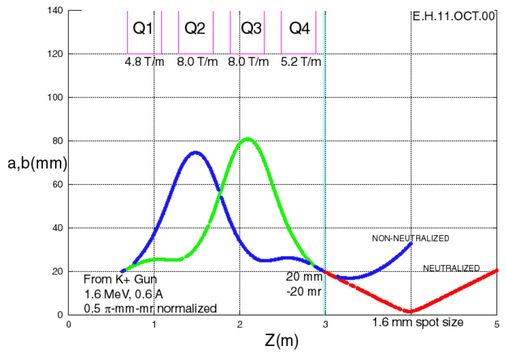
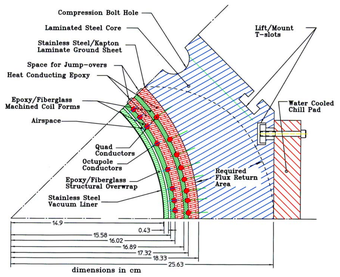
MAGNETIC LATTICE FOR NTX/HCX



REVISED MAGNET CROSS-SECTIONS

(SEE PAC2001, RPAH038, SHUMAN, D. FOR QUADRUPOLE DESIGN)

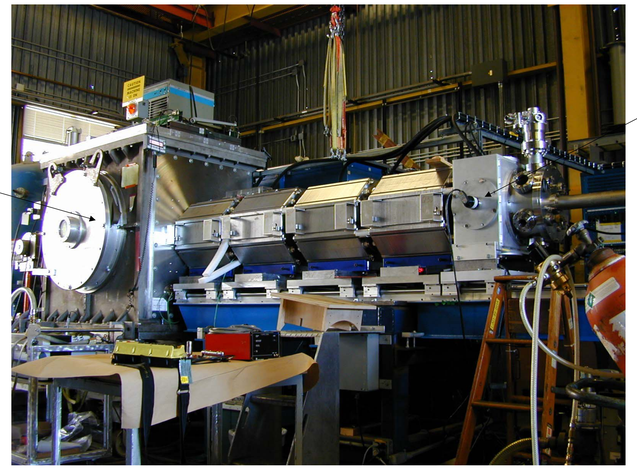


REVISED PULSED QUADRUPOLE PARAMETERS

(for 400 keV, 75 mA K^+ NTX beam;
quadrupole is designed to operate at 8 T/m for 1.6 MeV, 0.6A HCX K^+ beam)

Beam Aperture Radius, R_b	14.9	cm
Magnet Winding Radius, R_w	17.32	cm
Steel Inner Radius, R_{si}	18.33	cm
Steel Outer Radius, R_s	25.63	cm
Mag., Total Lengths, L_m, L_q	46, 50	cm
Magnet to magnet spacing	60	cm (ctr -ctr.)
Field Gradient, B'	2-5	T/m
Maximum Field, B	0.6	T, @12cm
Number of turns, N	8	Turns/coil
Σ H.O. 2D Field Coefficients, $\Sigma B_n/B_2$	7x10^{-4}	T/T @10cm
Conductor radius, r_c	4.65	mm
Magnet Current, I_{max} - I_{inj}	3.3- 8.2	kA
Magnet Resistance, R	.036	Ω
Magnet Inductance, L	232	μH
Pulse length (full half sine), t	2.2	mS
Magnet Voltage, max., V	2.7	kV
Pulse energy, max., U	7.8	kJ
Energy loss/pulse, max., Q_L	2.7	kJ
Max., Operating Pulse Rates	0.5, 0.1	Hz
Temp. Rise, max., steady state	25	°C, (0.5Hz P.R.)

NTX EXPERIMENT SHOWING THE FOUR PULSED QUADRUPOLES INSTALLED

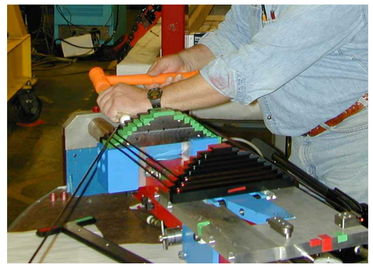


PULSED QUADRUPOLE FABRICATION

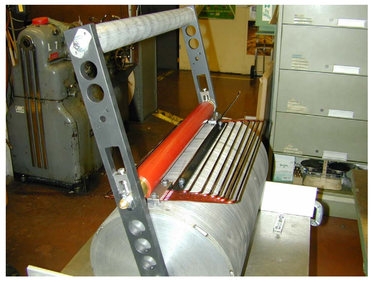
COIL WINDING AND STRETCHING MACHINE

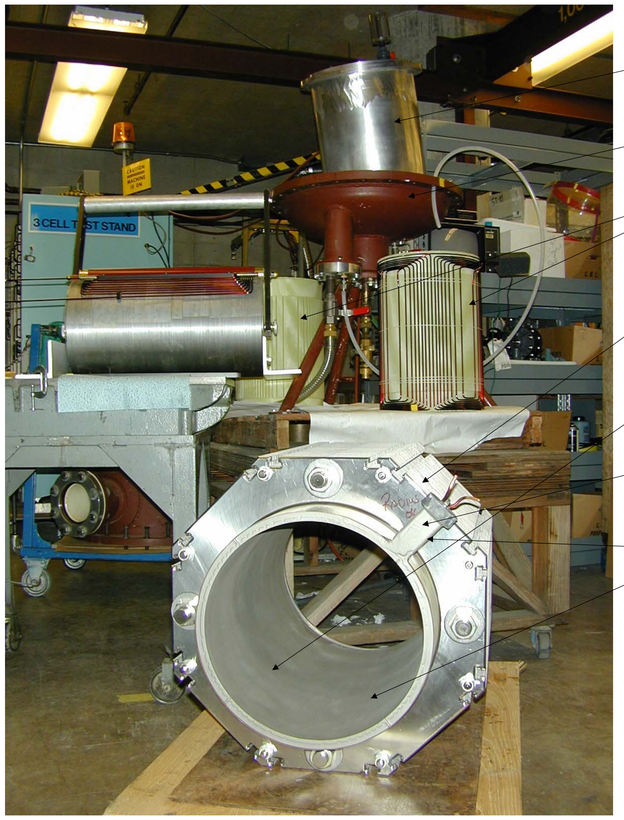
Originally used for Pulsed Elliptical Quadrupole (Shuman, Faltens, PAC99, THP159), adapted for wider NTX Coils. Stretching to conductor yield point after winding straightens conductors for precise placement in G-10 grooves.

Corner tapping of conductor is necessary, as it is wound, to provide a proper square radiused bend. Wire tension is maintained at ~80 lbf.



COIL END ARCING MACHINE





POTTING MOLD, WITH INTERNAL EXPANDING MANDREL TO HOLD COIL FORMS CYLINDRICAL DURING POTTING

VACUUM/ PRESSURE CHAMBER, LOWER HALF, WITH NYLON EPOXY FEED AND VACUUM/PRESSURE LINES

MACHINED G-10 COIL FORM WITH COILS ASSEMBLED AND CONNECTED

LAMINATED STEEL CORE, SUFFICIENT FOR <8 T/M, BOLTED WITH 3/8" THICK STAINLESS STEEL END PLATES (S.S. MINIMIZES EDDY CURRENTS)

COIL CASTING, NOT YET POTTED INTO CORE

LEADS ARE ENCASED IN EPOXY, WITH A G-10 DIVIDER, AND BROUGH TO THE EXTERIOR FOR EASE OF CONNECTION AND REPAIR

RESISTIVE PAINT GROUND LAYER (ZINC BASED SPRAY) COMPLETELY SURROUNDS COILS AND FLARES OUTWARDWHERE LEADS EMANATE FROM CASTING

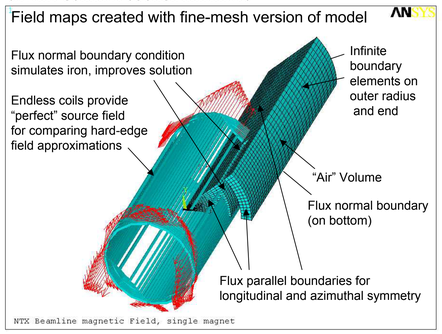
COILS, BEFORE AND AFTER THE END ARCING PROCESS

MAGNETIC FIELD ANALYSIS

3D STATIC

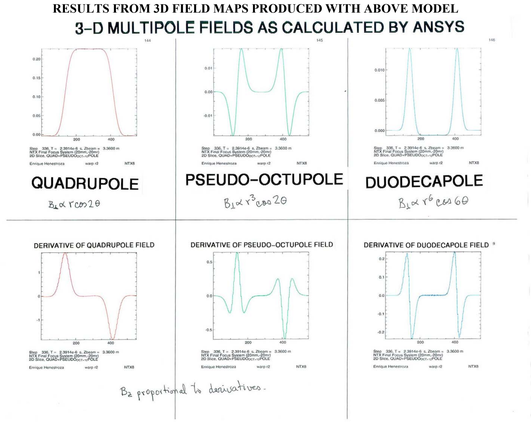
TO DEVELOP A 3D FIELD MAP THAT CAN BE USED TO DETERMINE BOTH NORMAL AND PSEUDOMULTIPOLE COEFFICIENTS

ANSYS F.E. MODEL USING SCALAR POTENTIAL FORMULATION WITH BIOT-SAVART CURRENT SOURCE ELEMENTS

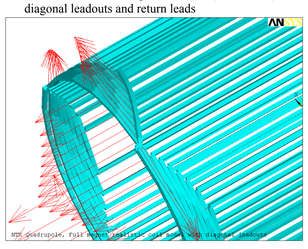


RESULTS FROM 3D FIELD MAPS PRODUCED WITH ABOVE MODEL

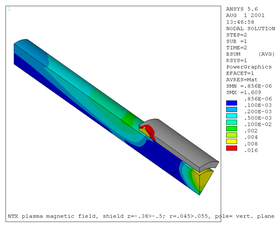
3–D MULTIPOLE FIELDS AS CALCULATED BY ANSYS



3D coil model featuring wound coils (not endless), diagonal leadouts and return leads



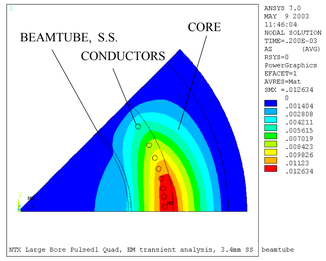
Various magnetic shielding schemes were analyzed, such as this plasma shield for downstream plasma region (~42 cm from center of last quad) where a 1G maximum B field is required.



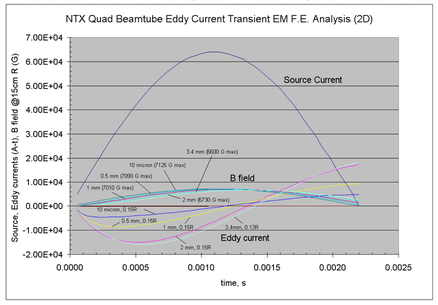
2D TRANSIENT

TO DETERMINE IMPACTS OF EDDY CURRENTS IN BEAMPIPES, FLANGES AND DIAGNOSTICS

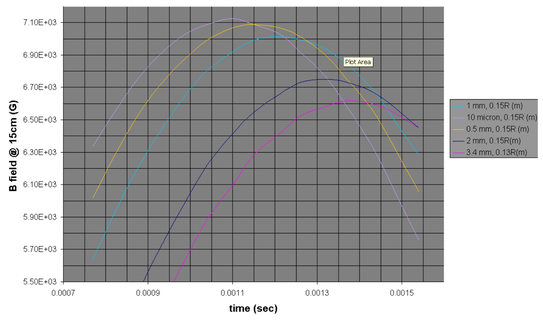
2D F.E. MODEL SHOWING B FIELD PENETRATION INTO BEAMTUBE



TIME HISTORY OF SOURCE, EDDY CURRENTS, AND B FIELD IN BEAMPIPE

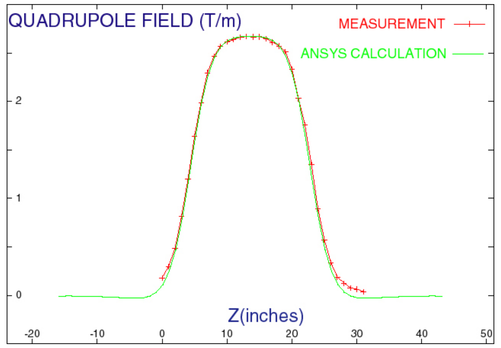


DETAILED PEAK FIELD CHART SHOWING INCREASING FIELD FALLOFF AND TIME LAG WITH INCREASING BEAMTUBE THICKNESS

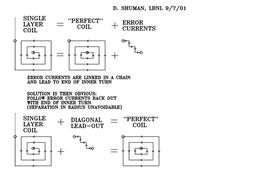


COMPLETED QUADRUPOLES WERE EACH GIVEN 1000 FULL CURRENT PULSES BEFORE INSTALLING ON THE NTX BEAMLINE.ONE QUADRUPOLE WAS GIVEN 10,000 FULL CURRENT PULSES. NO SHORTS OR BREAKDOWN BEHAVIOR WAS NOTED. NTX HAS BEEN OPERATING NOW FOR ~9 MONTHS, WITH SEVERAL THOUSAND PULSES. NO MAGNET PROBLEMS HAVE BEEN NOTED.

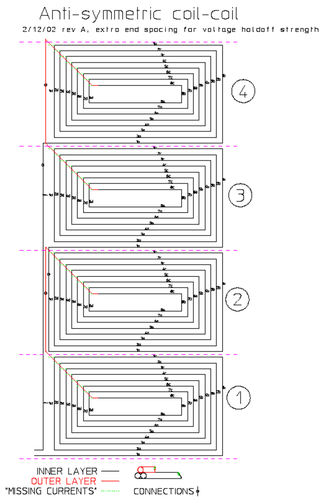
PULSED FULL CURRENT FIELD MEASUREMENTS USING INDUCTIVE COIL PROBE



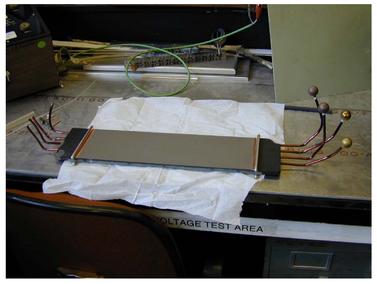
CONCEPTUAL DIAGRAM OF DIAGONAL LEADOUT



COIL WIRING DIAGRAM



COIL CONSTRUCTION H.V. TEST SPECIMEN



These specimens allowed accelerated testing of both conductor to conductor and conductor to ground high voltage resistance, simultaneously. An FET pulser provided a 25 Hz voltage pulse rate of up to 15 kV. Specimen cross section matches the magnet cross section, with stretched conductors laid into grooved machined into G-10 plate. Heat conducting epoxy was introduced under vacuum to simulate flow under and around conductors. Specimens were later machined away to verify proper epoxy capillary flow under conductors to fill grooves.

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*This work has been performed under the auspices of the US DOE by UC-LBNL under contract DE-AC03-76SF00098, for the Heavy Ion Fusion Virtual National Laboratory.