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HTS for Fusion – Fusion for HTS?

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ASC 2018

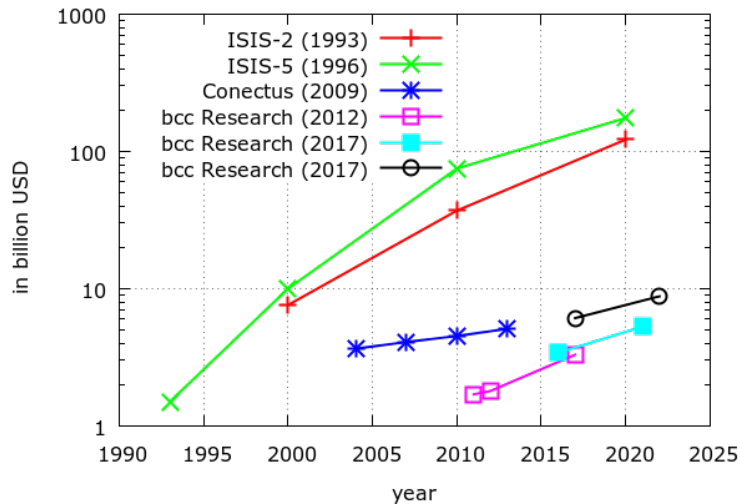
Seattle, 31st Oct 2018



HTS, fusion – high hopes, slow reality

Estimated global market for superconductivity applications

NATURE VOL. 233 OCTOBER 29 1971



Outlook for Controlled Fusion Power

J. L. TUCK

University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico

I shall take the two factors of increased fusion complexity and increased engineering experience with radioactivity as mutually compensating, and the development period for fusion to be the same as for fission—twenty years. **Competitive fusion can, therefore, be expected by the year 2000.**

"Predictions are very difficult, especially about the future" - Niels Bohr (?)

So why will it happen now?

Closer than ever, private sector starts to invests money in fusion:

Breakthrough Energy Ventures (Bill Gates, Jeff Bezos, Richard Branson), Goldman Sachs, Eni,...

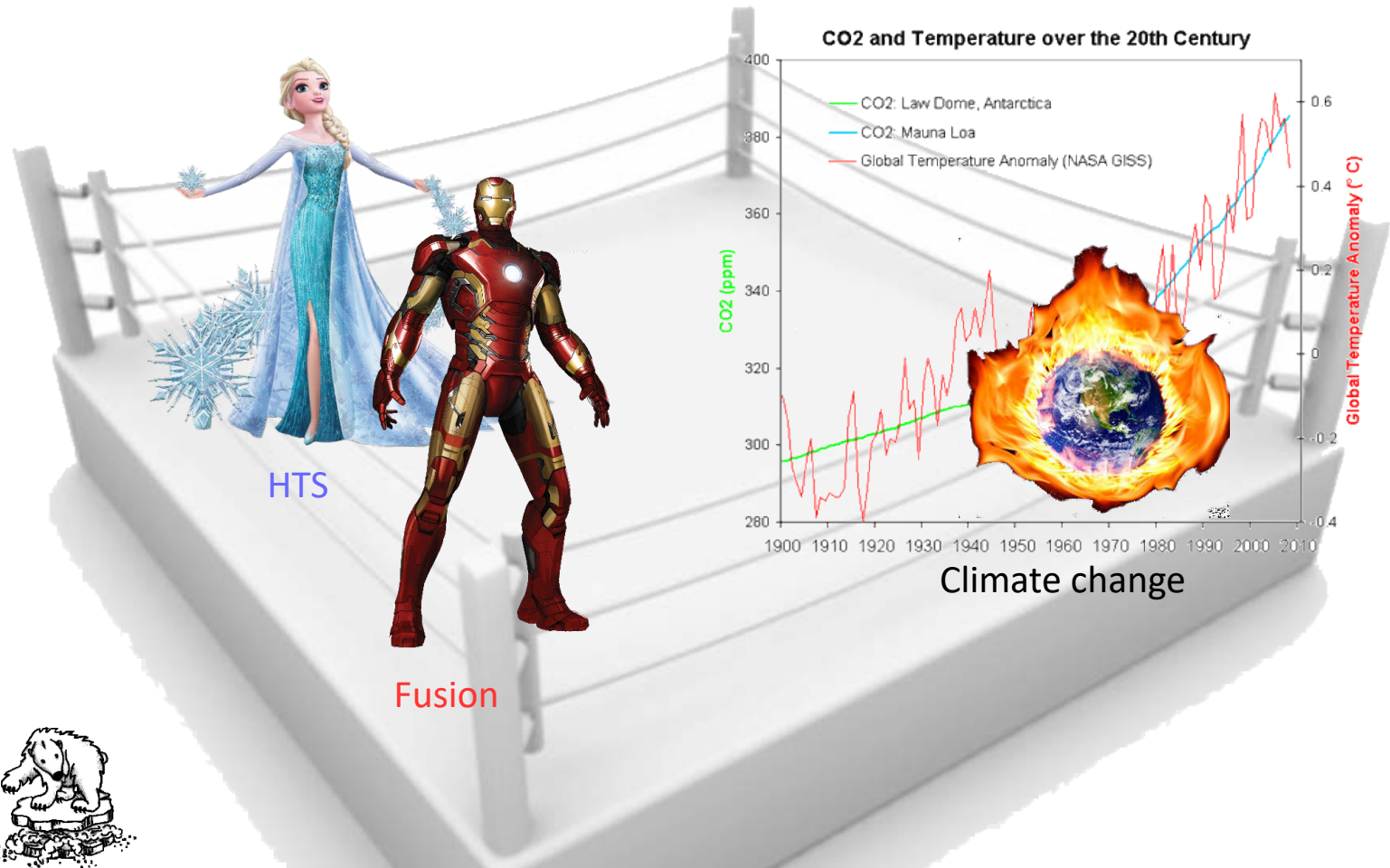


"Fusion will be ready when society needs it" - Lev Artsimovich, "the father of Tokamak"

→ we never needed it more than now, so let's better do something



Alliance of unlike heroes to rescue the world



HTS for fusion – fusion for HTS

Cheaper reactors (long term)

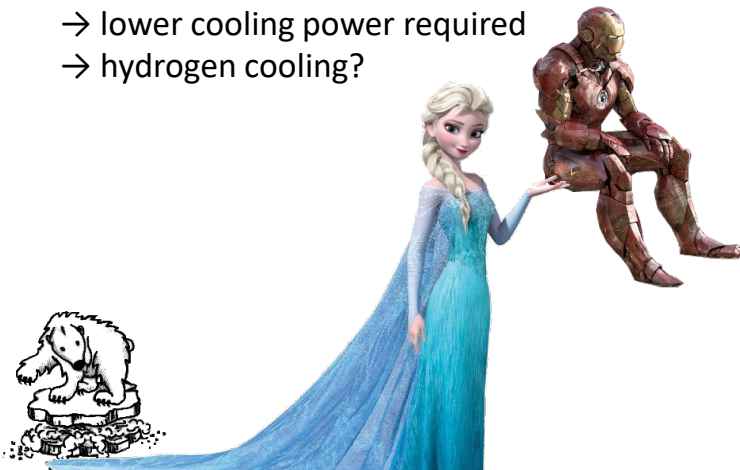
- $B_{c2} > 100$ T
 - higher magnetic fields
 - higher power density: $P \sim B^4$
 - smaller design possible

More efficient reactors

- $T_c \sim 90$ K
 - higher operation temperatures
 - lower cooling power required
 - hydrogen cooling?

Cheaper coated conductors

- High coated conductor demand
 - scaling up tape production
 - bringing costs down (raw materials are relatively cheap)
 - new applications get feasible





HTS for fusion

- High current cable development (low inductance of magnet desired)



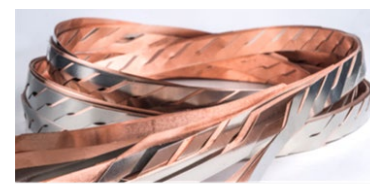
University of Twente



STARS TYPE-B



TSTC



CERN

- (Demountable) low resistive joints (still many kW of joule heating)

Lap joint



Bridge joint



Butt joint

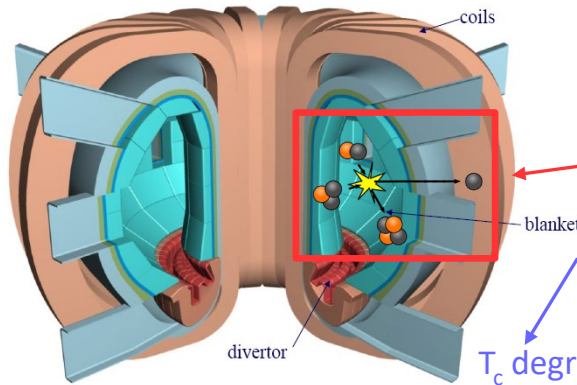


- Quench protection (fast detection, limit local heating)
- Neutron radiation

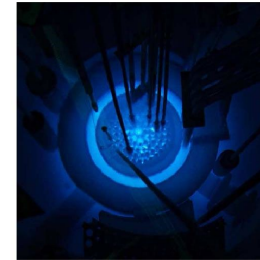




HTS for fusion – neutron irradiation

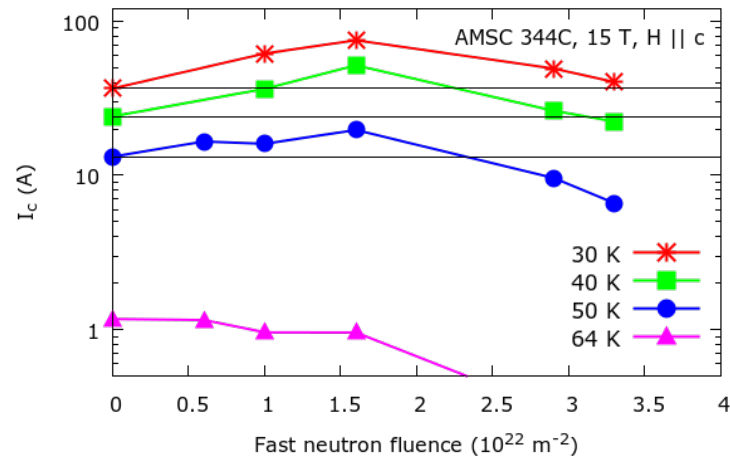
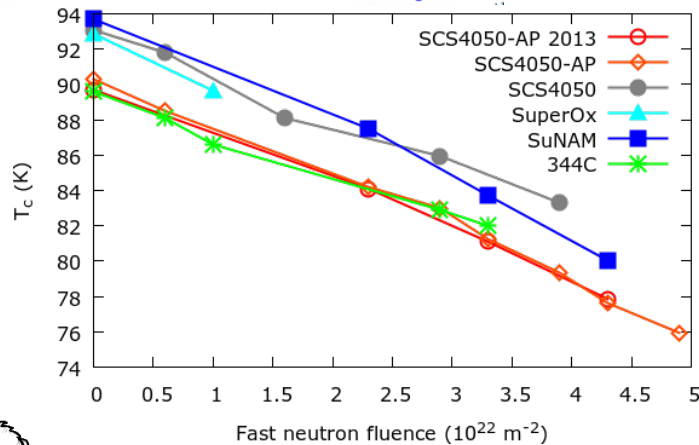


fusion neutrons hit superconductor
 → defects in material
 → change of superconducting properties
 → irradiation studies necessary



T_c degradation

Role of temperature



This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.



Fusion for HTS

Overall worldwide ever delivered coated conductors:
~3000 km (B. Holzapfel, EUCAS 2017)

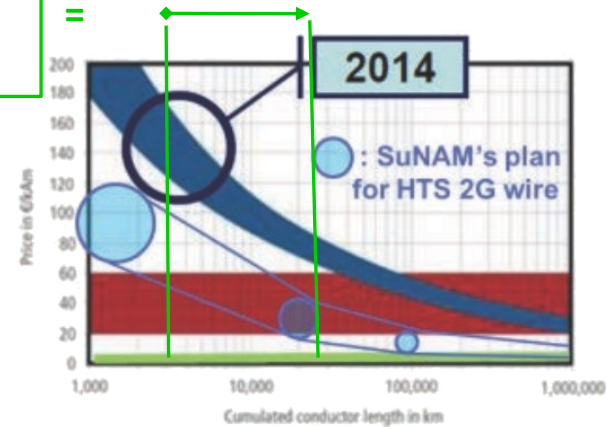
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Production volume x10
→ ~50 % price drop

+

500 MW fusion reactor:
~25000 km tape, 4 mm
(Z. Hartwig)

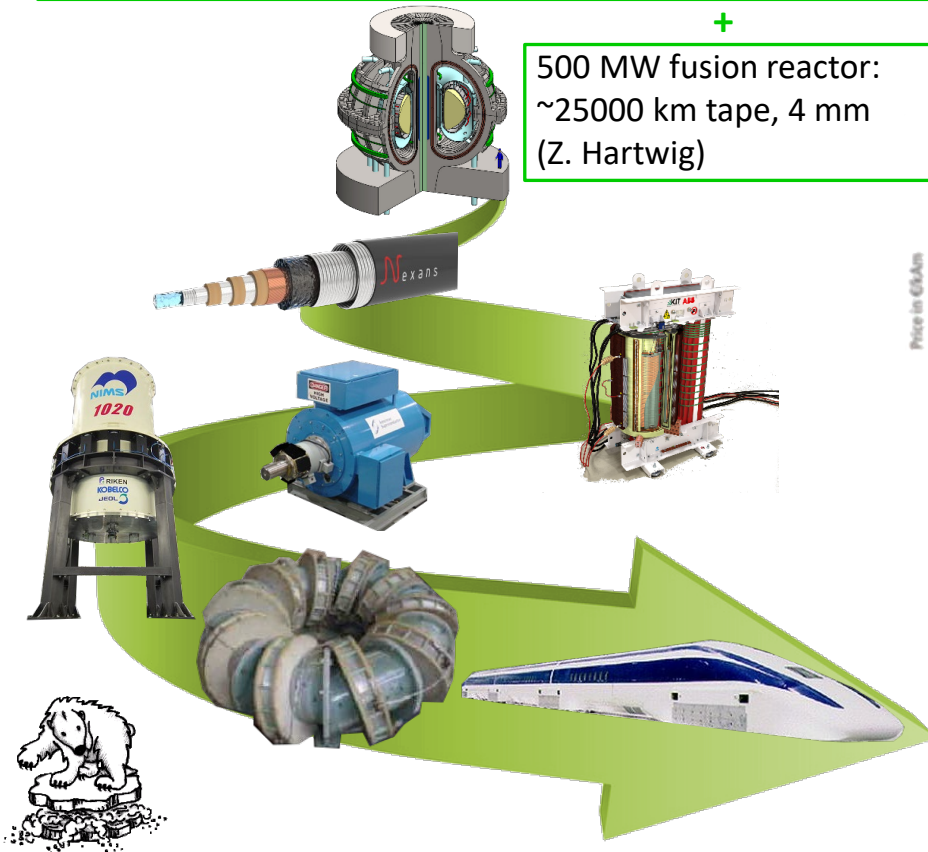
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- Copper Wire
- Prediction for 2G HTS wire
- 2G HTS wire material cost

Data: iv Supra, Siemens

(S. H. Moon, 1st WAMHTS 2014)



HTS & fusion, a dream team



HTS



Fusion

HTS is really cool technology,
nuclear fusion is pretty hot!
→ together they will achieve
greatness!

The (happy) end.

