Preliminary analysis with the BLM pattern recognition tool

E. Nebot, B. Dehning, E. B. Holzer, A. Marsili,
M. Nagel, B. Salvachua, G. Valentino and D. Wollmann.

Outlook

- Motivation
- Description of method
- Reference vectors
- Use cases
- Some interesting Fills
- Conclusions

Motivation

- Attempt to use BLM data to get some information about the beam dynamics.
- Compare beam losses with reference loss scenarios (losses in BLMs around IR7).
- Try to decompose the current loss into several components (B1V/B1H/B2H/B2V)

Description of the method

- Vector decomposition

$$\vec{x}' = \sum_{i=1}^{n} f_i \cdot \vec{r_i}$$

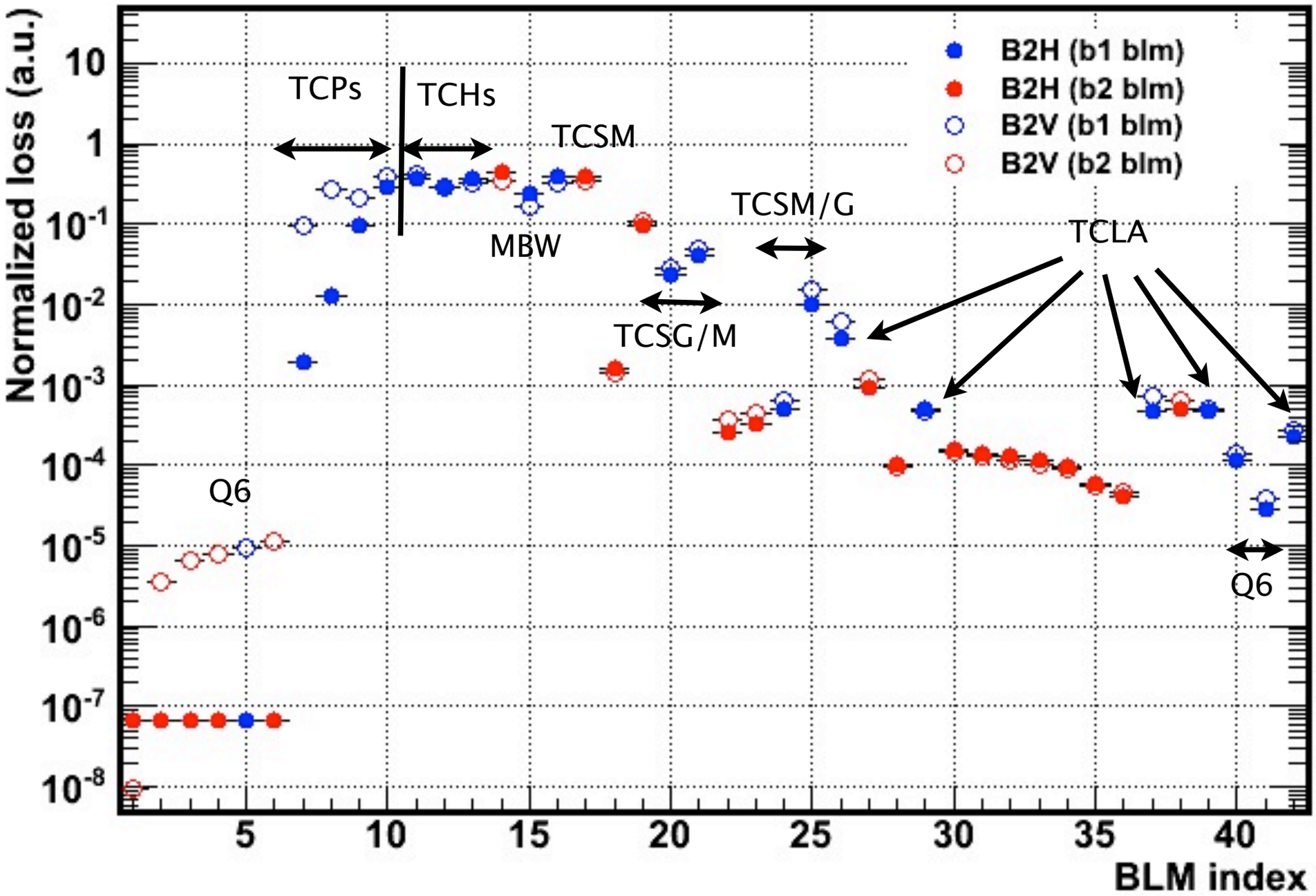
- Beam loss represented by a vector of m components (BLM signals in n specific monitors in IR7).
- Reference vectors. Loss maps r1=B1H, r2=B1V, r3 =B2H, r4=B2V.

$$\sum_{i=1}^{n} f_i \cdot \vec{r_i} \approx \vec{x}$$

- Computation of fi (fraction of loss in B1/2 H/V). Three independent methods:
  - Single Value Decomposition (SVD)
  - Gram-Schmidt
  - X-correlation

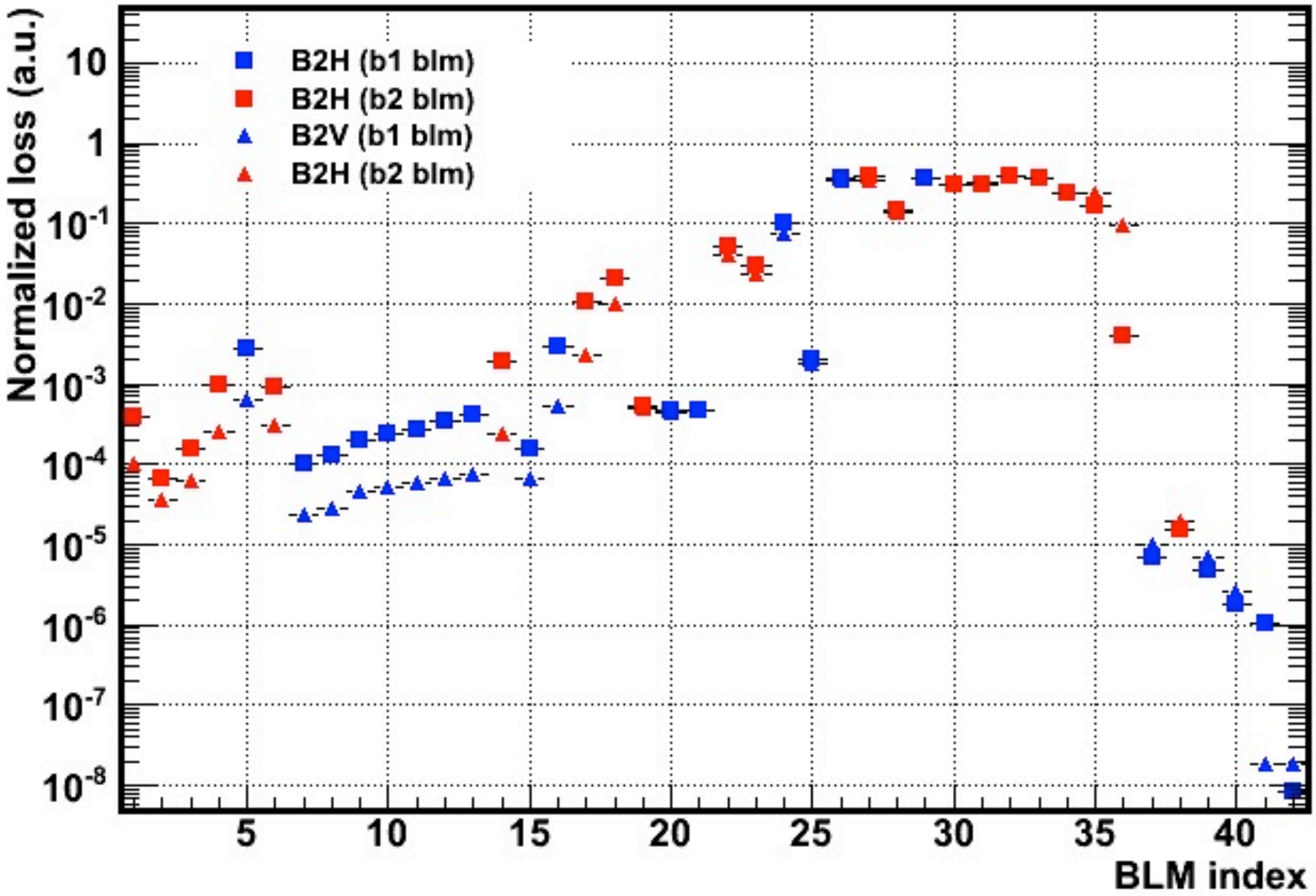
Reference vectors

- Loss maps: B1 (01/07/2012 physics)



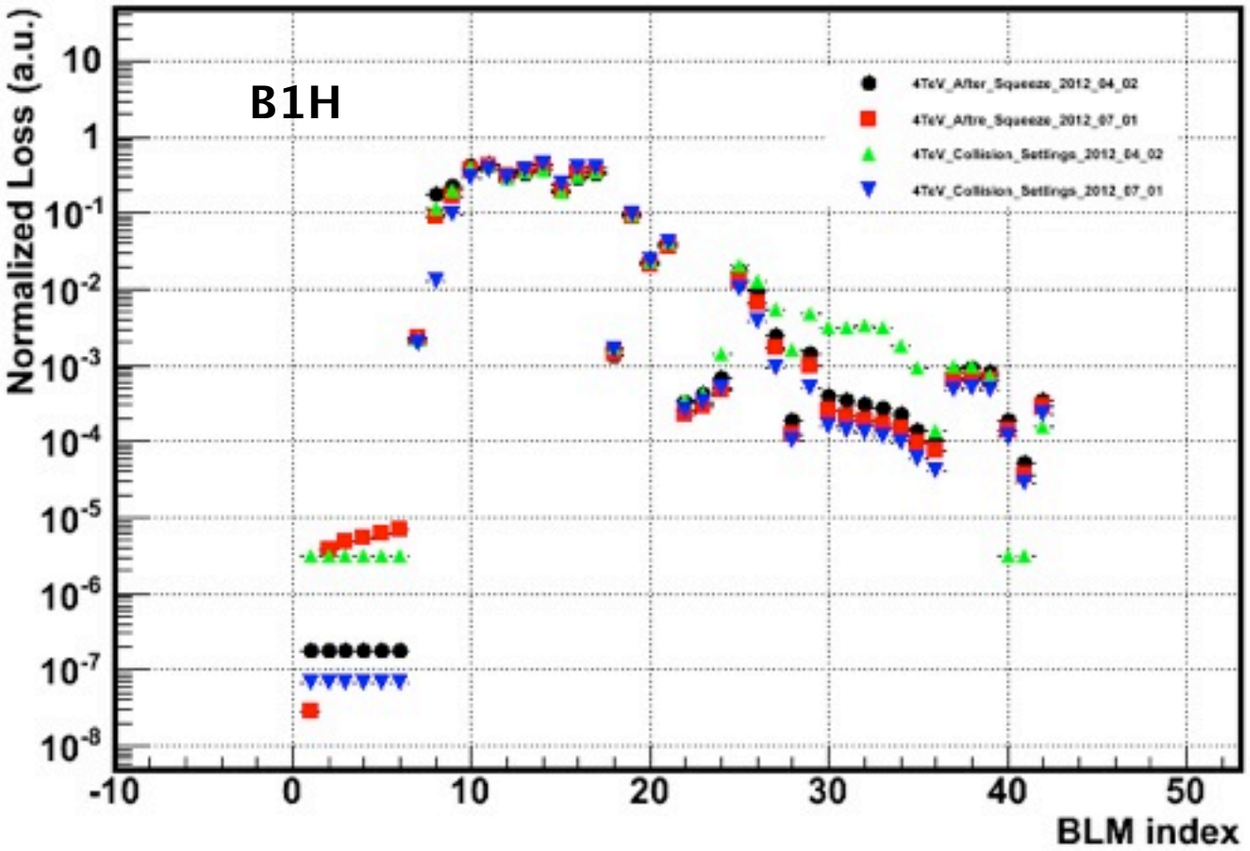
Reference vectors

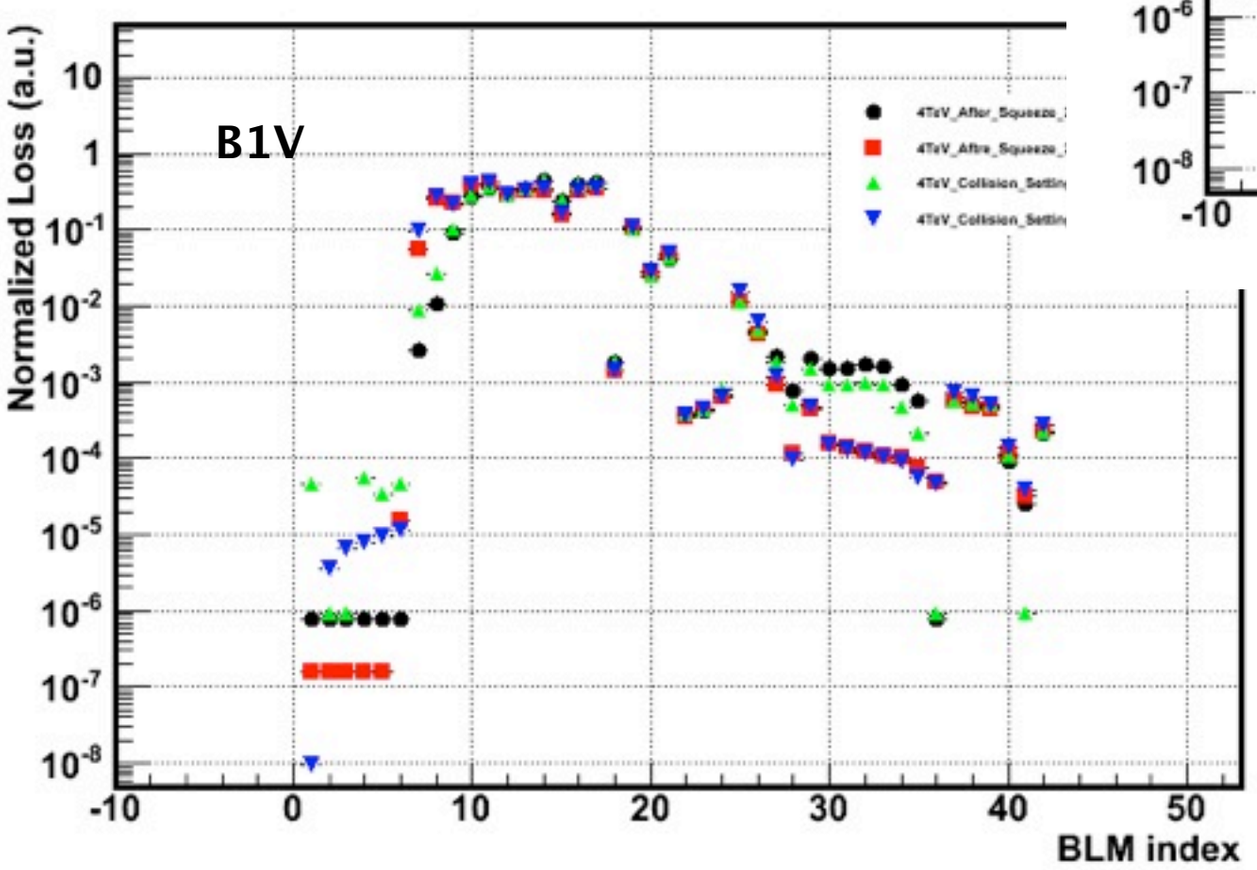
- Loss maps: B2 (symmetrically, 01/07/2012 physics)



Reference vectors

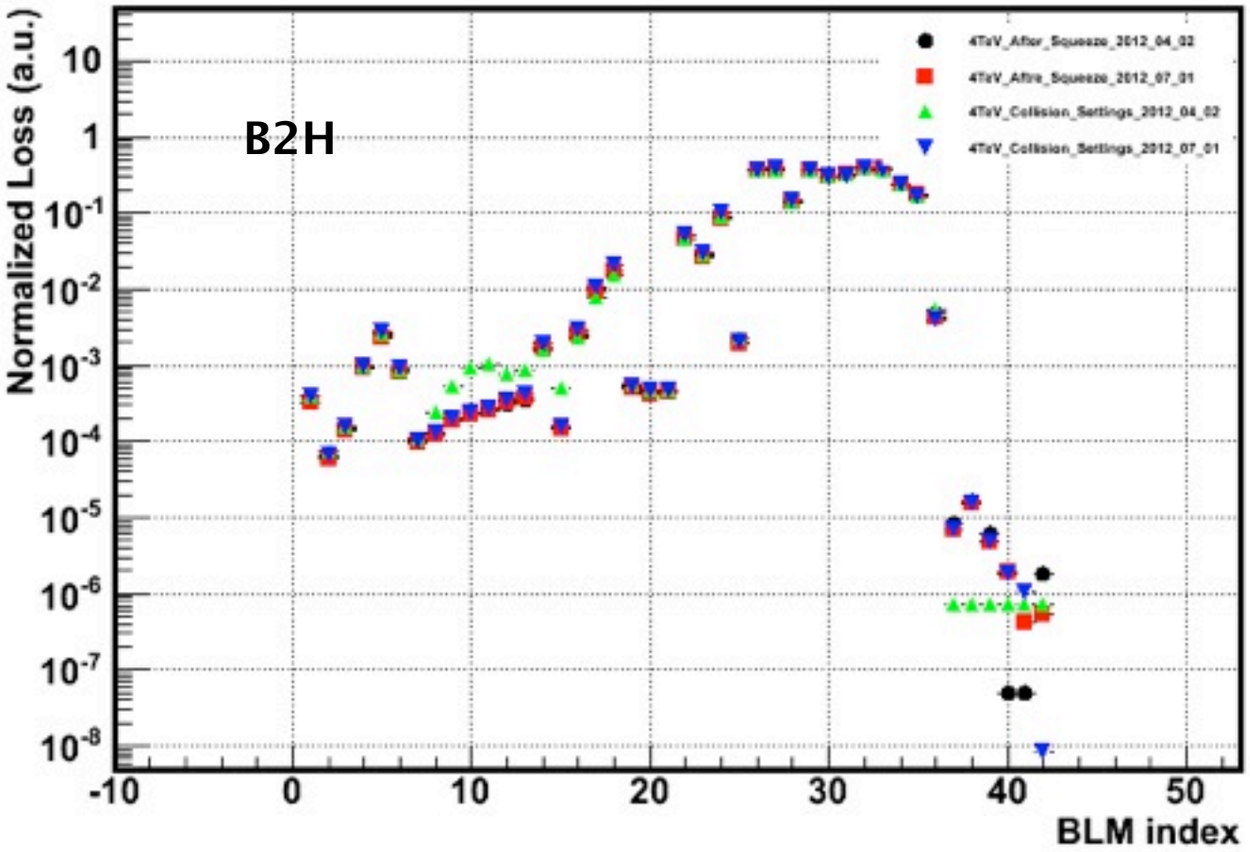
- Loss maps comparison (B1):
  - 01/07/2012 4TeV physics
  - 01/07/2012 4TeV after squeeze
  - 02/04/2012 4 TeV Coll settings
  - 02/04/2012 4 TeV after squeeze

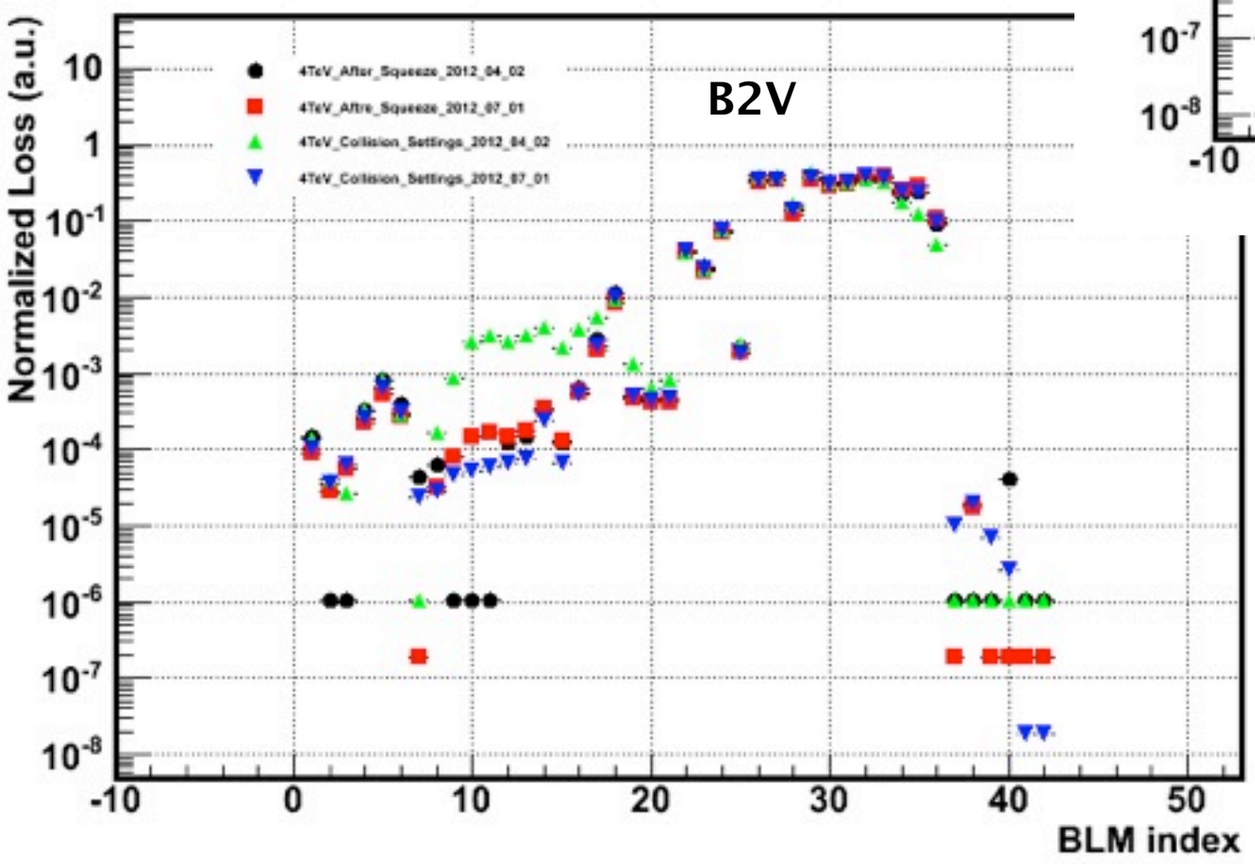




Reference vectors

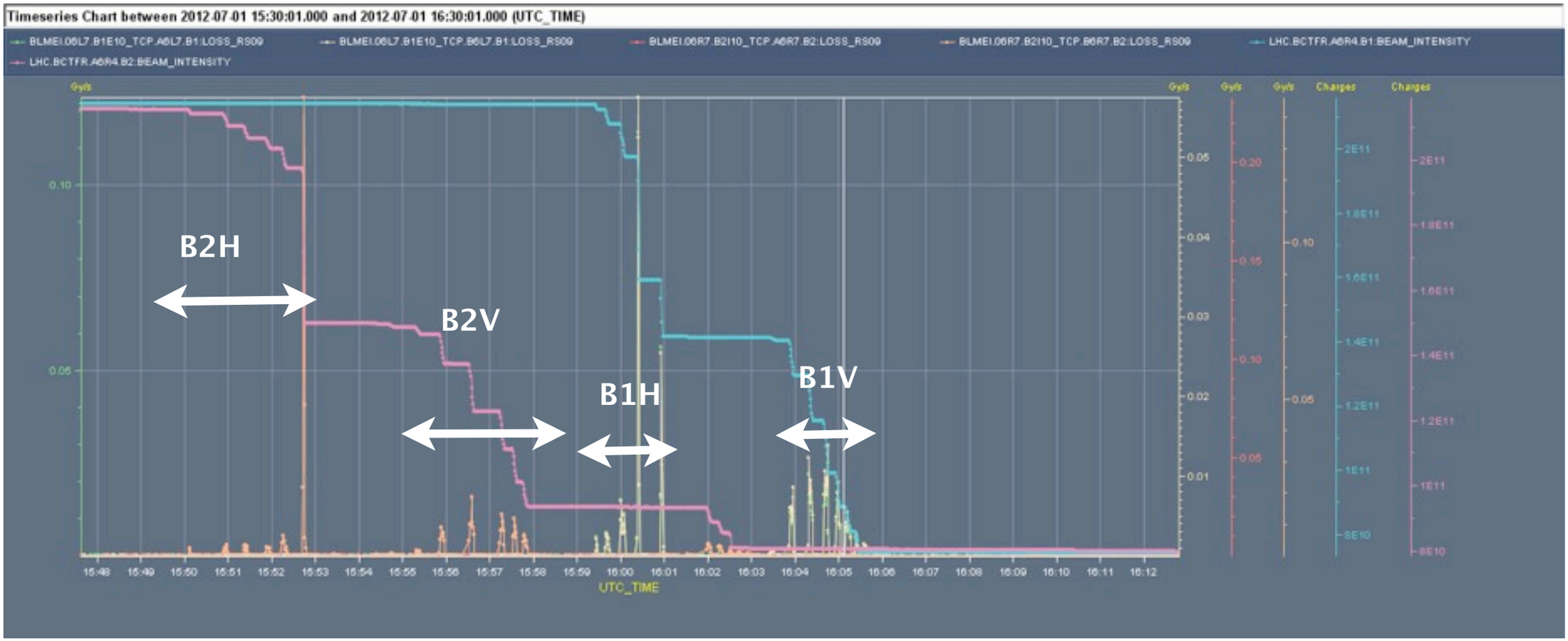
- Loss maps comparison (B2):
  - 01/07/2012 4TeV physics
  - 01/07/2012 4TeV after squeeze
  - 02/04/2012 4 TeV Coll settings
  - 02/04/2012 4 TeV after squeeze





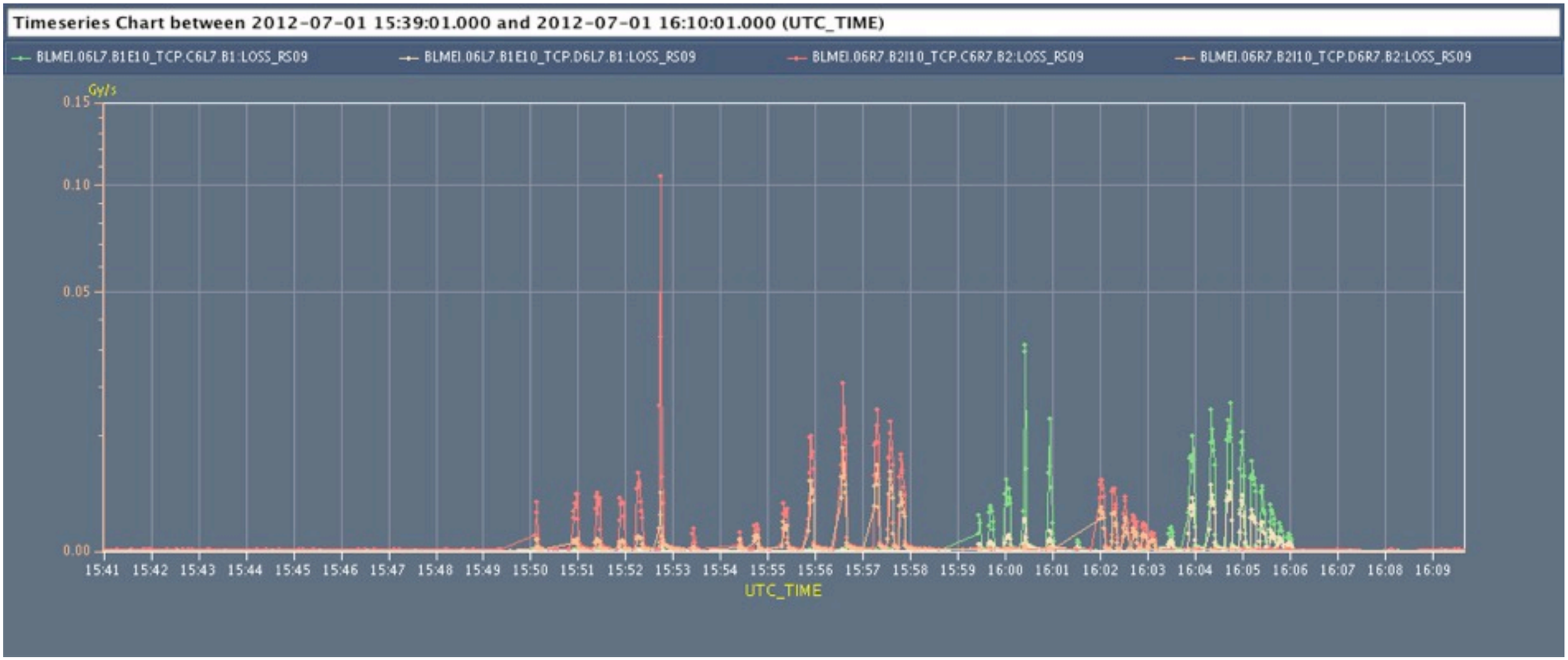
Use cases. Loss Maps 01/07/2012

- Loss map with ADT (physics collimation settings).



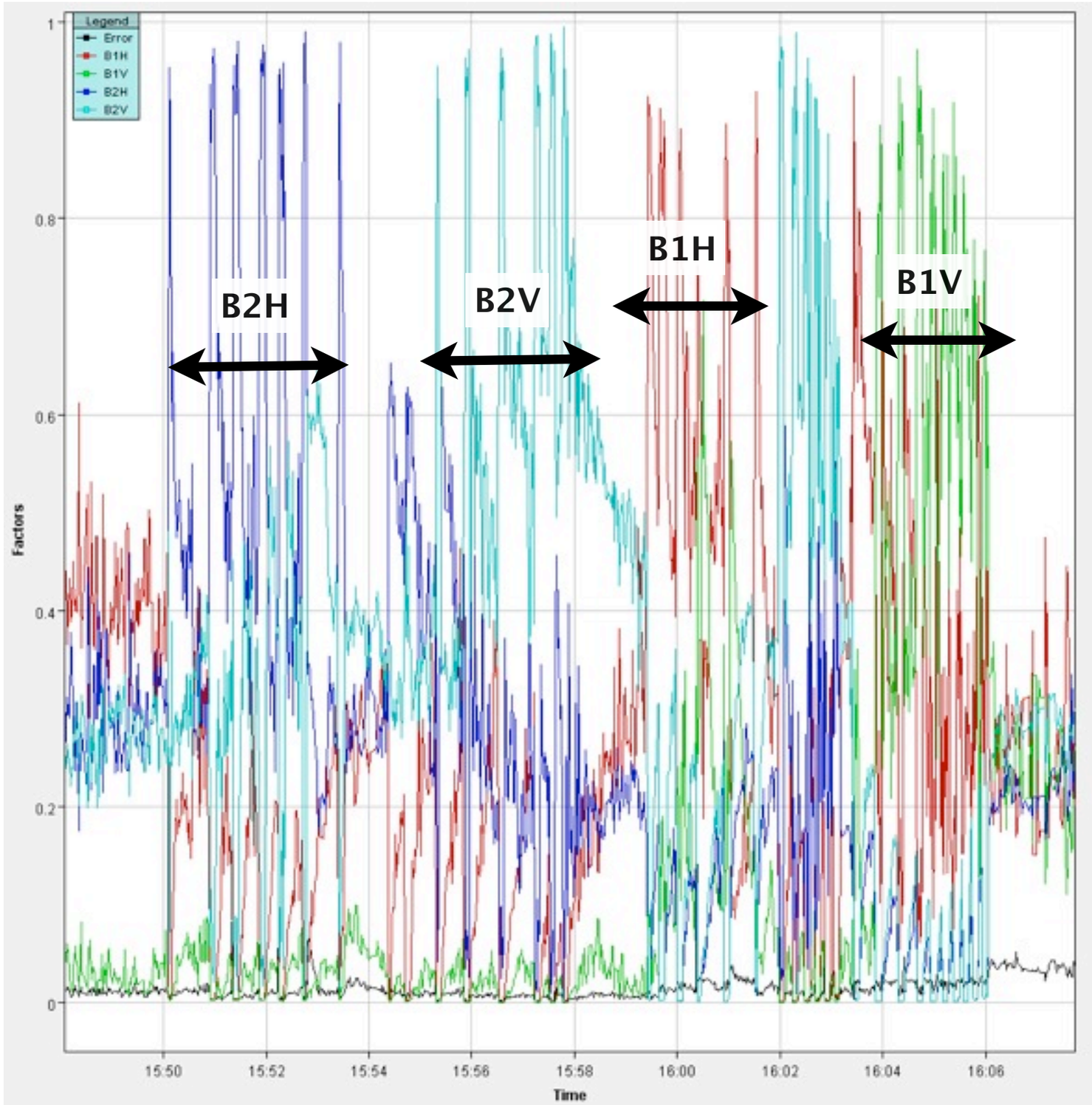
Use cases. Loss Maps 01/07/2012

- Loss map with ADT (physics settings).



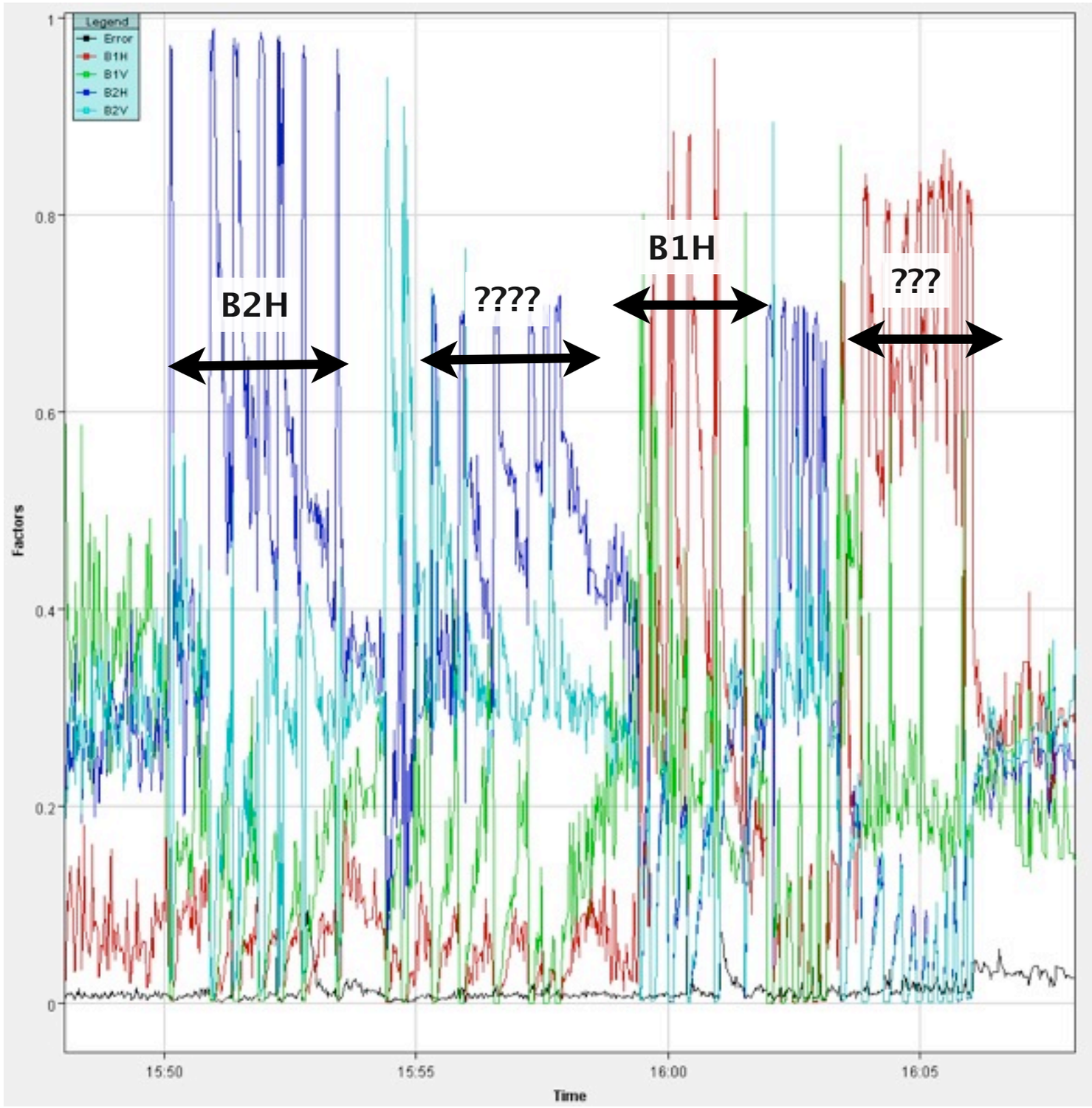
Use cases. Loss Maps 01/07/2012

- Reference. Loss map 01/07/2012 4TeV physics settings. Consistent results

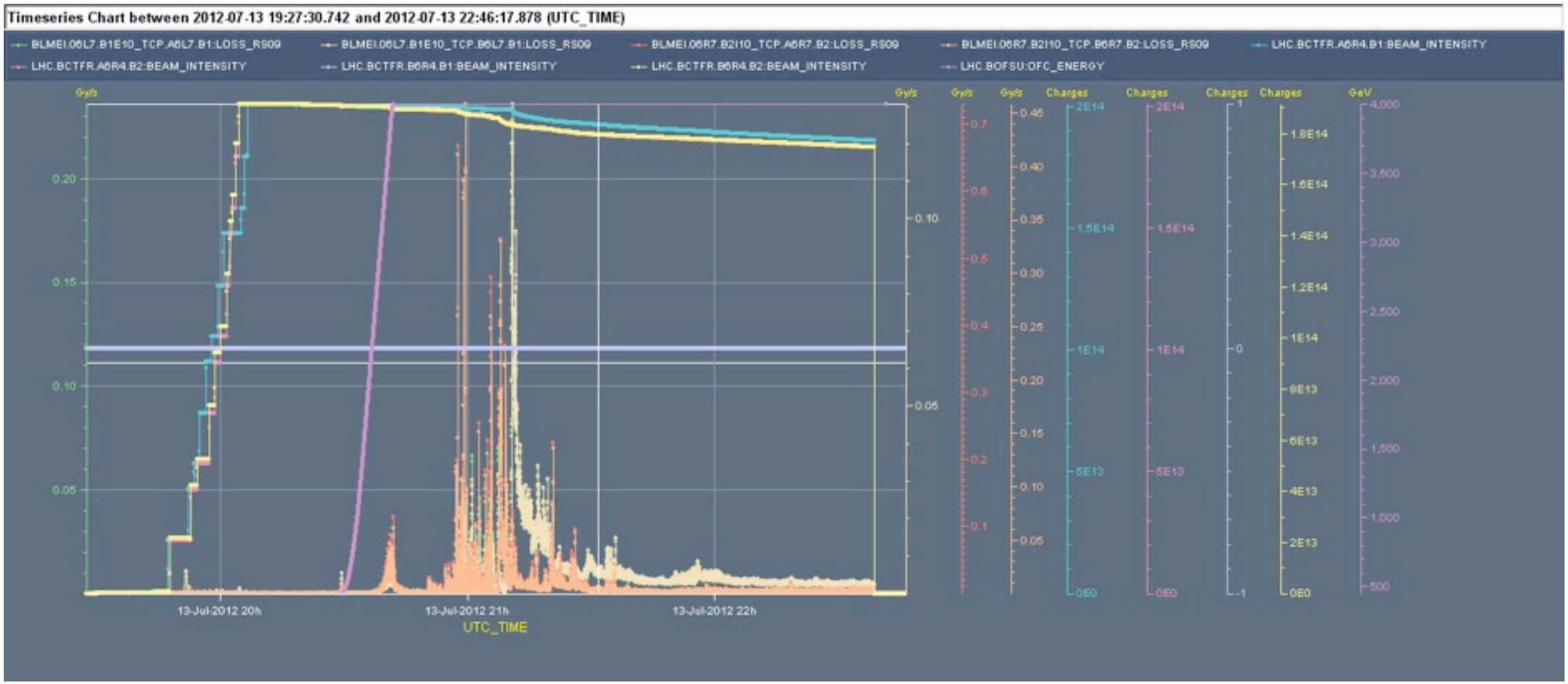


Use cases. Loss Maps 01/07/2012

- Reference. Loss map 02/04/2012 4 TeV. Physics settings. results?????

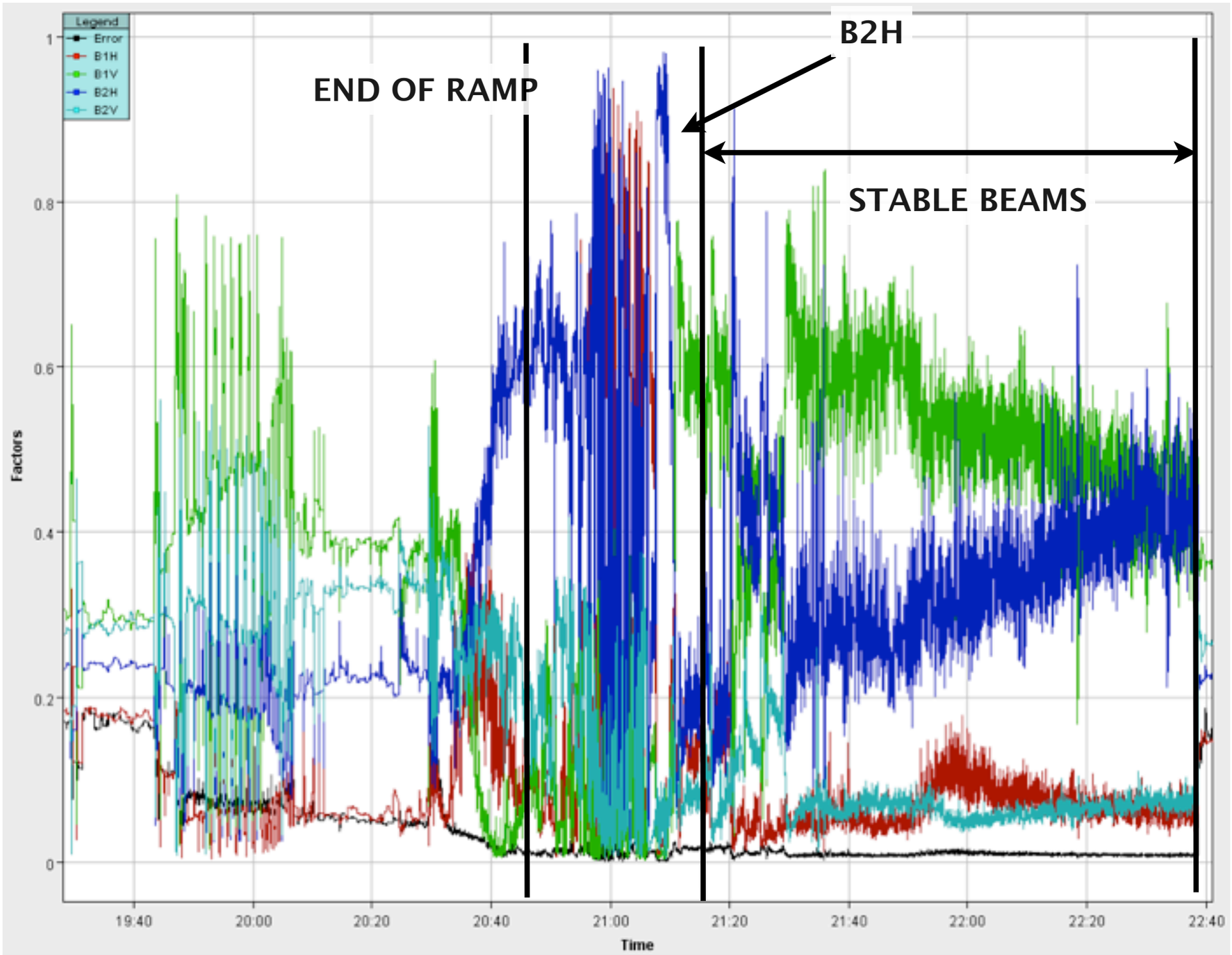


More systematic studies. Fill 2840



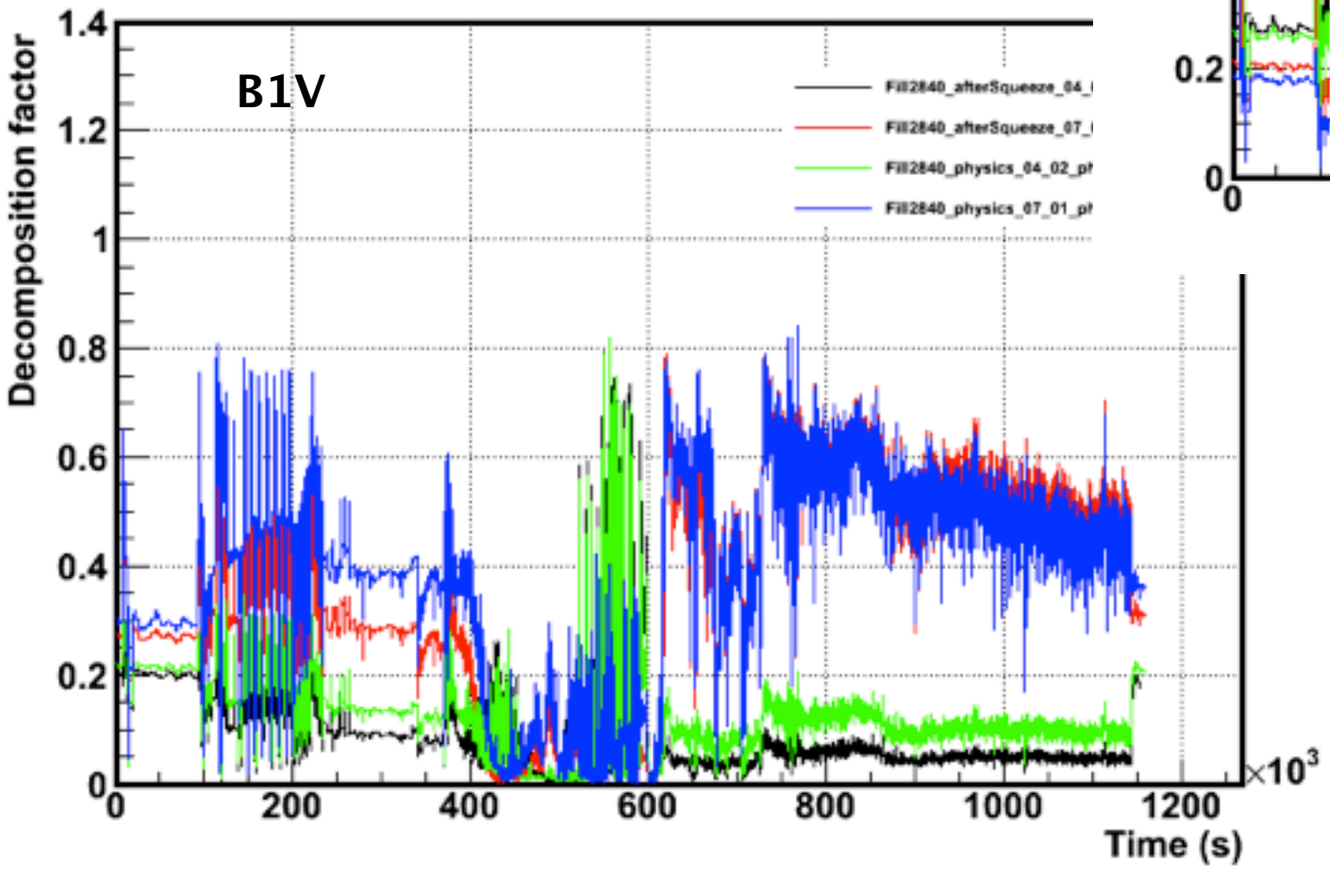
More systematic studies. Fill 2840

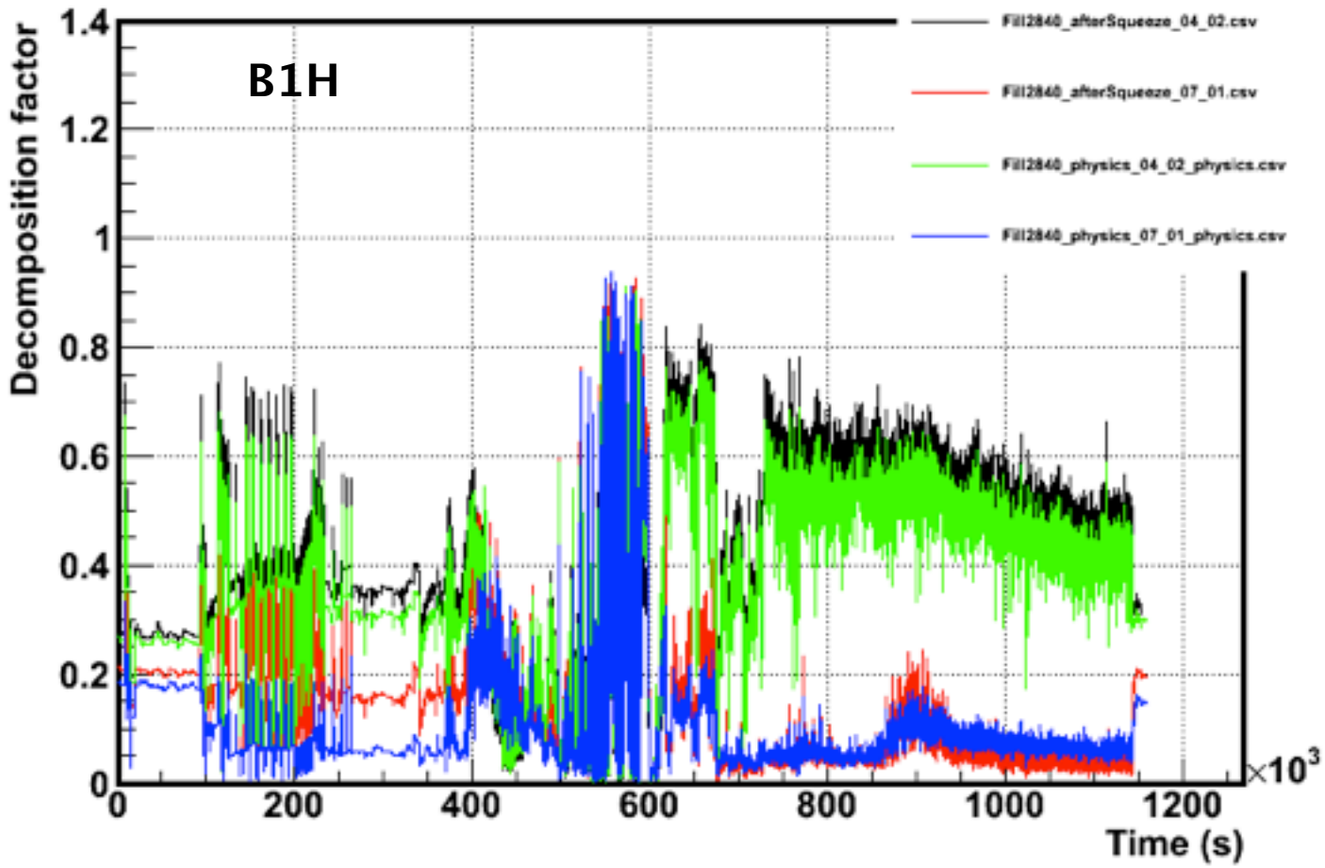
- Reference. Loss map 01/07/2012 4TeV physics settings.



More systematic studies. Fill 2840

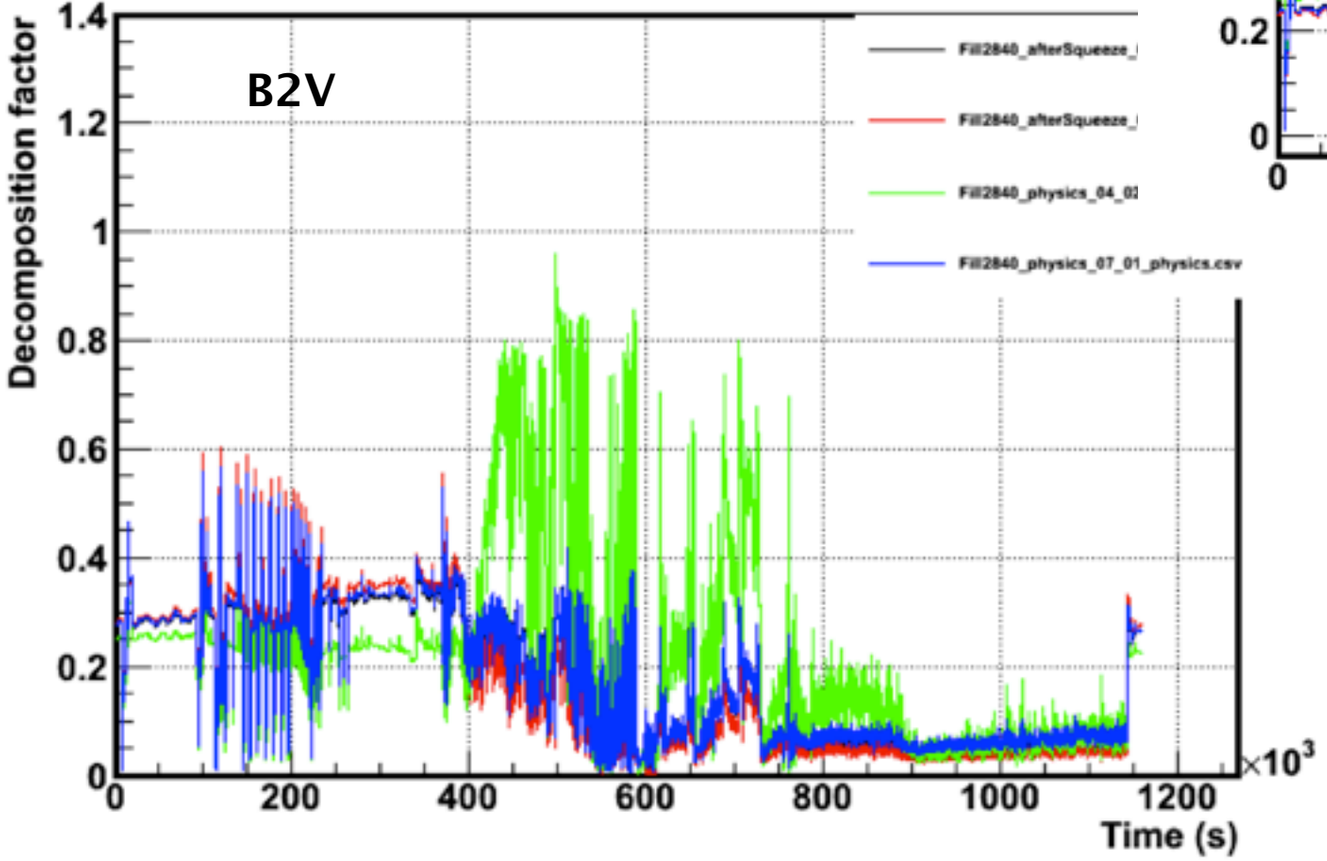
- Four 4 TeV loss maps.

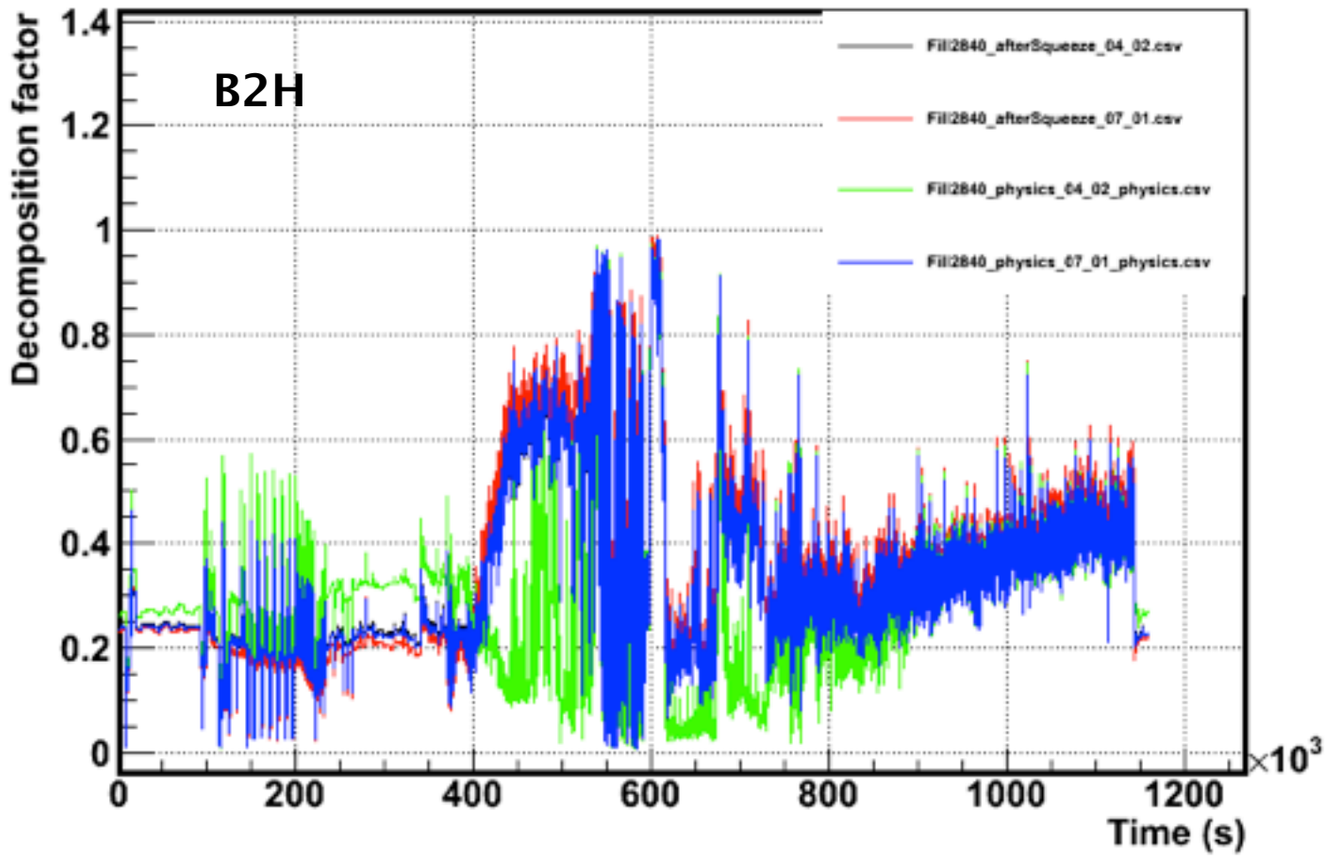




More systematic studies. Fill 2840

- Four 4 TeV loss maps. B2



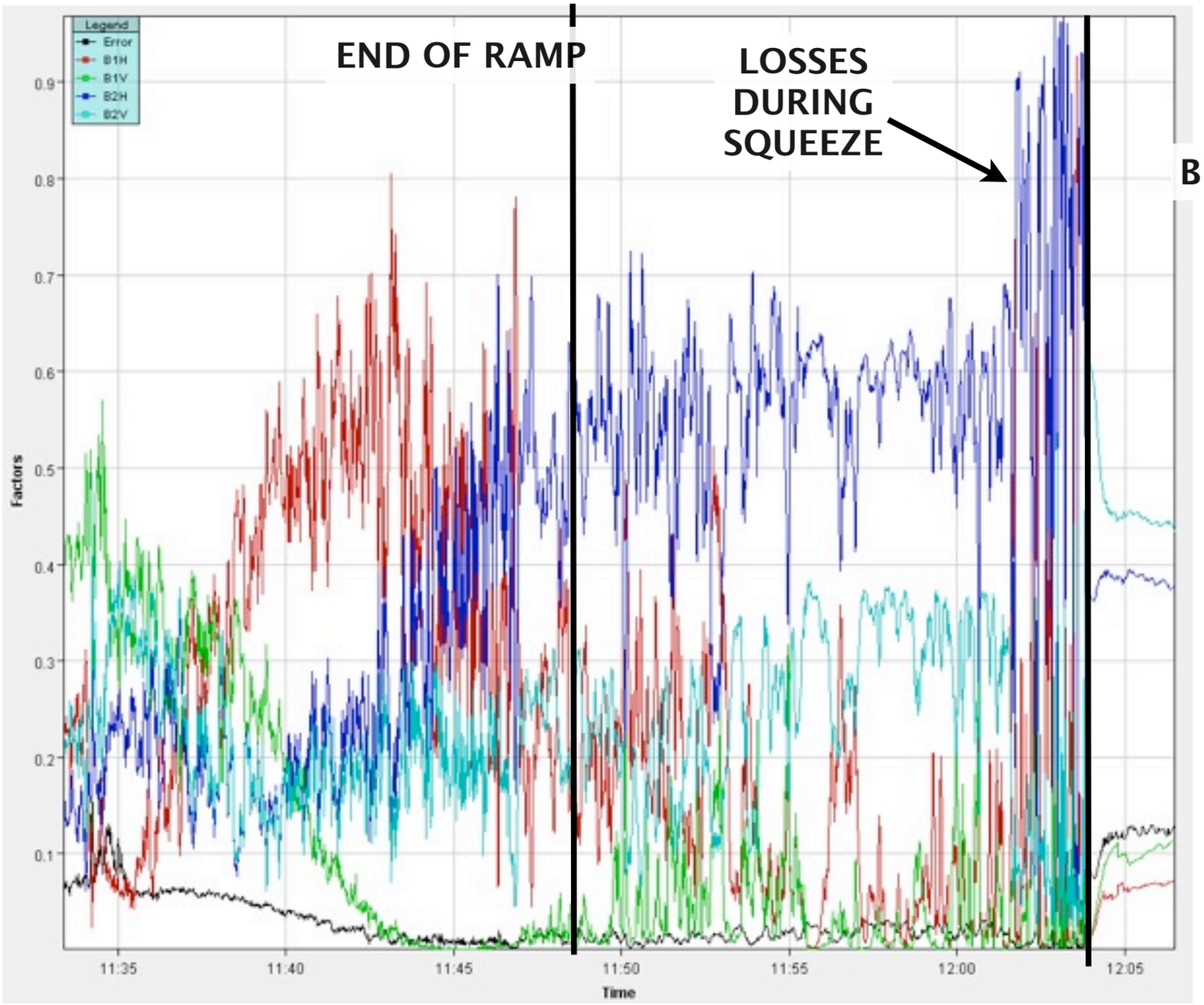


Analysis for several LHC fills

- Fix reference vector (01/07/2012 physics).
- Look at 7 LHC fills
- Three of the fills were dumped by losses during squeeze/adjust

Fill	Stable beams	Date
2838	0	13/07/2012
2840	1:14	13/07/2012
2841	0	13/07/2012
2842	11:32	14/07/2012
2843	7:46	14/07/2012
2846	0	15/07/2012
2912	7:43	08/04/2012

Example. Fill 2846



- All 7 analyzed fills (with reference loss map 01/07/2012, physics) show large B2H activity during adjust/squeeze.

Conclusions

- Three algorithms implemented for pattern recognition. Compare given loss scenario (loss vectors) with a set of known scenarios (loss map = reference vector)
- Large spread on reference vectors (loss maps)
- Result of the decomposition very sensitive to different references.
- Seven fills analyzed (with reference 01/07/2012 physics) seem to show a large B2H activity during adjust/squeeze.

Extra Slides

SDV method

Approximate the unknown loss as a linear combination of the loss scenarios that:

$$\sum_{i=1}^{n} f_i \cdot \vec{r_i} \approx \vec{x} \tag{1}$$

Rewrite as matrix equation:

$$M_{m \times n} \cdot \vec{f}_n \approx \vec{x}_m \tag{2}$$

Calculating the factor by inverting the matrix (pseudo inverse):

$$\vec{f}_n \approx M^{+}_{n \times m} \cdot \vec{x}_m \tag{3}$$

Error estimation:

$$\|\vec{e}\| = \|\vec{x} - M_{m \times n} \cdot \vec{f}_n\| \tag{4}$$

X-Correlation method

Measurement of the similarity based on the dot product:

$$corr(\vec{r}, \vec{x}) = \frac{\langle \vec{r}, \vec{x} \rangle}{\|\vec{r}\| \cdot \|\vec{x}\|} \in [0, 1] \tag{5}$$

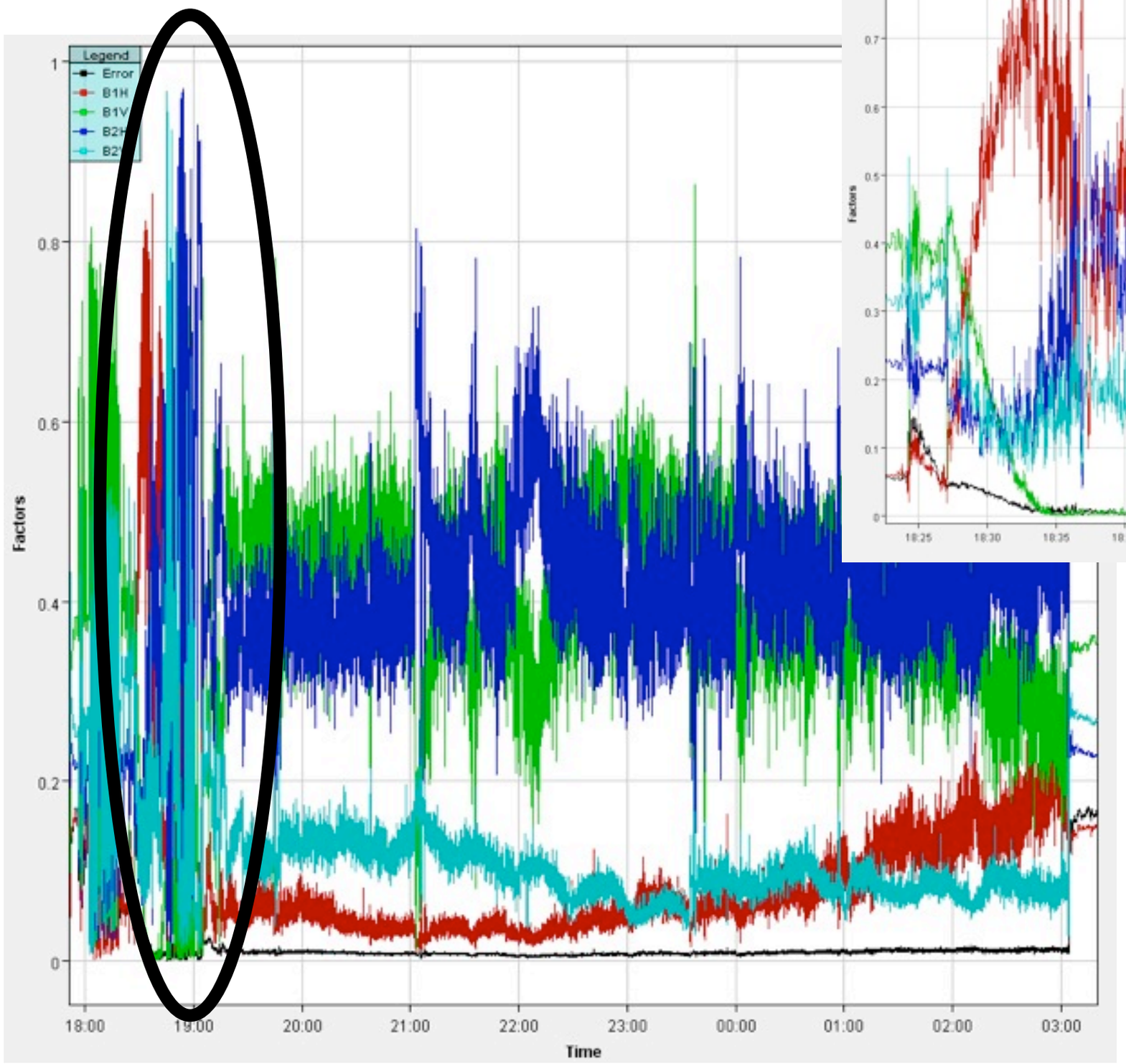
The factors (f_i) are the proportion of the similarity:

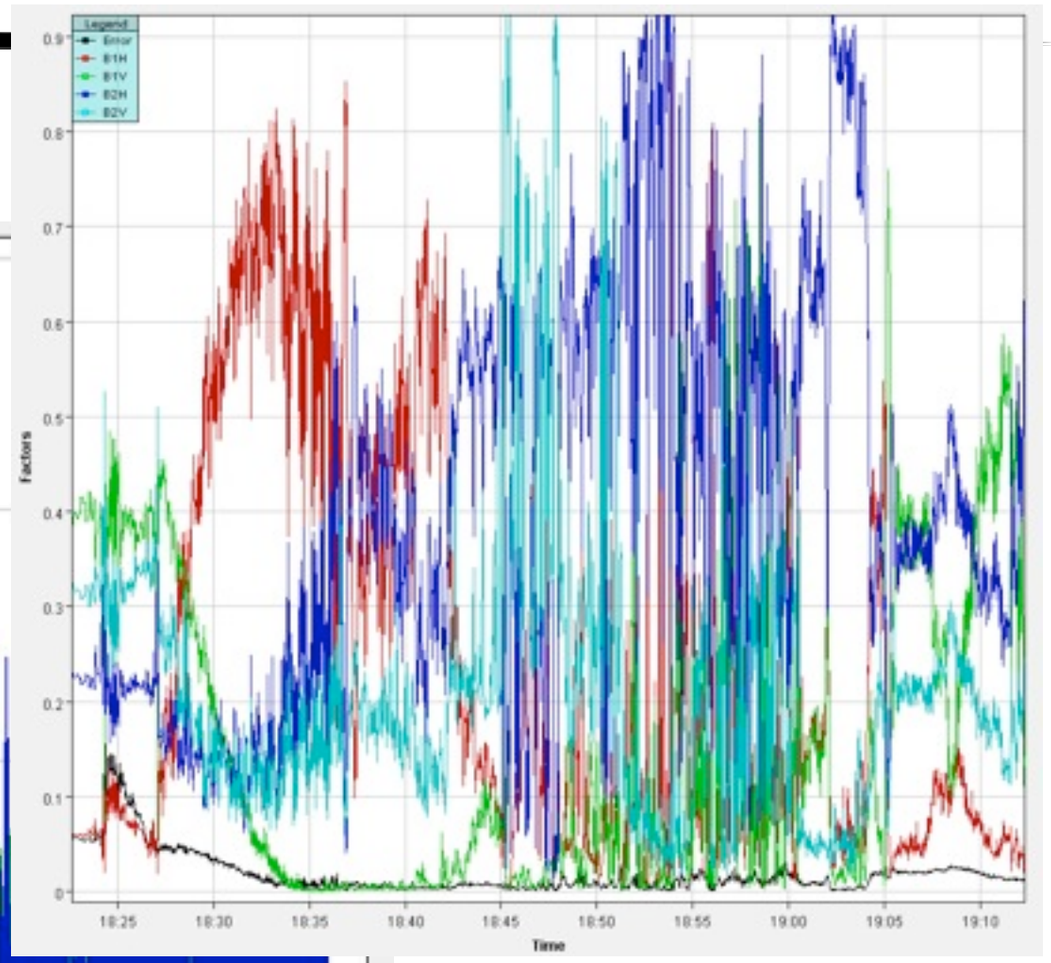
$$f_i(\vec{x}) = prop_{\vec{x}}(\vec{r_i}) = \frac{corr(\vec{r_i}, \vec{x})}{\sum_{j=1}^{n} corr(\vec{r_j}, \vec{x})} \tag{6}$$

Error estimation:

$$e(\vec{x}) = \sum_{i=1}^{n} (1 - corr(\vec{r_i}, \vec{x})) \cdot f(i) \tag{7}$$

Fill 2843


Legend
Error
B1H
B1V
B2H
B2V
1
0.8
0.6
0.4
0.2
0
Factors
18:00
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
Time


Legend
Error
B1H
B1V
B2H
B2V
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Factors
18:25
18:30
18:35
18:40
18:45
18:50
18:55
19:00
19:05
19:10
Time

Java application

http://bewww.cern.ch/ap/dist/lhc-blm-patternRecognition/PRO/