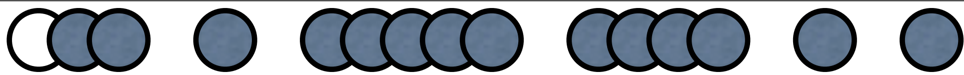
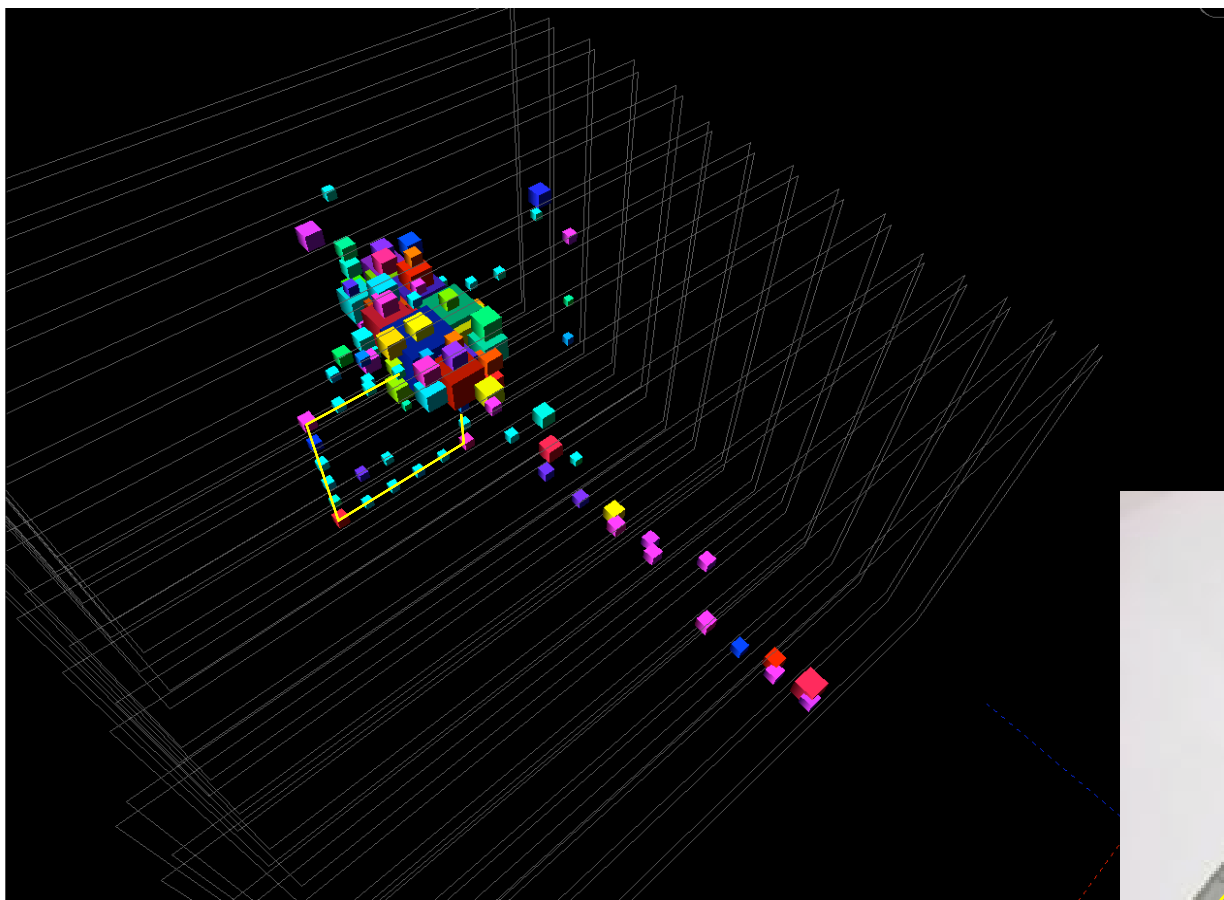
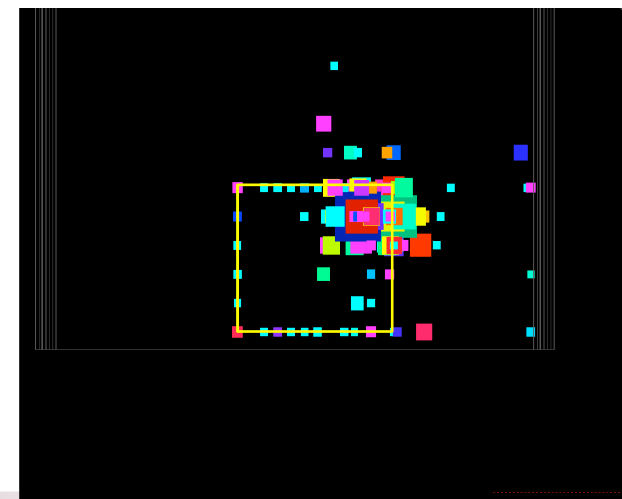
# Study of guard-ring design for Si-W wafer

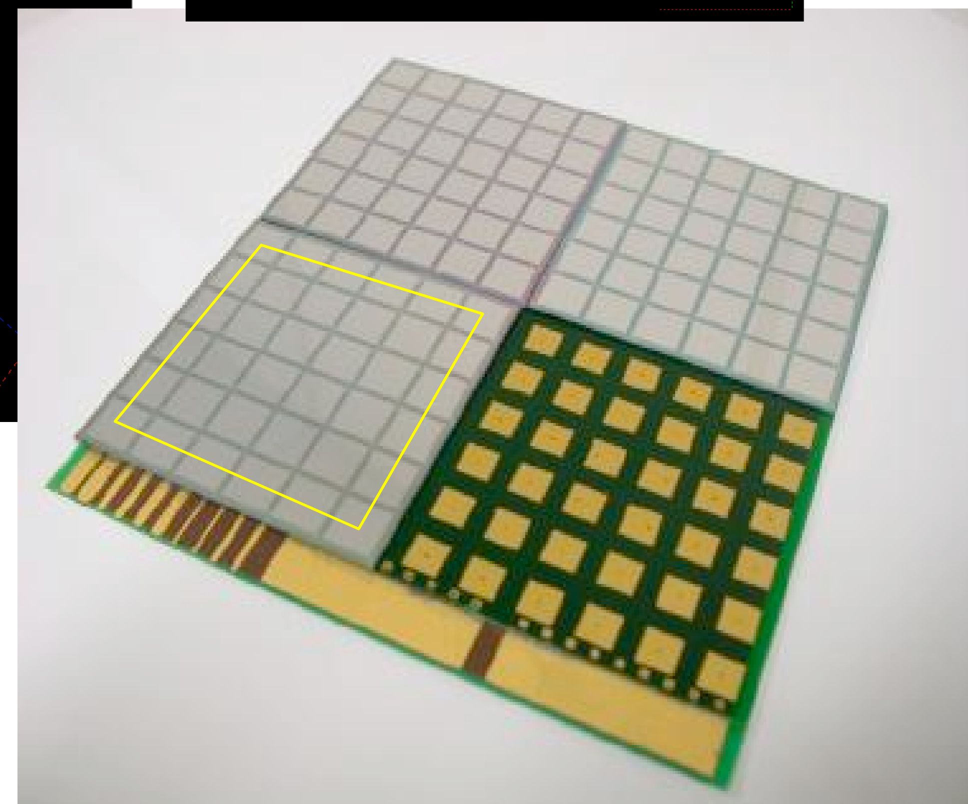
Mustapha Benyamna, Rémi Cornat, Akli Karar,
François Morisseau & Jean-Charles Vanel



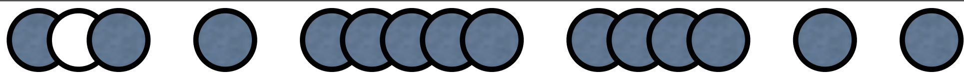
# Introduction







**Square Events**

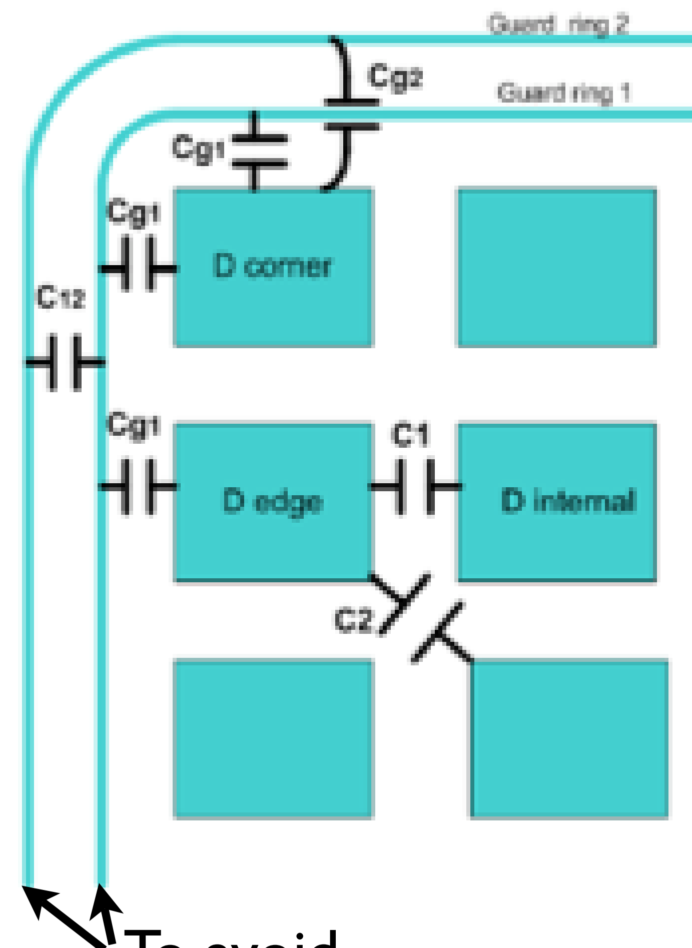


# Hypothesis

Run 300378 30 GeV Evt 7366 Layer 6

PadRow

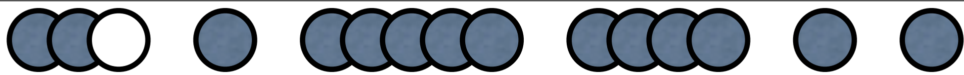
PadCol




To avoid
high leakage current

## Crosstalk

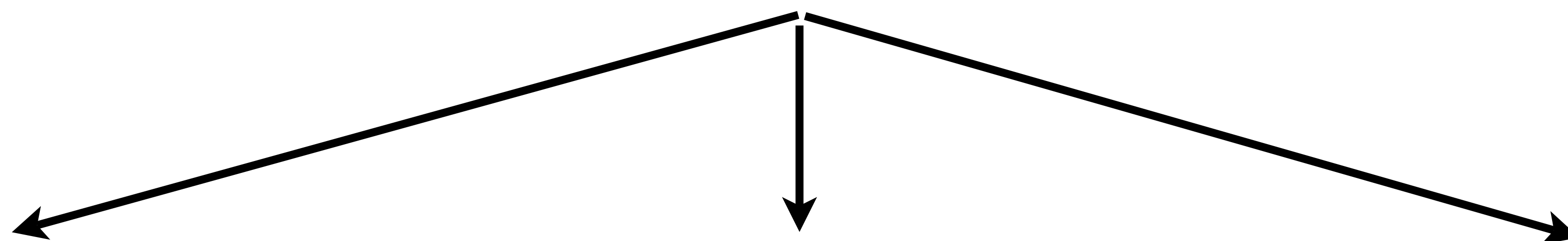
capacitance effect between guard-rings and wafer border pads.



CALICE
Calorimeter for ILC

# Study Overview

Aim:
test the previous hypothesis and evaluate different guard-ring options



**Test beam analysis**

- *importance of the effect*
- *finding pertinent variables*

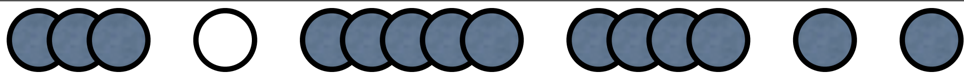
**Test bench**

① validate the measurement method with a Cu-Epoxy scale model.
(pure crosstalk effect study)

② characterise real 3x3 wafers

**Simulations with SILVACO package**

- *capacitances*
- *charge injections*



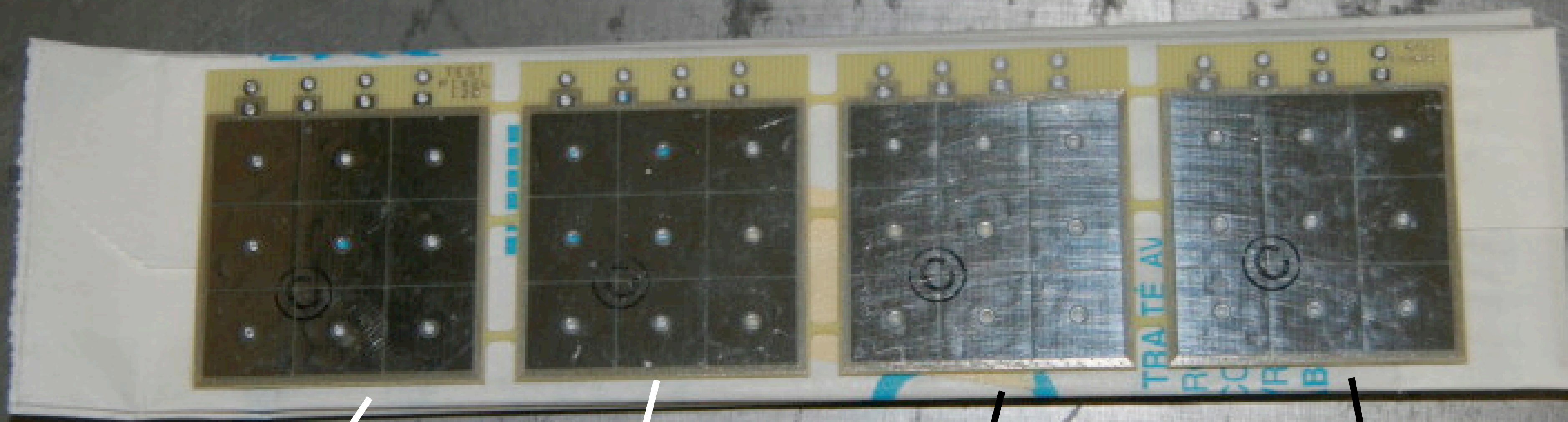
Calorimeter for ILC

# Outline

- **Set up**
  - Cu-Epoxy scale model
  - General description
  - 2 measurement protocols
- **Measurements**
  - First results
  - Geometrical crosstalk distributions
  - Impact of guard-ring positions
- **Conclusion**

# Cu - Epoxy

4 guard-ring options (4 layers each)




4 continuous

4 segmented
1cm

4 segmented
3 mm

2 segmented 1 cm
2 continuous

# General Set up

Binocular

Cu-Epoxy

Sin. wave generator

250 001 250 001

Power supply
(for the elec. card)

@LPC Clermont

CALICE
Calorimeter for ILC

# Injection and reading of signals through solder bonds

Calorimeter for ILC

Output (pad)

Input (guard-ring)

3
2
1

A
B
C

TEST PIXEL 120

# Injection and reading of signals through µ-positioners.

µ-positioner

Binocular

µ-positioner

output

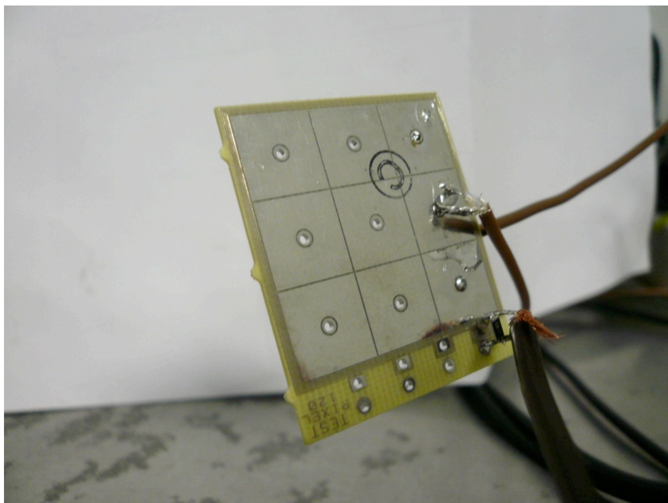
EM Shield

probehead

probehead

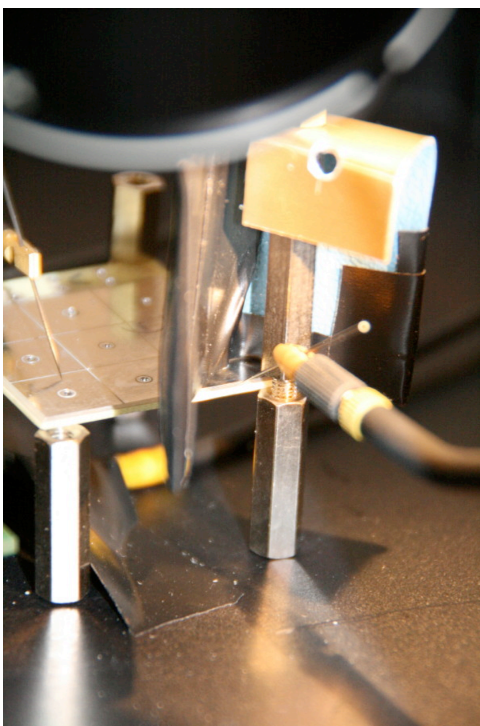
input

# Advantages and Drawbacks



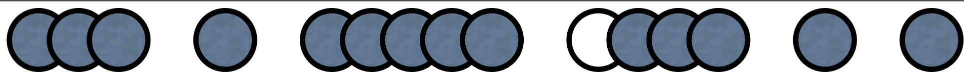
+ best electrical connections

- difficult to change the input or/and output position



+ easy to change the input or/and output position
+ same as for real wafers

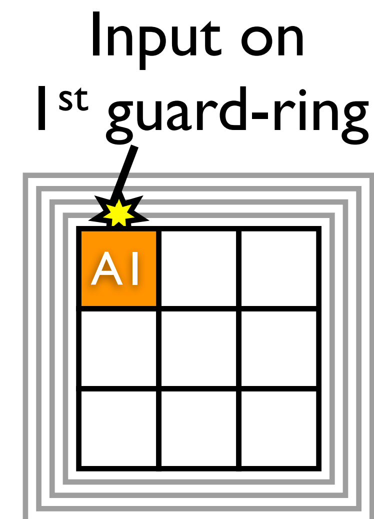
- EM radiations
- electrical connections not as good as they are with solder bonds



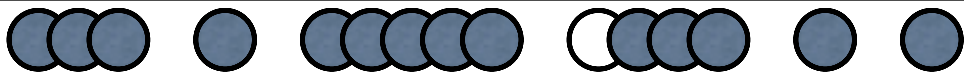
# First results

solder bonds

Input on
1 st guard-ring




G (dB)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
$10^5$
$10^6$
$10^7$
f (Hz)
1cm
Continuous
3mm
1cm + Continuous



CALICE
Calorimeter for ILC

# First results

G (dB)

0, -5, -10, -15, -20, -25, -30, -35, -40, -45

A2

A2

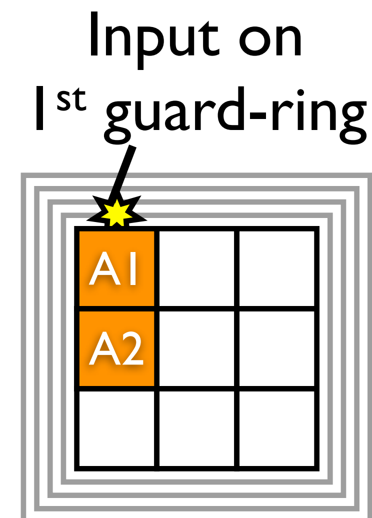
A2

A2

$10^5$ $10^6$ $10^7$

f (Hz)

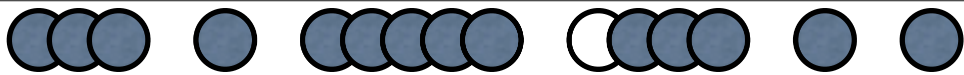
solder bonds




A1 ➡ A2

- 5 db (/1.8)
-20 db (/10)
-20 db (/10)
-20 db (/10)

Continuous
1cm
3mm
1cm + Continuous



# First results

solder bonds

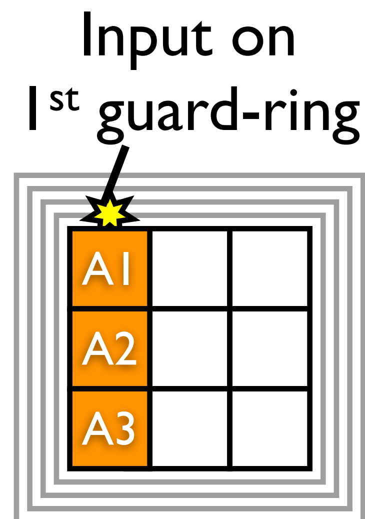
G (dB)

0, -5, -10, -15, -20, -25, -30, -35, -40, -45

A2 A3 A2 A2 A2 A3 A3 A3

$10^5$ $10^6$ $10^7$

f (Hz)




| | | | | |
|---|---|---|---|---|
| | - 5 db (/1.8) | | + 5 db (*1.8) | Continuous |
| A1 ➡ A2 | -20 db (/10) | A2 ➡ A3 | -18 db (/8) | 1cm |
| | -20 db (/10) | | <-10 db (/X , X>3) | 3mm |
| | -20 db (/10) | | <-10 db (/X , X>3) | 1cm + Continuous |

# Comparison between the two measurement protocols

G (dB)

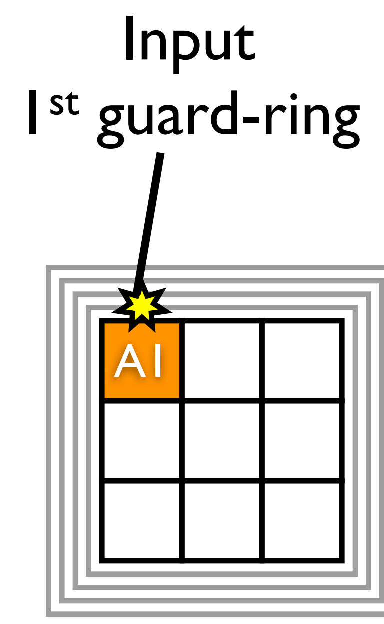
0, -5, -10, -15, -20, -25, -30, -35, -40, -45

$10^5$ $10^6$ $10^7$

f (Hz)

solder

probeheads

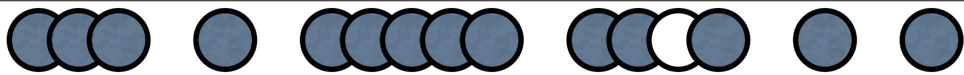



Continuous

1cm

3mm

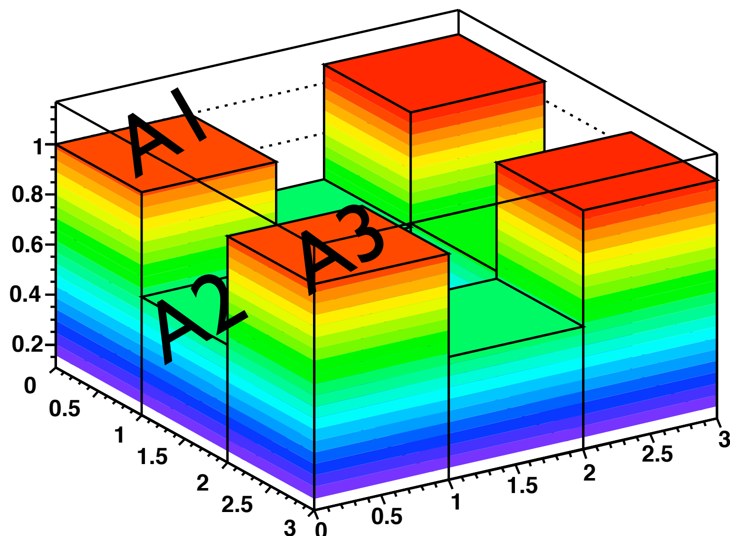
1cm + Continuous



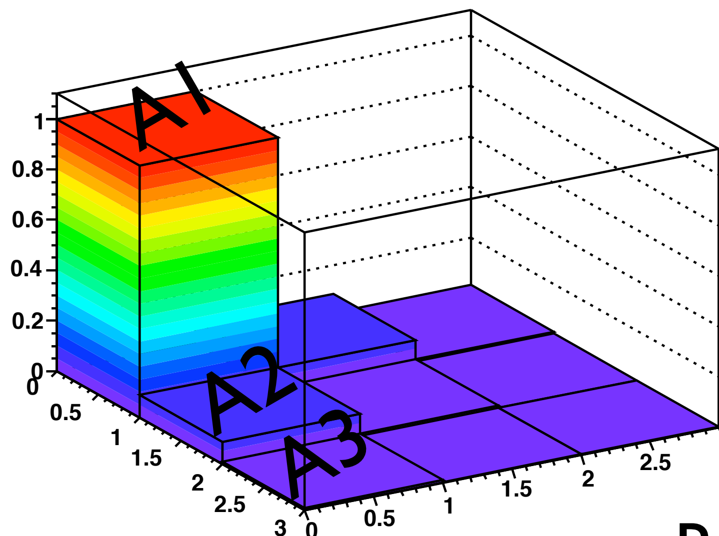
CALICE Calorimeter for ILC

# Distribution of the crosstalk

Continuous



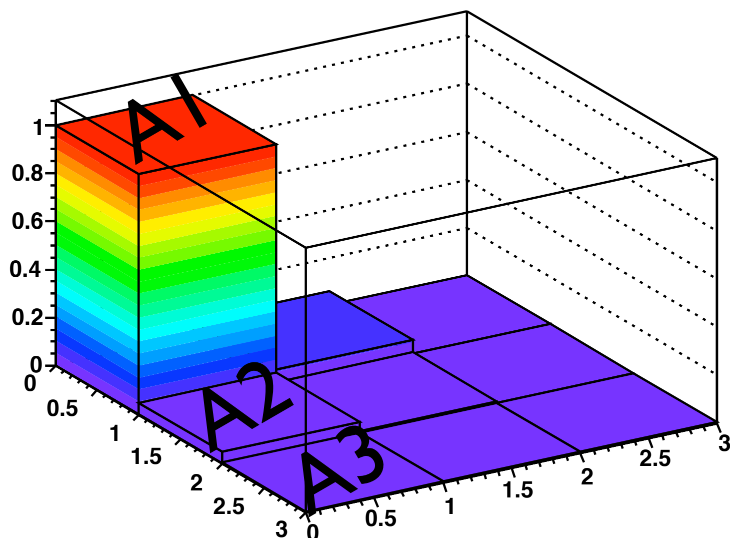

1cm



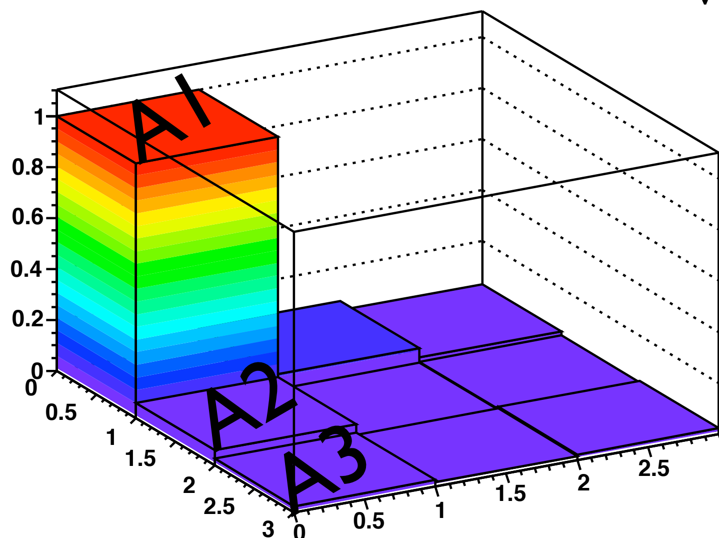

probeheads

f = 400 kHz

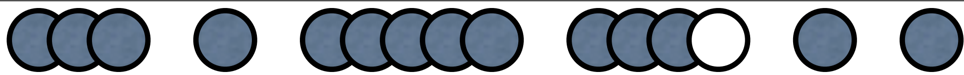
3mm




1cm + Continuous




Relative Weights
weight of A1 = 1



CALICE
Calorimeter for ILC

# Impact of the guard-ring position

**A1 f=400 kHz**

probeheads

G (dB)

0
-5
-10
-15
-20
-25
-30

Continuous

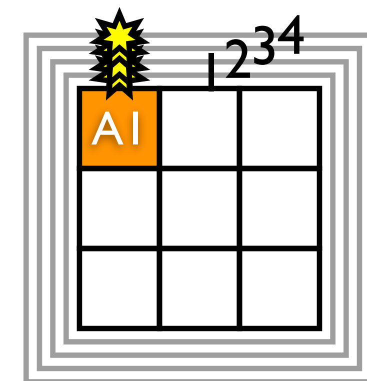
1cm

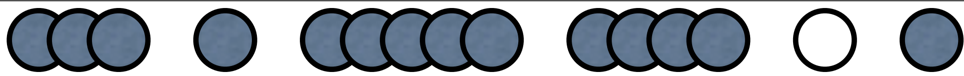
1cm + Continuous

3mm

1
1.5
2
2.5
3
3.5
4

**guard-ring position**





Calorimeter for ILC

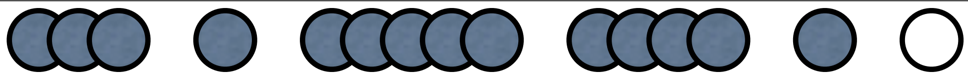
# Conclusion

3mm segmented guard-rings induce the lowest crosstalk.

It is the best guard-ring option for preventing from square events.

The measurement method has been validated.
The test bench is calibrated.

This study is just the first step, real 3x3 wafers will be measured *as soon as we'll get them...*



CALICE
Calorimeter for ILC

# Perspective

binocular
μ-positioners
Si wafer
black box