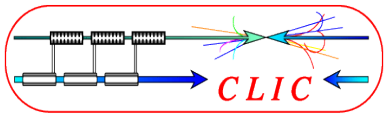
PETS TESTING ANALYSIS

4th X-band Structure Collaboration Meeting

3rd May 2010

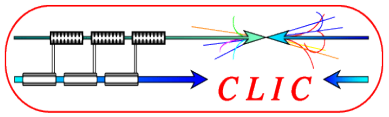
Alessandro Cappelletti for CLIC collaboration



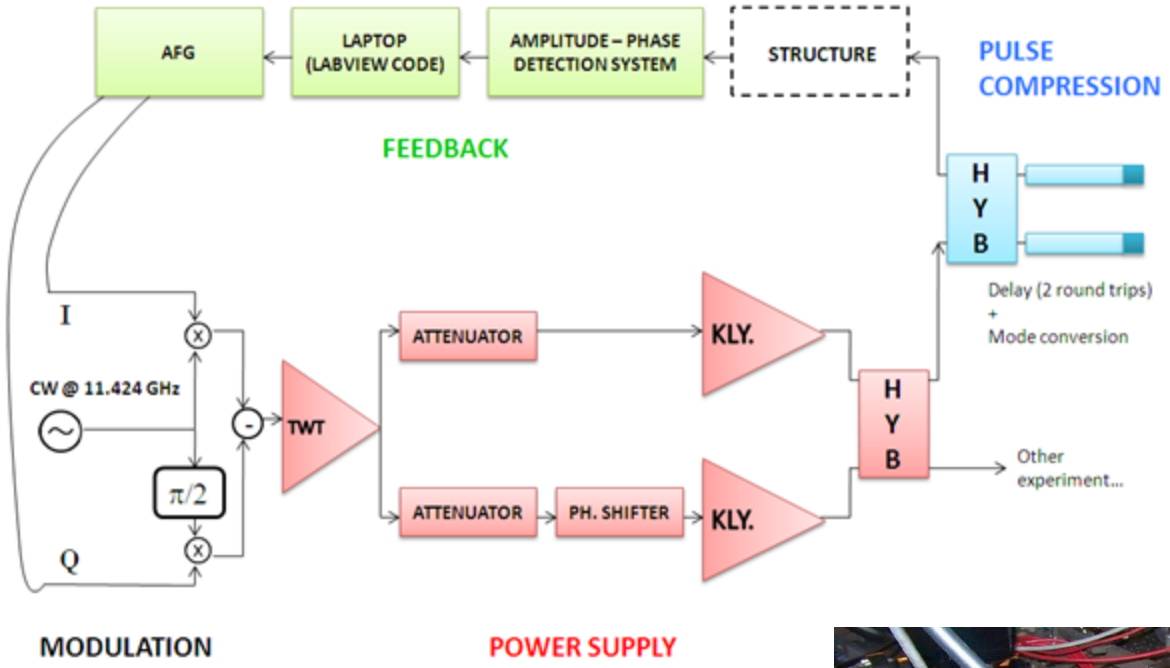
OUTLINE

- The PETS should generate **133 MWx240ns** pulses from the **12 GHz**, **100 A** drive beam and deliver this power to the main beam accelerating structure.

- Summary of the PETS processing
  - CERN - Beam driven
    - *CTF3*
  - SLAC - Klystron driven (up to 300MW, 60Hz rep. rate)
    - *High power processing performed by S. Tantawi, J. Lewandowski, A. Vlieks, J. Zelinski, V. Dolgashev with great support from the SLAC klystron Lab.*

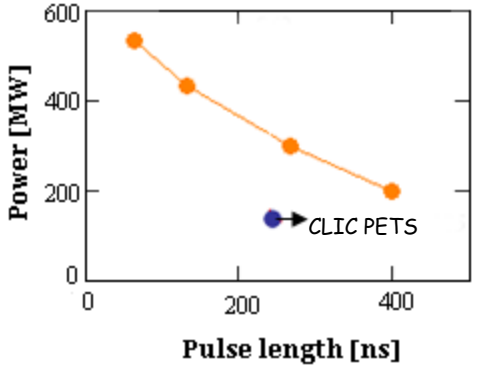


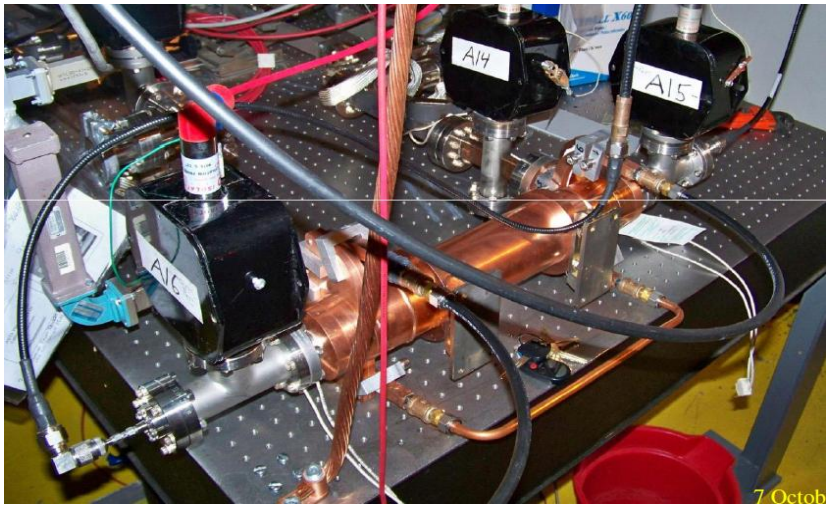
SLAC – Experiment layout



ASTA. General purpose test stand. Allows to process diverse high RF power equipment at X-band. The facility can provide pulse length and power level very flexibly.

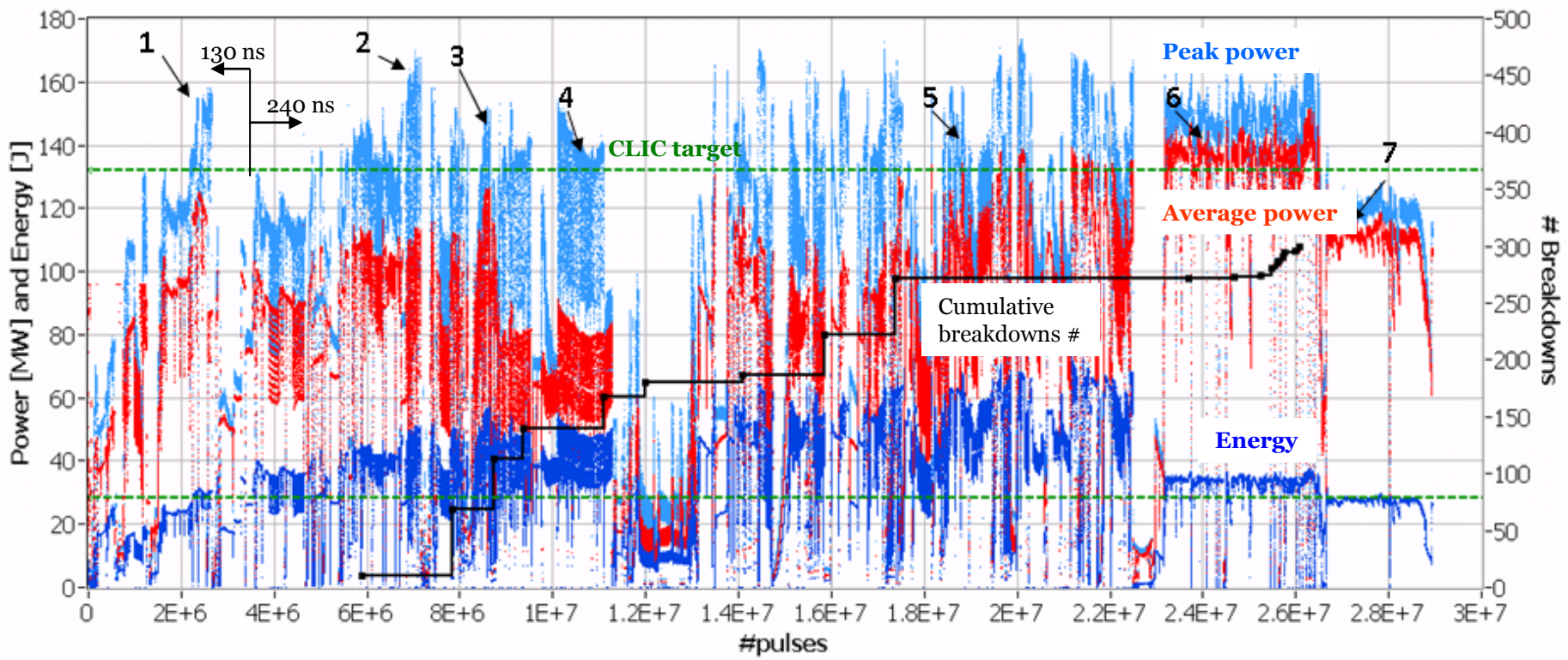
RF pulse @ power in the ASTA compressed arm

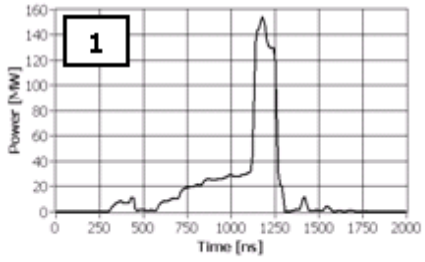


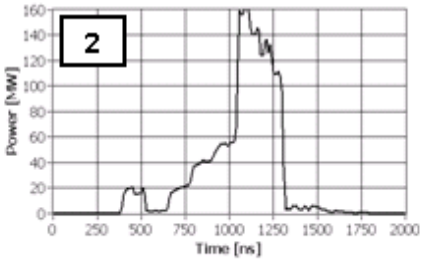


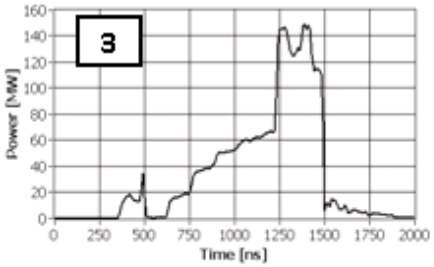
CLIC

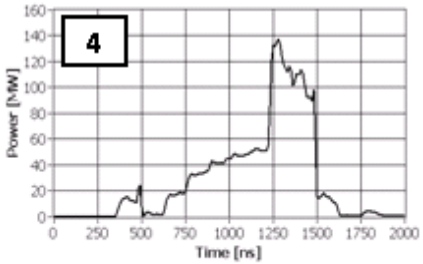
CERN

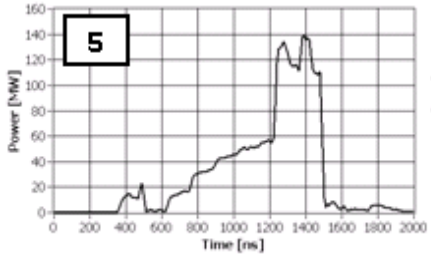


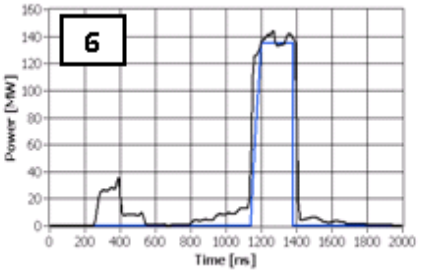


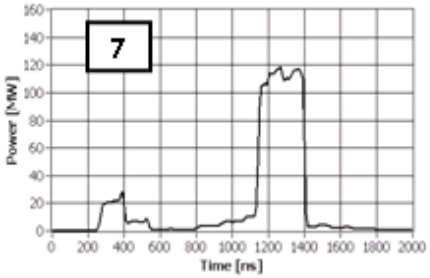






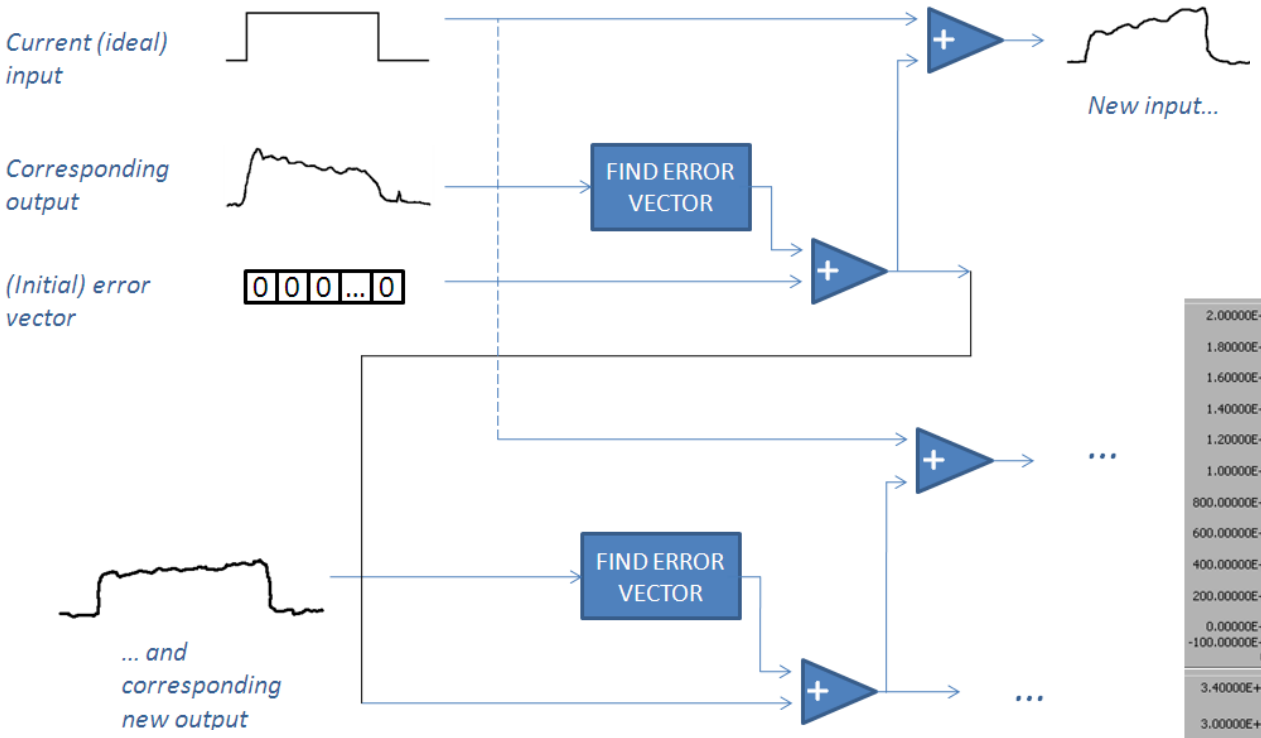


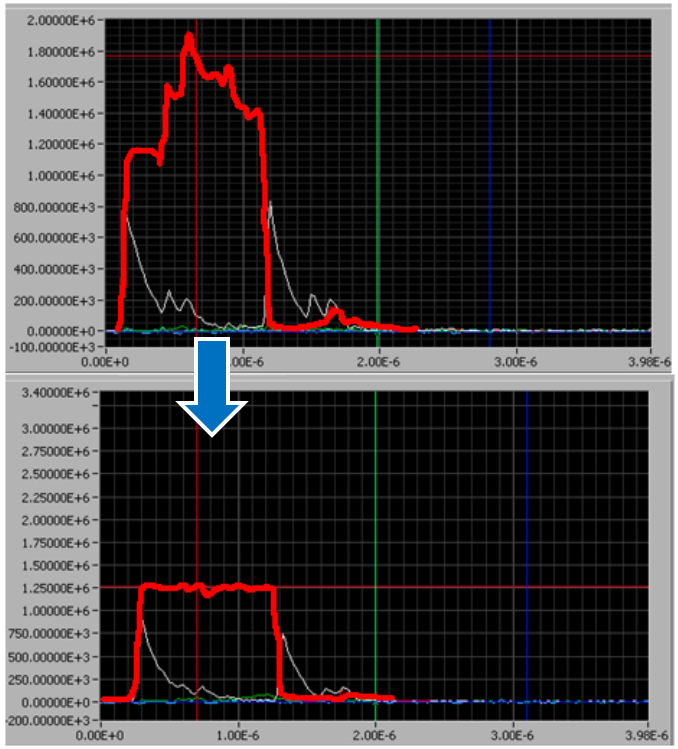




OCT-NOV 2009 PROCESSING RESULTS

Getting a ‘flat’ pulse

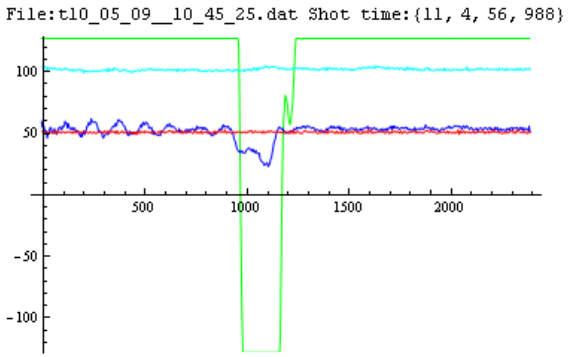


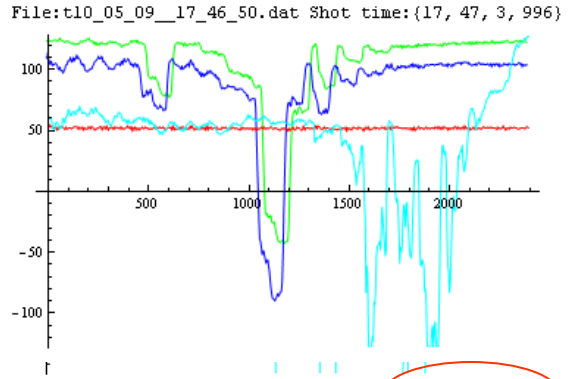


CLIC

Breakdowns “sifting” criteria

- Events with **no dark current bursts** (azure) but **high reflection** (green). We assume that the channels were not properly calibrated. These events appeared only at the very beginning of the processing period.
- The dark current burst appear **after** the RF pulse (no pulse shortening). This kind of event will be practically CLIC-undetectable and will not affect the acceleration.
- Cluster **accident**. In general the system should not allow such an event, thus we considered the cluster as a single breakdown.

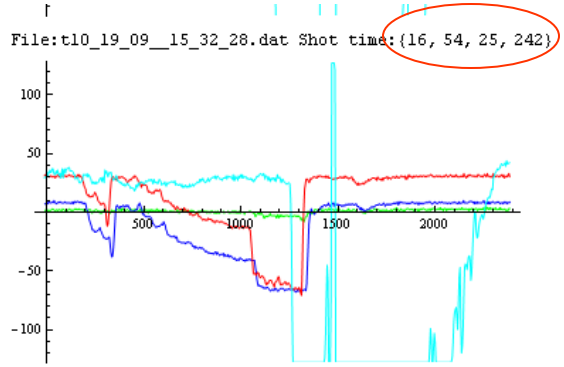


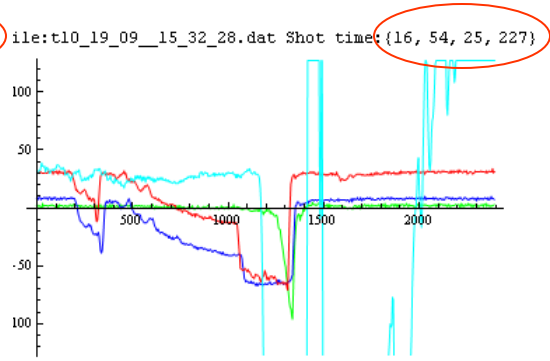


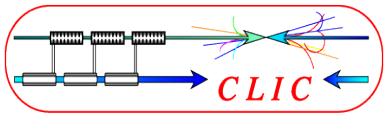
1200 b.d.

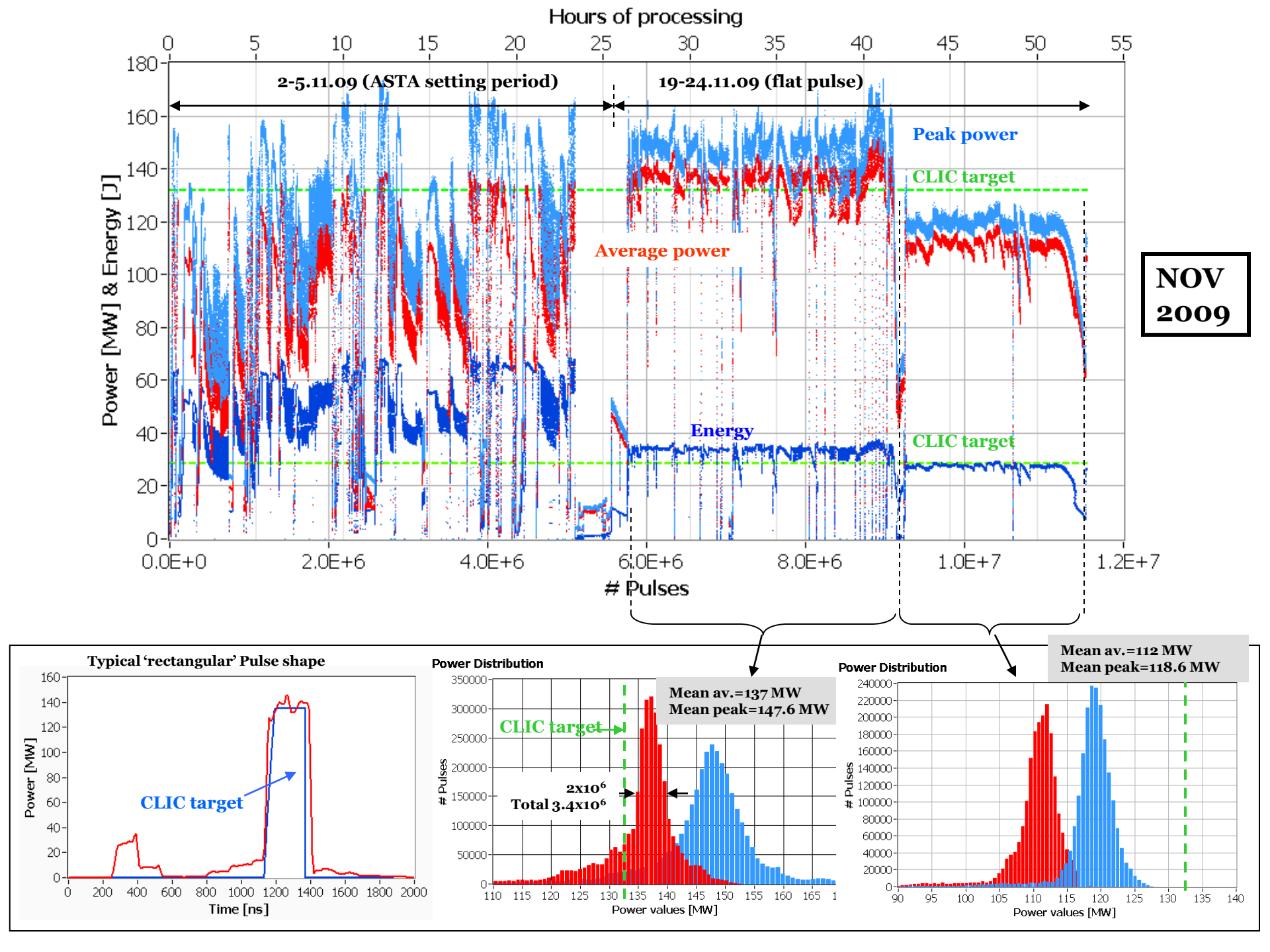
300 b.d.

Missing energy is sensibly measurable for ~10% of the total breakdowns #.

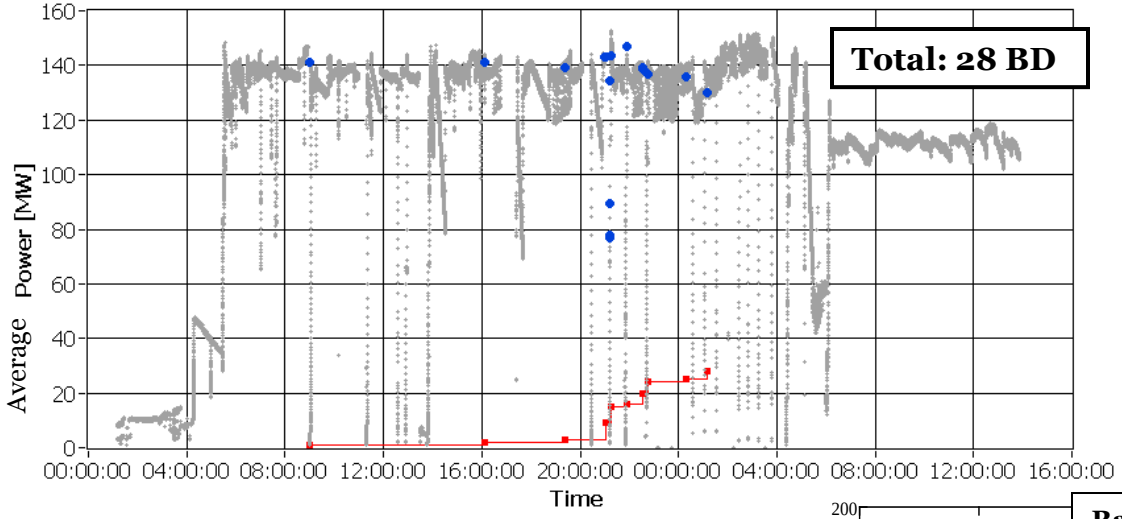


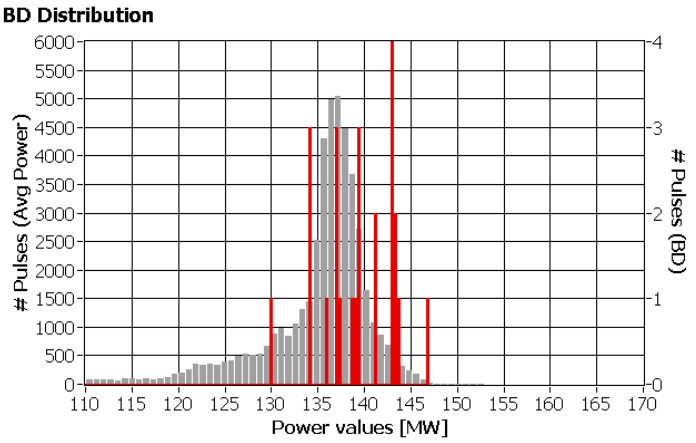


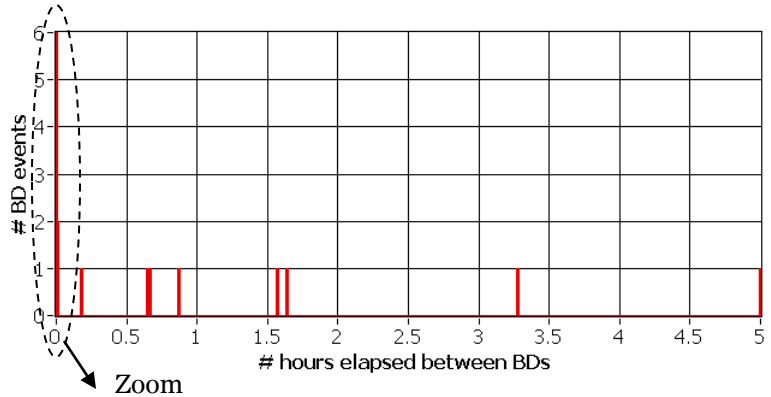


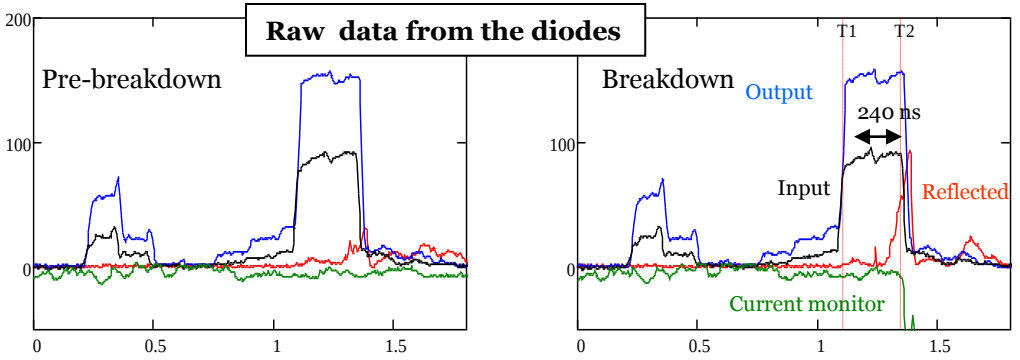

Hours of processing
2-5.11.09 (ASTA setting period)
19-24.11.09 (flat pulse)
Peak power
CLIC target
Average power
Energy
CLIC target
Power [MW] & Energy [J]
Pulses
NOV 2009
Typical 'rectangular' Pulse shape
CLIC target
Power [MW]
Time [ns]
Power Distribution
Mean av.=137 MW
Mean peak=147.6 MW
CLIC target
2x10⁶
Total 3.4x10⁶
Pulses
Power values [MW]
Power Distribution
Mean av.=112 MW
Mean peak=118.6 MW
Pulses
Power values [MW]

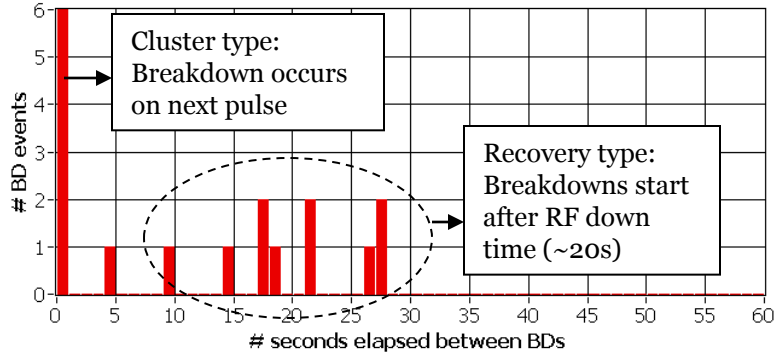
BREAKDOWN STATISTICS











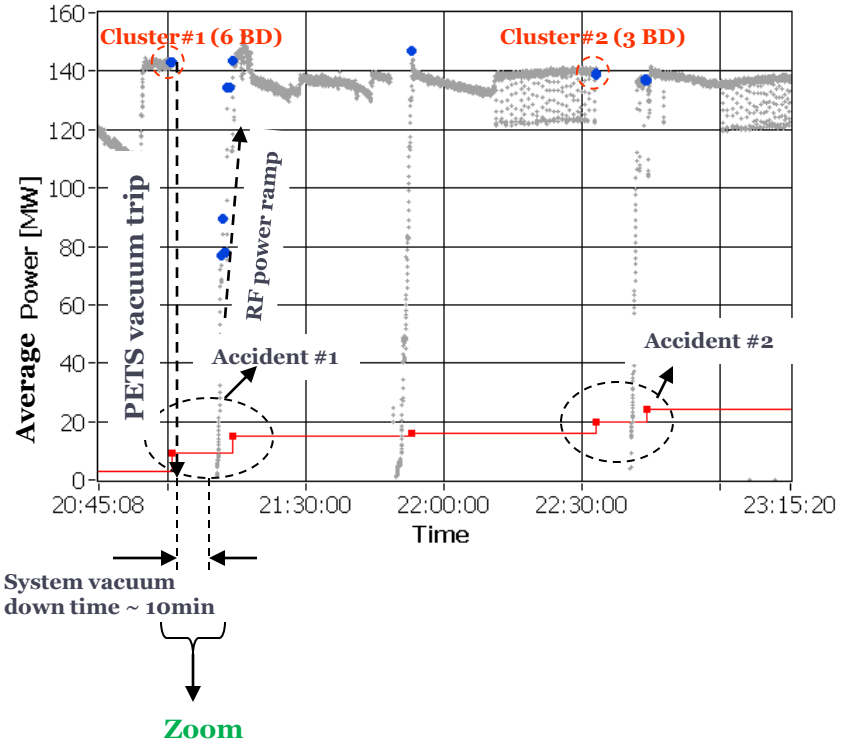
<u>Raw data</u> are recorded approximately every 1s.

<u>Breakdown event acquisition</u>. Threshold exceeded in the current monitor and/or reflected signal channel.

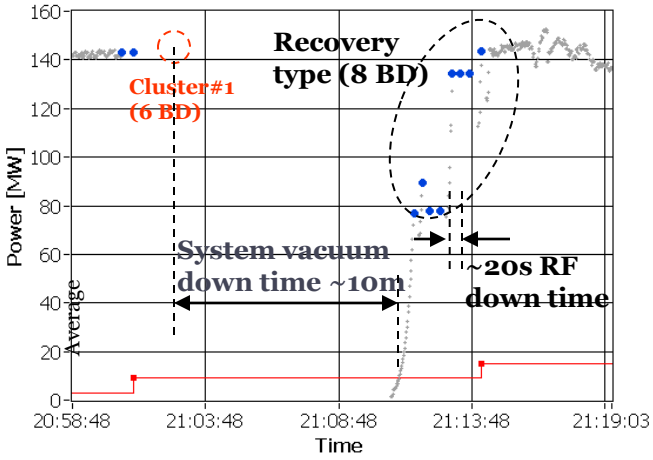
<u>Breakdown recovery</u>. RF power is kept down for ~20s.

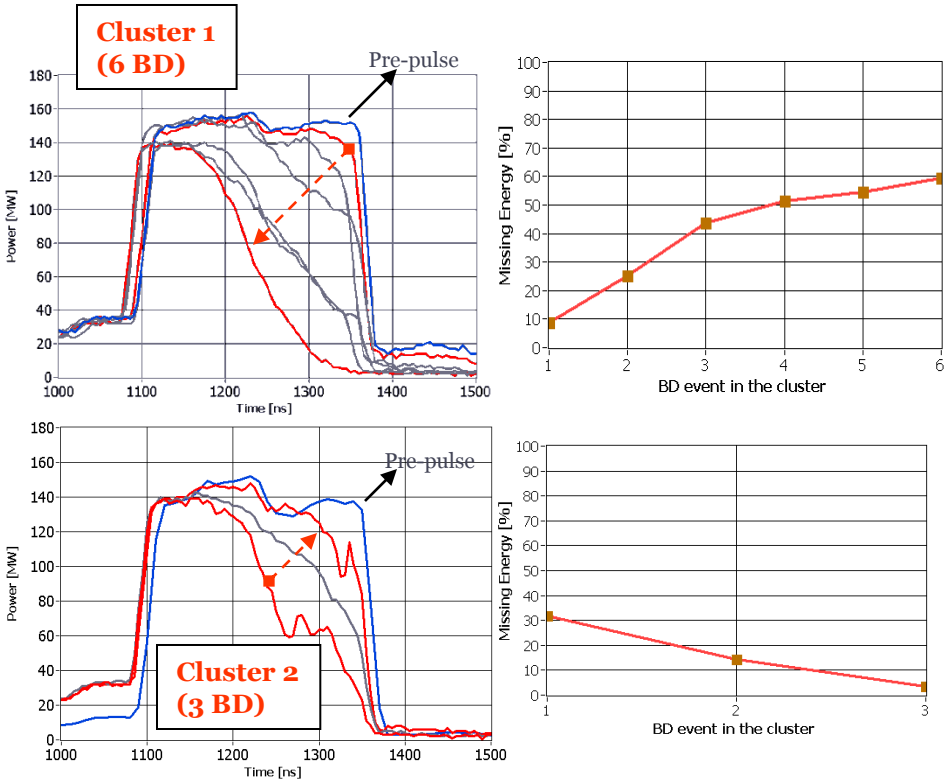
<u>Vacuum trip recovery</u>. Power is slowly (~30 sec) ramped up towards the former level.

ACCIDENT INVESTIGATION



Zoom





1. **Breakdowns cluster** → accident. Sharp increase of missing energy.

2. **Hypothesis**: clustered breakdowns initiate the pressure build-up in the PETS → klystrons are tripped by vacuum interlocks. It takes ~10m to recover.

3. **RF power ramping**. During this period (Recovery type) the RF power is tripped for ~20 s after each breakdown and is restarted from the previous level (is vacuum in the PETS still high?). Recovery breakdowns occurred only after cluster event and were not observed after individual breakdown and thus may be considered as a part of the accident.

For the breakdown statistic: this type of accident should count as a **single event** with parameters attributed to the first breakdown in a cluster.

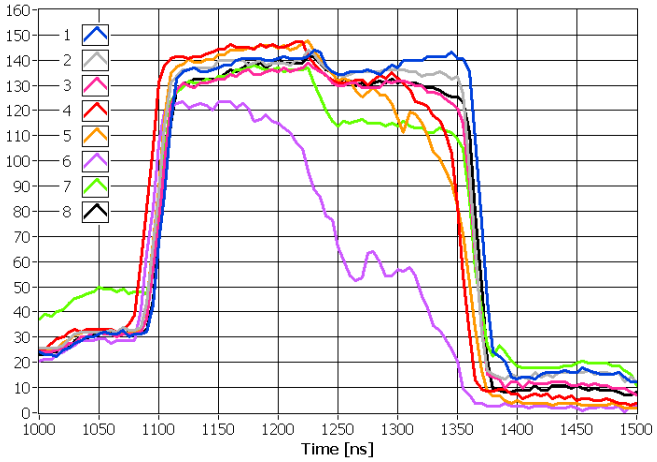
• A grand total of **8 breakdowns** was found.

• We may exclude the events where the current appears after the RF signal (Pulses 2, 7).

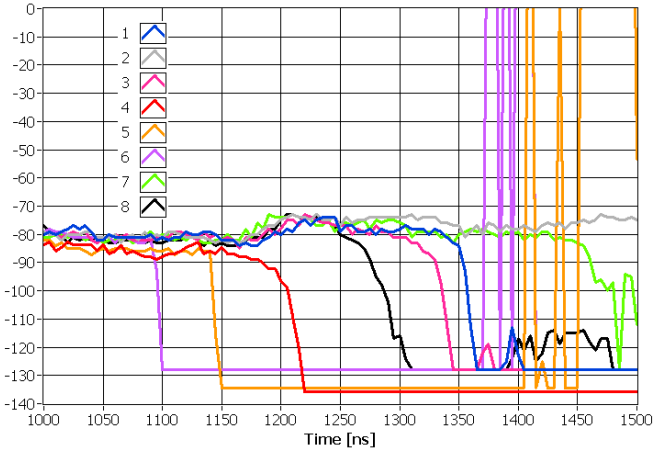
• Pulses 4, 5 could be removed too, since they belong to the high power level group (+10%).

• 1,3,6 and 8 are the remaining breakdowns; 1,3, 8 have very little missing energy ~ 1% and are not CLIC-detectable; however we should treat them as a breakdown.

TRANSMITTED PULSES

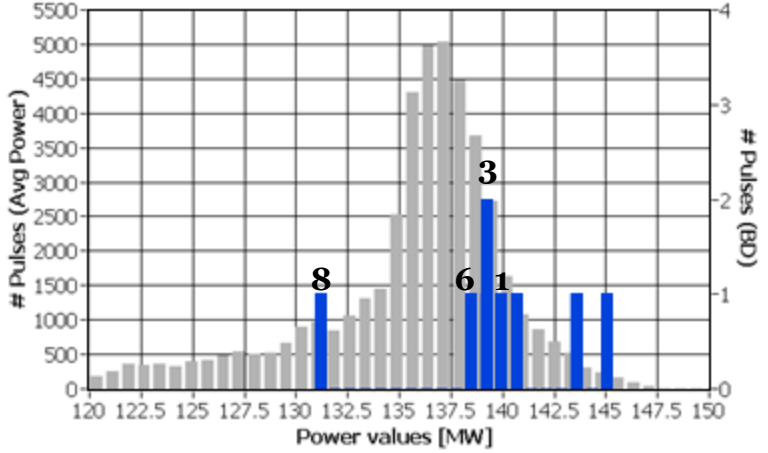


CURRENT MONITOR



Breakdown #	Missing Energy [%]	Average Power [MW]	
1	0.8	140.36	
2	2.41	141.7	
3	1.5	139.15	
4	7.4	143.58	→ First in a cluster#1
5	6.3	145.4	
6	31.88	138.7	→ First in a cluster#2
7	0.6	137	
8	1.4	130.8	

BD Distribution



CONCLUSIONS

- The impact that accidents have on the tests affects reliability → different processing approaches?
  - Reprocess pulse length, rather than amplitude? Increase recovery time after vacuum tripping?

- The in-depth study concerning the November 'flat-pulse processing' highlighted 4 breakdowns over 15 hours at ~ 137 MW and 260 ns pulses → **~ 1.2×10^{-6} BD/PETS/ pulse**.

- At **112 MW and 260 ns**, there were no breakdowns registered in 10 hours.
  - BDR < **4.6×10^{-7} /PETS/ pulse** (design: <3×10^{-7}).

- The new PETS has been built and running it equipped with damping material is what comes next.