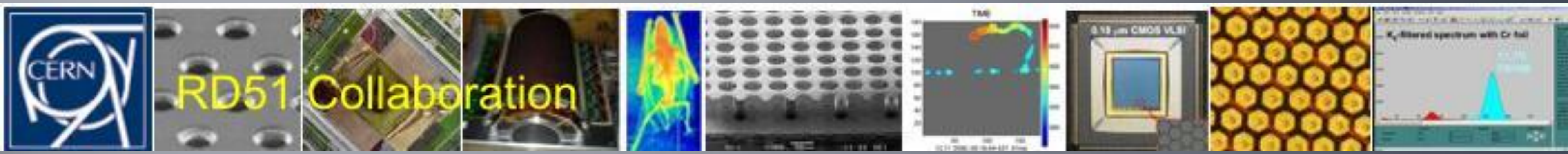
FREIBURG 24-04-10



Resistive protections for Bulk Micromegas

Rui de oliveira, Joerg Wotschack

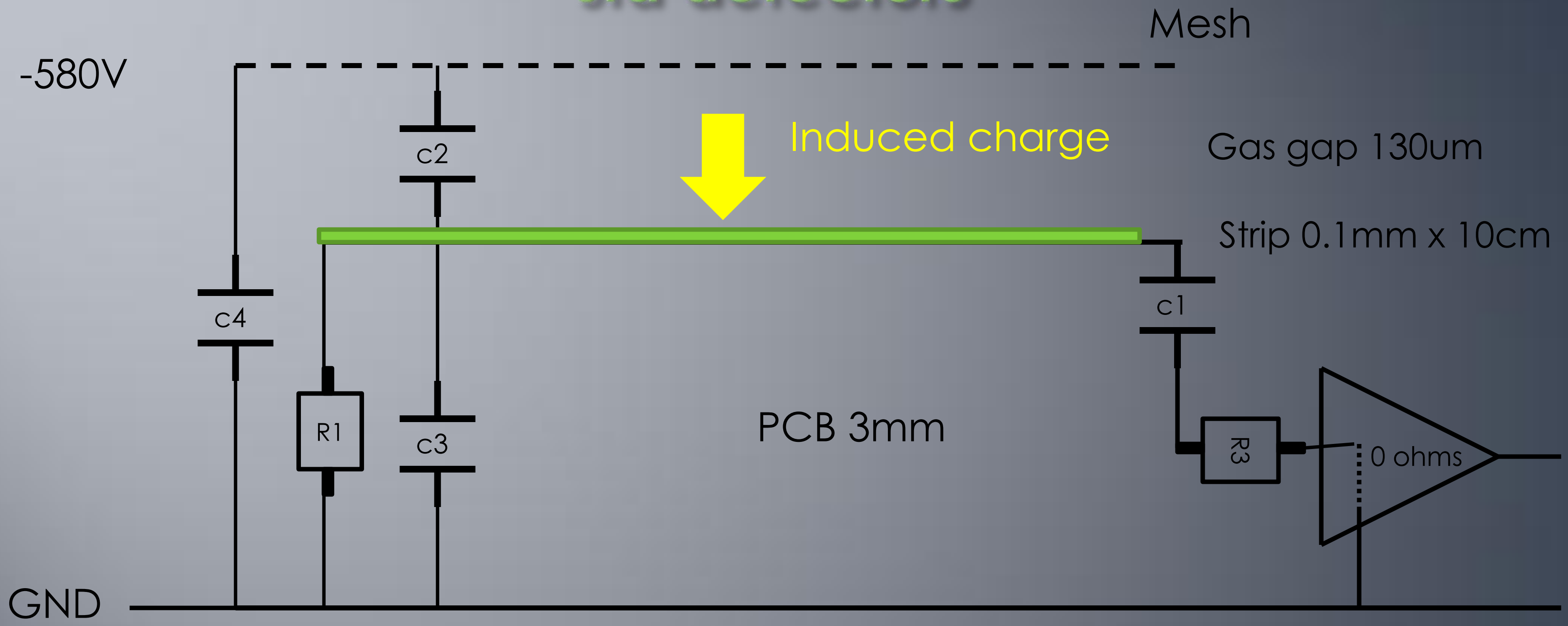
Venetios Polychronakos

Qualitative model of STD bulk and R11 read-out board

- Aim
  - Understand how it works
  - Give a direction during R&D and prototype phase
  - Help to define external components and their need
  - Predict the behavior in large detector

The impedances are not treated as complex during this talk in order to get a model as easy as possible to understand.

std detectors



C2 : in the range of 5pF — Parasitic capacitor mesh to strip

C3 : in the range of 1.5pF — Parasitic capacitor strip to GND

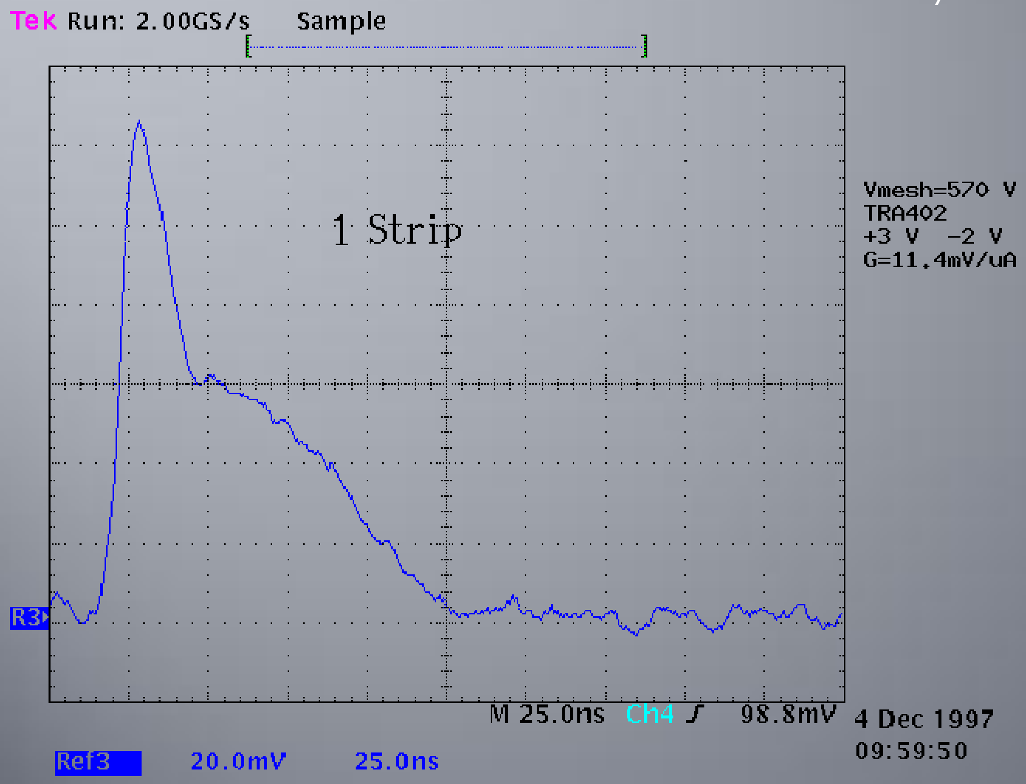
C4 : in the range of 4nF — Parasitic capacitor mesh to GND

R1 : ? 1MOhms — Resistor to discharge strip

R3 : ? — Resistor for spark current limiting

C1 : ? — Spark current limiting

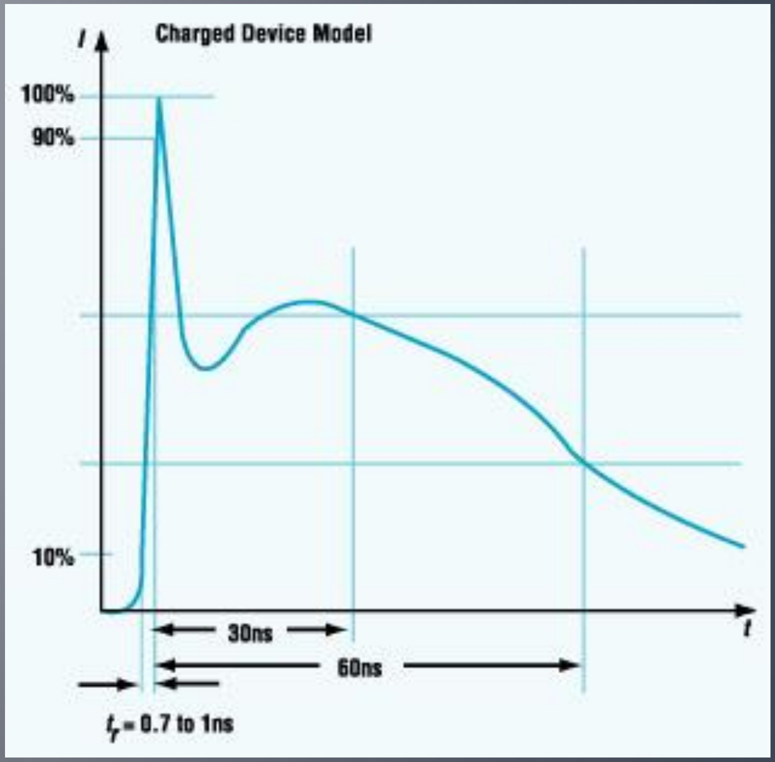
std signals



Typical induced signal
In a Micromegas detector

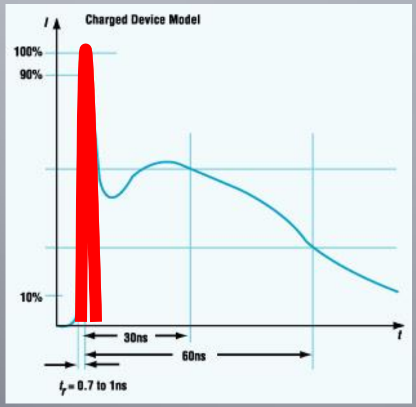
Sparks

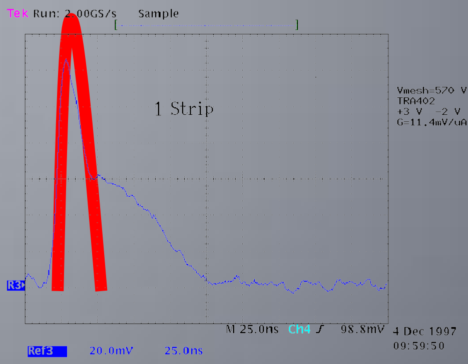
the rise time may be as quick as 0.7 ns, as defined by the new standard IEC 801-2:1991 (IEC 61000-4-2).

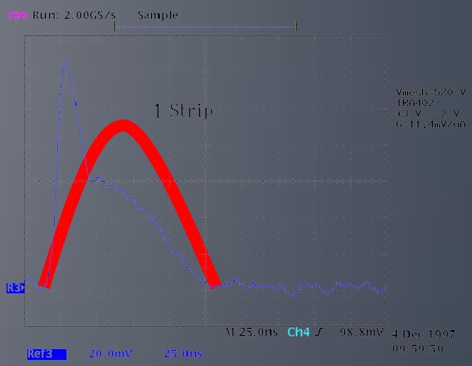


Typical capacitor discharge current with a spark mechanism in a low resistive charge

3 major frequencies







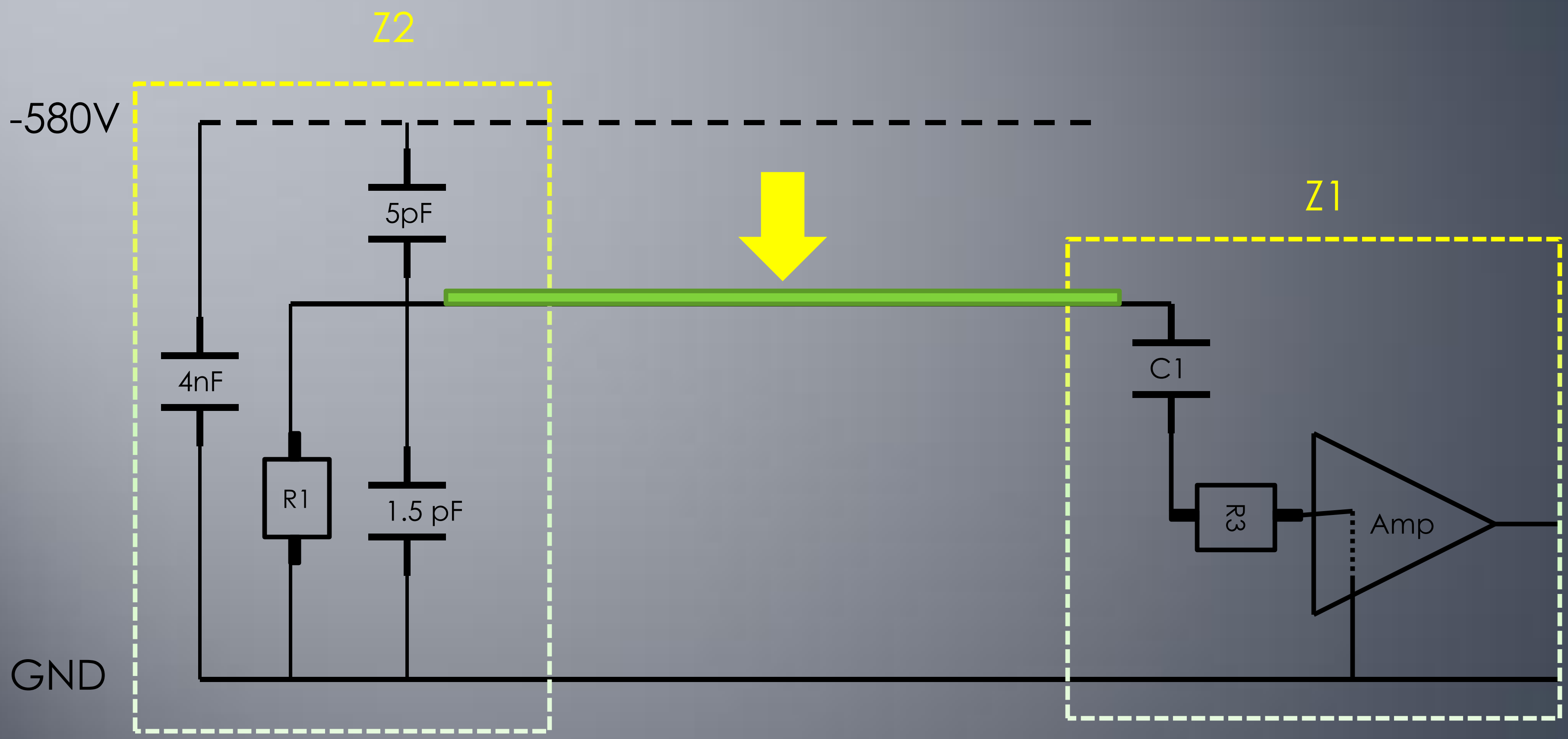
"spark" 1nS
In the range of 1 GHz

"Fast signal" 10nS (electrons)
In the range of 100 MHz

"Slow signal" 100ns (Ions)
In the range of 10 MHz

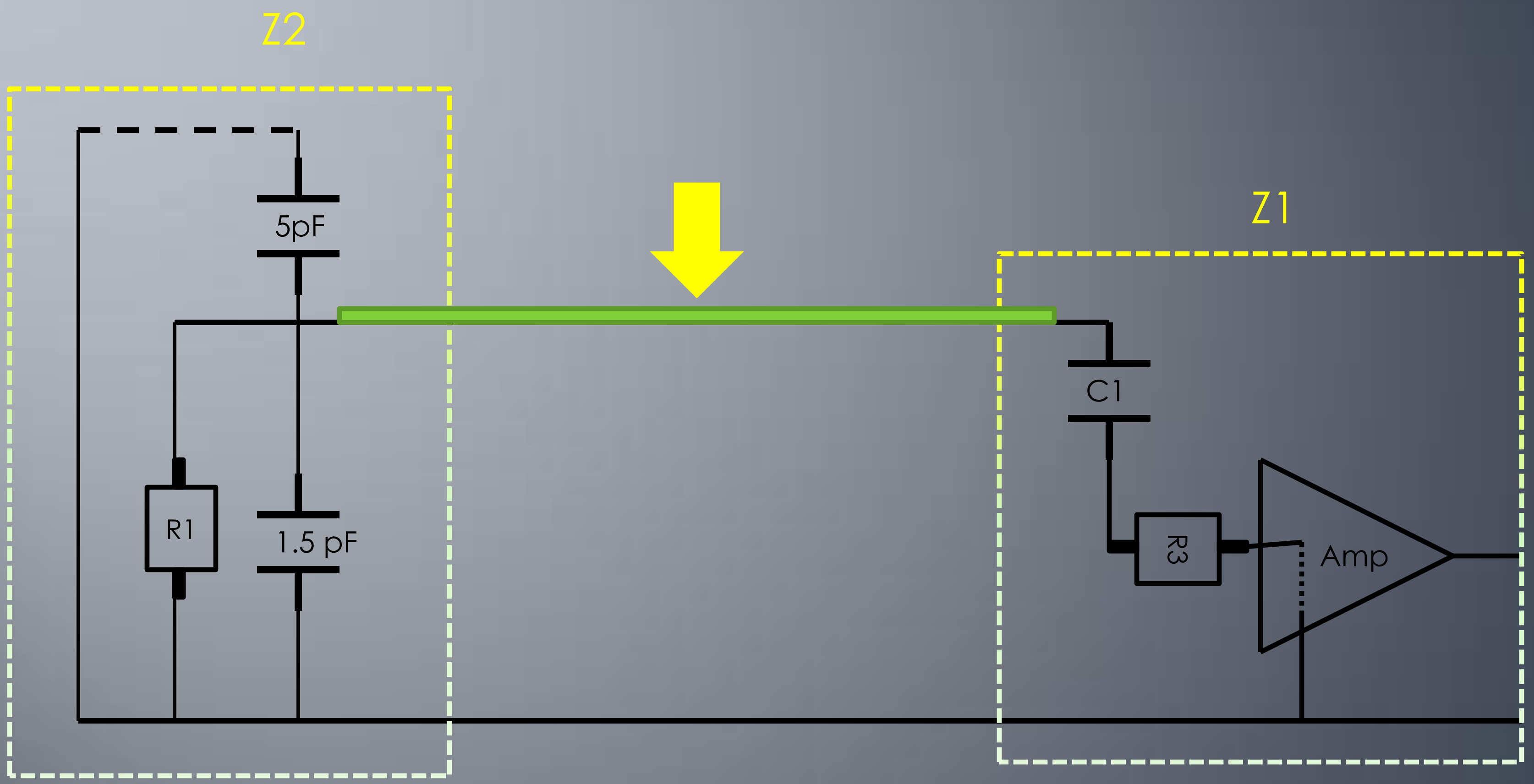
All the signals are above 10 MHz

Std BULK @ frequencies above 10MHz

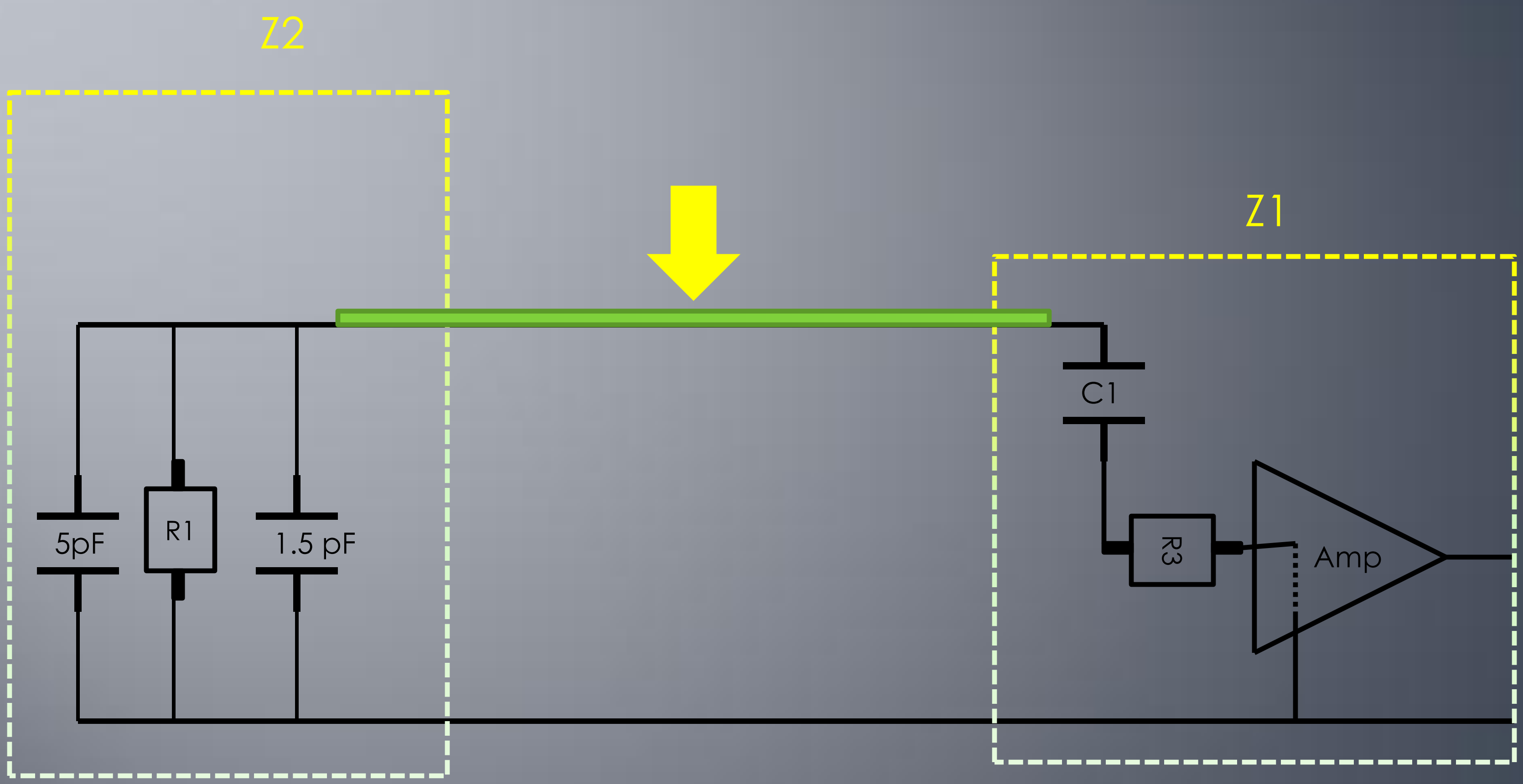


The power supply is a short at high frequencies
And in any case 5pF serial to 4nF = 5pF

@ frequencies above 10MHz

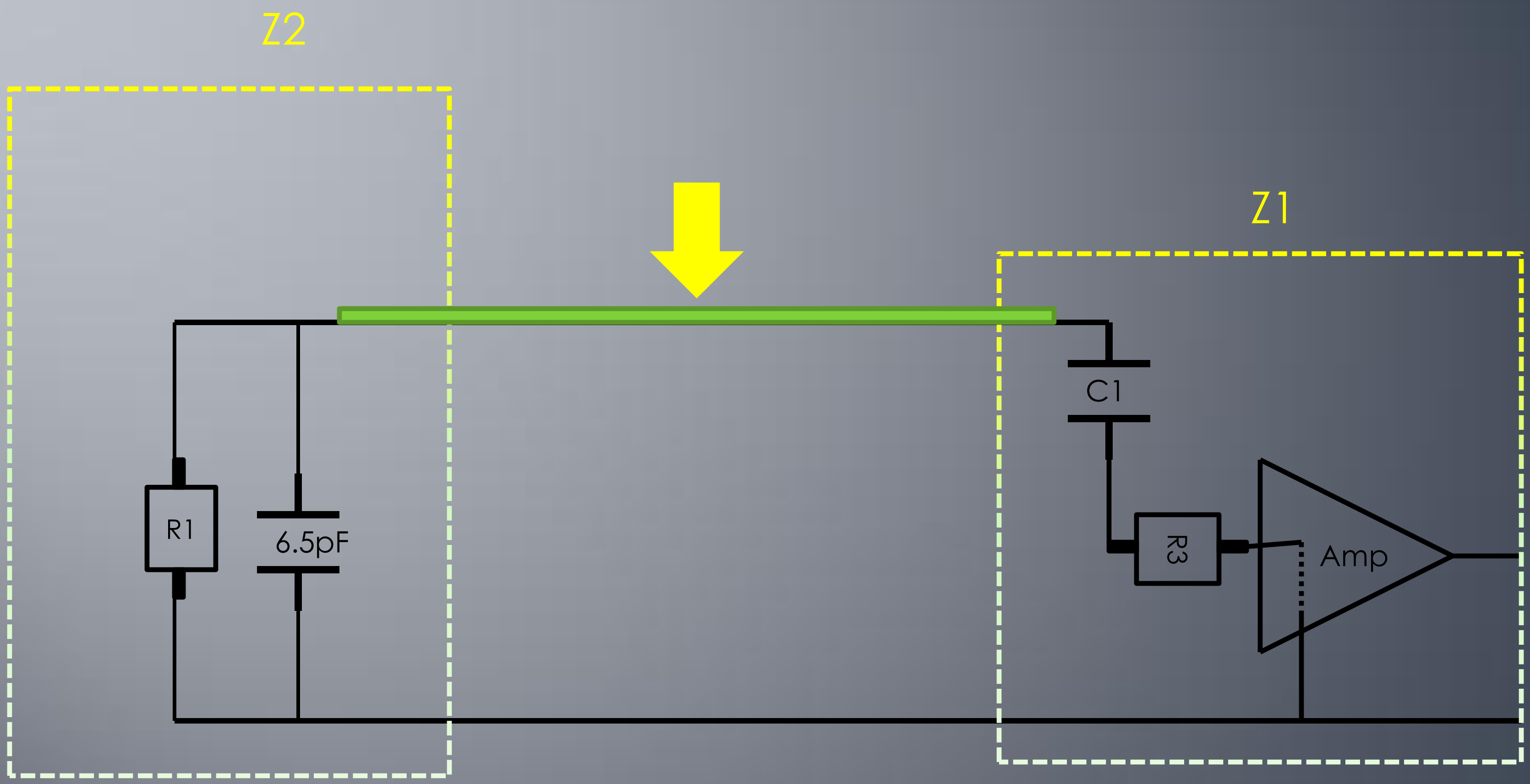


@ frequencies above 10MHz



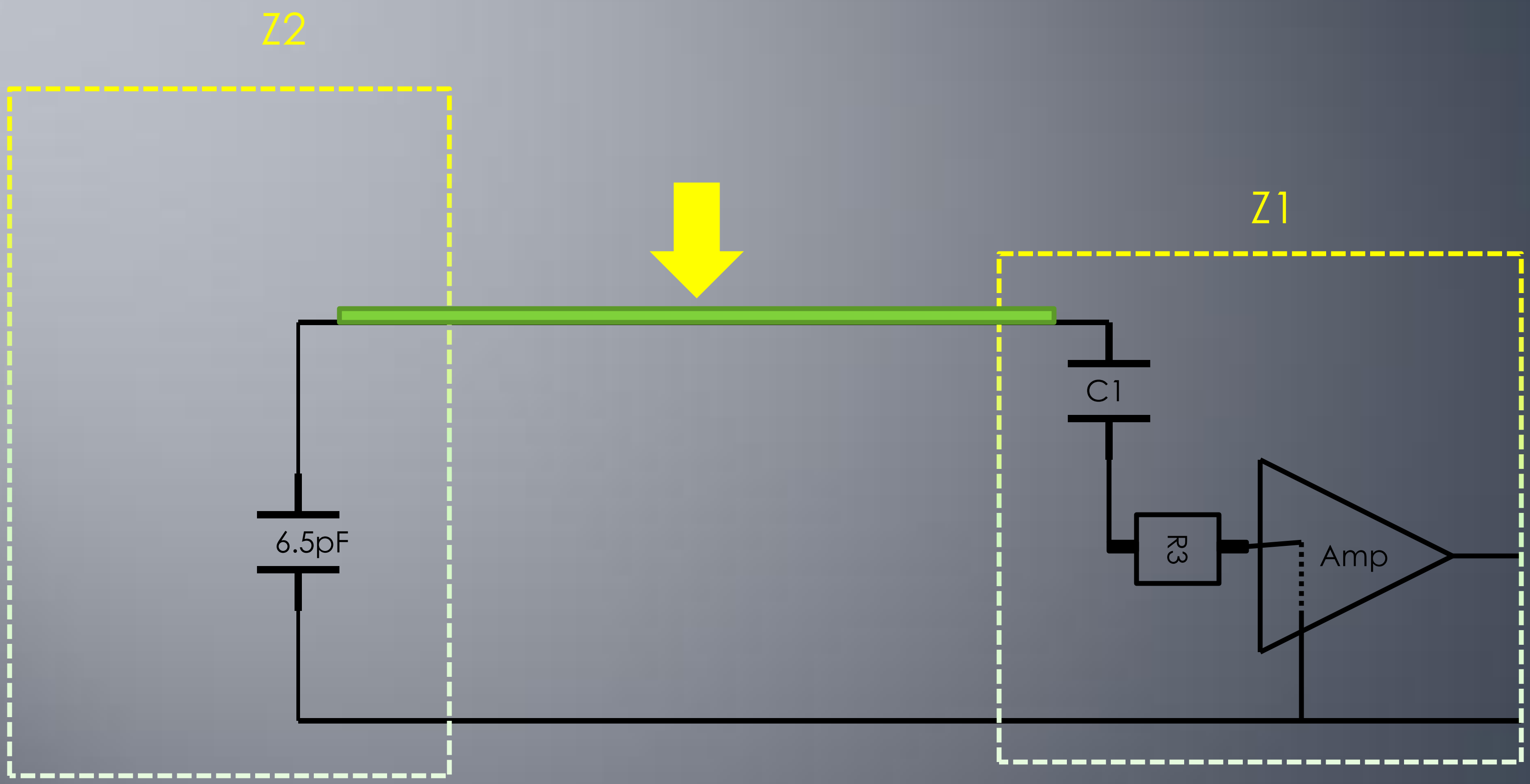
5pf // 1.5pF → 6.5pF

@ frequencies above 10MHz



Impedance of 6.5pF above 10Mhz < 2500 Ohms
R1 is above 1Mohms → negligible influence

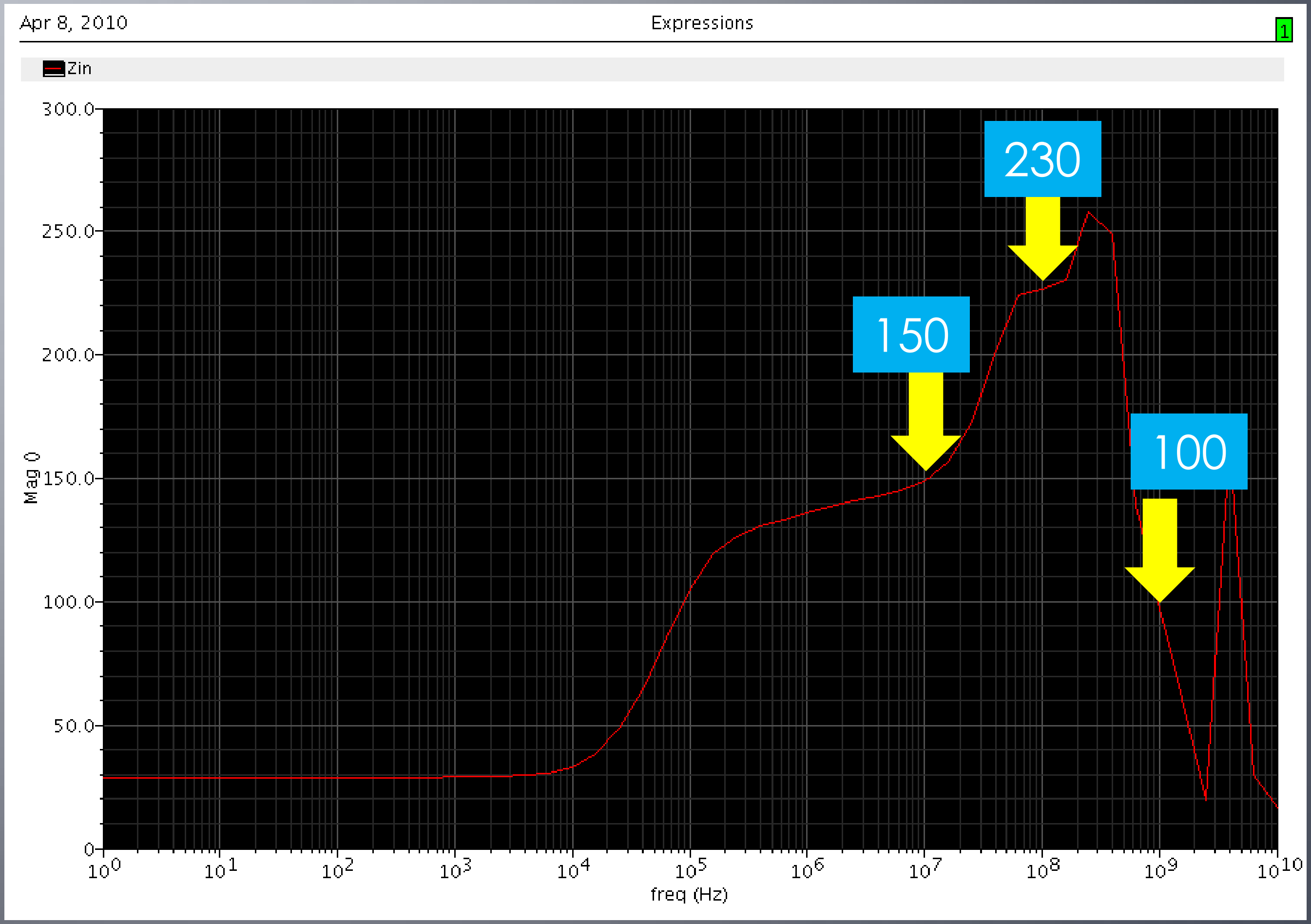
@ frequencies above 10MHz



Simplified equivalent schematic of one strip
In a 100mm x 100mm detector for f > 10MHz

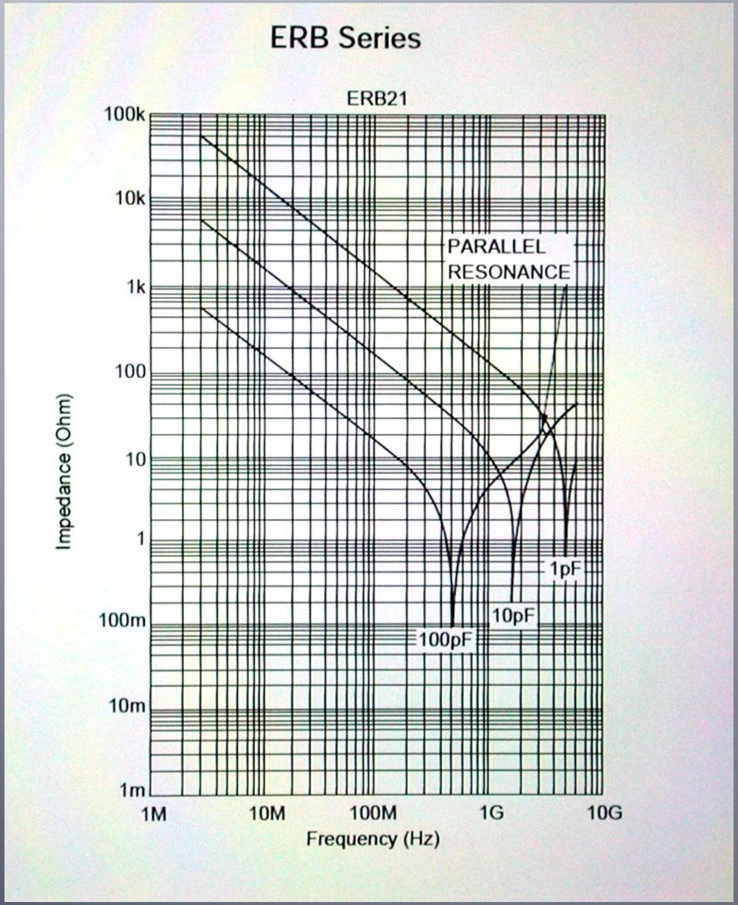
Let's look now at Z1 → First the Amp

Amplifier impedance



Ex: MICROROC Chip (being designed) input impedance
(Thanks to Renaud Gaglionne LAPP and LAL collaboration)

Capacitor impedance



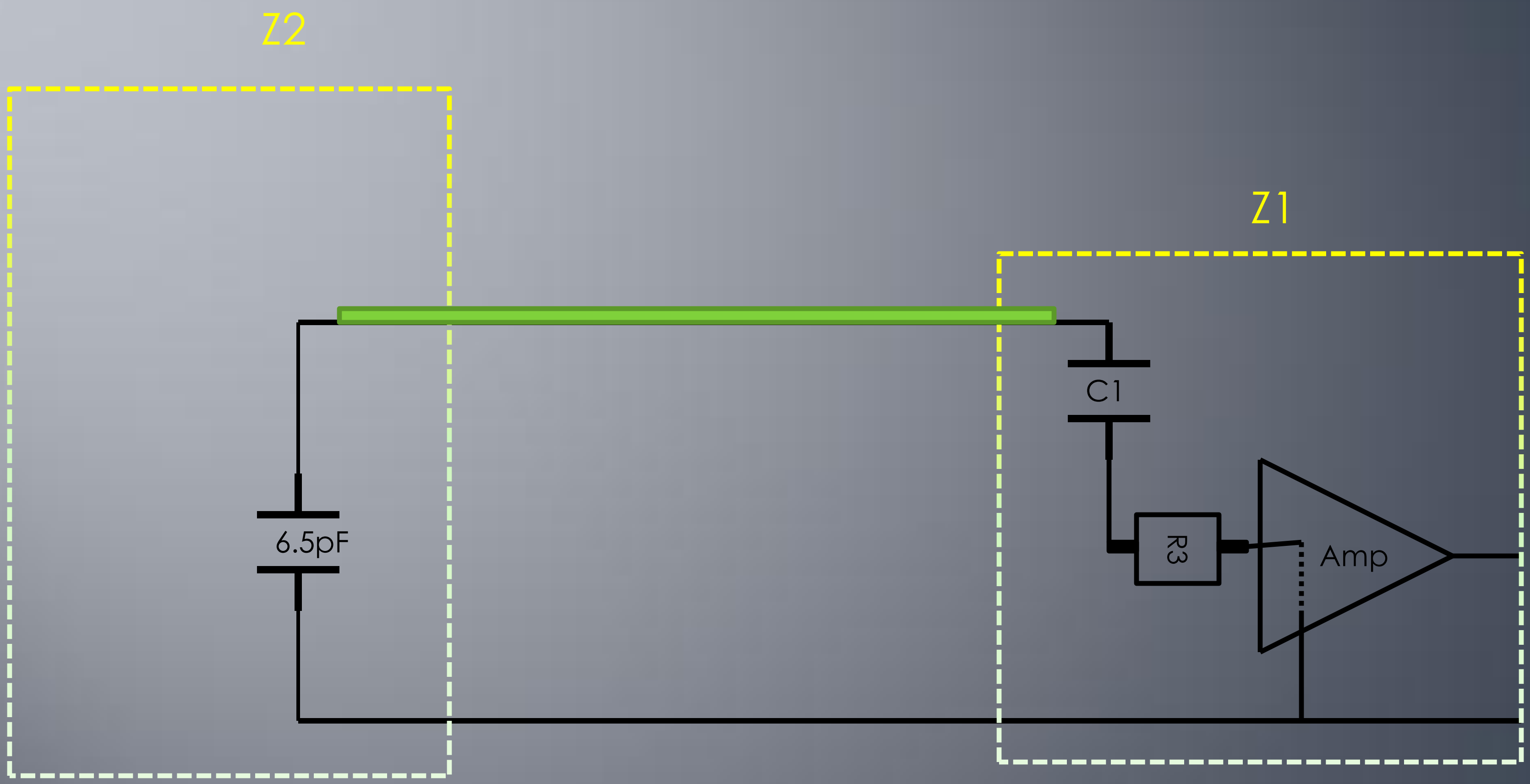
Murata capacitor catalog

Typical Capacitor impedance
at High frequencies
Ceramic capacitors NPO

The smaller is the capacitor the better
Is its behavior at high frequencies

@ 10Mhz	100pF → 200 Ohms
@ 100Mhz	100pF → 20 Ohms
@ 1Ghz	100pf → 4 Ohms

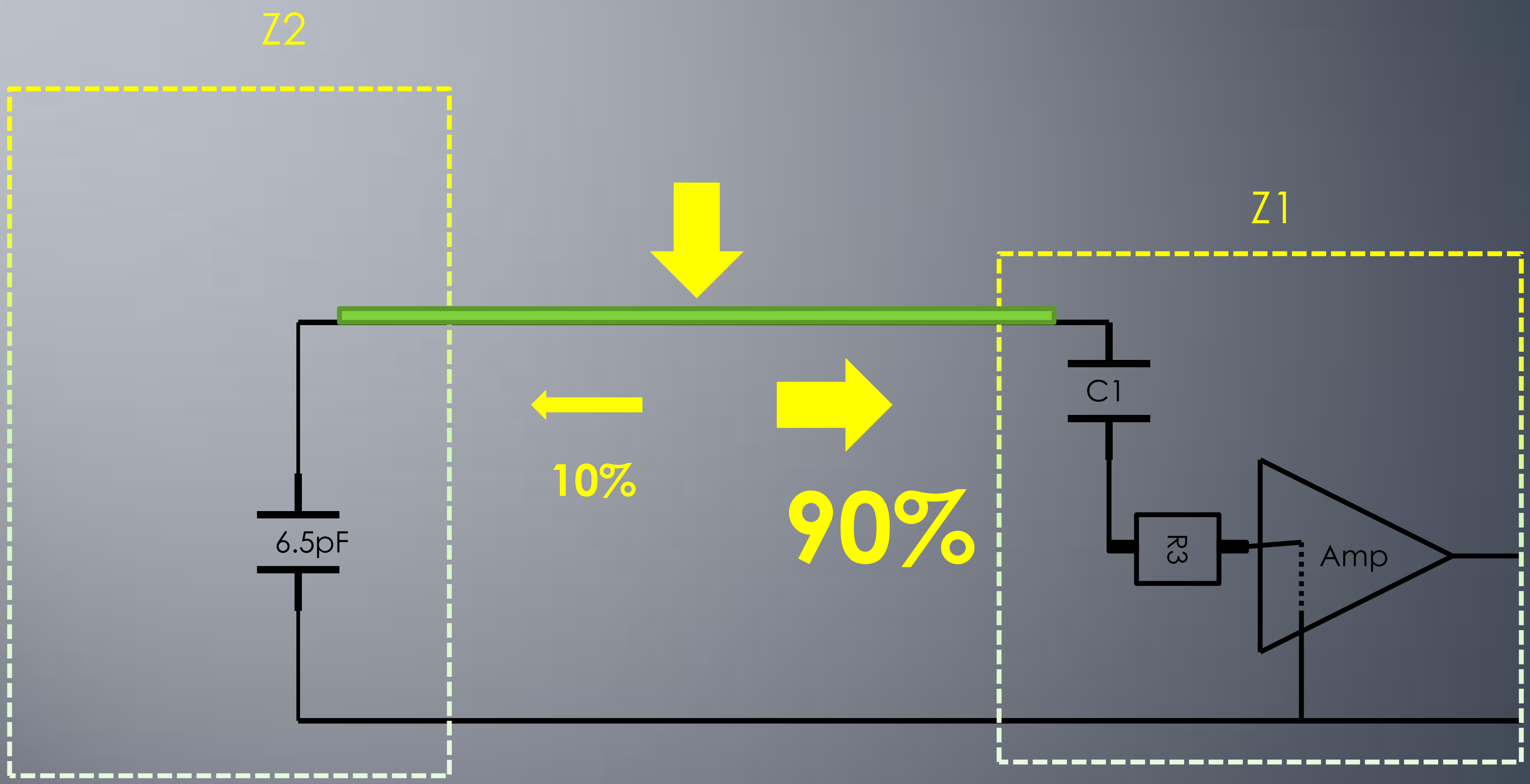
@ 10MHz Ions



6.5pF → **2500 Ohms**

R3 =10 Ohms
C1= 200 pF → 100 Ohms
Amp→ 150 Ohms
Total : **260 Ohms**

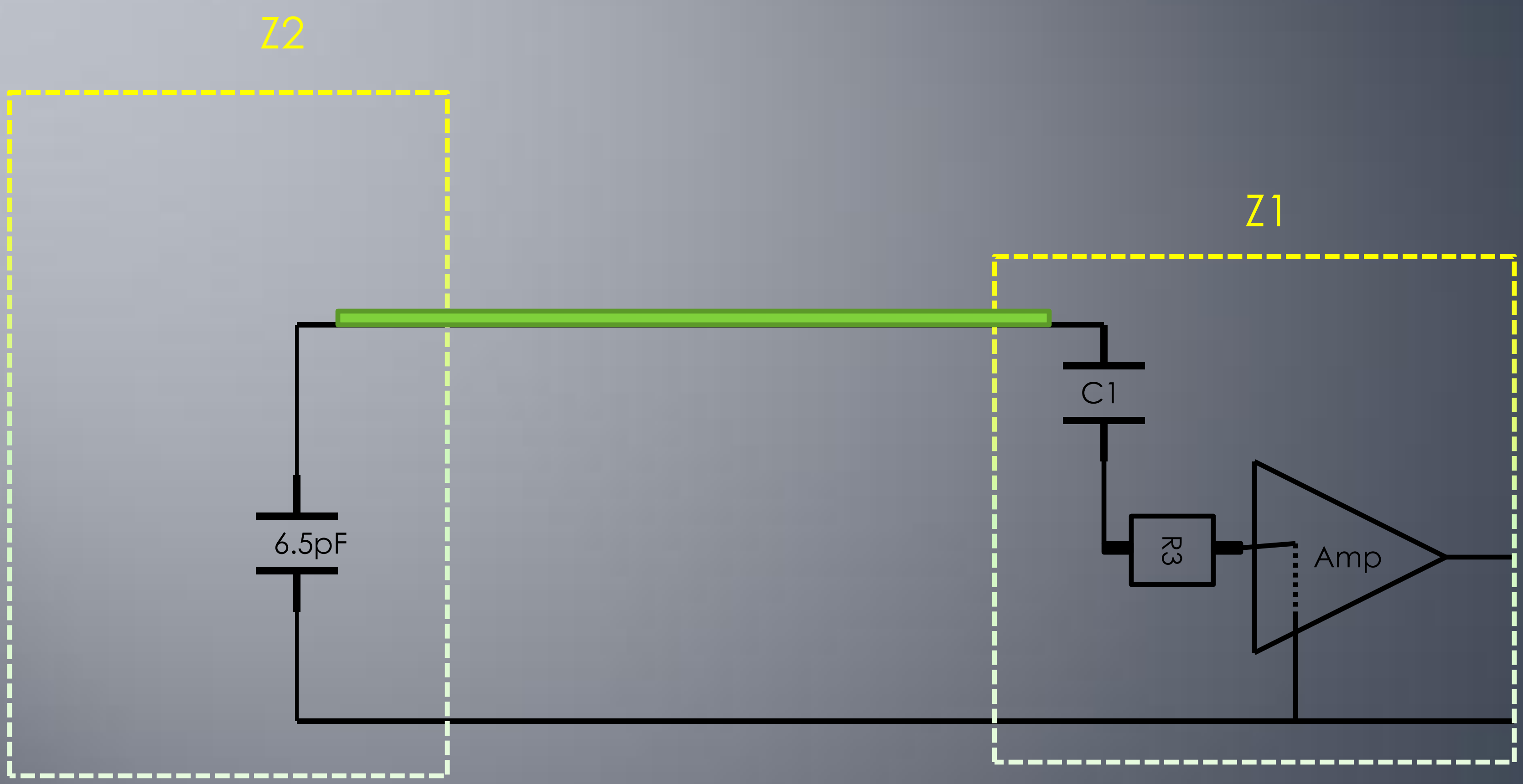
@ 10MHz Ions



6.5pF → **2500 Ohms**
(Value proportional to Detector size)

R3 =10 Ohms
C1= 200 pF → 100 Ohms
Amp→ 150 Ohms
Total : **260 Ohms**

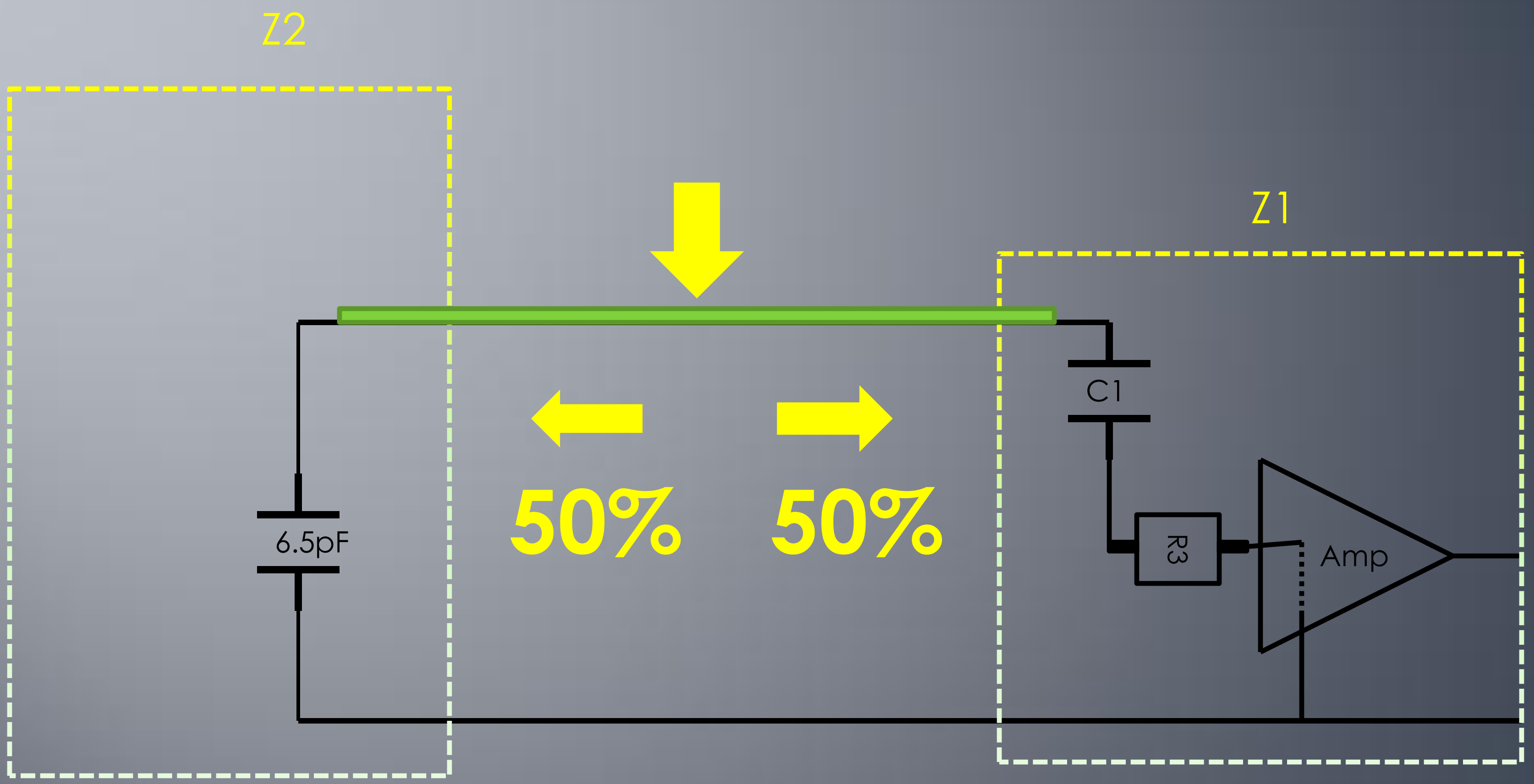
@ 100MHz electrons



6.5pF → **250 Ohms**

R3 =10 Ohms
C1= 200 pF → 10Ohms
!!!Amp→ 230 Ohms
Total : **250 Ohms**

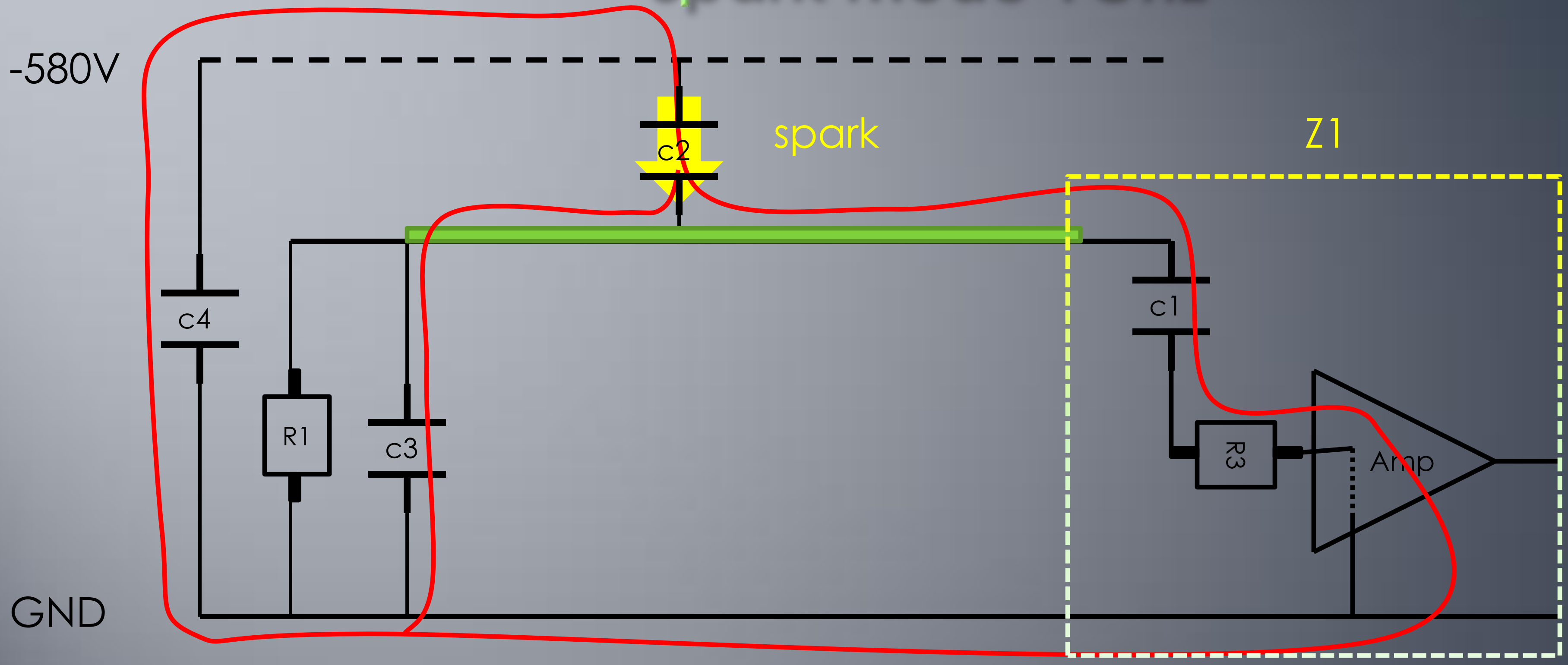
@ 100MHz electrons



6.5pF → **250 Ohms**

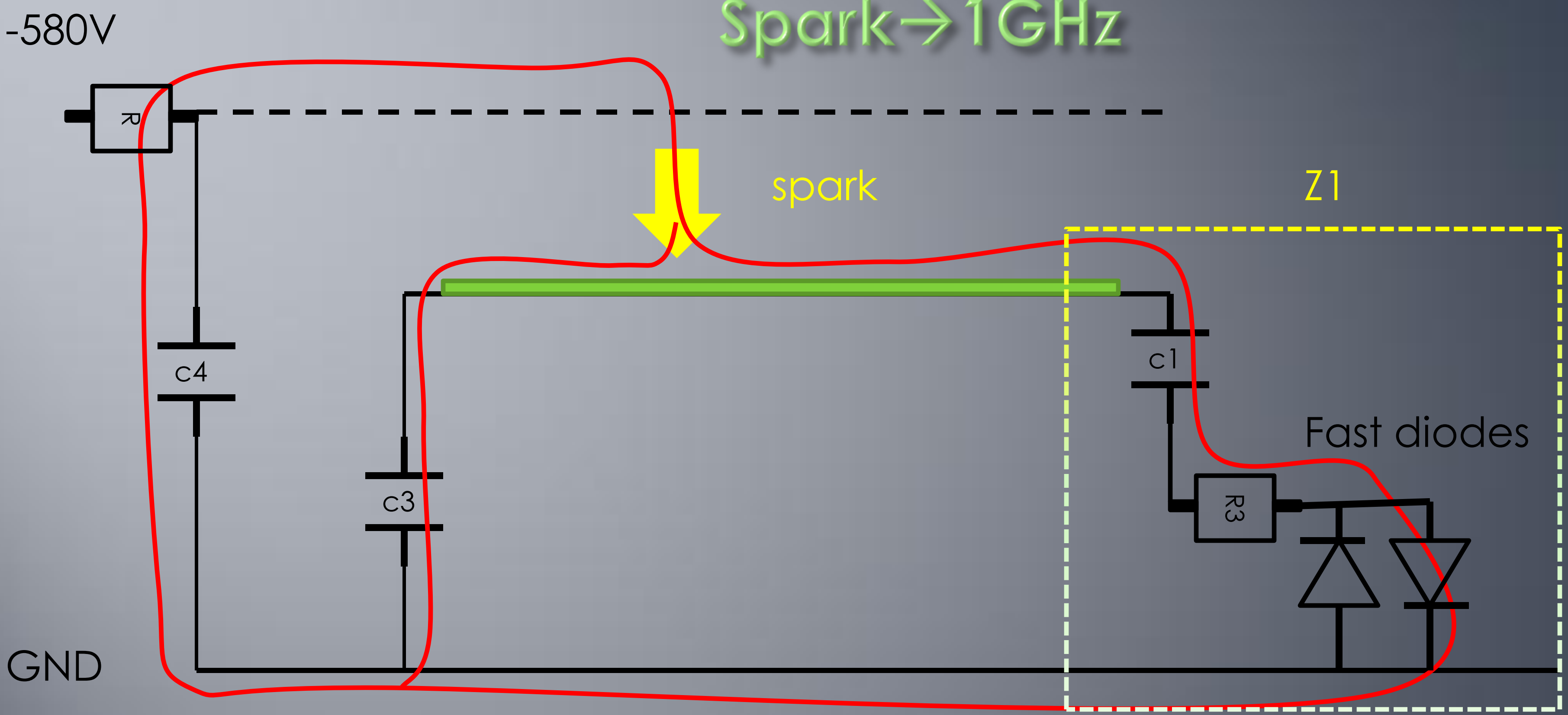
R3 =10 Ohms
C1= 200 pF → 10Ohms
!!!Amp→ 230 Ohms
Total : **250 Ohms**

Spark mode 1Ghz



R1 is to high to drive any significant current

Spark→1GHz



-C3 =1.5pF → around 150 Ohms

-C1 =200pF → 2 Ohms
-R3 = 10 Ohms
-Diodes → less than 1 Ohms

-Peak current = 580V/13 Ohms → 44Amps during a few ns
- C1 and C3 are charged with C4 discharge

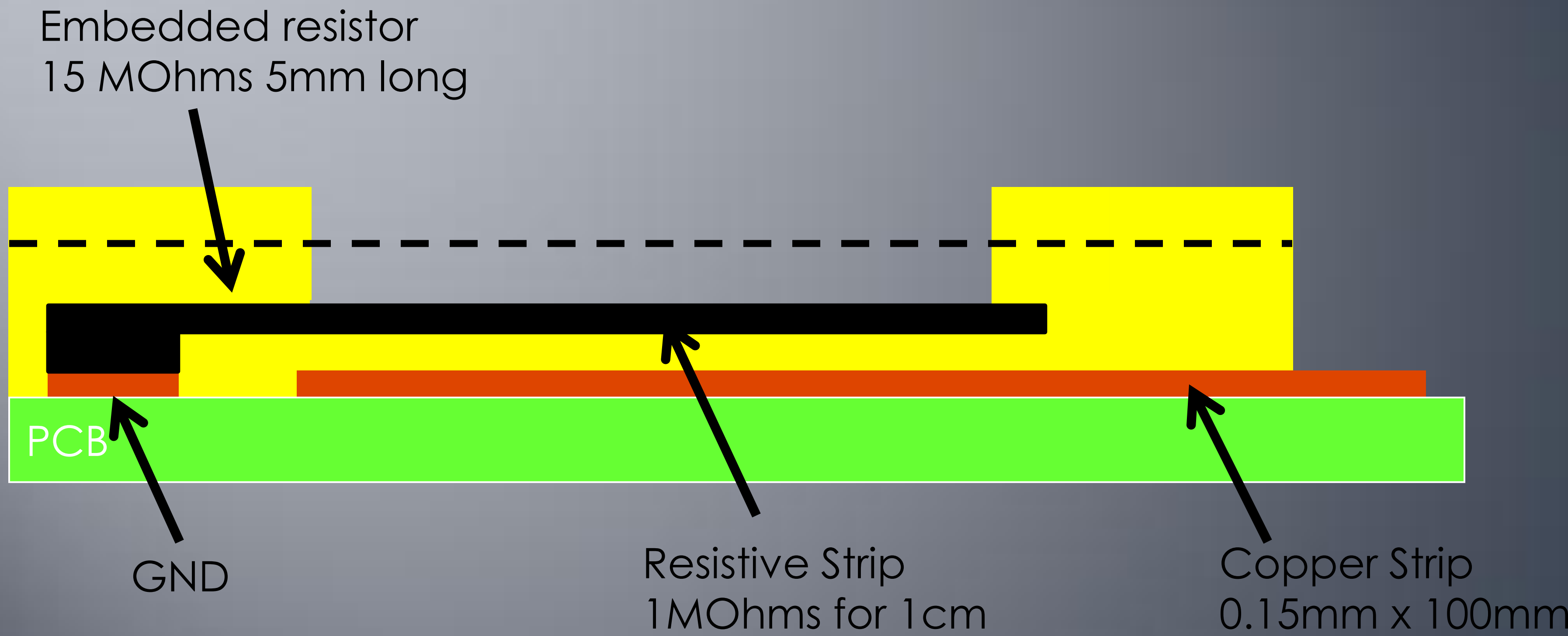
C4 can not supply this current and maintain the mesh voltage → Vmesh drops
At one point the voltage between C4 and C1 is not enough to maintain the spark.
The spark end and C4 is refill by the power supply through R.
This RC4 constant define the dead time of the detector. (usually a few mS, all the detector is affected)

Summary for 10cm x 10cm BULK

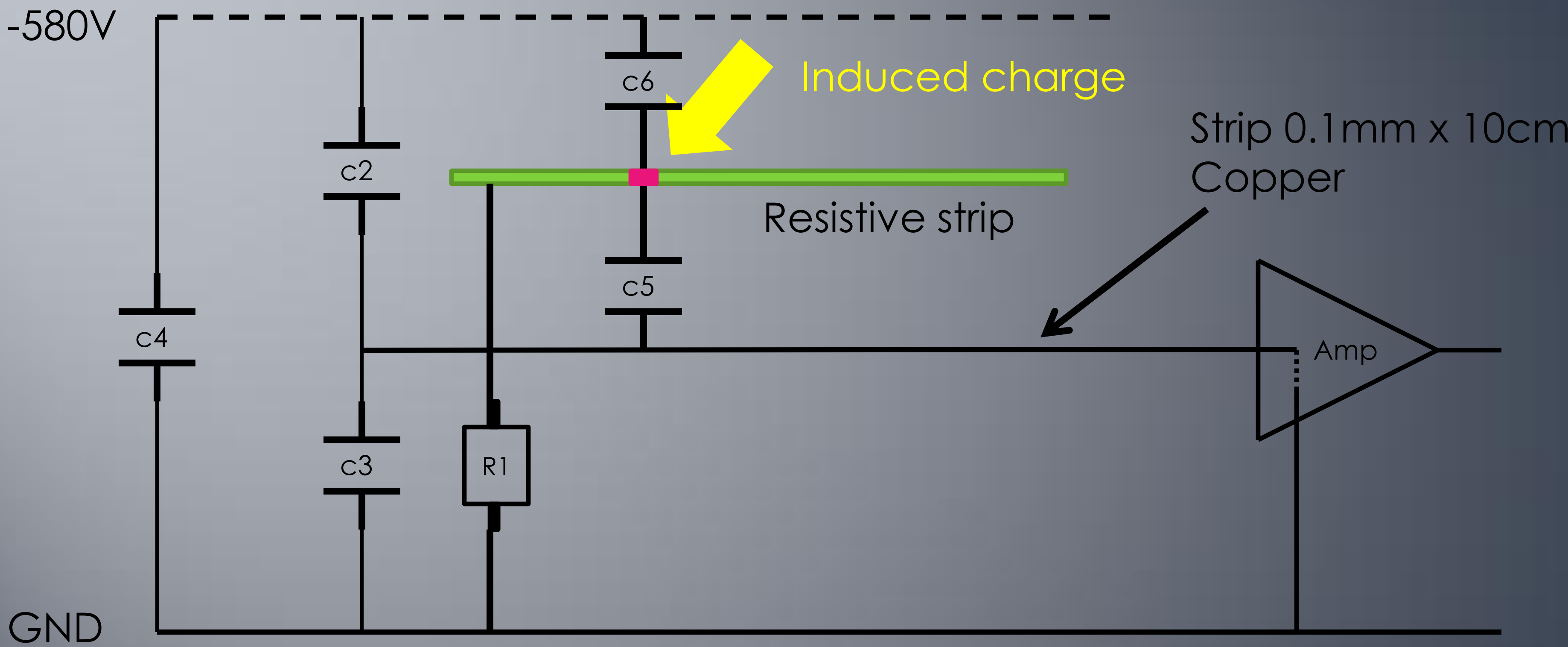
- C1 in the range of 100 to 200pf (600V min)
  - Smaller : reduce detector efficiency but increase protection
  - Higher : increase spark current
- R3 in the range of 10 to 20 Ohms
  - Higher : less efficiency for electrons
  - Less : higher spark current
- Amp
  - Can we improve its impedance !
  - Need protections for peaks currents in the range of 20 Amps during a few ns
- Capacitance of the mesh
  - As low as possible (segmentation)→ to stop the spark fast
- Parasitic capacitance of lines
  - As low as possible to reduce C1 and reduce sparks current.
  - As low as possible to avoid charge losses in the board.

R11

R11

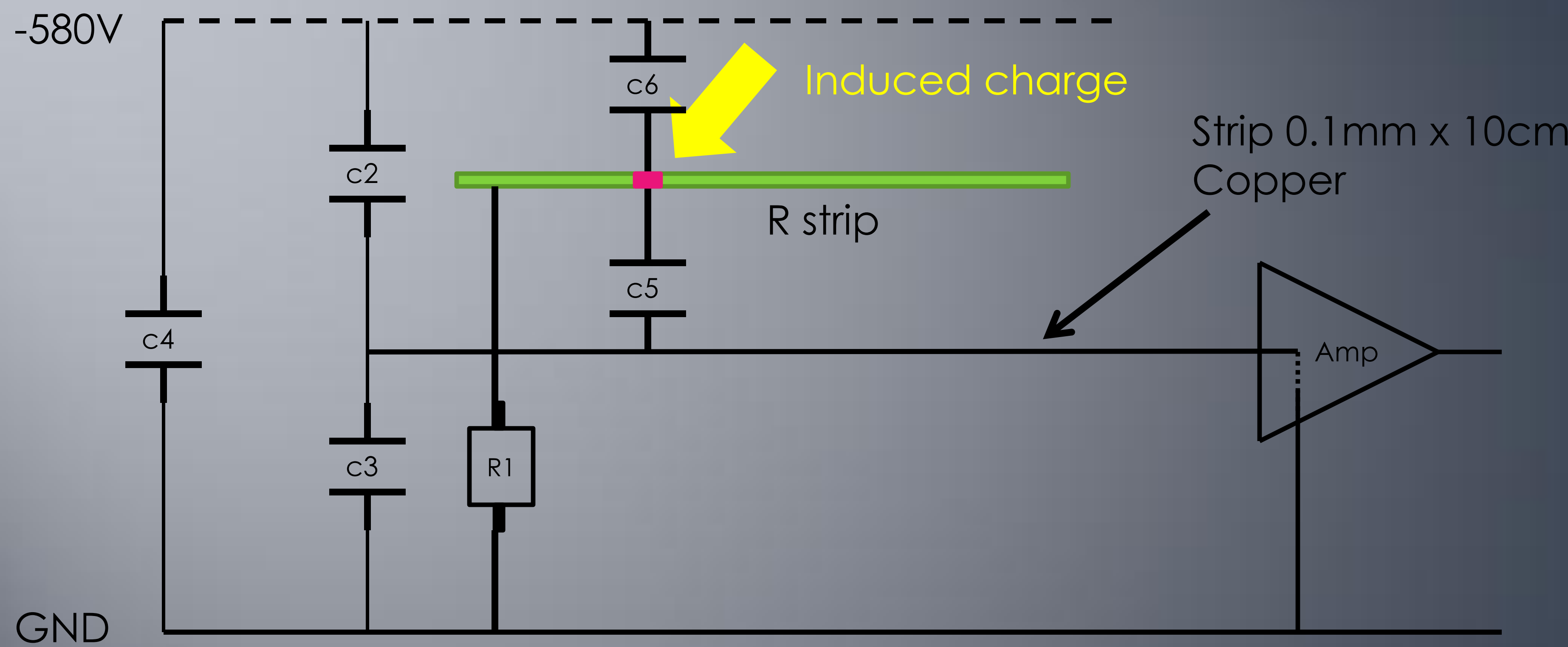

Embedded resistor
15 MOhms 5mm long
PCB
GND
Resistive Strip
1MOhms for 1cm
Copper Strip
0.15mm x 100mm

R11 normal operation



C2 : in the range of 5pF	Parasitic capacitor mesh to strip
C3 : in the range of 1.5pF	Parasitic capacitor strip to GND
C4 : in the range of 4nF	Parasitic capacitor mesh to GND
C5: ?	Parasitic capacitor R-strip to GND
C6: ?	Parasitic capacitor R-strip to read-strip
R1 : from 15 to 25 MOhms	Resistor to discharge R-strip

R11 normal operation above 10Mhz



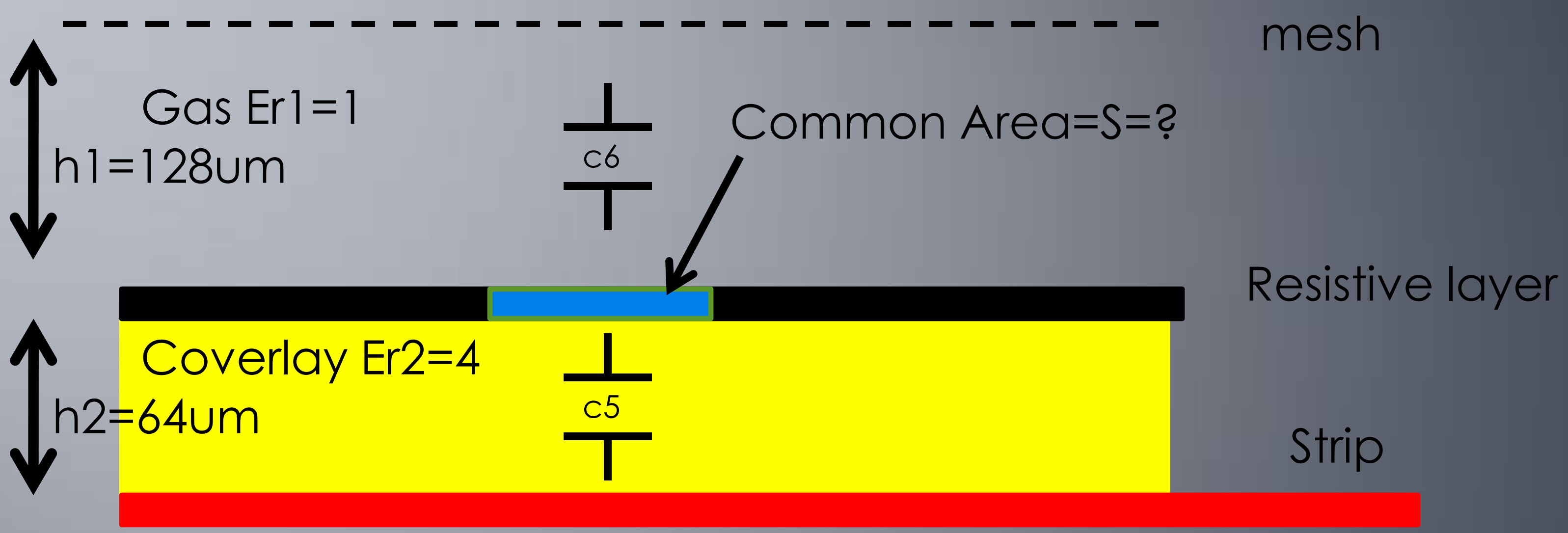
-In normal operation the induced charge will be split first only between C5 and C6

- both sides of C6 and C5 capacitors are virtually grounded above 10MHz

C6 on the mesh side is grounded at high frequencies with C4

C5 is grounded by the Amp (and also C3 assuming that C5<<C3)

C5 /C6 ratio?



C5 and C6 are sharing a common electrode in blue , this area is not known

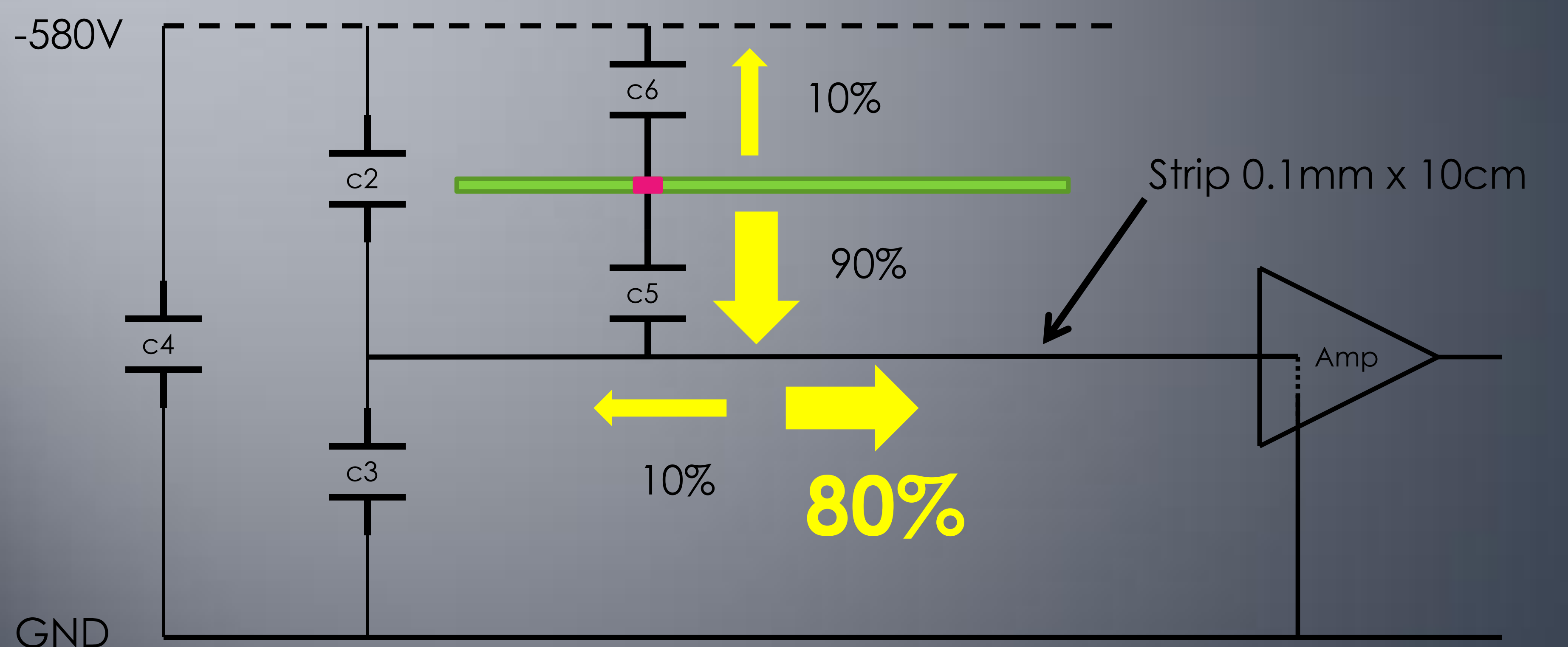
C5= Eo x Er2 x S/h2

C6= Eo x Er1x S/h1

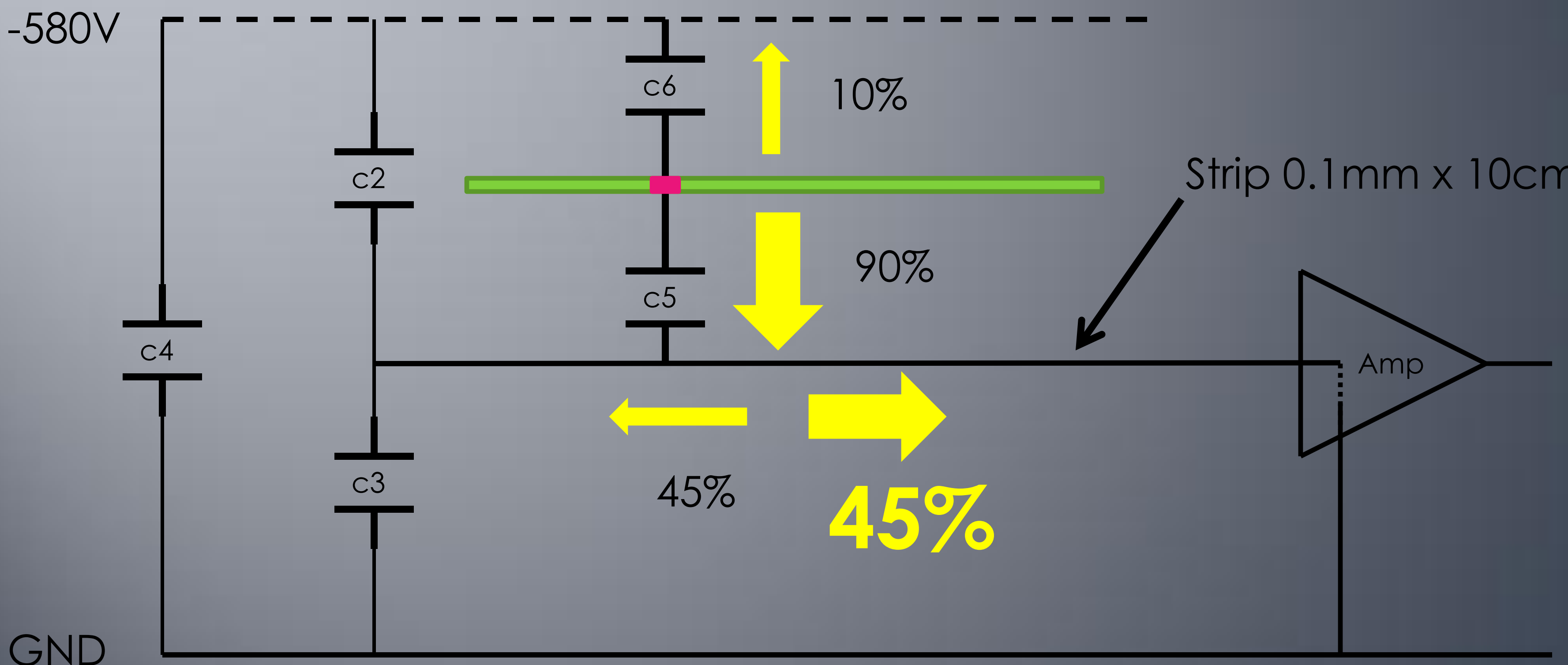
C5/C6= Er2 x h1 / Er1 x h2 = 8

More than 90% of the charges will flow through C5 whatever is the value of the area

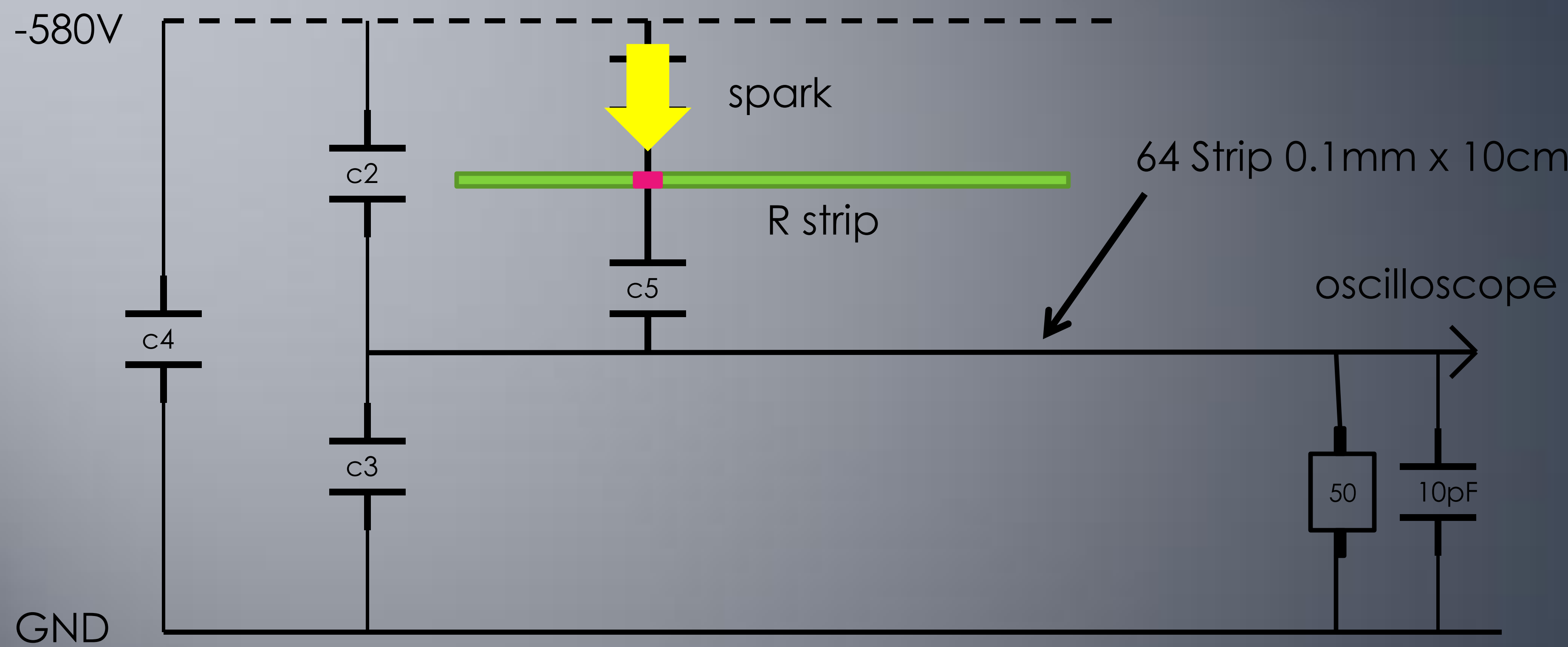
R11 normal operation @ 10MHz Ions



R11 normal operation @ 100MHz electrons

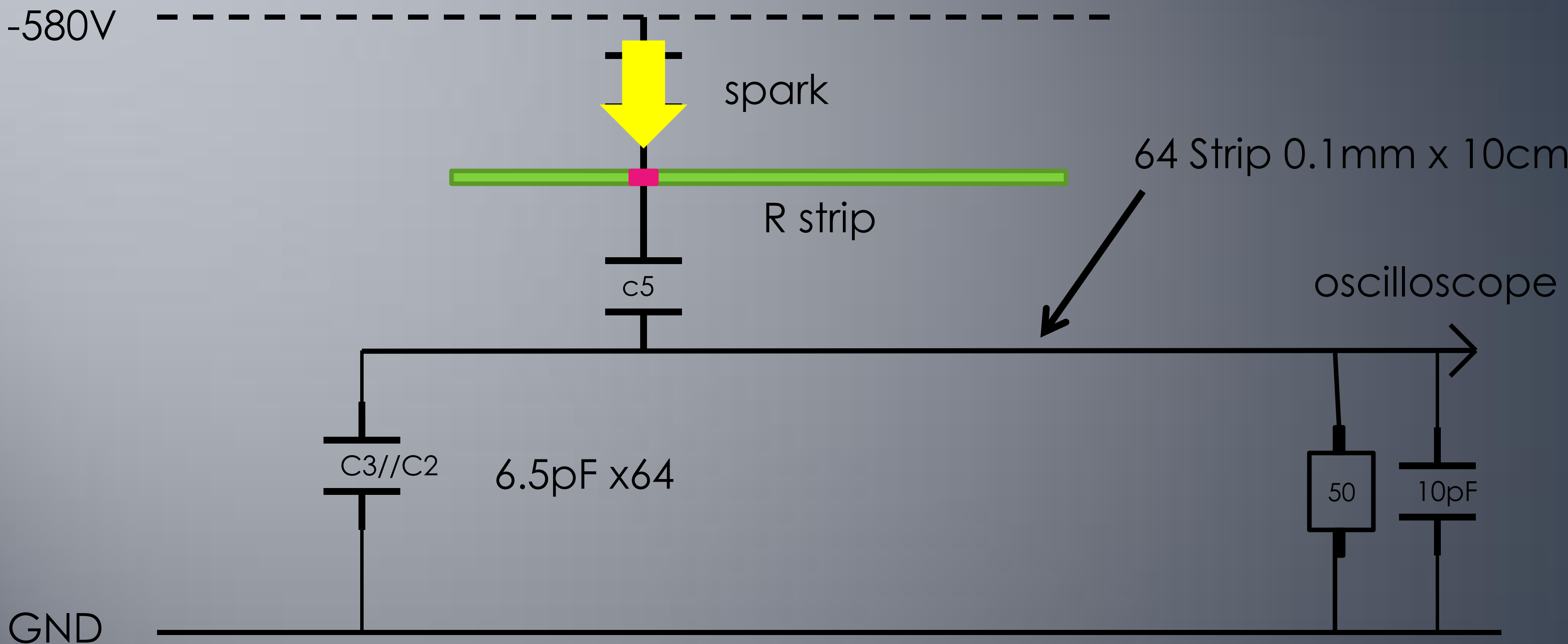


R11 Sparks (1GHz)

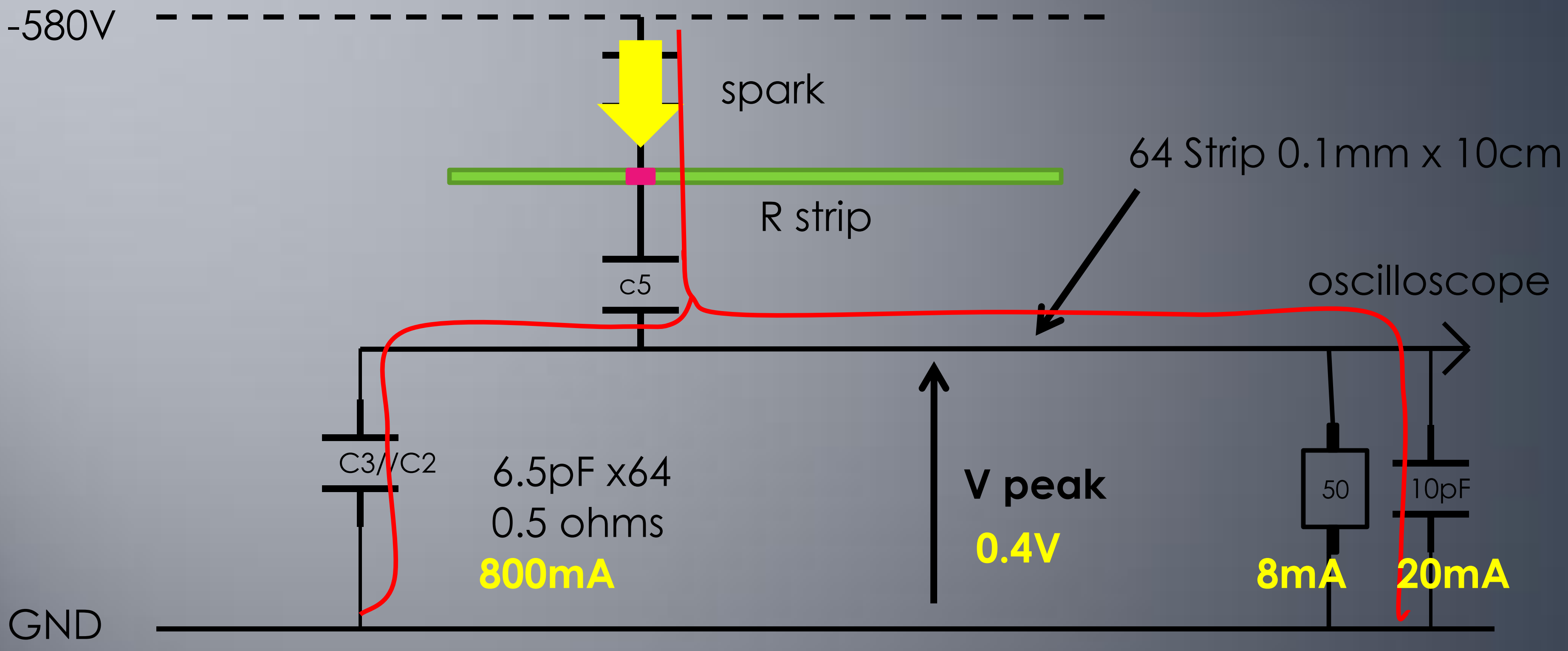


In the test 64 lines were connected together
The oscilloscope probe has 10pF capacitance

R11 Sparks (1GHz)



R11 Sparks (1GHz)



I peak in the 50 Ohms = 8mA
I peak in C3//C2 x 64 = 800mA
I peak in 10 pF= 20mA

I peak in C5 in the range of 800mA

C5 value?

The impedance of **64 x (C3//C2) // 50ohms// 10pF** is less than 1 ohm @1Ghz

So during 'mild sparks' C5 see the full voltage 580V

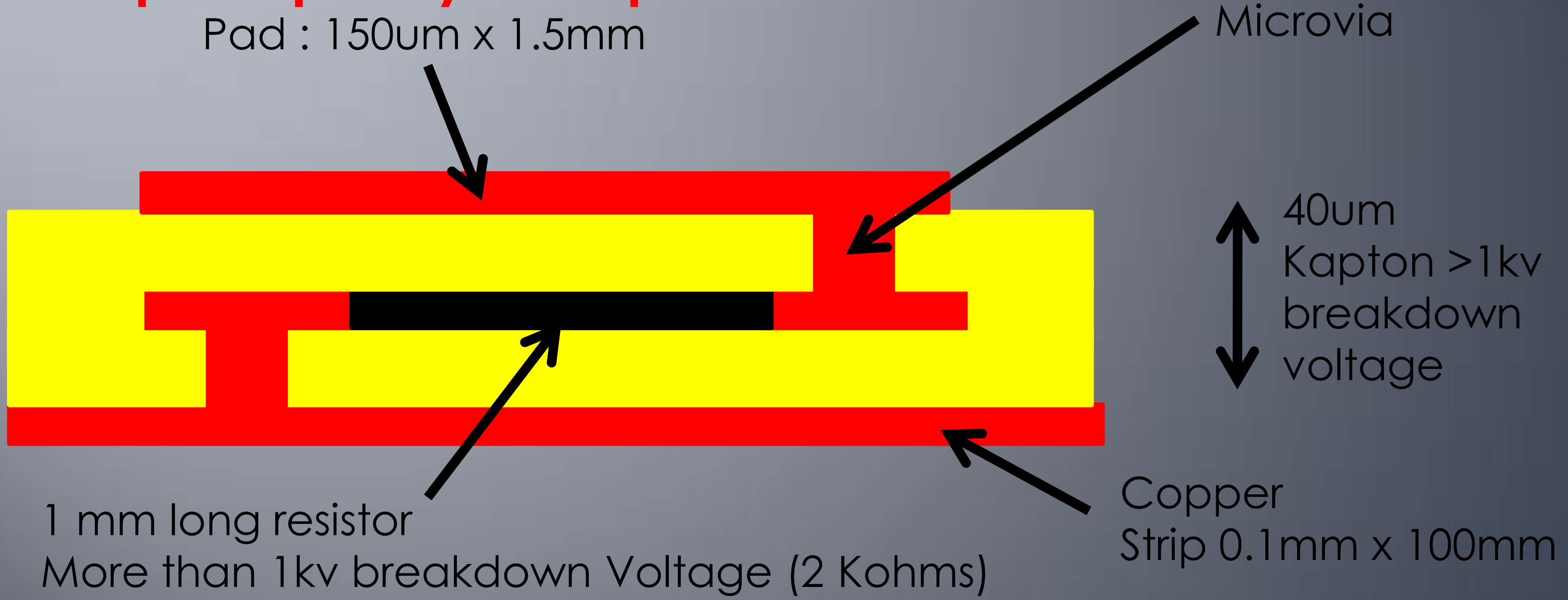
ZC5 @1Ghz is in the range of 580V/ 800mA → 725ohms

→ C5 in the range of 0.4pF

R5 and R11 behavior difference ?

R5

0.2pF capacity from pad to line.



R5 shows Higher gains than STD Bulk detectors ?

Why a so big difference during sparks between R5 and R11

- R5 pad capacity to strip 0.2pF
- R11 local capacity to strip 0.4pF

- R5 discharge resistor **2KOhms**
- R11 discharge resistor **15MOhms**

- R5 spark currents →power supply limitation
- R11 spark currents→ a few nA in average

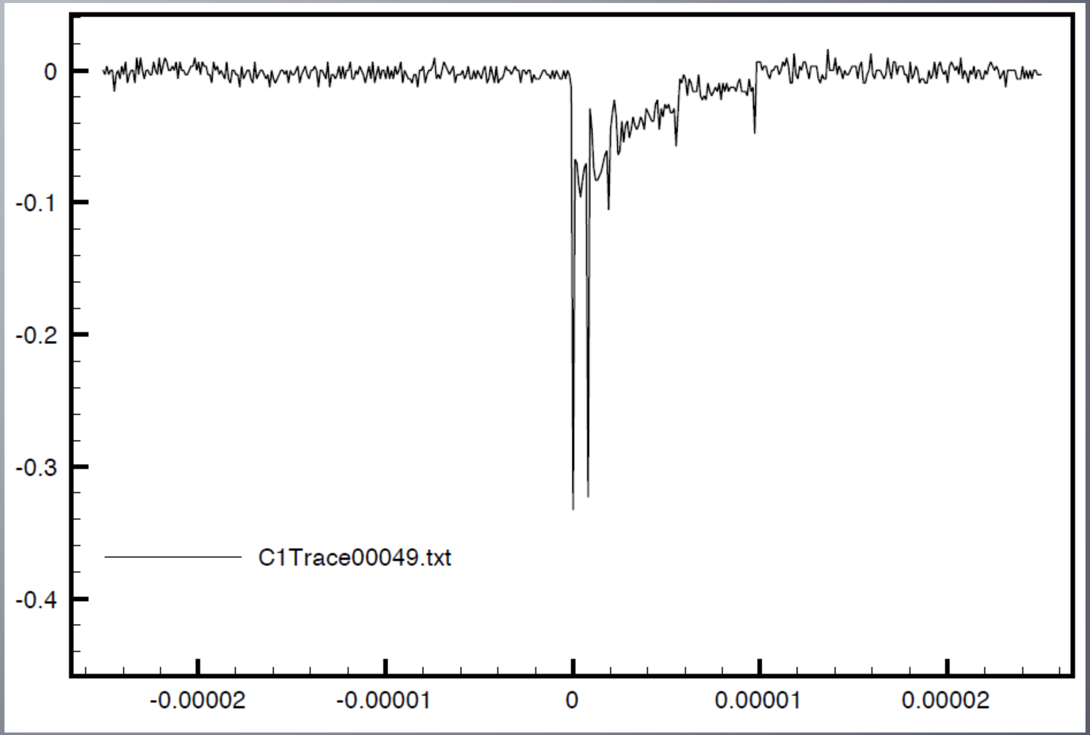
- We have some ideas to explain this effect but need some more measurements to be sure. It will also explain why:
  - R5 shows higher gains than Std Bulk
  - R11 has15us extra signal after spark

C4 Value?

- C4 (mesh capacity) value has no importance in normal operation
- During ‘mild sparks’ C4 should only charge C5
- C4 voltage drops during ‘mild sparks’ should not induce a charge to each strips bigger than 1000e-
- We still need to define precisely C4 (uF range)
- But we have no limitation on C4, we do not need to segment the mesh.

Spark

V on the 50Ohms



Time

No resonances → no big inductive effects
Should we adapt the lines to the amplifier?
There is some signs of reflection

Conclusion

- We still need to understand the R5 and R11 difference
- We need to define the optimum value of C4 in R11 detector
- We can start to predict the effect of the size on the detector behavior
- We are building now 2 new small detectors to:
  - Increase the statistics
  - Improve our understanding
  - See if we can reduce again the 'mild spark' currents
- We have also started to design a large size version of R11