

Final Sensors for EUDET Telescope: Progress Report

Evolution since June '07

Marc Winter

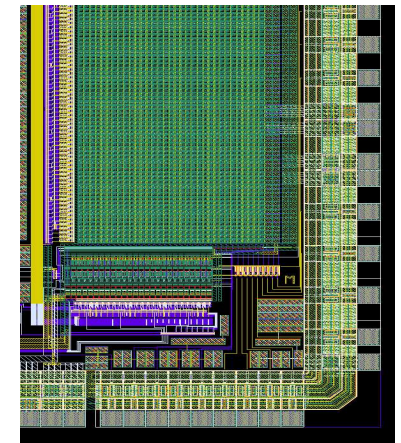
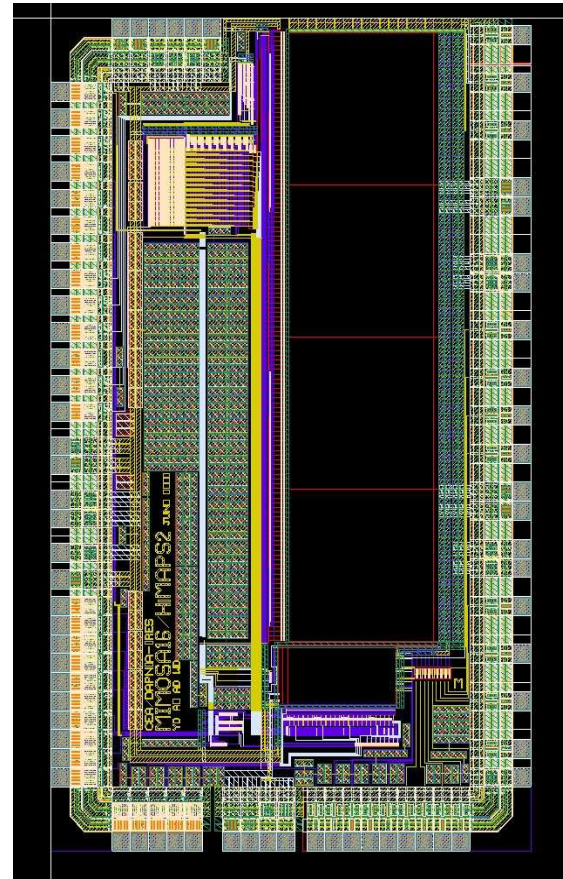
on behalf of DAPNIA-Saclay & IPHC-Strasbourg

OUTLINE

- MIMOSA-16: preliminary test results of data collected at CERN-SPS
- MIMOSA-22: status of design
- Ø micro-circuit : status of 1st prototype fabrication
- Towards the final sensor
- Summary

MIMOSA-16 design features :

- AMS-0.35 OPTO translation of MIMOSA-8
 - ↳ $\sim 11\text{--}15 \mu\text{m}$ epitaxy instead of $\lesssim 7 \mu\text{m}$
- 32 // columns of 128 pixels (pitch: $25 \mu\text{m}$)
- on-pixel CDS (DS at end of each column)
- 24 columns ended with discriminator
- 4 sub-arrays :
 - S1** : like MIMOSA-8 ($1.7 \times 1.7 \mu\text{m}^2$ diode)
 - S2** : like MIMOSA-8 ($2.4 \times 2.4 \mu\text{m}^2$ diode)
 - S3** : S2 with ionising radiation tol. pixels
 - S4** : with enhanced in-pixel amplification
(against noise of read-out chain)



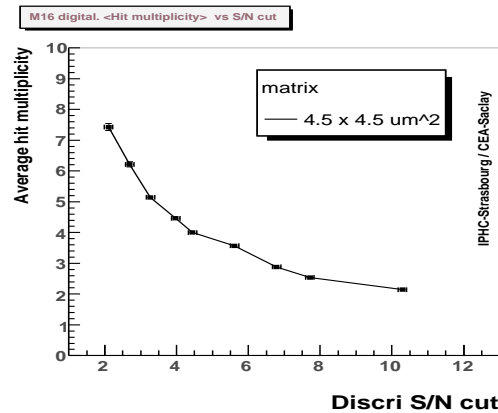
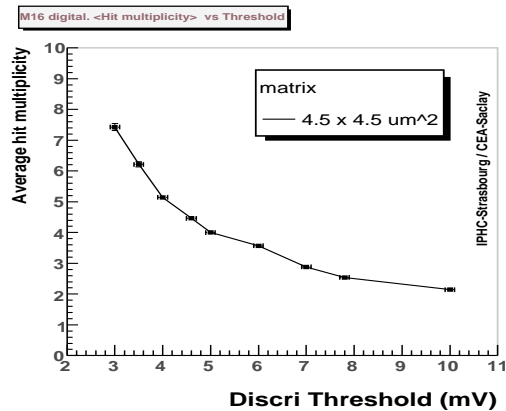
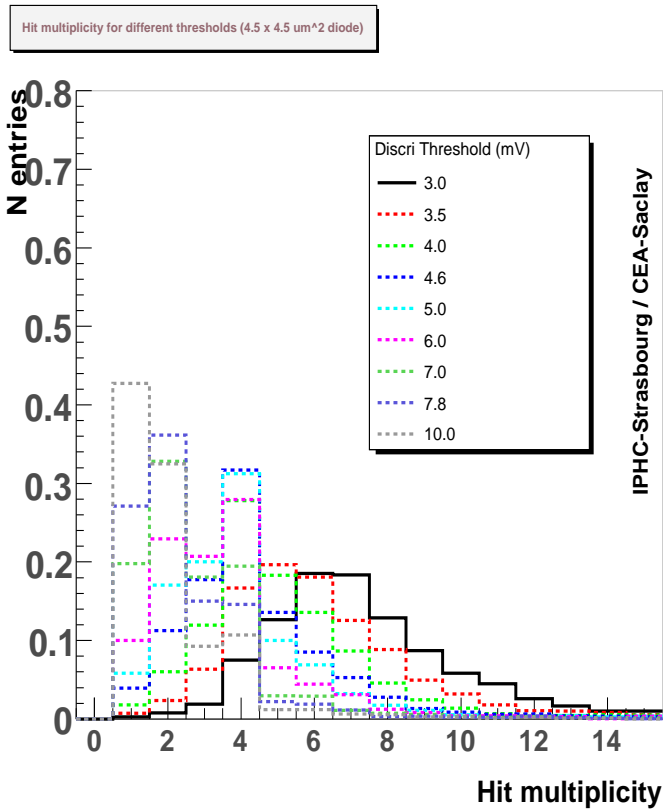
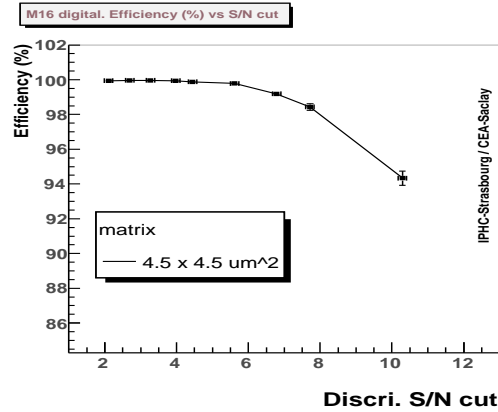
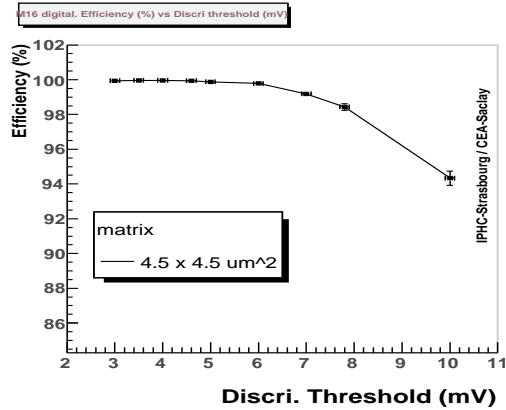
Preliminary tests of analog part ("20" & "14" μm epitaxy) performed in Saclay (shown previously):

- sensors illuminated with ^{55}Fe source and $F_{r.o.}$ varied up to $\gtrsim 150 \text{ MHz}$
- measurements of $N(\text{pixel})$, FPN (end of column), pedestal variation, CCE (3×3 pixel clusters) vs $F_{r.o.}$

Since last JRA-1 coll. meeting: m.i.p. detection with Si-stip telescope tested at CERN in Sept. '07

- CERN-SPS: T4 - H6 (180 GeV " π^- ")
- 1 week of run early Septembre with MIMOSA-16 chips mounted on Si-strip telescope
- Read-out time: 51 μs (20 MHz for each group of 8 columns))
- 6 individual sensors tested:
 - 3 MIMOSA-16 with "14" μm epitaxy thickness
 - 1 MIMOSA-16 with "20" μm epitaxy thickness
 - 2 MIMOSA-16bis with "14" μm epitaxy thickness
- Data still being analysed \rightarrow results shown are VERY preliminary

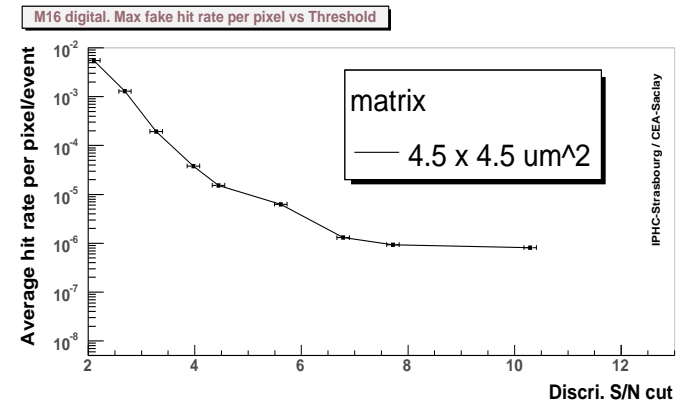
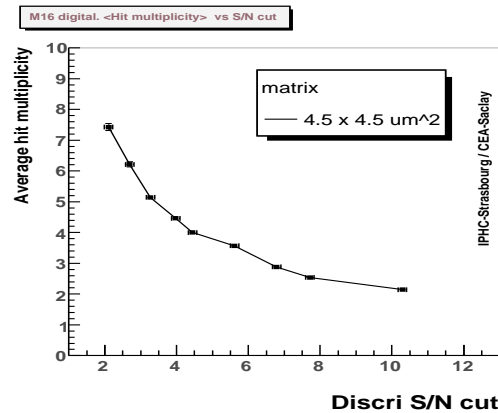
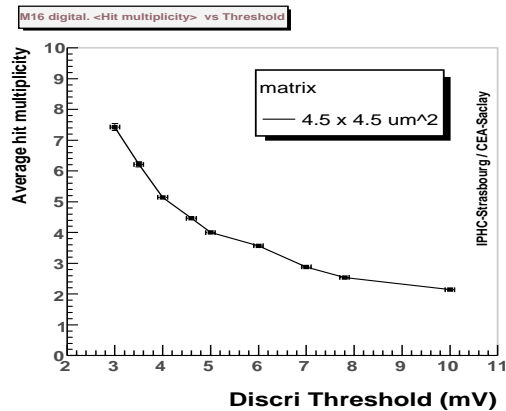
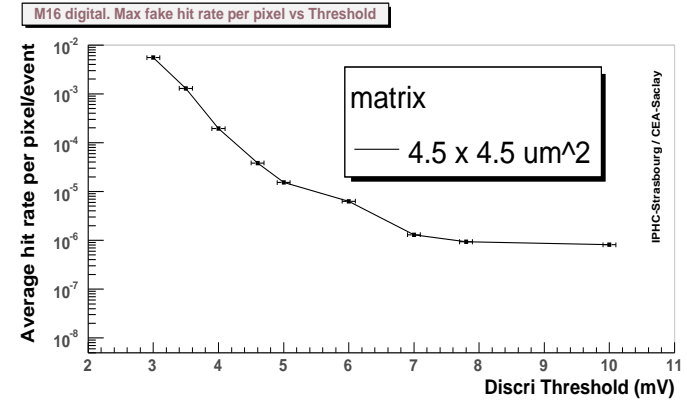
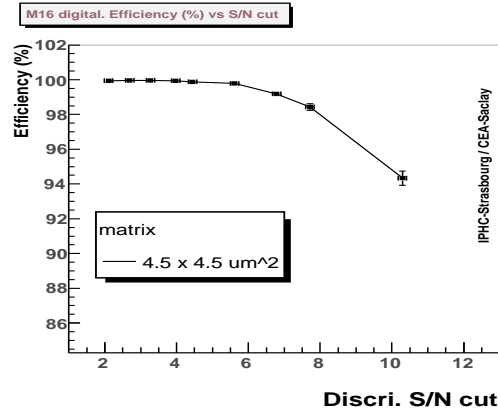
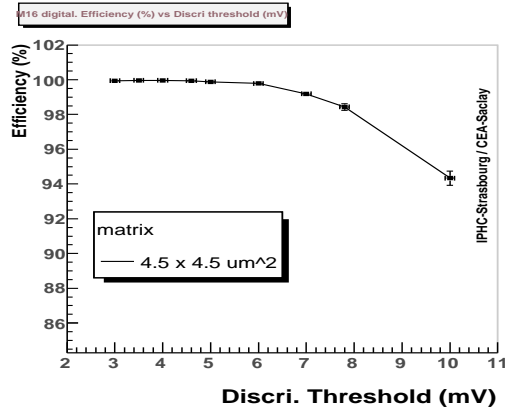
■ Preliminary analysis results of data collected with sub-array S4 (epi-14) \rightarrow SNR ~ 16



■ Detection efficiency (includes contributions from single pixel clusters):

- ▷ **Discr. threshold:** * 4 mV $\rightarrow \epsilon_{det} = 99.96 \pm 0.03$ (stat) * 6 mV $\rightarrow \epsilon_{det} = 99.88 \pm 0.05$ (stat)
- ▷ **Discr. threshold:** * 4 mV $\rightarrow \lesssim 2$ % of clusters with 1 pixel * 6 mV $\rightarrow \sim 10$ % of clusters with 1 pixel

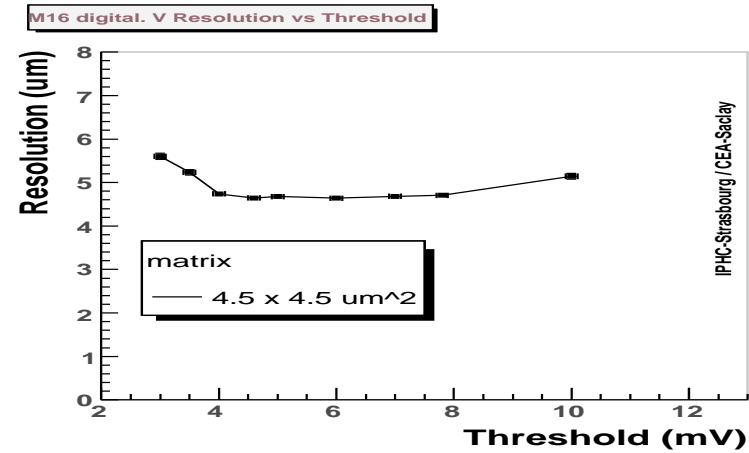
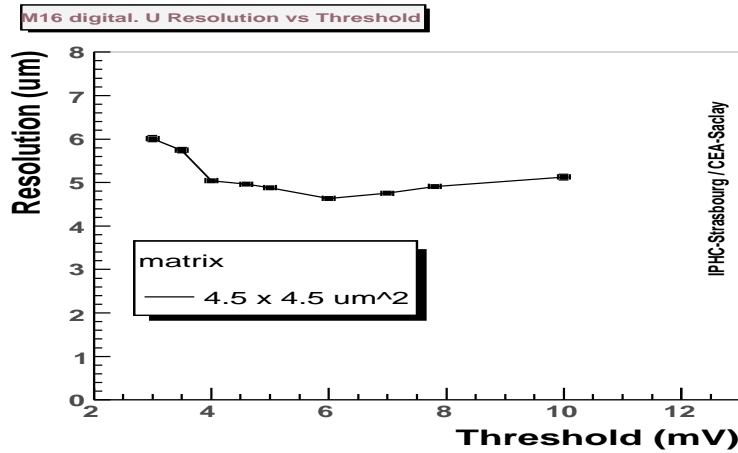
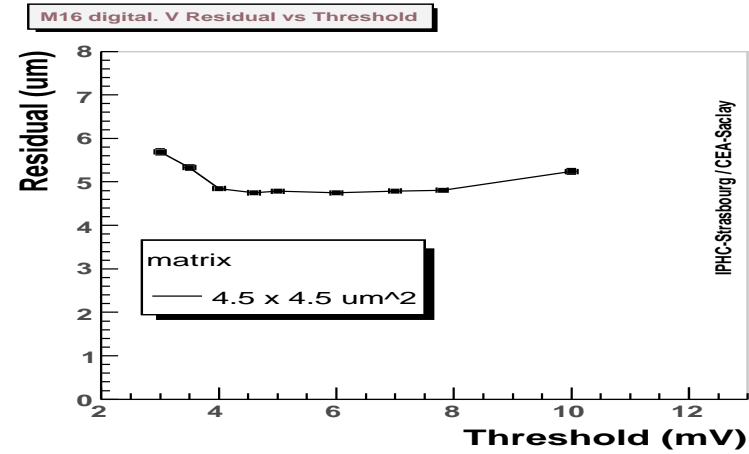
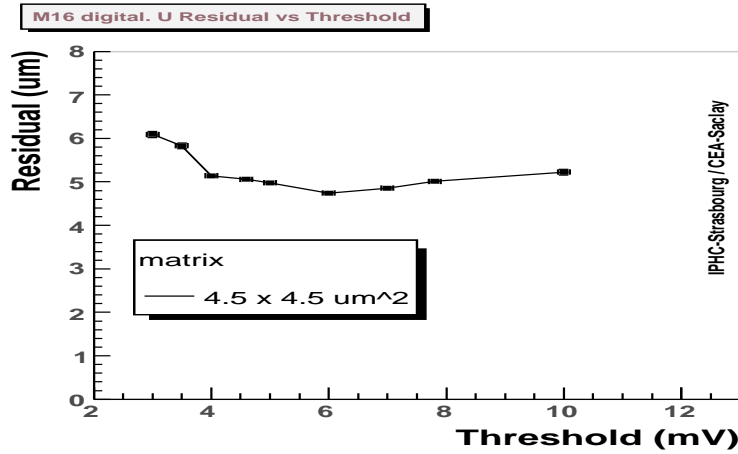
■ Preliminary analysis results of data collected with sub-array S4 (epi-14) \rightarrow SNR ~ 16



■ Fake hit rate (dominated by contributions from single pixel clusters):

▷ Discr. threshold: * 4 mV \rightarrow fake rate $\sim 2 \cdot 10^{-4}$ * 6 mV \rightarrow fake rate $< 10^{-5}$

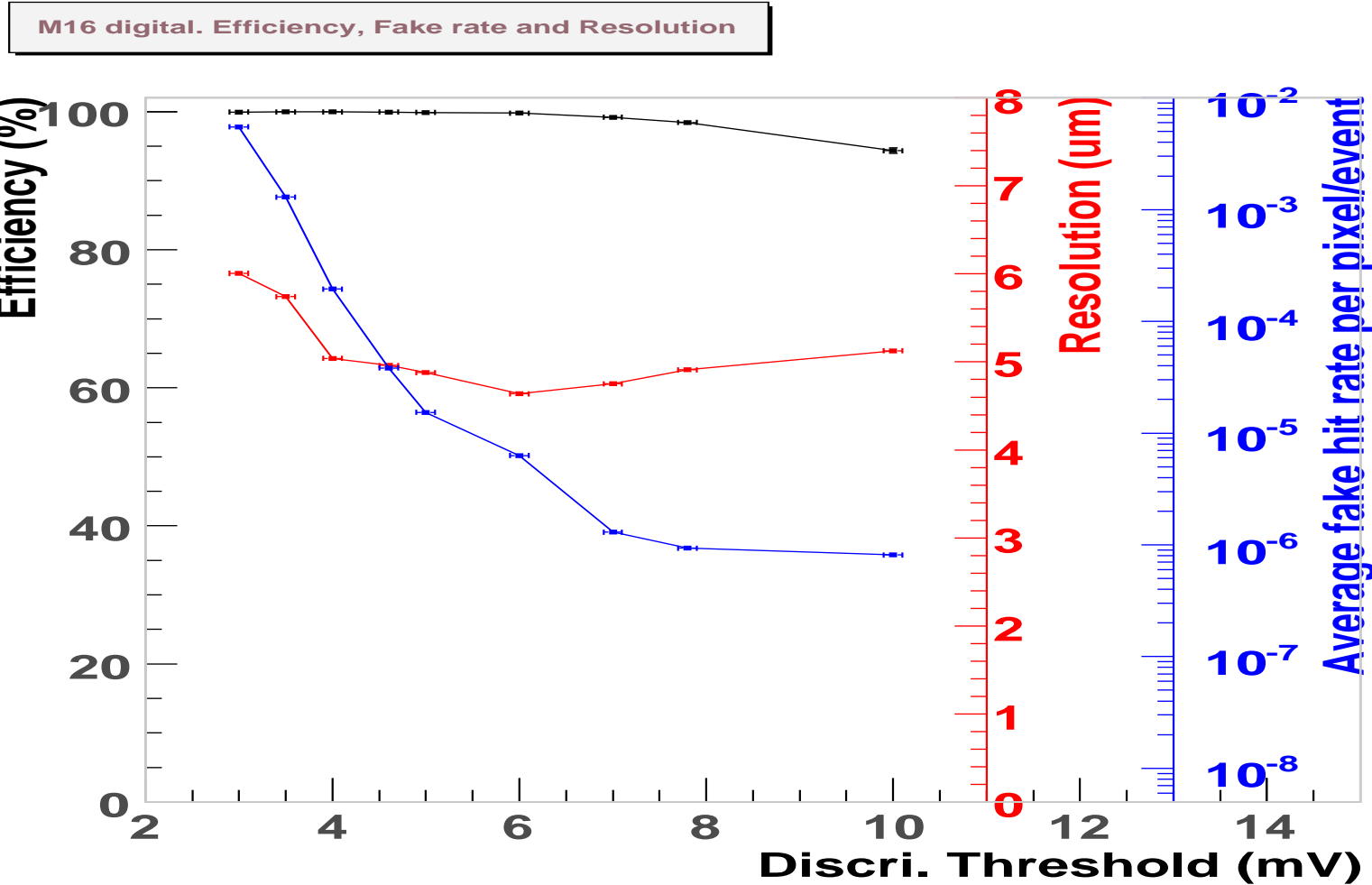
■ Preliminary analysis results of data collected with S4 sub-array (epi-14)



■ Single point resolution is well below the binary resolution reflecting the $25 \mu m$ pitch ($7.2 \mu m$) :

▷ Discr. threshold: $\ast 4 \text{ mV} \rightarrow \sigma_{sp} \sim 4.8\text{--}5.0 \mu m$ $\ast 6 \text{ mV} \rightarrow \sigma_{sp} \sim 4.6 \mu m$

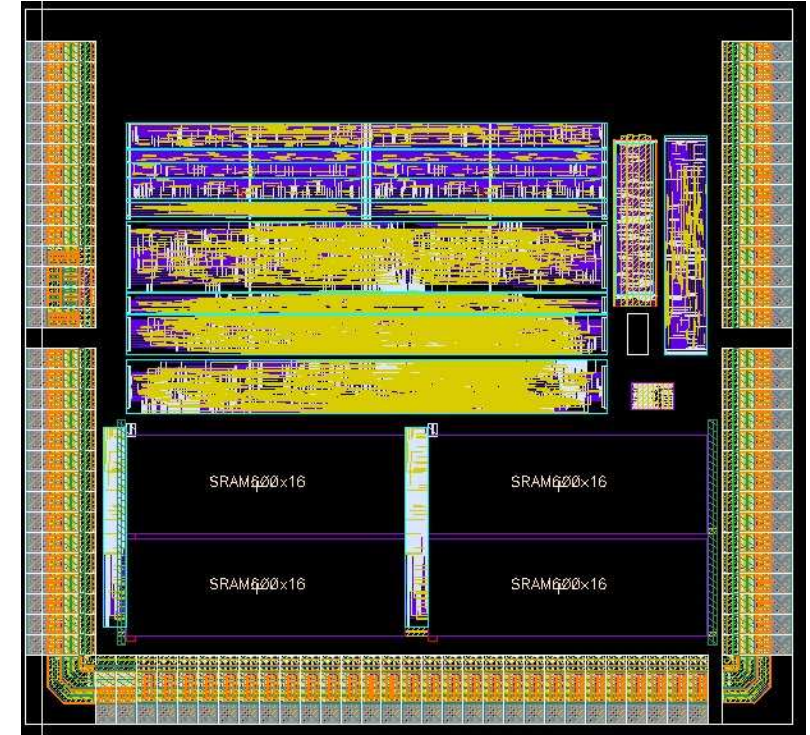
Summary of results obtained with S4 sub-array (epi-14) :



Main outcome of the tests: At least one pixel ⊕ discr. architecture validated for the final sensor

■ 1st chip (SUZE-01) with integrated \emptyset and output memories (no pixels) :

- ✳ 2 step, line by line, logic :
 - ◇ step-1 (inside blocks of 64 columns) :
 - identify up to 6 series of ≤ 4 neighbour pixels per line delivering signal $>$ discriminator threshold
 - ◇ step-2 : read-out outcome of step-1 in all blocks and keep up to 9 series of ≤ 4 neighbour pixels
- ✳ 4 output memories (512x16 bits) taken from AMS I.P. library
- ✳ surface $\sim (3.9 + 0.24) \times (3.6 + 0.24) \text{ mm}^2$
 - $\rightarrow \sim 10.3 \text{ keuros (EUDET budget)}$



■ Status :

- ✳ sent for fabrication end of July
- ✳ back from foundry end of Sept. \rightarrow tests are still getting prepared \Rightarrow test completion expected by end of year

■ MIMOSA-16 tests at the SPS \rightarrow **very preliminary analysis results:**

- ✧ *The column architecture works very well*
- ✧ *There is at least one pixel architecture which works fine (SNR \sim 16, $\epsilon \sim$ 99.9 %) \rightarrow Complementary info expected from the analysis of the other pixel architectures*

■ MIMOSA-22:

- ✧ *Has become final prototype \rightarrow more features and surface than foreseen originally*
- ✧ *Design well advanced, based on M-16 pixel and column architectures (still some technical difficulties ...) \rightarrow submission to foundry by end of this month !*
- ✧ *funding (\sim 40 keuros) via EUDET and DAPNIA resources*

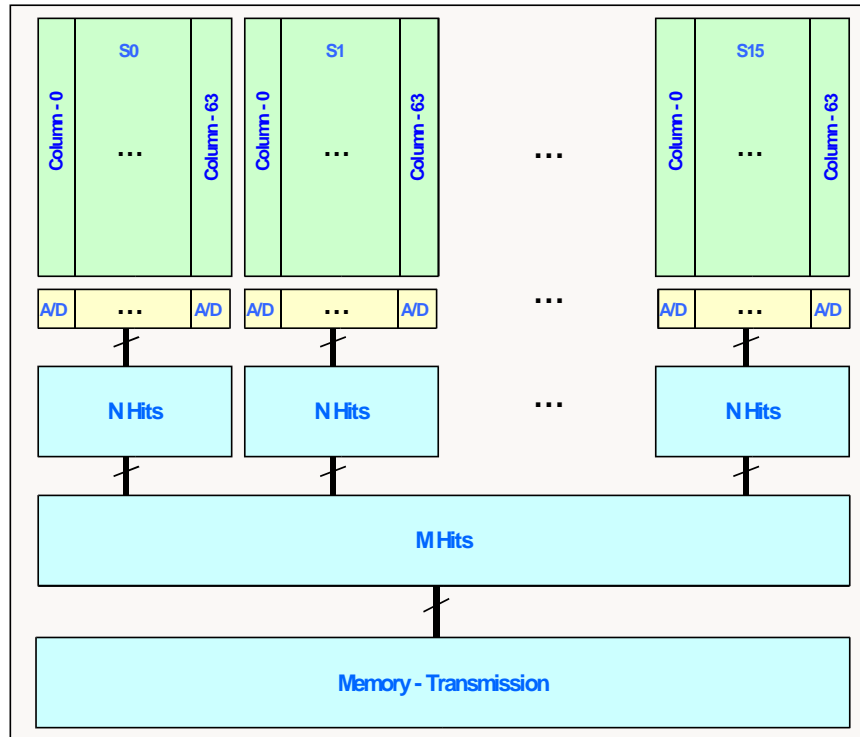
■ \emptyset suppression micro-circuit :

- ✧ *Back from foundry a few days ago*
- ✧ *Tests will start soon \rightarrow completed this year*

■ Final sensor combining MIMOSA-22 architecture and \emptyset micro-circuit : MIMOSA-22+

- ✧ *1088 \times 544/576 pixels (1×2 cm²)*
- ✧ *Design starting early 2008 (?) \rightarrow will integrate feed-back from MIMOSA-22 and SUZE-01 tests*
- ✧ *Expected to be submitted for fabrication in Autumn 2008*
- ✧ *... prepare its commissioning*

Chip readout architecture including digitization and zero suppression



Block diagram of readout architecture

- ▶ Pixel array : 1024x1024 pixels Readout row by row The row is divided into 16 groups
- ▶ Analog to digital conversion at the bottom of each column (Discriminator or ADC)
- ▶ Zero suppression algorithm :
- ▶ Find N Hits for each group
Find M Hits for each row
(With N and M determined by pixel array occupancy rate)
- ▶ Memory wich stores M hits and serial transmission

▶ Submission of a small size fully digital prototype in AMS 0.35 μm in June 2007