ZIEHL X WORKSHOP, BERLIN, 16.-17.04.2026

Supraleiter aus Deutschland für nationale Fusionsprogramme in Asien

Bruker EST
Bernd Sailer
16.04.2026

Bruker Corporation

- 1960 in Karlsruhe, DE, gegründet
- > 11,000 Mitarbeiter weltweit
- >10% investment in R&D
- > 75% Umsatz mit Diagnostik- und Analysesystemen

1960
Founded in **1960**

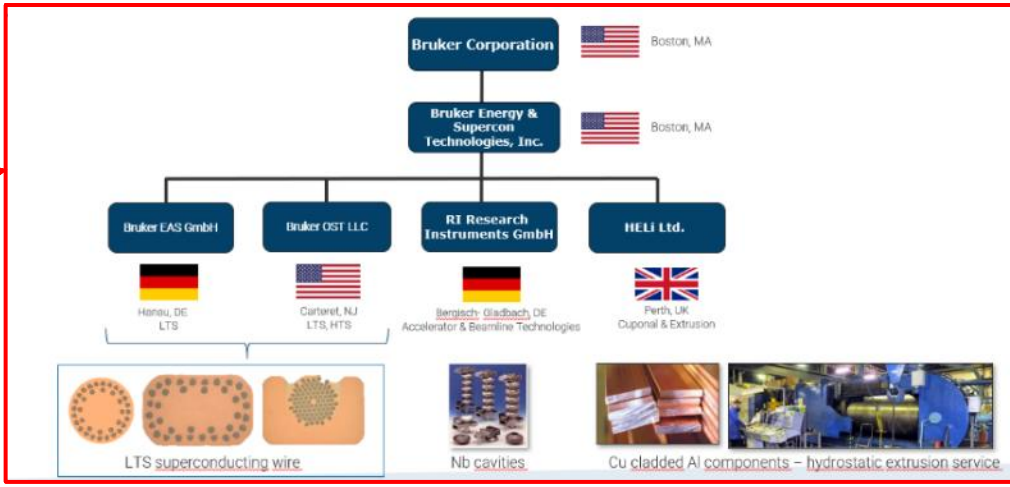
Market leader in **high-value** analytical technologies

Bruker brand stands for **innovation**.

FY 2024 revenue: **~ $3.37 billion**

R&D investment: **~ 11%** of revenue

11,396 employees worldwide



Standorte Supraleiterfertigung
Hanau, DE & Carteret, NJ, USA

Zwei unabhängige Standorte zur Herstellung von NbTi- und Nb_3Sn RRP® Drähten

- Hanau, DE: ~300 Mitarbeiter
- Carteret, NJ: ~160 Mitarbeiter
- Kapazität >> 150.000 km/a
- Große Fertigungstiefe

  unter Einschluss redundanter Supply Chains

Billet Assembly

- Machining & Gundrilling
- Etching
- Packing & Welding

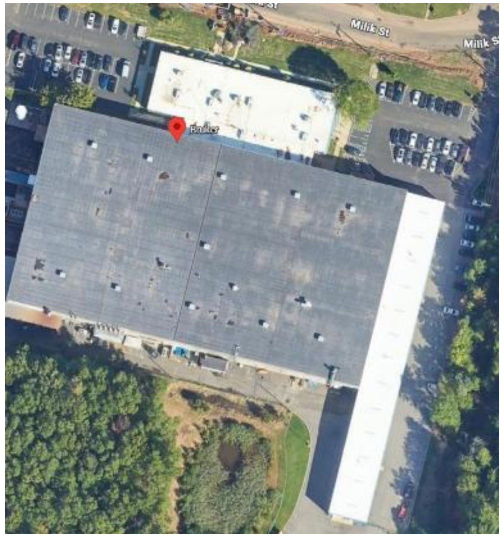
Final Manufacturing

- Soldering & braiding
- Overdraw
- Final Inspection/lab testing

Conductor Manufacturing

- Bar & Wire drawing
- Heat treatment
- Twist

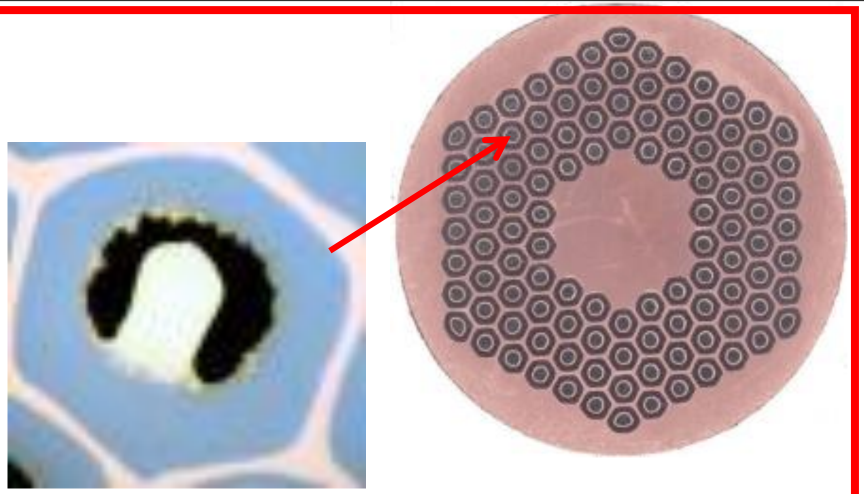
Bruker EAS



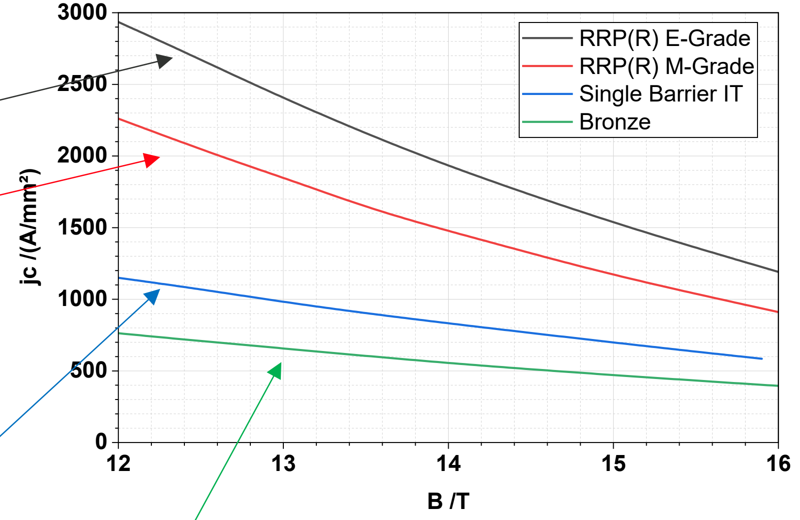
Bruker OST

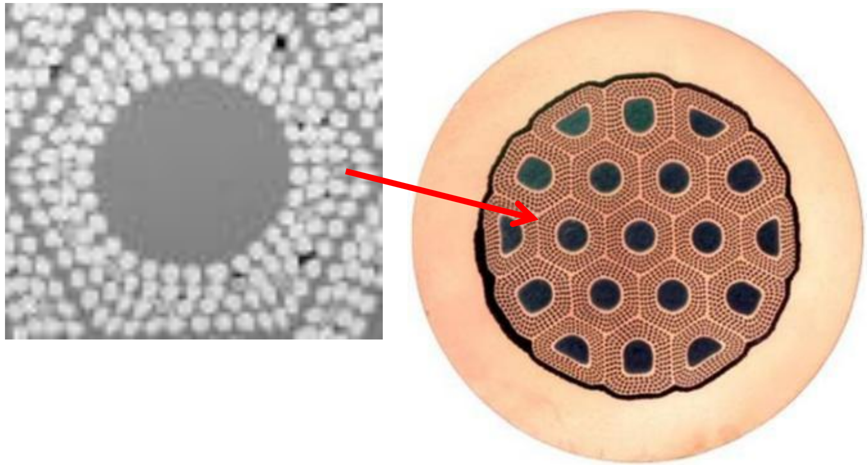
- Etching
- Billet Assembly
- Bar & wire drawing
- Twisting
- Soldering
- Braiding
- Overdraw
- Final testing
- Lab testing

Bruker produziert anwendungsoptimiert eine Vielfalt an Nb_3Sn Leitern

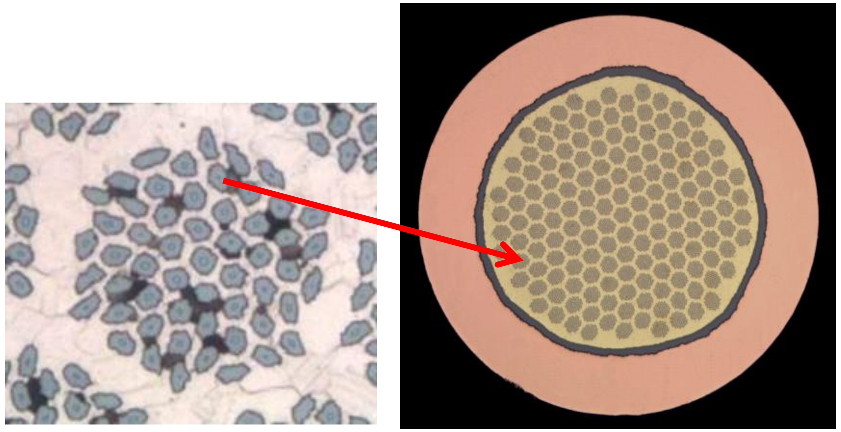


Distributed Barrier RRP® - high J_c





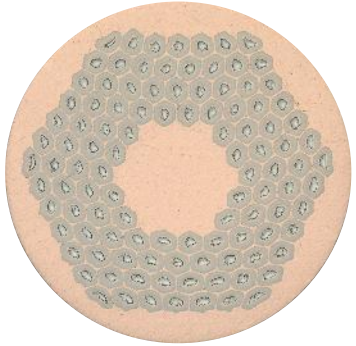
Single Barrier Internal Tin – High I_c, Low AC loss

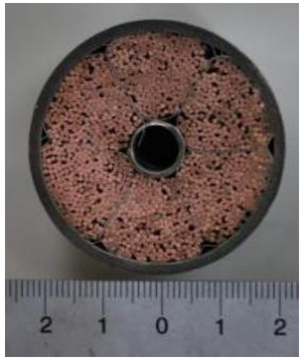


Single Barrier Bronze Route – Strong, very low AC loss

Was macht Nb_3Sn attraktiv?

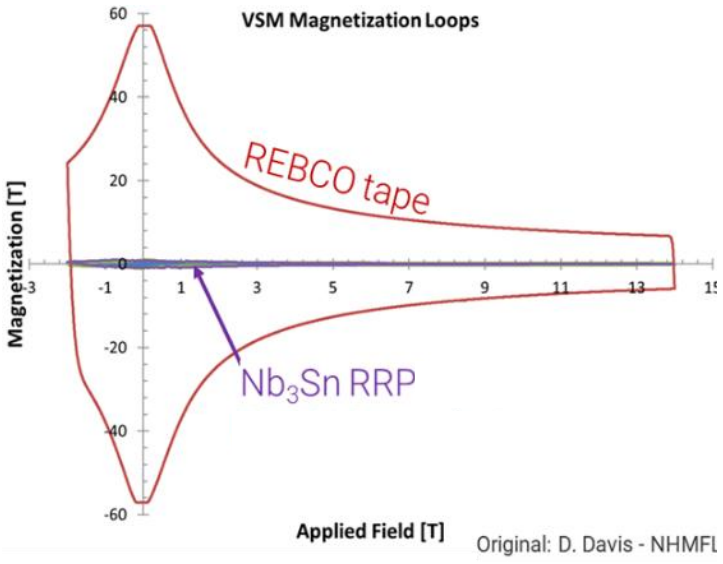
Runddraht
Einfaches Verkabeln



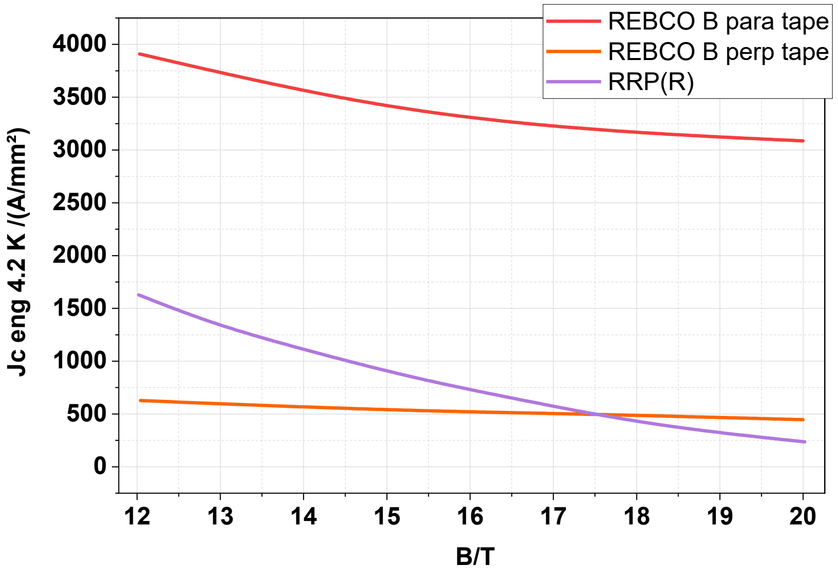


Transponierte und getwistete Filamente

- Wahl der Filamentgröße und Twistlänge erlaubt Finetuning der Magnetisierungsverluste



Isotrope Stromtragfähigkeit im Magnetfeld



… und industriell skalierbare Fertigung im 10-100 t/a Maßstab

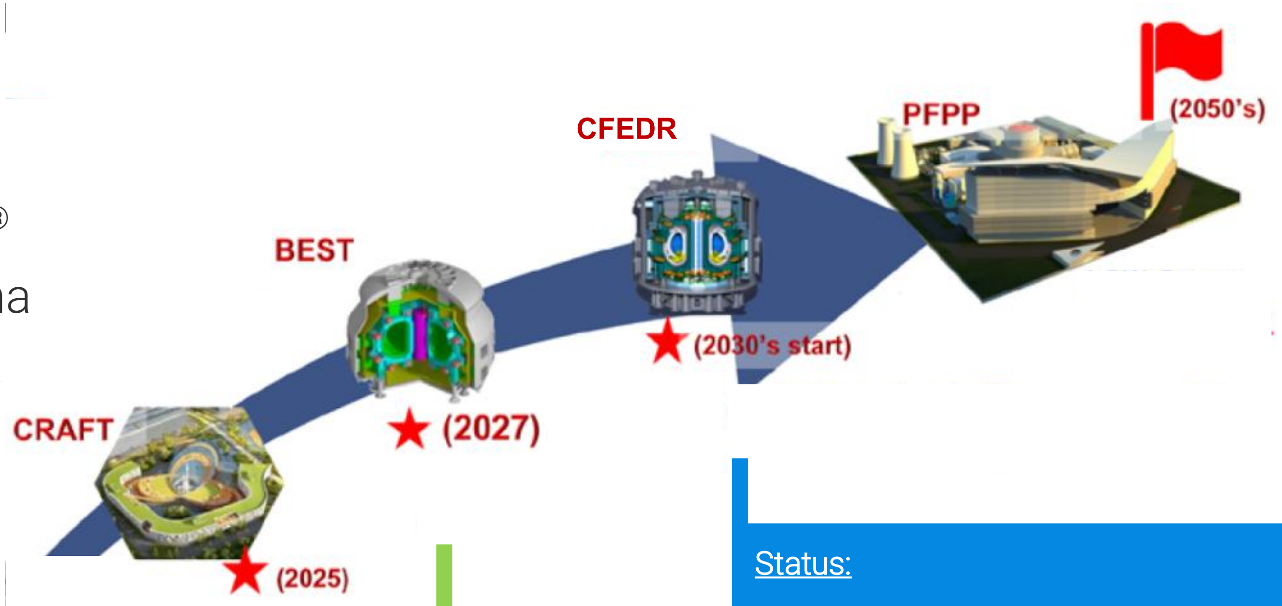
Aktuelle Fusionsprogramme (Auswahl)

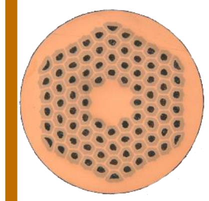
Im Bau	Plasma	Geplant/in Diskussion	Plasma
SPARC (CFS), 140 MW, Q=2	2027	Infinity 1 (Type One)	2028
		Infinity 2 (Type One), 350 MW electric	>2030
BEST (China),100 MW, Q=5	2027	CFEDR (China), >500 MW	>2030
		ALPHA (Proxima), Q=1	2031
ITER (public), 500 MW, Q=10	2034	Stellaris (Proxima), 1 GW electric	>2030
		ARC (CFS), 400 MW electric	>2030
DTT (ENEA), 45 MW, Q<1	2029	THEA, 390 MW electric	>2030
		Helical Fusion, 50 MW electric	2030-2035
		GIGA (Gauss Fusion), 1 GW electric	>2040
		STEP (UKAEA), 400 MW electric	>2040
Beinhaltet keine privaten/kommerziellen chinesischen Initiativen		VNS (EU), 30 MW material test	k. A.
		JA-DEMO (Japan)	>2040
		K-DEMO (Korea)	k. A.

Nb_3Sn basiert bzw. in Betracht gezogen

Fusion in China

- Bruker hat seit 2022 Nb_3Sn RRP® Leiter für Fusionsprojekte in China im >10 Tonnenmaßstab geliefert
- Unsere Stärken:
  - Innovative R&D
  - Technologie Erfahrenheit
  - Fortgeschrittene Fertigungsverfahren
  - Skalierbare Produktion mit MRI-NbTi Leitern
  - Hohe Fertigungstiefe





Bruker Lieferung:
5 t RRP® in 2021-2022

~1000 km

Bruker Lieferung:
26 t RRP®
in 2022-2025

~6000 km

Status:

Genehmigung demnächst erwartet

Budget:

~100 billion RMB (>12 Milliarden EUR)

Zeitplan:

Leiterlieferungen 2028-2030

Magnetspulen Fertigung 2030

Inbetriebnahme 2035

Nb_3Sn Drahtbedarf (Gesamtprojekt):

~300 t RRP® Nb_3Sn, ~65.000 km

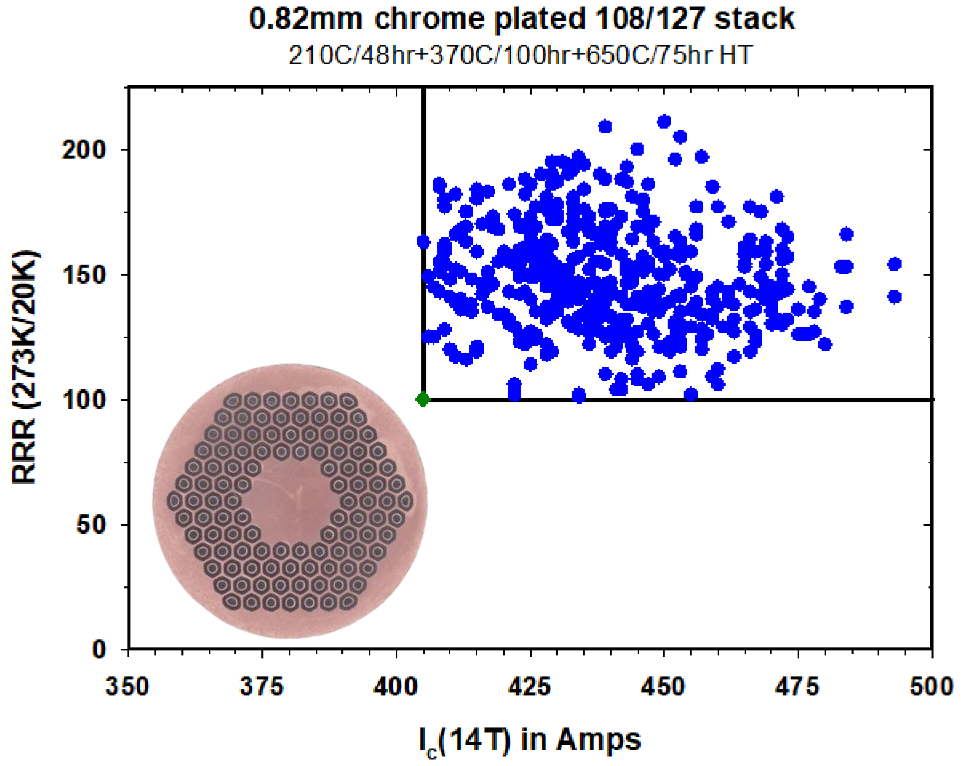
~600 t Single-Barrier IT Nb_3Sn, ~130.000 km

~150 tons of NbTi, ~45.000 km

RRP® Produktion für BEST bei Bruker

"Burning plasma Experimental Superconducting Tokamak"

- Das CICC Kabel verwendet high-Jc RRP® Nb_3Sn
- Strikter Projektzeitplan:
  - Produktionsbeginn 2023, Gesamtmenge 26 t (~6000 km)
  - Produktionsrate bis 20 Tonnen (4500 km) pro Jahr
  - Ende 2025 im Zeitplan beendet
  - Produktion in DE & USA



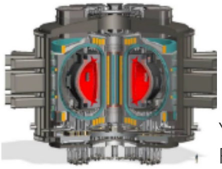
Stabile, vorhersehbare Leistung über zwei Jahre Leiterproduktion

Ausblick auf zukünftige asiatische Programme

Comparison of Preliminary CPD Design Parameters with KSTAR and K-DEMO

Parameters	KSTAR	CPD (CID) draft	CPD (SIT) draft	K-DEMO
Major radius, R0	1.8 m	~ 3.5 m	~ 2.0	~ 6.8 m
Minor radius, a	0.5 m	~ 1.1 m	~ 1.2	~ 2.2 m
Elongation, k	2.0	~ 2.0	~ 2.0	~ 1.2
Field on axis, B0	3.5 T	> 6.3 T	~ 6.0 T	~ 7.5 T
Plasma current, Ip	2.0 MA	~ 7.7 MA	~ 9.0 MA	~ 13 MA
betaN	> 3.0	~ 3.3	~ 3.6	~ 3.0
H		~ 1.5	~ 2.9	~ 1.28
Q		~ 5.5		~ 20
fGW (ne/nGW)		~ 0.95	~ 0.65	~ 1.1
Fusion power		~ 300 MA	~ 360 MW	~ 1500 MA
SC	NbTi, Nb3Sn	HTS / LTS	HTS	NbTi, Nb3Sn
Divertor	C, W	~15 MW/m		~ 20 MW/m

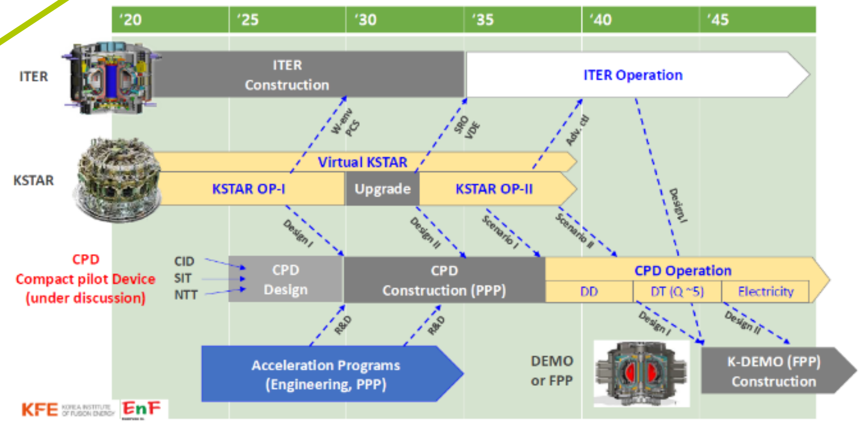
- Parameters can be changed according situation



Yeongkook Oh,
Fusion Power Associates,
Dec. 2-3, 2024

Fusion Power Associates, Dec. 2-3, 2024, ykoh@kfe.re.kr (KFE)

Proposed timeline of Key Fusion Programs *(Subject to Discussion)*



Fusion Power Associates, Dec. 2-3, 2024, ykoh@kfe.re.kr (KFE) 7

- K-DEMO (Korea)
  - Bedarf
    945 t Nb_3Sn
    ~200.000 km

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 63, Mar. 2026. Presentation given at ISS 2025, Nagasaki, Japan, Dec. 2025.

Option: Higher magnetic field & Larger TF coil

15

Required TFC R&D Items

- Development of a new attachment for TF coil fabrication
- Development of a high-current conductor
  - ✓85kA@ϕ39mm (Ic=71 A/mm²: 1.3 times that of the ITER conductor)
    - ➔Short twist pitch stranded wire, High-strength, high-performance SC wire
- Development of high strength cryogenic steel
  - ✓Stress on the coil case will increase by approximately 200 MPa
    - ➔R&D of high strength cryogenic steel

	ITER TFC	Option
SC strand	Nb3Sn	Nb3Sn
Number of TFC	18	16
B_{tmax}	11.8 T	~ 13 T
Conductor current	68 kA	85 kA
Number of turns per TFC	134	134
Total magneto motive force	164 MAT	182 MAT
Total magnetic energy	41 GJ	~55 GJ
Design stress	667 MPa	800 MPa
Width / Height of TFC	8/12.3 m	9.2/14.2 m

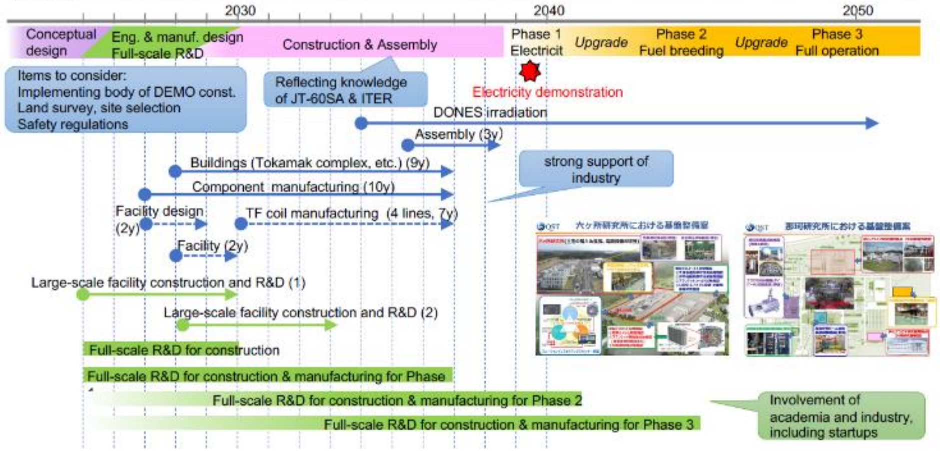
Hiroyasu Utoh
38th International
Symposium on
Superconductivity
(ISS2025)
December 2-4, 2025

- JA-DEMO (Japan)
  - Nb_3Sn Bedarf
    k. A. ,vermutlich
    >>500 t

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 63, Mar. 2026. Presentation given at ISS 2025, Nagasaki, Japan, Dec. 2025.

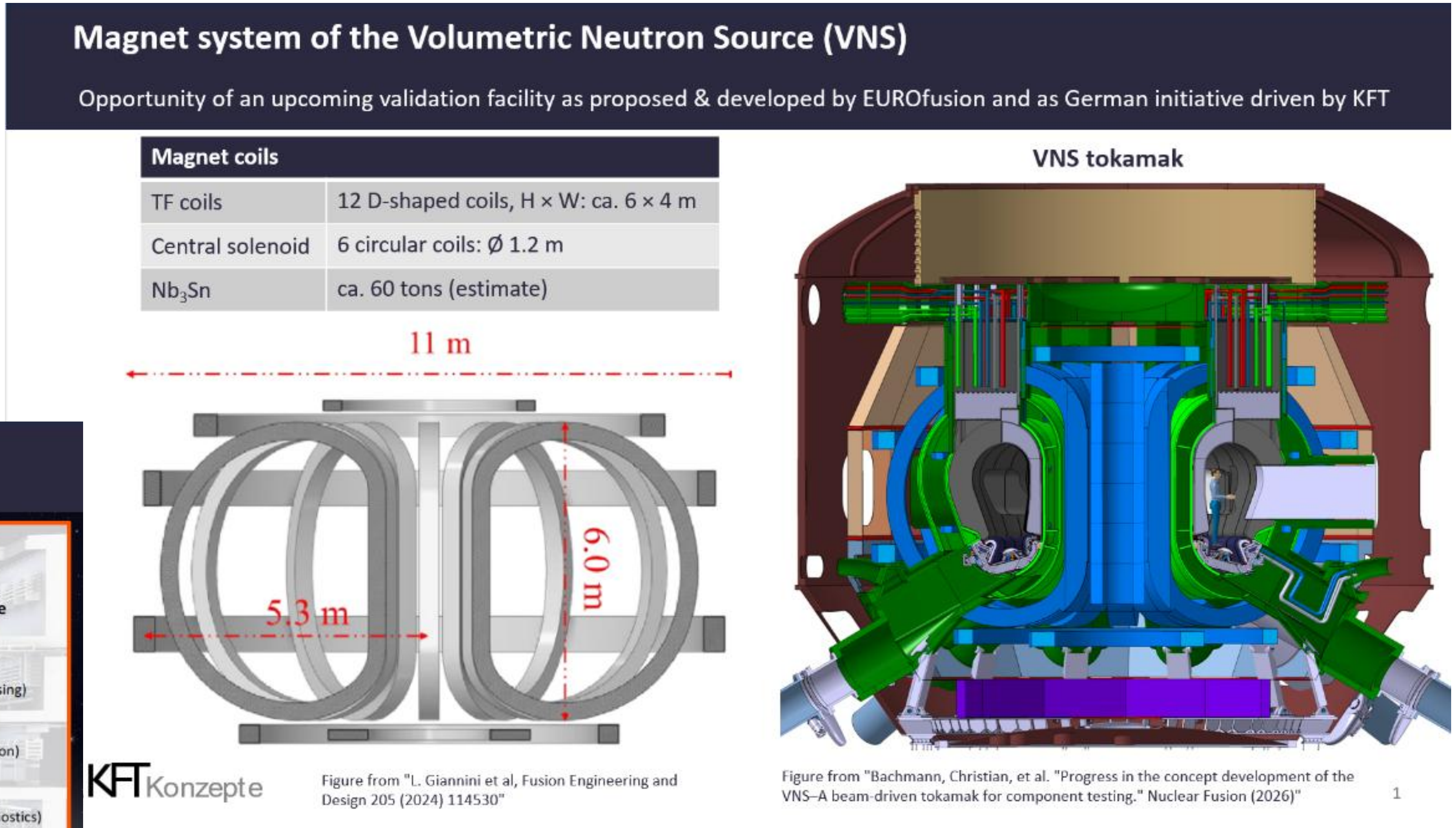
Image of schedule aiming for electricity demonstration in the 2030s

10

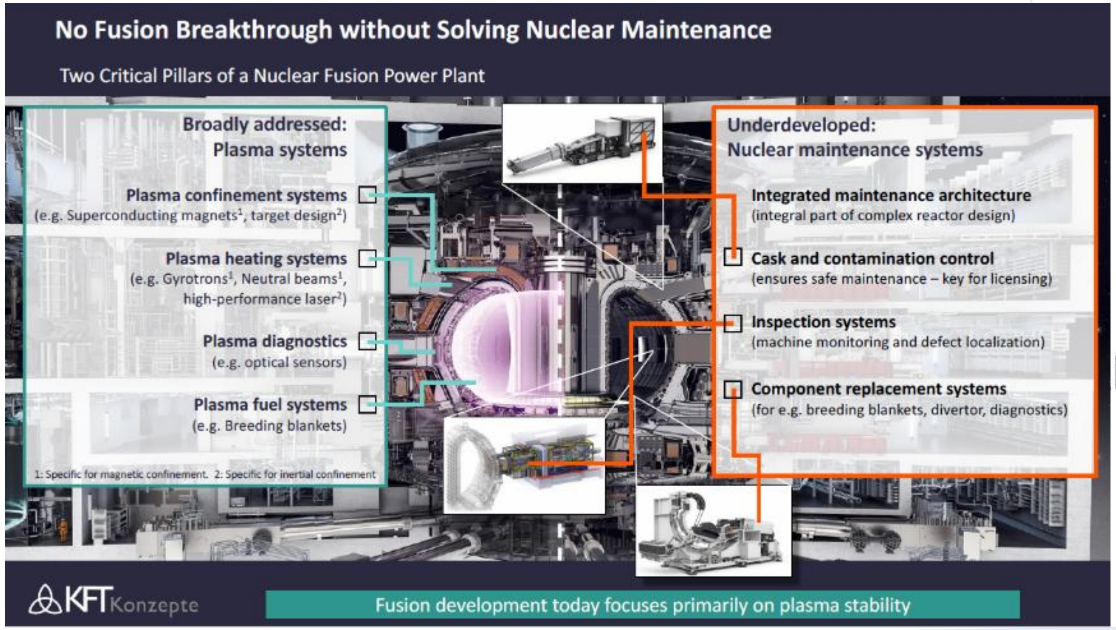


Ausblick auf europäische Programme

- Volumetric Neutron Source (VNS), EU
- Anlage, um niedrig TRL-Komponenten zu entwickeln und testen
- Nb_3Sn Bedarf 60 t ~ 13.000 km

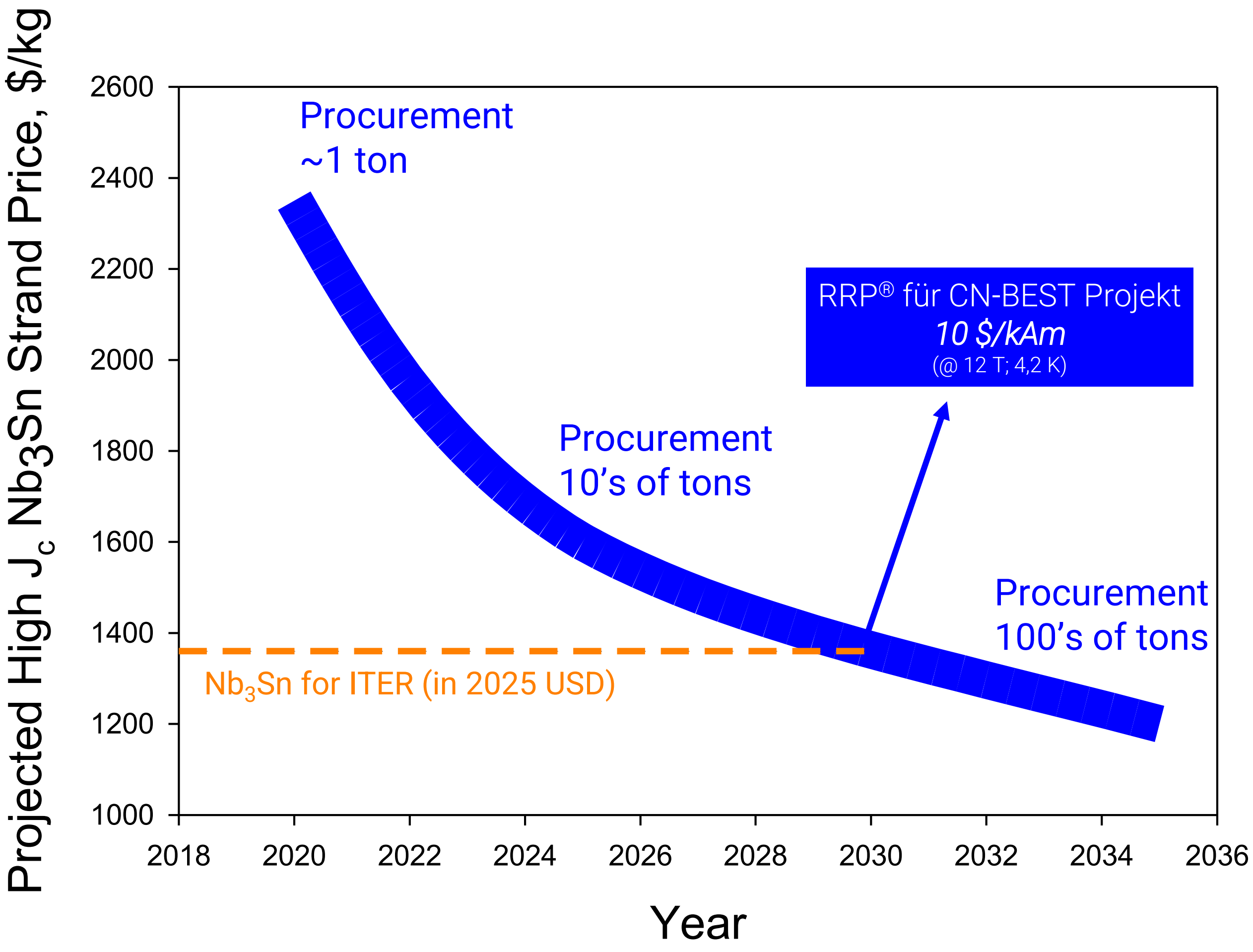


Magnet coils	
TF coils	12 D-shaped coils, H × W: ca. 6 × 4 m
Central solenoid	6 circular coils: Ø 1.2 m
Nb_3Sn	ca. 60 tons (estimate)



Schlussbemerkungen
Kostenprojektion, Skalierbarkeit & Supply Chain

- Der Nb_3Sn Bedarf für "mittelgroße" Fusionsprojekte (ASIPP BEST / ENEA DTT / VNS) ist auf einen 10 t Maßstab angewachsen
- Große Projekte wie ASIPP CFEDR, GIGA, JA/KR-DEMO, … werden hunderte Tonnen Nb_3Sn benötigen
- Nb_3Sn bietet Kostenvorteile durch Skalierungseffekte
  - Große Menge die durch große Anlagen gefertigt werden
  - *Synergie-Effekte* mit der NbTi SL-Draht-Fertigung, die *bereits im >100 t Maßstab produziert*
  - Existierende Supply Chain, *jedoch Notwendigkeit diese auch in Europa zu etablieren*
- Im Vergleich zu ITER-Leitern liefern *RRP®-Leiter* die *dreifache Stromdichte*
- *Der Nb_3Sn Preis wird in 5-10 Jahren durch Skalierungs-effekte deutlich unterhalb der ITER -Beschaffungskosten liegen*

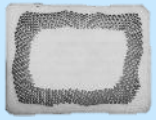


Thank you!

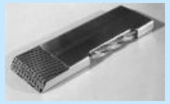
40 Jahre Erfahrung mit Supraleiter für Fusionsanwendungen

IEA Large Coil Task (LCT) - 1980

20 tons Cu/NbTi F800-4,7 wire for EFDA coil



Roebel cable in cooperation with KFK Karlsruhe GmbH, Krupp AG and Siemens AG



1 of 6 D-shaped coils tested in Oak Ridge

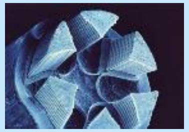
Tore Supra - 1982

20 t Cu/CuNi/NbTi Mixed matrix Type F-9438 (~5.4 MDM)

Tokamak made out of 18 round shaped coils

Polo - 1987

650kg NbTi/Cu/CuNi 1:5:3 Ø 1.25 mm



Cable with forced flow cooling

Tested in TOSKA facility in Karlsruhe

ITER CS Model Coil - 1995

6.6 tons NSTT4675 Ø 0,81 mm

Cable with forced flow cooling

CS Model coil

Wendelstein 7-X, Magnet - 2000

50% Bruker, 50% Europa Metalli, Italy Ø=0.57mm NbTi strand (Cu/non-Cu=2.6 with 144 filaments Ø=25µm

NbTi strand was cabled 3 x 3 x 3 x 3 x 3 = 243 strands, cladded with dispersion hardened Al

60km CICC (cable-in-conduit-conductor) produced, 7M€. Ic=35kA @ B=6T/T=4.2K, 16 CICCs stacked for coil winding

Wendelstein 7-X, HTS Current Leads - 2007

Soldered HTS stacks made by Bruker

Stacks inserted in grooves

Currents leads made at KIT

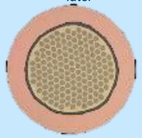
JT60-SA, HTS Current Leads - 2007

Soldered HTS stacks made by Bruker

Currents leads made at KIT

ITER – EU TF 2009 - 2014

37 tons NSTT8305Ta50 Ø 0,81 mm, 24.5 MEUR, Small follow-up order later



Cabling performed at Tratos, Italy (900 SC strands + 522 Cu strands)

2 of 18 TF coils 68000A at 11.8T, 5K

ITER – EU TF & US TF 2009 – 2014

58 tons Internal Tin (IT) Strand EU + 14.5 tons US £ 30 M +

Cabling performed at Tratos, Italy and New England Wire Technologies, US

3 of 18 TF coils EU ½ TF coil US

China –15 T Conductor Test Platform (CRAFT 2021 - 2023)

5 tons awarded $10M +

Magnet will be part of CRAFT testing capabilities

CRAFT supports technology development for CFETR

China **Burning plasma Experimental SC Tokamak (BEST – IPP, 2022 - 2024)**

10 tons awarded $15M + ~40 tons still to be procured

BEST is planned as a lower risk step towards CFETR