X-Band Traveling Wave Deflecting Mode Cavity

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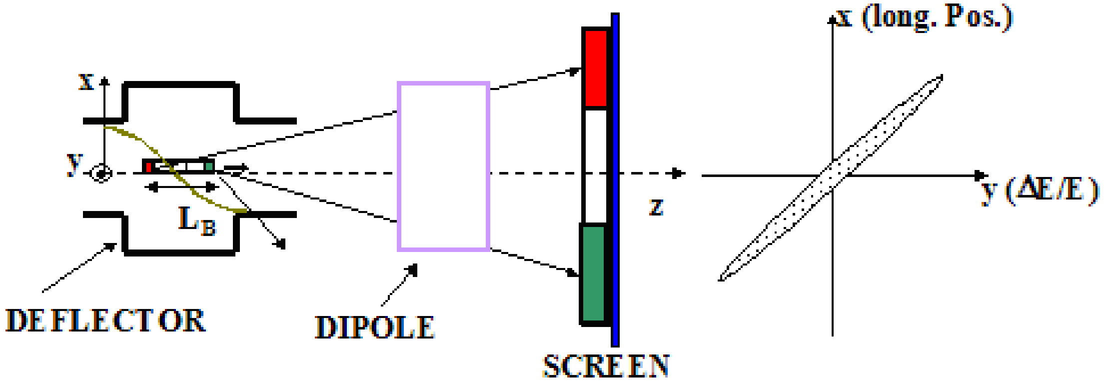
- **Motivation**
- Fabrication and Testing
- Experimental Plans

Motivation

- A precise longitudinal shaping of the relativistic electron bunches is a critical requirement for the on-going and future experiments and devices:
  - FELs (the gain length exponential dependency on peak current)
  - Advanced acceleration schemes (injection into the laser and plasma acceleration devices)
  - Thomson sources (short X-ray pulse production requires longitudinal beam shaping)
  - NLC (luminosity at the interaction point is a function of peak currents)
- X-band deflecting cavity offers unique resolution capabilities

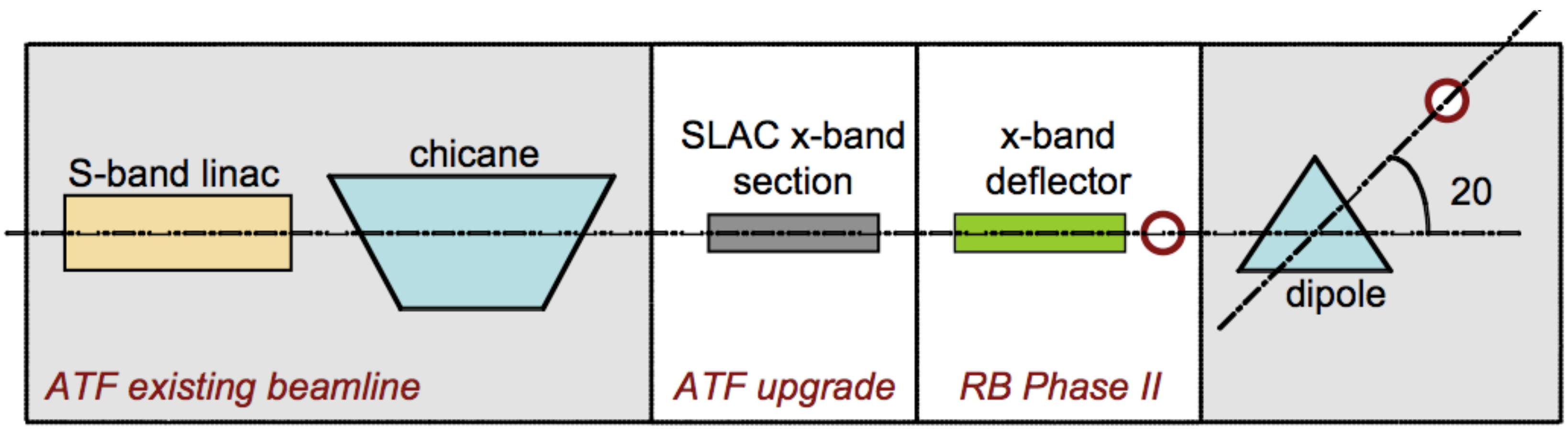
Motivation

- Important features:
  - directly map the electron beam longitudinal phase-space (including sliced measurements)
  - single-shot measurements
  - can be used to calibrate non-expensive and less destructive devices
  - does not rely on any pre-assumptions about the beam current profile
  - excellent temporal resolution



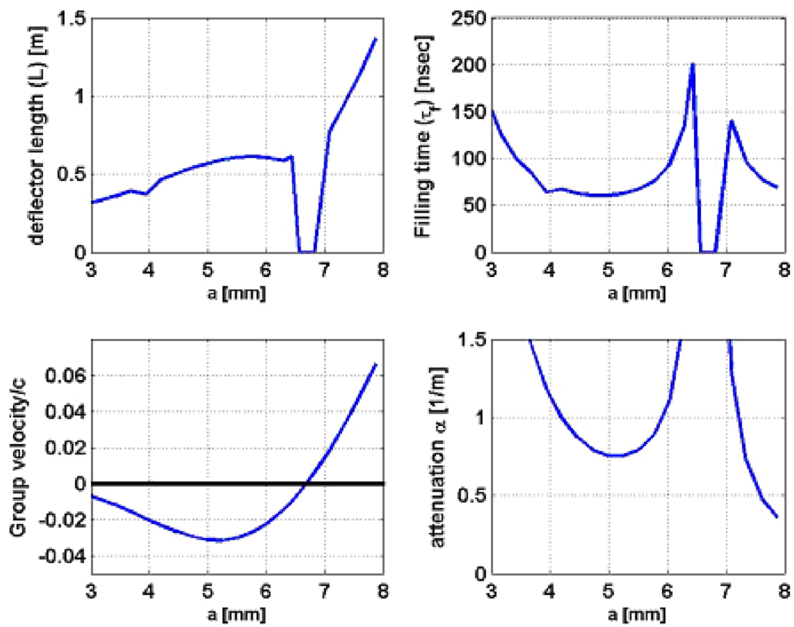
Experimental Layout

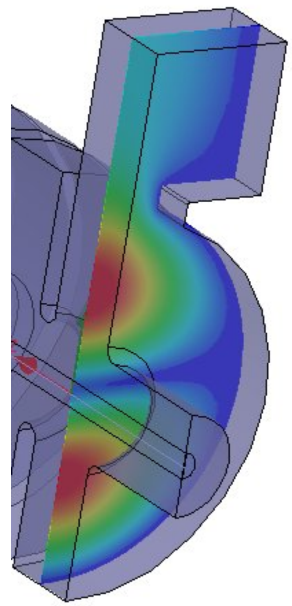
- Original plan was to install XTD at ATF in sequence with "silencer" cavity.



Design Parameters

- 3-D model was developed and optimized numerically:



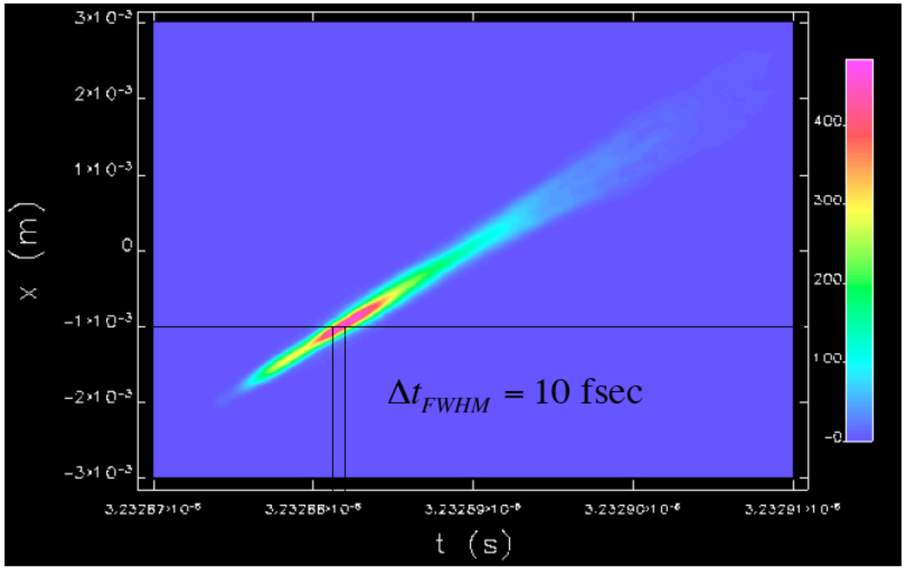


Parameter	Value	Unit
$\sqrt{Z}=E_0/P^{1/2}$	8.48	$kV/mW^{1/2}$
α	0.660	m^{-1}
v_g/c	0.0267	-
$E_{max}/P^{1/2}$	20.57	$kV/mW^{1/2}$
L_{TOT}	0.46	m
$E_{max}/P^{1/2}$	92	$kV/mW^{1/2}$
τ_F	57	ns
N_c	53	-
P_{out}/P_{in}	0.55	-

Designed Performance

- The deflector resolution was simulated to be 4 fs RMS, which is perfect for ATF compressor (~70 fs beam):

$$\Delta x_d = \omega_{RF} \Delta t \sqrt{\beta_d \beta_f} \left(\frac{eV_0}{E} \right) \sin\left(\Delta \psi_\beta\right)$$



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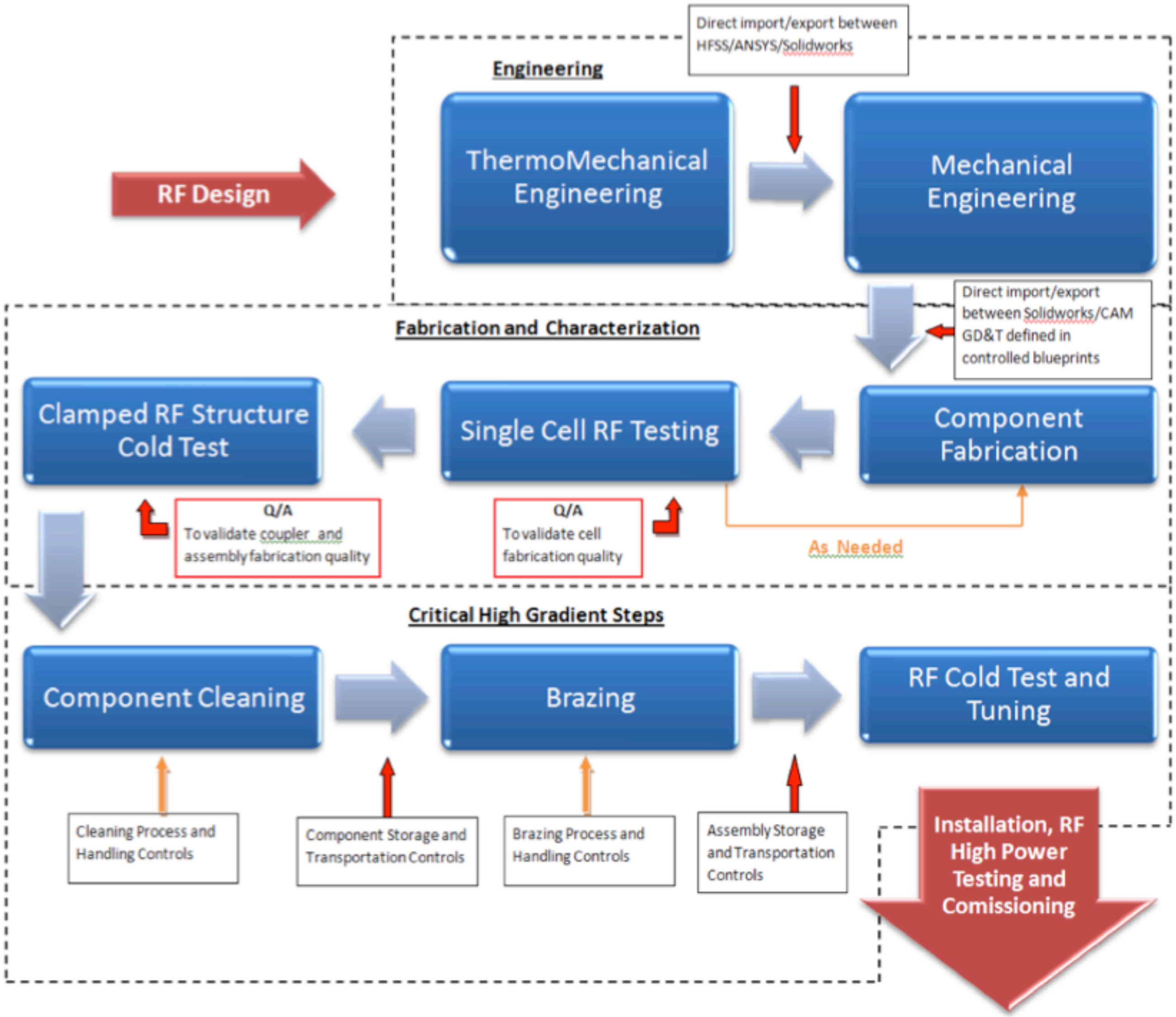
Manufacturing Process



Timeline

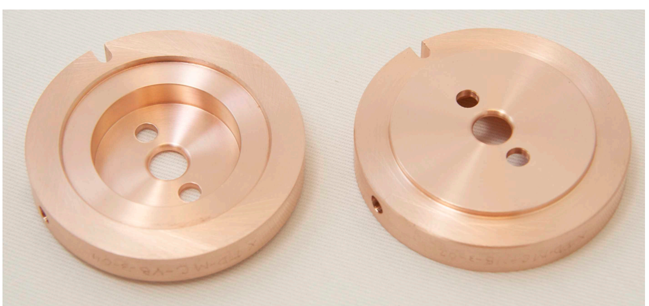
- 1st prototype built in late 2007; after QA decided to built in house;
- 2008-2009: in house manufacturing, CNC upgrade to improve surface finish, project runs out of funds;
- 2010: 2nd prototype tests, bead pull, 15 MHz red shift, debugging
- Installation at ATF – early 2011 (transfer to UCLA).

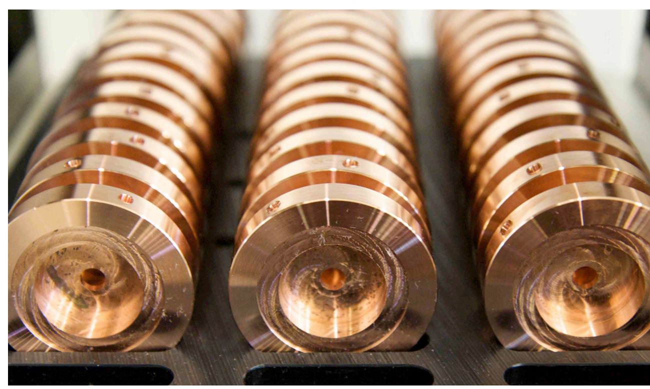
<u>From ATF Users meeting in 2007:</u>

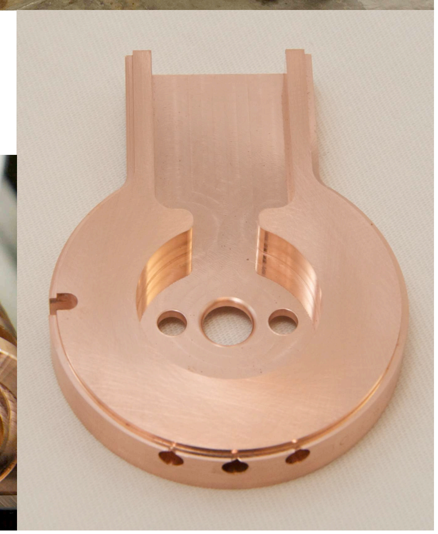
- Initial design and cold test were performed during Phase I (in 2006)
- 3-D RF design of the structure is finalized
  - single cell design;
  - couplers;
  - polarization control;
  - analysis of tolerances;
  - tuning requirements.
- Engineering design is nearly complete
  - 3-D CAD drawing;
  - cooling channels design;
  - waiting for a feedback from the vendors.
- Manufacturing
  - test of the geometry distortion due to brazing is on the way;
- Installation at ATF - end of 2007

Present Manufacturing Capabilities

	Specified tolerances	Achieved Tolerances*
Cell diameter	+/- 0.0005	+/- 0.0002
Cell Length	+/- 0.0005	+/- 0.0002
Iris Diameter	+/- 0.0005	+/- 0.0005
Flatness	.0005 inch	.0002 inch
Surface Finish	8 micro-inch	4-6 micro-inch

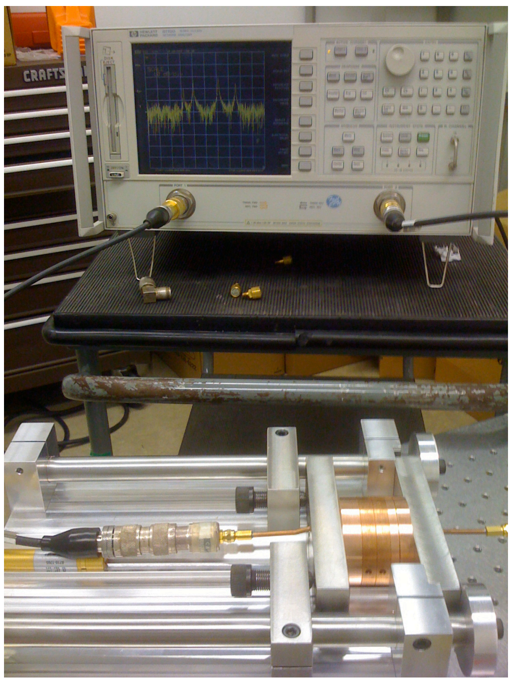


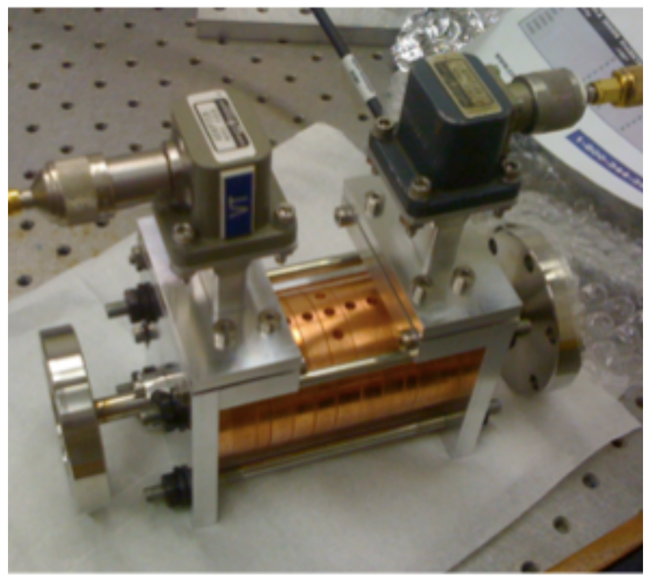


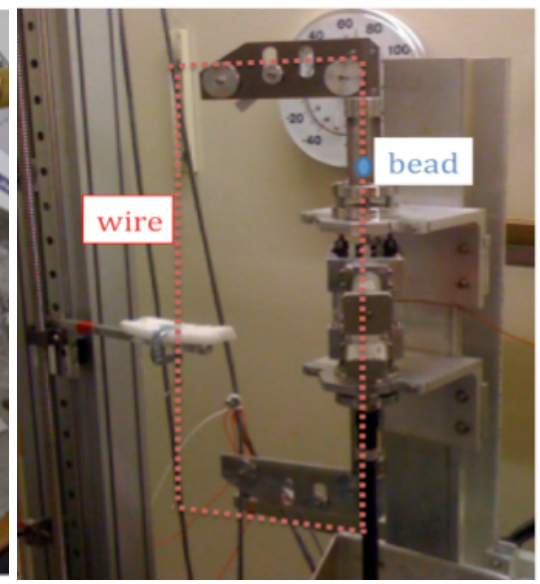


RF Testing

- RF Cell Stack testing at RadiaBeam
- 2nd prototype has been bead pull tested at SLAC







RF Test Results

- Good news after bead pull: couplers are close to perfect.
- Bad news – consistent red shift of 15-20 MHz throughout all of the RF measurements.
- Contributing factors:
  - NO filler 1.5 MHz down
  - Vacuum 1-2 MHz down
  - Humidity 1-2 MHz down
  - *Mode holes shape is slightly different in the model (10 MHz)*
- Compensated with 20 μm change in cells diameter, new cells are in fabrication.

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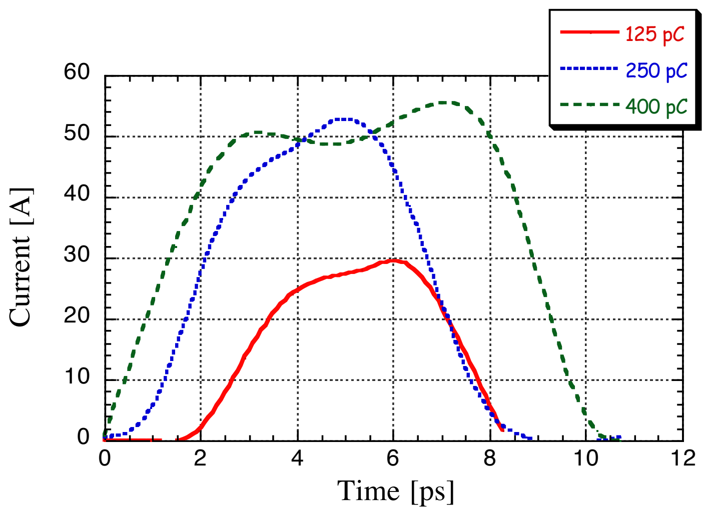
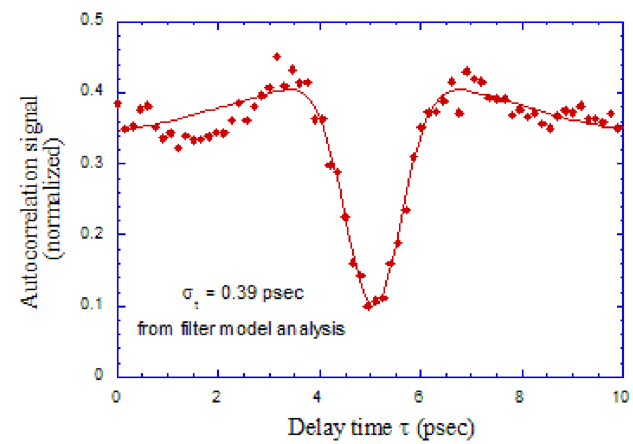
Experimental program

- Deflection cavity cross-calibration with other diagnostics:



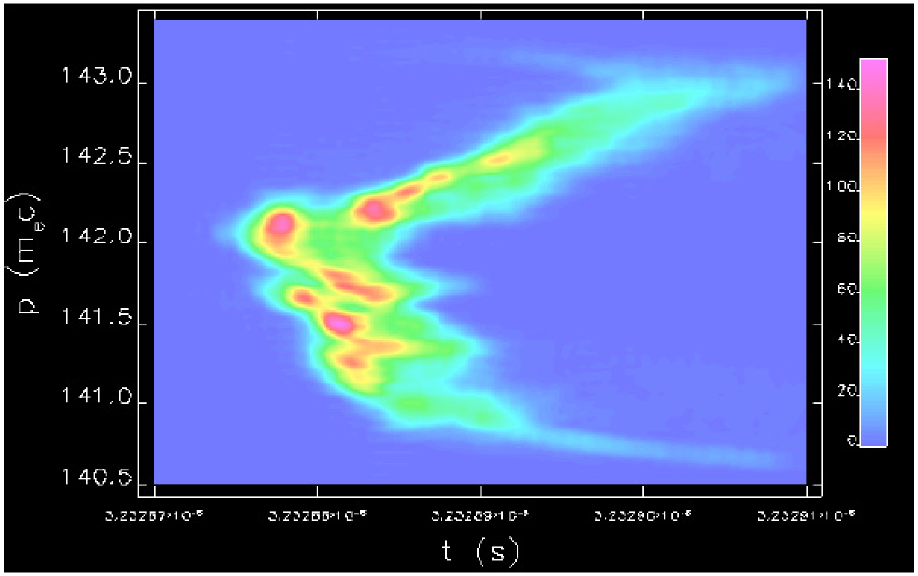
momentum-phase mapping with the linac

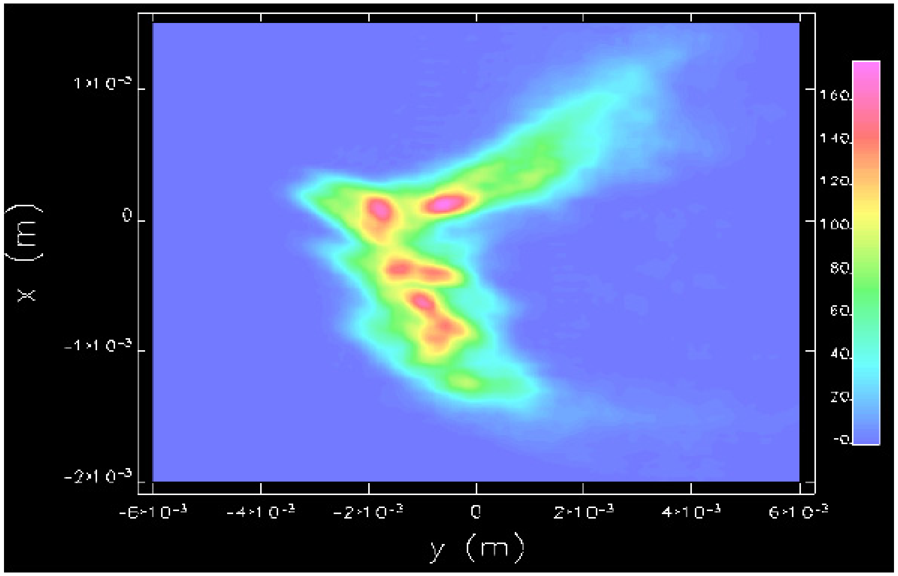


CTR autocorrelation

Experimental program

- Measuring CSR effect on the longitudinal phase space of the compressed beam:





Conclusions

- RadiaBeam is developing an X-band deflecting cavity.
- Target longitudinal resolution at ATF is in femtosecond range
- Present status: in fabrication
- Commissioning will be performed by UCLA
- This work is supported by DOE HEP SBIR grant No. DE-FG02-05ER84370