REBCO WIRE PRODUCTION AT THEVA

STATE OF THE ART AND PROSPECTS

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THEVA AT A GLANCE

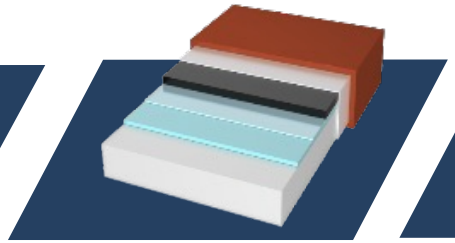
THEVA is the sole remaining European HTS wire supplier

Company: THEVA GmbH, HQ in Ismaning, Germany, established 1996

Team: 47 FTE (mainly engineering & production)

Product portfolio

HTS
Coils



HTS Tape
THEVA Pro-Line

Quality Control -
TAPESTAR™

Value proposition

- Reliable wire supply
- Robust, high performance products
- Expertise and engineering support

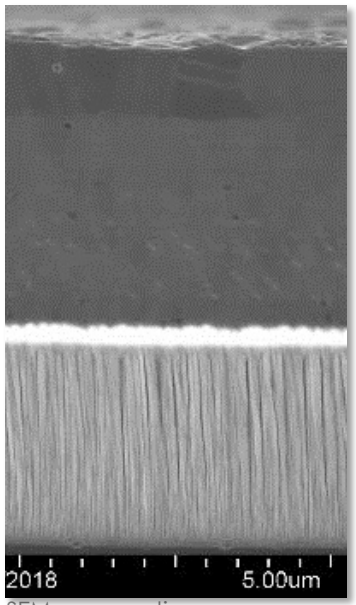
Main applications

- Magnets: high field, fusion, industry
- Current leads (with low heat input)
- HTS cables and bus bars for high current

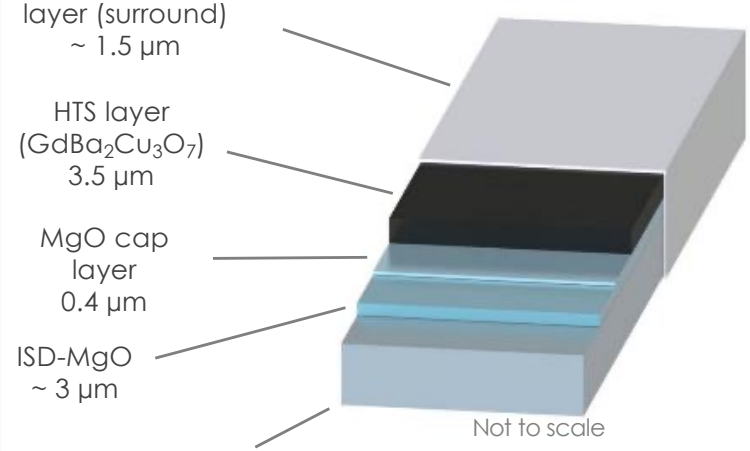
THEVA PRO-LINE HTS WIRE

Simple HTS tape architecture

- Few, inexpensive materials
- Thick, high-current HTS layers accessible
- Uniform PVD technology throughout all steps

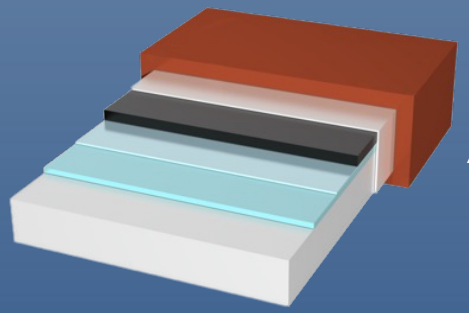


SEM cross section



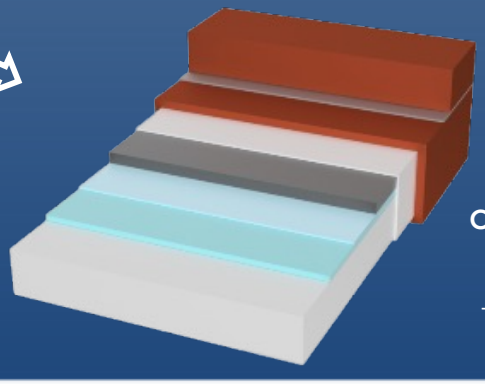
Customized technical wire

Slim, surround stabilized



Magnet coils
Ag, Cu, Sn, PbSn
5 -10 □m
Total: 70 □m

Laminated, robust, strong stabilization



Cable applications
Cu foil laminate
100 -150 □m
Total: 200-250 □m

THEVA PRO-LINE WIRE – THE ENGINEER'S CHOICE

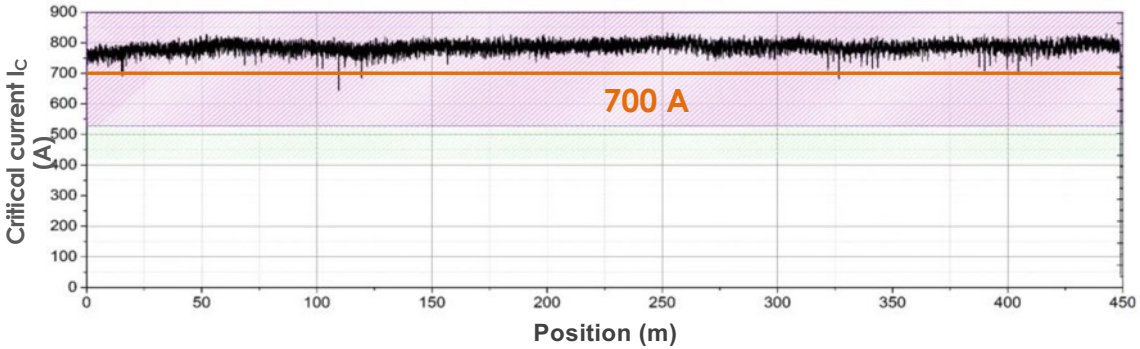
Laminated Tape For Cables

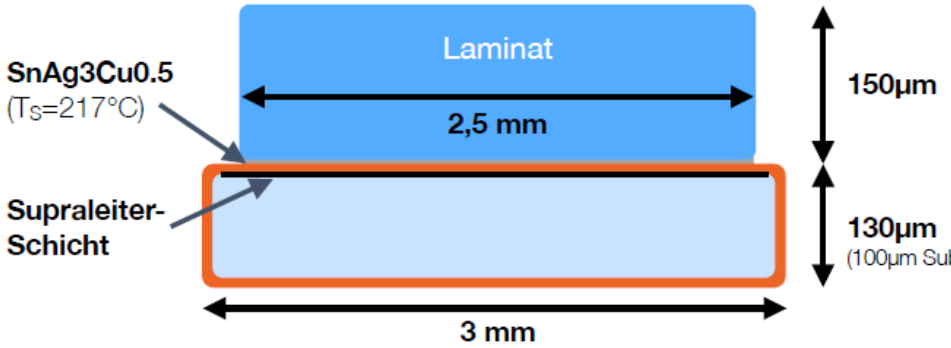
Regular standard production wire

$I_{C,min}$ (77K, s.f.) = 600 A – 700 A

Piece length: 150 m – 400 m

Robust, single-sided Cu lamination



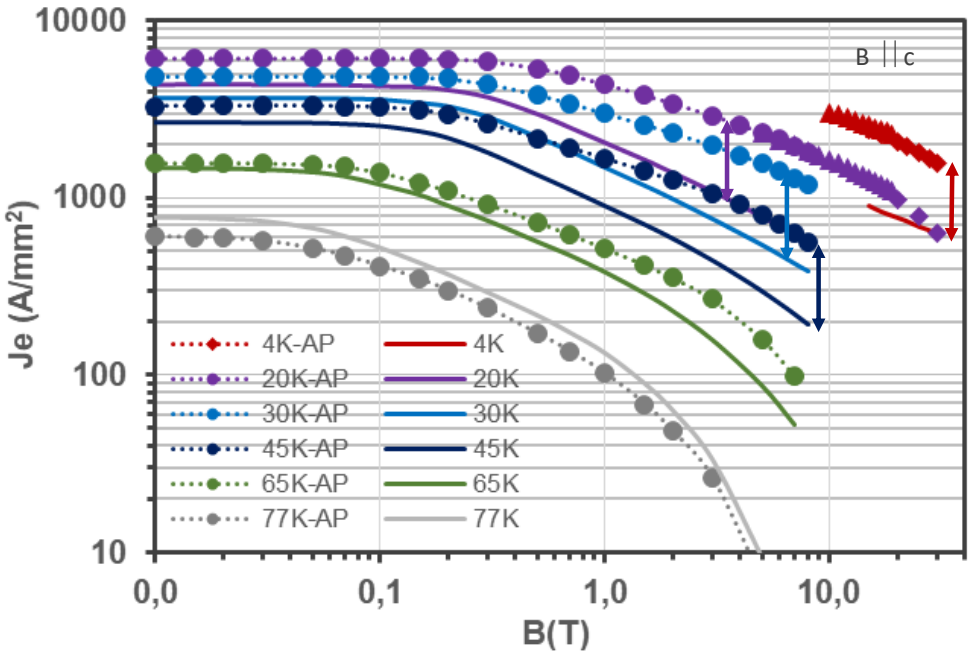


Optimized for cables with low AC-Loss

- Laser-slit: 3 ± 0,1mm width
- Trapezoidal shape to minimize gaps
- Sustain high compressive strain (up to -1,5%)
- Best at lay angles: 30°

AP-ReBCO wire for Ultr High Field Magnets

Field dependence of ReBCO-wire (+ $BaHfO_3$)



Below 50 K: **I_C(B) improvement by factor 2.5**

THEVA Pro-Line AP wire performance

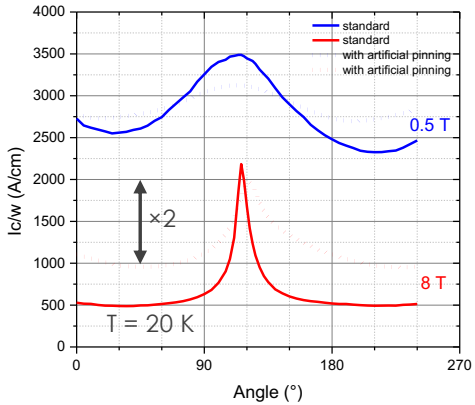
Current density for B || c of total 70 µm thick tape (50 µm substrate and 10 µm surround Cu coating)

- 10 T: 3000 A/mm²
- 20 T: 2000 A/mm² **@ 4.2 K**
- 30 T: 1550 A/mm²

@ 20 K, 20 T: 800 - 900 A/mm²

Reduced anisotropy

- AP randomly dispersed
- no columnar growth



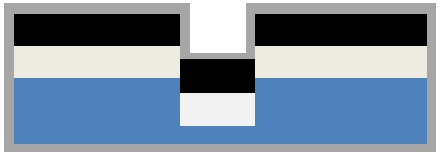
HF data from LNCMI Grenoble, Univ. Geneva, RRI Wellington

Development: Filamentized Tape

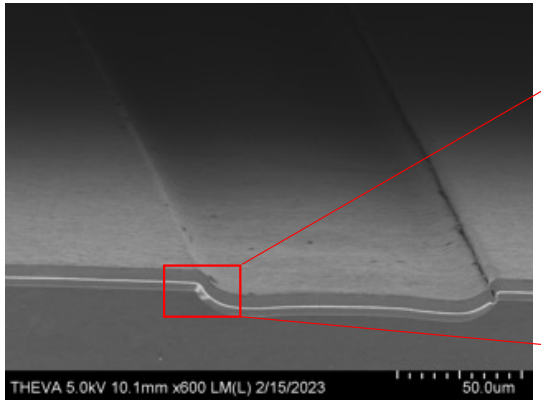
THEVA

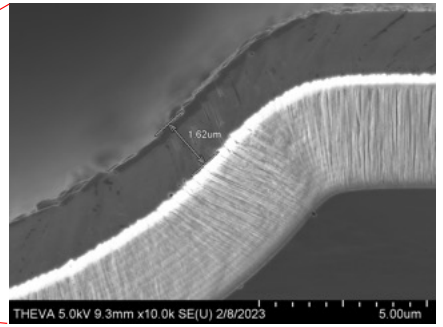
FILAMENTS4FUSION

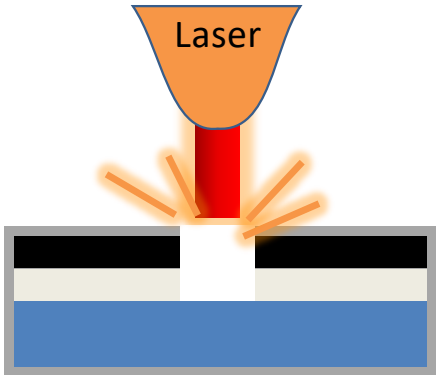
eurostars™



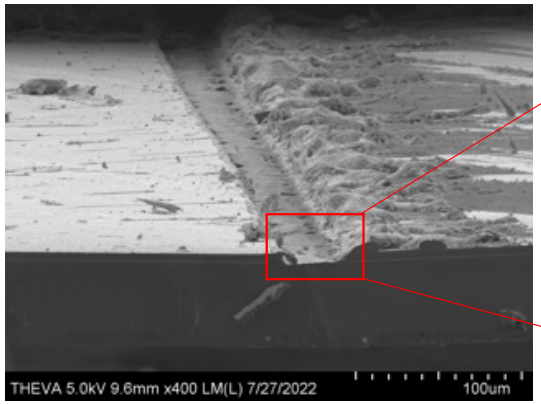
Bottom-up: Deposition on chemically etched substrate

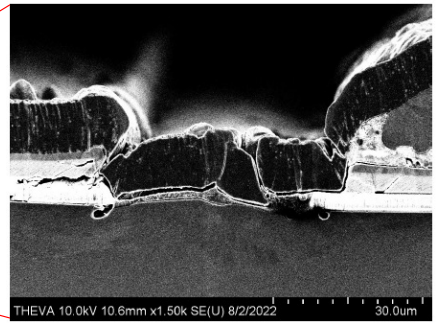






Top-down: Laser-scribing





APPLICATIONS

COST-EFFECTIVE COMMERCIAL COILS (LOW FIELD MAGNET< 3T)

Optimization at multiple fronts

Cryogenics

- Integrated cold bus

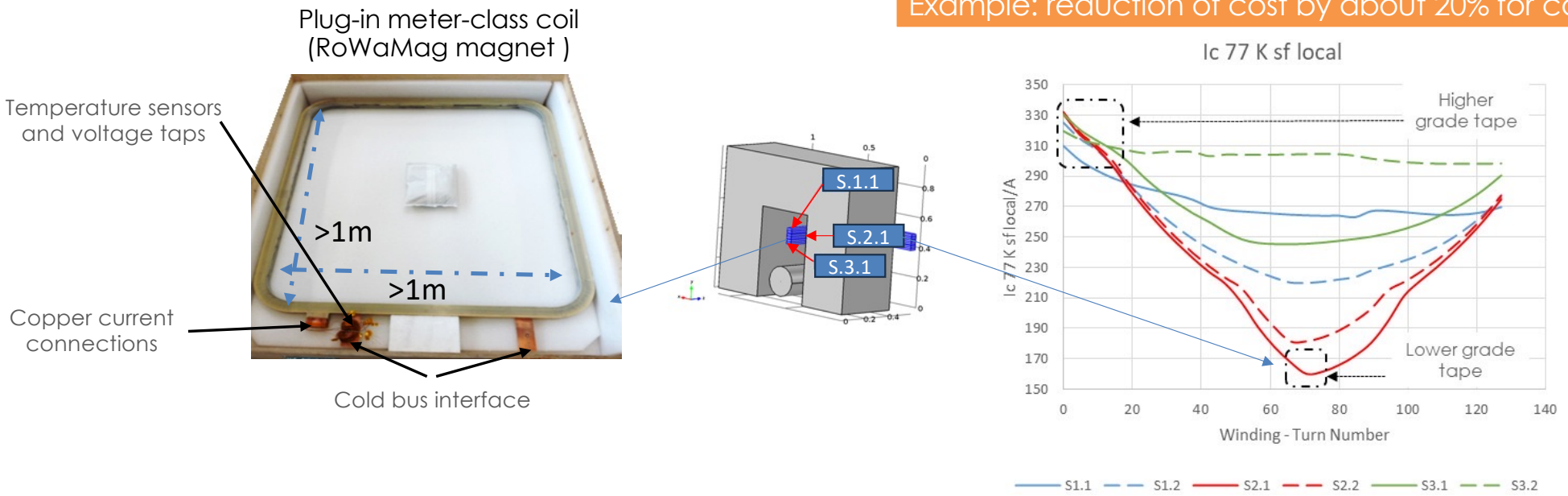
Assembly

- Assembly and maintenance made easier

HTS cost

- HTS tape grade used according to the magnetic field strength

Example: reduction of cost by about 20% for coil S2.1



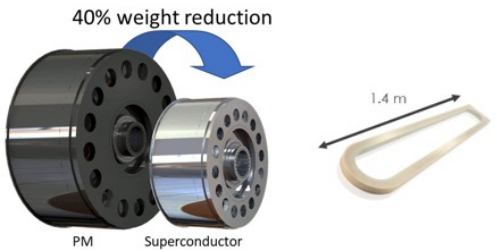
EXAMPLES APPLICATIONS

Industrial and research applications of low field coils <3T

3 MW wind turbine

- 44 coils manufactured
- 650 h of operation at 2-3 MW

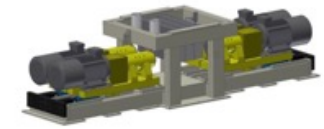
ecoswing

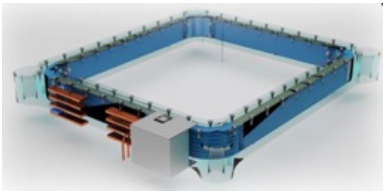


Magnetic heater of 2×300 kW

- Using HTS system can save over 56% of energy use per year
- Pack of 3 meter-sized DP delivered per system

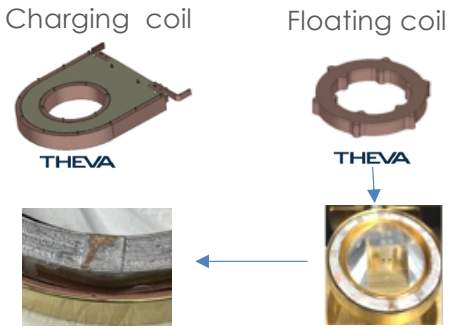
ROWAMAG





Research & Development

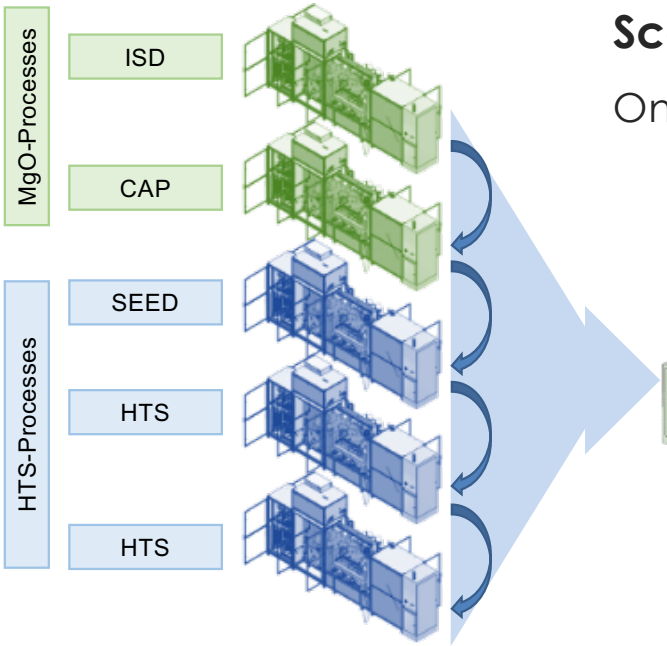
- Single pancake non insulated floating coil with high mechanical robustness and quench resilience
- Inductive charging coil



Repeatable low resistance cross joint for a short- circuited single pancake

THEVA HTS TAPE PRODUCTION

Future: Production Scaling

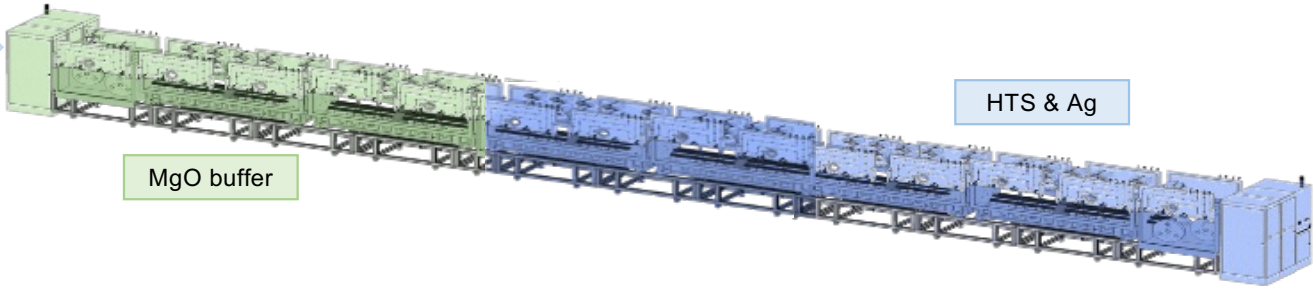


Scaling means more than cloning of current equipment

Only increased efficiency and productivity can reduce **unit cost**

ALPHA ⇒ BETA

100% ⇘ 25%



Tape width 12 mm

Capacity: 100+ km_{12}

Going wide

25 ×

Tape width 4 × 80 -100 mm

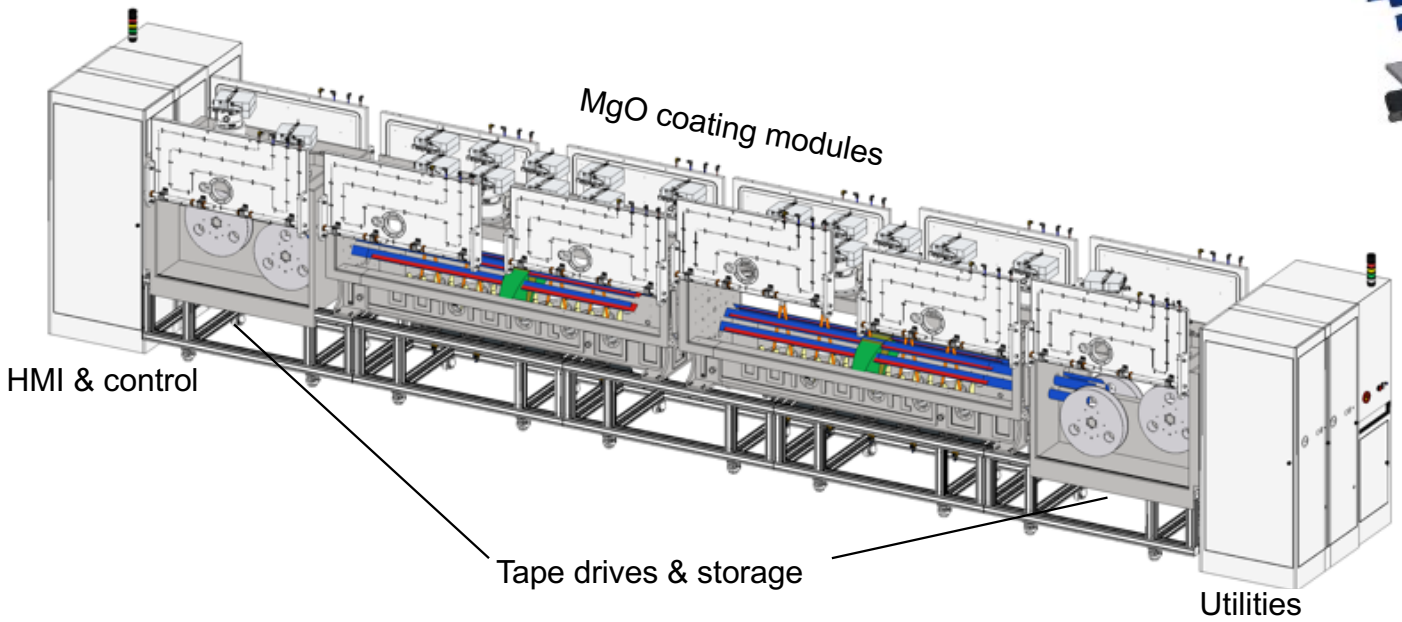
Capacity: 2500+ km_{12}

ALPHA 2023 — BETA 2025 — GAMMA – production facility 2027

Prerequisites for True Scaling

Scalability requires low complexity and modularity

- Inline arrangement of a large number of inexpensive sources (e-guns)
- High deposition rate, continuous operation, long service life
- Wide tapes covering large angle, straight transport – simple mechanics



Not Trivial: Smart Customization & Auxiliary Processes

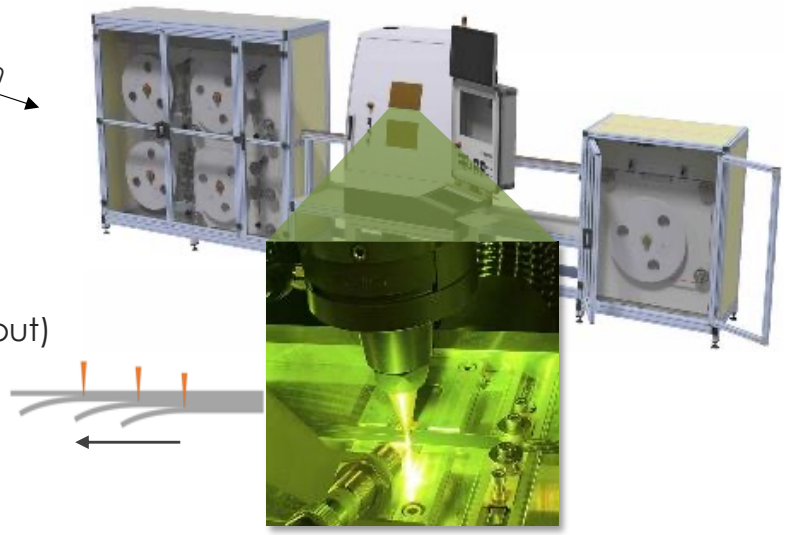
Scaling and automization of PVD processes straightforward, but ...

... **customization & logistics are labor-intense and substantial cost factors**

400 coils (PVD) ⇒ 10,000+ coils (customized wire & documentation)

Processes adding cost, but not a single kAm, and require high-yield handling

- Laser slitting (crucial technology)
- Metal surround coating (high speed PVD)
- Corrosion protection
- Lamination
- Insulation
- Quality inspection & marking (high throughput)
- Documentation (RFID, digitalization)
- Storage (warehouse robots)
- Packaging



OUTLOOK

➢ Market assessment

- The market is turning: demand exceeding supply
- Currently: 90% magnet applications (USP “performance”, lowest entry threshold)
- But mid-term: volume markets in electrical power engineering will take over

➢ Positioning

- THEVA ProLine wires are qualified for all applications (HFM, cables, drives)
- THEVA is well positioned for the future using truly scalable processes

➢ Outlook

- Scalability & cost leadership will make a difference
- Demand & customer commitment will set the pace

Thank you!

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