

Modern Experiments

Aaron White

Today

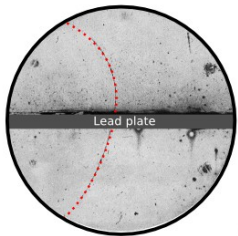
- Review accelerators
- Review detector technology
- Modern experiment slides
- ATLAS Lab tour

Review

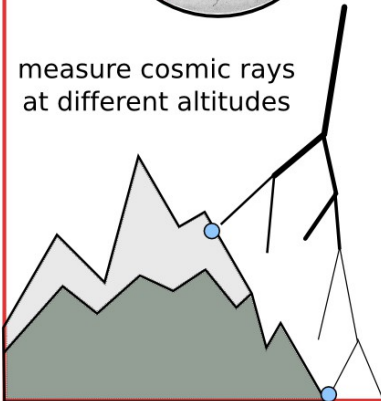
Methods of particle detection

Cloud Chamber

Particles leave tracks of ionization, clouds form

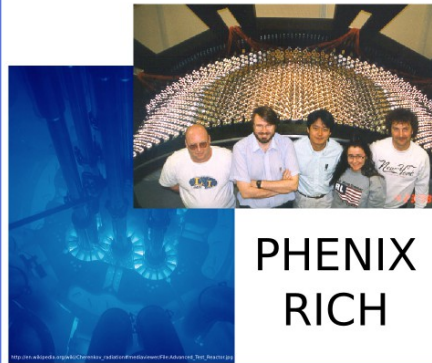
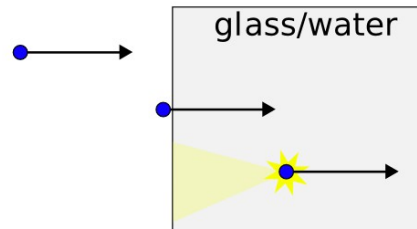


measure cosmic rays at different altitudes



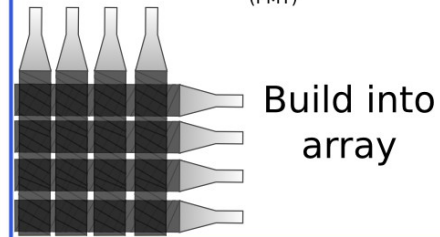
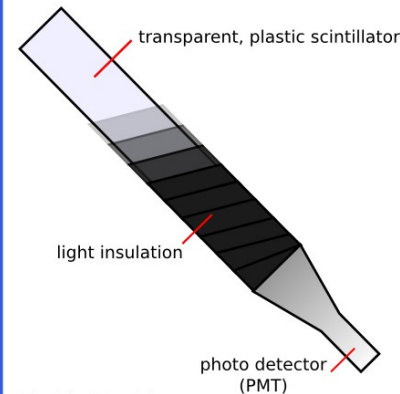
Cherenkov

Particles moving faster than speed of light in medium, polarize medium



Scintillation

Particles excite electrons in media, media emits light

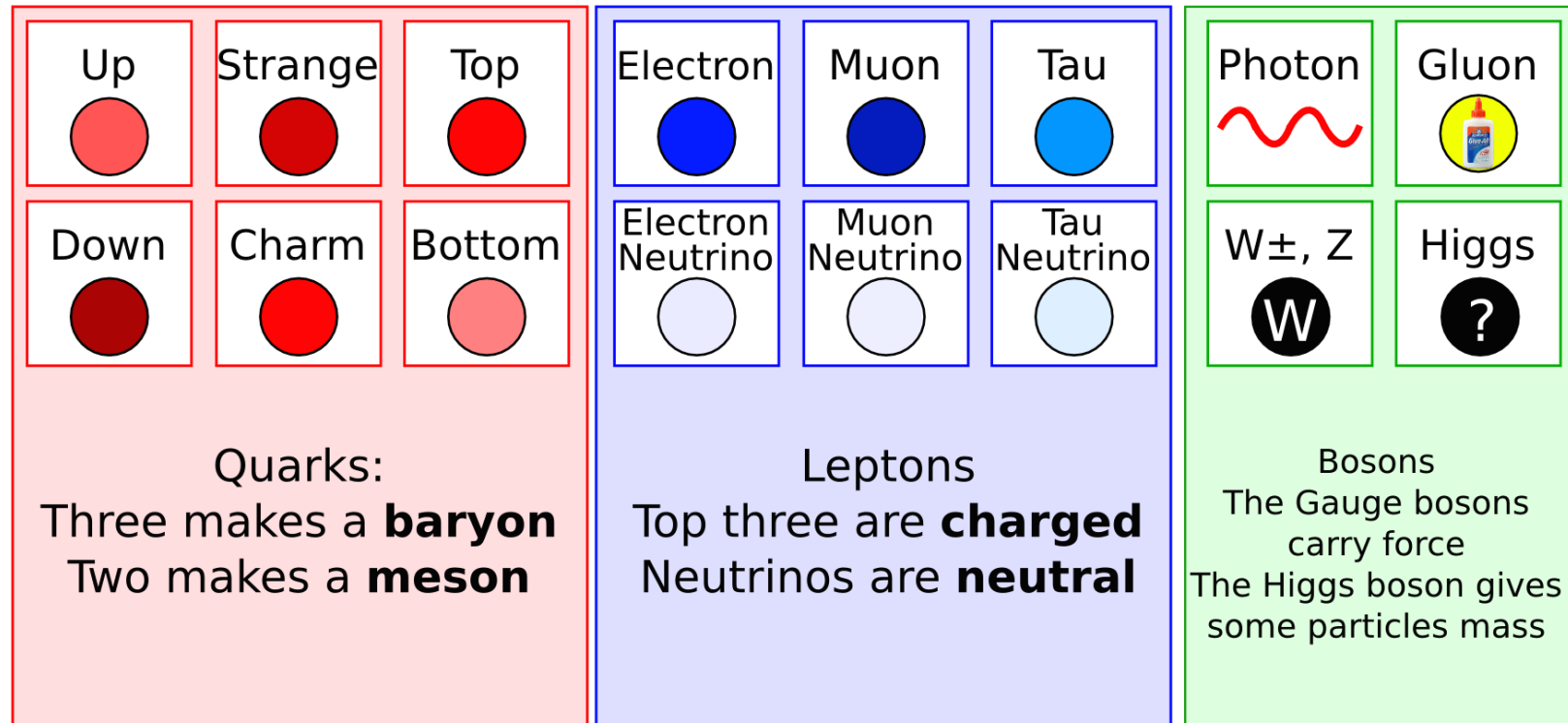


Silicon

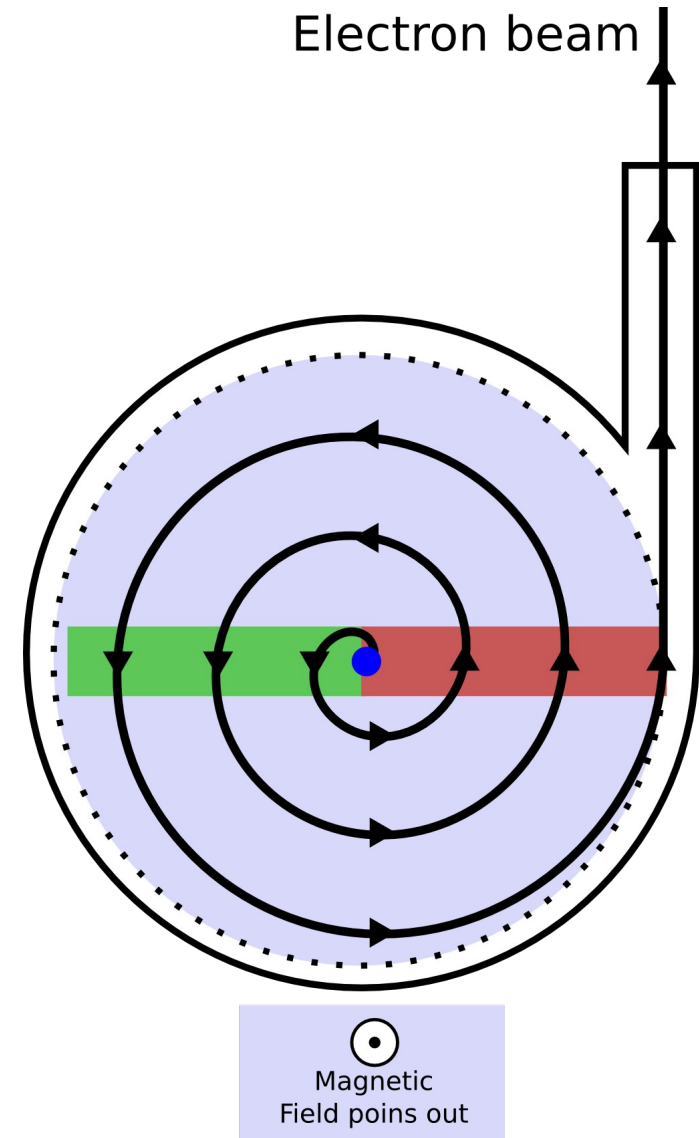
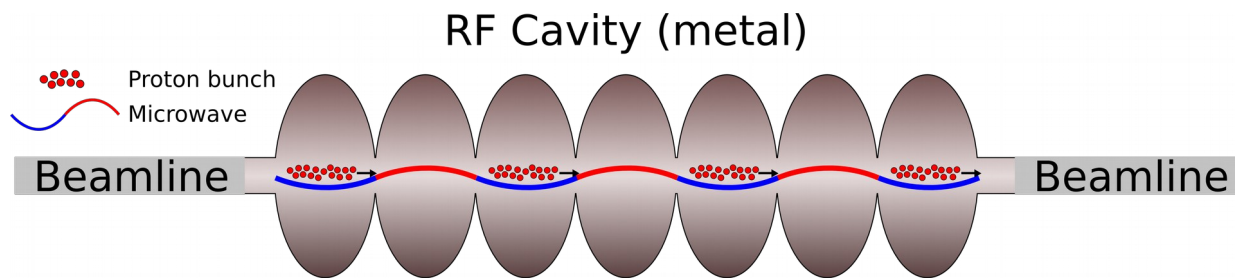
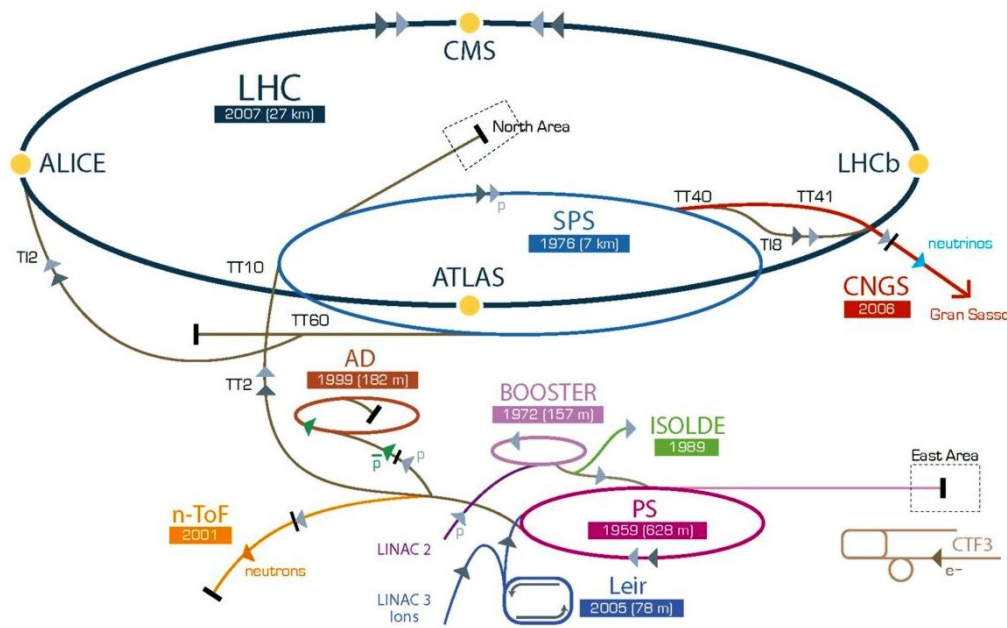
Silicon detectors used for precision tracking



The standard model



Accelerators

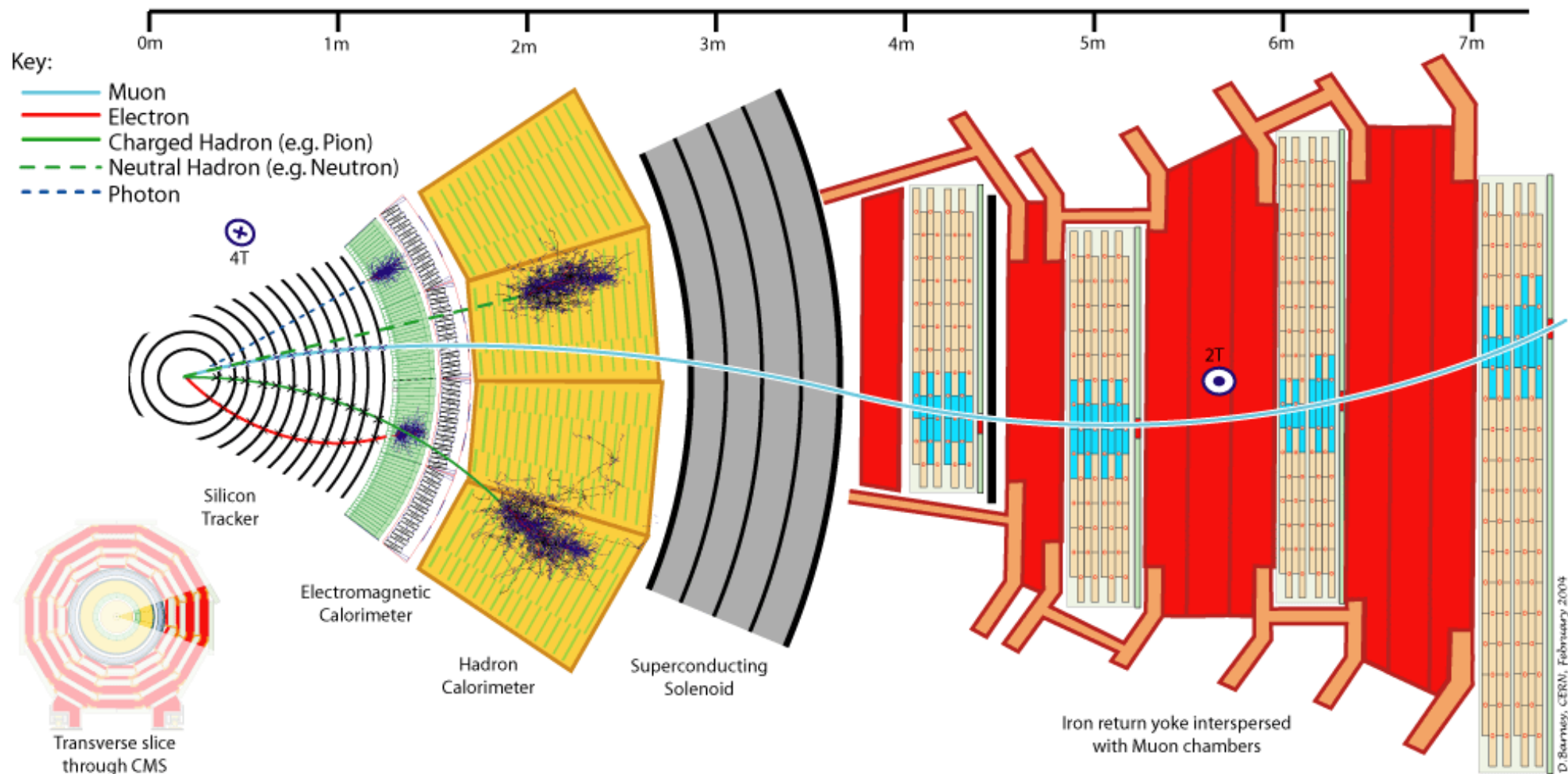


Modern Experiments

Detector Geometries

- What do you want to measure?
 - Rare interaction? Large volume
 - Angular distribution? Only build the detector there
 - Everything?
- Decision is based on:
 - Cost
 - Time
 - Physical space

Detector Composition



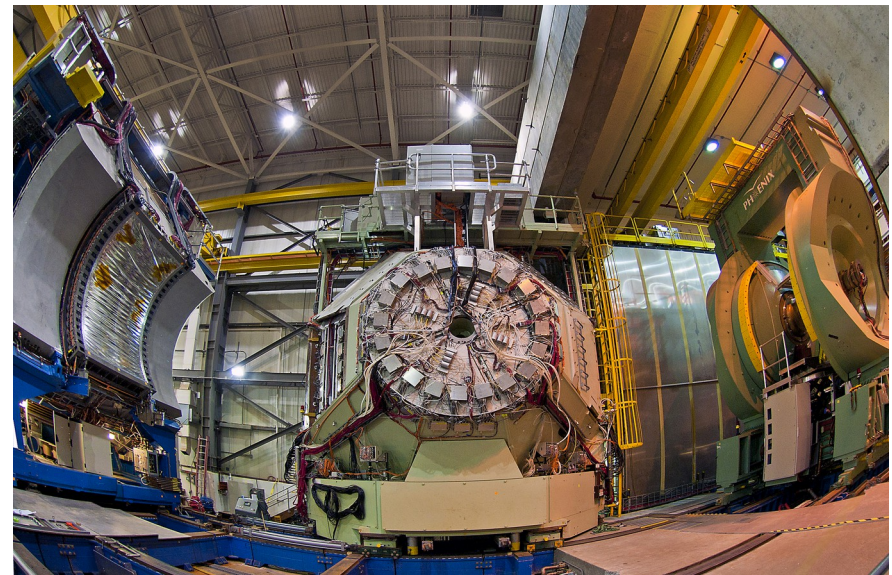
http://www.lhc-closer.es/img/subidas/CMS_Slice.gif

HEP Frontiers

- **Energy frontier**
 - The push for higher energy
 - new particles, more massive
- **Intensity frontier**
 - Low energy, high rate
 - Rare processes, neutrino
- **Cosmic frontier**
 - Dark matter
 - Dark energy, one day

Energy frontier: PHENIX

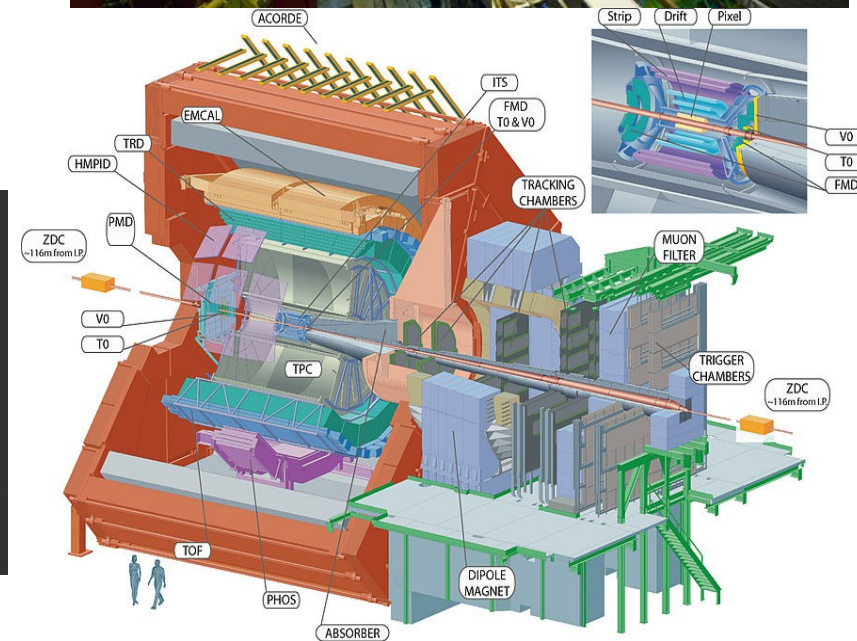
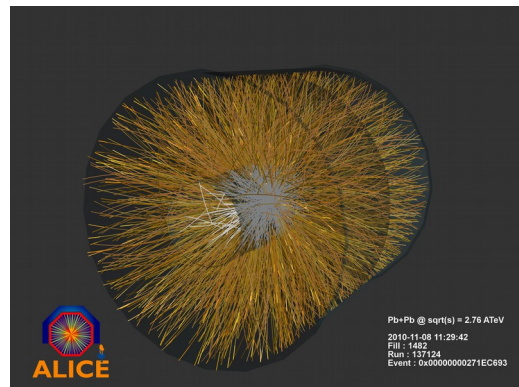
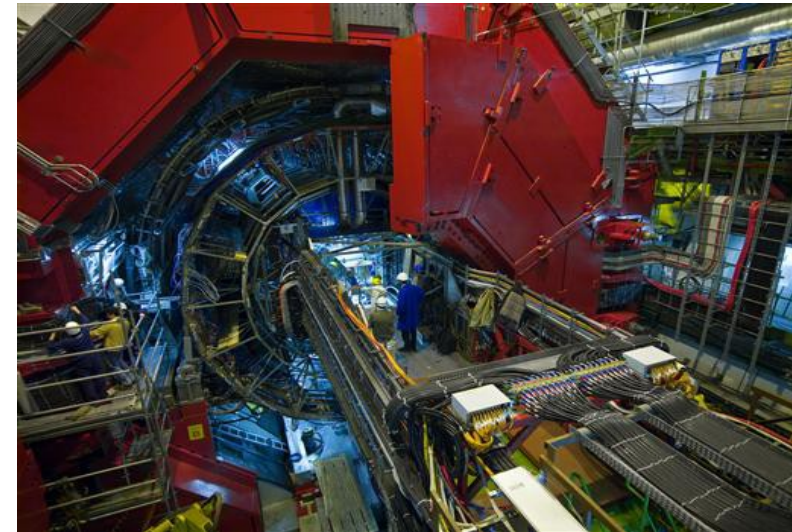
- At RHIC, BNL, Long Island
- Studies
 - Events where particles are emitted back-to-back
 - Physics perpendicular to the beamline
 - Quark gluon plasma in ion collisions



http://archive.sciencewatch.com/ana/st/hadron/11marSThadBNL5_300.jpg, http://www.bnl.gov/today/body_pics/2010/10/d1710810-phenix-hr.jpg

Energy frontier: ALICE

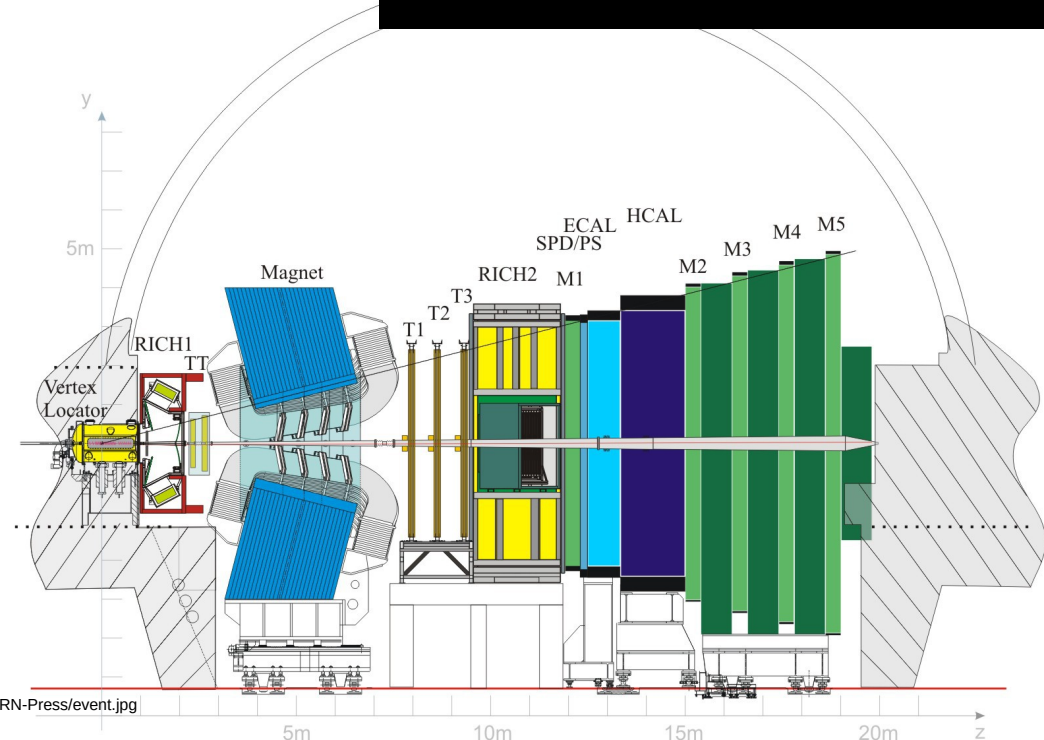
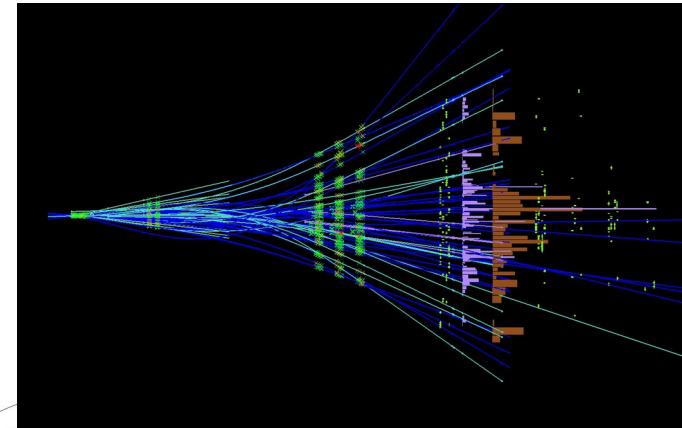
- At LHC, CERN
- Fully symmetric
- Access to higher energies
- Studies
 - Proton structure
 - Quark Gluon Plasma



http://www.uslh.cern.ch/images/events/alice_firstleadcoll.jpg,
http://mediaarchive.cern.ch/MediaArchive/Photo/Public/2008/0801022/0801022_04/0801022_04-A5-at-72-dpi.jpg,
http://upload.wikimedia.org/wikipedia/commons/thumb/a/a5/2012-Aug-02-ALICE_3D_v0_with_Text_%281%29_2.jpg/900px-2012-Aug-02-ALICE_3D_v0_with_Text_%281%29_2.jpg

Energy frontier: LHCb

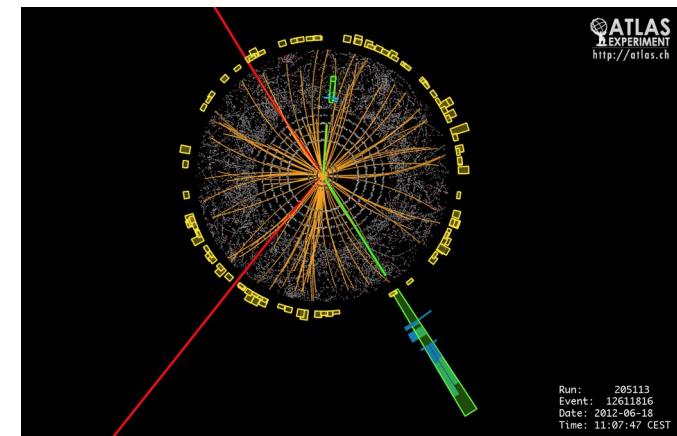
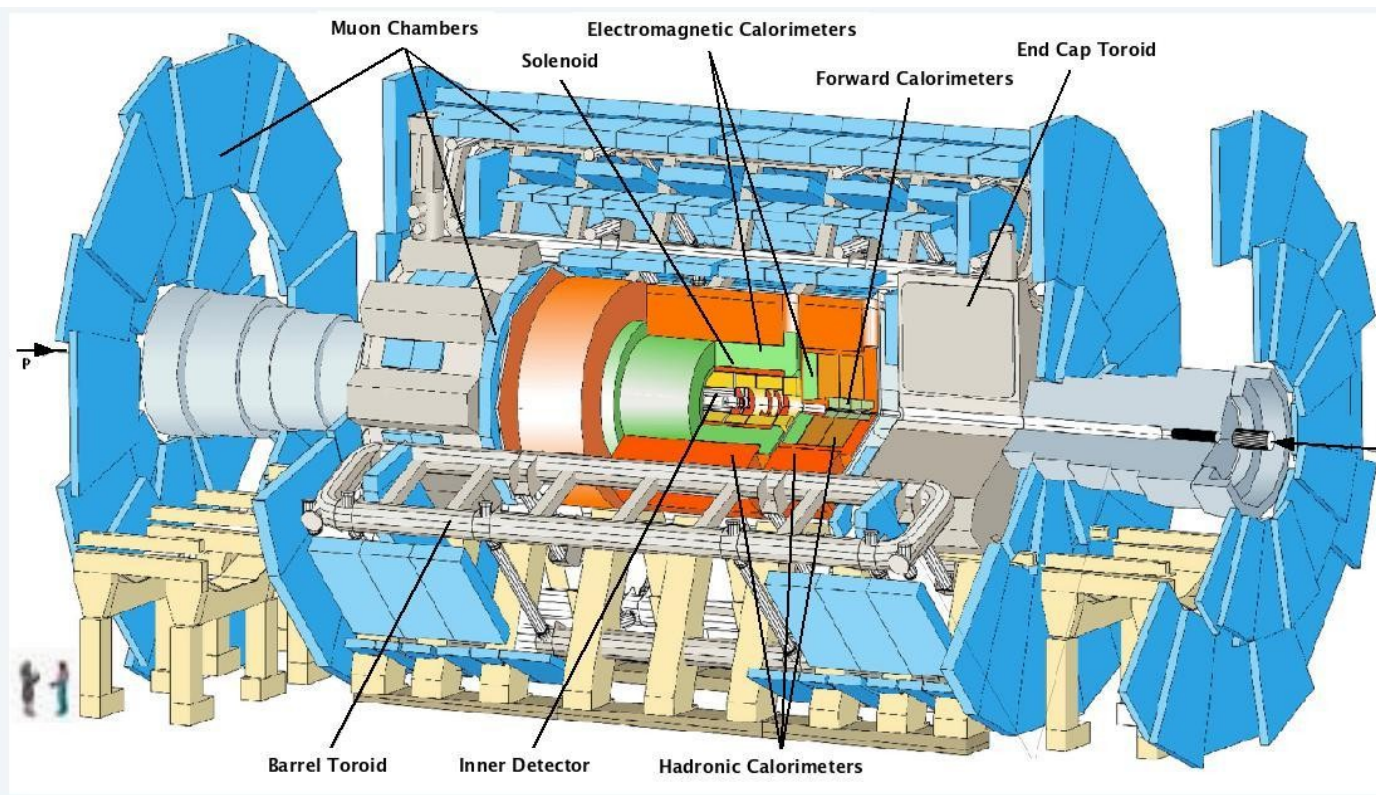
- LHC at CERN
- Forward detector
 - Studies b quark physics
 - CP violation – matter antimatter asymmetry
 - B quarks decay to matter 1% more often



<http://upload.wikimedia.org/wikipedia/commons/3/36/Lhcbview.jpg> , <http://lhcb-reconstruction.web.cern.ch/lhcb-reconstruction/Panoramix/PRplots/CERN-Press/event.jpg>

Energy frontier: ATLAS

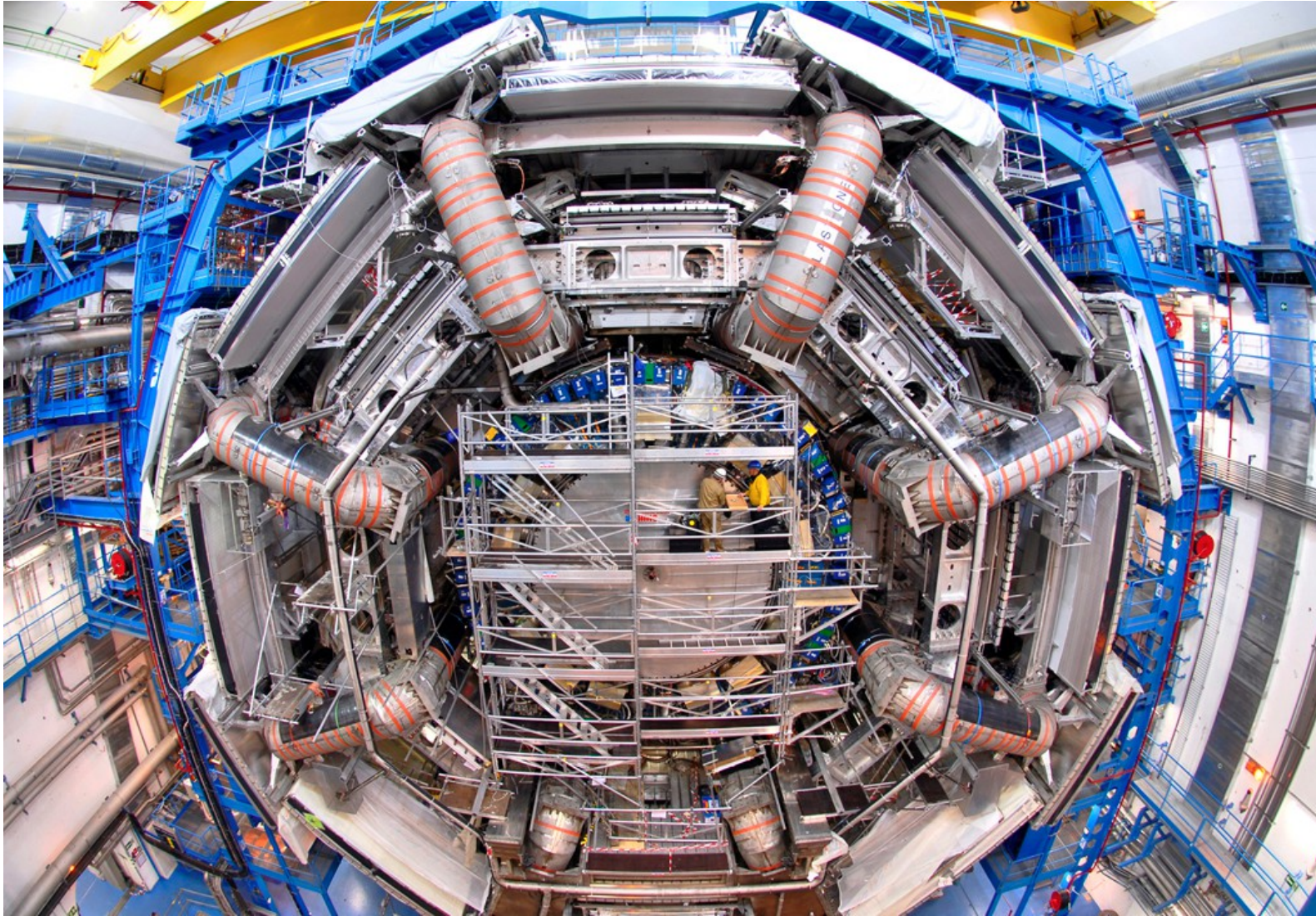
- LHC, CERN
- 25m tall, 40m long
- Searches: Higgs, dark matter, CP violation, SUSY, many more



<http://sites.uci.edu/energyobserver/files/2012/11/atlas-view-2.jpg> , http://atlas.ch/atlas_photos/selected-photos/full_detector/fde_gen_0207_001.jpg

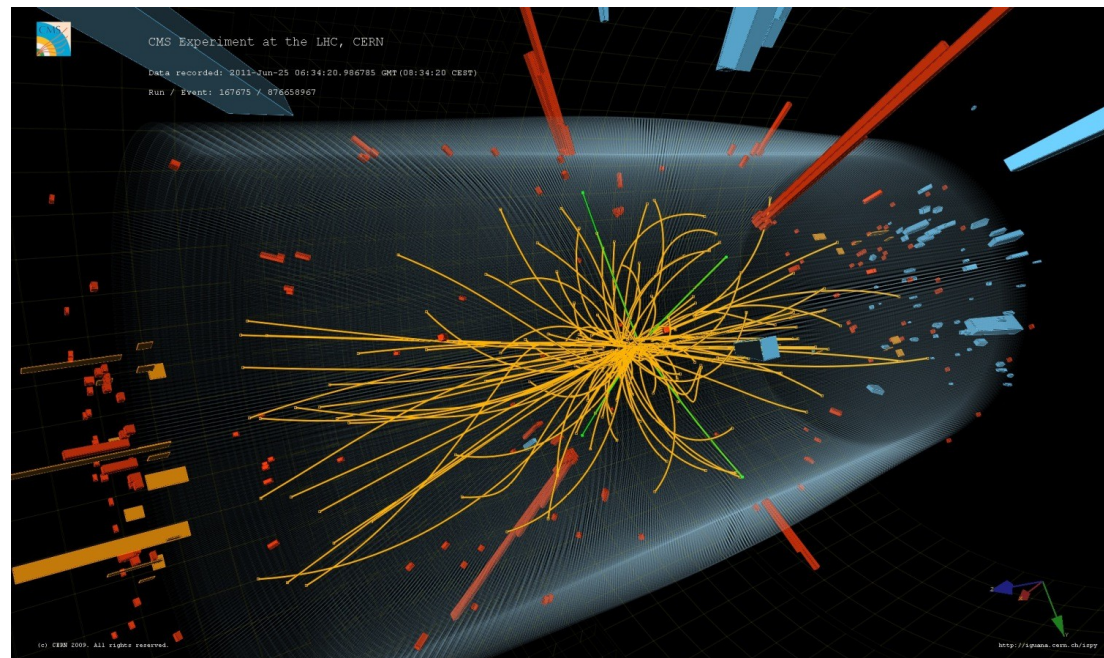
http://www.atlas.ch/photos/atlas_photos/selected-photos/events/run205113_evt12611816_DetailID.png

Energy frontier: ALTAS

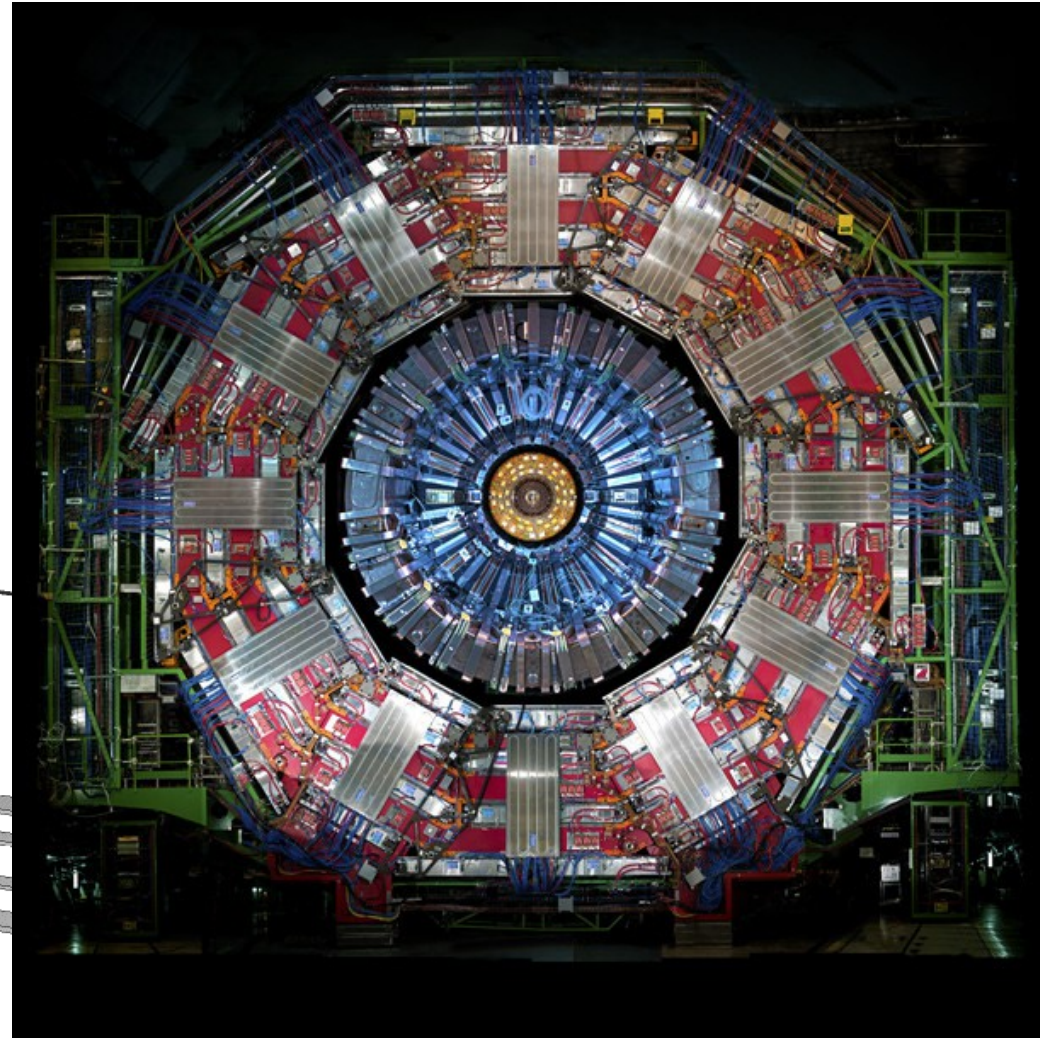
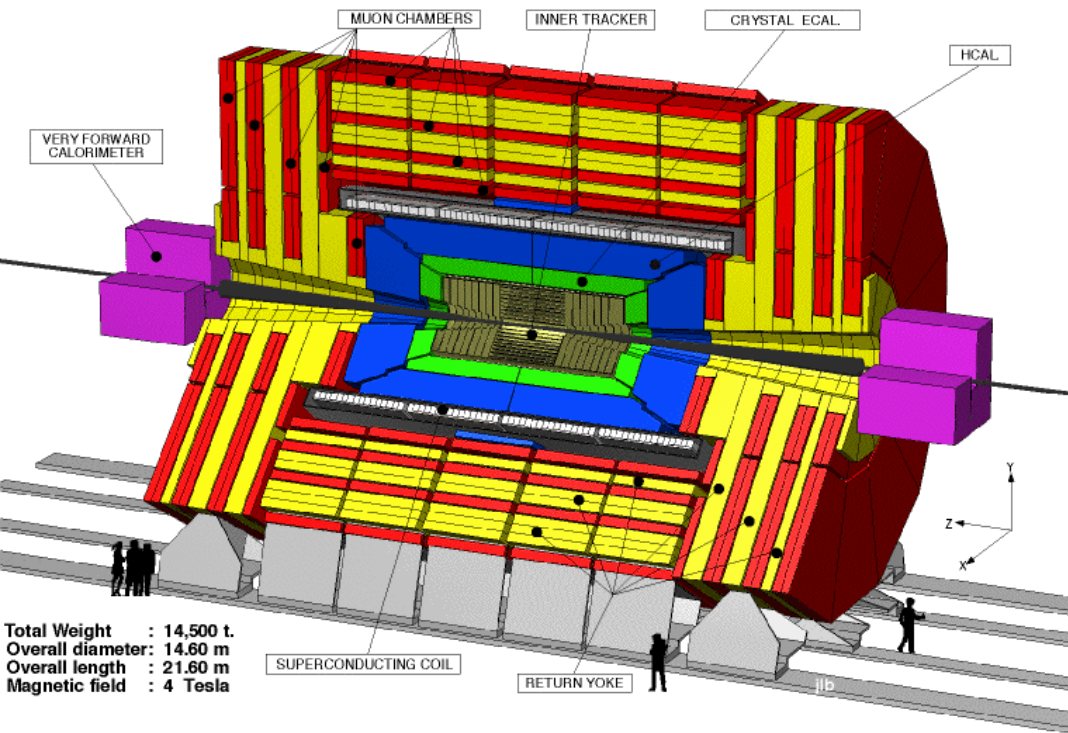


Energy frontier: CMS

- LHC, CERN
- Similar to ATLAS
- Hermetic
- Particle discovery
- Also does CP violation, exotic searches, dark matter



Energy frontier: CMS



http://msnbcmedia.msn.com/i/MSNBC/Components/Photo/_new/110831-coslog-cms-230p.jpg , https://c1.staticflickr.com/9/8174/8040228597_19bb374b03_z.jpg , <http://www.ncp.edu.pk/images/rpc/cms-3d-detector.gif>

Intensity frontier: MINOS

- **Muon** neutrinos produced high rate in Fermilab
- Beamed 735km underground to north Minnesota
- Detector is plastic scintillator
- Look for oscillation to **Electron** neutrinos

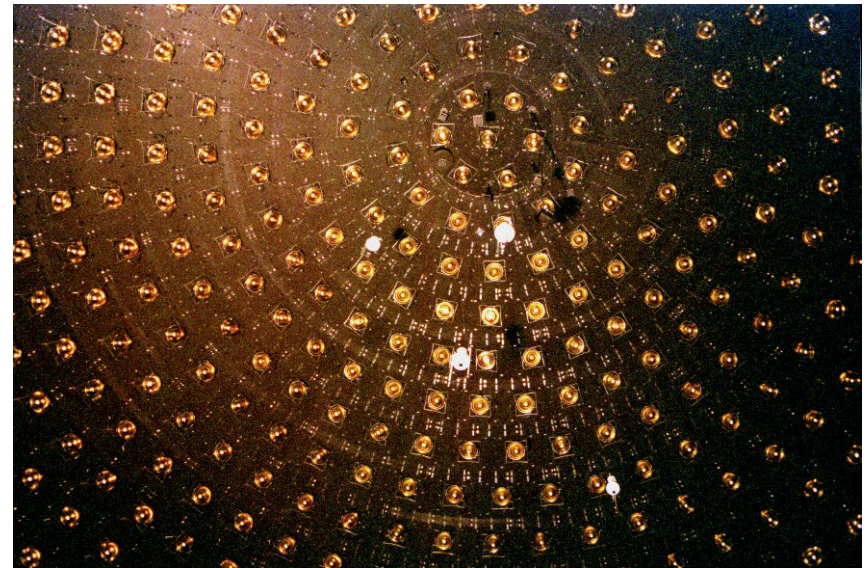


<http://www.hep.ucl.ac.uk/minos/photos/ndminos.jpg> , <http://www.quantumdiaries.org/wp-content/uploads/2011/03/minos9D2.jpg>



Intensity frontier: MiniBooNE

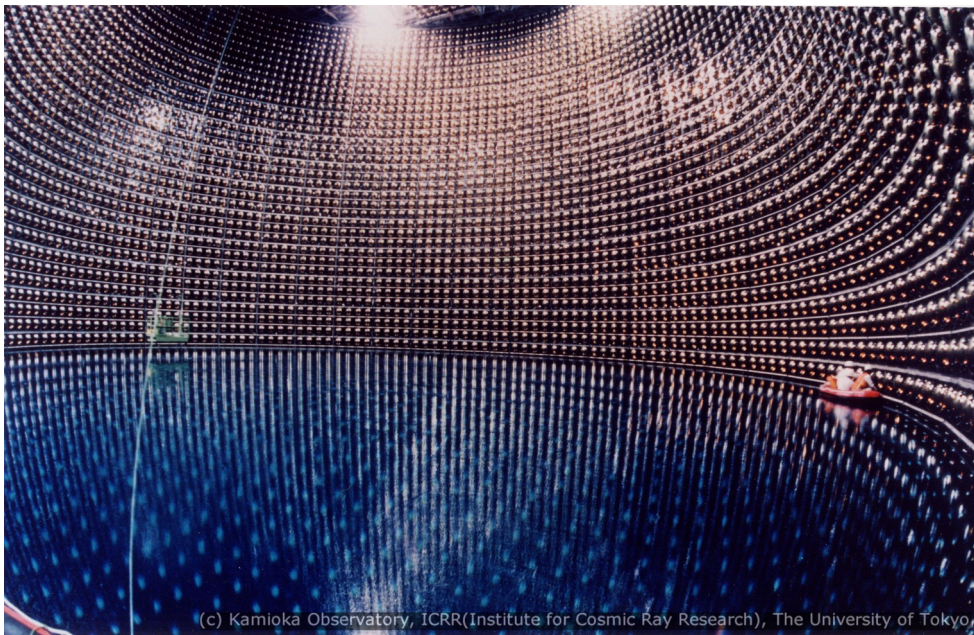
- Sphere filled with scintillating oil, PMTs
- Located at Fermilab
- Search for excess electron neutrinos in beam



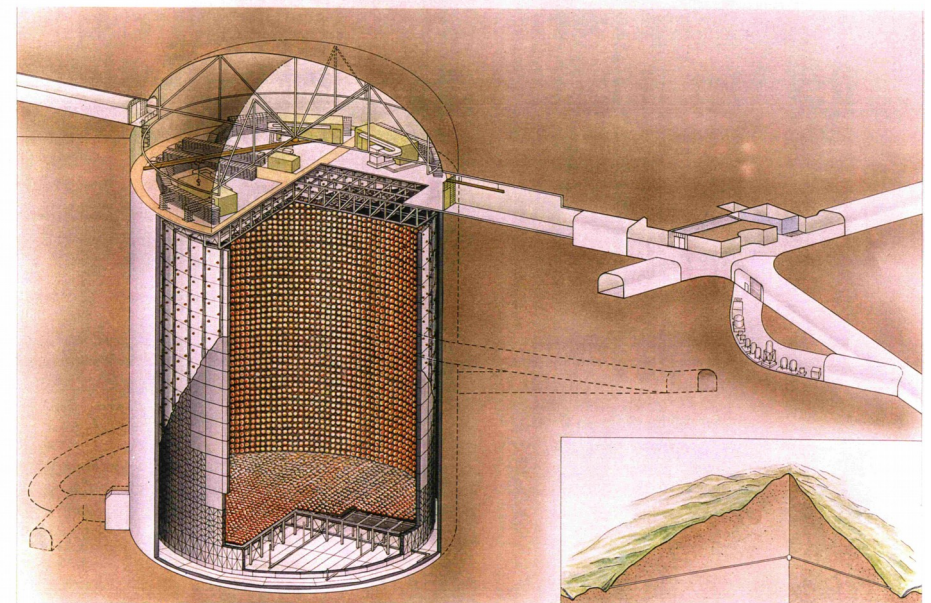
http://www.hep.princeton.edu/~meyers/boone_pub/pss_install/sep4-7/neg60-25a.jpg , <http://www.fnal.gov/pub/ferminews/ferminews03-12-01/mini-boone.jpg>

Intensity frontier: Super-Kamiokande

- Cherenkov detector, look for neutrinos via electron production
- 1km underground in mine
- First to discover neutrino oscillations



http://www-sk.icrr.u-tokyo.ac.jp/sk/gallery/wme/sk_build01h-wm.jpg



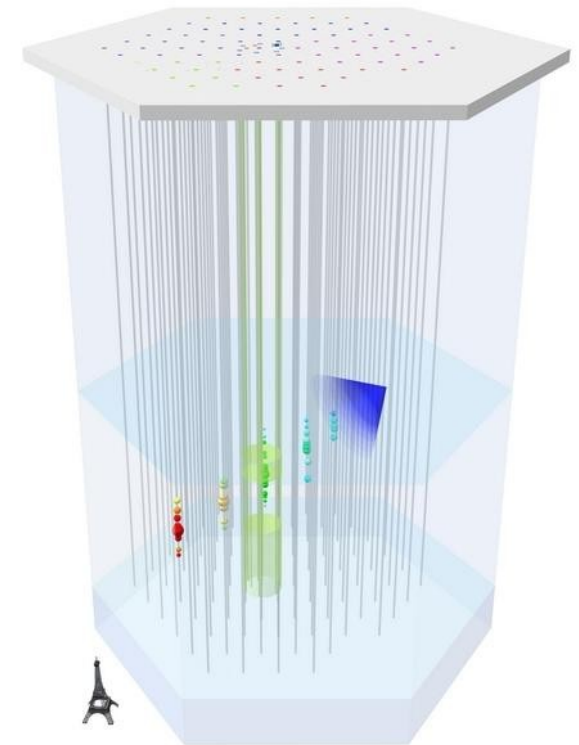
SUPERKAMIOKANDE (c) Kamioka Observatory, ICRR(Institute for Cosmic Ray Research), The University of Tokyo
INSTITUTE FOR COSMIC RAY RESEARCH UNIVERSITY OF TOKYO
NIKEN SEKKI

Cosmic frontier: IceCube

- South pole
- Chains of detectors, 2.4km buried in ice
- Cosmic neutrinos, coincident with gamma rays

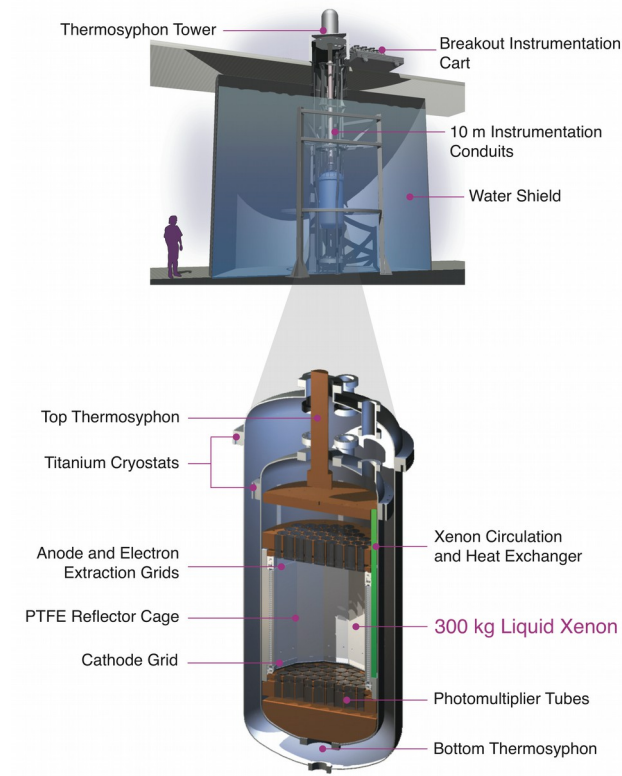
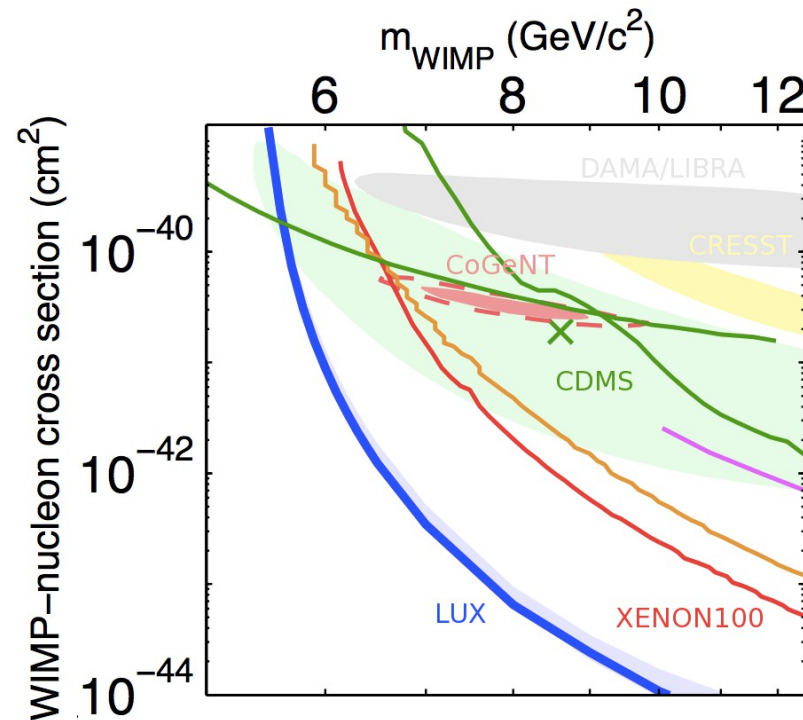


<http://gallery.icecube.wisc.edu/web/var/resizes/Press-Root-Album/Detector/detector-event.jpg?m=1371067628>



Cosmic frontier: LUX

- 370 kg liquid xenon ($\frac{1}{2}$ million \$), Homestake Mine, South Dakota, 1 mile deep
- Search for dark matter
- Exclusion plot



http://upload.wikimedia.org/wikipedia/en/5/5a/Large_Underground_Xenon_detector_diagram.png, http://www.sciogs.com/mine-dark-matter-crisis/files/2013/11/LUX_fig1.png

Notes about Fermilab Trip

Driver to pick up car

- Driver needed to pick up car
- Oct 13:
 - 8:00 Leave Ann Arbor
 - 12:00 Arrive at Fermilab, Check into housing
 - 13:00 Lunch in Wilson Hall, get badges, top floor exhibits
 - 15:00-16:30 Tour of D0 and Tevatron led by Stefan Gruenendahl
 - 17:00-19:00 Tour of SeaQuest and control room led by Josh Ruben
-
- Oct 14:
 - 8:00 Breakfast at Wilson Hall
 - 9:00 Fermilab Museum, Buffalo
 - 10:00-11:30 Tour of MINOS and MINERvA led by Bill Lee
 - 12:00 Lunch at Wilson Hall
 - 13:00 Possible tour of CMS control room
 - 13:00 Check out, leave Fermilab
 - 17:00 Arrive in Ann Arbor

Visit ATLAS Lab