Status of the C-Band Engineering Research Facility (CERF-NM) Test Stand Development at LANL

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Outline

- Purpose of the CERF-NM Test Stand
- Test Stand Layout
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  - Lead Enclosure
- Main Components of the Test Stand
  - Klystron
  - Waveguide
  - Mode Launchers and RF Cavities
- Summary and near term plans
- Acknowledgements and Thanks

Purpose of the CERF-NM Test Stand

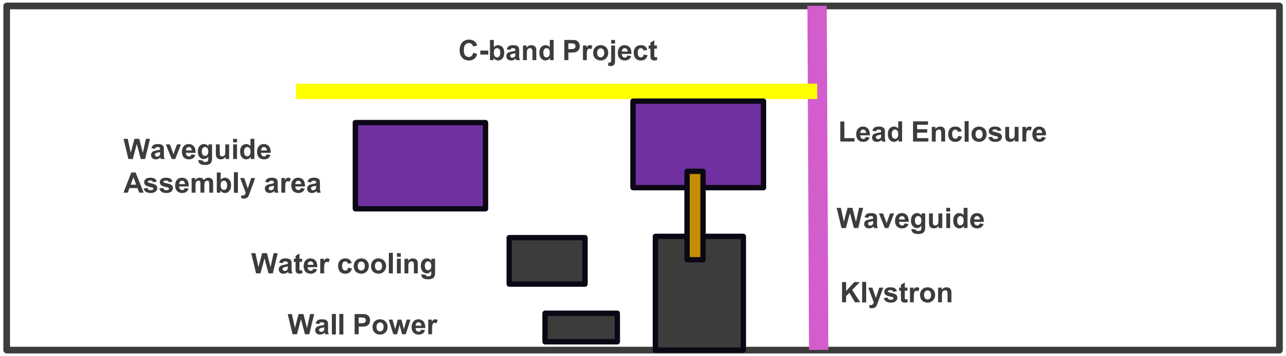
- C-band frequency for perspective rf cavities operation was identified as the most promising for acceleration of both, electron and proton beams
- High Gradient materials and accelerating structures research is one of the most rapidly growing areas, where LANL has very strong interest from both, the material science and from experimental nuclear science perspectives
- LDRD program ant LANL had supported the efforts in construction of the test facility, capable of performing as national center for research of C-band structures
- We have promising results near the mid-term of the 3 year long LDRD project, and we are planning to continue after the expiration of this project as a stand-alone C-band Engineering Research Facility in New Mexico

Purpose of the CERF-NM Test Stand (cont.)

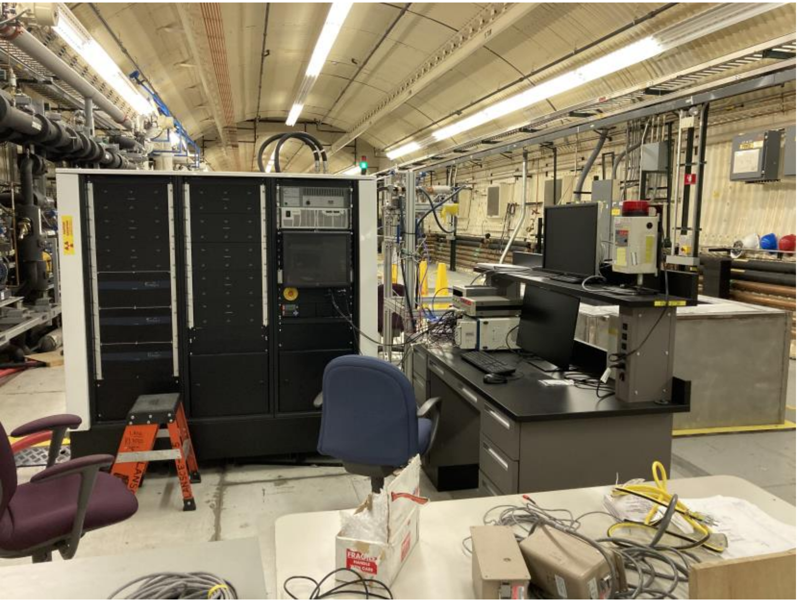
- CERF-NM is planned as a national center for testing of C-Band (5.712 GHz) RF structures
- One of the major goals is research of different materials and additional conditions (cryo) for achieving of the high accelerating gradients in such structures
- At present the limitations are **5 MeV, 1 mA** electrons are determined by the positioning of the test structures in the immediate vicinity of the klystron control station and other projects incident personnel. Future plans are to go over this limitation and testing up to **100 MeV** electrons with higher current
- Relatively small test stand would allow to have a quick turn around of the testing structures and receiving experimental data for comparison of the alternative cases
- Development of this test C-band facility would allow to expand this new technology for use in multiple present and future accelerating projects

Test Stand Layout: Beam Tunnel

- For implementing of the CERF-NM Test Stand the former LEDA tunnel at LANL was chosen
- This tunnel was designed to house RGD with up to 100 MeV, 100 mA charged particles (electrons or ions)
- At present we are sharing space with other projects and can not exceed the radiation levels that would present a challenge for control electronics



Test Stand Layout: Beam Tunnel

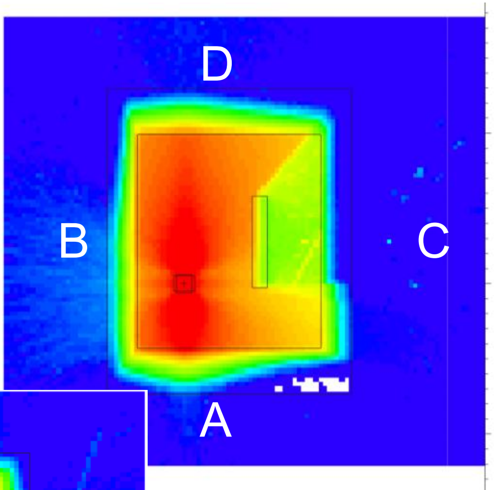


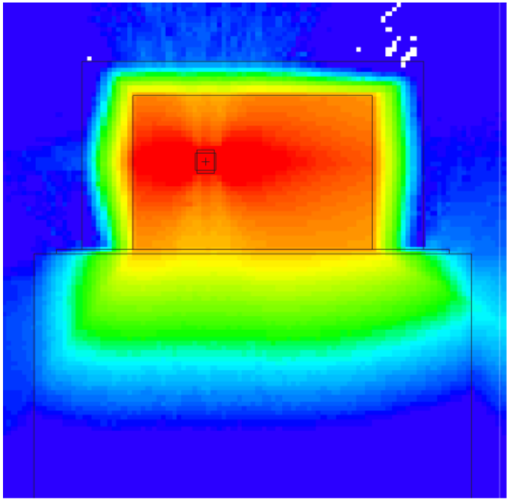
- The klystron was purchased, installed, and tested in 2019
  - Conditioned to 50 MW
  - Frequency 5.712 GHz (bandwidth 5.707-5.717 GHz)
  - 300 ns – 1 µs pulse length
  - Rep rate up to 200 Hz (typical 100 Hz)

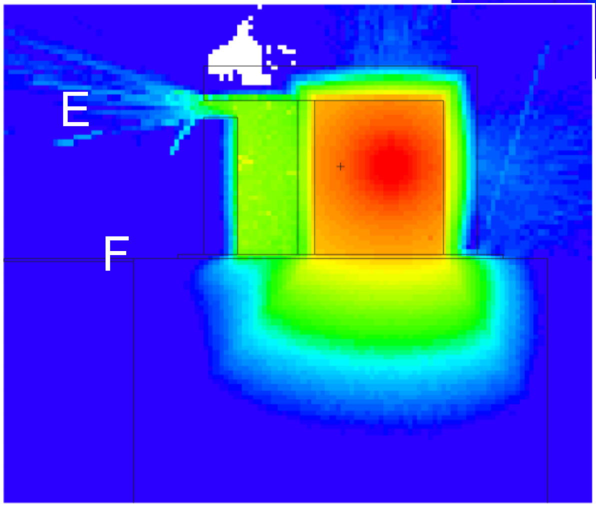
- To the right:
  - Lead enclosure (~25 tons)
  - To the left of the enclosure – klystron
  - Behind the lead box – waveguide assembly area

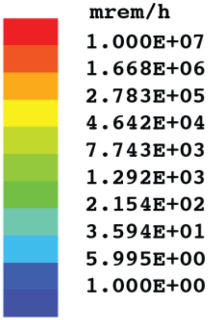
Test Stand Layout:
Lead Enclosure – Radiation fields simulations

- A=8,
- B=3,
- C=0.5,
- D=1.6,
- E=40,
- F=0.4 (all in mrem/h)
- All spill scenarios are for 5 MeV, 10 μA (CW-average)

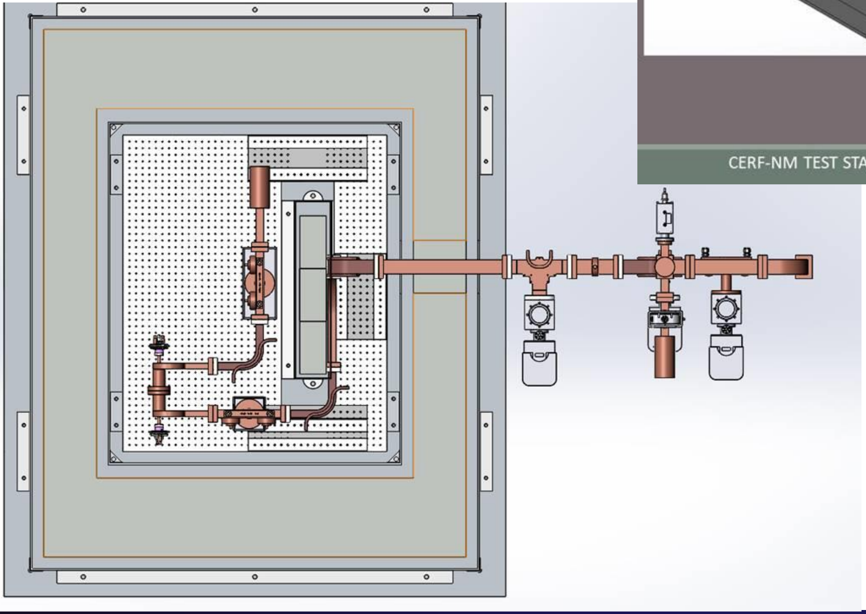


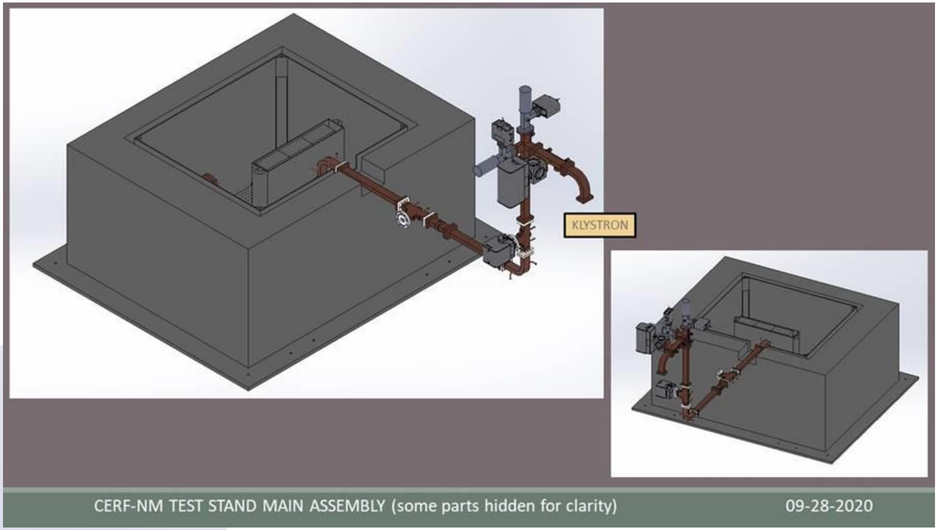






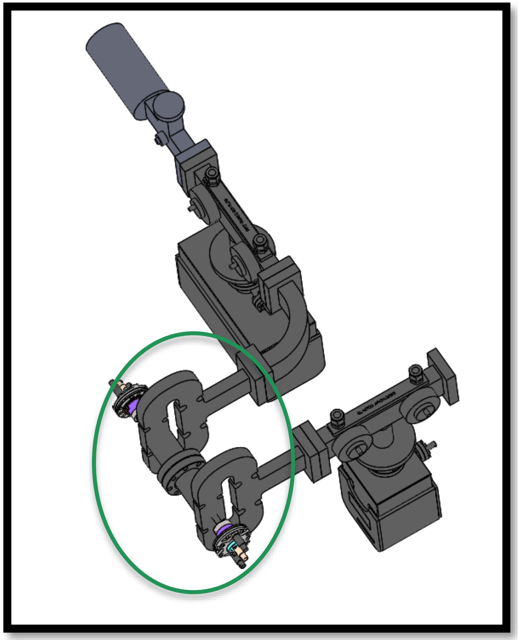
Main Components of the Test Stand: Waveguide

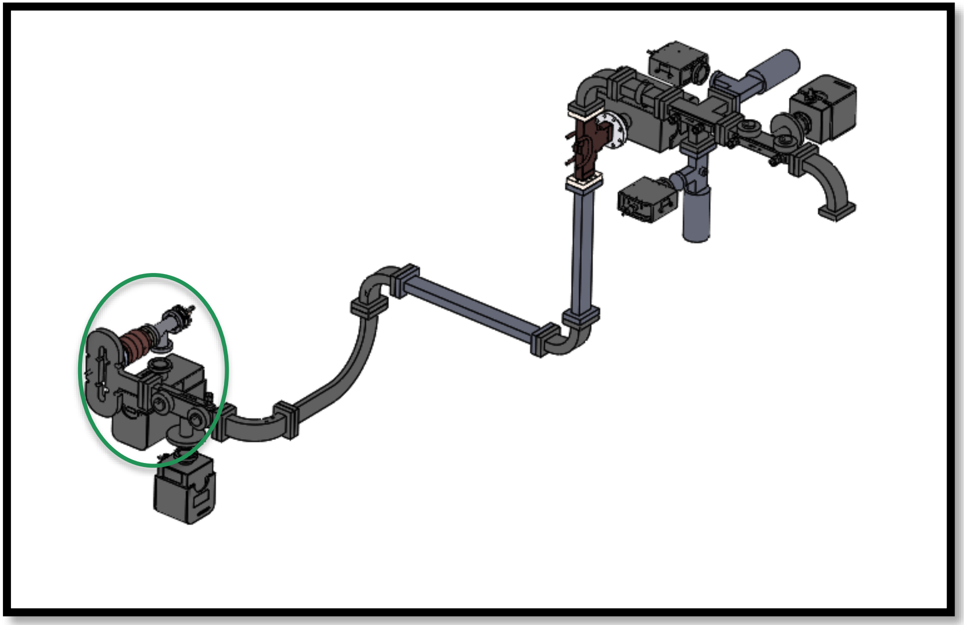




Main Components of the Test Stand: Waveguide options for Mode Launchers and RF Cavities

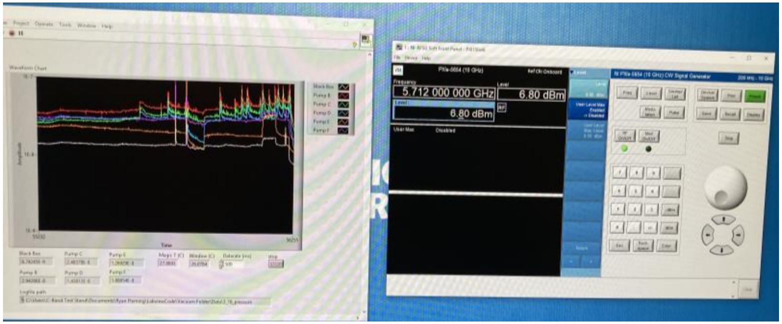
- The initial test run will have two Mode Launcher (Converters) back-to-back, for conditioning and confirming the wave conversion efficiency (left)
- All following setups will have a combination of single Mode Launcher and test cavity (right)

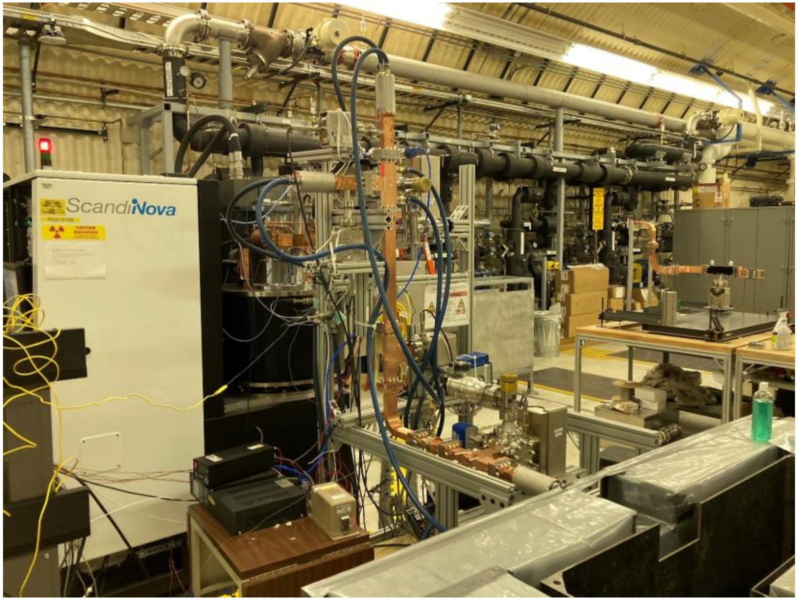




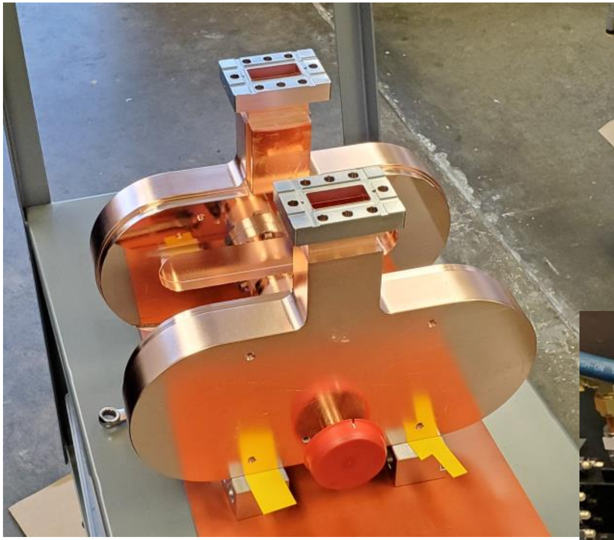
Main Components of the Test Stand: Waveguide

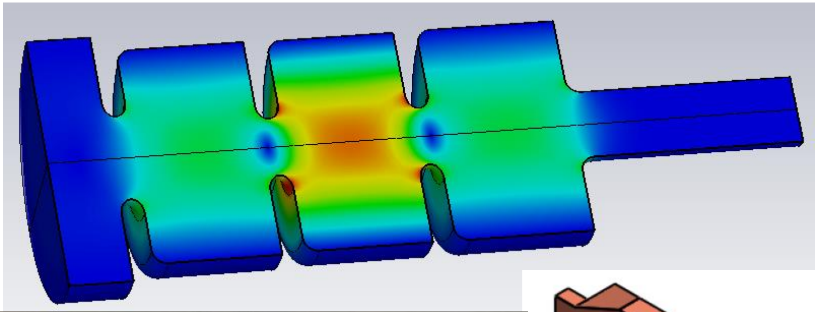
- The water cooled load terminated optical tables waveguide assembly is conditioned
- Mode Launchers are delivered and ready for installation
- To the right – typical waveguide conditioning screen with pressure variation and RF power control

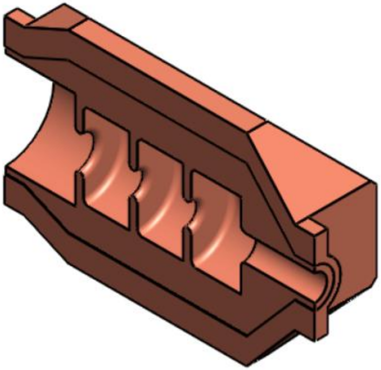


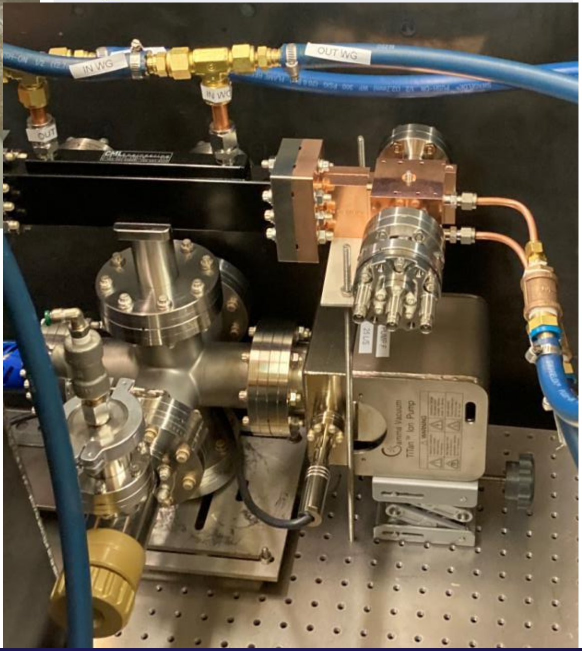


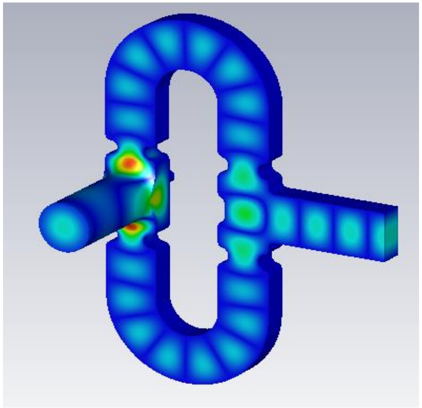
Main Components of the Test Stand:
Mode Launcher, RF Cavities











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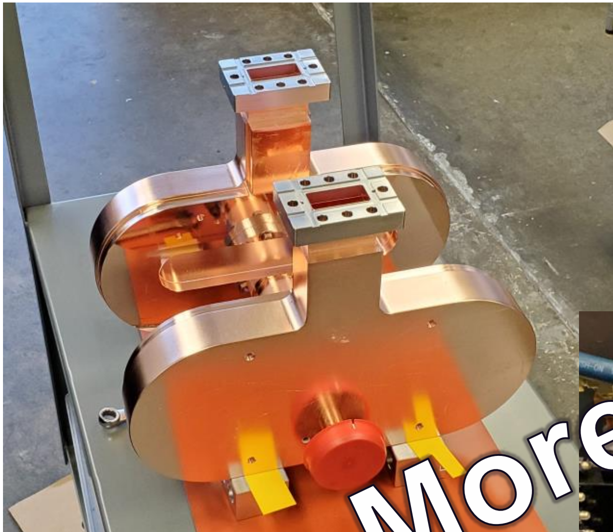
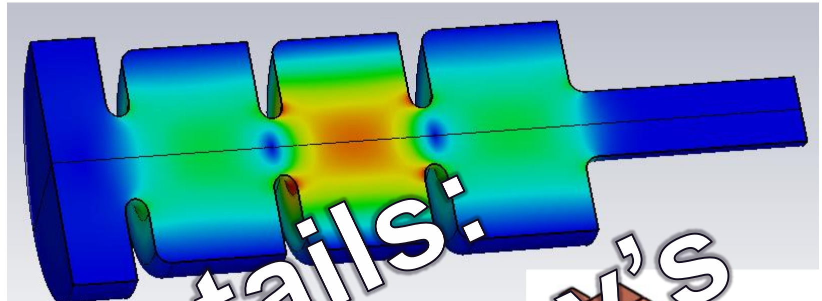
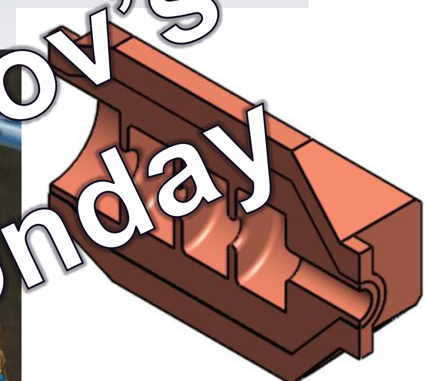
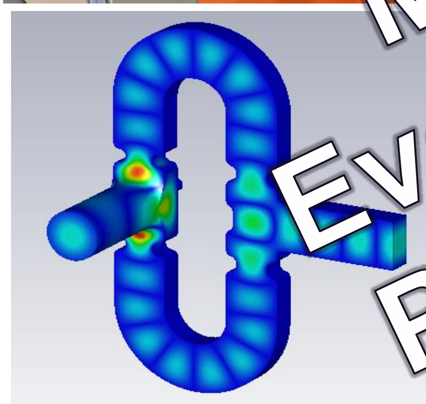




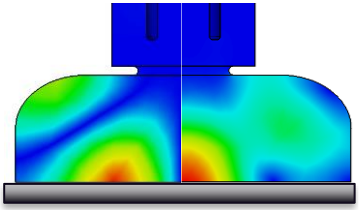




More Details: Evgenia Simakov's Poster on Monday

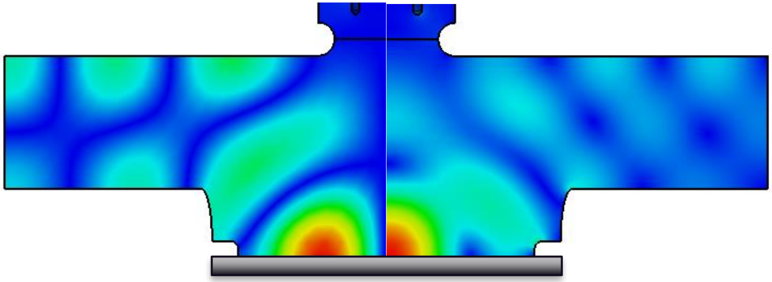
Candidate geometries for material coupon Testing Cavity

TM_{020}-like mode



- ✓ Smaller, simpler construction
- ✓ Lower RF power needed
- ✗ Low H_c/H_s ratio
- ✗ Probe ports (optical, field) problematic

TM_{041}-like mode



- ✓ More uniform field ratios
- ✓ Good options for probe port placement
- ✗ More complex fabrication
- ✗ Physically larger

Parameter	TM_{020}-like	TM_{041}-like
Q_0	16,800	23,500
E_c/E_s	2.89	2.33
H_c/H_s	1.42	2.33
R_e ($M\Omega/m^2$)	$5.7 \cdot 10^3$	$3.10 \cdot 10^3$

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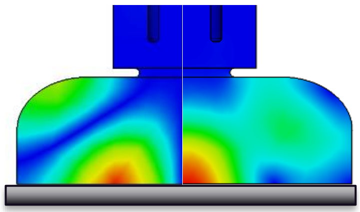

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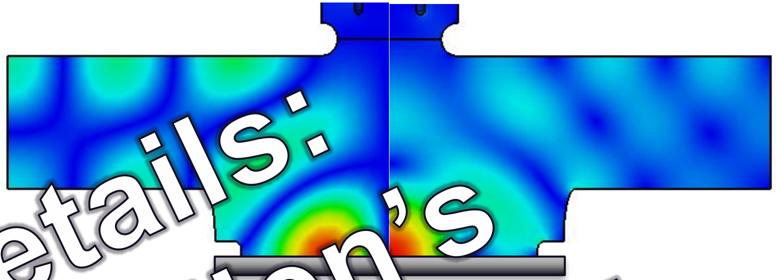

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Summary and near term test plans

- The High Gradient Test Stand CERF-NM is finally coming online
  - Klystron was purchased and commissioned in end of summer 2019
  - Lead enclosure was installed in summer 2020
  - Waveguide assembly was started in Jan. 2021 (delayed due to procurement schedule changes) and fully commissioned in Mar. 2021 for 30MW, 1 μs long pulses, 100 Hz repetition rate
  - The first cavity (from our collaborators at SLAC, OFHC Cu) testing is started in beginning of May 2021 (and is in progress right now)
- FY21 outlook
  - May-June, 2021: testing of SLAC's β(=v/c)=0.5 cavities (both, OFHC and CuAg alloy) for accelerating ions
  - July-August, 2021: conditioning of the mode launchers (converters) for regular test cavities
  - August-September, 2021: testing of room-temperature cavities (OFHC Cu, and CuAg alloys)
- FY22 outlook
  - Continue with room temperature cavities testing
  - Cryogenic temperature testing
  - Material coupons testing

Acknowledgements and Thanks

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- Leadership team (PI, co-PIs and advisors): John Lewellen, Samantha Lawrence, Danny Perez, Evgenya Simakov, Tsuyoshi Tajima
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- Facility support – klystron installation, lead work, etc.
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- Emeritus: Frank Krawczyk, Mark Kirshner
- Slides from: John Lewellen, Evgenya Simakov
- Colleagues at SLAC & UCLA

- **Collaborations at our C-Band Engineering Research Facility in NM are very welcome!**

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