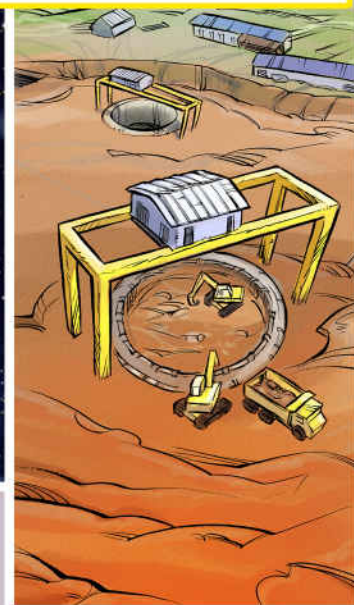


# HOW TO BUILD A PARTICLE HUNTER

CMS IS DEEP UNDERGROUND IN A HUGE CAVERN COMPLEX. THE MAIN CAVERN COULD HOLD THE ENTIRE HALF-MILLION POPULATION OF GENEVA (OK NOT COMFORTABLY, BUT ALL SQUEEZED LIKE SARDINES IN A TIN...).



BEFORE DIGGING, THE GROUND AROUND THE SHAFTS HAD TO BE FROZEN WITH LIQUID NITROGEN TO AVOID FLOODING WHEN THE DIGGER REACHED THE WATER TABLE, A LAYER OF WATER 40M UNDERGROUND.



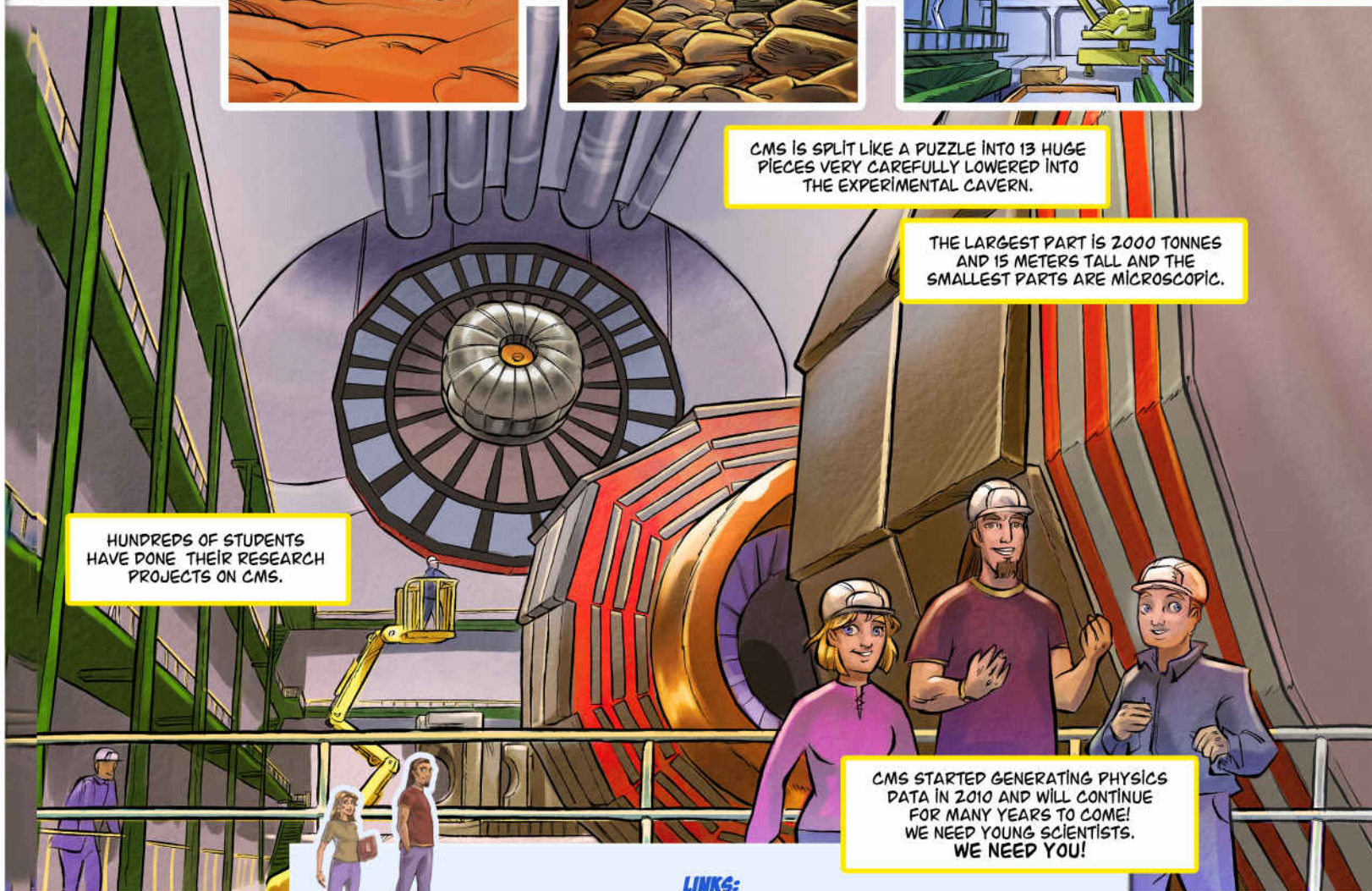
THE SHAFTS AND CAVERNS WERE DUG BY MECHANICAL HAMMERS AND DIGGERS WORKING CONTINUOUSLY FOR 4 YEARS.



CMS IS SPLIT LIKE A PUZZLE INTO 13 HUGE PIECES VERY CAREFULLY LOWERED INTO THE EXPERIMENTAL CAVERN.

THE LARGEST PART IS 2000 TONNES AND 15 METERS TALL AND THE SMALLEST PARTS ARE MICROSCOPIC.

HUNDREDS OF STUDENTS HAVE DONE THEIR RESEARCH PROJECTS ON CMS.



CMS STARTED GENERATING PHYSICS DATA IN 2010 AND WILL CONTINUE FOR MANY YEARS TO COME! WE NEED YOUNG SCIENTISTS. WE NEED YOU!

## LINKS:

(CERN) [HTTP://WWW.CERN.CH](http://www.cern.ch)  
(CMS) [HTTP://CMS.CERN.CH](http://cms.cern.ch)

## CREDITS:

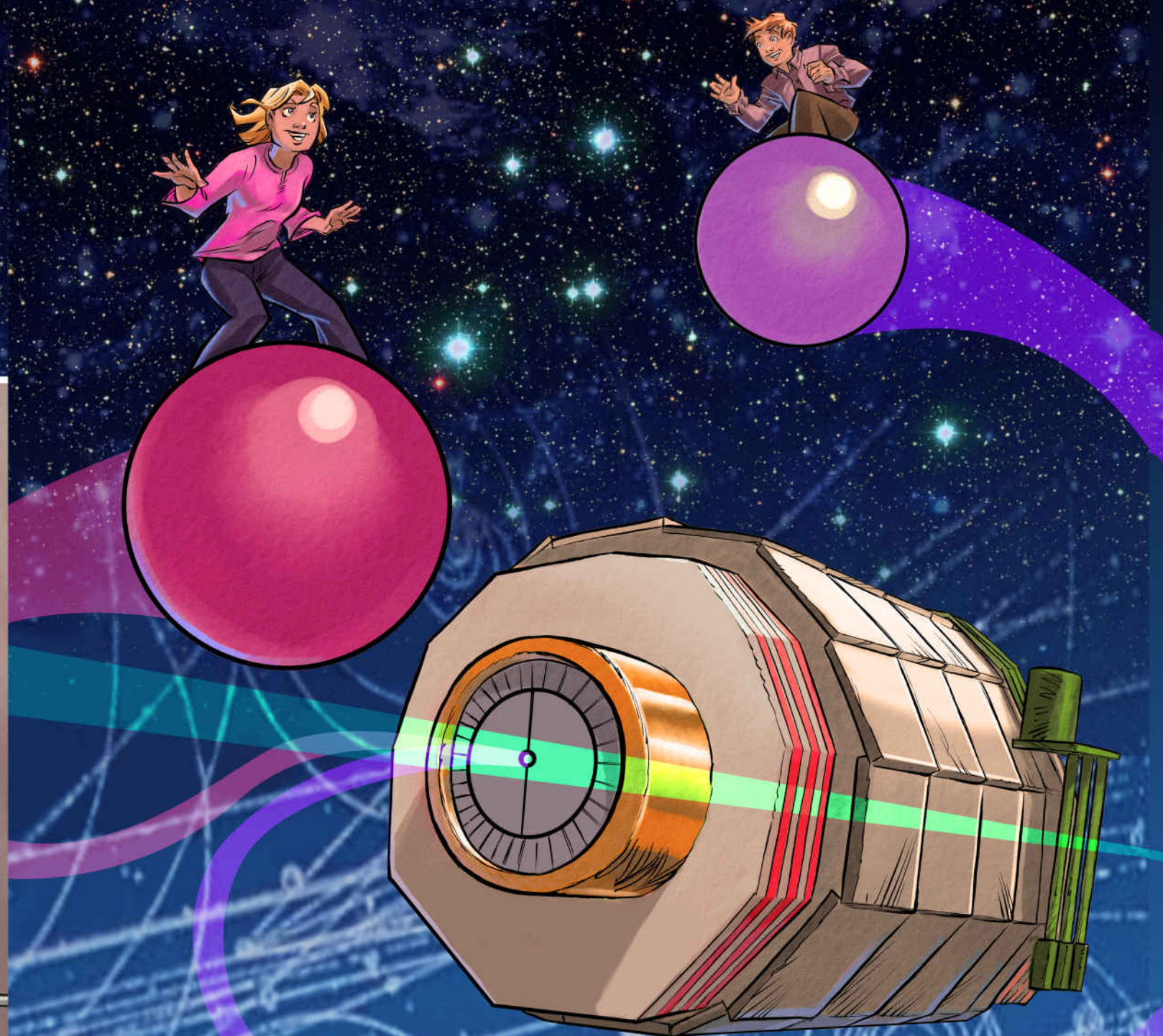
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A PROJECT FOR CMS OUTREACH, CERN PRESS OFFICE AND CERN EDUCATION SERVICE.



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# CMS: PARTICLE HUNTER



JOIN US IN ASKING NATURE THE OLDEST AND DEEPEST QUESTION:  
**JUST WHAT** EXACTLY ARE WE MADE OF?

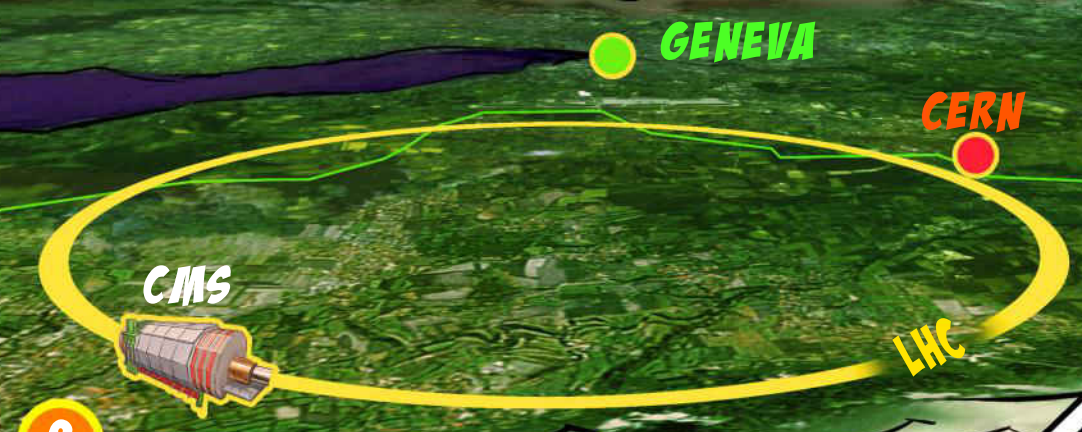


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# CMS: INVESTIGATING THE DEEPEST QUESTIONS IN THE UNIVERSE

**1** AT THE BORDER BETWEEN FRANCE AND SWITZERLAND, THE EUROPEAN CENTER FOR NUCLEAR RESEARCH: CERN.

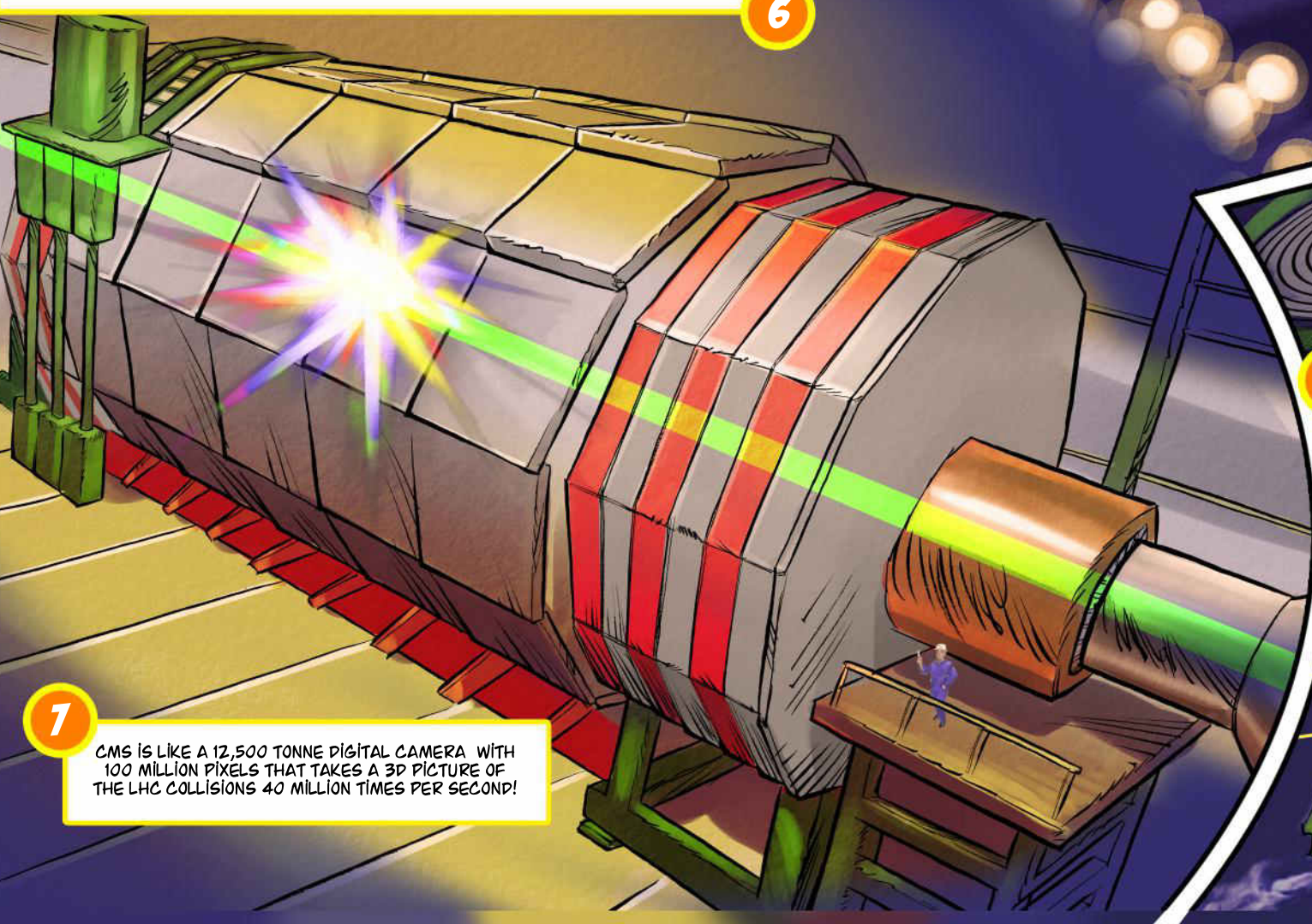


**2** 100M UNDERGROUND VAST CATHEDRAL-SIZED CAVERNS HOUSE FOUR GIANTIC PARTICLE DETECTORS FOR THE WORLD'S BIGGEST SCIENTIFIC TOOL: A MASSIVE PARTICLE ACCELERATOR, 27 KM AROUND, THE LHC: LARGE HADRON COLLIDER.

**3** THE PROTONS IN THE LHC ARE ACCELERATED TO 99.9998% OF THE SPEED OF LIGHT IN TWO BEAM LINES, MOVING IN OPPOSITE DIRECTIONS.

THESE ANCESTRAL PARTICLES SURVIVE FOR ONLY THE TINIEST FRACTION OF A SECOND BEFORE THEY DISINTEGRATE INTO CASCADES OF MORE FAMILIAR PARTICLES. SCIENTISTS NEED ULTRAFAST, ULTRAPRECISE DETECTORS, AND STATE-OF-THE-ART CUSTOM MADE ELECTRONICS TO SEE THE CASCADE...THEY NEED CMS: THE COMPACT MUON SOLENOID.

**6**



**7** CMS IS LIKE A 12,500 TONNE DIGITAL CAMERA WITH 100 MILLION PIXELS THAT TAKES A 3D PICTURE OF THE LHC COLLISIONS 40 MILLION TIMES PER SECOND!

**4** THOUSANDS OF POWERFUL SUPERCONDUCTING MAGNETS STEER THE PROTON BEAMS AROUND THE HUGE RING AND THEN FOCUS THEM TO LESS THAN THE WIDTH OF A HUMAN HAIR... READY TO CRASH AGAINST EACH OTHER. THESE SUPERCONDUCTING MAGNETS RUN AT  $-271^{\circ}\text{C}$ : EVEN COLDER THAN OUTER SPACE. THE LHC IS THE BIGGEST CRYOGENIC SYSTEM EVER MADE.

**5** THE COLLISION GENERATES SO MUCH ENERGY THAT PARTICLES EXIST SINCE THE BIG BANG (14 BILLION YEARS AGO), LIKE THE HIGGS PARTICLE, REAPPEAR BRIEFLY.

**9** CMS HAS BEEN ASSEMBLED IN LAYERS FROM MILLIONS OF PARTS WITH WATCH-MAKING PRECISION. EACH LAYER OF DETECTORS HAS A SPECIAL JOB TO DO: TO IDENTIFY AND MEASURE AS MANY PARTICLES AS POSSIBLE.

**10** A TOTAL OF 1 TERABYTE OF DATA IS GENERATED IN CMS EVERY SECOND, EQUIVALENT IN VOLUME TO STORING THE NAMES AND ADDRESSES OF EVERY LIVING HUMAN BEING.

**11** TO CRUNCH AND SWALLOW ALL THIS INFORMATION IS JUST NOT POSSIBLE. POWERFUL ELECTRONICS FILTERS THE DATA SIGNALS SO THAT, EVERY SECOND, ONLY THE RESULTS FROM THE 100 MOST INTERESTING COLLISIONS ARE STORED.

**8** LOOKING AT A SLICE THROUGH THE DETECTOR.



**12** A HUGE COMPUTING NETWORK, THE GRID, SENDS THE CMS DATA OUT ALL OVER THE WORLD...



**13** A PHYSICS STUDENT SAT AT THEIR PC ANYWHERE IN THE WORLD CAN HARNESS THE POWER OF THOUSANDS OF PCS OVER THE GRID...



**14** TO SEARCH FOR RARE COLLISIONS AND NEW PHYSICS...