New tools for ATLAS DSS

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25 August 23

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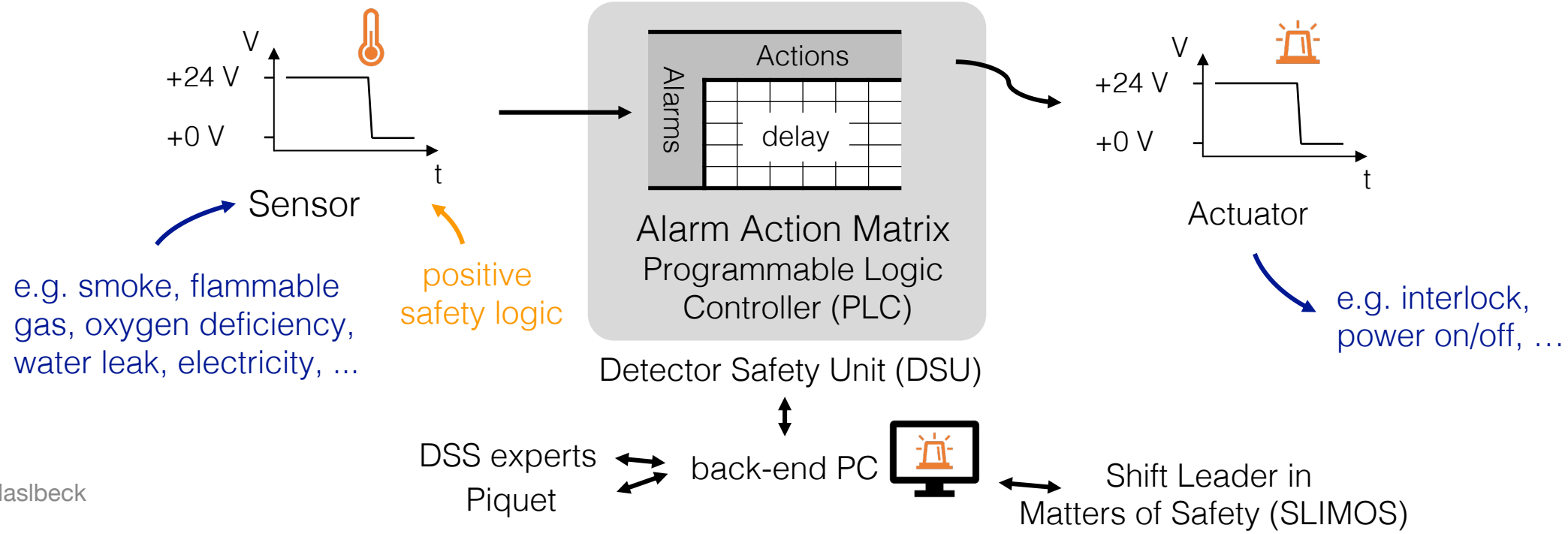
What is the ATLAS Detector Safety System (DSS)?

- hardware-based interlock system shared across LHC experiments
- returns the detector + infrastruture to safe state
  taking predefined “actions” given signal inputs
- any alarm is followed up by operators, and discussed in weekly operations meeting
- inputs + outputs are defined on ”positive safety logic” (low = true, high = false)
  ⇨ trigger also if no power



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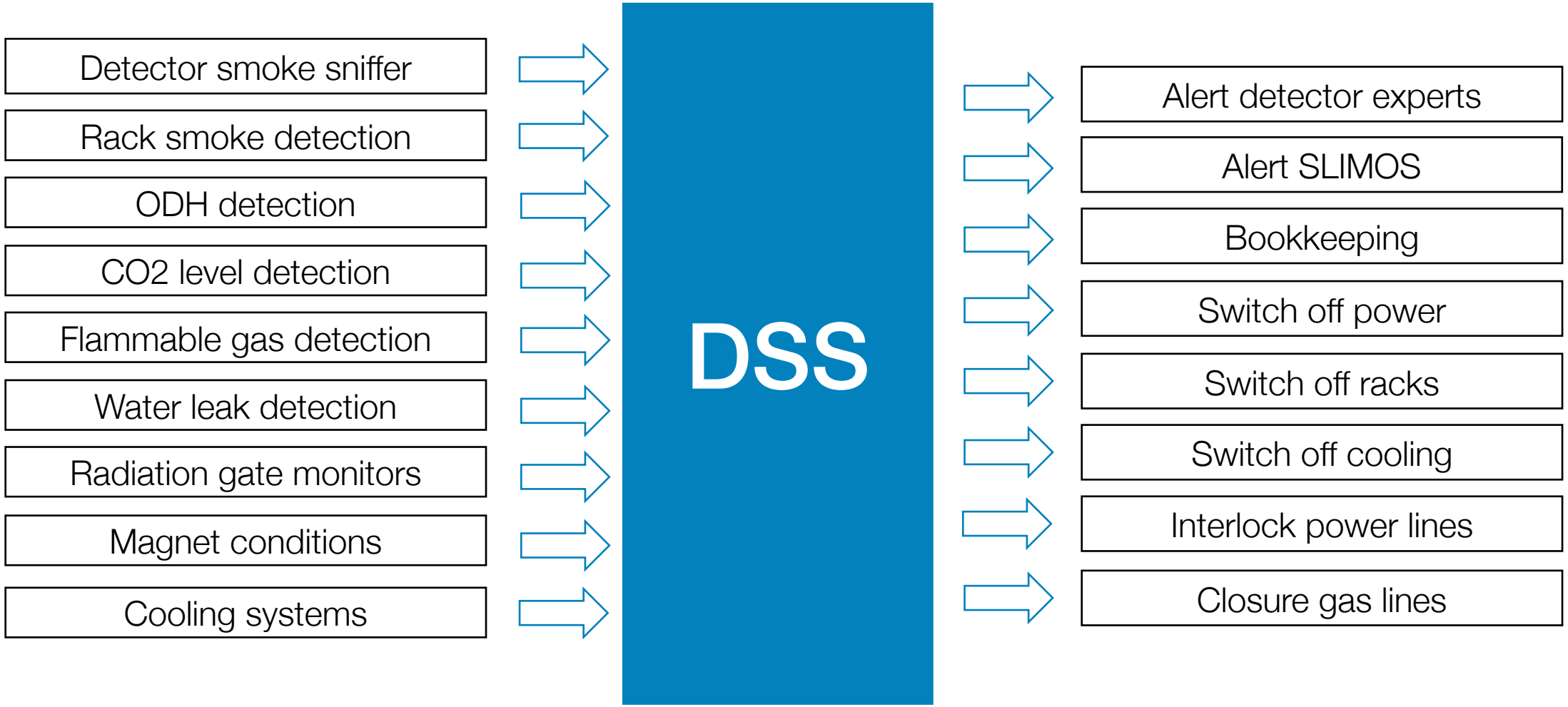


What is the ATLAS Detector Safety System (DSS)?

ATLAS Subsystems are described to varying degree of detail in DSS (alarms and actions)

Human safety is treated by separate system (CSAM) that is linked to firebrigade on-site

DSS alarms are categorised in 4 criticality levels:

Criticality	Description	Total 850	
Level 3	Immediate threat to detector or personnel.	145	→ Fire brigade
Level 2	Medium impact to detector.	595	
Level 1	Contained impact to other systems	65	
Level 0	Purely informative.	34	

A recent example of DSS in action

Smoke event inside the Inner Detector volume

16:02:02 DSS alarm: Stop of the Inner Detector cooling plant

16:07:42 → DSS actions to interlock racks inside Inner Detector

DSS alarm: Smoke inside Inner Detector (Level 2) —also input to→ Fire Brigade is called by separate system (CSAM)

→ DSS actions to interlock power to racks inside Inner Detector volume

16:07:45 DSS alarm: Smoke inside Inner Detector (Level 3)

→ DSS actions cut power to Tile calorimeter, Muon gas

DSS alarm: Smoke in the Inner Detector Macro Area

DSS alarms: Evacuations of the three ATLAS caverns

→ DSS actions cut power to Inner Detector, Pixel and TRT, and Tile Calorimeter

16:08:16 DSS alarm: Stop of Muon gas (TGC) system

What tools do we need and want for DSS

DSS is designed for highest reliability.
Tools are used to understand and predict alarms.

Tools must be:
- very reliable
- easy to understand (by anyone in the control room)
- any uncertainty / interpretation must be left to the operators as they have to take the ultimate decision.

Challenges:

- ATLAS is a highly complex system with many interdependencies
- various degrees of information per sub-system (for DSS)
- small dataset as luckily things work most of the time ;)

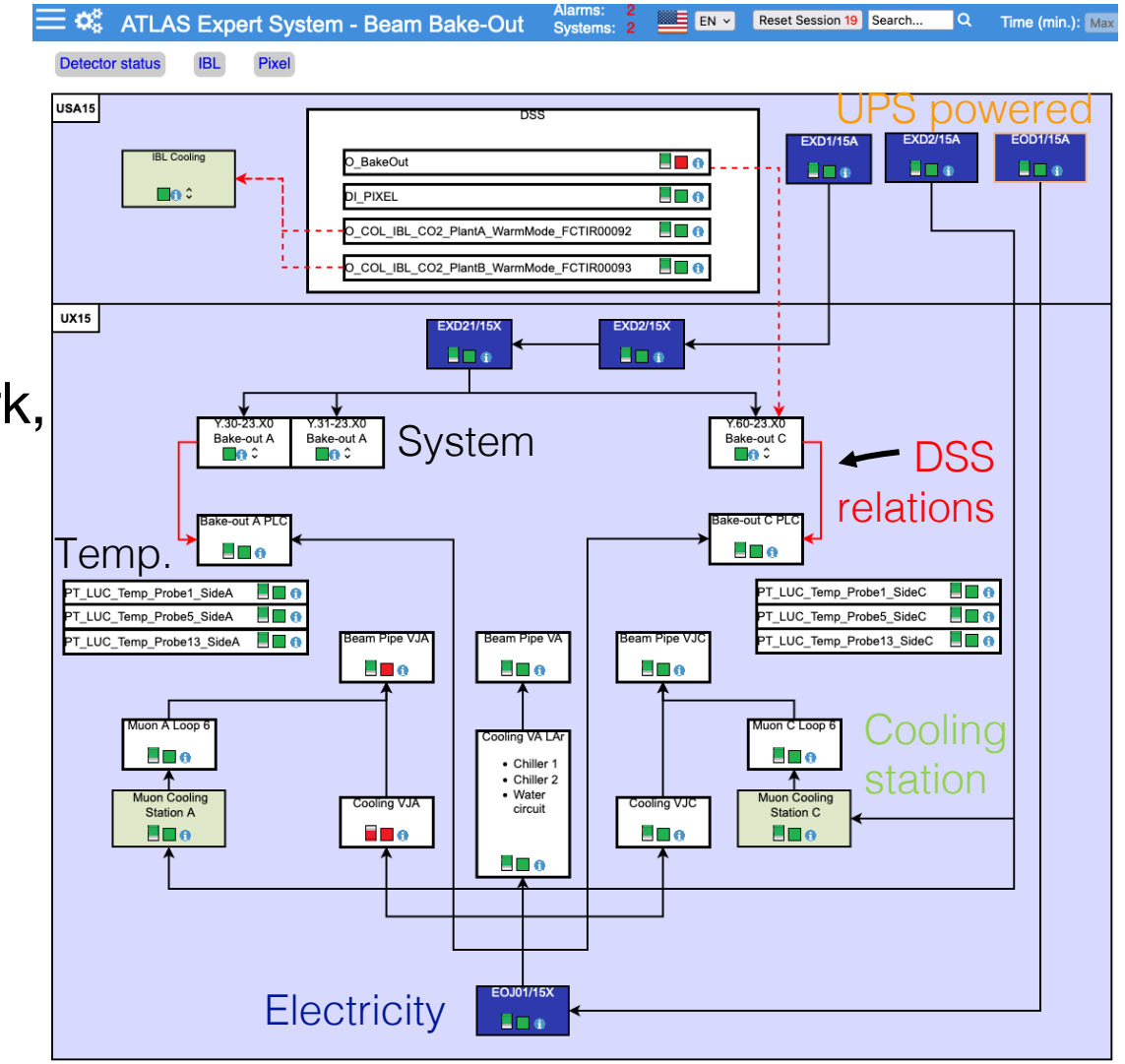
Tools: Technical Coordination Expert System

object orientated,
rule-based description
of detector and infrastructure

- 13000 elements,
  89000 relations
- power, water, gas, network, DSS

accessible via website

is extensively used to predict interventions and
to review events



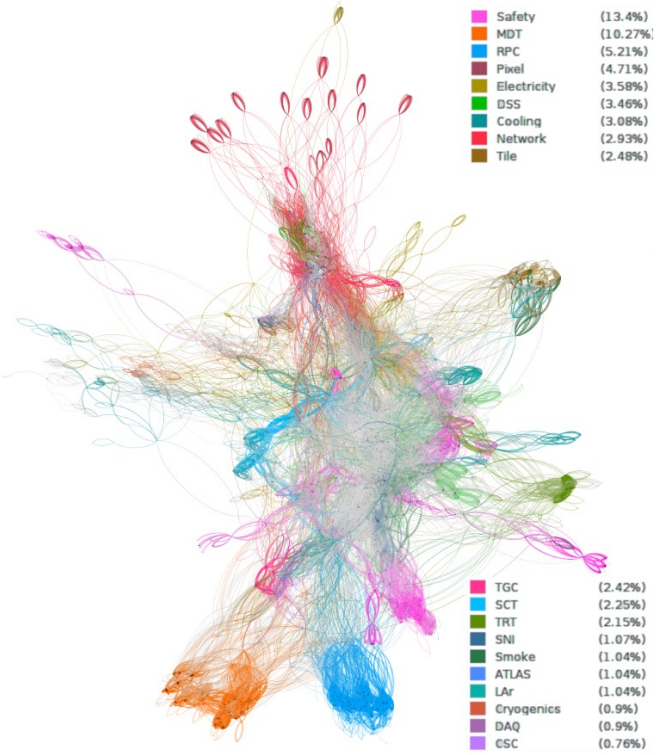
DSS Alarms

Alarms (32) CSV	Status
Search...	
AL_COL_BeamPipe_VA_ChillerFailure	
AL_COL_BeamPipe_VJA_CoolingNotRunning	
AL_COL_BeamPipe_VJC_CoolingNotRunning	
AL_COL_IBL_CO2_CoolingNotReady	
AL_COL_IBL_CO2_CoolingNotRunning	
AL_COL_IBL_CO2_PlantA_NOTinBakeOutMode	
AL_COL_IBL_CO2_PlantB_NOTinBakeOutMode	
AL_Emergency_ATLAS_OFF	
AL_INF_BakeOut_EmergencyStop	
AL_INF_Smoke_USA15_2Areas	
AL_INF_Smoke_USA15L3_CVArea	
AL_INF_Smoke_UX15	
AL_INF_US15_Flooding	
AL_INF_USA15andUX15_Flooding	
AL_LUC_TempTooHigh_SideA	
AL_LUC_TempTooHigh_SideC	
AL_PIX_IBL_Temperature_Interlock	
AL_PIX_Temperature_Interlock	
AL_SN2_Smoke_InnerDetectorA	
AL_SN2_Smoke_InnerDetectorC	
AL_SN3_Smoke_BWA_and_BWC	
AL_SN3_Smoke_CentralTrench	
AL_SN3_Smoke_InnerArea_and_BWA	
AL_SN3_Smoke_InnerArea_and_BWC	
AL_SN3_Smoke_InnerArea_and_MuonBarrel	
AL_SN3_Smoke_InnerDetector	
AL_SN3_Smoke_MacroArea_BWA_2alarms	
AL_SN3_Smoke_MacroArea_BWC_2alarms	
AL_SN3_Smoke_MacroArea_InnerArea_2alarms	
AL_SN3_Smoke_MacroArea_MuonBarrel_2alarms	
AL_SN3_Smoke_MuonBarrel_and_BWA	
AL_SN3_Smoke_MuonBarrel_and_BWC	

atlas-expert-system.web.cern.ch/

Tools: Most probable cause algorithm

Get possible points of failures for affected systems based on Expert system description



Graph representation of Expert system databse

idea:
traverse graph, identify the common predecessors of affected systems from predecessors

Problems:

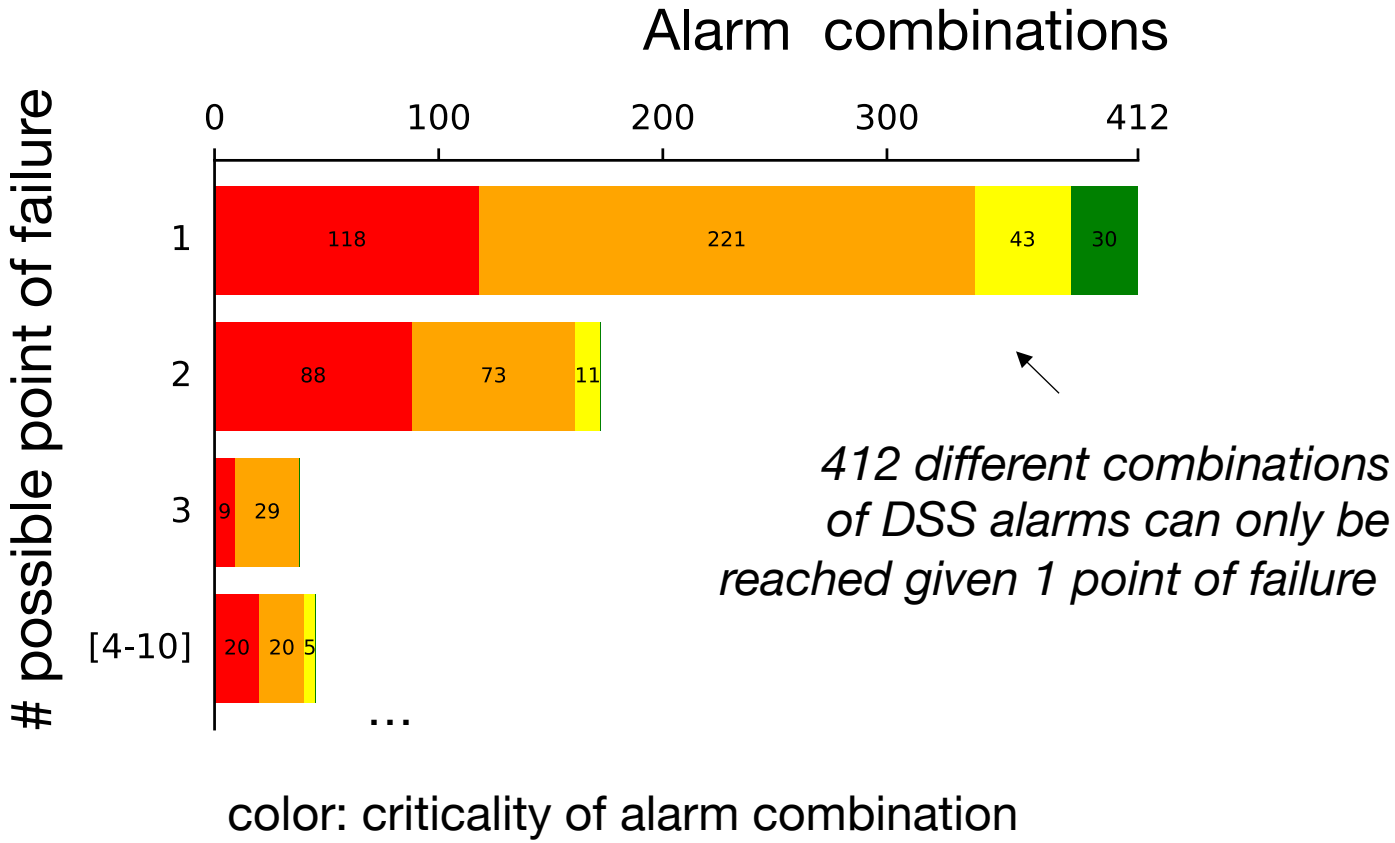
- graph is imbalanced as sytems are described to different detail (⇨biased sorting)
- graph iteration can become slow
- current algo. can returns O(100) points of failure if any object is already off or alarm was triggered before

Tools: pre-calculated simulation

Speed up MPC tool by pre-calculating some simulations:

Simulate switching off each element individually
and store any switched off elements.

many failures have “unique” alarms
⇨ map DSS alarms to failure



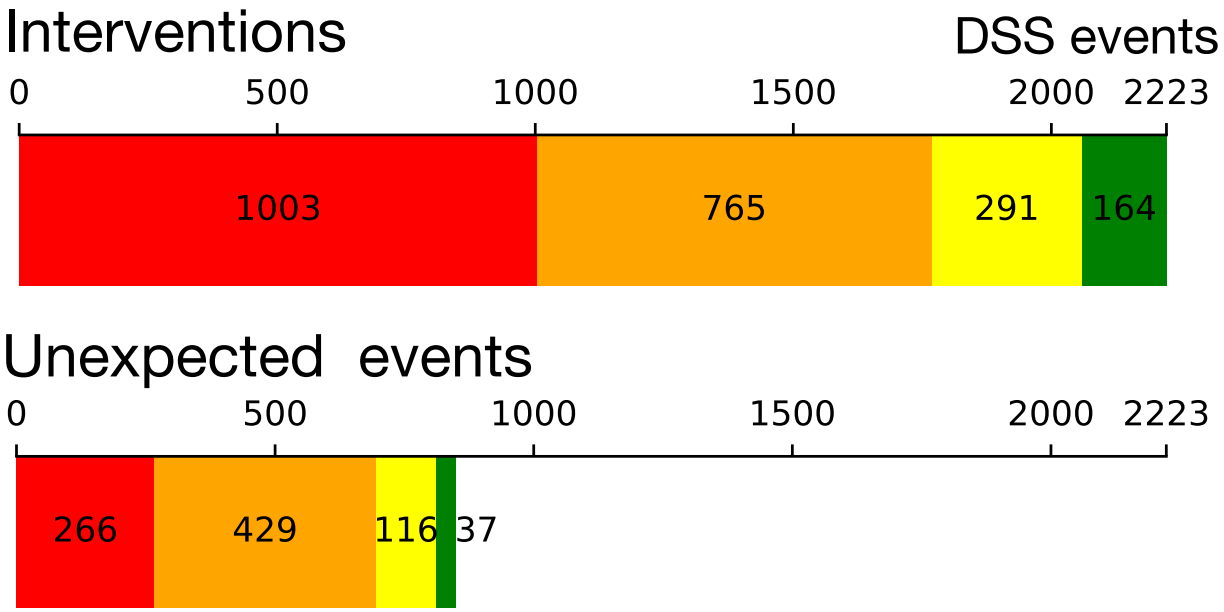
Tools: Alarm helper (in development)

Alarms can be caused accidently, e.g. switch off of a system

Current tools have no access to historical events.

Event analysis:
Use weekly review of events (2018 – 2023) to categorise in
- intervention: due to repairs, maintenance etc
- unexpected: errors and faults

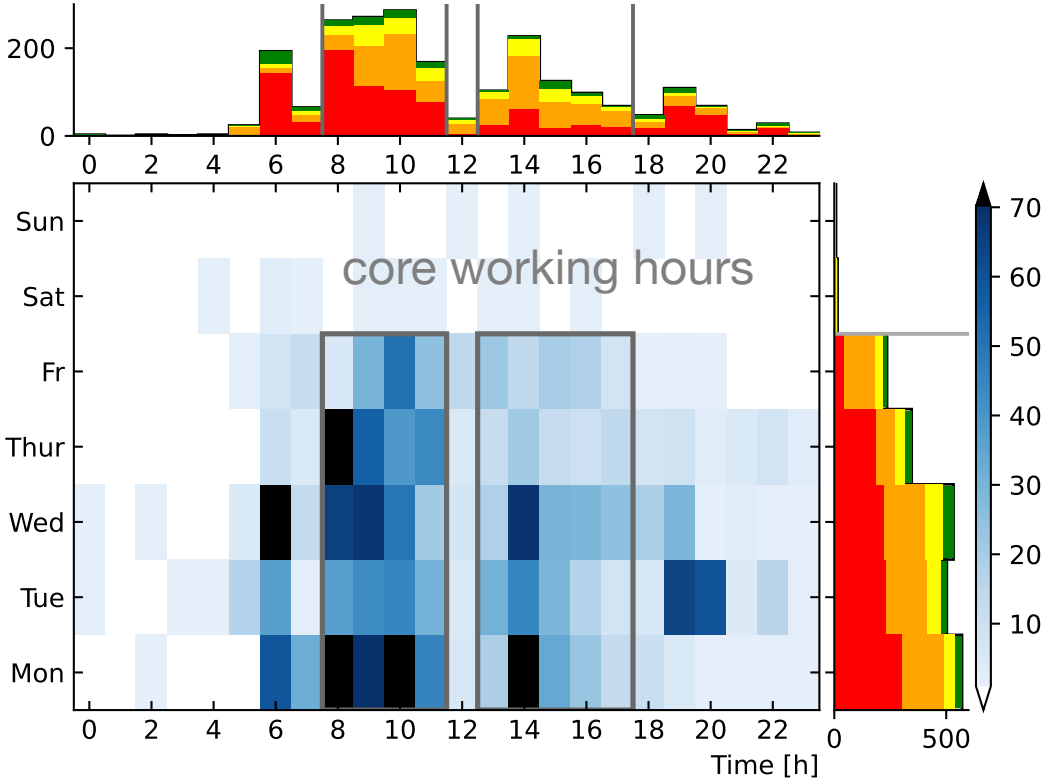
⇨ majority of events are caused by interventions!
⇨ ”false” alarms can damage detector (e.g. cooling) and lessen attention



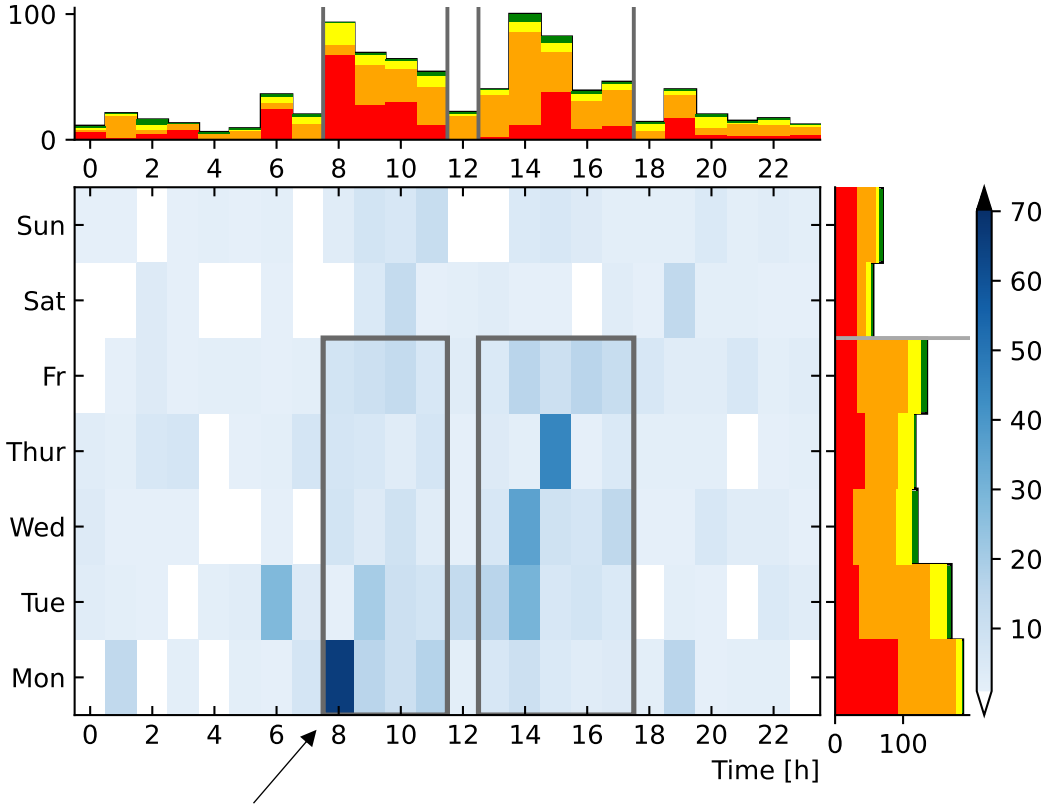
Tools: Alarm helper (in development)

Time analysis of events

Interventions



Unexpected events

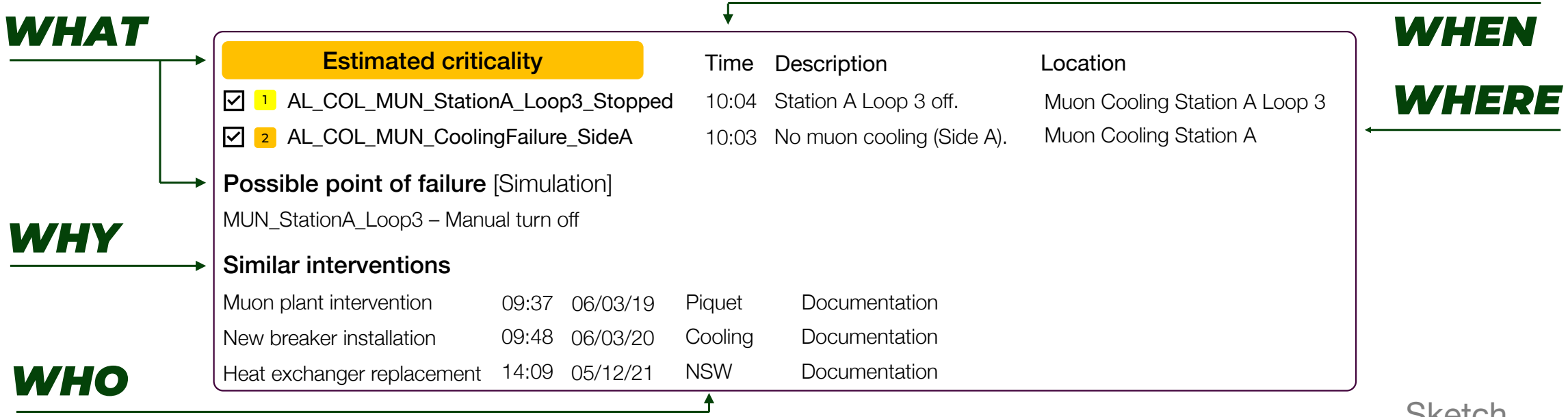


might be taken wrongly as intervention!

Tools: Alarm helper (in development)

New database with historical events (and particular the impact of interventions!)

Publish similar events and other useful information (e.g. ongoing interventions) in website.
Use Expert system, MPC, tabulated simulation, documention, …



Sketch

Tools: Alarm helper (in development)

Knowing the impact of interventions can help optimising planning

Idea: autogenerate weekly forecasts that can be used in weekly reviews.

Conclusion

- DSS: reliable, hardware based system to keep ATLAS safe
- majority of alarms are currently caused by interventions
- tools are used to find point of failure and to predict impact of interventions
- various challenges make “traditional” MVA hard
- looking forward to your ideas and inputs!