Barrel Sensors
Options and Constrains

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Pixel-Replacement Discussion Meeting

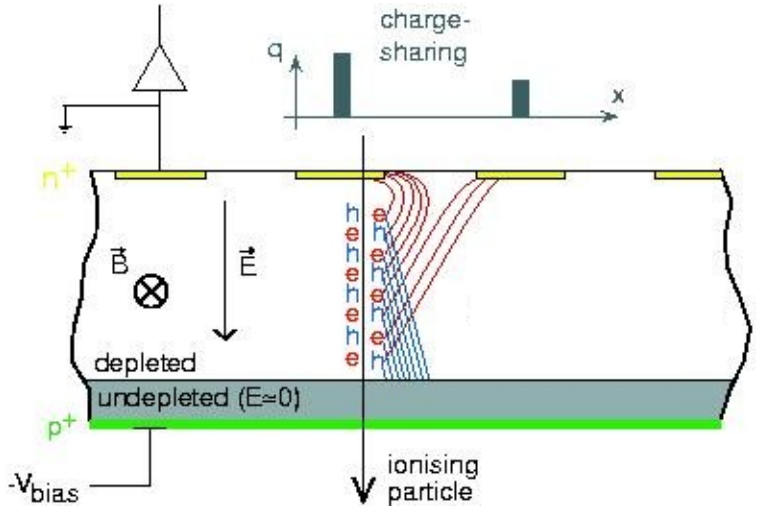
CERN, Oct. 9, 2008

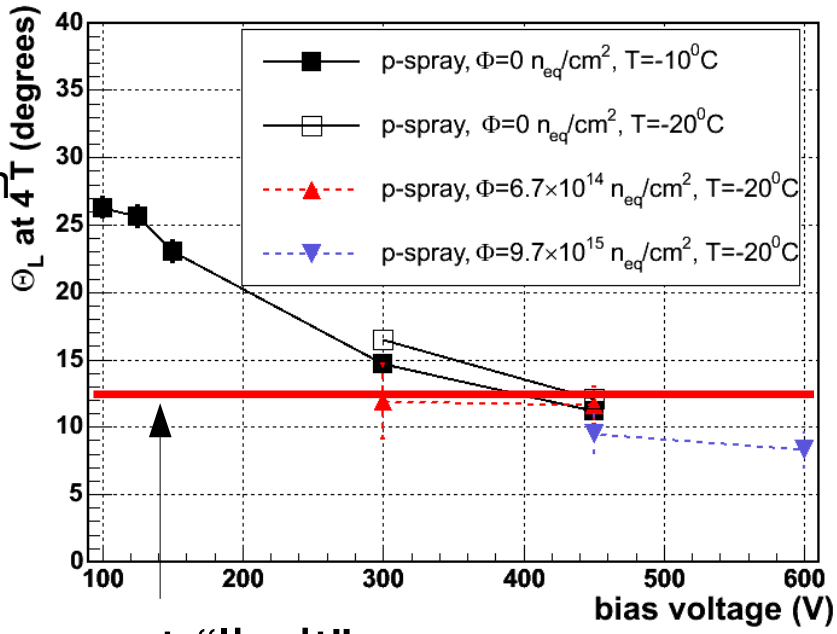
Introduction

- About 2013 a replacement of the whole Pixel detector is scheduled
  - 4 cm layer might be kept operational up to this (degradation is steady)
  - Replacement date cannot be shifted infinitely (inner layer might not be sufficiently operational after more the 250 fb^{-1})
  - 1st batch of sensors has be delivered ~2 years before installation (for a 3 layer system!)
  - Delivery time for the present detectors: 4-6month (+ 2-4 weeks for UBM)
    - Sensor order has to be placed mid 2010
    - (Additional safety margin of at least 6 month highly advisable)
  - **2 years for R&D and prototyping**

Degradation of Spatial Resolution

- High field reduces mobility of charge carriers
- Lorentz angle is also reduced
- Fraction of double hits is reduced
- Only binary resolution (~30μm with current pitch) is achieved
- Process is slow and steady
- Detector might become "useless" for impact parameter measurement although detection efficiency is still high (>90%)
- 1×10^{15} N_{eq} might be reachable (~250 fb^{-1}, 4cm layer)
- Any higher demand → smaller pitch in rϕ (not realistic)



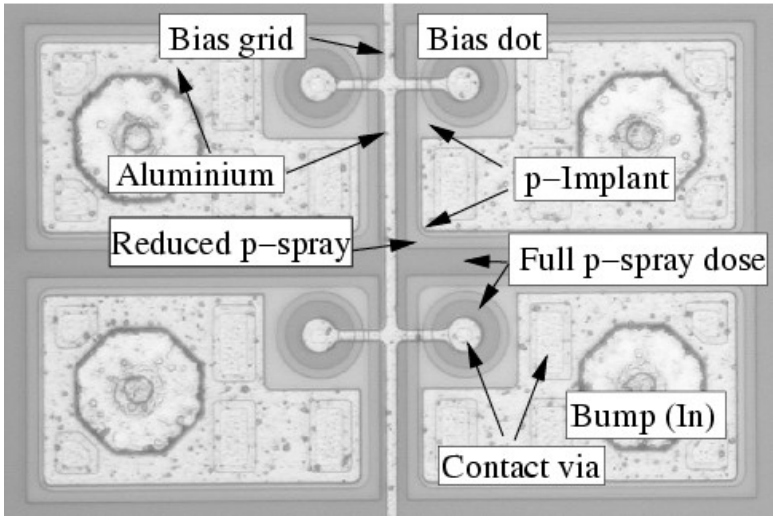


A. Dorokhov NIM A530 (2004) 71-76

present "limit"

Possible Fields of R&D

- Radiation hardness not an issue (for 2013 replacement)
  - Change of pitch seems not realistic
- Minor design optimisation:
  - Substrate (DoFZ, MCz)
  - pixel capapacitance:
    - test sensors available and irradiated (source test ongoing with PIRE students)
    - decision (probably) possible without new prototyping
    - Can wait with decision up to last moment (2010)
  - gurad rings:
    - presently 900-1200μm wide, reduction might be appreciated
    - submission of 1 test batch necessary (6month, ~30kCHF)
    - irradiation + evaluation (1year)
    - order of test batch 2009

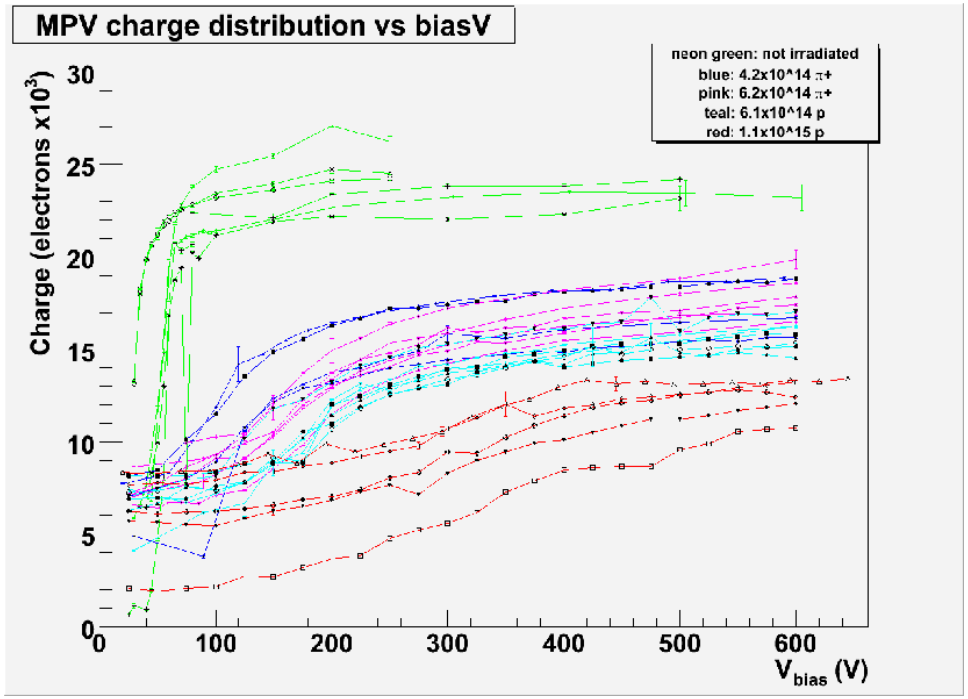


Single Sided Sensors

- Cheaper by factor > 2 (?)
- **No experience with**
  - **implant dimensions**
  - **guard rings**
  - **module construction**
- Small number of samples (RD50, SMART) available
- Need
  - at least 1 prototype submission (6month, ?? CHF)
  - irradiation and evaluation (1 year)
  - pre-series production of full size modules
    - components available??
    - can be done in parallel with irradiation
  - **Order of prototype in 2009 needed**

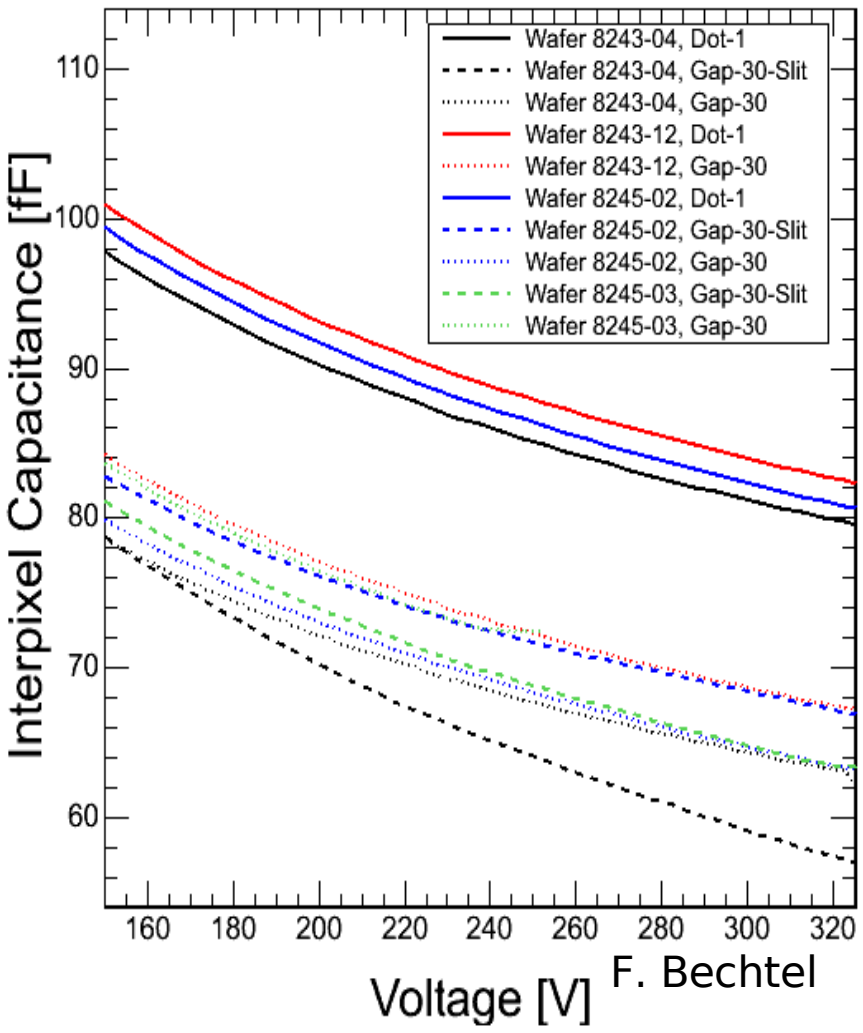
Present Activities

- Charge collection studies (PIRE-students)
  - A large number of irradiated Bpix single chip sensors (DOFz) including minor design modifications irradiated with π and p up to $\Phi > 10^{15} \times N_{eq}$
  - Signal induced by Sr-90 source, random triggers (extended clock cycle)
    - Find limits of the n-in-n sensors
    - Try to understand the operation of highly irradiated ROCs (SLHC)
    - **Do the sensors with larger gap behave differently ?**
      - Charge collection
      - Breakdown behaviour
  - Improvements possible



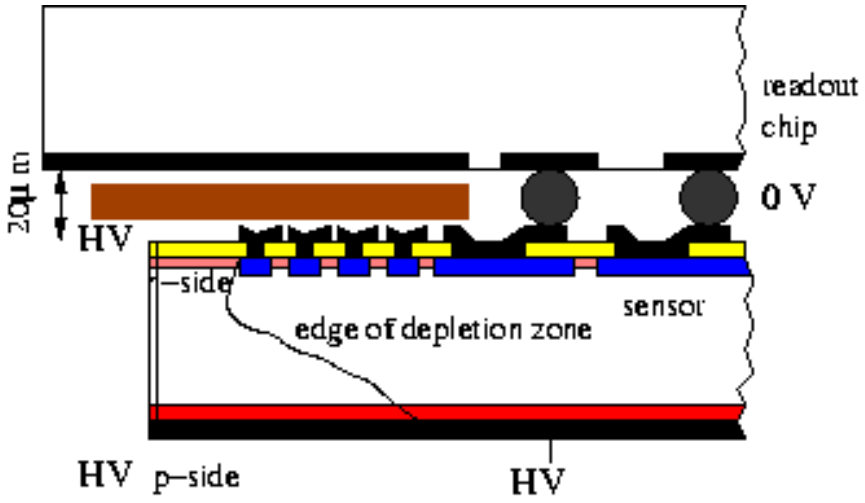
Present Activities 2

- Capacitance Measurements
  - Effort started 2006 in collaboration with Uni HH
  - Is planned to be continued with PIRE students and within the MC-PAD network
  - Some questions open
    - Dependence on process parameters not yet understood
    - Irradiation dependence not checked
    - Bias dependence of capacitance not understood (ISE-TCAD simulation?)



Present Activities 3

- Single Sided Sensors
- Small number of samples (Mcz, FZ) availale from
  - RD50 (Micron), already bump bonded at PSI
  - SMART (Irst), just arrived
  - Participation in CMS wide HPK submission
- Tasks
  - Find limitations from “edge break down problem”
  - Check feasibility of underfill
    - Kapton, Glue, ??
  - Irradiation
  - Charge collection studies



Summary

- Time is short
- Need money + resources in 2009
- Available at PSI
  - V.R. and PIRE students
  - Position for PhD-student granted (EU, MC-PAD, applications welcome)
    - http://mc-pad.web.cern.ch
  - T.R.