Front-end pixel chips for tracking in ALICE and particle identification at LHCb

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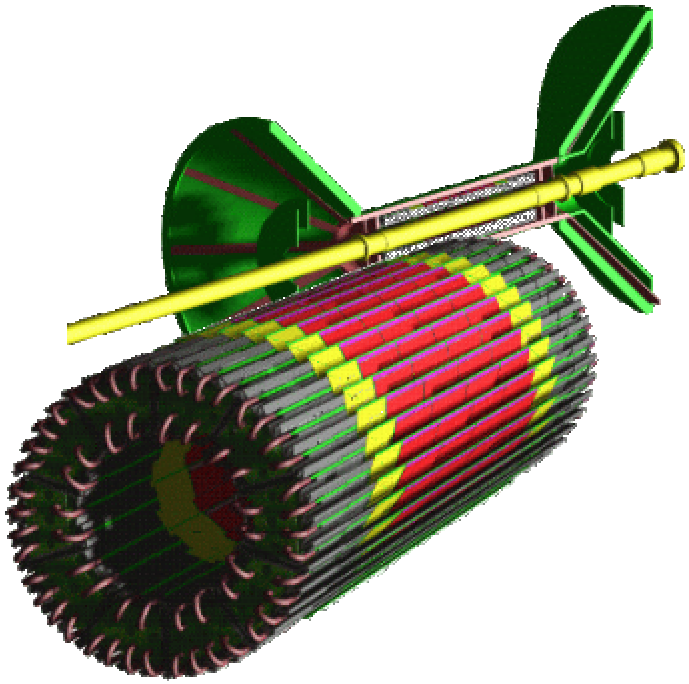
OUTLINE

- **The two applications: ALICE and LHCb**
- **ALICE1LHCB: General chip description**
- **Pixel cell description**
- **The two operational modes: ALICE and LHCb**
- **ALICE1LHCB: Results**
- **LHCBPIX1: Version 2**
- **LHCBPIX1: Results**
- **Conclusion and future plans**

Pixel electronics for tracking in ALICE

See earlier talks by Petra Riedler and Alex Kluge



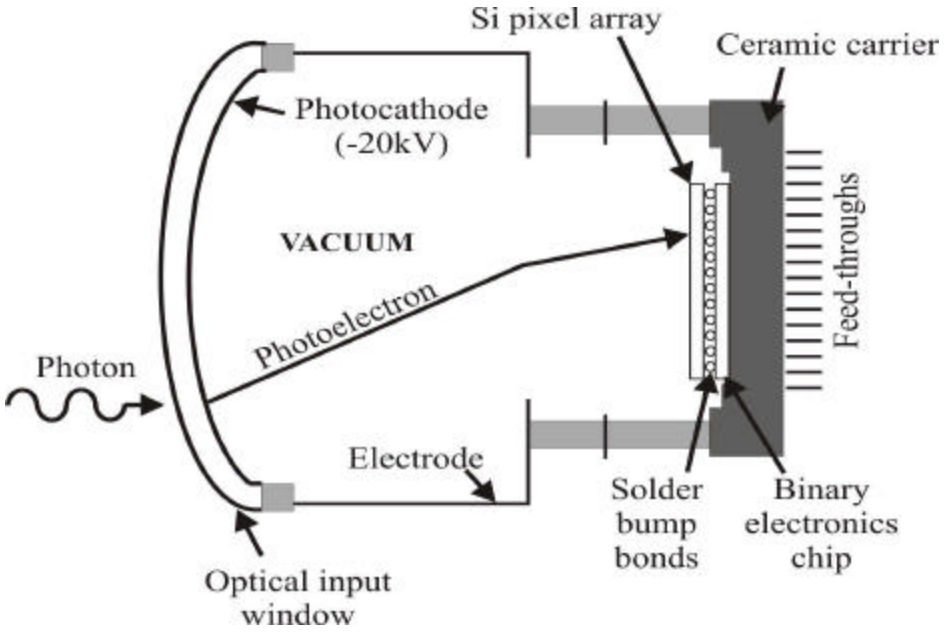
- **Spatial resolution of 12mm in r-f => 50um pixel**
- **Thin sensors (12000 e⁻ signal)**
- **Data buffers before both Level-1 & Level-2 triggers**
- **10MHz readout clock**
- **Radiation tolerant to ~ 500 krad**
- **Low power consumption**
- **Tight mechanical constraints**

Pixel electronics for particle ID in LHCb

Baseline photo-detector in the LHCb RICH:

Hybrid Photon Detector (HPD)

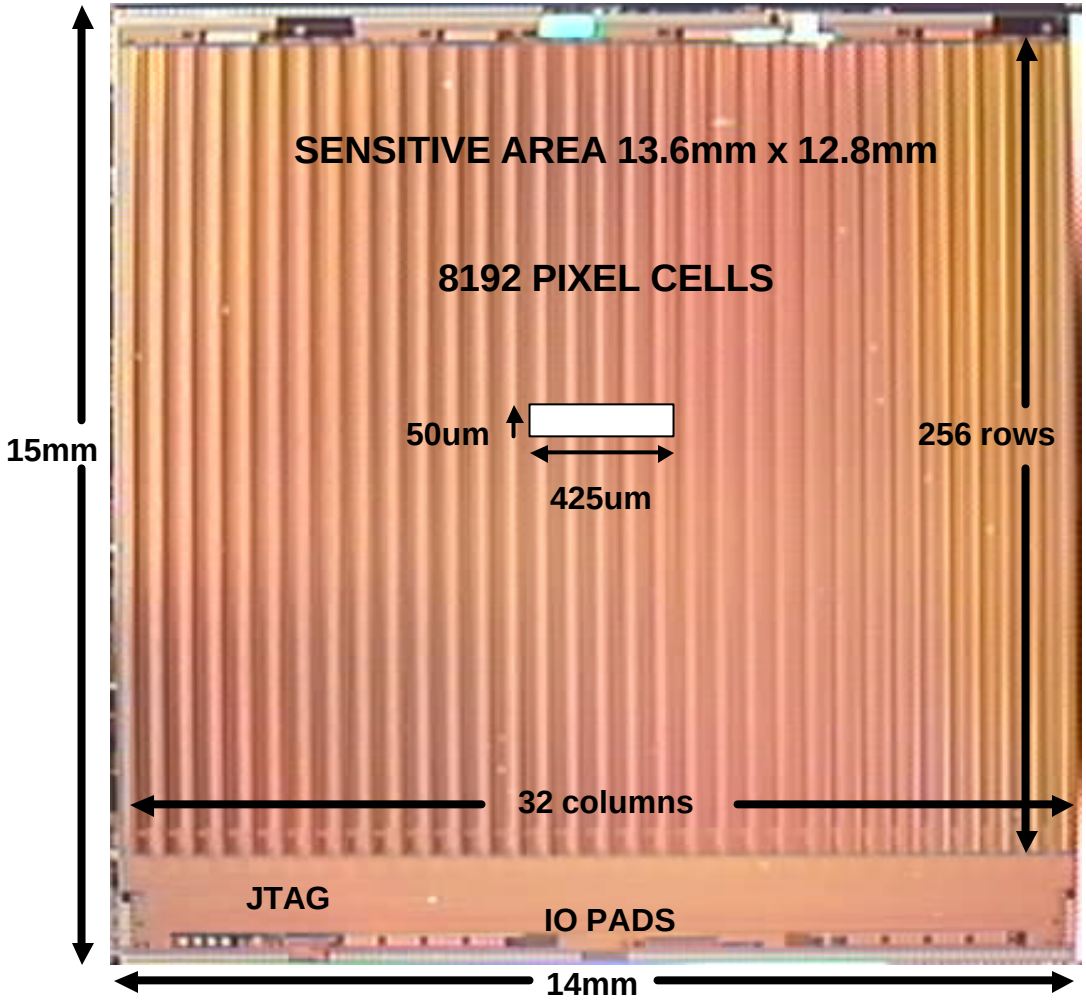
(See talk on Thursday)



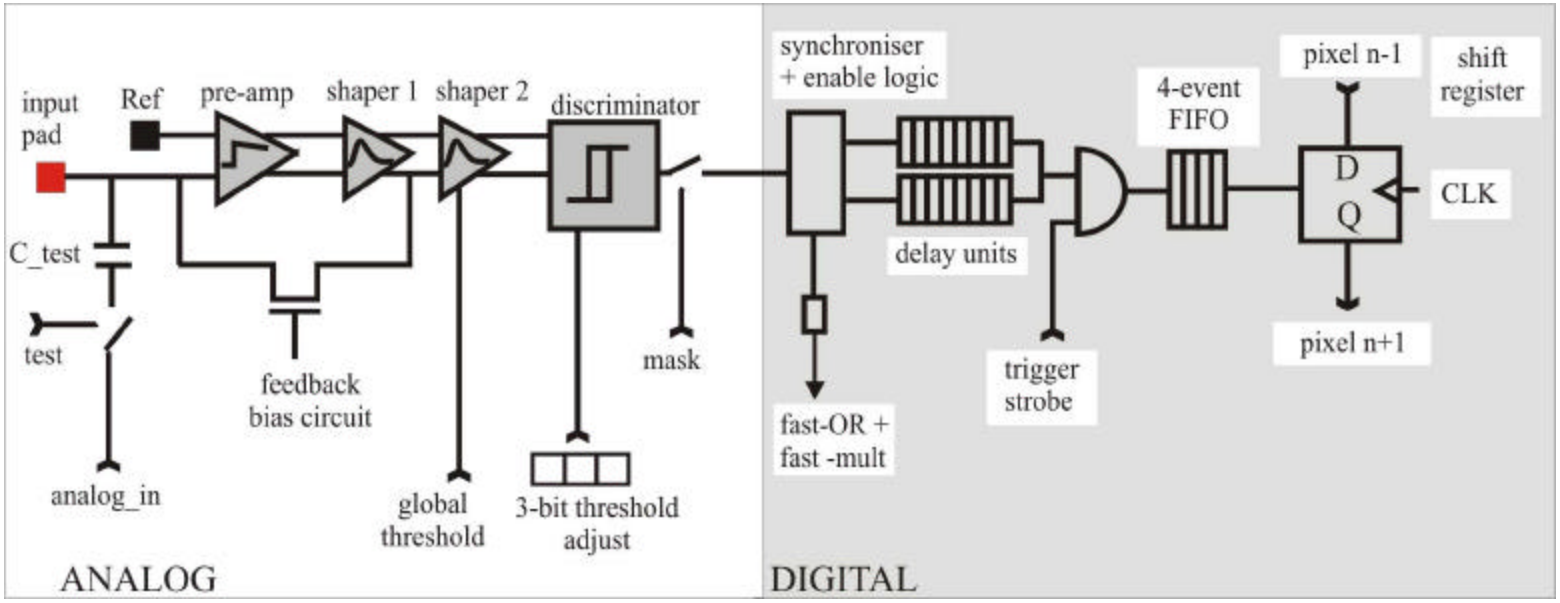
- **5000e⁻ most probable signal (20kV H.T.)**
- **25ns time precision**
- **500μm x 500μm channel size**
- **8% maximum time occupancy**
- **1MHz average Level-0 trigger rate**
- **Buffering of Level-0 triggered events**
- **40MHz readout clock**

ALICE1LHCB General Chip Description

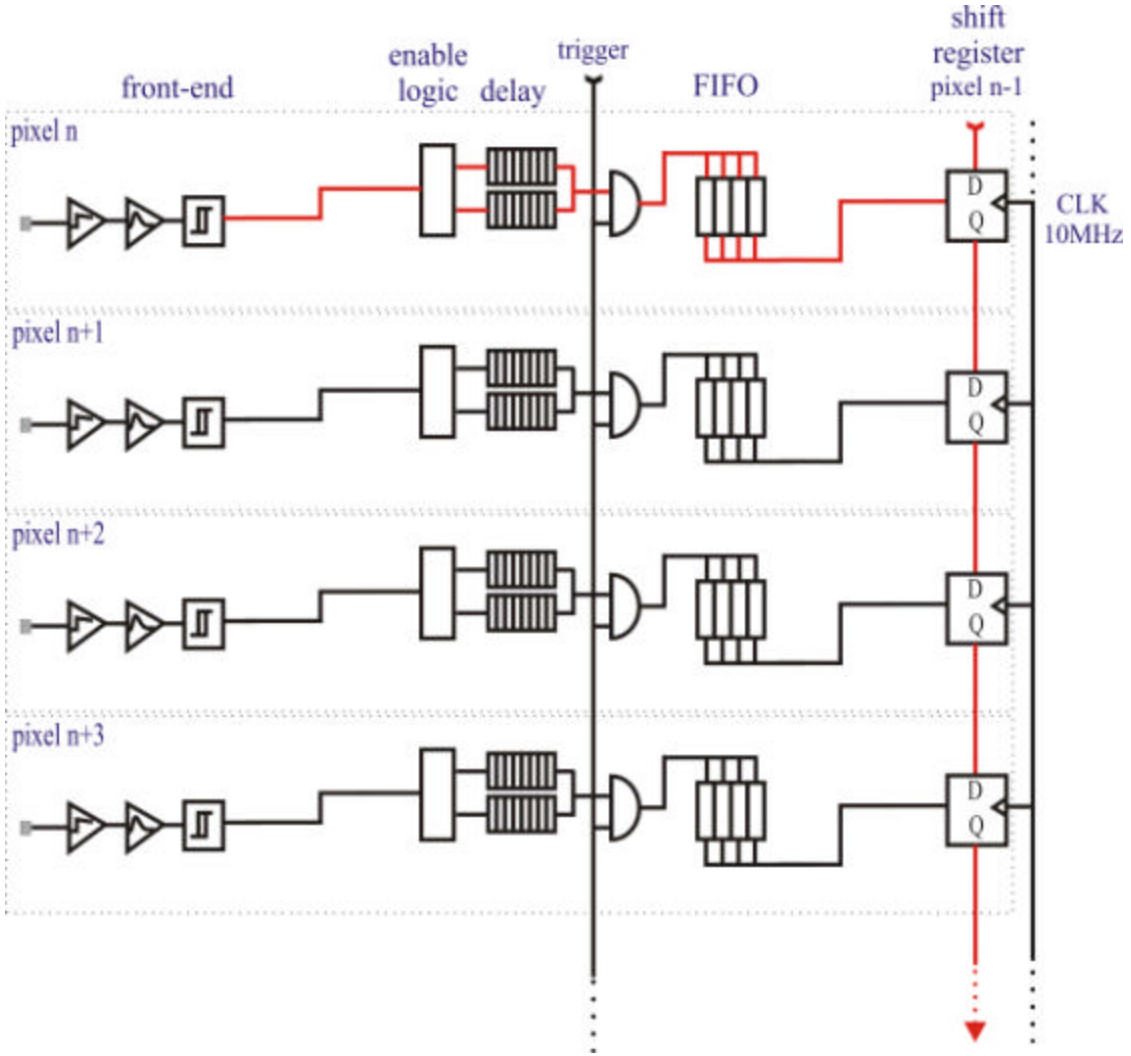
- Commercial 0.25㎜m CMOS process
- 6 metal layers
- Radiation-tolerant layout
  - Total dose
  - SEU
- 13 million transistors
- 800mW total power
- Current-starved logic
- Internal bias DACs
- Configurable via JTAG



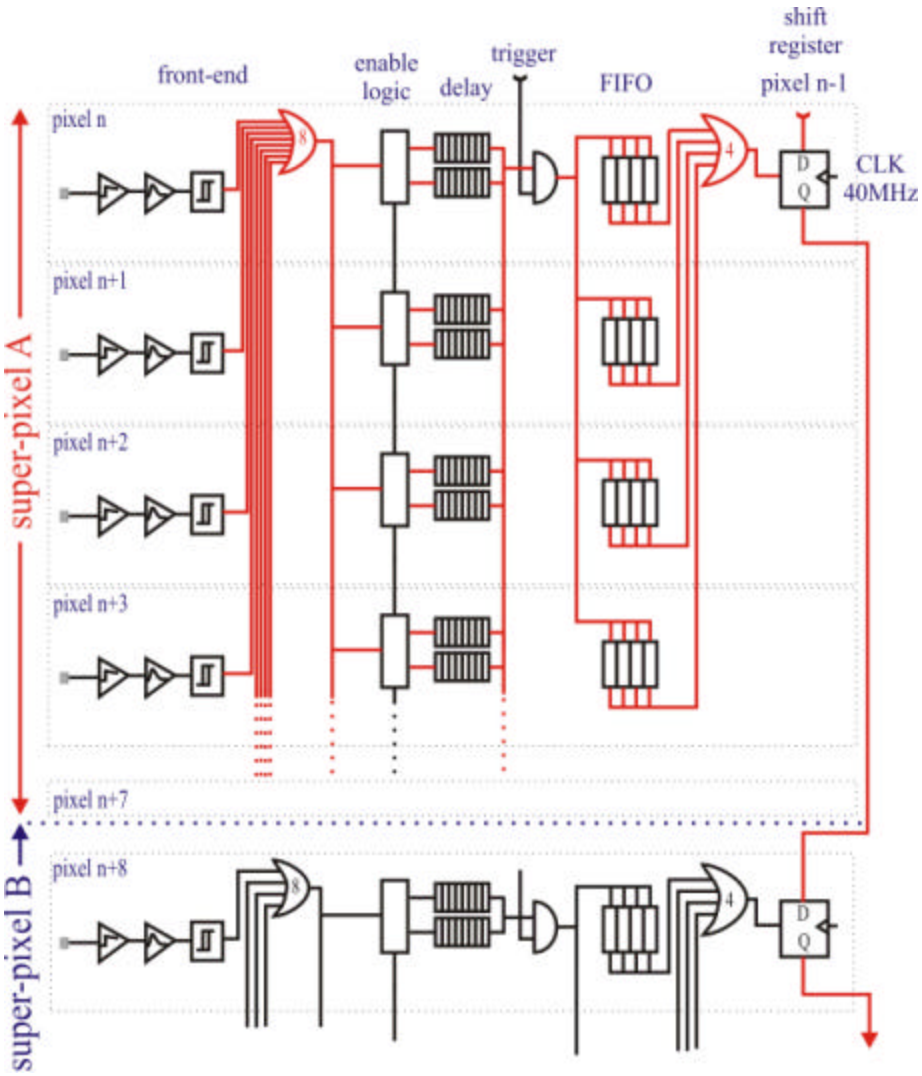
Pixel Cell Description



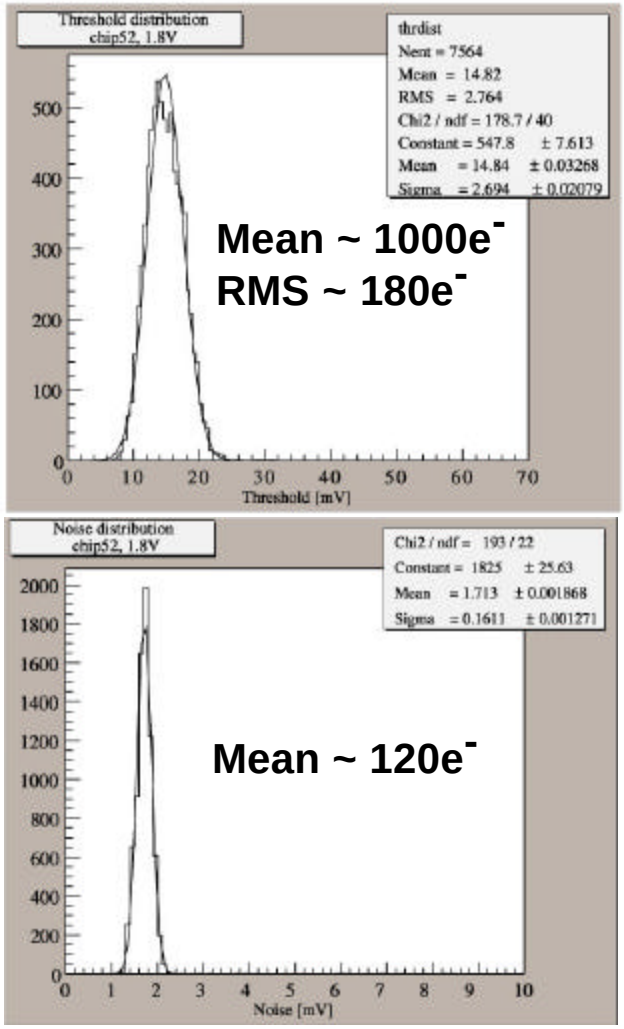
Two modes: ALICE mode



Two modes: LHCb mode



ALICE1LHCB results 1



- Front-end performance good ☺
  - Minimum threshold ~ 1000 e^-
    RMS ~ 180e^- (no adjust)
  - Noise ~ 120e^-
- Radiation-tolerance OK ☺
  - Total dose > 10Mrad
  - SEU threshold > 6.3 MeVmg^{-1} cm^2

⇒ OK for ALICE & LHCb

ALICE1LHCB results 2

- **Digital performance – full functionality**
  BUT limited to ~ 15MHz maximum clock frequency
    OK for ALICE ☺
    Not OK for LHCB ☹

  Biggest problem:
  Power supply drops within chip due to
  - **mechanical constraints,**
  - **limits on metal layer coverage**

- **Calibration pulse poorly distributed**

LHCBPIX1: the sequel

Schematically similar to ALICE1LHCB

Relaxed mechanical constraints for LHCb:

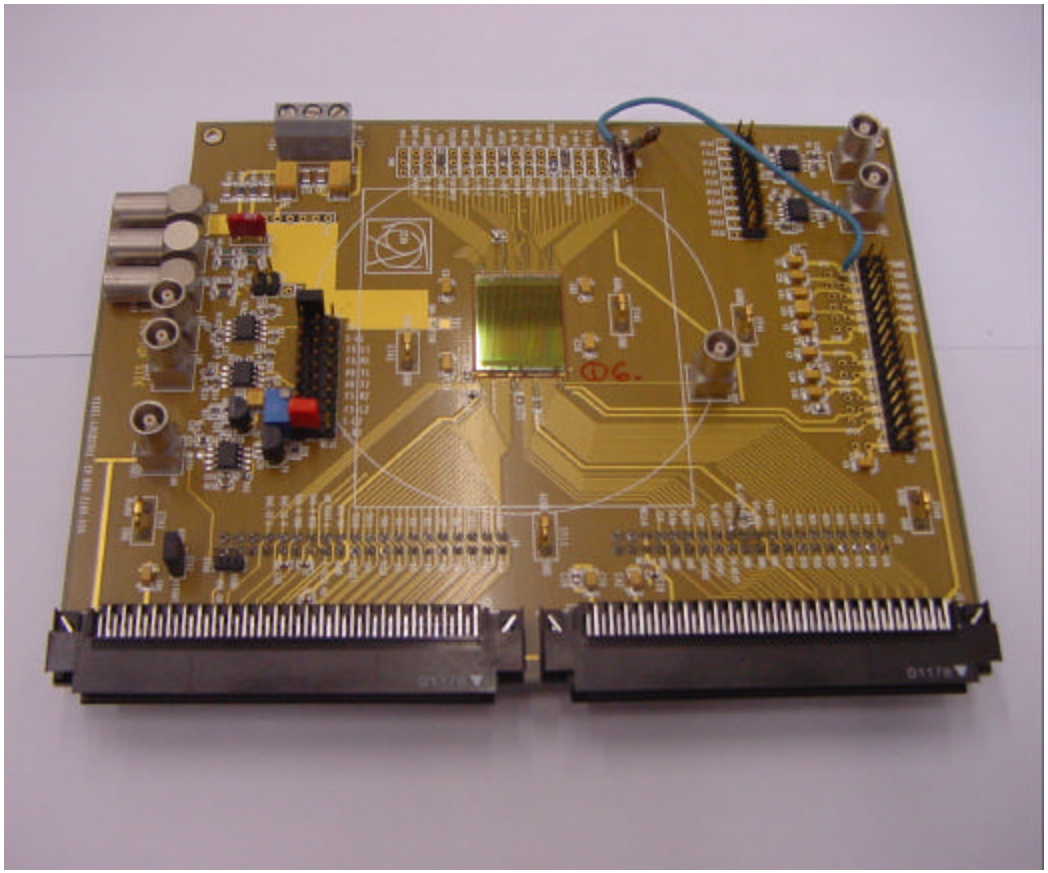
- **Stretch of pixels: 62.5μm x 500μm (superpixel: 500μm x 500μm)**

  ⇒ **more metal for power & decoupling**

- **Space available above pixel matrix**

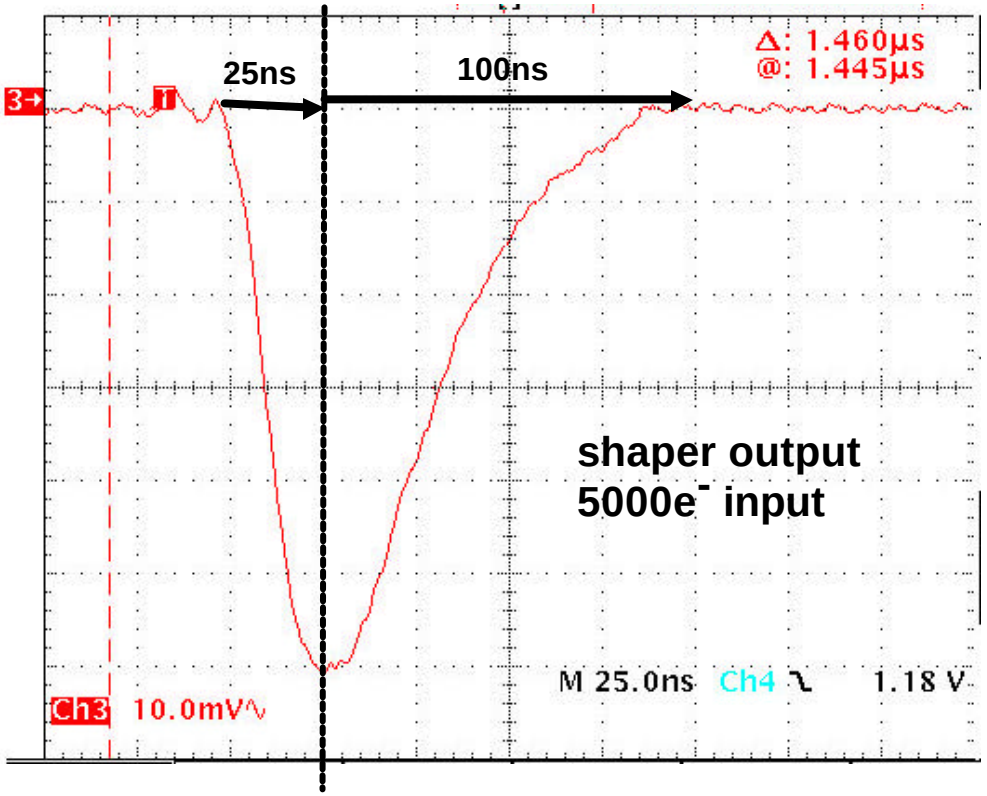
  ⇒ **power pads & routing, calibration pulse distribution**

Chip is BIG! 16mm x 21mm

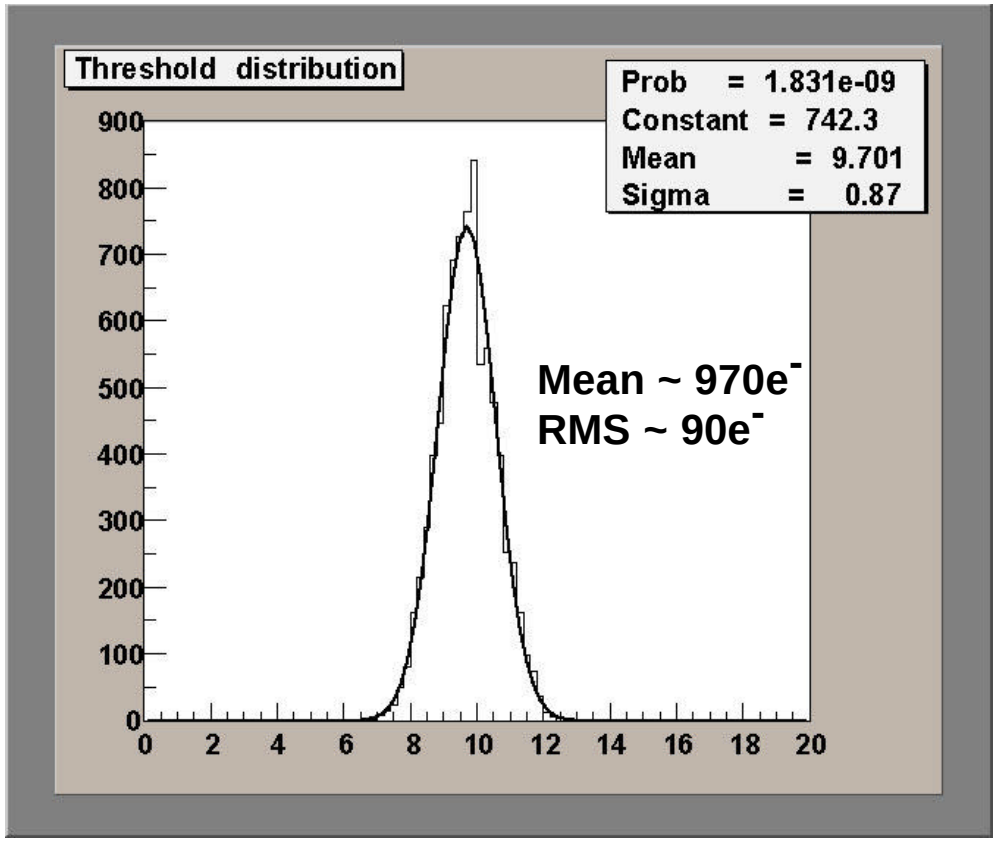


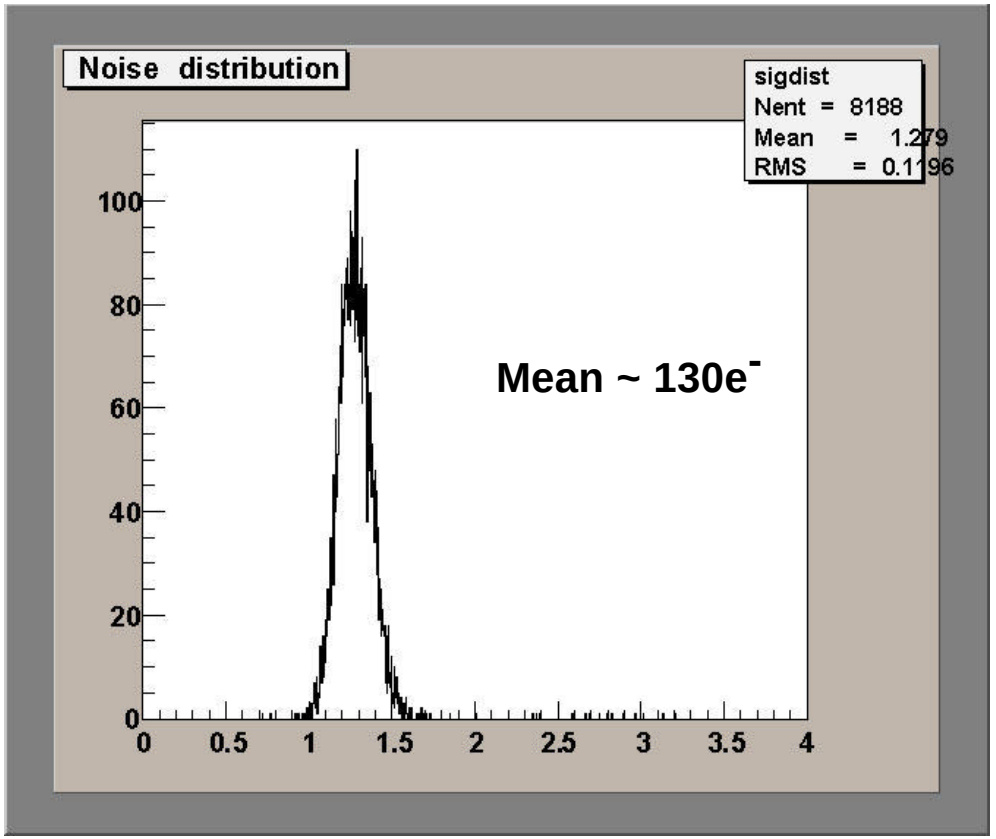
LHCBPIX1: results 1

- Operation @ 40MHz clock freq ☺
- Power consumption = 1.7W @ 40MHz
- Analog front-end performance good ☺



LHCBPIX1: results 2



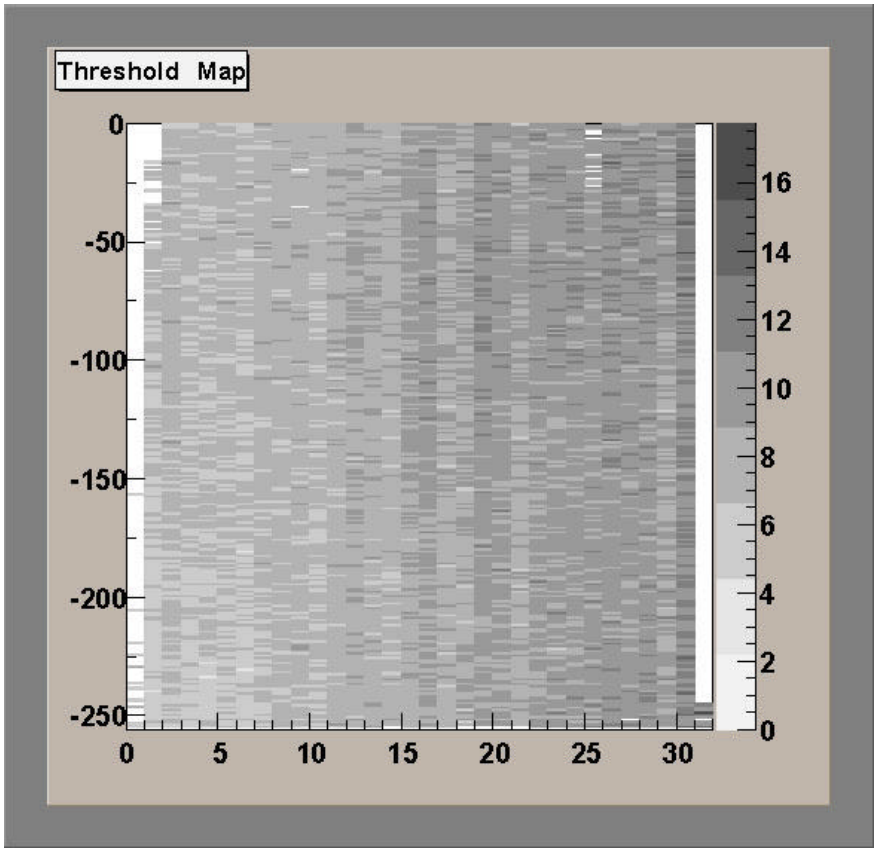


(Without individual threshold adjustment)

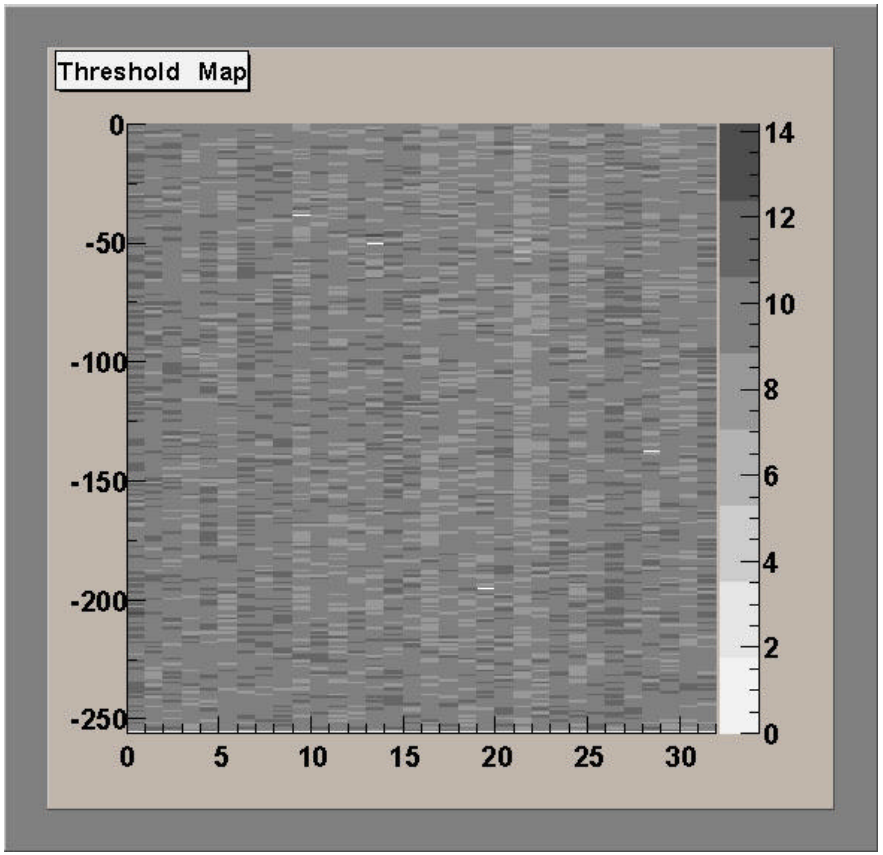
LHCBPIX1: results 3

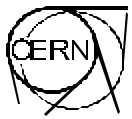
- Calibration pulse uniform ☺ – makes life easier!

ALICE1LHCB



LHCBPIX1





Conclusion and Future Plans

- Architecture to meet requirements of ALICE and LHCb
- Version 1 (ALICE1LHCB):
  - Analog performance good
  - Digital limited in clock frequency
- Bugs diagnosed (problems of a BIG chip)
- Version 2 (LHCPIX1) satisfies LHCb specs

- ALICE1LHCB:
  - continuing tests of ALICE prototype modules
  - ALICE plans to use this chip
  - encapsulation in prototype HPDs
- LHCBPIX1:
  - Bump-bonding planned for start 2003
  - Encapsulation in HPD in spring 2003
- Production runs for ALICE and LHCb