Performance of Laser Distance Sensors

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February, 13^{th} 2015

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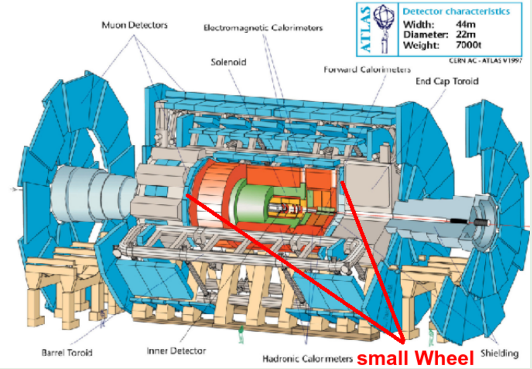
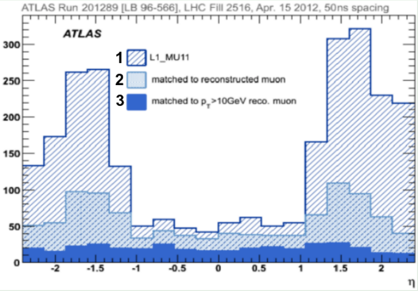


2018: New Small Wheel

Trigger Isue

Level 1 Trigger Rate

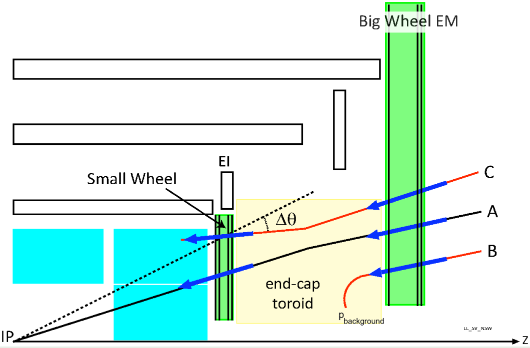


1. all L1_MU11 Triggers (10 GeV muons)
2. reconstructed tracks with $P_T > 3\ GeV$
3. reconstructed tracks with $P_T > 10\ GeV$
   homogeneous distribution
   90% false triggers in endcap region ($|\eta| > 1$)

- Extrapolated rate of L1_MU20: 60 kHz for design luminosity $\mathcal{L} = 10^{34}$
- Close to bandwidth limit: 100 kHz

Reasons for High Trigger Rate

1/4 of ATLAS detector



- Sofar only Big Wheel included in L1 trigger
- including angular information

After reconstruction a currently good μ-trigger in Big Wheel can be:

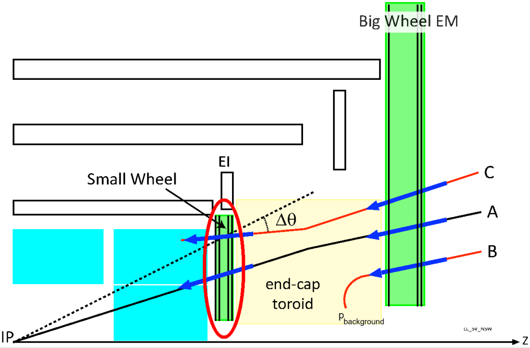
A Track pointing to IP
Correct muon track

B No hit in Small Wheel
e.g. proton faking muon

C Track not pointing to Interaction Point
e.g. background event

Reasons for High Trigger Rate

1/4 of ATLAS detector



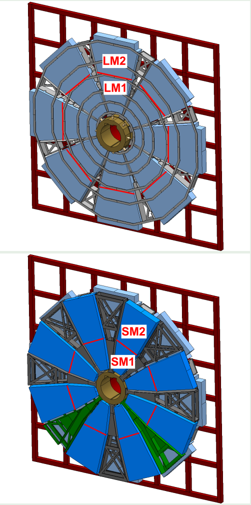
Idea

False triggers can be sorted out by including the Small Wheel in the Level 1 trigger.

$\Rightarrow$ Upgrade of the Small Wheel, $\Delta\theta \leq 1$ *mrad*

New Small Wheel Assembly

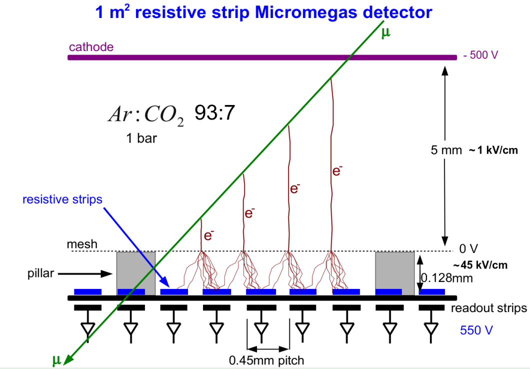
Sectors of NSW



- disklike structure:
  - eight large sectors
  - eight small sectors
- Each sector subdivided into two detector units
- Detector unit: two quadruplets of MM and sTGC each
- trigger: eight layers of sTGC
- precision: eight layers of Micromegas
- SM2 to be built at LMU

Working Principle of Micromegas Detectors

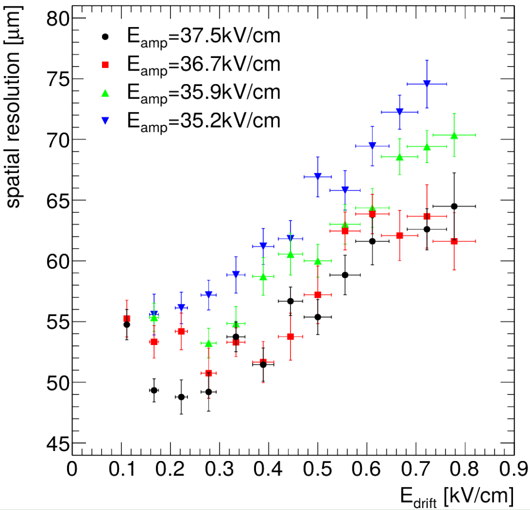
Sketch of a MM Detector



- electronic single strip readout
- measure charge center $\sigma < 50\ \mu m$
- need of a precise readout plane
  - pitch
  - planarity
  - drift gap
  - amplification gap

Achieved Resolution

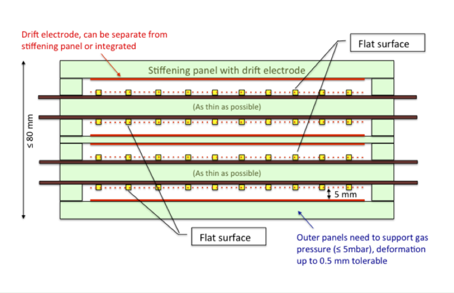
Resolution of Micromegas (Bortfeld, 2014)



($50 \times 50\ cm^2$ MM,
120 GeV Pions,
H6-Beamline CERN,
perpendicular beam)

MM Construction as quadruplets

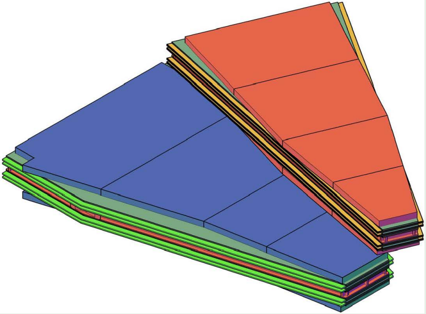
Sketch of a MM Quadruplet



- 1 quadruplet = 5 sandwhich panels
- Panel size $\approx 2\ m^2$ (SM2)
- Planarity requirement 80 μm over 2 m^2
- About 160 surfaces to measure
- Measurment duration / panel:
  Tactile: $\approx 8\ h$
  Laser: $\approx 1\ h$

Sectors of the New Small Wheel

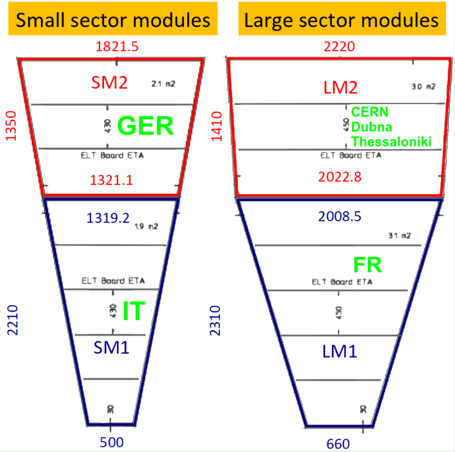
Small and large sector



- Red and Blue:
  sTGC's: small strip Thin Gap Chambers
  for trigger
- Orange and green:
  Micromegas: micromesh gaseous structure
  for precision coordinate
- Structure of a single sector:
  one module sTGC
  one module Micromegas
  one module Micromegas
  one module sTGC

Sectors of the New Small Wheel

Small and large sector

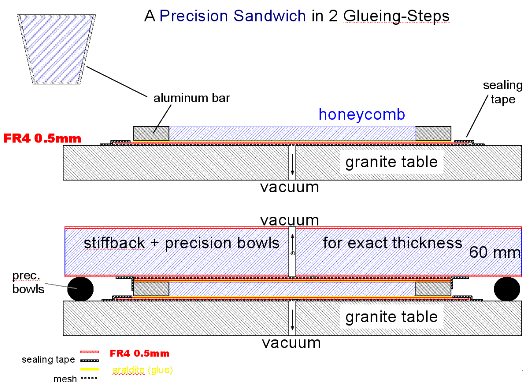


SM2:

- three readout boards per readout plane
- 1024 strips each
- 0.45mm pitch
- alignment requirement: $20\ \mu m / 2\ m = 10^{-5}$

Glueing Process

Steps of the glueing process

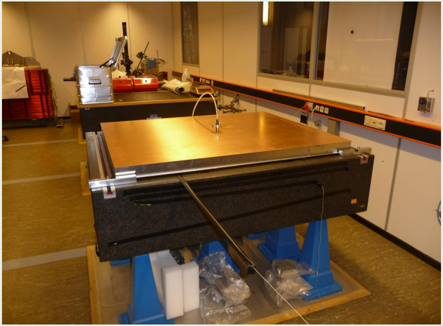


- Two step glueing process
- Need precision needed during glueing
- Need to monitor the glueing process using the stiffback

Glueing Process of a Prototype

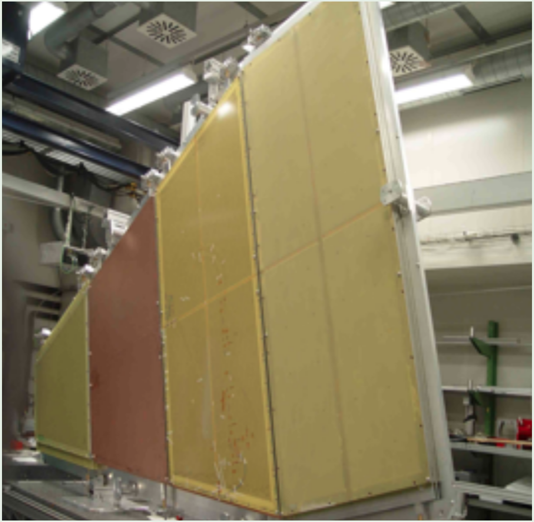
Glueing the first side

Glueing the second side



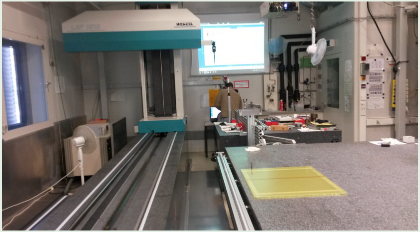
Assembly of Four Mechanicle Prototypes in Freiburg

Mechanicle Prototype in Freiburg



Planarity Measurment Freiburg - Tactile

CNC - Measurment Freiburg

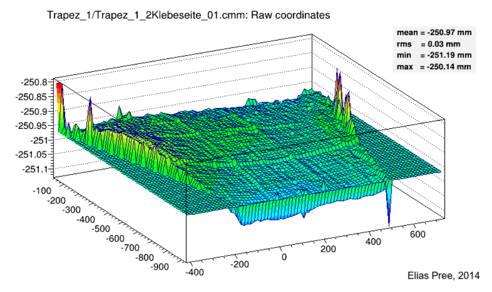


- CNC coordinate measurment system
- Topology Measurement of all five panels

Sensor of CNC Machine

Result of Planarity Measurment in Freiburg

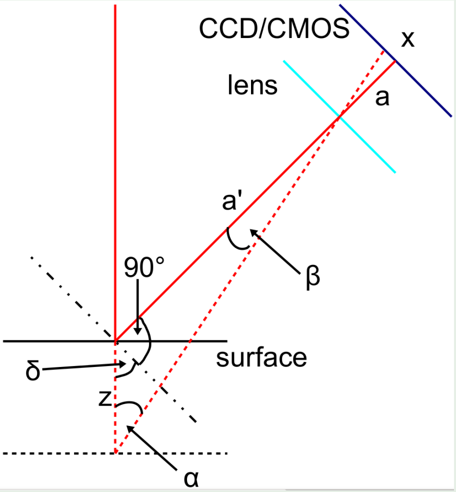
Topology of a Panel



- Grid visible
- 15 μm structure included intentiully for diagnostics
  $\Rightarrow$ Planarity OK
- Edge effects outside active area

Laser Distance Sensor Using Triangulation

Scheme of Triangulation



- Known constants: $a,\ a', \delta$
- According to the scheme one gets

$$\alpha = 90^\circ - \delta - \beta \equiv \delta' - \beta \quad (1)$$

$$\tan\beta = \frac{x}{a} \quad (2)$$

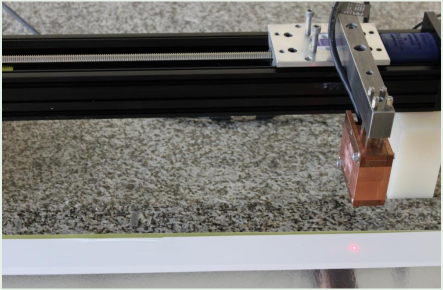
$$\frac{\sin\alpha}{a'} = \frac{\sin\beta}{z} \quad (3)$$

- Using (1), (2) and (3) one obtains

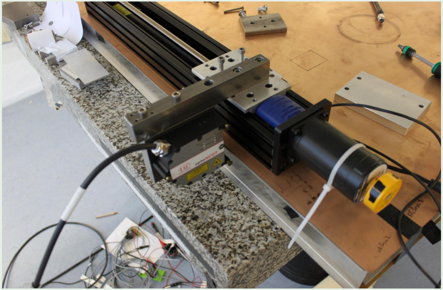
$$z = x \cdot \frac{a'}{a} \cdot \frac{1}{\sin\delta' - \frac{x}{a}\cos\delta'} \quad (4)$$

Available Sensors

Panasonic HLG-112-S-J



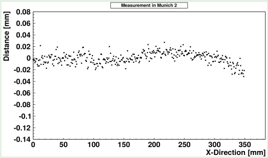
microEpsilon ILD2300-20



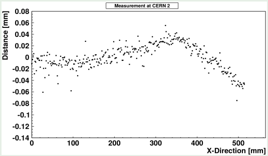
Results obtained with both sensors mounted on a vertical translator will be displayed in the following slides

Comparison between Laser Sensor and Reference Measurement

quad. panel



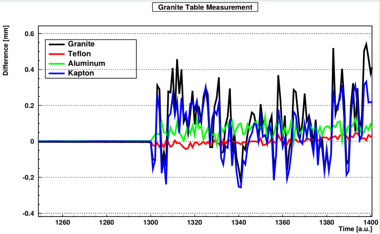
quad. panel (ref)



- $50 \times 54 cm^2$ panel
- Differences caused by permanent deformation
- Time between measurments ≈ 0.5 *a*
- Laser based topology measurement seems aplicable

Semitransparent Surfaces measurable using Panasonic?

Measurement of Granite Table



- Granite table as reference surface
- Four line measurements along identical line:
  - Granite table: contains semitransparent crystals
  - Kapton foil: 20 μm semitrsparent
  - Aluminum: rough surface
  - Teflon: smooth non transparent surface

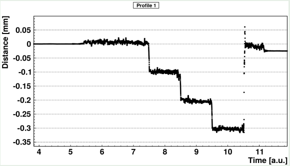
$\Rightarrow$ Panasonic sensor not suitable for semitransparent surfaces

microEpsilon Sensor

- Spot size $40 \times 40\ \mu m^2$
- specular reflection measurment mode (for semiransparent surfaces)
- 40 *mm* working distance ± 10 *mm*

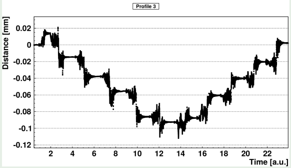
Topology of Calibration Profiles

Profile 1

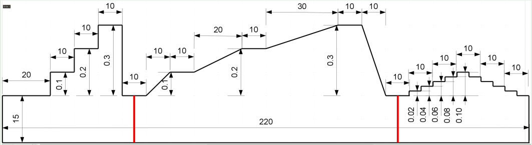


Profile 2

Profile 3



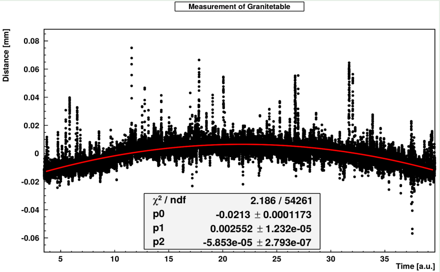
Machined Aluminum Profile



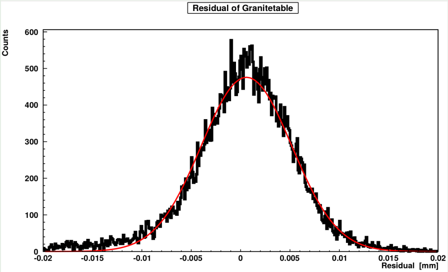
- Possibility to measure very small deviations.

Sag of Aluminum Profile against Granite Table

Measurement of Granite Table



Residuals of Granite Table



- Visible bending of aluminum profile
- Deviation from parabolic fit $\Rightarrow$ additional non planarity
  - granite surface
  - imperfection in alu profile
- Overall planarity: $\sigma = 4.6\ \mu m$

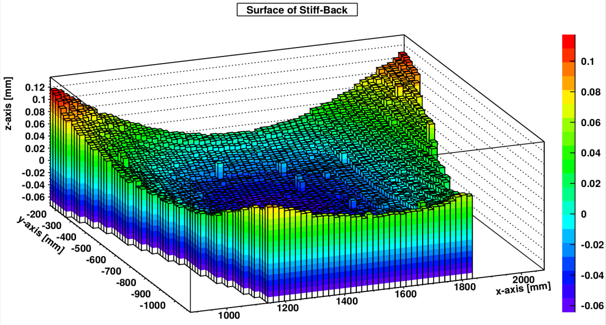
Summary

- Upgrade project of the ATLAS muon spectrometer
- Construction of SM2 modules at LMU
- Quality controll of the MM panel surface mandatory
- Non tactile, laser based measurements
- Panasonic Sensor HLG-112-S-J:
  1. 8 μm Resolution
  2. Able to measure nontransparent surfaces
- microEpsilon ILD2300-20:
  1. 0.3 μm Resolution
  2. Able to measure semitransparent surfaces such as PCB or granite table
  3. Smaller beamspot $\Rightarrow$ strips can be resolved
  4. total resolution of measurment system $< 10\ \mu m$

Thank you

Planarity Measurment of Stiff-Back in Freiburg

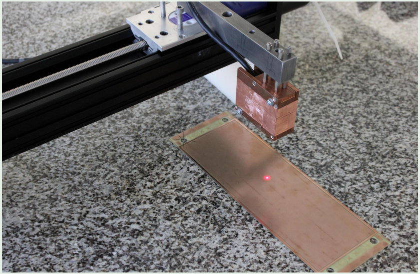
Topology of Old Stiffback (E. Pree)



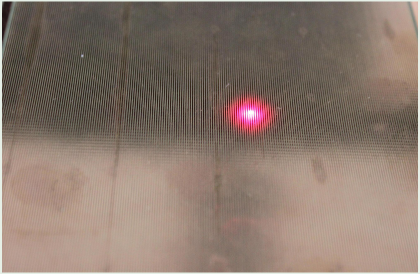
- Stiff-back shows a sag of more than 160 μm under its own weight
- Explanation of deformation of panels
- A more rigit stiff-back is needed for NSW production

Micromegas Strip Pattern

Topology of Strippattern

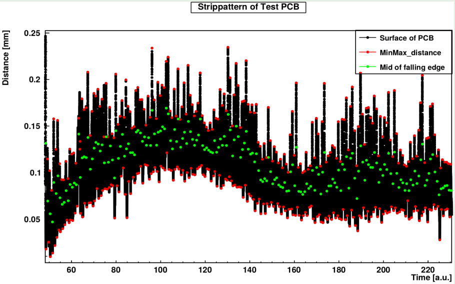


Topology of Strippattern



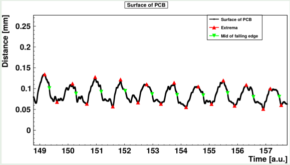
Topology of PCB with Cu Strips

Topology of Strippattern



- Strip pattern with 203 strips and 450 μm pitch
- Measuring the strip pitch by
  1. Distance between min / max $\mu = 450.8\ \mu m$; $\sigma = 74.5\ \mu m$
  2. Distance between falling edges $\mu = 451.1\ \mu m$; $\sigma = 52.5\ \mu m$

Zoom



Strip Pitch