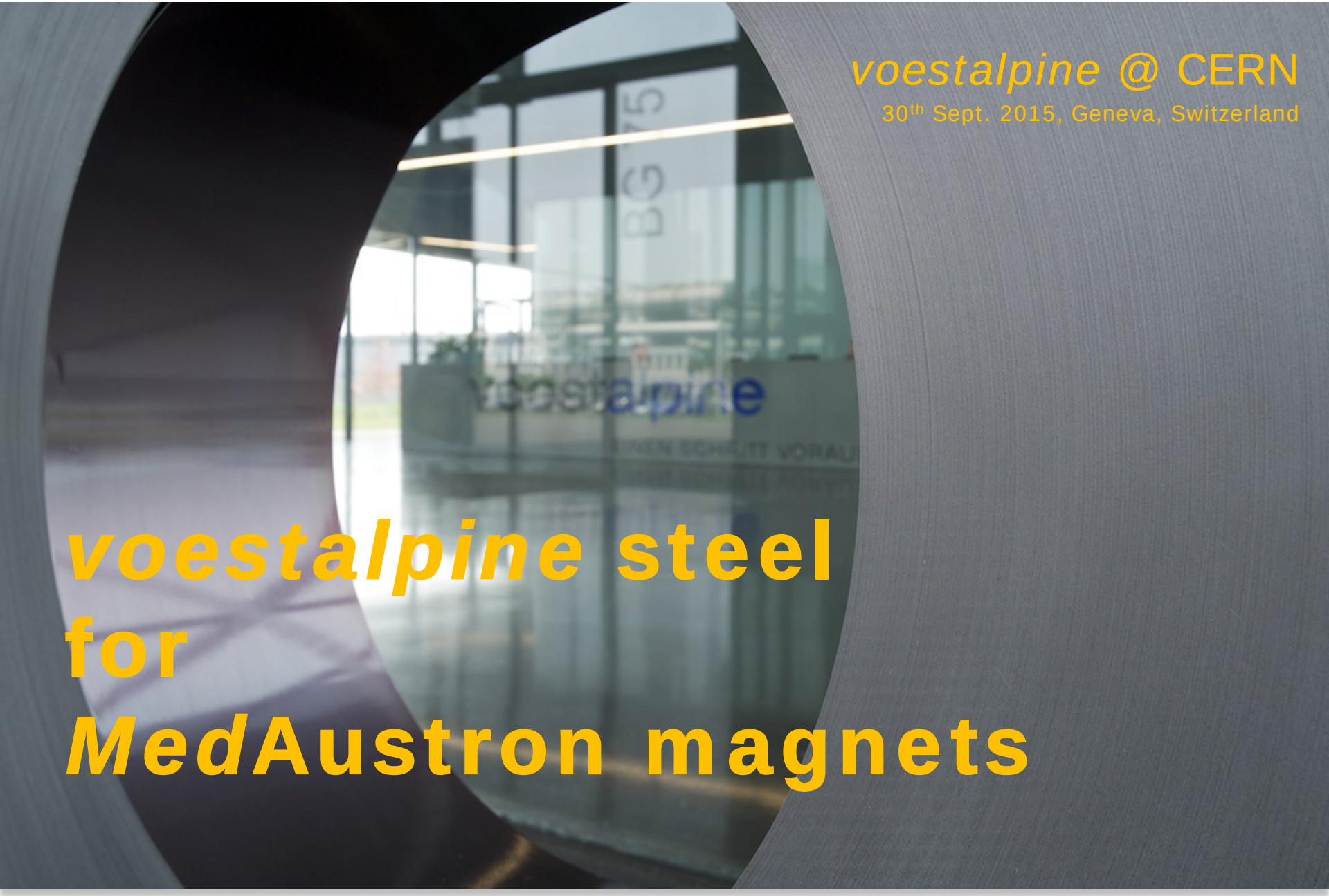


voestalpine @ CERN

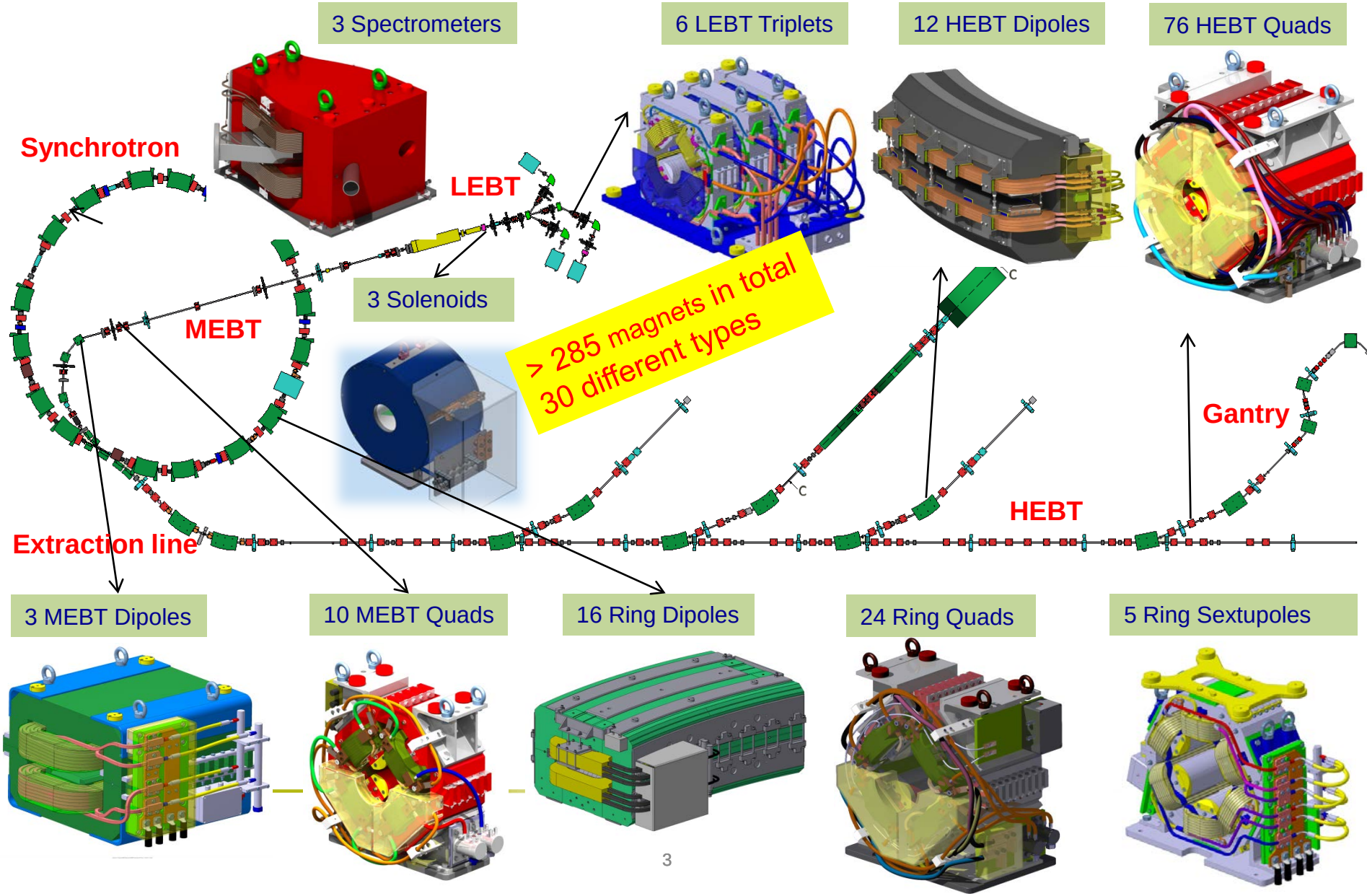
30th Sept. 2015, Geneva, Switzerland

voestalpine steel for *Med*Austron magnets

Outline (...of a success story)

- Magnet types at MedAustron
- Magnet design & production
- Magnet manufacturing
- Steel specification & procurement strategy
- Steel production
- Conclusions

Magnet types at MedAustron



Magnet design & manufacturing strategy

Magnet types at MedAustron

Magnet design & production

Magnet manufacturing

Steel specification & procurement strategy

Steel production

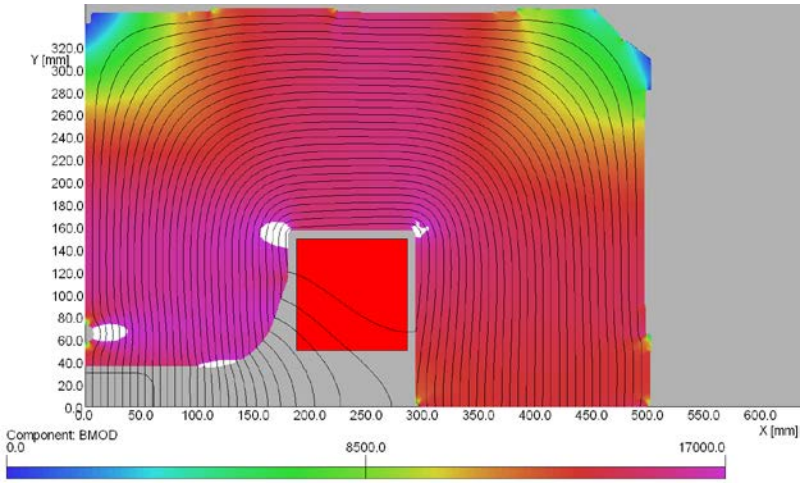
Conclusions

Electro-magnetic design at CERN:

- 2D and 3D FE models for each type
- Most important parameters: pole geometry and steel properties
- Large number of types required to work in series
- Large dynamic operation range was challenging for the EM-design

Manufacturing in industry:

- Suppliers with large production capacity and good experience needed
- According to detailed Technical Specification
- Procurement of materials and components by Contractor
- Pre-series to validate design before series production
- Systematic QA, tests and measurements at the Contractor's
- First contract: summer 2009
- Last contract: spring 2013
- Last magnet: end 2014



Magnet manufacturing

Magnet types at MedAustron

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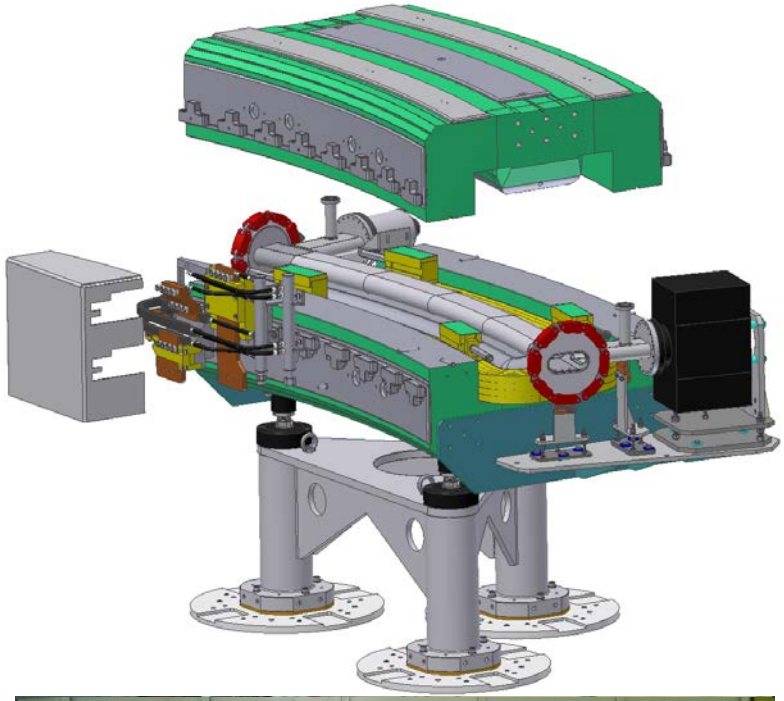
Conclusions

Synchrotron main dipole

- Lamination punching
- Sorting and stacking
- Baking (polymerization)
- Welding/Machining
- Mechanical measurements



Steel specification & procurement strategy

Magnet types at MedAustron

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Conclusions

Specified requirements:

- 1 mm thick, cold rolled, non-grain oriented, electrical steel
- Thickness variation <7 µm perpendicular to the rolling direction
- Suitable for fine blanking (tolerances < 20 µm)
- Two-side epoxy coating for electrical insulation and bonding
- Permeability variation < 1%, coercivity variation < ±2 A/m
- Same grade for all types (except 'fast' magnets): 700 to in total
- Required batch quantities: 100 kg to 200 tons
- But: minimum order quantities > 18 tons
- Short production lead times

→ *MedAustron was searching for a steel grade with very specific characteristics*

Strategy: Common procurement for all magnets

- Reproducible quality
- Material properties know at the design phase
- For synchrotron magnets: measurement, selection and sorting to assure most homogenous quality (permeability, coercivity)
- Fully under the control of MedAustron → risk minimization
- Produce total quantity in several batches (limited shelf-life time of coating)
- 'Just-in-time delivery' to magnet manufacturers' upon request

Steel production

Magnet types at MedAustron

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Conclusions

After informal discussions and the analysis of the tenders, *voestalpine* seemed to be the ideal partner offering a suitable product respecting the specified requirements

Contract signed with *voestalpine* in February 2010

- 700 tonnes isovac 1300-100 A

Particularities of this contract:

- Requirements certainly more demanding than EN 10106
- Tight tolerances on critical parameters (H_c, μ_r and thickness)
- Intensive measurement campaign (>5x per mother coil):
  Mechanical properties, magnetic properties (DC), thickness, bonding strength
- Production of extra-wide strips to decrease thickness variation
- Selection and delivery according to measurement results
- Intermediate storage at steel supplier under correct conditions
- Challenging logistics:
  5 different magnet manufacturers
  >30% of the steel was shipped to Novosibirsk/Russia

Steel selection

Magnet types at MedAustron

Magnet design & production

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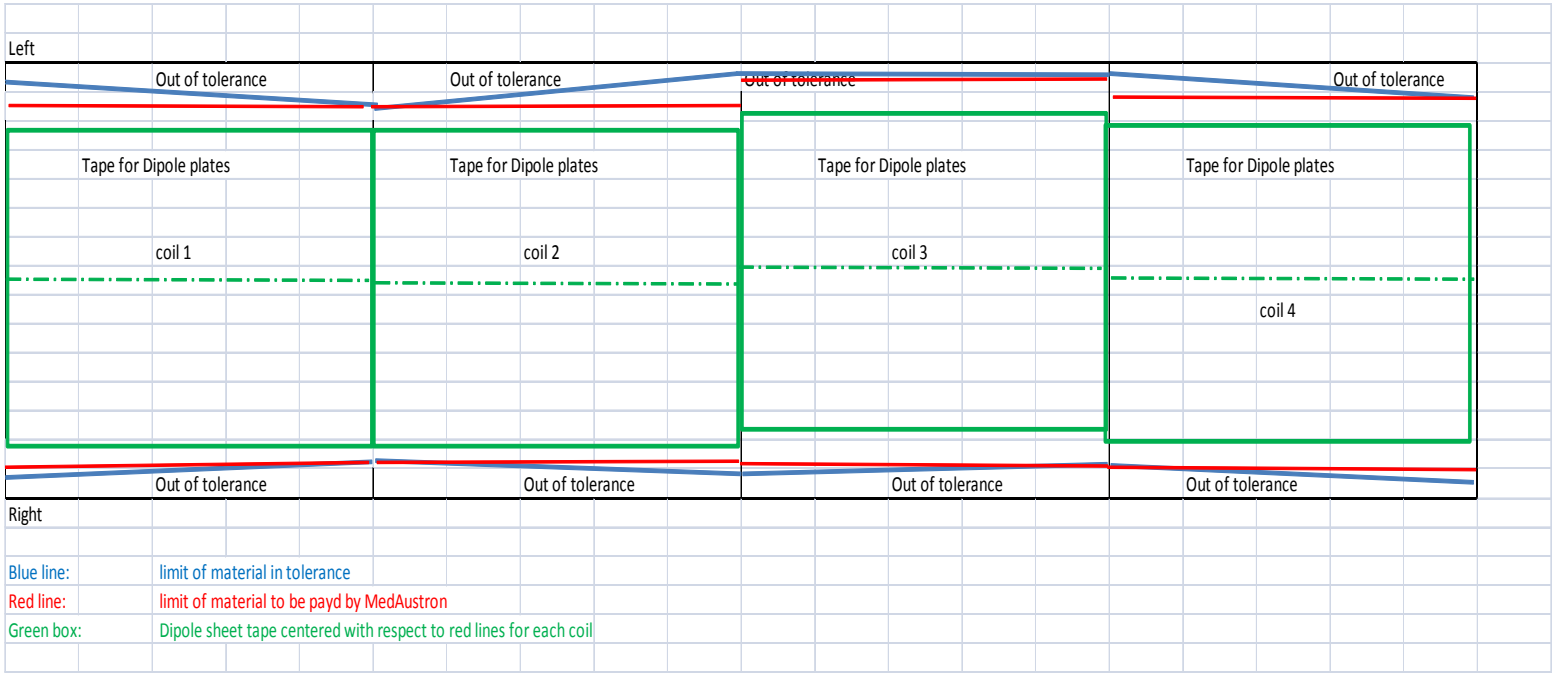
Selection and splitting after thickness measurement



Courtesy T. Tortschanoff

Steel selection

- Magnet types at MedAustron
- Magnet design & production
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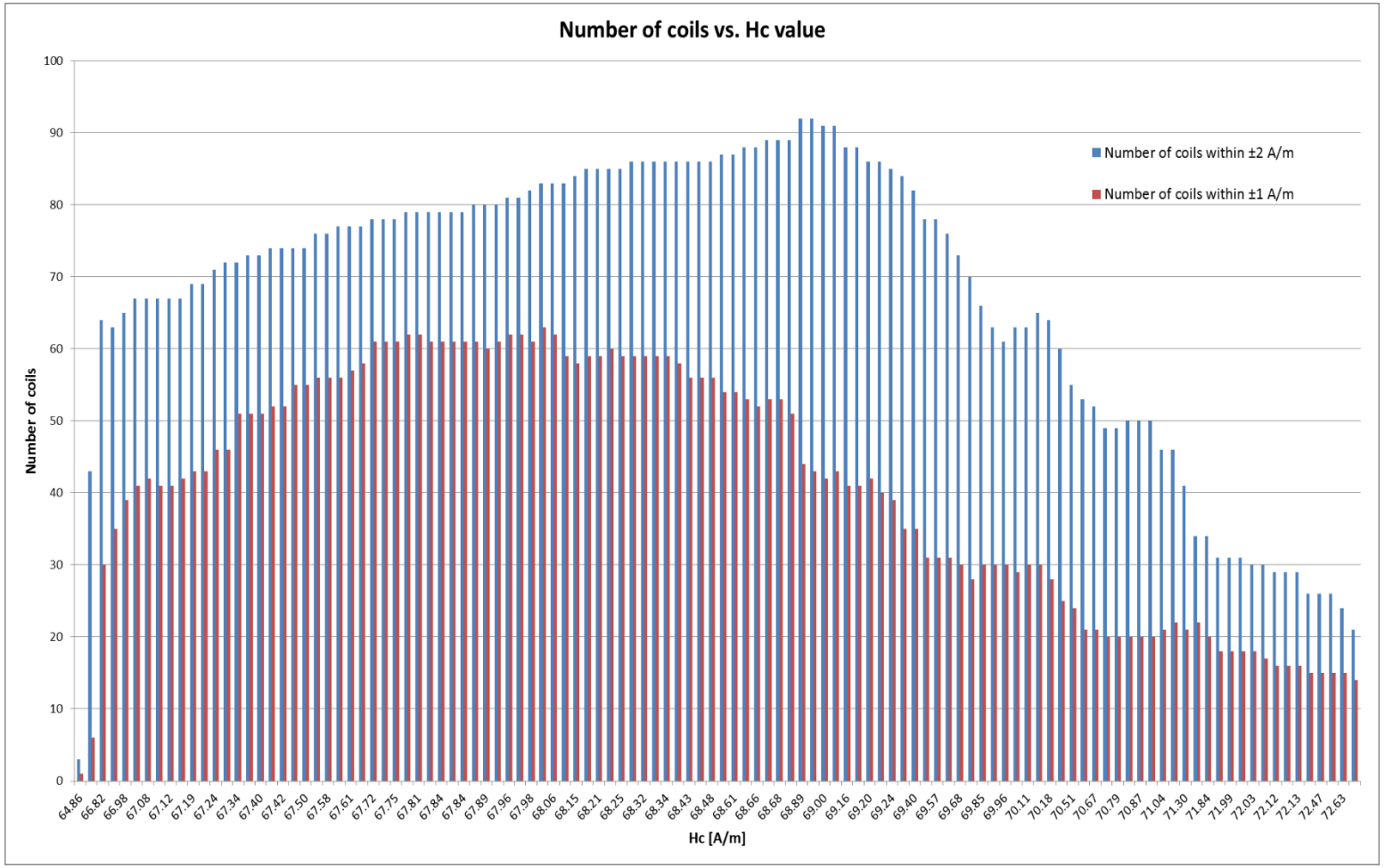
- Conclusions



Steel production

Magnet types at MedAustron

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Conclusions

Upcoming issues could be solved without major impact on the project:

Discrepancy in magnetic measurement data provided (isovac 1300-100 A)

- Error in initial DC measurements → wrong data used for all FE-simulations
- Repetition of most critical FEM calculations
- Cross-check measurements by CERN and 3 independent institutes
- 'New' properties could be used for most magnet types
- Small impact on magnet production schedule
- *voestalpine* proposed different grade (isovac 250-35 HP) for 'special magnets'

Problem with bonding of insulation layer (isovac 250-35 HP)

- Several weeks delay in MQZ-C production
- Replacement material produced and delivered within short delays

Conclusions

Magnet types at MedAustron

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Conclusions

- *voestalpine* delivered a specialized product fully compliant with MedAustron specification and beyond EN 10106 standard
- Quality of 1300-100A extremely good

  Variation of H_c and μ_r well below specified tolerances
- Excellent customer support from *voestalpine*
- Highest flexibility and reactivity shown by all departments (technical, commercial and logistics)
- Despite challenging schedule and logistics, the material was delivered in time
- Good communication due to regular visits, email exchange and telefon conferences
- Many helpful and constructive discussions during the contract
- All upcoming issues were solved with high level of proficiency in shortest possible time

Many thanks to you and your staff for this productive and successful collaboration!

Without your support and the outstanding quality of the supplied steel, the MedAustron magnet production would have certainly been more difficult.