A DEPFET pixel-based Vertexdetector for TESLA

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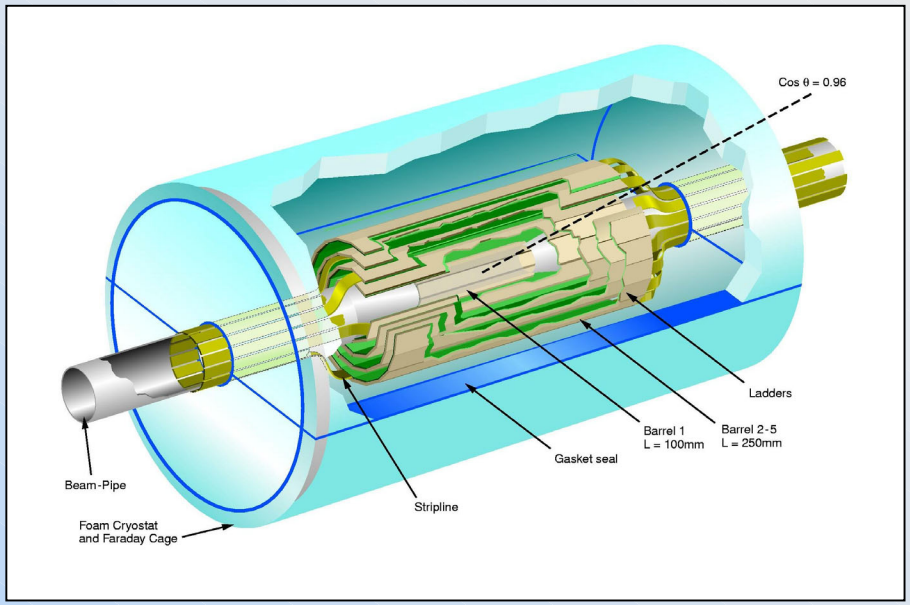
CONTENT

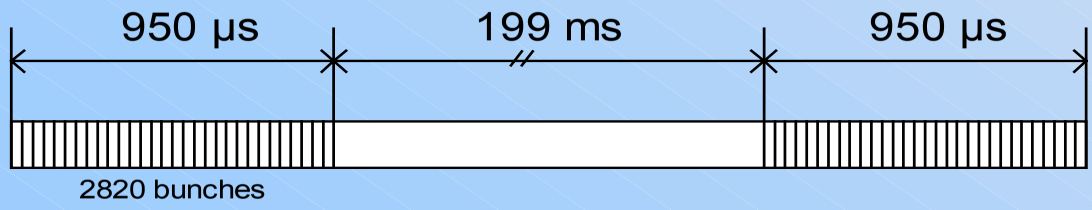
- Vertex Detection at TESLA
- The DEPFET Principle
- DEPFET pixels for TESLA
- Present Status
  - detector
  - thinning
  - Switcher (steering)
  - CURO (readout)
- Summary

Vertex Detection at TESLA

- **geometry:**
  same for all proposals
  - pixel size: 20-30 µm
  - close to IP, r = 15 mm (efficient c-tagging)
  - high spatial resolution: few µm
  - 5 barrels – stand alone tracking
  - thinned sensor: d = 50µm, ~0.1% X_0
  - overall: ~ 1GPixel



- **time structure**



high e^+e^--background:
80 hits / (mm^2 train)

50µs readout time for module / detector

Required clock rate: up to 50MHz for TESLA @ Layer I

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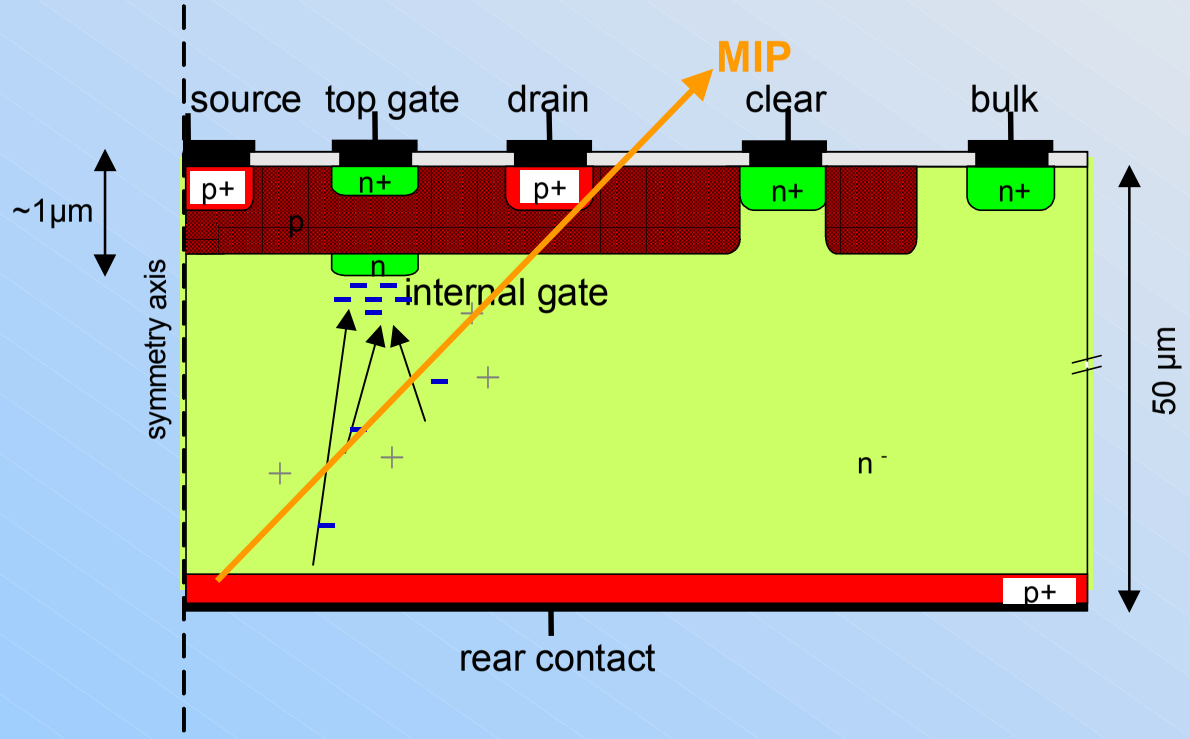
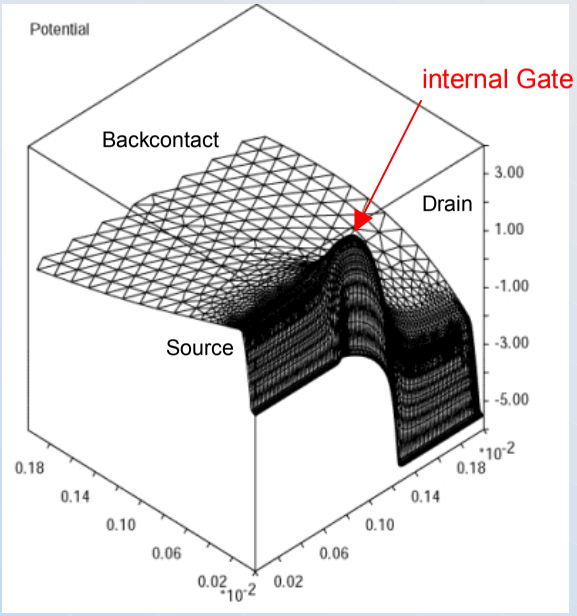
DEPFET-Principle of Operation



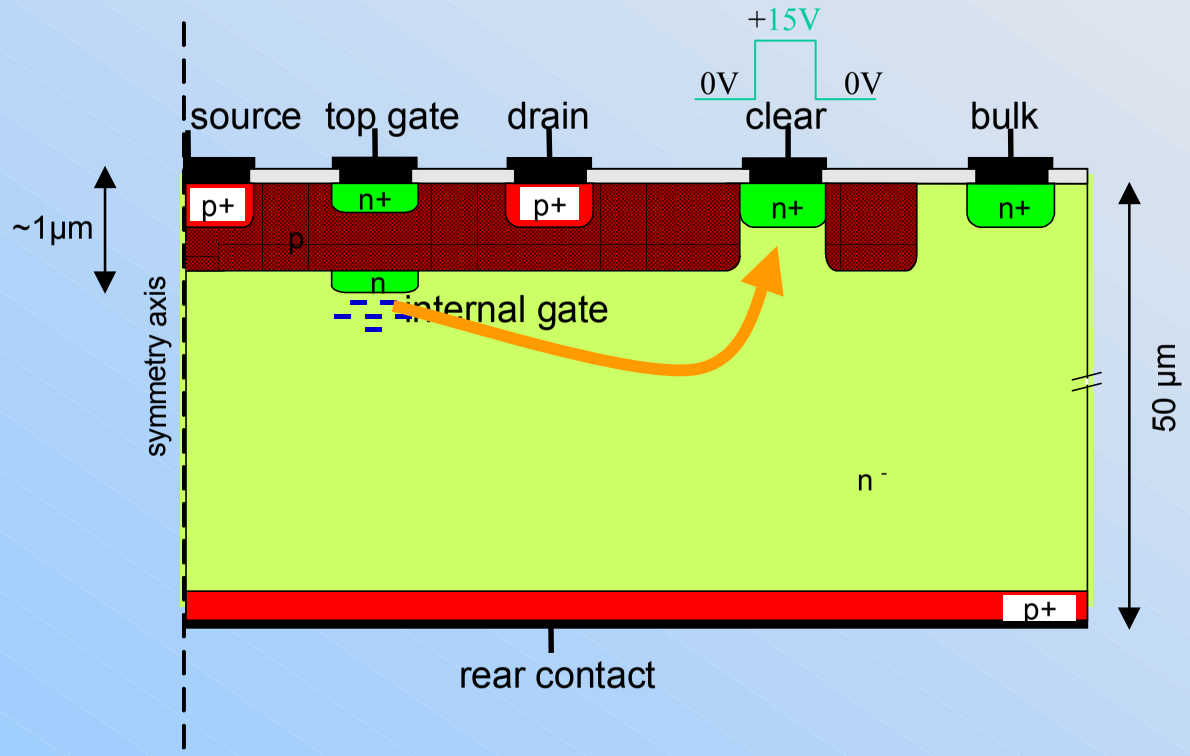
Potential distribution:



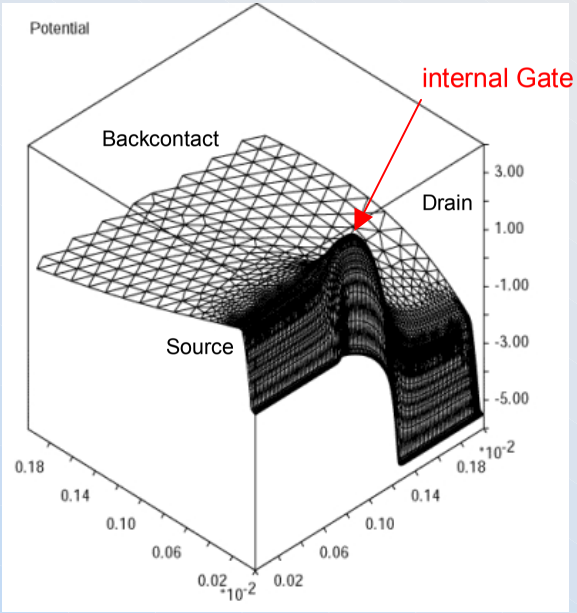
[TeSCA-Simulation]

- FET-Transistor integrated in every pixel (first amplification)
- Electrons are collected in „internal gate“ and modulate the transistor-current
- Signal charge removed via clear contact

DEPFET-Principle of Operation



Potential distribution:



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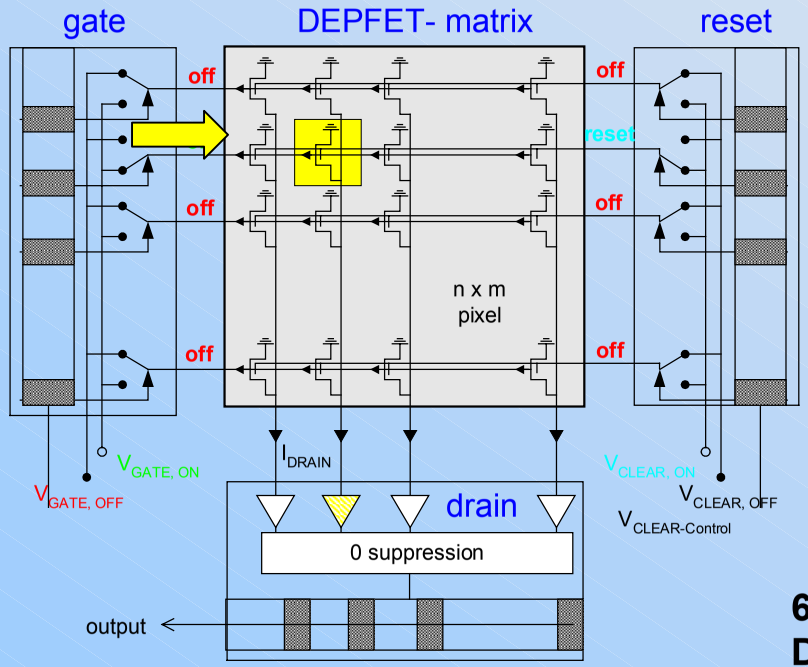
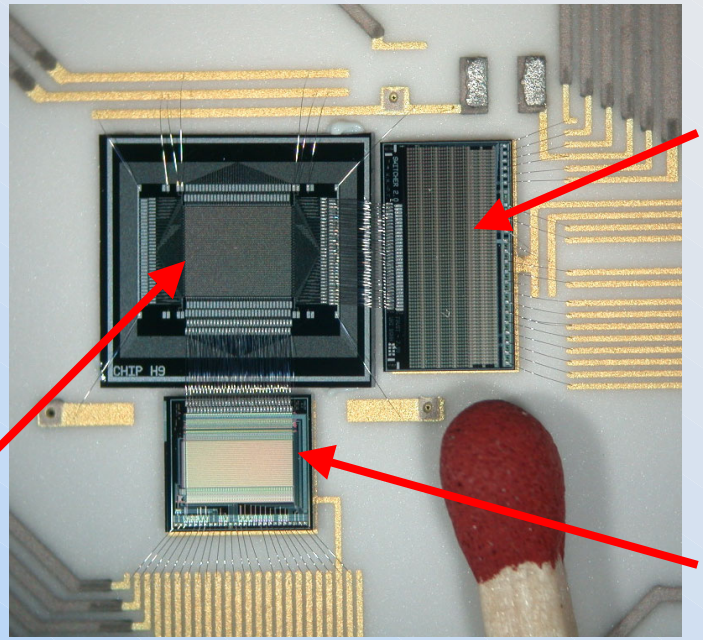
Matrix Operation

Matrix-scheme:



DEPFET-Hybrid:

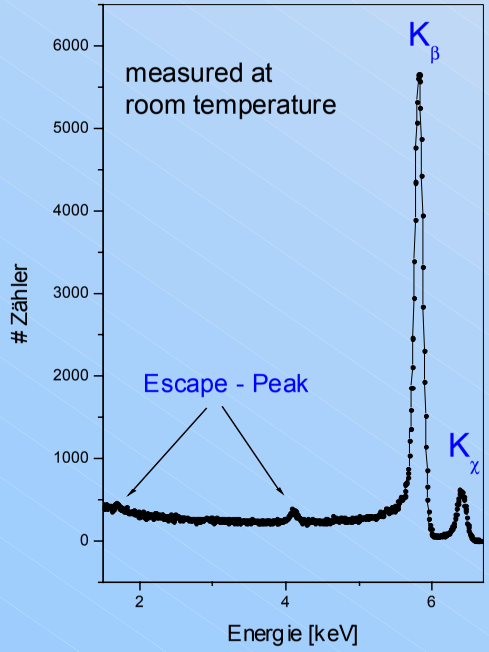


- read pixel-current at drain
- reset pixel / clear internal gate (row wise)
- read pedestal current

- 64 x 64 matrix with 50 x 50 µm² pixel
- designed for Biomedical Applications
- clock rate : 50 kHz
- achieved noise in matrix: ~100e⁻
  (due to operation mode)

achieved performance

Single-pixel spectra:



^{55}Fe-spectra @ 45±C

ENC = 4.8 +/- 0.1 e$^-$

Matrix-picture with ^{55}Fe:

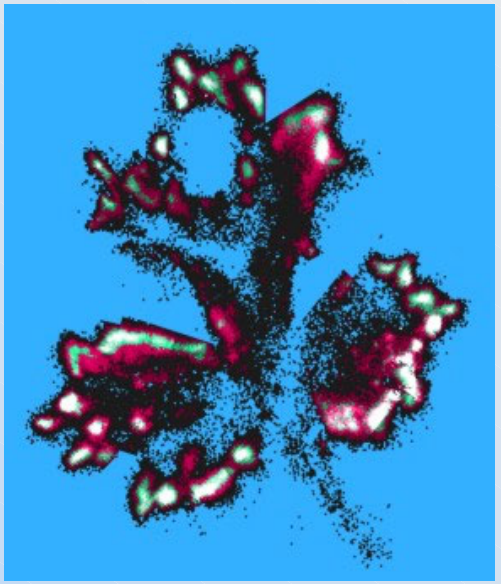
~ 3.2 mm

spatial resolution (50x50 µm^2 pixel):

~ **4.5µm** (22 keV, ^{109}Cd)

~ 6.5µm (6 keV, ^{55}Fe)

Autoradiogram with ^{3}H:



~ 10 mm

detection of Tritium ^{3}H
(5,6 keV mean energy)

[J.Ulrici, Bonn]

SI LAB
Silizium Labor Bonn

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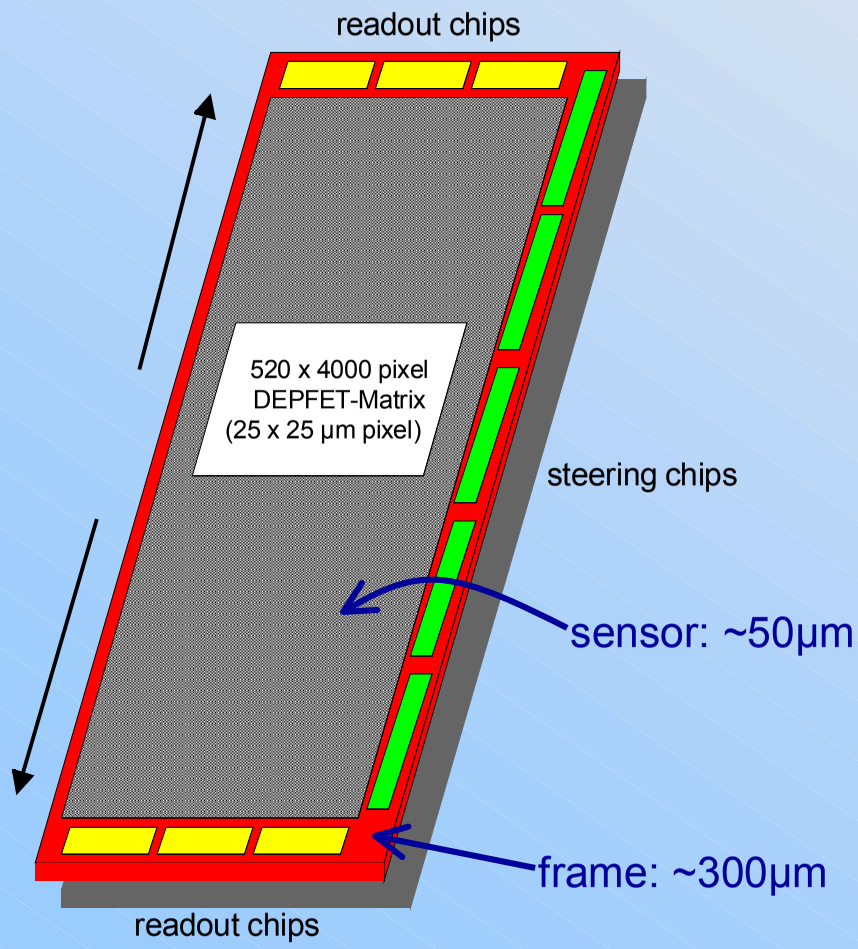
DEPFET-Pixels for TESLA

Layer I - Module:



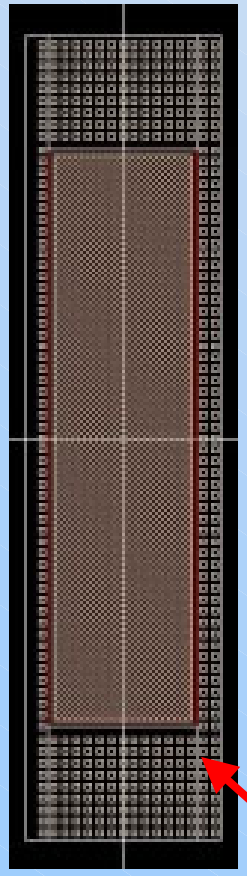
attractive features for TESLA:

- small pixel size **(20-30µm)**
- low noise → **thin** (50µm) → **S/N > 70** @ RT
  - thin sensor (50µm) + frame →!0.11% X_0 / layer
- **low power consumption → little cooling !**
  - in active area : sensor + R/O chip or steering chip
  - whole vtx-d (5 layers / pulsed mode) :
    - sensor : 0.3W
    - steering: ~ 3-4 W
    - R/O chip: 1-2 W

whole vtx-d: ~5W

Marcel Trimpl, Bonn University

DEPFET-Pixels for TESLA



perforated frame
for reduced material

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whole vtx-d: ~5W

steps towards TESLA :

- new DEPFET-sensor fabrication - finished ✓
  - smaller pixels (25µm)
  - improved performance for TESLA
- develop thinning of sensors - first results ✓
- fast (50 MHz) steering chip - fabricated ✓
- fast readout chip with 0 suppression - prototype ✓
- (full size) prototype system

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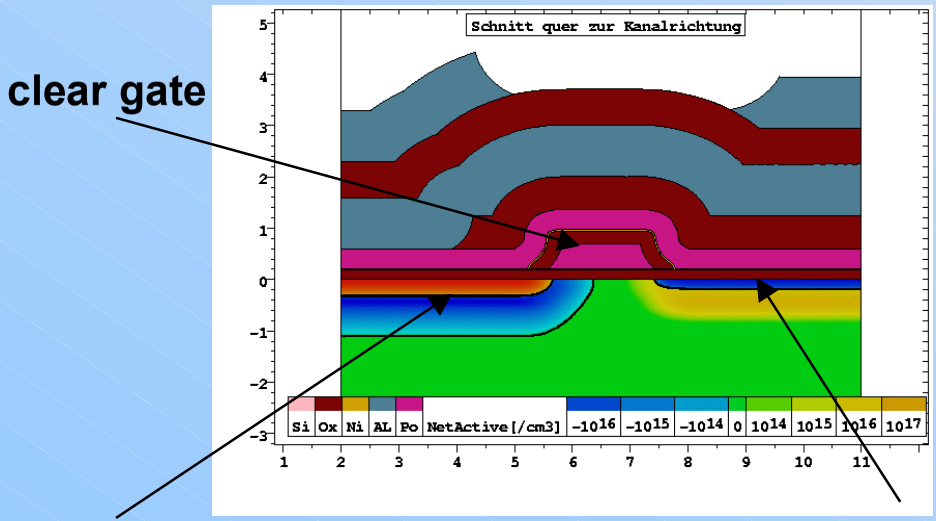
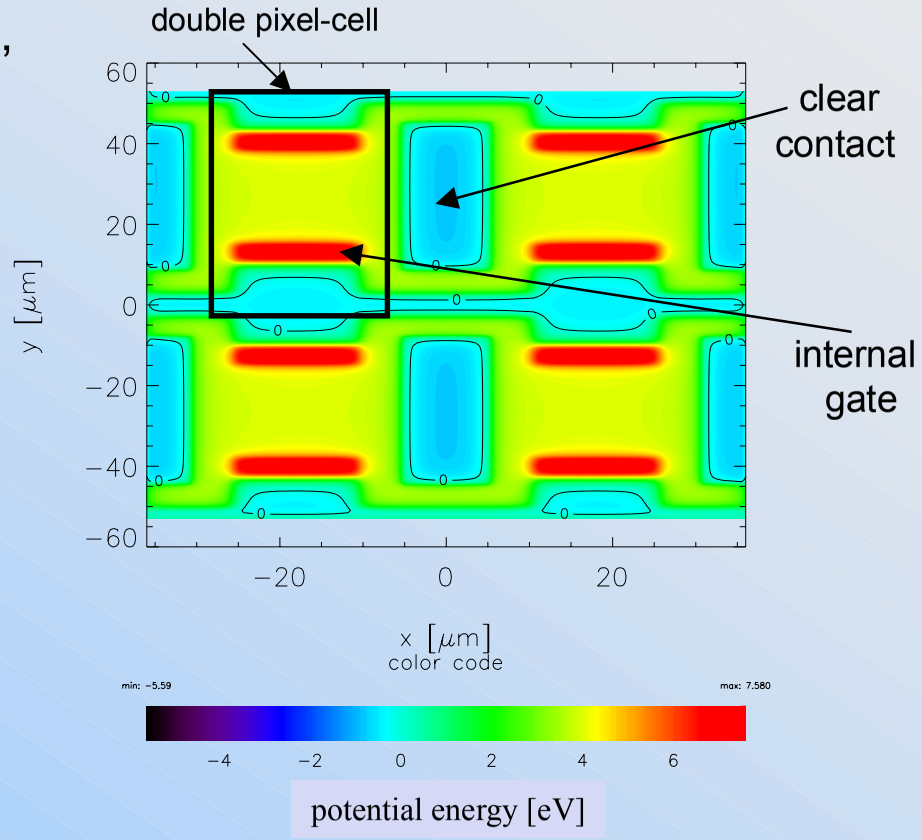
new sensors for TESLA

new sensors:

- from JFETs to MOSFETs
  → less device variation (large sensors), linear transistors (small pixels)
- double metal process (large sensors)
- higher amplification (1nA/e⁻)
- fast and complete clear



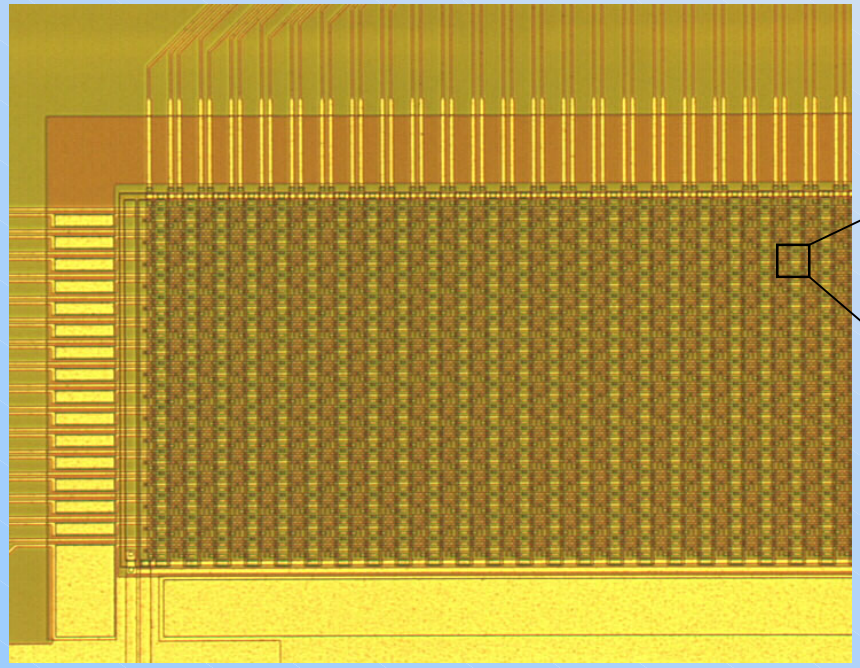
Potential distribution (1µm depth)



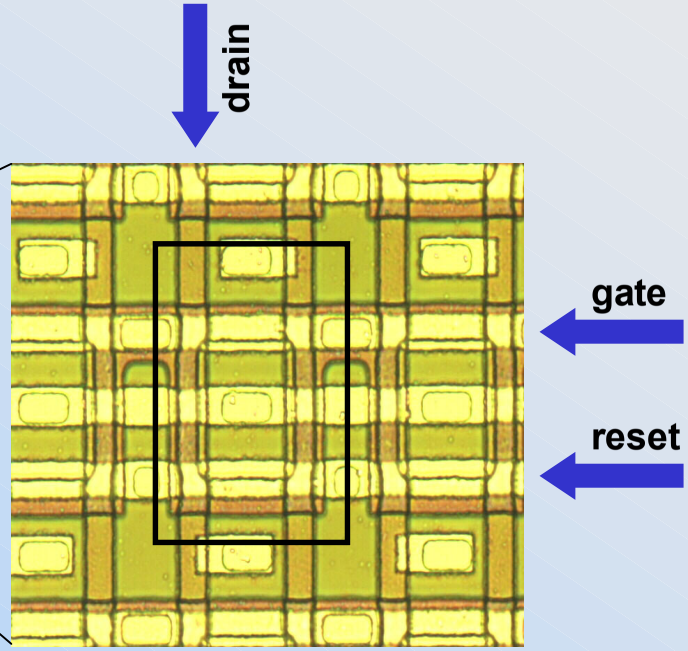
[Poseidon 3d – Simulator]

new fabrication

just finished (April 2003) ...



16x128 DEPFET-Matrix



double pixel cell 33 x 47 µm^2
in DEPFET-Matrix