Design and Testing of Advanced Photonic Band-gap (PBG) Accelerator Structures

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THOBN5

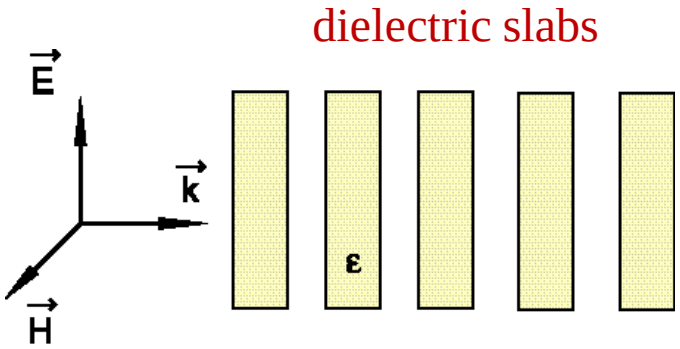
Outline

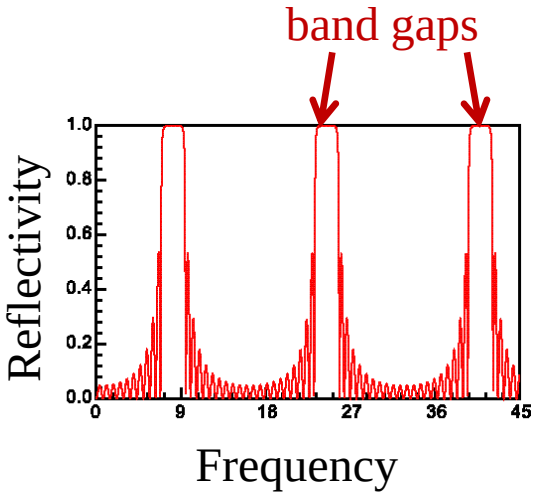
- Introduction
- Testing at 11 GHz
  - Elliptical-rod Design at 11 GHz
  - SLAC Experimental Setup
  - Preliminary Results
- Testing at 17 GHz
  - MIT Test Stand
  - 17 GHz Photonic Band-gap Structure
- Conclusions

Frequency Selective PBG Lattice

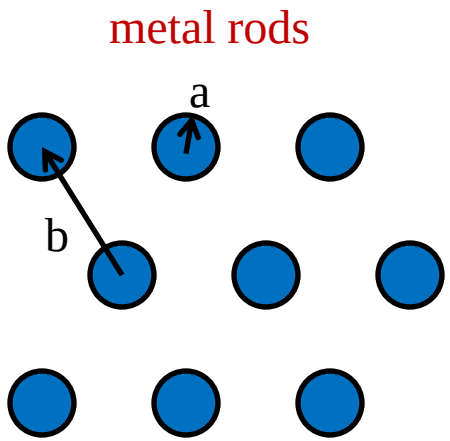
- Wave propagation is disallowed at certain frequency ranges [**Photonic Band-gap (PBG)**] in a periodic lattice.

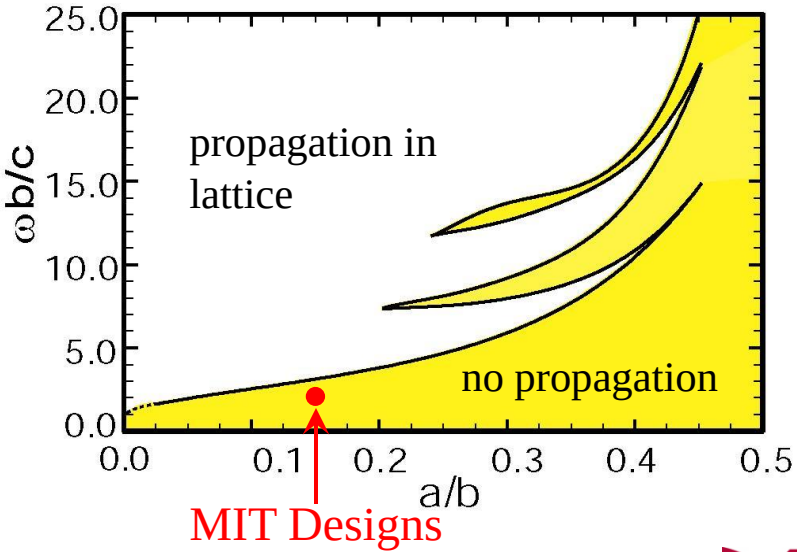
1D lattice:





2D lattice:





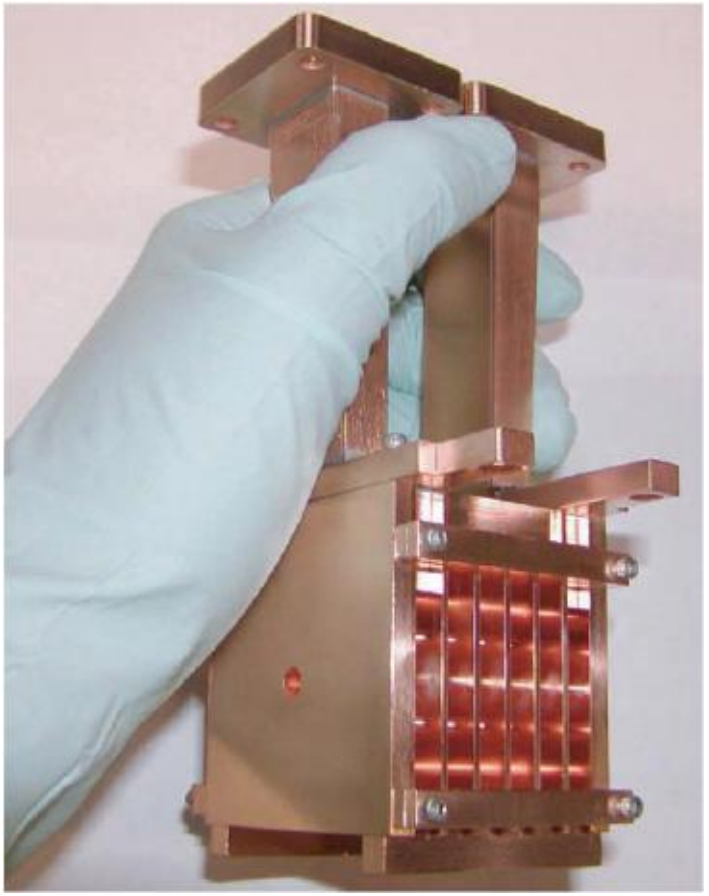
Smirnova et al. , J. Appl. Phys., 2002

Microwave PBG Accelerators

- Previous experimental results validate concept

- Demonstrated acceleration at 17 GHz at MIT (Smirnova 2005)
  - 35 MV/m achieved

- High-power testing at SLAC at 11 GHz (Marsh 2009)
  - 100 MV/m achieved
  - Showed influence of high H fields on breakdown
    - can these be reduced?



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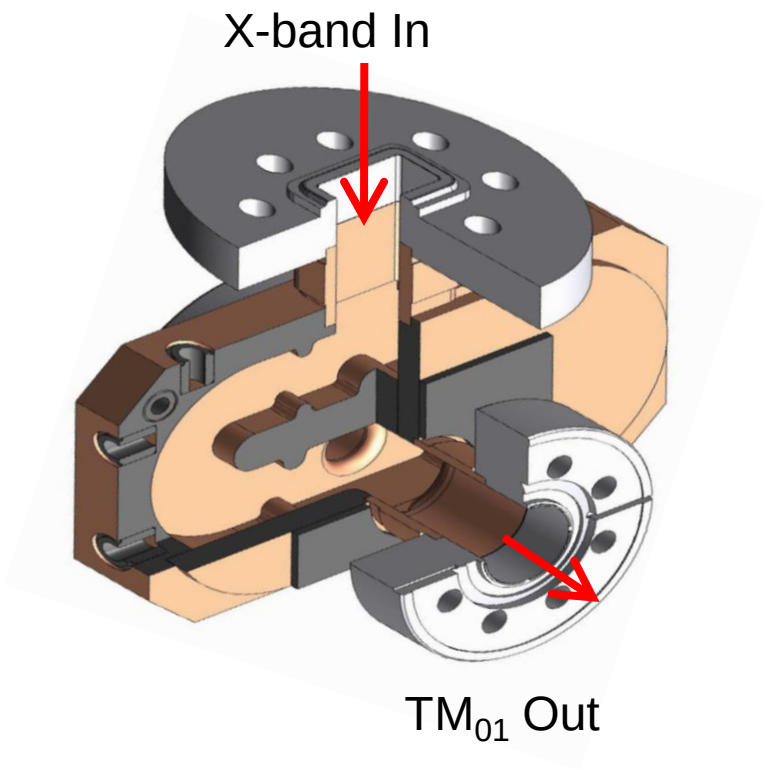
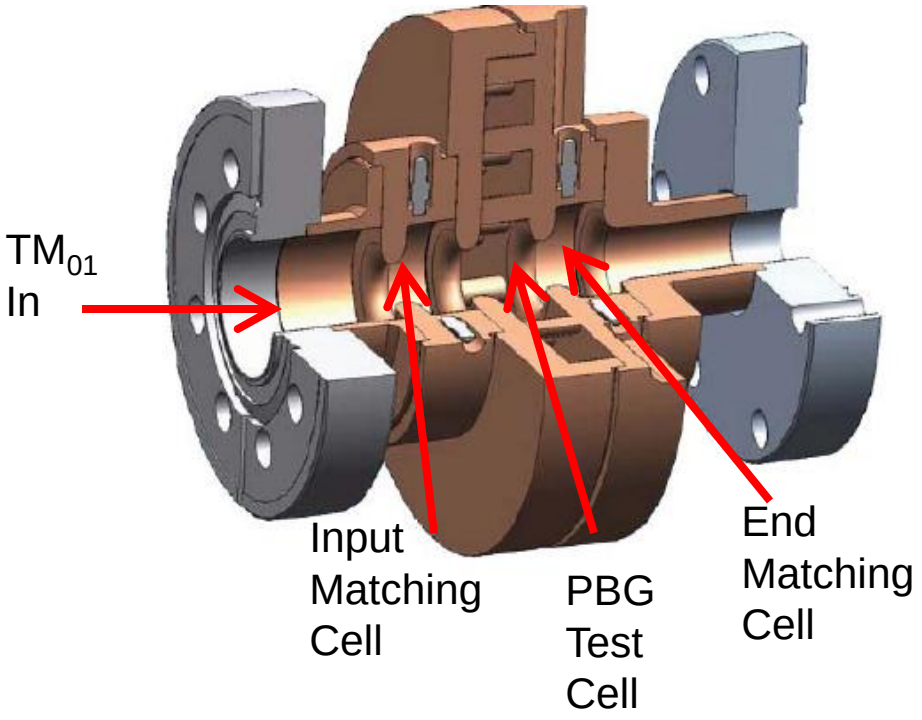
Elliptical-rod Design at 11 GHz

- Standing wave design with 2 matching cells, one test cell
- Axially powered via TM_{01} mode launcher

Mode Launcher

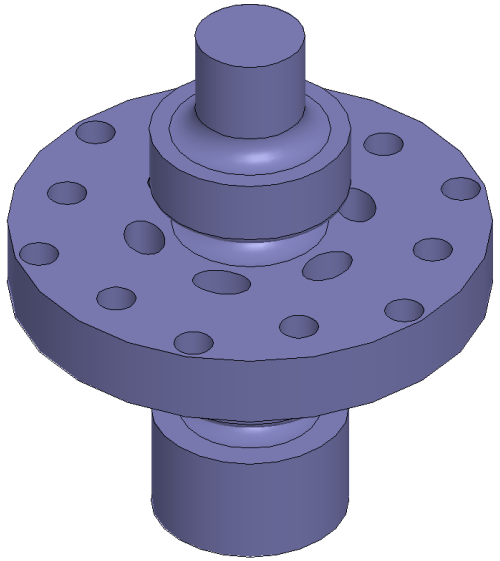


Structure

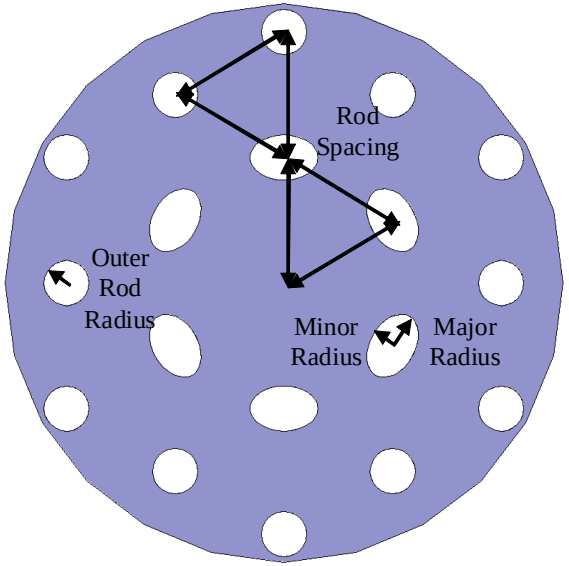


Elliptical-rod Design at 11 GHz

- Standing wave design with 2 matching cells, one test cell
- Axially powered via TM_{01} mode launcher
- Structure has elliptical inner rods
  - Spread large H field over larger region
    → reduce pulsed heating

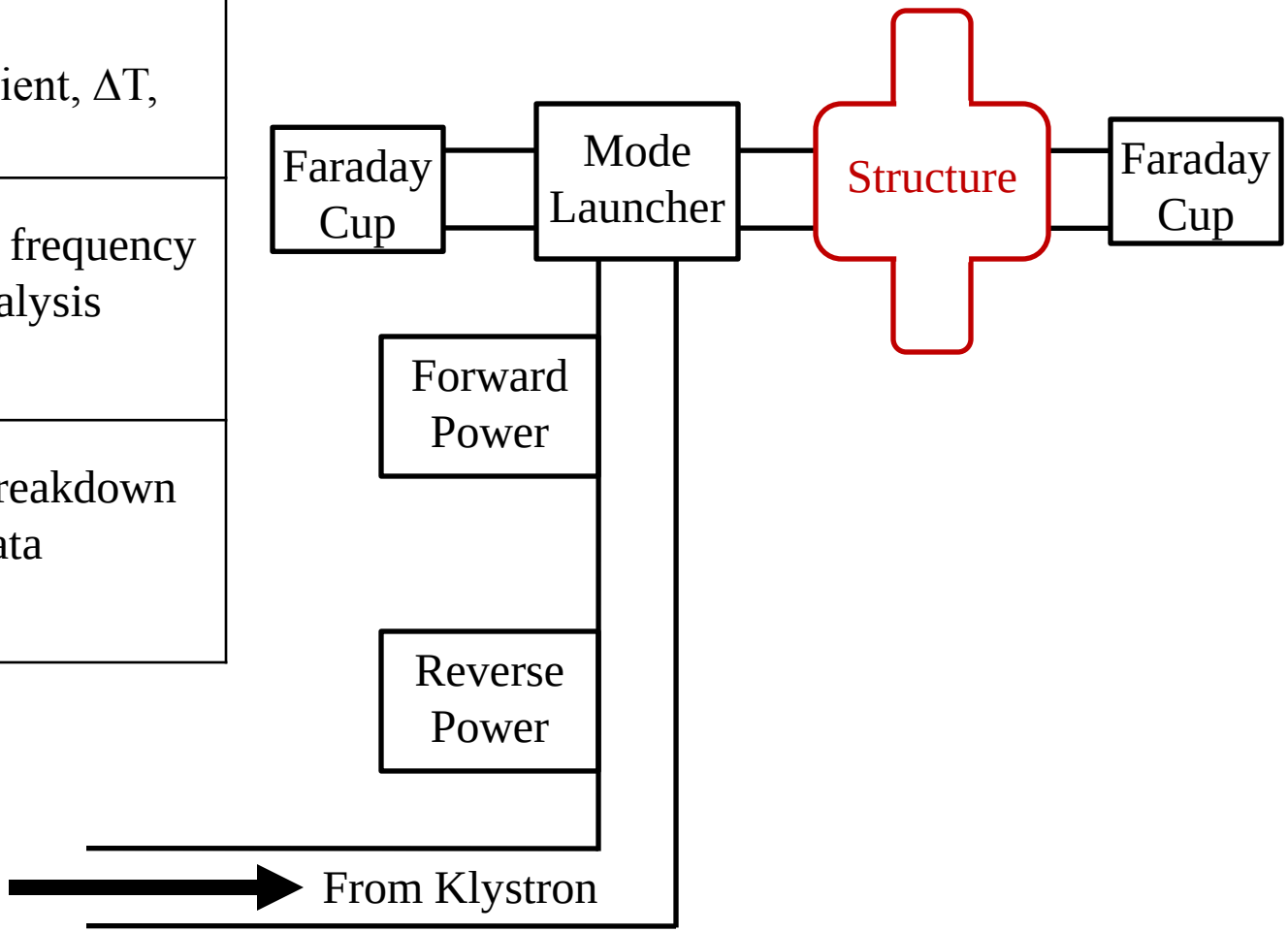


Performance at 100 MV/m		
	Round	Elliptical
Power	5.9 MW	4.4 MW
Peak Surface E Field	208 MV/m	207 MV/m
Peak Surface Magnetic Field	890 kA/m	713 kA/m
Pulsed Heating for 150ns Flat Pulse	131 K	84 K



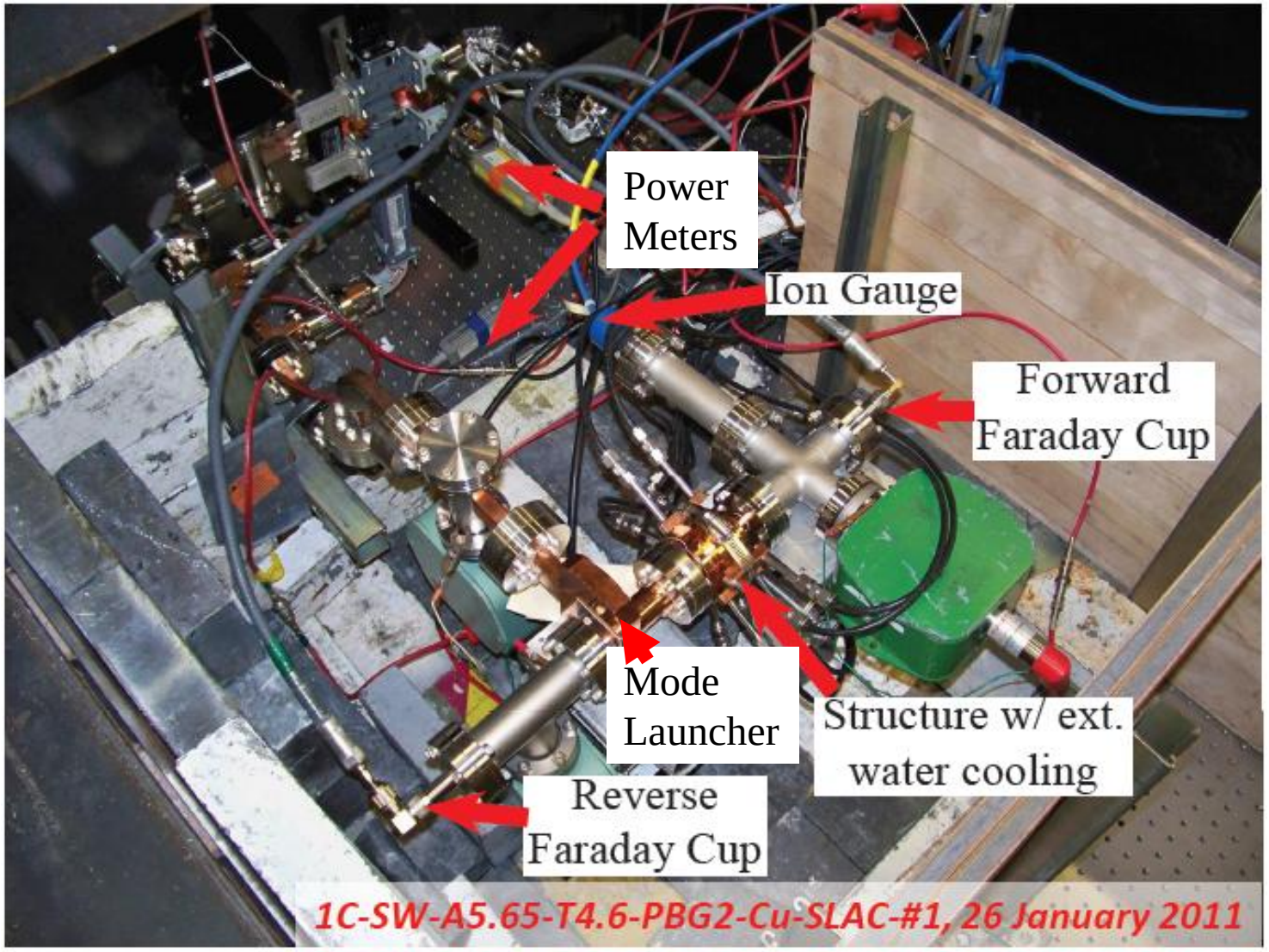
Experimental Setup at SLAC

Diagnostic	Uses
Forward Power	•Feedback power level •Find gradient, ΔT, etc.
Reverse Power	•Feedback frequency •Check analysis results
Faraday Cups	•Trigger breakdown counter, data recording



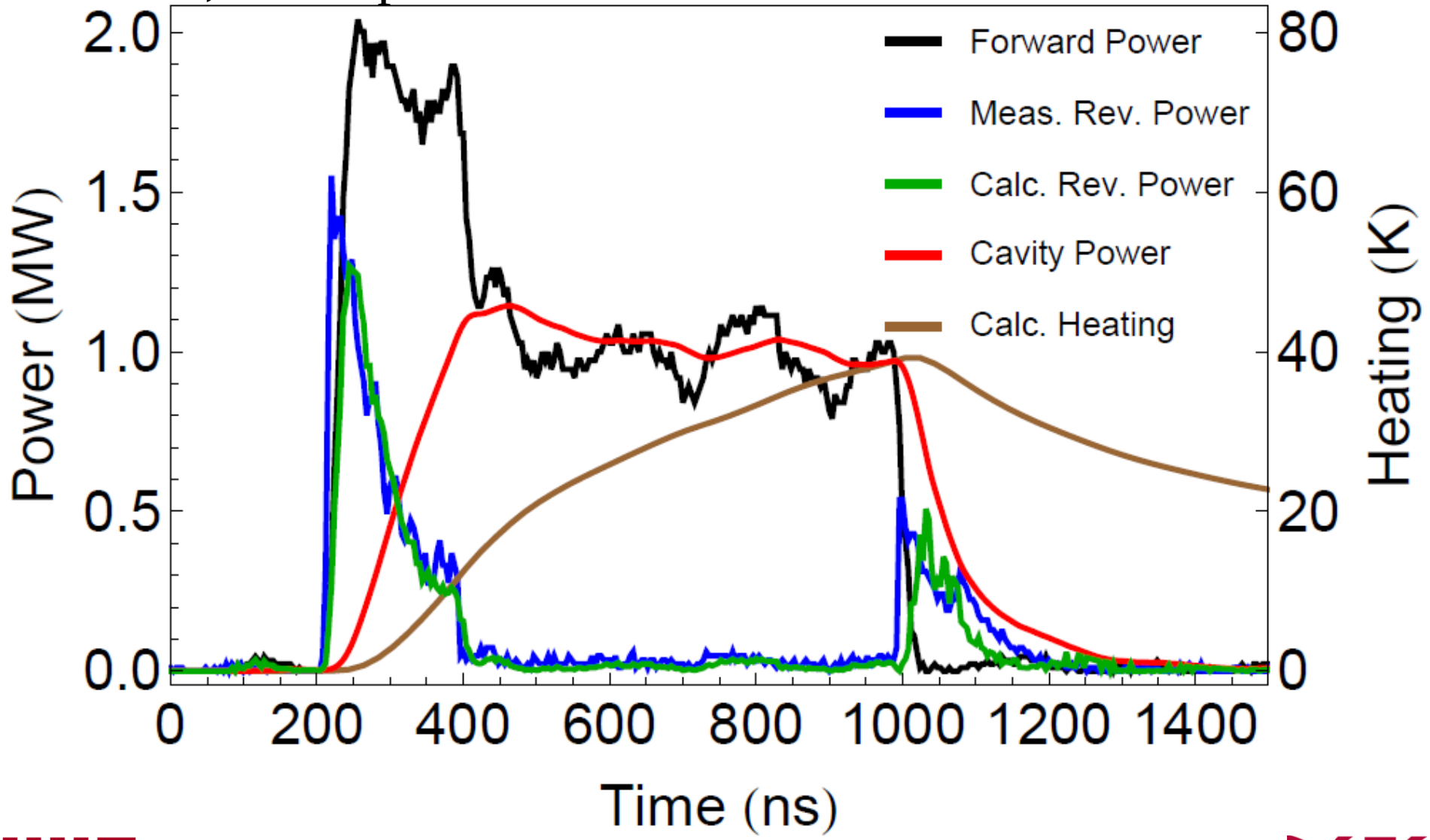
Experimental Setup at SLAC

- Both structures tested at SLAC Test Stand 04:



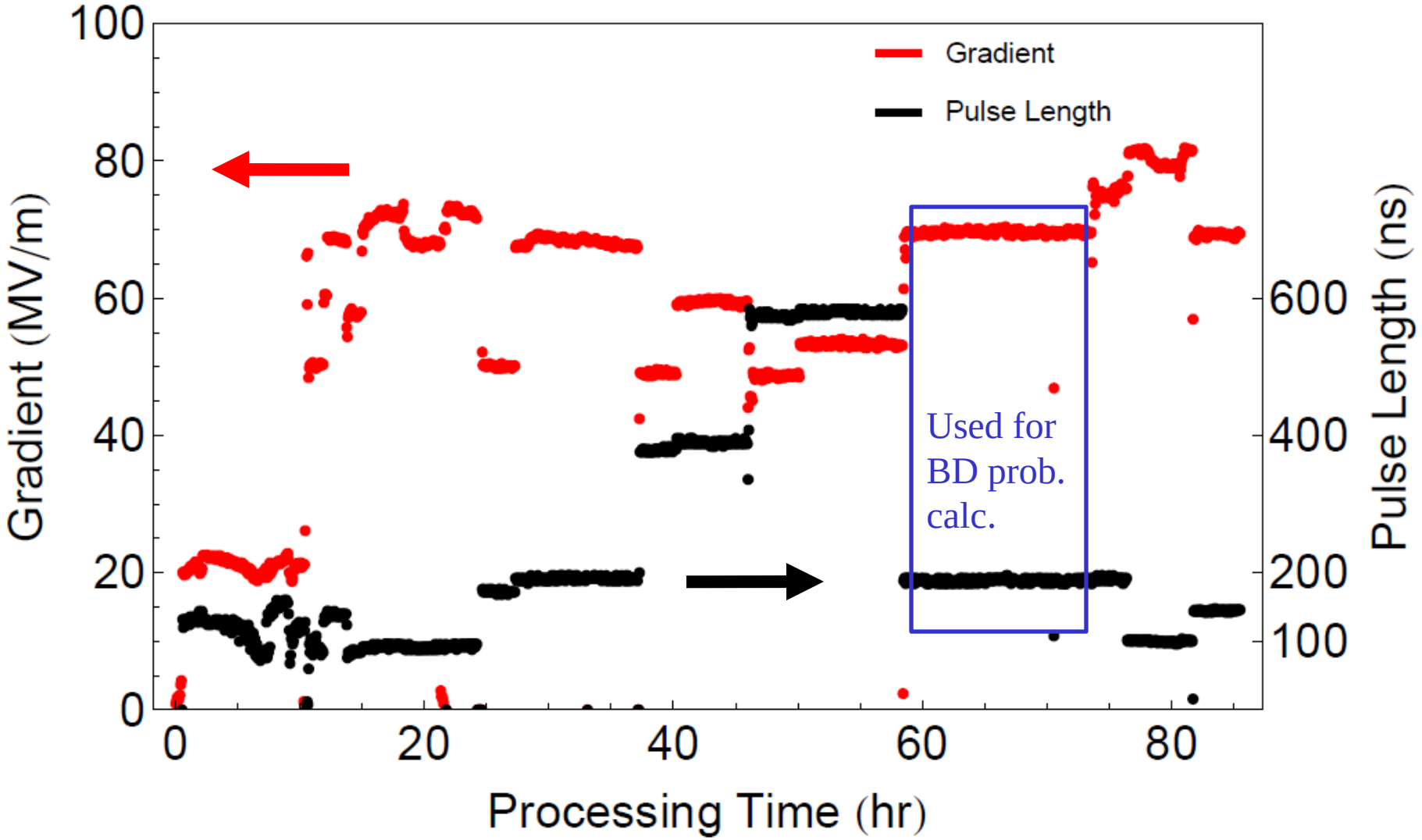
Sample PPM Traces (Elliptical-rod Structure)

- 600ns, 1MW pulse



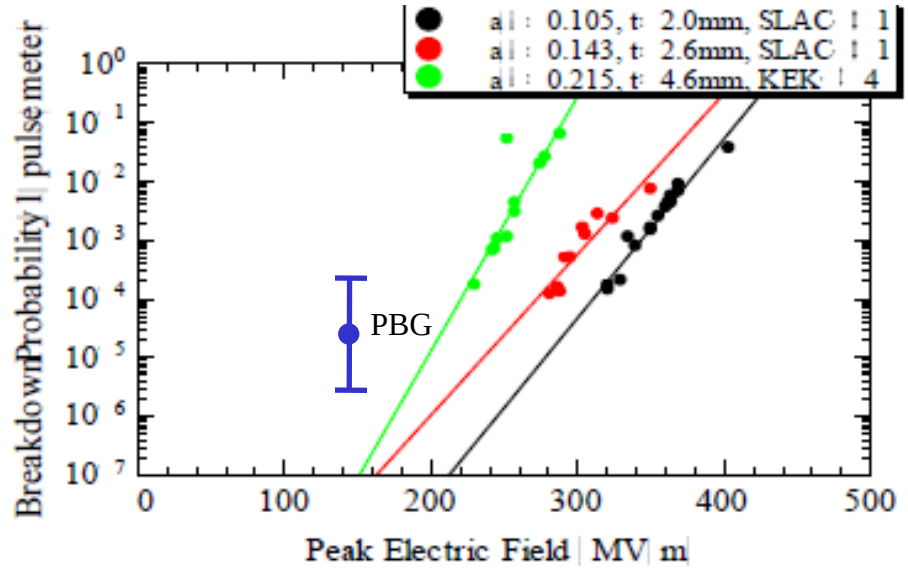
Preliminary Elliptical-rod Gradient and Pulse Length

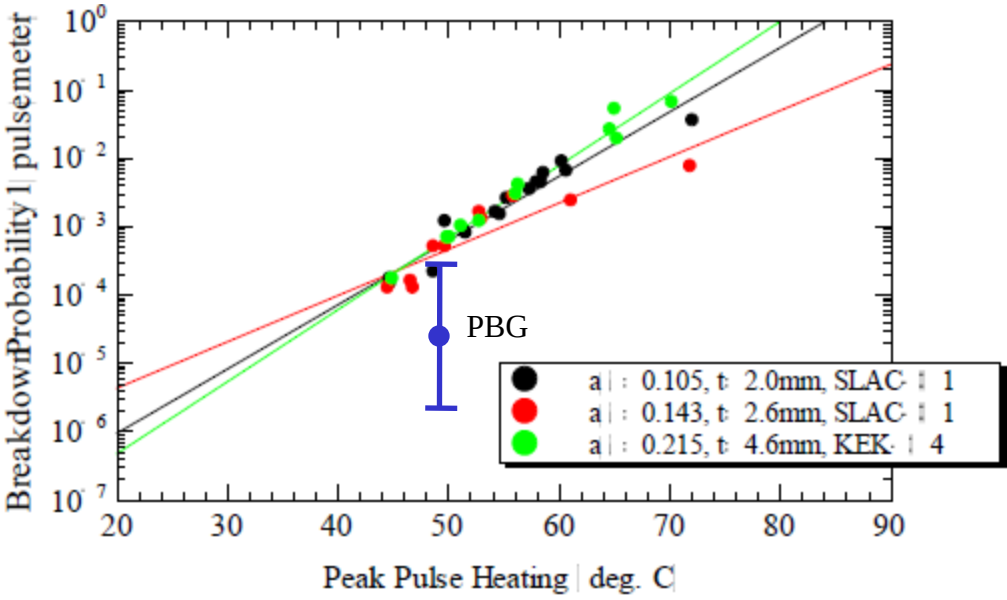
- Structure not fully processed, expect ≥ 100 hrs more proc.



Preliminary Elliptical-rod Breakdown Probability

- Breakdown probability may change with more processing
- Preliminary result gives breakdown probability of $\sim 3 \cdot 10^{-5}$/pulse/meter at 70 MV/m and 50K pulsed heating
- Same iris geometry as green structure at right





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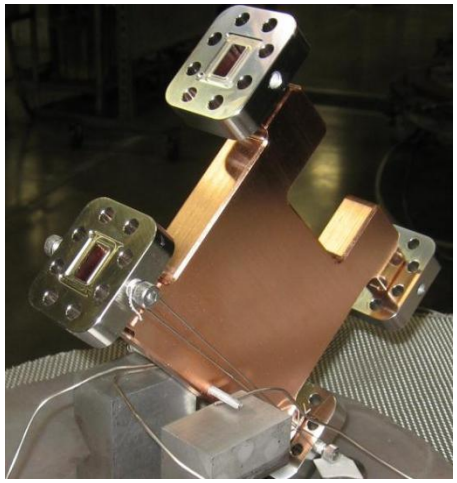
17 GHz Test Stand

- Powered by HRC 17 GHz Haimson Research Klystron
  - 4.2 dB hybrid coupler; up to 4 MW of power @ 1.0 μs available
- Test stand will be completed in Spring, 2011
  - 17 GHz TM_{01} mode launchers built by SLAC
- Planned experiments on MIT Photonic Band-gap structures
  - Microwave breakdown with improved diagnostics
  - Metallic Photonic Band-gap Structures
  - Dielectric Photonic Band-gap Structures



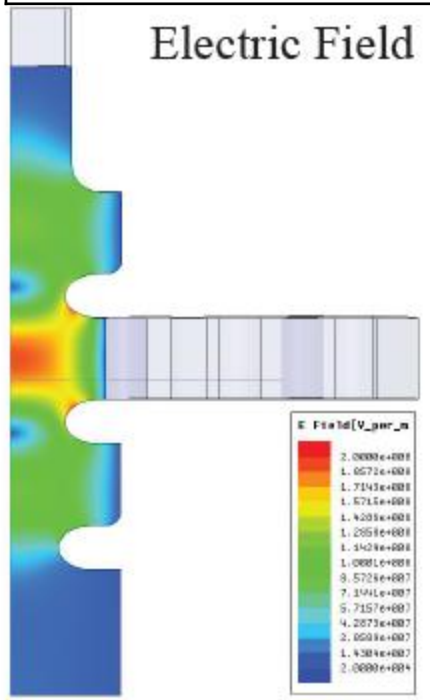
HRC Hybrid

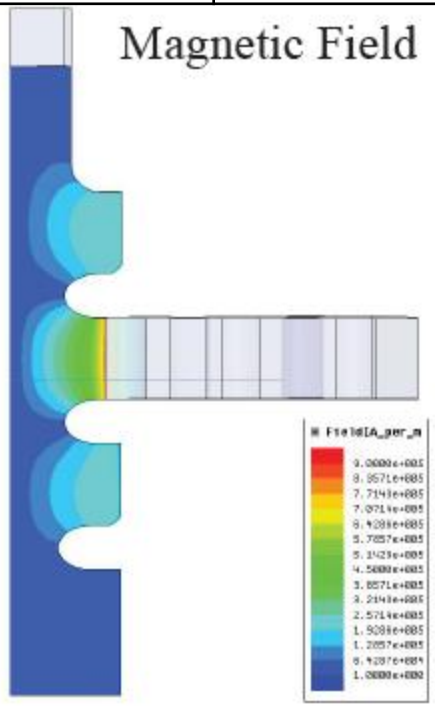
SLAC 17 GHz Launcher

17 GHz Structure

- Round-rod design based on standing structures tested at SLAC
- Structure has open outer wall
  - Must be contained in external vacuum chamber
- Higher heating due to increase in surface resistivity with freq.

Performance at 100 MV/m	17 GHz
Power	2.4 MW
Peak Surface Electric Field	200 MV/m
Peak Surface Magnetic Field	900 kA/m
Pulsed heating for 150 ns flat pulse	163 K
a/b	0.18





Conclusions

- Elliptical-rod photonic band-gap structure under test at SLAC
  - Pulsed heating reduced by almost 40%
  - Structure processing still in progress
  - Very few breakdowns up to 70 MV/m
    - Expect at least 100 MV/m gradient before testing complete

- MIT standing wave test stand
  - Construction in progress
  - Will be operational spring 2011
  - Studies of microwave breakdowns with improved diagnostics
  - Metallic and dielectric (see A. Cook's paper in proceedings) photonic band-gap structures to be tested
  - Users welcome!

Collaborators/Acknowledgements

MIT

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D. Yeremian

HRC

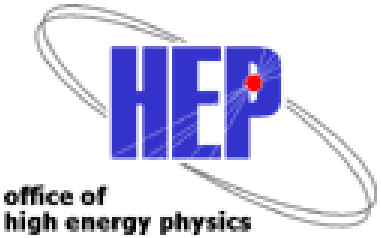
J. Haimson

LANL

E. Smirnova

LLNL

R. Marsh



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