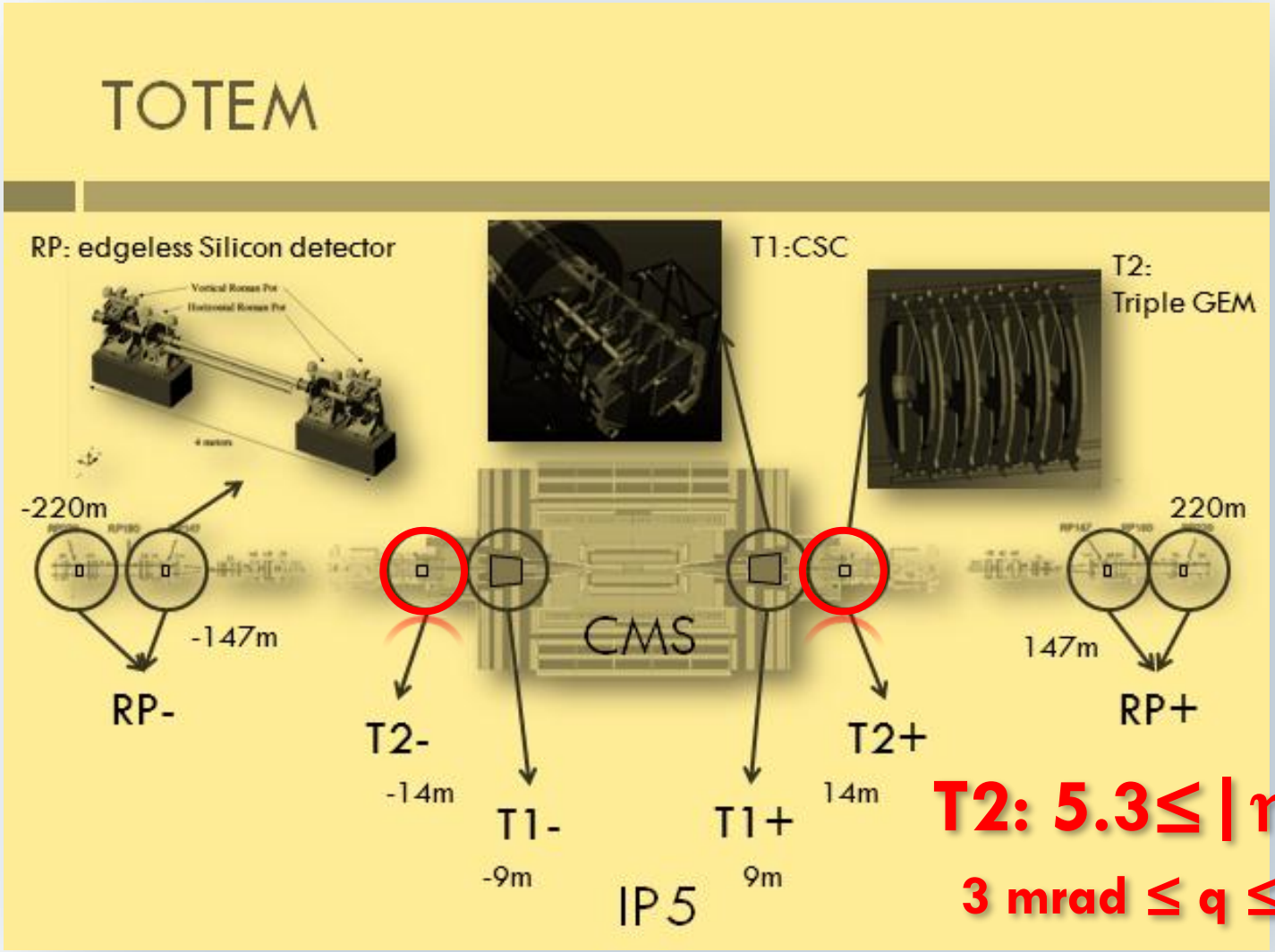
TOTEM 2011 RD51 TEST BEAM

PnPR → PnP Transition in the TRIPLE GEM & VFAT2 SYSTEM

TOTEM Genova, Helsinki, Pisa-Siena Groups

From the RD51 mini week of 2010…

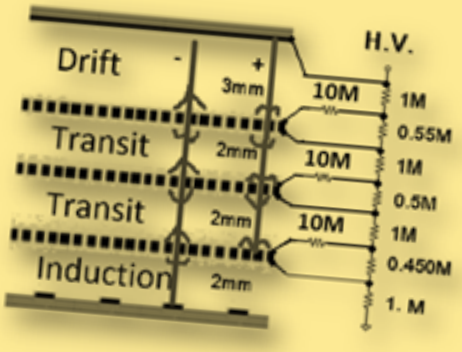


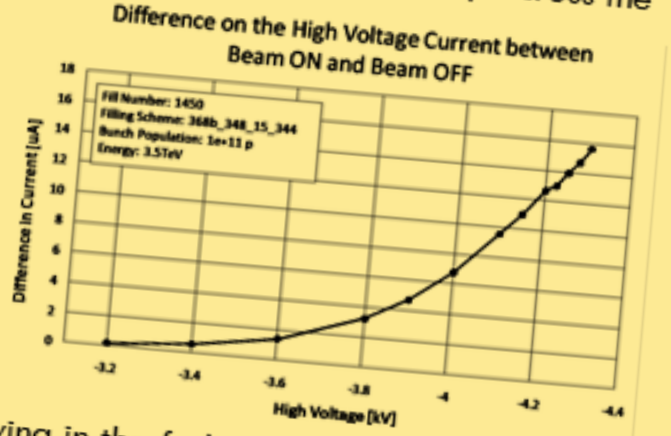
From the RD51 mini week of 2010…

T2: a T2 limit with high luminosity

T2 Environment: Large amount of particles (primary and secondary) per collision.
T2 Gain: High GAIN to be efficient in the actual configuration

The amplified charge collected by the foils will cause a voltage drop across the 10Mohm protection resistors.

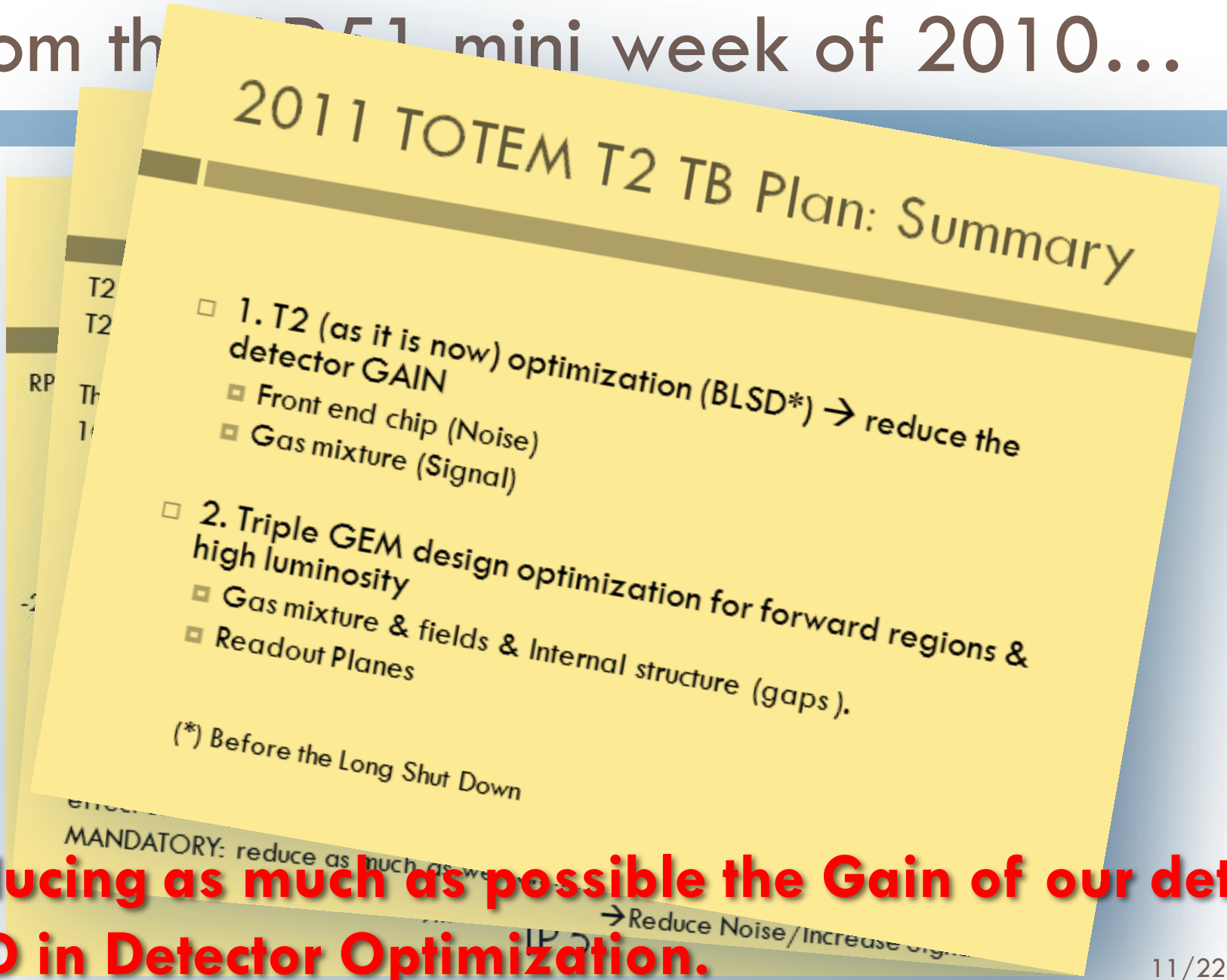




In high intensity beams the current flowing in the foils can reach few μA and the effect on the gain is not negligible.
MANDATORY: reduce as much as we can the detector GAIN
→Reduce Noise/Increase Signal.

≈ 100 Particles (primaries and secondaries) per Collision @ √s=7TeV in T2

From th… mini week of 2010…



-Reducing as much as possible the Gain of our det.

-R&D in Detector Optimization.

Gain Reduction: Playing with the S/N Ratio

- 1. FE chip (VFAT2) Optimization. - **Noise**

  Laboratory measurements had shown promising setting. Test beam data needed to confirm the goodness with the signal (efficiency and timing).

- 2. Gas Mixture. - **Signal**

  Faster Signal to better match the FE characteristics.

- 3. Internal Structure

  R&D studies on detector optimization. Internal gaps analyzed (induction and drift). - **Signal**

PnPR → PnP Transition in the Triple GEM & VFAT2

PnPR (Plug and PRAY)

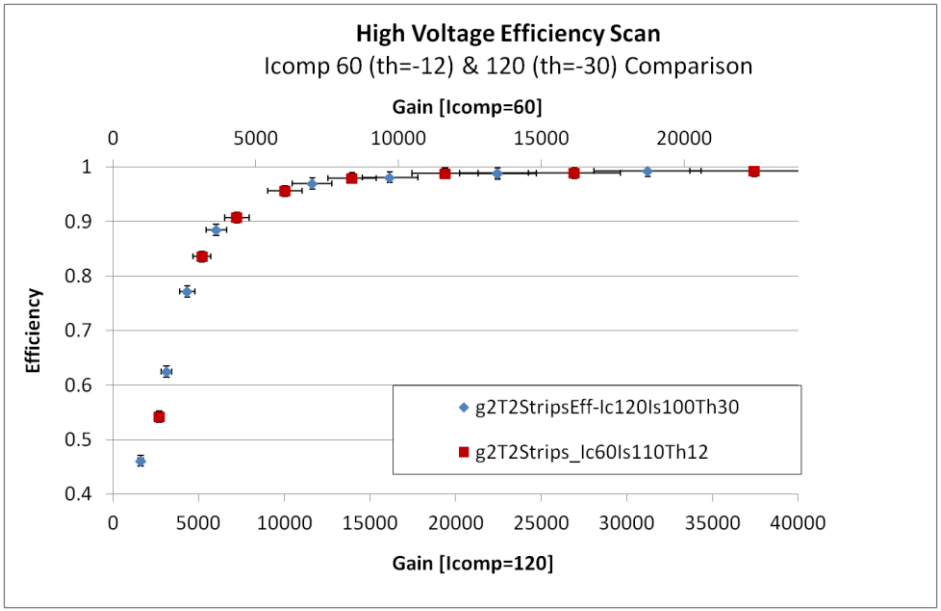
PnP (Plug and PLAY)

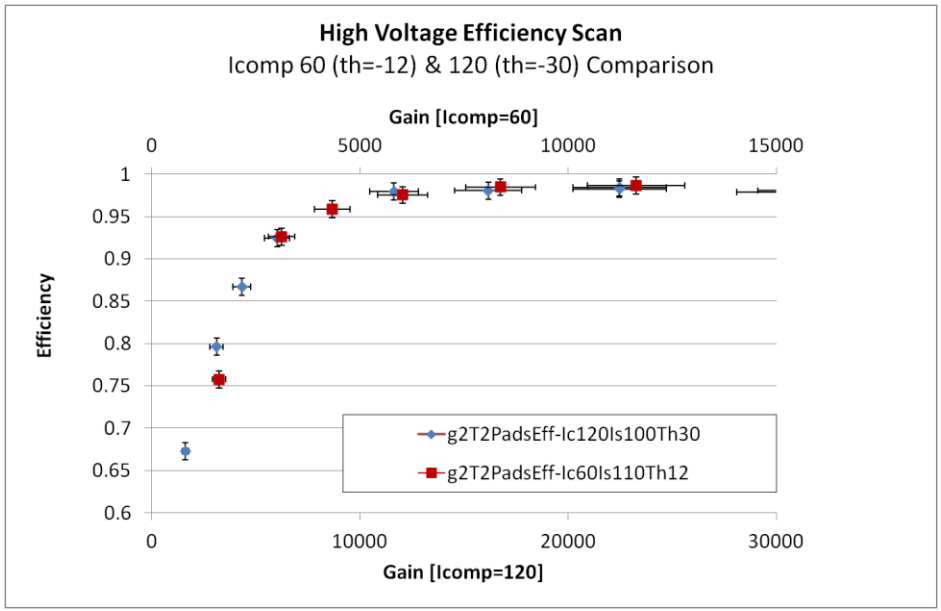
BEFORE ICOMP

AFTER ICOMP

The new settings represents for us the passage from a "plug and pray" chip to a "plug and play" one.

VFAT2 Settings: Internal Comparator Current





Gain Reduction Factor:

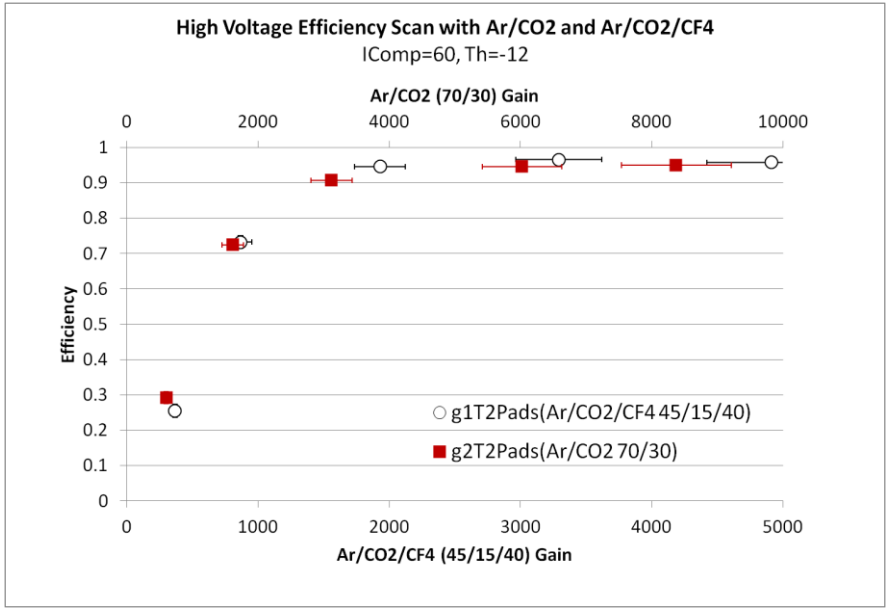
Icomp Register std value :120
Lowered down to 40 preserving a good behavior

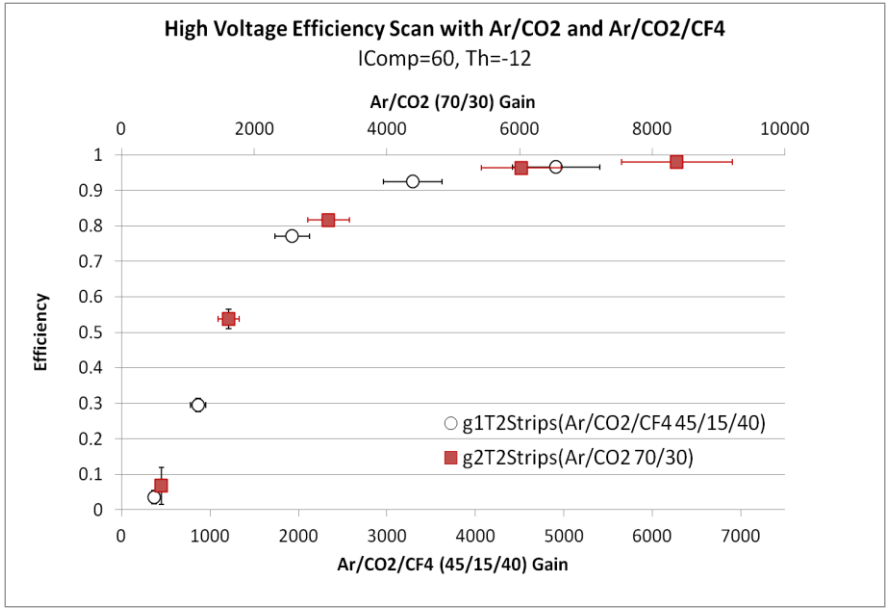
T2TripleGEM in **H8: 1.5(strips)/2(pads)**
(result referred to a silent detector)

Roughly all threshold in IP5 >40/45@ Icomp75 (here we have 30 @ Ic120)

We could expectT2TripleGEM in **IP5: 3/5(?)/…(??)**

Gas Mixture: from Ar/CO2 to Ar/CO2/CF4





Gain Reduction Factor:

Faster Signal, better VFAT2 response

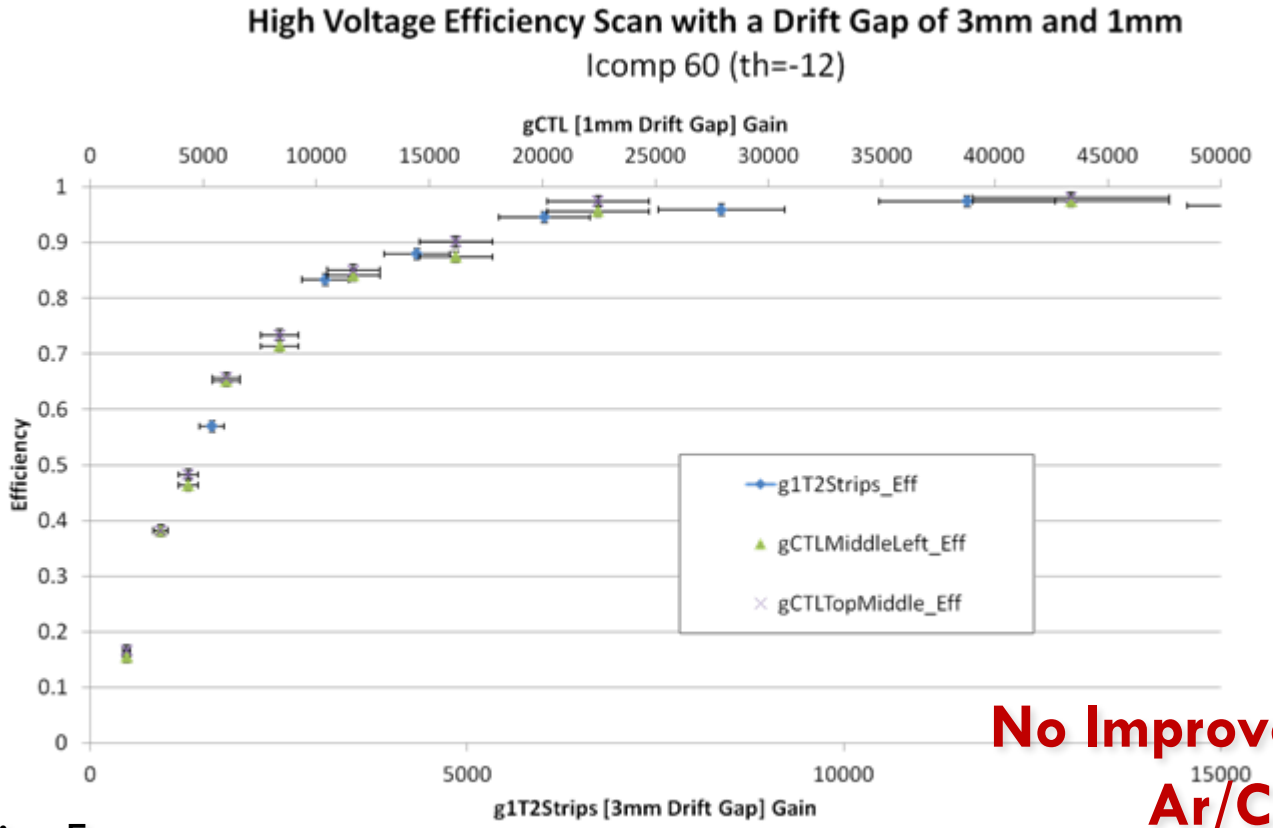
Ar/CO2/CF4 (45/15/40): **1.3(strips)/2(pads)**

Ar/CO2/CF4 (60/20/20): 1.3(pads) [2010 RD51 H4 test beam data on Large GEM]

Going from 2mm to 1mm Induction gap: **2/3(?)/4(??)**

Internal Structure : Drift Gap

Drift gaps of 2mm or 1mm are obviously less efficient but we would like to cut away the signal "not-efficiently used" by our FE



No Improvement with Ar/CO2 (70/30) … with CF4? 2012 tb…

Gain Reduction Factor:

No Gain Reduction Observed with Ar/CO2.

Compensation of the missing charge needed (i.e. increasing the detector Gain)

Summary

- Gain Reduction Factor in T2 as it is:
  - VFAT Setting: 3/5/…
  - Gas Mixture (+CF4): 1.5/2…
  - Drift Gap: No Improvement

TOTAL GAIN REDUCTION: between 3 and 10 (or hopefully higher, depending on the detector noise level)

- Trying to push more… new detectors…
  - 1mm Induction 1.5/2(CF4) → 2/3/4(?)
  - 2/1 mm Drift & CF4 (???)

The achieved results are good but an effort on design a new high voltage divider (with a particular attention on the protection circuit) is nevertheless needed to guarantee our operation ($5.3 \leq |\eta| \leq 6.5$) in the high luminosity LHC environment.

2012 RD51 TB

- 1. FE chip (VFAT2) Optimization.

  - Other settings still untouched…

  - VFAT2 & SRS System (different Hybrid & Powering Configuration… interesting for us to understand if there is any improvement).

- 2. Test on TOTEM T2 with a new HV divider (different solution for the actual protection resistors and new internal field optimized for mixtures with CF4) to will be replaced during the LHC long shut down.

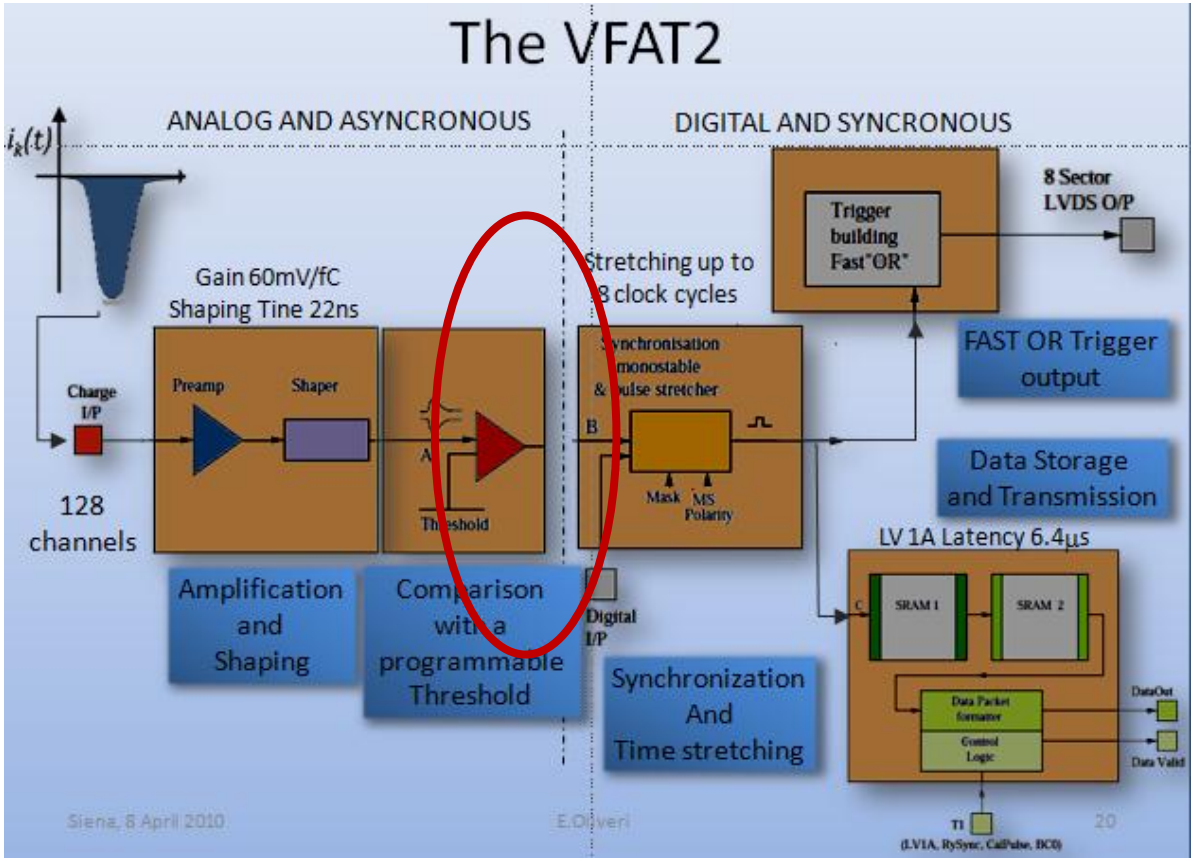
- 3. R&D on different Internal Structures: Gaps & Gas.

- A little bit more on the FE chip (VFAT2) Optimization

(just because it has been the most promising item and it could help other VFAT2 users)

Noise Improvement: VFAT2 Settings

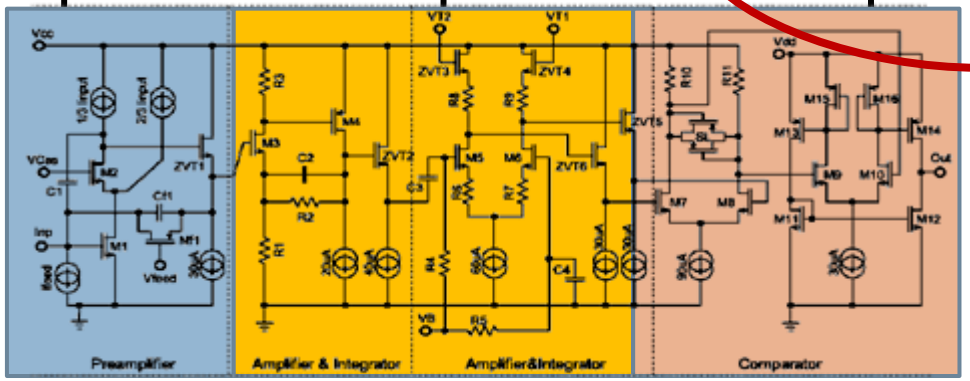
- Front End chip VFAT2
  - Internal Settings optimization: The Comparator Current



Noise Improvement: VFAT2 Settings

- Front End chip VFAT2
  - Internal Settings optimization

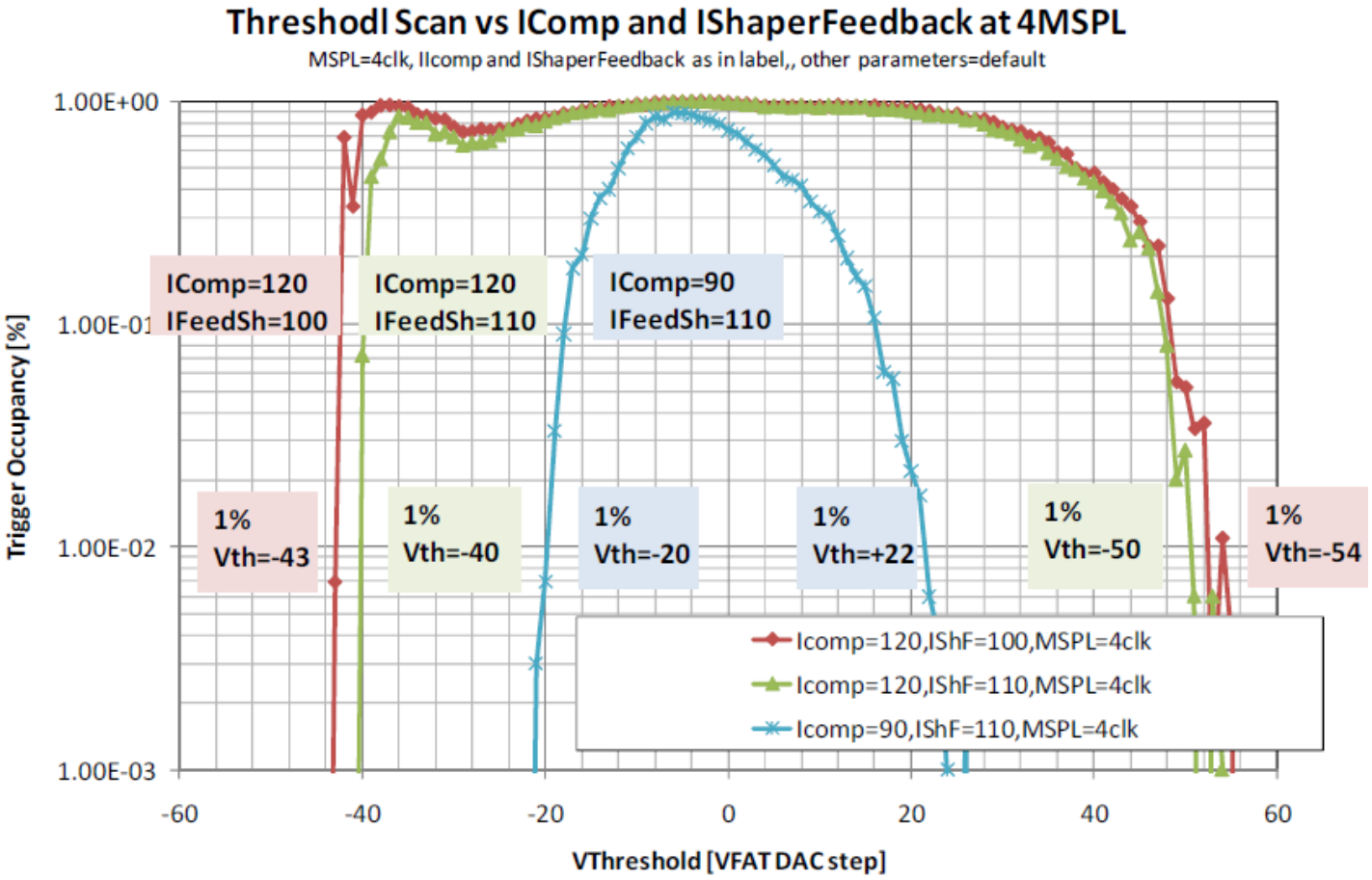
Preamplifier Shaper Comparator.



- Reducing the Internal Comparator Current we observed:
  - 1.1 Noise Reduction (mainly the cross talk components ever observed in 2D readout).
  - 1.2 Signal Attenuation (negligible respect with the noise reduction)
  - 1.3 Time Resolution not affected.

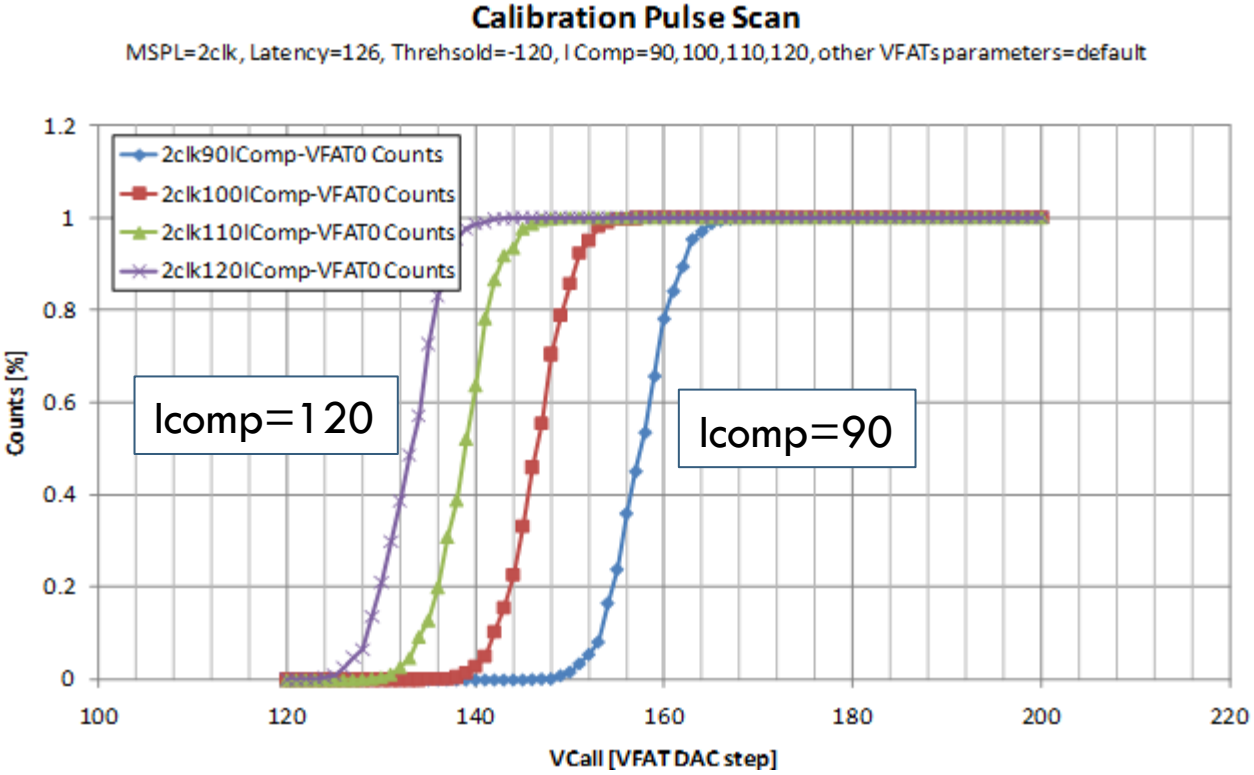
VFAT2 Settings: IComp & Noise (lab)

- Lab Test: Effects of IComp on the Noise → Threshold Scan



VFAT2 Settings: IComp & Signal(lab)

- Lab Test: Effects of IComp on the Signal → Calibration Scan (S Curve)



VFAT2 Internal Amplification Reduced.

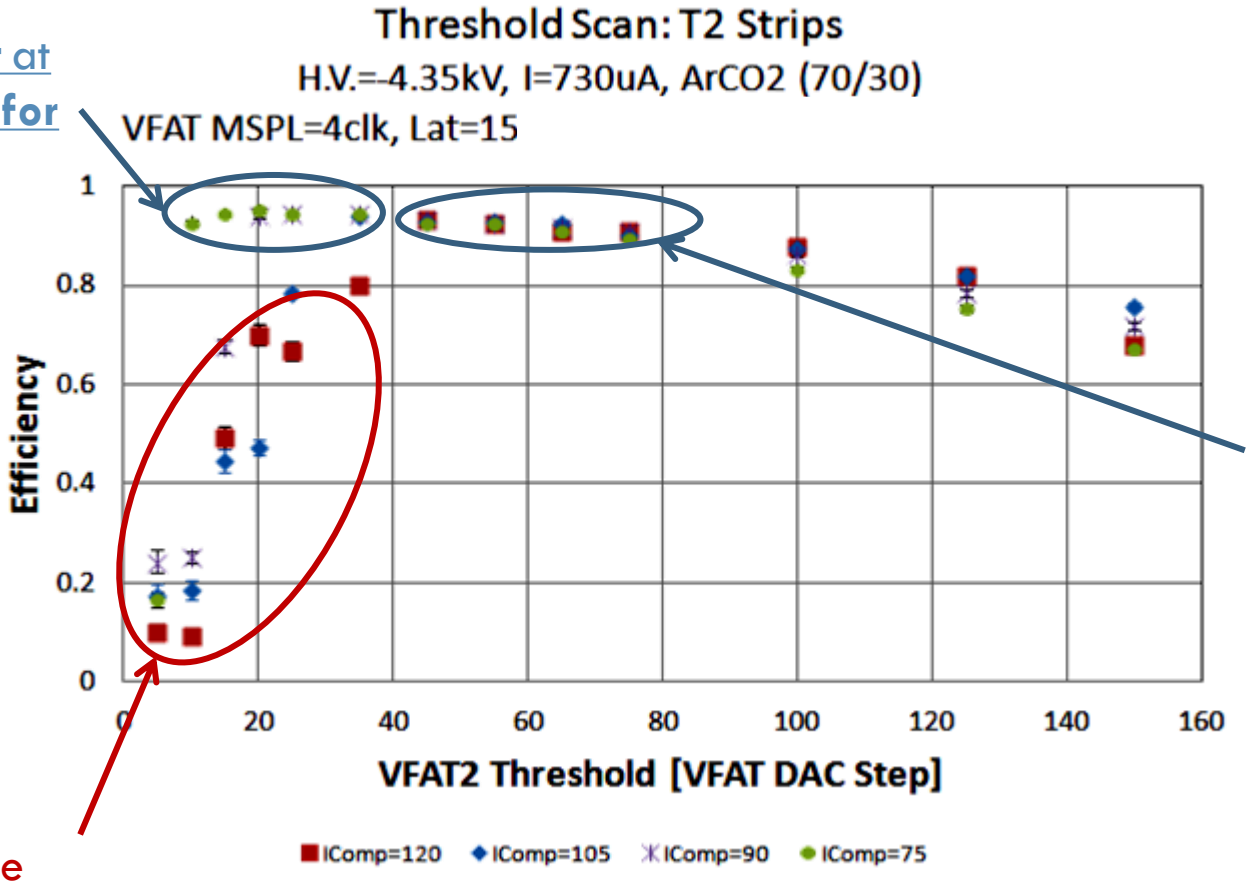
The loss of internal gain is however negligible compared with the improvement offered by the noise reduction.

Slow signals (compared to the cal pulse) as the one of our gas detector, are moreover less affected by this loss of signal.

VFAT2 Settings: IComp & Signal(beam)

- H8 Beam: Efficiency vs Threshold for different IComp

Good Behavior at lower threshold **for Smaller IComp**

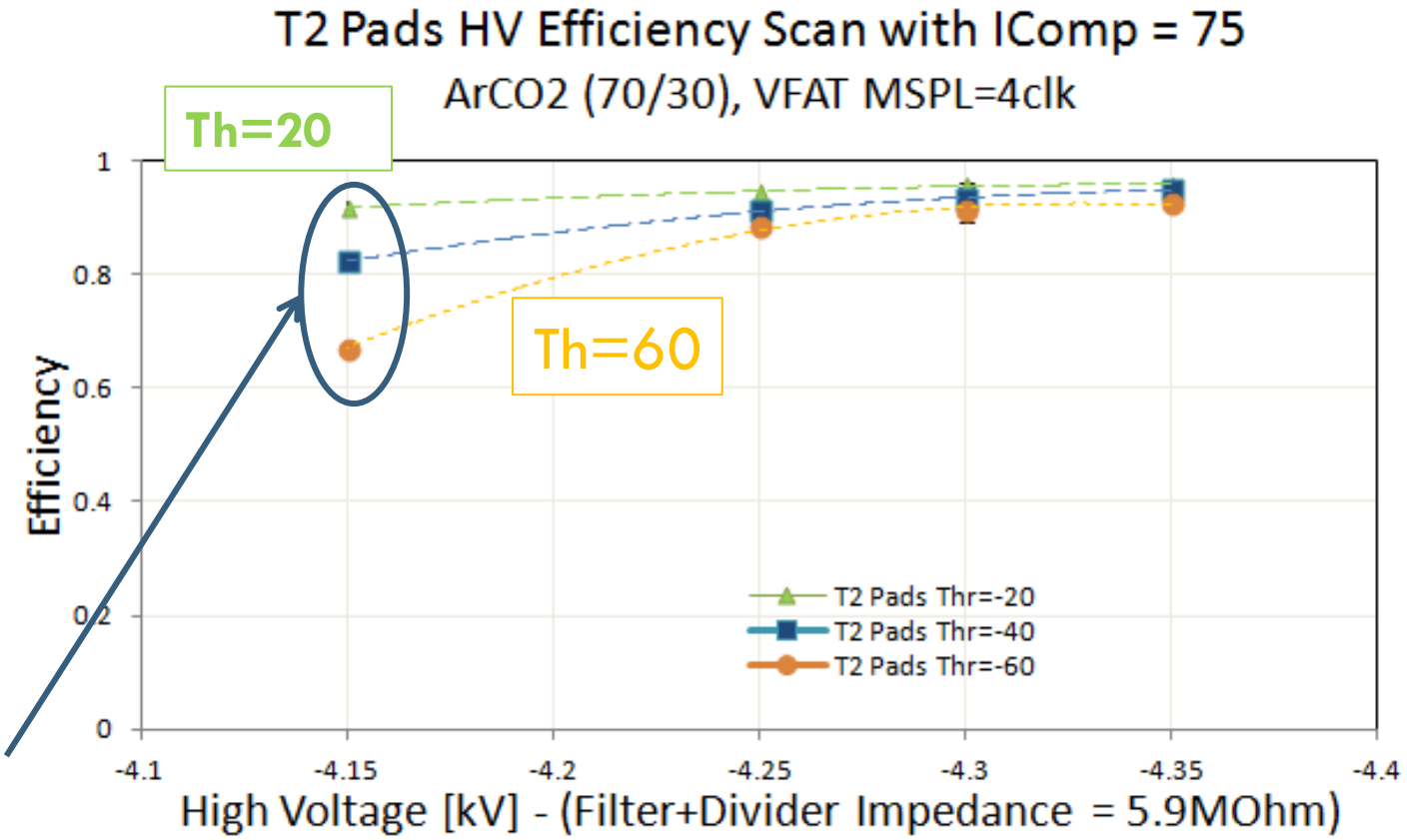


No relevant loss of signal in region outside the noise for smaller IComp

Degradation of the signal due to the noise **for higher IComp**

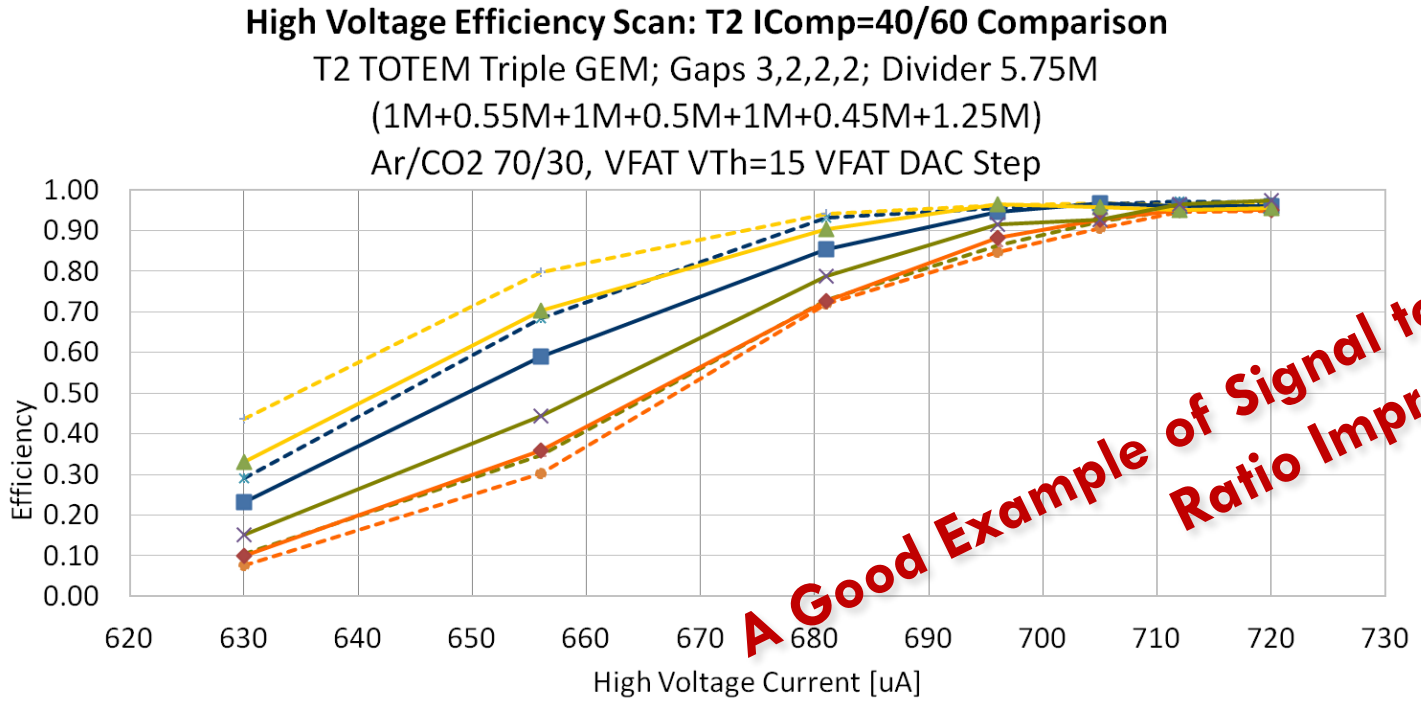
VFAT2 Settings: IComp & Signal(beam)

- H8 Beam: Efficiency vs HV for different Threhsold



Higher Efficiency @ lower Gain Because of the threshold reduction

VFAT2 Settings: Icomp & S/R optimization



A Good Example of Signal to Noise Ratio Improvement

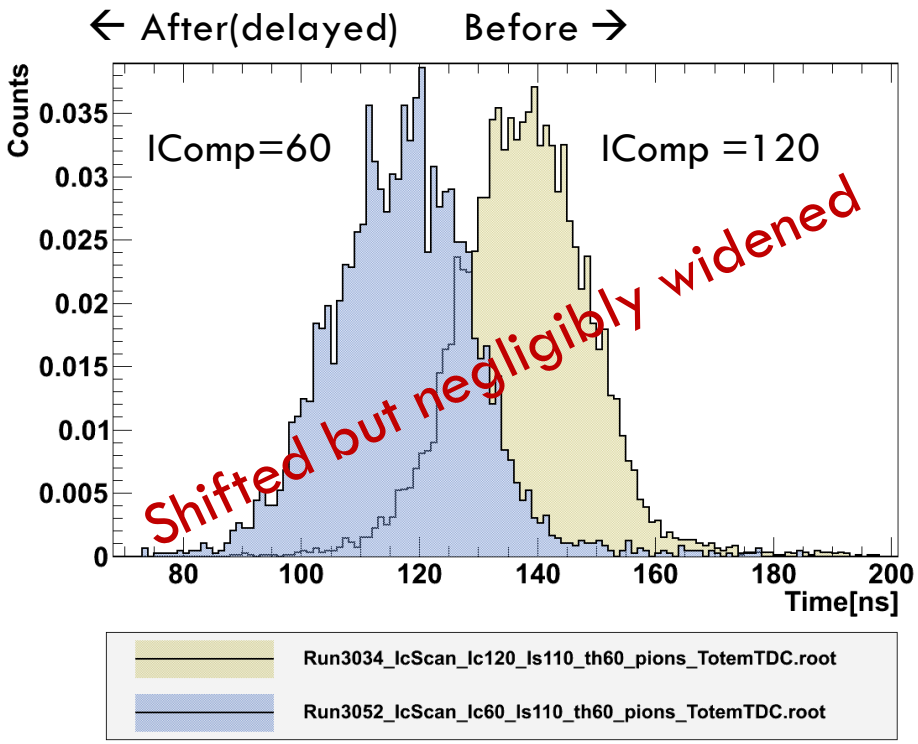
Run0034-Run0061

IC40 preferred by pads

IC60 preferred by strips because we cannot reduce the threshold as for pads

VFAT2 Settings: IComp & Timing(beam)

- H8 TB Data: IComp Effects on the Timing of the Signal



TDC Measurement: No degradation of the timing performance of the FE+T2GEM system.

Reducing IComp, we observed an offset (delay) but the effects on the time resolution was negligible (same RMS)

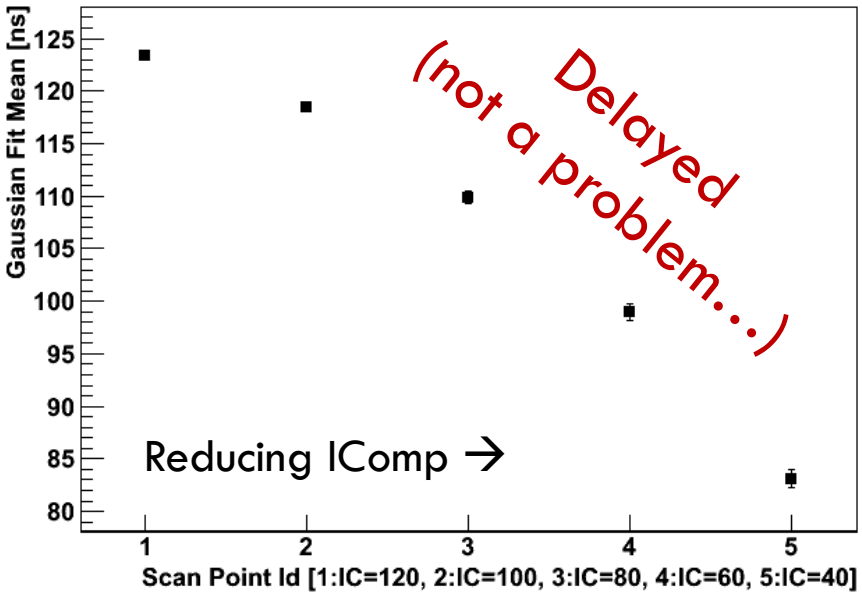
We measured the difference in time between the VFAT2 Trigger SBit Signal and the Scintillators Coincidence. (higher distribution mean means before in time in our set up).

VFAT2 Settings: IComp & Timing(beam)

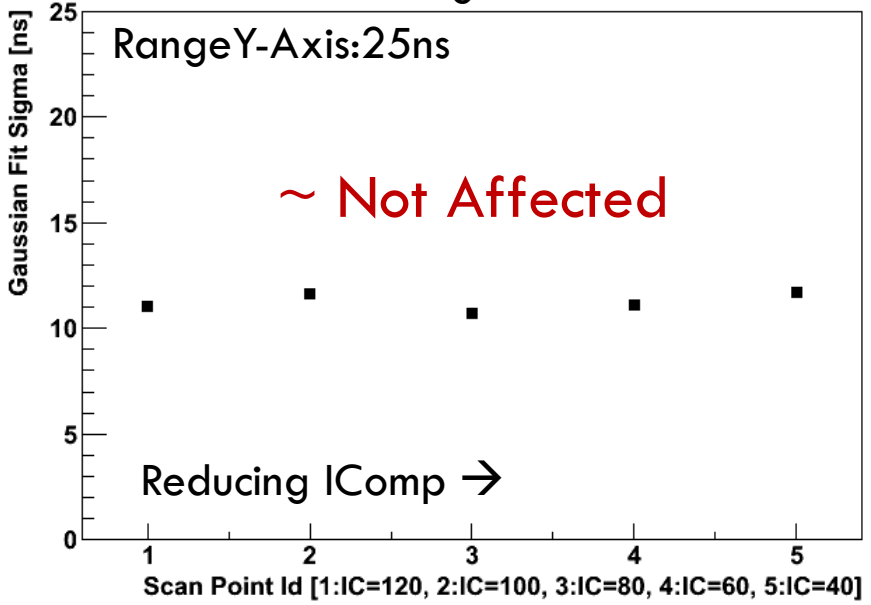
- H8 TB Data: Timing and VFAT2 Comparator Current

Ar/CO2 70/30

TDC: Gauss. Fit Mean



TDC: Gauss. Fit Sigma



Delay → Affected

Resolution → Not Affected

- VFAT2 cross talk in 2D readout

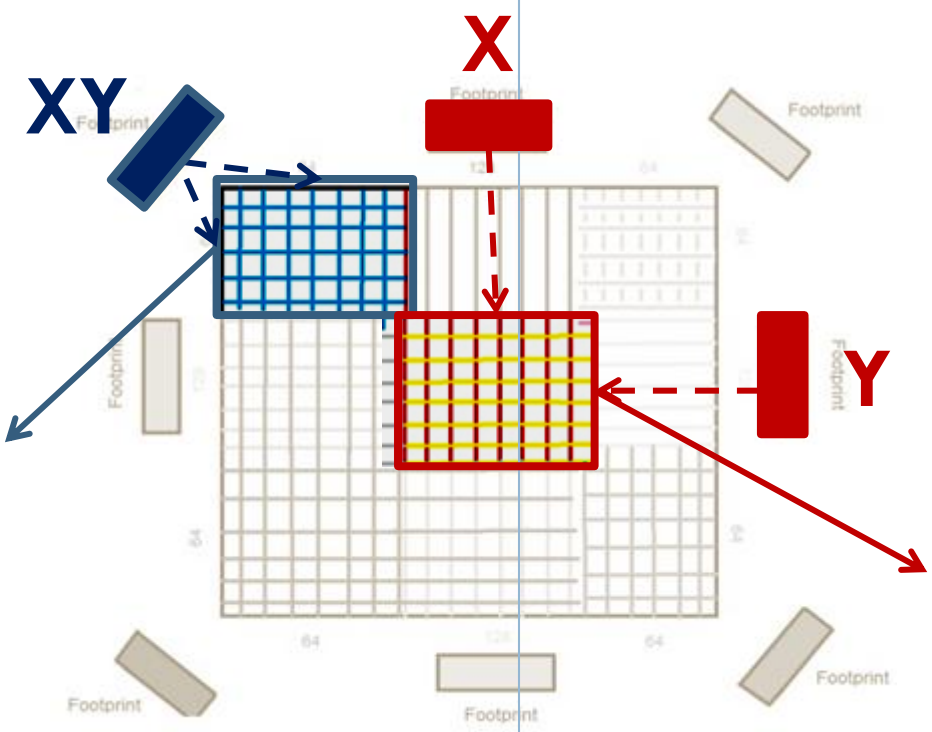
Powering and grounding
… a key point

VFAT2 Powering/Grounding

- A Multi Pattern Readout Board has been designed to understand the role played by the FE chip and/or the readout pattern in the observed cross talk noise.
- The performed measurement address the observed cross talk to the FE powering and grounding (different power/ground fluctuation between different chips inject noise through the coupling provided by the readout).
- Possible Improvement: redesigning of the FE hybrid and of the FE powering/grounding scheme.

FE Powering/Grounding Optimization

XY Strips Multi-Pattern Readout.



XY readout Strips Belonging to a single VFAT2

We compared the behavior of a XY Strips readout for two configurations:

1. XY on a single chips
2. XY on two chips

XY readout Strips Belonging to two VFAT2

[Readout designed/provided by Helsinki Group: F. Garcia Fuentes]

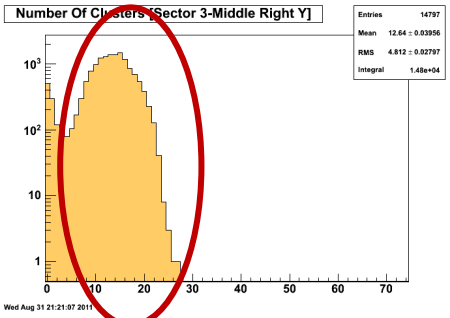
FE Powering/Grounding Optimization

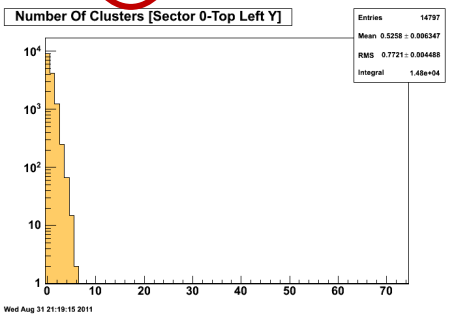
Number of Clusters and Cluster Size at low threshold (partially inside the noise)

XY on Two Chips

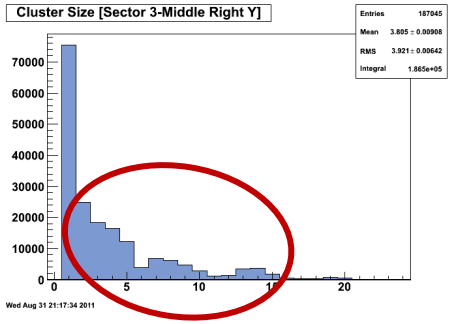
XY on Single Chip

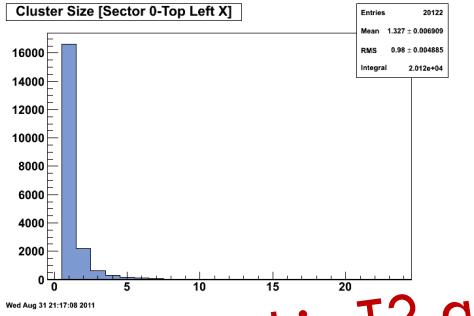
Number Of Clusters





Cluster Size





The typical signature of the cross talk observed in T2 has been found only in the configuration with two different chips connected to the XY readout.

Typical Cross Talk Observed in T2 and in any Multilayer Readout with Multiple chips not Observed in the XY Strips - single Chip configuration

thanks