CMS-GEM Test Beam in 2021

RD51 Mini-Week

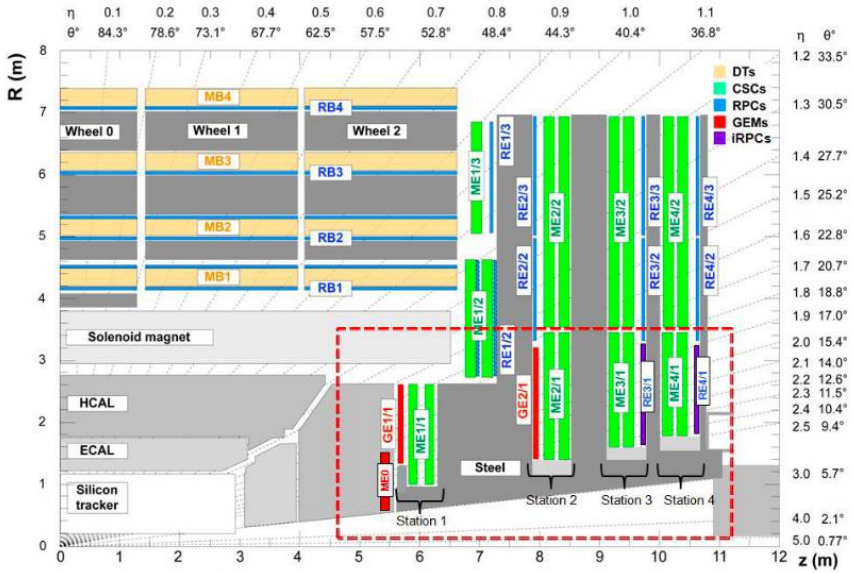
Feb 19th 2021

Piet Verwilligen

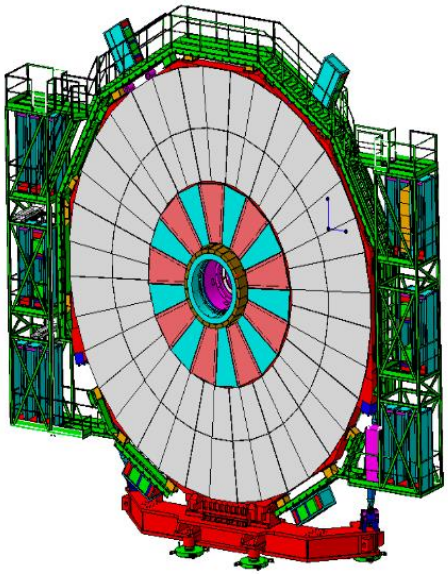
For the CMS GEM Collaboration

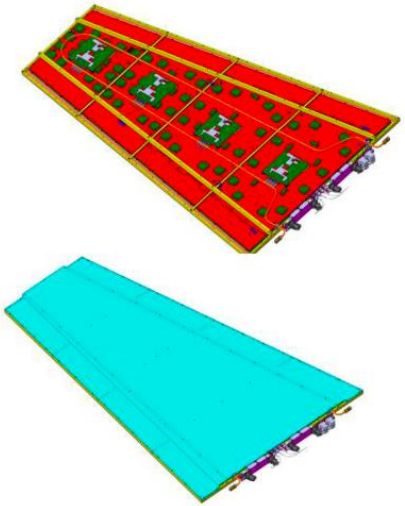
CERN, Feb 19th 2021

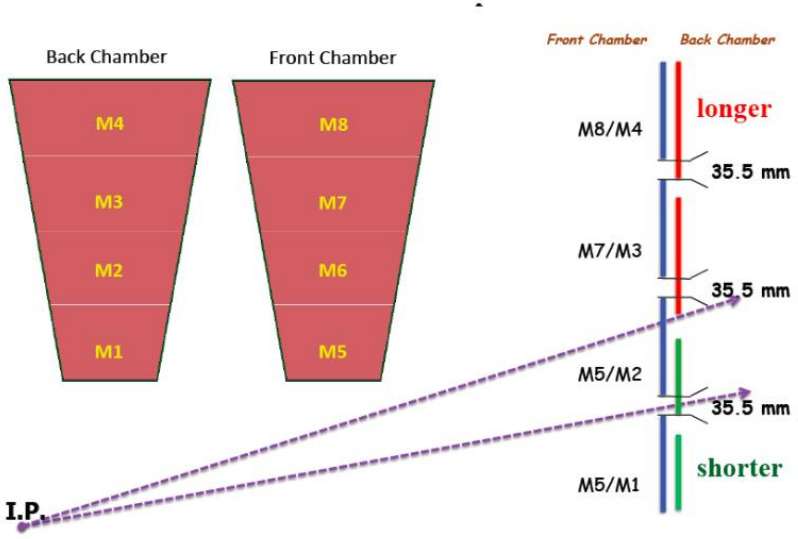
The GE2/1 Project



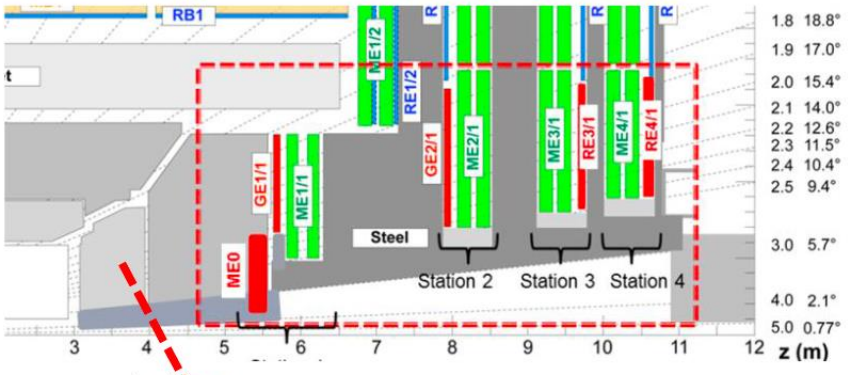
- GE21 Detector System
  - 72 chambers arranged in 2 layers installed
  - On-chamber and off-chamber
    - 4 triple GEM modules per chamber
  - 20^0 Chambers, layout similar to GE1/1, but covering much larger surface. ($1.62<\eta<2.43$)
  - Same technical solution successfully adopted for the GE1/1 (3/1/2/1 mm gaps)



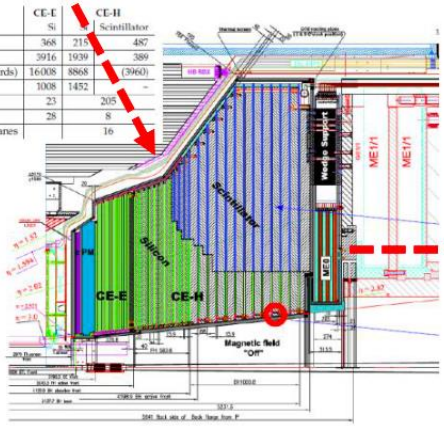


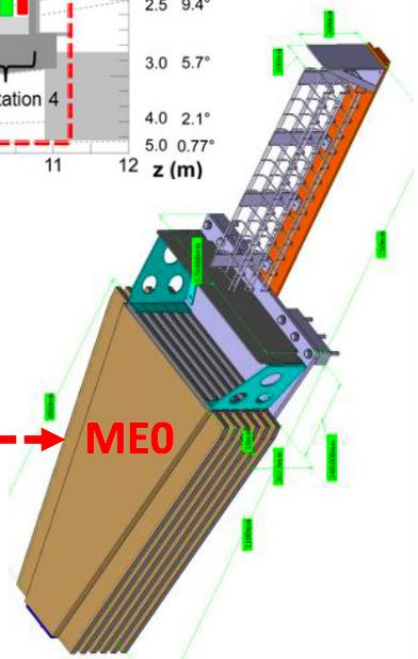


The ME0 project: challenges



	CE-E Si	CE-H Si	CE-H Scintillator
Area (m²)	368	215	487
Channels (k)	3916	1939	389
Si modules (Tileboards)	16008	8868	(3960)
Partial modules	1008	1452	-
Weight (t)	23		205
Si-only planes	28		8
Mixed (Si+Scint) planes			16

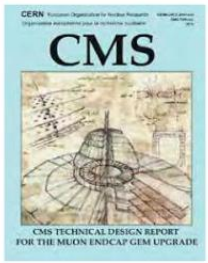


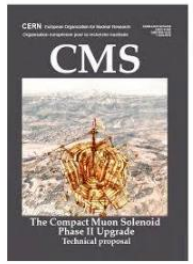


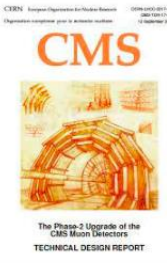
- Requirements:
  - 97% module efficiency
  - $< 500 \mu$rad resolution
  - 8-10 ns time resolution
  - $\leq 15\%$ gain uniformity
  - *Work in high rate environment: 50kHz/cm²*
  - *Survive harsh radiation environment: 280mC/cm²*
  - *Discharge rate that does not impede performance or operation*

- 6-Layer Triple-GEM stack installed behind HGCAL (complex environment)

  $2\ x\ 18$ stacks (20°) covering $2.0 < \eta < 2.8$



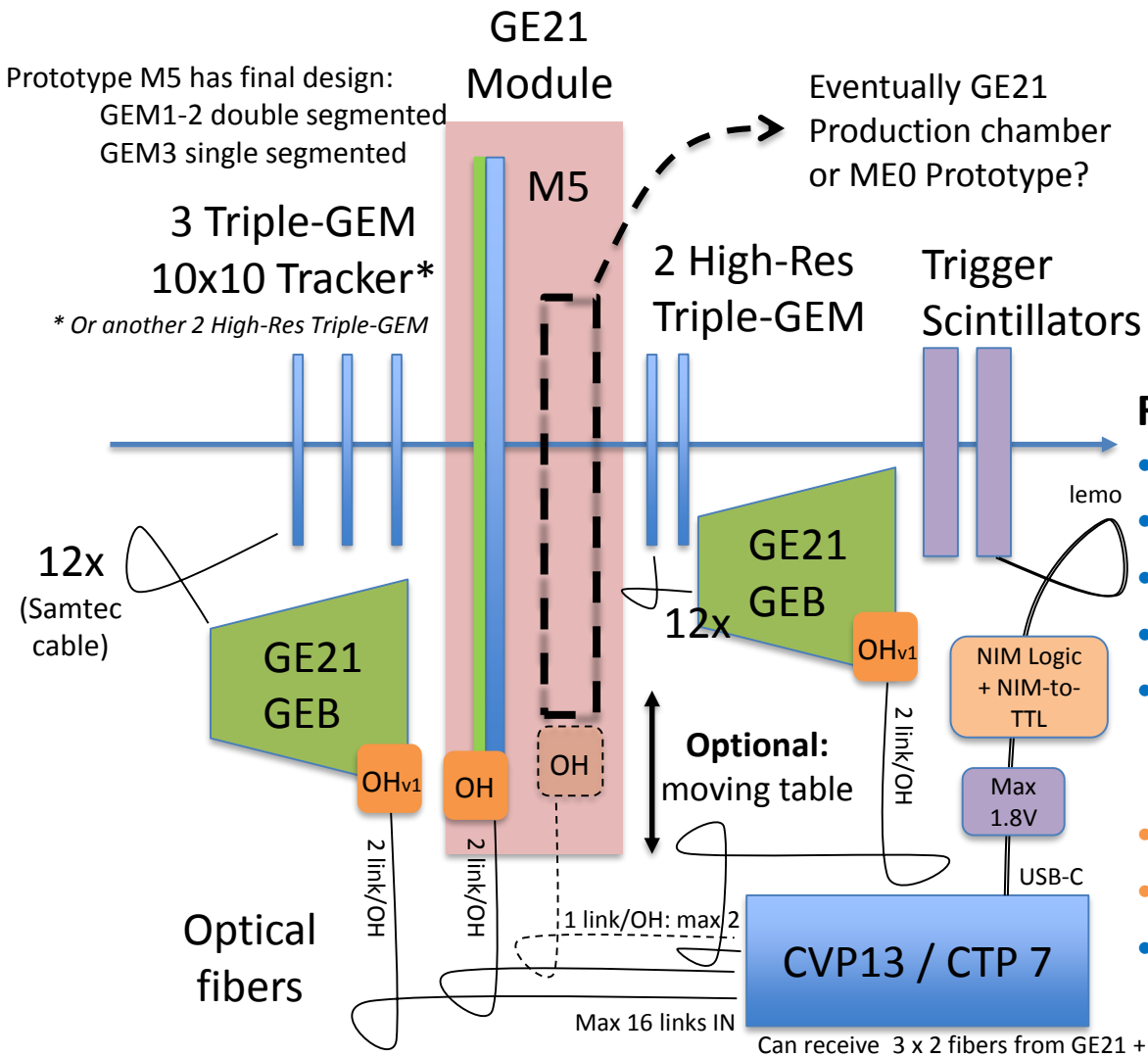




Motivation: GEM Phase-2 Performance Meas

- **Opportunity to test our "final" GE21 chambers together with final electronics. Test ME0 Prototypes.**
- **We should measure the final performance of the Phase-2 chambers: spatial resolution, rate capability, efficiency, time resolution, …**
- Last chance to test VFAT3 @ 100kHz/cm^2 before production of VFAT3 wafers for ME0
- **Fundamental test for the validation of the Electronics**
- Gain Measurement at high rate (100kHz/cm^2 (?)) to **validate Rate Capability Measurements for ME0**
- Measure Efficiency & Spatial Resolution of "High Res" Triple-GEM detectors (260um pitch – expected 75um spatial resolution)

Simple Layout 2021 Test Beam



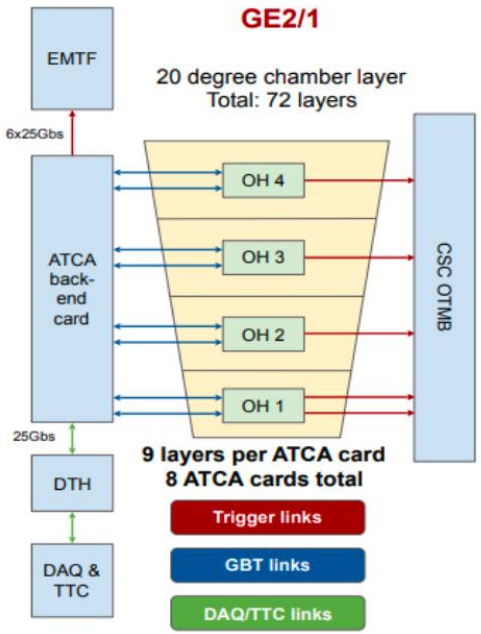
Motivation:

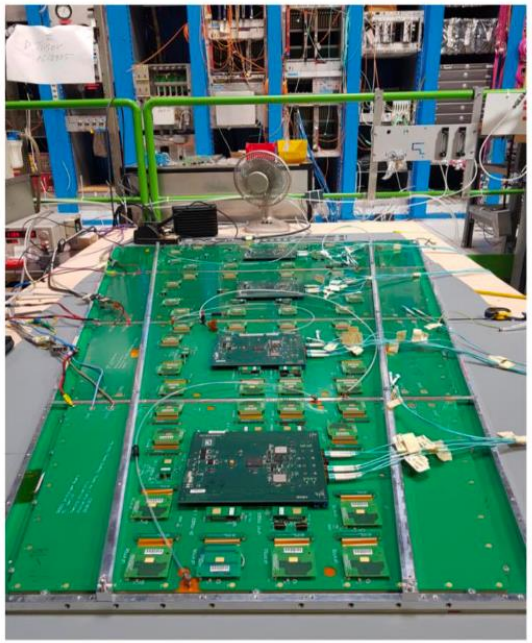
- **Test GE21 & ME0 chambers with final electronics**
- Measure final performance of Phase-2 chambers: eff, spatial res, time res, rate cap
- Test VFAT3 at high rate
- Gain Measurements at high rate (input for ME0 design)

Requirements:

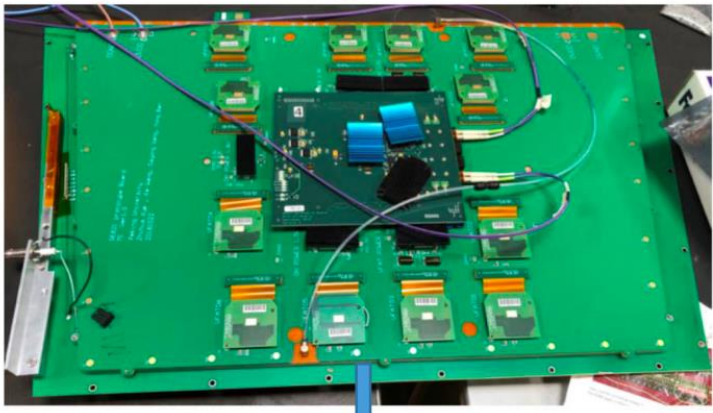
- Beam Requirements: μ, π
- Intensity: max available
- Spot size: small (before magnet)
- Gas: Ar:CO_2 70:30, no B-field
- Request: 2 weeks in Fall
  (July impossible because of GE11 Commissioning in P5)
- Movable table?
- Support to move to beam height?
- Length: 1.5-2m

GE2/1 Electronic Overview





GE2/1 chamber: composed of 4 modules



GE2/1 module:

- GEM detector
- GEB board
- 12 plugin cards with the VFAT3b
- OH board

Links:

- 576 GBT links @4.8 Gbps for tracking data & commands
- 360 trigger links @ 3.2 Gbps to CSC OTMB
- 48 links @25 Gbps from concetrator to EMTF

GE2/1 ESR scheduled for 1st December 2020
Full electronic review will take place in that occasion, here will focus our attention on the VFAT3 to fulfill the comments/questions from previous reviews

ME0 Triple-GEM Prototype

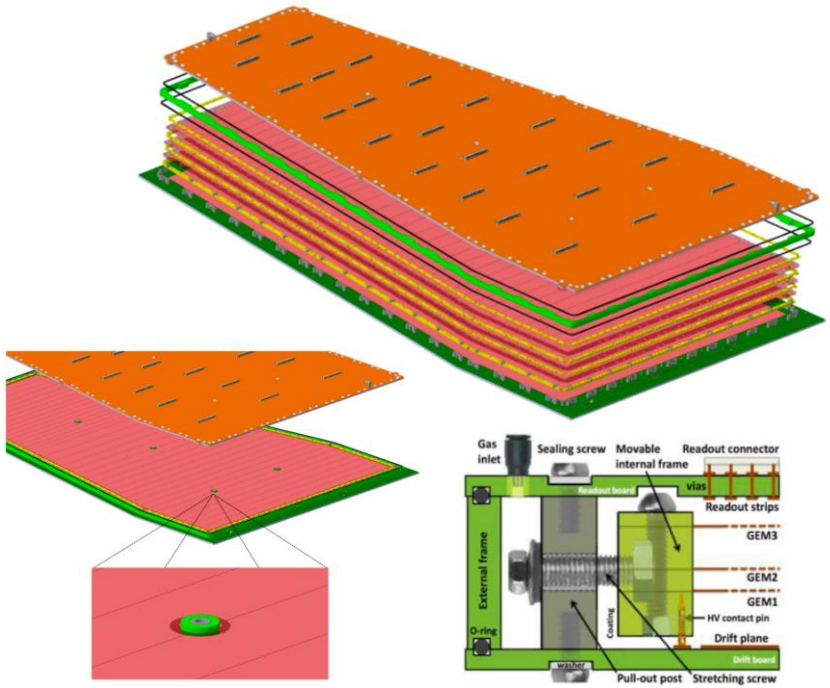
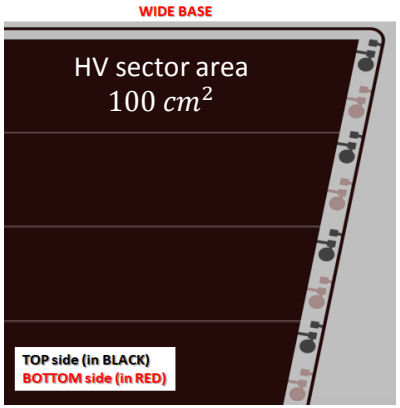
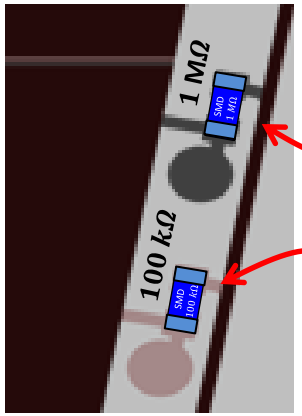


Figure 2. *Top: Exploded view of the mechanical design of a ME0 triple-GEM detector module and its main assembly components. Bottom: Magnified view of the section of the ME0 module with GEM foils stack tensioned against the pull-outs mounted onto the drift board and surrounded by outer frame having O-ring on its grooves (left). Concept and mechanism employed to stretch the GEM foils (right).*

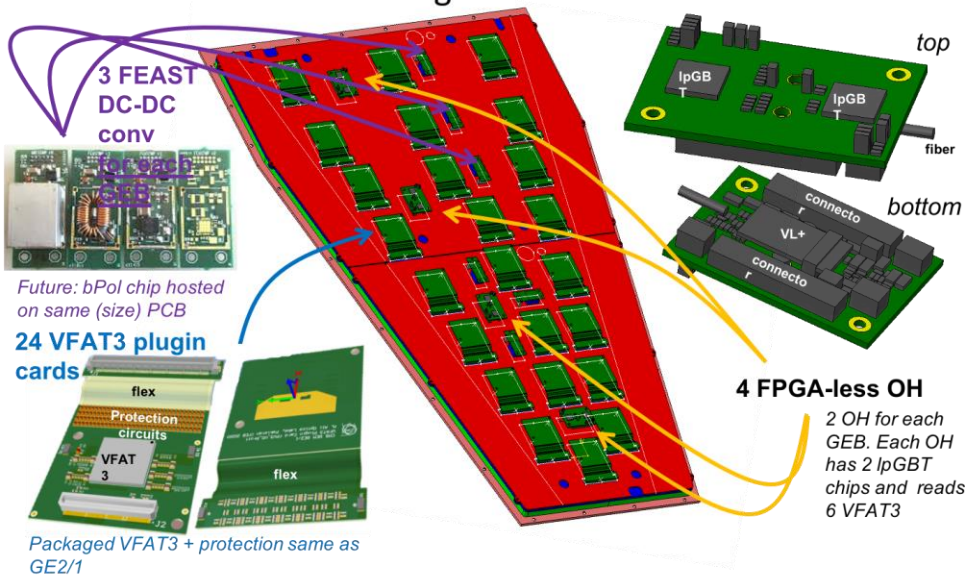




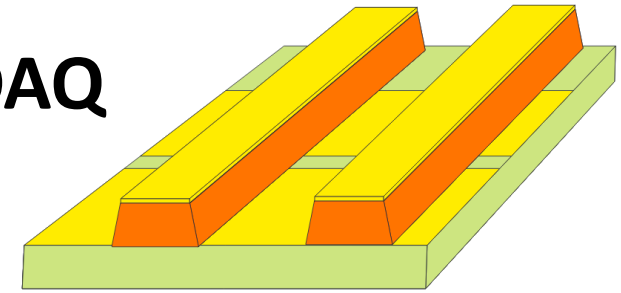
Top Protection resistor

Bottom Protection resistor

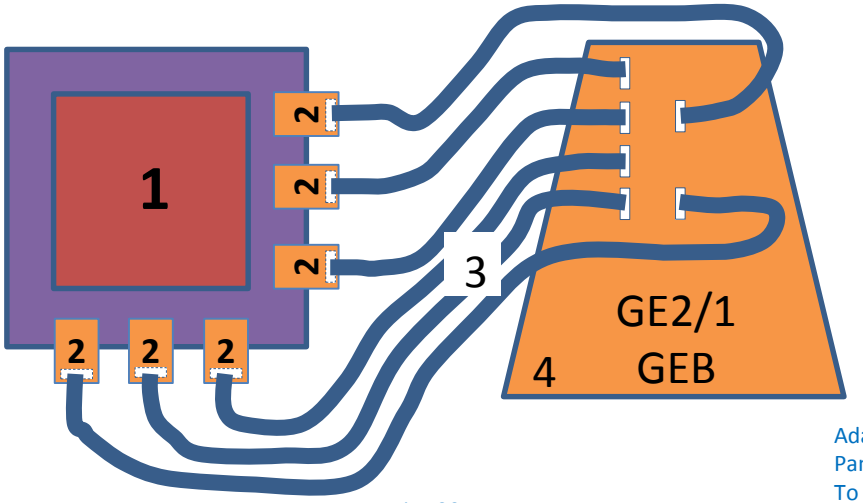
- **Moving from Design to Prototyping**
- 6 ME0 modules assembled in 2020 (CERN-FIT-INFN BARI) now being assembled in 6L Stack
- Follows design from GE1/1 and GE2/1
  - Improve uniformity: add small spacers
- GE1/1 Discharge studies & GE2/1 X-talk studies
  - double-segmented foils (for GEM1, GEM2) single-segmented foil GEM3
  - and with GE2/1 cross-talk mitigation solution (GEM1 & 2 double segmented; GEM3 single seg)
- Full Electronics chain:
  - 2-GEB Mechanical Design verified with 3D model



High-Res 10x10 GEM read by CMS DAQ



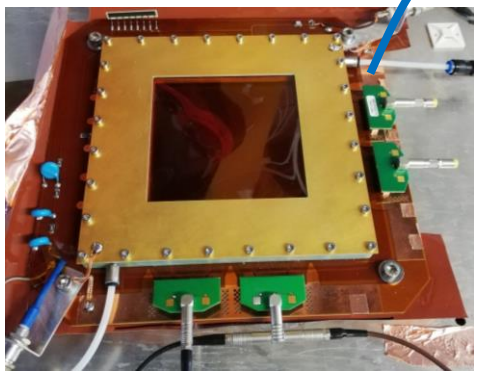
- Provide **TRACKER** before & after the magnet: 10 x 10 cm^2
- Offered pitch: 260um = resolution 75um
- New readout board for standard 10x10 with 366 strips for each coordinate
- Digital readout with VFAT3: 260um/$\sqrt{12}$ = 75um



1: 10x10 Triple GEM with modified readout board:
3*122 = 366 strips in X,Y (260um pitch)
2: VFAT3b hybrid boards
3: SAMTEC cables (new) for high speed (~70EUR/piece) with SAMTEC-TO-PANASONIC adaptors (custom made)
4: CMS GEM GE2/1 GEB

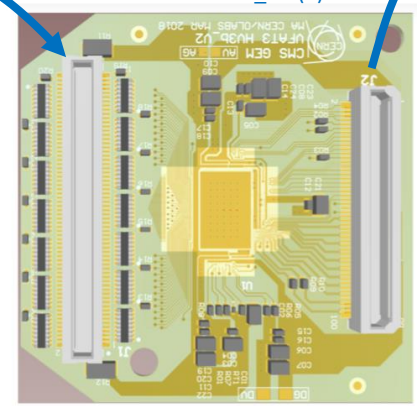
CVP13 + Cooling in PC

Triple-GEM (1)



Panasonic 130

VFAT3 HV3b_V2 (2)



Adapter-board
Panasonic 100
To SAMTEC Firefly

GE2/1 GEB + Opto-Hybrid

CTP7 Board in uTCA crate

Backup

CERN, Feb 19th 2021