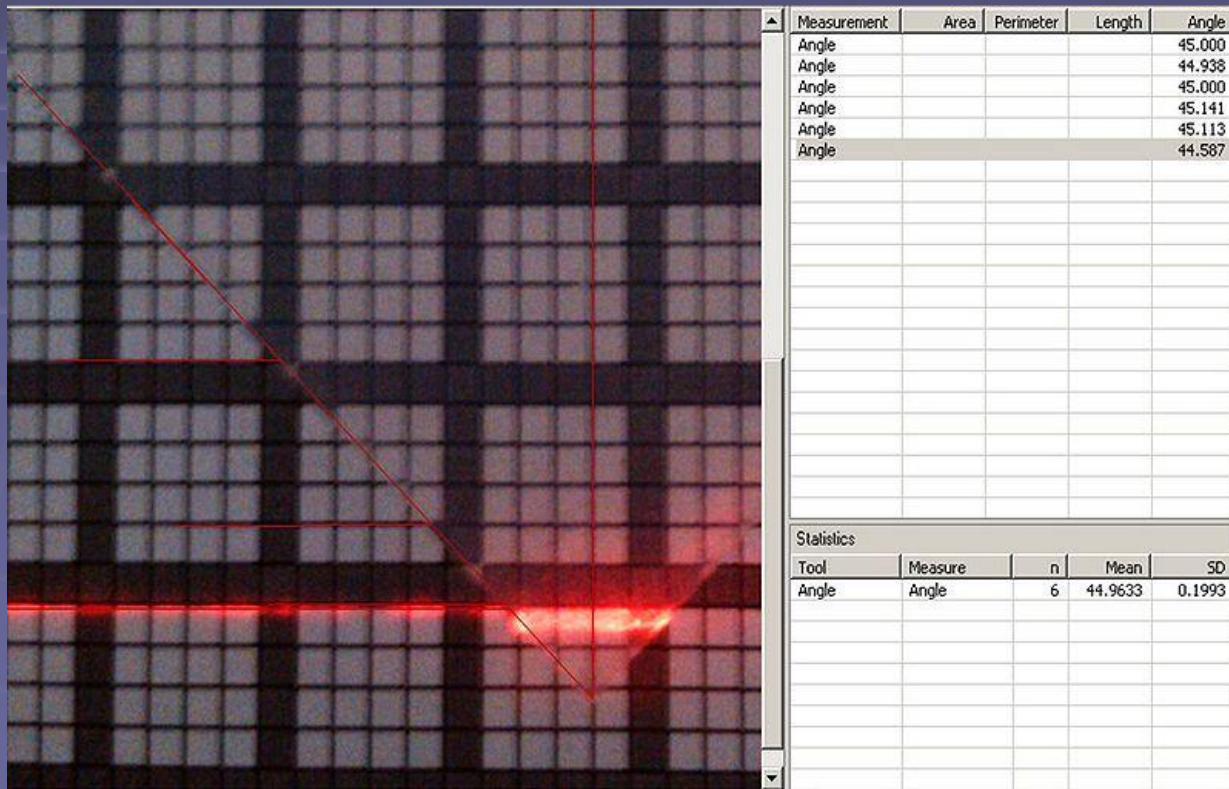


# Progress Report

July 23, 2012

# Uncertainty Measurements

- We started using image analysis to reduce our error and provide more accurate results.



# Calculations by Hand

+

7/13/12

Test 11

Box 1 top

$$\Delta: 54.3 \quad 54.81 = 54.555 \pm .255 \text{ mm}$$

$$D: 34 \frac{1}{32}, 35 \frac{1}{32} = 887.4125 \pm 2.38125 \text{ mm}$$

$$\alpha: 47.8097 \pm .0318$$

$$n = \sqrt{\sin(\alpha)^2 + \cos(\gamma - \alpha)^2} \cdot \Delta A$$

$$v \frac{\Delta}{D} = \frac{\Delta}{D} \sqrt{\left(\frac{v\Delta}{\Delta}\right)^2 + \left(\frac{vD}{D}\right)^2} =$$

$$\frac{\Delta}{D} = .061476 \pm .000331$$

$$v \gamma = \begin{cases} \tan^{-1}\left(\frac{\Delta}{D} + v \frac{\Delta}{D}\right) - \tan^{-1}\left(\frac{\Delta}{D}\right) = .018893 \\ \tan^{-1}\left(\frac{\Delta}{D} - v \frac{\Delta}{D}\right) - \tan^{-1}\left(\frac{\Delta}{D}\right) = .018894 \end{cases}$$

$$\gamma = \tan^{-1}\left(\frac{\Delta}{D}\right) = 3.517888 \pm .018894$$

$$v(\gamma - \alpha) = \sqrt{v\gamma^2 + v\alpha^2} = .038990$$

$$\gamma - \alpha = -39.291312 \text{ } \xrightarrow{+} \text{ using } \sin$$

$$v \sin(\alpha)^2 = 2(\sin \alpha)(.000407) = .000553$$

$$v \cos(\gamma - \alpha)^2 = 2(\cos(\gamma - \alpha))(.000409) = .000633$$

$$\sin(\alpha)^2 = .461801 \pm .000553$$

$$\cos(\gamma - \alpha)^2 = .598977 \pm .000633$$

$$v(\sin + \cos) = \sqrt{(\sin)^2 + (\cos)^2} = .000841$$

$$vn = \frac{1}{2} (\sin(\alpha)^2 + \cos(\gamma - \alpha)^2)^{-\frac{1}{2}} (.000841) (1.000293) = .00040$$

$$n = 1.030243 \pm .000408$$

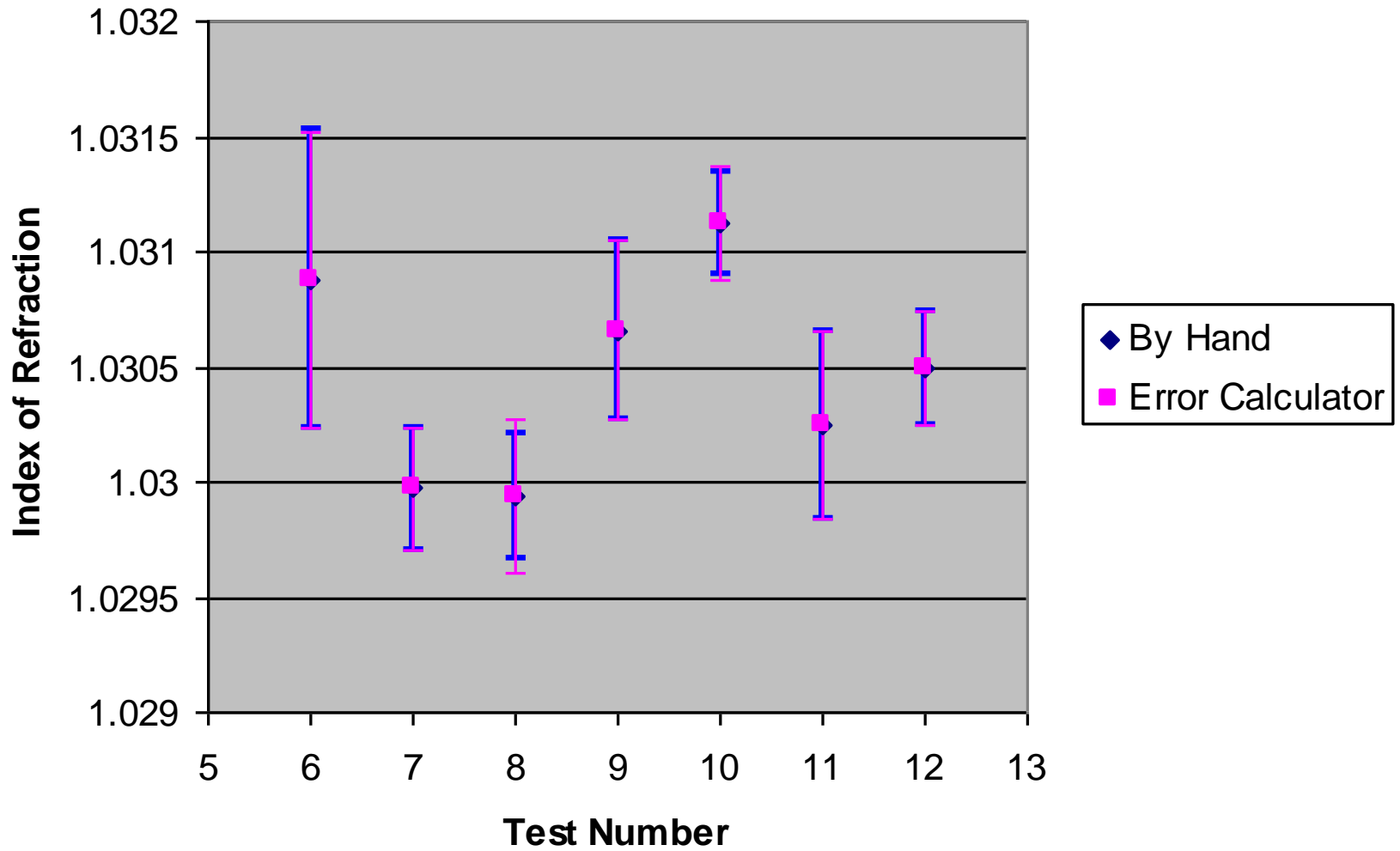
# The Error Calculator

- A snapshot of the error calculator we have been using.

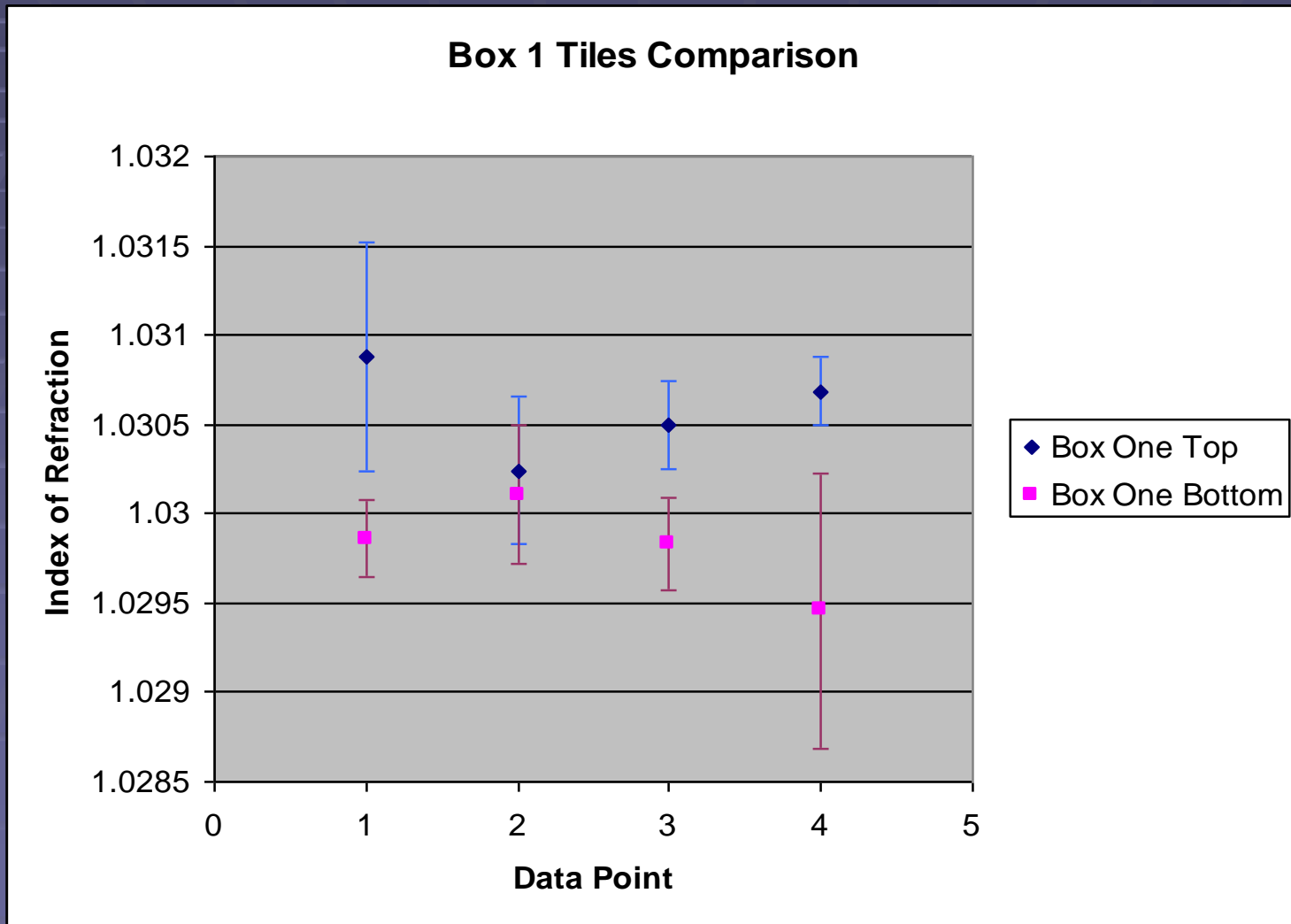
The screenshot shows the 'Gustavus Physics Department: Error Analysis Calculator' interface. The main display area shows a value of  $1.03049220240341$  with an error of  $\pm 6.51890598191676E-04$ . Below the display are radio buttons for 'Rad', 'Deg', 'Deg->Rad', and 'Rad->Deg'. The calculator keypad includes buttons for M+, Ln, Sin, ASin, pi, e, Del, Clear, M-, e^x, Cos, ACos, 7, 8, 9, %, x, MClr, Log10, Tan, ATan, 4, 5, 6, ÷, -, MRcl, 10^x, sqrt, X^2, 1, 2, 3, +, =, X^Y, 1/X, 0, ., +/-, n!, EE+, EE-, Display History (checked), Advanced Mode (unchecked), Save State, About, and Help. On the right side, there is a history table with columns for the current value, error, and the operation performed.

Value	Error	Operation
45	.04	Sin
.7071067812	.0004936536598	=
.7071067812	.0004936536598	^2
.5	.0006981317008	=
3.55655	.05285	-
45	.04	
-41.44345	.06628063443	=
-41.44345	.06628063443	Cos
.7496093511	.0007656735113	=
.7496093511	.0007656735113	^2
.5619141792	.001147912048	=
.5619141792	.001147912048	+
.5	.0006981317008	
1.061914179	.001343536357	=
1.061914179	.001343536357	sqrt
1.030492202	.0006518905982	=

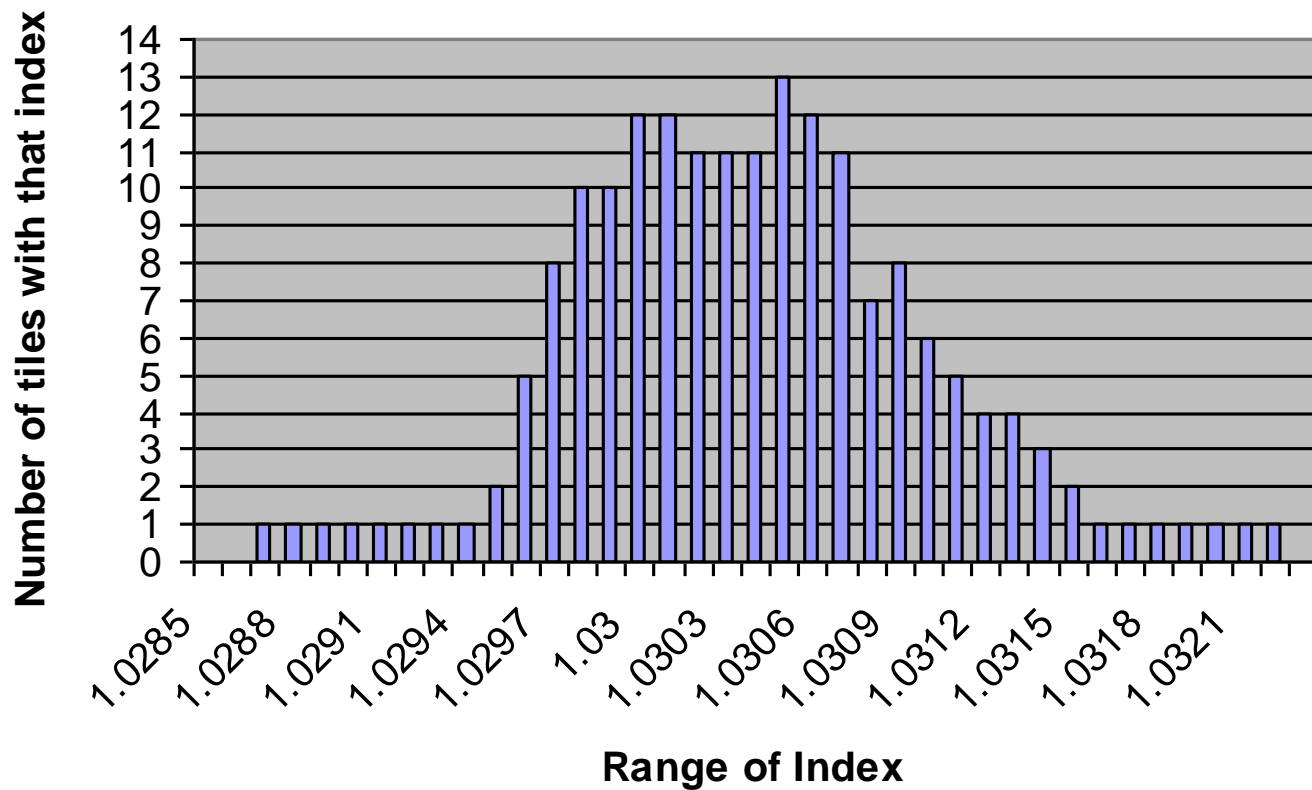
## Comparison between Hand and Calc



# Comparison of Two Tiles



### Histogram of all tiles



# Results

Measurements with Error Propagation

