STATUS OF QUADRUPOLE MAGNETS DESIGN

M. Statera on behalf of the
PAX accelerator group

THE LOW BETA SECTION

- FOCUS THE BEAM INTO THE ACCUMULATION CELL (1 CM x 1CM x 40 CM)
- COSY (FZJ)
- AD (CERN)
- APR? (GSI)
- HIGH FLEXIBILITY

THE MAGNETS

magnetic length: 400 mm

beam envelope max: ϕ 136 mm

field quality: $A_n/A_2 < 10^{-3}$

2 OPTIONS

HIGH GRADIENT: 75 T/m

- ✓ fast ramping not possible with the actual technology
- ✓ no solution compatible with stochastic cooling in the proposed section of AD
- ✓ possible solution: move low β on opposite section of the ring
- ✓ not openable detector (any sensor)
- ✓ State of the art of SC technology
- ✓ COLD

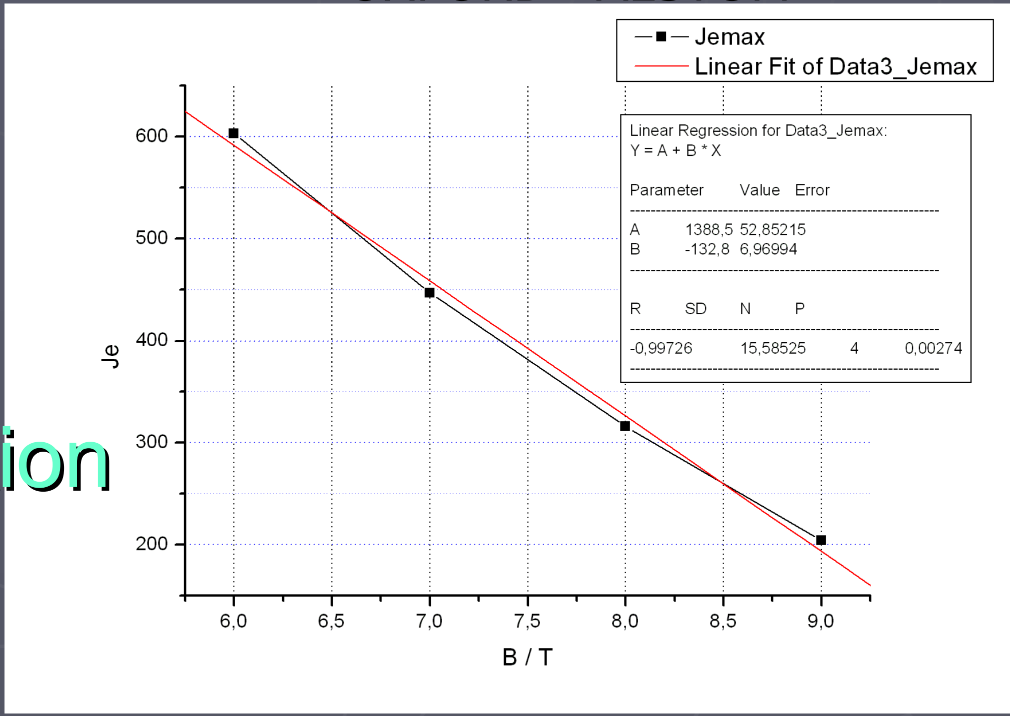
LOW GRADIENT: 20T/m

- ✓ fast ramping not required
- ✓ solution proposed by P.B. compatible with stochastic cooling in AD
- ✓ no necessity to move the (HERMES like) detector
- ✓ standard technology
- ✓ cold
- ✓ warm ?

CONSTRAINTS

- longitudinal space
- magnetic feasibility
  - current
  - field quality
- magnetic axis position

Engineering critical current Vs field
OXFORD - ALSTOM



THE COILS

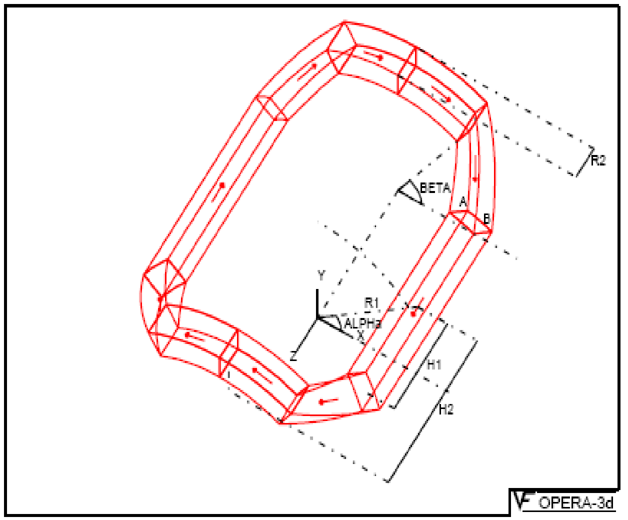


Figure 12 A Helical End

WHICH COILS?

- COS PHI

length too small (ACCEL)

- RACETRACK

WHAT KIND OF CABLE?

SQUARE CROSS SECTION: POSITIONIG

- SINGLE WIRE high inductance
- RUTHEFORD high current
- RIBBON

RACETRACK 1

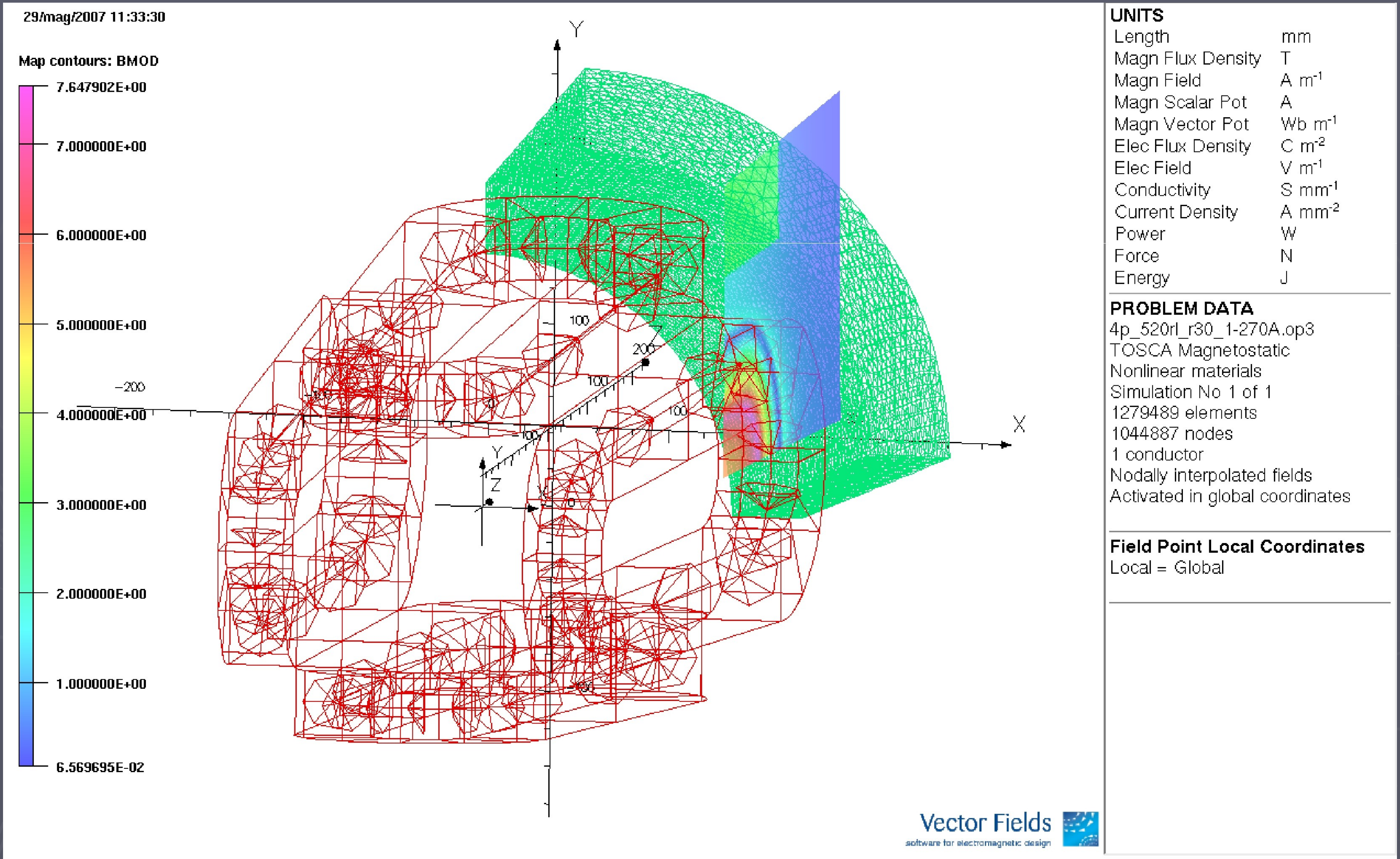
- length 520 mm
- 270 A/mm^2
- max field 7.64 T
- radial field @68mm 4.3 T
- margin to quench: 21%
- integrated radial field @68mm 1.017 Tm

  the ideal integrated field is 1.020 Tm

RACETRACK 2

- cross section 45x40 mm^2
- total current 486 kA
- iron shield 140-180 mm
- energy stored ½BH ~ 225 kJ

RACETRACK 3



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6.000000E+00
5.000000E+00
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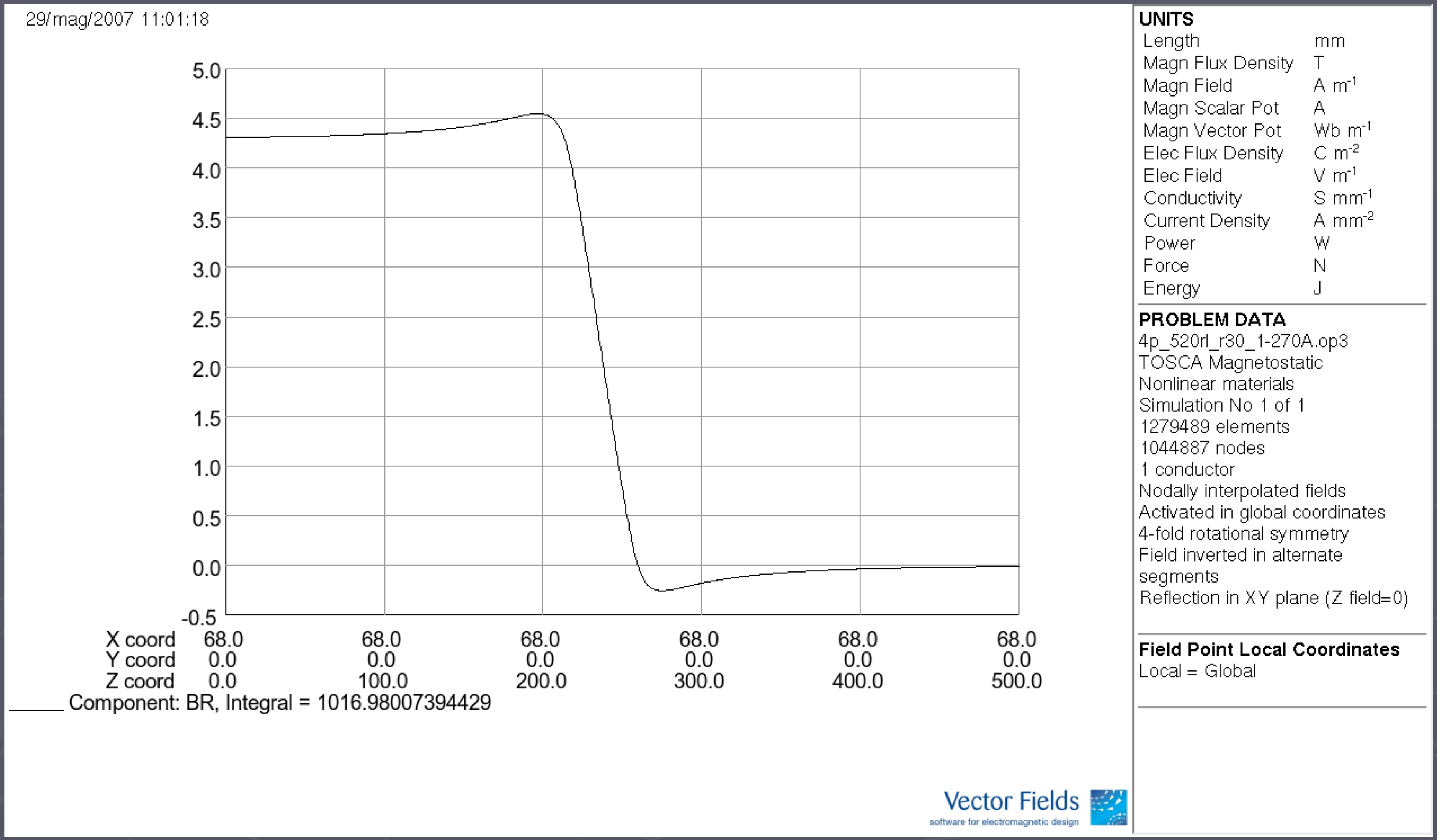
2.000000E+00
1.000000E+00
6.569695E-02
Y
X
Z
UNITS
Length mm
Magn Flux Density T
Magn Field A m-1
Magn Scalar Pot A
Magn Vector Pot Wb m-1
Elec Flux Density C m-2
Elec Field V m-1
Conductivity S mm-1
Current Density A mm-2
Power W
Force N
Energy J
PROBLEM DATA
4p_520rl_r30_1-270A.op3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 1 of 1
1279489 elements
1044887 nodes
1 conductor
Nodally interpolated fields
Activated in global coordinates
Field Point Local Coordinates
Local = Global
Vector Fields
software for electromagnetic design

RACETRACK 4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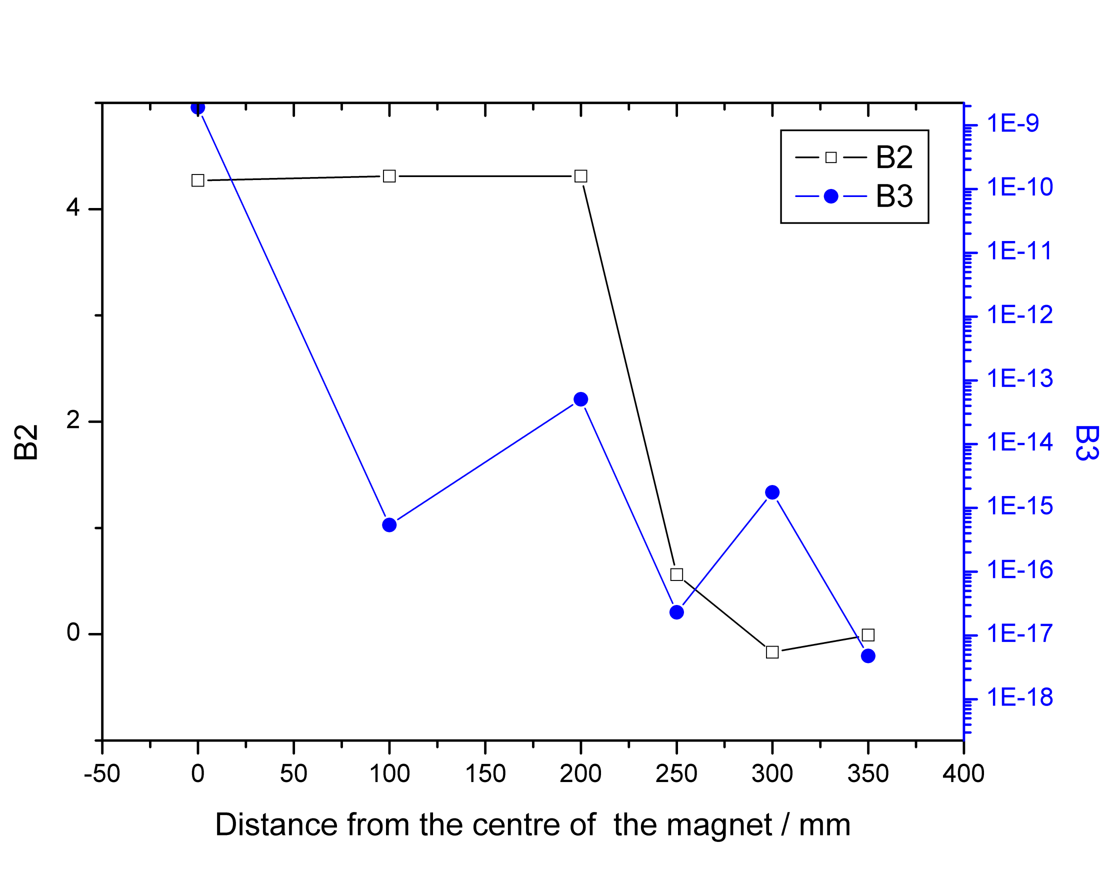
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
X coord 68.0 68.0 68.0 68.0 68.0 68.0
Y coord 0.0 0.0 0.0 0.0 0.0 0.0
Z coord 0.0 100.0 200.0 300.0 400.0 500.0
Component: BR, Integral = 1016.98007394429
UNITS
Length mm
Magn Flux Density T
Magn Field A m-1
Magn Scalar Pot A
Magn Vector Pot Wb m-1
Elec Flux Density C m-2
Elec Field V m-1
Conductivity S mm-1
Current Density A mm-2
Power W
Force N
Energy J
PROBLEM DATA
4p_520rl_r30_1-270A.op3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 1 of 1
1279489 elements
1044887 nodes
1 conductor
Nodally interpolated fields
Activated in global coordinates
4-fold rotational symmetry
Field inverted in alternate segments
Reflection in XY plane (Z field=0)
Field Point Local Coordinates
Local = Global
Vector Fields
software for electromagnetic design

FIELD QUALITY

- HARMONICS
- FRINGE FIELD
- KEYSTONING

small curvature

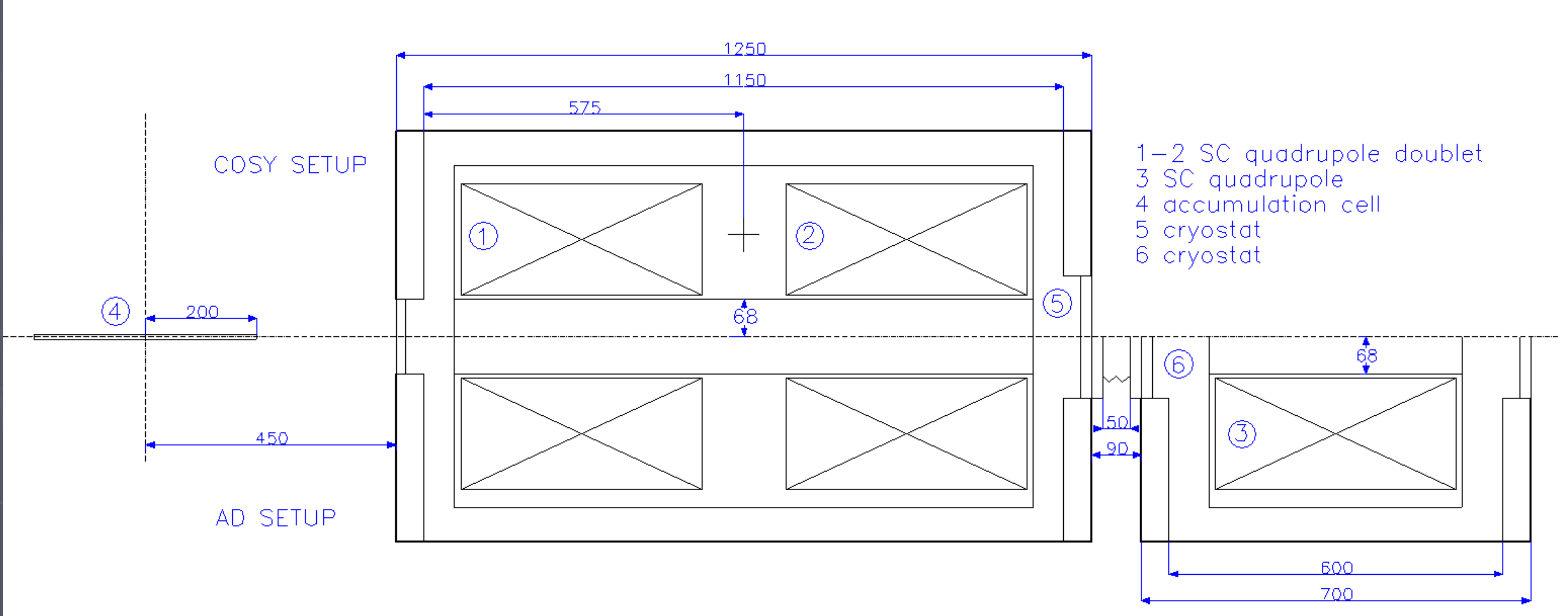


THE CRYOSTAT

- LONGITUDAL DIMENSION FIXED
- NO CRYOGENIC SUPPLIES
- HELIUM BATH
- ZERO (LOW) HELIUM CONSUMPTION
- POSITION ERROR < 0.2 mm
- FLEXIBLE
- MOVABLE

COSY & AD SETUP

- 3-5 (1.5 W @ 4K) CRYOHEADS
- 100 K THERMAL SHIELD

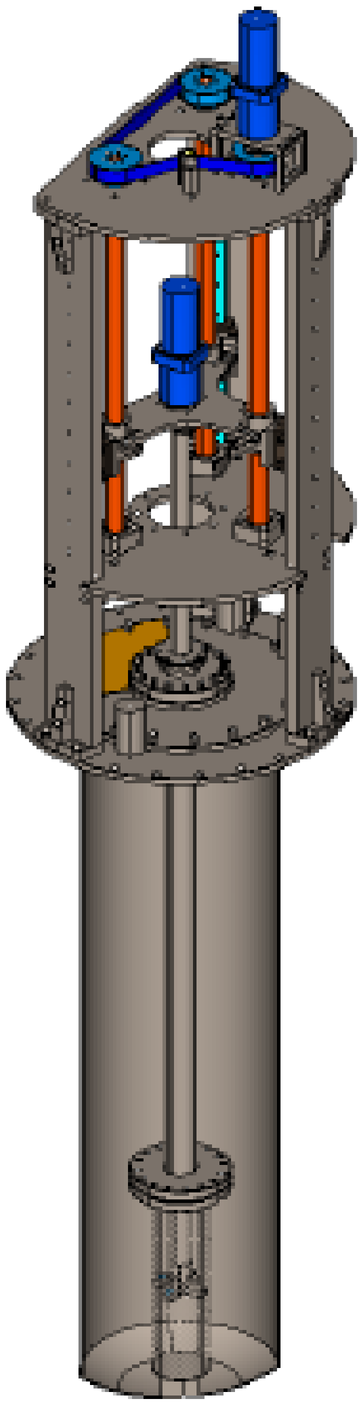


cheaper than a helium liquifier

no liquid helium and nitrogen required (first cooldown only)

FIELD MAPPING

- MAGNETIC PERFOMANCE
  - MAGNETIC DESIGN
  - COILS CONSTRUCTION
  - MAGNET'S SUPPORT
- TEST BENCH IN FERRARA
  - HALL PROBES



TEST BENCH

- **VACUUM CHAMBER IN THE MAGNET BORE**
  - $p<10^{-3}$ mbar
  - Good thermal insulation
  - No ice formation
  - Compatible with $p<1$ bar
- **9 HALL PROBES**
  - 360° rotation, vertical movement (0.7 m)
  - **NON MAGNETIC MATERIALS**
    $\mu<1.005$ AISI 316LN
- **AUTOMATED MEASUREMENT**

HARMONICS MEASUREMENT

- 6POLE MEASUREMENT
  - field mapping along axis
  - A_n/A_3 error 10^{-2}

- 4POLE MEASUREMENT
  - decrease mechanical tolerances
  - improve errors analisys
  - A_n/A_2 error 10^{-3}

NEXT

- IMPROVE 75 T/m DESIGN AND FEASIBILITY STUDY
- 20 T/m DESIGN
- IMPROVED TEST BENCH COMMISSIONING