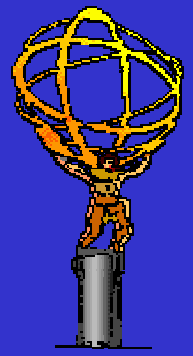
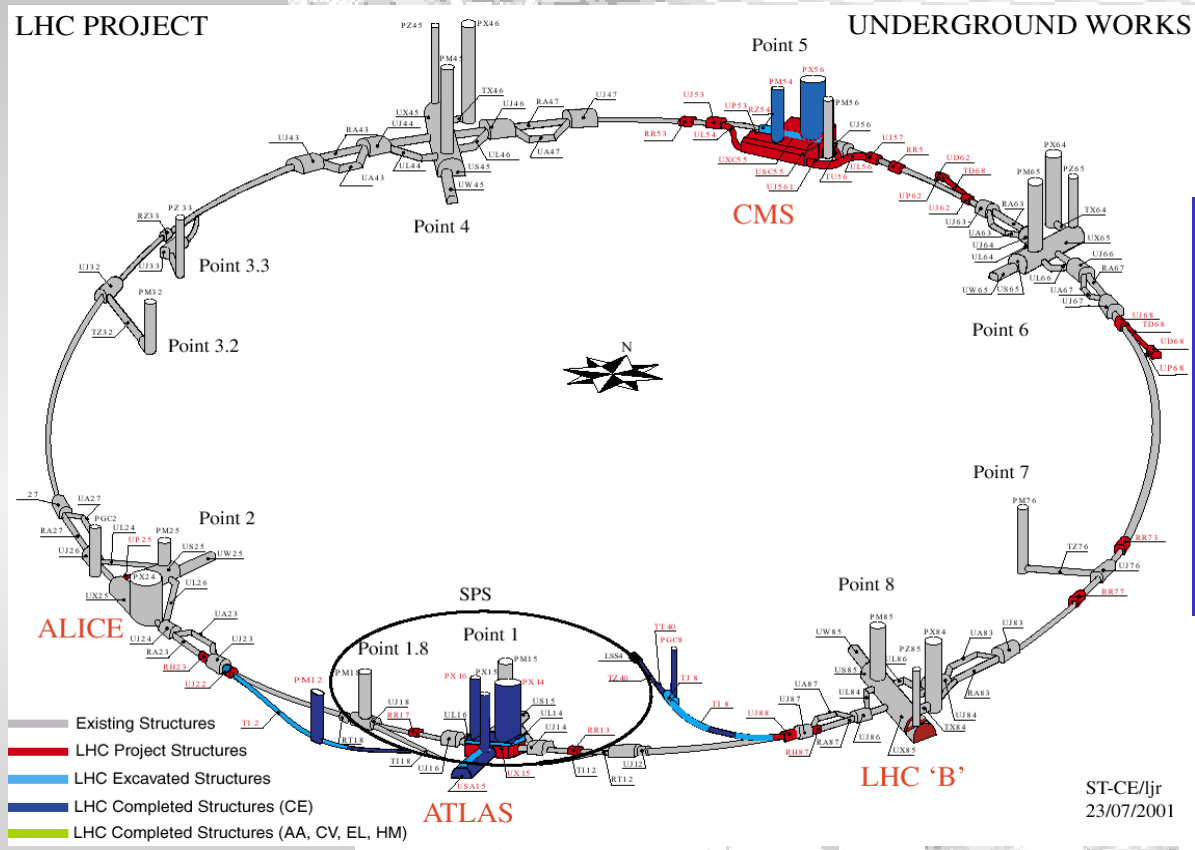
# The ATLAS Detector - Concept and Realization



- the LHC accelerator
- physics at the LHC
- how to access the physics
  - constraints: high luminosity/high radiation
- (sub-)detectors
  - inner detector
  - calorimeter
  - muon detectors
- current status / outlook

Young Scientist Workshop
Ringberg October 2004

# Input: The LHC Accelerator

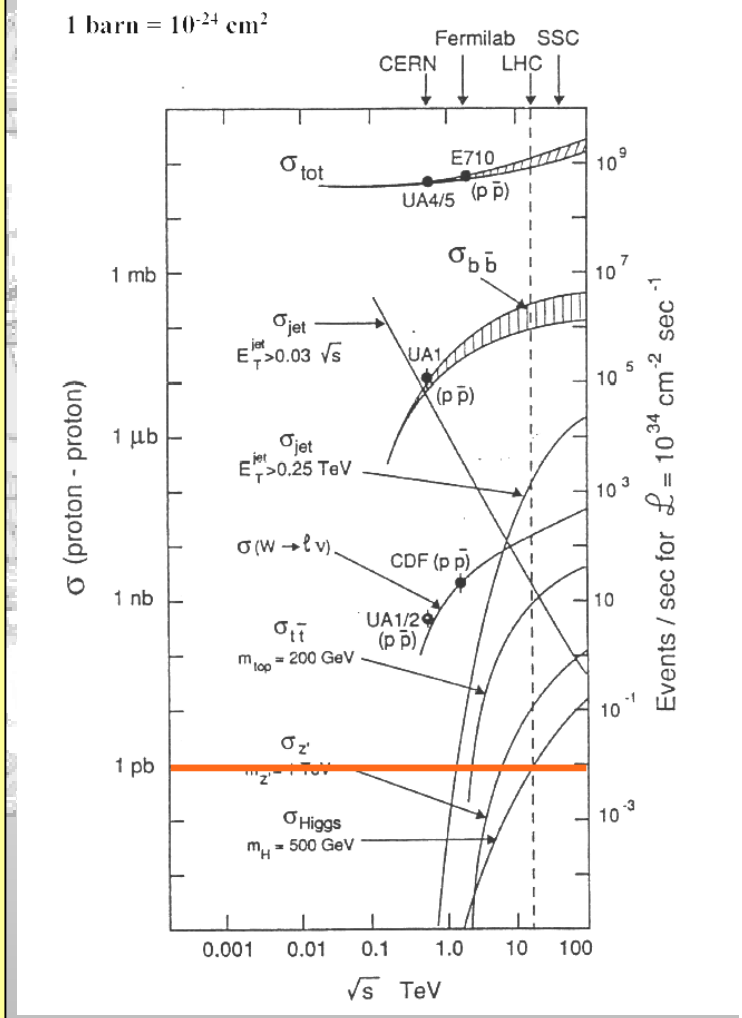



pp-collider installed in the previous LEP tunnel

proton accelerated to 7 TeV → $\sqrt{s}$=14 TeV
luminosity: (0.12 x ) $10^{34}$ $cm^{-2}s^{-1}$
time between bunches: 25 ns

# Physics Opportunities at the LHC

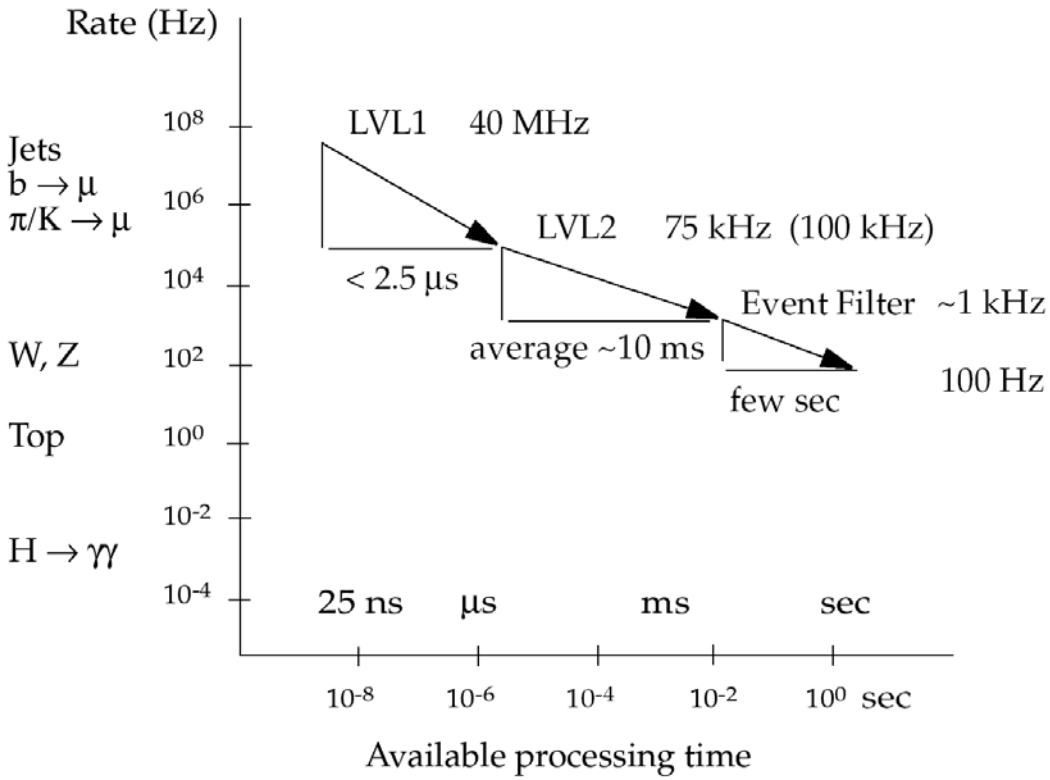
- origin of the mass at the EW mass scale
  - sensitivity to the largest higgs-mass range
- search for supersymmetry, compositeness, heavy W/Z like objects
- investigation of CP-violation in B-decays
- detailed study of top-quarks



# The Trigger Challenge

eventrate = 40 Mhz = $\Delta$t=25 ns

about $10^7$ readout channels (without pixel)

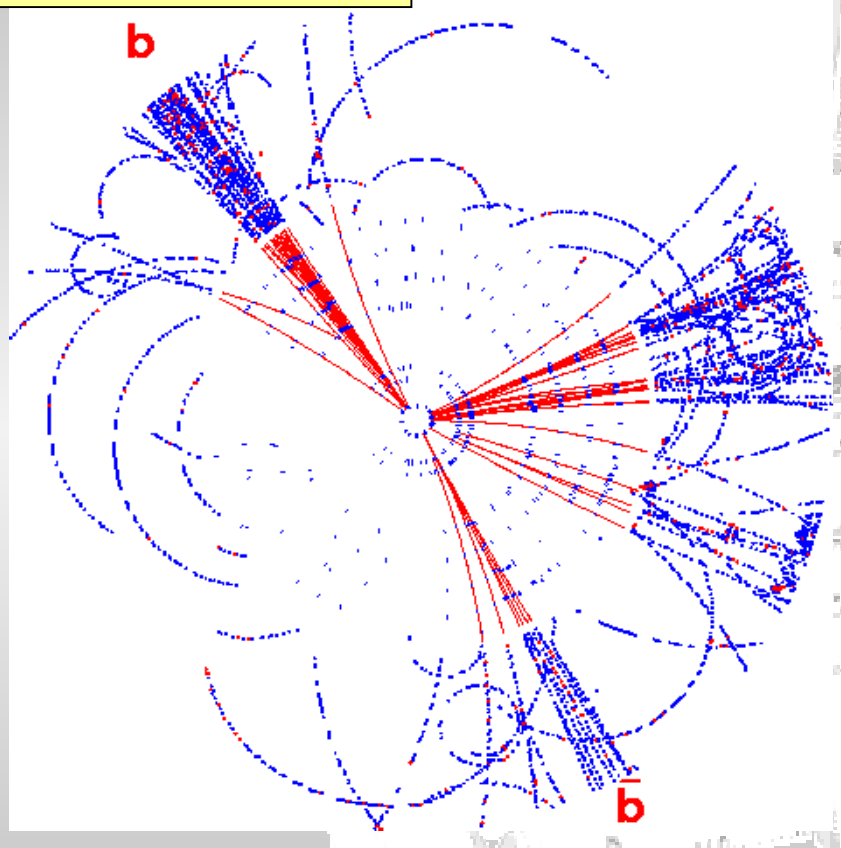


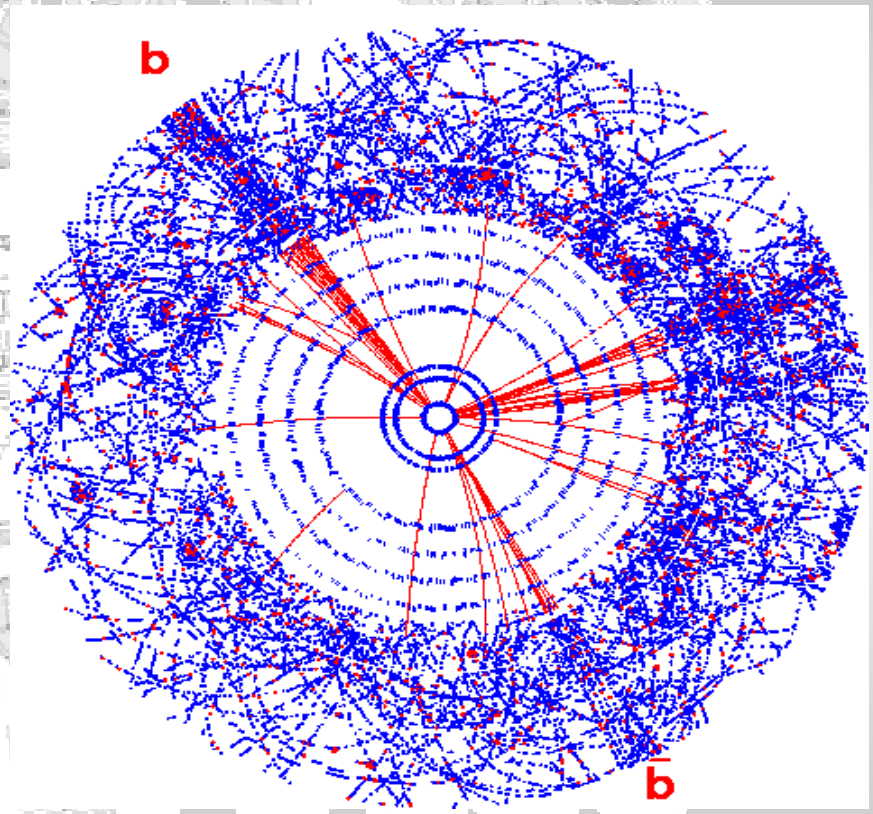

- about $10^9$ events per second
- very fast detector response
- fast trigger decision

- 11 orders of magn. between higgs- and total cross section
- trigger only on interesting events

# The 'underlying' Event

$H \rightarrow b\bar{b}$ event



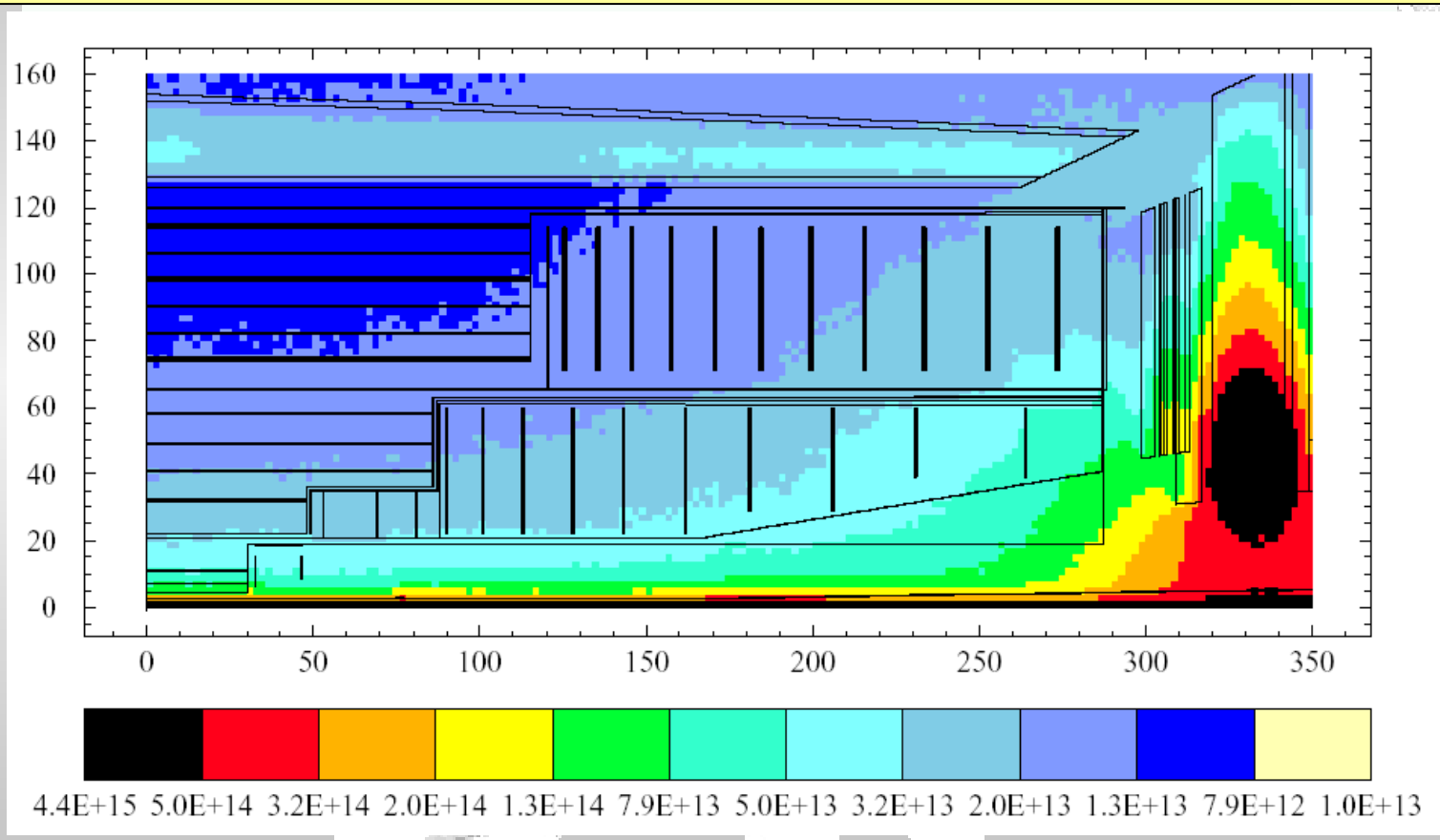




high occupancy!

$H \rightarrow b\bar{b}$ event
+ 22 'minimum bias' Events

# Further Challenge : Radiation

Neutronenfluss (>100 keV) nach $5 \times 10^5$ pb$^{-1}$ (10 Jahre LHC)



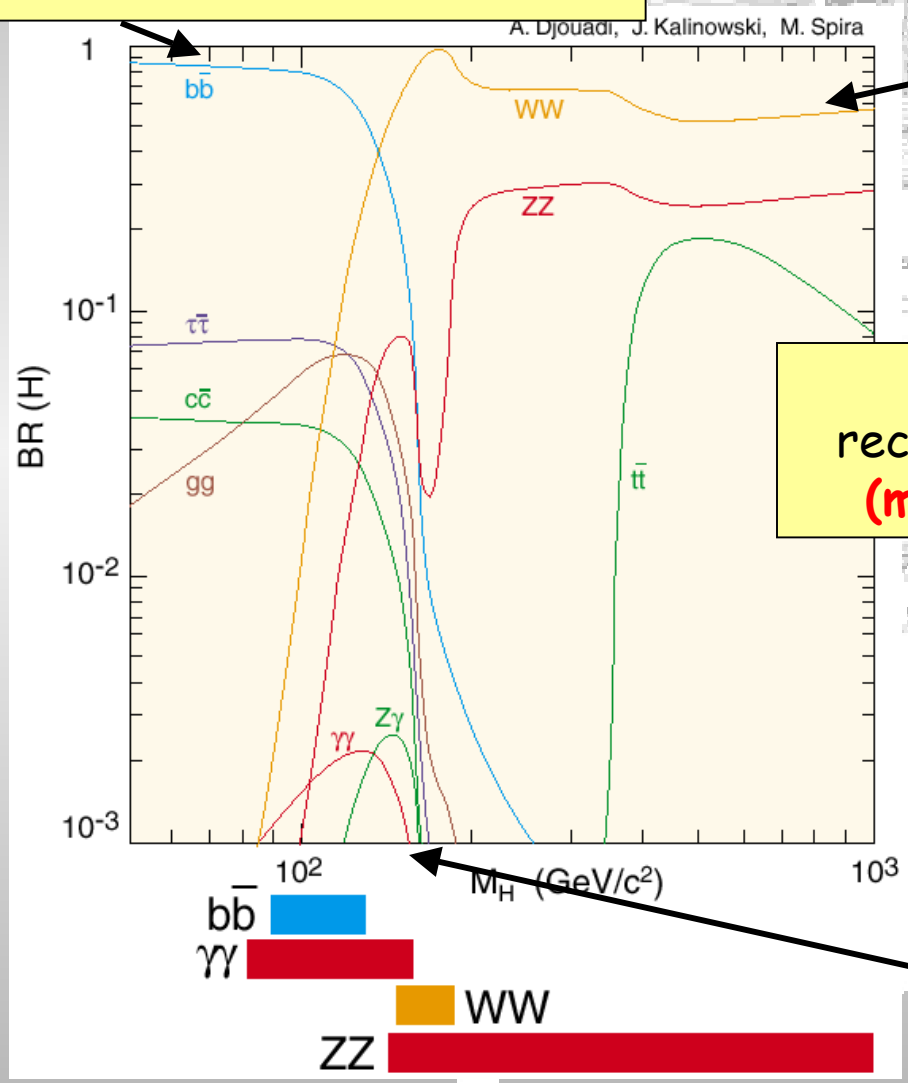

CMS

Tschernobyl ~ 0,5 Gray
natürlich ~ 2,5 mGray

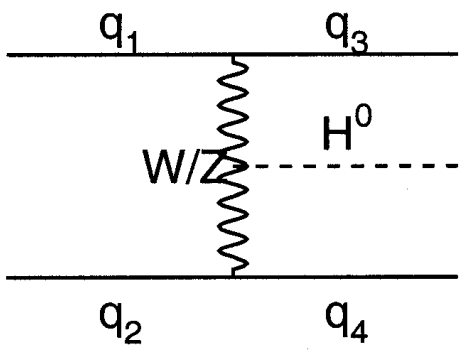
Q=1

# Detector Components

light higgs: decay to bb → **vertex reconstruction**




decay of vector bosons in leptons (**muon**) → good Lepton reconstruction (incl . **momentum**)




mass reconstruction **(momentum)**

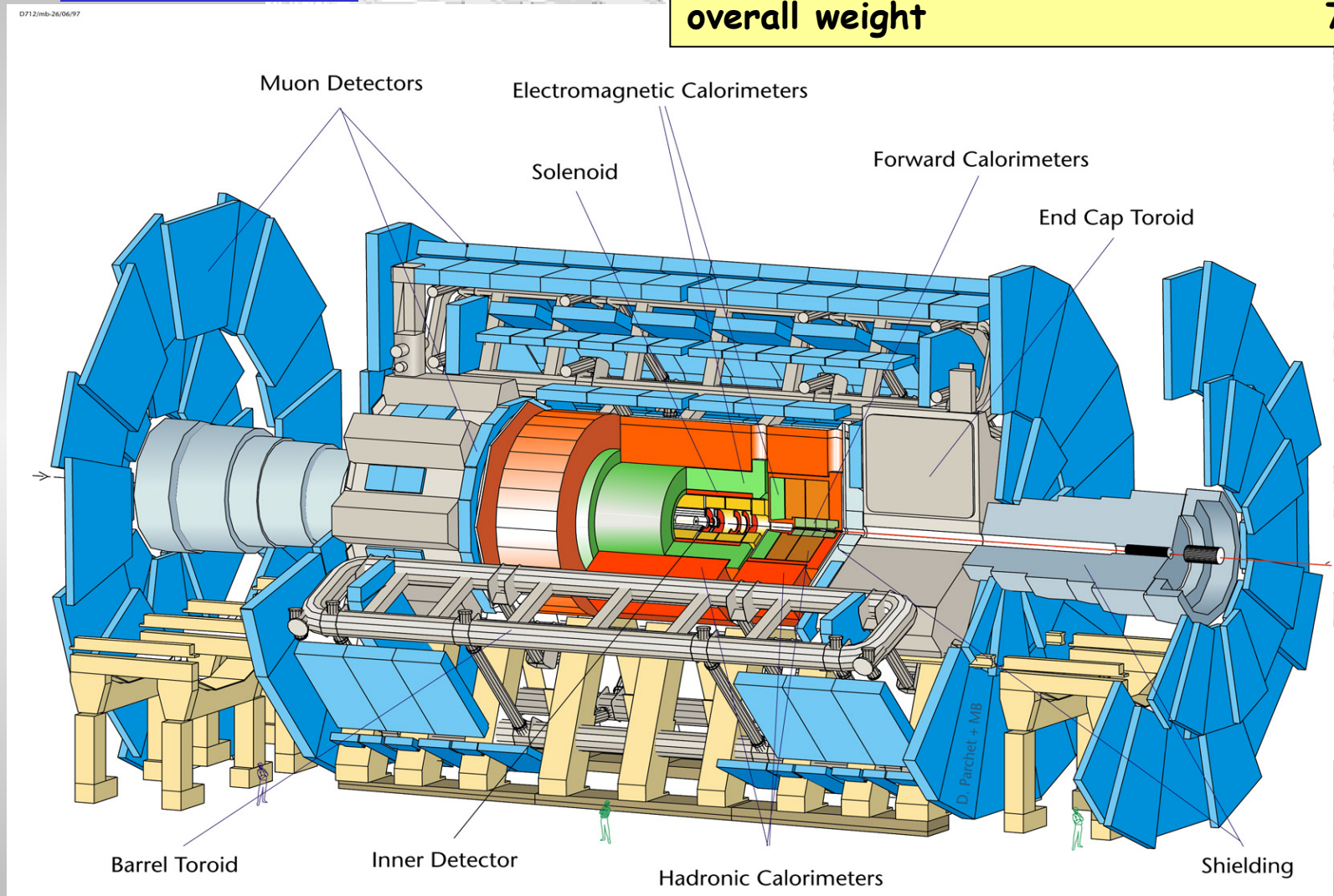
**hadron calorimeter** for jet measurement

decays with missing energy **hermetic coverage with calorimeters**

decay H → $\gamma\gamma$ : good **electromagnetic calorimeter**

# Atlas

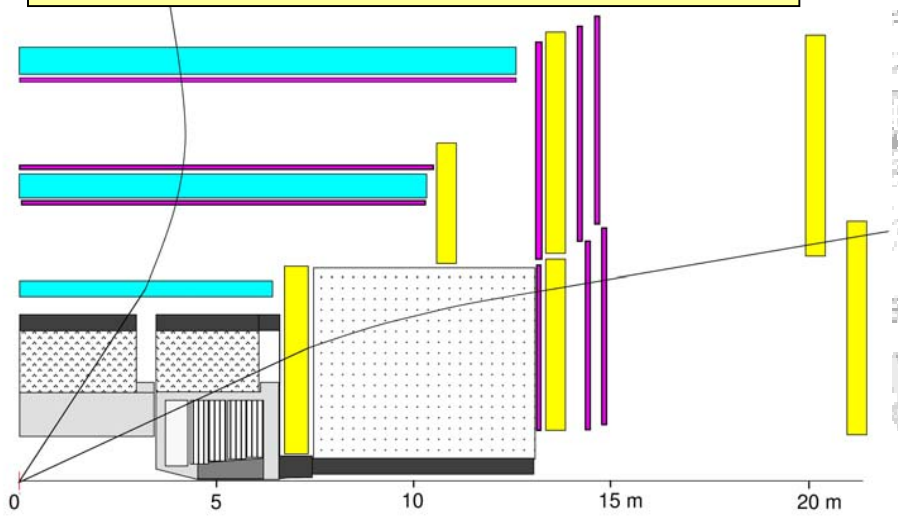
| | |
|---|---|
| diameter | 25 m |
| barrel toroid length | 26 m |
| end-cap end-wall chamber span | 46 m |
| overall weight | 7000 Tons |



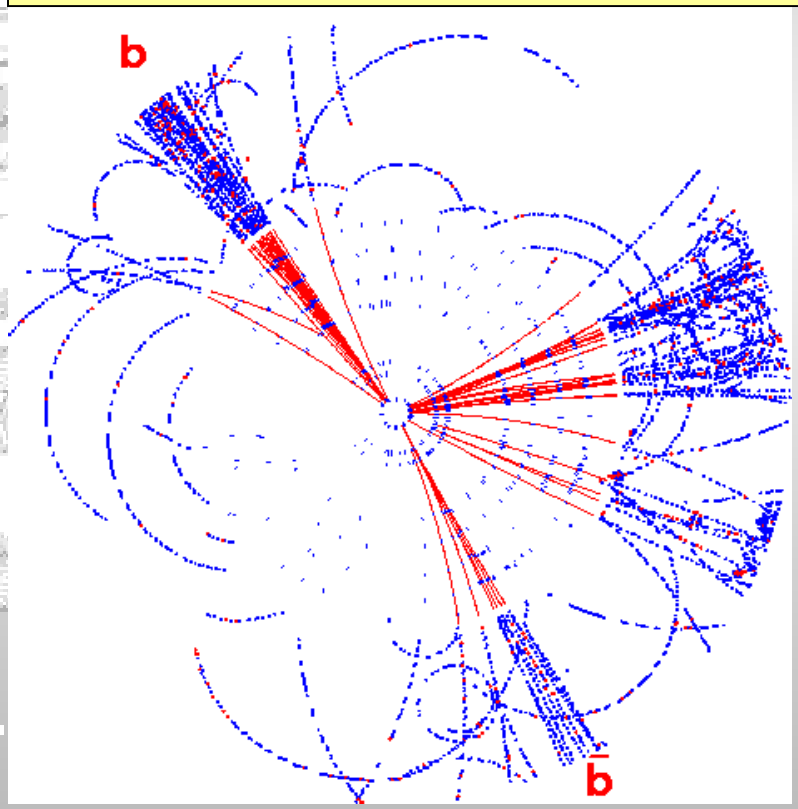
# Momentum Measurement

**charged particles are deflected in a magnetic field according to their momentum**

track in toroidal B-field:



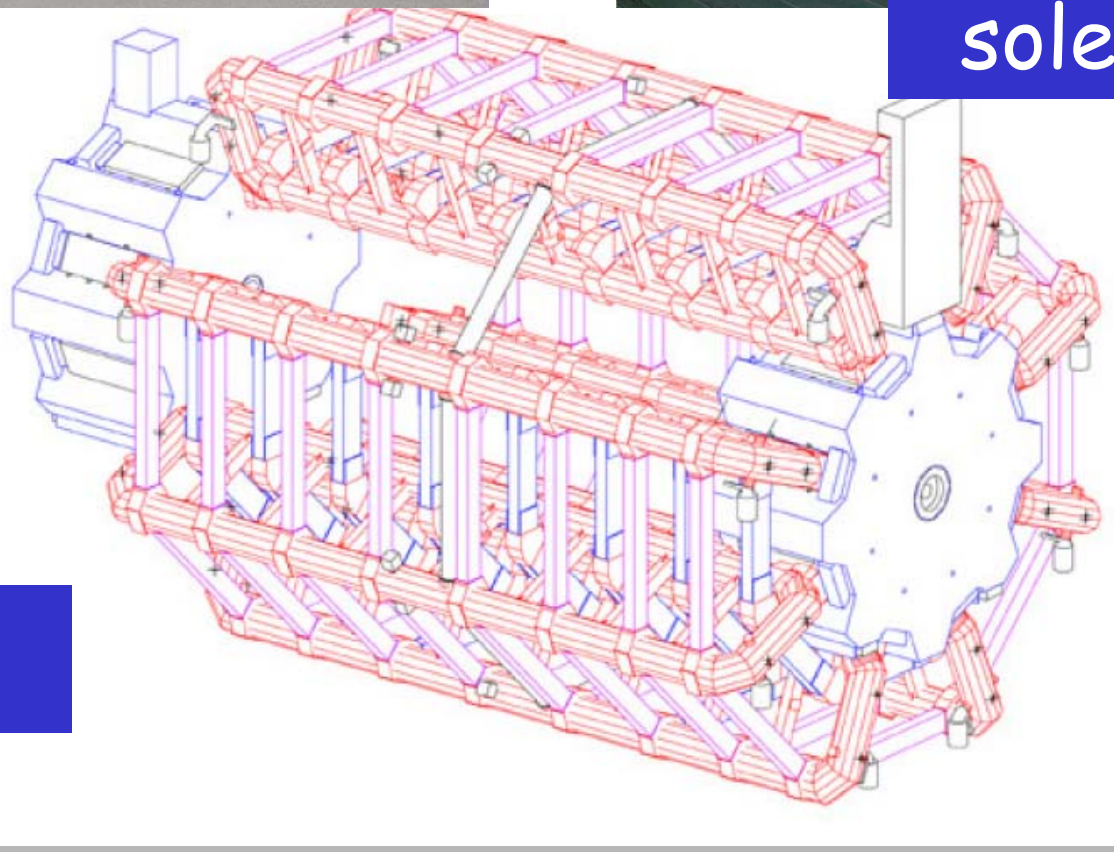

track solenoidal B-field:




2 T solenoid

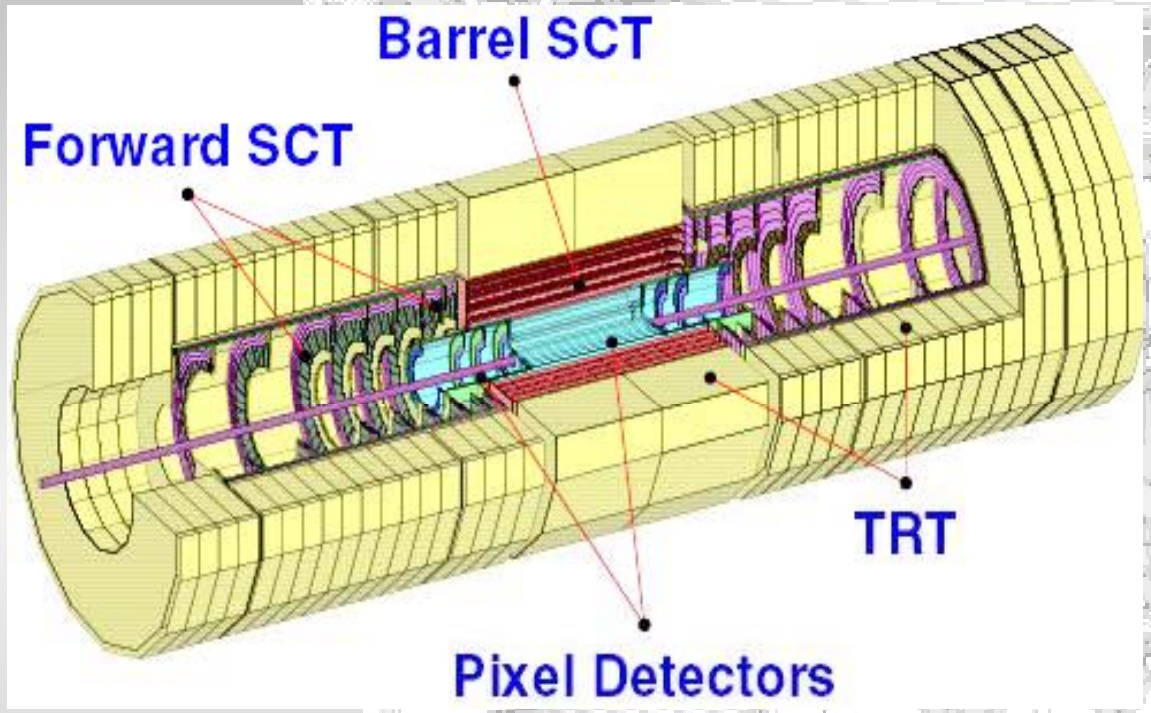
3.9 T barrel toroid


solenoid



toroid

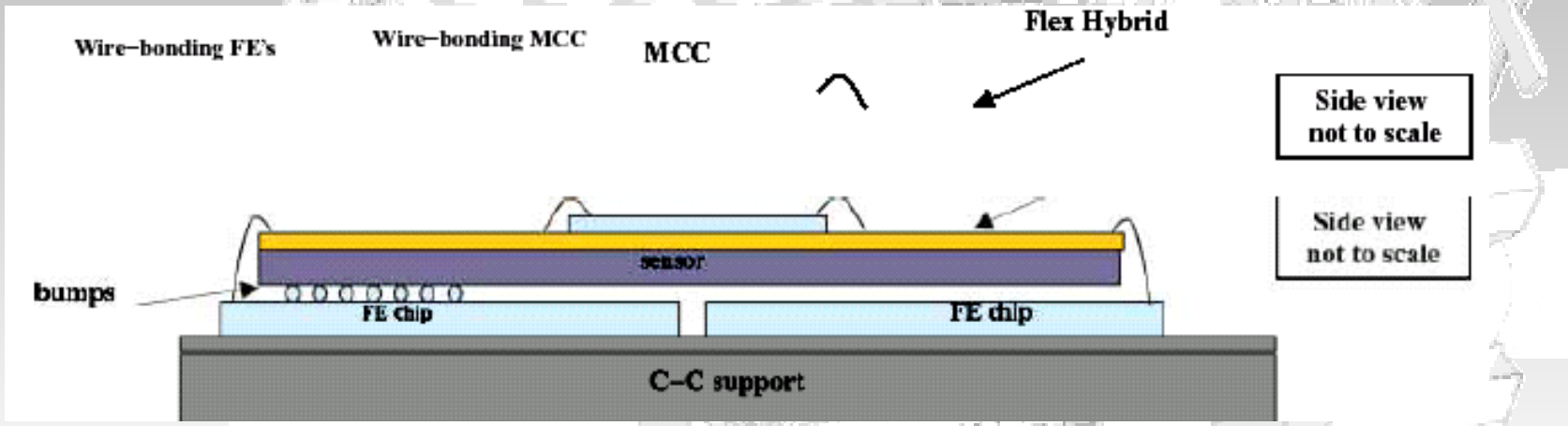
# Inner Detector (ID)



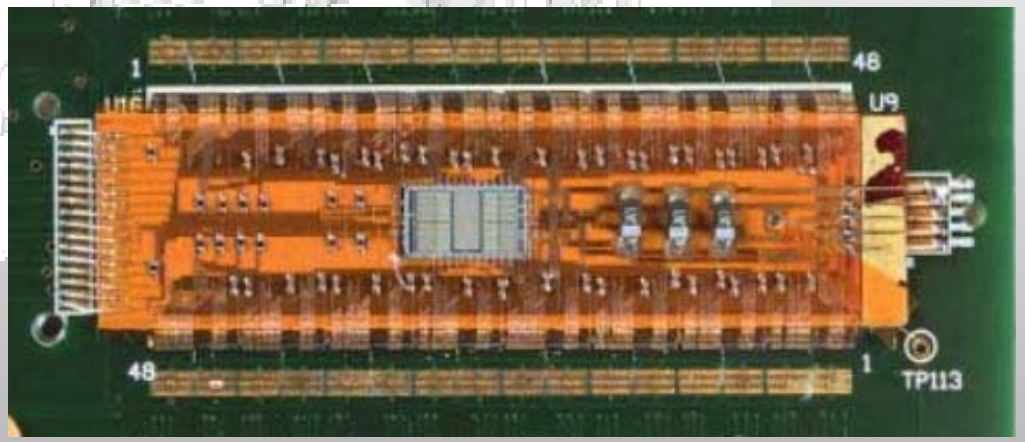

- momentum measurement of particles
- secondary vertex reconstruction

- low occupancy
- radiation hardness

# Silicon Pixel Detector



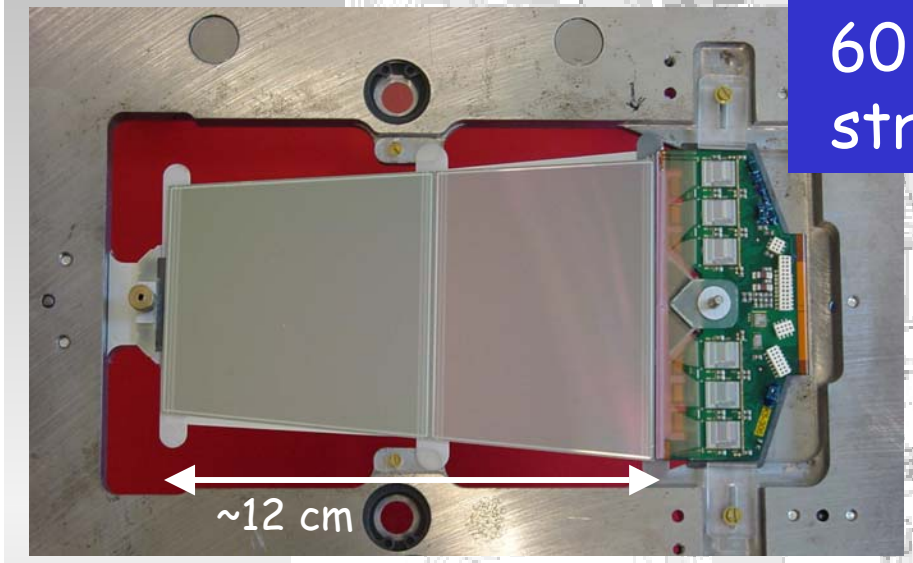

ATLAS pixel detector:
120 M channels
pixel size: 50x400 μm

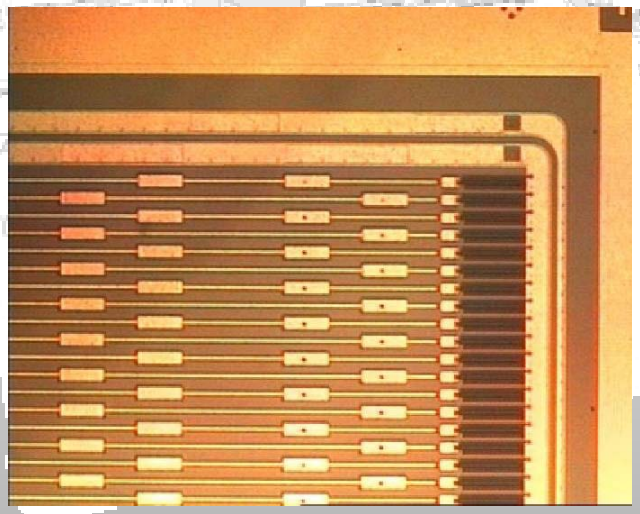


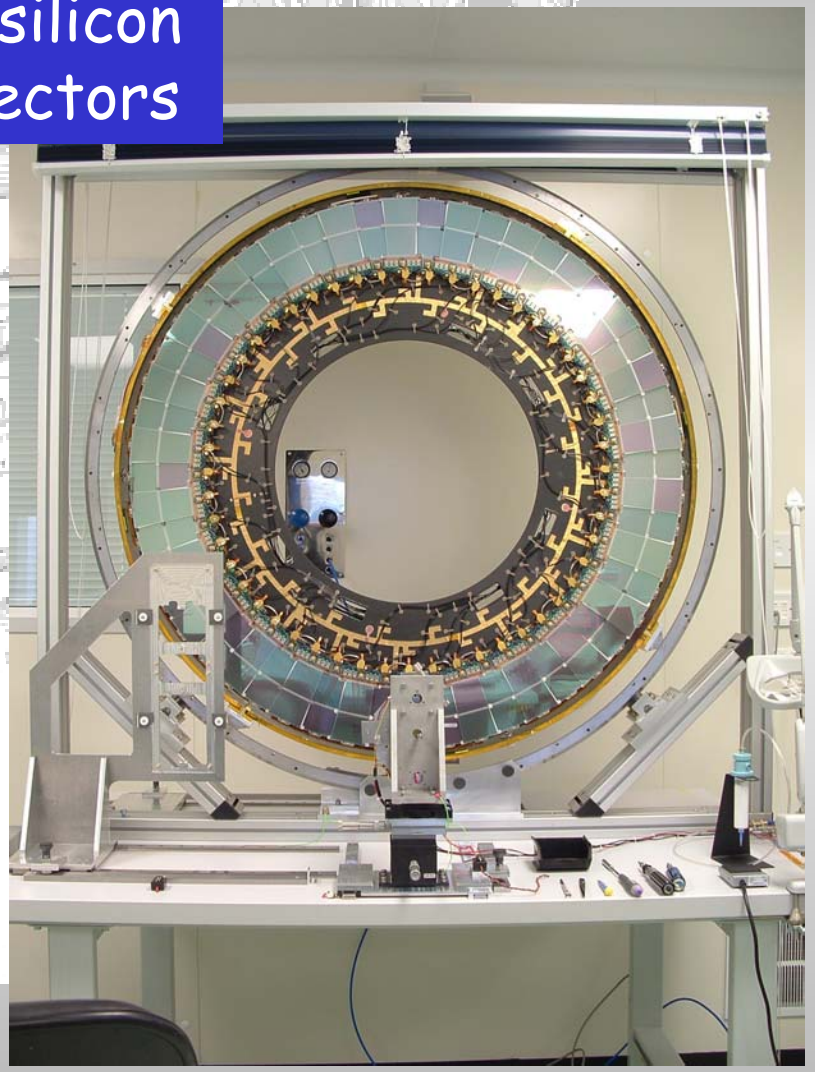
MPI!

# Silicon Strip Detector

60 m² of silicon strip detectors





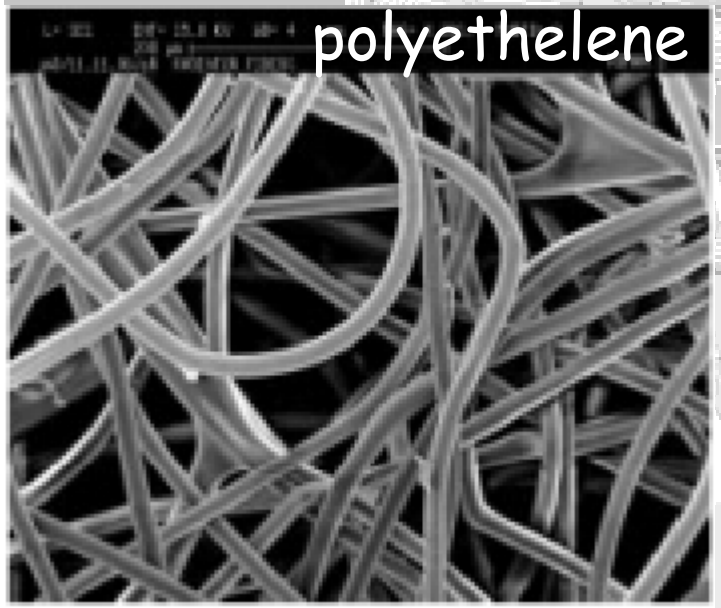
2 sensors /side

768 strips/sensor

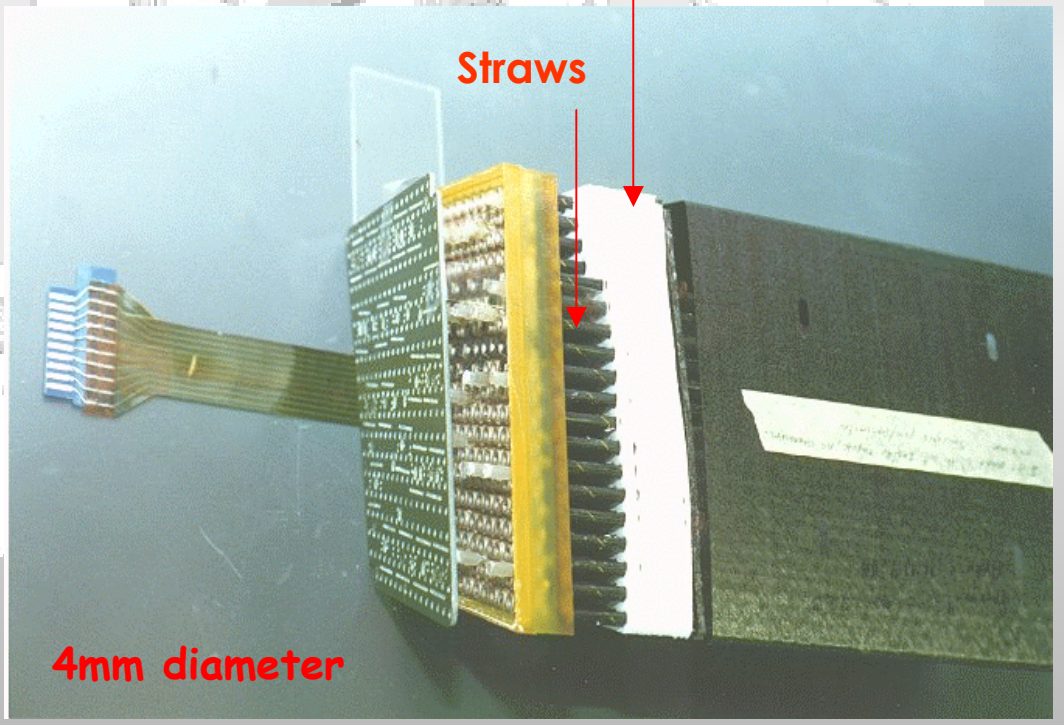
50-90 μm pitch

4088 module

# TRT Transition Radiation Tracker

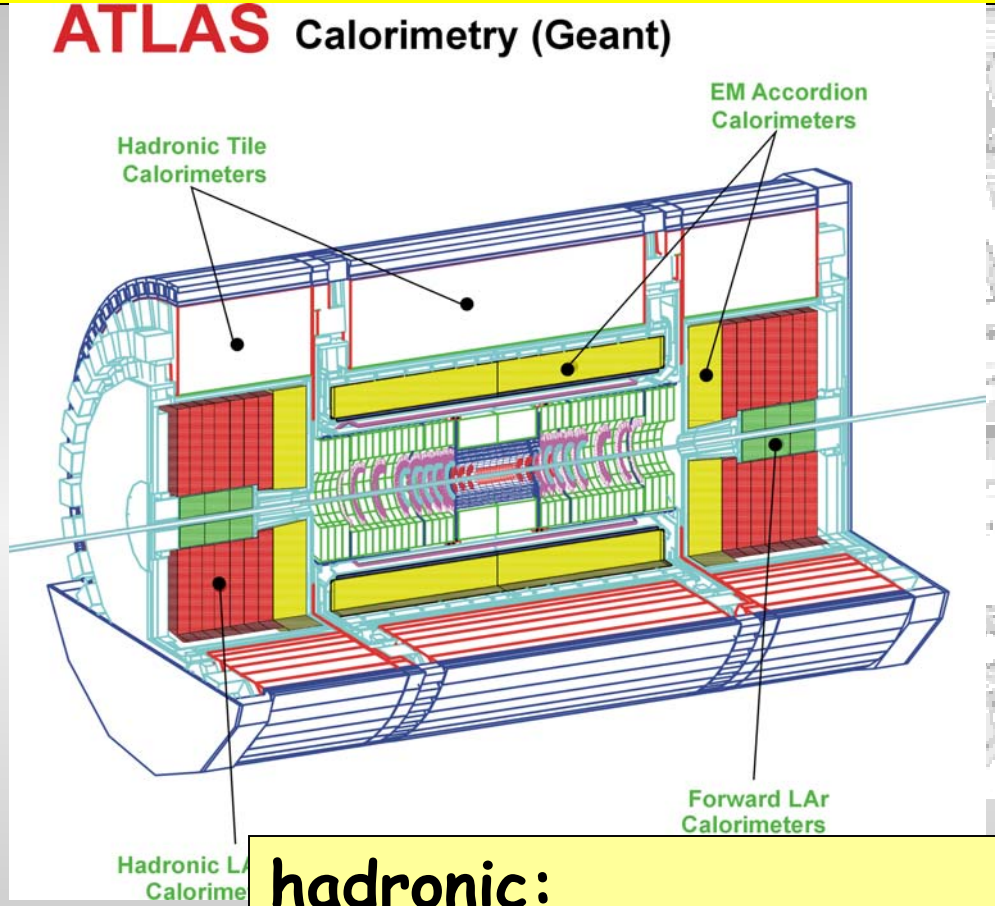



combined straw tracker and transition radiation detector




- radiation material between straws for electron identification

# Calorimeter



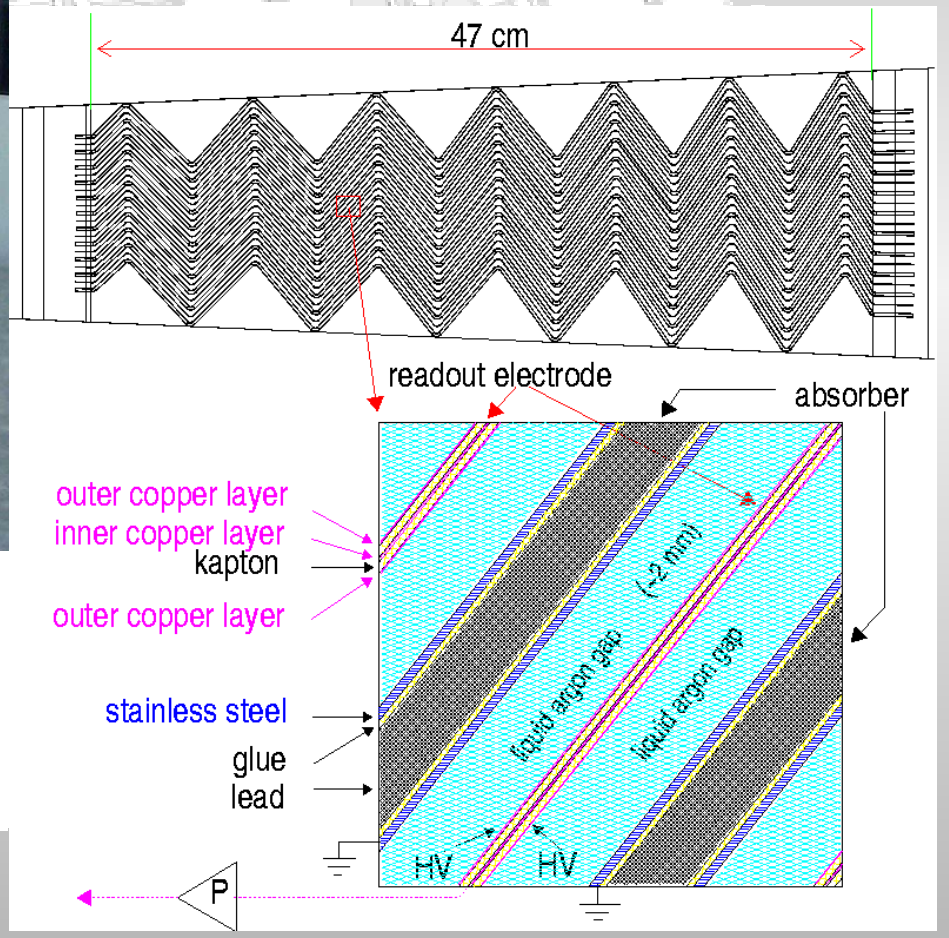

sandwich calorimeter

**electromagnetic:**
absorber: **iron**
active material:
**liquid argon**

**hadronic:**
barrel: **iron / scintillator**
endcaps: **copper / liquid argon**
forward: **copper or tungsten / liquid argon**

# Electromagnetic Calorimeter

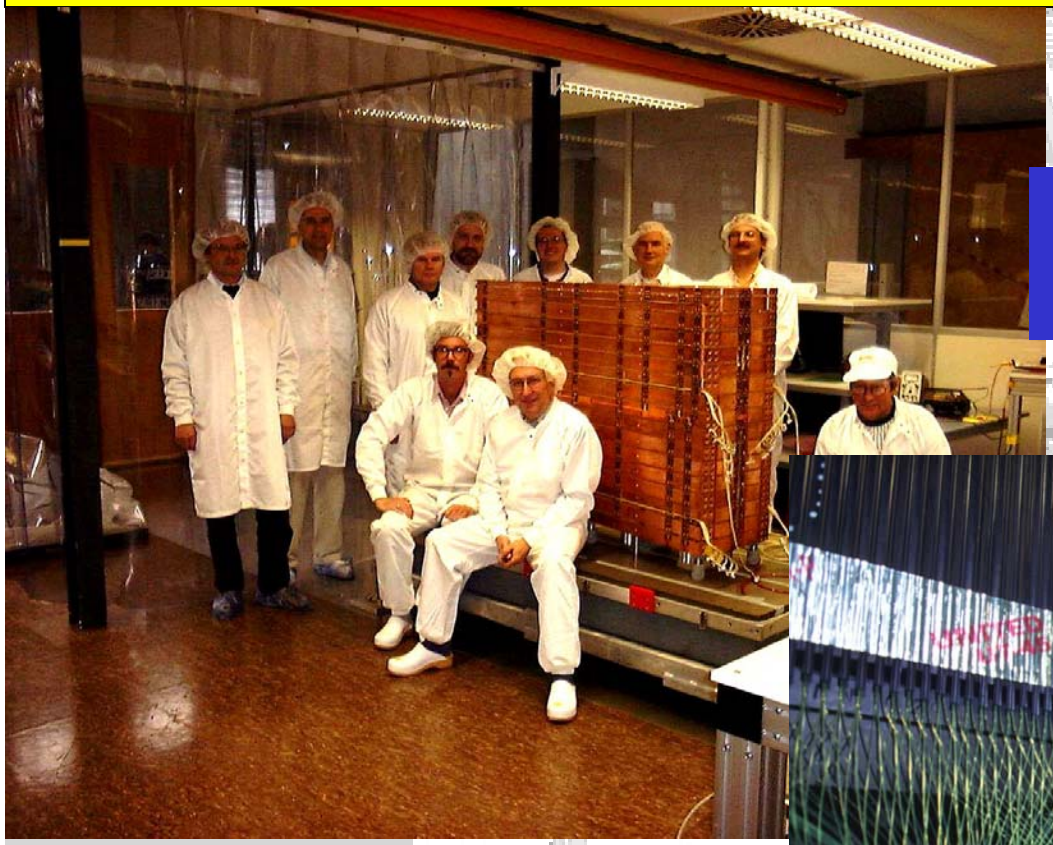
accordion structure of EM



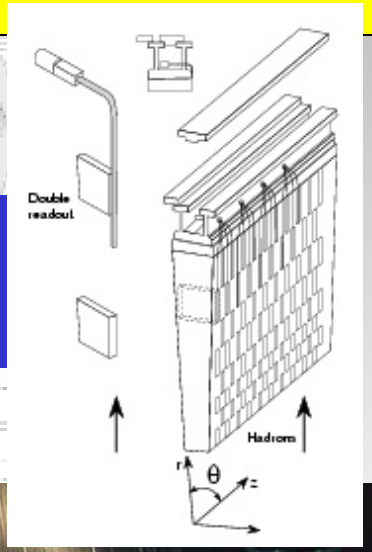

**readout at the end**

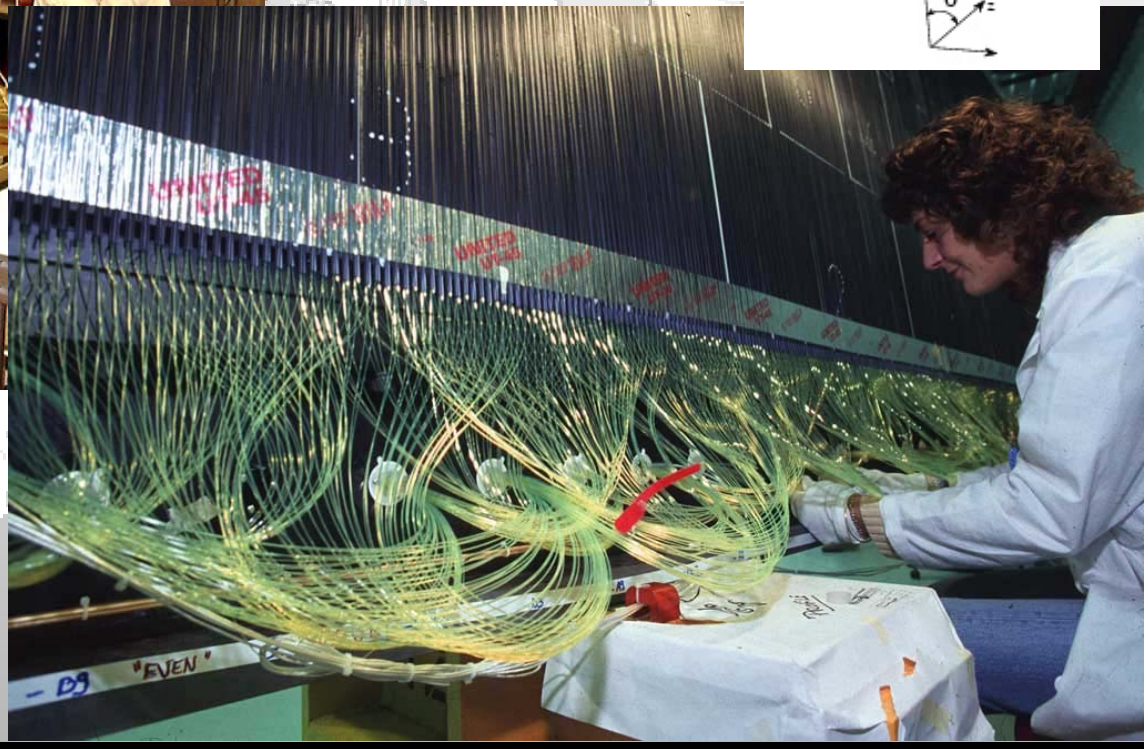
MPI!

# Hadron Calorimeter



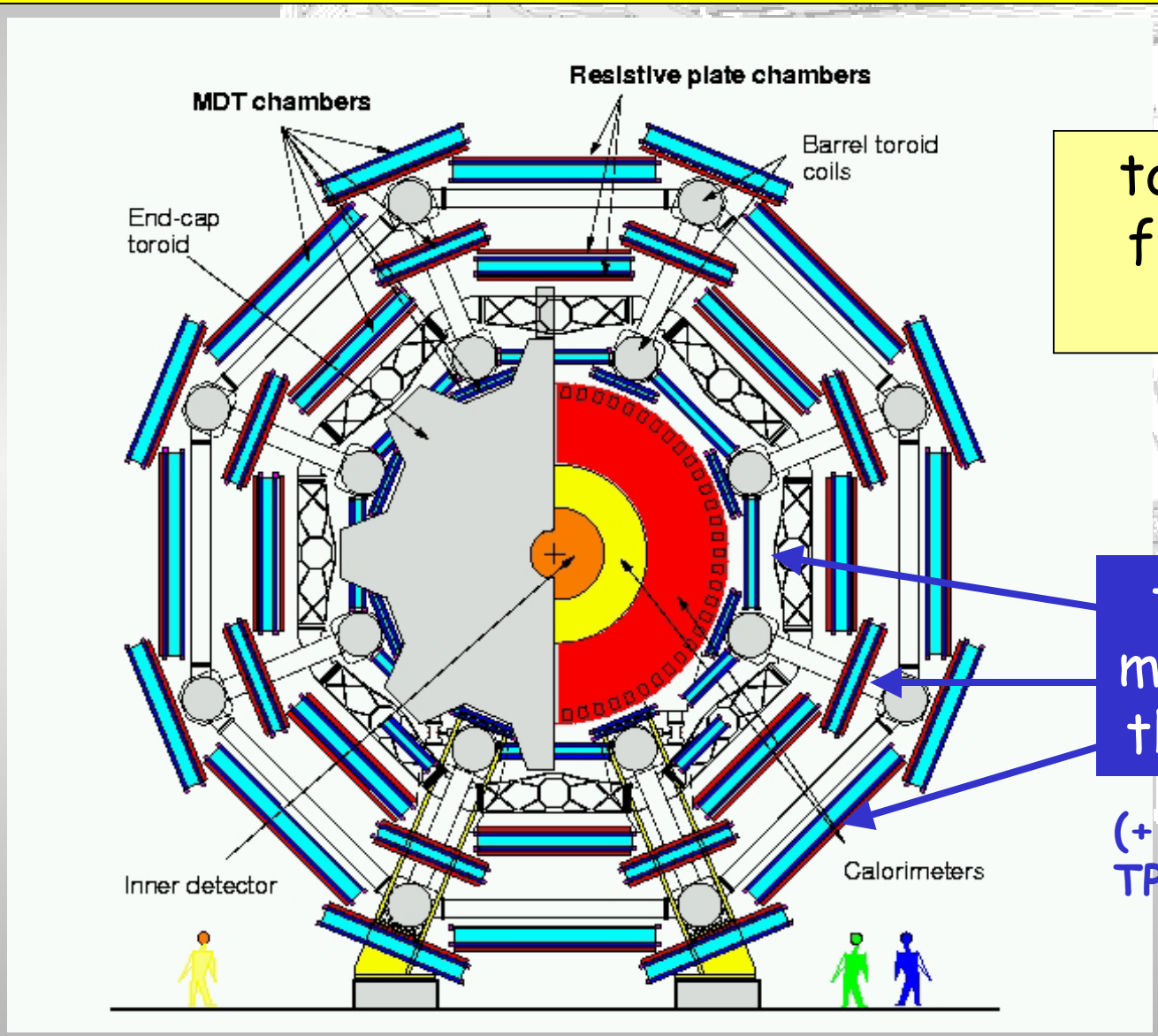
barrel hadron calorimeter



hadron endcap production at the MPI

# Muon Detector




toroidal magnetic field outside the calorimeter

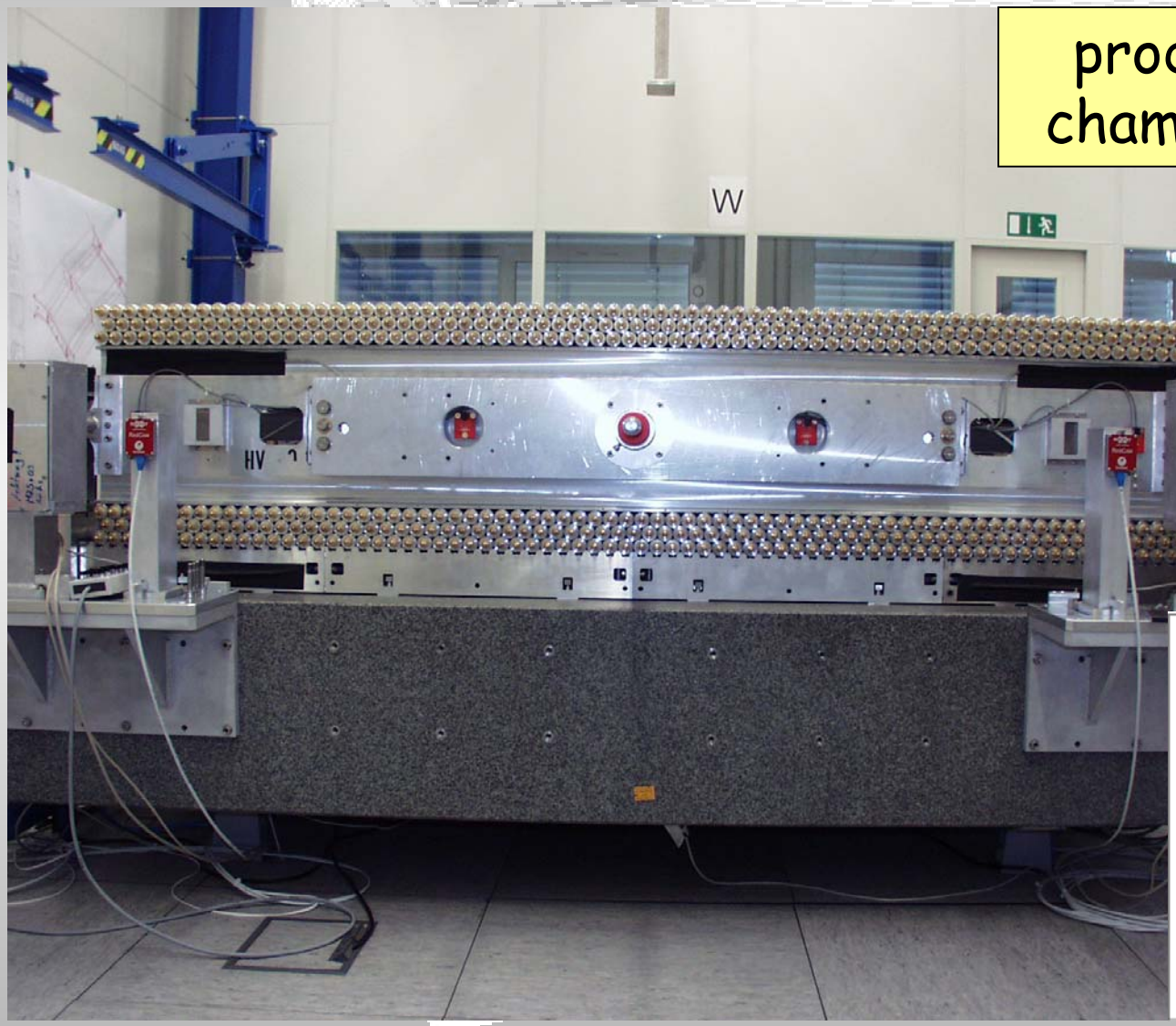
three layers of muon chambers in the barrel region

(+ trigger chambers, TPCs)

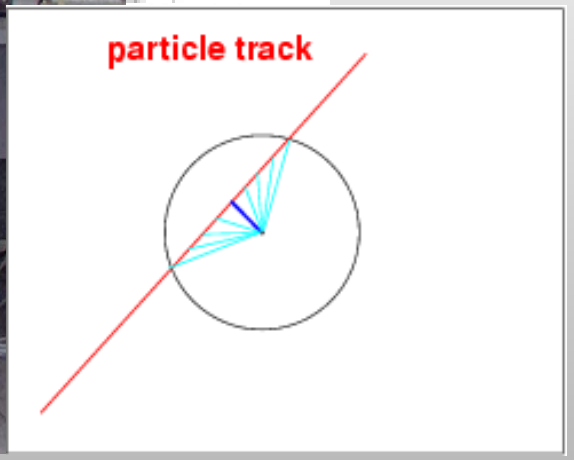
MPI!

# Muon Chambers

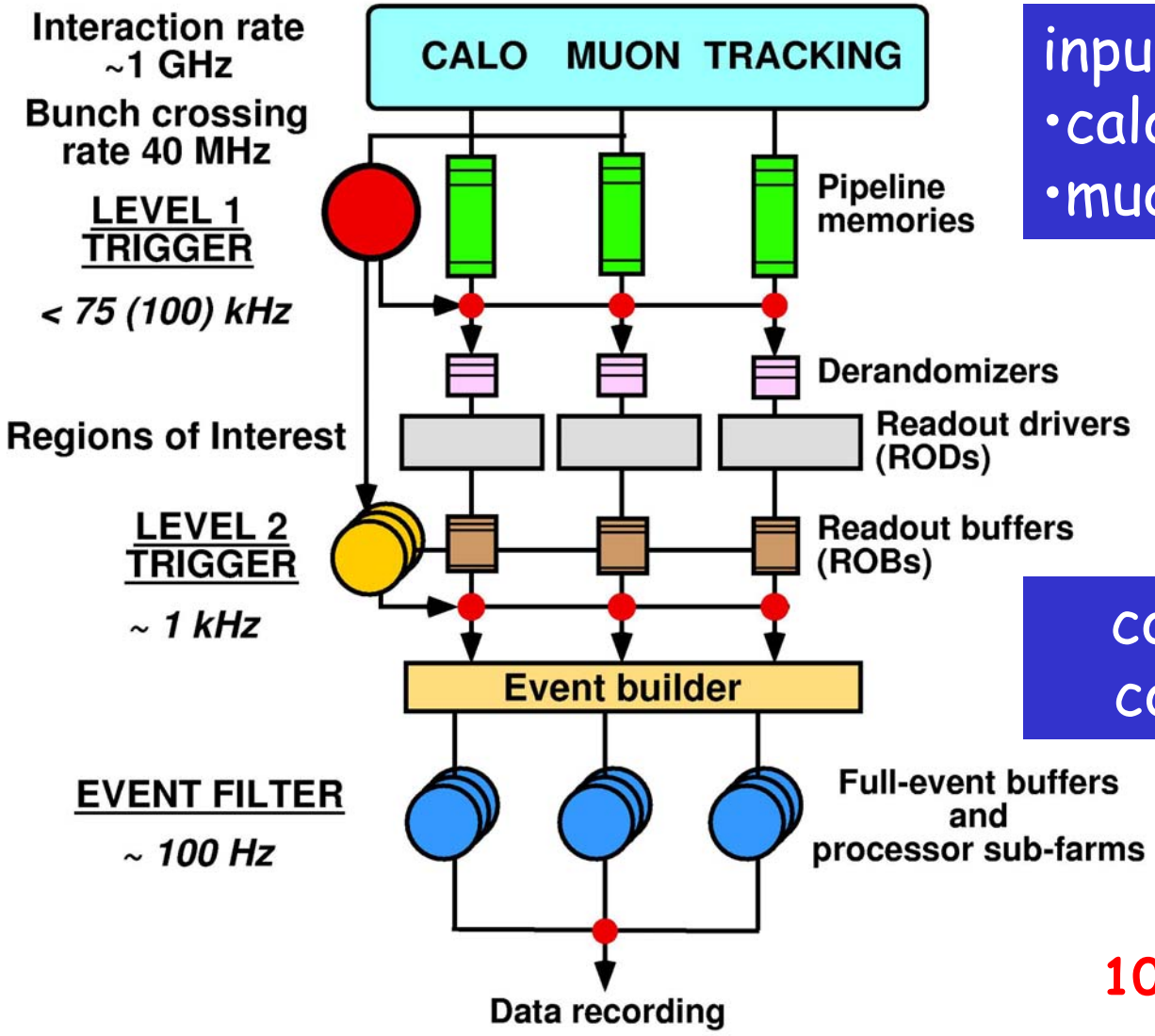
production of muon chambers at the MPI




- 2 x 3 layers of drift tubes in each chamber



# finally…The Trigger




$10^{14}$ Bytes/s

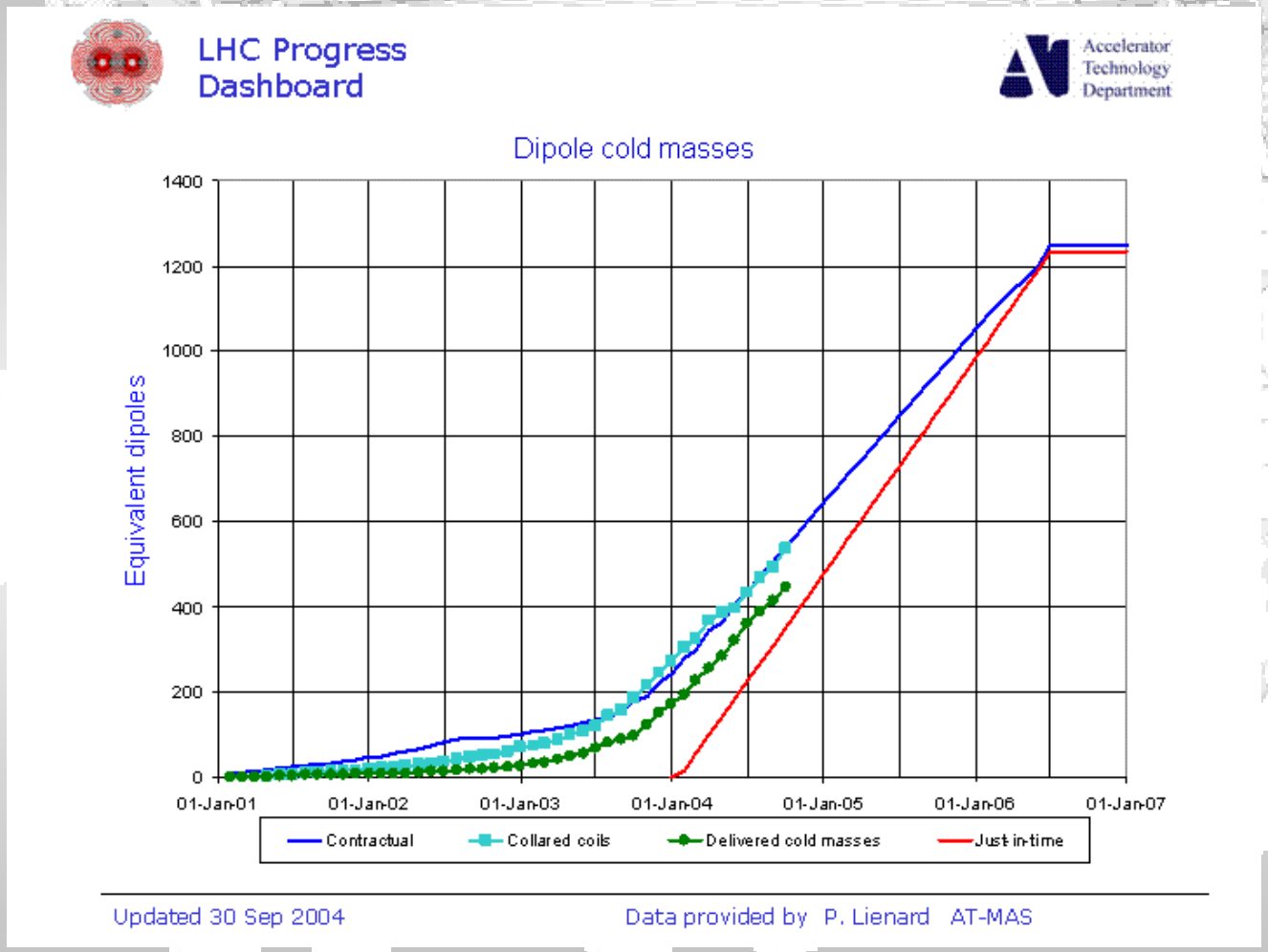
input to level 1 trigger:
- calorimeter
- muon chambers

pipeline for ~2 μs

construction of complete event

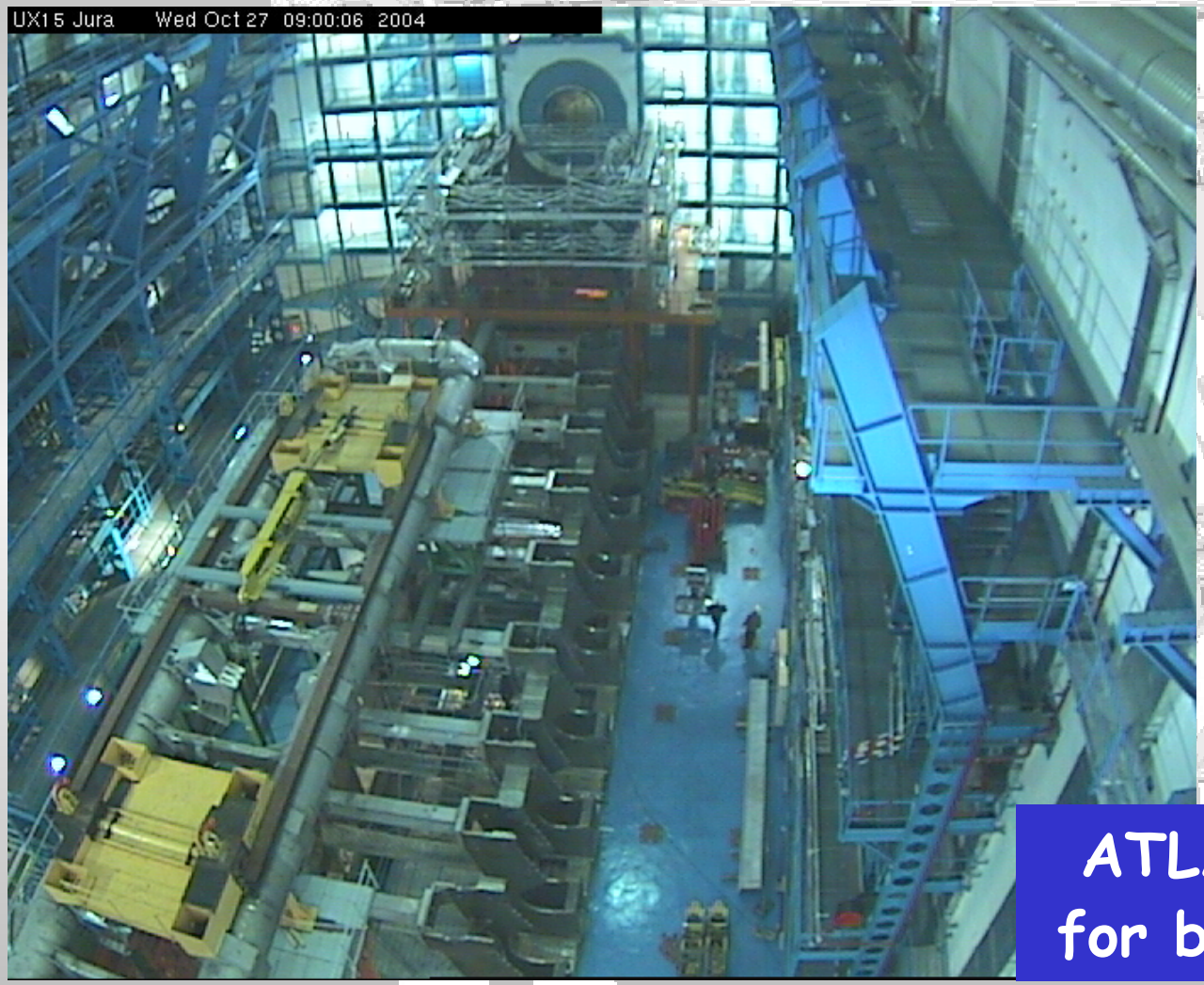
$10^{7}$-$10^{8}$ Bytes/s

# Status of the Accelerator




**first beam in LHC: 1st April 2007**

# Status of the ATLAS Experiment




**ATLAS will be ready for beam 29th Dec '06**

http://atlaseye-webpub.web.cern.ch/atlaseye-webpub/web-sites/pages/UX15_webcams.htm

# Summary

- ATLAS will be a multi-purpose Detector for physics at the LHC
- expected luminosity 10 $fb^{-1}$/year (low lum.)
- construction of ATLAS is well under way

and will be finished

in time

- exciting results

expected in 2007/8

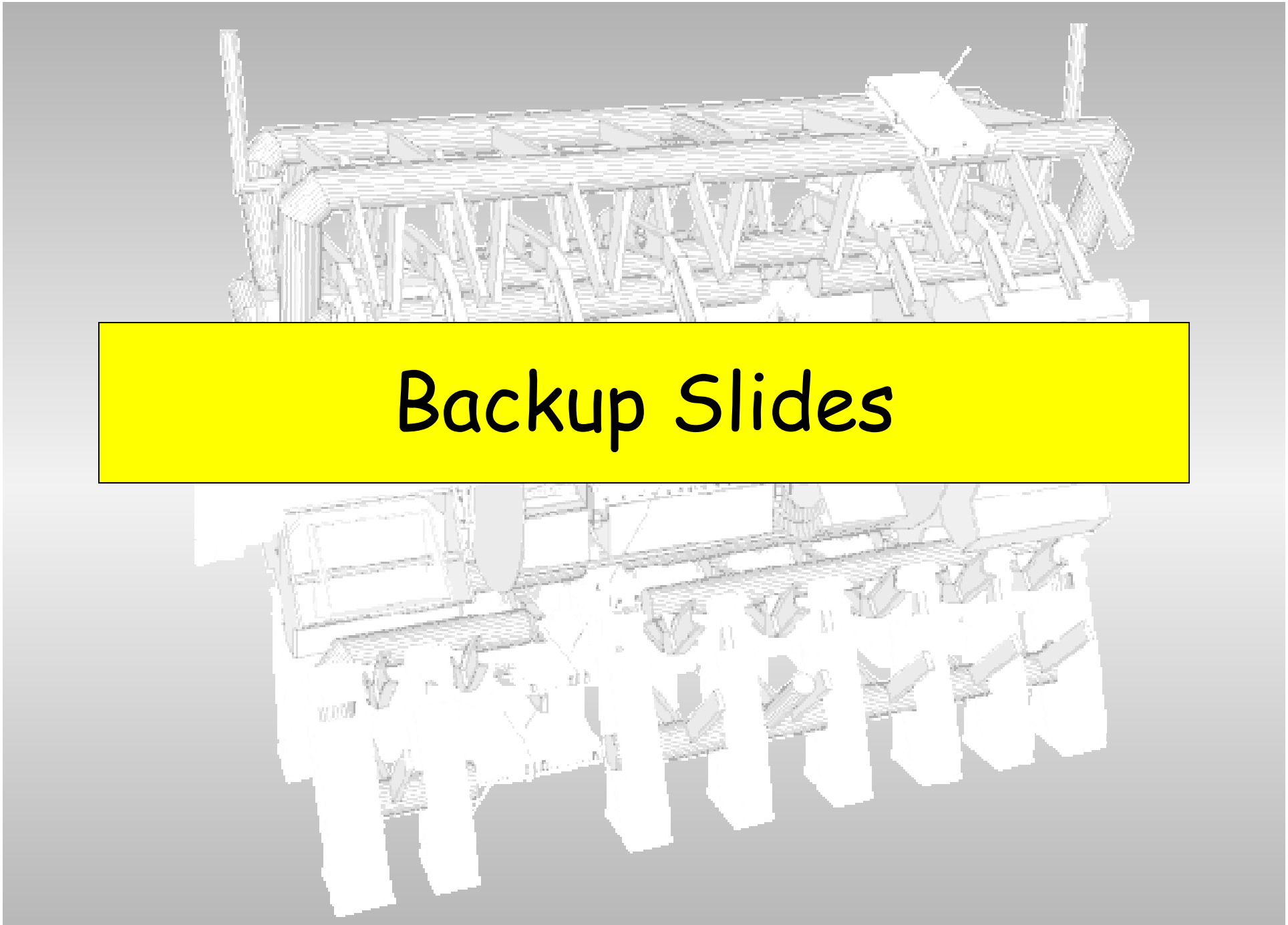
$H^0$ § $J^{PC} = 0^{++}$

Charge = 0

Mass m = $120.3 \pm 0.1$ GeV [a]

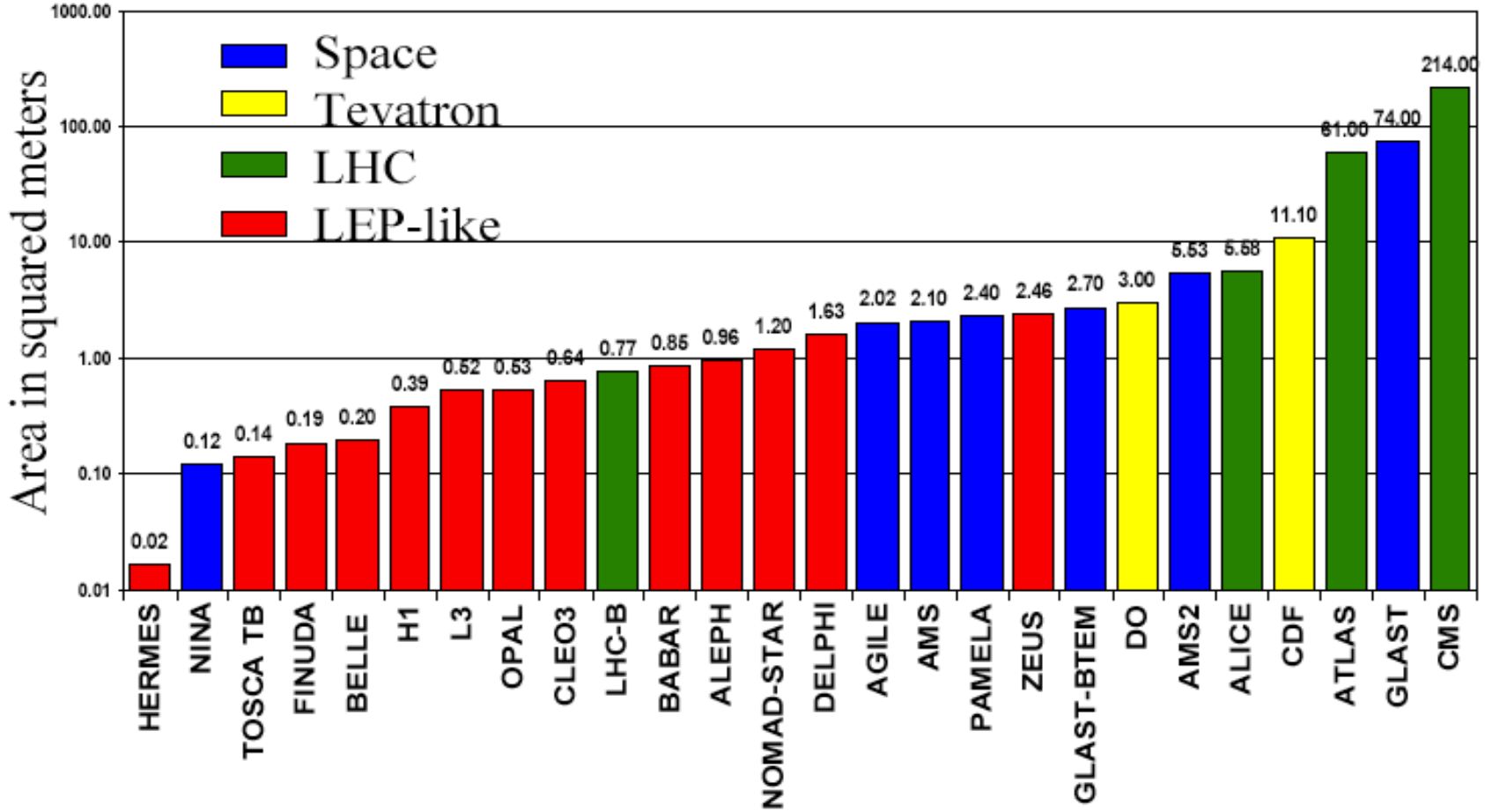
Full width $\Gamma = 2.20 \pm 0.18$ MeV [b]

| $H^0$ DECAY MODES | FRACTION | CL |
|---|---|---|
| $b\bar{b}$ | $(66.3 \pm 1.9)\%$ | 95% |
| $WW$ | $(13.5 \pm 3.4)\%$ | 95% |
| $\gamma\gamma$ | $(0.21 \pm 0.09)\%$ | 95% |



# Backup Slides

# Experiments using silicon strip detectors




E. do Couto e Silva – SLAC/Stanford University  Vertex 2000, Sept 10-15, National Lakeshore, MI, USA

# Calorimeter

Allgemeine Parametrisierung der Energieauflösung eines Kalorimeters:

$$\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \otimes \frac{b}{E} \otimes c$$

(quadratisch addiert)

a: statistischer Term

statistische Fluktuation der primären Teilchen

b: Rausch-Term

Rauschen

c: konstanter Term

Signalverlust, Inhomogentitäten, nicht-kompensation, Kalibrationsfehler

# Calorimeter

| | Statistischer Term ~1/√E | Rauschen ~1/E | Konstant |
|---|---|---|---|
| Atlas (Barrel EM) | 0.10 | 0.4 | 0.01 |
| CMS (3x3 Kristall EM) | 0.03 | 0.2 | 0.005 |
| Atlas (HadronTile ) | 0.50 | | 0.03 |
| CMS (HCAL only) | 0.65 | | 0.05 |