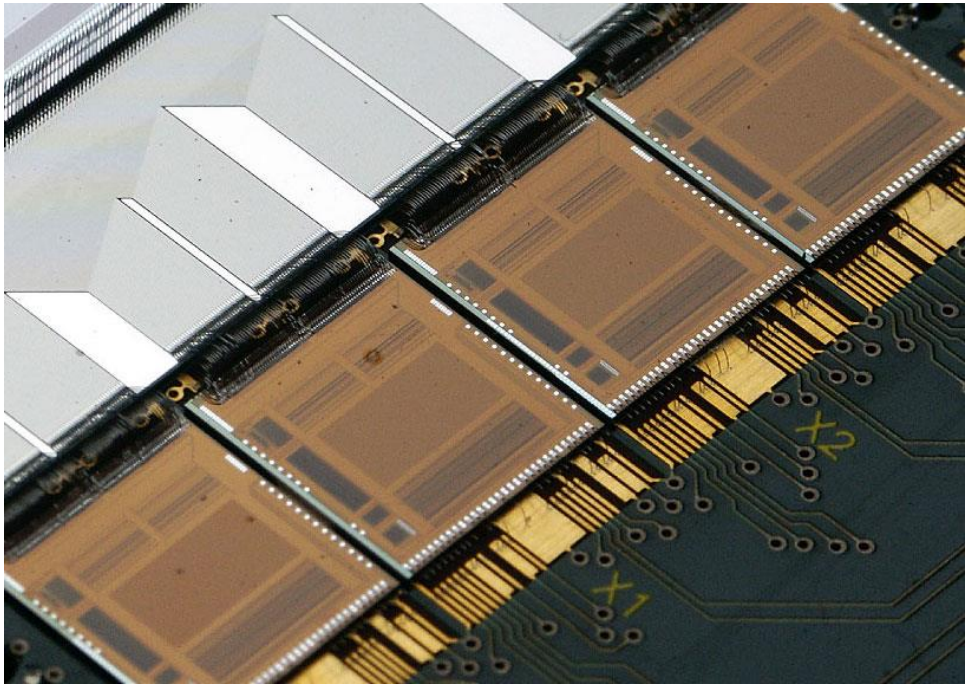


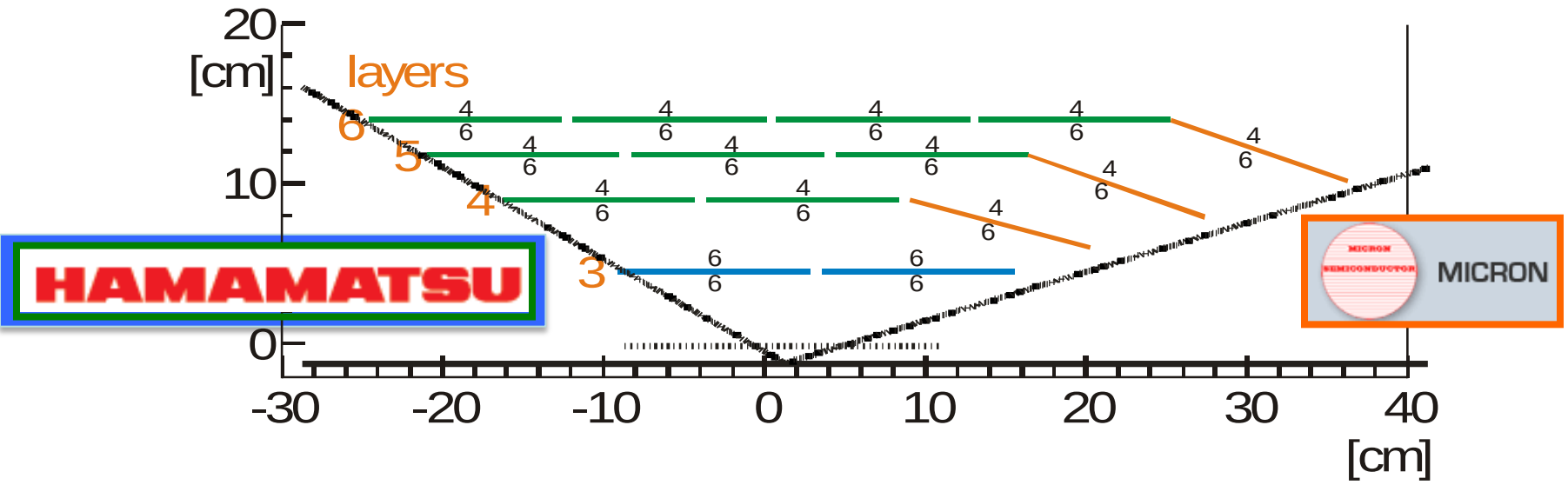
Components and ladder quality control and testing procedures

Thomas Bergauer (HEPHY Vienna)

SENSOR CHARACTERISATION

Sensor Accounting

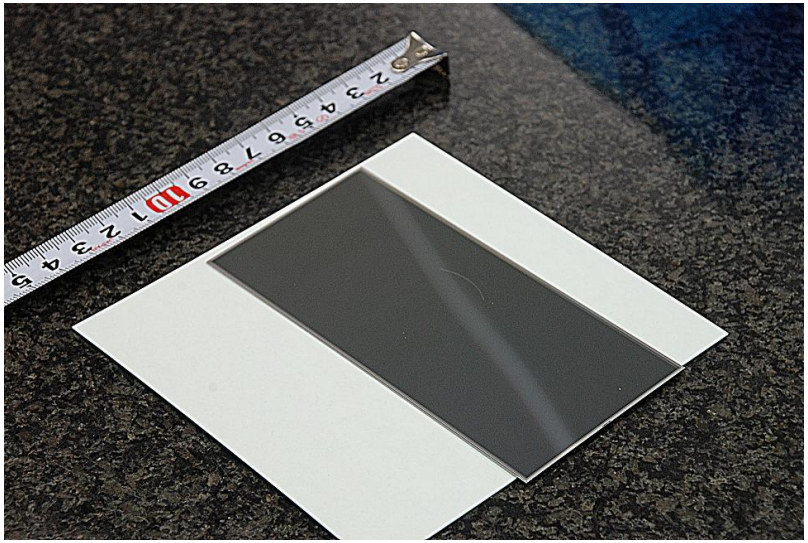
Two vendors, three layouts

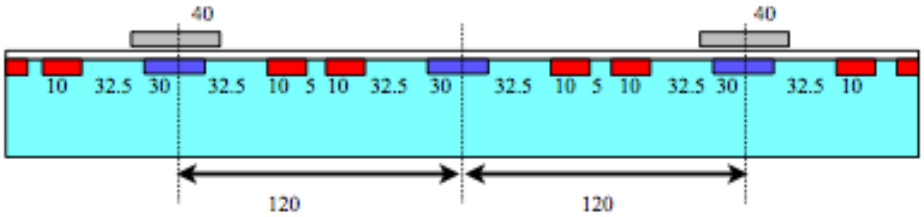


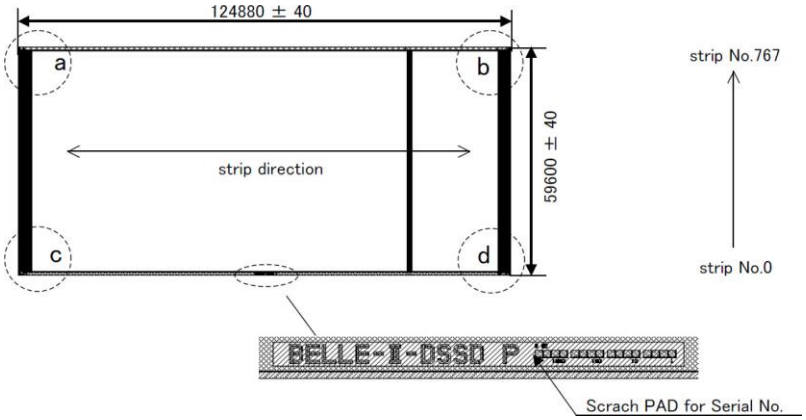
Layer	# of Ladders	Rect. Sensors [narrow]	Rect. Sensors [wide]	Wedge Sensors	APVs
6	16	0	64	16	800
5	12	0	36	12	480
4	10	0	20	10	300
3	7	14	0	0	168
Sum:	**49**	**14**	**120**	**38**	**1748**

Rectangular Sensors from Hamamatsu

- HPK re-started production of DSSDs on 6” wafers
  - Old 4” production line was decommissioned
- We evaluated first batches
- Quality was constantly improving and is now at an acceptable level
- Technical details (layers 4,5,6):
  - Dimensions: 59.6 x 124.88 mm^2
  - **p-side:** 768 strips, pitch: 75 µm
  - **n-side:** 512 strips, pitch: 240 µm



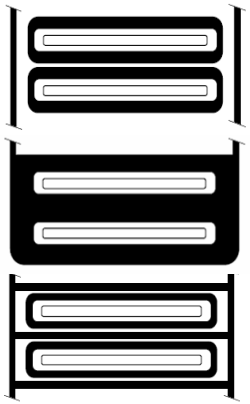




Trapezoidal Sensors from Micron

MICRON SEMICONDUCTOR ltd

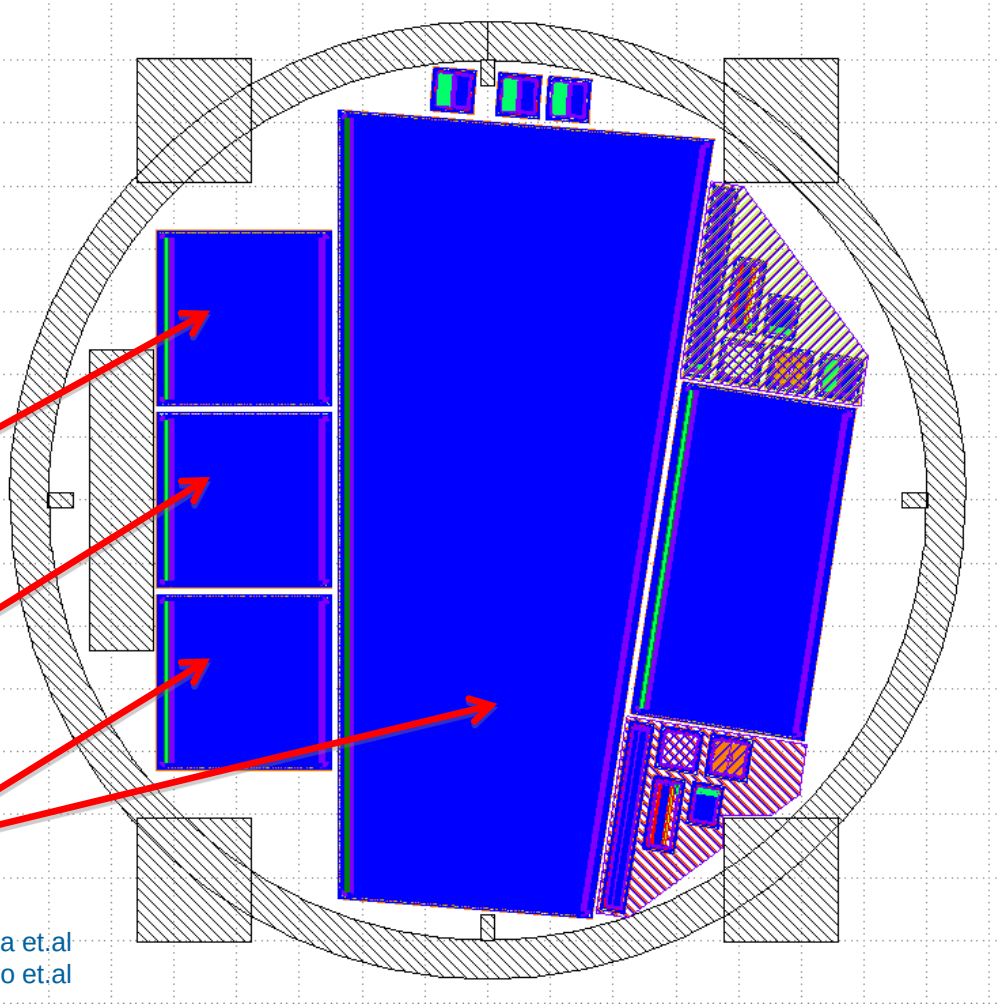
- Trapezoidal sensor for forward region
- Different p-stop layouts on test sensors



Atoll p-stop

Common p-stop

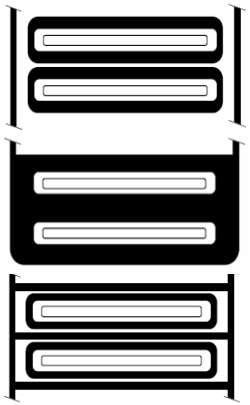
Combined p-stop, Favoured by:



[1] IEEE Transactions On Nuclear Science 45 (1998) 303-309 - Iwata et.al
[2] IEEE Transactions On Nuclear Science 45 (1998) 401-405 - Unno et.al

Modules for Beam Test 2010

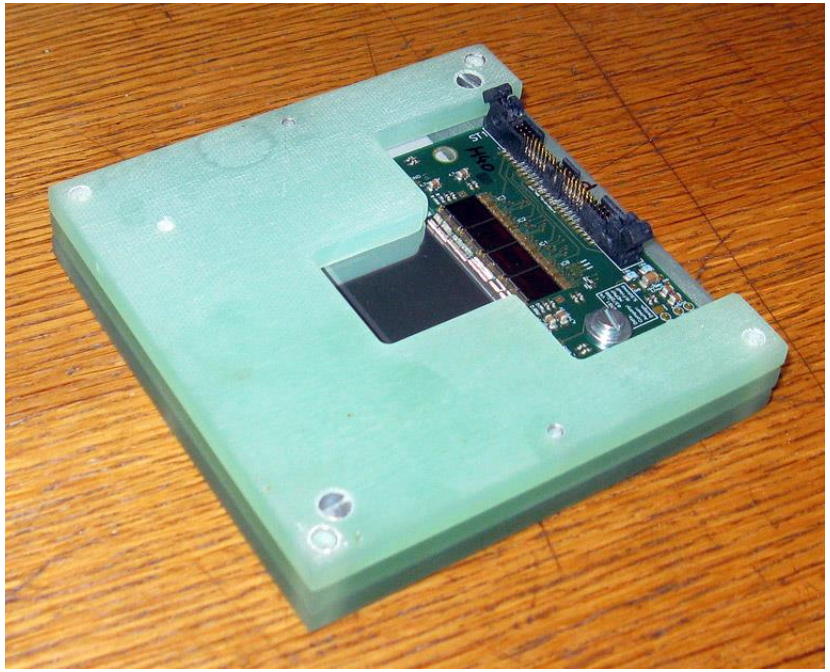
- Read out by APV25 (CMS)
- Baby Module used to verify p-stop geometries:



Atoll p-stop

Common p-stop

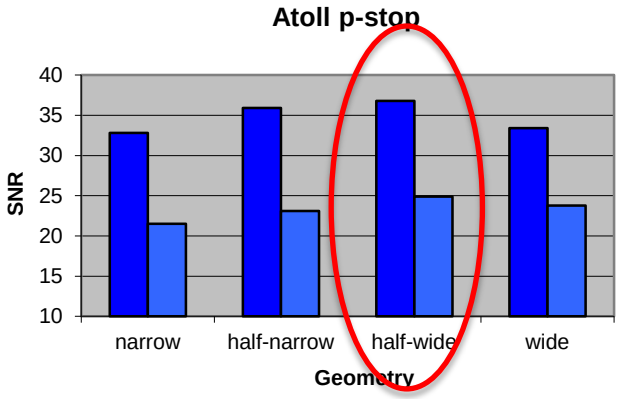
Combined p-stop

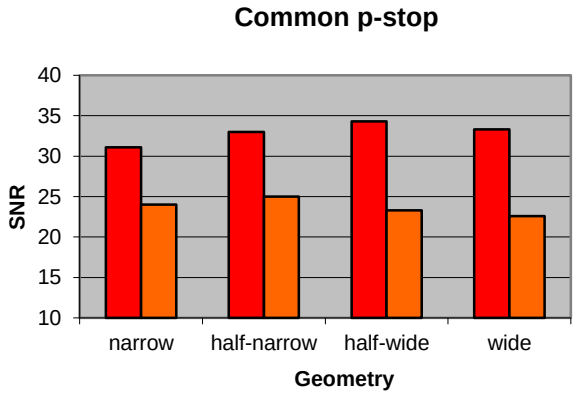


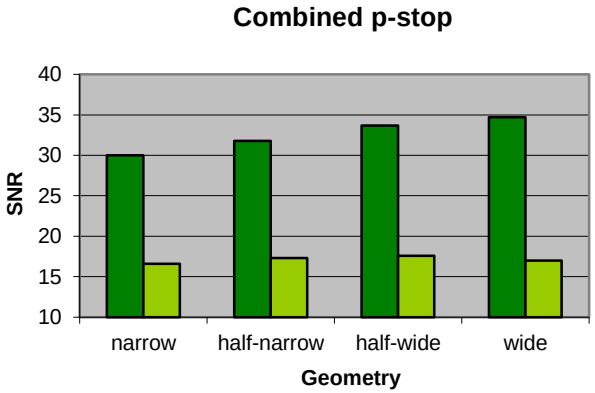
Baby Module

Signal-to-noise-ratios

- Test sensors have been Gamma-irradiated with Co-60 (70 Mrad)
- Tested before and after at CERN beam test (120 GeV hadrons)



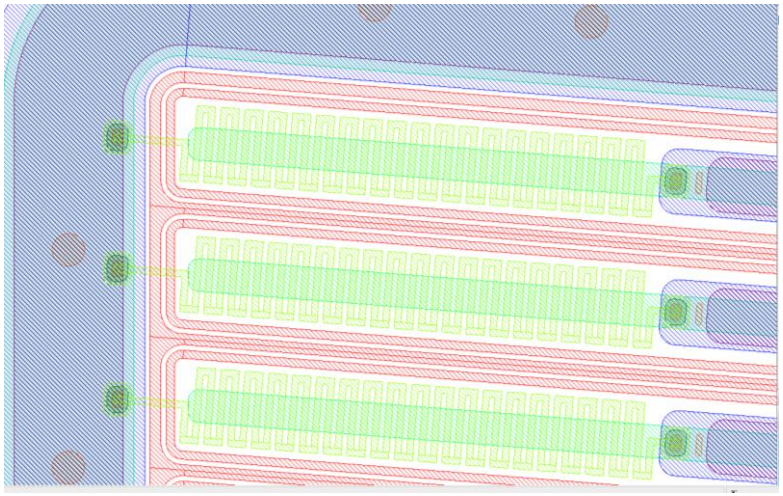


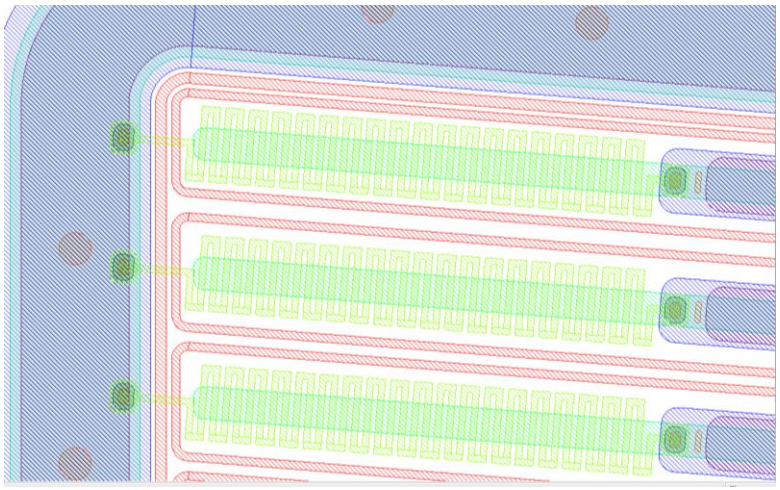


- Dark colors: non-irradiated, Light colors: irradiated
- Atoll pattern (half-wide) performs best, both irradiated and non-irradiated
- Charge accumulation in non-implanted regions after irradiation

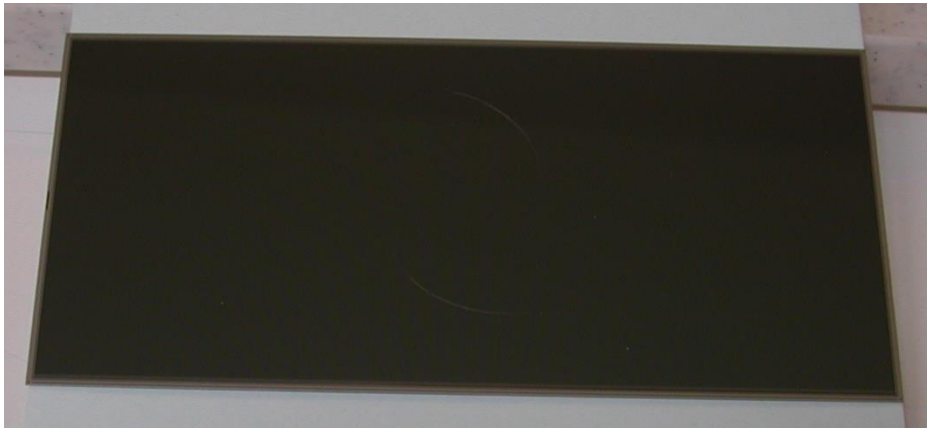
New prototype order with Atoll p-stop

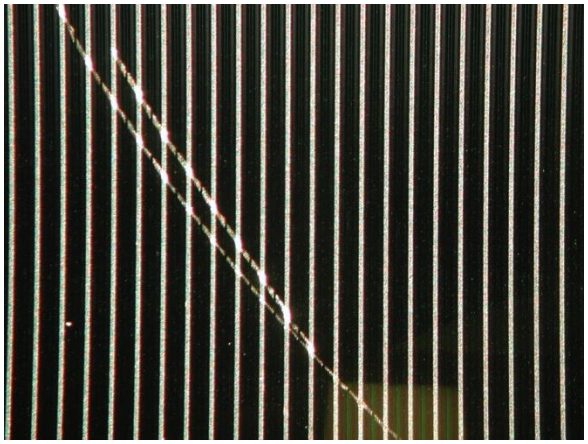
- Three new masks ordered at Micron Semiconductor
  - P-stop, metal, via
- P-stop: Atoll pattern (half-wide) [like HPK n-side]
- Three prototype detectors ordered in 2012
  - Delivery for spring 2012
  - beam test and irradiation summer/autumn 2012
- Order placed for mass production beginning 2013



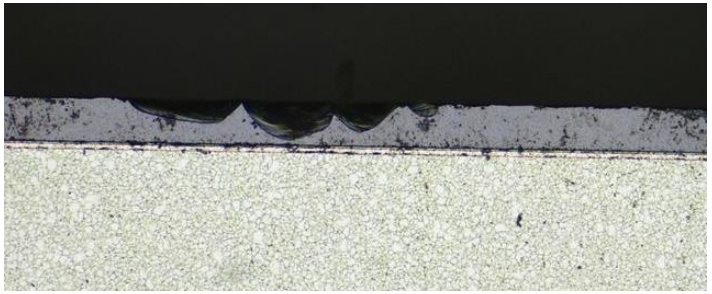


Optical inspection Scratches & Marks



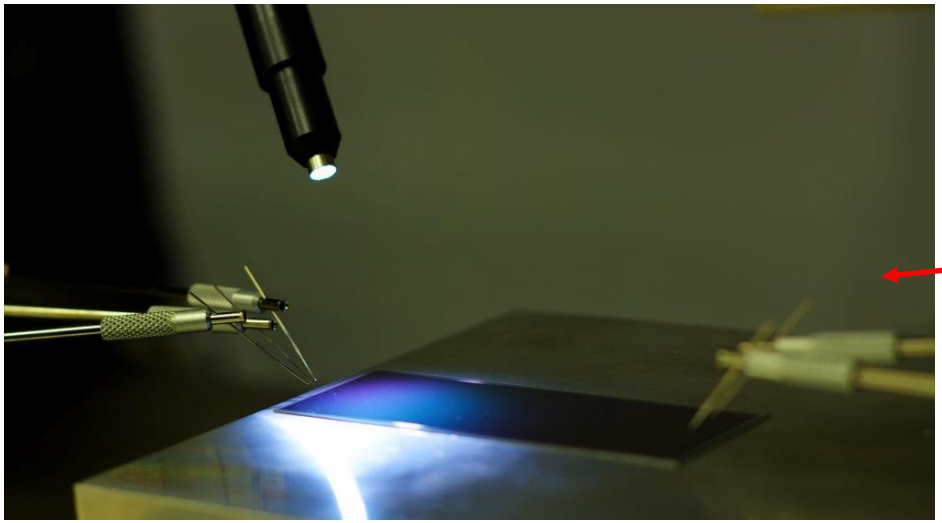


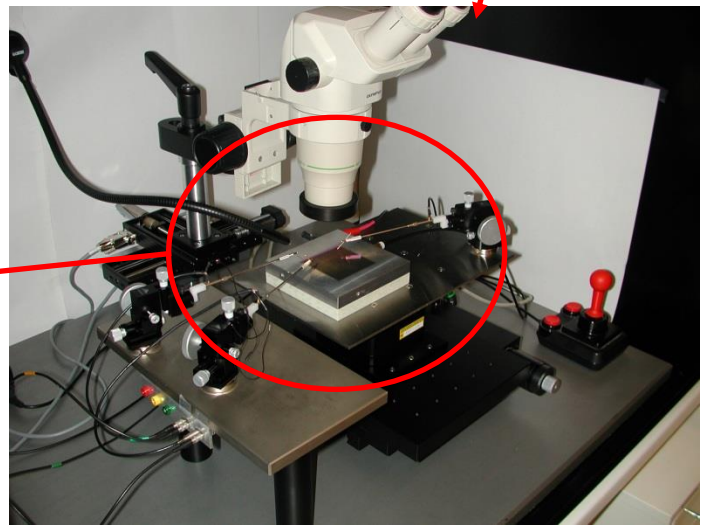
- Round scratches
  - occur on every sensor
  - maybe due to automatic sensor handling?



Strip-by-strip Test Setup

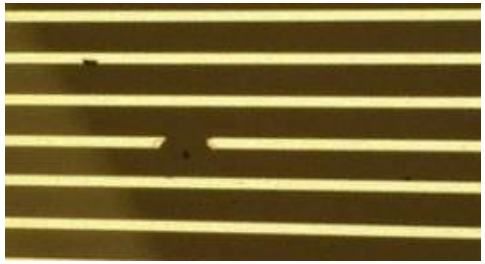
- Sensor in Light-tight Box
- Vacuum support jig is carrying the sensor
  - Mounted on movable table in X, Y and Z
- Needles to contact different structures on sensor
- What do we test?
  - Electrical parameters
  - strip failures



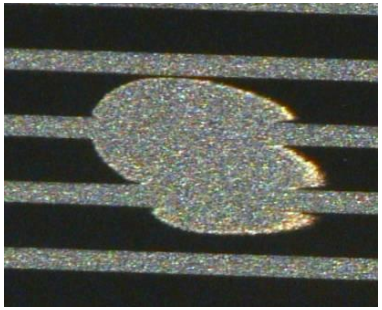


Common strip failures

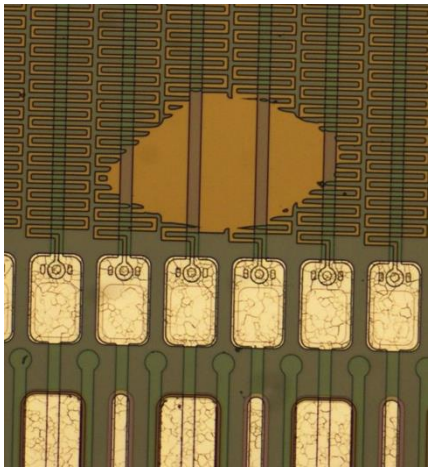
Open Strip:



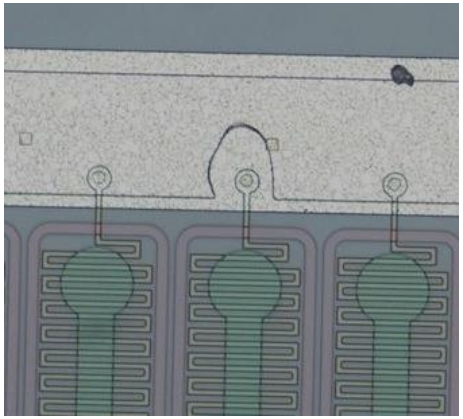
Shorted Strip:



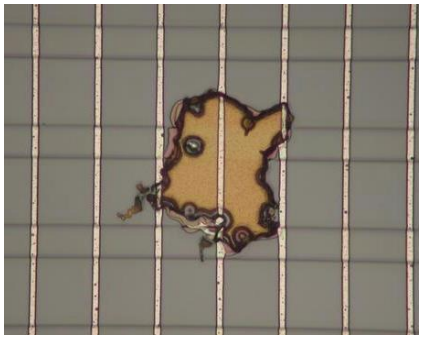
Open bias resistor:



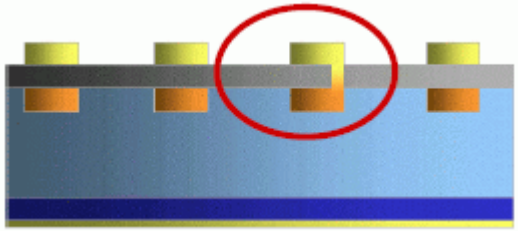
Open implant at via:



Open implant:

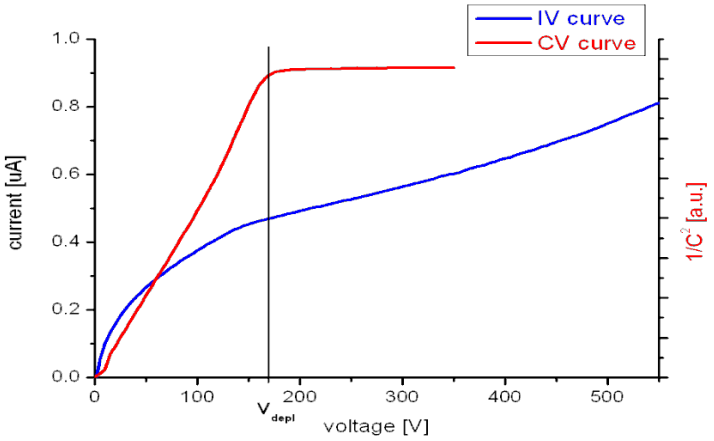


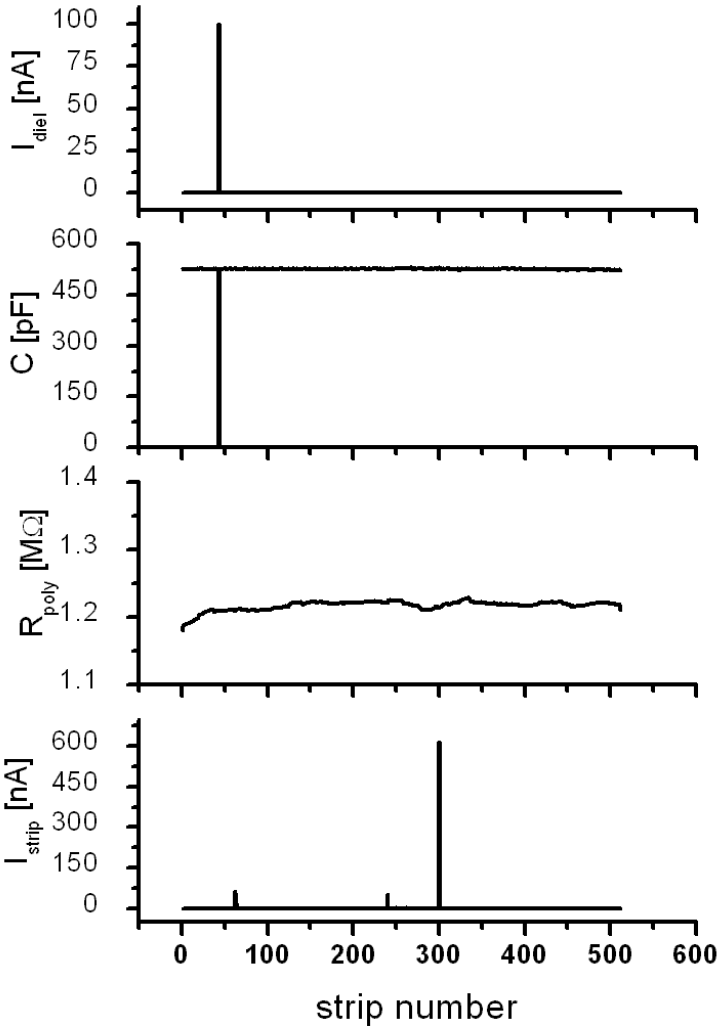
“Pinhole” (short between implant and metal):



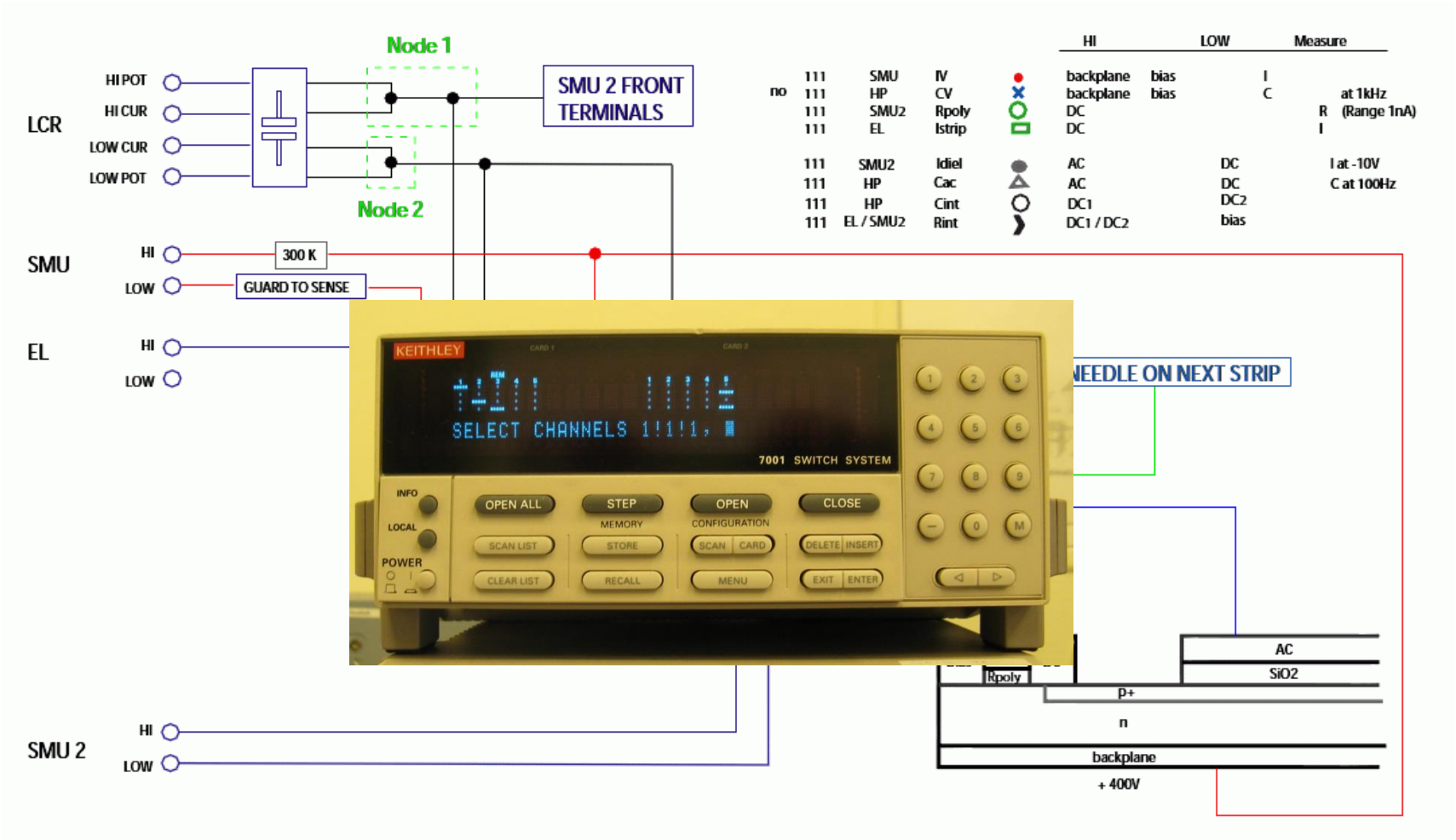
What do we test?

- Global parameters:
  - **IV-Curve:** Dark current, Breakthrough
  - **CV-Curve:** Depletion voltage, Total Capacitance
- Strip Parameters e.g.
  - strip leakage current I_{strip}
  - poly-silicon resistor R_{poly}
  - coupling capacitance C_{ac}
  - dielectric current I_{diel}





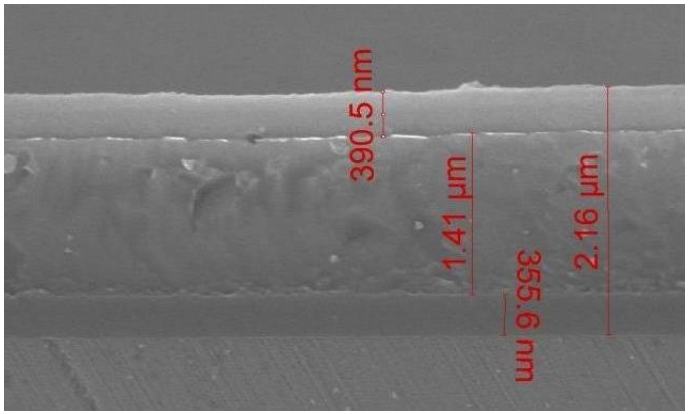
Switching Scheme

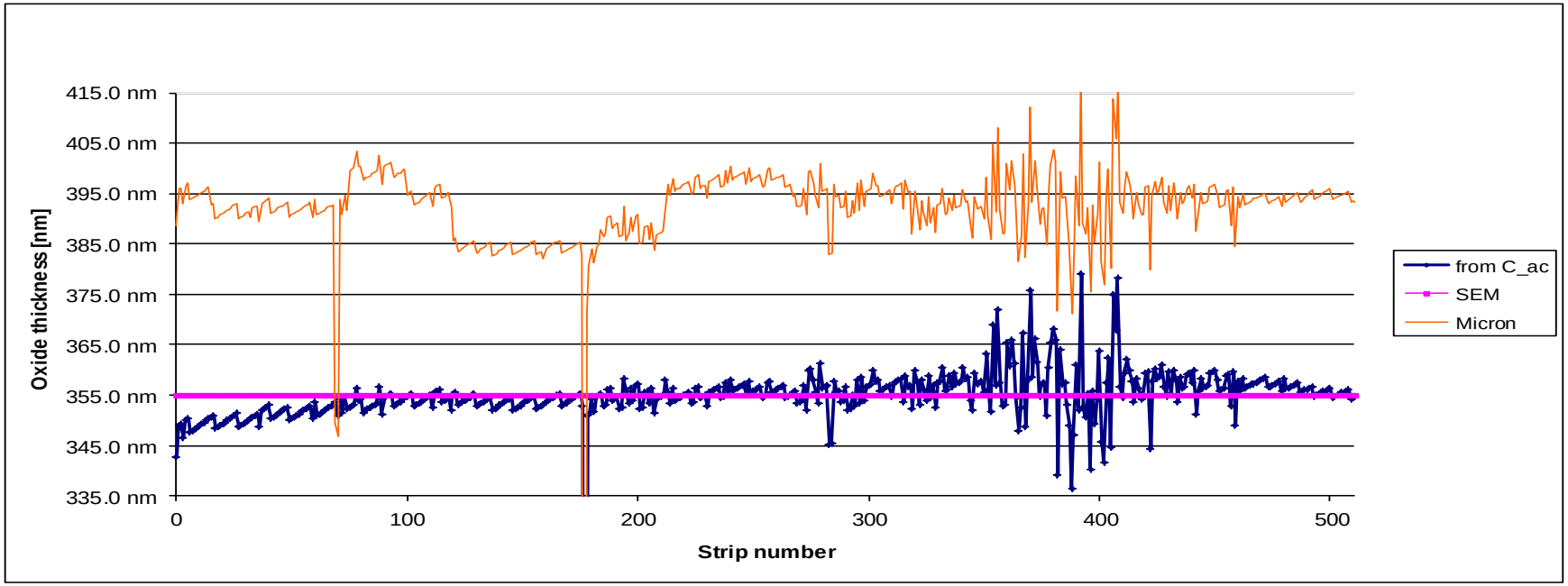


Measurement validation

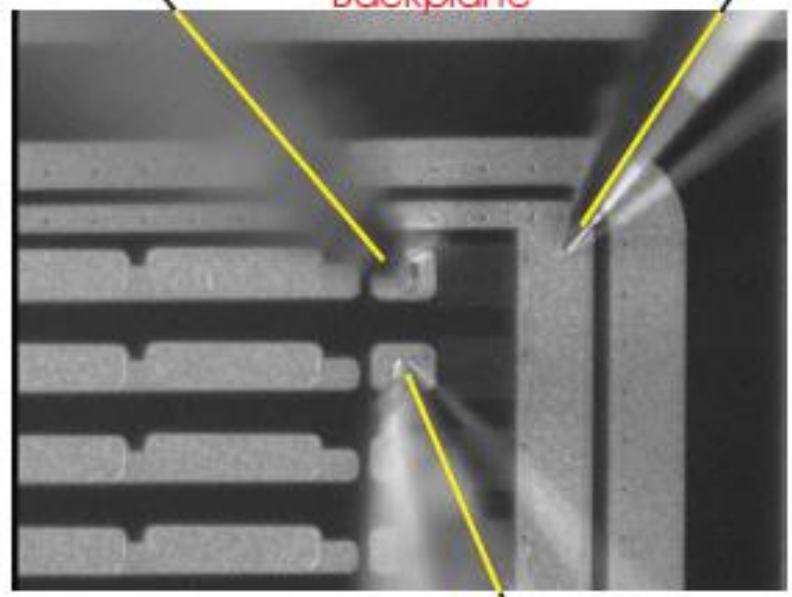
Direct measurement of oxide thickness by electron microscopy

SEM result: 355 nm
average from C_ac measurement: 354 nm
Vendor average: 391.8 nm





Measurement of the inter-strip resistance



SMU 1

-100V

GND

applies bias voltage

Electrometer

A

GND

Current at 0V is strip leakage current, interstrip resistor value from slope of current when ramping

SMU 2

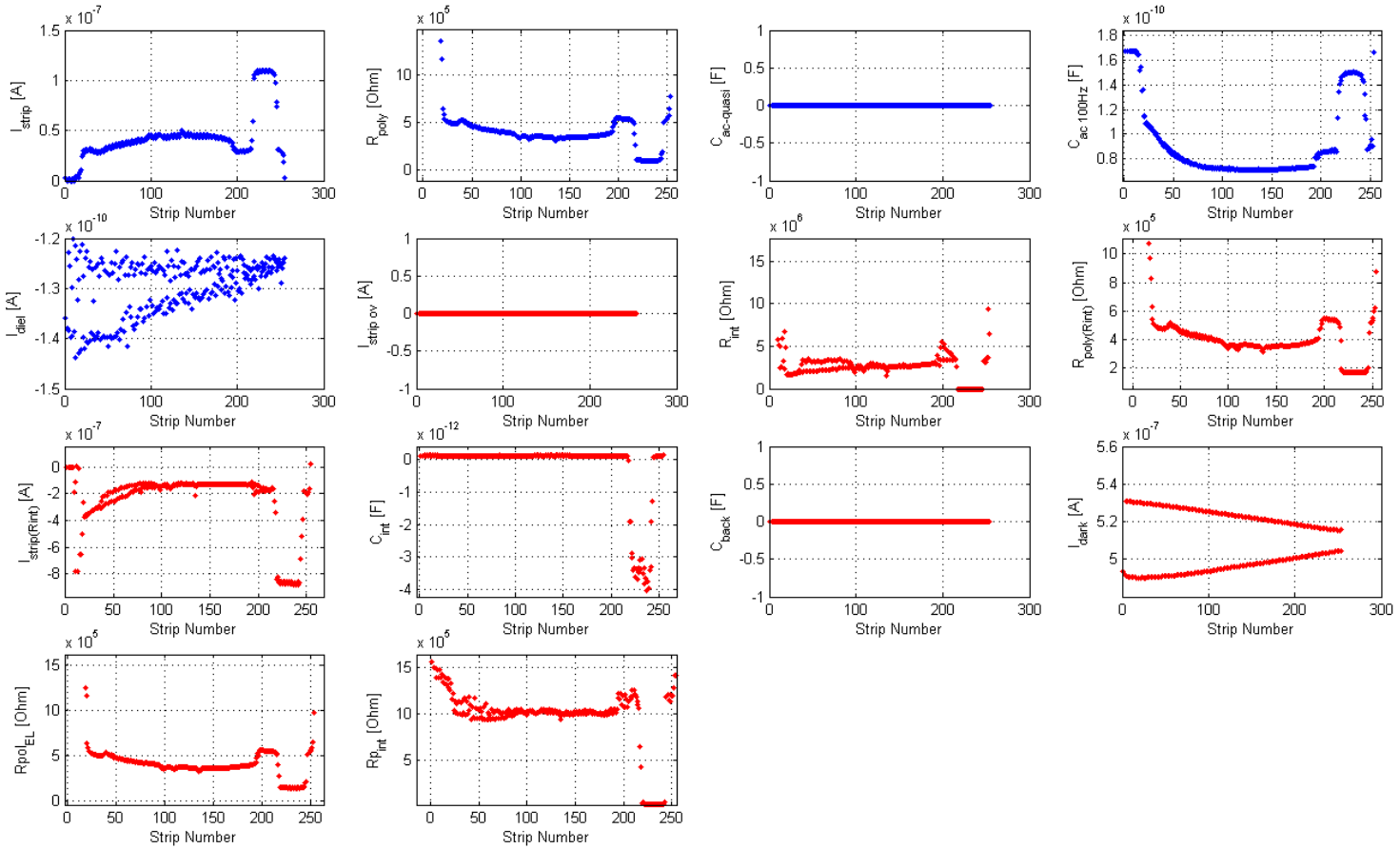
0...3V (5V)

A

GND

ramps potential on neighbouring DC pad -> Bias resistor value from slope of current

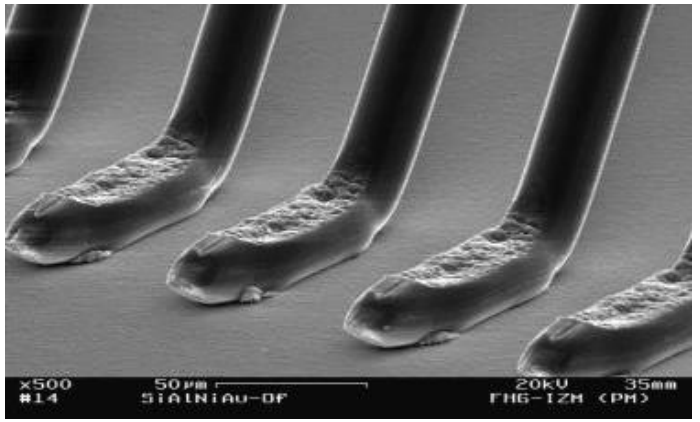
Full Strip-by-strip results



METROLOGY DURING LADDER ASSEMBLY

Wire bonding

- Ultrasonic welding technique
- 25 micron bond wire of Al-Si-1%
- Thin Wedge usually used for 17.5um wire
- Pull-tests to verify bond quality



Mechanical parameters

- Measurement of
  - Mechanical precision of CF ribs
  - Alignment of sensors w.r.t hybrid

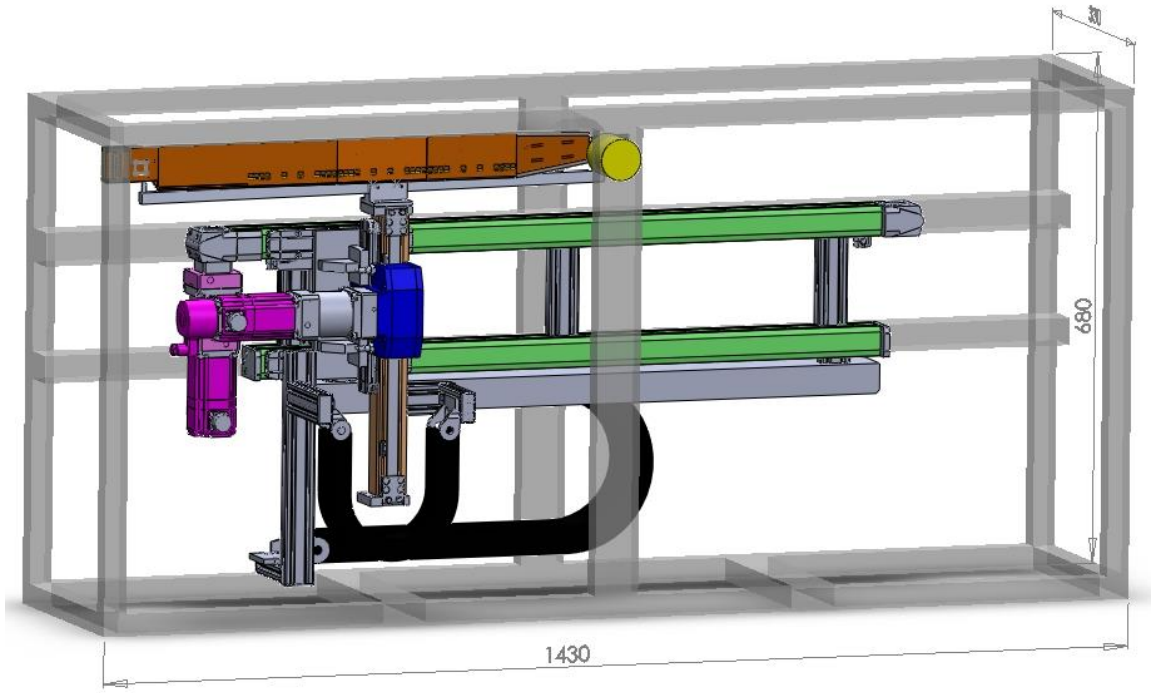
  Using 3D mechanical measurement system

- Coordinate measurement machine (CMM)

LADDER TESTING

Box with motorized XZ Table

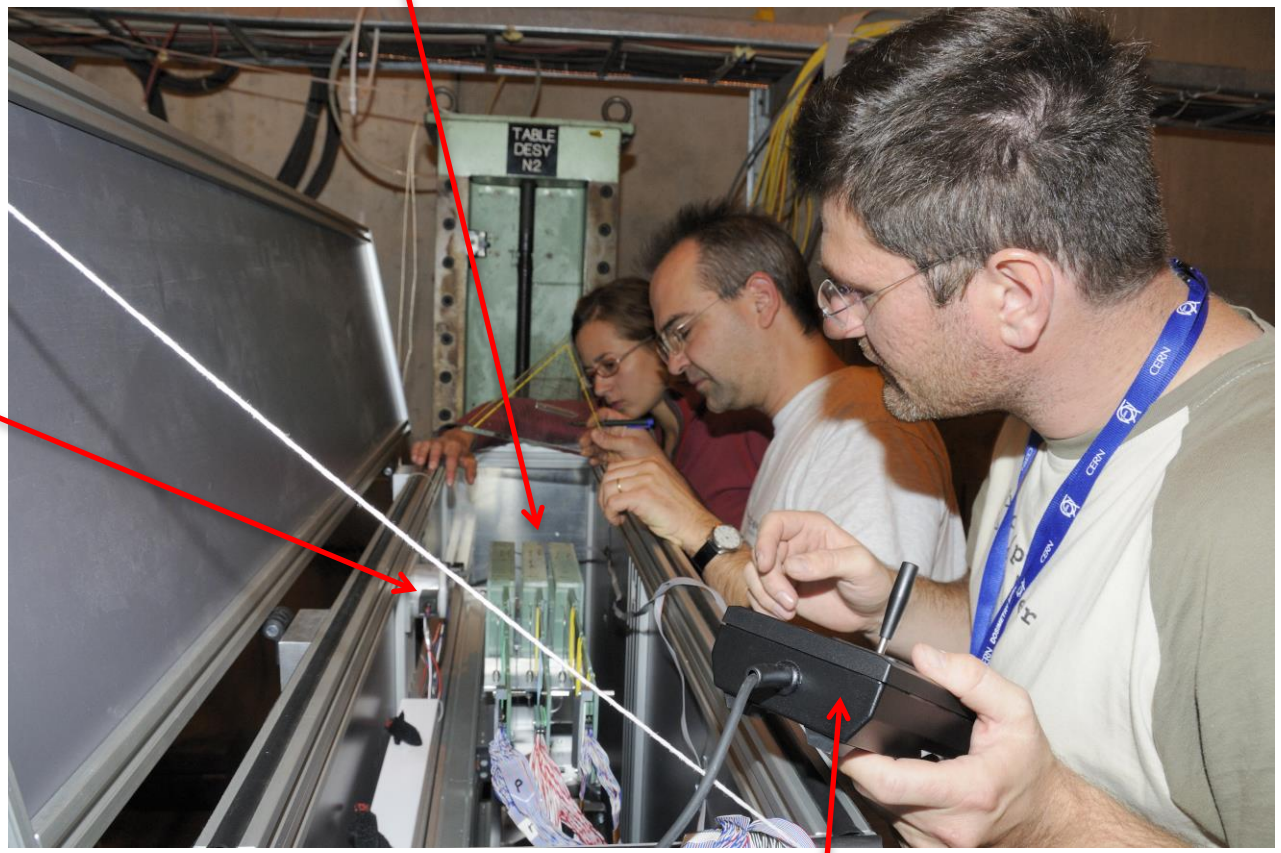
Setup built for automatized ladder tests in Vienna



- Motorized stages remotely controllable via TCP/IP
- HPK mini-PMT with Scintillator for triggering

The setup

DUTs on x-z-table



Scintillator and photomultiplier for trigger

Joystick for moving the x-y-table
(one of many interfaces for user error…)

Components and ladder quality control and testing procedures

LADDER AGING AND BURN-IN

Climate Chamber

Key parameters:

- Volume 350l
- Space for 5 ladders
- Temperature range -40 up to +200 degC
- Rel. Humidity 0 to 95%

Order placed mid March

- Will be delivered in June this year

Will be used for:

- Burn-in tests at elevated temperature
  - 60-80 degC
  - For durability checks of design (on pre-production ladders)
- Thermal cycling
  - To verify proper function of every single ladder

How to store metrology data?

CONSTRUCTION DATABASE

Belle II construction database

- Aim is to keep track of each (expensive) component:
  - Sensors
  - Hybrids
  - Modules
  - Ladders
- => **Logistics:** Registration, Shipments, Assembly

- Add **measurement results**

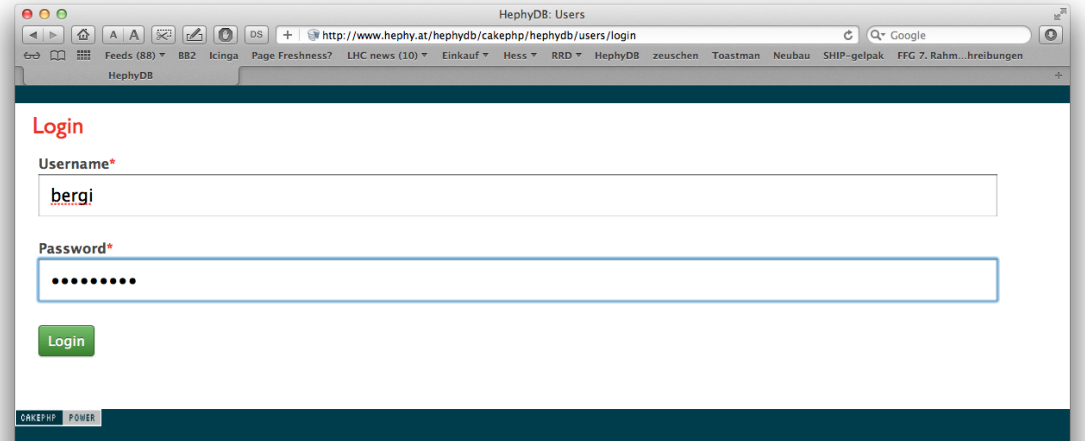
Key features

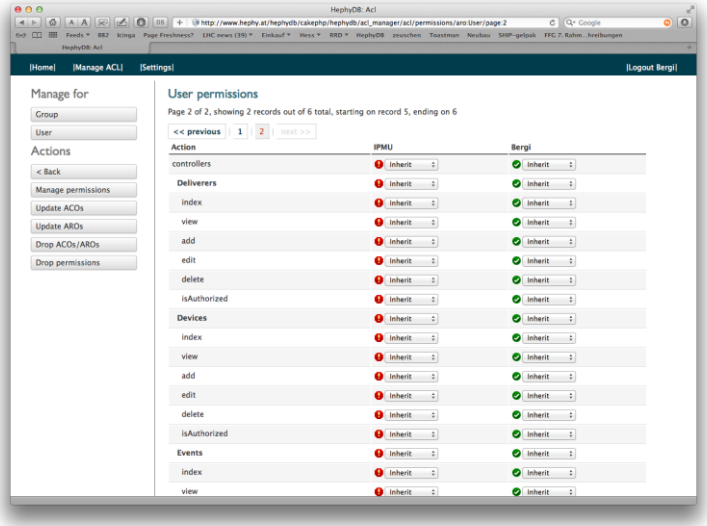
- **User access system** (benefit of CakePHP framework)
  - Authentication
  - User/Group permissions
- **Logistics Module** [already implemented]
  - Registration: “Add item”
  - View Inventory of one or all “locations”
  - Location is e.g. HEPHY, KEK, IPMU,…
- **Measurement module** [not yet implemented]
  - Store measurement results
  - Retrieve data with nice-looking plots
- **Administration Module** [already implemented]
  - Add/change/remove users and groups
  - Add new “locations”, “item types”,..

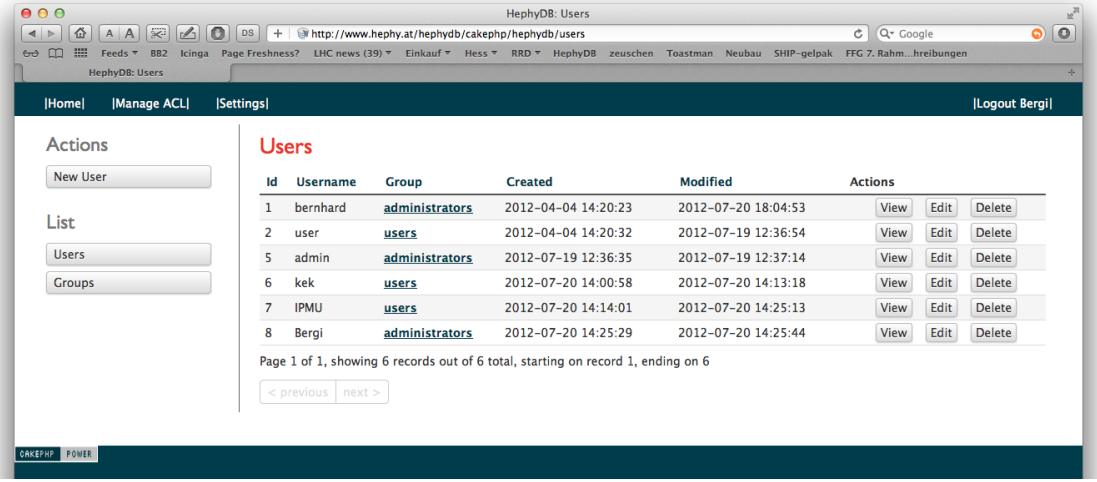
Let’s have a look to each of those…

User access system

- Individual user accounts
- Linked to location, e.g. user Bergi=HEPHY





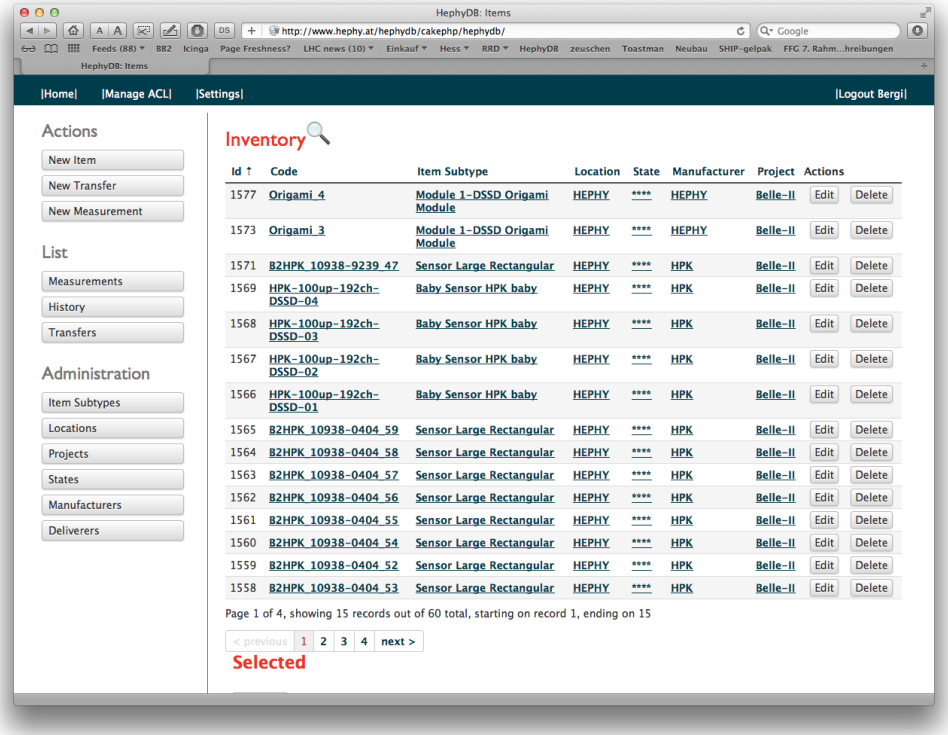


Logistics Module

To view and search for inventory.

Works only if

- Each new component is entered
  - "Add item" page
- Shipments are entered
  - "Transfer" page
- Assembly steps are followed in the db
  - "Assembly" page



Measurement module: not yet implemented

- Upload measurement results as ASCII files directly to web server (HTTP POST command).
- Can be done
  - directly from measurement software (e.g. Labview)
  - Manually
- Uploaded ASCII files will be parsed at server side and data will be put into database
- Query module will allow to retrieve data (e.g. position of non-working strips) and nice-looking plots (e.g. IV curve on sensor)

Summary

- Sensor tests well defined
  - Fraction of full strip-by-strip scan not yet defined (rely on tests done by vendor)
- Metrology during ladder assembly via CMM
- Climate chamber to be commissioned for burn-in and thermal cycling
- Web-based logistics database for SVD has been implemented at http:/www.hephy.at/hephydb

END