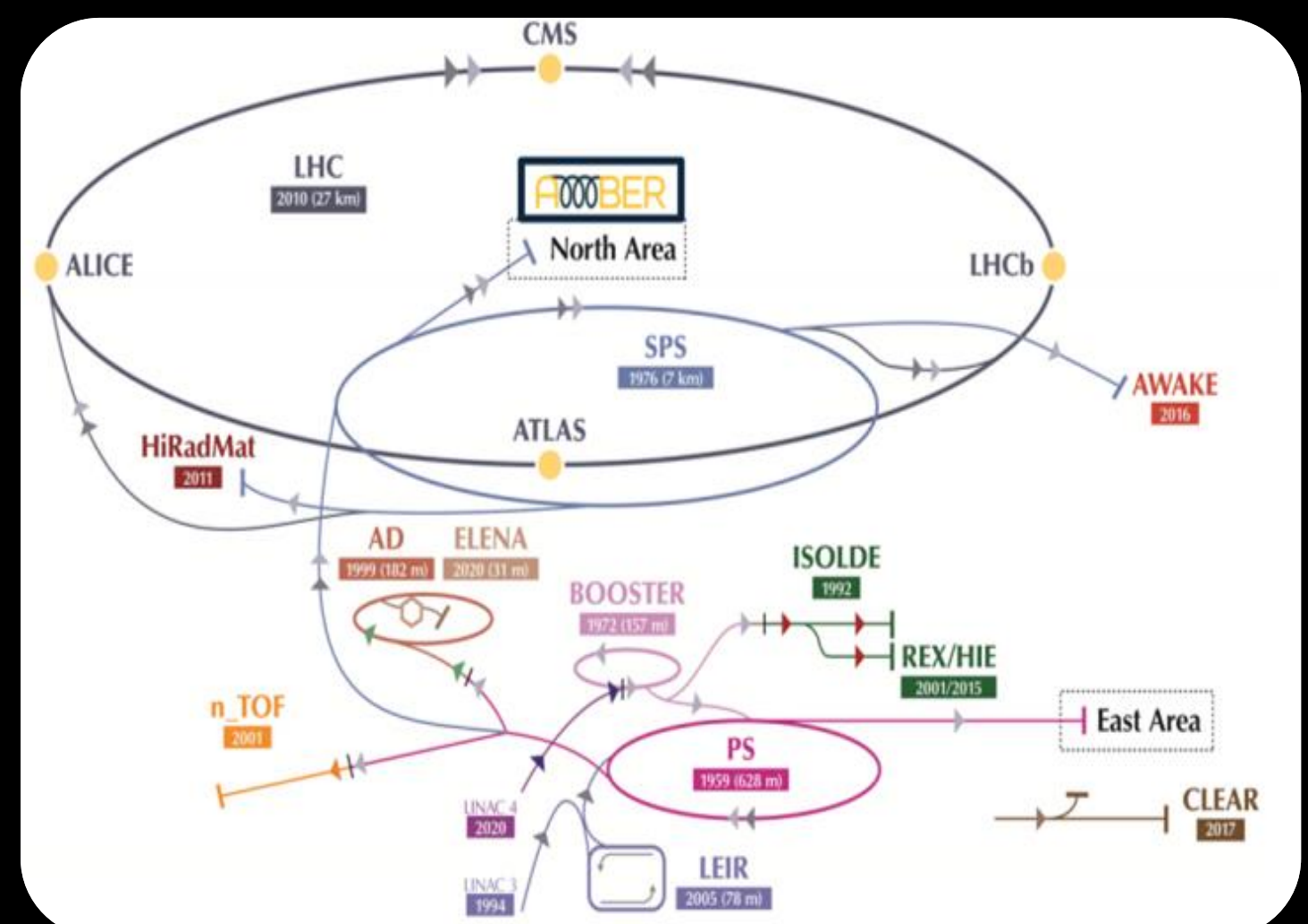


AMBER experiment at CERN

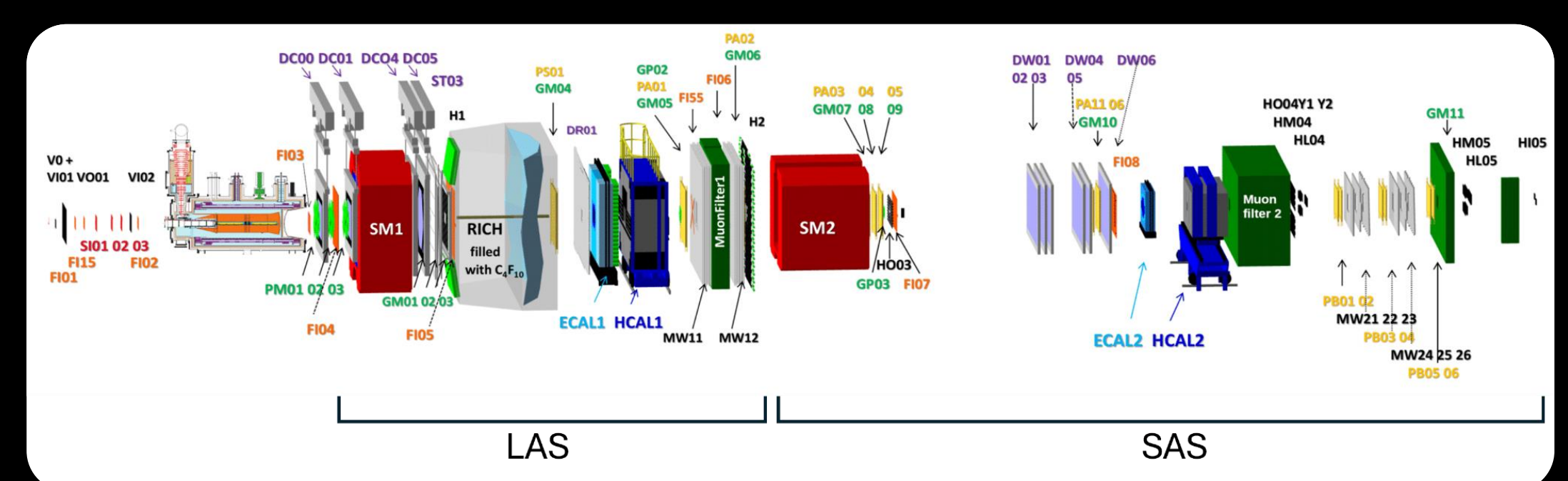


AMBER^[1] (NA66) is a fixed target experiment at the M2 beam-line in the North Area of CERN. It is located in the same experimental hall (EHN2) in which COMPASS experiment was.

The physics program, starting in 2023, will last for well over a decade to realize. AMBER will make use of the versatile beam delivery available at the M2 beam line. This beam line is fed by the SPS proton accelerator and a production target providing muon, proton, pion and kaon beams of both charges with energies ranging from 50 GeV up to 280 GeV. This program consists of a variety of topics in hadron structure and spectroscopy, making best use of the versatile beams and flexible target configurations.

Physics program phase-1:

- Antiproton production cross-section for indirect Dark Matter search (APX)
- Proton radius measurement (PRM)
- Drell-Yan processes for Kaon and Pion PDFs (DY)



The former COMPASS spectrometer is being used for APX measurement and will undergo several upgrades for the mid- and long-term program.

Torino group is responsible for the Multi-Wire Proportional Chamber (MWPC) tracking stations and the Rich Wall Mini-Drift Tubes (MDTs) detector. Part of the MWPCs will be substituted by Micro-Pattern Gaseous Detectors (MPGD) to face their structural aging.

Large area micromegas detector

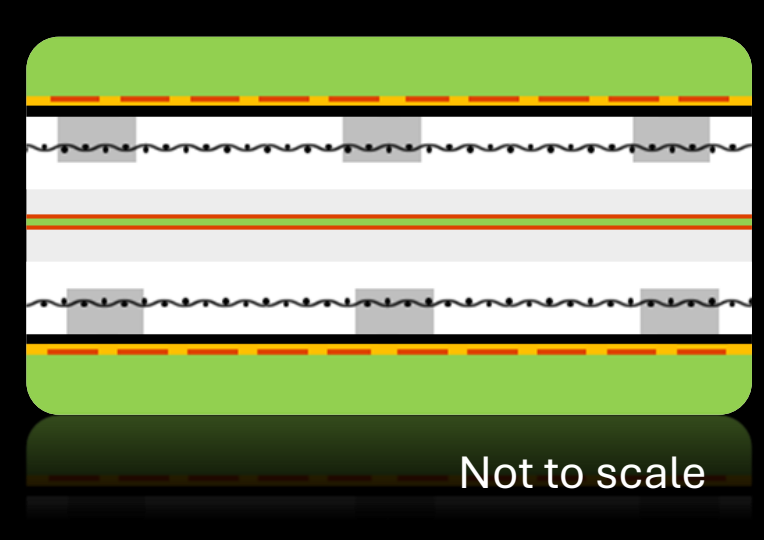
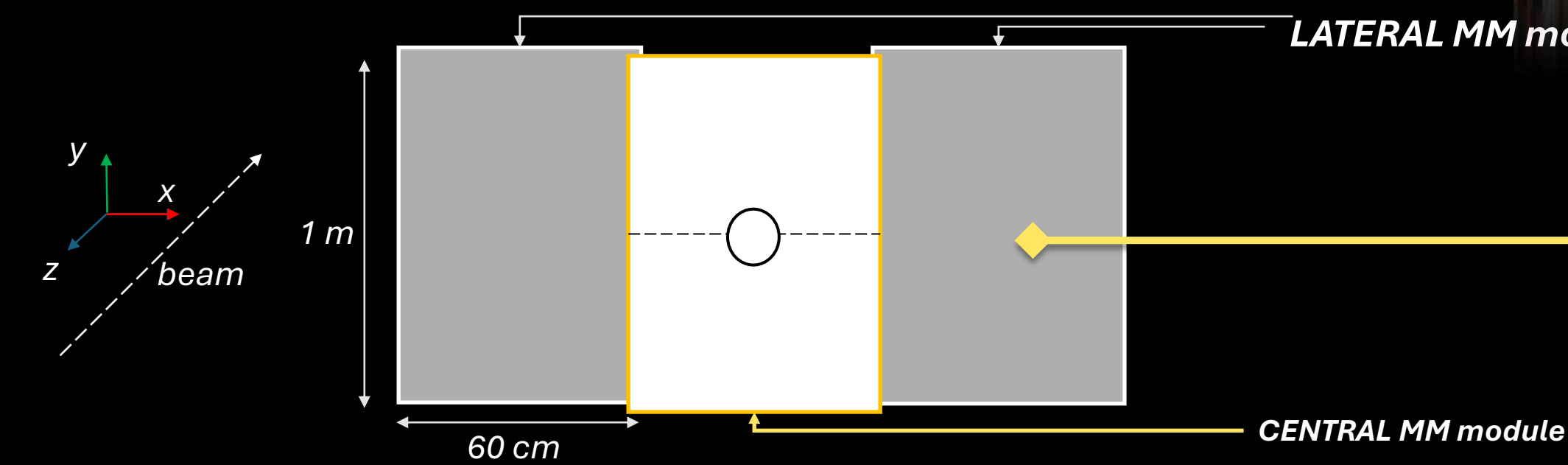
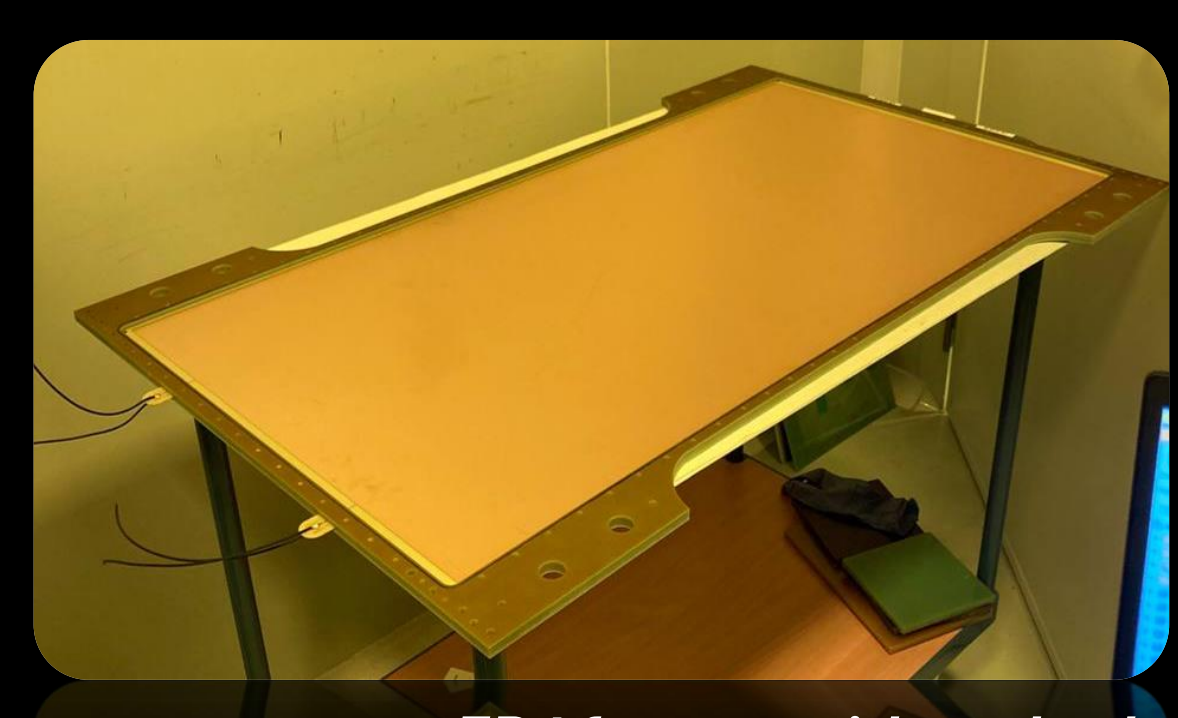
1. Motivation and detector design concept

AMBER MWPC stations are **structurally aged**. Over the last few years we carried out a refurbishment campaign for MWPC-PB type.

Within AMBER upgrades plans for mid and long-term physics program part of the MWPCs (3 stations of PA-type) will be substituted with a **micromegas** detector.



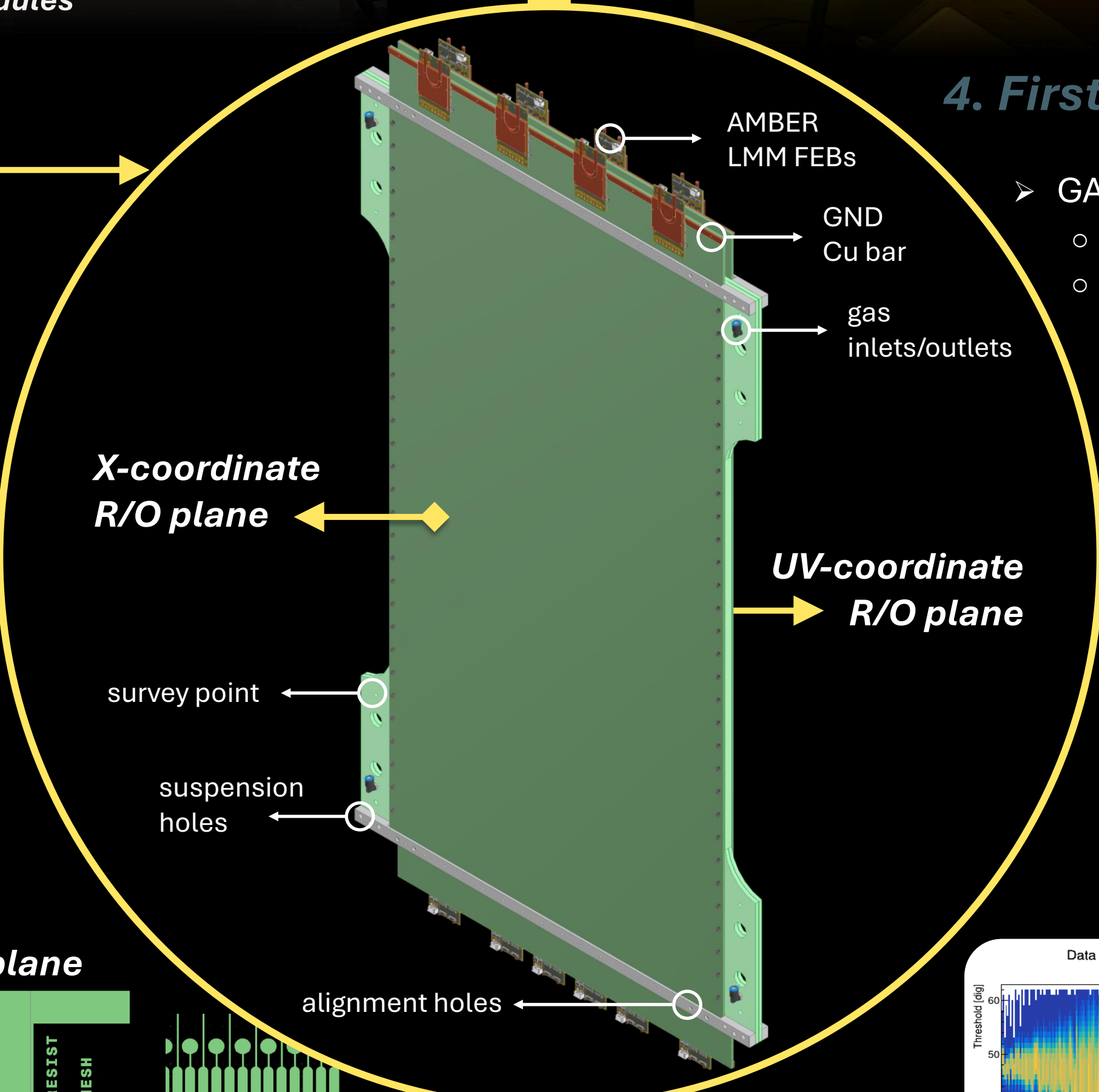
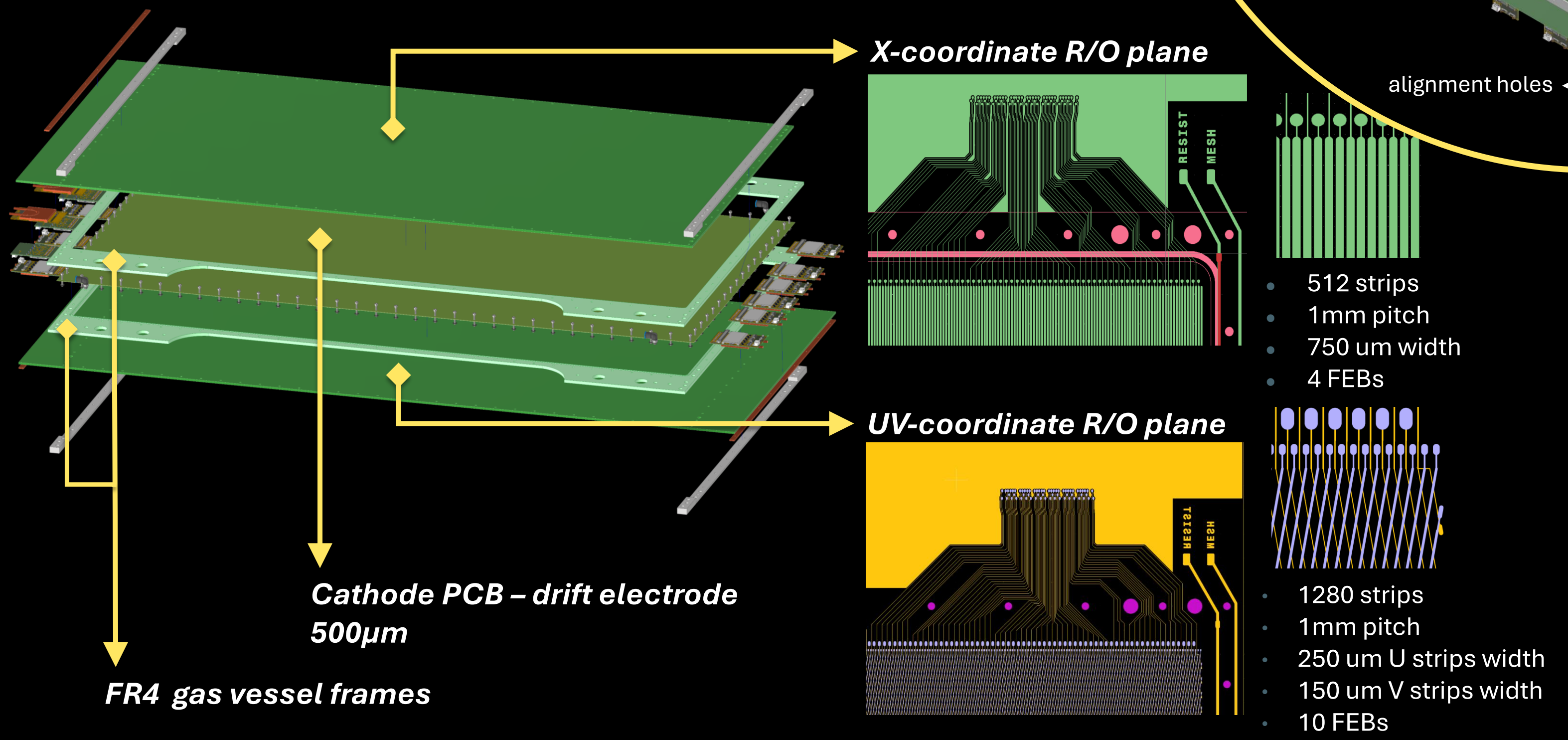
3. LMM lateral module prototype production



The large-area MM detector (LMM) for AMBER will be composed of three different modules covering a total active area of 1.5 m x 1 m

Each independent module will be a **bulk resistive micromegas** in a «face-to-face» configuration

2. Mechanical design and anodes pattern



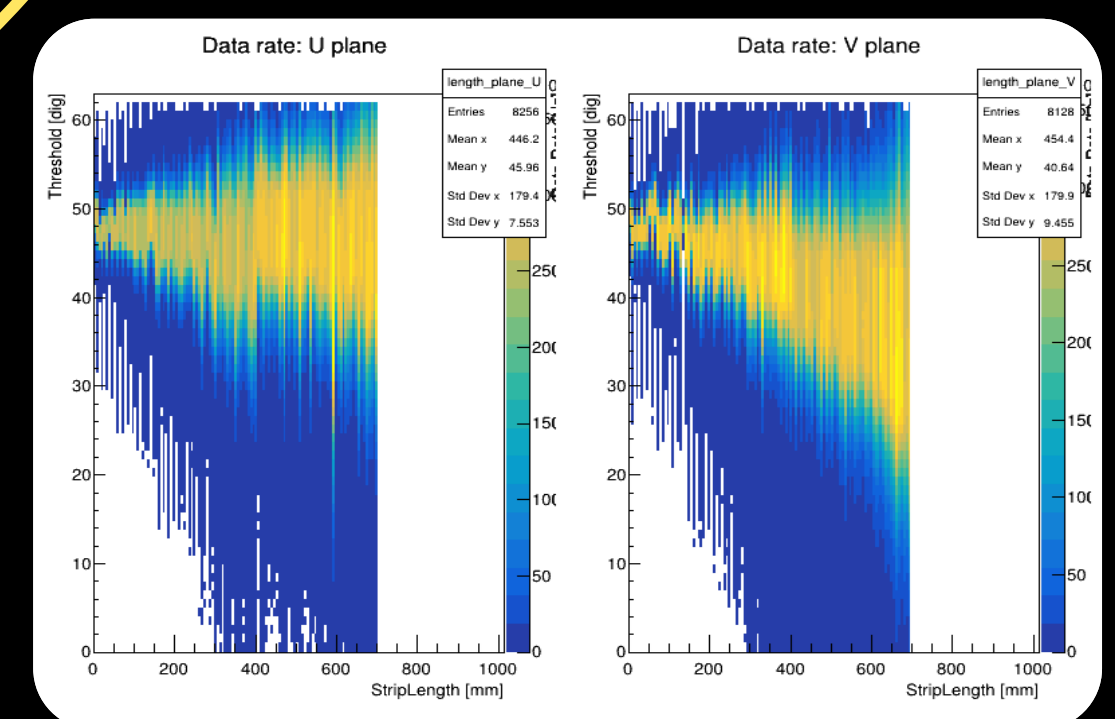
4. First test @ AMBER

- GAS lines:
 - Ar/CO₂ 93/7
 - Ar/CO₂/iC₄H₁₀ 93/5/2
- LV power supplies: KEYSIGHT E36313A
- HV power supplies: CAEN A18221HN, CAEN A1560HDP
- 10Gb Network switch for data transmission.
- TIGER^[3]-based electronics:
 - 6 front-end boards → 2 TIGERs each (128ch/feb)
 - 3 GEMROCs DAQ modules

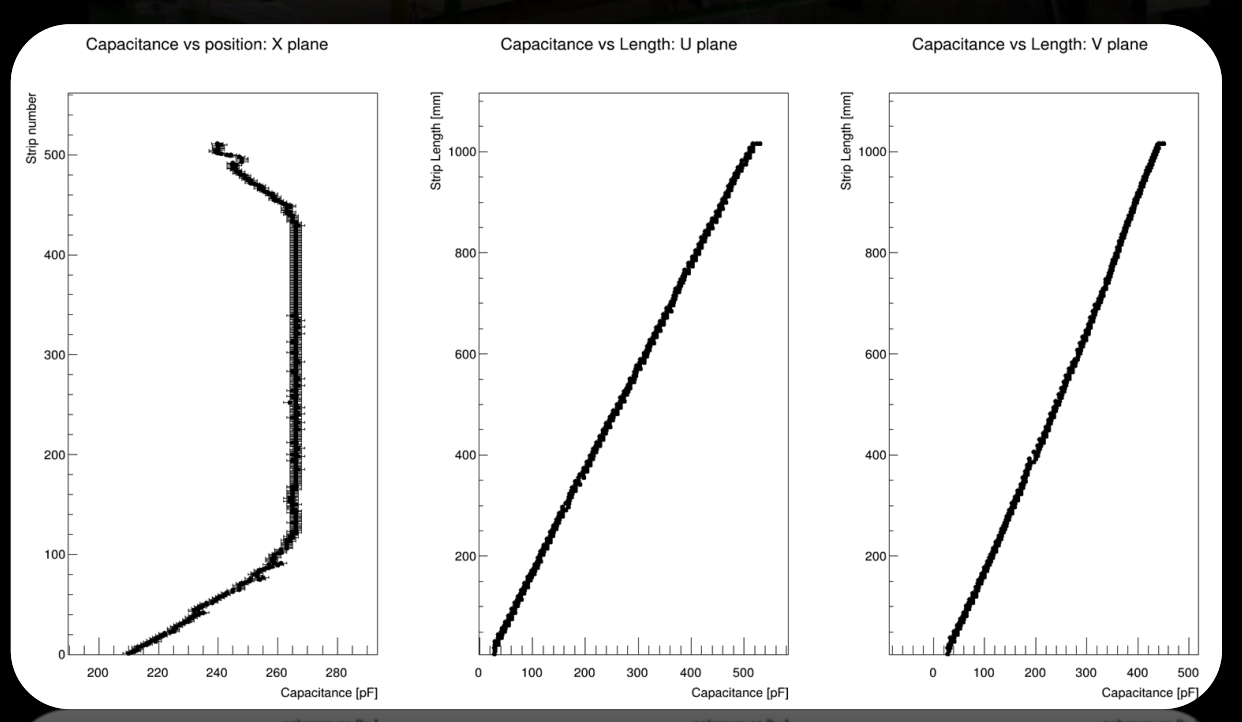
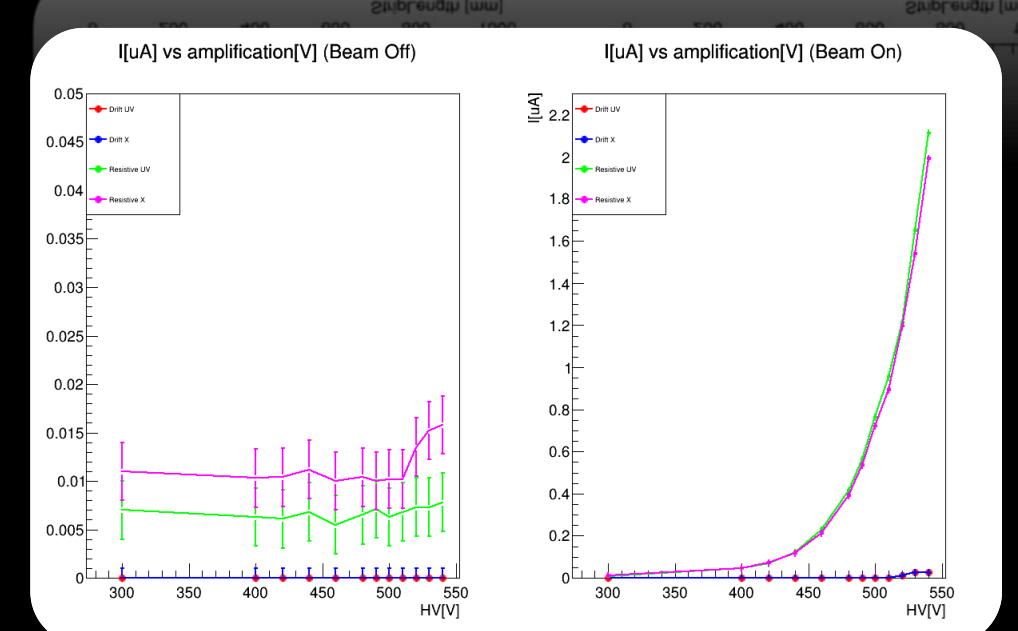
Test-area downstream SM2



Noise study



HV stability



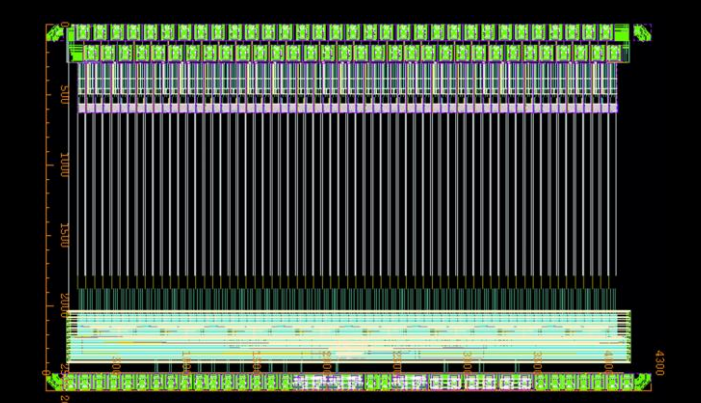
- X strips range: 210-250pF
- U strips range: 30-530pF
- V strips range: 28-450pF

- ✓ HV stability achieved. Currents drawn as expected
- ✓ Validity of the mechanical elements
- ✓ TIGER-based DAQ infrastructure
- ✓ cooling system
- ✓ data transmission proven

ToRA-based readout

Torino Readout for AMBER^[4] will be a 64 chs ASIC with a fully digital interface aiming for compatibility with MPGD and Wire chambers.

- ❖ ToA, peak time and linear ToT
- ❖ 4 programmable gains
- ❖ 4 programmable peaking times
- ❖ 65 nm CMOS technology
- ❖ digital back-end inherited from a silicon-proven design with assembled design methodology
- ❖ Clock frequency : 200 MHz



The ASIC front-end design development was done providing simulated signals with Garfield++ to optimize amplification and conditioning in the FE architecture.

ToRA v1 submission May 2025
ToRA readout chain design first GeneSys2 (Kintex-7 based)

Front-end

Amplification stage:

- ➔ Charge Sensitive Amplifier (CSA)
- ➔ Programmable gain: 2,6,8, 12 mV/fC
- ➔ Both polarities handling using current buffer with programmable inversion

Discriminator stage:

- ➔ Double threshold signal detection
- ➔ Peak detector
- ➔ Peak holder for ToT measurement (charge)

Shaping stage:

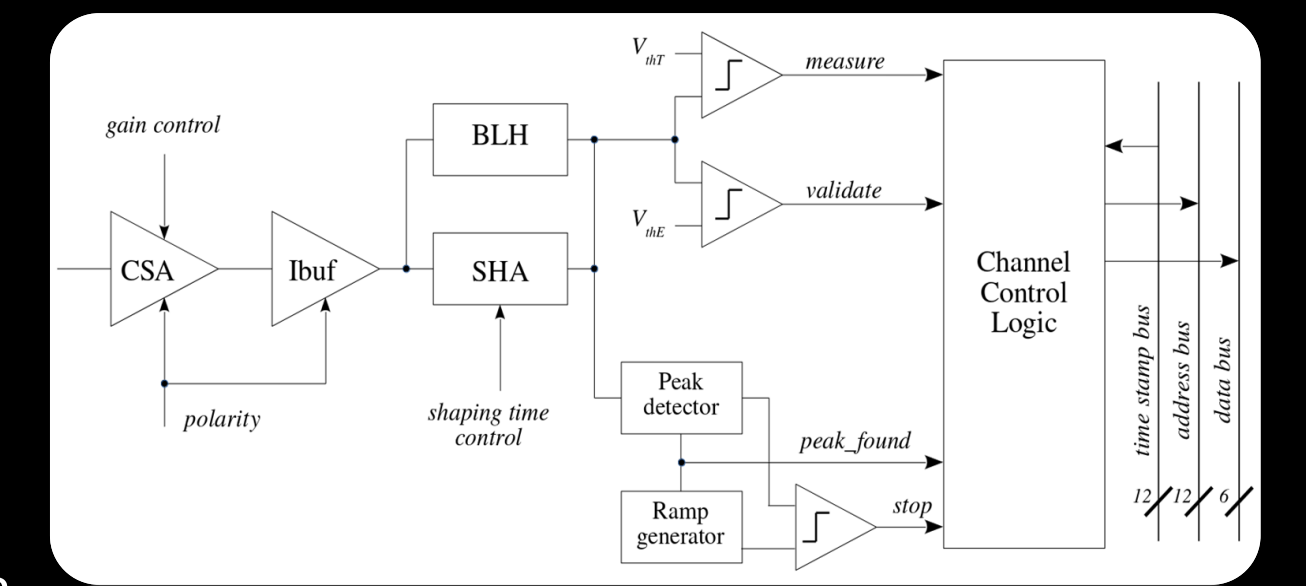
- ➔ 3rd order shaper one real, two cc poles
- ➔ Programmable peaking time: 25,50,150 and 250ns

Back-end

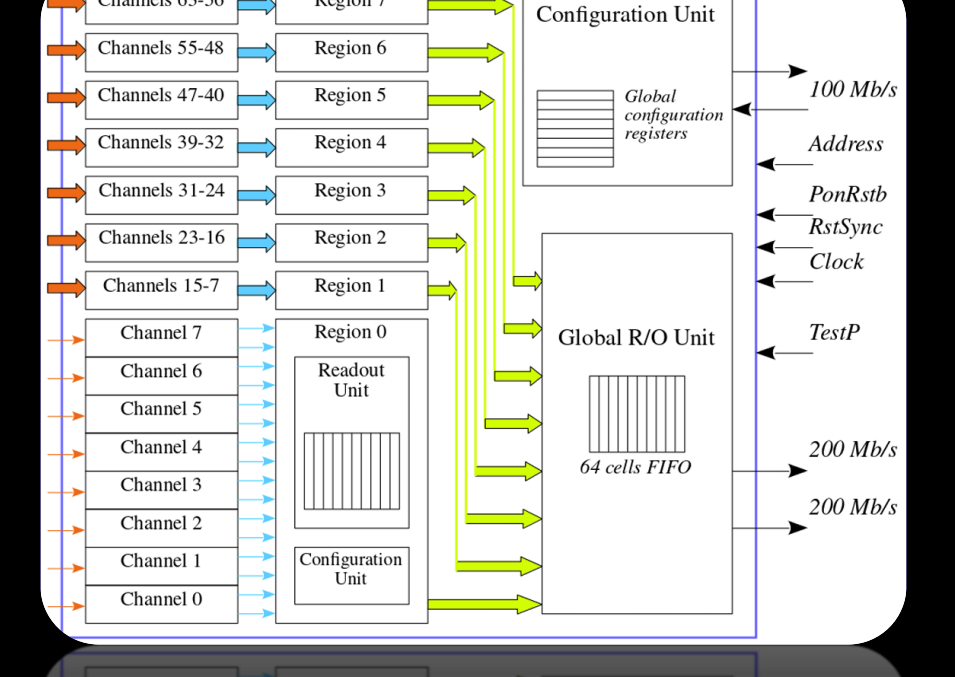
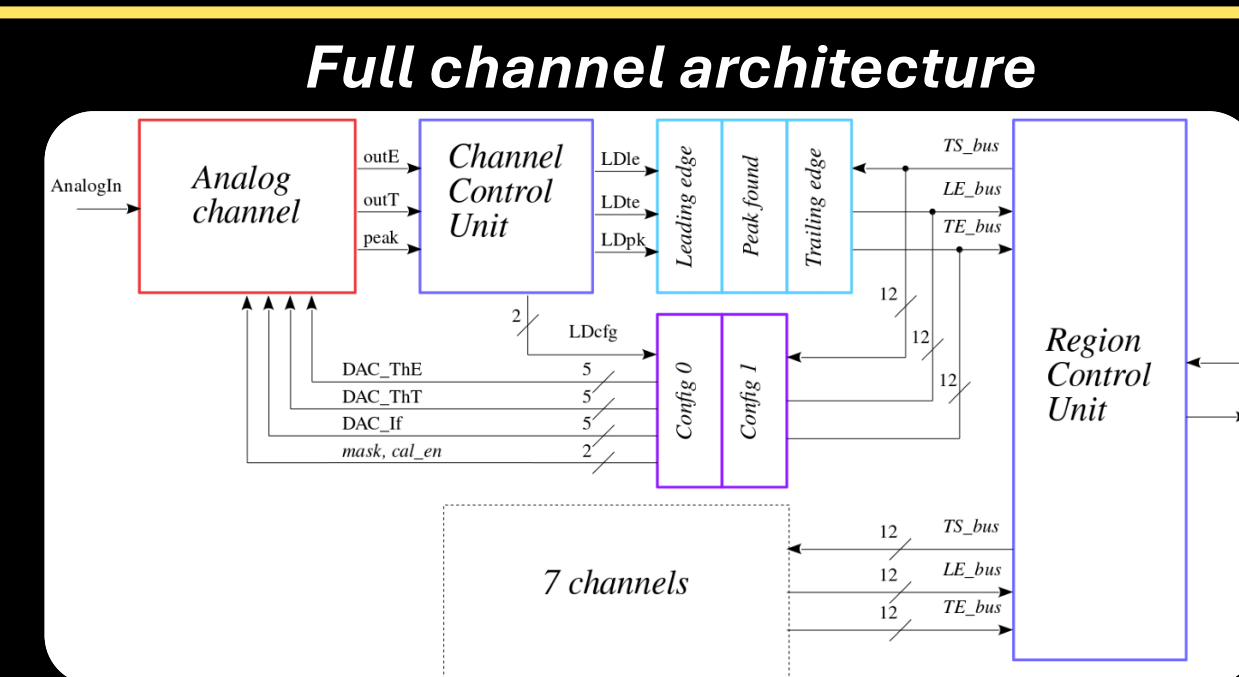
- ➔ Common time stamp distributed to all channels
- ➔ 3 data register for time acquisition
- ➔ 2 configuration registers
- ➔ Data output in 32 bits words over 200 Mb/s serial links
- ➔ It can be configured to use 1 or 2 links
- ➔ Frame length : 20.48 μs at 200 MHz

Packet type	Header 1 1 bit	Header 2 3 bit	Data 28/31 bits
Header	1	010	ChipId[6:0] Reserved[12:0] FrameN[7:0]
Trailer	1	101	DataCnt[11:0] CRC[15:0]
Sync	1	000	1100 1100 1100 1100 1100 1100 1111
Data	0	Region[2:0] Channel[2:0] Lc[11:0] Pk[5:0] Te[6:0]	

Courtesy of Gianni Mazza internal INFN-to-microelectronics group meeting



ToRA ASIC architecture



References

- [1] Adams et al., Letter of Intent: A New QCD facility at the M2 beam line of the CERN SPS (COMPASS+/AMBER), 2019
- [2] C. Alice et al., Development and test of the Micromegas detector prototype and its readout electronics for the AMBER experiment at CERN, Journal of Instrumentation, 2023.
- [3] Rivetti et al., TIGER: A front-end ASIC for timing and energy measurements with radiation detectors, Nucl. Inst. Meth. A, 2019
- [4] G. Mazza et al., ASIC developments for the AMBER MM experiment, 2nd DRD1 collaboration meeting, 2024.