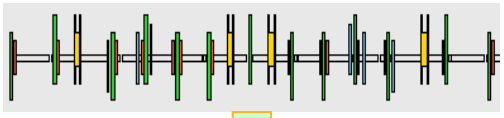
Turn-by-Turn Monitor using Fast Gate Switches

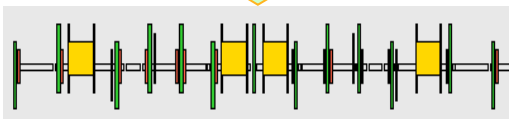
Makoto Tobiyama

KEK Accelerator Laboratory

ERL2011

Replace LER dipoles with longer ones (0.82m->4.2m) to reduce emittance





Optimize beam optics for low emittance beam

Positron beam 3.6 A

Belle II

New IR

Electron beam 2.6 A

Super-KEKB

New beam pipe & bellows

Construct positron damping ring

Damping ring

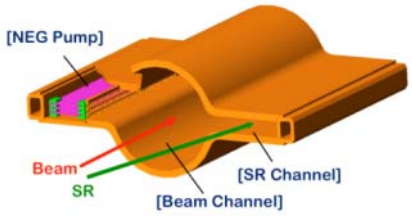
Positron source

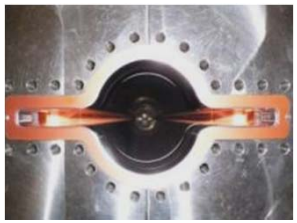
Adaptic optics for higher positron yield

Low emittance gun for high-quality electron beam (HER)

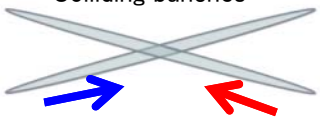
Extend RF system for high beam current operation

Antechamber with TiN coating to suppress electron cloud instability

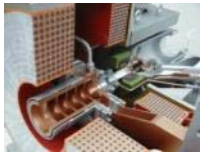




Colliding bunches



Superconducting quadrupoles to shrink colliding beam at IP



$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_{\pm}\xi_{\pm y}}{\beta_y^*}\frac{R_L}{R_y}$$

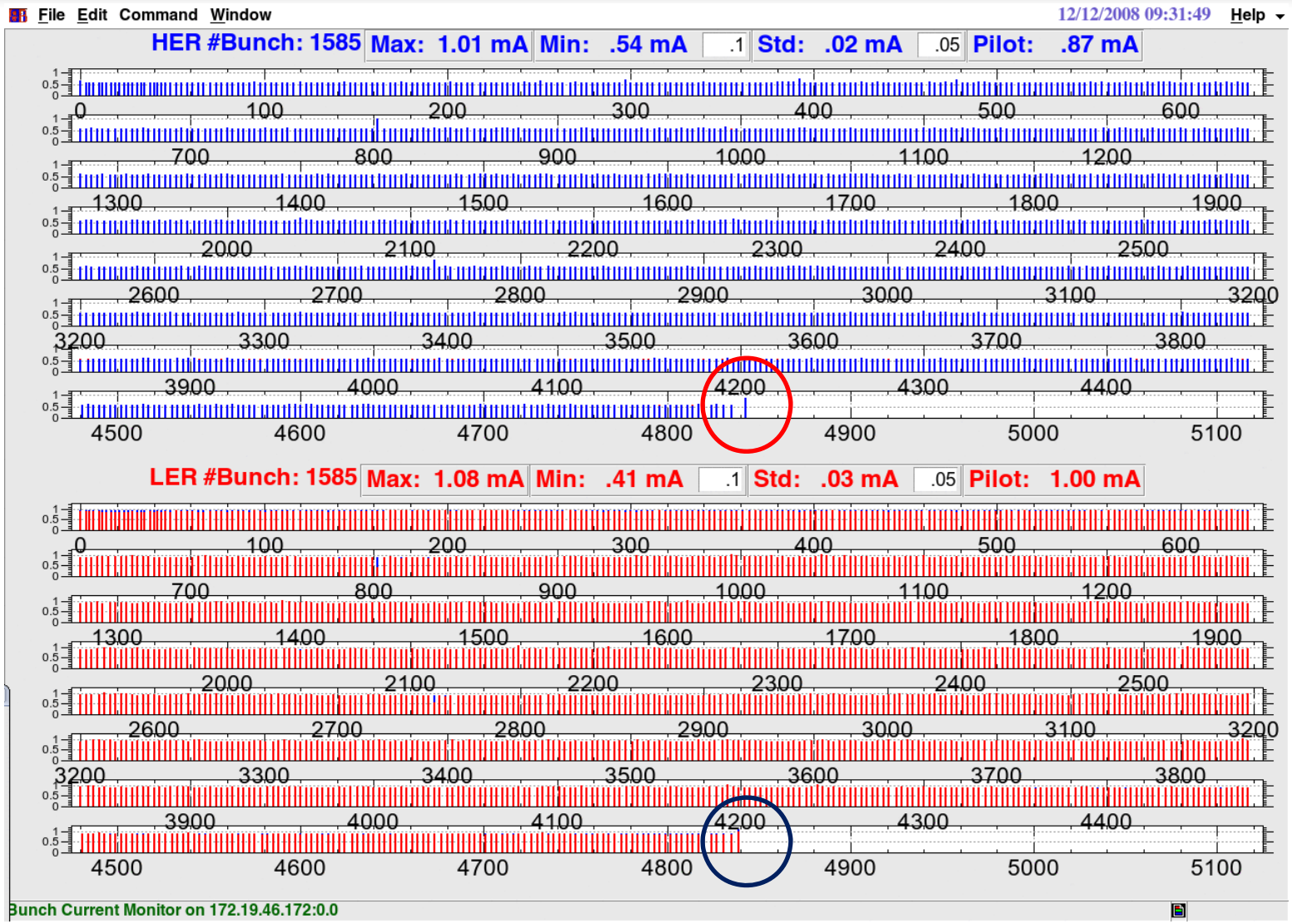
40 times gain in luminosity
with nano-beam, double beam current

SuperKEKB project

- **Operation point very near to strong resonance.**
  - Need to control the betatron tune during collision
- **Very narrow dynamic aperture due to huge chromaticity coming from collision point**
  - Need to correct the optics
    - With low beam current (xy-coupling, betatron function, dispersion)
    - During collision (xy-coupling and betatron functin) under huge beam currents with fairly strong beam-beam effects.

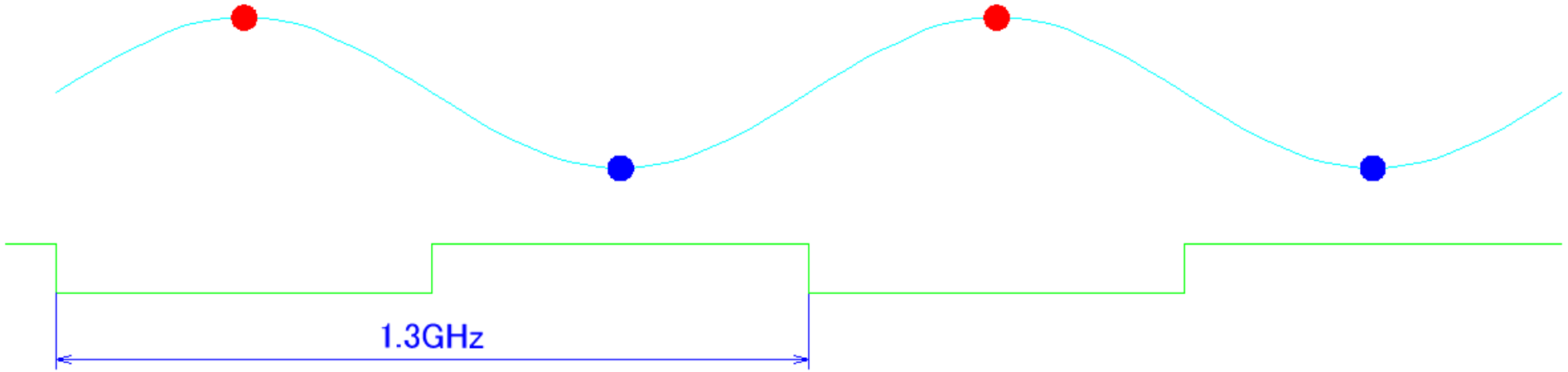
- **Prepare non-colliding, no-bxb feedback bunch ("Pilot bunch") and measure the betatron tunes and optics during collision.**

Pilot bunch


File Edit Command Window
12/12/2008 09:31:49
Help
HER #Bunch: 1585
Max: 1.01 mA
Min: .54 mA
.1
Std: .02 mA
.05
Pilot: .87 mA
LER #Bunch: 1585
Max: 1.08 mA
Min: .41 mA
.1
Std: .03 mA
.05
Pilot: 1.00 mA
Bunch Current Monitor on 172.19.46.172:0.0

For ERL

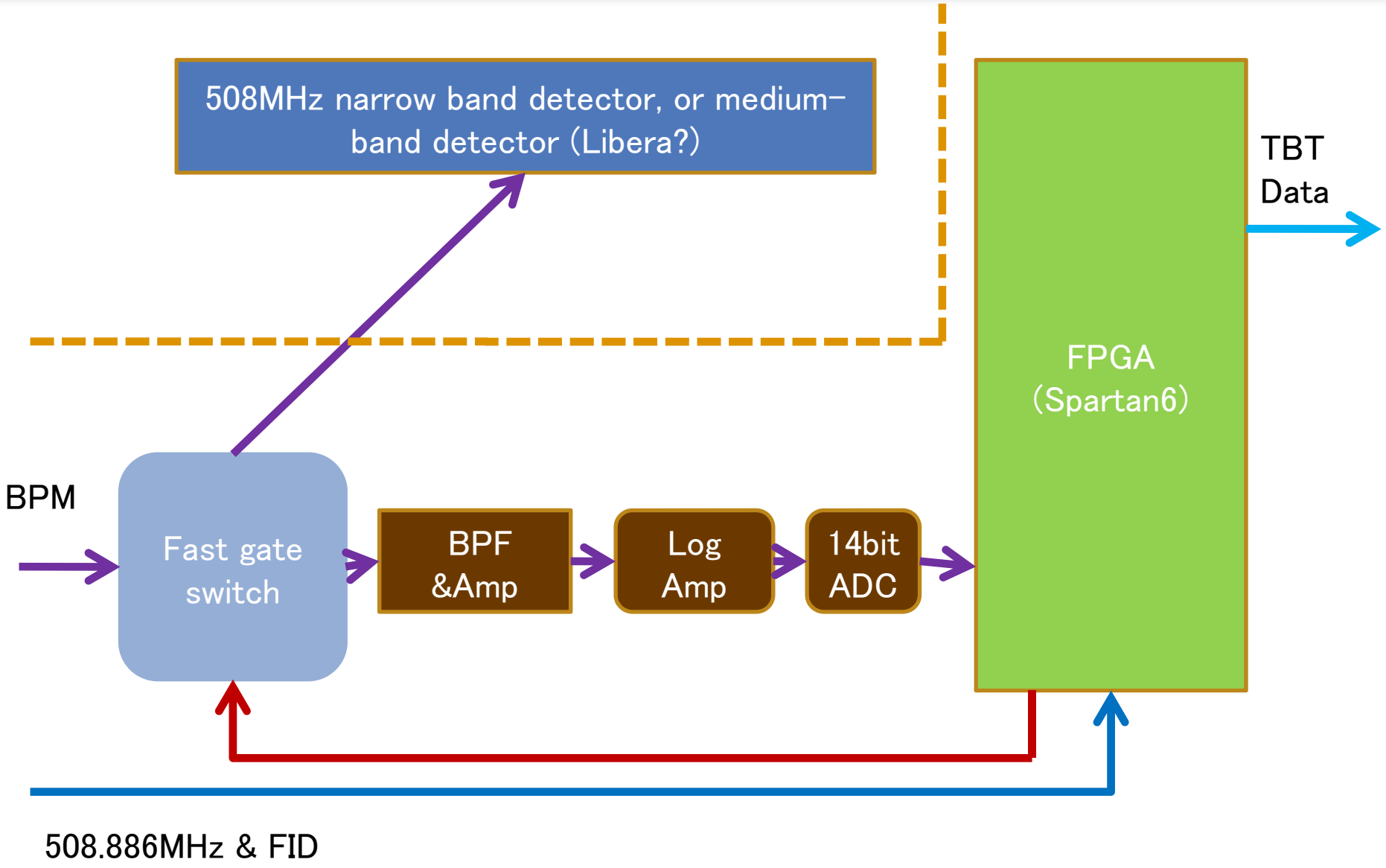
- Separate the BPM signal form acceleration phase and deceleration phase at cavity section.



Turn-by-turn monitor

- **Record the bunch position with turn-by-turn base.**
  - FFT the position data
    - Betatron phase advance between the monitors.
    - X-Y coupling
    - Low frequency oscillations and their source.
- **Need to share the same BPM signal with narrow-band or medium-band BPM detector.**
  - Should not disturb the signal to narrowband system.

Proposed TBT monitor system



Gated optics measurements

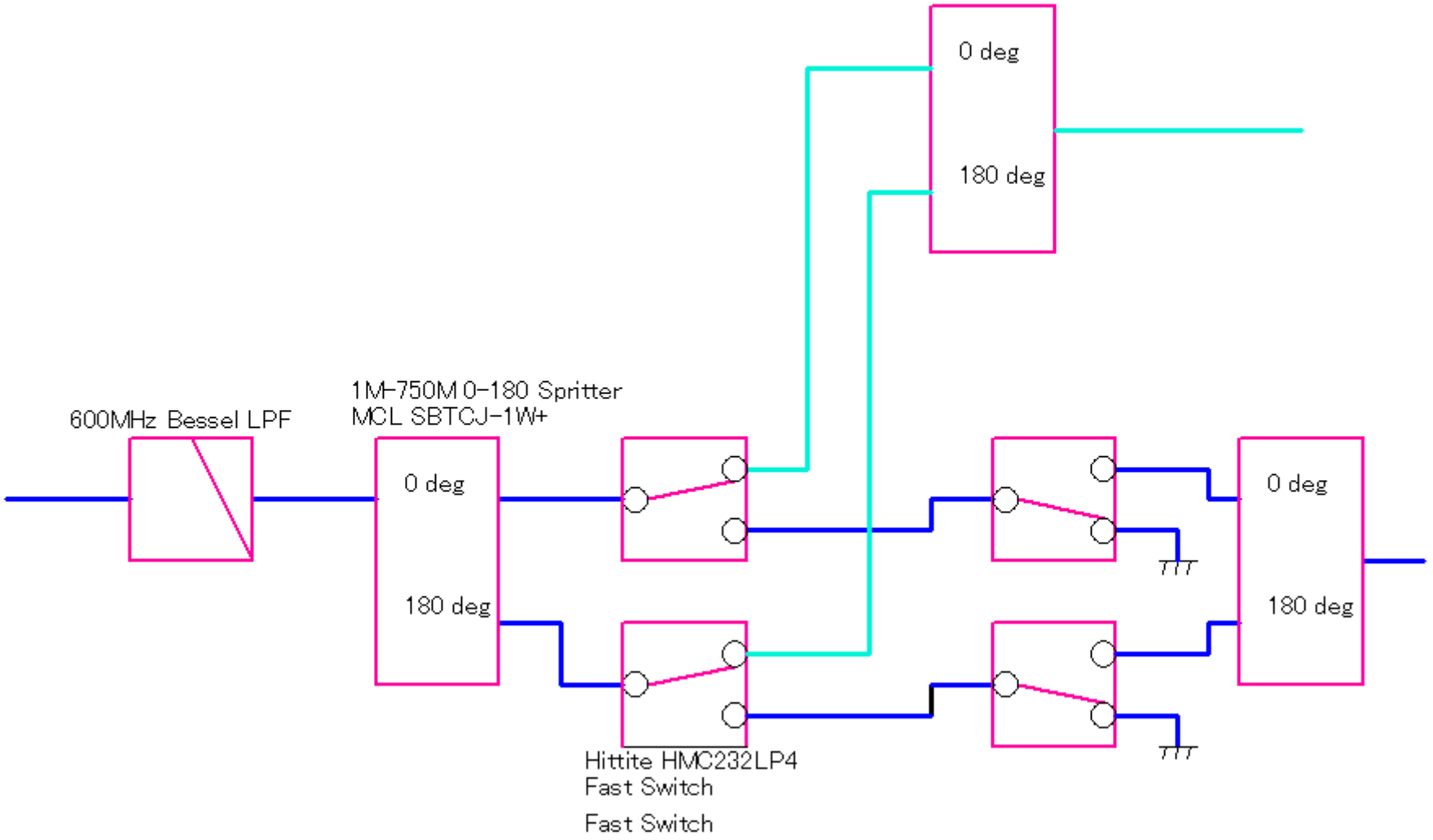
- Excite betatron oscillation of pilot bunch (=non colliding bunch) with PLL
- Extract the signal of pilot bunch with fast beam switch , detect the signal with L/R detector to get the beam position of the pilot bunch, while most of the signal (2499/2500) is detected with narrow band COD detector.
  - FFT the signal to get the betatron phase advance.
  - Measure X-Y coupling
- Correct optics function, couplings with colliding condition.

Fast gate switch

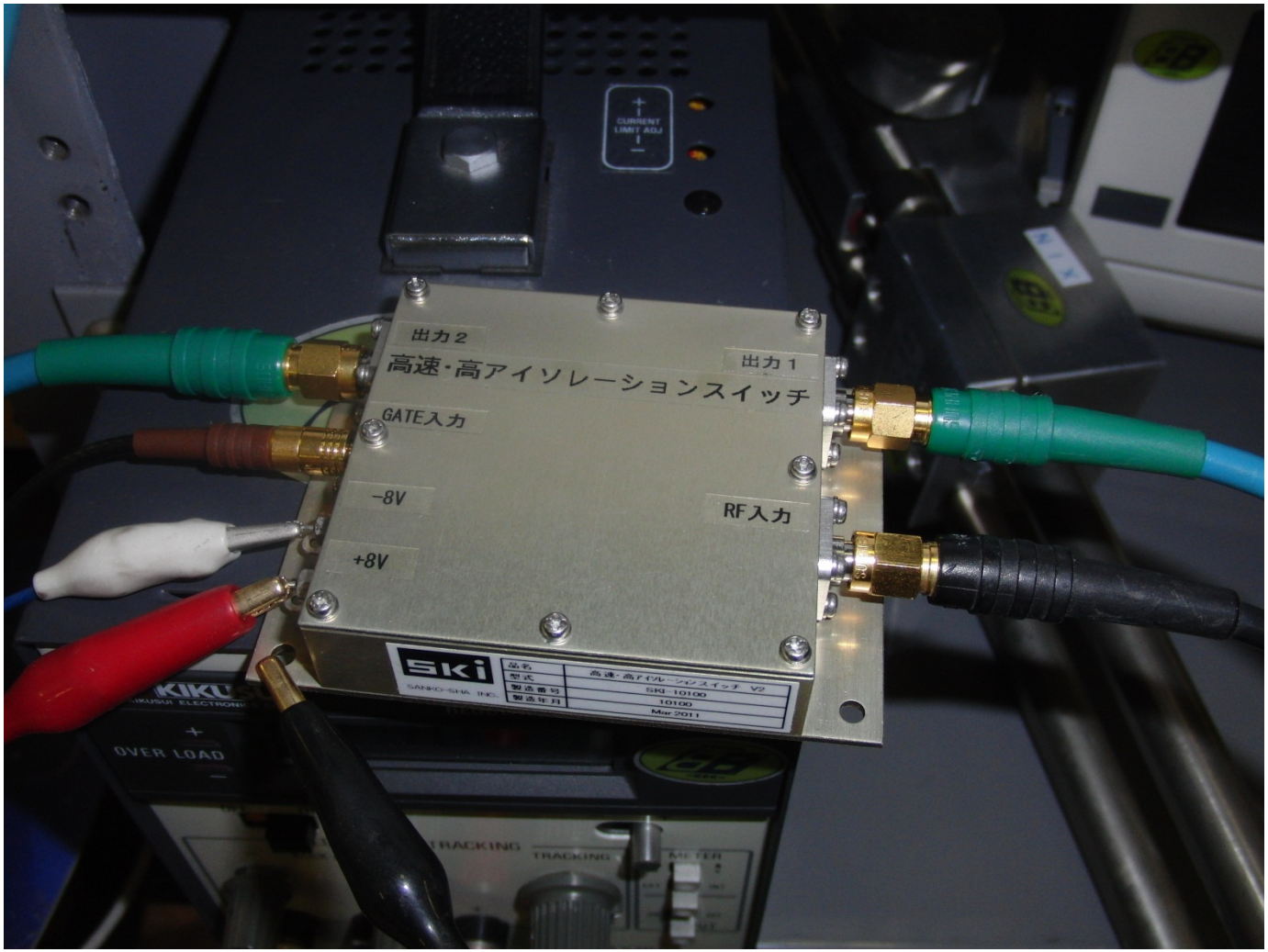
	Hittite HMC234C8	Tyco SW-283-PIN	Mini-Circuit M3SW-2-50DR+	Agilent HMMC-2027	AVAGO AMMC-2008
Input Power -1dB_c (dBm)	+26	+27	+25	+27	+14
Bandwidth (GHz)	DC - 8.0	DC - 3.0	DC - 4.5	DC - 26.5	DC - 50.0
Switching Time (ns)	3	2	5	< 1	0.1
Isolation (dB@2GHz)	52	25	50	55	46
Insertion Loss (dB@2GHz)	1.4	1.8	0.9	1.4	1.6
Control	0/-5 V	-8.5/+5 V	TTL	0/-10 V	0/-3.0 V

Switching noise

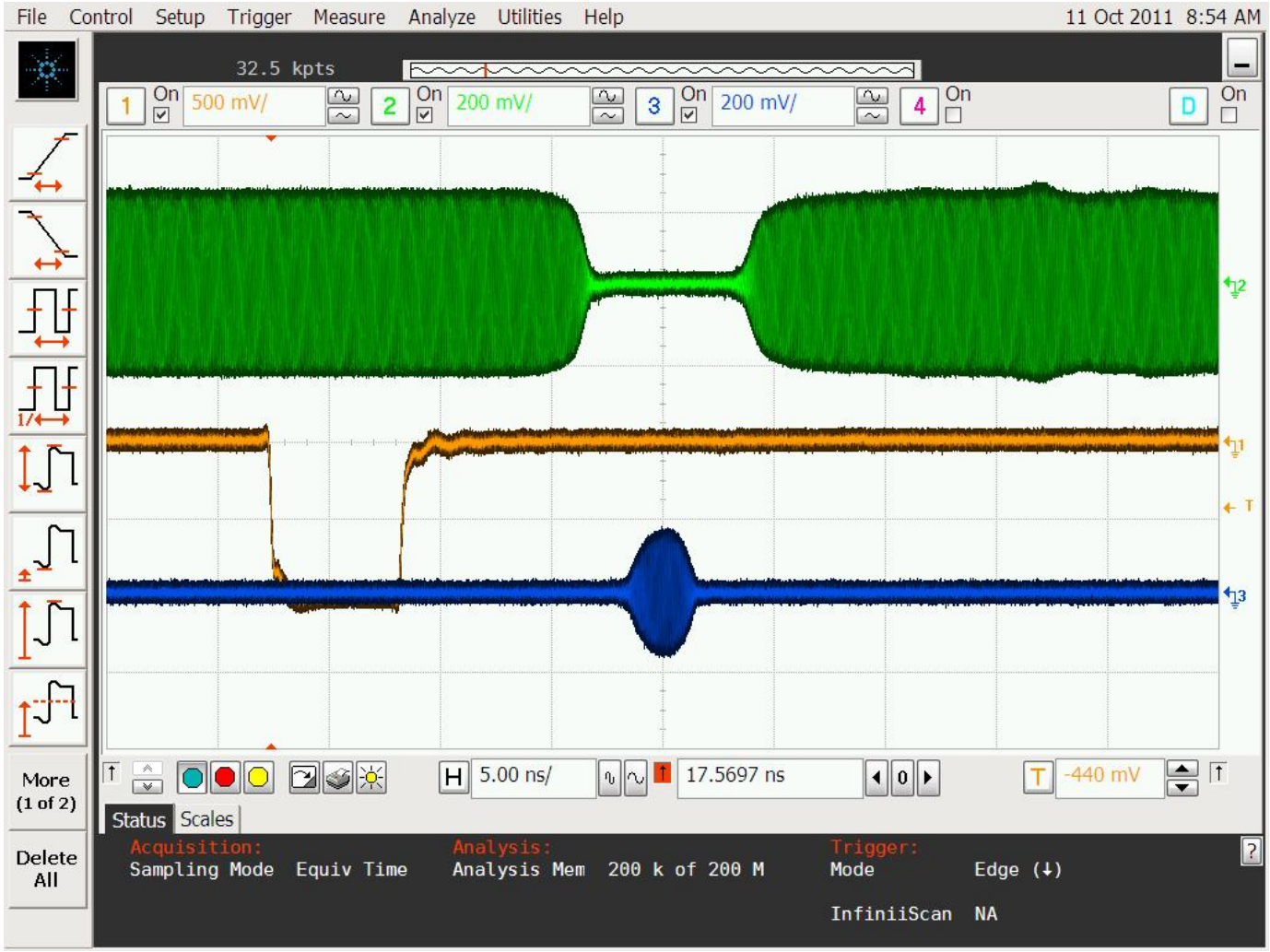
Better isolation and switching noise cancellation



Proposed and tested by Dr. T. Naito


出力２
高速・高アイソレーションスイッチ
出力１
GATE入力
−8V
RF入力
+8V
SKI
SANKO-SHA INC.
品名
型式
製造番号
製造年月
高速・高アイソレーションスイッチ V2
SKI-1010D
1010D
Mar 2011
CURRENT LIMIT ADJ
OVER LOAD
TRACKING
METER

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
H 5.00 ns/
17.5697 ns
T -440 mV
More (1 of 2)
Delete All
Status Scales
Acquisition:
Sampling Mode Equiv Time
Analysis:
Analysis Mem 200 k of 200 M
Trigger:
Mode Edge (↓)
InfiniiScan NA

SW noise


File Control Setup Trigger Measure Analyze Utilities Help
11 Oct 2011 8:56 AM
32.5 kpts
1 On 500 mV/
2 On 10.0 mV/
3 On 10.0 mV/
4 On
D On
H 5.00 ns/
17.5697 ns
T -430 mV
More (1 of 2)
Delete All
Status Scales
Acquisition:
Sampling Mode Equiv Time
Analysis:
Analysis Mem 200 k of 200 M
Trigger:
Mode Edge (↓)
InfiniiScan NA


File Control Setup Trigger Measure Analyze Utilities Help
11 Oct 2011 11:41 AM
20.0 kpts
1 On 500 mV/
2 On 200 mV/
3 On 100 mV/
4 On
D On
H 2.00 ns/
19.5582 ns
T -430 mV
More (1 of 2)
Delete All
Status Scales
Acquisition:
Sampling Mode Equiv Time
Analysis:
Analysis Mem 200 k of 200 M
Trigger:
Mode Edge (↓)
InfiniiScan NA


File Control Setup Trigger Measure Analyze Utilities Help
11 Oct 2011 11:47 AM
32.0 kpts
1 On
2 On 200 mV/
3 On 200 mV/
4 On
D On
More (1 of 2)
Delete All
H 5.00 ns/
22.9628 ns
T -620 mV
Status Scales
Acquisition:
Sampling Mode Equiv Time
Analysis:
Analysis Mem 200 k of 200 M
Trigger:
Mode Edge (↓)
InfiniiScan NA

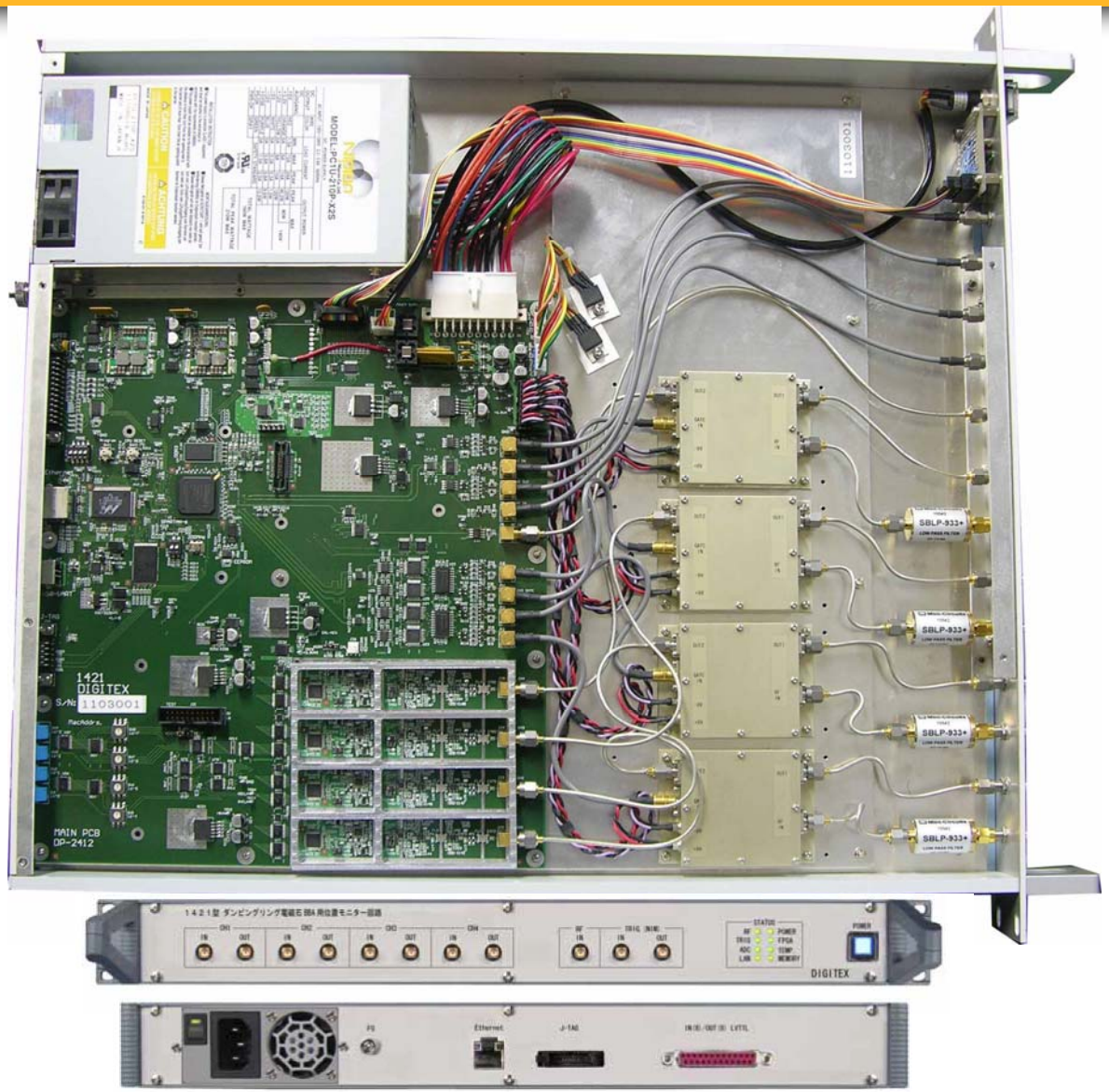
RF to No.1 (SW off)

RF to No.1 (SW ON)

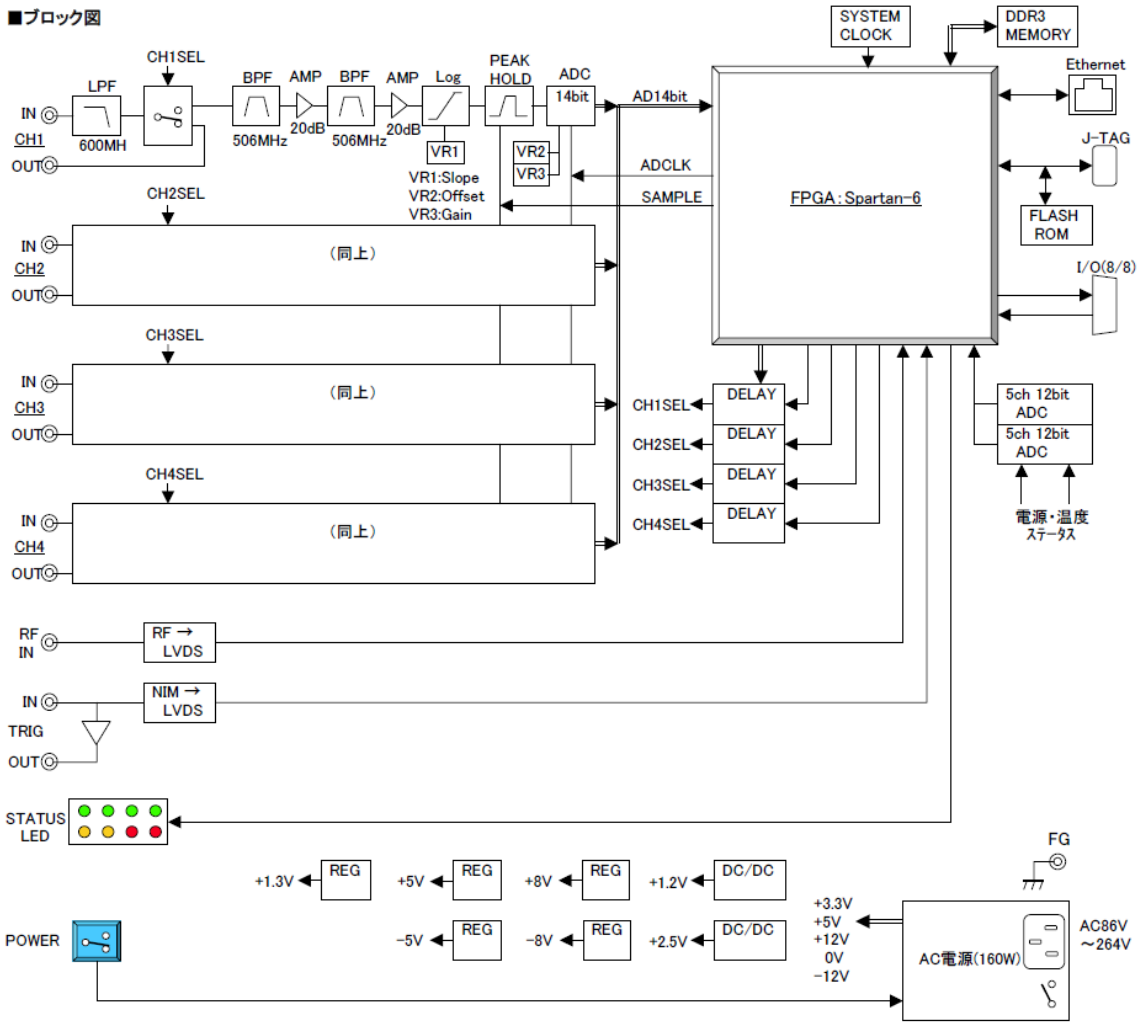
RF to No.2 (SW ON)

RF to No.2(SW OFF)

Circuit


1421
DIGITEX
S/No 1103001
MAIN PCB
DP-2412
SBLP-933+
SBLP-933+
SBLP-933+
SBLP-933+
DIGITEX

Block Diagram



Log ratio detector

- 506MHz BW 24MHz SAW filter
- ADL5521 20dB Low noise amplifier x 2
- ADL5513 Log amplifier
- Peak-hold circuit
- ADS850 14bit 10MSPS BW 270MHz ADC

Digital control

- **Based on SP605 evaluation board**
  - Spartan-6 XC6SLX45T FPGA
  - DDR3-1066 128M memory
  - GbE and UART interface

- **Timing control (508MHz /5120, delay (2ns step), fine delay tuning through EP195 (10ps step)) to fast gate SW**
- **Power and temperature monitor**
- **Using MicroBlaze to control and communicate.**

For ERL application

- **Need better time-domain response for the monitor head.**
  - Difficulty in using stripline electrode
  - Button electrode with improved time response?
- **Need to use faster switch**
  - There exist several candidates. Still existing difficulty in driving circuit, though.
- **Symmetric structure in noise cancellation part might be needed that increases insertion loss.**