Results of analysis of data from Fermilab cosmic muon stand and CMS test beam at CERN

(CMS Endcap Muon Anode Front-End Electronics Project at CMU)

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- **Introduction**
- **Results from Cosmic Muon Test Stand at Fermilab**
- **Preliminary analysis of CMS test beam data at CERN**
- **Conclusion and future plans for analysis**

Introduction

- **The key features of Cathode Strip Chambers (CSC) front-end anode electronics:**
  - high efficiency bunch crossing identification (92% per station) within 25 nsec bunch crossing interval
  - muon trigger primitives for the Level 1 trigger
  - coarse measurement of muon hit radial position

- **Use of a coincidence** $>= 4$ **planes ON from 6 planes in each CSC station:**
  - reduces the large spread of CSC drift times (with a maximum of 50-70 nsec) to a level of < 25 nsec
  - the 2-nd arriving hit in time gives the best time mark of the bunch crossing and decreases an accidental overlap with random background hits

- **The main analysis goals:**
  - time resolution of signal from single plane anode, the 1-st, 2-nd, etc. anode signals from the 6 planes
  - the corresp. efficiencies in the gates of 20, 25 nsec
  - their dependence on HV, thresholds, angle of incident track and background rate

- **The first full scale prototype anode front-end cards (with new chips ASD16) were ready and installed on the P2 CSC prototype by May 1998**

- **The data were taken:**
  - on the cosmic muon stand at Fermilab - May 1998 (analyzed in June)
  - on the CMS test beam at CERN - June thru August 1998 (analysis in progress, first results in July - August)

Data from Fermilab Cosmic Muon Stand

- **Efficiencies of single channels**
  - readout was limited to 16 channels/plane (due to DAQ)
  - 8 channels/plane are old anode electronics (Ohio St., discrete elements)
  - first attempt to tune the thresholds of new cards
  - high efficiency at a HV above the nominal (Fig. 1)
  - the minimum thresholds (oscillations free) are too high at nominal HV

- **Time distributions of anode signals**
  - for a single plane, the RMS=11 nsec, and about 60 nsec wide at the base (Fig. 2)
  - first arriving signal for coincidence of >= 4 planes is much narrower (RMS=7 nsec). This corresponds to 93% efficiency for 25 nsec gate
  - fit by two semi-gaussians with the same center, but different standard deviations σ_1 and σ_2, convenient for comparison at different cond., Figs. 3-4

Preliminary analysis of CMS test beam data at CERN

- **Data were taken in two beam locations:**
  - H2 beam (calibration, HV, θ and ϕ scans)
  - Gamma Irradiation Facility (GIF) beam (Fig. 5) (HV, thresholds scans; anode and cathode trigger electronics tests, measurements with GIF 15 Ci Cs^{137} γ-source to simulate high intensity random background)
  - the beam is mostly 20-150 GeV μ
  - reference tracking detectors (SSD, PWC) were used to predict the hit coordinate in CSC (Fig. 6)

- **HV and threshold scan (GIF source OFF):**
  - additional grounding for ASD16 chips was made (allowed 1.5 times lower threshold oscillation free)
  - high efficiency ($> 90\%$) at HV which is 50 V above the nominal (Fig. 7) - good result for the first prototype
  - further improvements ($\sim$ 2 times lower thresholds) are needed and possible in the current chip design

- **Bunch tagging efficiency (GIF source OFF)**
  - HV scan at minimum threshold and software gate of 25 and 20 nsec (Fig. 8)
  - tagging on the 2-nd hit in $>=$ 4 hits from 6 has efficiency above 92% (baseline) at nominal HV=3.85 kV for the 25 and 20 nsec gates.

- **Bunch tagging efficiency (GIF source ON)**
  - 15 Ci Cs^{137} γ-source, $4.7 \cdot 10^{11}$ γ/sec, $E_\gamma = 662$ keV, data were taken with shields reducing irradiation by 5, 10 and 20 times and rate from anode channels was 20-60 kHz (Fig. 9)
  - analysis in progress (to see the broadening of the time distribution, the change of the efficiency for bunch crossing identification, and measure the recovery time of the anode front-end electronics)

- **Conclusion**

  - the first full-size prototype anode front-end cards almost meet the baseline requirements and provide 92% efficiency for bunch crossing identification within 25 nsec gate
  - analysis of the data is in progress, plan to study: efficiency vs. track angle, the threshold, gain and time-offset stability of the electronics as a function of time, and the cross-talk probability

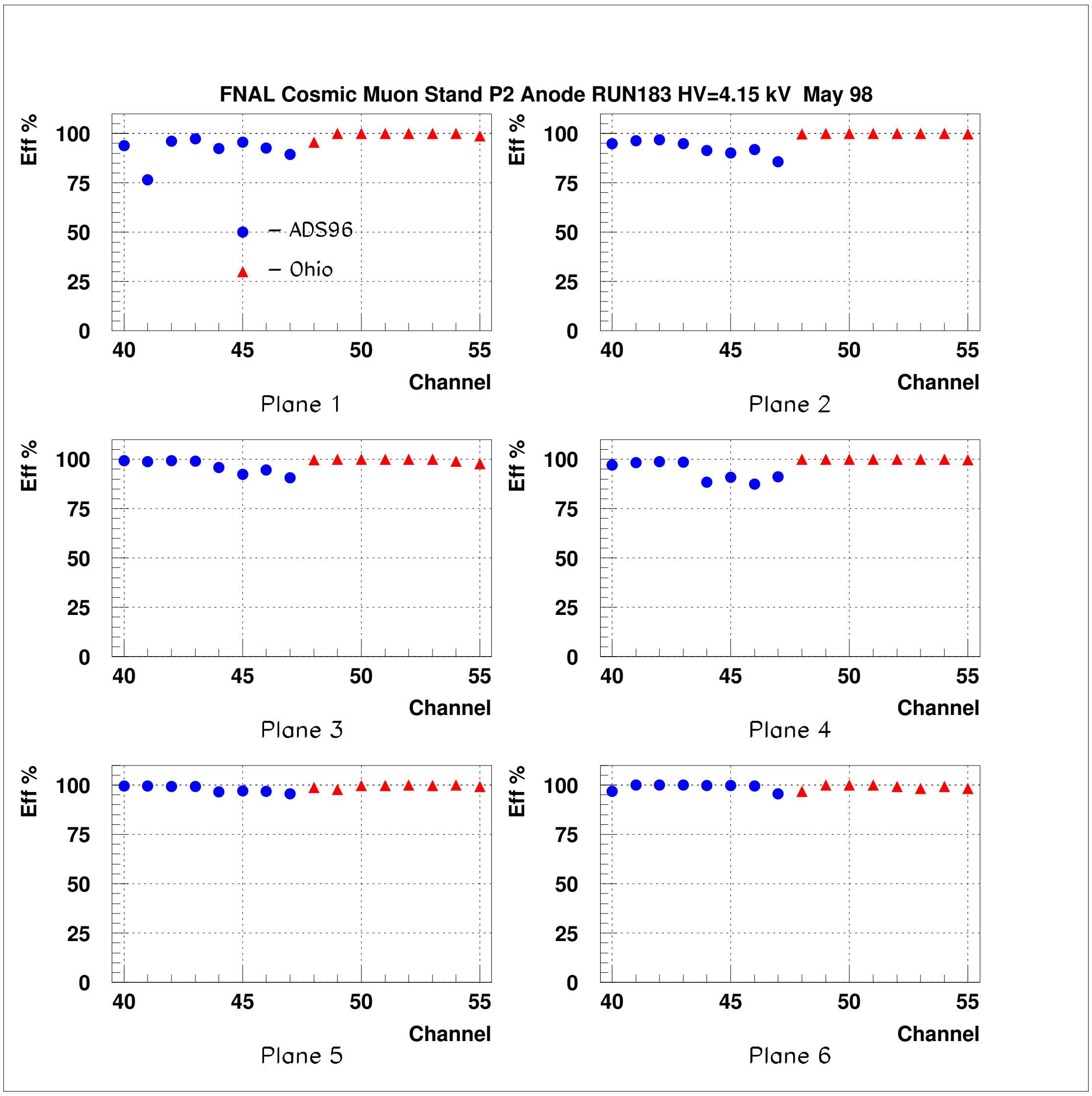

Figure 1: Efficiency of anode front-end (ADS96 and Ohio) electronics for US P2 CSC prototype at FNAL Cosmic Muon Stand

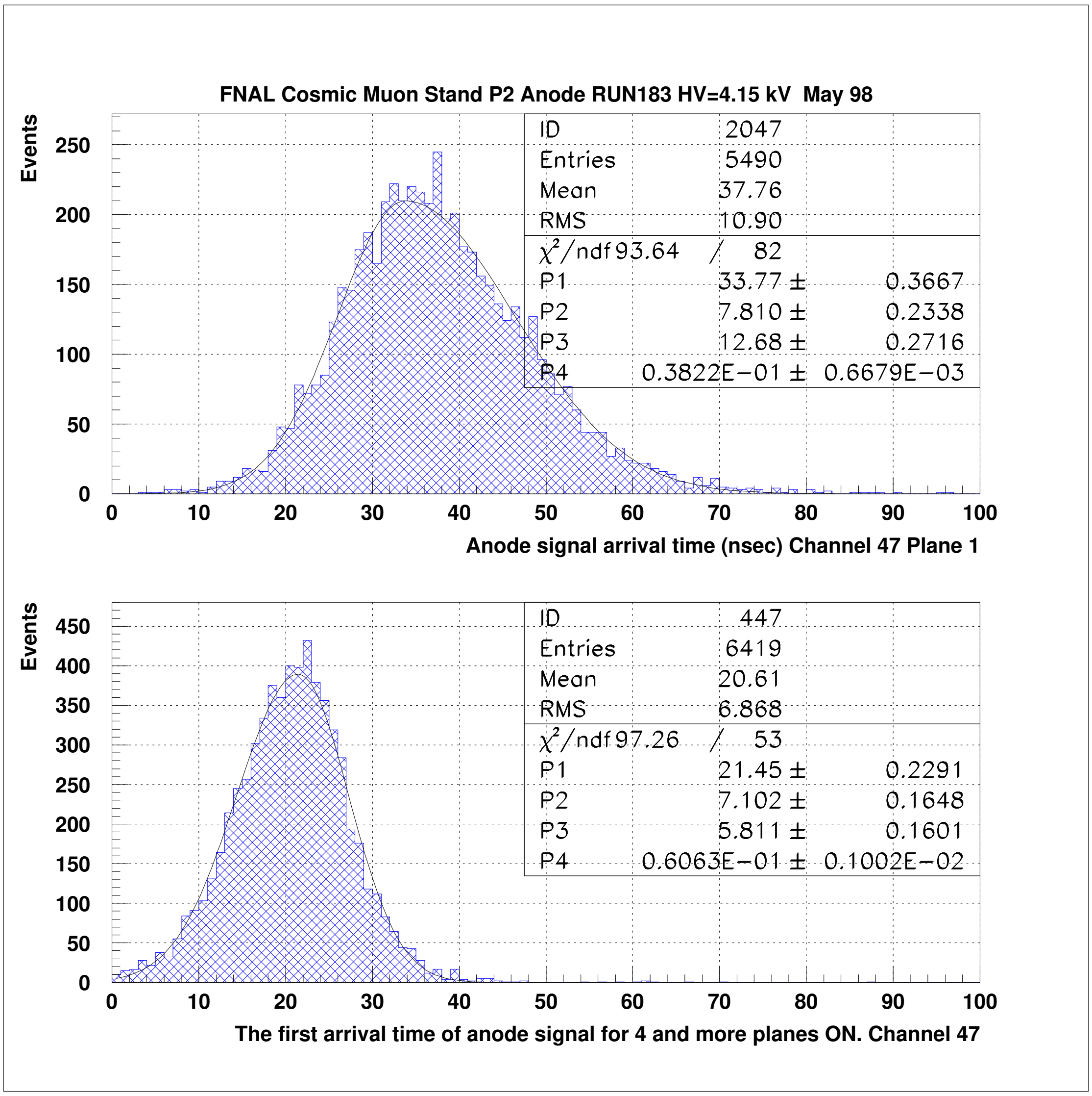

Figure 2: Time distributions of signal from one ADS96 channel (top) and first arriving time distribution (bottom)

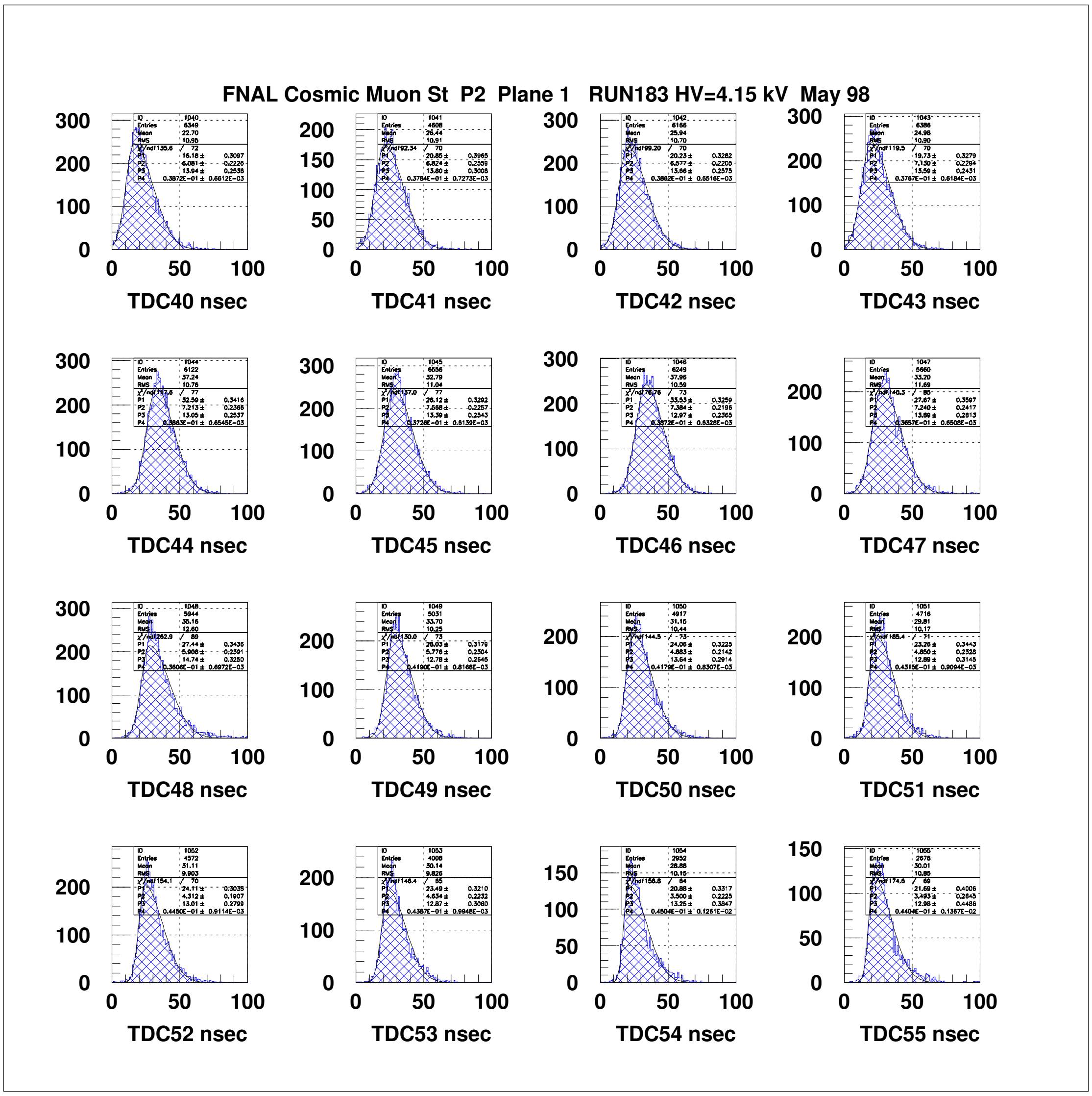

Figure 3: Time distributions of signals from individual channels, ch. 40-47 for ADS96, 48-55 for Ohio front-end

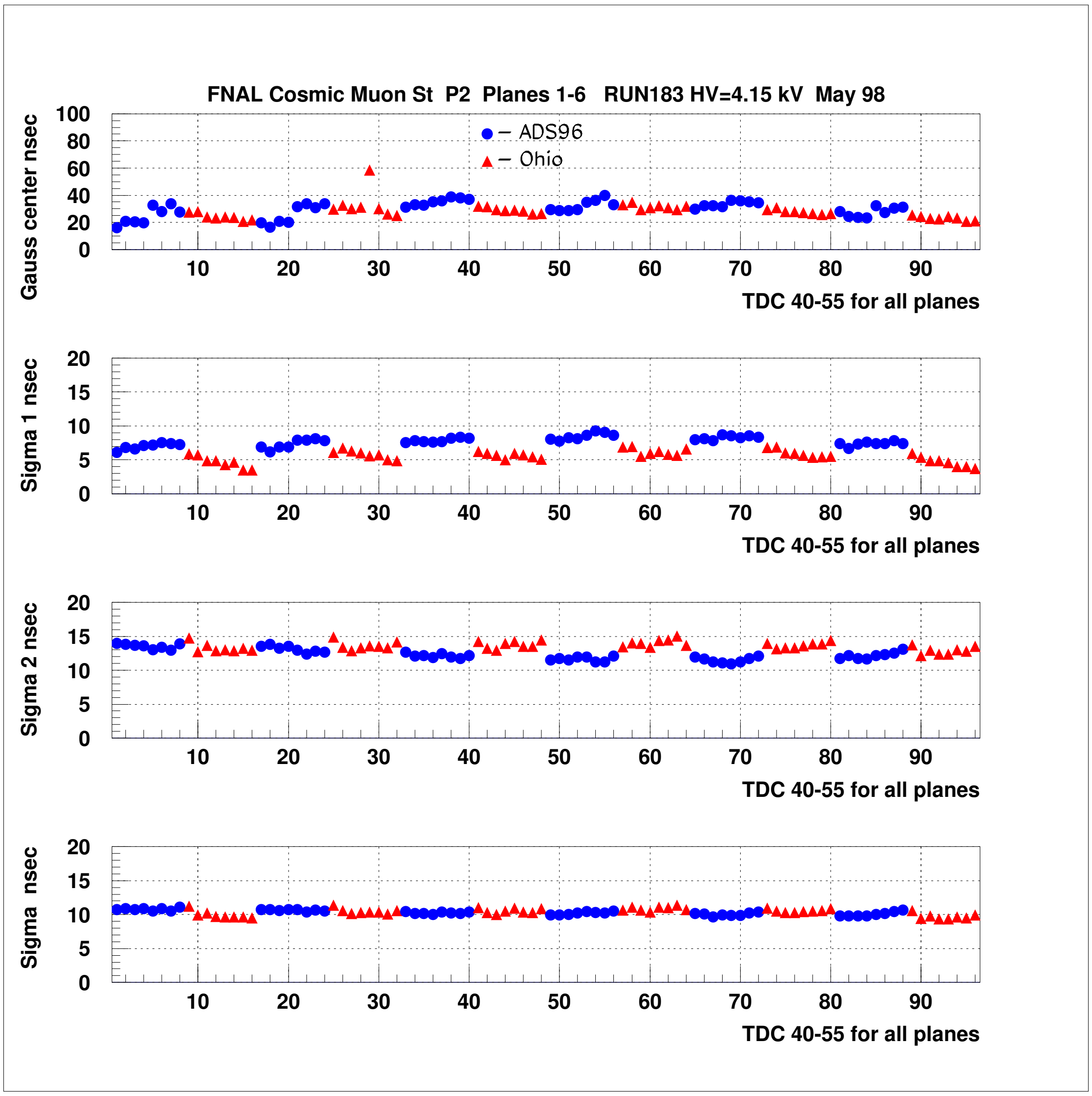

Figure 4: Fit parameters for all channels, all planes. Sigma=sqrt((sigma1**2+sigma2**2)/2)

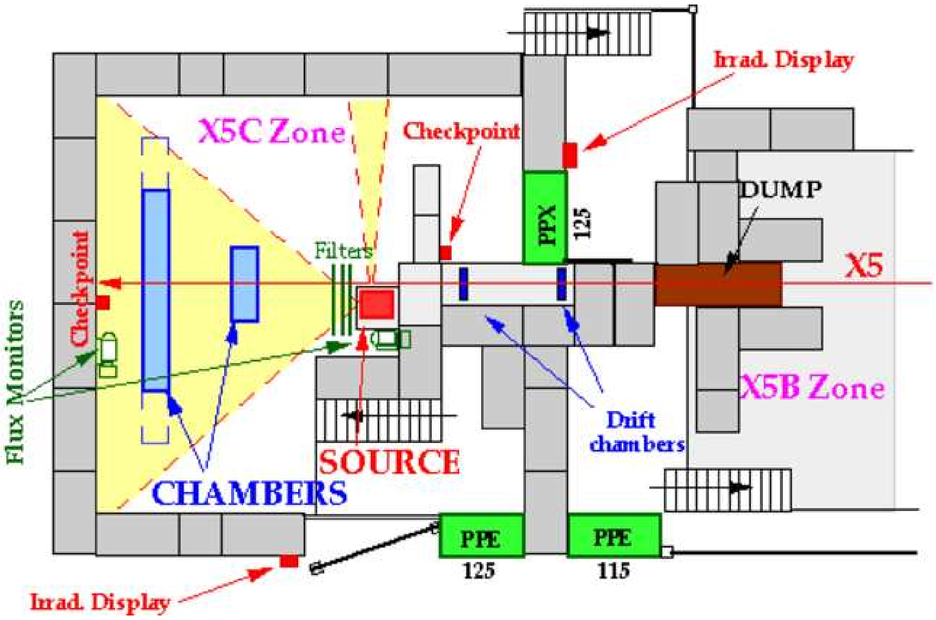

Figure 5: The layout of Gamma Irradiation Facility at CERN

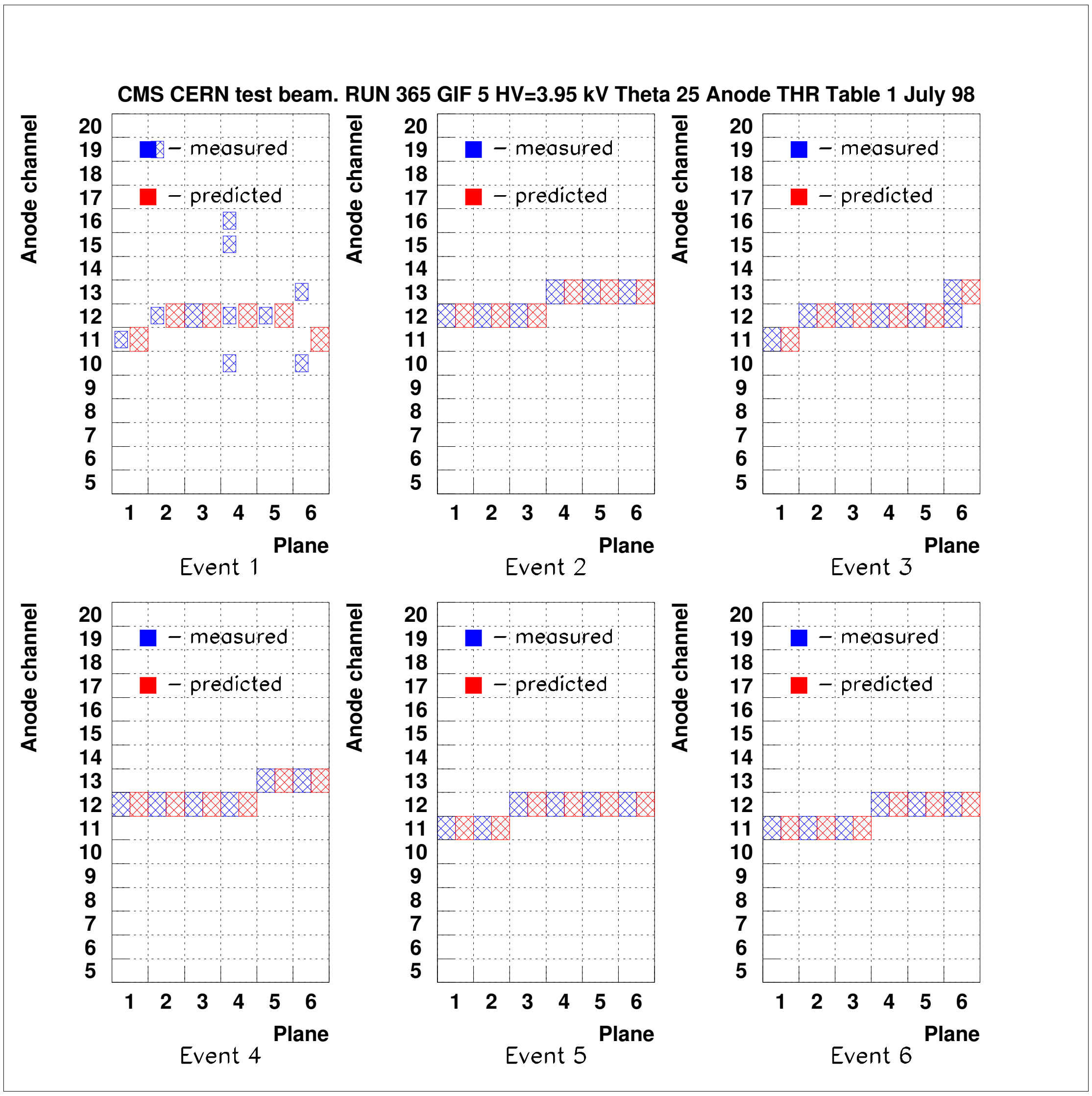

Figure 6: Event display for measured and predicted hits in anode front-end channels. Prediction made from beam chambers

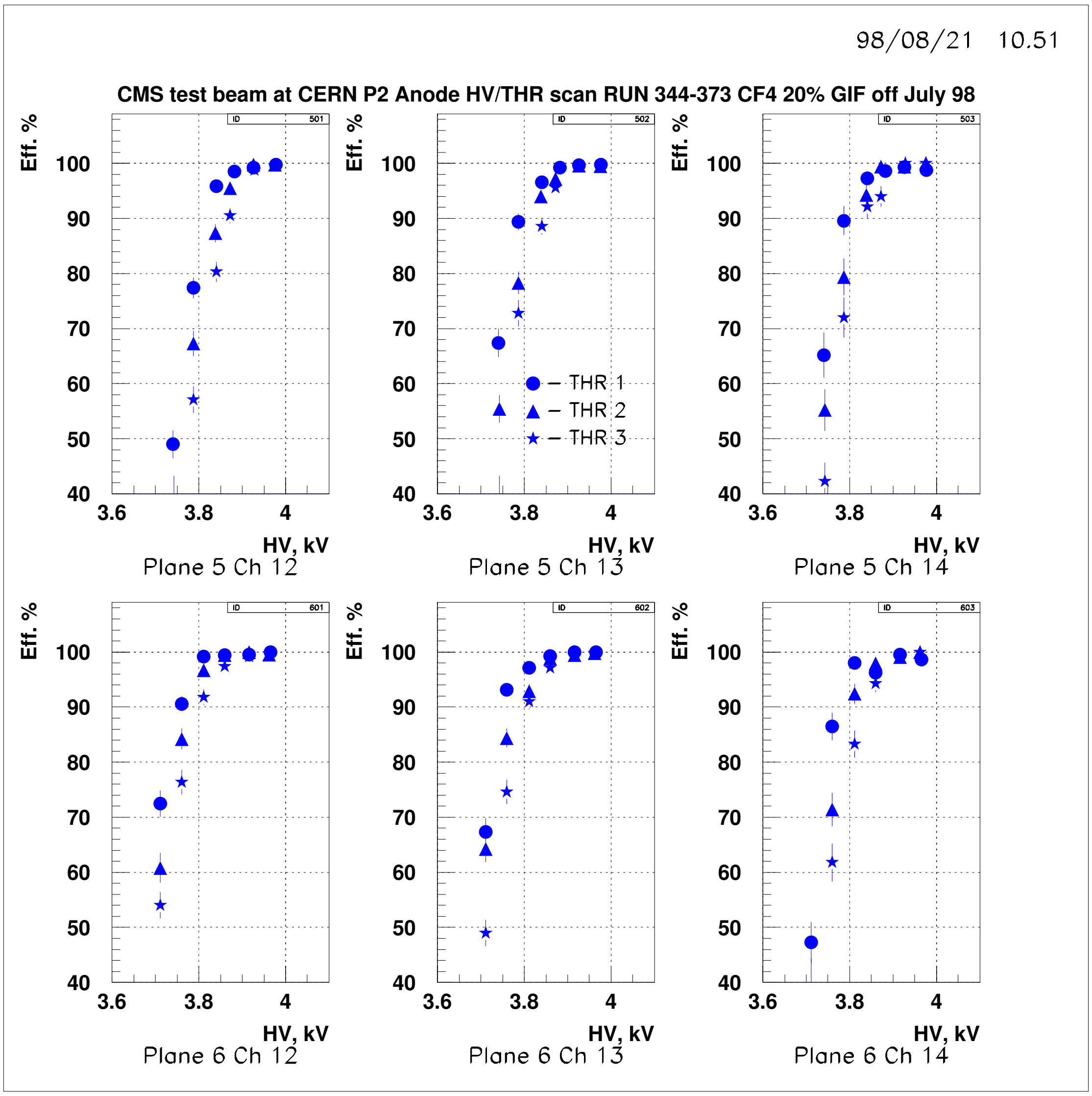

Figure 7: HV and threshold scan for efficiency (example for planes 5 and 6)

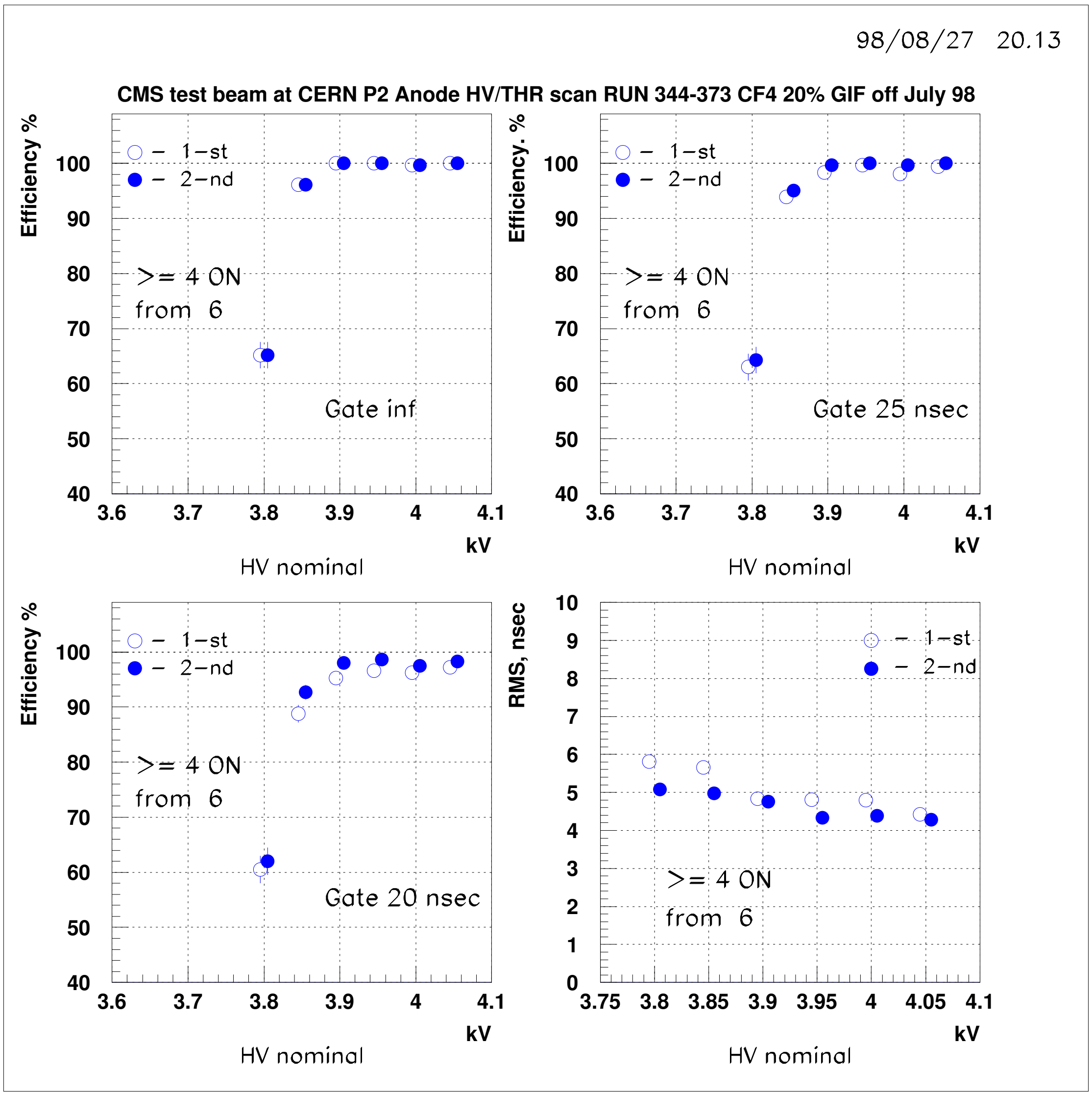

Figure 8: Efficiencies (with different gates) and RMS vs HV for the 1-st and the 2-nd arriving signals when 4 and more planes from 6 are ON.

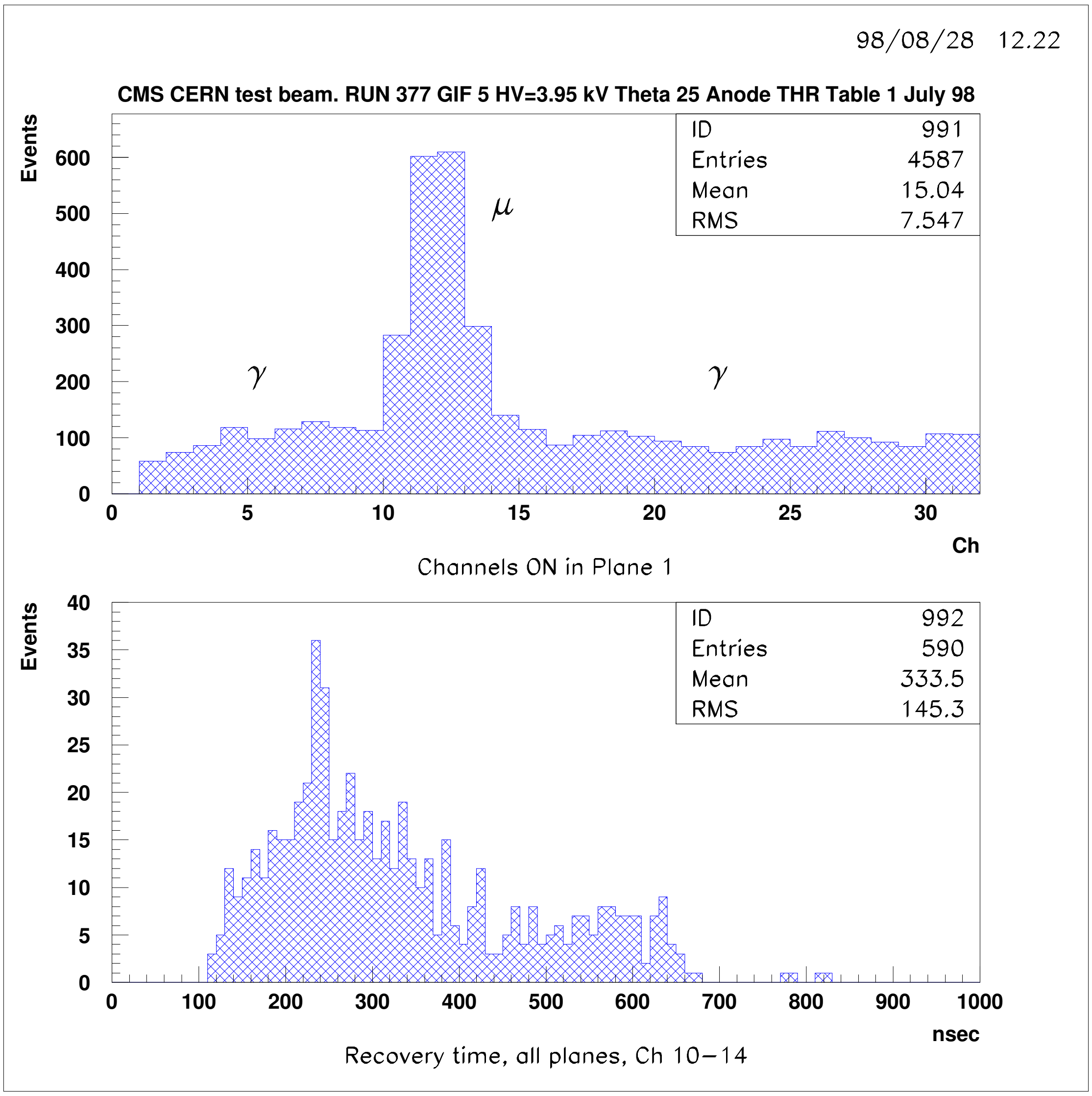

Figure 9: Distribution of the anode hitted channels (plane 1) when GIF irradiation reduced by factor 5 (top). Recovery time as difference between leading edges of the 1-st and 2-nd signals (bottom)