Vibration Isolation

On the determination of direct disturbance forces

Msc. graduation presentation

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Or: Transistors 101 How to be a billionaire in times of crisis

Contents

Intro
- Transistors 101
- Writing in stone - Lithography

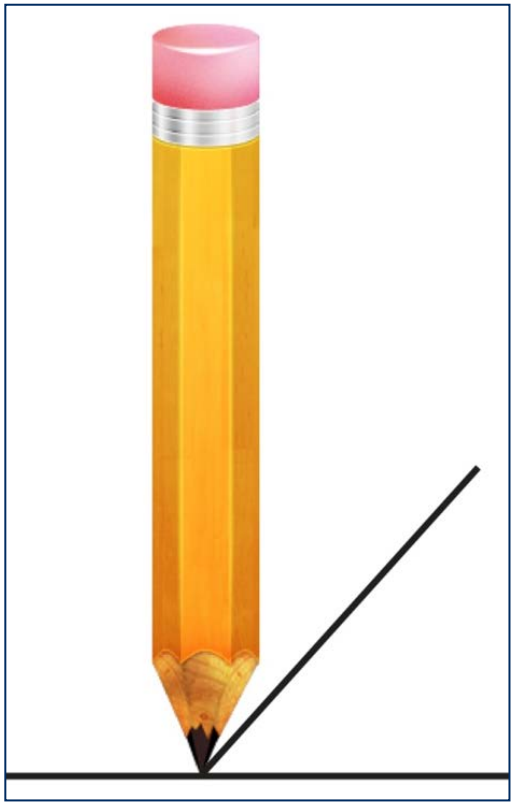
Body
- Smaller parts = smaller errors

End
- Final conclusions
- Questions

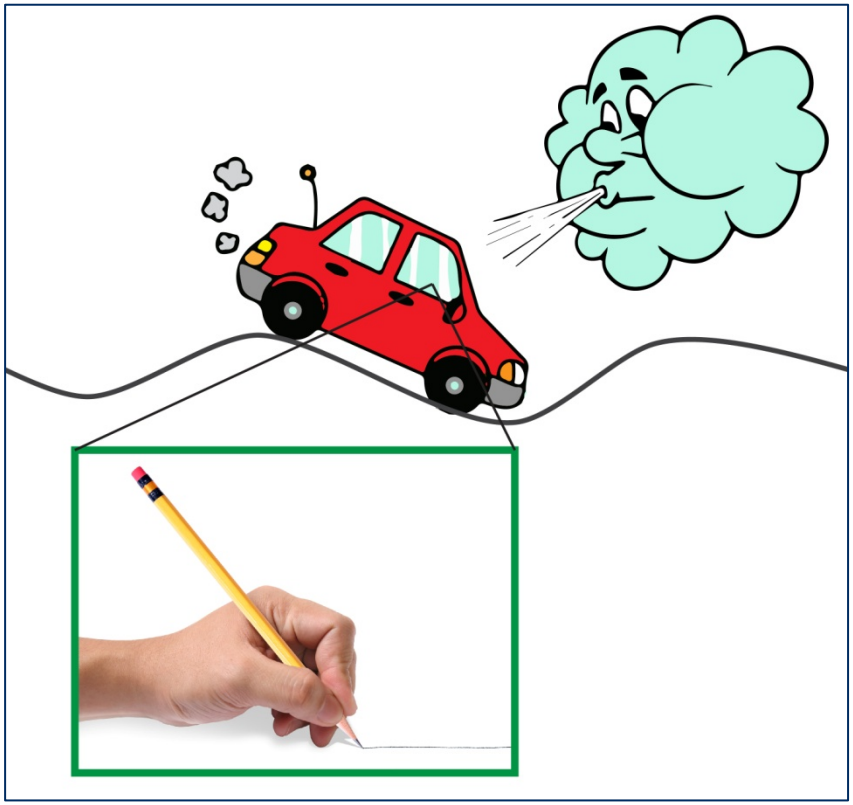
Two main examples

Try to imagine...

Example 1:
Writing a line on a moving paper



Example 2:
Doing the same but in a moving car



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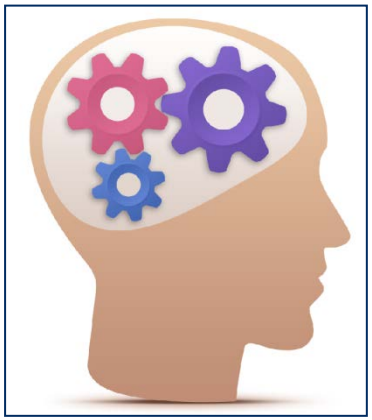
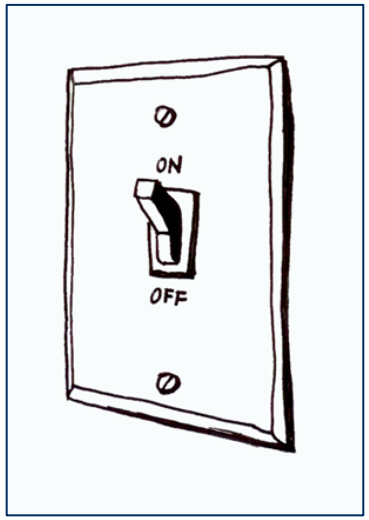
TRANSISTORS 101

WHY YOU ARE A BILLIONAIRE

The transistor

The fundamental building block





Internet → Computer → Processor → Transistor

Astronomical numbers

Why you are a billionaire

- +/- 200 billion transistors per person
- Intel: produces 5 billion transistors per second
- More transistors than grains of sand on earth..

200 – 600 billion stars

40 x – 120 x

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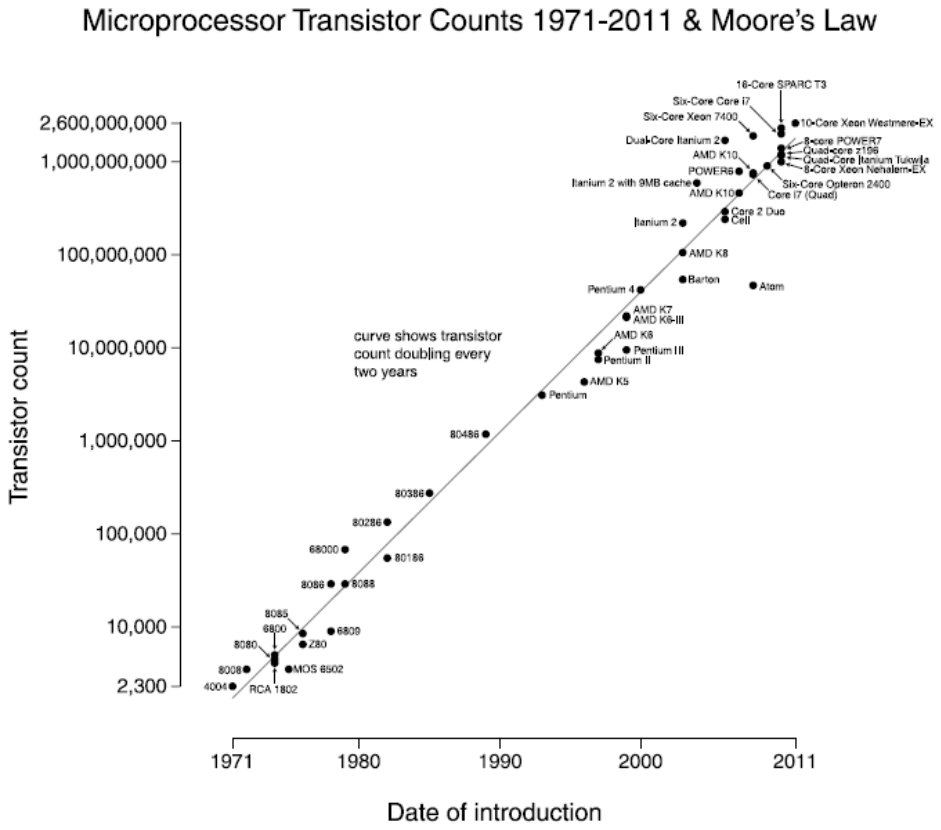
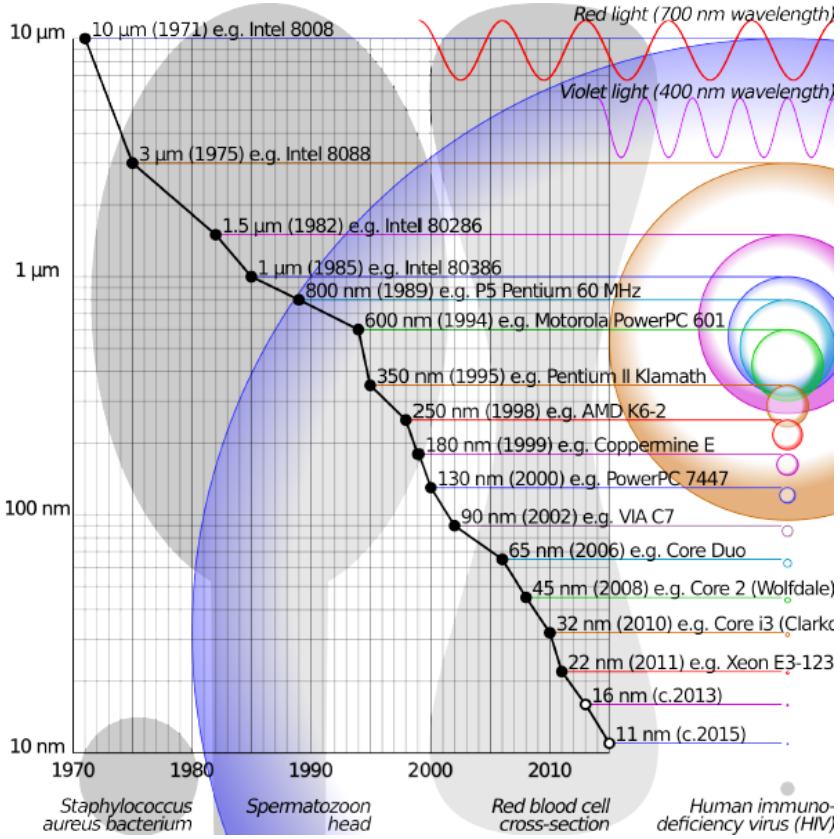
WRITING IN STONE

HOW DID YOU BECOME SO RICH?

Moore's Law

2 x more transistors in 2 years

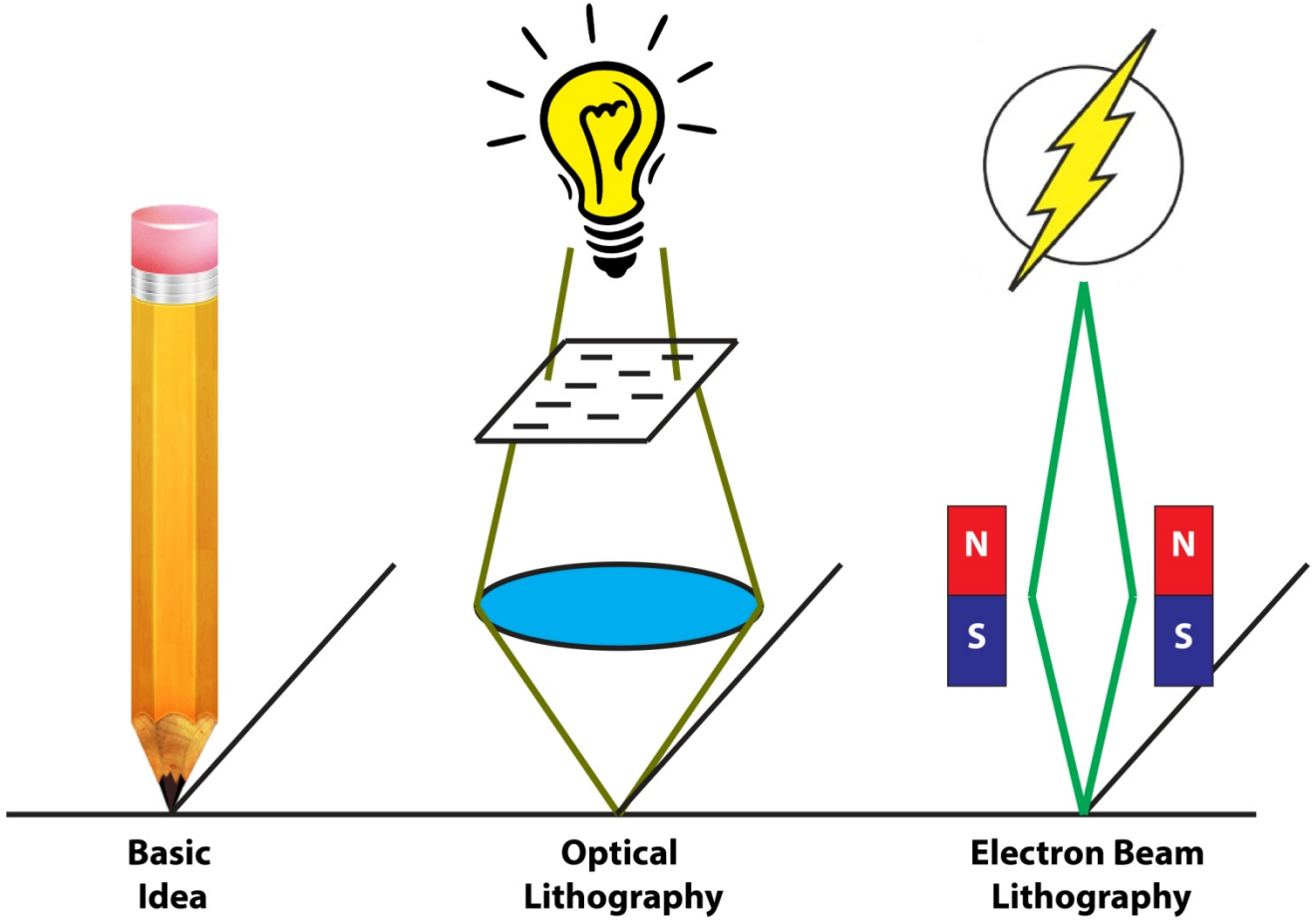




More transistors on same surface = Smaller parts

Lithography tools

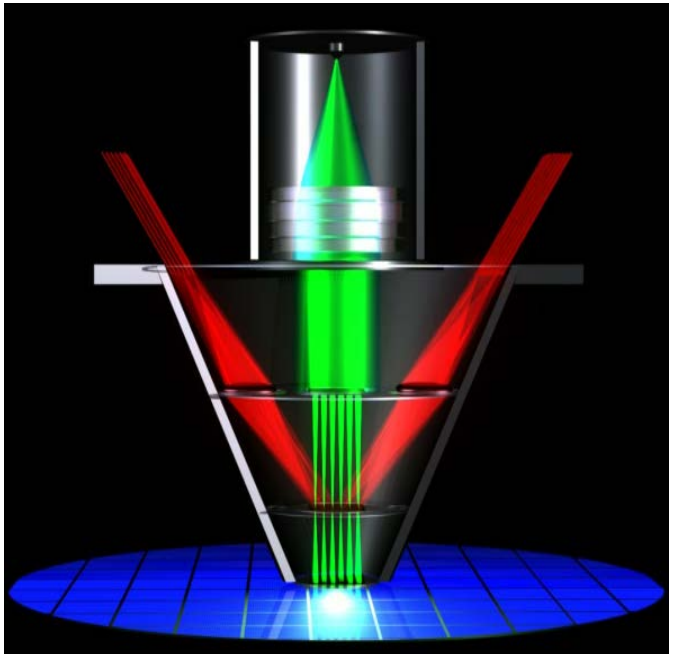
The better the pen the smaller the line

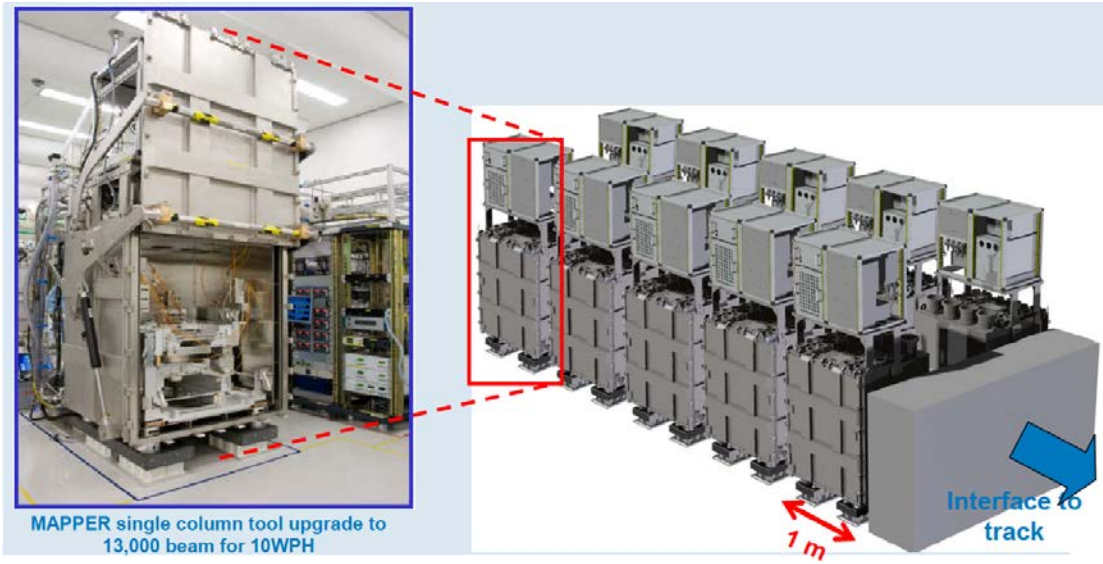


Meet David

We know how that story ended..

- Mapper Lithography
- Different advantages and disadvantages





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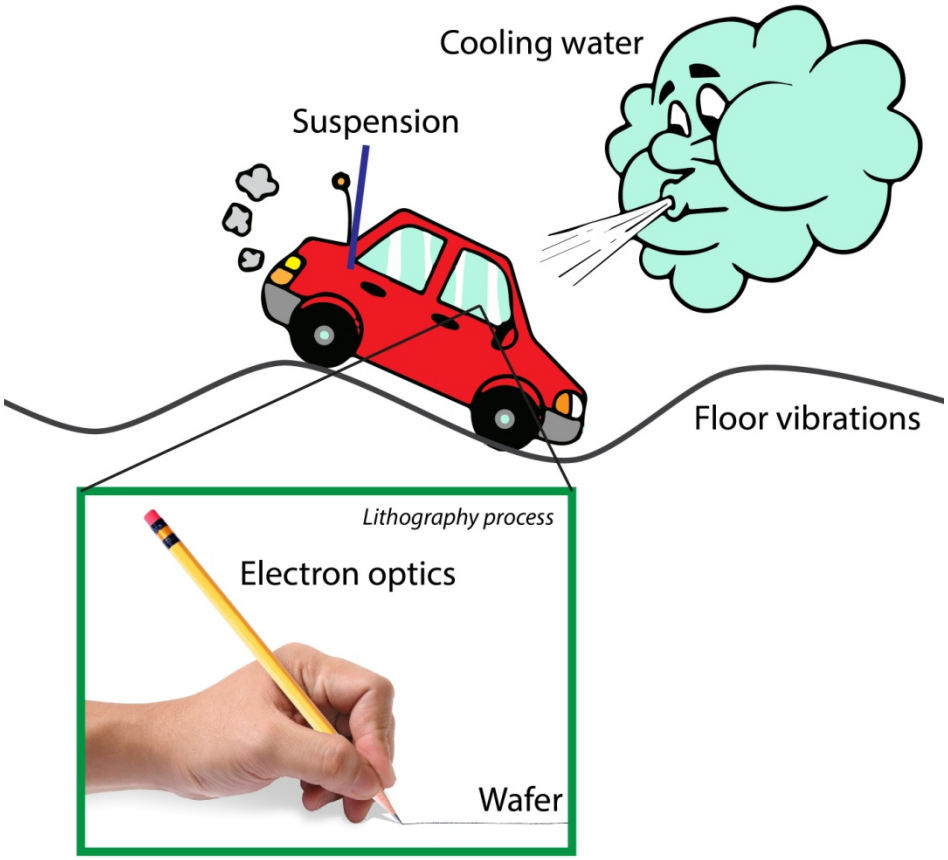
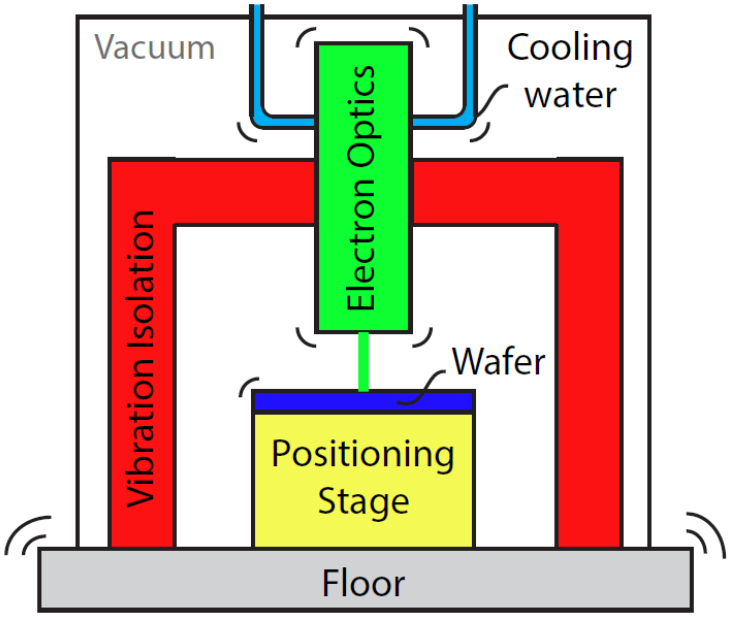
SMALLER PARTS = SMALLER ERRORS

MOORE IS LESS

The Mapper machine

Enter the Matrix



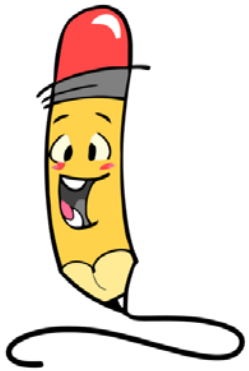


Main challenge

What is the strategy?

Reduce the error in alignment between the electron optics and the wafer caused **by the disturbances** acting on the **vibration isolation system** to 1 nm 3-σ RMS

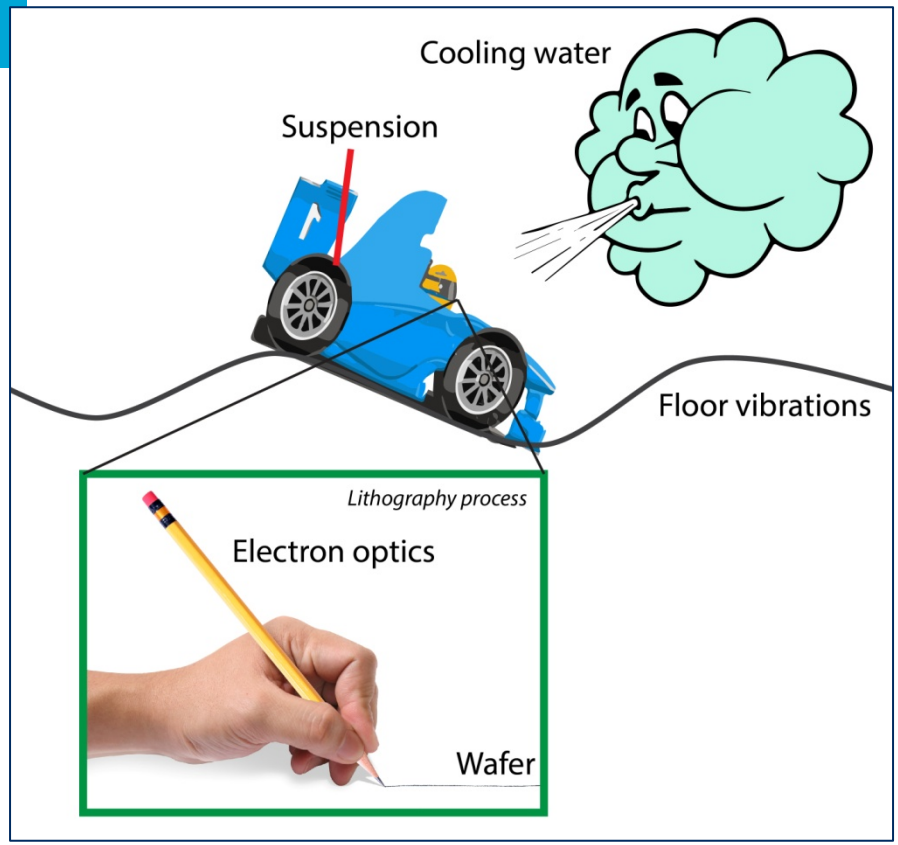
- What are the properties of the vibration isolation system?
- How do the properties influence the performance?
- Investigate the property which limits the performance
- Discuss the results

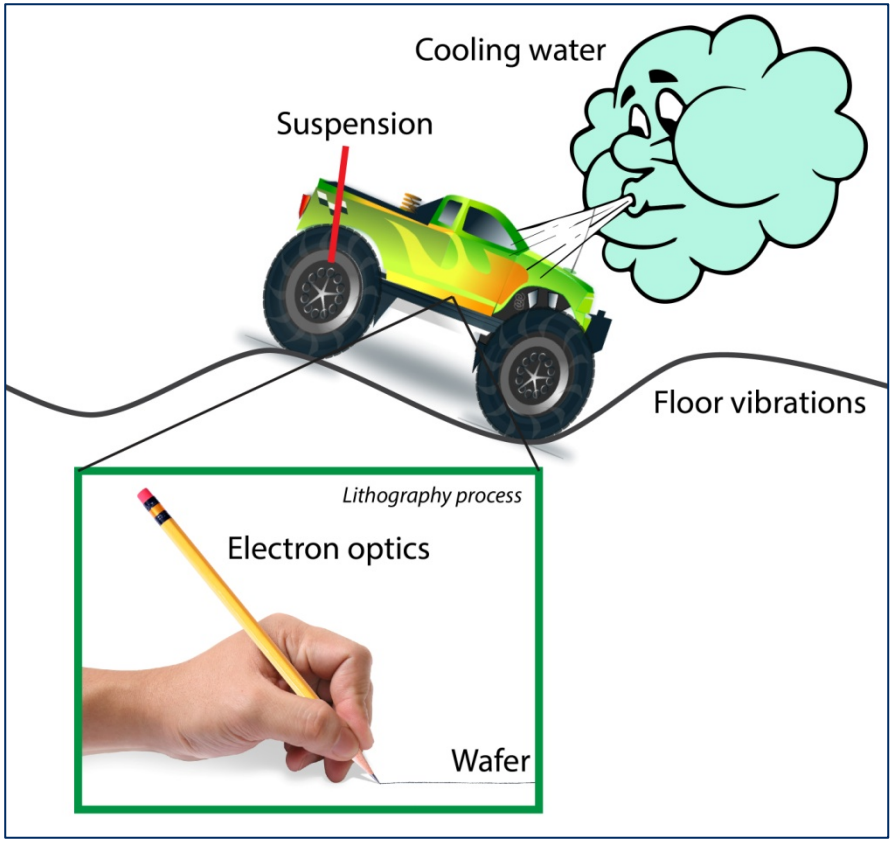


Investigate → Identify → Characterize

Vibration isolation

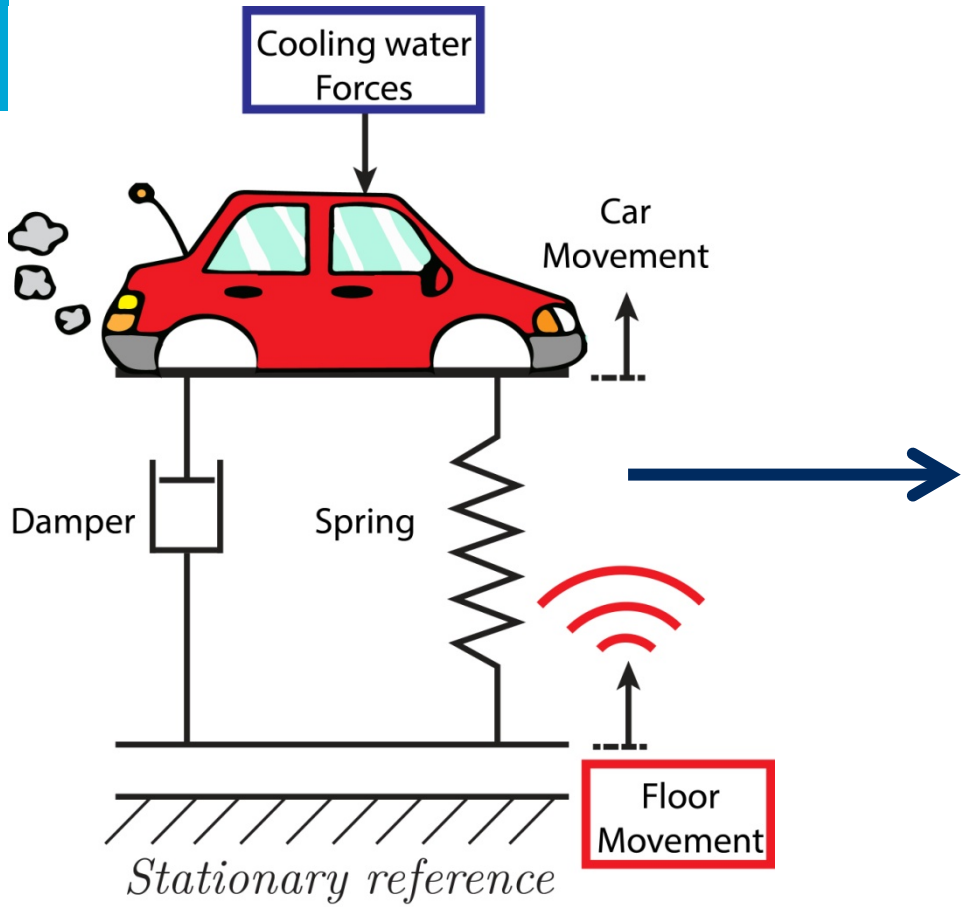
What and how ..

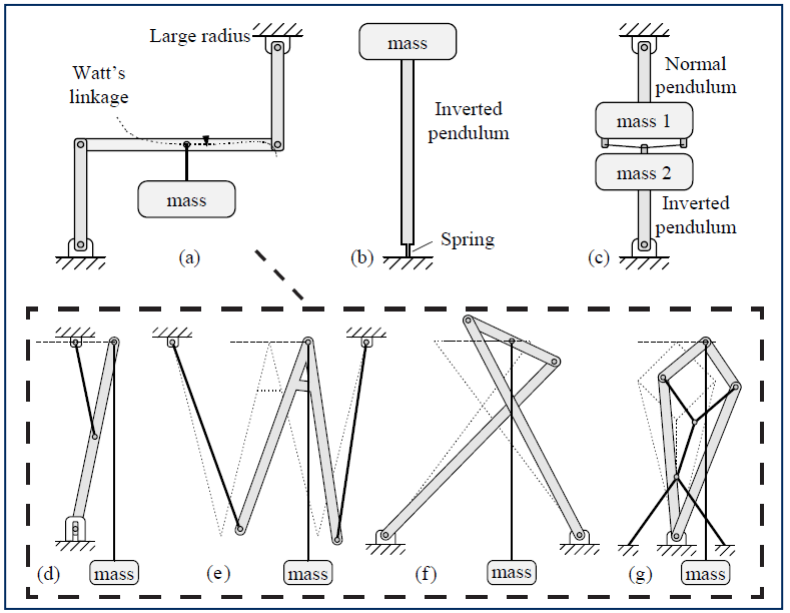


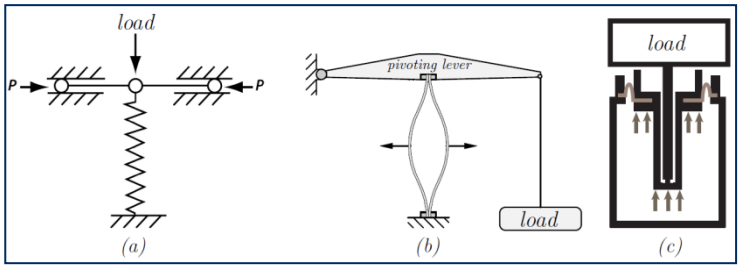


Vibration isolation

Designing the suspension



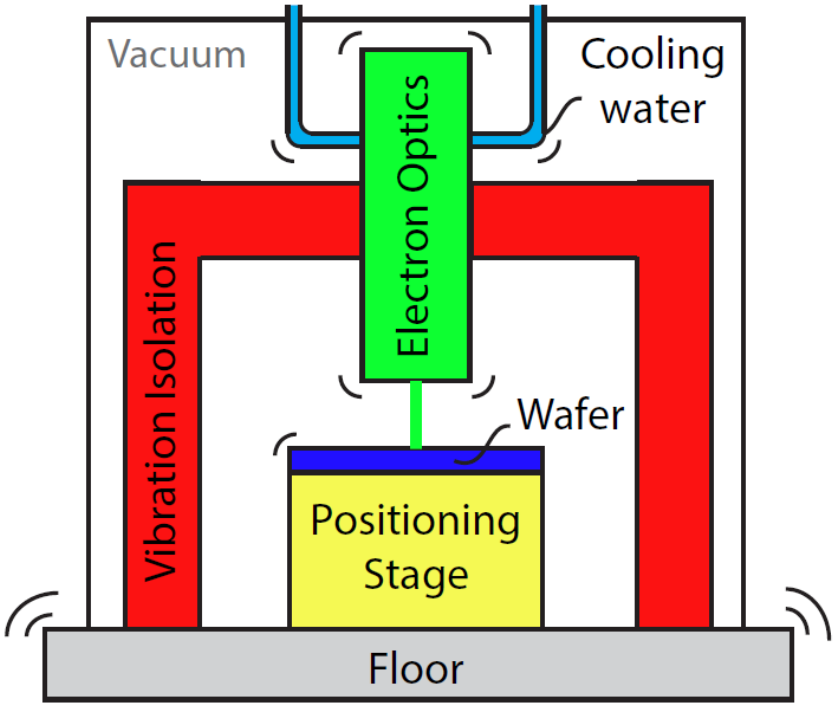




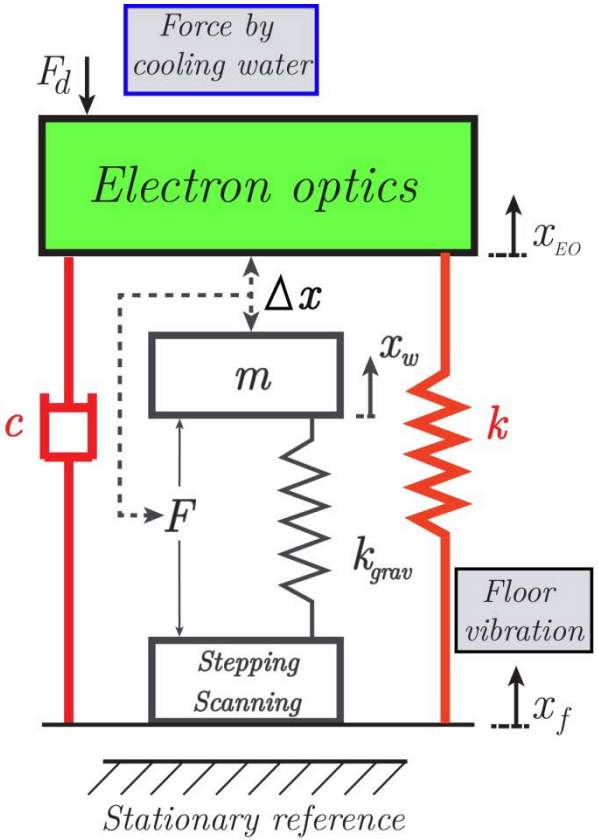
Dynamic error budgeting

Predicting the error

Basic model

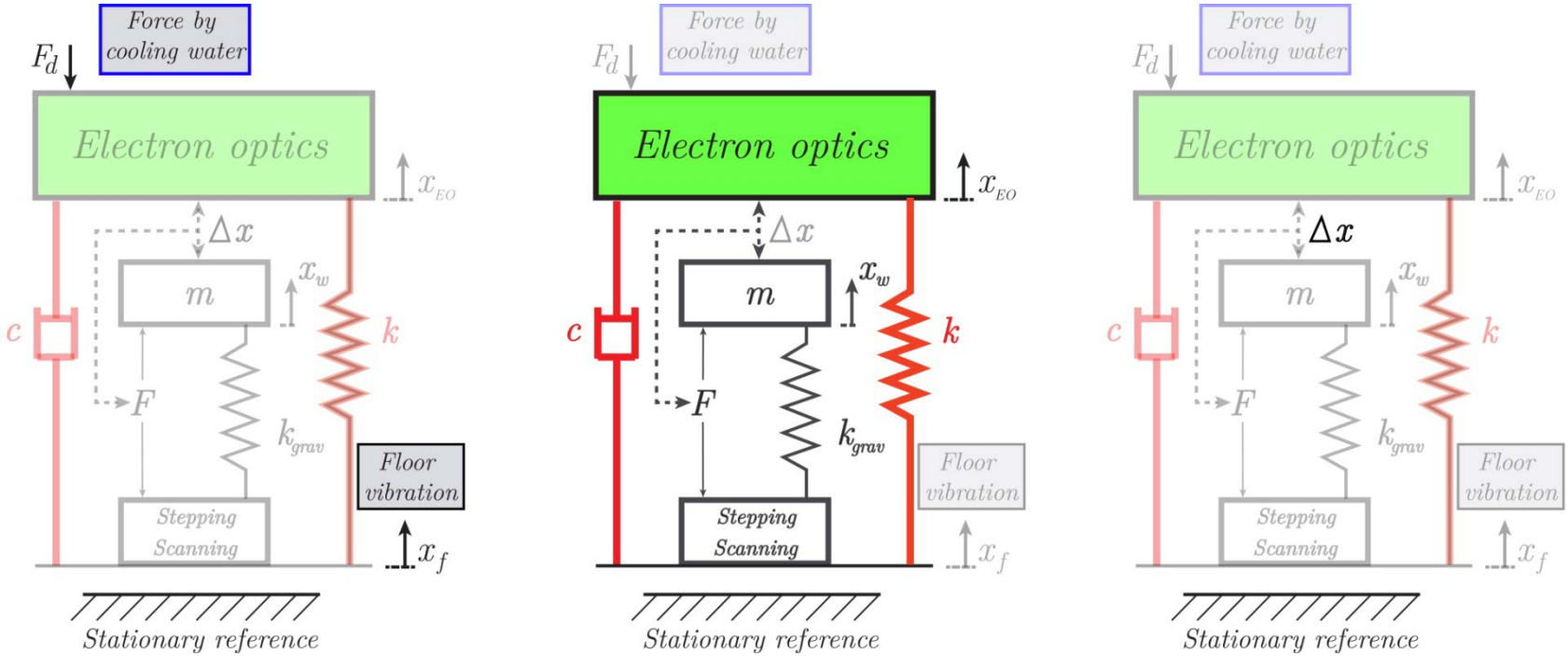


Mathematical model



Dynamic error budgeting

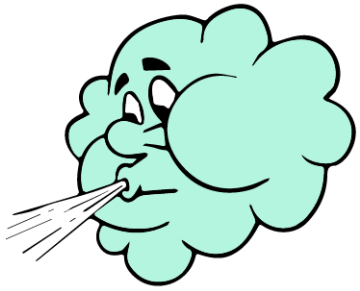
Predicting the error



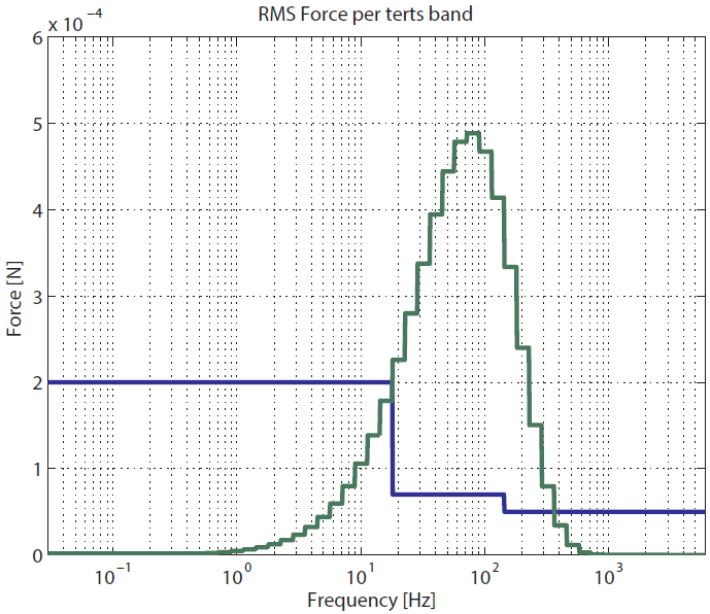
Input → Filter → Result

Dynamic error budgeting

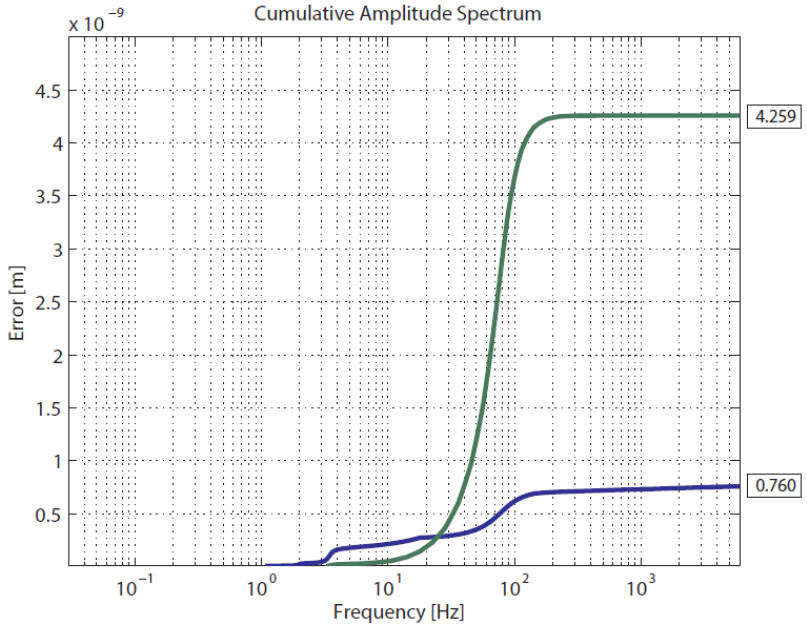
Performance limiting factor



Different force by cooling water



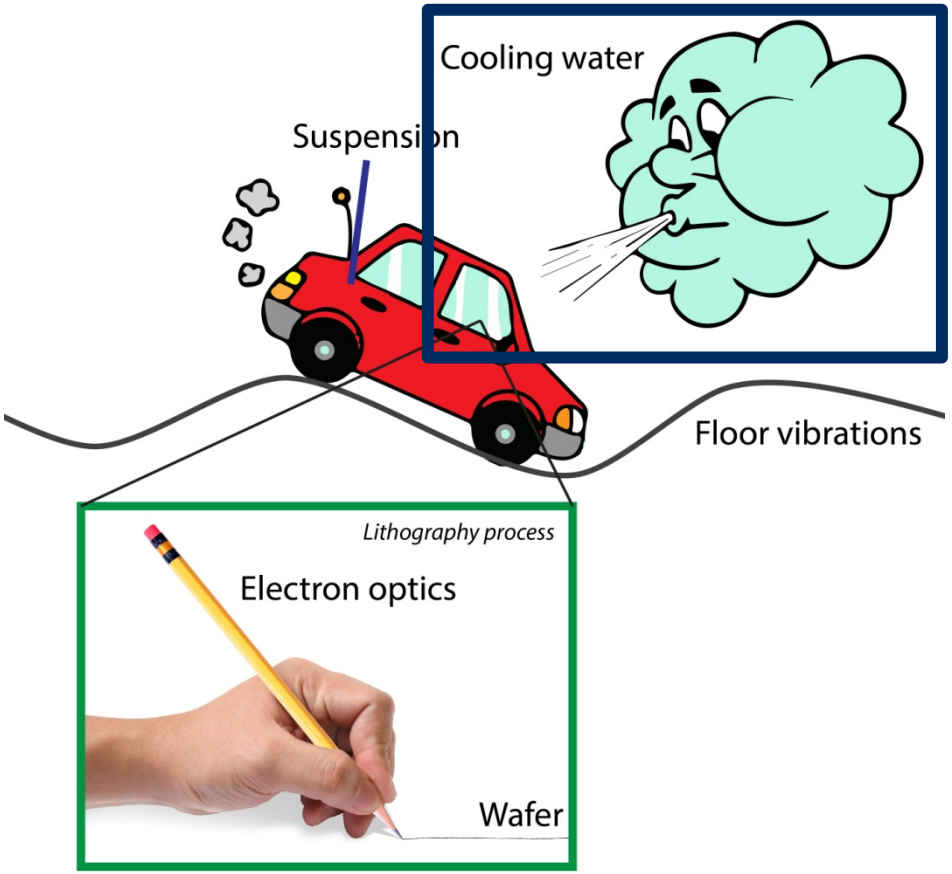
Large resulting error



Input → **Filter** → **Result**

Performance limiting factor

Measuring the force of water



Many factors:

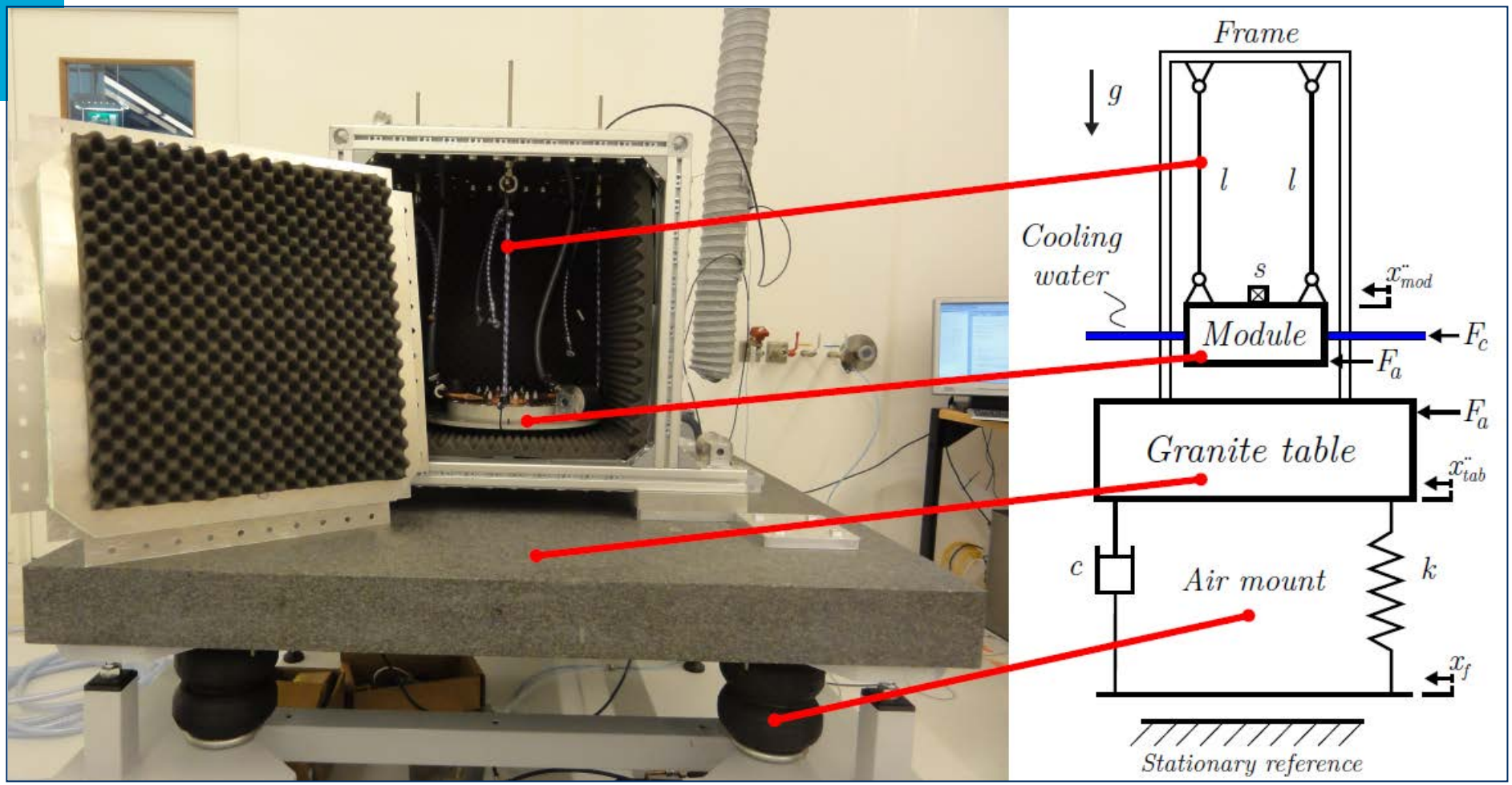
- Flow
- Pressure
- Geometry

Characterize by:

- Literature
- Calculations
- **Measurements**

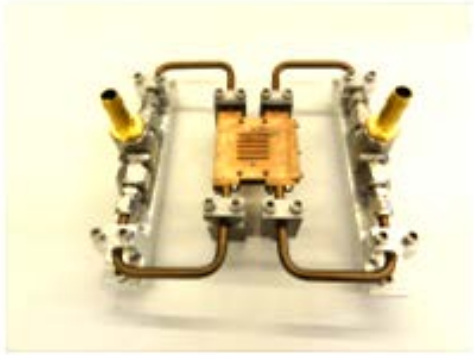
Measuring cooling water forces

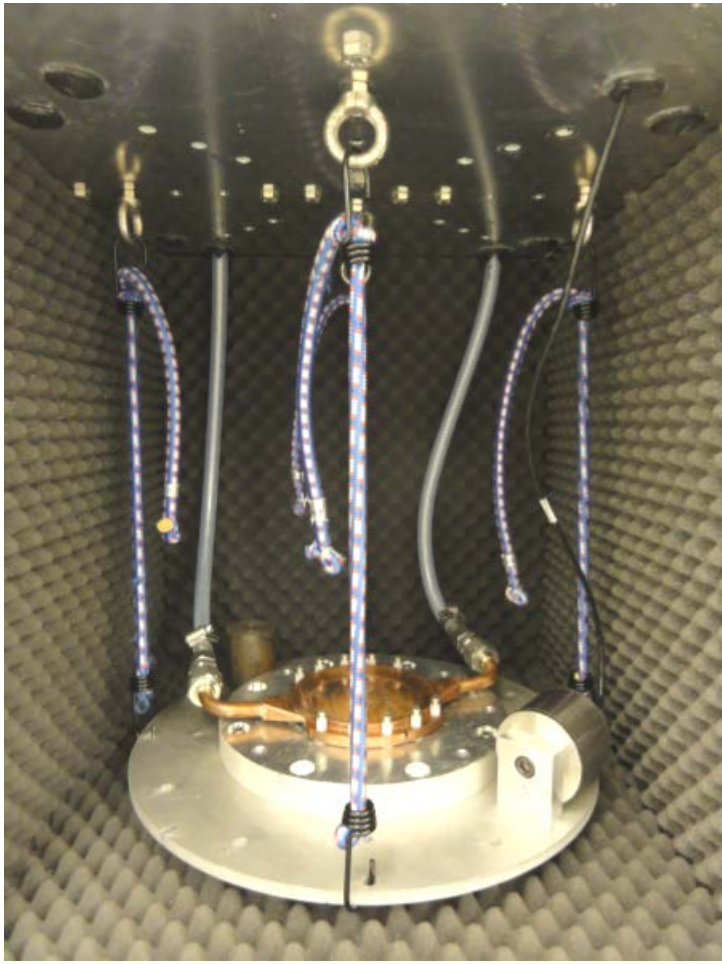
Vibronix



Measure cooling water forces

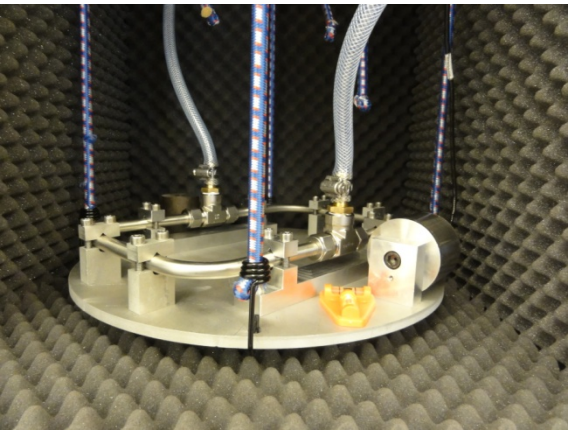
Different geometries

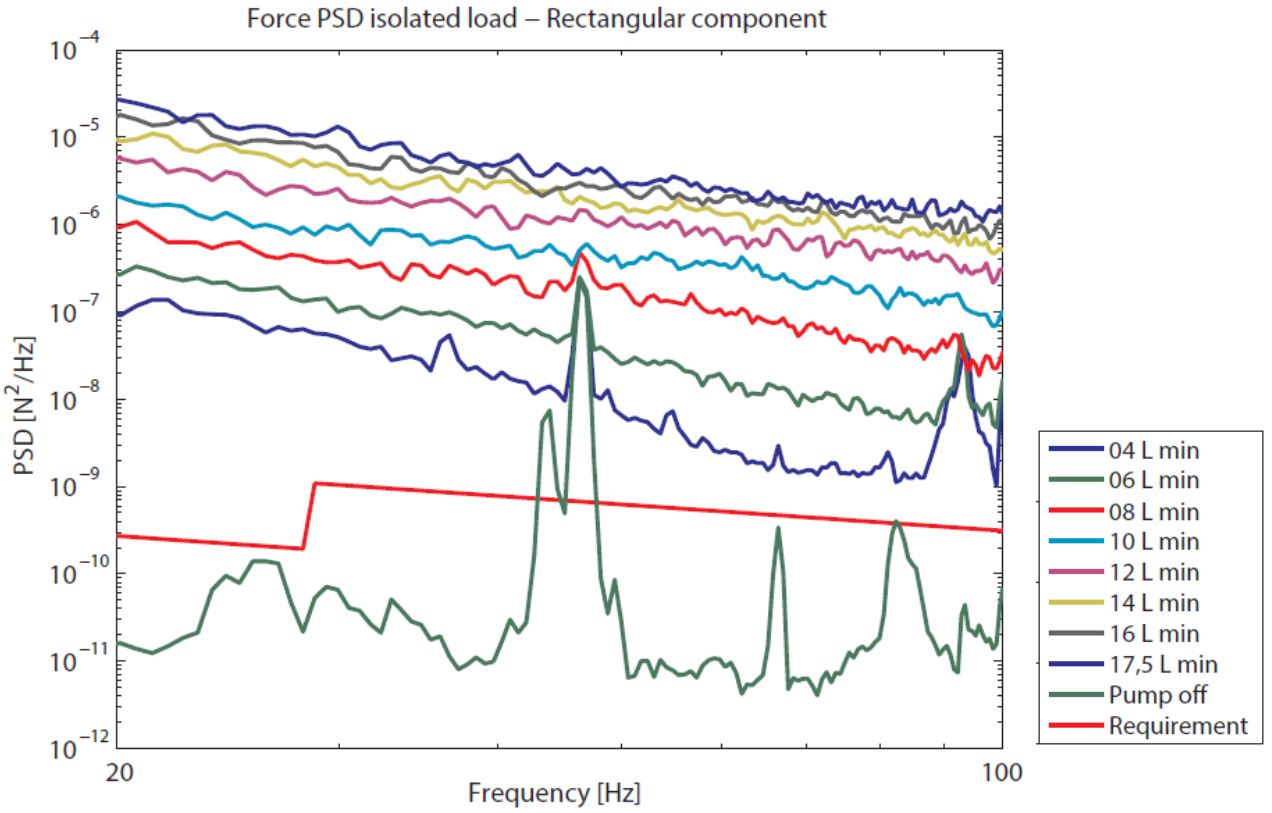




Measuring the forces..

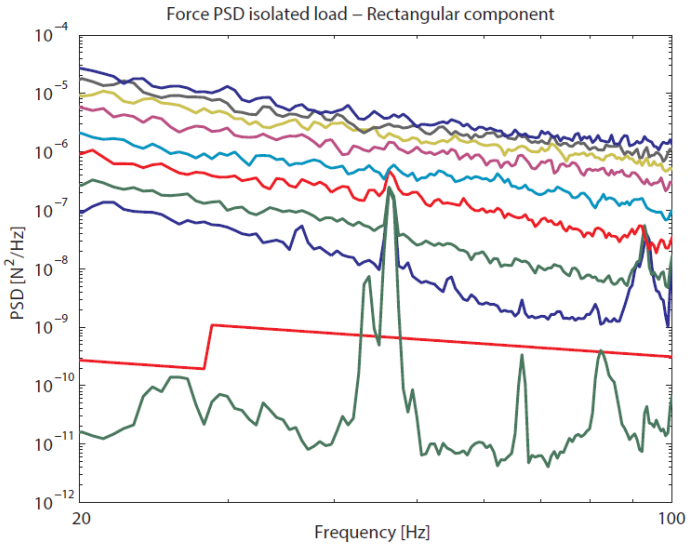
The proof of the pudding..

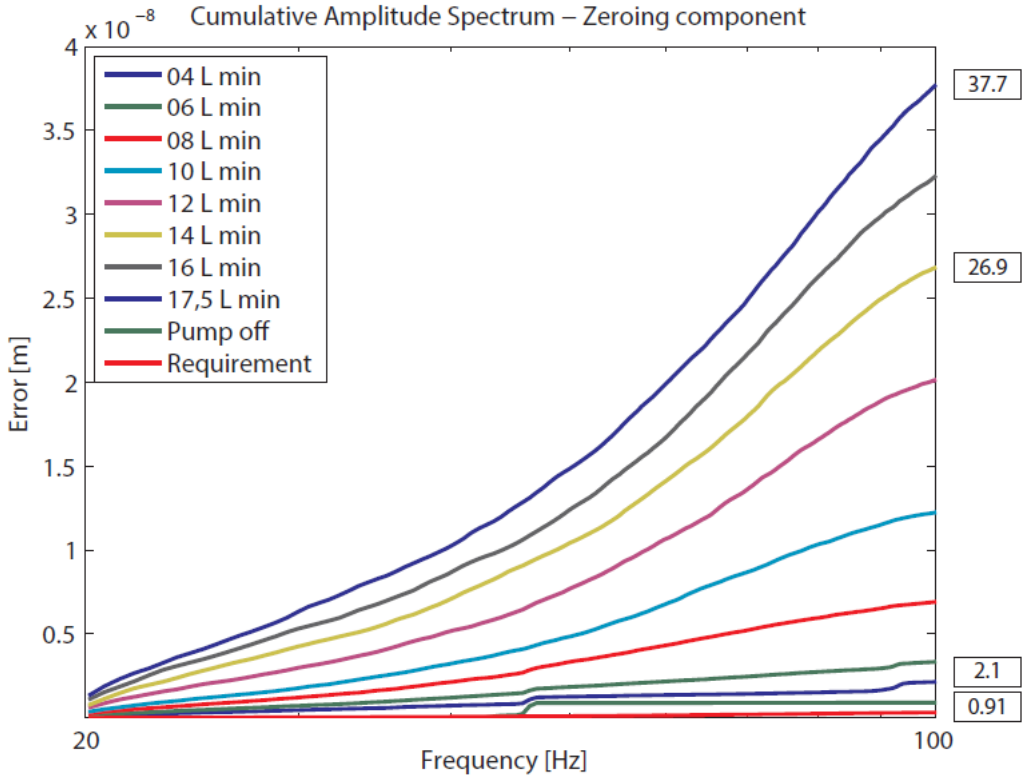




.. results in an expected error

.. is in the eating

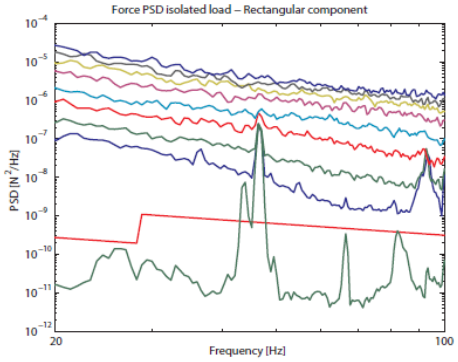




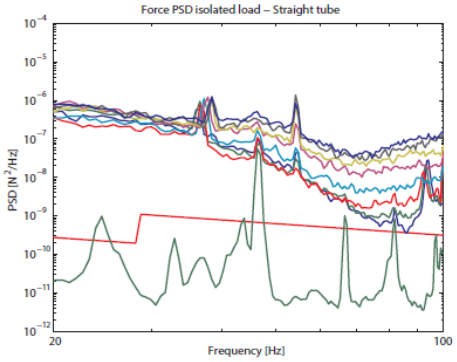
Input → Filter → Result

Different results

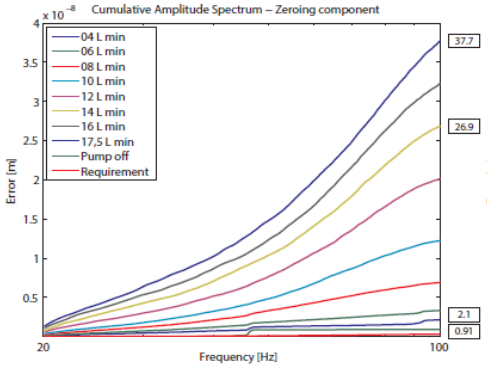
For different geometries



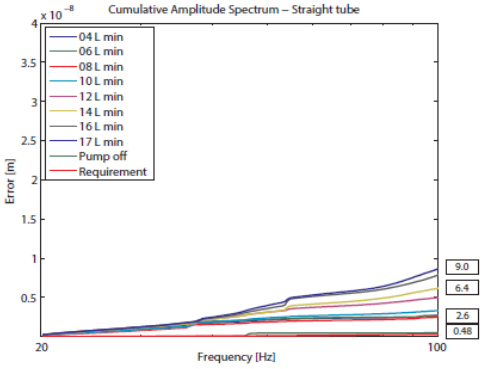
(a) Rectangular component



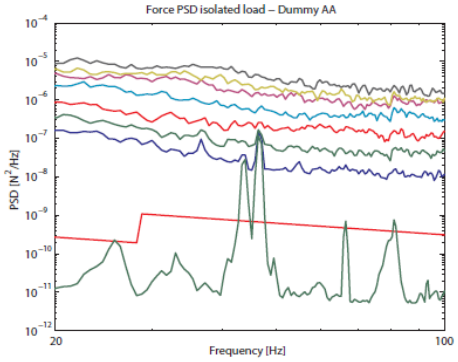
(b) Straight tube



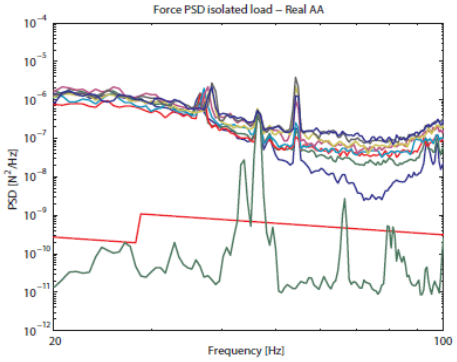
(a) Rectangular component



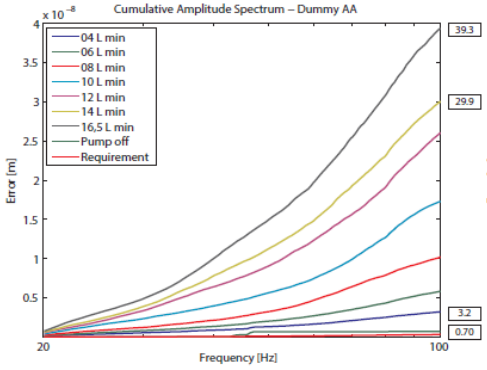
(b) Straight tube



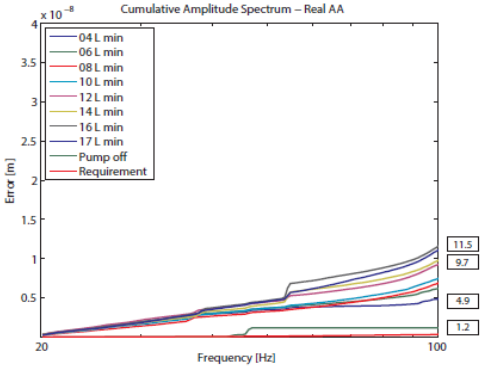
(c) Dummy AA



(d) Real AA



(c) Dummy AA

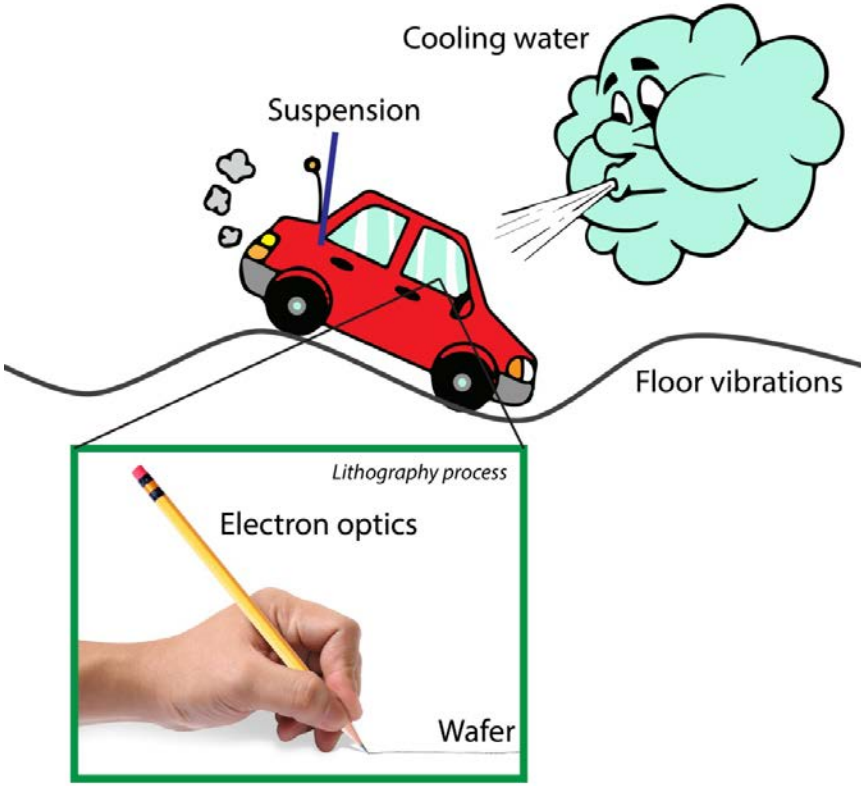


(d) Real AA

Main lessons from Vibronix

Moore to find out..

- Forces are much larger than expected
- Resulting error is much larger than accounted for



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- Smaller parts = smaller errors

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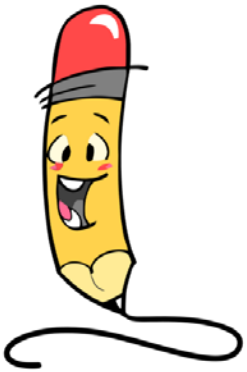
FINAL CONCLUSIONS

WRITING THE FUTURE

Final conclusions

Writing the future

Reduce the error in alignment between the electron optics and the wafer caused **by the disturbances** acting on the **vibration isolation system** to 1 nm 3-σ RMS



- Dynamic error budgeting = Essential
- Limiting factor of system = Cooling water forces
- Measuring the forces = Vibronix
- Measured forces = Larger than allowed
- To meet the challenge = Reduce or eliminate forces

Questions?

And fun facts…

- During this presentation ~ 9000 billion transistors were produced by Intel only..
- The price of a single transistor is only ~ 1.9*10^-7 dollar per transistor, are you really rich?
- Expected amount of transistors in 2015: 1.2 sextillion (10^22)
  Estimated amount of stars in the entire universe: 70 sextillion
- For the price of one grain of rice you can buy ~5000 transistors