

# Sandia National Laboratories CT Equipment and Applications

45<sup>th</sup> Weapons Agency Nondestructive  
Testing Organization Meeting

November 1, 2011

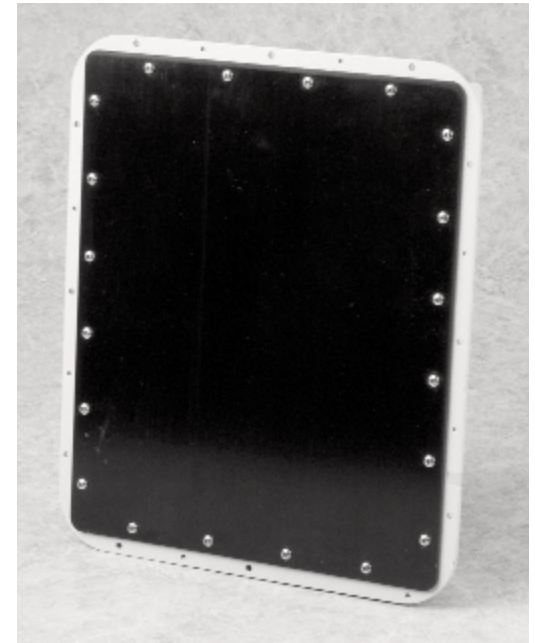
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Sandia National Laboratories  
Experimental Mechanics, Non-Destructive Evaluation, & Model  
Validation Department

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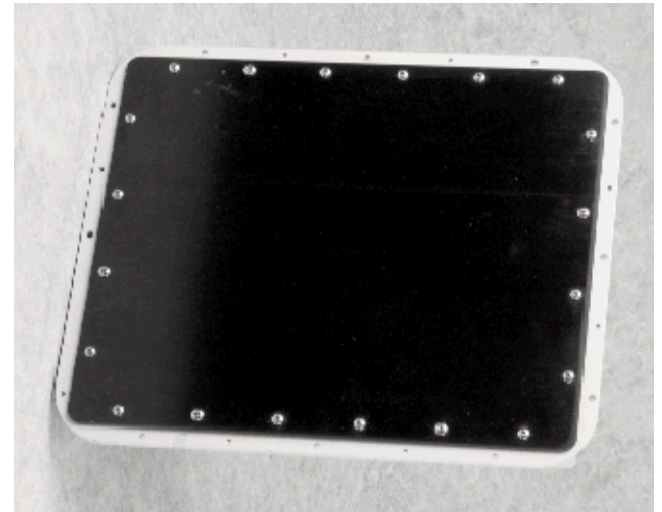
## Computed Tomography Detectors (Varian 2520V)

- Varian 2520V (~\$80K)
  - 127 micron pixels
  - ~4 lp/mm
  - Gigabit network interface
  - ~250x~200 mm area
  - 1920x1536 total pixels
  - 1900x1516 active pixels
  - 14-bit (~75% usable)
  - CsI phosphor (48% MTF @ 1 lp/mm)
    - Energy?



## Computed Tomography Detectors (Varian 2520V)

- Varian 2520V panel
  - More computer/network interface speed needed
  - No command processor
  - Acquisition software compatibilities
  - Less shielding
    - lower energy x-rays
    - (225kV limit)
  - Internal scatter
    - (not quantified)



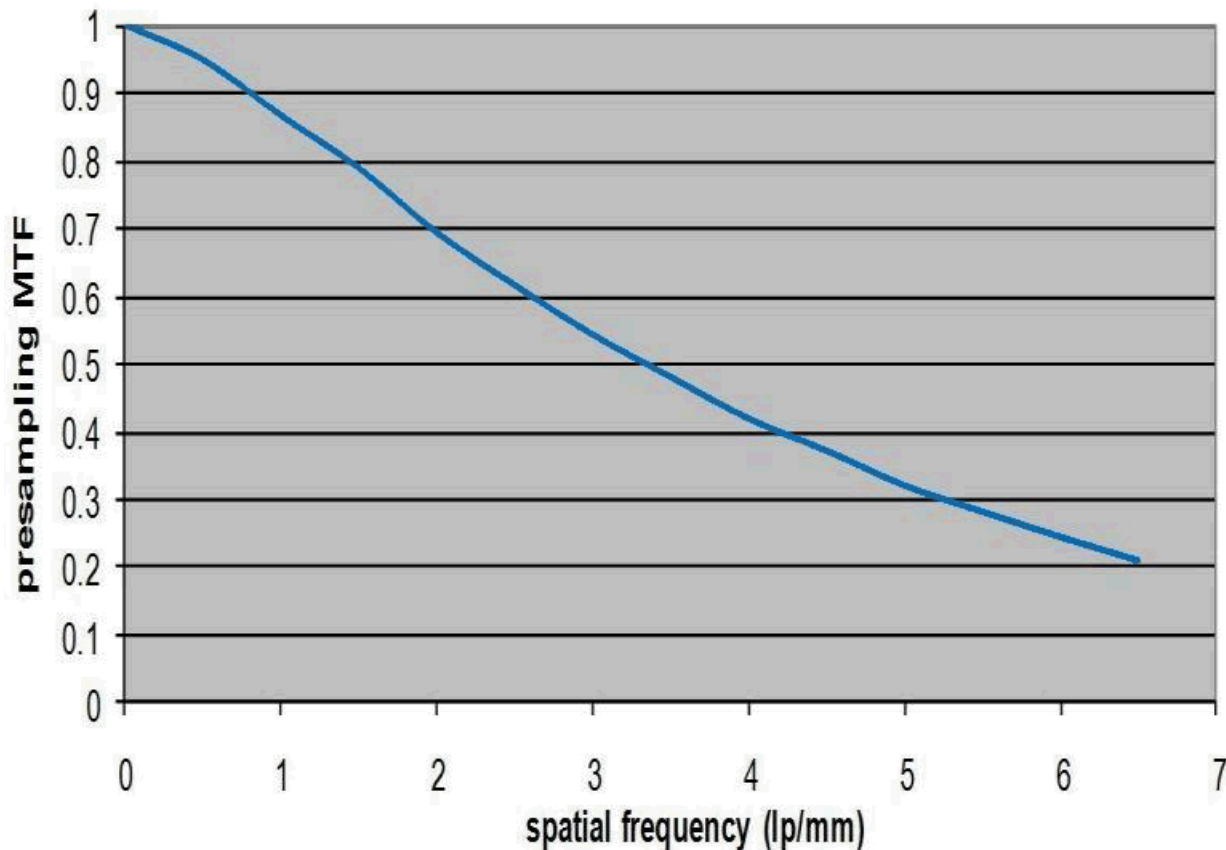


## Computed Tomography Detectors (Dexela 2923)

- Dexela 2923 (Perkin Elmer) (~\$100K)
  - 74.8 micron pixels
  - ~6.7 lp/mm
  - CMOS active pixel sensor
    - Fiber coupled (shielded)
  - Camer Link & Gigabit network interface
  - ~290x~230 mm area
  - 3888x3072 active pixels
  - 14-bit
  - CsI phosphor
  - 225 kVp limit

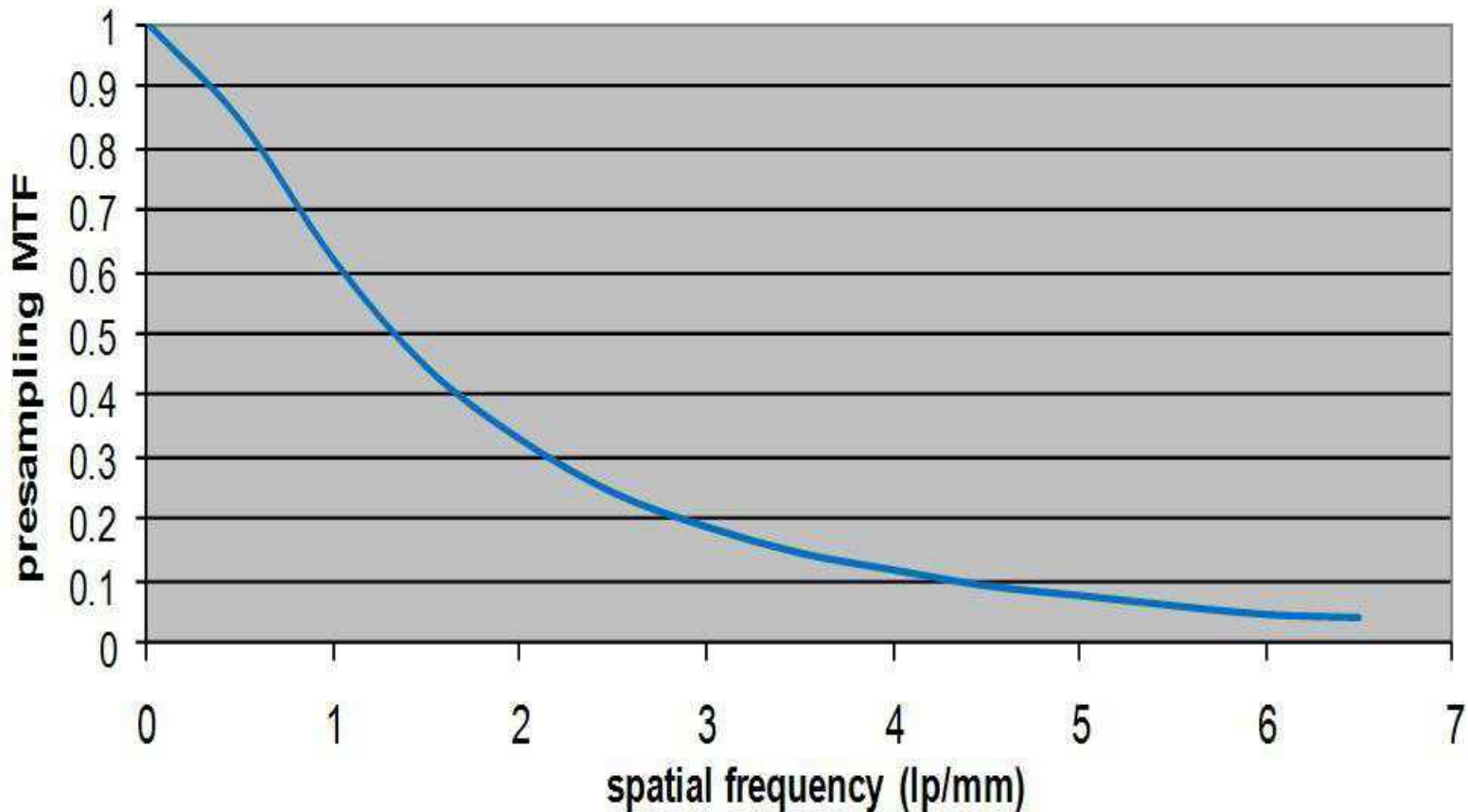
## Computed Tomography Detectors (Dexela 2923)

- Dexela 2923 (Perkin Elmer)
  - 150 micron CsI (energy?)



## Computed Tomography Detectors (Dexela 2923)

- **Dexela 2923 (Perkin Elmer)**
  - 600 micron CsI (energy?)





## Computed Tomography Detectors (Dexela 2923)

- Dexela 2923 (Perkin Elmer)
  - 74.8 micron pixels
  - Binning options vs. Frame Rate (fps)

Bin	Camera Link	Ethernet
• 1x1	26	3
• 1x2	53	6
• 1x4	72	11
• 2x1	35	6
• 2x2	70	11
• 2x4	81	23
• 4x1	39	11
• 4x2	79	23
• 4x4	86	46

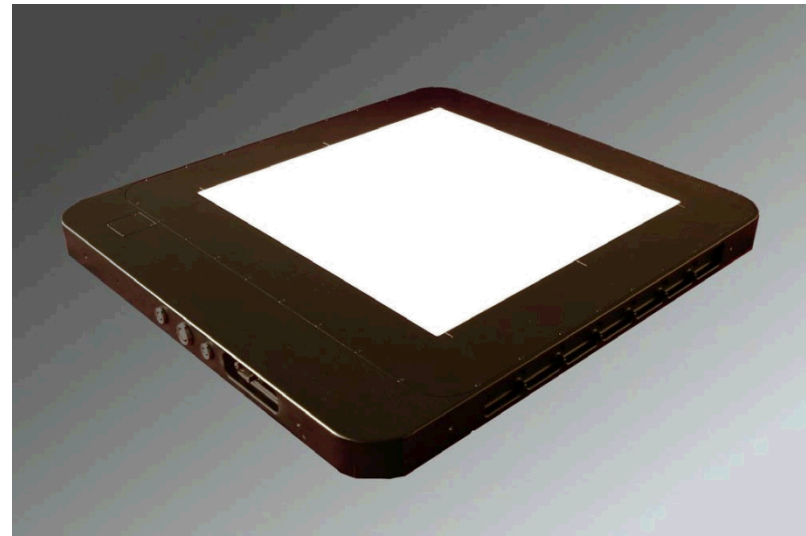


## Computed Tomography Detectors (Dexela 2923)

- Dexela 2923 panel
  - More computer/network interface speed needed
  - Camera Link extended needed
  - Acquisition software compatibilities
  - Massive dataset sizes
  - Less shielding
    - lower energy x-rays
    - (225kV limit)
  - Internal scatter
    - (not quantified)

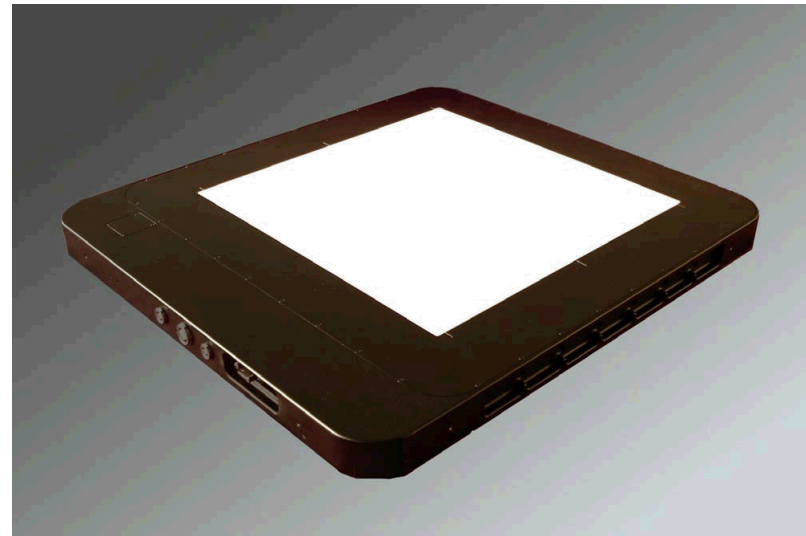
## Computed Tomography Detectors (Perkin Elmer XRD 1621 AN22 ES)

- Perkin Elmer XRD 1621 (\$100K-\$130K)
  - 200 micron pixels
  - ~2.5 lp/mm
  - Gigabit network interface
  - ~410x~410 mm area
  - 2048x2048 total pixels
  - 2000x2000 active pixels
  - 16-bit
  - CsI phosphor
  - $\leq 15$  MeV
  - 15 fps @1x1, 30 fps @2x2



# Computed Tomography Detectors (Perkin Elmer XRD 1621 AN22 ES)

- Perkin Elmer XRD 1621
  - Plan to use NSI acquisition software
  - Investigate alternate acquisition software
    - SDK?
  - New fixturing required
  - Plan to use with
    - 450 kVp
    - 6 MVp
  - Have three panels





# Computed Tomography Acquisition Software

- North Star Imaging (NSI) (~\$50K)
  - Supports multiple detectors
    - Varian 2520V
    - Dexela 2923
    - Perkin Elmer XRD 1621 (not tried yet)
  - Acquires entire detector image (no cropping)
  - Bad pixel selection/display easy/convenient
  - Multi-level image correction
    - User acquires as many correction images as desired
  - Acquires scan geometry calibration dataset
    - Requires NSI phatoms
    - Required before NSI reconstruction software can be used
  - Data saved in TIFF files (32-bit float)
    - Data stored raw (uncorrected)
    - Separate project file (XML format?)
    - RTF scan report files
    - Specific Directory structure used to store data
  - Dataset cropping/conversion provided by addition software



## Computed Tomography Reconstruction Software

- North Star Imaging (NSI) (~\$90K-\$180K)
  - Guided multi-step process
  - Requires additional separate files
    - Correction files
    - Calibration files
  - Geometry calibration is very accurate ( $< 1$  mm)
  - Supports multiple NVIDIA Tesla cards (~2000 cores)
  - Multipoint correction (5-10) seems to be considerably better than previous two point corrections
  - Centering done via system Calibration with manual fine-tuning
  - Visualization integrated with reconstruction
    - Volume cropping done from low resolution 3D object
  - Advanced Menus
    - Beam hardening correction
    - Ring removal correction



## Computed Tomography Visualization Software

- North Star Imaging (NSI)
  - Realtime 3D rotation/translation
  - Export orthogonal datasets (TIFF/AVI)
  - Export Volume Graphics compatible datasets
  - Clipping data manipulation done in interactive 3D environment
  - 3D movie creation is basically a screen recorder
    - Don't have ability to create movie scripts
  - Fine detail in the reconstructions doesn't look as good as it could be
  - Still learning the software



# Computed Tomography Reconstruction Software

- Volume Graphics
  - CT Reconstruction is an add-on option (~\$2500)
  - Can import data from several CT systems
    - HYTEC/IMTEC
    - PHOENIX
    - Dage
    - YXLON
    - Daimler Chrysler
    - Custom if CT geometry and file structure is known (ie NSI)
  - Clipping data manipulation done in interactive 2D orthogonal images
  - Reconstructions can be done using CPU's or GPU's
    - Appears to be OpenCL –based (supports ATI and NVIDIA)
  - Only supports a single GPU card
  - Reconstructed data saved in a proprietary format
    - Can export data to TIFFs and other file formats
  - Some beam hardening correction
  - No ring removal
  - Automated Centering with manual adjustments (occasionally can be labor intensive)



## Computed Tomography Visualization Software

- Volume Graphics
  - Cost ~\$10K to \$50K (depending on base package and options)
  - Can create scripted 3D movies and fly-throughs
  - Can import image stacks from several formats
    - TIFF
    - HYTEC/IMTEC
    - Etc.
  - Additional options
    - Wall Thickness
    - Defect/Porosity Analysis
    - Coordinate Measurement
    - Actual/Nominal Comparison
    - CT Reconstruction
  - Still learning the software (a lot of features to learn)



# Computed Tomography Reconstruction Software

- Recon (LANL & SNL)
  - Supports multiple platforms (Windows & Linux)
  - Supports multiple computing structures
    - Single CPU
    - Multiple CPU same box (OMP)
    - Multiple CPU same or networked boxes (MPI)
    - Hybrid (OMP & MPI)
  - Currently under development
    - Porting to GPU Windows-based (initial results show >20x performance)
  - Text input file driven
  - Supports HYTEC and LLNL input/output file formats
  - RAW and TIFF input files being implemented
  - Supports many reconstruction algorithms
  - GUI planned
  - No visualization capabilities



## Future Computed Tomography Efforts

- Submicron CT (nano CT) with moderate field of view (1 cubic cm)
- Volume Graphics Training (coordinated with other sites?)
- Integrate Perkin Elmer XRD 1621 detectors into existing CT systems
- Characterize new flat panel detectors
- Explore Multi-energy CT
- Explore other options for CT acquisition software
- Implement vibration isolation and higher precision stages on selected CT systems
- Continue Recon development
  - GPU implementation
  - Explore iterative algorithms



# SNL Computed Tomography Contribution Acknowledgements

- Burke Kernen
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- David Moore
- Peter Smith (LANL)
- James Hunter (LANL)