



Handheld Active Millimeter Wave Camera

In-Space Non-Destructive Technology Workshop

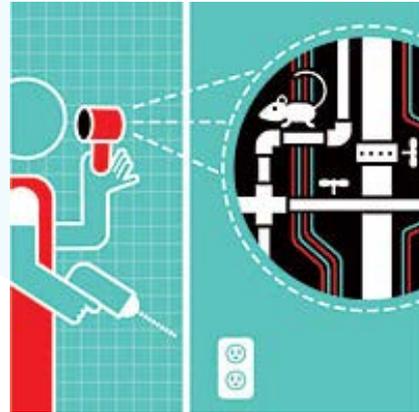
February 29, 2012

Overview

- Discuss current 24 GHz through-wall imager
 - Antenna design
 - Active illumination
 - Image scanning example
 - Pictures: Through wall imagery
 - Resolution/Standoff optimization
- Roadmap- 60 GHz MMW imager
 - Improved resolution and standoff

Handheld MMW Imaging

- 24 GHz imager 'Looks' into walls
 - 'Looks Through'- Drywall, plaster, fabrics, wood, tile, others
 - Detects- Plastic, metal, wood, water, dielectrics, others
- Detect- listening devices, explosives, contraband etc.
- 24 GHz FMCW within ISM Band (no licensing)
- Active illumination
- Battery powered
- Low cost



Multiple Security Applications



- **Current device**

- Through Wall Imager
- Search and Clear
- 24 GHz FMCW radar
- Image through walls with position tracking omni-wheels

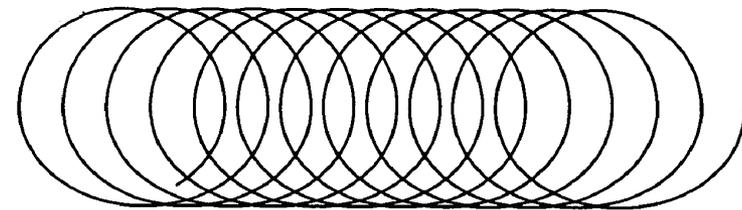
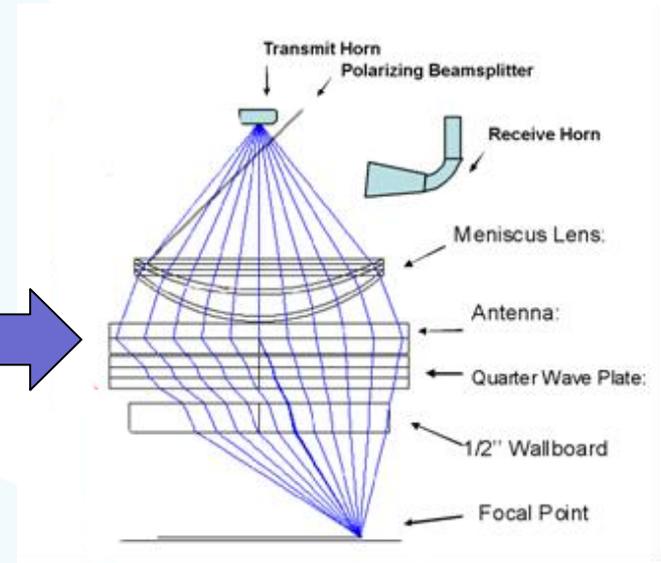
- **Next generation device**

- Package and Personnel
- Anomaly Resolution
- 60 GHz radar
- Non-contact target tracking

Scanning, Focusing, Illumination and Polarization Control using molded plastic antenna components



Off Axis FZP Antenna
Focusing/ Scanning



Scan pattern

Quasi-Optic Antenna Design

Ring-Field Scanner



Full Assy.



OAFZP



Camera

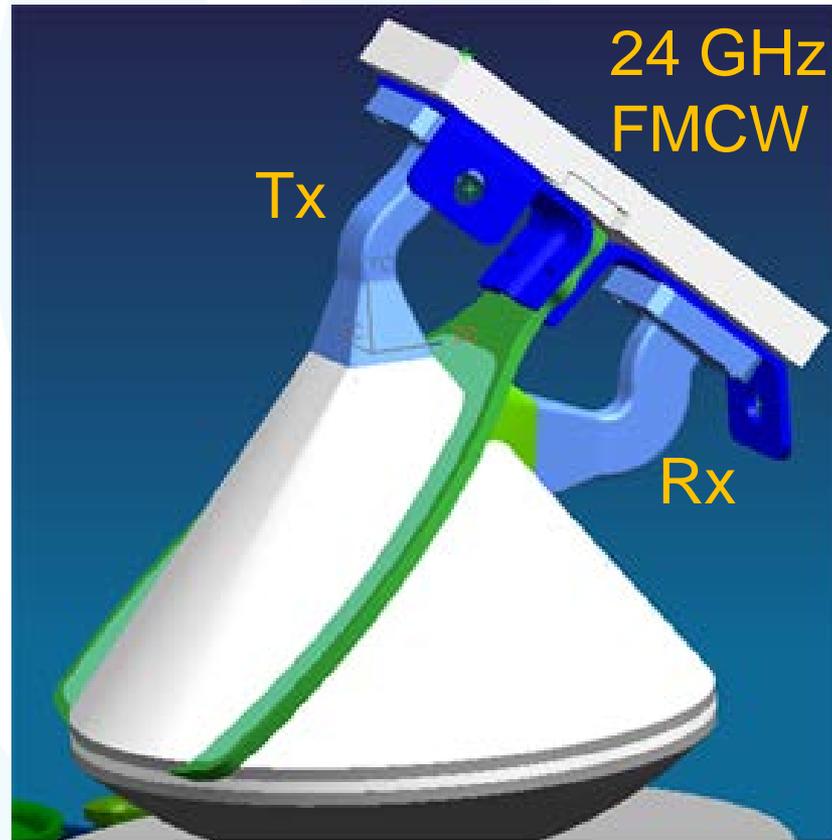


QWP



Range Test

Confocal Tx and Rx Beams



Confocal Illumination- Standoff and Resolution Benefit

Internal Structure

- Omni-Wheels for Wall Tracking
- Antenna Spin Drive
- 24 GHz FMCW
- Wire Grid Polarizing Beamsplitter

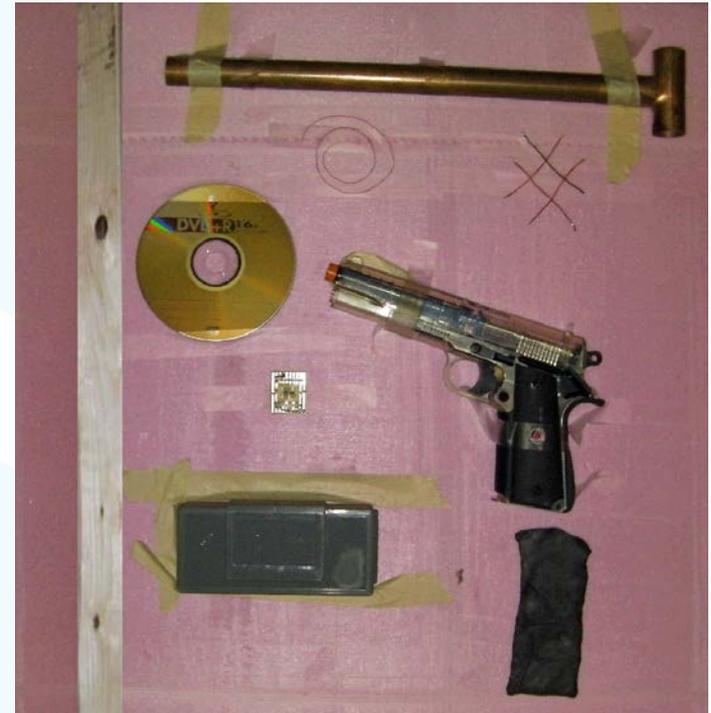


Stitching Scanner- Image Acquisition

(targets behind 1/2" drywall)

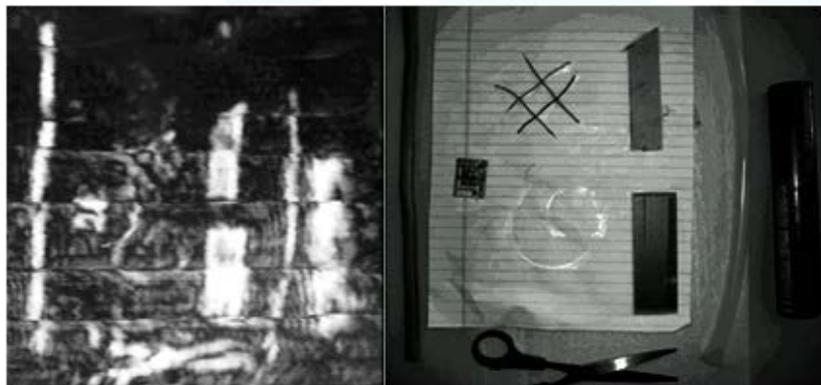


Video of MMW Image Acquisition

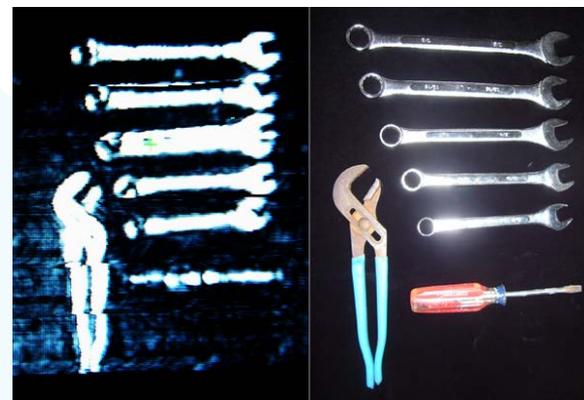


Target Scene

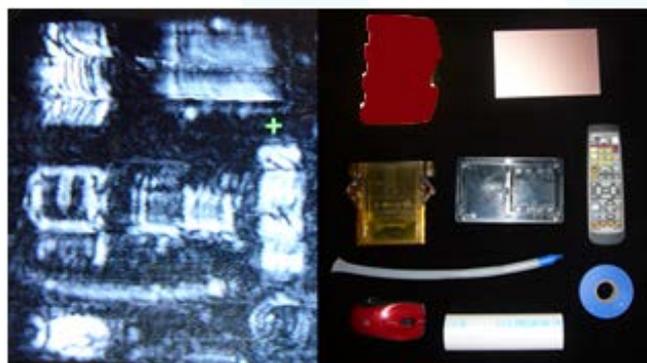
MMW Images- Objects Behind 1/2" Wallboard



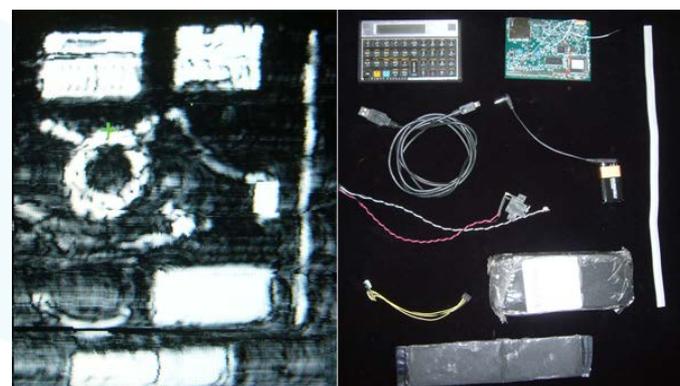
Wood, Wire, Plastic, Metal



Metal Tools

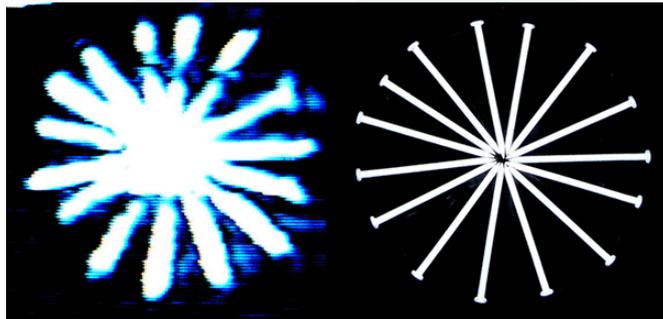


Plastic and Metal

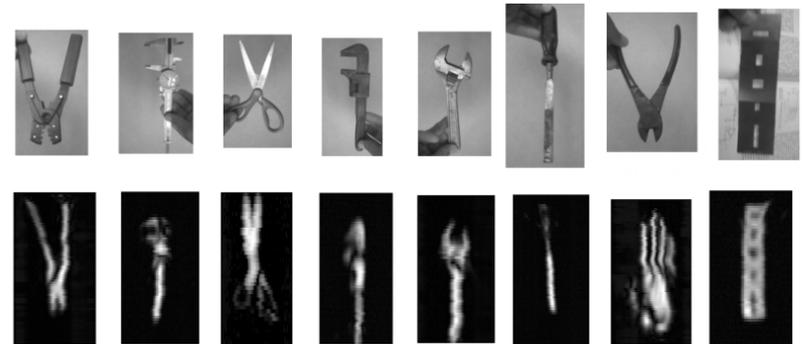


Electronics, Wire, C4 Simulant

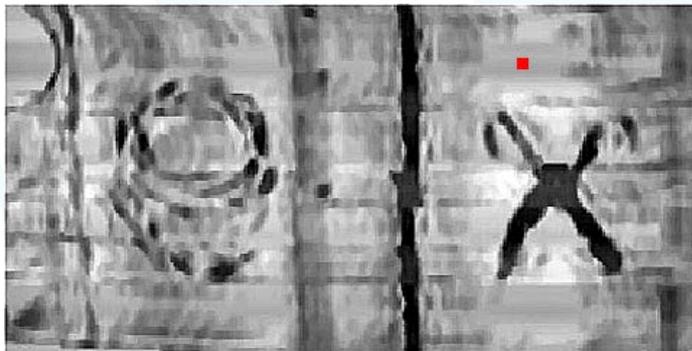
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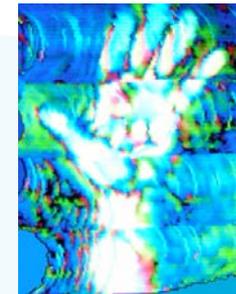
Star Test



Metal, Plastic, Water



Plastic pipe, Wire, Stud, Metal Pipe, Tool



False Color

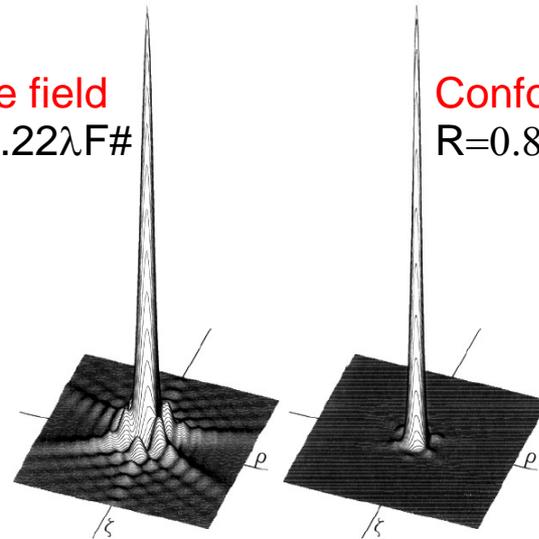
Confocal Illumination ~40% Resolution Benefit

- Diffraction dominates at MMW
- Target illumination matters
- Tapered antenna fill also effective

MMW Point Spread Function

Wide field
 $R=1.22\lambda F\#$

Confocal
 $R=0.81\lambda F\#$



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Rep. Prog. Phys. 59 (1996) 427-471.

Next Step- 60 GHz Imager

- Resolution and Standoff Increase

24 GHz to ≥ 60 GHz

Standoff Design $\sim 10''$

Wide scan field $\sim 12''$

- Non-Contact Tracking

- Result

$\sim 10X$ more image information

Increased cost (but still low cost)

- Augment existing methods





Plastic Gun on Skin

Visible and 24GHz MMW Image



Under velvet fabric



Under corduroy fabric

Conclusion

- A new MMW imaging architecture
 - Low cost
 - Ease of use
- Extensible to higher MMW frequencies
 - 60 GHz RF chipsets maturing for commercial purposes
 - Improved resolution and standoff
- All things being equal:
 - Image information content $\sim (\text{Frequency})^2$
 - Increased standoff allows wider field
 - Easy to increase current performance $\sim 10X$
- A new platform to augment inspection tasks



Thank You