GENEVE, SUISSE

Date: 10th January 2017

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CMS-I-UR-0275
EDMS: 1751642

CMS – RE+3/1

SCANNING OF YE+2 & YE+3 FOR RE+3/1 INTEGRATION STUDIES

CERN – UXC55 – JANUARY 2017

- Scanning campaign for RE+3/1 integration studies -

The EDMS document 1751642 containing this report is available at the following address:
https://edms.cern.ch/document/1751642

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1 INTRODUCTION

Following a request from Ian CROTTY and Nebojsa SMILJKOVIC, in order to determine the available space for RE+3/1 RPC chambers, surfaces between YE+2 and YE+3 around the CSC chamber ME+3/1/13 (below the beampipe on far side) have been measured with the laser scanner. Traditional measurements with theodolite have also been done to set the scan data onto local Yoke Endcap coordinate system and to measure some M12 holes on YE+3.

This report describes the work done by survey team. As a result, point clouds compatible with CATIA software have been transferred to Nebojsa SMILJKOVIC from the CMS integration office. The point clouds (igs. files) are available on dfs at the following address:
\\cern.ch\dfs\Support\SurveyingEng\Instruments\LaserScanner\DataSets\Experiments\CMS\170110_RE3-1_ZP_Endcaps

NB: The full point cloud data measured are still available at the survey office, in case of need of another part of the measured area (in CMS/Scans survey folder on dfs)

Measurements have been done at CERN – UXC55 on 10th January 2017.

Accuracy of each individual point: XYZ: +/- 3 mm at one sigma level (estimated value)
Results are provided in Yoke Endcap YE+2 or YE+3 local coordinate system

Data acquisition with the 3D laser scanner took 1.5 hour in UXC55 cavern.
Complete post-processing treatment of the data took 3 working days in office.

2 COORDINATE SYSTEM

2.1 YE+2 Coordinate system

The calculation has been done in the YE+2 local coordinate system given by the photogrammetry of the Yoke Endcap YE+2, made on the reference holes. For further details concerning this photogrammetry, please see the EDMS report CMS-SG-UR-0067 version 2.

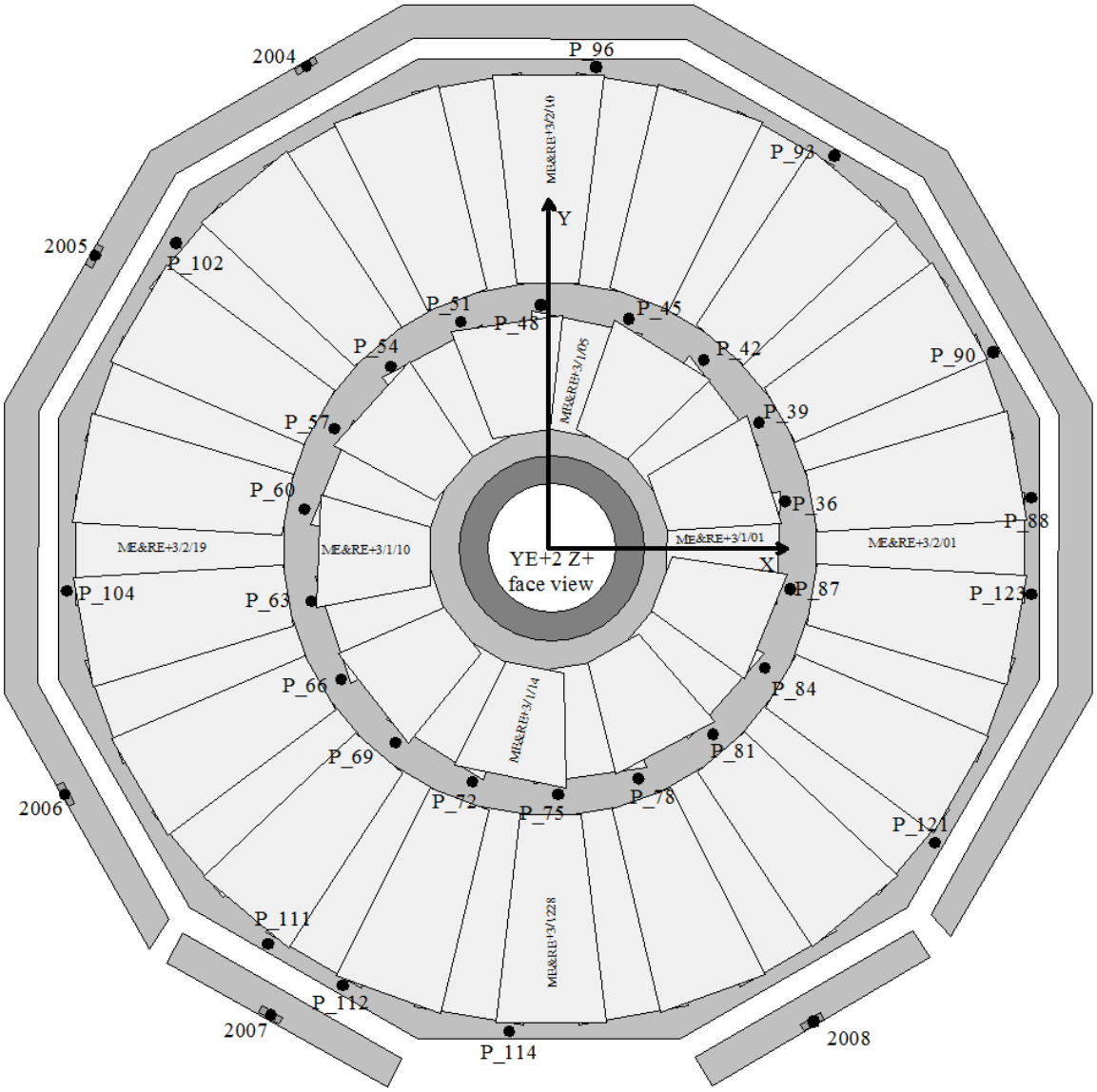

Figure 1. YE+2 Z+ face

2.2 YE+3 Coordinate system

The calculation has been done in the YE+3 local coordinate system, given by the fiducilisation of the Yoke Endcap YE+3, made on the reference holes. For further details concerning this fiducialisation, please see the EDMS report CMS-SG-UR-0177.

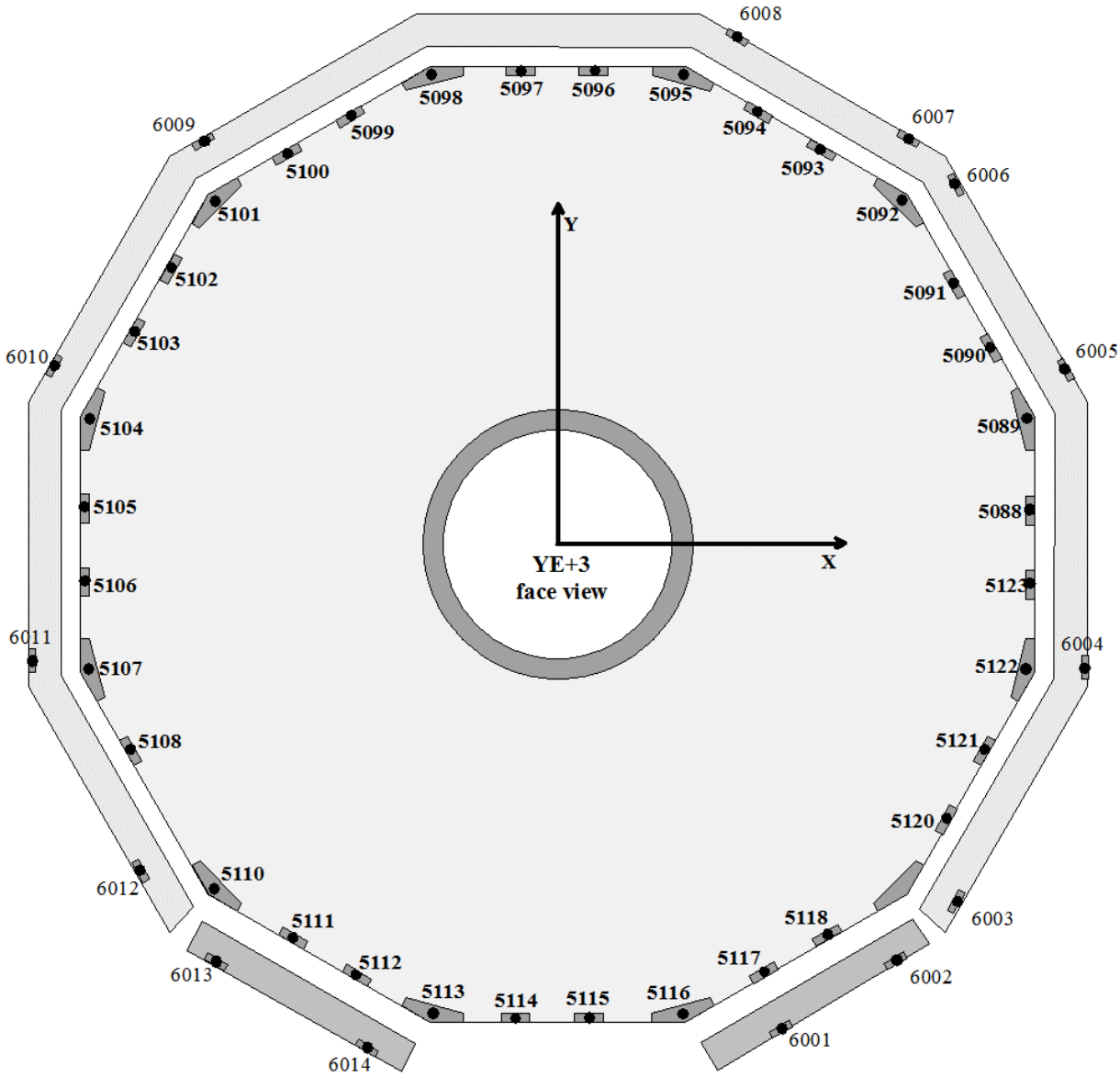

Figure 2. YE+3 Z+ face

2.3 CMS Physicist coordinate system

The **CMS system** is a direct Cartesian system defined as:

- The origin is the Interaction Point of CMS (IP5)
- The XCMS axis is the radial axis and positive to the LHC center.
- The Y CMS axis is elevation and perpendicular to the Z CMS axis and positive to the top.
- The Z CMS follows the beam line and positive from 56 towards 54.

The local geometry of the cavern UXC55 is a local transformation on the geometry of the LHC delivered by EN/ACE/SU as for the end of LS1

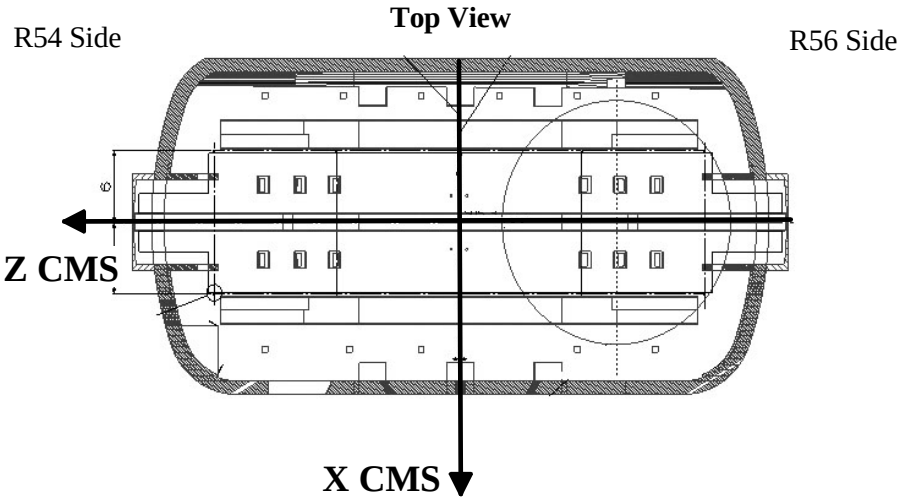

Figure 3. Top view of the UXC55 and the system CMS

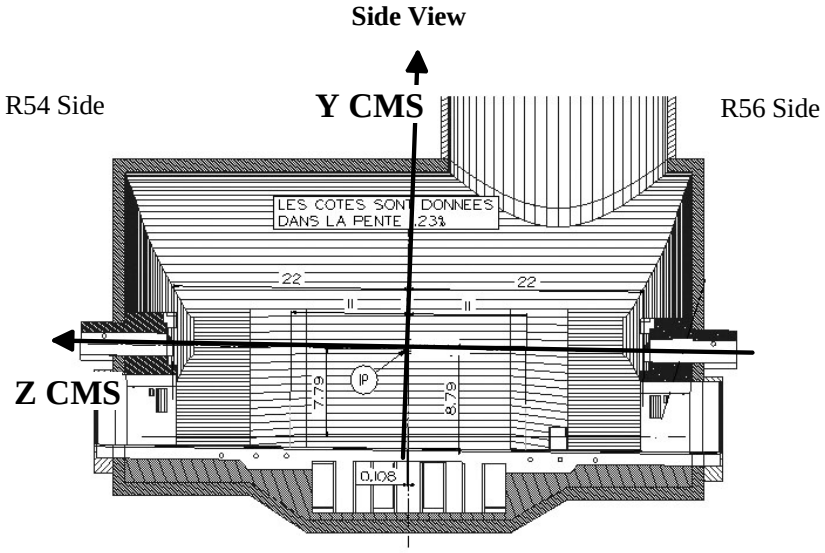

Figure 4. Side view of the UXC55 and the System CMS

3 MEASUREMENT IN UXC55

3.1 Theodolite measurements

The position of YE+2 and YE+3 in UXC55 cavern have been measured by theodolite (i.e. traditional method) to transfer the scan data from CMS physicist coordinate system onto local yoke endcap coordinate system by best-fit on survey reference holes of each yoke endcap.

The following table gives the measured coordinates of the survey reference holes and the calculated position of the centre of each yoke endcap in the CMS physicist coordinate system.

Survey reference holes on YE+2 (CMS Phy)				
NAME	**Xphy [m]**	**Yphy [m]**	**Zphy [m]**	
YEP2_Centre	0.0055	-0.0051	12.7473	[*]
YEP2_2006	-6.7840	-3.1659	13.3103	
YEP2_2007	-4.0993	-6.2389	13.3012	
YEP2_2008	3.8267	-6.4109	13.3062	
YEP2_P_111	-4.0254	-5.7545	13.4209	
YEP2_P_112	-2.9648	-6.3673	13.4189	
YEP2_P_114	-0.6096	-7.0011	13.4199	

[*] Calculated by best-fit

Survey reference holes on YE+3 (CMS Phy)				
NAME	**Xphy [m]**	**Yphy [m]**	**Zphy [m]**	
YEP3_Centre	0.0080	0.0054	17.5761	[*]
YEP3_6002	5.2597	-5.5857	18.3839	
YEP3_6003	6.2771	-4.0633	18.3828	
YEP3_6011	-7.4570	-1.5080	18.3513	
YEP3_6012	-6.2683	-4.0595	18.3611	
YEP3_6014	-4.2298	-6.1620	18.3528	

The following table gives the coordinates of the survey reference holes on each yoke endcap in the local yoke endcap coordinate system. For further details about those values, please see EDMS report CMS-SG-UR-0067 v2 for YE+2 and EDMS report CMS-SG-UR-0088 for YE+3.

Survey reference holes on YE+2 (Local YE+2)			
NAME	**Xloc [m]**	**Yloc [m]**	**Zloc [m]**
YEP2_Centre	0.0000	0.0000	0.0000
YEP2_2006	-6.7856	-3.1654	0.5759
YEP2_2007	-4.0995	-6.2349	0.5718
YEP2_2008	3.8229	-6.4026	0.5711
YEP2_P_111	-4.0257	-5.7506	0.6902
YEP2_P_112	-2.9653	-6.3624	0.6889
YEP2_P_114	-0.6103	-6.9929	0.6900

Survey reference holes on YE+3 (Local YE+3)			
NAME	**Xloc [m]**	**Yloc [m]**	**Zloc [m]**
YEP3_Centre	0.0000	0.0000	0.0000
YEP3_6002	5.2558	-5.5899	0.7897
YEP3_6003	6.2722	-4.0675	0.7882
YEP3_6011	-7.4627	-1.5173	0.7896
YEP3_6012	-6.2731	-4.0685	0.7932
YEP3_6014	-4.2338	-6.1696	0.7785

The following table gives the position of some M12 holes measured in the area of YE+3 in front of the CSC chamber ME+3/1/13. Offset from YE+3 disk surface is more than 20mm and not the same for each M12 hole, as the adapter was not in contact with YE+3 disk surface.

M12 holes on YE+3 (Local YE+3)				
NAME	**Xloc [m]**	**Yloc [m]**	**Zloc [m]**	
YEP3_M12_1	-2.1634	-1.6094	-0.1516	[*]
YEP3_M12_2	-0.7289	-3.0207	-0.1481	[*]
YEP3_M12_3	-0.6223	-2.6232	-0.1535	[*]
YEP3_M12_4	0.1930	-3.1012	-0.1514	[*]
YEP3_M12_5	0.1564	-2.6913	-0.1503	[*]

[*] Survey adapter was not in contact with YE+3 disk surface

All coordinates are given at the centre of the survey target (20mm offset from contact surface for reference holes). Accuracy (X,Y, Z) +/-1mm at one sigma level.

3.2 Laser scanning measurement

The surfaces between YE+2 and YE+3 have been measured with the laser scanner Leica HDS6200 of EN/ACE-SU section from one scan station. The scan data has been set in the CMS physicist coordinate system using laser scanner reference targets distributed in the area on the survey geodetic points (offset of 90 mm in the Zsu direction (local vertical) compared to the traditional survey target (Taylor & Hobson Ball)). Geodetic network has been measured during Winter 2015/2016 by theodolite. Targets have been removed after the measurements.

Coordinates of the targets in the CMS physicist coordinate system determined by theodolite:

Geodetic survey points used for data transfer onto CMS physicist coordinate system							
NAME	**Xphy [m]**	**Yphy [m]**	**Zphy [m]**	**NAME**	**Xphy [m]**	**Yphy [m]**	**Zphy [m]**
N0P6	10.2467	-7.2812	17.6414	F2P6	-10.1653	-0.5031	17.5597
F0P6	-9.9995	-7.2632	17.4254	F2M6	-12.9037	-0.4228	14.1510

Coordinates are given at the centre of the laser scanner targets in the CMS physicist coordinate system. Accuracy (X,Y, Z) +/-1mm at one sigma level.

Final point clouds result from 1 position of the laser scanner (scan station).

The following sorts of point clouds have been produced:

- A “high” resolution scan with the maximum field of view of the scanner (360º*270º)
- “target” scan: for each laser scanner reference target not well measured in the previous point cloud, to determine the target centre, to set the scan data in CMS physicist coordinate system.

4 PROCESSING OF THE DATA – RESULTS

4.1 Pre-treatment under Cyclone software

The laser scanning measurement gives a point cloud in local coordinate system, linked to the laser scanner device. During the pre-treatment in Cyclone software, the point cloud is transferred by best-fit on geodetic survey targets onto the CMS physicist coordinates system.

Steps in Cyclone software:

1. Import in the scanning project of a txt file containing the coordinates in the CMS physicist coordinate system of the HDS targets inserted in the geodetic survey brackets
2. Best-fit calculation of the scan data onto the txt file to transfer the scan data in the CMS physicist coordinate system. For this measurement, the average error of the best-fit transformation is +/- 2.5 mm and the maximum error is of +/-3 mm.
3. Export of the point cloud in XYZ files format (compatible with CATIA and Geomagic).

4.2 Additional treatment under Geomagic Studio Software

The full point cloud has been cleaned manually (removal of not interesting parts, measurement errors) and also automatically ("select disconnected" and "select outliers"). Then, the point cloud has been divided in two Geomagic files (one for each yoke endcap).

Steps in Geomagic for each yoke endcap file:

1. Duplication of the point cloud to obtain 2 identical point clouds:
   - In one point cloud, sampling of the data to keep a point each 1 cm
   - In the other point cloud, removal of the areas not around CSC chamber ME+3/1/13 and no sampling, to keep full point cloud density from the measurement.
2. Creation of two additional point clouds containing only "features" points, to insert the data from theodolite measurements.
   - One point cloud with theodolite values in CMS physicist coordinate system, including also M12 holes position
   - One point cloud with theodolite values in local yoke endcap coordinate system (YE+2 or YE+3).
3. Assembly of 3 point clouds: the one sampled at 1 cm density, the extract with full density around CSC chamber ME+3/1/13 and the points in CMS physicist coordinate system
4. Best-fit calculation of the point cloud assembly onto the "features" point cloud in local yoke endcap coordinate system ("RPS Alignment") to transfer the data to that system. For YE+2, the average error of the best-fit transformation is +/- 1.8 mm and the maximum error is of +/- 3.0 mm. For YE+3, the average error of the best-fit transformation is +/- 0.3 mm and the maximum error is of +/- 0.4 mm.
5. Export of the point cloud and of the "features" points in igs files format

4.3 Resulting files for CATIA software treatment

Point cloud, survey reference points and yoke endcap centre have been exported in igs file format for import in CATIA. All data are stored on dfs public folder at the following address:
\\cern.ch\dfs\Support\SurveyingEng\Instruments\LaserScanner\DataSets\Experiments\CMS\170110_RE3-1_ZP_Endcaps

- *Content of the folder for link indicated above:*
  - 170110_YEP2_RE31.igs: point cloud data of the YE+2
  - 170110_YEP2_RE31_Point_Features.igs: survey reference hole and YE+2 centre
  - 170110_YEP3_RE31.igs: point cloud data of the YE+3
  - 170110_YEP3_RE31_Point_Features.igs: survey reference hole and YE+3 centre, M12 holes

Data are provided in meters in local yoke endcap coordinate system (YE+2 or YE+3). M12 holes are not measured on the contact surface.

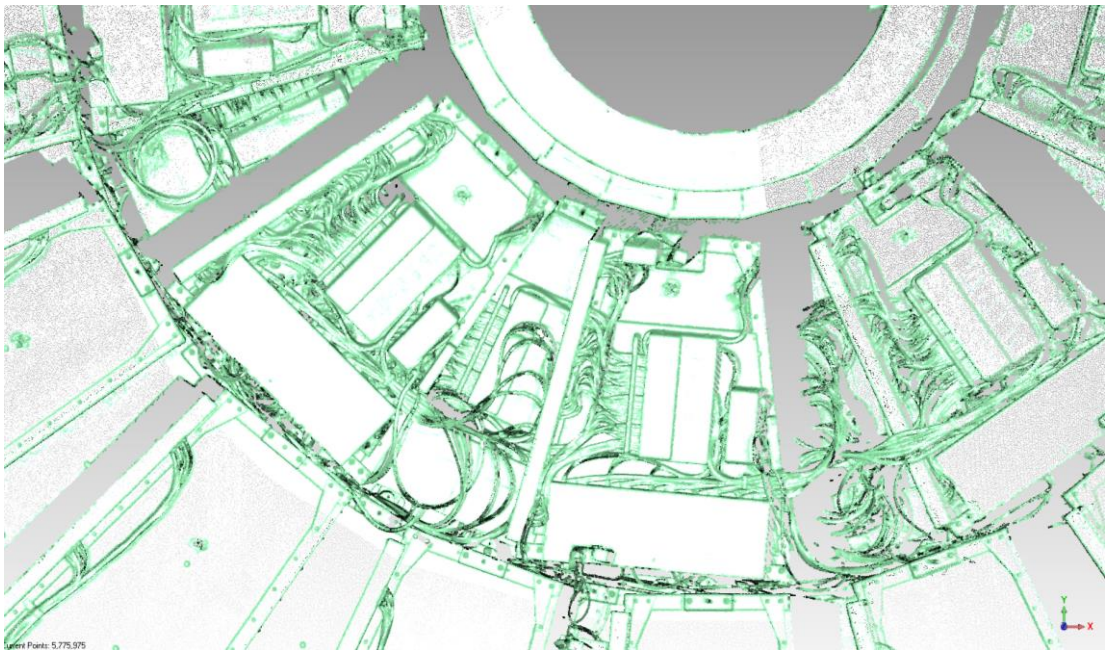

Figure 5. Extract of YE+2 point cloud, area around CSC chamber ME+3/1/13

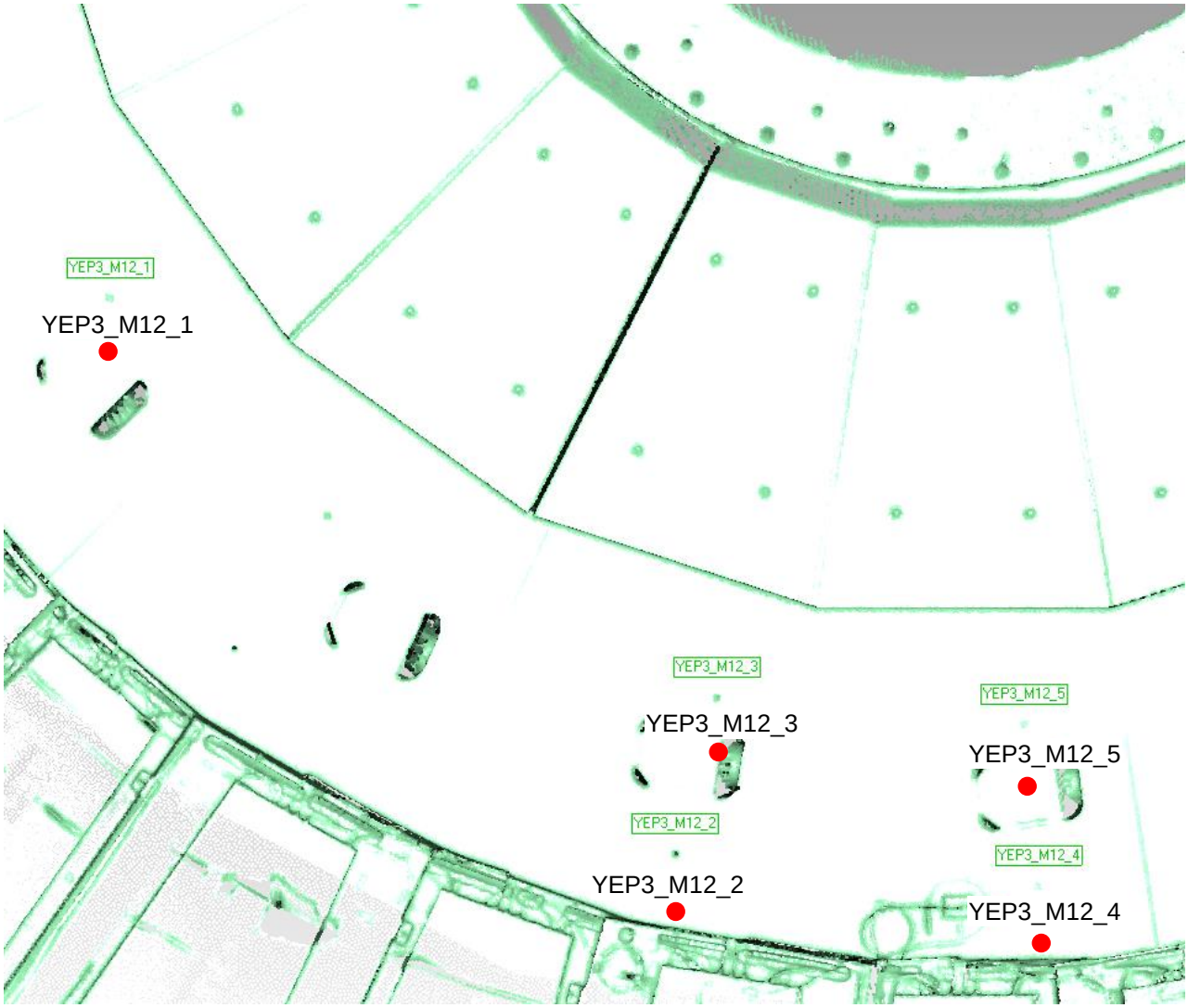

Figure 6. Extract of YE+3 point cloud, area in front of CSC chamber ME+3/1/13