
# Silicon Lab @ SINP MSU

*Mikhail Merkin*

*Skobeltsyn Institute of Nuclear Physics,*

*Moscow State University*


# Who we are:

Group of 15 people in Experimental High Energy Physics Department Institute of Nuclear Physics of Moscow State University.

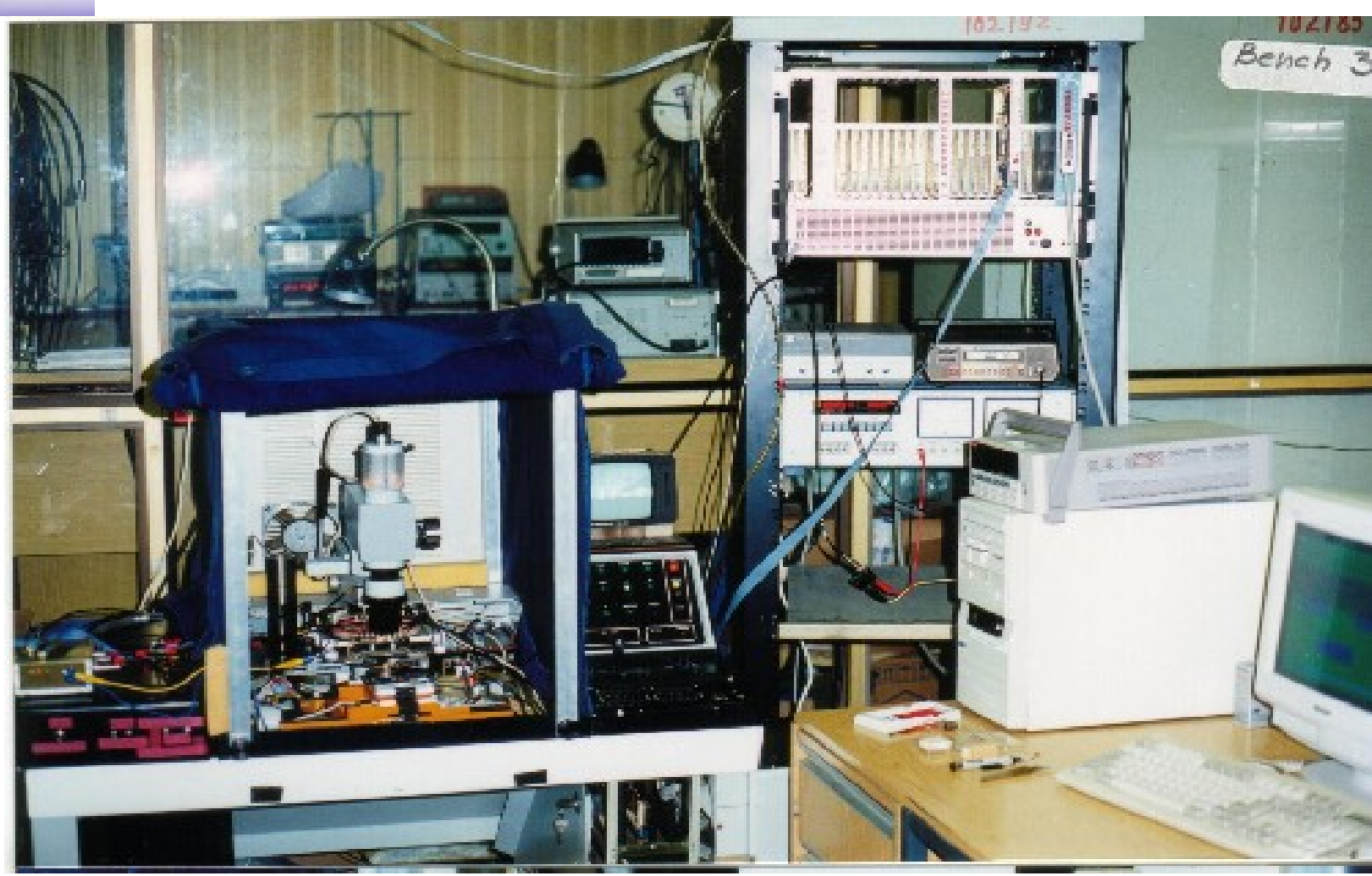
5 physicists, 5 engineers, 2 programmer, 3 technicians.

Lab has been created 15 years ago initially for electromagnetic calorimetry at UNK.


# Who we are:

- SiLab has almost all necessary equipment for detectors' measurements.
- 2 automatic probe stations (RADAR and A4).
- 2 manual probe stations.
- http://silab.sinp.msu.ru

# RADAR Automatic Probe Station



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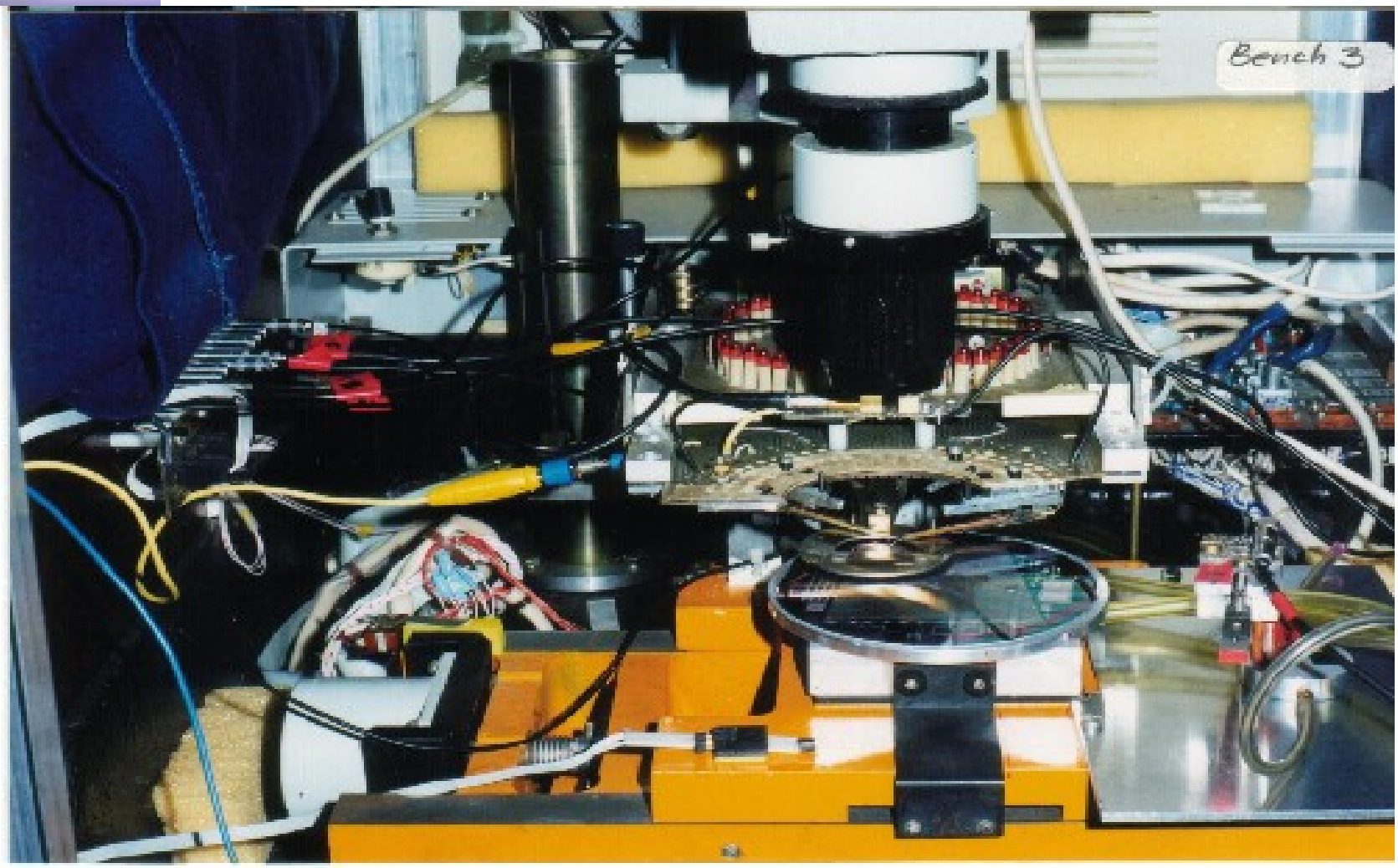
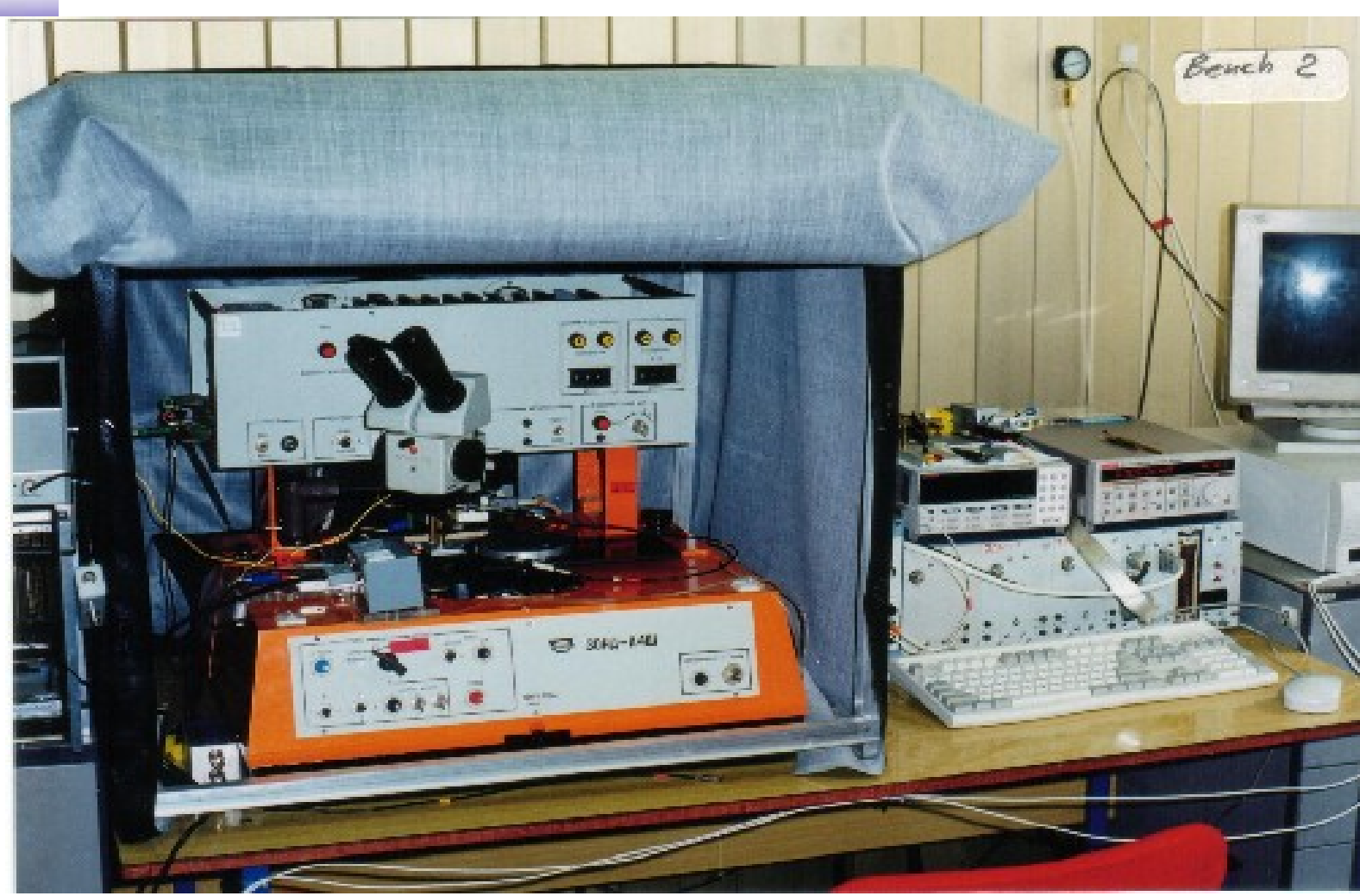
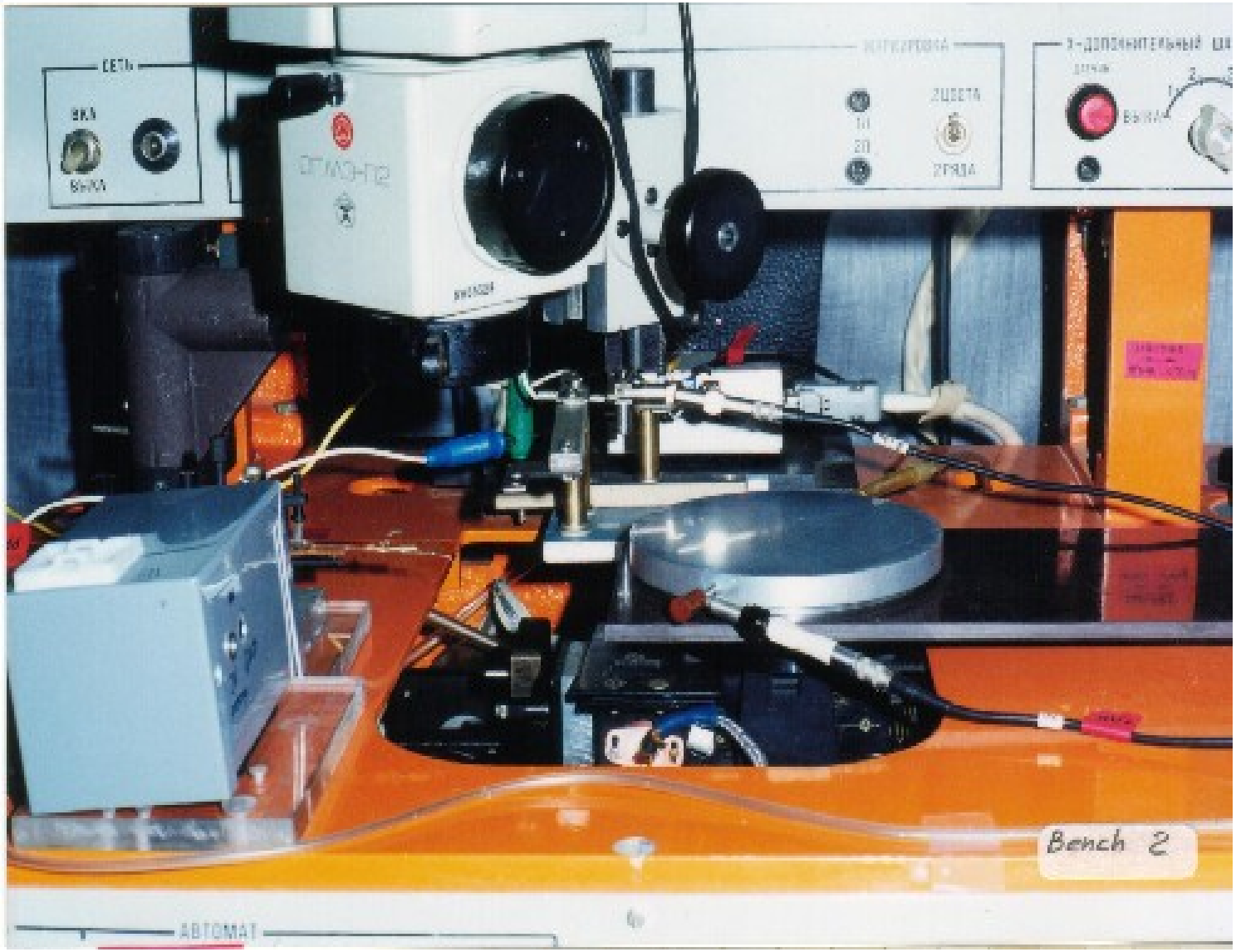


# A4 Automatic Probe Station



# A4 Automatic Probe Station



# Manual Probe Station

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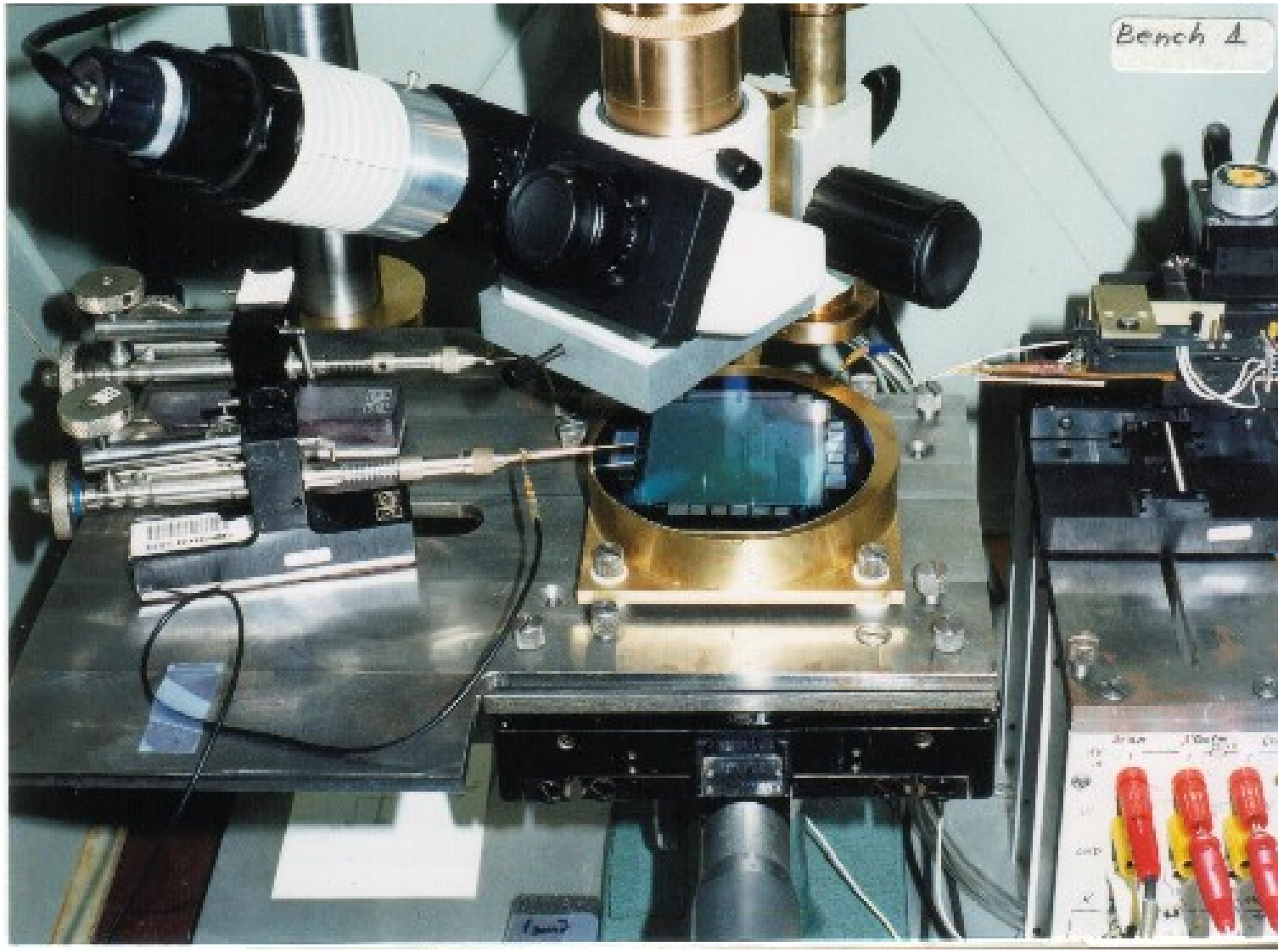


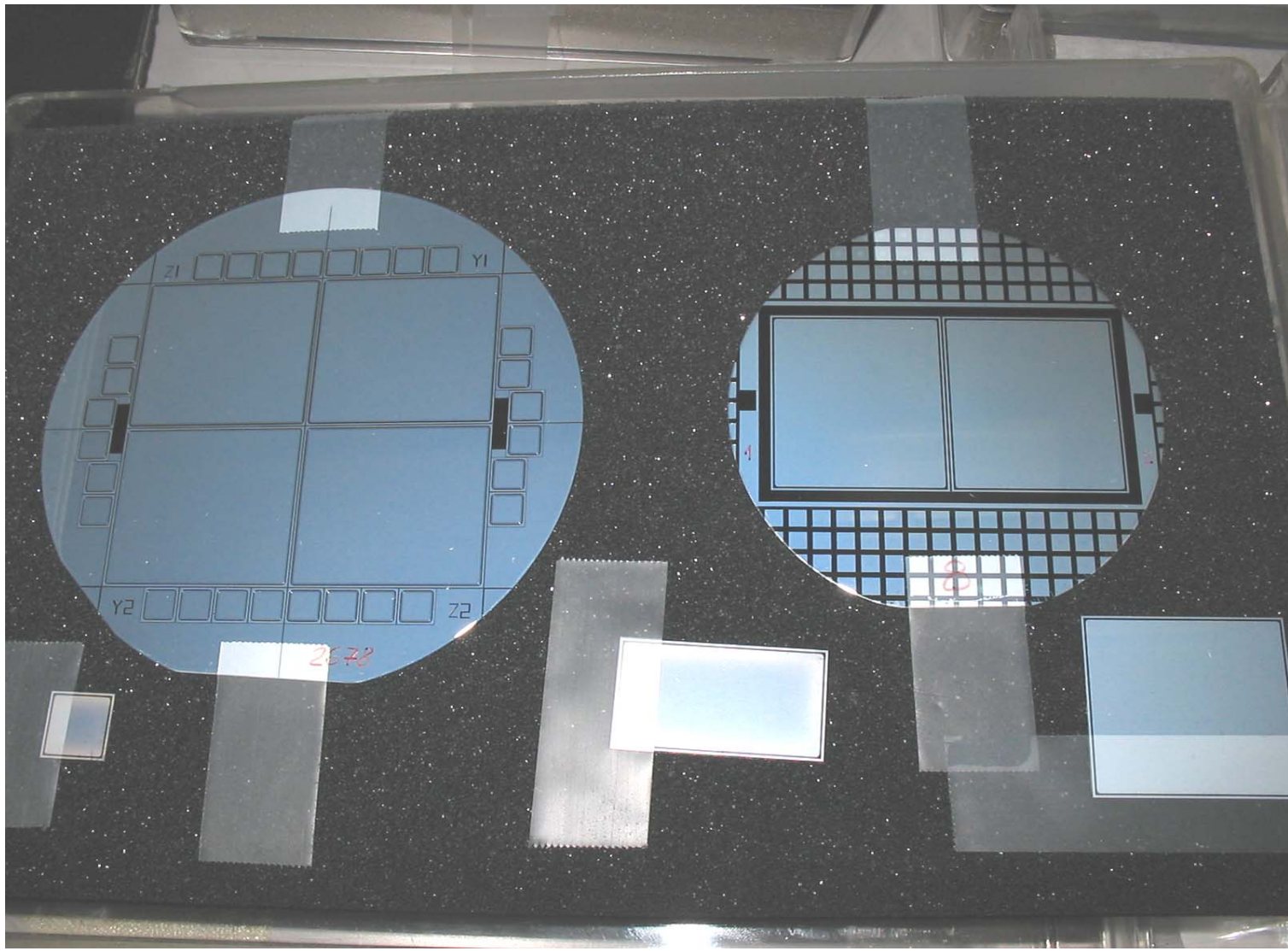

# What we can:

- Silicon pad, strip and microstrip detectors design and development
- Silicon detectors production and tests in cooperation with Russian industry
- Front-end electronics for silicon detectors
- Slow control hard- and soft-ware for silicon detectors systems

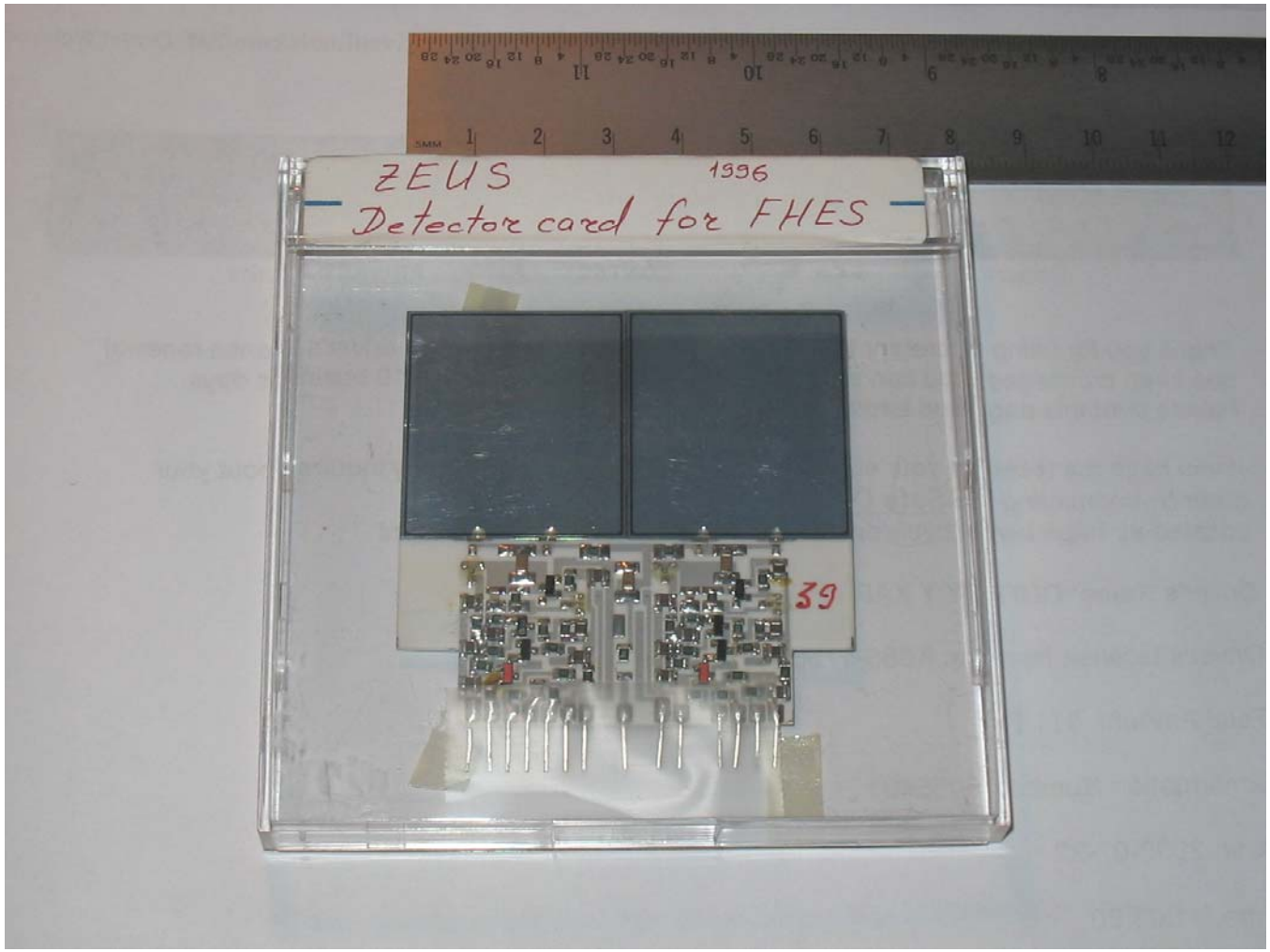

# Experiments

- Hadron-electron separator @ ZEUS (DESY)
- Advanced Thin Ionization Calorimeter (ATIC) - Balloon Experiment
- Forward part of D0 (FermiLab) silicon tracker – H-disks
- SVD-2 – open charm experiment on U-70 at IHEP (Protvino)

# ZEUS detectors on 3" & 4" wafers



# Ceramic board with 2 sensors and 2 preamps for ZEUS FHES

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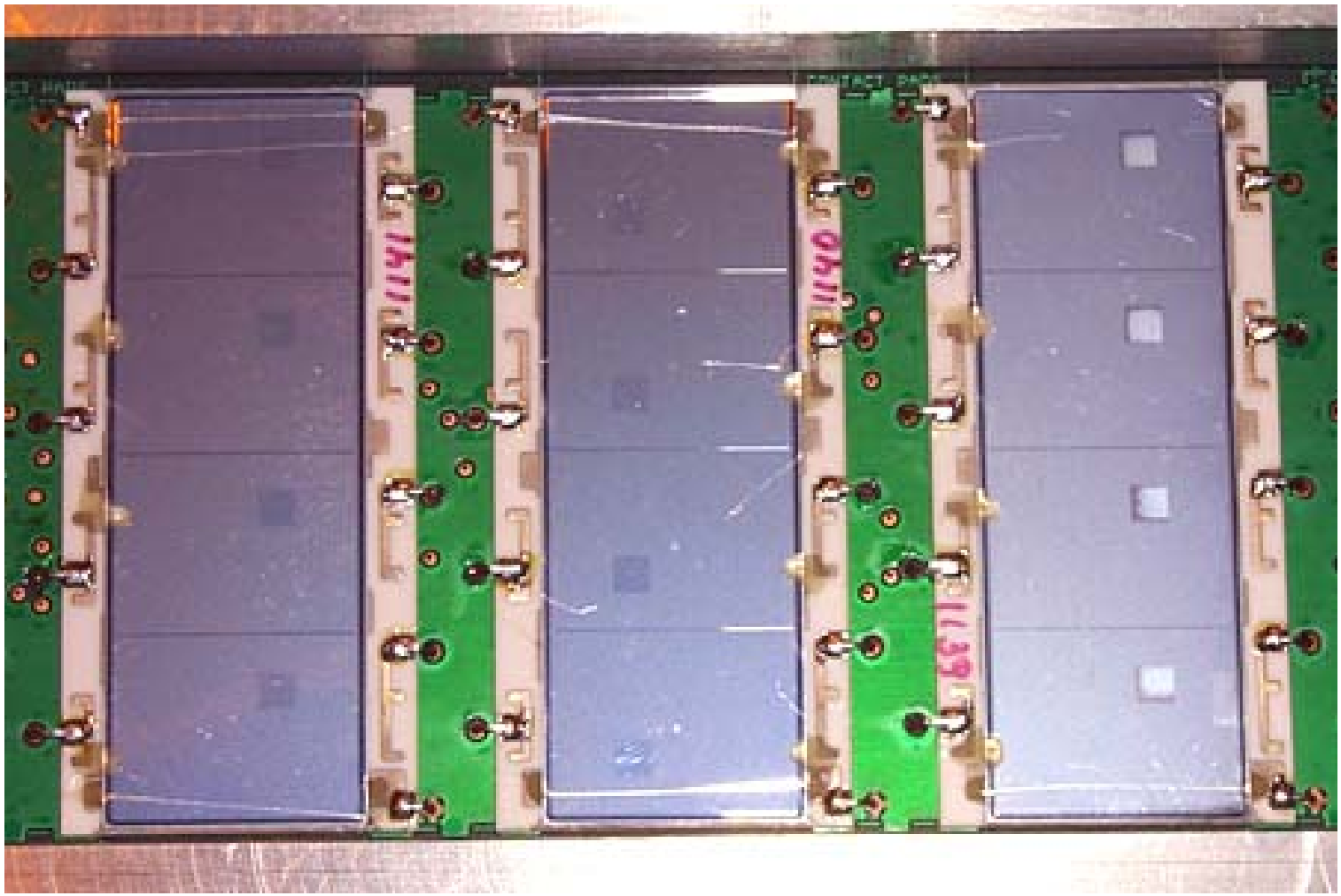
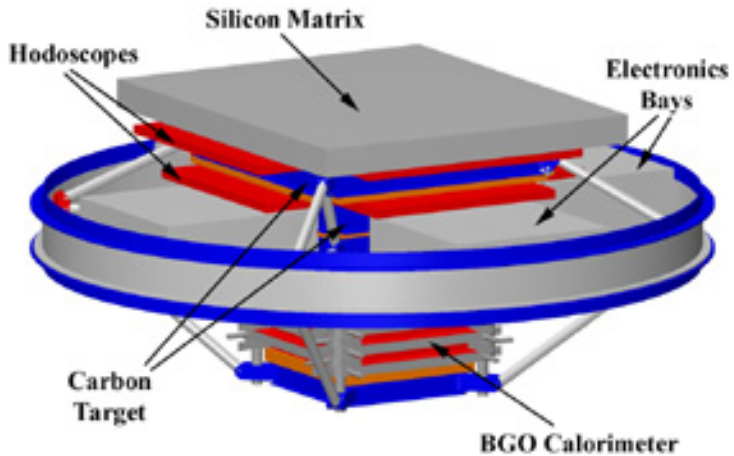
# Ceramic board for ATIC



# ATIC

## Silicon Matrix detector components




## Schematic of the ATIC instrument


# Experiments

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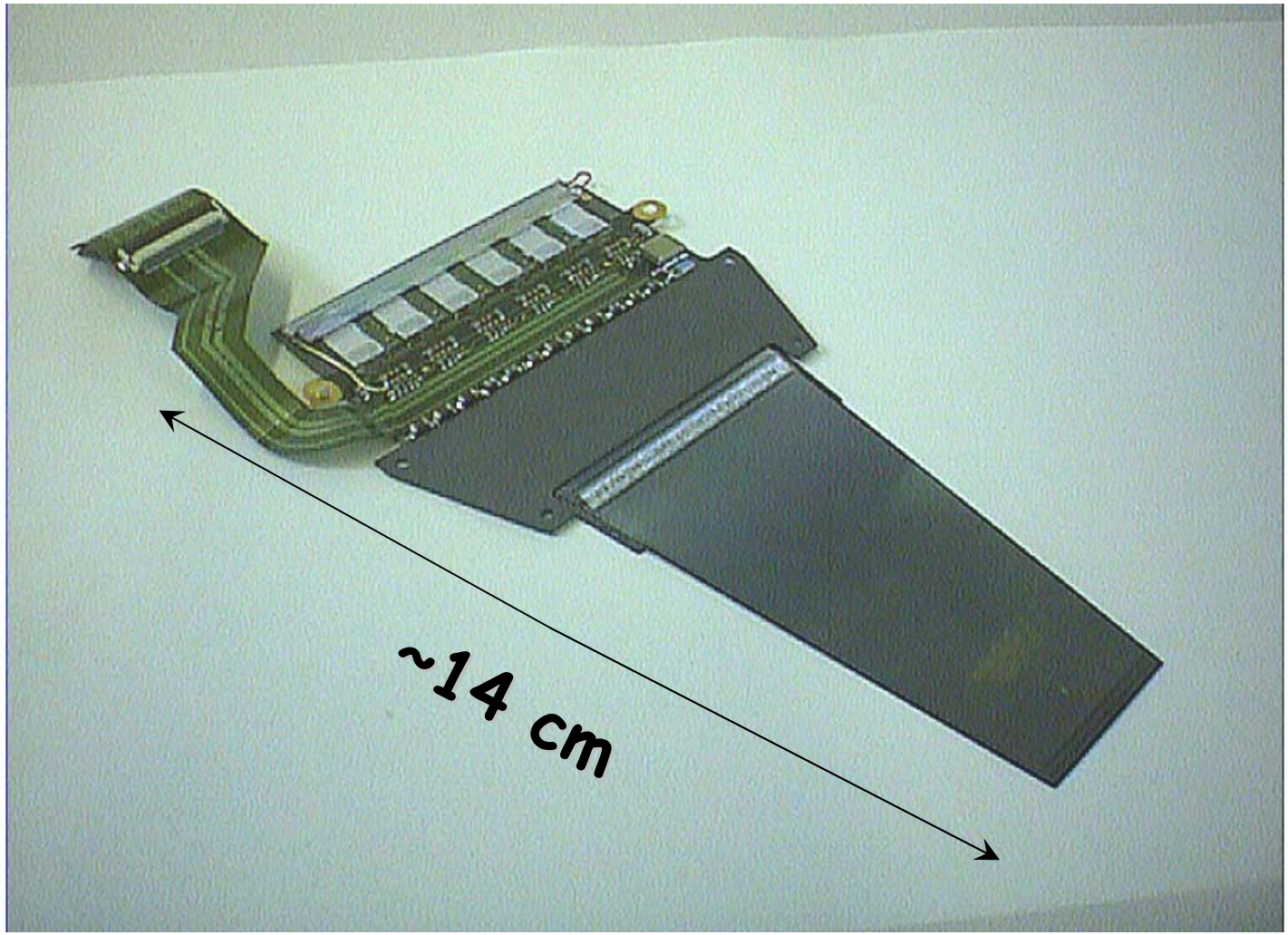
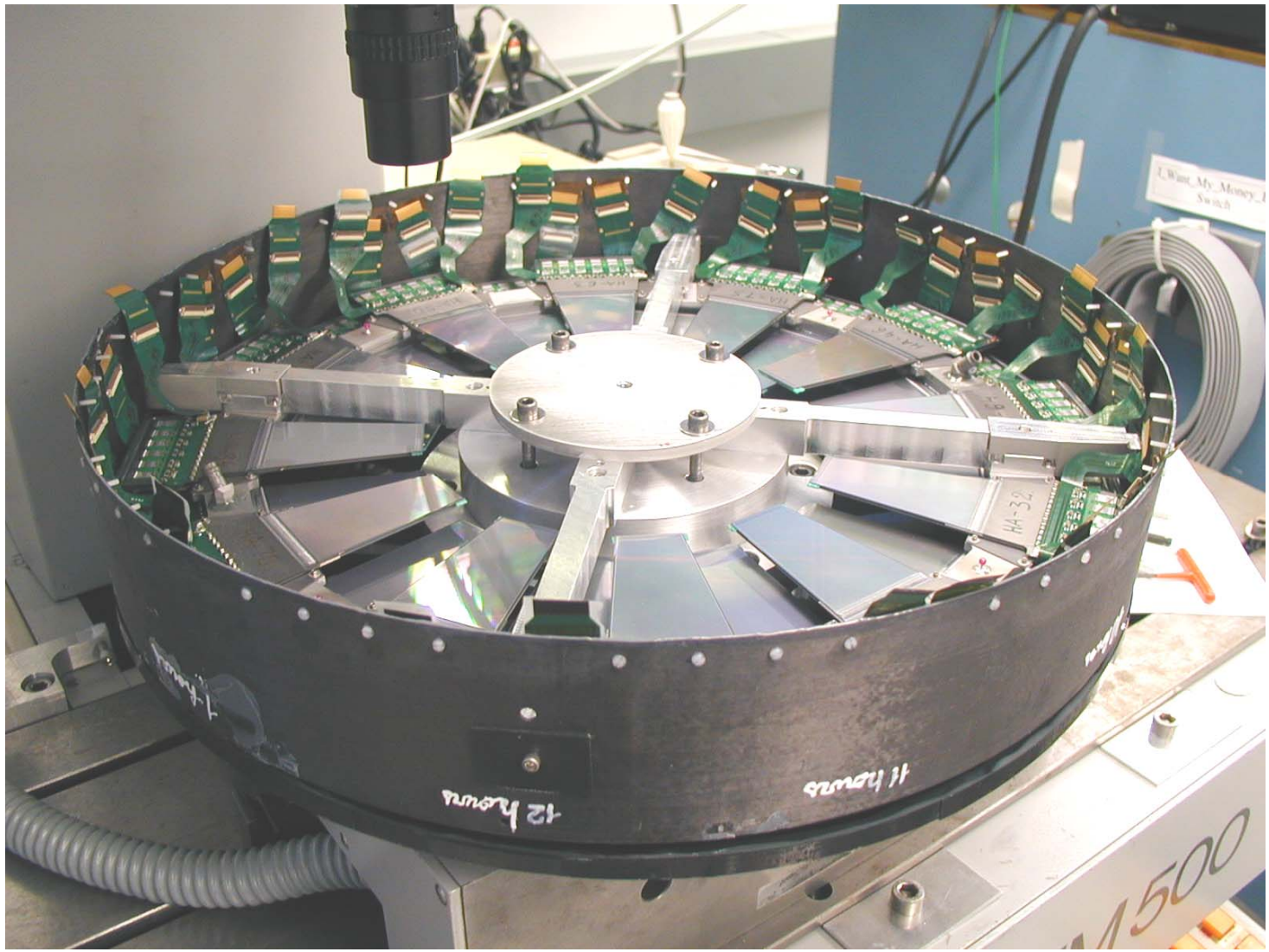
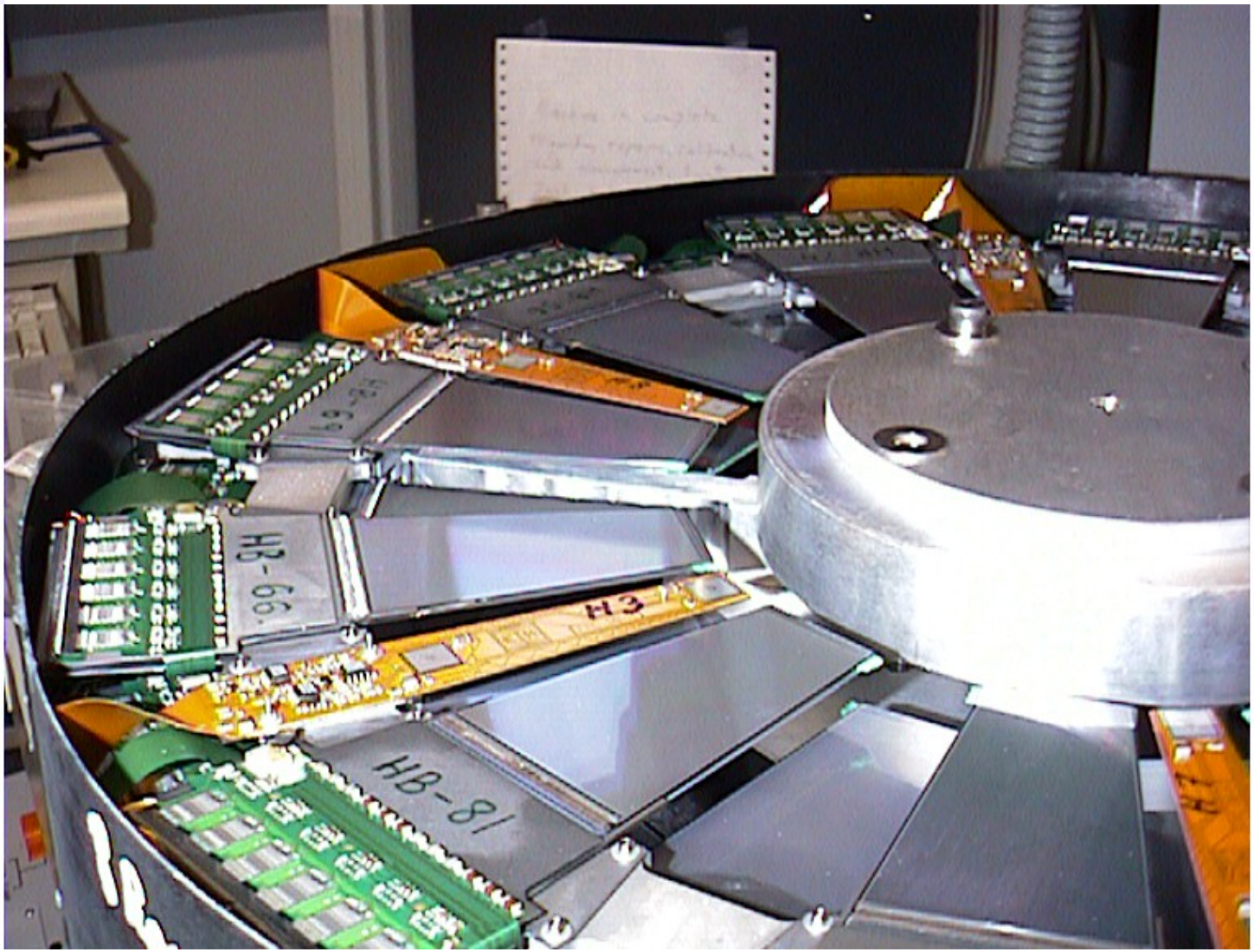
# D0 H-disk wedge



# D0 H-disk



# D0 H-disk




# Experiments

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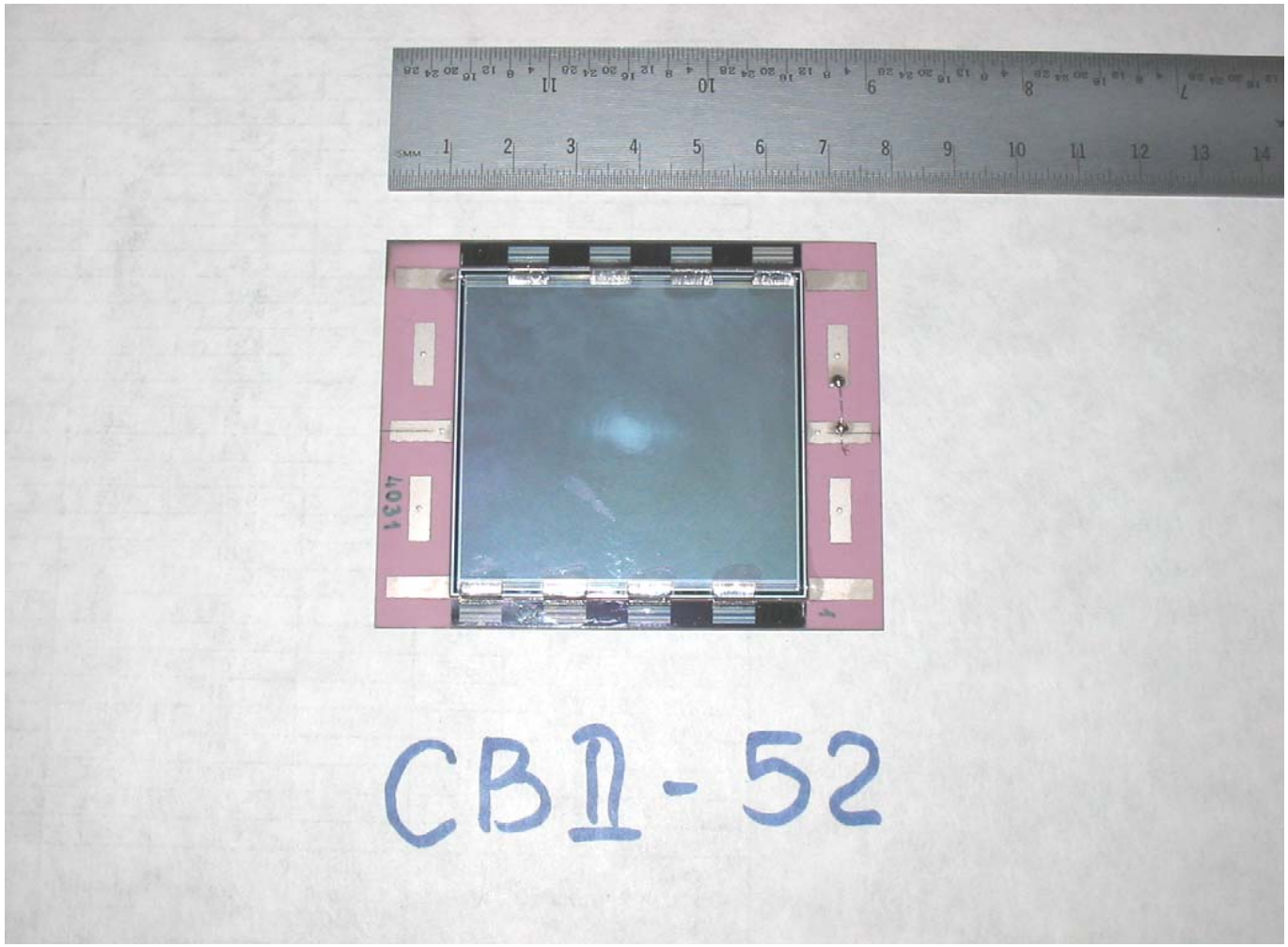
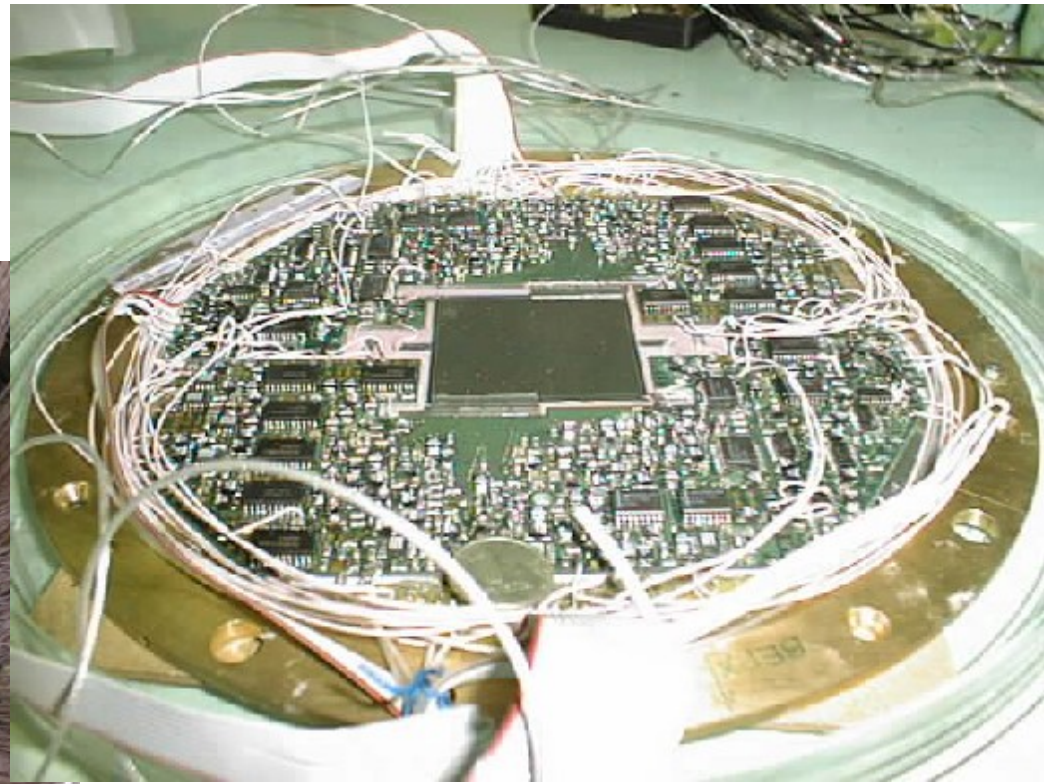
# 25 μm pitch sensor for SVD-2 experiment

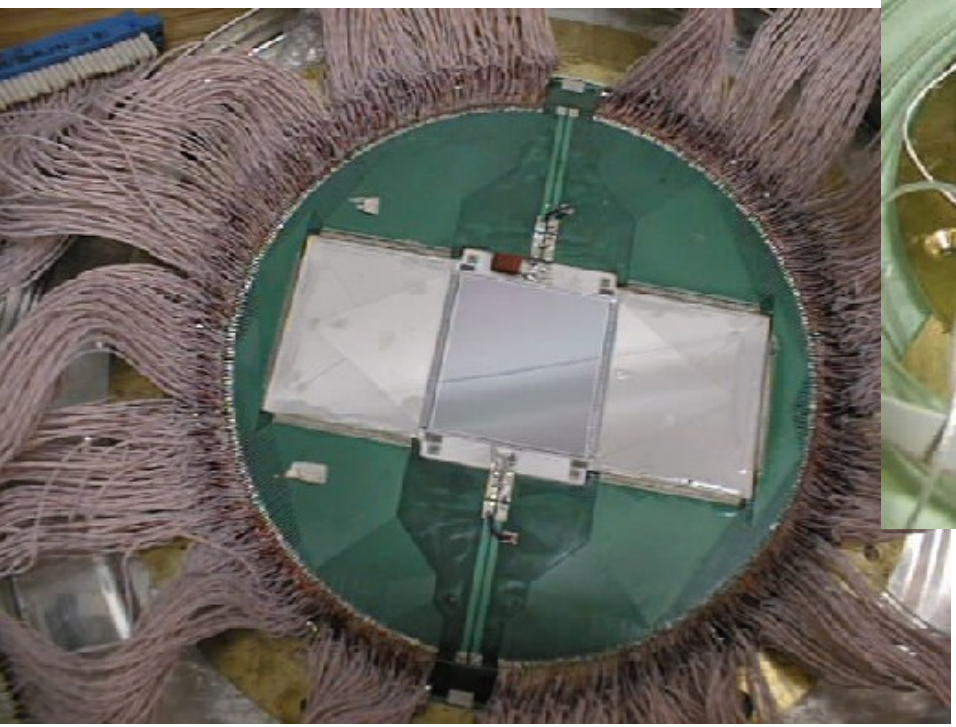
# 50 µm pitch sensor



# SVD-2 Silicon Tracker

VA-1 Readout ⟶





⟵ GASSIPLEX Readout


# Experiments and RDs

- ECAL for Future Linear Collider (TESLA)
- Nose Cone Calorimeter for Phenix experiment at RHIC (BNL)
- CBM (Compressed Baryonic Matter) Experiment at GSI (Darmstadt)
- D0 RunIIb


# TESLA Sensors: parameters

- 4" high resistivity wafers
- wafer thickness 525 μm
- sensor size: 62.0+0.0 -0.1 mm
- scribe line: 60 μm
- active area size: 60.0
- the dead zone width is about 1 mm

# Pad array design (future)

Along with the diodes, the technique used for fabrication of *bias resistors* and *coupling capacitors* represents an important issue:

- *polysilicon resistors* – production of the tile needs 7-8 masks; *can be the source of additional yield reduction.*

But should not be a problem to have:

- resistors 1 - 10 MΩ and
- capacitors - 1-10 nF.

# Pad array design (future)

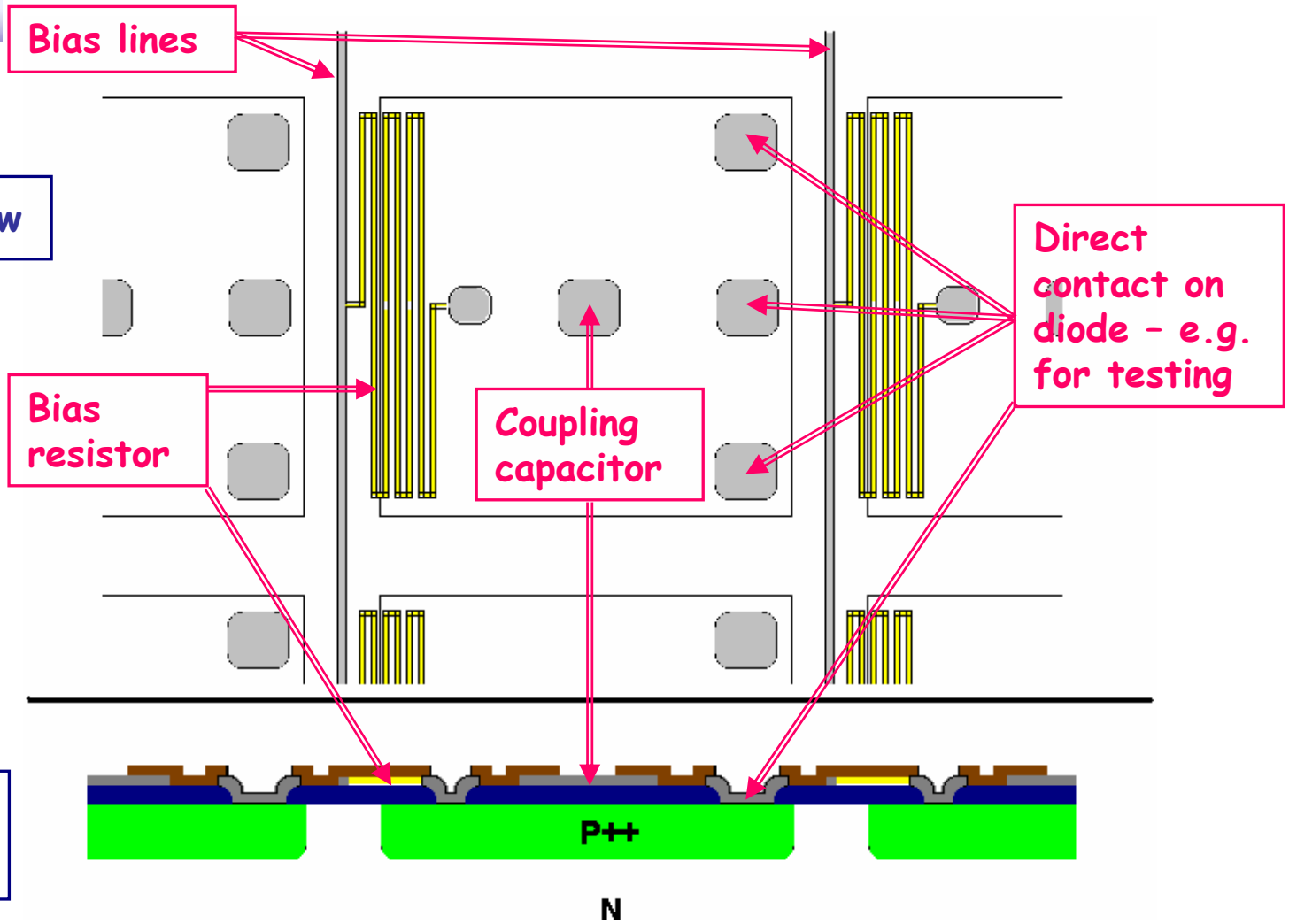
- *punch through resistors* – production needs about 4 or 5 masks;

  *easy to produce, but needs to check whether required parameters can be achieved,*

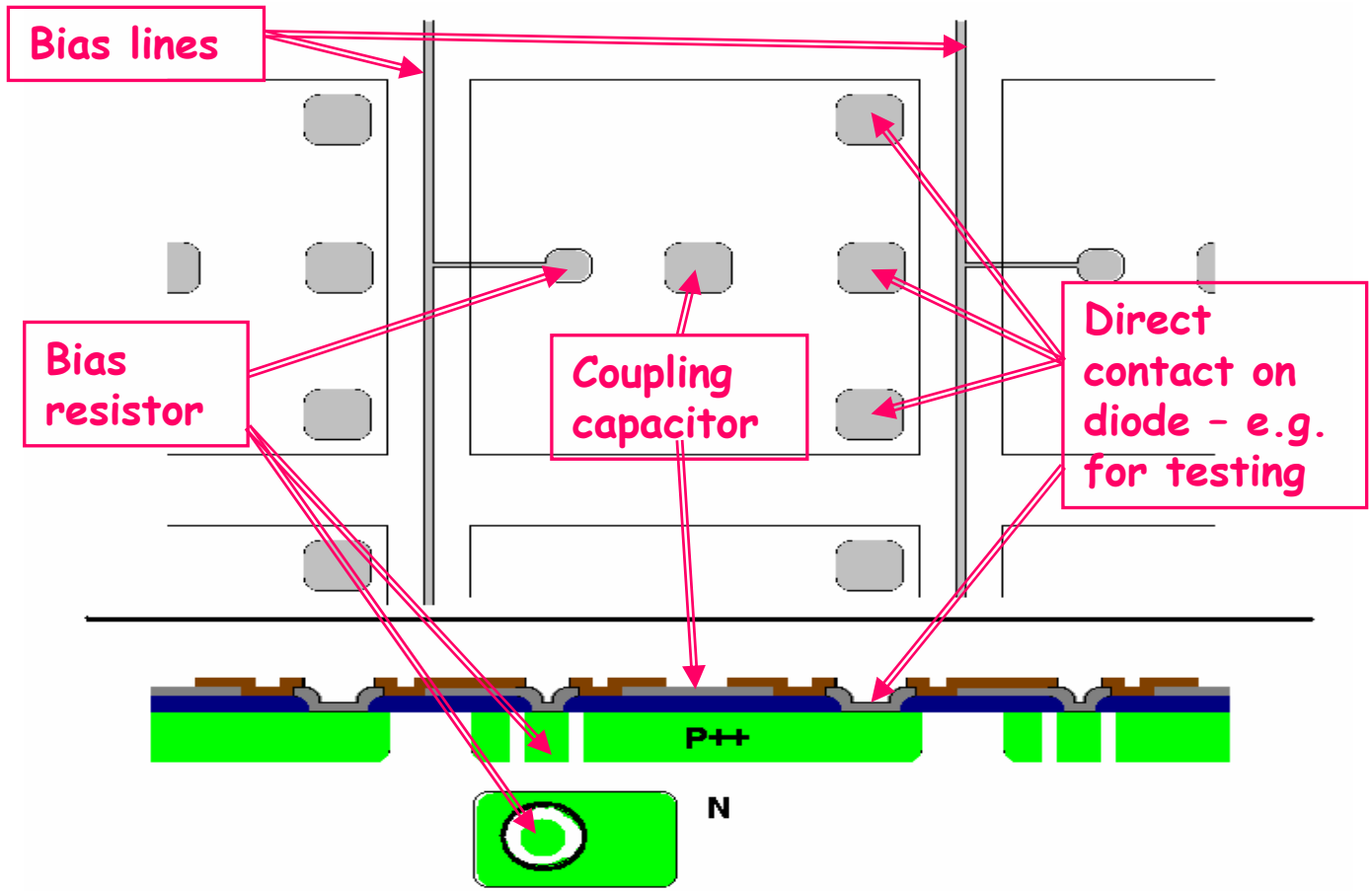
  *has very low radiation hardness.*

  *In case of integrated capacitors, it needs at least 6 masks*

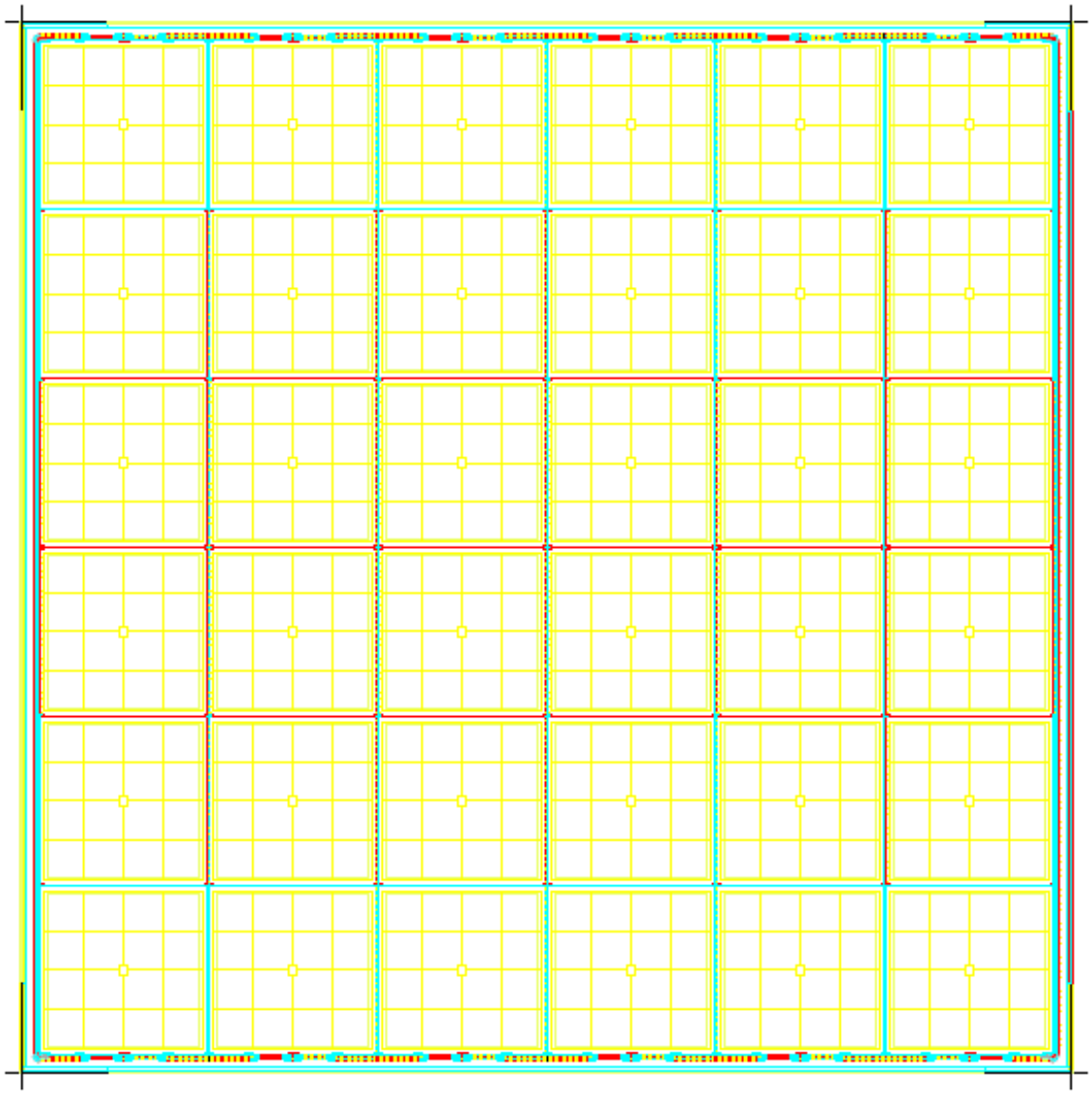
# Polysilicon resistors (option)



# Punch through resistors (option)



# TESLA Sensors: design



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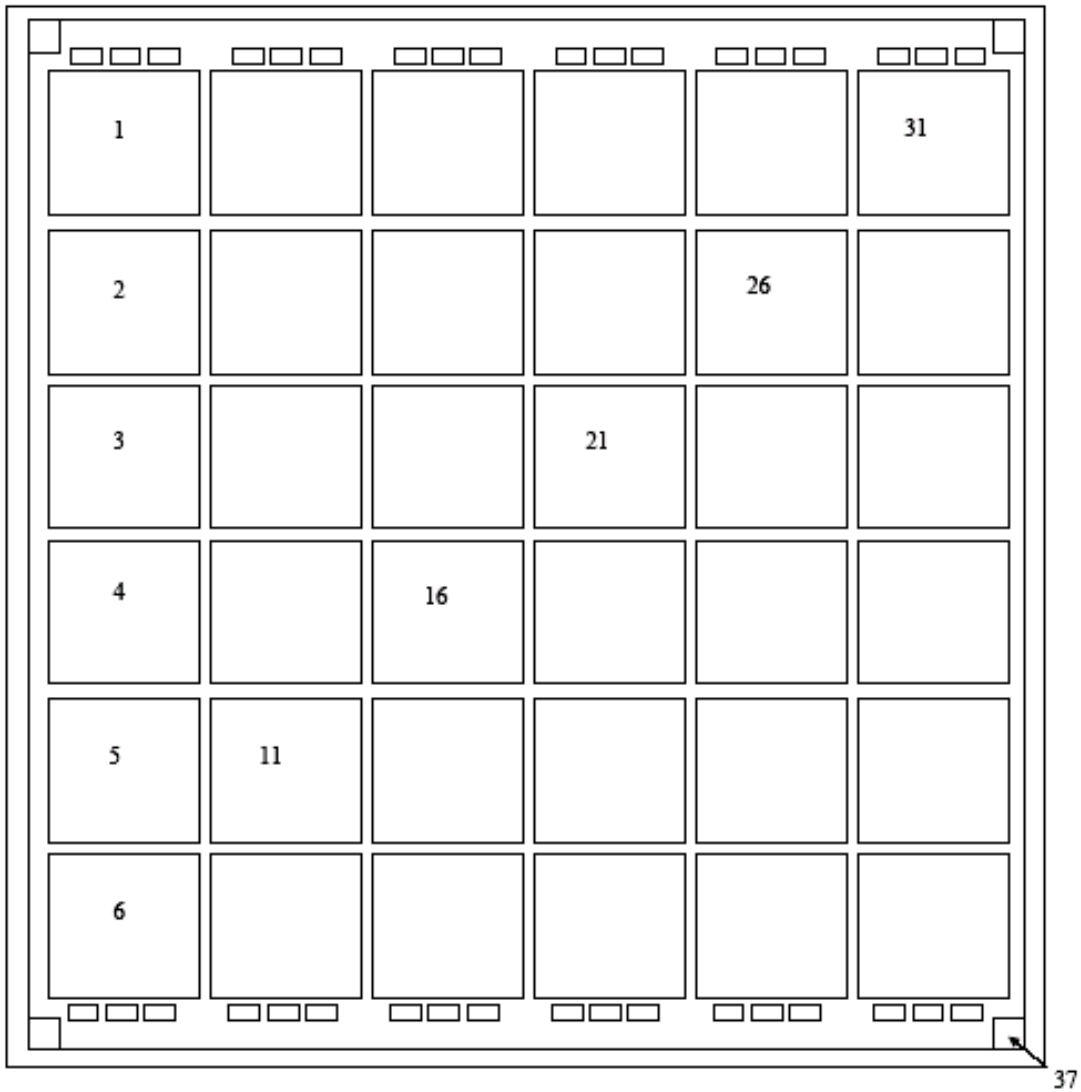

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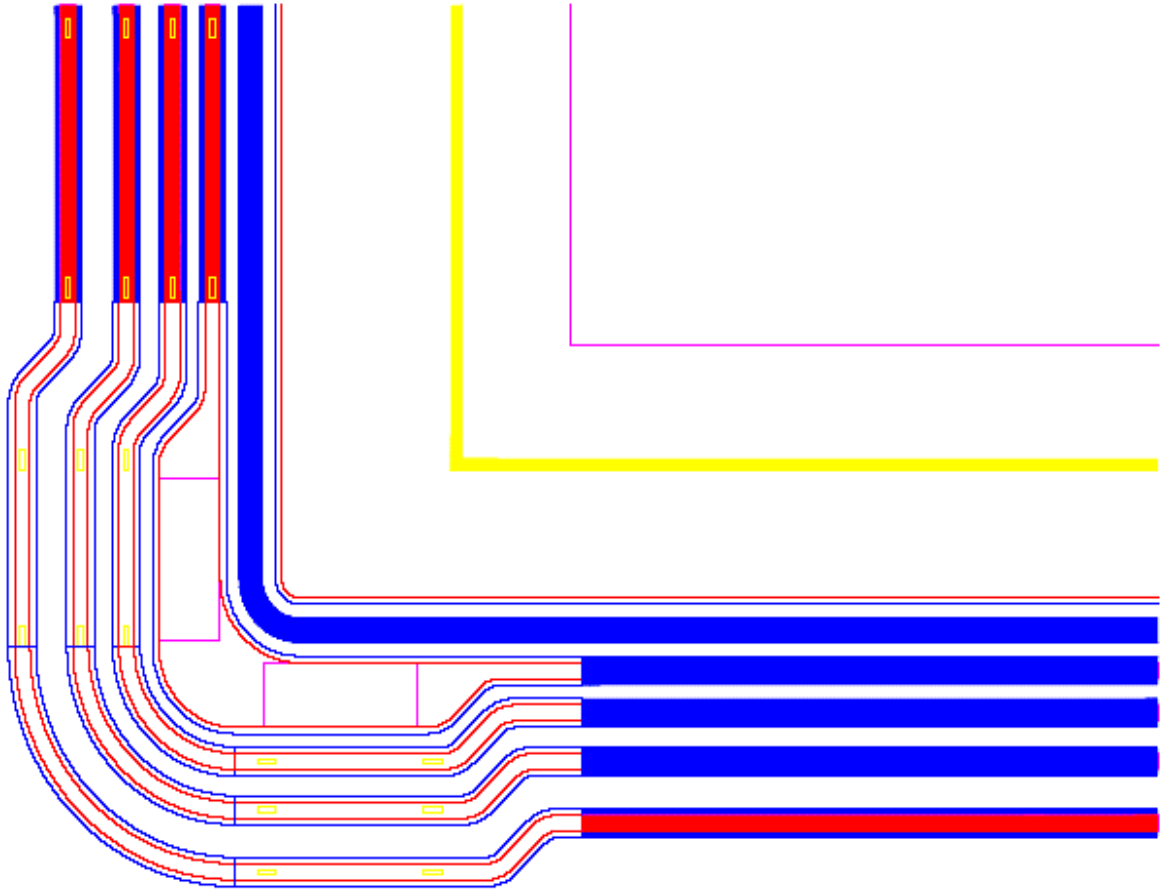

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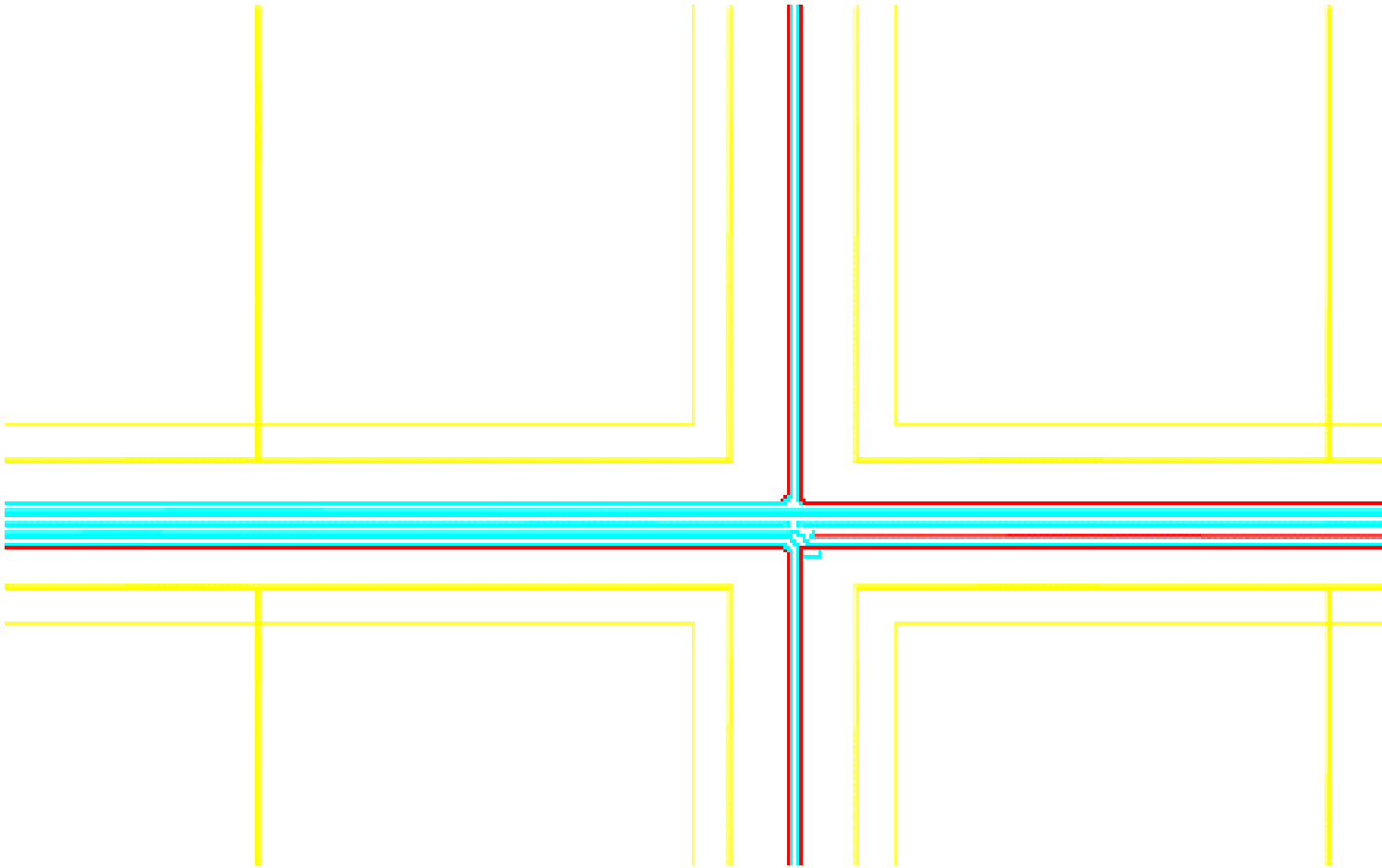

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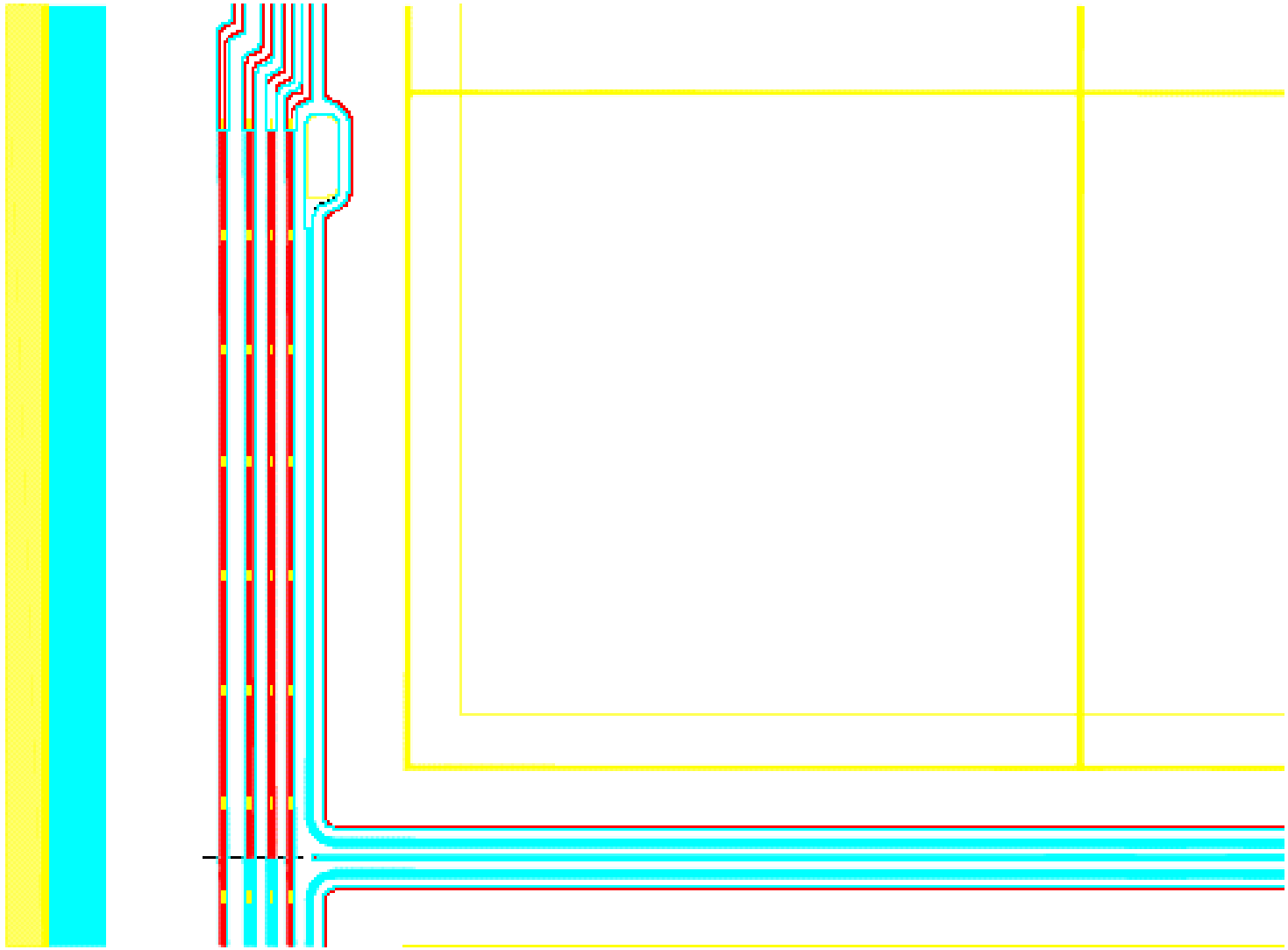

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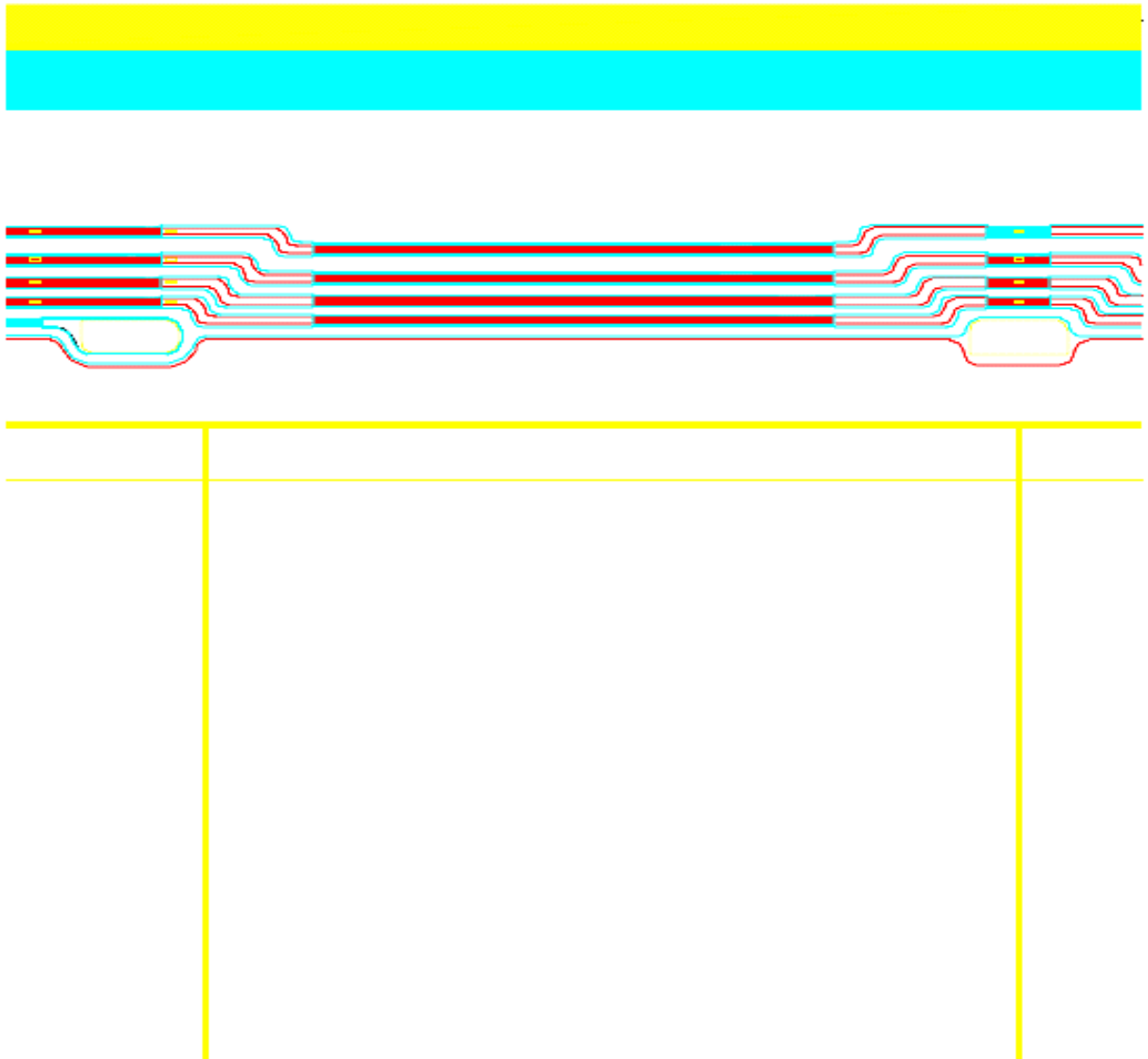

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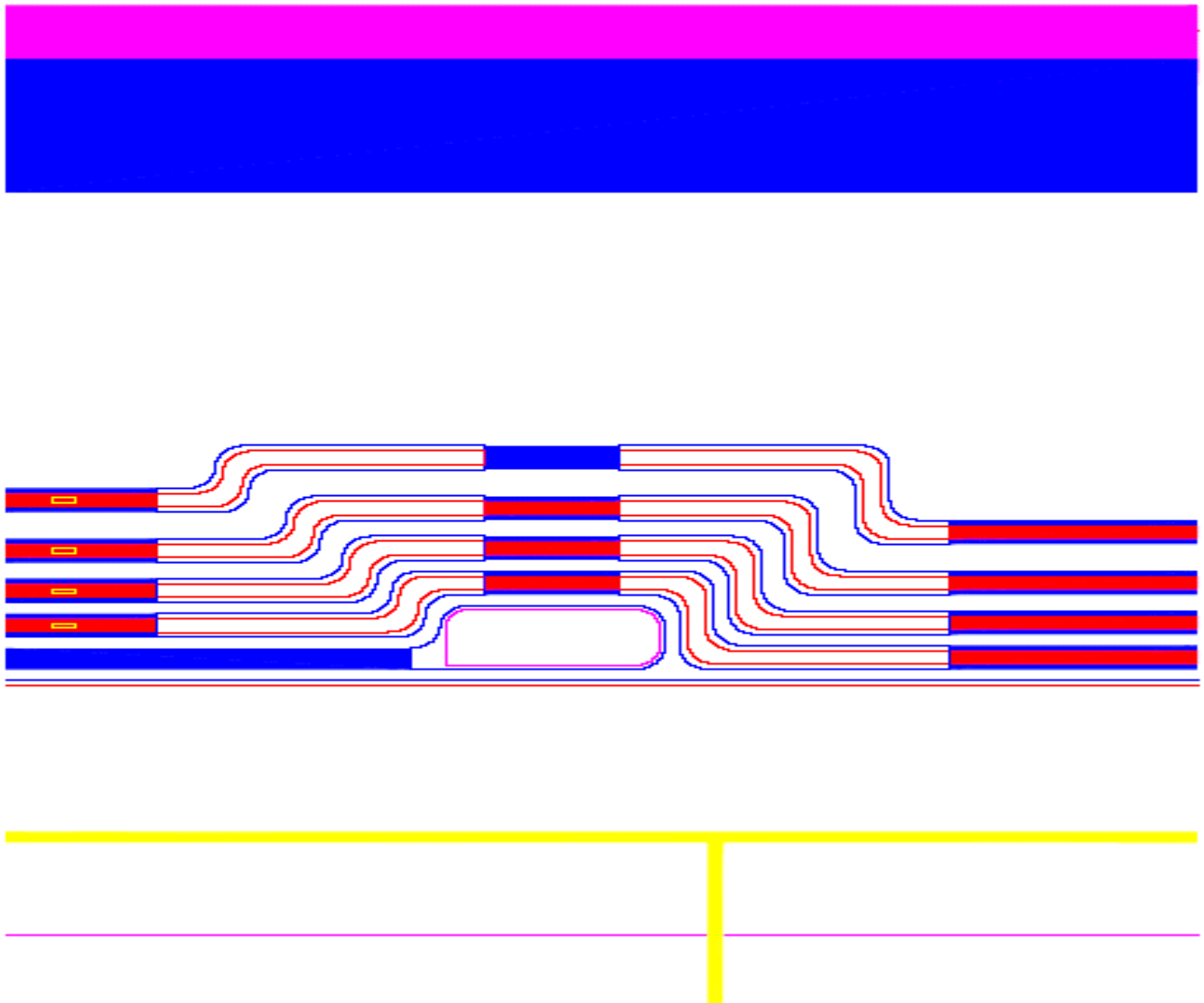


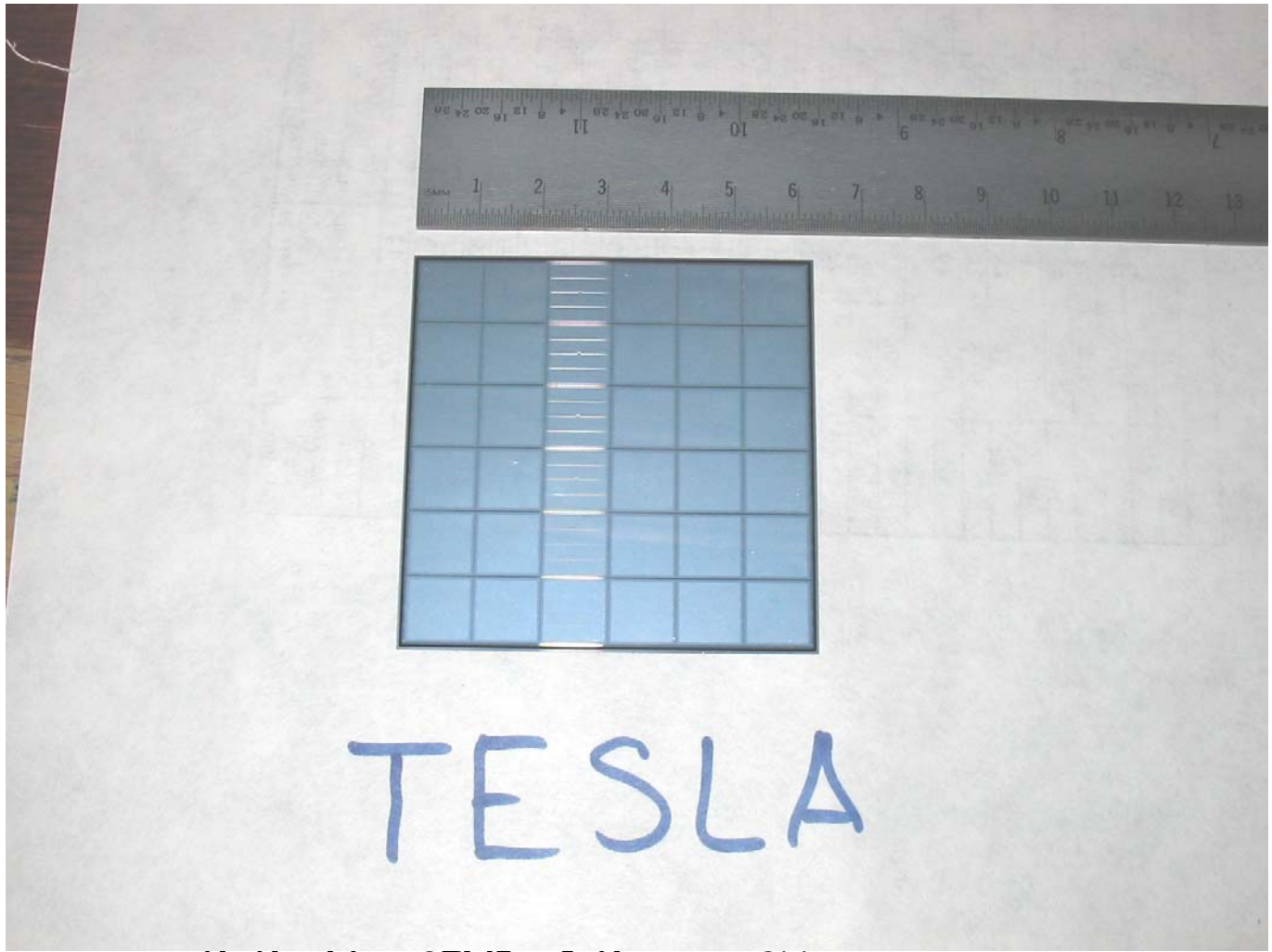
# Production Status

- Total 183 wafers have been developed
- Number of good sensors – 132
- Yield – 72%
- We had a few minor problems, but might be, it is because of fraction not good wafers.

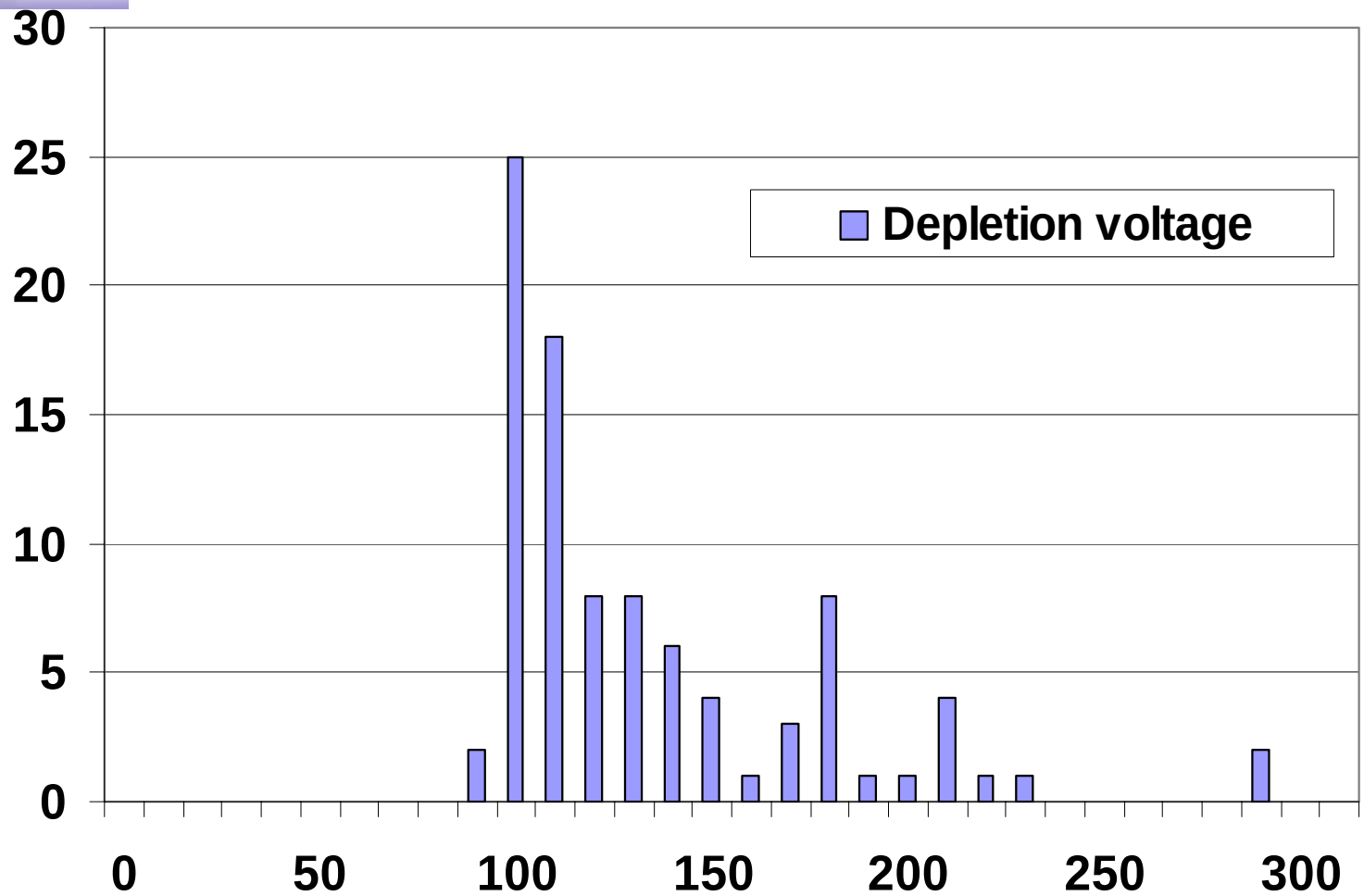

# Silicon Sensor Parameters

- pad area around ~1 $cm^2$,
- capacitance per pad - ~20 pF,
- leakage current < 100 nA/sensor,
- depletion voltage < 150 V,
- operation voltage > 150V,
- breakdown voltage > 400V.

# TESLA Sensors: prototype



# TESLA Sensors: results



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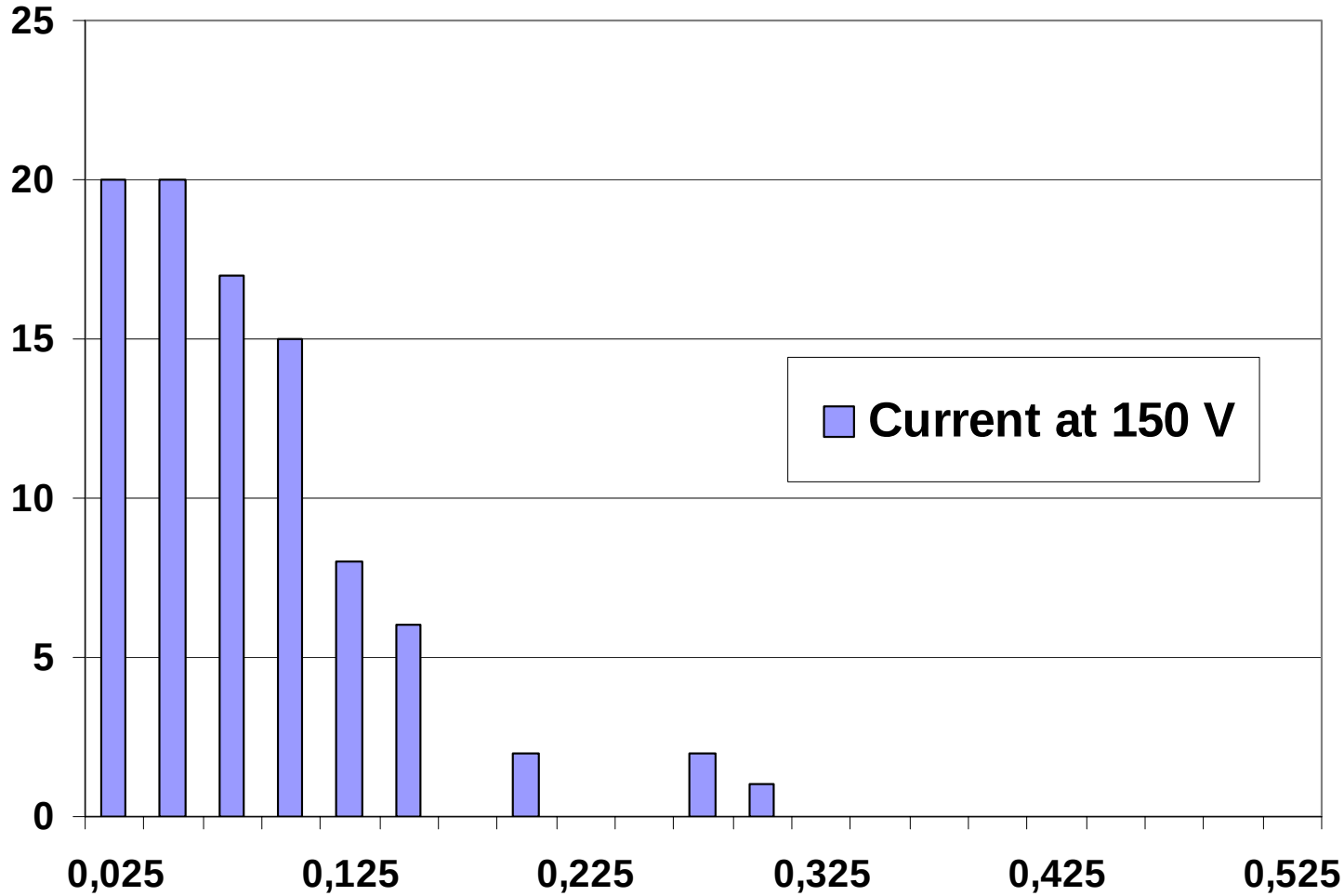

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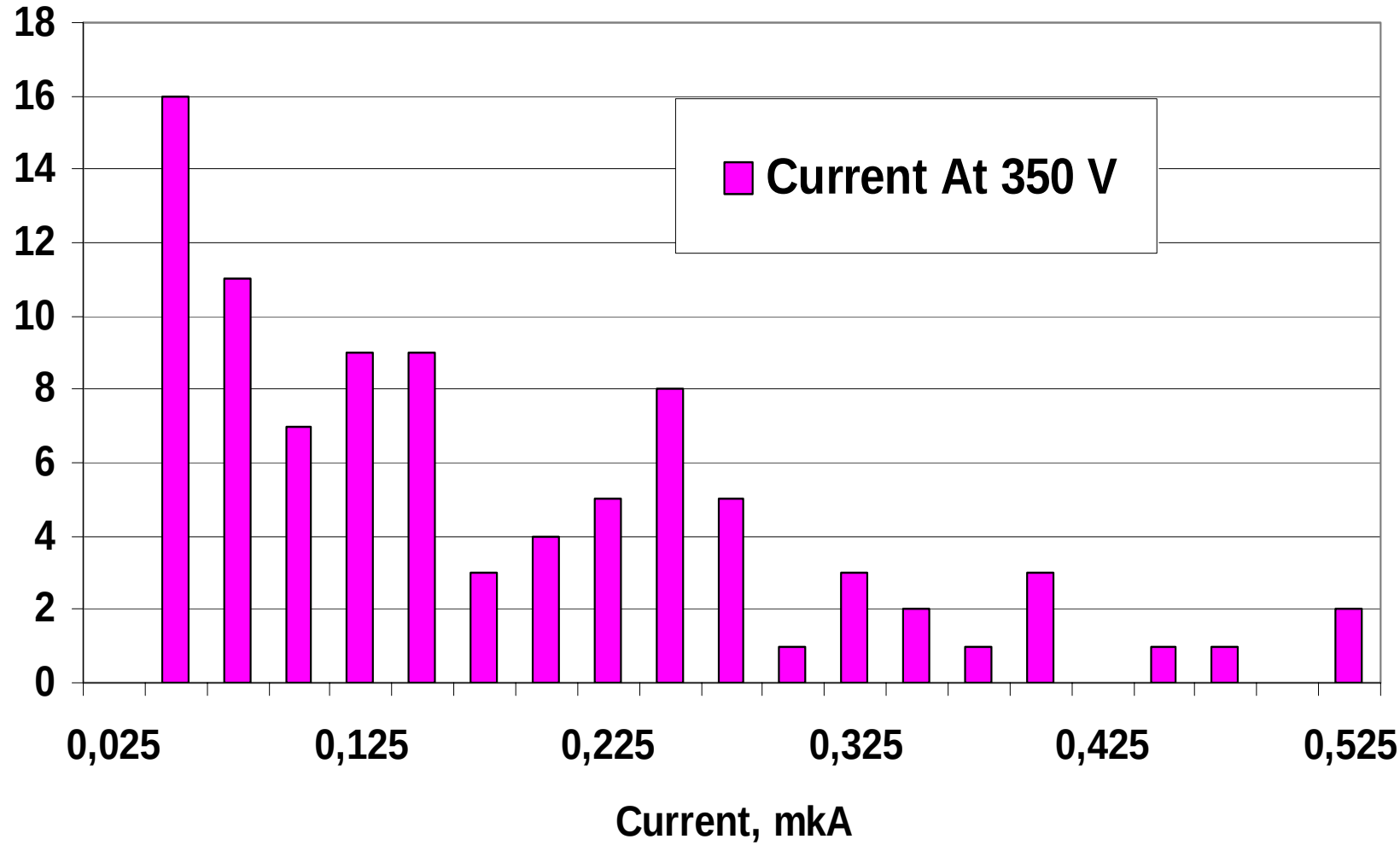
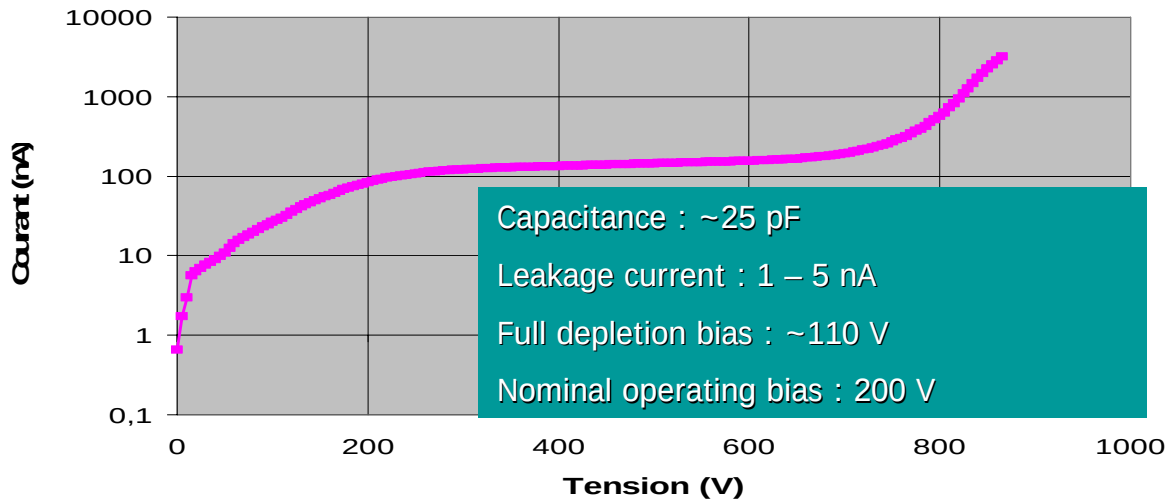
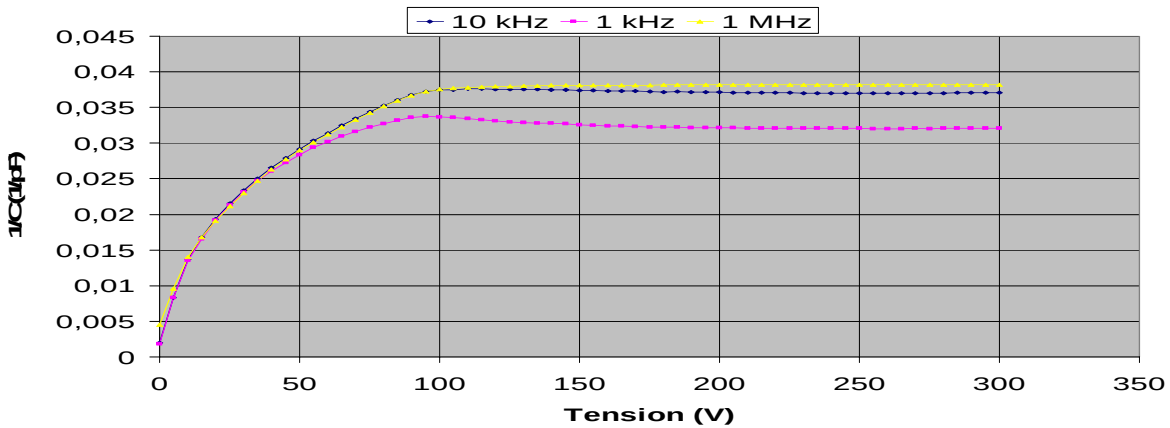


# TESLA Sensors: results

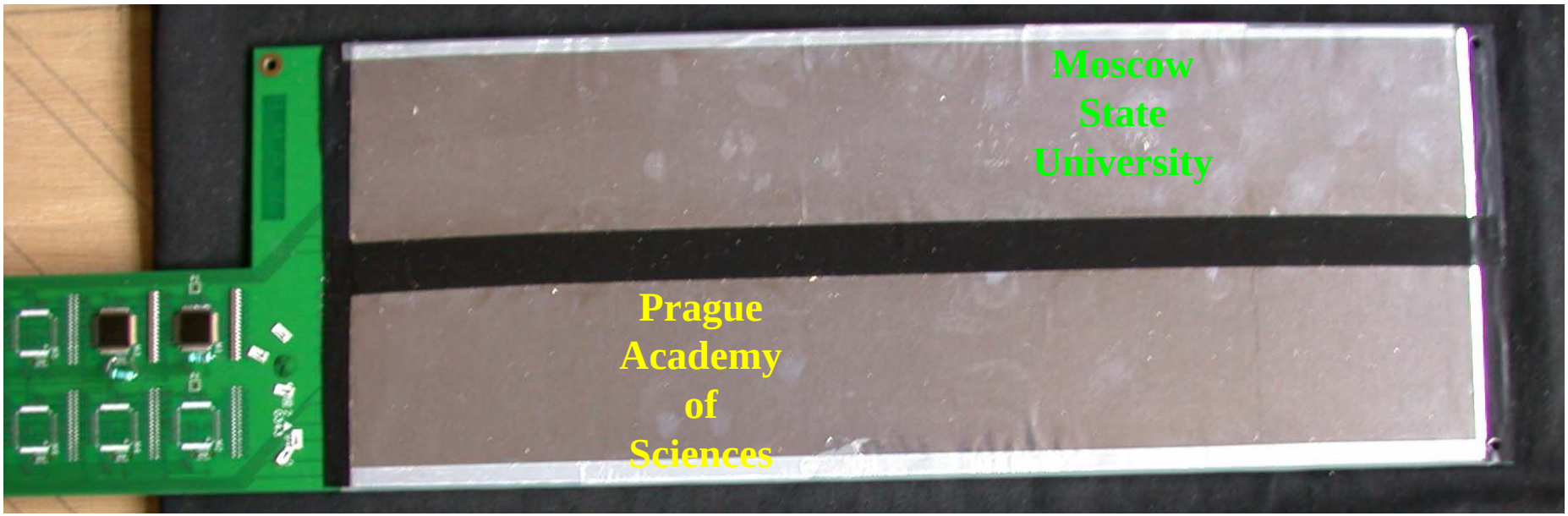
**Institute of Nuclear Physics**
**Moscow State University**



# TESLA Sensors: results

First test with a complete detector slab



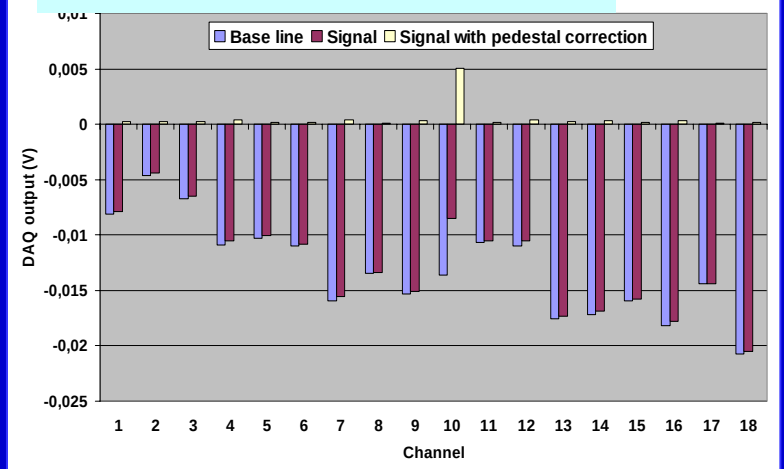
# TESLA Sensors: results

## "internal" signal

**1 MIP injected in channel 10 with CALIB chip and measurement made on 100 points**

-Theoretic result : 4.97mV ($C_f$=1.35pF)

-Measured : 5.05mV

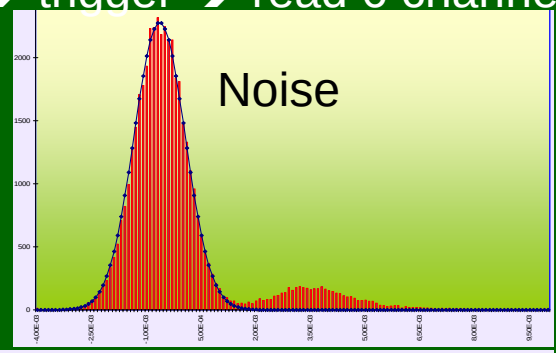


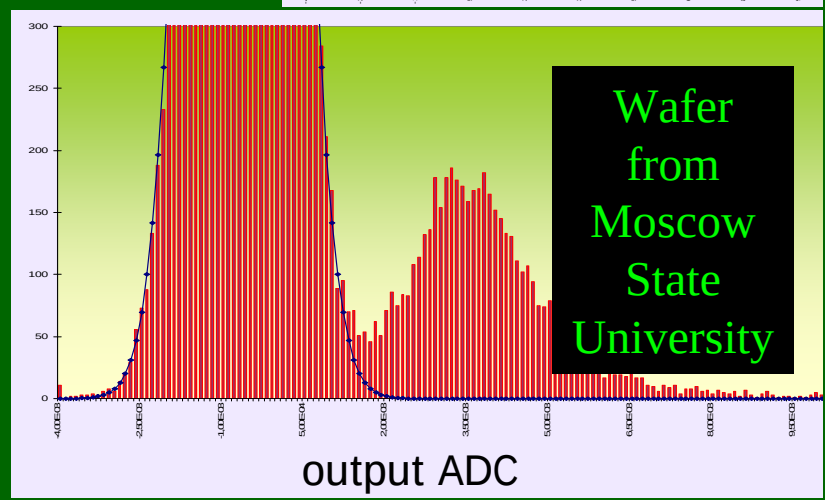

## "external" signal

$Sr^{90}$ source ➔ trigger ➔ read 6 channels

Only ONE with signal

$$\frac{MIP}{Noise} \approx 7.5$$




# Experiments and RDs

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# PHENIX Forward Calorimeter

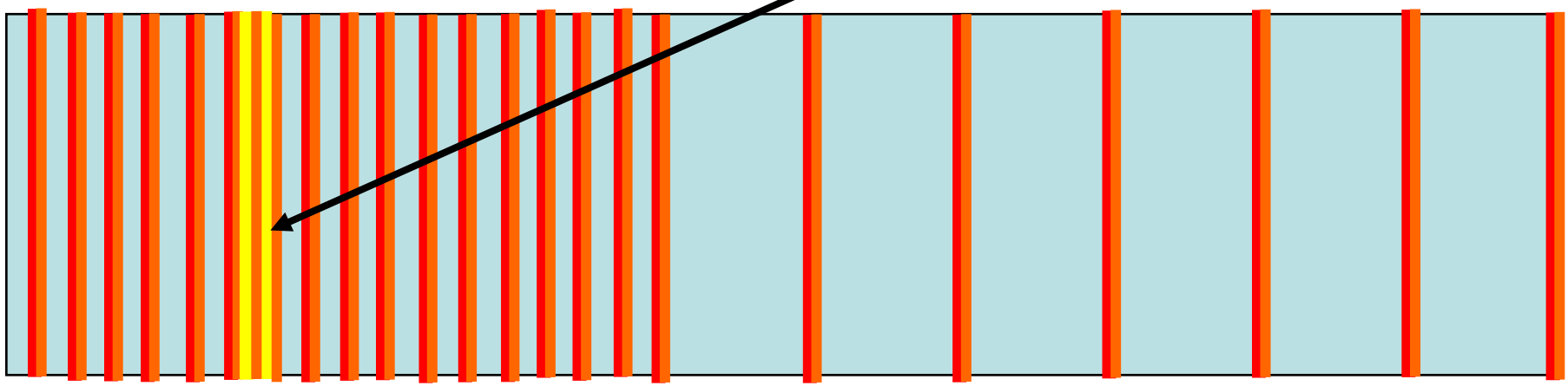
## Fine compartment

Photon converter section

Shower section

## "Coarse" (leakage) compartment

$\pi^0/\gamma$ identifier (strip layers)



Tungsten absorbers (2.5 mm)

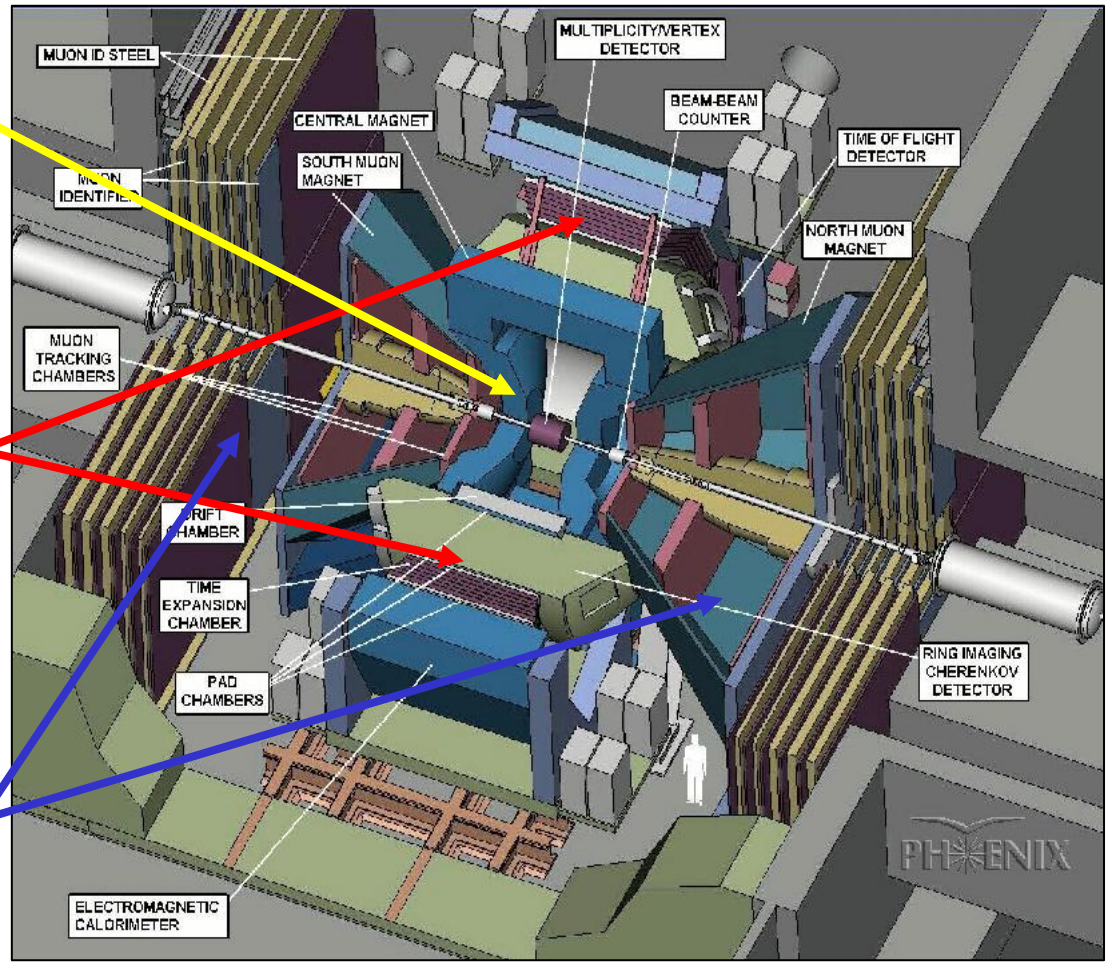
Tungsten absorbers (16 mm)

# PHENIX Forward Calorimeter

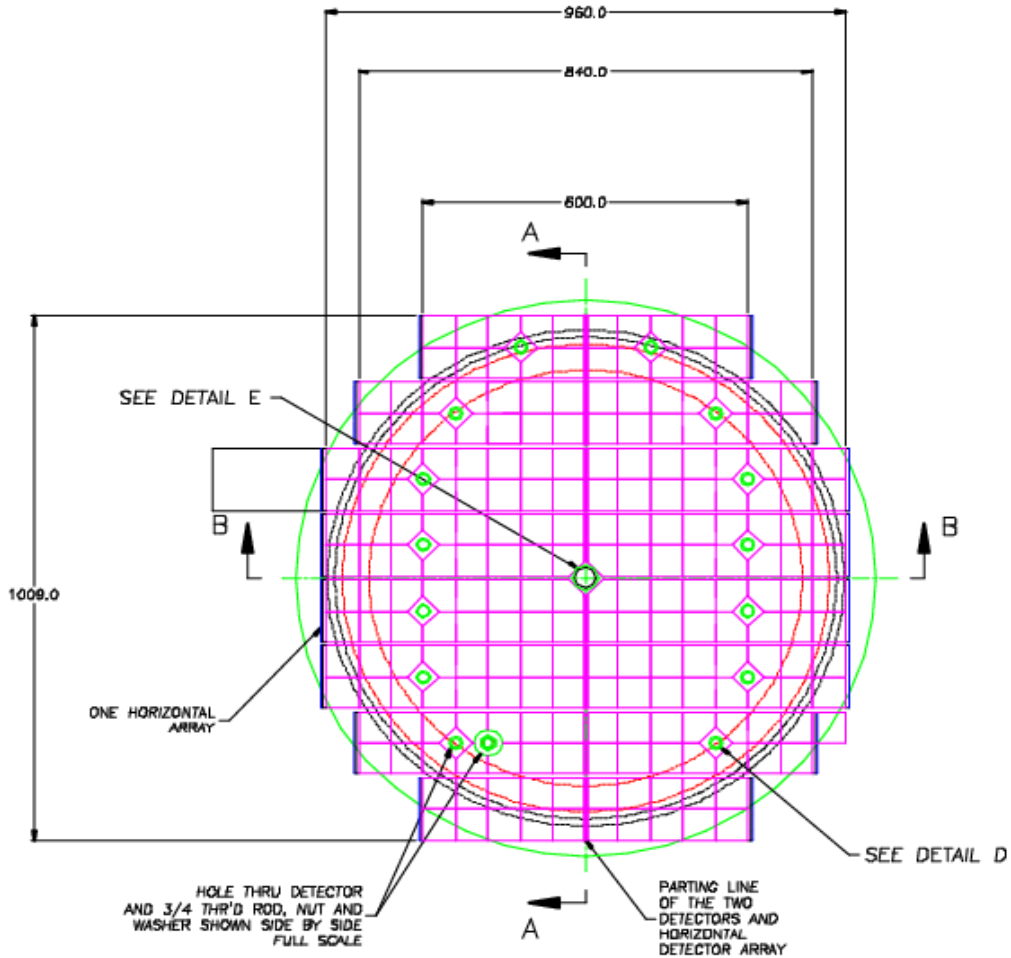
**Event characterization detectors in middle**

**Two central arms for measuring hadrons, photons and electrons**

**Two forward arms for measuring muons**



# PHENIX Forward Calorimeter



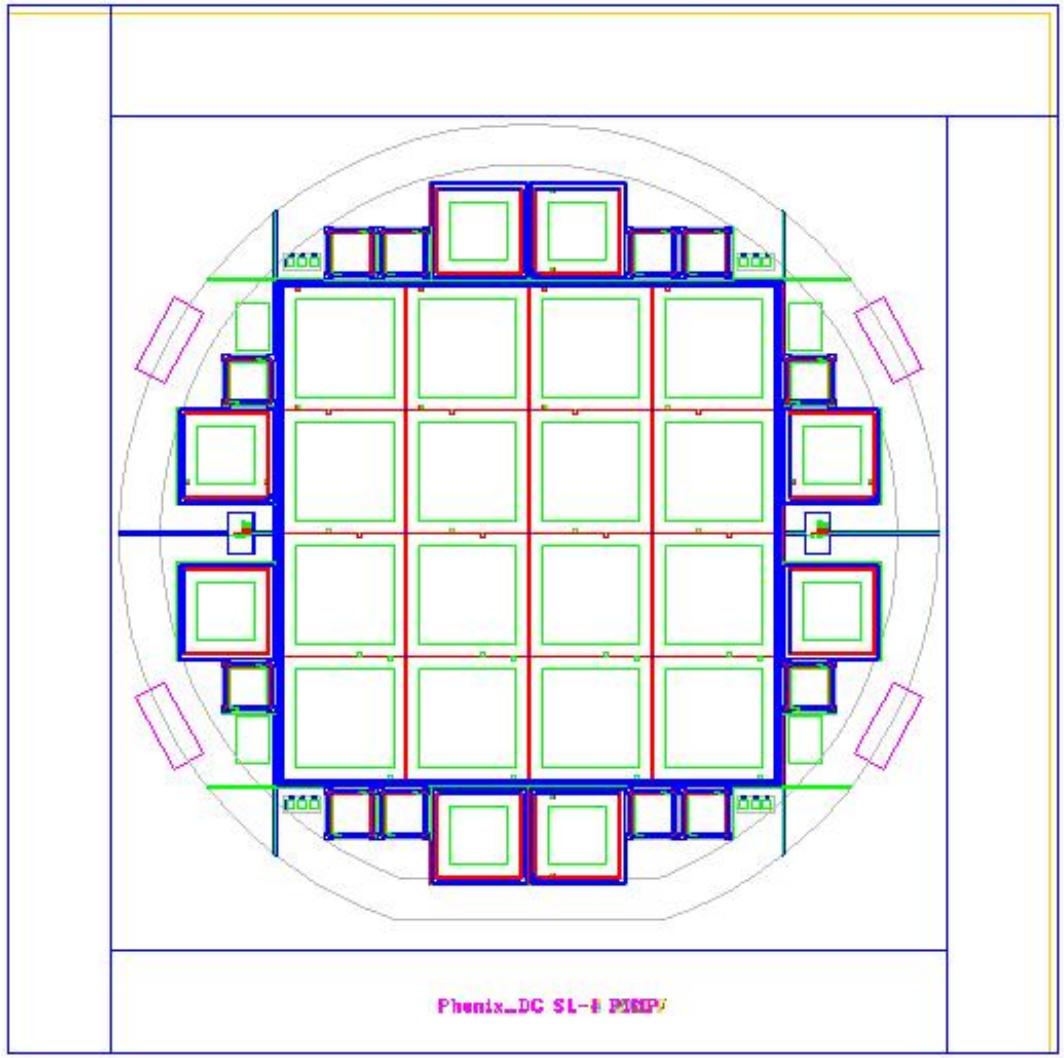

# PHENIX Forward Calorimeter

- Starts at Z - 40 cm
- Radial Coverage - 50 cm
- Geometrical Depth - 20 cm
- Absorber - W
- Sampling cells - 22
- Total depth (Rad. length) - ~40
- Expected EM en. Resol. - 20%
- Cell size - 1.5*1.5 $cm^2$


# PHENIX Forward Calorimeter

| Parameter | Value |
|---|---|
| Sensor active size (cm) | 6 x 6 |
| Pixel size (cm) | 1.5 x 1.5 |
| Pixels per sensor | 16 |
| Sensors per sampling layer (max) | 216 |
| Sensors in the detector | 3656 |
| Total area of Silicon ($m^2$) | 13 |
| Preamp | 32 channels |
| Chips / sensor | 0.5 |
| Channels / layer | <3500 |
| Readout channels | ~10000 |
| Dynamic range (MIP's) | 100 to 500 |

# PHENIX Sensors



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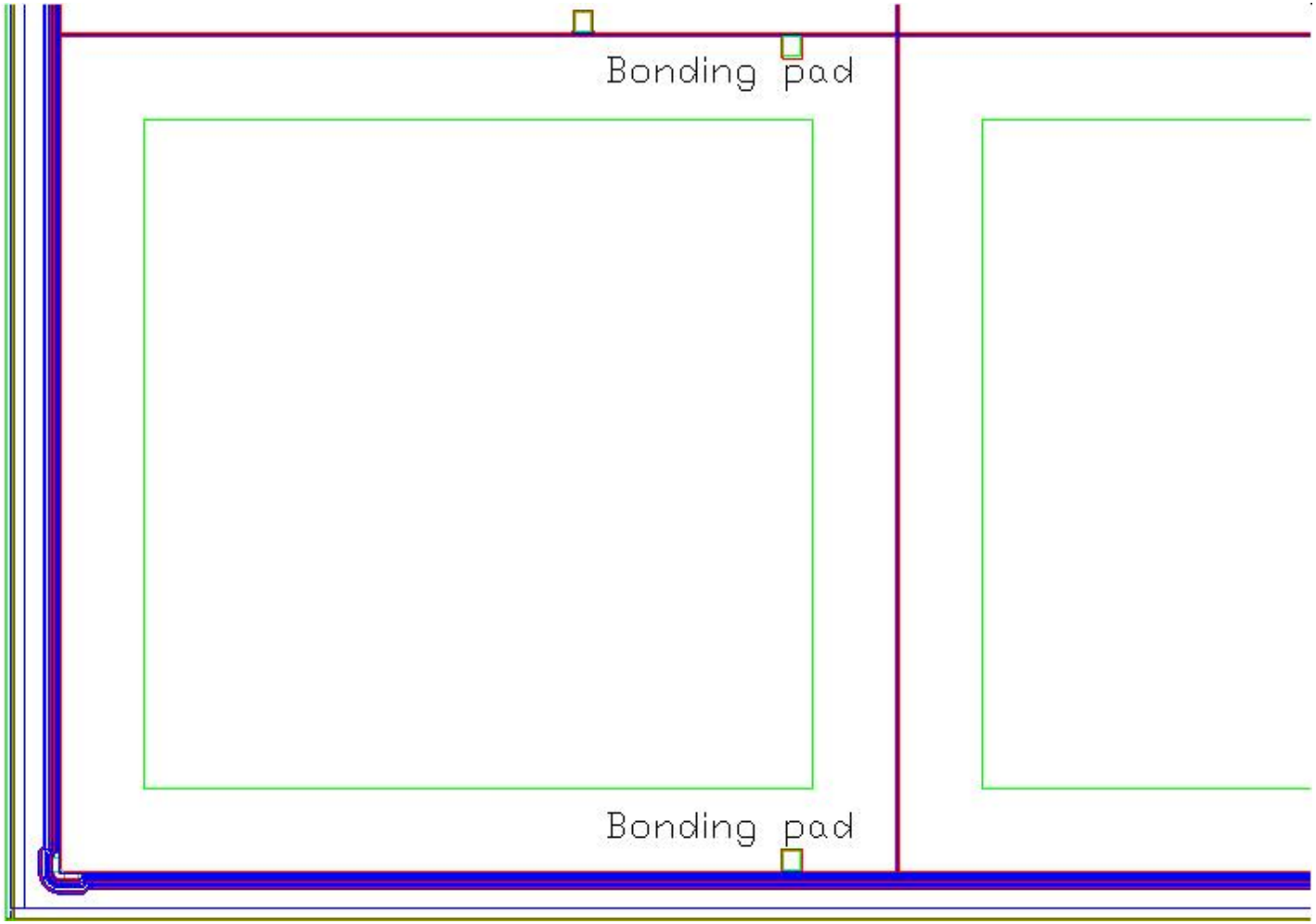
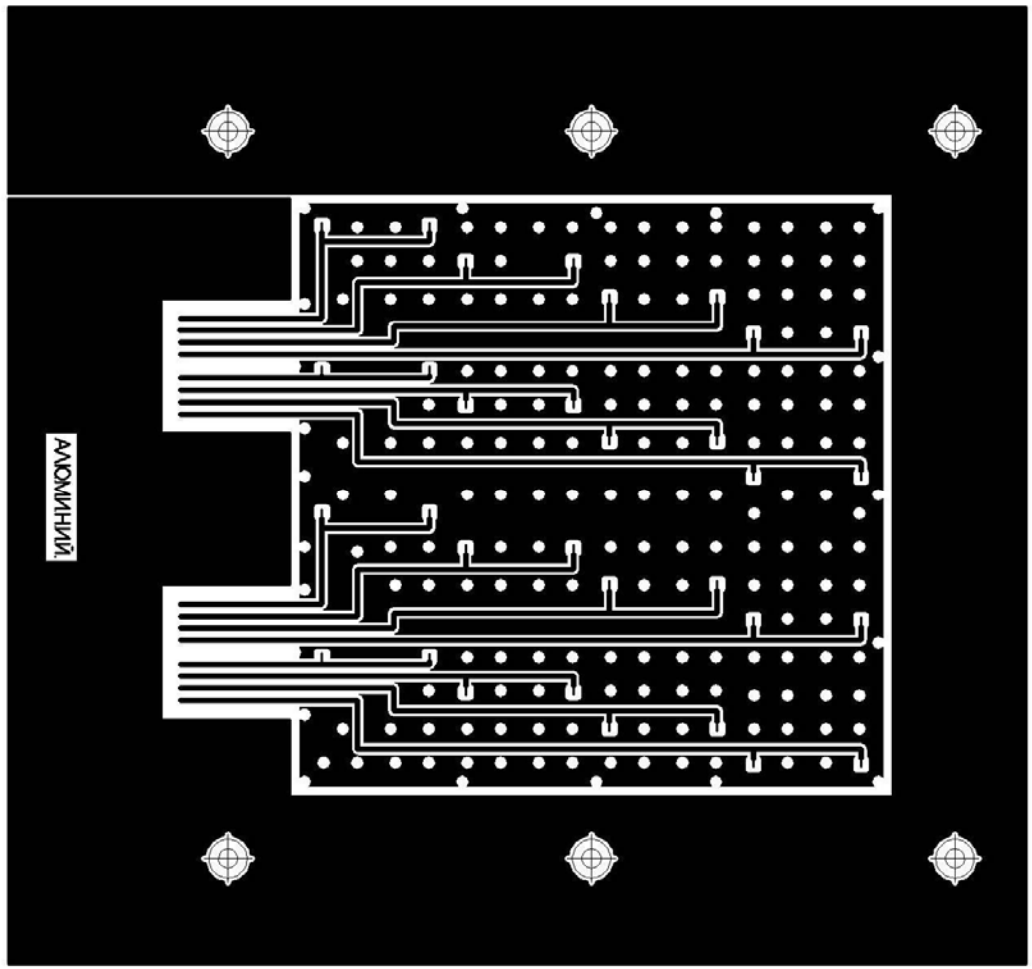


# PHENIX Forward Calorimeter

## Flex interconnect




# Plans

- Detector design:
  - 6" wafers
  - Radiation hard detectors & high voltage application
  - Double side & double side double metal detectors
- Electronics in collaboration with MEPhI:
  - Front-end electronics for silicon detectors: fast, low power consumption, high dynamic range
- Simulation in collaboration with Obninsk University


# Plans

- Large area integrated capacitors
- AC Couple pad sensors
- PHENIX full depth prototype by the end of 2005 (hope earlier) with DC sensors and 32 channels R/O boards.
- Strip sensors for PHENIX (?)