NMIS TIME CORRELATIONS FOR DETERMINING THE SHAPE OF PLUTONIUM USING SECOND ORDER STATISTICS

Lisa G. Chiang
Oak Ridge National Laboratory
July 15-19, 2001

Introduction

- **NMIS time correlations are position sensitive.**
- **Previous work using third-order time correlations and three detectors used to identify distribution of ^{252}Cf point sources (plutonium surrogate).**
- **Caveats**
  - **third-order correlations converge slowly.**
  - **distributions were restricted to X-Y plane.**

Proposal:

- **Determine fission site locations using detector-detector cross correlations (2nd-order correlations).**
- **Use multiple detector-detector cross correlations to provide multiple views of object (three-dimensional).**
- **Use linear response of cross correlations to unfold the shape of the plutonium object (RX=B).**

Methodology

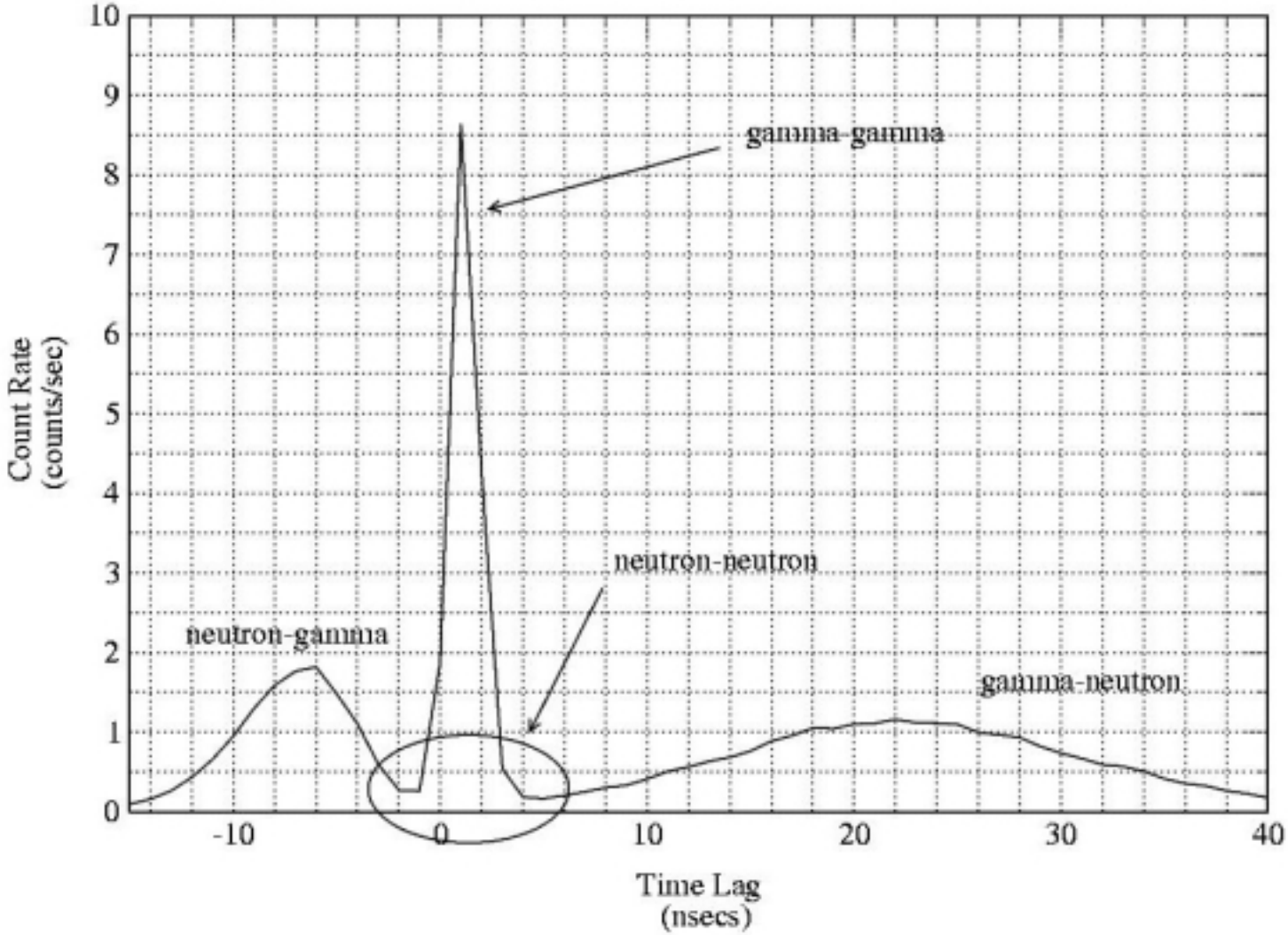
- **Use ^{240}Pu distributed in plutonium as source of gammas and neutrons.**
- **Time correlate radiation pairs to form detector-detector cross correlations.**
- **Cross correlations are additive - model object as a collection of point sources.**

Methodology (cont'd)

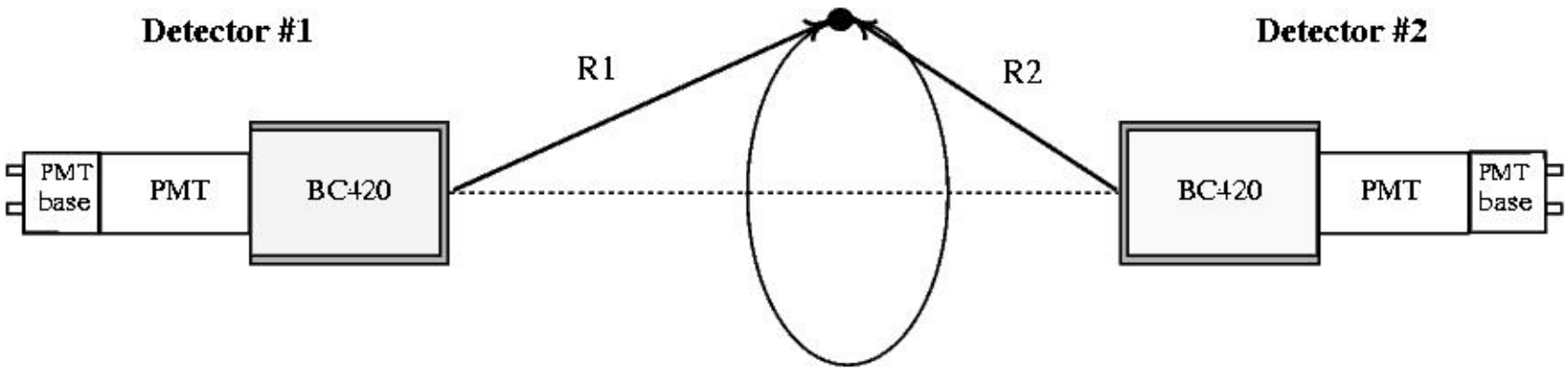
- **Divide the volume of interest into a set of grid points.**
- **Generate the response matrix, R, from the set of cross correlations measured from a point source placed at each grid point.**
- **Measure a set of cross correlations B, for an unknown distribution.**
- **Unfold the unknown distribution, X, from the linear system, RX=B.**

Caveats

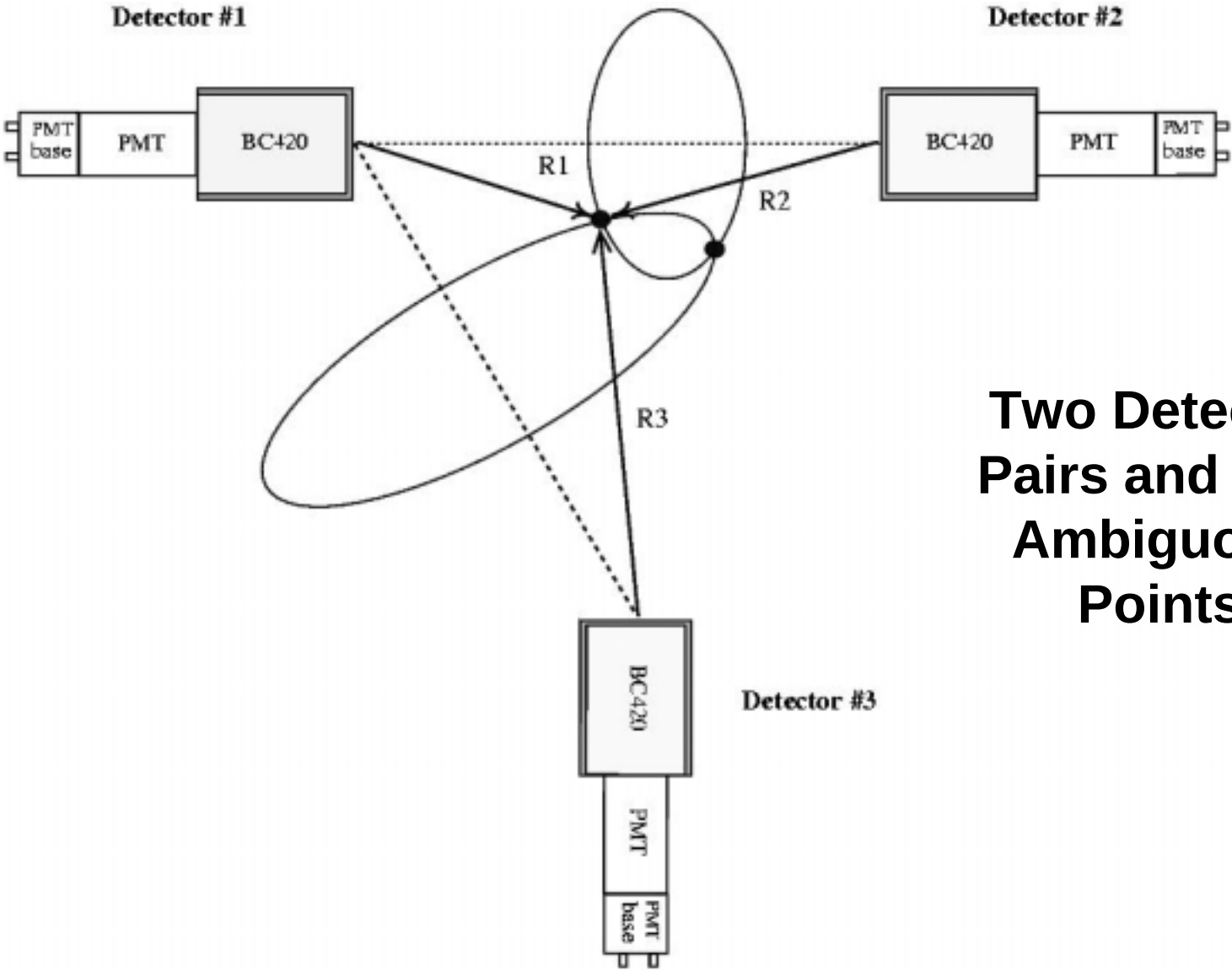
- **Superposition of cross correlations restricts the object to non-multiplying and non-attenuating shapes (point sources, ring or line sources, thin shells).**
- **Spatial resolution is limited by fission spectrum of ^{240}Pu.**



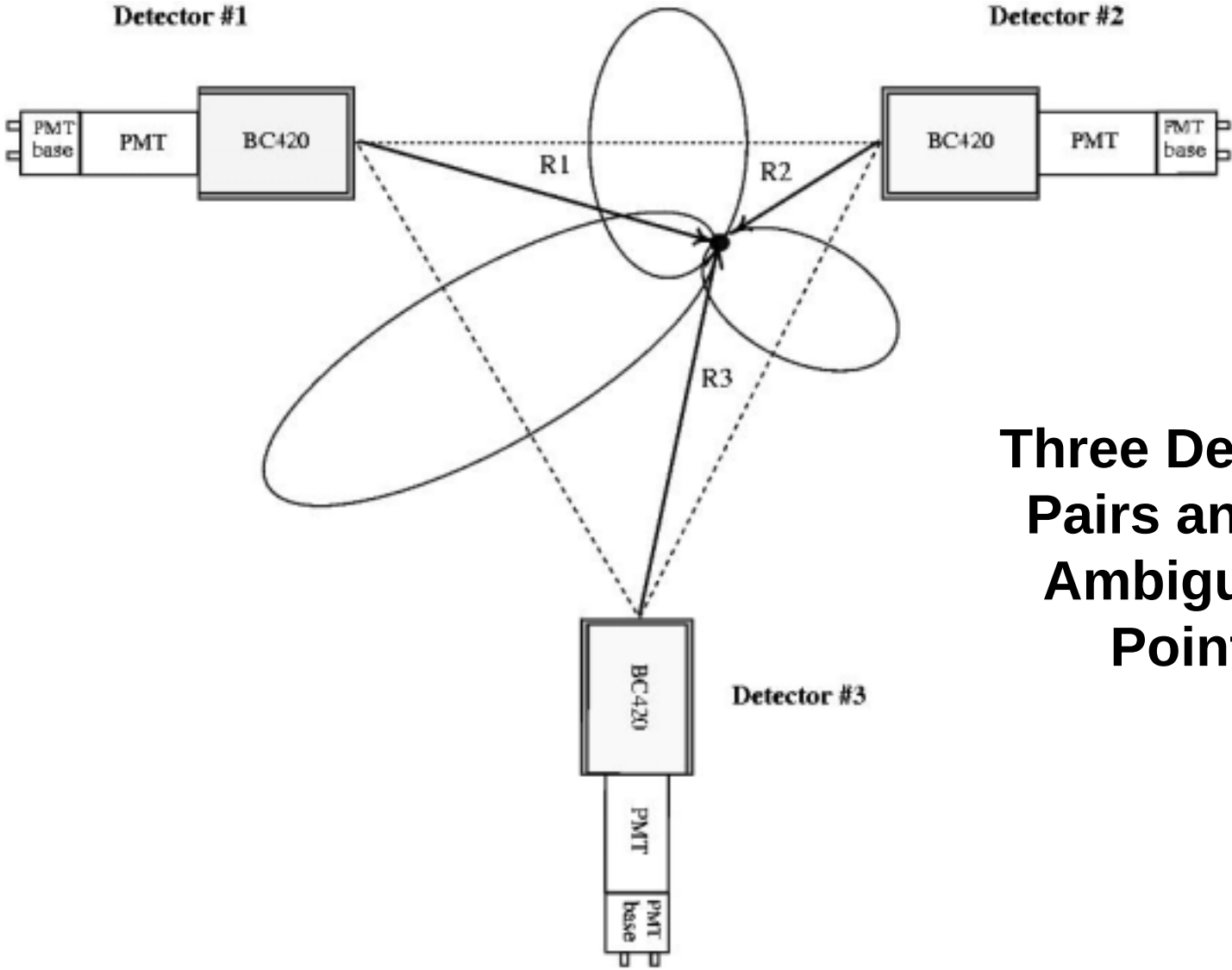
Cross Correlation of Asymmetrically Placed Source



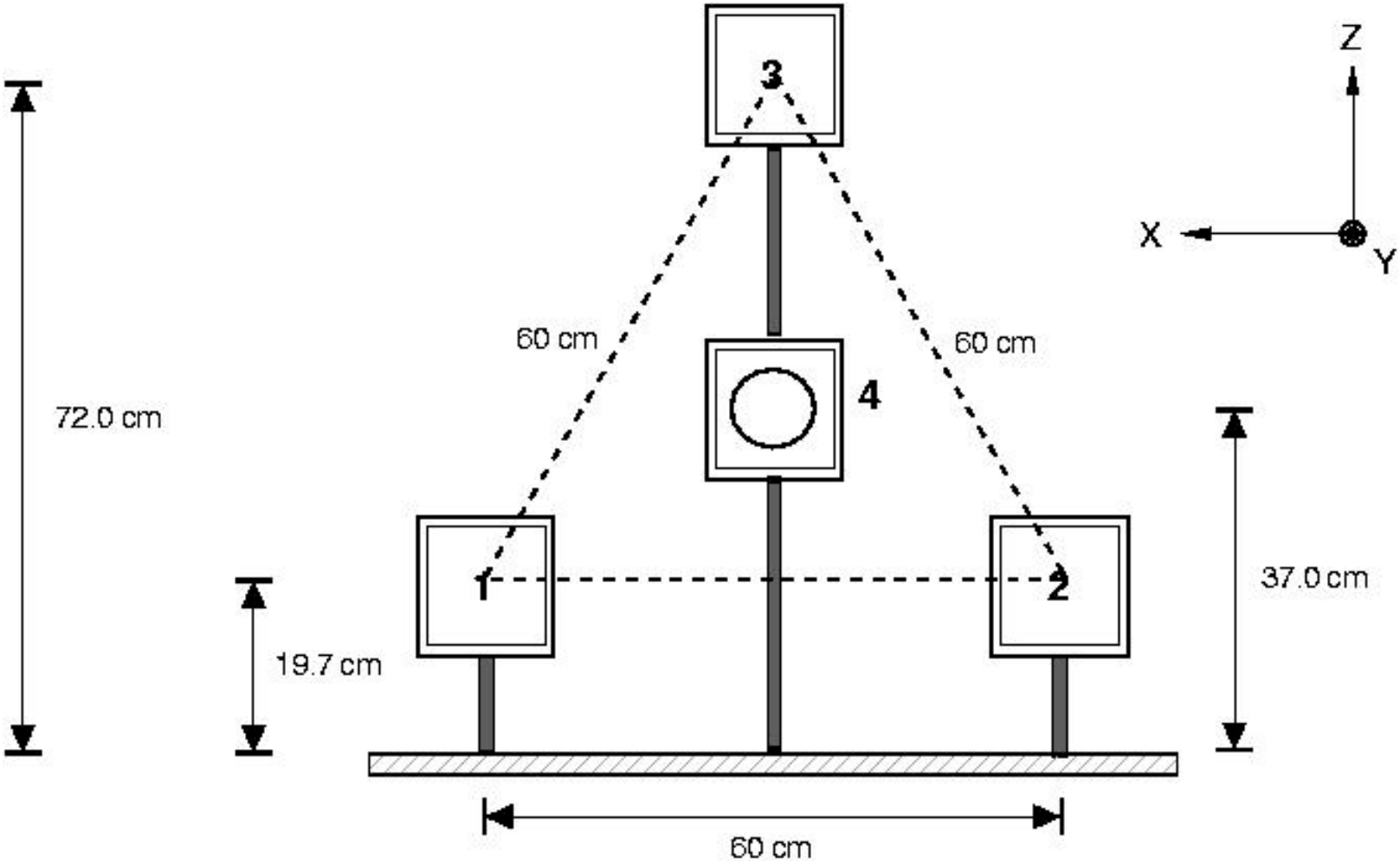
Locus of Ambiguous Points for Two Detectors



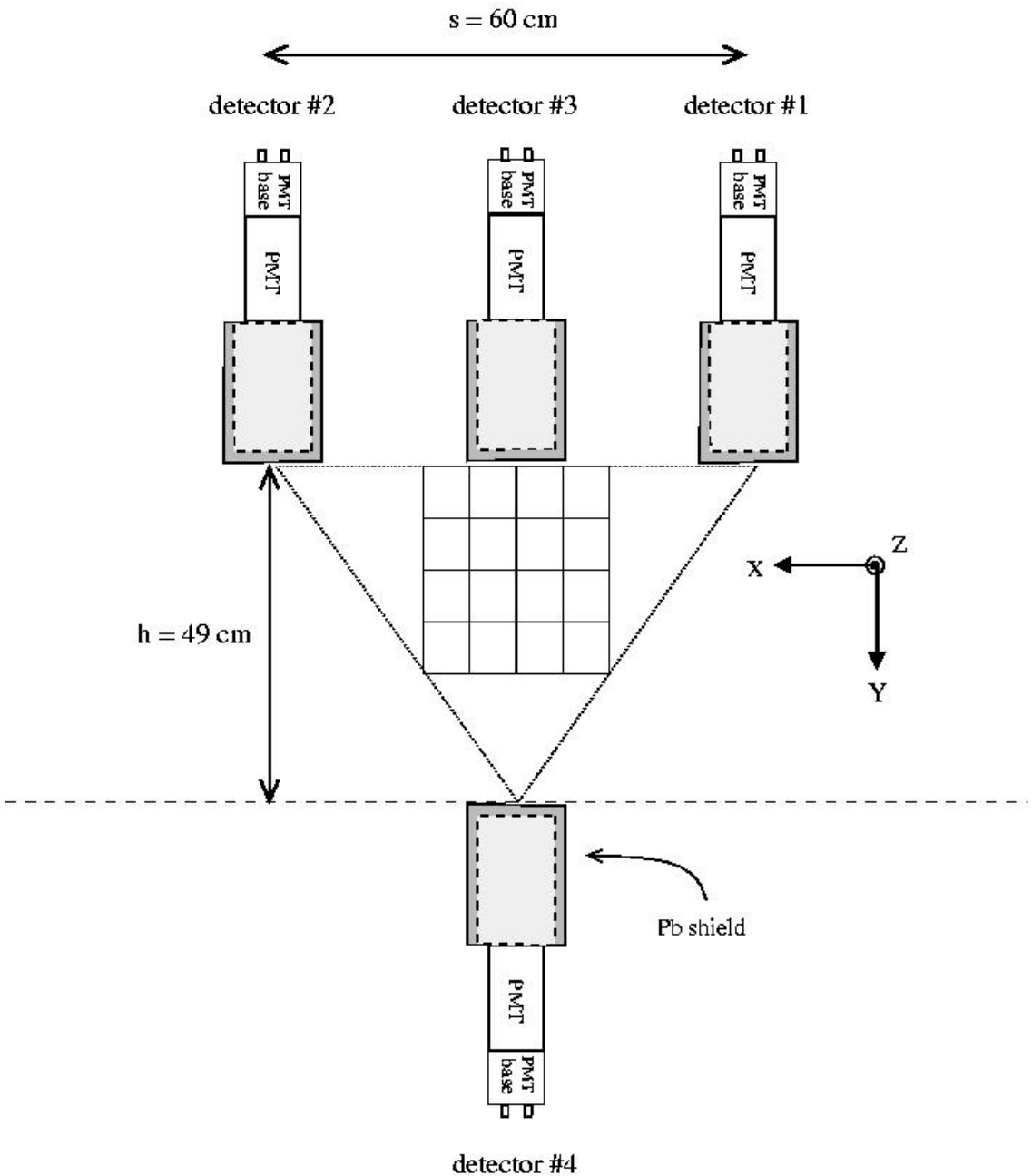
Two Detector Pairs and Two Ambiguous Points



Three Detector Pairs and No Ambiguous Points

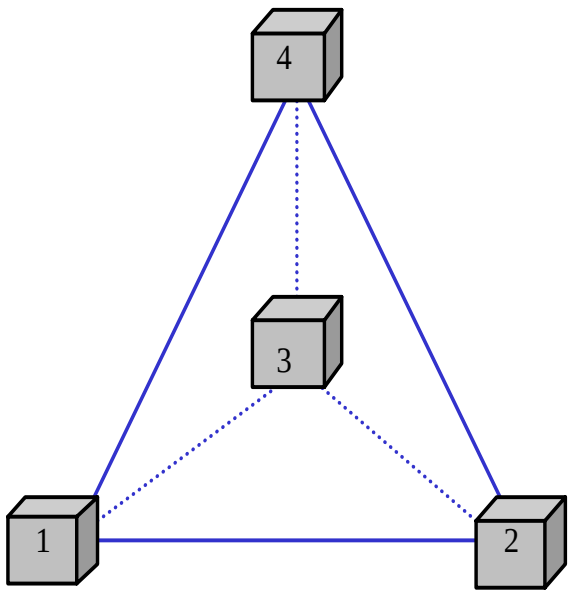


Side View of Tetrahedral Configuration



Top View of Tetrahedral Configuration

UT-BATTELLE



Tetrahedral Configuration

Detectors	Cross Correlations
1-2-3	R_{12}, R_{13}, R_{23}
1-2-4	R_{12}, R_{14}, R_{24}
2-3-4	R_{23}, R_{24}, R_{34}
1-3-4	R_{13}, R_{14}, R_{34}

Detector Triplets and Possible Cross Correlations

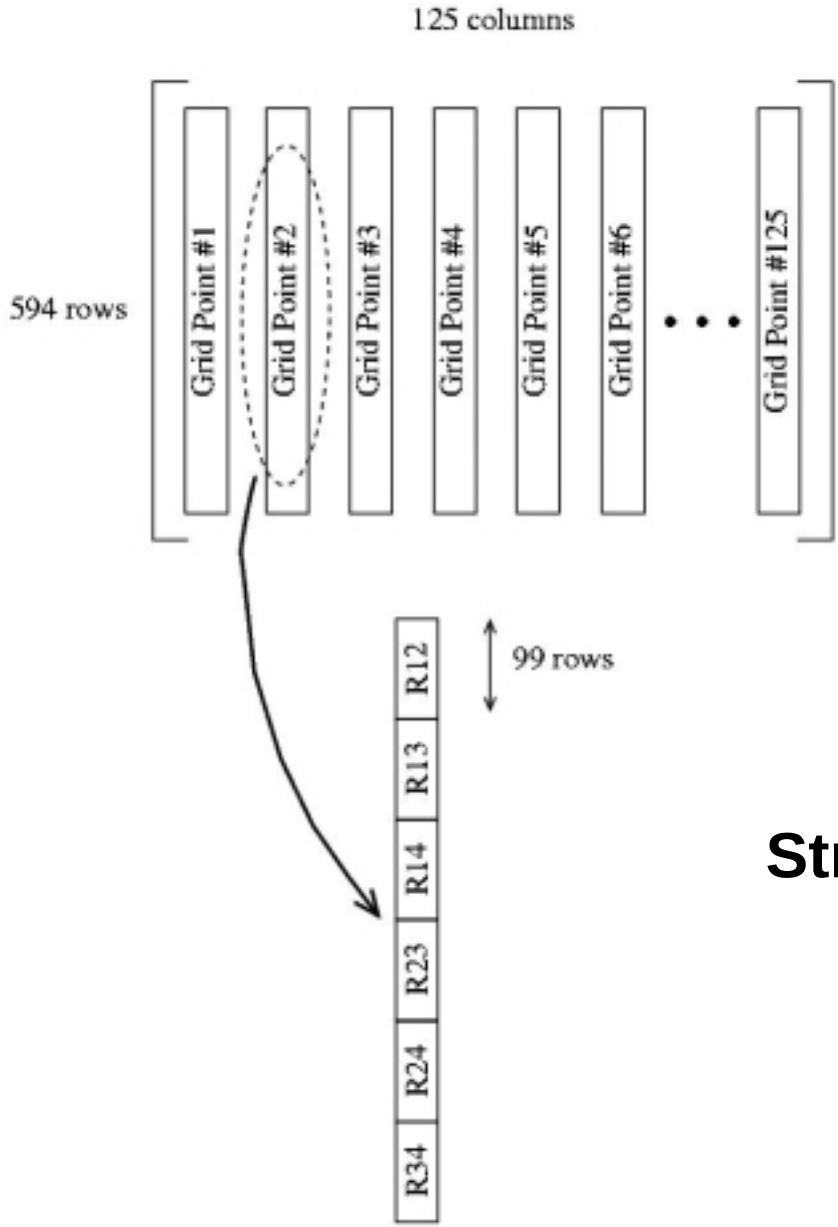
Solving The Linear System, RX=B

$$\min_{X} \| RX - B \|_2, \text{ subject to } l \le X \le u$$

Bounded Least Squares

$$\min_{X} \| RX - B \|_2, \text{ subject to } X \ge 0$$

Non-Negative Least Squares



Structure of R- Matrix