U.S. Plan for Cavity Production

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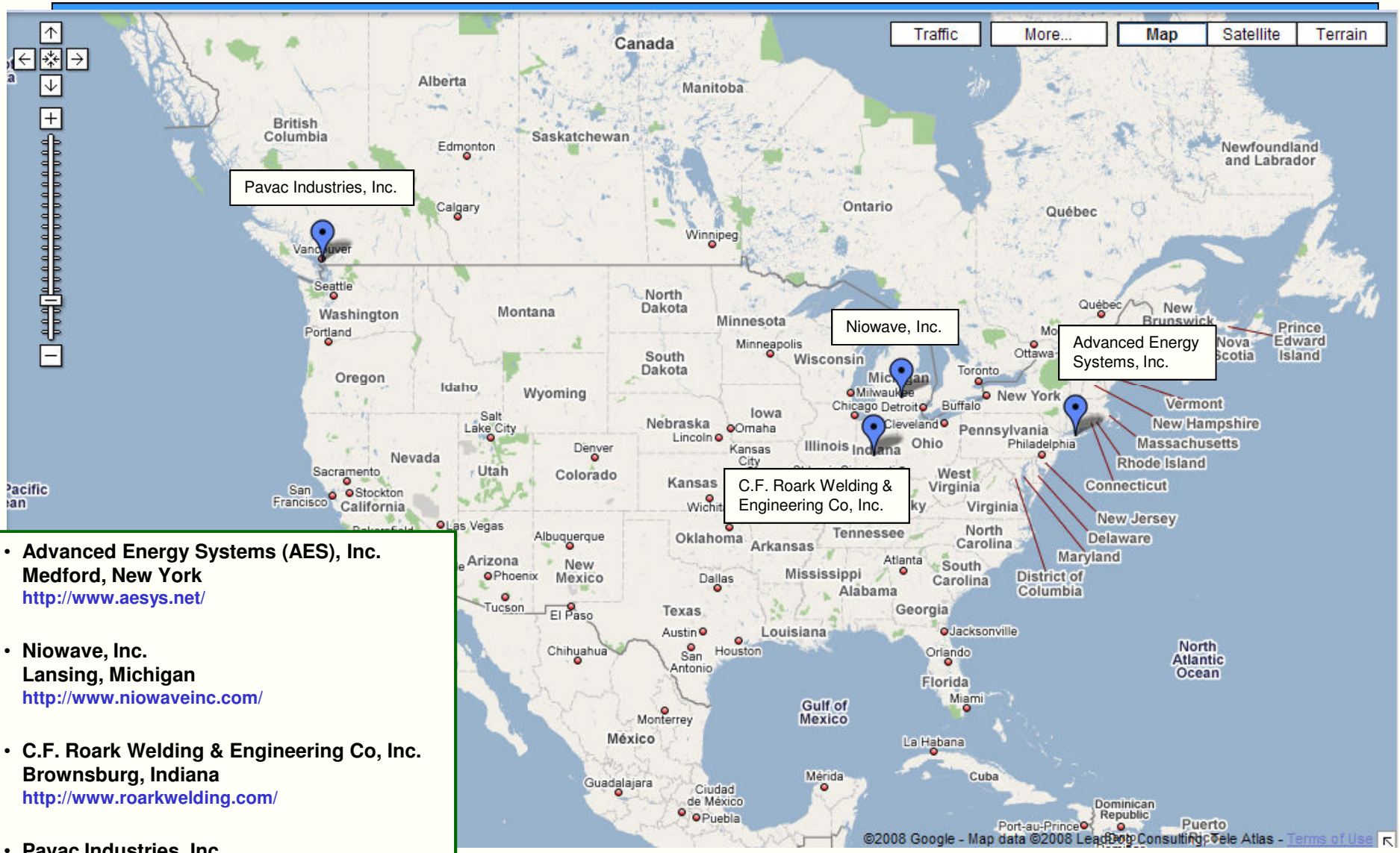
Introduction

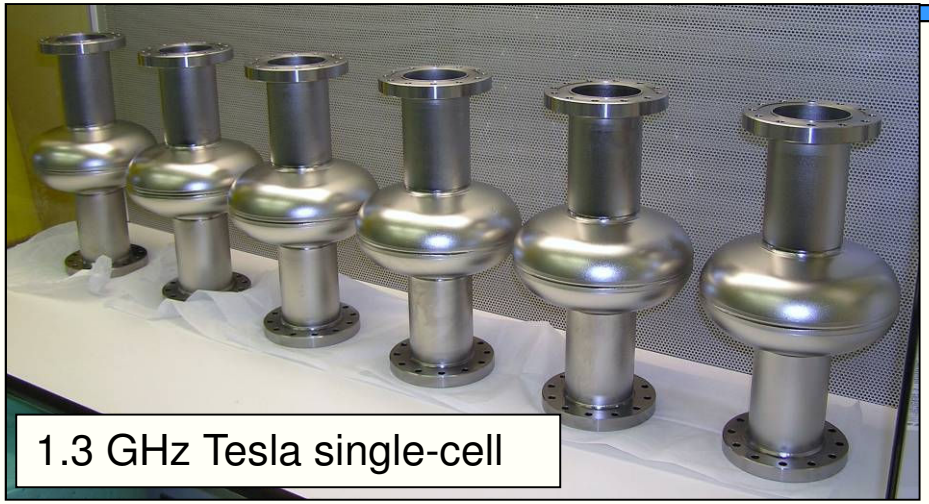
- This talk contains the current U.S. plan for procurement of 1.3 GHz elliptical cavities
- Cavity procurements are needed to support cavity R&D, build cryomodules, and develop cavity vendors
- We currently plan only to purchase Cavities with the "TESLA" shape
- Vendor development in North America is motivated as follows:
  - Promotes competition which should lead to increasing cavity performance and decreasing cavity prices
  - Multiple qualified vendors will ensure product availability in case one vendor ceases operations
  - Increases industrial capacity in preparation for Project X or ILC

North American Cavity Vendors

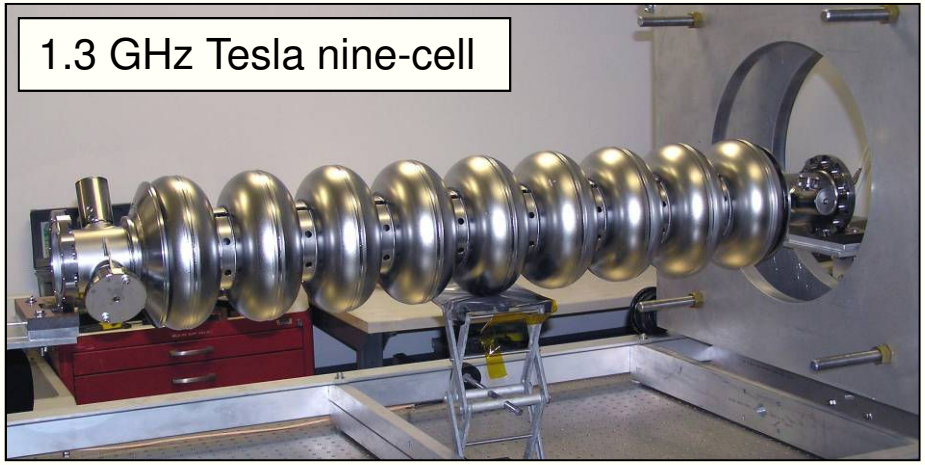


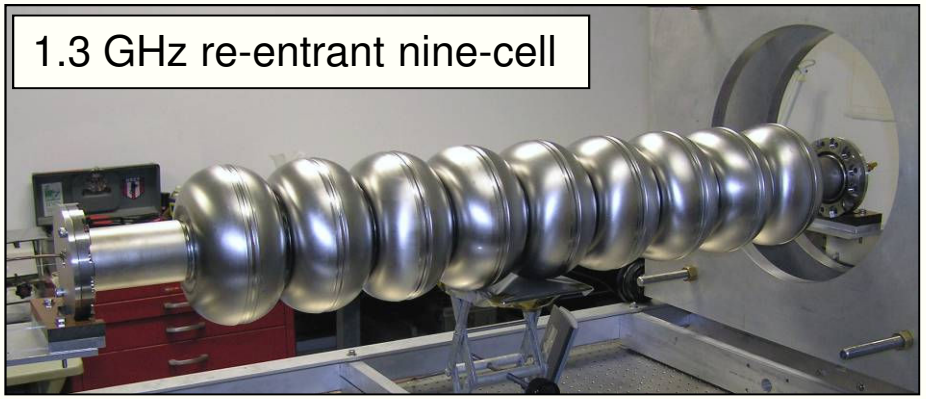
- **Advanced Energy Systems (AES), Inc.**
  Medford, New York
  http://www.aesys.net/
- **Niowave, Inc.**
  Lansing, Michigan
  http://www.niowaveinc.com/
- **C.F. Roark Welding & Engineering Co, Inc.**
  Brownsburg, Indiana
  http://www.roarkwelding.com/
- **Pavac Industries, Inc.**
  Richmond, British Columbia
  http://www.pavac.com

AES has complete production capability on-site
10 nine-cell Tesla cavities delivered to date; 6 more in production


1.3 GHz Tesla single-cell

Electron-beam welding facility

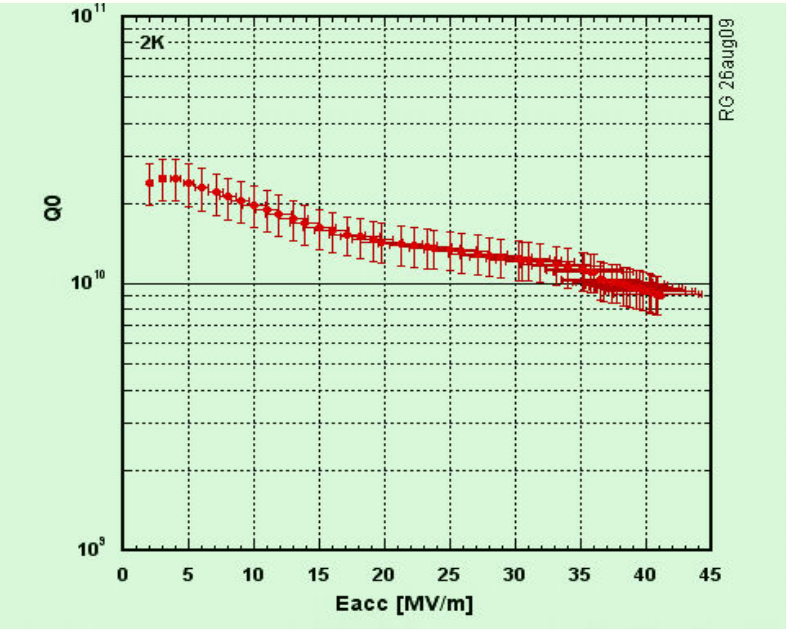

1.3 GHz Tesla nine-cell

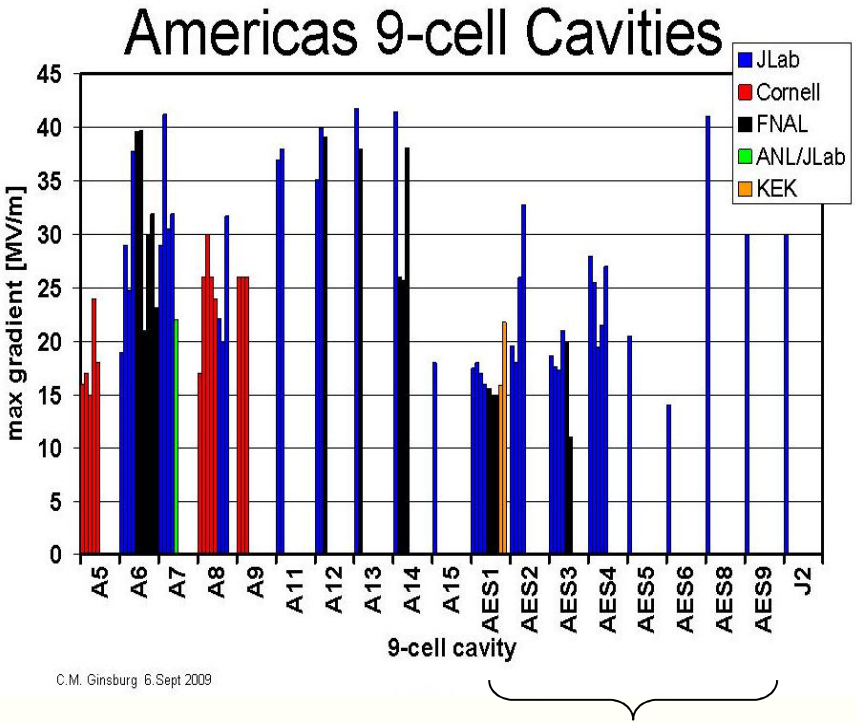

1.3 GHz re-entrant nine-cell

Performance of AES 9-cell cavities

- **Only one of the first batch of 4 AES cavities reached > 30 MV/M**
- **In second batch of 6 cavities, 2 of 4 tested so far reached > 30 MV/M**
- **AES recently reached 41 MV/M!**

AES8 after 1st light EP at JLAB





Yield from latest batch is 25 - 50% but based on low statistics… recent results very encouraging!

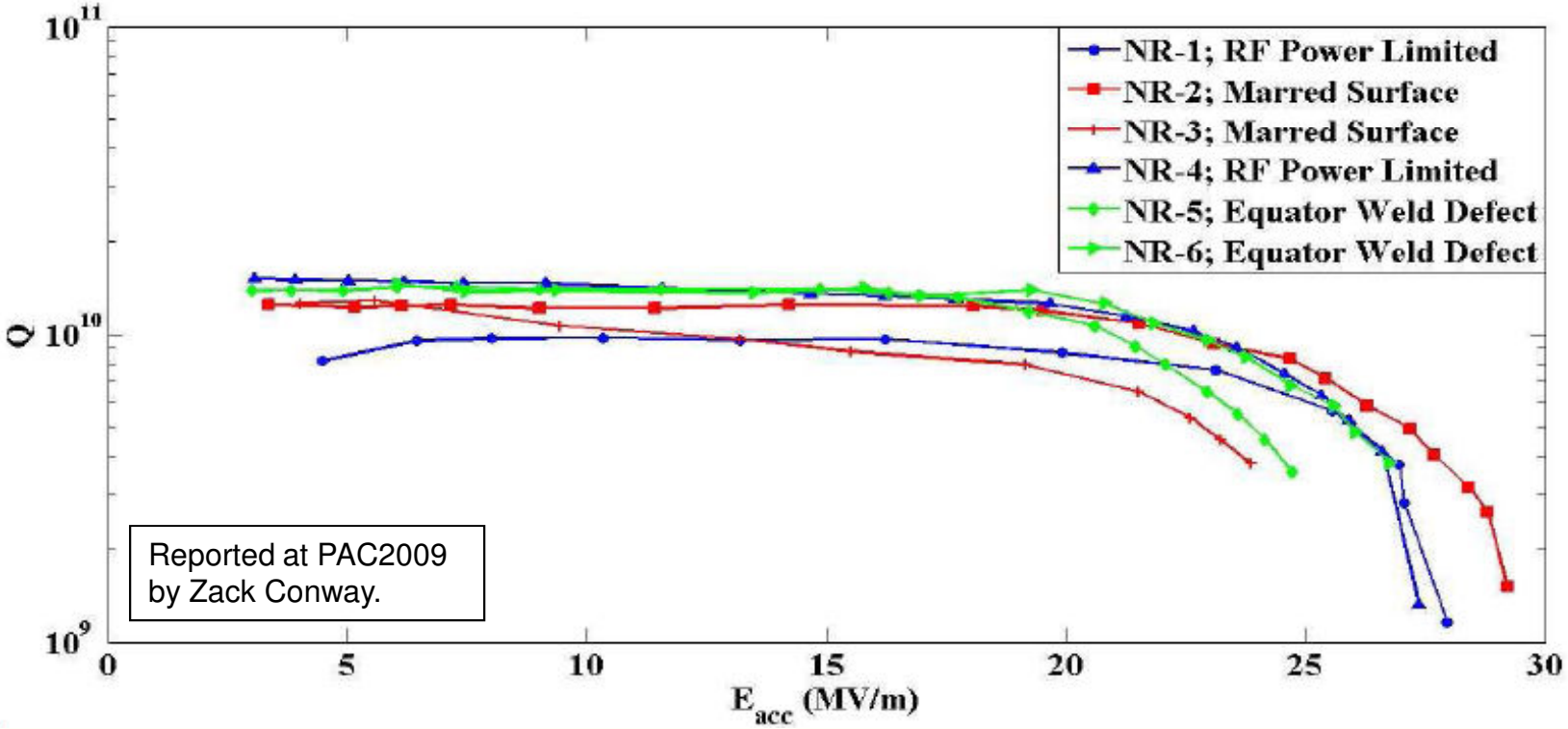
Niowave & Roark collaborate on 1.3 GHz cavities
Roark is working independently on low-beta structures

- Niowave-Roark Tesla single-cell cavities
  - Delivered June 2008
- Six nine-cell cavities currently in production

- Roark 325 MHz beta=0.22 single-spoke cavity
- Delivered Summer 2008
- Design = 10 MV/M @ 4K
- Exceeded 30 MV/M @ 2 K

Pre-Qualified Niowave/Roark Cavities

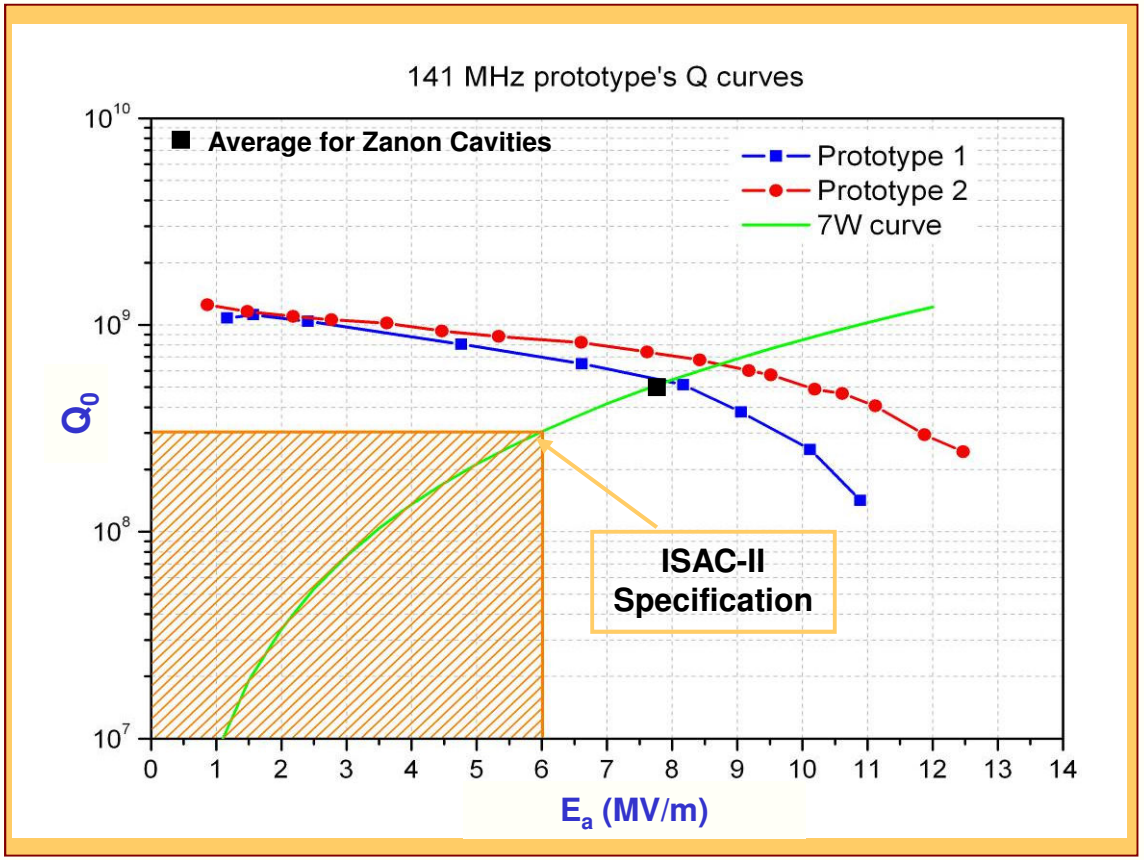
- **Quick pre-qualification of 6 Niowave/Roark 1-cell cavities in 13 cold tests.**
  - **BCP (~150 µm), Ultrasonic Degreasing, HPR, and Clean Assembly.**
- **2 cavities did not quench and showed the expected Q-slope limit due to BCP.** (NR-1, NR-4)
- **2 cavities quenched due to "surface bump" from a defect on the manufacturing die.** (NR-2, NR-3)
- **2 cavities quenched due to pits on equator weld.** (NR-5, NR-6)
- **All quench locations were located by 2nd sound detection and inspected with a Questar long distance microscope.**



Reported at PAC2009 by Zack Conway.

PAVAC is producing 20 coaxial resonators in collaboration with TRIUMF for the ISAC-II Phase-II extension

- Two prototypes manufactured and tested; production under way.
- Both prototypes perform significantly above ISAC-II specifications; average values of E_a=8.2MV/m, Ep=40MV/m cw (specification 6MV/m)
- Pavac is preparing to produce Tesla 1.3 GHz cavities in collaboration with TRIUMF and Fermilab (6 single-cell and 2 nine-cell cavities)



Cavity inventory and planned procurements

Tesla-shape nine-cell cavities		
Description	**No. Cavities**	**Status**
AES 1-4	4	tested
AES 5-10	6	received; testing in progress
AES 11-16	6	due Oct 2009
Accel 6-9	4	tested
Accel 10-17	8	received Mar 2008; testing in progress
Accel 18-29	12	due May 2009
Jlab fine-grain 1-2	2	fabrication complete; testing in progress
Niowave-Roark 1-6	6	due Oct 2009
Stimulus Procurement	40	still in the planning stages; assume first cavities ~April 2010
Total	**88**	
Already Received	24	
Tesla-shape single-cell cavities		
Description	**No. Cavities**	**Status**
AES 1-6	6	tested at Cornell; further testing in progress
Accel 1-6	6	received Dec 2008; testing in progress
Niowave-Roark 1-6	6	tested at Cornell; further testing in progress
PAVAC	4	requisition in progress
Total	**22**	
Already Received	18	

Development of the beta=0.81 cavity for Project X

- **Design principles for the 1.3 GHz beta=0.81 cryomodule:**
  - **The beta=0.81 cryomodule design will be based on the Fermilab Type-4 cryomodule**
  - **Strive to maintain compatibility and similarity between the beta=0.81 and beta=1.0 cryomodules**
    - **Sharing of components → reduced development and construction costs**
- **Start with the beta=0.81 cavity design that was prototyped at MSU**
  - **MSU will process & test two seven-cell prototype cavities**
- **Optimize the cavity design with respect to:**
  - **Number of cells**
  - **Cell geometry and coupling**
  - **HOM spectrum and HOM damping requirements**
  - **Multipacting**
  - **Integration with Type-4 cryomodule design**
- **Work to be done in collaboration with MSU and Indian Institutions**

Complete cavity design capabilities exist at Fermilab

- **We have the people and the software tools needed to design new cavities as needed**
  - **Two good examples: the 3.9 GHz cavities and the 325 MHz single-spoke cavity (beta=0.4)**
  - **Electromagnetic, multipacting, mechanical, and thermal computations performed mainly in the Technical Division / SRF Development Dept.**
  - **Beam dynamics computations performed mainly in the Accelerator Physics Center**
  - **Mechanical design and design/drafting performed in Technical Division and Accelerator Division**

U.S. Plan for Vendor Development

- The vendors learn through experience, so in general they will improve their manufacturing processes over time
- But, feedback from the laboratories is key to obtaining performance improvements
  - We have to process and test cavities quickly and report our findings to the vendors
- Relatively small cavity orders allow for feedback between productions
  - AES made substantial improvements in tooling and installed an electron-beam welder after their first production of 4 nine-cell cavities
- Close communication and regular visits
- Assistance from experts at Cornell and JLab
- Stimulus procurements will give cavity vendors a big boost

Fermilab Meeting with North American Cavity Vendors held in March 2009

Objectives

Fermilab

- **Present the latest results from world-wide cavity gradient R&D**
  - **a series of presentations describing experimental results, theoretical studies, and practical experience**
- **Engage the vendors in discussion of the fabrication, performance and yield issues**
- **Reiterate our interest in increasing North American industrial expertise and capacity for the production of niobium RF cavities**
  - **We seek multiple vendors of high-gradient high-yield TESLA-shape nine-cell cavities for Project X at Fermilab and for the ILC project**
  - **Project X also requires a number of other types of niobium cavities, including beta=0.81 elliptical cavities at 1.3 GHz and an assortment of single-spoke and triple spoke low-beta cavities at 325 MHz**

One significant outcome was that we should have a similar meeting with the niobium vendors!

Another was a program for a set of EBW samples for evaluation

Start Times	Duration	Description	Speaker	Affiliation
8:30	10	Introduction	Mark Champion	Fermilab
8:40	30	Overview of nine-cell cavity progress	Camille Ginsburg	Fermilab
9:10	30	Observations at Fermilab	Genfa Wu	Fermilab
9:40	30	Observations at Cornell	Zack Conway	Cornell
10:10	20	Break	all	
10:30	30	Observations at Jefferson Lab	Rongli Geng	Jefferson Lab
11:00	30	Fundamental studies and issues	Lance Cooley	Fermilab
11:30	15	Material studies	Chris Compton	MSU
11:45	15	Fermilab plans for Cavity Development in Industry	Bob Kephart	Fermilab
12:00	60	Lunch	all	
1:00	120	Discussion	all	
3:00		Close	all	

Summary

- Cavity procurements are needed for cavity R&D, cryomodule fabrication, and vendor development
- Fermilab is engaged in vendor development with three North American cavity vendors: AES, Niowave/Roark, and PAVAC (in collaboration with TRIUMF)
- Fermilab has complete cavity design capabilities
- The beta=0.81 cavities for Project X are being developed in a collaboration between Fermilab, MSU and Indian Institutions
- We are enthusiastically pursuing vendor development, which depends on timely processing and testing of cavities as well as a strong cavity R&D program