Division of experimental High Energy Physics

Proton-proton collisions

Heavy ion (e.g. Pb-Pb) collisions

Electron-proton collisions

ATLAS

D0

ALICE

PHENIX

H1

Proton structure,...

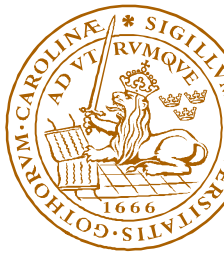
Top-quark, new physics: super-symmetry, Higgs,...

Search for quark-gluon plasma,...

Grid

Software

Electronics



LUNI
UNIVERSI

Researchers and projects

- ATLAS, D0
  - P. Eerola, V. Hedberg, G. Jarlskog, O. Smirnova, T. Åkesson. PhD students C. Driouichi.
- Grid (distributed computing)
  - P. Eerola, B. Konya, O. Smirnova
- Delphi (e+e- collisions, finishing)
  - V. Hedberg, G. Jarlskog. PhD students S. Ask, P. Tyapkin.
- ALICE
  - H.-Å. Gustafsson, A. Oskarsson, I. Otterlund, E. Stenlund.
- PHENIX
  - H.-Å. Gustafsson, A. Oskarsson, E. Stenlund. PhD students S. Rosendahl, H. Tydesjö, E. Haslum.
- H1
  - L. Jönsson, H. Jung. PhD students M. Hansson, A. Knutsson, S. Osman.

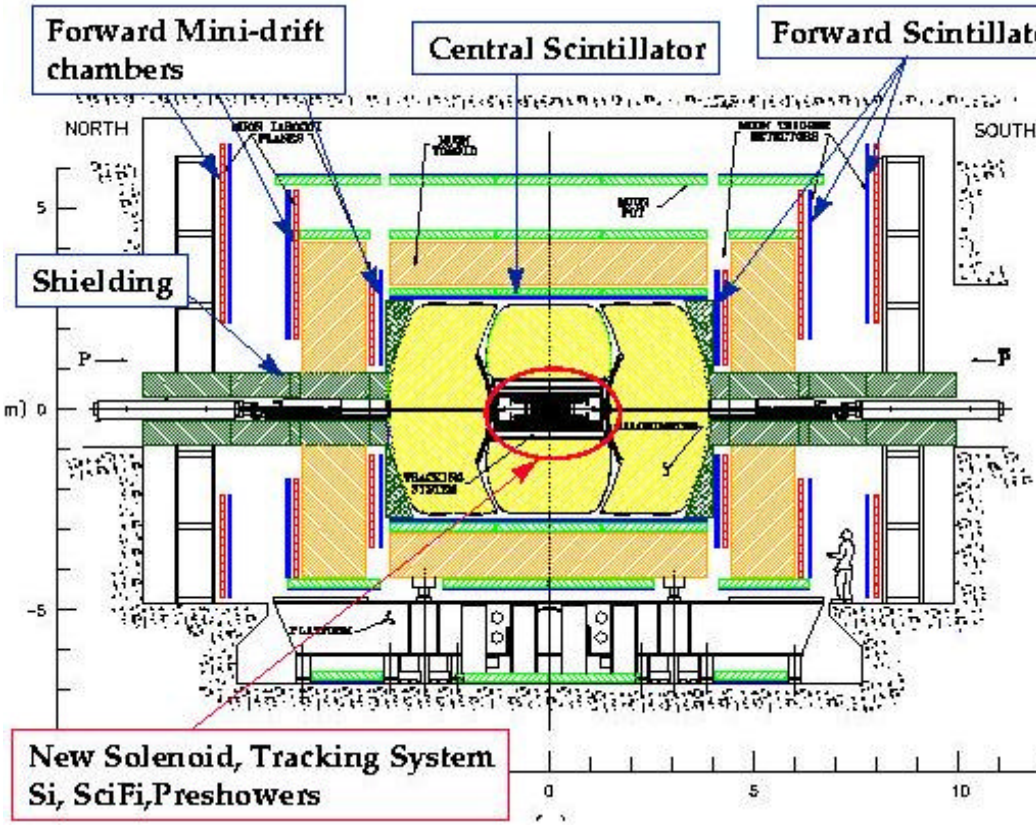
DØ: experiment at Tevatron, Fermilab. Proton-proton collisions at 2 TeV cms energy

Tracking

- silicon vertex detector
- fiber tracker
- 2T magnetic field

Calorimetry

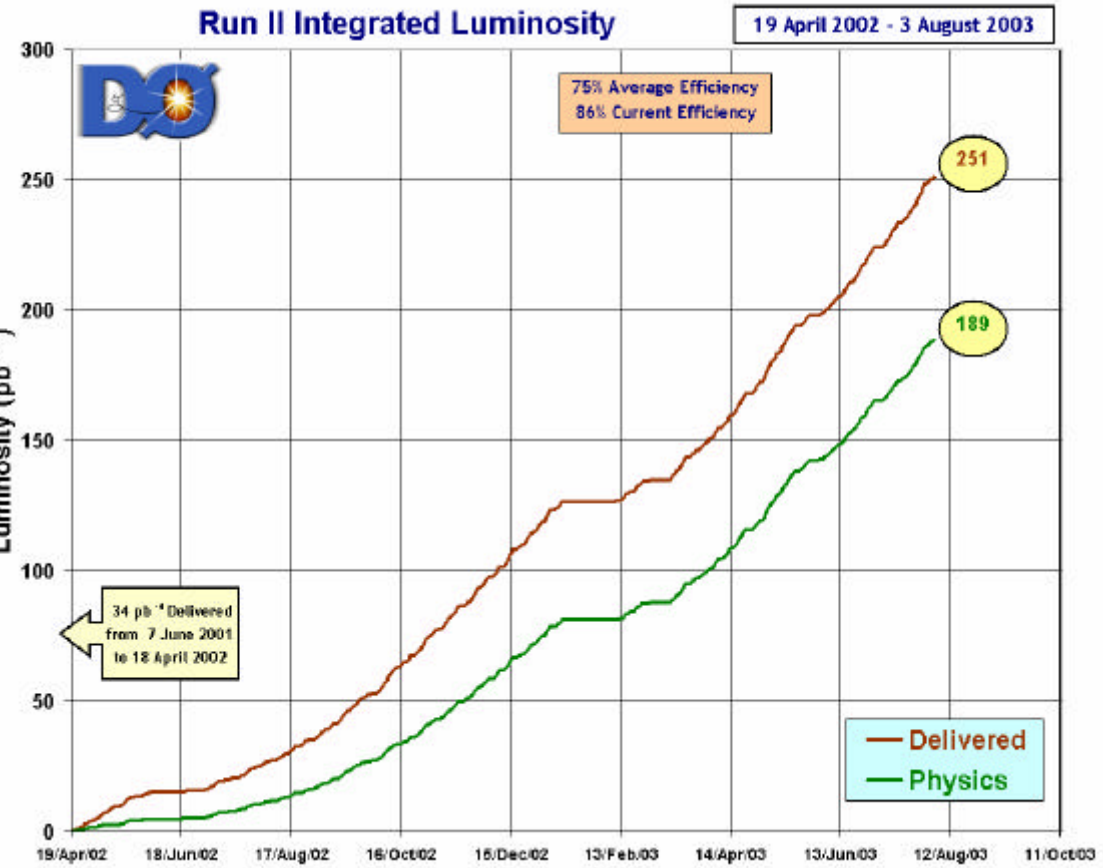
- Preshower detector
- U/Lar calorimeters



Muon

- drift tubes and scintillator

Current Run II: start 2002



- cms energy: 2 TeV
- Tevatron delivered: L > 250 pb^{-1}
- recorded with full detector: L > **190 pb^{-1}**
- **current operating efficiency: ~90%**

Lund participates in D0 together with other Swedish groups from SU, UU, KTH.

Top physics

- Top quark has been discovered by CDF and DØ collaborations in 1995 at Tevatron with data of ~50 pb^{-1};
- Top quark is the only known fermion with a mass on the electroweak scale:
  - Study of the top quark provides an excellent probe of the electroweak symmetry breaking mechanism;
  - New physics may be discovered in either its production or decays;
- Tevatron is the only place to study top quark properties before LHC operation.

The Swedish group has concentrated in top-quark cross-section measurements.

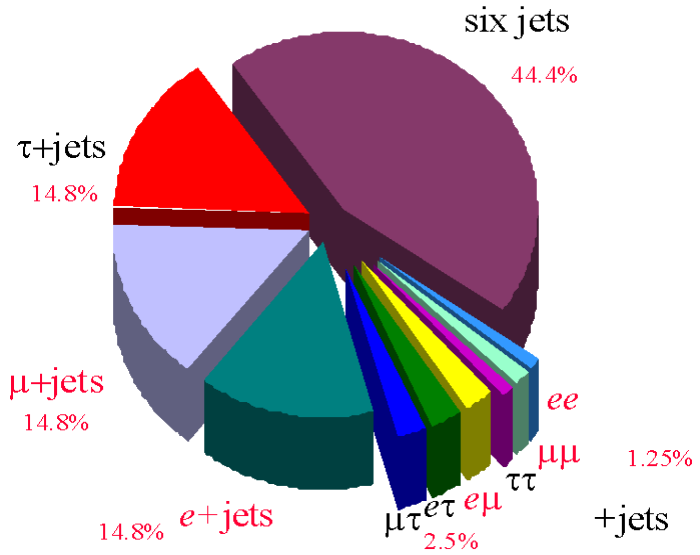
Top physics

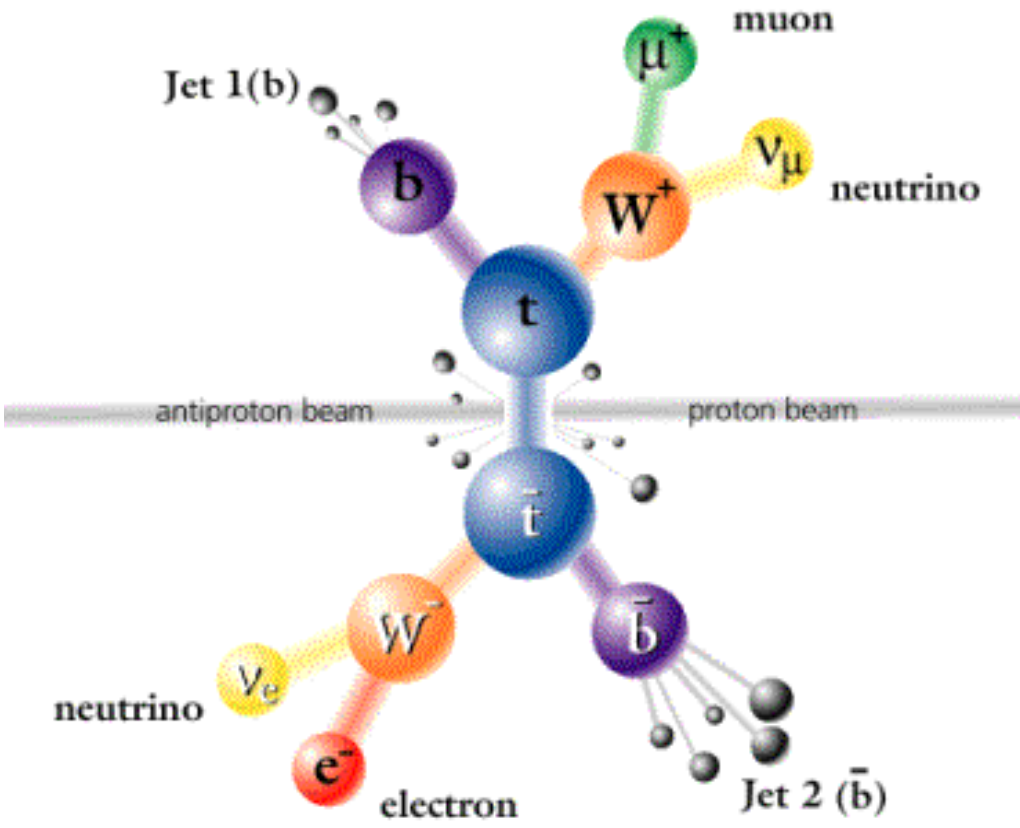
op-antitop production

- mainly quark-antiquark annihilation

V and b-quark decays specify final states

- W-decay: isolated high P_T leptons
- b-quark decays: soft leptons jets, detached vertices in je



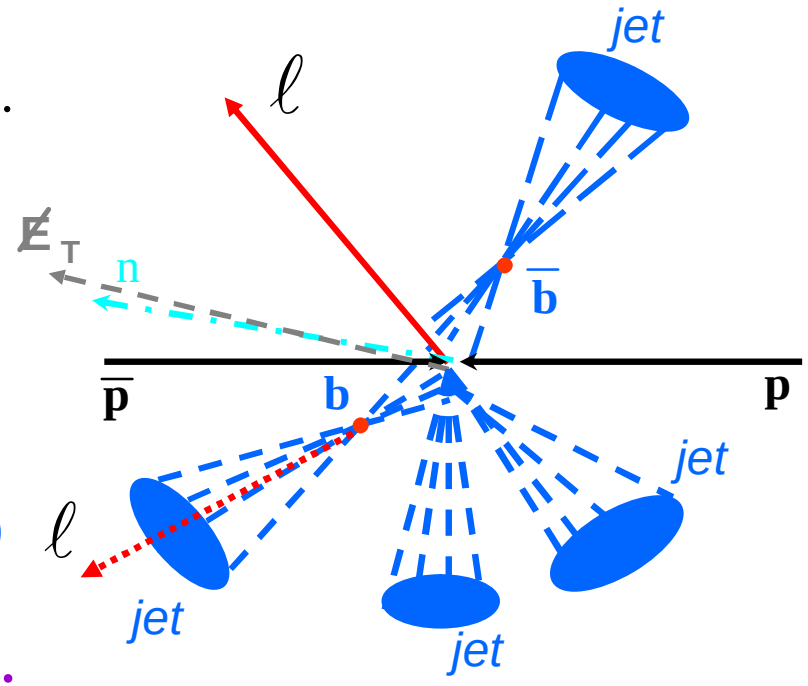


Lepton +jets channels

➢ *"Golden" mode for top studies:* ~30% yield and relatively clean

Event preselection:

- 1 high p_T isolated charged lepton (e,μ).
- Neutrinos: large missing E_T
- Large jet multiplicity
- dilepton veto



- topological analysis: n ≥ 4 jets
- tag b jets with Soft Lepton Tag (SLT)

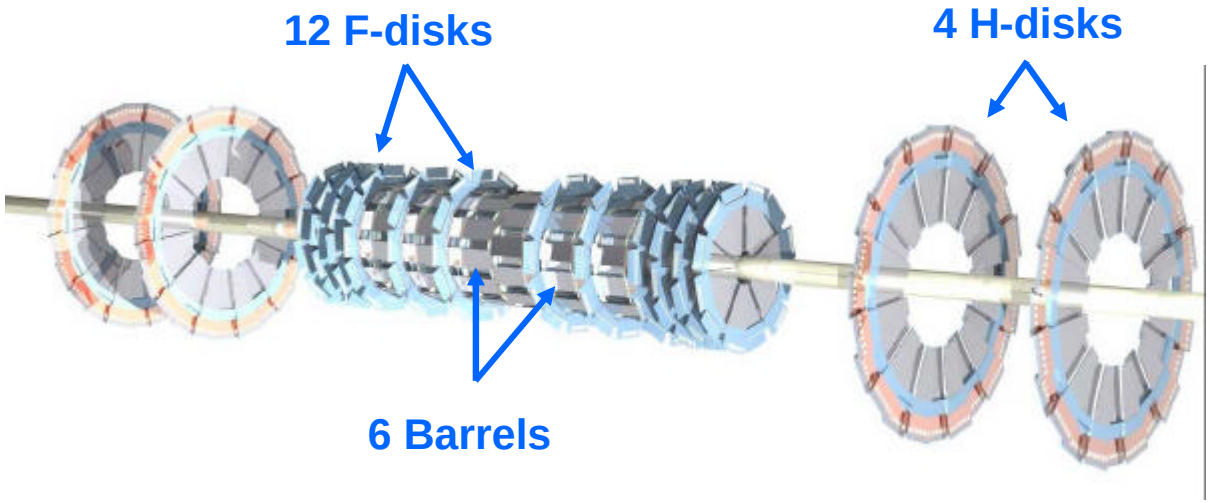
  ≥ 3 jets, ≥ 1 SLT
- **tag b jets with displaced VTX or IP:**

  ≥ 3 jets, ≥ 1 b tag

$t(\rightarrow W^{\pm}b)\ t(\rightarrow W^{\pm}b)$

$\rightarrow e^{\pm},\mu^{\pm}$ $\rightarrow qq$

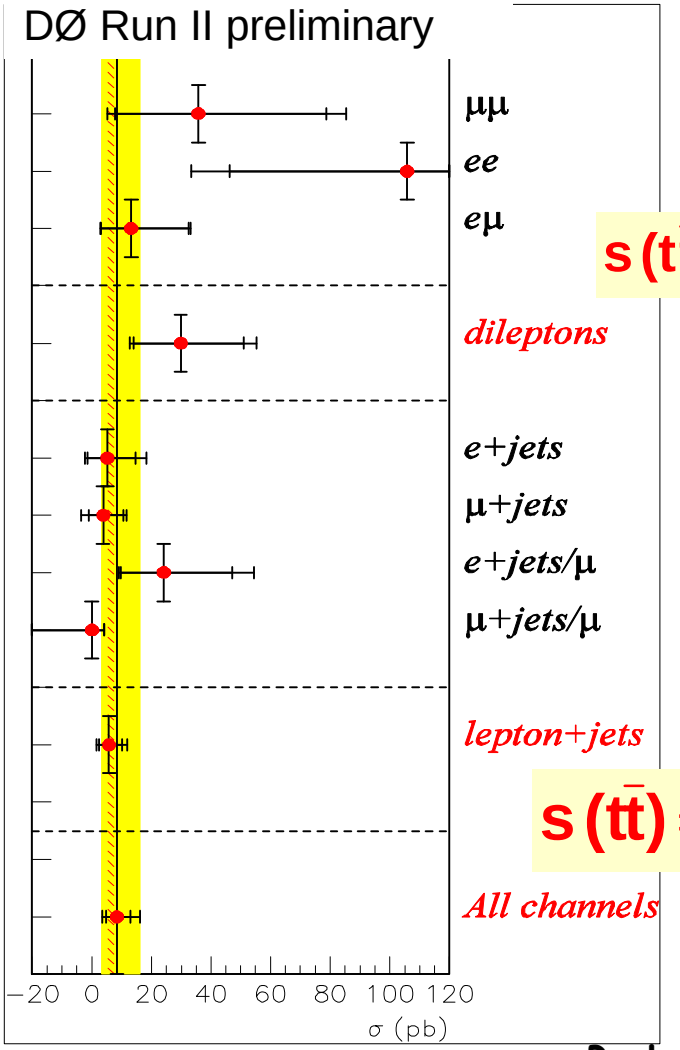
B-tagging using the Silicon Microstrip Detector (SMT)



SMT combines vertex and tracking capabilities and provides good primary and secondary vertex resolutions → an essential detector for top-quark physics, B-physics, Higgs searches, etc..

The Swedish D0 groups have participated in building and testing the SMT.

Cross-section from topological analyses



lepton+jets channels only

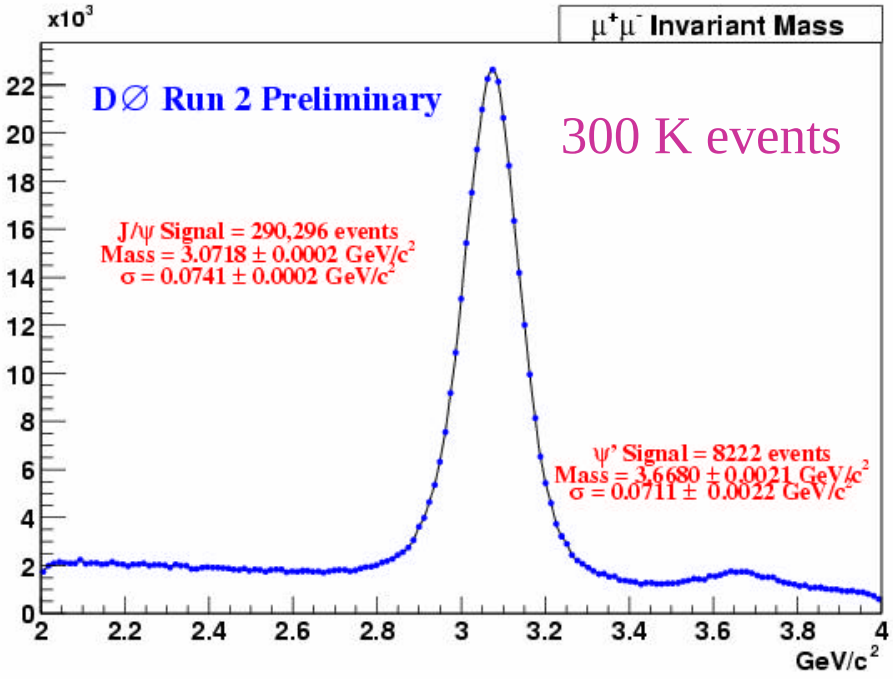
$$\sigma(t\bar{t}) = 5.8^{+4.3}_{-3.4}(\text{stat})^{+4.1}_{-2.6}(\text{sys}) \pm 0.6(\text{lumi})\ \text{pb}$$

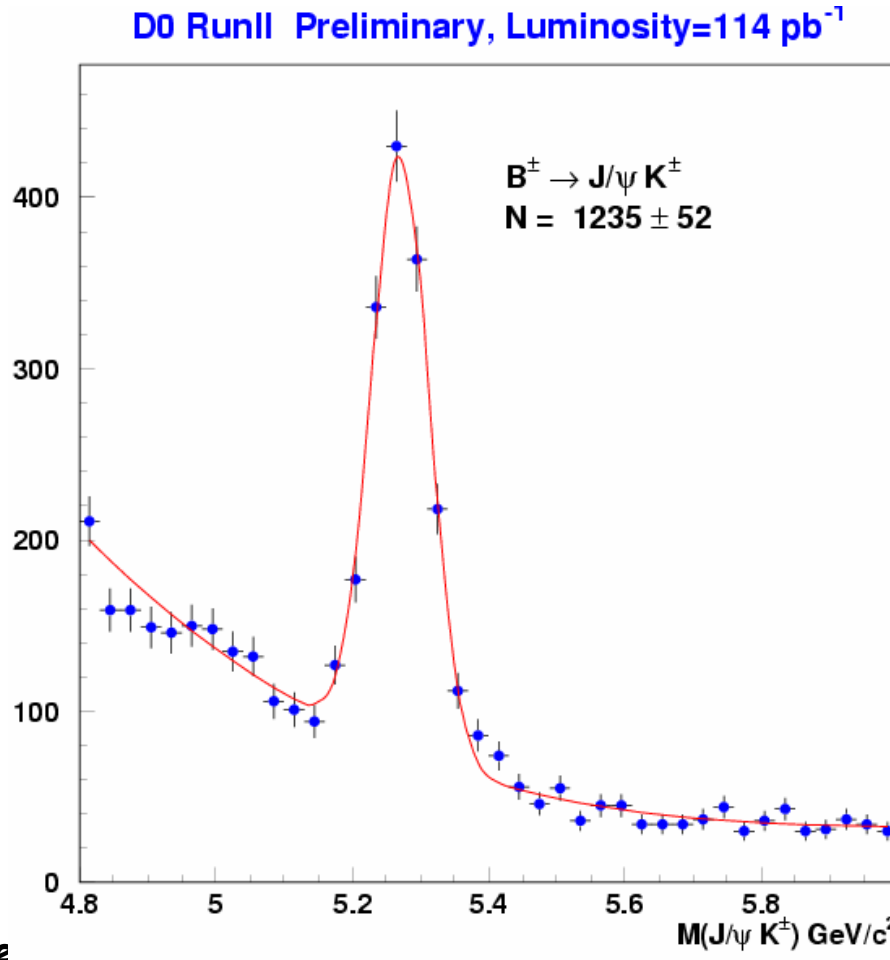
all combined

$$\sigma(t\bar{t}) = 8.5^{+4.5}_{-3.6}(\text{stat})^{+6.3}_{-3.5}(\text{sys}) \pm 0.8(\text{lumi})\ \text{pb}$$

B-physics at D0

Example: $B^+ \to J/yK^+$ signal





Why do we need a new, even bigger particle collider?

All material particles discovered?

- 6 quarks, 6 leptons

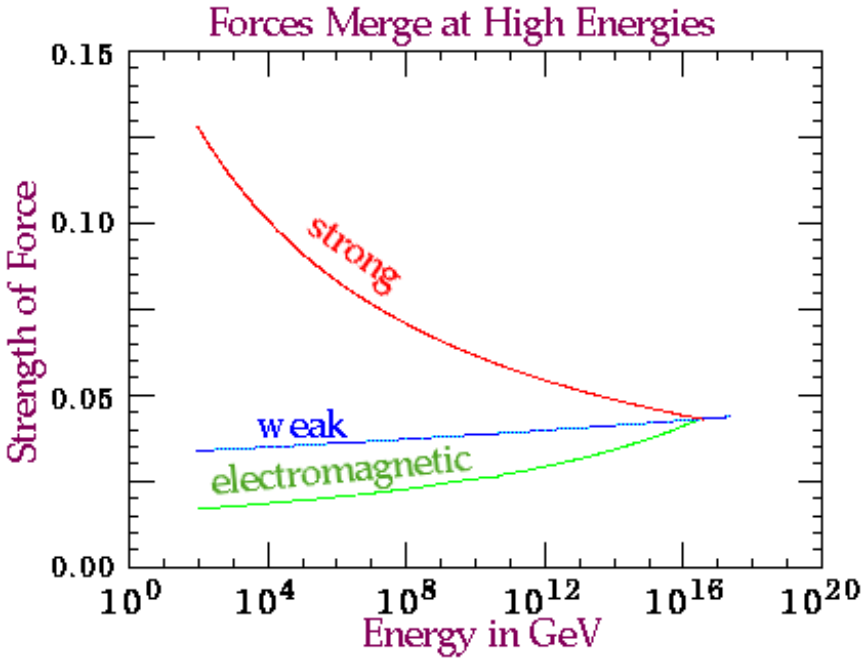
All force particles discovered? (except graviton)

- Photon, W, Z, gluons

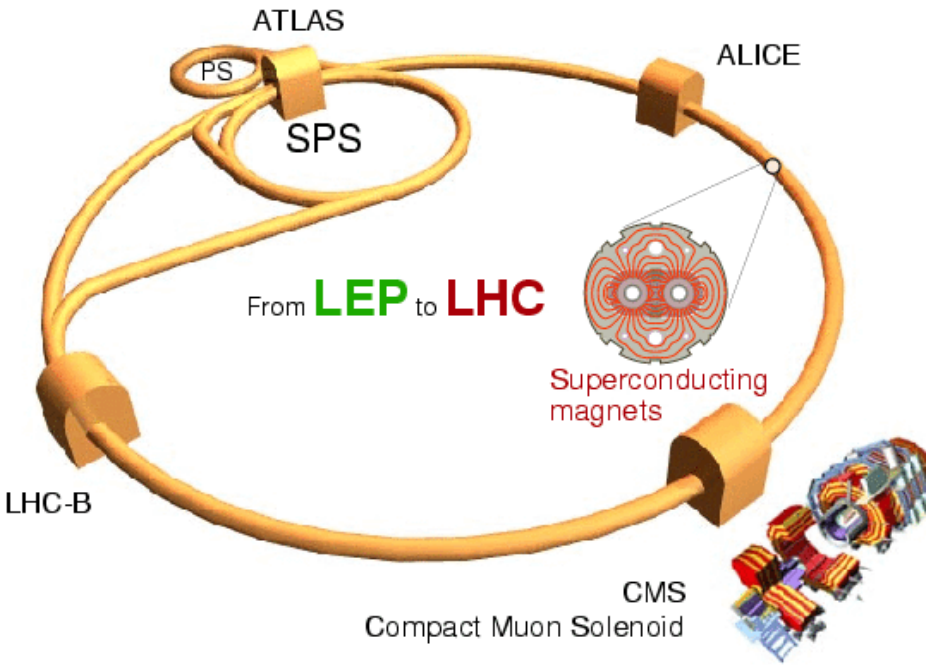
BUT there are open questions:

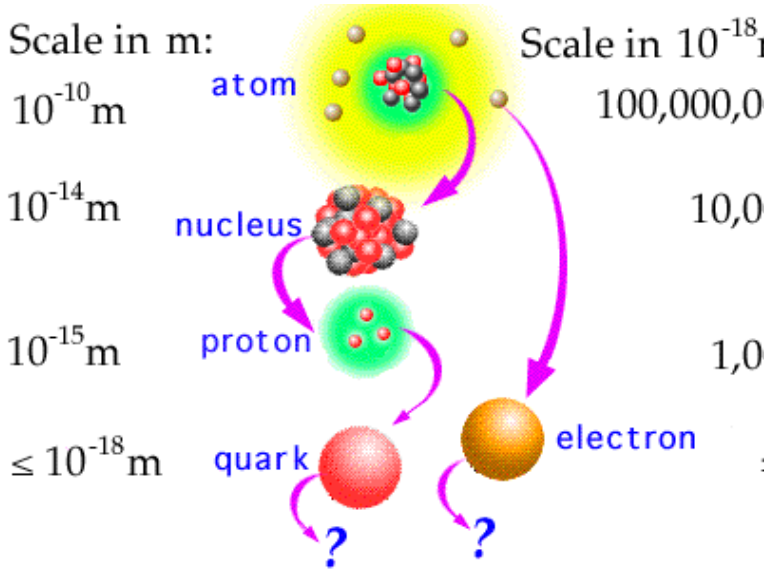
- Why do particles have mass ←→ Higgs mechanism
- Why is matter-antimatter and left-right symmetry (CP) broken in the Universe ←→ CP violation
- Can we unify all 4 forces? Can we do it with Supersymmetry?

LHC is needed to answer these questions!



The Large Hadron Collider at CERN, Geneva



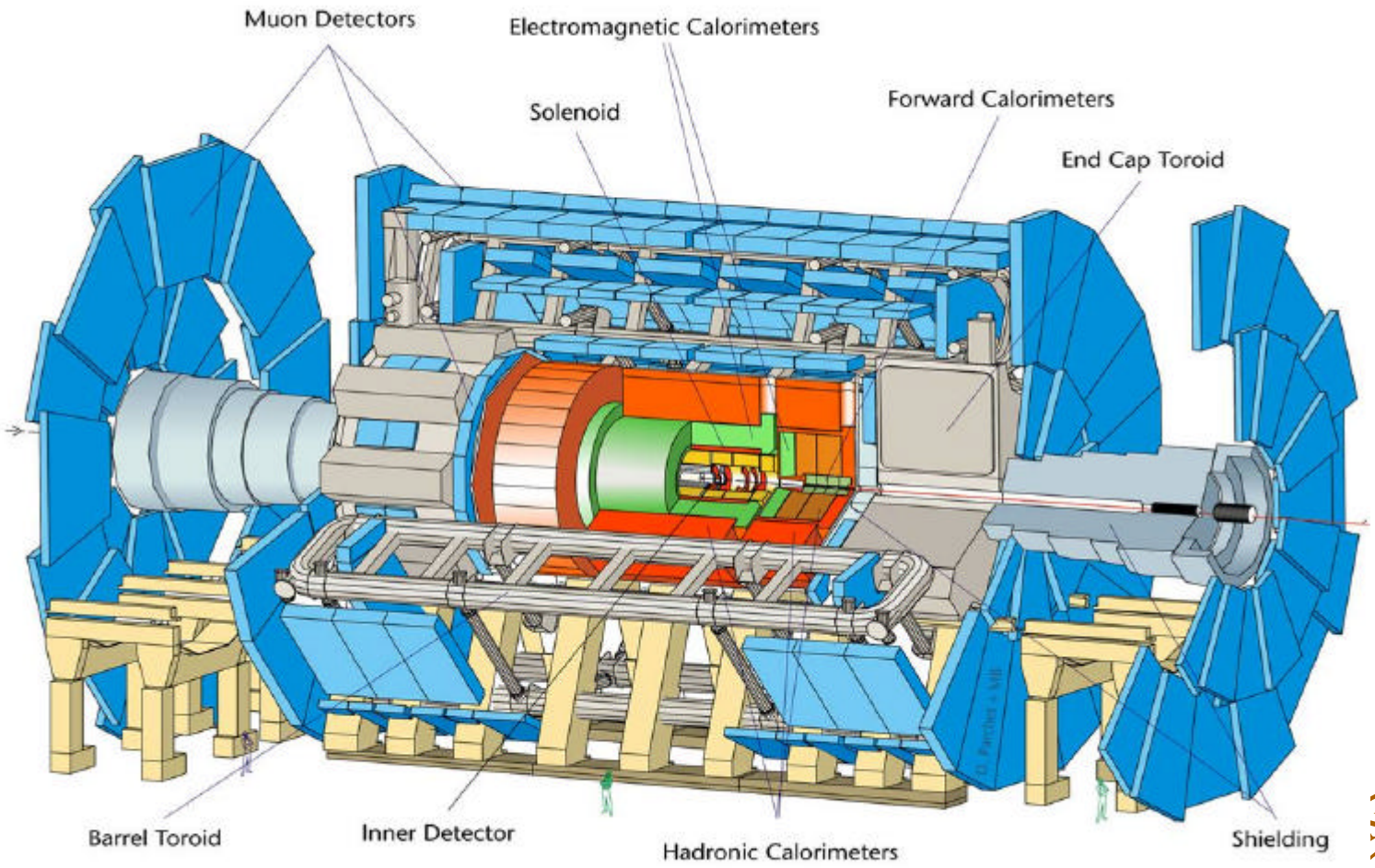


	Beams	Energy		Luminosity
LEP	e+ e-	200	GeV	10^{32} cm^{-2}s^{-1}
LHC	p p	14	TeV	10^{34}
	Pb Pb	1312	TeV	10^{27}

Start 2007

ATLAS experiment

http://atlasexperiment.org/



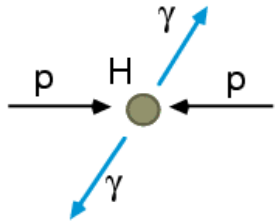
ATLAS experiment, current status

Thu 26 Feb 2004 16:30

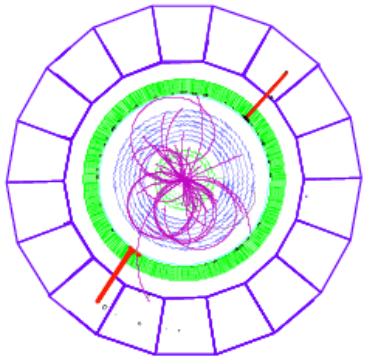
Higgs physics

- 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

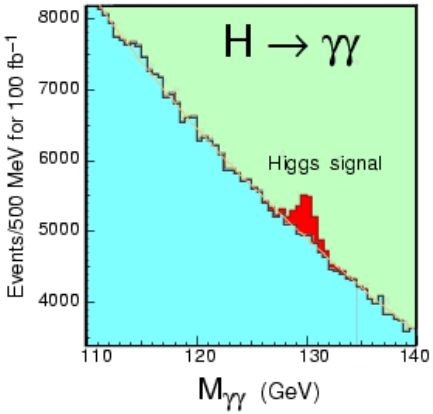
Higgs to 2 photons ($M_H < 140$ GeV)



$H^0 \rightarrow \gamma\gamma$ 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 $M_{\gamma\gamma} \sim 100$ GeV is better than 1%, resulting in a S/B of ≈1/20



M_{Higgs} = 100 GeV



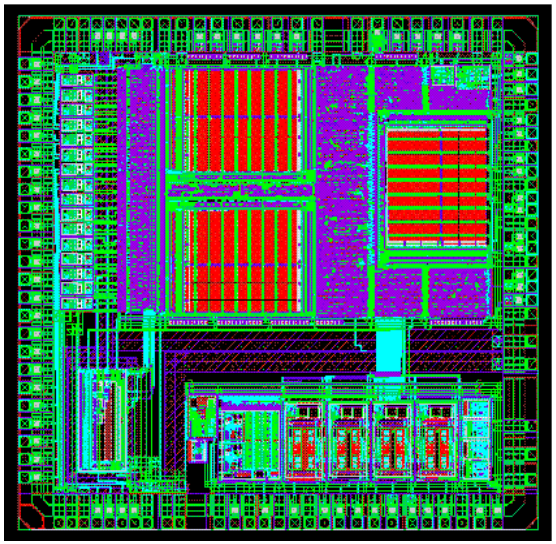
What do we do here in Lund?

http://www.hep.lu.se/

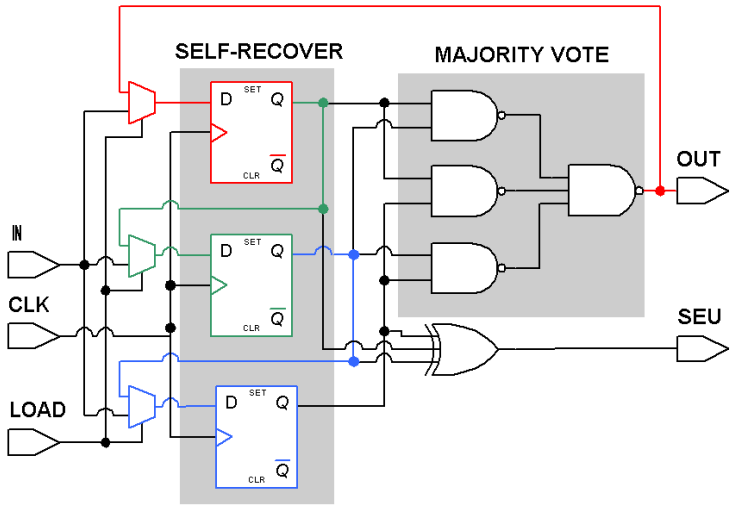
- Physics research in ATLAS and D0:
  - CP violation, top physics
  - Supersymmetry and New Physics
- Software development: GRID
- ATLAS detector construction: Transition Radiation Tracker (TRT)
- Who? A group of about 5 physicists, 2 engineers and 2 students in the division of elementary particle physics

ATLAS Transition Radiation Tracker TRT

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



DTMROC-S layout



Triple-voting scheme

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.

Student opportunities

- Introduction to Particle Physics FYS225 (5p), spring 2004, end of January-beginning of March
- Examensarbeten/diploma work
  - Physics simulation/analysis on top, CP violation, supersymmetry,…
  - Grid-development and interface between physics and Grid
  - ATLAS detector hardware: module testing NOW.
- 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 2004
  - Application deadline end of January 2004
- More info: contact us!