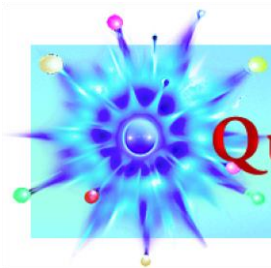




Using Data Two Ways



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LHC



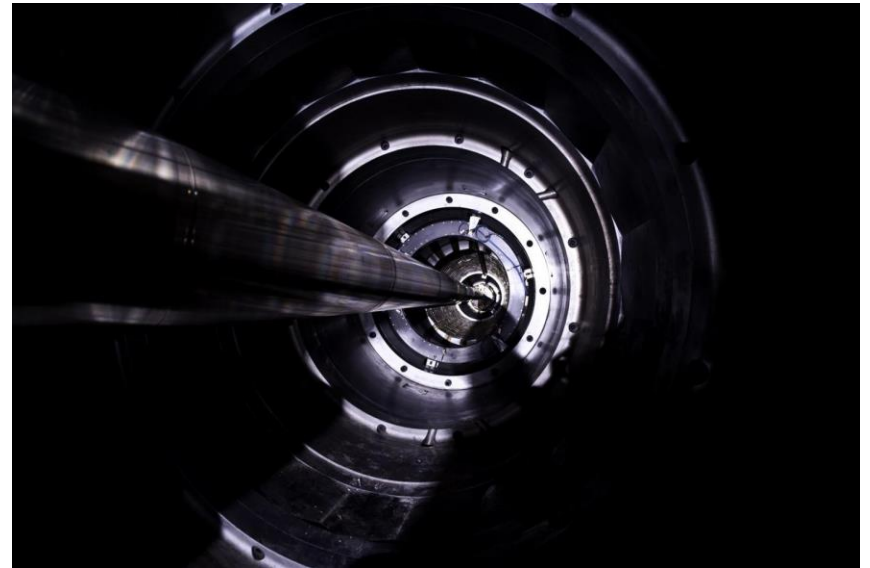


TOTEM

TOTEM

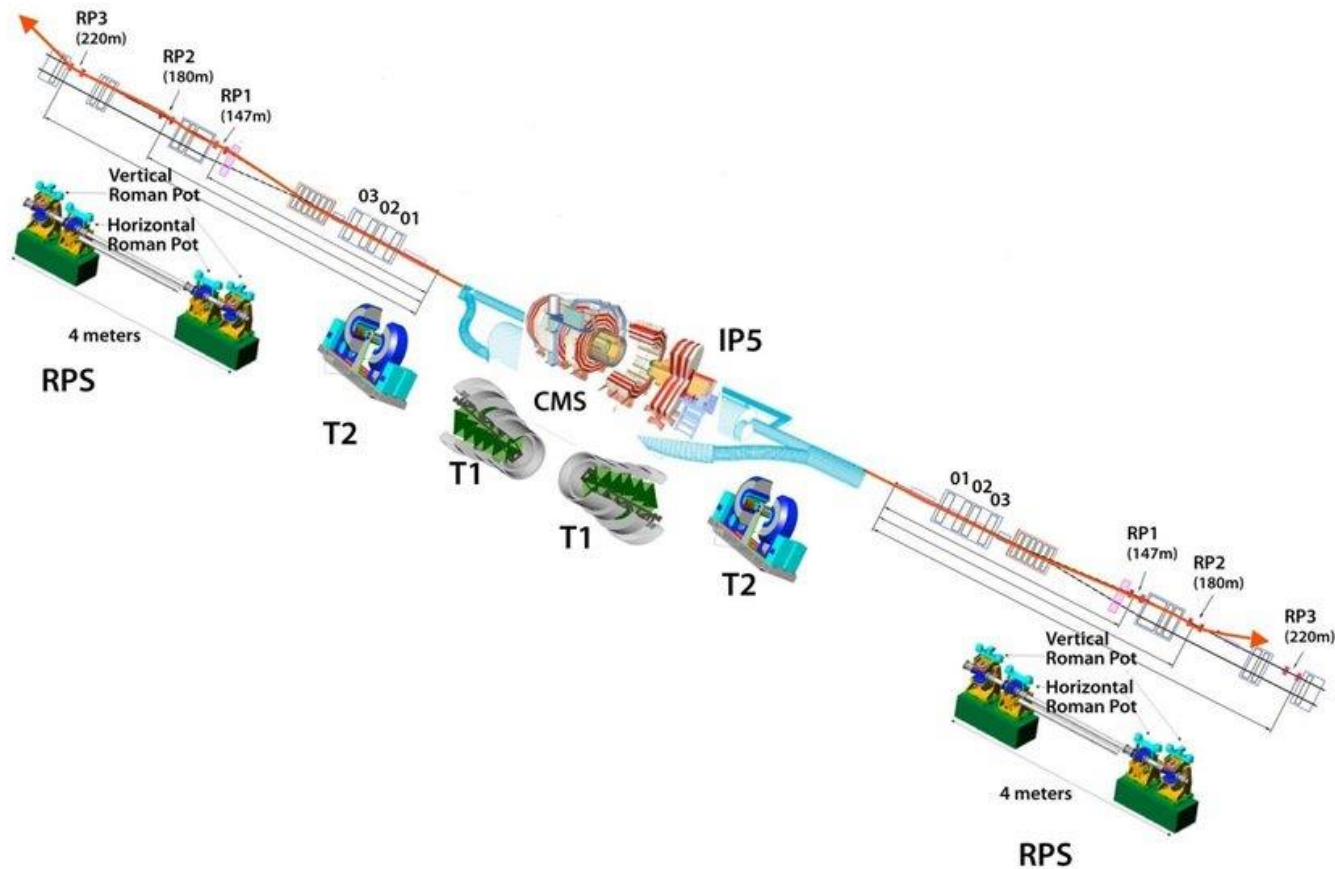
**TOTAL cross-section,
Elastic scattering and
diffractive dissociation
Measurement**

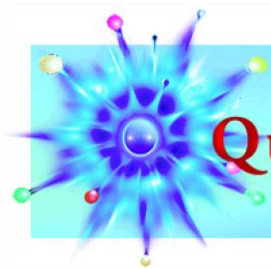
TOTEM's physics program is dedicated to the precise measurement of the proton-proton interaction cross section, as well as to the in-depth study of the proton structure which is still poorly understood.---*from the experiment web site*
<http://totem-experiment.web.cern.ch/>





TOTEM





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TOTEM 1

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Data Activities
Third page of Activities



TOTEM

LEARNING OBJECTIVES

Students will know and be able to:

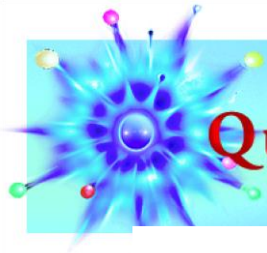
1. Make observations by examining a data table.
2. Create and interpret scatter plots generated from the data.
3. Interpret the slope and intercept of the scatter plots.
4. Use measurements to show that quantum particles (protons) conserve momentum in their interactions.



TOTEM

ENDURING UNDERSTANDING

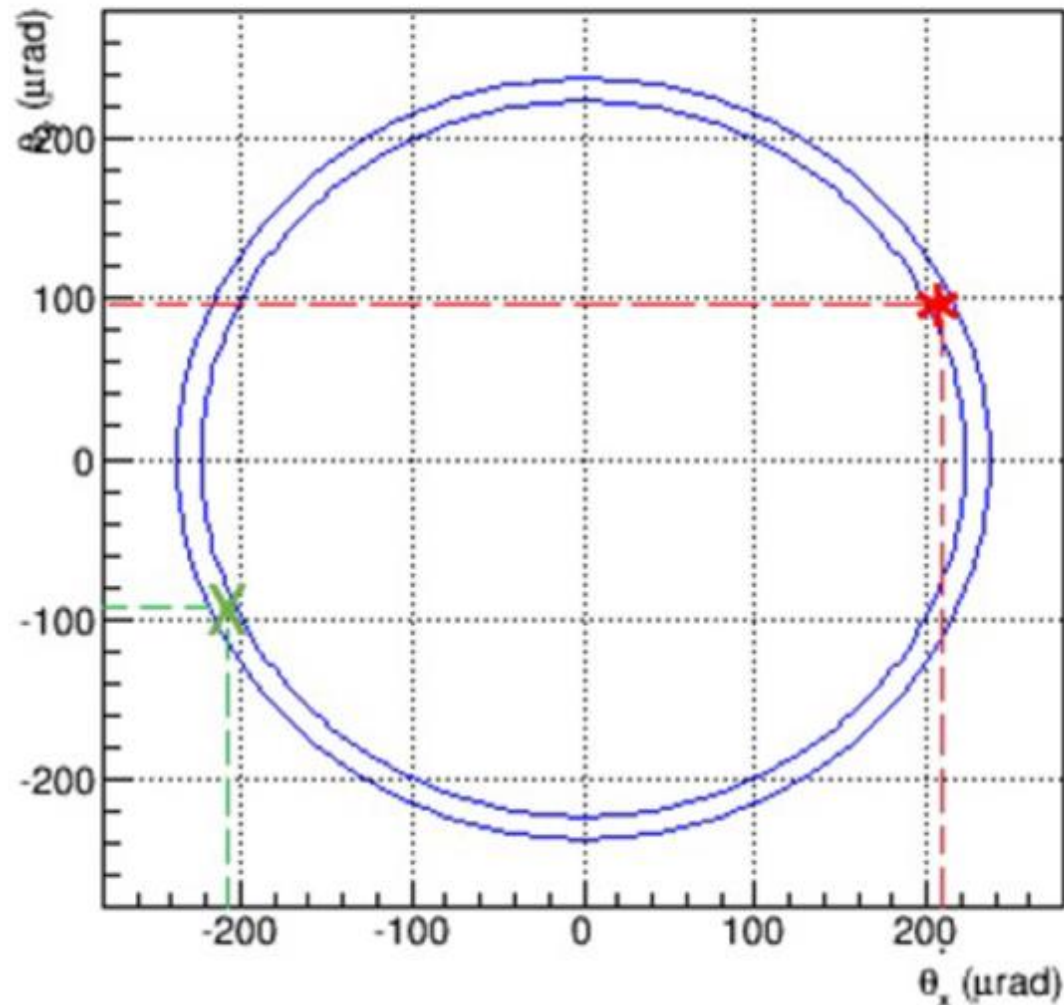
Particle physicists use data to determine conservation rules.

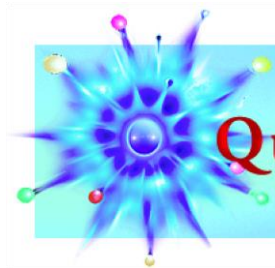


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TOTEM

Angular Topology





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TOTEM

Table 1: θ_x

Event Number	θ_x (μrad , red star)	θ_x (μrad , green X)	$\Delta\theta$ (μrad , estimate)
89	+160	-160	5
92	+130	-30	5

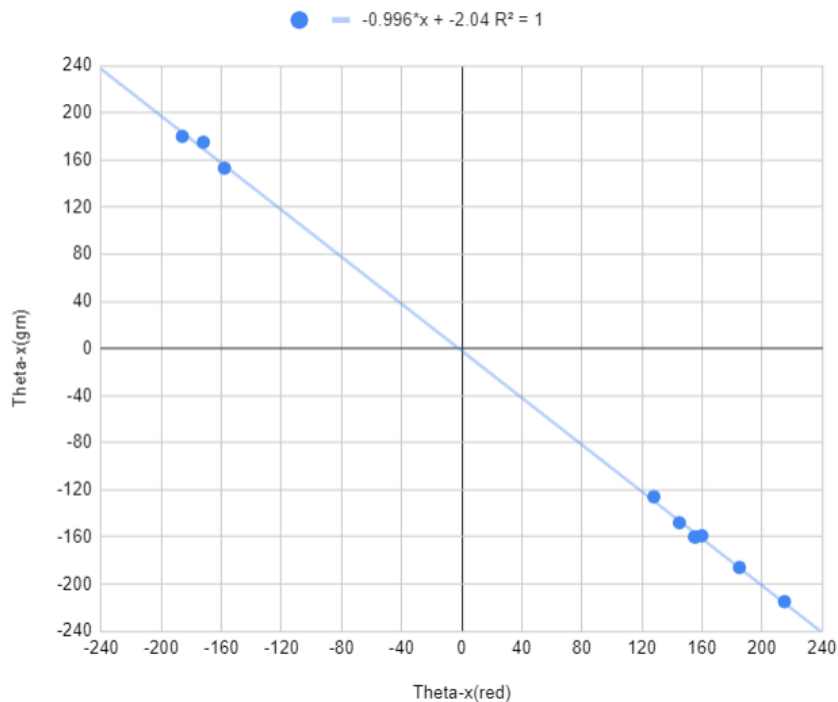
Table 2: θ_y

Event Number	θ_y (μrad , red star)	θ_y (μrad , green X)	$\Delta\theta$ (μrad , estimate)
89	+95	-96	5
92	-88	+89	5

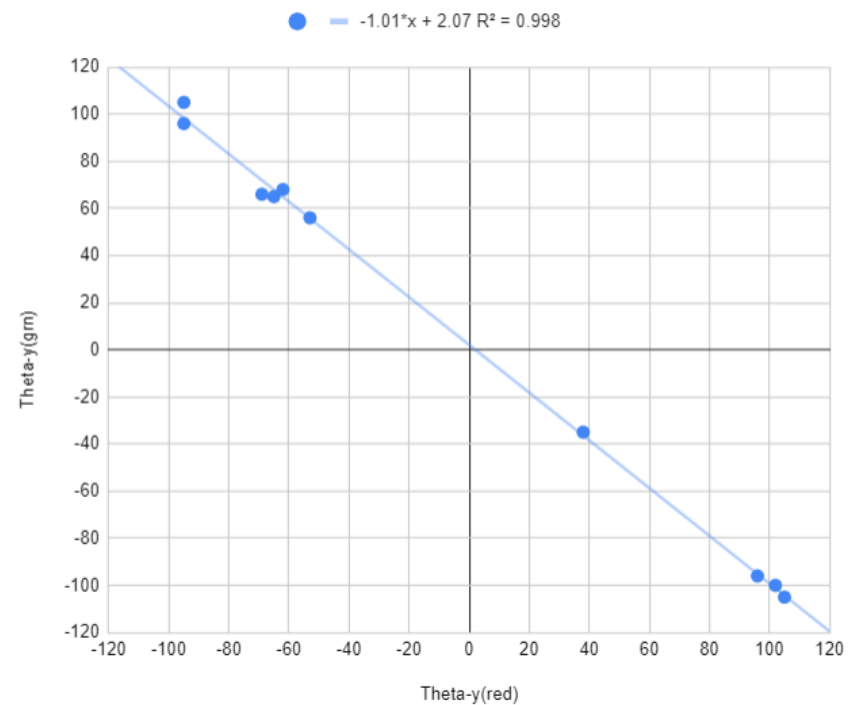


TOTEM

Theta-x(grn) vs. Theta-x(red)



Theta-y(grn) vs. Theta-y(red)

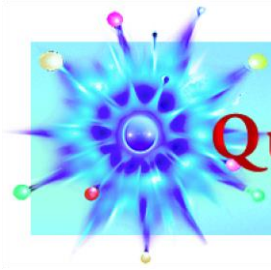




TOTEM

Questions for class discussion:

- Examine the data in your tally sheet for q_x and q_y . Describe any trends.
- Examine the class plots. What is the value for the slope of the line on each graph? What is the value of the y-intercept of the line on each graph?
- Write the equation for each graph.
- Describe the evidence to support or fail to support the claim that quantum objects follow the principles of conservation of momentum.



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Data Activities
Third page of Activities



TOTEM

LEARNING OBJECTIVES

Students will know and be able to:

1. Create and interpret a histogram from data.
2. Examine the histogram to observe wave interference characteristics.
3. Discuss the limitations of models used in this activity.

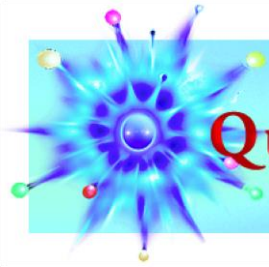


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TOTEM

ENDURING UNDERSTANDING

- Fundamental particles display both wave and particle properties, and both must be considered to fully understand them.
- Scientists use models to make predictions about and explain natural phenomena.



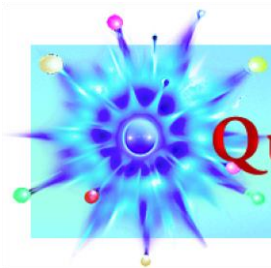
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TOTEM

$$\lambda = \frac{hc}{pc}$$

h is Planck's constant
 $4.1 \times 10^{-15} \text{ eV} \cdot \text{s}$.

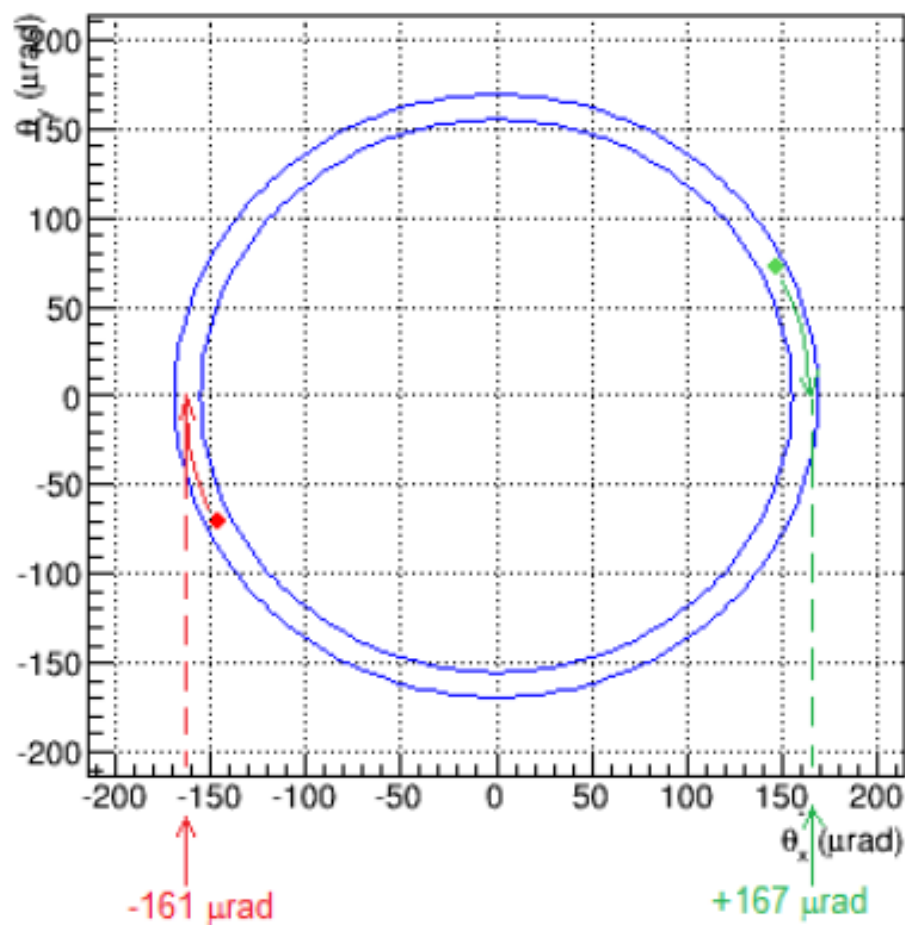
Proton momentum $4 \text{ TeV}/c$

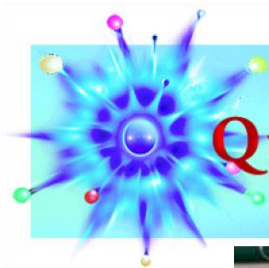


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TOTEM

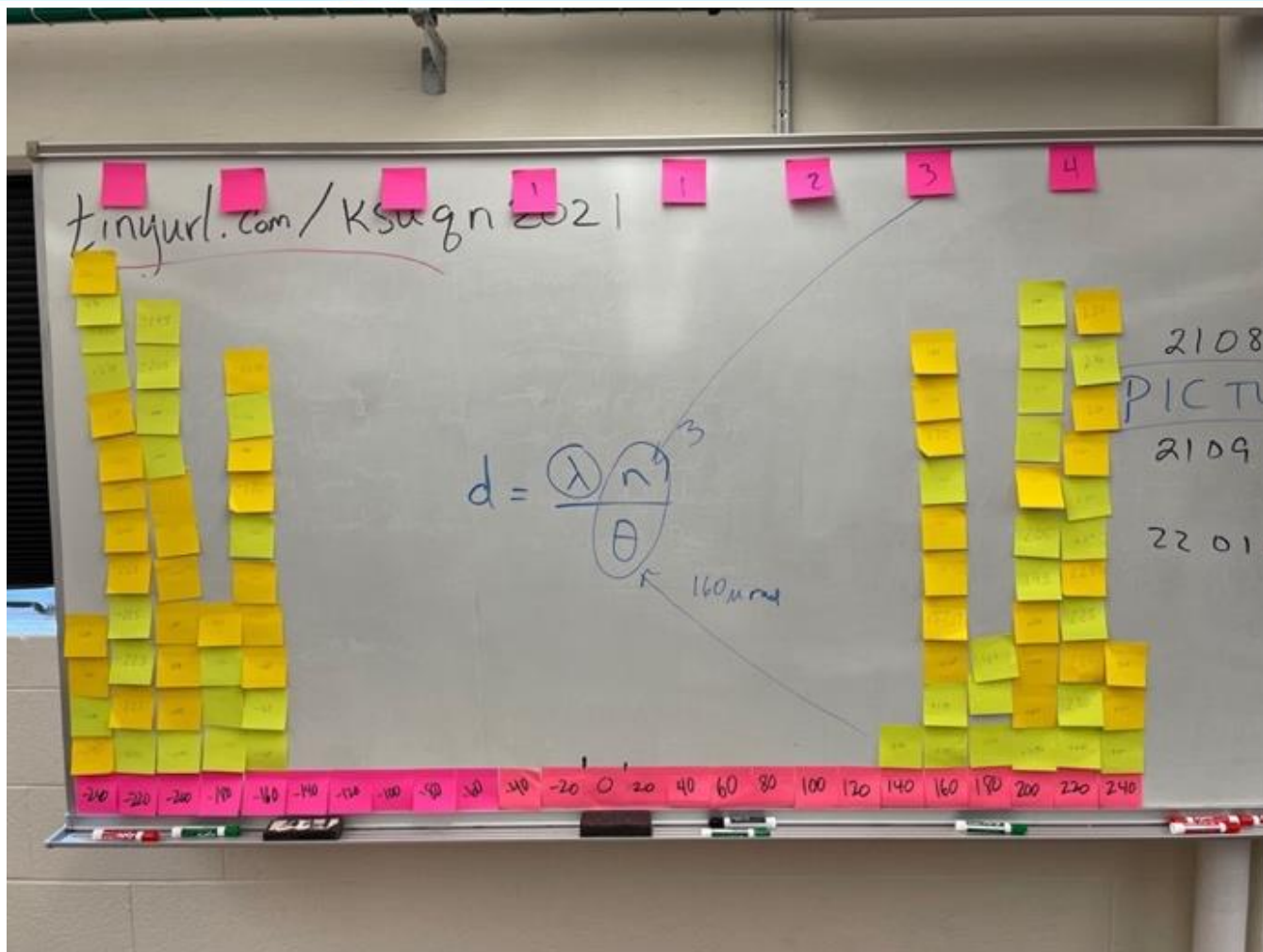
Angular Topology





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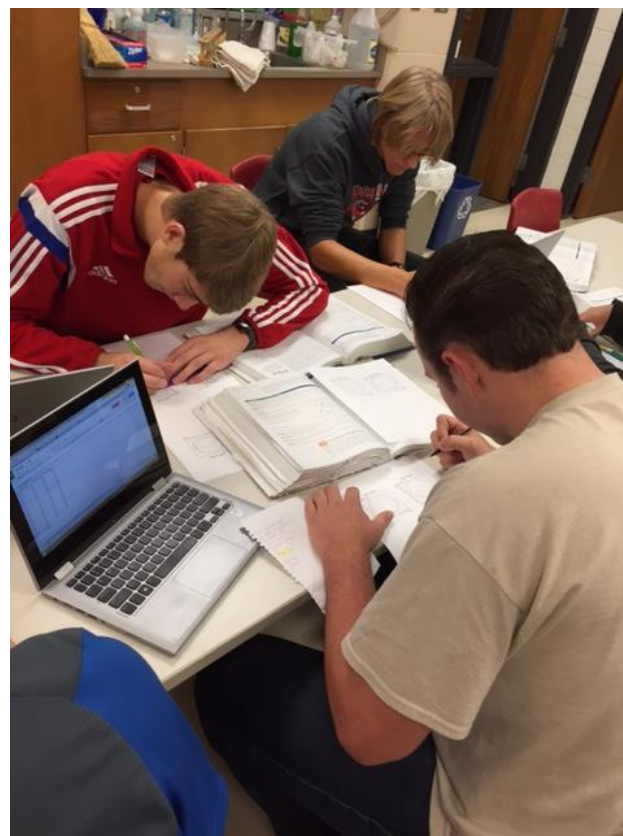
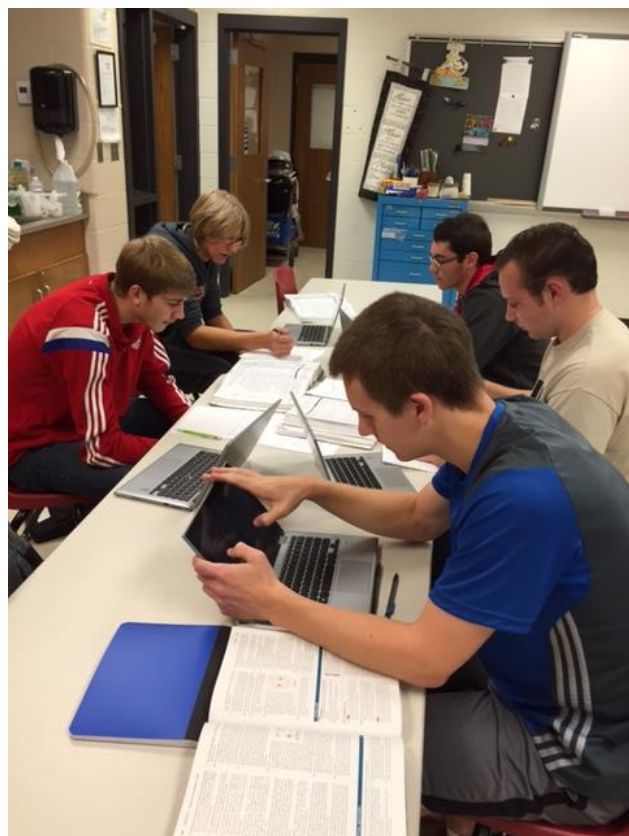
TOTEM





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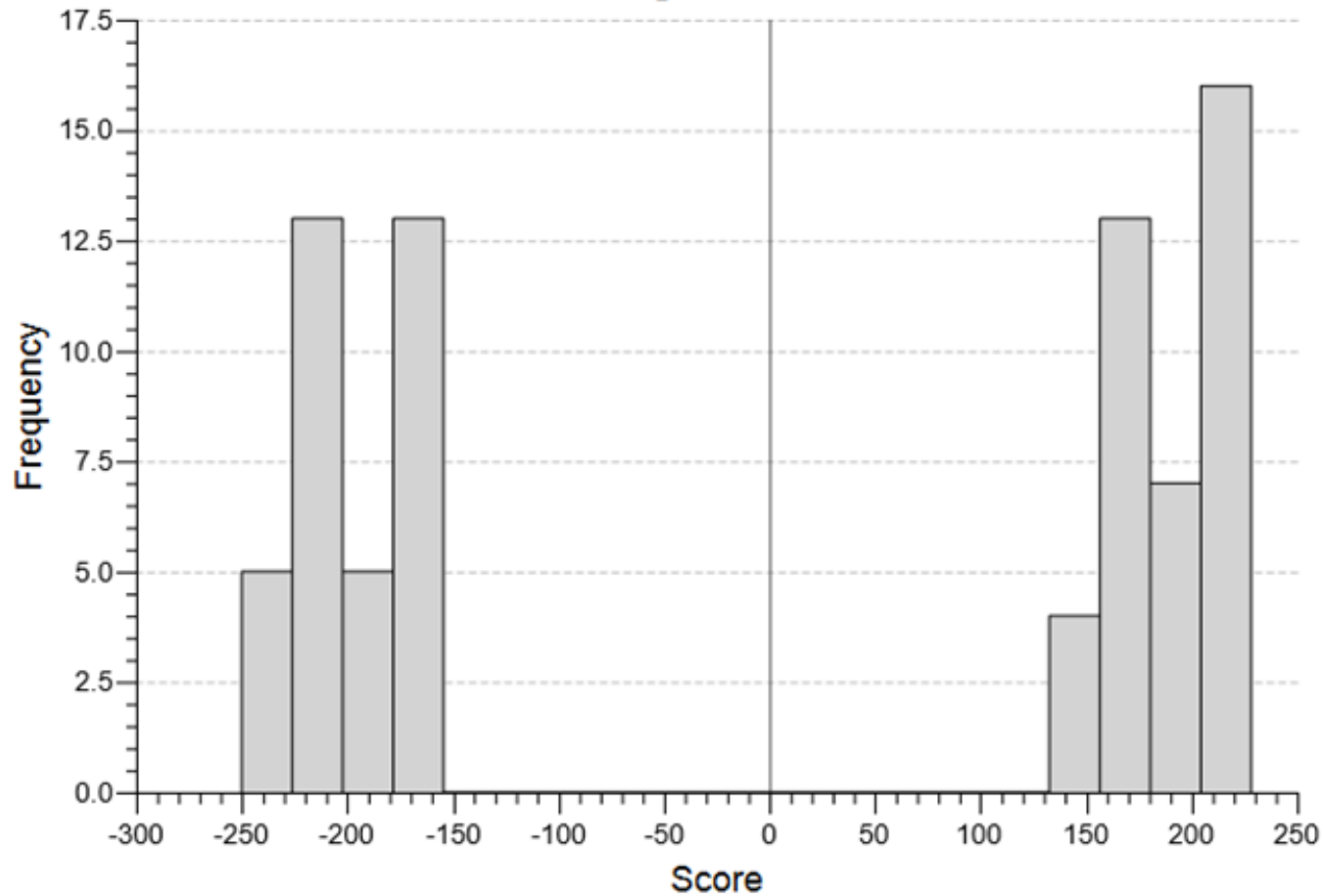


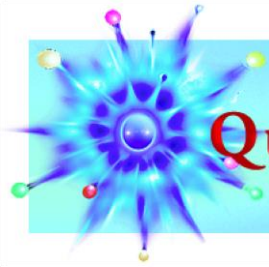
Marla Glover, IN-AAPT, 4-15-23



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Histogram





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$$d \sin \theta_{min} = n\lambda$$

TOTEM ————— CMS ————— TOTEM 3meters
440meters

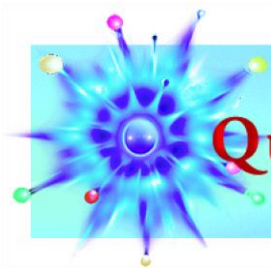




TOTEM

Discussion questions:

- What are the parts of the model that you used to find your result?
- What evidence supports the model?
- Describe which assumptions cause our model to fall short.



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Thank you for your time.

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Doctoral Student at Purdue University