NOVEL TECHNIQUES FOR THE POSITION CALIBRATION OF FAUST

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The Forward Array Using Silicon Technology (FAUST) consists of 68 detectors. Detectors identify and measure the energy of charged particles. Recently upgraded to position-sensitive detectors. Structural tolerances may result in inaccurate relative positioning. Position must be accurately known for upcoming experiments.
Current induced by charged particle
Voltage determines position with:

\[ X\text{-Position} = \frac{\text{Back2}-\text{Back1}}{\text{Back1}+\text{Back2}} \]
\[ Y\text{-Position} = \frac{\text{Front2}-\text{Front1}}{\text{Front1}+\text{Front2}} \]

THE FAUST ARRAY MASK

- Mask blocks particles and creates striped pattern on detectors
- Stripes on detectors will be misplaced by detector motion
- Goal is to find how far detectors are from expected positions

2 phases to accomplish:
1.) Identify stripes on detector
2.) Find set of linear transformations applied to detector which will reposition the stripes to the expected values
PHASE 1 PROCESS

0. Collect Data
1. Noise Removal
2. Rotation
3. Projection onto y-axis
4. **K-means algorithm**
5. Data Selection and Linear Fit
6. Display Result
1. Noise Removal

- Collected from $^{228}$Th Source
- Cut electrical noise at low energy
- Stretch out data empirically
  - Trying to understand characteristics of compression
2. Rotation

- Rotate data by expected angle of slope
- Makes projecting and fitting easier.
3. Project Data onto $y$-axis

After projecting onto $y$-axis, large peaks correspond to stripes.
Description of K-means:

1. Initialize k random points
2. Calculate average position of data associated with each point
3. Reset point to average position
4. Repeat until convergence

Picture from:
4. Run K-means Algorithm

- Use K-means to identify location of stripes
- Must select best K-value
5. Data Selection

- Approximate location of stripe
- Linear fit to data
6. Final Result

- Rotate lines back by 45 degrees
- Colors show which points were used in fit
- Left shows plot from step 2
- Right shows finished product.
PHASE 2

- Data collected with $^{228}$Th Source and $^4$He@15MeV/A+ $^{\text{nat}}$Au
- Want to get blue and red data points closer to orange
Geometry Simulation

- Geometry Simulation
- “Perfect World” expectation
- Alpha particle simulation perfect elastic scattering

$^{228}\text{Th}$ Source

- Can see stripes on ring C, not ring A
- 2-3 stripes on detectors
Geometry Simulation

• Geometry Simulation
• “Perfect World” expectation
• Alpha particle simulation perfect elastic scattering

\[^4\text{He} \oplus 15\text{MeV/A}^+ \text{nat Au}\]

• Low stats on ring C
• Similar stripes to source
• Agrees with source for ring C
Description of Hill Climbing:

- Define set of free parameters $P$
- Define method $\text{eval}(P)$ to evaluate parameters to a single value

HC tries to find the global maximum of $\text{eval}(P)$ by changing $P$.

The picture to the left shows a successful Hill Climb with one free parameter. Local maxima causes difficulty for successful HC.

Preliminary testing of Hill Climbing algorithm.

Setup:
- Two initially parallel lines are rotated randomly
- Hill Climbing is told to make them parallel again through rotations
- 6 free parameters (3 per line)
Setup:
• Ring of detectors rotated by .5 degrees about beam-axis
• Each detector is rotated randomly within a given range
• Hill Climbing is told to rotate ring such that the set of stripes are as close to expected as possible
Setup:

- 1 free parameter
- Cutting on eval(P) allows better accuracy
- As the range increases inaccuracy grows
SUMMARY

- FAUST Detectors measure position but need to be calibrated
- Mask allows for 2-phase process for calibration
- Phase one identifies stripes with linear fits
- Phase two needs to be tested more before implementation
ACKNOWLEDGEMENTS

This work was supported by:
- the Robert A. Welch Foundation under Grant No. A-1266
- U. S. Department of Energy under Grant No. DE-FG03-93ER-40773
- National Science Foundation under Grant No. PHY-1263281

Works Cited: