Research Needs for HTS Power Delivery Technology

Presented at the DOE-OE
Wire Development
Workshop

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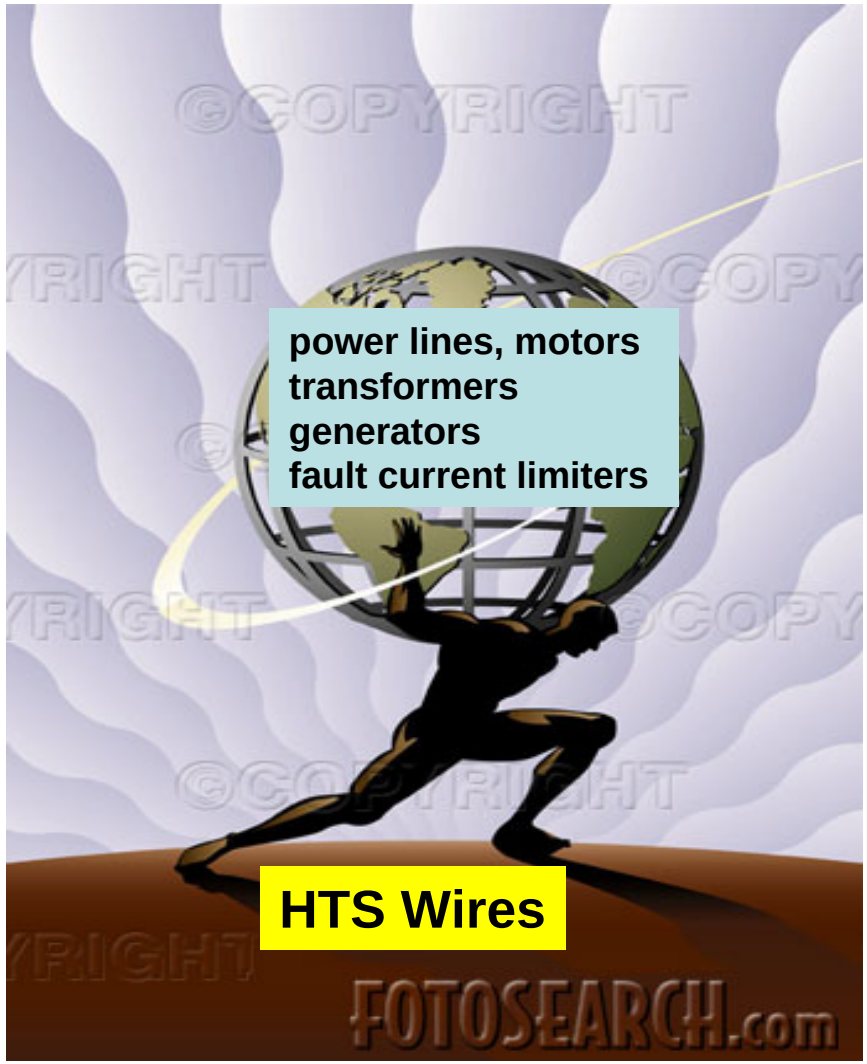

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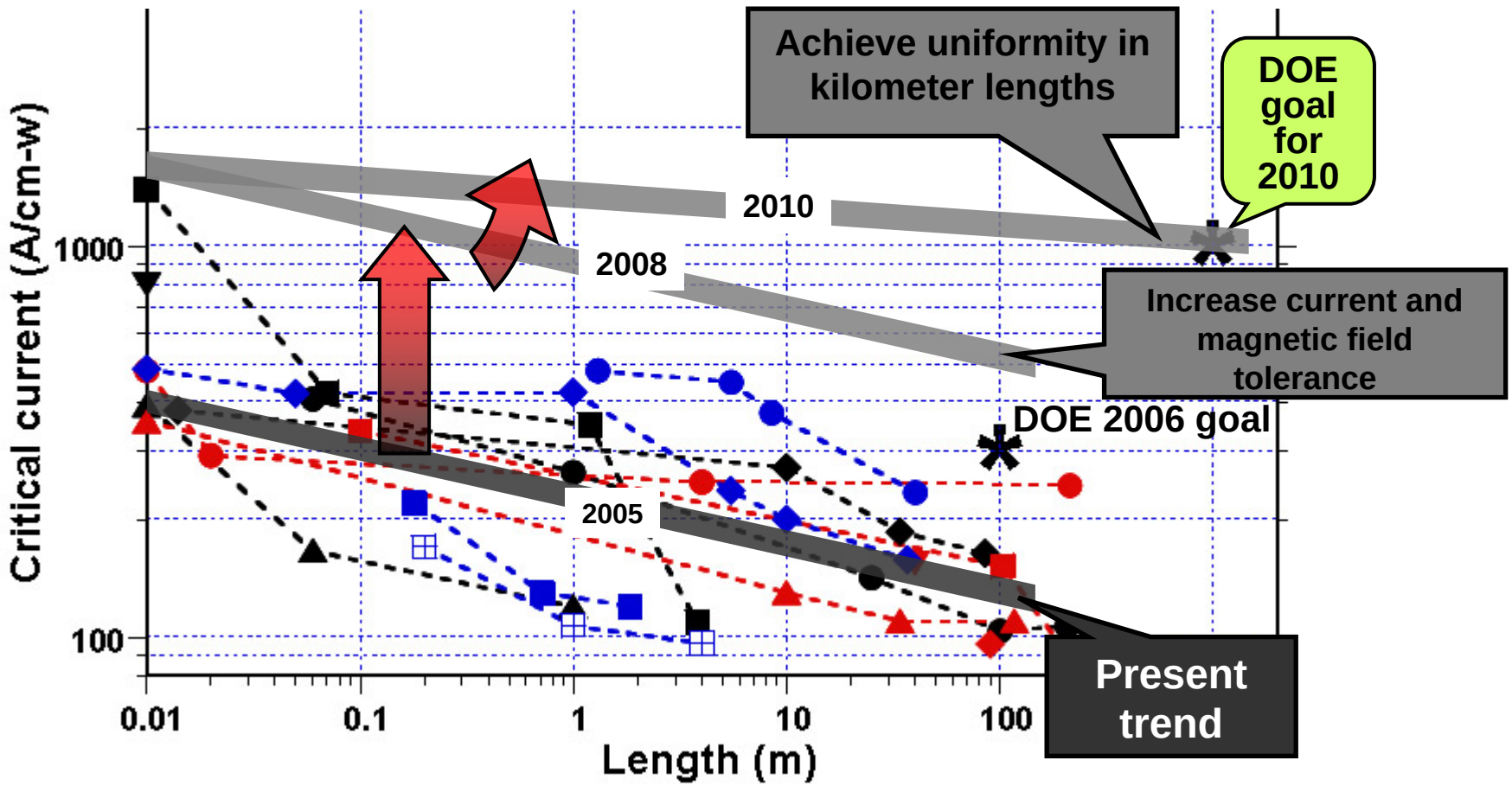
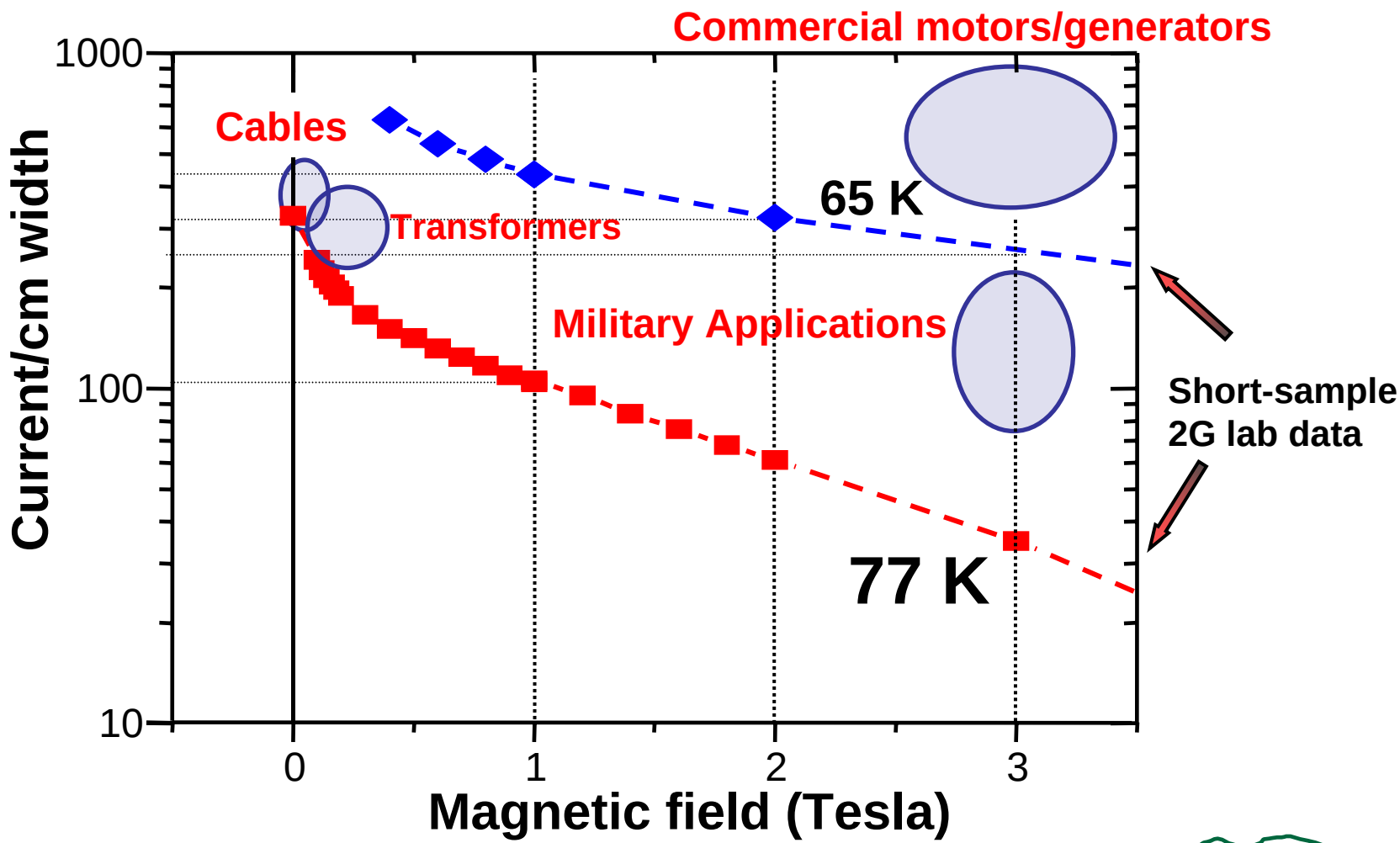
Need to increase short sample performance and long length uniformity in low and high magnetic fields to reach DOE goals.



Magnetic field requirements have been met under laboratory conditions --- and need to be proven with scalable processes under industrial conditions



Must drive the cost down by increasing performance and researching innovative processes

- **Furukawa Electric: "HTS wire must get to $25/kA-m to have actual cable cost directly equivalent to XLPE (underground) cable cost alone."**

…few believe 1G can get there

- **Innovative processes must be researched and developed to take cost out of all parts of the wire**
  - **Proof-of-principal: "make kilometer-long wires using semiconductor fabrication processes" may not enable performance/cost ratio**

- **Need increased understanding of the intrinsic limits to current in these wires**
  - **Helps drive the processing R&D**

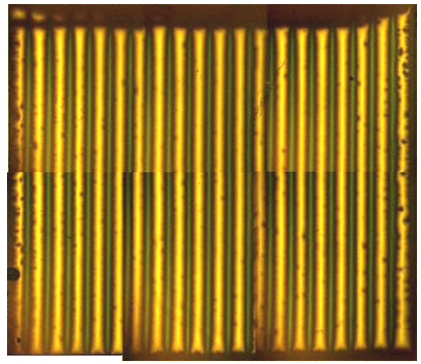
- **Finally, for the broadest applications---**
  - **Today's pre-commercial 2G is the wrong shape**
  - **Need to be able to twist and transpose**
  - **Strategic research needed to make this happen**

R&D needs for superconductivity in electric power systems: wires

- **Higher currents in longer lengths**
- **AC loss reduction**
- **Mechanical strength improvement**
- **Higher magnetic field capability**
- **Reduce process complexity and cost**
  - **Reduce processing steps and use of different processing techniques**

Need to reduce ac loss while maintaining high currents through materials improvement and conductor design & engineering.

- HTS grid applications can significantly raise efficiency
  - Resistance losses are negligible
  - But, maintaining cold operating temperature consumes energy and remaining losses (thermal and ac) must be minimized
- Conductor geometry R&D can reduce ac losses



Hysteresis losses were minimized by creating a multifilamentary structure in the YBCO coated conductor (USAF)

2G Roebel conductor (THEVA)

Need to develop cryogenic (20-80 K) electric insulation materials for grid applications

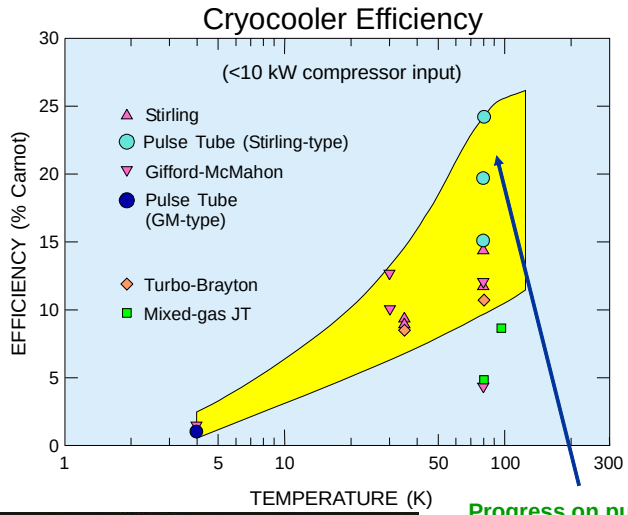
- DOE Program Goals: High voltage/low temperature electrical insulation materials
  - Dielectric materials are application-specific
- AC grid applications require high voltage standoff for the component lifetime – 10^{11} ac cycles
  - A *single* dielectric failure can shut the device down.
- New high voltage materials that can provide electrical insulation at temperatures 30-80 K are needed.
  - *Need to research and develop more materials to make engineering tradeoffs in real devices*
- A Cryogenic Dielectrics Initiative (2006-2008) is proposed

800 kV lightning impulse generator

Need to develop high-efficiency, low-cost cryogenic cooling equipment.

- Broad goals from the DOE Cryogenic Roadmap require R&D expenditures
  - Reliability increase to allow availability > 99.8%
  - Efficiency increase to achieve 30 % of Carnot
  - Cost decrease from $100 to $25/watt at ~ 65-80 K

Cycle efficiency vs. operating temperature



Progress on pulse tubes is encouraging

Cryocoolers used in MRI systems and HTS motors