LUND UNIVERSITY

# *Lund Activities in ATLAS*

ATLAS

## ▶ Electronics for the TRT

(Paula Eerola, Björn Lundberg, Ulf Mjörnmark,
Torsten Åkesson, Vincent Hedberg, Oxana Smirnova)

## ▶ Shielding

(Vincent Hedberg)

## ▶ Radiation

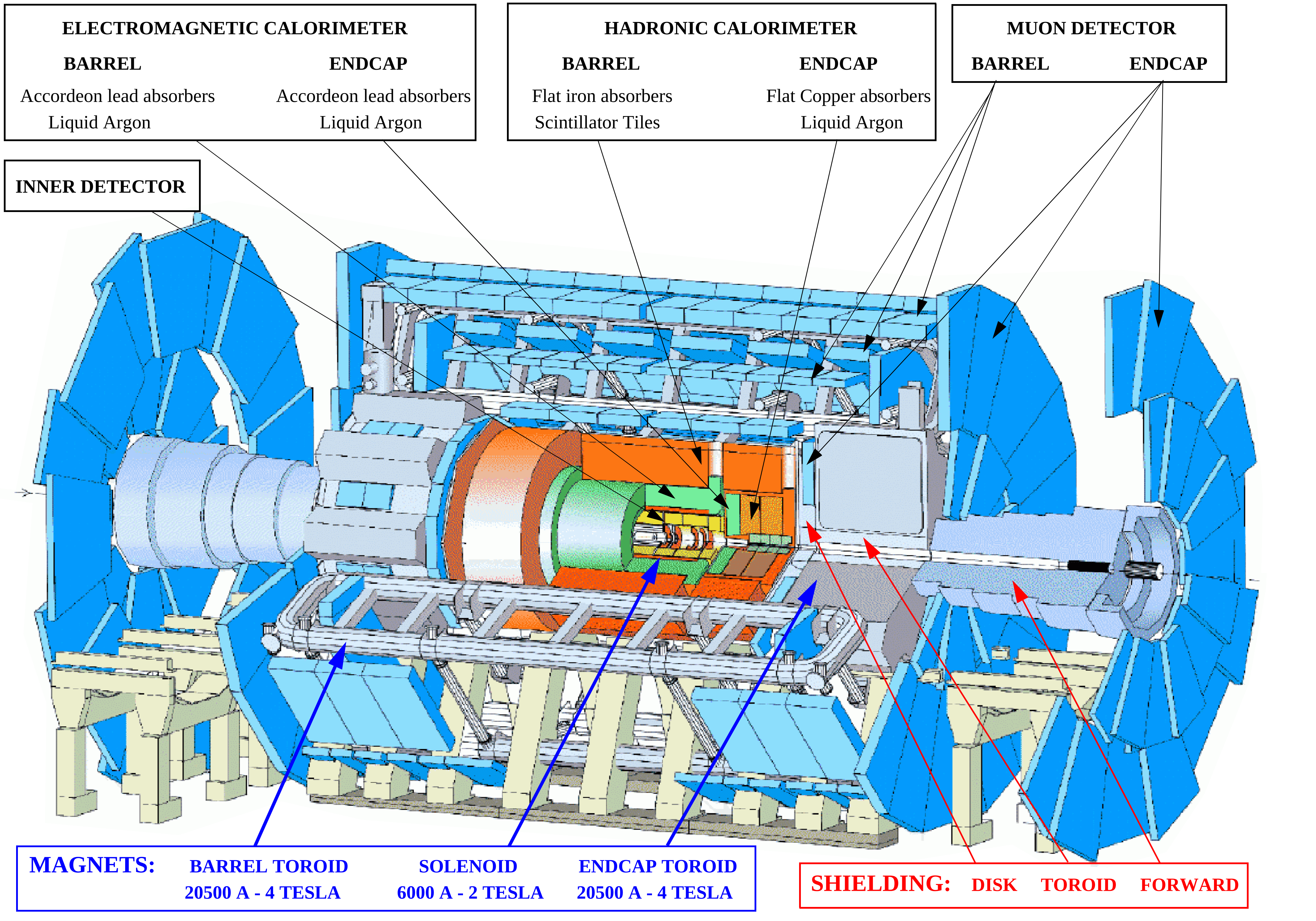
(Vincent Hedberg)

## ▶ Luminosity

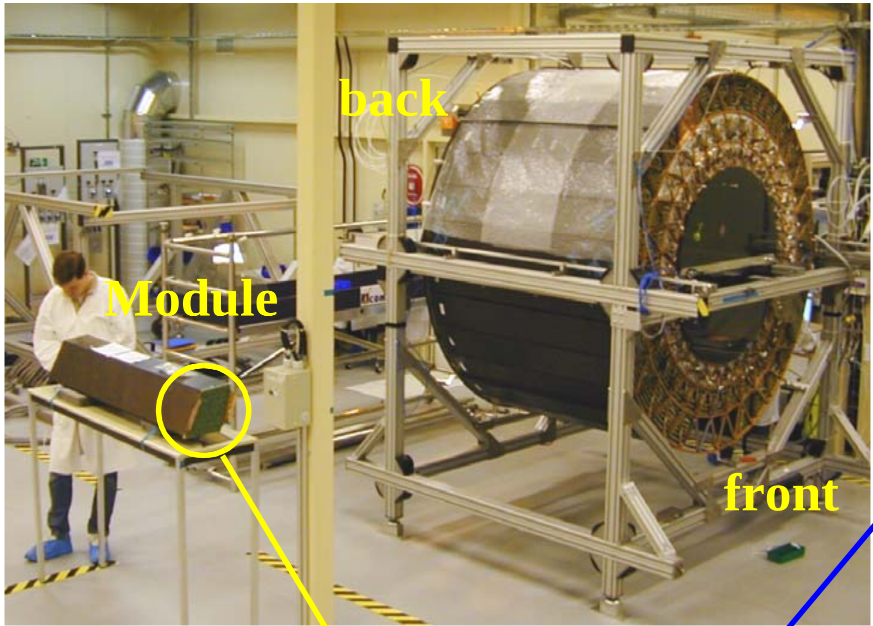
(Vincent Hedberg, Björn Lundberg, Lennart Österman,
Ulf Mjörnmark, Göran Jarlskog, Stefan Ask - CERN)

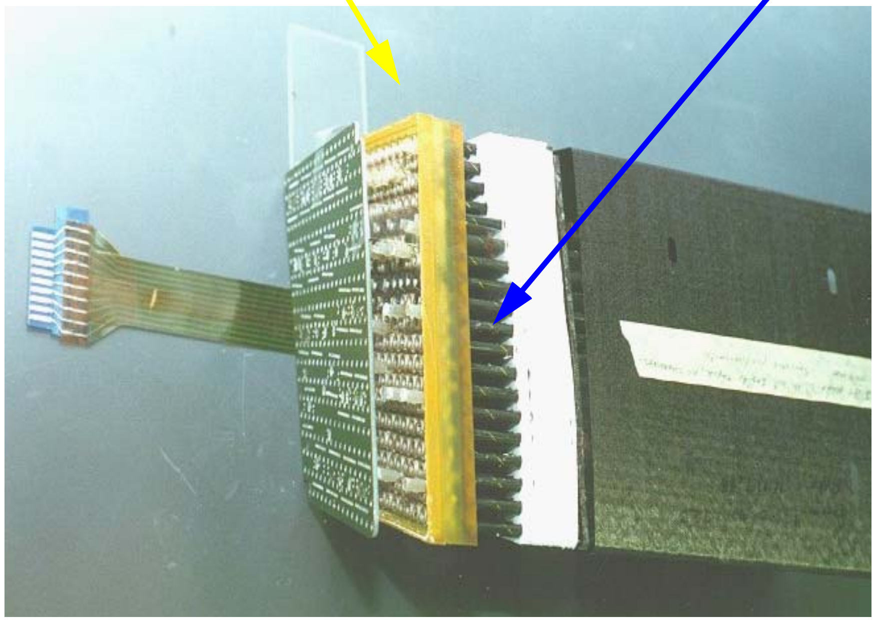
## ▶ Monte Carlo data production

(Oxana Smirnova, Balazs Konya)


ELECTROMAGNETIC CALORIMETER
BARREL
Accordeon lead absorbers
Liquid Argon
ENDCAP
Accordeon lead absorbers
Liquid Argon
HADRONIC CALORIMETER
BARREL
Flat iron absorbers
Scintillator Tiles
ENDCAP
Flat Copper absorbers
Liquid Argon
MUON DETECTOR
BARREL
ENDCAP
INNER DETECTOR
MAGNETS:
BARREL TOROID
20500 A - 4 TESLA
SOLENOID
6000 A - 2 TESLA
ENDCAP TOROID
20500 A - 4 TESLA
SHIELDING:
DISK
TOROID
FORWARD

# The Transition Radiation Tracker



**The detector part of the barrel TRT was completed in February 2005.**

**It consists of 96 modules. All modules have been HV tested, gain- and gas leak tested.**

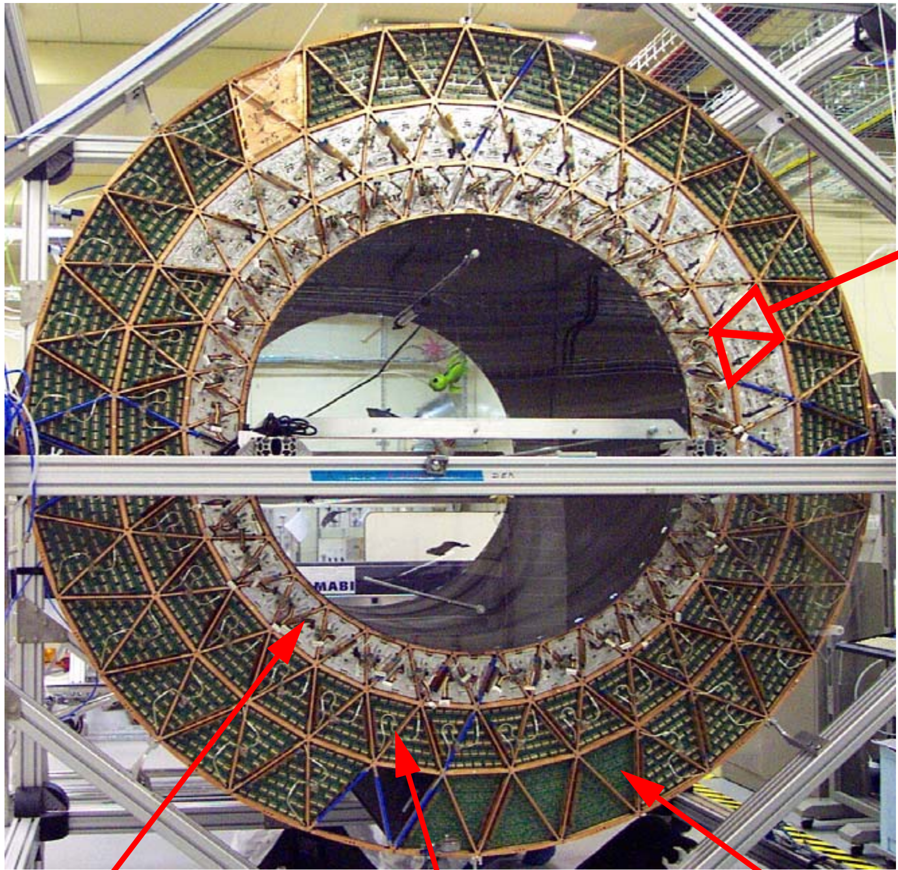
**The detector has 52544 kapton straws with a diameter of 4 mm.**

**In each kapton straw is a 30 μm gold-plated tungsten wire.**

**Each straw acts as a small cylindrical proportional chamber with the wire as an anode at 1.78 kV and the straw wall as the cathode.**

**Electrons will produce transition radiation photons in the radiator placed between the straws and these can be detected with the help of the Xenon gas in the straws.**

## Front-End Electronics



**Ring 1**

**All boards are mounted and tested.**

**Ring 2**

**Front:**
**Boards are made but not mounted.**

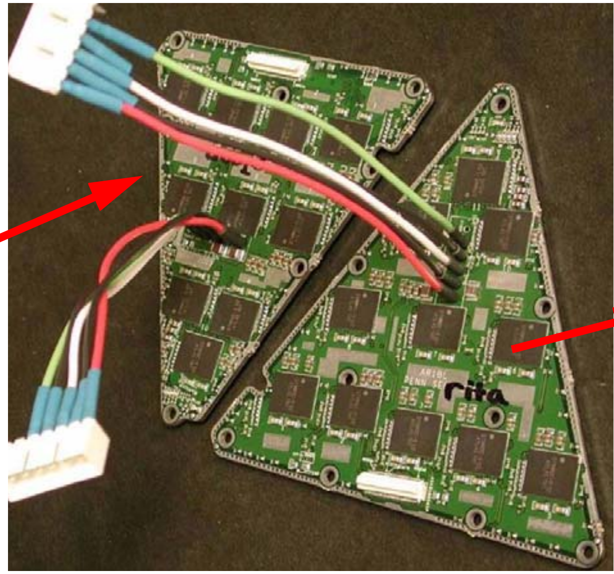
**Back:**
**All boards are mounted and tested.**

**Ring 3**

**Front:**
**Boards are expected in May.**

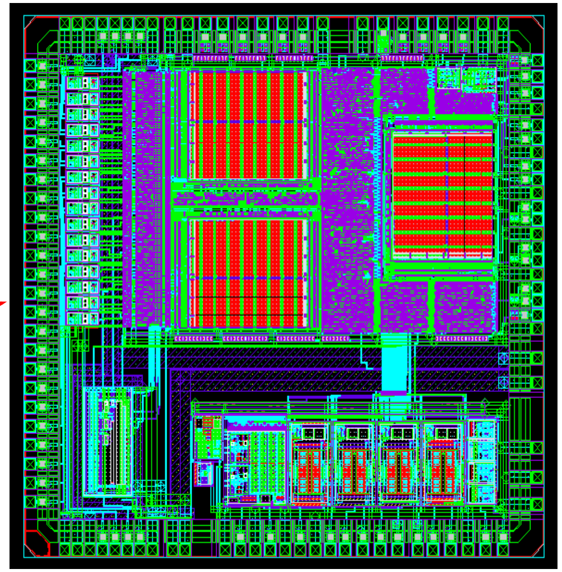
**Back:**
**Boards are made but not mounted.**

## Active Roof Boards



**The two boards provide pre-amplification, signal shaping and digitisation of the signals from the straw tubes in one module.**

## Drift Time Measurement Read-Out Chip

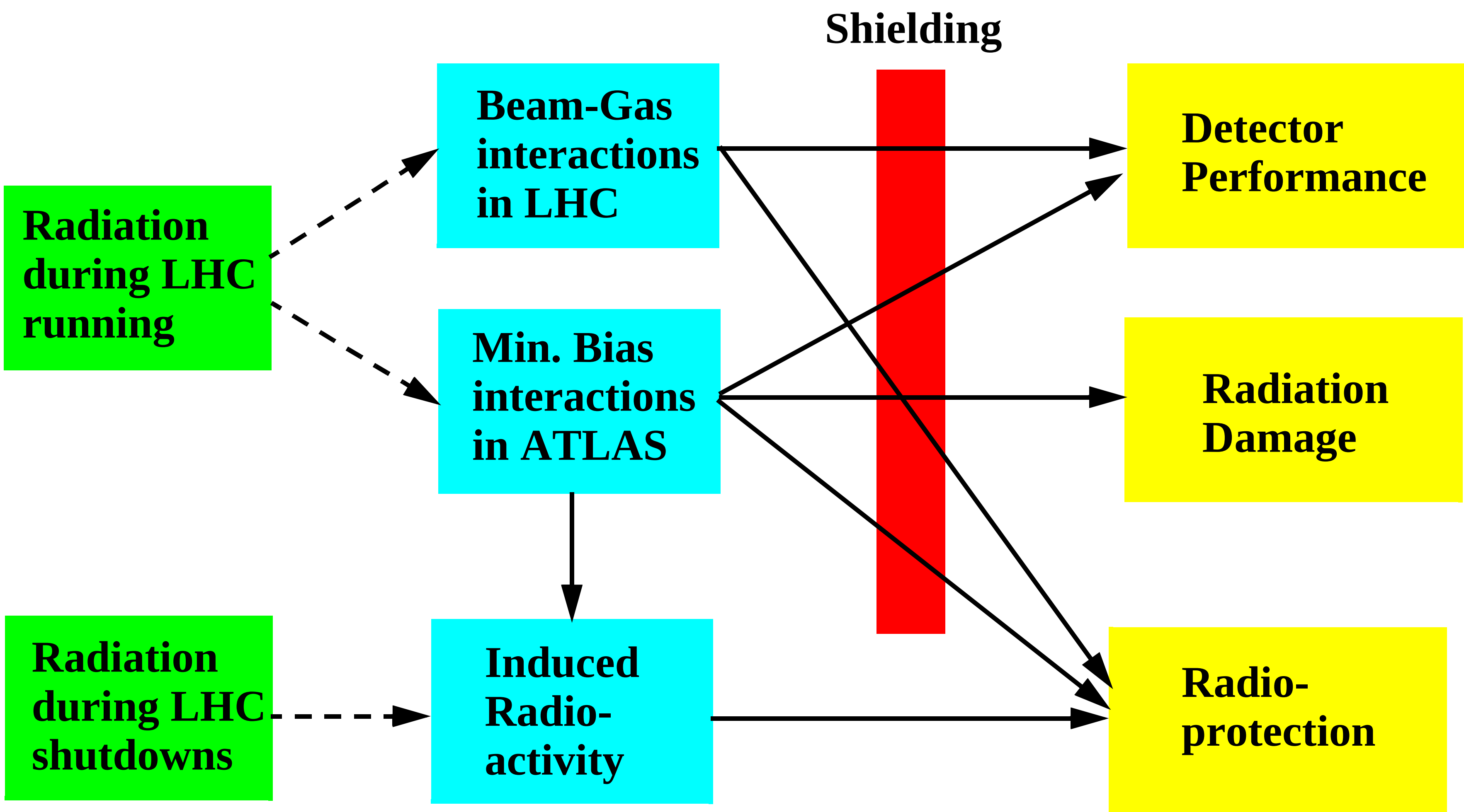


**The DTMROC provides position measurements of the tracks by measuring the drift-time of the ionisation electrons inside each straw.**

**All chips have been made and have been tested.**

Summary:
The design work is finished.
The production is almost finished.
Testing and mounting of the boards remains.

# Radiation & Shielding in ATLAS



# The ATLAS Shielding Project

**Original budget: 6.8 MCHF (40 MSEK) CERN manpower not included**

ATLAS

***Radiation calculations Shielding physics design*** — ***Mechanical design*** — ***Market surveys Tendering Contracts*** — ***Production*** — ***Transport*** — ***Assembly*** → ***Installation***

**Radiation calculations / Shielding physics design**

**~100 GCALOR simulations each taking 1 week of CPU time at the ATLAS BNL computer center**

**Mechanical design**

**324 drawings**

**29 Technical Specifications**

**FE calculations**

**Reactor tests of radiation hardness**

**Tests of flammability**

**Market surveys / Tendering / Contracts**

**3 MCHF (18 MSEK) in orders made**

**Production**

**Czech republic** (4 companies)
**Serbia** (2 companies)
**Armenia** (2 companies)
**Poland** (1 company)
**Belgium** (1 company)
**Pakistan** (2 companies)
**Spain** (1 company)
**Italy** (1 company)
**France** (1 company)
**Germany** (1 company)
**Switzerland** (1 company)

**Transport**

**Example:**

**10 x 100 tons special transports Plzen-CERN**

**Assembly**

**In the Czech republic and at CERN**

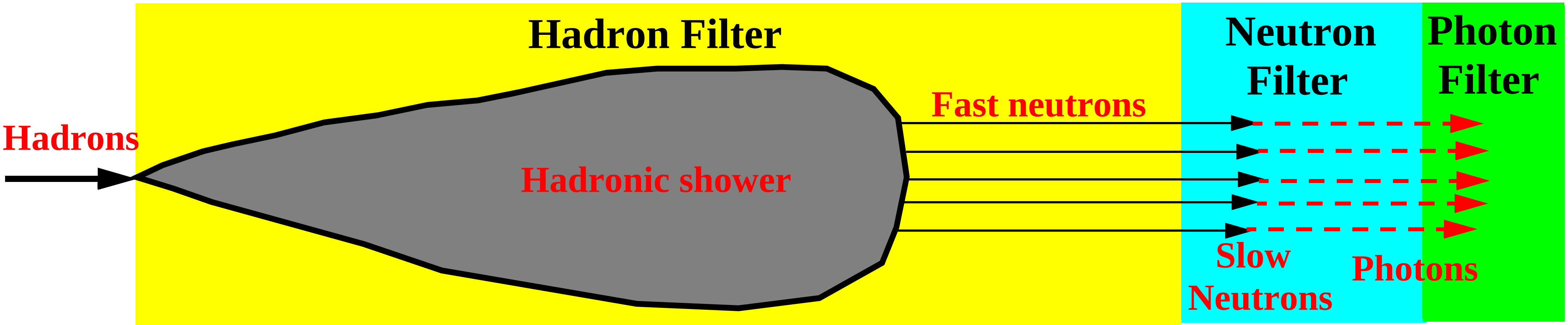
**Installation**

**Scheduled for 2005 2006 2007**

# Shielding Optimization

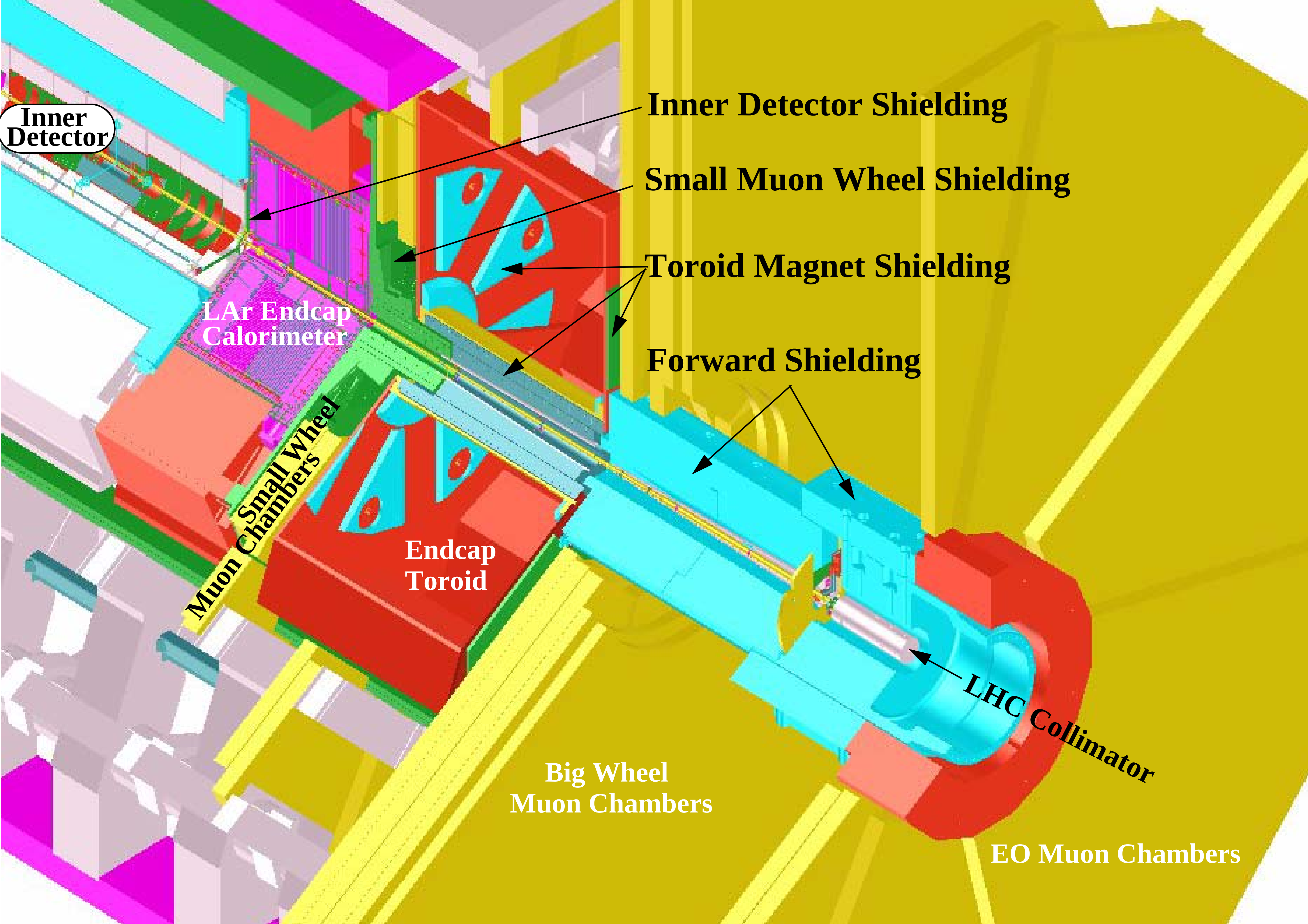
ATLAS

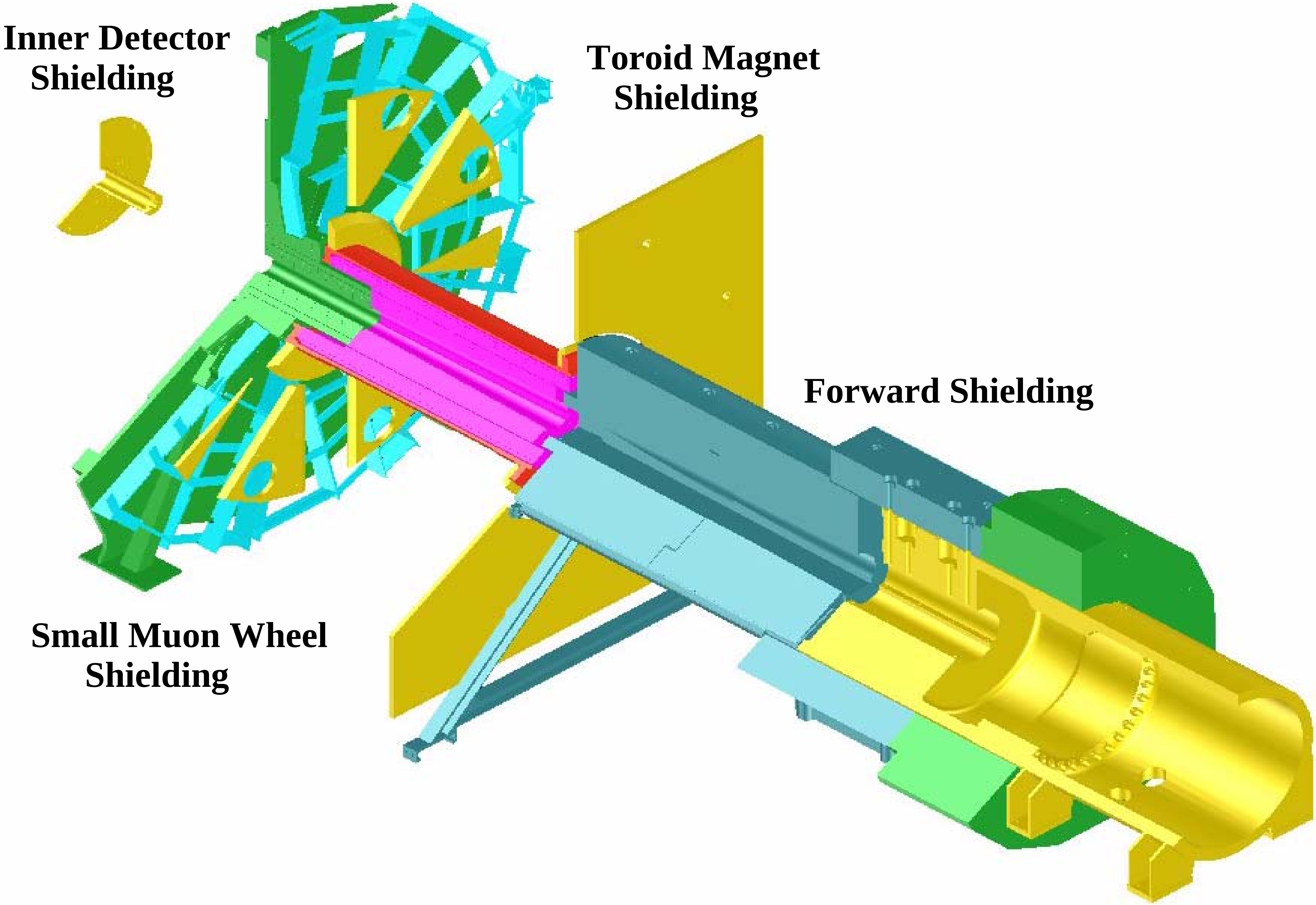
ATLAS is using a layered shielding design which requires a multi-parameter optimization:



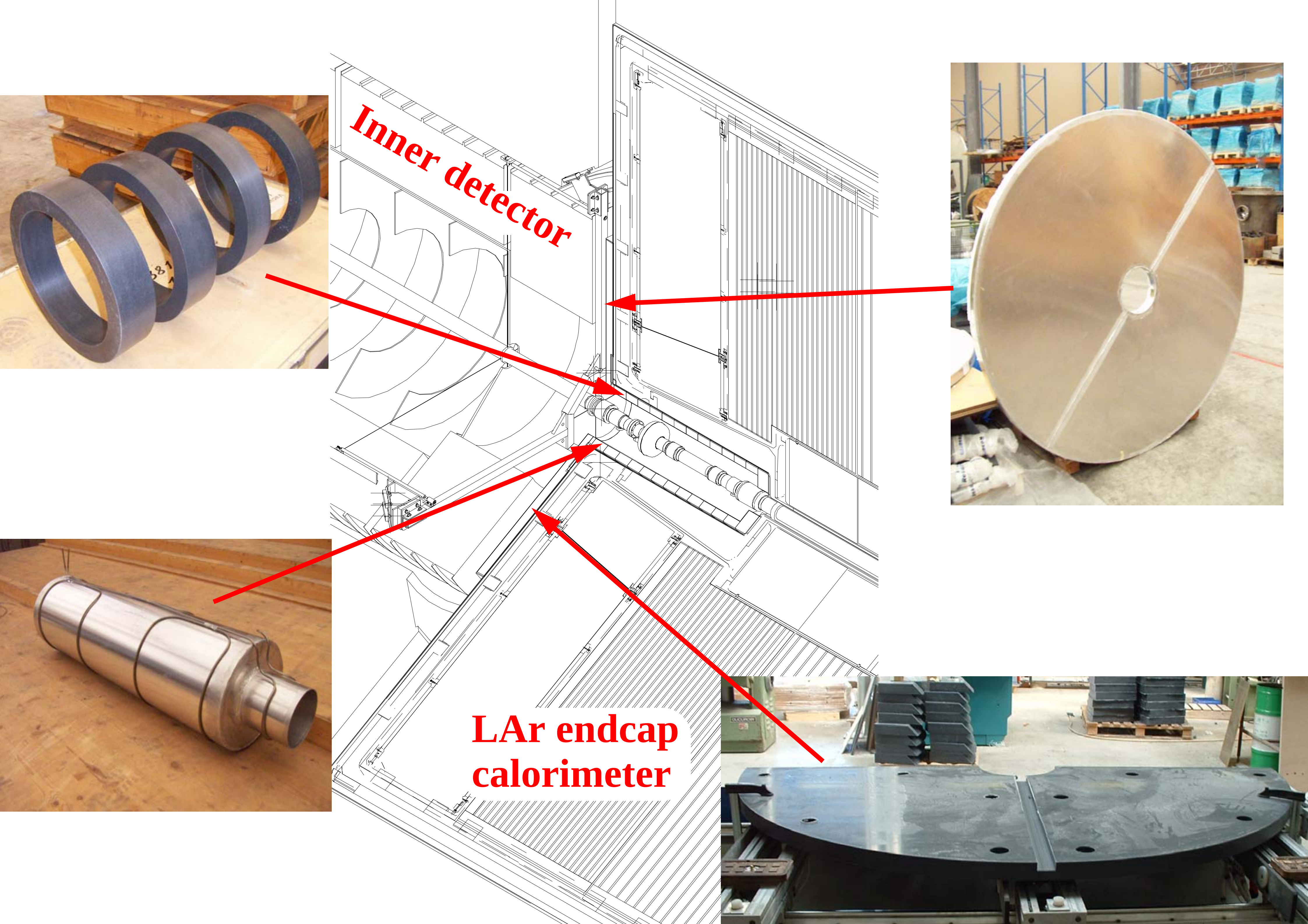

**PARAMETERS**

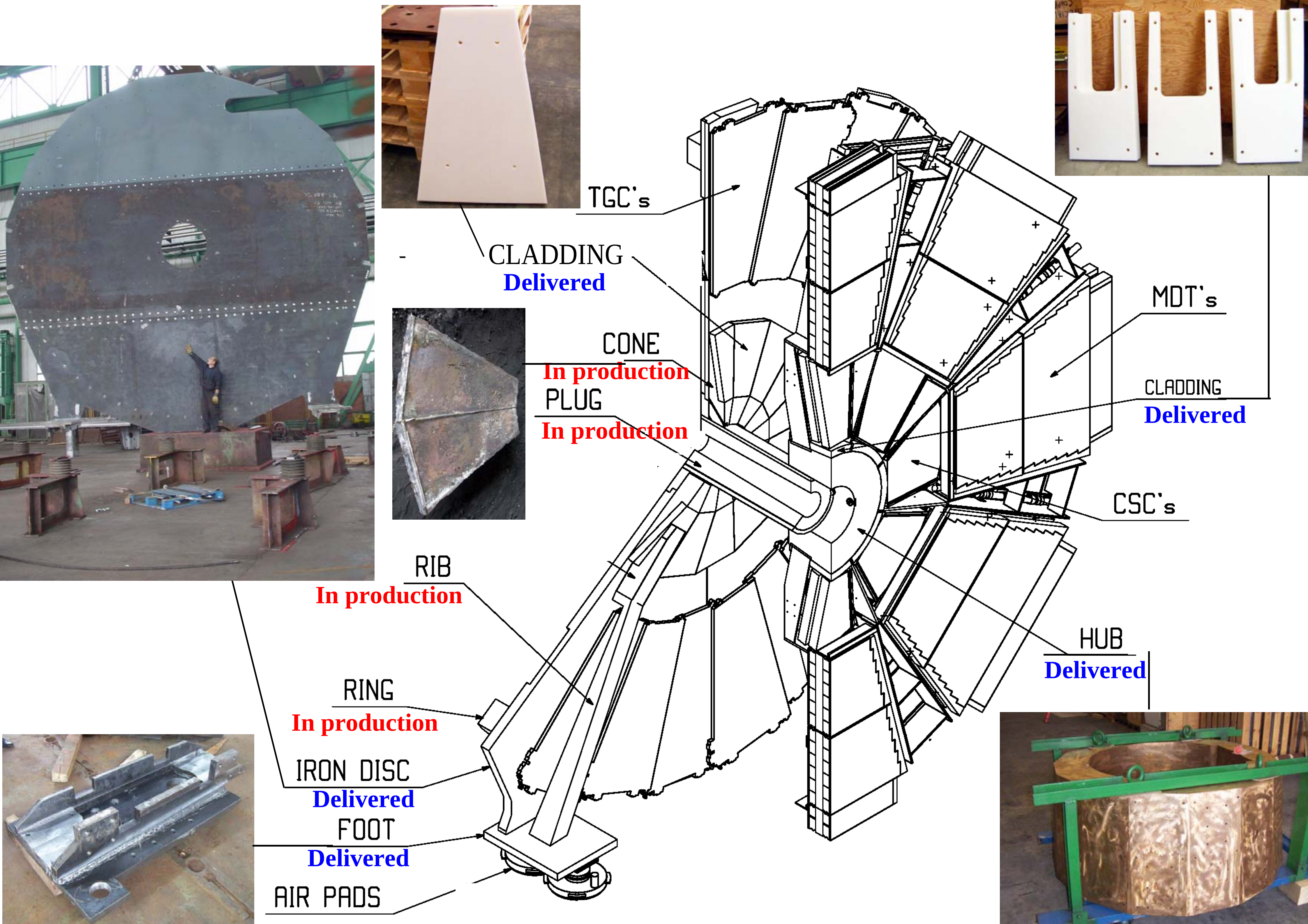
| | Hadron Filter | Neutron Filter | Photon Filter |
|---|---|---|---|
| **Materials:** | Ductile Iron, Stainless Steel, Bronze, Gray Steel | Polyethylene doped with $B_4C$, $B_2O_3$ $H_3BO_3$, LiF | Lead<br>Steel |
| **Thickness:** | 10-20 $\lambda$ | 5-8 cm | 3 cm |
| **Properties:** | Mechanical characteristics<br>Magnetic properties | Flammability<br>Rad. hardness | |
| **Cost** | | | |


Inner Detector
Inner Detector Shielding
Small Muon Wheel Shielding
Toroid Magnet Shielding
LAr Endcap Calorimeter
Forward Shielding
Small Wheel Muon Chambers
Endcap Toroid
LHC Collimator
Big Wheel Muon Chambers
EO Muon Chambers



Inner Detector Shielding
Toroid Magnet Shielding
Forward Shielding
Small Muon Wheel Shielding

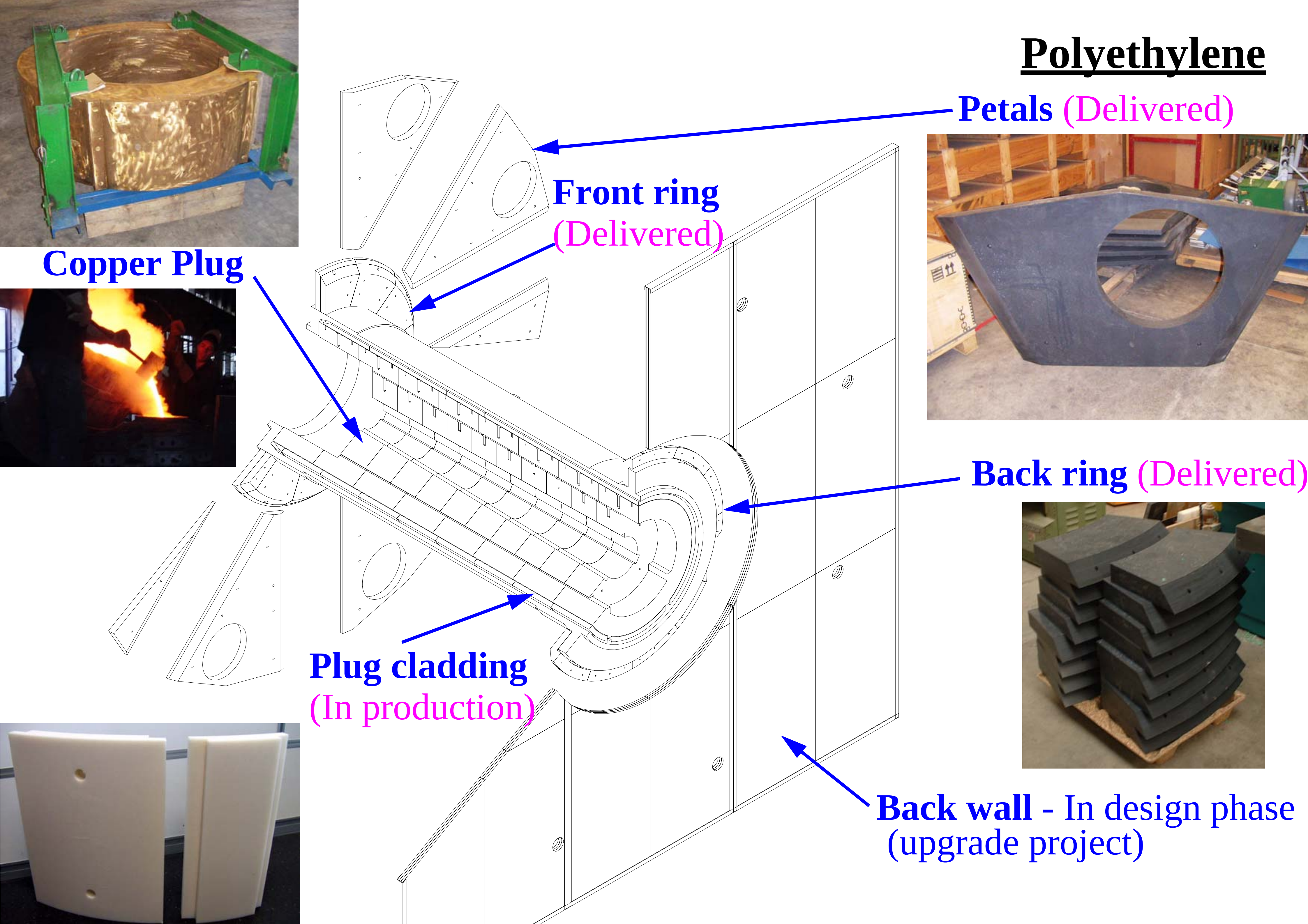

Inner detector
LAr endcap
calorimeter

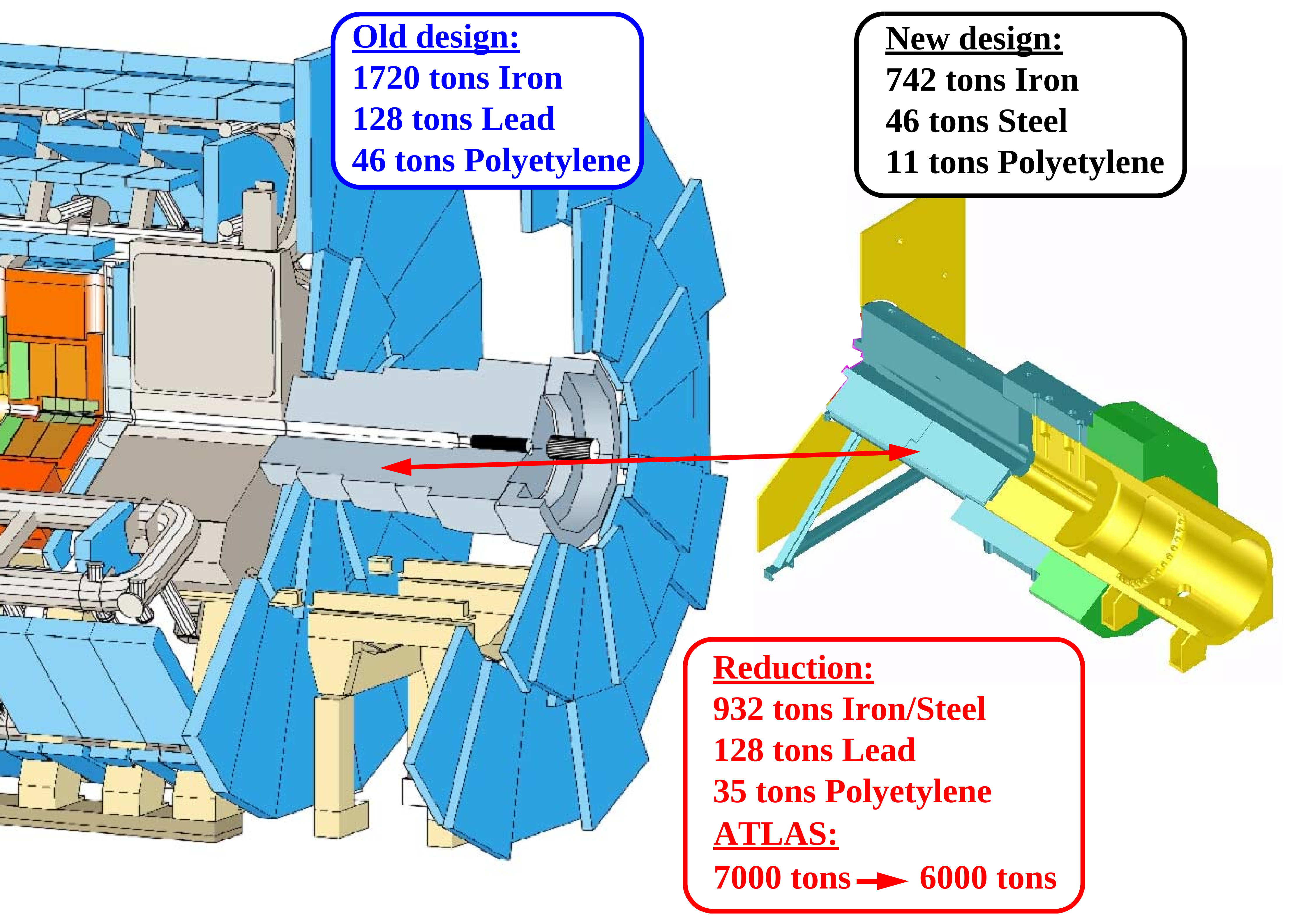


TGC's
CLADDING
Delivered
CONE
In production
PLUG
In production
MDT's
CLADDING
Delivered
CSC's
RIB
In production
HUB
Delivered
RING
In production
IRON DISC
Delivered
FOOT
Delivered
AIR PADS

# *Shielding in the endcap magnet*

ATLAS

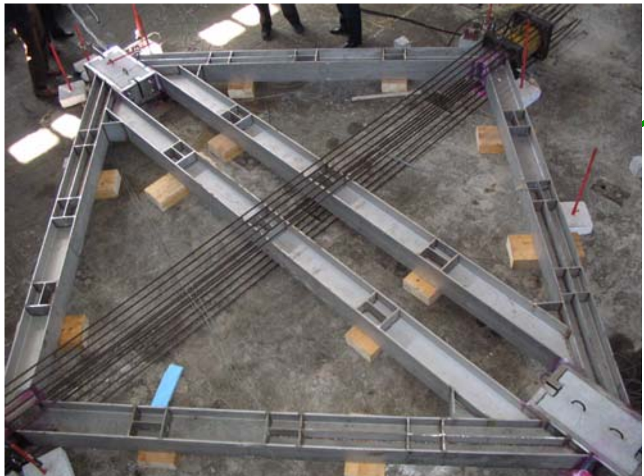

Polyethylene
Petals (Delivered)
Front ring
(Delivered)
Copper Plug
Back ring (Delivered)
Plug cladding
(In production)
Back wall - In design phase
(upgrade project)


Old design:
1720 tons Iron
128 tons Lead
46 tons Polyetylene
New design:
742 tons Iron
46 tons Steel
11 tons Polyetylene
Reduction:
932 tons Iron/Steel
128 tons Lead
35 tons Polyetylene
ATLAS:
7000 tons → 6000 tons

**Steel plates**

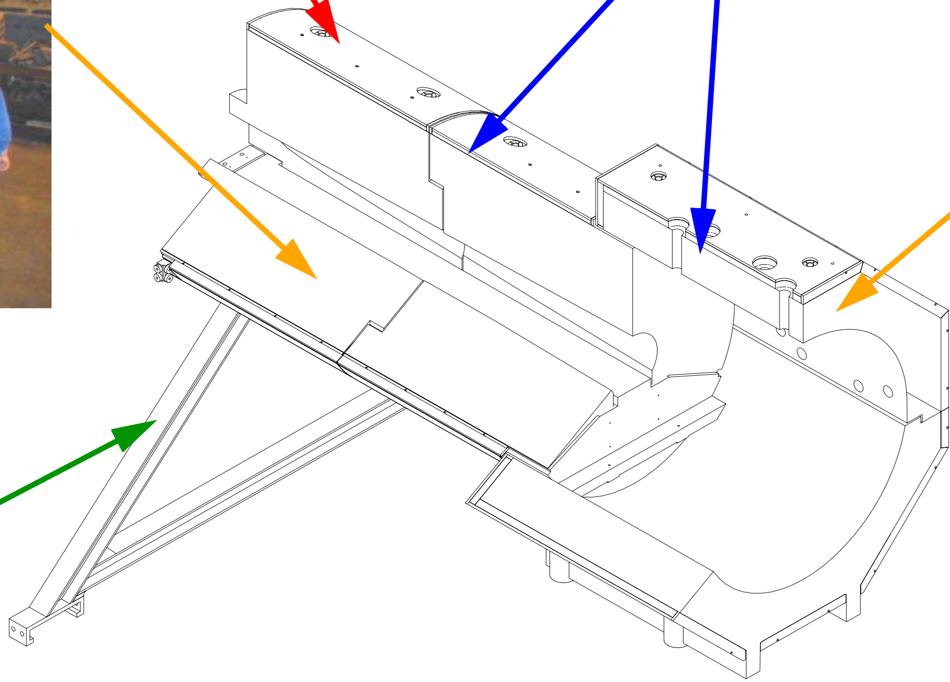
**Ductile Cast Iron**

**Stainless steel support**



**Polyethylene**

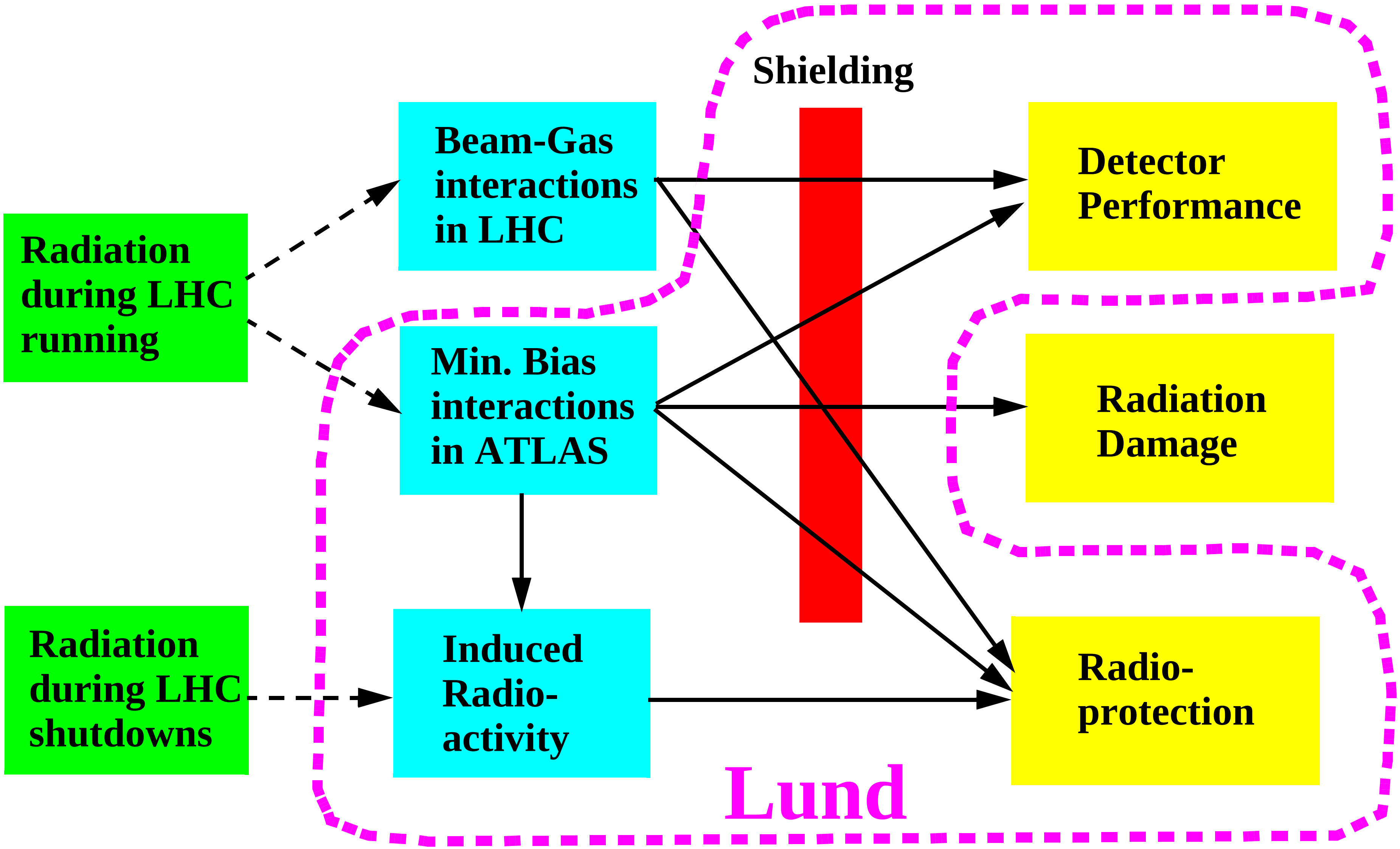
**11000 boron-doped poly-ethylene bricks have been assembled.**



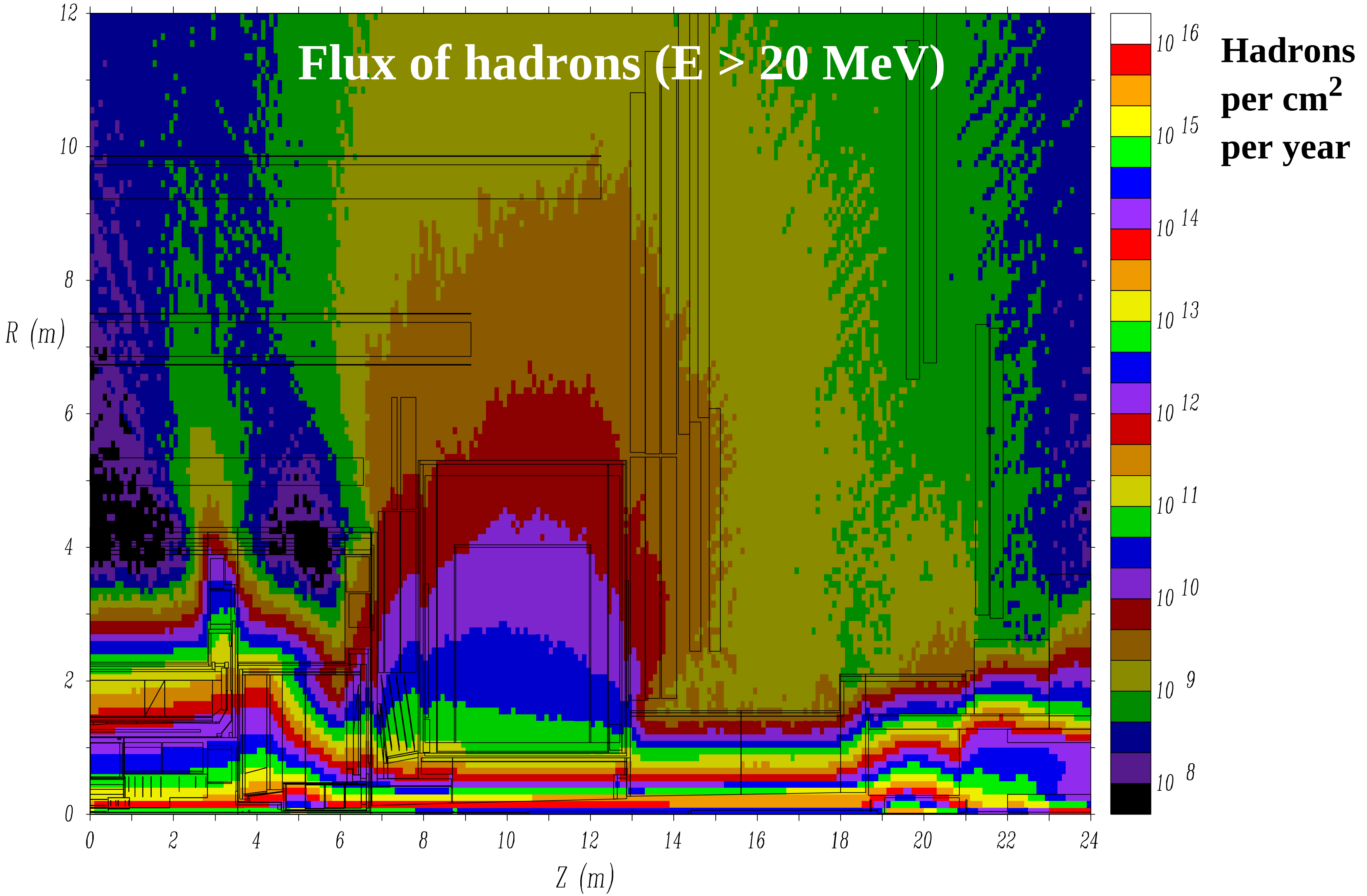
**Ductile Cast Iron**

**The support is test-loaded with 173 tons.**

# Radiation in ATLAS

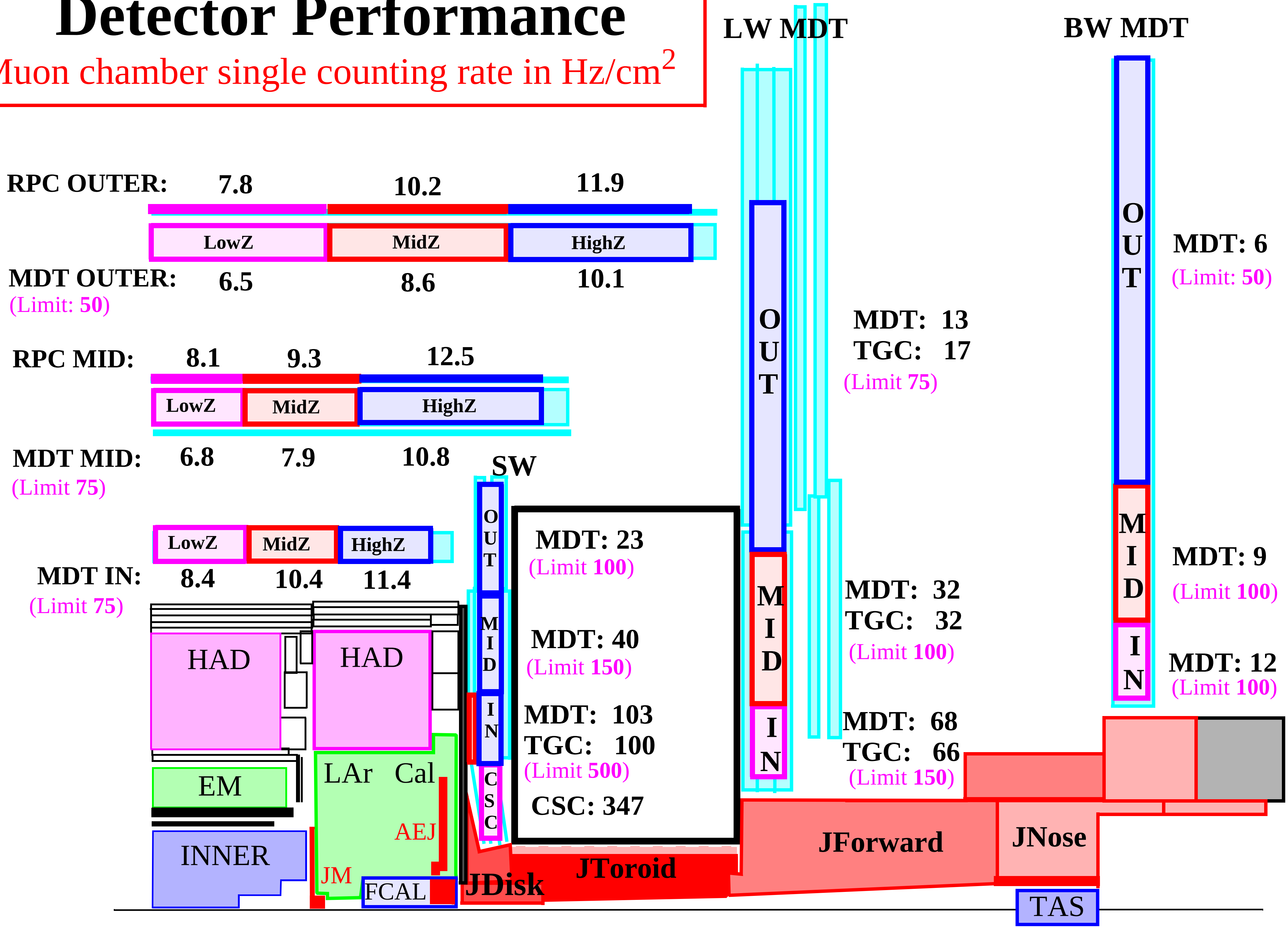


# Example of GCALOR simulation (by M. Shupe - Univ. Arizona) used to design the shielding.



# Detector Performance

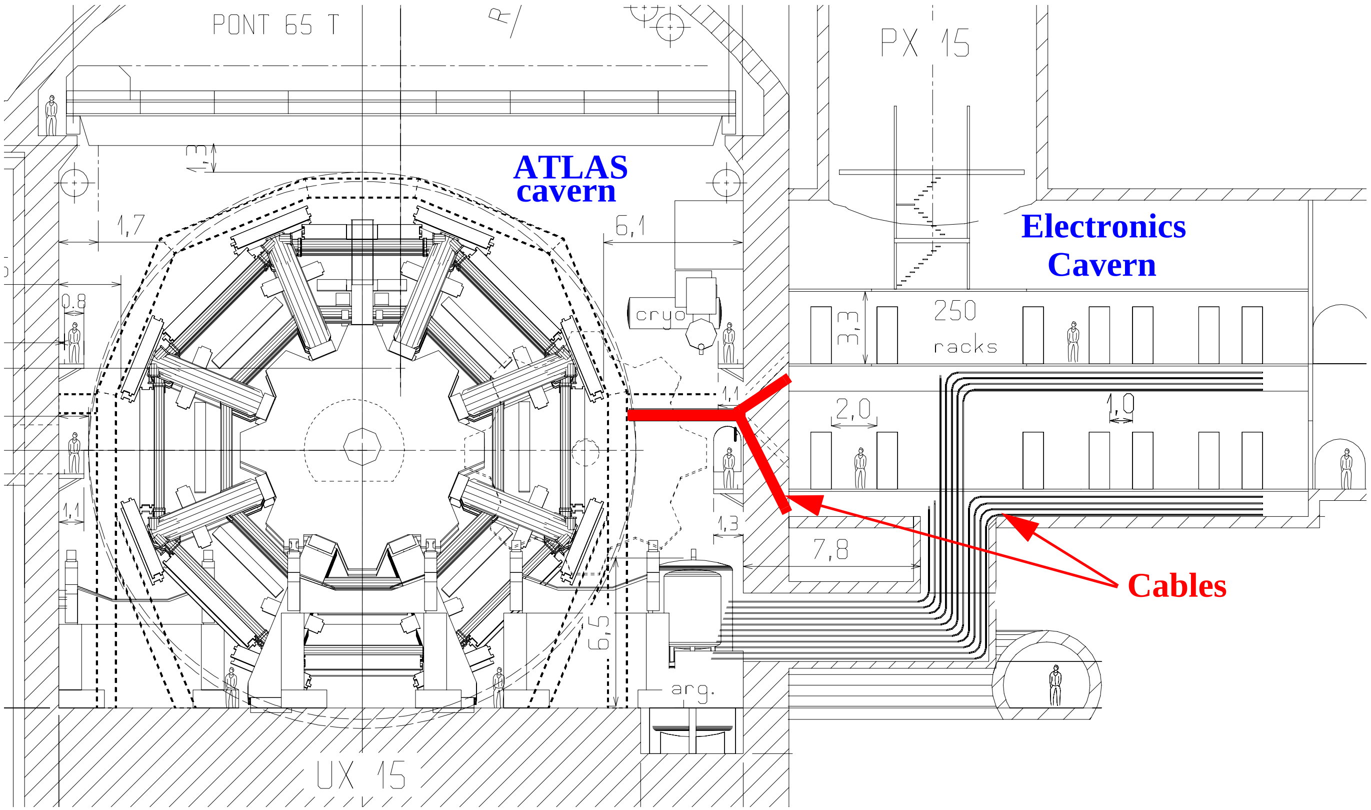
Muon chamber single counting rate in Hz/cm$^2$



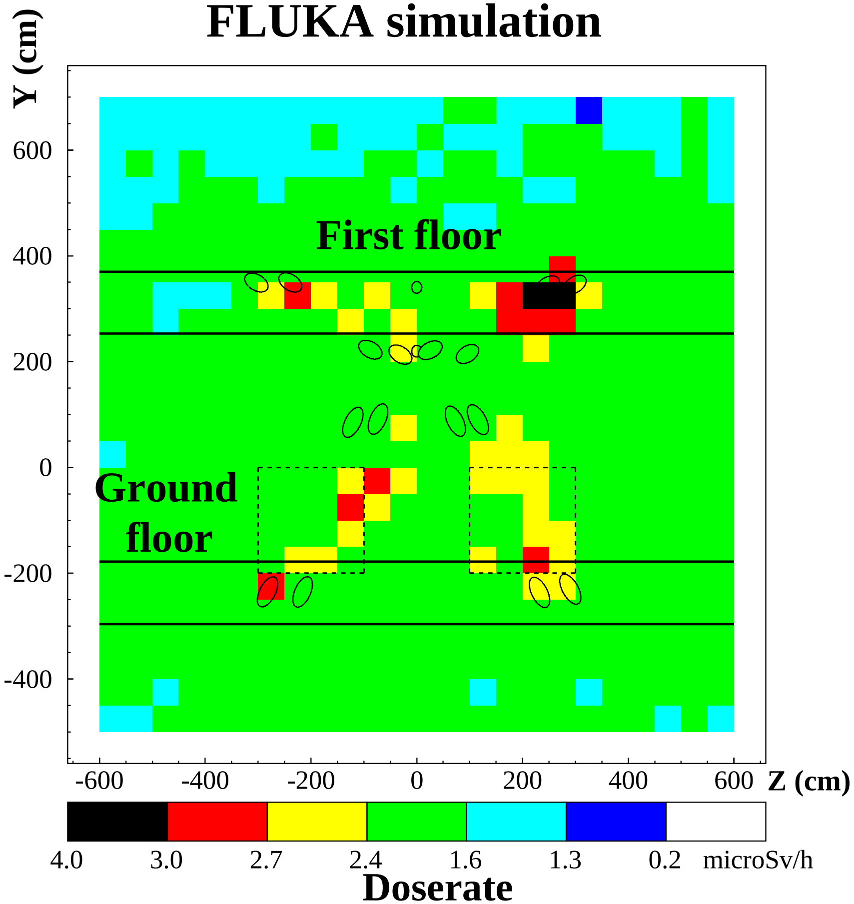
# *Radiation in the electronics cavern*

**The 2 m thick wall between the ATLAS cavern and the electronics cavern was designed such that it could be designated as a simple controlled area (i.e. unlimited access with film badge).**

**Since the predicted radiation levels in ATLAS has increased and the limits are decreasing a new study of the radiation in the electronics cavern has been made.**



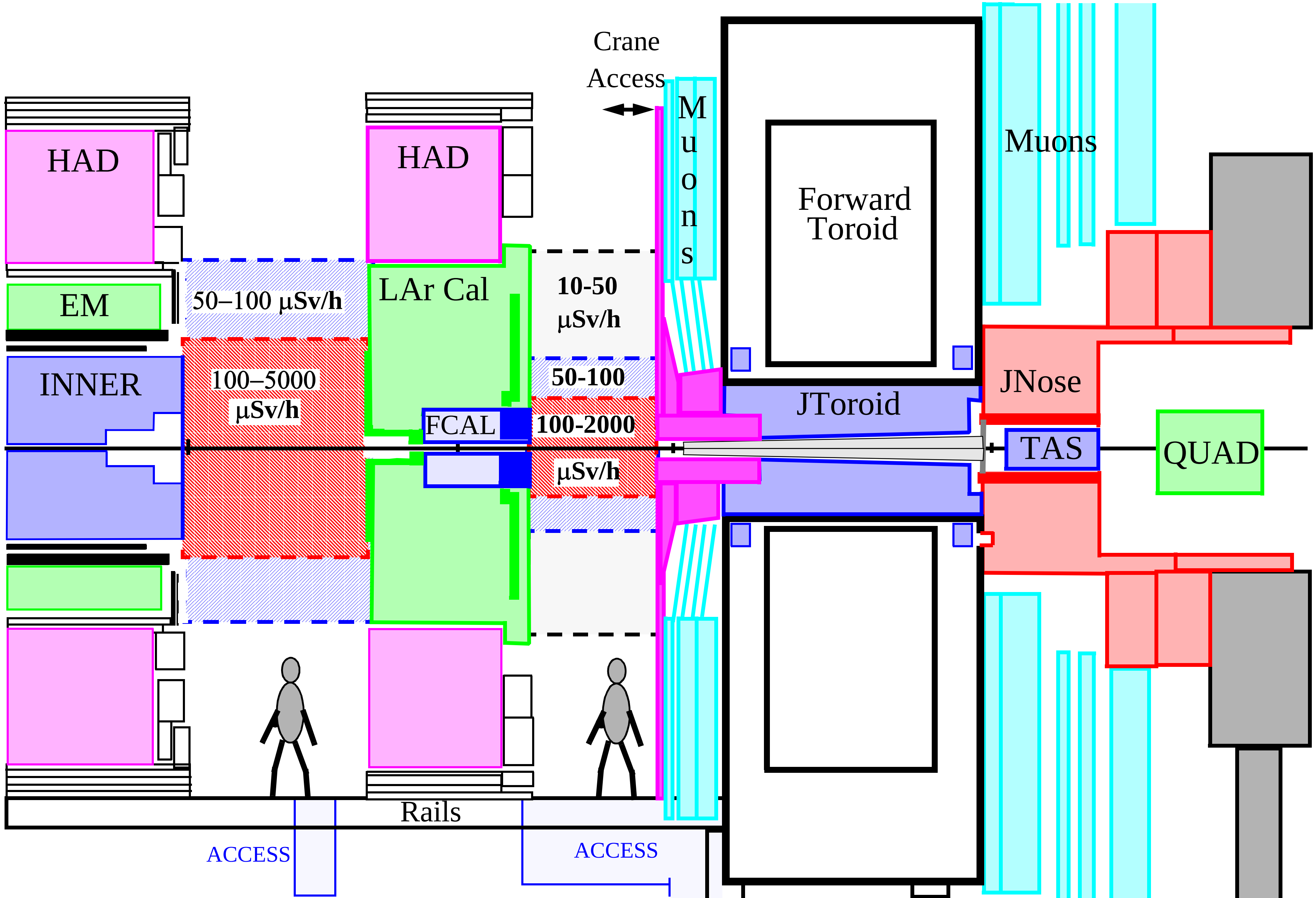

**FLUKA simulation**




**Conclusion: The dose rate in the cavern is predicted to be about 4 μSv/h which would be close to the new limits for a controlled area.**

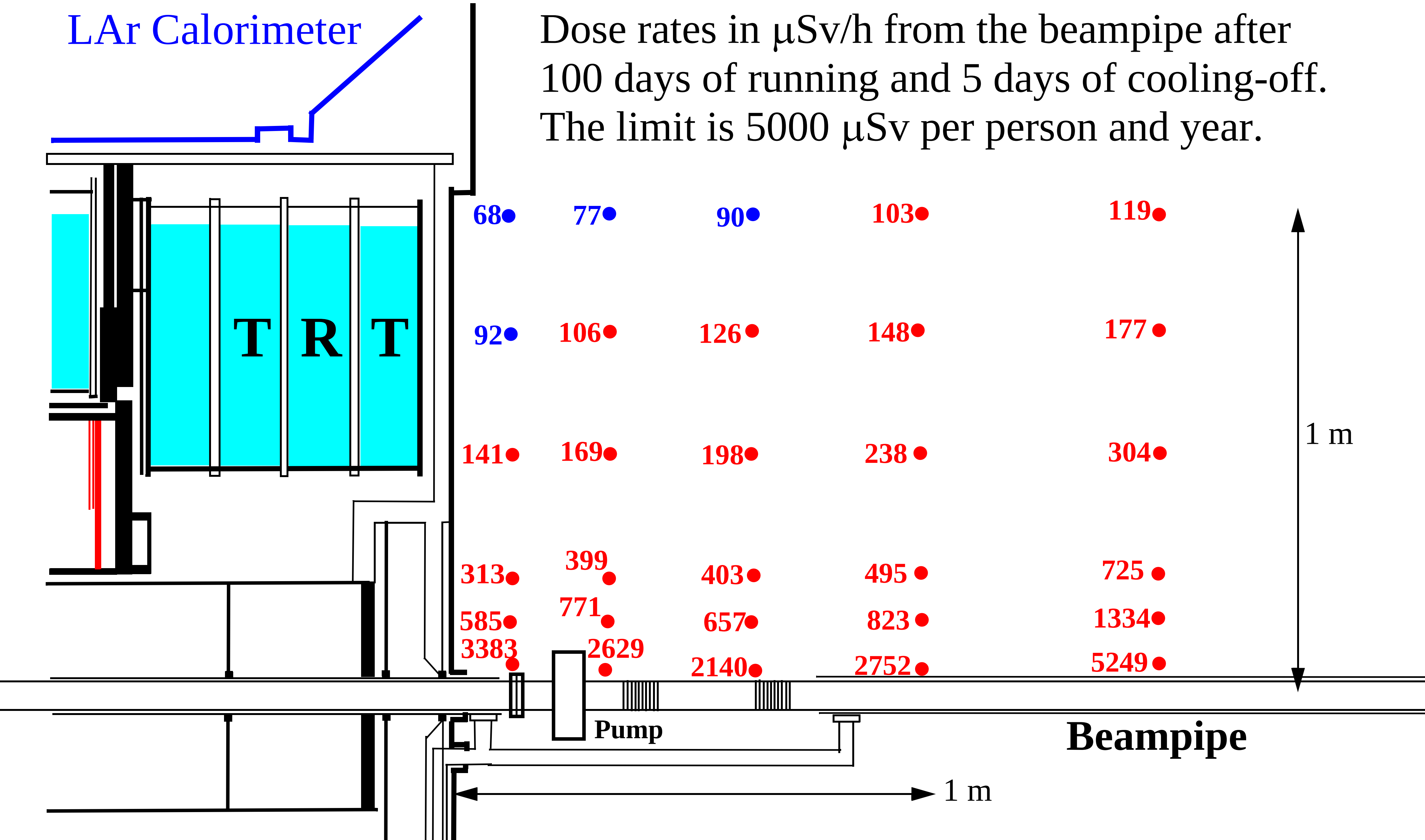
# *Induced Radiation*

Lund has collaborated with a group from the Moscow Engineering Physics Institute in order to produce maps of the induced radioactivity in ATLAS.



**Example of one out of 600 radiation maps that have been produced for different regions, running times and cooling-off times.**

Dose rates in μSv/h from the beampipe after 100 days of running and 5 days of cooling-off. The limit is 5000 μSv per person and year.



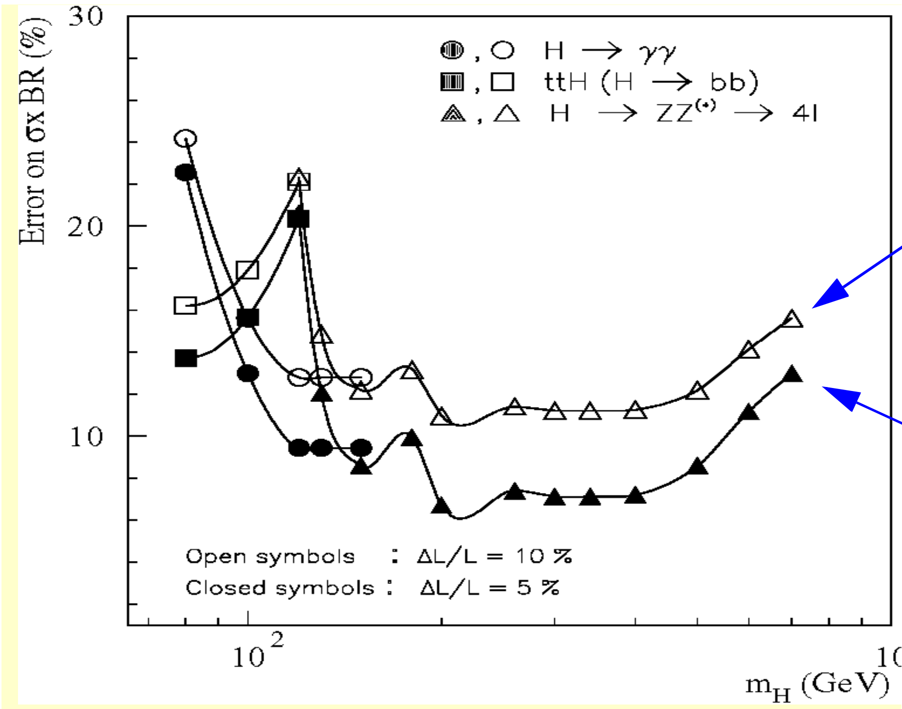
# *Luminosity determination*

ATLAS

**Higgs coupling**

**WHY ?**

**Example** →




$\frac{\Delta L}{L} = 10\%$

$\frac{\Delta L}{L} = 5\%$

**STRATEGY ?**

**Measure elastic scattering at low luminosity**
**Measure rates of well-calculable processes e.g. QED, QCD**
**Measure relative luminosity with luminosity monitors**

**GOAL ?**

**Measure the luminosity with 2-3% accuracy**

# Luminosity

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ATLAS

**Luminosity using elastic scattering data**

**Lumi = $10^{27}$ $cm^{-2}s^{-1}$**

**Roman Pots** equipped with scintillating fibre detectors will be used to measure the protons in elastic scattering events.

**Luminosity using single W/Z production**

**Lumi > $10^{30}$ $cm^{-2}s^{-1}$**

**The rate of $W \rightarrow l\nu$ is expected to be 60 Hz at high luminosity**

The uncertainty in the rate of W/Z events is currently about 4%

**Luminosity using $\gamma\gamma \rightarrow \mu\mu$ data**

**Lumi > $10^{30}$ $cm^{-2}s^{-1}$**

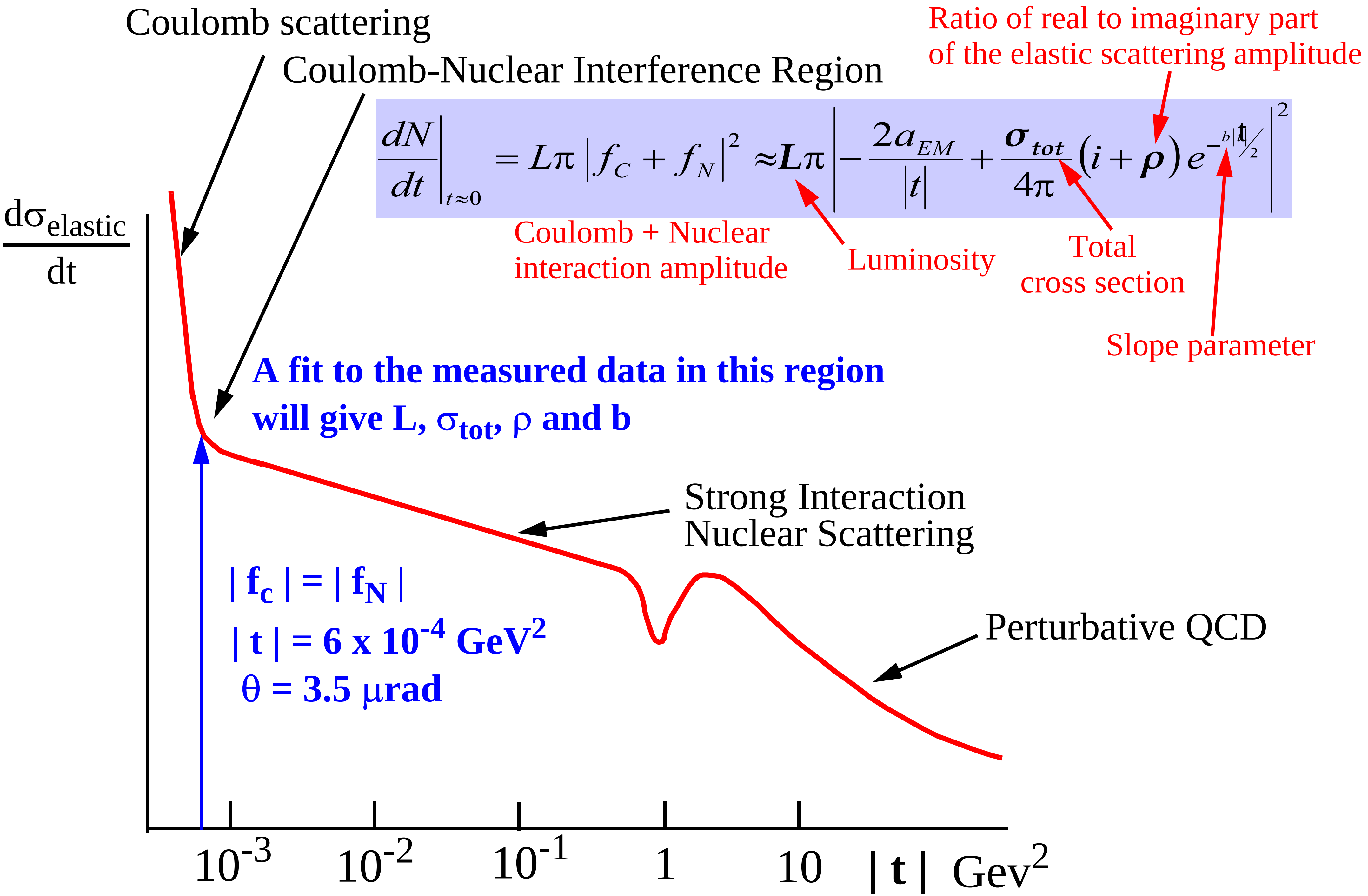
**QED process**

About 10k events/day at high lumi if $P_T$>3 GeV (1.5k if $P_T$>6 GeV)

**Overall calibration of a Luminosity monitor**

**LUCID:** A detector consisting of Cherenkov tubes that surrounds the beampipe. No absolute luminosity measurement !

# *Elastic scattering*

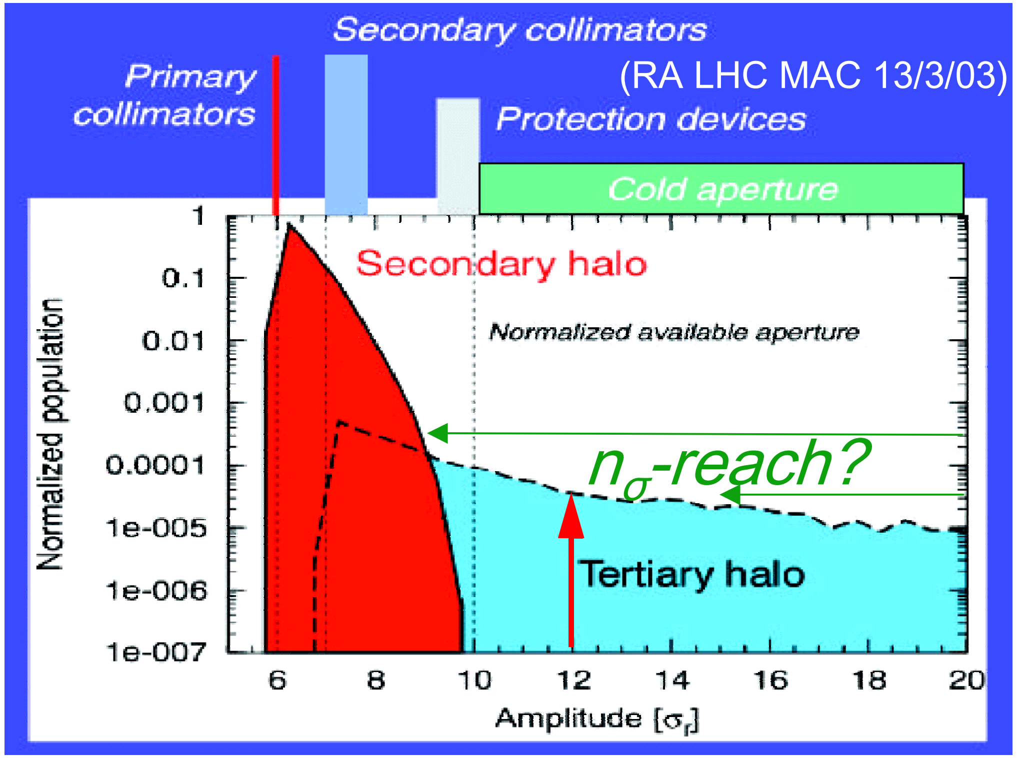


# Detector requirements

ATLAS

**The measurement of elastic scattering in the Coulomb region at the LHC is very challenging and requires a detector with the following requirements:**

- **The active area has to be very close to the beam (~1.5 mm)**
- **The detector has to be far away from the interaction point (240m)**
- **The dead space at the edge of the detector has to be small (< 100 μm)**
- **The detector resolution has to be about 30 μm**
- **The times resolution has to be about 1 ns.**

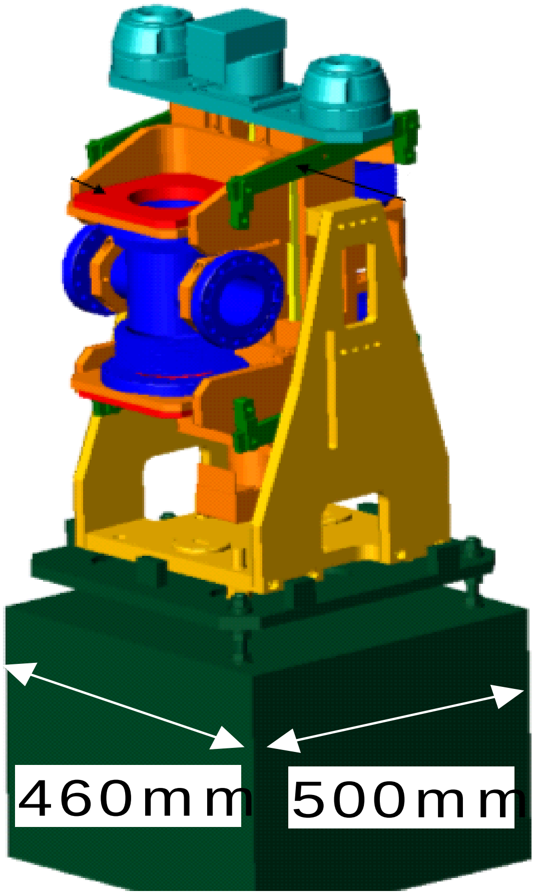


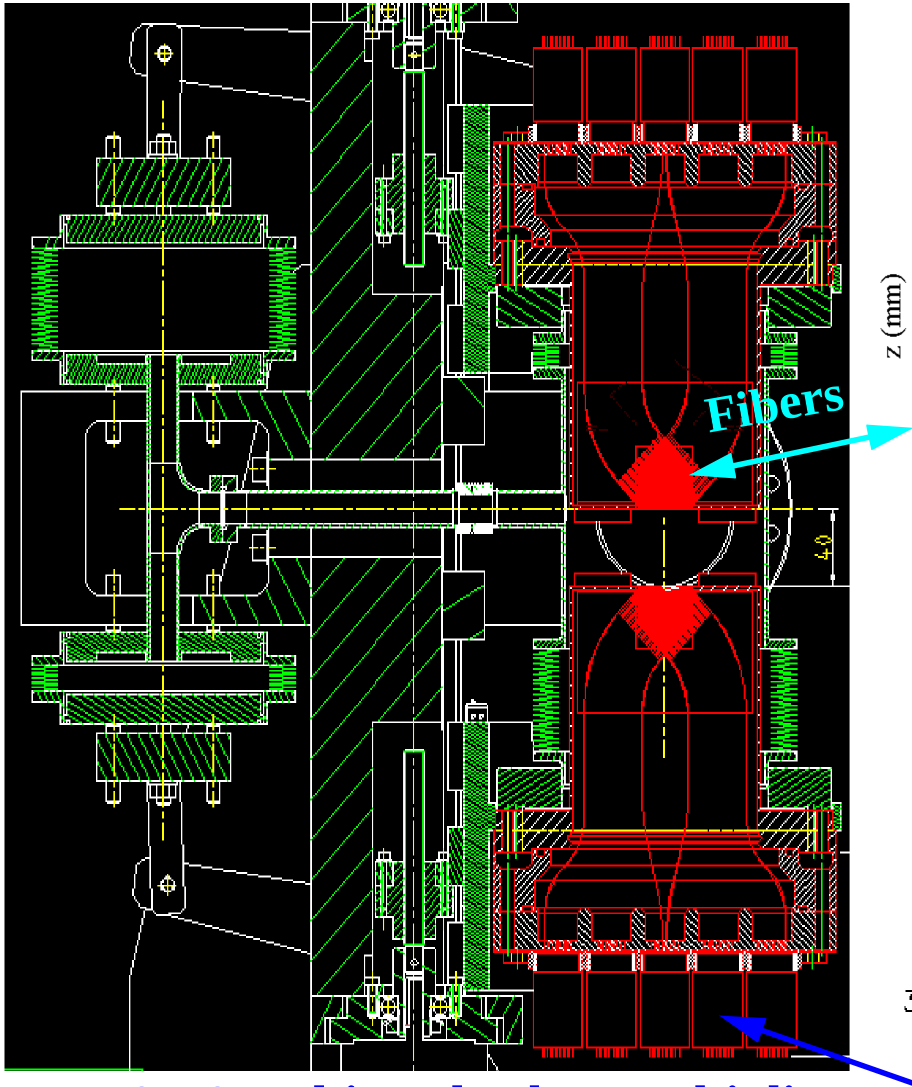

- **The detector should be insensitive to the electromagnetic pulse from the LHC beam.**

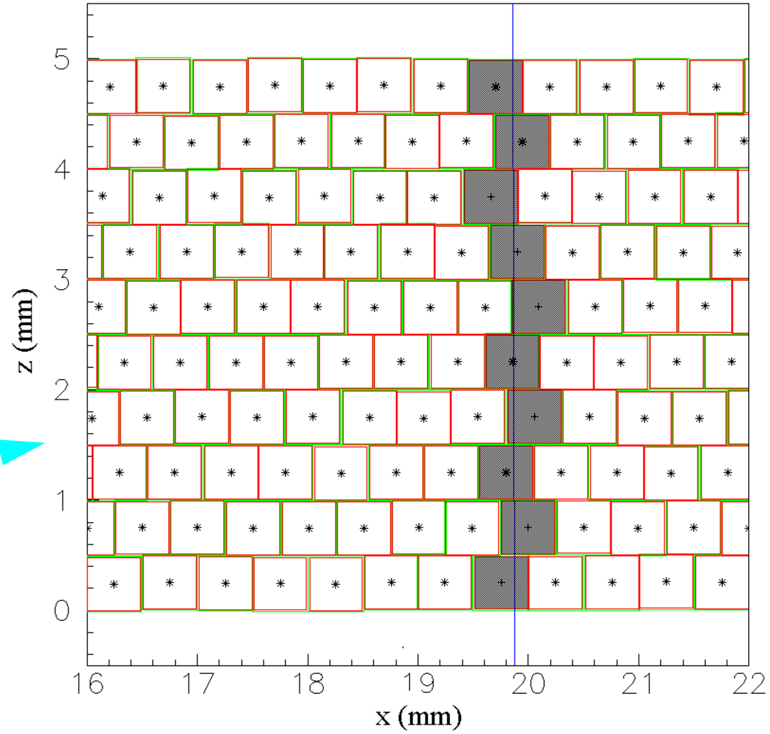
**but this is not all..... a special LHC optics is also needed to reach the Coulomb region i.e. special dedicated LHC runs are needed.**

The Roman Pots are the devices which allows the detectors to get close to the beam.

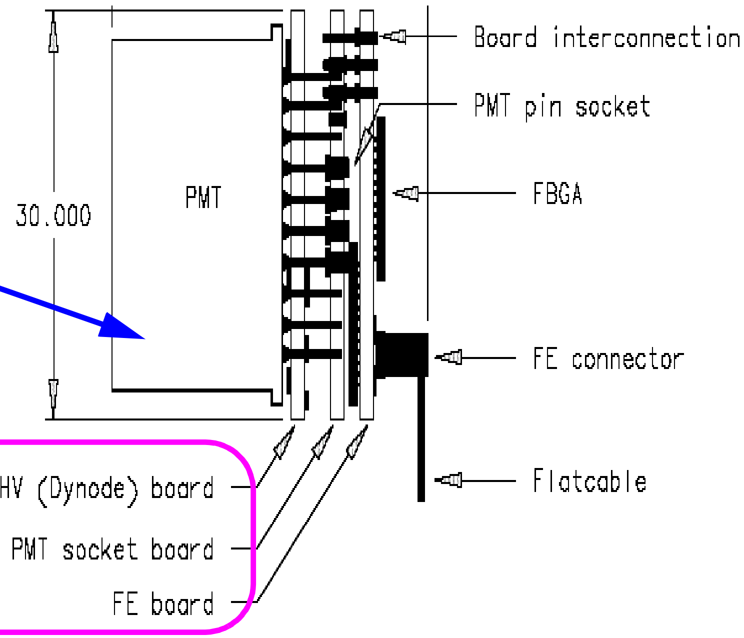
10 layers of square 0.5 x 0.5 mm scintillating fibers



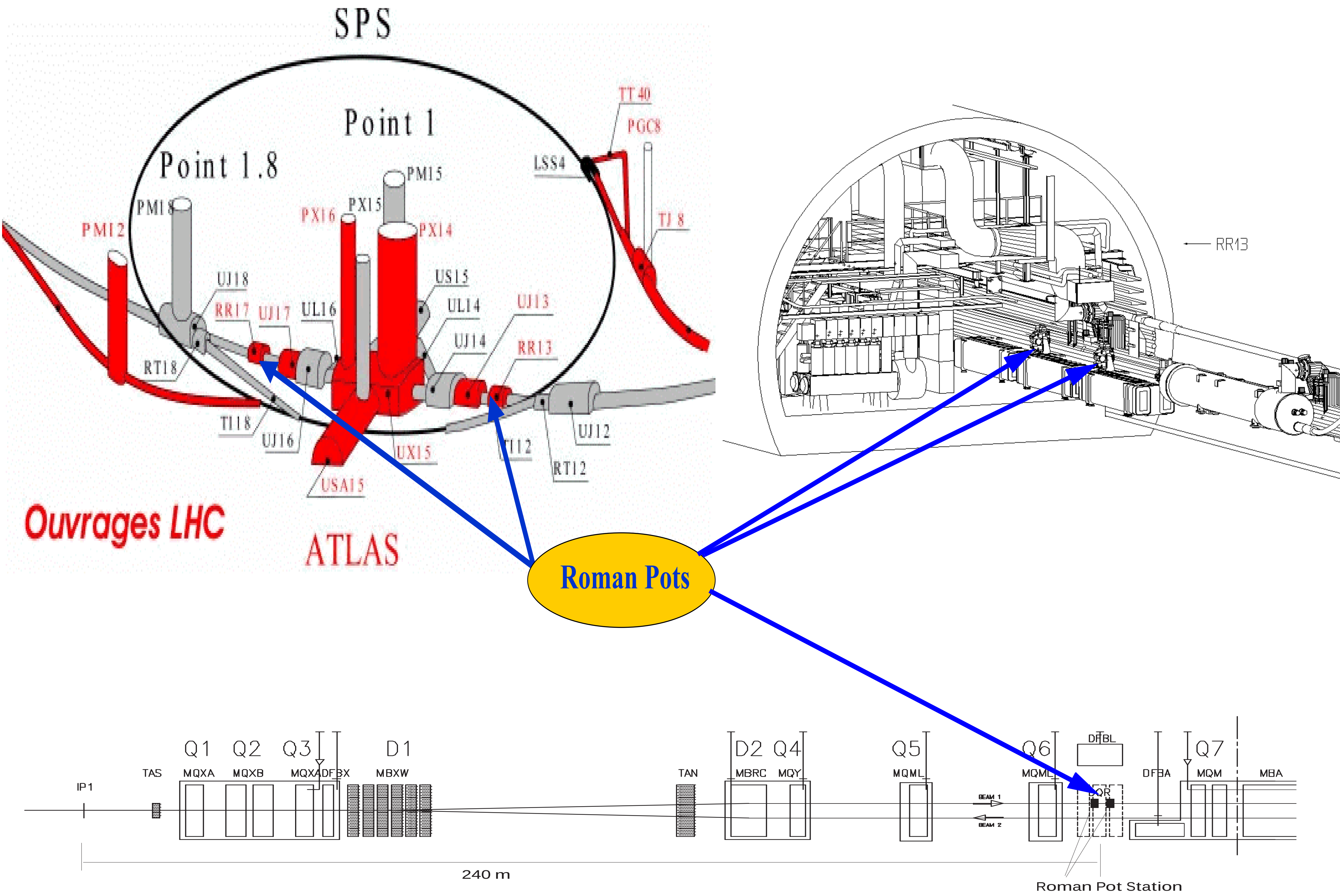




8 x 8 multianode photomultipliers




Lund is making the PC boards for the front-end electronics


SPS
Point 1
Point 1.8
PM15
PX15
PX16
PX14
PM18
PM12
LSS4
TT 40
PGC8
TJ 8
US15
UL14
UJ13
UJ18
RR17
UJ17
UL16
UJ14
RR13
RT18
TI18
UJ16
UX15
TI12
RT12
UJ12
USA15
Ouvrages LHC
ATLAS
Roman Pots
RR13
IP1
TAS
Q1
Q2
Q3
D1
MQXA
MQXB
MQXA
DFBX
MBXW
TAN
D2
Q4
MBRC
MQY
Q5
MQML
Q6
MQML
DFBL
DFBA
Q7
MQM
MBA
BEAM 1
BEAM 2
240 m
Roman Pot Station

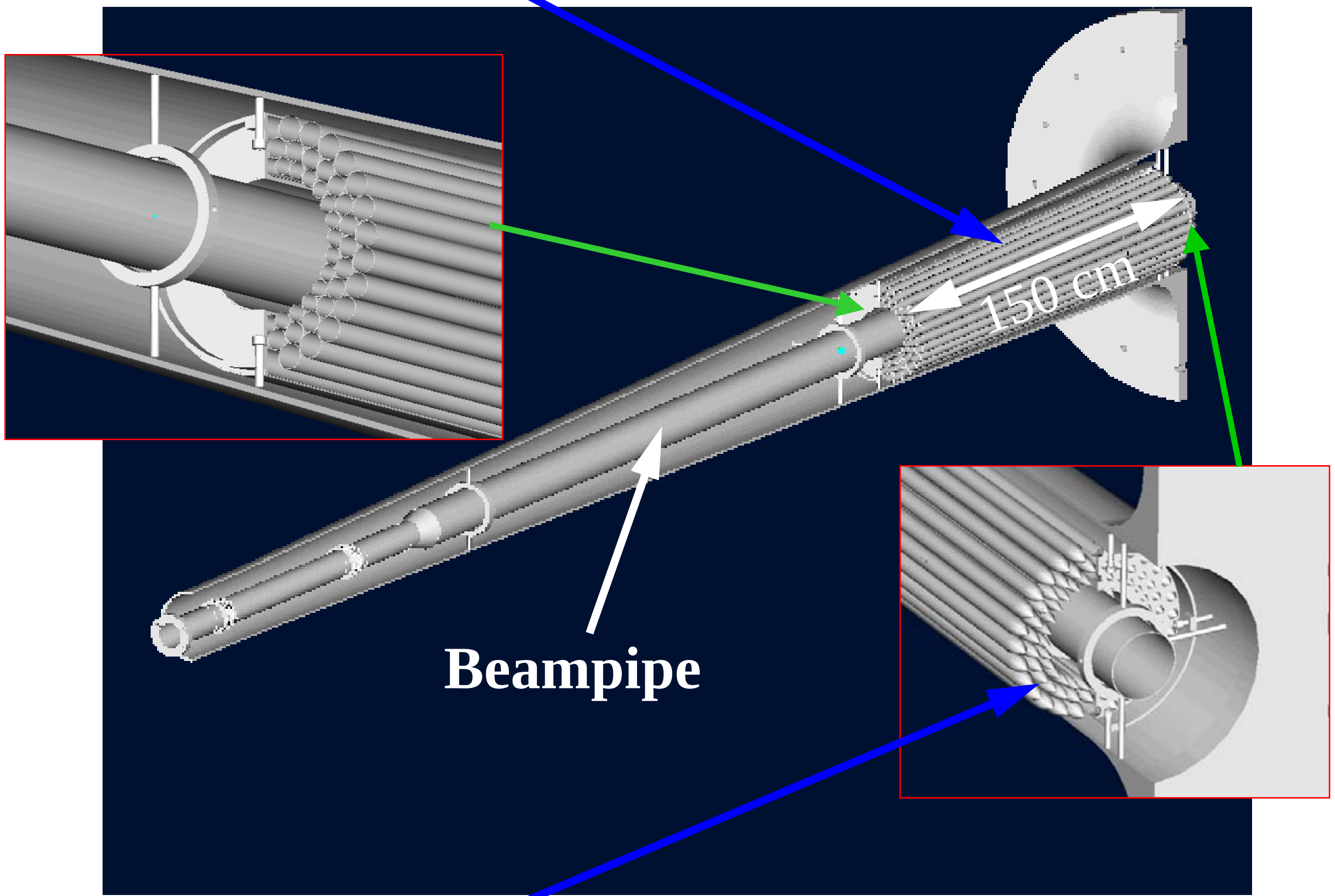
# *The LUCID Luminosity Monitor*

LUND UNIVERSITY

ATLAS

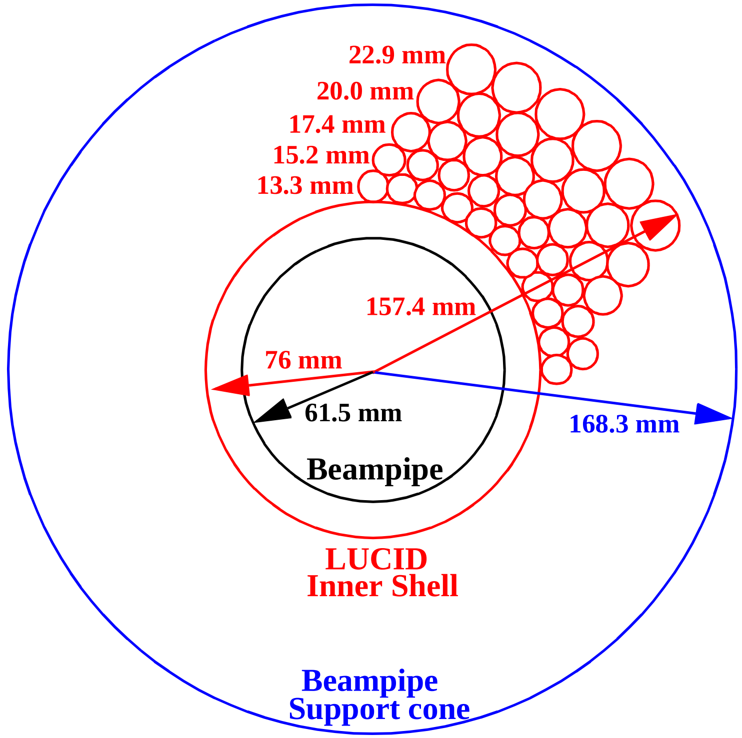
**LUCID: LUminosity measurement using a Cherenkov Integrating Detector**

2 detectors x 200 Al tubes filled with $C_4F_{10}$ or Isobutane at atmospheric pressure



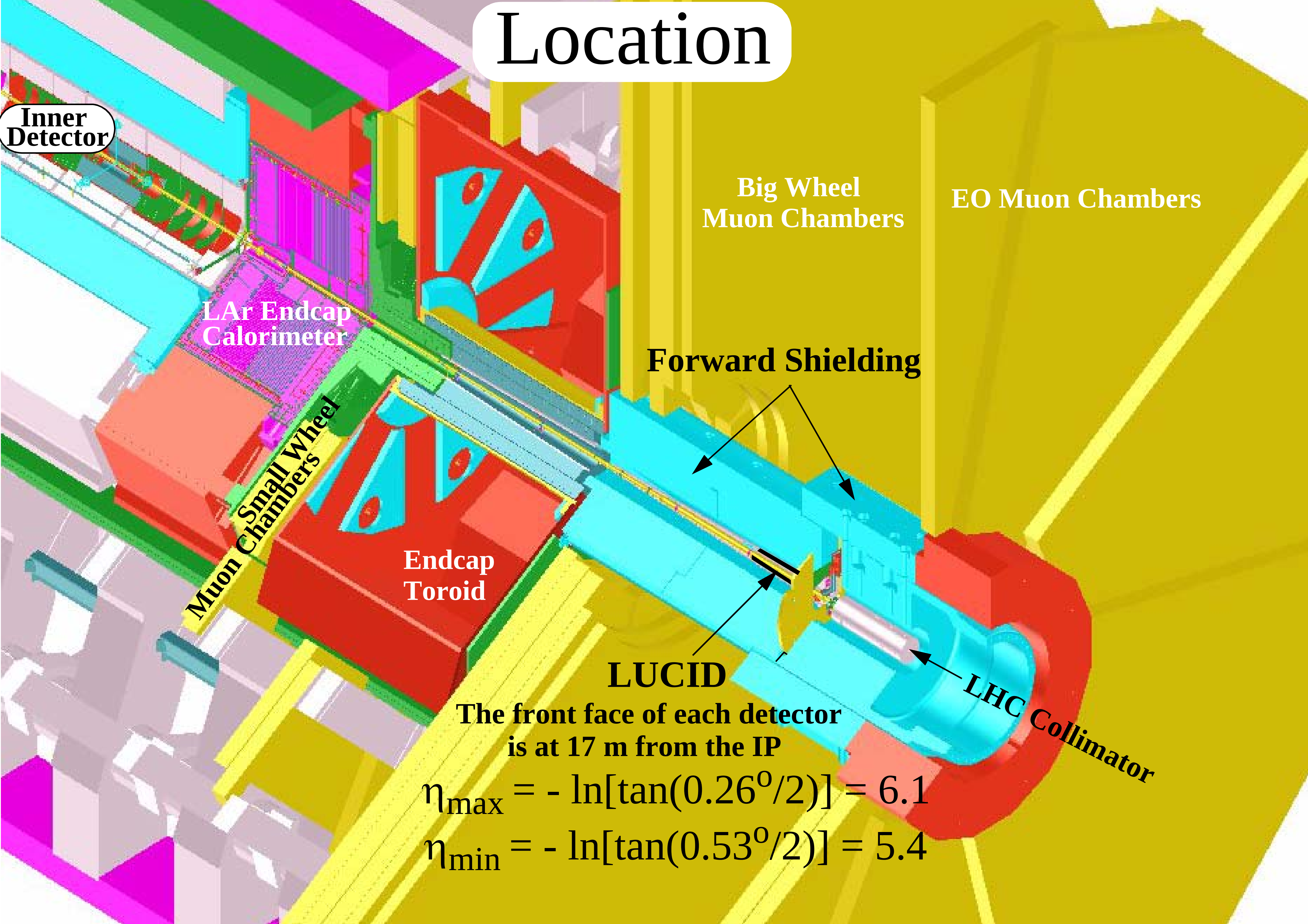

**Front view** **(Z = 16976 mm)**

**5 layers with 40 tubes each**




Winston cones at the end of the tubes focus the Cherenkov light onto quartz fibres

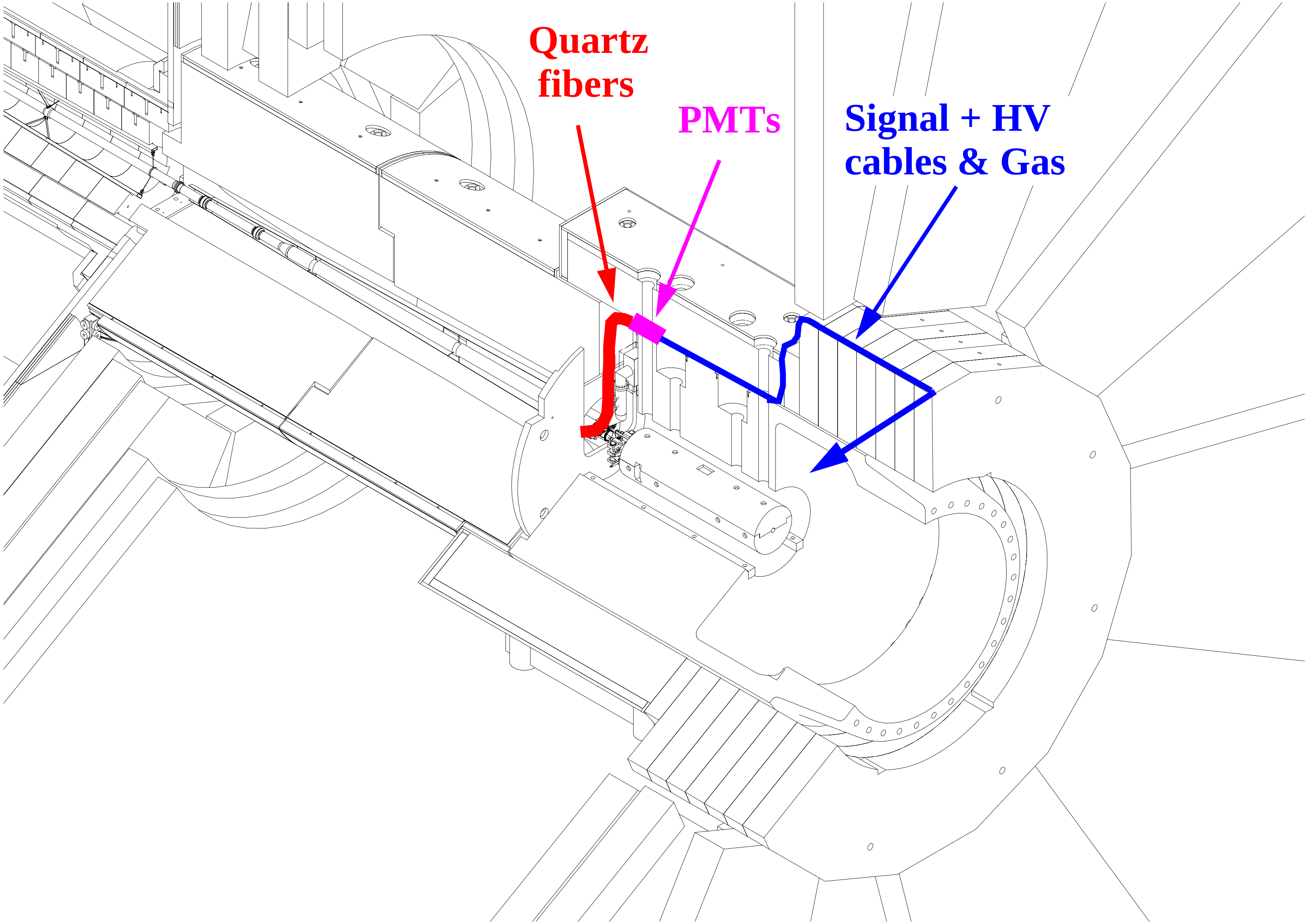
# Location




**The front face of each detector is at 17 m from the IP**

$$\eta_{max} = -\ln[\tan(0.26^o/2)] = 6.1$$

$$\eta_{min} = -\ln[\tan(0.53^o/2)] = 5.4$$

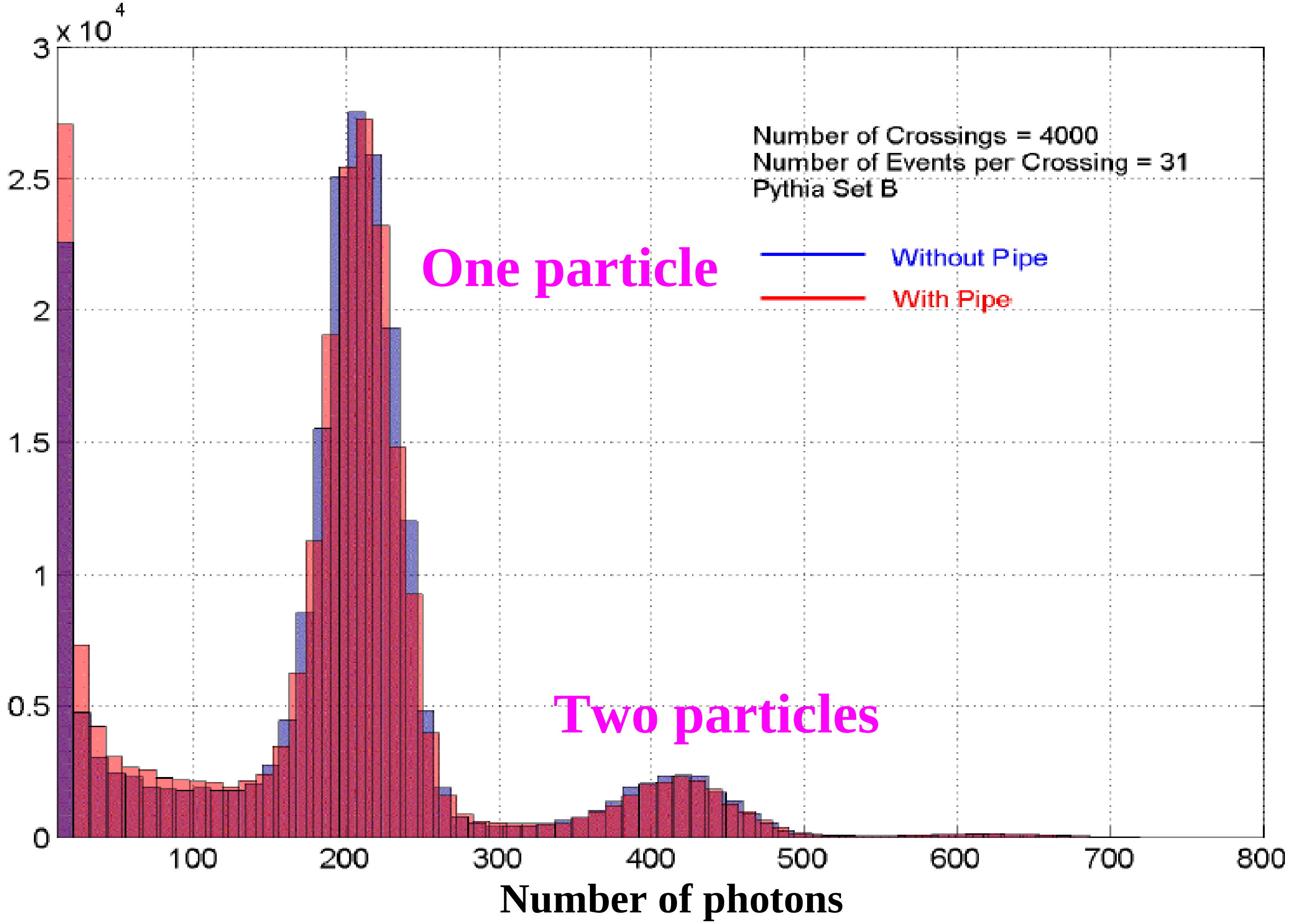

Quartz fibers
PMTs
Signal + HV cables & Gas

# LUCID Simulations

Since there is no Landau fluctuations for Cherenkov light emission one gets an excellent amplitude resolution.

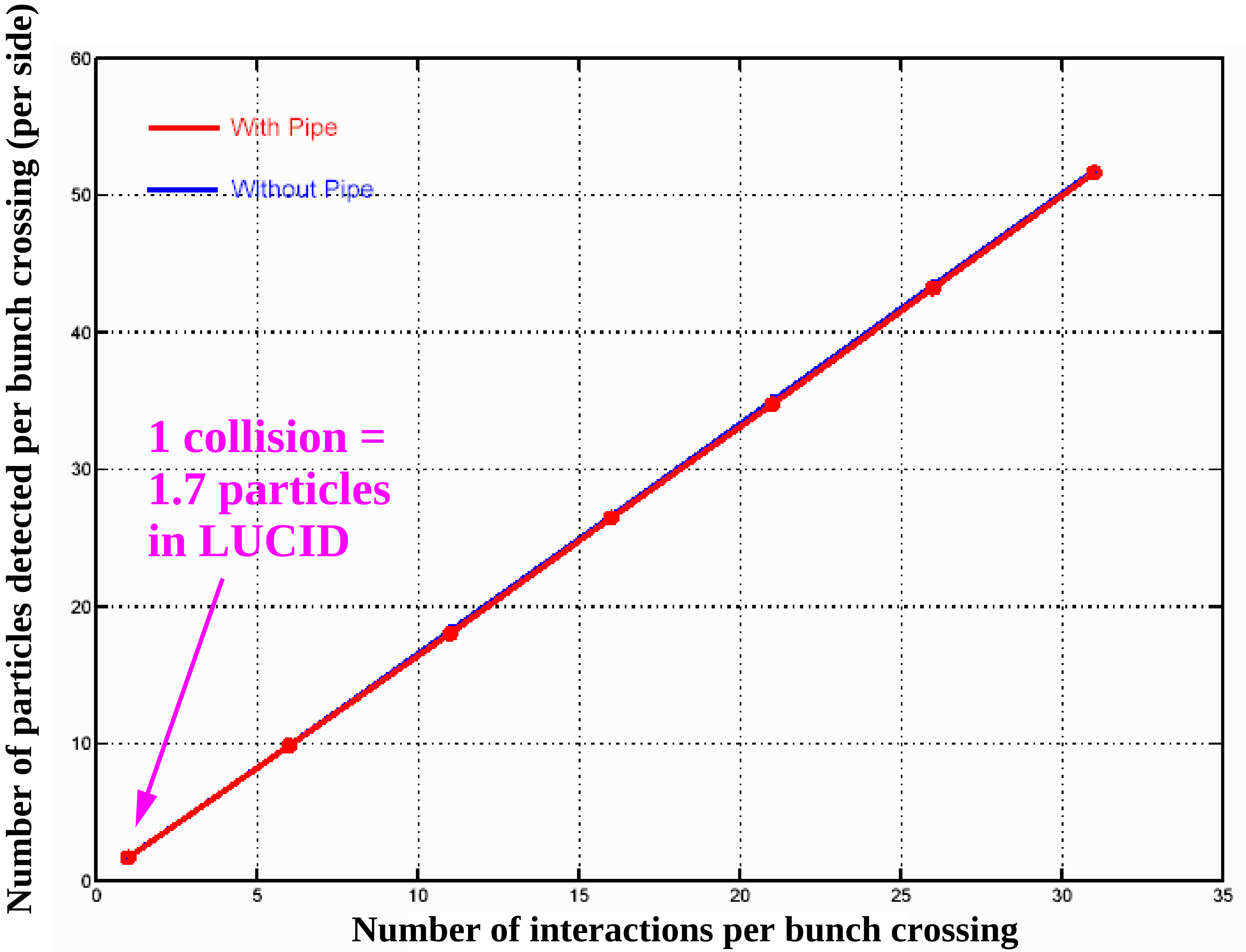
**- One can count multiple particles/tube**

**- No saturation of the detector even at very high luminosity**



# LUCID Simulations

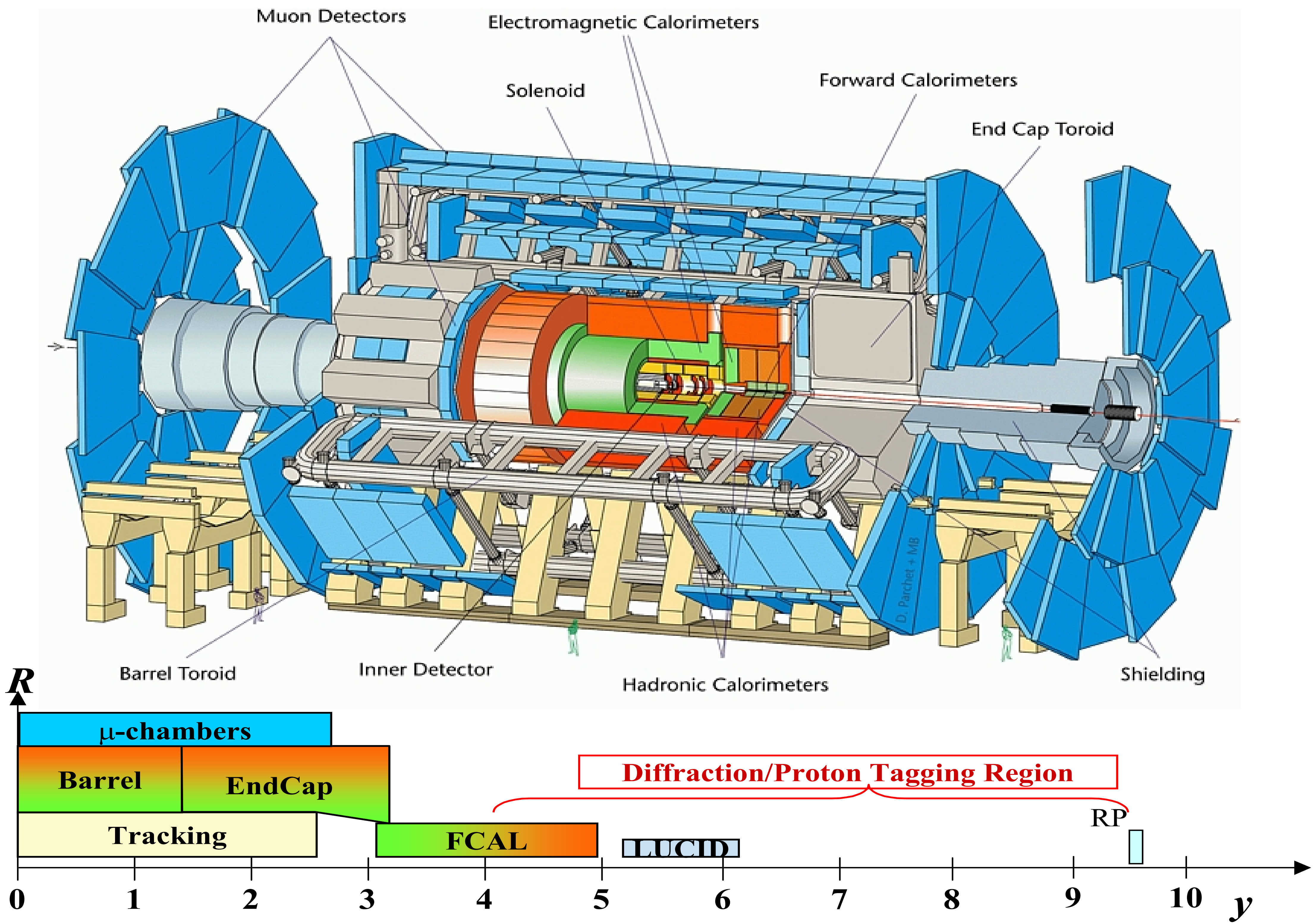
Simulations shows a perfectly linear relationship between the number of particles measured in LUCID and the luminosity.



# Detector Characteristics

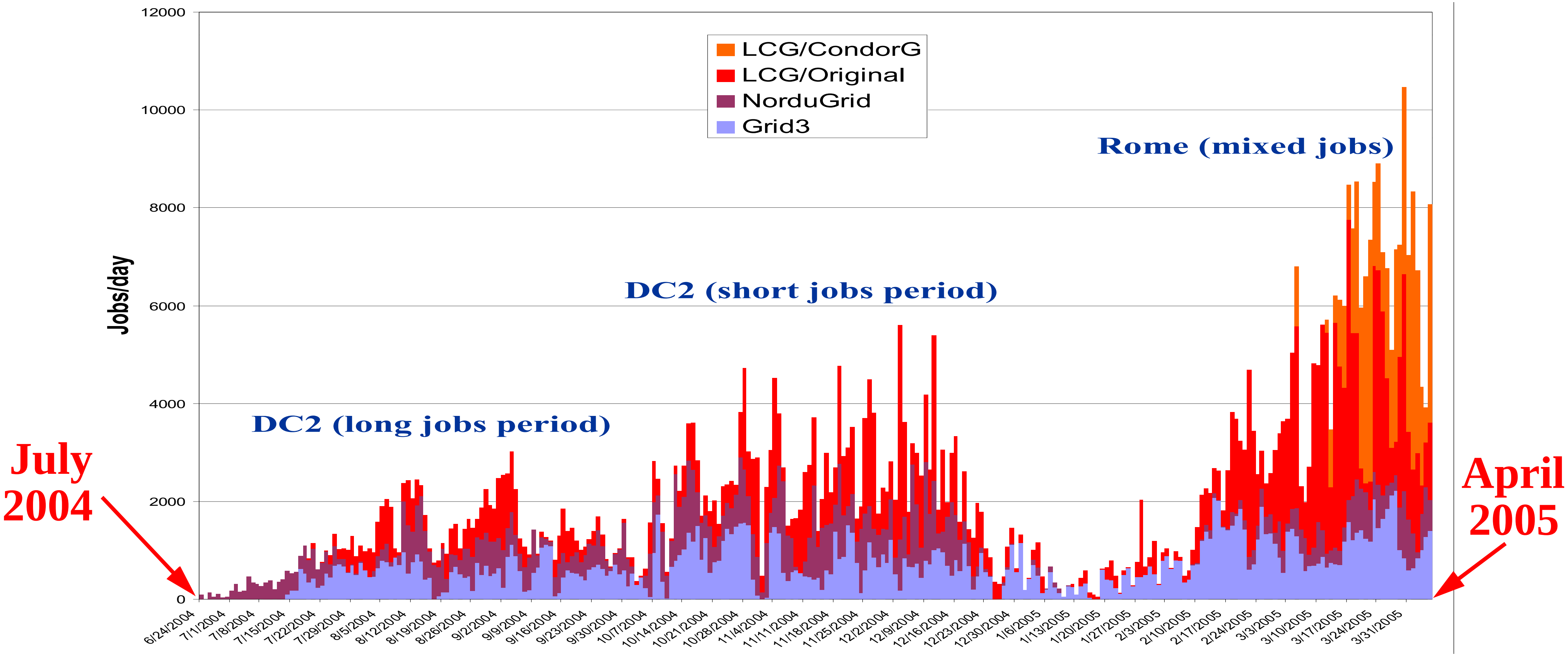
- LUCID is a 400 channel Cherenkov detector made of aluminium tubes and read out by quartz fibres connected to multianode photomultipliers.
- It is very radiation hard.
- A good time resolution makes it possible to follow individual bunches.
- It is insensitive to soft background particles due to the Cherenkov threshold.
- A measurement of the pulseheight can be used to determine when several particles goes through one tube. No saturation is expected at even the highest LHC luminosity.
- A simple, robust and cheap construction.
- A similar detector is in operation at the CDF experiment.

Lund is working on the integration of the detector in ATLAS and on front-end electronics.


Muon Detectors
Electromagnetic Calorimeters
Solenoid
Forward Calorimeters
End Cap Toroid
Barrel Toroid
Inner Detector
Hadronic Calorimeters
Shielding
R
μ-chambers
Barrel
EndCap
Tracking
FCAL
LUCID
Diffraction/Proton Tagging Region
RP
0
1
2
3
4
5
6
7
8
9
10
y

# Data Challenge 2

- ATLAS DC2 started in July 2004
- The simulation part was finished by the end of September and the pile-up and digitization parts by the end of November
- 10 million events were generated, fully simulated and digitized and ~2 million events were “piled-up”
- Event mixing and reconstruction was done for 2.4 million events in December.



# Contribution of the Lund group

ATLAS

- People: Oxana Smirnova, Balázs Kónya
- Main contribution: participation in ATLAS production via NorduGrid/ARC
  - Hardware resources (Balázs Kónya):
    - Lund Farm (~60 CPUs), contributed to DC2 computations
    - Hathi the Storage Element (~3 TB), stored DC2 production data
  - Production activities (Oxana Smirnova):
    - Production at NorduGrid/ARC: coordination, data replication, job definitions, database operations, monitoring
    - Production system: contributions to design, development and operations
    - Monitoring: design, development of tools, actual monitoring
    - Tier0-exercise (simulation of 1 day of data taking at CERN): coordination
    - Daily Grid issues: user requirements, assistance, security, general architecture decisions etc

# Summary

## Electronics for the TRT

The design of the electronics has been finished and most of the chips and boards have been manufactured. Some installation and testing work remains to be done.

## Shielding

Most pieces have been manufactured or are in production.

## Radiation

The project to predict the radiation levels and the impact of the radiation is to a large extent finished.

## Luminosity

Lund in now participating in the development of front-end electronics for both the Roman Pot and the LUCID Cherenkov detectors.

## Monte Carlo data production

Lund has participated in the Data Challenge 2 production of Monte Carlo data.