

Particle Physics in the LHC Era

Organizers: Cao Zexian and Sabine Lammers

CHAIR:

Reinhard Schwienhorst, Michigan State University

SPEAKERS:

Particle Physics beyond Standard Model

Wang Qing, Tsinghua University, Beijing

*The Status, Challenge and Promise of the Big Bang Machine
and Its Experiments*

Junjie Zhu, University of Michigan

Particle Physics in the LHC Era

Introduction

Reinhard Schwienhorst
Michigan State University

**Chinese-American
Kavli Frontiers of Science
2011**

The LHC question

The LHC question



- What happened in the very first moments after the big bang?

The LHC questions

The LHC questions

Dark Matter?



The LHC questions

Dark Matter?



Matter-Antimatter
asymmetry?



The LHC questions

Dark Matter?



Origin of
particle mass?



Matter-Antimatter
asymmetry?



The LHC questions

Dark Matter?



Origin of
particle mass?



Matter-Antimatter
asymmetry?



What makes the LHC era special

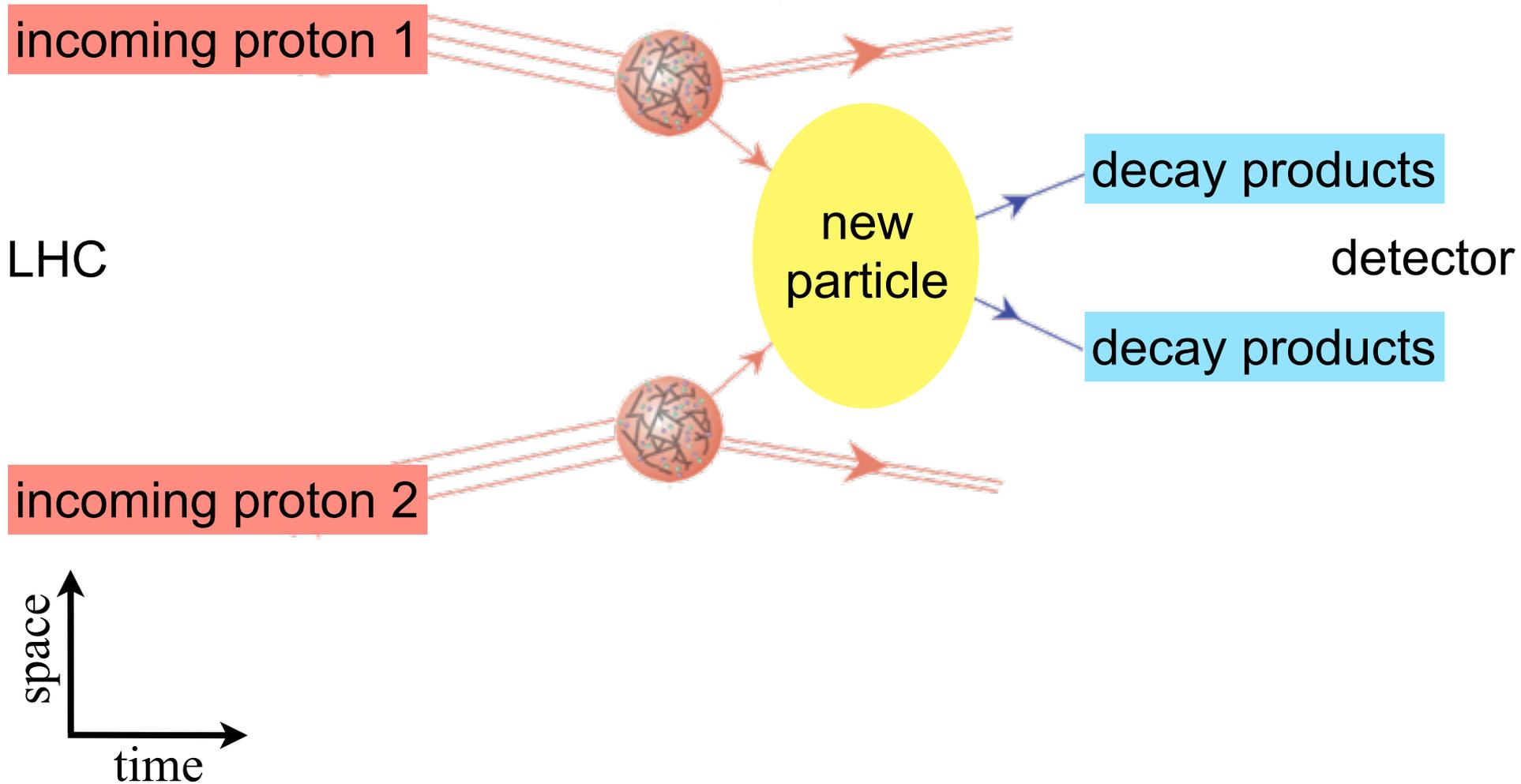
- We are now in a position to answer several of these questions
- Particle masses:
 - We will find the Higgs boson or we will find that there is no SM Higgs
- Matter-antimatter asymmetry:
 - We hope to find symmetry-breaking mechanisms
- Dark matter:
 - We expect to find the particle responsible for dark matter and measure its properties

Large Hadron Collider

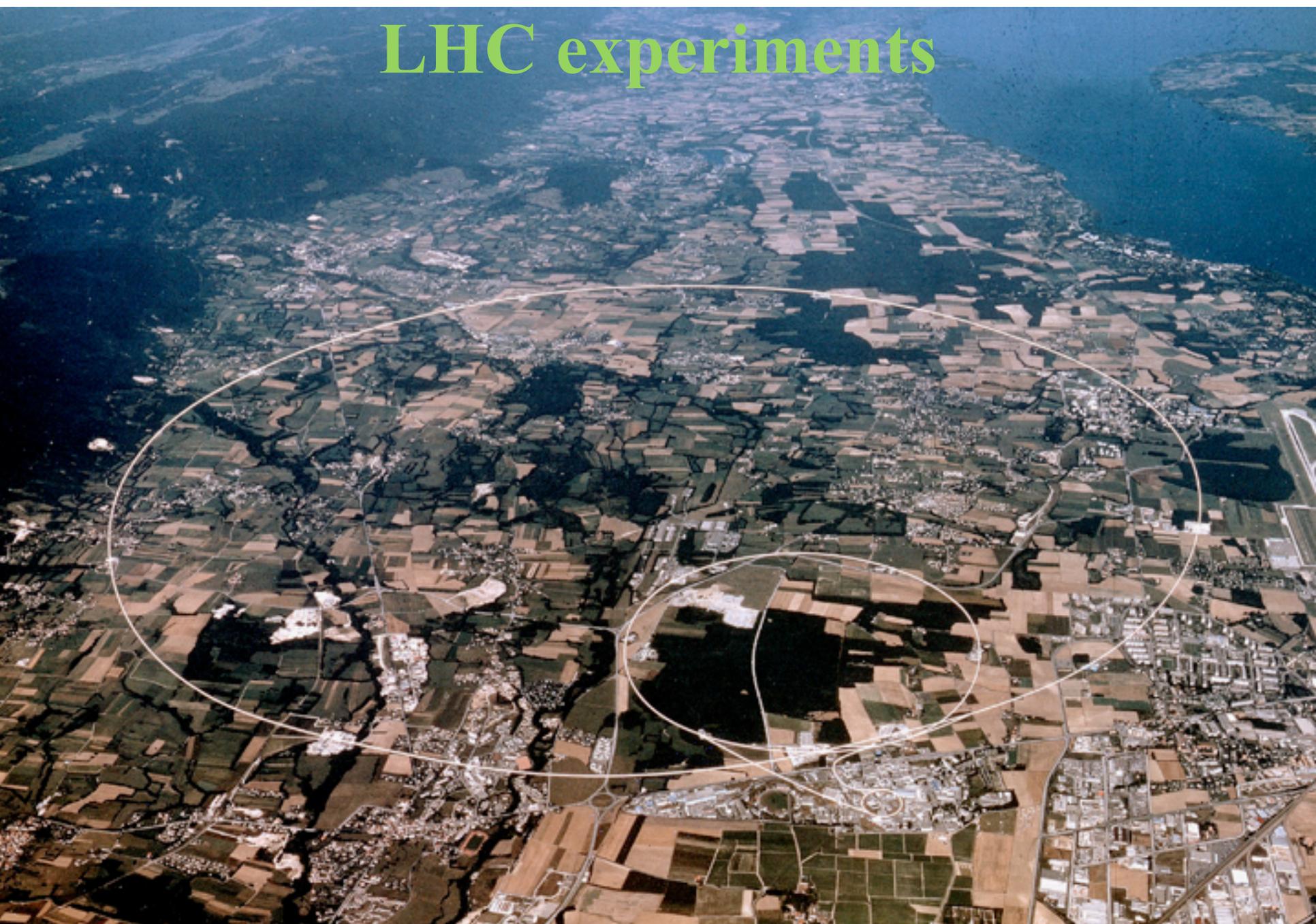
Large Hadron Collider



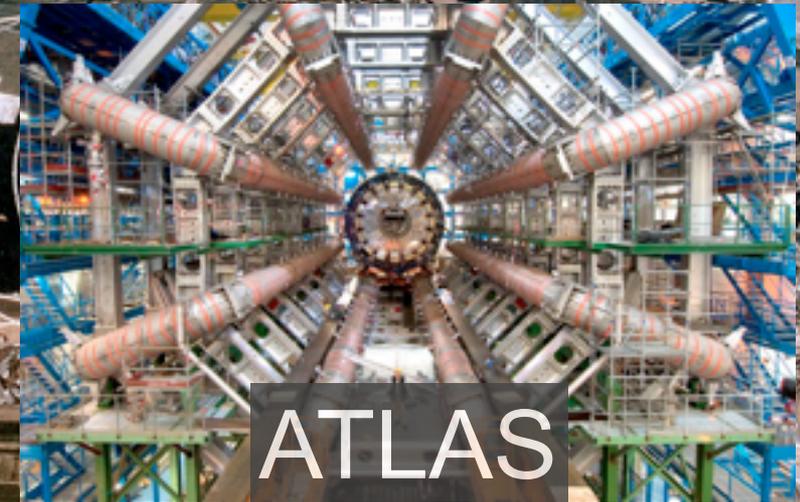
Proton accelerator, quark/gluon collider



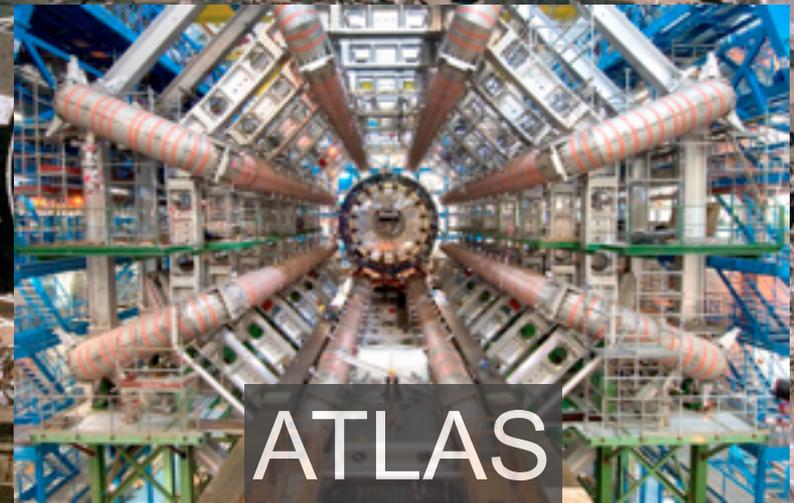
LHC experiments



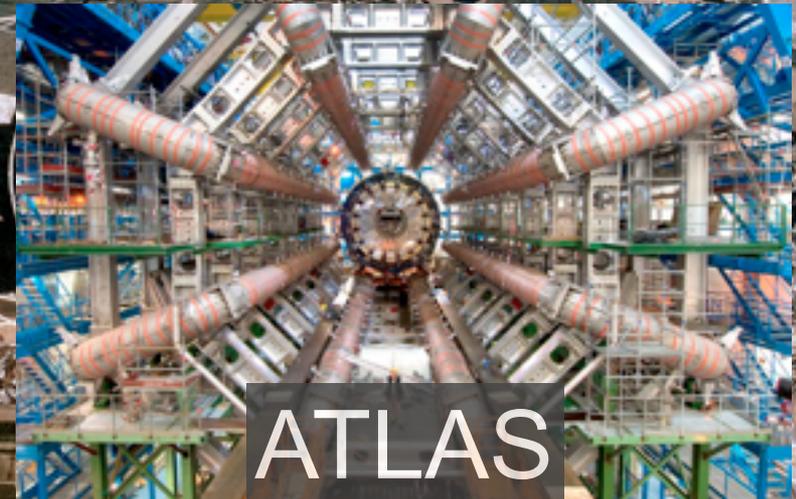
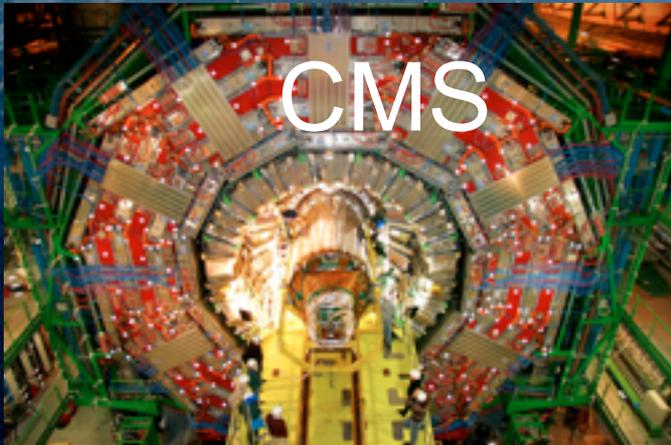
LHC experiments



LHC experiments



LHC experiments



Expected LHC measurements

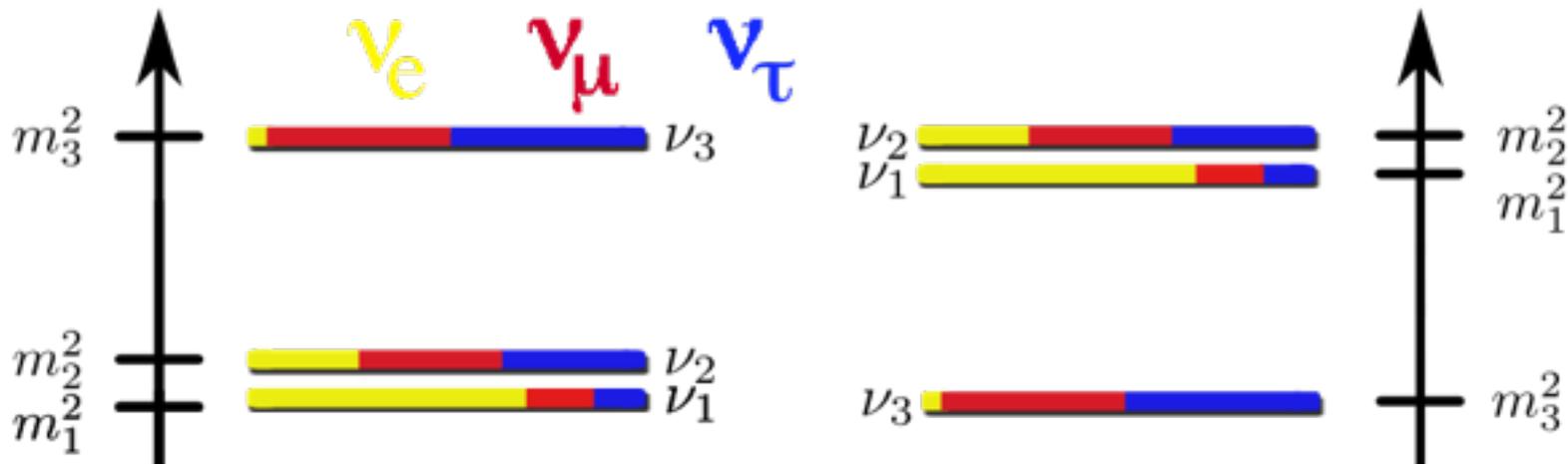
- Everyone dreams!
- Find new particles
 - Find Higgs particle
 - Find dark matter particle
- Find answers to our puzzles
 - Higgs, dark matter, matter vs antimatter
- Find something unexpected
 - Find many other new particles
 - Find new puzzles

LHC measurements have started

- Lots of measurements already made
 - With first year dataset
- Sensitivity for many measurements now best of the world
- No new particles discovered yet
- No new mechanisms discovered yet

- Uncharted territory
 - Precision measurements are important
 - Double beam energy in 2014
 - Run for the next 20 years

Three neutrinos and oscillations



- LHC will (likely) not be able to probe neutrino mass origins
- Several experiments ongoing to understand neutrino masses better
- See poster by Chris Walter

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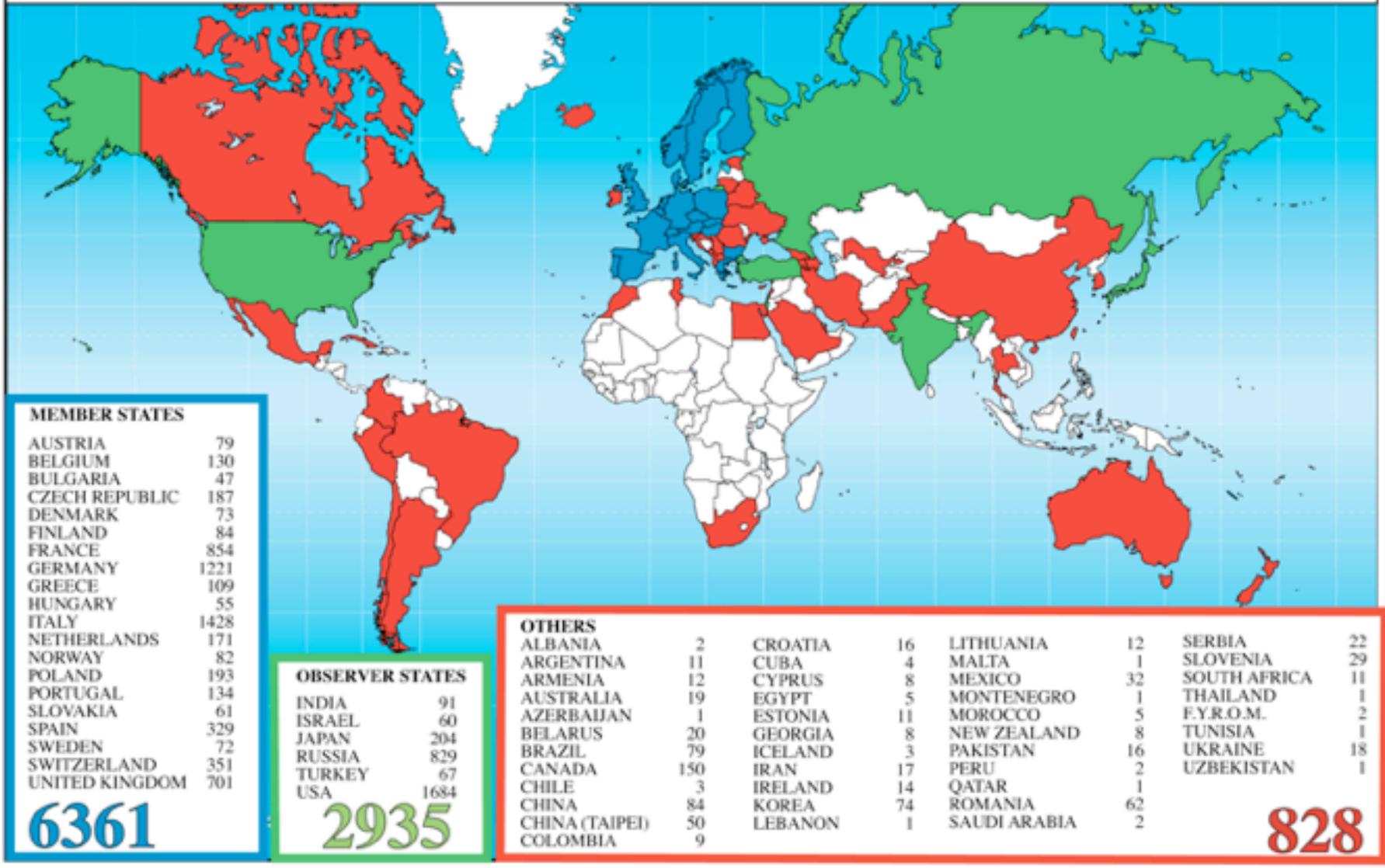
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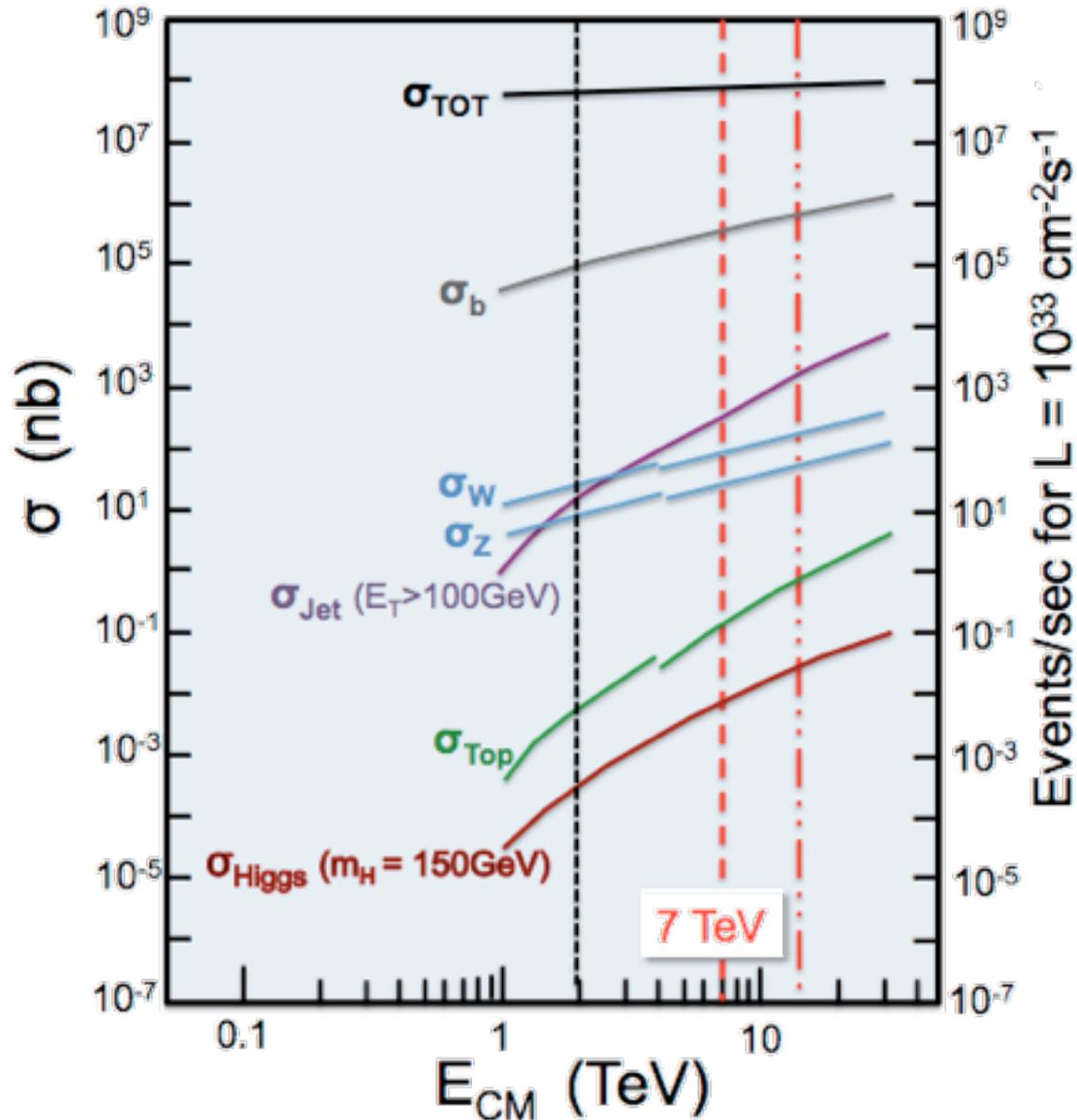
Backup slides

Global physics experiments

Distribution of All CERN Users by Nation of Institute on 6 January 2011



LHC Physics Program



Particle production at the LHC

LHC

Quark-antiquark production

Bottom quark pairs

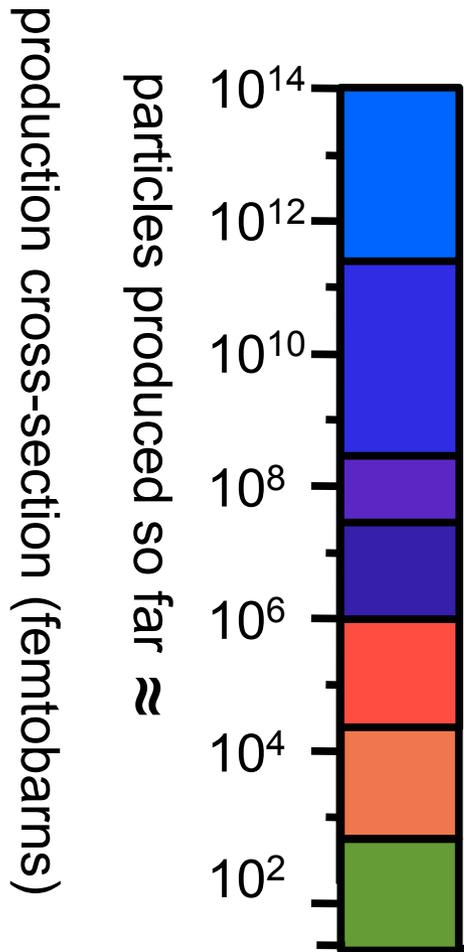
W bosons

Z bosons

top quarks

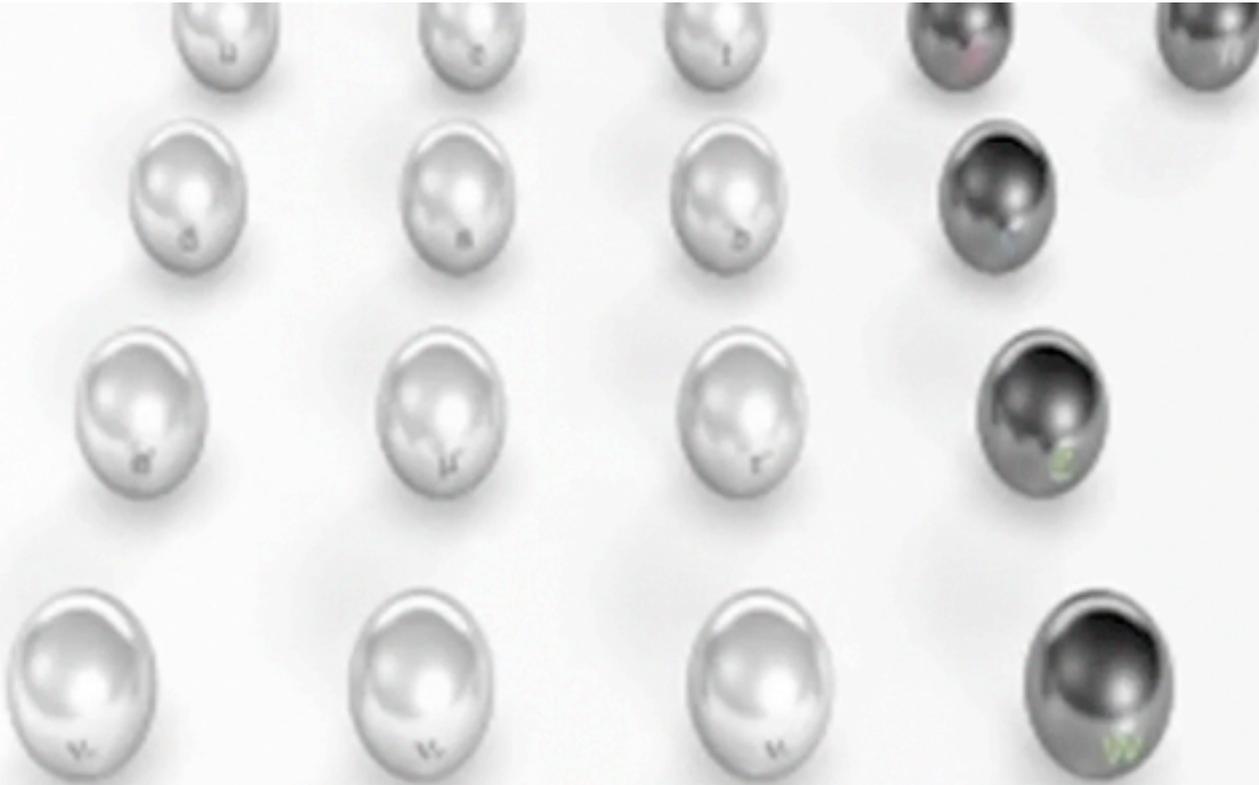
Origin of dark matter & particle masses

Something unexpected?

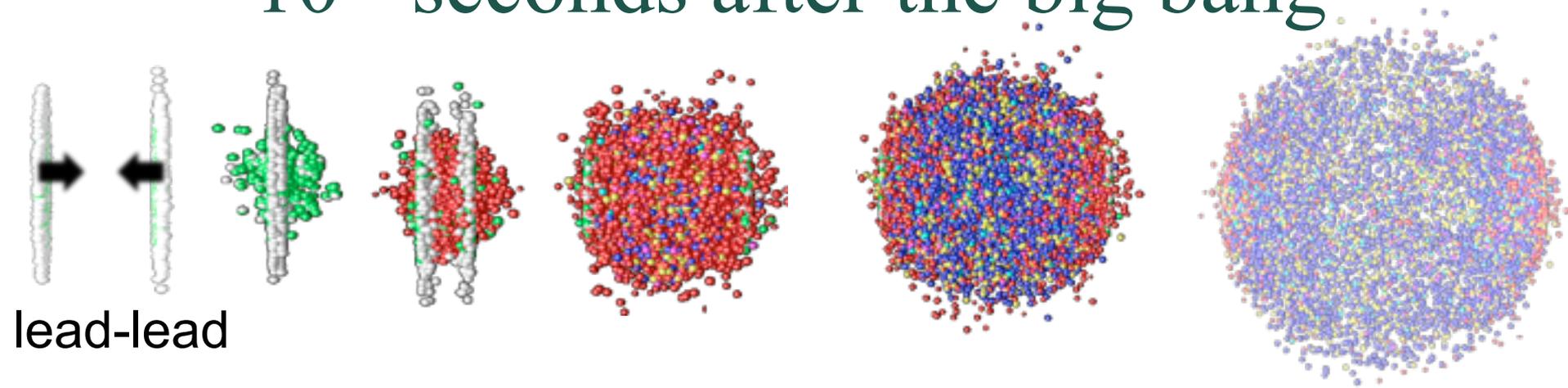


ATLAS and the LHC - reaching beyond

ATLAS and the LHC - reaching beyond



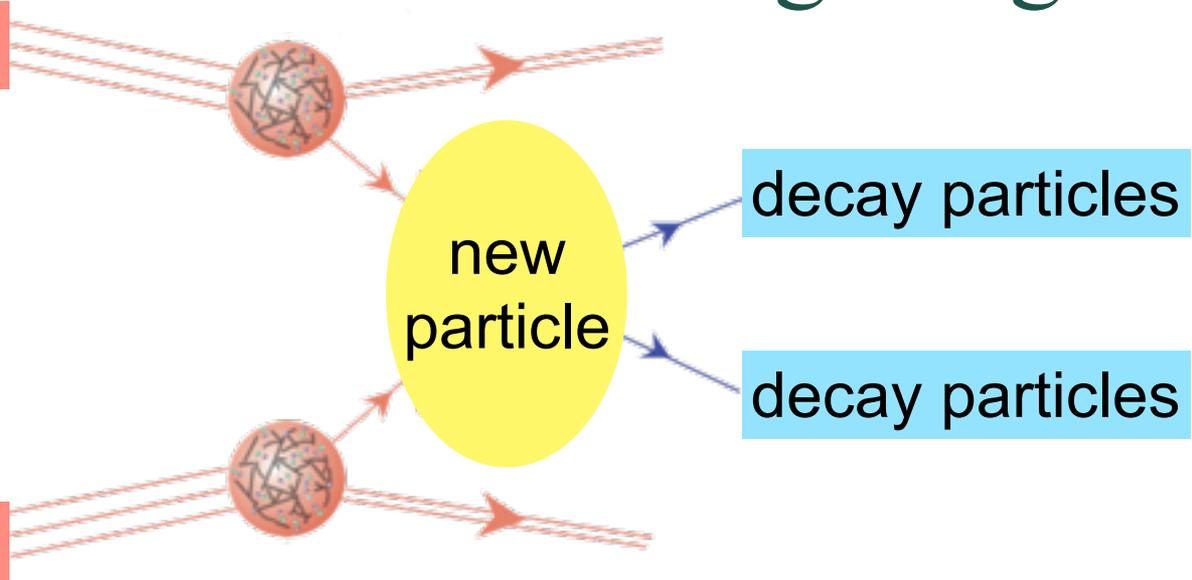
10^{-6} seconds after the big bang



10^{-12} seconds after the big bang

incoming proton 1

incoming proton 2



The Questions have been clear for a while

- Origin of electroweak symmetry breaking
 - Why does the sun shine and not explode?
- Origin of particle masses
 - Why isn't everything moving at the speed of light?
- Matter-antimatter asymmetry
 - Why haven't I annihilated with my antimatter self?
- Dark matter
 - 80% of the matter in the universe is invisible
- Dark energy
 - 95% of the energy in the universe is in an unknown form

Particle Physics in the LHC era session

- Junjie Zhu, University of Michigan
Experimental overview
- Wang Qing, Tsinghua University, Beijing
Theoretical challenges
- Discussion