Parallel Worlds: Connecting the Micro and Macro; Turning the Invisible to Visible

About CERN, Physics, and Breakthrough Innovation

CREA Virtual Workshop, April 20, 2020

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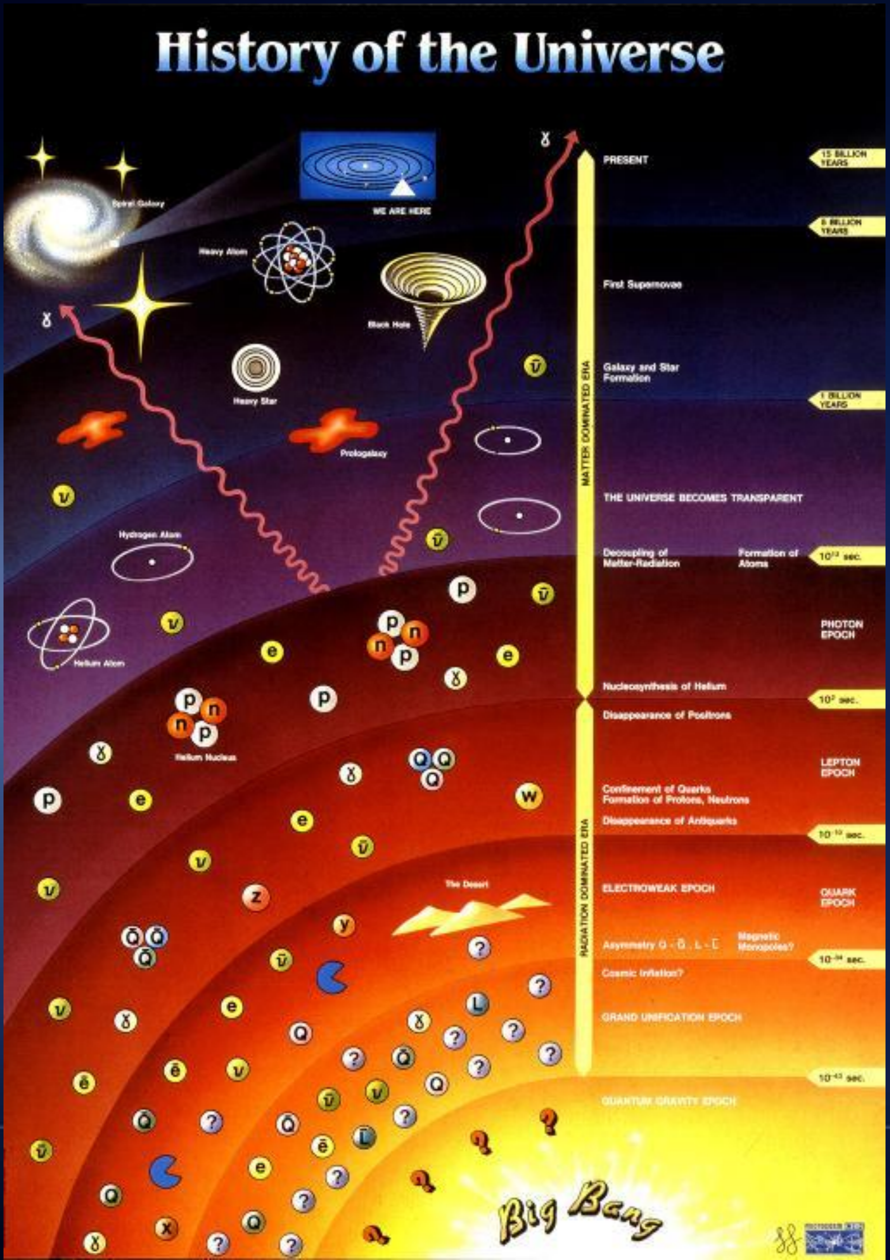
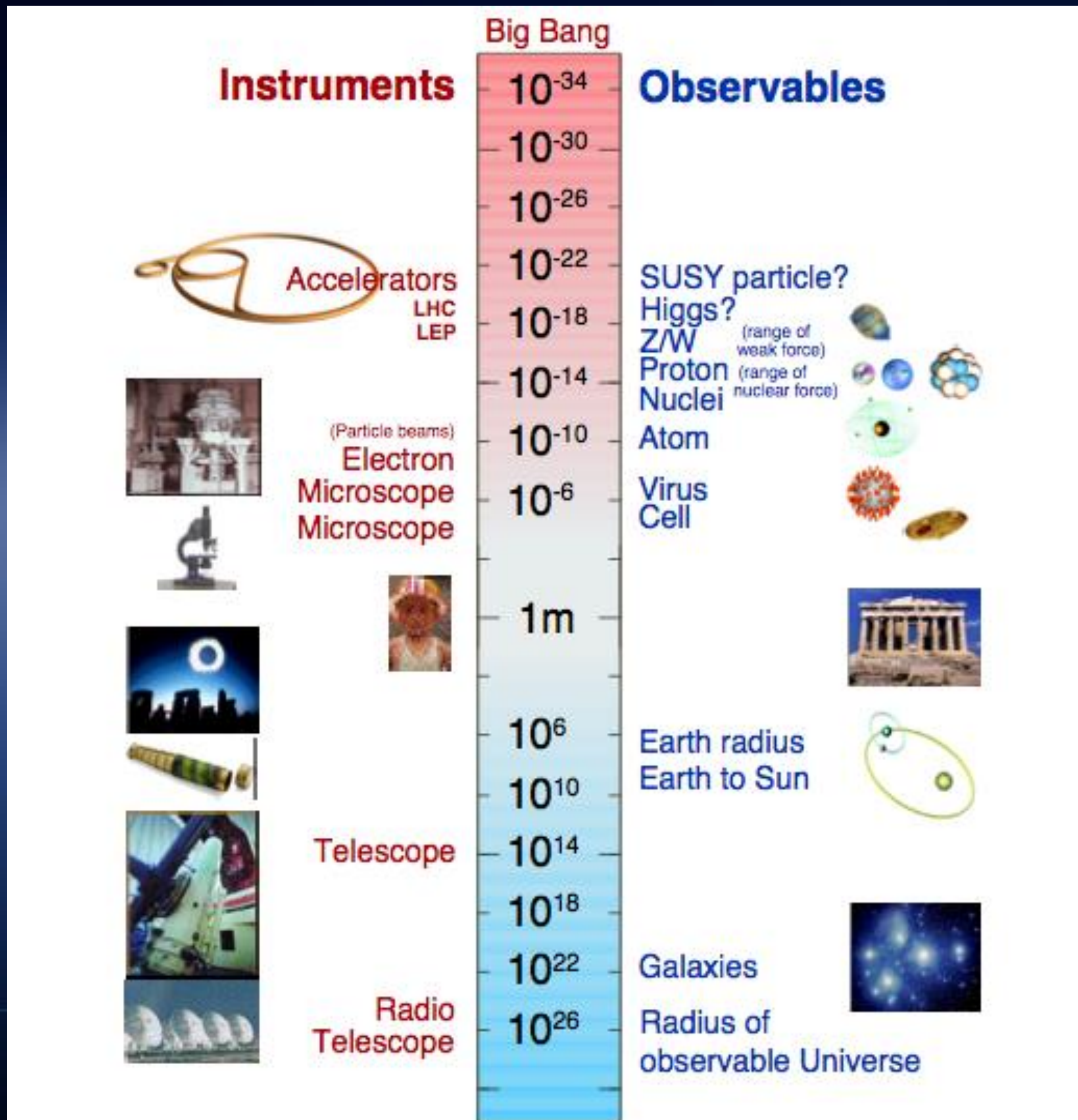
What does CERN Connect?

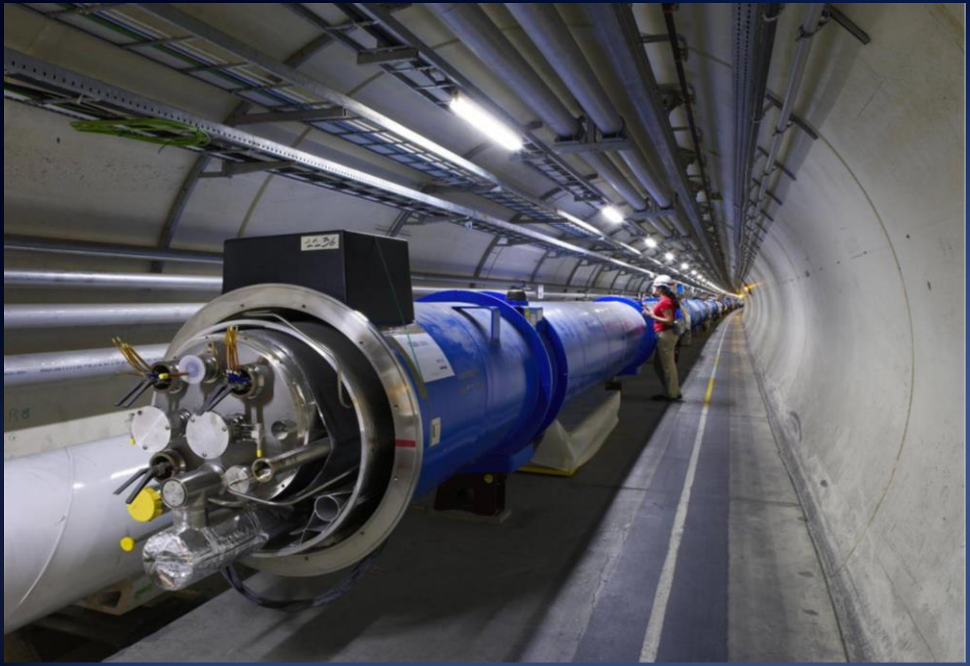


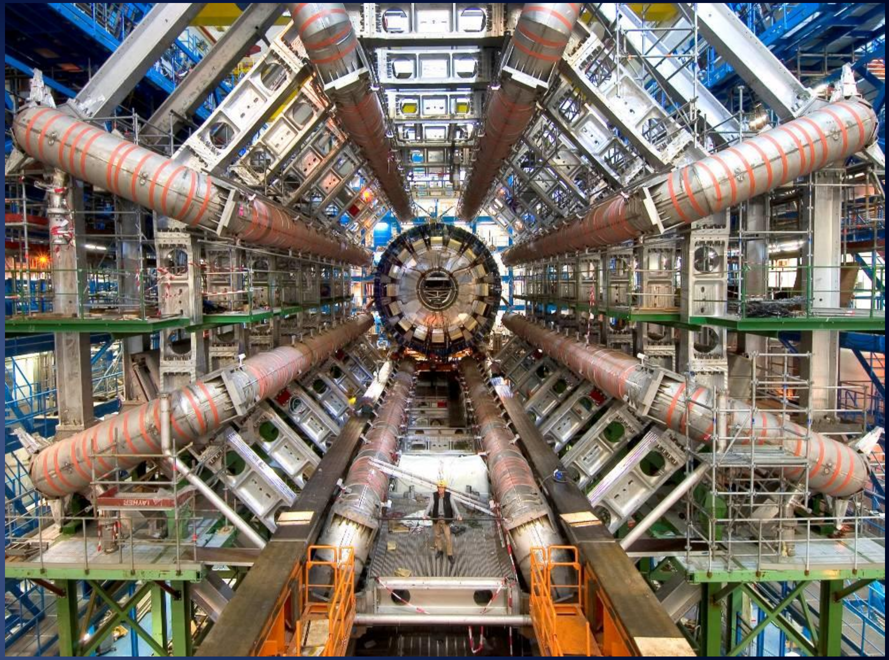
Size of things

How does CERN Measure?

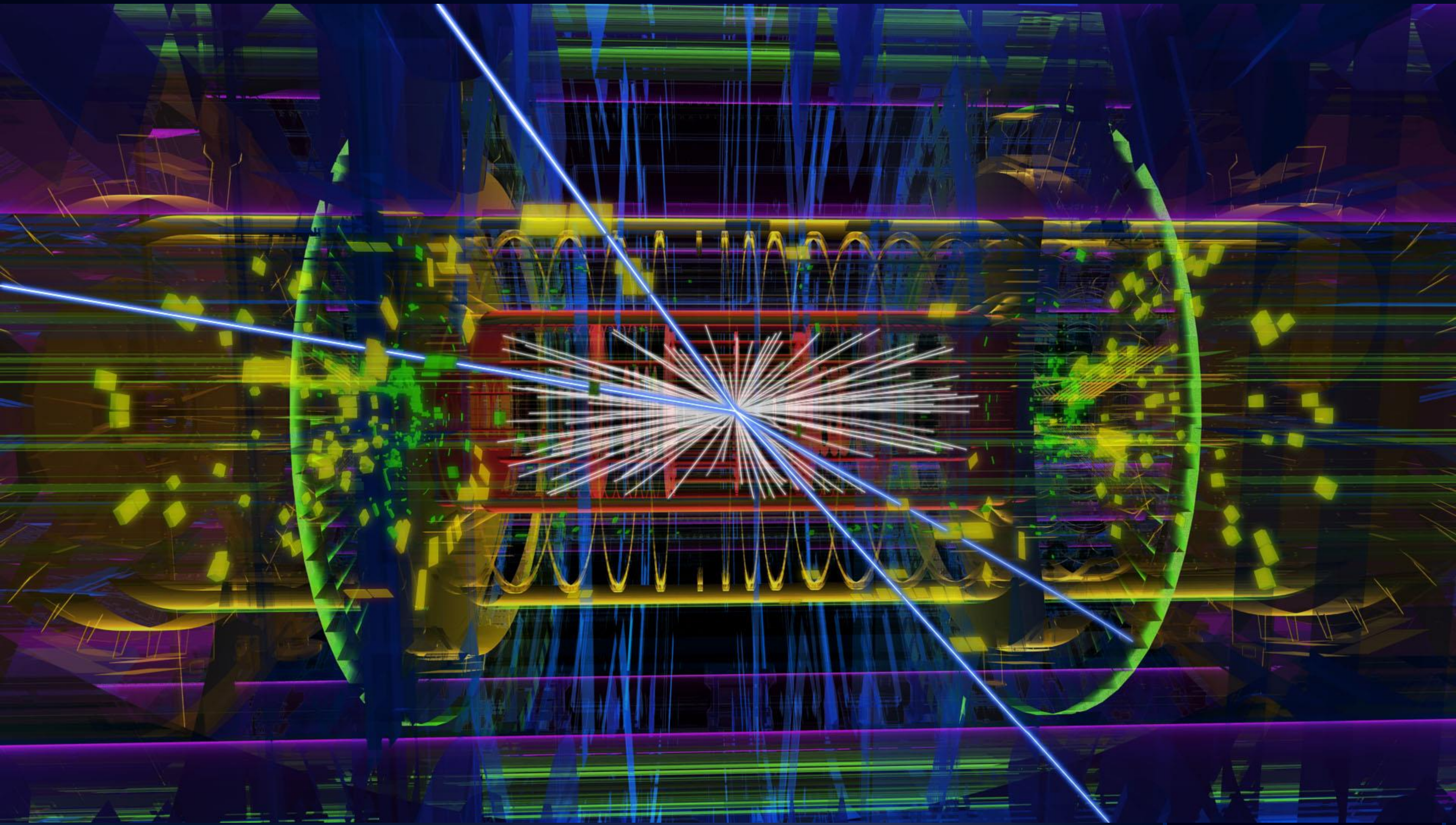


How: Seeing the Micro needs the Macro (scopes)





Seeing the Invisible

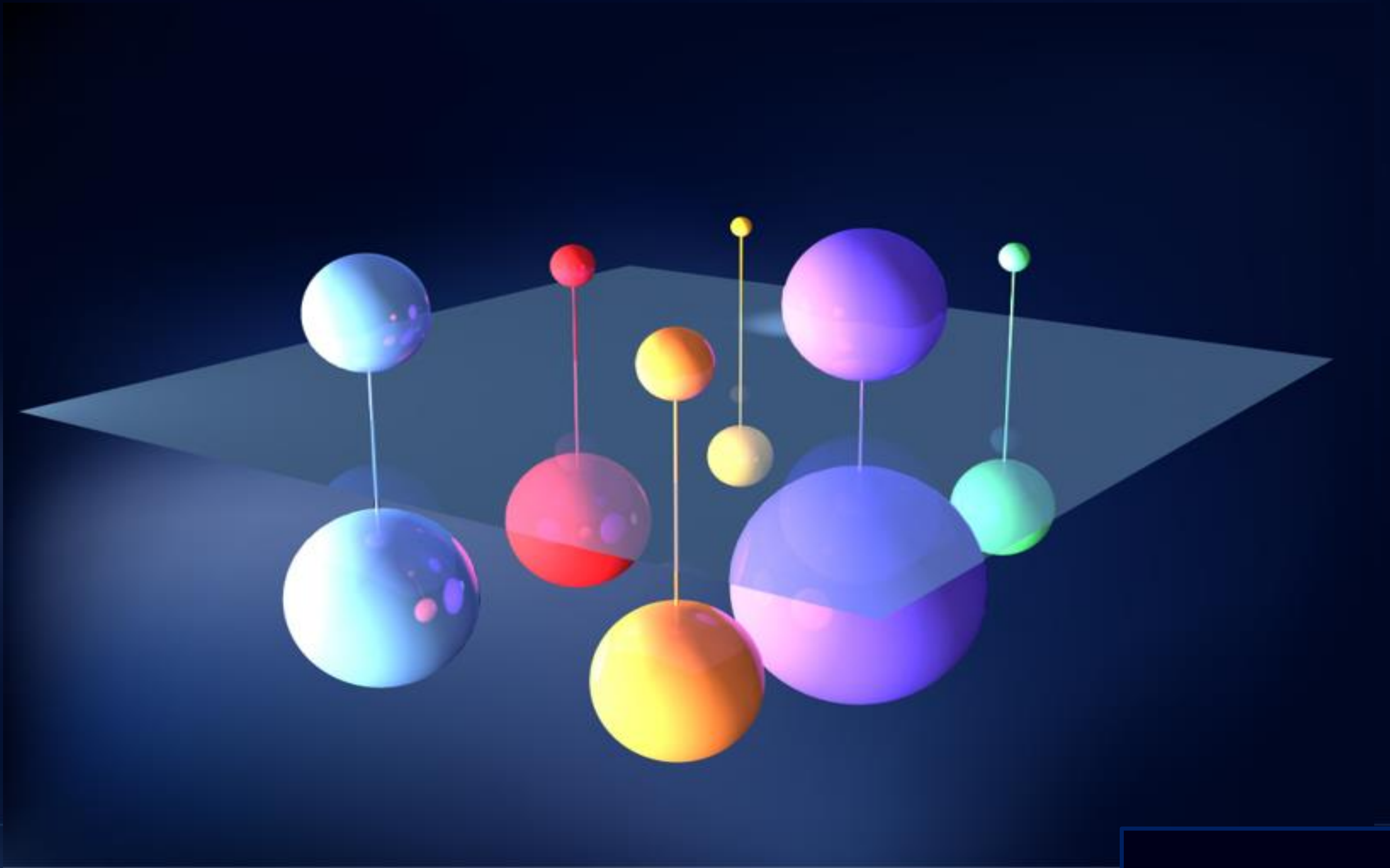


Basic Principles in Detection & Imaging

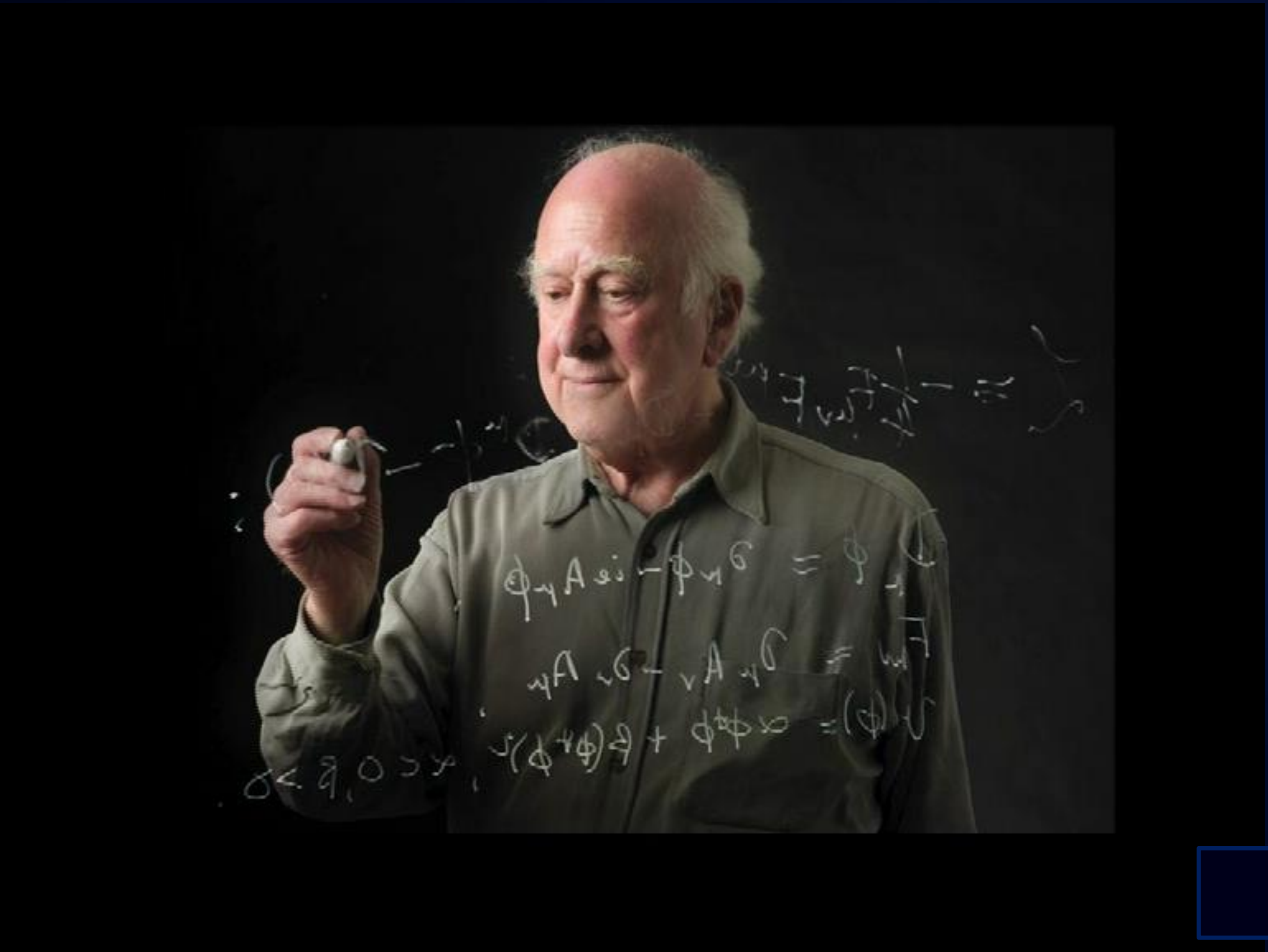
- To make the infinitely small visible, this is what you need:
  - 1. A source of energy
  - 2. Interaction with the object
  - 3. A receiver
- Simple laws of physics
  1. Energy (mass) does not appear from nothing or disappear into nothing
  2. No perpetual machines, please (unfortunately)
  3. The smaller things you want to observe, the more energy you need
  4. Speed of light is the maximum speed to transmit information
  5. If unobserved, you can be everywhere at the same time!

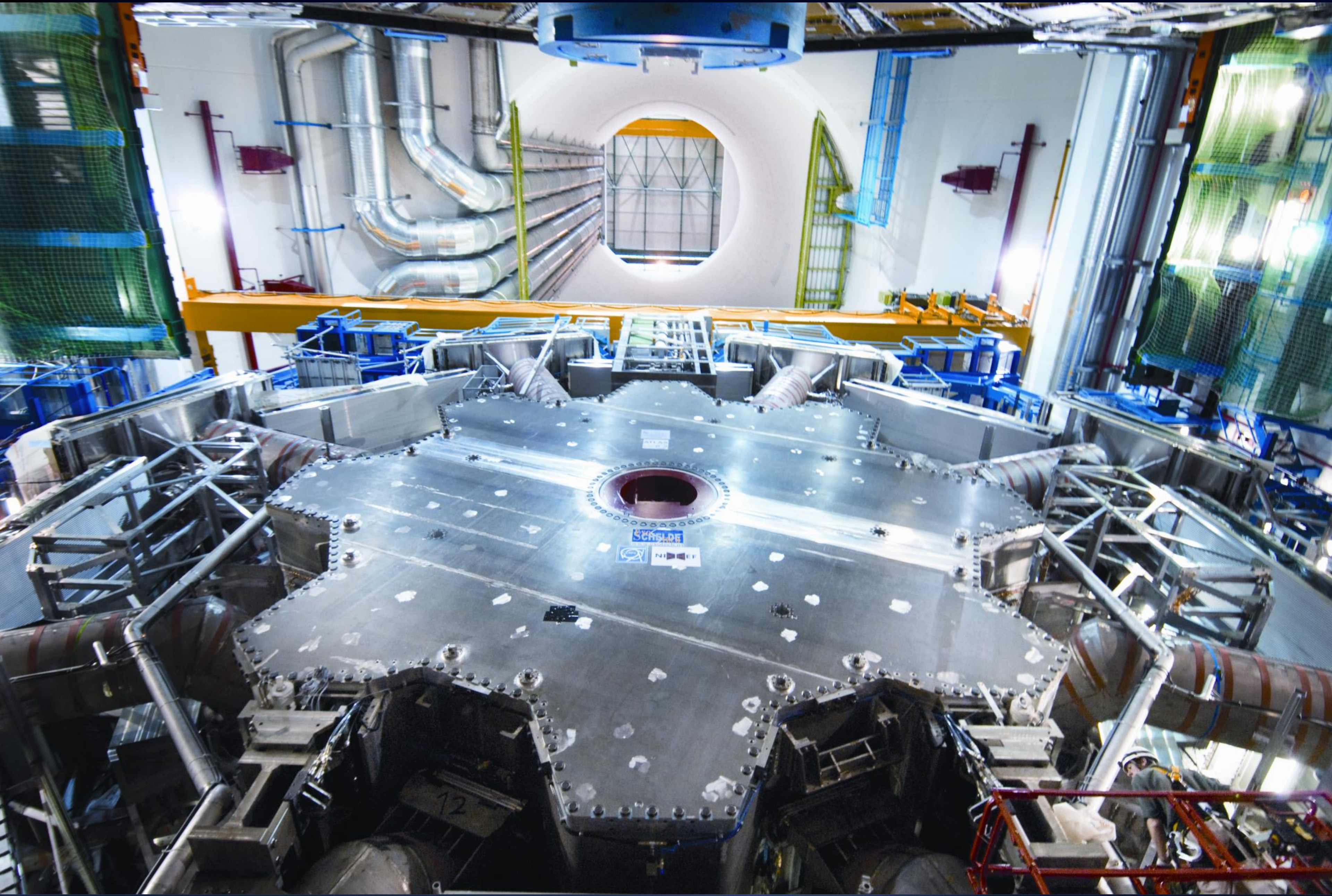
What is Wrong with this Picture?

Where Is It in the Mirror?



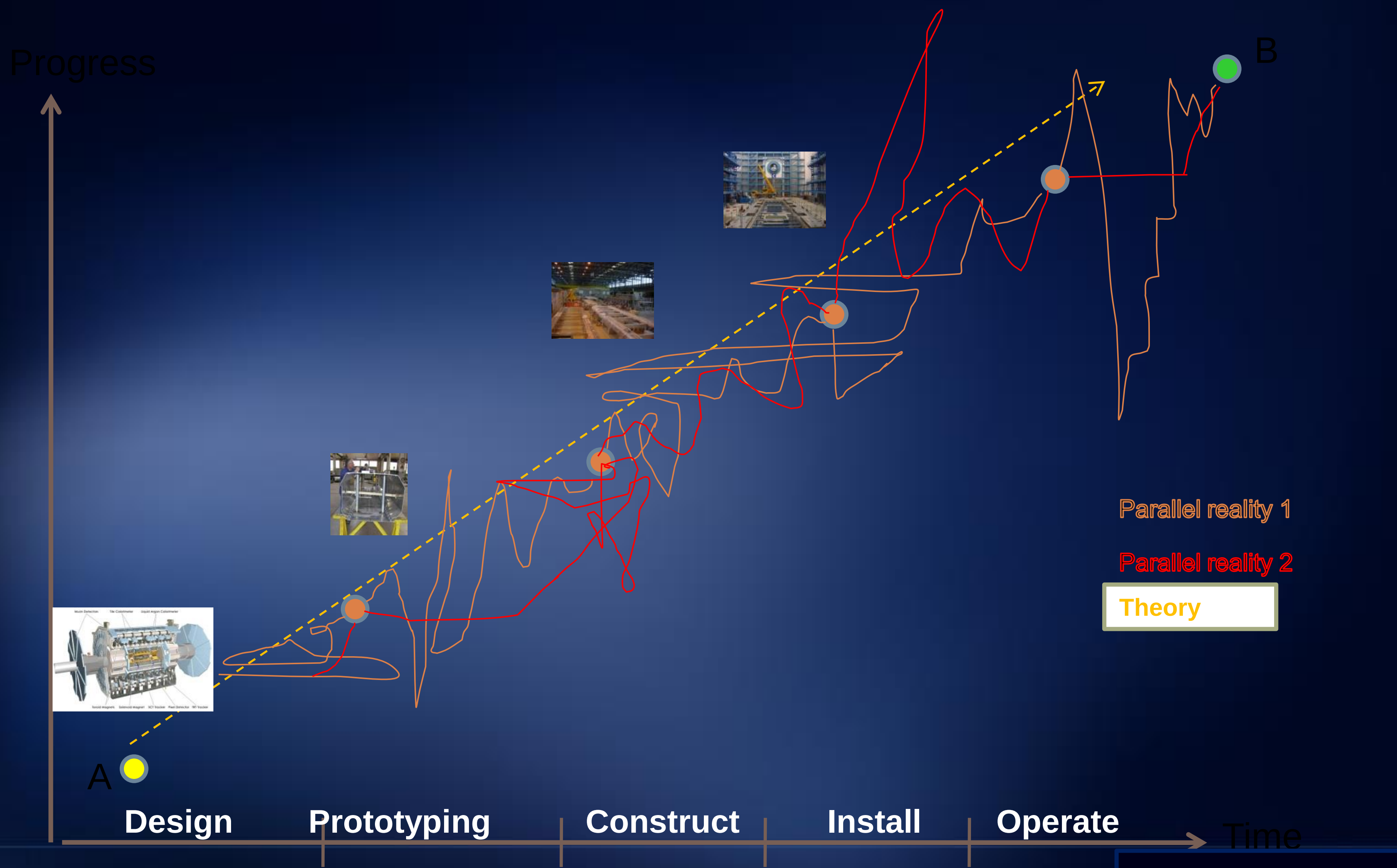
Where do we start?





ATLAS EXPERIMENT

Innovation is Not Linear



Charged-particle multiplicities in pp interactions at $\sqrt{s} = 900$ GeV measured with the ATLAS detector at the LHC ☆,☆☆

ATLAS Collaboration

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ABSTRACT

The first measurements from proton–proton collisions recorded with the ATLAS detector at th
are presented. Data were collected in December 2009 using a minimum-bias trigger during col
at a centre-of-mass energy of 900 GeV. The charged-particle multiplicity, its dependence on tran
momentum and pseudorapidity, and the relationship between mean transverse momentum and ch
particle multiplicity are measured for events with at least one charged particle in the kinematic
$|\eta| < 2.5$ and $p_T > 500$ MeV. The measurements are compared to Monte Carlo models of proton-
collisions and to results from other experiments at the same centre-of-mass energy. The charged-p
multiplicity per event and unit of pseudorapidity at $\eta = 0$ is measured to be 1.333 ± 0.003(s
0.040(syst.), which is 5–15% higher than the Monte Carlo models predict.

1. Introduction

Inclusive charged-particle distributions have been measured in pp and $p\bar{p}$ collisions at a range of different centre-of-mass energi
13]. Many of these measurements have been used to constrain phenomenological models of soft-hadronic interactions and to p
properties at higher centre-of-mass energies. Most of the previous charged-particle multiplicity measurements were obtained by sel
data with a double-arm coincidence trigger, thus removing large fractions of diffractive events. The data were then further correct
remove the remaining single-diffractive component. This selection is referred to as non-single-diffractive (NSD). In some cases, desig
as inelastic non-diffractive, the residual double-diffractive component was also subtracted. The selection of NSD or inelastic non-diffr
charged-particle spectra involves model-dependent corrections for the diffractive components and for effects of the trigger selecti
events with no charged particles within the acceptance of the detector. The measurement presented in this Letter implements a dif
strategy, which uses a single-arm trigger overlapping with the acceptance of the tracking volume. Results are presented as incl
inelastic distributions, with minimal model-dependence, by requiring one charged particle within the acceptance of the measureme
This Letter reports on a measurement of primary charged particles with a momentum component transverse to the beam dire

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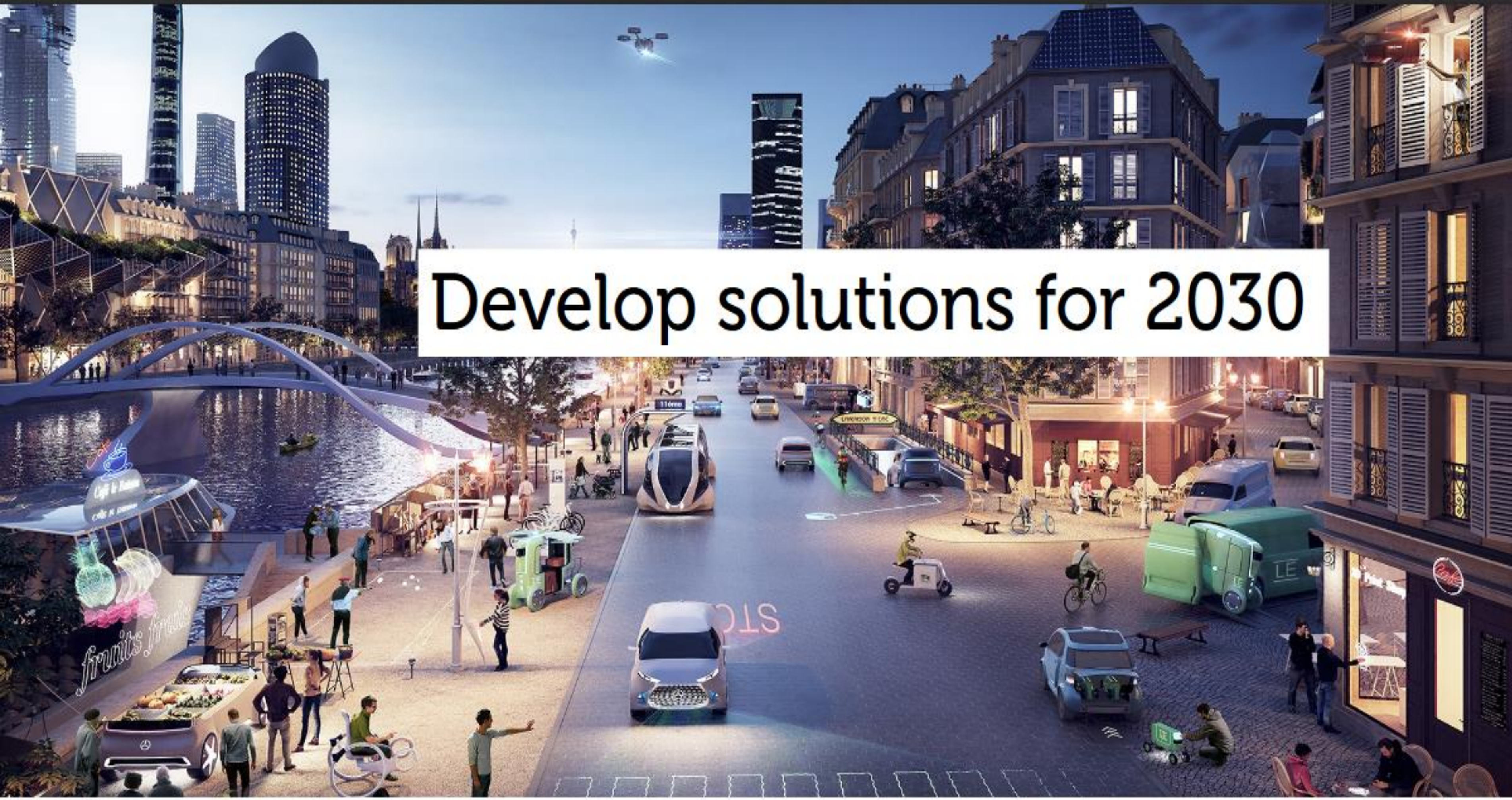

Some Present Challenges in Detection & Imaging Technologies

(Integrated) 3D detectors for photon and electron identification (<< 1 ps, 1micron spatial resolution). Useful in medical imaging

Fast (< 1ps, 100Mcounts/s) preamplifiers and TDC electronics. Usefull for medical imaging

Additive manufacturing for integrated detector support structures. Useful for compact electronic systems for Avionics

Decentralised network architectures for massive computing. Would enable the Internet of Things (IoT)

Augmented Reality (AR) and Virtual Reality (VR) systems for Large Infrastructure Maintenance. Applicable for intelligent cars

Algorithms for real time optimisation of particle track analysis. Useful for energy distribution in smart cities

What Is It We Sense in the Mirror?

How To Sense the Invisible?