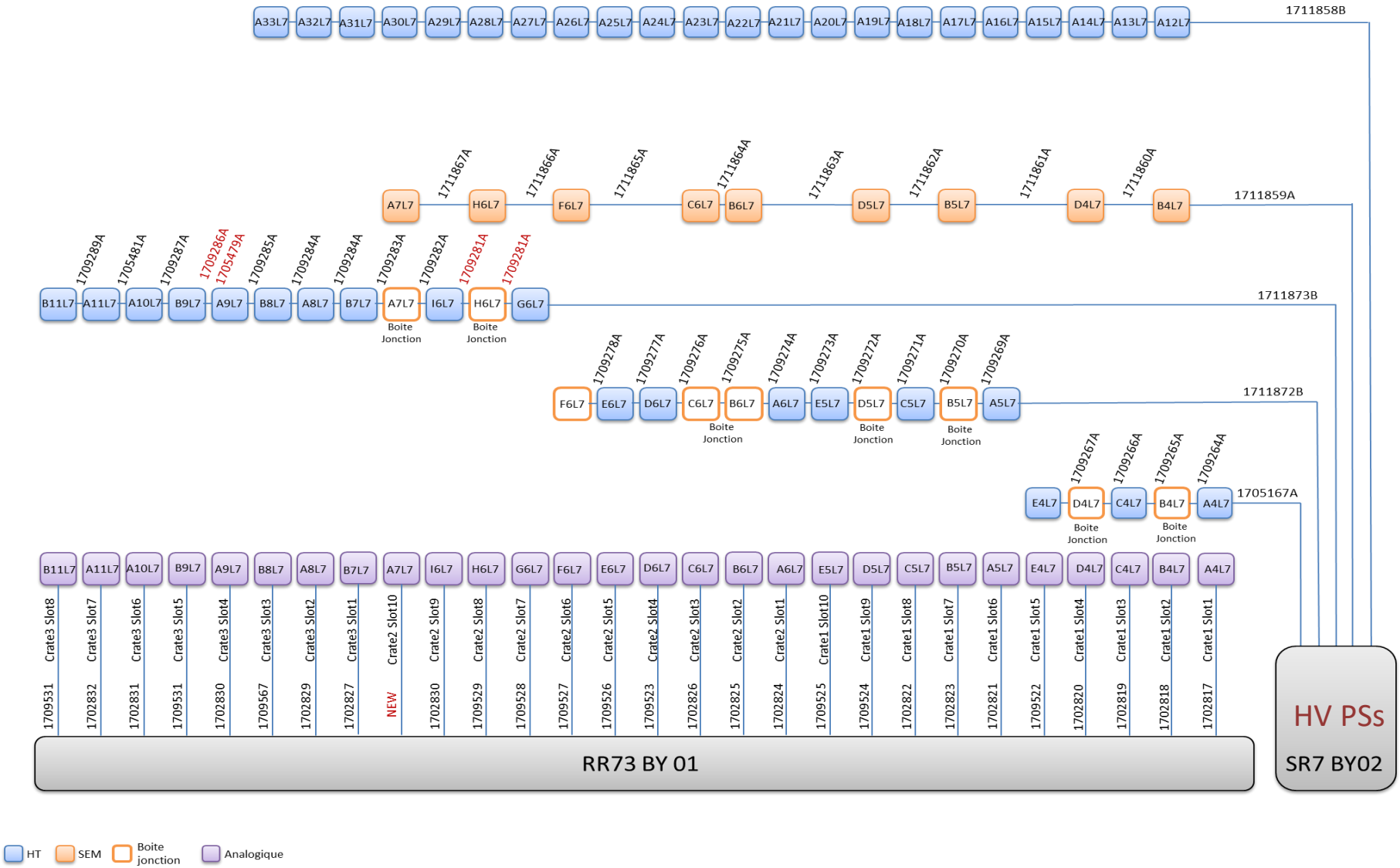
Proposal for modification of HV interlock

Ewald Effinger for BL section

Motivation for the changes in the BLM HV distribution

- HV cable cut in IP4 due to work on the surface (morning of 12.4.2011)
  -> Error wasn't detected, since check was not enabled!
  -> Problem detected with the sanity check (HV modulation)!
- HV Software interlock implemented (14.4.2011)
  -> reaction time of 10s on all racks
- Several beam dump trigger due to HV in 4.2011-7.2011
  -> Modification of the reaction time in center crates in IP3/7 to 60s (22.7.2011)
- SIS triggered after the BLM_SR7_C_HV_STATUS went to Fault [21/04/2012]
  -> Losses starting at 12:28 and continuously increasing until the dump
- SIS triggered after the BLM_SR7_C_HV_STATUS went to Fault [21/04/2012]
  -> Slow losses in IR7 on TCP.R7 for beam 2;
  -> Integration over long time provoked again a trip of HV on the BLM
  -> HV threshold on 10 BJBHT changed (TS#1)
- SIS triggered after the BLM_SR7_C_HV_STATUS went to Fault [19/06/2012]
  -> BLM high voltage through SIS interlock - high losses (but none reaching dump threshold) during MD
- SIS triggered after the BLM_SR7_C_HV_STATUS went to Fault [07/08/2012]
  -> SIS BLM HV-status interlock with high losses in P7 at end of squeeze
- SIS triggered after the BLM_SR7_C_HV_STATUS went to Fault [10/08/2012]
  -> The SB was dumped by the SIS HV BLM in IP7 due to the loss of CMS solenoid.
  -> Adding of suppressor diode and 10k resistor parallel to filter resistor! (TS#3)
- No trigger and HV warning detected in the modified HV boxes since change!
- Increase from 100kW to 500kW of continuous losses in IR 7
- Decrease quantity of warnings due to HV levels

HV distribution (e.g. IP7 left)



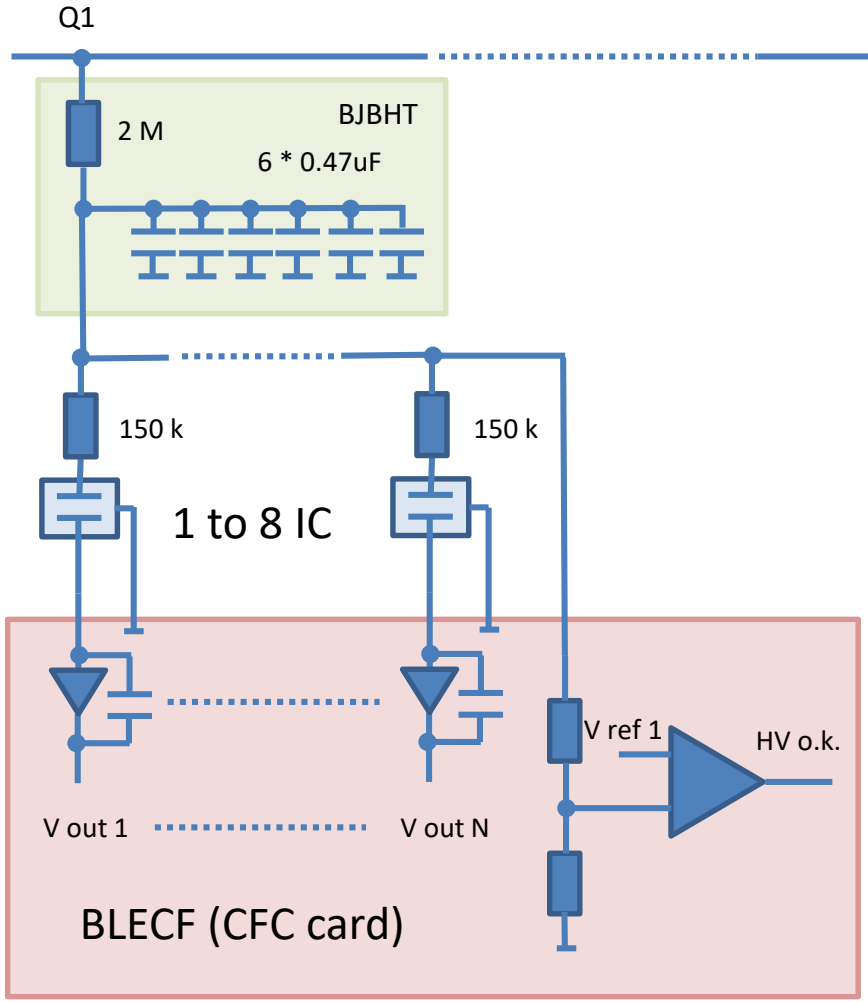
HV Supply in the surface building SR

- Two Henzinger HV supplies per IP
  - Specification V out = 0-3000V, I max = 20mA
  - One HV supply is operational ($V_{Nominal\ 1}$ = 1450V)
  - Second as backup HV ($V_{Nominal\ 2}$ = 1440V)
  - Maximal total current: $I_{HV\ max}$ = 40mA per IP => 740Gy/s

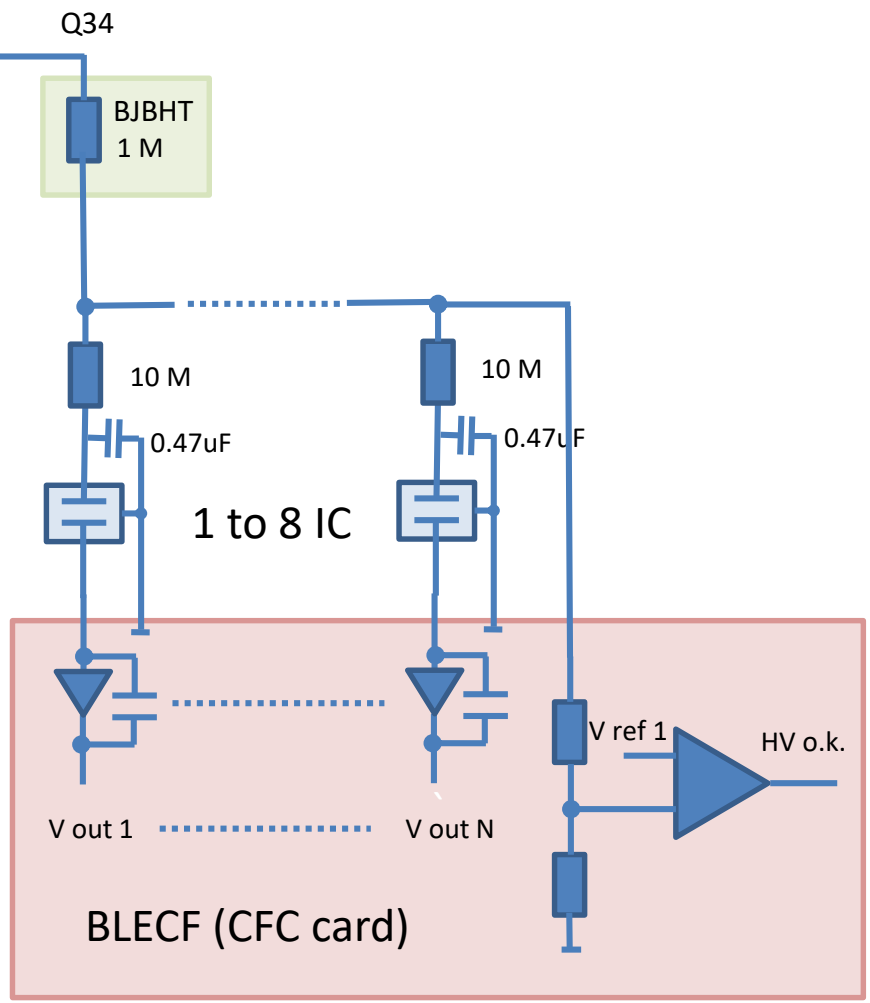
- Different HV nets are in place
  - Separation of low and high loss areas
  - Diodes used to separated HV nets (cross talk)

- HV is controlled by BLECS (combiner card)
  - Voltage and Current feedback of both supplies are monitored and logged!

Two different high voltage schemes

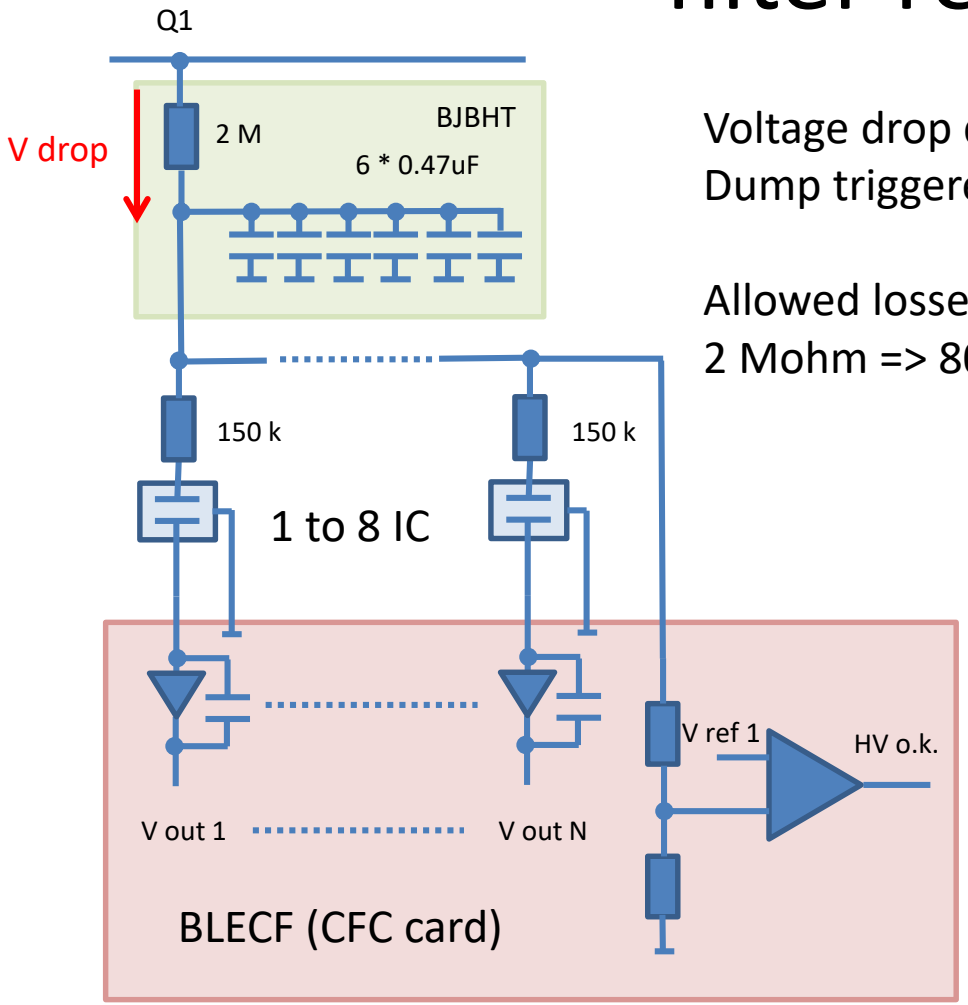


HV scheme in high radiation area (e.g. collimation)



Standard HV scheme (e.g. arc)

HV SIS trigger due to HV drop on the filter resistor



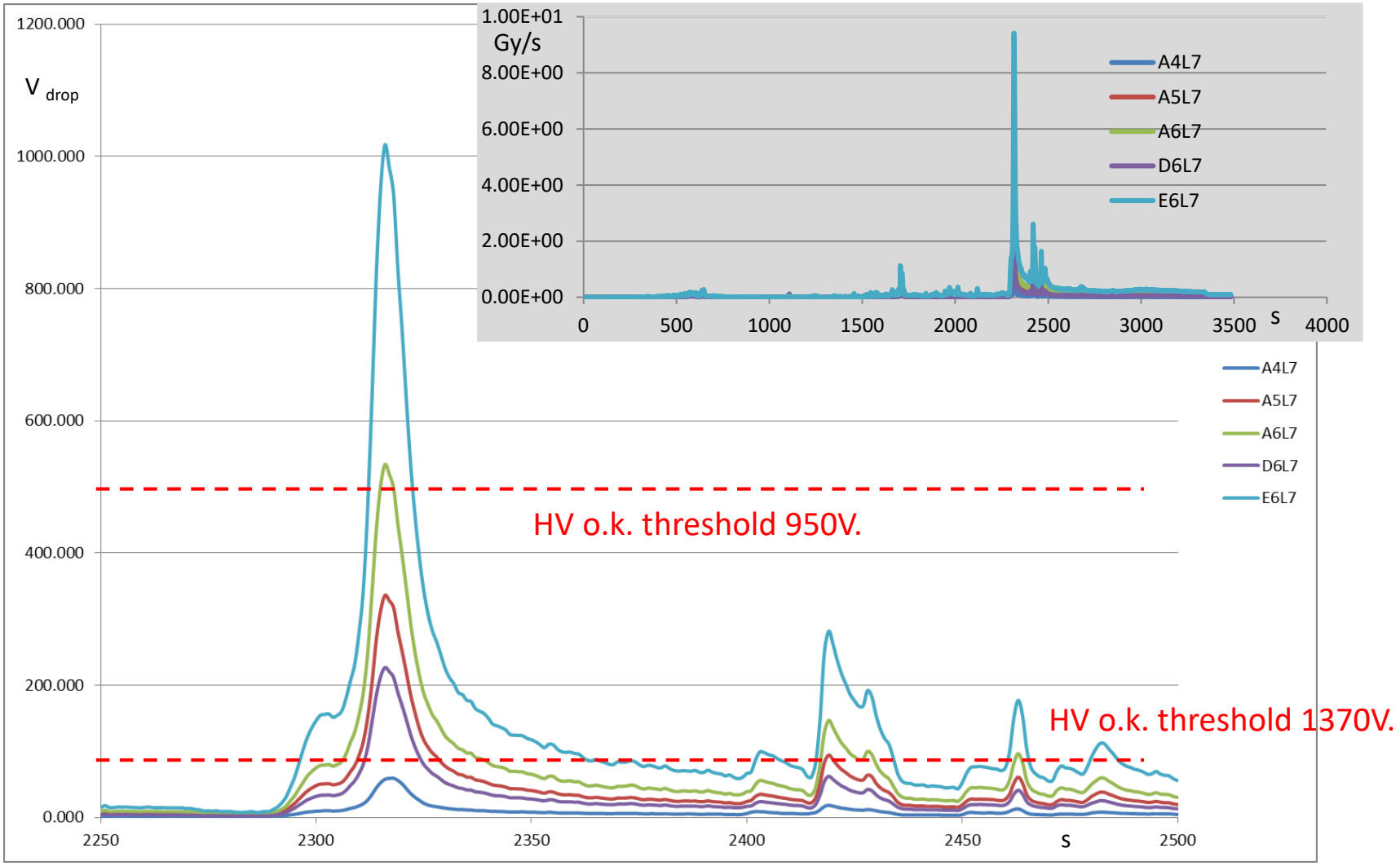
Voltage drop due to current in filter resistor
Dump triggered if V drop ≥ 80V for 10s or 60s

Allowed losses without dump trigger ! HV Th = 1370V
2 Mohm => 80V/2M = 40uA => 0.74Gy/s

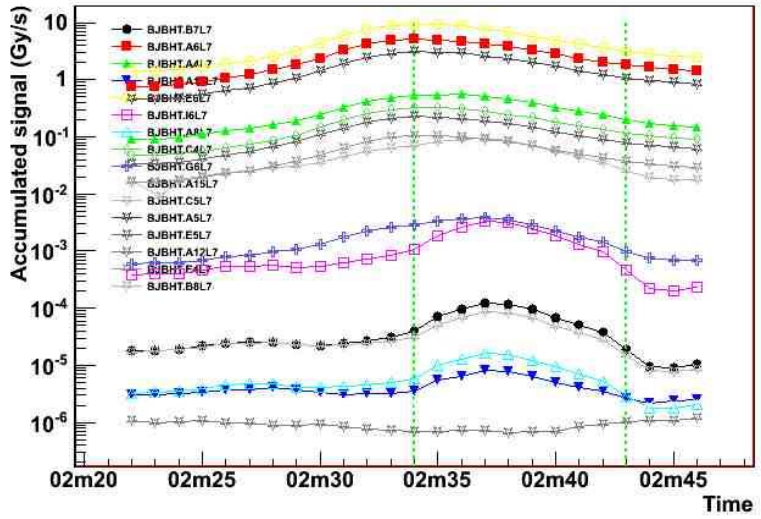
Maximum given due to design (theoretical, for 8 ICs!)
1450/(2M+18.75k) = 0,72mA => 13.2Gy/s
=> V drop = 1436V

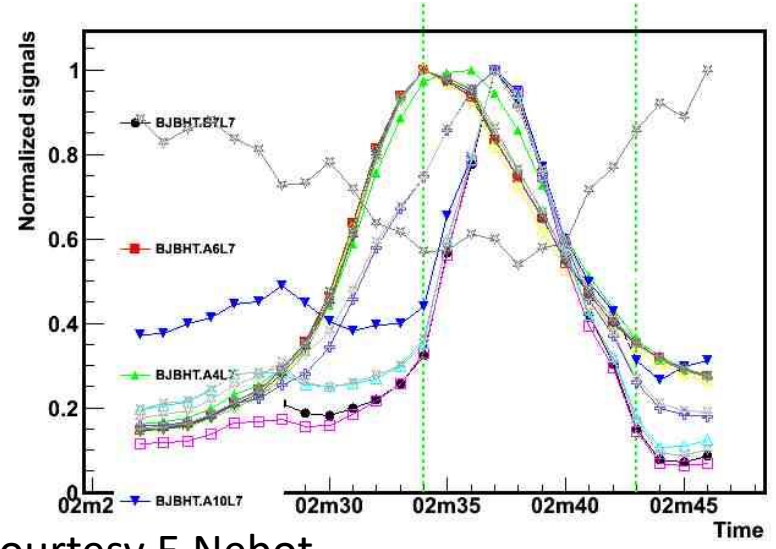
HV scheme in high radiation area (e.g. collimation)

Examples of the voltage drops during losses in IP7

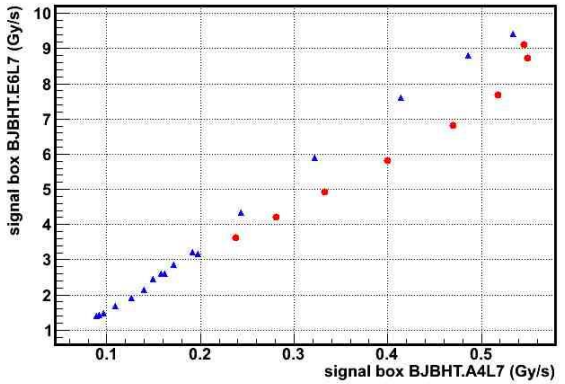


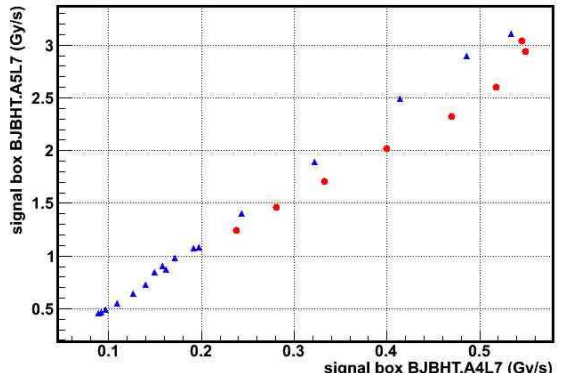
Behaviour of boxes with HV drop

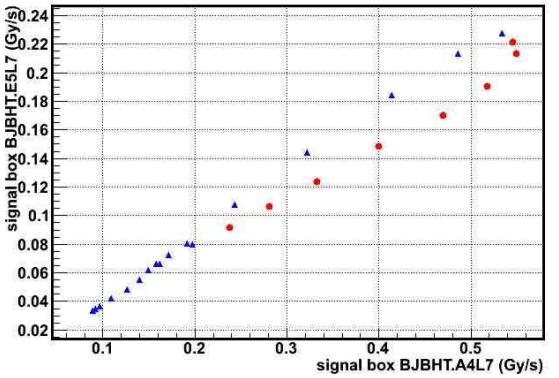




Courtesy E.Nebot



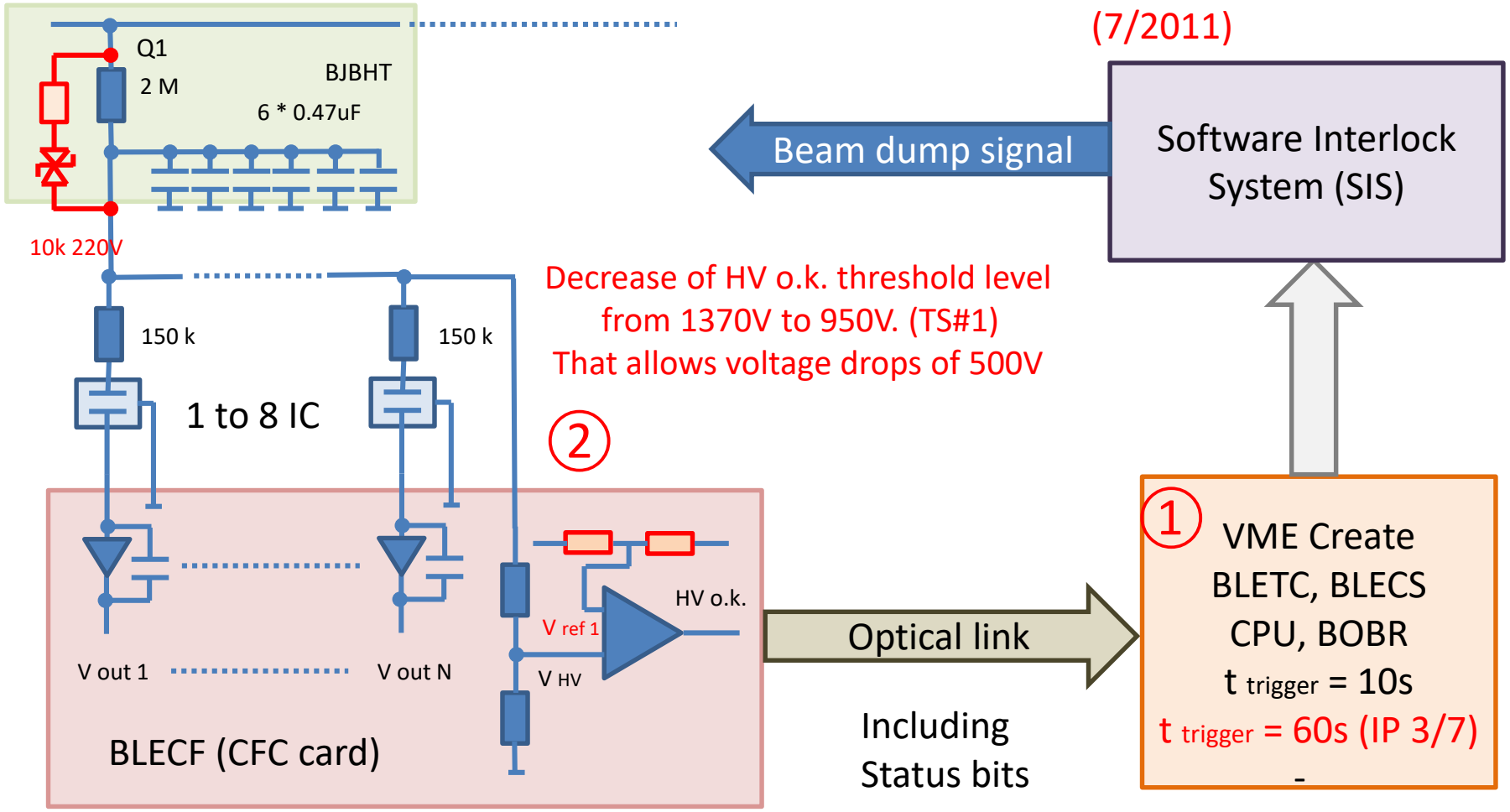




Changes done since the HV SIS beam dump enabled in April 2011

③ Limitation of voltage drops to 220V by a suppressor diode, with not disturbing the system (e.g. modulation). (TS#3)

Increase of time from 10s to 60 in the center creates (7/2011)



Situation with the 3 changes in dedicated high radiation areas (filter in the BJBHT, collimation)

Change 1: (delay time increase)
$t_{trigger}$ = 10s and $t_{trigger}$ = 60s

Change 2: (threshold change)
2 Mohm => 80V/2M = 40uA => 0.74Gy/s ; $HV_{Thres.}$ = 1370V
Allowed losses without dump trigger ! $HV_{Thres.}$ = 950V
2 Mohm => 500V/2M = 250uA => 4.62Gy/s

Change 3: (limitation of voltage drop)
Allowed losses without dump trigger ! HV Th = 950V
V_{10k} = 1450V - 220V - 950V = 280V
$I_{trigger}$ = 280V/10k = 28mA => 518Gy/s
I_{max} = (1470V-220V)/(10k + 18.75k) = 42mA => 792Gy/s

⇒Due to the three changes a local loss of 518Gy/s per BJBHT for a time of 60s is needed to trigger a beam dump! (up 8 LHCBLMs connected to 1 BJBHT)
Values of maximal loss location:
Threshold@4TeV for 500kW losses = 53-143Gy/s ≤ 518Gy/s
Measured Losses @4TeV at 200kW and scaled to 500kW = 36Gy/s ≤ 518Gy/s

Situation with the 2 changes in remaining areas (filter in the BJBHT, e.g. arc)

Change 1: (delay time increase)

$t_{trigger}$ = 10s

Change 2: (threshold change)

1 Mohm => 80V/1M = 80uA => 1.48Gy/s; $HV_{Thres.}$ = 1370V

Allowed losses without dump trigger ! $HV_{Thres.}$ = 950V

1 Mohm => 500V/1M = 500uA => 9.26Gy/s

I_{max} = 1450V/ (1M + 1.25M) = 644uA => 11.93Gy/s

=> Due to the two changes a local (8 LHCBLMs connected to 1 BJBHT) loss of 9.26Gy/s for a time of 10s is needed to trigger a beam dump!

Threshold in arc: 10mGy/s ≤ 9.26 Gy/s

Threshold in LSS (not in collimation) = 500mGy/s ≤ 9.26 Gy/s

Conclusion for HV distribution of the BLM System

a) SIS Dump request
- In IP 1,2,4,5,6,8 = 10s (under HV o.k level)
- In IP 3 and 7 = 60s (under HV o.k level)

b) Change of HV o.k. Threshold
- Changes of divider on all BLECF card (~750 cards in the tunnel) to have identic BLECFs
- Not sufficient for constant losses of 36Gy/s (=> 500kW), c) is needed!

c) Additional 220V suppressor diode and 20k resistor
- Modification dedicated (HV box with filer capacitors) area with high loss needed
- No influence on modulation test
- Voltage drop decreased
- Threshold@4TeV for 500kW losses = 53-143Gy/s ≤ 259Gy/s
- Measured Losses @4TeV at 200kW, scaled to 500kW = 36Gy/s ≤ 259Gy/s
- By using a 20k power dissipation is decreased in the diode and resistor
- No changes in FPGA firmware in the BLECS card

d) Failure mode for suppressor diode
- Diode becomes high- ohmic –> Situation like with a & b (dump trigger can occur)
- Diode has short-circuit –> Detected by modulation test!
- Protection of the machine is always ensured!
- Irradiation test for suppressor diode up to 1MGray foreseen

Additional Slides

Maximum Threshold

------ HV Box BJBHT.A4L7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.04L7.B2I10_TCSM.A4L7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.04L7.B2I10_TCSG.A4L7.B2	171106198	0.476464951354	2.57291073731e-05
BLMEI.04L7.B1E10_TCSG.B4L7.B1	171106198	0.476464951354	2.57291073731e-05
BLMEI.04L7.B1E10_TCSM.B4L7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.04L7.B1E10_TCSG.A4L7.B1	171106198	0.476464951354	2.57291073731e-05
BLMEI.04L7.B1E10_TCSM.A4L7.B1	8388608000	23.3590468923	0.00126138853218
Total	25679142594.0	0.00386135291867	71.506535531

------ HV Box BJBHT.A5L7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.05L7.B1E10_TCSG.B5L7.B1	1330812792	3.70580177465	0.000200113295831
BLMEI.05L7.B1E10_TCSM.B5L7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.05L7.B1E10_TCSG.A5L7.B1	1330812792	3.70580177465	0.000200113295831
BLMEI.05L7.B2I10_TCSM.B5L7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.05L7.B1E10_TCSM.A5L7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.05L7.B2I10_TCSG.B5L7.B2	1330812792	3.70580177465	0.000200113295831
BLMEI.05L7.B2I10_TCSM.A5L7.B2	8388608000	23.3590468923	0.00126138853218
Total	37546870376.0	0.00564589401623	104.553592893

------ HV Box BJBHT.A6L7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.06L7.B1E10_TCSM.B6L7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.06L7.B1E10_TCSG.A6L7.B1	1330812792	3.70580177465	0.000200113295831
BLMEI.06L7.B1E10_TCSM.A6L7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.06L7.B2I10_TCLA.A6L7.B2	2455659196	6.83806637655	0.000369255584334
BLMEI.06L7.B2I10_TCSM.6L7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.06L7.B2I10_TCSG.6L7.B2	1330812792	3.70580177465	0.000200113295831
Total	30283108780.0	0.00455364777255	84.3268106028

------ HV Box BJBHT.D6L7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.06L7.B2I10_TCLA.B6L7.B2	2455659196	6.83806637655	0.000369255584334
BLMEI.06L7.B1E10_MBW.B6L7	8388608000	23.3590468923	0.00126138853218
BLMEI.06L7.B1E10_MBW.A6L7	8388608000	23.3590468923	0.00126138853218
Total	19232875196.0	0.0028920326487	53.5561601612

------ HV Box BJBHT.E6L7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.06L7.B1E10_TCP.D6L7.B1	1520928641	4.23520129263	0.000228700869802
BLMEI.06L7.B1E10_TCP.C6L7.B1	1520928641	4.23520129263	0.000228700869802
BLMEI.06L7.B1E10_TCP.B6L7.B1	1520928641	4.23520129263	0.000228700869802
BLMEI.06L7.B1E10_TCP.A6L7.B1	633721403	1.76467036835	9.52921998911e-05
BLMEI.06L7.B1E10_TCHSV.6L7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.06L7.B1E10_TCHSH.6L7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.06L7.B1E10_TCHSS.6L7.B1	8388608000	23.3590468923	0.00126138853218
Total	30362331326.0	0.00456556040585	84.5474149232

------ HV Box BJBHT.A4R7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.04R7.B1E10_TCSG.A4R7.B1	171106198	0.476464951354	2.57291073731e-05
BLMEI.04R7.B1E10_TCSM.A4R7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.04R7.B2I10_TCSM.A4R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.04R7.B2I10_TCSG.A4R7.B2	171106198	0.476464951354	2.57291073731e-05
BLMEI.04R7.B2I10_TCSM.B4R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.04R7.B2I10_TCSG.B4R7.B2	171106198	0.476464951354	2.57291073731e-05
Total	25679142594.0	0.00386135291867	71.506535531

------ HV Box BJBHT.A5R7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.05R7.B1E10_TCSM.A5R7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.05R7.B1E10_TCSG.B5R7.B1	1330812792	3.70580177465	0.000200113295831
BLMEI.05R7.B1E10_TCSM.B5R7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.05R7.B2I10_TCSM.A5R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.05R7.B2I10_TCSG.A5R7.B2	1330812792	3.70580177465	0.000200113295831
BLMEI.05R7.B2I10_TCSM.B5R7.B2	8388608000	23.3590468923	0.00126138853218
Total	36216057584.0	0.0054457807204	100.847791119

------ HV Box BJBHT.A6R7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.06R7.B1E10_TCSG.6R7.B1	1330812792	3.70580177465	0.000200113295831
BLMEI.06R7.B1E10_TCSM.6R7.B1	8388608000	23.3590468923	0.00126138853218
BLMEI.06R7.B1E10_TCLA.A6R7.B1	2455659196	6.83806637655	0.000369255584334
BLMEI.06R7.B2I10_TCSM.A6R7.B2	8388608000	23.3590468923	0.00126138853218
Total	20563687988.0	0.00309214594453	57.2619619358

------ HV Box BJBHT.C6R7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.06R7.B2I10_TCSG.A6R7.B2	1330812792	3.70580177465	0.000200113295831
BLMEL.06R7.B2I20_TCSG.A6R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEL.06R7.B2I21_TCSG.A6R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEL.06R7.B2I22_TCSG.A6R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.06R7.B2I10_TCSM.B6R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.06R7.B2I10_MBW.A6R7	8388608000	23.3590468923	0.00126138853218
BLMEI.06R7.B2I10_MBW.B6R7	8388608000	23.3590468923	0.00126138853218
Total	51662460792.0	0.00776844448894	143.860083128

------ HV Box BJBHT.E6R7

BLMNAME	Threshold(BITST)	Threshold(Gy/s)	Threshold(A)
BLMEI.06R7.B1E10_TCLA.B6R7.B1	2455659196	6.83806637655	0.000369255584334
BLMEI.06R7.B2I10_TCHSS.6R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.06R7.B2I10_TCHSH.6R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.06R7.B2I10_TCHSV.6R7.B2	8388608000	23.3590468923	0.00126138853218
BLMEI.06R7.B2I10_TCP.A6R7.B2	633721403	1.76467036835	9.52921998911e-05
BLMEI.06R7.B2I10_TCP.B6R7.B2	1520928641	4.23520129263	0.000228700869802
BLMEI.06R7.B2I10_TCP.C6R7.B2	1520928641	4.23520129263	0.000228700869802
BLMEI.06R7.B2I10_TCP.D6R7.B2	1520928641	4.23520129263	0.000228700869802
Total	32817990522.0	0.00493481599019	91.3854812997

Measured losses while HV warning

TimeStamp	BJBHT.A4L7		BJBHT.A5L7		BJBHT.A6L7		BJBHT.D6L7		BJBHT.E6L7		BJBHT.A4R7		BJBHT.A5R7		BJBHT.A6R7		BJBHT.C6R7		BJBHT.E6R7	
	Gy/s	A	Gy/s	A	Gy/s	A	Gy/s	A	Gy/s	A	Gy/s	A	Gy/s	A	Gy/s	A	Gy/s	A	Gy/s	A
05/06/2012 12:22:11	1.78E-01	9.63E-06	2.31E-01	1.25E-05	4.33E-01	2.34E-05	2.11E-01	1.14E-05	4.99E-01	2.70E-05	2.48E-01	1.34E-05	1.69E+00	9.10E-05	2.61E+00	1.41E-04	1.09E+00	5.88E-05	4.79E+00	2.58E-04
05/13/2012 01:28:51	2.73E-01	1.48E-05	4.77E-01	2.58E-05	8.49E-01	4.58E-05	3.97E-01	2.15E-05	7.87E-01	4.25E-05	3.25E-01	1.76E-05	1.78E+00	9.63E-05	3.36E+00	1.81E-04	1.54E+00	8.32E-05	5.59E+00	3.02E-04
05/25/2012 01:03:06	3.65E-01	1.97E-05	1.31E+00	7.06E-05	2.24E+00	1.21E-04	1.05E+00	5.67E-05	3.48E+00	1.88E-04	4.78E-01	2.58E-05	1.91E+00	1.03E-04	2.74E+00	1.48E-04	1.12E+00	6.06E-05	4.94E+00	2.67E-04
06/01/2012 11:01:40	1.93E-01	1.04E-05	1.61E-01	8.71E-06	2.44E-01	1.32E-05	1.11E-01	6.00E-06	3.36E-01	1.82E-05	2.23E-01	1.21E-05	1.33E+00	7.18E-05	2.51E+00	1.36E-04	1.17E+00	6.33E-05	4.22E+00	2.28E-04
06/01/2012 13:29:16	1.78E-01	9.62E-06	3.34E-01	1.80E-05	5.48E-01	2.96E-05	2.44E-01	1.32E-05	8.93E-01	4.82E-05	2.20E-01	1.19E-05	1.29E+00	6.97E-05	1.96E+00	1.06E-04	8.33E-01	4.50E-05	4.11E+00	2.22E-04
06/05/2012 06:40:41	1.55E-01	8.40E-06	2.94E-01	1.59E-05	5.15E-01	2.78E-05	2.48E-01	1.34E-05	5.84E-01	3.15E-05	2.09E-01	1.13E-05	1.37E+00	7.38E-05	2.08E+00	1.12E-04	8.92E-01	4.82E-05	4.17E+00	2.25E-04
06/09/2012 09:38:53	1.59E-01	8.60E-06	9.92E-02	5.36E-06	1.45E-01	7.85E-06	6.95E-02	3.75E-06	1.73E-01	9.33E-06	2.13E-01	1.15E-05	1.41E+00	7.61E-05	2.13E+00	1.15E-04	9.13E-01	4.93E-05	4.18E+00	2.26E-04
06/14/2012 13:58:07	2.63E-01	1.42E-05	1.90E-01	1.02E-05	2.85E-01	1.54E-05	1.44E-01	7.76E-06	3.29E-01	1.78E-05	3.69E-01	1.99E-05	2.30E+00	1.24E-04	3.57E+00	1.93E-04	1.44E+00	7.80E-05	6.72E+00	3.63E-04
06/16/2012 20:05:33	2.01E-01	1.08E-05	1.98E-01	1.07E-05	3.52E-01	1.90E-05	1.65E-01	8.92E-06	4.56E-01	2.46E-05	2.74E-01	1.48E-05	1.77E+00	9.55E-05	2.67E+00	1.44E-04	1.12E+00	6.03E-05	5.22E+00	2.82E-04
06/19/2012 23:51:47	1.37E-01	7.42E-06	6.01E-02	3.25E-06	9.83E-03	5.31E-07	6.24E-04	3.37E-08	5.63E-04	3.04E-08	1.52E-01	8.20E-06	9.04E-01	4.88E-05	1.51E+00	8.14E-05	6.47E-01	3.49E-05	3.44E+00	1.86E-04
06/23/2012 20:50:24	1.38E-01	7.48E-06	6.79E-02	3.67E-06	4.45E-02	2.40E-06	3.36E-03	1.82E-07	2.46E-03	1.33E-07	1.89E-01	1.02E-05	1.24E+00	6.67E-05	1.84E+00	9.91E-05	7.79E-01	4.21E-05	3.71E+00	2.00E-04
07/03/2012 14:34:36	2.55E-01	1.38E-05	1.49E-01	8.02E-06	1.62E-01	8.73E-06	7.23E-02	3.90E-06	1.88E-01	1.01E-05	3.49E-01	1.88E-05	2.30E+00	1.24E-04	3.45E+00	1.86E-04	1.51E+00	8.18E-05	7.13E+00	3.85E-04
07/03/2012 17:44:05	1.78E-01	9.63E-06	1.31E-01	7.07E-06	1.75E-01	9.47E-06	8.16E-02	4.41E-06	1.79E-01	9.67E-06	2.41E-01	1.30E-05	1.57E+00	8.47E-05	2.37E+00	1.28E-04	1.04E+00	5.61E-05	4.97E+00	2.68E-04
07/04/2012 09:31:01	2.12E-01	1.14E-05	5.04E-01	2.72E-05	7.63E-01	4.12E-05	2.89E-01	1.56E-05	1.39E+00	7.50E-05	2.62E-01	1.41E-05	1.42E+00	7.69E-05	2.72E+00	1.47E-04	1.29E+00	6.97E-05	4.81E+00	2.60E-04
07/06/2012 01:29:22	3.18E-01	1.72E-05	4.11E-01	2.22E-05	6.88E-01	3.71E-05	3.24E-01	1.75E-05	8.23E-01	4.44E-05	3.94E-01	2.13E-05	2.32E+00	1.25E-04	4.34E+00	2.34E-04	2.04E+00	1.10E-04	7.54E+00	4.07E-04
07/14/2012 04:01:57	3.89E-01	2.10E-05	4.37E-01	2.36E-05	7.96E-01	4.30E-05	3.82E-01	2.06E-05	8.88E-01	4.79E-05	5.43E-01	2.93E-05	3.58E+00	1.93E-04	5.38E+00	2.91E-04	2.34E+00	1.27E-04	1.11E+01	5.98E-04
07/20/2012 22:25:37	2.95E-01	1.59E-05	1.93E-01	1.04E-05	1.92E-01	1.03E-05	7.27E-02	3.93E-06	1.71E-01	9.26E-06	3.98E-01	2.15E-05	2.59E+00	1.40E-04	3.90E+00	2.10E-04	1.70E+00	9.16E-05	7.97E+00	4.30E-04
07/21/2012 01:03:23	4.07E-01	2.20E-05	1.96E-01	1.06E-05	1.36E-01	7.34E-06	4.00E-02	2.16E-06	8.15E-02	4.40E-06	5.51E-01	2.98E-05	3.68E+00	1.98E-04	5.52E+00	2.98E-04	2.44E+00	1.32E-04	1.16E+01	6.25E-04
07/21/2012 06:41:39	3.81E-01	2.06E-05	1.73E-01	9.32E-06	1.27E-01	6.87E-06	5.20E-02	2.81E-06	1.43E-01	7.72E-06	5.06E-01	2.73E-05	3.51E+00	1.89E-04	5.36E+00	2.89E-04	2.35E+00	1.27E-04	1.10E+01	5.92E-04
08/03/2012 03:42:44	3.97E-01	2.14E-05	7.49E-01	4.04E-05	1.14E+00	6.14E-05	4.64E-01	2.50E-05	1.77E+00	9.56E-05	5.29E-01	2.86E-05	2.65E+00	1.43E-04	4.61E+00	2.49E-04	2.15E+00	1.16E-04	8.63E+00	4.66E-04
08/03/2012 09:15:03	2.32E-01	1.25E-05	6.22E-01	3.36E-05	9.59E-01	5.18E-05	3.57E-01	1.93E-05	1.75E+00	9.43E-05	2.73E-01	1.48E-05	1.77E+00	9.57E-05	3.40E+00	1.84E-04	1.65E+00	8.90E-05	6.01E+00	3.25E-04
08/07/2012 02:40:52	2.54E-01	1.37E-05	5.54E-01	2.99E-05	1.01E+00	5.46E-05	4.67E-01	2.52E-05	1.08E+00	5.83E-05	3.36E-01	1.81E-05	1.86E+00	1.01E-04	2.75E+00	1.49E-04	1.20E+00	6.46E-05	5.67E+00	3.06E-04
08/09/2012 20:15:02	3.42E-01	1.85E-05	4.39E-01	2.37E-05	6.28E-01	3.39E-05	2.79E-01	1.51E-05	7.85E-01	4.24E-05	4.14E-01	2.23E-05	2.37E+00	1.28E-04	4.68E+00	2.53E-04	2.28E+00	1.23E-04	9.97E+00	5.38E-04
08/10/2012 08:19:02	2.81E-01	1.52E-05	2.44E-01	1.32E-05	2.79E-01	1.50E-05	9.76E-02	5.27E-06	3.19E-01	1.72E-05	3.80E-01	2.05E-05	2.41E+00	1.30E-04	3.71E+00	2.00E-04	1.60E+00	8.61E-05	7.81E+00	4.22E-04
09/08/2012 19:10:37	4.42E-01	2.39E-05	2.72E+00	1.47E-04	4.42E+00	2.39E-04	1.70E+00	9.19E-05	7.56E+00	4.08E-04	7.00E-01	3.78E-05	4.11E-01	2.22E-05	6.21E-01	3.35E-05	2.61E-01	1.41E-05	1.23E+00	6.63E-05
09/08/2012 22:18:50	5.11E-01	2.76E-05	3.17E+00	1.71E-04	4.98E+00	2.69E-04	1.88E+00	1.01E-04	8.77E+00	4.74E-04	8.14E-01	4.40E-05	1.05E+00	5.69E-05	1.82E+00	9.84E-05	8.55E-01	4.62E-05	3.52E+00	1.90E-04

Calculation for 220V suppressor and 20k

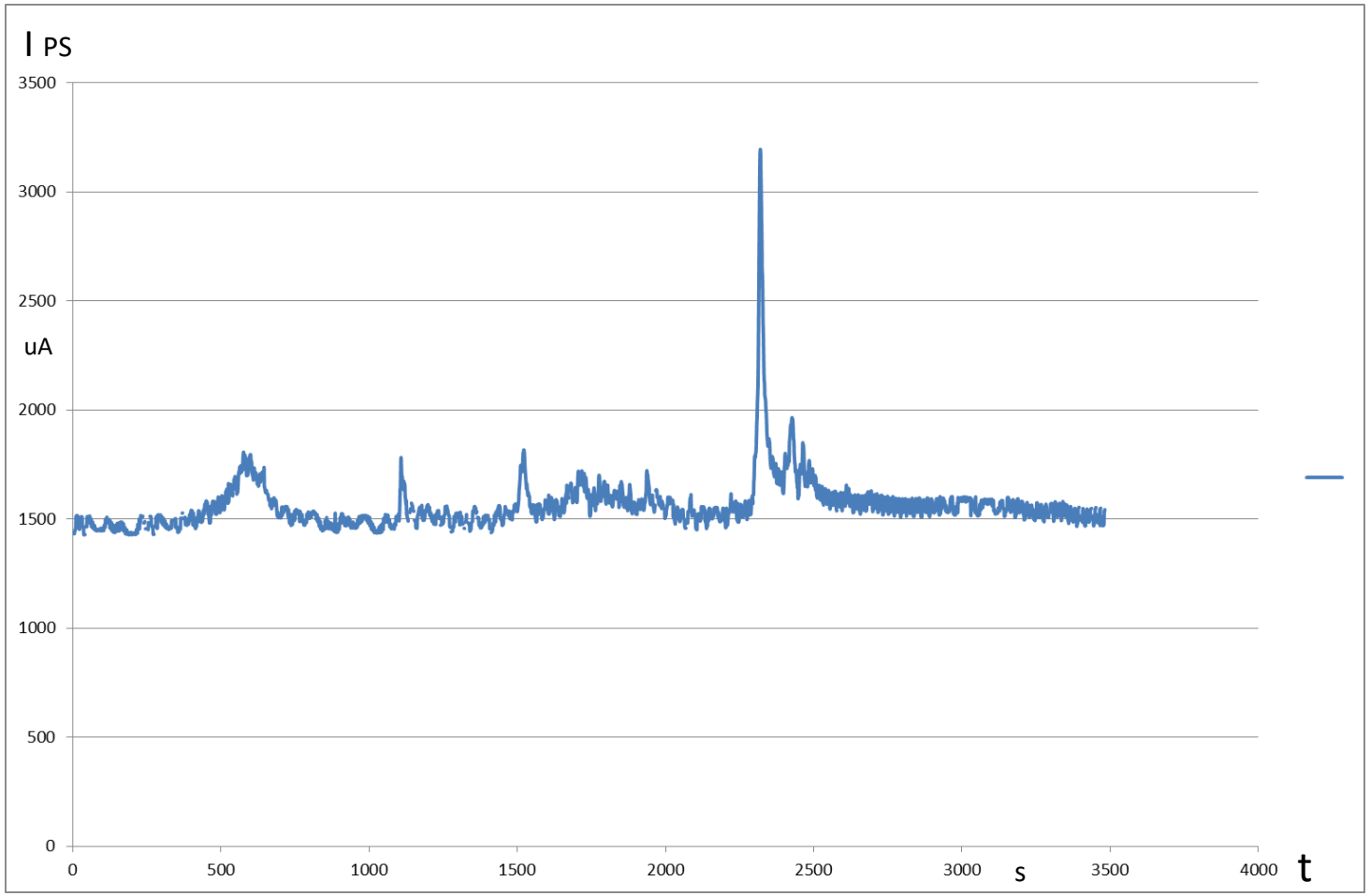
Change 3: 220V suppressor diode and 20k resistor
Allowed losses without dump trigger ! HV Th = 950V
V_{20k} = 1450V - 220V - 950V = 280V
$I_{trigger}$ = 280V/20k = 14mA => 259Gy/s
I_{max} = (1470V-220V)/(20k + 18.75k) = 32.2mA => 597Gy/s

Due to the three changes a local loss of 259Gy/s for a time of 60s is needed to trigger a beam dump! (up 8 LHCBLMs connected to 1 BJBHT)

Threshold@4TeV for 500kW losses = 53-143Gy/s ≤ 259Gy/s

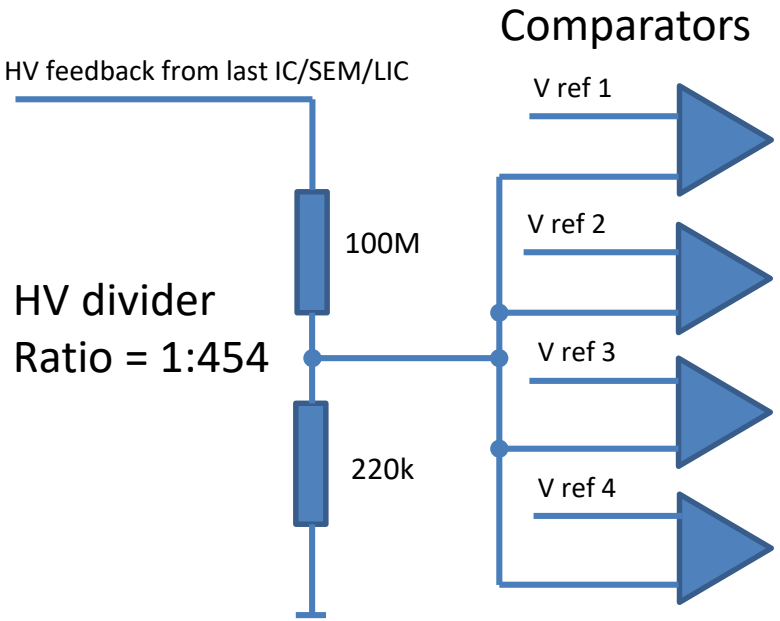
Measured Losses @4TeV at 200kW and scaled to 500kW = 36Gy/s ≤ 259Gy/s

Current in the high voltage supply in point 7



HV monitoring with comparator in the BLECF (CFC card)

- Nominal HV ≈ 1450V (IP depending see table below)
- Average margin of = 80V (Divider tolerance depending see drawing below)



- HV o.k. = 1370V (3.007V)
- HV o.k . = 950V (2.107V)
- HV nom = 1450V
- Test CFC = 1580V (3.468V)
- HV test = 1655V
- DAC RST = 1740V (3.820V)
- HV DAC = 1825V
- GOH RST = 1915V (4.204V)
- HV GOH = 2000V

HV levels per IP

Command	HV nominal		TEST_CFC		DAC_RST		GOH_RST				FPGA_RST				HV Startlevel		Resuts from Scan
Duration	240s		240s		240s		240s				20min (15min + 240s to enter in GOH_RST)				for Scan		on the
Value	[V]	bits	[V]	bits	[V]	bits	[V] min	bits	[V] nom	bits	[V] min	bits	[V]	bits	[V]	bits	
IP1	1445	31566		0	1806.7	39467		0		0		0		0	1200	26214	
IP2	1454	31763	1638	35782	1800	39321	1984	43340	2000	43690	1984	43340	2000	43690	1200	26214	16.09.09
IP3	1453.63	31755	1639.67	35819	1807.63	39488	1972.61	43092	2000	43690	1972.61	43092	2000	43690	1200	26214	22.09.09
IP4	1431.6	31273	1615.56	35292	1784.52	38983	1990.25	43477	2000	43690	1990.25	43477	2000	43690	1200	26214	02.10.09
IP5	1456.77	31823	1642.3	35876	1807.7	39489	1977.35	43195	2000	43690	1977.35	43195	2000	43690	1200	26214	31.08.09
IP6	1459.94	31892	1648.7	36016	1816.07	39672	1984.31	43347	2000	43690	1984.31	43347	2000	43690	1200	26214	02.10.09
IP7	1440.27	31463	1624.2	35481	1789.16	39084	1974.04	43123	2000	43690	1974.04	43123	2000	43690	1200	26214	12.10.09
IP8	1441.38	31487	1621.53	35422	1748.02	38185	1964.37	42912	2000	43690	1964.37	42912	2000	43690	1200	26214	02.10.09

Improvement of HV levels with new HV divider (foreseen to exchange all HV dividers while LS1)