ILC Cryogenic System Shallow versus Deep Tunnel

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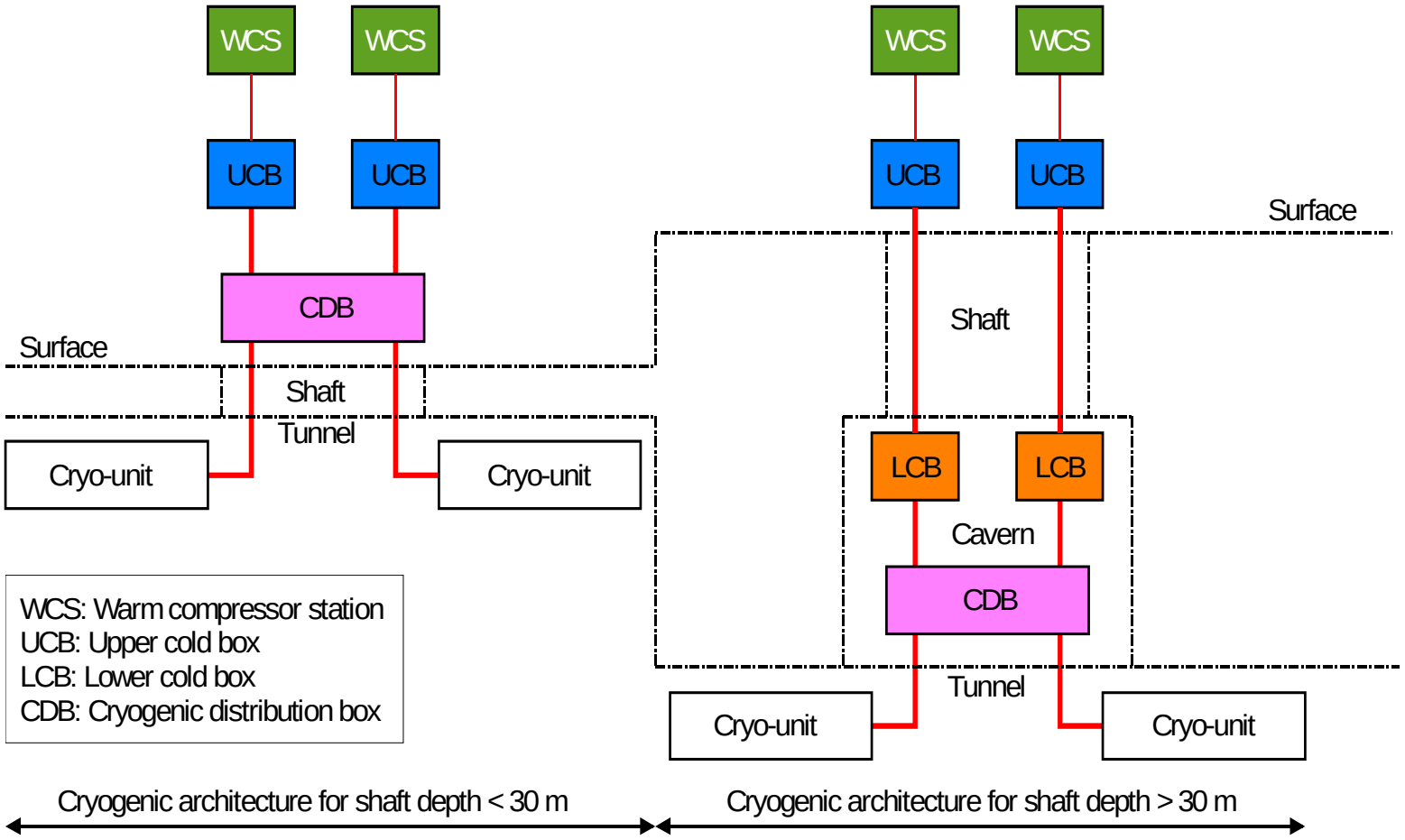
Illustration of shallow versus deep layout

(Slide from Laurent Tavian, CERN)



Lower coldbox installation at CERN

About 7 meters long and
7 meters tall, 2 m dia

Contents of lower cold box for deep site

- Heat exchangers
- Valves
- Cold compressors
- Turbo-expanders
- Assuming as much hardware on the surface as possible, minimal in the caverns, still means effectively the sub-20 Kelvin part of the cryogenic plant below ground

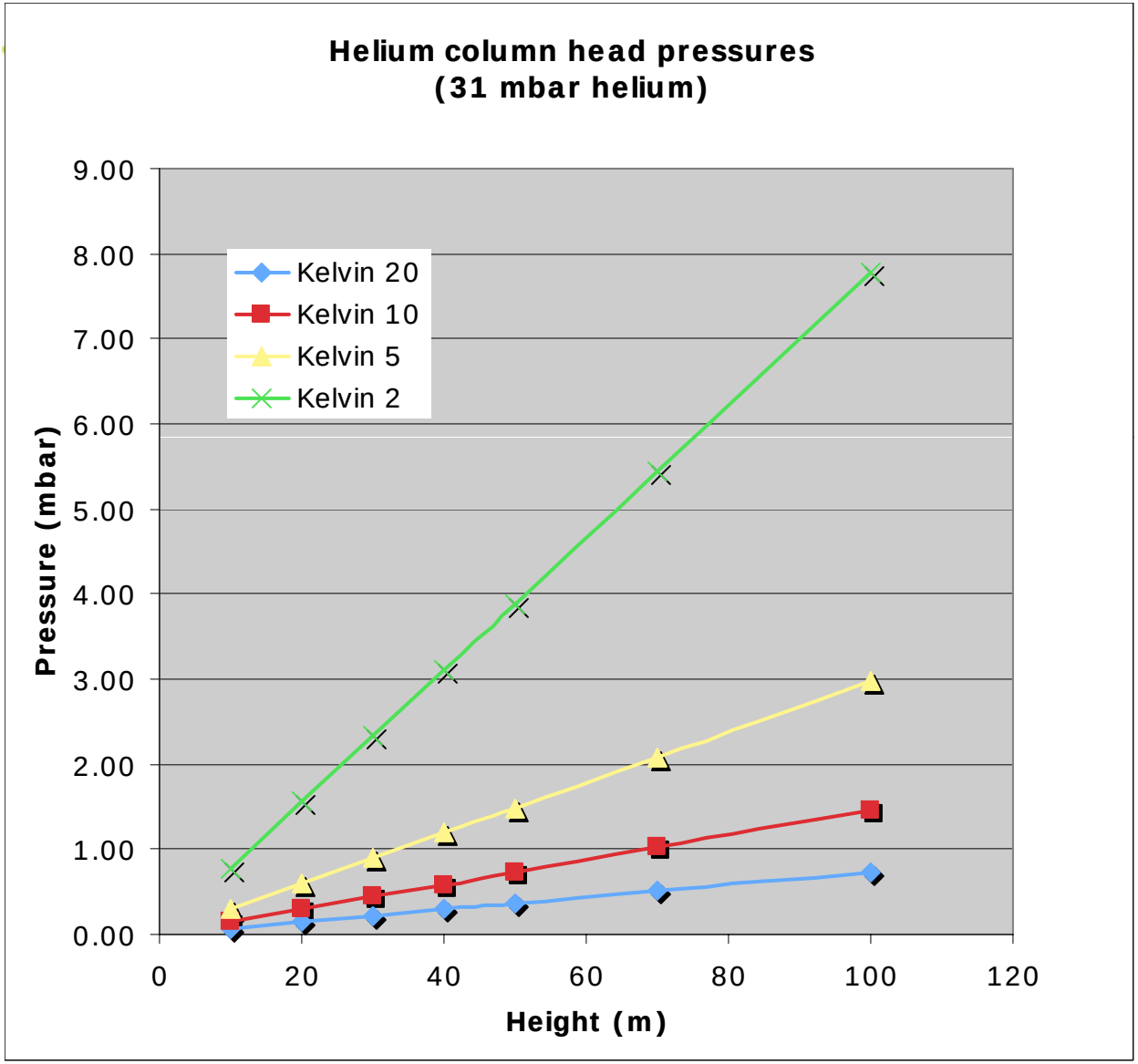
Vertical transfer line for the deep site

- About 300 - 600 mm OD vacuum jacket
- Inner lines include
  - **~20 K to and from lower cold box**
  - **40 K supply and 80 K return thermal shield lines**
  - **Auxiliary piping for cool-down and off-design operation**

Piping into ATLAS cavern

Why 20 K break and why 30 m?

- A 30 meter column of helium vapor at 2 Kelvin results in a pressure of about 2.3 mbar
  - **This is about 10% of the cold compressor inlet pressure**
  - **So effectively have reduced cold compressor efficiency due to compression of column**
  - **For cold compressor elevated -- increases tunnel “2 K” temperature by about 1 mK per meter**
  - **Selected 30 m limit above which split the cold box**
- 20 K provides low density for small pressure head up to 100 meters or more


Helium column head pressures
(31 mbar helium)
Pressure (mbar)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
20
40
60
80
100
120
Height (m)
Kelvin 20
Kelvin 10
Kelvin 5
Kelvin 2

Comments

- Shallow site (<30 meters deep) allows most cryogenic plant hardware to remain on the surface
  - **Just distribution in the tunnel**
- Reduces cavern occupancy
- Not a big cost difference in terms just of cryogenic hardware
- Additional installation costs for cold box in deep tunnel

Additional comment

- Access to the surface may be a more important factor than tunnel depth, but confounded with tunnel depth in our experience
- A shallow tunnel with no access to the surface except for the same very widely spaced locations as a deep tunnel “looks” much like a deep tunnel in terms of cryogenic system constraints except for the “lower cold box” requirement at refrigerators for the deep tunnel