FS2010 Lecture 5 - 7

# Simulation

## L5: Theory, Experiment, and Simulation

Definition • Examples

## L6: Design, Modelling, and Simulation

Design • Monte Rosa • Future Cities Project

## L7: Analysis, Prediction, and Simulation

Simulation of Complex Systems


iA
Chair for Information Architecture

FS2010 Lecture 5

# Simulation:

## Design Perspective

Animation • Renderings • Models • Why PC? • Digital Chain

## Science View

Theory • Experiment • Simulation

Simulation As An Assistance

Simulation As Visualisation

Simulation As An Experiment

Simulation As Visualisation

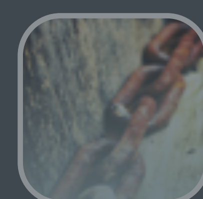
iA
Chair for Information Architecture

# Simulation: An Attempt Of An Overview

## Design Perspective







Animation • Renderings • Models • Why PC? • Digital Chain

## Science View



Theory • Experiment • Simulation

Simulation As An Assistance

Simulation As Visualisation

# Simulation: Definition

„Simulation is the imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviours of a selected physical or abstract system.

Simulation is used in many contexts, including the modeling of natural systems or human systems in order to gain insight into their functioning.[1] Other contexts include simulation of technology for performance optimization, safety engineering, testing, training and education. Simulation can be used to show the eventual real effects of alternative conditions and courses of action.

Key issues in simulation include acquisition of valid source information about the relevant selection of key characteristics and behaviours, the use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes.“

http://en.wikipedia.org/wiki/Simulation

# Theory and Experimentation

„Traditionally the 2 main aspects of science were theory and experimentation. For the theory part, scientists would use a pen and paper to try to think about and describe the mathematical nature of the physical process they were studying. They would then solve the equations and try to see if the predictions made by the equations match reality. This is where experiments come in. What we mean by the predictions matching reality is whether the predictions match the results of well controlled experiments.

Experimentation is a time honoured tradition in science. When a scientist performs an experiment, he is attempting to measure certain aspects of the physical system he is interested in, under certain conditions.

For example, a scientist may drop a weight off a tall platform and measure the amount of time taken to reach the ground. The scientist may have a theory about the effect of gravity on the falling weight. If the predictions of the theory match the results he gets from experiments, the scientist can conclude that theory may be correct. He still isn't sure. But if the predictions of the theory are different from the experimental results, he knows for sure that the theory is wrong.“

http://www.tchpc.tcd.ie/node/67

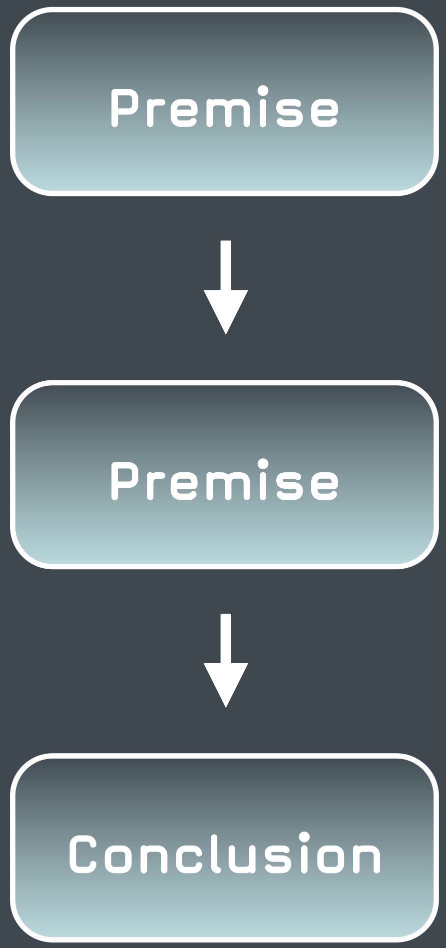
# Sience: Experiments and Prediction

1. **Philosophy of Sience**
   Deduction, Induction

2. **Prediction and Decision Process**
   Decisions Based on Predictions and Scenarios

# Science

## Deduction:

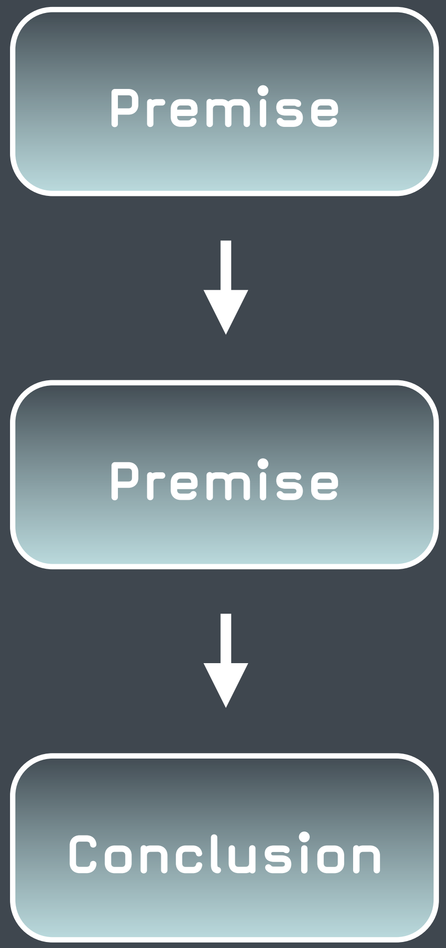



(H. Kahane, Logic and Contemporary Rhetoric, 1998)

# Science

## Deduction:

„Everything made of copper
conducts electricity




(H. Kahane, Logic and Contemporary Rhetoric, 1998)

# Science

## Deduction:

„Everything made of copper conducts electricity — Premise

↓

This wire is made of copper — Premise

↓

Conclusion

(H. Kahane, Logic and Contemporary Rhetoric, 1998)

# Science

## Deduction:

„Everything made of copper conducts electricity — **Premise**

↓

This wire is made of copper — **Premise**

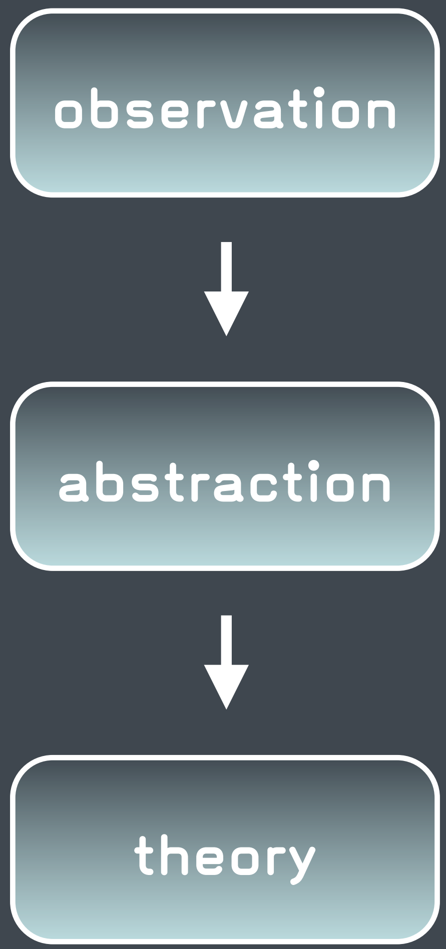
↓

This wire will conduct electricity" — **Conclusion**

(H. Kahane, Logic and Contemporary Rhetoric, 1998)

# Science

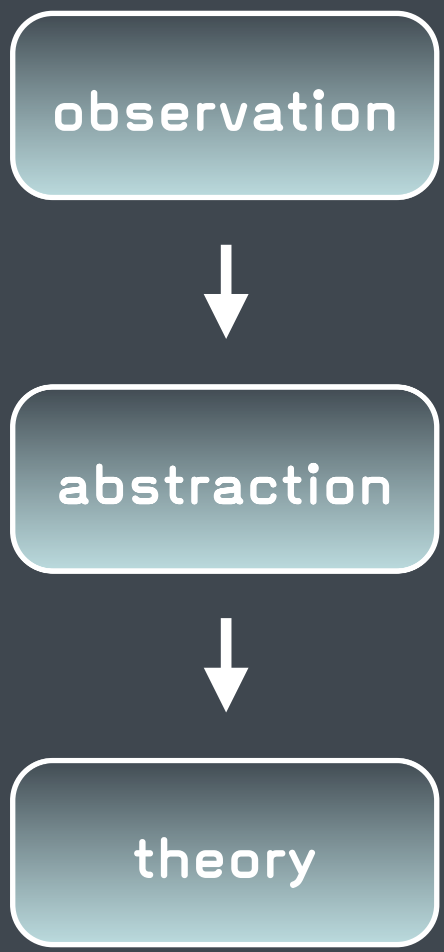
## Induction:



# Science

## Induction:

the stars aren‘t at the same place in the morning as they were in the evening



# Science

## Induction:

the stars aren't at the same place in the morning as they were in the evening — **observation**

↓

all stars move in the same direction — **abstraction**

↓

**theory**

# Science

## Induction:

the stars aren‘t at the same place in the morning as they were in the evening — **observation**

↓

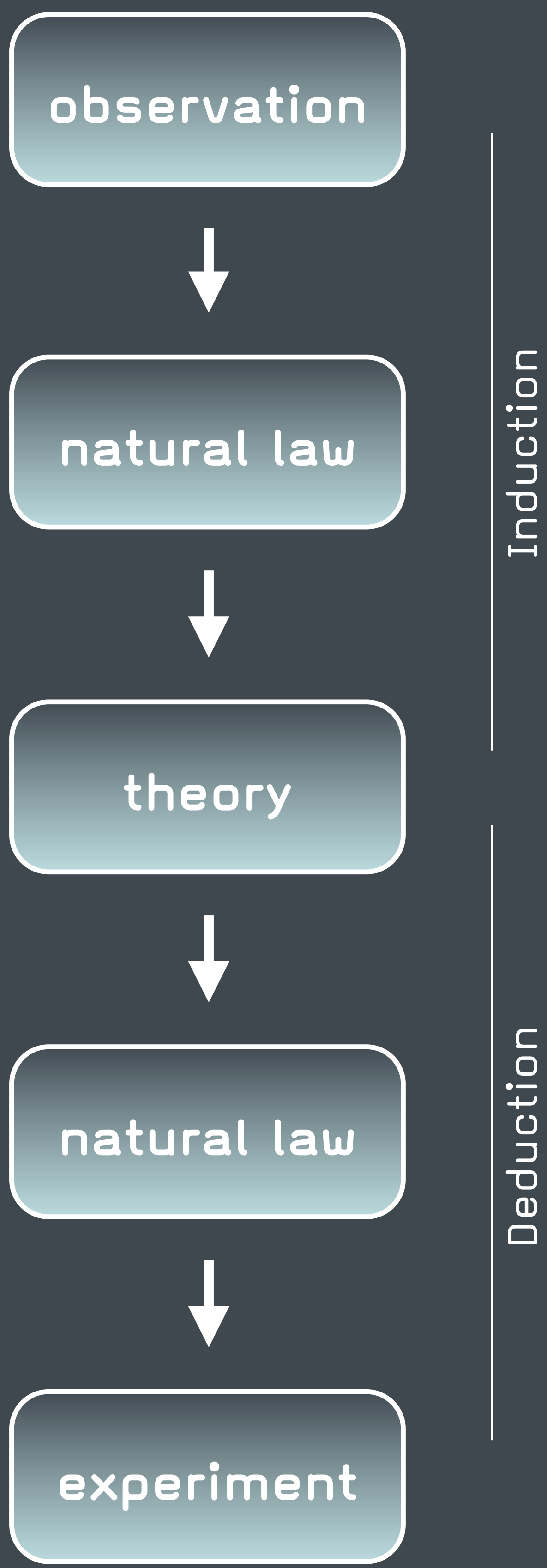
all stars move in the same direction — **abstraction**

↓

the earth is turning — **theory**

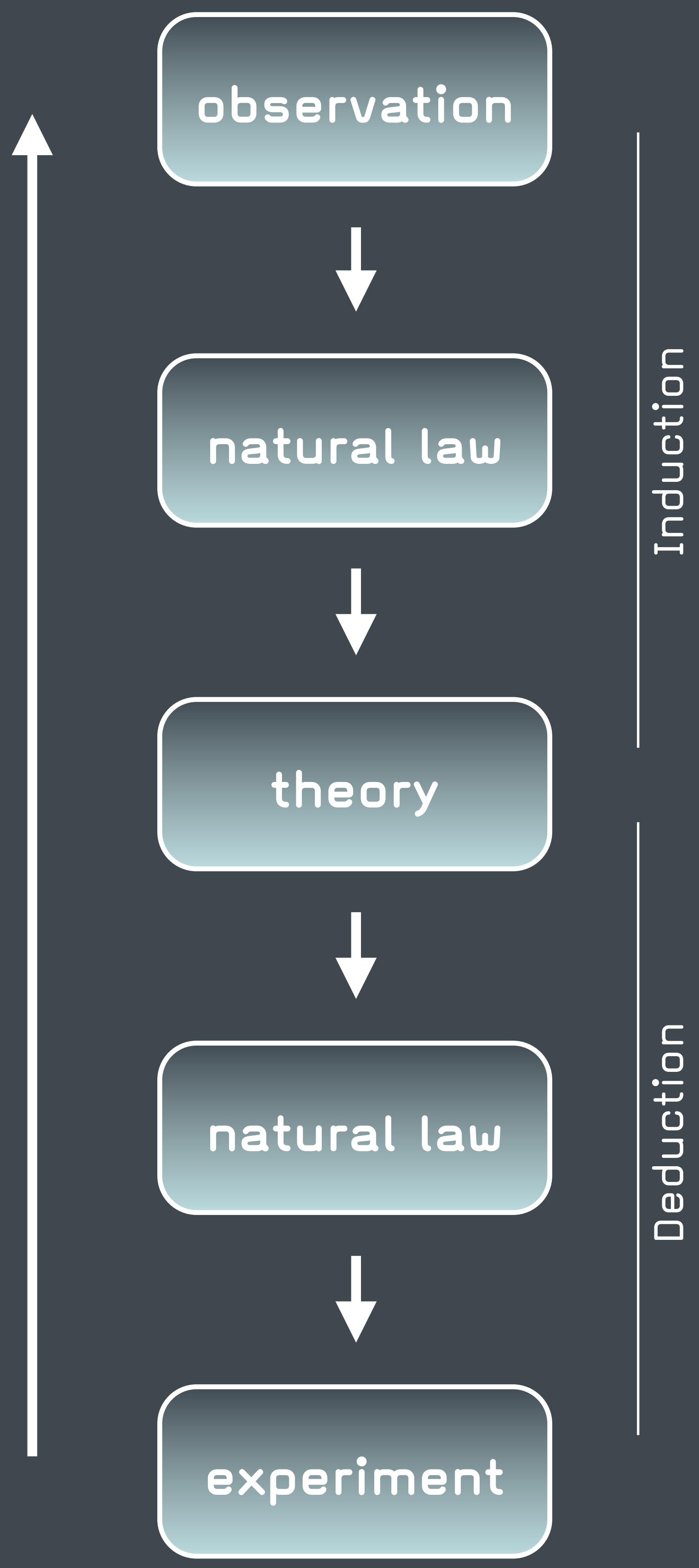
# Induction and Deduction

## Induction and Deduction:



# Induction and Deduction

## Induction and Deduction:



# Induction and Deduction

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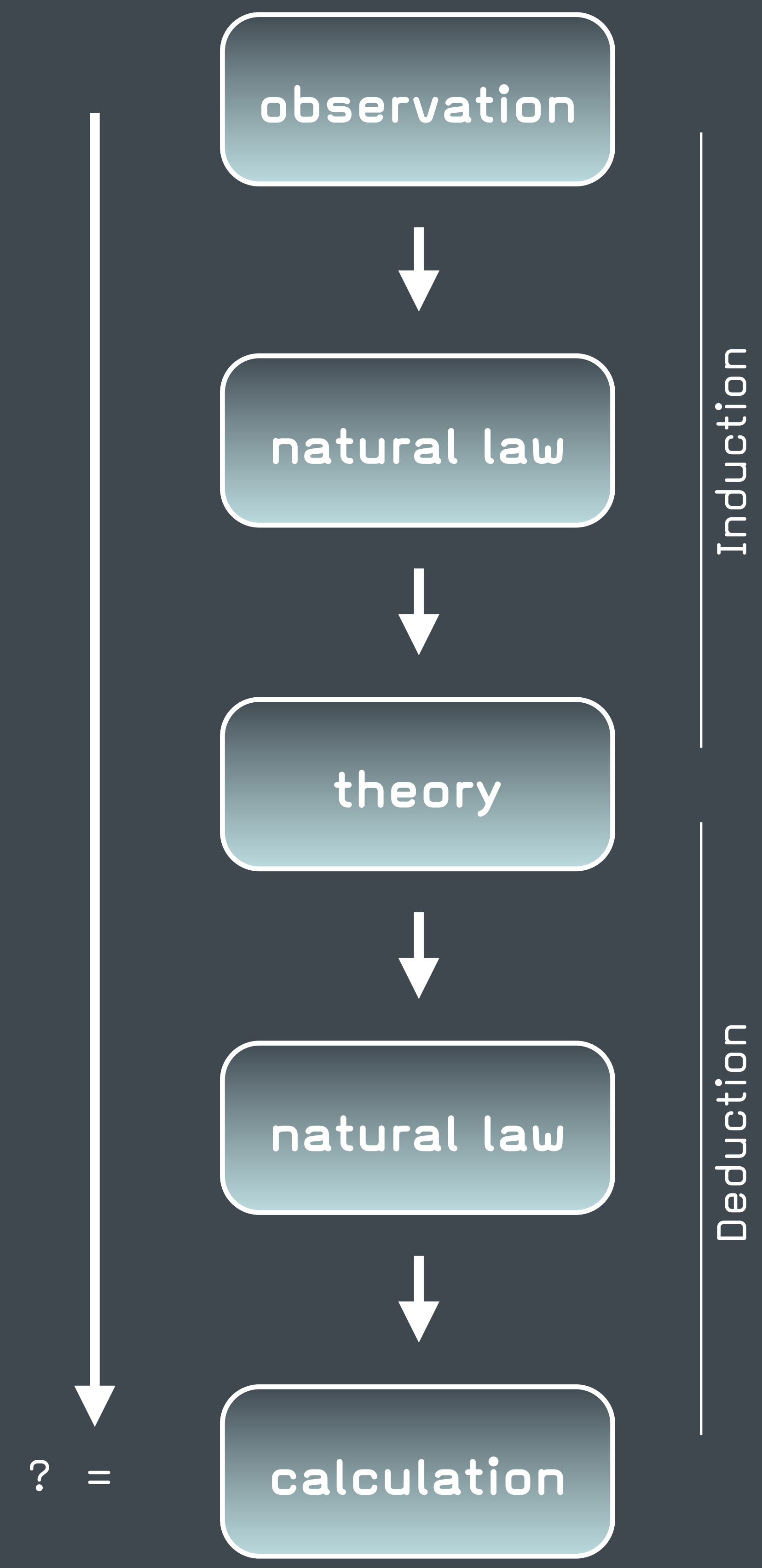
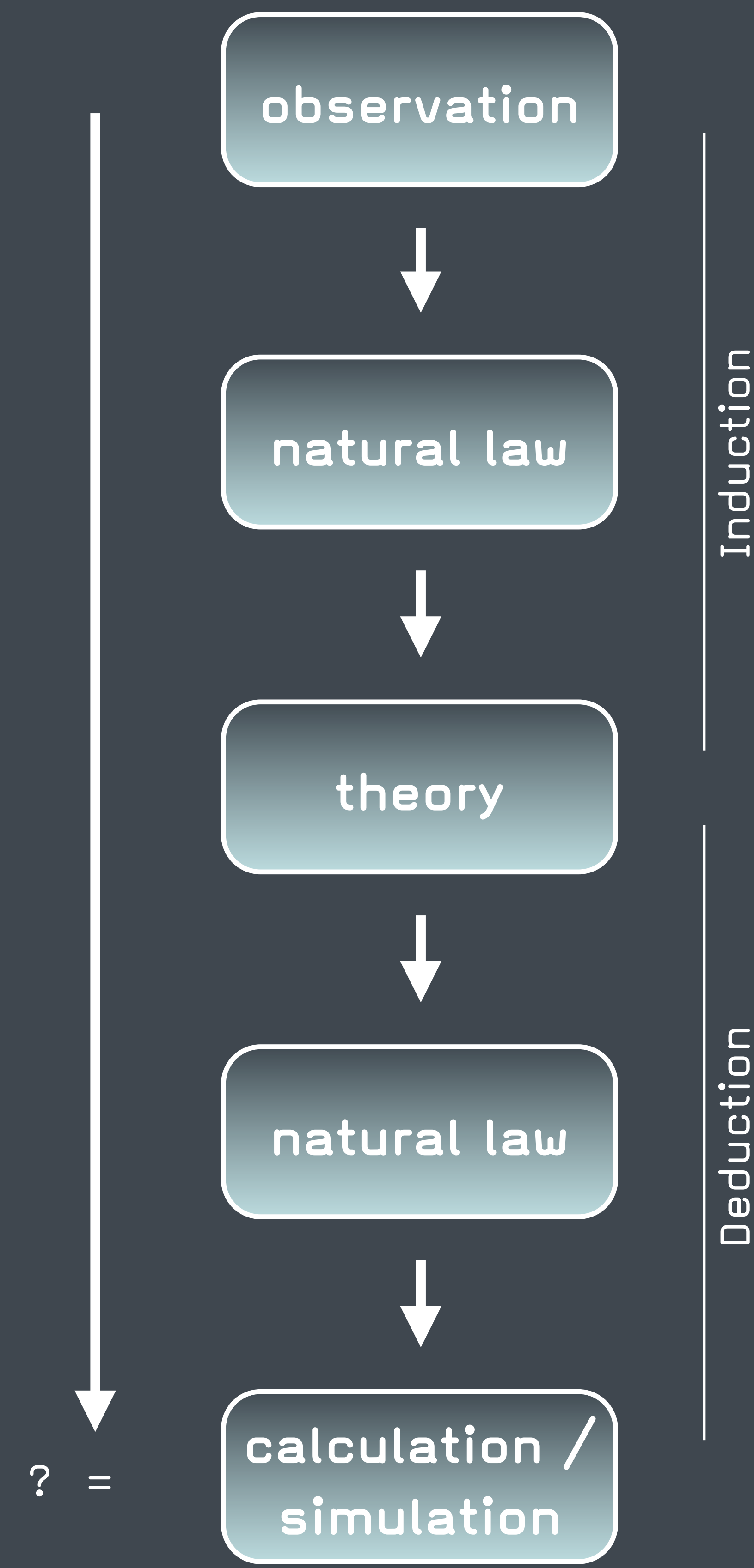


# Induction and Deduction

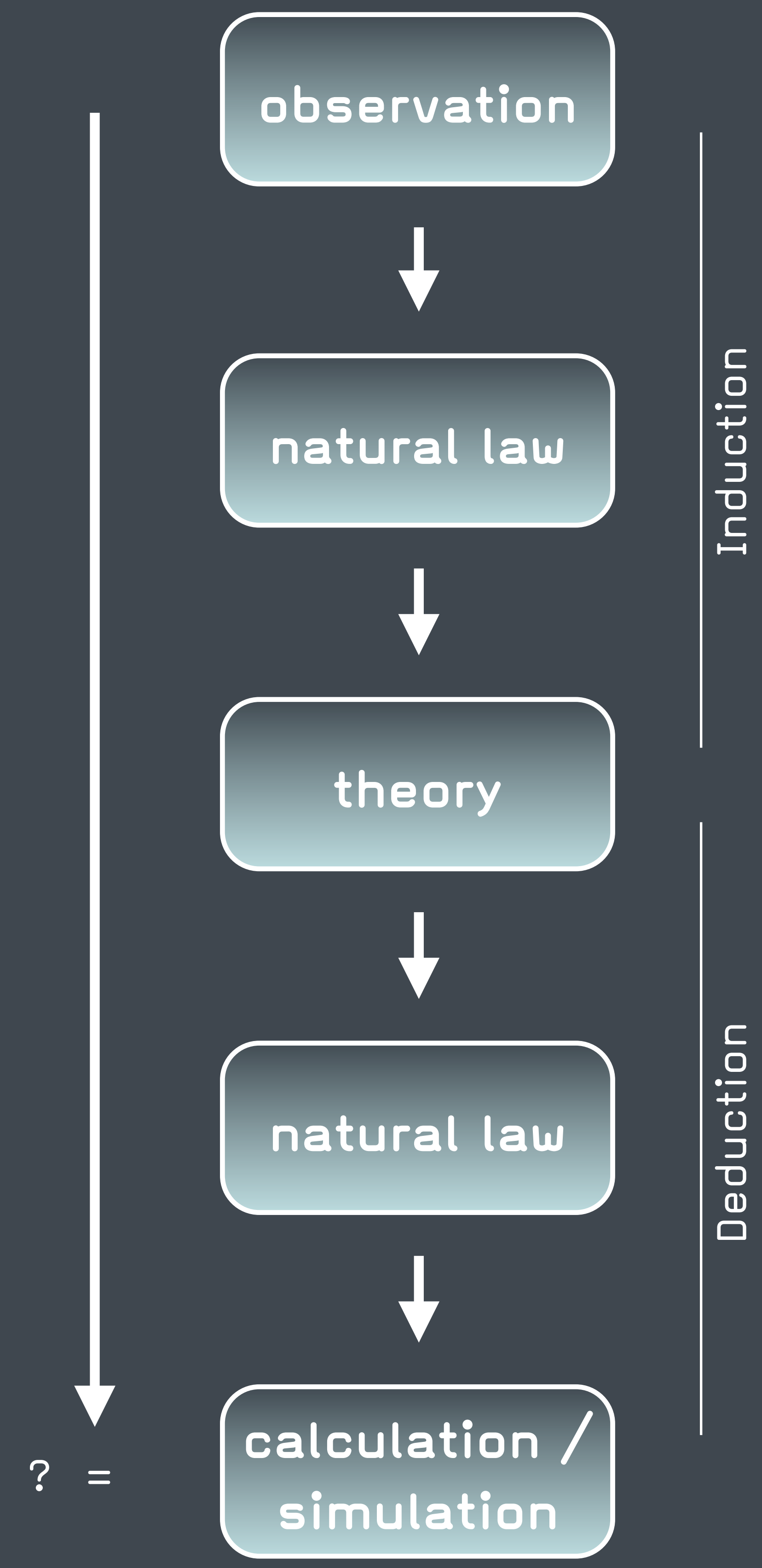
## Induction and Deduction:



# Induction and Deduction

## Induction and Deduction:

= theory and experiment!



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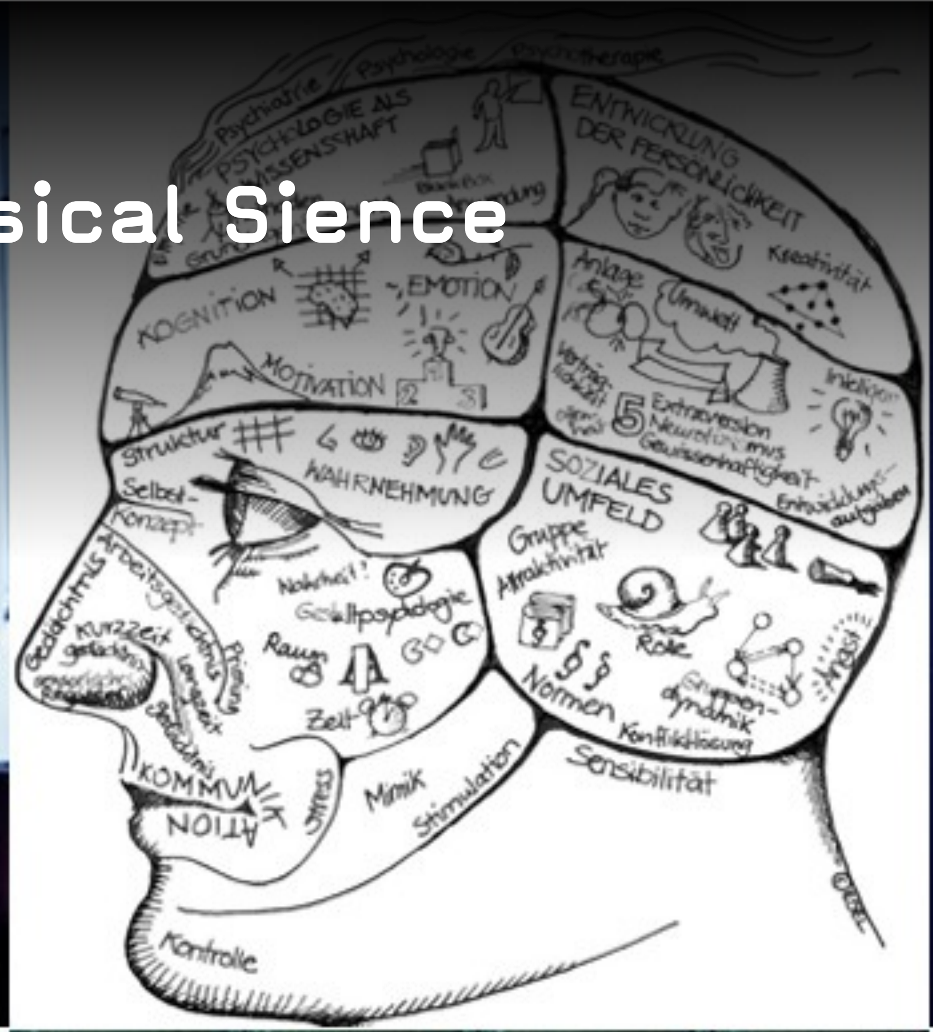
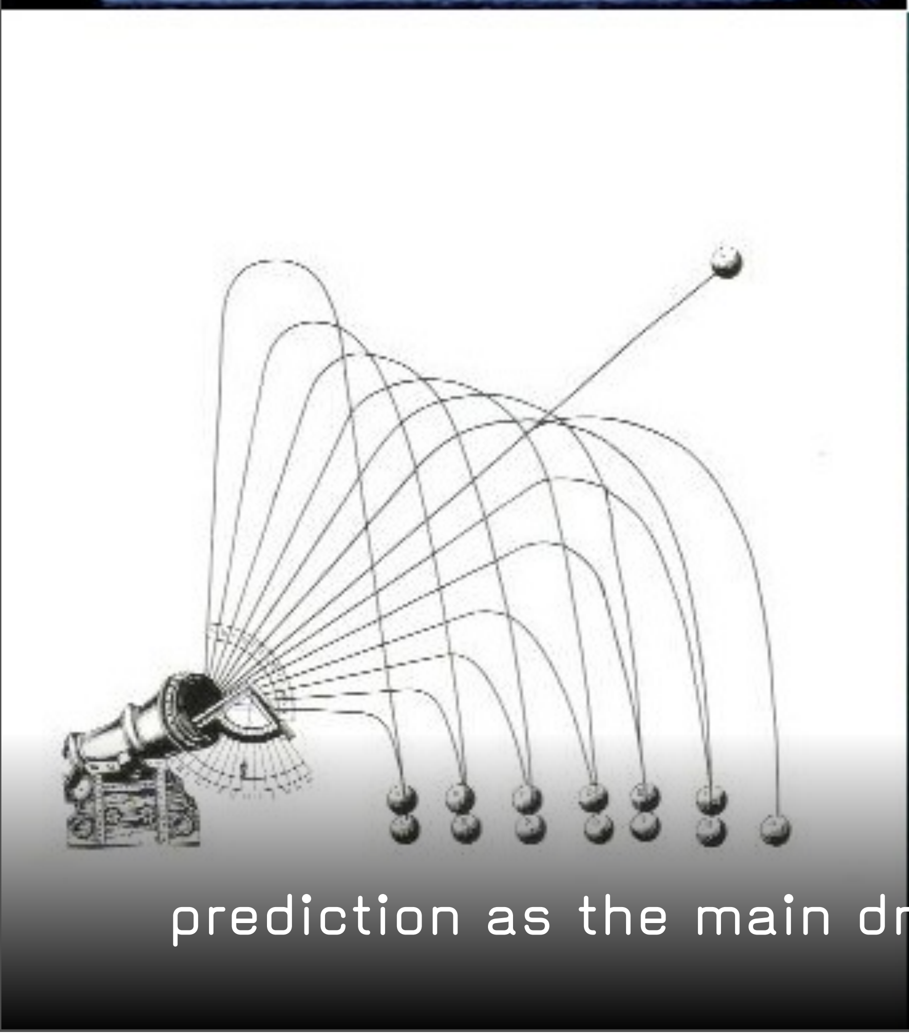
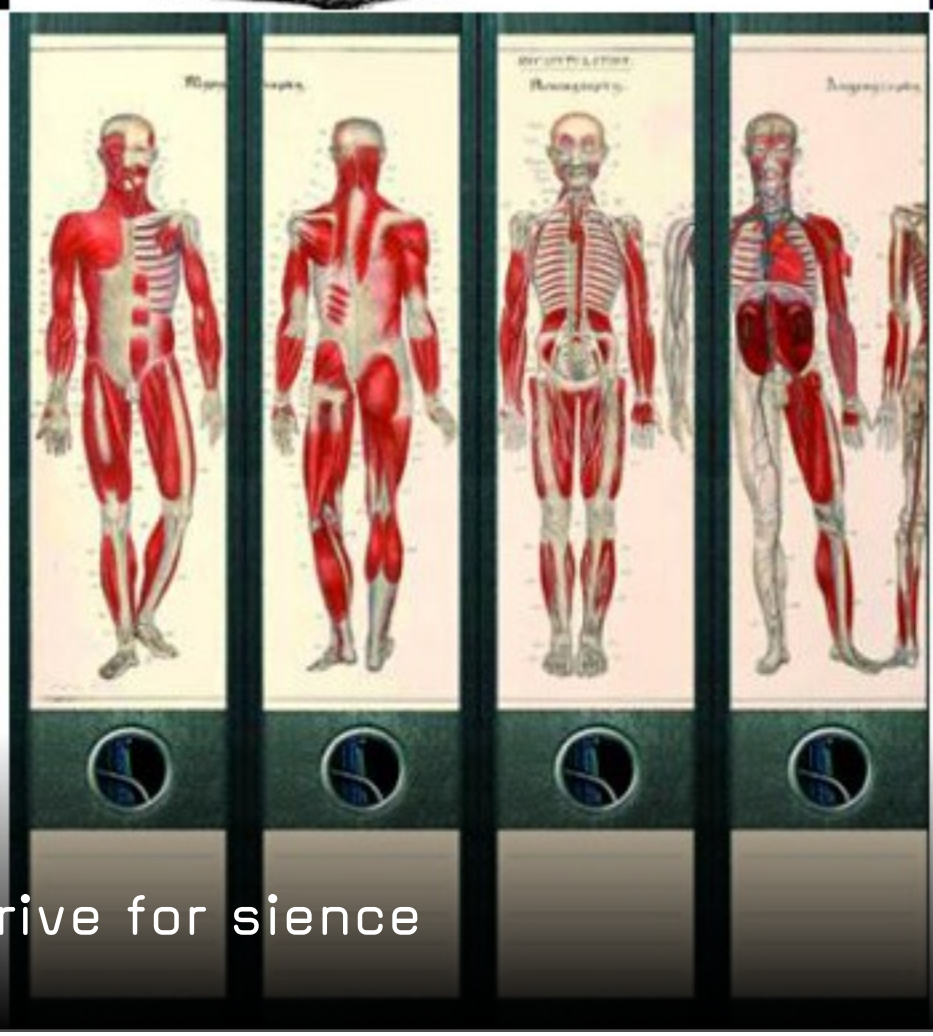
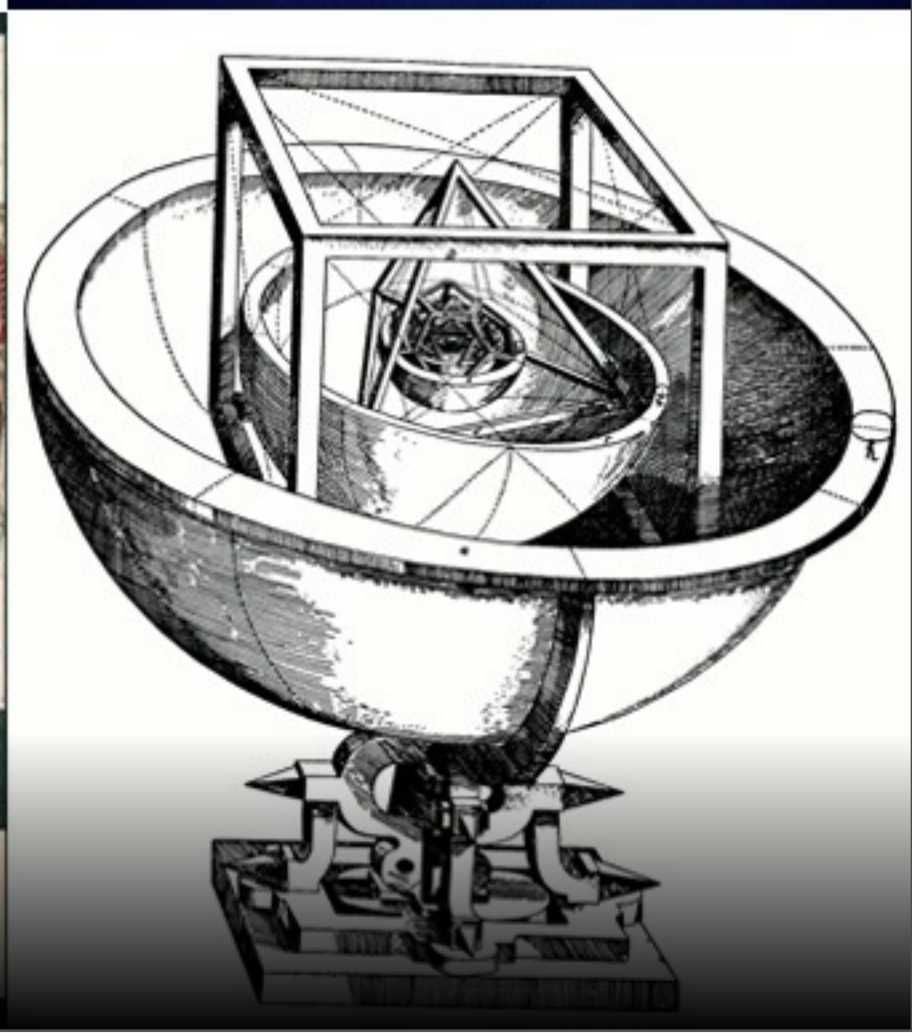
# Examples - Classical Sience





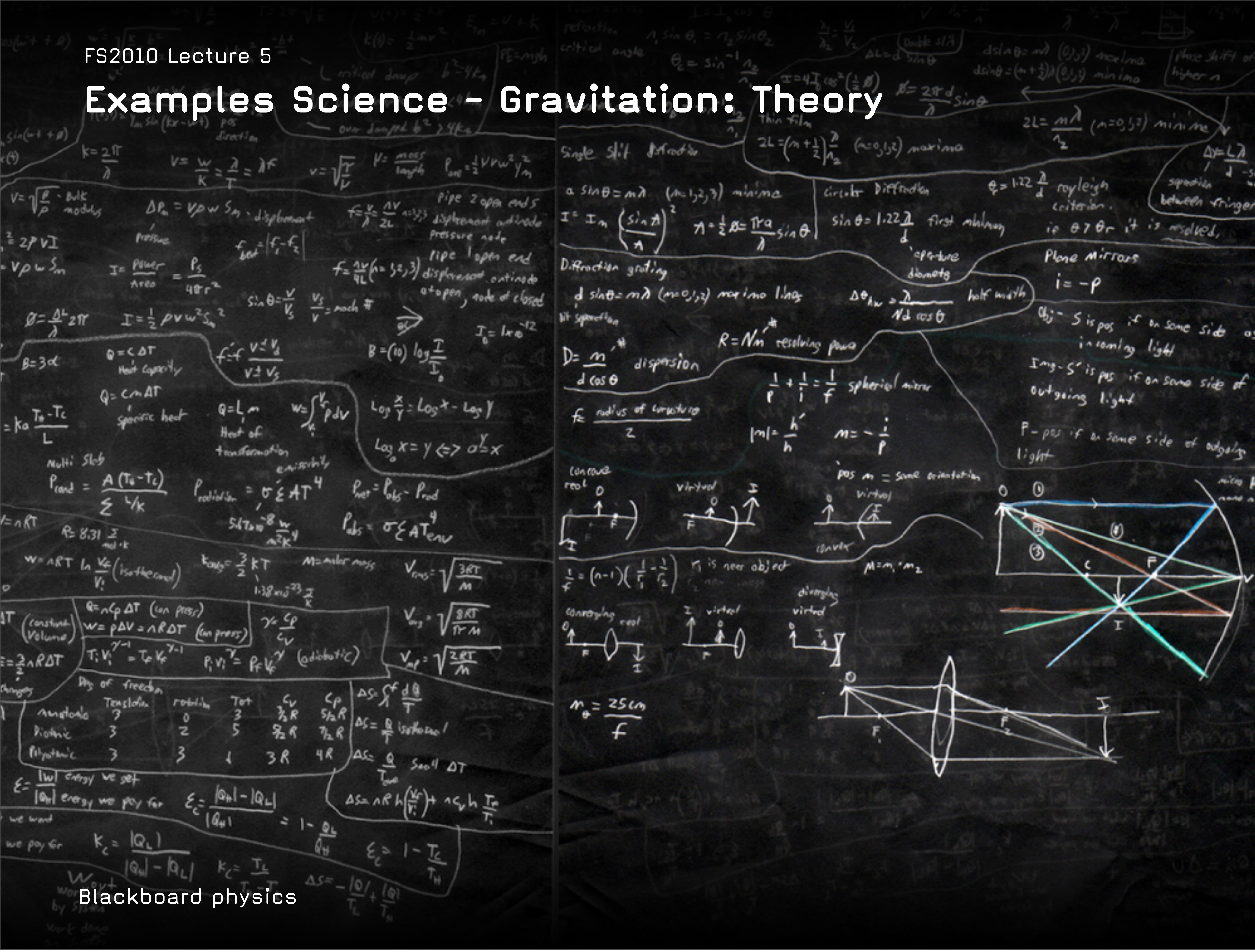






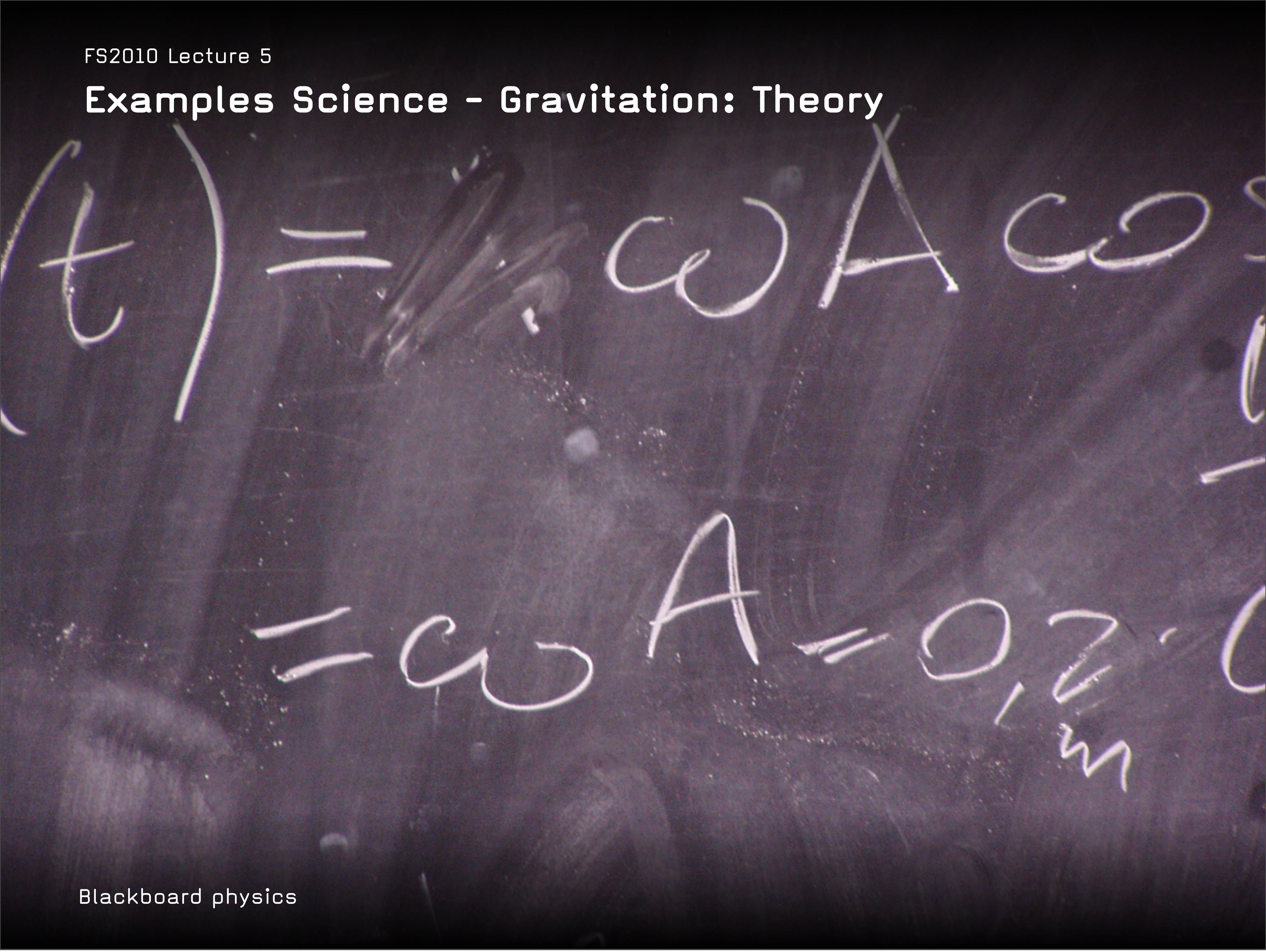
prediction as the main drive for sience

# Examples Science - Gravitation: Theory



Blackboard physics

# Examples Science - Gravitation: Theory



Blackboard physics

# Examples Simulation - Large Hadron Collider

March 29, 2010

## Auf dem Weg zu einem weiteren Weltrekord

Morgen ist es am Cern so weit: Erstmals sollen bei einer Energie von 7000 Milliarden Elektronenvolt im LHC Protonen miteinander kollidieren. Der ETH-Professor und Teilchenphysiker Günther Dissertori erzählt über Hoffnungen und Unsicherheiten, mit denen die Experten der Kollision entgegenblicken.

http://www.ethlife.ethz.ch/archive_articles/100329_LHC_7TVE_su/index

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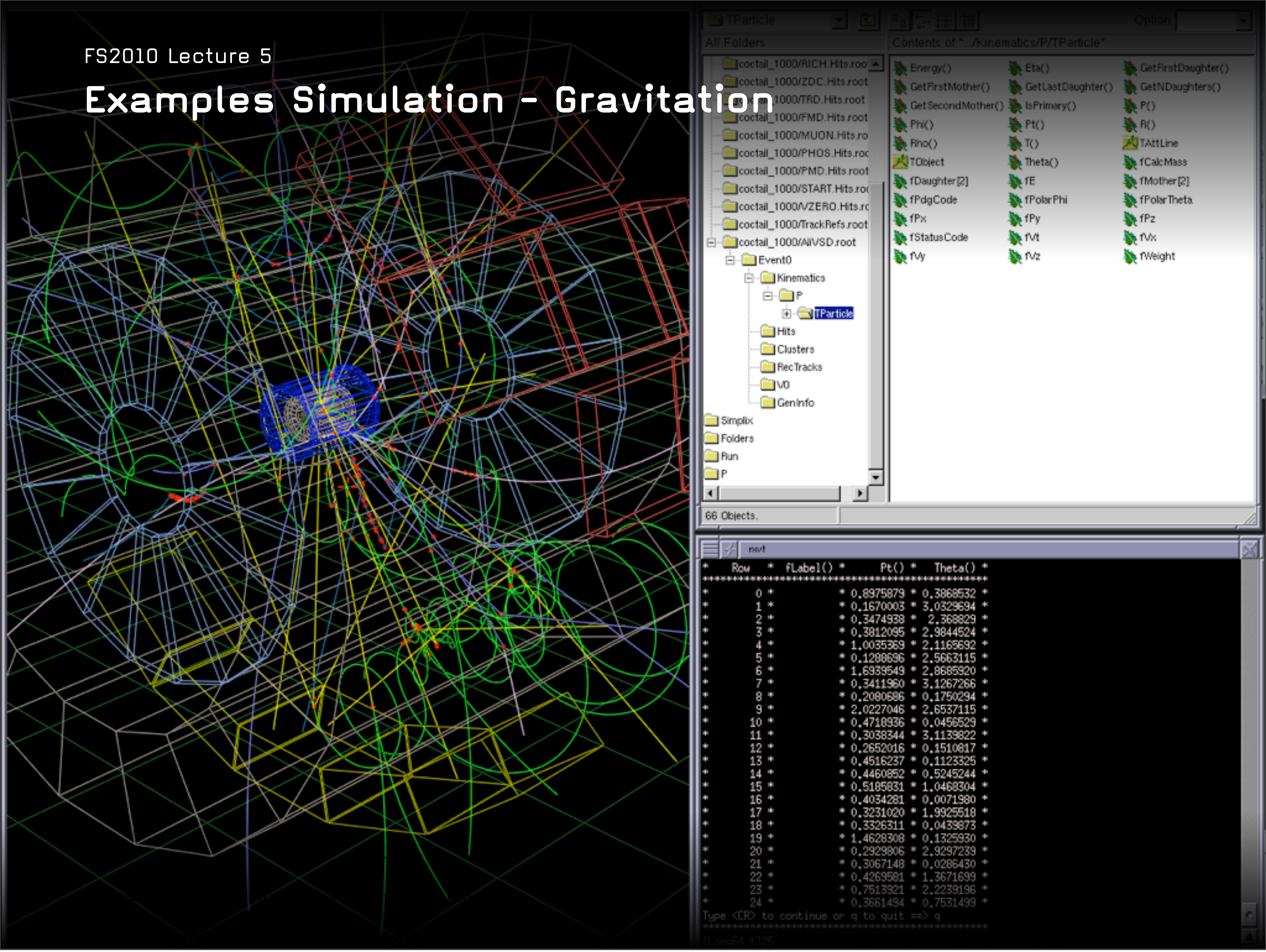
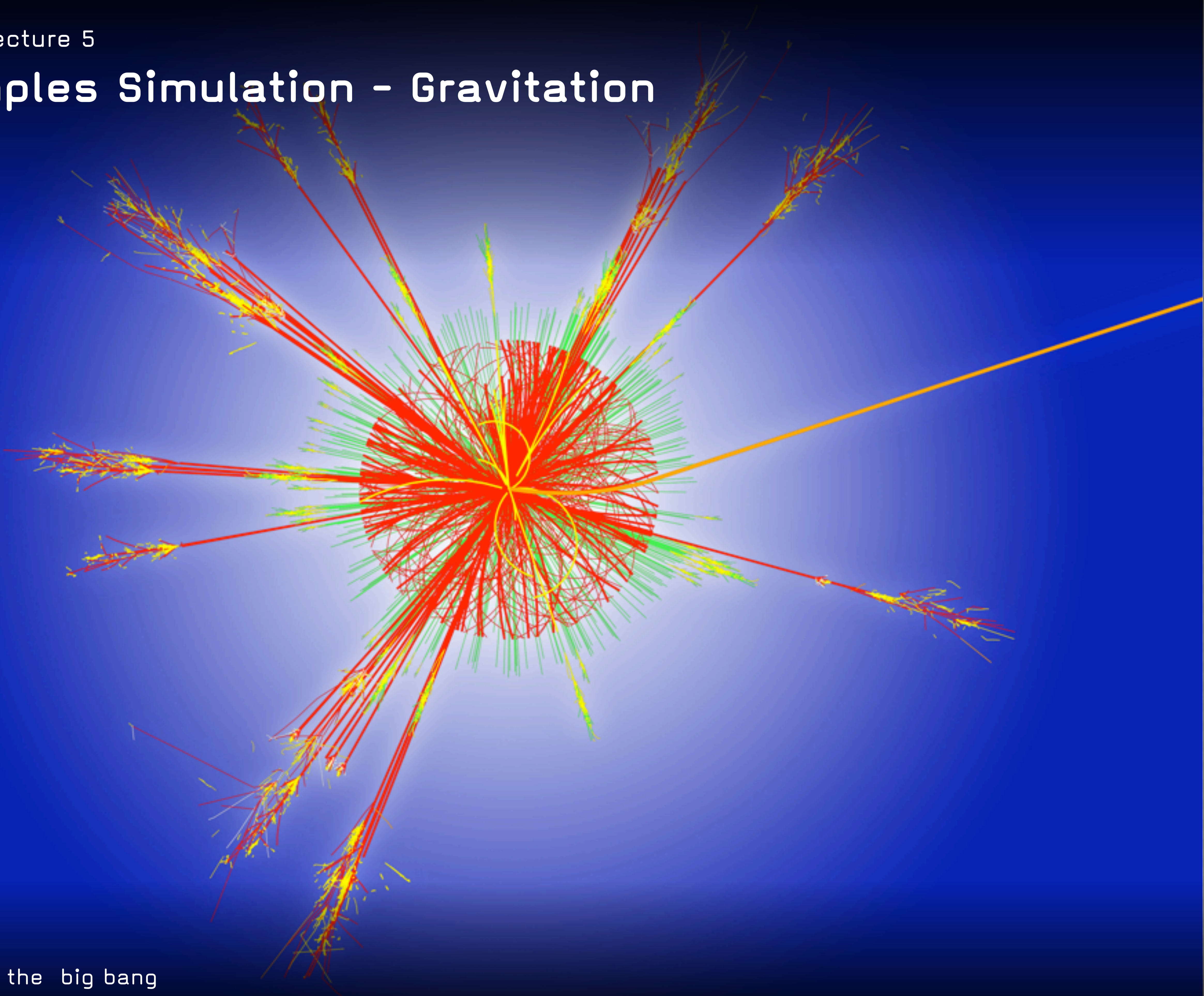
# Examples Simulation - Gravitation



# Examples Simulation - Gravitation



Simulating the  big bang

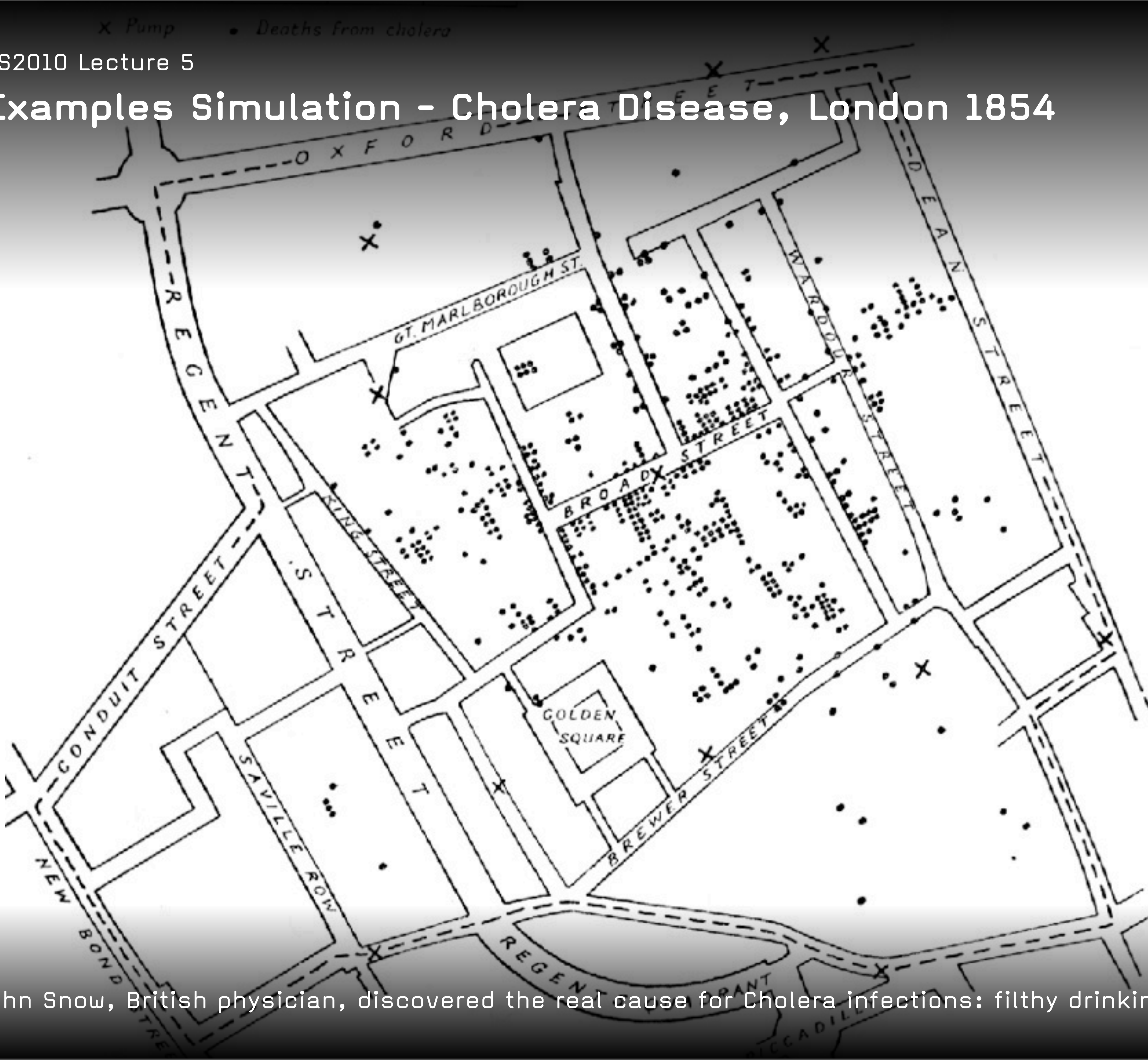
# Examples Science - Astronomy


prediction of astronomical constellations like solar eclipses

# Examples Science - Astronomy

Keplers new heliocentric paradigm • elliptical orbits instead of circular

# Examples Simulation - Cholera Disease, London 1854



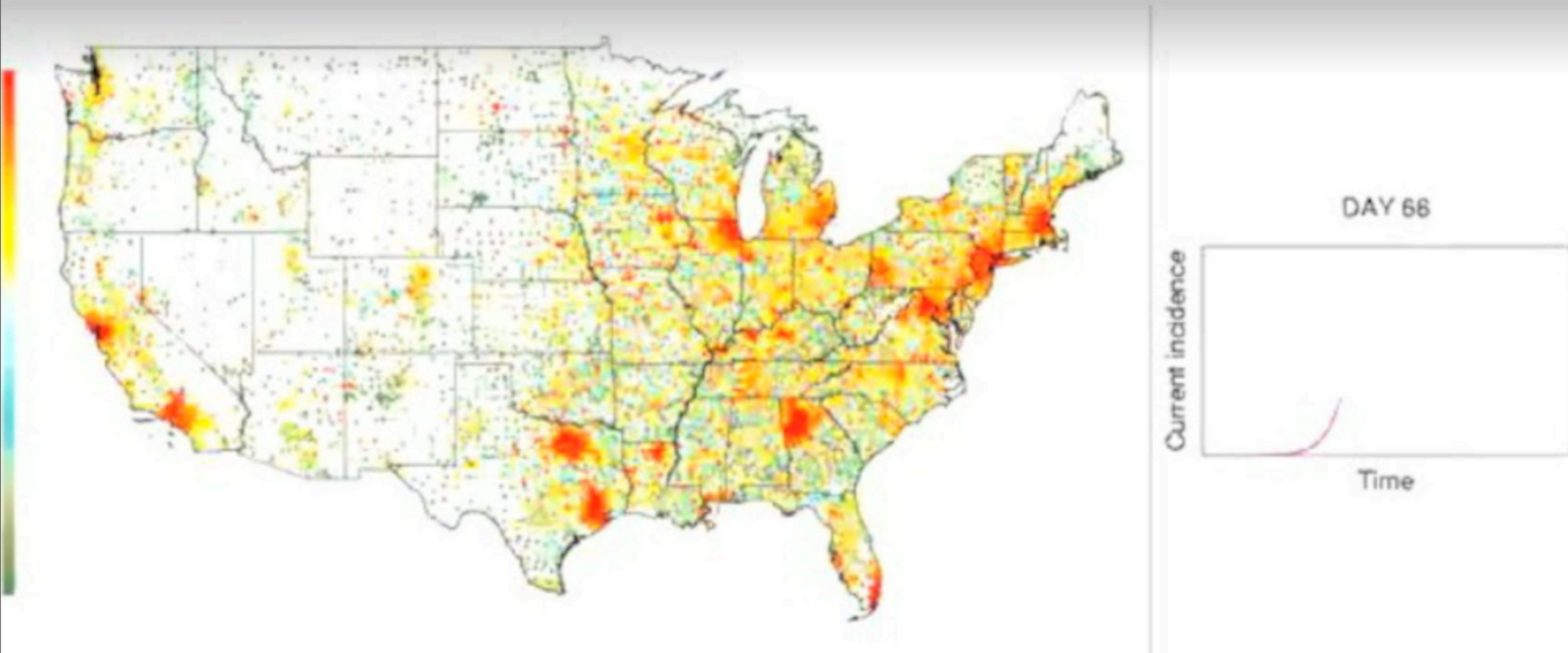

John Snow, British physician, discovered the real cause for Cholera infections: filthy drinking water.

# Examples Simulation - Pandemic

Pandemic flu initially introduced by the arrival of 10 infected individuals in Los Angeles.

Los Alamos National Laboratory

# Examples Simulation - Pandemic




Pandemic flu initially introduced by the arrival of 10 infected individuals in Los Angeles.
Los Alamos National Laboratory

# Philosophy of Science

## Calculation vs. Simulation

# Philosophy of Science

## Calculation vs. Simulation

How long does it take for an apple to fall down a tree?

# Philosophy of Science

## Calculation vs. Simulation

How long does it take for an apple to fall down a tree?

Calculation:

I know the rules.
I calculate based on
experiments made earlier.

# Philosophy of Science

## Calculation vs. Simulation

How long does it take for an apple to fall down a tree?

Calculation:

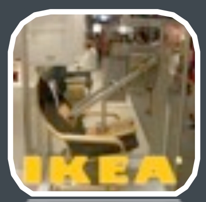
I know the rules.
I calculate based on experiments made earlier.

Simulation:

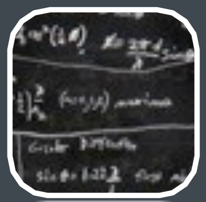
I simulate a system that knows gravity, mass, time. Then - within this system - I drop an apple and I stop the time it takes to reach the ground.

# When do I need simulation?

Simulation of an experiment, because it is cheaper, faster.

Simulation because a exact calculation is too complex.
--> Numerical brute force.



Simulation of data to get a better understanding.
--> Visualisation.



# Simulation Lectures at ETH (only core lectures)

529-0613-00L **Process Simulation and Flowsheeting**
- Chemie- und Bioingenieurwissenschaften Master
- Energy Science and Technology Master

529-0004-00L **Computer Simulation in Chemistry, Biology and Physics**
- Computational Biology and Bioinformatics Master

252-0207-00L **Modelling and Simulation**
- Zertifikatslehrgang in Informatik

**40** elective courses at ETH

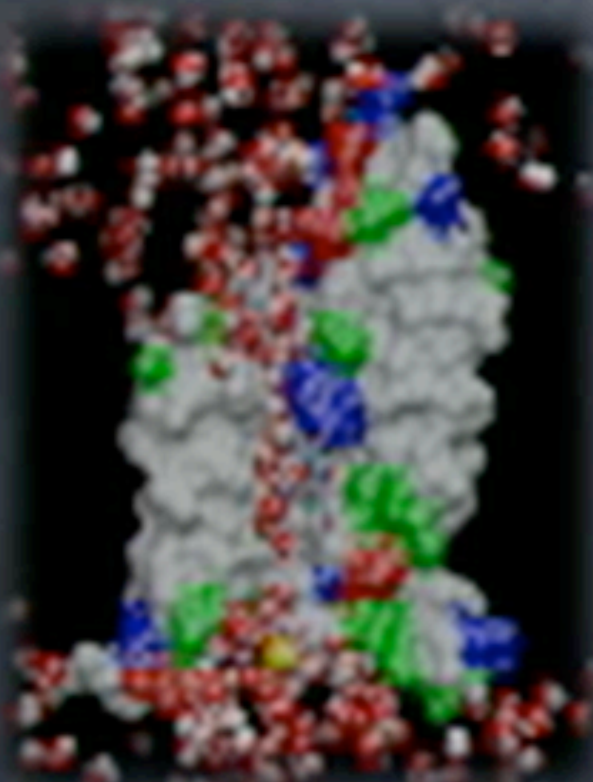
**10** courses at University of Zurich

# Advanced Computational Science Lecture FS09

# COMPUTERS for SIMULATIONS

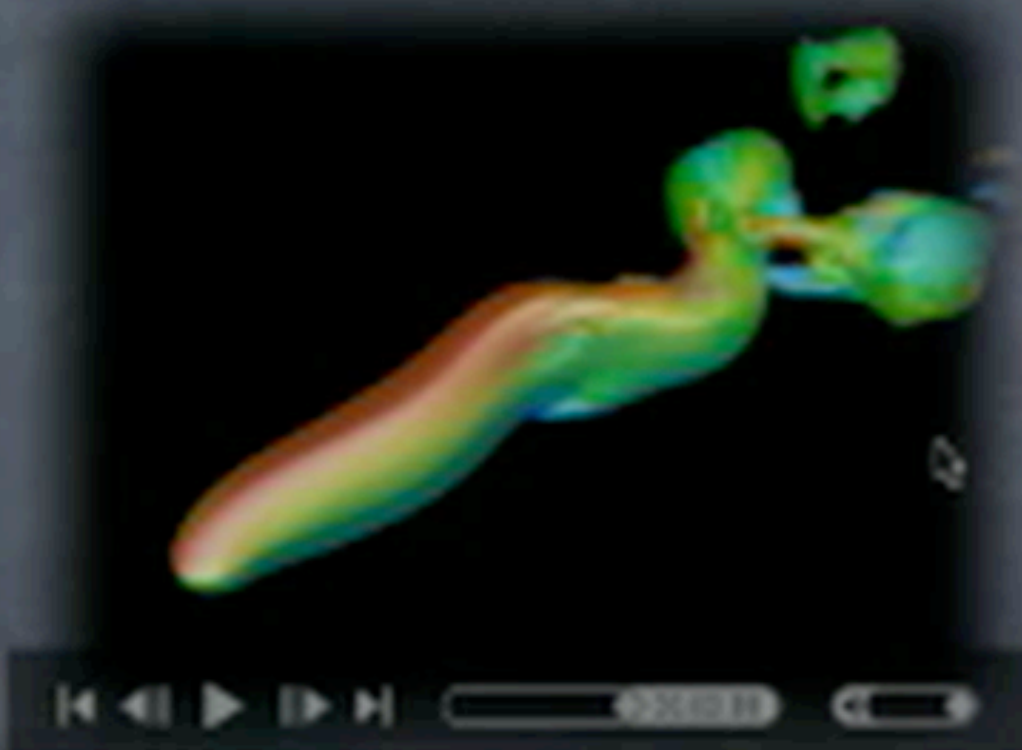
## Advances in Hardware - Theory - Data Processing

-9



Transport in aquaporins
Schulten Lab, UIUC

0



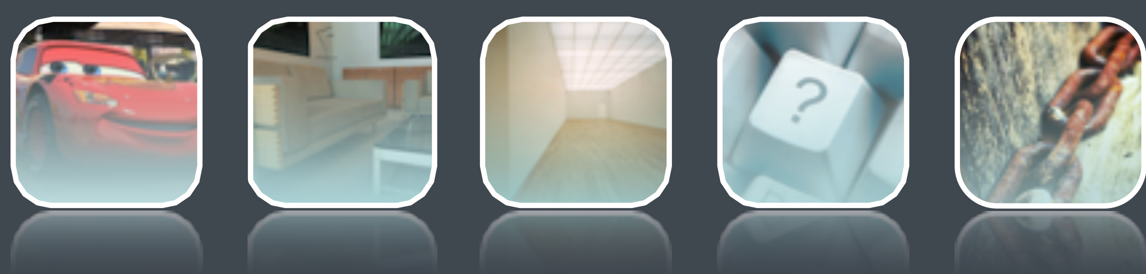
Anguilliform Swimmers
Koumoutsakos Lab, ETHZ

+9

Growth of Black Holes
Springel, MPE - Hernquist, Harvard

# Simulation: An Attempt Of An Overview

## Design Perspective



Animation • Renderings • Models • Why PC? • Digital Chain

## Science View

Theory • Experiment • Simulation

Simulation As An Assistance

Simulation As Visualisation

# Simulation: Exercise 2

One Image and short description of architectural or urban design simulation from your perspective

To be handed in per e-mail until April 12, 2010 to

coleman@arch.ethz.ch

Format: Powerpoint or Keynote

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# Design: Rendering


http://maxwellrender.com/ • Multilight Feature → Light Simulation? Animation?

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# Design: Rendering

http://www.cheetah3d.com • Cheetah3D is a lightweight version of Cinema4D

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# Design: Rendering


http://maxwellrender.com/

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# Design: Rendering

http://www.mentalimages.com • Mental Ray Renderer

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# Design: Rendering

FryRender • http://randomcontrol.com/

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# Design: Rendering

Vue Digital Nature • http://www.e-onsoftware.com/

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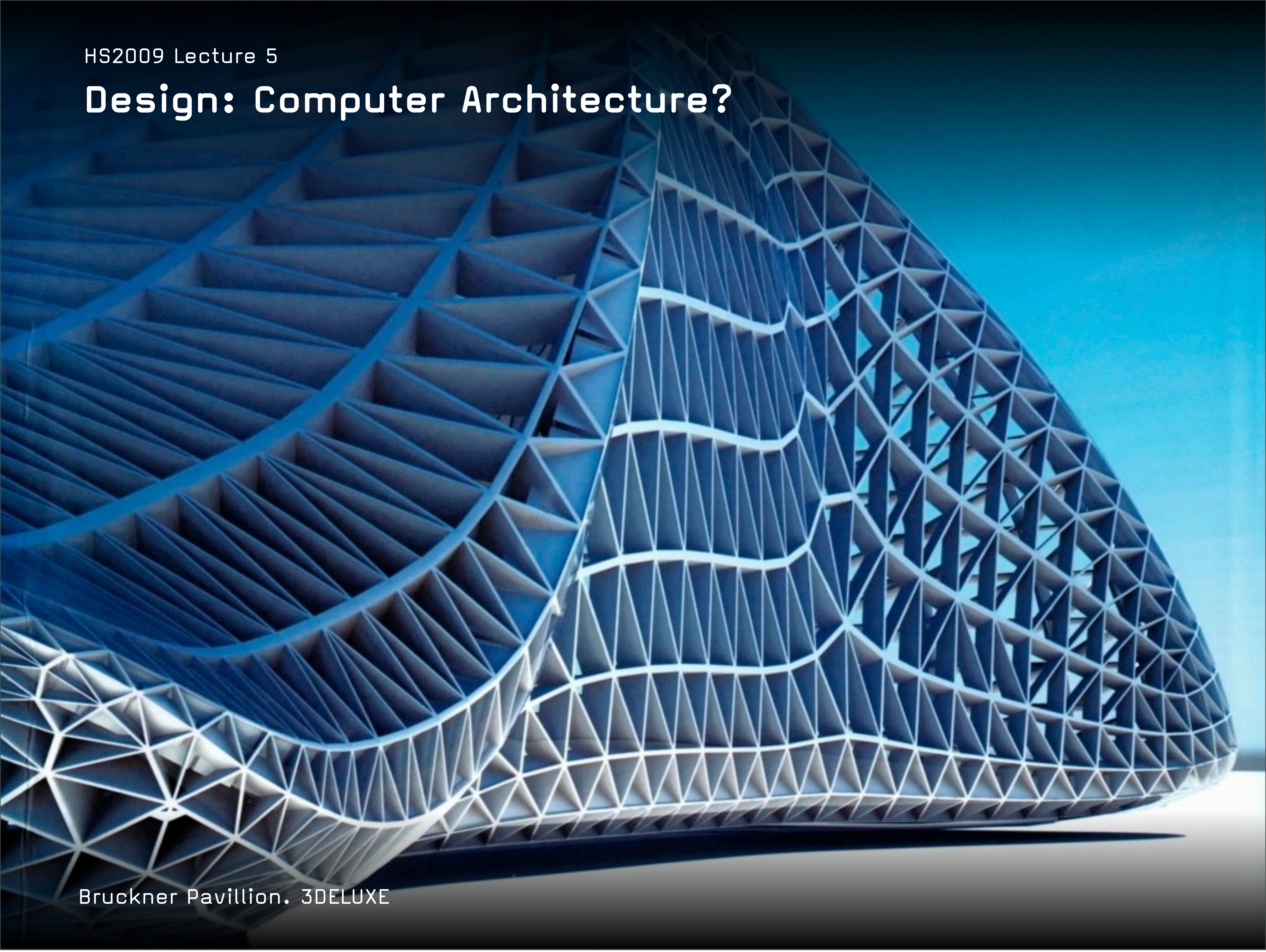
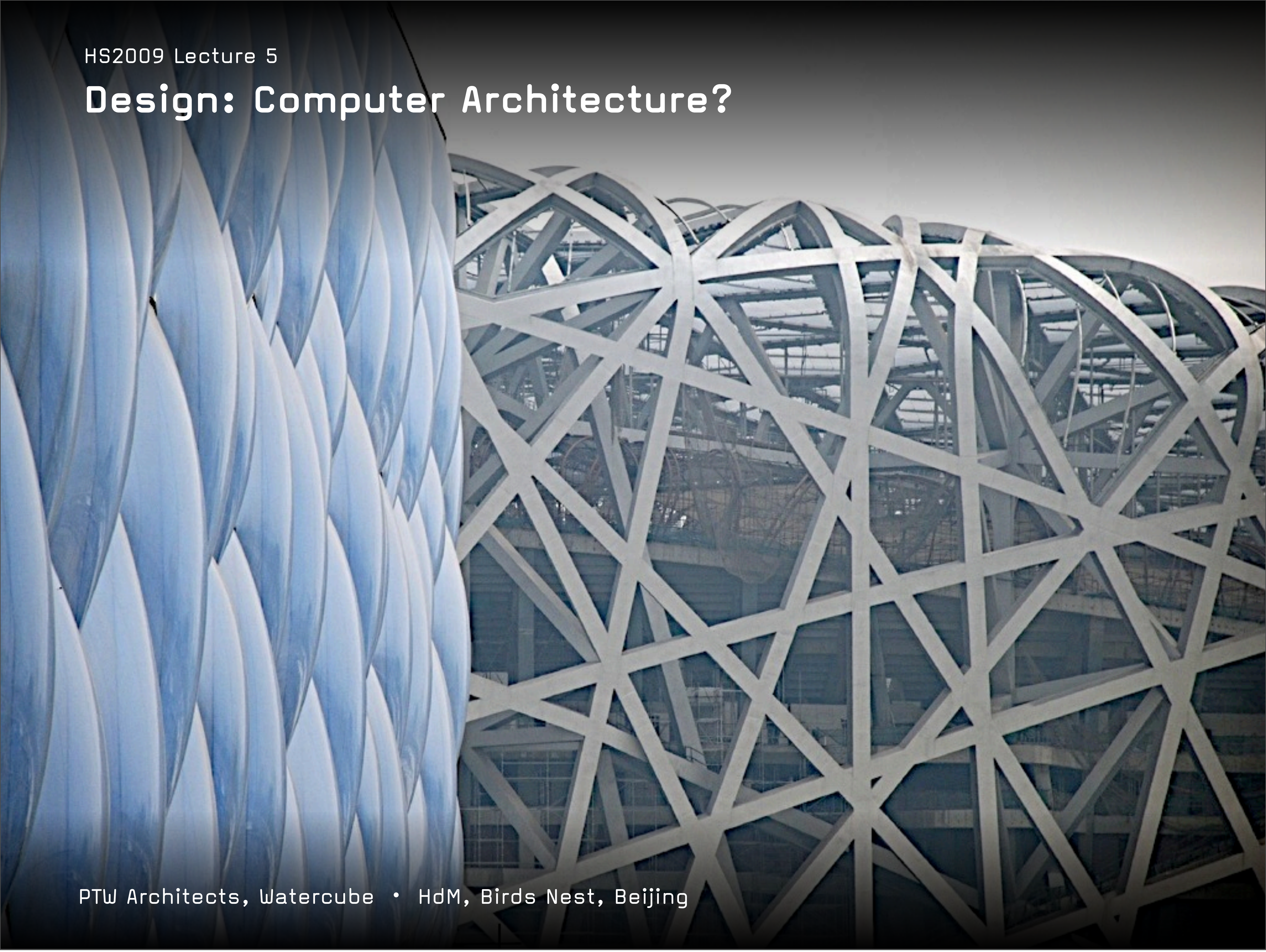
# Design: Computer Architecture?



Bruckner Pavillion. 3DELUXE

HS2009 Lecture 5

# Design: Computer Architecture?



PTW Architects, Watercube • HdM, Birds Nest, Beijing

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# Design: Computer Architecture?

PTW Architects, Watercube, Beijing

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# Design: Computer Architecture?

Marqués de Riscal in La Rioja, Gehry Partners 2007

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# Design: Computer Architecture?

TWA Terminal in New York, Eero Saarinen 1956 - 62

Thema

# Example: Simulation in Urban Design (L 7)

**Module 1: DESIGN**

**Urban design group**

**3D model of case studies**

**Socio-economic/climate scenarios**

**Module 2: SIMULATION**

Ecological, economical, social **quality criteria, process models, and rules**

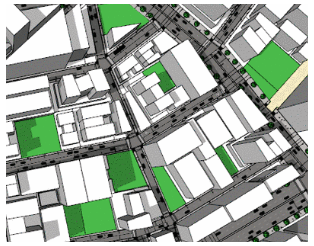
**PROCEDURAL URBAN MODEL**

**Design quality criteria and rules**

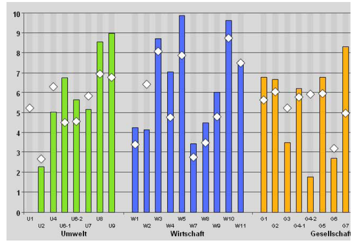
*Dt ≈ 20 yrs until 2050*

**Module 3: ANALYSIS/ COLLOBORATIVE MODELING**

**URBAN PATTERNS**



**SUSTAINABILITY INDICATORS**



**Stakeholder responses: change of trade-off rules**

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Chair for Information Architecture

# Prediction, Simulation and Decision Process

## Sience

- fundamental **research**
- theory to **explain reality**
- simulation to help find a theory/ simulation to **describe reality**
- experiments for **verification**

## Design

- daily life **research**
- assumption to **describe reality** (in case no explanation exists)
- simulation /visualization to compare with
- experiments being made on earlier projects (**verification**)

# Prediction, Simulation and Design Process

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# Simulation Preview Lecture 6, April 12, 2010

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Definition • Examples

## L6: Design, Modelling, and Simulation

Design • Monte Rosa • Future Cities Project

## L7: Analysis, Prediction, and Simulation

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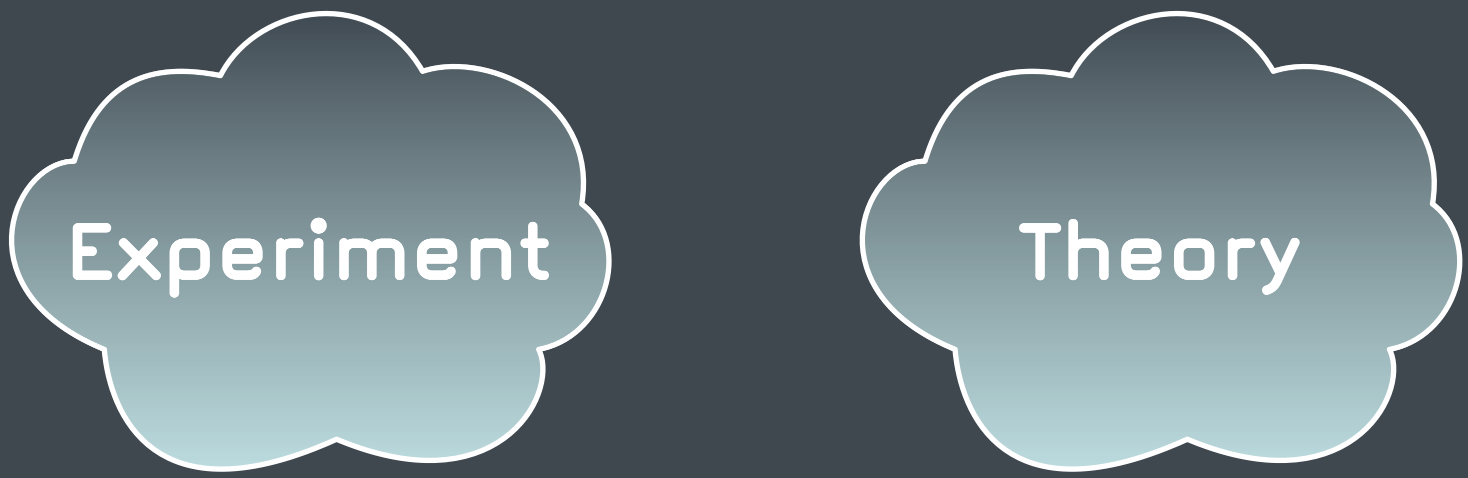
# Conclusion



# Conclusion

Experiment

Simulation

Theory