AERnnova engineering

FRP DISK for NEUTRON CHOPPERS

ESS Chopper Jamboree Nov 13-14

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INSTRUMENTS AND SPECIFICATIONS

THE SPECIFICATIONS FOR THE RESEARCH PROTOTYPE DISC HAVE BEEN OBTAINED FROM KNOWN EXISTING EQUIPMENT REQUIREMENTS:

AMATERAS

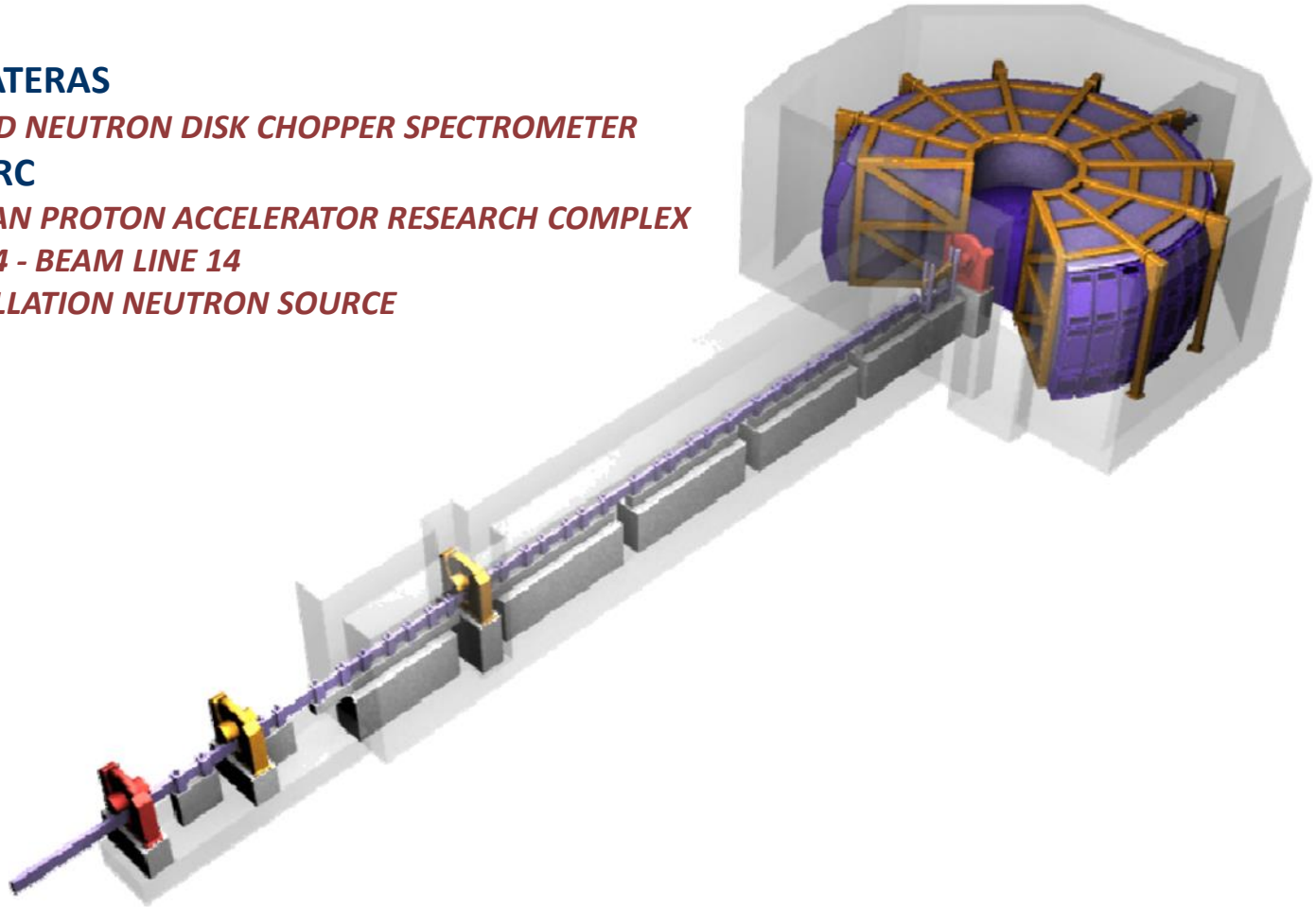
COLD NEUTRON DISK CHOPPER SPECTROMETER

J-PARC

JAPAN PROTON ACCELERATOR RESEARCH COMPLEX

BL14 - BEAM LINE 14

SPALLATION NEUTRON SOURCE



INSTRUMENTS AND SPECIFICATIONS

GEOMETRICAL CONSTRAINTS

DISC DIAMETER 700mm, NEUTRON GUIDE DIMENSIONS 90 mm x 40 mm

FUNCTIONAL CONSTRAINTS

OPERATIONAL SPEED 22.000 rpm

ULTIMATE DESIGN SPEED 27.000 rpm

ACCELERATION TIME < 30 min

COLD NEUTRON TRANSMISSION $<10^{-4}$

MAINTENANCE AND OPERATIONS

1000 CYCLES ACELERATION-DECELERATION

10 YEARS MAINTENANCE FREE

THE SPECIFICATIONS WERE SELECTED LOOKING FORWARD TO BE MORE RESTRICTIVE THAN CURRENT APPLICATIONS IN INSTRUMENTS LIKE:

AMATERAS (J-Parc)

IN5 (Institute Laue Langevin)

NEAT (Helmholtz Zentrum Berlin)

DESIGN AND DEVELOPMENT

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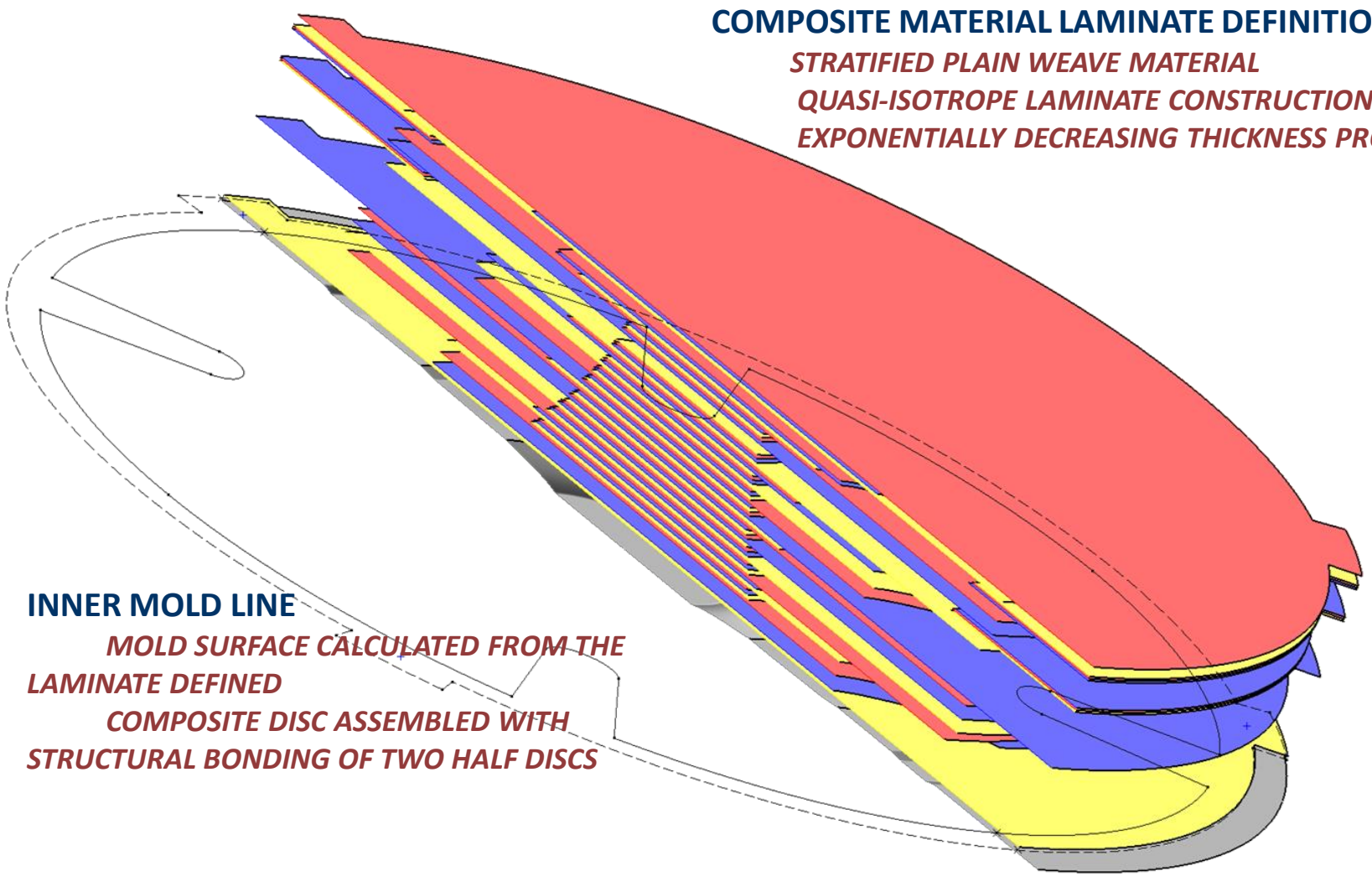
COMPOSITE MATERIAL LAMINATE DEFINITION

STRATIFIED PLAIN WEAVE MATERIAL
QUASI-ISOTROPE LAMINATE CONSTRUCTION
EXPONENTIALLY DECREASING THICKNESS PROFILE

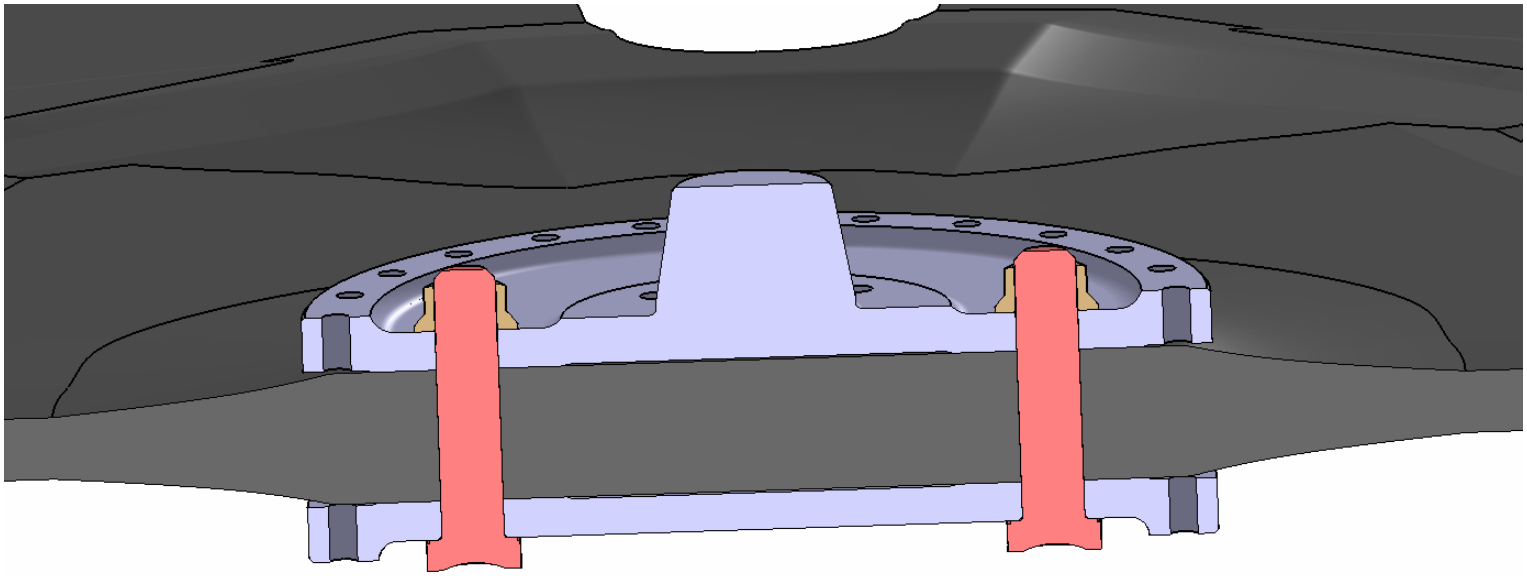


INNER MOLD LINE

MOLD SURFACE CALCULATED FROM THE LAMINATE DEFINED
COMPOSITE DISC ASSEMBLED WITH STRUCTURAL BONDING OF TWO HALF DISCS

DESIGN AND DEVELOPMENT

AERNNOVA – FRP DISKS

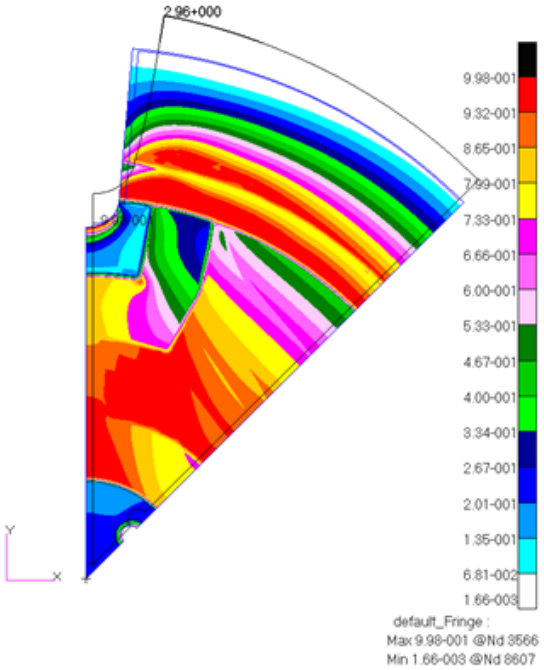


JOINT BETWEEN

CONICAL COUPLING FOR EASY AND ACCURATE ASSEMBLY
ALLOWANCES FOR DISC BALANCE
DEVELOPED JOINTS WITH AND WITHOUT CENTRAL HOLE
HIGH STRENGTH, CLOSE TOLERANCE CRES BOLTS WITH REDUCED HEAD

AERNNOVA – FRP DISKS

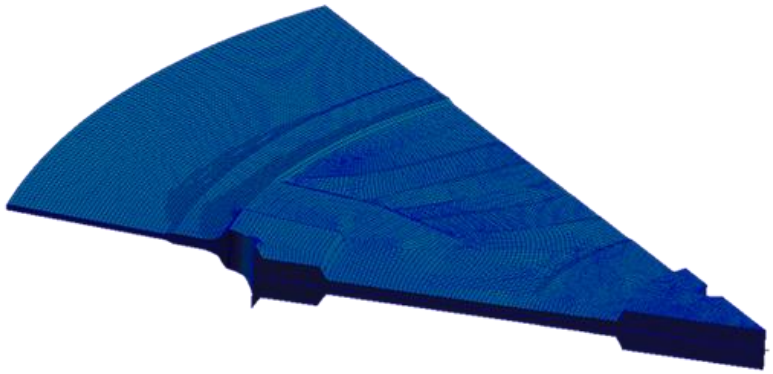
DESIGN AND DEVELOPMENT



FEM 2D SHELLS - NASTRAN

STRESS, STRAIN AND FAILURE INDEX ANALYSIS

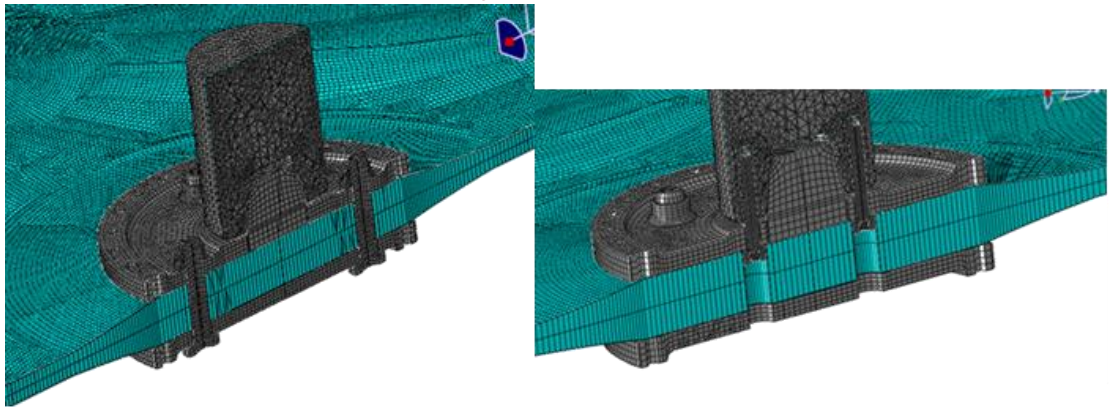
LAMINATE OPTIMIZATION FOR HIGH SPEED



FEM 3D ABAQUS

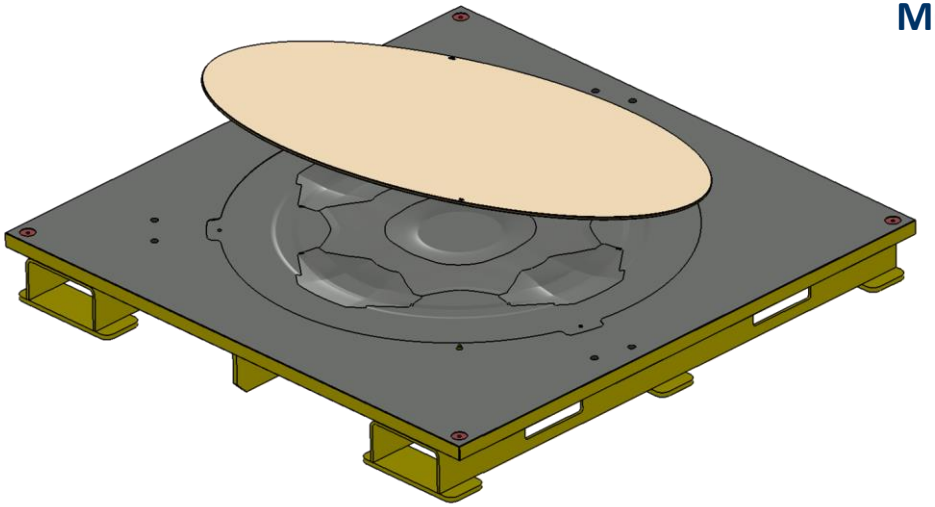
CONTACTS LOADS

STRAIN IN BOLTS, DISC AND PLATES DUE TO THE JOINT



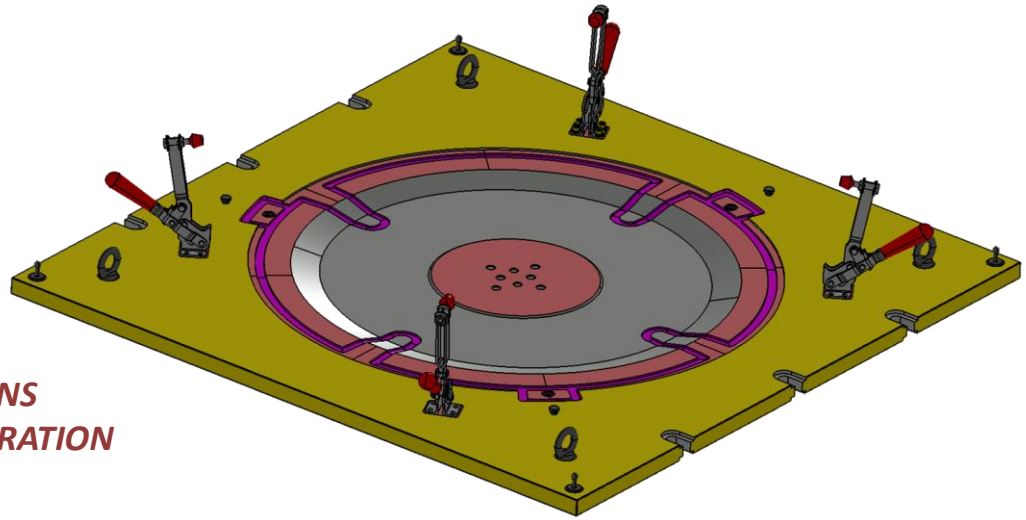
DESIGN AND DEVELOPMENT

AERNNOVA – FRP DISKS



MOLDING TOOL

FEMALE STEEL TOOL
FLAT CAUL PLATE IN THE BONDING SURFACE
TOOLING HOLES DRILLING BRIDGES
LASER PROJECTORS FOR PATTERNS POSITIONING

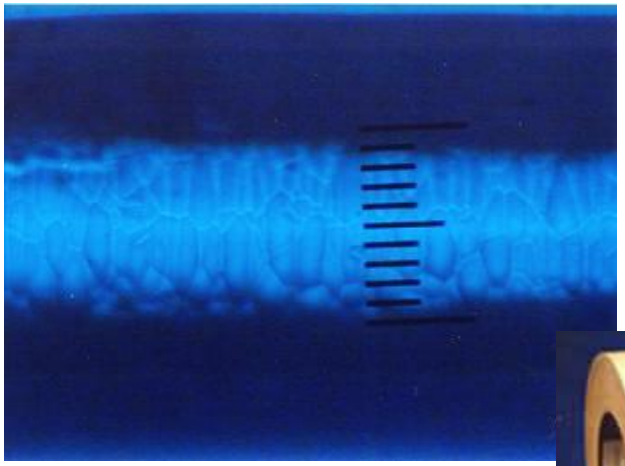


TRIMMING TOOL

DISC SUPPORT FOR MACHINING OPERATIONS
DISC POSITIONING FOR THE BONDING OPERATION

AERNNOVA – FRP DISKS

NEUTRON SHIELDING



BORON FIBER

15 µm WOLFRAMIUM FILAMENT
100 µm BORON IS DEPOSITED OVER THE WOLFRAMIUM FILAMENT
FINAL BORON FIBER DENSITY IS 2,0 g/cm³

BORON TAPE

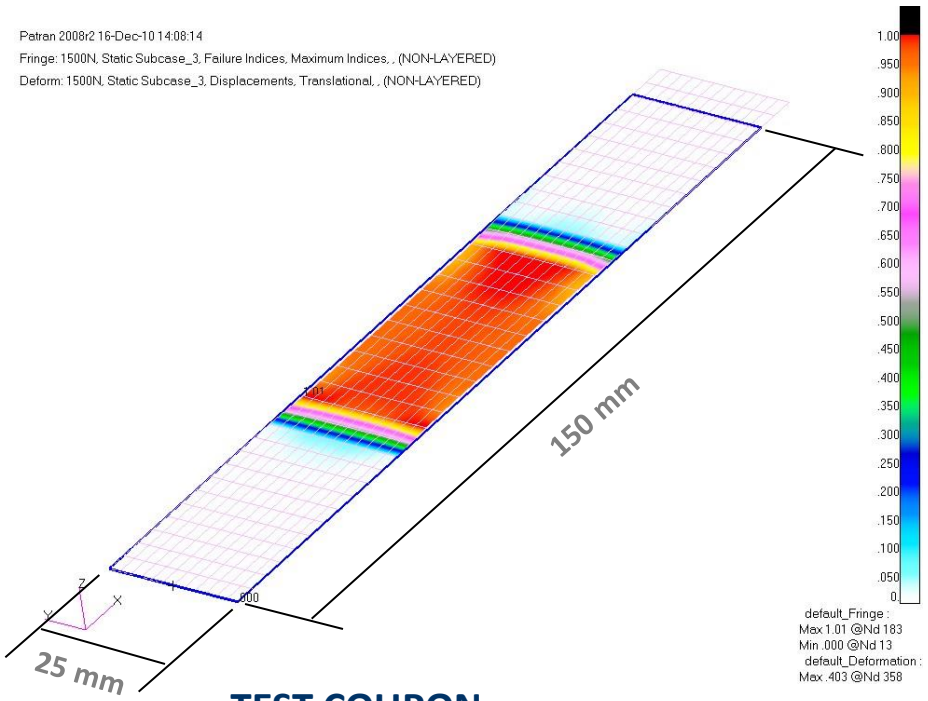
4.0 mil BORON FILAMENTS
EPOXY RESIN 5505
WIDTH 150 mm
THICKNESS 0,13 mm

DEMOSTRATOR PANEL (SIMILAR TO DISC EDGE FLANGE)

6 layers CARBON – EPOXY plain weave
12 layers BORON – EPOXY tape
Dimensions 75 mm x 150 mm
Thickness 2,75 mm

NEUTRON SHIELDING

BORON FIBER ACTS AS NEUTRON SHIELDING AND AS A STRUCTURAL MATERIAL



TEST COUPON

LOW DENSITY (< 2 g/cm³)
HIGH STRENGTH(> 550 N/mm²)
NEUTRON TRANSMISSION (ESTIMATED < 10^{-4})

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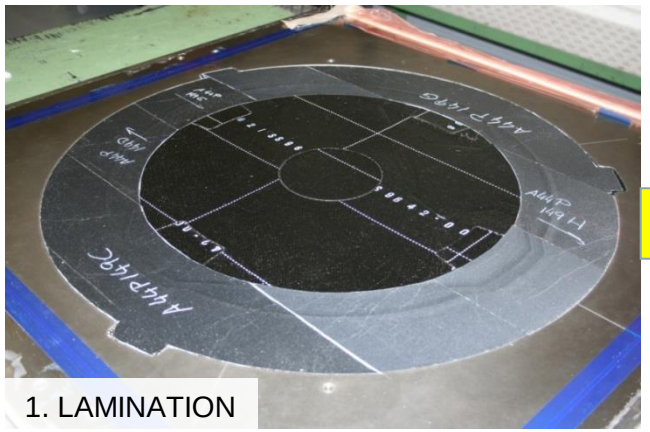
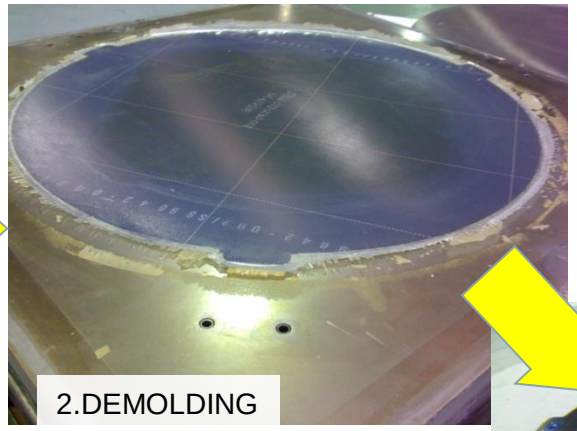
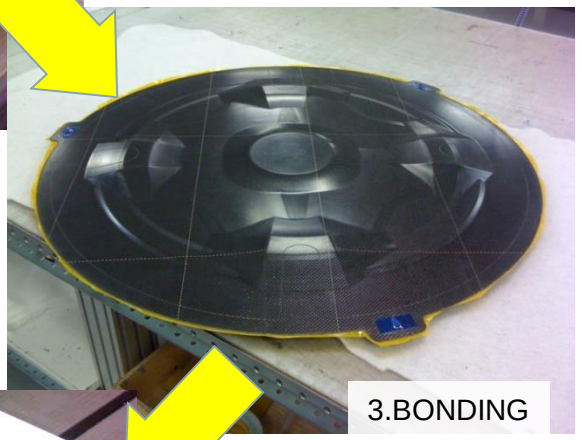
MANUFACTURING PROCESS



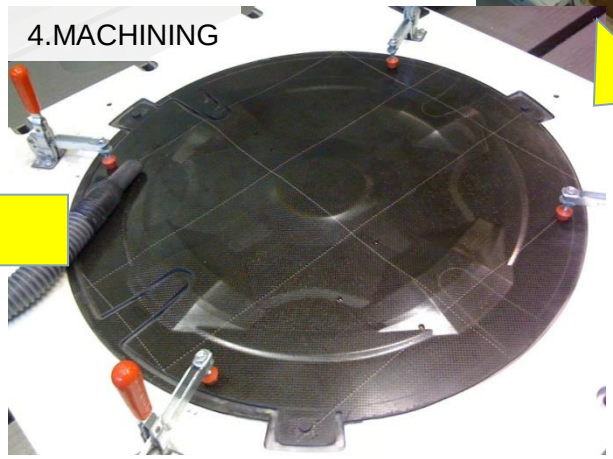
1. LAMINATION



2.DEMOLDING



3.BONDING



4.MACHINING

5.INSPECTION

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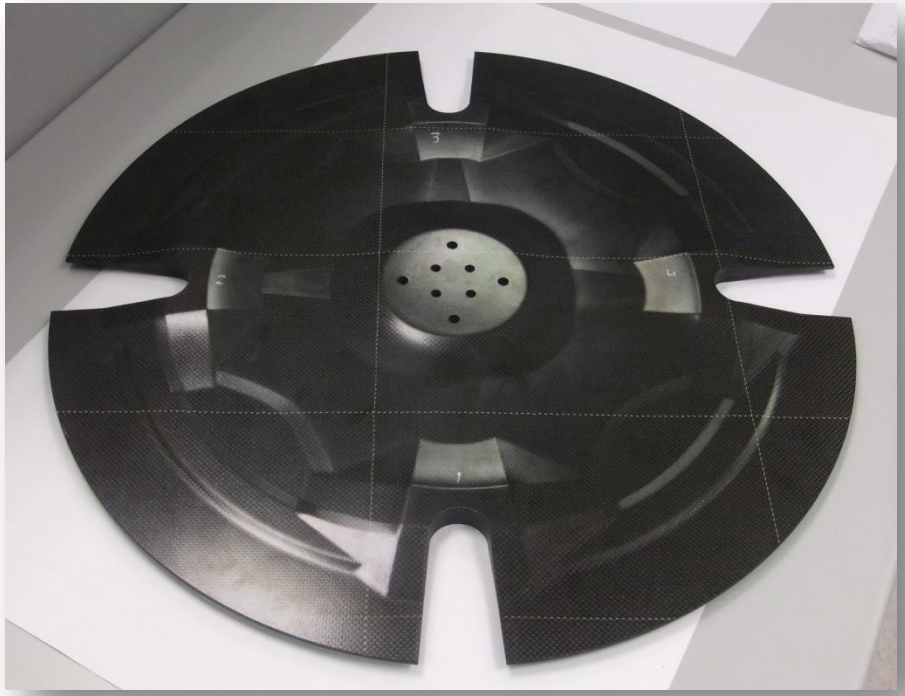
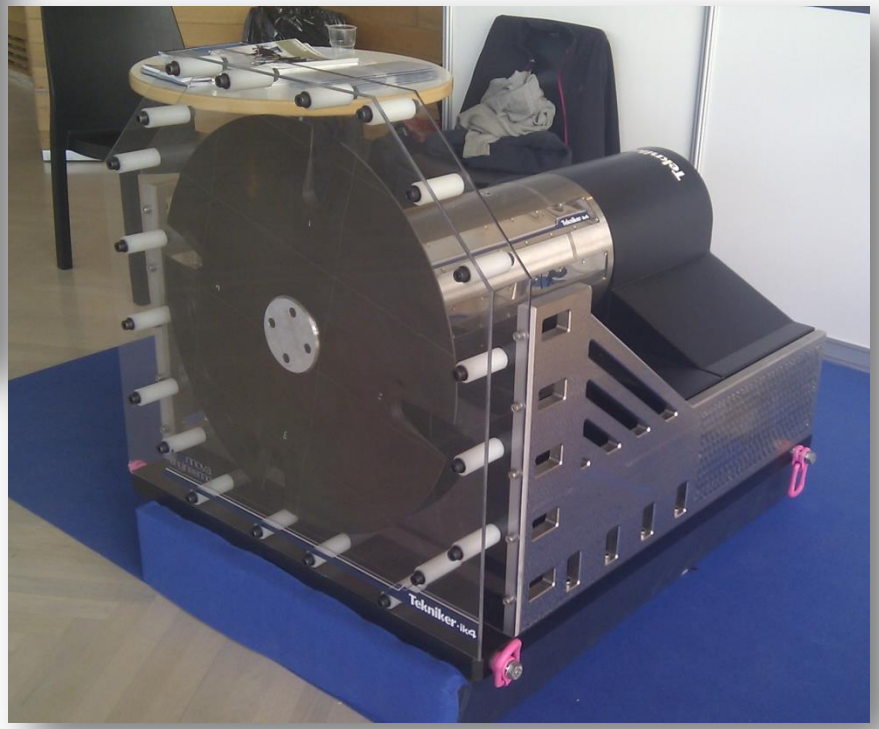
FINISHED DISC

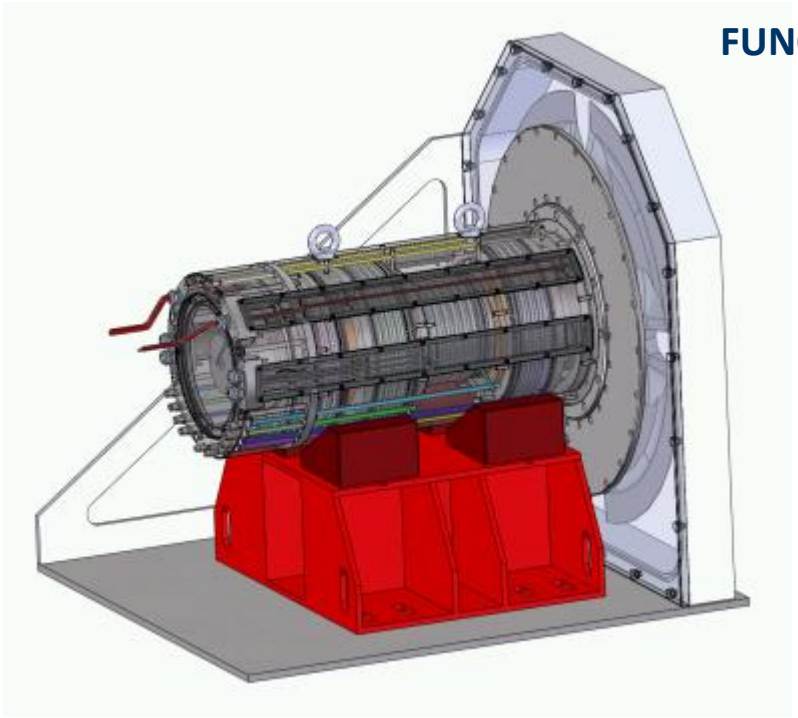


DISC WITH TEKNIKER SPINDLE



DEVELOPMENT FOLLOW UP

HIGH SPEED DISC VALIDATION



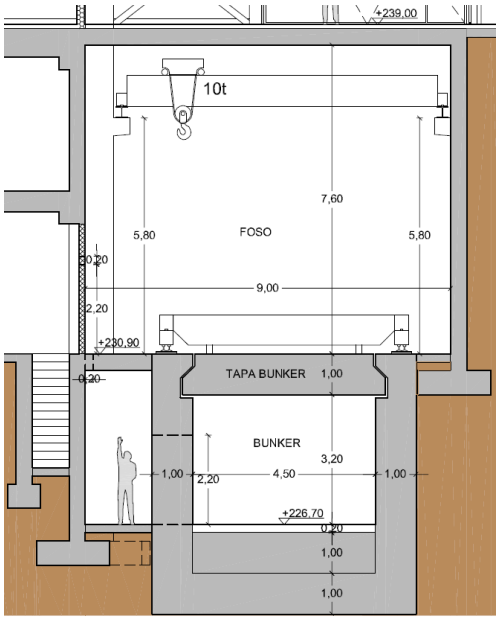
FUNCTIONAL TESTS

QUALIFY THE DISC FOR HIGH SPEED OPERATION

DEMONSTRATE SPEED ANF PHASE CONTROL

(with IK4 TEKNIKER spindle)

QUANTITATIVE MEASURE OF NEUTRON TRANSMISSION



ONGOING CENTRIFUGAL TESTS

OPERATING SPEED > 21000 RPM

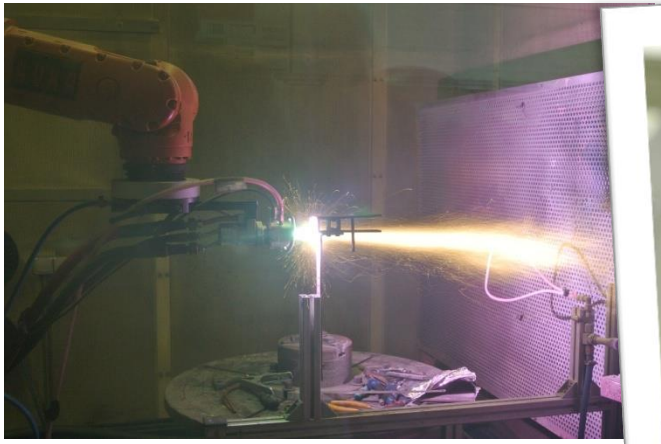
START – STOP CYCLING TESTS

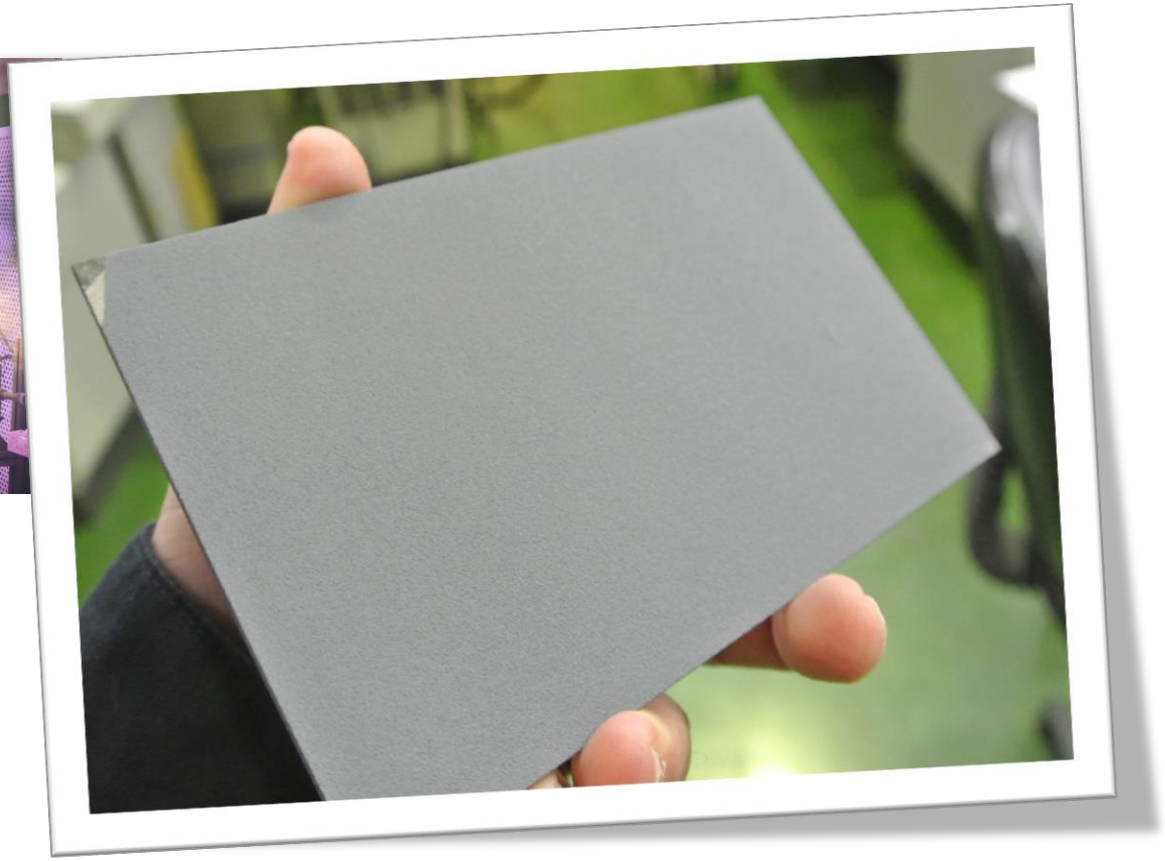
BUNKER OPERATIVE WITHIN TEKNIKER FACCILITIES

DEVELOPMENT FOLLOW UP

FURTHER DEVELOPMENT TO IMPROVE THE BORON COATING

DEVELOPMENT OF SOLID FLAME SPRAY BONDED COATINGS
DEVEOPMENT OF DOPED INKJET COATINGS
MANUFACTURING OF COUPONS
DEMONSTRATION OF ADHERENCE AND NEUTRON TRANSMISSION CHARACTERISTICS





DEVELOPMENT FOLLOW UP

STRUCTURAL HEALTH MONITORING

DEVELOPMENT AND IMPLEMENTATION OF WIRELESS COMMUNICATION AND MULTIPLE CONTROL SOFTWARE FOR PERFORMING MULTIPLE TYPES OF AUTOMATED TESTS AND TOOLS SHM DATA PROCESSING AND IMAGING FOR DAMAGE ASSESSMENT AND ASSEMBLY QUALITY