Fabrication Process Options

Gary Varner

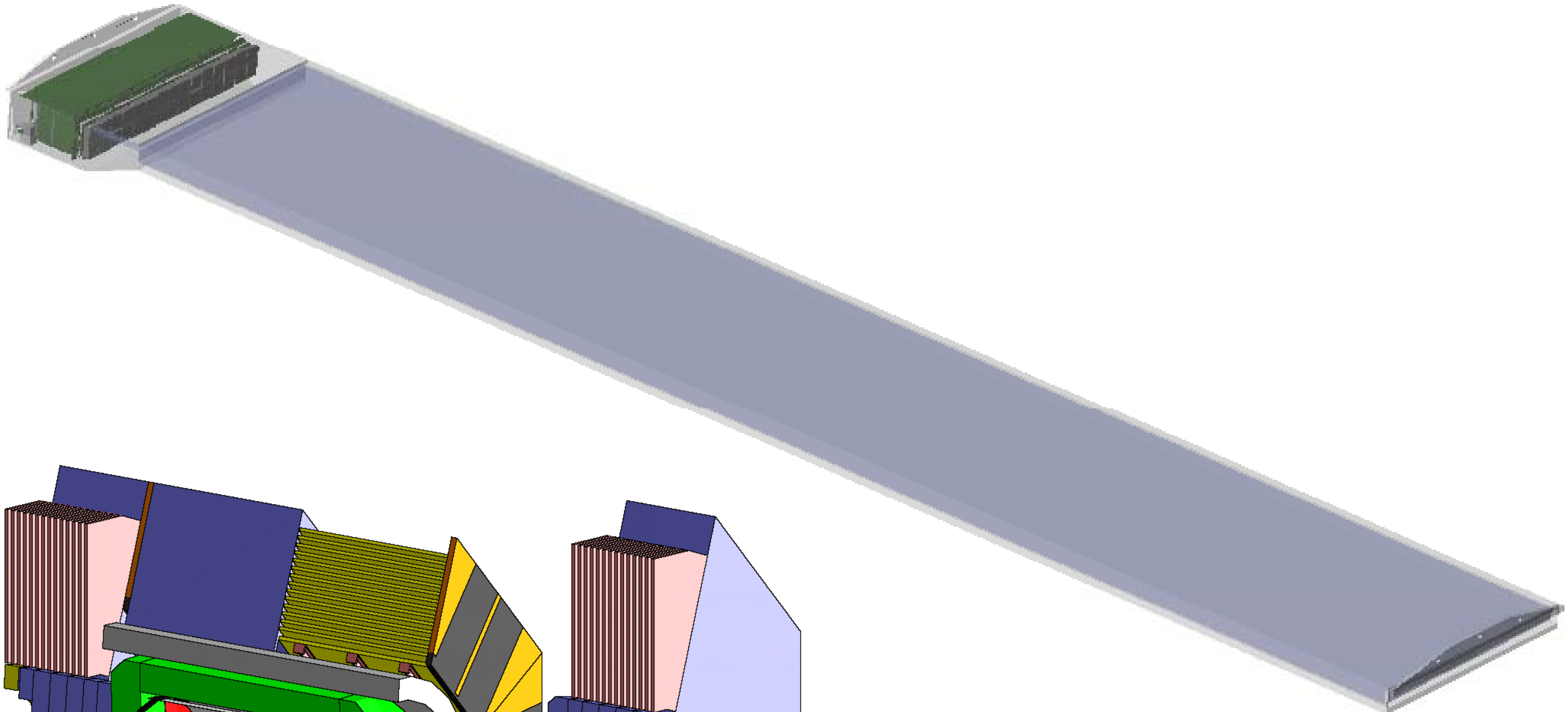
Specification Details are often

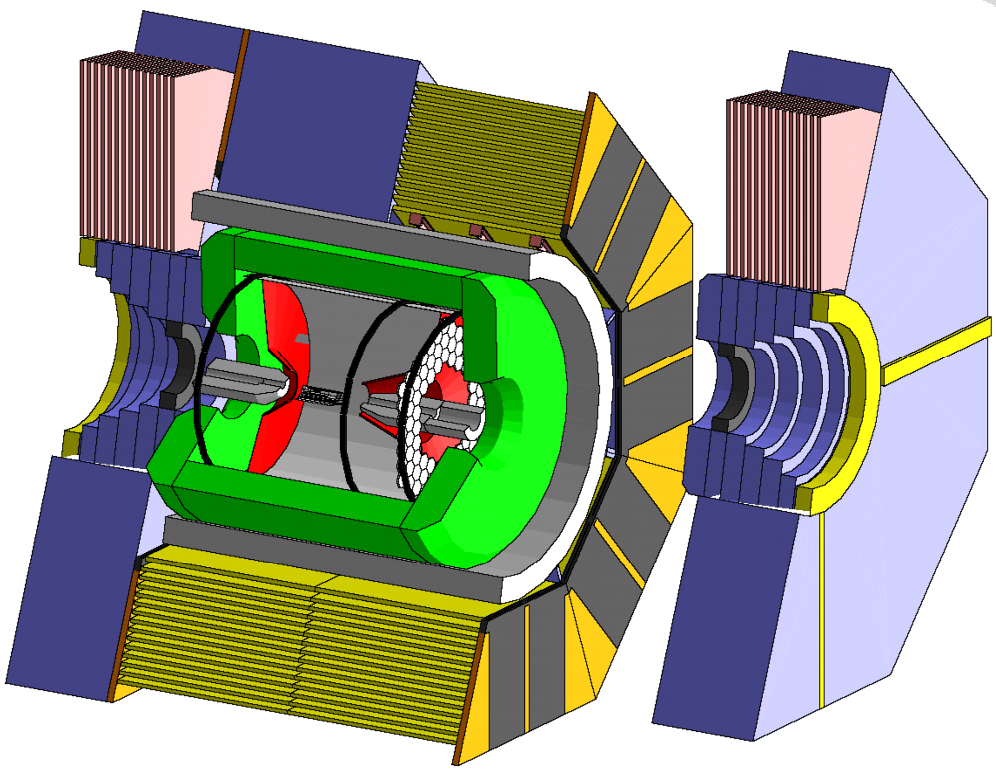
Application Specific

Is IBM 130nm always the best choice?

6-OCT-2010 Electronics GPC Review

An example app: single γ timing

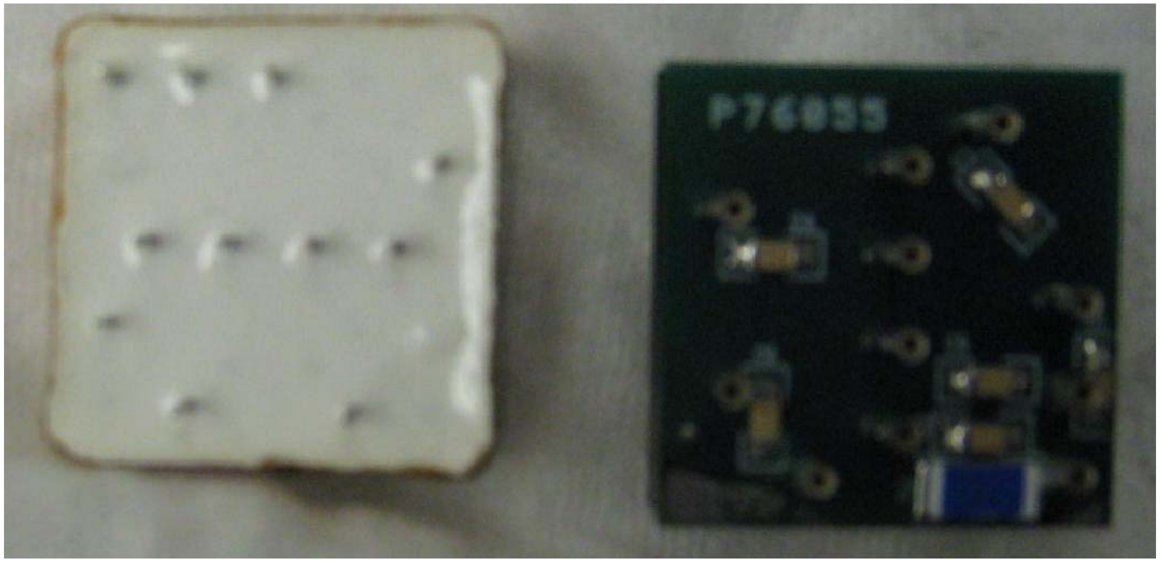


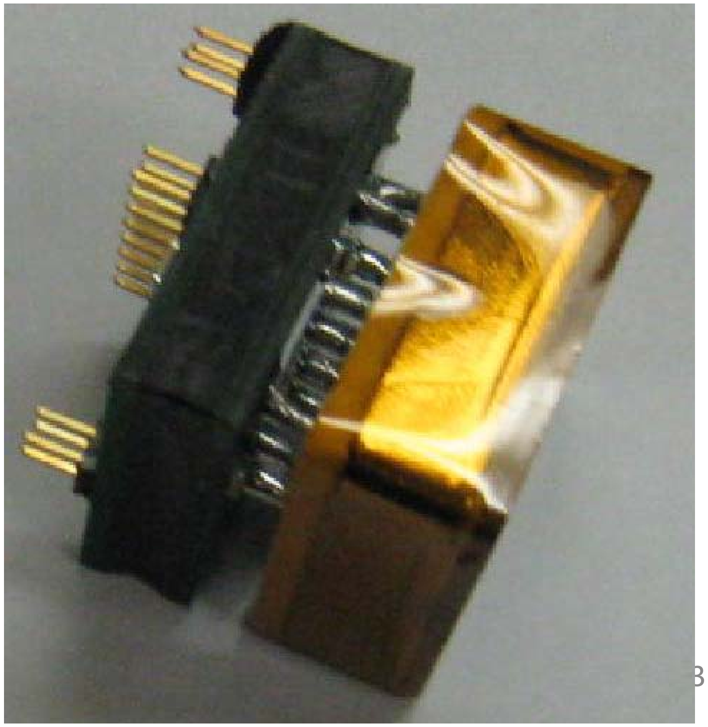


Belle II imaging TOP
(PID upgrade)

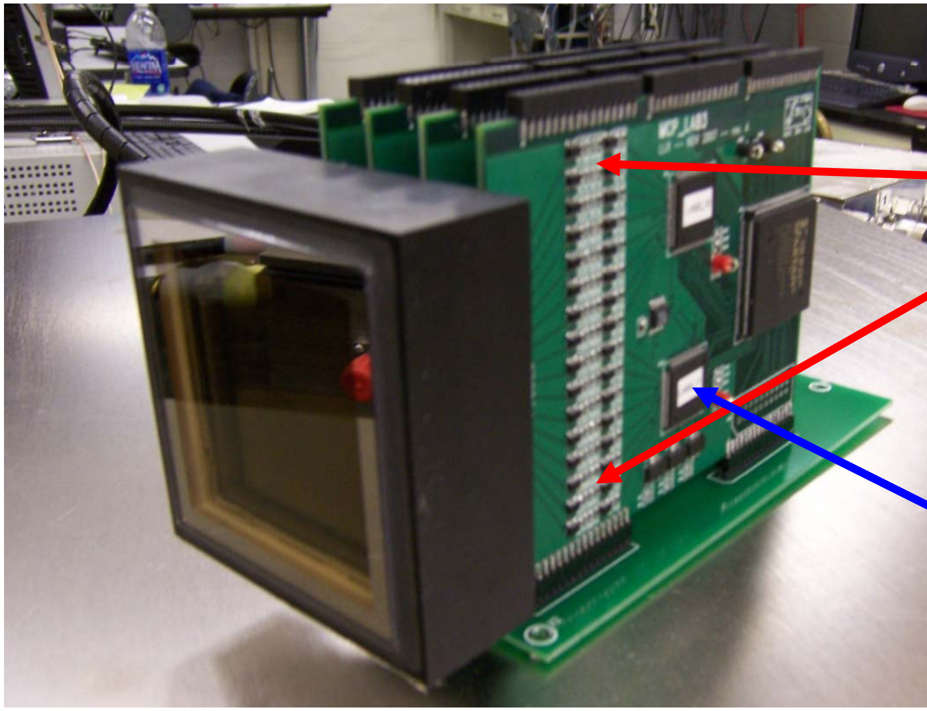
Photo-detector: Hamamatsu SL-10

- Approximate 1” x 1”
- 4 x 4 multi-anode
- Interesting mechanical challenges (case at HV)
- Lifetime protection





Gain Needed



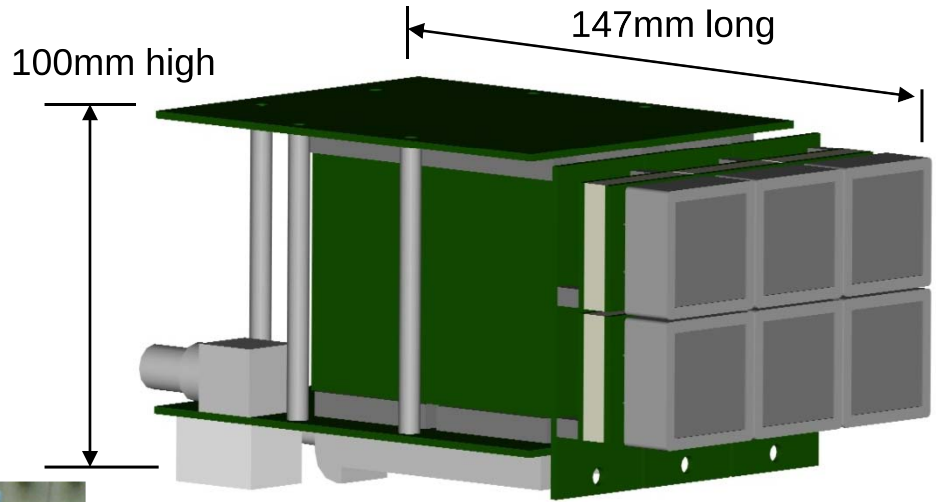
Amplifiers dominate board space

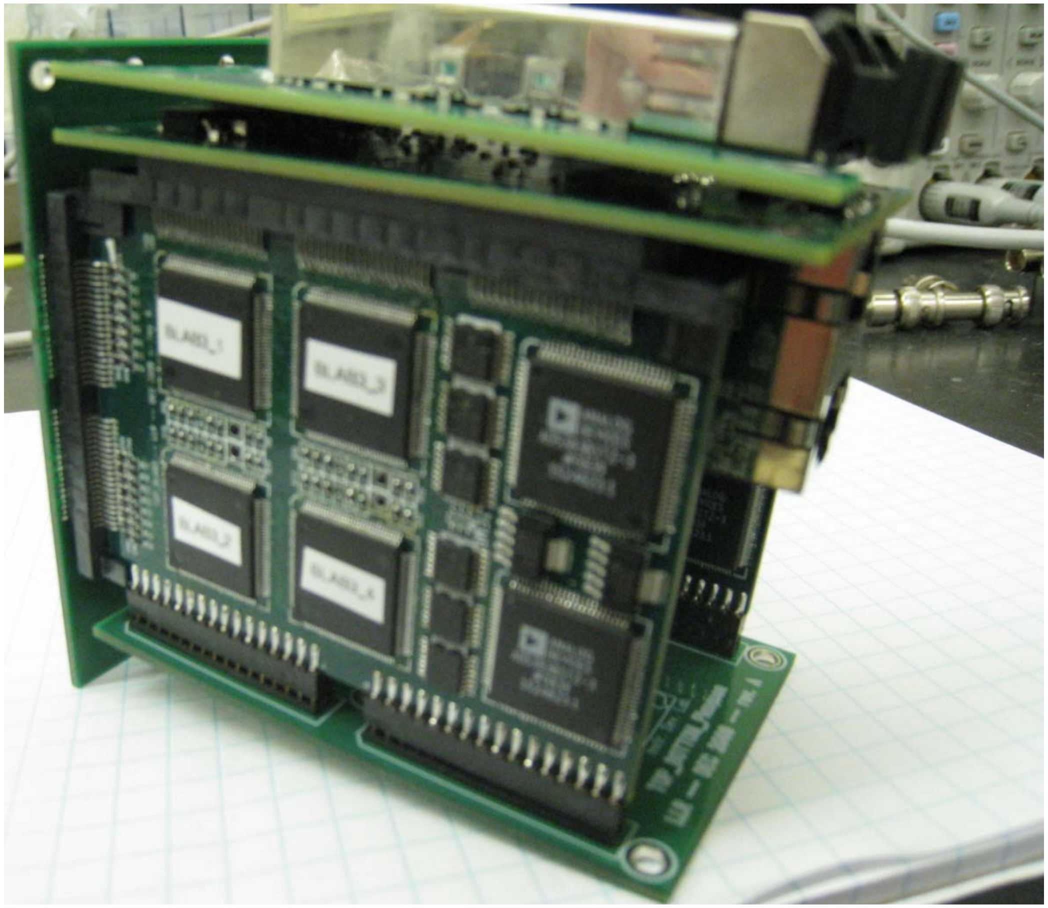
Readout ASIC pair

- What gain needed?
  - At 10^6 gain, each p.e. = 160 fC
  - At $2x10^5$ gain (better for aging), each p.e. = 32 fC
  - In typical ~5ns pulse, Vpeak = dQ/dt * R = 32uA * R = 32mV * R [kΩ] (6.4mV)

Gain Estimate	
Rterm	1 p.e. peak
50	1mV
1k	20mV
20k	400mV

Highly integrated readout electronics

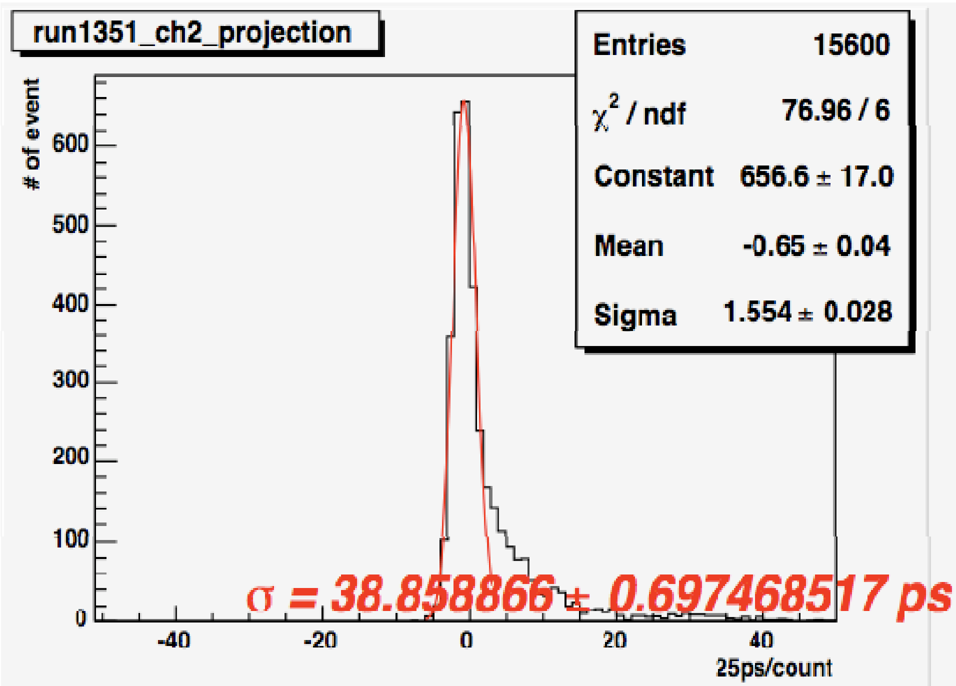




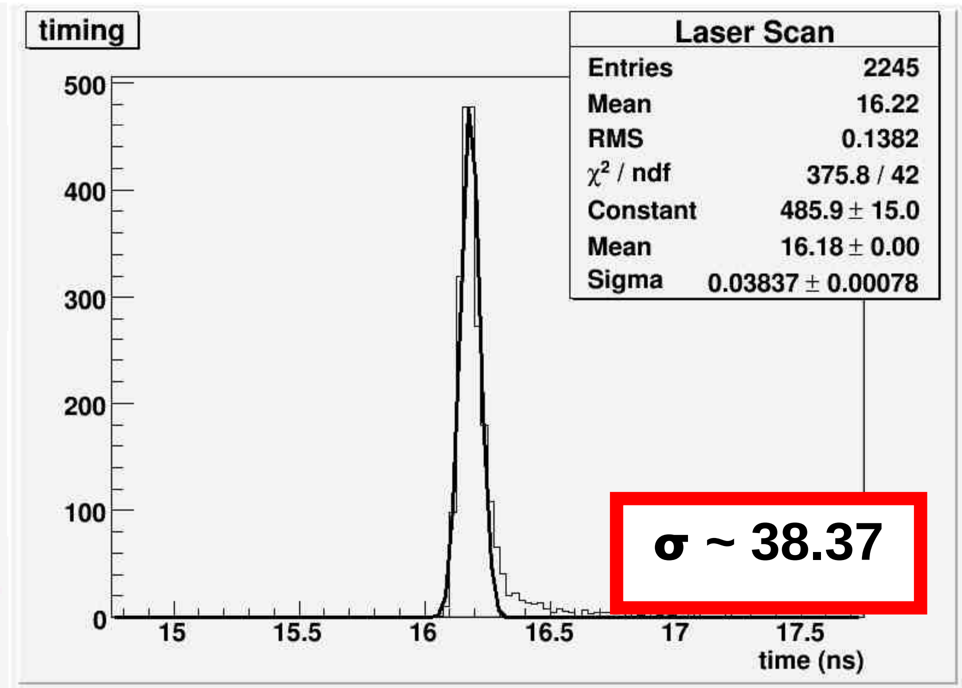
front-end module

SL-10 Timing Performance

Nagoya

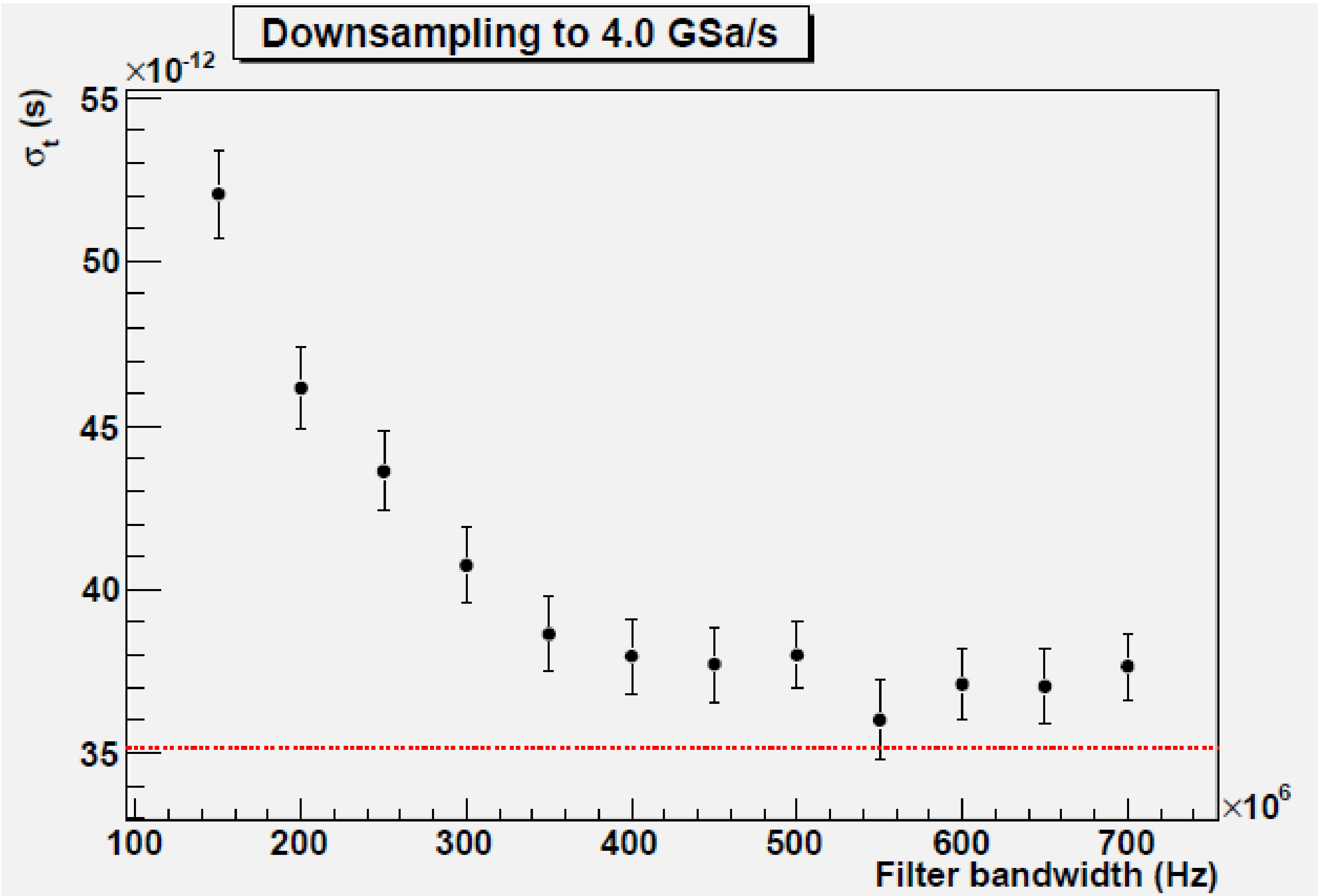


Hawai'i



- Nagoya = constant fraction discriminator + CAMAC ADC/TDC
- Hawai'i = waveform sampling + feature extraction

Updated results – single γ



➔ **Relaxes needed bandwidth: 400-500 MHz looks adequate**

ASIC options

ASIC	ABW [GHz]	Sampling [Gsa/s]	# of Channels	Amp G [dB]	SCA depth	Fab vendor	Size [nm]
PSEC3	~2?	~10	4	0	256	IBM	130
DRS4	~1	~5	8	Ext.	1k	IBM	250
BLAB3	~0.2	~4	8	27	32k	TSMC	250
BLAB3A	~0.7	~4	8	36	32k	TSMC	250
IRS	1.0	4/8	8/4	0	32k	TSMC	250
IRS2*	1.5	4/8/12/16/32	8/4/3/2/1	0	32k	TSMC	250
STURM2	~3	10-100	8	0	4x8	TSMC	250
TARGET2*	~0.5	0.5-2	16	30	16k	TSMC	250
TARGET2B*	1.0	0.5 - 4	16	0	16k	TSMC	250

IBM Fabrication Schedule — 2010

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2011 Fabrication Schedule

See **Taxi Runs** for selected processes: 5HP/5AM, 5DM, 5PA, 6HP/6DM, 6RF, 7SF, 7HP, and 9SF. Taxi runs can be ordered to start at any time for all the processes below.

2010 Fabrication Schedule

Technology		Customer Submission Date											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
32SOI [1]	32 nm									27			
12SOI [1]	45 nm							12					
10LPE [1]	65 nm	19		15					9				
10SF [1]	65 nm		1				21						
9LP	90 nm		22			24				27			6
8HP	0.13 µm		16			17				13			6
8RF [2]	0.13 µm		16			10			9			8	
8WL	0.13 µm		16			24				20			13
7HV	0.18 µm					3				13		29	
7RF	0.18 µm		16		19		14		16		11		6
7RFSOI	0.18 µm	11		15			7		16		11		13
7WL	0.18 µm	19		15		3		12		7		8	
6WL [1]	0.25 µm	19			5			12			4		
5HPE [1]	0.35 µm		1		19			6				1	
5PAE [1]	0.35 µm	19			12						11		

About 1 submission every 3 months

TSMC Fabrication Schedule — 2010

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2011 Fabrication Schedule

2010 Fabrication Schedule

Technology		Customer Submission Date											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CLN40/CMN40	40 nm			22	19	17	21	19	16	20	18	15	
CLN45/CMN45	45 nm			22	19	17	21	19	16	20	18	15	
CLN65/CMN65	65 nm	4 19	8 22	8 29	12 26	10 24	7 28	12 26	9 23	7 27	11 25	8 22	6
CMN65T	65 nm										11 (5)		
CLN90/CMN90	90 nm	4	8	8	5	3	1	6	2 30		4	1 29	
CMN90T	90 nm										11 (5)		
CL013/CM013	0.13 µm	19	8 22	8 29	12 19	3 17	1 28	26	23	27	25	22	
CL013LP	0.13 µm	19	8 22	8 29	12 19	3 17	1 28	26	23	27	25	22	
CL013LV	0.13 µm	19	8 22	8 29	12 19	3 17	1 28	26	23	27	25	22	
CL018/CM018	0.18 µm	4 19	8 16	8 15 22	5 19	3 10 17	7 14 21	6 19	2 9 16 30	7 20	4 18	1 8 15 29	6
CL018HV	0.18 µm	4		8		3		6	30			1	
CL018LP	0.18 µm	4 19		8 15	19	3	14	6 19	30	7	18	1	6
CL018LV	0.18 µm	4 19	8 16	8 22	5 19	3 10 17	7 21	6 19	2 9 16 30	7 20	4 18	1 8 15 29	6
CL025/CM025	0.25 µm	4 19	22	29		10	14	6 19	2 30	20	4	1 15 29	

TSMC Fabrication Schedule — 2010

Generated on: 04-Oct-2010 15:30:00

2011 Fabrication Schedule

2010 Fabrication Schedule

Technology		Customer Submission Date											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CLN40/CMN40	40 nm			22	19	17	21	19	16	20	18	15	
CLN45/CMN45	45 nm			22	19	17	21	19	16	20	18	15	
CLN65/CMN65	65 nm	4 19	8 22	8 29	12 26	10 24	7 28	12 26	9 23	7 27	11 25	8 22	6
CMN65T	65 nm										11 (5)		
CLN90/CMN90	90 nm	4	8	8	5	3	1	6	2 30		4	1 29	
CMN90T	90 nm										11 (5)		
CL013/CM013	0.13 µm	19	8 22	8 29	12 19	3 17	1 28	26	23	27	25	22	
CL013LP	0.13 µm	19	8 22	8 29	12 19	3 17	1 28	26	23	27	25	22	
CL013LV	0.13 µm	19	8 22	8 29	12 19	3 17	1 28	26	23	27	25	22	
CL018/CM018	0.18 µm	4 19	8 16	8 15 22	5 19	3 10 17	7 14 21	6 19	2 9 16 30	7 20	4 18	1 8 15 29	6
CL018HV	0.18 µm	4		8		3		6	30			1	
CL018LP	0.18 µm	4 19		8 15	19	3	14	6 19	30	7	18	1	6
CL018LV	0.18 µm	4 19	8 16	8 22	5 19	3 10 17	7 21	6 19	2 9 16 30	7 20	4 18	1 8 15 29	6
CL025/CM025	0.25 µm	4 19	22	29		10	14	6 19	2 30	20	4	1 15 29	

IBM Fabrication Schedule — 2011

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2010 Fabrication Schedule

See **Taxi Runs** for selected processes: 5HP/5AM, 5DM, 5PA, 6HP/6DM, 6RF, 7SF, 7HP, and 9SF. Taxi runs can be ordered to start at any time for all the processes below.

2011 Fabrication Schedule

Technology		Customer Submission Date											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9LP	90 nm		28			31			29			28	
8HP	0.13 µm	18			18			11			17		
8RF [2]	0.13 µm		7			9			8			7	
8WL	0.13 µm		22			31				19			12
7HV	0.18 µm		14			2			1			28	
7RF	0.18 µm		14		18		6		15		10		5
7WL	0.18 µm	18		14		2		11		6		7	
6WL [1]	0.25 µm			7			13			6			5
5HPE [1]	0.35 µm		7			23			29			7	
5PAE [1]	0.35 µm	18			11			5			10		
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Project about 1 submission every 3 months

TSMC Fabrication Schedule — 2011

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2010 Fabrication Schedule

2011 Fabrication Schedule

Technology		Customer Submission Date											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CLN40/CMN40	40 nm	24	14	21	18	16	13 P	18 P	15 P	19 P	24 P	28 P	
CLN45/CMN45	45 nm	24	14	21	18	16	13 P	18 P	15 P	19 P	24 P	28 P	
CLN65/CMN65	65 nm	10		7	11	9	6	5 P	8 P	6 P	10 P	7 P	5 P
CLN90/CMN90	90 nm	3 31	28		4	2 31	27 P	25 P	22 P	26 P	31 P		5 P
CL013/CM013	0.13 µm	3	7 28		4	2 31	20 P	25 P	22 P	19 P	10 P	14 P	12 P
CL013LP	0.13 µm	3	7 28		4	2 31	20 P	25 P	22 P	19 P	10 P	14 P	12 P
CL013LV	0.13 µm	3	7 28		4	2 31	20 P	25 P	22 P	19 P	10 P	14 P	12 P
CL018/CM018	0.18 µm	10 24	7 22 28	7 28	11 25	2 9 23 31	6 20 P	5 P 18 P	1 P 22 P	6 P 19 P	3 P 17 P	7 P 21 P	5 P
CL018HV	0.18 µm	10 (3)		7 (4)	11 (4)		6 (3)		1 P		3 P		5 P
CL018LP	0.18 µm	10 24	28	7	11 25	31	6	5 P	22 P	6 P	17 P	21 P	
CL018LV	0.18 µm	10 24	7 22 28	7 28	11 25	9 23 31	6 20 P	5 P 18 P	1 P 22 P	6 P 19 P	3 P 17 P	7 P 21 P	5 P
CL025/CM025	0.25 µm	3 31	14 28		4 18	2 31	27 P	11 P	8 P	6 P 19 P	24 P	21 P	12 P
CL035/CM035	0.35 µm		14		18		20 P		22 P		17 P		12 P
CL035HV_BCD	0.35 µm				18				22 P				12 P
CL035HV_DDD	0.35 µm		14 (2)		18 (1)		20 P		22 P		17 P		12 P
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

About 1-2 submissions/month foreseen

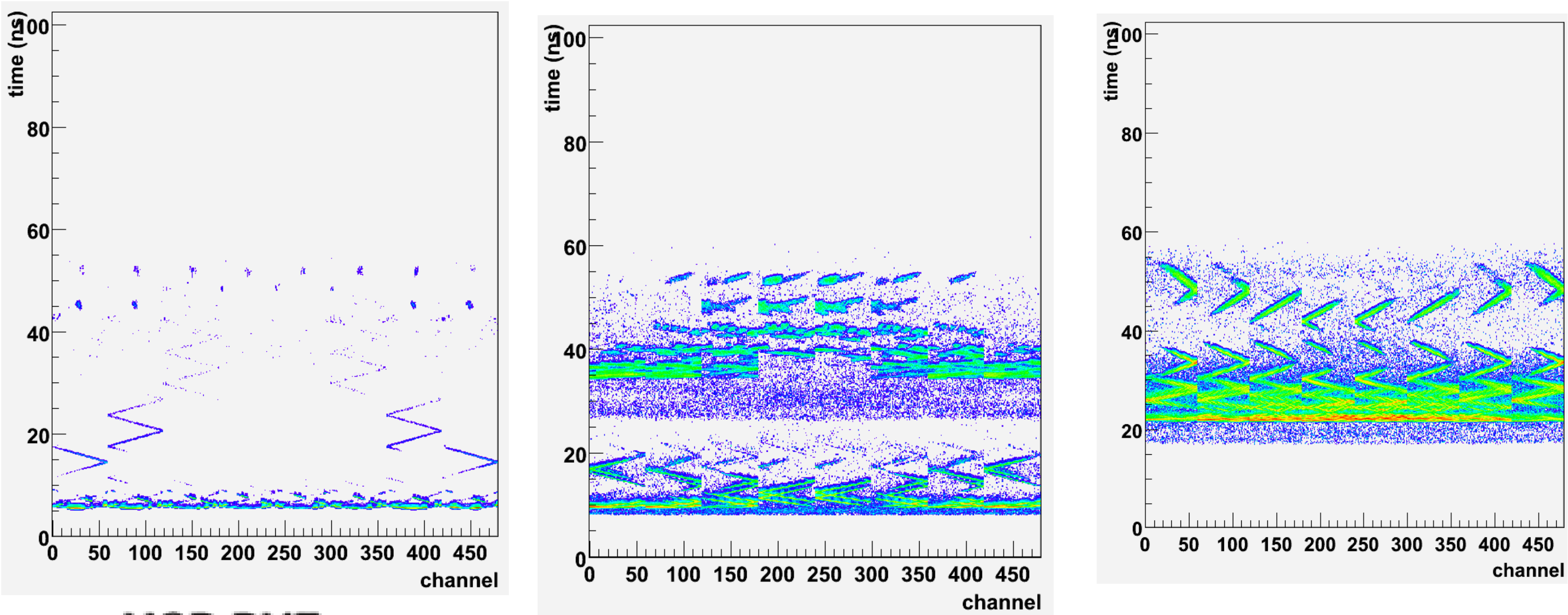
Discussion:

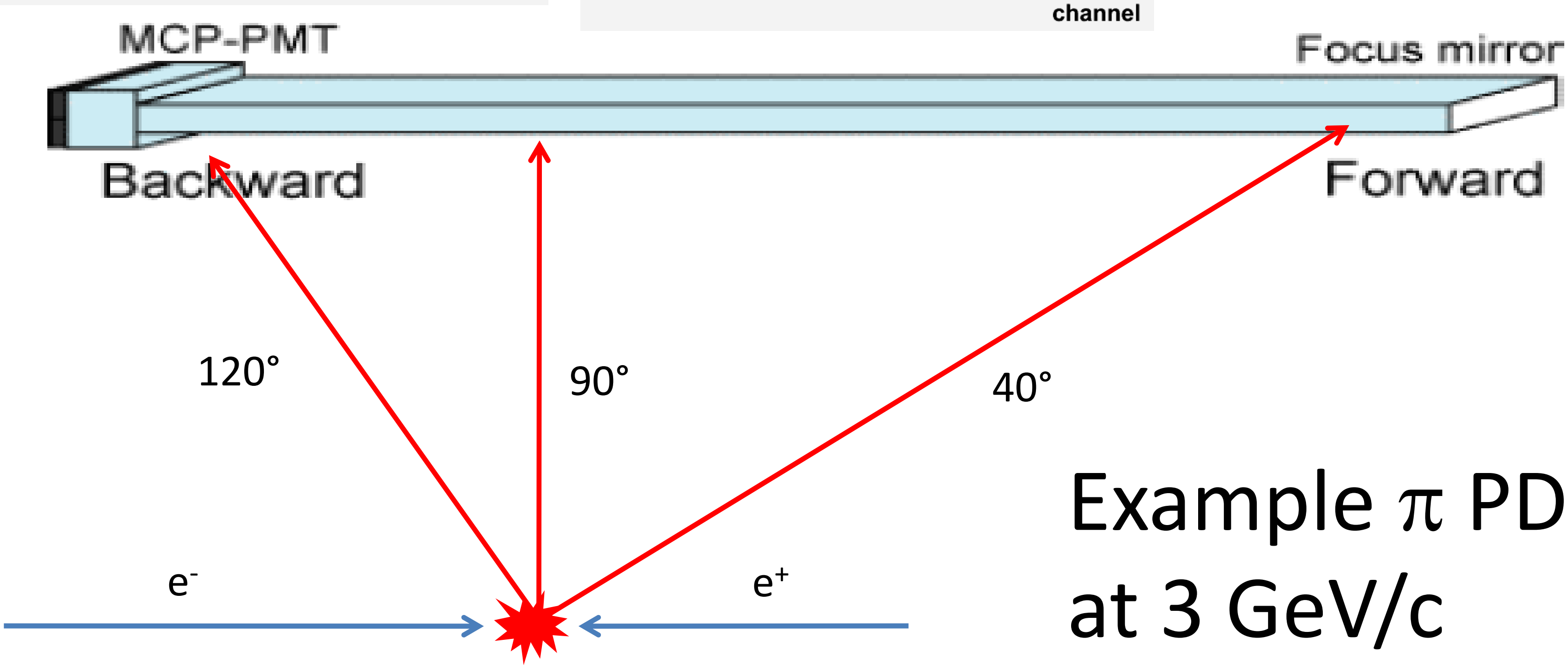
Is IBM 130nm always best choice?

- CERN is certainly committed to the process
- Fewer fab options, process requirements fussier
- Many more designs in the 0.25um process:
  - 2.5V VDD vs. 1.2V
  - fA vs. pA leakage currents
  - Other techniques to get same performance results?
- Do plan to submit further CSA design (later)

Backup Slides

Some background context…

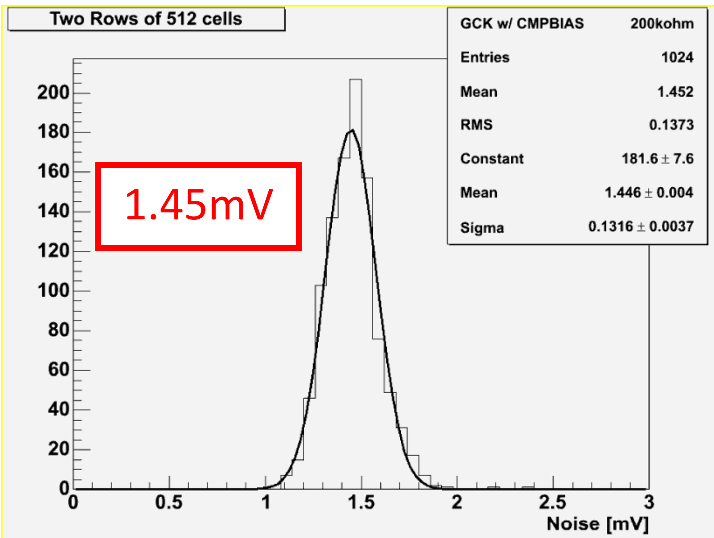




Example π PDFs at 3 GeV/c

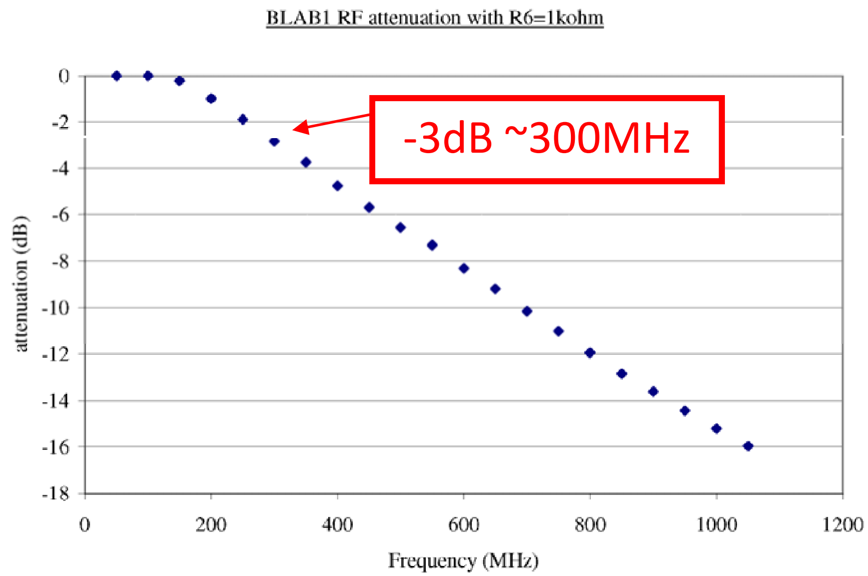
Buffered LABRADOR (BLAB1) ASIC

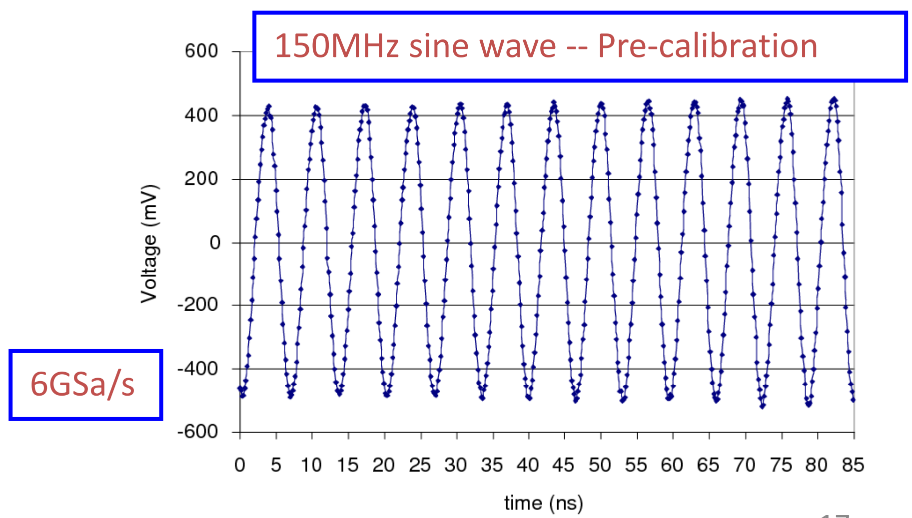
Measured Noise



1.8V dynamic range

- 10 real bits of dynamic range, single-shot
- Target few $$/channel
- Low power



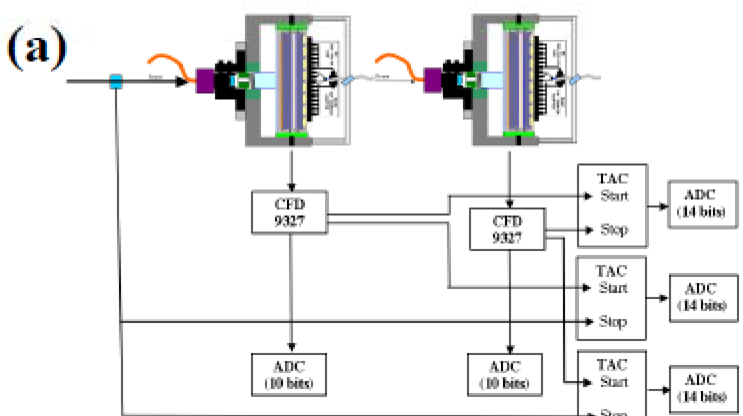


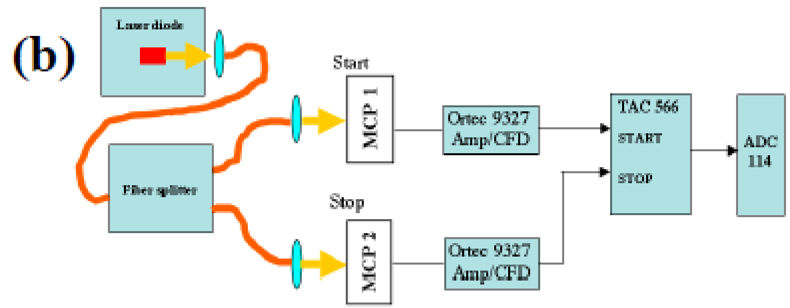
CFD Test Conditions

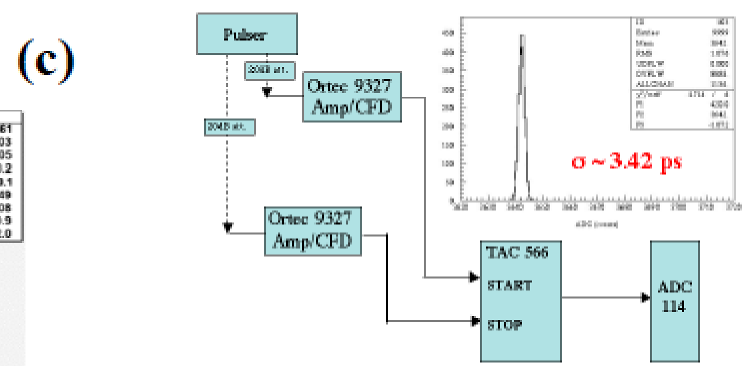
a) Fermilab test beam (120 GeV/c proton)

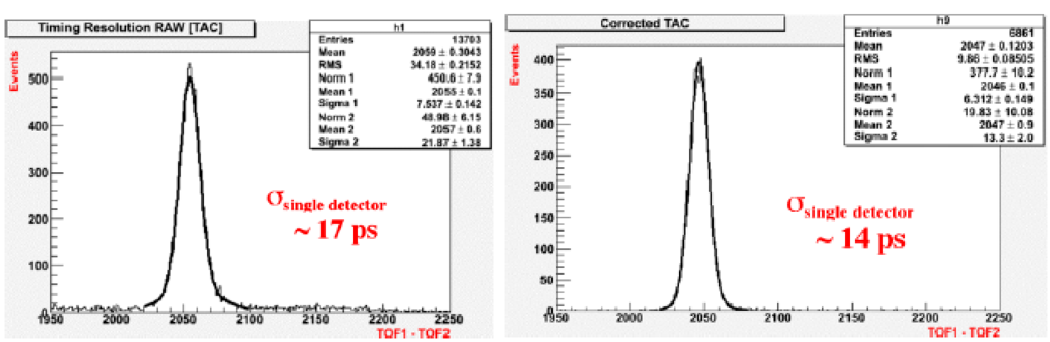
b) Laser test setup

c) Electronics calibration setup









Test beam data raw (left) and time walk corrected (right). Laser results comparable.

Constant Fraction Algorithm

- Relatively simple, but still some knobs to tune…
  - Between waveform points, is it better to use linear interpolation or something else (e.g., spline).
  - Which fraction optimizes timing resolution?