

Water cooling XFEL

Design of the XFEL water cooling system

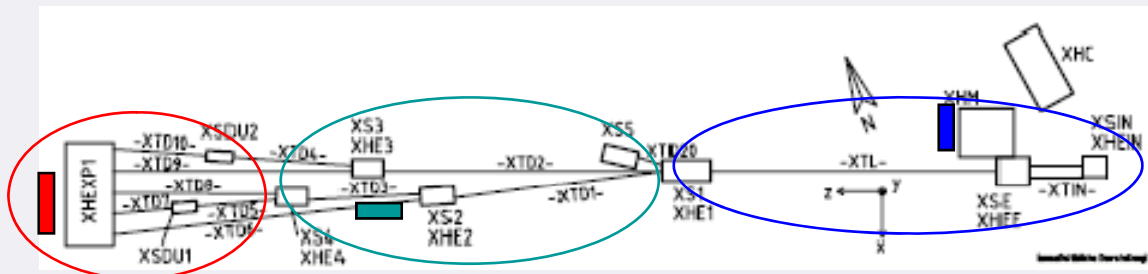
- ❖ Pipes
- ❖ Recooler
- ❖ Chiller
- ❖ Water treatment
- ❖ Pumps

Some special ideas

- ❖ Cooling schemata of a klystron
- ❖ Cooling schemata at one TESLA-hall
- ❖ Cooling schemata of a gun
- ❖ Variation of a gun schemata
- ❖ A possibility of cost cutting

Design of the water cooling system XFEL

Pump stations,	supplied sections	and	recooling power
➤ DESY	linac and injector tunnel		17 MW
➤ Distribution	undulator tunnel		2 MW
➤ Experiment	photon tunnel, dumps, hall..		8 MW



Main components of the cooling system

- ❖ Pipes
- ❖ re cooler
- ❖ chiller machines
- ❖ water treatment
- ❖ pumps

Pipes (and property of water) - XTL

Main cooling water (30°C <-> 50°C)

- low conductivity water ($S \leq 1 \mu S/cm$)
direct cooling from high-voltage-devices
- DN 300 PN 10 / 1.4541 (ASI 316 Ti)
return pipe insulated
- length over all 2 x 2100 m
- welded 6m or 12m pieces
- flanged axial compensators or
flexible metal tube
- every 50m outlet DN 65 (valve)

Cold water (18°C <-> 25°C)

- not controlled LC-water
 - DN 125 PN 10 / 1.4541
 - every 50m outlet DN 25
 - length over all 2 x 2100 m
 - not insulated
dew point in the ambient air is lower
- Other points similar to the main cooling

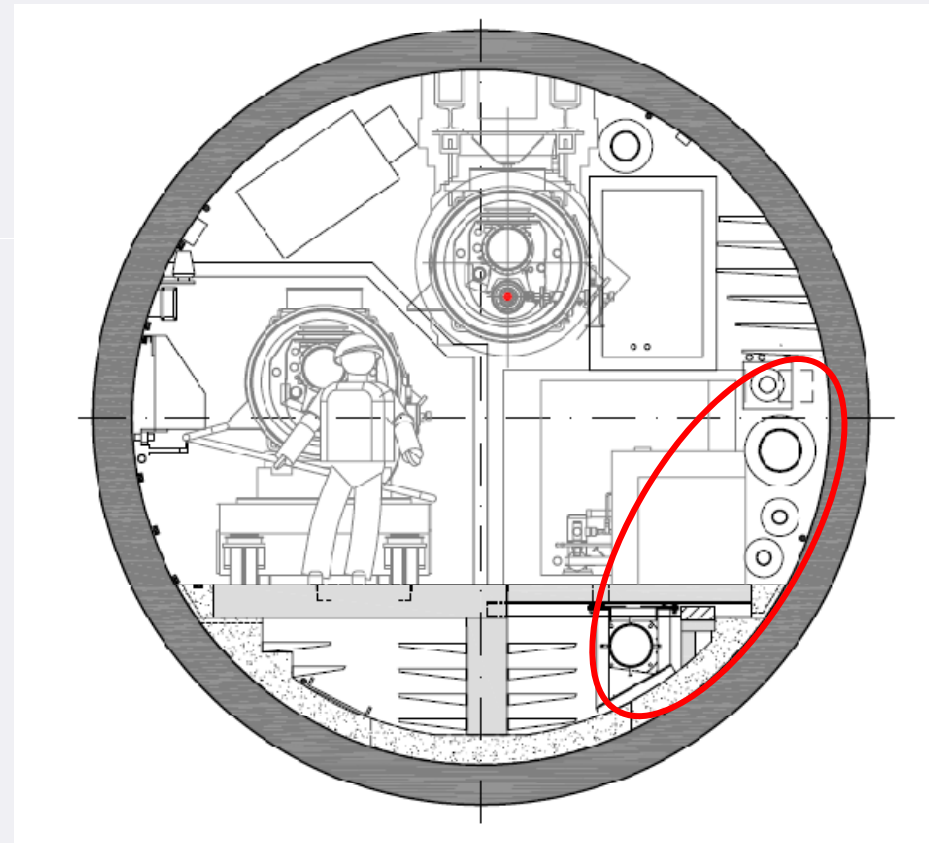
Pipes (and property of water) - XTL

Auxiliary Pipes

- water and gas
- DN 125 - DN 15
- 1.4541 or SF-Cu
pressed air, nitrogen, drainage water, pure water to the recoler

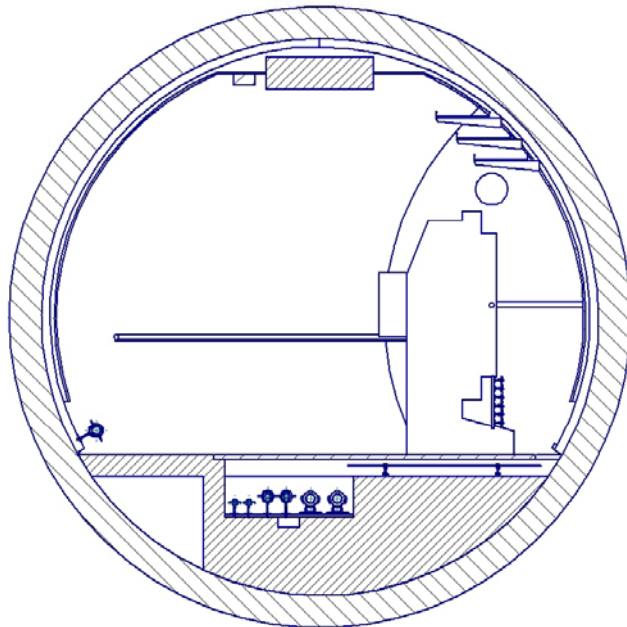
Chilled water (6°C ↔ 12°C)

- not controlled LC-water
- DN 250 - DN 25 PN 10
- 1.4541 or SF-CU
Supply pipes for air conditioning

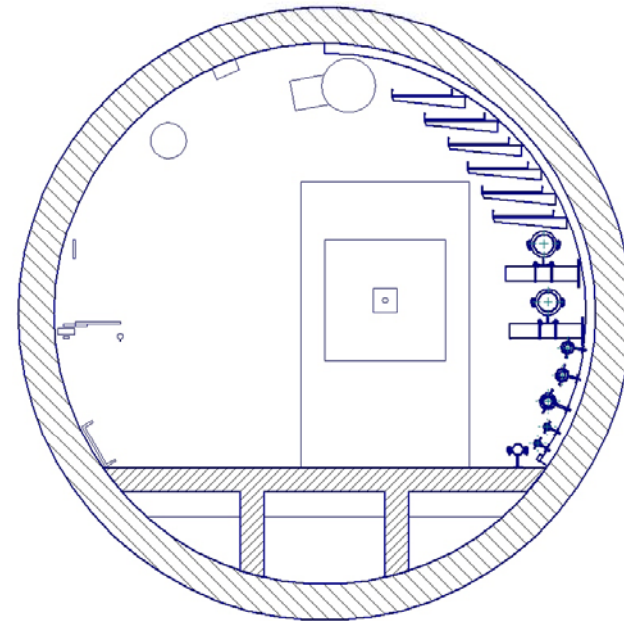


Tubes (Distribution Tunnels - XTD..)

Main cooling water / Cold water / Auxiliary pipes

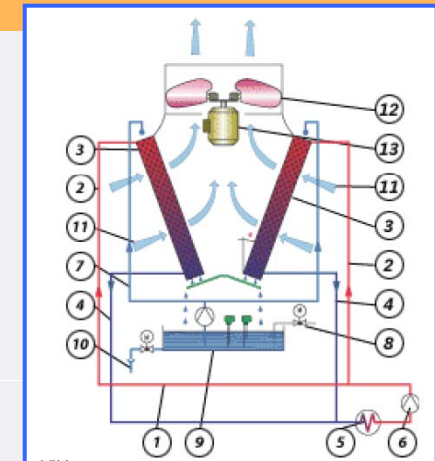
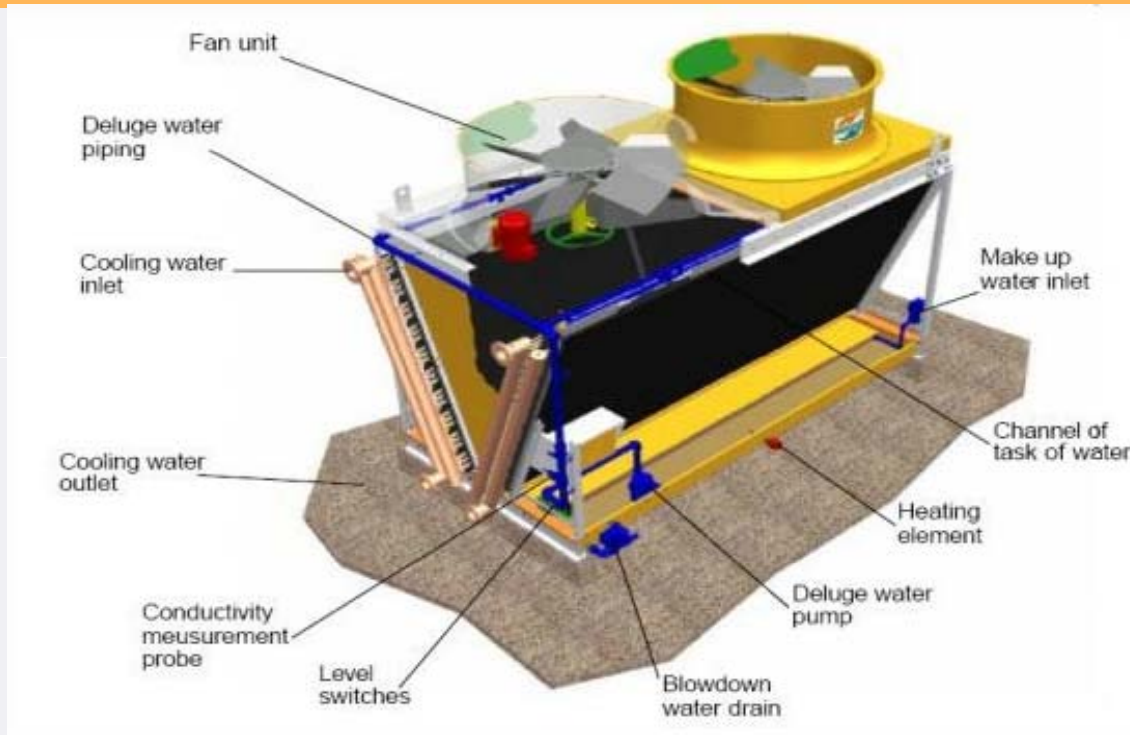


Undulator tunnel



Photon tunnel

Recooler : Hybrid Cooling Tower



1. Primary cooling circuit
2. Cooling water inlet
3. Cooling elements
4. Cooling water outlet
5. Heat source
6. Cooling circuit pump
7. Wetting water circuit
8. Make-up water
9. Wetting water tank
10. Waste water
11. Ambient air
12. Fan
13. Fan motor

Hybrid cooler

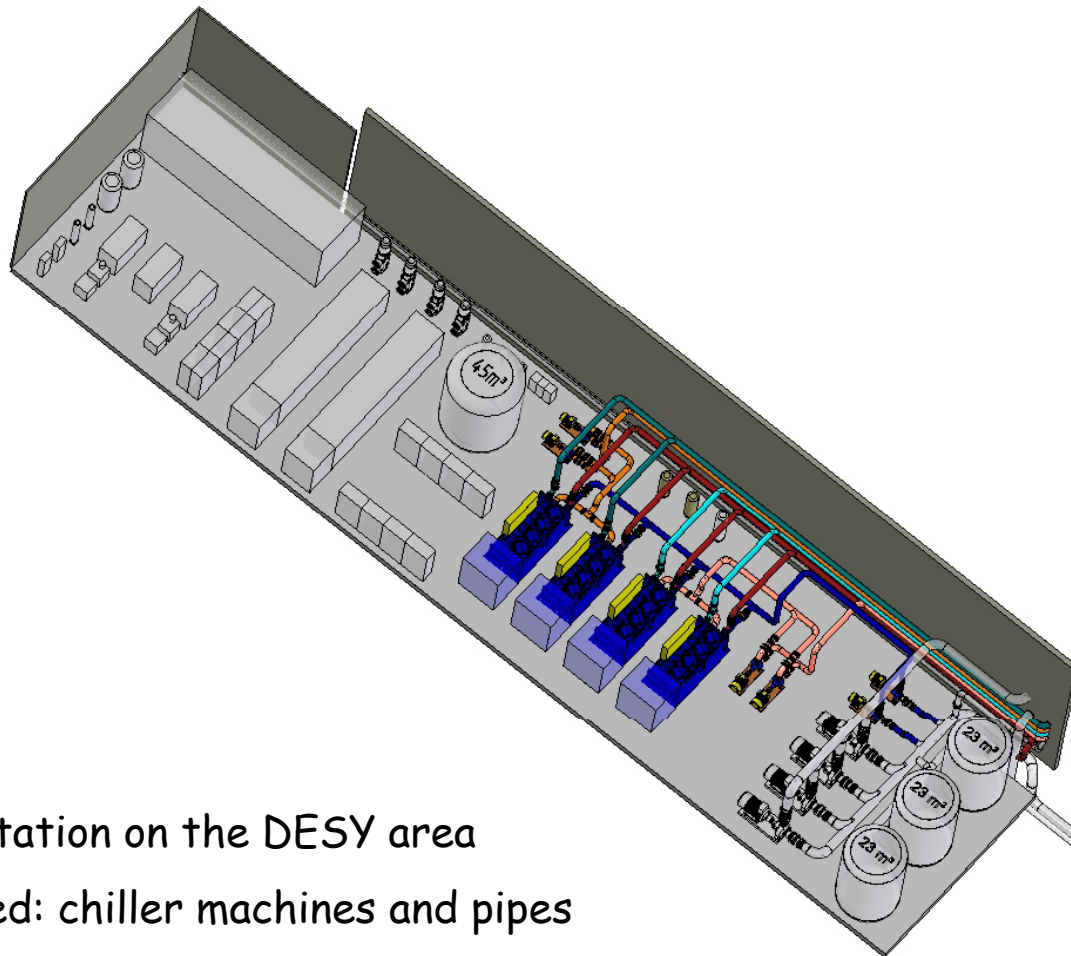
- heat transfer: dry or evaporation
- ambient air temperature > threshold temperature : wetted finned tubes
- operating mode = f (head load, velocity of the fans, ambient air conditions)

Recooler : Hybrid Cooling Tower

Technical details and demands

- design point temperature : 35°C / 30% r.h.
- threshold temperature dry/wet of ≥ 15 °C
- no visible vapour plume
- low noise level (< 50/35 dB(A) at 80m)
- easy to maintain and to inspect
- finned tube has to be completely wetted (only water drops in the air not sufficient)
- low space requirement
- drain system to prevent freezing (no Glycol additives)
- wetted with make-up water ($S \leq 15$ $\mu\text{S}/\text{cm}$)
To avoid damage caused by calcification

Chiller



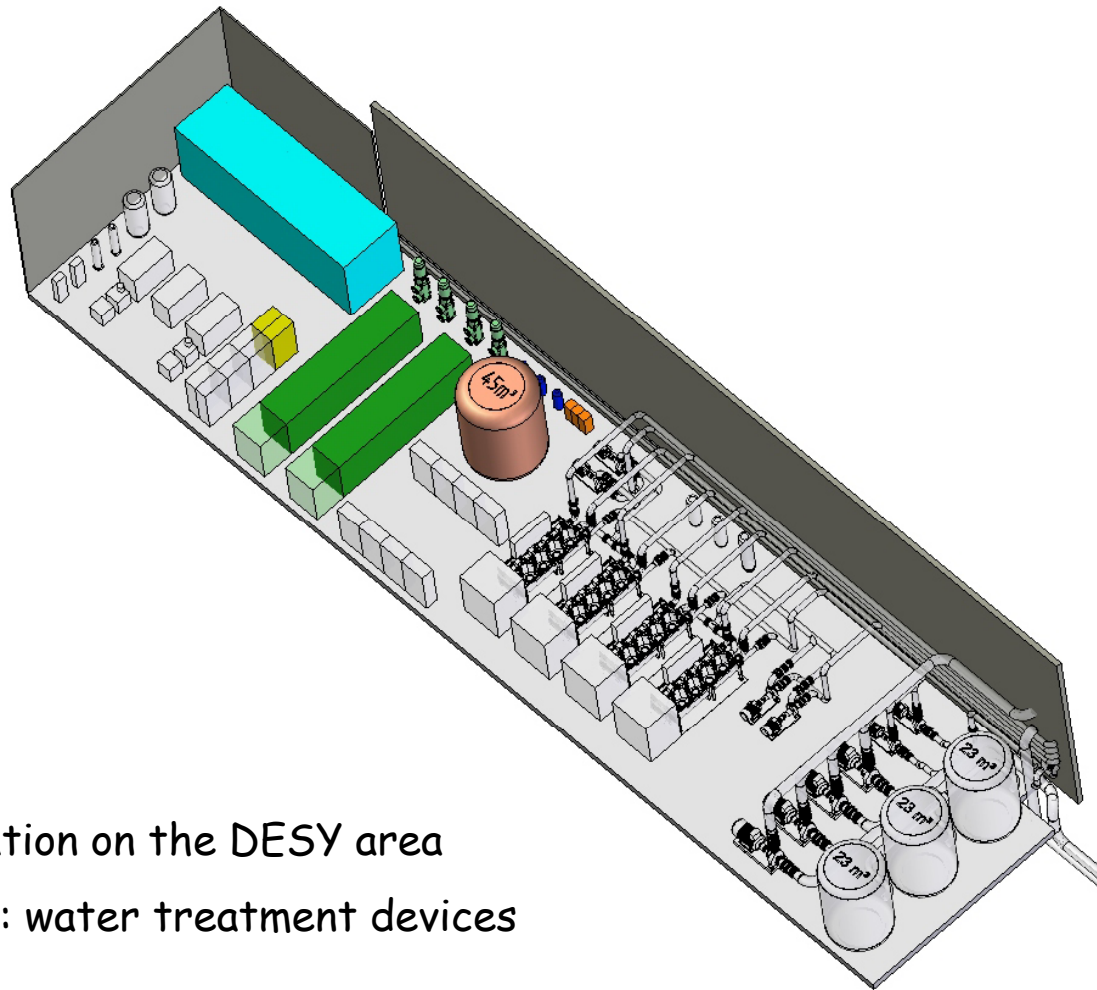
Pump station on the DESY area
Coloured: chiller machines and pipes

Chiller

Technical details and demands

- Power: ~ 3,7 (6,2) MW
(in units from 200 kW to 1800 kW)
- number ~ 10 (16)
- Temperature 18°C or 6°C
- upgradeable machines
- regulation without steps
- operation range 20% ... 100%
- refrigerant R134a
- temperature at the re-cooling-side > 45°C
e.g. flow-controlling to increase the temperature to the cooling tower in case of reduction of the chill power

Water Treatment



Pump station on the DESY area
Coloured: water treatment devices

Water Treatment

Well water after iron removal (750 $\mu\text{S}/\text{cm}$)

Water softening preferred by scale inhibition

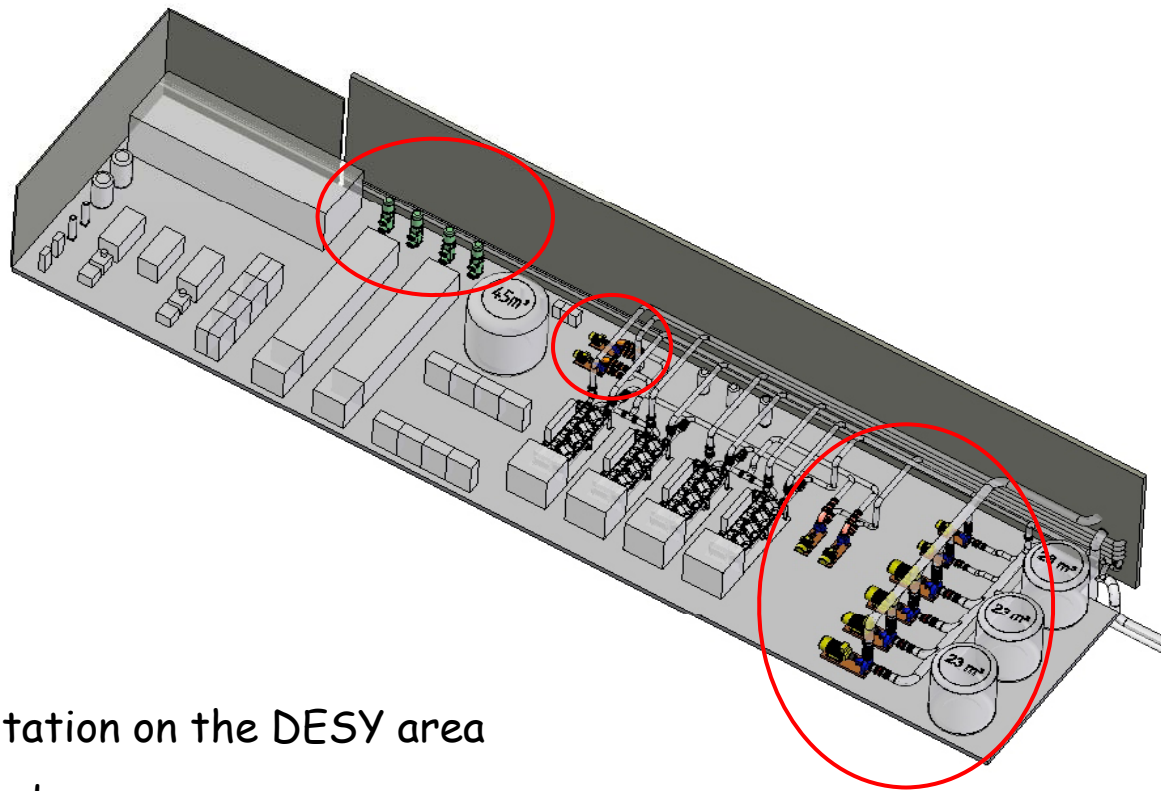
Reverse osmosis (15 $\mu\text{S}/\text{cm}$) \longrightarrow Hybrid cooler
only at DESY

Ion-exchanger cartridge (< 1 $\mu\text{S}/\text{cm}$) \longrightarrow Cooling water
at every pump station for refilling and stabilization of
the conductivity circuits

Technical details and demands

- treatment capacity ca. 45 (60) m^3/h
switched off during the winter and a fraction of this value during
most of the time of the year
- stabilization 5 .. 10 m^3/h
- permeate buffer tanks for the peak demand of
the hybrid cooler at hot days
- regeneration done by tender

Pumps



Pump station on the DESY area

Coloured: pumps

Pumps

Technical details and demands

- power 132 kW ... < 1,5 kW
- cast-bronze or stainless steel
- number > 100 pieces
- sound pressure level < 75 dB(A) f (# pole pairs, power)
- vibration damping (> 90%)
- frequency controlled electro motors
pressure = speed set point

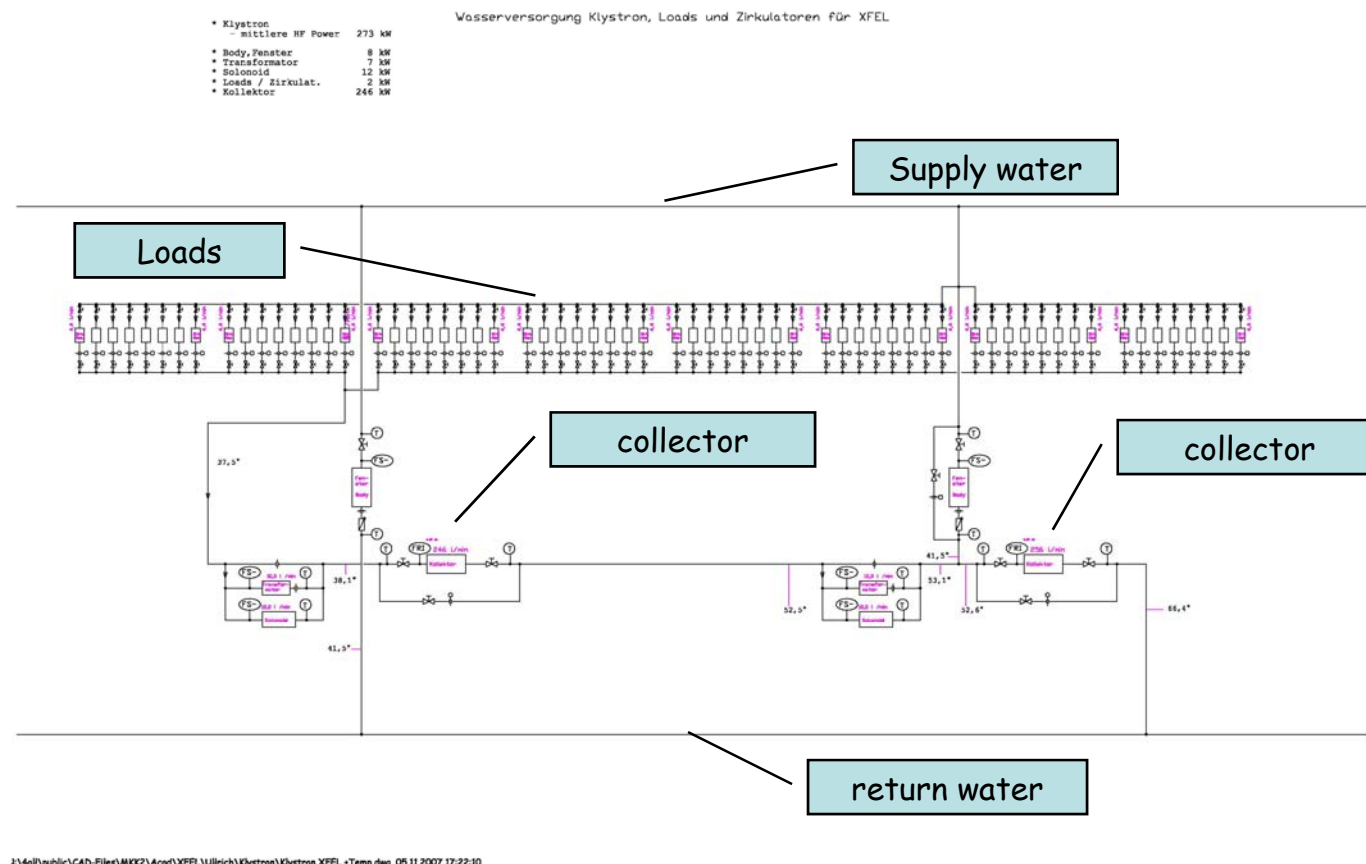
Cooling schemata of a klystron

Two klystrons in serial

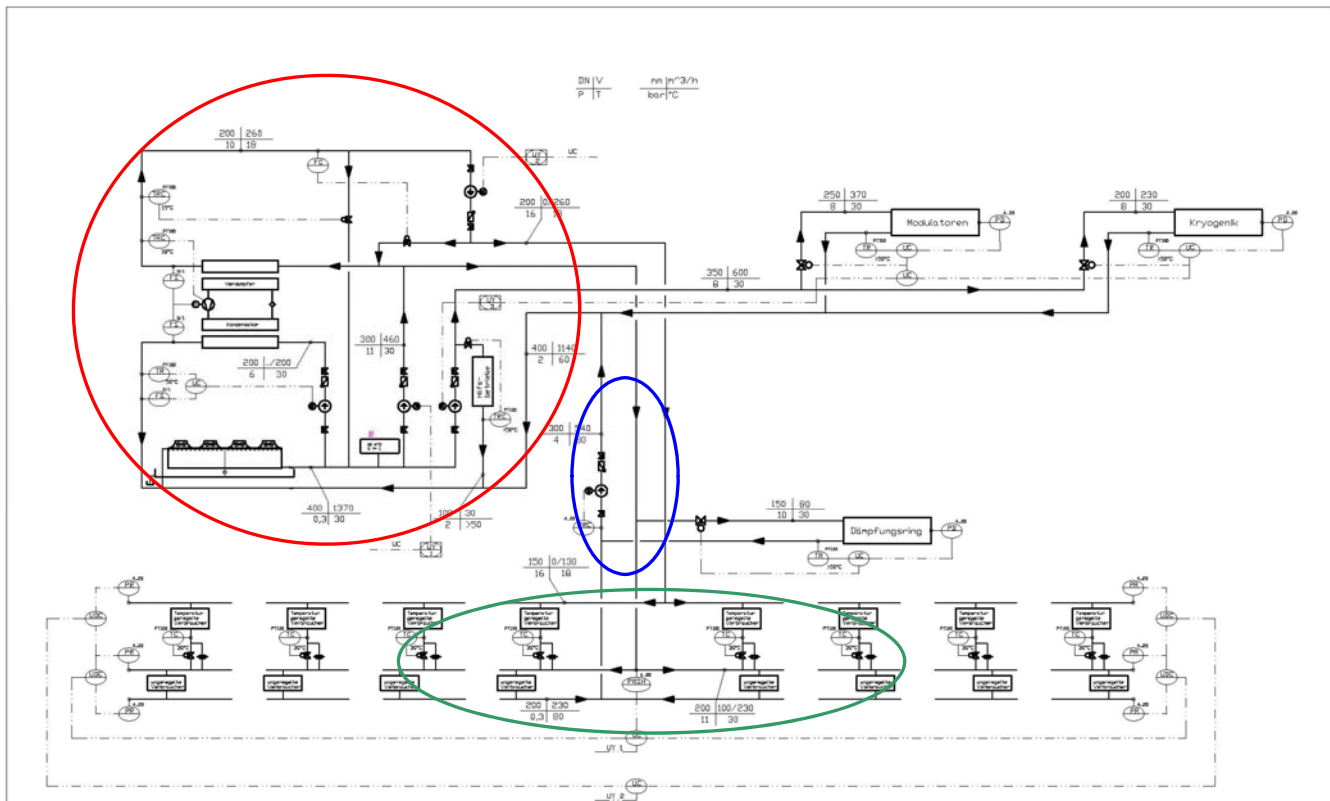
to have a high temperature

and to save water

Or if the **pressure drop** in the collector is **to high**:
one klystron station with a pump for recirculation of the return water



Cooling schemata at one TESLA-hall



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pumpstation

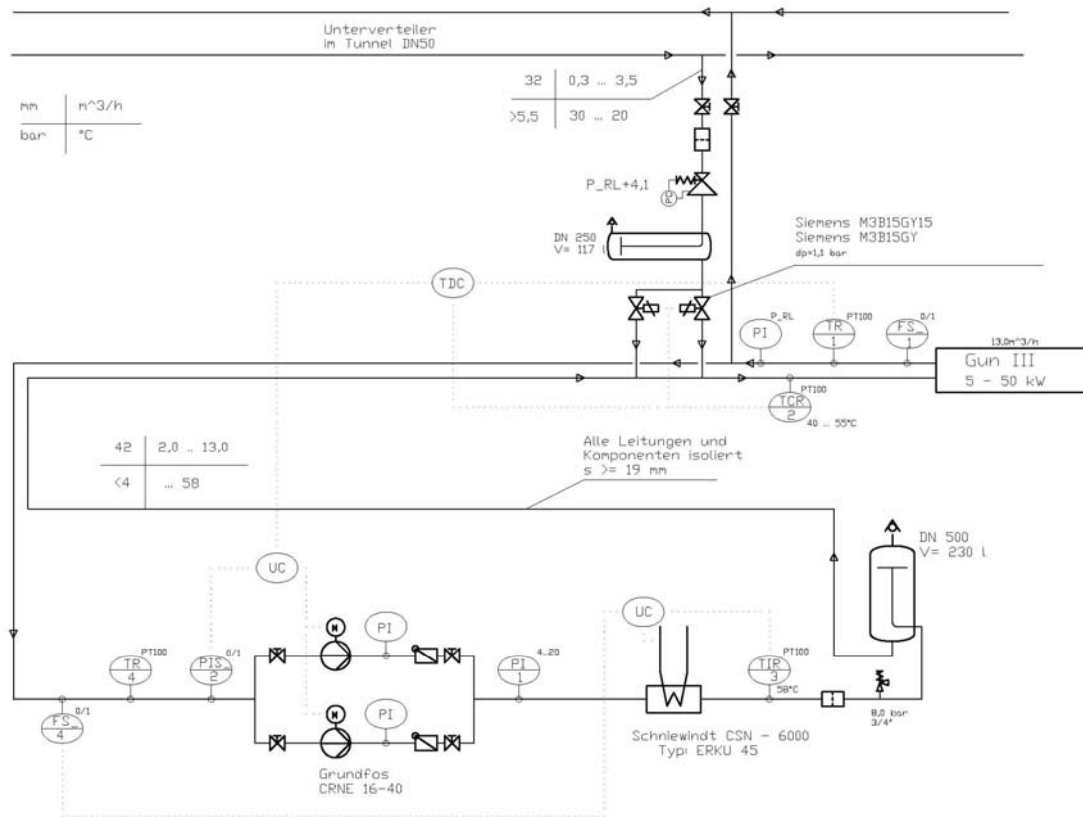
shaft

tunnel

30°C feed line is
the return line for
the 18°C water

Extra water loops
to avoid trouble
with the chillers

Cooling schemata of the gun



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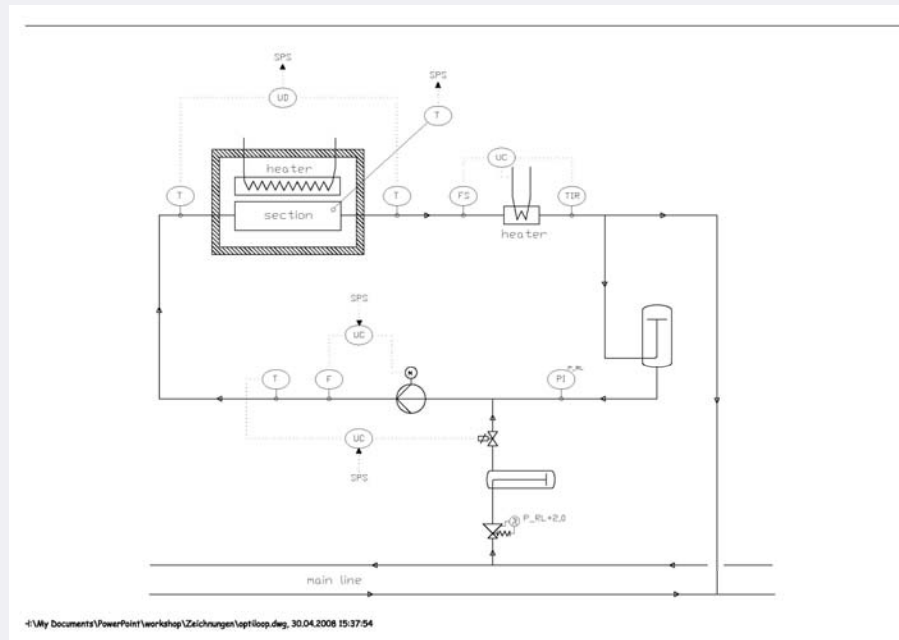
Gun-Loop
temperature
higher than
supply water
line

Controlling
by mixing

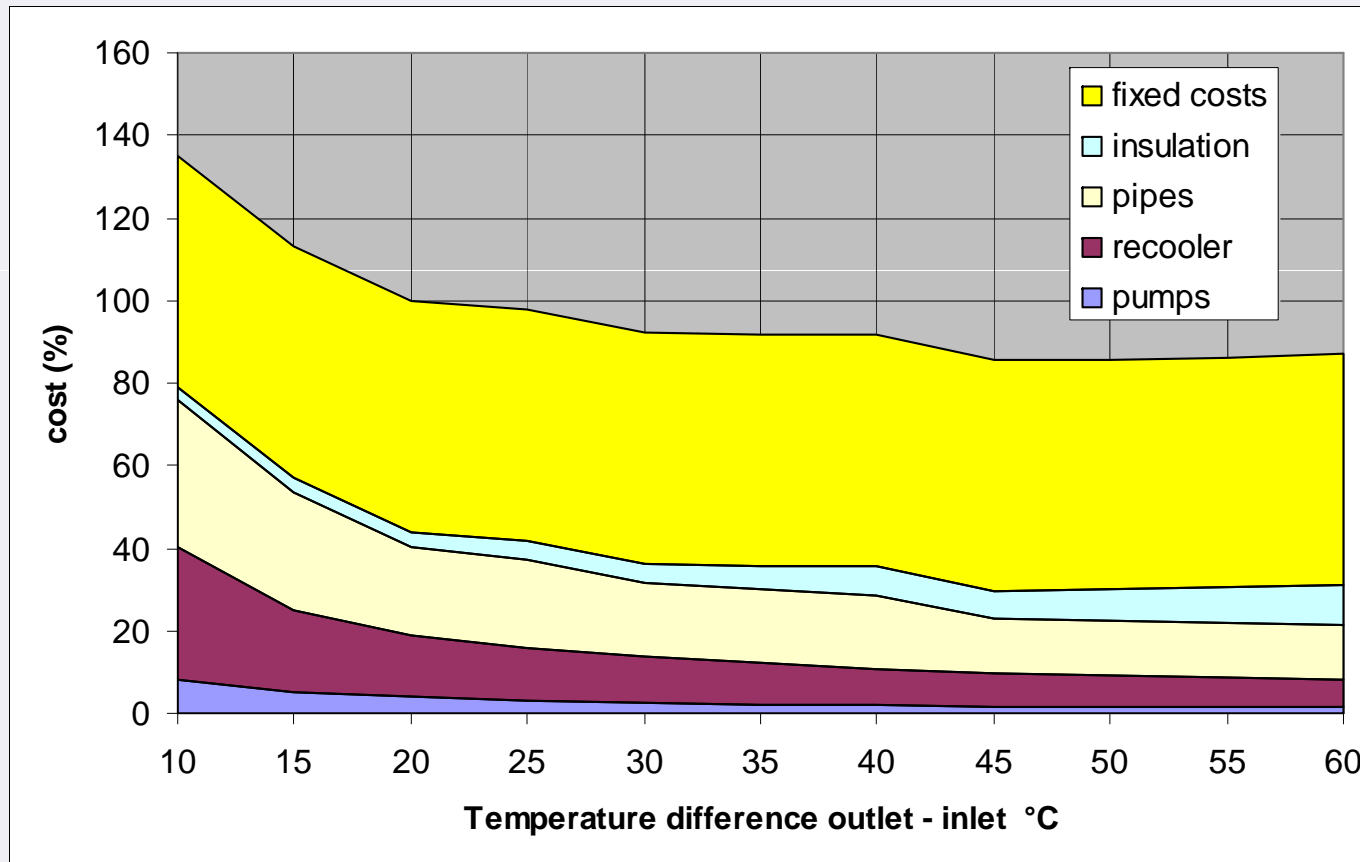
Only two-
way-valves
and split-
range
controlling

Another cooling schemata of the gun

- **future developments**
 - ✓ storage tank to avoid oscillations
 - ✓ two-way-valve to be able to optimize
 - ✓ no hot water line
- **additional options**
 - ✓ speed regulation at the pumps
 - ✓ Heating-covers on the structure
 - ✓ Controlling with different temperatures



Cost cutting by increasing the temperature difference



Fixed costs:
chillers, pressed air,
water treatment,
auxiliary pipes, etc

recooler:
constant temperature
difference for the
heat flow at the cold
side (e.g. the air
temperature)

insulation:
always the same heat
flow

The outlet
temperature should
be less than 70°C:

Otherwise the water
will be too hot for
some equipments

Thank you for your attention!

**Благодарю за
внимание и желаю
всего наилучшего!**