Introduction

Data Science and Machine Learning Workshop

M. Gonzalez-Berges
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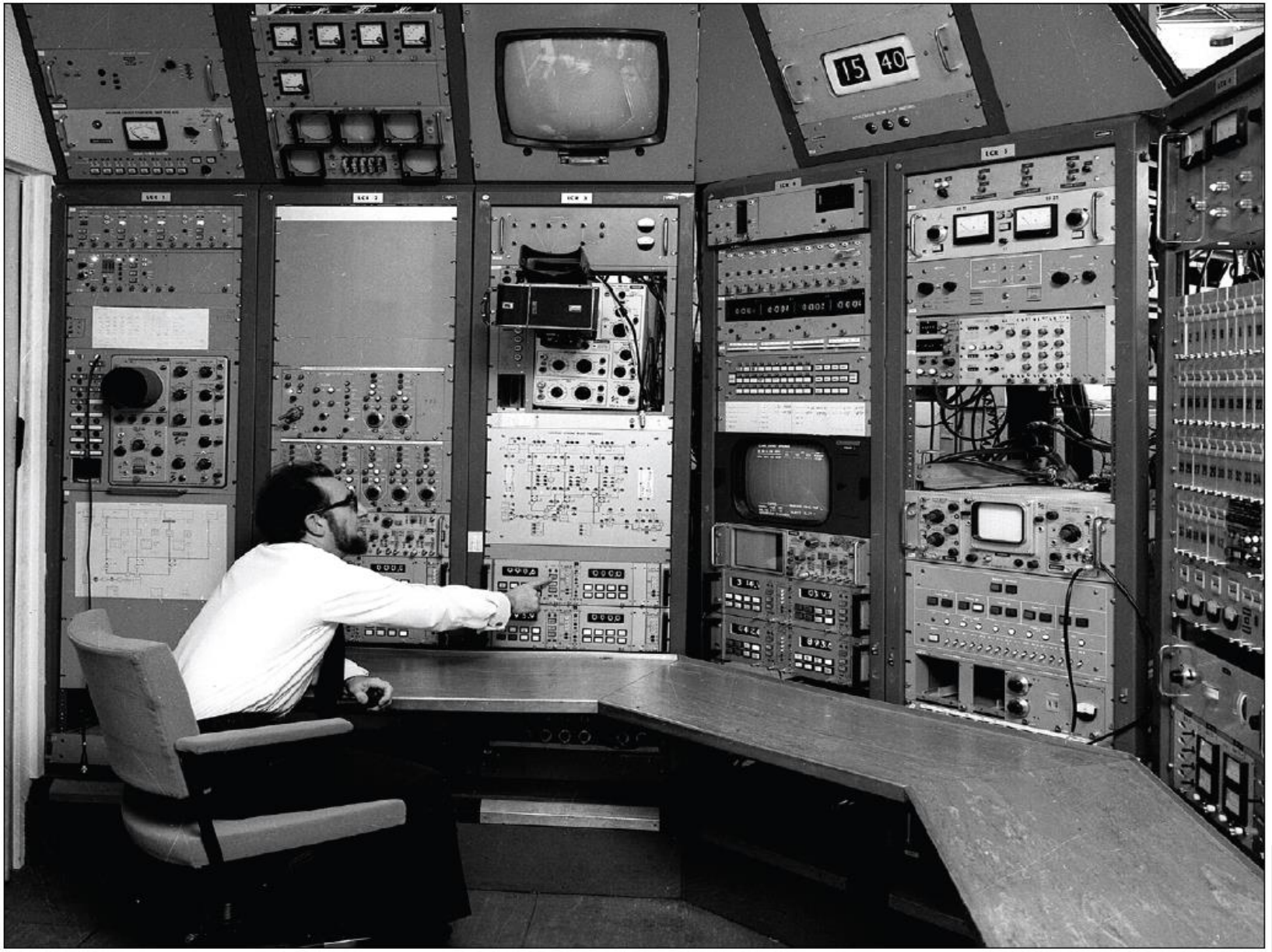
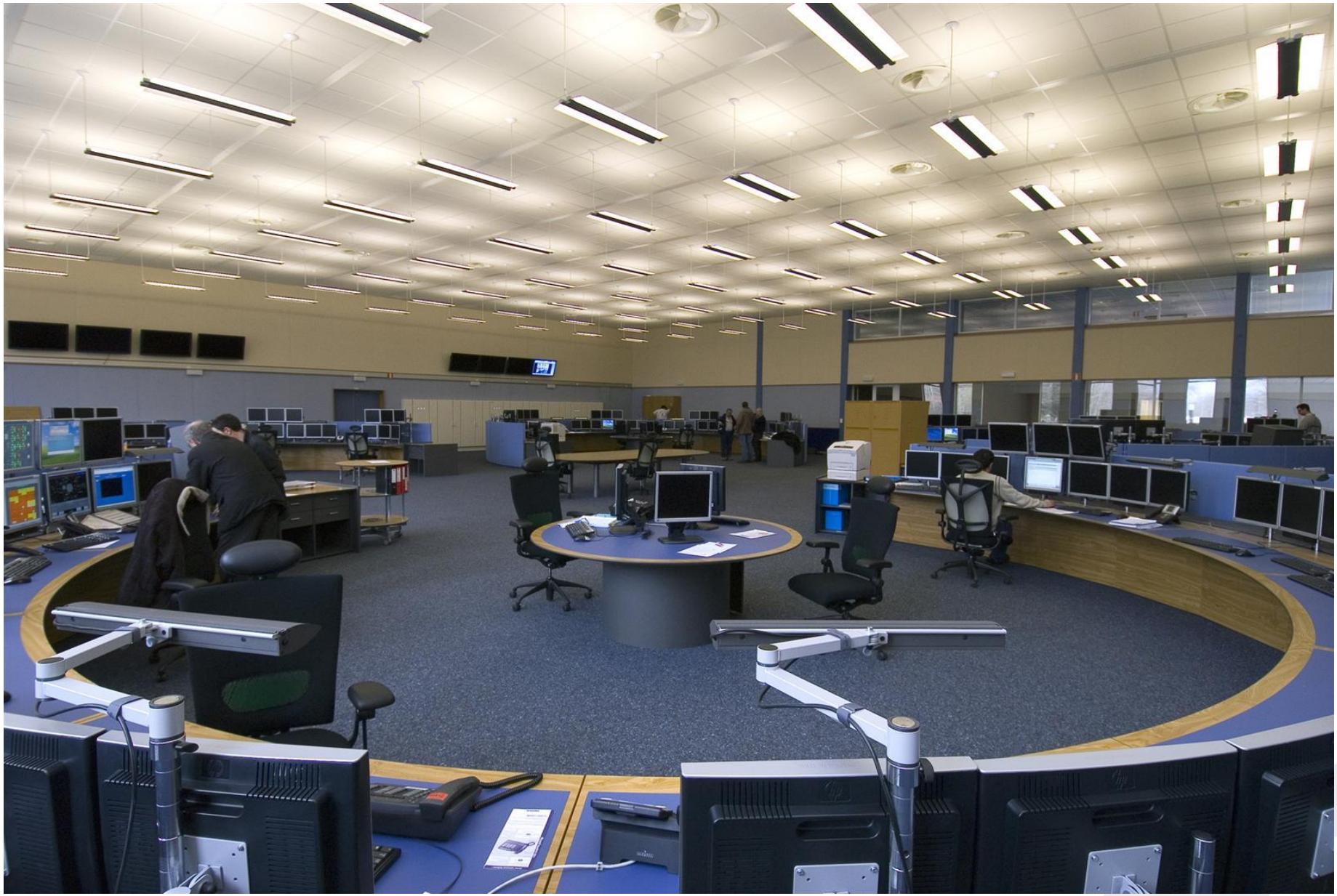
The Control Room '70s
the Analog Age

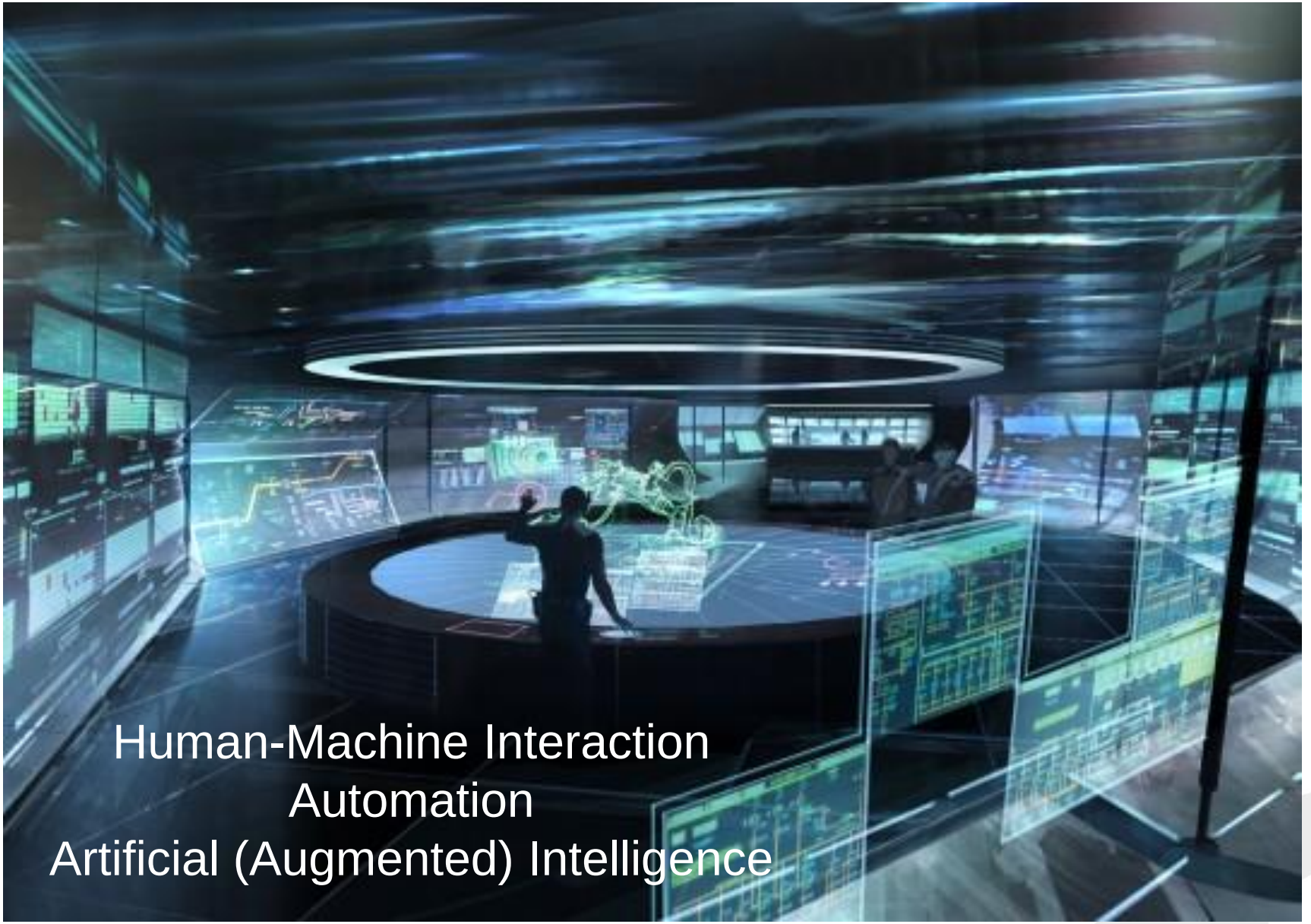


The Control Room '80s
the Digital Age

The Control Room '90- now the Communication Age



Control Room in the future
the Cognitive Age



Increasing interest in AI

- European Commission view of Artificial Intelligence (Joint Research Centre - JRC):
  "*The digital transformation of society has just begun: AI is central to this change and offers major opportunities to improve our lives*"

- USA is the first country to have developed a strategic plan for AI in 2016
- China has started a Development Plan for AI with the goal to become the world leader in AI by 2030

- USA Government Investments (Science Foundation, DARPA and Department for Transportation): US$ 5.3 billion
- MIT (Massachusetts Institute of Technology) has announced an investment of US$ 1 billion and the creation of 50 new chairs
- European Union has decided to increase the budget for AI in Horizon 2020 up to € 1.5 billion
- UK announced a new investment of € 1 billion, Germany € 3 billion, France € 1.5 billion, ...

but !!

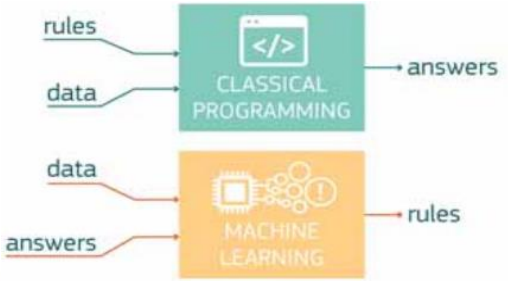
- Amazon investments in R&D: US$ 16.1billion in 2017

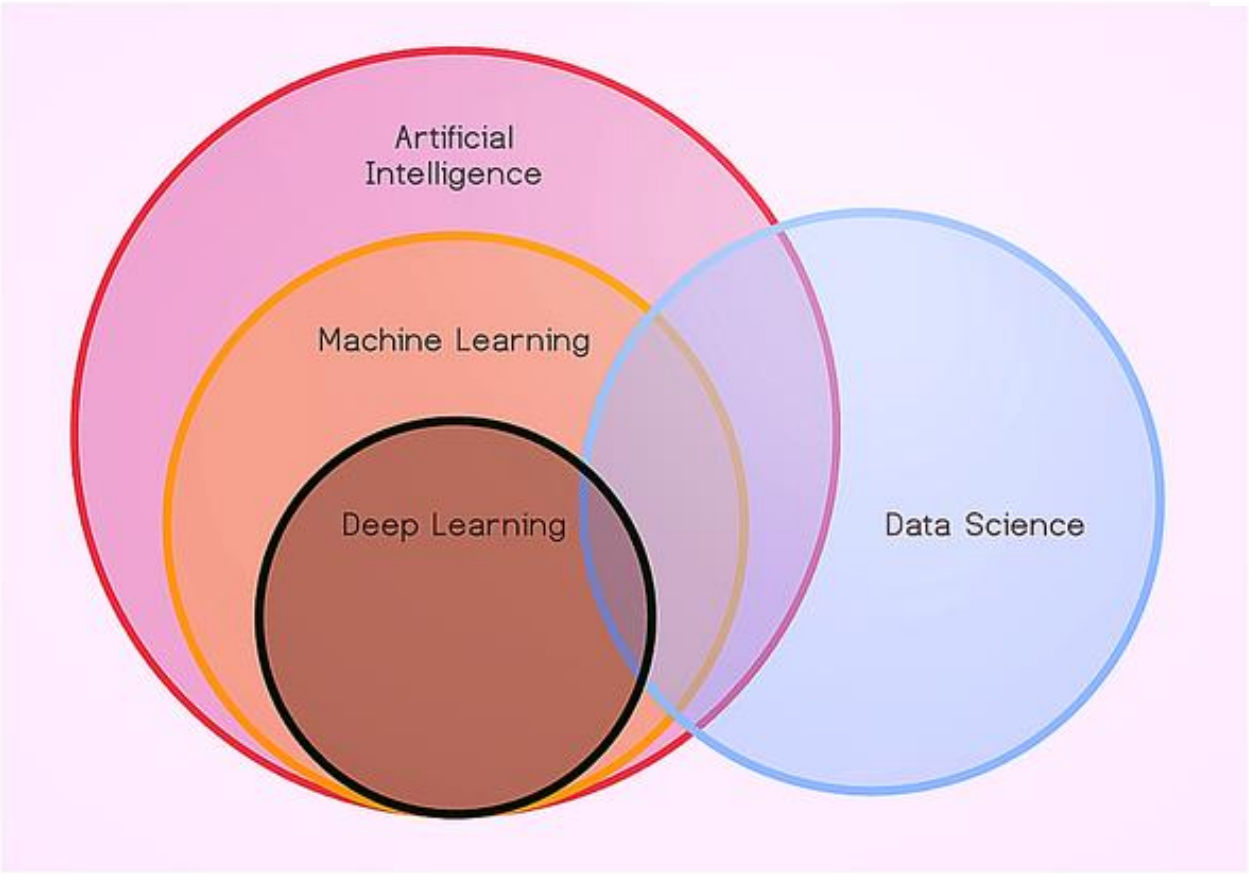
- Alibaba, will invest in AI US$ 15 billion in three years

Some definitions

"*Data Science* is a multi-disciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from data"

"*Machine Learning* is an application of Artificial Intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed"





Our Expectations on Machine Learning

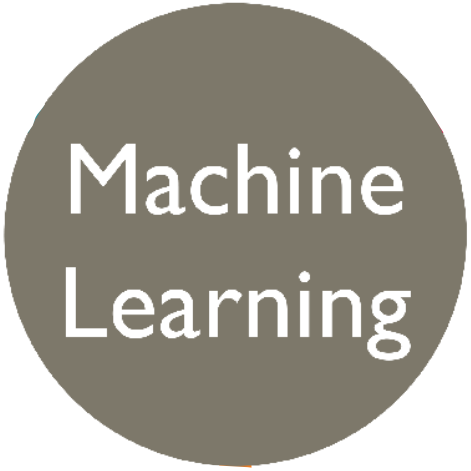
What do we want Data Science and Machine Learning to do?

help engineers, physicist and operators to understand and manage complicated machines and physics phenomena often generating big amounts of data

Examples:

- *anomaly detection*
- *virtual diagnostics*
- *machine tuning*
- *performance optimization*
- *machine models*
- *....*

Techniques used in ML applications



https://www.linkedin.com/pulse/business-intelligence-its-relationship-big-data-geekstyle/

A quick history of Machine Learning

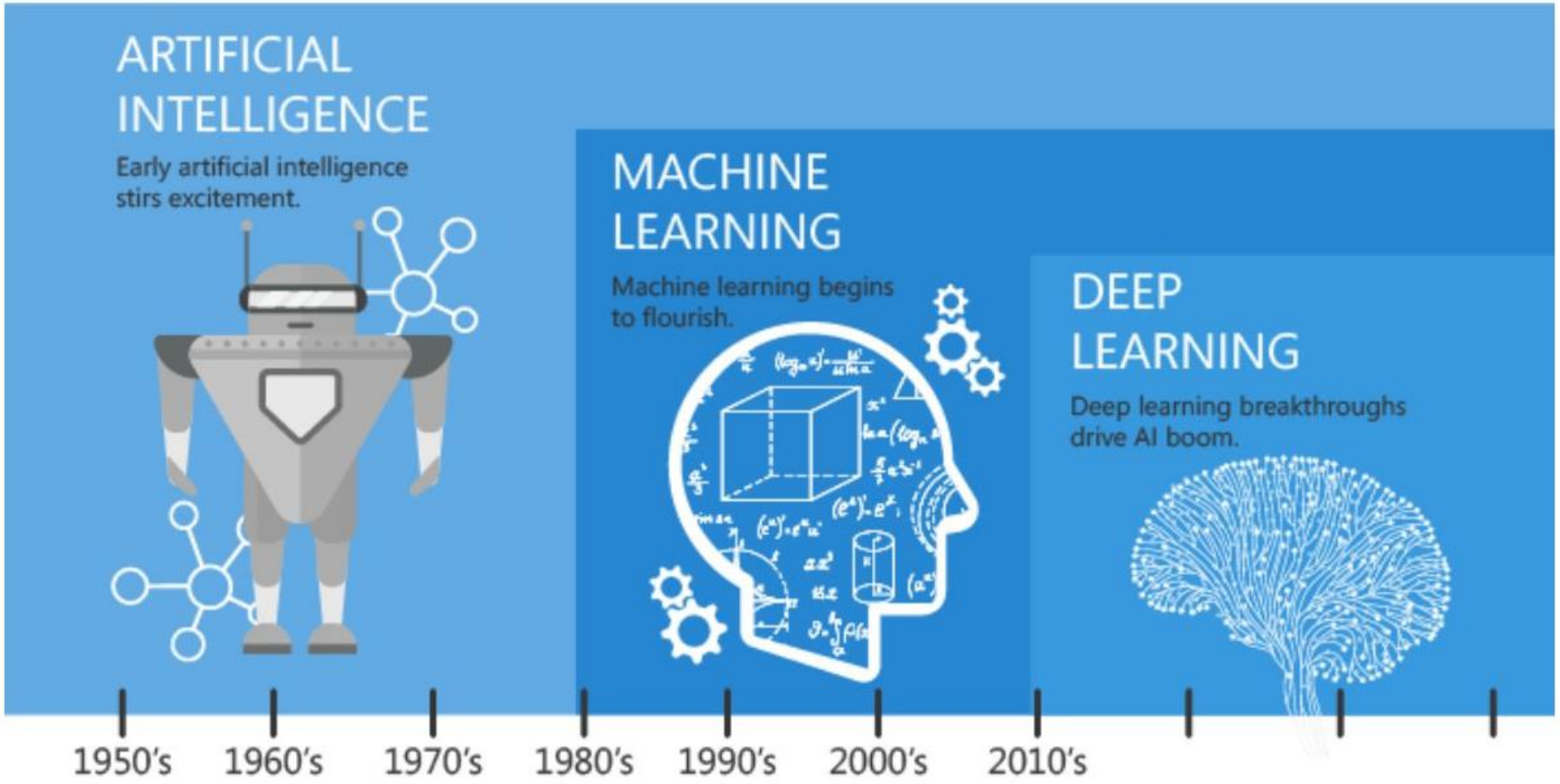
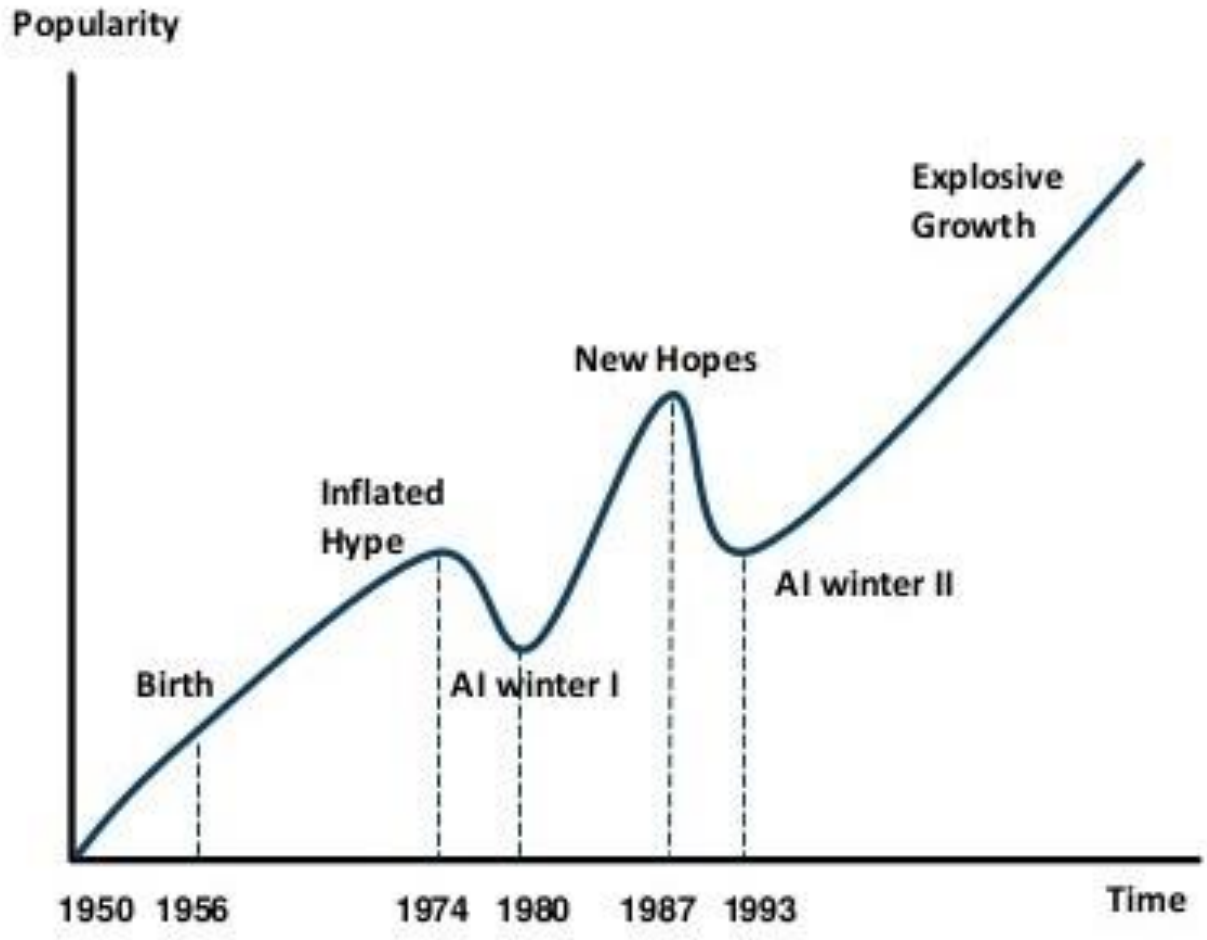


Image: Linked In | Machine Learning vs Deep learning

The "AI Winters"

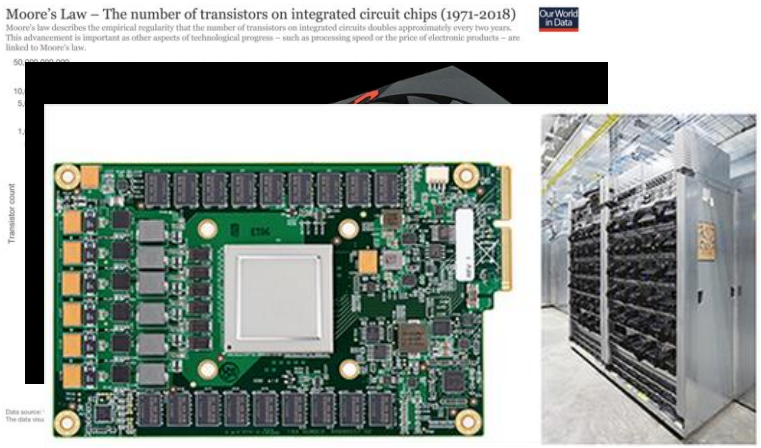
AI HAS A LONG HISTORY OF BEING "THE NEXT BIG THING"...

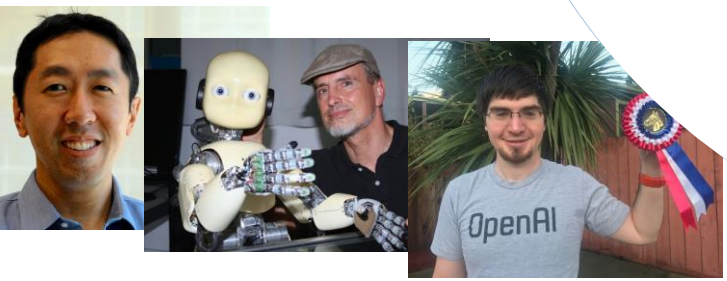


Timeline of AI Development

- **1950s-1960s**: First AI boom - the age of reasoning, prototype AI developed
- **1970s**: AI winter I
- **1980s-1990s**: Second AI boom: the age of Knowledge representation (appearance of expert systems capable of reproducing human decision-making)
- **1990s**: AI winter II
- **1997**: Deep Blue beats Gary Kasparov
- **2006**: University of Toronto develops Deep Learning
- **2011**: IBM's Watson won Jeopardy
- **2016**: Go software based on Deep Learning beats world's champions

Why ML now?





…and many more

PyTorch

TensorFlow

Keras

Gym

Spark MLlib

GNU Octave

Scientific Communities looking at ML

- ✓ HEP Experiments
  - Established since some years
  - Several results obtained
  - Presentations at ML conferences
  - E.g. https://iml.web.cern.ch/
- ✓ Accelerators
  - Started recently
  - Some workshops
    - *Intelligent Controls for Particle Accelerat*
    - *2 ICFA workshops organized : 2018 at S*
  - Increasing interest of the accelerators co
    - *Machine Learning, Data Mining and Big*

      New Mexico) (Invited at IPAC'19, Melbou
    - *Machine Learning Demonstrations on Ac*

      Lansing Michigan, September 2019
  - Not many concrete applications so far!

Machine Learning in control systems

Presented at Orbit Correction and Analysis Workshop,
BNL, Upton, New York, December 1-3, 1993.

BNL-61253

Conf-931254--10

Neural Network Technique for Orbit Correction in Accelerators/Storage rings. *

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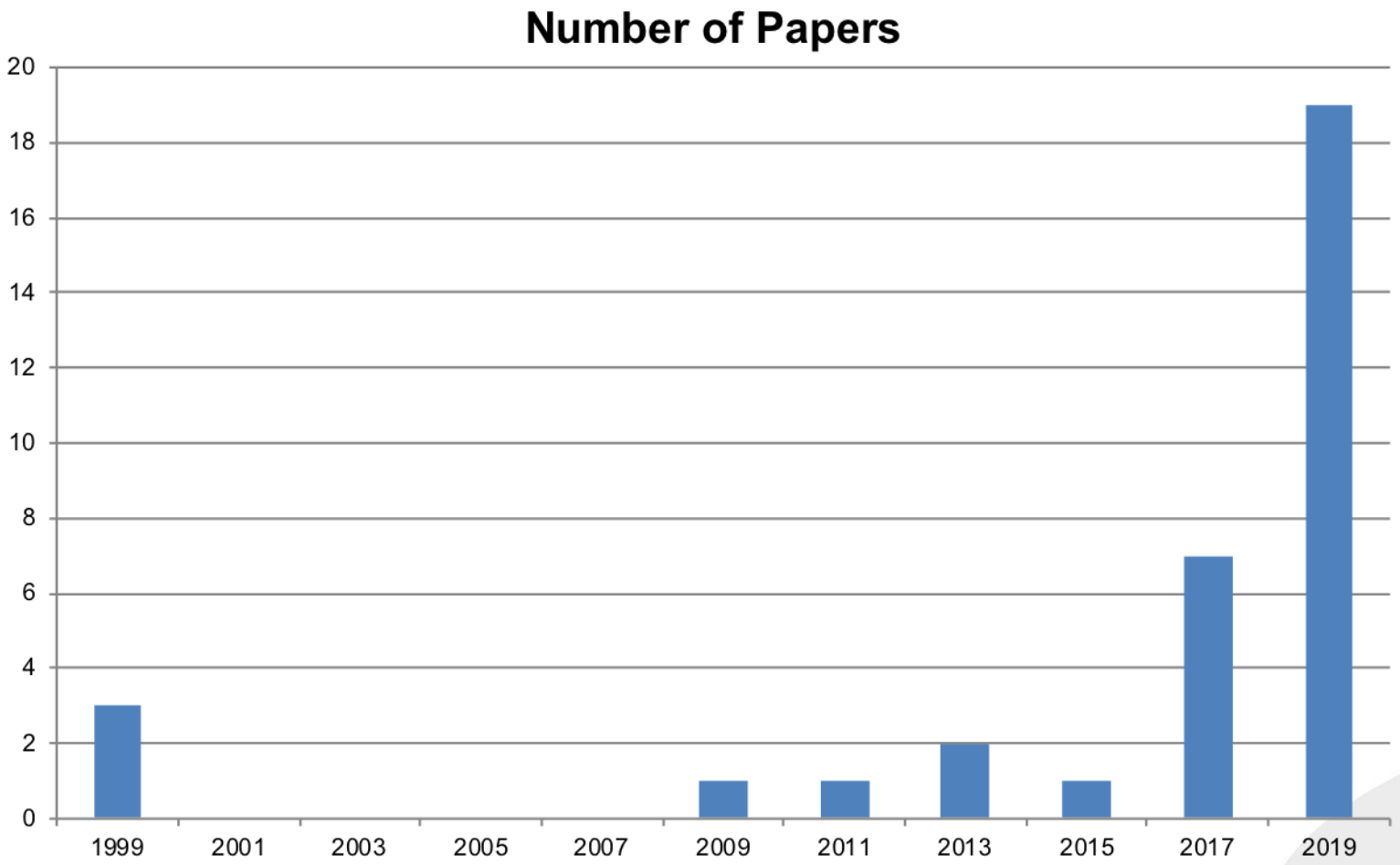
Abstract

We are exploring the use of Neural Networks, using the SNNS simulator [1], for orbit control in accelerators (primarily circular accelerators) and storage rings. The orbit of the beam in those machines are measured by orbit monitors (input nodes) and controlled by orbit corrector magnets (output nodes). The physical behavior of an accelerator is changing slowly in time. Thus, an adoptive algorithm is necessary. The goal is to have a trained net which will predict the exact corrector strengths which will minimize a measured orbit. The relationship between "kick" from the correctors and "response" from the monitors is in general non-linear and may slowly change during long-term operation of the machine. In the study, several network architectures are examined as well as various training methods for each architecture.

ML at ICALEPCS conferences

Keywords: *Expert Systems, Machine Learning, Articicial Intelligence, Artificial Neural Networks, Genetic Algorithms, ...*



Past ICALEPCS tracks with ML papers

- ✓ ICALEPCS 2013 **Knowledge-based Techniques**
- ✓ ICALEPCS 2015 **Feedback Systems, Tuning**
- ✓ ICALEPCS 2017 **Feedback Control and Process Tuning - Data Data Analytics** (ML mentioned in track descriptions for the first time)
- ✓ ICALEPCS 2019 **Data Analytics - Feedback Control and Process Tuning - Experiment Control**

ICALEPCS 2019

ID	Code	Topic
1201	MOCPL04	Tuning
1621	WEMPR010	Anomaly Detection
1493	MOPHA011	HMI
1430	MOPHA043	Data Analysis
2061	MOPHA114	Performance Optimization
1630	MOPHA146	Tuning
1520	TUCPL01	Prediction/Anomaly Detection/Tuning
1594	TUCPL06	Performance Optimization
1476	WEMPL001	Prediction
1830	WEPHA021	Performance Optimization
1684	WEPHA025	Fault Classification
1667	WEPHA138	Tuning
1464	THBPP03	Prediction/Tuning/Optimization
1961	THCPL01	Report of 2nd ICFA workshop by Andreas Adelmann
2021	THCPL02	Tuning
1431	THCPL03	Performance Optimization
1403	WEPHA123	Anomaly Detection/Virtual Diagnostics/Tuning
2022	THCPL07	Anomaly Detection
1543	WEPHA121	Anomaly Detection