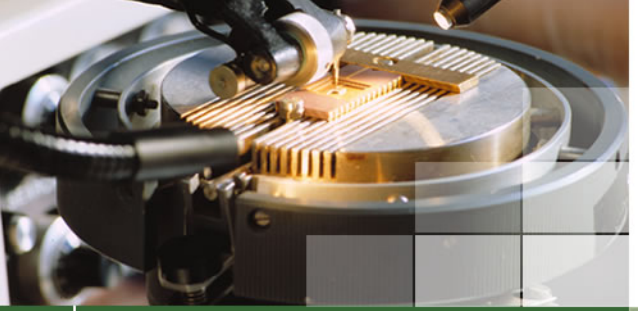


POLITECNICO DI MILANO

Dipartimento di
Elettronica e Informazione

Front End Electronic Design

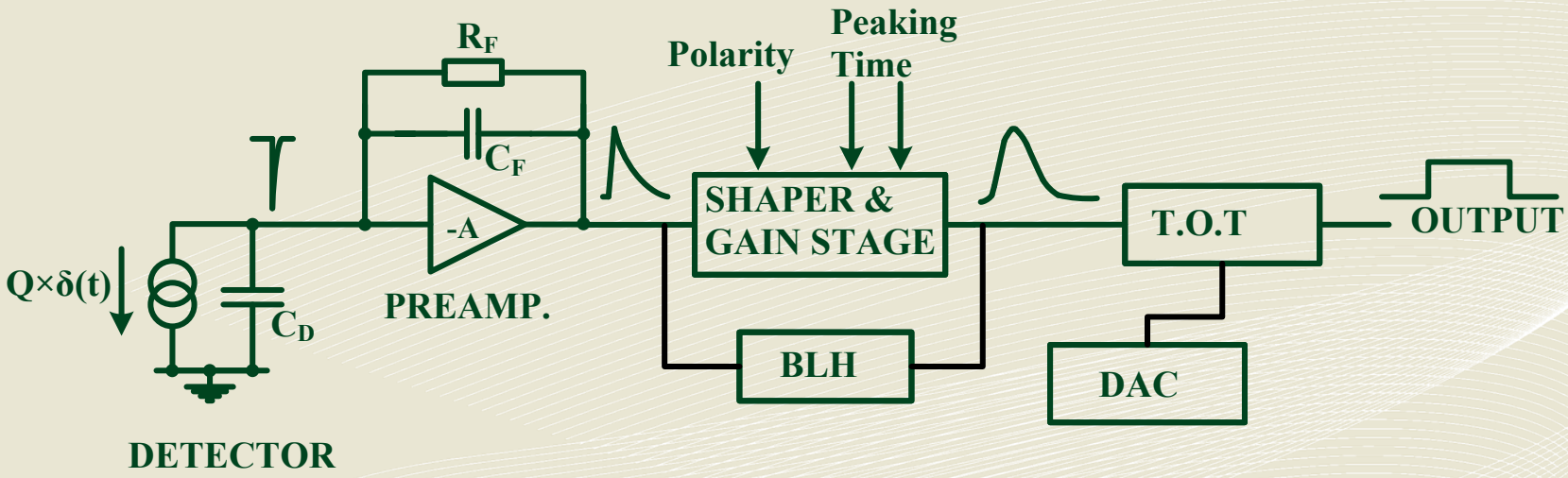
For outer Layers of SVT(L.4 & L.5)

Team: **Luca Bombelli, Bayan Nasri, Carlo Fiorini, Paolo Trigilio**

Table of Contents

Remind of chosen architecture

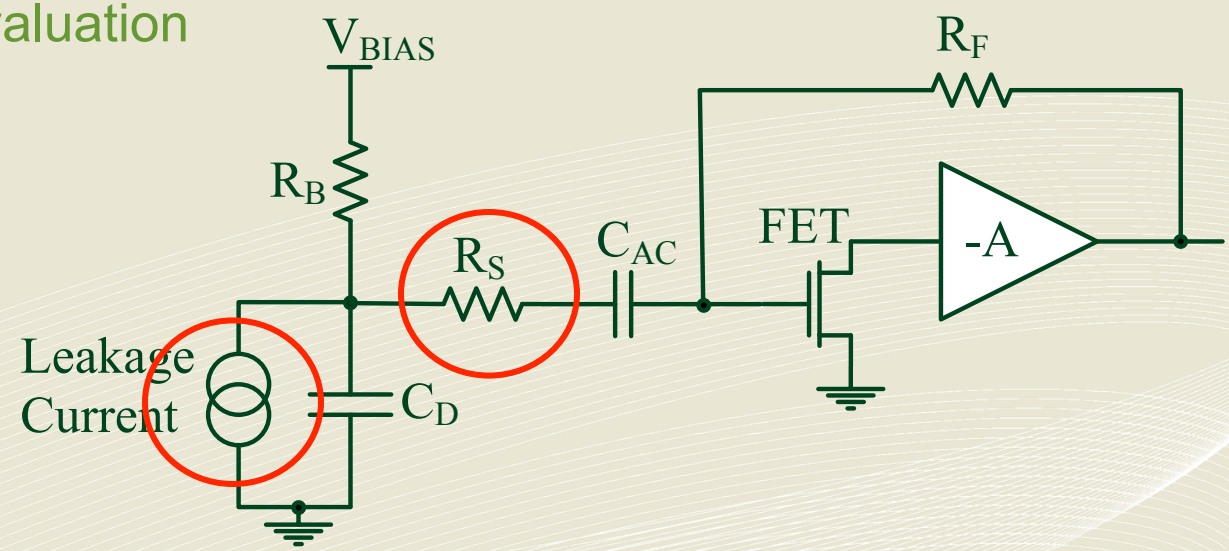
FE-Block Diagram



Third order complex-pole shaping

ENC Contributions

Example of ENC evaluation



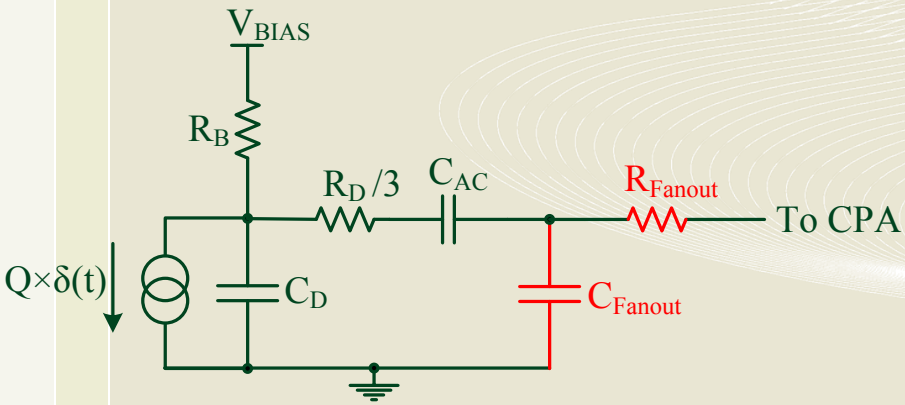
Tp(ns)	375	500	750	1000
ENC_FET	600	529	444	395
ENC_Rs	468	407	333	290
ENC_RB	234	270	329	379
ENC_Rf	579	583	589	590
ENC_Leakage	149	172	210	241
ENC_others	539	498	434	408
ENC_Total	**1132**	**1066**	**998**	**978**

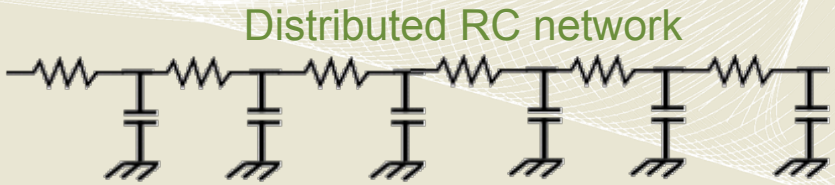
Detector Model used in simulation
(including ganging)

- Detectors Parameters (Updated by Luciano Bosisio May 20, 2012):

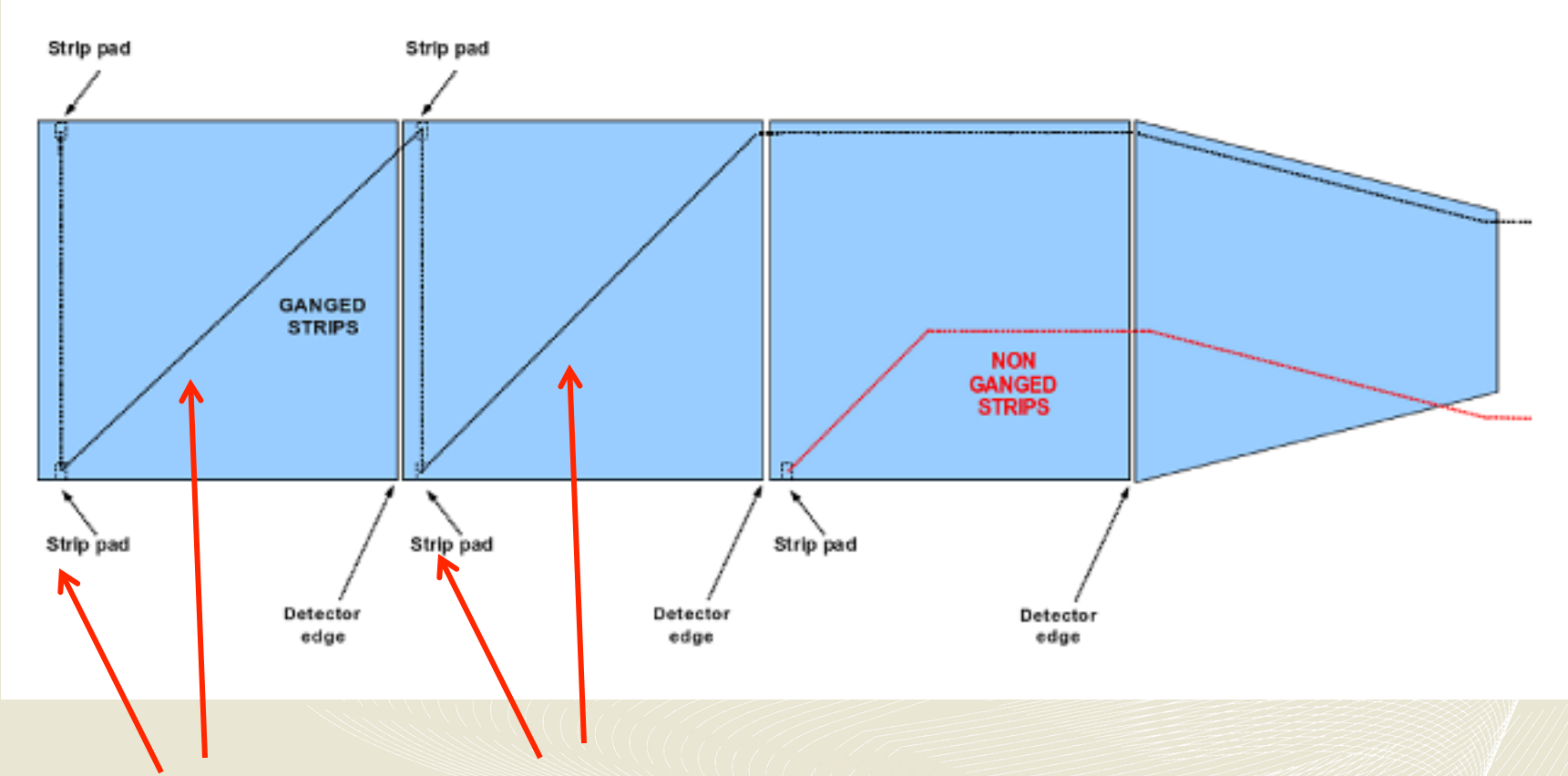
Strip side	Layer	Type	Strip length (cm)	C_D (pF)	R_D (Ω)	R_B (MΩ)	I_{leak} at startup (nA)	I_{leak} 7.5y BK (nA)	I_{leak} 7.5y 5xBK (nA)	C_{AC} (pF)	C_{fanout} (pF)	R_{fanout} (Ω)
Phi	4	p	30.34	51.6	121	2.7	6.1	102	484	1213.6	1.5	3.2
Phi	5	P	38.04	64.7	152	2.5	7.6	44	187	1521.6	1.5	3.2
Z	4	n	15.42	26.2	46	2.7	3.1	105	513	925.2	21	53
Z	5	n	15.42	26.2	46	3.3	3.1	34	156	925.2	26	66

Temperature = 20°C





Connection of the Z-Strip



Distributed R-C network both on detector and on fanout

Moreover the 2 type of networks are interleaved several times for ganged strips!

FE-Model

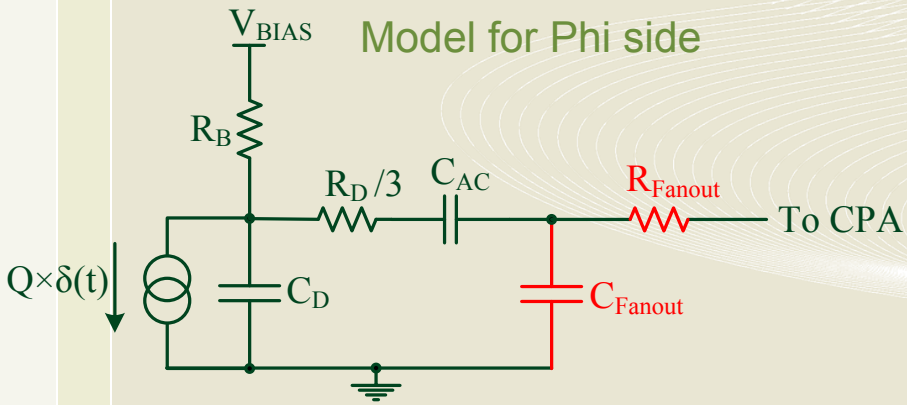
Detector Model used in simulation (including ganging)

- Detectors Parameters (Updated by Luciano Bosisio May 20, 2012):

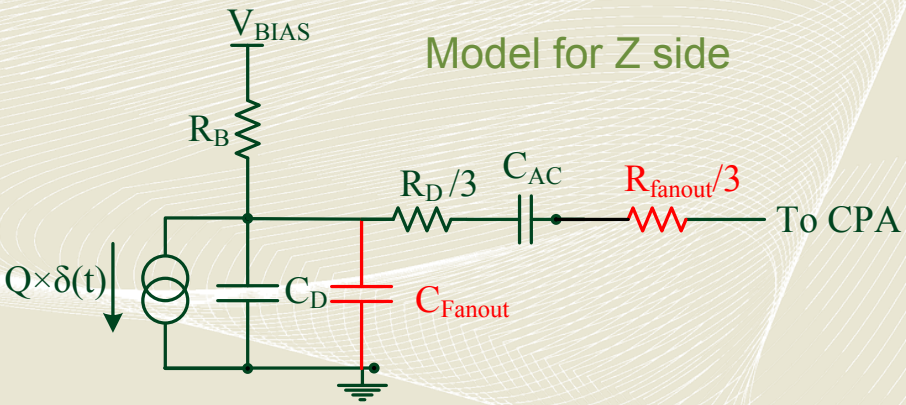
Strip side	Layer	Type	Strip length (cm)	C_D (pF)	R_D (Ω)	R_B (MΩ)	I_{leak} at startup (nA)	I_{leak} 7.5y BK (nA)	I_{leak} 7.5y 5xBK (nA)	C_{AC} (pF)	C_{fanout} (pF)	R_{fanout} (Ω)
Phi	4	p	30.34	51.6	121	2.7	6.1	102	484	1213.6	1.5	3.2
Phi	5	P	38.04	64.7	152	2.5	7.6	44	187	1521.6	1.5	3.2
Z	4	n	15.42	26.2	46	2.7	3.1	105	513	925.2	21	53
Z	5	n	15.42	26.2	46	3.3	3.1	34	156	925.2	26	66

Similar ratios

Model for Phi side



Model for Z side



ENC Estimation before radiations damage

- Phi-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	596	491	437	376
ENC_Rs	483	392	343	288
ENC_RB	207	251	288	345
ENC_Rf	600	644	646	640
ENC_Leakage	234	282	324	388
ENC_others	695	638	586	507
ENC_Total	**1237**	**1166**	**1121**	**1077**

- Z-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	533	463	406	346
ENC_Rs	389	320	280	233
ENC_RB	200	249	283	330
ENC_Rf	384	427	425	418
ENC_Leakage	128	170	194	228
ENC_others	581	427	396	384
ENC_Total	**988**	**879**	**836**	**810**

- Phi-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	591	525	452	405
ENC_Rs	546	477	401	351
ENC_RB	261	300	360	415
ENC_Rf	648	651	653	655
ENC_Leakage	543	622	745	859
ENC_others	648	600	505	471
ENC_Total	**1360**	**1328**	**1316**	**1359**

- Z-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	496	441	375	336
ENC_Rs	377	330	273	240
ENC_RB	222	256	303	351
ENC_Rf	429	428	420	420
ENC_Leakage	350	398	471	546
ENC_others	472	429	389	359
ENC_Total	**983**	**946**	**925**	**947**

ENC Estimation before radiations damage

- Phi-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	596	491	437	376
ENC_Rs	483	392	343	288
ENC_RB	207	251	288	345
ENC_Rf	600	644	646	640
ENC_Leakage	234	282	324	388
ENC_others	695	638	586	507
ENC_Total	**1237**	**1166**	**1121**	**1077**

- Z-Strip
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Tp(ns)	250	375	500	750
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ENC_others	581	427	396	384
ENC_Total	**988**	**879**	**836**	**810**

- Phi-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	591	525	452	405
ENC_Rs	546	477	401	351
ENC_RB	261	300	360	415
ENC_Rf	648	651	653	655
ENC_Leakage	543	622	745	859
ENC_others	648	600	505	471
ENC_Total	**1360**	**1328**	**1316**	**1359**

- Z-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	496	441	375	336
ENC_Rs	377	330	273	240
ENC_RB	222	256	303	351
ENC_Rf	429	428	420	420
ENC_Leakage	350	398	471	546
ENC_others	472	429	389	359
ENC_Total	**983**	**946**	**925**	**947**

ENC Estimation before radiations damage (OLD SLIDE)

- Phi-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	596	491	437	376
ENC_Rs	483	392	343	288
ENC_RB	207	251	288	345
ENC_Rf	600	644	646	640
ENC_Leakage	117	141	162	194
ENC_others	695	638	586	507
ENC_Total	**1220**	**1140**	**1086**	**1024**

- Z-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	533	463	406	346
ENC_Rs	389	320	280	233
ENC_RB	200	249	283	330
ENC_Rf	384	427	425	418
ENC_Leakage	64	85	97	114
ENC_others	581	427	396	384
ENC_Total	**982**	**866**	**819**	**786**

- Phi-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	591	525	452	405
ENC_Rs	546	477	401	351
ENC_RB	261	300	360	415
ENC_Rf	648	651	653	655
ENC_Leakage	158	181	217	250
ENC_others	648	600	505	471
ENC_Total	**1257**	**1187**	**1106**	**1083**

- Z-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	496	441	375	336
ENC_Rs	377	330	273	240
ENC_RB	222	256	303	351
ENC_Rf	429	428	420	420
ENC_Leakage	102	116	137	159
ENC_others	472	429	389	359
ENC_Total	**925**	**866**	**808**	**790**

ENC Estimation after 7.5 years (without safety factor)

- Phi-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	596	491	437	376
ENC_Rs	483	392	343	288
ENC_RB	207	251	288	345
ENC_Rf	600	644	646	640
ENC_Leakage	956	1160	1330	1592
ENC_others	695	638	586	507
ENC_Total	**1545**	**1620**	**1709**	**1883**

- Z-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	533	463	406	346
ENC_Rs	389	320	280	233
ENC_RB	200	249	283	330
ENC_Rf	384	427	425	418
ENC_Leakage	878	1166	1326	1566
ENC_others	581	427	396	384
ENC_Total	**1316**	**1450**	**1555**	**1749**

- Phi-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	591	525	452	405
ENC_Rs	546	477	401	351
ENC_RB	261	300	360	415
ENC_Rf	648	651	653	655
ENC_Leakage	1309	1498	1797	2071
ENC_others	648	600	505	471
ENC_Total	**1808**	**1903**	**2099**	**2324**

- Z-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	496	441	375	336
ENC_Rs	377	330	273	240
ENC_RB	222	256	303	351
ENC_Rf	429	428	420	420
ENC_Leakage	1140	1295	1532	1772
ENC_others	472	429	389	359
ENC_Total	**1465**	**1553**	**1727**	**1934**

ENC Estimation after 7.5 years (without safety factor) (OLD SLIDE)

- Phi-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	596	491	437	376
ENC_Rs	483	392	343	288
ENC_RB	207	251	288	345
ENC_Rf	600	644	646	640
ENC_Leakage	478	580	665	796
ENC_others	695	638	586	507
ENC_Total	**1353**	**1271**	**1263**	**1282**

- Z-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	533	463	406	346
ENC_Rs	389	320	280	233
ENC_RB	200	249	283	330
ENC_Rf	384	427	425	418
ENC_Leakage	439	583	663	783
ENC_others	581	427	396	384
ENC_Total	**1074**	**1041**	**1049**	**1104**

- Phi-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	591	525	452	405
ENC_Rs	546	477	401	351
ENC_RB	261	300	360	415
ENC_Rf	648	651	653	655
ENC_Leakage	381	436	523	603
ENC_others	648	600	505	471
ENC_Total	**1304**	**1251**	**1204**	**1214**

- Z-Strip
  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	496	441	375	336
ENC_Rs	377	330	273	240
ENC_RB	222	256	303	351
ENC_Rf	429	428	420	420
ENC_Leakage	332	377	446	516
ENC_others	472	429	389	359
ENC_Total	**977**	**937**	**913**	**930**

ENC Estimation after 7.5 years (Safety factor=5)

- Phi-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	595	491	437	376
ENC_Rs	483	392	343	288
ENC_RB	207	253	288	348
ENC_Rf	600	644	646	640
ENC_Leakage	2080	2530	2898	3470
ENC_others	704	635	588	505
ENC_Total	**2411**	**2771**	**3091**	**3613**

  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	591	525	452	405
ENC_Rs	546	478	401	351
ENC_RB	262	301	360	415
ENC_Rf	648	651	653	655
ENC_Leakage	2700	3092	3703	4266
ENC_others	647	596	507	472
ENC_Total	**2974**	**3306**	**3859**	**4395**

- Z-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	533	463	406	346
ENC_Rs	389	320	280	233
ENC_RB	198	249	283	335
ENC_Rf	385	427	425	418
ENC_Leakage	2046	2578	2930	3462
ENC_others	581	427	396	384
ENC_Total	**2269**	**2718**	**3041**	**3548**

  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	496	441	375	336
ENC_Rs	377	330	273	240
ENC_RB	225	256	303	351
ENC_Rf	429	428	420	420
ENC_Leakage	2439	2772	3280	3799
ENC_others	472	429	389	359
ENC_Total	**2607**	**2902**	**3376**	**3877**

ENC Estimation after 7.5 years (Safety factor=5) (OLD SLIDE)

- Phi-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	595	491	437	376
ENC_Rs	483	392	343	288
ENC_RB	207	253	288	348
ENC_Rf	600	644	646	640
ENC_Leakage	1040	1265	1449	1735
ENC_others	704	635	588	505
ENC_Total	**1639**	**1696**	**1804**	**2005**

  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	591	525	452	405
ENC_Rs	546	478	401	351
ENC_RB	262	301	360	415
ENC_Rf	648	651	653	655
ENC_Leakage	786	900	1078	1242
ENC_others	647	596	507	472
ENC_Total	**1474**	**1478**	**1530**	**1629**

- Z-Strip
  - Layer 4

Tp(ns)	250	375	500	750
ENC_FET	533	463	406	346
ENC_Rs	389	320	280	233
ENC_RB	198	249	283	335
ENC_Rf	385	427	425	418
ENC_Leakage	1023	1289	1465	1731
ENC_others	581	427	396	384
ENC_Total	**1417**	**1551**	**1675**	**1899**

  - Layer 5

Tp(ns)	375	500	750	1000
ENC_FET	496	441	375	336
ENC_Rs	377	330	273	240
ENC_RB	225	256	303	351
ENC_Rf	429	428	420	420
ENC_Leakage	710	807	955	1106
ENC_others	472	429	389	359
ENC_Total	**1162**	**1178**	**1244**	**1350**

Noise summary

Strip side	Layer	Peaking time (ns)	S/N At startup	S/N after 7.5 years Nomonal background	S/N after 7.5 years 5x Background
Phi	4	250	19	16	10
		375	21	15	9
		500	22	14	8
		750	22	13	7
Z	4	250	24	18	11
		375	27	17	9
		500	29	15	8
		750	30	14	8
Phi	5	375	18	13	8
		500	18	13	7
		750	18	11	6
		1000	18	10	5
Z	5	375	24	16	9
		500	25	16	8
		750	26	14	7
		1000	25	12	6

MIP = 24000 el

1us peaking time not useful.

Probably can be eliminated.

Noise summary (OLD SLIDE)

Strip side	Layer	Peaking time (ns)	S/N At startup	S/N after 7.5 years Nomonal background	S/N after 7.5 years 5x Background
Phi	4	250	20	18	15
		375	21	19	14
		500	22	19	13
		750	23	19	12
Z	4	250	24	22	17
		375	28	23	15
		500	29	23	14
		750	31	22	13
Phi	5	375	19	18	16
		500	20	19	16
		750	22	20	16
		1000	22	20	15
Z	5	375	26	25	21
		500	28	26	20
		750	30	26	19
		1000	30	26	18

MIP = 24000 el

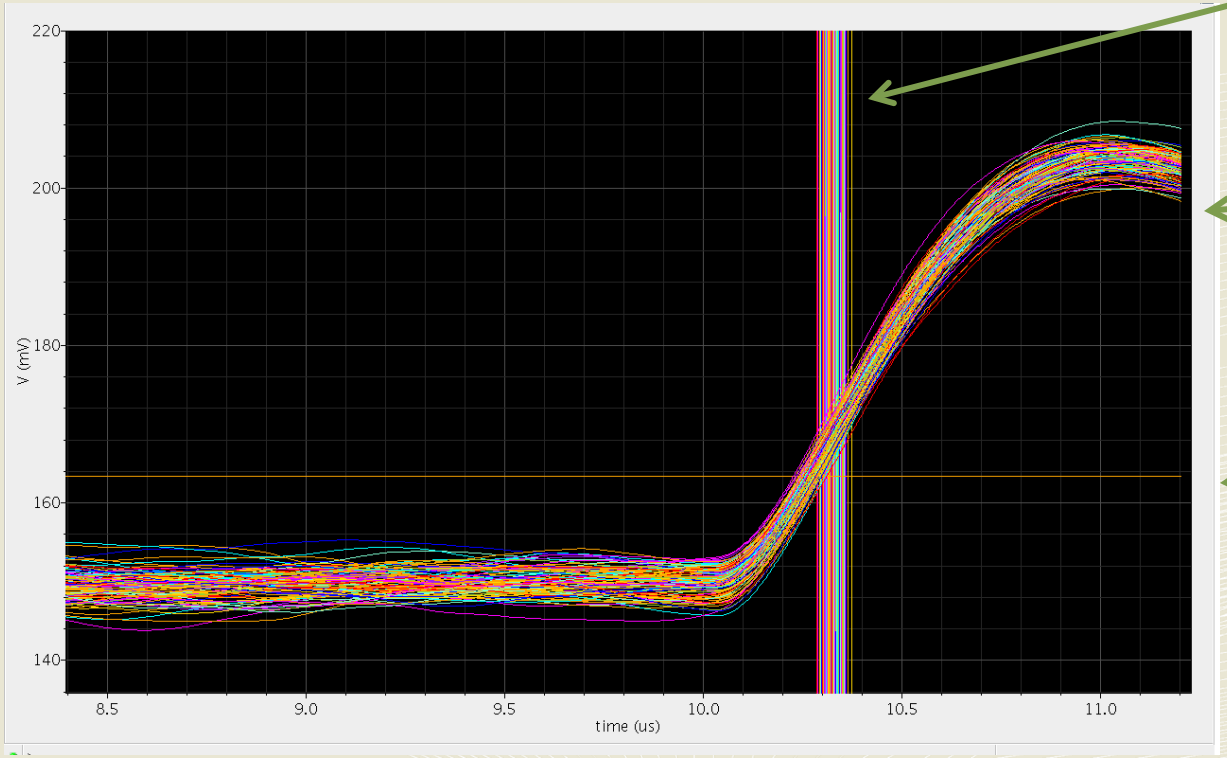
1us peaking time not useful.

Probably can be eliminated.

Table of Contents

Timing Resolution with TOT – Noise jitter

Transient noise simulations

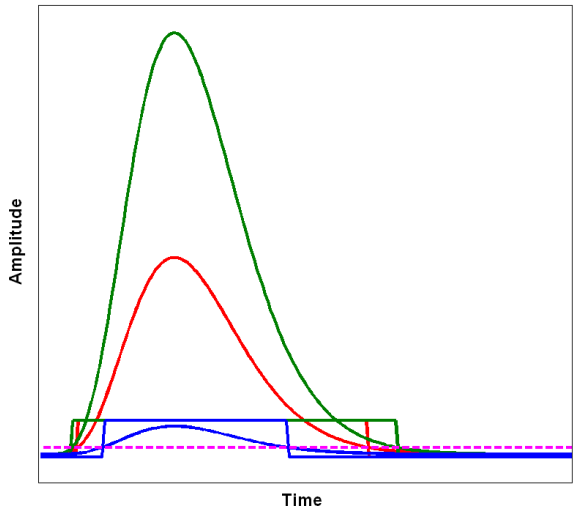


Time jitter depends on the S/N ratio and on the signal amplitude.

Assumed: S/N of 20

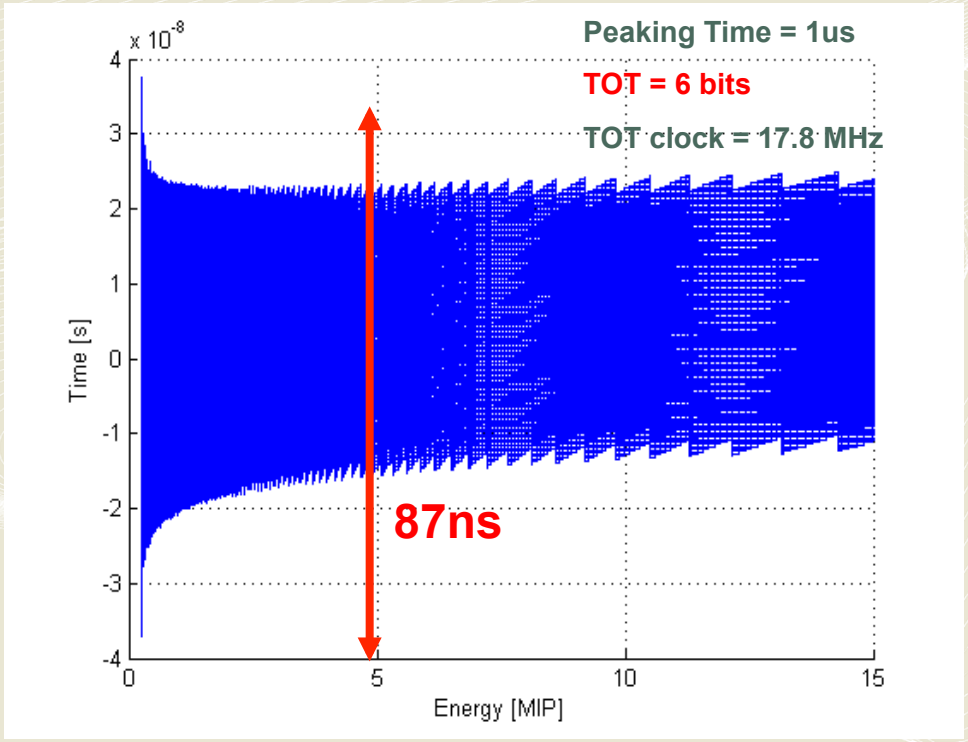
Minimum signal of 0.3 MIP

Timing Resolution with TOT



Time error due to:

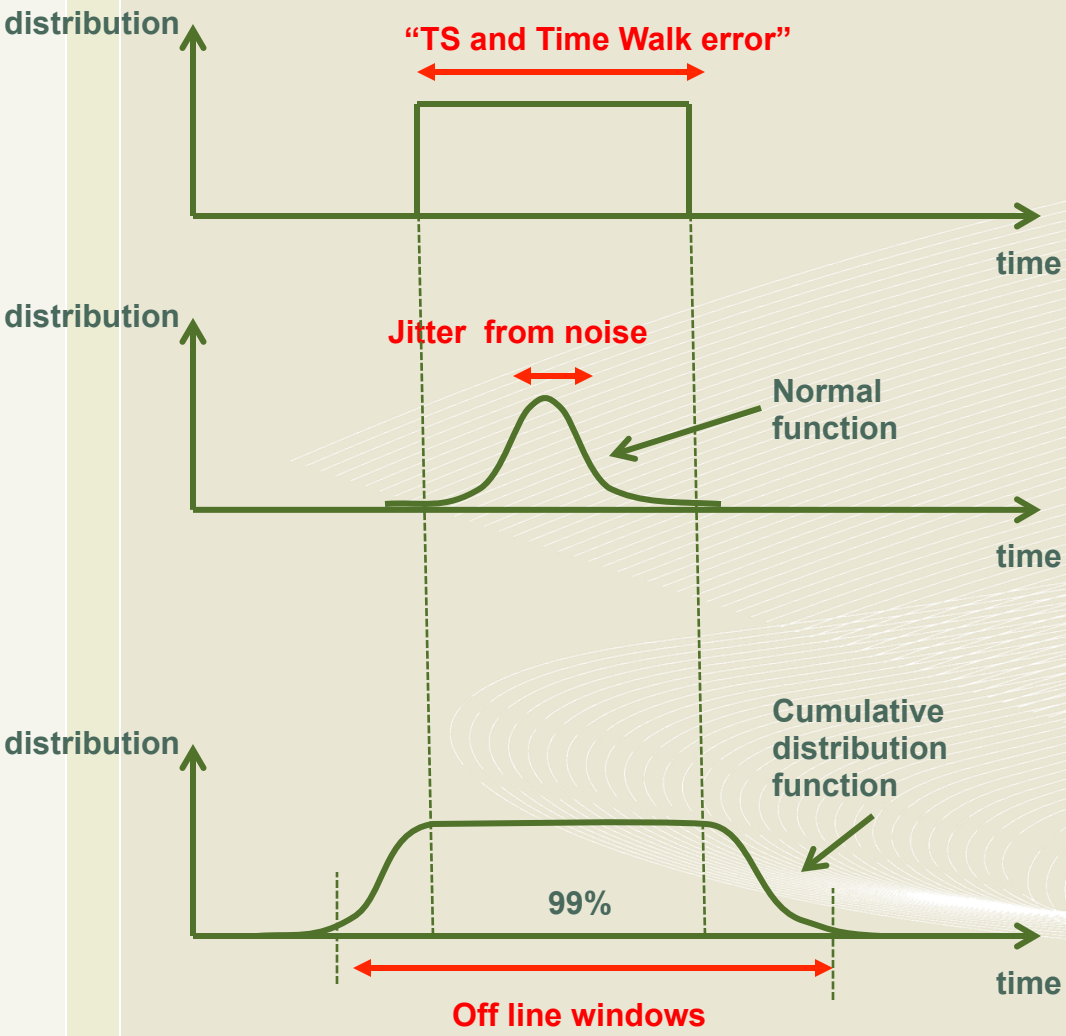
- Time stamp clock (33MHz)
- Time walk, corrected with TOT amplitude
- Effect of TOT error (TOT clock)



- Max Time window = 87ns
- Time Error rms = 25ns

(smallest signal only)

Combining the 2 effect



Error from TS clock and time walk

Jitter form noise

Resulted distribution

Approximate the **TS and Time walk error** as Gaussian and quadratically sum the sigmas.

Timing Resolution with TOT

Peaking time (ns)	TOT bit	TOT clock (Mhz)	TS and Time walk error rms (ns)	Jitter for 0.3 MIP (ns)	Time resolution (ns)	Example Offline window (ns)
375	4	11.3	33	35	**48**	**290**
	6	47.5	15		**38**	**230**
500	4	8.5	41	43	**59**	**360**
	6	35.7	17		**46**	**280**
750	4	5.66	56	60	**82**	**500**
	6	23.8	21		**64**	**380**
1000	4	4.25	72	78	**106**	**640**
	6	17.8	25		**82**	**500**

Time window calculated as ±3sigma

Conclusion and next activities

1. Noise adequate for nominal background up the end of 7.5 years.
2. x5 safety factor on BK leads to little low S/N due to increase on leakage current of the strips.

   Cooling can be improved?

1. Design of TOT comparator and of shaper BLH completed.

   Prototype submission of FE asic is foreseen Nov. 2012.