

SVT Radiation Monitor: First results with a monocrystalline CVD diamond

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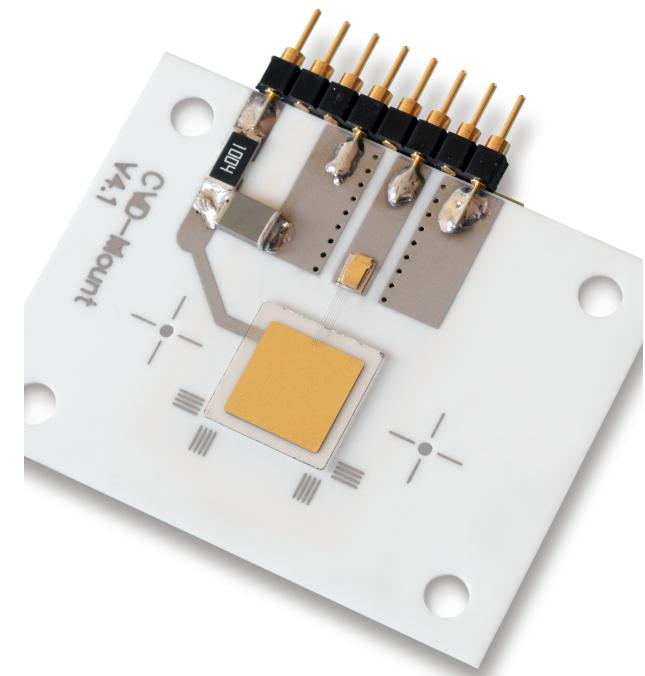
2nd Super-B Collaboration meeting 14/12/2011
Frascati

CVD Diamond Sensors as Radiation Monitor

- Radiation monitor crucial to protect the Silicon tracker from a high radiation dose due to i.e. beam losses or high background rates
 - Need to abort beam in presence of a current spike or a prolonged radiation dose lethal for the SVT
- A **fast, radiation hard detector with a low leakage currents** is required
- In the past 5-6 years **CVD diamond sensors** employed for **as beam monitoring** by the experiments
 - BaBar, Belle, CDF, ATLAS, CMS, LHC-b, ALICE

CVD Diamond Properties

- Fast timing (**1 ns**)
- High Radiation tolerance (**>1 MGy**)
- Single-particle detection and current monitoring
- Efficiency for charged particles practically **100%**
- 500 V @ 100 pA, so very **low power consumption**
- **Leakage current of a few pA**, do not increase with the accumulated dose
- insensitive to **temperature** variation



Beam monitoring with Diamonds

- OUR GOAL: measure interaction rate and background level in a high radiation environment near the IR
- Input to background alarm and beam abort

- **“DC current or dosimeter”**

- Uses beam induced DC current to measure dose rate close to IP
 - Benefits from very low intrinsic leakage current of diamond

- **Simple DC (or slow amplification) readout**

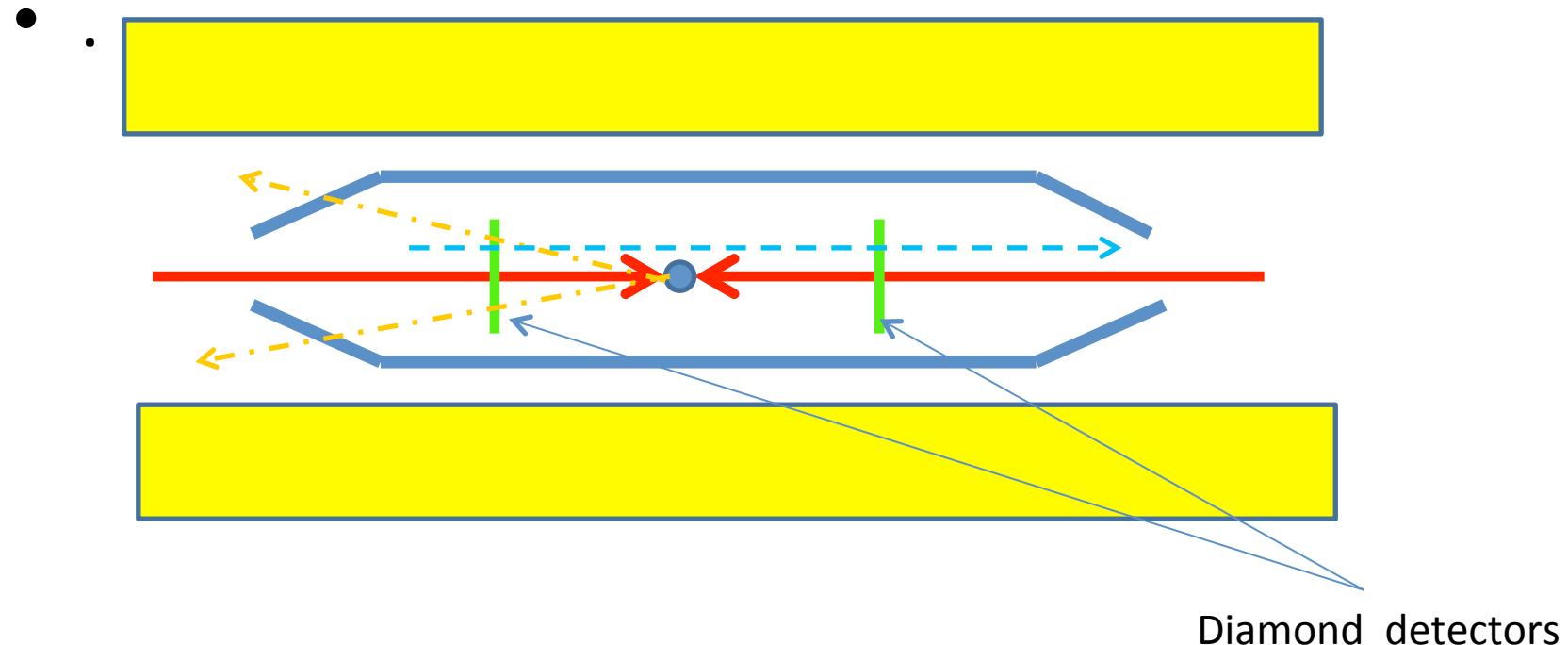
- Examples:Babar, Belle,CDF

- **Single particle counting**

- Detect min. ionizing particles
 - Benefits from fast diamond signal
 - Allows more sophisticated logic coincidences, timing measurements

- **Requires fast electronics with very low noise**

Radiation Monitor

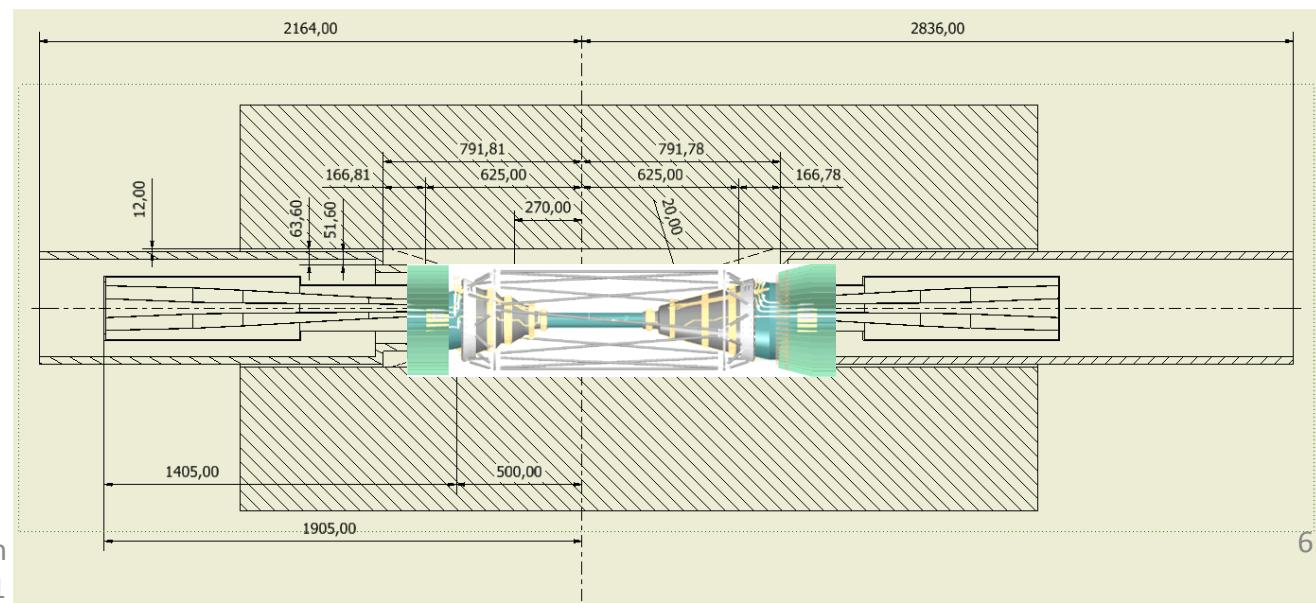
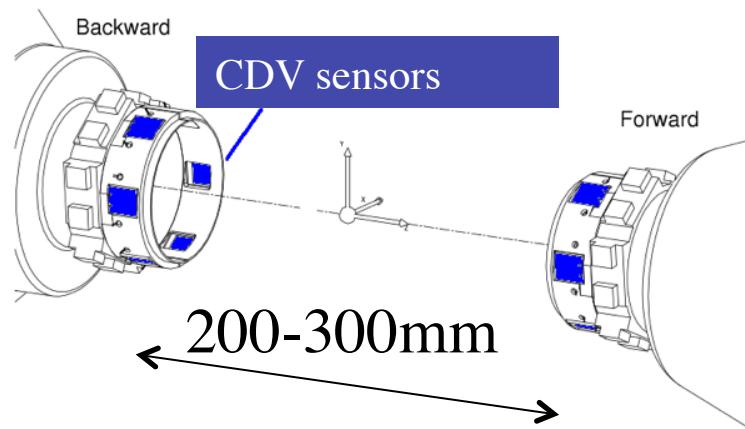


Diamond detectors

Idea: time of flight measurements to distinguish collisions events from background

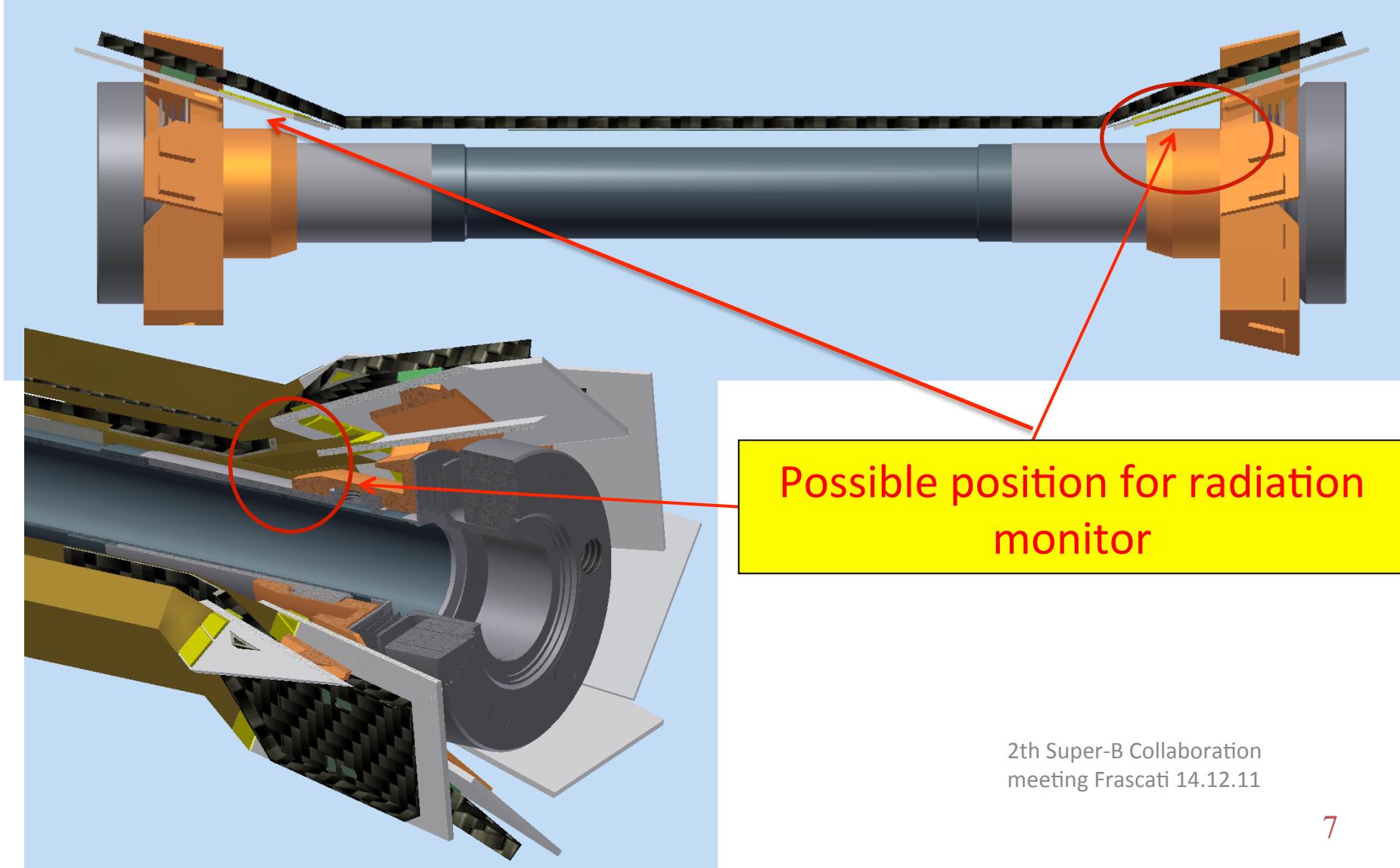
SVT RadMon location

- Under study the position and the geometry of the CVD detector near inner tracking in Super-b
 - In contact with F.Bosi
(space limitation is an issue)



Radiation Monitor position

From F. Bosi's presentation In London



2th Super-B Collaboration
meeting Frascati 14.12.11

Diamond detector under test

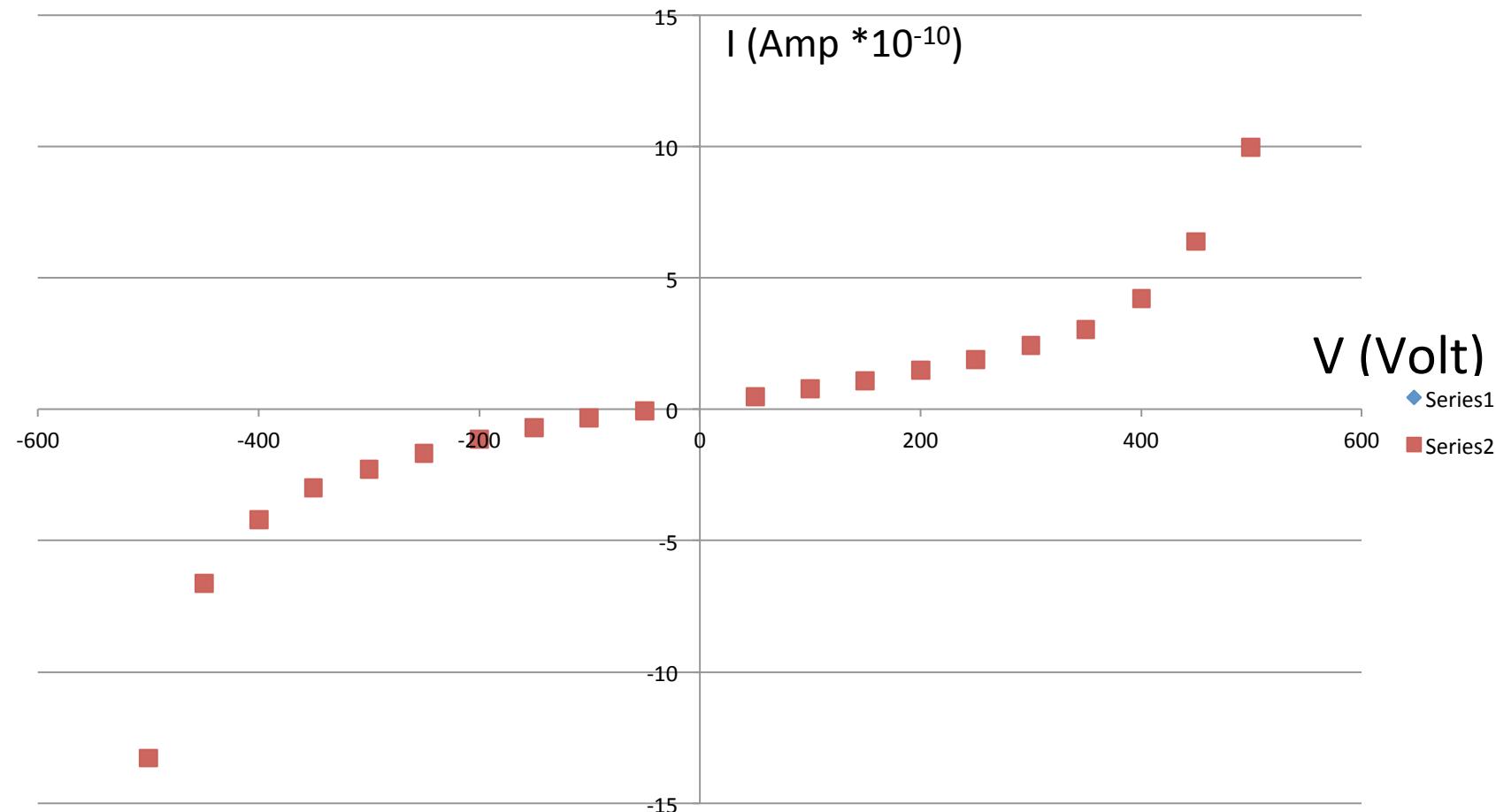
Detector:

- Mono crystal diamond
- thickness 0,5 mm
- Area 4 x 4 mm²
- HV 400 Volt

3 different amplifiers used in the test :

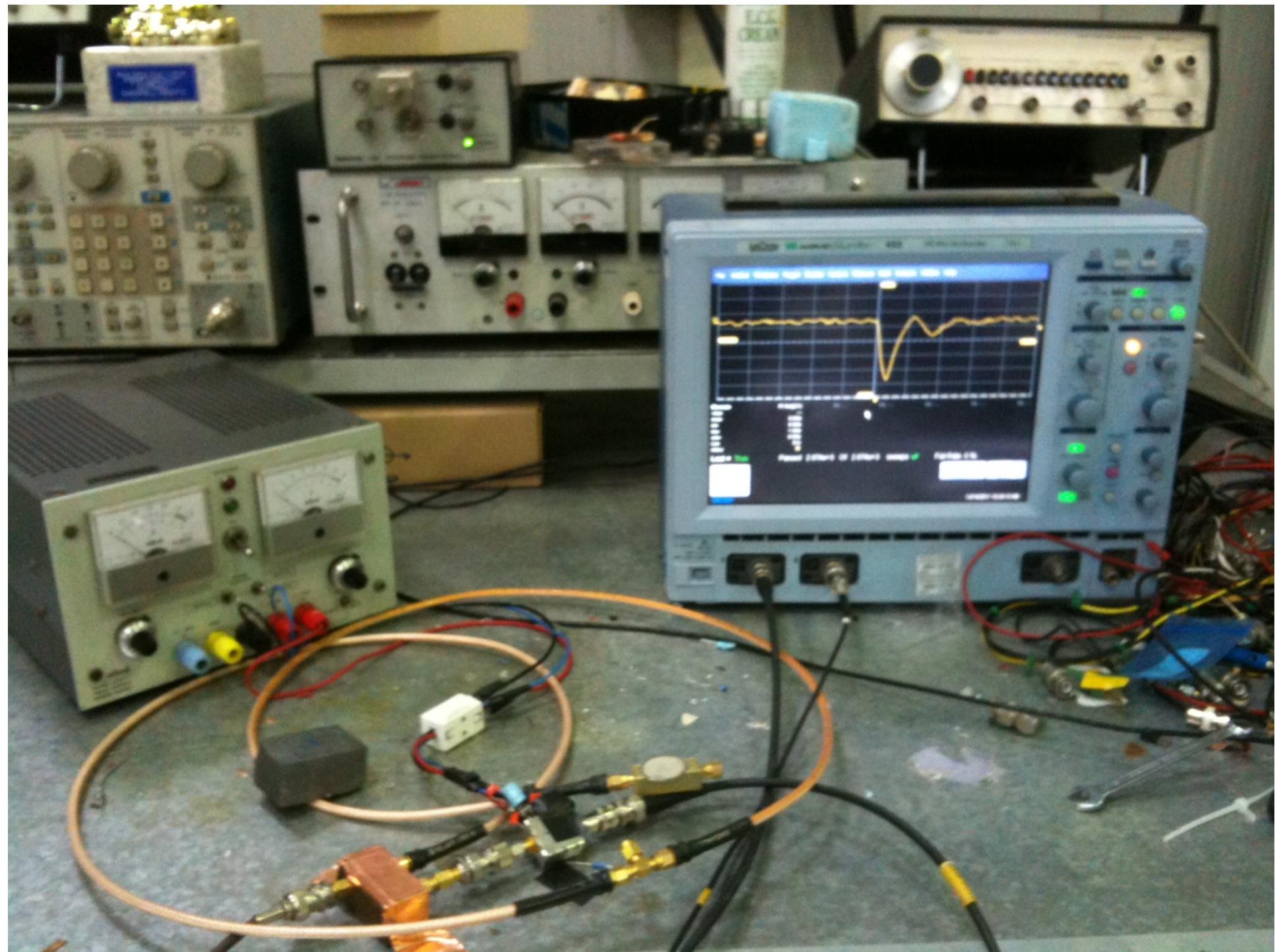
- Two stage amplifier, AC, (BJT Si BFQ67)
- AC, (BJT SiGe, BFP650)
- AC, (BJT SiGe, BFP740)

I vs HV (sCVD- diamond detector)



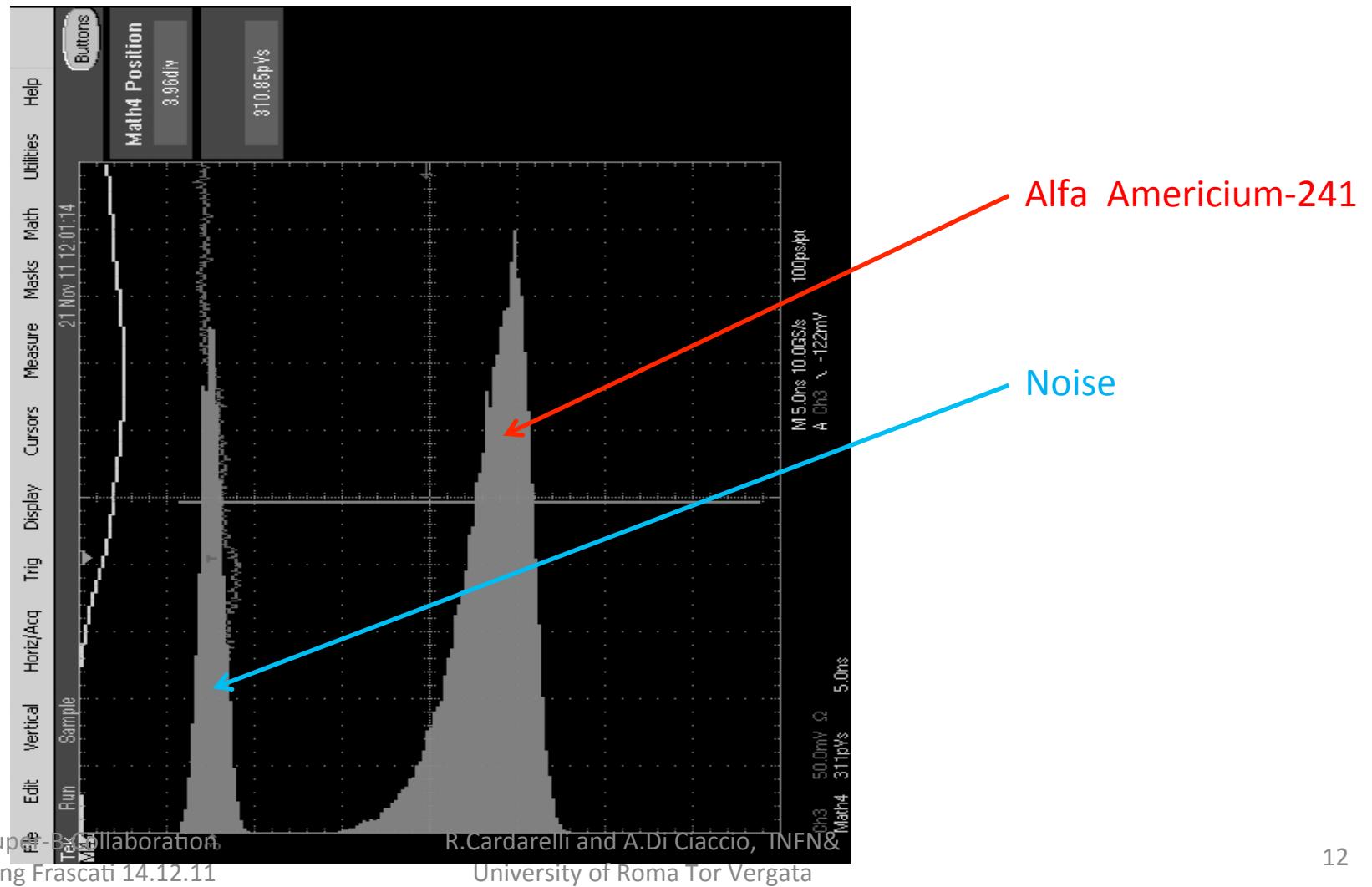
1) Two stage ac amplifier, AC, (BJT Si BFQ67)

- Voltage supply 5 Volt
- Sensitivity 6 mV/fC
- noise 4000 e⁻ RMS
- Input impedance 50 Ohm
- B.W. 30 MHz
- Power consumption 10 mW/ch
- Low cost 2 – 3 eur./ch



Alfa Americium – 241

(sCVD+BJT Si BFQ67)



BJT Si v.s. SiGe

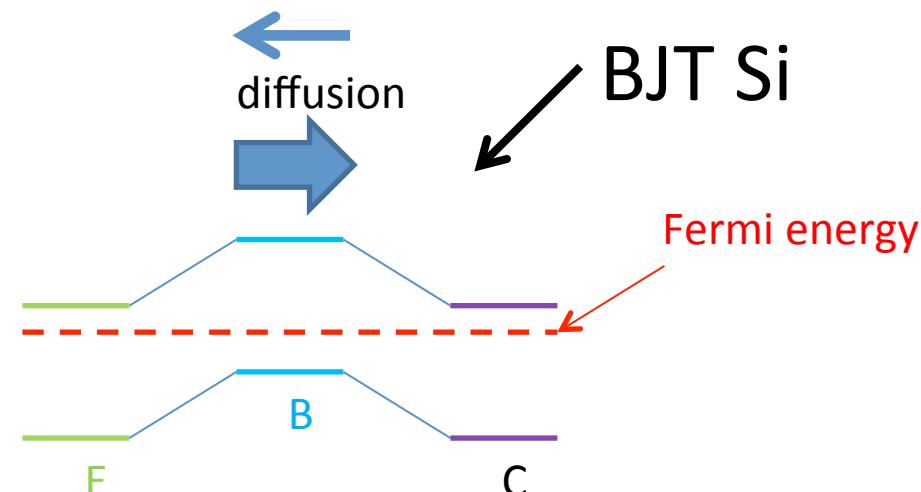
BJT performances

- $\beta = \tau_c / \tau_t$
- $f_t = 1 / \tau_t$
- $N = K^* \tau_t$

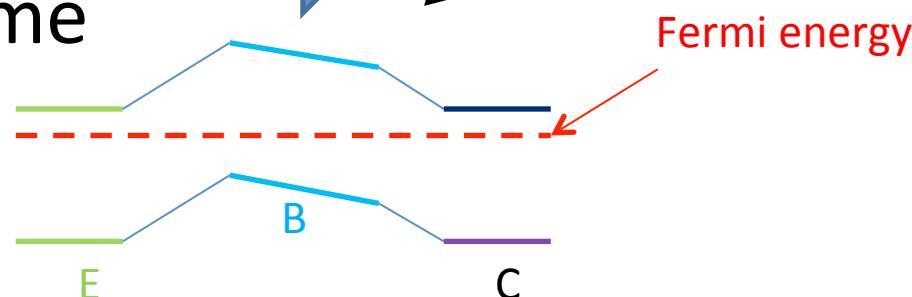
τ_c = base life time

τ_t = base transient time

τ_t (Si) >> τ_t (SiGe)



acceleration

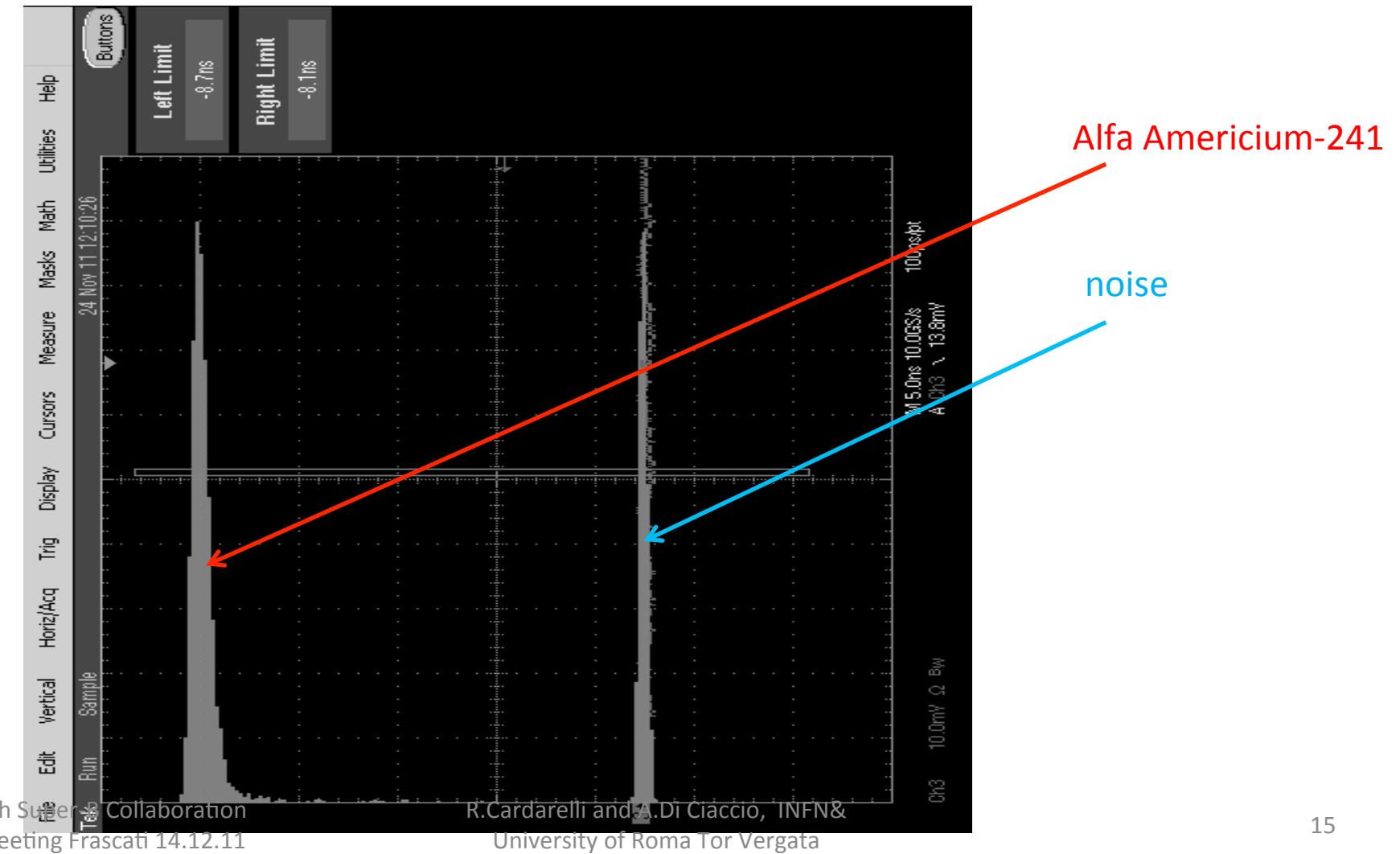


2) Amplifier, AC, (BJT SiGe, BFP650)

- Voltage supply 5 Volt
- Sensitivity 6 mV/fC
- noise 1000 e⁻ RMS
- Input impedance 50 Ohm
- B.W. 30 MHz
- Power consumption 10 mW/ch
- Low cost 2 – 3 eur./ch
- Radiation hardness 50 Mrad, $10^{15} \text{ n cm}^{-2}$

Alfa Americium – 241

(sCVD+BJT SiGe, BFP650)



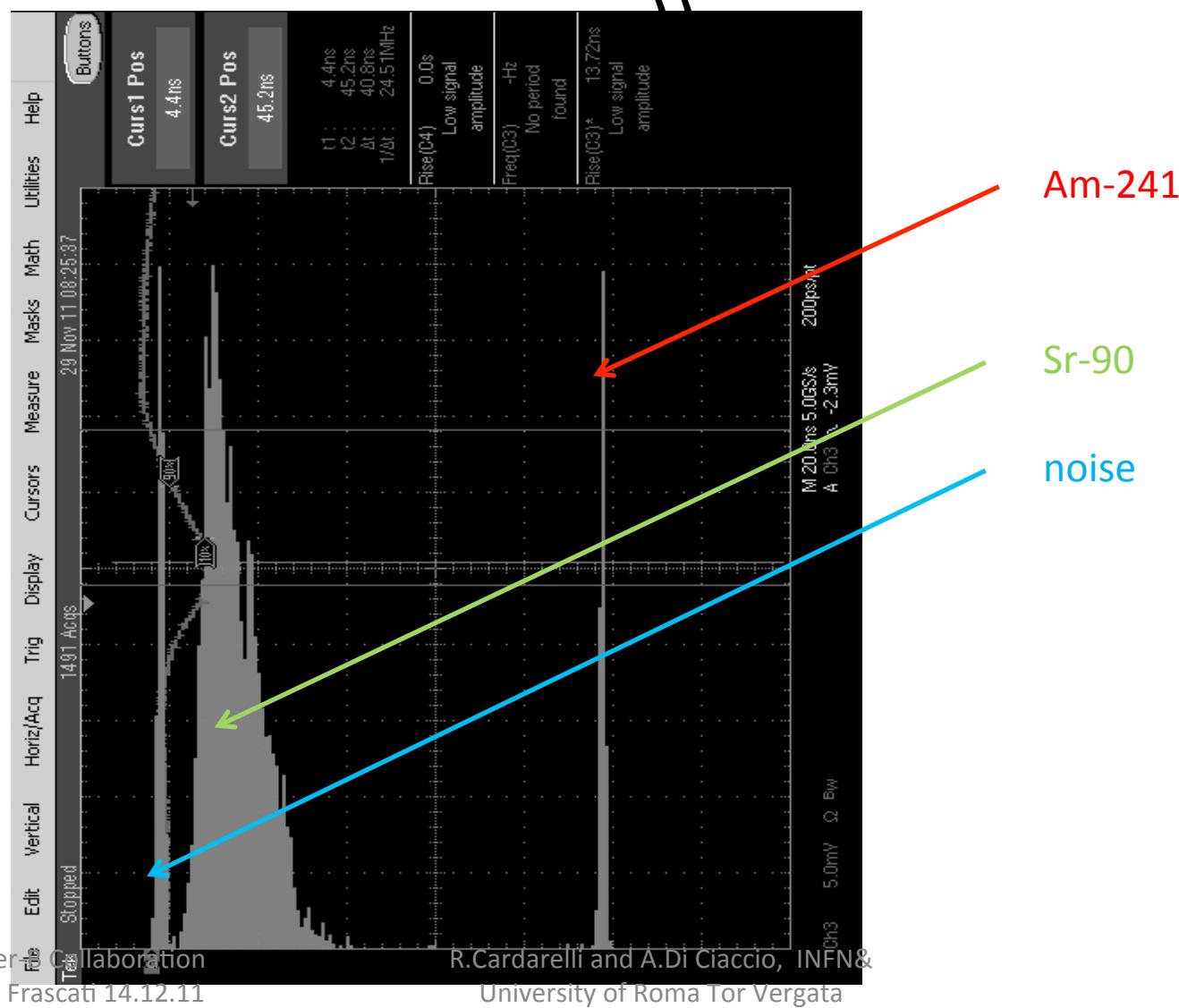
Signal : minimum ionization particle



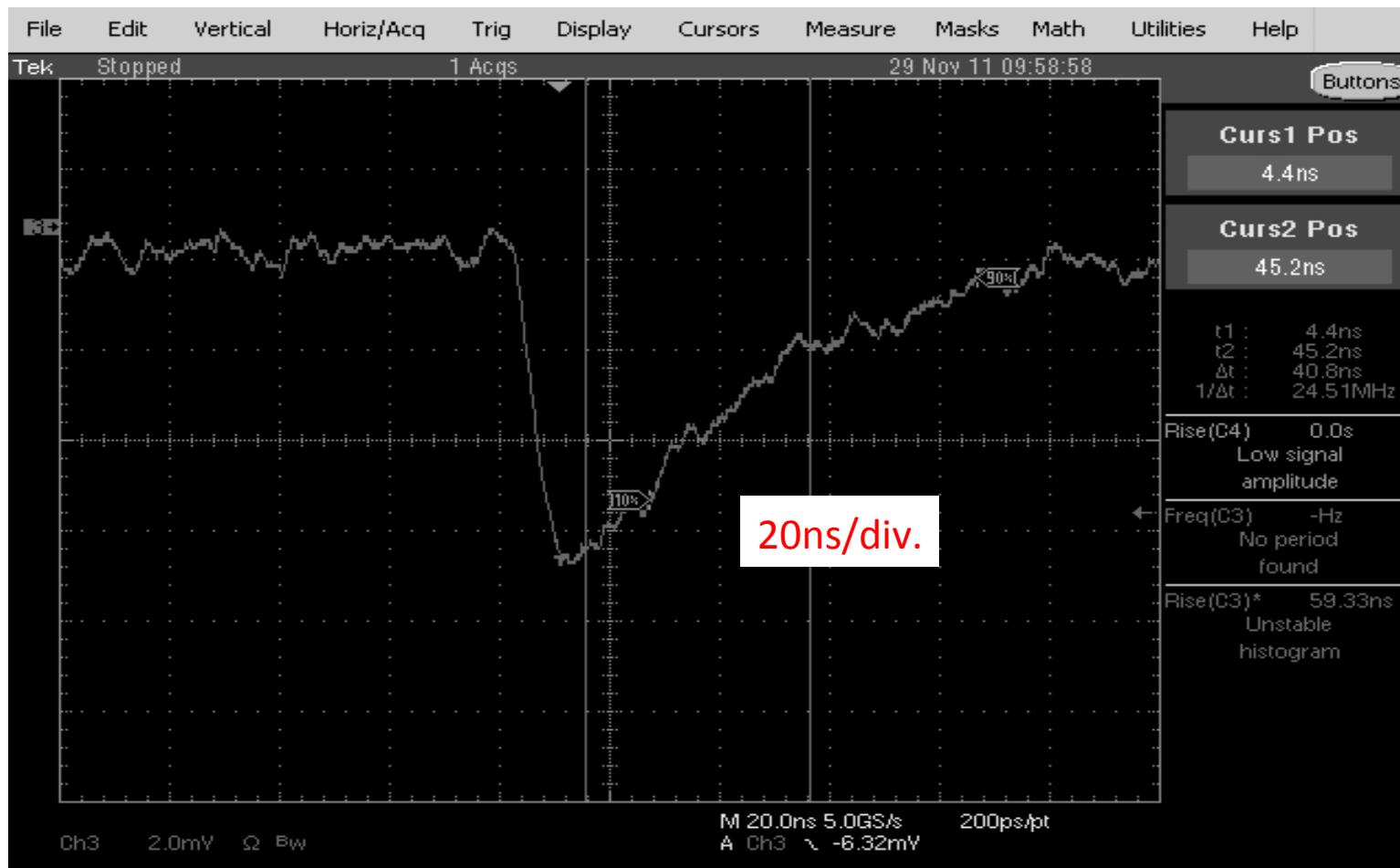
3) Amplifier, AC, (BJT SiGe, BFP740)

- Voltage supply 5 Volt
- Sensitivity 6 mV/fC
- noise 500 e⁻ RMS
- Input impedance 50 Ohm
- B.W. 30 MHz
- Power consumption 10 mW/ch
- Low cost 2 – 3 eur./ch
- Radiation hardness 50 Mrad, $10^{15} \text{ n cm}^{-2}$

Americium-241 + Sr-90 (sCVD+BJT SiGe, BFP740)



Signal: minimum ionization particle



Conclusions

- First tests with ^{241}Am and ^{90}Sr sources of a monocrystalline CVD diamond read out by a SiGe amplifier very promising
- Next steps:
 - Compare results of monocrystalline CVD diamonds vs a polycrystalline CVD sensor
 - Test at BTF (time already allocated in January)
 - Define the best location of detectors near IR (F.Bosi)
 - Geant4 MC simulation to study the expected background and optimize the geometry and position of the detector

Noise distribution

