ELLIPTICAL SCRF CAVITIES

- **Established Fabrication Method**

  Disks are cut from high purity niobium sheet and scanned for pits, scratches or inclusions of foreign material. Disks failing scan are rejected.

  Half-cells deep drawn from disks: extra material left at iris and equator to allow for weld shrinkage and tuning.

  Half-cells EB welded at iris to form dumbbells: stiffening rings EB welded to prevent Lorentz Force detuning -- dumbbells measured for frequency and equators trimmed accordingly.

  End tubes, FPCs and HOMs formed by vendor preferred method (rolled and seam welded, back extruded, etc) -- flanges and other components machined.

  End assemblies EB welded, measured for frequency and end half-cells trimmed accordingly.

  Dumbbells EB welded at equators to form cell structure: end assemblies EB welded to cell structure to complete cavity.

  NOTE: Each EB welding operation above requires parts to be degreased and BCP acid etched as weld preparation. **There are ~ 70 EB welds per cavity**.

ELLIPTICAL SCRF CAVITIES

- **Why EB welding?**

  EB welds produce localized heat effected zone resulting in minimum distortion (a necessity with the tight tolerances on cell profile).

  EB welds are fusion welds -- no secondary medium required.

  Depth of penetration is easily controllable.

  Excellent repeatability.

  EB are welds done in vacuum, thus reducing the opportunity for contamination.

ELLIPTICAL SCRF CAVITIES

- **Cavity fabrication cost: mass production mode (DESY)**

  ~ $60K per cavity

  Material 45%

  Machining 42%

  Welding 6%

  Other 7%

  Maximum gains in cost reduction achievable by reducing machining and/or material costs

ELLIPTICAL SCRF CAVITIES

- **Alternative cavity fabrication methods**

Motivation based on potential cost savings -- no known alternative methods claim to improve performance.

1. Methods to reduce material costs (niobium film coating on substrate)
2. Methods to reduce machining costs (hydroforming, spinning)
3. Methods to further automate fabrication steps (innovative welding fixture design, EB welding machine configuration)

1. Hydroforming or spinning cell structure

From seamless niobium tube or from niobium clad copper tube

Alternatives to the Standard

Hydro-forming

(Singer-DESY, KEK)

Spinning

(Palmieri-INFN)

ELLIPTICAL SCRF CAVITIES

Potential advantages:

Eliminate machining of dumbbell equators.

Eliminate welds in high field regions of the cavity.

If formed from niobium clad copper tubes may significantly reduce material (niobium) costs.

Potential disadvantages:

Seamless niobium tube production possessing uniform formability properties and sufficient length for 9-cell cavity requires further R & D.

Niobium clad copper tubes may delaminate from stresses due to thermal cycling.

Single pass EB welds required to join 9-cell structure to end assemblies -- difficult.

ELLIPTICAL SCRF CAVITIES

2. Form end assemblies from brazed copper components followed by niobium film coating.

Potential advantages:

Reduce material (niobium) costs.

Eliminate some EB welding costs.

Potential disadvantages:

Complex internal end assembly geometry makes uniform niobium film deposition problematic.

Possibility for copper migration into critical weld joint.

ELLIPTICAL SCRF CAVITIES

- **SCRF cavity fabrication at FNAL -- completed, in progress and planned:**

  1. 3.9 GHz 3rd harmonic cavities

  Cryomodule with four cavities promised to DESY.

  Three cavities completed (FNAL/JLAB) -- apparent problem with HOM design -- fourth cavity with modified HOM in final assembly stage at Jlab.

  Six additional cavities with revised HOM design are in progress.

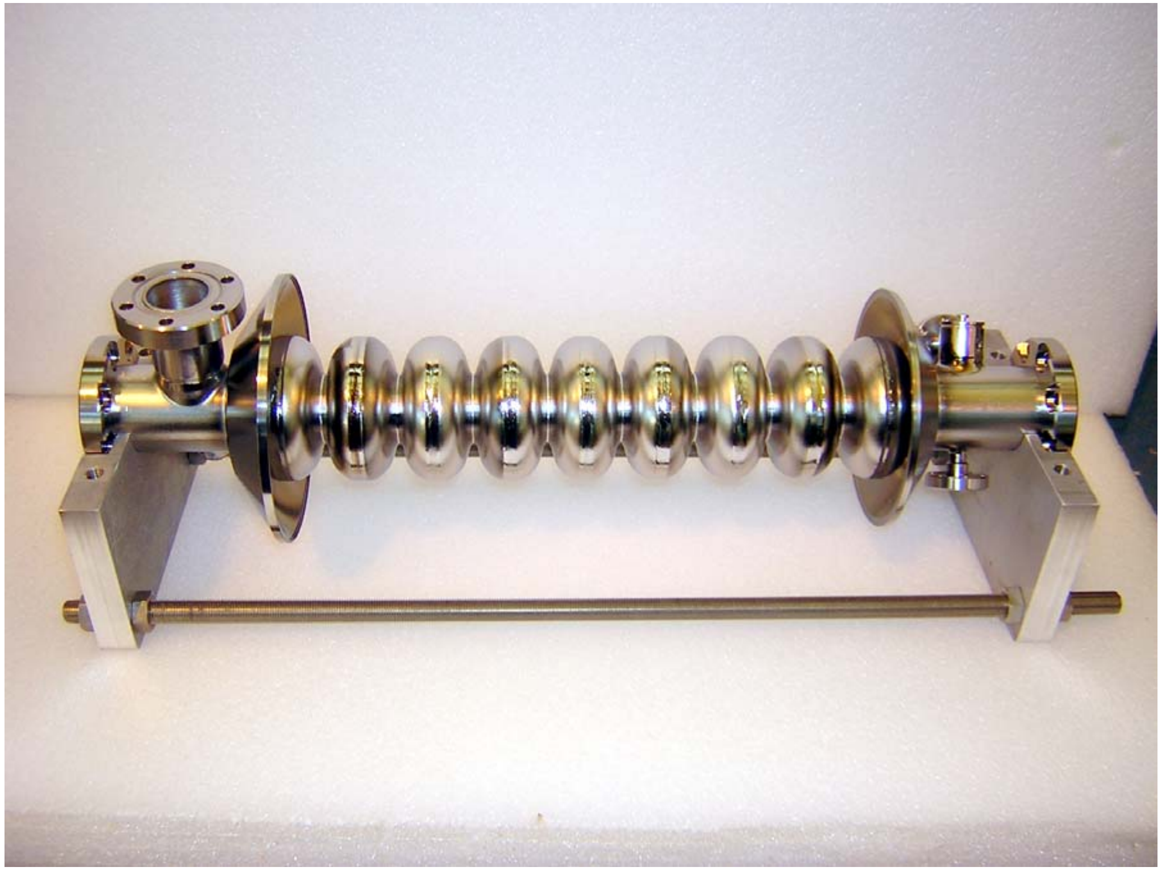
  Large grain one-cell cavity planned (FNAL).

  Single grain one-cell cavity planned (JLAB).

  Three one-cells complete (FNAL) and three one cells in progress at Roark.

  Single-cell cavities useful for R & D studies on cavity processing methods (EP, tumbling, etc).

ELLIPTICAL SCRF CAVITIES



ELLIPTICAL SCRF CAVITIES

2. 3.9 GHz deflecting mode cavities

Various one-cell and 3-cell cavities.

One 9-cell and one 13-cell.

New design in progress at low level of priority.

3. 1.3 GHz ILC cavities

Four ACCEL (asymmetric end tubes) received.

Four AES (asymmetric end tubes) in final assembly stage.

Eight ACCEL (symmetric end tubes) on order.

Six AES (symmetric end tubes) on order.

Two JLAB large grain (symmetric end tubes) due February.

Two JLAB (asymmetric end tubes) in progress.

FY2007 plan: order 24 cavities COST ~ $1.7M

ELLIPTICAL SCRF CAVITIES

- **Industrialization: US vendor development**

  Must involve industry more and utilize their expertise

  AES -- experienced, but need to prove capability with ILC cavities -- awaiting tests of first four cavities.

  ROARK -- appear capable, but need significant hand holding. Currently fabricating three 3.9 GHz 3rd harmonic one-cell cavities (funded at ~ $45K) as Phase 1 of a potential three phase effort. Phase 2 would entail building one single-cell 1.3 GHz ILC cavity (**need ~ $120K to fund this phase**). Phase 3 would be

  NIOWAVE/ROARK collaboration -- complementary capabilities. Fabricate two nine-cell1.3 GHz ILC cavities (**need ~ $400K to fund this phase**).

ELLIPTICAL SCRF CAVITIES

- **Need for EB welding machine at Fermilab: Why?**

  Remove dependence on Sciaky. Sciaky machines in use for contract welding are always for sale. In FY2005 the machine we were using for 3rd harmonic cavity fabrication was sold causing an eight month delay in our schedule. Also, transportation of parts to Sciaky and their machine shop environment increase the potential for damage and/or contamination.

  It will facilitate the investigation of alternative fabrication methods so as to reduce cavity cost.

  It can be used to investigate alternative cavity cell shapes with the goal of improving accelerating gradient.

  Utilize as a training facility to transfer cavity fabrication methodology to potential US vendors.

  COST ~ $1.5 - 2.0M M&S plus $200K SWF

  Locate in CPF where ultrasonic cleaning tanks, pre-weld BCP facilities, clean rooms, and RF measurement equipment will be available.

ELLIPTICAL SCRF CAVITIES