Recent work on 3D and pixel detectors at IMB-CNM

- Double-sided 3D at CNM
- Recent 3D fabrication runs
  - Strips
  - Medipix2
  - ATLAS pixels
- Bump bonding at IFAE-CNM

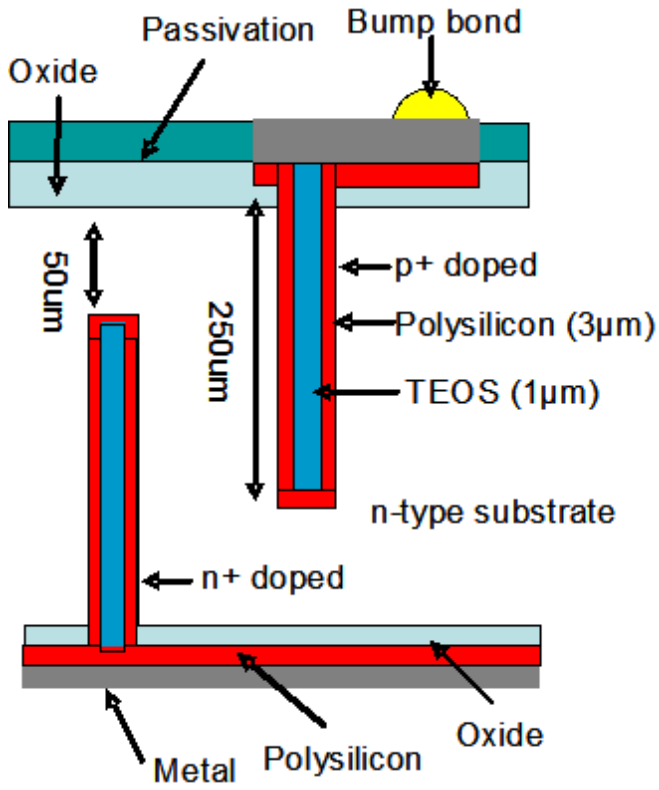
Celeste Fleta , Manuel Lozano, Giulio Pellegrini
(CNM, Barcelona)

Reminder: double-sided 3D at CNM

- Columns etched from opposite sides of substrate and don't pass through full thickness
- All fabrication done in-house

Electrode fabrication:

1. ICP etching of the holes: Bosch process, ALCATEL 601-E
2. Holes partially filled with 3 µm LPCVD poly
3. Doping with P or B
4. Holes passivated with 2 µm TEOS SiO_2



Double-sided 3D, n-type

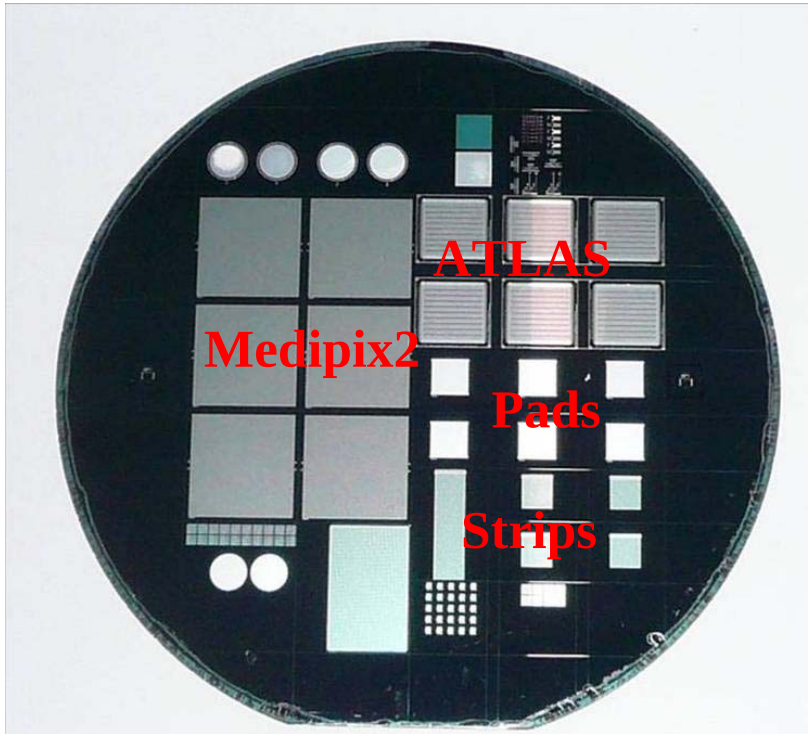
Double-sided 3D fabrication runs

First run (Nov'07): n-type, 2 wafers

- **1 for electrical tests and charge collection with strips, 1 for bump bonding of Medipix**

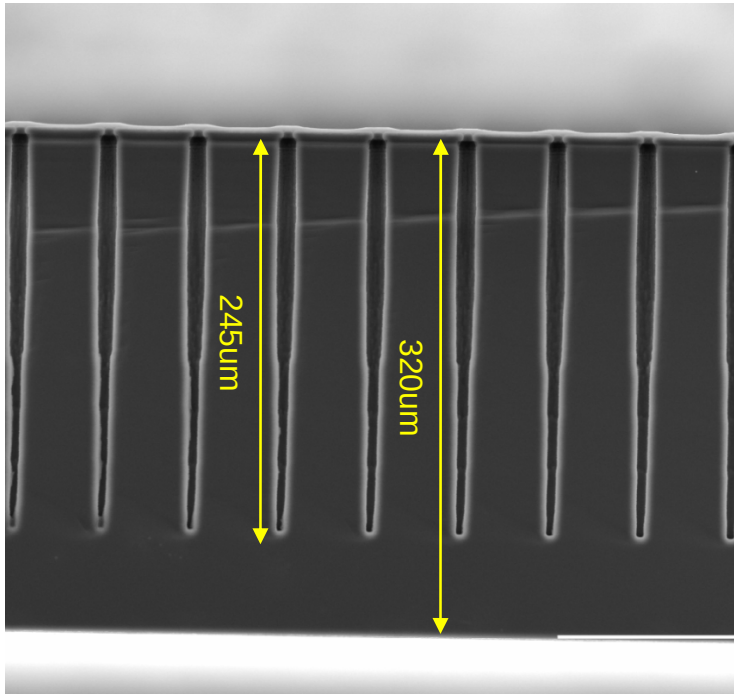
<u>Two new fabrication runs in October 2008</u>:

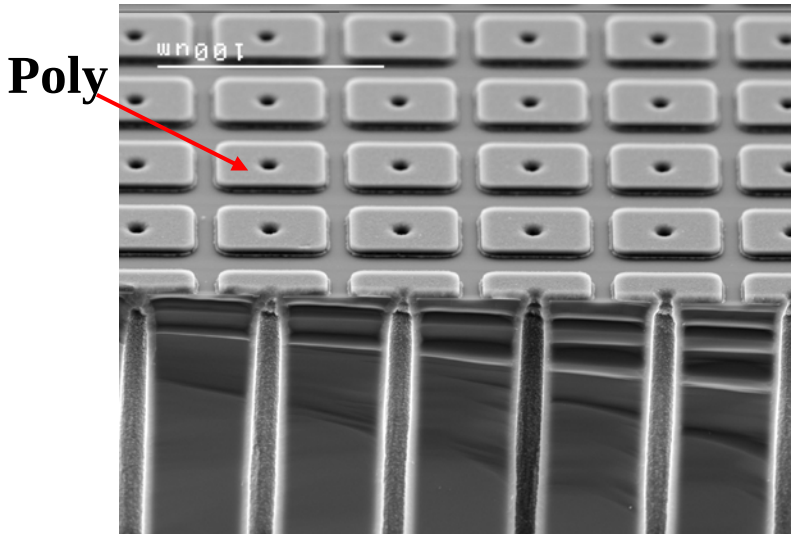
- **8 n-type wafers - two were damaged during the process**
- **8 p-type wafers**
  - **p-stop isolation**
  - **Electron collection -> ATLAS pixels will be usable**



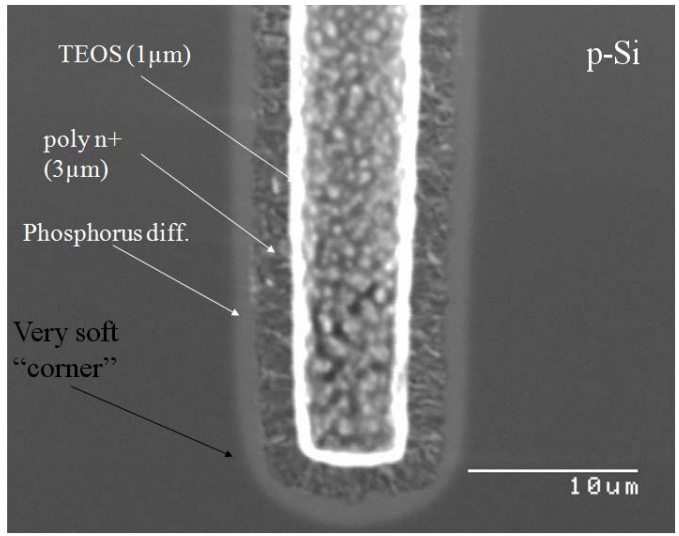
4'' 3D-wafer

3D Electrodes



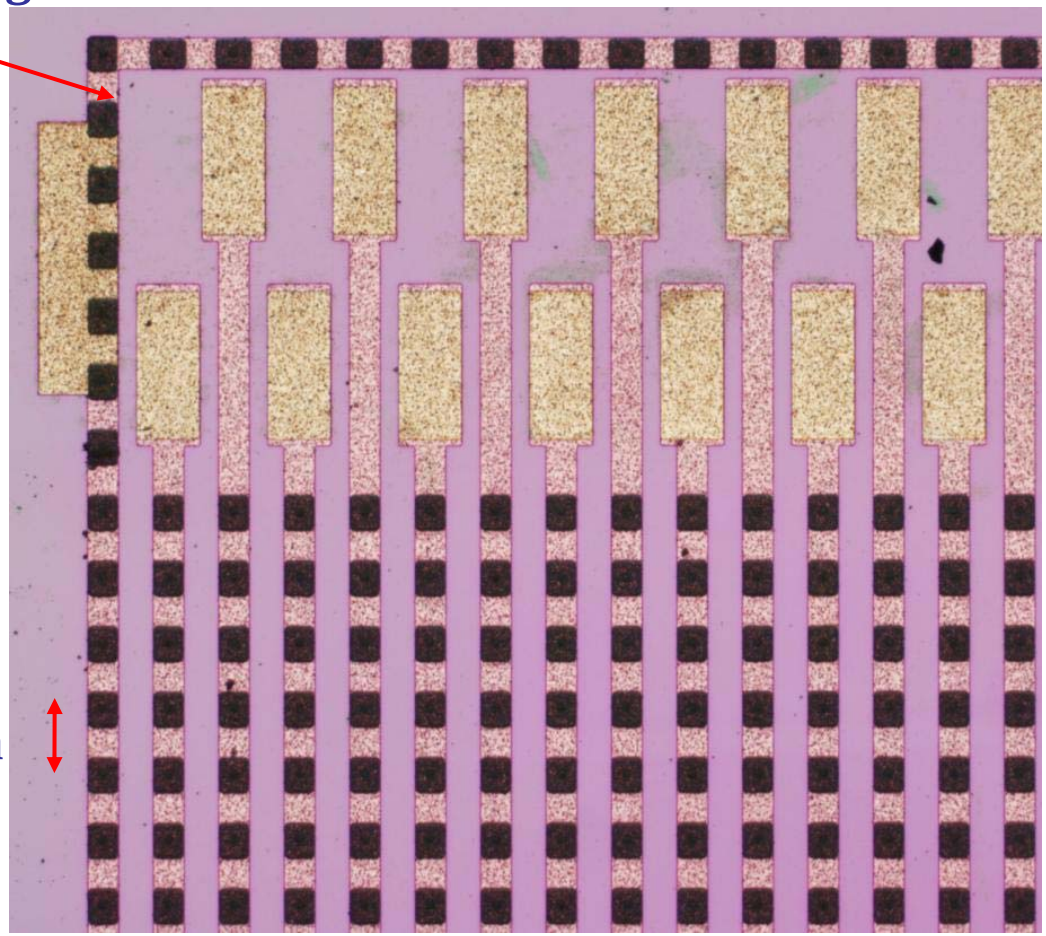


Hole aspect ratio up to 25:1 (columns are 10µm diameter, 250µm deep)



Strip detectors

3D guard ring



80 µm

80 µm

50 strips
DC coupled
50 electrodes/strip

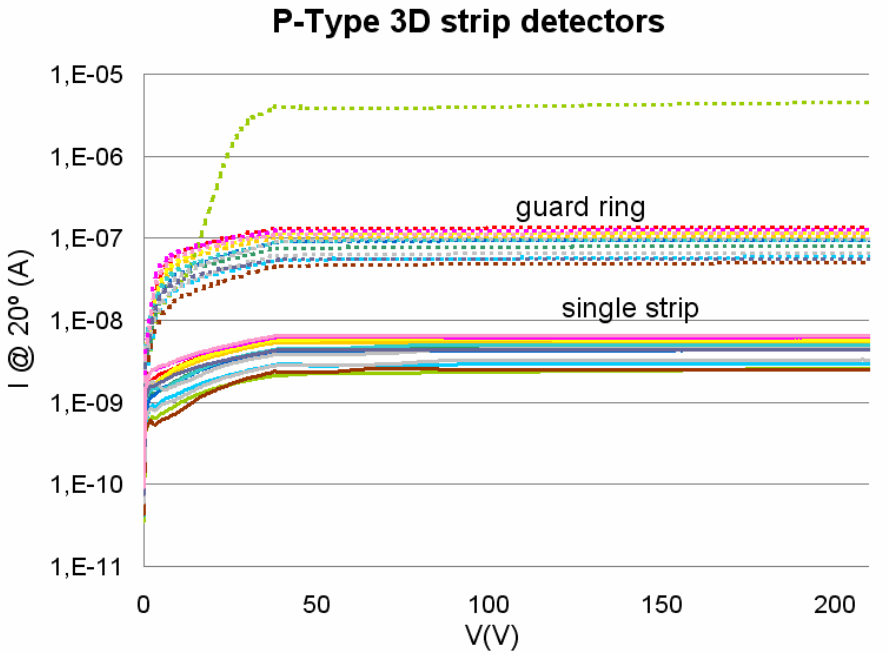
Strip detectors

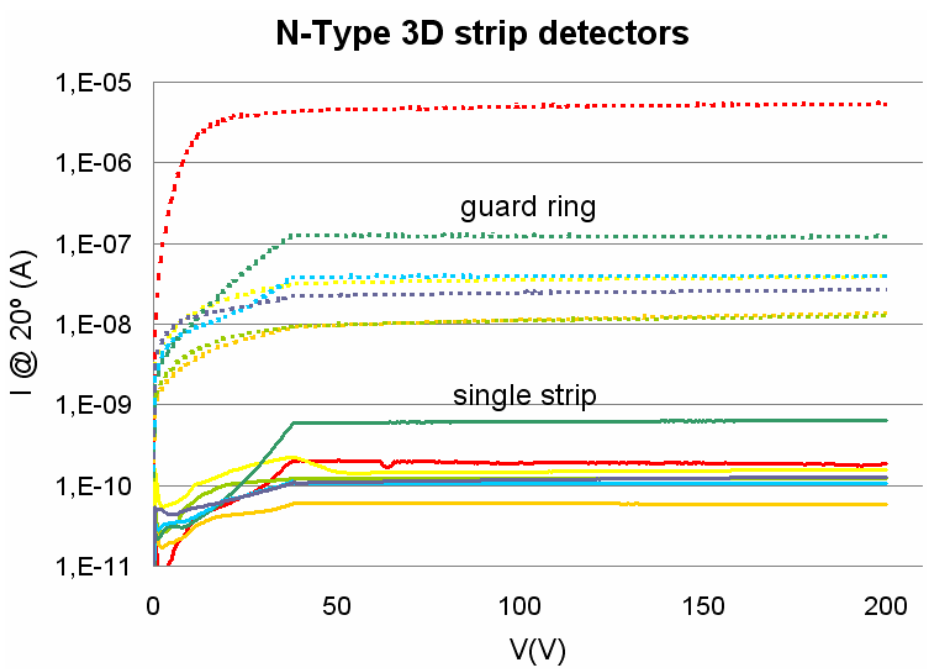
P-type

- VFD ~ 30V
- 2 – 6 nA/strip, very homogeneous between wafers
- Only 2 detectors (of 16 tested) with breakdown < 50V -> 87.5%

N-type

- VFD ~ 10V
- 0.1 – 0.6 nA/strip
- Currents less homogeneous and stable than in the ptype
  - Beneficial effect of p-stops in the ptype sensors or effect of different doping profiles?
- 3 detectors (of 10) with BD < 50V -> 70%





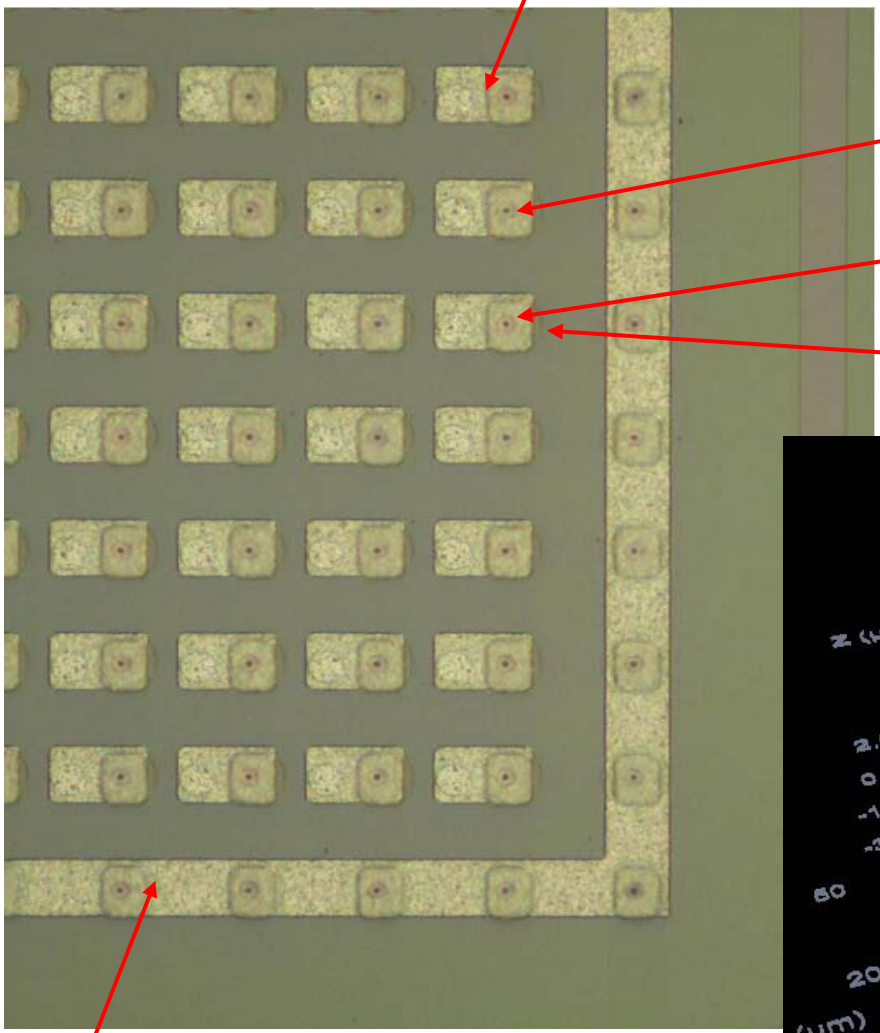
Strip detectors – Status and test plans

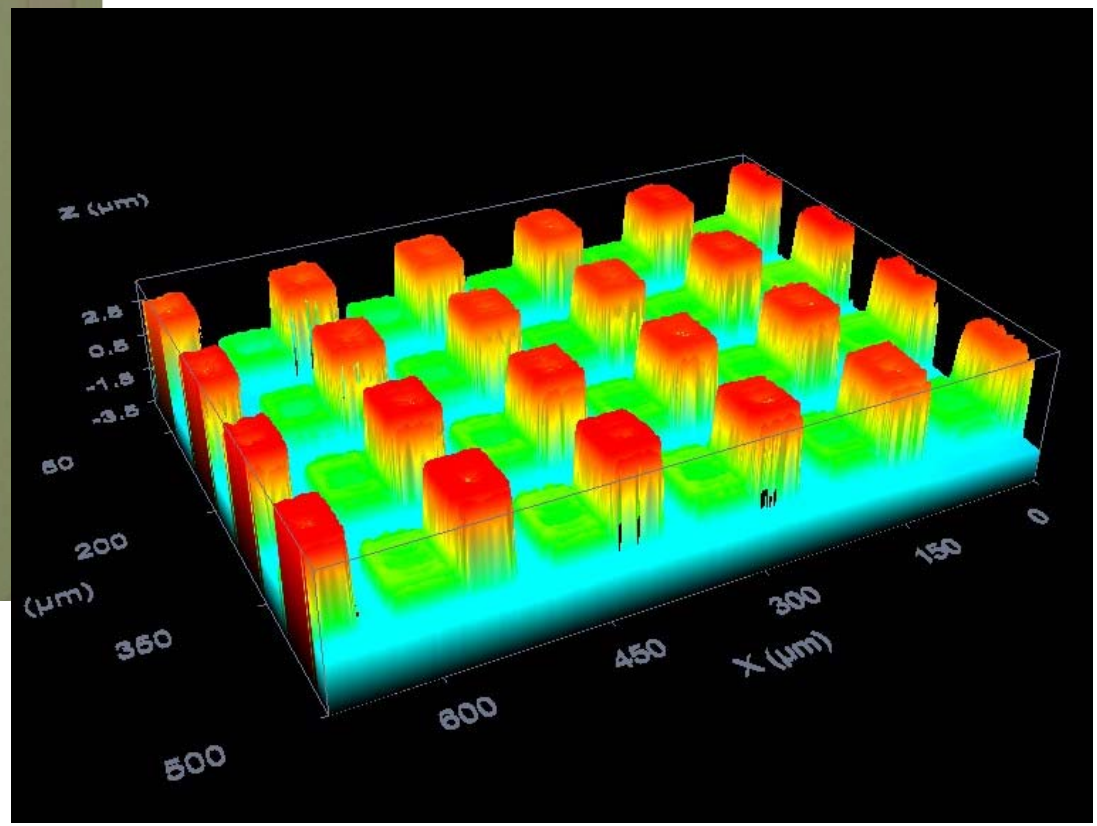
- **A batch of double-sided 3D strip detectors has been irradiated at Karlsruhe with 26 MeV protons.**
  - **Irradiations coordinated by Freiburg - thanks!**
- **Detectors will be distributed and tested with Alibava systems in Glasgow, Freiburg, CNM.**
  - **Aim for standardisation of measurements**

Fluence (n_{eq}/cm^2)	# P devices	# N devices
5E14	2	0
1E15	2	0
2E15	2	2
5E15	2	0 (+2*)
1E16	2	2
2E16	2	2

(* first run)

Medipix2

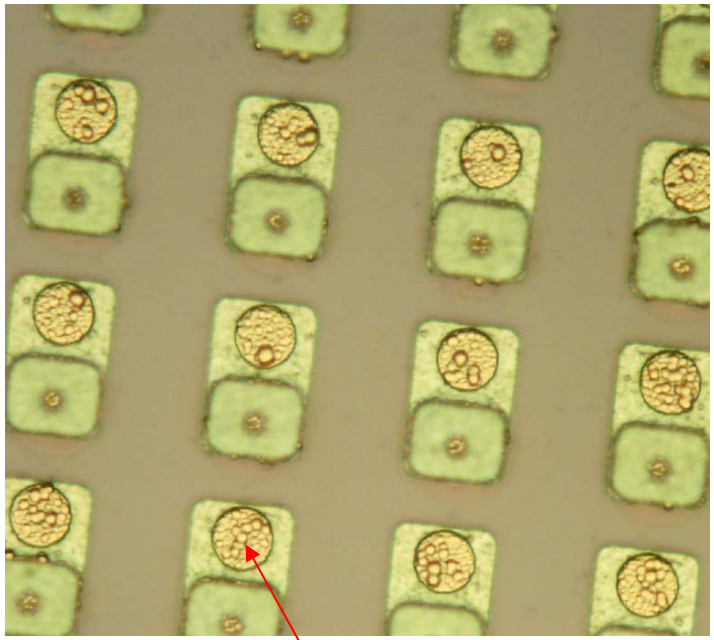

Al
N-hole (collecting electrode)
Polysilicon
Individual pstop around each column
3D guard ring


Z (µm)
2.5
0.5
-1.5
-3.5
50
200
(µm)
350
500
600
450
300
150
0
X (µm)

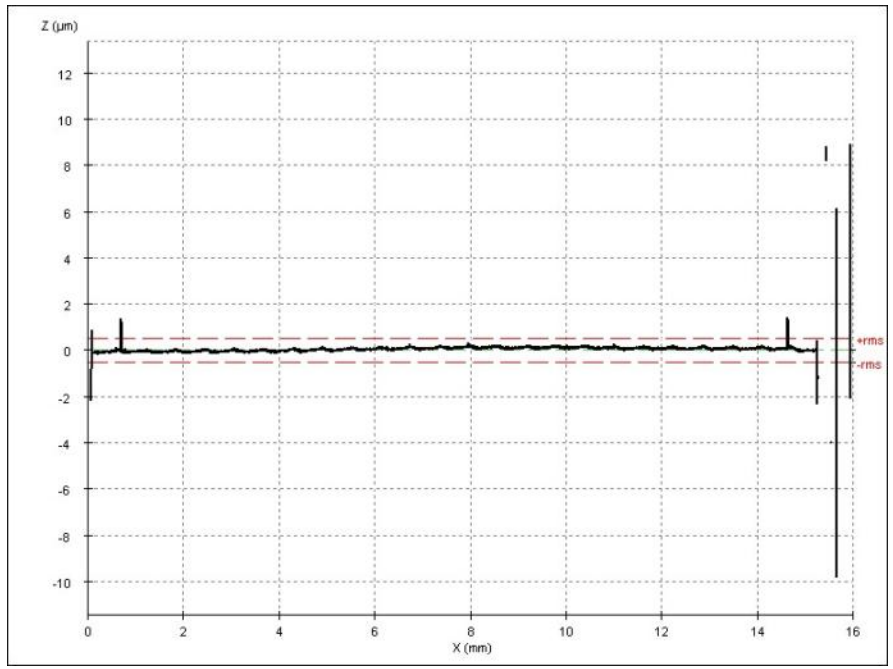
Medipix2 - Bump bonding and tests

- 18 sensors (10p+8n) were bump-bonded at VTT with Sn/Ag to Medipix2 and Timepix chips (partially financed by RD50)

- Tested with microfocussed X-rays at the Diamond Light Source Synchrotron in May – see Chris's talk today

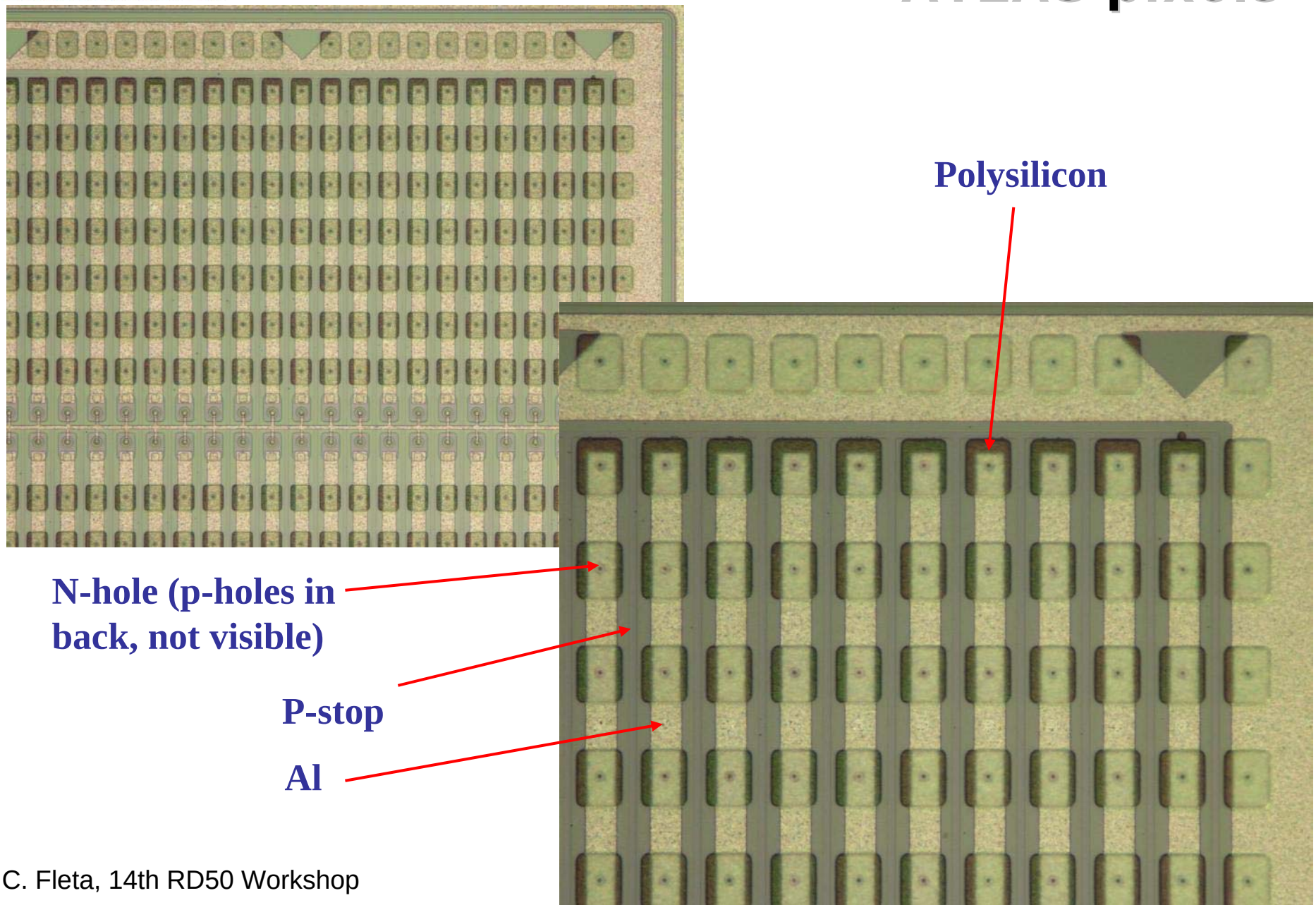


Electroless
Ni/Au UBM

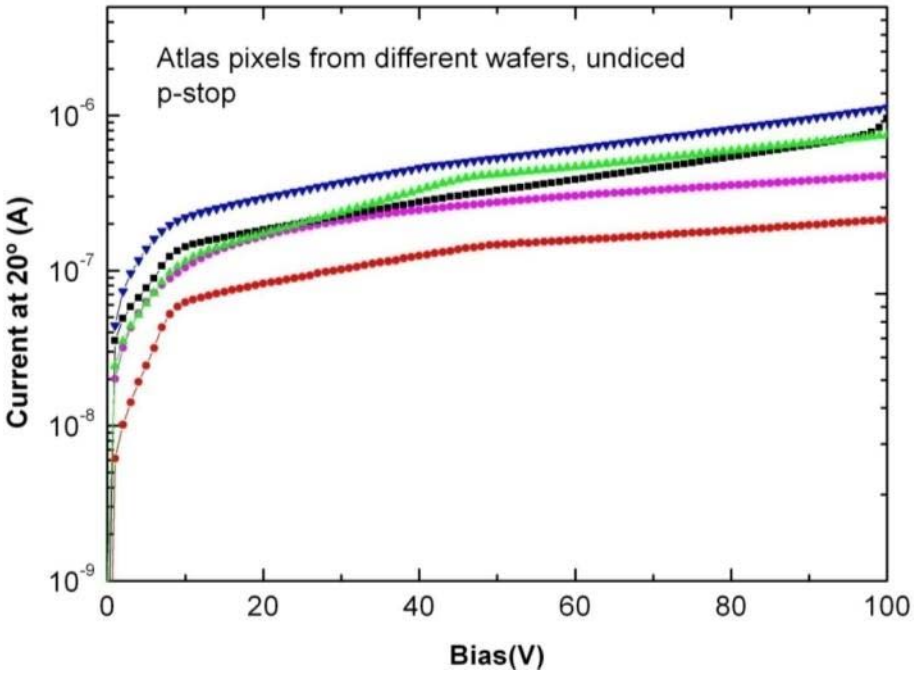


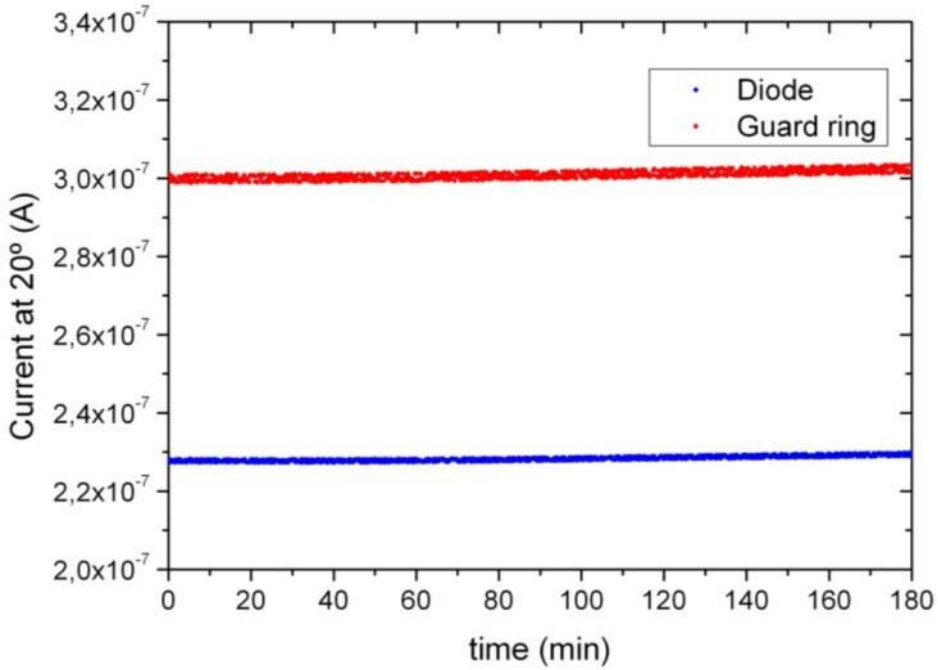
Curvature measured in Medipix2 chip

ATLAS pixels



ATLAS pixels





- **Current/pixel in full depletion, 20ºC: 80-150 pA**
- **43% sensors with VBD > 50 V, I @ 50V, 20ºC < 1uA**

- **Total current in p-type ATLAS sensor, 40V, 18ºC**
- **2% variation in 3 hours**

ATLAS pixels - plans

Bump bonding

- 6 3D-ATLAS sensors sent to VTT to bump-bond to FPIX chip (partially financed by RD50)
- Glasgow in contact with IZM for bonding with FE-I3

Tests

- ATLAS pixels will be tested by Glasgow (FP420 ATLAS upgrade programme)
- IFAE (Institute for High Energy Physics, Barcelona) has adquired a TurboDAQ system – next year we'll be able to test ATLAS pixels in Barcelona
- Liverpool and CNM to produce fan-ins to test ATLAS pixels with strip readout – this will allow to test irradiated pixel detectors

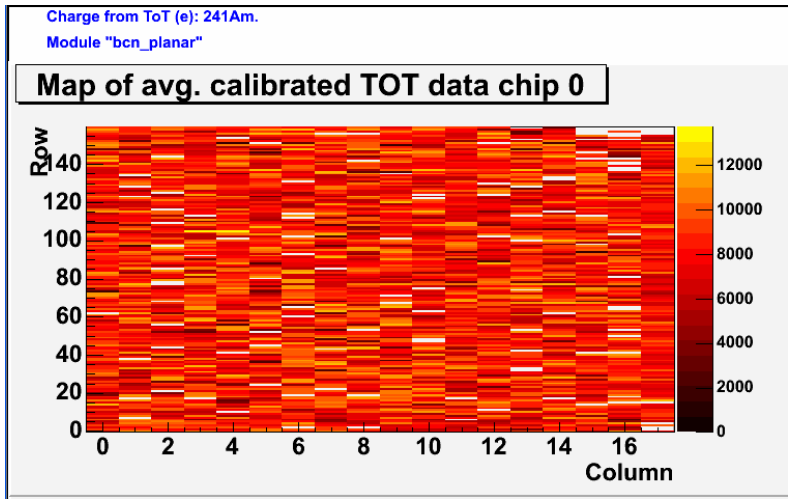
Bump bonding at CNM-IFAE

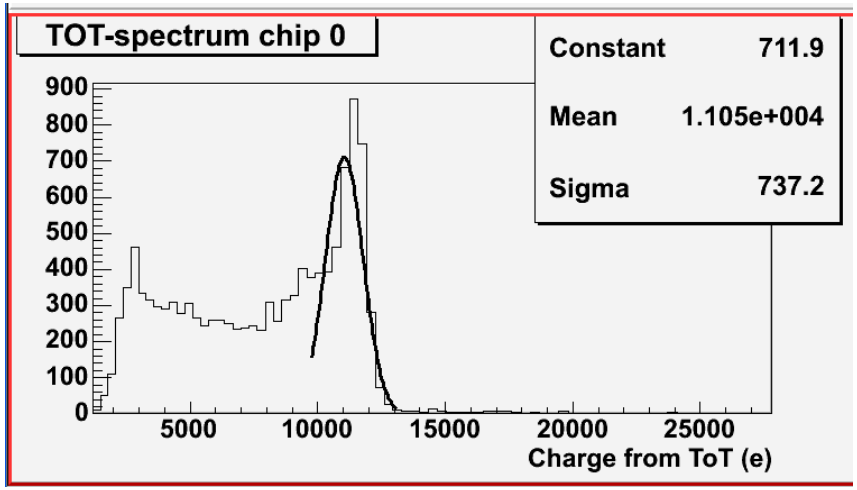
- Joint development CNM-IFAE (Institute of High Energy Physics, Barcelona)
- Class 100 clean room at CNM dedicated to packaging
- Techniques:
  - Manual SMD
  - Manual wirebonding
  - Flipchip
    - Standard temperatures
    - High temperatures: 280ºC
- Equipment:
  - Dek248 screen printer
  - ATV reflow oven with vacuum
  - Manual Pick&Place machine
  - SET FC150 flip chip machine

Enric Cabruja (CNM) and Mokhtar Chemeissani (IFAE)

Bump bonding at CNM-IFAE

- **SET/Süss Microtech FC150 for fine pitch flip chip**
  - **Installed early 2009**
  - **Efficiency in bump-bond contact > 99.5% (aim for 99.99% or better)**
  - **First working ATLAS pixel sensor (planar) bonded in Spain two weeks ago!**
  - **Aim to produce Medipix assemblies soon**





First results using 241Am alpha source.
Readout ATLAS FEI3 chip, tested at CERN, 22-May

Conclusions

3D fabrication:

- 14 wafers (8p + 6n) of double-sided 3D detectors fabricated at the CNM clean room
- Double side processing has proved to be very reliable and repeatable
- Good tested sensors: 70% (N-strips), 87% (P-strips), 43% (P-ATLAS pixels)
- All fabrication steps available in-house
- CNM is able to do “large” productions

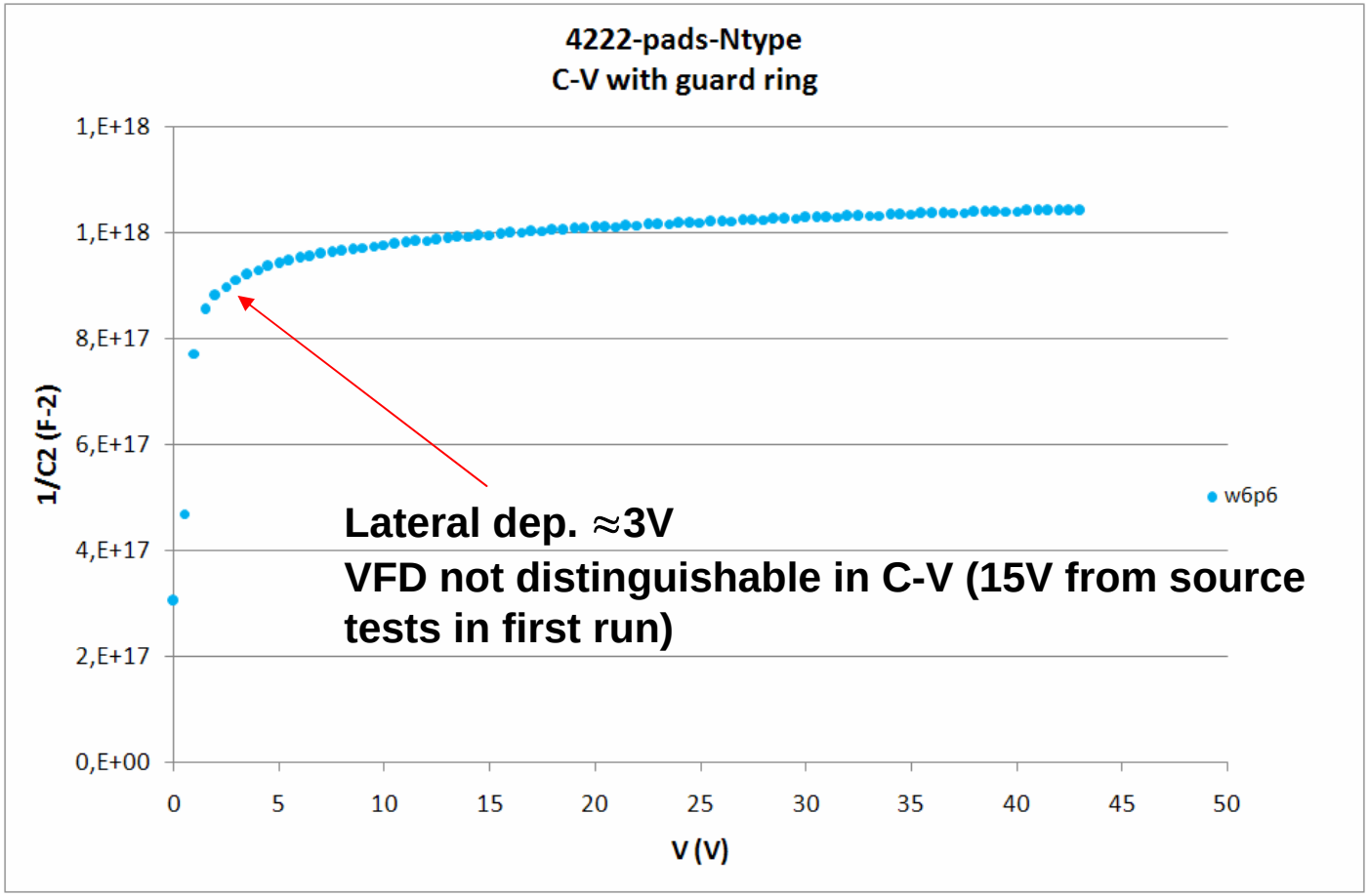
3D sensors:

- Strip detectors irradiated up to $2x10^{16}$ n_{eq}/cm^2
- Will be distributed for tests with ALIBAVA
- Medipix detectors successfully tested at the Diamond Light Source Synchrotron

Bump bonding

- Fine pitch bump bonding achieved at IFAE-CNM
  - Contact efficiency > 99.5%
  - First working ATLAS pixel detector bump bonded

Depletion n-type



Depletion p-type