Ultra-high Gradient S-band Linac for Laboratory and Industrial Applications

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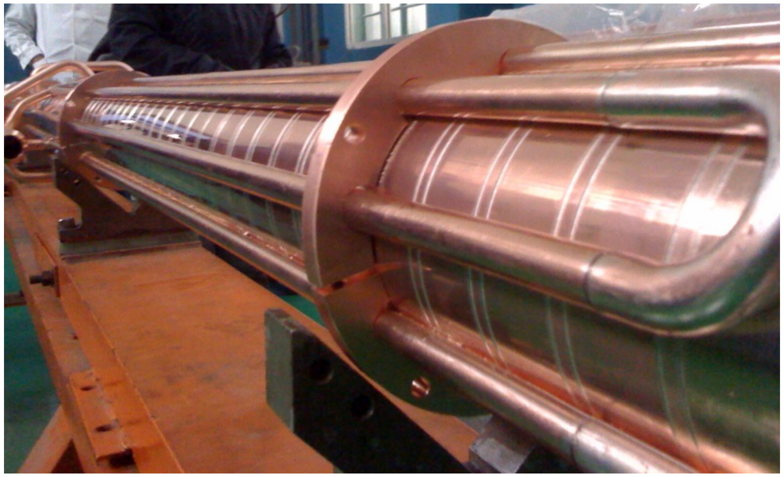
Demand for Compact Structures

- A thrust to increase the gradient of RF accelerating structures has been mostly driven by High Energy Physics goal of building multi-TeV linear colliders.
- In addition, there is an existing and growing demand for compact high gradient structures with more modest performance goals:
  1. Energy upgrade needs in accelerator users facilities where real estate is at premium, such as in hospitals and universities.
  2. Compact injectors into FELs; 4^{th} generation light sources; Compton X-ray sources;
  3. Emerging defense and homeland security applications requiring up to a GeV range accelerators on a moving platform;
  4. Accelerators on a gantry or a robotic arm.

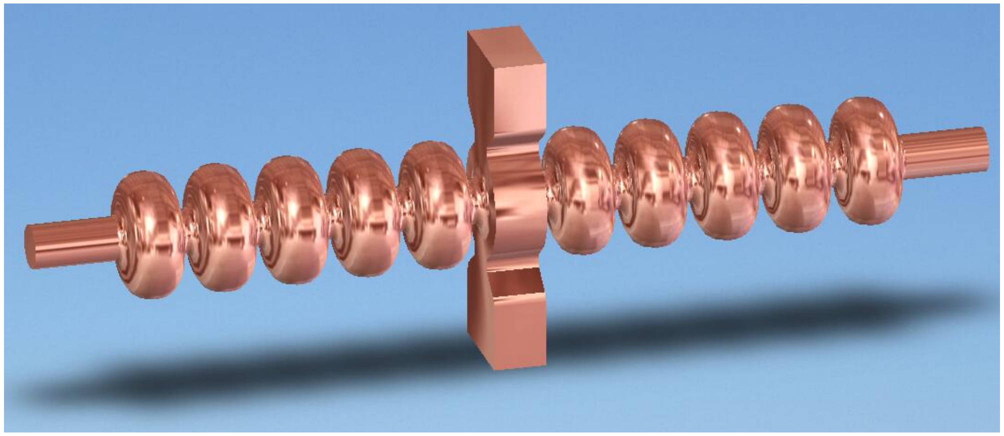
State of the Art

- Experimental X-band structures developed in the context of NLC, routinely cross 100 MV/m gradient boundary.
- However, 100 MW grade X-band klystrons are not readily available.
- SLAC-type 3-m structures, and the likes remain the state-of-the-art industrial offerings since 60's:



DECA Structure

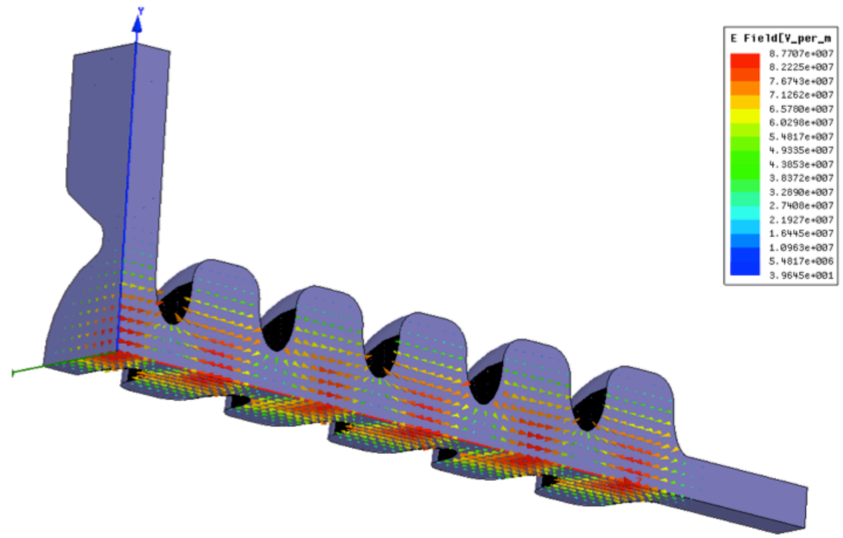
- DECA-Double Energy Compact Accelerator
- Adapt NLC X-band (and S-band photo-injector) design and fabrication solutions towards developing compact, standing wave S-band linac:
  1. Fewer cells per coupler.
  2. Shortened RF pulses (SLED).
  3. Mirror surface finish; advanced cleaning and handling procedures.
  4. Rounded corners, elliptical cells geometry.
- Project goal: demonstrate 50 MV/m accelerating gradient.

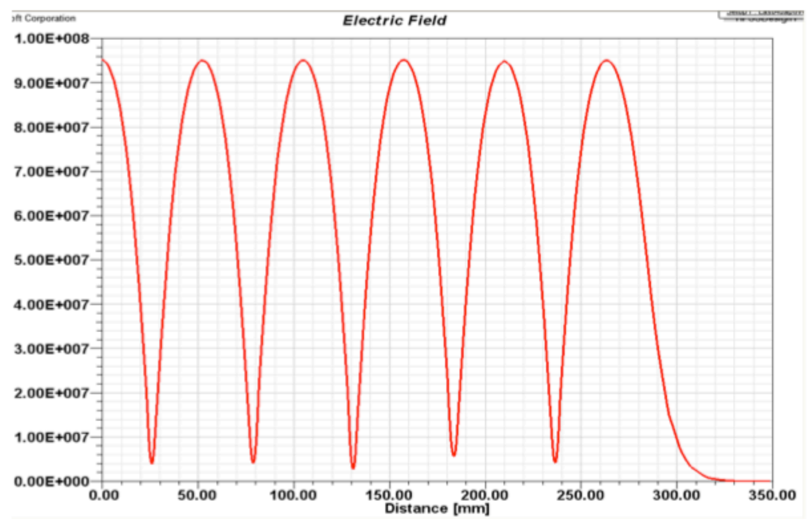


EM-Design

- 3-D electro-magnetic model using HFSS code.
- Optimized parameters:

Operating frequency	2.856 GHz
# of cells per structure	11
Modes separation	3 MHz
Operating gradient	50 MV/m
Input power	30 MW

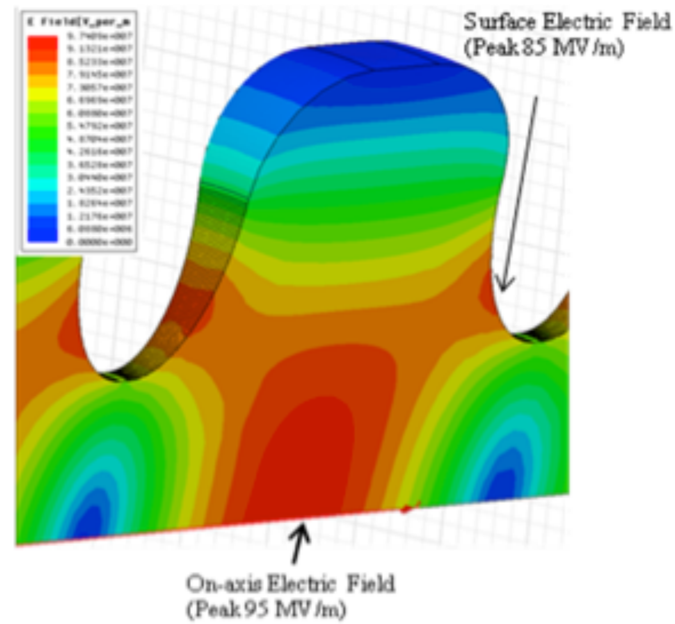


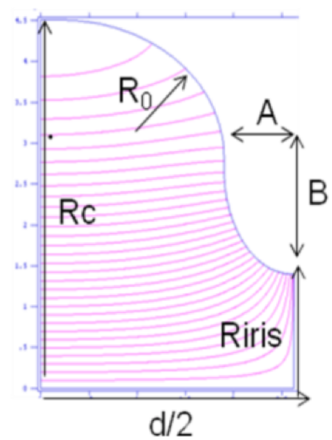


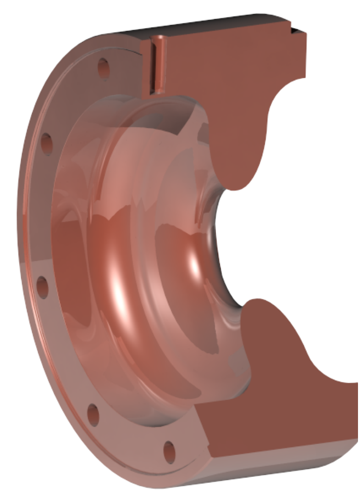
Single Cell Design

- Cell shape was optimized in HFSS
- Elliptical iris shape improves shunt impedance, and reduces surface field

	Circular	Elliptical
Q_0	15,500	18,800
Modes separation	3 MHz	3 MHz
Shunt Impedance	57.8 MΩ/m	78.5 MΩ/m
On-axis peak field	95 MV/m	95MV/m
Surface peak field	106 MV/m	85 MV/m
Field ratio	1.11	0.89
Power dissipation	3.5 MW	2.8 MW

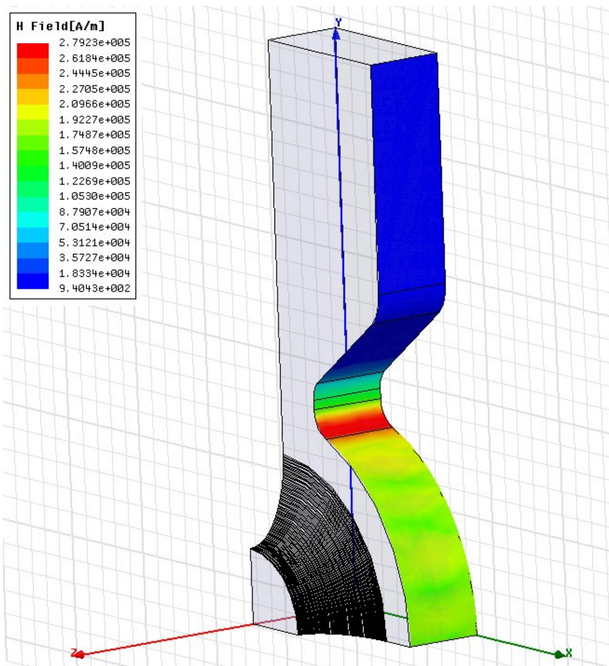


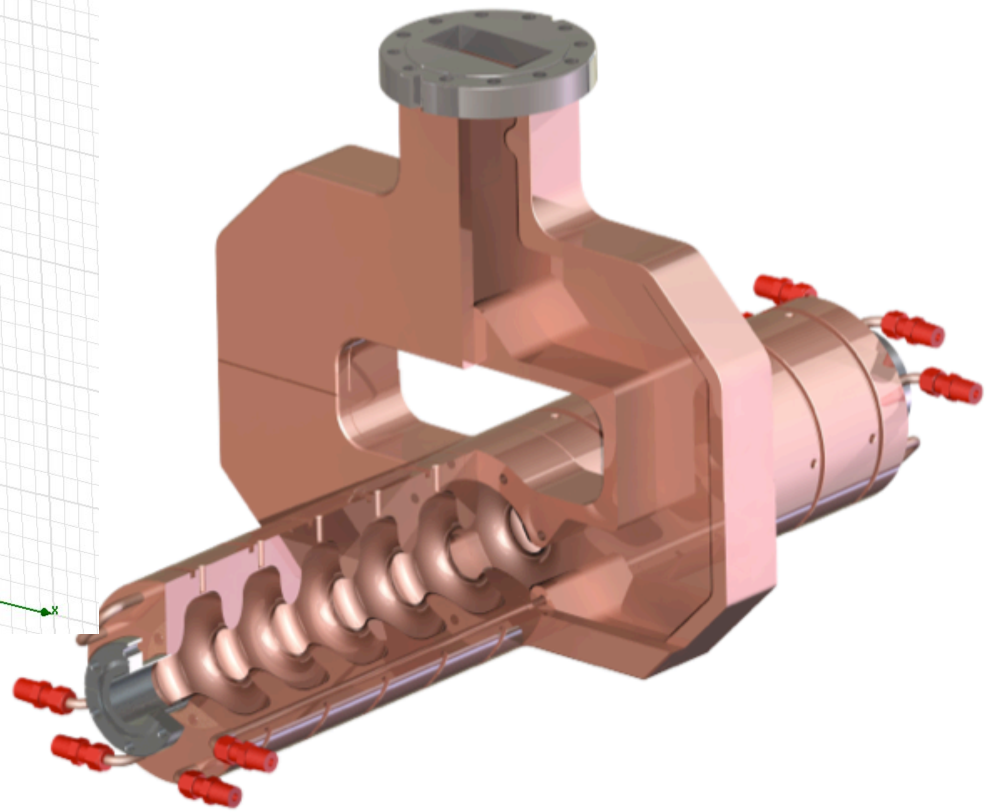


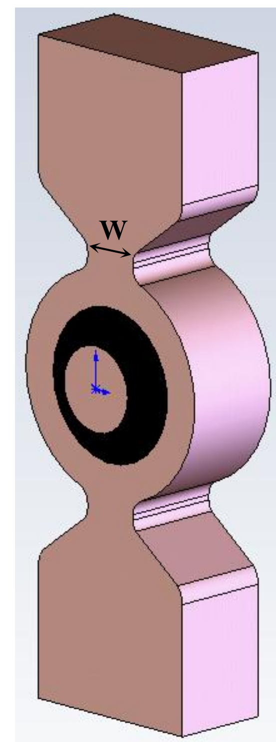


Coupler Design

- Race-track geometry
- Dual feed
- “Fat lip” geometry to minimize magnetic field at the surface

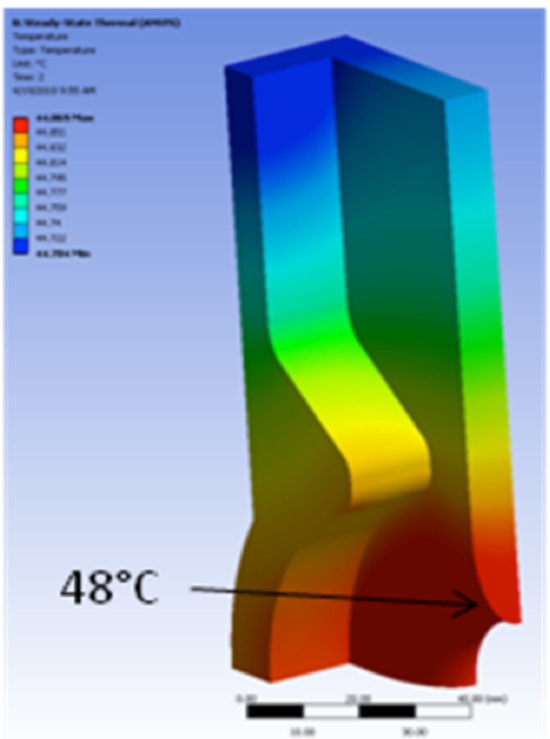


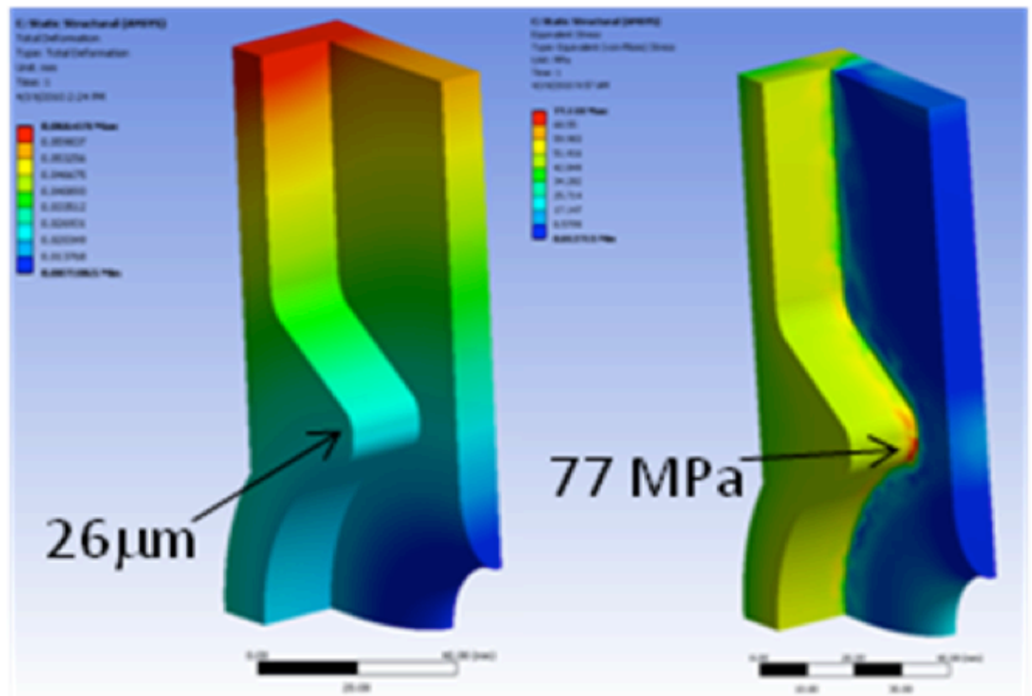




Thermo-Mechanical Analysis

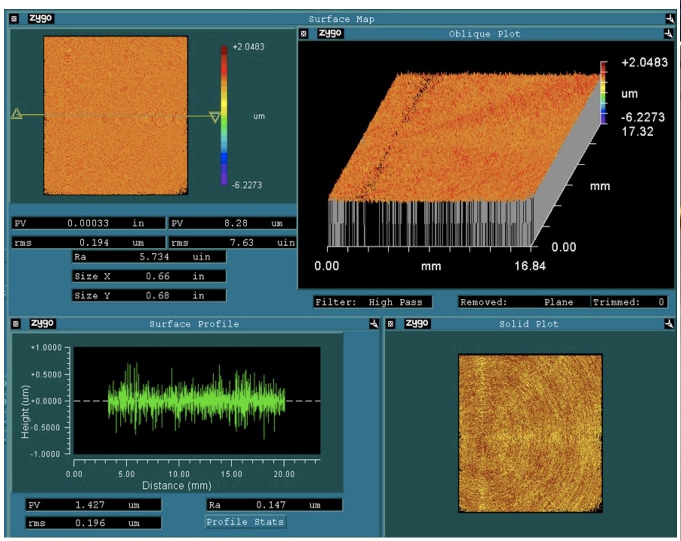
- HFSS field map imported to E-physics
- Thermal and mechanical stress analysis show satisfactory performance

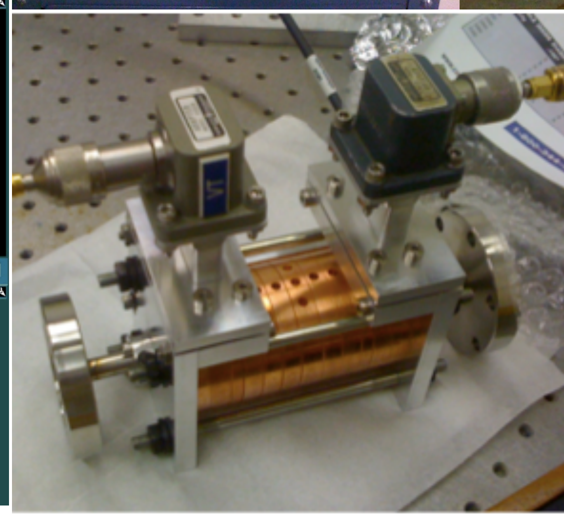


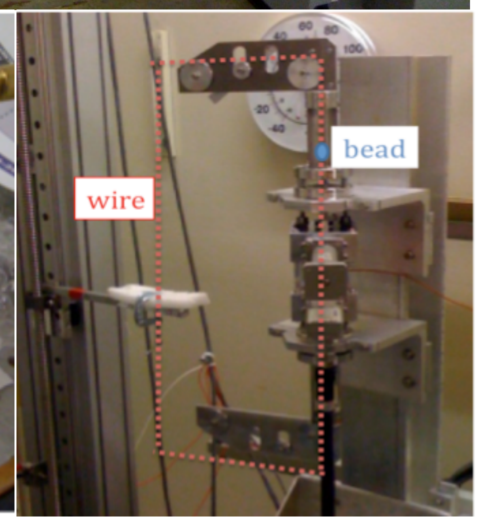


RadiaBeam RF Manufacturing Capabilities

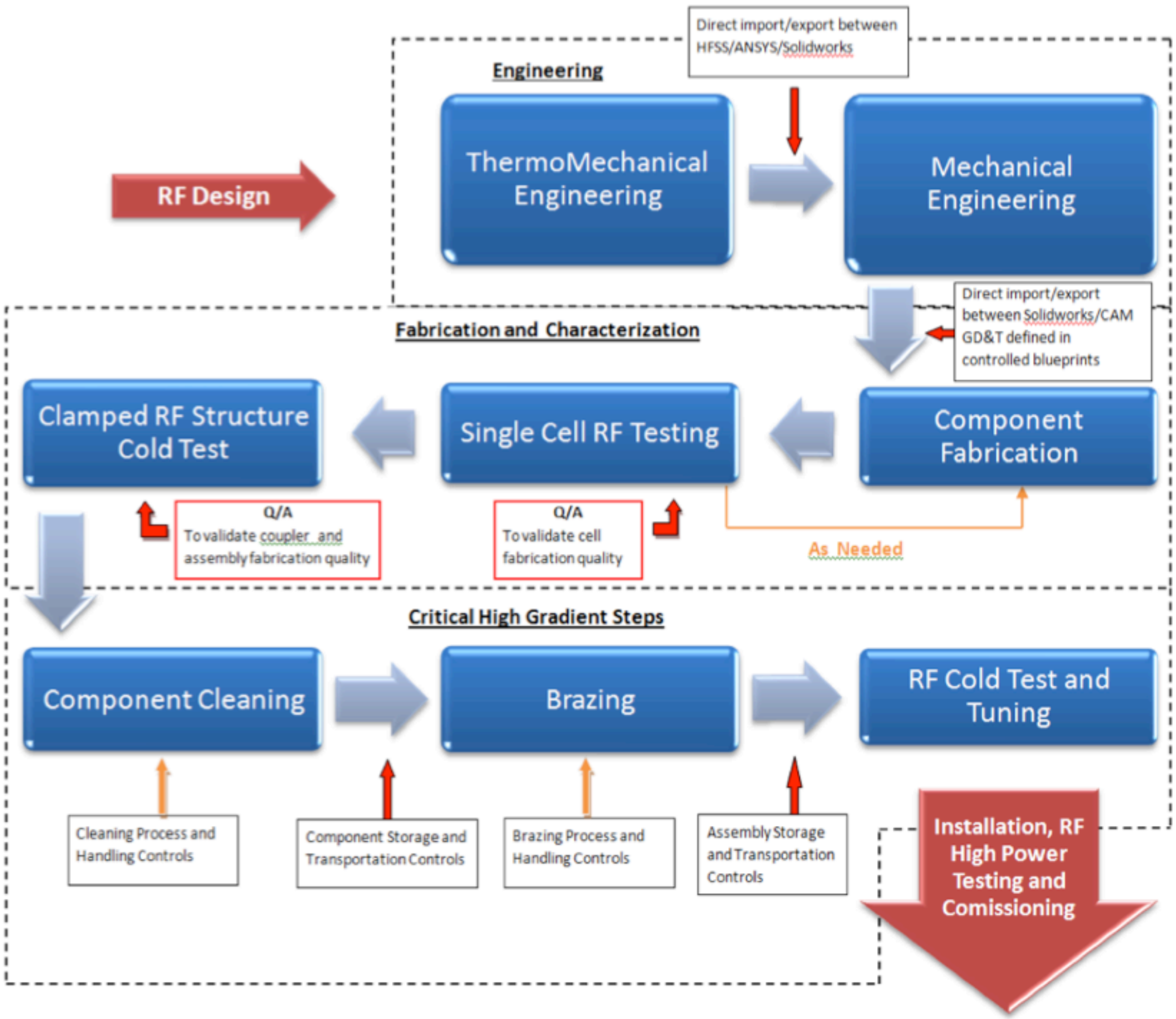
- Presently building X-band deflecting cavity
- In-house manufacturing
- Cleaning room
- Help from SLAC with bead-pull





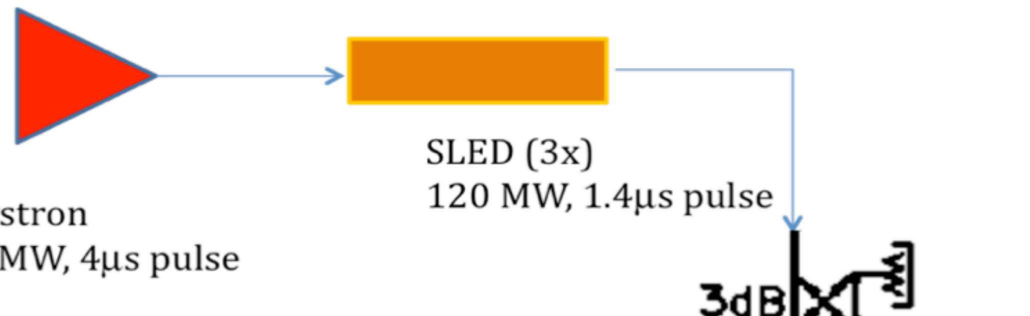


Manufacturing Process



Prototype plans

- Build 2 DECA structures
- Perform proof-of-principle studies at ATF
- Stand-alone high gradient test cell



Conclusions

- RadiaBeam is developing a high-gradient standing wave structure for research and industrial applications.
- Target gradient is 50 MV/m
- Phase II SBIR project started on October 1st
- Planning prototype structures test at ATF BNL
- The prototype tests will
  - validate the product;
  - provide a useful data point on the RF breakdown at S-band;
- This work is supported by DOE HEP SBIR grant No. DE-SC0000866
- Thank you!