The Road to Room Temperature Superconductivity

Summary I

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Disclaimer

All lists are incomplete

No names are listed.
Those that are listed are mixed up

Not claiming that I always understood what you meant

Only my view

The Road to Room Temperature Superconductivity

Interesting Scientific Conference? **Yes!**

Better conductors are important

Let's get rid of the cold!

Products & Services

- HTS WIRE
- MOTORS, GENERATORS & SYNCHRONOUS CONDENSERS
- INDUSTRIAL POWER QUALITY SOLUTIONS
- POWER CONVERTERS
- TRANSMISSION GRID SOLUTIONS

Applications

- SEMICONDUCTOR
- INDUSTRIAL
- WIND ENERGY
- UTILITY
- SHIP PROPULSION

HTS Wire

HTS Wire Frequently Asked Questions

Q: What is HTS wire?

A: HTS stands for "High Temperature Superconductor" and designates superconducting materials having transition temperatures above 20 K to 40 K. HTS wire is wire that utilizes the benefits of high temperature superconductors and is one of American Superconductor's core commercial products. Please see our Introduction to Superconductivity for more information on high temperature superconductors. Also, please see our Product Information, Wire Architectures and Wire Glossary regarding our HTS wire.

Q Can I use the wire at room temperature?

A: HTS or High Temperature Superconductors are materials that can superconduct at higher temperatures than Low Temperature Superconducting materials (LTS). However, even these materials need to be cooled down to at least 125 K to superconduct. Our HTS wires operate below 115 K and nominal operating temperatures range from 20 K to 77K. The temperature at which the wire can operate depends upon the amount of current, magnetic field and other criteria. For more information, please see our Introduction to Superconductivity.

HTS WIRE PRODUCTS

- Compression Tolerant Wire
- High Current Density Wire
- High Strength Wire
- Hermetic Wire
- CryoBlock™ Wire
- Second Generation (2G) HTS Wire
- HTS Wire Glossary

APPLICATIONS FOR HTS WIRE

- Electric Power Applications
- Rotating Machines
- HTS Cable
- HTS Magnets

FAQs

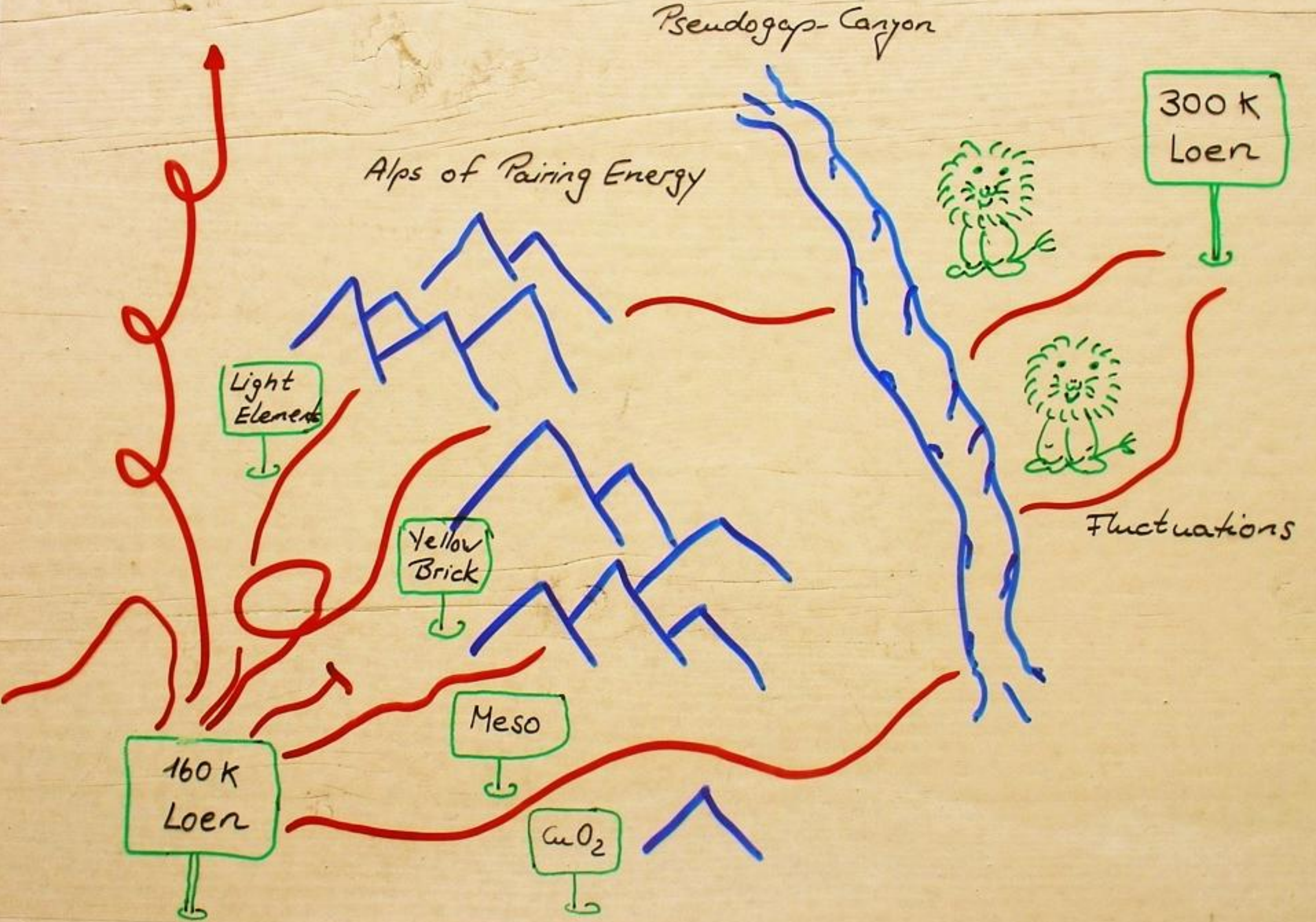
Learn more about our HTS wire products.

PRODUCT LIBRARY

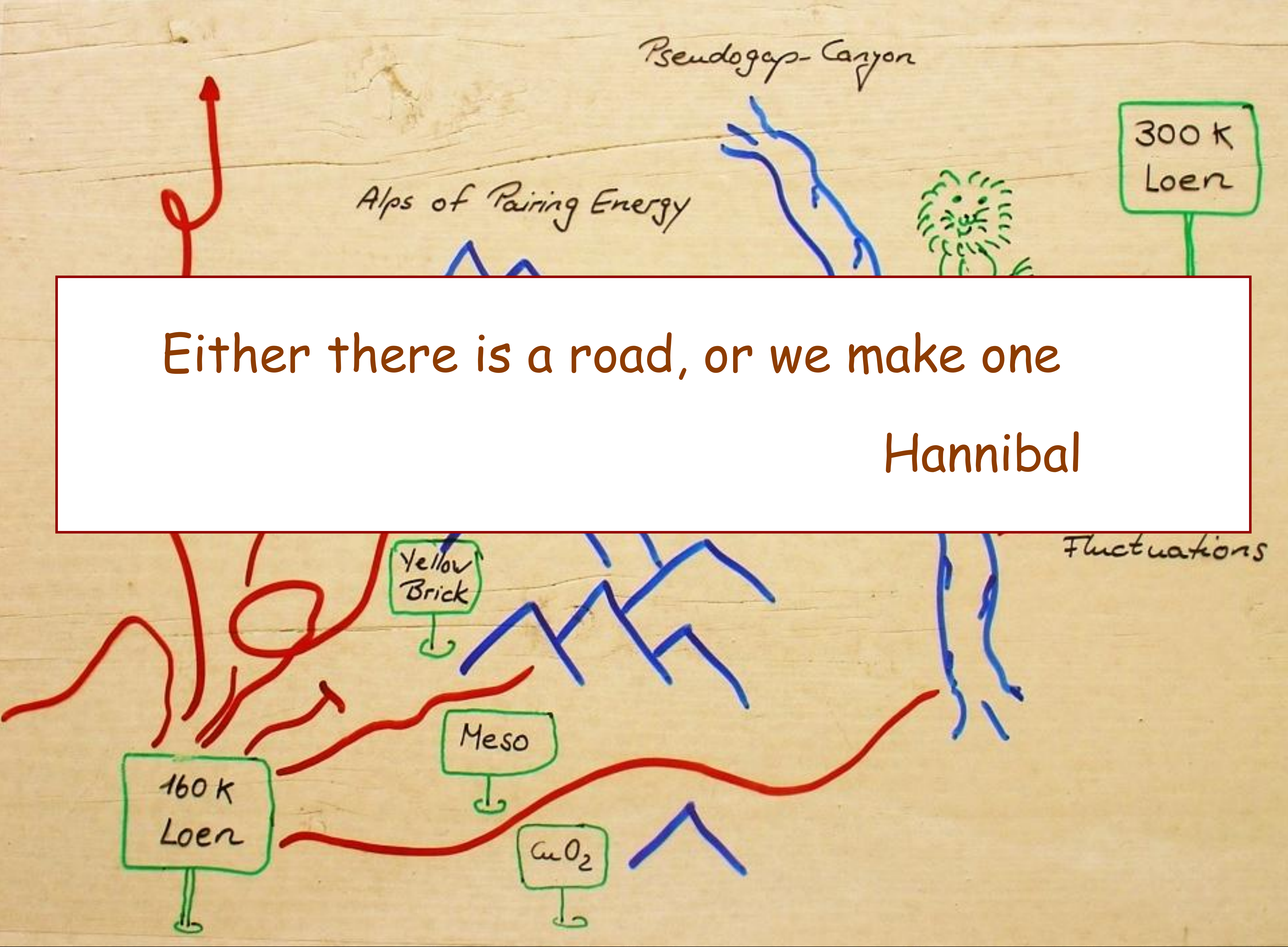
- Data Sheets
- Technical Papers
- Service Notes

An empty stomach is a bad advisor

A. Einstein



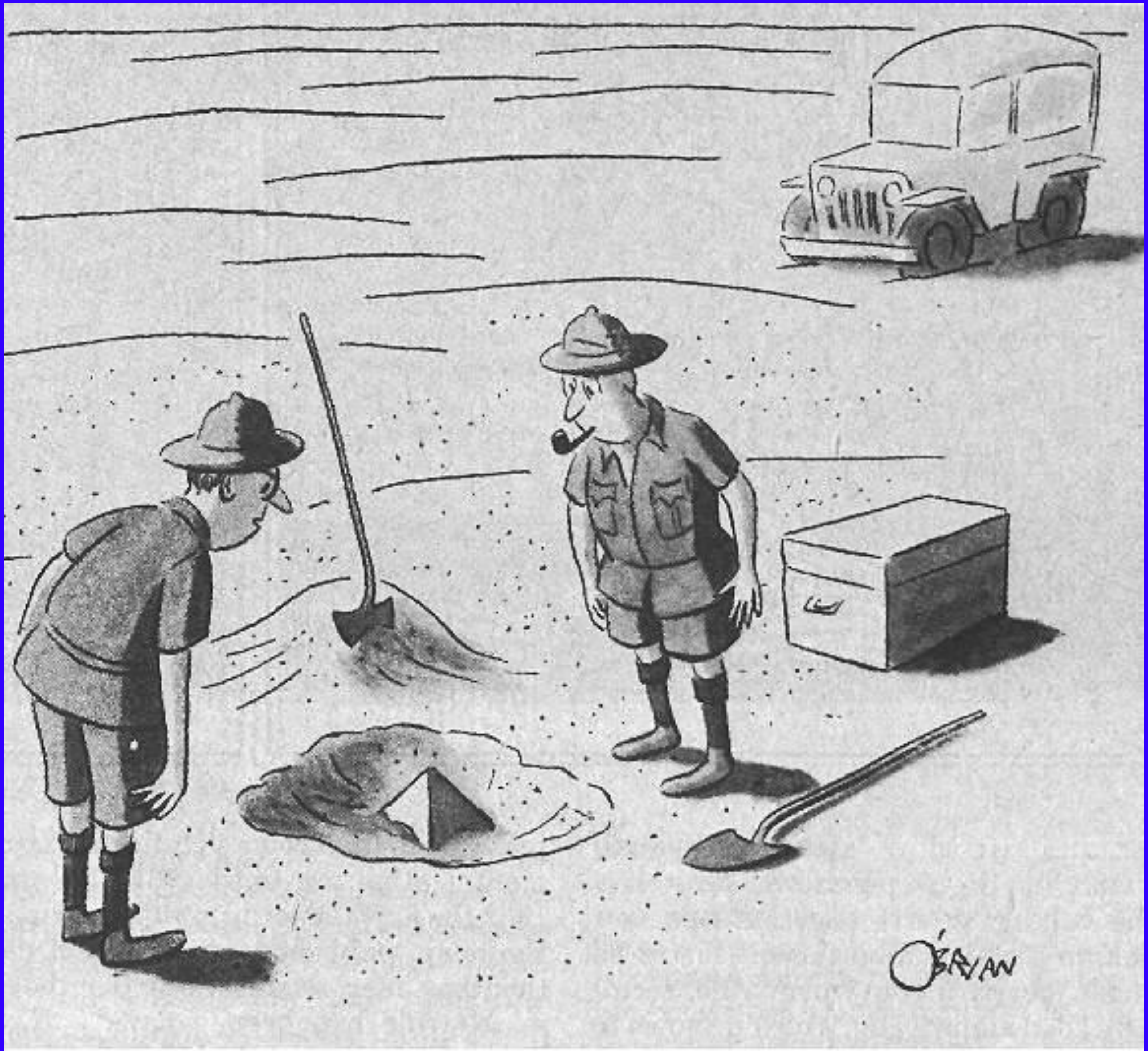
Pseudogap-Canyon
300 K
Loen
Alps of Pairing Energy
Light
Elements
Yellow
Brick
Fluctuations
Meso
160 K
Loen
CuO2



Either there is a road, or we make one

Hannibal

Some Roads:



"This could be the discovery of the century. Depending, of course, on how far down it goes."

Some Roads:

- negative U-Centers - valence skippers, potential to increase their Tc by leveling the energies
  play with the chemistry, understand the ions,
  find new negative U-centers

Some Roads:

- optimized electron-phonon coupling, light elements, metallic H, B-doped diamond (“please no diamond-type diamond”, “diamonds are getting even better”), B-doped SiC, Li-B, Be_2Li (70 K?), intermetallics of light elements

  MgB_2 is a sweet spot, specific sheets of FS couple to specific phonons (average λ does not count),
  provides great inspiration, rolled up MgB_2, fullerenes,
  C36 (100K predicted Tc), C60 in BN,tuned nanotubes,
  ammonia-compounds, $Li(NH_3)_4$ with enhanced DOS at E_F,
  Li doped Be-hydride

Hey theorists - let your lights shine!

Some Roads:

- cuprates: the CuO_2 plane is unique, slim hope for an even better alternative

  "cuprates are dying to be a RTS, you just have to provide the phase stiffness (input from theory?)

  optimized cuprates (squares are ideal)
  super-ladders (doped Cu_2O_3 planes?, use electrochemistry)
  fluorinated cuprates (Tc=138 K)

Some Roads:

- nickelates, Ni^{+} ?
- layered BKBO
- ammonia-compounds, $Li(NH_3)_4$ with enhanced DOS et E_F
- Na_xWO_{3-y}, inverse-opal technology: Li_xWO_{3-y} T_c=132K???
- boosted Chevrels
- HFS, PuCoGa5: Tc=18 K, where is the end set by strong the interactions?

Some Roads:

- reduce disorder (apical oxygen planes);
  Bi2212 Tc=98.5 K; where is the limit?

- negative dielectric constants

- search for metastable phases (laser heating & measurement
  under large pressure, at interfaces)

- pressure

Some Roads:

Meso- and nanoscopically structured superconductors / interfaces

Little & Allender-Bray-Bardeen provided inspiration

- nanoclusters with almost magic electron numbers
  Ga 56 (T_c=160 K), Zn 190 (T_c=105 K), Al 45 (c_v jump at 200 K?)
  next steps would be: growth of layers, coupling of grains
- superconductors with self-organized structure:
  match with optimized underlying structure
- applying regular patterns of defects (e.g. Zn in CuO_2)
- bundles of metallic and semiconducting nanotubes
- “hybrid superconductors” use second phases to boost interface Tc

Some Roads:

- epitaxial films and heterostructures

  -> Summary by Ivan Bozovic

If you want to find a RTS, you just have to hire another Alex Müller

(Ø. Fischer)

What about the organics?

The progress that will be made in striving for RTS will spin-off to many areas of solid state physics and materials science

Phenomena Used in Support of Pointing out the Road To RTS

quantum tornadoes

Conemara

bunch of sherpas

flying monkeys

snake-oil

lawyers

Napoleon cakes

cheese

Charlie Watts

Condy Rice

quantum tornadoes

yeast

ruby slippers

Shrek

dynamic vacuum

big bangs

Ginzburgers

WMD

magic carpets

Kansas

da Vinci

superconduct-ress

antidotes

Where to do our measurements?

- American office
- edge of university
- Fuji-san
- space shuttle
- dark side of the moon
- dark side of the earth
- surface of Pluto
- edge of universe

How do I operate my dilution fridge at room temperature?

Guidance

- 2D or 3D not so important for T_c=300 K; for applications: 3D!
- s or d-wave not so important for T_c=300 K; for applications: s!
- no reason why e-ph should not be good enough for 300 K
- large DOS - also for applications

Guidance

- practical Tc likely provided by breakdown of phase stiffness, not by end of pairing
- purely repulsive e-e interaction is sufficient (according to Hubbard)

New Directions?

Materials are the Drivers

At the extreme forefront of research in superconductivity is the search for new materials (Malcolm Beasley, 1983)

Issues to accelerate search:

- growth of new materials needs to be strengthened
  teams, e.g. pairs of physicists and chemists
- required: brains, time and freedom

View on Models and Theories from the Experimental Side

- theories will not and can not catch all new possibilities, theories are obviously important for providing directions & answering questions

- real materials: cm-size, defects how stable are theories towards defects?

- theories for inhomogeneous materials, interfaces, real materials (cm-size, with defects)

Wish-list for Applications

- Tc > 450-500 K
- Jc > 10^7 A/cm^2
- stable
- 3D, isotropic
- uniform on nano-scale
- large n, large superfluid density

Wish-list for Applications

- not Josephson coupled
- good Josephson junctions
- large ξ
- decently small unit cells
- ductile, shapeable
- cheap
- not too much Pu

Compatible with fundamental requirements for RTS?

T=300 K:

- thermal noise in active devices and detectors!
- cables operating in Tesla-fields: pinning will be problematic!

Wish-list from Applications-Troll

- a viable RTS

- a well behaving, isotropic superconductor with Tc > 95 K
  for large scale applications: nitrogen cooling is not so bad

RTS world

★ : RTS electronic device

S. Hasuo

- Ubiquitous Superconductive Electronics !!!

ISTEC

Without cooling, research, development & applications would become a completely new game

Possibly broad areas of applications

- key advantage: R=0
- sensors, active devices: advantages as compared to conventional solutions shrinks

Apparently No Show-Stoppers

We have no real understanding of the limits of existence of superconductivity (Mac Beasley)

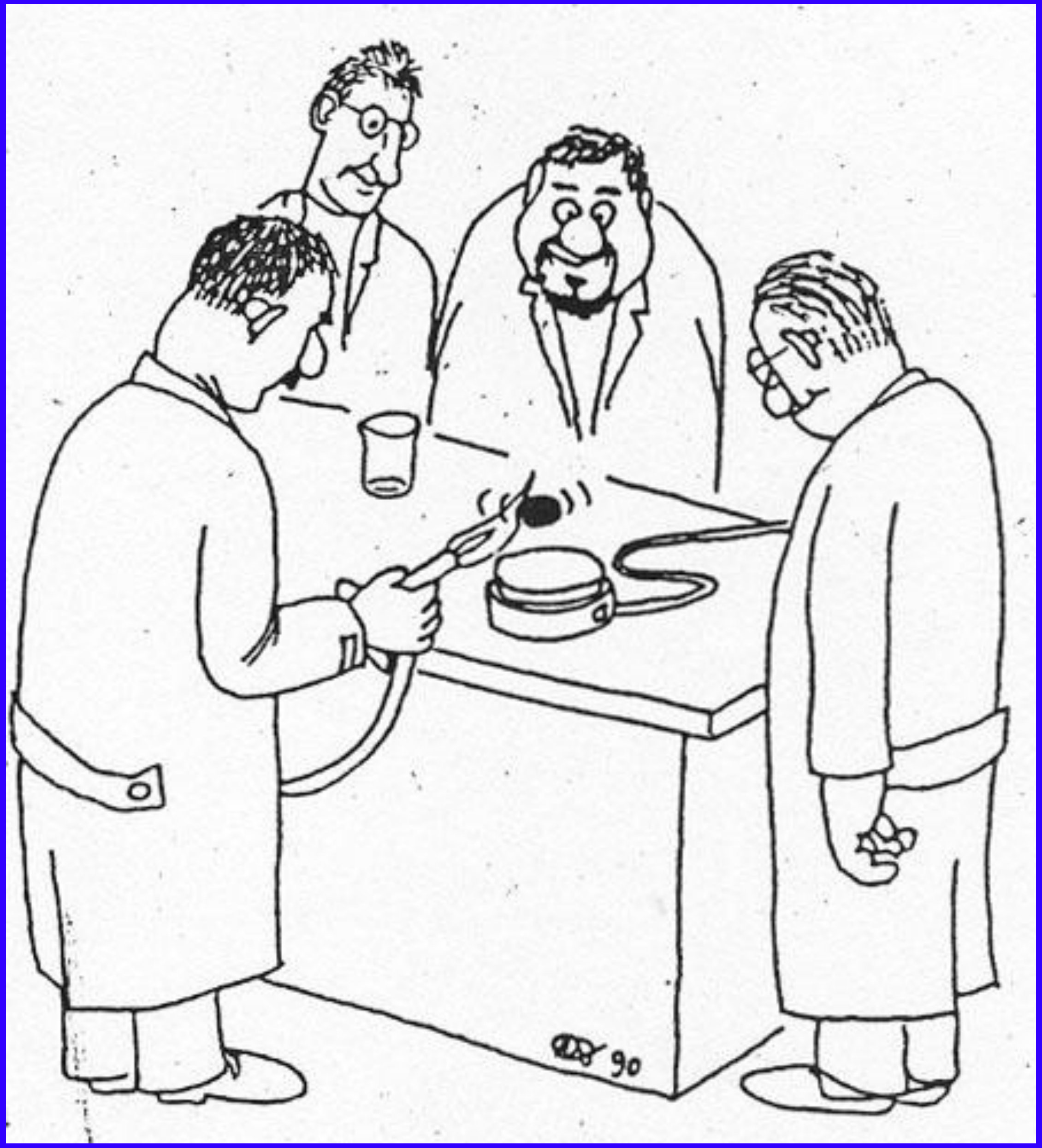
There is no evidence, experimental or theoretical, telling us that RTS is impossible (Paul Chu)

This was a great, inspiring meeting!

G. Larkin

"I am cautious, although optimistic about RTS"

Paul Chu



Th. Kettenring

See you soon at the next workshop!