



# Vernier Picket Fence Test Using 2D Detector Array

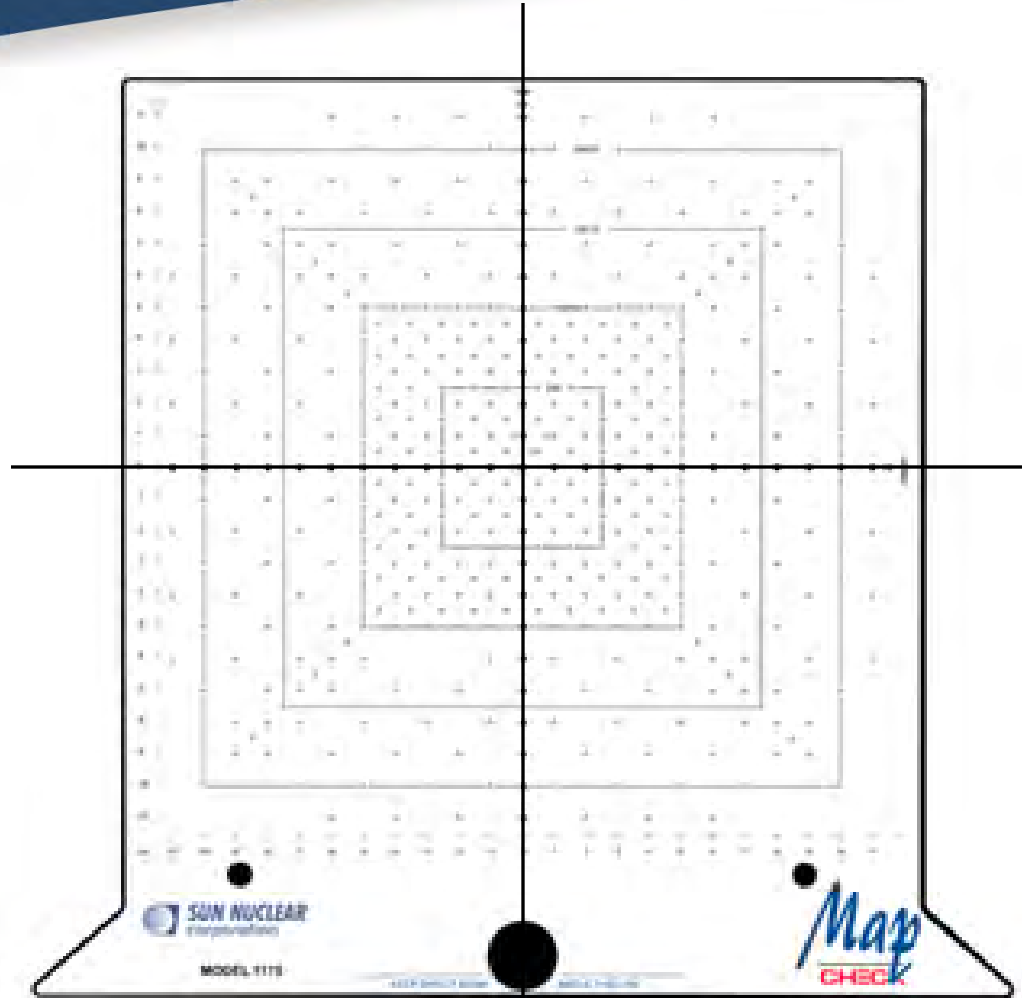
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# Outline

- Overview
- Background: Vernier Scale
- Methods
- Results
- Conclusions
- Future Work

# How well can you set up MapCheck?



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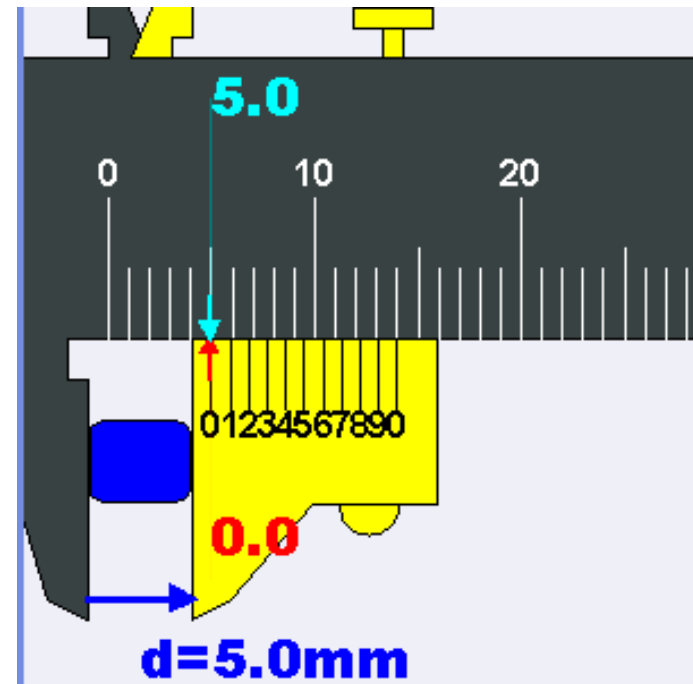
| Device               | Accuracy                            | Aligned With?        |
|----------------------|-------------------------------------|----------------------|
| Crosshair            | 0.1-0.5 mm                          | Mechanical Isocenter |
| ExacTrac             | ~0.2 mm                             | Imaging Isocenter    |
| OBI/CBCT             | ~0.2 mm for OBI<br>~0.5 mm for CBCT | Imaging Isocenter    |
| Vernier Picket Fence | <0.02 mm                            | Radiation Isocenter  |

# Overview

- Vernier Picket Fence (VPF) test is a tool to:
  - Identify the radiation isocenter
  - NOT for MLC leaf QA
- By delivering 2-3 extra radiation fields, the user can identify the radiation isocenter, up to 0.02 mm accuracy

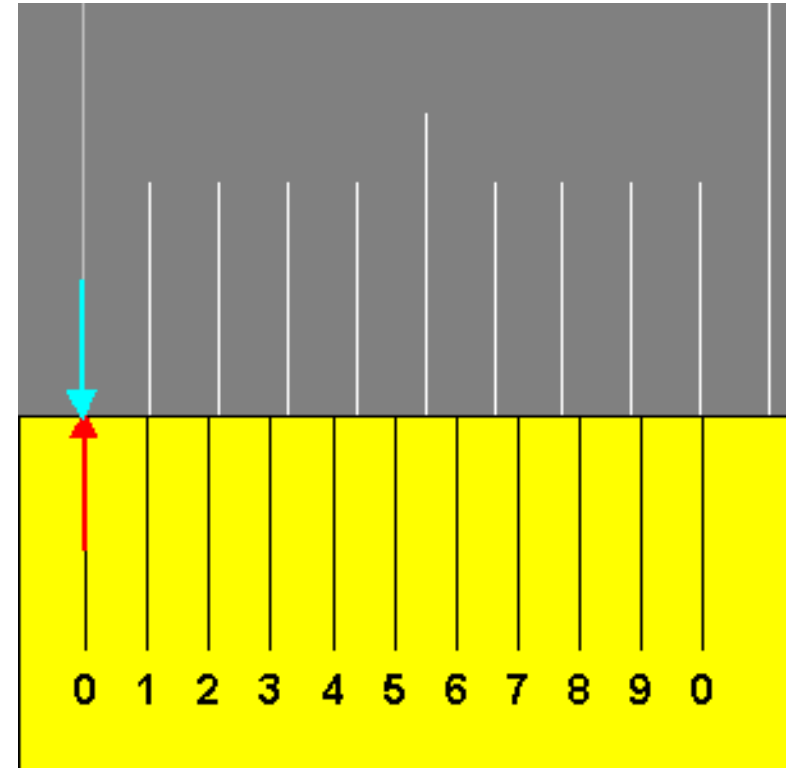
# Vernier Scale in a Caliper

- Moving arm has a vernier scale spaced at nine tenths of the main scale on the fixed arm
- Measure up to 0.1 mm precision

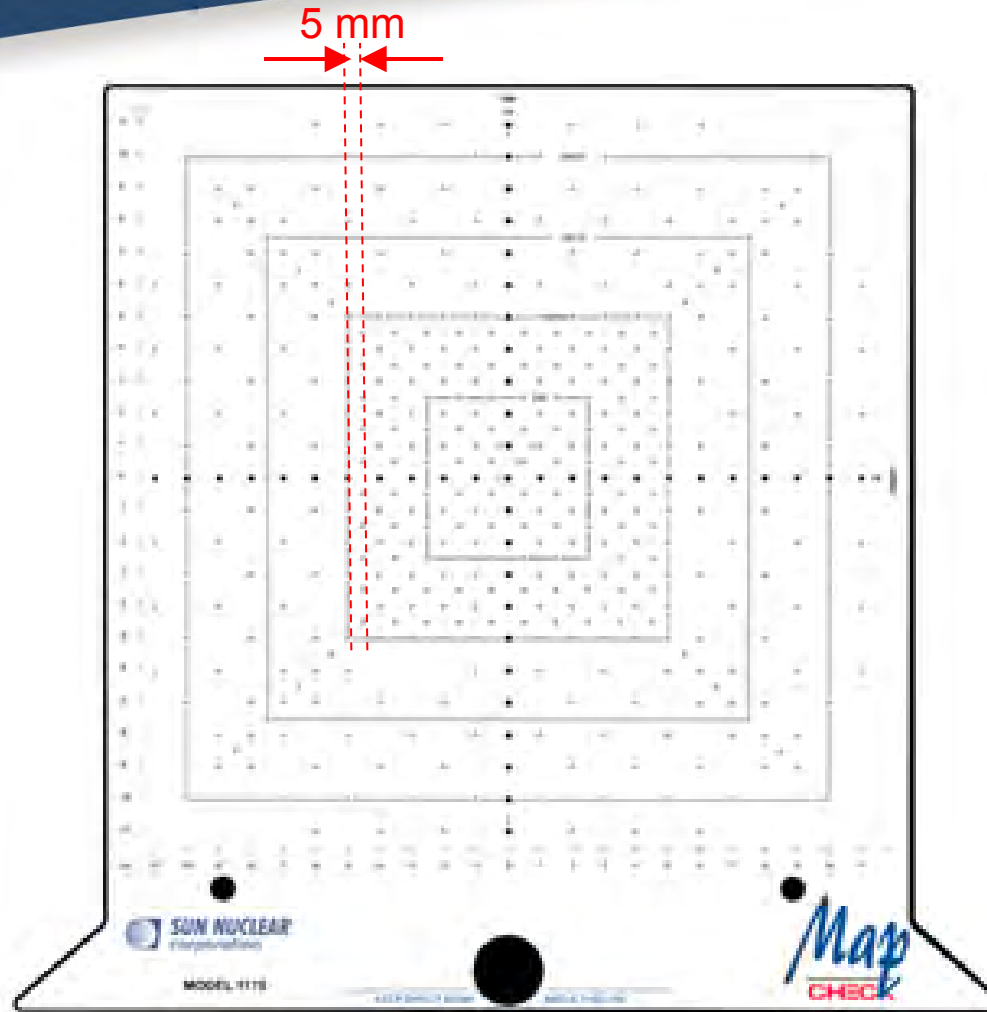


# Vernier Scale

- Best match between two marked lines
- 0.1 mm offset will move the matched lines from one pair to the next
- Magnification Factor  $N=10$



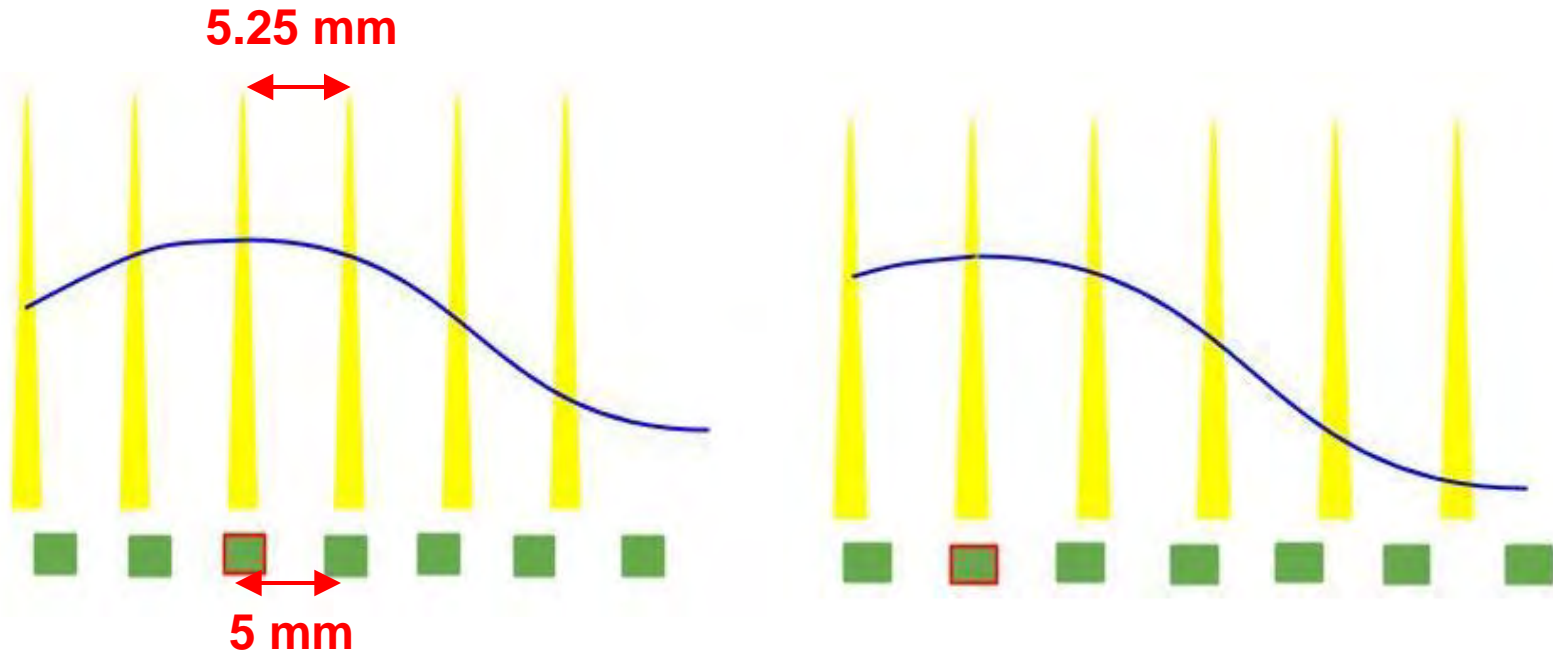
# MapCheck QA Device





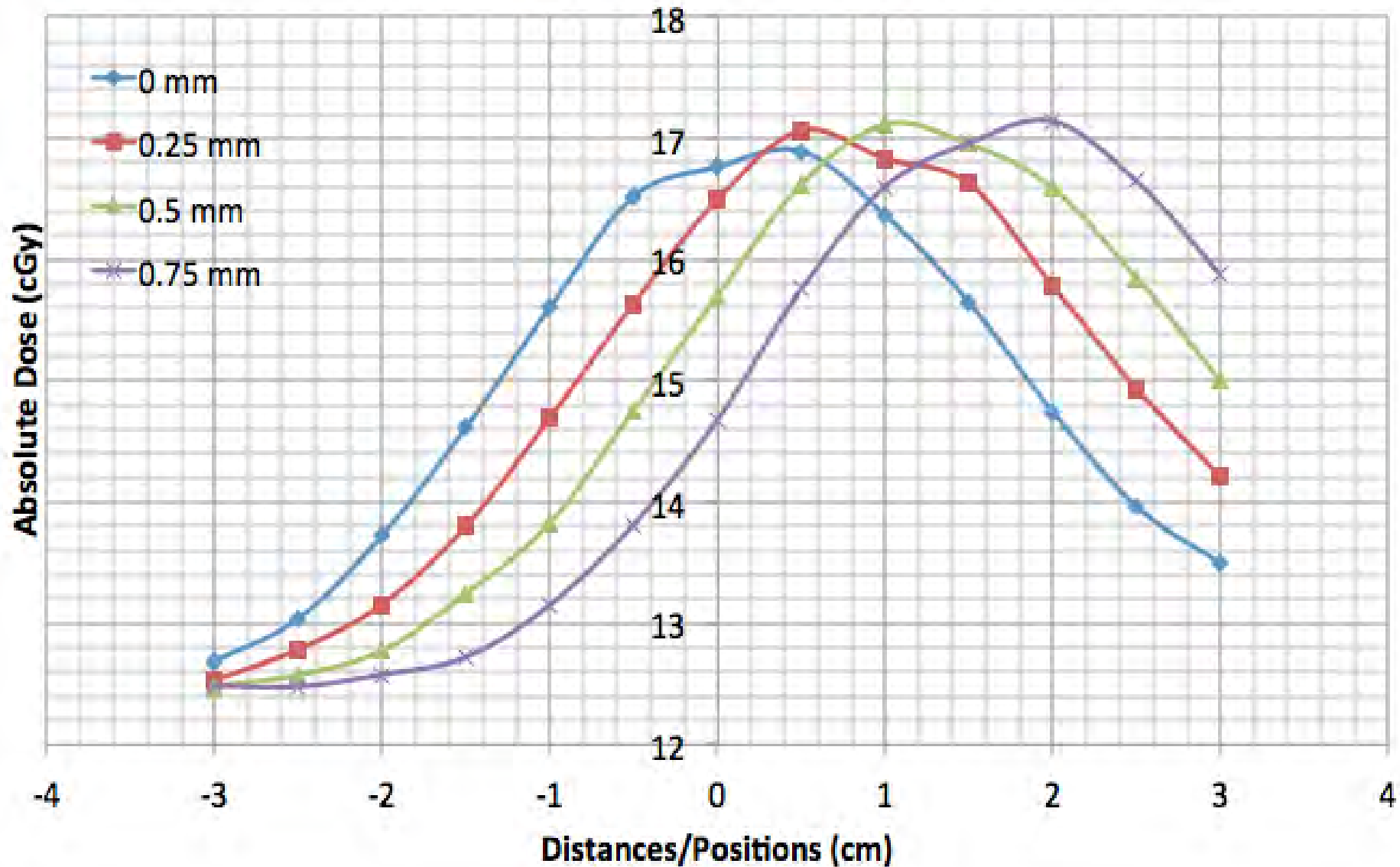
# Location of Maximum Signal

- Relative position between MapCheck and VPF



# 0.25 mm Offset Moves Measurement Curve by 5 mm

## Magnification Factor = 20



# Methods

- VPF tests are read by finding the maximum signal, which give a 0.25 mm accuracy

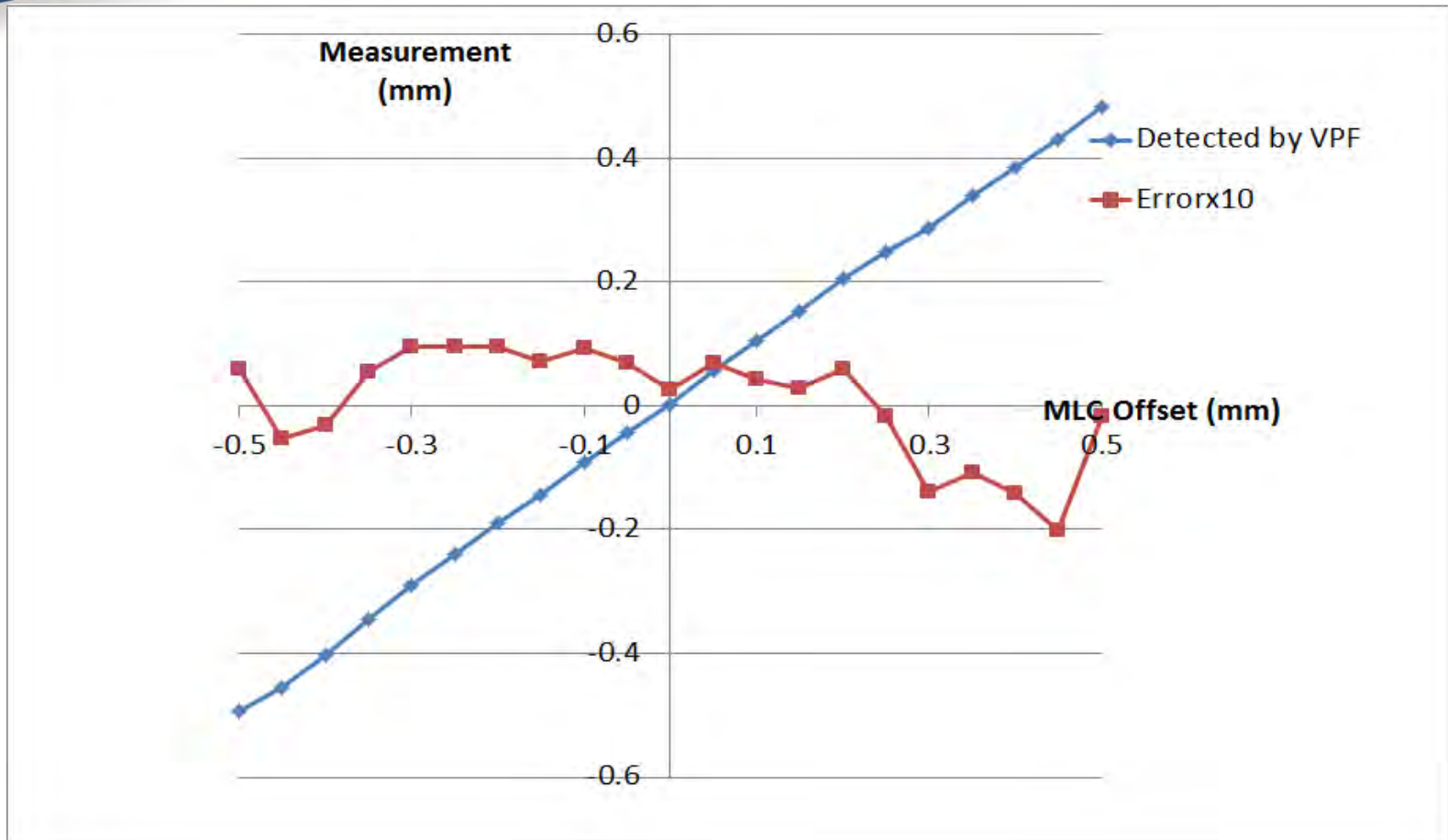
Can we do better?

- VPF tests can also be read by computers
- Detector signals are fit with a Gaussian curve to determine the peak position

# MLC Offset Test

- A sequence of VPF fields were delivered with different MLC offsets for every 0.05 mm step size
- We tested how accurately our algorithm can detect the offset

# VPF Accuracy = 0.02 mm

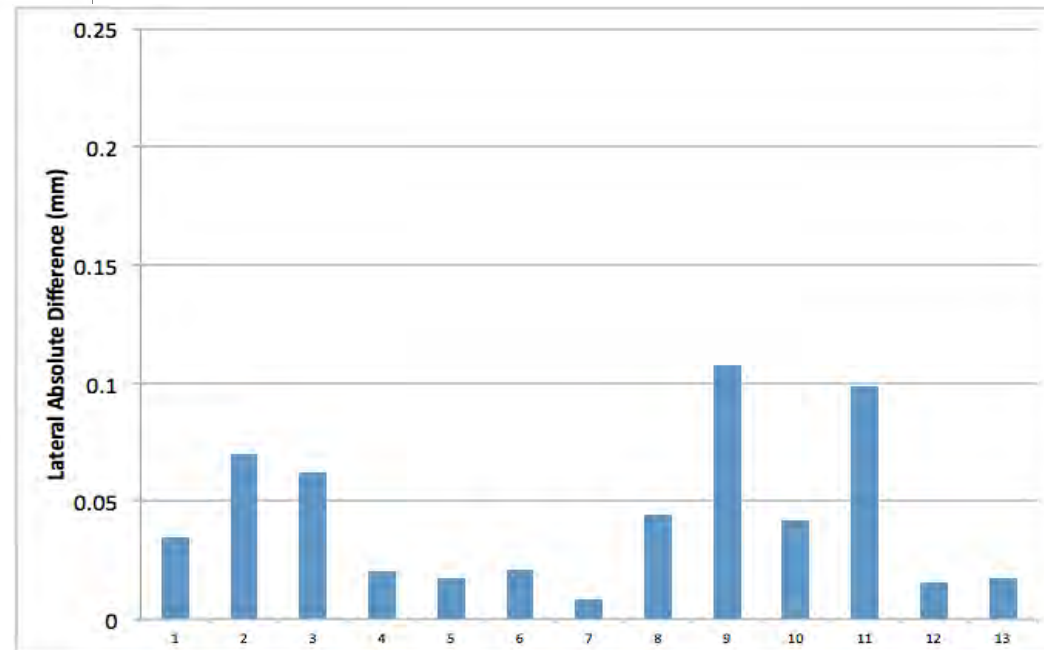
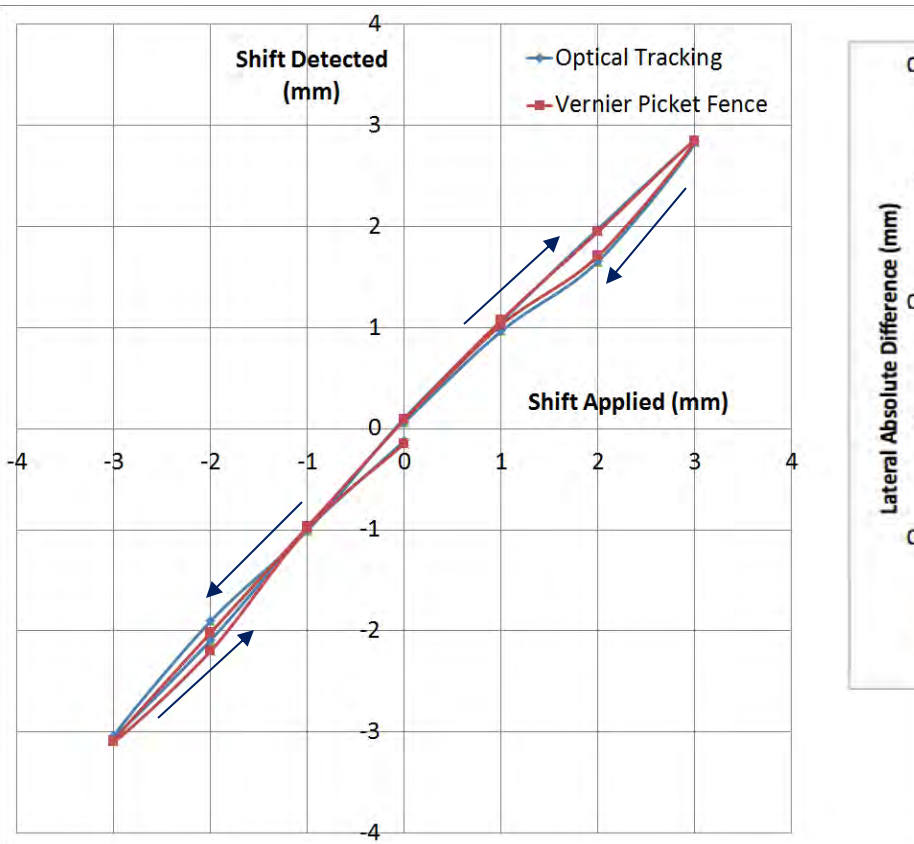


# ExacTrac Cross Validation & Couch Hysteresis

- Couch was programmed to move along one direction and back to the starting position
- 0° gantry angle with 0° and 90° collimator angles to determine the lateral and longitudinal shifts
- Results from the VPF tests were compared with optical tracking (OPT) of the ExacTrac system

# Lateral Shift Results

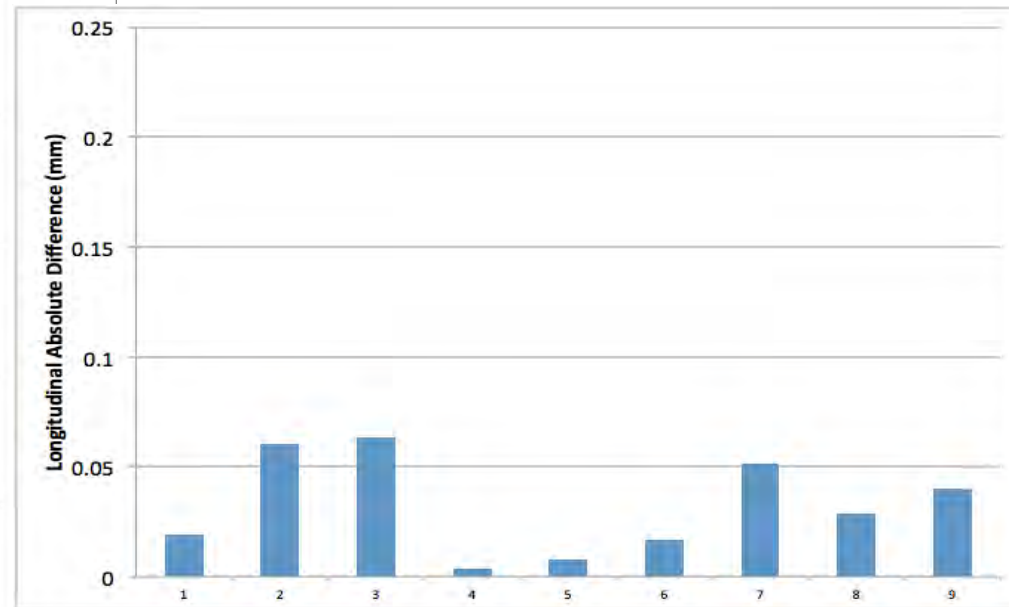
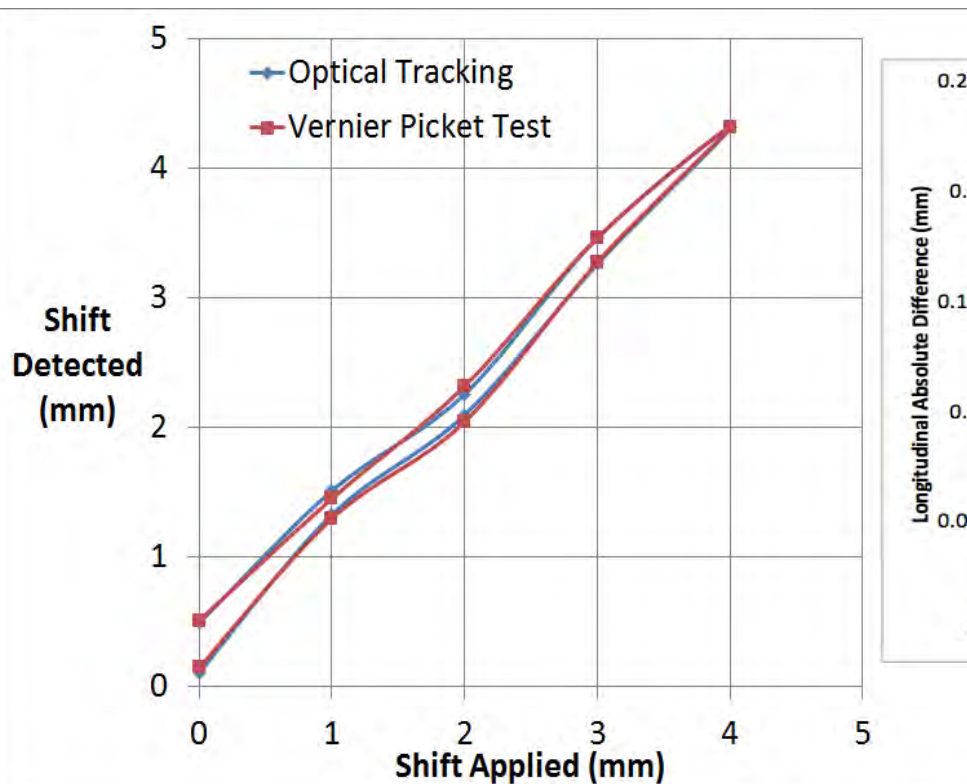
- Both methods detect couch hysteresis (up to 0.3 mm)
- VPF agreed with optical tracking ( $\sigma = 0.055$  mm)





# Longitudinal Shift Results

- Couch hysteresis is large for longitudinal direction (up to 0.5 mm)
- VPF agreed with optical tracking ( $\sigma = 0.041$  mm)





# Conclusions

- VPF tests can be use to identify the radiation isocenter with sub-millimeter accuracy
- MLC offset test shows that VPF is accurate up to 0.02 mm
- Cross validation shows that VPF agrees with optical tracking within 0.05 mm

# Potential Applications

- A useful tool to identify the radiation isocenter:
  1. IMRT/VMAT QA setup: especially for small SRS fields
  2. Winston-Lutz QA setup
  3. Check crosshair or laser: mechanical isocenter
  4. Check CBCT: imaging isocenter

# Future Work

- Measure the VPF for the vertical direction to implement a 3D correction
  - Gantry angle =  $45^\circ$
- Apply VPF tests to other QA phantoms such as the Delta4

# Question?