Fast RF trip diagnostics using GPS and IRIG-B

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SL/LRF

- Motivation
- Requirements
- Implementaion
  - Hardware
  - Software
- Results

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- G. Beetham, JB Ribes, L. Arnaudon, P. Ribeiro, A. Bland

The problem (end of 1999):

1 or more units trip (or something else)

Beams lost

Big reflected power transient in all units

Many units trip

Don’t know which one was first

“Beam lost - RF trips”

Requirements

- **Need a “precise” timestamp for**
  - **each unit trip**
  - **beam loss**

- **Timescales:**
  - **Cavity filling time ~ 2ms**
  - **Coupling via beam ~ 1 synchrotron period ~ 1ms**
  - **Cavity tuner bandwidth ~ 5ms**

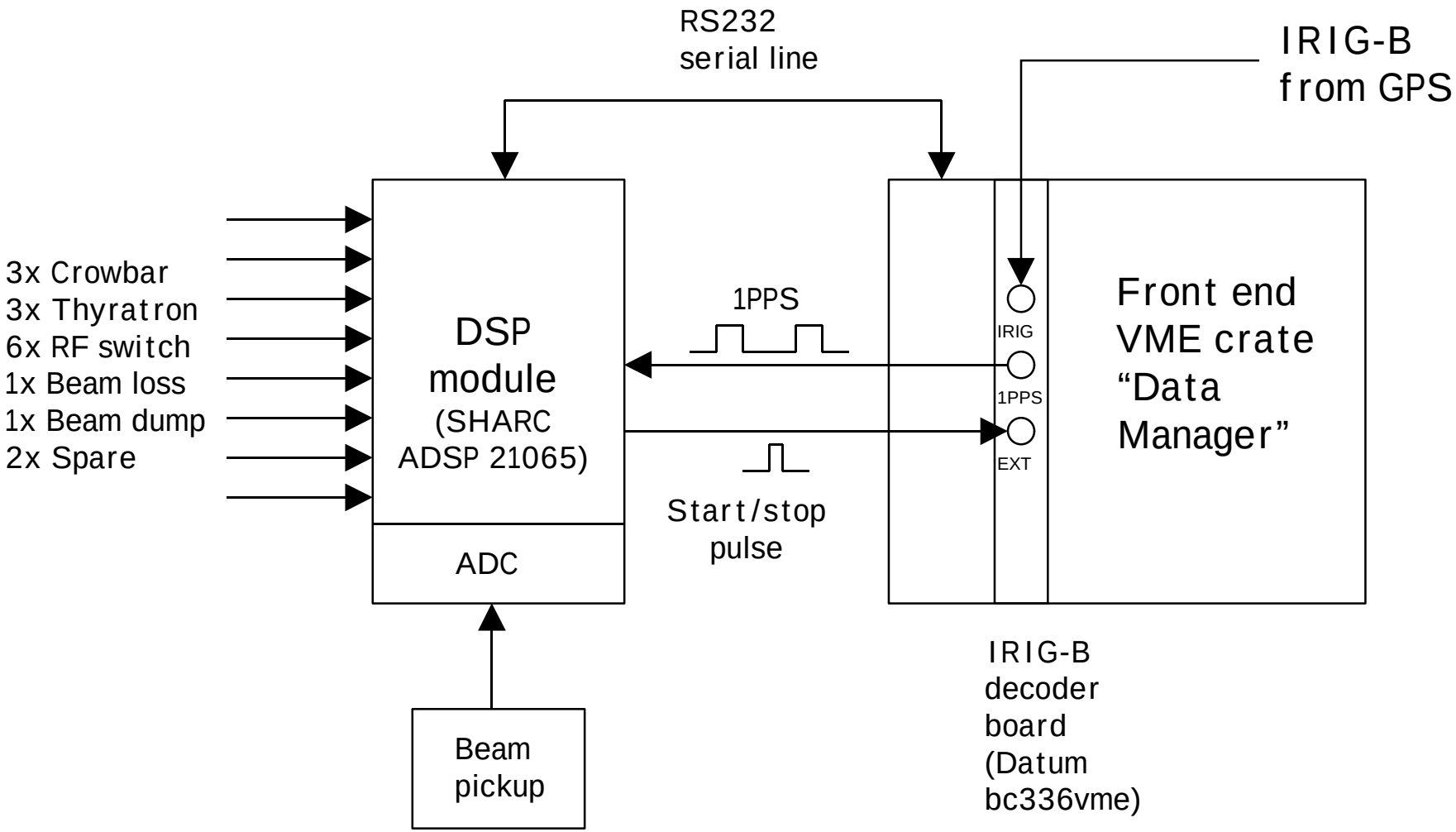
  → **~100μs precision is sufficient**

- **Data is**
  - **logged in ORACLE DB (for RF experts)**
  - **available in PCR (for operators)**

The solution

- **Use Time-of-Day (IRIG-B) synchronised to GPS distributed to each RF sector (SL/CO)**
  - **IRIG-B receiver in 1 RF front-end (Data Manager) per RF sector (LRF_232, LRF_272, LRF_432, ...)**
    - → **Total of 8 IRIG-B VME modules**
  - **Each IRIG-B module is used to synchronise a DSP board which timestamps trips from 3 RF units**
    - **1 MCB, 1 Crowbar, 2 RF switches per unit**
  - **Each DSP system also uses a pickup to monitor the beam current and timestamp the beam loss**

Hardware details



Software

- **Start of coast:** DSP start command sent via RS232
- DSP waits for next 1PPS and replies with start pulse → captured by IRIG module
- DSP polls 16 digital I/O lines + 1 ADC every 10μs
- DSP writes a record in memory at every change of state (or change in I_{beam} of > 100μA)
- Record is timestamped using the DSP's internal clock (resolution of 10μs, accurate to ~10ppm)
- DSP clock is resynchronised once per second using the 1PPS signal from the IRIG module (→10μs max. error)
- **After a beam loss:** DSP stop command sent via RS232
- DSP replies with stop pulse → captured by IRIG module
- State change history table read out of memory via RS232 and stored in ORACLE database
- Control room diagnostics generated from DB table

→ Correlation with alarm from slow diagnostics

RF fast diagnostics: the end result

Fill number: 7210

Date	Time	Relative ms	Unit	Event type	Current	
05/19	11:42:19.718	-8016.9	833_1	RF OFF		<----
05/19	11:42:27.720	-14.4	233_2	RF OFF		<----
05/19	11:42:27.734	0.0		Losing beam...	4028	
05/19	11:42:27.734	0.0		Current	3588	
05/19	11:42:27.734	0.1		Current	3140	
05/19	11:42:27.734	0.1		Current	2736	
05/19	11:42:27.735	0.1		Current	2268	
05/19	11:42:27.735	0.2		Current	1788	
05/19	11:42:27.735	0.2		Current	1336	
05/19	11:42:27.735	0.3		Current	900	
05/19	11:42:27.735	0.4		Current	480	
05/19	11:42:27.735	0.7		Current	76	
05/19	11:42:27.736	1.5	833_2	RF OFF		
05/19	11:42:27.737	2.5	473_1	RF OFF		
05/19	11:42:27.738	3.7	831_2	RF OFF		
05/19	11:42:27.740	5.1	632_2	RF OFF		
05/19	11:42:27.740	5.7	832_2	RF OFF		
05/19	11:42:27.741	6.4	672_1	RF OFF		
05/19	11:42:27.742	7.4	632_1	RF OFF		
05/19	11:42:27.743	8.5	432_2	RF OFF		
05/19	11:42:27.745	10.2	233_1	RF OFF		
05/19	11:42:27.745	10.7	432_1	RF OFF		
05/19	11:42:27.746	11.2		Current	0	
05/19	11:42:27.746	11.2	872_2	RF OFF		
05/19	11:42:27.747	13.0	871_1	RF OFF		
05/19	11:42:27.749	14.8	431_2	RF OFF		
05/19	11:42:27.751	16.7	872_1	RF OFF		
05/19	11:42:27.813	78.7	433_2	RF OFF		
05/19	11:42:27.823	88.1	471_1	RF OFF		
05/19	11:42:27.846	111.1	232_1	RF OFF		

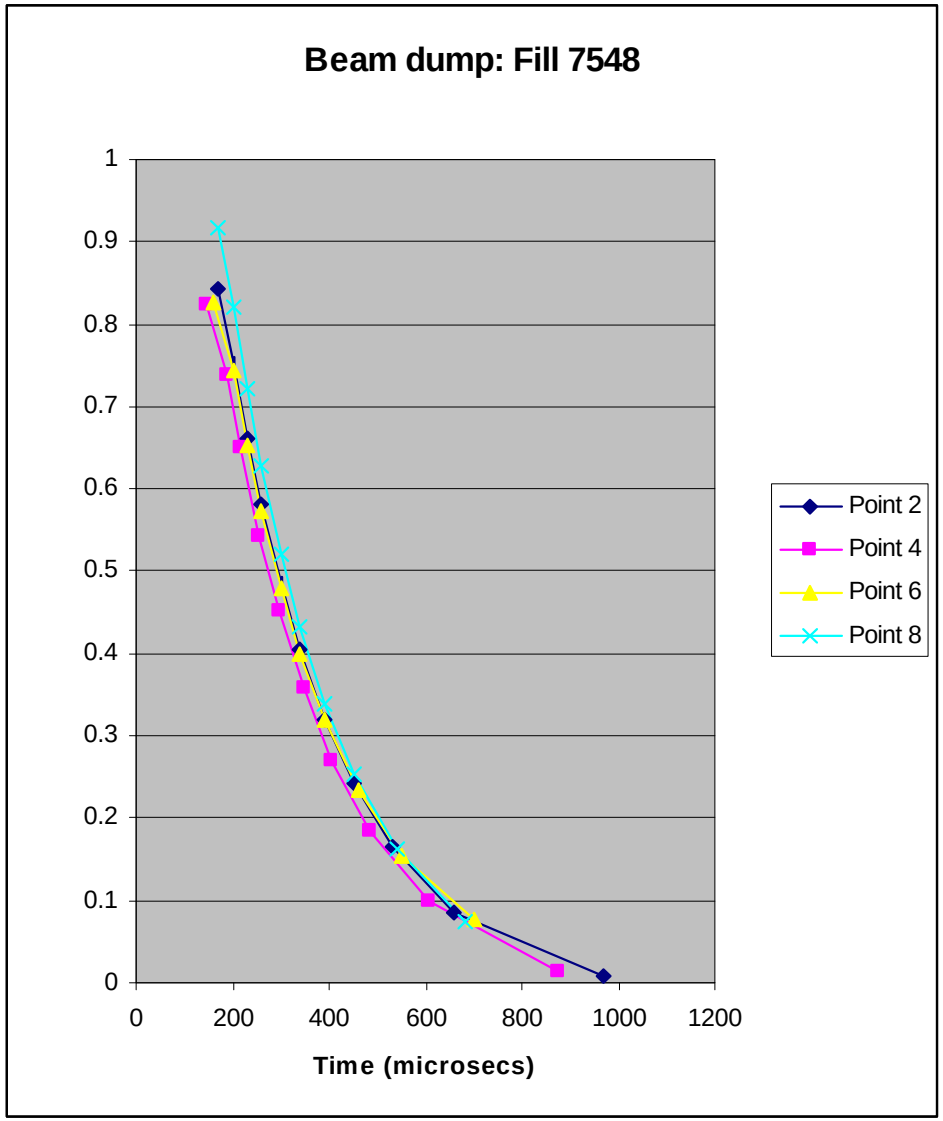
1 unit off since 8 seconds

2nd unit trips (RF beam dump trigger)

14 ms later the beam is dumped

Many units trip as a result of the beam loss

Timing check



- Look at the decay of beam current at a beam dump
- Timestamps at all IPs agree to within 30μs
- Limited by
  - DSP sampling rate
  - DSP clock drift
  - differences in integration time of current measurement electronics

→ More than adequate for our needs

In conclusion:

- The system was implemented using a “quick and easy” approach, but works very well
- It was installed and working for LEP high energy startup 2000
  - Some minor problems due to defects in the IRIG decoder board firmware took about 2 months to iron out
- Now an essential tool for RF system optimisation as we push for the highest possible energy