Mass Production Assembly of CMS GE1/1

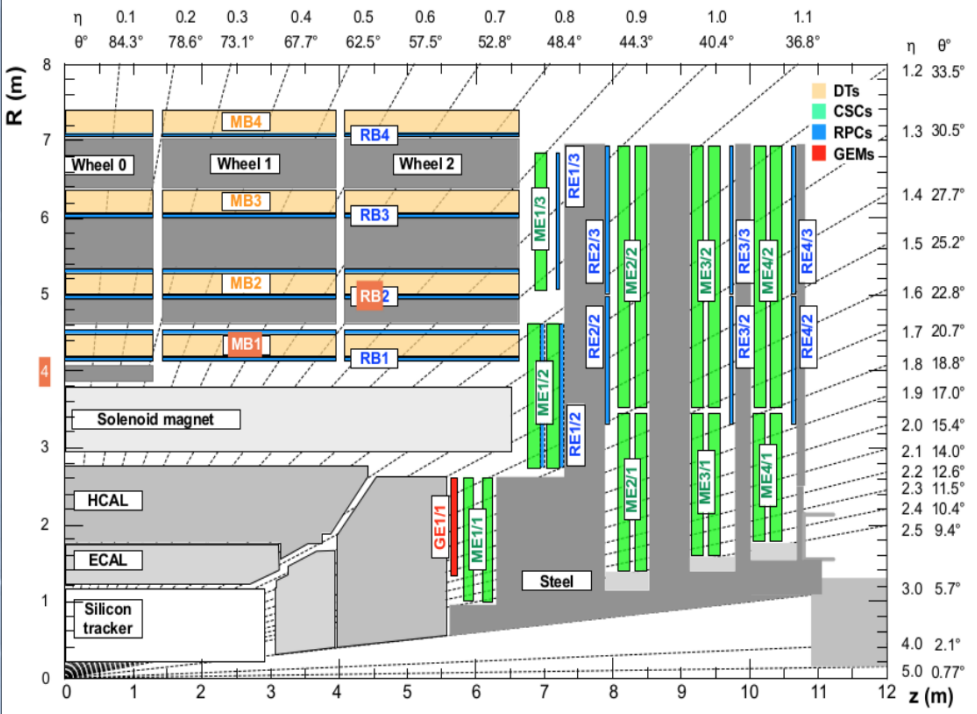
RD51 meeting
22/06/2017

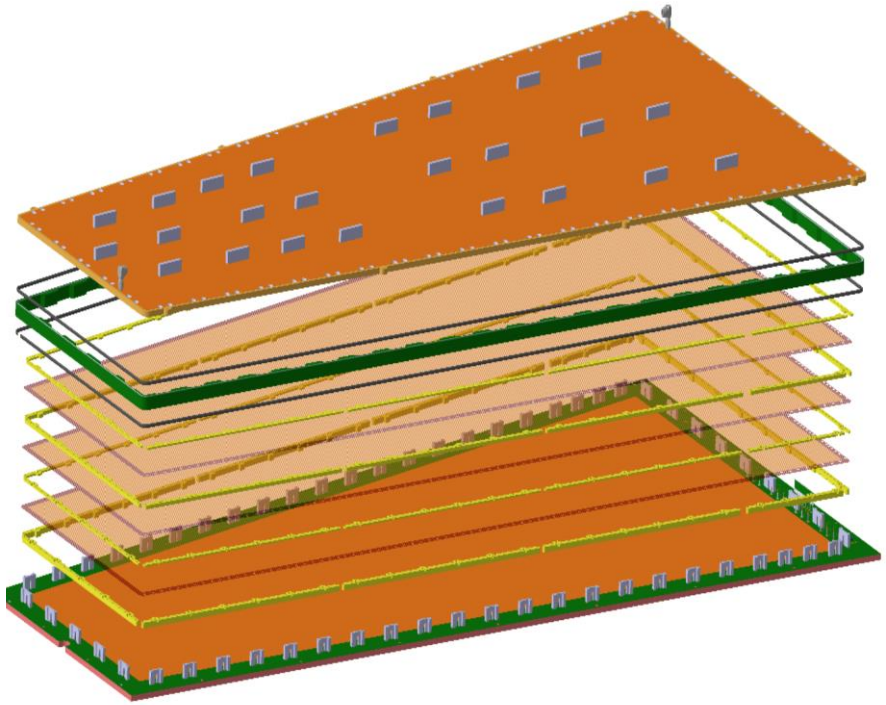
Jeremie A. Merlin
CERN

On behalf of the CMS GEM group

Introduction

CMS GE1/1 detector project:





GE1/1 detector		
Specification	Short	Long
Chamber Shape	Trapezoidal	Trapezoidal
Chamber Dimensions	L:106.1 cm, W:(23.1-42.0) cm, D:0.7 cm	L:120.9 cm, W: (23.1-44.6) cm, D: 0.7 cm
Chamber Thickness	3.5 cm	3.5 cm
Active readout area	0.345 m^2	0.409 m^2
Active chamber volume	2.6 liters	3 liters
Geometric acceptance in η	1.61-2.18	1.55-2.18

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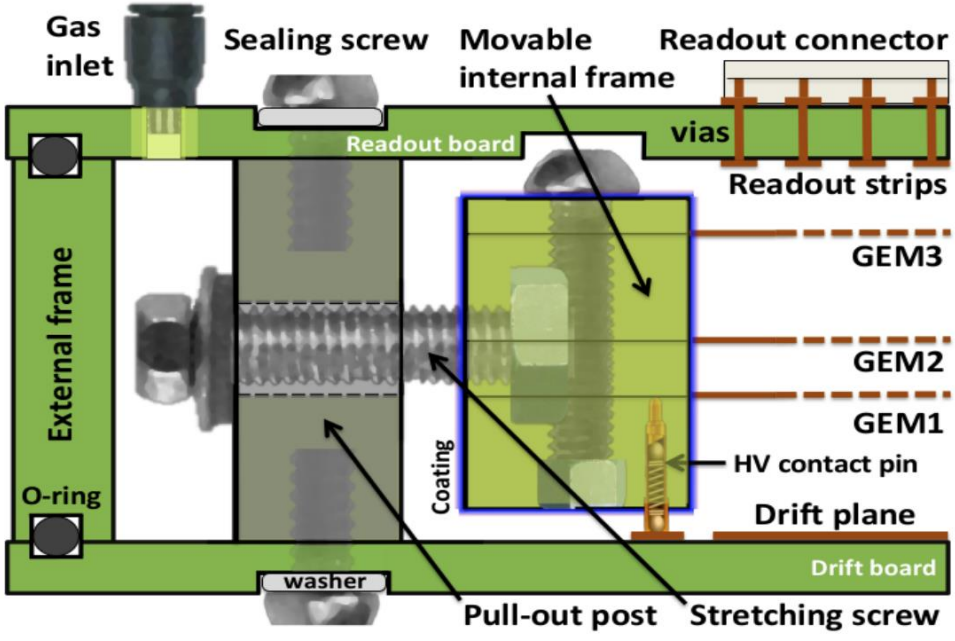

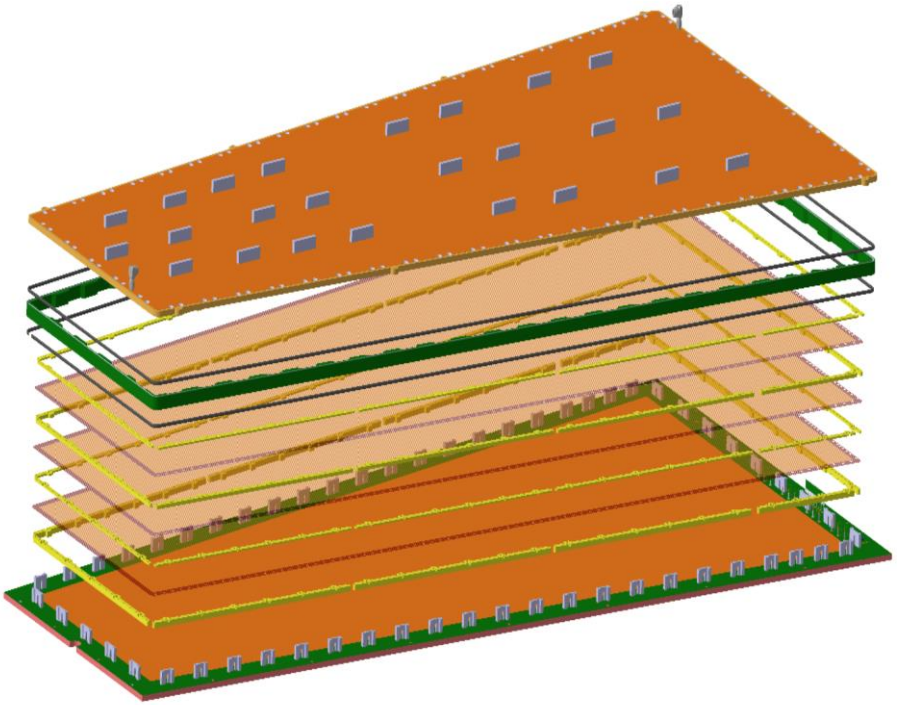

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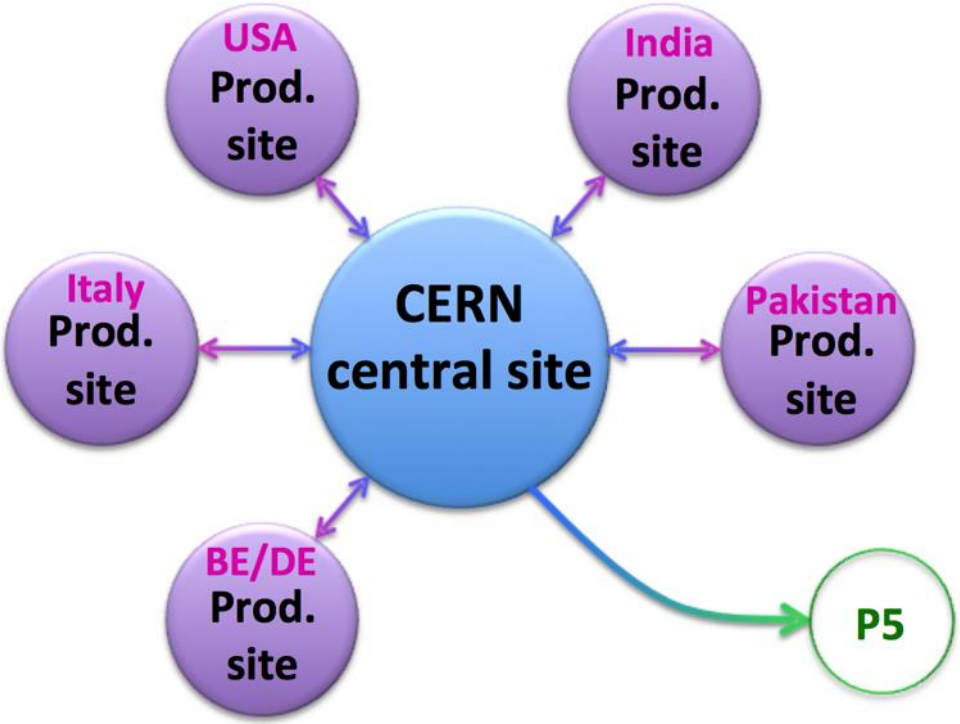
Production Organization

→ **Distribution of the production in various sites:**

- **Share the effort with CMS GEM institutes**
- **Generate a large community of GEM experts**
- **Equip production sites with infrastructure, tooling and knowledge for GE2/1 and ME0 productions**



Production Organization

- Only approved sites can produce LS2 chambers
- QC Jamboree procedure:
  - → 2-years training program divided into three stages
    - Testing small prototypes
    - Testing GE1/1-size prototypes
    - Producing and testing final LS2 chambers
- All sites are equipped with the same infrastructure and follow the same procedures
- All QC deliverables are reviewed by the entire community for complete approval

Production Organization

- **Approval procedure and training material for GE1/1 production:**

  → **The Site Checkout Document is a set of requirements, recommendations, comments and procedures to support the last stages of the approval of GE1/1 production sites:**

  10+ pages

  - *list of managerial practices, items/facilities, recommendations, suggestions.*

  → **The Quality Control Instructions Manual describes the test stands, procedures and deliverables:**

  50+ pages

  - *step-by-step procedure of all QCs, operation of the setup, usage of HW/SW.*

  → **The Technical Assembly Manual describes the preparation and assembly:**

  60+ pages

  - *step-by-step procedures of all assembly steps.*
  - *instructions to ensure the safety of the sensible components and recommendations.*

  → **The Assembly video tutorial illustrates the preparation and assembly:**

  1h+ video

  - *step-by-step procedures.*

  → **Assembly Trainings at CERN : 10 sessions organized with all production sites from April 2017 to September 2017 + QC Training at CERN since 2015.**

Production outside CERN

- **Approval procedure and training material for GE1/1 production:**

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- *step-by-step procedure of a... ...W/SW.*

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Available at https://cernbox.cern.ch/index.php/s/xU30wpDWYqx8iyy

GE1/1 Assembly Summary

Procedure:

- ***Pre-assembly work***
- Preparation of the drift board (HV pins, SMD HV circuit, pull-outs, cleaning)
- Preparation of the RO board (brass inserts, gas plugs, cleaning)
- Preparation of the frames (PU coating, O-ring, cleaning)
- ***Assembly in clean room***
- Cleaning of the assembly room and tooling
- Initial cleaning and testing of the GEM foils
- Mounting of the GEM stack (+ cleaning)
- Securing of the GEM stack + transfer to drift board (+ cleaning)
- Fixation and stretching of the GEM stack (+ cleaning)
- Closing of the chamber
- ***Post-assembly work***
- Final testing of the gap/GEM impedance
- Testing of the impedance between last GEM and RO board

Comments:

- **In total the assembly of one chamber takes 2-3 hours but few more hours are required before entering the cleanroom to prepare the components → this step can be easily parallelized to gain time.**

Example from Assembly Manual

1. One readout board.
2. Two gas connectors Parker Legris PN:3299 03 09.
3. Eight brass inserts Titanox PN: M0002292.

The components are shown on Fig. 1.

(a) Readout board. (b) Gas connectors. (c) Brass inserts.

Figure 1: List of components required for the readout board preparation.

(a) Clamping hand. (b) Tap wrench.

(c) Araldite 20 11. (d) Metallic support.

Figure 2: List of components required for the readout board preparation.

List of components and tools

Step-by-step procedure with pictures and comments

+ warnings, suggestions and recommendations

Step 7: Before applying the glue, remove the teflon washer from the gas plugs. This washer is a white circular piece sitting under the body of the connector (Fig. 10).

Figure 10: Removing the O-ring front he gas connector.

Figure 11: Applying glue to the gas connector.

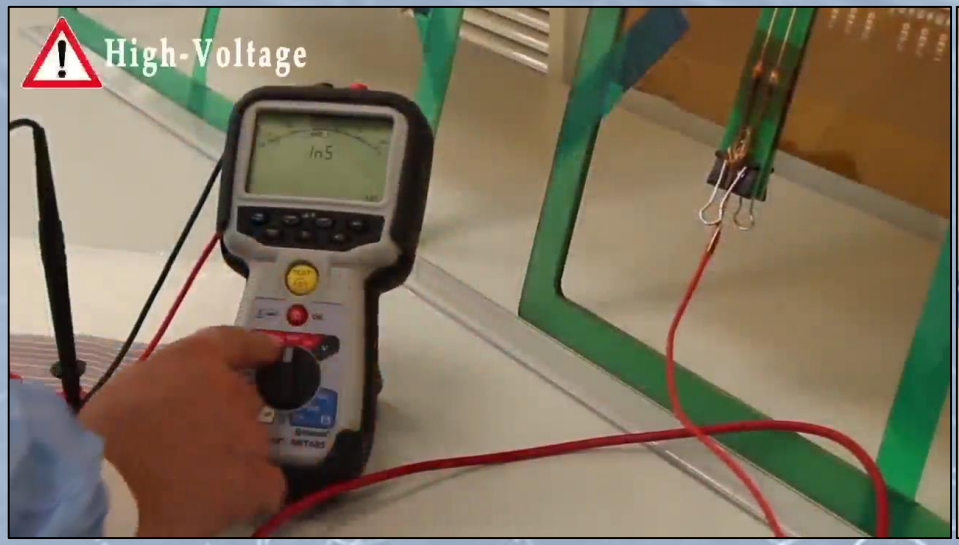
Step 8: Then use the metallic stick to apply a thin ring of glue between the body and the threaded part of the connector (Fig. 11).

Step 9: Gently screw the connector on the board until the base of the connector's body touches the readout board (Fig. 12 left). Make sure that the glue forms a nice and smooth ring all around the base of the connector (Fig. 12 right).

Figure 12: Fixing the gas connector onto the board.

Example from Video Tutorial

Reduced quality for the ppt version



Reduced quality for the ppt version

Comment:

- About 1 hours of step-by-step tutorial
- High quality footage from different points of view and animated schematics
- Audio description recorded (to be added soon to the video)

Example from QC Manual

1 Prerequisites 3
1.1 Site Planning and Management . . . 3
1.2 Gas Supply Log . . . 4
1.3 Personal Lab Notebook . . . 5
1.4 The Centralized E-Log . . . 5

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2.5 QC2 fast in dry gas . . . 17

3 QC3: gas leak test 21
3.1 Description of the setup . . . 21
3.2 Procedure . . . 22
3.3 Typical results . . . 25

4 QC4: HV test 26
4.1 Description of the setup . . . 26
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4.3 Typical Results . . . 29

5 QC5: gain calibration 30
5.1 QC5: preparation and installation of the chamber. . . . 30
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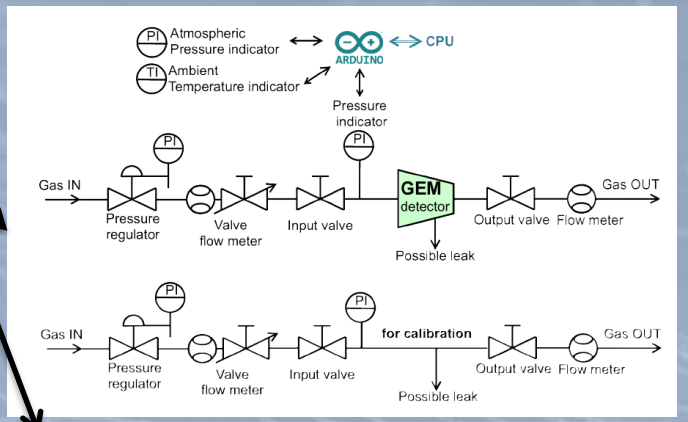
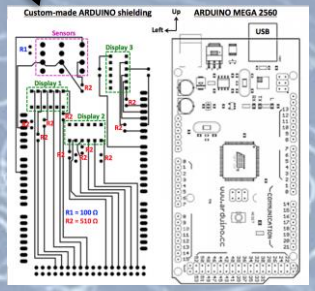
5.3 QC5: response uniformity . . . 40
5.3.1 Description of the setup . . . 40
5.3.2 Preparation of the detector . . . 41
5.3.3 Preparation of the DAQ system . . . 42
5.3.4 Uniformity test . . . 43
5.3.5 Analysis . . . 48
5.3.6 Typical results . . . 52

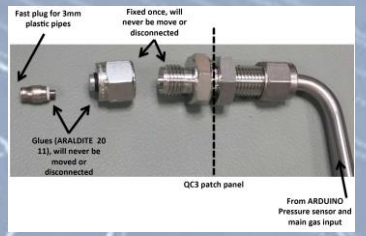
Technical description of the setup, tools and SW + custom made designs

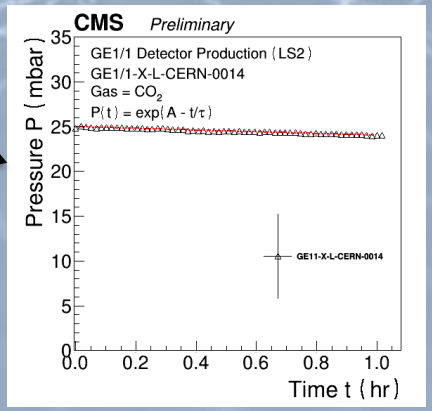
Step-by-step procedures and detailed guide for SW/HW operation

Typical results and instructions to follow in case of problems or unexpected behaviors

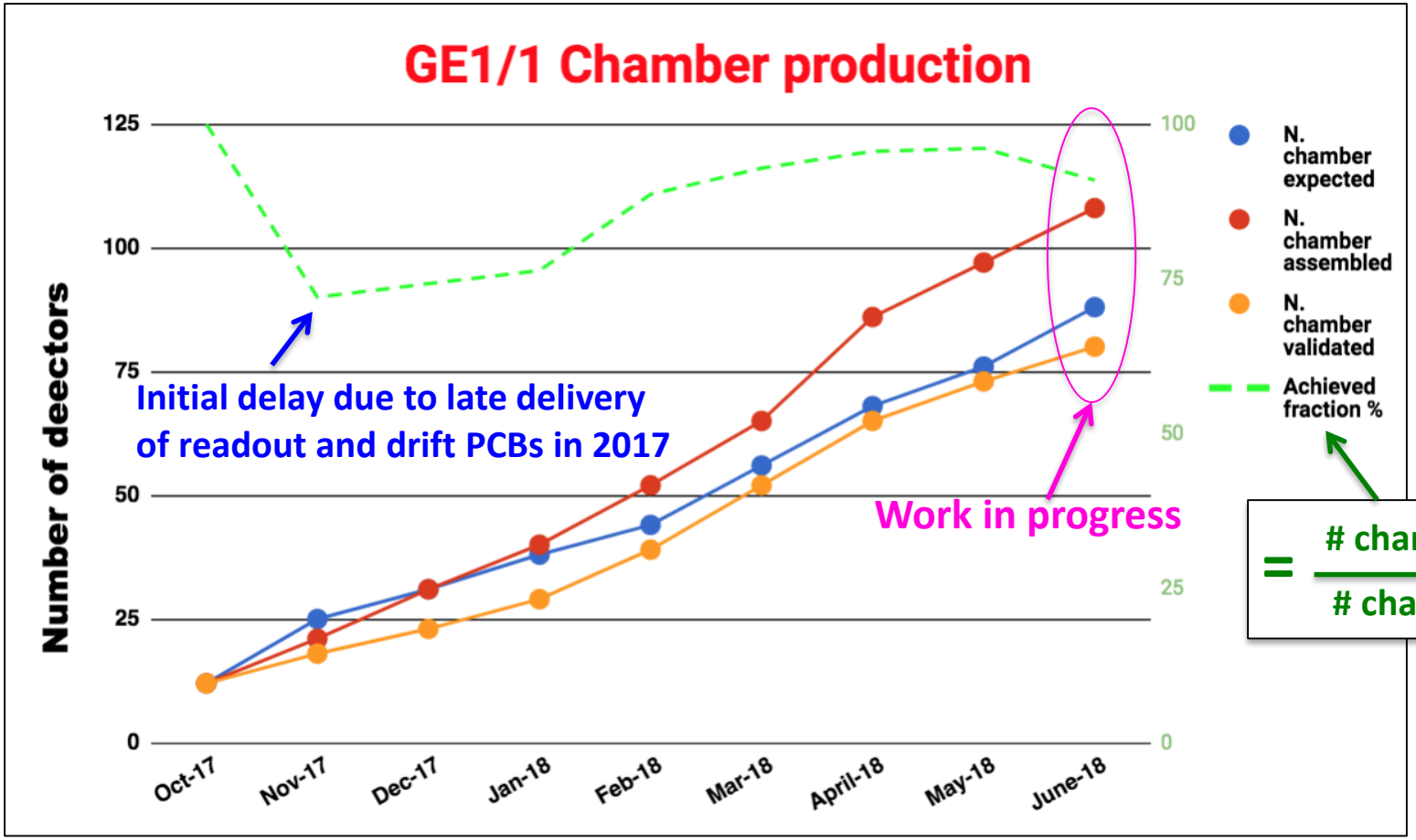








Production Status



Comment:

- **Despite of the significant delay induced by late PCB delivery in 2017, the CMS GEM community managed to recover the time loss and get back on schedule**
- **Mostly due to efficient knowledge transfer and successful sharing of production**

Conclusions

GE1/1 production:

- ***Production shared among 9 institutes***
  - all sites followed the 2-years training program before final approval

- ***Extensive documentation of detector production and QC***
  - managerial practices
  - test infrastructures and tooling
  - step-by-step assembly procedure
  - step-by-step QC procedures

  → documents are updated regularly to cope with new issues

- ***Regular production reviews and chamber validation by the entire community***

- **Regular training sessions at CERN**
  - Assembly and QCs

THANK YOU

Link to assembly manuals and video tutorial:
https://cernbox.cern.ch/index.php/s/xU30wpDWYqx8iyy