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Timing with Diamond Detector

N. Randazzo[1],* S. Aiello[1], G. Chiodini[2], G.A.P. Cirrone[3], G. Cuttone[3], M. De Napoli[1], V. Giordano[3], S. Kwan[8], E. Leonora[1], F. Longhitano[1], D. Lo Presti[1,5], L. Moroni[4], C. Pugliatti[1,5], R. Rivera[8], V. Scuderi[3], V. Sipala[6,7], C. Stancampiano[1], C. Tuvè[1,5], L. Uplegger[8]

[1] INFN of Catania, Italy
[2] INFN of Lecce, Italy
[3] INFN Laboratori Nazionali del SUD, Italy
[4] INFN of Milano-Bicocca, Italy
[5] Department of Physics, University of Catania Italy.
[6] INFN of Cagliari, Italy
[7] University of Sassari, Italy
[8] FNAL - Batavia (USA)

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OUTLINE

✦ MEASUREMENTS

- Motivations
- Setting up
- Results

✦ CONCLUSION AND NEXT STEPS

WP5: Fast timing with diamond Detectors

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Diamond pros:
- Fast rise time (<< 140 ps)
- Reduced ballistic effect
- Low Capacitance
- Rad-hard

Diamond cons:
- Small signal

The "jitter" σ_t of the timing distribution

$$\sigma_t = \frac{\sigma_n}{(dS/dt)_{S_T}} \approx \frac{t_r}{S/N}$$

Time walk: corrected by constant fraction techniques or offline by amplitude
Time jitter: reduced by lower noise, faster signal and higher gain

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Motivations

Our target

Create a reference setup (detector and electronics) in order to compare different material and read out solutions developed by the collaboration.

Reference Detector

Single crystal hyper-pure CVD supplied by DDL LTD
Size 4,5x4.5 mm2 and 500 um thickness

Reference Electronics

100 MHz bandwidth Charge Sensitive Amplifier
2 GHz wide band voltage amplifier
both amplifier supplied by Cividec.

Experimental setup @ LNS
62 MeV Proton Beam

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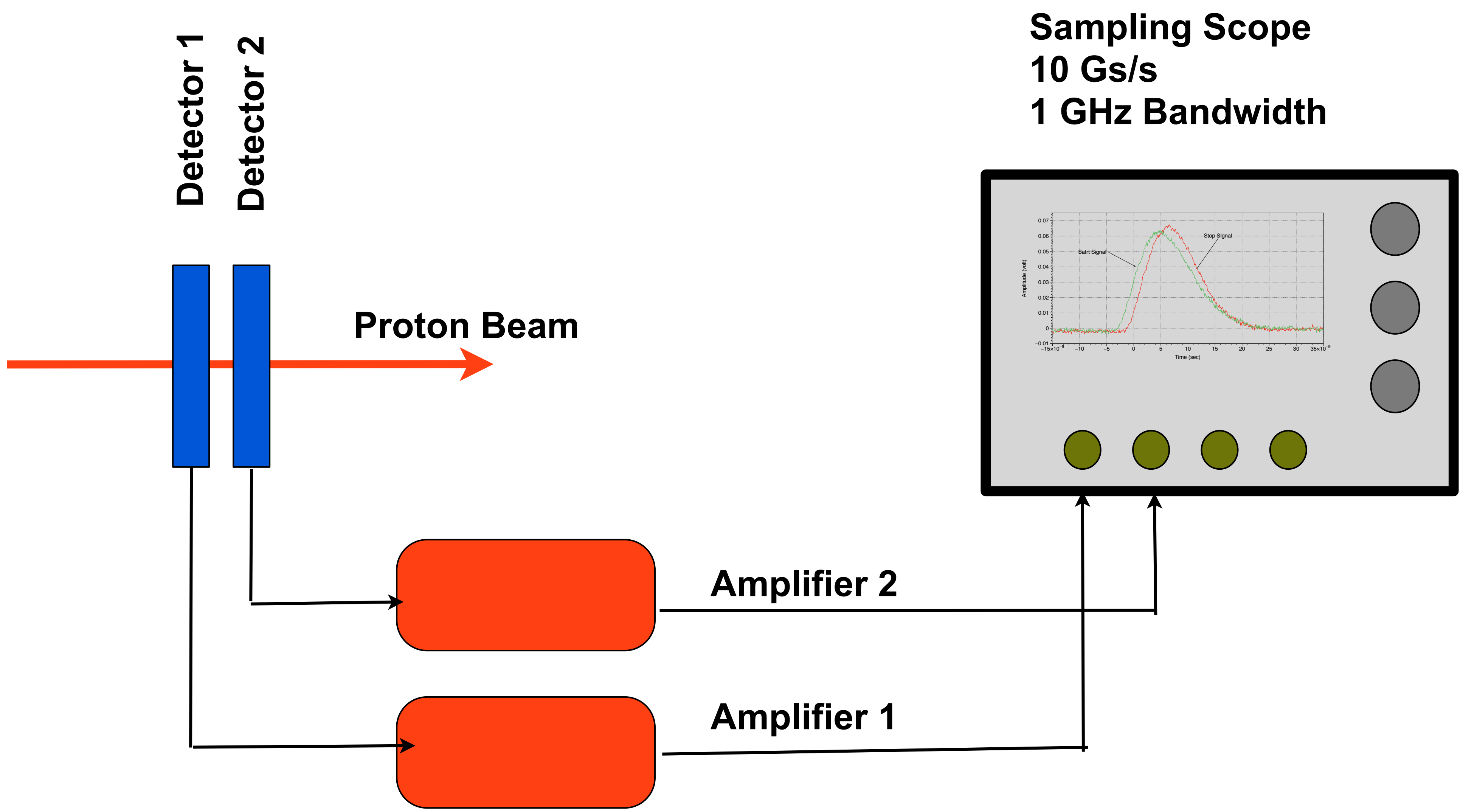
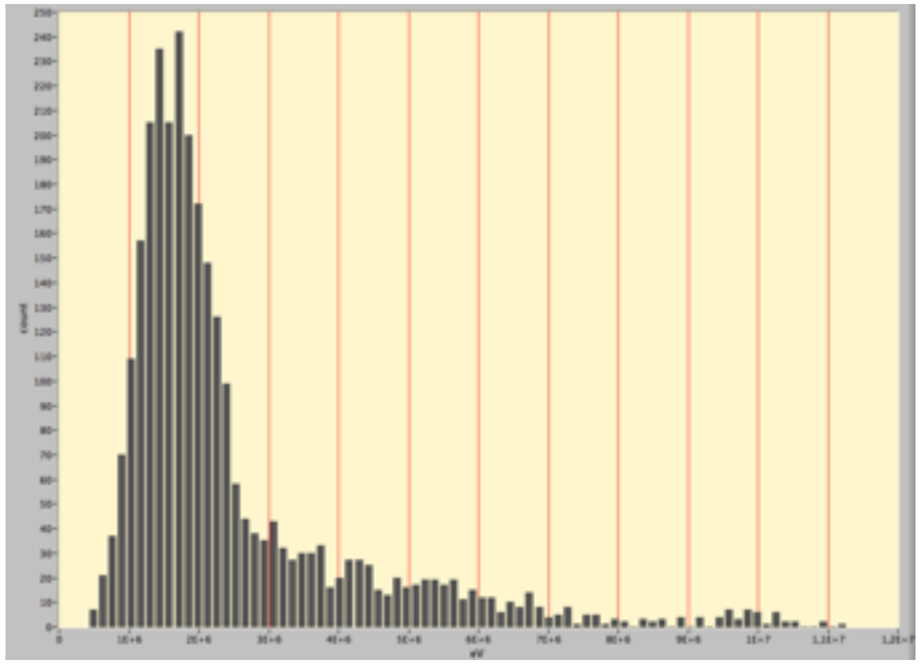
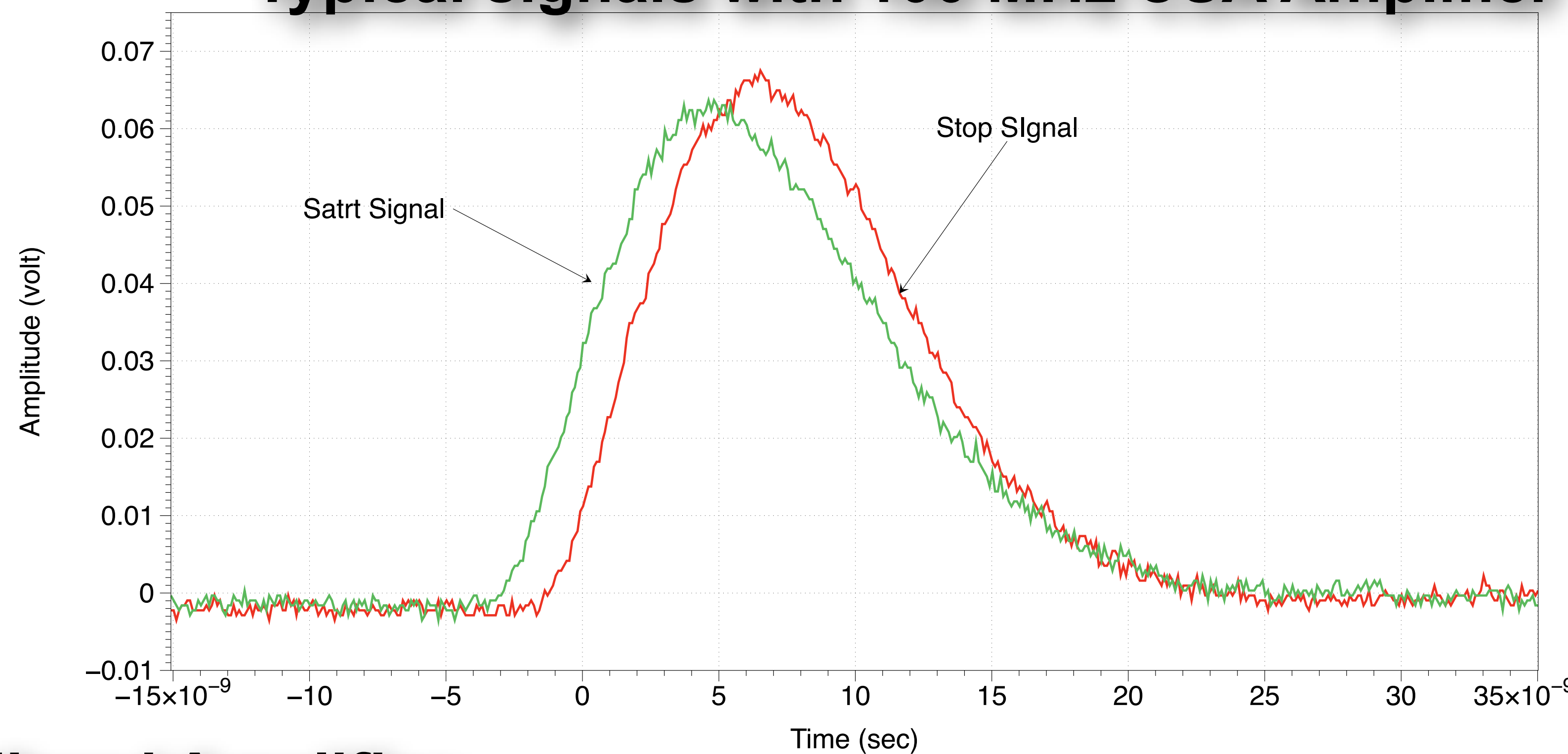


Detector 1 & 2 = Single crystal from DDL
AMPLI 1 & 2 = CSA 100 MHz & 2 GHz Braodband voltage amplifier from CIVIDEC

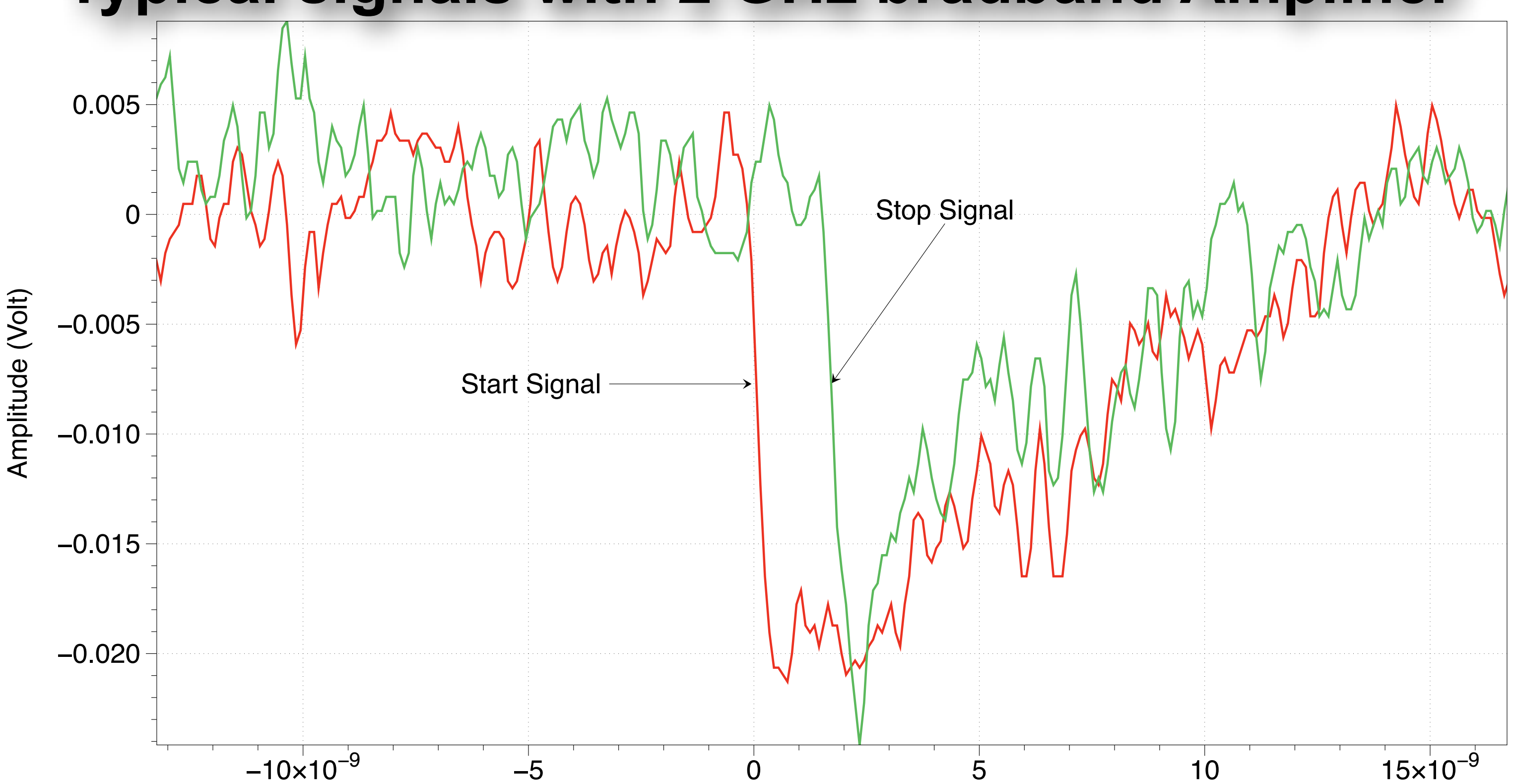
Energy Distribution 62 MeV proton beam



Typical signals with 100 MHz CSA Amplifier

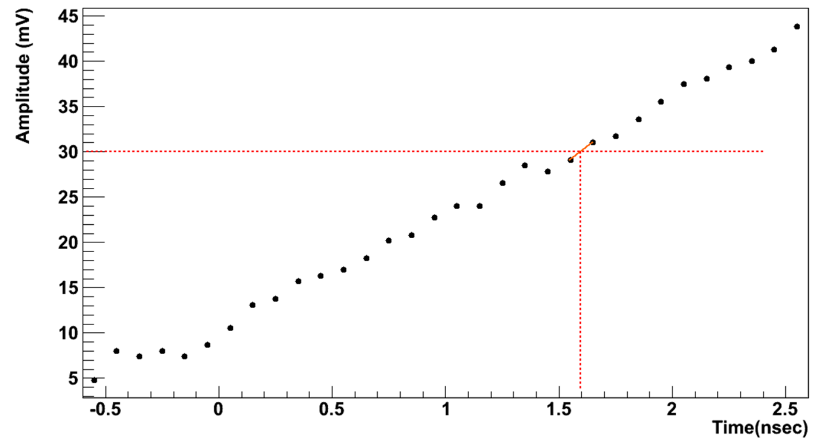


Typical signals with 2 GHz bradband Amplifier

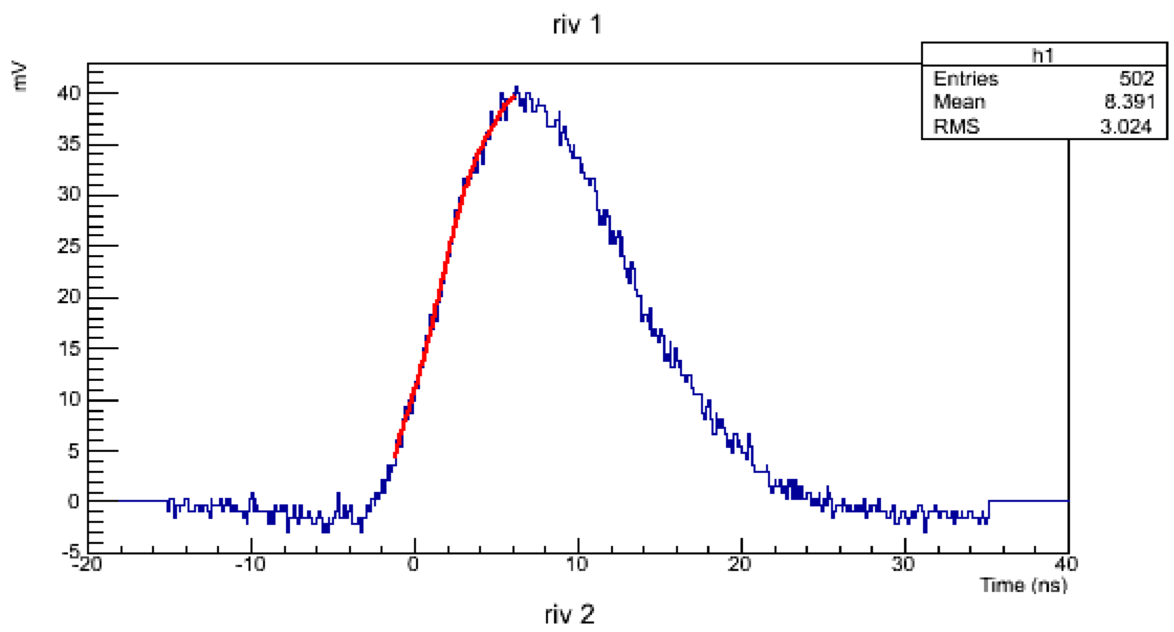


Several methods of offline analysis

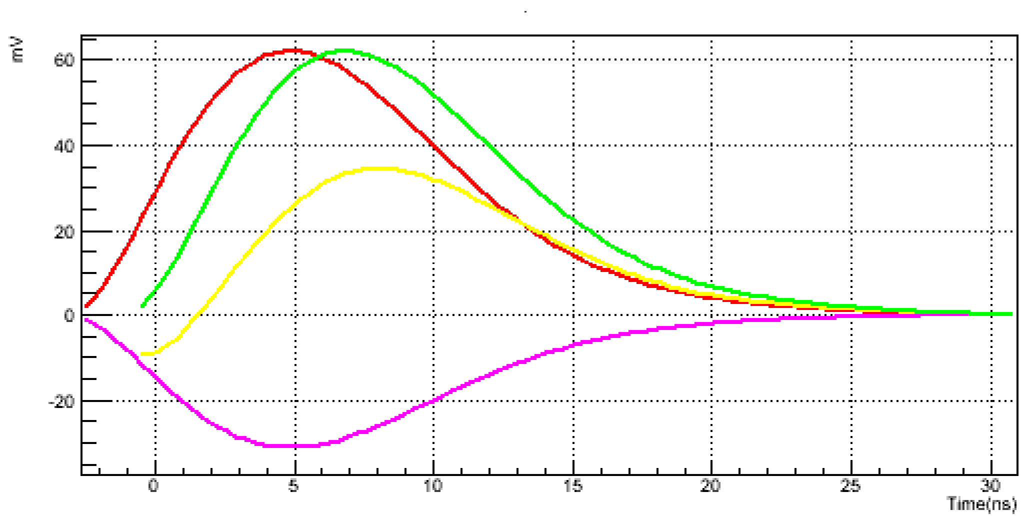
✦Leading edge - simple interpolation

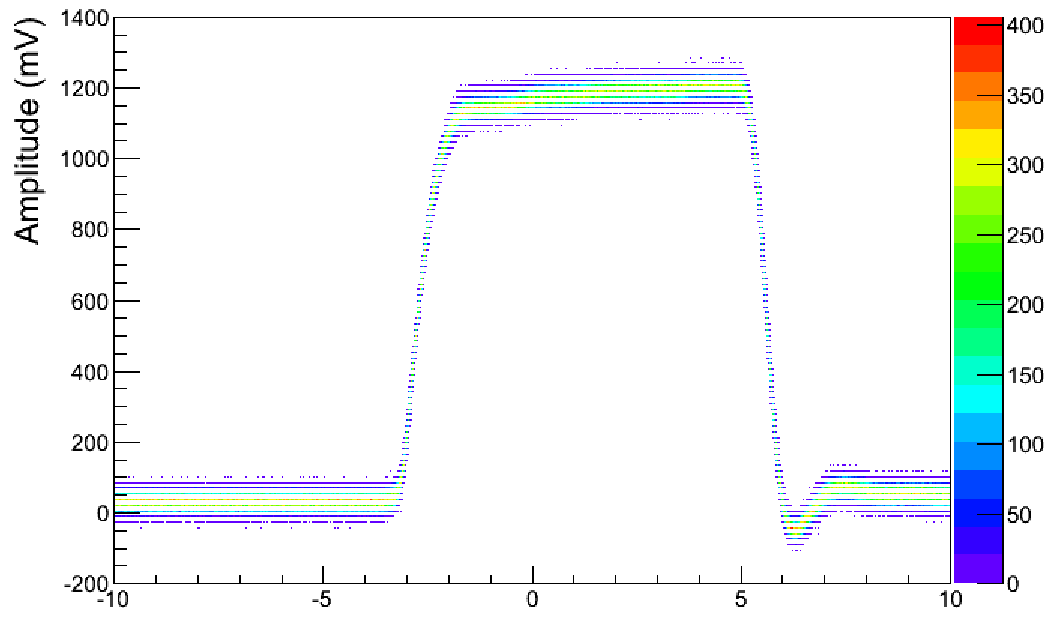


✦Leading edge - polynomial fit



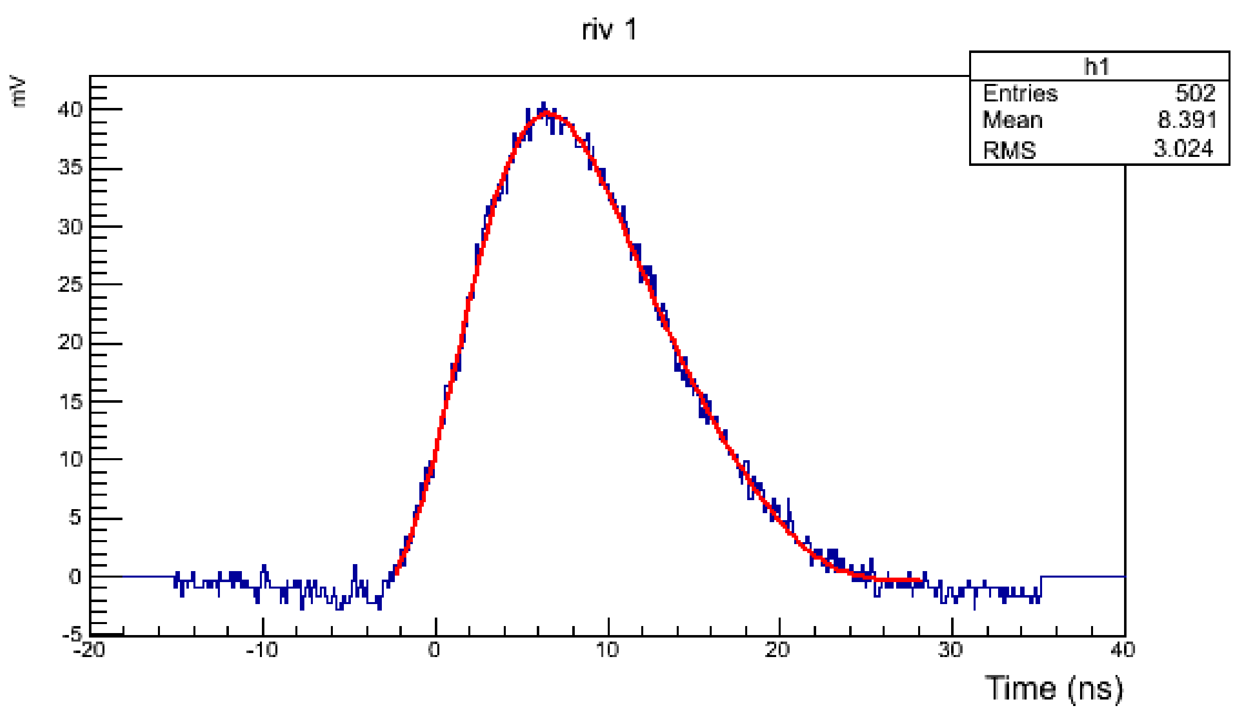
✦Software Constant fraction discriminator





Real CFD

✦Normalized threshold polynomial fit - (Walk compensation)



Comparison of results with 62 MeV Proton beam

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Analysis Method	*resolution* *100 MHz CSA* *(sigma)*	*resolution* *2 GHz Voltage Amplifier* *(sigma)*
Leading edge - simple interpolation	**246 ps**	***70 ps***
Leading edge - polynomial fit	**241 ps**	--
Normalized threshold simple interpolation (Walk compensation)	**95 ps**	--
Normalized threshold polynomial fit (Walk compensation)	***64 ps***	--
Software Constant fraction discriminator	**84 ps**	--
Real Constant Fraction Discriminator	**90 ps**	**do not work**

Theoretical prediction with 62 MeV proton Beam and 100 MHz Charge Sensitive Preamplifier

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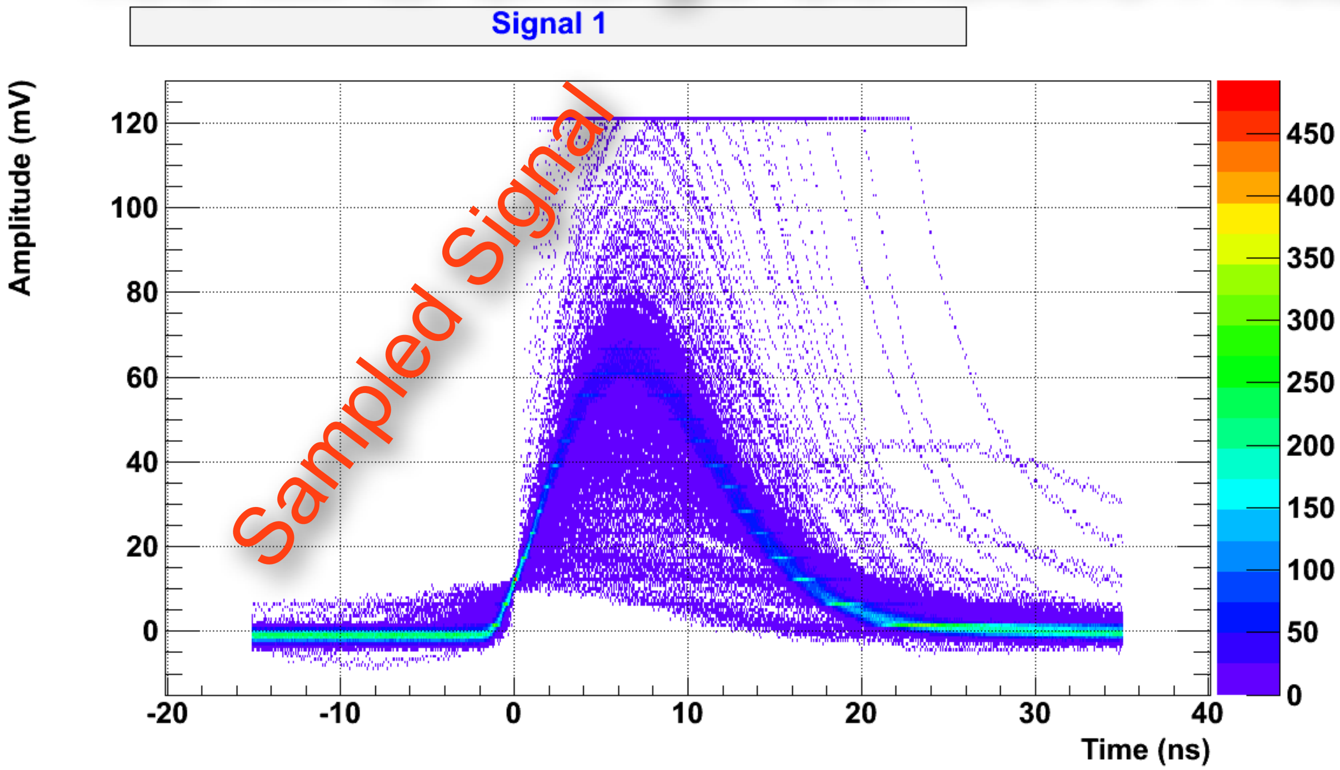

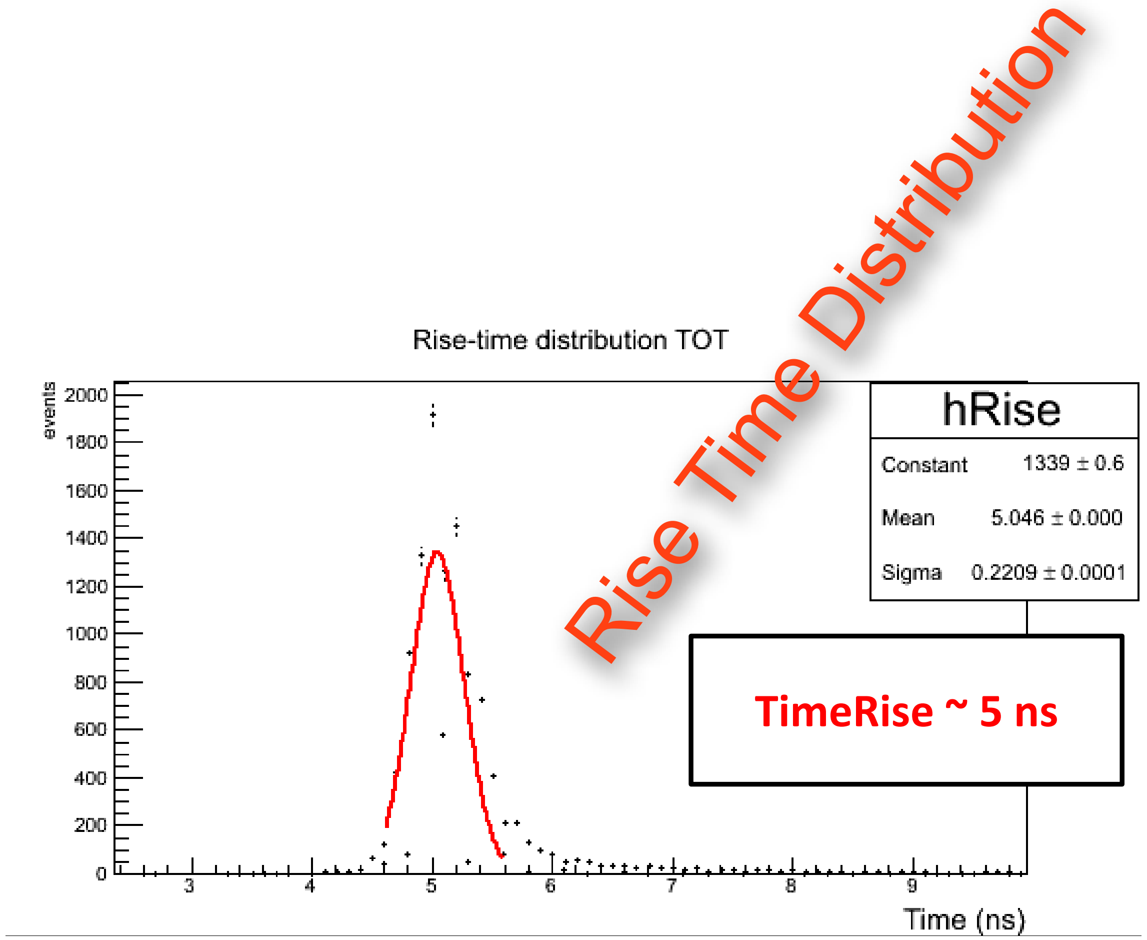

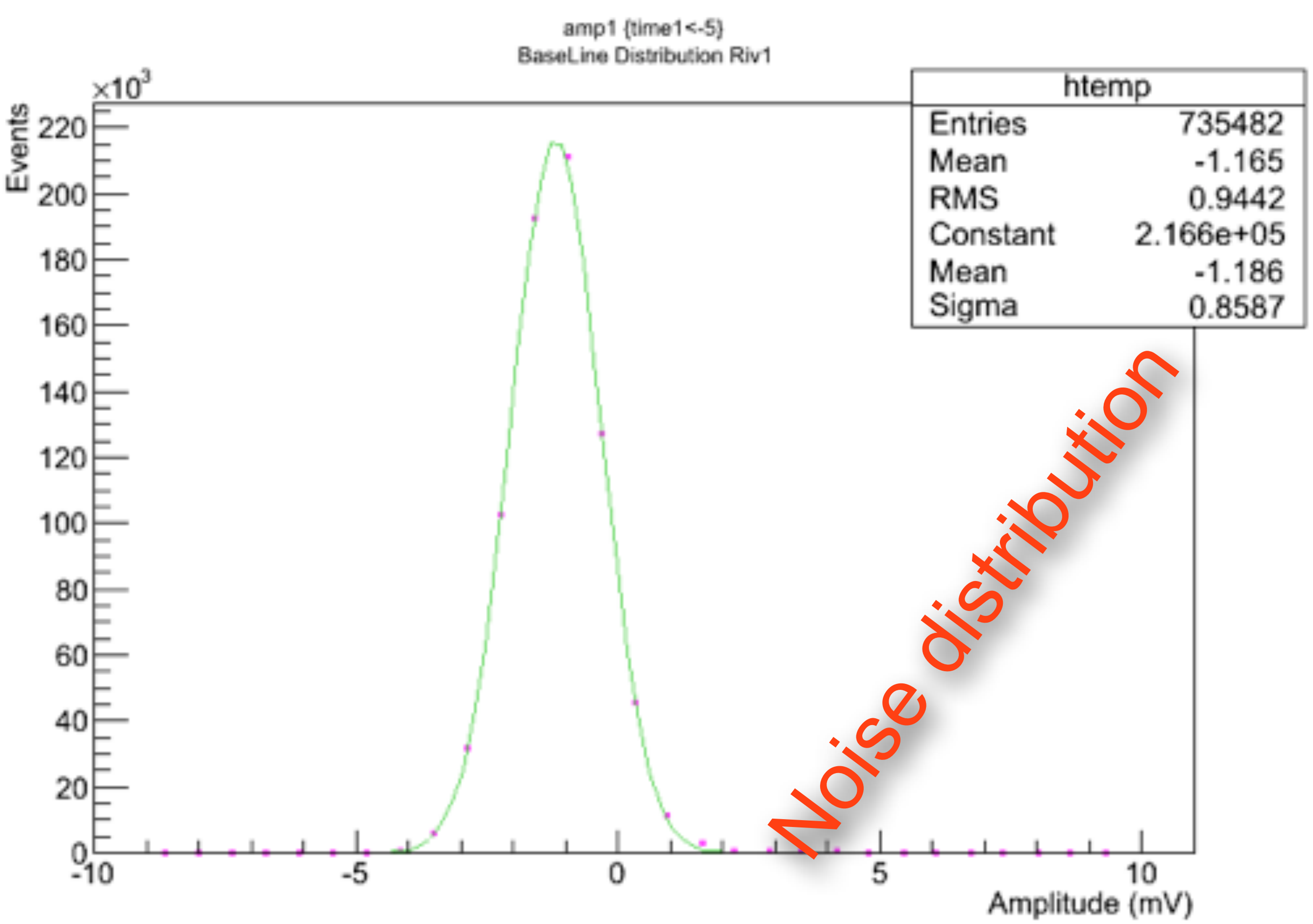

$$\sigma_t = \frac{\sigma_n}{(dS/dt)_{S_T}} \approx \frac{t_r}{S/N}$$

↓

66 ps

Experimental setup @ FNAL
120 GeV proton beam

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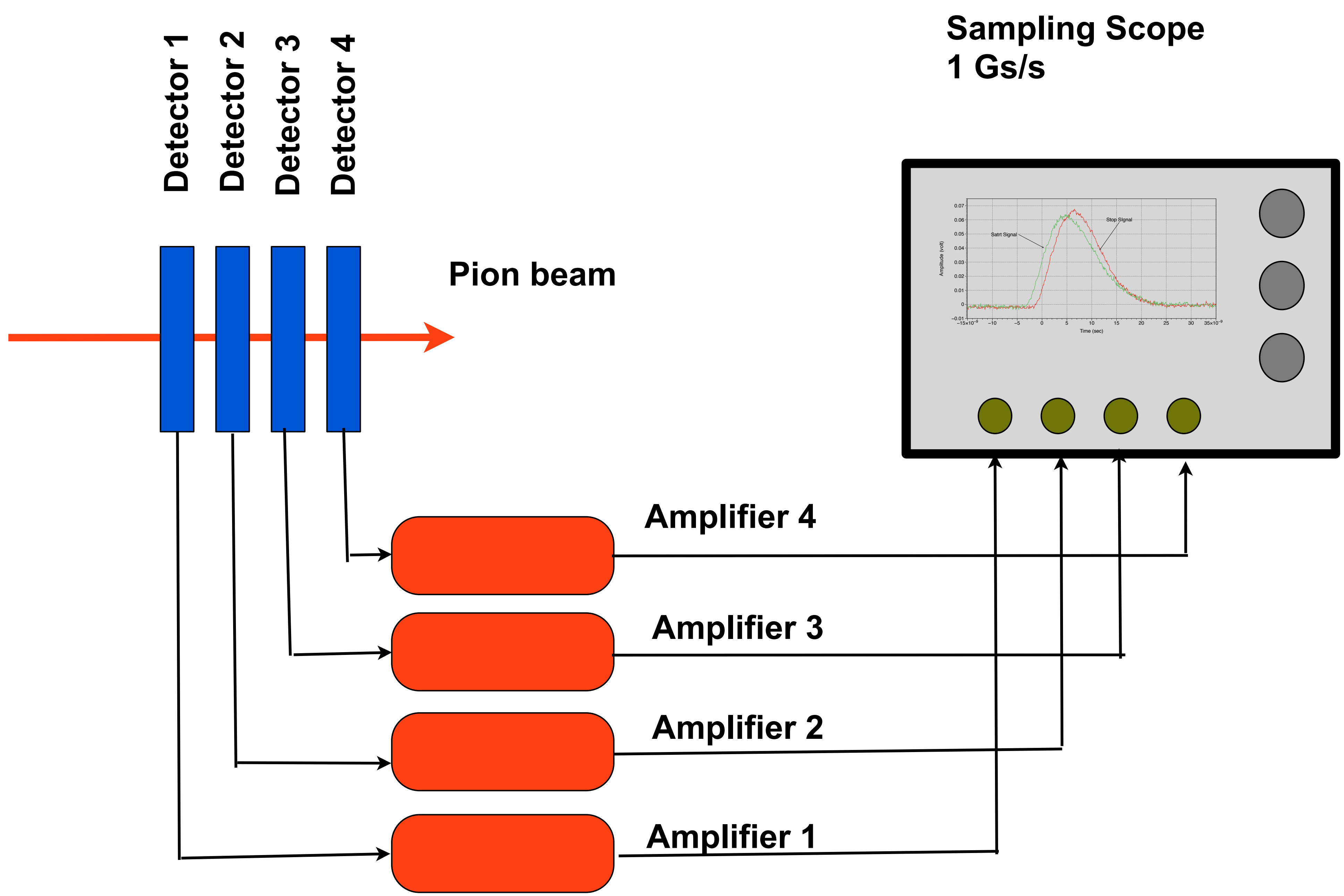

Detector 1 & 2 = Single crystal from DDL
Detector 3 & 4 = poly-crystal from DDL 300um thickness
AMPLI 1 & 2 = CSA 100 MHz from CIVIDEC

Signal with 120 GeV Pion Beam (MIP) and 100 MHz CSA

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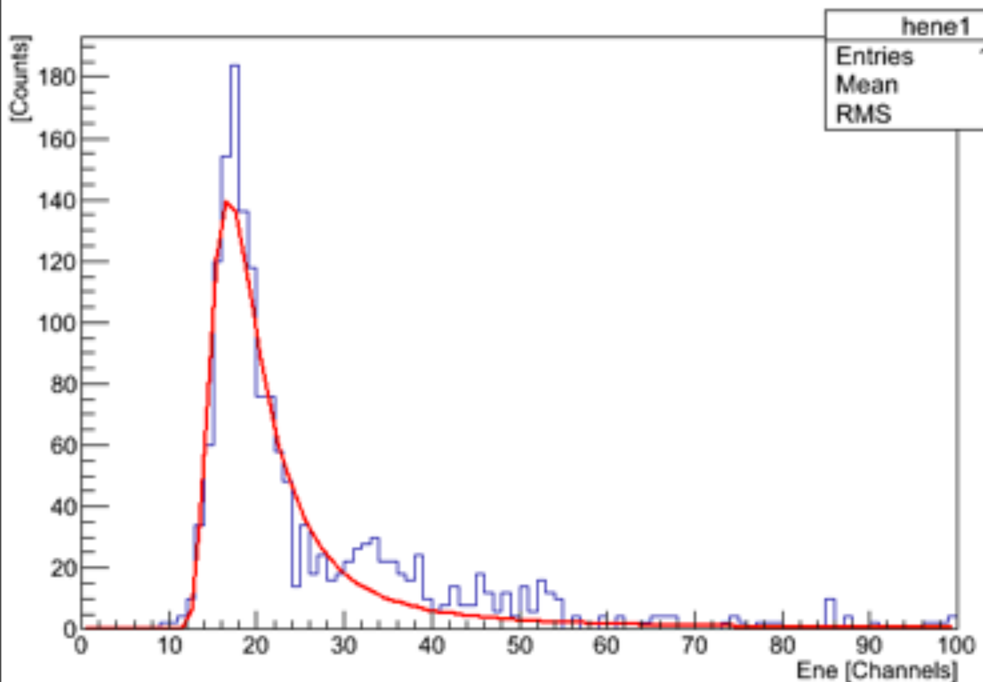
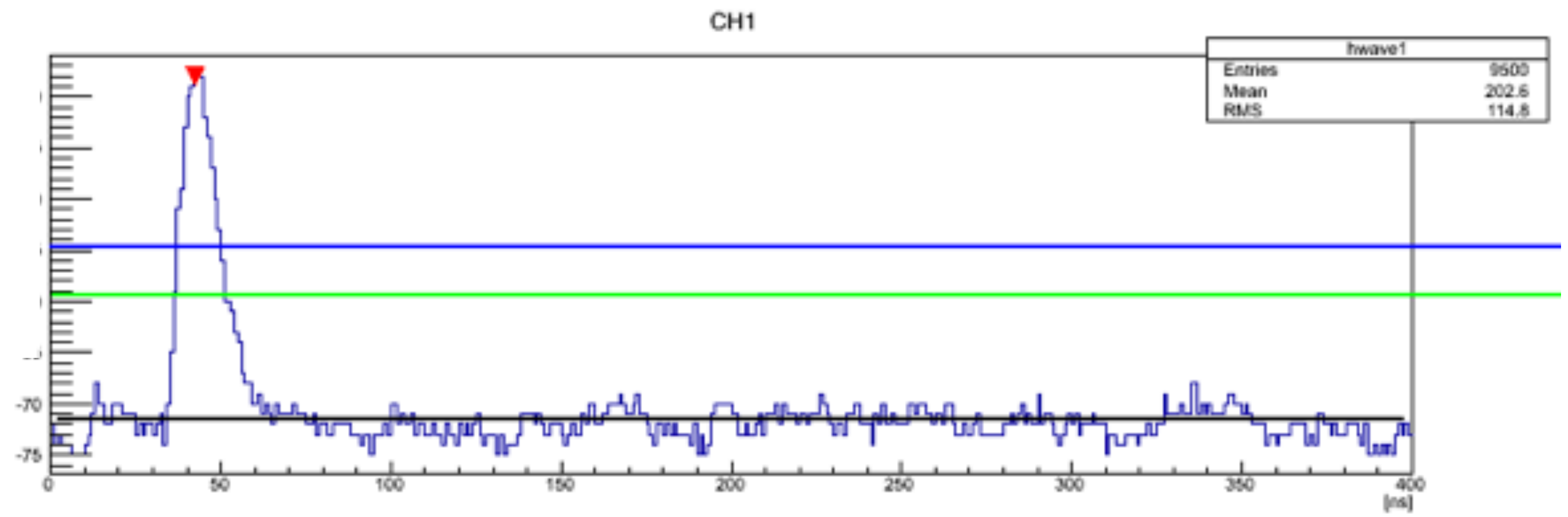
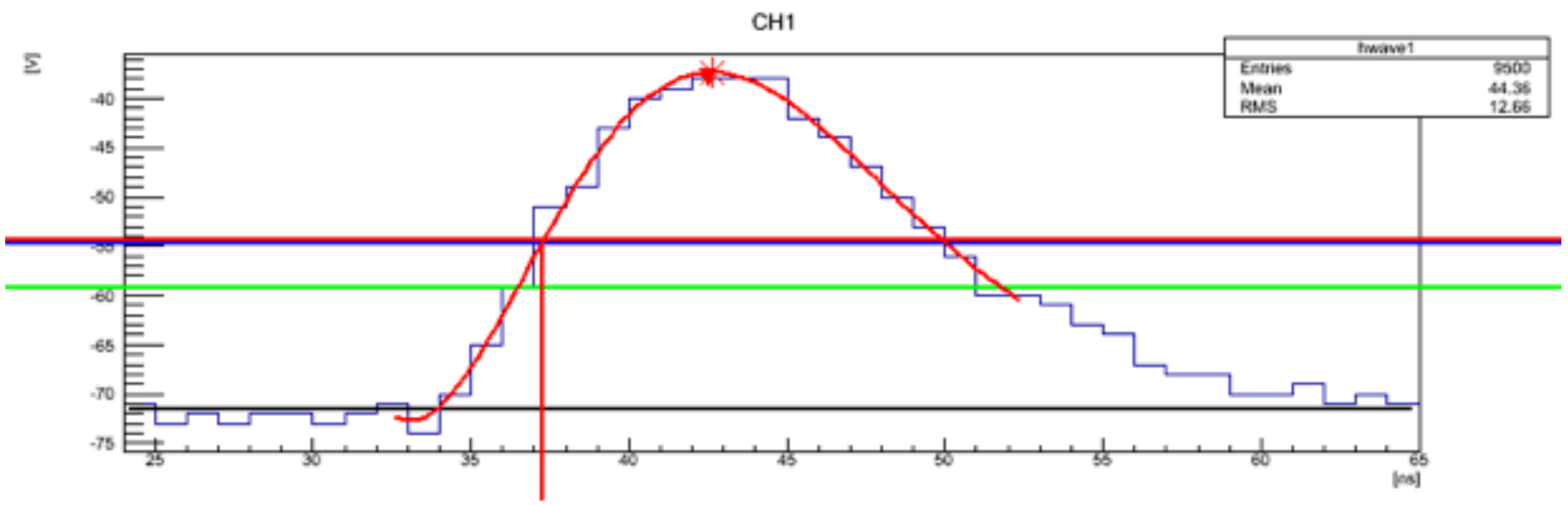


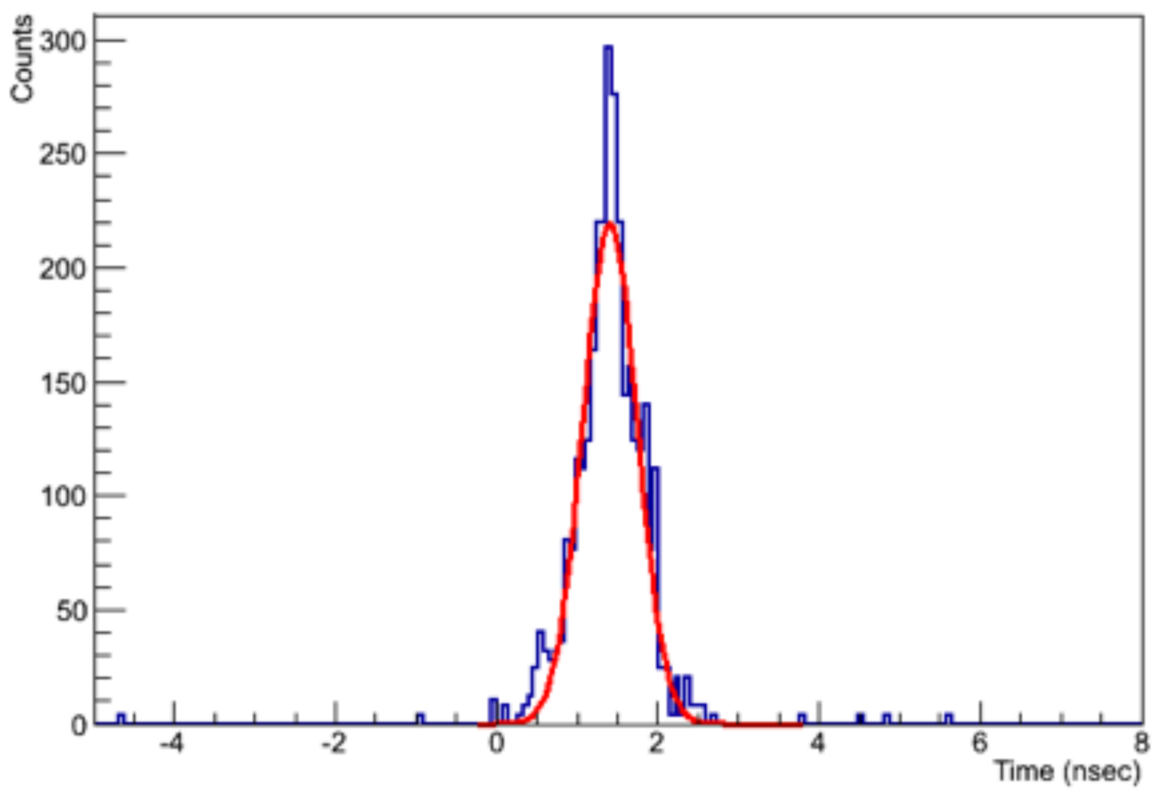
Energy distribution



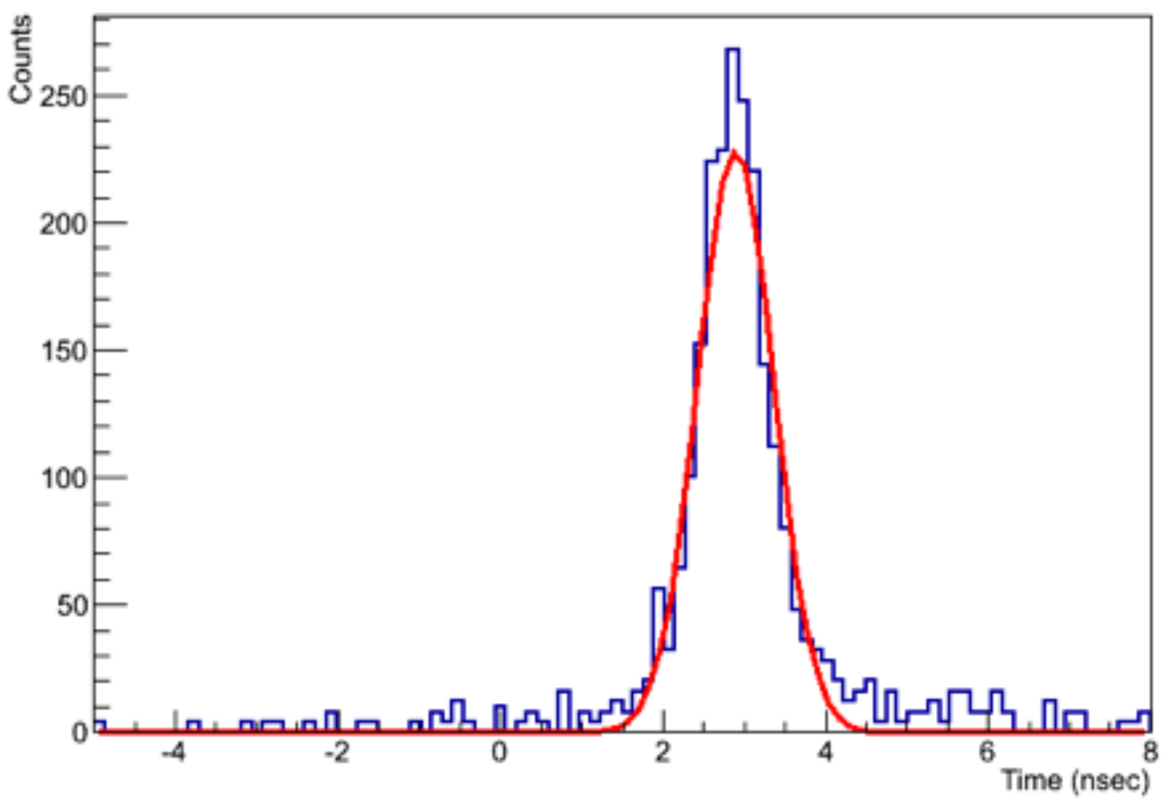


Analyzed with normalized threshold and polynomial fit

Timing @ MIP



With two single crystal 337 ps
Theoretical prediction 280 ps



Start with single crystal
Stop with Poly-crystal
568 ps
Theoretical prediction 480 ps

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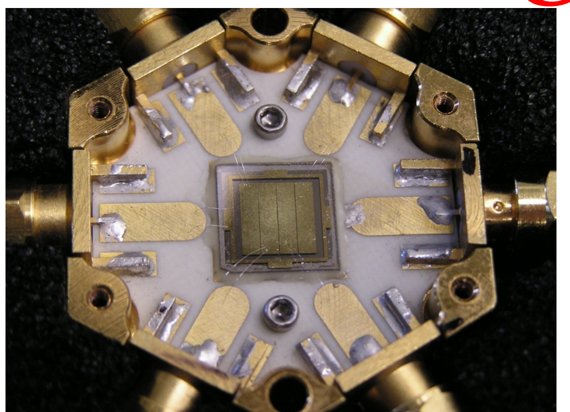
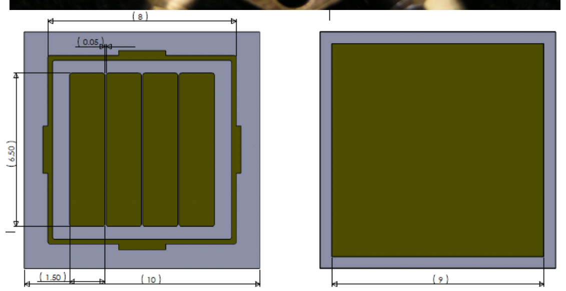
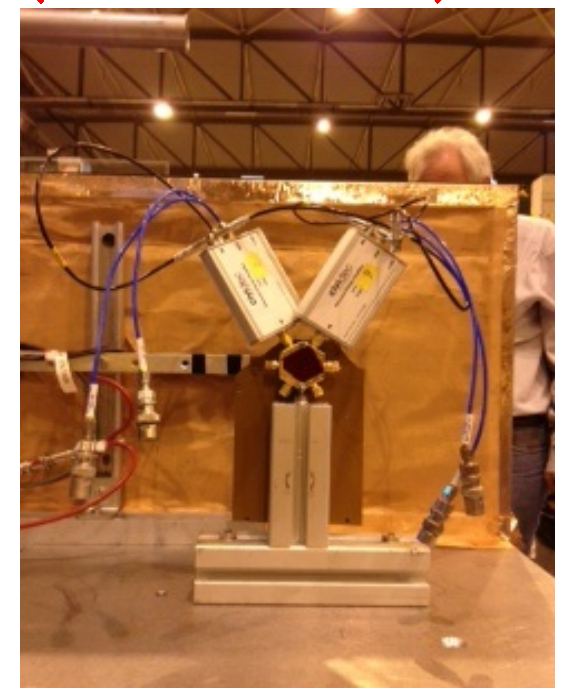
Timing vs track angle at SPS (Oct 12)





Diamond strip detector from INFN-DIAPIX experiment.
- 10x10x0.5mm3 Polys-crystal
- 4 strips
- 1.5 mm pitch and 6.5 mm length (0.89pF)
- Only two strips instrumented

Commercial electronics from CIVIDEC
- Fast charge sensitive amplifier
- 100 MHZ BW, 2 ns rt, 7 ns pulse width
- Gain=8mV/fC, noise=450 e-



Track Angle	Mean Amp (mV)	Sigma(T1-T2) (ps)
0	130	740
25	127	769
45	180	610
65	195	428
90 (nominal)	233	400

Electronics and packaging not optimized for best timing!!!

TESTBEAM GOALS
- Study S/N ratio as a function of beam angle
- Verify relation time resolution = rise-time / S/N ratio

Timing vs track angle at SPS (Oct 12)

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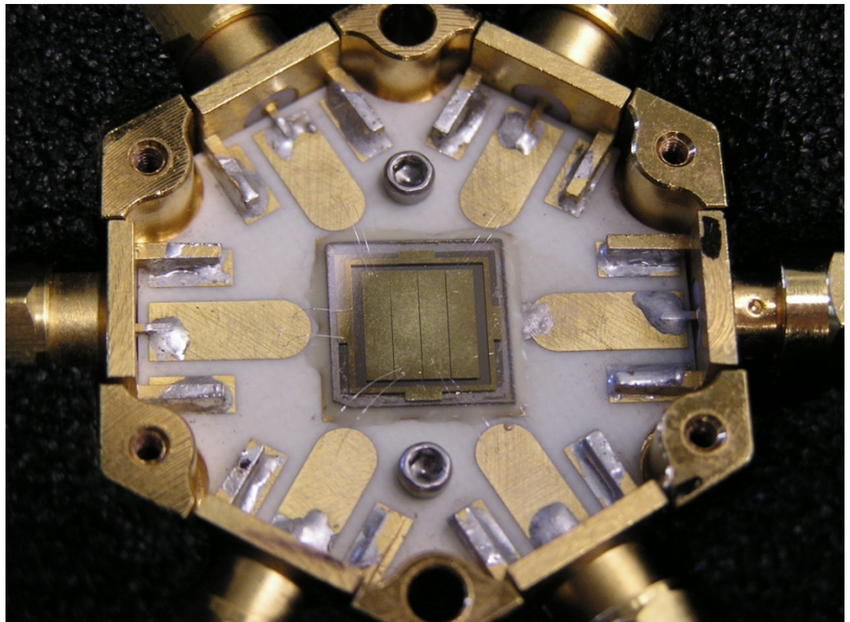

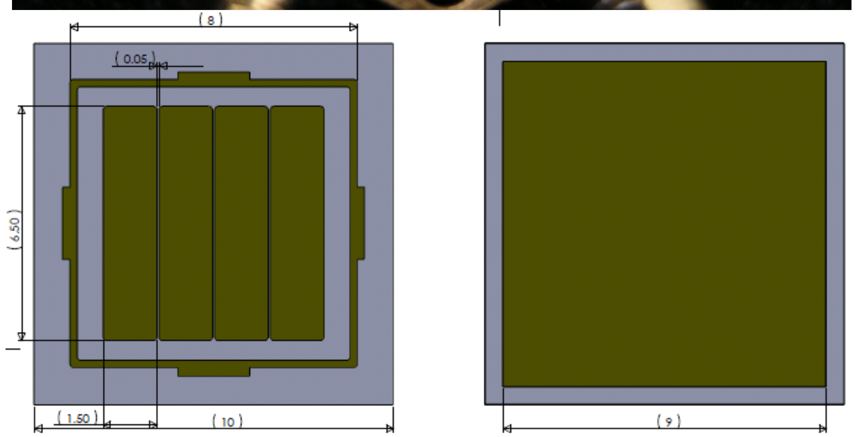

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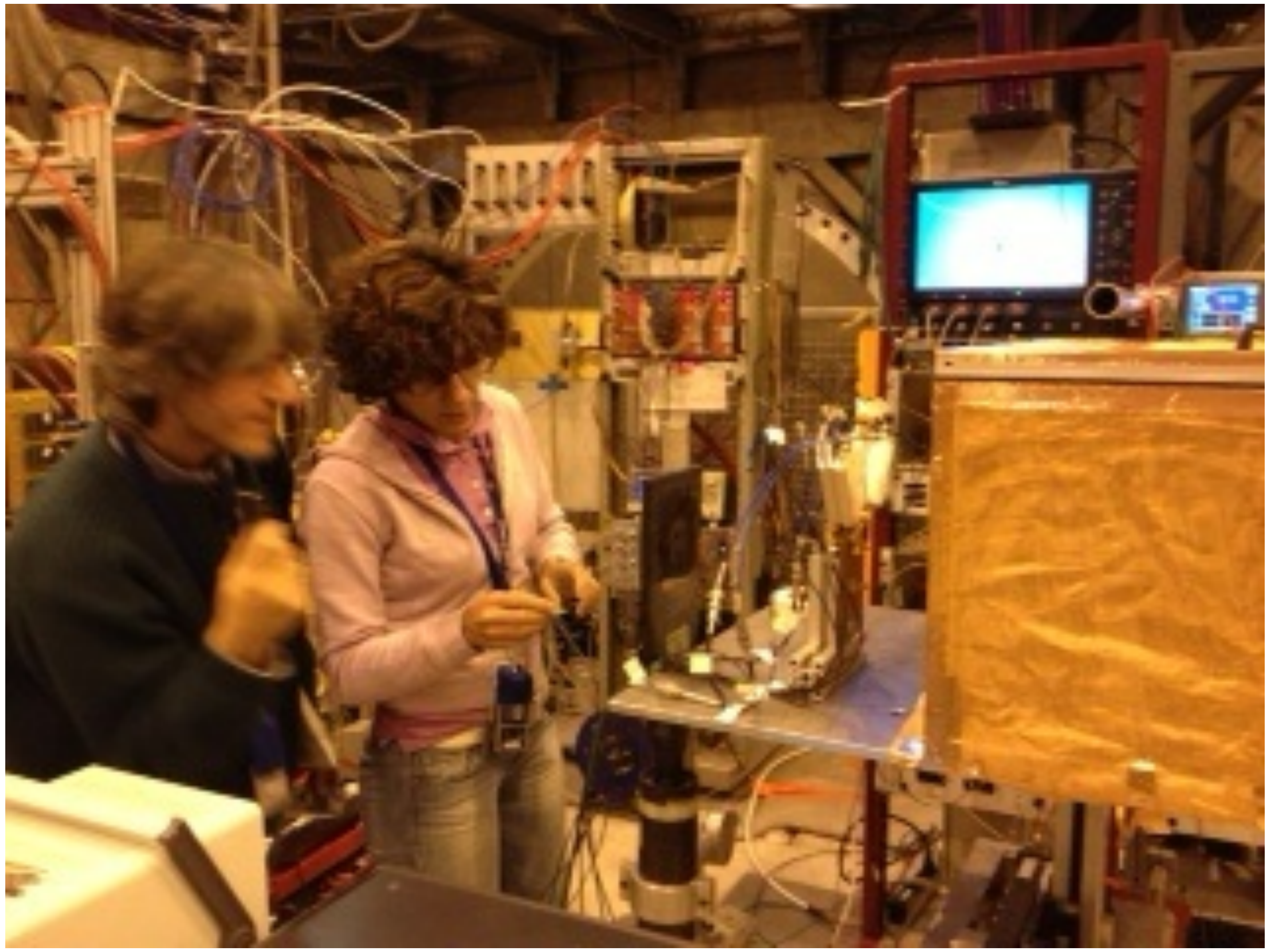

Results

Track Angle	Mean Amp (mV)	Sigma(T1-T2) (ps)
0	130	740
25	127	769
45	180	610
65	195	428
90 (nominal)	233	400

A fast and low noise charge sensitive preamplifier in 90 nm CMOS technology

A. Baschirotto,[a,b] **G. Cocciolo,**[c] **M. De Matteis,**[c] **A. Giachero,**[a,b] **C. Gotti,**[b,d,1] **M. Maino**[a,b] **and G. Pessina**[a,b]

[a] *Dipartimento di Fisica, Università degli Studi di Milano Bicocca, Piazza della Scienza 3, I-20126, Milano, Italy*

[b] *INFN — Sezione di Milano Bicocca, Piazza della Scienza 3, I-20126, Milano, Italy*

[c] *Dipartimento di Ingegneria dell'Innovazione, Università del Salento, Via Per Monteroni, I-73100, Lecce, Italy*

[d] *Dipartimento di Elettronica e Telecomunicazioni, Università degli Studi di Firenze, Via S. Marta 3, I-50139, Firenze, Italy*

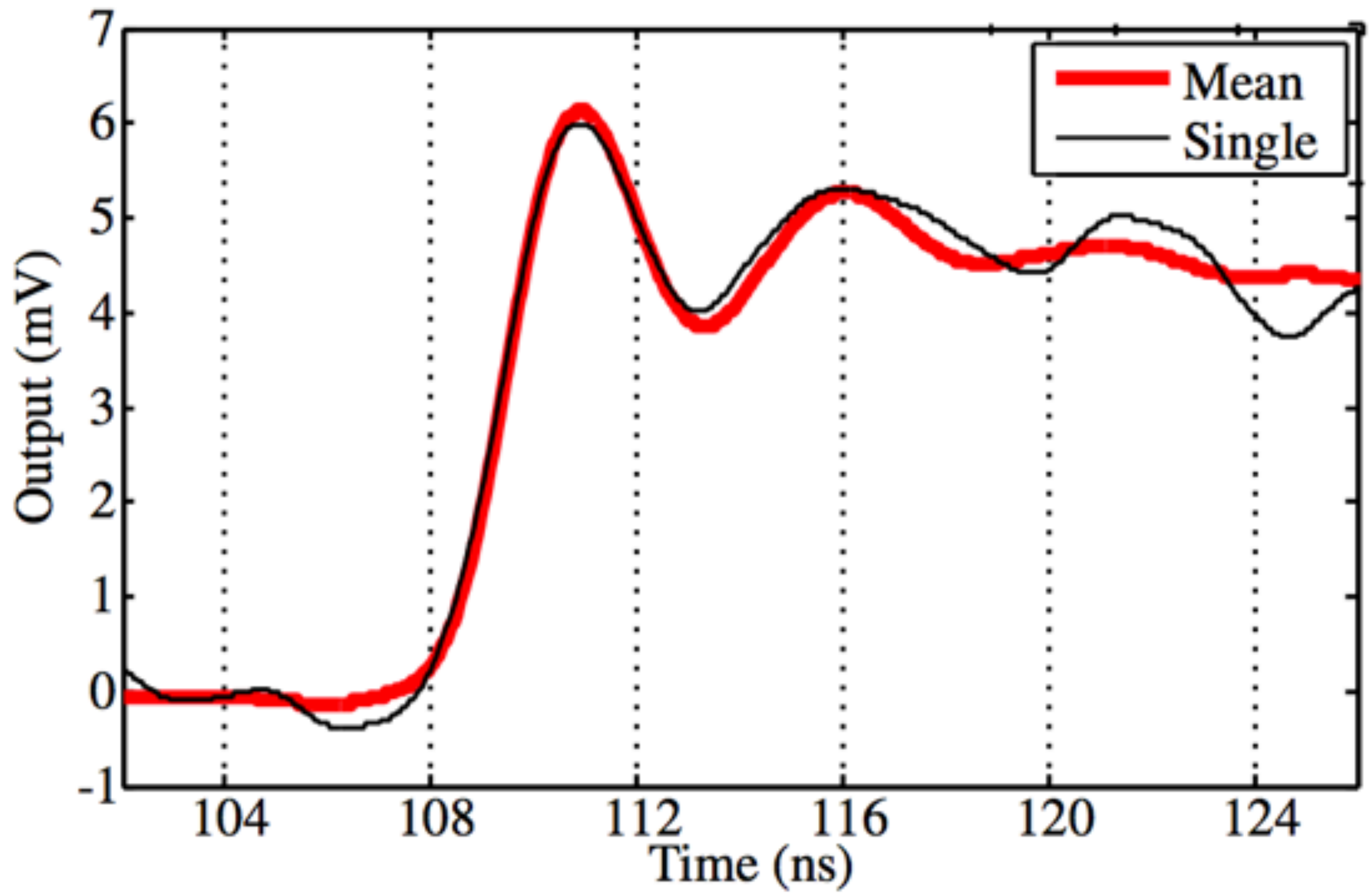

Figure 5. Fastest risetime with a 1 pF source.

- ENC (equivalent noise charge) of about 350 electrons RMS with a detector capacitance of 1 pF.
- Power consumption is 5 mW for one channel,
- Bandwith is about 180 MHz
- Rise Time 2 ns
- better then CIVIDEC CSA in timing performances by factor 2-3

Conclusion

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A reference measuring system was setting up

Theoretical prediction are in agree with test result

Next step

Dedicated front-end electronics “closed” to detector

Boosting signal with different detector configuration (i.e staked detectors)