

AN INTRODUCTION TO DEEP LEARNING FOR ASTRONOMY

Marc Huertas-Company

ECOLE EUCLID 2019
Banyuls, August 26-27 2019



institut
universitaire
de France



PRACTICAL INFORMATION

- THREE SESSIONS:
 - MONDAY: 9AM-12:30PM - **LECTURES**
 - MONDAY: 5:30PM - 7:30PM: **TUTORIAL (“OPEN SESSION”)**
 - TUESDAY: 2PM - 4:30PM: **LECTURES/TUTORIALS**
- INFO: GITHUB REPO [<https://github.com/mhuertascompany/EDE19>]
+ SLACK CHANNEL #DEEPLEARNING

REFERENCES

SEVERAL SLIDES / INFOS SHOWN HERE ARE INSPIRED/
TAKEN FROM OTHER WORKS / COURSES FOUND ONLINE

- Deep Learning: Do-It-Yourself! [Bursuc, Krzakala, Lelarge]
- DEEPMLEARNING.AI [COURSERA, Ng, Bensouda, Katanforoosh]
- MACHINE LEARNING LECTURES [Keck]
- EPFL DEEP LEARNING COURSE [Fleuret]

Thanks to all of them!

SOME PRELIMINARY NOTES

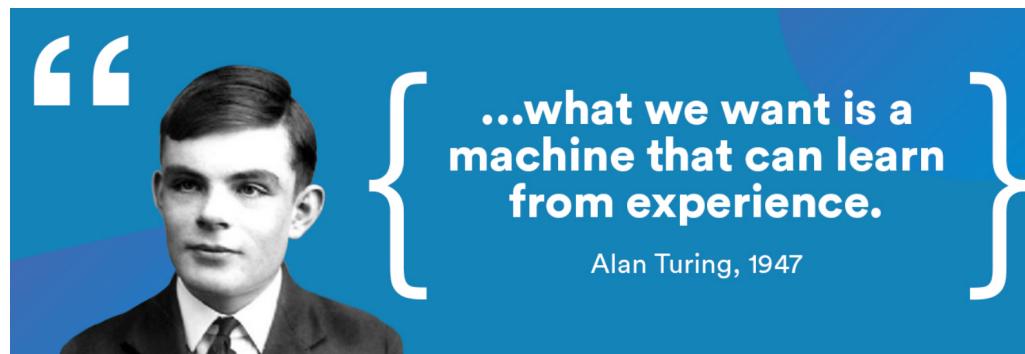
I AM NOT A MACHINE LEARNING RESEARCHER

SOME PRELIMINARY NOTES

I AM NOT A MACHINE LEARNING RESEARCHER

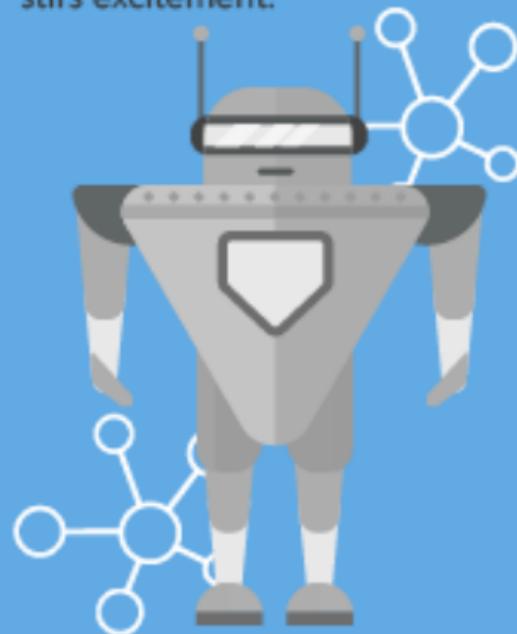
ONLY AN ASTRONOMER WHO HAS BEEN USING MACHINE
LEARNING FOR THE LAST ~14 YEARS FOR MY RESEARCH

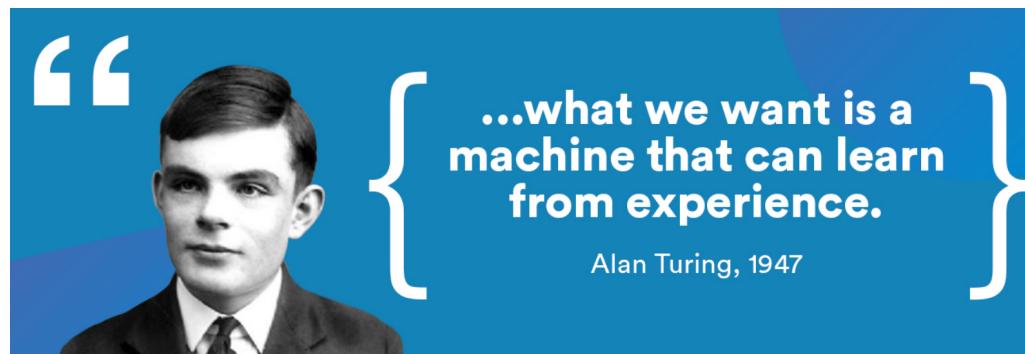
THESE LECTURES ARE INTENDED TO PROVIDE A **GLOBAL**
UNDERSTANDING OF HOW AI TECHNIQUES WORK AND
ESPECIALLY **HOW TO USE THEM FOR YOUR RESEARCH**



ARTIFICIAL INTELLIGENCE

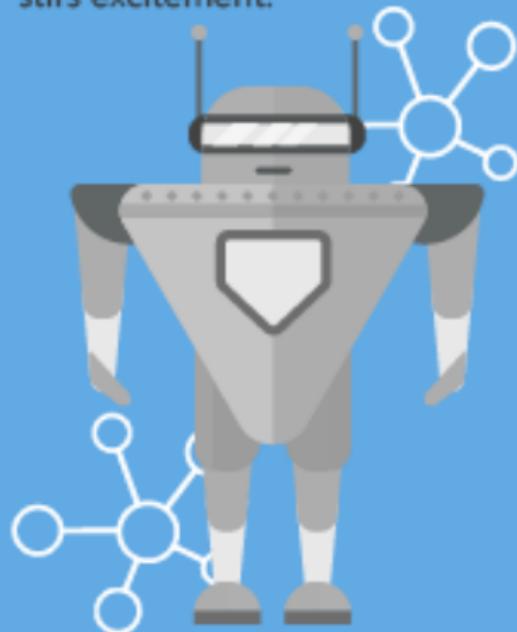
Early artificial intelligence stirs excitement.





ARTIFICIAL INTELLIGENCE

Early artificial intelligence stirs excitement.



1950's

1960's

1970's

1980's

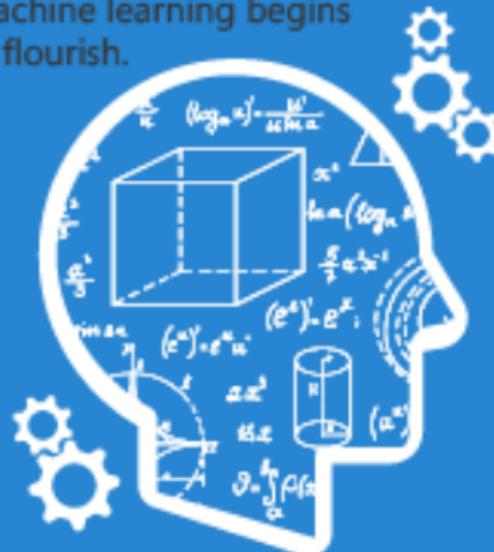
1990's

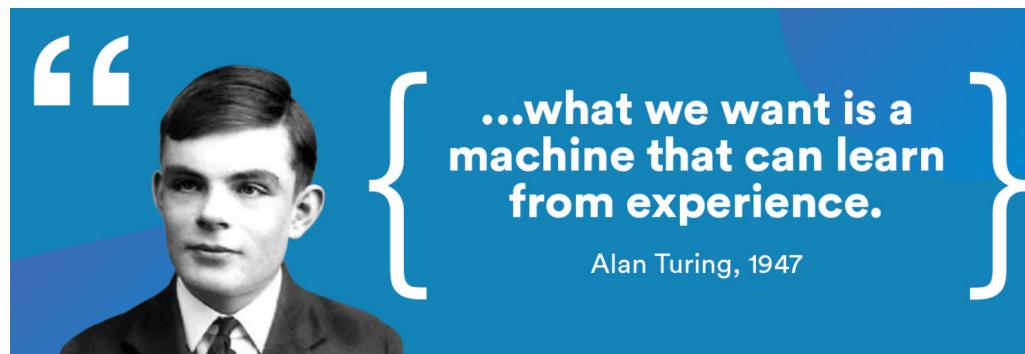
2000's

2010's

MACHINE LEARNING

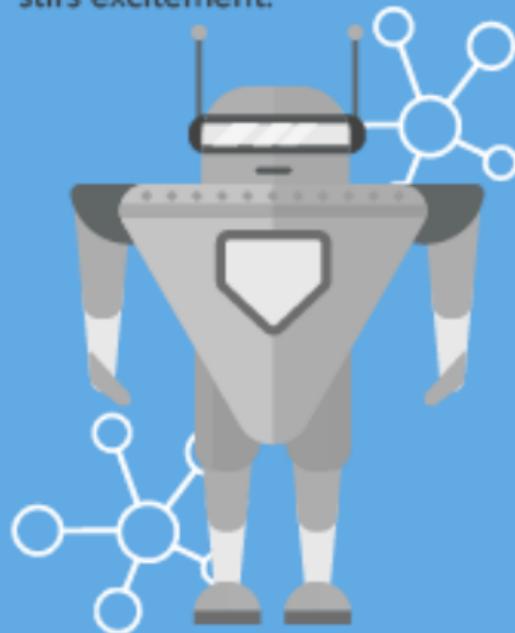
Machine learning begins to flourish.





ARTIFICIAL INTELLIGENCE

Early artificial intelligence stirs excitement.



1950's

1960's

1970's

1980's

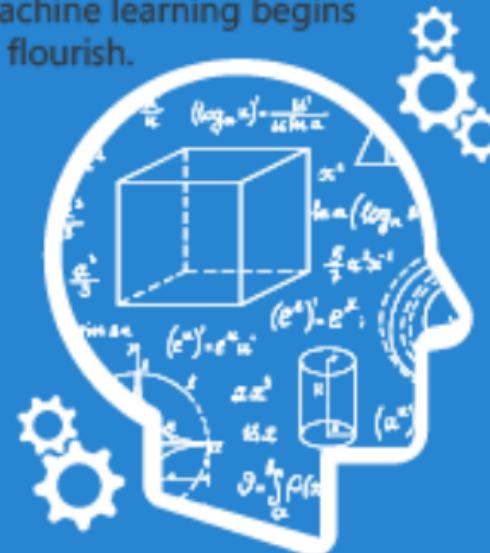
1990's

2000's

2010's

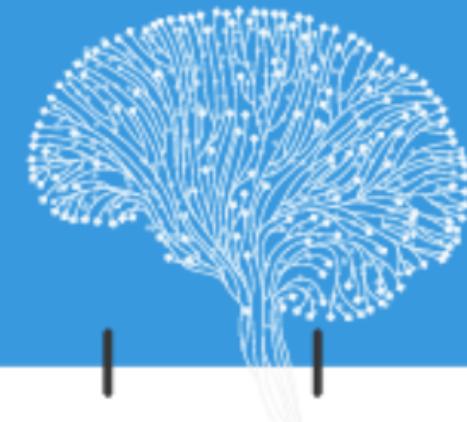
MACHINE LEARNING

Machine learning begins to flourish.



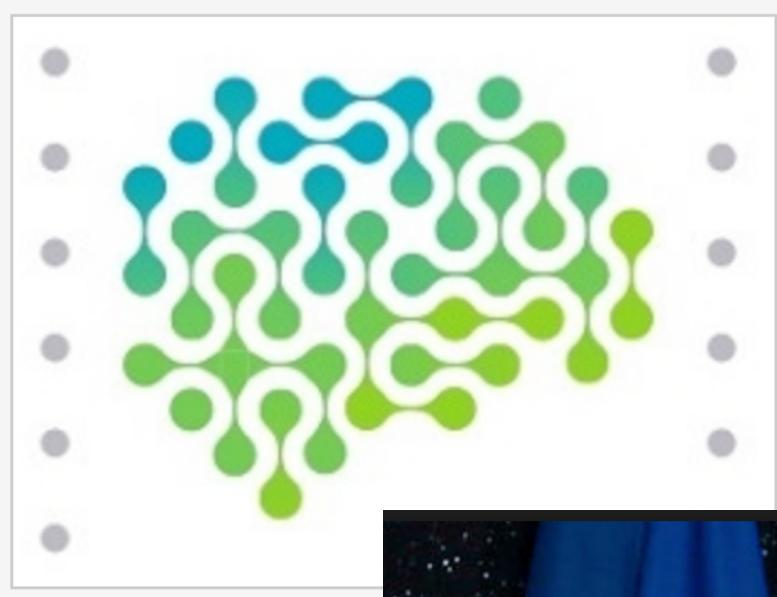
DEEP LEARNING

Deep learning breakthroughs drive AI boom.



AI FEVER?

AN AMAZING MEDIA ATTENTION

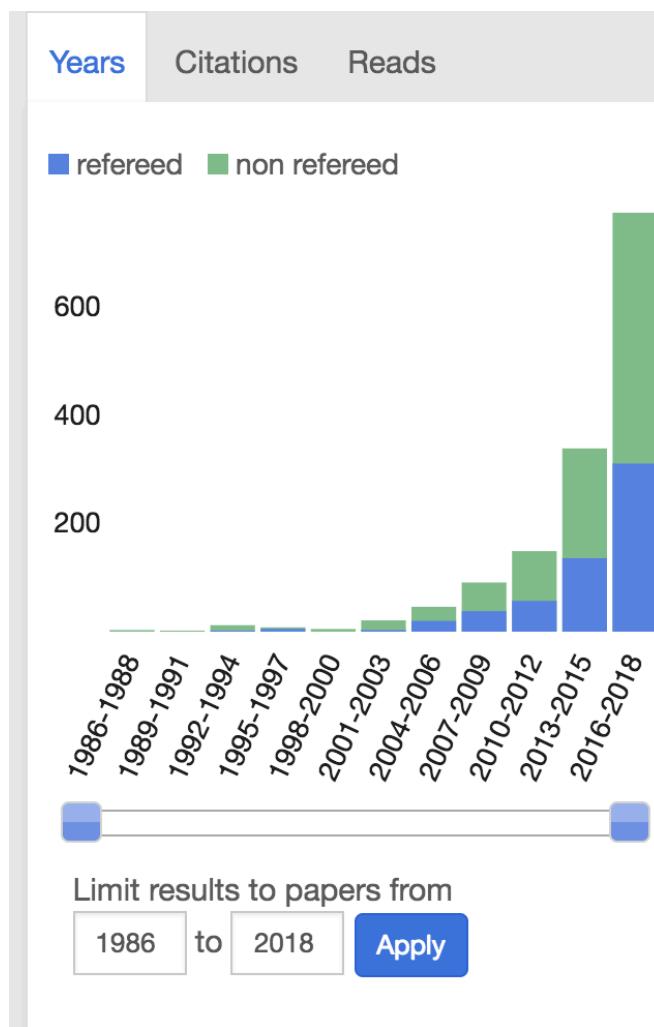


Le CNRS, Inria, l'université PSL et les entreprises Amazon, Criteo, Facebook, Faurecia, Google, Microsoft, NAVER LABS, Nokia Bell Labs, le Groupe PSA, SUEZ et Valeo font converger intérêts académiques et industriels et s'unissent pour créer, à Paris, l'Institut PRAIRIE dont l'objectif est de devenir une référence internationale de l'intelligence artificielle.

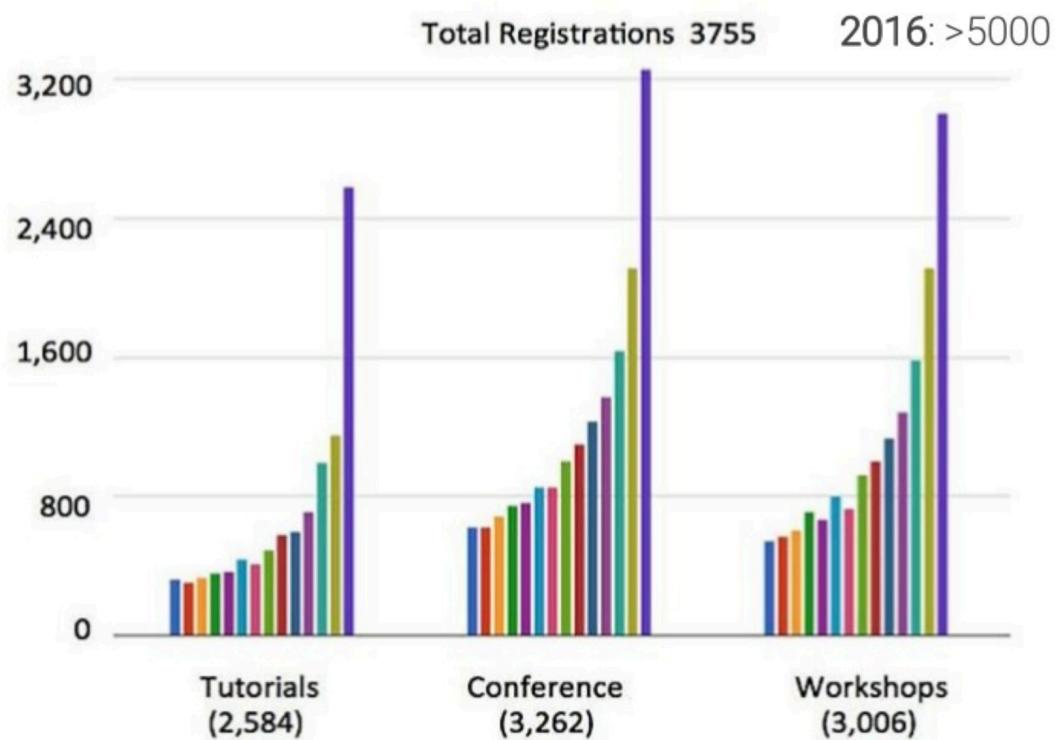


AI FEVER?

PUBLICATIONS (ADS)

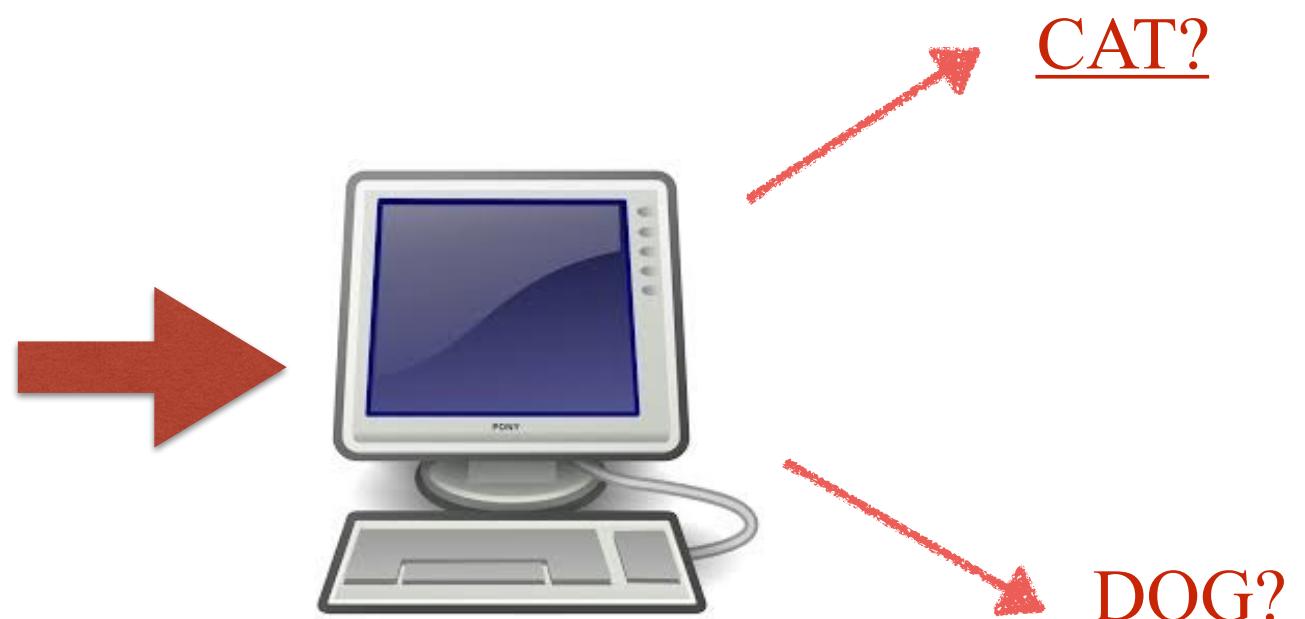


CONFERENCES



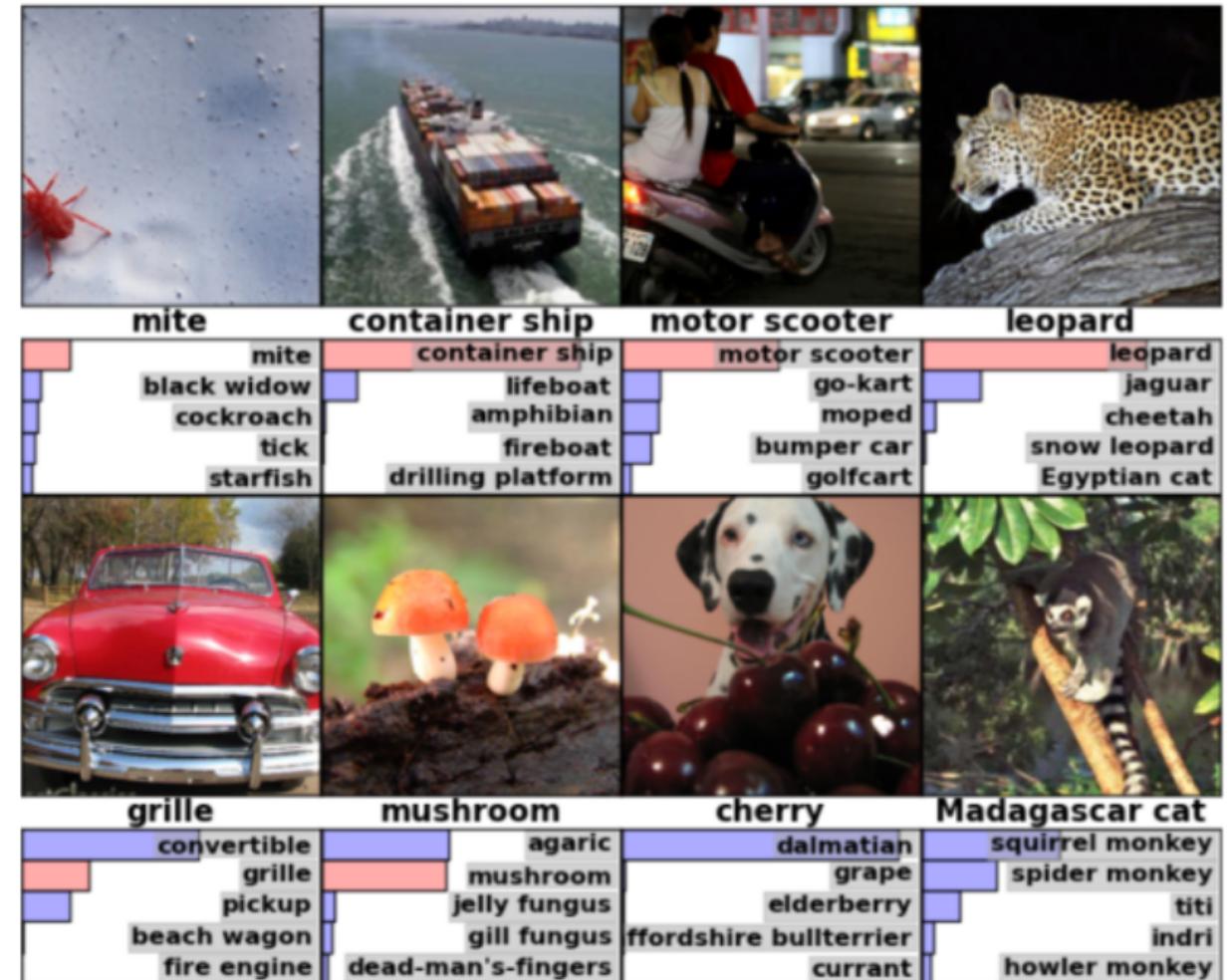
Source

BEFORE 2012....



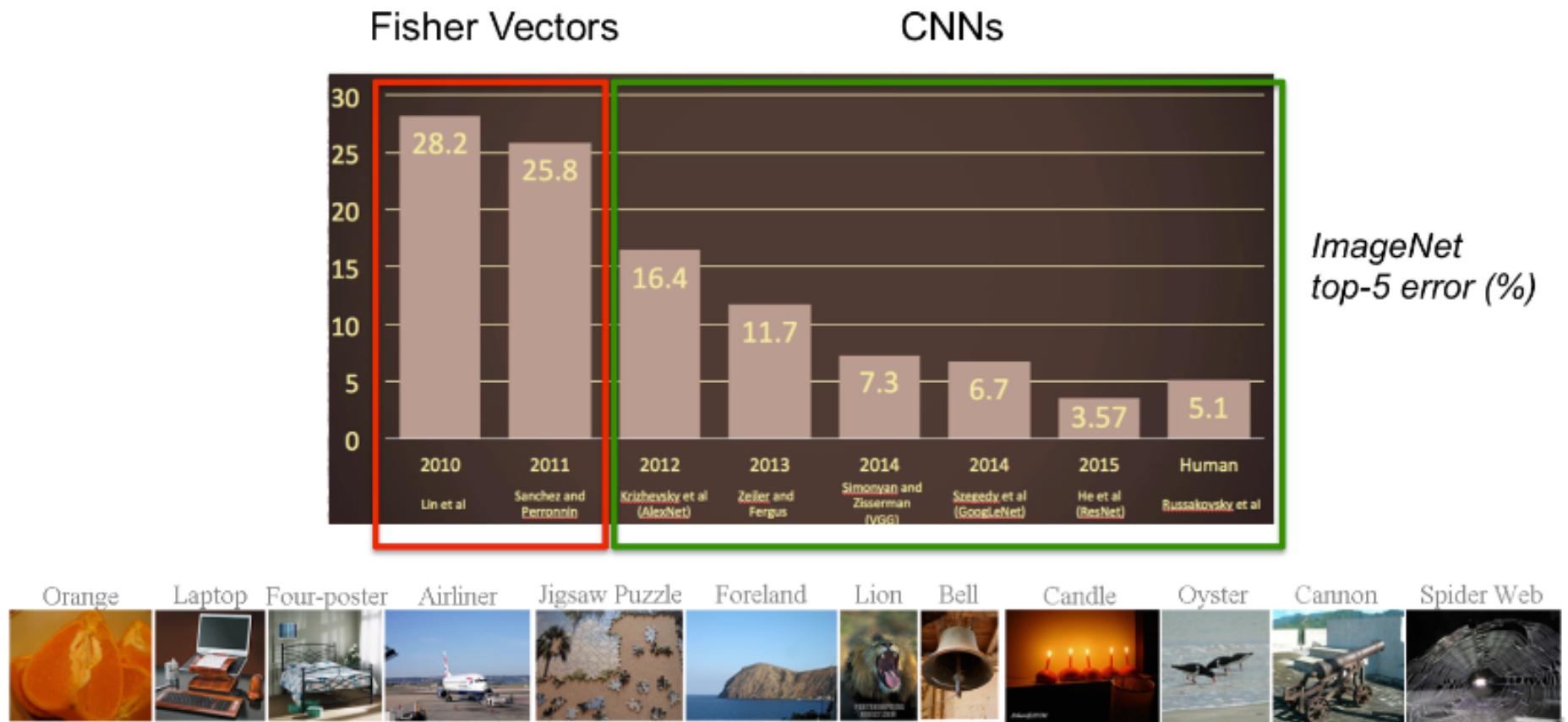
TRIVIAL HUMAN TASKS REMAINED
CHALLENGING FOR COMPUTERS

AFTER 2012



IT HAS BECOME TRIVIAL....

THIS IS A CHANGE OF PARADIGM!



ONE OF THE MAIN REASONS OF THIS
BREAKTHROUGH IS THE AVAILABILITY OF VERY
LARGE DATASETS TO LEARN



COMBINED WITH THE TECHNOLOGY TO
PROCESS ALL THIS DATA



ONE OF THE MAIN REASONS OF THIS
BREAKTHROUGH IS THE AVAILABILITY OF VERY
LARGE DATASETS TO LEARN

HOWEVER THERE HAS NOT BEEN A MAJOR
REVOLUTIONARY IDEA



WHAT IS THIS LECTURE ABOUT?

BASICS OF CLASSICAL MACHINE LEARNING

BASICS OF DEEP LEARNING
(BOTH SUPERVISED AND UNSUPERVISED)

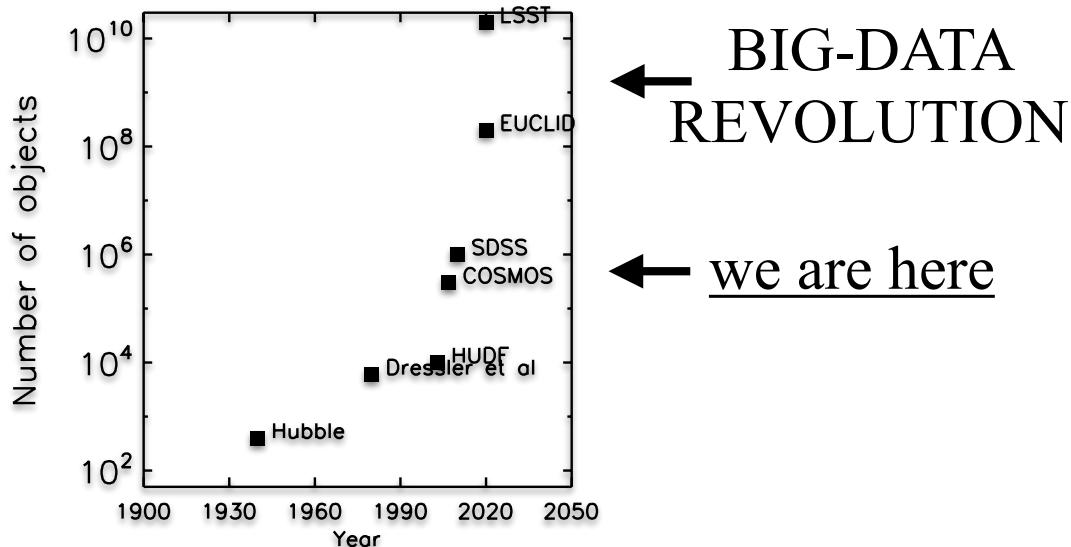
HOPING THAT THIS WOULD BE USEFUL FOR YOUR
RESEARCH!

(Apologies in advance for biases on Extra-Galactic Science +
imaging)

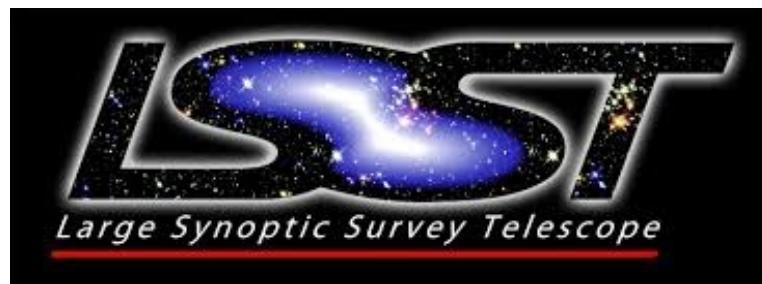
WHY DO WE NEED THESE TOOLS IN ASTRONOMY?

WHY DO WE NEED THESE TOOLS IN ASTRONOMY?

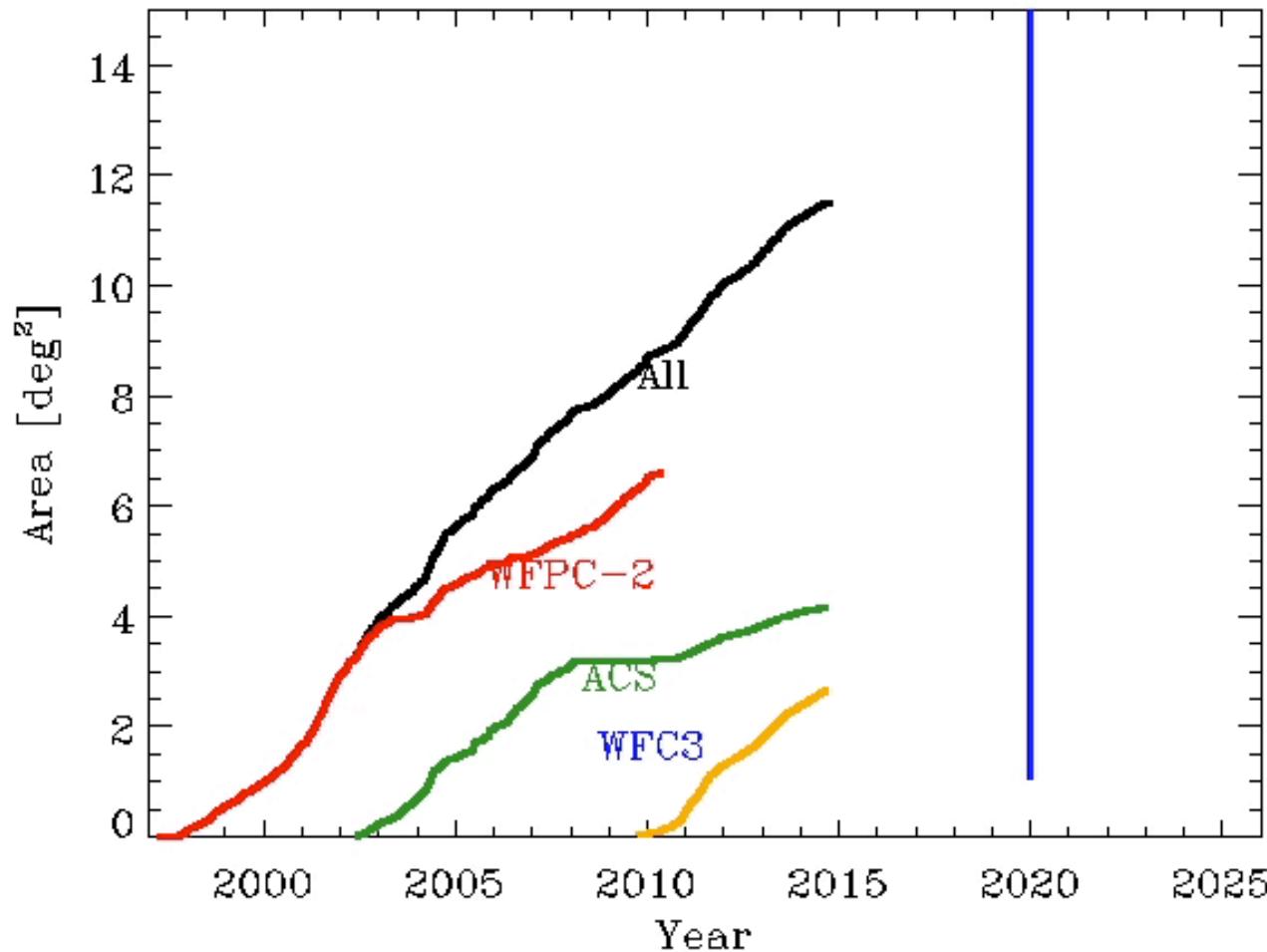
AS IN MANY OTHER DISCIPLINES THE BIG-DATA REVOLUTION HAS ARRIVED TO ASTRONOMY TOO



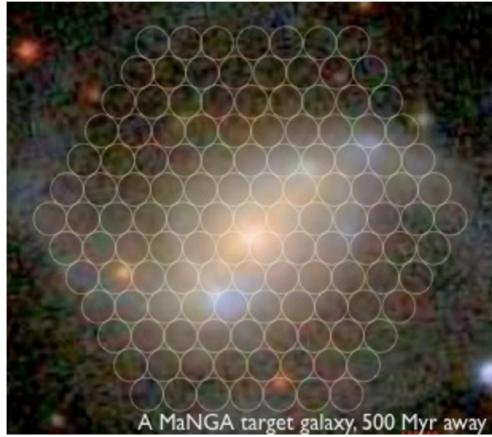
EXTREMELY LARGE IMAGING SURVEYS DELIVERING BILLIONS OF OBJECTS IN 2-5 YEARS



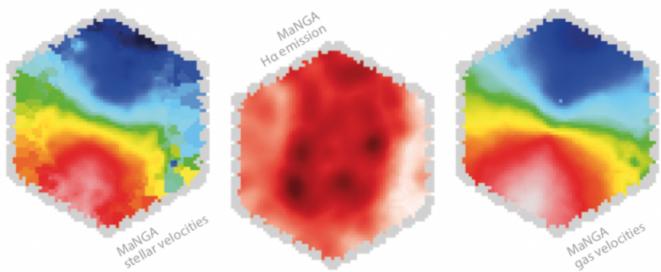
LSST simulation



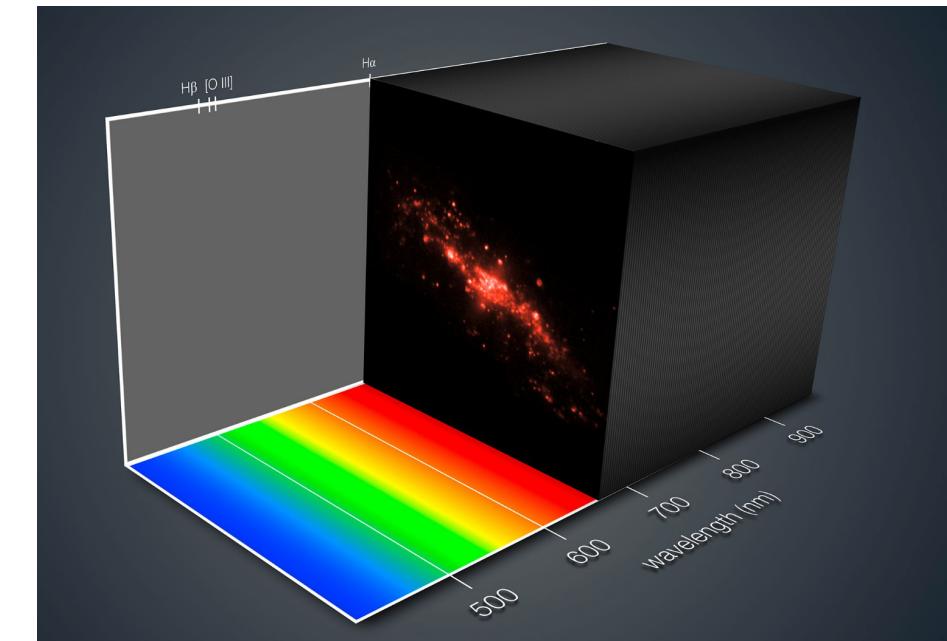
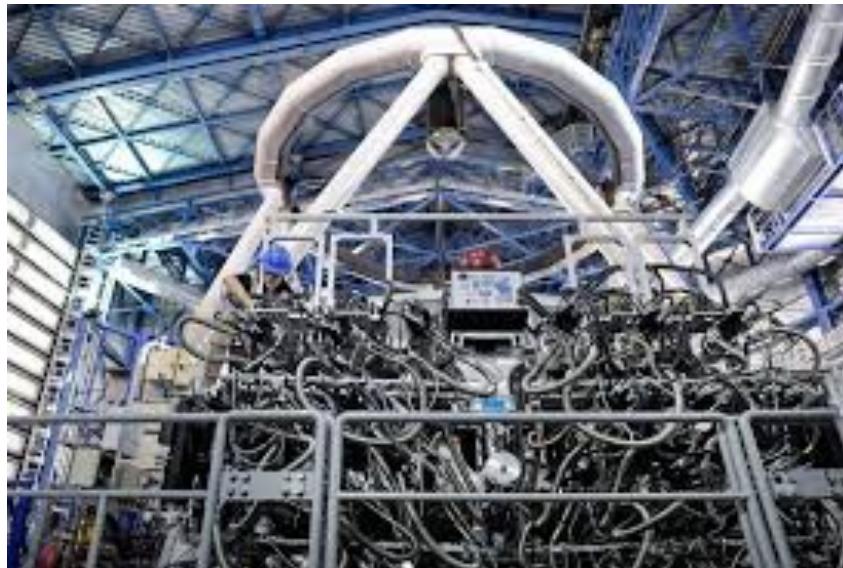
(Thanks to J. Brinchmann)



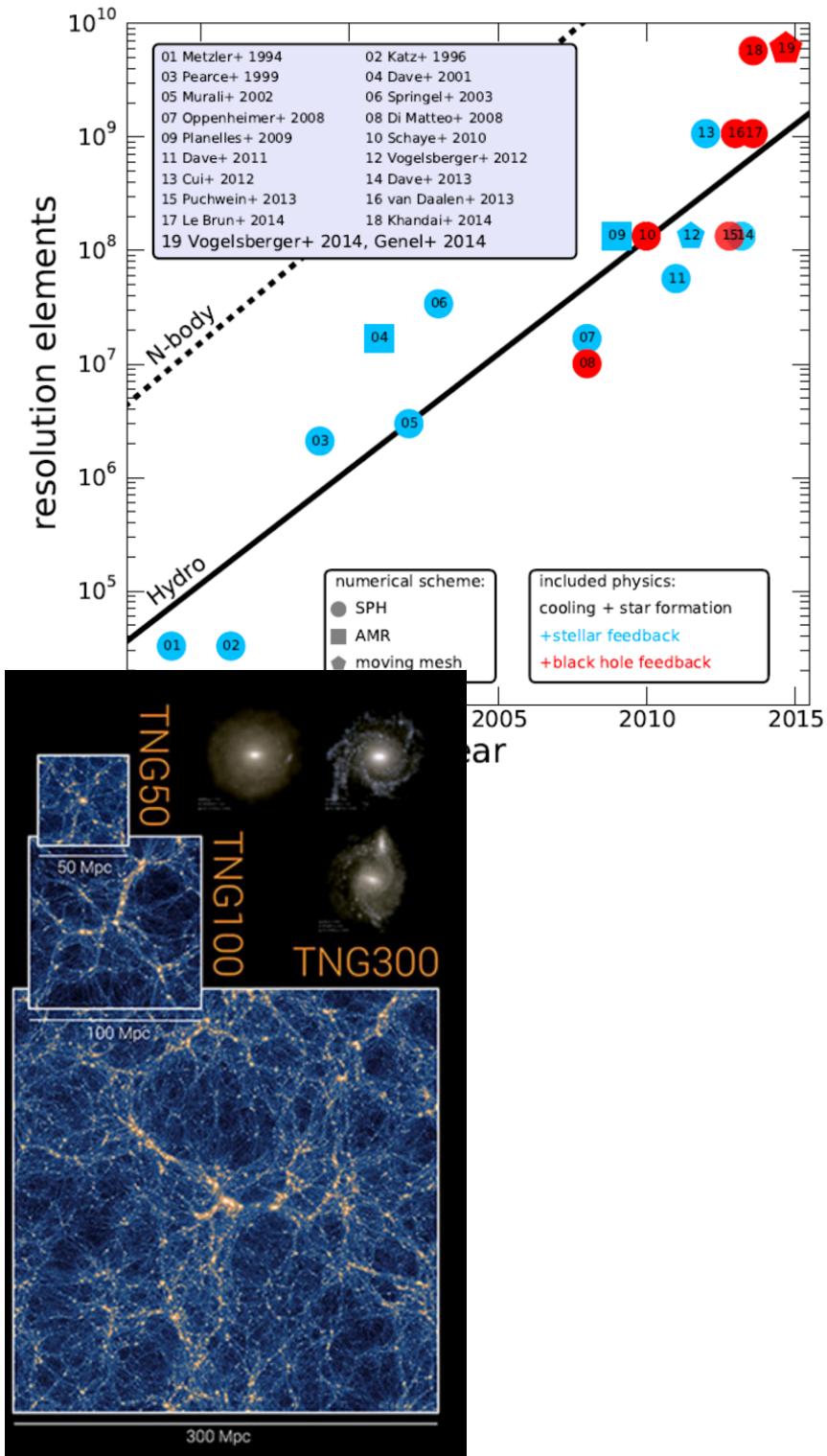
NOT ONLY VOLUME: AN INCREASING COMPLEXITY OF DATA



MANGA Survey

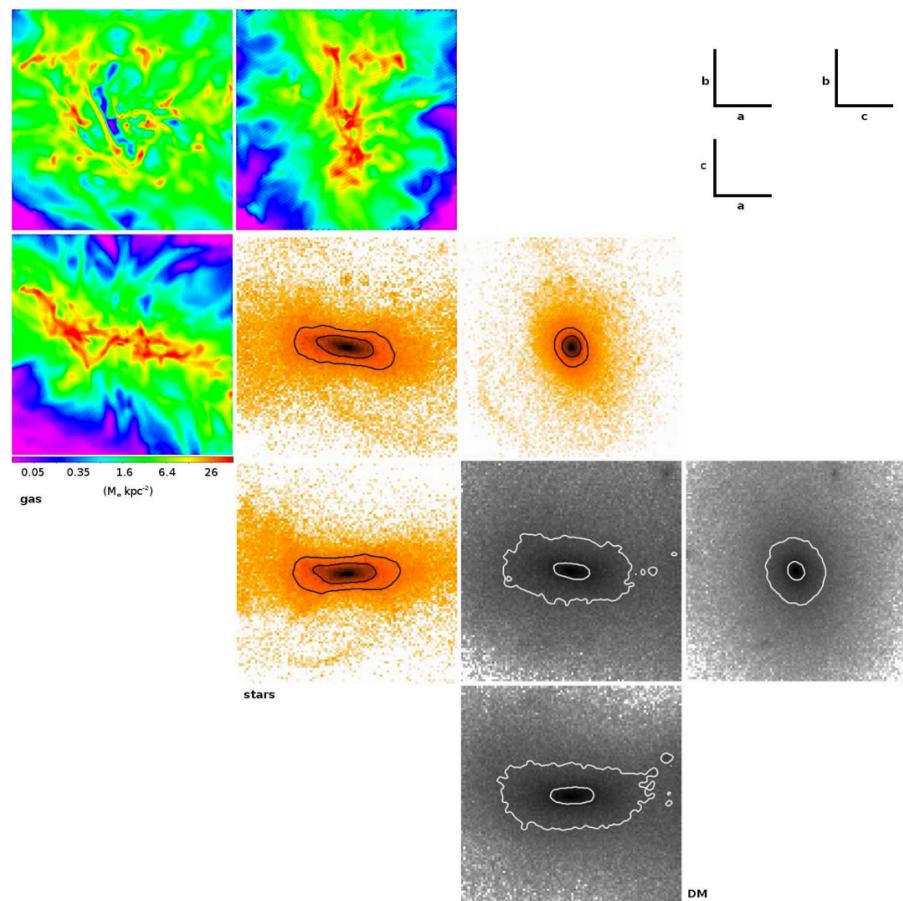


MUSE@VLT



Genel+14

AND ALSO
SIMULATIONS!



Ceverino+15

PROGRAM FOR THE TWO DAYS

- PART I: A VERY QUICK INTRODUCTION TO
‘CLASSICAL’ SUPERVISED MACHINE LEARNING
 - UNSUPERVISED / SUPERVISED
 - GENERAL STEPS TO “TEACH A MACHINE”
 - “CLASSICAL” CLASSIFIERS: RFs, KERNEL
MACHINES

PROGRAM FOR THE TWO DAYS

- **PART II: FOCUS ON ‘SHALLOW’ NEURAL NETWORKS**
 - PERCEPTRON, NEURON DEFINITION
 - LAYER OF NEURONS, HIDDEN LAYERS
 - ACTIVATION FUNCTIONS
 - OPTIMIZATION [GRADIENT DESCENT, LEARNING RATES]
 - BACKPROPAGATION
 - LOSS FUNCTIONS

PROGRAM FOR THE TWO DAYS

- **PART III: CONVOLUTIONAL NEURAL NETWORKS**
 - CONVOLUTIONS AS NEURONS
 - CNNs [POOLING, DROPOUT]
 - VANISHING GRADIENT / BATCH NORMALIZATION
 - FCNNs (IMAGE2IMAGE NETWORKS)
 - CNN VISUALIZATION

PROGRAM FOR THE TWO DAYS

- PART IV: INTRODUCTION TO UNSUPERVISED
MACHINE (DEEP) LEARNING
 - CLUSTERING ALGORITHMS
 - DEEP GENERATIVE MODELS
 - DEEP PROBABILISTIC MODELS

PROGRAM FOR THE TWO DAYS (IF TIME ALLOWS)

- **PART V: SOME PRACTICAL CONSIDERATIONS**
 - HOW DO I SETUP MY CNN?
 - HOW LARGE DO TRAINING SETS NEED TO BE?
 - OPTIMIZING YOUR NET: HYPER PARAMETER SEARCH
 - VISUALIZING CNNs [DECONVNETS, INCEPTIONISM, INTEGRATED GRADIENTS]

HANDS-ON SESSION

WE WILL TRY TO IMPLEMENT SOME OF THE THINGS
LEARNED

**FOR NOW THREE GOOGLE COLAB TUTORIAL
AVAILABLE:**

- GALAXY MORPHOLOGY CLASSIFICATION
 - IMAGE SEGMENTATION
- GALAXY SIZE/ELLIPTICITY PROBABILISTIC MEASUREMENT

LET'S TRY TO DISCUSS AS MUCH AS POSSIBLE!