Paper Evaluation and Summary

Name: Lukas Nies
Paper: Schlamminger et al. (Measurement of G using Beam Balance: Brief report in 2002 and letter with extensive procedure and results in 2006)

- What is the main finding of this paper and why is it important?
  Schlamminger et al. measured the gravitational constant G in 2006 with a significant better precision (10^{-5}) than former experiments by using not the torsion balance method but the beam balance method which reduces many systematic uncertainties and yields a result of $G = 6.674252(109)(54) \times 10^{-11} m^3 kg^{-1} s^{-2}$ by using larger scaled weights with around 13.5 tons of attractor mass and $1.1kg$ of test mass and measuring the gravitational force parallel instead of perpendicular to the local acceleration. The systematic uncertainty is therefore roughly $50ppm$ and an improvement of around factor 2 compared to the Gundlach paper of 2000.

- Describe at a high level the basic technique used. Try a series of "steps" here if necessary, if there is a sequence to be followed (like a recipe).
  Calibrate test weights (Copper, later Tantalum) before and after each test series. Perform the following position measurements while going through the measurement cycle (described below):

  1. The separation of the two tanks in position A (apart).
  2. The separation of the two tanks in the position T (together).
  3. The position between the two test masses (TMs)
  4. The center of the position of the combined attractor masses (FMs) in both position A and T.
  5. The distance of both the FMs center of mass and TMs center of mass in position T.

  The measurement cycle is as follows:

  1. Start in the position A.
  2. Measure the mass difference of the test masses in ULU order (upper-lower-upper) by loading four wire weights.
  3. Repeat the measurement with different wire loading and LUL scheme.
  4. Repeat 2 and 3 such that 32 different wire loadings were measured (eight cycles needed).
  5. Repeat steps 2 to 4 in alternating positions T and A in order to get measurements of all 256 possible wire loadings (eight large cycles)

- Choose an interesting technical aspect of the experiment and describe its relation and importance to the measurement.
  In order to avoid large systematic uncertainties due to nonlinearities of the balance itself a new method was used to average out the nonlinearity in situ. For doing this the amplitude of the signal of the modified mass comparator was measured and compared at several differend working positions while calibration. This eliminates, according to the paper, the influence of the nonlinearity of the balance by averaging the different results.

- Pick one systematic uncertainty issue that you find interesting and describe its importance and the author's method of addressing it.
  After modifying the mass comparator from the firm Mettler-Toledo by "removing non-essential part" (?!?) and reducing the number of windings of the coils to obtain higher sensitivity it has been found that changing the test masses introduces a periodic oscillation with a life time of several days (undamped). The resulting amplitudes were not attenuated by the digital filters and had to be taken into account by "weighting" and calibrating with calibration masses.

- Where did you get lost? Was there anything you did not understand?:
  How does the accuracy of the local gravity affect the total measurement, does local g change over time (measurement was 10 years earlier) ?!?!