Development of scanning technique for a NSW chamber production quality control for the ATLAS upgrade

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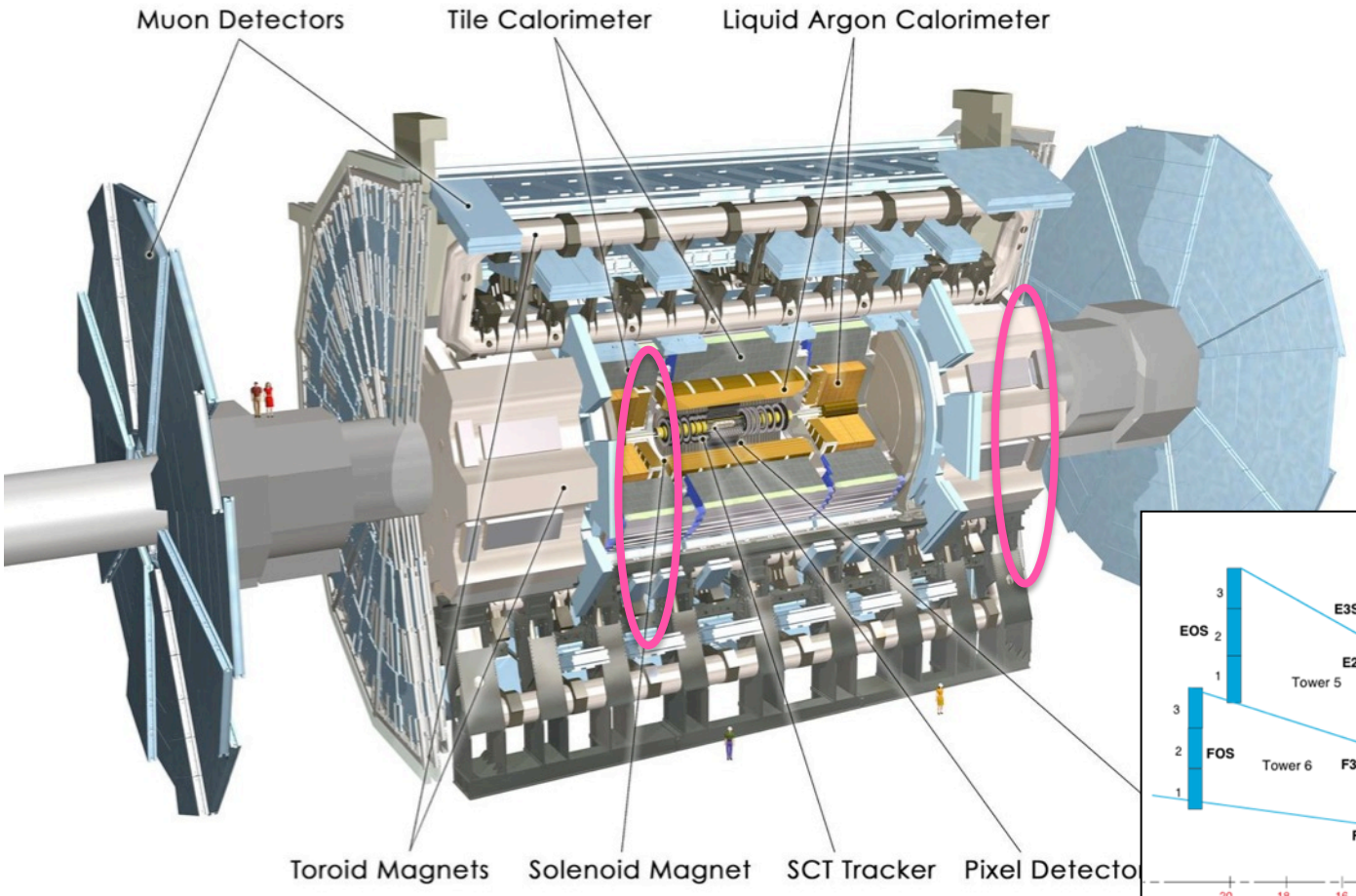
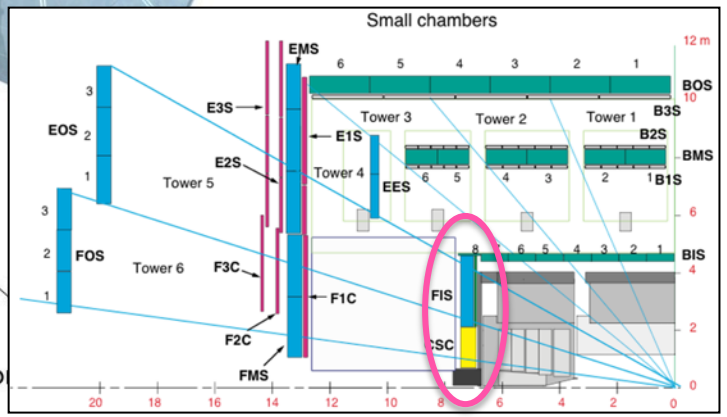
The ATLAS Detector – (New) Small Wheels

New Small Wheels will replace the present Innermost endcap station of the Muon Spectrometer

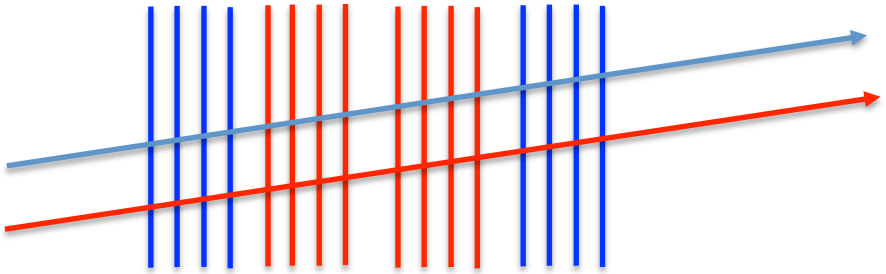


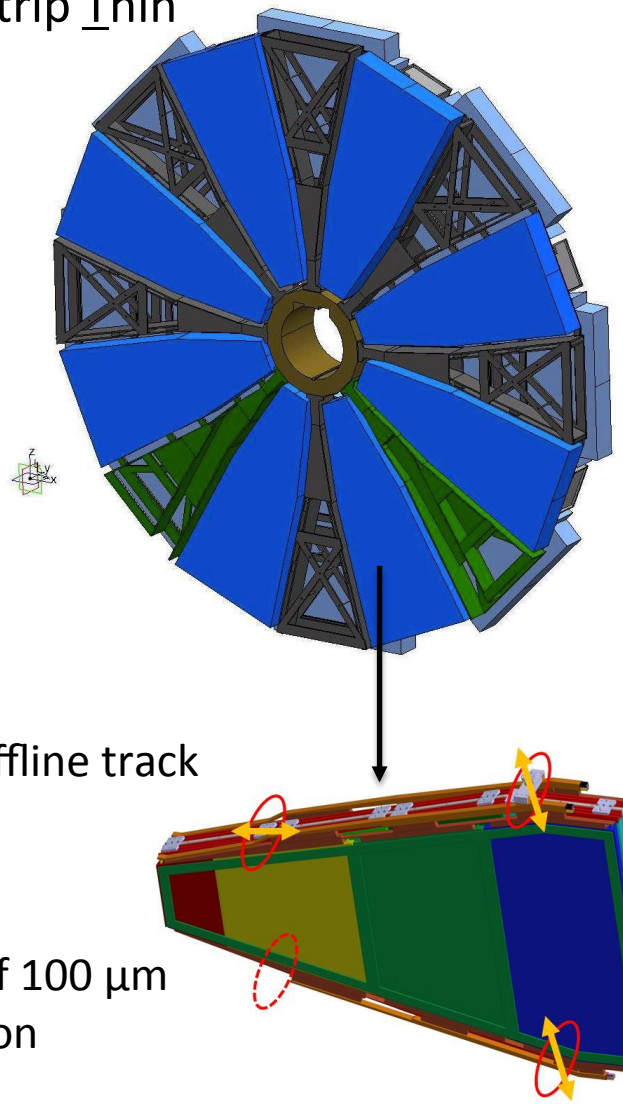
Small Wheels
10m ∅



New Small Wheels: Layout

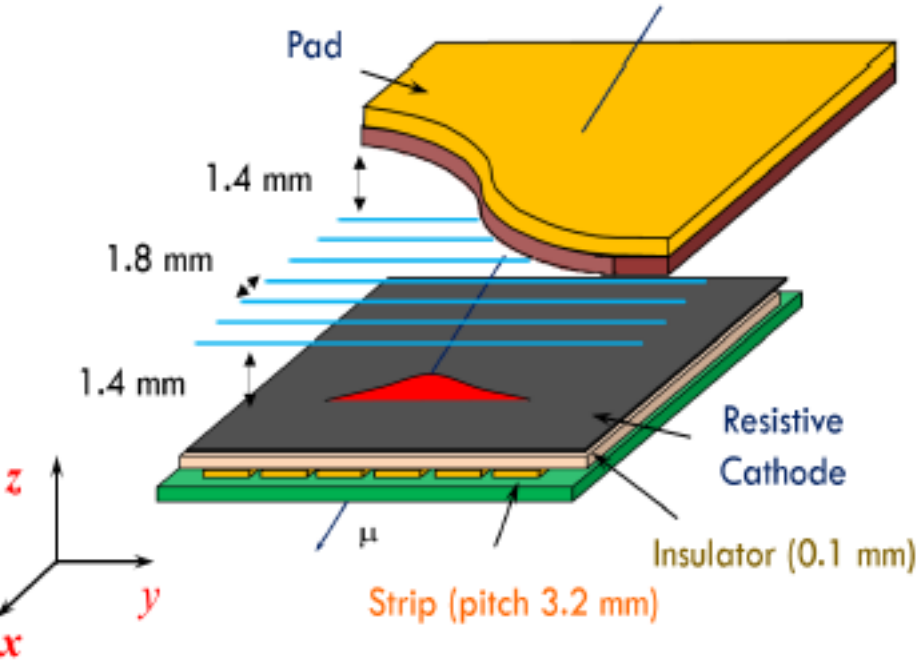
- 2 detector technologies for NSW chambers: small strip Thin Gap Chambers (sTGC) and MicroMegas (MM)
- 4 + 4 + 4 + 4 detection planes

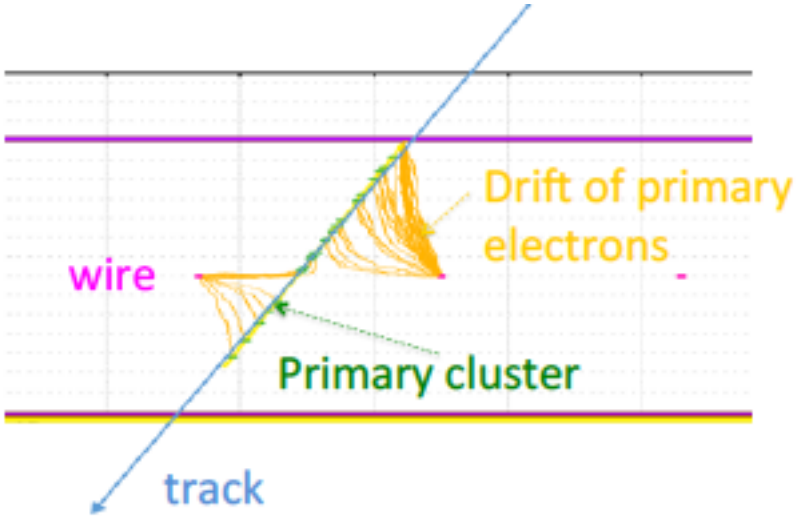




- sTGC – Primary trigger detector
  - Outside → longer lever arm
  - Track vector with angular resolution < 1 mrad
  - Good space resolution --- contribute to resolution offline track reconstruction, redundant tracking
- MM – Primary tracking detector
  - 500 µm strip pitch – very good position resolution of 100 µm independent of track angle, excellent track separation capabilities
  - Provide independent track vector – redundant triggering

sTGC Design



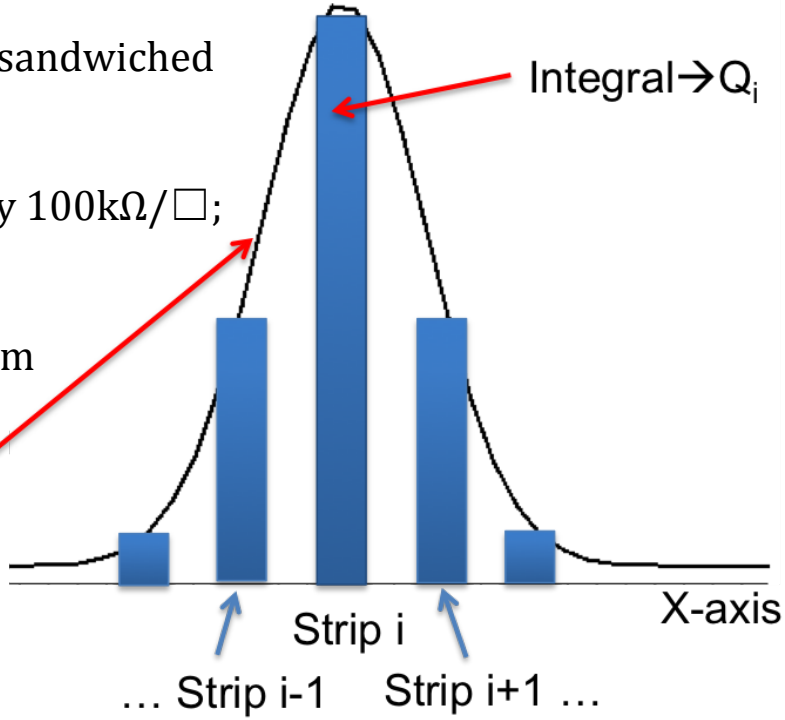


Anode50µm gold-plates tungsten wires, spaced 1.8mm apart sandwiched between two cathode planes

Cathode planes: Graphite-epoxy mixture, surface resistivity 100kΩ/□; sprayed on a 100 µm thick G-10 plane.

Operational gas: CO2 + n-pentane C_5H_{12} (55% / 45%), 1 atm

Sum of all charge distributions of a single event, on a single layer (the sum usually is not of Gaussian shape, here I just use an arbitrary shape to illustrate the method)



Motivation

Various technological defects such as:

- **missing wires,**
- **wires which have low tension,**
- **cathode strip shape and thickness defects,**
- **conducting dust and particles inside the gap,**
- **gluing defects,**
- **gap thickness non-uniformity**

may cause operation instabilities, a loss of a chamber efficiency or bad coordinate accuracy.

The X-ray scanner qualification of sTGC chambers is a gas-gain measurement which can help to eliminate these problems on the production sites

X-ray studies of the sTGC prototype

Tube conditions:
Voltage 40-50 kV
Current 75-80 uA

The main goal:

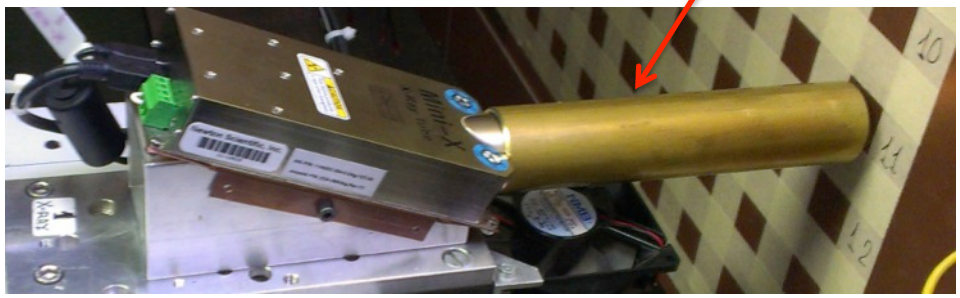
Obtain some experience with the detector operation, understand detector behavior with different gases and define possible modes of scanning.

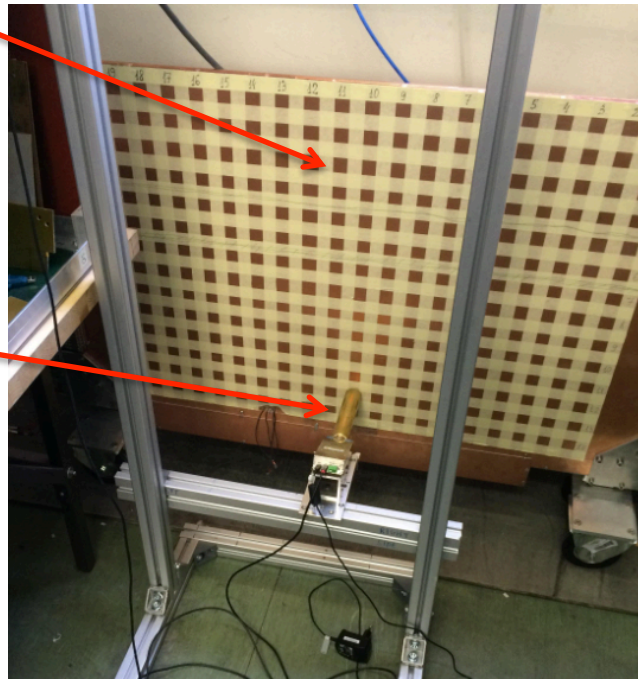
Tests were carried out with one of the first sTGC test beam prototypes in "manual mode". Scans were done with **2.5 cm step** with collimator of **3 cm** diameter.

Studied:

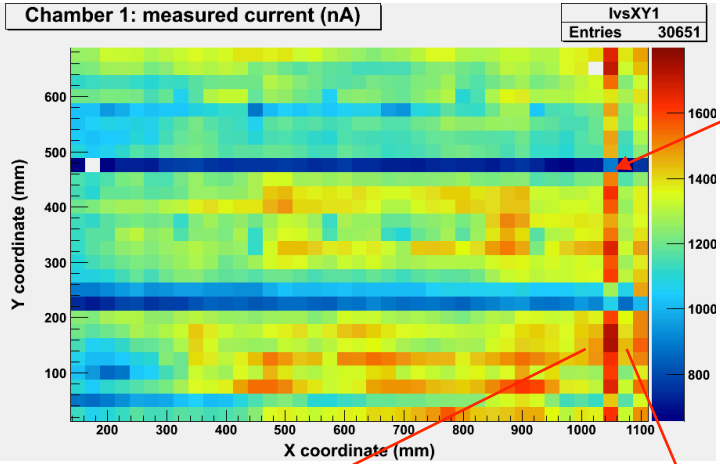
- Gas gain uniformity
- Reproducibility
- Hot spots
- Some other issues

Collimator





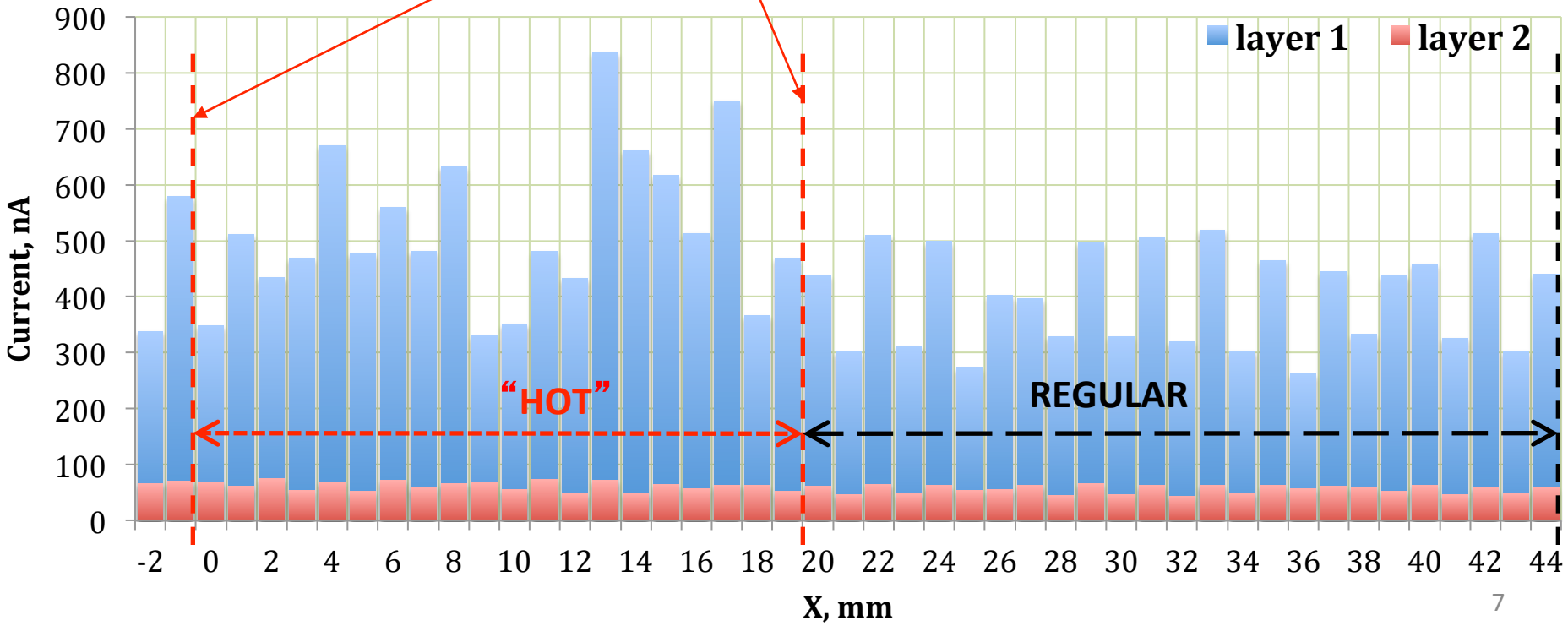
Study of sensitivity of X-ray canning technique to the chamber effects: wire problem



"Hot" wire problem?

Detailed scan with a slit of 1 mm was performed.

- Some areas with gas gain up to factor of 2 more than regular one were found.
- The reason not clear (wires offset?).



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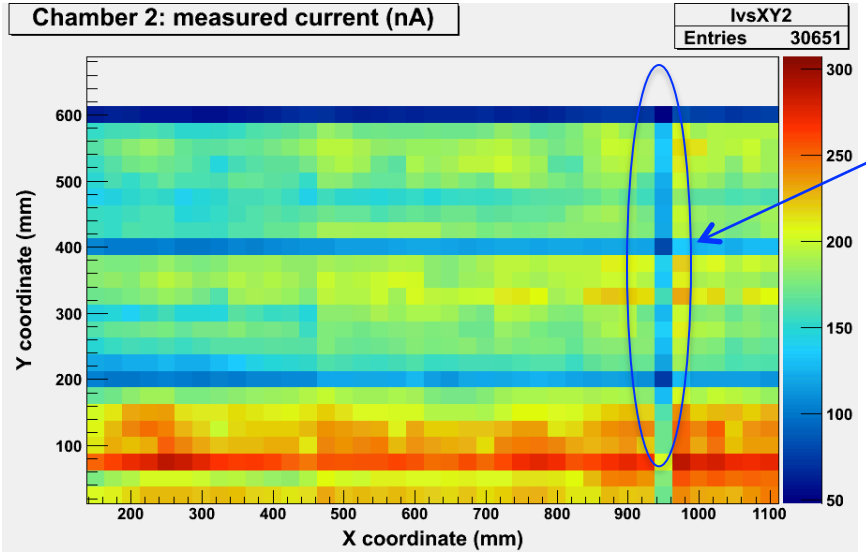
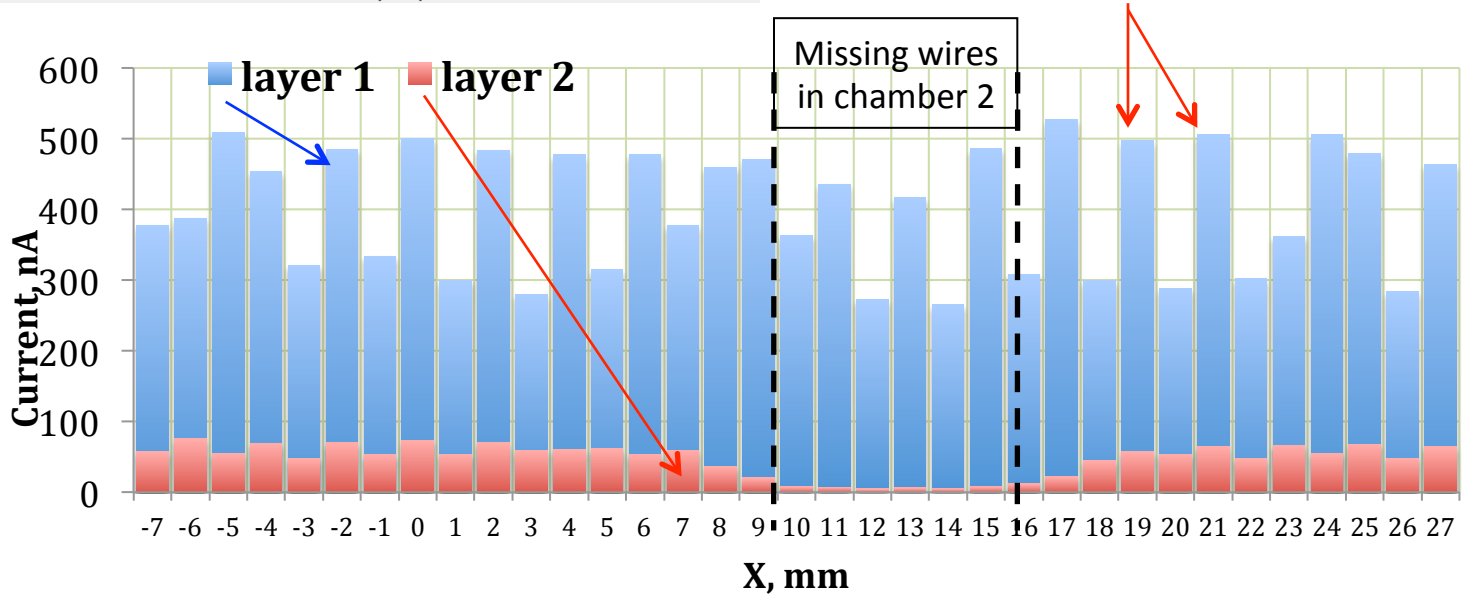


Gas gain drop?

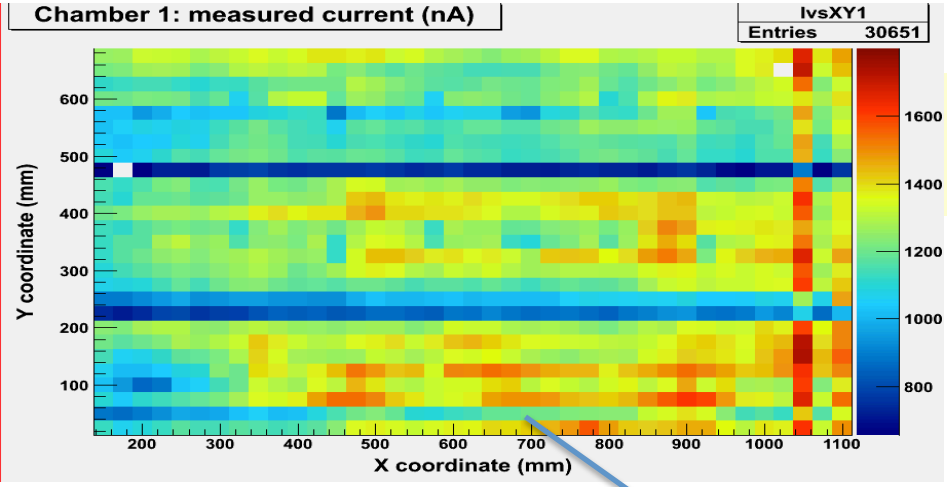
Detailed scan with a slit of 1 mm was performed.

- Missing wires were found.
- Periodic structure shows that significant part of ionization comes from X-ray interactions with wires.



- **Wire problems lead to reduction of accuracy of measurements**
- **The method helps to indicate wires with electrical contact problems and cut wires**

Study of sensitivity of X-ray canning technique to the chamber effects: Cathode strip problem



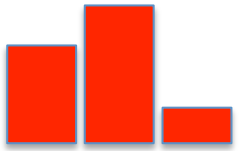
Amplitude uniformity along the wire (across strips) is important for coordinate measurements

In "regular" areas current fluctuations <5%/10 mm

In the "hot" area >50%/4mm.

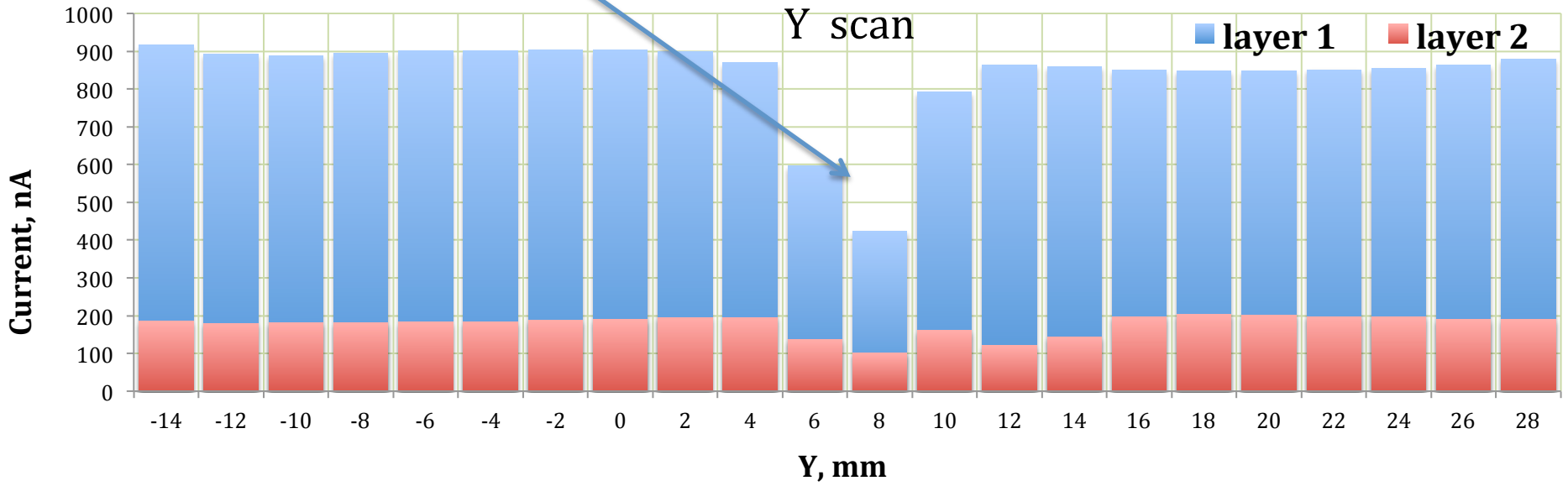
Signals from particle on strips

"regular"



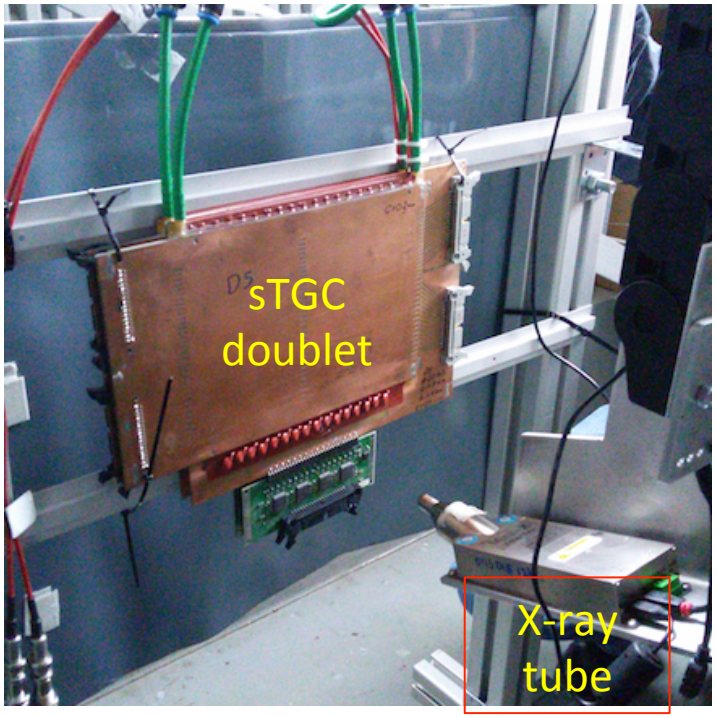
"hot"

Step 2 mm, slit 2 mm



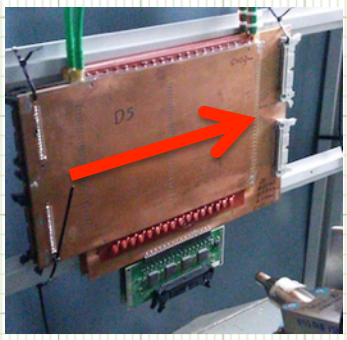
•The cathode strip problems lead to reduction of accuracy of measurements

Test of the X-ray scanner prototype

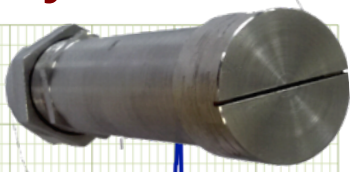


- X-ray scanner (X-Y CNC) with stepper motors. LPT &USB interfaces
- X-ray tube (Amptek mini-x, Ag) with collimators; 50keV / 75uA
- Caen NIM HV 4ch supply N1471H
- Trolley-mounted sTGC prototipe (20x12 cm)
- PC

Study of the chamber mechanical structure with X-ray scanner: wire positioning

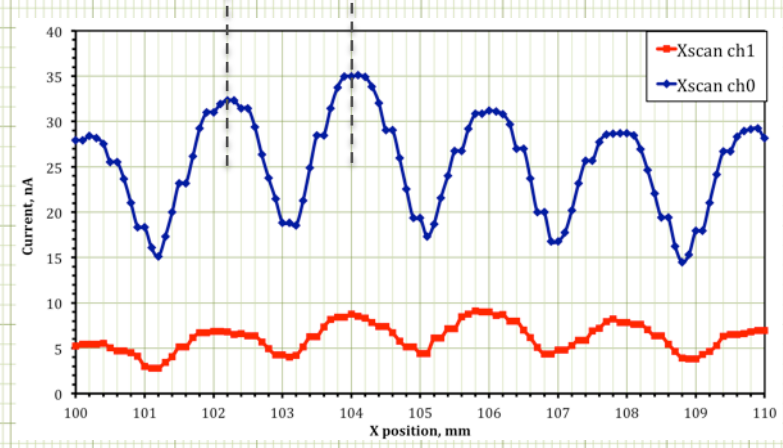


X-ray tube movement along strips



Collimator with slit 1mm

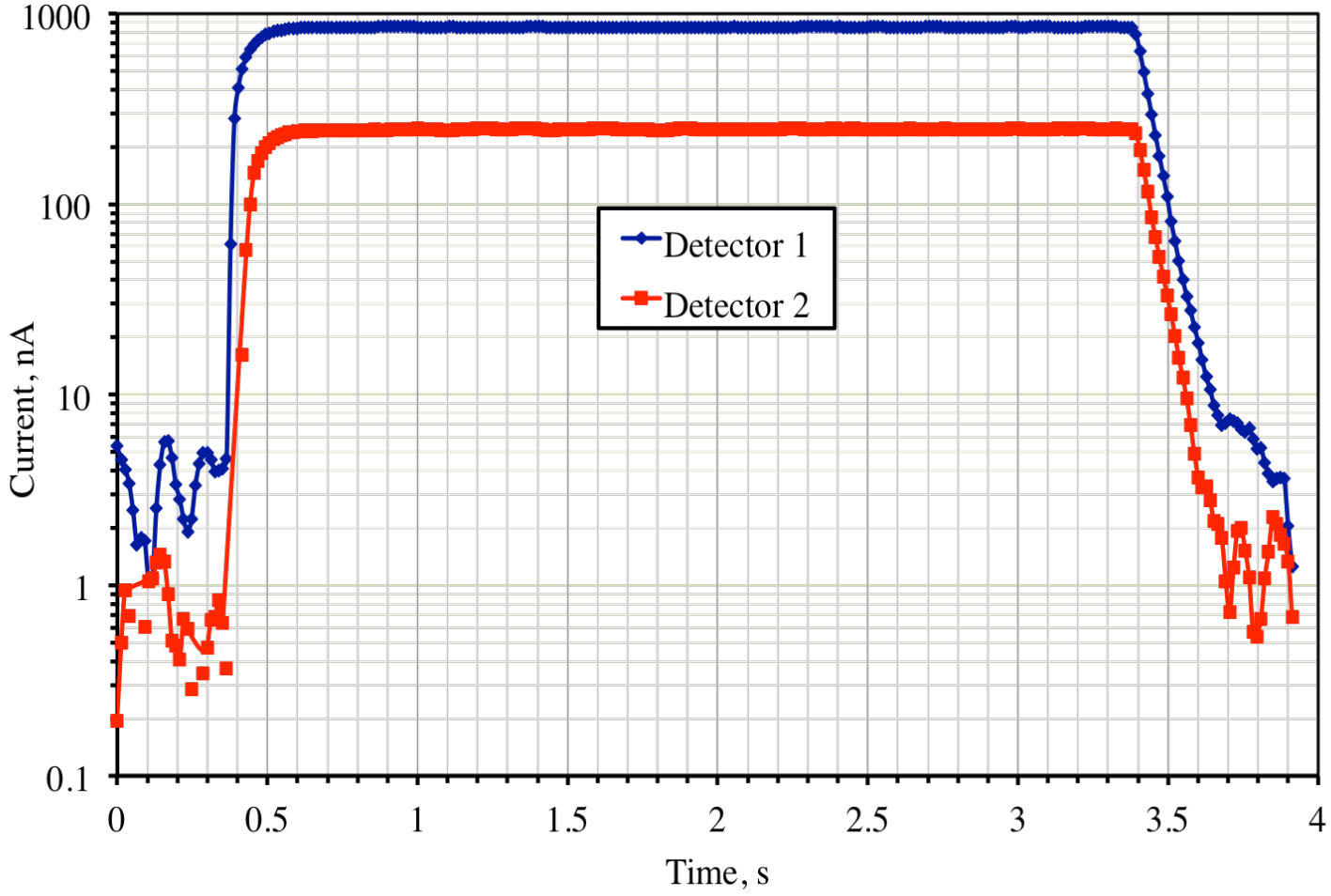
1.8 mm = Distance between wires



Step mode: Collimator 1 mm Scan step 0.1 mm Measurement time 1 s (1 point/step)

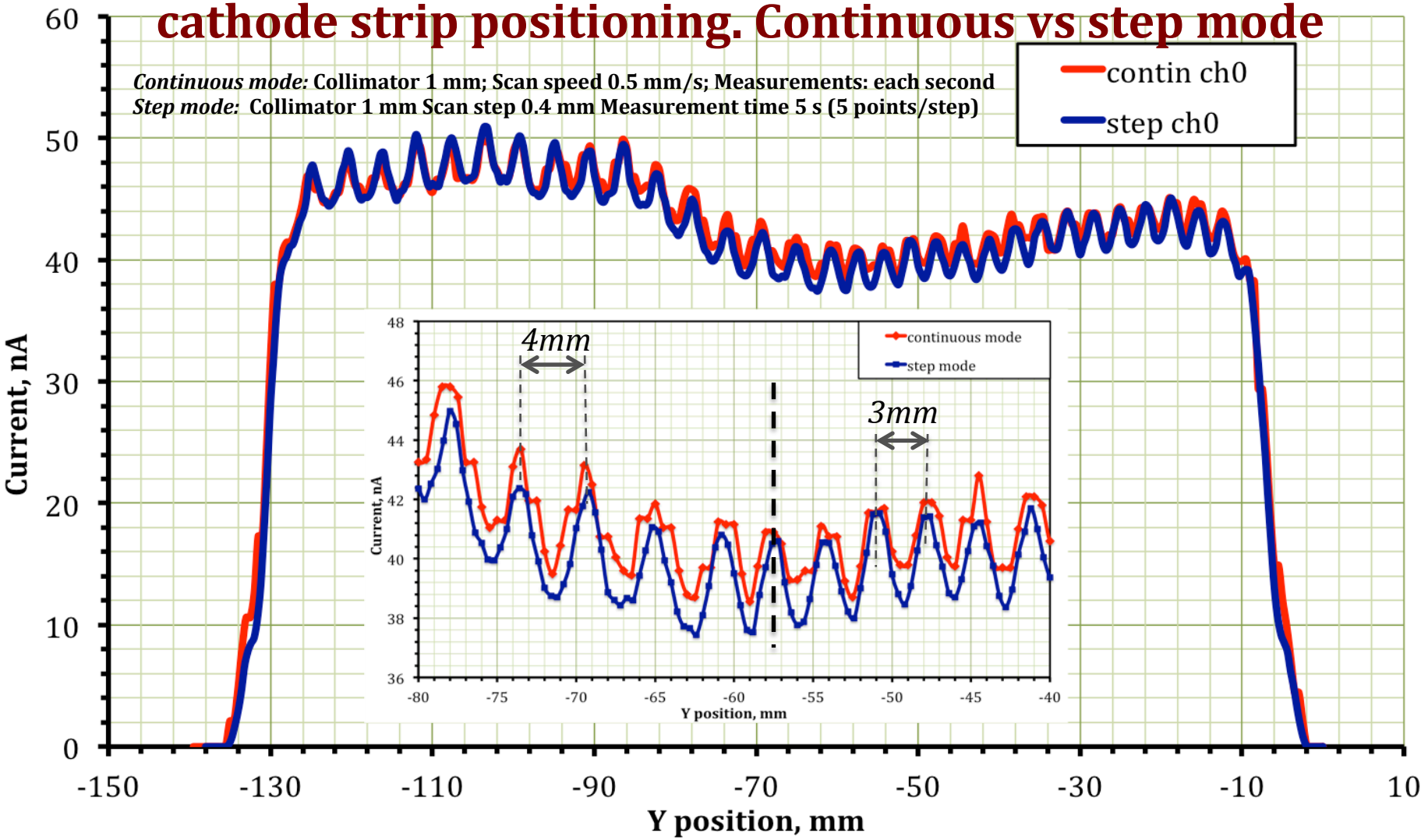
- **The precise scan mode allows to observe wire structure of the sTGC chamber**
  - **Both chambers: 90 wires**

Chamber time-resolution and edge measurement with wide beam



- **Data acquired via analogous HV power supply**
- **Current in chamber reaches stable value (within few %) in ~0.2 sec after X-ray turned on**
- **CAEN N1471H measurement frequency 1 Hz**

Study of the chamber mechanical structure with X-ray scanner: cathode strip positioning. Continuous vs step mode



- The chamber has strips with 2 different widths: 3 mm and 4 mm
- Scan results confirm chamber constructive features
- Continuous mode results are in a good compliance with step scan results
- Scan speed of 0.5 mm/s is enough to study strip structure of the sTGC

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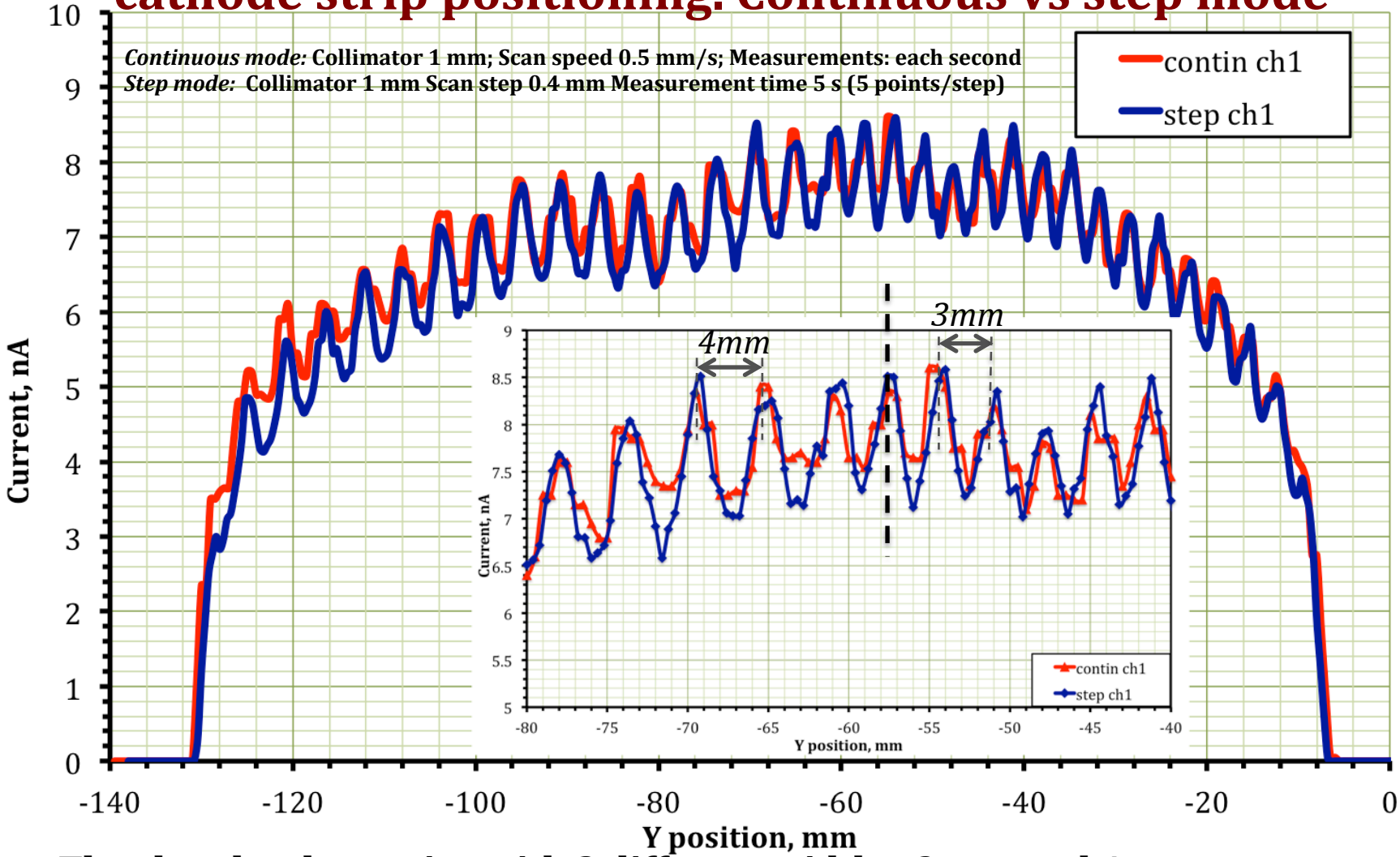

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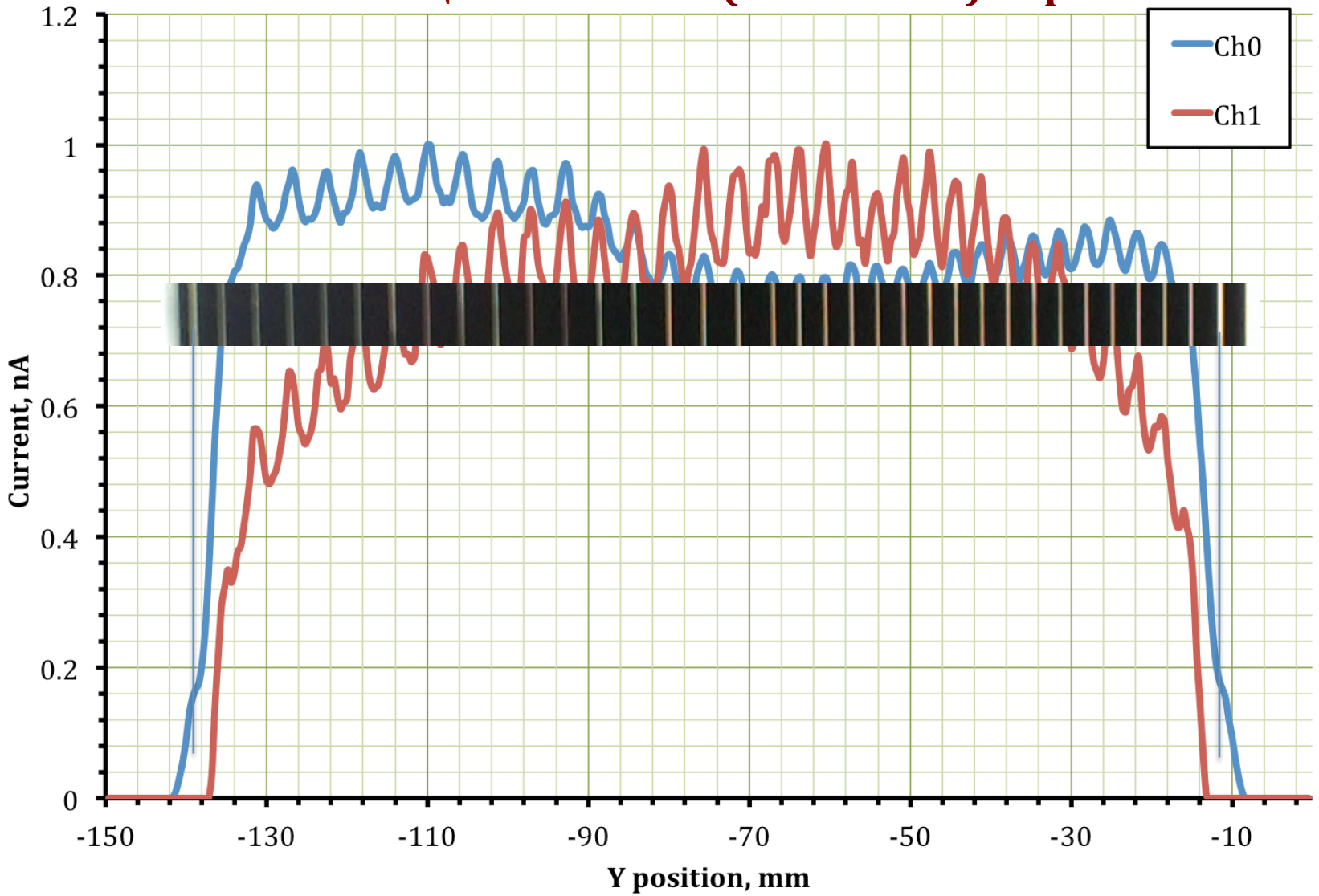
Study of the chamber mechanical structure with X-ray scanner: measurements ща 2 chambers (normalized) vs photomask



- The photomask drawing overlayed onto the Current vs Position graph
- The measured peak corresponds to srip-free area (with less absorption – copper has the biggest impact to absorption)

Conclusions

- **The scanning procedure allows to obtain current response mapping of the sTGC**
- **Precision scans with narrow slit collimator allow to observe strip and wire structure**
- **Various types of defects are observed: “hotspots”, cathode strip defects, wire defects**
- **The time-resolution of the sTGC chamber is enough to perform continuous scan with no stop for data taking**
- **Continuous mode results are in a good compliance with step scan results**