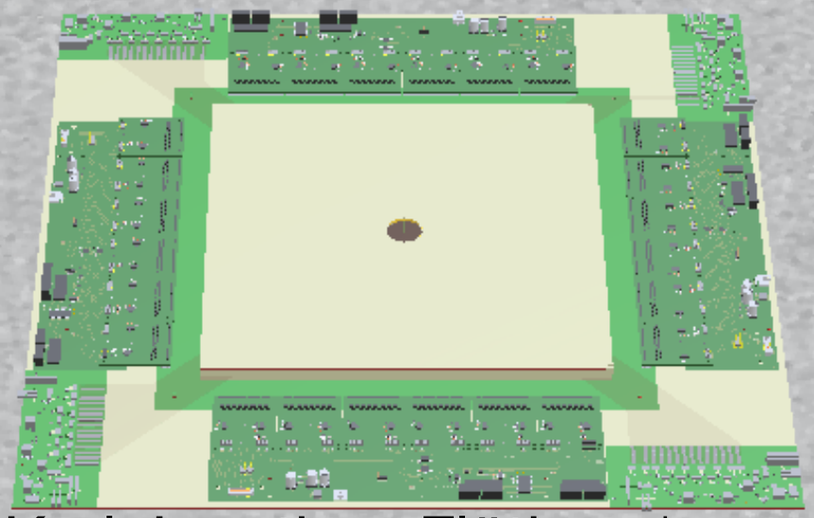
Status Report of the CG3G-Production



Karl Jonathan Flöthner*
Helmholtz-Institut für Strahlen- und Kernphysik
University of Bonn

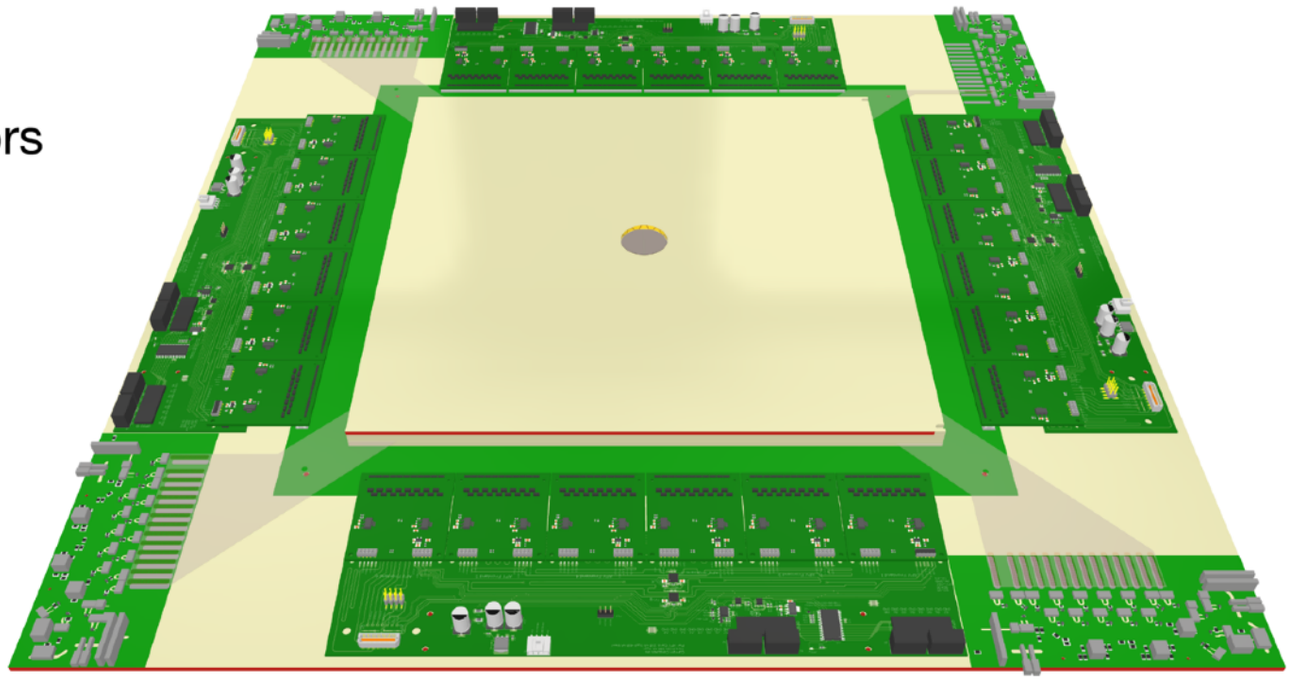
COMPASS/AMBER Technical Board

23.03.2021

*floethner@hiskp.uni-bonn.de

New Detectors for 2021 (CG3G)

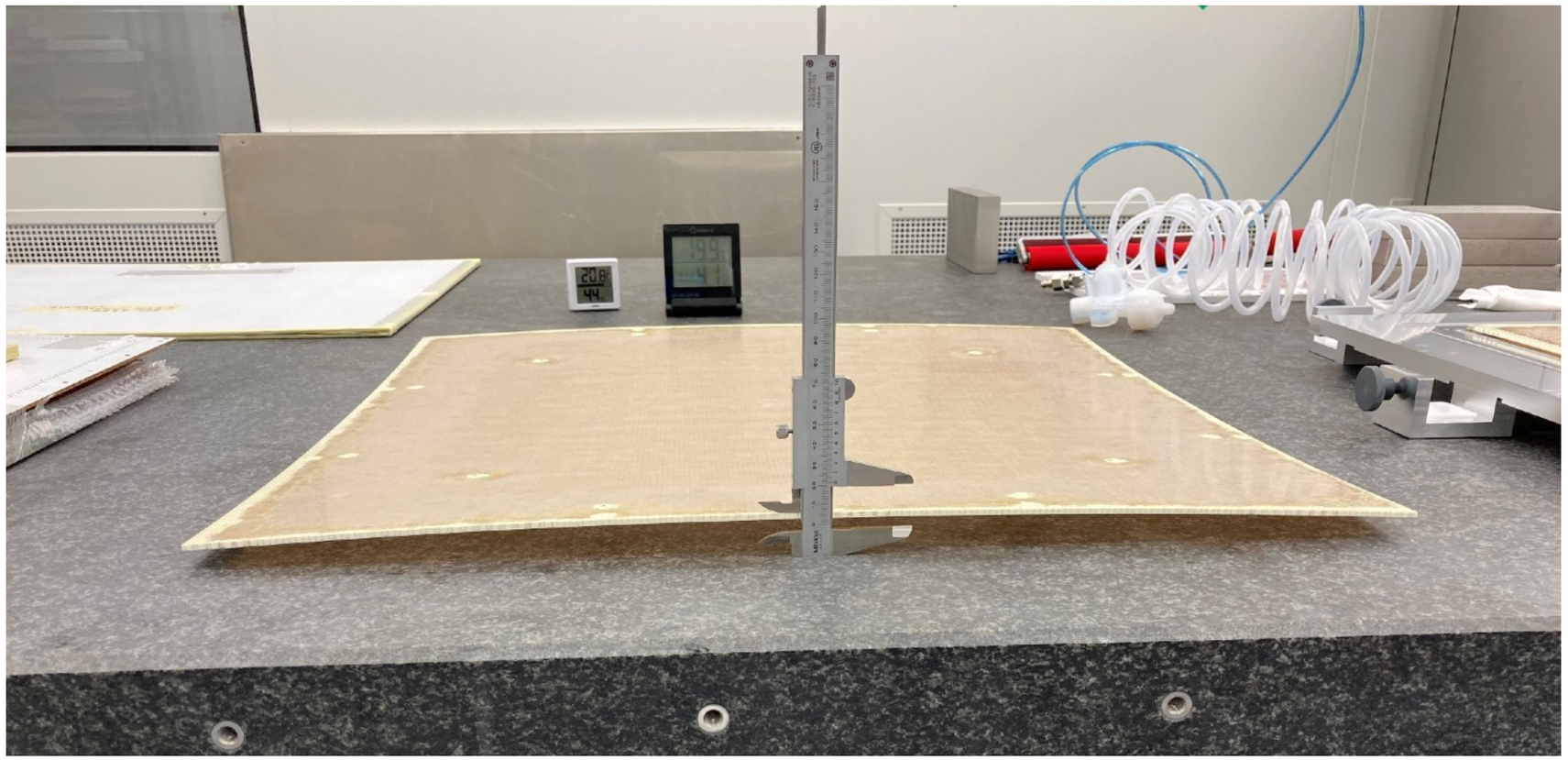
- Triple-GEM tracking detector
- Replacement for CG1G detectors (30.7 cm x 30.7 cm active area)
- No spacer grids
- Cut strips without centre pixels (extendable in future)
- Additional copper etching
- Avoid gas blocking due to rims



- Central region can be deactivated remotely
- HV distribution via Stabilized-Voltage-Divider
- Helpful knowledge from previous production & ALICE upgrade

Status of Production TB 19.01.2021

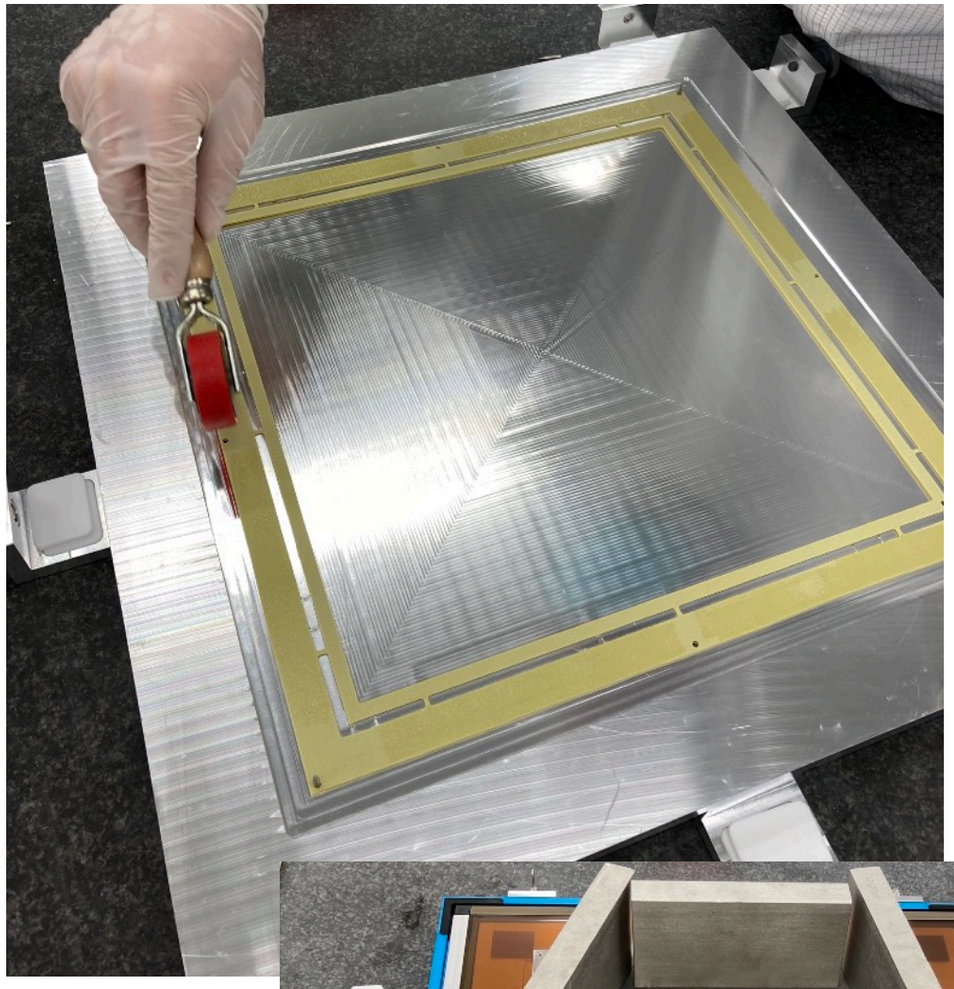
- GEM foils and readout circuits for 2 detectors received from CERN, optical test ok
- frames for 2 detectors received, being prepared
- support plates for 2 detectors received, strong bending of large ones observed, will be reproduced by company



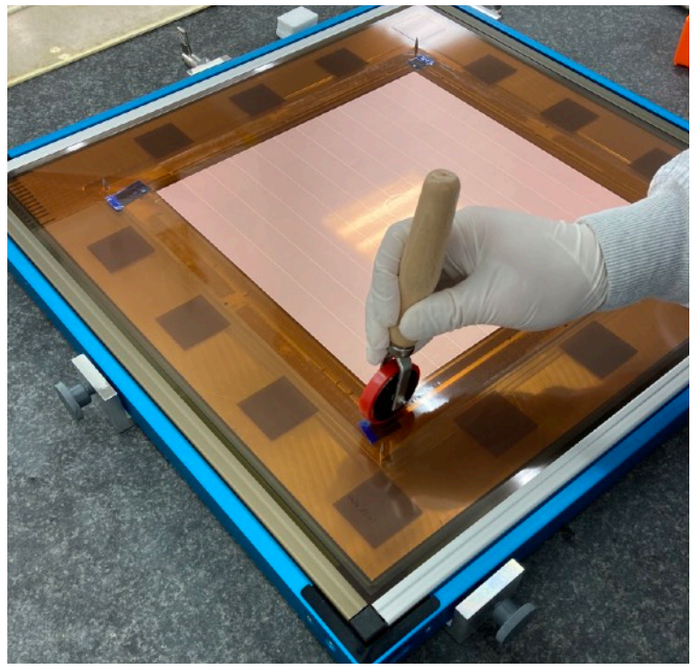
Status of Production TB 23.03.2021

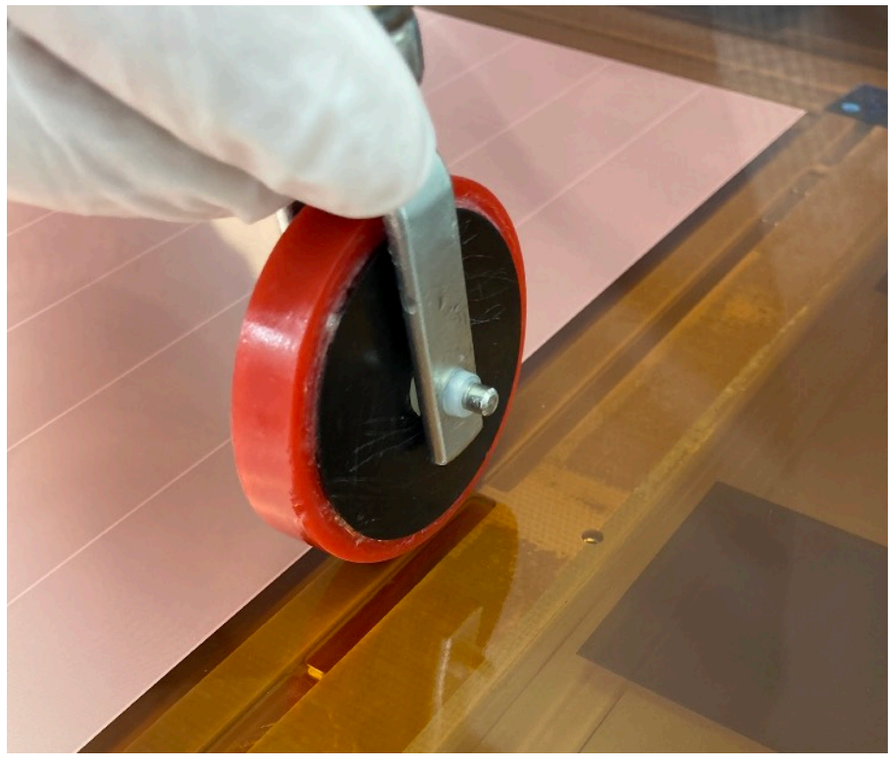
- 3 GEM foils framed
- 1 drift-foil glued on HC-plate
- Successful reproduction of large HC-Plates
- Orders in preparation for material for 4 detectors (in total)

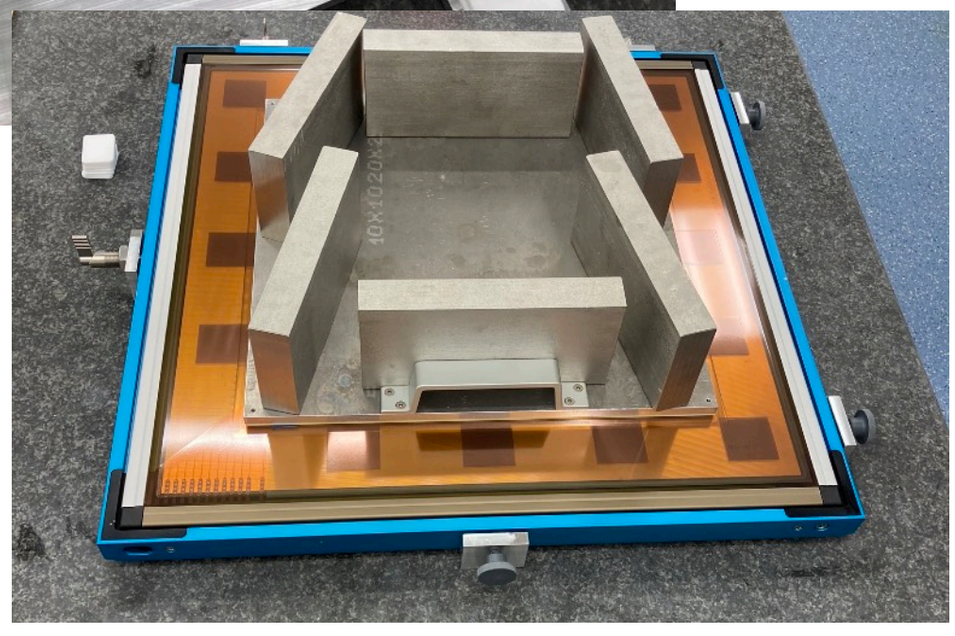
First Production

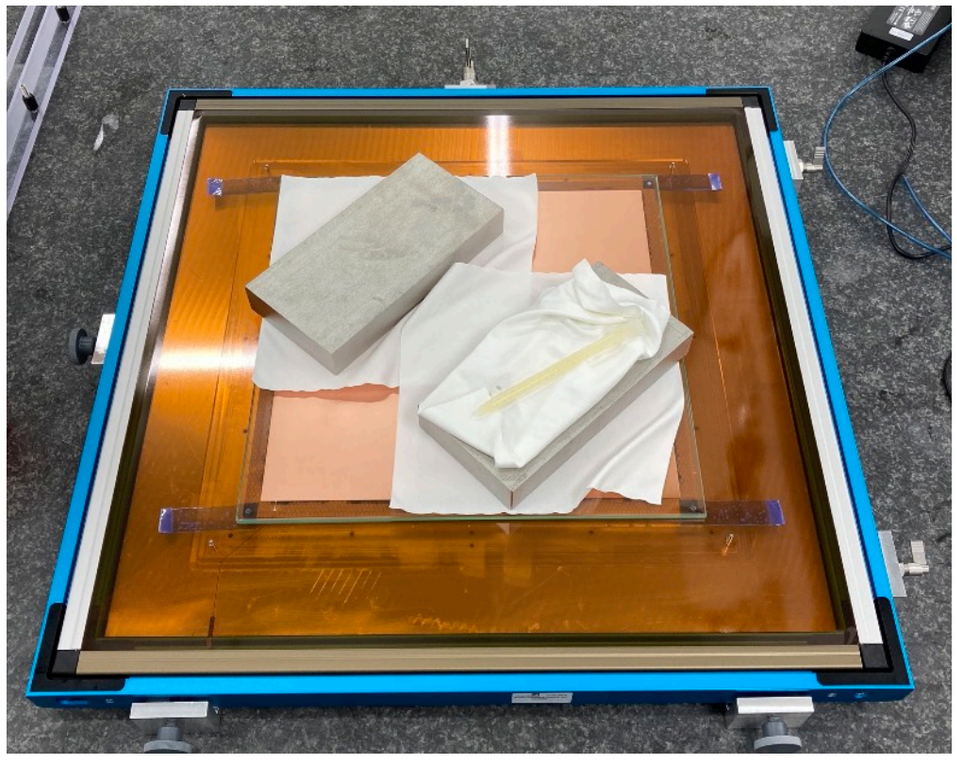


Glueing



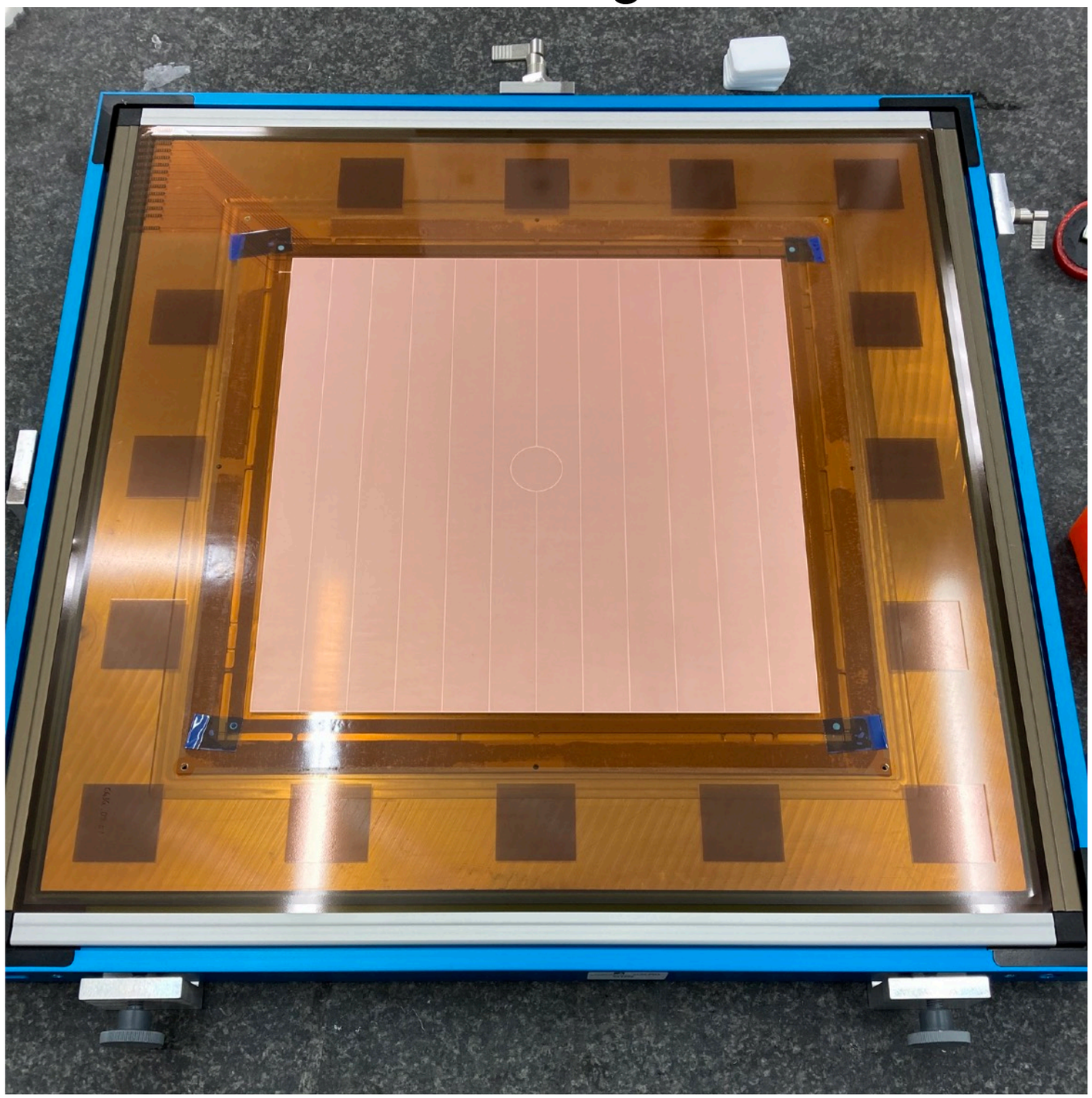






First Production

Glueing



The CG3G-Production

(p.d. - per detector)

In lab:

- 3 framed GEMs
  (3 GEM foils, 2 spacer frames, 1 drift frame)
- 3 GEM foils
  (2 not yet tested and 1 with increasing current for a segment)
- 3 drift foils
- 3 R/O foils
  (2 random 1 complete tested- no shorts found)
- 2 spacer frames
- 2 R/O frames
- 1 drift frame
- 3 large HC plates
- 2 small HC plates

Additional material for 4 detectors in total:

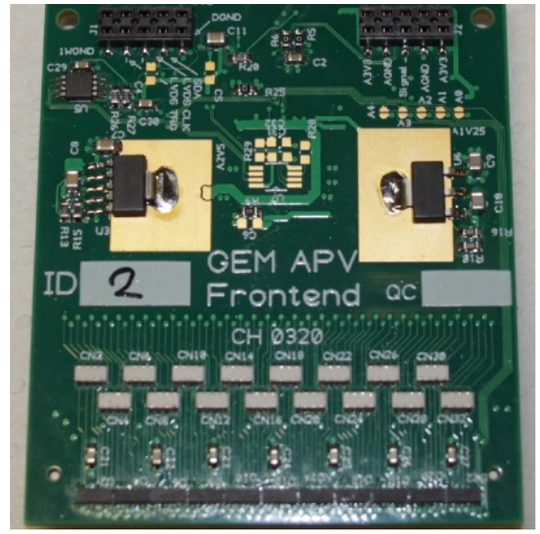
- min. 7 GEM foils (+3 p.d.)
- min. 1 drift foil (+1 p.d.)
- min. 1 R/O foil (+1 p.d.)
- min. 4 spacer frames (+2 p.d.)
- min. 2 R/O frames (+1 p.d.)
- min. 2 drift frames (+1 p.d.)
- min. 1 large HC-plate (+1 p.d.)
- min. 2 small HC-plates (+1 p.d.)

Costs for additional material:

- ~18-20k for foils
- ~3k for HC-plates
- ~6k for pitch adapter -> see APV

Electronics

APV

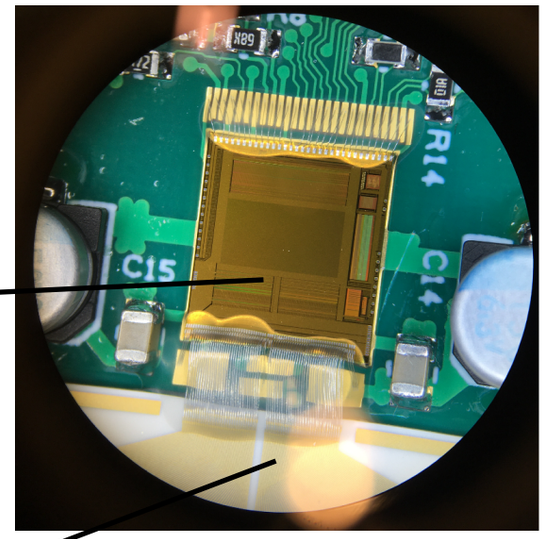


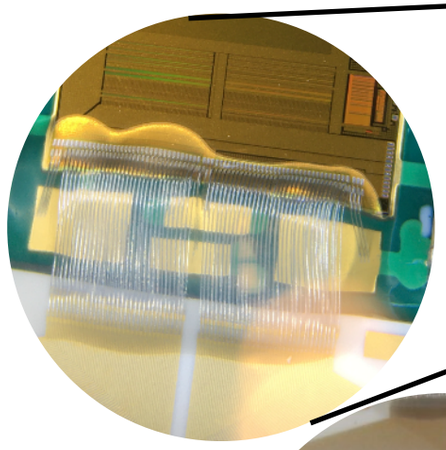
Current Status:

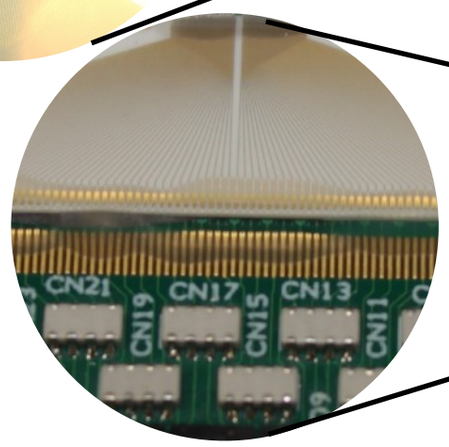
- 10 FE-cards in Lab
- Ca. 50 FE-cards possible with existing pitch adapters
- Wire bonding done at PI, Univ. Bonn
  New: potting of bonds

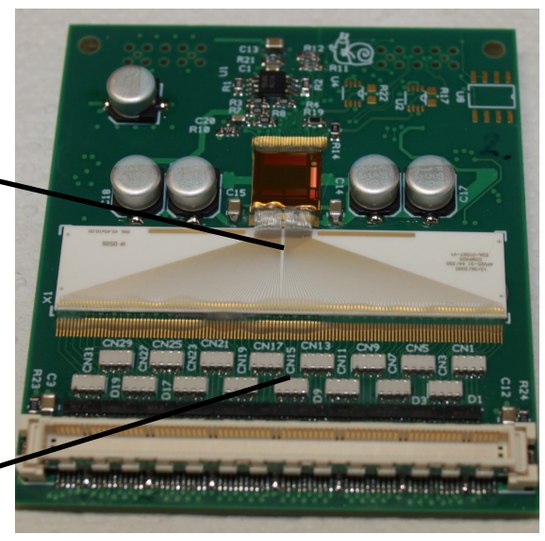
Required (p.d.):

- 24 FE-cards
- 4 fanout-cards
- 2 (new) ADCs









—> Ca. 50 FE-cards needed in addition
(pitch adapter needed 3k+3k)

Electronics

ADC

Done:

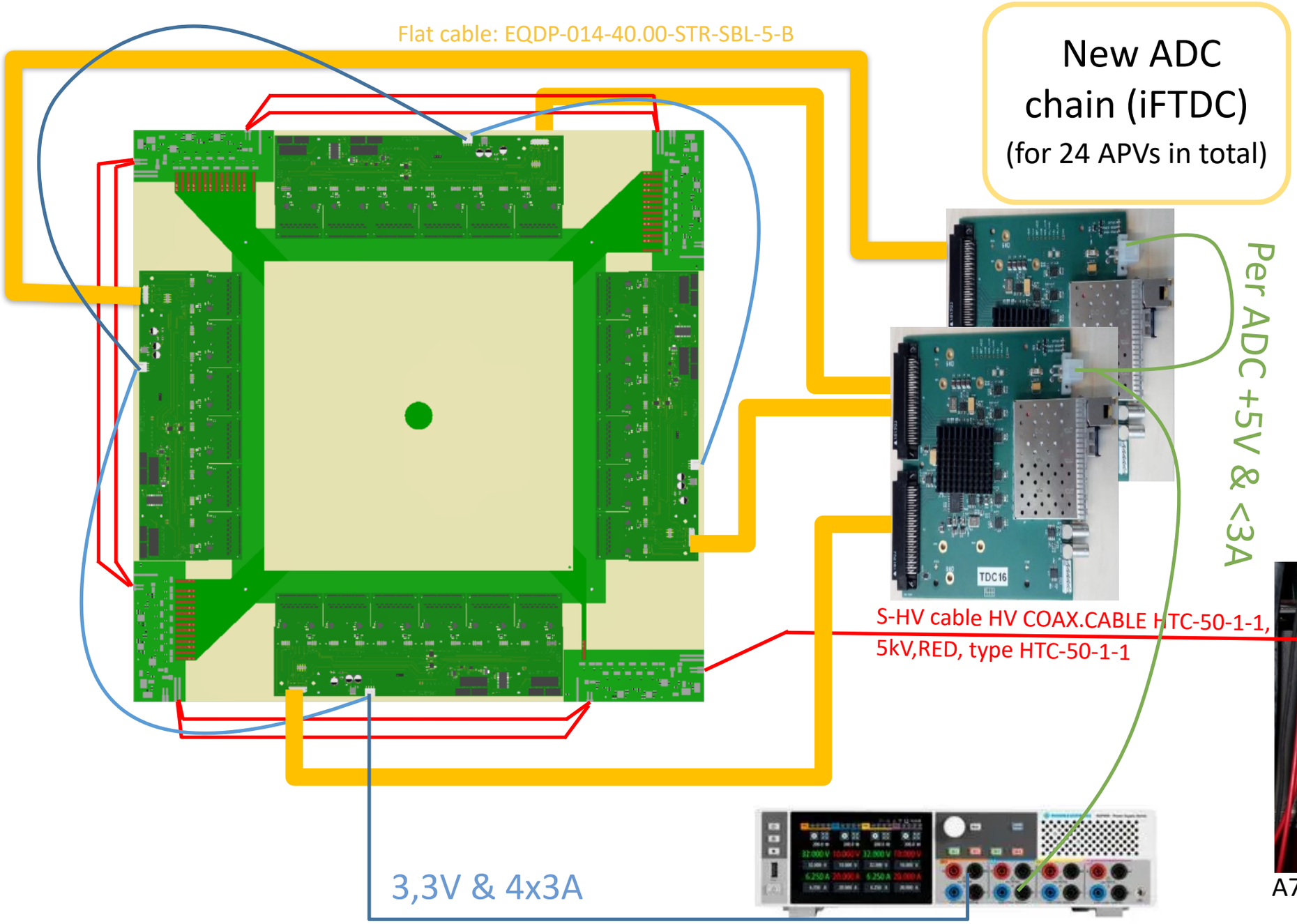
- Schematic (Igor, TUM)
- Layout
  (C. Tezel, C. Honisch, HISKP Bonn)
- Order PCB / Pasting template for 3 prototypes

Necessary:

- Order components
  (Igor will provide some, still has to be clarified)
- Assembly (will be done at HISKP Bonn)
- Smoke test
  (we can probably do this in Bonn)
- Status of firmware?
- General functionality test (for this one needs suitable firmware and an IFTDC)

—> CG3G can only be fully red out with new ADC and corresponding R/O-chain
(Currently not possible in Bonn -> to be set up)

Upgraded Triple GEMs (CG3G)



- 1 station = 2 detectors = 4 planes
- 24 APV25 (S1) per plane

Required Power Supply Rails for 1 Detector:

- 4 kV, 1 mA for GEMs & Drift
- 3.3 V, 3 A (4x) for APV Supply (floating, remote sense wires)
- 5 V, 3 A for each ADC (floating)

LV Configurations

green: existing
dark orange: plan for 2021
light orange: possible future

Generation	p.s. type	GMnnU1	GMnnV1	GMnnX1	GMnnY1
CG1G	APV: CAEN A516	2ch, ±3.5V, -0.9A, +0.7A	2ch, ±3.5V, -0.9A, +0.7A	2ch, ±3.5V, -0.9A, +0.7A	2ch, ±3.5V, -0.9A, +0.7A
	APV: NGP804	2ch, ±3.5V, -1.8A, +1.4A		2ch, ±3.5V, -1.8A, +1.4A	
	ADC: DN35-5	2ch, ±5V, +3.2A, -0.6A			
CG2G (PGEM)	APV: DN35-5	2ch, ±3.5V, -1.8A, +1.4A		2ch, ±3.5V, -1.8A, +1.4A	
	ADC: DN35-5	3ch, ±5V, +6A, -3A			
CG3G	APV: NGP804	1ch, +3.3V, 8-12A		1ch, +3.3V, 8-12A	
	ADC: NGP804	1ch, +5V, <6A		1ch, +5V, <6A	
CG4G	VMM (SRS): NGP804	1ch, 1.9-3.5V, 19.2A		1ch, 1.9-3.5V, 19.2A	
	Auxiliary	1ch, 2.9-3.5V, 2.4A		1ch, 2.9-3.5V, 2.4A	

For Center HV switch: 1 ch 12V, no current ⇒ find simpler solution

LVPSU Costs

ROHDE&SCHWARZ

Item	Model Description / Estimated Delivery (Weeks)	Part Number	Qty. pc.	Unit Price CHF	Total Price CHF
1	NGP800 Power Supply		10		
1.1	**NGP804** Four-channel power supply 0V to 32V, max. 20A per channel max. 200W per channel (800W total) 5" capacitive touch screen QuickArb, Sense electronic fuse, FuseLink OVP, OPP, OTP USB/LAN interface Country of Origin: Malaysia	5601.4007.02	10	4,290.00 -15.00%	42,900.00 **36,465.00**
1.2	**ZZA-GE23** 19 inch rack adapter, 2HU, for R&S®NGP800 power supplies (accessory) Country of Origin: Czech Republic	5601.4059.02	10	286.00 -15.00%	2,860.00 **2,431.00**
	Item Price (1) CHF			4,576.00 -15.00%	45,760.00 **38,896.00**
	Total Net Price			**CHF**	**38,896.00**

Essential technical modifications may make it necessary to replace certain items ordered by the customer with new successor items. In this case, the customer agrees to the modification of the subject matter of the contract even after placement of the order, provided that the agreed terms and conditions are retained and that the successor item complies with the technical specifications of the item ordered by the customer.

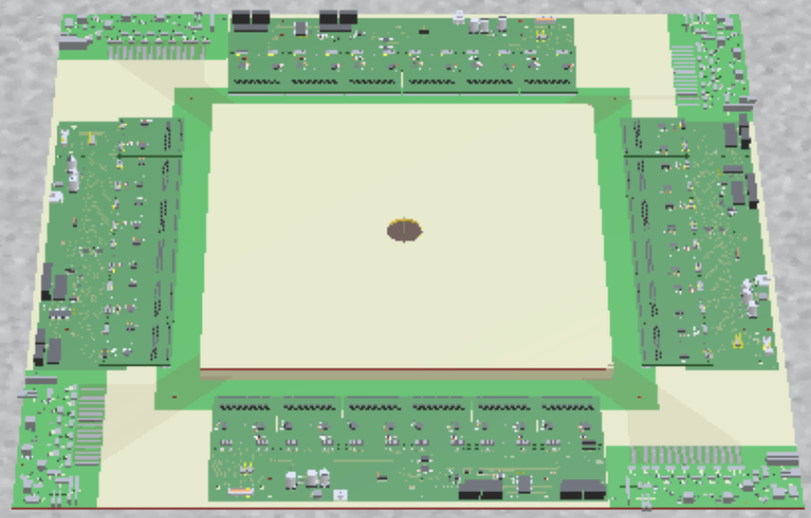
The customer has to make all payments from a bank account under their name. The customer is liable for all payments from the contractual relationship and must ensure compliance with all applicable legislation, in particular on the prevention of money laundering.

Status of GEM Stations

GM03-GM05, GM06XY, GM07-GM09, GP02	tested without Problems
GM01 und GM02	not tested
GM06UV (port 5)	problem concerning FPGA (comment 63023) ->port 5&6 were excluded in database
GM10	cable too short for HV (comment 63024) ->only LV was turned on
GPXX	some empty entries while occupancy measurement ->should be tested in next dry run

—> Plan: all stations will be ready for dry run (except GM11)

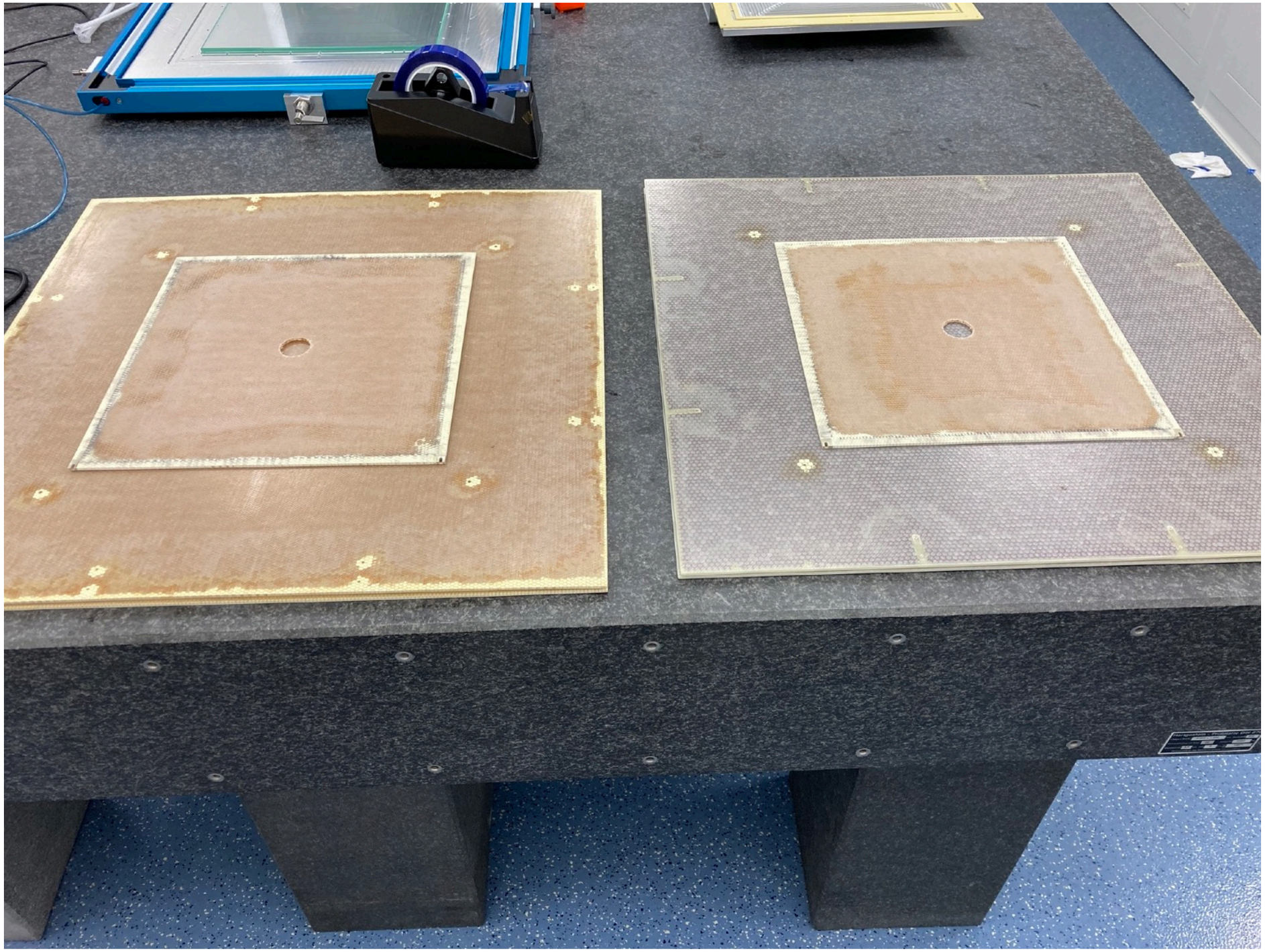
Thanks
-
stay healthy



CG3G in fictional Lab

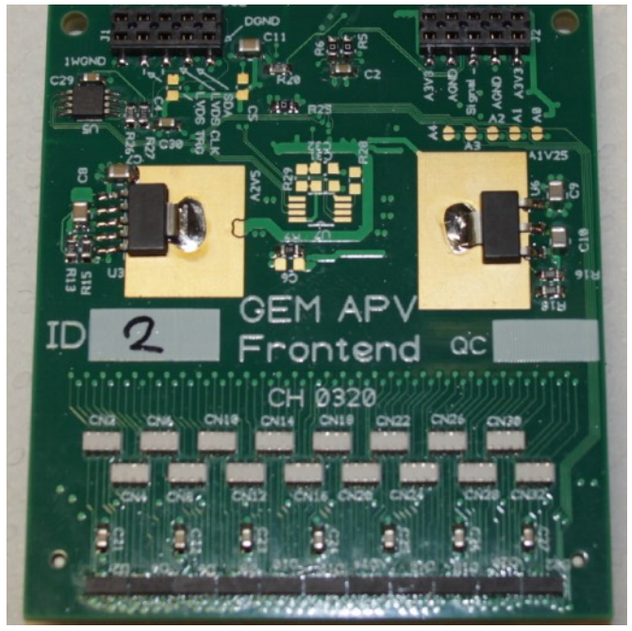
First Production

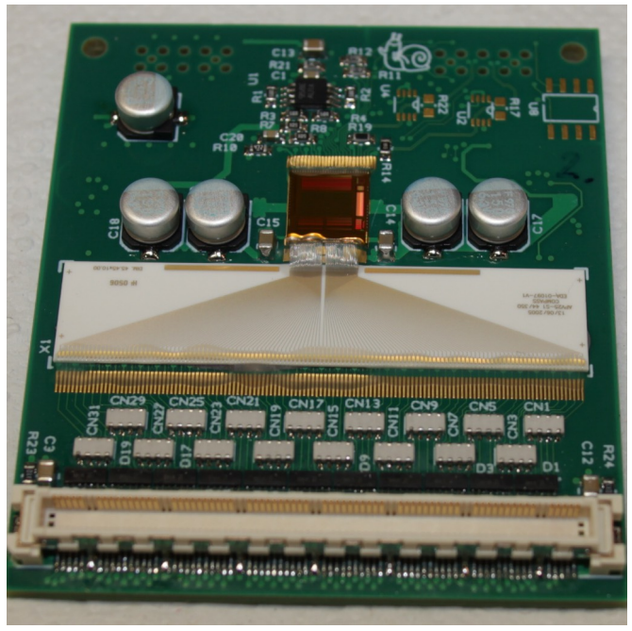
HC-Plates

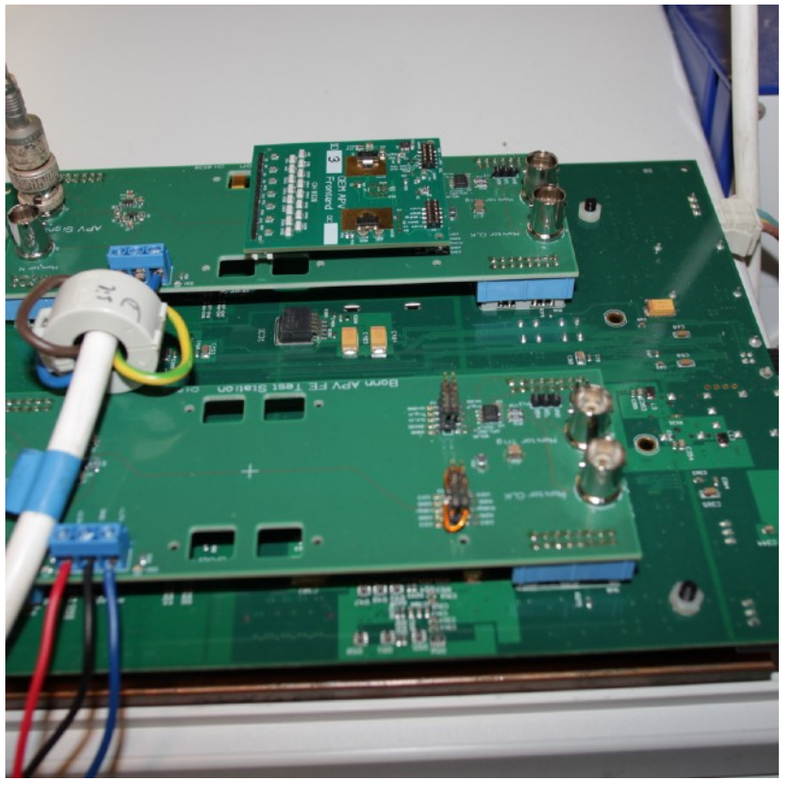


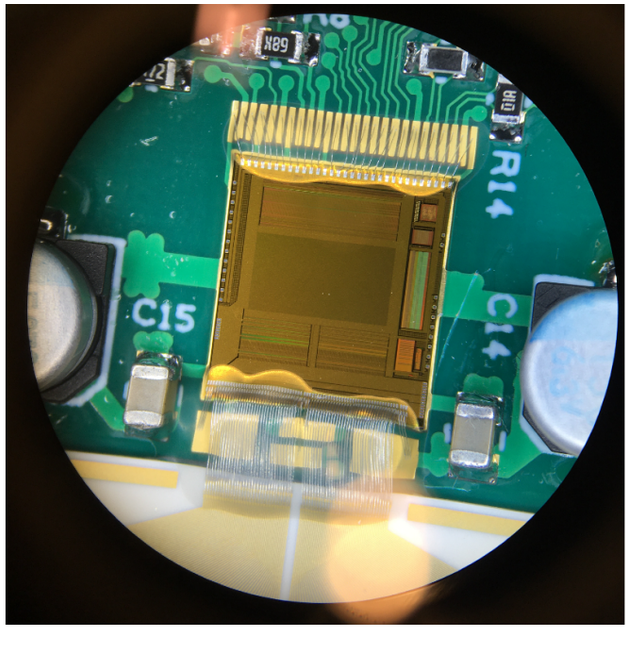
First Production

APV



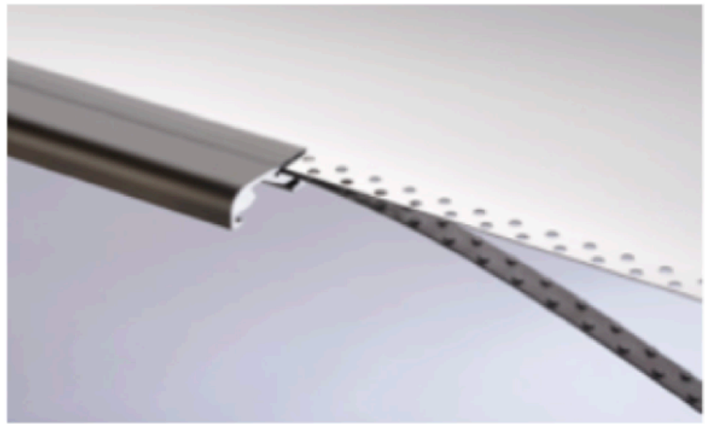




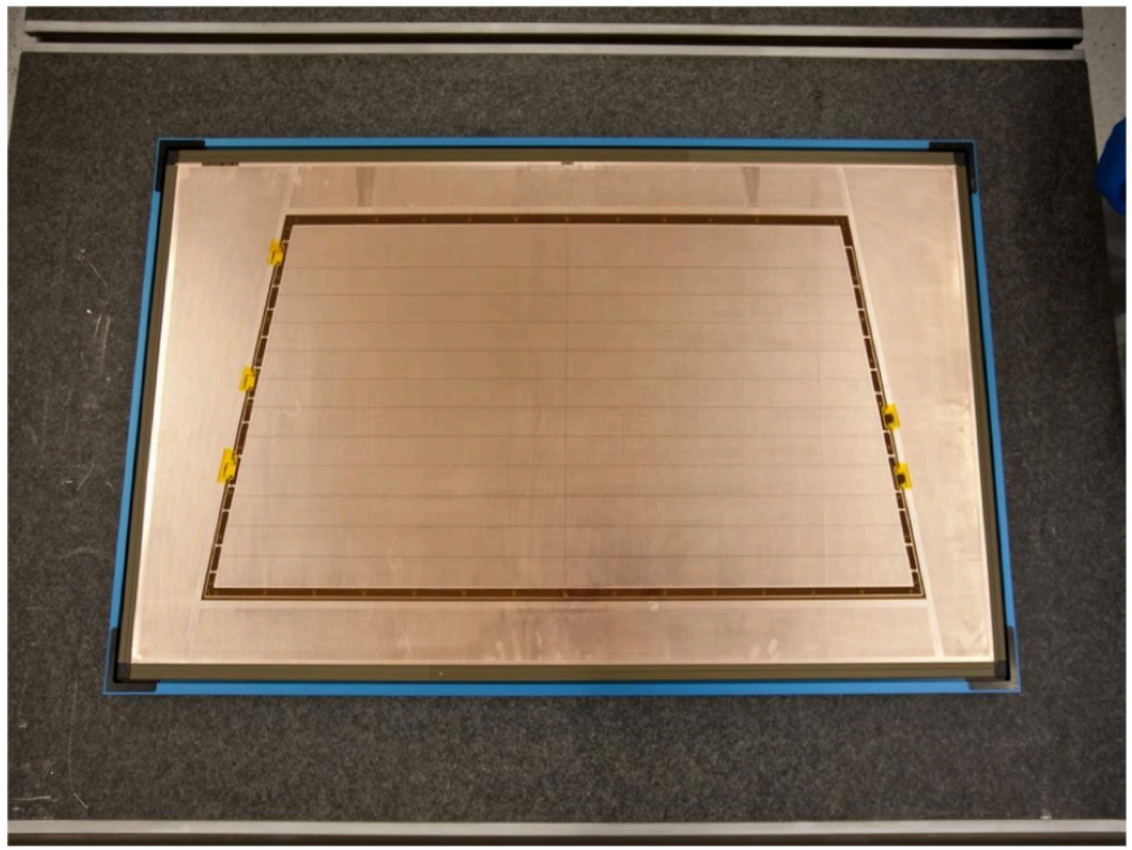


STRETCHING TOOLS

- Foil stretching by pneumatic DEK (Vectorguard®) frame produced by ASM Assembly.
- Foils equipped in aluminium profiles (Optiguard®) – see "*QA of GEM foils*"
- Foil in a profile is installed in the DEK frame
- By applying 0.5 MPa pressure DEK claws open allowing foil to be installed
- Releasing pressure closes DEK claws which stretch GEM
- DEK frame stretching force: **10 N/cm**



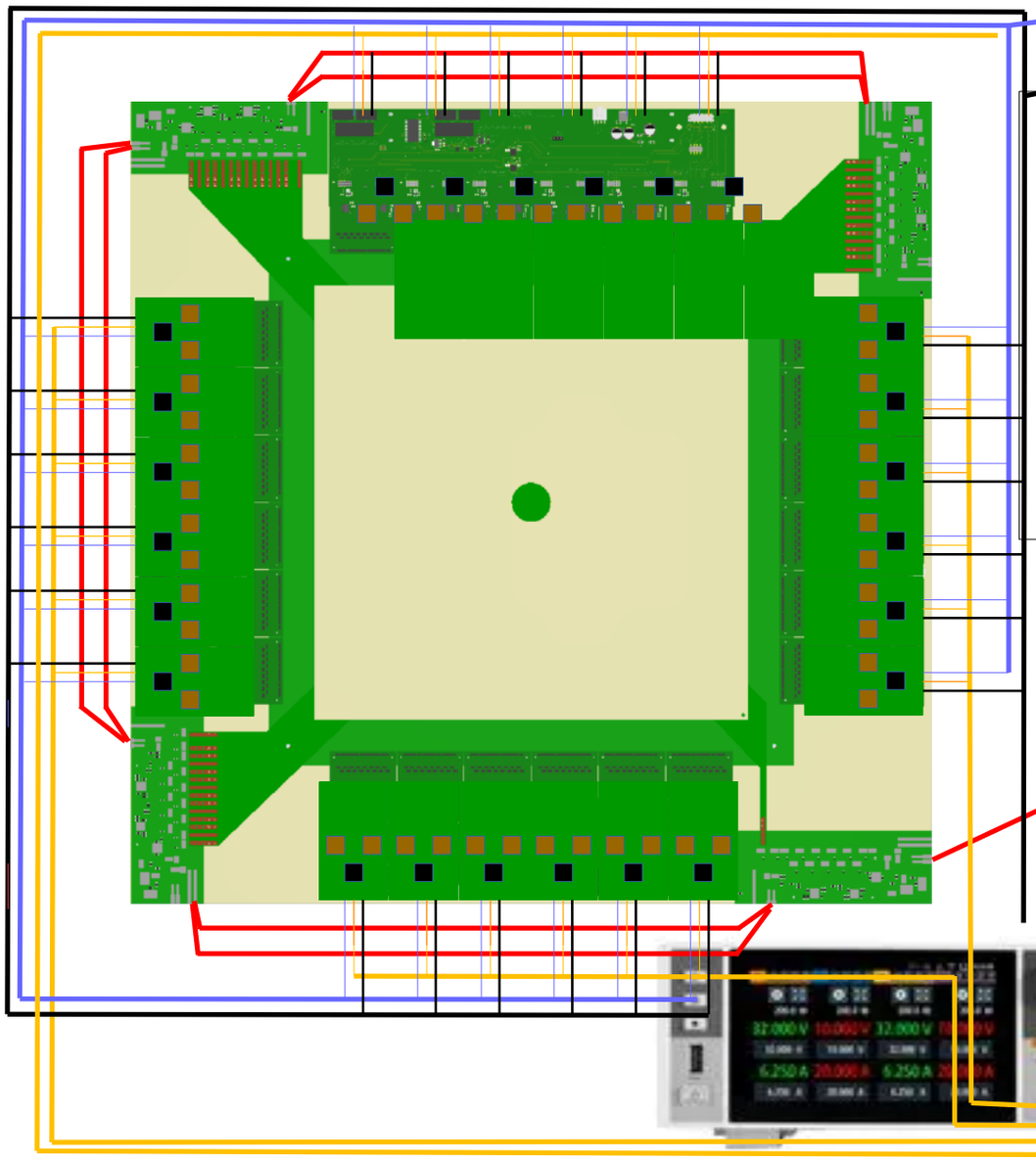
Optiguard® profile



Blue DEK frame with a stretched GEM

Triple GEMs with VMM (CG4G)

Auxilary front-end electronics: (2.9 – 3.5) V, 2.4 A
→ 6.9 – 8.4 W

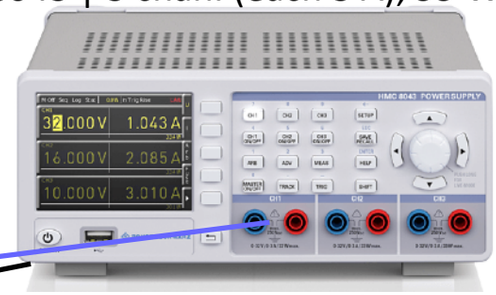


Example SRS VMM hybrid:
- *2 VMM ASICs, Aux.(FPGA, ...)*
- *VMMs: (1.9-3.5) V @ 1.67 A*
- *Aux.: (2.9-3.5) V @ 0.1 A*

→ 24 hybrids/detector

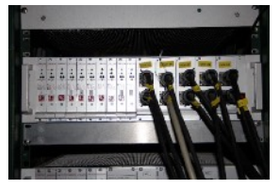
Bare VMM ASIC: ~0.8 A @ 1.2 V
48 VMM ASICs need/detector

Rohde&Schwarz HMC8043 | 3 chan. (each 3 A), 99 W



Deutronics DN35W-5 (5.5V, 6A)

Or



- 1 station = 2 detectors = 4 planes
- 24 VMM3a ASICS per plane

Required Power Supply Rails for 1 Detector:
- 4 kV, 1 mA for GEMs & Drift
- VMM ASICs:
- (1.9 – 3.5) V, 24 x 1.67 A grouped to 4 x 10 A
- Auxilary front-end electronics:
- (2.9 – 3.5) V, 2.4 A (all front-end boards)

S-HV cable HV COAX.CABLE HTC-50-1-1, 5kV,RED
type HTC-50-1-1

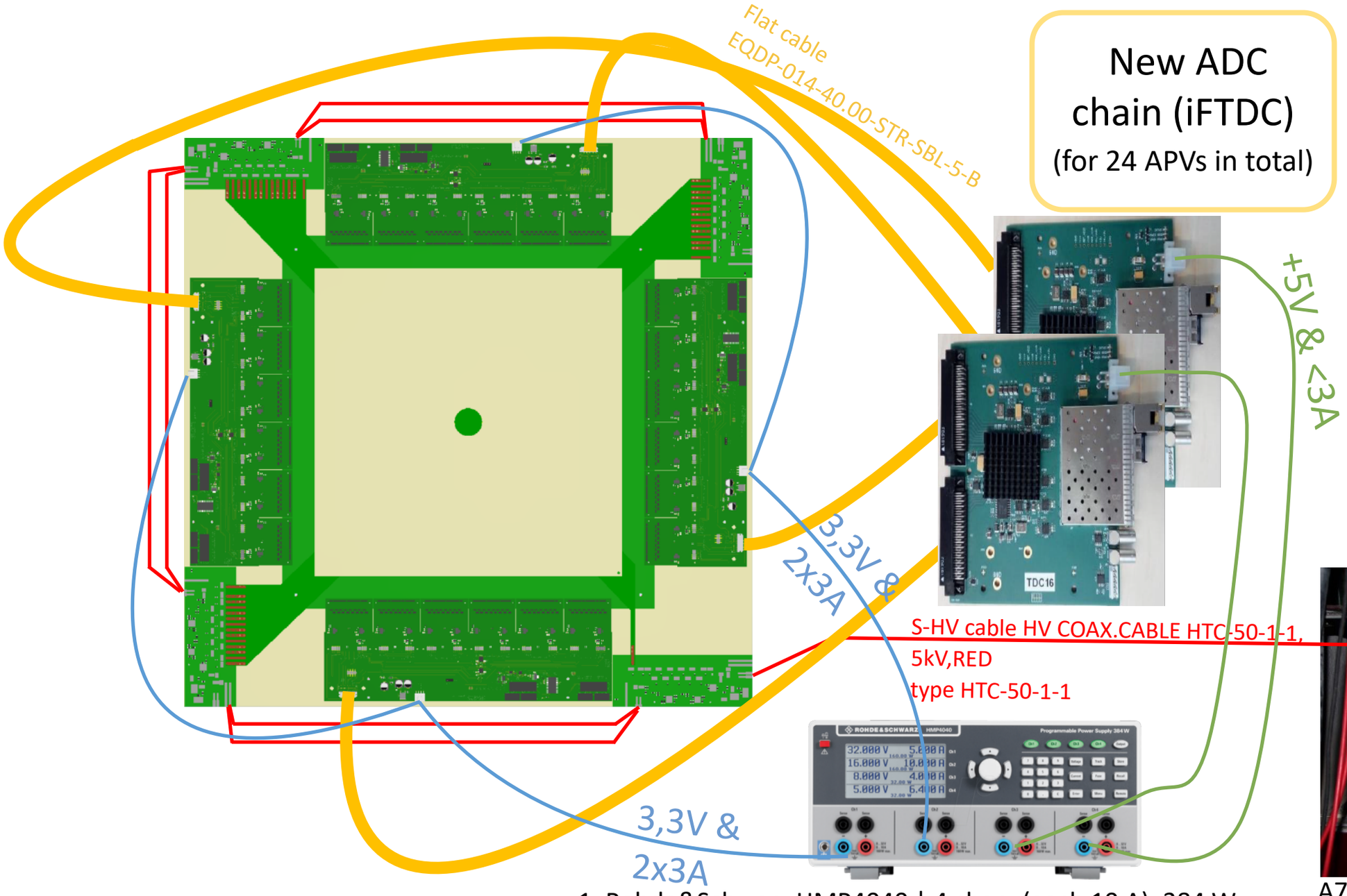
Rohde&Schwarz NGP804 | 4 chan. (each 20 A), 800 W

A732N (6kV, 1mA)

CAEN SY527 Mainframe

VMM ASIC Power: (1.9 – 3.5) V, 4 x 10 A
→ 76 – 140 W

Upgraded Triple GEMs (CG3G)



- 1 station = 2 detectors = 4 planes
- 24 APV25 (S1) per plane

Required Power Supply Rails for 1 Detector:

- 4 kV, 1 mA for GEMs & Drift
- 3.3 V, 3 A (4x) for APV Supply (floating, remote sense wires)
- 5 V, 3 A for each ADC (floating)

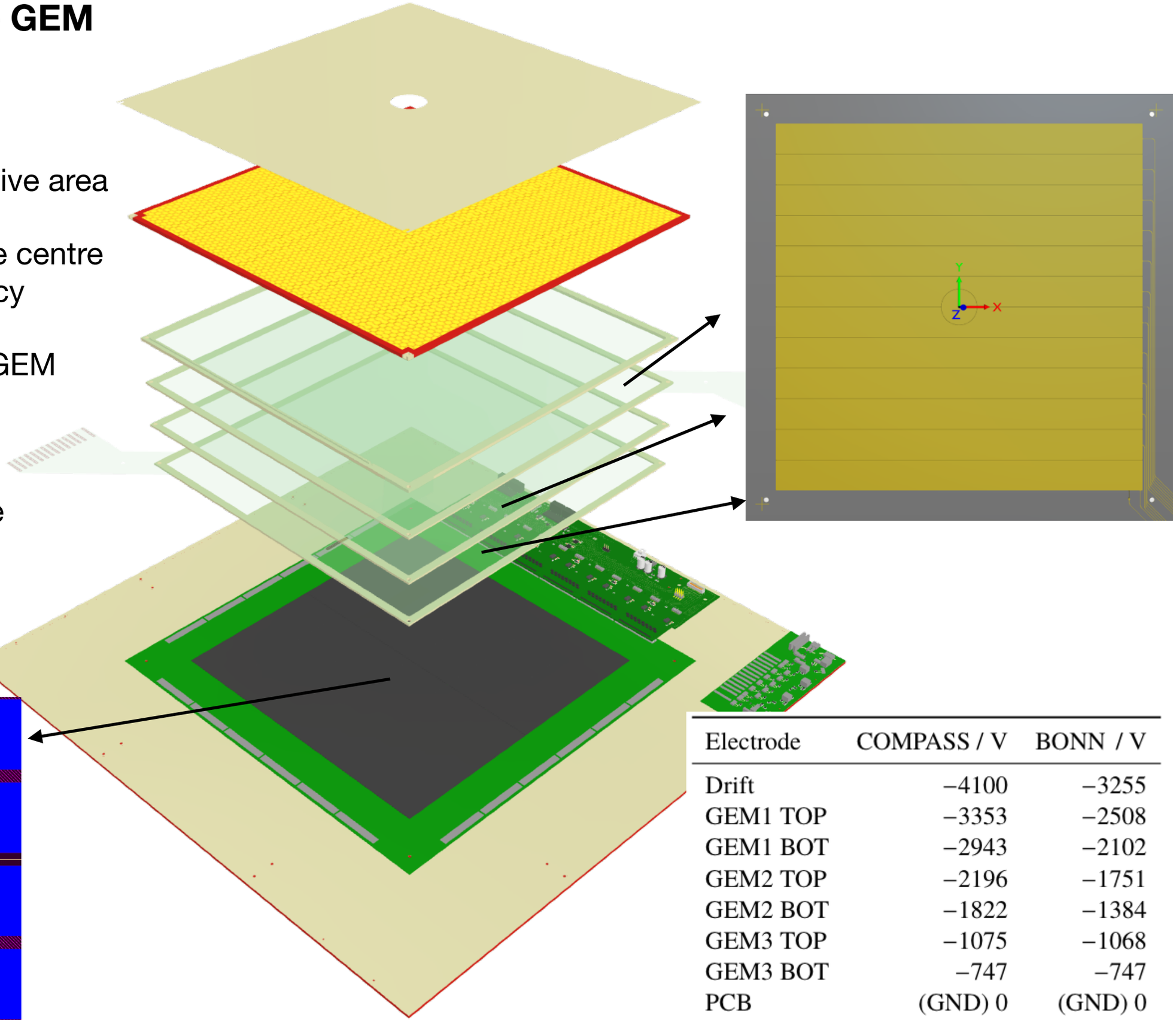
1. Rohde&Schwarz HMP4040 | 4 chan. (each 10 A), 384 W
2. Rohde&Schwarz NGP804 | 4 chan. (each 20 A), 200 W p.ch.
   (-> only one PS per station?)

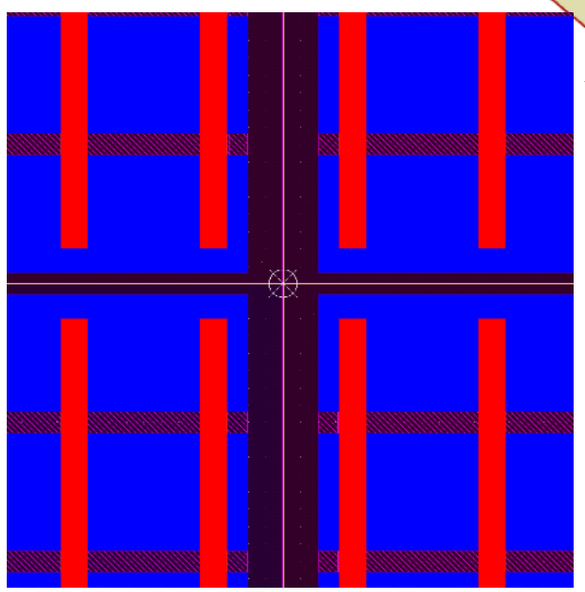
Open Questions

- GEM11?
  (place GEM04)
- Status of spare-electronics for first generation
- Status PoSu
- Summation-cards for first tests of CG3G
- Business travel to CERN for Tasks?
- Which tasks need to be done before dry-run?

Ongoing large-size GEM (CG3G)

- 30.7 cm x 30.7 cm active area
  - Strips divided in the centre to reduce occupancy
- 13-fold top-sectored GEM
- Spacer without grids
- Gas-inlet via drift plate
- Honeycomb plates

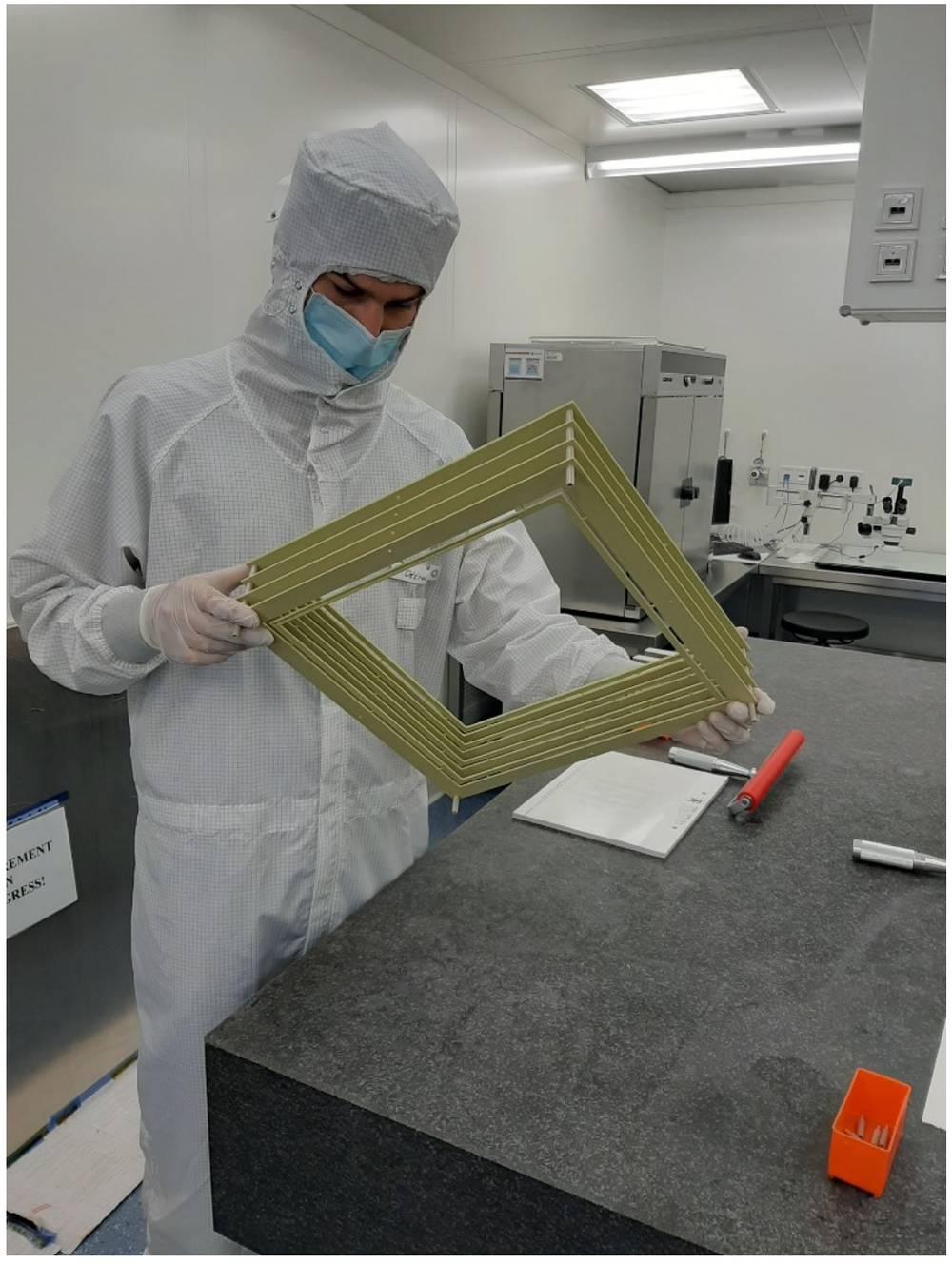




Electrode	COMPASS / V	BONN / V
Drift	−4100	−3255
GEM1 TOP	−3353	−2508
GEM1 BOT	−2943	−2102
GEM2 TOP	−2196	−1751
GEM2 BOT	−1822	−1384
GEM3 TOP	−1075	−1068
GEM3 BOT	−747	−747
PCB	(GND) 0	(GND) 0

[4]

Frames for one Detector



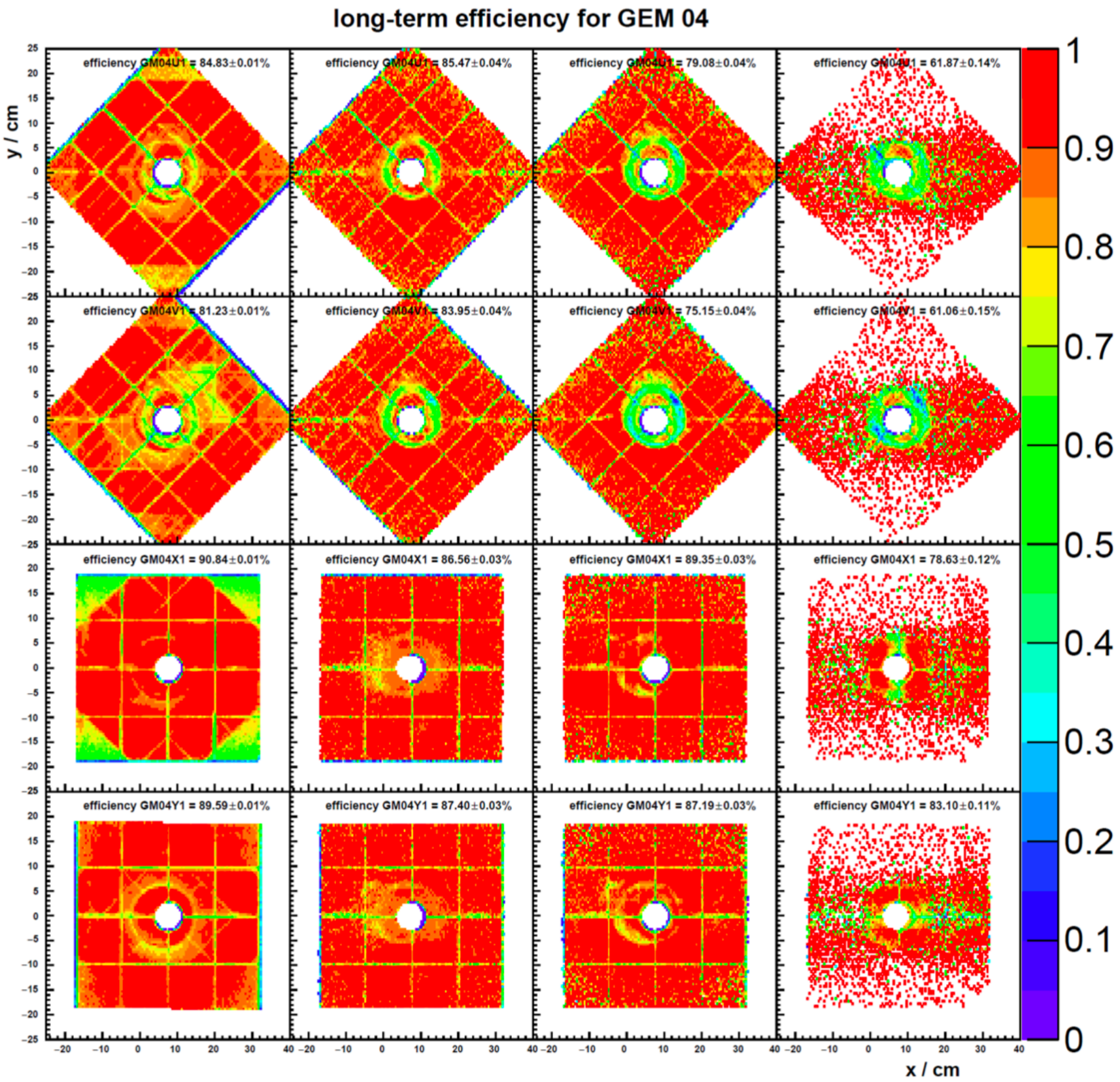
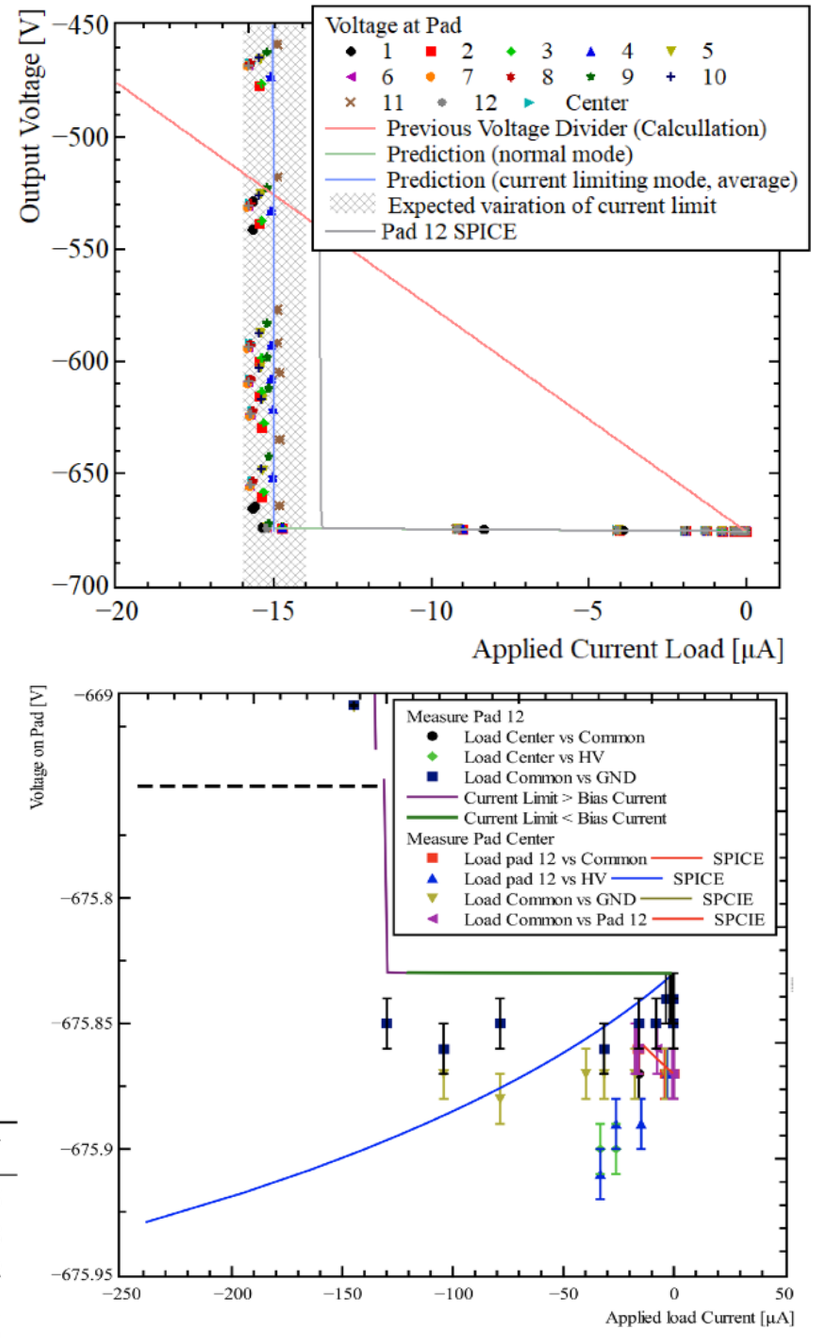
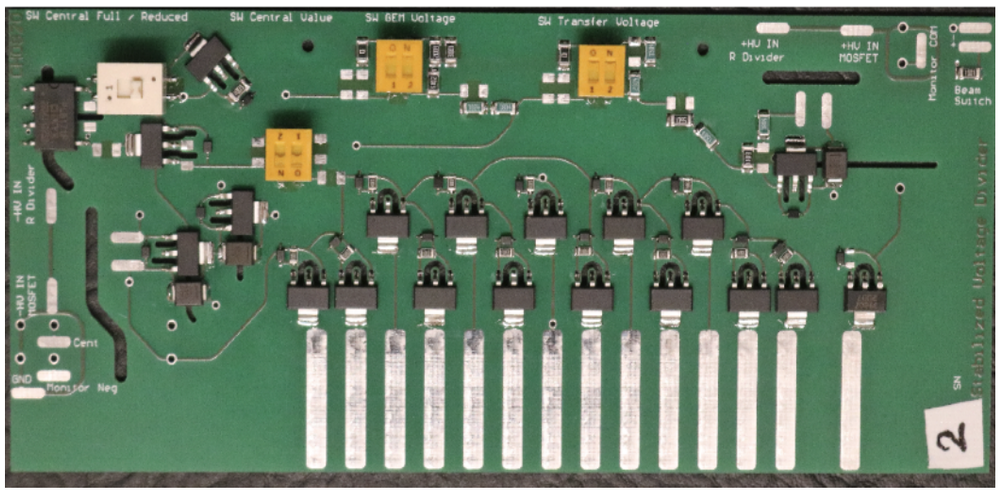


Figure B.4: 2D efficiency maps for each projection of GEM4 for years 2008, 2015, 2016 and 2017

Stabilized Voltage Divider

- Prototypes assembled + tested
  - Output voltage stable for small loads
  - Current limited (~15µA)
  - even smaller voltage change when loading neighboring pad
- Todo:
  - Test in detector



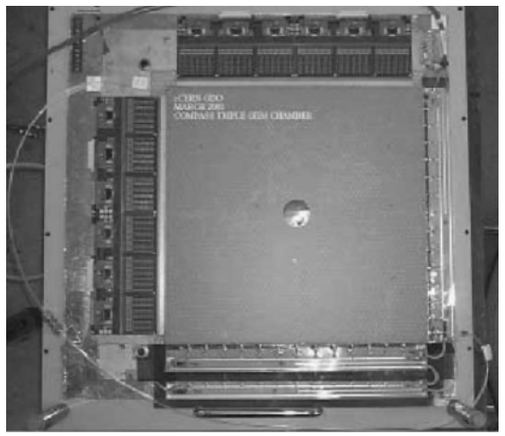


Electrode	COMPASS / V	BONN[3] / V
Drift	−4100	−3255
GEM1 TOP	−3353	−2508
GEM1 BOT	−2943	−2102
GEM2 TOP	−2196	−1751
GEM2 BOT	−1822	−1384
GEM3 TOP	−1075	−1068
GEM3 BOT	−747	−747
PCB	(GND) 0	(GND) 0

Progression

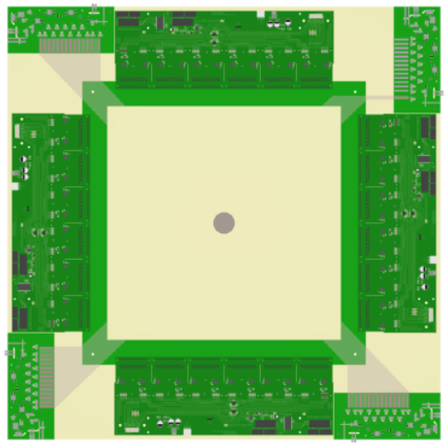
Of CompassGemGenerations

CG1G



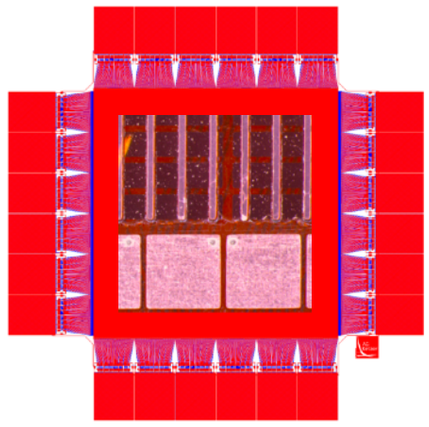
Large-size GEM

CG3G



Updated Large-size

CG5G

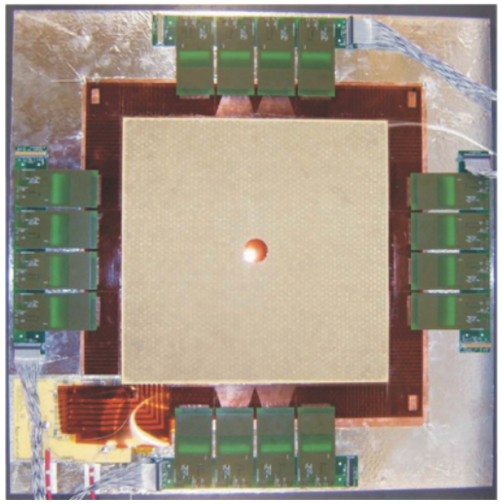


Large-size with Pixel

2001 — 2021 — 2023 - 2024? — not to scale

2008

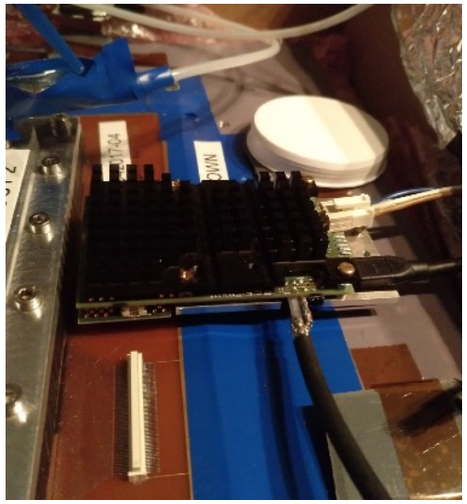
CG2G



Pixel GEM

2022

CG4G

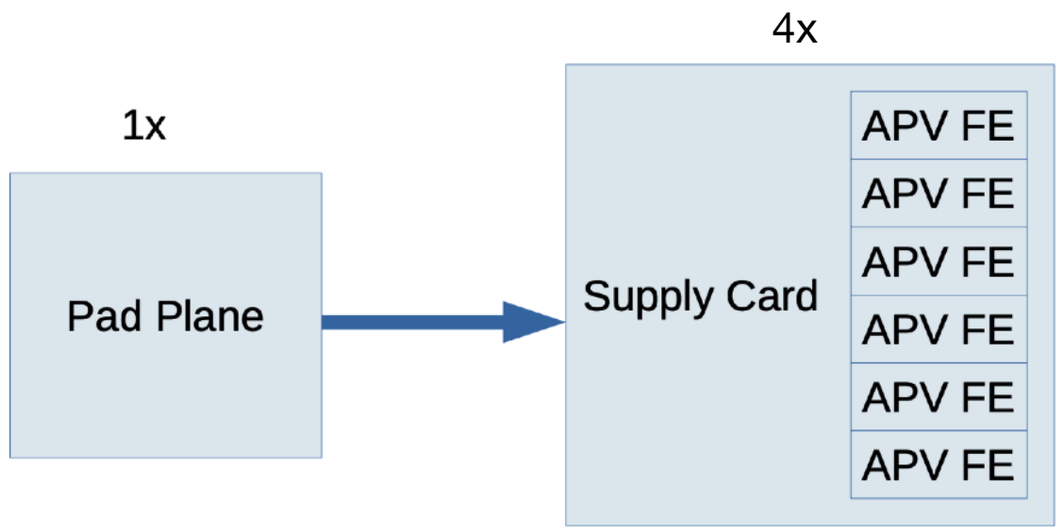


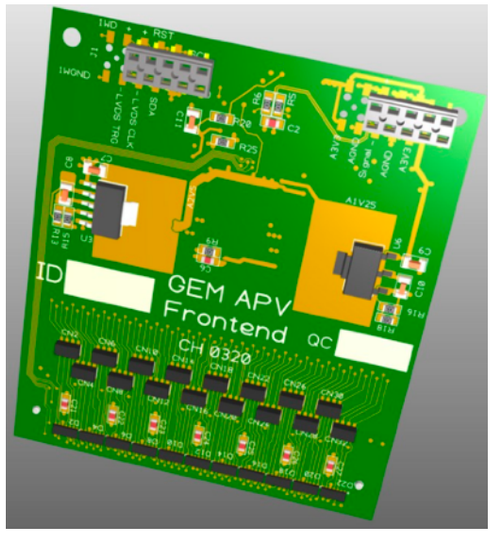
Self triggered readout
e.g. with VMM

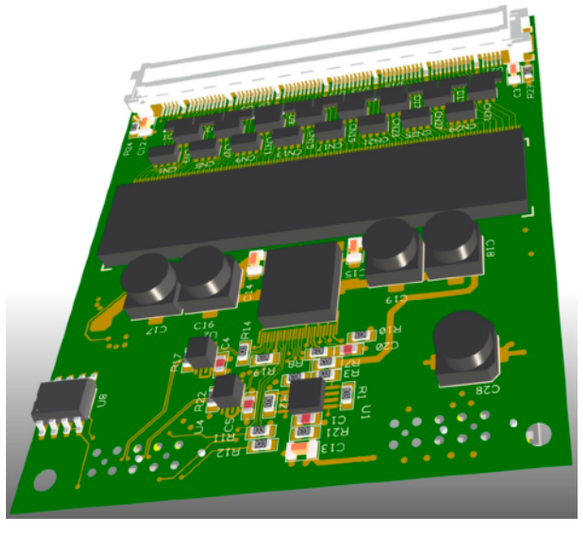
APV Frontend

Christian Honisch (honisch@hiskp.uni-bonn.de)

- One Detector:
  - 4x Supply card
    - ➡ Each 6x APV Front-End
- Improved input protection
- I²C temperature sensor
- I²C addresses: via detector connection



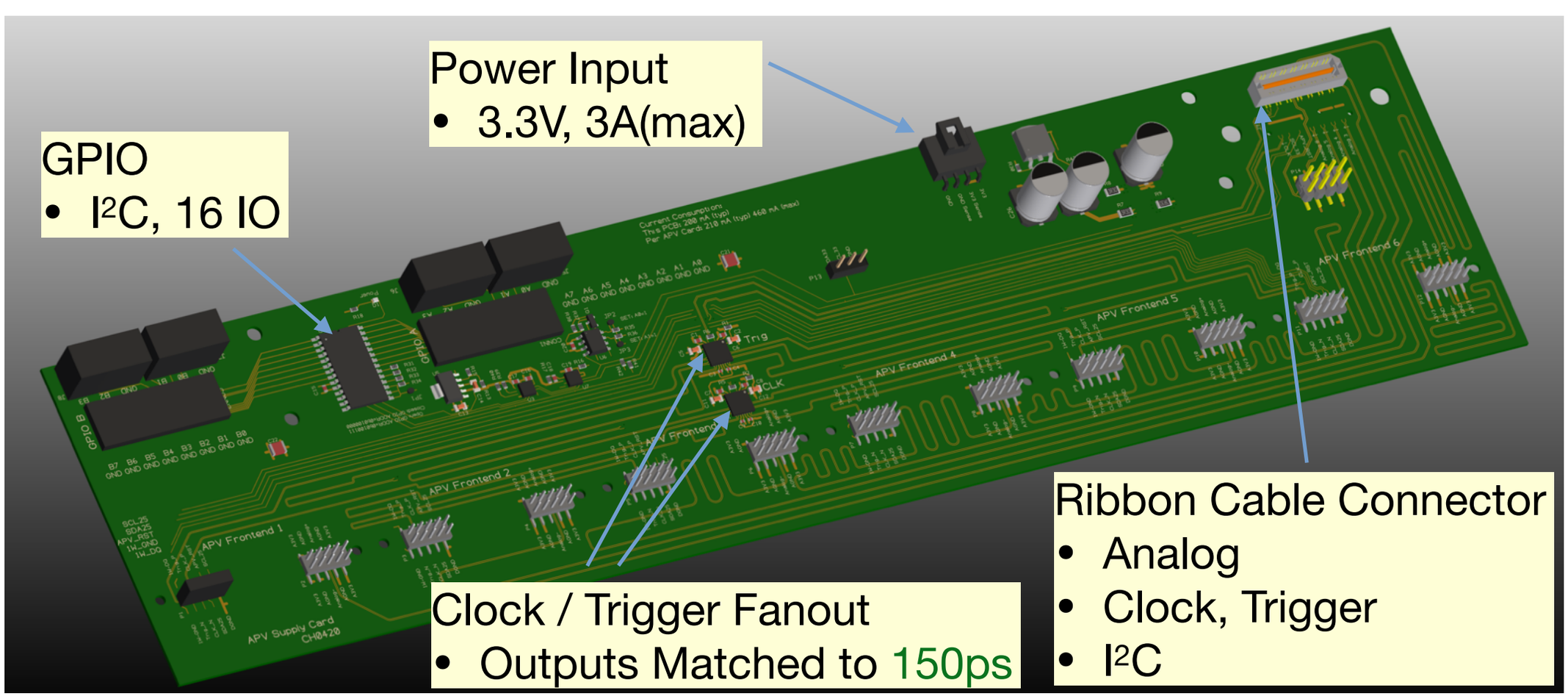


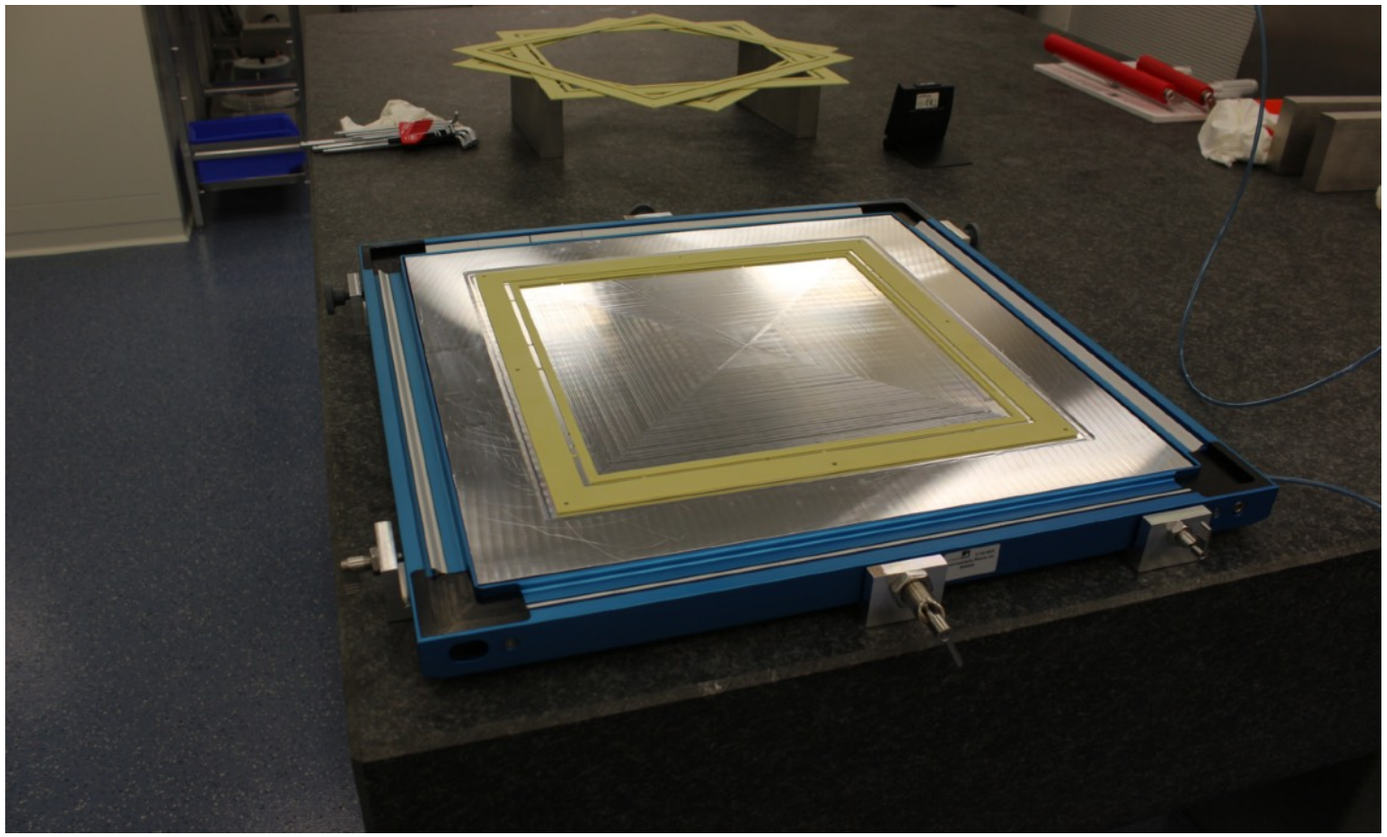


APV Frontend

Christian Honisch (honisch@hiskp.uni-bonn.de)

- Provides Power, Clock, Trigger to APV-FE
- Concentrates analog signals from APV-FE
- **Clock, Trigger, Analog: Matched Lengths**





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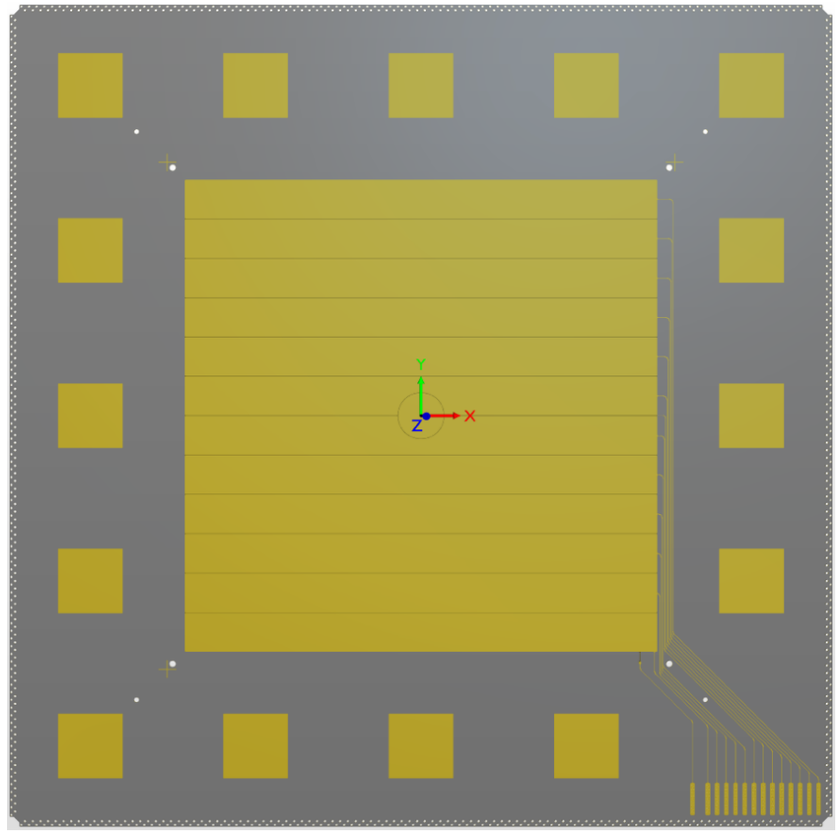

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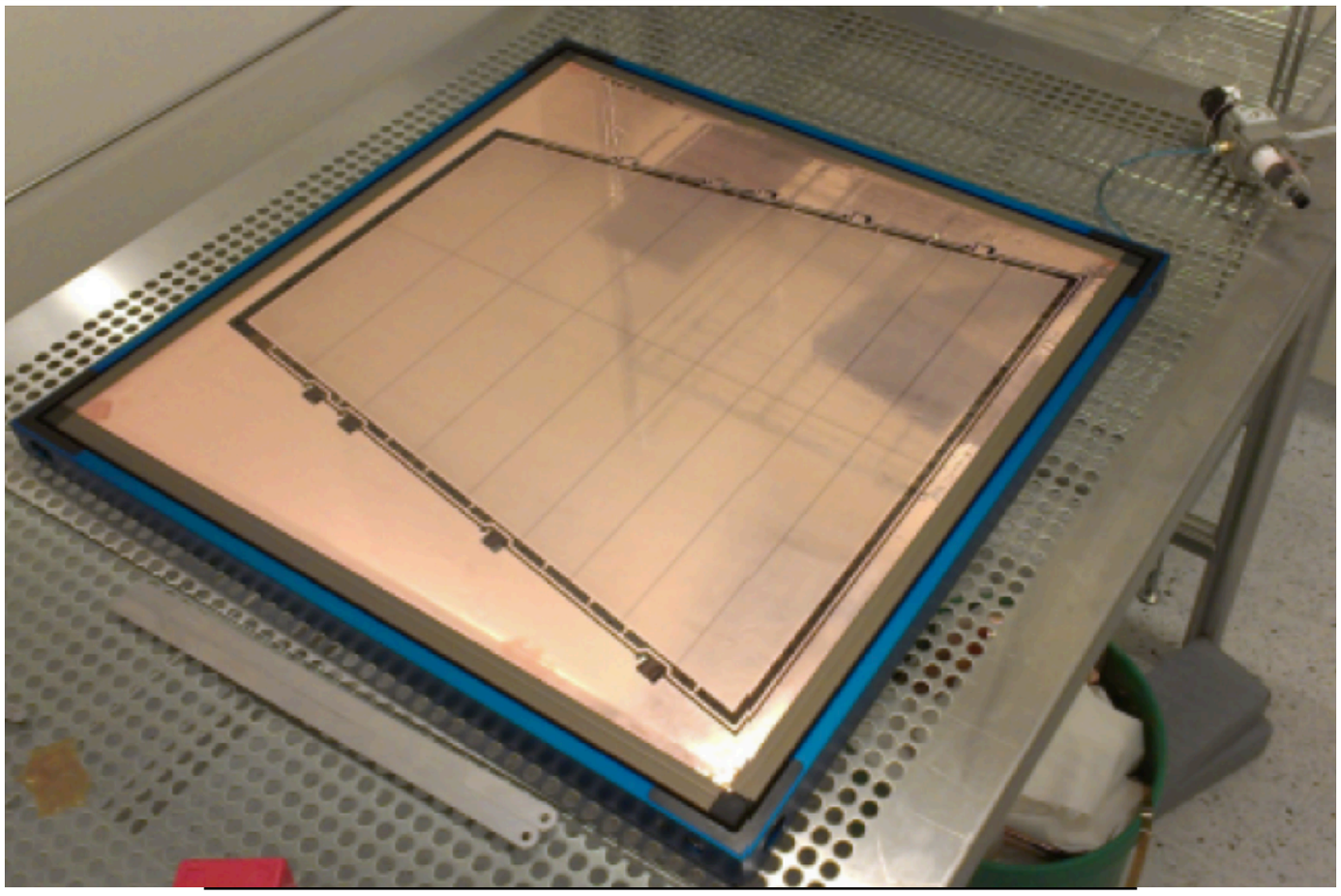
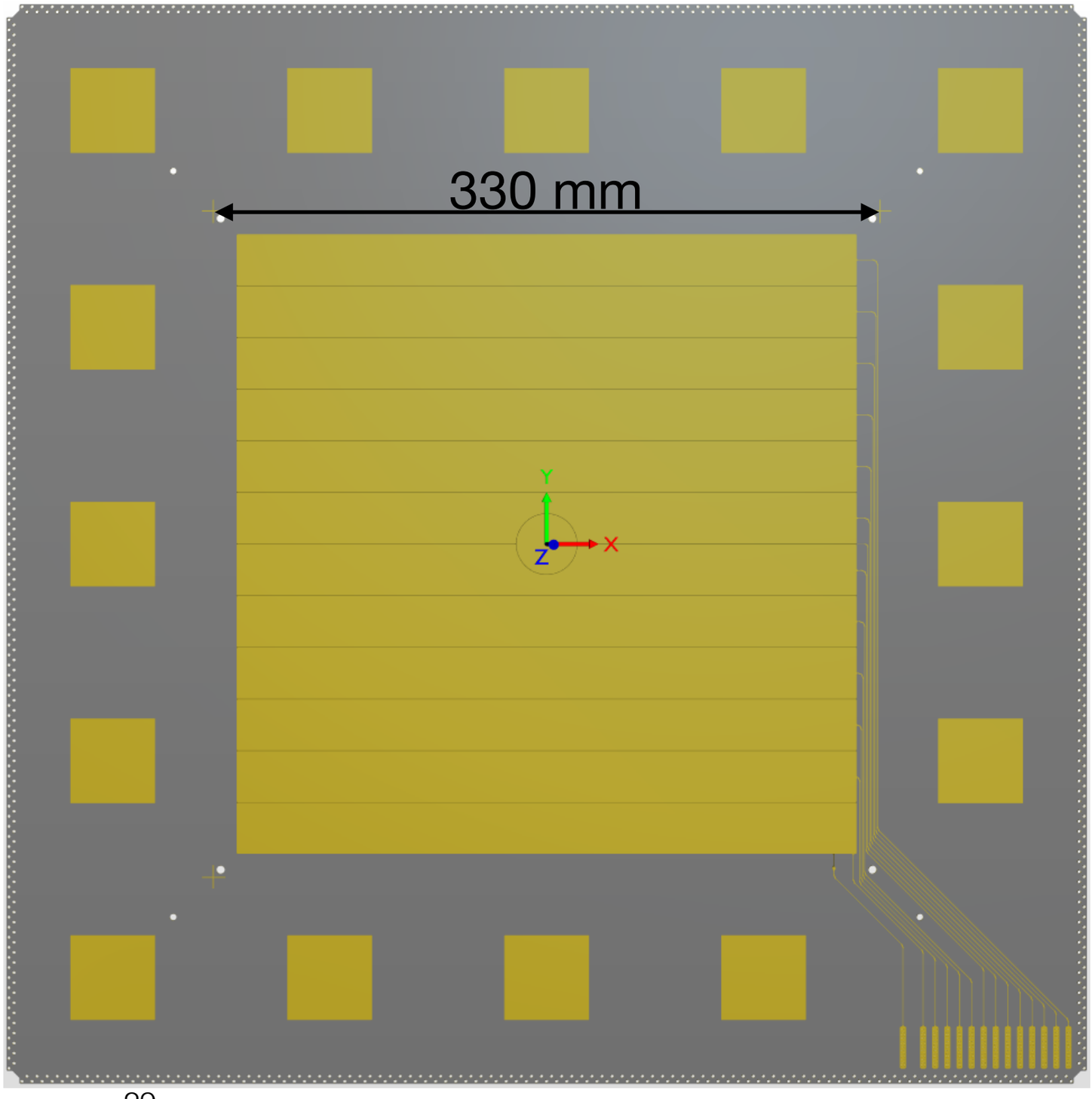


ALICE IROC GEM foil in stretching frame

GEM Foil Design

- Triple GEM stack
- Foils segmented on one side: 12 sectors + centre
- All lines guided through one corner with coverlay protection
- Foils rotated in stack by 90°
- Cu thickness reduced



Readout Plane

- Readout from all sides
- 4x768 strips (cut in middle)
- Hirose FX10 replace older Panasonic P5 series