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APV25 with long input lines

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Outline

- Introduction
- Setup
- Results
- Noise Calculation
- Shielding
- Summary and Outlook

Web http://belle.hephy.at

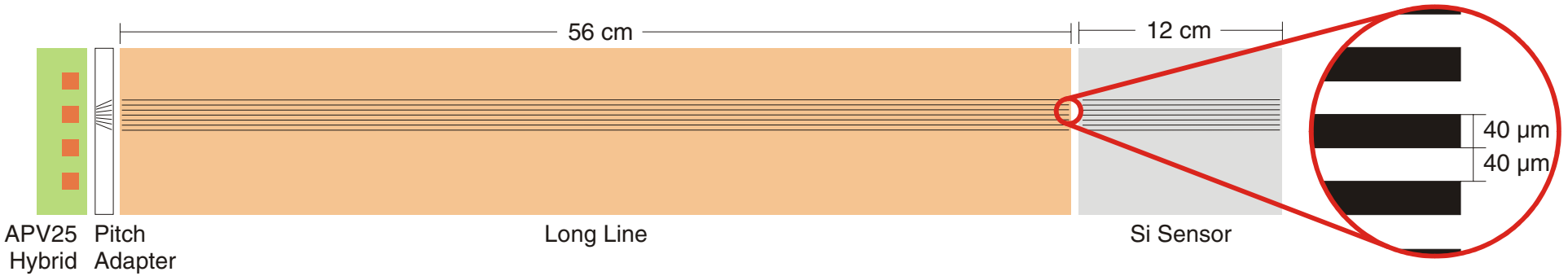
Introduction

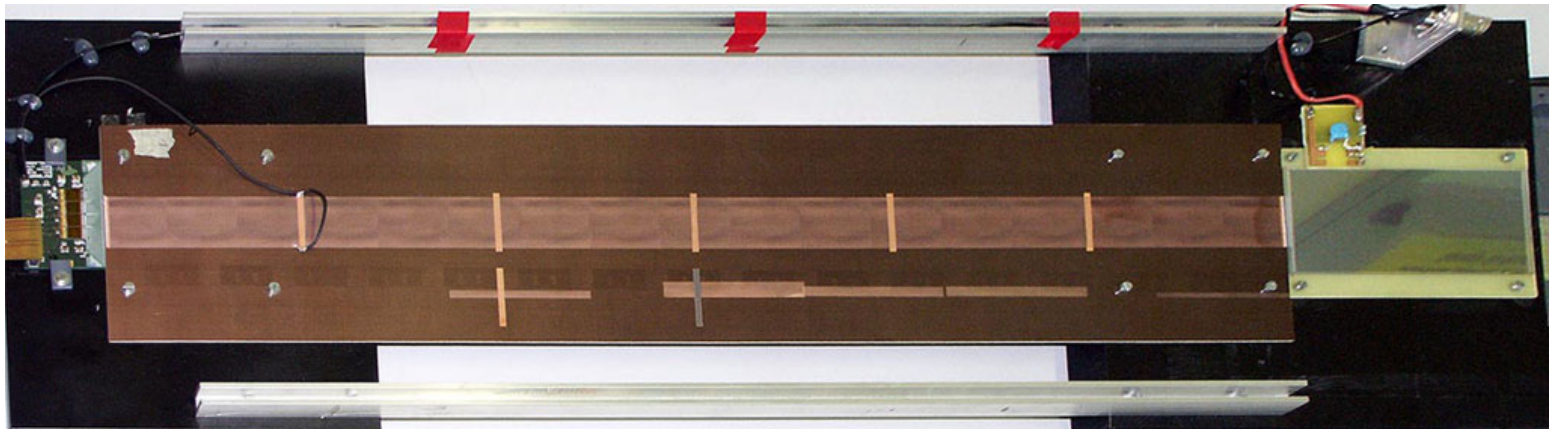
APV25
- Preferred readout chip for Belle SVD upgrade
- Developed for CMS Tracker

Features
- 50ns (default) peaking time, ≥100ns possible
- 40MHz (default) clock, ≥80MHz possible
- 192-cell deep pipeline
- Low noise: 250 e + 36 e/pF (peak mode)

However
- Not designed for long input lines
- Need to be tested: Stability, signal, noise

Setup





Long line — Made by ILFA (Germany)

Sensor — CMS type IB1 (12cm long, 80μm pitch, 320μm thick, LowRes)

Test conditions

APV25 settings	CLK=40MHz
	Peak mode
	~100ns peaking time
I^2C settings	Default except ISHA=8 (default=34), IMUXIN=30 (34), VFP=100 (30)
	LAT=95
	I^2C tuning could be optimized with final configuration (shaping curve depends on input load)
Test pulse	ICAL=26 (~1 MIP, 22400 e)

Results

Noise [e] Calculated from assumption test pulse or source=22400 e

Test pulse

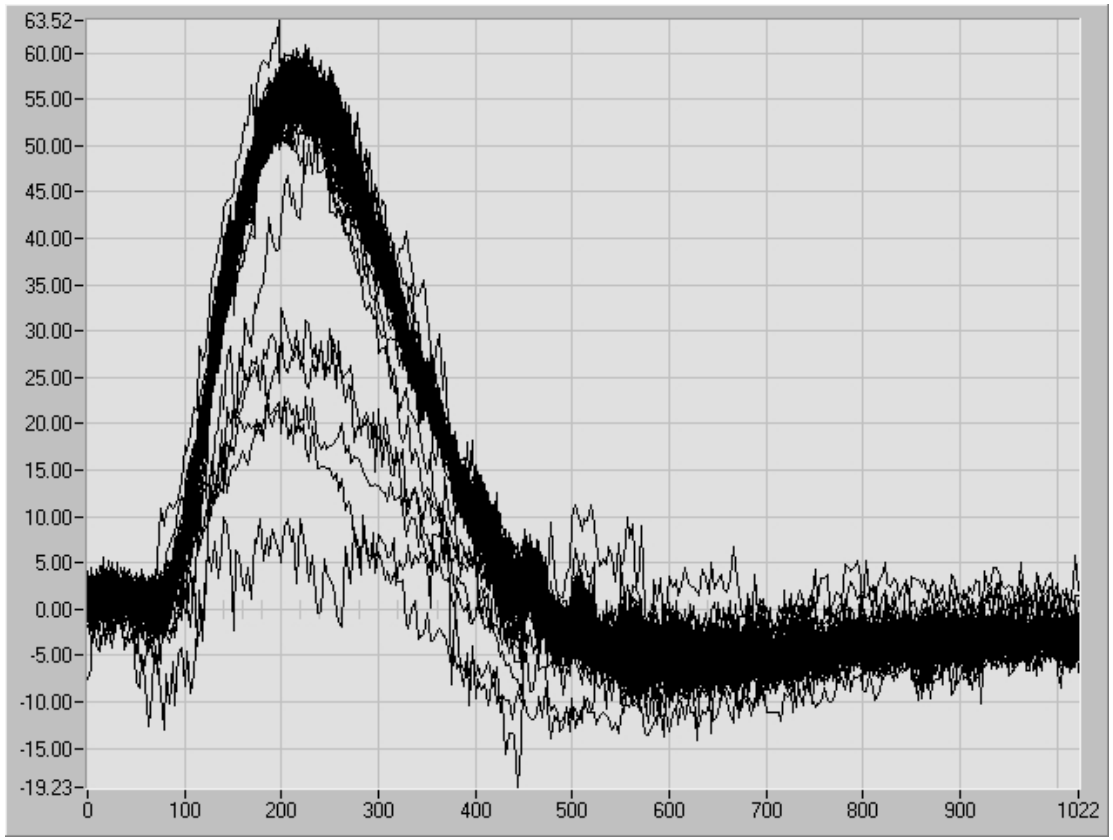
Condition	SNR	Noise [e]
APV25 only	47	477
APV25 + pitch adapter + long line	9.5	2358
APV25 + pitch adapter + long line + sensor	7.2	3111

^{90}Sr Source

Condition	SNR	Noise [e]
APV25 + pitch adapter + long line + sensor	9.4	2383

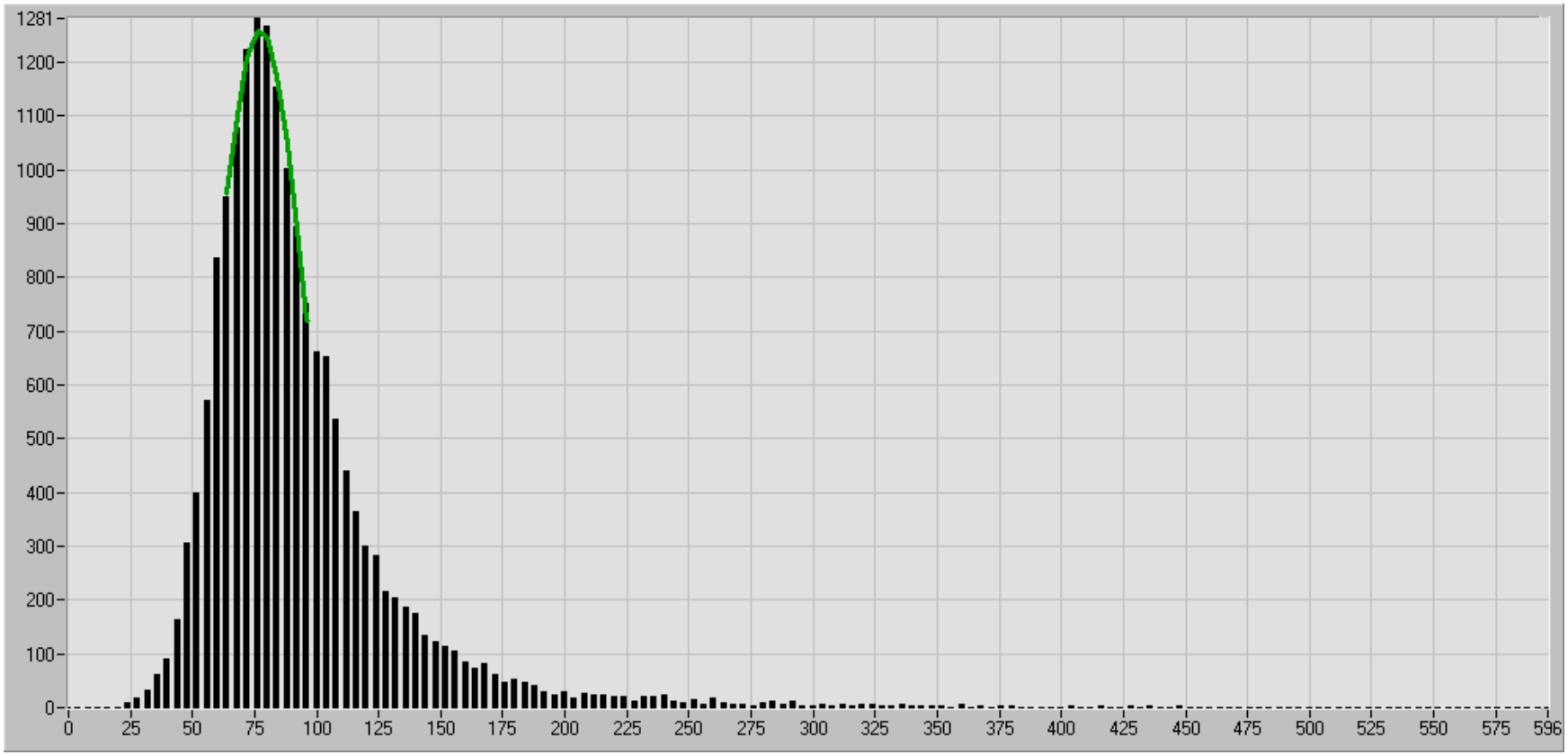
Conclusion Test pulse too low and/or source signal slightly above MIP

Internal Calibration



Graph	Some channels are shorted (1/2 signal)
Peaking time	~135ns with full input load (pitch adapter + long line + sensor)

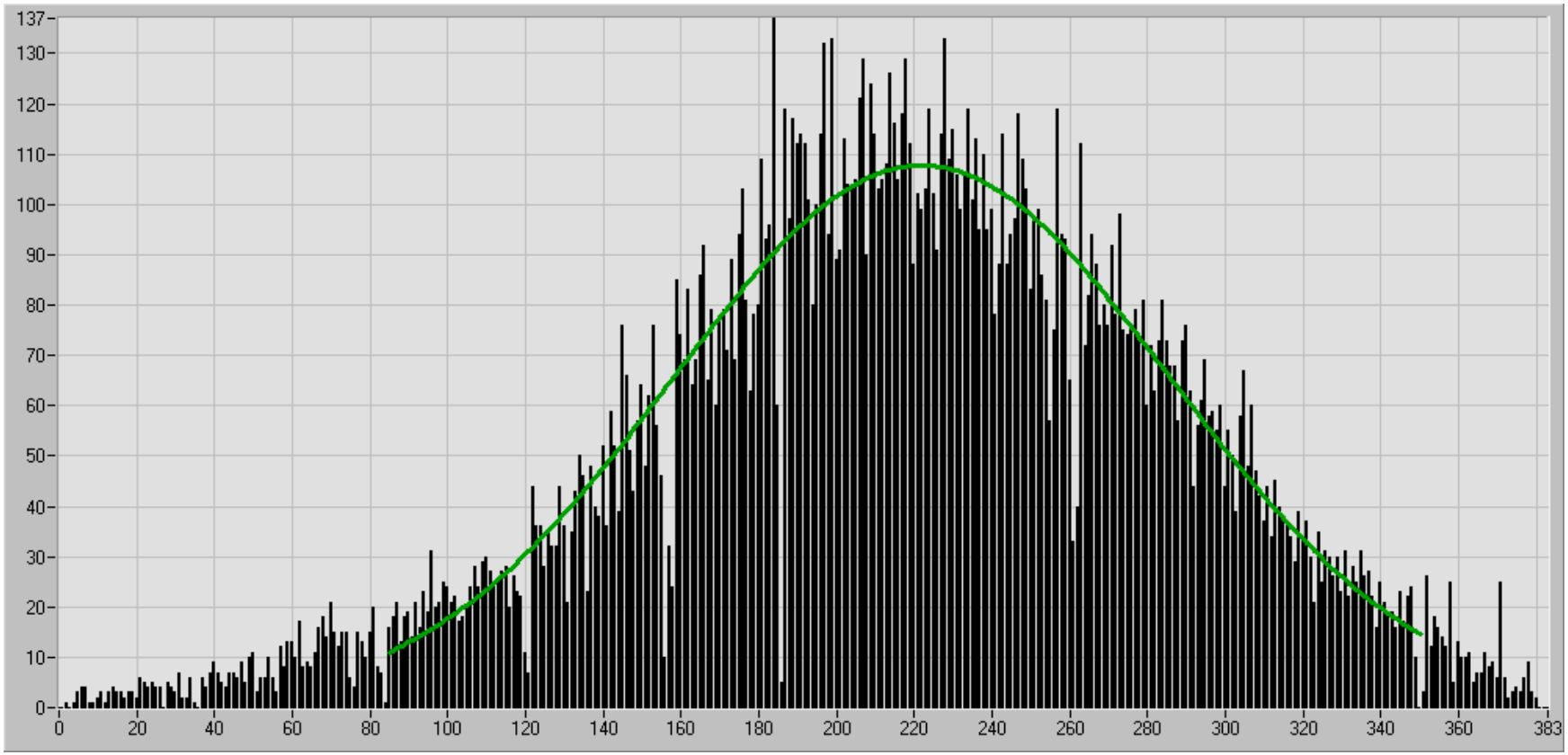
Source Signal



Graph Nice Landau distribution

Cuts Seed/Neighbor/Cluster: 4/2/4

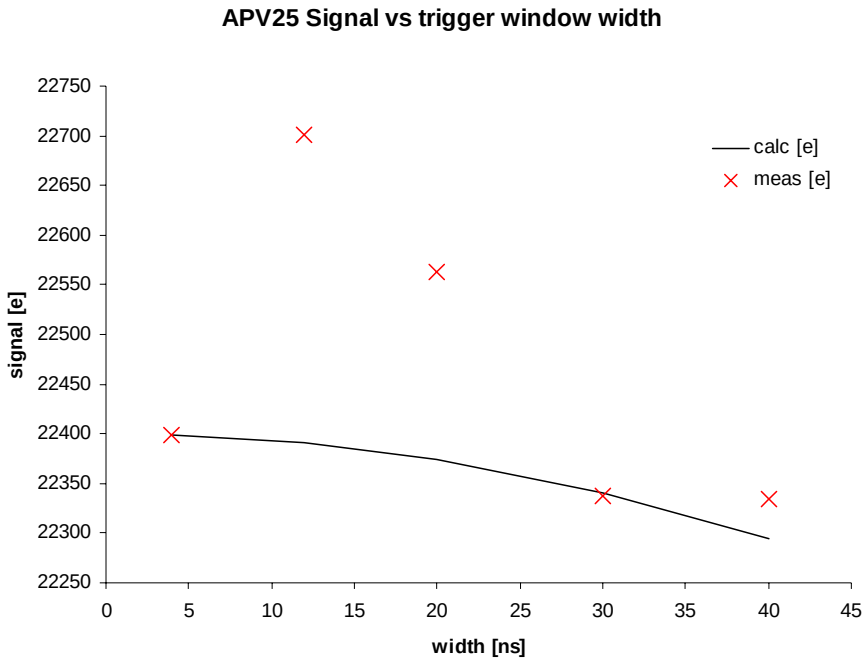
Source spatial distribution



Graph Nice Gaussian distribution

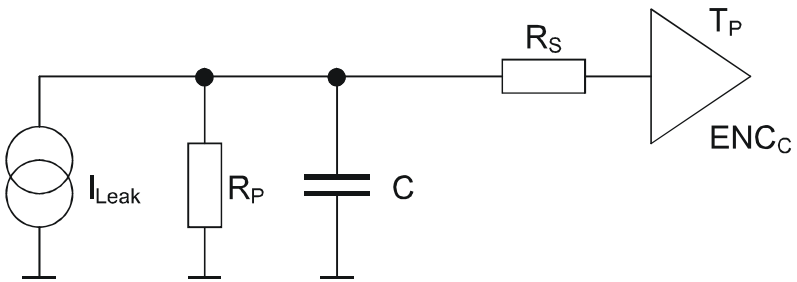
Cluster Average cluster size: 1.8 strips (80μm pitch)

Sampling and trigger jitter



Trigger window	Variable width around peak of 135ns shaping curve
Loss	Only 0.5% even at 40ns → negligible
Conclusion	Shaping time of ~100ns should be sufficient

Noise calculation



$$ENC_C = k + C\,d$$

$$ENC_{ILeak} = 106\sqrt{I_{Leak}\,T_P}$$

$$ENC_{RP} = 758\sqrt{\frac{T_P}{R_P}}$$

$$ENC_{RS} = 0.395\,C\sqrt{\frac{R_S}{T_P}}$$

with ENC [e], k [e], d [e/pF],
I_{Leak} [nA], T_P [μs], R_P [MΩ], R_S [Ω]

APV25 (peak): ENC_C [e]=250+36 C

C_{det} [pF]=14.7 pF
$C_{longline}$ [pF]=40 pF
C_{fanout} [pF]=1 pF

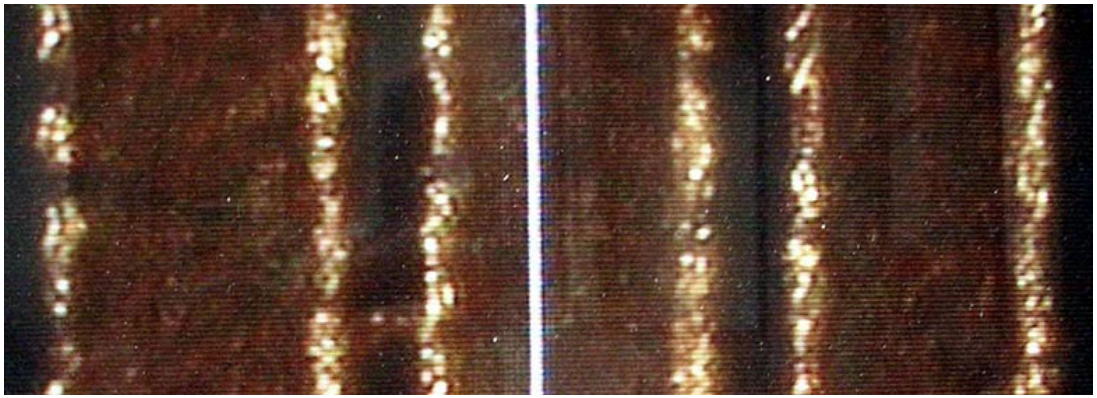
$ENC_{Readout}$=500 e

Quantity	Value	ENC [e]
C	55.7 pF	2255
I_{Leak}	0.65 nA	30
RP	0.54 MΩ	356
RS	23 Ω	305
Total		2357

SNR=9.5 (measured: 9.4)

Noise: Dominant term: capacitance of long line → geometry with minimum C

Geometry of long line



Long line type A

Producer: ILFA (Germany)

Width / Gap: 55 / 25 μm

Metal: 17 μm (copper)

$C_{Neighbor}$: 20 pF

RS: 13 Ω

Long line type B

Producer: CERN (Switzerland)

Width / Gap: 35 / 45 μm

Metal: 5 μm (gold plated copper)

$C_{Neighbor}$: 14.5 pF

RS: 122 Ω

So far, only type A has been tested, expecting lower noise from B

Shielding of long line

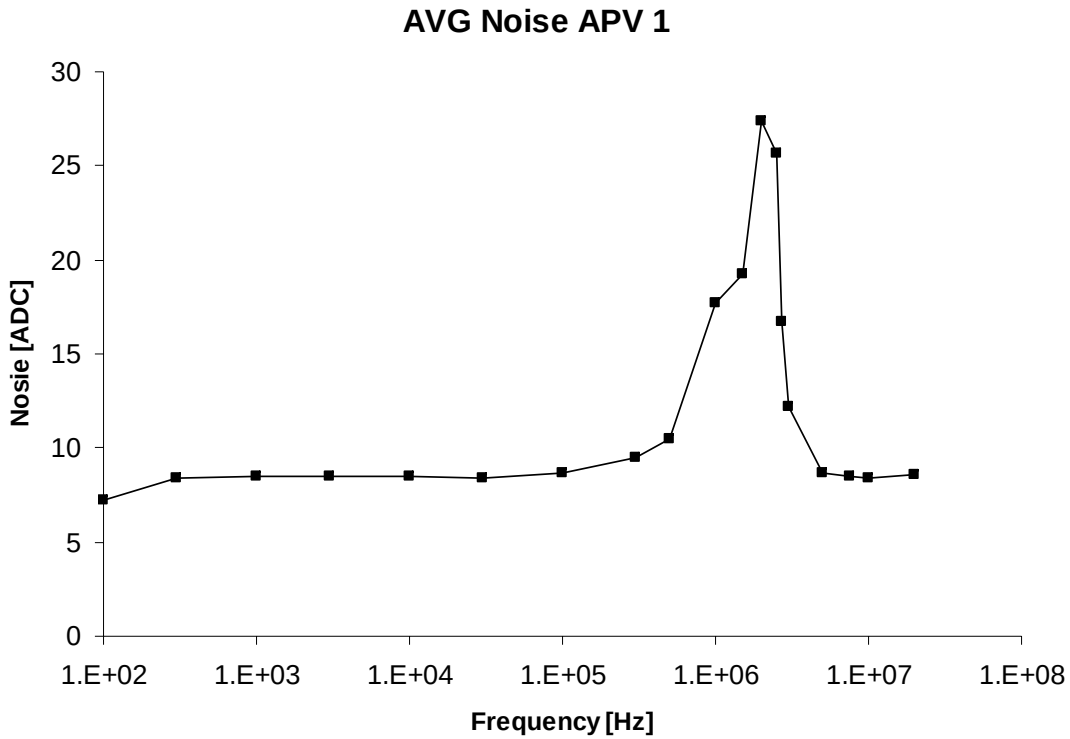
Results

Condition	Noise [ADC]
Without shield	8.2
With grounded shield beneath long line	7.9
With grounded shield on top and beneath long line	8.0

Conclusion

Improved shielding compensates capacitance increase

Interference



Signal: Bottom plate: GND, top plate: Sine wave, 40 mV_{pp}

Noise: Receptive only in the 1 MHz regime

Summary and Outlook

General
- Feasibility of APV25 and 56cm long input lines demonstrated

Signal
- Shaping curve stretched by high (capacitive) input load
- Perfect Landau-distributed source signal with SNR=9.4
- Trigger jitter has negligible effect with shaping times $\geq$ 100ns

Noise
- Dominated by long line capacitance
- $\rightarrow$ Long line design should achieve minimum C

Shielding
- Little effect on capacitance/noise
- APV25 sensitive only around 1MHz

Future
- Continue tests with long line type B (expecting better performance)
- Attach UV sensor (instead of CMS sensor)