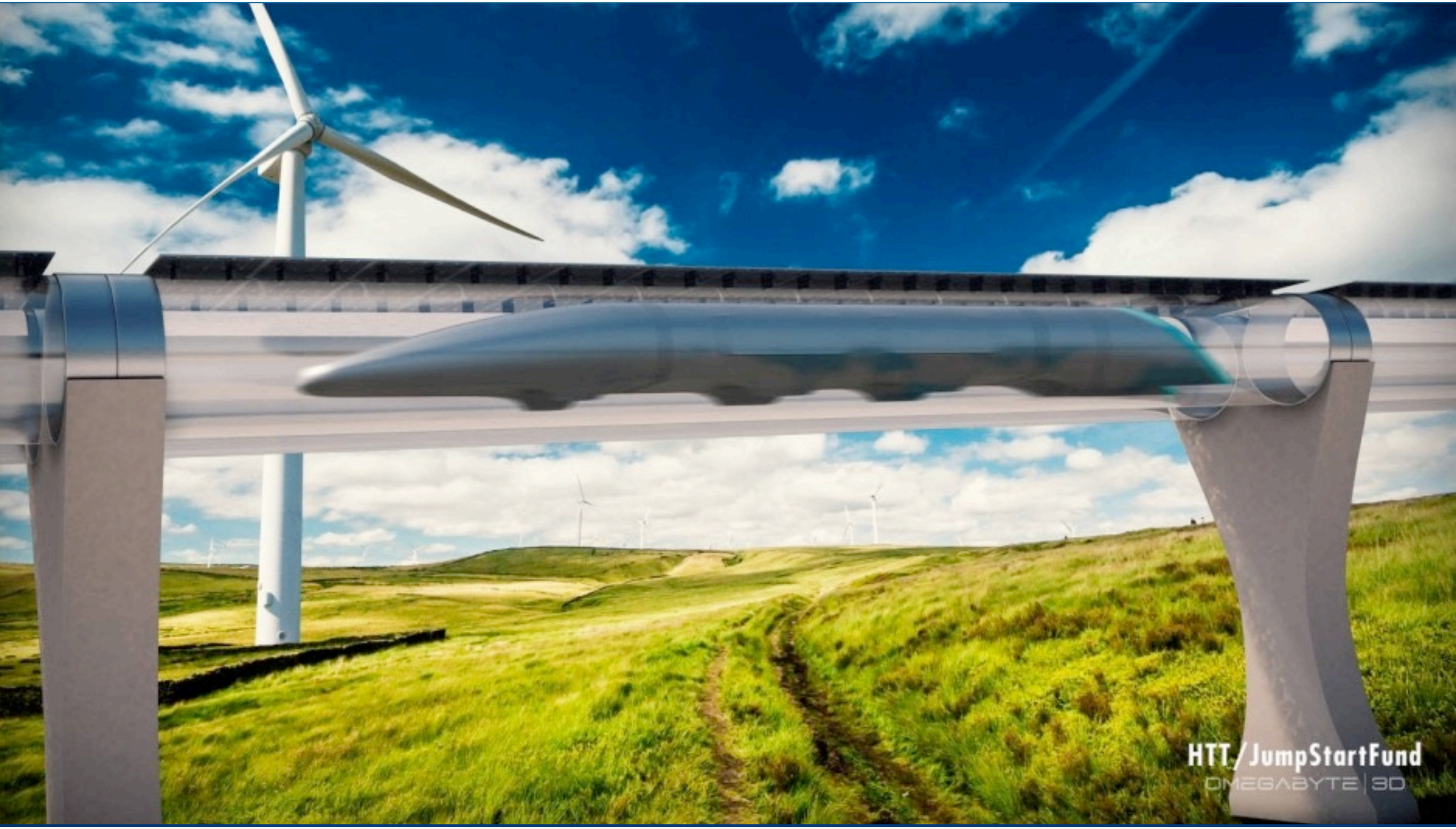
ZIEHL 2016

Berührungsloses Tragen und Manipulieren mit Supraleitern

Oliver de Haas, Lars Kühn

evico

Hyperloop-Projekt - Luftlager



Elon Musk, Tesla, Space X

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Elektromagnetische Levitation

Bild: techcrunch.com

Bild: Schaeffler FAG

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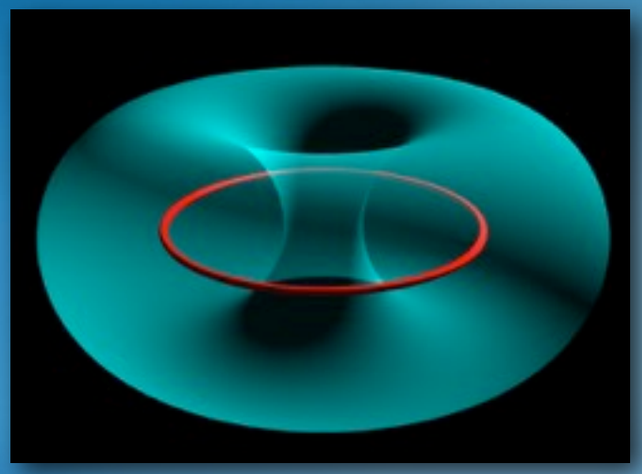
Das Earnshaw Theorem

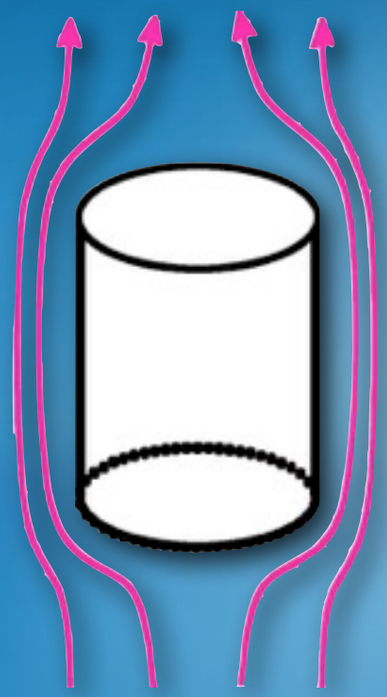


- Samuel Earnshaw 1842:

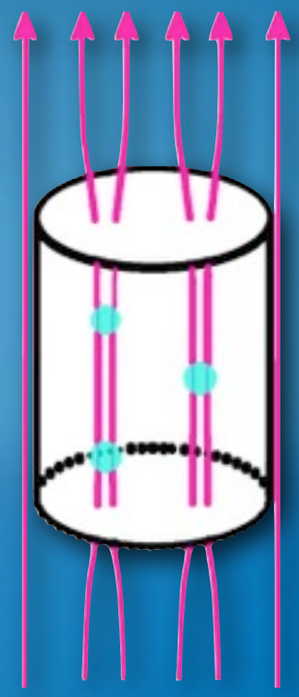
Ein stabiler Schwebezustand kann allein durch statisch Magnetfelder oder statische elektrische Ströme **NICHT** erreicht werden,

Universität Leiden, NL

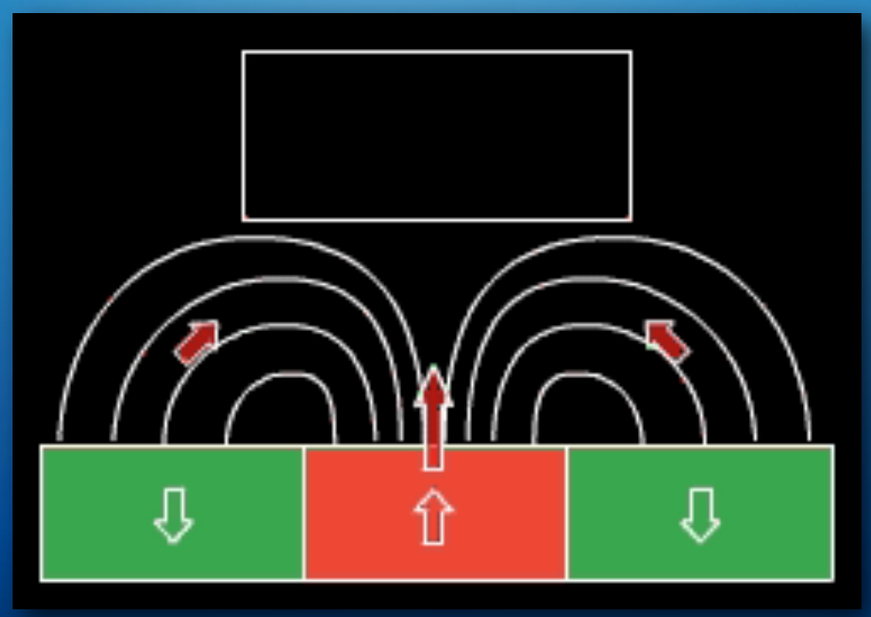
Supraleiter im Magnetfeld

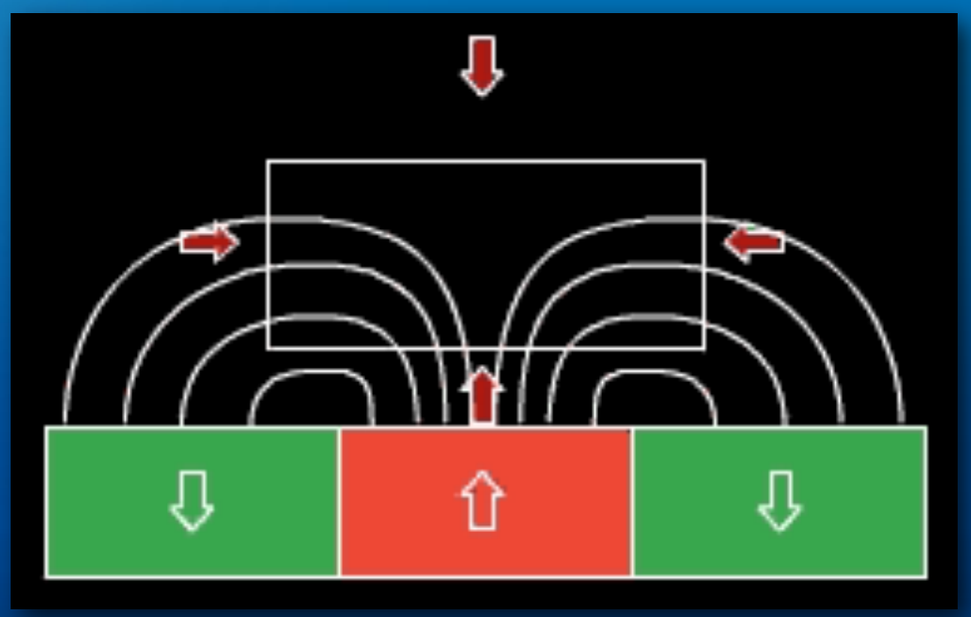


- Superconductor verdrängt das Magnetfeld
- Meißner-Ochsenfeld-Effekt oder
- Idealer Diamagnetismus
- **Das Feld verdrängt den Supraleiter!**



- Typ-II-Supraleiter
- Magnetfeld kann den Supraleiter in Form magnetischer Flusslinien durchdringen
- Pinnig-Effekt
- **Einfrieren des Magnetfeldes im**





Feldverdrängung und Flussverankerung

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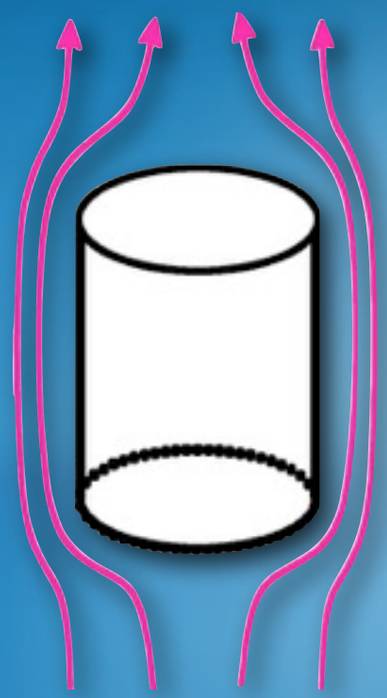
Supraleiter im Magnetfeld



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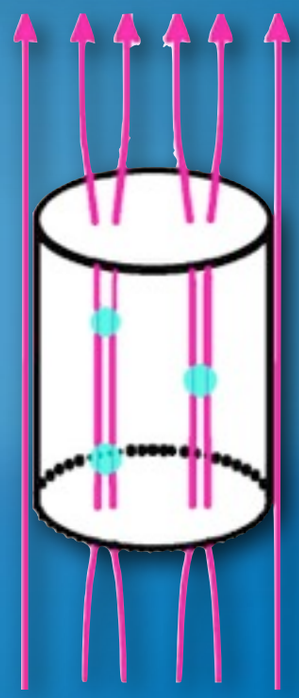

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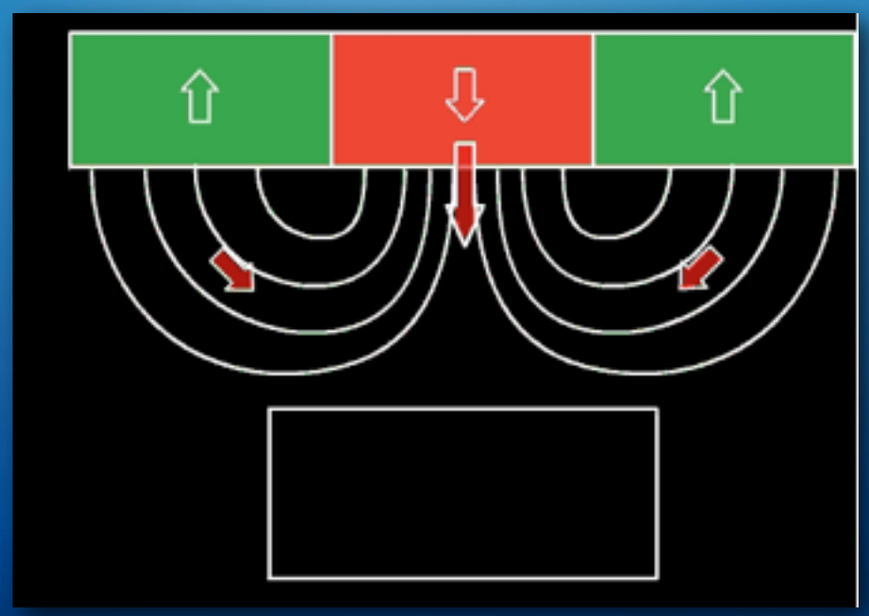

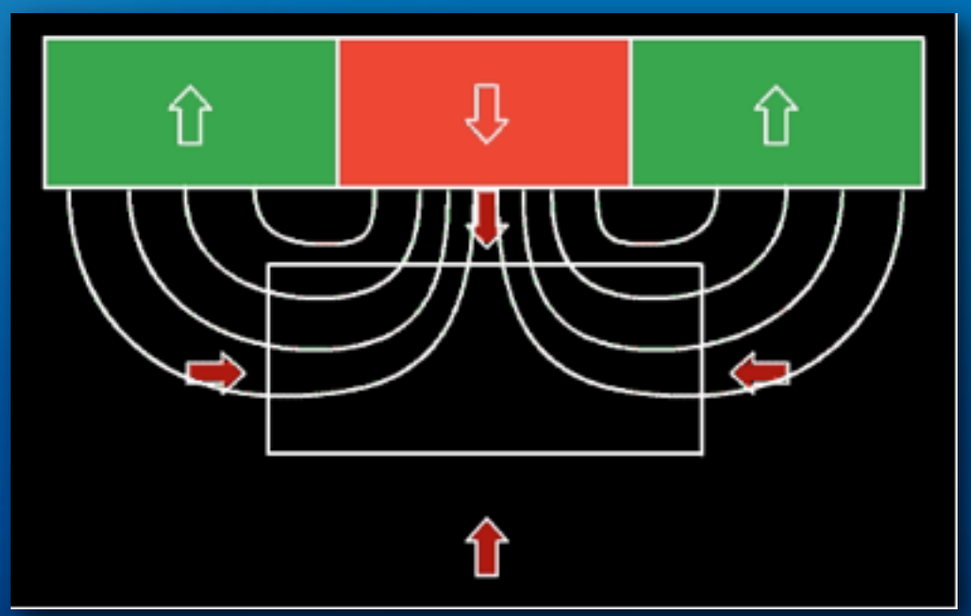

Feldverdrängung und Flussverankerung

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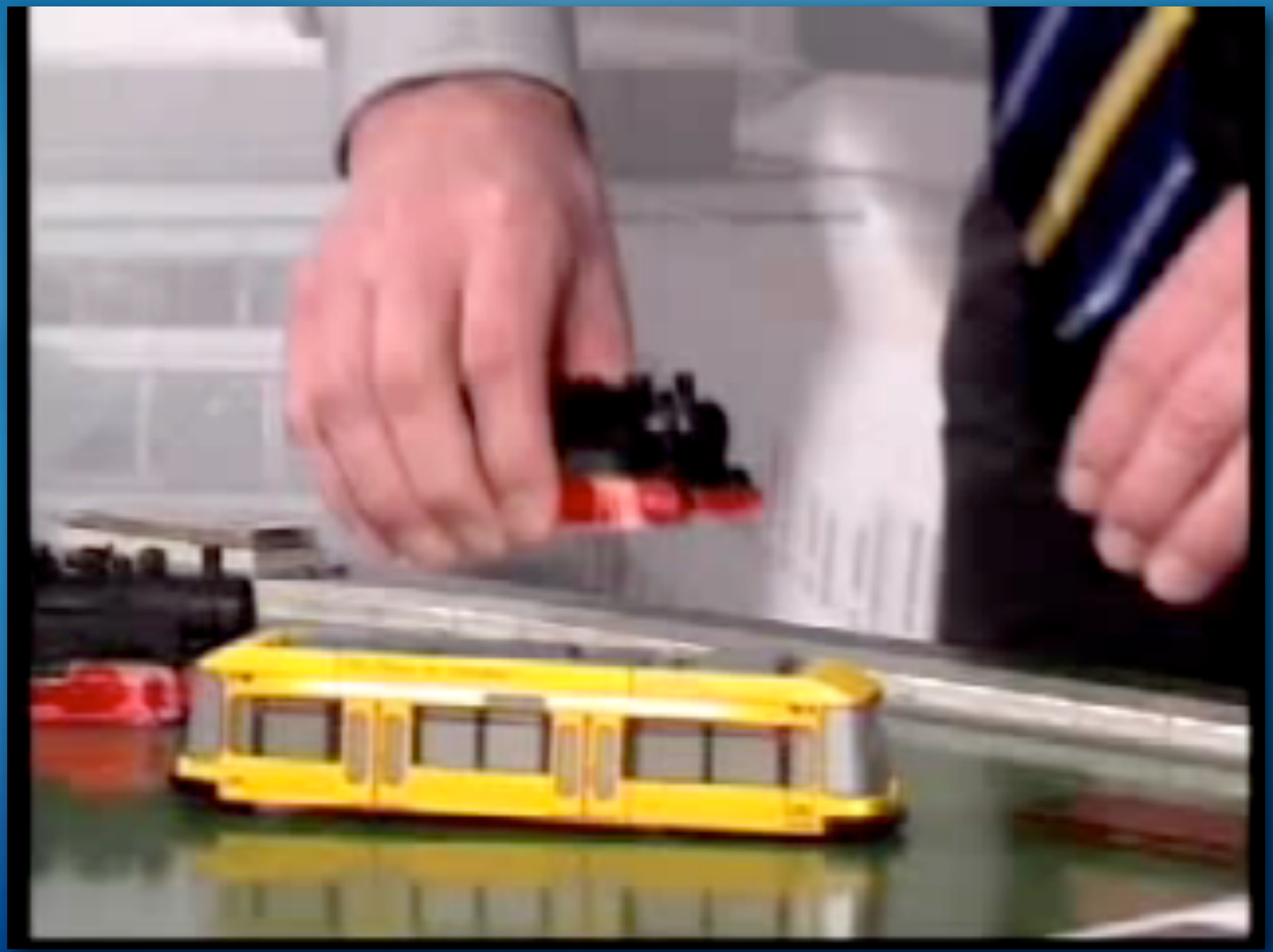
Supraleitende Magnetschwebebahn



Leibniz-Institut
für Festkörper- und
Werkstoffforschung
Dresden

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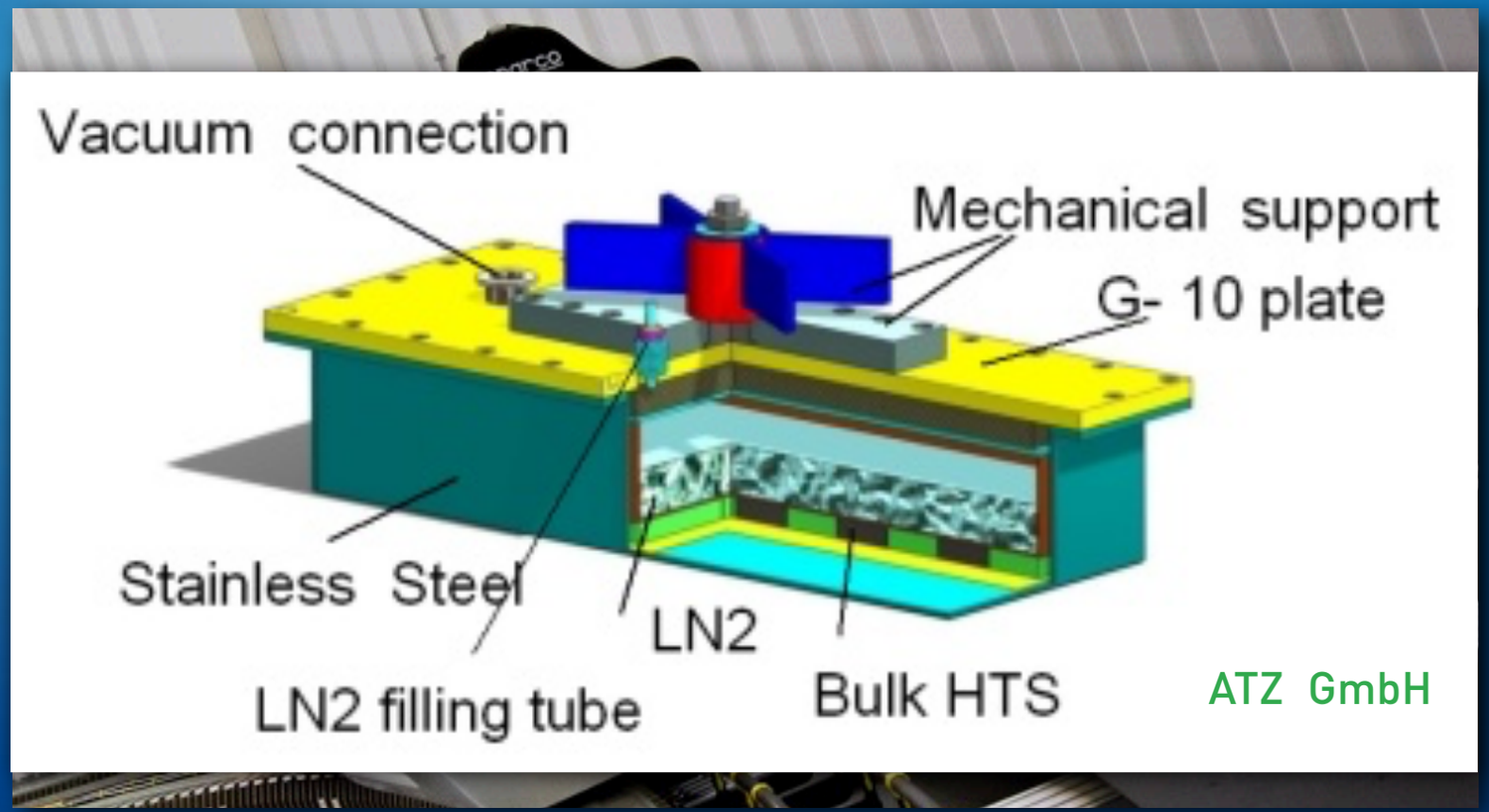
SupraTrans II



Fahrversuchsanlage für SL Magnetschwebebahn

= **Fahrweg**

80 m ovaler Rundkurs

16 kW berührungslose Energievers.

1 Fahrwegverzweigung

Passiver Linearstator

= **Fahrzeug**

2 Passagiere

800 kg gelagerte Gesamtmasse

2 unabhängige Bremssysteme

1 m/s² Beschl. des Linearmotors

On board Fahrzeugsteurung

Design: Airport Gate-to-Gate Shuttle

Die Bundesregierung
Wir bauen Zukunft

IFW Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden

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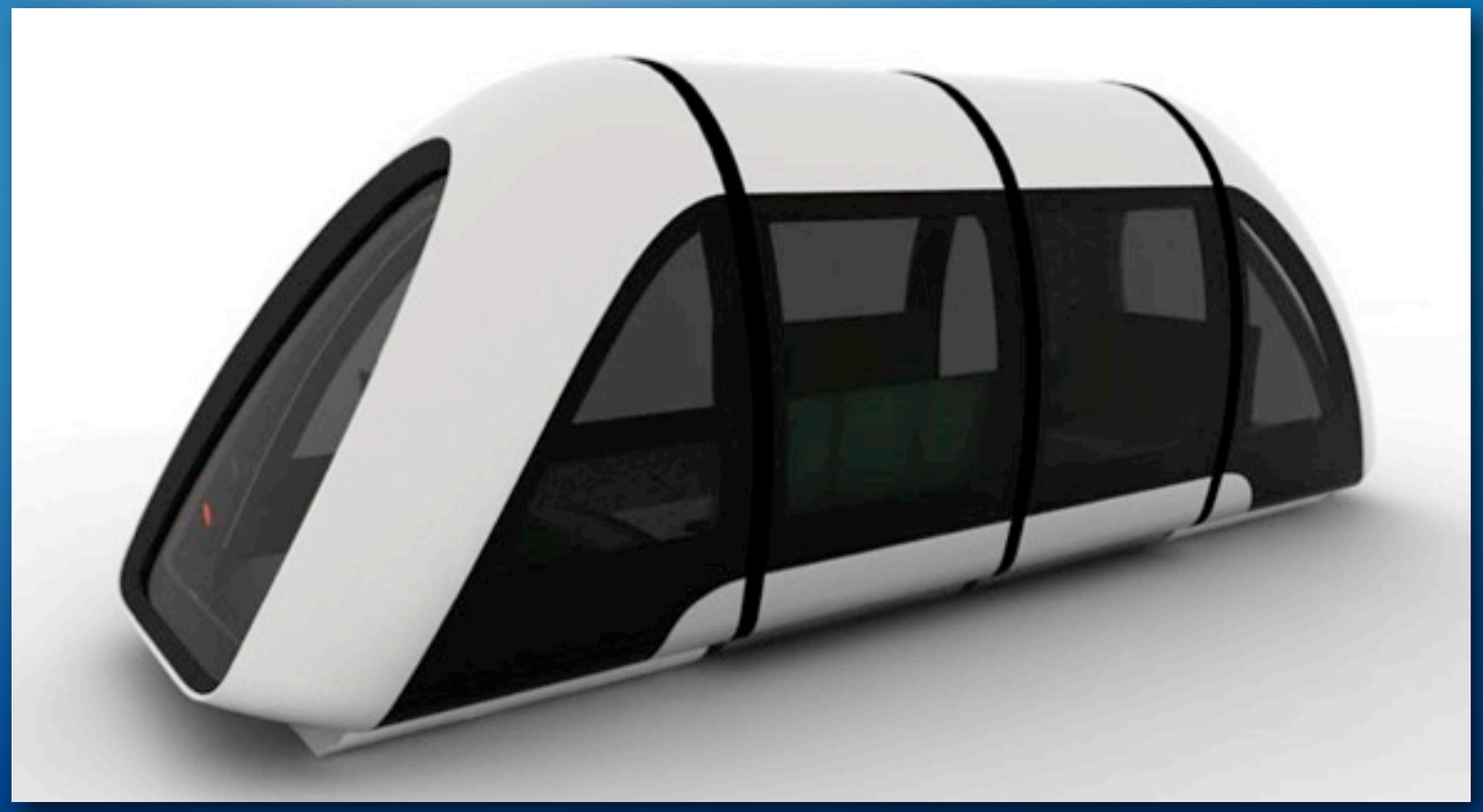
Maglev Cobra - Rio de Janeiro



Maglev Cobra

Gleis: 200 m

connecting 2 buildings within the UFRJ

(Federal Univ. Rio de Janeiro)

Fahrzeug: 4 gekoppelte Wagen

Gesamtlänge: 6 m

Passagiere: 24

Bilder: UFRJ Maglev Cobra

Prof. Richard Stephan

evico

Super-Maglev Chengdu, China

Super Maglev

Strecke: Oval ø ≈ 12 m

Geschwindigkeit: 40-50 km/h

1 Passagier

Evakuierte Röhre: 0.1 bar ???

Bilder:

SWJTU Chengdu, China, Prof.

Deng Z. G.

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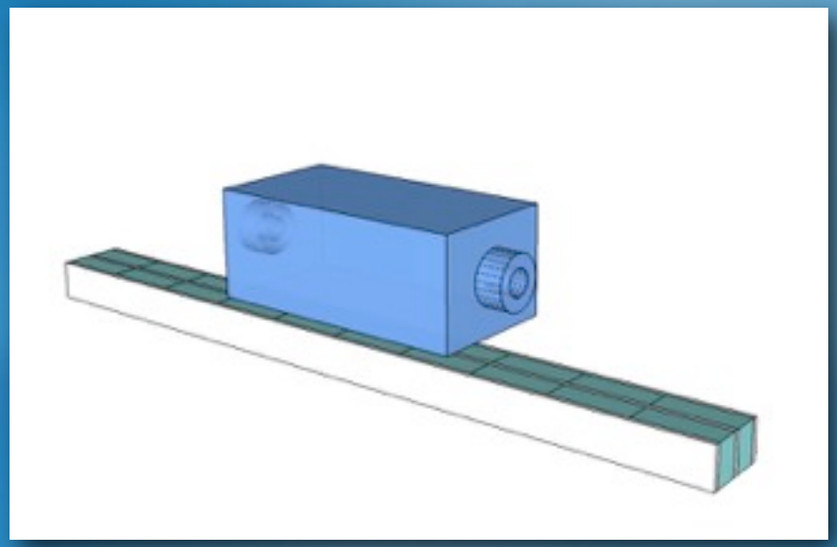
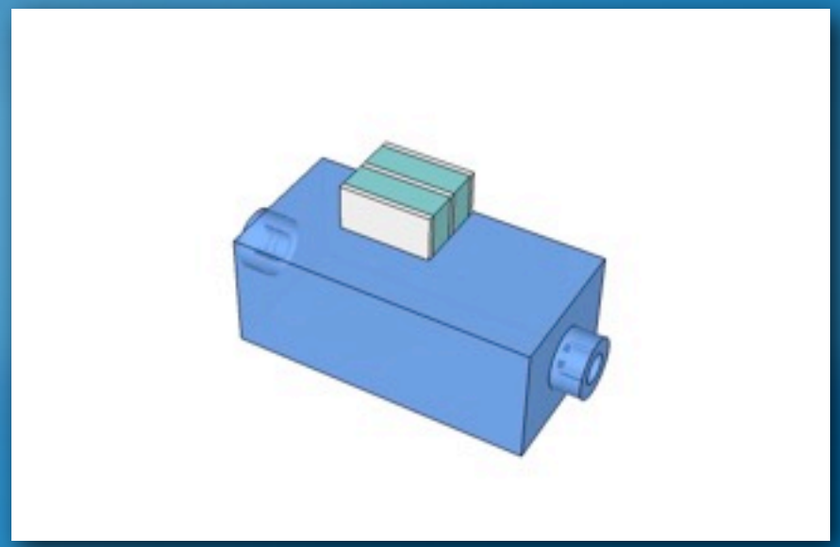
Klassifizierung Magnetlager

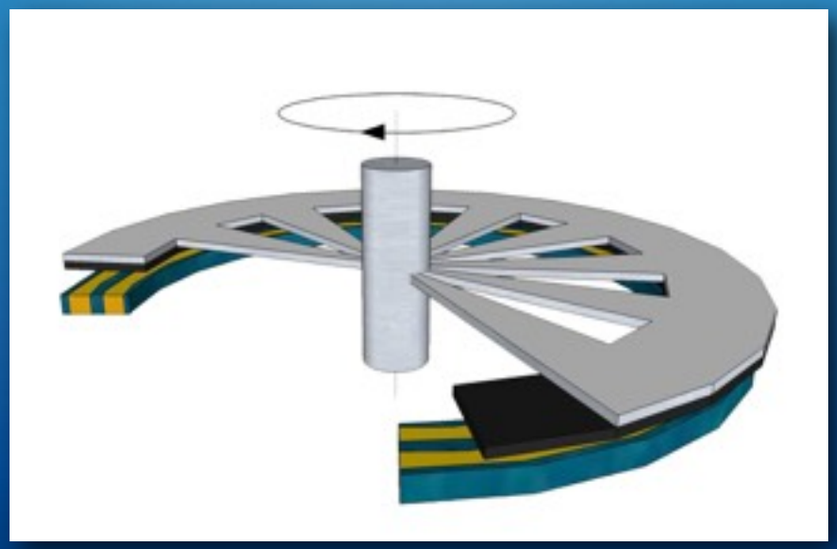
Linearlager



Festes Lager



Axiallager



Radiallager

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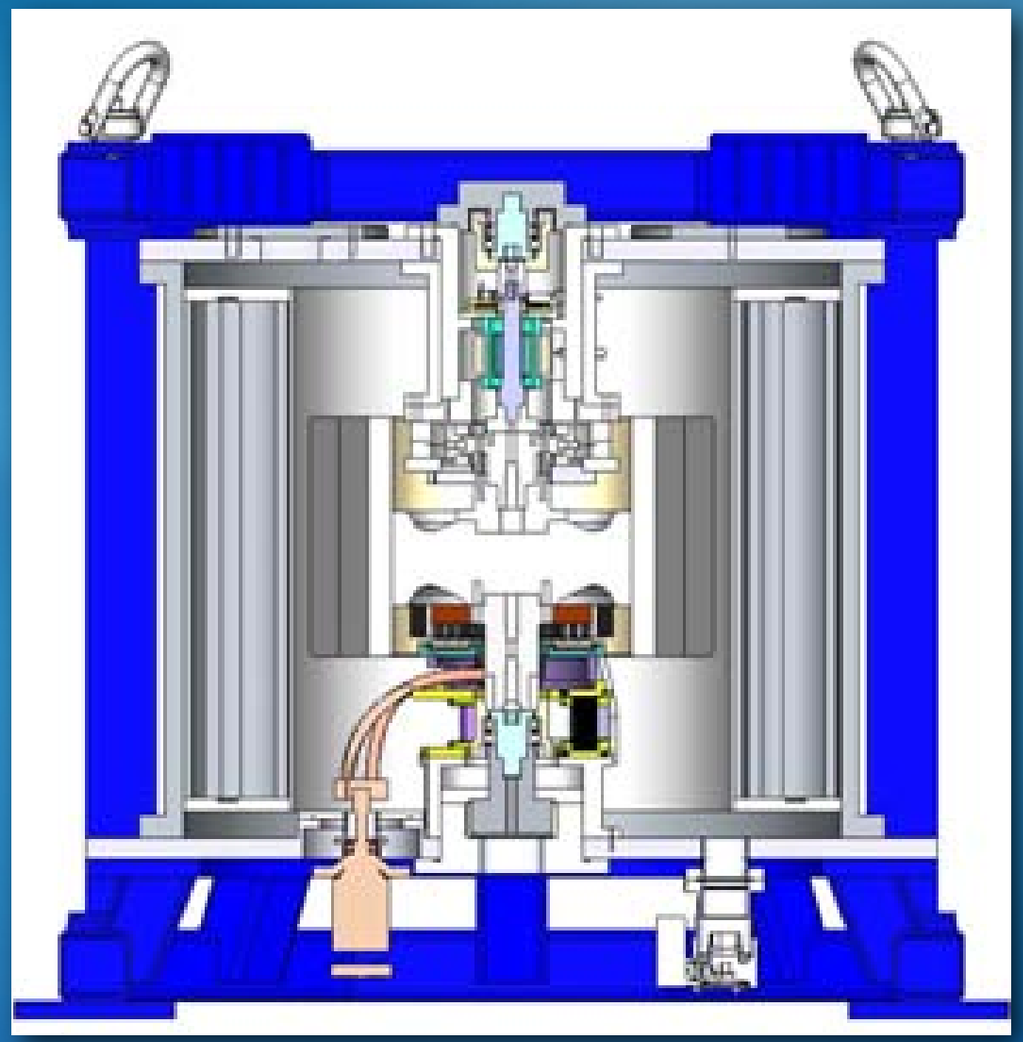
Schwungmassenspeicher (FESS-Flywheel)



- **Boeing** F&E Ergebnisse
- 5 kWh / 3 kW
- Rotationsgeschwindigkeit: 22.500 rpm
- Thermische Verluste 2 - 3 W
  (60 - 90 W Leistungsaufnahme)

Systemvorteile aus Boing-Sicht (perspektivisch:

- Umweltfreundlich
- Wartungsarm
- Potential für hohe Leistungsdichte (W/ kg) und hohe Energiedichte (Wh/ kg)
- Schnelle und häufige Lade- und Entladezyklen ohne Abnutzung
- Lebensdauer >25 Jahre
- Weiter Arbeitsbereich bzgl. Umgebungstemperatur

M. Strasik, J. R. Hull et al.
2010 Energy Storage Systems Program, November 2-4, 2010 Washington DC

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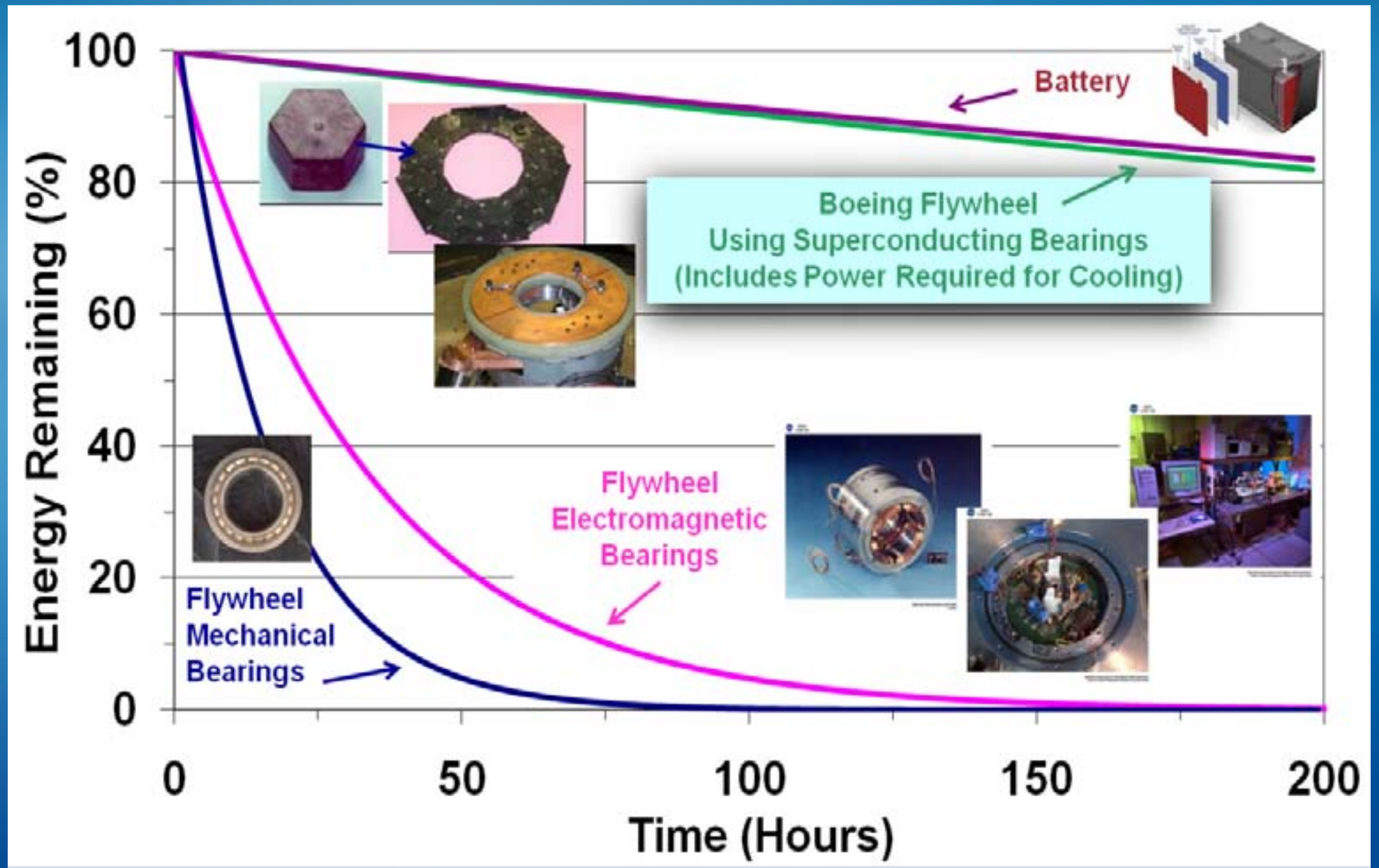
Schwungmassenspeicher (FESS-Flywheel)



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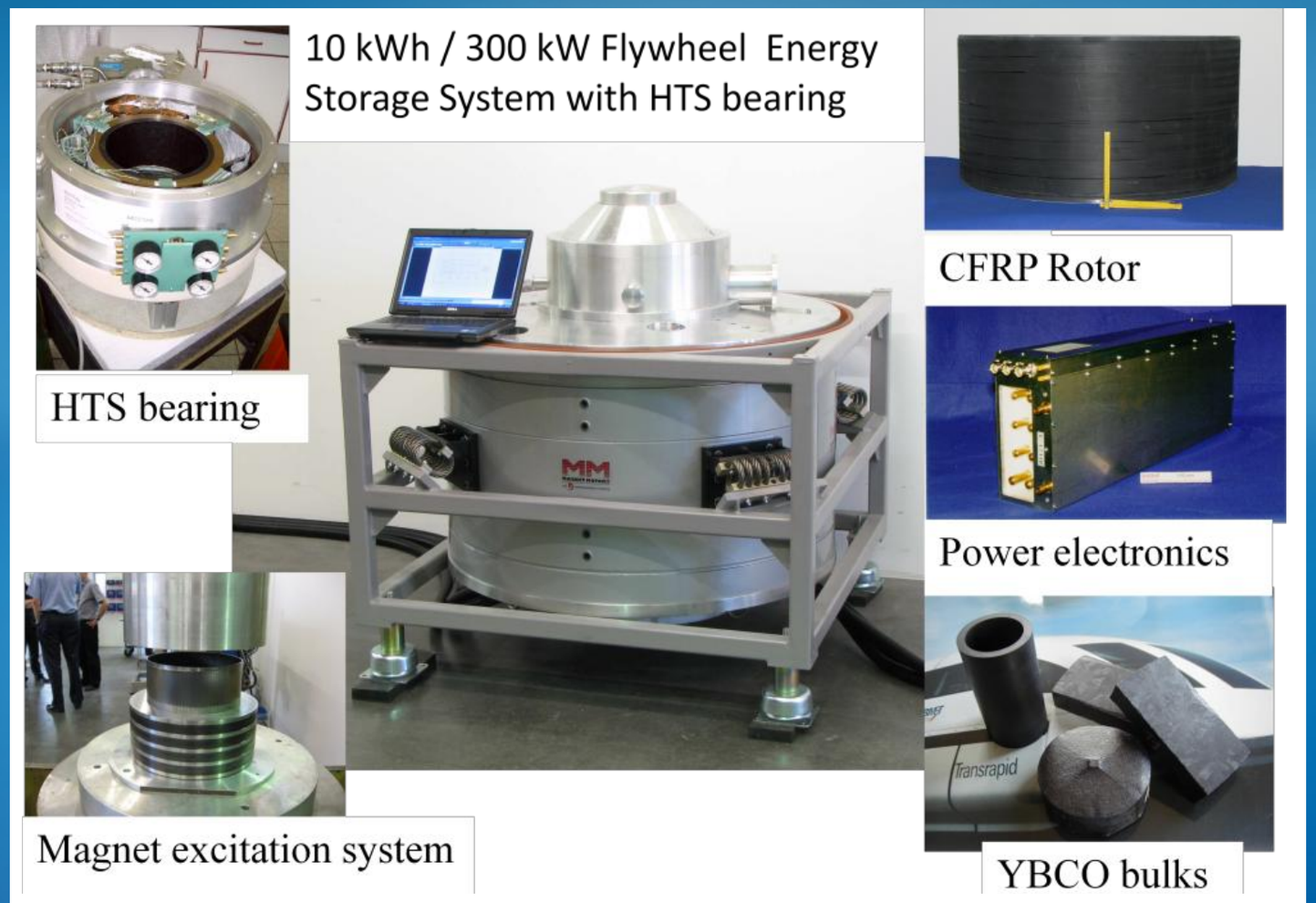

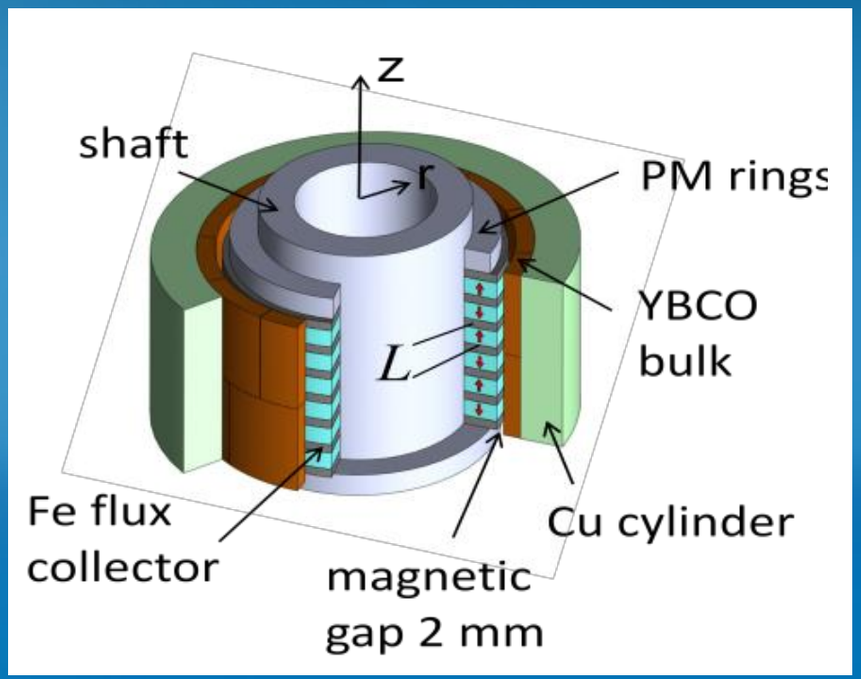

ATZ GmbH / Magnetmotor

Axiallager für 1 Tonne

5 - 10 kWh / 250 - 300 kW

1.8 kW Kältemaschine

800 kg Kohlefaser-Rotor

LEISTUNGSSPEICHER - UPS

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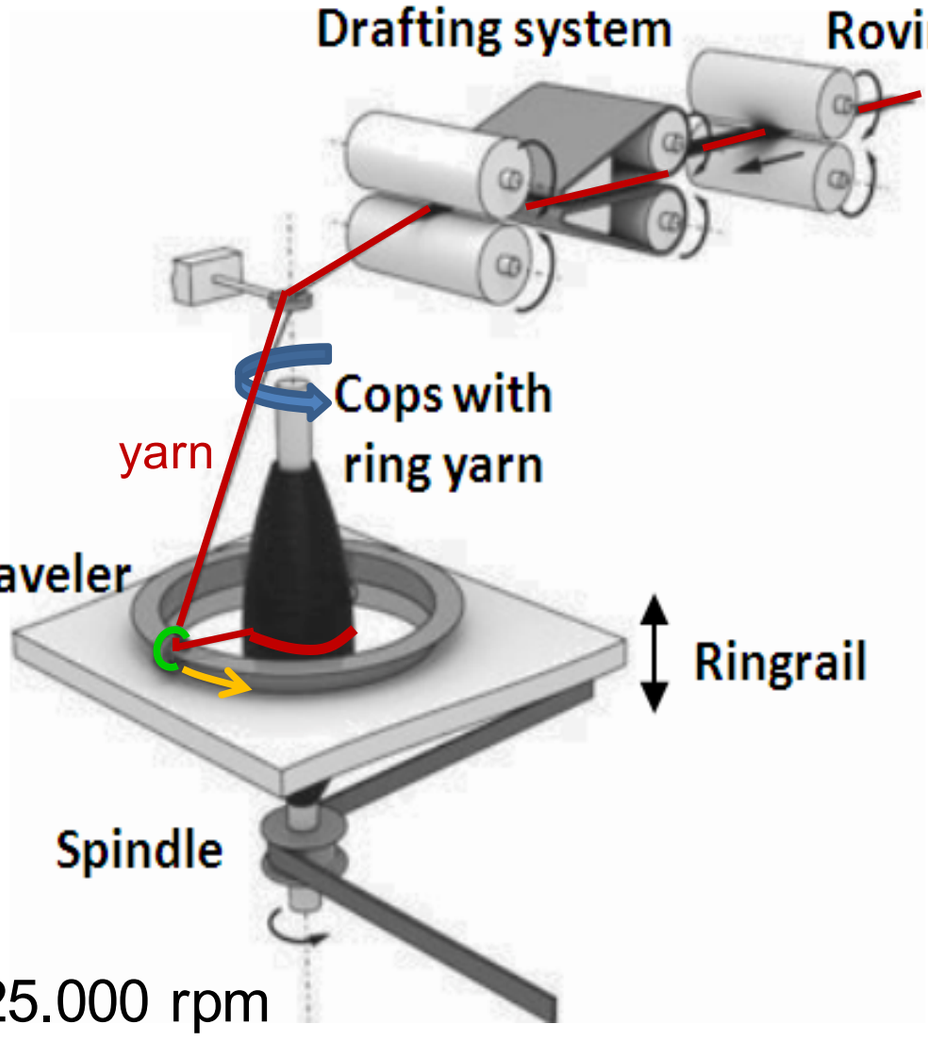
Ring spinning

Conventional ring spinning system: ring - traveler twisting element



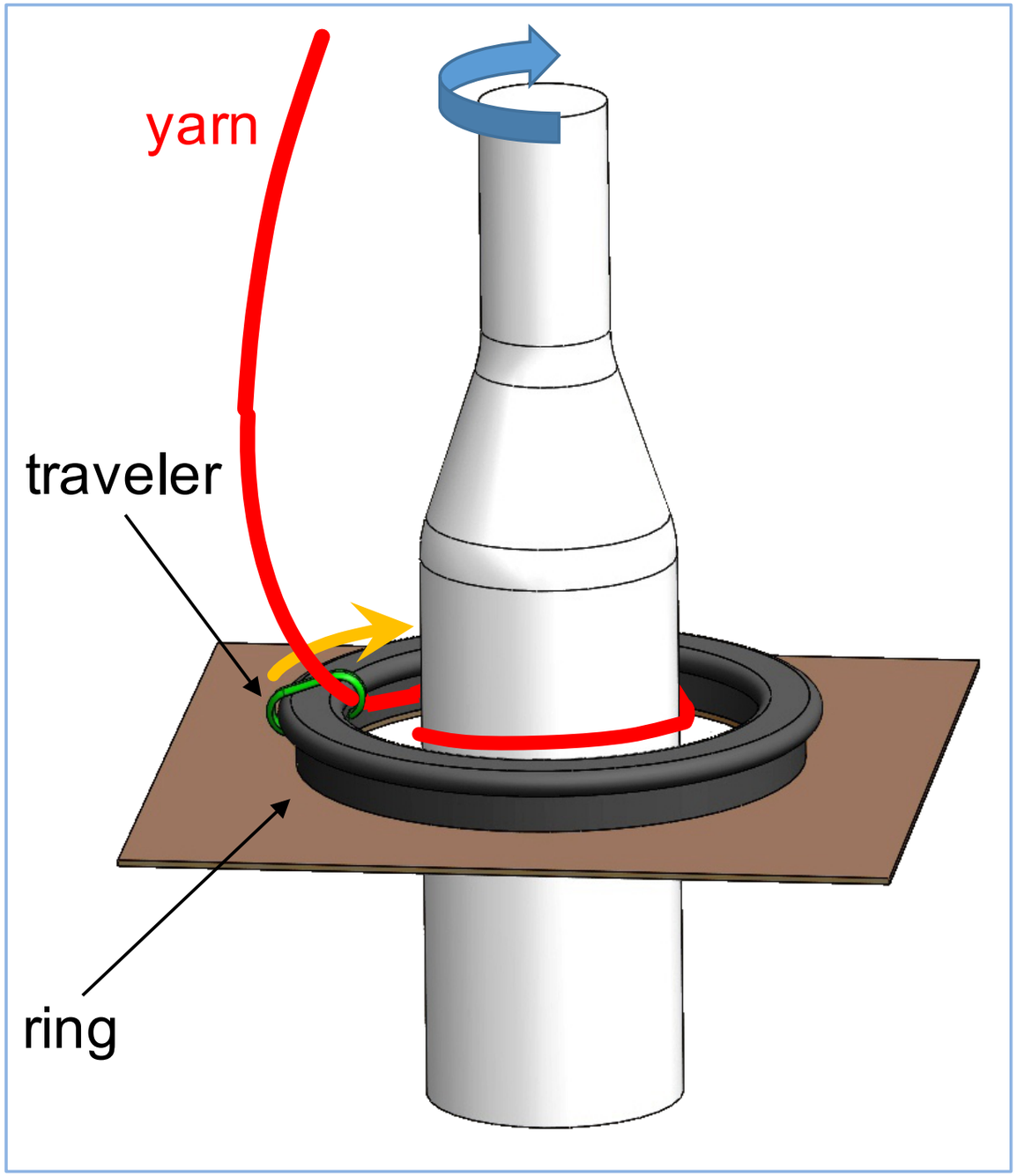
n_{max} = 25.000 rpm

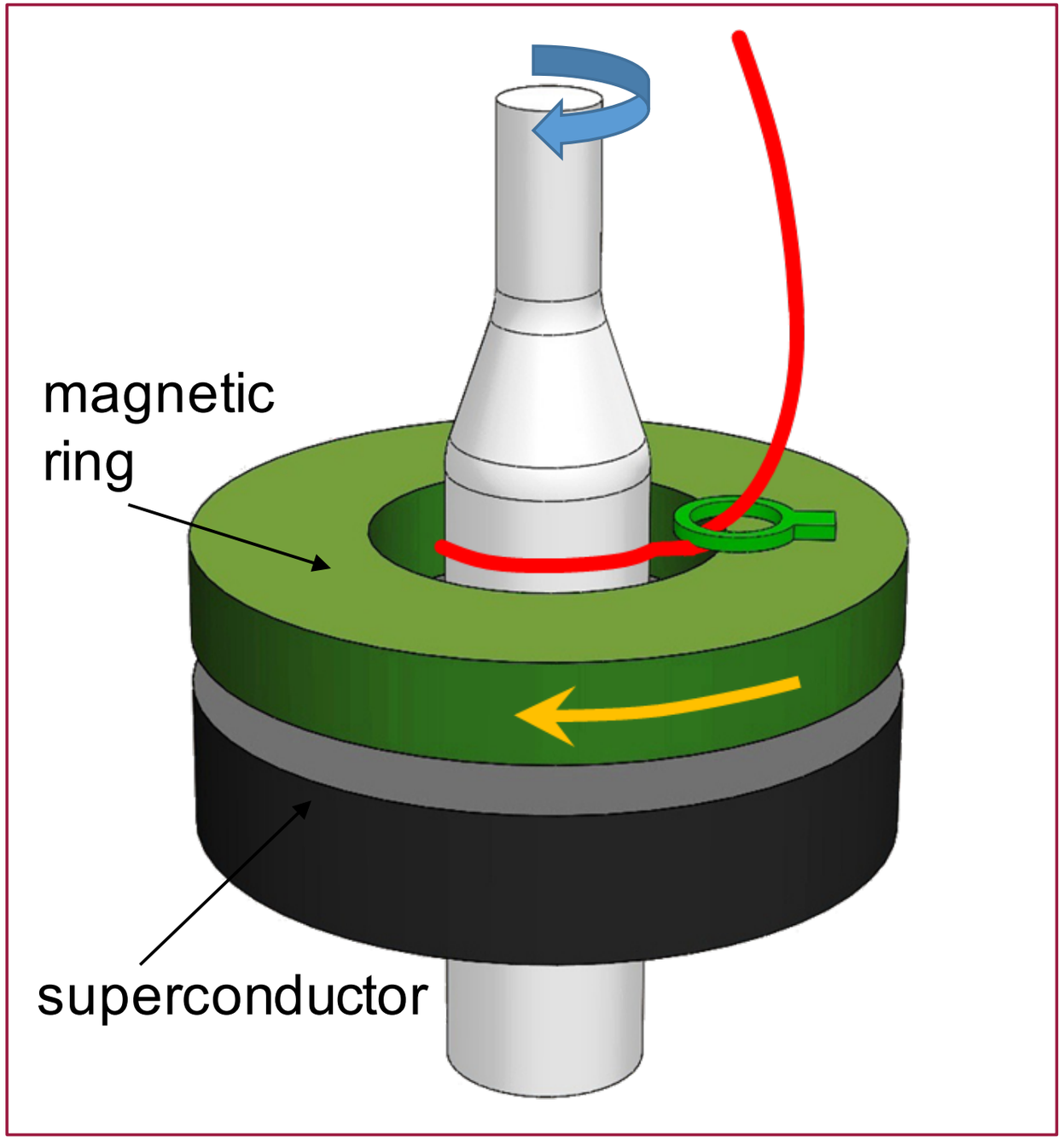
Traveler is dragged along the immobile ring by the yarn, winding onto the cops.

yarn throughput limited by ring-traveler friction
→ heat
→ wear and melting of synthetic yarns

Superconducting magnetic bearing (SMB) as twisting element

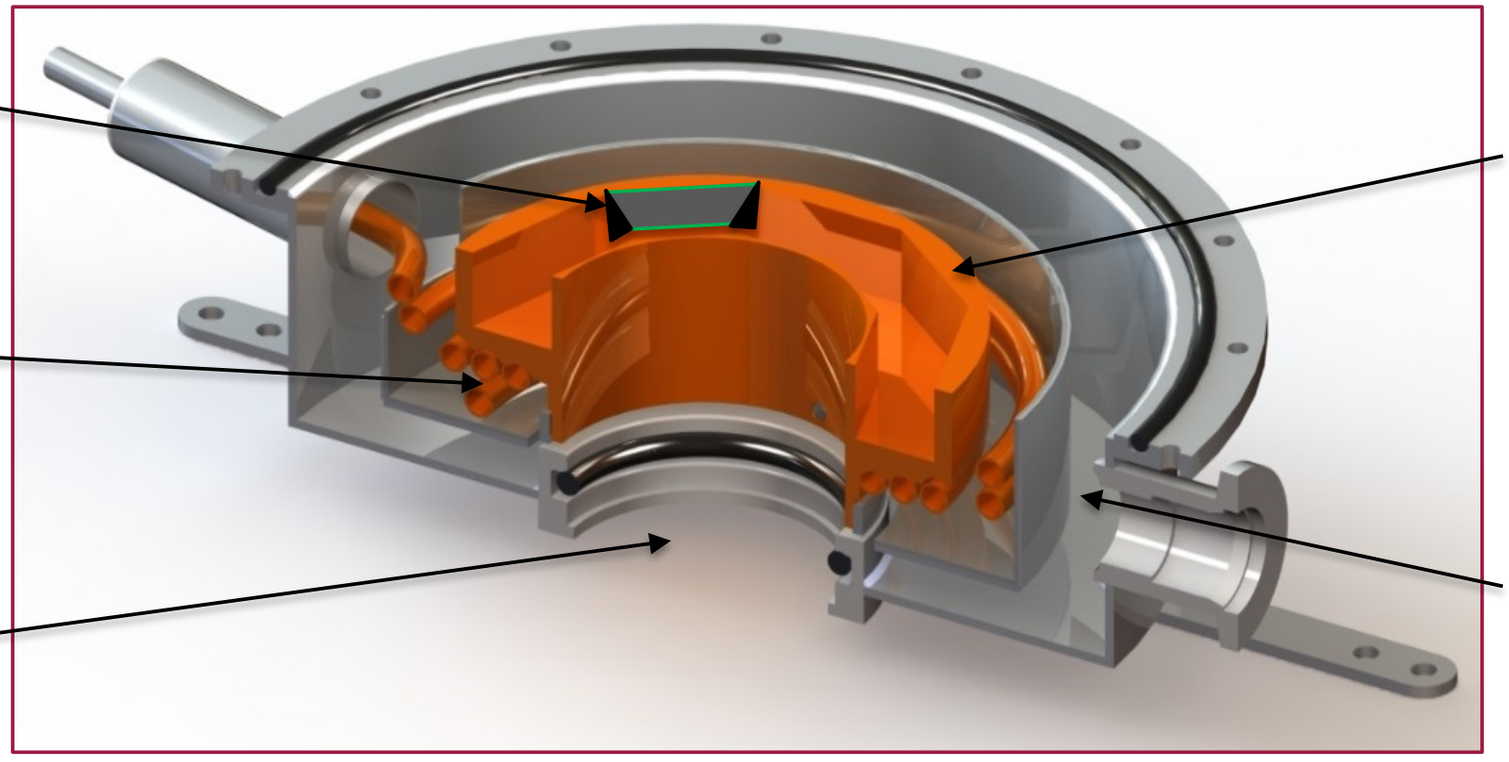
➢ Replacement of ring - traveler system with ring-shaped SMB



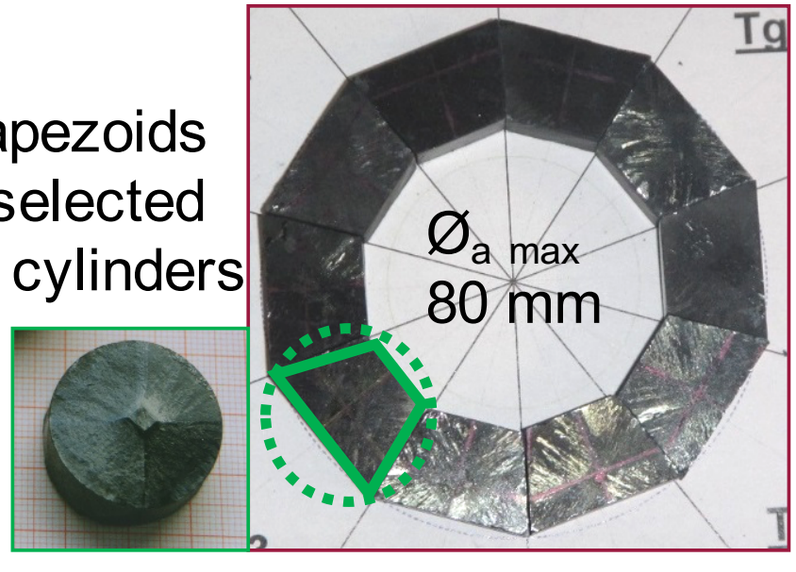


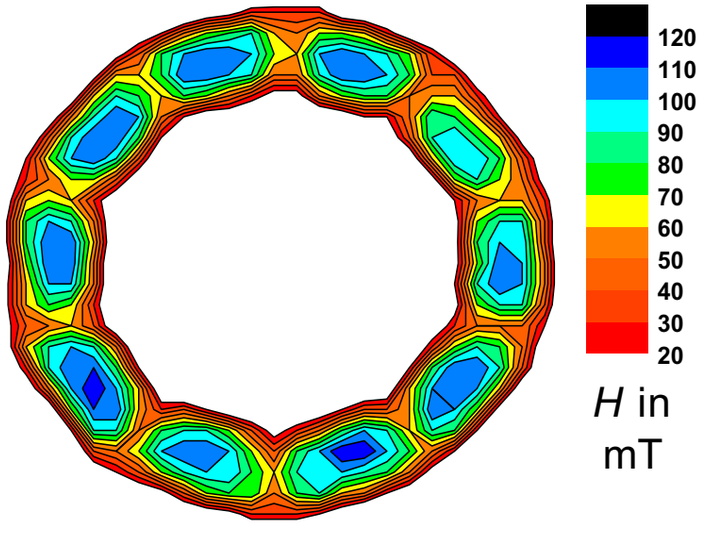
Superconducting magnetic bearing as twisting element

- **Enclosure of superconducting YBCO ring in a flow-through cryostat**



10 YBCO trapezoids cut from preselected melttextured cylinders

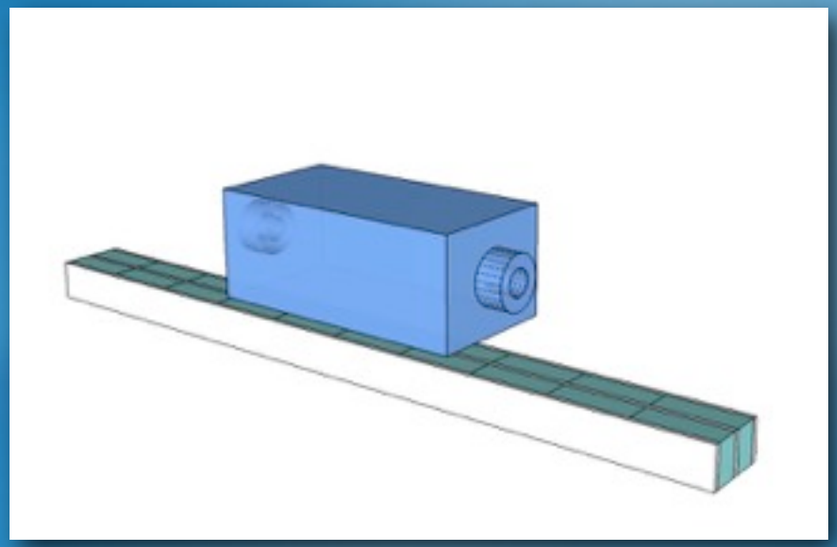




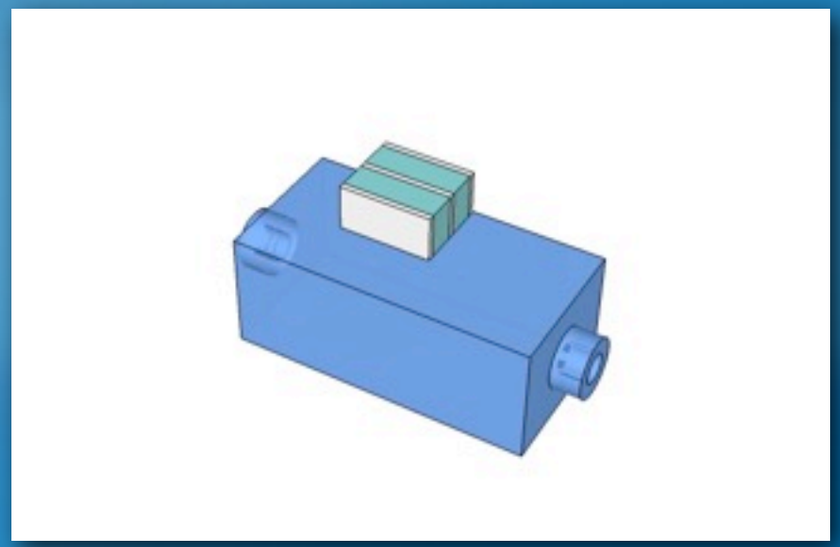
remanent field after field cooling at ~200 mT, 77K

Klassifizierung Magnetlager

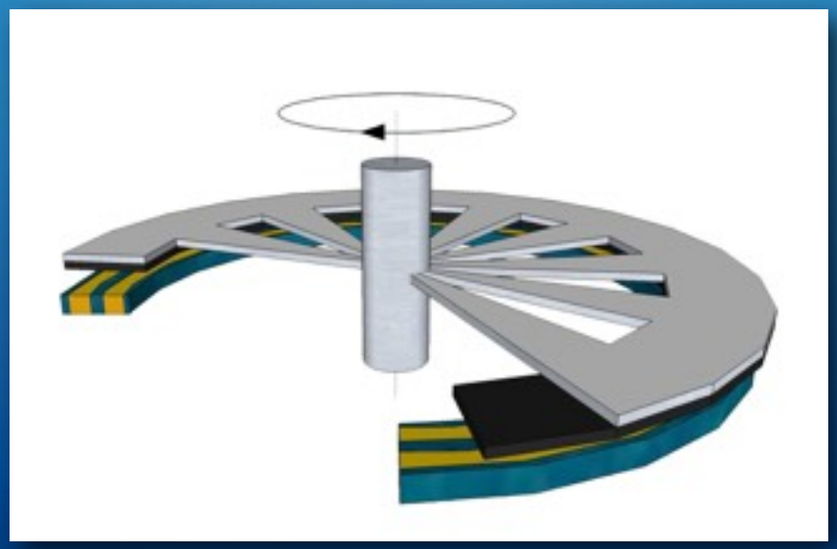
Linearlager



Festes Lager



Axiallager



Radiallager

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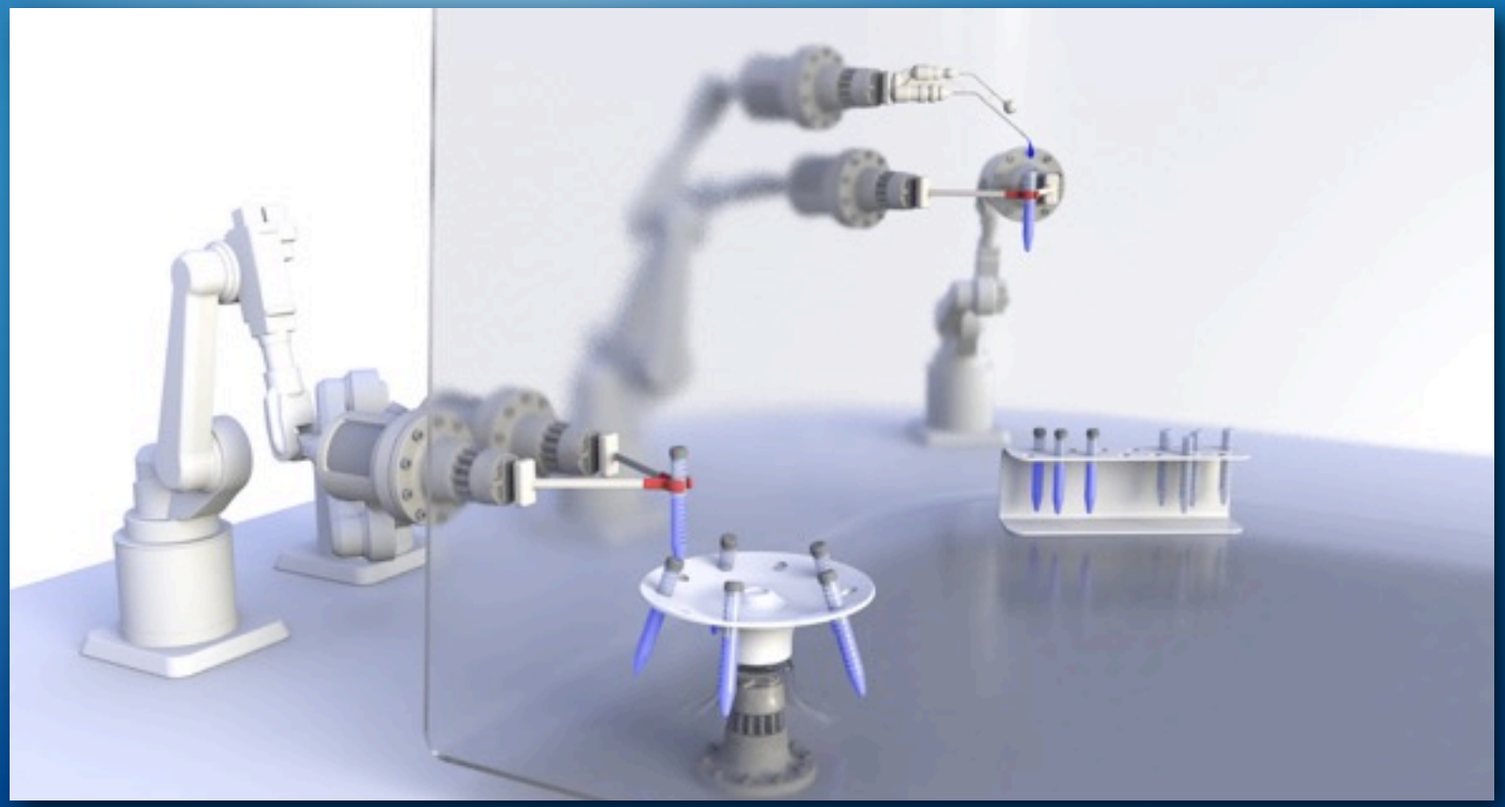
Festes Lager: Manipulatoren



- Handhabung von Proben
- Labor- und Prozess-automatisierung

Visionary study - visualization

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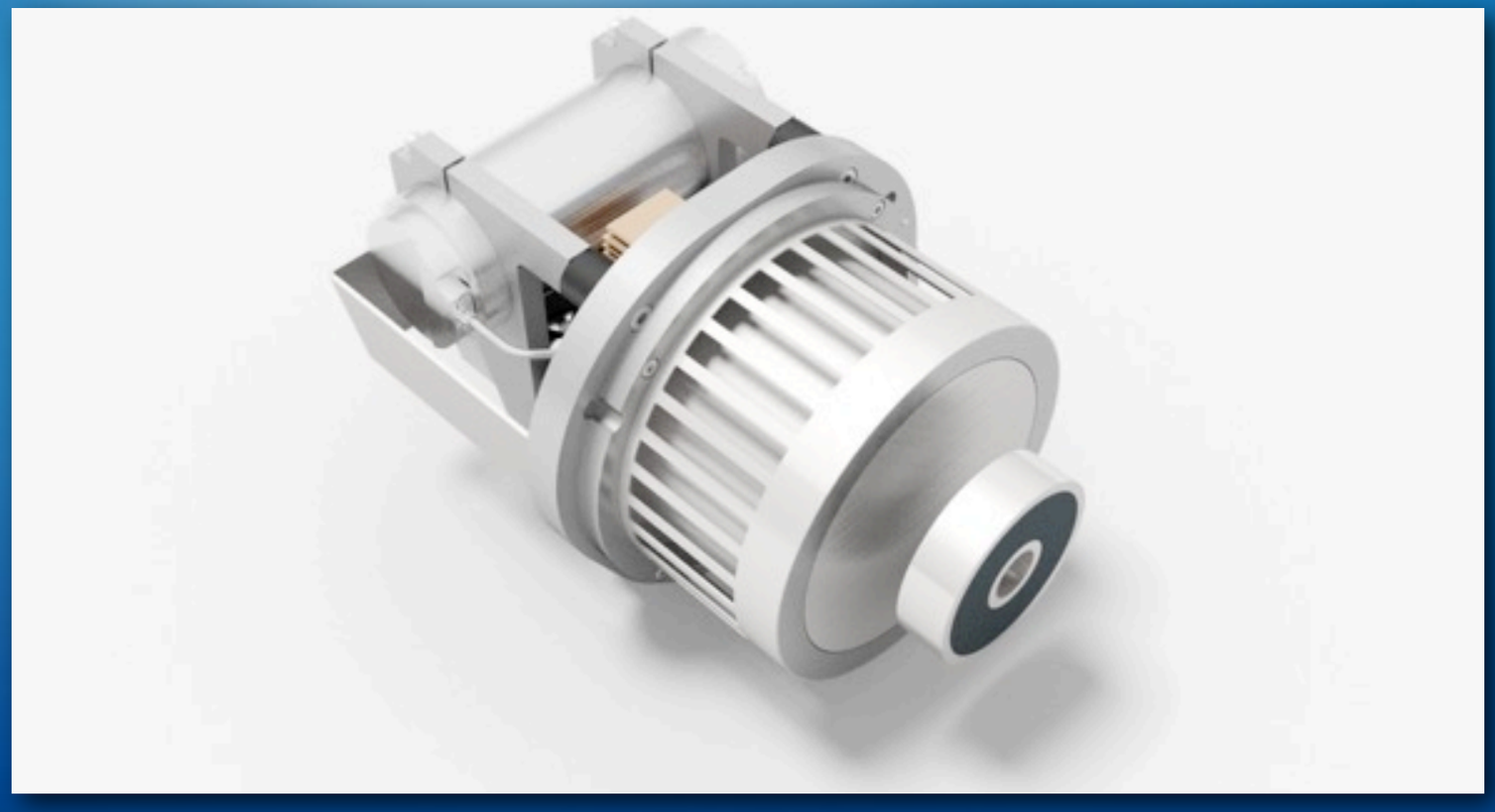
Supraleiterkryostat



- Kompakt
- Plug and play
- Effizient!!!
- Lebensdauer ist noch zu verbessern

First prototype in cooperation with FESTO AG & Co. KG

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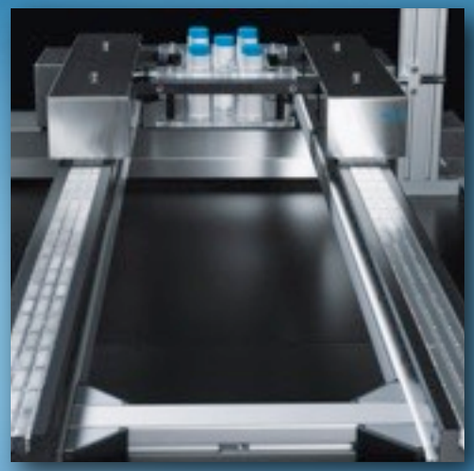
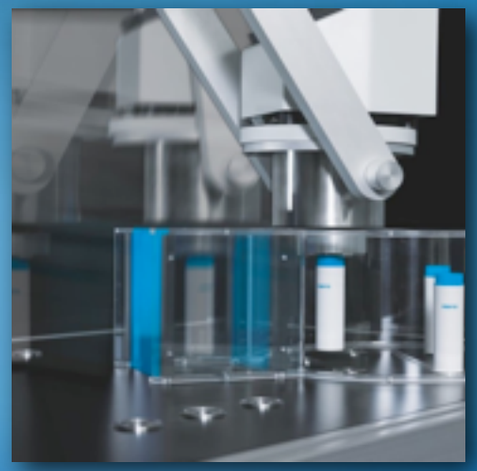
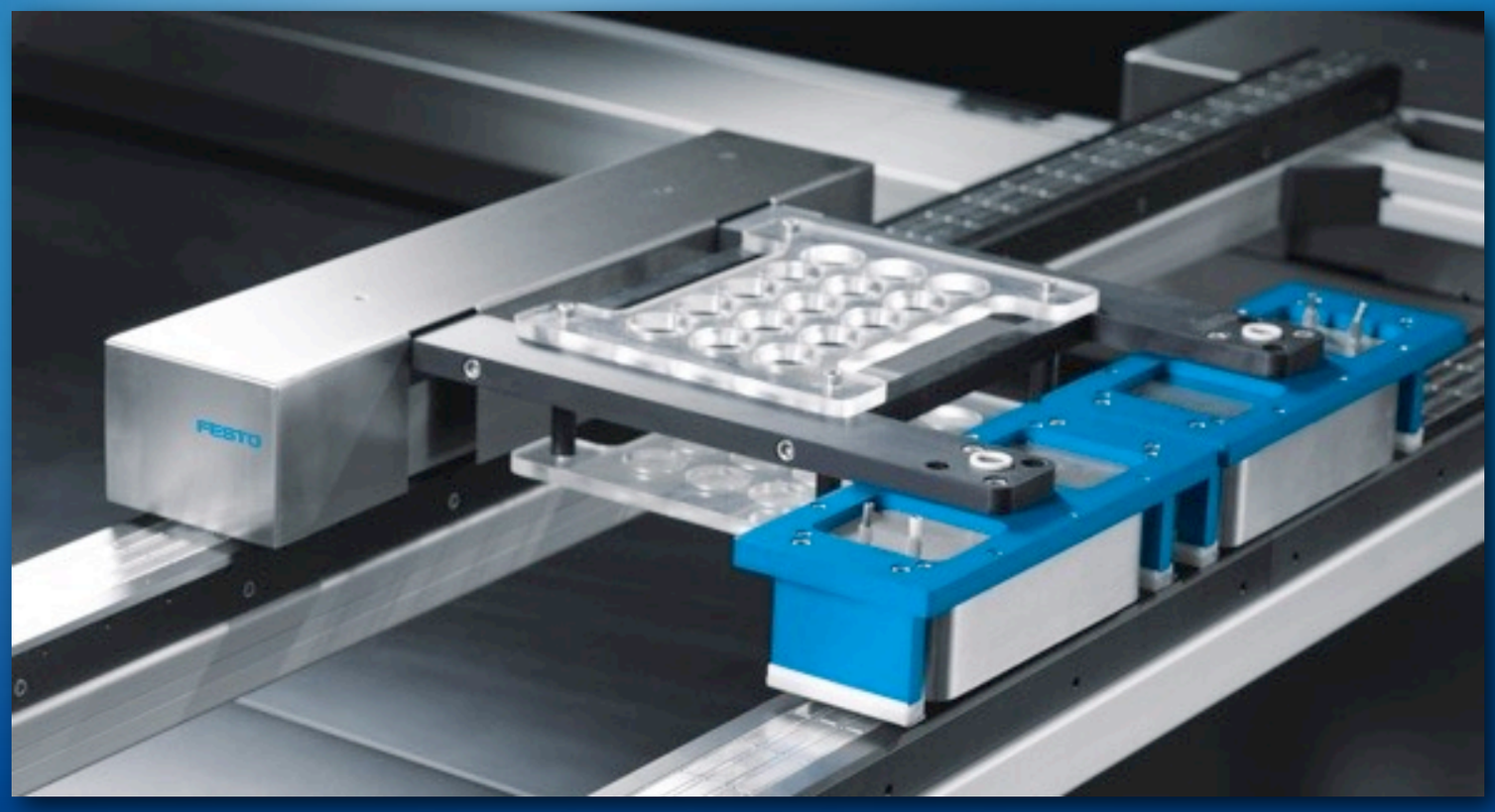
FESTO SupraMotion - Hannovermesse 2013







= **FUTURE CONCEPTS: scouting for application scenarios of superconductor bearings**

= **SupraLinearMotion**

= **SupraHandling**

= **SupraPicker**

Pictures: © Festo AG & Co. KG

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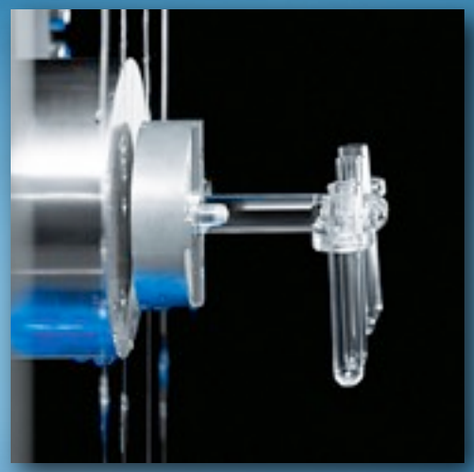
FESTO SupraMotion 2.0 - Hannovermesse 2014



- **FUTURE CONCEPTS: scouting for application scenarios of superconductor bearings**
- **SupraHandling 2.0**
- **SupraShuttle**
- **SupraChanger**

Pictures: © Festo AG & Co. KG

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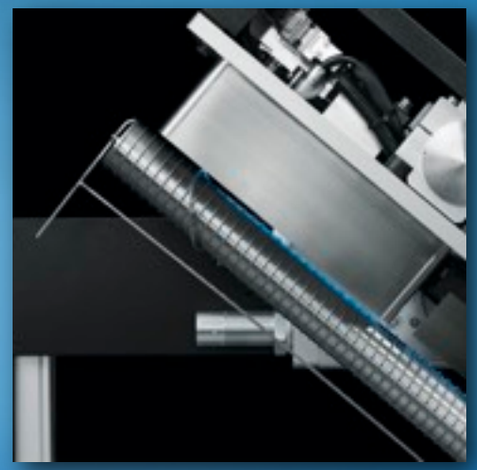
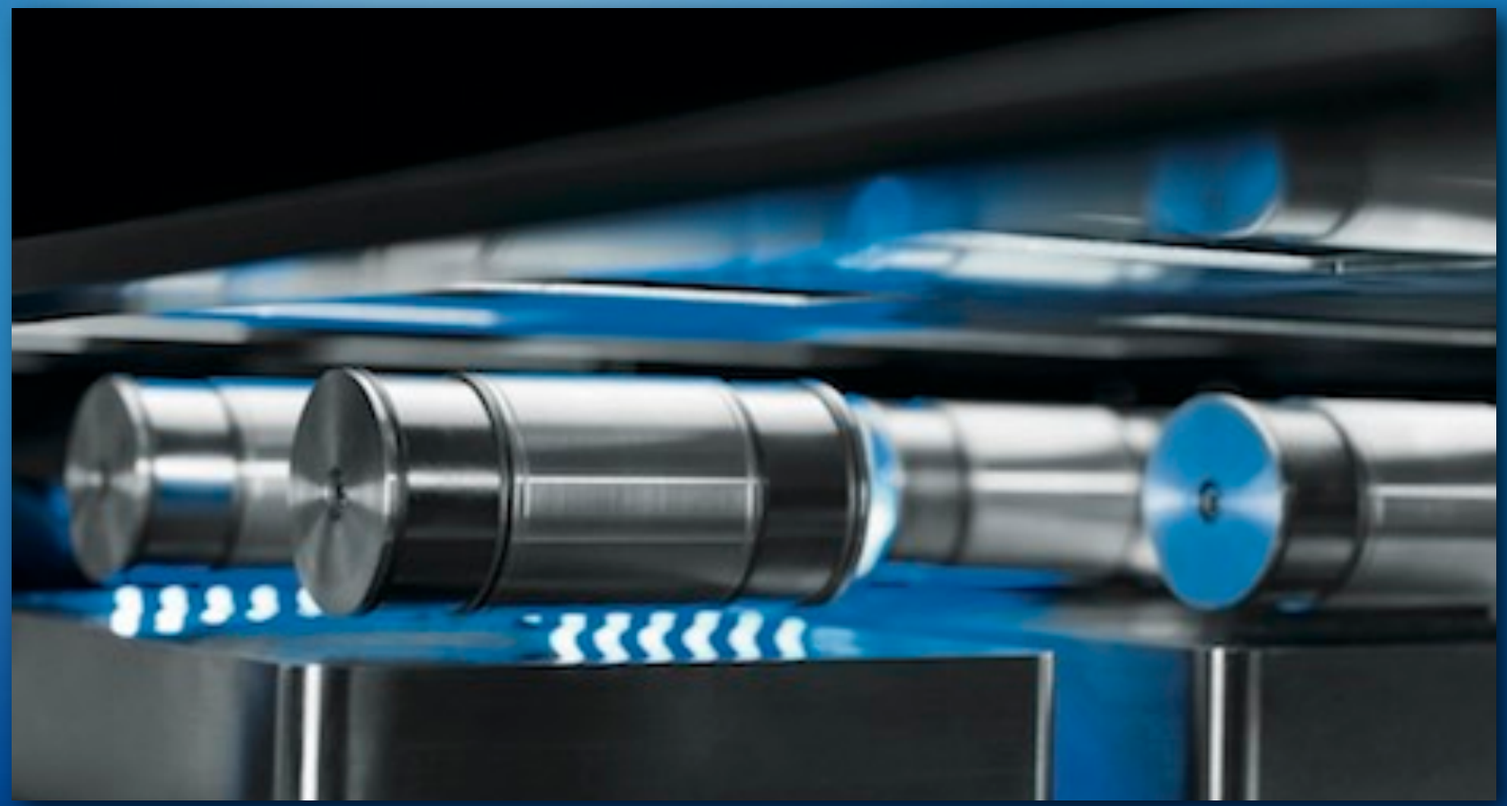
FESTO SupraMotion 3.0





= Suche nach Anwendungsszenarien Supraleitender Magnetlager in der Industrieautomation

= SupraCarrier

= SupraCycle

= SupraHelix

Pictures: © Festo AG & Co. KG

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Megatrend: Innovating to Zero*

= **Saubere Produktion**

= **Nachhaltige Produktion**

= **Sichere Produktion**

- **Kein Abrieb:** Null Toleranz für Keime in Lebensmitteln und Medikamenten
- **Keine Reibung:** Null Wärmeeintrag in die Kühlkette
- **Kein Verschleiß:** Lange Lebensdauer für komplexe Lagerbauteile
- **Keine Berührung:** Null Verschleppung von radioaktiven, giftigen oder verseuchten Stoffen

* Frost & Sullivan: Top Ten Mega trends, Sarwant Singh

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Lexus - Amazing in Motion

Lexus
Amazing in Motion

designed and built by Lexus and evico GmbH, and ridden by pro skateboarder Ross McGouran. The video was created as a PR piece for Lexus, to show off their forward-thinking, creativity and technology. Built and tested in Germany, final film with “hoverpark” near Barcelona, Spain

Partner:

Lexus International
CHI & Partners Ltd
evico GmbH
IFW Dresden

2014 - 2015

Pictures: © Lexus International

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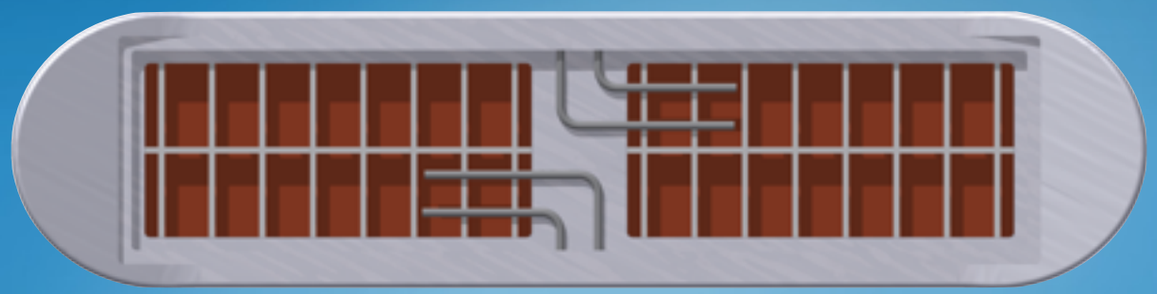
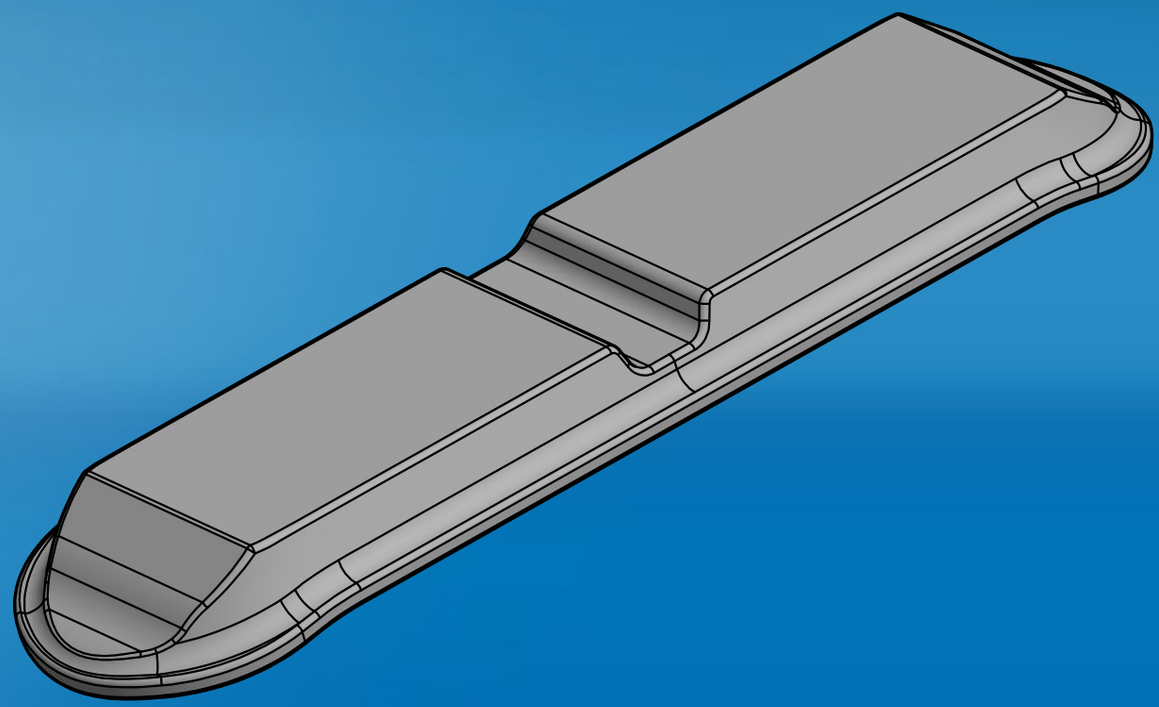
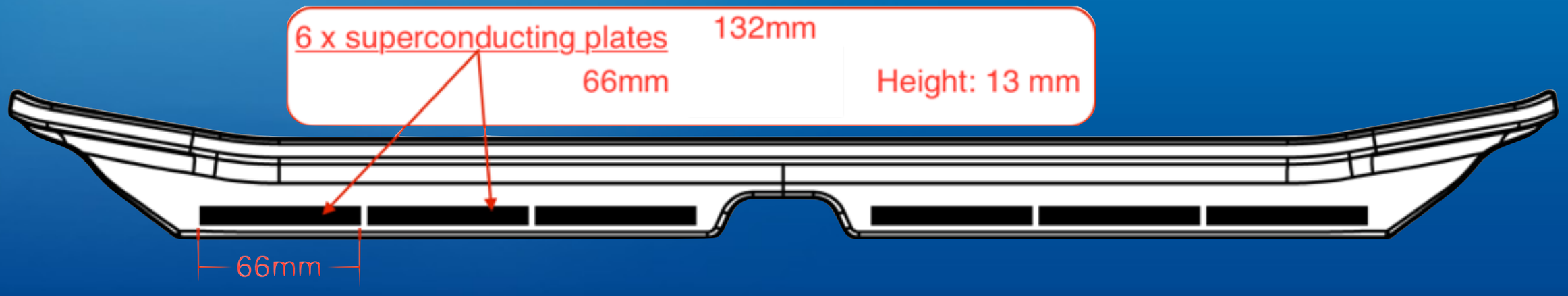
Lexus - Amazing in Motion







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www.lexus-int.com

Thank you for your attention