HELIUM PROPAGATION AFTER A SUDDEN RELEASE

Results of tests of the propagation mechanism after a sudden release from the cryogenic system of HERA's proton ring

**(P. Albers, M. Ewers, Y. Holler, G. Horlitz, U. Laatzen, K. Sinram,
W. Stahlschmidt – Deutsches Elektronen-Synchrotron DESY, Hamburg)**

Klaus Sinram

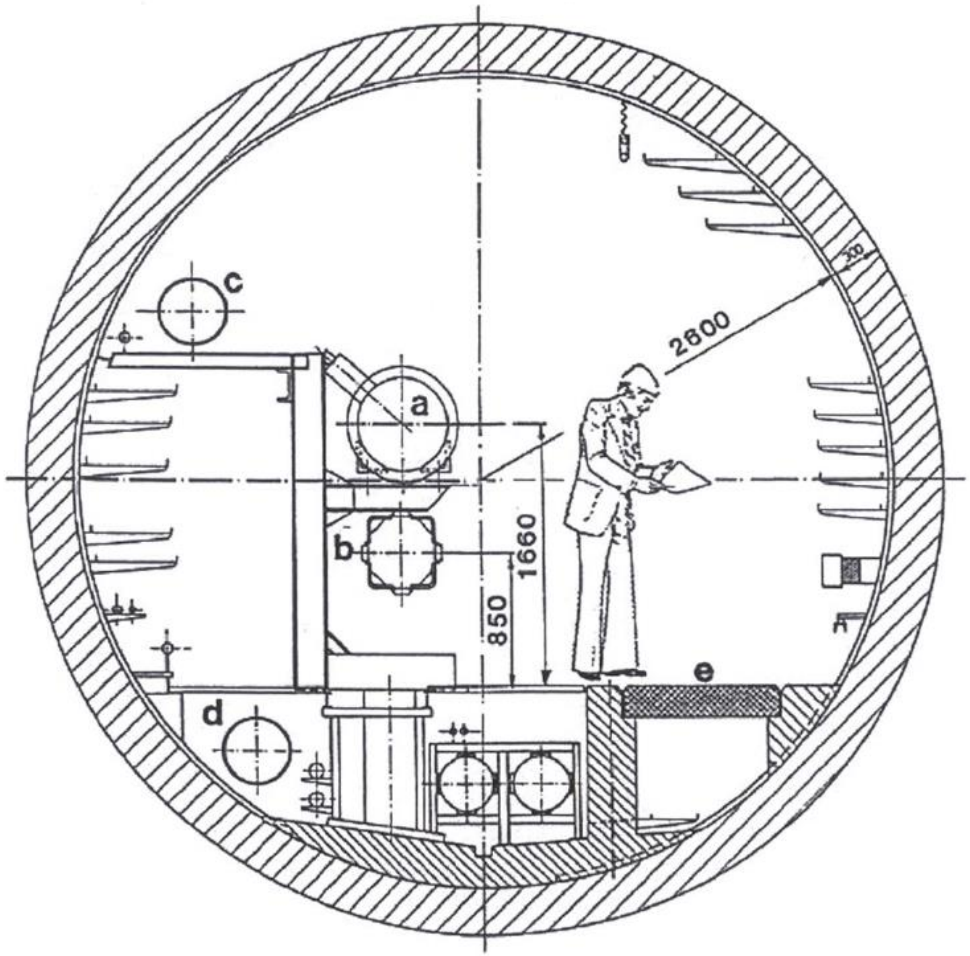
Mini-Workshop on ILC Infrastructure and CFS for Physics and Detectors, KEK, May 16, 2017

Europe-Japan Accelerator Development Exchange

HERA AT DESY

Areal view of the DESY site. Indicated are the positions of the 2 storage rings HERA (length 6336 m) and PETRA (length 2604 m).

THE HERA TUNNEL



Radius 2.8 m

Standard cross section of the HERA-tunnel (arc-section) containing beamguidance-magnets of the proton-accelerator (a) and electron-accelerator (b), Helium-transfer-line(c), quench-line (d) and driveway (e).

THE HERA TUNNEL

Introduction

- Extensive installations for liquid Helium inside the HERA -tunnel for the operation of SC HERA proton accelerator magnets

- In case of damage: substantial flow-out (~ 120 kg liquid He) into the tunnel within 10 s
-
  ➔ oxygen deficiency, extreme cold
  ➔ danger for persons in the tunnel

- Requires constant monitoring of oxygen levels and potentially the carrying of a respirator?
-
  ➔ Necessity depends on propagation conditions of Helium inside the tunnel.

- Two tests to determine propagation properties carried out.

First test – setup

- Aim: Get rough idea of propagation speed in the tunnel.
- Setup: Arbitrary selection of measuring sections 20m against and 100m towards tunnel ventilation.
- 10 measuring positions were specified at z = -20 m, -10 m, -5 m, -2 m, 2 m, 5 m, 10 m, 20 m, 50 m, 100 m.
- Measurements in three heights (h = 0.8, 1.6, 3.5 m)
- Technical details:
  - 30 electrochem, sensors for oxygen-level measurements
  - 30 NiCr-Ni thermal-elements for temperature measurements
  - Data-logger with 64 channels for recording

First test – procedure

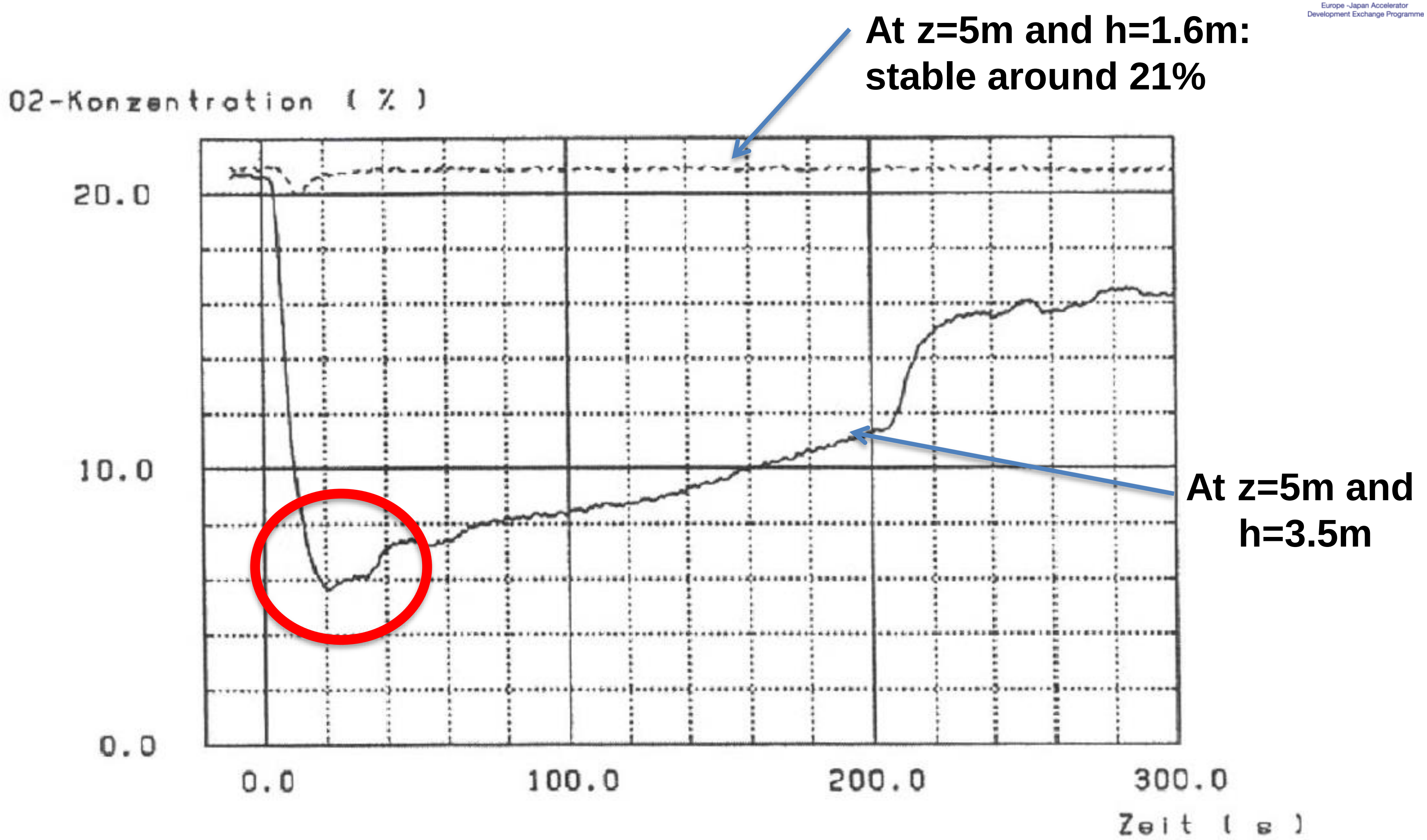
- The liquid Helium was brought in by a mobile Dewar-container with a capacity of 500 l at 6 bar.
  - Outflow controlled by electro-pneumatically controlled valve; outflow direction upwards up to 2.5 m, then free spreading out into the tunnel.
- Two camcorders (at 30 and 50 m) used to record speed and shape of propagation of Helium cloud.
  - Control of speed via distance marks
- The 500 l = 62.5 kg liquid He leaked out in 10s into a volume of ~370 m^3 after heating up to tunnel temperature
  - The air speed measured to be at 0.5 ± 0.1 m·s-1.
- Observations:
  - The Helium heats up quickly and immediately ascends towards the ceiling
  - The Helium does not mix with the tunnel air and expands far quicker than given by the tunnel ventilation
  - The Helium proceeds a lot further than 20 m against the airflow.
  - Substantial effects appeared only on the sensors at a height of 3.5 m.

First test – results

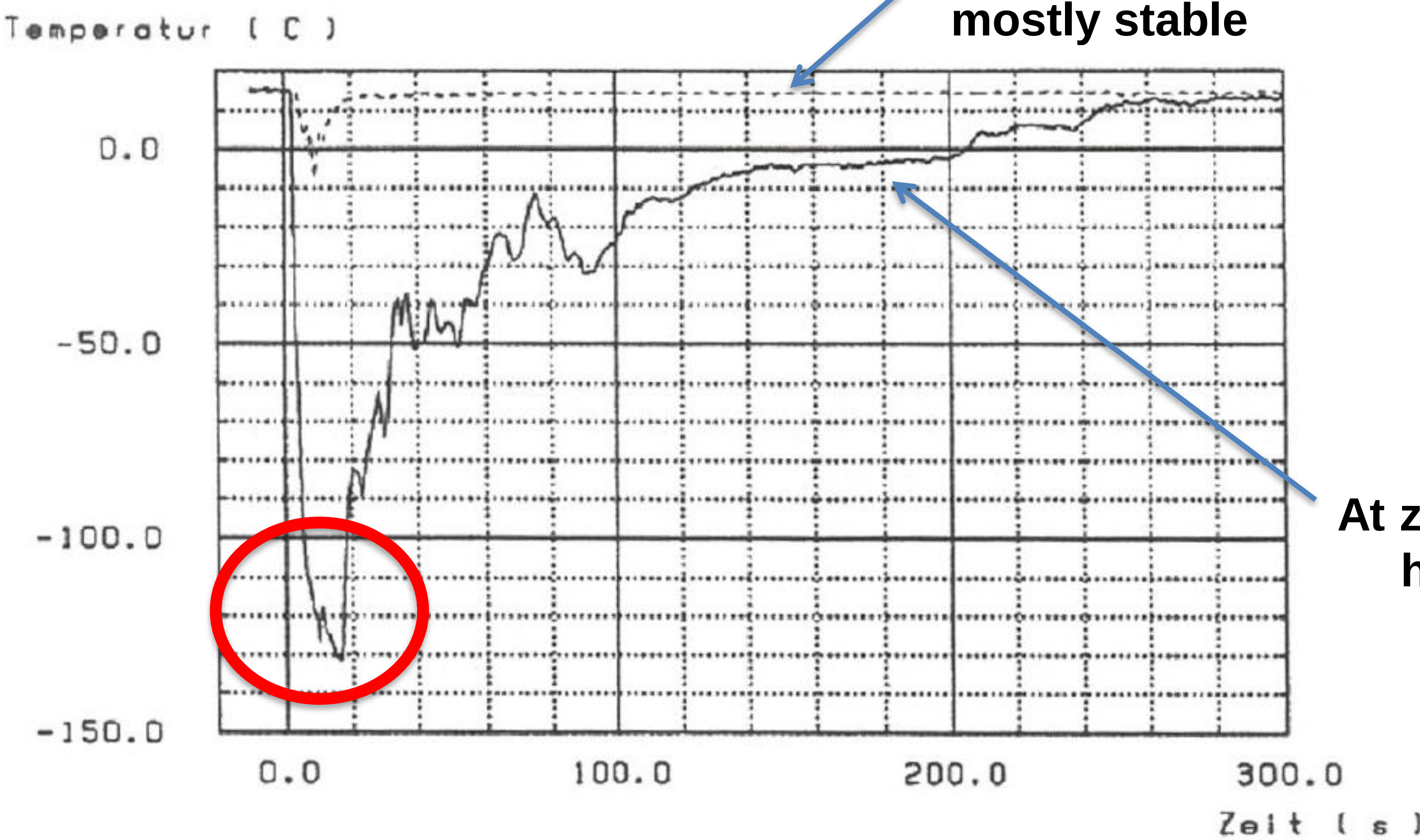
z	t	$v_{average}$	$V_{O2,min}$ (1.6 m)	T_{min} (1.6 m)	$V_{O2,min}$ (3.5 m)	T_{min} (3.5 m)
-20	13	1.5	(20.9)	(16)	6.3	-104
-10	6	1.7	(20.9)	(16)	5.6	-115
-5	3	1.7	(20.9)	14	4.9	-126
-2	1		20.6	0	4.7	-163
2	1		20.8	13	4.2	-156
5	2	2.5	20.0	-7	5.6	-131
10	4	2.5	20.8	6	6.4	-107
20	8	2.5	(20.9)	13	7.2	-97
50	23	2.2	(20.9)	15	8.8	-71
100	55	1.8	(20.9)	(16)	14.0	-6
[m]	[s]	[$m \cdot s^{-1}$]	[%]	[°C]	[%]	[°C]

Results of the first test for h = 1.6 m and 3.5 m

First test: O2 concetration vs time



First test: temperature vs time



At z=5m and h=1.6m: mostly stable

At z=5m and h=3.5m

Second test:

- Propagation speed established in first test
- Now extend measuring range from -100m to +200m with measuring stations at -100 m, -60 m, -30 m, -10 m, -5 m, -2 m, 2 m, 5 m, 10 m, 30 m, 100 m, 150 m, 200 m
- Simulate Helium out flow 1 m above roadway level facing downwards, according to the worst-case-scenario of the leakage of one of the lowest arranged superconducting magnets.
- Double amount of Helium to 1000 l with a second, identical Dewar-container
  - corresponds to the maximum possible amount of flow-out (one HERA octant).
  - Second container opened with delay of 10 s, and with longer flow-out time (~60 s)

Second Helium Test Video

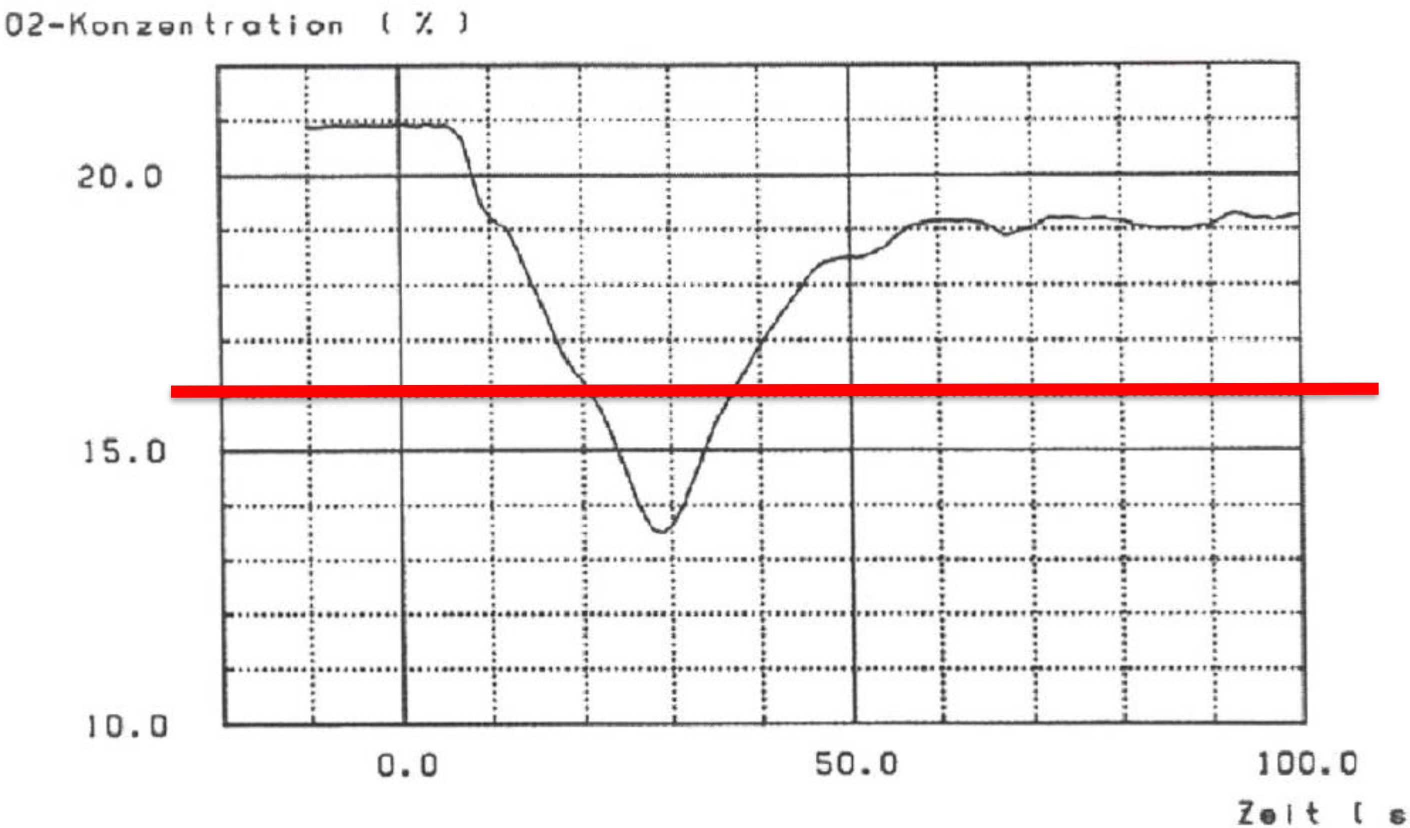
Second test: results

According to the changed test conditions, also in low heights near the outbreak, up to ±10 m the O2-levels and the temperature partially drop very strongly

z	h = 0.8 m		h = 1.6 m		h = 3.5 m	
	$V_{O2,min}$	T_{min}	$V_{O2,min}$	T_{min}	$V_{O2,min}$	T_{min}
-100			(20.9)	(18)	10.0	-27
-60			(20.9)	(18)	8.1	-38
-30			(20.9)	(18)	8.2	-51
-10			17.4	5	7.3	-53
-5	17.6	-37	12.6	-63	6.9	-63
-2	14.6	-99	13.3	-64	6.9	-66
2	9.0	-112	11.5	-111	7.1	-77
5	14.5	-25	12.9	-44	7.5	-72
10			13.5	-36	7.7	-60
30			19.5	8	8.7	-32
100			(20.9)	(18)	11.4	-22
150			(20.9)	(18)	12.6	-11
200			(20.9)	(18)	16.7	7
[m]	[%]	[°C]	[%]	[°C]	[%]	[°C]

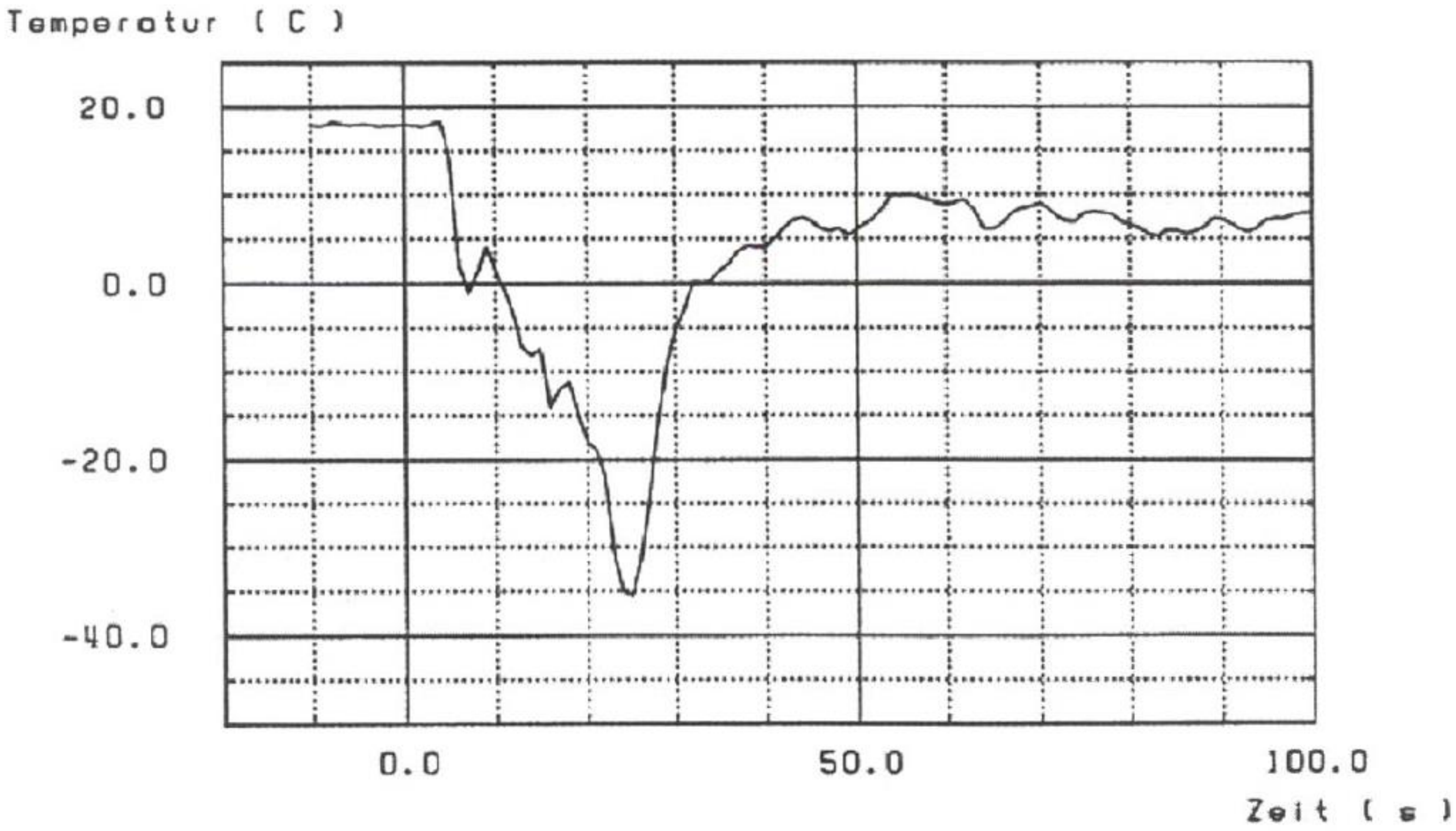
Also stronger mixing of Helium with air → reduced propagation speed of 1m/s.

Second test: O2 vs time



Temporal development of the O2-concentration at z = 10 m, h = 1.6 m

Second test: temperature vs time



Temporal development of the temperature at z = 10 m, h = 1.6 m

Conclusions

- Effects of dropping O2-levels and temperature restricted to a few 10 s.
- Endangerment of persons in the vicinity can be classified as not serious (except for direct contact at outflow),
  - appearance of dense fog cloud and heavy noise
  - ➔ compel people to immediately leave the hazardous area.
  - Those alarm flags can be seen as sufficient warning for persons working in the upper part of the tunnel cross section at a greater distance from the outbreak
- Second test also showed that a stationary system for monitoring the O2-content of the fresh air is not necessary inside the HERA-tunnel.
  - The usage of oxygen rebreathers is not reasonable because the time needed to put on that equipment is sufficient to leave the hazardous area.