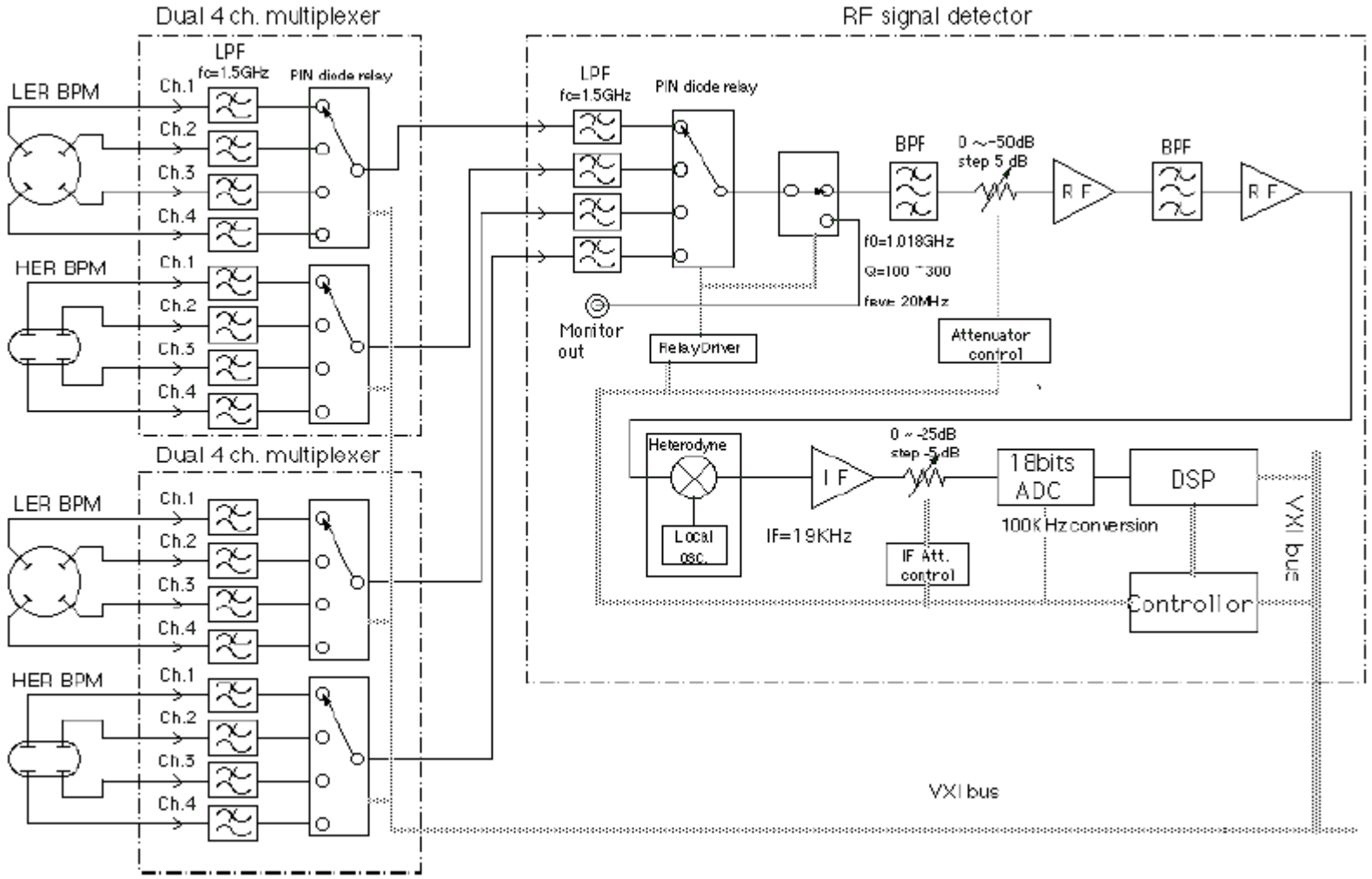
Beam diagnostics, Feedback systems

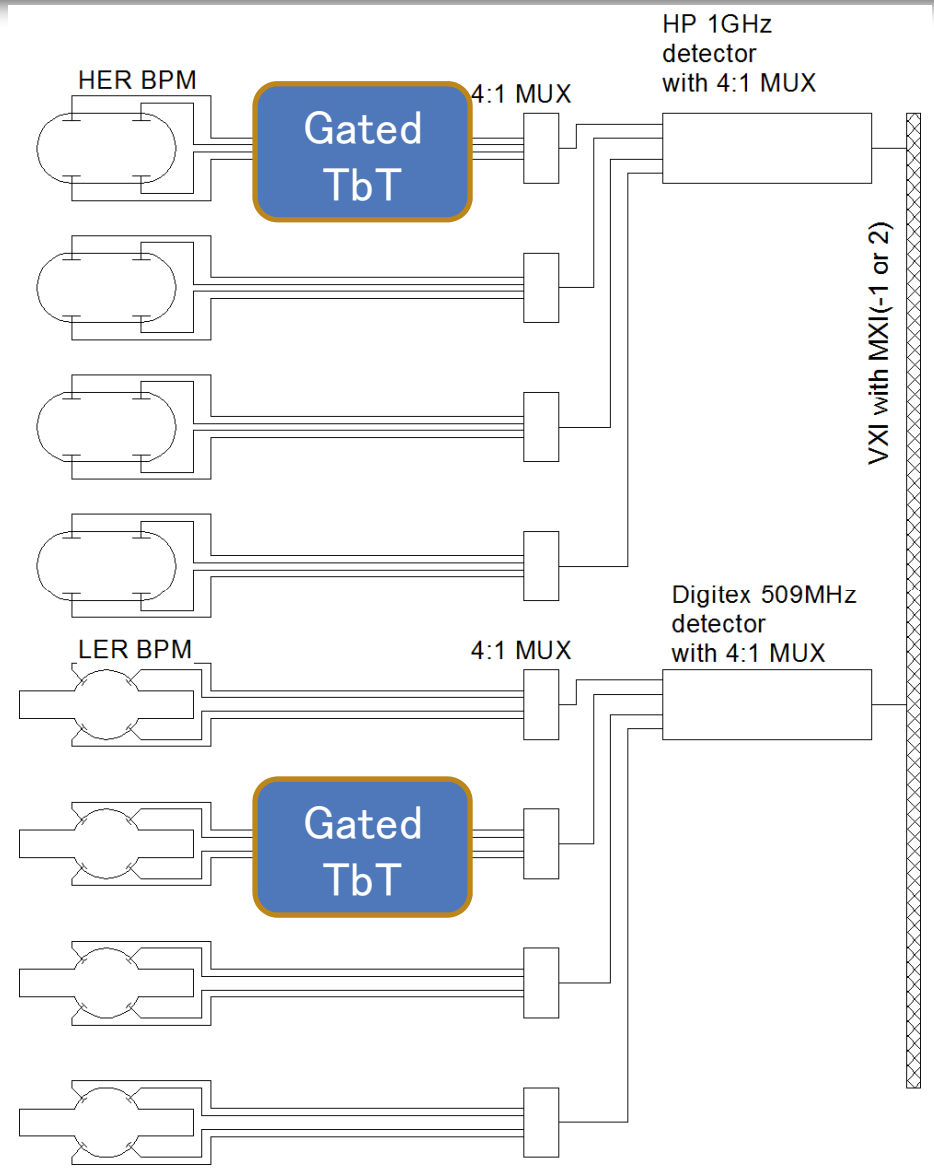
Makoto Tobiyama

KEK Accelerator Laboratory

KEKB COD measurement system

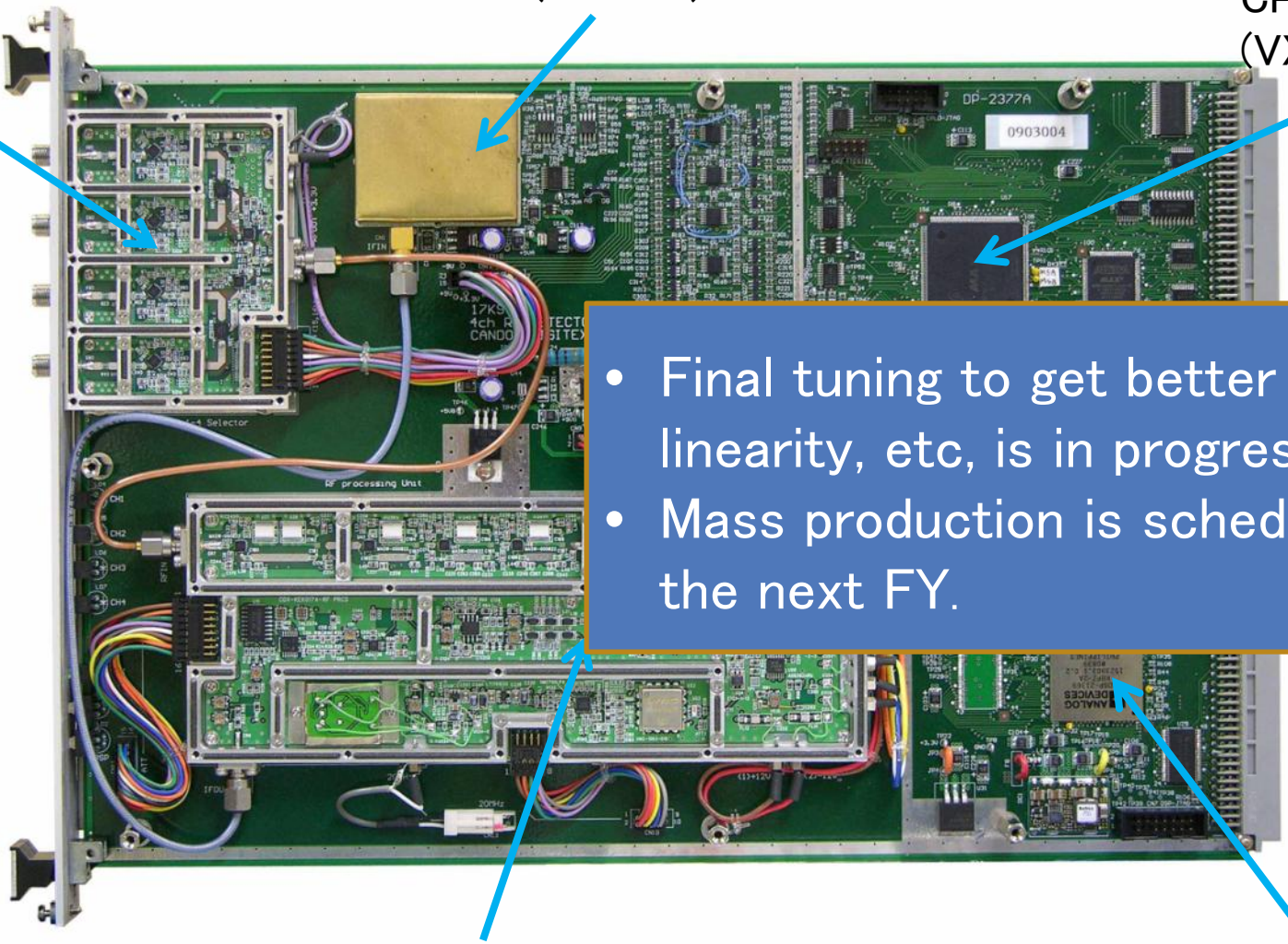


SuperKEKB COD measurement



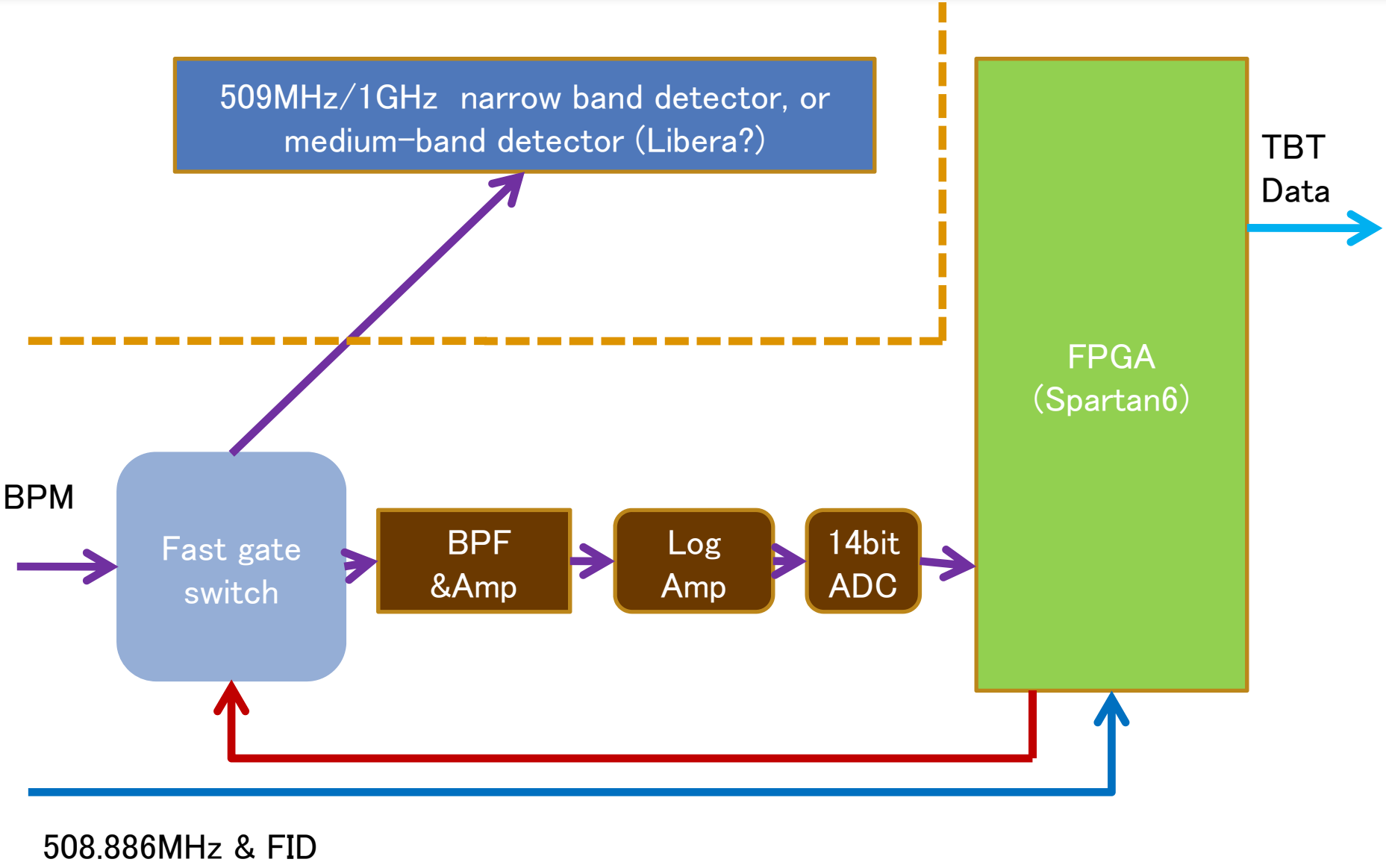
- Separate HER and LER BPM systems
  - Cutoff freq. of LER chamber lower than 1GHz.
- Continue to use VXI system with MXI (1/2) connection.
- Selected BPMs have gated turn-by-turn monitor function.

Digitex 17K94A 509MHz detector

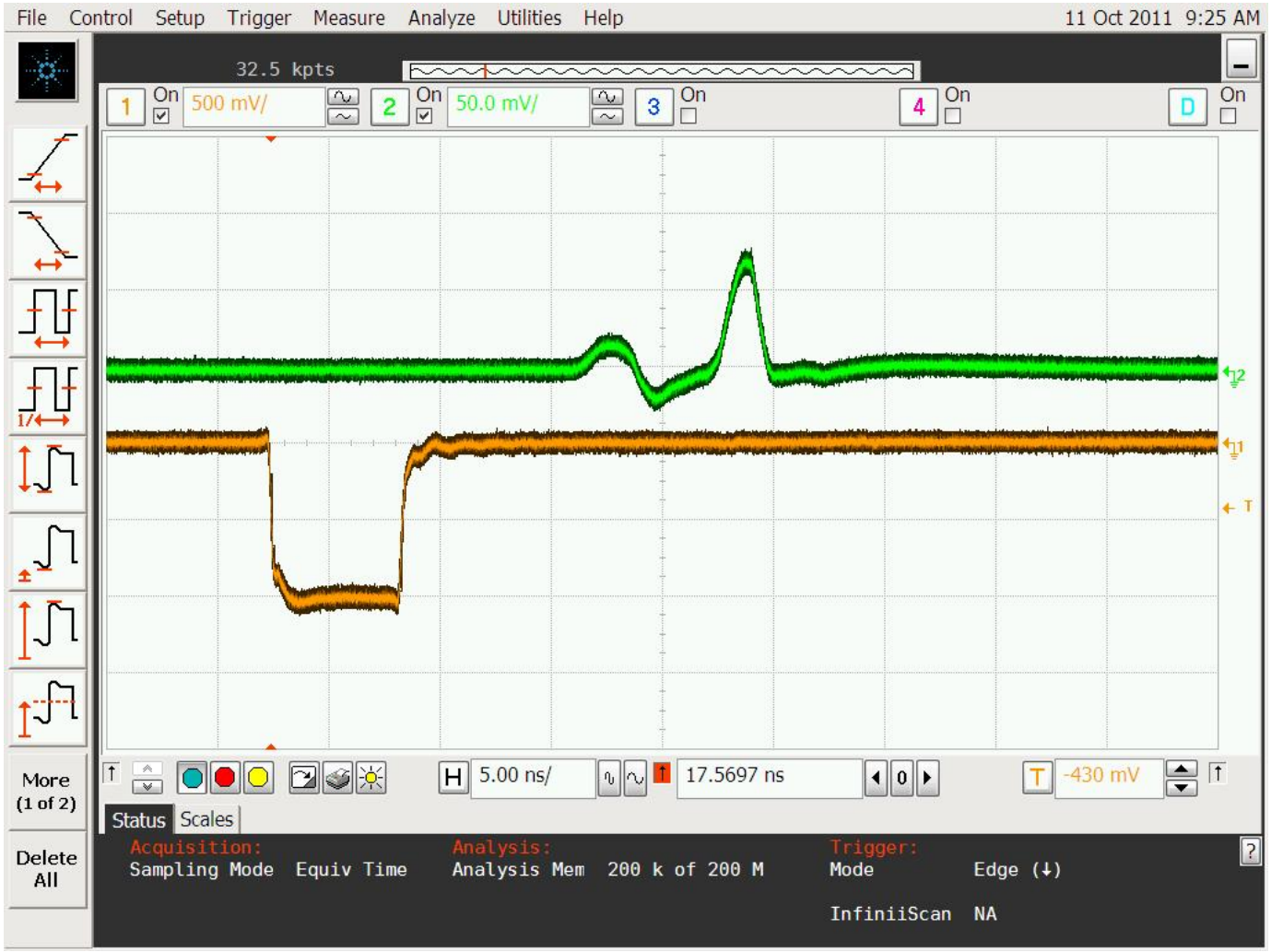


- Final tuning to get better S/N, linearity, etc, is in progress.
- Mass production is scheduled in the next FY.

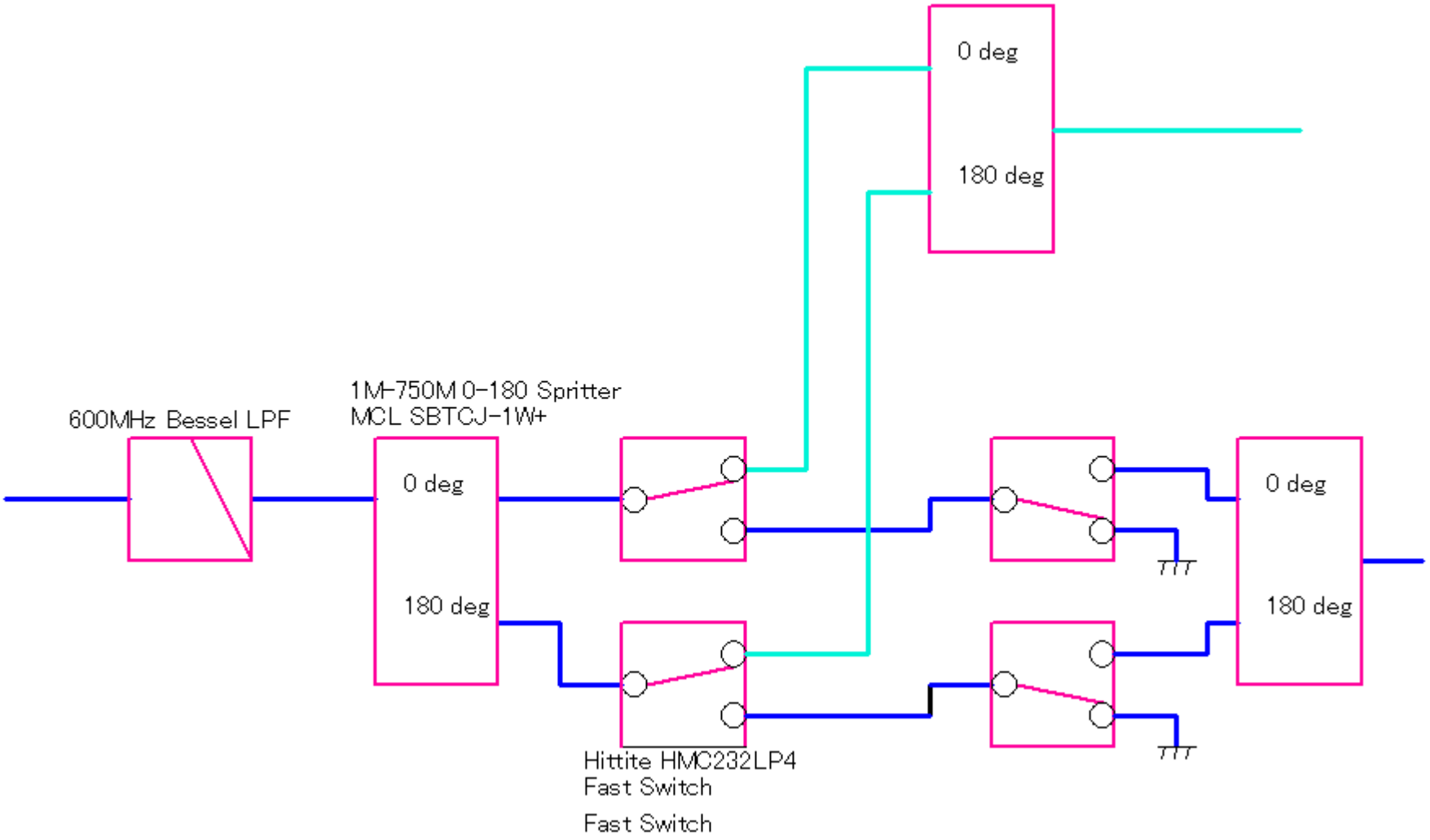
Gated turn-by-turn monitor



Switching noise

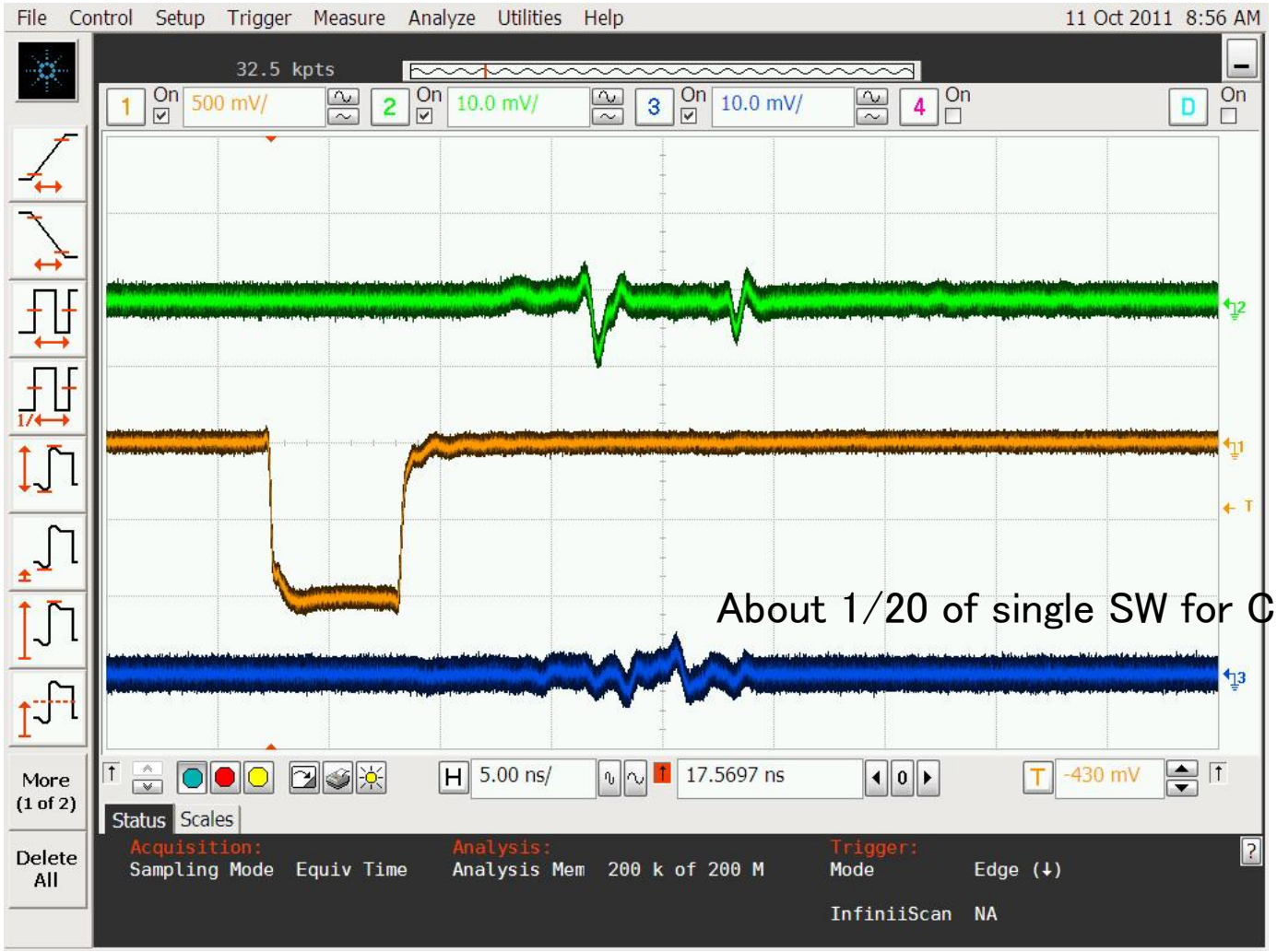


Better isolation and switching noise cancellation



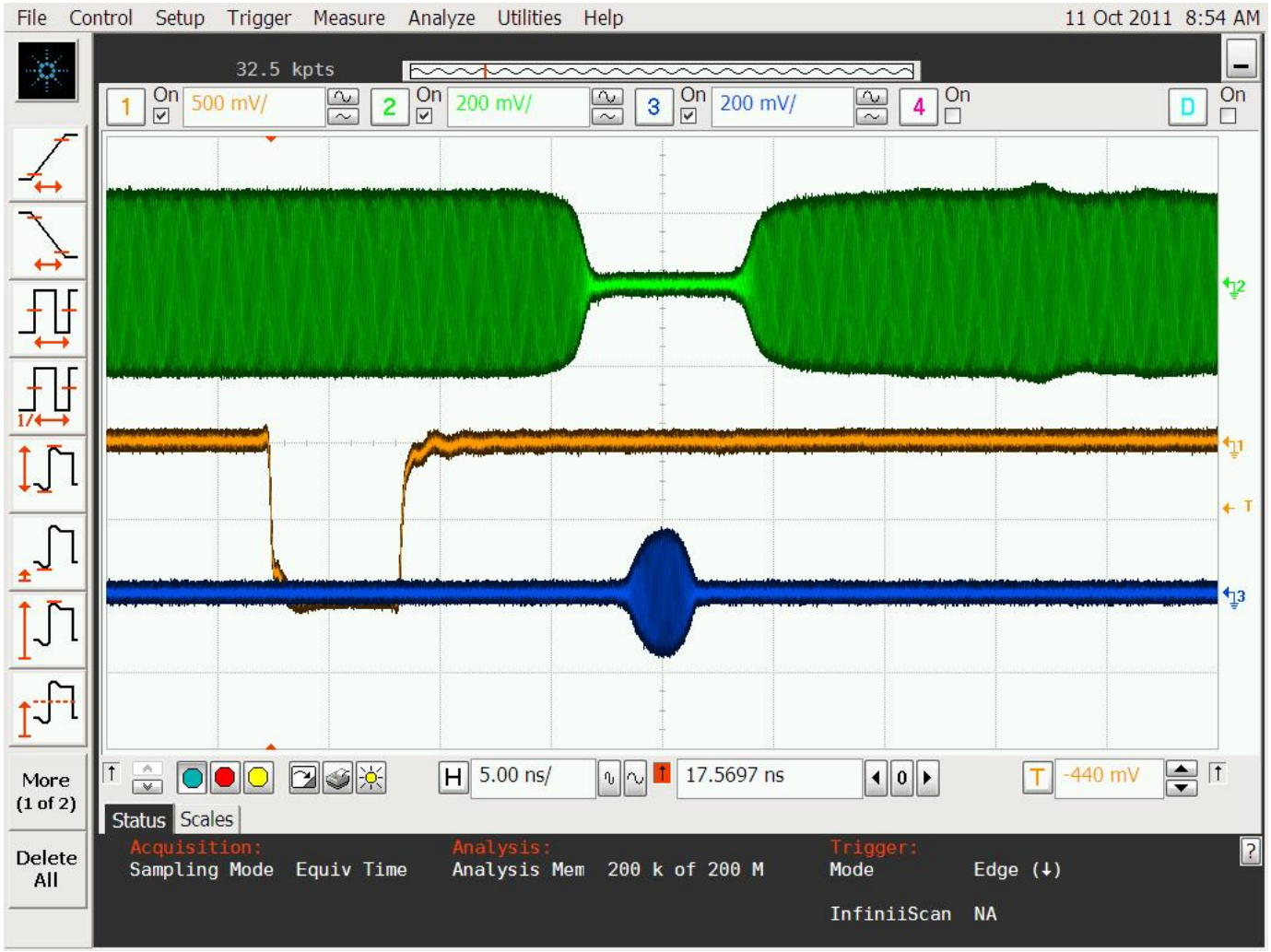
Proposed and tested by Dr. T. Naito

Switching noise

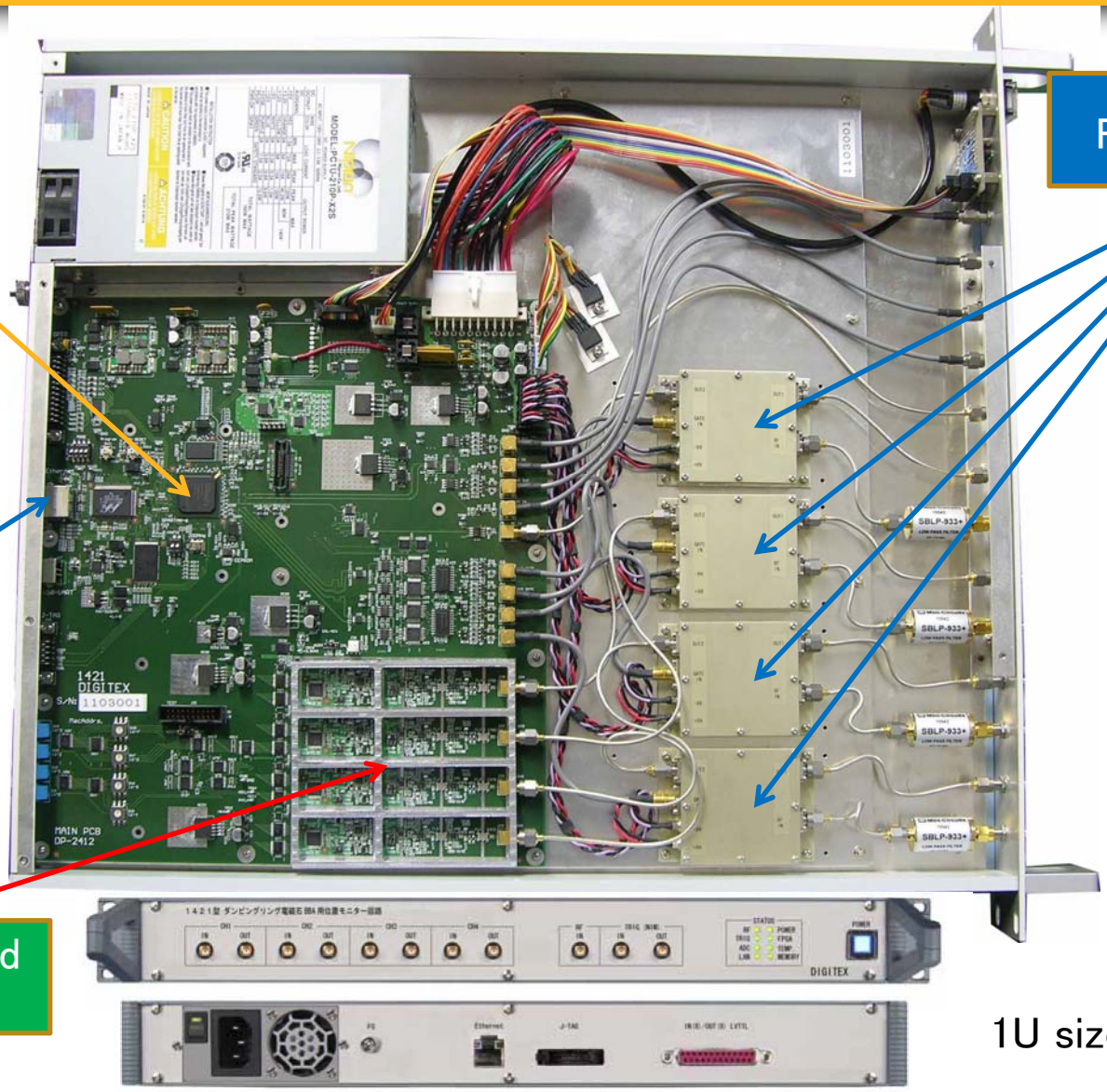


About 1/20 of single SW for CH2

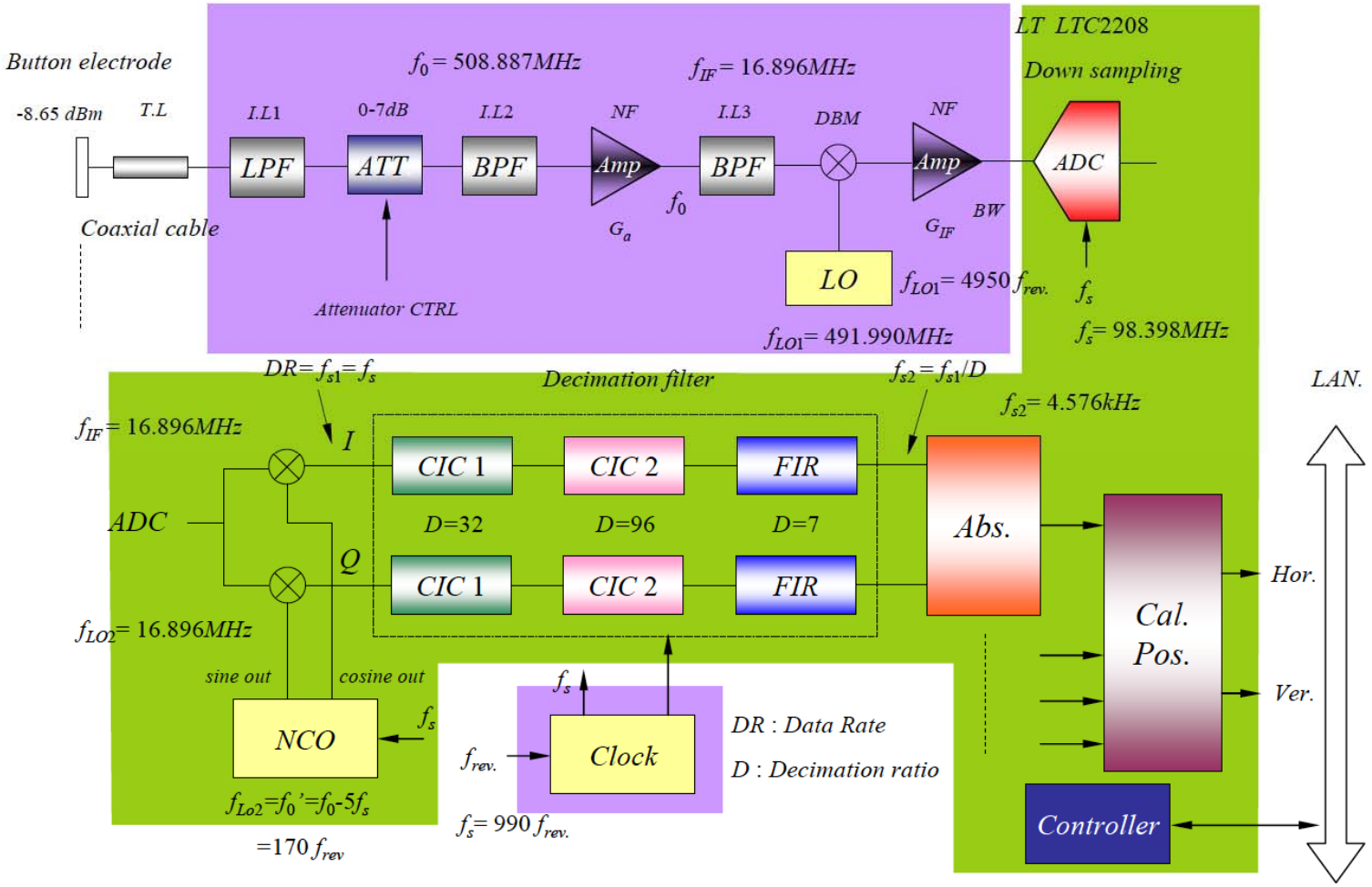
Switching


File Control Setup Trigger Measure Analyze Utilities Help
11 Oct 2011 8:54 AM
32.5 kpts
1 On 500 mV/
2 On 200 mV/
3 On 200 mV/
4 On
D On
More (1 of 2)
Delete All
H 5.00 ns/
17.5697 ns
T -440 mV
Status Scales
Acquisition:
Sampling Mode Equiv Time
Analysis:
Analysis Mem 200 k of 200 M
Trigger:
Mode Edge (↓)
InfiniiScan NA

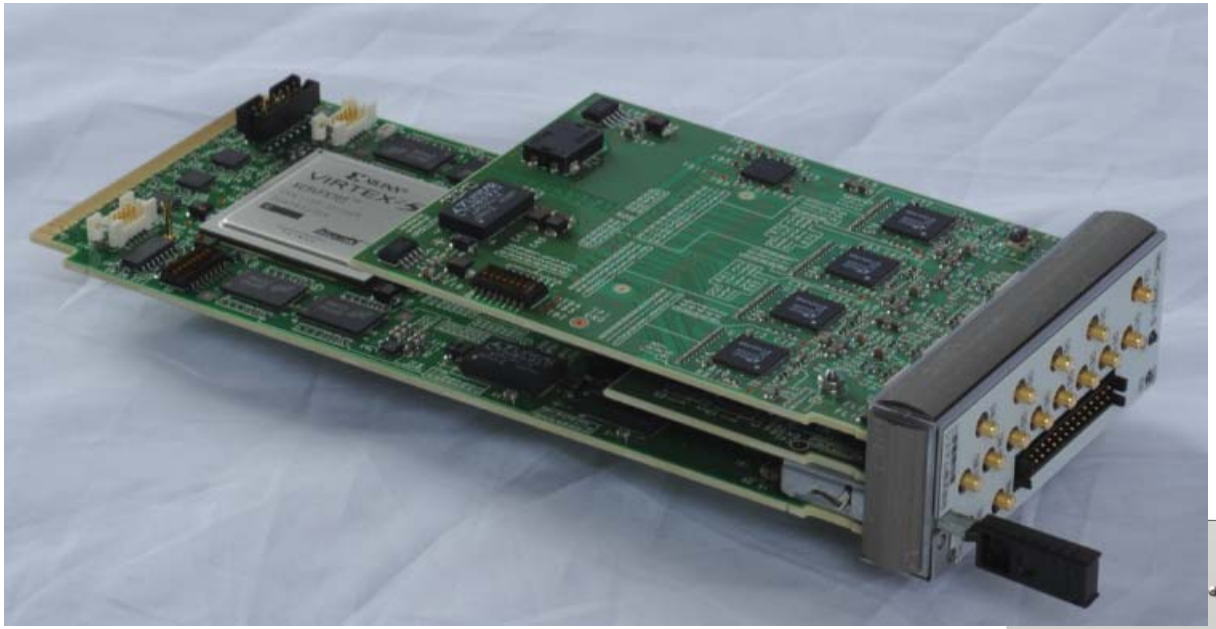
Board view


Fast Gate SW
Spartan6LX
100T FPGA
GbE port
Log amp and
14bit ADC
1U size

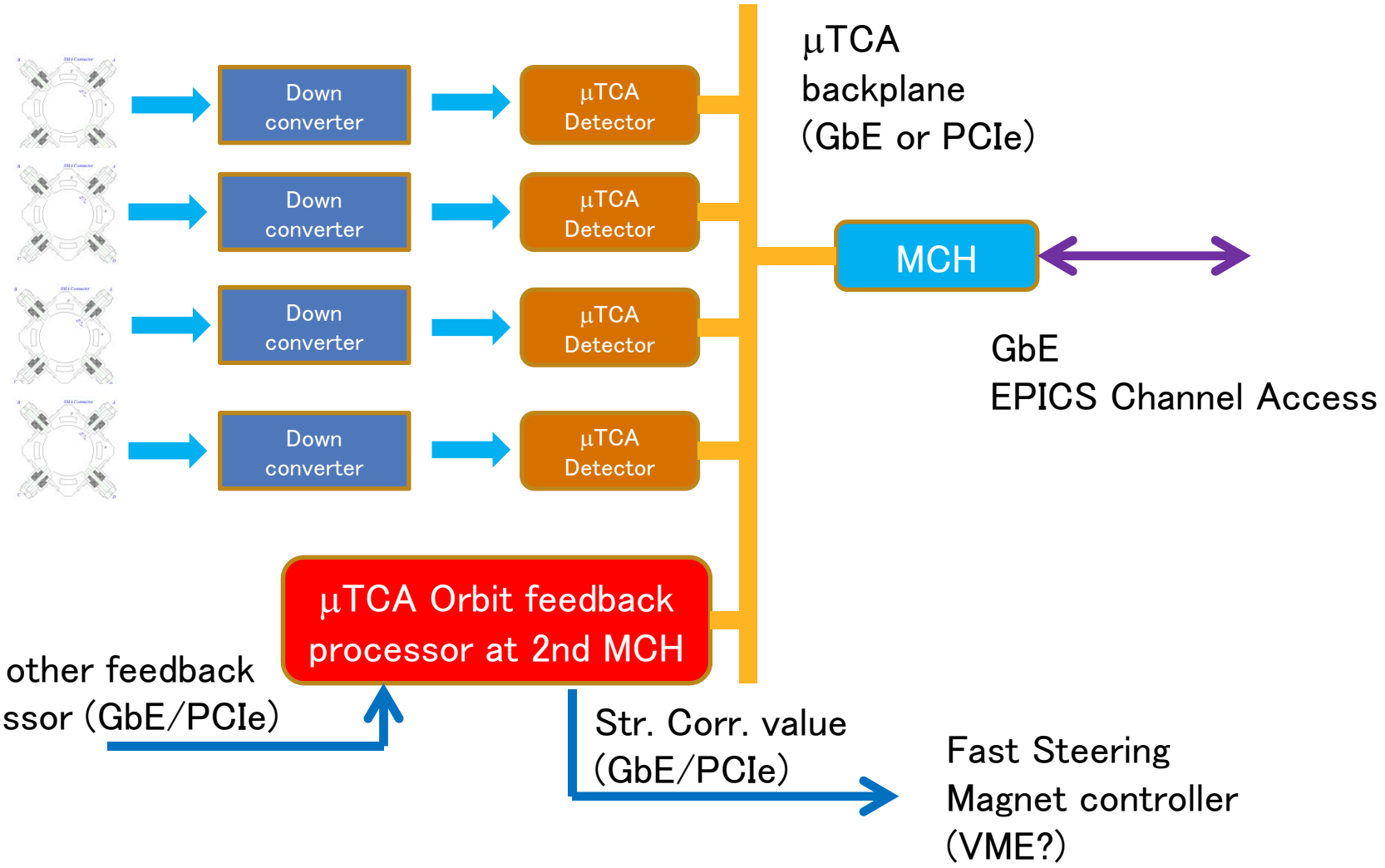
IR feedback detector



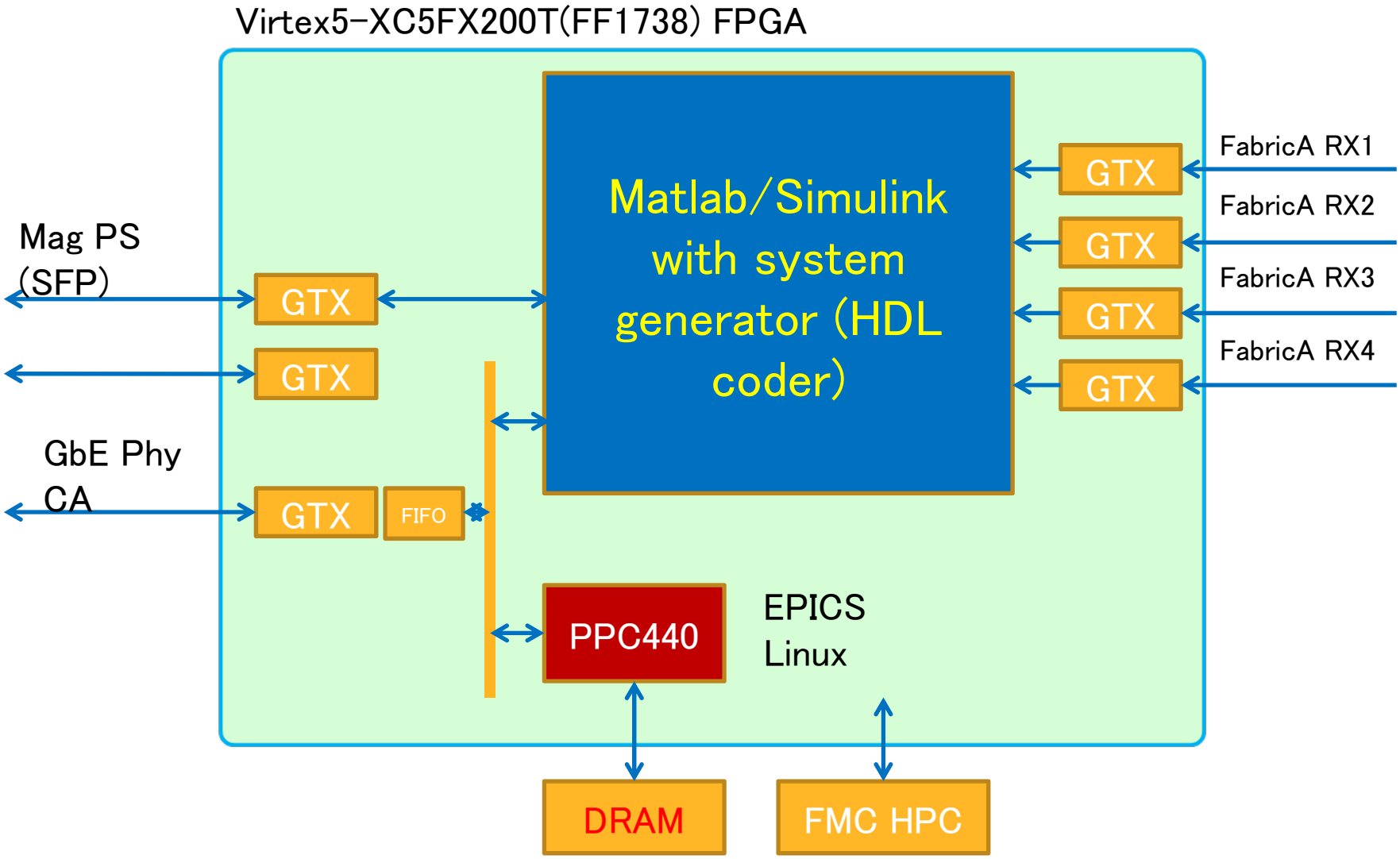
μTCA size board



IR orbit feedback



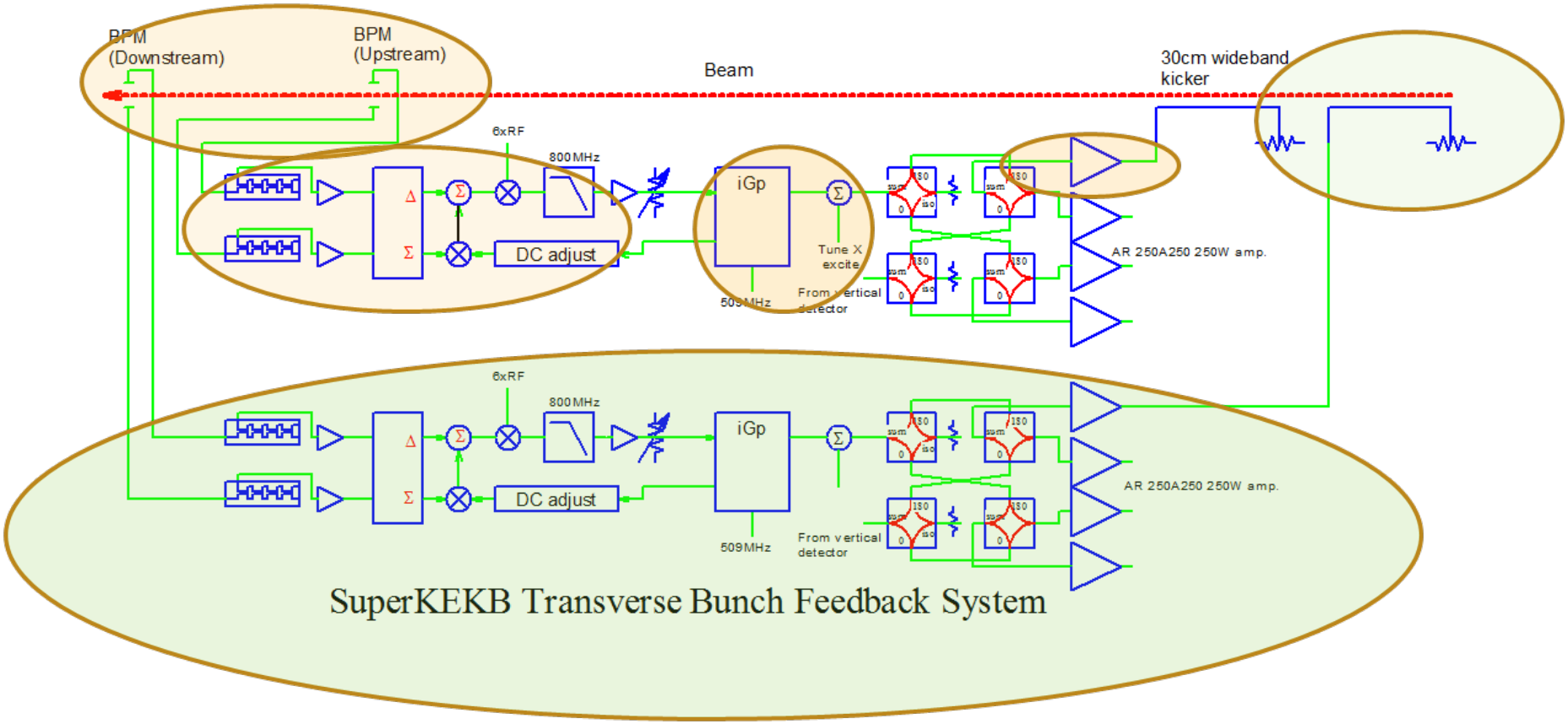
Feedback processor board



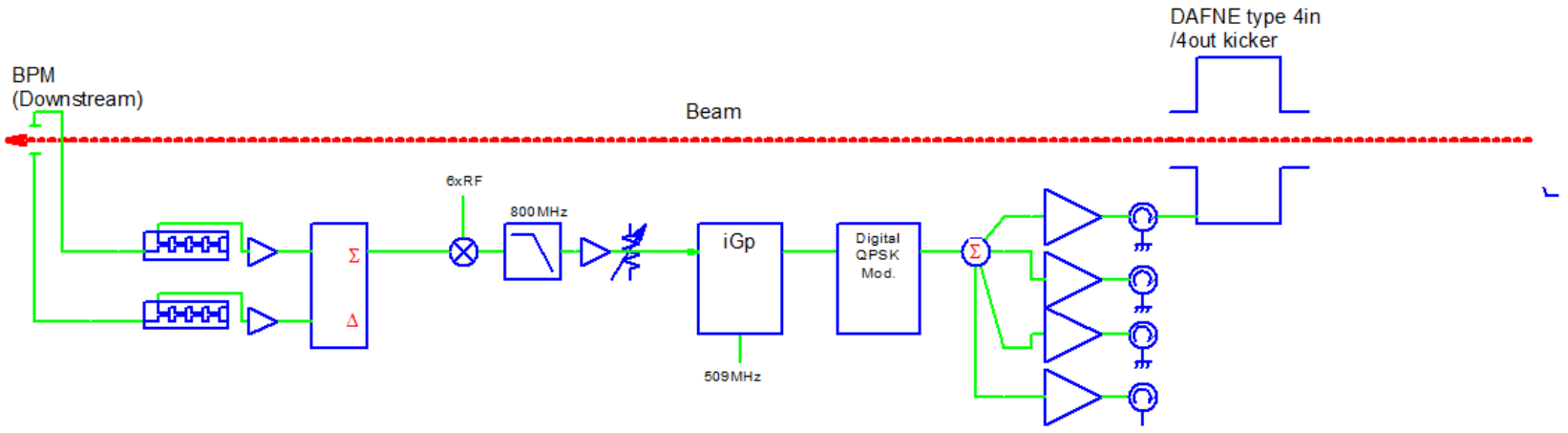
Might we need medium band detector?

We have bought a Libera Brilliance+ with orbit feedback unit to evaluate the performance.

SuperKEKB Transverse FB plan



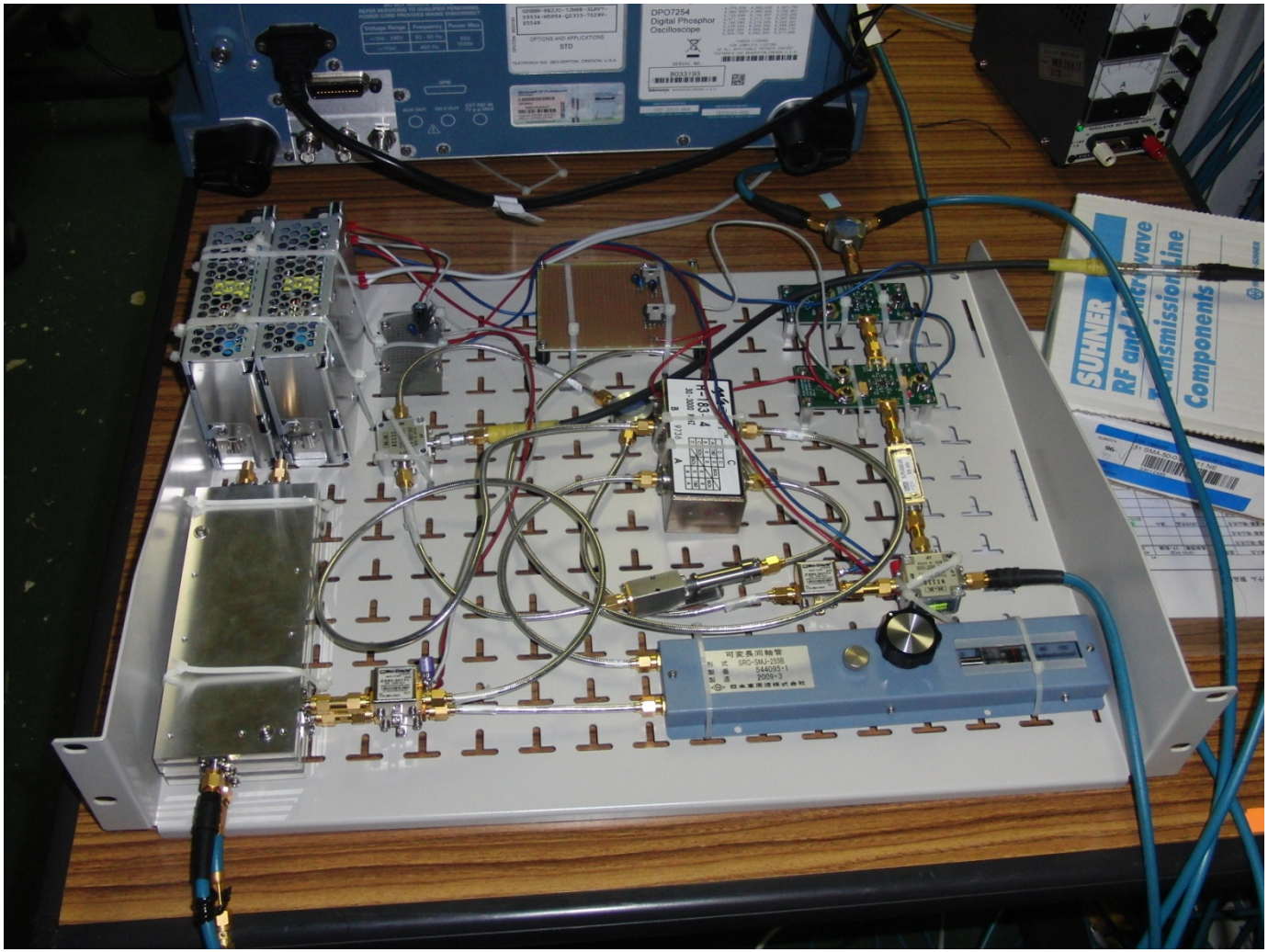
SuperKEKB Longitudinal FB plan



SuperKEKB Longitudinal Bunch Feedback System

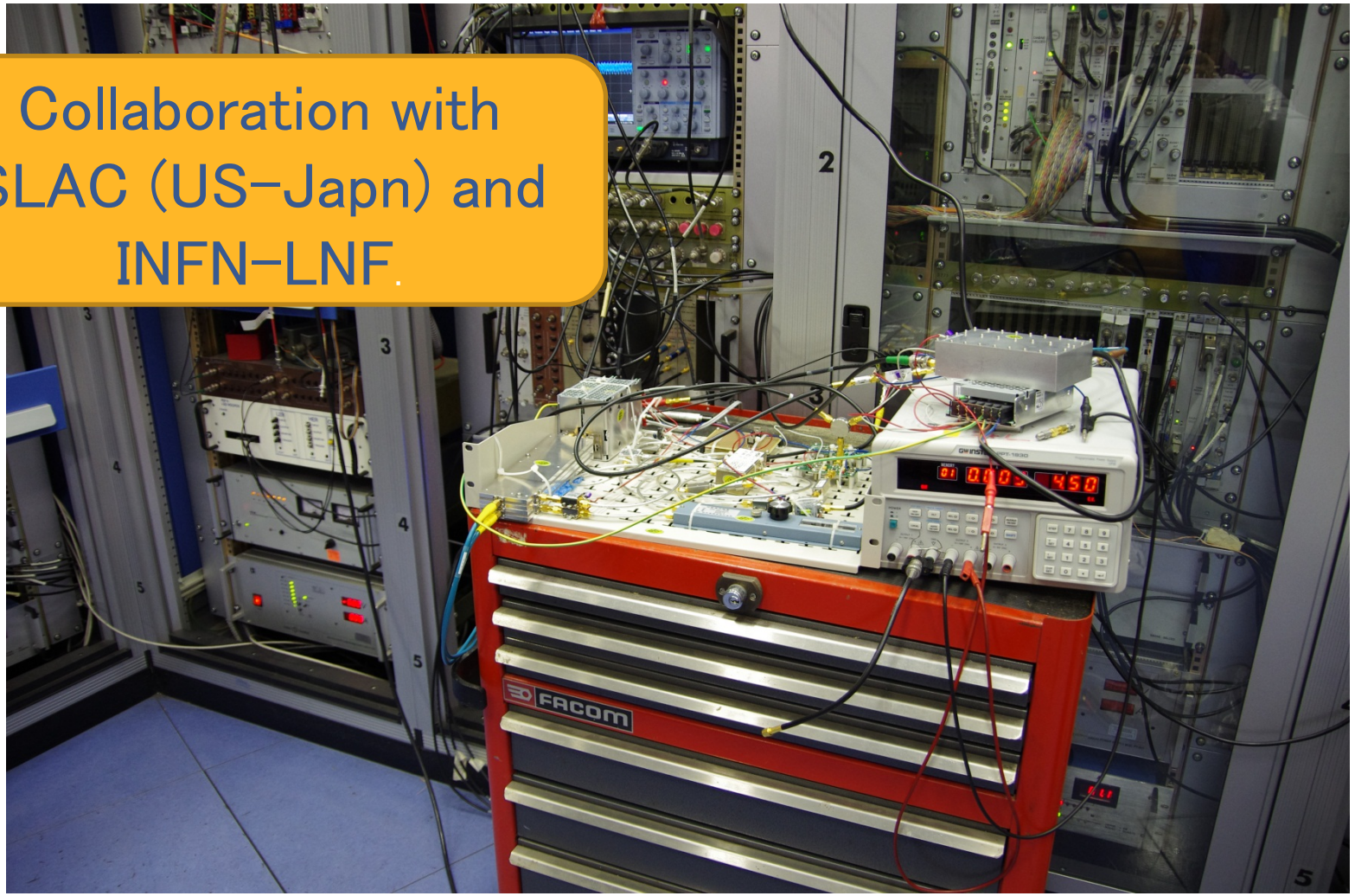
Install L-FB in LER only. HER is optional.
Considering to use 4 DAFNE type kicker, with 2-input, 2-output ports for larger capture range.

Bunch position detector prototype



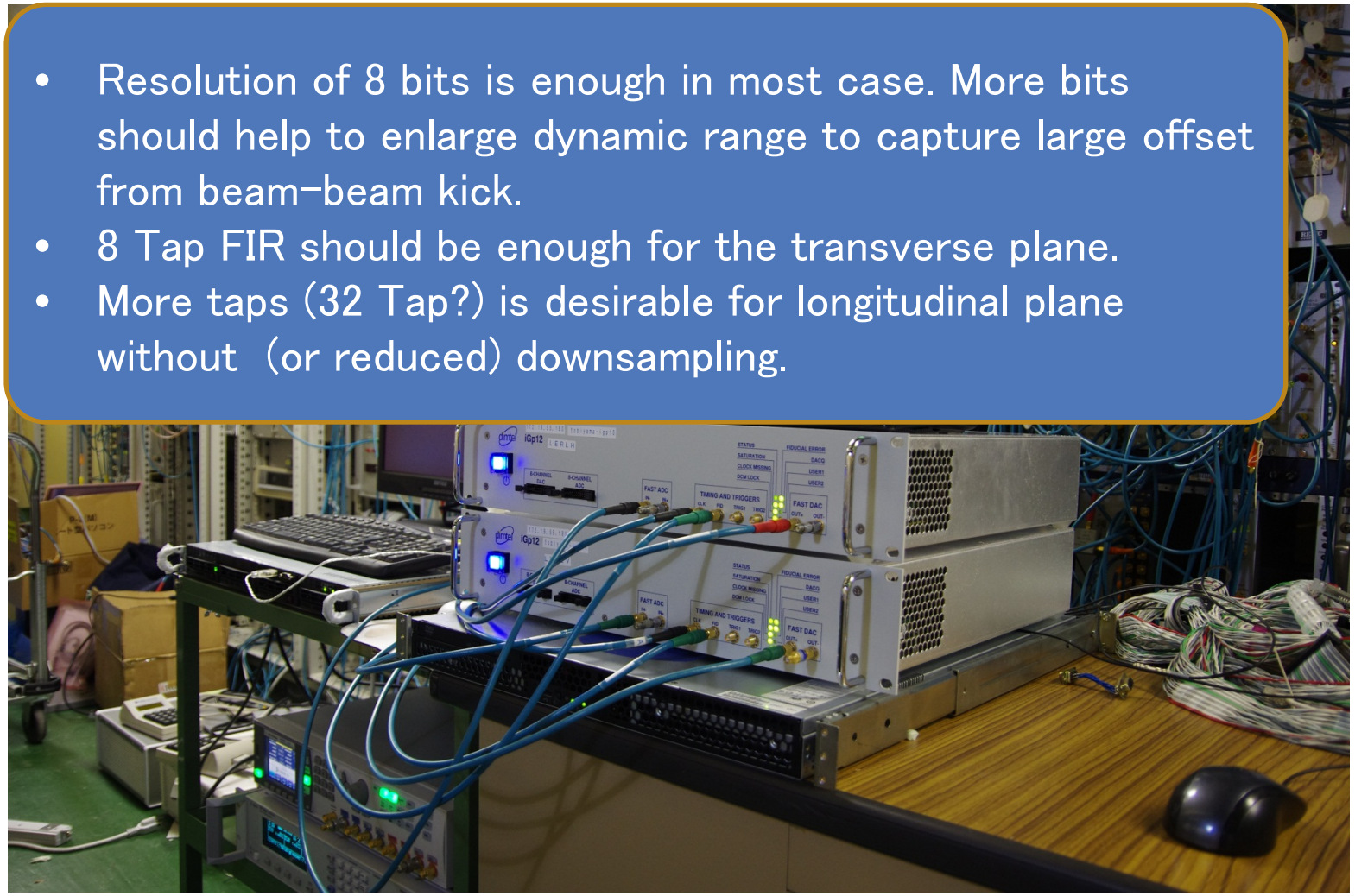
DAFNE FB experiment

Collaboration with SLAC (US-Japn) and INFN-LNF.

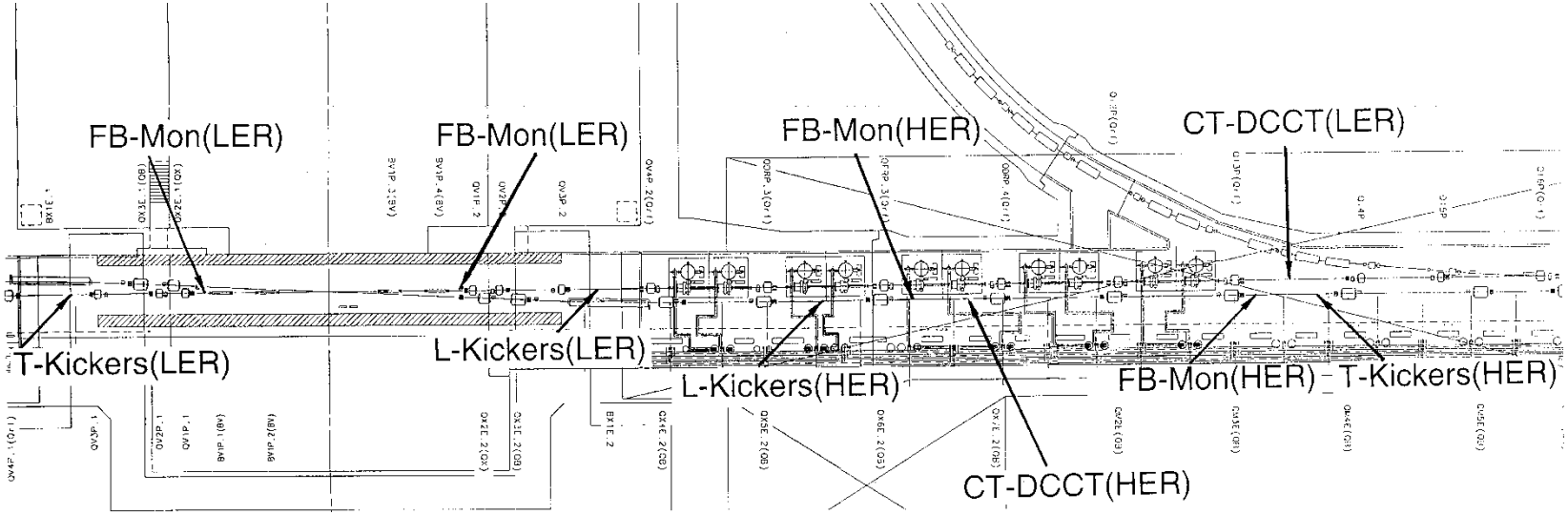


Feedback digital filter(iGp12)

- Resolution of 8 bits is enough in most case. More bits should help to enlarge dynamic range to capture large offset from beam-beam kick.
- 8 Tap FIR should be enough for the transverse plane.
- More taps (32 Tap?) is desirable for longitudinal plane without (or reduced) downsampling.



BxB feedback system location (Fuji)



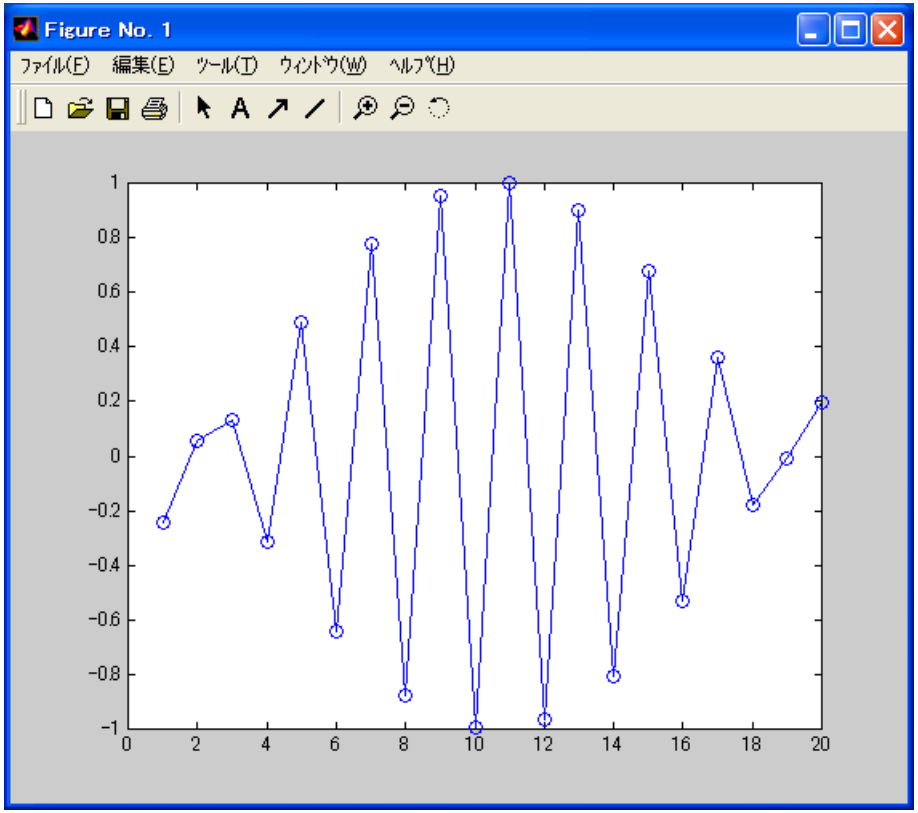
LER(1604) optics

- Tune (*.53, *.57)
- Phase advance between FB monitor, Kicker
  - PPU1(U) to PPU2(D): H:62deg, V:53 deg
  - PPU1(U) to Kicker (include one turn): H 170 deg, V: 177 deg
  - PPU2(D) to Kicker (include one turn):H 62 deg, V:53 deg
- Phase advance from collision point to FB detector
  - PPU1(U): H: 346deg, V:153deg
  - PPU2(D):H 48deg, V:205deg
- Phase advance from injection point
  - PPU1(U): H 346 deg, V:43 deg
  - PPU2(D): H 48 deg, V:95 deg

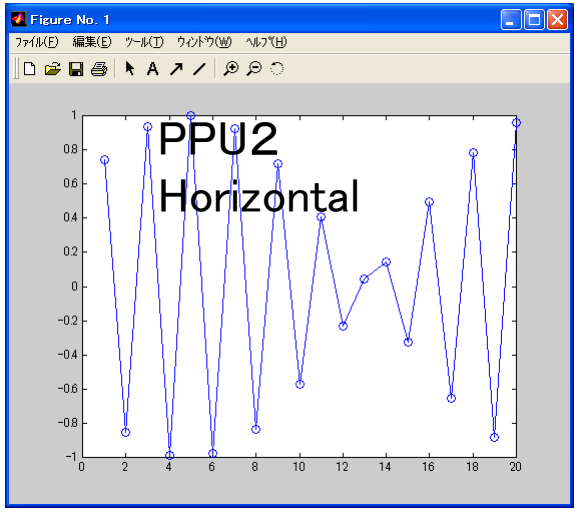
HER(5605)

- Tune (*.53, *.57)
- Phase advance between FB monitor, Kicker
  - PPU1(U) to PPU2(D): H:200deg, V:42 deg
  - PPU1(U) to Kicker (include one turn): H 145 deg, V: 201 deg
  - PPU2(D) to Kicker (include one turn):H 307 deg, V:159 deg
- Phase advance from collision point to FB detector
  - PPU1(U): H: 245deg, V:173deg
  - PPU2(D):H 85deg, V:215deg
- Phase advance from injection point
  - PPU1(U): H 270 deg, V:335 deg
  - PPU2(D): H 108 deg, V:17 deg

Horizontal tune is near 0.5

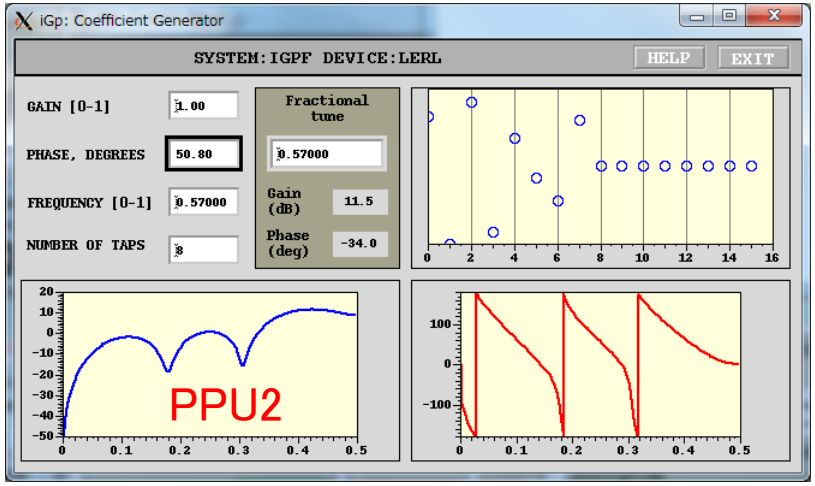


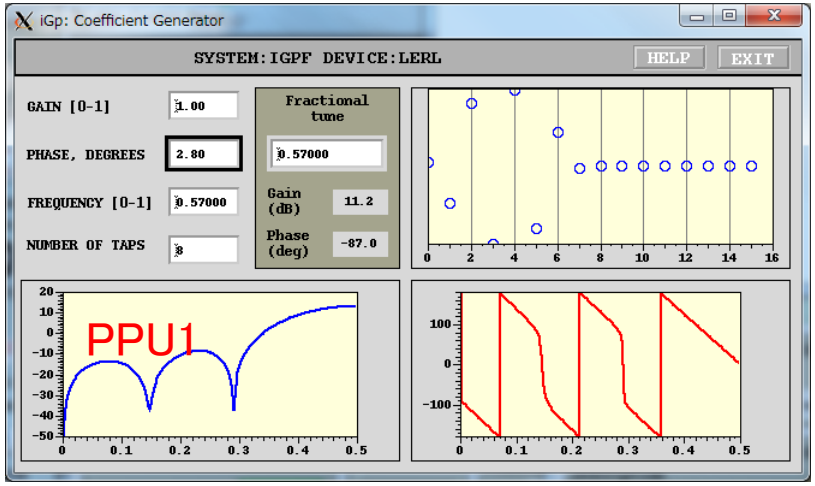
- Need several turns of revolution to observe real kick if the phase relation between the source and the monitor is not so good.
- Using two feedback loop with betatron phase advance around 90 deg might solve this difficulty.



Simulated horizontal beam oscillation starting beam-beam kick measured at PPU1 (Upstream).

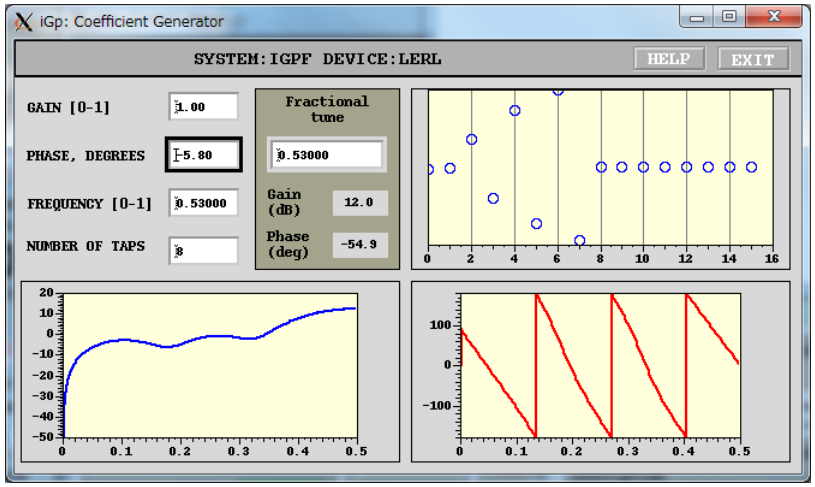
Phase shift by digital filter

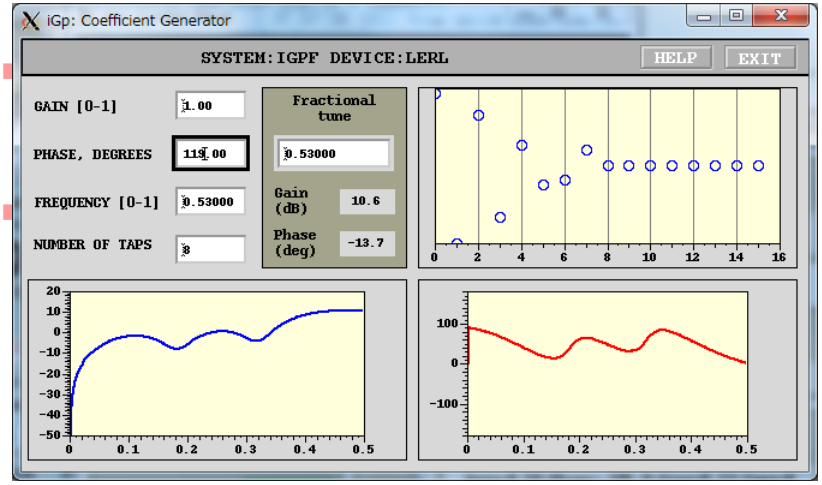


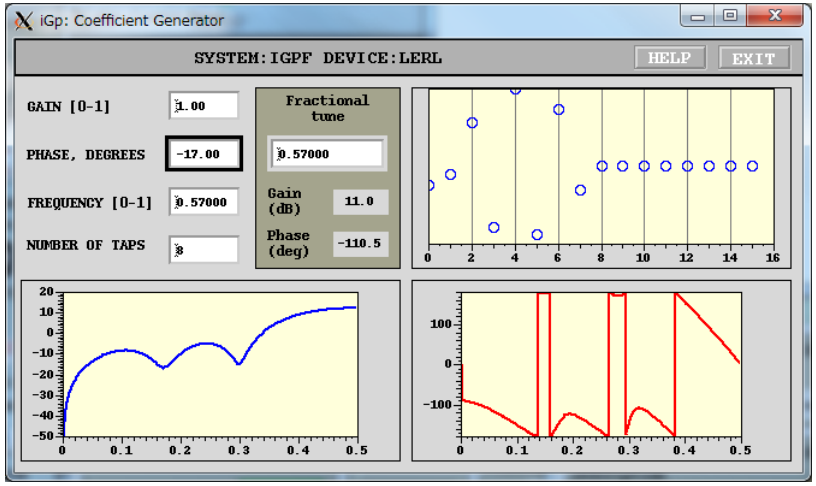


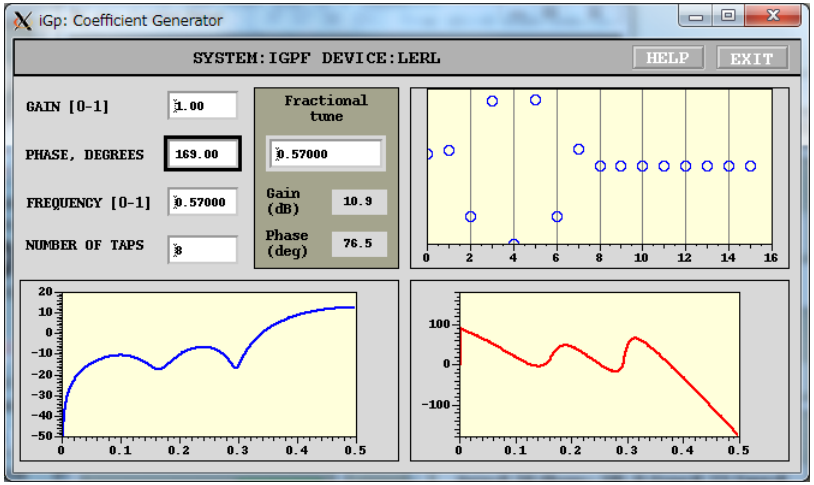
- Creating near 90deg phase shift in the digital filter makes the stability limit worse.
- LER (PPU1 and PPU2) might be acceptable.

HER PPU1 (U) situation

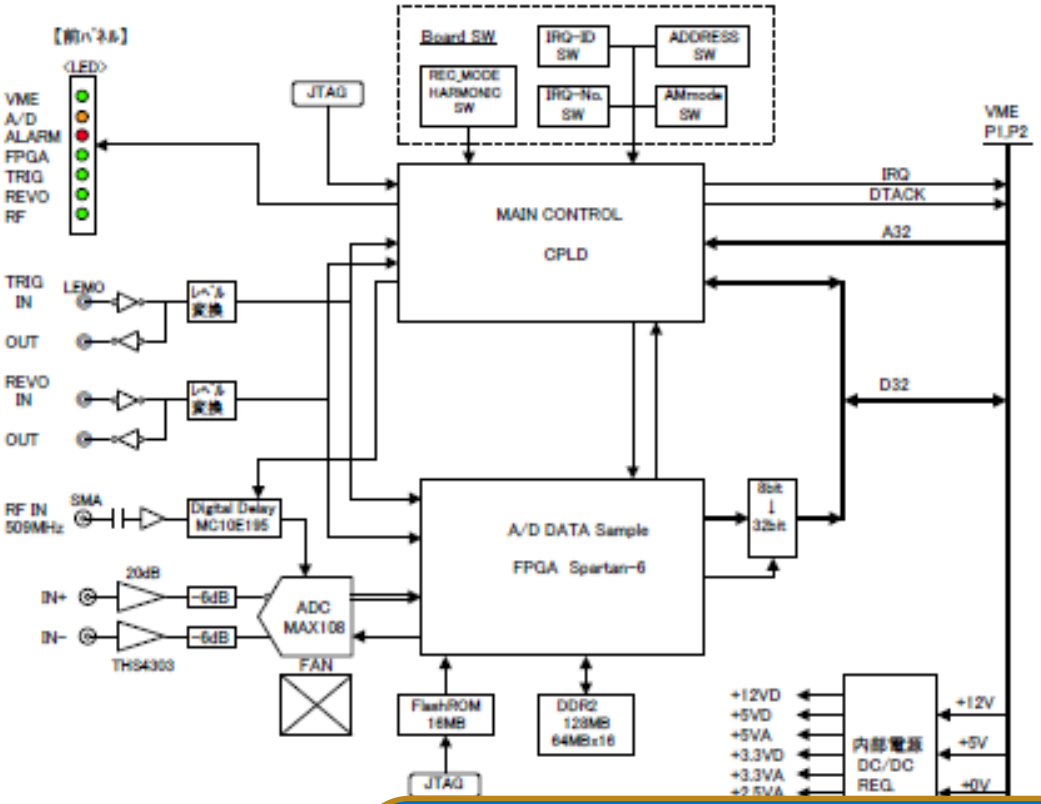








Bunch current monitor



MAX108 8bit ADC
Spartan6 FGPA
VME 2W size

Bunch current information will be send through reflective memory (real time) to the bucket selection system during injection period.

Schedule

- **BPM heads for LER antechamber**
  - 1/2 of needed BPM will be delivered soon. The rest will be fabricated in the next fiscal year.
- **509MHz narrow band detector**
  - Final tuning to improve the performance (S/N, linearity) in progress.
  - Mass production will be starting on next fiscal year.
- **Gated turn-by-turn monitor**
  - Prototype test is in progress (with many difficulty).
  - 2nd trial production might be needed.
  - Waiting for the decision by the optics group for the place (and the total number) of the monitor.

Schedule (cont.)

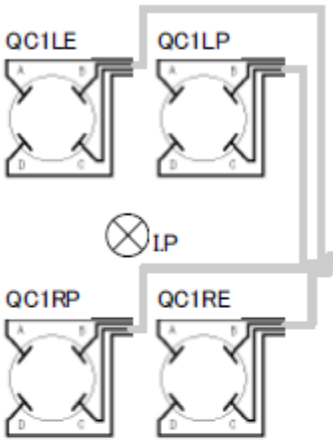
- **Fast orbit feedback**
  - 2nd trial production of the detector (uTCA) is planned in the next FY.
  - Feedback processor unit will also be ready.
  - Simulation work using Simulink/Matlab is in progress.
- **Bunch by bunch feedback system**
  - Feedthroughs (button, high power) will be delivered by E/Mar.
  - High power amplifiers (10k-255MHz 500W x 8, 0.8-1.8GHz 500W ×8) will be delivered by E/Mar..
  - Waiting for the decision of the chamber structure around the feedback systems to design the vacuum components such as monitor, feedback kicker.
  - iGp12 will be used for the digital filter.
  - Continue the collaboration with SLAC and INFN-LNF.

backup

軌道フィードバックBPM　データ転送・軌道演算システム　Ver. 1.01

2011/07/12

BPMはQC1に付いている4台



BPM信号処理回路（MMC-BPM01-B)データ出力形式

・出力データ	X,Yビーム位置（mm）
・データ出力レート	5kHz
・データフォーマット	？
・データビット数	固定小数点で24bits以上
・データ出力	シリアル
・出力インターフェース	GbE, PCI Express μTCA Back planeを使用
・測定の同期	？

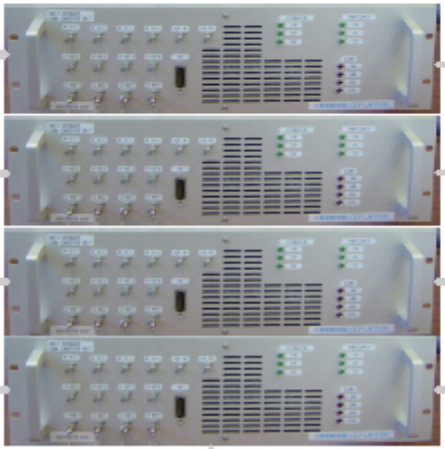
データ収集・演算用コントローラ（信号処理回路のディジタル部分を使用する）

・信号処理回路とのインターフェース	GbE、PCI Express　μTCAの μTCA Back planeでデータをやり取り
・OS	IOC化するならLinux？
・EPICSは動作させるのか	IOC化するなら
・要求演算性能	データ収集、出力、演算を5kHzの Ratencyで行なえる必要あり？
・演算結果出力レート	5kHz
・必要演算精度	固定小数点で24bitsi以上？
・BPM何台分演算するのか	最初は4台
・演算式、パラメータ	簡単自由に動作中にも変更可能なこと
・記憶する項目と容量	？
・出力インターフェース	？
・ファームウエア書き換え	リモートでFlashROM書換可？

データ収集・演算用コントローラの
外部との通信

遅いIOC測定（KEKBでいう所のIOC）へ
演算結果、Bump情報を通知する必要あり
データ収集・演算用コントローラの処理に
余裕がある場合。IOCを実装しEPICSにて
必要な通信を行なうのがよいか？

アナログ信号処理部

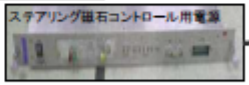


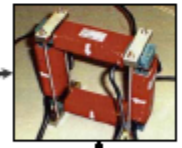
RF clock供給　508.887MHz

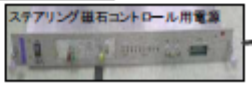
どうデータ送信するか
全く不明

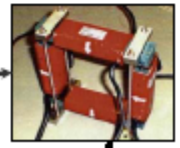
HER Hor. 4台
Ver. 4台

LER Hor. 4台
Ver. 4台



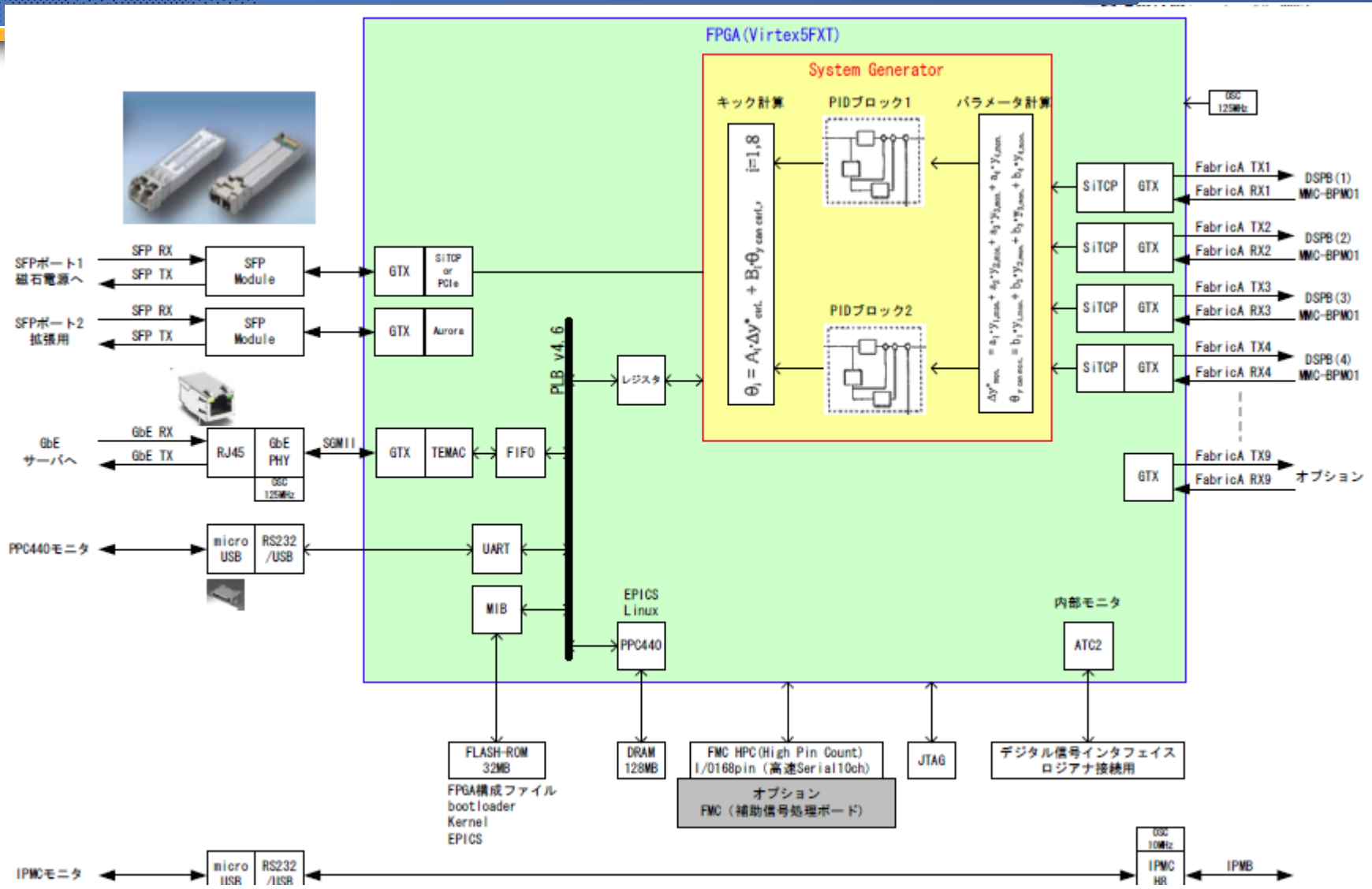


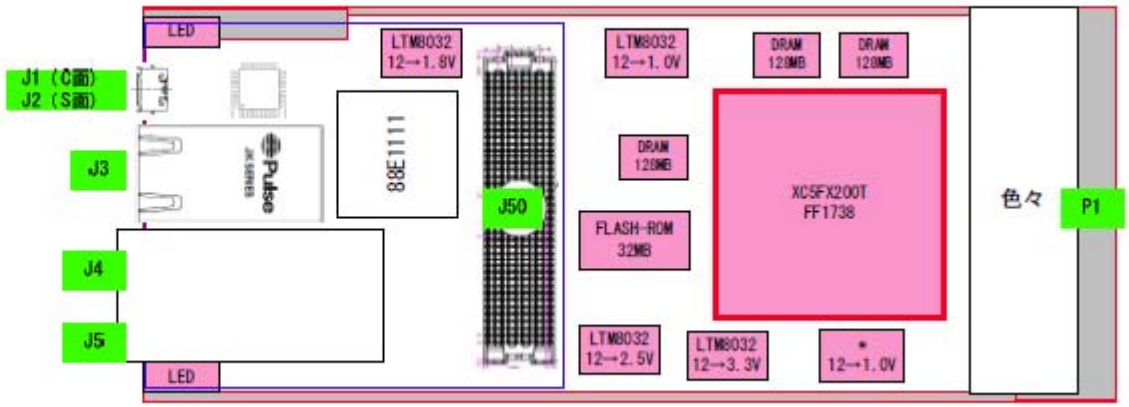




電源へのデータ設定

・出力データ種類	？
・データ設定レート	5MHz
・データフォーマット	？
・データビット数	？
・出力インターフェース	？


FPGA(Virtex5FXT)
System Generator
キック計算
PIDブロック1
パラメータ計算
PIDブロック2
OSC 125MHz
SFPポート1
磁石電源へ
SFP RX
SFP TX
SFP Module
GTX
SiTCP or PCIe
SFPポート2
拡張用
Aurora
PLB v4.6
レジスタ
SiTCP
FabricA TX1
FabricA RX1
DSPB(1) MMC-BPM01
FabricA TX2
FabricA RX2
DSPB(2) MMC-BPM01
FabricA TX3
FabricA RX3
DSPB(3) MMC-BPM01
FabricA TX4
FabricA RX4
DSPB(4) MMC-BPM01
GbE
サーバへ
GbE RX
GbE TX
RJ45
GbE PHY
SGMII
TEMAC
FIFO
FabricA TX9
FabricA RX9
オプション
PPC440モニタ
micro USB
RS232 /USB
UART
MIB
EPICS Linux
PPC440
内部モニタ
ATC2
FLASH-ROM 32MB
FPGA構成ファイル
bootloader
Kernel
EPICS
DRAM 128MB
FMC HPC(High Pin Count)
I/O168pin (高速Serial10ch)
オプション
FMC (補助信号処理ボード)
JTAG
デジタル信号インタフェイス
ロジアナ接続用
IPMCモニタ
OSC 10MHz
IPMC HR
IPMB

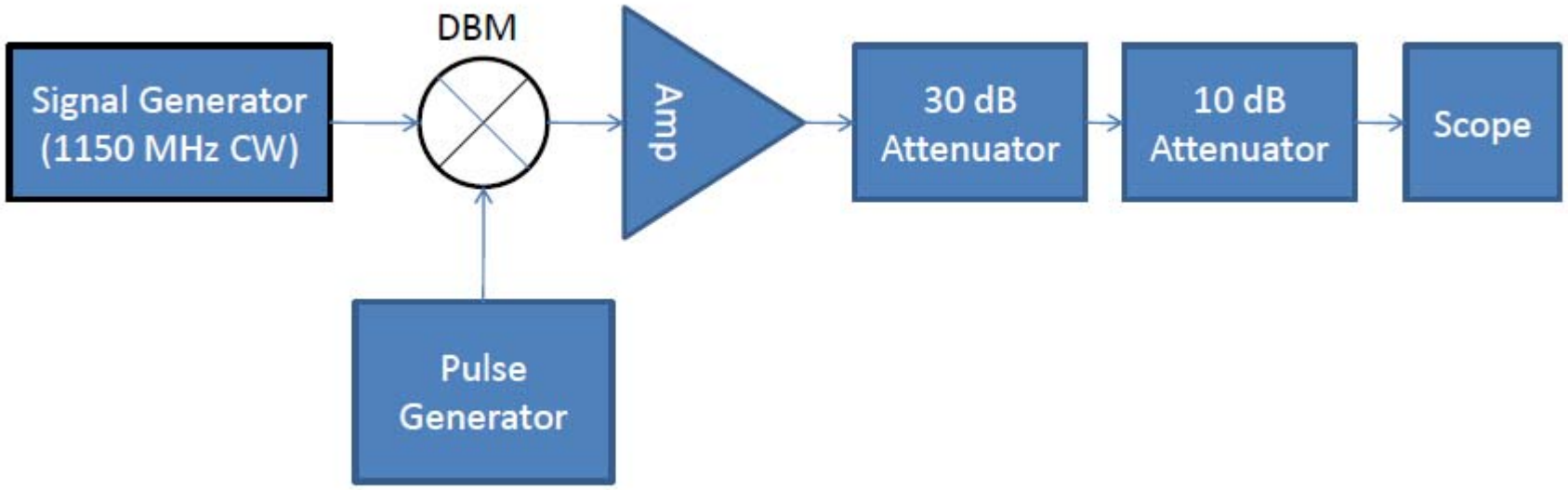

LED
J1 (C面)
J2 (S面)
J3
J4
J5
LED
LTM8032
12→1.8V
88E1111
J50
LTM8032
12→1.0V
DRAM
128MB
DRAM
128MB
DRAM
128MB
FLASH-ROM
32MB
XC5FX200T
FF1738
LTM8032
12→2.5V
LTM8032
12→3.3V
*
12→1.0V
色々
P1

SO-DIMM type FPGA(SP6-LX45)

http://www.enclustra.com/en/products/fpga-modules/mars-mx1/

Milmega

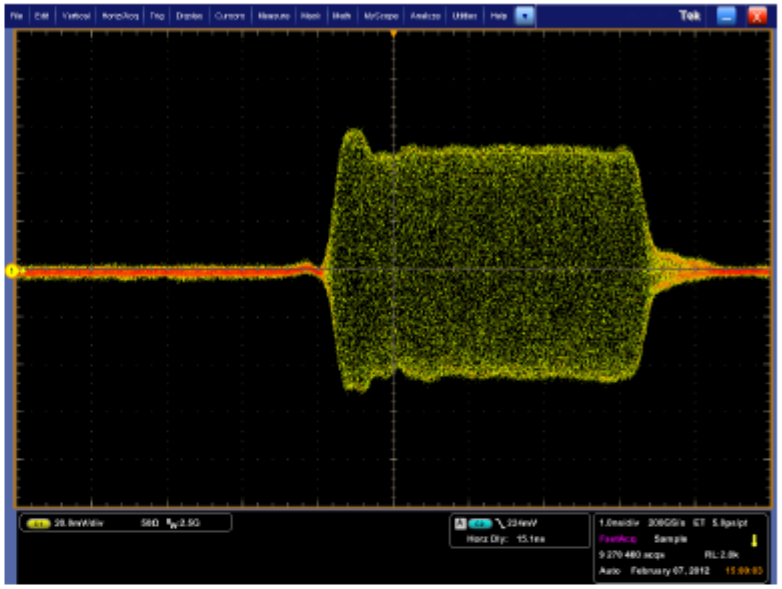
R&K


DBM
Signal Generator
(1150 MHz CW)
Amp
30 dB
Attenuator
10 dB
Attenuator
Scope
Pulse
Generator

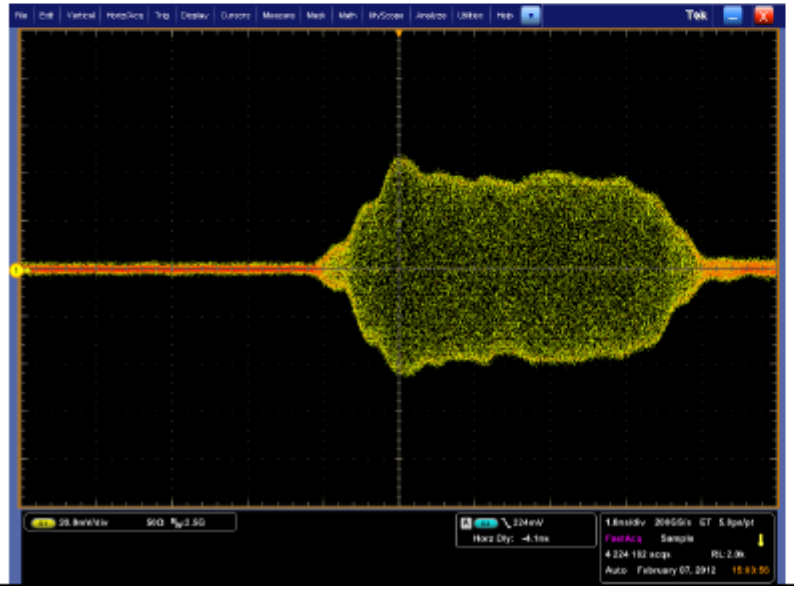
入力：

1.15 GHz

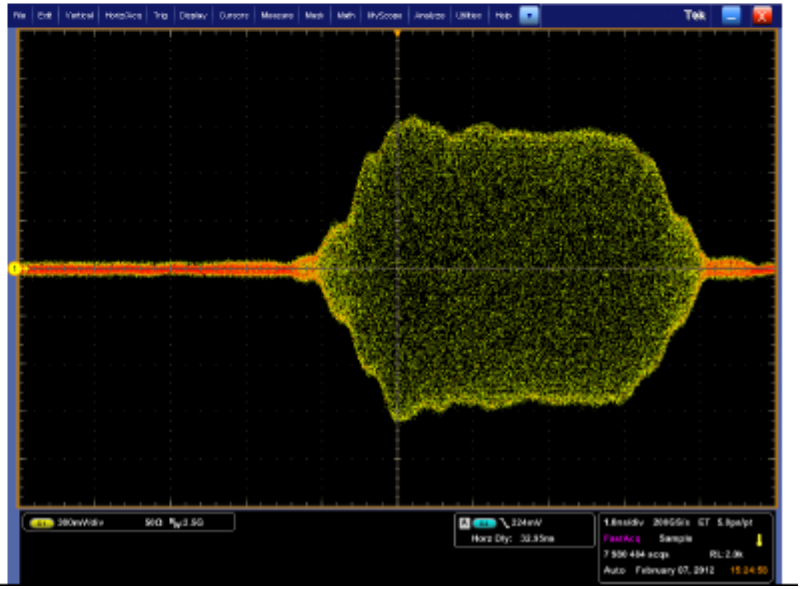
パルス幅4 ns



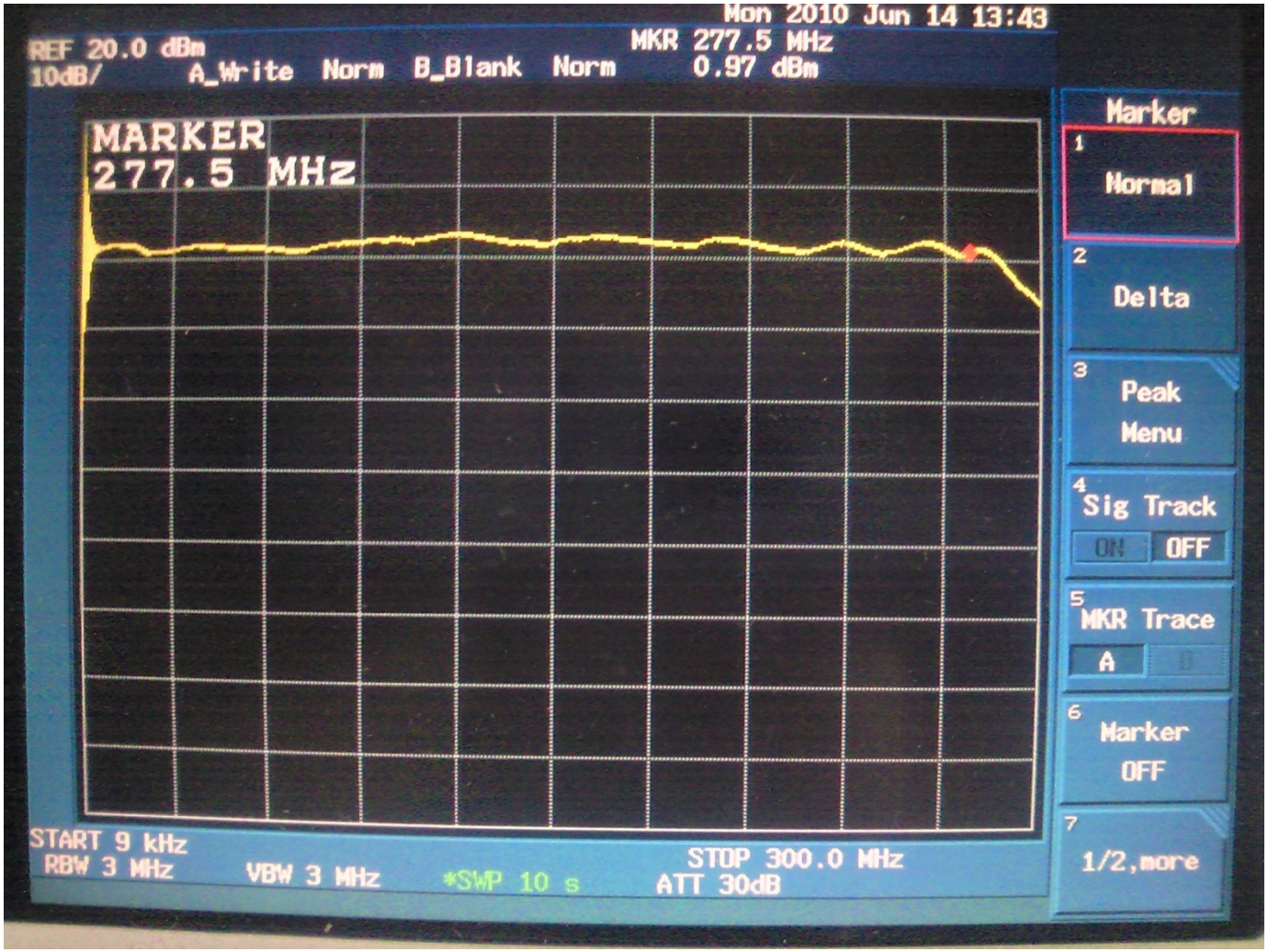
出力：Milmegaのアンプ



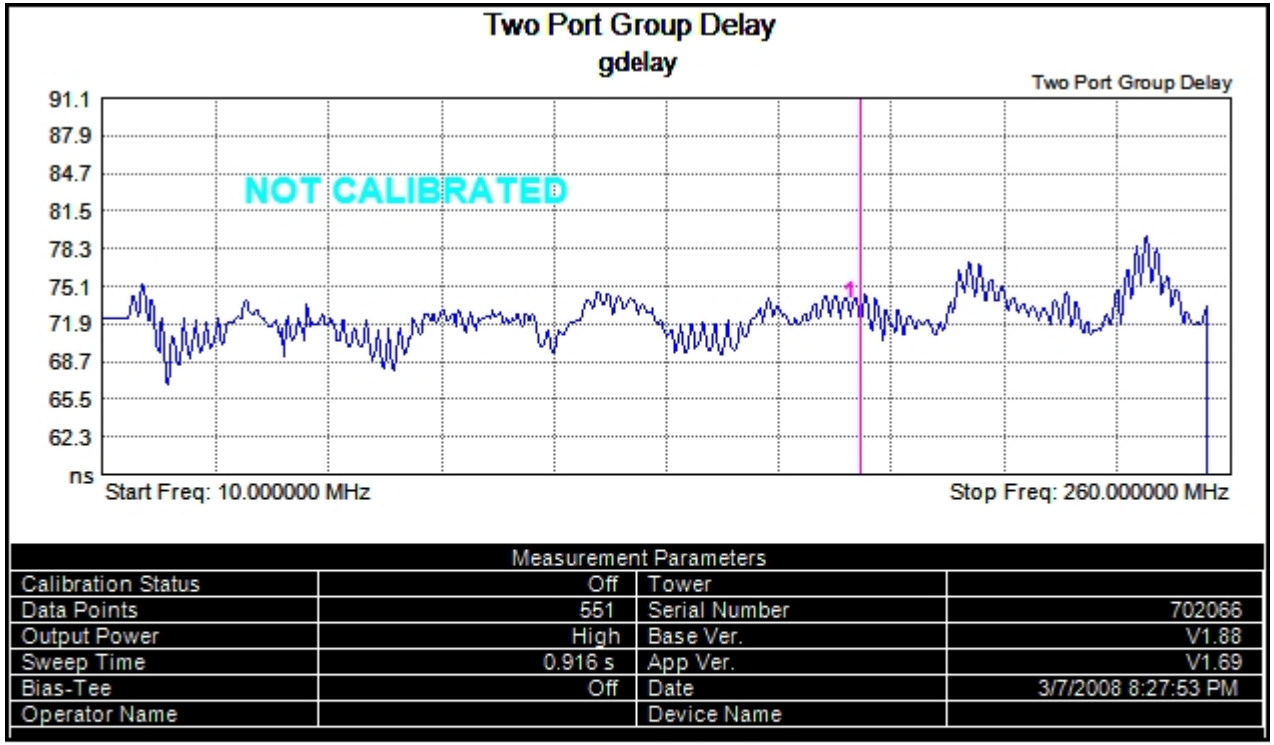
出力：R&Kのアンプ



周波数応答(−10dBm)


Mon 2010 Jun 14 13:43
REF 20.0 dBm
10dB/
A_Write Norm B_Blank Norm
MKR 277.5 MHz
0.97 dBm
MARKER
277.5 MHz
Marker
1 Normal
2 Delta
3 Peak Menu
4 Sig Track
ON OFF
5 MKR Trace
A B
6 Marker OFF
7 1/2,more
START 9 kHz
RBW 3 MHz
VBW 3 MHz
*SWP 10 s
STOP 300.0 MHz
ATT 30dB

群遅延特性



Measurement Parameters			
Calibration Status	Off	Tower	
Data Points	551	Serial Number	702066
Output Power	High	Base Ver.	V1.88
Sweep Time	0.916 s	App Ver.	V1.69
Bias-Tee	Off	Date	3/7/2008 8:27:53 PM
Operator Name		Device Name	

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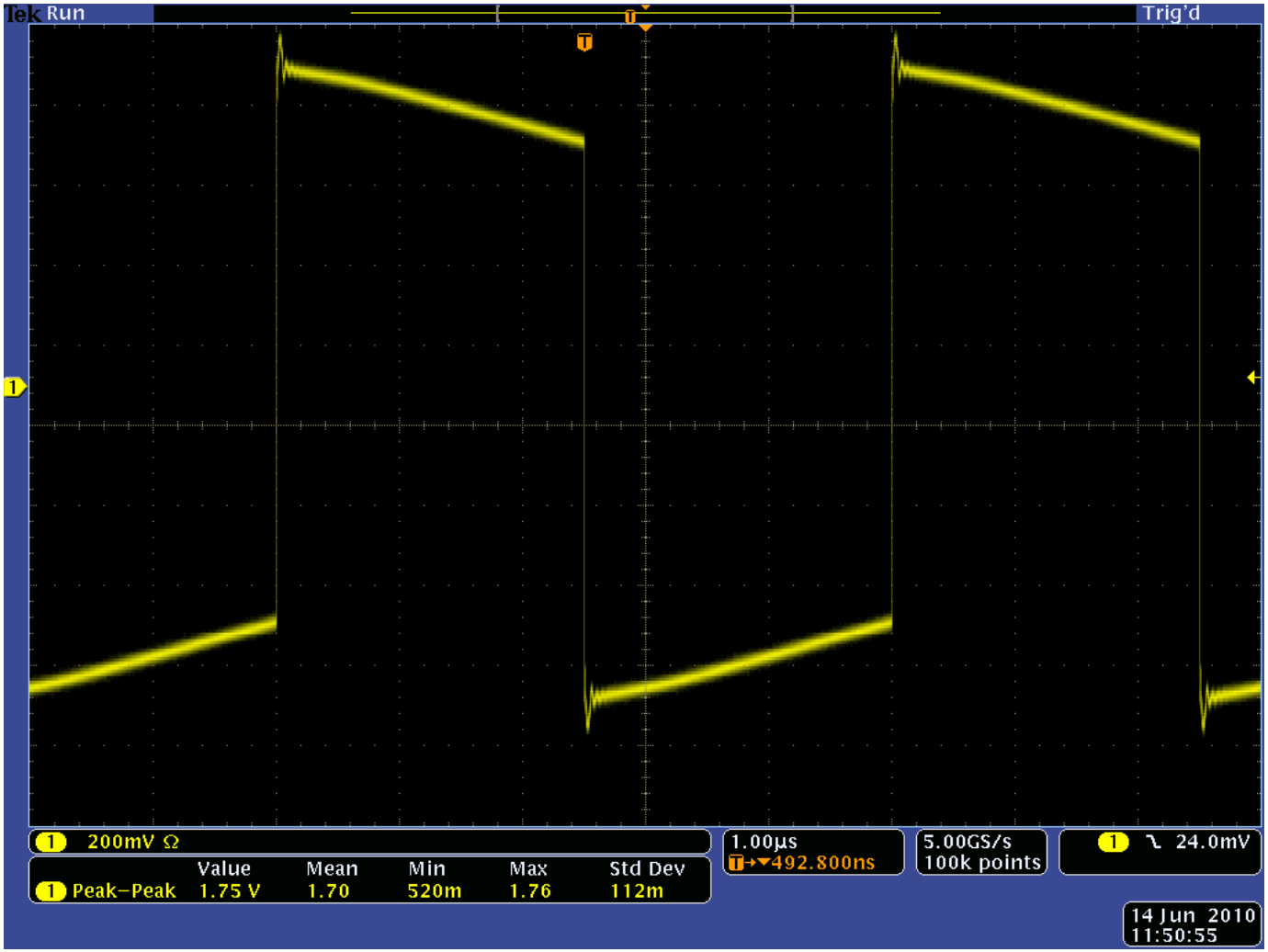
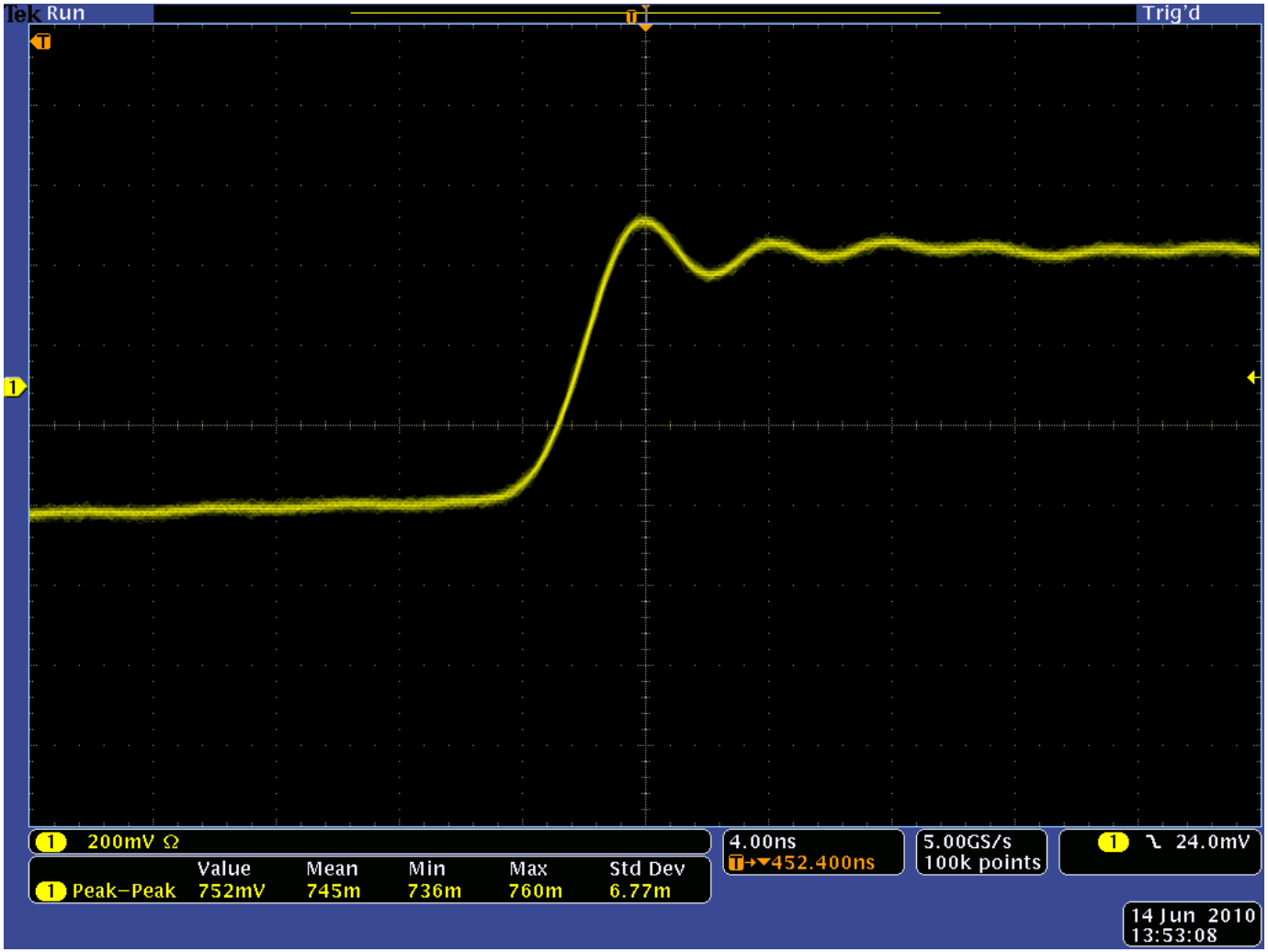
Sweep Time	0.916 s	App Ver.	V1.69
Bias-Tee	Off	Date	3/7/2008 8:27:53 PM
Operator Name		Device Name	

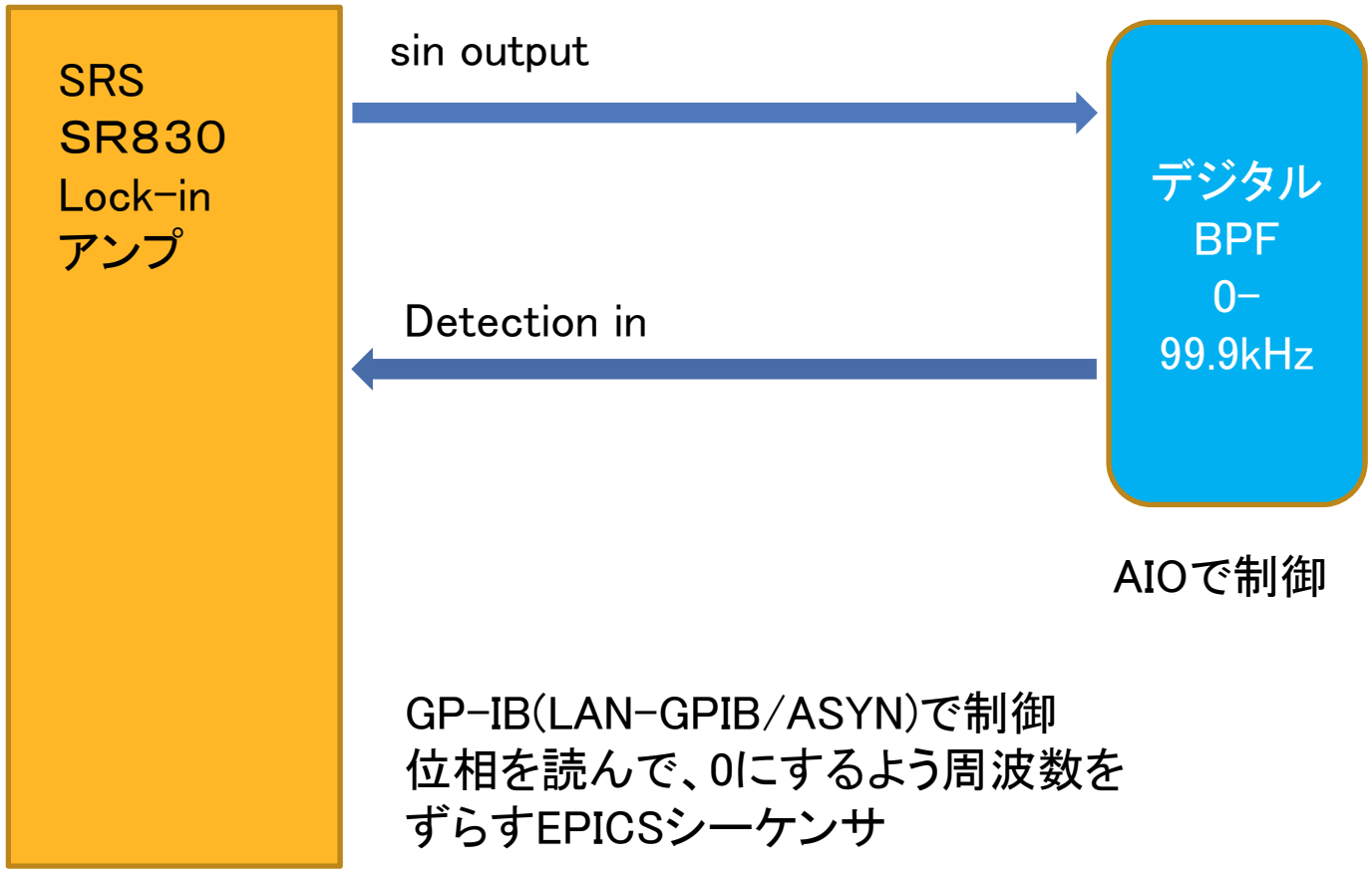
420mVpp(500W)



立ち上がり(240MHz FG)



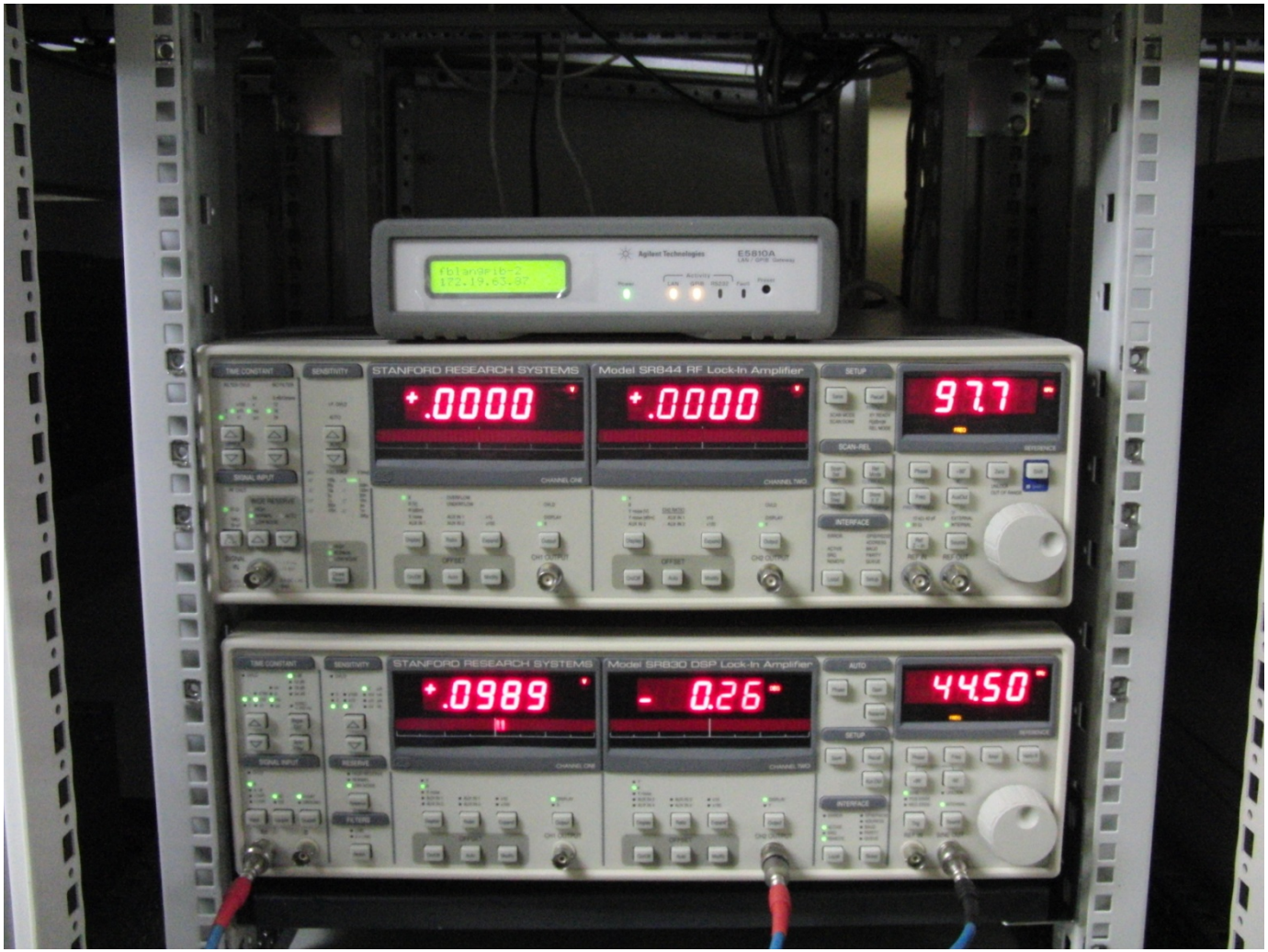
SR830の場合



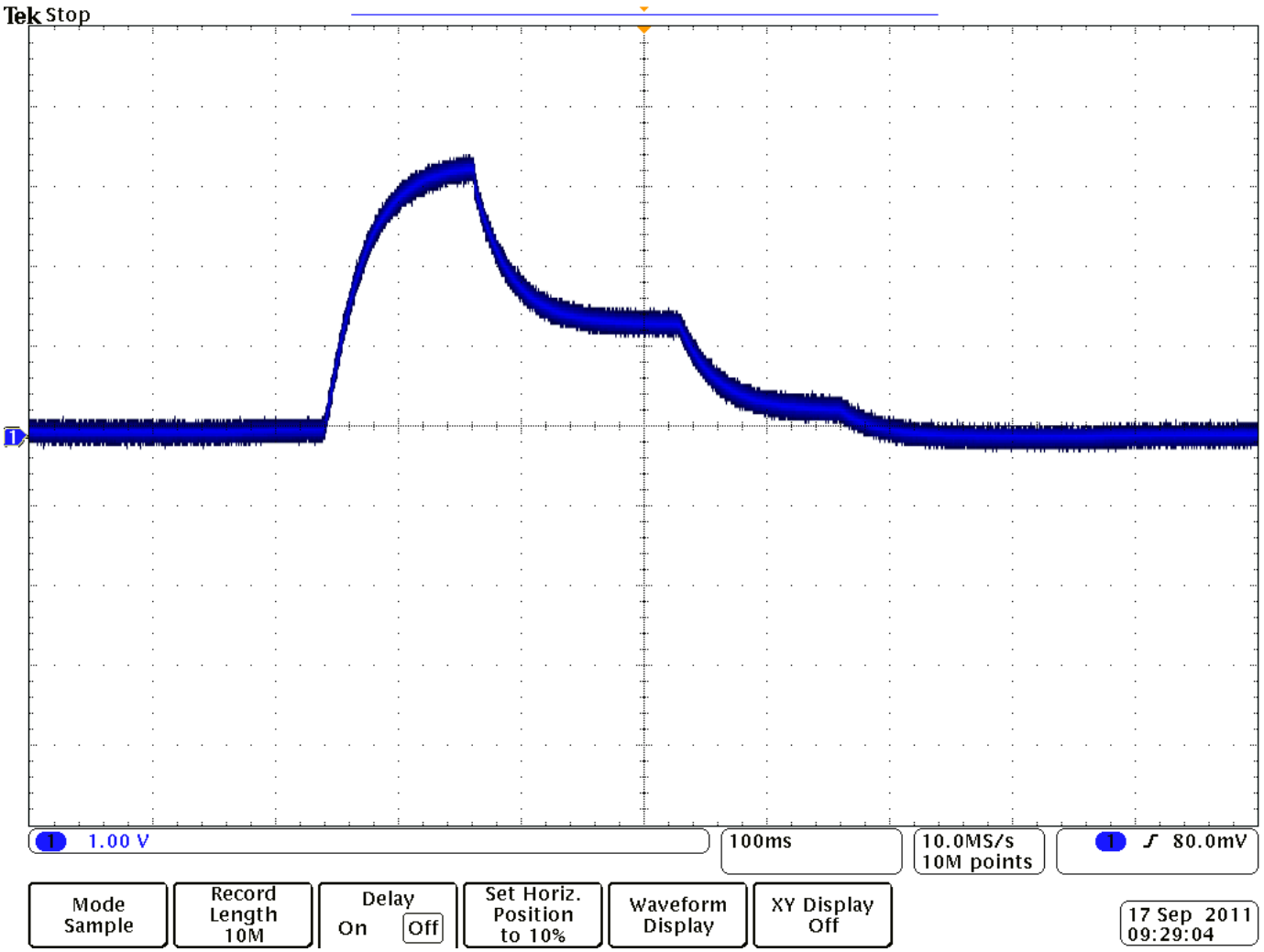
AIOで制御

GP-IB(LAN-GPIB/ASYN)で制御
位相を読んで、0にするよう周波数を
ずらすEPICSシーケンサ

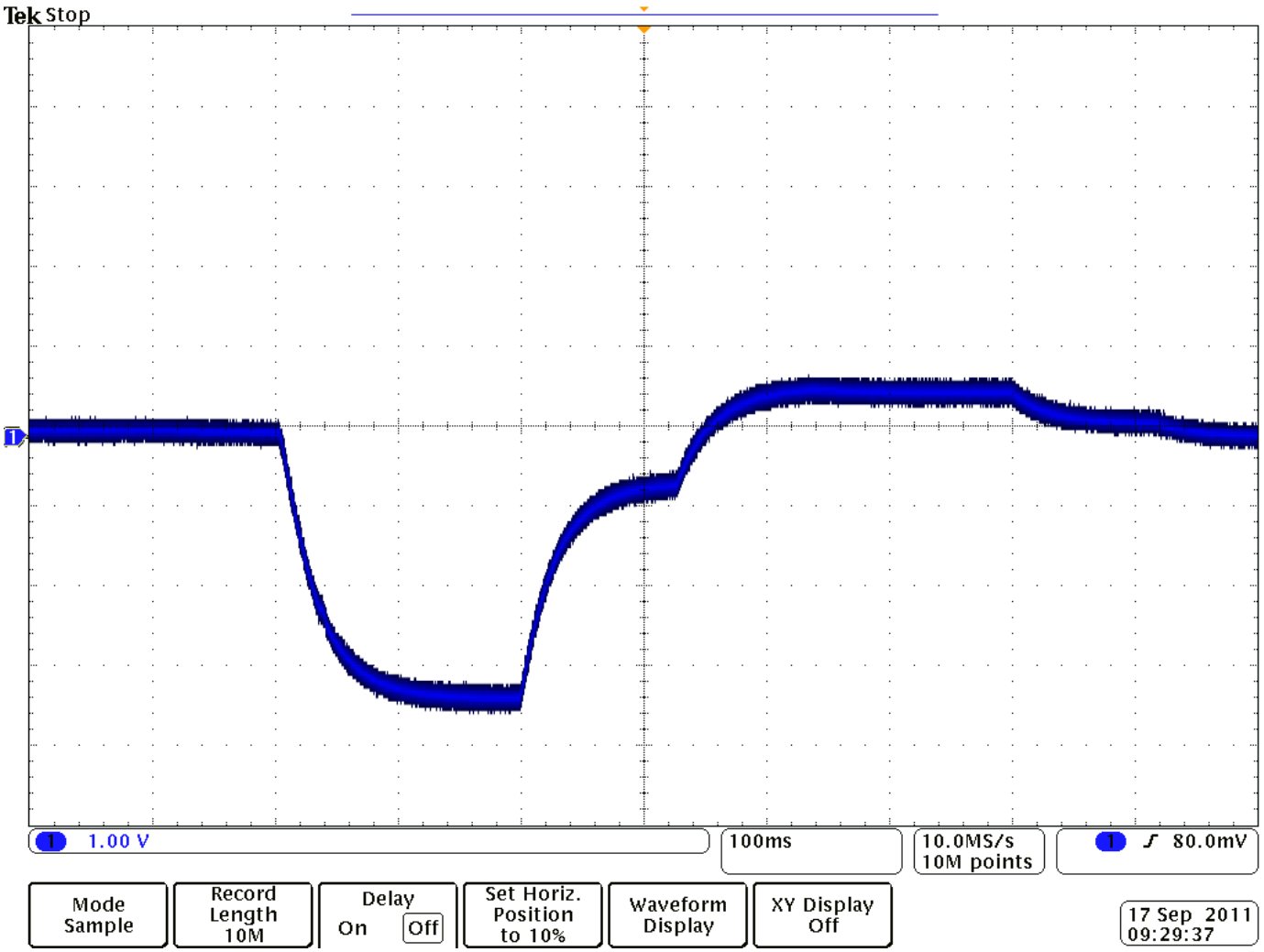
Lock-inアンプ


Agilent Technologies
E5810A
STANFORD RESEARCH SYSTEMS
Model SR844 RF Lock-In Amplifier
+.0000
+.0000
97.7
STANFORD RESEARCH SYSTEMS
Model SR830 DSP Lock-In Amplifier
+.0989
- 0.26
44.50

gain 0.8、44k−45kステップ



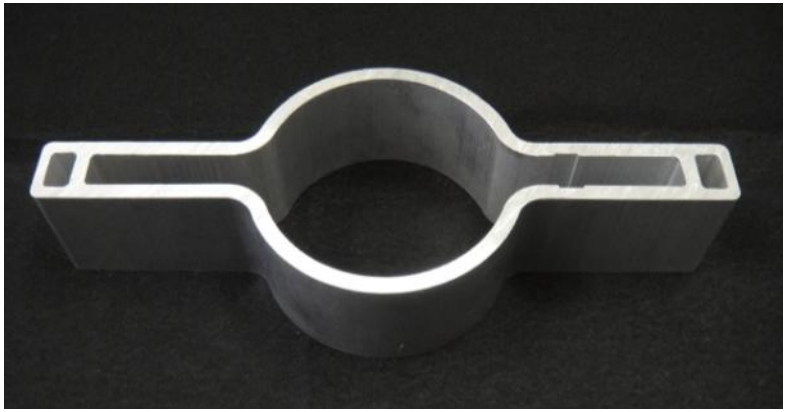
gain0.8 45k−44kステップ



Vacuum chamber

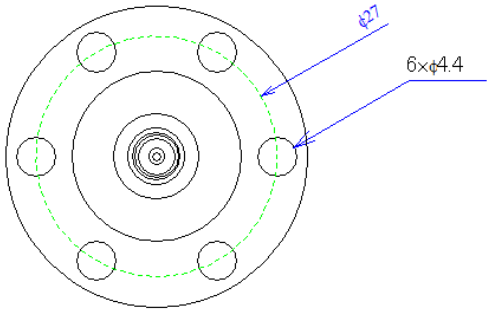
- Aluminum alloy antechamber
- cutoff frequency <1 GHz

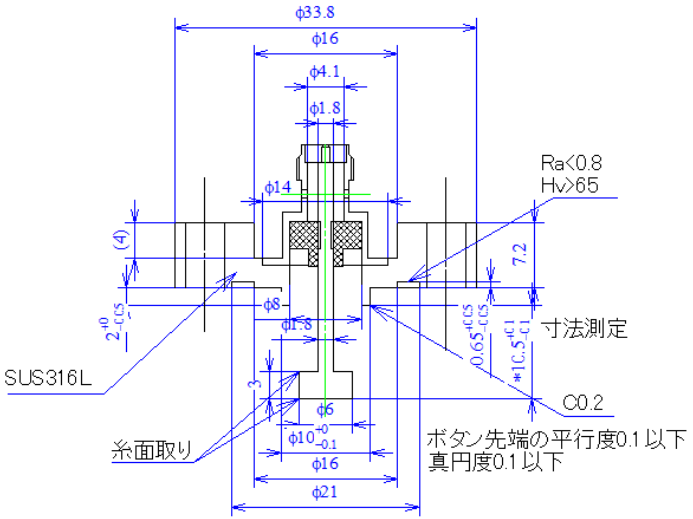
Aluminum-alloy duct



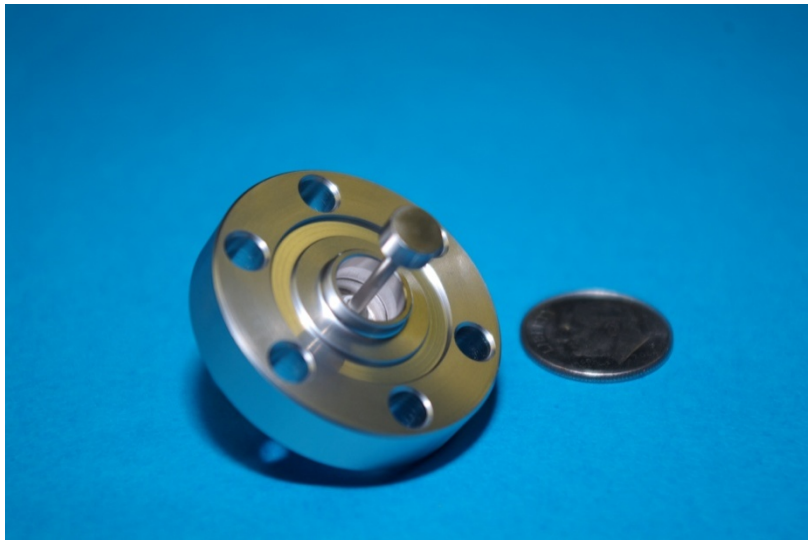
Aluminum-alloy duct

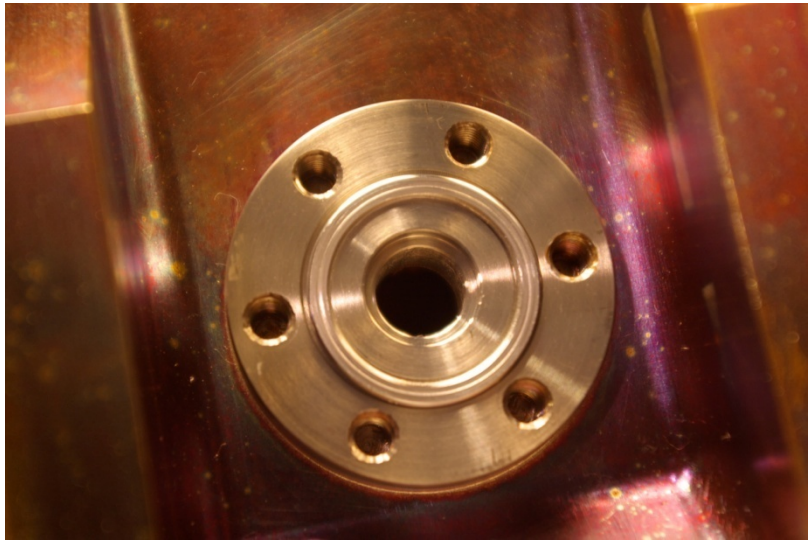
BPM head



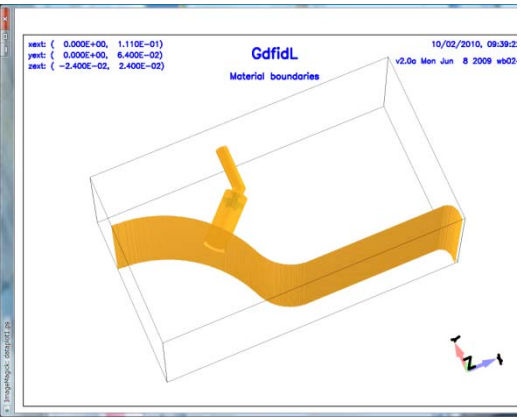


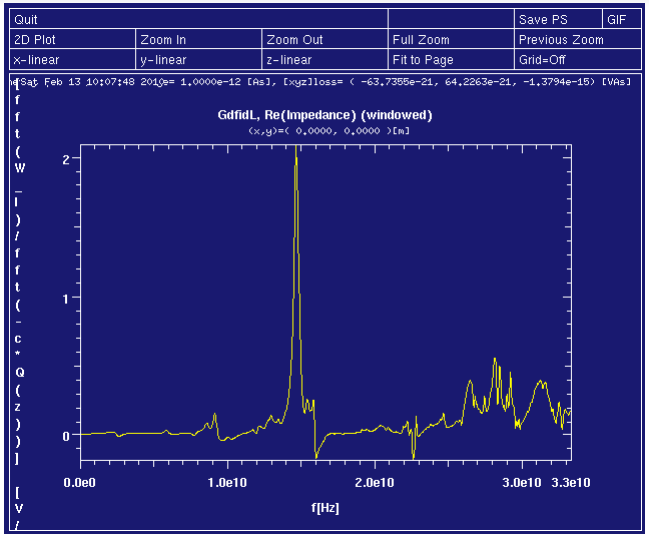
SuperKEKB用BPM model-E1
作図: M.Tobiyama 6/Oct/2006
修正: M.Tobiyama 8/Nov/2006

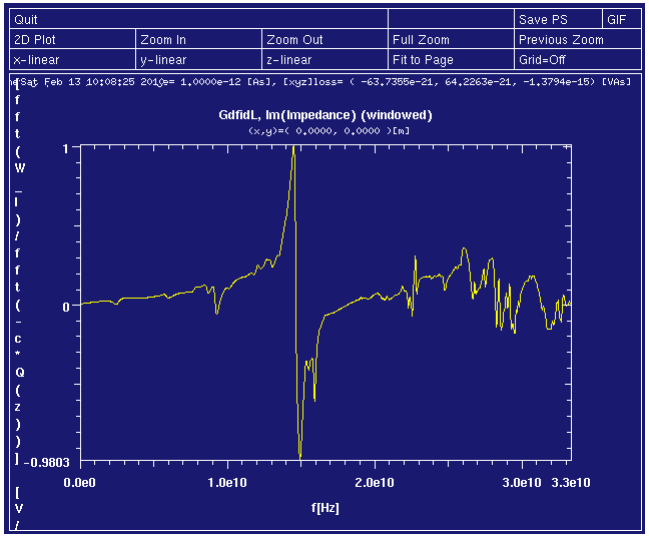


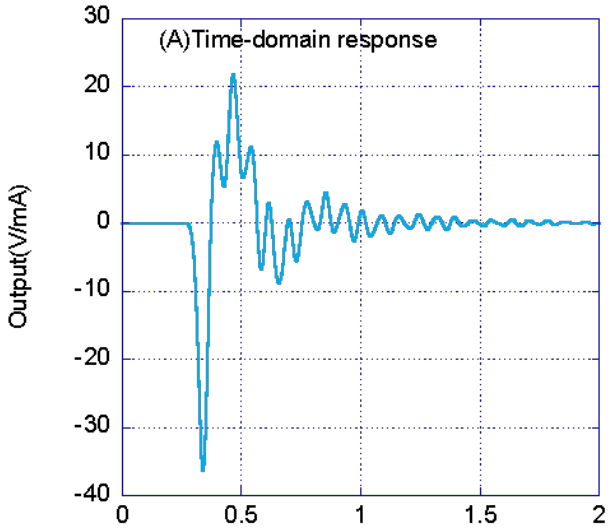


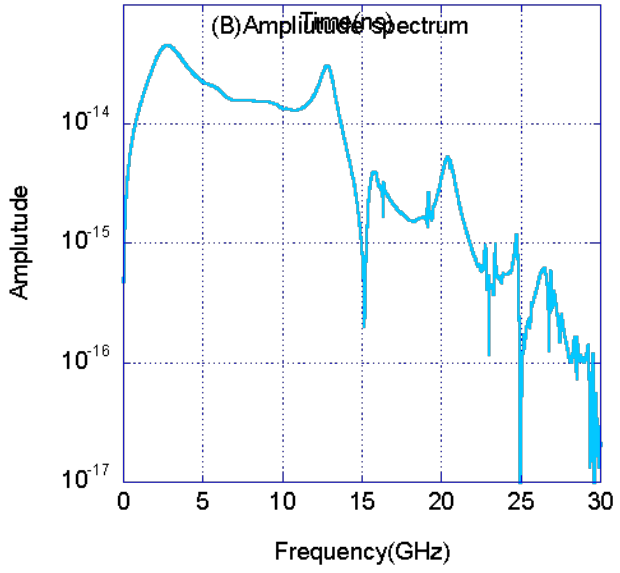
Impedance/button output simulation











RF to No.1 (SW off)

RF to No.1 (SW ON)

RF to No.2 (SW ON)

RF to No.2(SW OFF)