Status of MEBT development

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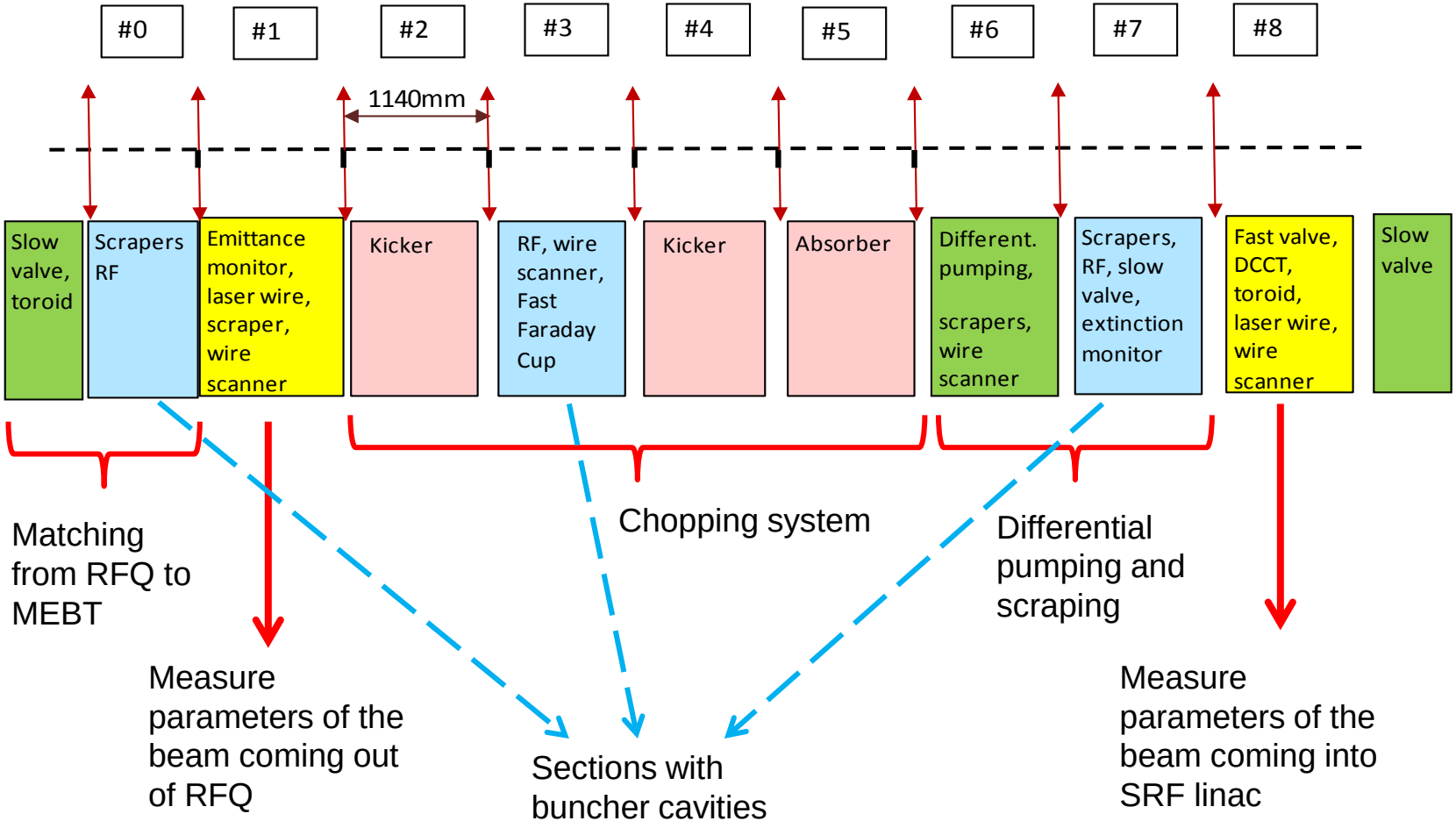
Project X meeting, June 7, 2013

MEBT scheme



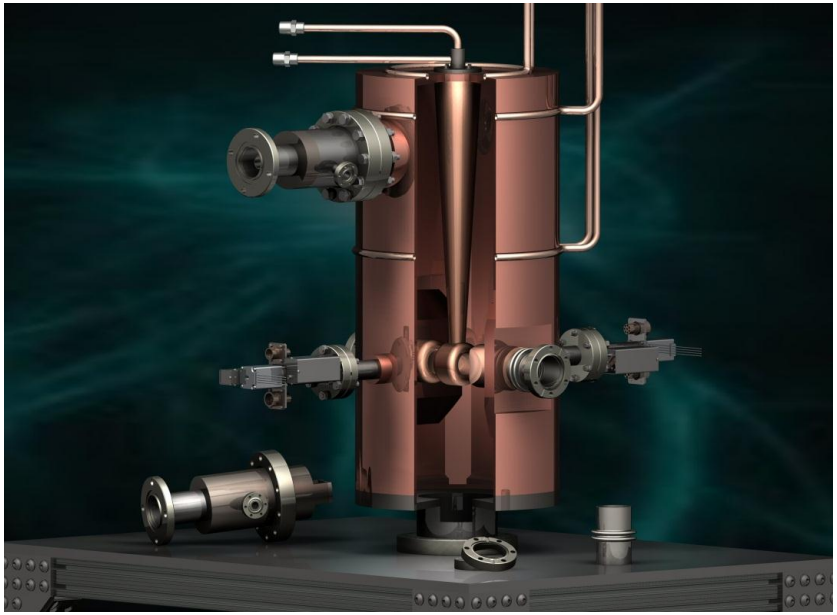
- Structure, optics, dimensions are unchanged in more than a year

Development efforts

- Chopping system (next slides)
  - Two version of kicker and absorber
- Bunching cavities (next slides)
- Quadrupoles (next slides)
  - BARC, India
  - In parallel with development of the vacuum chamber
- BPMs
  - Design of the pickup
  - Draft of FRS and several meetings about specifications and possible solutions
- Scrapers
  - Draft of FRS
  - First attempts to look at the simplest solutions
- Requesting for FY14 a mechanical engineer to be responsible for MEBT
  - Overall mechanical design of MEBT

Bunching cavities

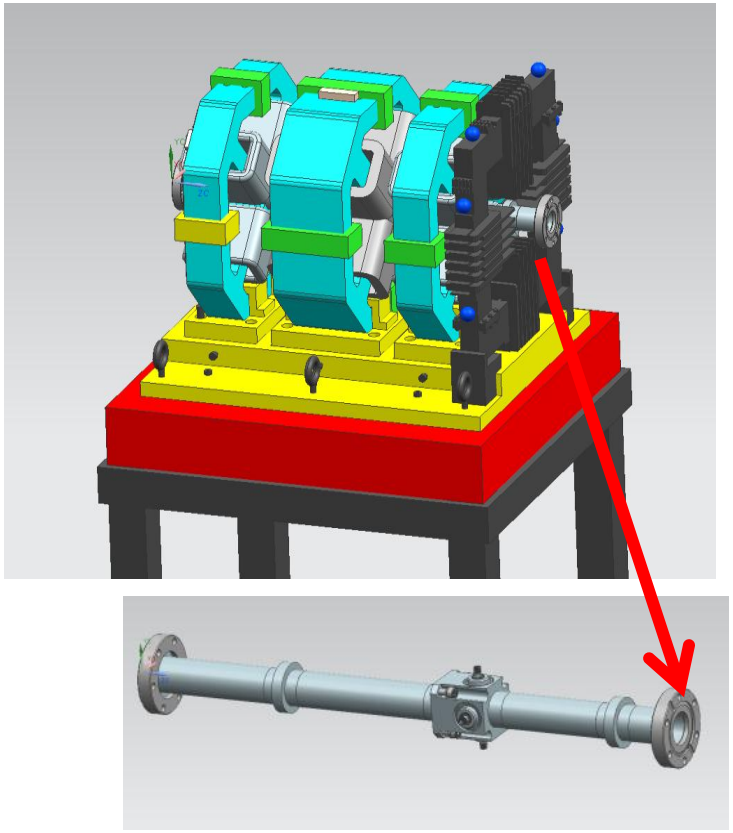
- Cavity design is complete
  - I. Terechkine, G. Romanov, I. Gonin, T. Khabiboulline, M. Chen,, J. Coghill,
- Production drawings of a prototype cavity are complete
- Package for bidding (one prototype cavity) has been prepared
  - Expected cost 50-70k$
- Plan to test the prototype in FY14



3D model of MEBT bunching cavity.

Quadrupoles

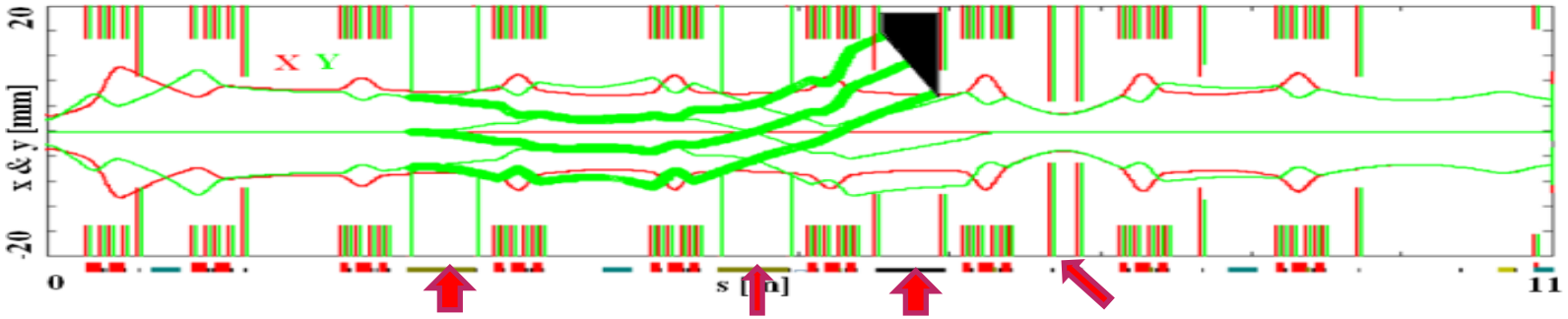
- FRS written and signed
  - Air – cooled triplets and doublets with dipole correctors
    - Each triplet/doublet includes a BPM
- BARC, India develops the design
  - Magnetic design is close to completion
  - Conceptual mechanical design is in progress
    - Drawings of a triplet prototype are expected in FY2013
  - Triplet's vacuum chamber with a BPM is designed in parallel at Fermilab
    - The BPM with the vacuum chamber is mounted to the poles of the central quadrupole
    - A mock-up will be made at Fermilab and shipped to BARC



3D concept of MEBT quadrupole triplet with dipole correctors (design: BARC) and installed vacuum chamber with BPM (design: M. Alvarez)

Kickers

- MEBT employs two kickers working synchronously
  - Separated by 180º of the betatron phase
- Travelling – wave, broadband kickers
  - 0.5m, ±250V on each plate, 16mm gap; 6σ beam length is 1.3 ns
- Two versions distinguished by the structure impedance are being developed in parallel
  - 50 and 200 Ohm versions



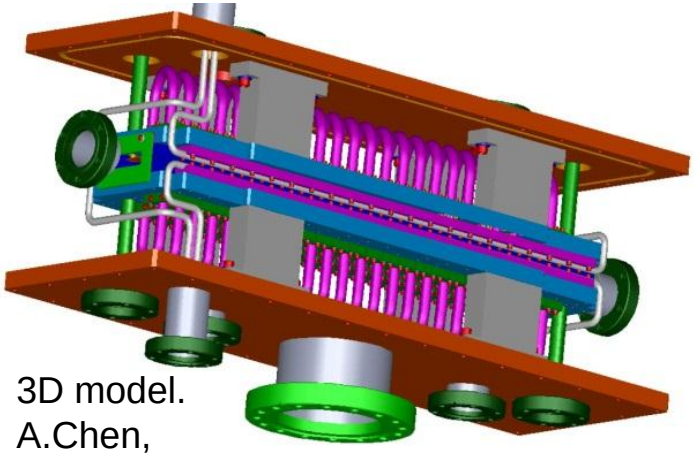
Two kickers separated by 180º

Absorber

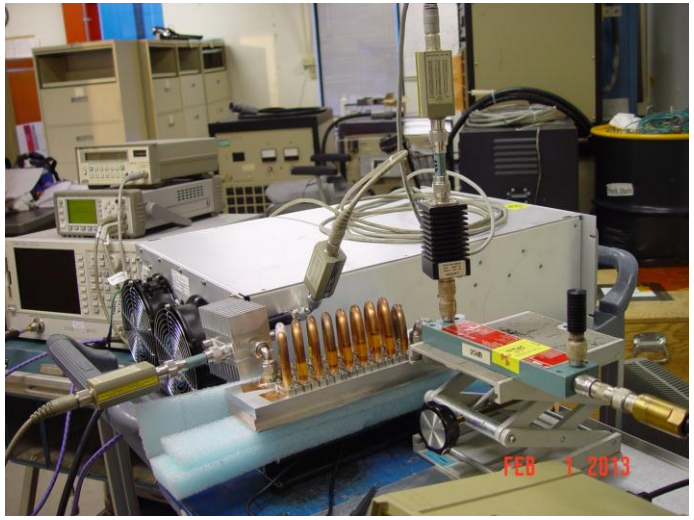
Differential pumping

50 Ohm kicker

- Structure: 25 electrodes (per side) connected with rigid cables in vacuum
- The production drawings are ready for bidding
- 9 –plate prototype was successfully tested
  - Low-power RF tests and power test in air
- All cables were bent; samples were tested for baking and trimming
- Plan to test a full – capability prototype in FY14



3D model. A.Chen, D.Sun



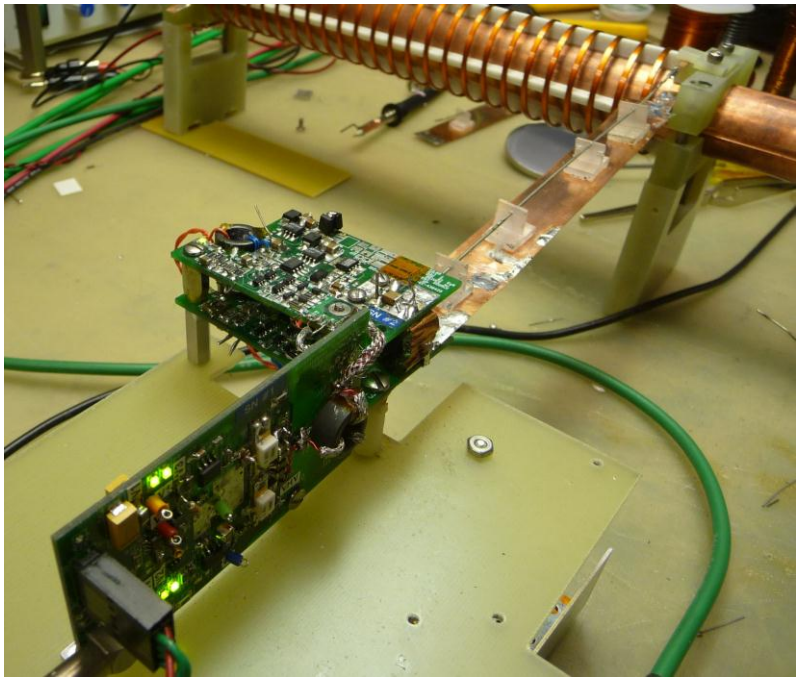
Power test of 9-plate prototype. D.Sun, R. Pasquinelli

50 Ohm driver

- Driver: commercial linear amplifier with pre-distortion
  - Successful tests of a lower-power version of the driver (150 W vs 1 kW) were made a year ago
  - Request to buy one amplifier (~180k$) in FY14 for development of the driver and tests

200 Ohm kicker

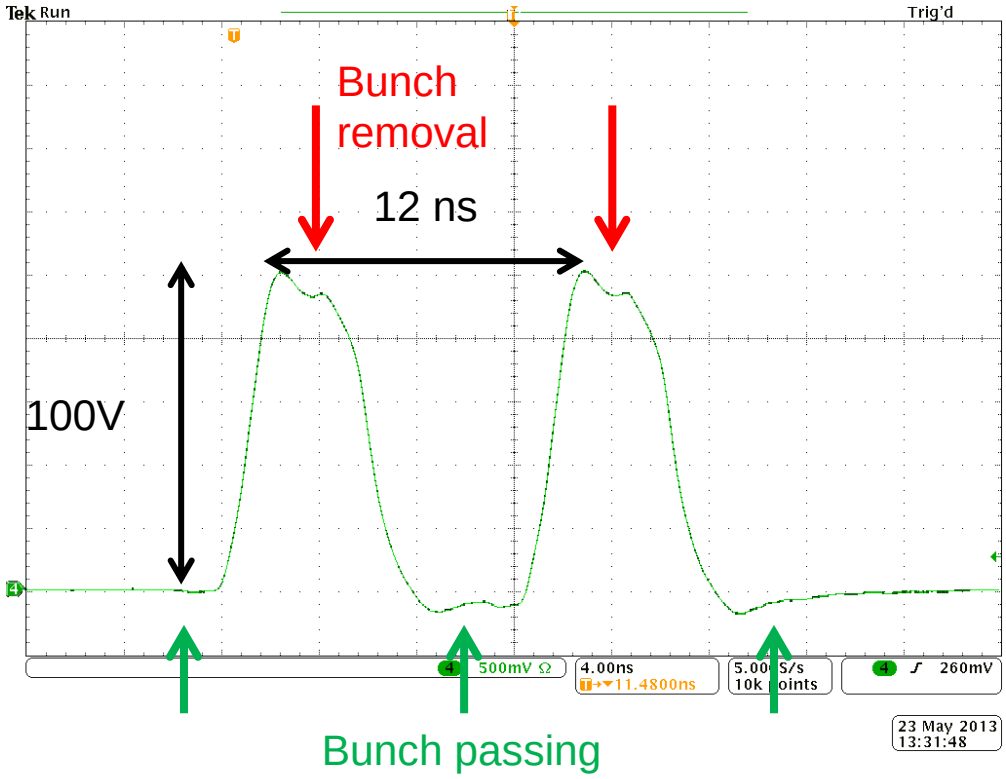
- Helix as travelling-wave structure
  - 46 electrodes (per side) attached to helix wound around a ground tube
  - RF simulations and prototyping are mostly done
  - All 200 Ohm feedthroughs and a prototype 200 Ohm load have been manufactured
  - Changing the mechanical concept to accommodate a possible heat load from the beam (40W)
    - High thermal conductivity ceramic and vacuum - compatible epoxy
  - Plan to assemble a mockup (in air) of the helix, transmission line, feedthrough, and load
- Plan to order, manufacture, and test the kicker prototype in FY14



Test setup of helix prototype with transmission line and 100V driver. G. Saewert

200 Ohm driver

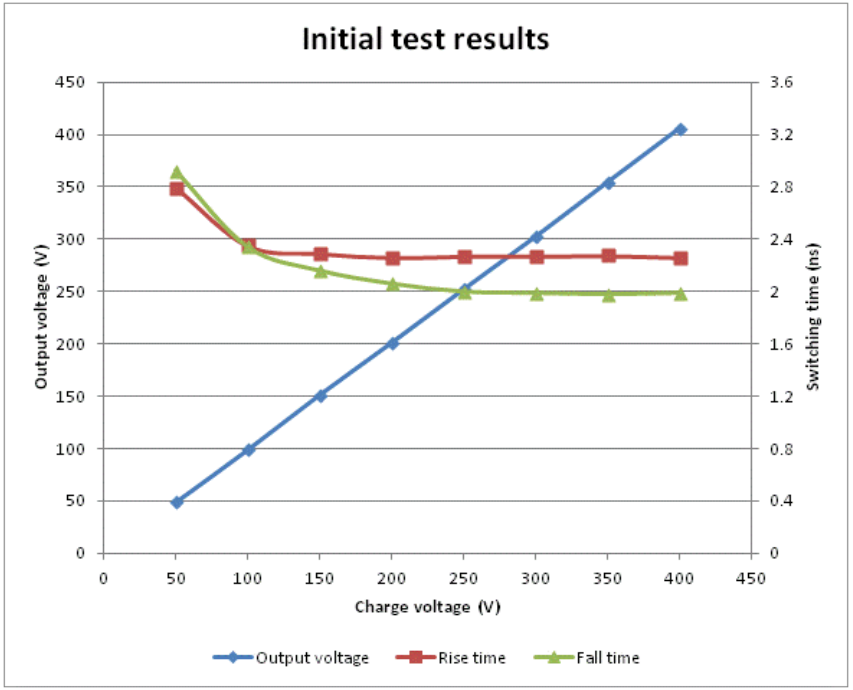
- Driver: broadband, DC coupled switches in push-pull configuration
  - Fermilab development (G. Saewert)
  - Performance of 500V single switch was demonstrated a year ago
  - Full 100V driver is under testing
- 500 V prototype driver is planned to be assembled in FY13

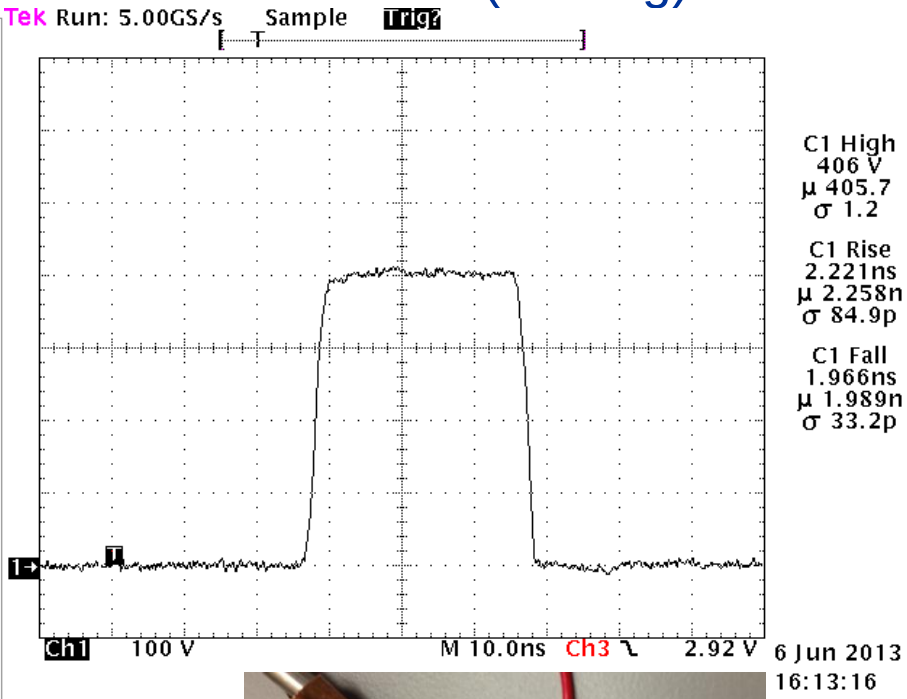


Example of the 100V driver prototype output. The shape satisfies the requirements.

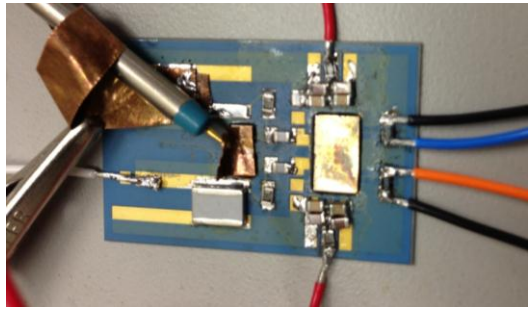
200 Ohm driver - SLAC

- Parallel development of alternative scheme at SLAC (T. Tang)



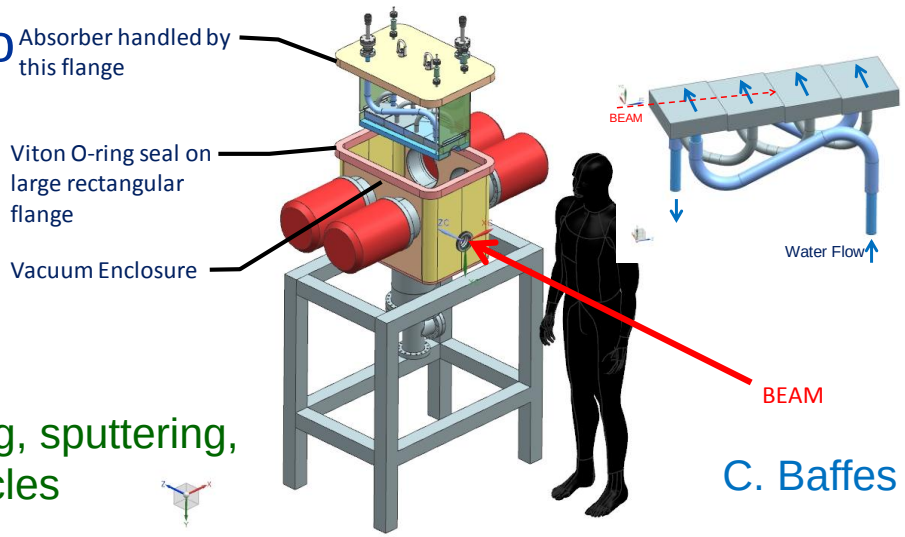


- With 400V charging:
  - 2.26ns rise time; 1.99ns fall time
  - Totem pole configuration; no load connected; single shot operation
    - Test switching speed

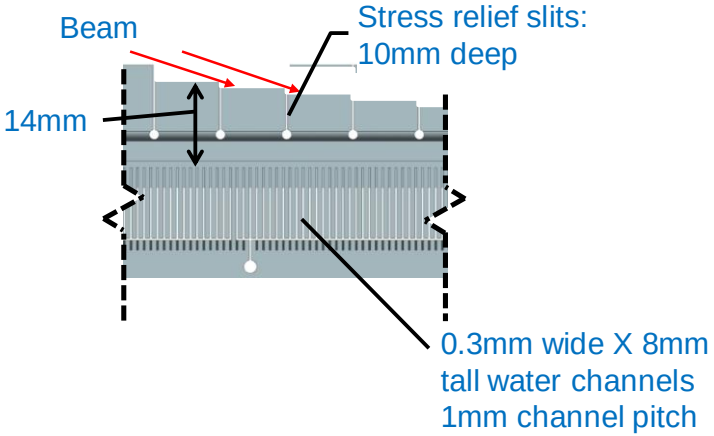


Absorber

- Concept was developed a year ago
  - Parameters:
    - Beam power - 21 kW CW
    - Beam rms radius – 2 mm
    - Available length ~ 0.5 m
  - Issues to address
    - Heat removal, thermal stress, blistering, sputtering, radiation, outgassing, secondary particles
  - Concept
    - 29 mrad incident angle
    - Mo alloy TZM
    - Stress relief slits and steps to shadow the slits
    - Microchannels for water cooling
    - Made from 4 nearly identical modules
- Detailed thermal and stress simulations

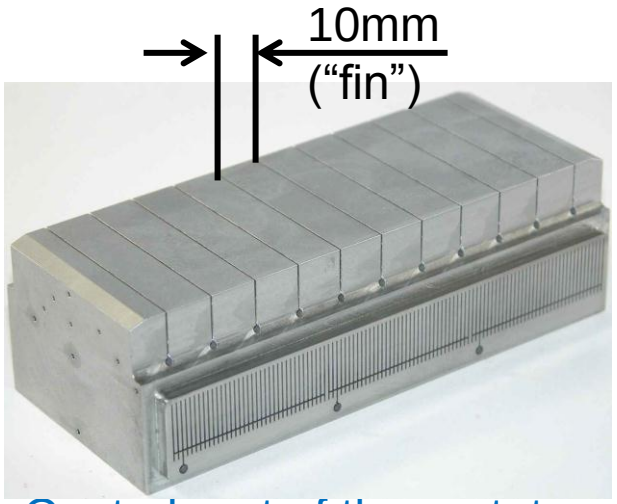


C. Baffes



Absorber prototype

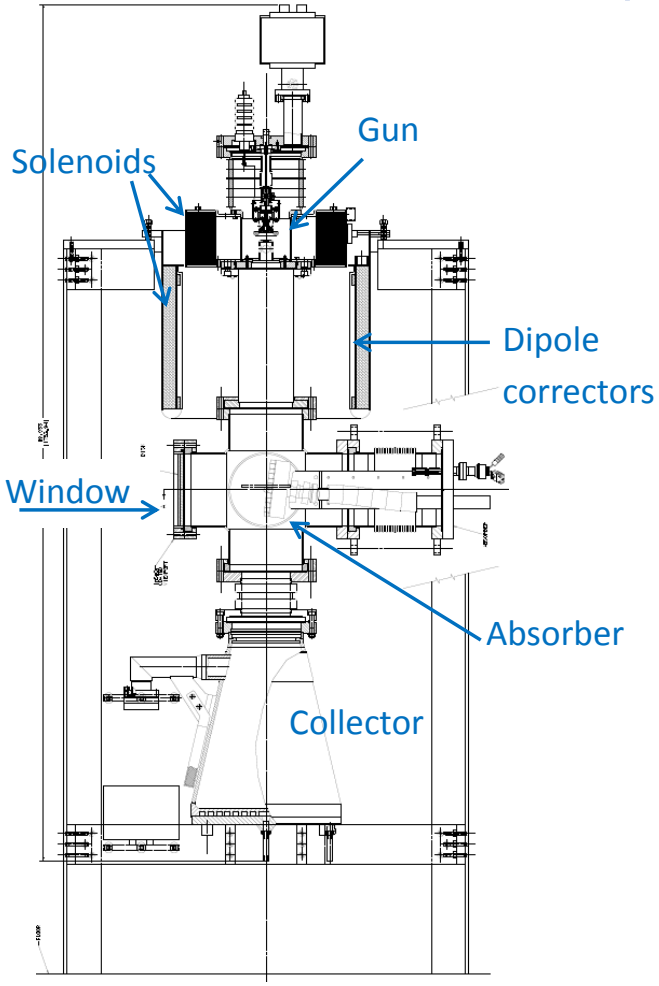
- A ¼ size prototype was designed, manufactured, and is being tested with an electron beam
- Goals
  - Go through the full manufacturing cycle
  - Test thermal properties of the TZM absorber with an electron beam at a comparable power surface density
  - Validate FEA modeling approach, investigate film boiling transition
  - Develop instrumentation
- In tests, the electron beam comes to the surface at a larger angle, ~150 mrad
  - A similar beam surface power density can be created with a significantly lower power
  - Slits suppress the longitudinal heat transfer, and tests with a beam footprint longer than one fin already make sense



Central part of the prototype

Absorbing prototype test stand

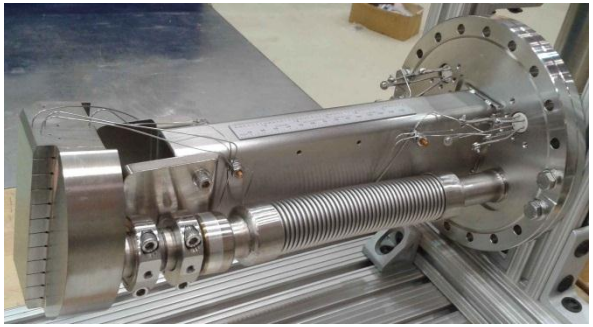
- Test stand capable of producing e-beam: 28 keV, up to 0.2A



- The absorber can be moved in and out of the beam pass
- Instruments:
  - Thermocouples; OTR and thermal radiation
- Large portion of the incident power is reflected
  - Heat on the vacuum test chamber walls
  - Lower absorbed power
    - Difficult to measure accurately: precision of flow meter, unknown composition of cooling liquid
    - Will calibrate by passing the beam into the collector

Absorbing prototype testing

- The absorber prototype has been tested at the absorbed power density ~10 W/mm^2 a comparable with that required for the MEBT absorber (~17 W/mm^2 for 10mA operation)
  - If stable at these parameters, may be used as is at PXIE up to ~2mA for initial tests
- Hope to reach full power density as soon as feel more comfortable with power measurements
- Hope to develop a simpler and more robust prototype



Absorber prototype assembly

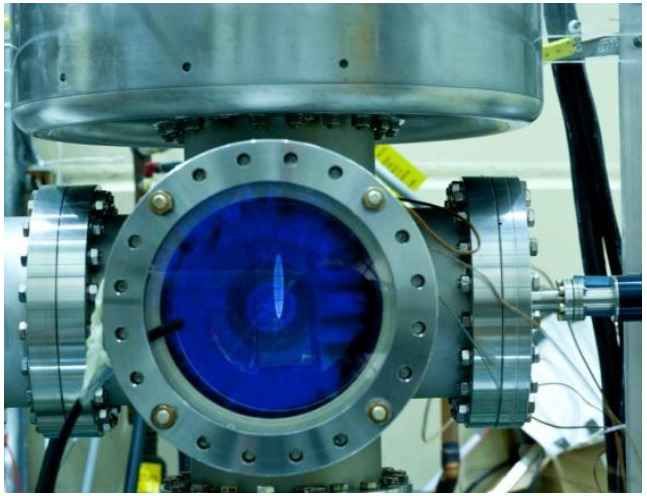


Photo of the beam footprint on the absorber prototype (photo by M. Murphy).
I_e= 190mA, axes of footprint ellipse are ~50x7 mm. Incident beam power density ~20 W/mm^2.

Plans

- Bunching cavity prototype: place order in FY13 and test in FY14
- Quadrupoles (BARC): design in FY13 and manufacture a triplet + dipole correctors prototype in FY14
- Kicker
  - 50 Ohm structure: place order in FY13 and test in FY14
  - 50 Ohm driver: purchase the amplifier in FY14 and start tests
  - 200 Ohm structure: design, manufacture, and start testing in FY14
  - 200 Ohm driver: test 500V driver prototype in FY14; design final version
- Absorber
  - Manufacture and test a second prototype in FY14
  - Design the full-size absorber in FY14
- BPMs: agree on FRS in FY13; design and start production in FY14
- Scrapers: design in FY14
- 3D model of MEBT in FY14 (including decisions on vacuum system)