HEPHY
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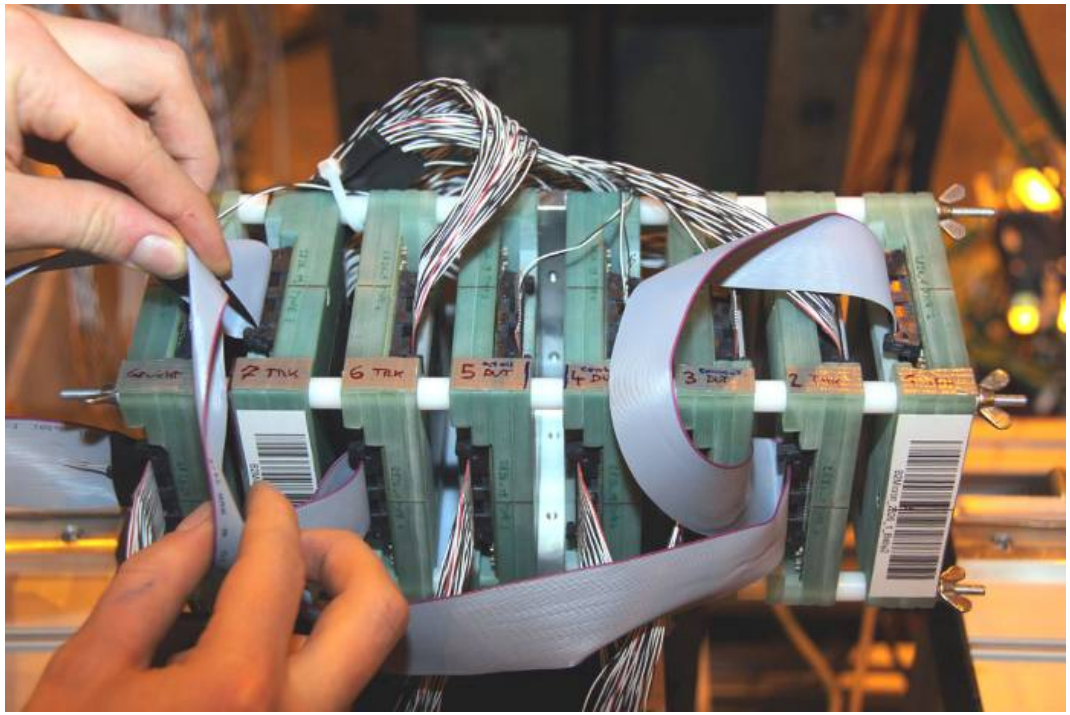

Optimization of strip isolation for silicon sensors

TIPP 2011, Chicago

M. Valentan, T.Bergauer, M. Dragicevic
M.Friedl, C.Irmler, E. Huemer, W. Treberspurg

Outline

- The sensors under test
- The experimental setup
- Comparison of p-stop patterns
- What happens in unimplanted regions?
- Summary and plans

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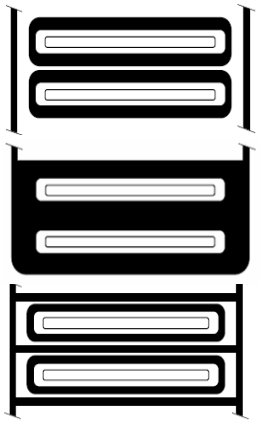
Sensor purchase for Belle II (Japan)

MICRON SEMICONDUCTOR ltd

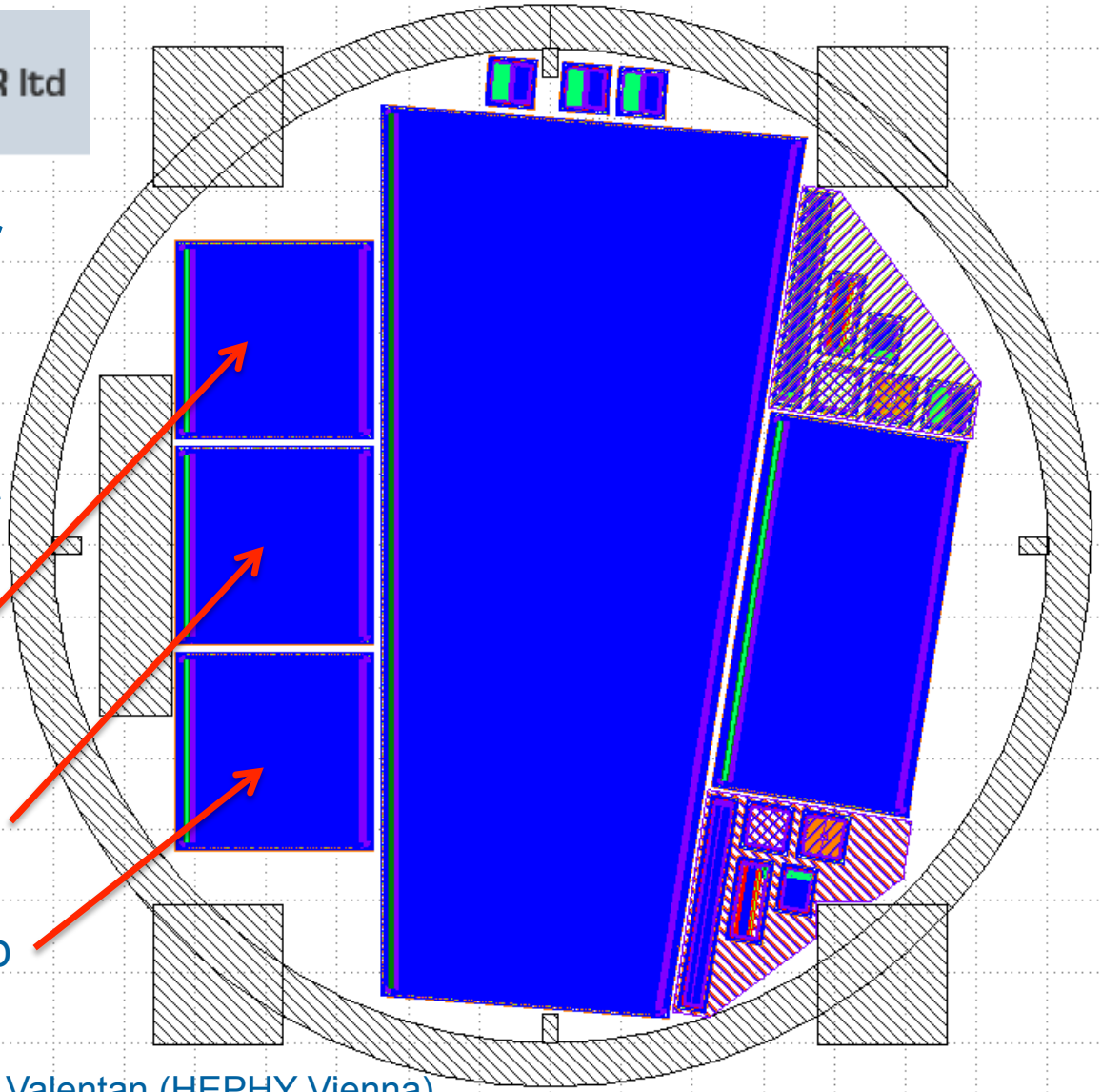
- Trapezoidal sensor for forward region
- *This talk focuses on the test sensors*



Atoll p-stop

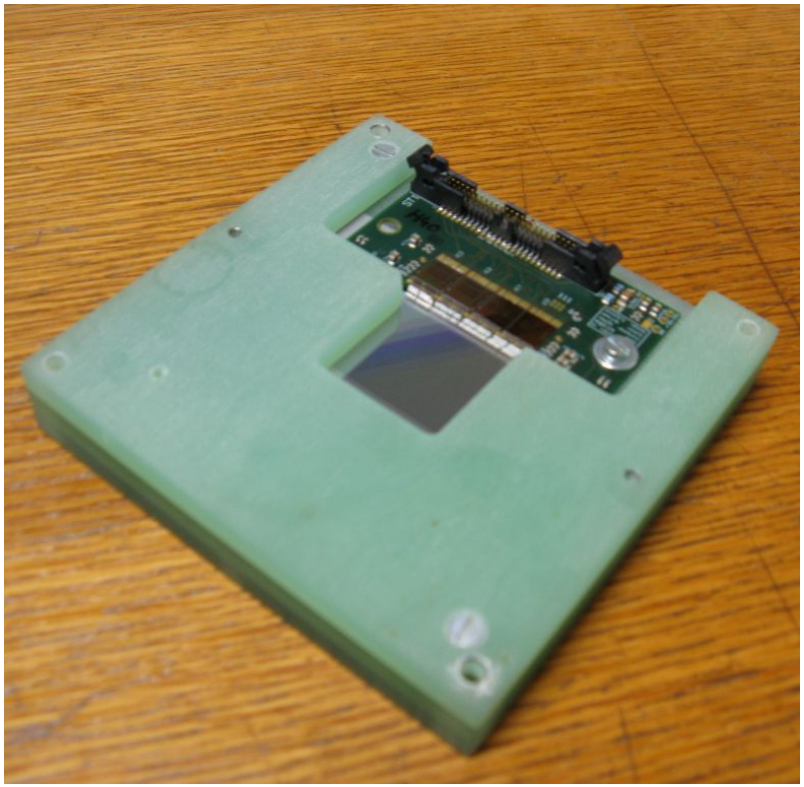
Common p-stop

Combined p-stop



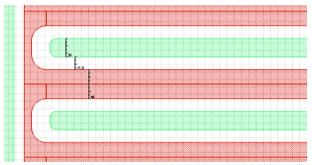
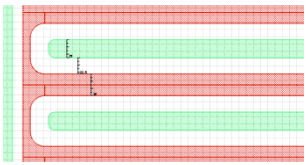
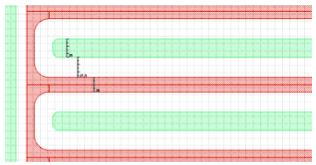
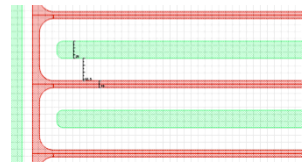
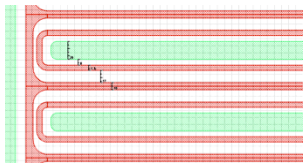
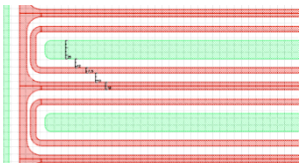
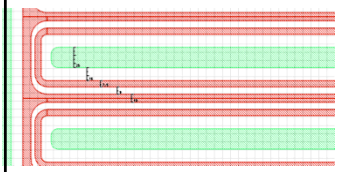
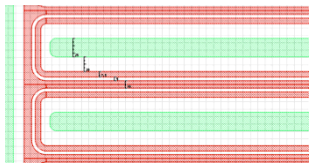
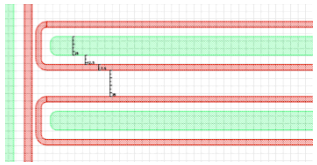
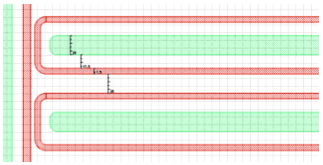
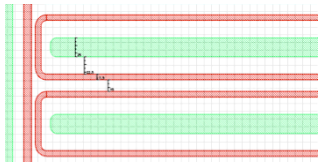
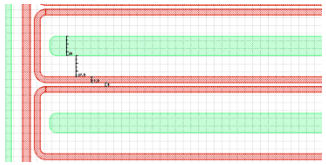
The device under test

- Double sided silicon detector (DSSD)
- n-type substrate
- V_{depl} = 60V
- Focus on n-side
  - 256 n-doped strips
  - 100 µm pitch
  - Strip isolation by p-stop blocking method
- Readout by APV25 chip (CMS)
  - Analogue readout of pulse height



p-stop layouts of the test sensors

- Three different p-stop patterns
- Per pattern, four zones with different geometry
- Green: strip implant (n), Red: p-stop

	Narrow	half-narrow	half-wide	wide
Common				
Combined				
Atoll				

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- The sensors under test
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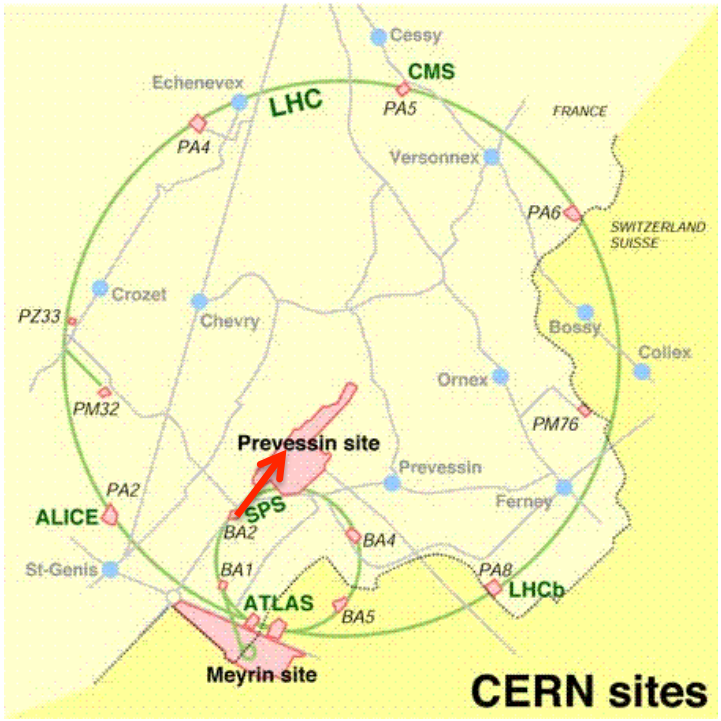
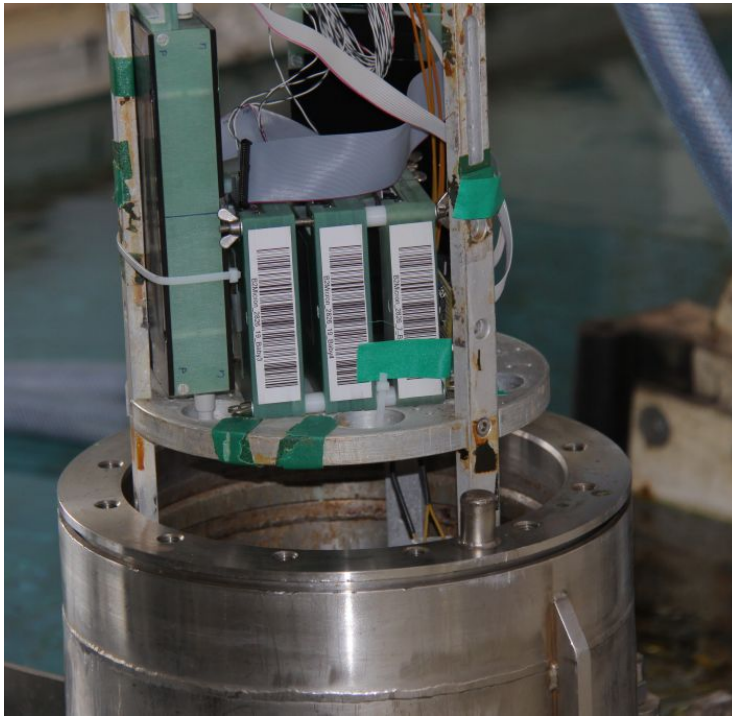
The locations





- CERN, beam line H6B of SPS
- September 27 – October 11, 2010
- 120 GeV hadrons, mostly pions
- 100k events
- EUDET telescope

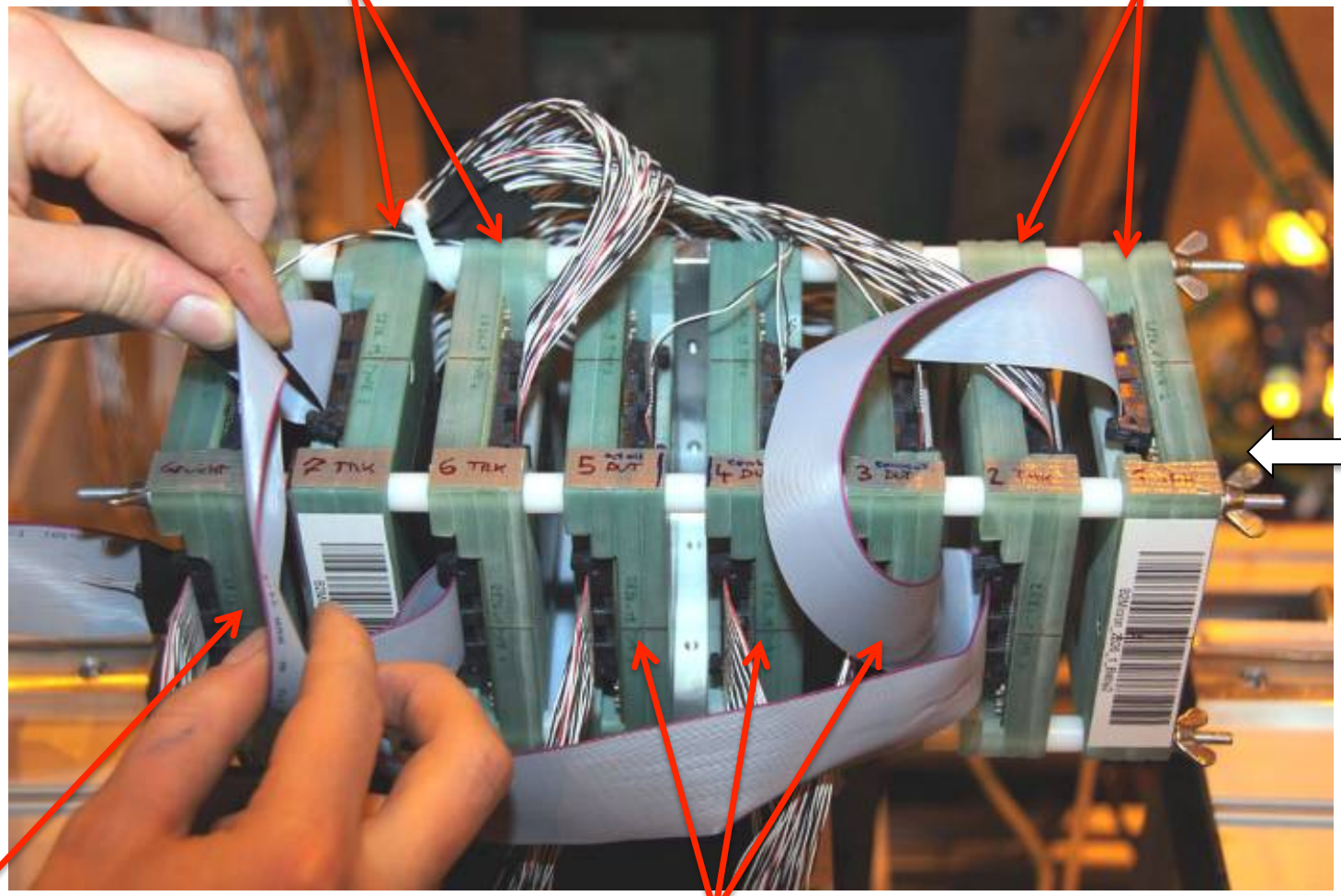
- SCK-CEN, Mol, Belgium
- October 3 – 5, 2010
- ^{60}Co gamma source
- 2.5 MRad per hour
- Irradiation to 70 MRad

SCK•CEN
STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

Stack setup

Two sensors for tracking (p-side)

Two sensors for tracking (p-side)



120 GeV hadrons (mostly π)

One module just for balance

Three DUTs, one of each p-stop pattern (n-side)

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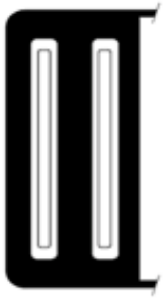
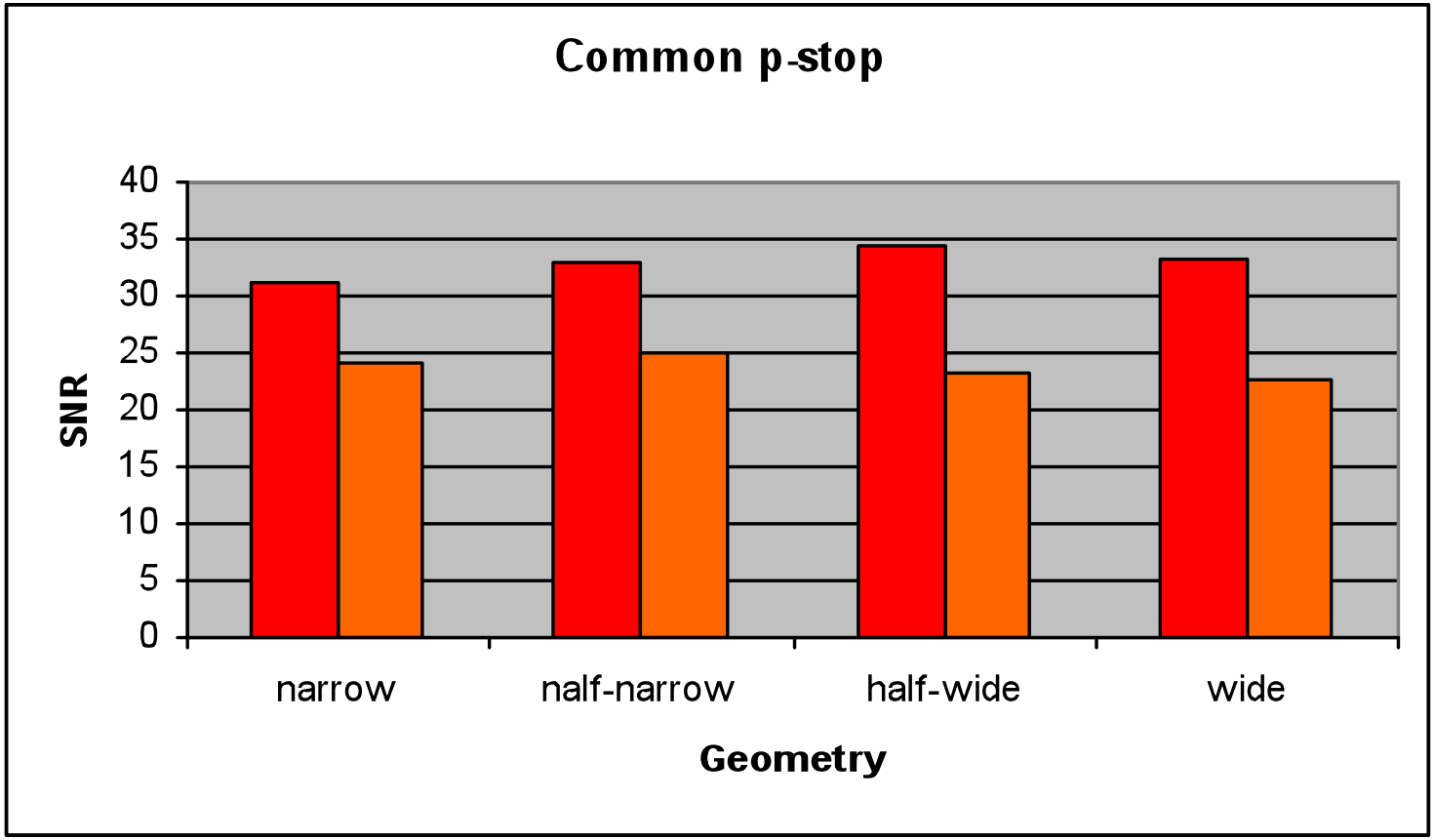
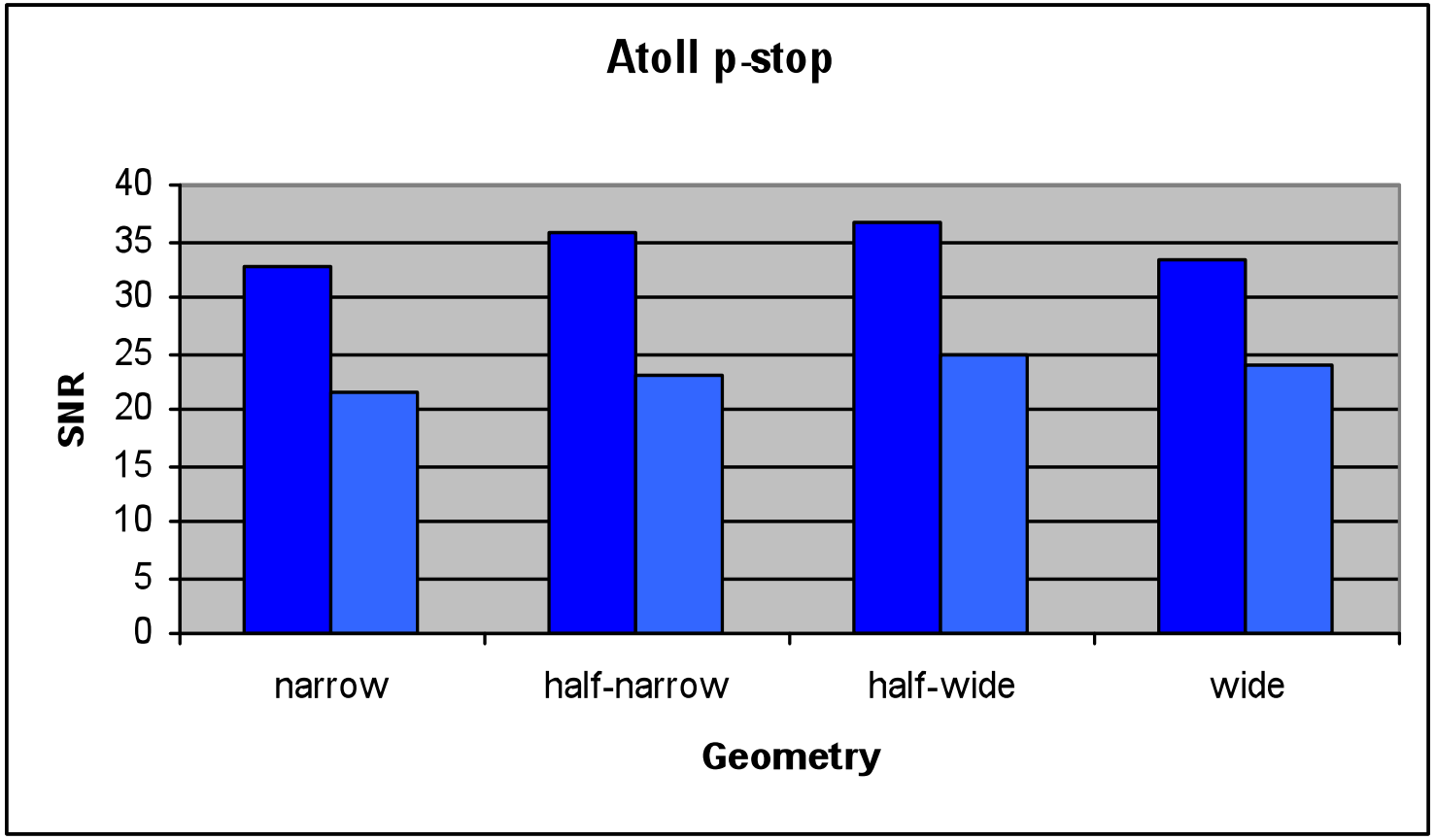
Signal-to-noise-ratio of common p-stop





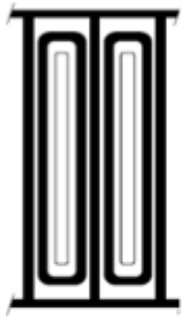
- Red: unirradiated, Orange: irradiated
- Half-wide geometry performs best

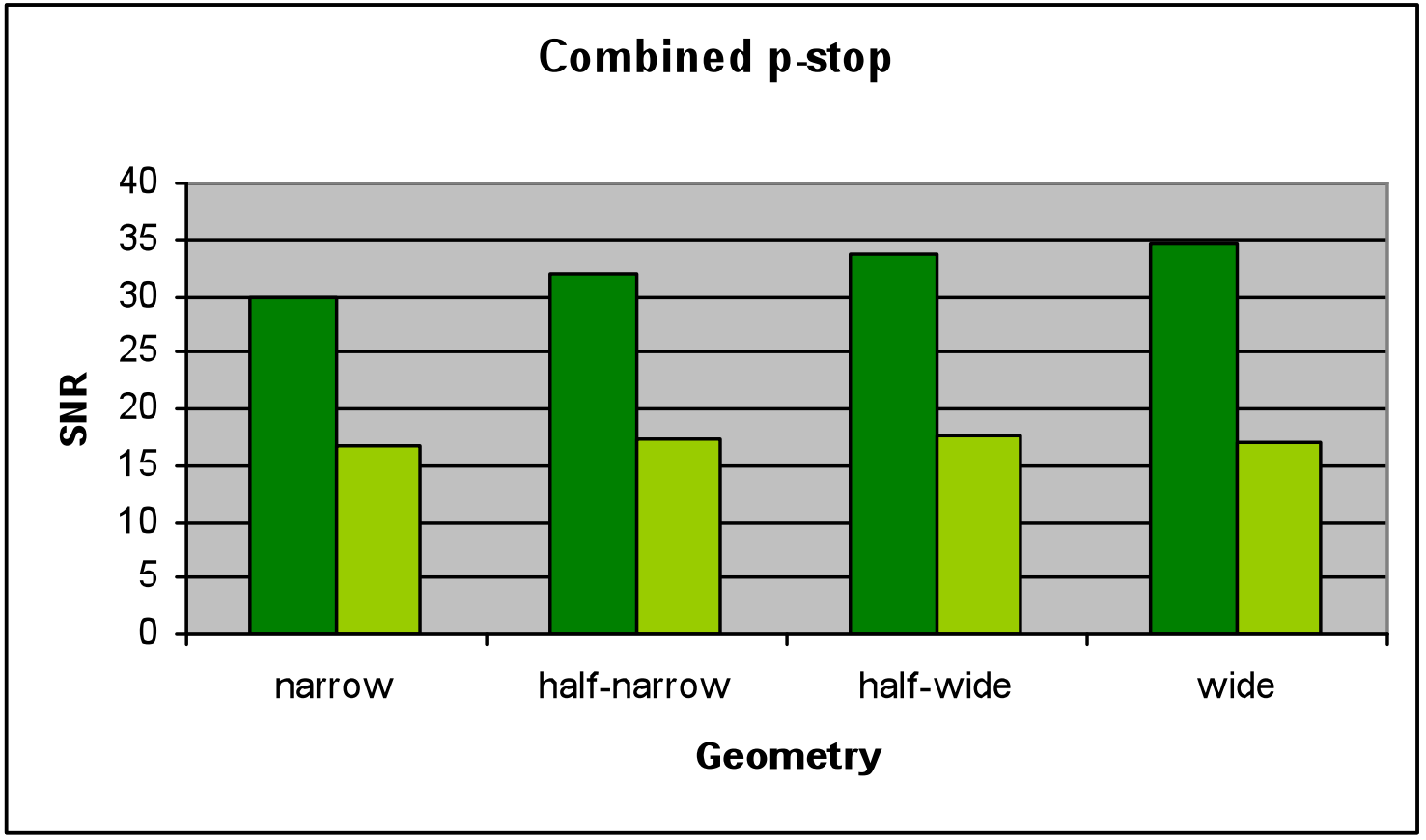
Signal-to-noise-ratio for atoll p-stop



- Dark blue: unirradiated, Light blue: irradiated
- Unexpected: wide geometry NOT best one!

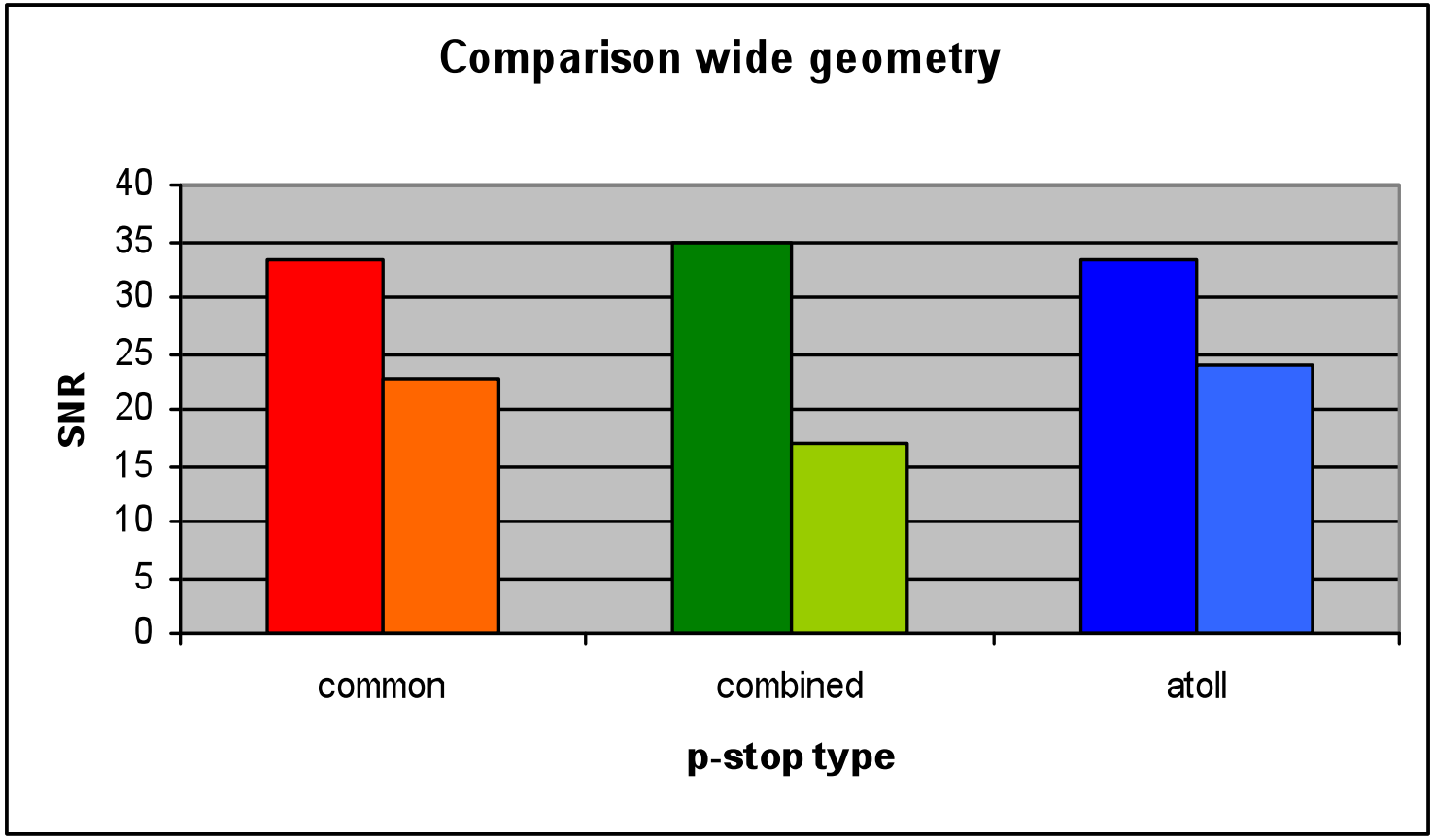
Signal-to-noise-ratio of combined p-stop





- Dark green: unirradiated, Light green: irradiated
- Wide is best, as expected
- Suffers strongly from irradiation

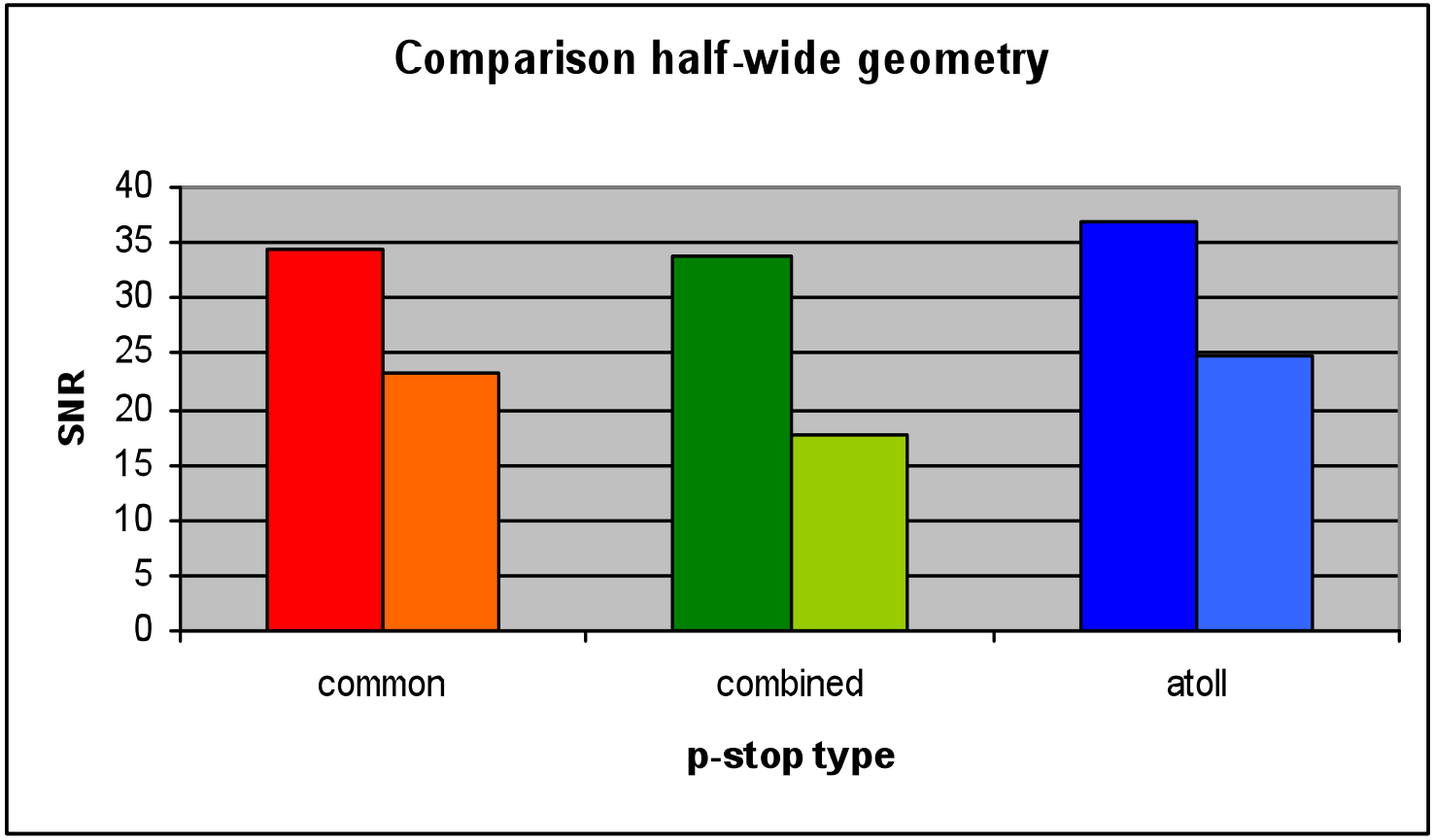
Comparison of wide geometry



- Combined is best, but only unirradiated
- 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

Comparison half-wide geometry



- Atoll is best, both for unirradiated and for irradiated case
- Shows highest SNR of all variants

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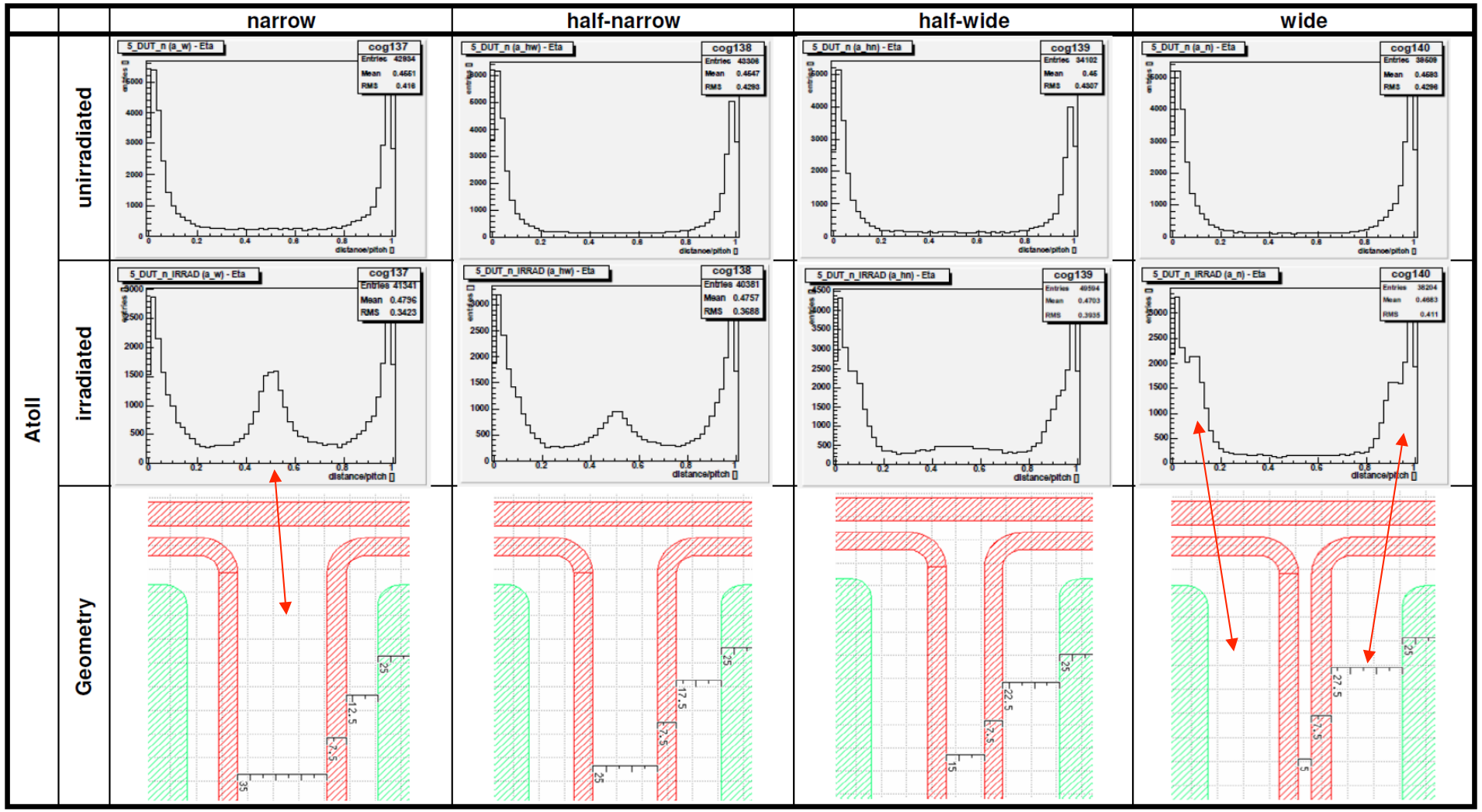
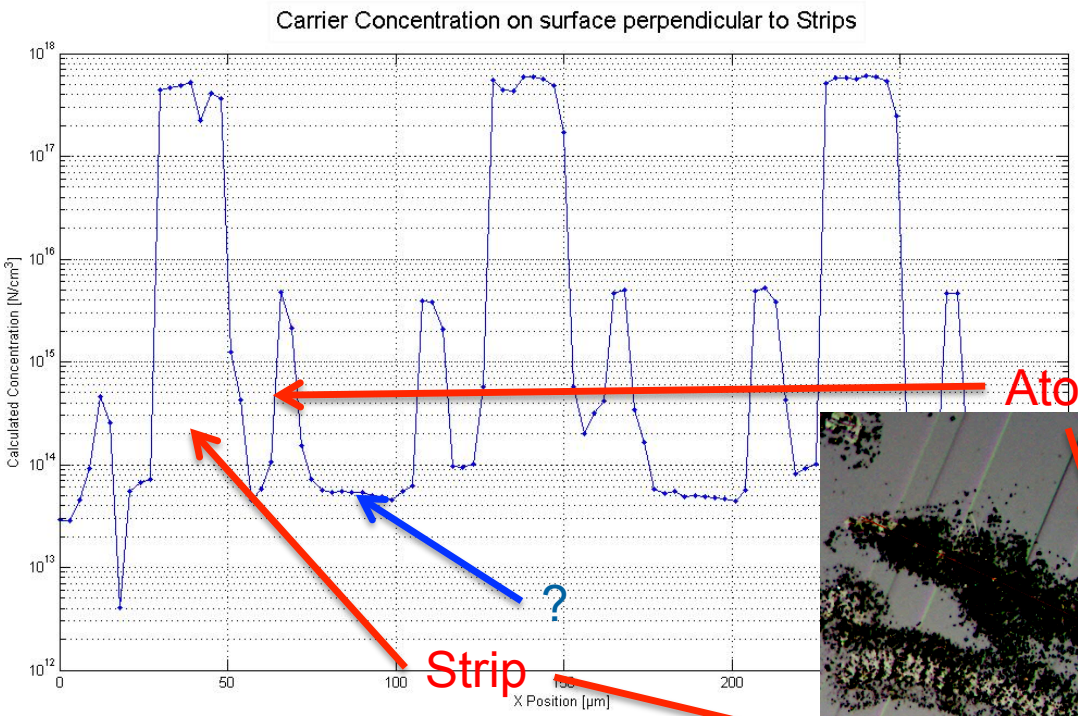
eta distribution for atoll p-stop

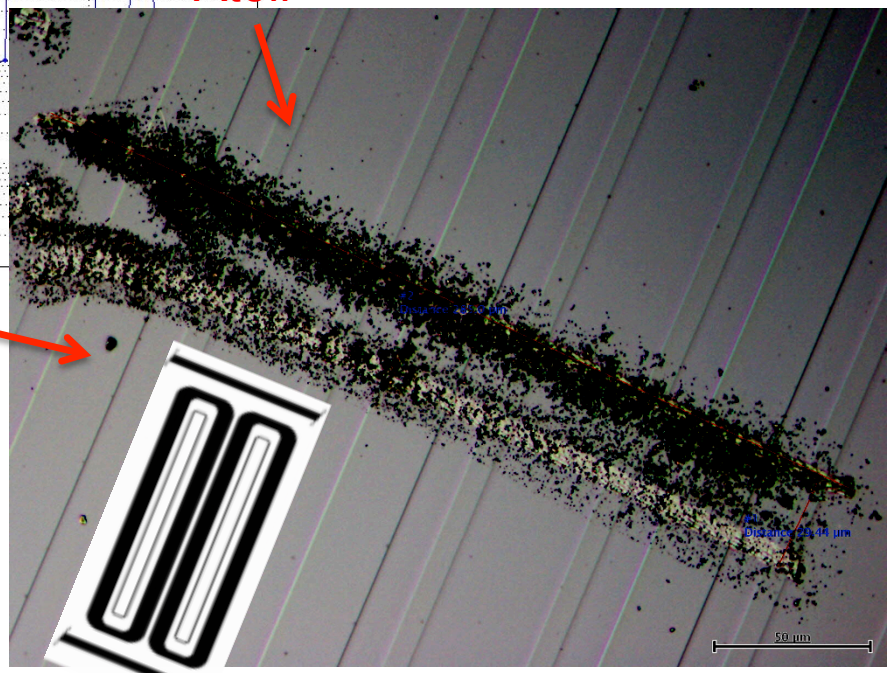


Charge accumulation in unimplanted region

Spreading resistance profiling (SRP)



- Measure resistance between neighbouring needles
- Scan substrate surface



- Identification of strip and atoll
- No recogniseable change of carrier concentration between atolls

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Summary

- We developed test sensors featuring three different p-stop patterns, with four different geometries per pattern
- The half wide atoll pattern was found to perform best in terms of signal-to-noise-ratio, both unirradiated and irradiated
- We found charge accumulation in unimplanted regions after irradiation, seems to happen in the oxide

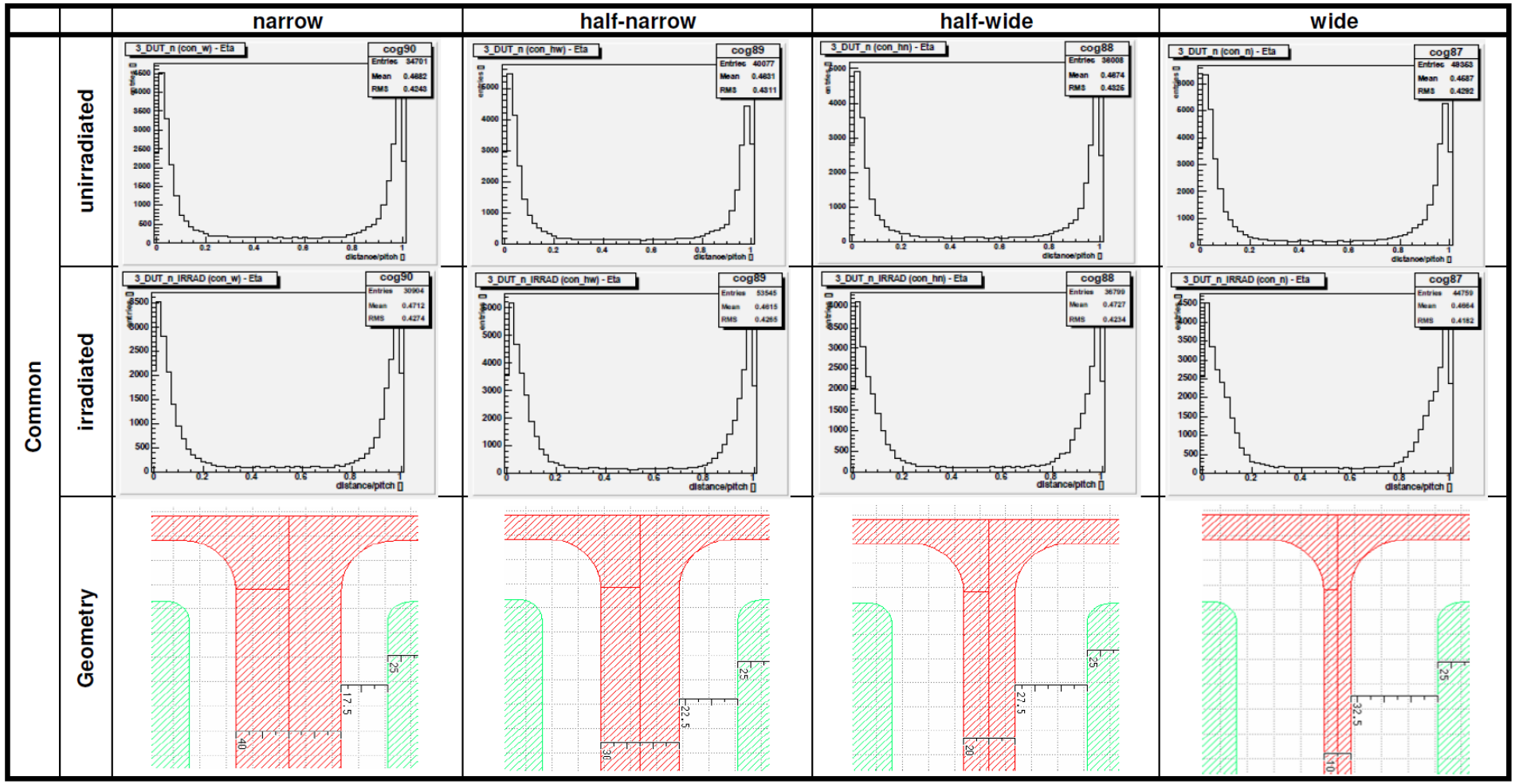
Plans

- Belle II uses sensors with intermediate strips which are not read out.
  ➔ Remove every second bond to mimic the behavior of a sensor with intermediate strips
  - Ongoing
- Purchase new batch of sensors with finer variation between wide and half-wide geometry
  - Design in progress
- Beam test in October at SPS, CERN

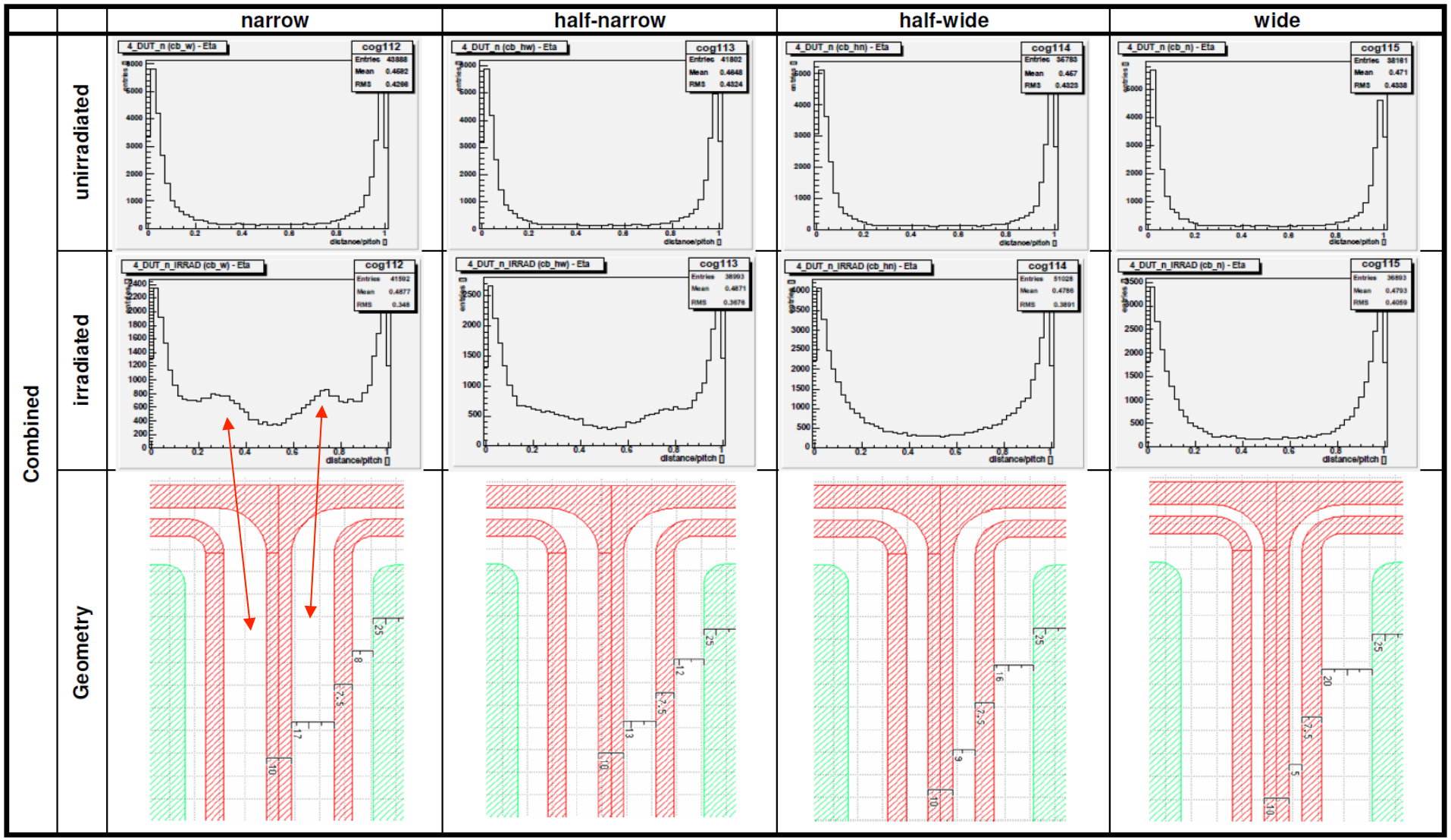
Optimization of strip isolation

Backup slides

eta distribution for common p-stop

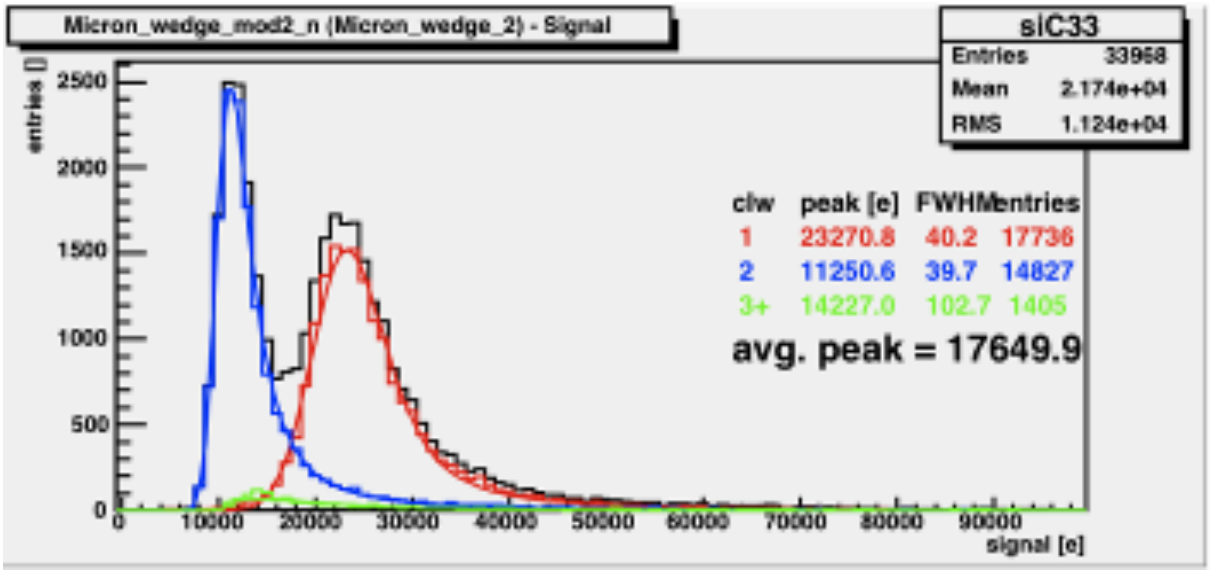


eta distribution for combined p-stop



Signal distribution of Wedge sensor

- We observed pronounced double peak in signal distribution of the trapezoidal sensor
- Uses wide combined p-stop pattern, but with intermediate strip!



Signal distribution of test sensor

- Wide combined pattern
- unirradiated and irradiated
- Baby sensors have NO intermediate strip
- No double peak -> reason must be the intermediate strip!