# MEBT status

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PIP-II collaboration meeting

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U.S. DEPARTMENT OF ENERGY

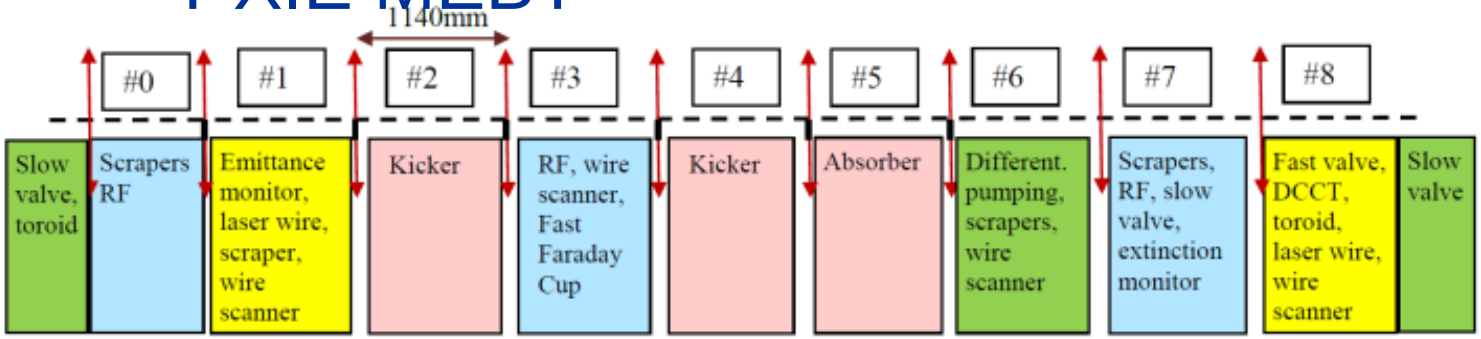
Fermilab

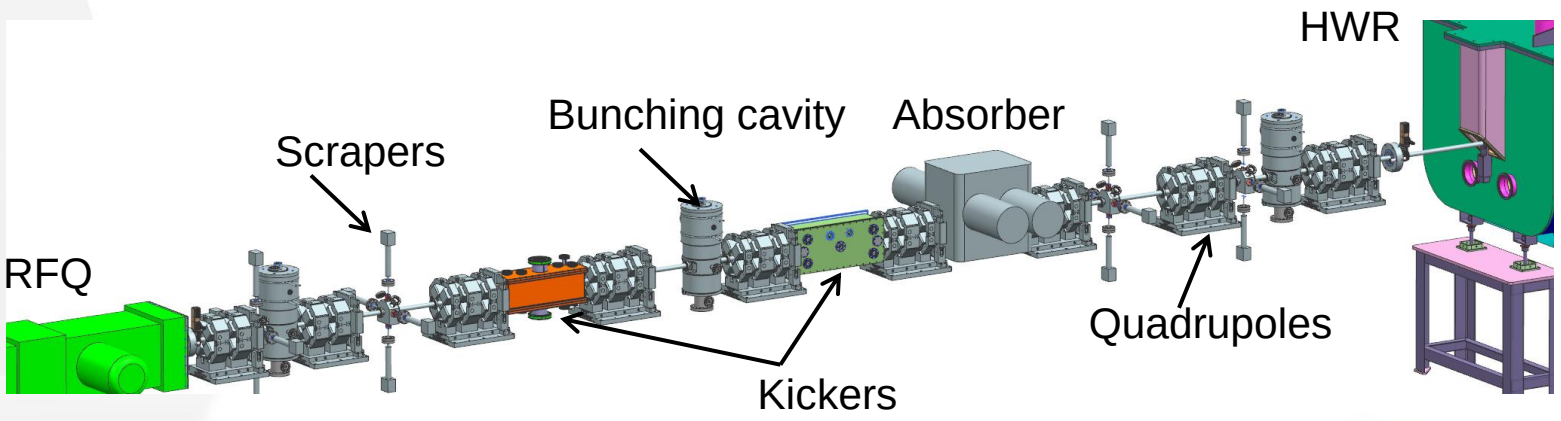
# Goals and status

- Main goals stay the same:
  - Demonstrate creating an arbitrary bunch pattern from initially CW 5-10 mA, 2.1 MeV H- beam
  - Compatibility with SRF downstream
- Plan to use parts of MEBT to characterize the beam from RFQ
- MEBT will provide all modes that may be required for PIP-II
  - E.g. bucket-to-bucket filling of the Booster

- The specifications and scheme did not change
- All major components are under development
- Work on the 3D model of the entire MEBT has begun

# PXIE MEBT


1140mm
#0
#1
#2
#3
#4
#5
#6
#7
#8
Slow valve, toroid
Scrapers RF
Emittance monitor, laser wire, scraper, wire scanner
Kicker
RF, wire scanner, Fast Faraday Cup
Kicker
Absorber
Different. pumping, scrapers, wire scanner
Scrapers, RF, slow valve, extinction monitor
Fast valve, DCCT, toroid, laser wire, wire scanner
Slow valve
X Y
x & y [mm]
20
-20
0
s [m]
11

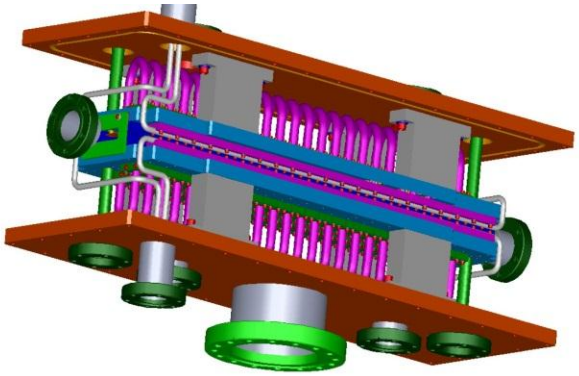

HWR
Bunching cavity
Absorber
Scrapers
RFQ
Quadrupoles
Kickers

# Development of MEBT elements

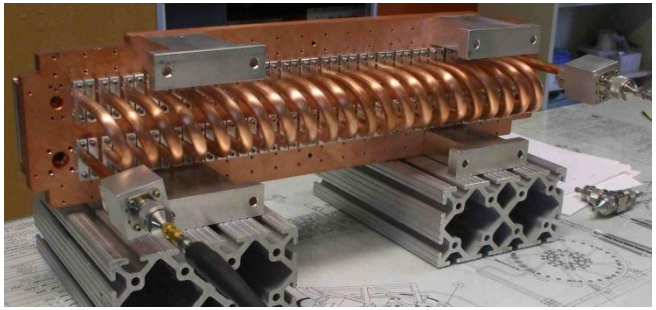
- Kickers
  - ΔU=500V on each plate; two 50-cm kickers; 6.15 ns bunch separation, 1.3 ns 6σ bunch length
  - Two versions, 50 Ohm and 200 Ohm
- Absorber
- Quadrupoles and dipole correctors
  - BARC, India
- Bunching cavity
- Scrapers
- Diagnostics

# 50 Ohm kicker

- Kicker
  - 24 electrodes per plate connected in vacuum by 50 Ohm cables
  - One half has been assembled, and low-voltage RF tests are done
    - Excellent characteristics
  - Vacuum and power tests in FY14
- Driver
  - Commercially available linear amplifier
    - Do not plan to purchase yet
    - The concept has been tested with a similar lower-power amplifier



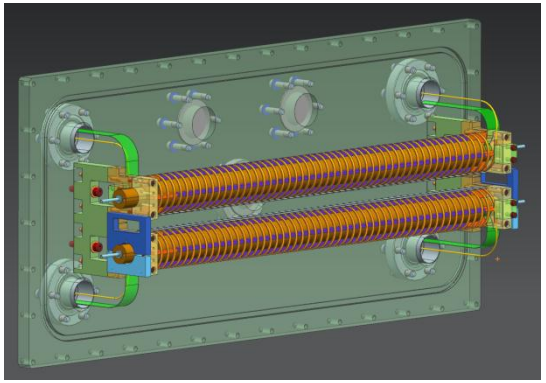
D. Sun, A. Chen



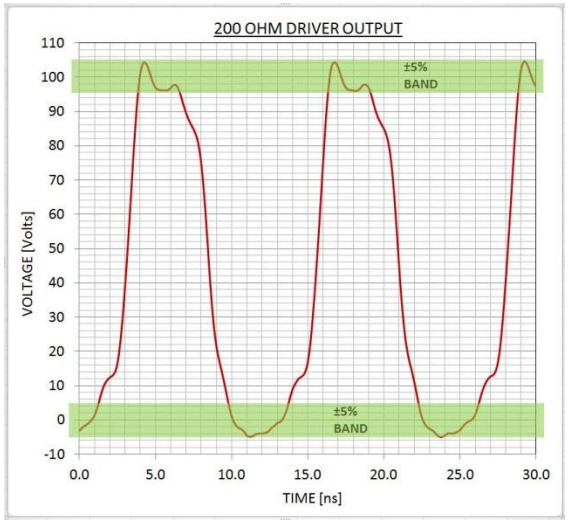
RF testing of one kicker plate. D.Sun

# 200 Ohm kicker

G.Saewert, A.Chen



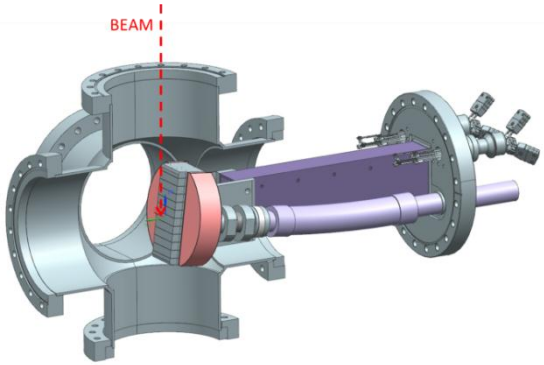
- Helix as a travelling-wave structure
  - Finishing mechanical design, starting production
  - Measurements in beginning of FY15
- Driver is being developed at Fermilab
  - Broadband, DC coupled switches in push-pull configuration
  - Single switch was tested to 0-500V
  - Push-pull driver was tested 0-100V
  - 200 V push-pull configuration is under tests



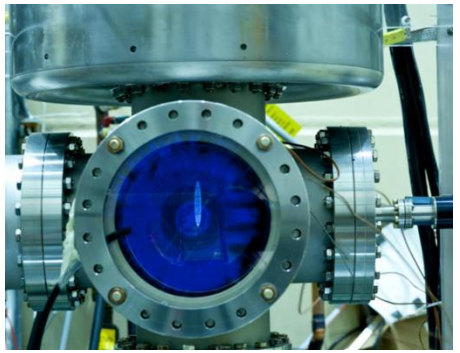

Example of 100V driver output to 200 Ohm load, modelling kicking out every other bunch. 80 MHz CW. Rise/fall time 2.7/3.2 ns. G.Saewert

# Absorber

- 21 kW CW, 2mm 1σ beam, 50 cm length, 17 W/mm$^2$
- A ¼-size prototype was successfully built and tested with an e-beam of comparable power density
  - Molybdenum alloy TZM, monolithic design, transverse slits, shadowing steps
  - Tested surface power density up to 17 W/mm$^2$ with surface temperature up to 1300 K
  - Reasonable agreement with ANSYS simulations
- Building a second ¼-size prototype
  - Improve complicated manufacturing process
  - Remove chances to develop a crack to water channels
  - Better management of reflected particles

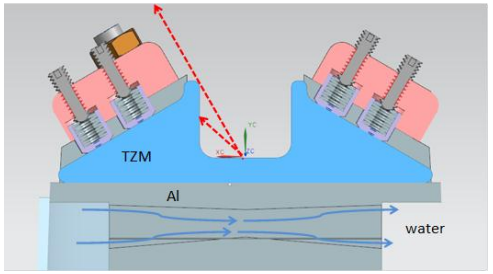


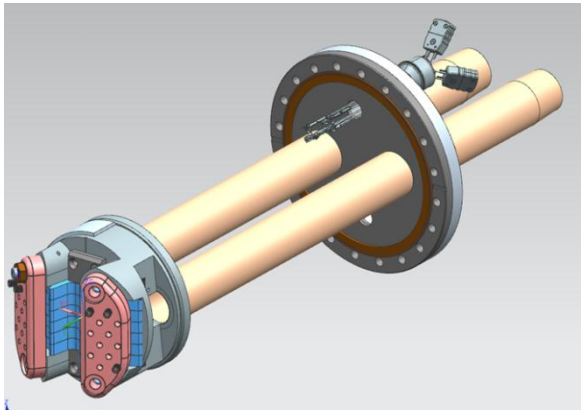

C. Baffes



# Absorber prototype – 2nd version

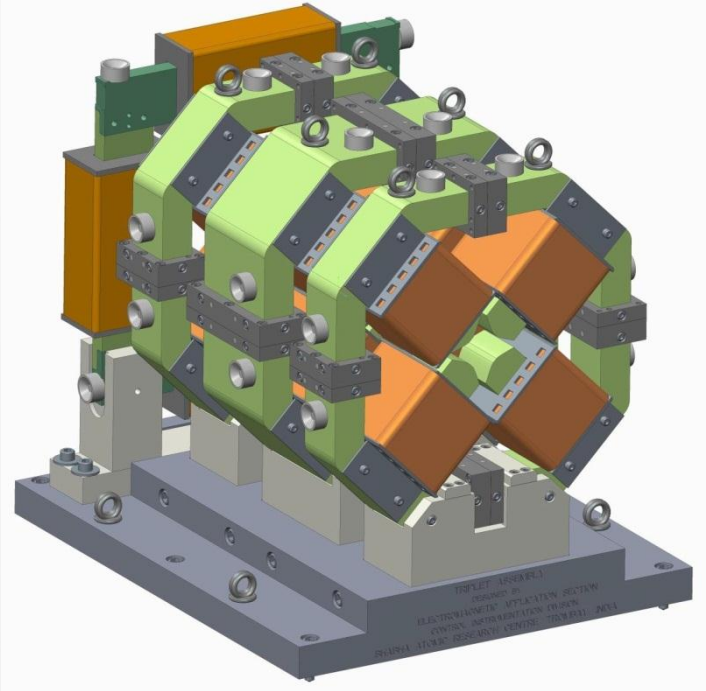
- Short TZM pieces pressed against an aluminum strongback with a graphite sheet in between
  - Expect ~25% higher temperature rise, still within capabilities of TZM
- In production
  - Will test with e-beam in FY14
- Plan to use at PXIE as well
  - To test blistering resistance before building a full-size absorber
  - Should be capable of intercepting 5 kW beam for chopping tests



# MEBT magnets

- MEBT needs 2 doublet and 7 triplet assemblies
  - Each assembly includes two dipole correctors
  - Design incorporates a BPM inside triplets/doublets

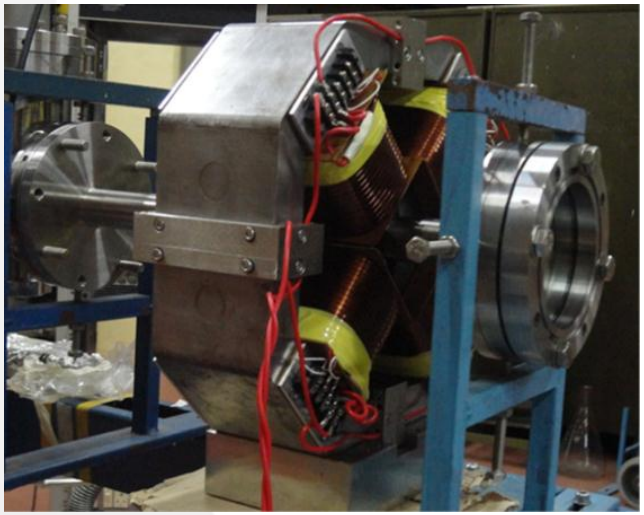


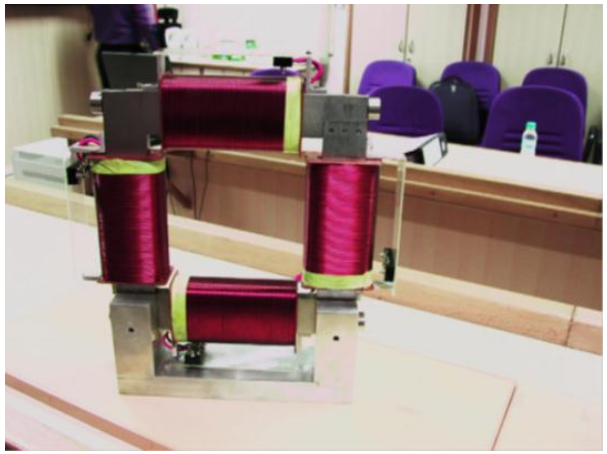
Triplet assembly. Image courtesy of BARC, India.

Triplet vacuum chamber with a mockup BPM. M. Alvarez

# MEBT magnets (2)

- Quadrupoles and dipole correctors have been developed and will be built at BARC, India
  - Prototype magnets have been built, measured, and tested with beam
    - Quality is within specifications
  - Parts are ordered for complete doublet and triplet
  - Two doublet sets are expected to be installed at MEBT by the time of RFQ commissioning





Prototypes of the quadrupole F and dipole correctors. Images courtesy of BARC.

# Bunching cavity

- Bunching cavity
  - 162.5 MHz, 100 kV max
  - Order has been placed in Feb 2014 for 1 cavity, expected in Sep 2014
  - Will be high-power tested before installation into the beam line

I. Terechkine et al.

# Scrapers

- Scrapers
  - Electrically isolated, movable, radiation-cooled, rated 50 W/jaw
  - A prototype was tested with an electron beam up to 150W
  - Under design

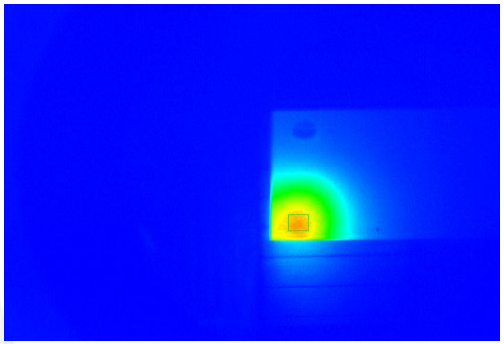
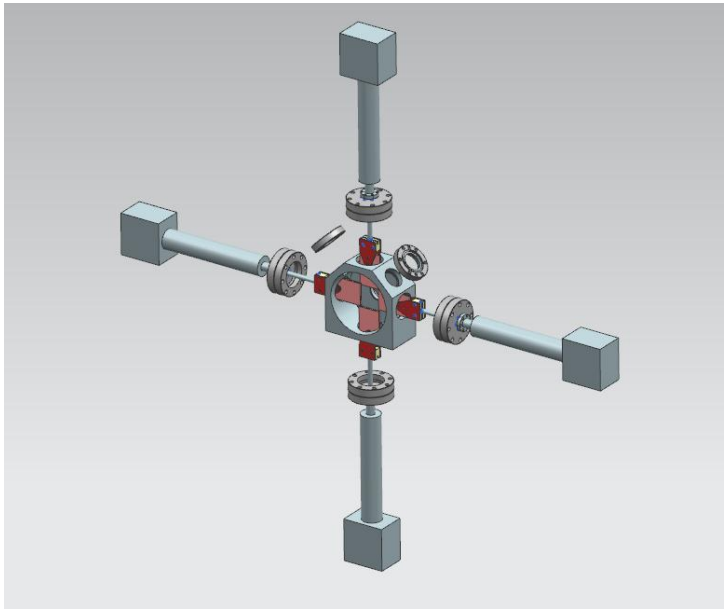


Image (in false colors) of thermal radiation from a TZM plate irradiated by a 140W electron beam.



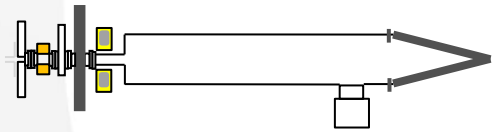
Model of scraper assembly. C.Baffes

# Diagnostics

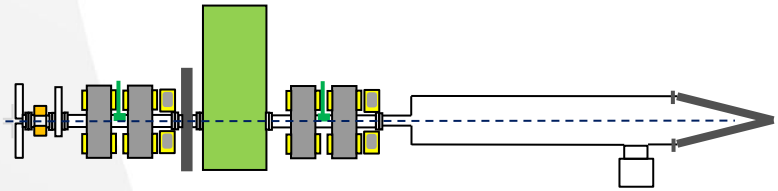
- Will be mainly in two “diagnostics” sections of the final MEBT
  - The final set may include: 9 BPMs, 2 toroids, DCCT, 4 x 4 scrapers, emittance scanner, 2 wire scanners, Fast Faraday Cup, 2 laser wires, extinction monitor
  - Should be enough for complete beam characterization
- For optimum use of resources, the diagnostics will be installed sequentially over years
  - FY15: toroid, 4 BPMs, 2x4 scrapers, Fast Faraday Cup (originally from SNS). Should be enough for initial RFQ characterization
  - BPM pickups designed; buttons for 3-4 ordered; electronics will be based on ASTA’s

# Initial stage

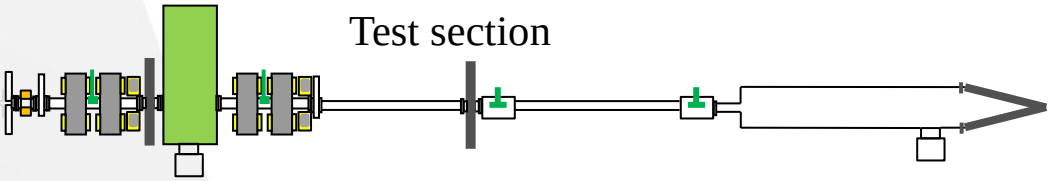
- In FY15, parts of MEBT will be used for the RFQ beam commissioning and characterization
  - Expected to be in steps, while MEBT is being built



"SNS dump", toroid, set of 4 scrapers, dipole correctors.
Pulse/CW beam, beam loss in RFQ (to 1%)



+ 1st MEBT section (2 doublets, 2 BPMs, bunching cavity)
+ 10 kW CW




+ "test" section, 2 BPMs, set of 4 scrapers, Fast Faraday Cup
+ estimations of emittances; energy measurement to 1%

# Milestones

- FY2015 – characterization of beam from RFQ
- FY2017 – Stage 1
  - Full-length MEBT with prototype kickers and absorber, temporary dump, bunchers, some diagnostics
- FY 2018- Stage 3
  - MEBT in final configuration
  - Bunch-by-bunch selection