BPM button gains from tbt data

Fitting strategy
There are 5 parameters

- The four button gains g_1, g_2, g_3, g_4
- geometry constant c

Minimize χ^2 with respect to g_1, g_2, g_3, g_4, c (B_j^i is the intensity on the j[th] (of 4 buttons) on the i[th] turn)

$$\chi^2 = \sum_i^{turns} \left((g_1 B_1^i - g_2 B_2^i - g_3 B_3^i + g_4 B_4^i) - \frac{c}{I}(-g_1 B_1^i + g_2 B_2^i - g_3 B_3^i + g_4 B_4^i)(g_1 B_1^i + g_2 B_2^i - g_3 B_3^i - g_4 B_4^i) \right)^2$$

4 gains and the scale factor c (factor specific to BPM geometry)

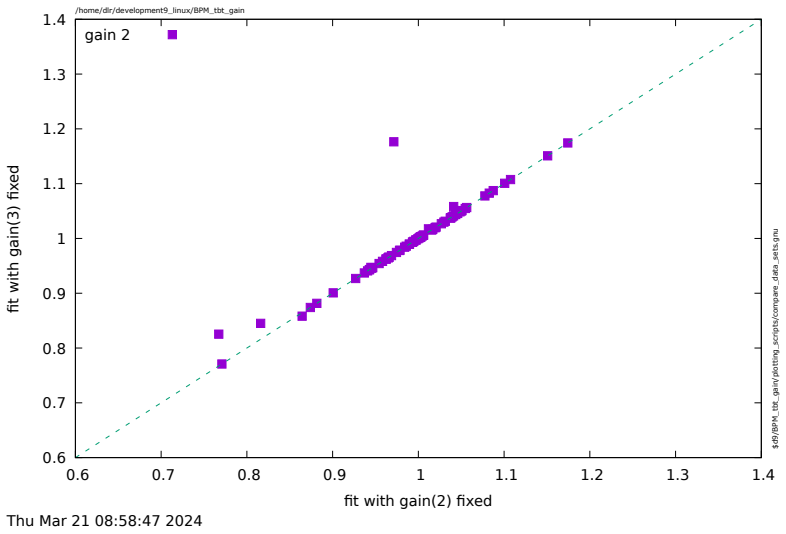
The 5 parameters are not independent

The data can be fit by setting any one of the gains to unity, and the constant c to ~ unity
If the fit is robust, the fitted gains, if all scaled so that gain[1] = 1, will be the same independent of which of the 5 parameters is fixed.

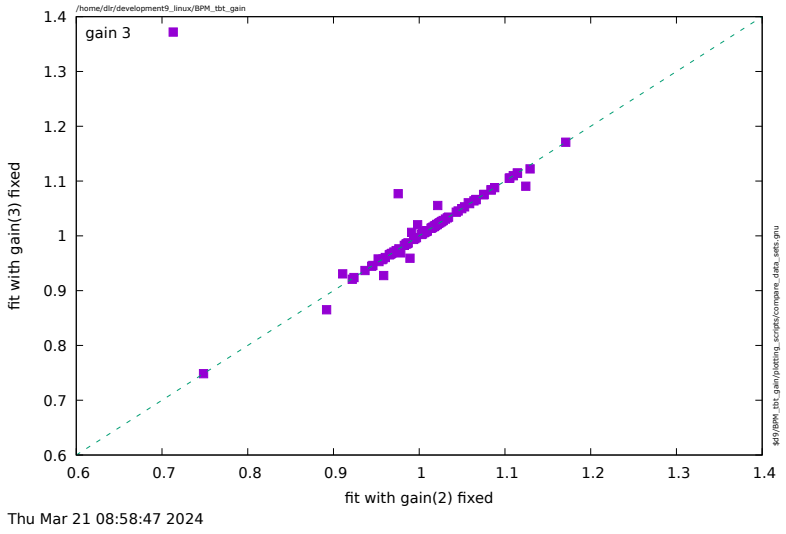
Procedure:

- Fit gains 1,3,4 with button 2 gain = 1. Normalize: gain(1:4) => gain(1:4)/gain(1) – horizontal axis
- Fit gains 1,2,4 with button 3 gain = 1. Normalize: gain (1:4) => gain(1:4)/gain(1) – vertical axis

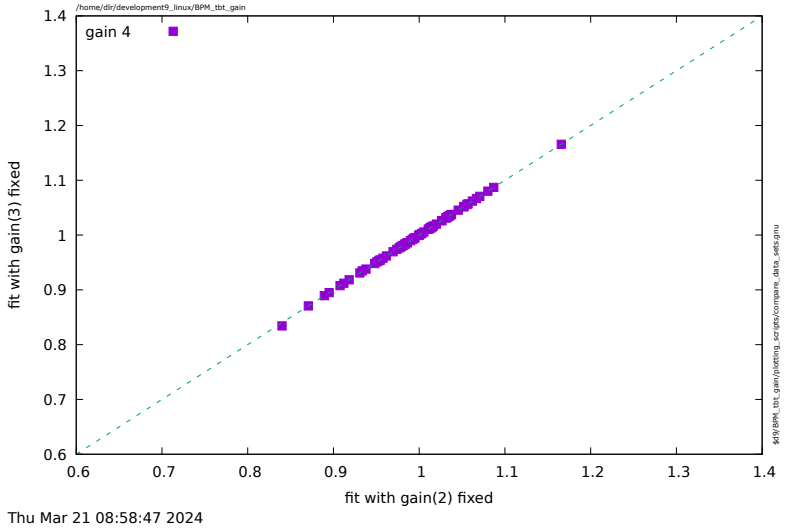
Fitted gain button 2



Fitted gain button 3

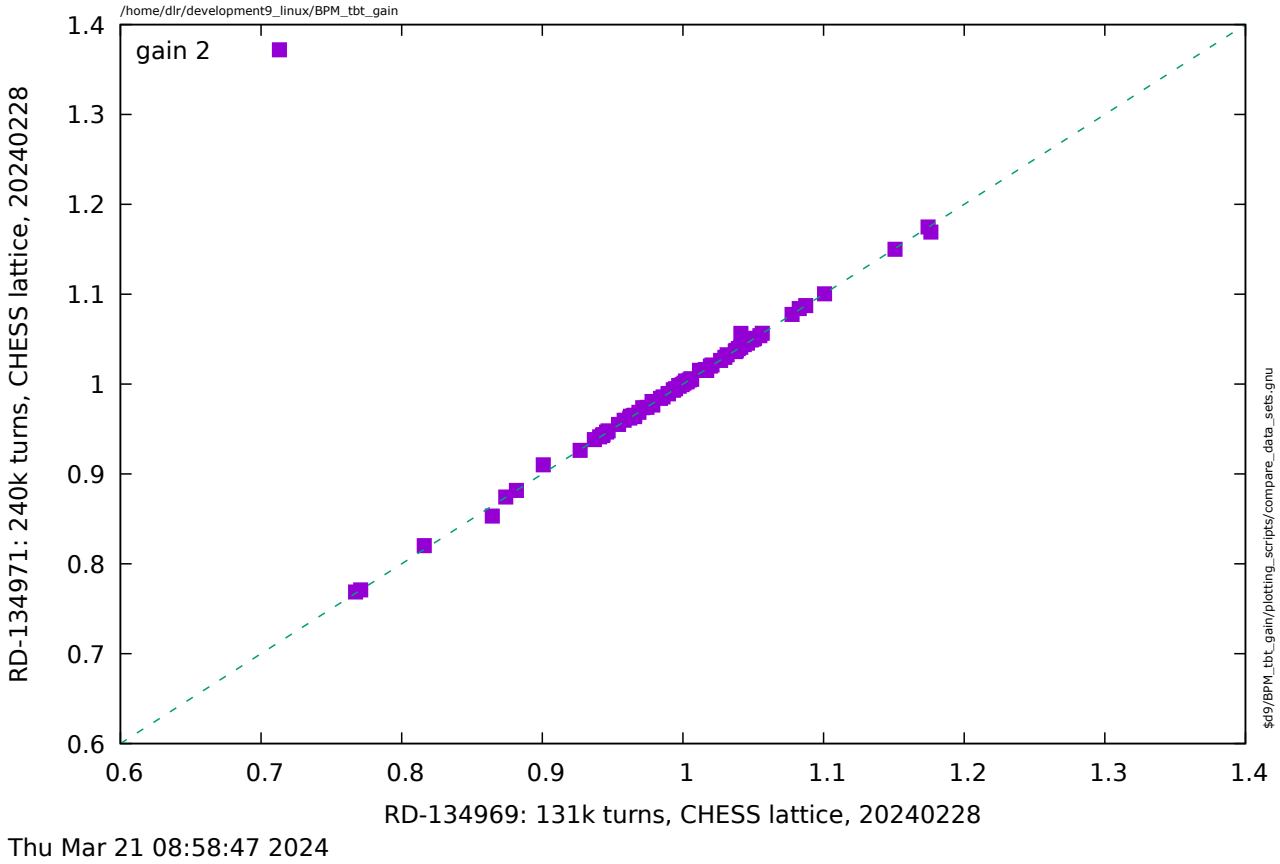


Fitted gain button 4

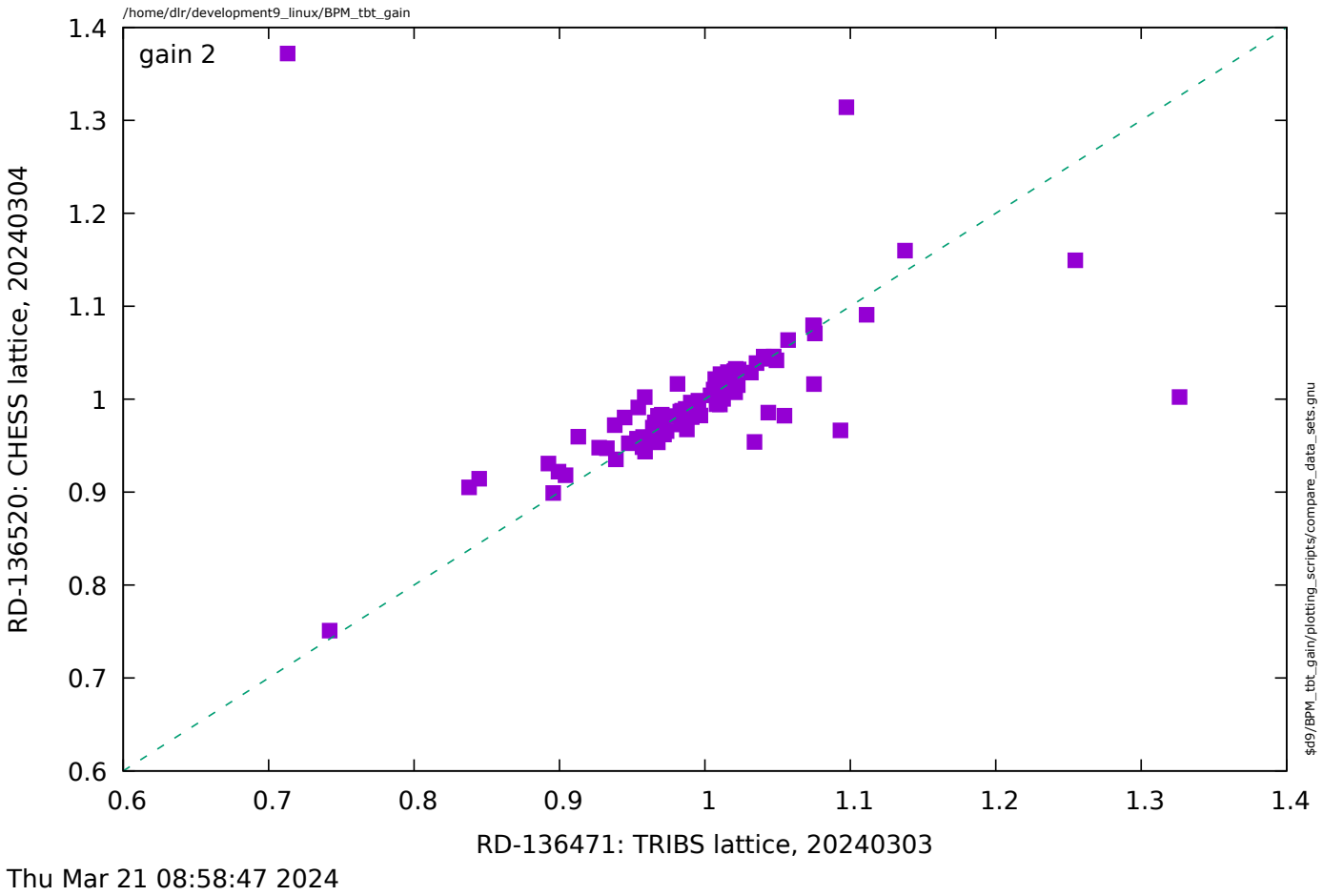


(Fitted gains are always normalized so that gain(1) = 1)

Compare data sets collected consecutively



Compare fits to data sets collected on different days



Comparing fits of different data sets.

The fitted gains are scaled so that the gain of button 1 is unity.

That will ensure that if we compared fits of different data sets that we will always get the same gain for button 1., namely unity.

That strategy pushes button 1 errors to 2,3,4

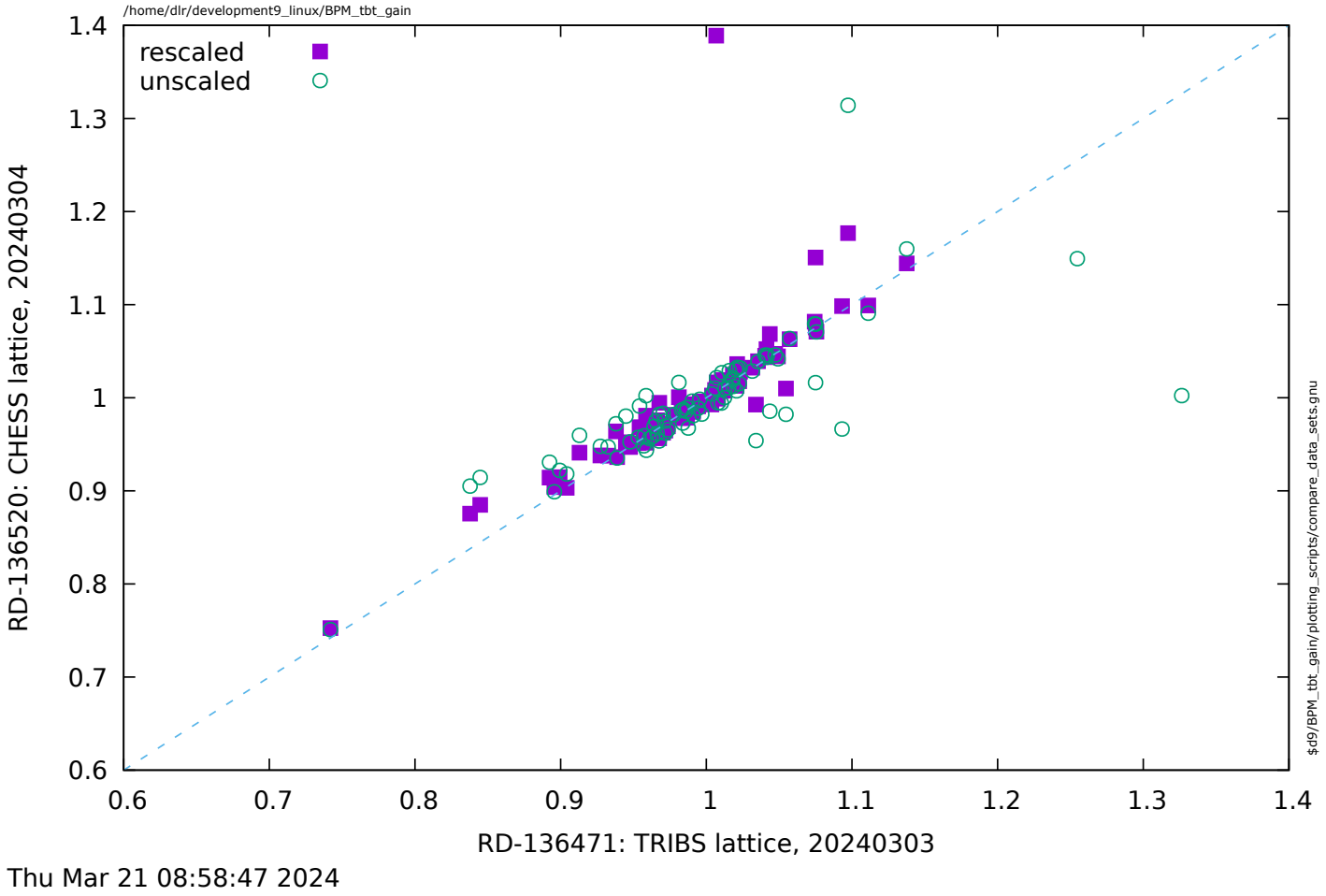
We can always rescale to minimize

$$\chi^2 = \sum_{i=1}^{4} (g_i^A - k g_i^B)^2$$

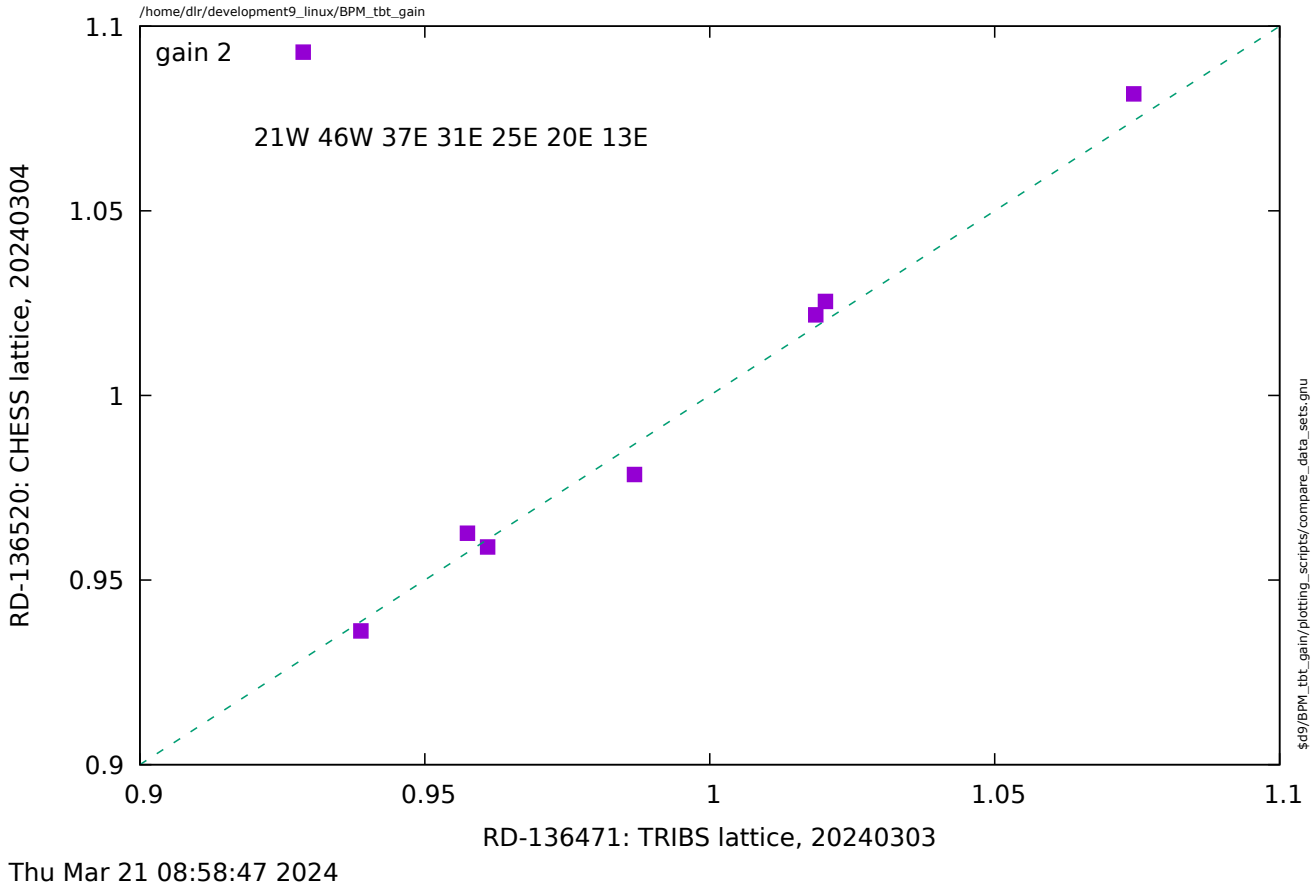
=>

$$k = \frac{\sum g_i^A g_i^B}{\sum (g_i^B)^2}$$

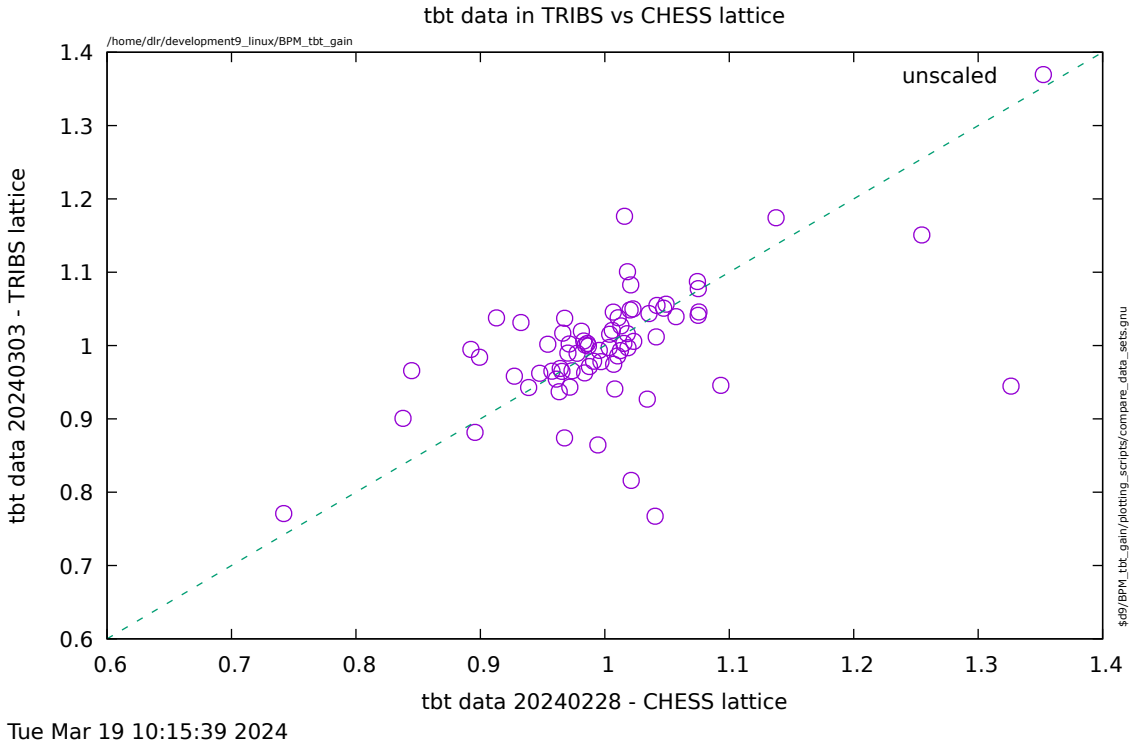
Compare fits from different data sets



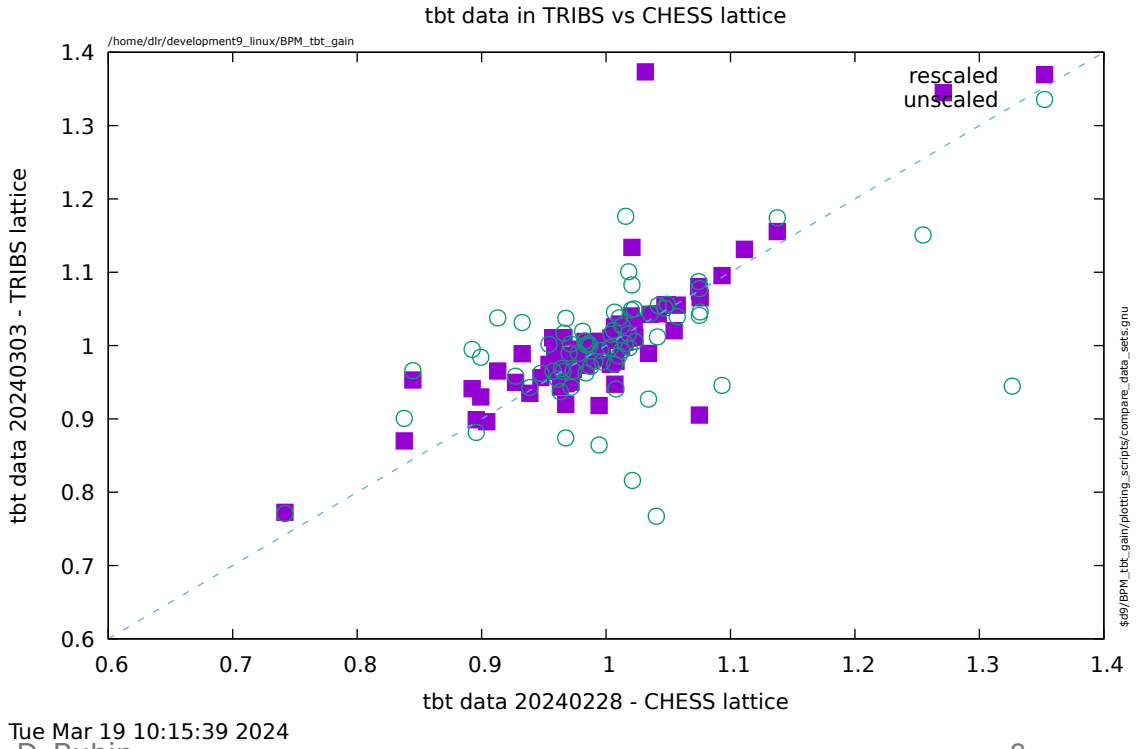
Subset



rescaled



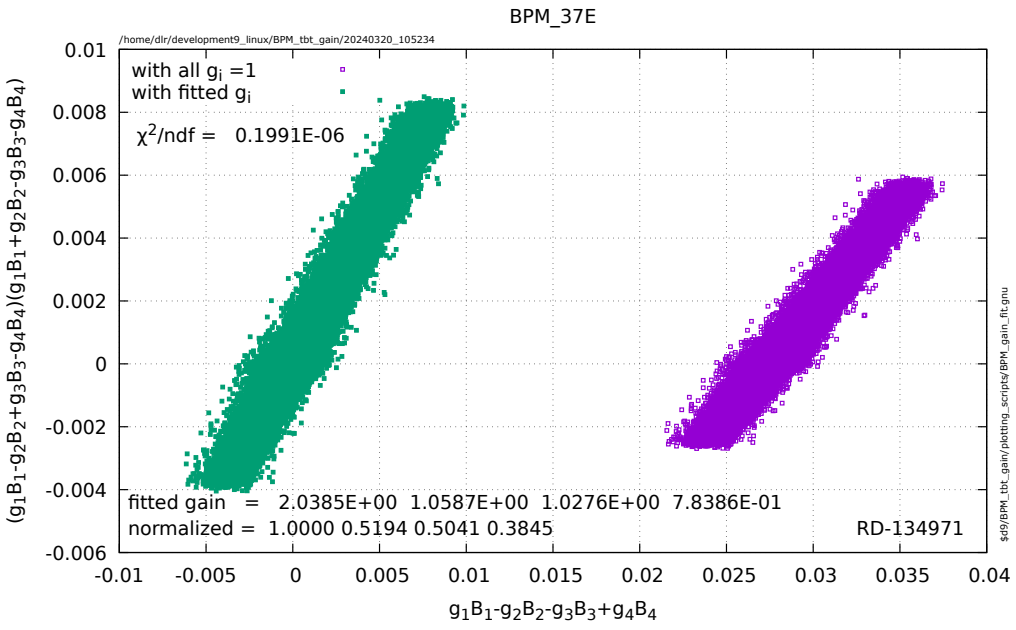
Compare fits to tbt data collected in the TRIBS lattice vs CHESS lattice



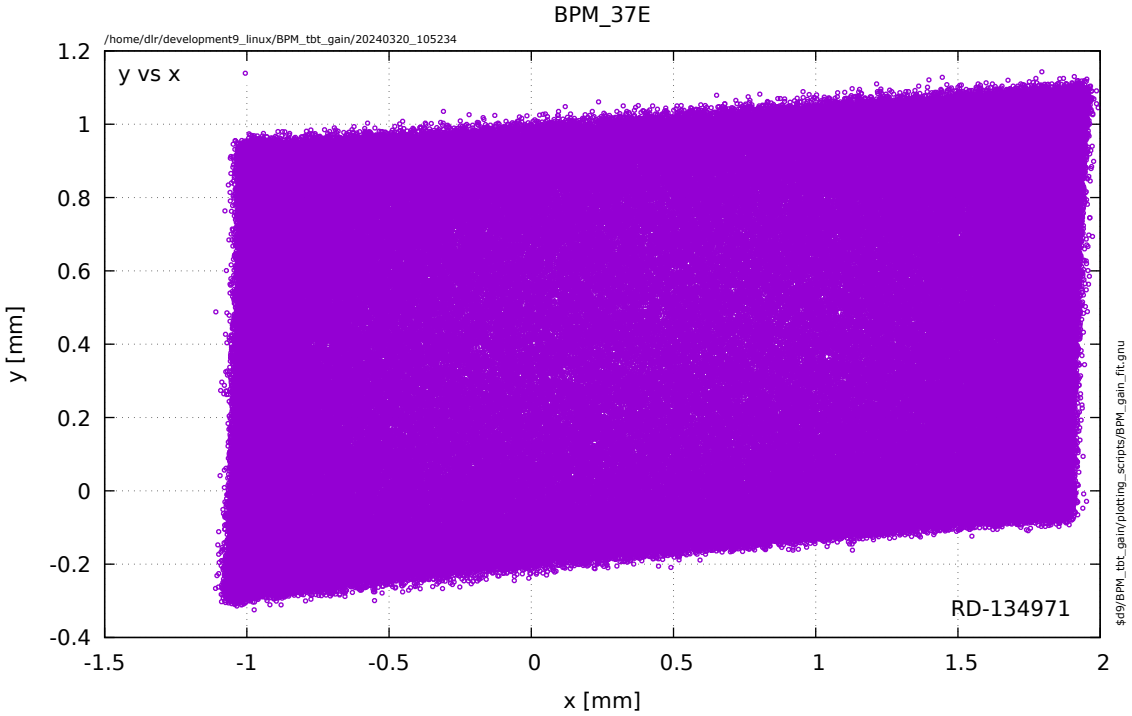
How to explain the irreproducibility from one day to the next?

- Orbit shift
- Sensitivity to shaking amplitude
- Imperfect fitting of button data
- Noise
- Real dependence of gain on temperature of BPMs, electronics, …

Noise?



Wed Mar 20 12:10:11 2024



Wed Mar 20 12:10:20 2024