# Coded Aperture X-Ray Fluorescence for Cargo Inspection

David Castañón, Clem Karl and Zach Sun

Boston University

Department of Electrical and Computer Engineering

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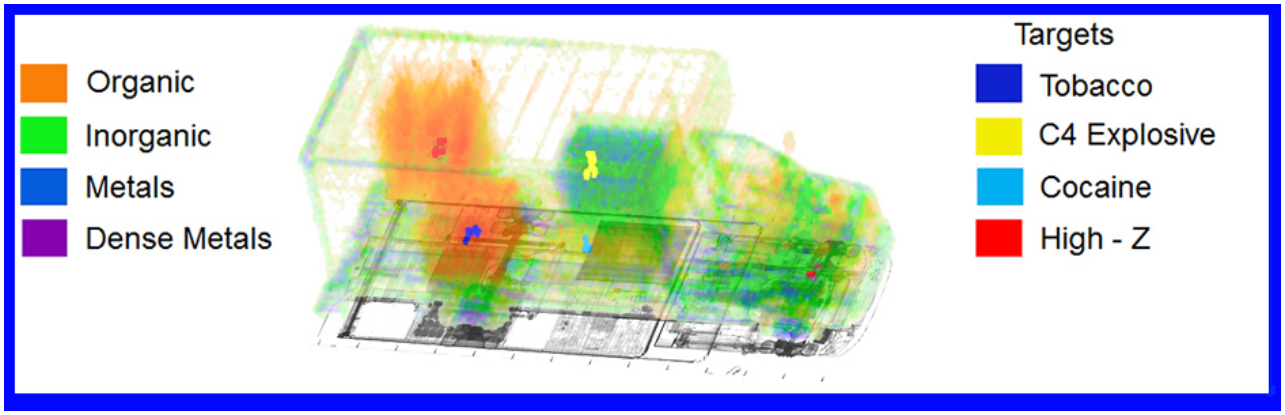
AWARENESS AND LOCALIZATION OF EXPLOSIVES-RELATED THREATS
DETECTION
MITIGATION
RESPONSE
ALERT

# Conclusions

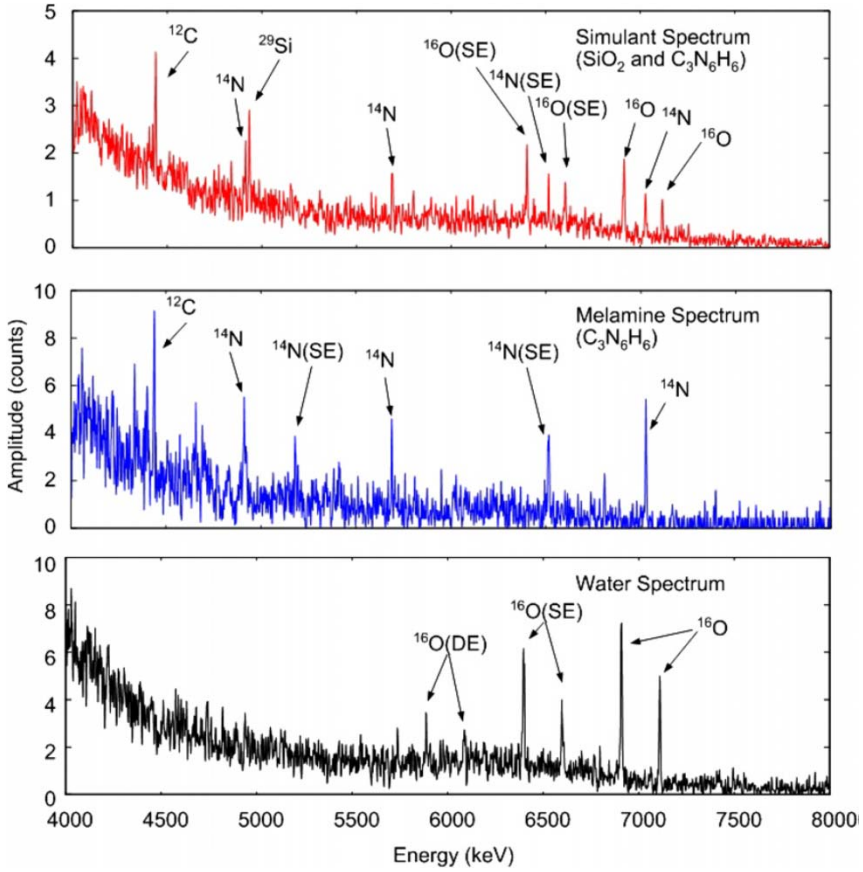
- Nuclear Resonance Fluorescence provides information on material properties
- Obtaining localization through collimated sensing reduces counts and makes acquisition time slow, limiting use to selective areas
- Using a coded aperture can increase SNR and lower acquisition time, but …
- Much more to analyze – secondary radiation, multispectral excitation, inverse problems, classification, system concepts & cost, …

http://www.passportsystems.com/



# Nuclear Resonance Fluorescence

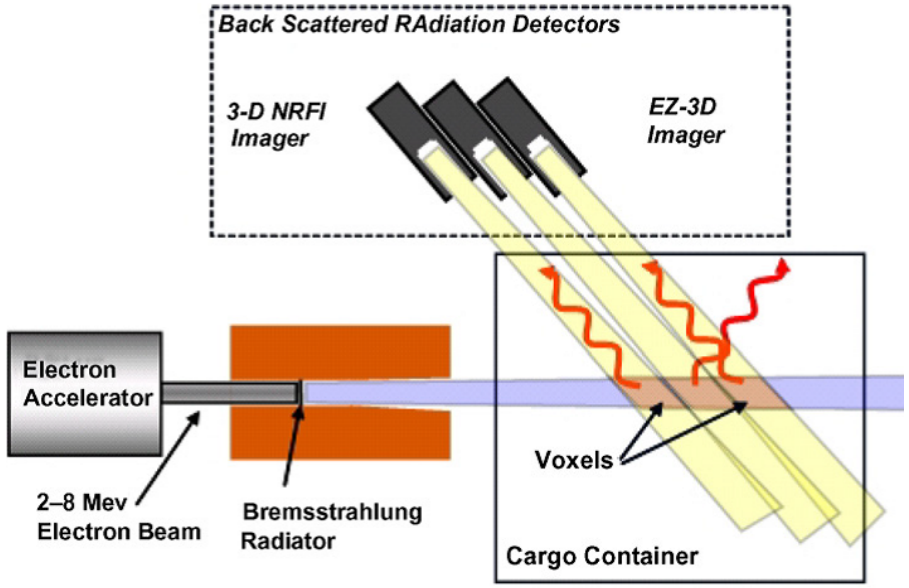
- Nucleus absorbs and reemits high-energy photons (> 1MeV)
- Reemission profile vs energy is characteristic of material
- Can obtain information on elemental composition




Bertozzi, et al, 2007

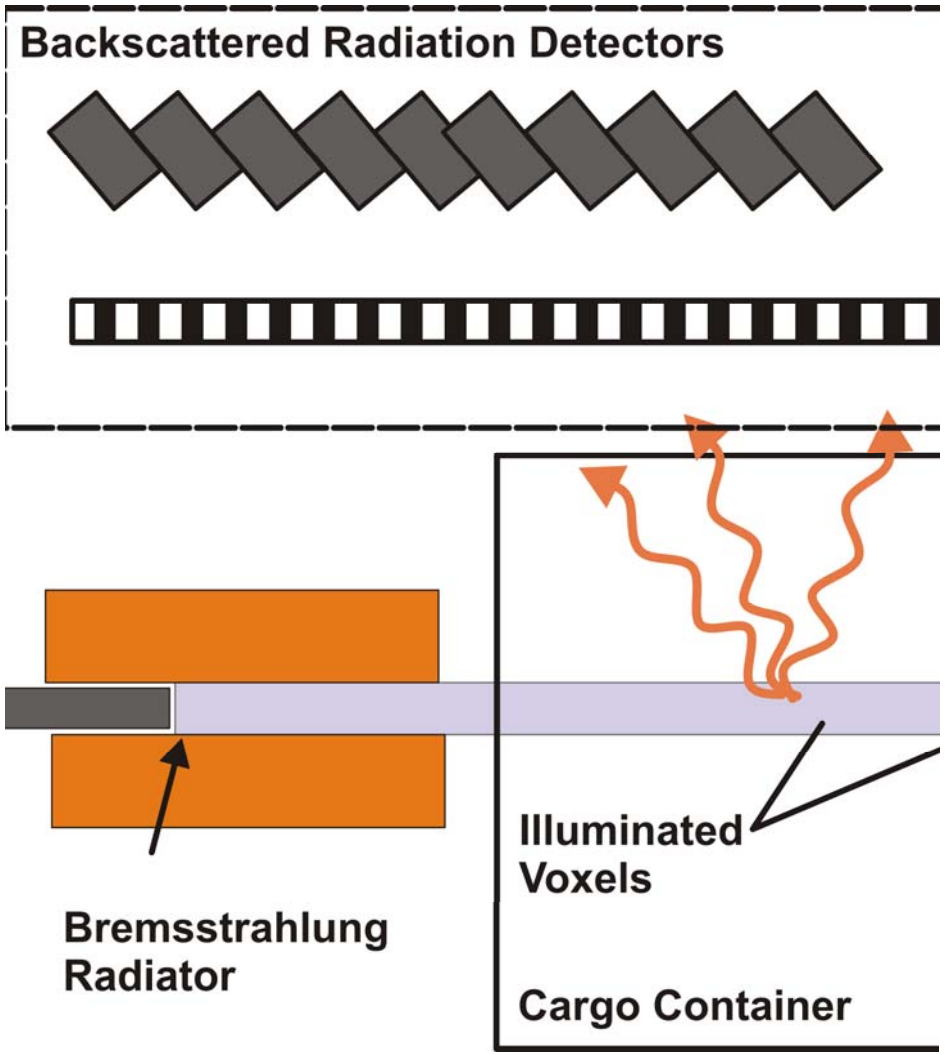
# Imaging with NRF (Passport Systems)

- Use pencil beam scanning coupled with collimation to localize emission
- NRF Imager inspects localized areas of interest
- Collimation reduces signal preventing NRF from being used on a larger scale

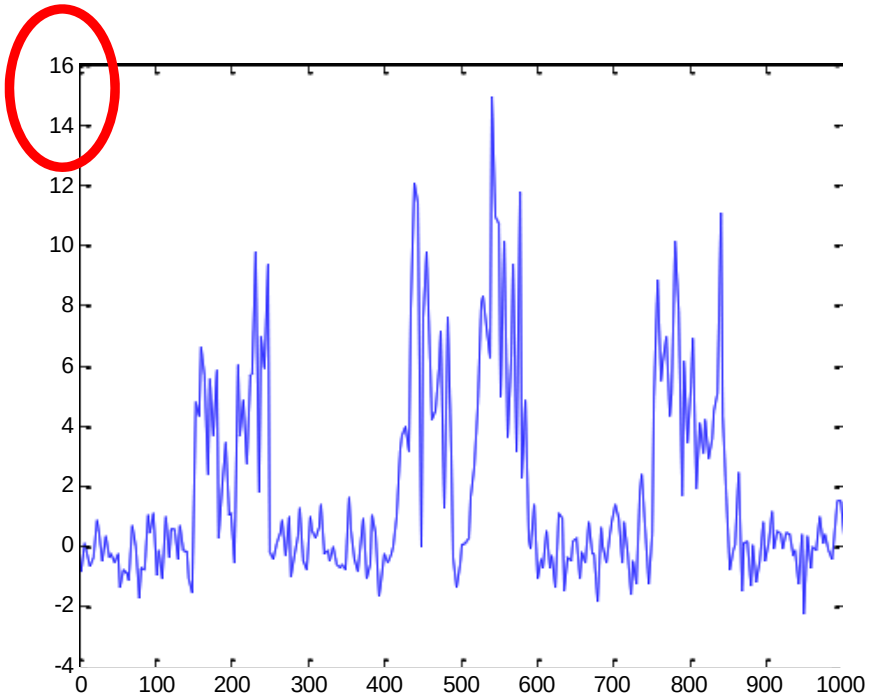


# Concept: Use Coded Aperture vs Collimation

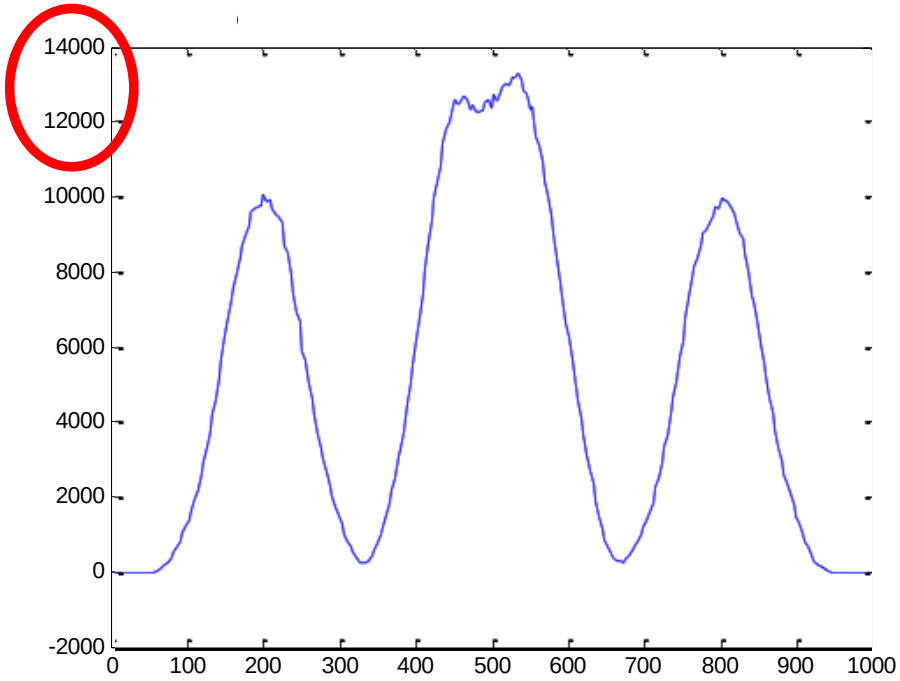
- Coded mask can increase effective aperture size, photon efficiency
- Improve measured SNR to reduce acquisition time



# Higher SNR of Coded Aperture System




Measured Collimated Signal Profile




Measured Coded Signal Profile

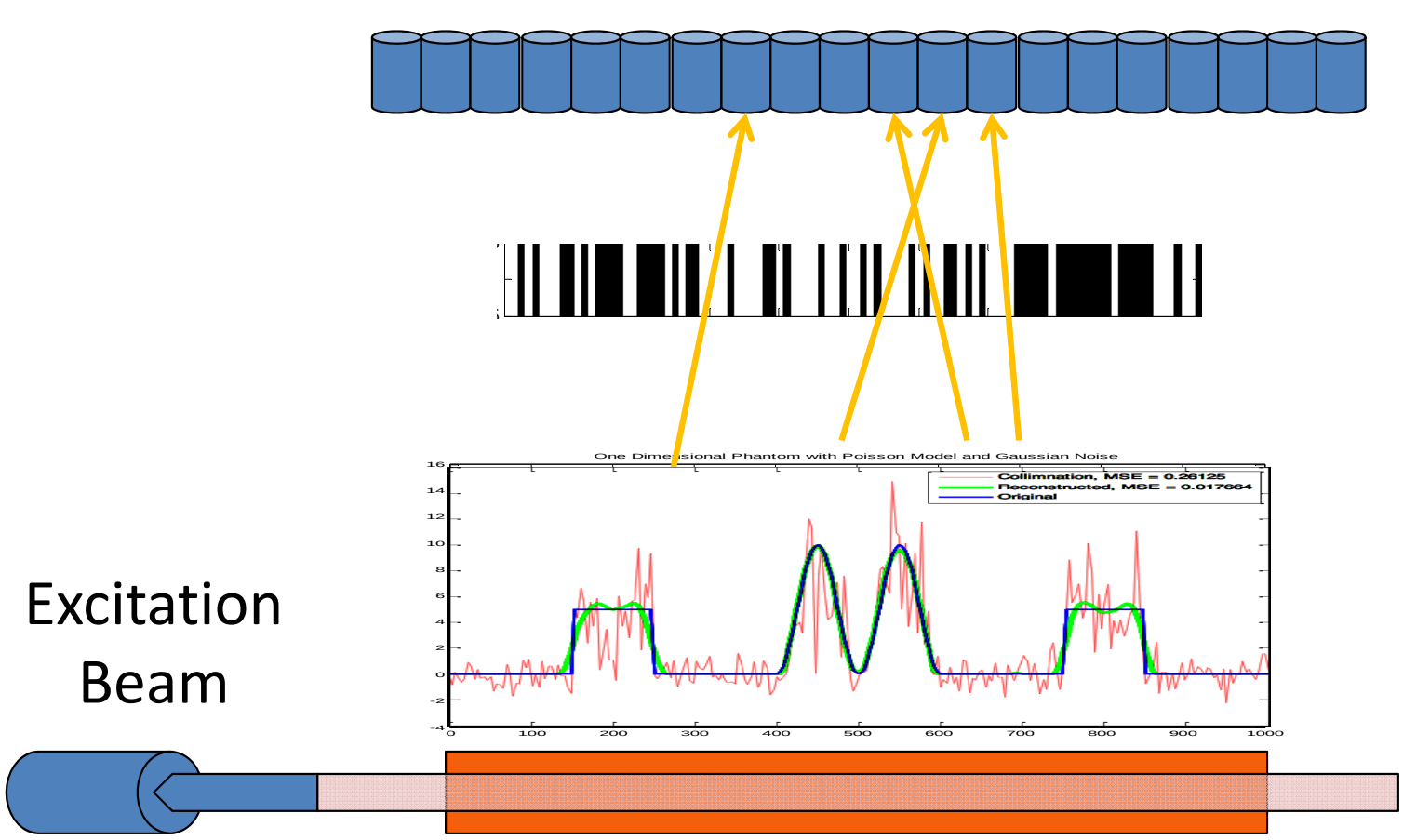
- Single energy, 1-D profile – Improved SNR by 1 order of magnitude

# Signal Inversion Approach

$$\|y - Cx\|^2 + \alpha \|Dx\|^2$$


- Assume:
  - Emission independent at each energy
  - No photon interaction between emission and detection
  - Coding mask effect is linear, identical for each energy
  - Independent linear inversion problem at each energy

# 1-D Simulation Geometry



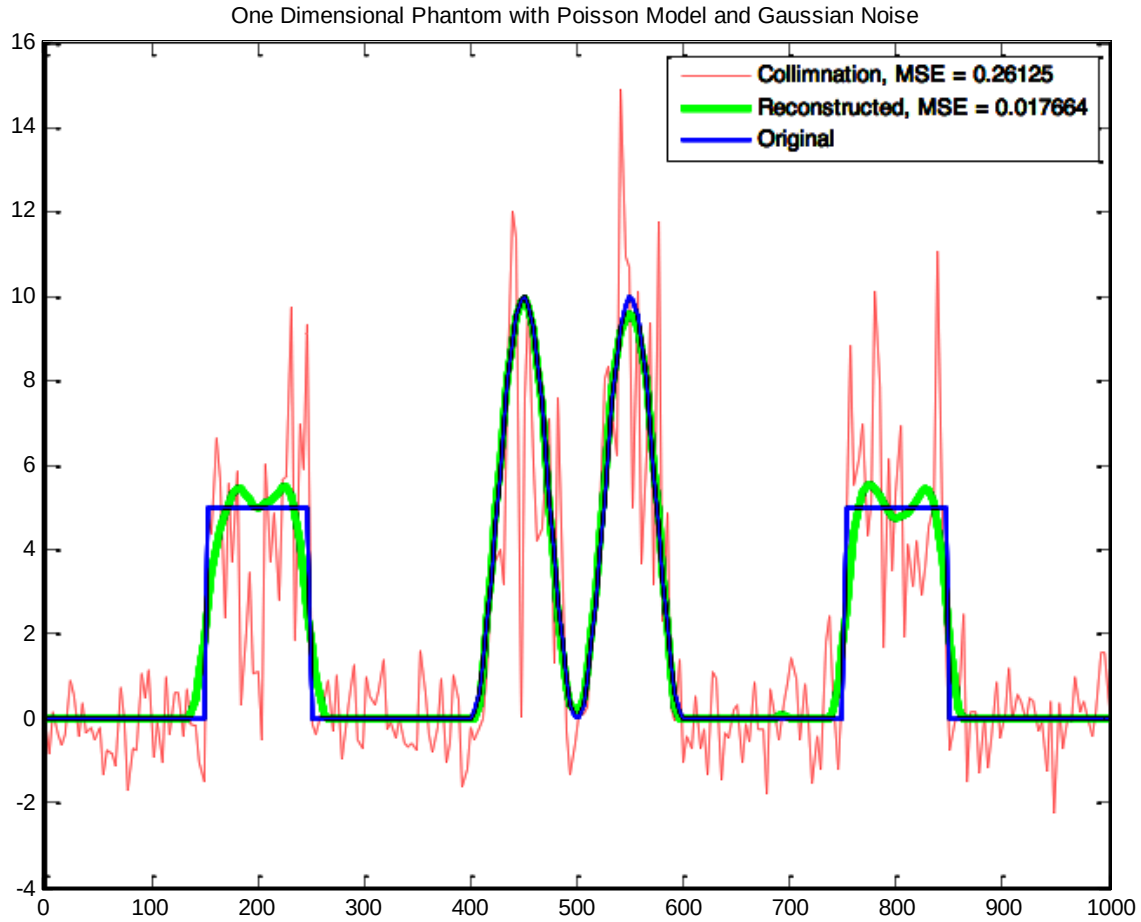

Detector Array

Random Mask

Material Emission Profile

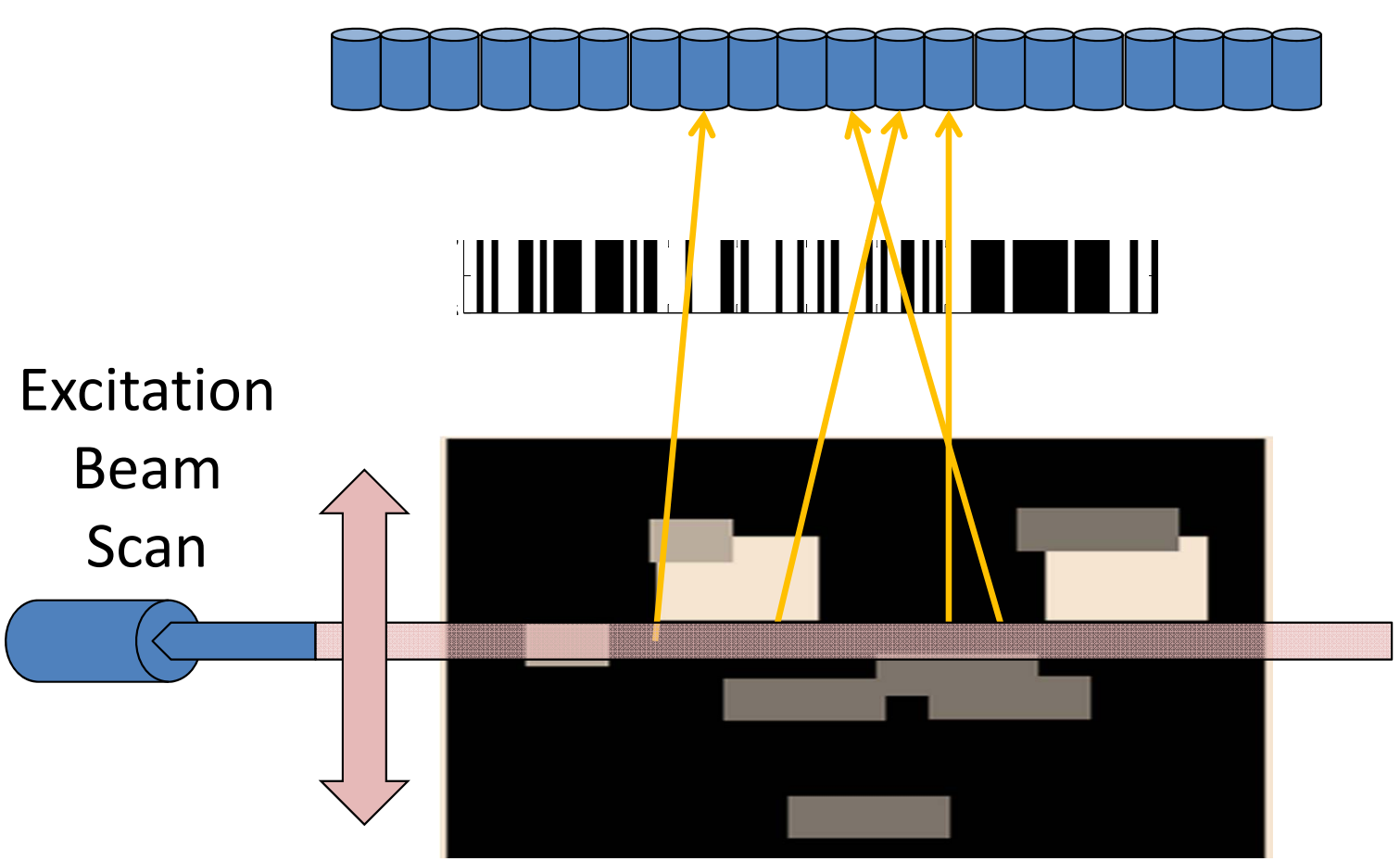
Excitation Beam

# 1-D Simulation Recovered Profiles

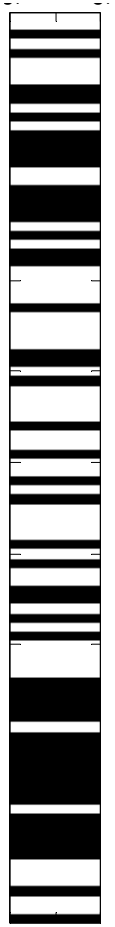


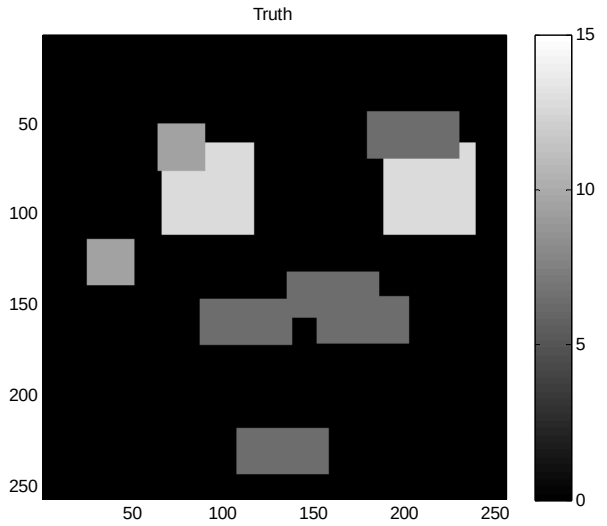

Data: 1000 units wide
Mask: 100 units
Sensor array: 1000 units, 3.9 unit res.
Distance Mask to Data: 300 units
Distance Sensor to Mask: 300 units

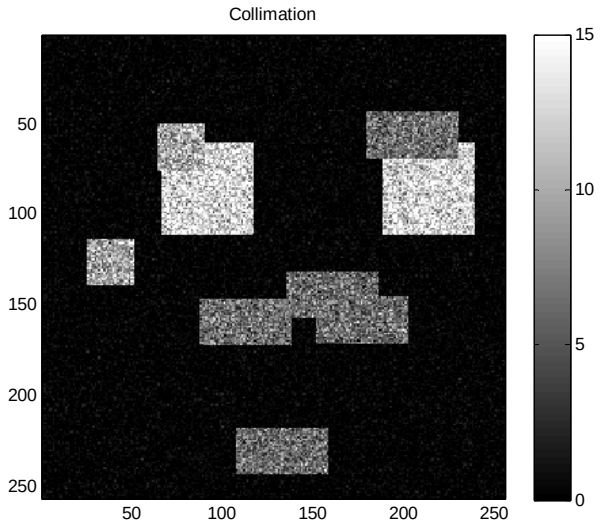
# 2-D Simulation Geometry

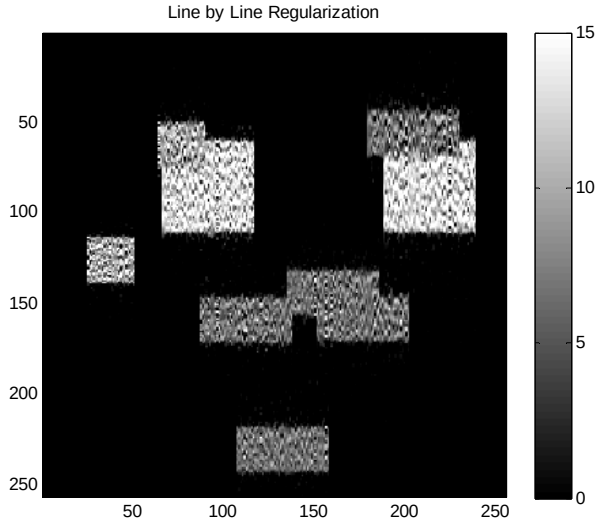


# Two-Dimensional Reconstructions





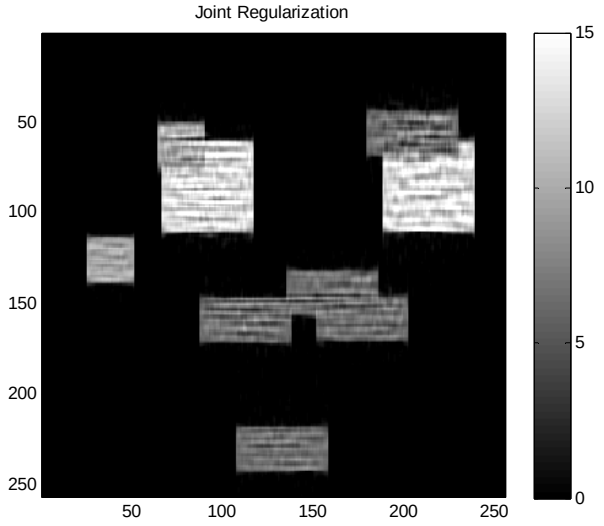
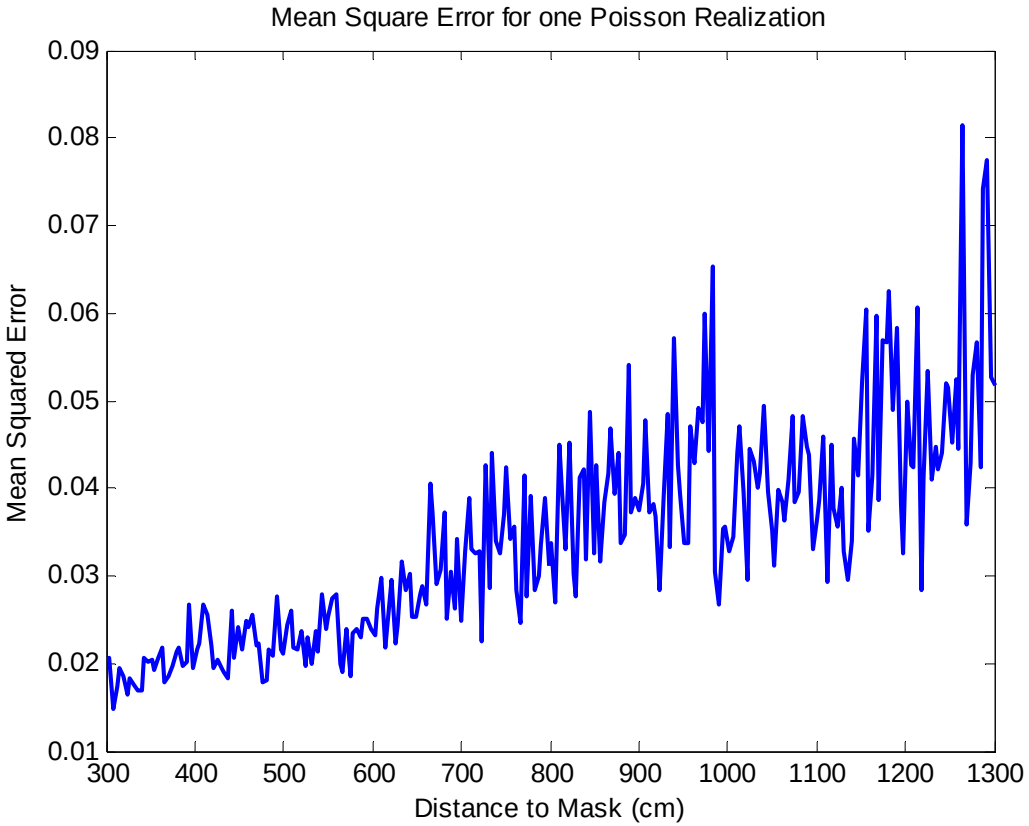




Image: 1000 x 1000
Sensor: 1000
Mask: 100
Mask to Image: 300
Sensor to Mask: 300

# Two Dimensional Simulation



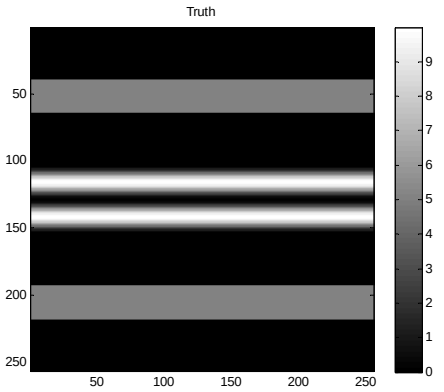
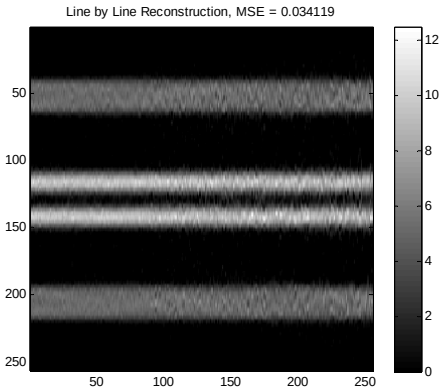
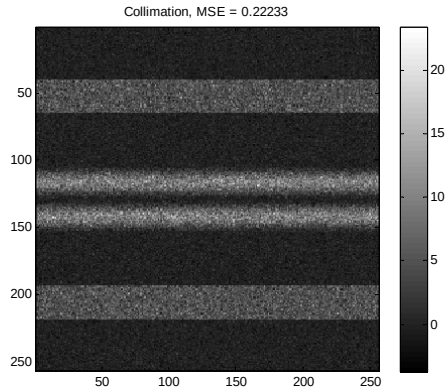




Image: 1000cm x 1000cm (256 x 256)
Sensor: 1000cm (256 px)
Mask: 100cm
Distance Mask to Left of Image: 300cm
Distance Sensor to Mask: 300cm



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