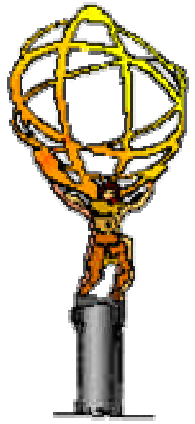
ATLAS experiment



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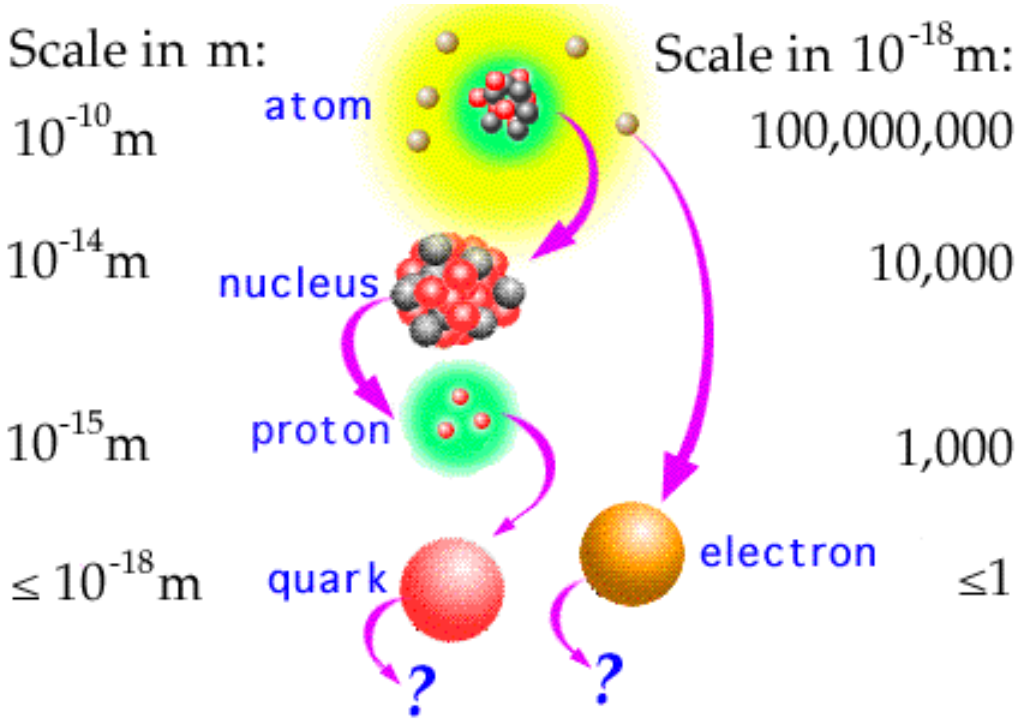
ATLAS experiment: New energy frontier in the particle world

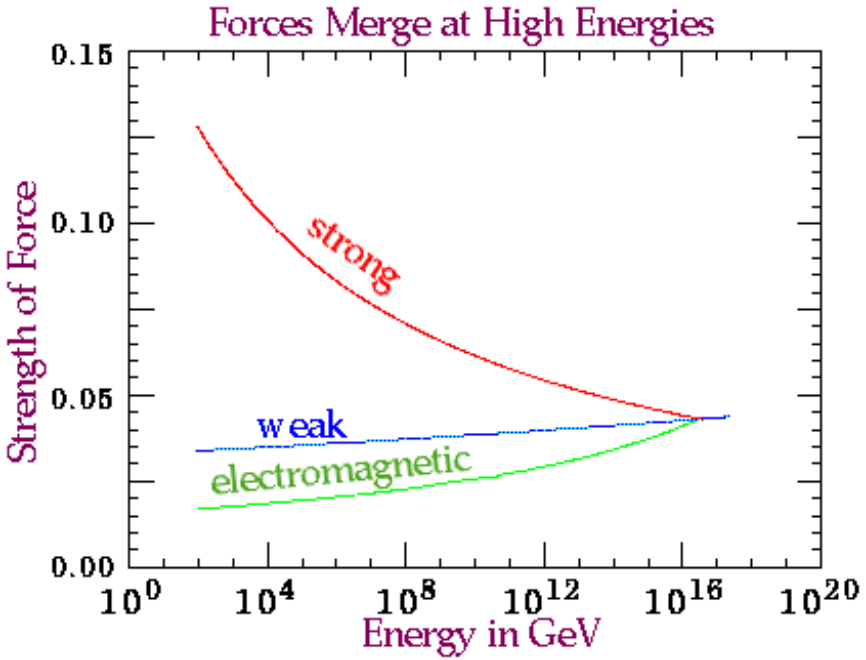
- Physics at the Large Hadron Collider (LHC)
- The ATLAS detector
- What do we do here in Lund?



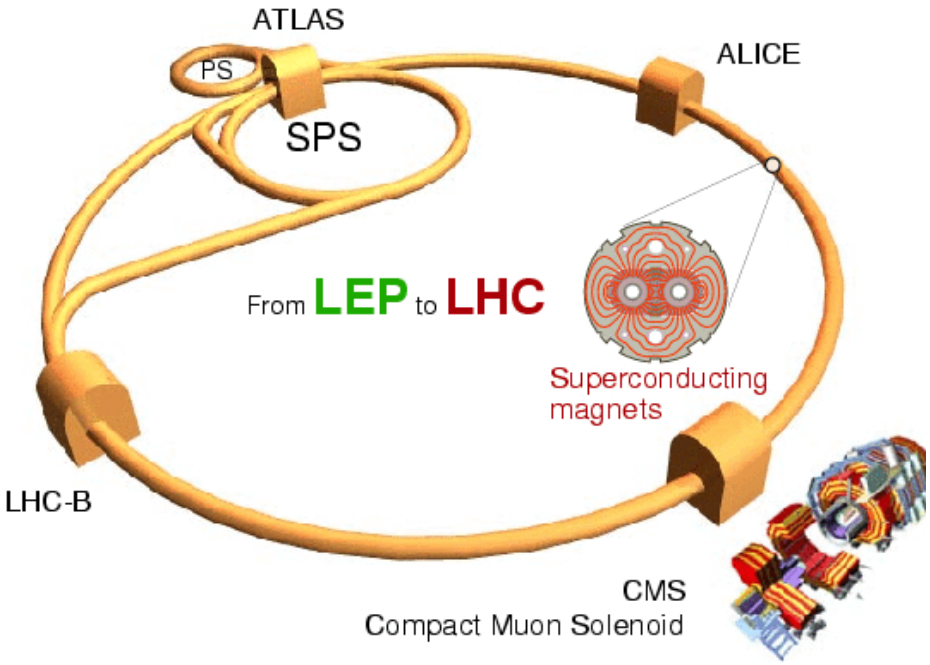
Why do we need a new, even bigger particle collider

- All material particles discovered
  - 6 quarks, 6 leptons
- All force particles discovered (except graviton)
  - Photon, W, Z, gluons
- BUT there are open questions:
  - Why do particles have mass ←→ Higgs mechanism
  - Why is matter-antimatter and left-right symmetry (CP) broken in the Universe ←→ CP violation
  - Can we unify all 4 forces? Can we do it with Supersymmetry?

LHC is needed to answer these questions!

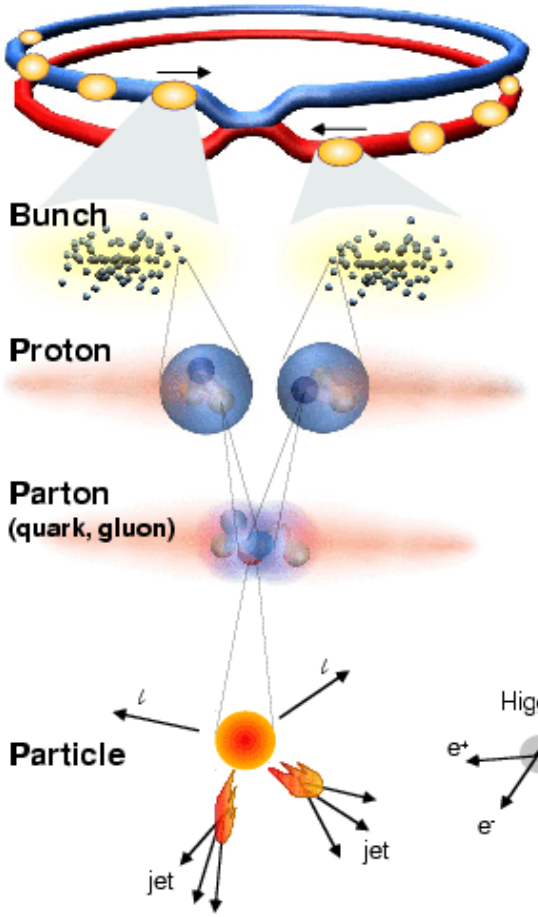


The Large Hadron Collider at CERN, Geneva



	Beams	Energy	Luminosity
LEP	e+ e-	200 GeV	10^{32} cm^{-2}s^{-1}
LHC	p p	14 TeV	10^{34}
	Pb Pb	1312 TeV	10^{27}

Collisions at LHC



Proton-Proton	(2835 x 2835 bunches
Protons/bunch	10^{11}
Beam energy	7 TeV (7×10^{12} eV
Luminosity	10^{34} cm^{-2} s^{-1}
Crossing rate	40 MHz
Collisions ≈	10^{7} - 10^{9} Hz

Higgs

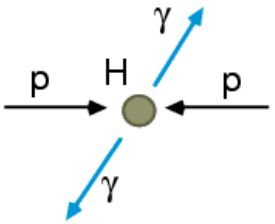
SUSY.....

Selection of 1 in 10,000,000,000,000

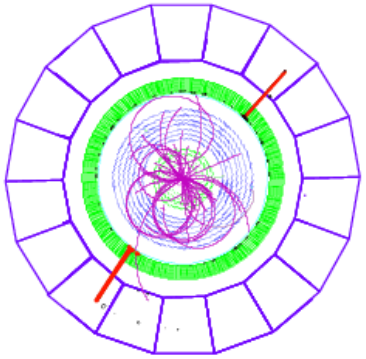
Higgs physics

- Why do particles have mass?
- The Higgs mechanism (or something similar) is required to generate particle masses
- BUT Higgs particle has not been found yet!
- Present tests: Higgs must be heavier than 115 GeV
- LHC: Higgs can be found if mass is 115-1000 GeV
- Search for Higgs through decays H→gg,bbbar, H→ZZ→l^+l^- l^+l^- (l=e,m)

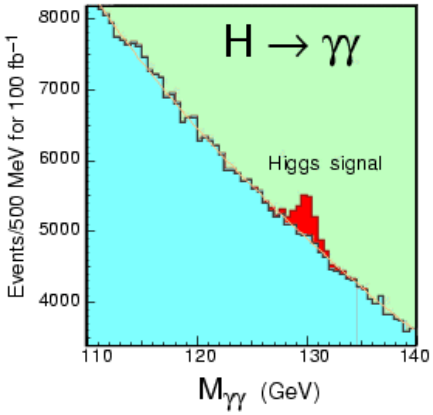
Higgs to 2 photons (M_H < 140 GeV)



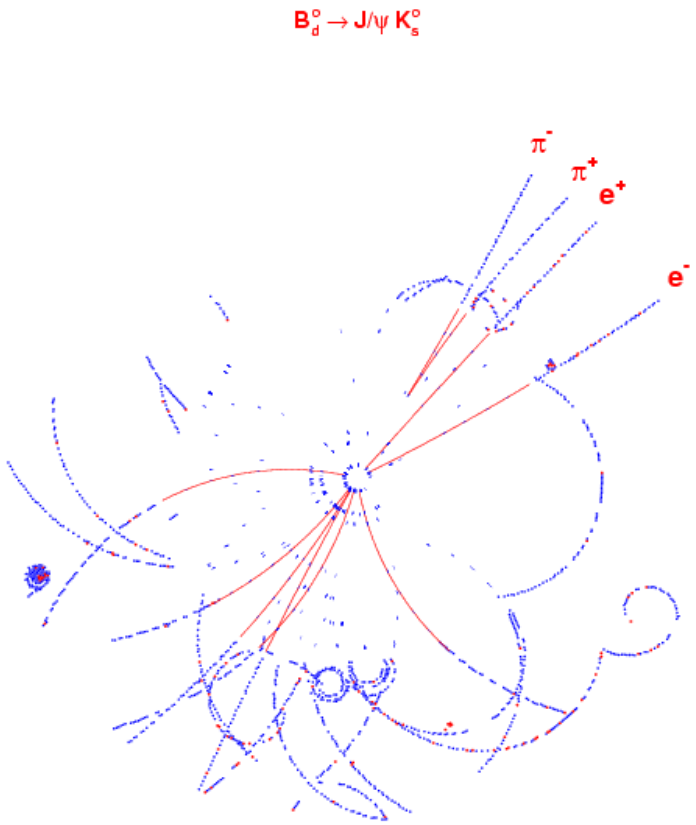
$H^0 \rightarrow \gamma\gamma$ is the most promising channel if M_H is in the range 80 – 140 GeV. The high performance $PbWO_4$ crystal electromagnetic calorimeter in CMS has been optimized for this search. The $\gamma\gamma$ mass resolution at $M_{\gamma\gamma}$ ~ 100 GeV is better than 1%, resulting in a S/B of ≈1/20



M_{Higgs} = 100 GeV



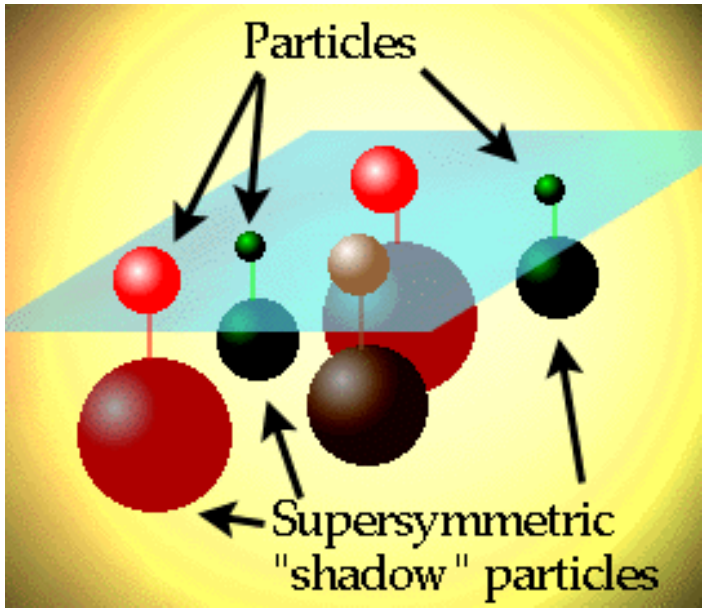
CP violation



- CP violation is needed to create our Universe, which consists of mostly matter, and not antimatter.
- LHC: measure CP violation in B-meson decays.
- LHC is the ultimate B-factory: s(bbbar)=500 mb→produce 5×10^{12} bbbar-pairs per year.

Supersymmetry

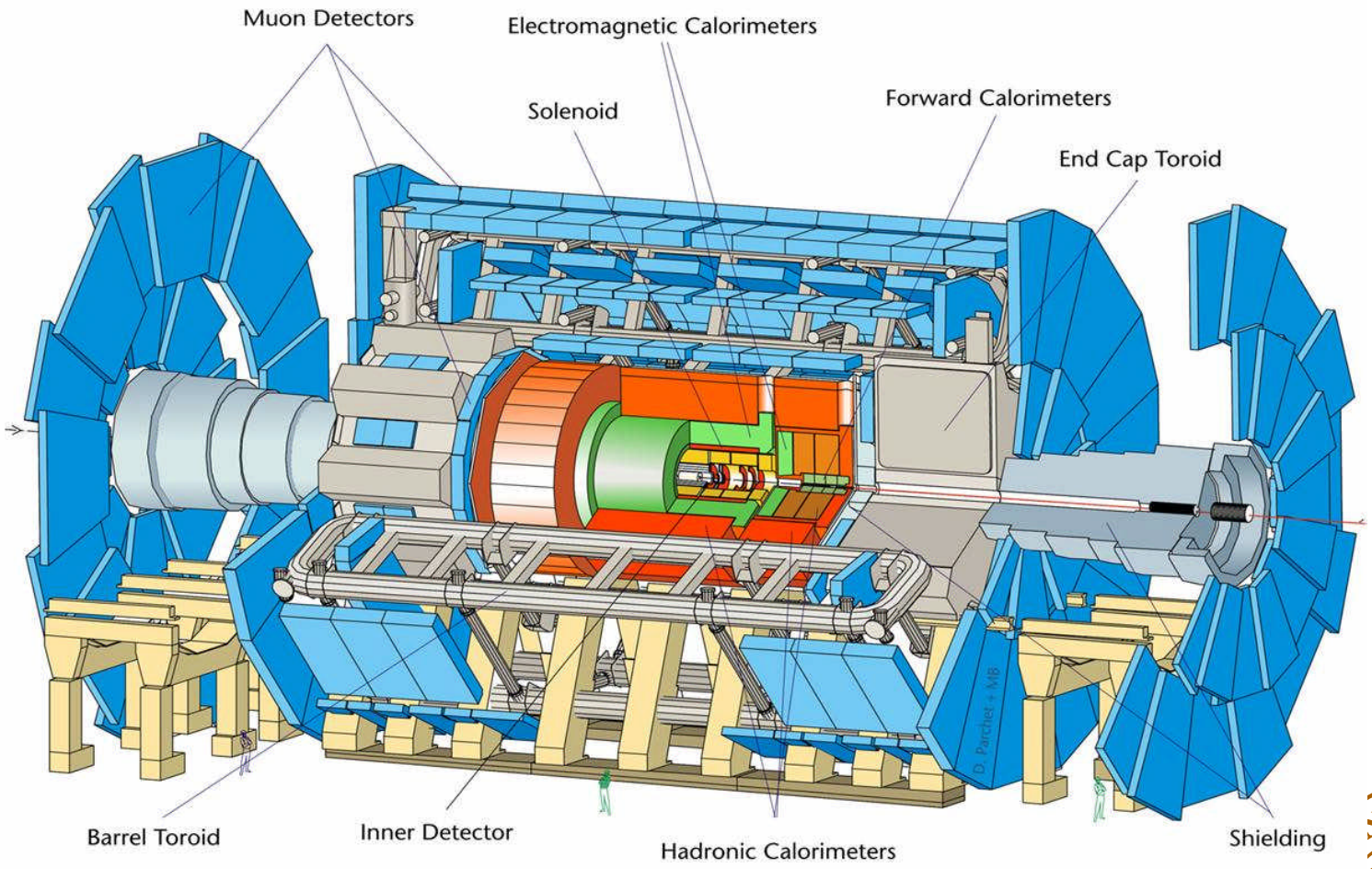
is a new theory which would unify all the 4 forces.



- Supersymmetry=fermion-boson symmetry: all particles have SUSY-partners with spin +(-)1/2
- SUSY-partners of quarks and leptons are squarks and sleptons, with spin=0
- SUSY-partners of force-particles (g,W,Z,gluon,graviton) are "photinos, winos, zinos, gluinos, gravitinos" with spin=1/2 (3/2)
- Lightest SUSY-particle maybe stable→dark matter candidate?
- LHC: very good chances to observe squarks, gluinos, supersymmetric Higgses,...

The ATLAS Detector

http://atlasexperiment.org/



The ATLAS detector

- General purpose experiment at LHC
- 22m high, 46 m long, weight 7000 tons
- Consists of
  - Inner detector for p measurement (inside a solenoid magnet) and for measuring coordinates of primary and secondary vertex.
  - E.m. Calorimeter for g/e energy measurement
  - Hadron calorimeter for p/n/p energy measurement
  - Muon detectors for m measurements. Muon detectors are inside a toroid magnet.
- pp collisions every 25 ns→fast electronics
- Interesting events: typically 1/10 000 000 000→Need efficient trigger system.
- Detectors, electronics and data links have to be radiation hard.
- Data output: more than 1 PByte (1 million GBytes) per year→distributed data processing→Grid

What do we do here in Lund?

http://www.quark.lu.se/~atlas/

- Physics research:
  - CP violation
  - Supersymmetry and New Physics
- Software development: GRID
- Detector construction: Transition Radiation Tracker (TRT)
- Who? A group of about 5 physicists, 2 engineers and 2 students in the division of elementary particle physics
  - Paula Eerola, professor, LHC physics, Grid, TRT
  - Torsten Åkesson, professor, deputy spokesman of ATLAS
  - Vincent Hedberg, lecturer, ATLAS detector construction
  - Oxana Smirnova, research assistant, LHC physics and Grid
  - Balazs Konya, researcher, Grid
  - Björn Lundberg, electronics engineer, TRT
  - Ulf Mjörnmark, research engineer, TRT
  - Chafik Driouichi, PhD student, LHC physics and TRT
  - Robert Siljan, PdD student, LHC physics

LHC physics

- Simulation studies of CP violation, Supersymmetry, extra dimensions…
- Work together with Nordic particle physicists (Nordic network) and ATLAS colleagues.

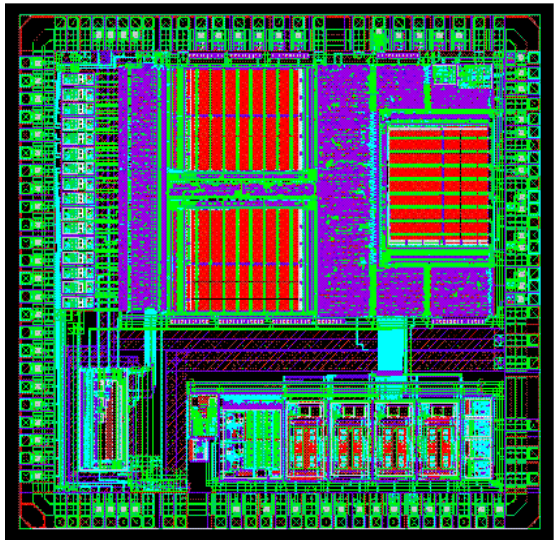
- ATLAS Physics working groups.
  - Working groups meet about 3 x year
- Nordic Workshops:
  - Nordic workshops twice a year, including student training courses. Next meeting: Bergen 05/2003

NorduGrid

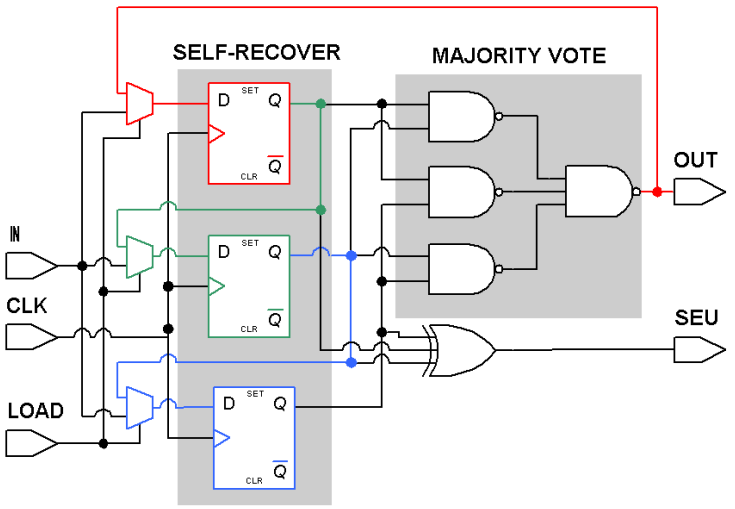
- Grid: technology to share and access distributed computing resources. WWW →World Wide Grid
- Research in Grid-systems is performed in the framework of the Nordic NorduGrid project.

Transition Radiation Tracker TRT

- Electronics design: Digital Read-out Chip DTMROC, electronics read-out system for the barrel TRT, chip tester.
- Analysis of data from prototype modules, participation in beam tests.



DTMROC-S layout



Triple-voting scheme

Student opportunities

- Introduction to Particle Physics FYS225 (5p), spring 2003, end January-beg March
- Examensarbeten/diploma work
  - Physics simulation on CP violation, supersymmetry,…
  - Grid-development and interface between physics and Grid
  - Detector hardware: chip tester development
- CERN Summer Student programme: see http://public.web.cern.ch/Public/
  - 3 months summer training at CERN, including research and lectures
  - About 100 best students from CERN member states
  - Requirement: 3 years of studies by summer 2003
  - Application deadline end of January 2003
  - See included material
- More info: contact us!