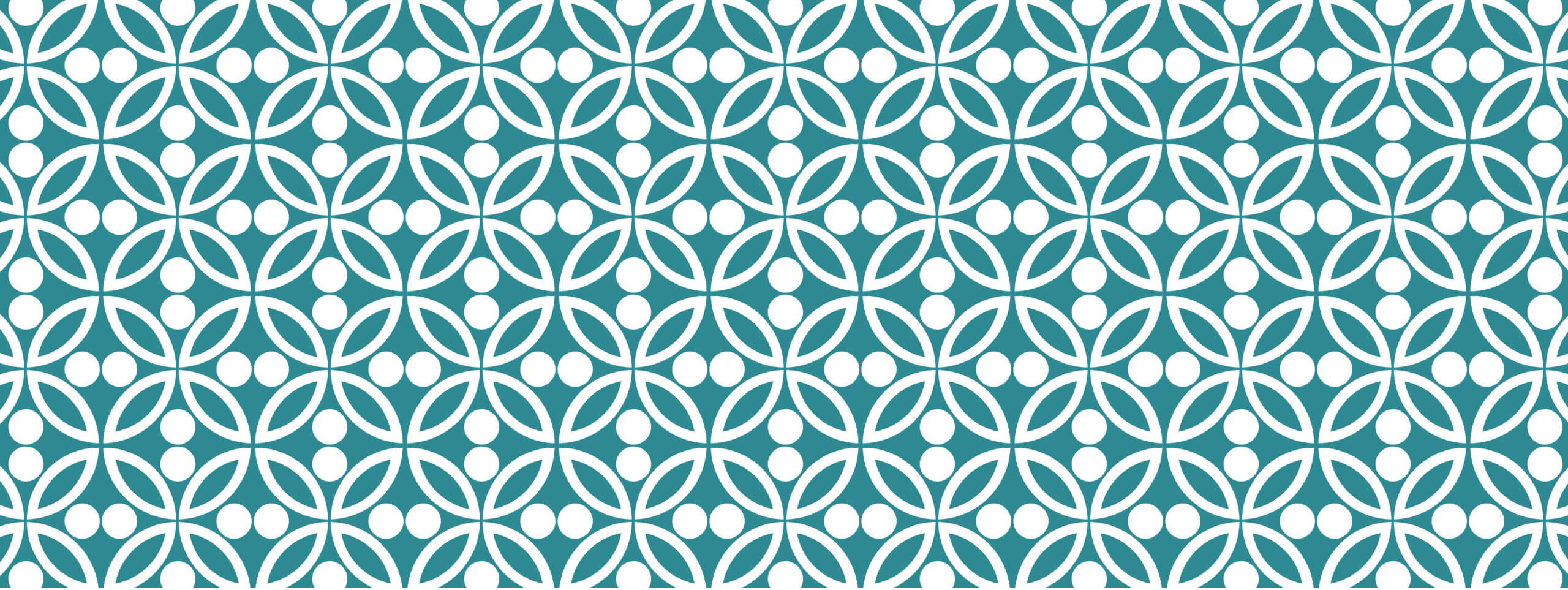


# INVERSE SCATTERED PROBLEMS

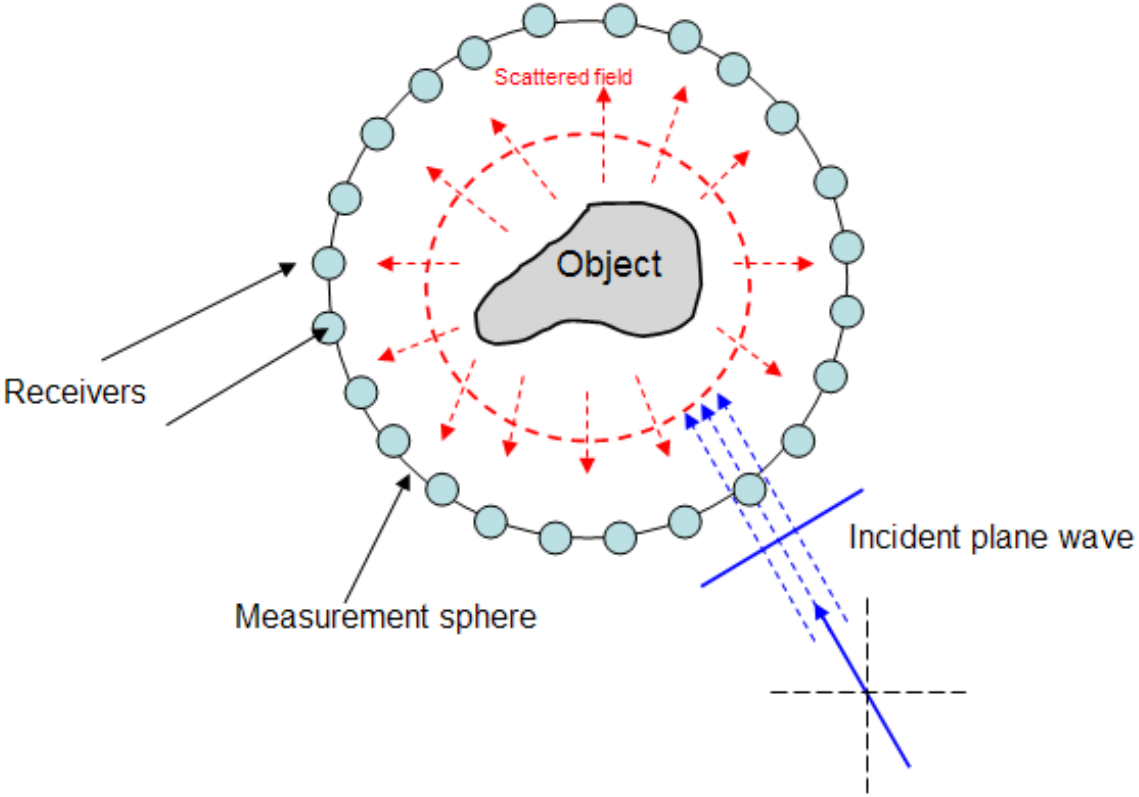
BY: MIKAELA COOSE

# PORTFOLIO

- **Home:** Twin Lakes, WI
- **Education:** Olivet Nazarene University
- **Major:** Engineering—Electrical Concentration
- **Minor:** Mathematics
- Varsity Tennis Team
- SWE—President 2017-2018

- **Internships:**
  - Intermatic Inc. Summer 2016
  - Northrop Grumman Corp. Summer 2017
- **Barry Goldwater Scholarship:**
  - 2017 Honorable Mention
- **Future Plans:**
  - Graduate School
  - Electromagnetics or Digital Electronics

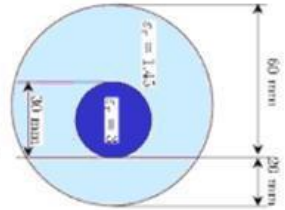
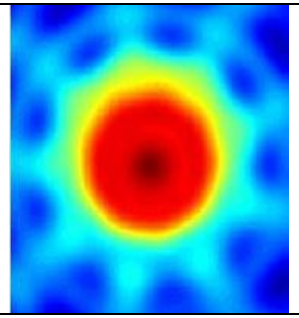
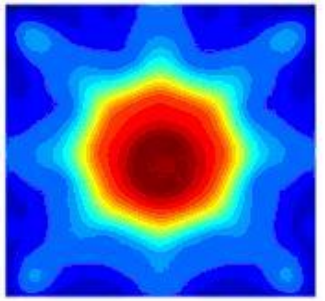
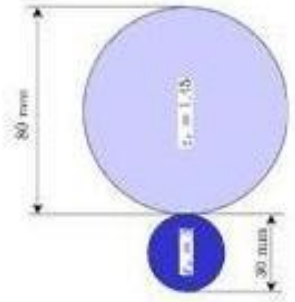
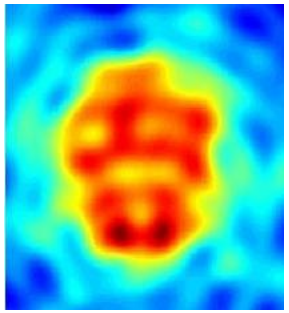
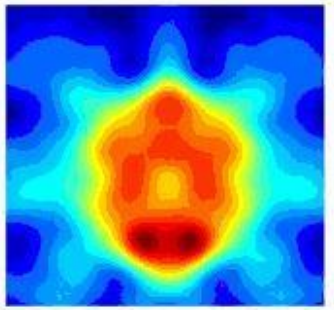
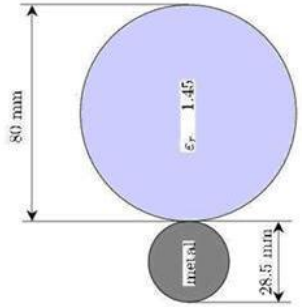
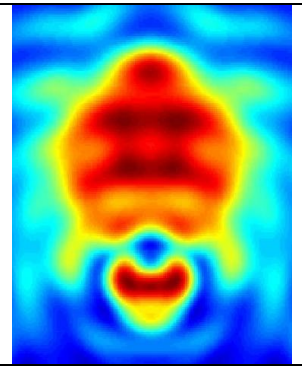
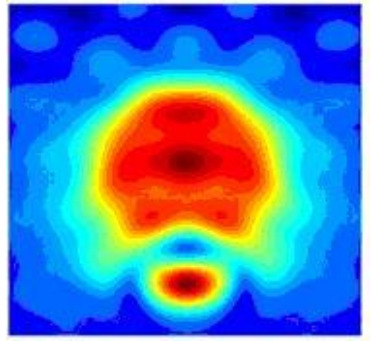
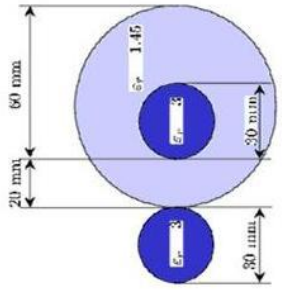
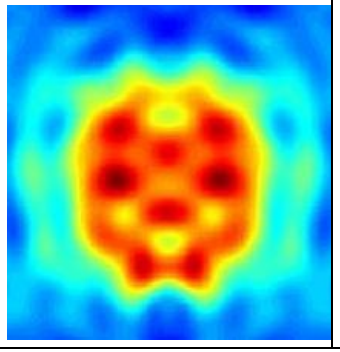
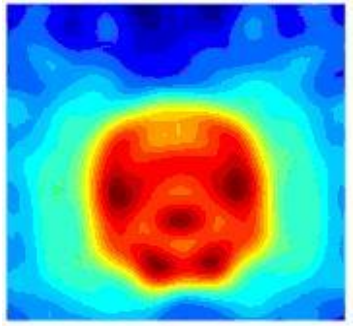
# DIFFRACTION TOMOGRAPHY



# METHOD VALIDATION

**ADVANTAGES:**

- ❑User-friendly
- ❑Cost effective
- ❑Time efficient
- ❑Unlimited parameters

| | Institut Fresnel Target Setup | Born Image from Simulated Data | Born Image from Institut Fresnel Measured Data |
|---|---|---|---|
| FoamDielInt |  |  |  |
| FoamDielExt |  |  |  |
| FoamMetExt |  |  |  |
| FoamTwinDiel |  |  |  |

# RESEARCH EXPERIMENTAL TRIALS

## CONTROL VARIABLES

- **Dimension:** $\lambda=60mm$
- **Frequency:** $f=5GHz$
- **Sources:** 36 (per 10 degrees)
- **Receivers:** 360 (per degree)

## TESTING VARIABLES

- **Permittivity:** $\varepsilon=[1.1, 5.9]F/m$ (per $0.1F/m$)
- **Target Shapes:**
  - **1 Regular Square:** $L=2\lambda=120mm$
  - **1 Large Square:** $L=4\lambda=240mm$
  - **2 Squares:** $L=2\lambda=120mm$ for both
  - **2 Circles:** $r=\lambda=60mm$
  - **2 Equilateral Triangles:** $L=2\lambda=60mm$

# EXPERIMENTAL PROCEDURE

**COMSOL**

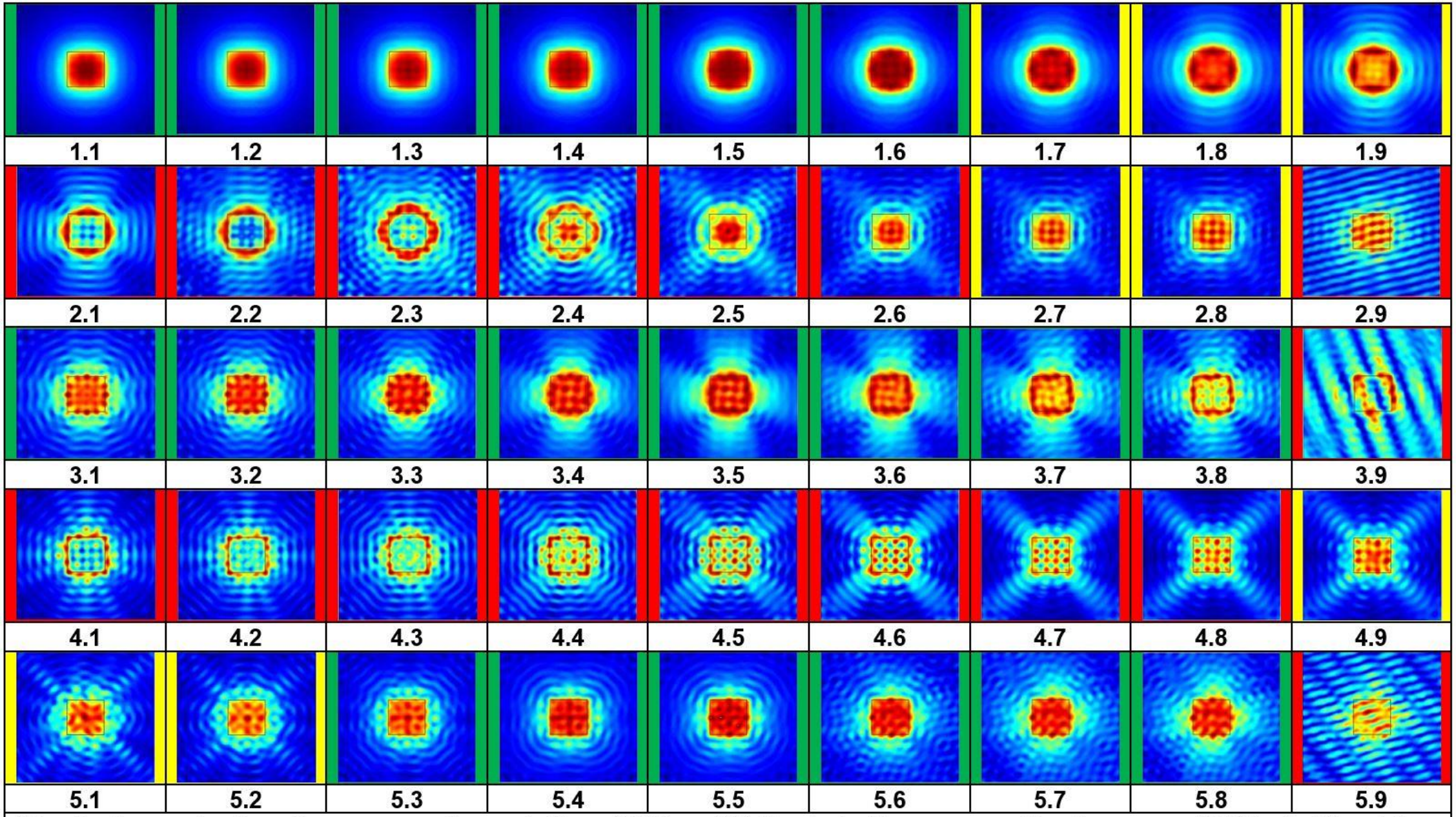
- Parameters set
- Collect data table

**EXCEL**

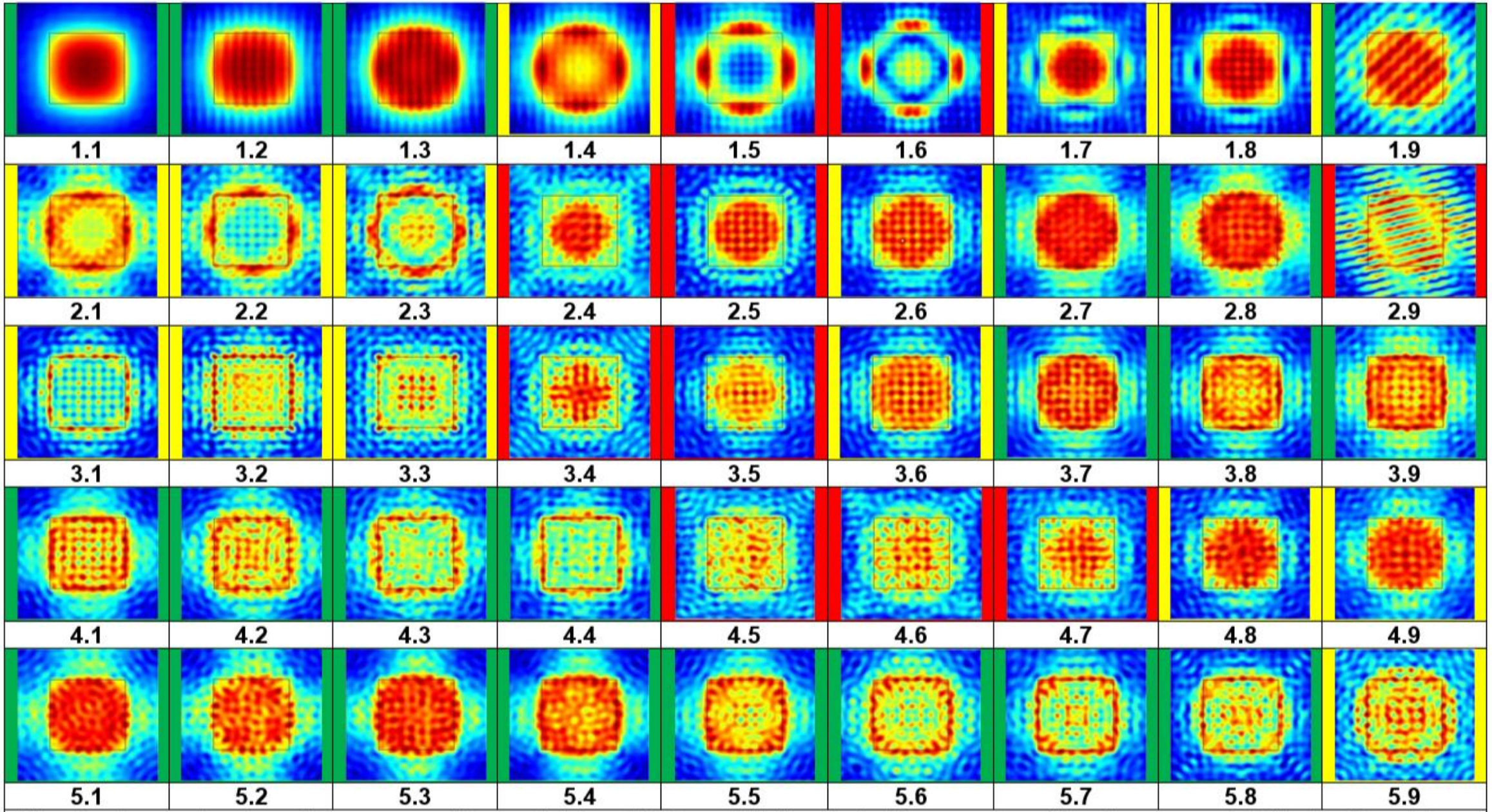
- Format data table

**MatLAB**

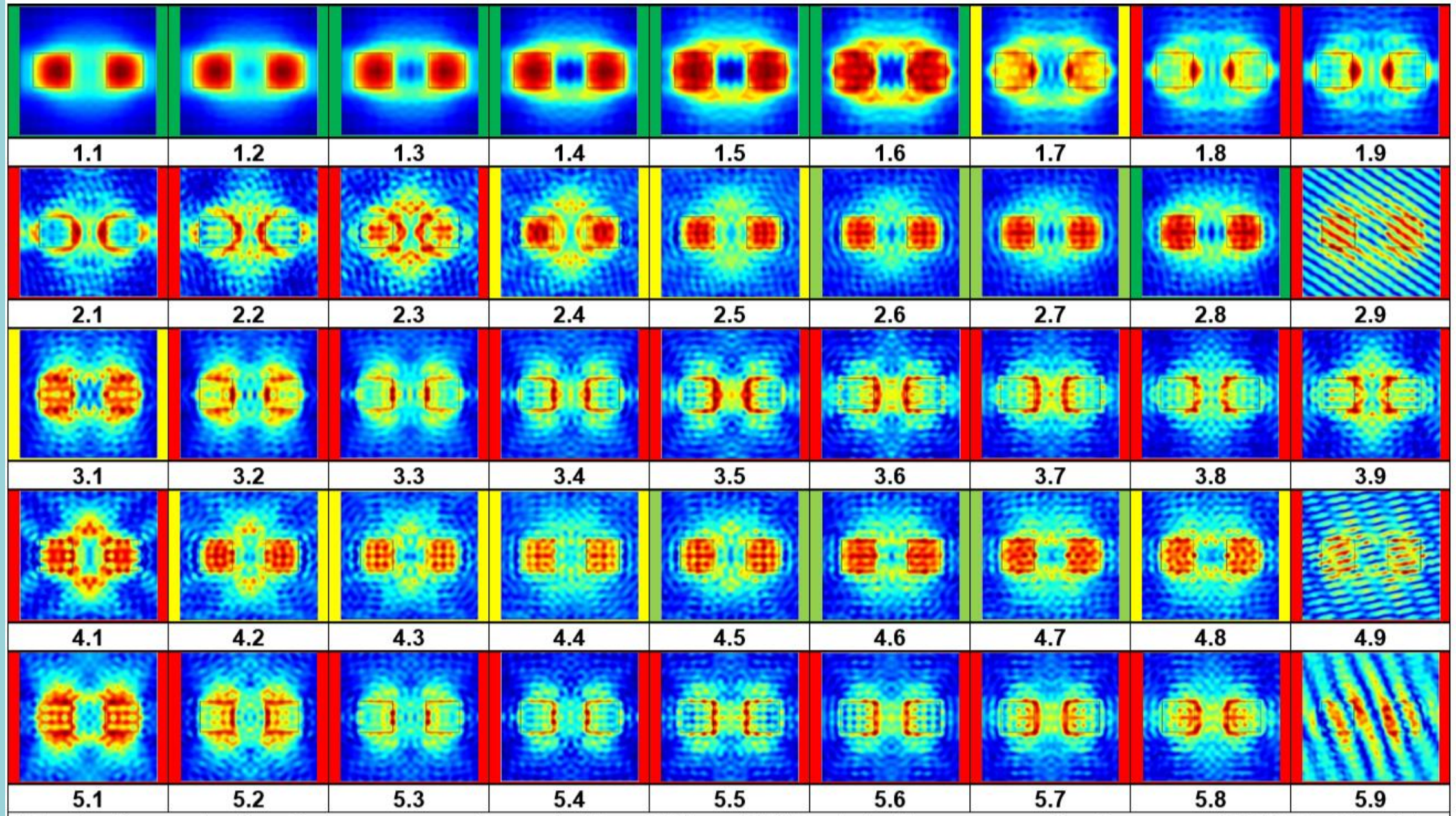
- Run program
- Generate images



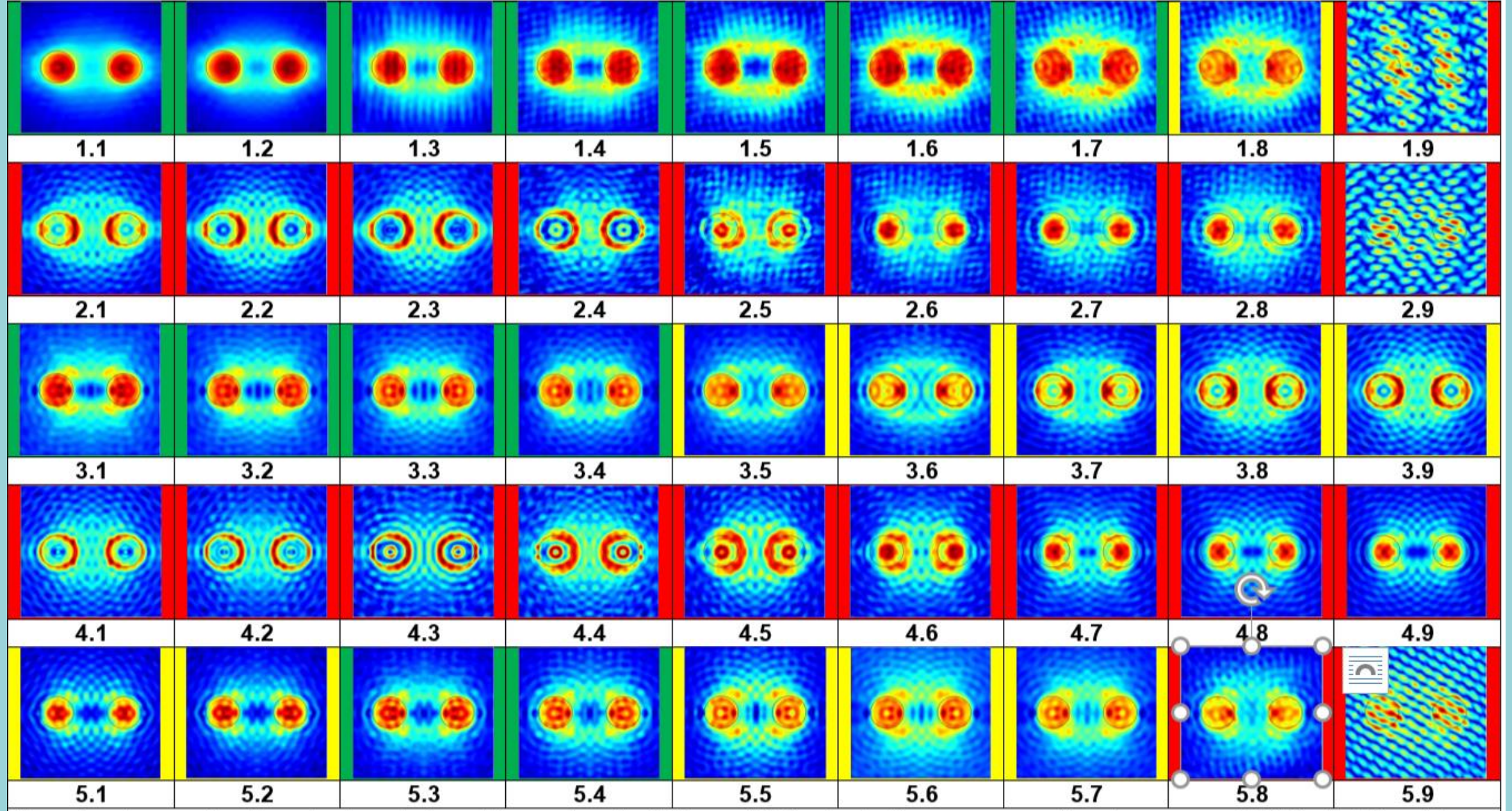

*Family of reconstructions for a square with equal sides of 120mm (2λ) illuminated by a source with a frequency of 5GHz (λ=60mm) for a permittivity range of 1.1F/m to 5.9F/m. There are 360 receivers, a resolution of 250x250 on each image with increasing permittivity from left to right. The permittivity is shown underneath each target. The degrees of freedom to reconstruct a proper image of the target are indicated as *satisfied* in green, *marginal* in yellow, and *insufficient* in red.



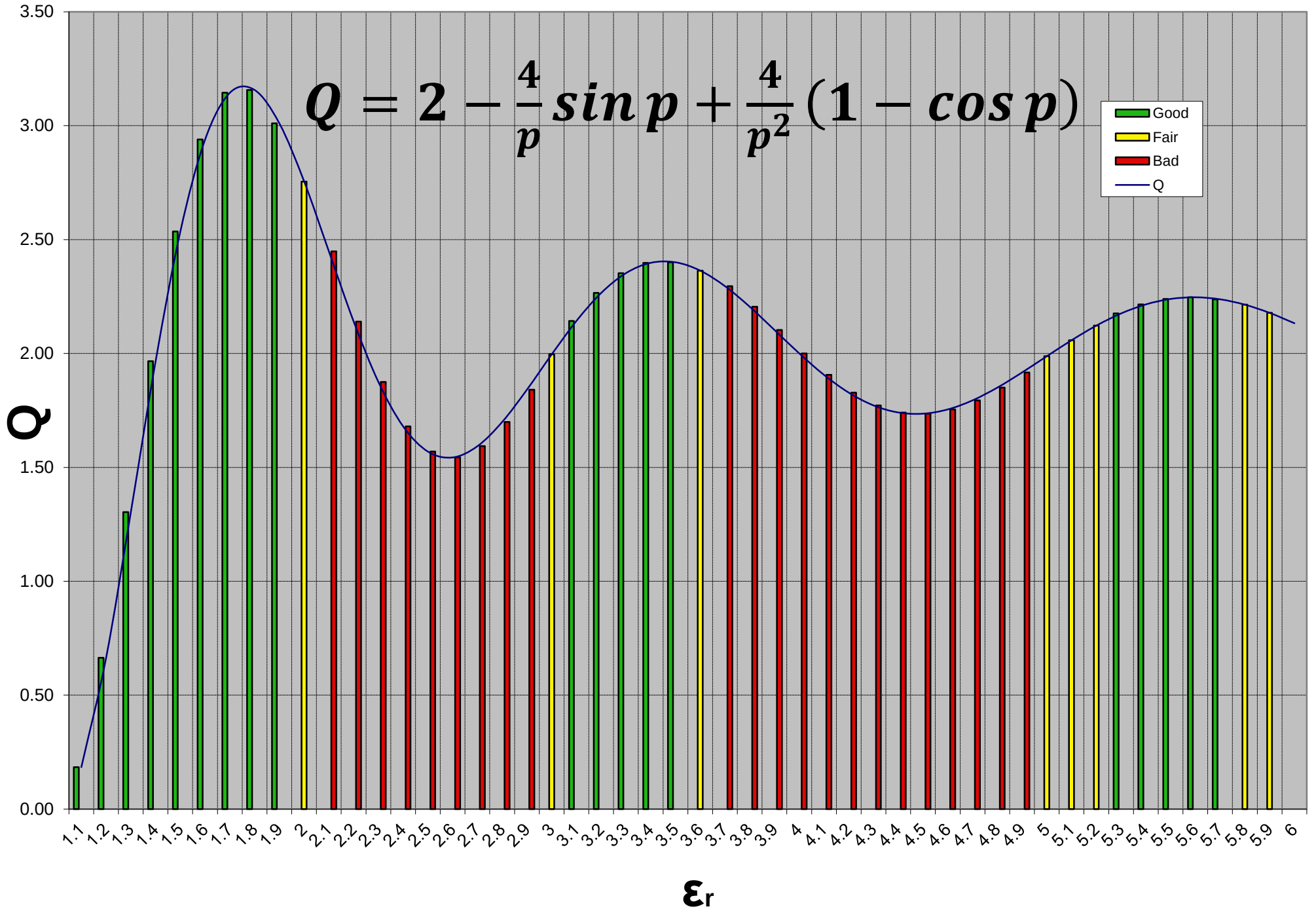

*Family of reconstructions for a square with equal sides of 240mm (4λ) illuminated by a source with a frequency of 5GHz (λ=60mm) for a permittivity range of 1.1F/m to 5.9F/m. There are 360 receivers, a resolution of 250x250 on each image with increasing permittivity from left to right. The permittivity is shown underneath each target. The degrees of freedom to reconstruct a proper image of the target are indicated as *satisfied* in green, *marginal* in yellow, and *insufficient* in red.



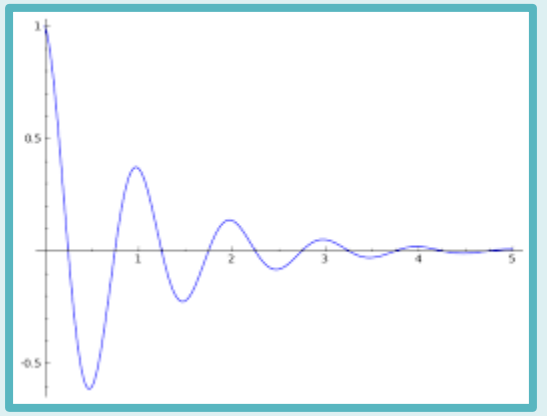

*Family of reconstructions for two squares with equal sides of 120mm (2λ) illuminated by a source with a frequency of 5GHz (λ=60mm) for a permittivity range of 1.1F/m to 5.9F/m. There are 360 receivers, a resolution of 250x250 on each image with increasing permittivity from left to right. The permittivity is shown underneath each target. The degrees of freedom to reconstruct a proper image of the target are indicated as *satisfied* in green, *marginal* in yellow, and *insufficient* in red.



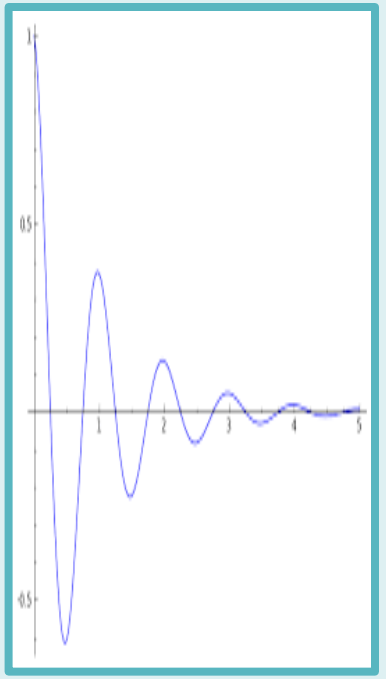

*Family of reconstructions for two circles with equal radii of 60mm (λ) illuminated by a source with a frequency of 5GHz (λ=60mm) for a permittivity range of 1.1F/m to 5.9F/m. There are 360 receivers, a resolution of 250x250 on each image with increasing permittivity from left to right. The permittivity is shown underneath each target. The degrees of freedom to reconstruct a proper image of the target are indicated as *satisfied* in green, *marginal* in yellow, and *insufficient* in red.

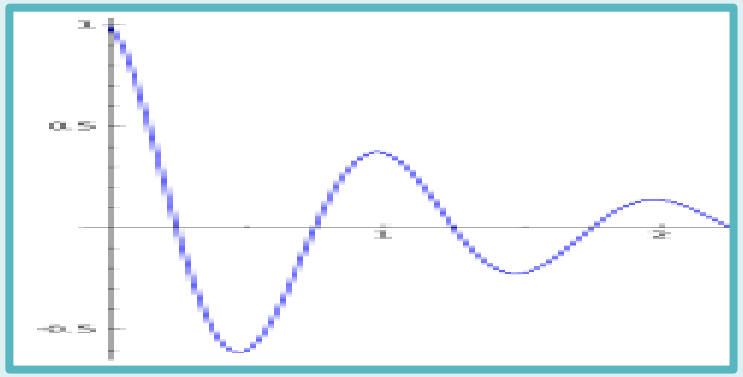

$Q = 2 - \frac{4}{p} sin\, p + \frac{4}{p^2}(1 - cos\, p)$
Good
Fair
Bad
Q
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Q
1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 5 5.1 5.2 5.3 5.4 5.5 5.6 5.7 5.8 5.9 6
εr

# RESULTS: RESONANCE PATTERNS

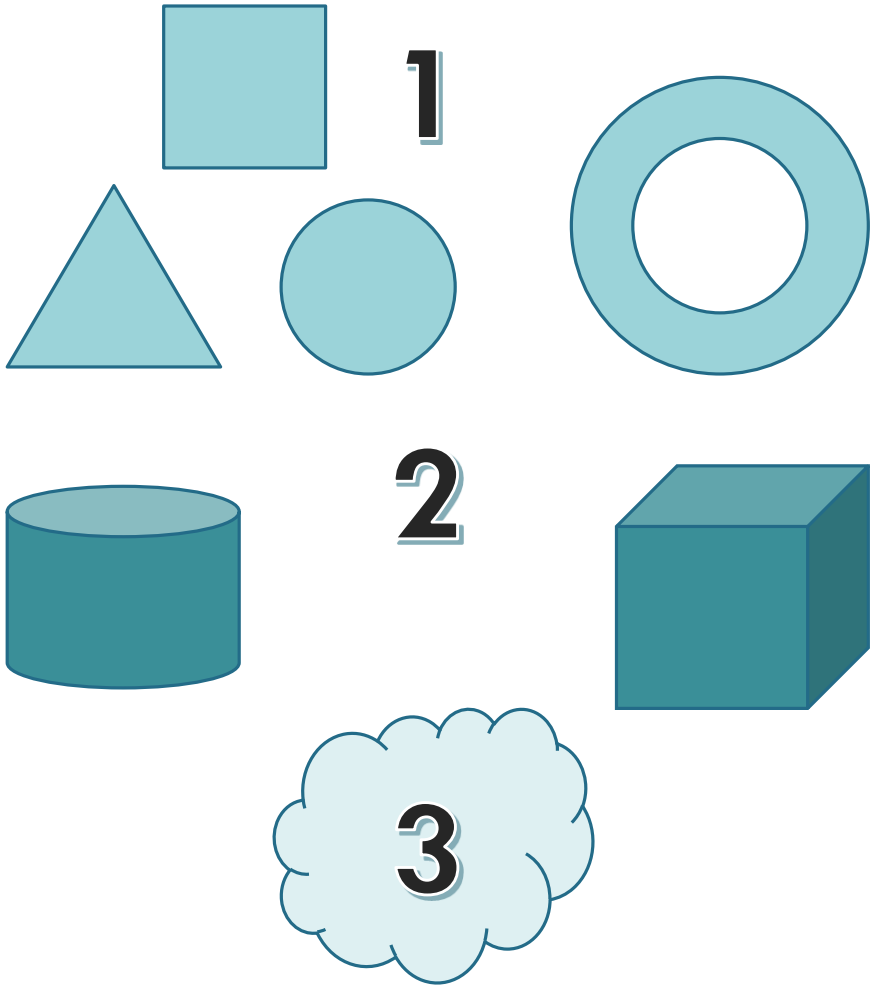


- **Resonance of Reg. Square ≈ Reg. Circle ≈ 2 Circles**
  - Optimal permittivity=1.0, 3.0 and 5.0F/m range
- **Resonance of Large Square: more oscillatory**
  - Optimal permittivity=5.0F/m range
- **Resonance of 2 Squares: less oscillatory**
  - Optimal permittivity=1.0 and 4.5F/m range





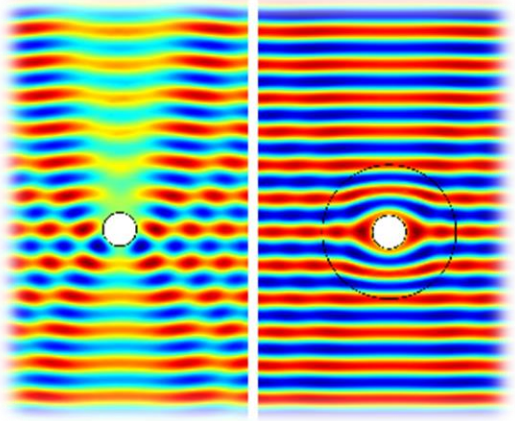
# FUTURE RESEARCH

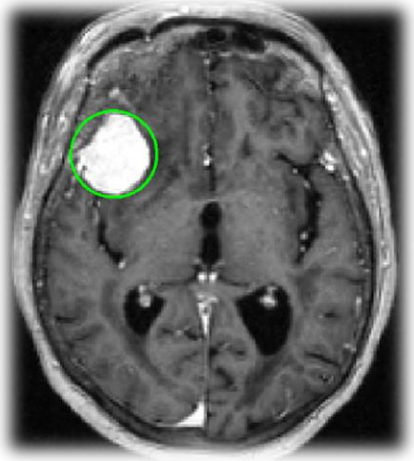


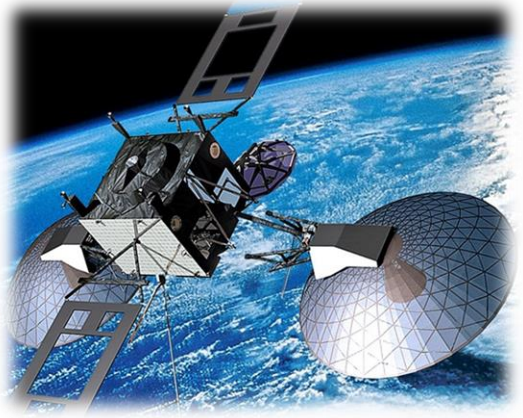

- ❑**Extend permittivity range:** negative values
- ❑**Vary dimensions:** new λ
- ❑**New target shapes:** (1)
  - ❑Square, Triangle and Circle
  - ❑Donut Circle
- ❑**Vary frequency:** 2GHz to 8GHz
- ❑**3-D target shapes** (2)
- ❑**Real World Data:** tumors (3)

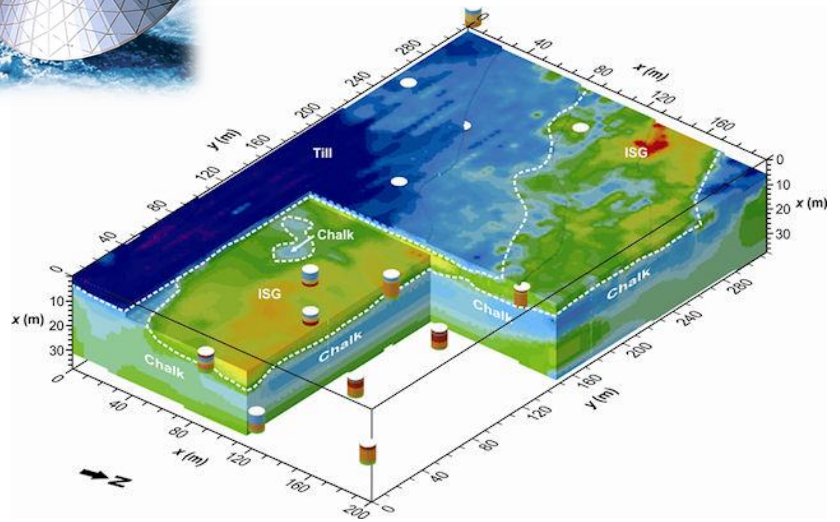
# MODERN APPLICATIONS

- ❑**Target Identification**
- ❑**Structure Synthesis:** Invisible Metamaterials
- ❑**Remote Sensing:** Satellites
- ❑**Biomedical Imaging:** Tumors
- ❑**Geophysical Tomography:** Radar
- ❑**Other Non-destructive Testing**









# Thank You

*Special thanks to Dr. Ritter for mentoring and supervising this unique research opportunity!*