



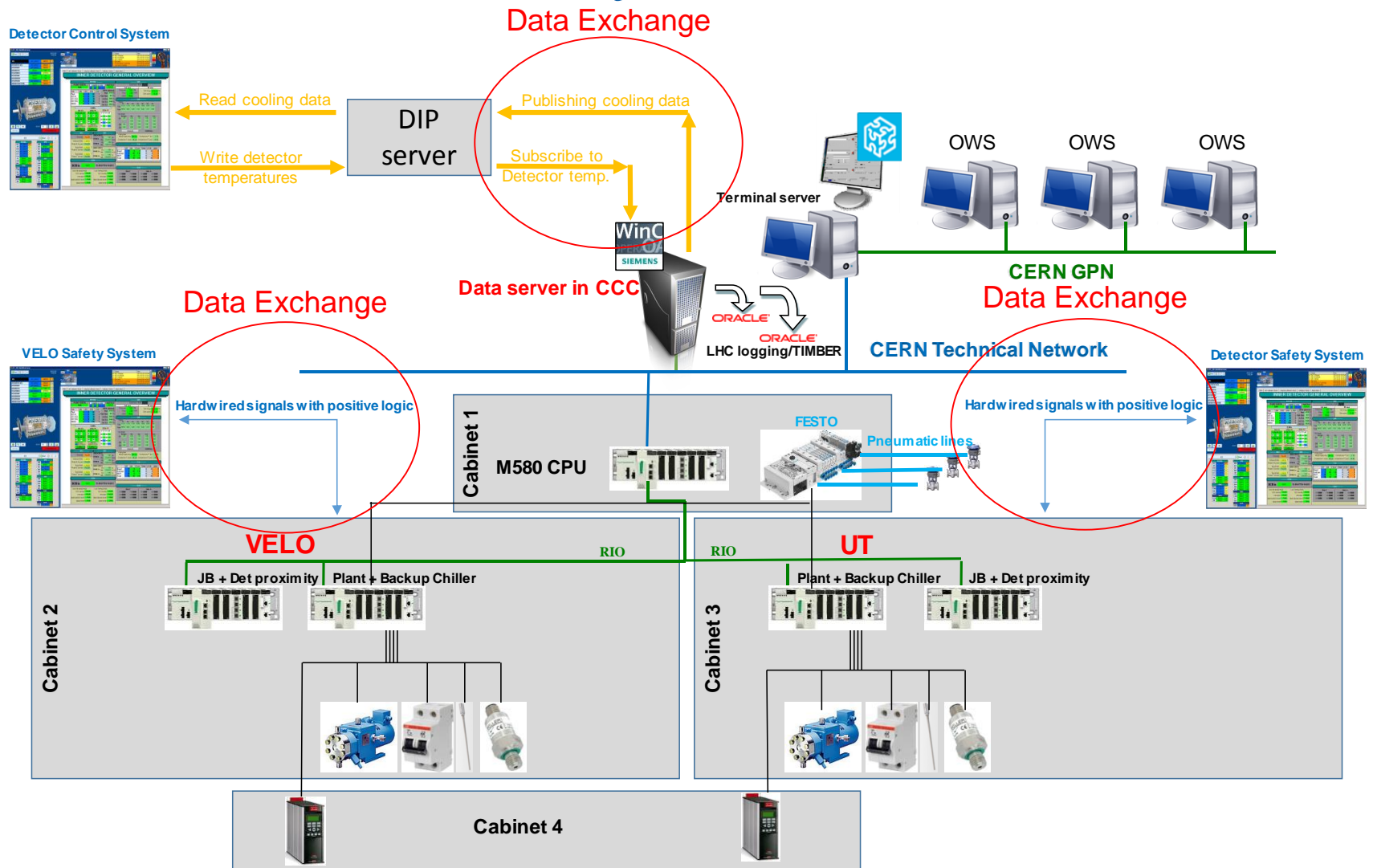
MAUVE Cooling Plant / Detector Data Exchange

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CERN EP/DT/FS
October, 2019

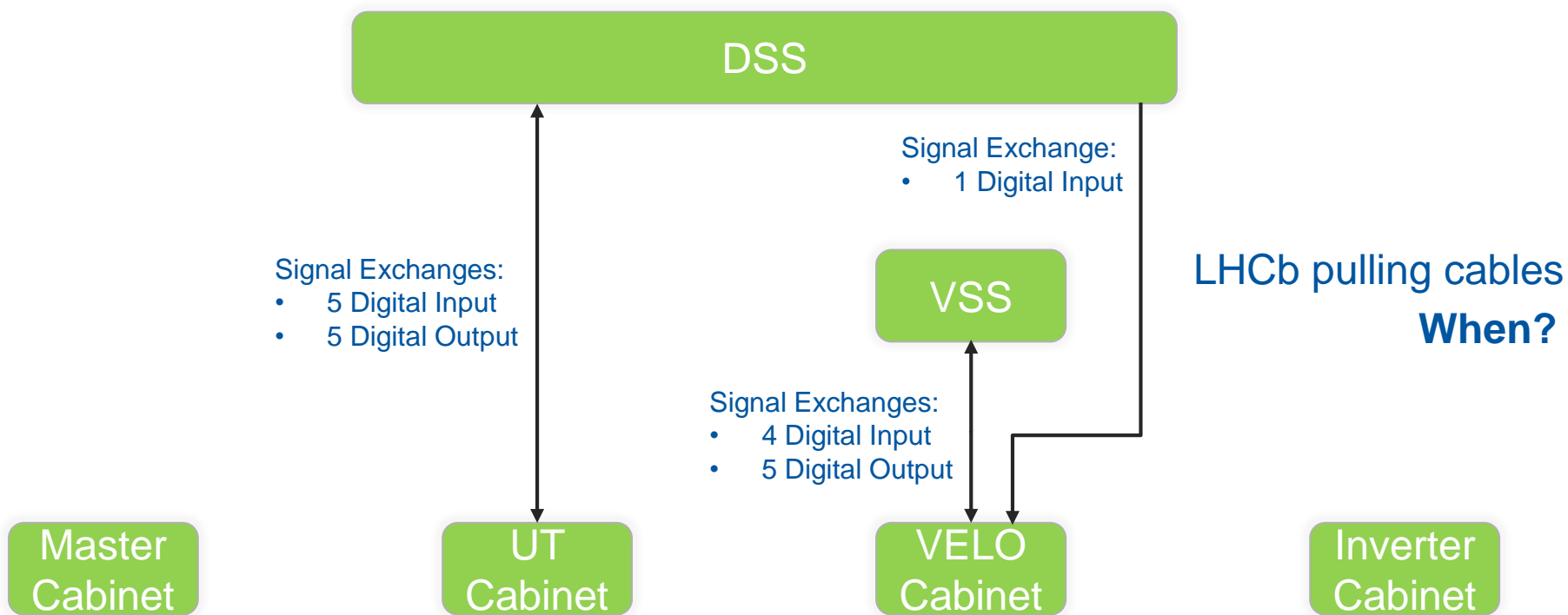
European Organization for Nuclear Research (CERN),
CH-1211 Geneva 23, Switzerland



MAUVE Control System Architecture



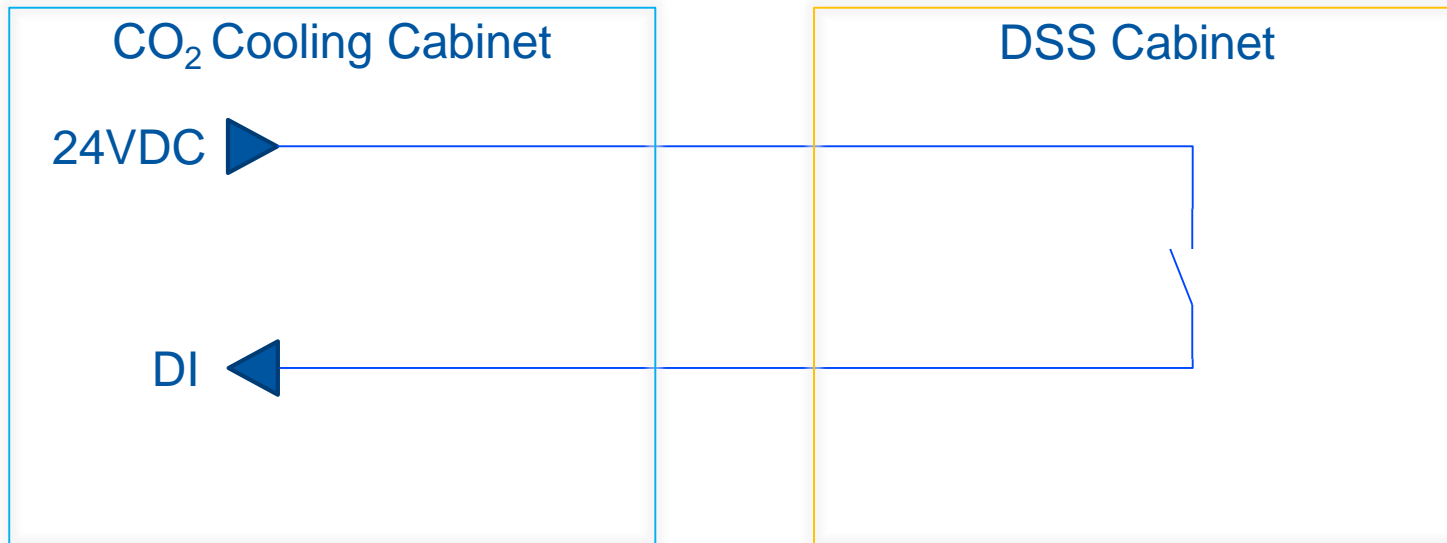
Hardwired Interlock Scheme between CO₂ cooling cabinets and **DSS** & **VSS**



DSS input for UT cooling plant

■ Cooling input signals

- DSS_IN1 : DSS interlock, stop the plant (if 0 = stop)
- DSS_IN2 : DSS cooling cold allowed (if 0 = go to warm operation 17 °C)
- DSS_IN3 : DSS cooling flow allowed (if 0 = at start-up do not allow to open liquid supply valves)
- DSS_IN4 : Spare
- DSS_IN5 : Spare



DSS & VSS input for VELO cooling plant

- Cooling input signals

DSS

- DSS_IN1 : DSS interlock, stop the plant

VSS

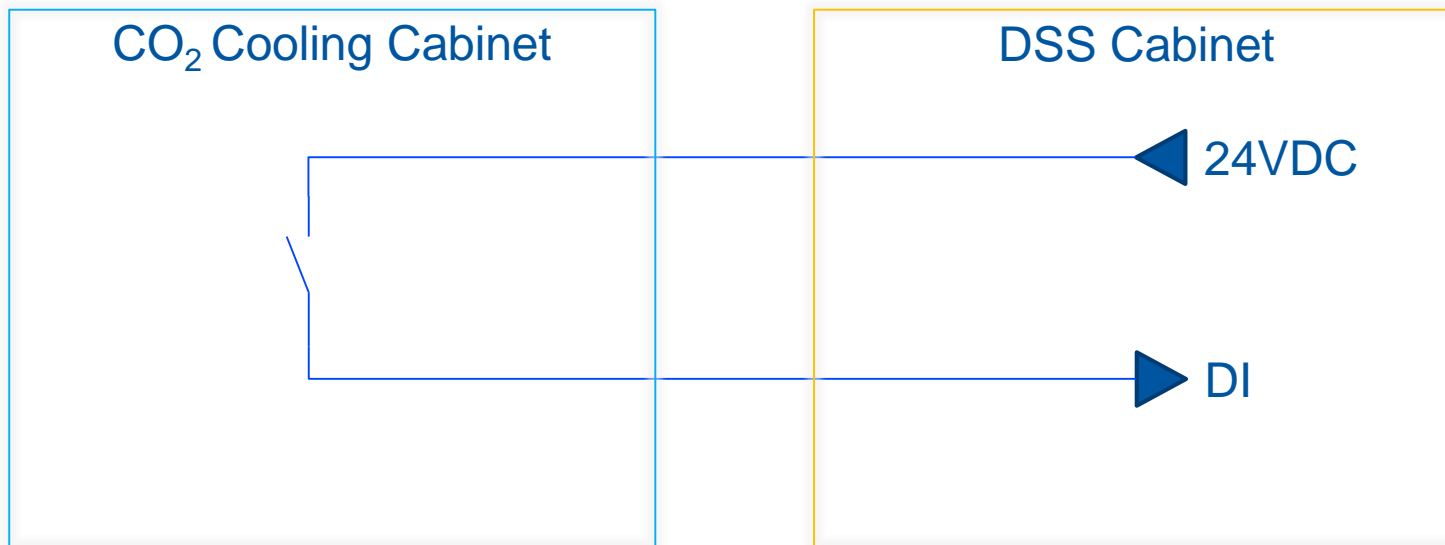
- VSS_IN2 : VSS interlock, stop the plant (if 0 = stop)
- VSS_IN3 : VSS cooling cold allowed (if 0 = go to warm operation 17 °C)
- VSS_IN4 : VSS cooling flow allowed (if 0 = at start-up do not allow to open liquid supply valves)
- VSS_IN5 : Spare



DSS output for UT cooling plant

■ Cooling output signals

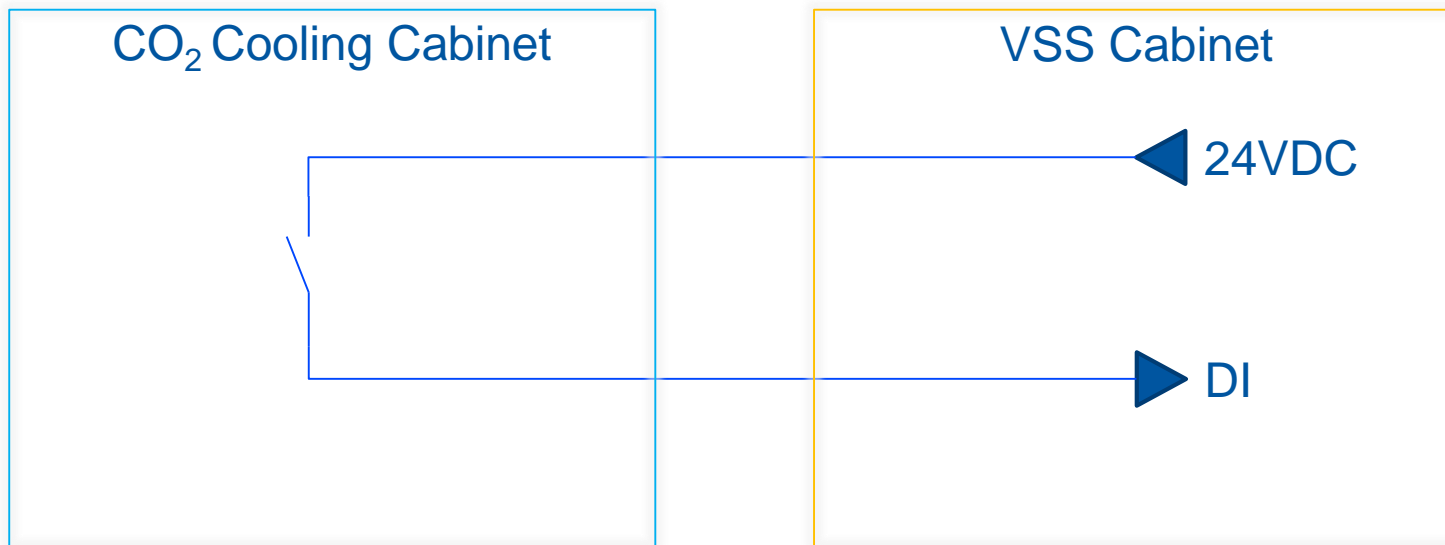
- DSS_OUT1: A side cooling ready (if 0 = No cooling power delivered to detector A side)
- DSS_OUT2: C side cooling ready (if 0 = No cooling power delivered to detector C side)
- DSS_OUT3: Full cooling available (if 0 = CO2 plant working on backup chiller)
- DSS_OUT4: Set point reached (if 0 = SP not reached)
- DSS_OUT5: Backup mode (if 0 = One Plant is cooling both detectors)



VSS output for VELO cooling plant

■ Cooling output signals to VSS only

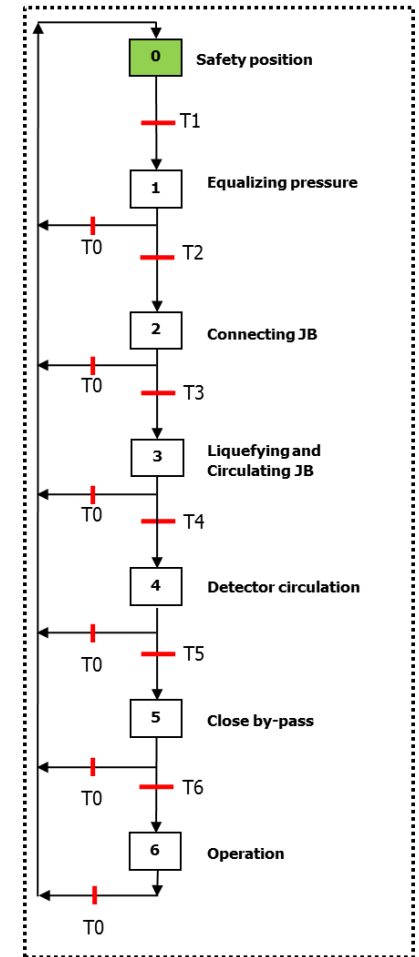
- VSS_OUT1: A side cooling ready (if 0 = No cooling power delivered to detector A side)
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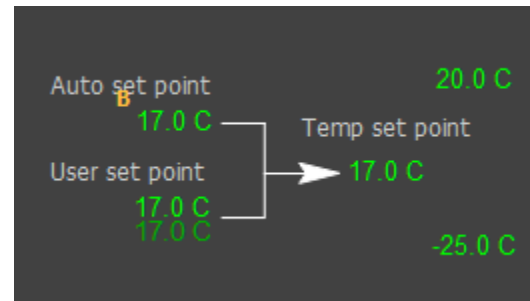
MAUVE Temperature Management

JDB PCO
Operation

- MAUVE CO₂ control system is automatically changing the applied saturation temperature set point during process:
 - **Equalization:** Set point of the plant will change in order to obtain equivalent pressure with the detector
 - **Liquefying:** Set point of the plant will change in order to liquefy CO₂ present in the detector
 - **Circulation/Operation:** User set point is requested
- All these operation are following the different rules applied on the set point:
 - Speed change request
 - Minimal and maximal thresholds

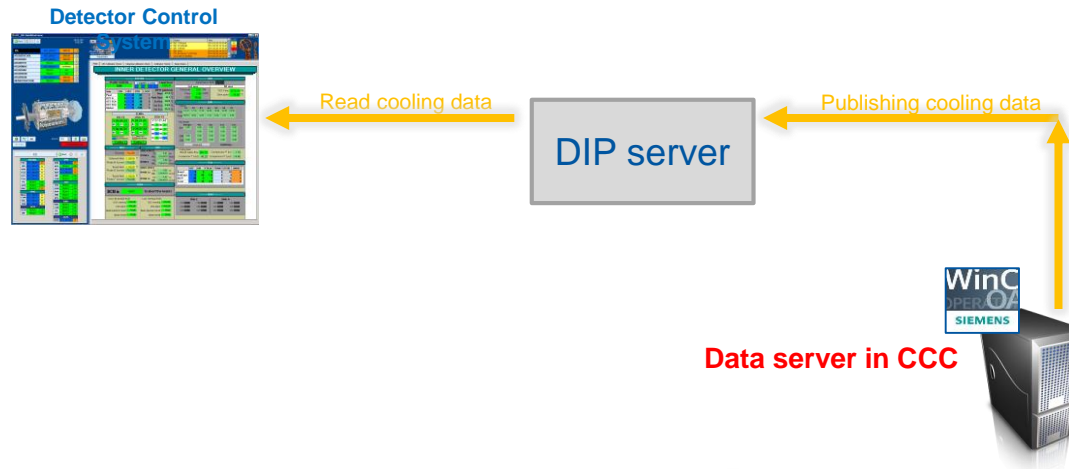


Control of User Temperature



- User Set point can only be set up inside MAUVE CO₂ control system
- **One detector responsible** who will have the right to change user set point for both cooling plants inside MAUVE CO₂ SCADA system: Heinrich?
- **One responsible per detector** who will have right to change user set point for dedicated plant.

DIP publications from MAUVE CO₂ cooling system

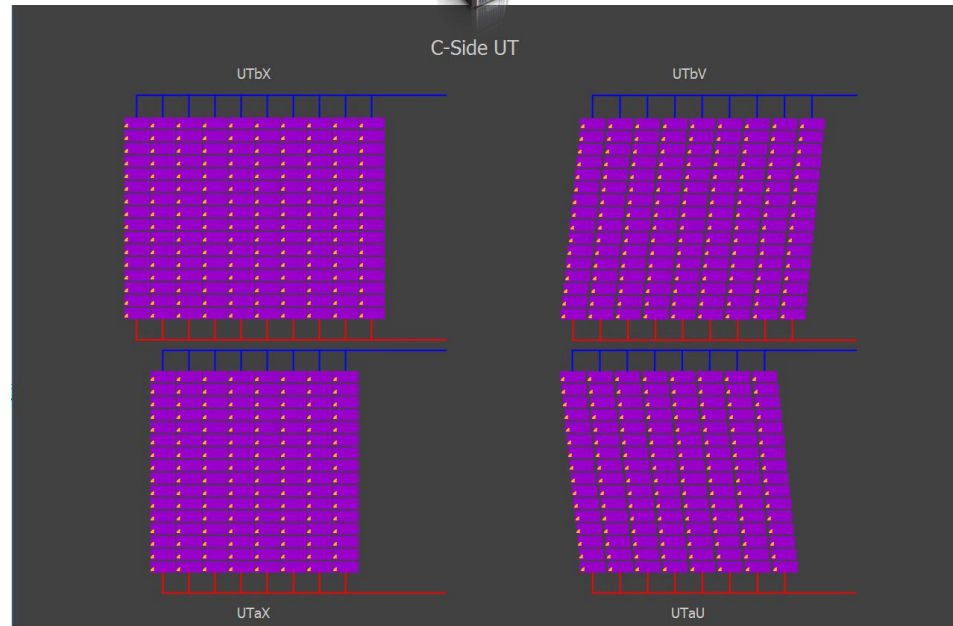
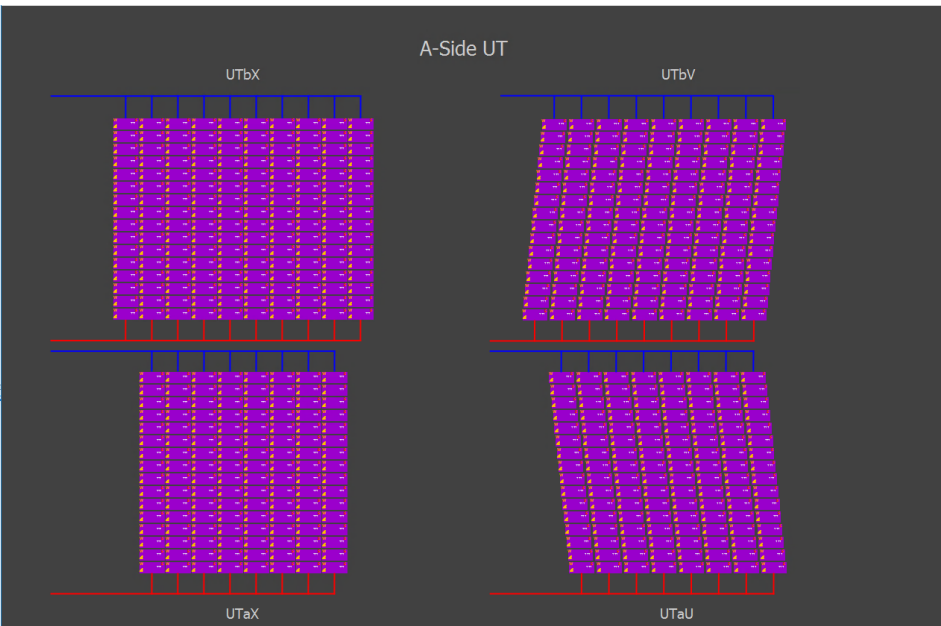
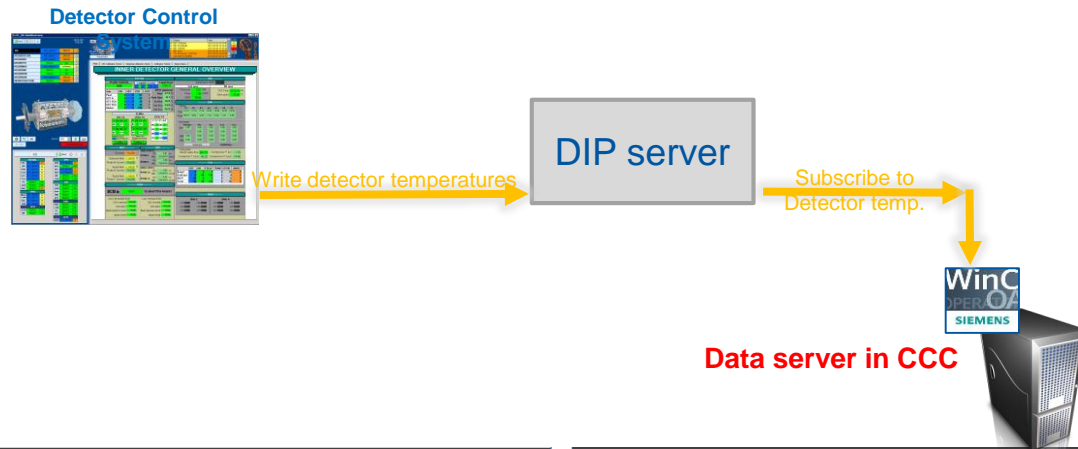


- PCO state
- Sensors values
- Sub cooling and super heating values
- Actuators state of full system (valves position, heater power applied...)
- **PLC Live counter***
- Set point (User, automatic, applied)
- JDB stepper state & Transition
- **Major alarms groups**

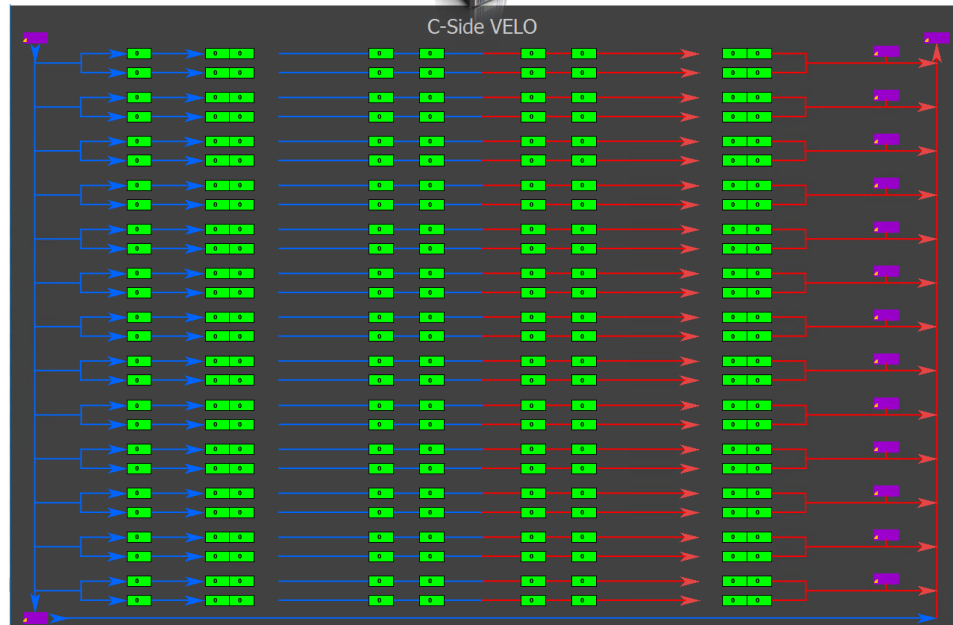
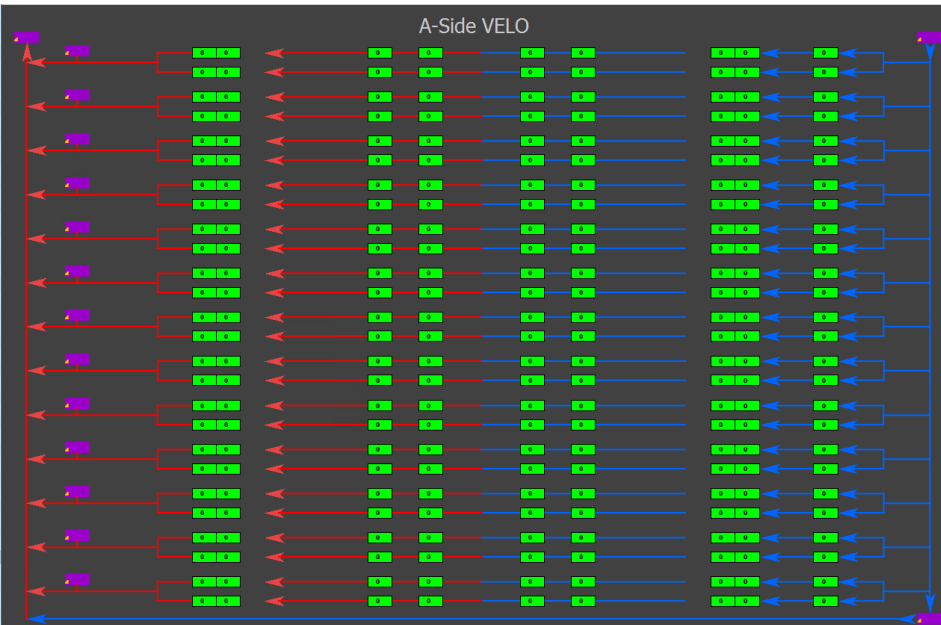
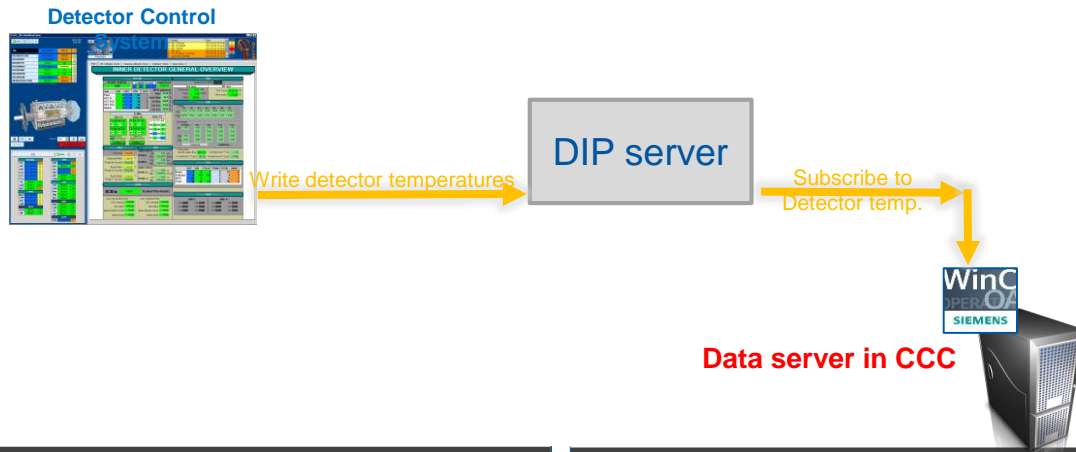
Possibility to create dedicated P&ID based diagnostic panels in DCS

*Live counter is needed in DCS to check communication is alive

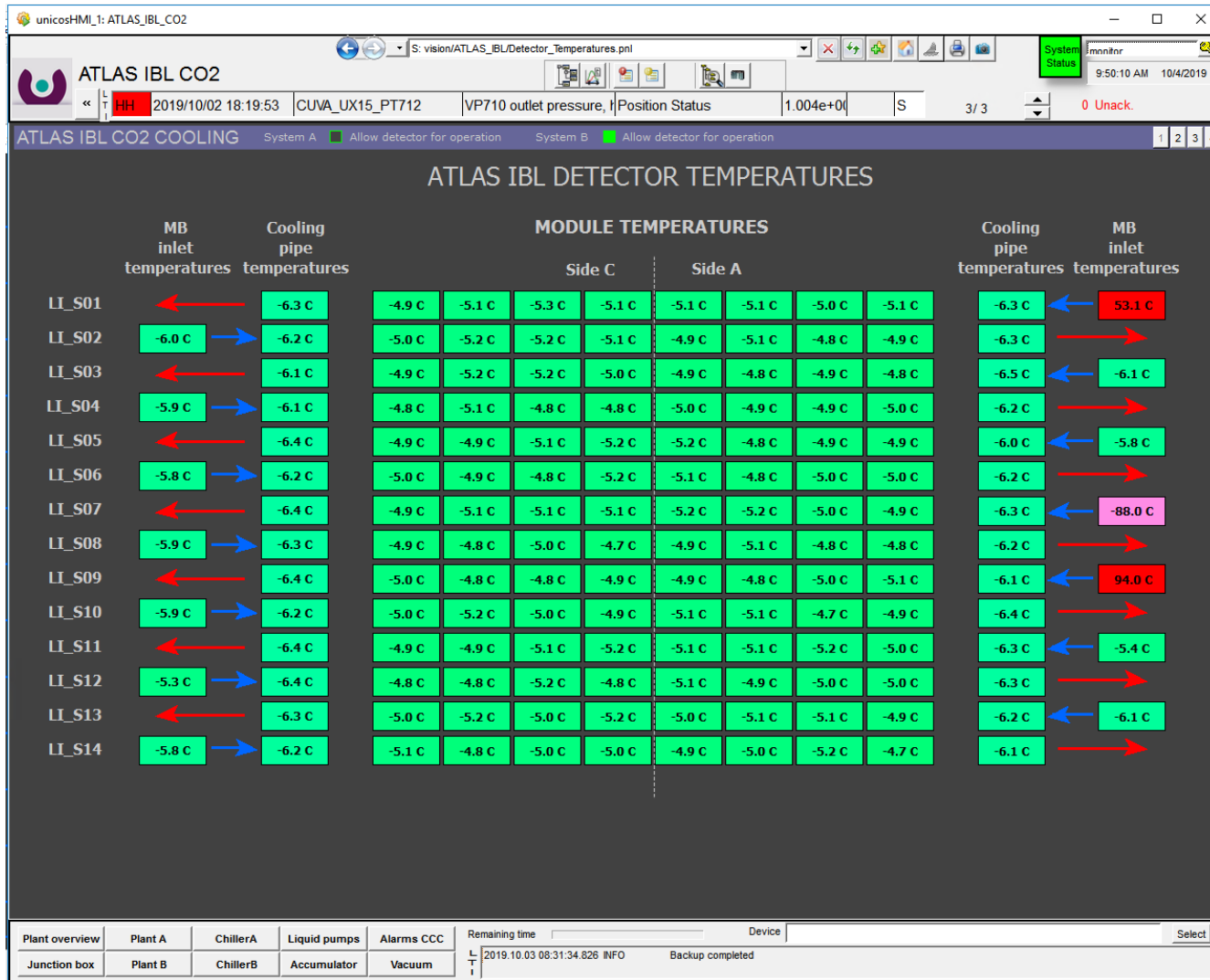
DIP publications from UT



DIP publications from VELO



DIP Publication example (ATLAS IBL)

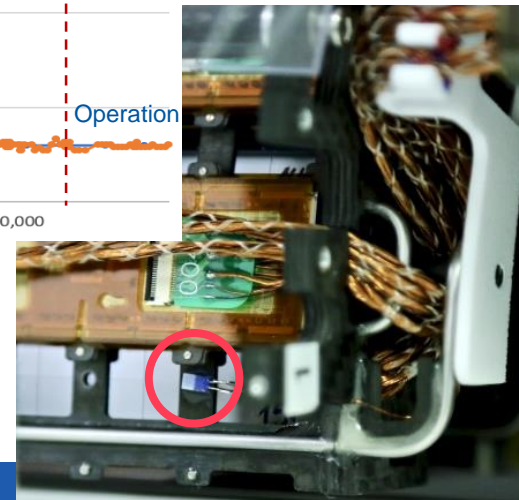
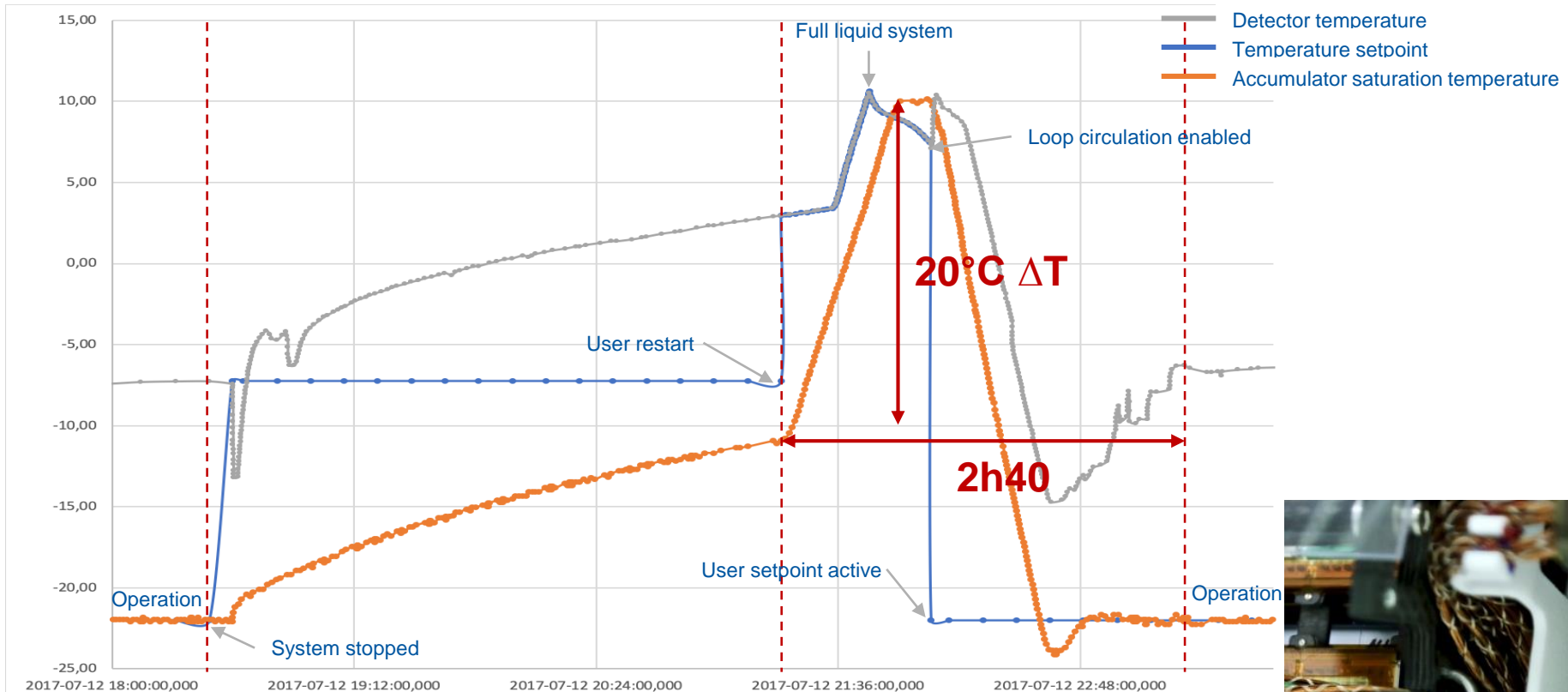


Detector Temperature

- Reading a single detector temperature value and using it as input to the PLC is possible
 - External connection (4-20mA)
 - FieldBus connection (Modbus)
 - DIP (Development to do to bring the value from SCADA to PLC)
- Difficulties encountered with automatic detector temperature reading used as T set point for start: long delays, communication issues...
- Reading detector temperatures value through DIP could bring enough diagnostic for cooling system debugging and start process will be using local boxes sensors

Backup slides

Pixel Phase 1 restart example

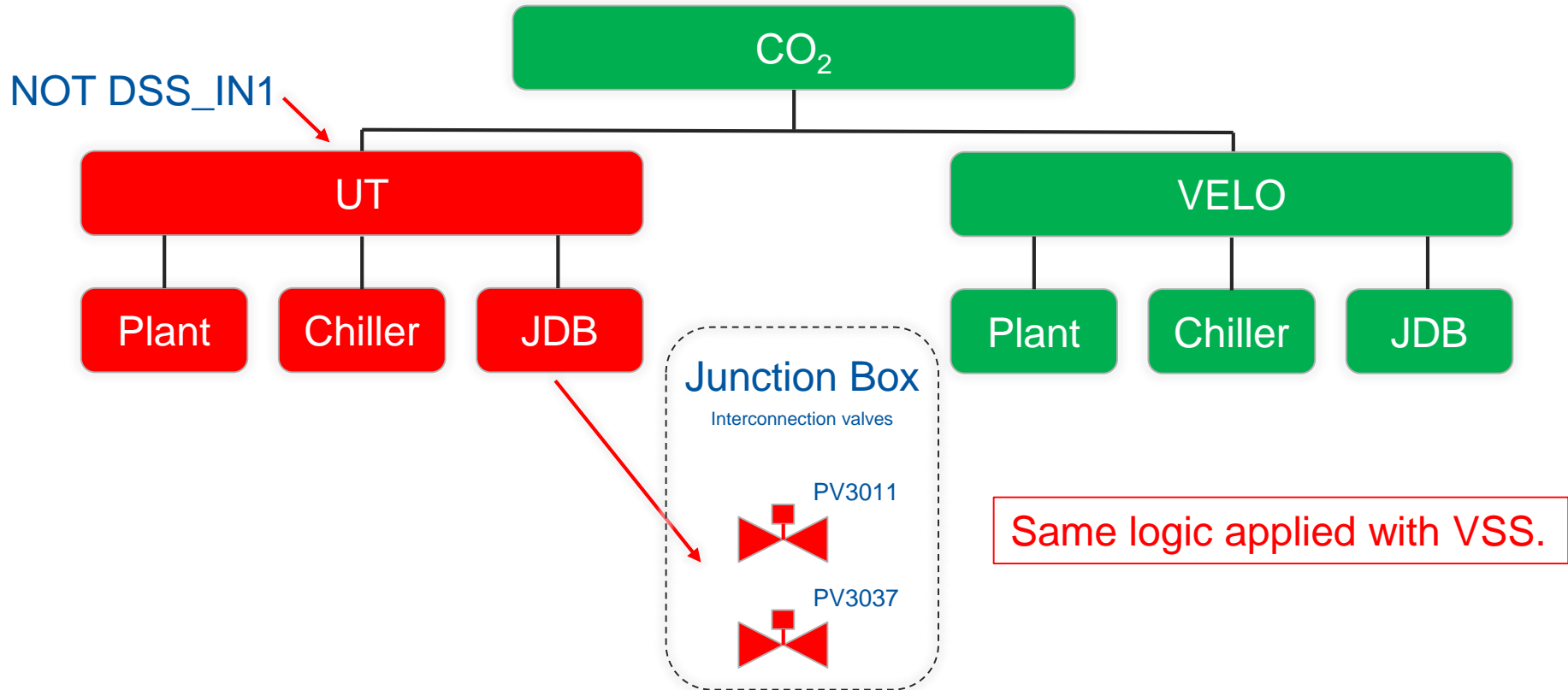


- BPix example where sensors are glued on the carbon fibres next to the cooling pipe
- Temperature offset (15°C) cause unnecessary delays and temperature cycles

Backup mode open question

- Bsp? (backup setpoint?)
- Tsp_Bsp? (Backup setpoint speed)
- Bsp_tH? (Backup setpoint high limit)
- Bsp_tL? (Backup setpoint low limit)

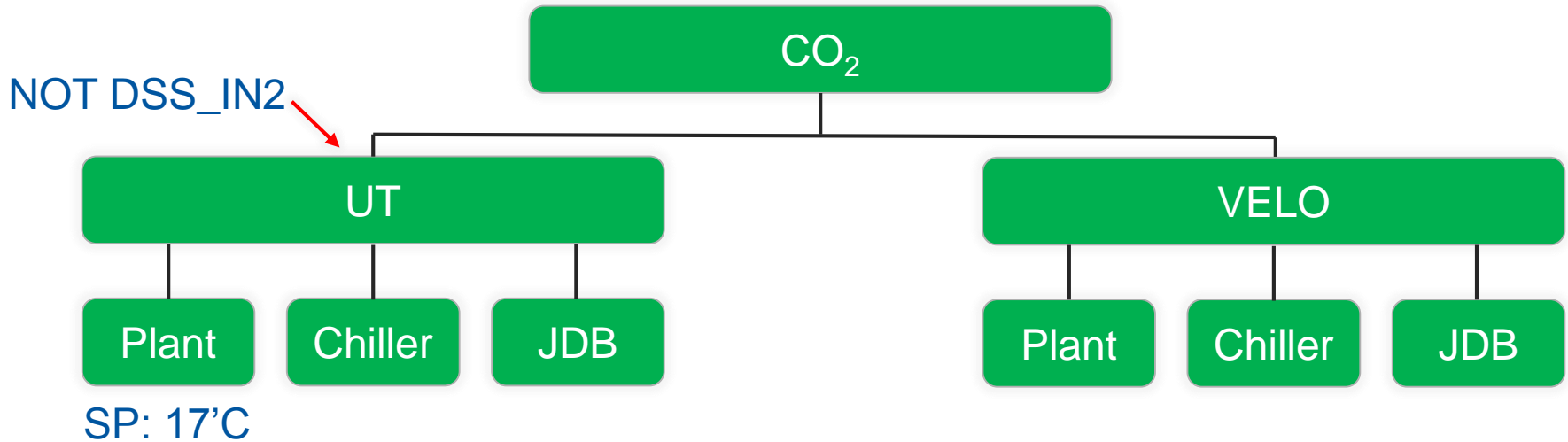
DSS_IN1 : Stop the plant



DSS_IN1: Full Stop on UT PCO (Full Stop of UT Plant, backup Chiller and JDB)

It will put the interconnection valves to their safety position, so in case of backup mode it will stop circulation through UT if VELO is the active Plant and will Stop VELO PCO if UT is the active Plant.

DSS_IN2: Cooling cold allowed



In case of backup mode, only DSS can request warm operation on UT Plant.
And only VSS can request warm operation on VELO Plant.
This to avoid unexpected warm operation on the detector running with his dedicated plant in backup mode.

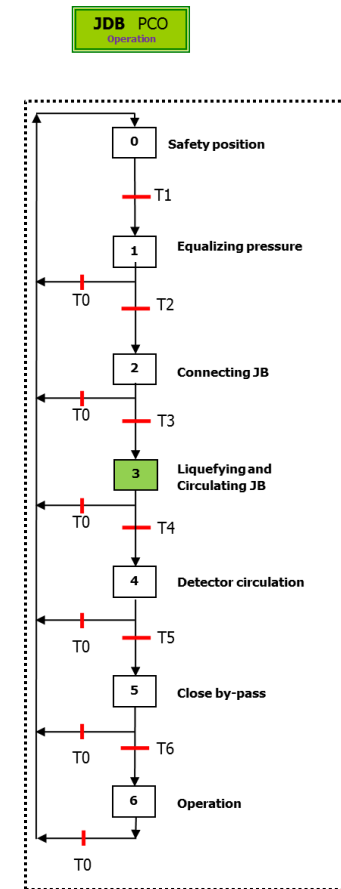
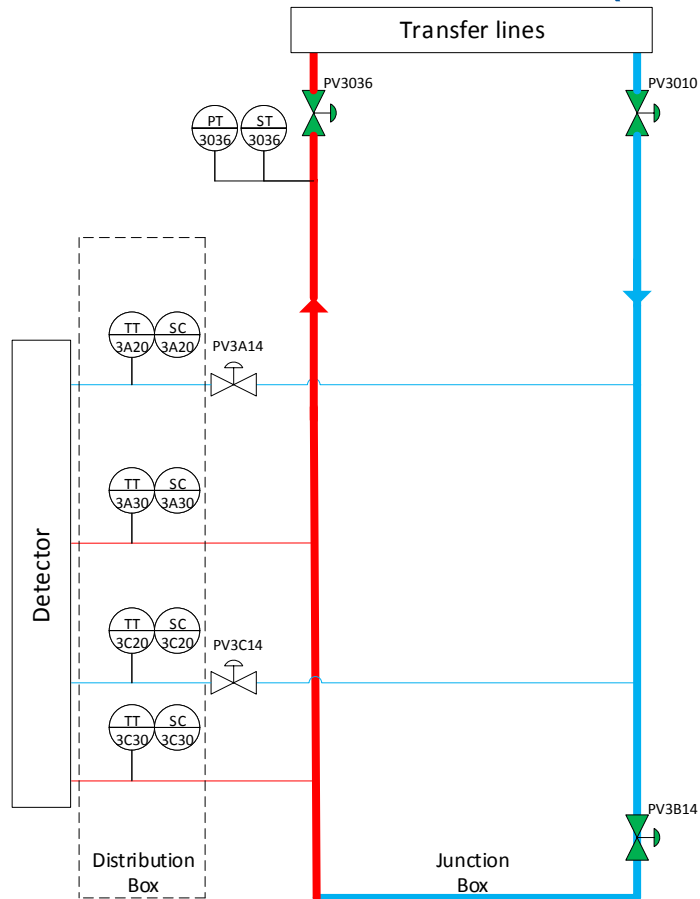
DSS_IN3: Used only in the start-up to allow circulation of CO₂

■ Liquefying and Circulation in JB (Step3)

The **transition 4** is valid when all the conditions below are fulfilled:

- JDB PCO Run Order status is active
- Valve PV3010 has to be open and the other valves (PV3036, PV3A14, PV3B14 and PV3C14) are still in the same position as in the previous step
- The subcooling values of the supply and return lines (SC3A20, SC3C20, SC3A30, and SC3C30) are higher than a parametrical value (typically set @-4K)
- **The specific detector safety system (VSS for VELO and central DSS for UT) is sending the signal to allow cooling flow in the detector**

In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



DSS output for UT cooling plant

- **DSS_OUT1:**
 - Normal Operation: UT is in operation, supply/return valves needed for UT A side are opened to circulate liquid CO₂ in detector and DP over the A side of the detector is correct (analog alarm enabled when step 6) (no information about the chiller used or feedback on setpoint)
 - Backup mode: The active plant is in operation and supply/return valves needed for UT A side are opened to circulate liquid CO₂ in detector and DP over the A side of the detector is correct (no information about the chiller used or feedback on setpoint)
- **DSS_OUT2:**
 - Normal Operation: UT is in operation and supply/return valves needed for UT C side are opened to circulate liquid CO₂ in detector and DP over the C side of the detector is correct (no information about the chiller used or feedback on setpoint)
 - Backup mode: The active plant is in operation and supply/return valves needed for UT C side are opened to circulate liquid CO₂ in detector and DP over the C side of the detector is correct (no information about the chiller used or feedback on setpoint)
- **DSS_OUT3:**
 - Normal Operation: UT system is running with the main chiller (no information about CO₂ distribution in the system and current step in JDB process)
 - Backup mode: The active plant is running with the main chiller (no information about CO₂ distribution in the system and current step in JDB process)
- **DSS_OUT4:**
 - Normal Operation: UT system reached his setpoint and JDB is in operation (no information about CO₂ distribution in the system)
 - Backup mode: The active system reached the common setpoint and JDB is in operation (no information about CO₂ distribution in the system)
- **DSS_OUT5:**
 - UT plant is cooling both detectors: **should we change it for a more general information (Backup mode: One plant is cooling both detectors)**

Combination of these 4 bits should be used to confirm CO₂ cooling is ready. Any of them missing should not allow powering the detector.

Only information

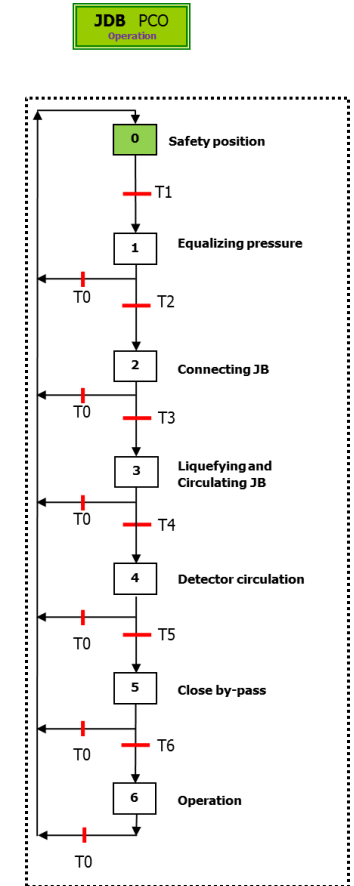
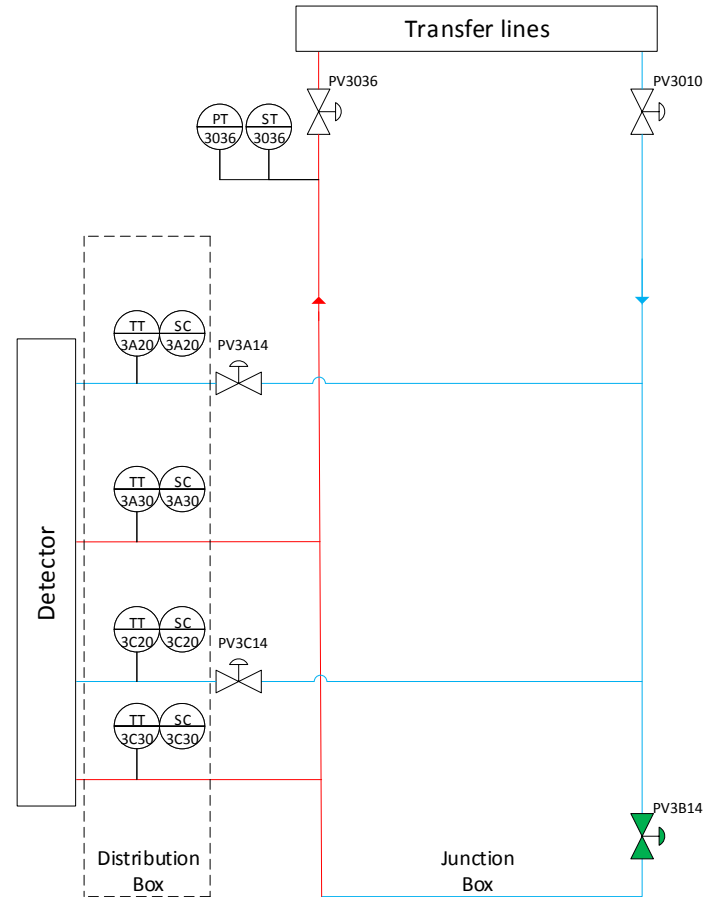
Process Description - JDB

■ Safety Position

The transition 1 is valid when all the conditions below are fulfilled:

- JDB PCO Run Order status is active
- All valves are closed except PV3B14.

In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



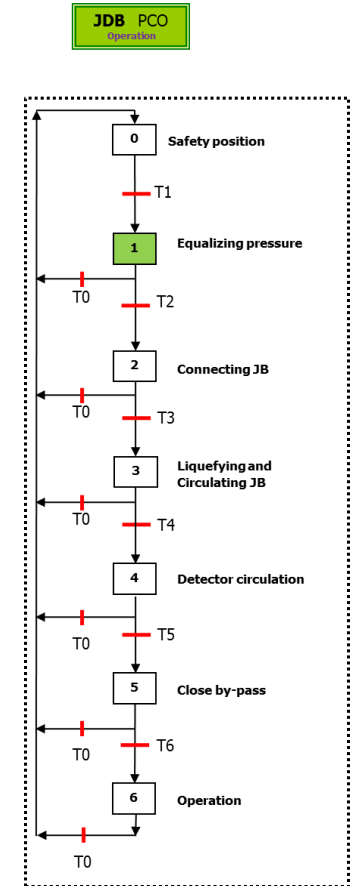
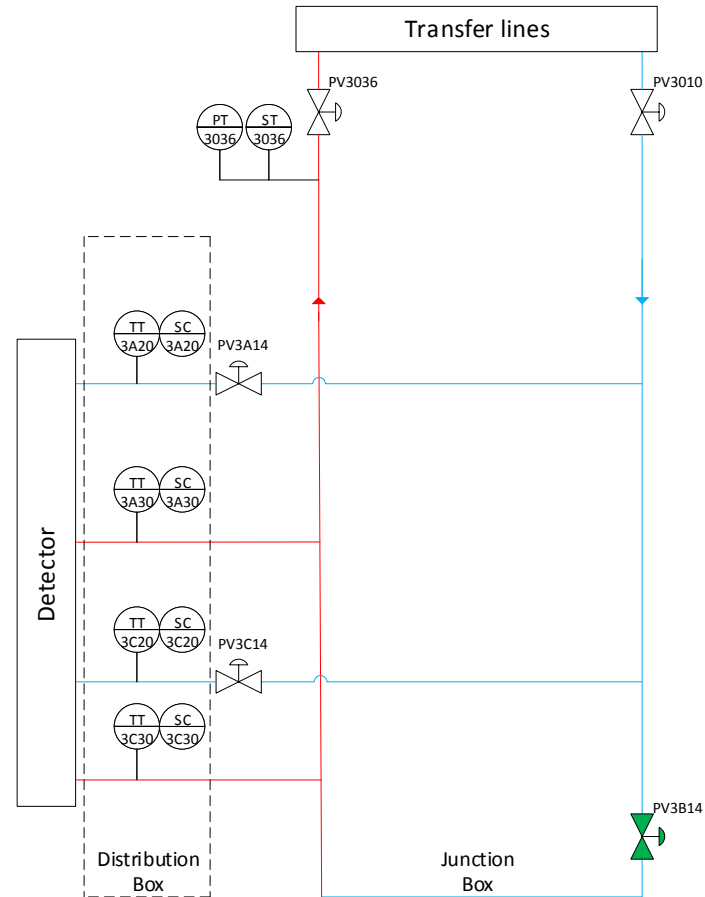
Process Description - JDB

■ Equalizing Pressure

The transition 2 is valid when all the conditions below are fulfilled:

- JDB PCO Run Order status is active
- All valves are closed except PV3B14
- The pressure in the accumulator (PT4060) is equal to the pressure in the return line (PT3036) with a deadband tolerance

In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



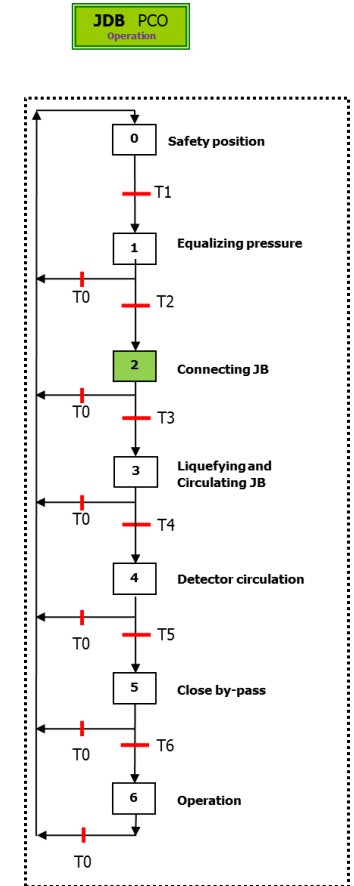
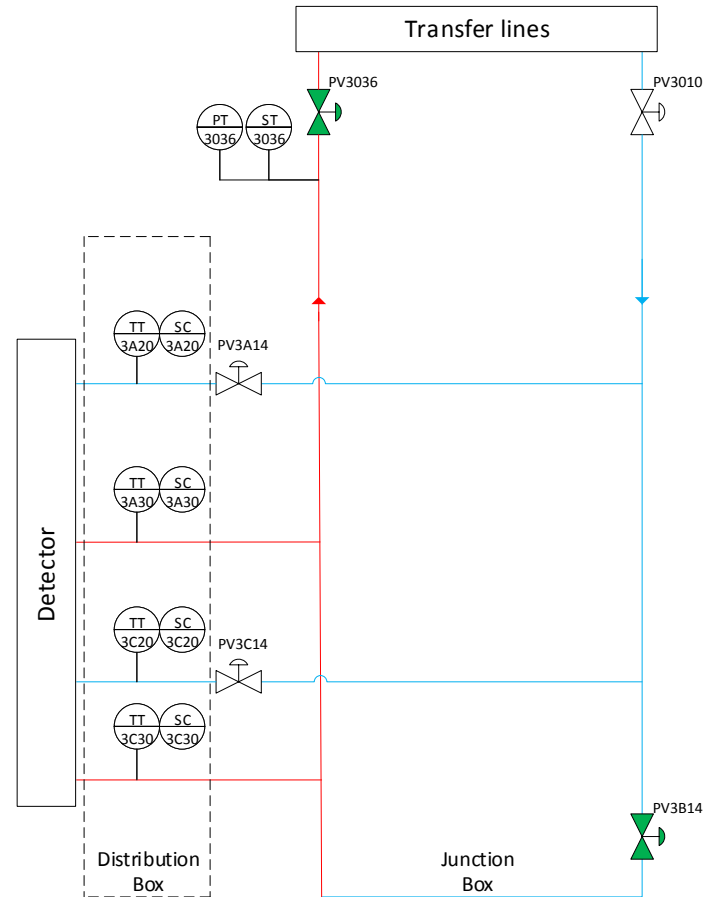
Process Description - JDB

■ Connecting Junction Box

The transition 3 is valid when all the conditions below are fulfilled:

- JDB PCO Run Order status is active
- This valve (PV3036) is fully open
- The other valves (PV3010, PV3A14, PV3B14 and PV3C14) are still in the same position as in the previous step

In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



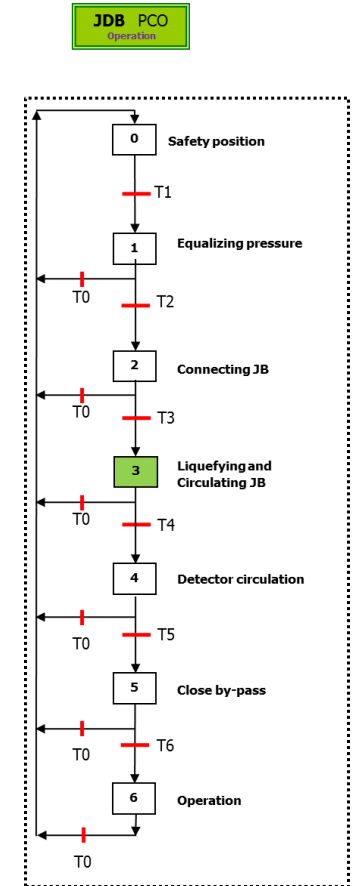
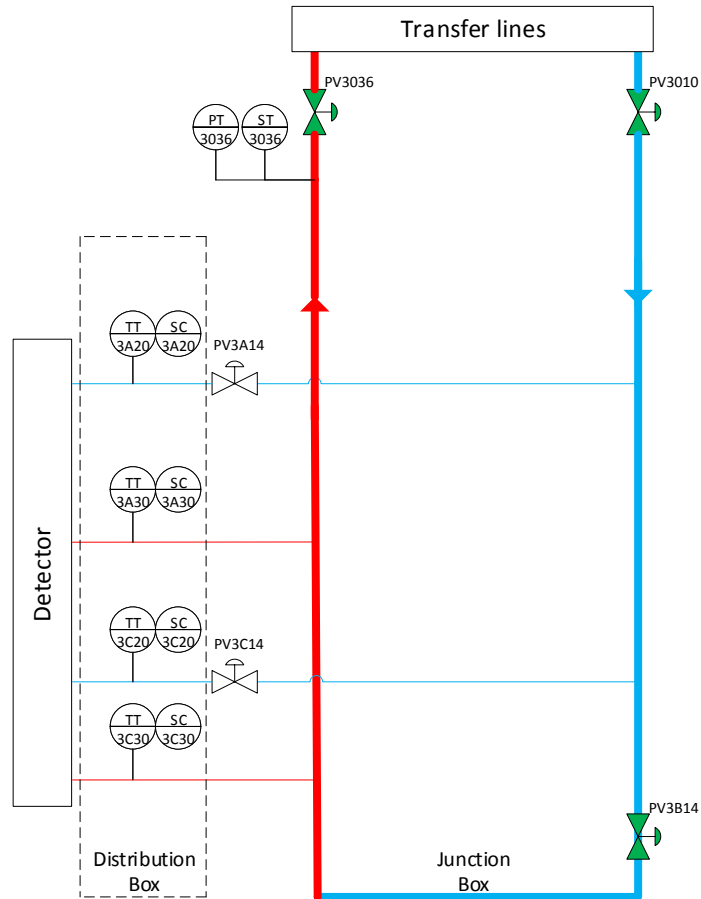
Process Description - JDB

■ Liquefying and Circulation JB

The transition 4 is valid when all the conditions below are fulfilled:

- JDB PCO Run Order status is active
- Valve PV3010 has to be open and the other valves (PV3036, PV3A14, PV3B14 and PV3C14) are still in the same position as in the previous step
- The subcooling values of the supply and return lines (SC3A20, SC3C20, SC3A30, and SC3C30) are higher than a parametrical value (typically set @-4K)
- The specific detector safety system (VSS for VELO and central DSS for UT) is sending the signal to allow cooling flow in the detector

In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



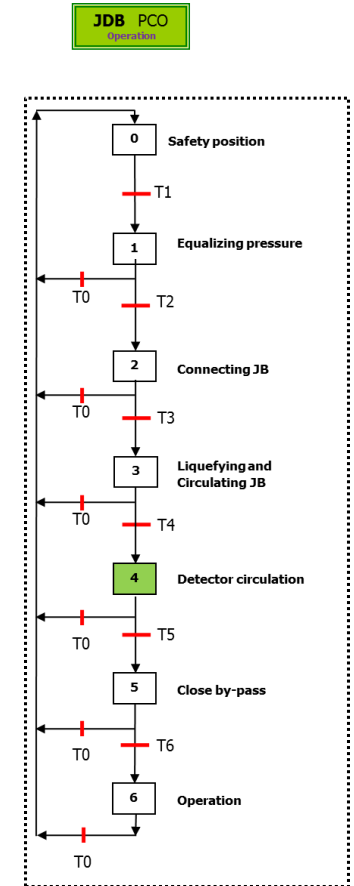
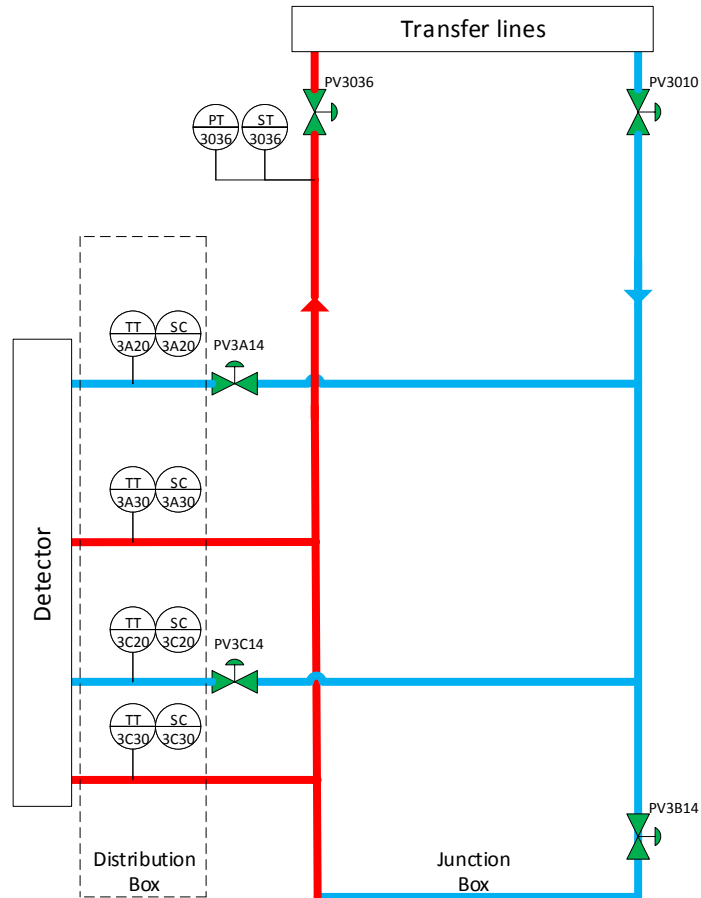
Process Description - JDB

■ Detector Circulation

The transition 5 is valid when all the conditions below are fulfilled:

- JDB PCO Run Order status is active
- PV3A14 and PV3C14 are fully open
- The other valves (PV3010, PV3036 and PV3B14) are still in the same position as in the previous step

In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



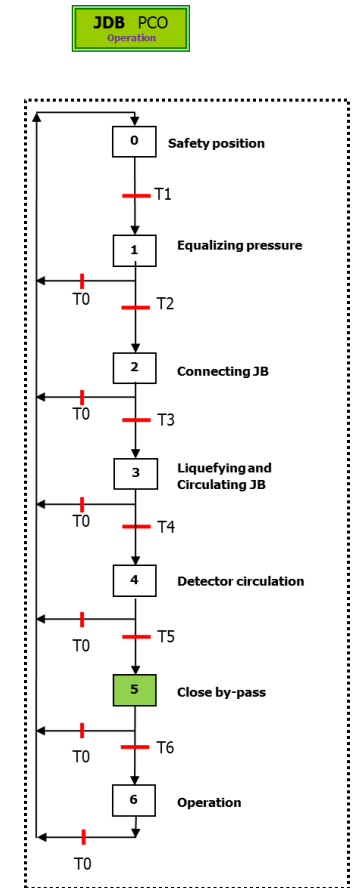
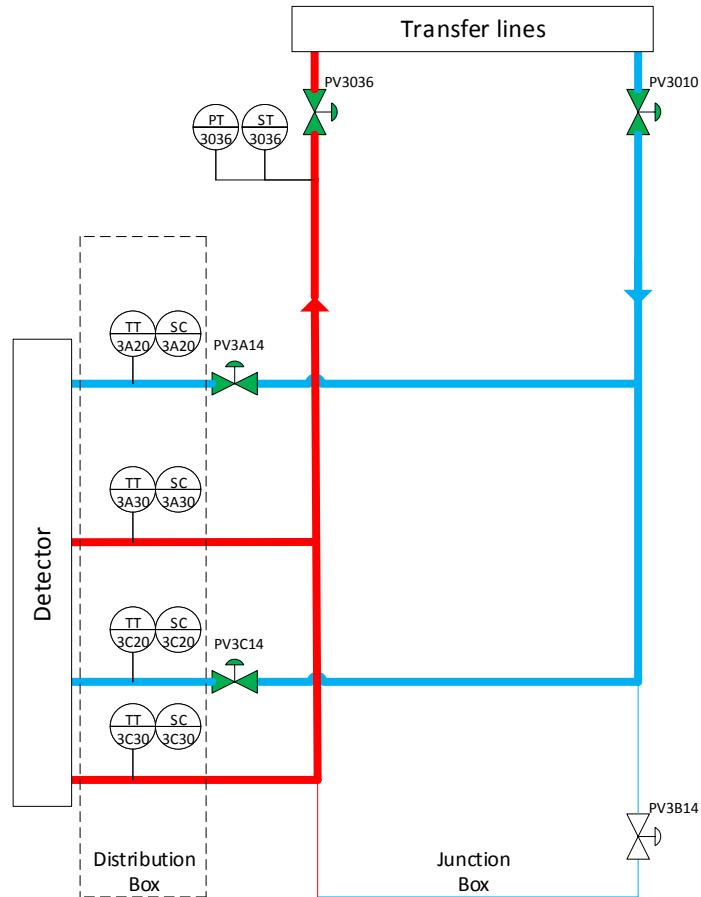
Process Description - JDB

■ Close by-pass

The transition 6 is valid when all the conditions below are fulfilled:

- JDB PCO Run Order status is active
- PV3B14 is fully closed
- The other valves (PV3010, PV303, PV3A14 and PV3C14) are still in the same position as in the previous step

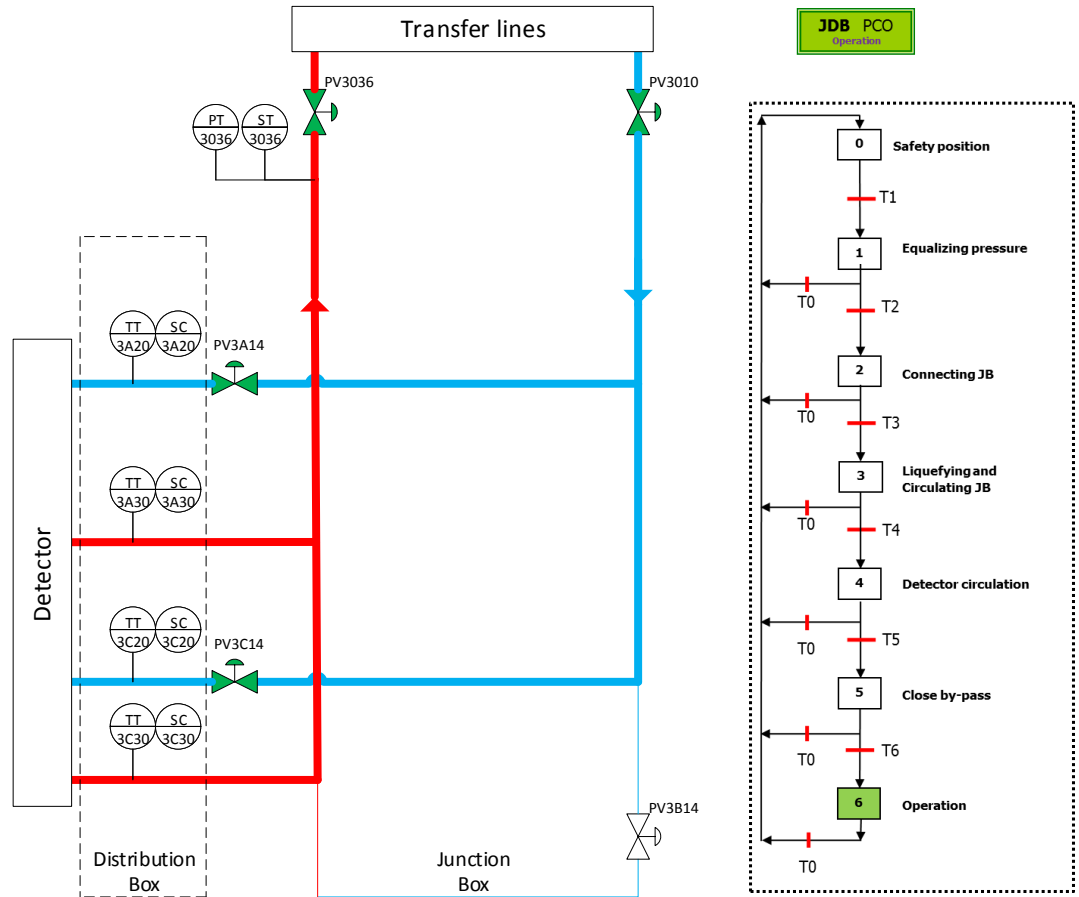
In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



Process Description - JDB

■ Operation

In the case Transition 0 is active, the stepper is going back to its safety position whatever step is executed at the moment. This transition is active in case the JDB PCO is stopped (manual request, full stop interlock...).



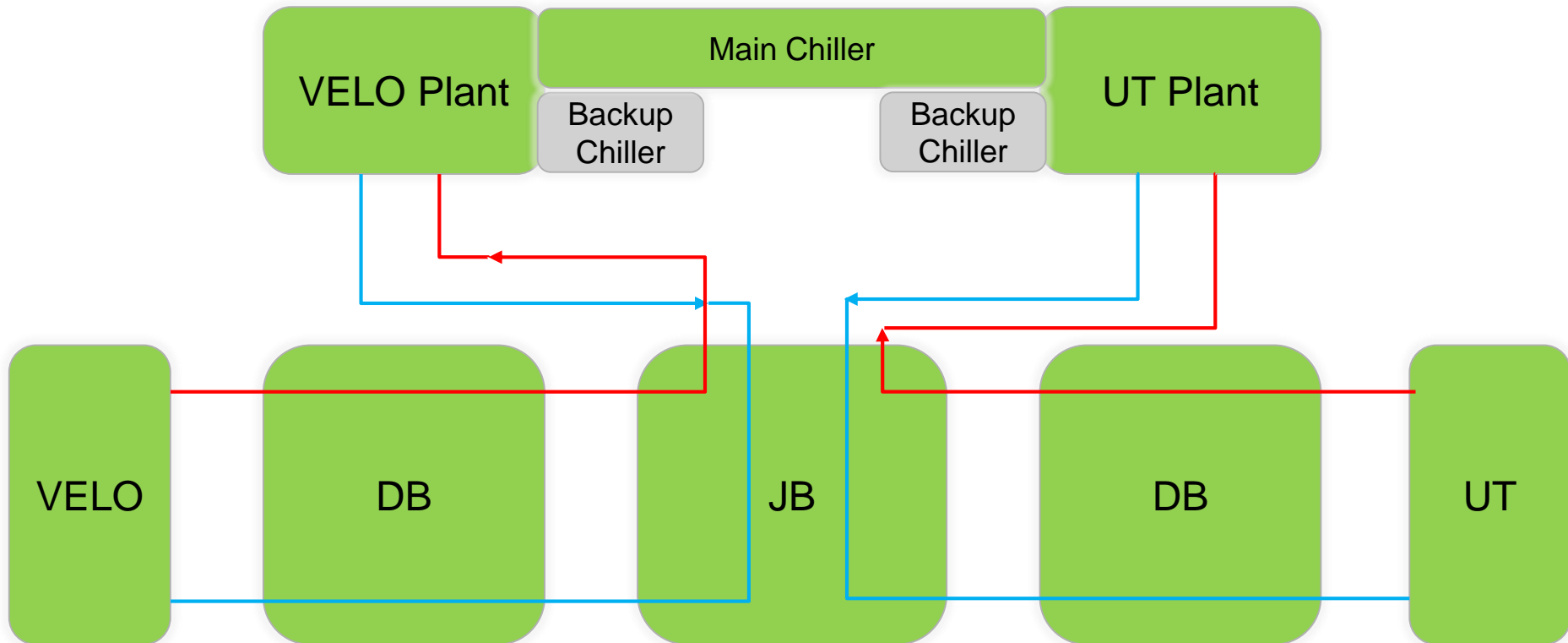
Operation Mode – Normal Operation

VELO Dedicated Parameters:

- Saturation Temperature Setpoint
- Setpoint speed (default: 1C/min)
- Minimal allowed temperature

UT Dedicated Parameters:

- Saturation Temperature Setpoint
- Setpoint speed (default: 1C/min)
- Minimal allowed temperature



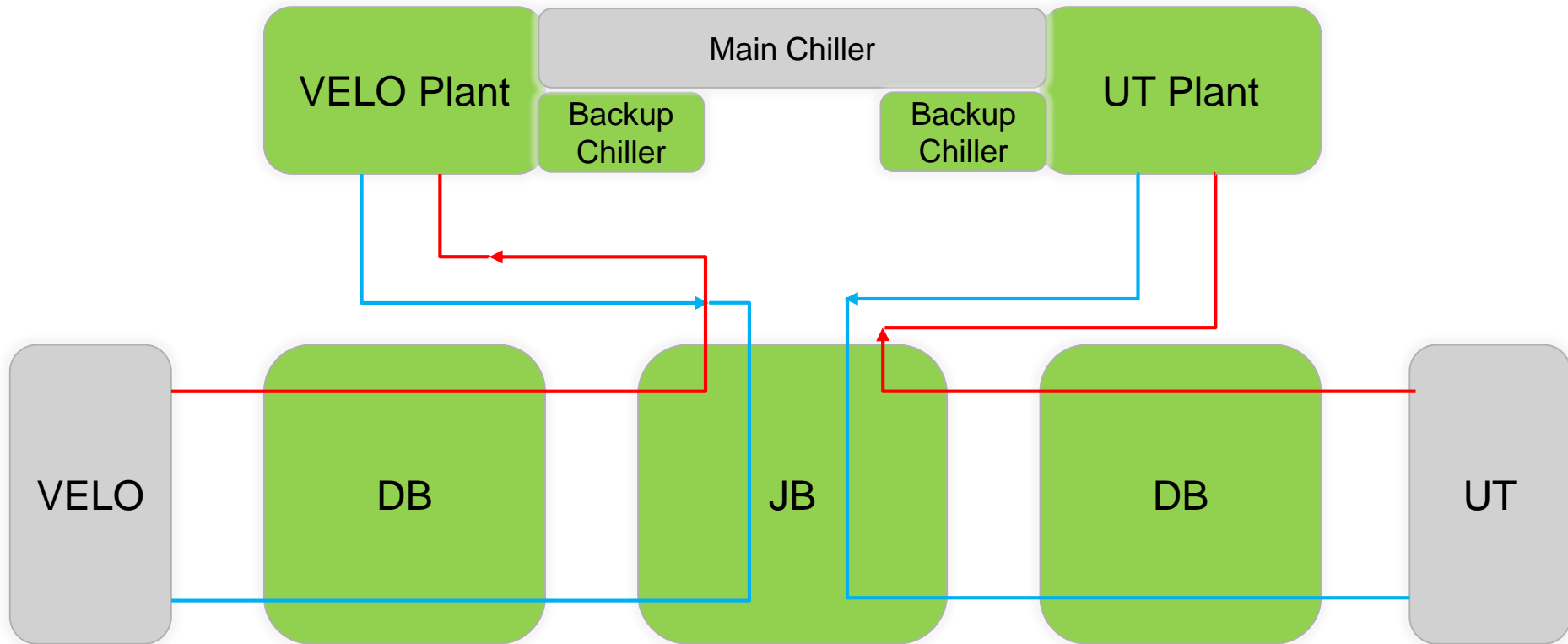
Operation Mode – Normal Operation with Backup Chillers

VELO Dedicated Parameters:

- Saturation Temperature Setpoint
- Setpoint speed (default: 1C/min)
- Minimal allowed temperature

UT Dedicated Parameters:

- Saturation Temperature Setpoint
- Setpoint speed (default: 1C/min)
- Minimal allowed temperature

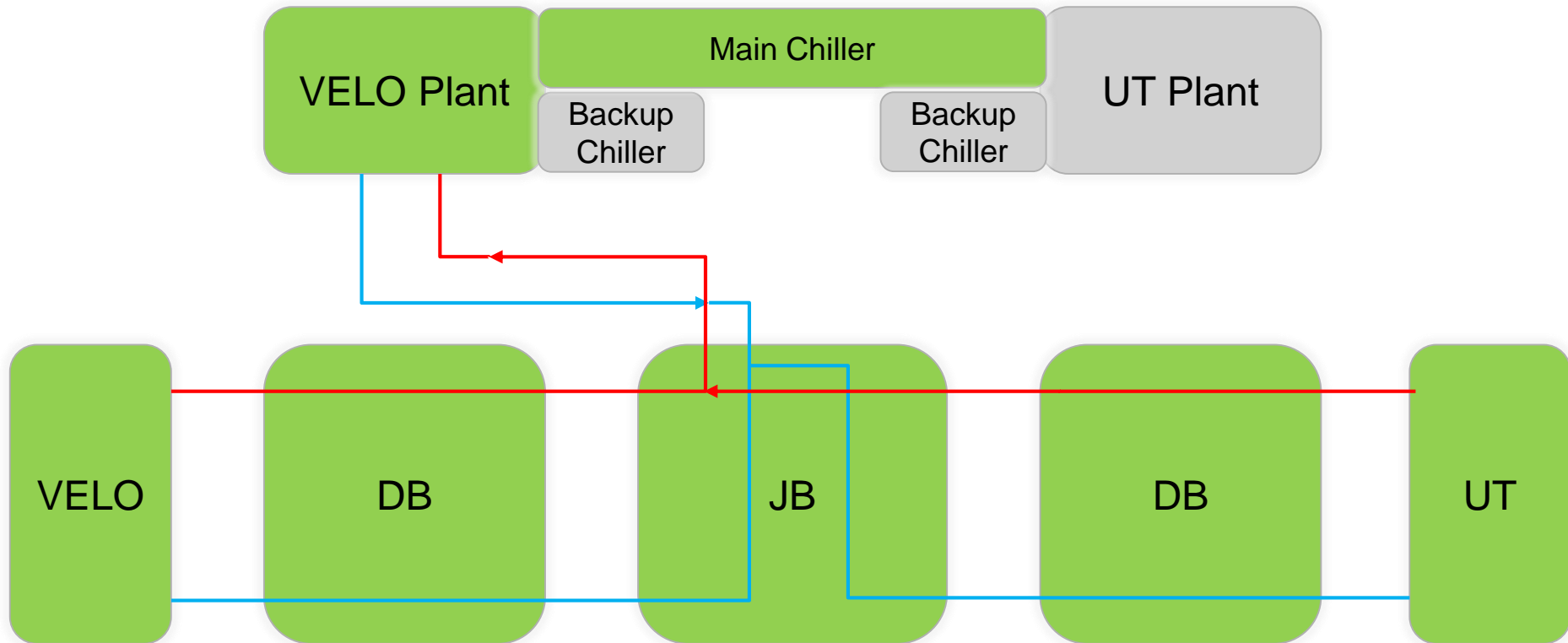


Backup chillers keep detectors cold if they are not running

Operation Mode – Backup mode

VELO & UT Common Parameters:

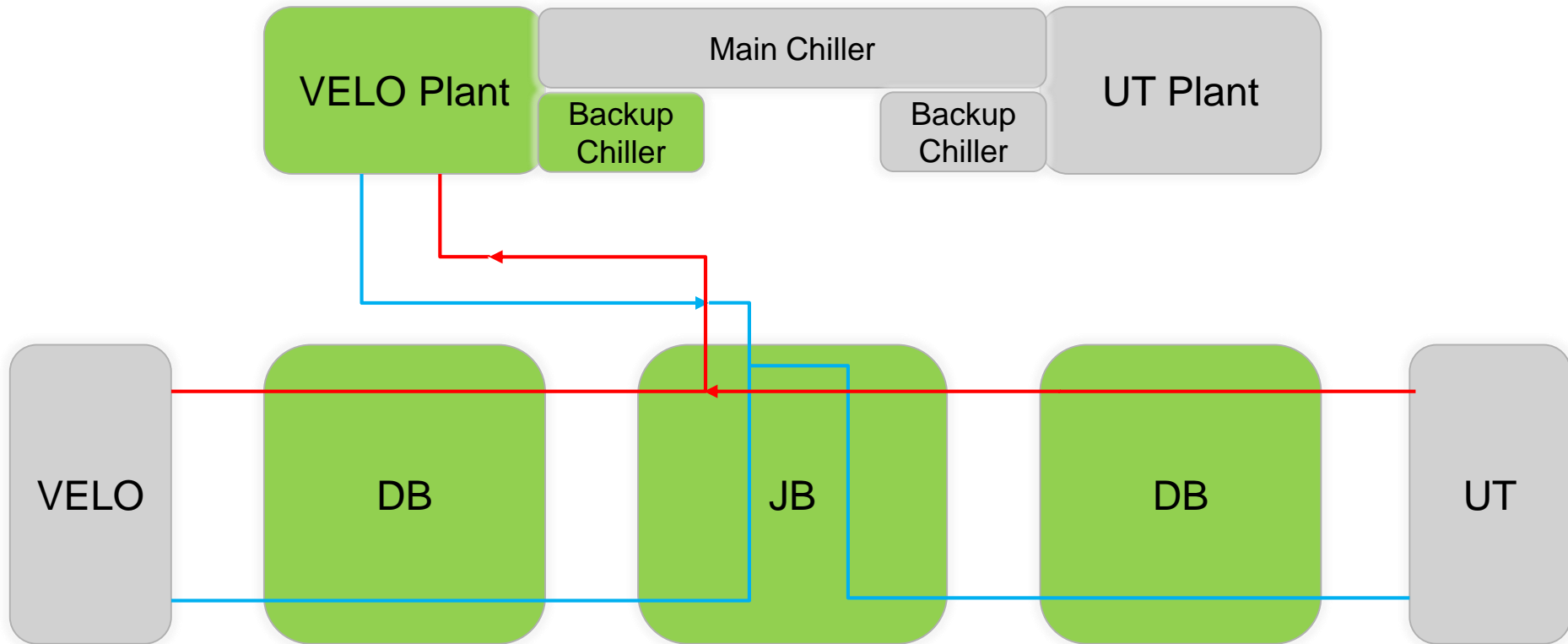
- Saturation Temperature Setpoint
- Setpoint speed (default: 1C/min)
- Minimal allowed temperature



Operation Mode – Backup mode with Backup Chiller

VELO & UT Common Parameters:

- Saturation Temperature Setpoint
- Setpoint speed (default: 1C/min)
- Minimal allowed temperature



Backup chiller keeps detectors cold if they are not running

