Performance with Deformed Jaws

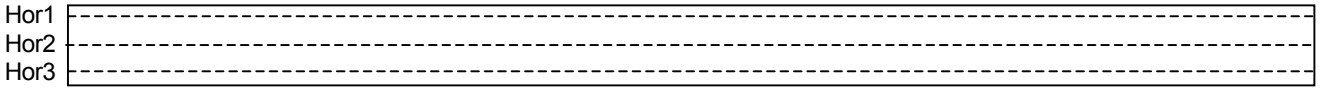
September 12th, 2005

- AP collimation team:
  C. Bracco, S. Redaelli, G. Robert-Demolaize, R. Assmann
- Study on implementing “banana” jaws into simulation had started already before measurements on TT40 (➔ C. Bracco).
- After discovery of deformation:
  - Crash program to quantify consequences for performance.
  - Not completed yet (highly CPU intensive).
  - So far: Worst case – all collimator jaws deformed the same way.
- R. Assmann presents results for the team (Stefano is away, Guillaume is studying orbit and beta beat, too early for Chiara, …).

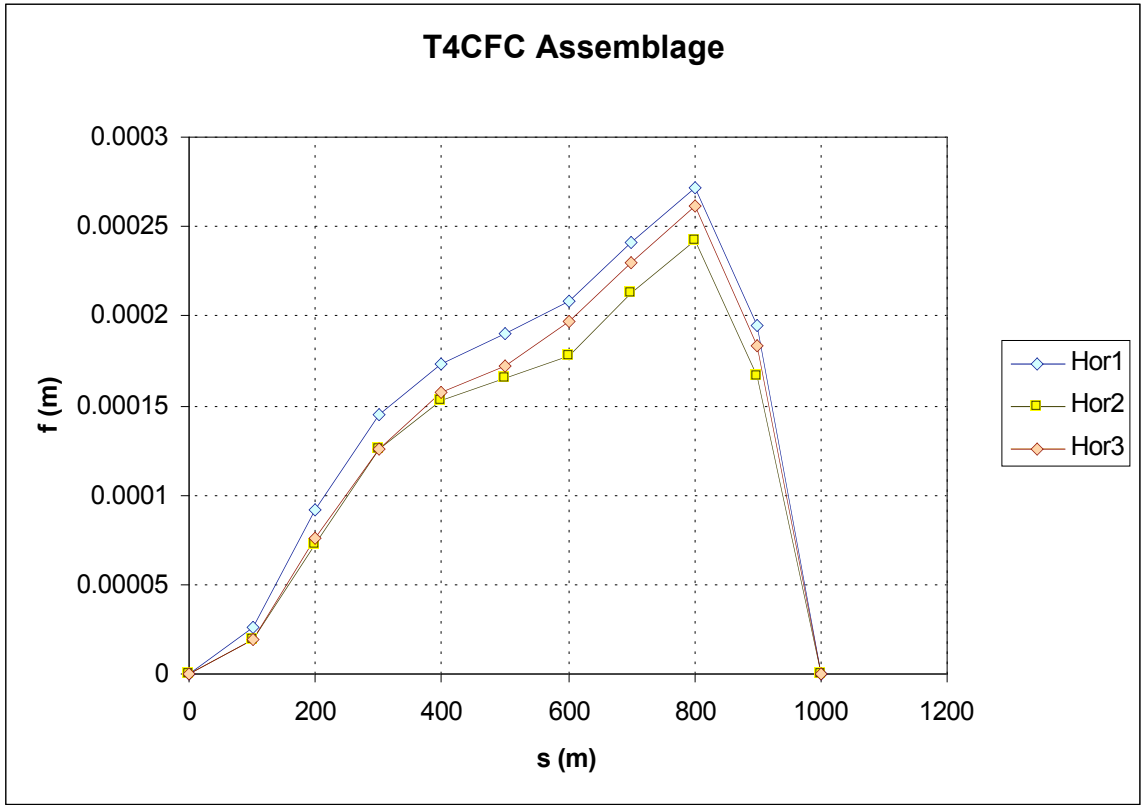
CFC

Collimator positioned horizontally.

Measures of flatness taken along three lines of the collimator :



Uncertainty : ±0.005 mm



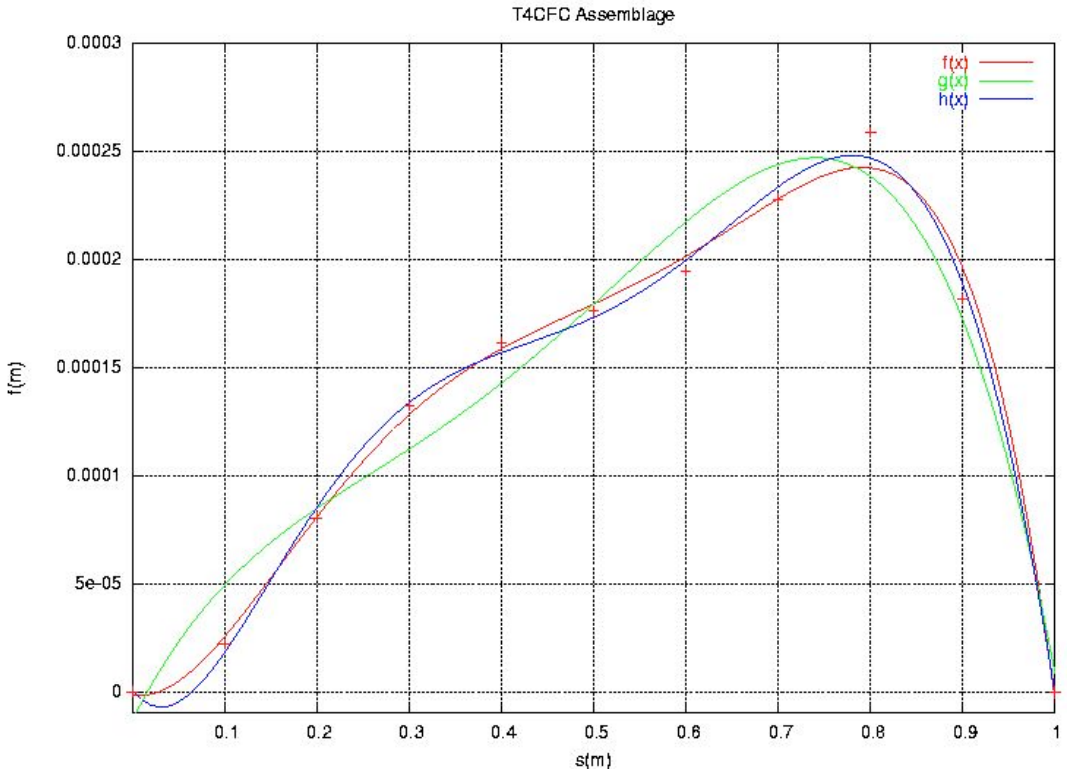
CFC

Average of the data and fit using:

g(x) 4th order polynomial

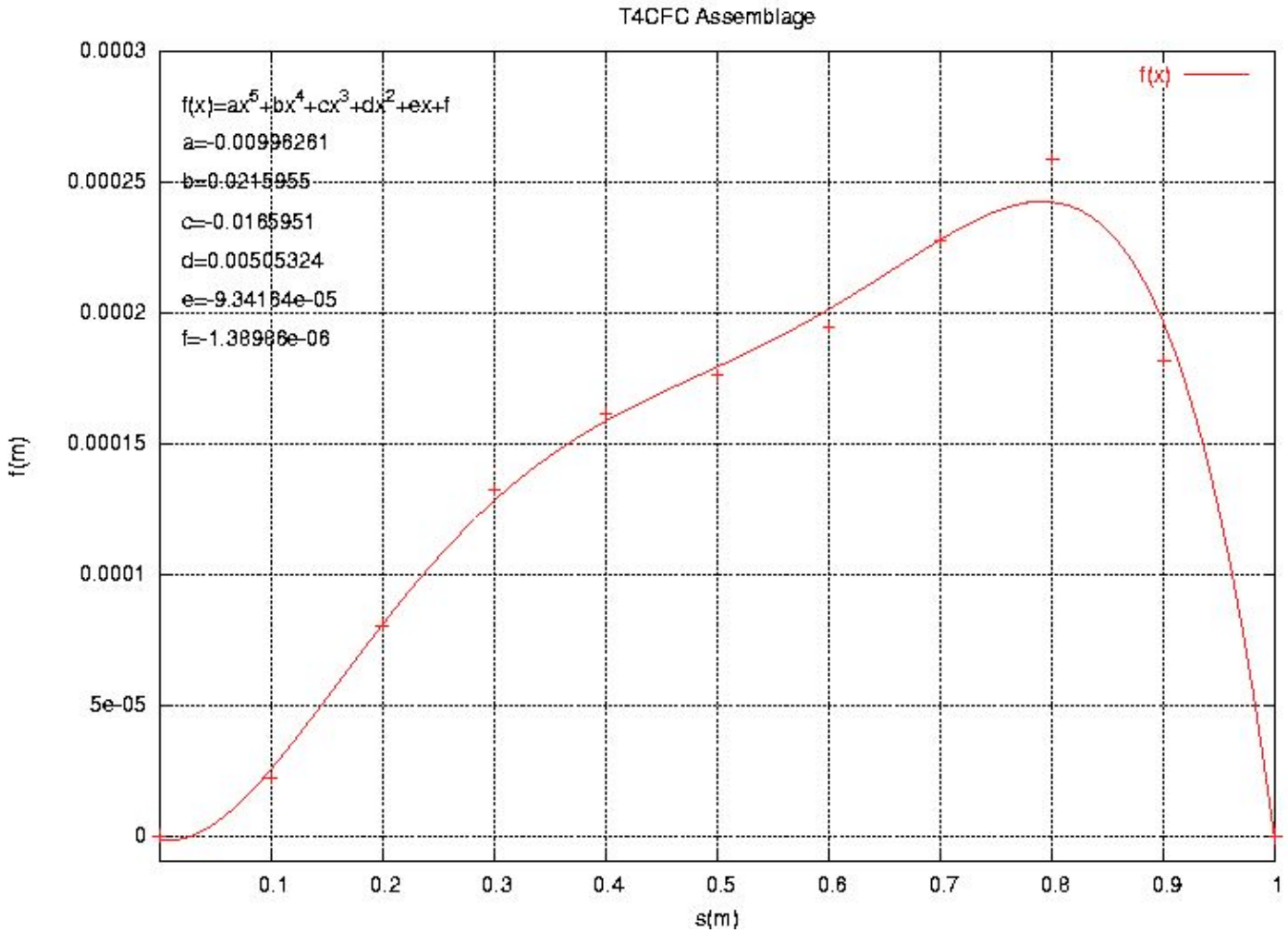
f(x) 5th order polynomial

h(x) 6th order polynomial



CFC

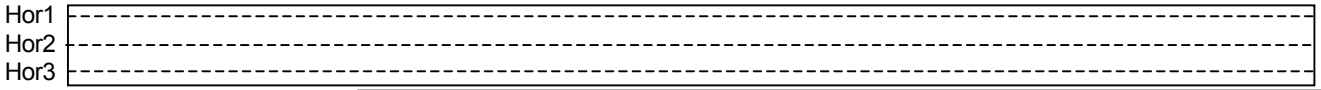
Best fit: 5th order polynomial



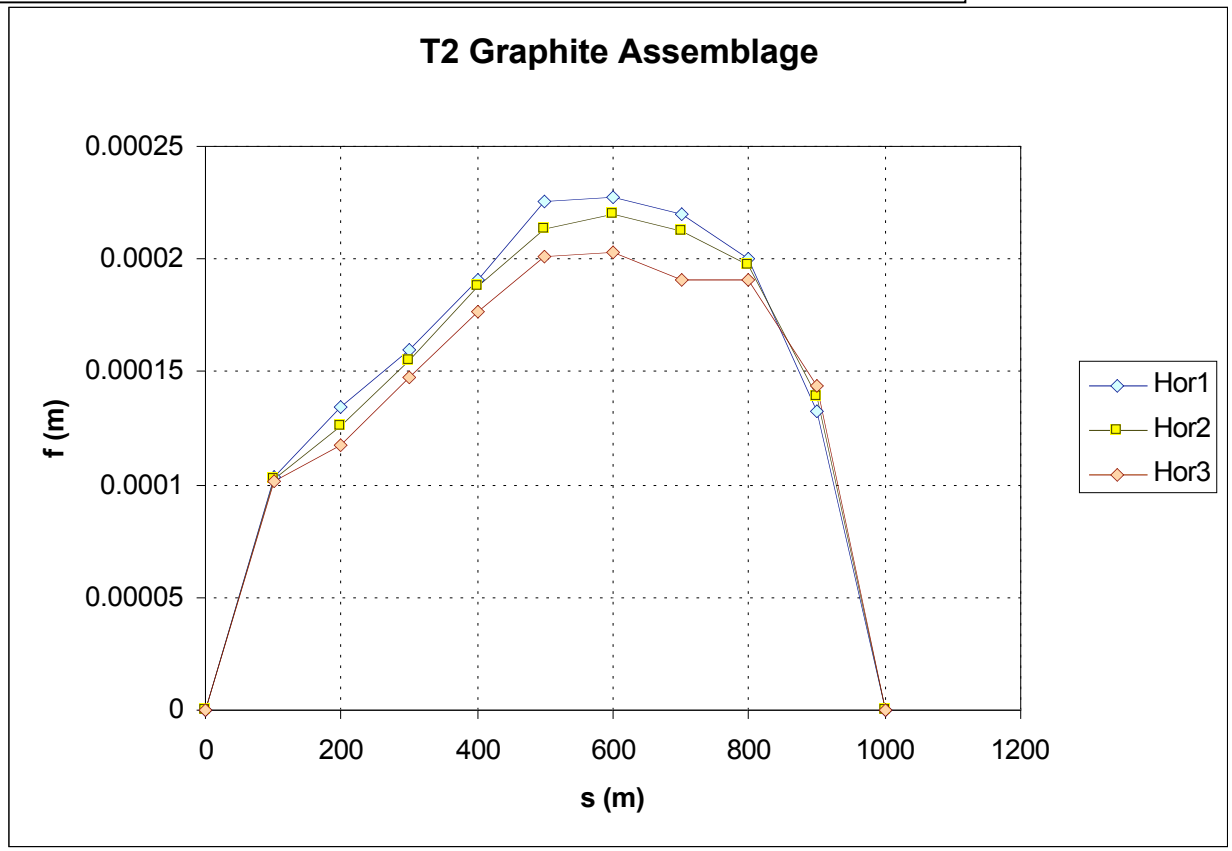
Graphite

Collimator positioned horizontally.

Measures of flatness taken along three lines of the collimator :



Uncertainty : ±0.005 mm



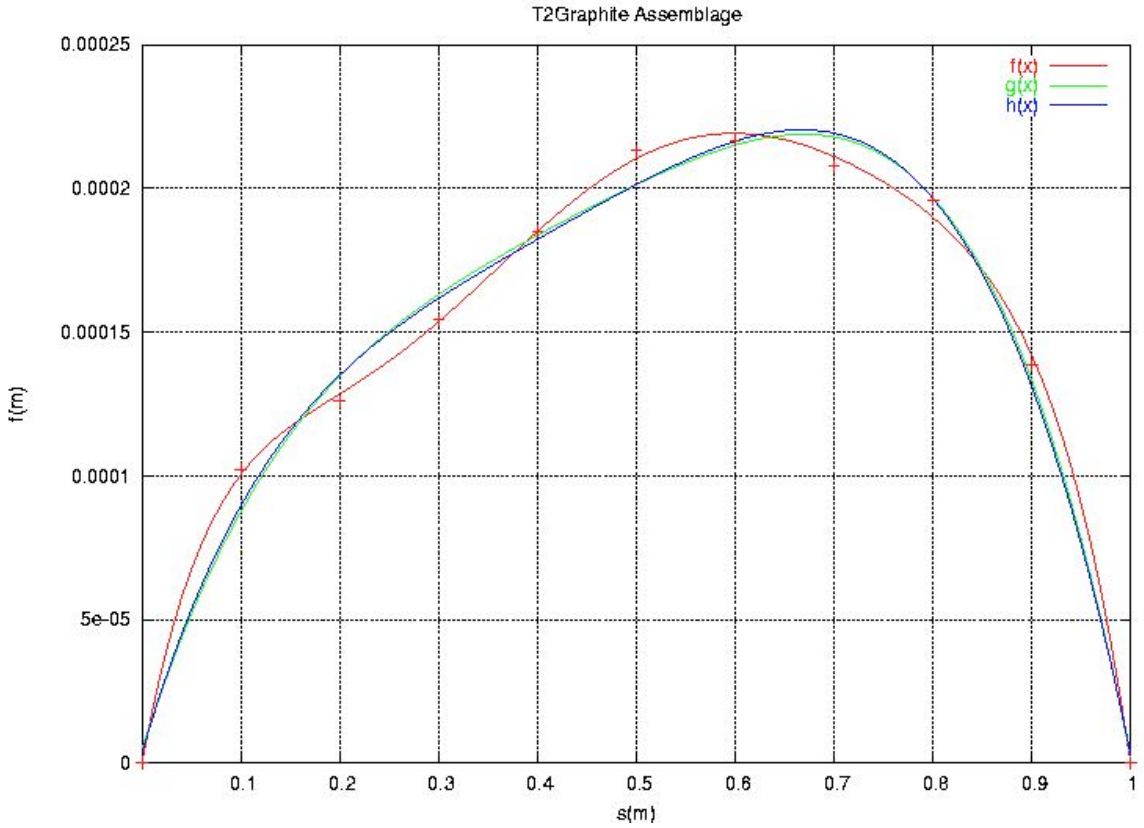
Graphite

Average of the data and fit using:

g(x) 4th order polynomial

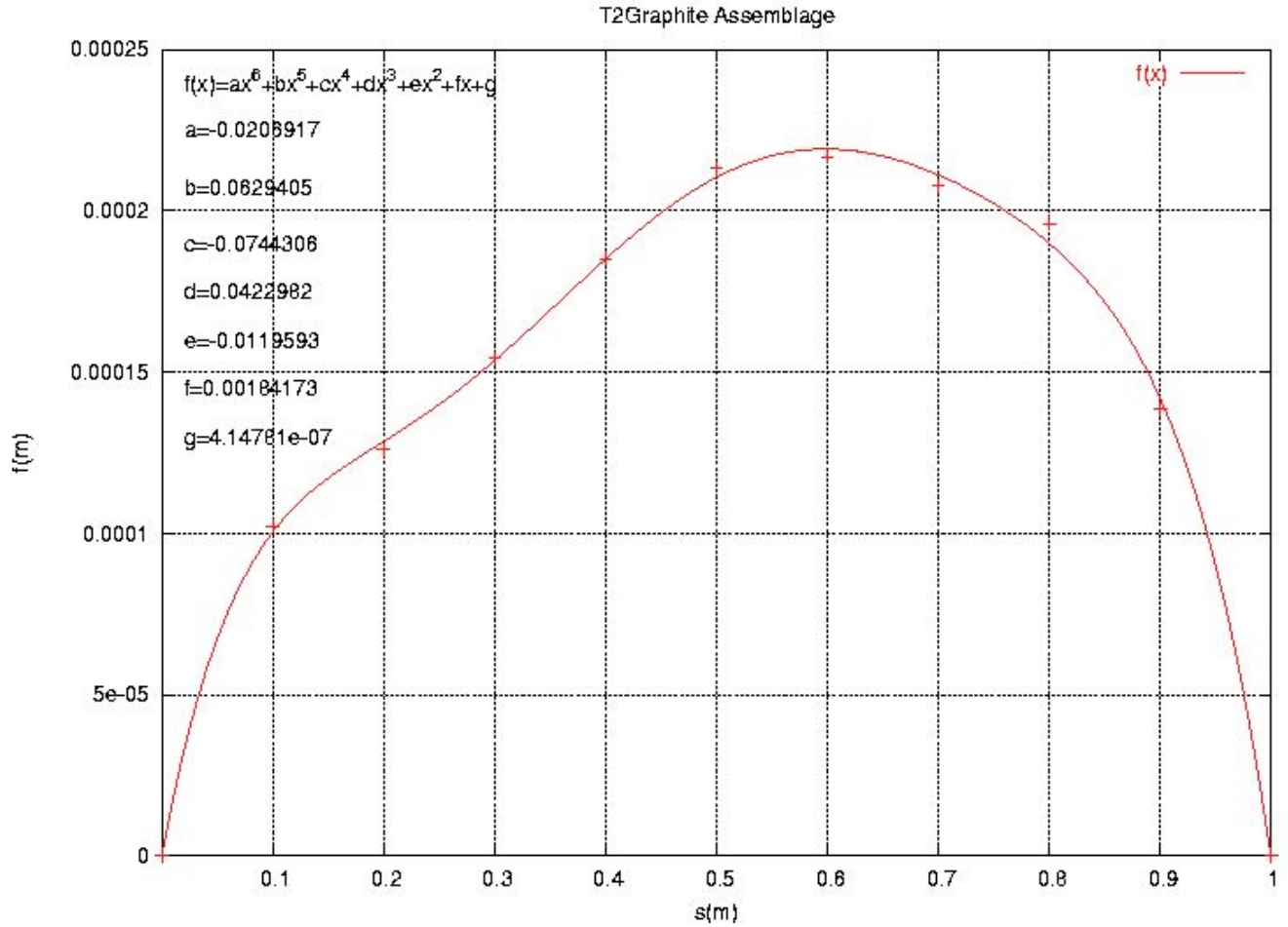
h(x) 5th order polynomial

f(x) 6th order polynomial



Graphite

Best fit: 5^{6h} order polynomial



Put into Perspective

- Already good outcome of TT40: Fully functional collimator and vacuum after 5 damaging events.
- Deformations will, however, limit cleaning efficiency:

  ➔ **BY HOW MUCH?**
- Good reproducibility of deformation for Graphite and CFC ➔ systematic effect.
- Experiment simulated 5 damaging events (mis-kick of 450 GeV full injected batch) on each jaw.
- 7 TeV similar to 450 GeV!?
- If we assume 5 such events per year in the LHC, equally distributed over all jaws, then all jaws would look like the measured ones **after 80 years**.
  (about 80 CFC jaws in IR3 and IR7, 2 per collimator)

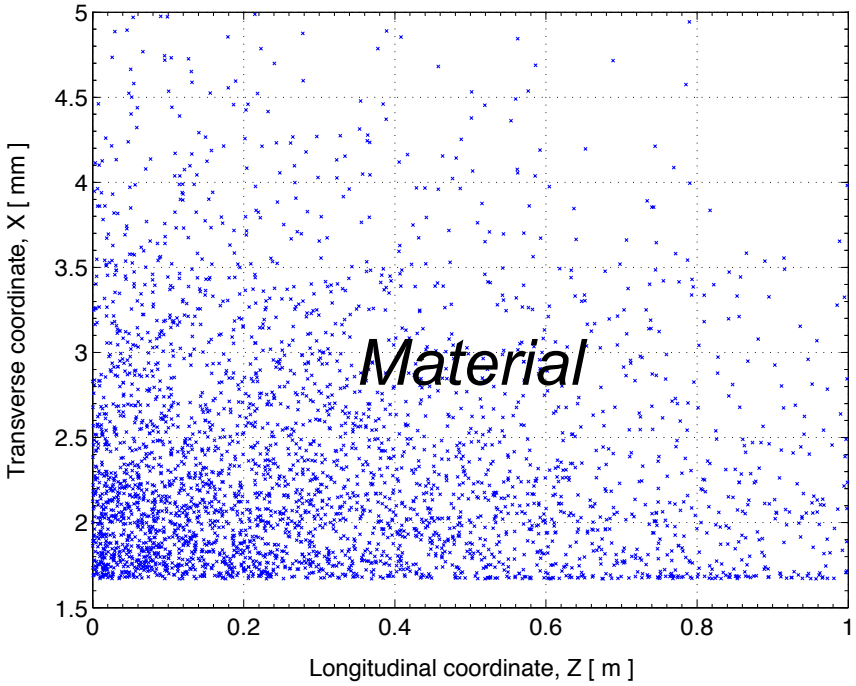
Simulation

- Break collimator into pieces.
- Change offset and angle for each collimator jaw piece.
- Observe cleaning efficiency as a function of deformation.

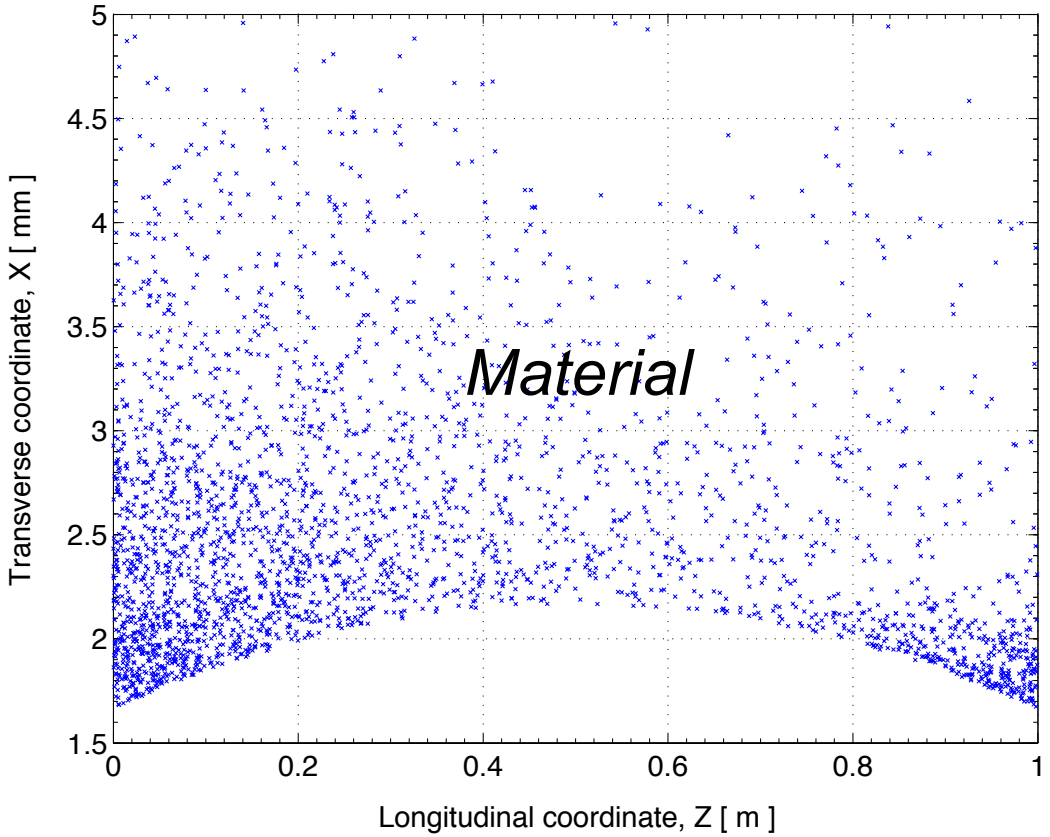
➔ Programming: R. Assmann, S. Redaelli, G. Robert-Demolaize.

➔ Simulations S. Redaelli.

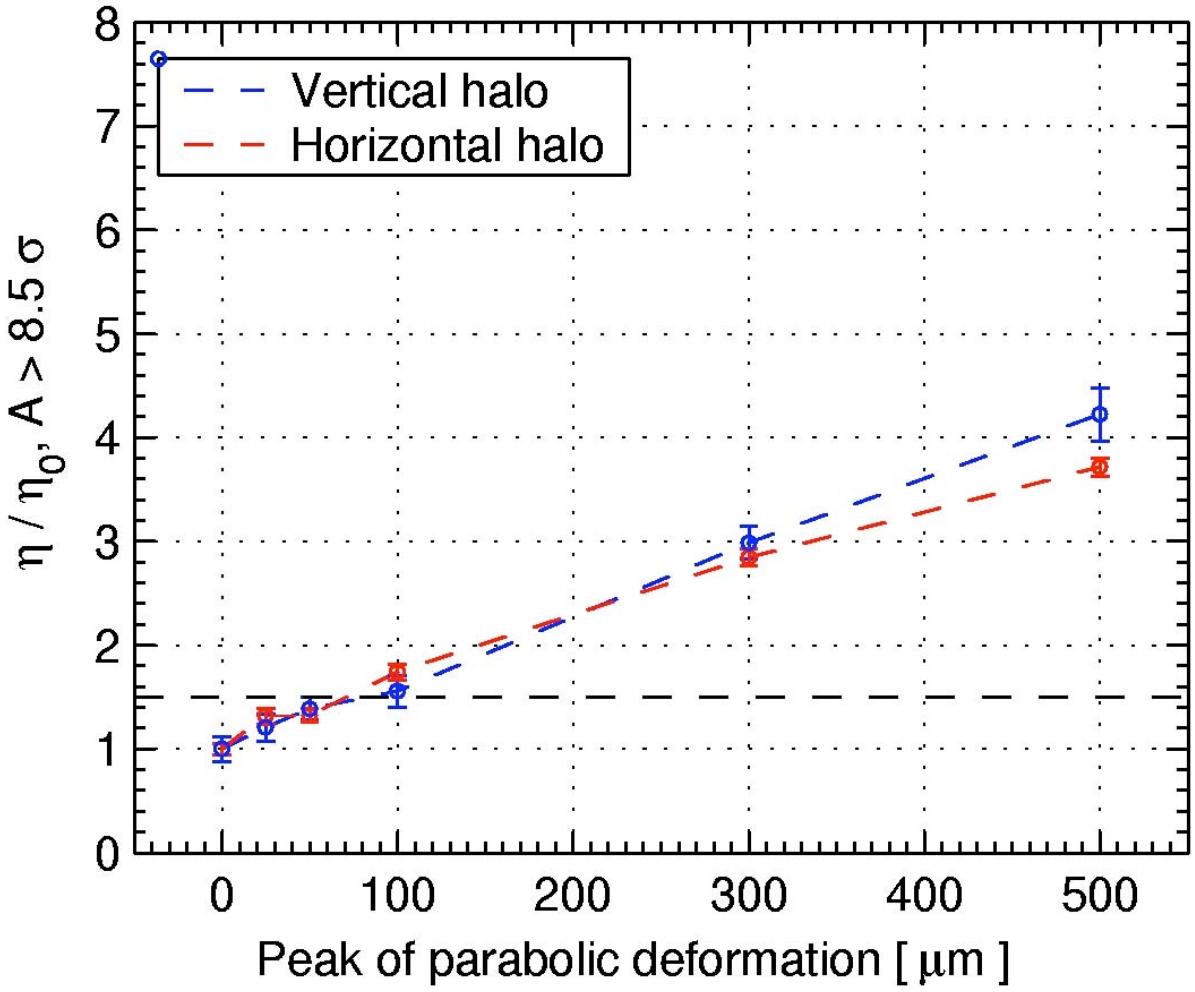
Inelastic Interactions in Jaw



"banana"



Inefficiency vs Deformation (INJ)

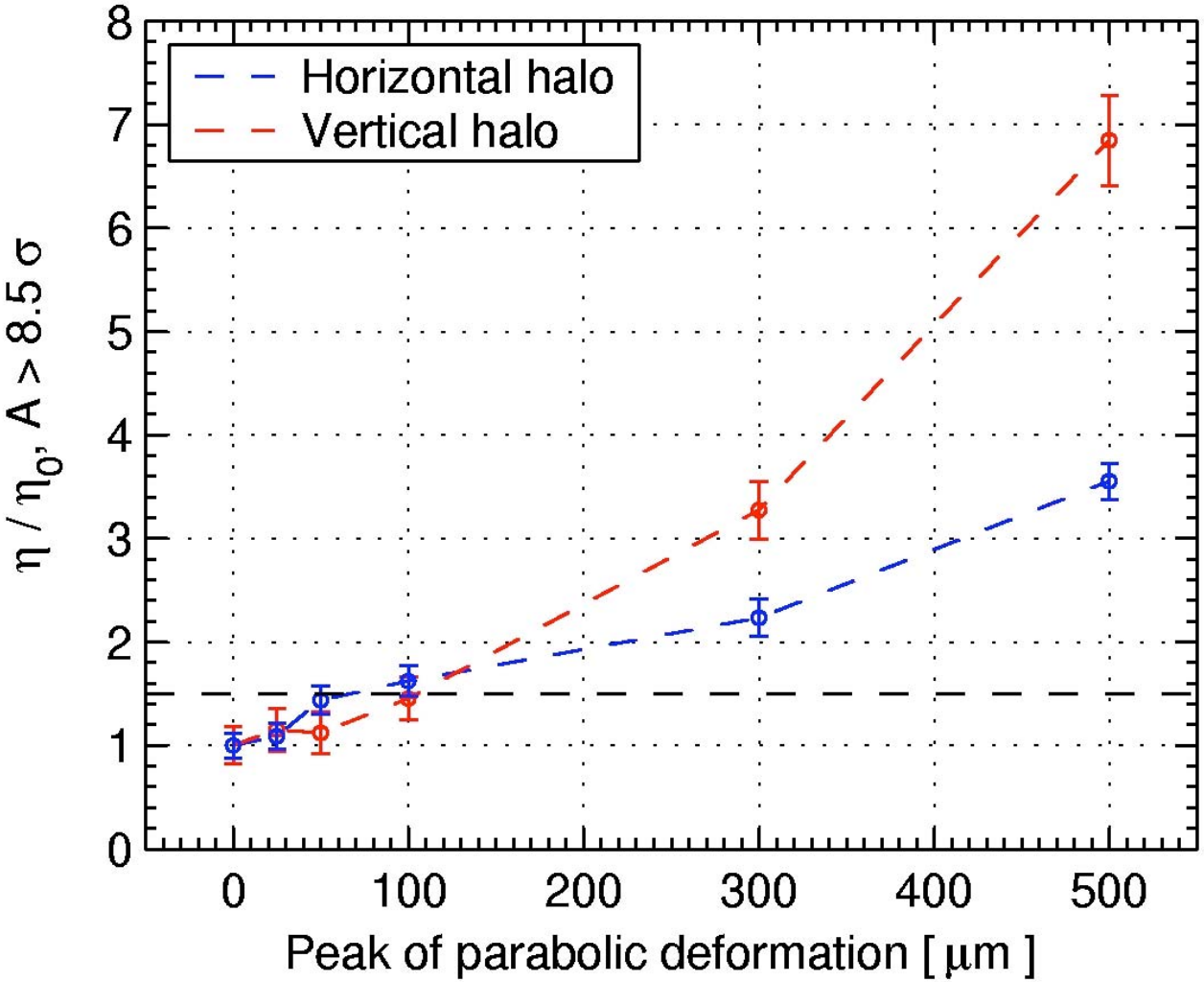


Worse

50% increase

Factor 3 loss for 300 μm

Inefficiency vs Deformation (TOP)



Worse

50% increase

Factor 2.5-3.5 loss for 300 μm

Conclusion

- Overall flatness tolerance (25-50 μm for 50% higher inefficiency) is reproduced in full simulation with good accuracy.
- If all jaws get the 300 μm deformation:
  ➔ Loose about factor 3 in efficiency!
- Would mean beam current limit reduced by factor 3! However, only after each jaw has received 5 accidents (many years or never)!
- Conclusion for average loss:
  - We have 28 IR7 jaws per beam for 300% increase in inefficiency for 5 accidents.
  - Increase "average" inefficiency per jaw by ~10% for 5 accidents (or 2% per accident?)…
- Simulate now: Deformations of single jaws!
  - Worst and best case.
  - Fold with probability…

Project Conclusion

- Good to find this problem: Shows value of prototyping and beam tests.
- Solution has been produced to avoid problem ➔ agreement here?
- Solution can still be implmented into series production and even for sample jaws!
- Redo beam test (damage) with modified design in 2006?
- Worrisome: Was found almost too late to react! Could have been found ~six months earlier if more manpower!
- Illustrates risk that we are taking at CERN with too restricted resources: It does not make sense to build a prototype, do beam tests (quite some investment) and then to not have the resources to do fast and proper analysis!