Cryogenics

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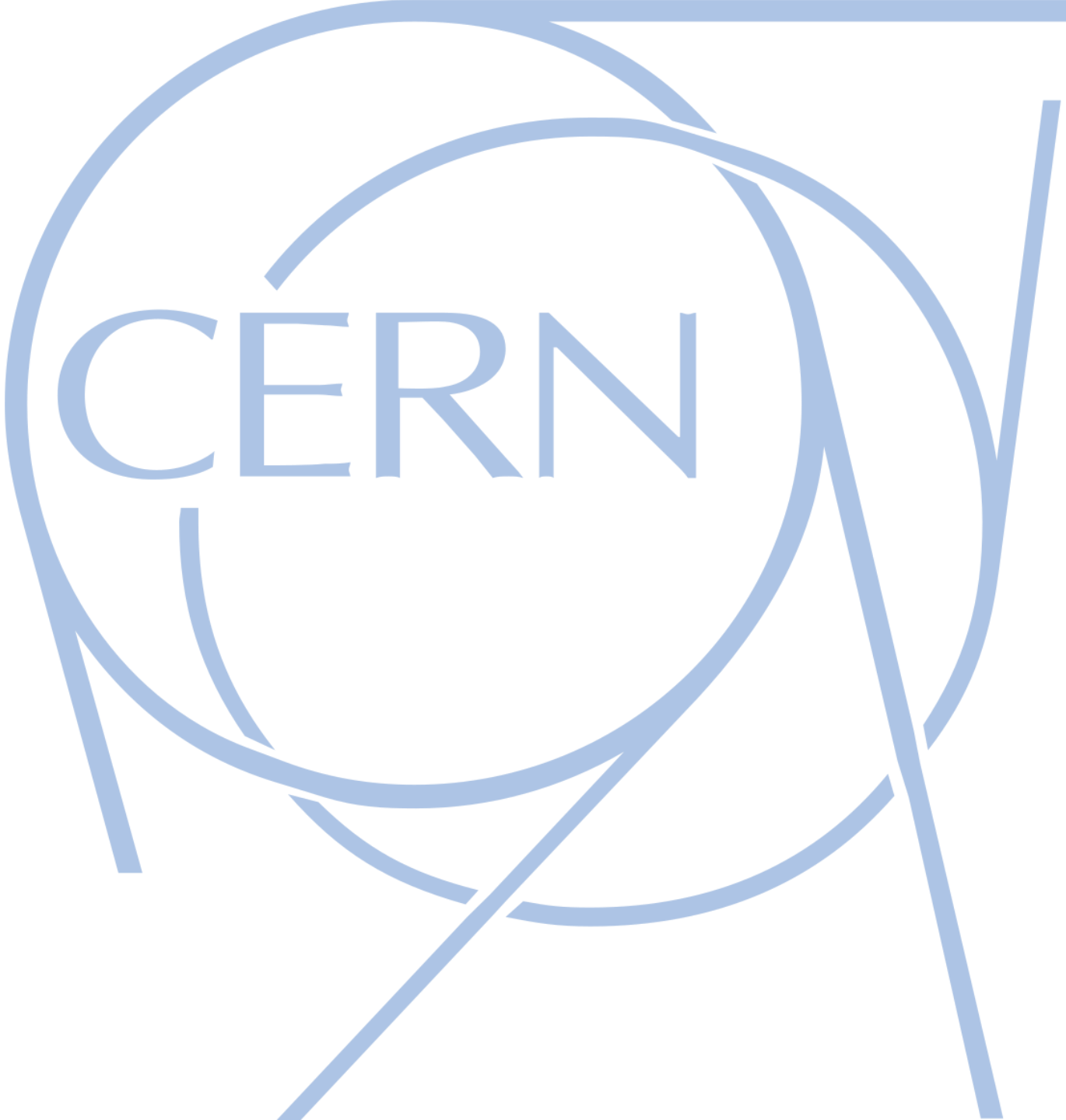
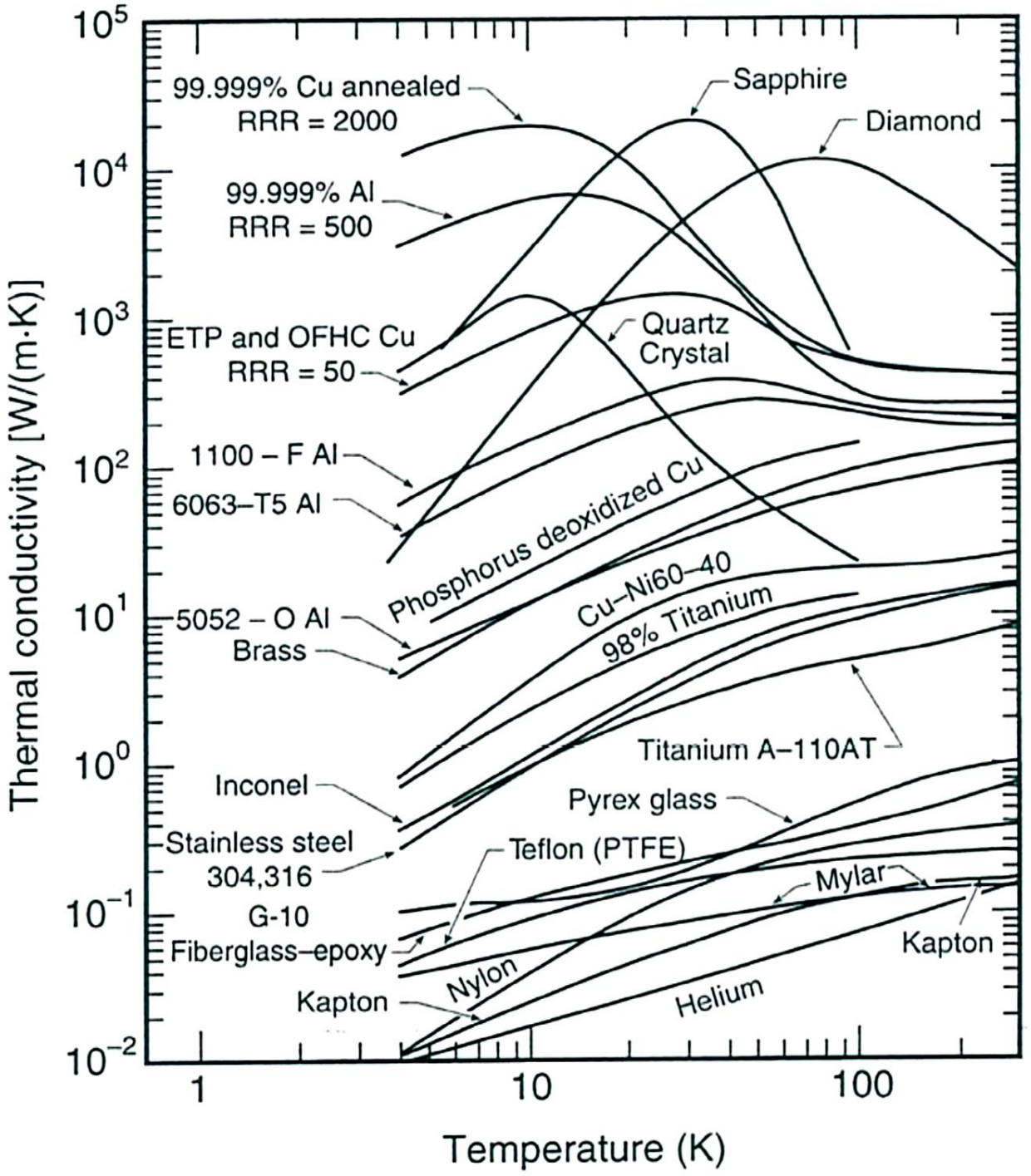
- Cooling
- Superfluidity
- Heat transfer
- Utilities



Cryogenics


Thermal conductivity [W/(m·K)]
Temperature (K)
99.999% Cu annealed
RRR = 2000
99.999% Al
RRR = 500
ETP and OFHC Cu
RRR = 50
1100 – F Al
6063–T5 Al
5052 – O Al
Brass
Inconel
Stainless steel
304,316
G-10
Fiberglass–epoxy
Kapton
Sapphire
Diamond
Quartz
Crystal
Phosphorus deoxidized Cu
Cu–Ni60–40
98% Titanium
Titanium A–110AT
Pyrex glass
Teflon (PTFE)
Mylar
Kapton
Nylon
Helium

Important dates for cryogenics:

Air liquefaction:
L. Cailletet and
R. Pictet (1877)

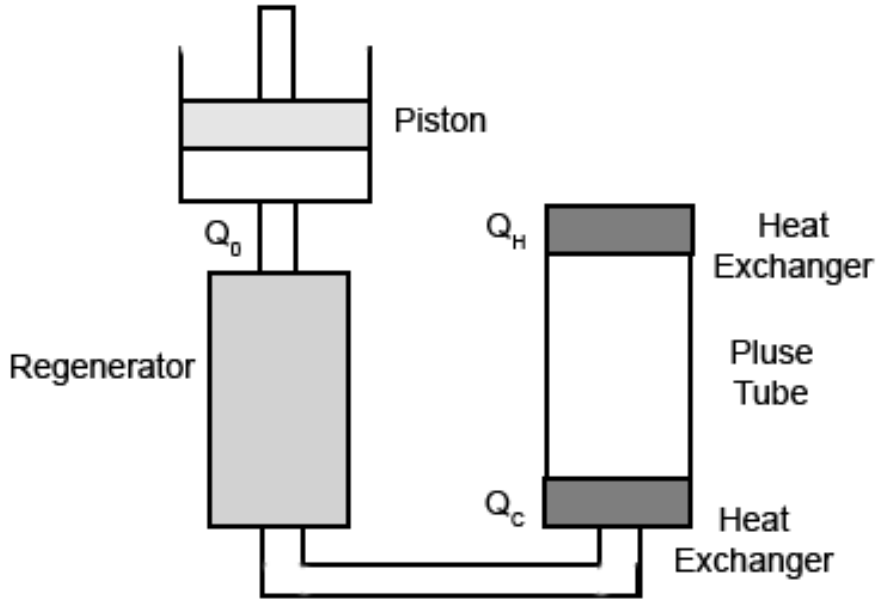
Oxygen and Nitrogen liquefaction:
K. Olszewski and
S. Wróblewski (1883)

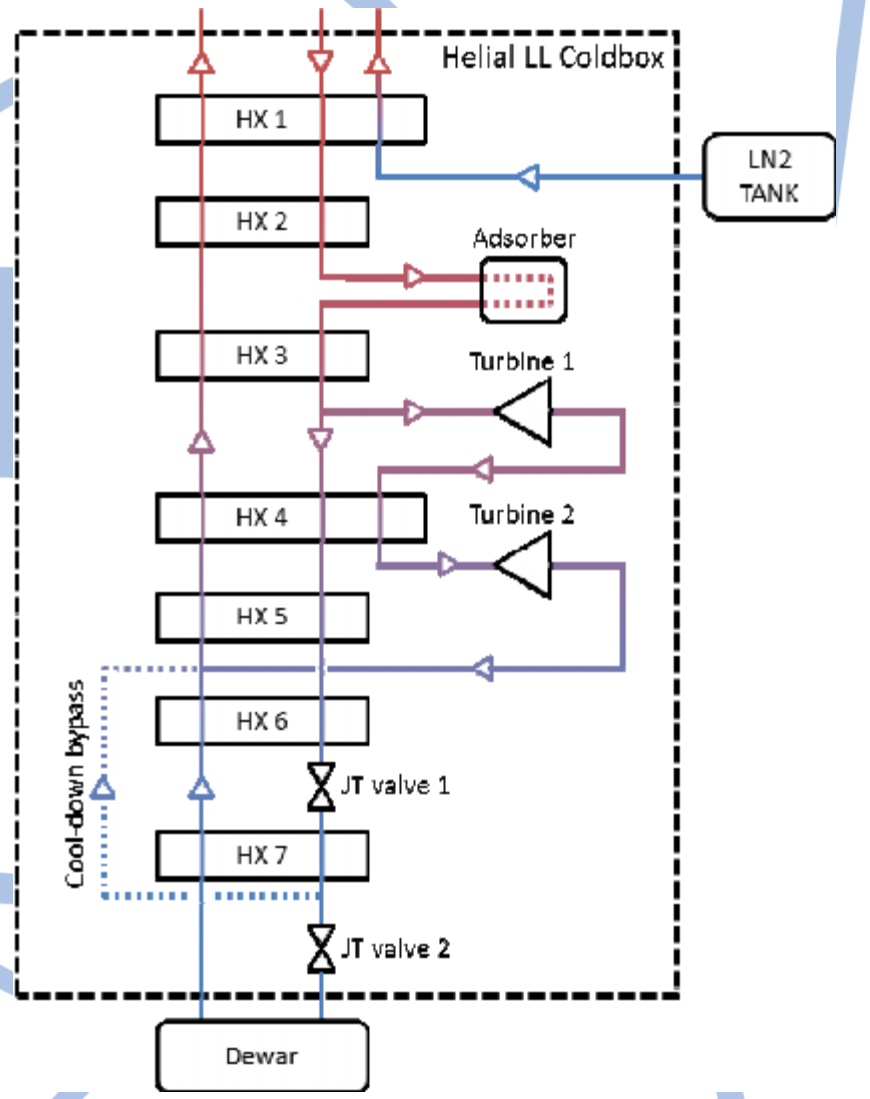
Liquefaction of Hydrogen:
J. Dewar (1898)

Liquefaction of Helium & superconductivity:
H. Kamerlingh Onnes (1909 & 1911)

Cooling

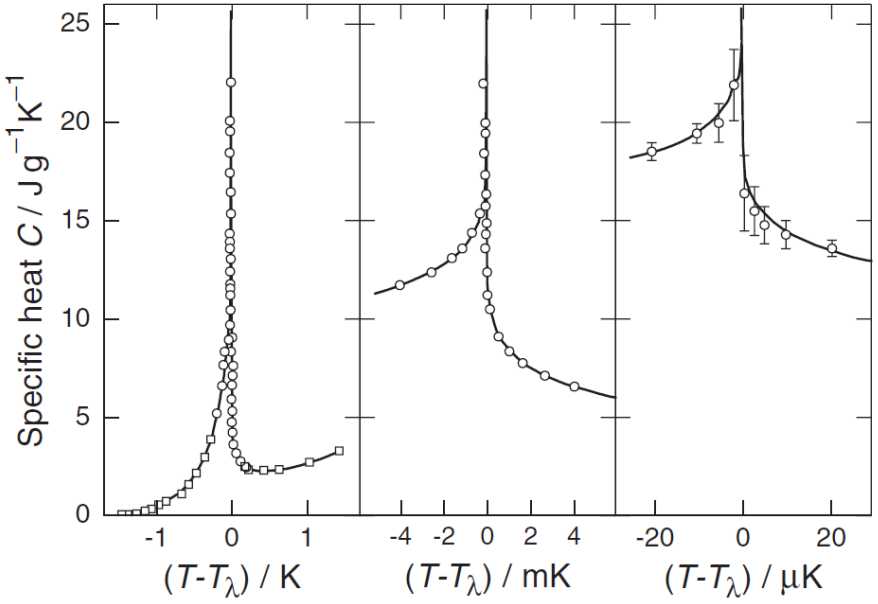
- Fluid production
- Compressor and turbine
- Heat exchange
- Cryocooling

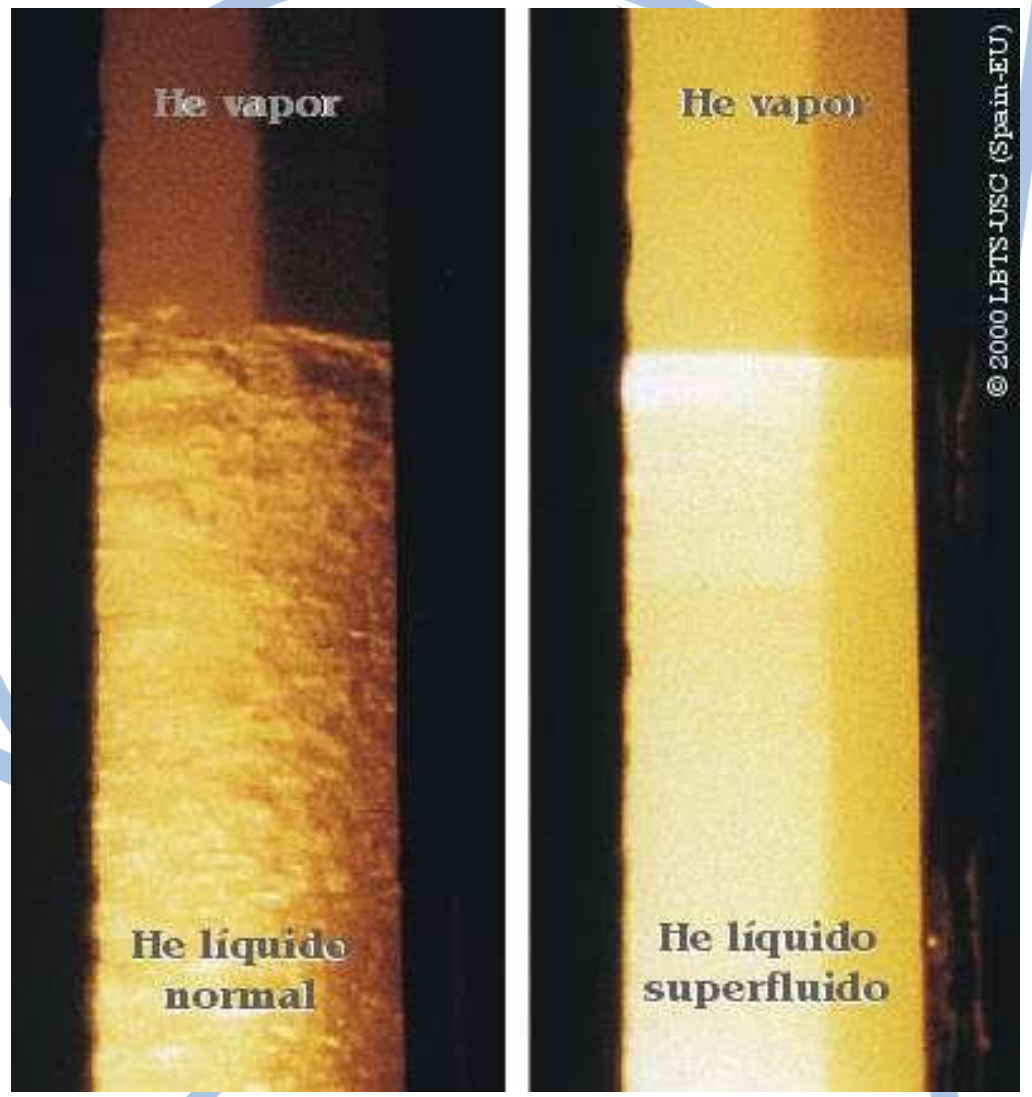




Cooling helium

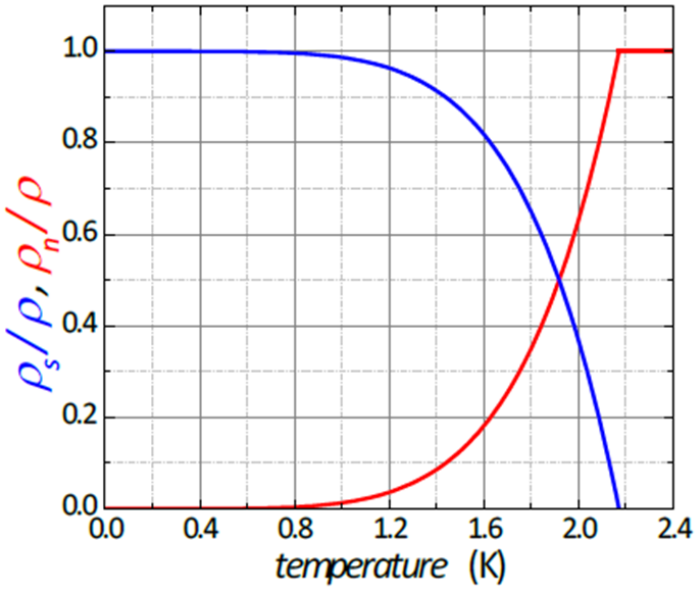
- Vacuum pump
- Boiling
- Lambda point at 50 mbar
- Change in thermal conductivity



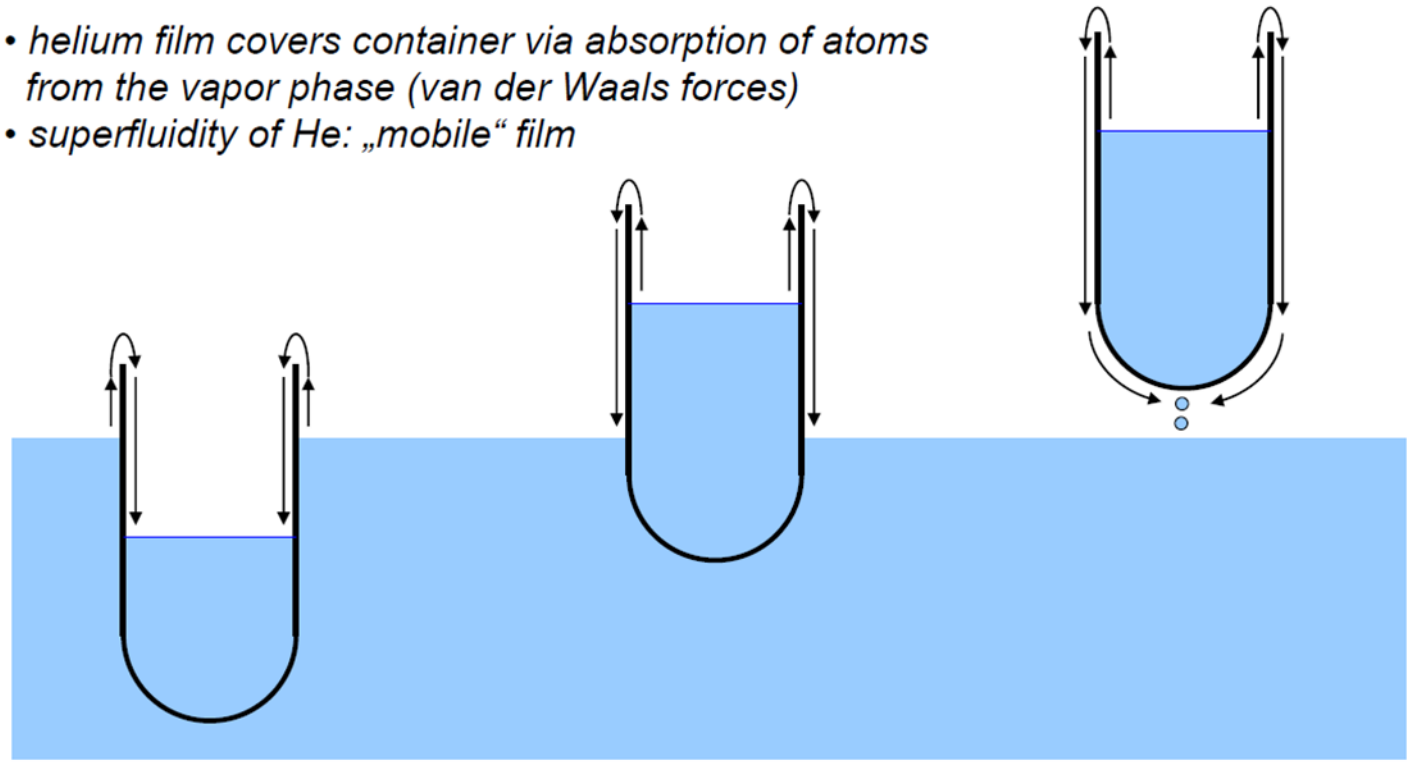


Superfluidity

- Tλ(helium) = 2,17 K
- No viscosity
- Very good heat transfer
- Super fluid film flow



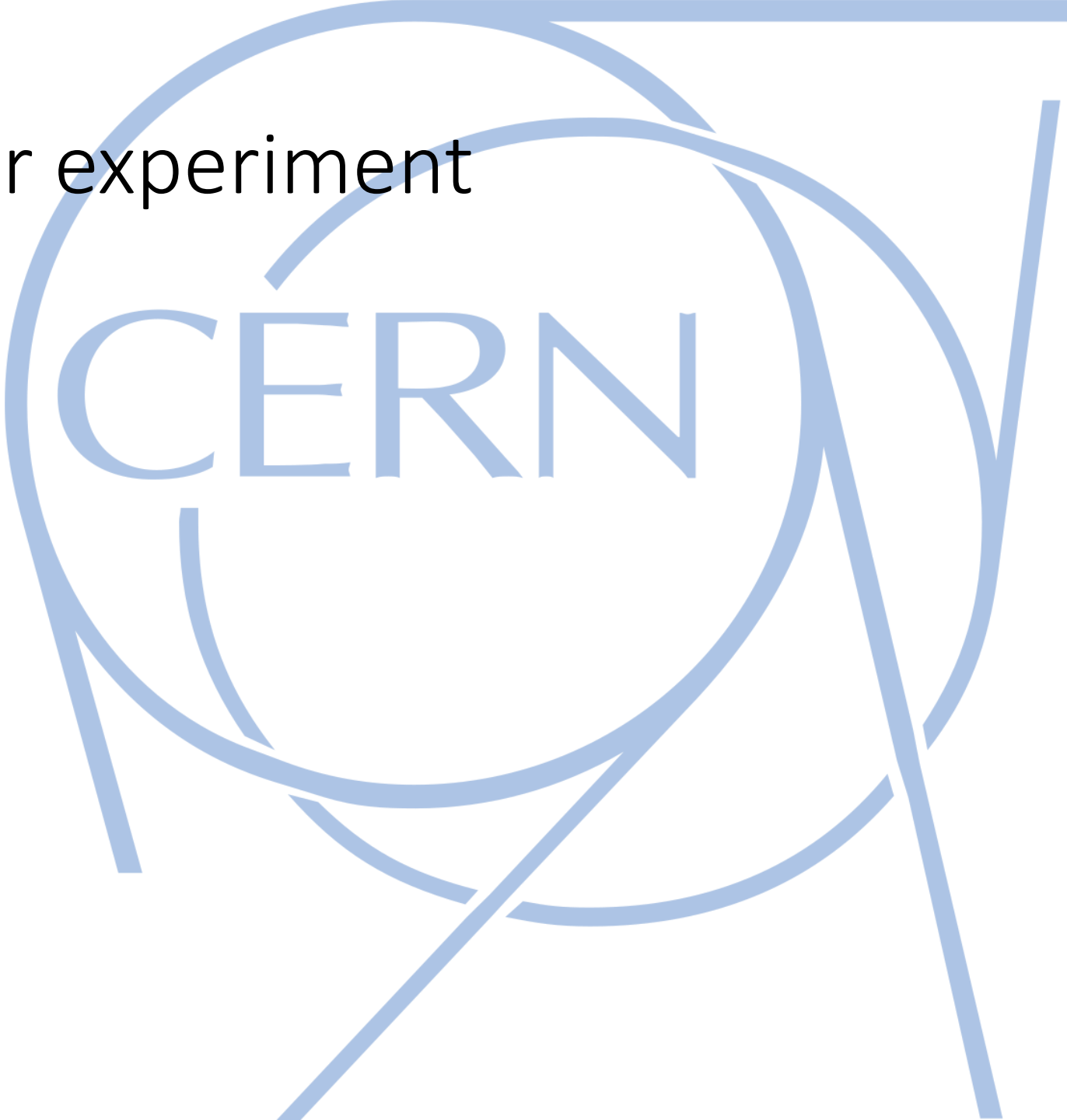
- *helium film covers container via absorption of atoms from the vapor phase (van der Waals forces)*
- *superfluidity of He: „mobile“ film*



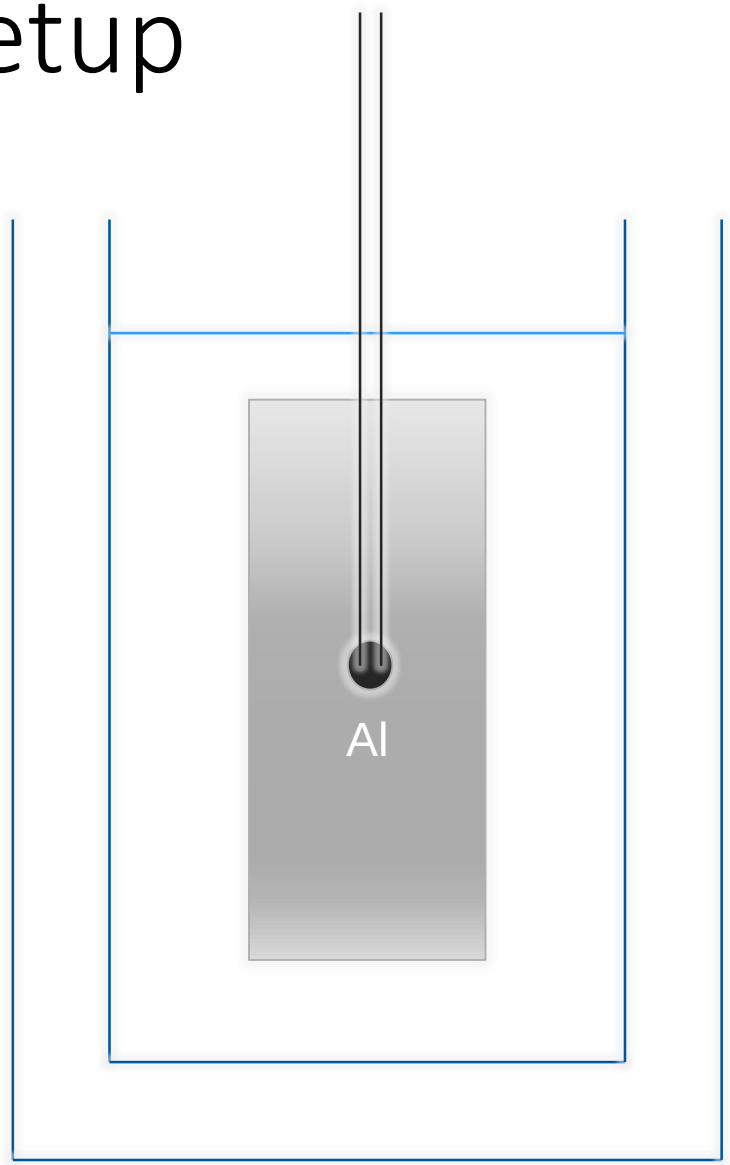
container fills up ***container is draining out*** ***container drips empty***

overshoot during fill up and draining out ➔ oscillation of filling height

Heat transfer & Our experiment



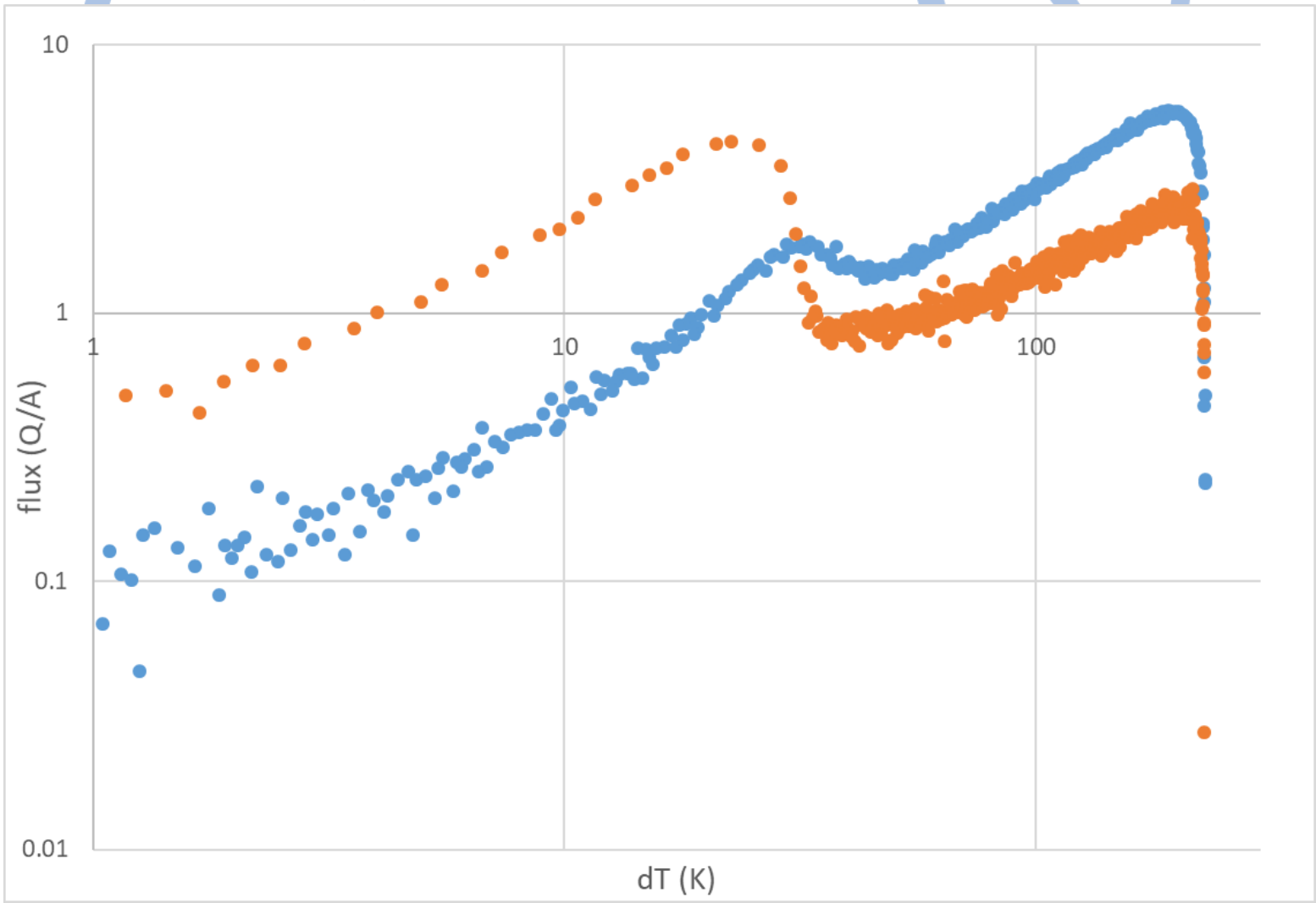
Setup



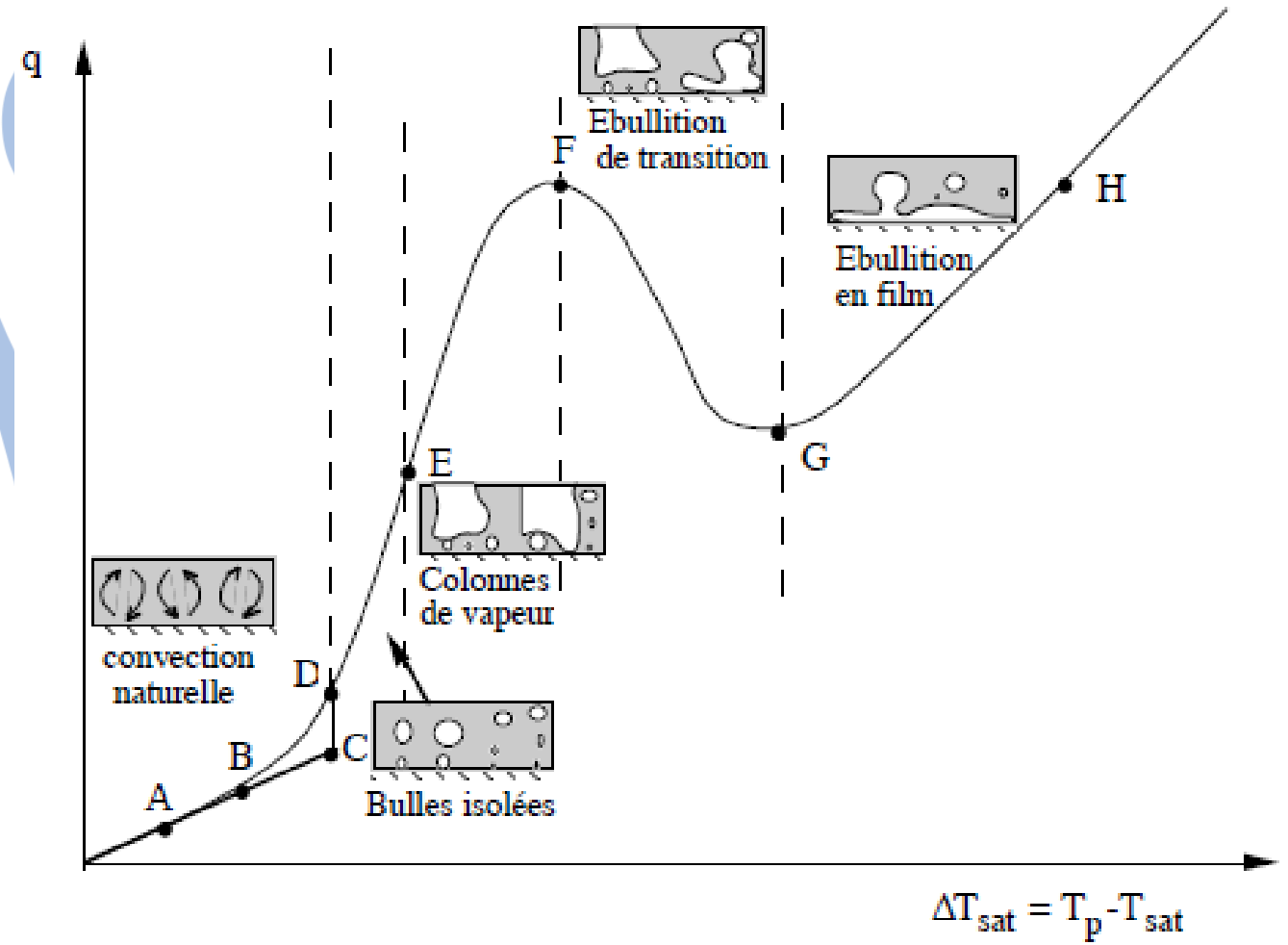
Results

Blue: insulated

Orange: non-insulated

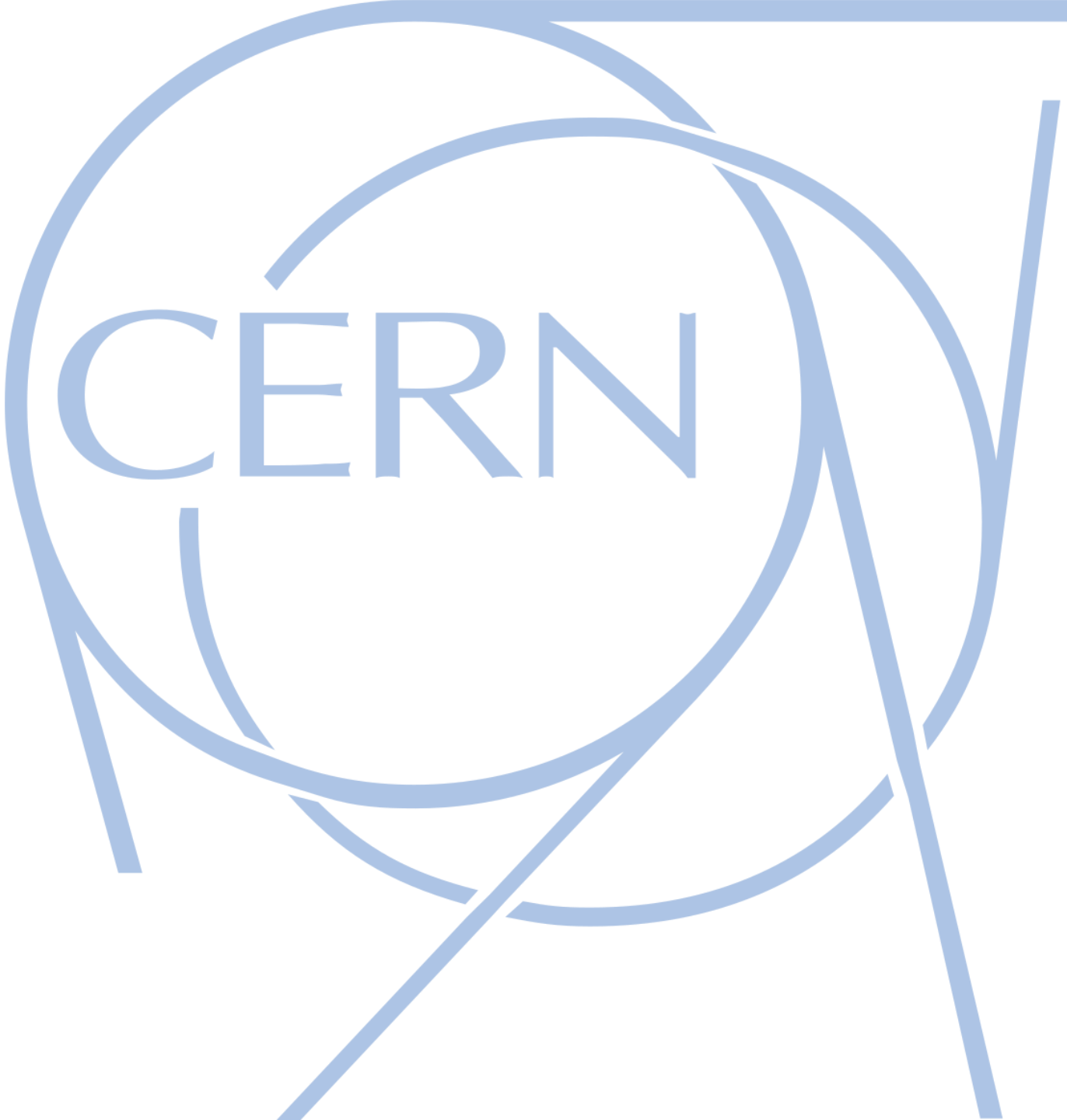


Explaination

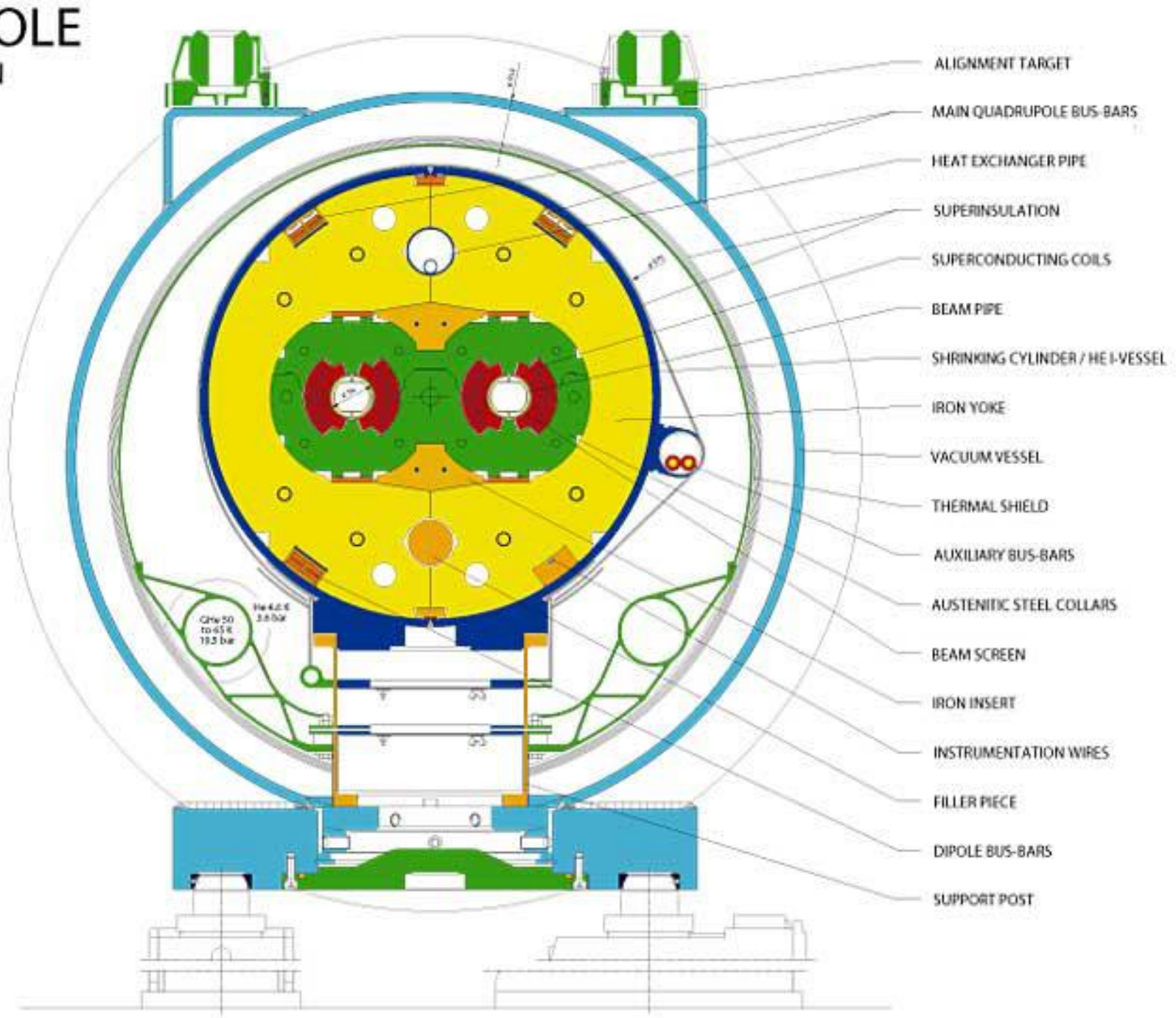


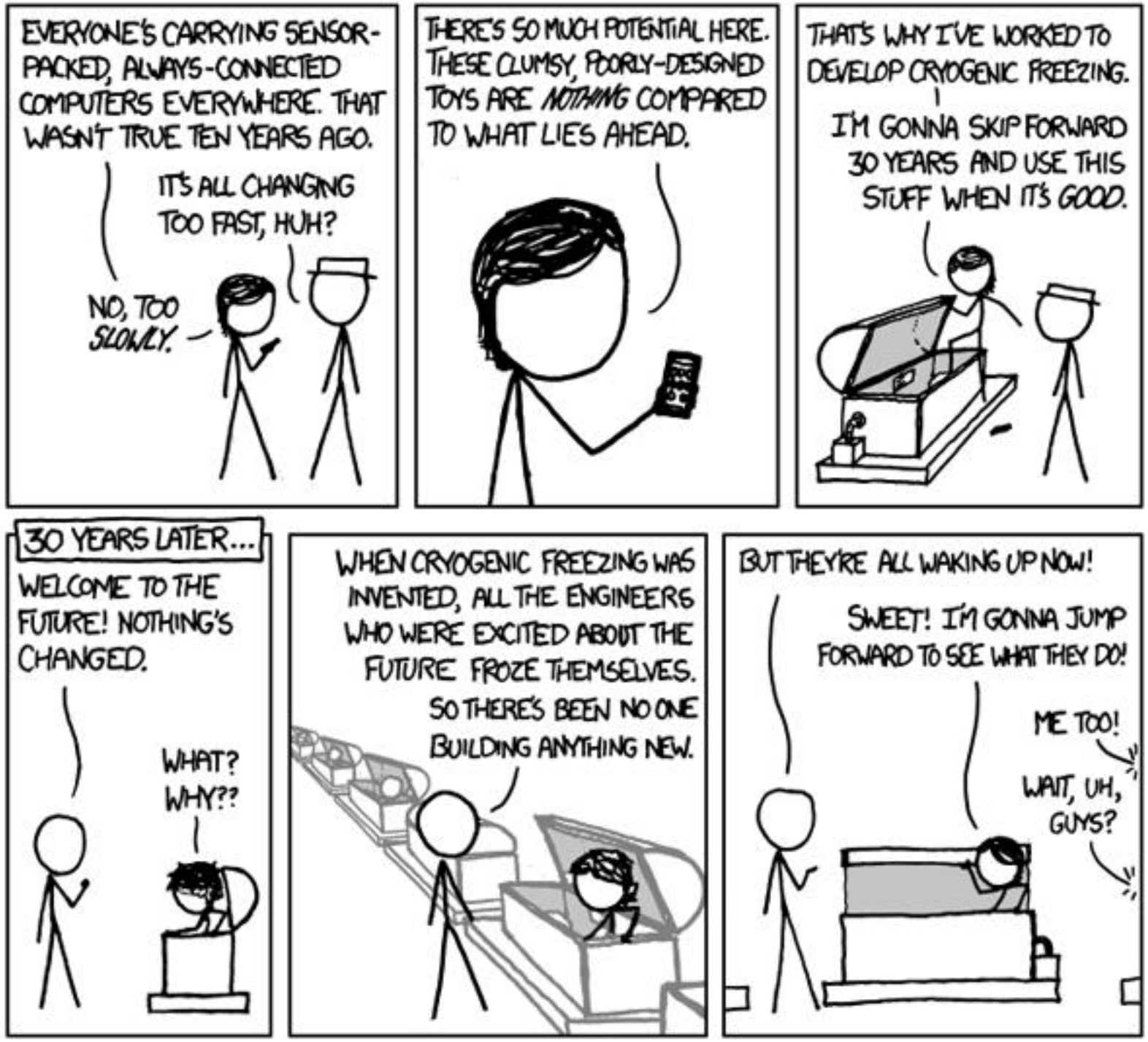
Utilities

- Superconduction
  - MRI-scanners
  - Aerospace engineering
  - LHC



LHC


LHC DIPOLE
CROSS SECTION
ALIGNMENT TARGET
MAIN QUADRUPOLE BUS-BARS
HEAT EXCHANGER PIPE
SUPERINSULATION
SUPERCONDUCTING COILS
BEAM PIPE
SHRINKING CYLINDER / HE I-VESSEL
IRON YOKE
VACUUM VESSEL
THERMAL SHIELD
AUXILIARY BUS-BARS
AUSTENITIC STEEL COLLARS
BEAM SCREEN
IRON INSERT
INSTRUMENTATION WIRES
FILLER PIECE
DIPOLE BUS-BARS
SUPPORT POST
CERN AC/DI/MM — 2001/06


EVERYONE'S CARRYING SENSOR-PACKED, ALWAYS-CONNECTED COMPUTERS EVERYWHERE. THAT WASN'T TRUE TEN YEARS AGO.
IT'S ALL CHANGING TOO FAST, HUH?
NO, TOO SLOWLY.
THERE'S SO MUCH POTENTIAL HERE. THESE CLUMSY, POORLY-DESIGNED TOYS ARE NOTHING COMPARED TO WHAT LIES AHEAD.
THAT'S WHY I'VE WORKED TO DEVELOP CRYOGENIC FREEZING.
I'M GONNA SKIP FORWARD 30 YEARS AND USE THIS STUFF WHEN IT'S GOOD.
30 YEARS LATER...
WELCOME TO THE FUTURE! NOTHING'S CHANGED.
WHAT? WHY??
WHEN CRYOGENIC FREEZING WAS INVENTED, ALL THE ENGINEERS WHO WERE EXCITED ABOUT THE FUTURE FROZE THEMSELVES. SO THERE'S BEEN NO ONE BUILDING ANYTHING NEW.
BUT THEY'RE ALL WAKING UP NOW!
SWEET! I'M GONNA JUMP FORWARD TO SEE WHAT THEY DO!
ME TOO!
WAIT, UH, GUYS?