Specific Aims:

Work in the present project period was aimed at technologies that would elevate the performance of SPECT and PET imaging systems. In particular, various forms of Compton scatter apertures were evaluated. Highly relevant to proposed work in the next project period was successful demonstration of very high resolution PET using a "degenerate" Compton camera. Because the developments involved in creating a very high resolution PET demonstrator parallel those required to advance Compton cameras for single photon imaging but have relaxed performance requirements, work in the next project period will focus on high resolution PET demonstrations. If successful, the proposed work will likely lead to PET instruments having outstanding spatial resolution (<1mm FWHM) for animal imaging. Moreover, the concepts can be used to create PET probes for very high-resolution human imaging including high resolution positron emission mammography (PEM).

Phase I Demonstrations:

1. Develop a more complete benchtop system (as in another). UM
2. Demonstrate energy discrimination → UM
3. Demonstrate the additional position resolution capabilities
   a. Calibration of BGO modules → UM/OSU
   b. Readout of BGO modules → UM/OSU
4. Develop a Monte Carlo model of the specific platform UM/Valencia/OSU
5. Compare Monte Carlo predictions with experiment UM/Valencia/OSU
6. Develop and implement appropriate image reconstruction software UM/OSU
7. Timing studies – what should next VATA's look like? UM/Ljubljana/Ideas
8. Evaluation of data processing technologies, multi-resolution image reconstruction. UM
9. Evaluate the value of information from multi-resolution measurements UM

Development Tasks for Phase II Demonstration:

1. Refine detector and electronics requirements. UM/OSU/CERN/Ideas
   a. Optimum pad size? (i.e., maximum size w/o affecting resolution)
   b. Countrate requirements
   c. Noise requirements
   d. Time resolution requirements
2. Data acquisition requirements
   a. Countrate requirements (singles and coincidence at various points in the system)
   b. Event processing architecture (e.g., where can kinematics info be easily incorporated).
3. Evaluate technologies for achieving detector element sizes on the order of 0.3 – 0.8 mm
   a. Evaluate double-sided silicon strip detectors (timing seems bad, work-arounds?)
   b. Evaluate capacitive readout
   c. Evaluate methods for reducing inactive area associated with guard-rings
4. Evaluate packaging technologies and cooling technologies
   a. Kapton ribbons
   b. TAB bonding

    c. Wire bonding? (low-profile?)
    d. Peltier cooling

5. Develop next generation VATA circuits with improved timing performance
6. Further development of data processing technologies (using Compton kinematics to reject scatter and random coincidences, for example).
7. Final design and initial testing of readout, coincidence, and other DAQ electronics

Phase II Demonstration

1. Develop two densely-packed detector stacks for a more complete demonstration of the concepts prior to scale-up.
2. Implement appropriate 3D reconstruction software
3. Readout electronics? (detector, coincidence, scintillator, etc.)
4. Develop a simple demonstration of the 3D PET concept
5. Monte Carlo modeling, compare predictions and experiment
6. Experiments to characterize performance / extrapolation to full system

Fundamental research on high-resolution PET devices

Technologies for scale-up

3D high-res PET demonstrator