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Nanostructured Scintillators 'Nanoguide' as Image Plates for Improved Fast Neutron Radiography

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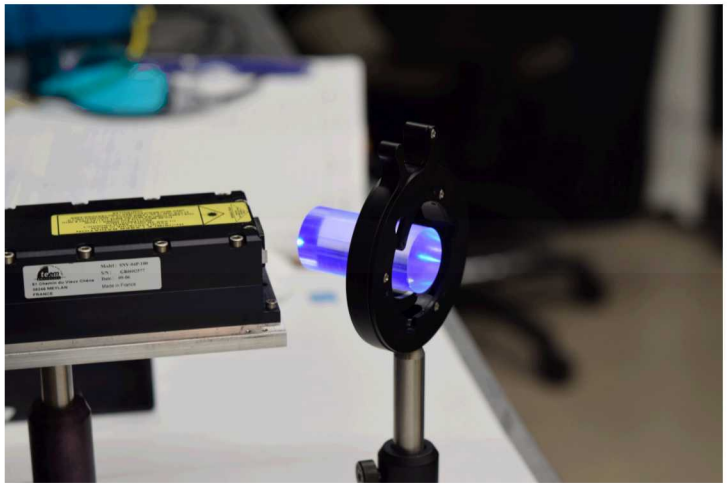
Introduction

- Need: Scintillation detector that provides spatial/temporal resolution of neutron events
  - Application 1: Fast neutron transmission imaging
  - Application 2: Source localization via fast neutron double-scatter reconstruction

- Capability Gap: Bulk scintillator
  - Limitations: Light spreading leads to poor spatial and temporal resolution



Light spreading effects in bulk plastic scintillator

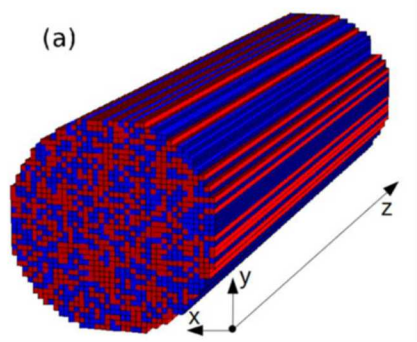
- Capability Gap: Optical fiber bundle
  - Limitations: Optical crosstalk, low TIR efficiency for scintillation emission, large fraction of scintillation-inactive material (cladding), micron-scale pixellation

Introduction (cont.)

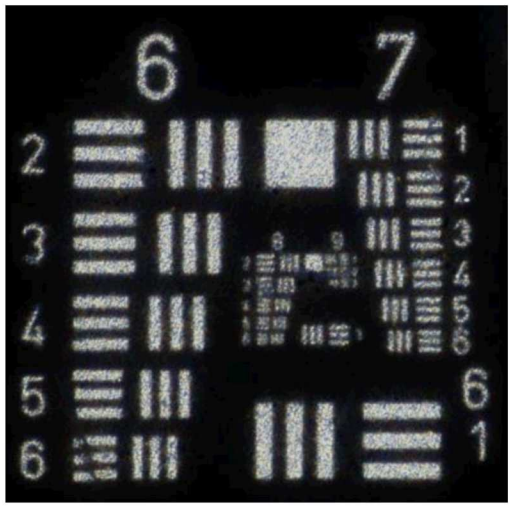
- Proposed Solution: Nanostructured scintillator ('Nanoguide') based on Transverse Anderson Localization phenomenon
  - Envisioned Advantages:
    1) Optical photon confinement at any angle
    2) Higher light yield
    3) Sub-micron spatial resolution

  - Technical Challenges:
    1) Does improved optical image resolution translate to scintillation/ radiography?
    2) Scintillation light yield and timing characteristics

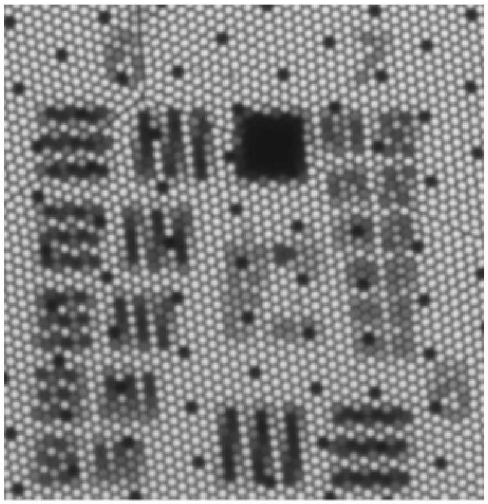
'Nanoguide' Structure
(nanoscale domain sizes)



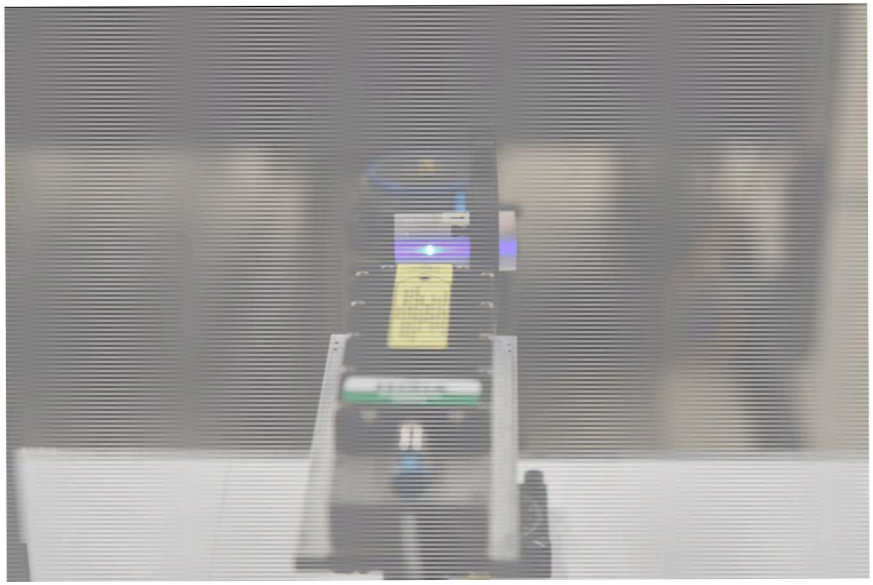
'Nanoguide' Image Plate

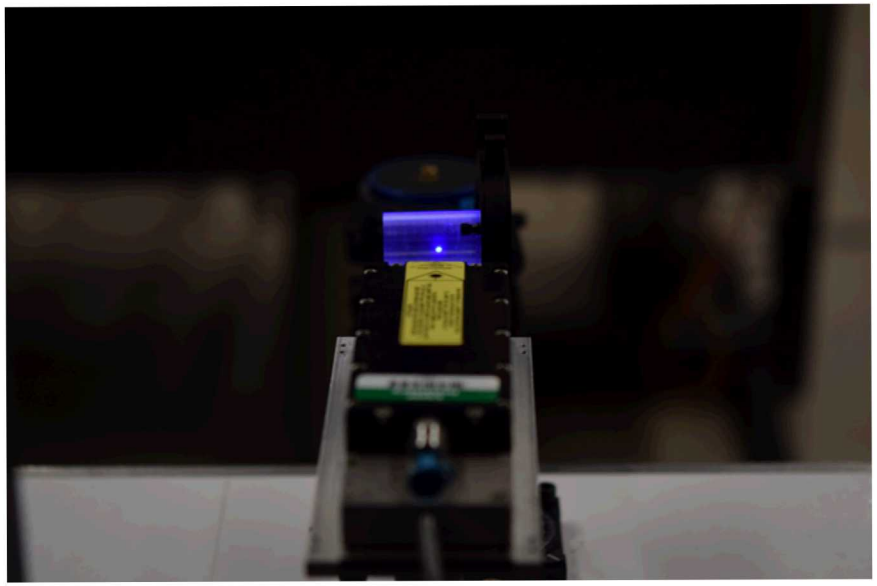


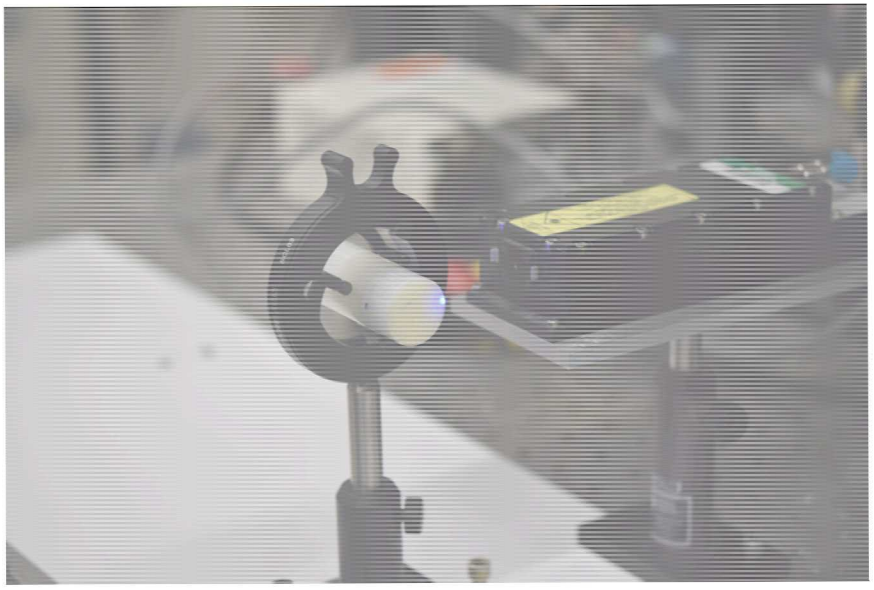
Fiber-Based Image Plate

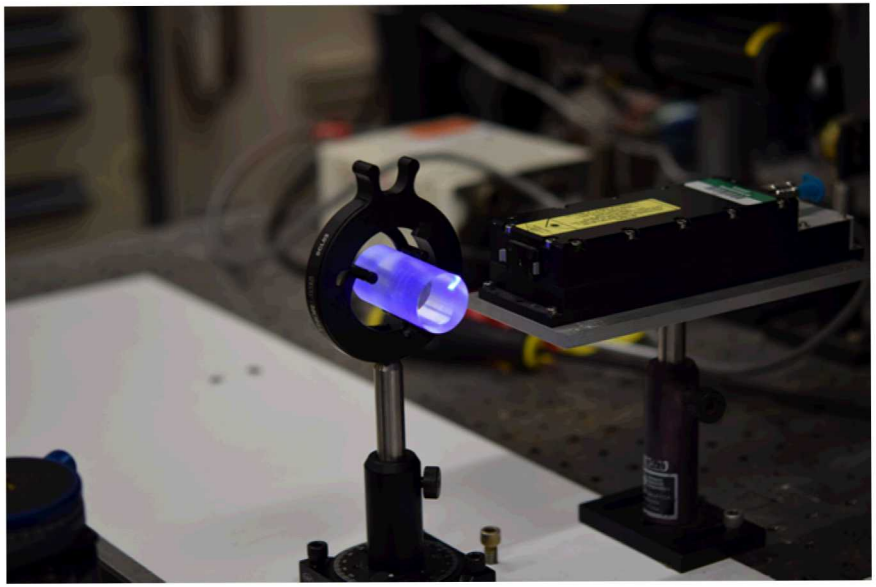


Fluorescence Light Guiding

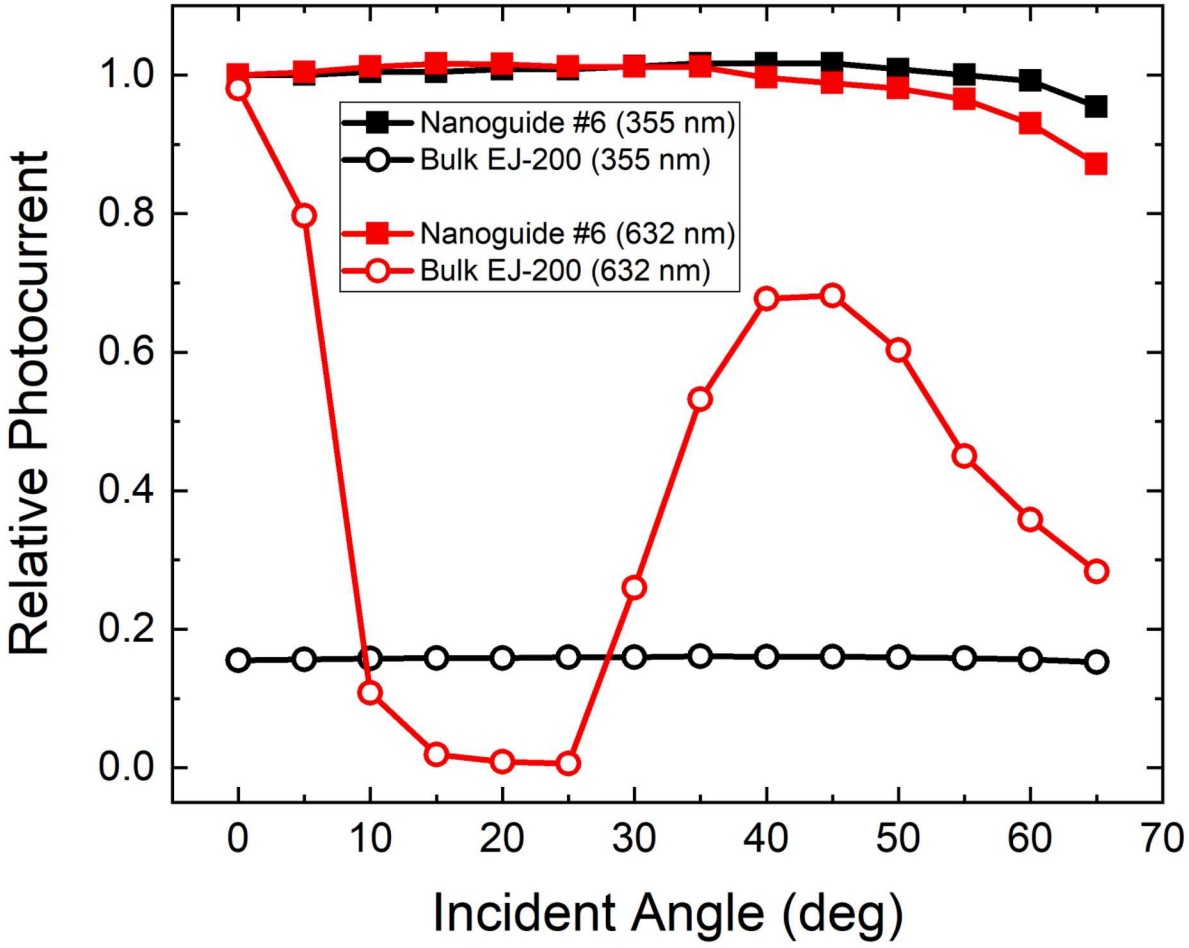






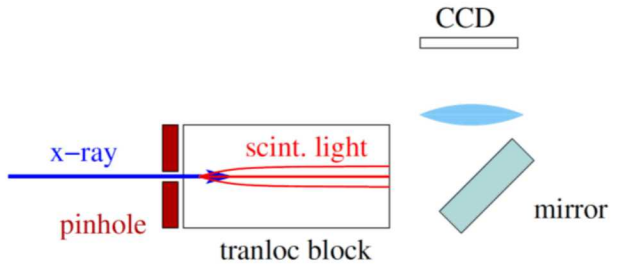


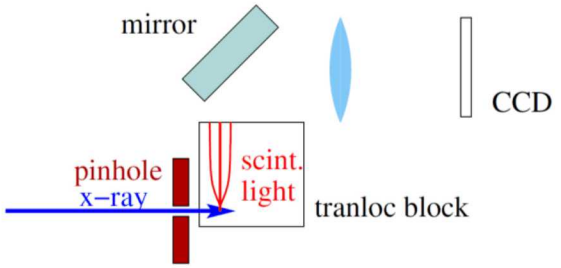
Light Guiding Comparison

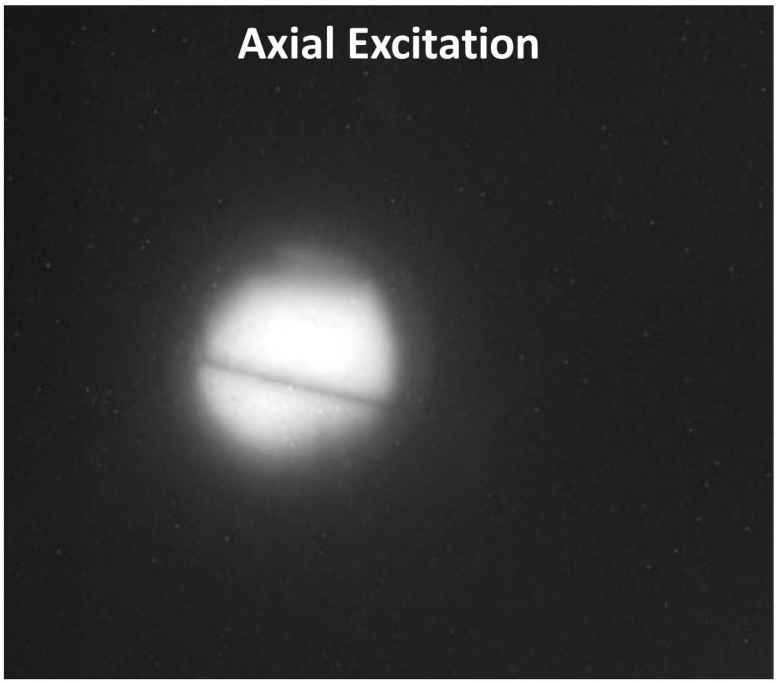


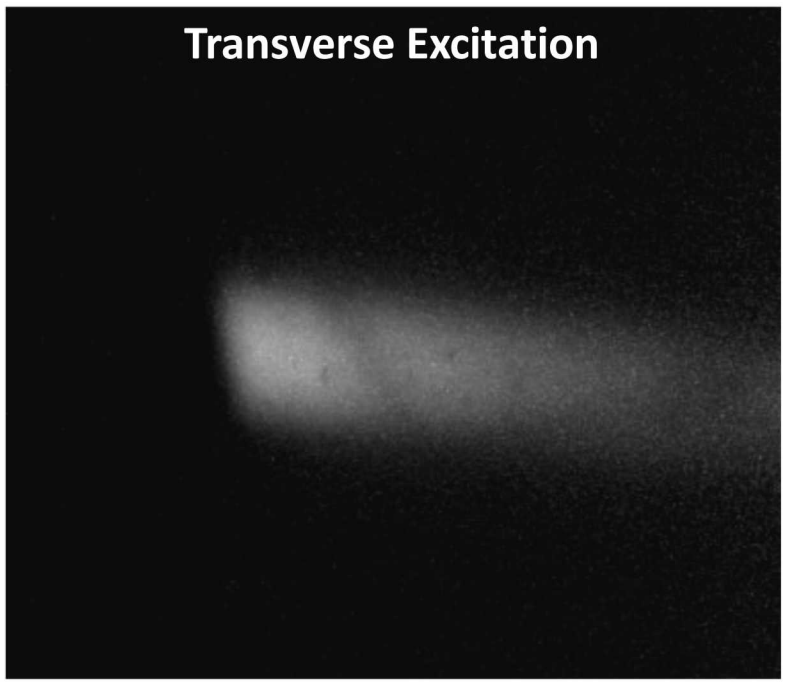
- Nanoguide scintillator shows nearly invariant angular dependence at both wavelengths
- Bulk scintillator exhibits strong angular dependence at 632nm due to TIR
- Bulk scintillator shows flat angular response at 355nm, but ~6x intensity reduction due to light spreading losses

X-ray Characterization









- Initial Nanoguide X-ray imaging results are similar behavior to optical/fluorescence results:
  - Elongated spot in transverse orientation due to penetrating nature of X-rays
  - Otherwise, imaged spot diameter is consistent with X-ray pinhole size

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