Chemical Engineering 412

Introductory Nuclear Engineering

Lecture 32

Nuclear Industry and Research (II)

Radiation Affecting Materials

- radioactive catalysis
- food preservation
- biological growth inhibition
- insect disinfestation
- Mossbauer effect
- radiolysis
- static elimination
- synthesis
- modification of fibers
- increasing biological growth
- sterile-male insect control
- luminescence
- polymer modification
- biological mutations
- bacterial sterilization
- x-ray fluorescence

Use of Energy

- thermal power sources
- electric power sources

Food Irradiation

- Food treatment comparable to pasteurization
  - Kills pests/microorganisms without food degradation
  - Controls sprouting
- Does not make the food radioactive
- FDA Approved
- Must be labeled

Consumer Products

- Smoke Detection Equipment
- Self-powered Lighting in Exit Signs
- Lighted Aircraft Instrumentation
- Pharmaceutical Detection
- Bomb/Weapons Detection
- Scanning and Surveillance Equipment
- Theft Deterrent Systems

Economics

America derives substantial economic and employment benefits from the use of radiation and radioactive materials:

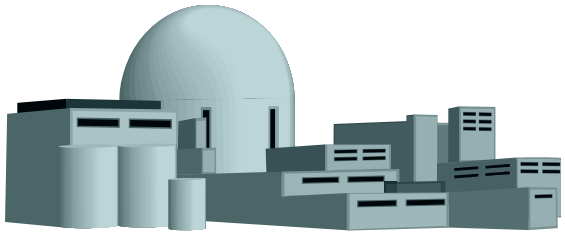
$330.7 billion annually in total industrial sales

4,000,000 jobs

$60 billion in tax revenues to local, state & federal governments

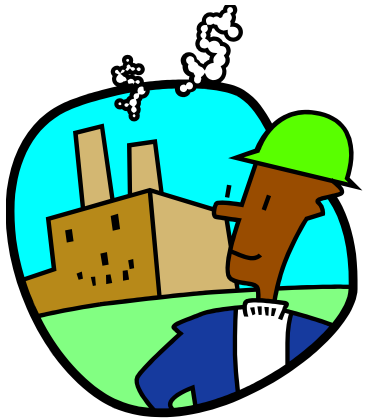
Economics

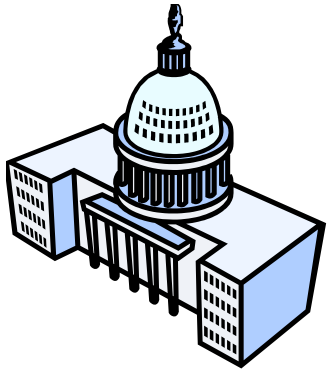
Nuclear energy's direct and indirect economic impacts in the US:



$90 billion in total sales of goods & services

442,000 jobs



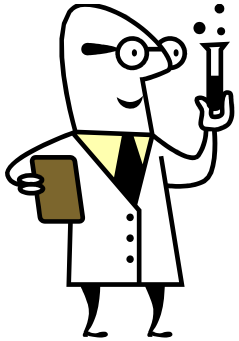


$17.8 billion in local, state & federal tax revenues

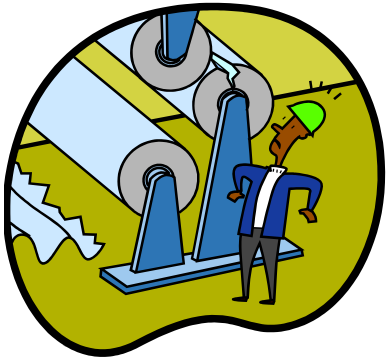
Destination

Once they are produced, they are packaged and shipped safely to users throughout the United States; users are:

Universities



Laboratories

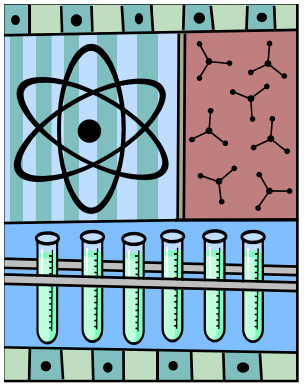


Industries

Hospitals

Scientific Research

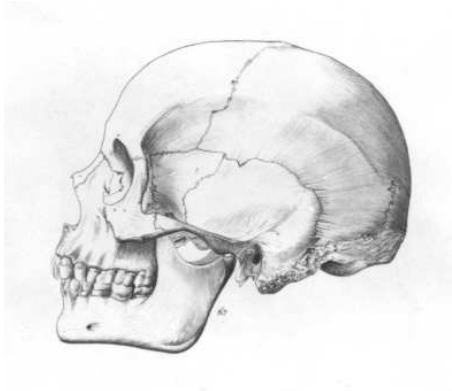
The FDA requires that all new drugs be tested for safety and effectiveness; more than 80% are tested with radioactive materials



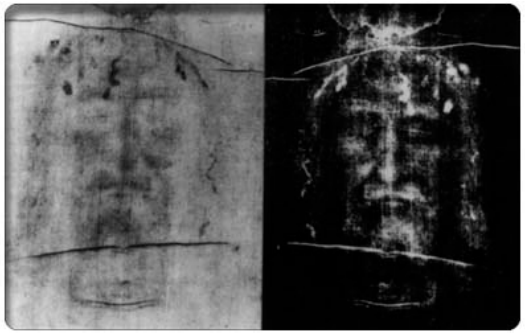
Radioactive materials are also used in biomedical research, metabolic studies, genetic engineering and environmental protection studies

Scientific Research

Archaeologists use ^{14}C to date artifacts containing plant or animal material



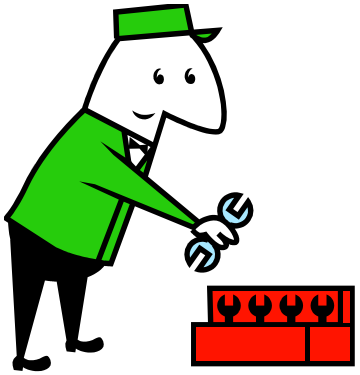
Criminal investigators use radiation to examine evidence



Museums rely on radioactive materials to verify authenticity of art objects and paintings

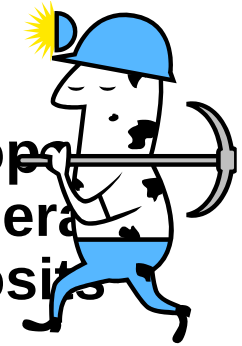
Industrial Uses

Automobile industry makes use of isotopes to test the quality of steel in cars



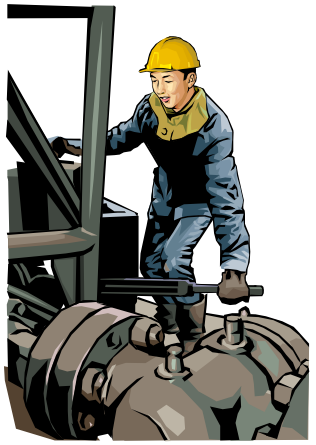
Aircraft manufacturers use radiation to check for flaws in jet engines

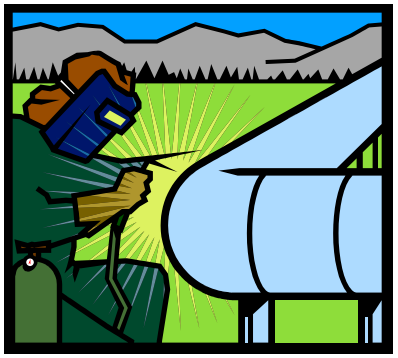
Mining & petroleum companies use isotopes to locate and quantify geological mineral deposits



Industrial Uses

Oil gas & mining companies use isotopes to map geological contours (using test wells) and mine bores and to determine presence of hydrocarbons





Pipeline companies utilize radioactive isotopes to look for defects in welds

Construction crews use radioactive materials to gauge soil moisture content and asphalt density

Agricultural Uses

Hardier and more disease resistant crops (peanuts, tomatoes, onions, rice, soybeans, barley) have been developed using radioactive materials in agricultural research

Nutritional value, baking and melting qualities of some crops and cooking times have been improved using isotopes

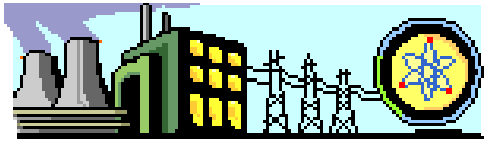
Radioactive materials pinpoint where illnesses strike animals to breed disease-resistant livestock

Agricultural Uses

Radioactive materials show how plants absorb fertilizer; this helps researchers figure where and how much to apply to crops for maximum yield

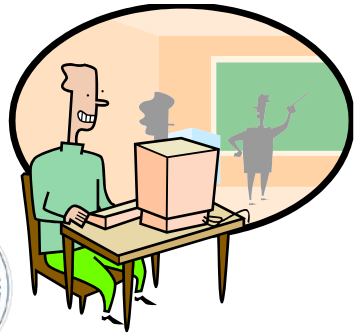
Isotopes help farmers and scientists control pests; e.g., California has used radiation sterilization since the mid-70s to control Mediterranean fruit fly infestations

Consumer Products & Services



103 US nuclear power plants provide ~20% of electricity

Smoke detectors installed in ~90% of America's homes rely on 1-2 μCi of ^{241}Am to monitor for smoke to signal a fire



Computer disks retain data better when treated with radiation

Consumer Products & Services

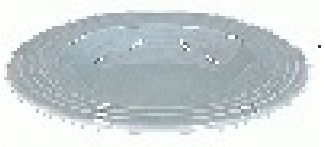
Non-stick pans are treated with radiation to retain the coating

Photocopiers and plastic manufacturers use small amounts of radiation to eliminate static and prevent jamming

Cosmetics, hair products and contact lens solutions are sterilized with radiation to remove irritants and allergens

Consumer Products & Services

Radioactive materials are used to sterilize medical bandages and implements as well as foodstuffs to kill pathogens



1930s Fiestaware contains uranium in the ceramic glazes

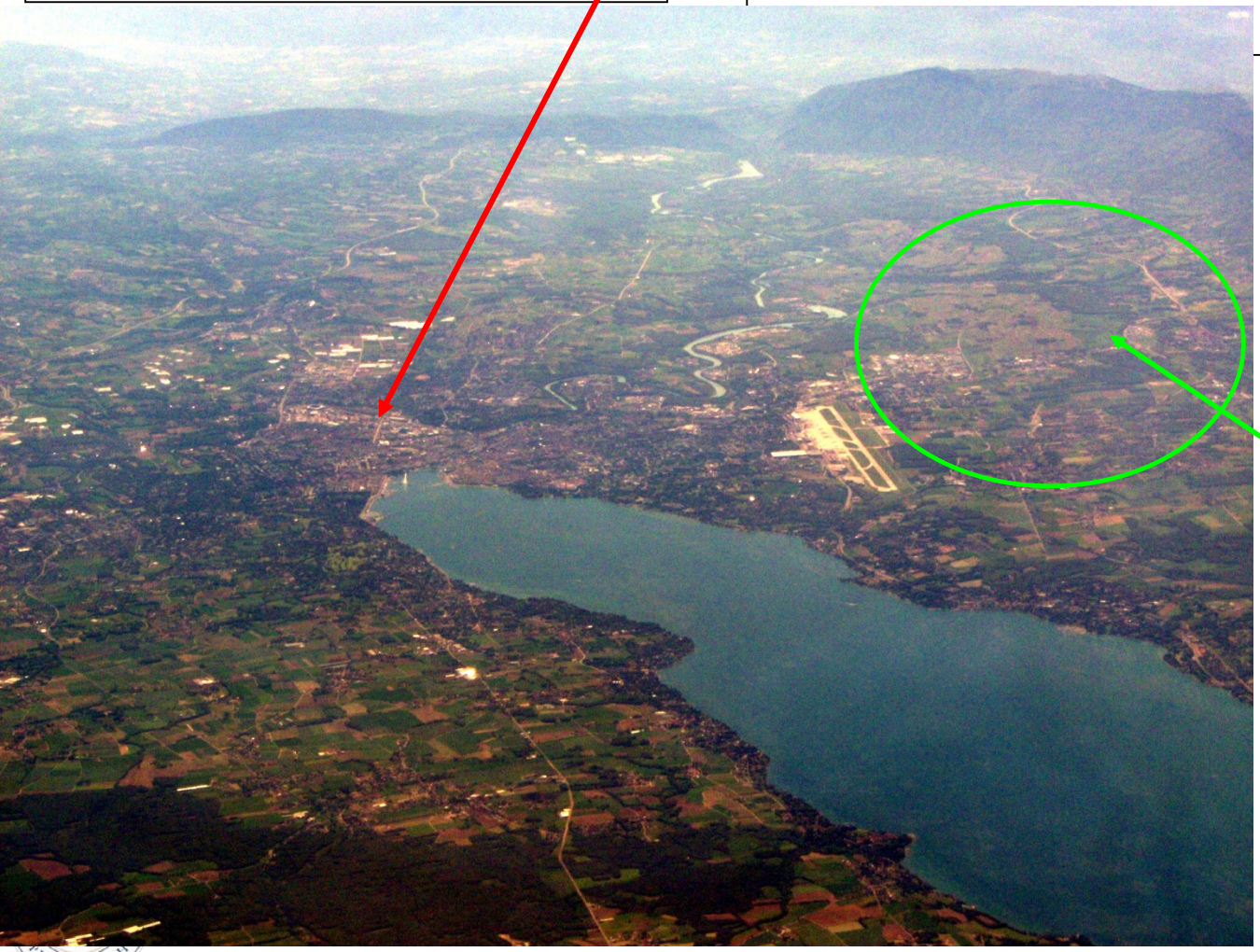
To maximize light output, some lantern mantles contain radioactive thorium nitrate

The Large Hadron Collider

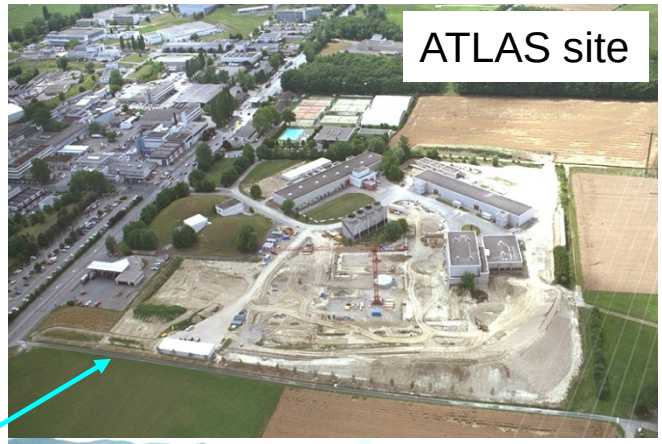
LHC is located at CERN
CERN is located near Geneva
Part of CERN is in France

The LHC collides protons
Center of Mass E=14 TeV ~7X Fermilab
Very high luminosity ~100X Fermilab

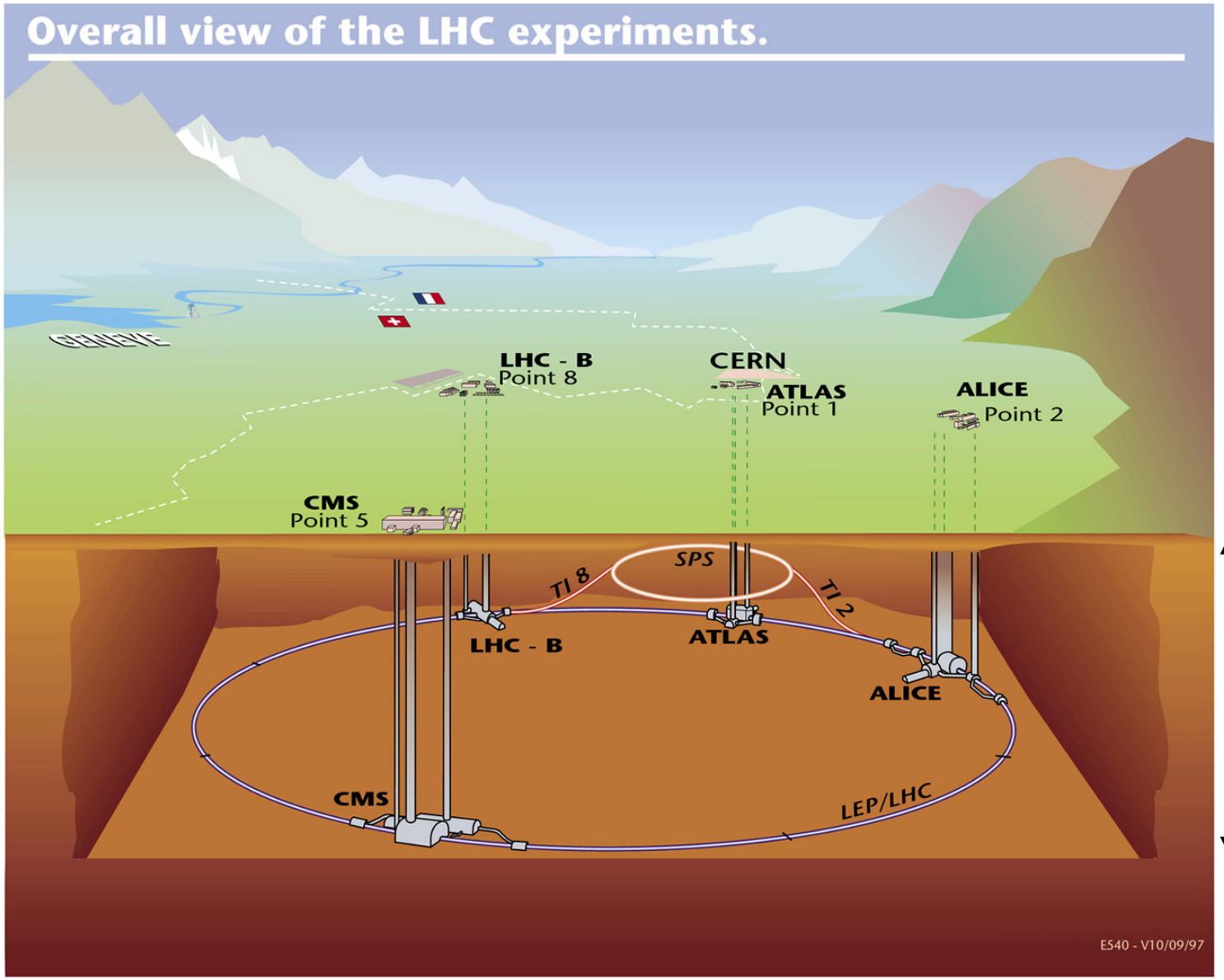
Goal: discover Higgs+SUSY+???



The Large Hadron Collider

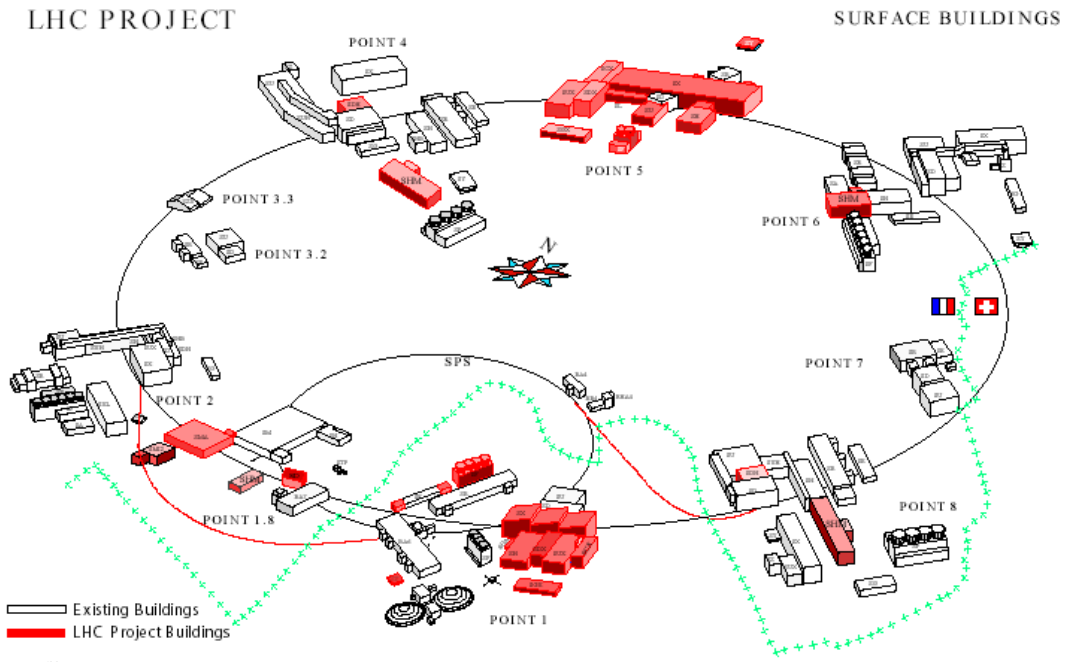


The Large Hadron Collider

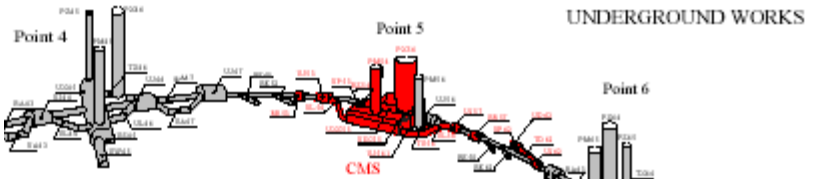


50-175m

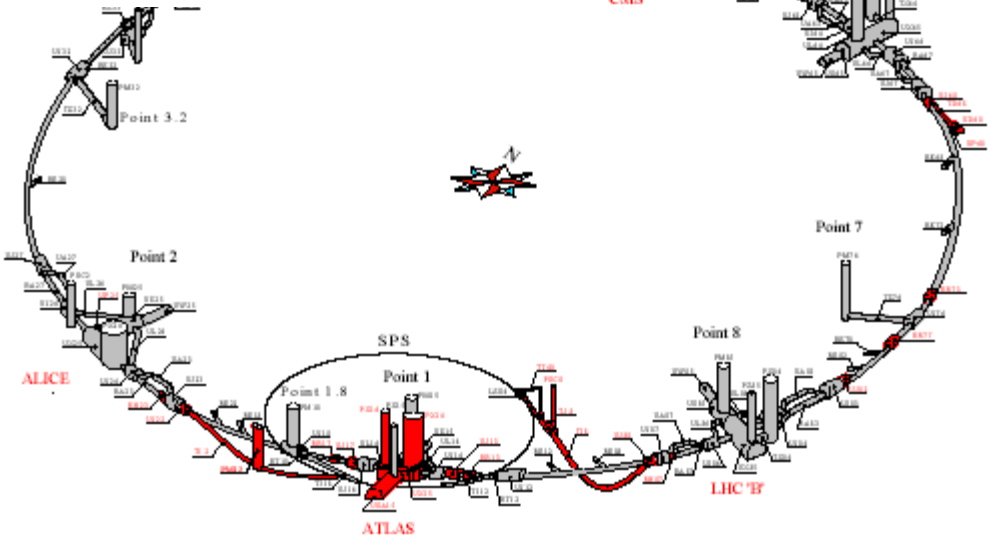
The Large Hadron Collider



Above Ground

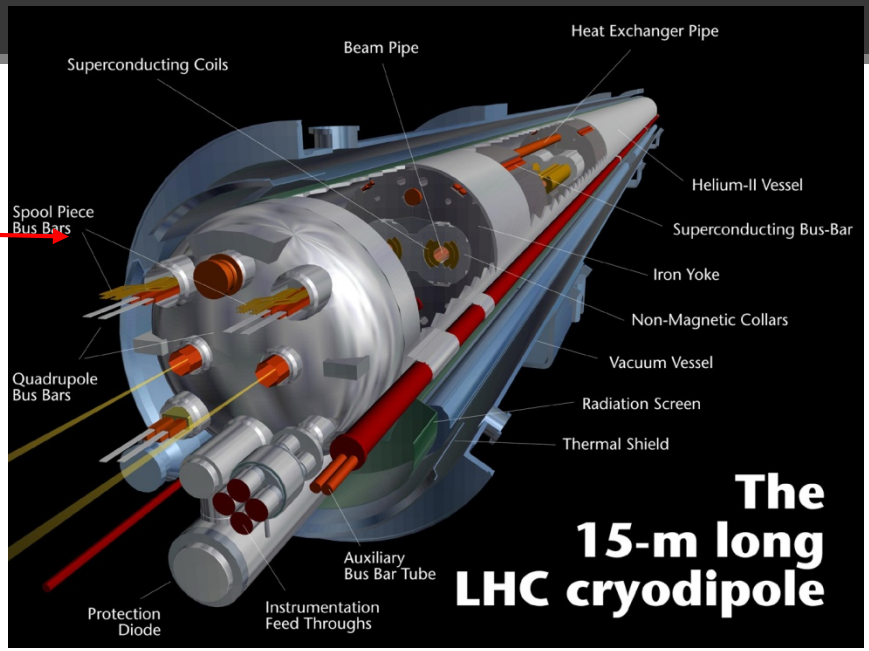


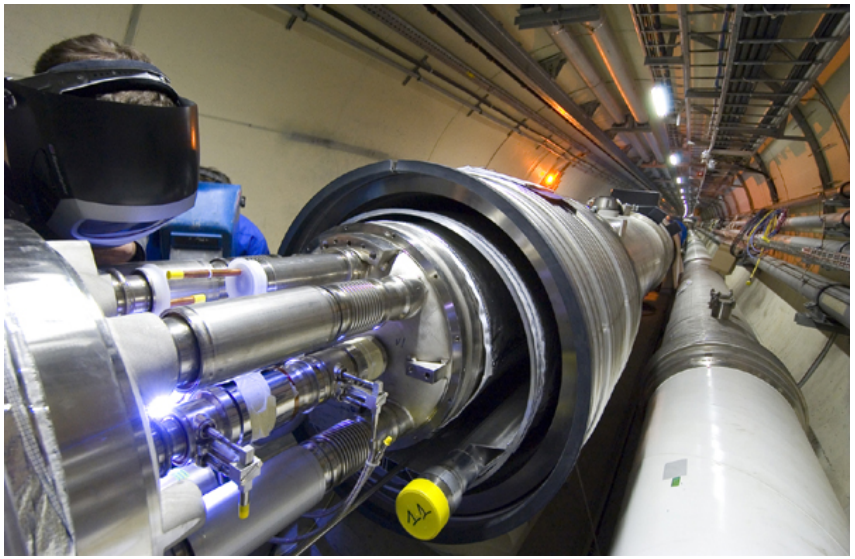
Below Ground



The Large Hadron Collider

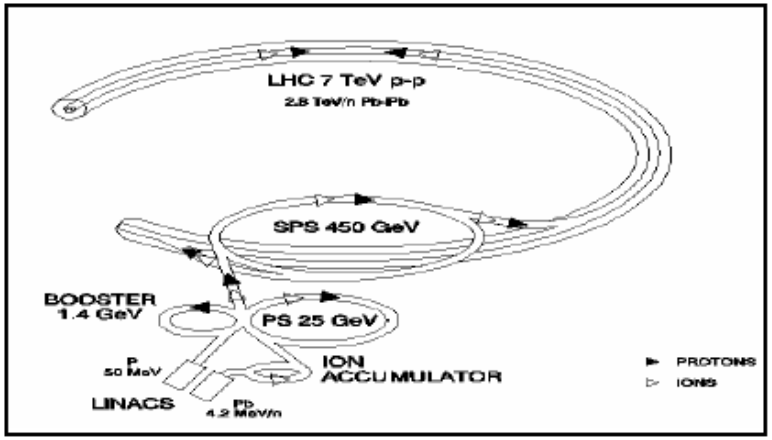
Magnetic field at 7 TeV: 8.33 Tesla
Operating temperature: 1.9 K
Number of magnets: ~9300
Number of main dipoles: 1232
Number of quadrupoles: ~858
Number of correcting magnets: ~6208
Number of RF cavities: 8 per beam;
Field strength at top energy ≈ 5.5 MV/m
Power consumption: ~120 MW



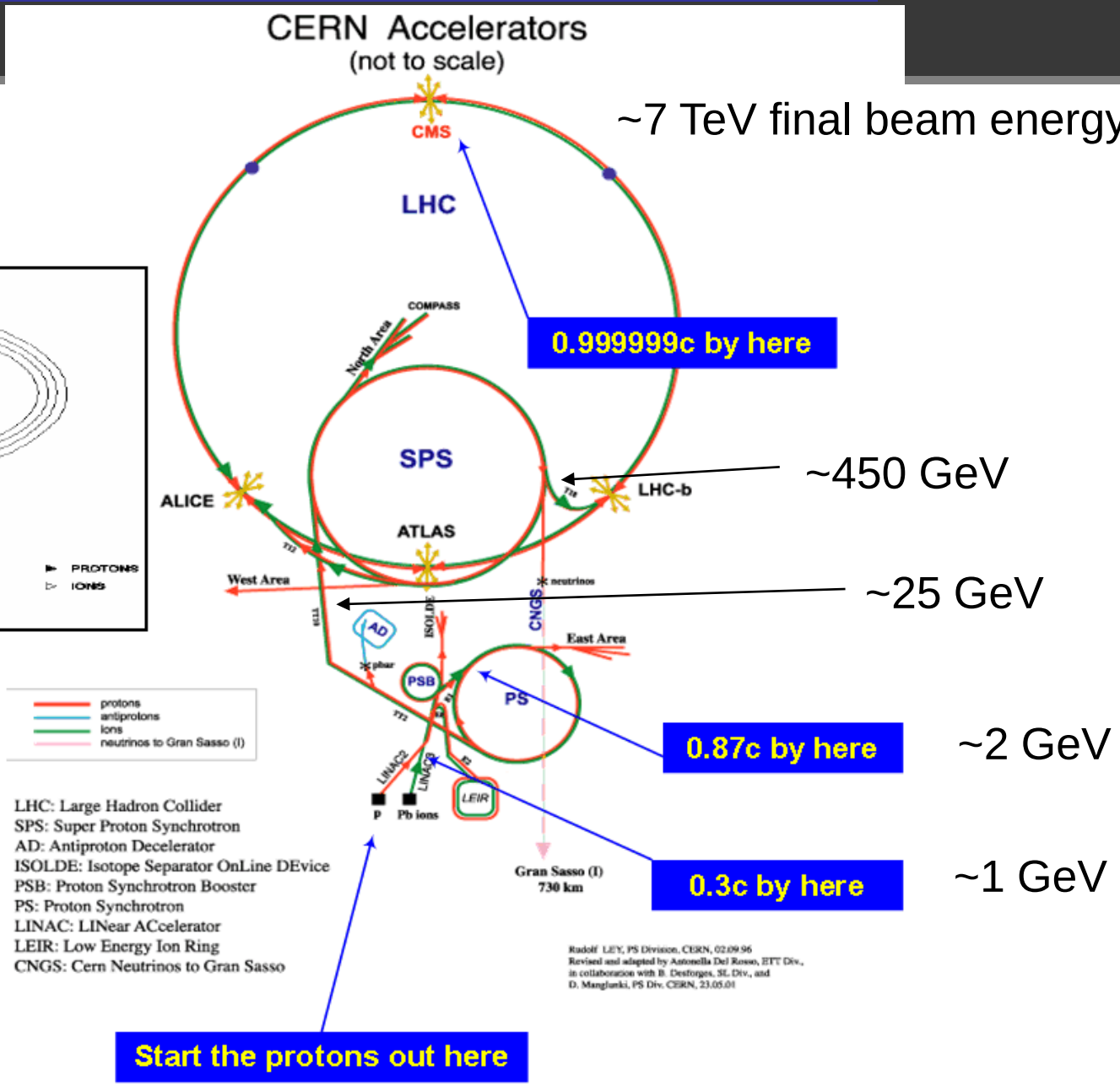


How Do We Get 7 TeV Protons?

LINAC→PSB→PS→SPS→LHC



~10^{11} protons/beam



~7 TeV final beam energy

0.999999c by here

~450 GeV

~25 GeV

0.87c by here

~2 GeV

0.3c by here

~1 GeV

Start the protons out here