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SPALLATION
SOURCE

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Student projects in ML at ESS

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European Spallation Source

Mission: Design, build, and operate a world leading research facility using neutron scattering techniques

2003
Concept design of ESS presented

2009
Decision to site ESS in Lund

2012
ESS design update phase complete

2014
Start of construction

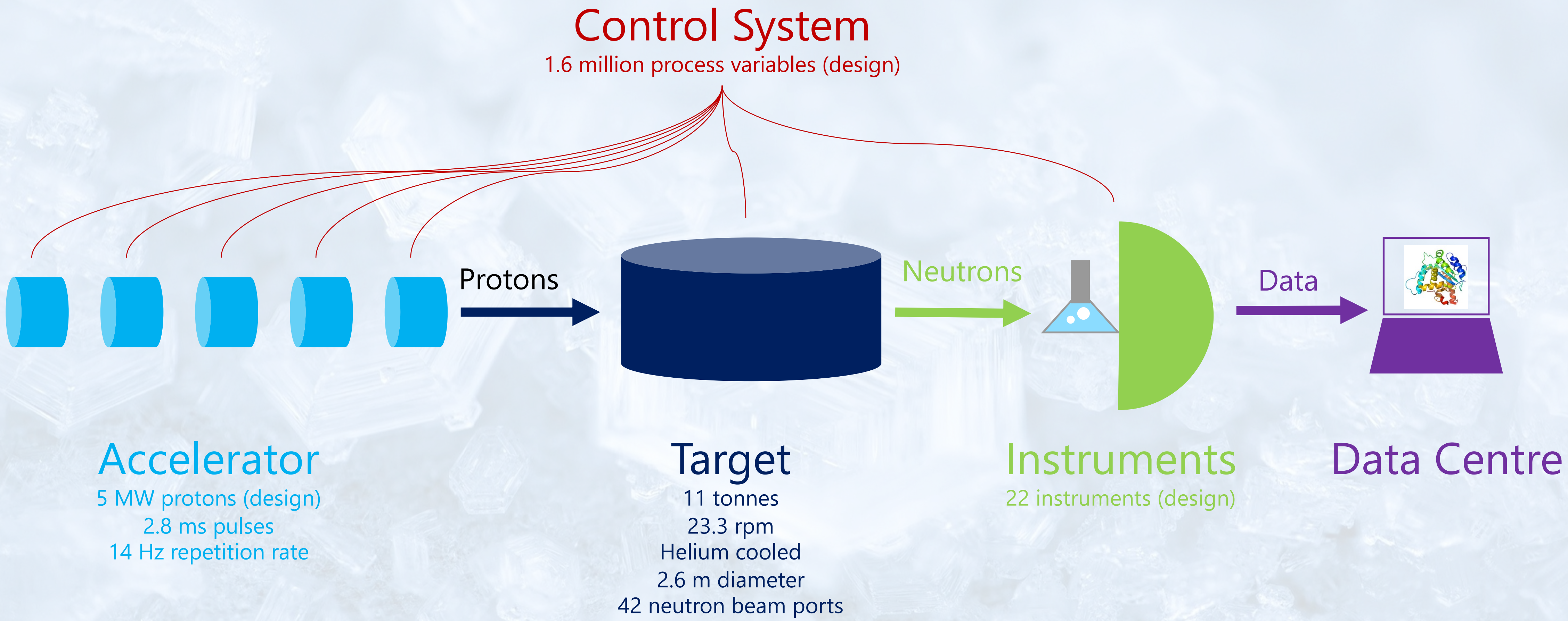
2019
Start of initial operations phase

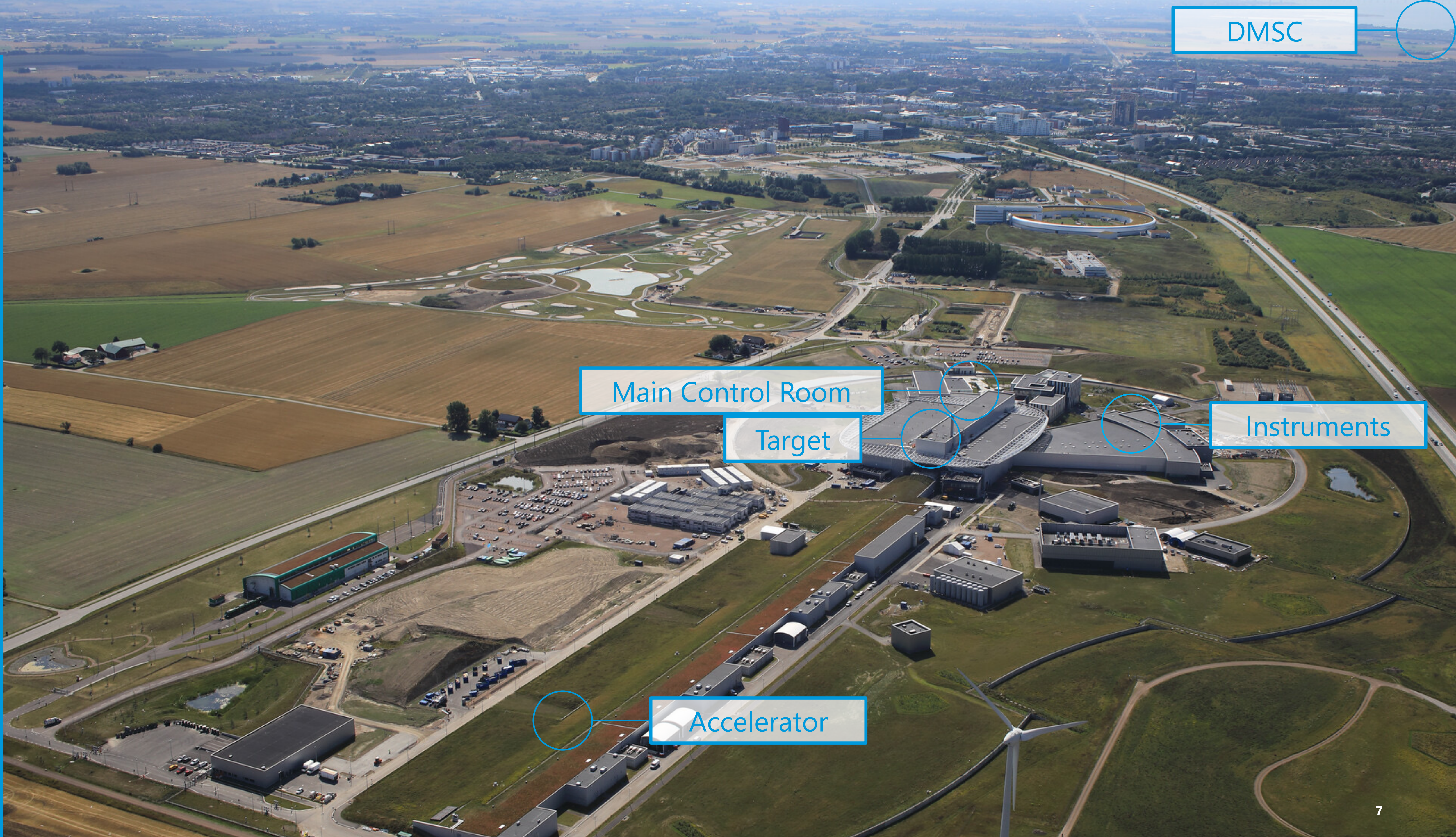
2027
First science

Video: Courtesy of PSI


MEDICINE & HEALTH
Drug development
New generation MRI
Cellular biology
ENERGY
Better batteries
Green fuel
Improved solar cells
ENGINEERING
Lighter, stronger materials
Superconductivity
Better catalytic systems
WORLD AROUND US
Advanced data storage
Disease resistant crops
Examining artefacts

The ESS Machine



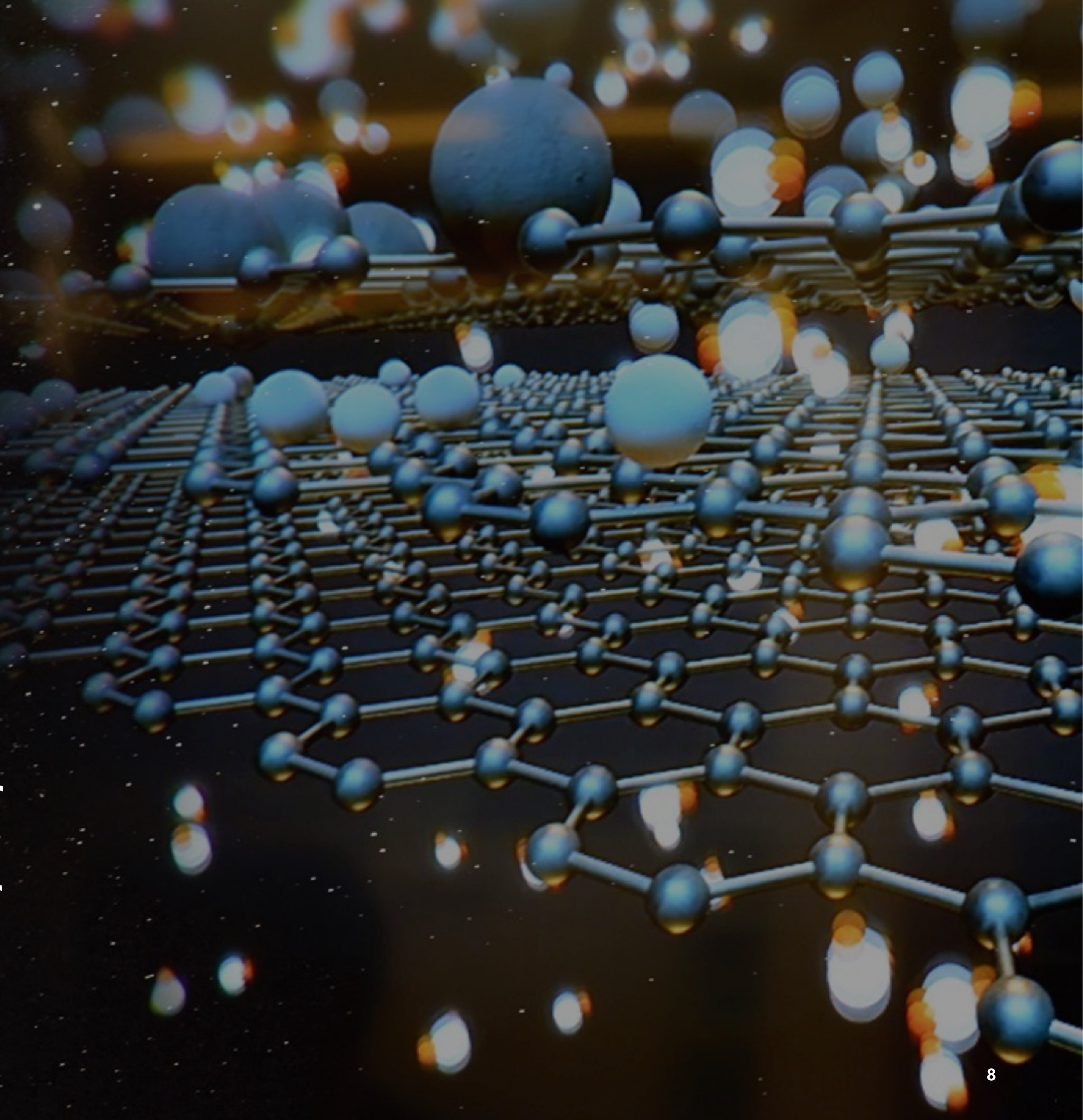

DMSC
Main Control Room
Target
Instruments
Accelerator

ESS is a *user facility*.

Scientists from all over the world will be welcomed to ESS with their specimens to do experiments.

Expectations:

- 800 experiments per year
- 3 000 guest scientists per year



Challenges

- Accelerator – based facilities are some of the worlds most complex systems
- ESS is a user facility with a 95% availability goal
  - High availability requirements on equipment
  - The control system plays a key role for the availability of the facility

Control System Machine Learning Project

2019 - 2023

Explore if machine learning can be used to:

- Increase facility availability.
- Increase efficiency of operation
- Enhance process understanding
- Lower operational and maintenance costs
- Decrease commissioning time

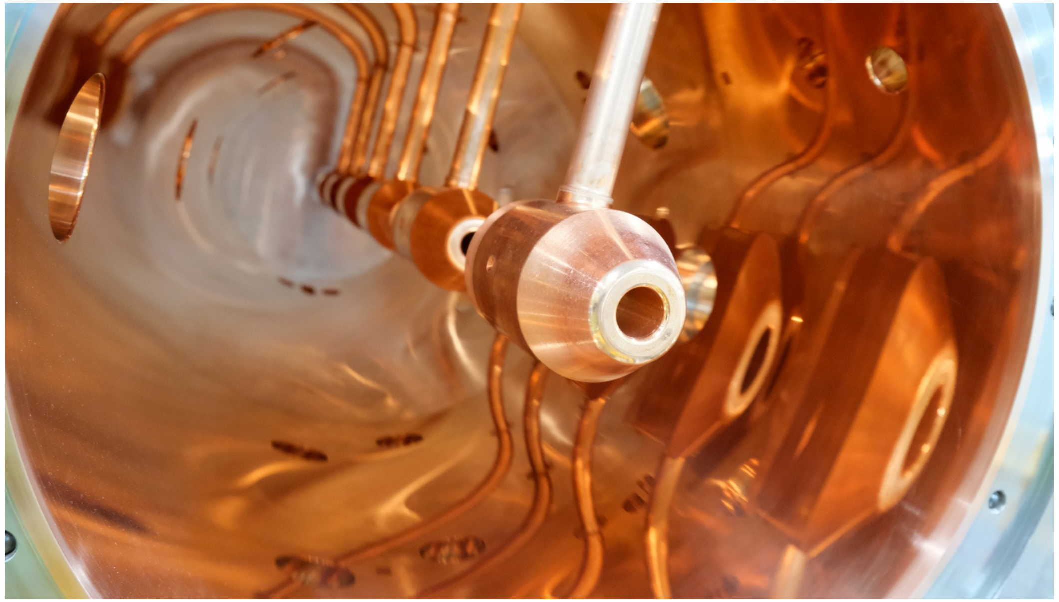
Student Project: Tuning the DTL

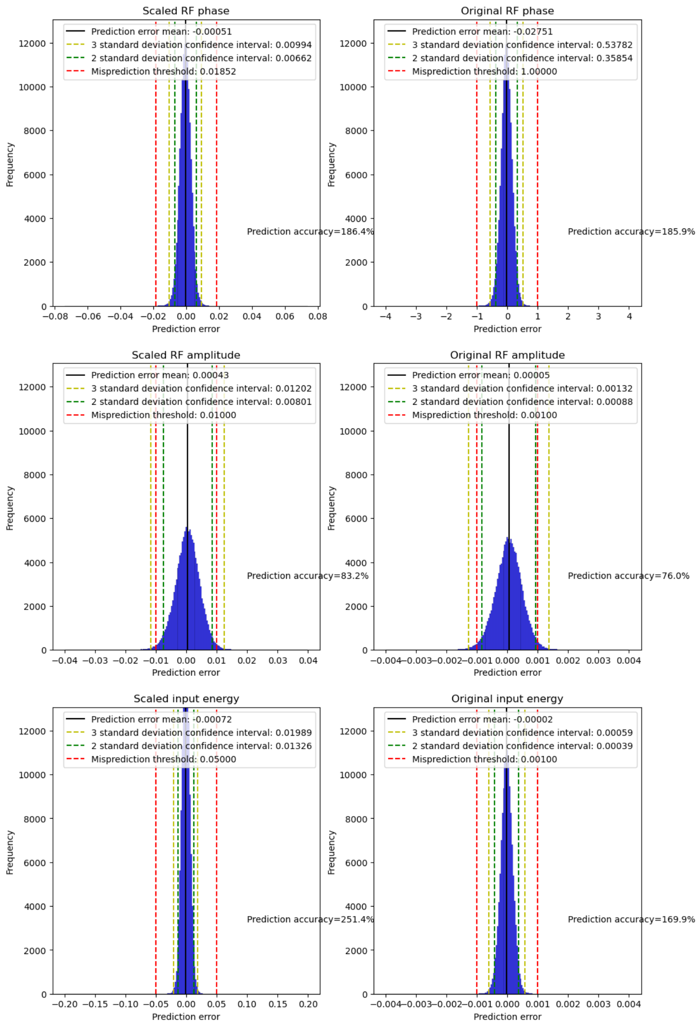
Developing an ML-based model for RF tuning of DTL machine at ESS

Institute: Automatic Controls LU

Course: Master's Program in Machine Learning, Systems and Control

ESS Supervisor: Natalia Milas (accelerator)

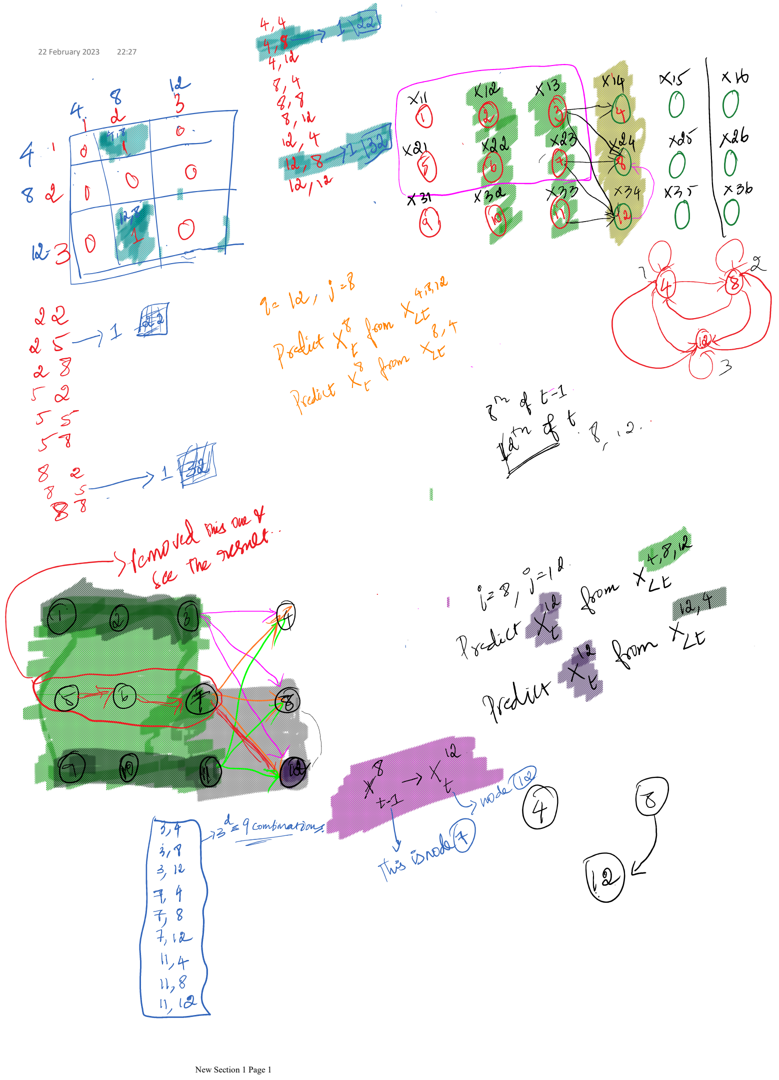




Student project: Alarms

Causal event processes and alarm analysis at ESS

- Department: Automatic controls, Lund University.
- Degree: MsC in Machine Learning, Systems and Control



Student Project: Alarm Cascades

https://drops.dagstuhl.de/opus/volltexte/2023/19098/

Common Alarm Problems

- Many alarms are unnecessary
- Some alarms are missing
- Many alarms have badly tuned parameters
- Some alarms has a higher priority than others.
- Many alarms are only relevant in certain operational states
- A fault often leads to several consequences

Analyzing Complex Systems with Cascades Using Continuous-Time Bayesian Networks

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Abstract

Interacting systems of events may exhibit *cascading* behavior where events tend to be temporally clustered. While the cascades themselves may be obvious from the data, it is important to understand which states of the system trigger them. For this purpose, we propose a modeling framework based on *continuous-time Bayesian networks* (CTBNs) to analyze cascading behavior in complex systems. This framework allows us to describe how events propagate through the system and to identify likely *sentry states*, that is, system states that may lead to imminent cascading behavior. Moreover, CTBNs have a simple graphical representation and provide interpretable outputs, both of which are important when communicating with domain experts. We also develop new methods for knowledge extraction from CTBNs and we apply the proposed methodology to a data set of alarms in a large industrial system.

2012 ACM Subject Classification Mathematics of computing → Markov processes; Mathematics of computing → Bayesian networks

Keywords and phrases event model, continuous-time Bayesian network, alarm network, graphical models, event cascade

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1 Introduction

Many real-world phenomena can be modeled as interacting sequences of events of different types. This includes social networks where user activity influences the activity of other users [11]. In healthcare, patient history may be modeled as a sequence of events [46]. In this paper, we focus on an industrial application in which the events are alarm signals of a complex engineered system. As an illustration, consider Figure 1. Three different alarms (*A*, *B*, and *C*) monitor a process each within an industrial system. These processes may, for instance, represent measured temperatures or pressures. An alarm transitions to *on* when its the process it monitors leaves a prespecified range of values and transitions to *off* when the

30th International Symposium on Temporal Representation and Reasoning (TIME 2023).
Editors: Alexander Artikis, Florian Bruse, and Luke Hunsberger; Article No. 8; pp. 8:1–8:21
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LIPICS Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

Student project: Anomaly detection

https://gupea.ub.gu.se/handle/2077/78206

Title: A Software Process Workflow for Smart Anomaly Detection Systems

Degree: BSc Software Engineering and Management

ESS Supervisor: Target division and ICS

University: Chalmers and Göteborg University

Next Project

Find a system owner with a problem to solve and data.

- Coupler motors in the super conducting cavities?
- Vibrations target wheel?
- Camera control sampling environment?

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