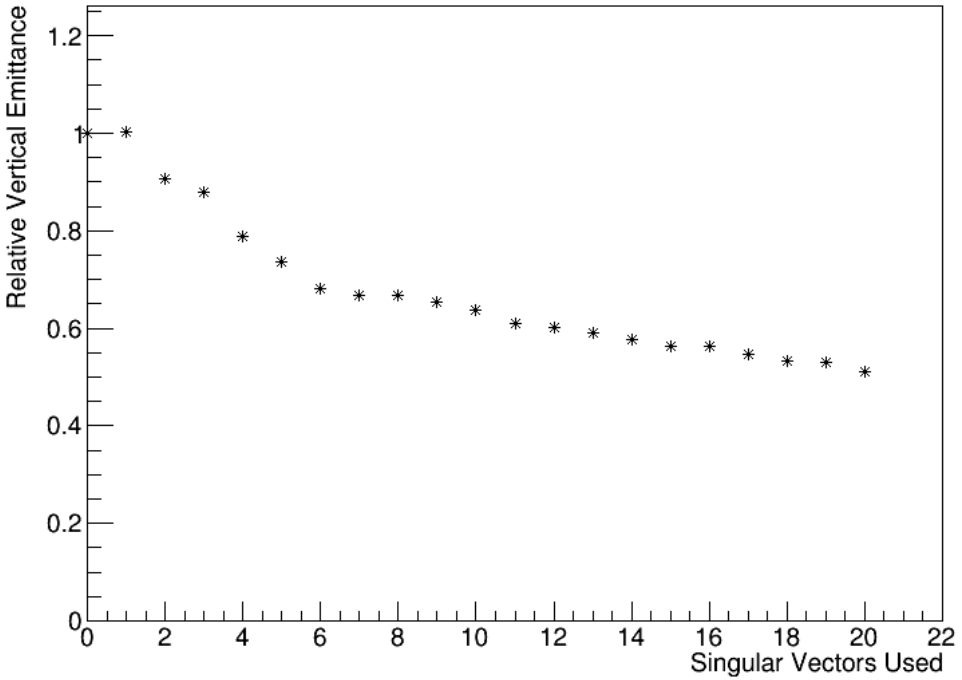
Constrained Hessians?

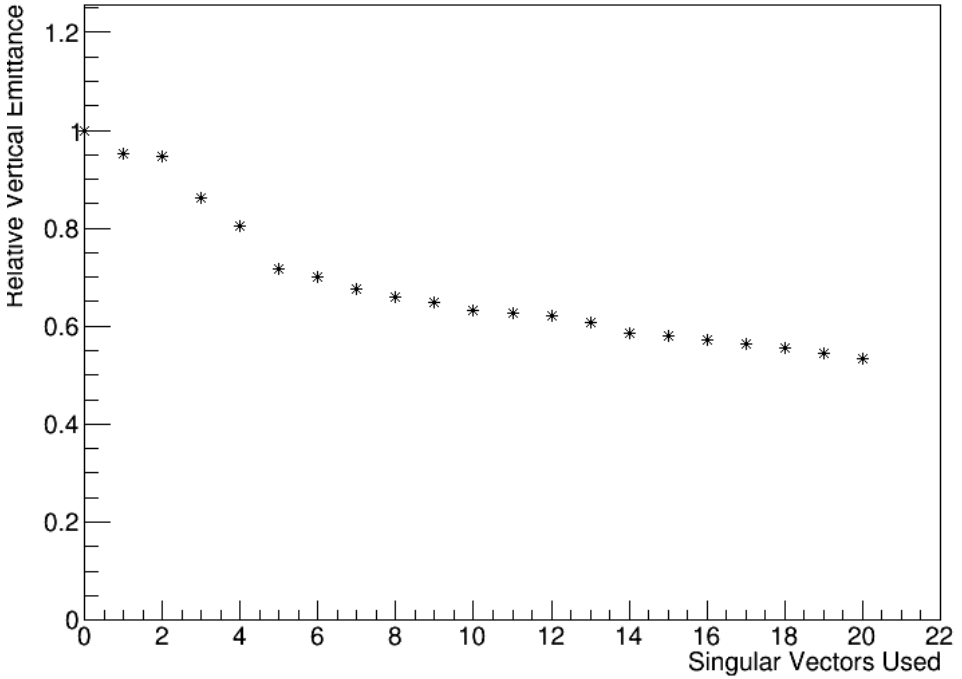


Skew-Only Knobs



Skew Only Knobs (L)
and
Unconstrained Knobs (R)

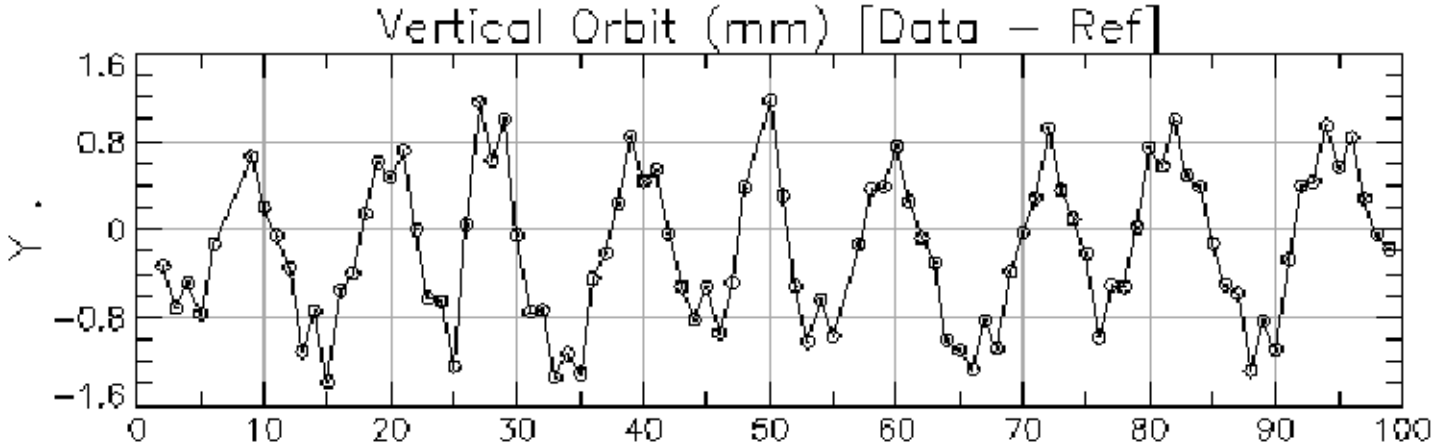


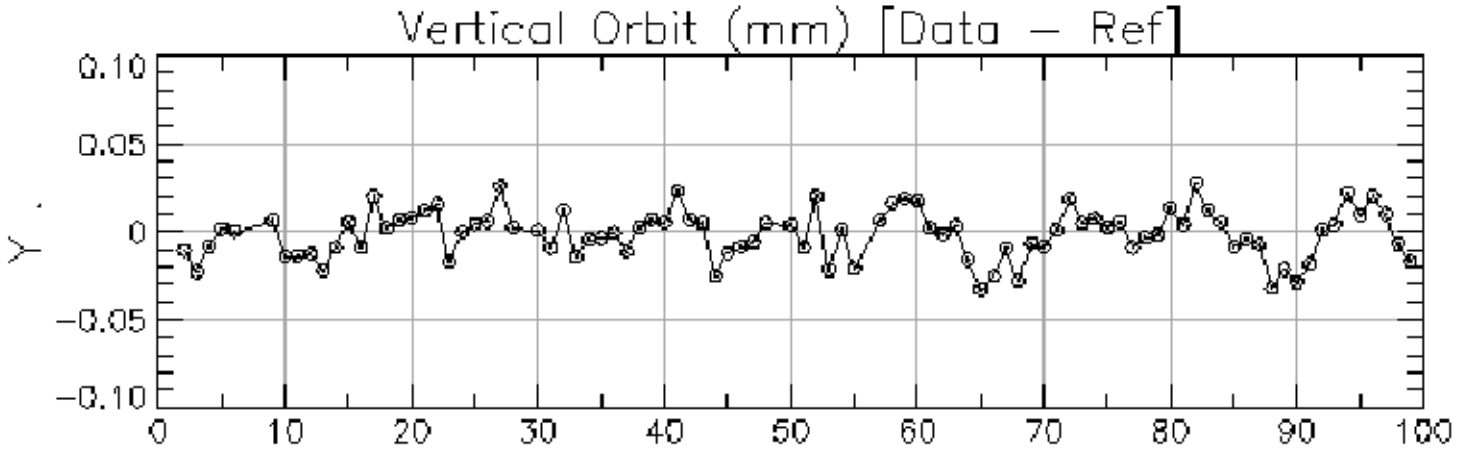


Results

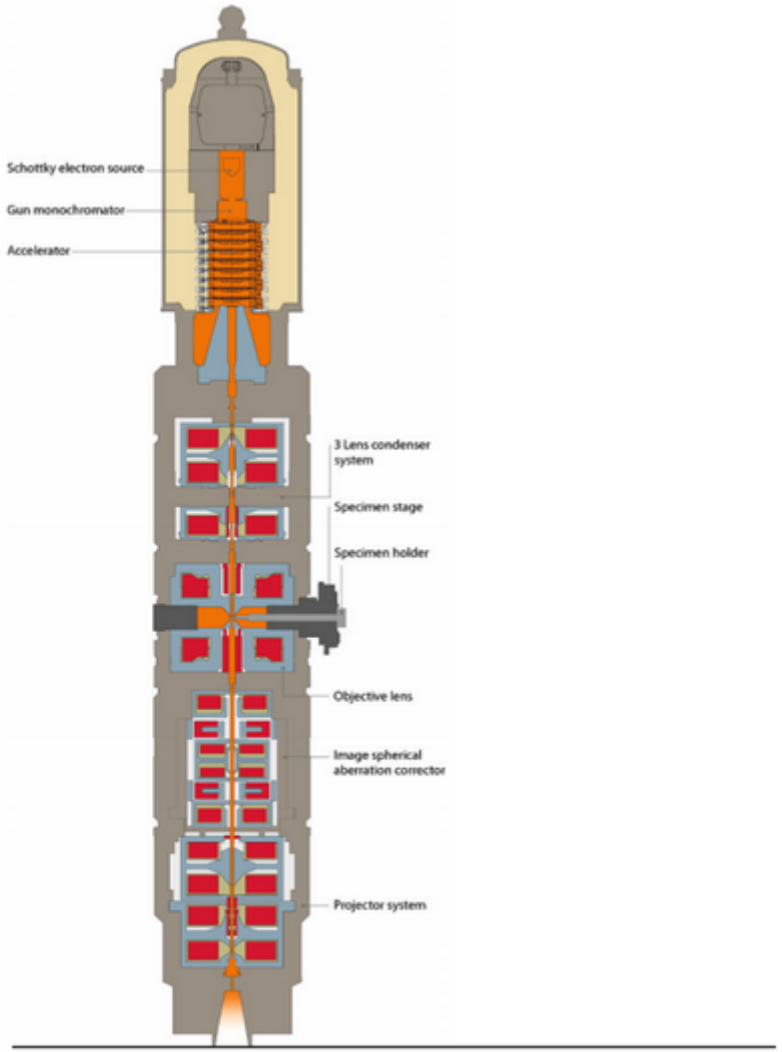
	Beam Size (μm)
Tuned Normally	31.20 ± 0.26
Use Unconstrained Knobs	28.31 ± 0.20
Use Skew-only Knobs	28.91 ± 0.25

Orbit Shifts

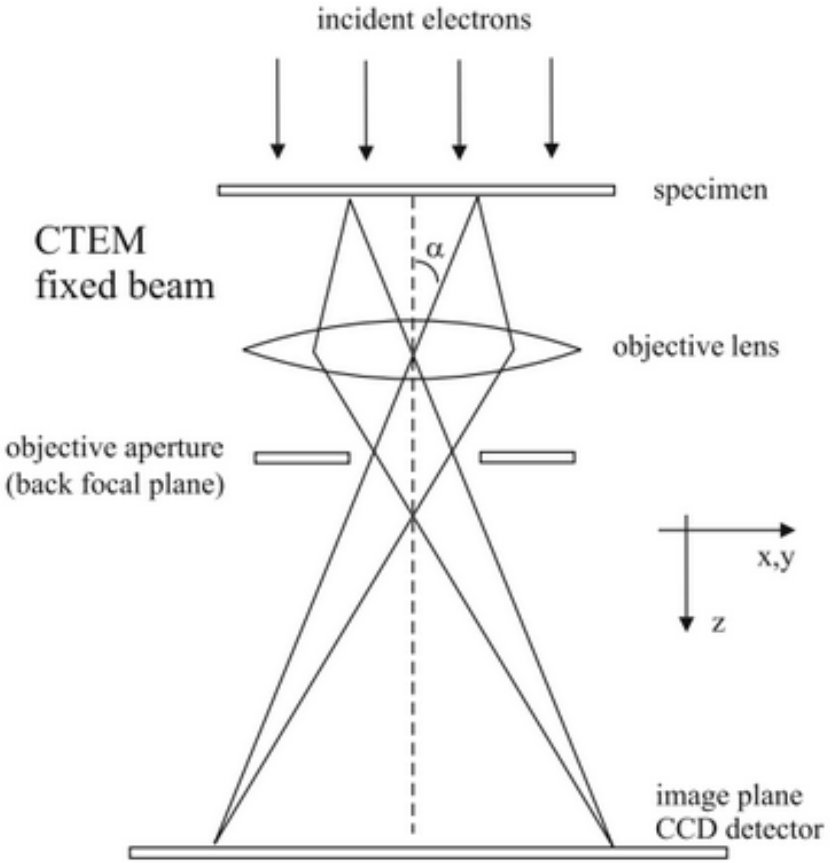




Applicability



[1]Images from Kirkland 2010



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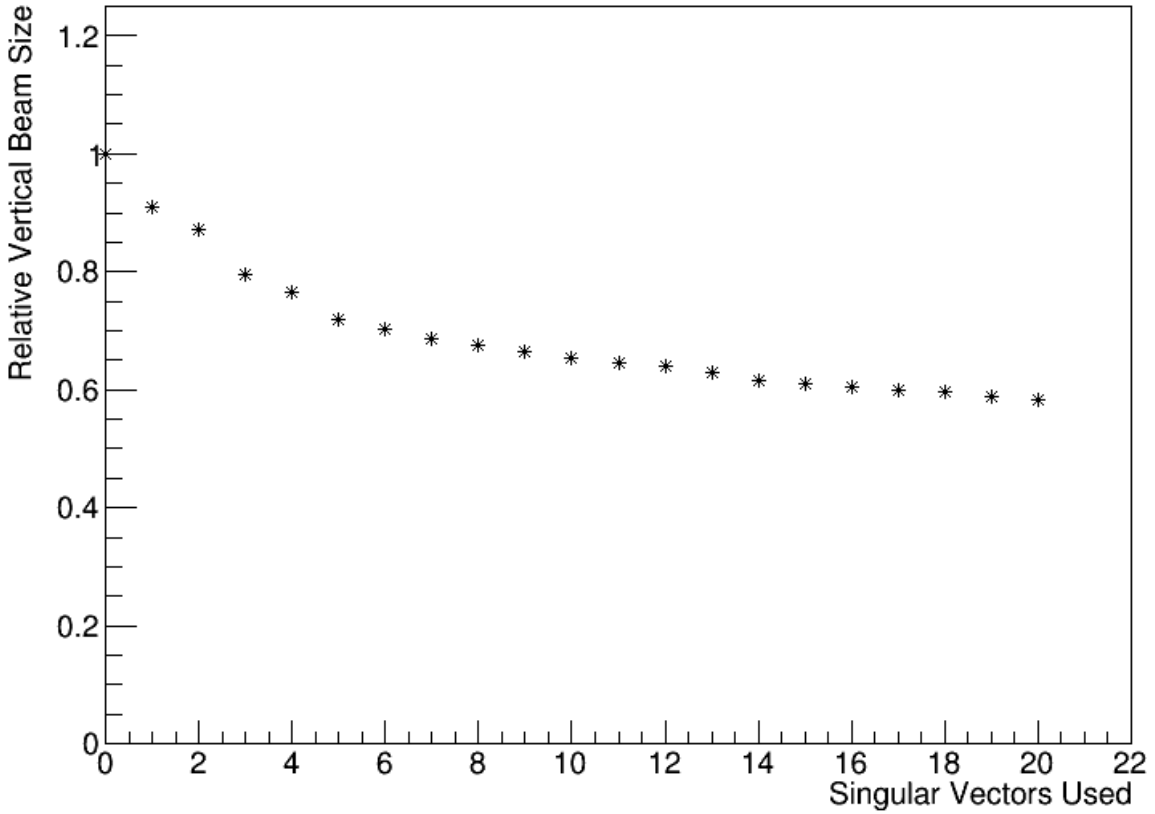
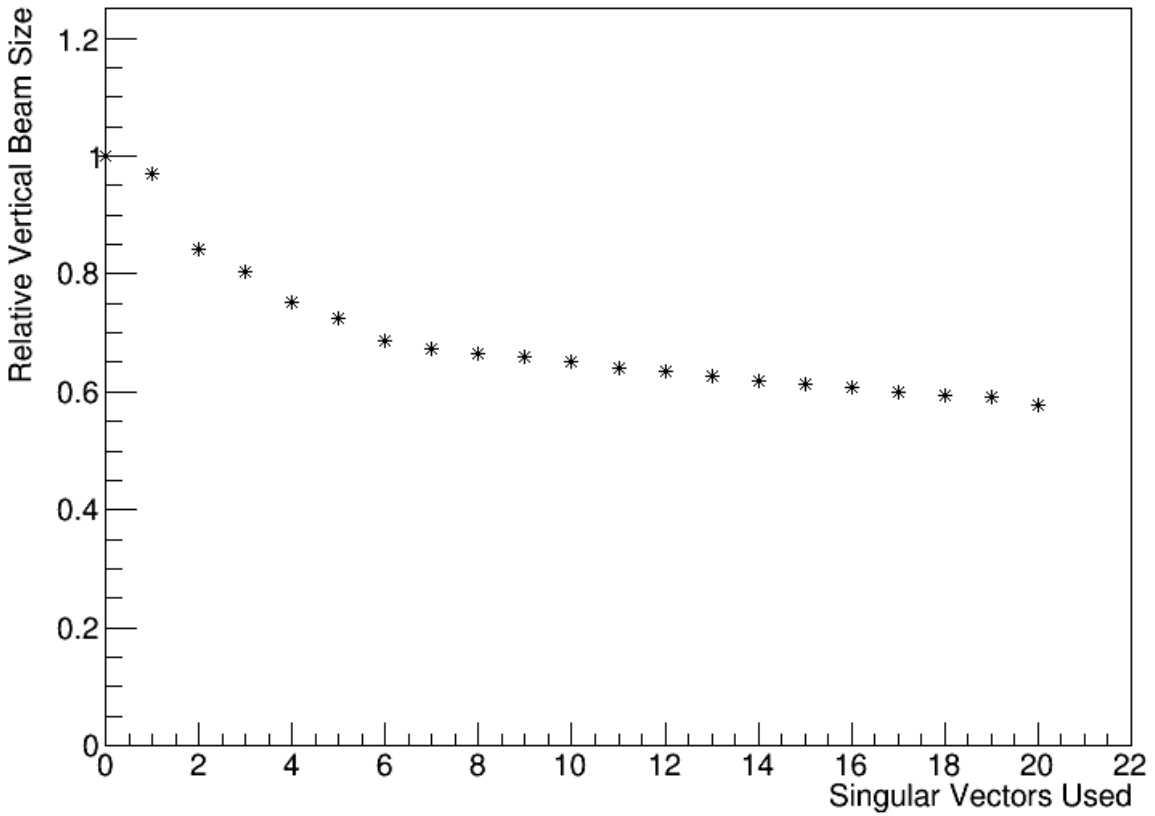
Backup Slides

Beam Size
Unconstrained Hessian



Beam Size
Skew-only Hessian



Finding Good Directions

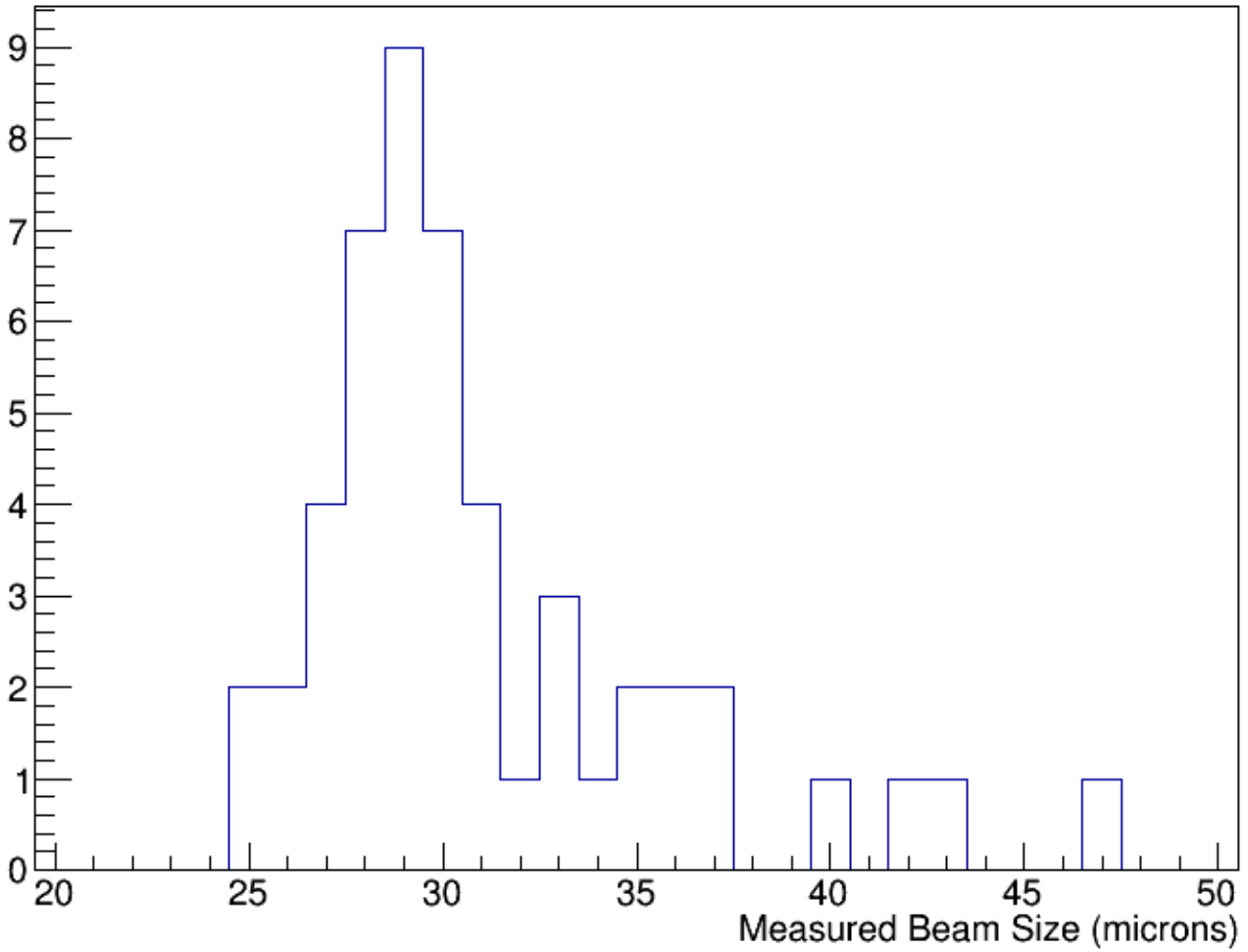
$$\begin{bmatrix} \frac{\partial^2 \epsilon}{\partial x^2} & \frac{\partial^2 \epsilon}{\partial x \partial y} & \frac{\partial^2 \epsilon}{\partial x \partial z} & \cdots \\ \frac{\partial^2 \epsilon}{\partial y \partial x} & \frac{\partial^2 \epsilon}{\partial y^2} & \frac{\partial^2 \epsilon}{\partial y \partial z} & \cdots \\ \frac{\partial^2 \epsilon}{\partial z \partial x} & \frac{\partial^2 \epsilon}{\partial z \partial y} & \frac{\partial^2 \epsilon}{\partial z^2} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

Finding Good Directions

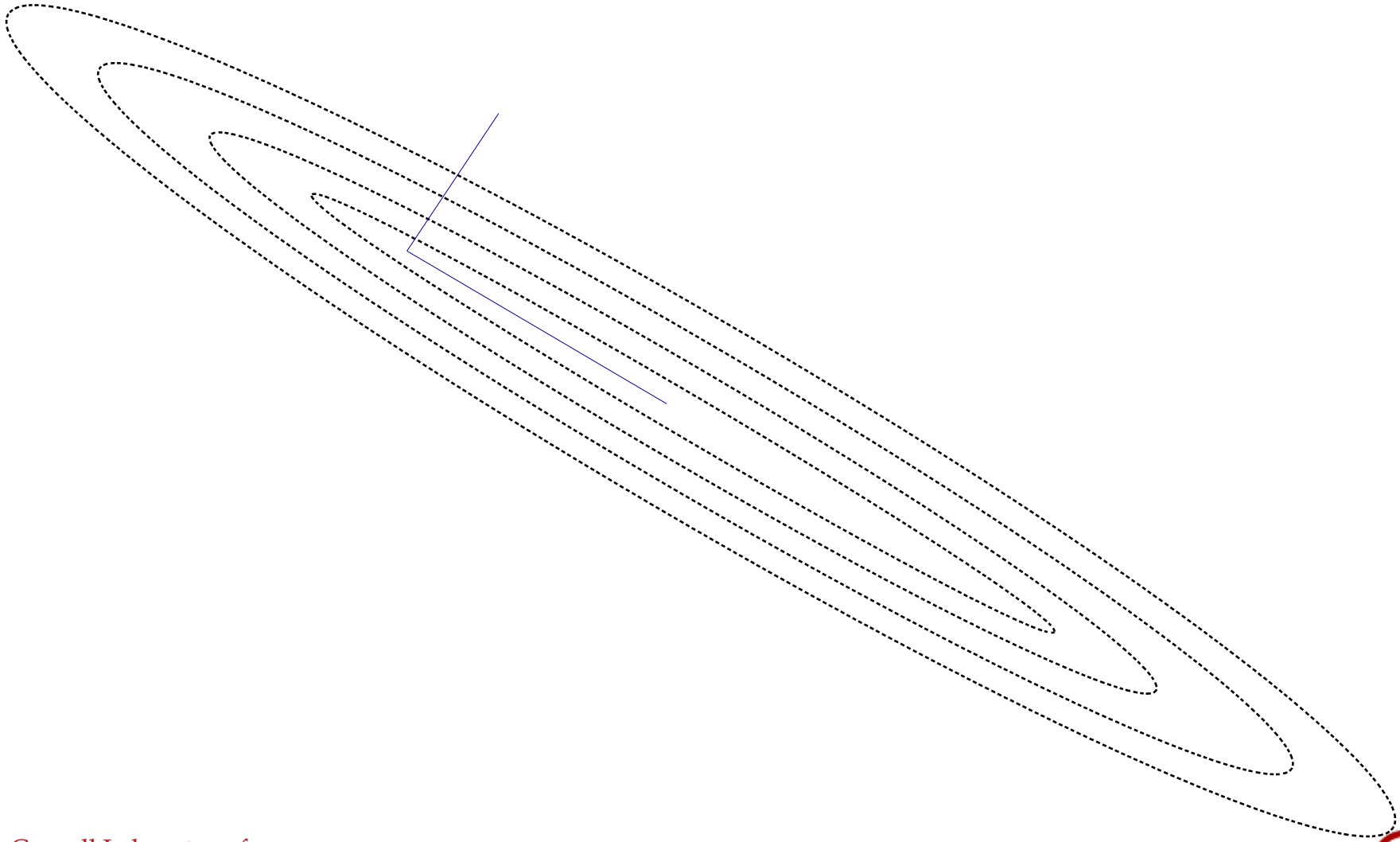
$$\epsilon = \epsilon_0 + \frac{1}{2} c^T H c$$

$$\epsilon = \epsilon_0 + \frac{1}{2} H_1 c_1^2 + \frac{1}{2} H_2 c_2^2 + \frac{1}{2} H_3 c_3^2 + \cdots$$

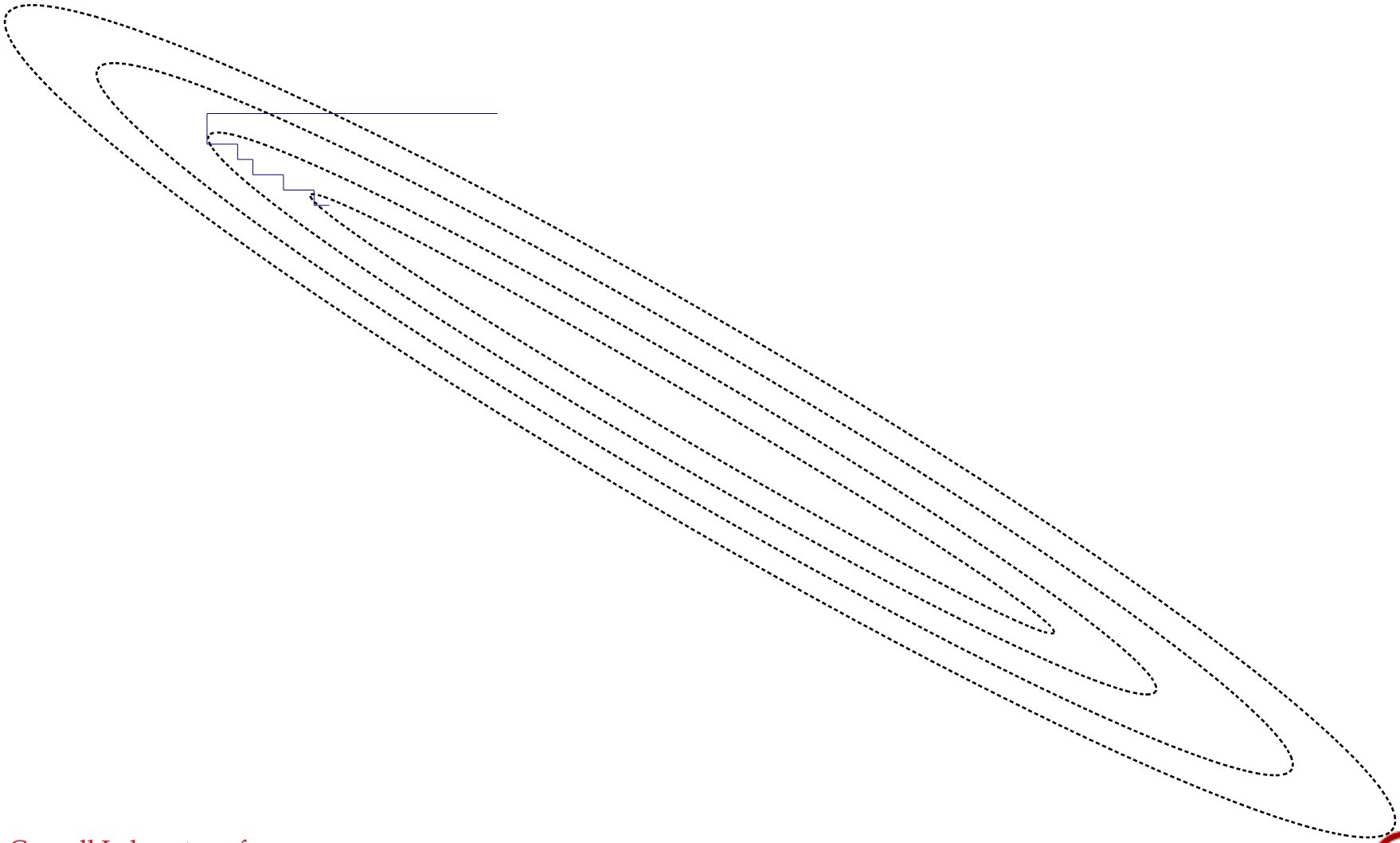
Measuring Beam Size



Sloppy Models



Sloppy Models



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