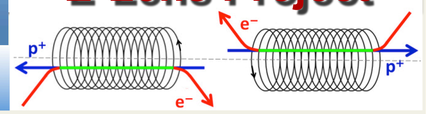
IBIC 2013
International Beam Instrumentation Conference

BROOKHAVEN NATIONAL LABORATORY
Collider-Accelerator Department

RHIC
Relativistic Heavy Ion Collider
Accelerator Research & Development Division

E-Lens Project



MOPF31 Toby Miller

Design and Performance of the Biased Drift Tube System in the BNL Electron Lens

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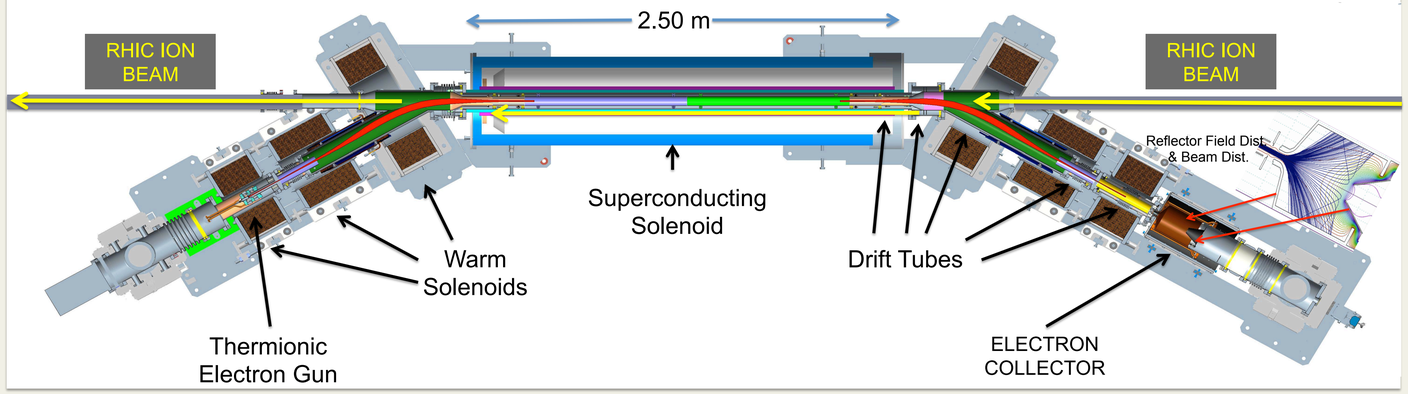
Abstract

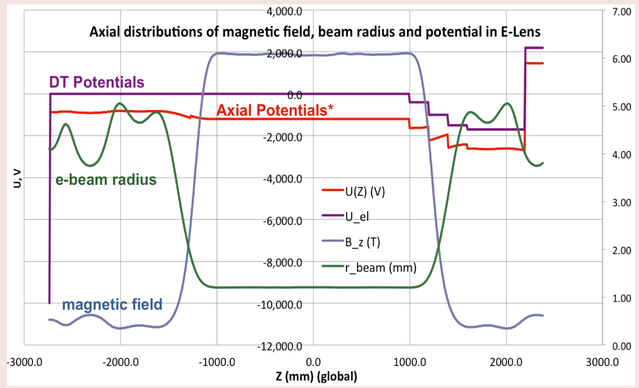
The Electron Lenses in RHIC are designed with a series of biased drift tubes through which the electron beam propagates in the opposite direction of the RHIC ion beams. An electric field gradient created by selectively biasing the drift tubes sweeps out ions generated through residual gas ionization and trapped in the central magnetic field where the electron beam interacts with the RHIC beam. The image currents induced on the drift tubes by the RHIC beam develop high voltages at RF frequencies that are detrimental to the electron and ion beams. This paper presents the design and commissioning results of the biased drift tube system with its axial electric field gradient, and the custom high voltage RF bias tees that were developed as well as instrumentation incorporated into the drift tube system to measure beam loss signals.

E-LENS MACHINE CROSS SECTION

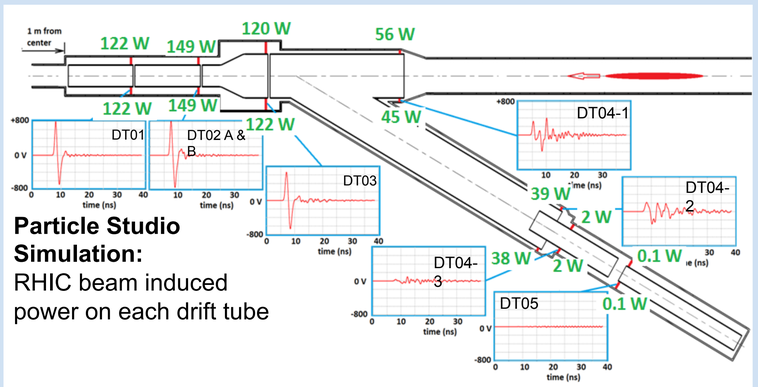


ION CONTENT CONTROL

- Ions develop in the interaction region
- Ions get trapped in the magnetic potential well of the central solenoid
- Ion build-up can disrupt the electron & ion beams
- Voltage gradient on drift tubes extracts trapped ions

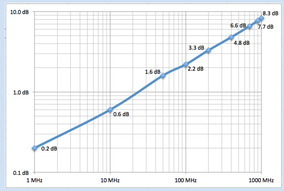


PARTICLE STUDIO SIMULATIONS



Particle Studio Simulation:
RHIC beam induced power on each drift tube

Attenuation of RG213 Cable



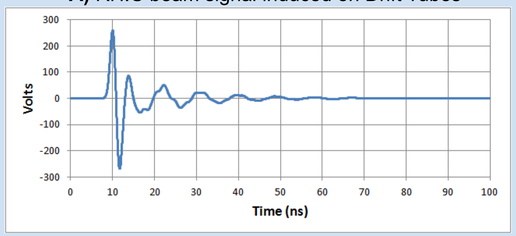
Drift Tube	Max volts	Min volts	PWR (W)
DT1	145	-120	11
DT2A	120	-140	11
DT2B	120	-140	11
DT3	230	-125	16
DT4	100	-170	11
DT4	52	-61	2
DT4	52	-61	2
DT5	1	-1	0.1
DT00	1	-1	0.1

Reduced power at bias tees after cable attenuation

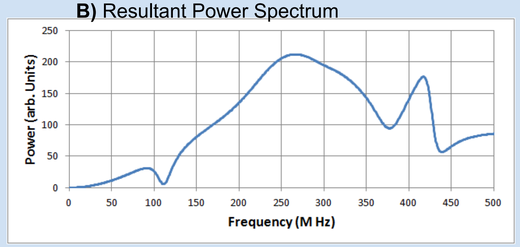
Power calculation procedure:

1) Get power from data (A) for two beams with 110 bunches each.
2) Normalize (B) to that power.
3) Convolute with cable attenuation
4) Get reduced power by integrating

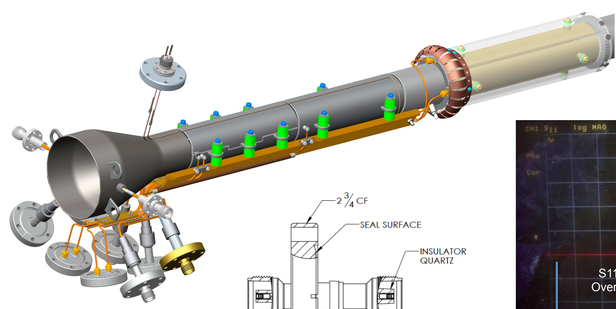
A) RHIC beam signal induced on Drift Tubes

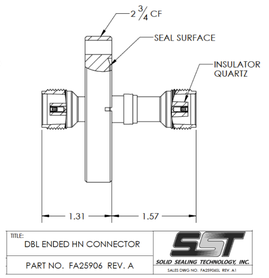


B) Resultant Power Spectrum

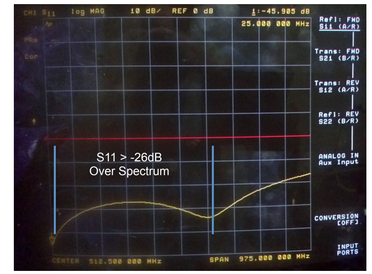


CUSTOM VACUUM FEEDTHROUGH



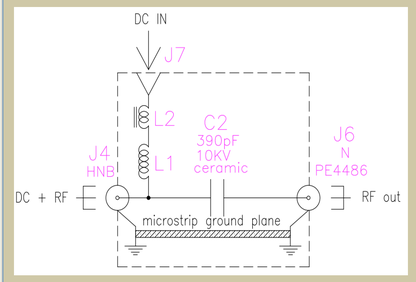


Custom designed Feedthrough for 7kV and good RF response.
1) double ended HN (quartz)
2) single ended HN.

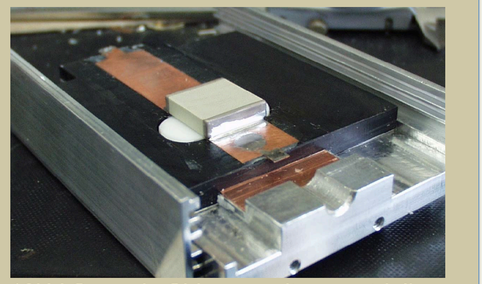


Network Analyzer tests of feedthrough show acceptable response.

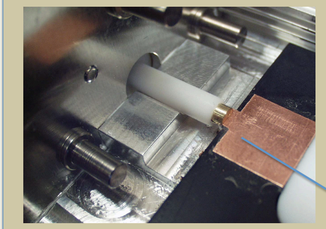
HV RF BIAS TEE DESIGN



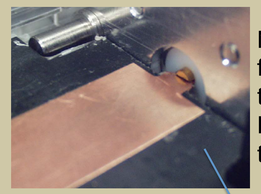
Barth Electronics
custom 10kV RF Bias Tee
with HN connector



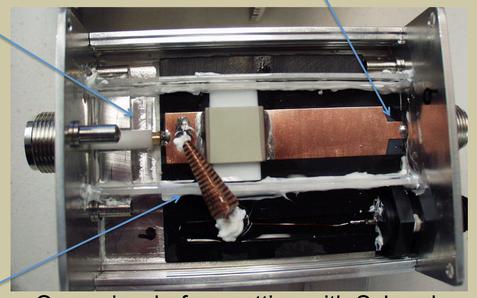
10kV Ceramic Chip capacitor on stripline between HNB and N connectors



HNB HV 50Ω
feedthrough to stripline
for Drift Tube connection



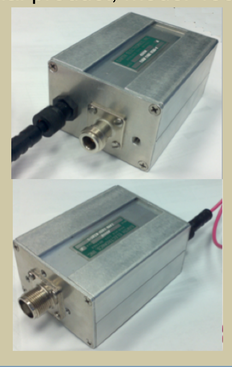
N type 50Ω
feedthrough
to stripline for
RF output
to load

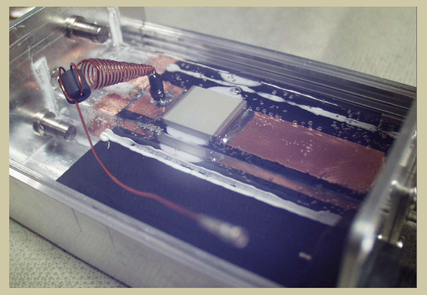


Open view before potting with Sylgard

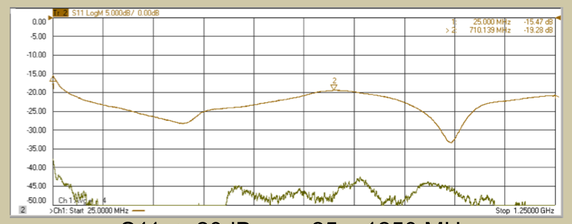
Helical coil and
toriod isolating
external
capacitor and
DC Bias

Final product, model 45350





Open view after potting with Sylgard

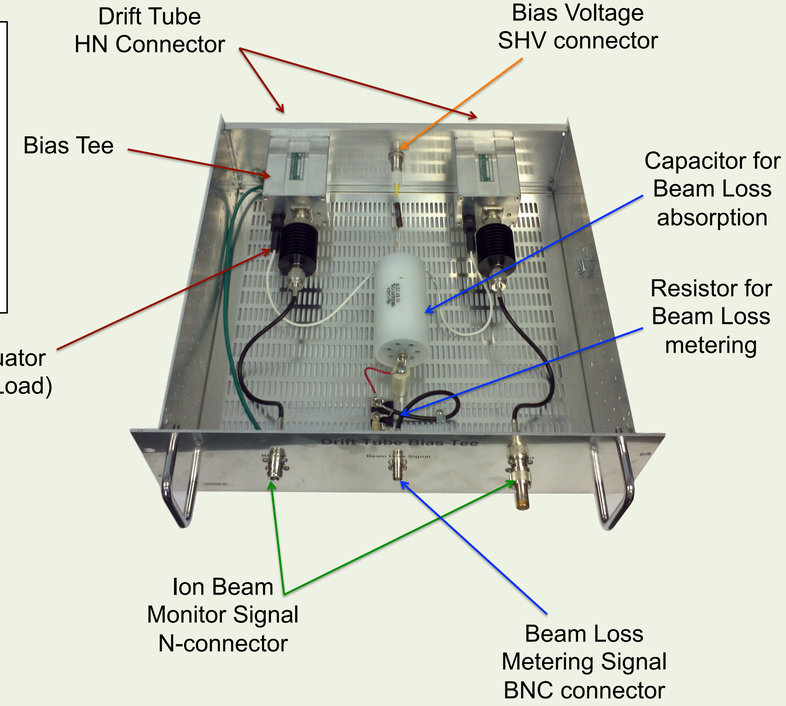


S11 < -20dB over 25 – 1250 MHz

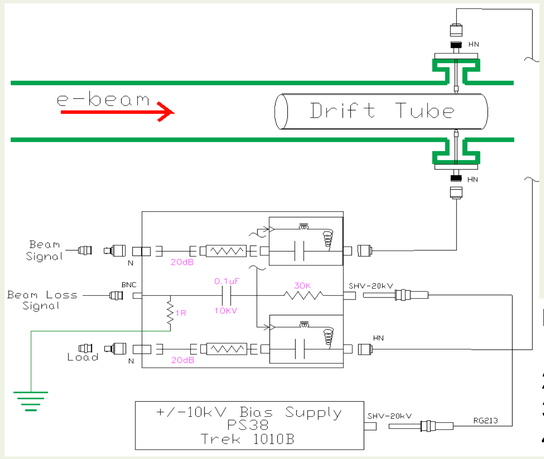
BIAS TEE CHASSIS DEISGN & INSTRUMENTATION

DESIGN CRITERIA

- Limit drift tube voltage excursion to 1kV during DC operation
  - 100% of 1A beam for 100uS (MPS shutdown delay) — Thus C4 = 100nF
    - => Vmax = I*t/C = 100%1A*100uS/100nF = 1kV
    - => Energy = ½ CV^2 = ½ 0.1uF*$1kV^2$ = 50mJ
- Limit drift tube voltage excursion to 1kV during 100Hz pinhole beam scan — Thus R2 = 30k
  - 1A pulse @ 10uS
    - => Vmax = I*t/C = 1A*10uS/100nF = 100V
  - Bias voltage on capacitor must recover before next pulse :
    There is a current limiting resistor in series with the HV bias supply that limits the current to and from the supply. This resistor must be high enough to limit the current but low enough to recharge the capacitor between consecutive pulses @ 100Hz.
    - => 3τ = 3RC = 3*(30K*100nF) = 9mS (< 10mS period @ 100Hz)



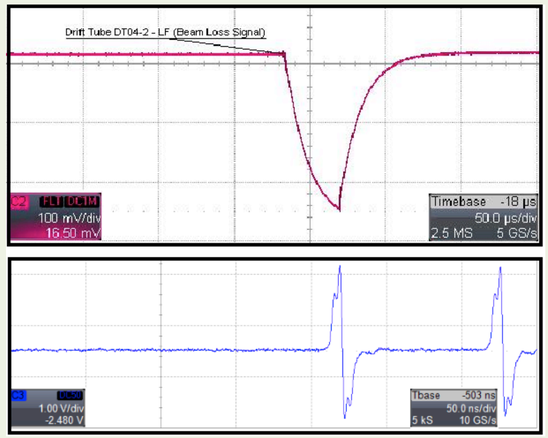
Bias Tee Chassis schematic



FUNCTIONALITY:

1) Bias Supply Protection
2) RF & HV interconnection
3) Electron Beam Loss Detection
4) RHIC Beam Signal Monitoring

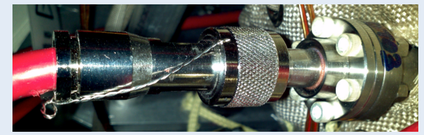
Electron Beam (130mA beam, 36uA pulse) on Drift Tube



RHIC ion beam signature signal

SAFETY

HN connector chosen for HV rating and good RF response. BUT not finger safe!



Safety wire requires a tool to open.

Procedure & tags inform of risks:
1) High DC bias voltage
2) High induced voltages by RHIC beam