



# APPLICATION OF HUMAN CENTRIFUGE TO SIMULATE PARABOLIC FLIGHT: EARLY EXPERIENCE

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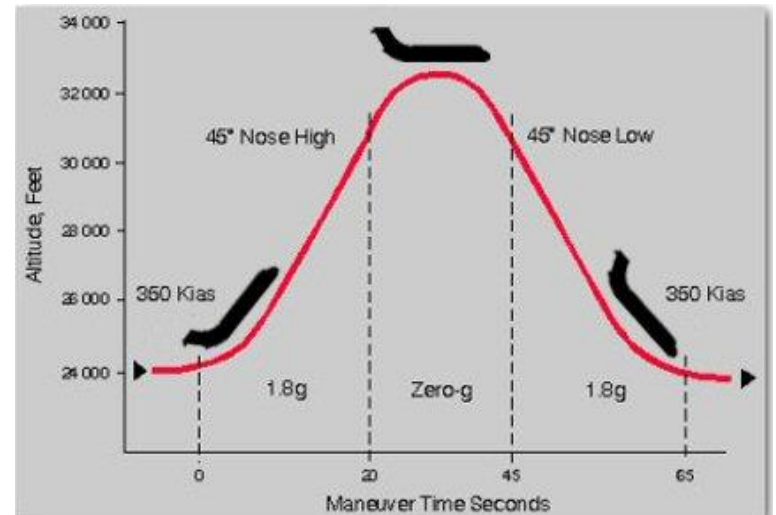
# AGENDA

- Some history
- Purpose of experiment
- Material and methods
- Results
- Discussion
- Recommendations
- Plans for the future

# Little bit of history...

- Konstantin Ciolkovsky had predicted microgravity and problems associated with it in 1920's
- Reduced gravity was needed at the advent of spaceflights.
- First experiments – USAF School of Aviation Medicine Randolph AFB – professor Heinz Haber

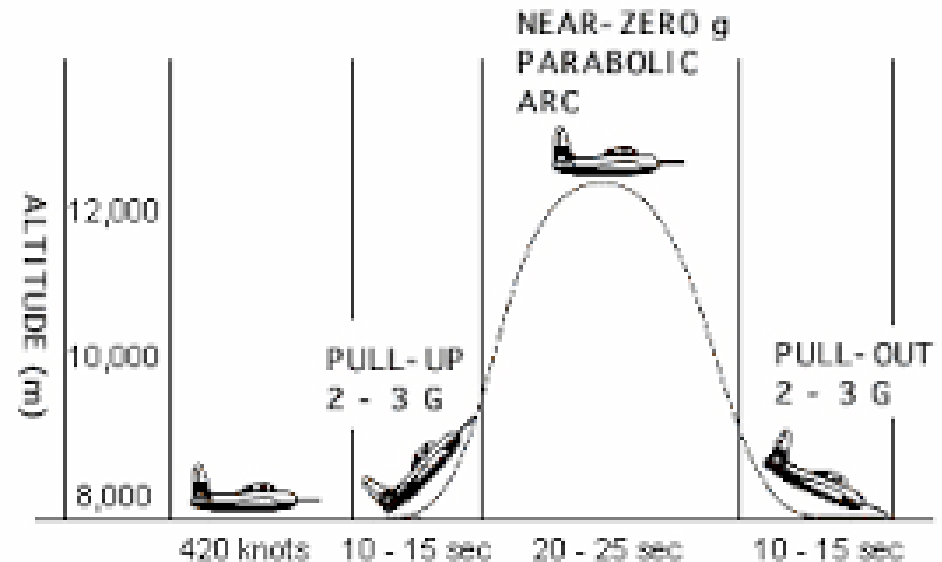
# Heinz Haber



- <https://ntrs.nasa.gov/info?id=MSFC-9605274> retrieved from: [https://commons.wikimedia.org/wiki/File:Haber\\_Braun.jpg](https://commons.wikimedia.org/wiki/File:Haber_Braun.jpg)

# Parabolic flight

- Around 20 sec of „weightlessness”
- Possible usage:
  - Research
  - Mobility training
  - Precise operations
- and of course....



# .... some great photos.



[http://www.esa.int/spaceinimages/Images/2008/02/View\\_inside\\_the\\_Zero-G\\_A-300\\_Airbus\\_during\\_the\\_46th\\_ESA\\_Parabolic\\_Flight\\_Campaign](http://www.esa.int/spaceinimages/Images/2008/02/View_inside_the_Zero-G_A-300_Airbus_during_the_46th_ESA_Parabolic_Flight_Campaign)

<https://upload.wikimedia.org/wikipedia/commons/f/fd/PeterZG-small.jpg>



# Purpose of experiments

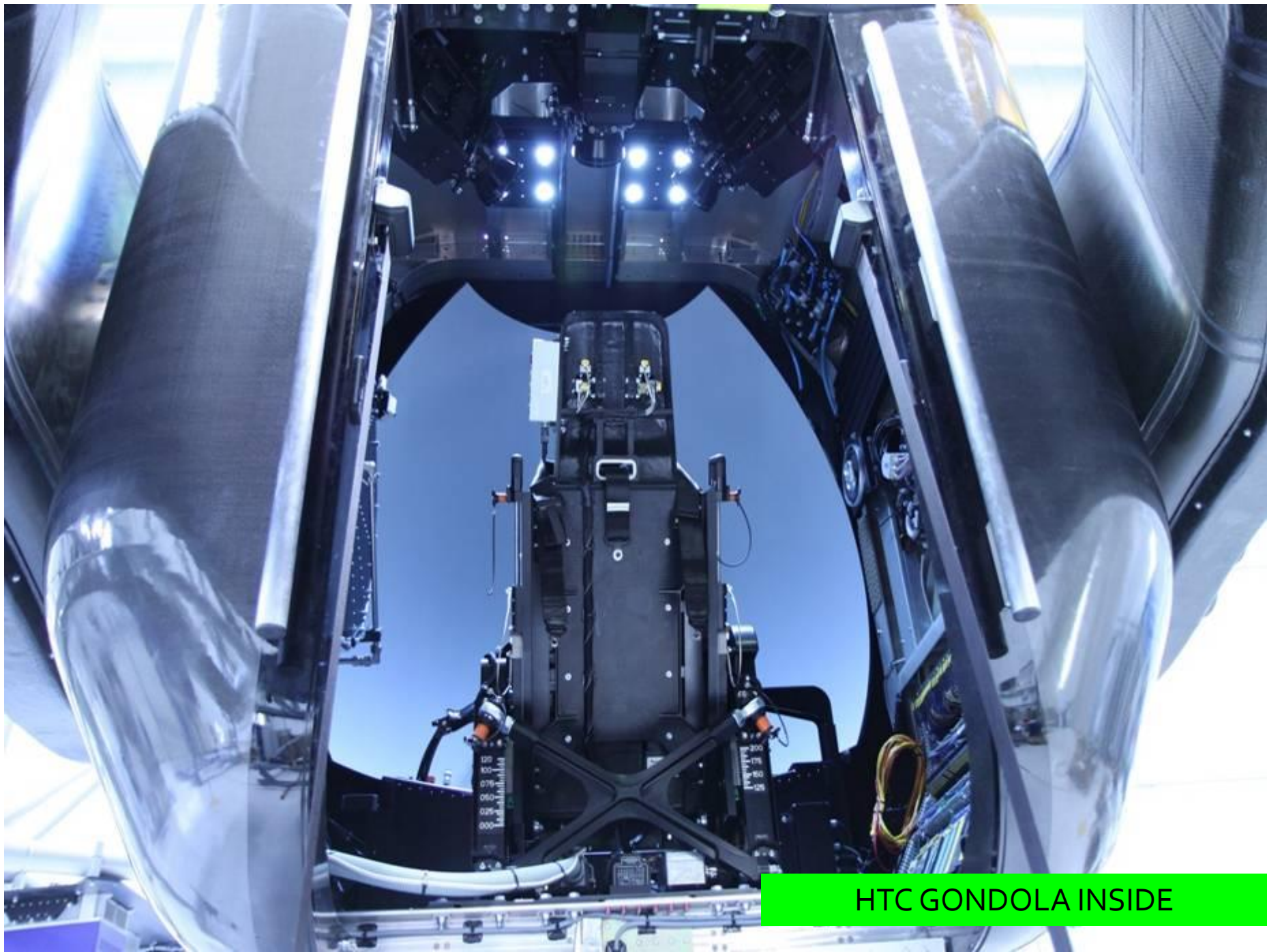
- Recreation of parabolic flight gravitational profile with the centrifuge with active gondola.
- 0Gz demonstration
- Precise movement training
  
- Can we make it cheaper and more available?



- Arm length – 8,5meters
- Max G +16Gz
- Max onset 15,5Gz/sec
- Max payload 350kg
- Two interchangeable cockpits Mig 29/F-16
- Wide angle, NVG compatible screen



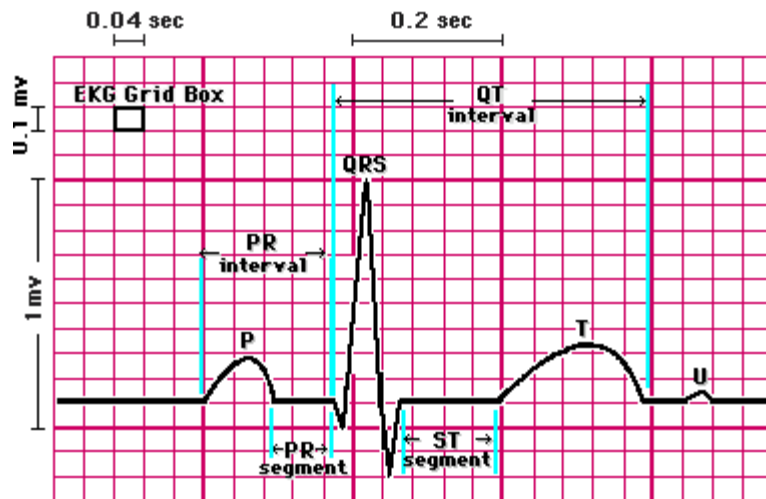




HTC GONDOLA INSIDE



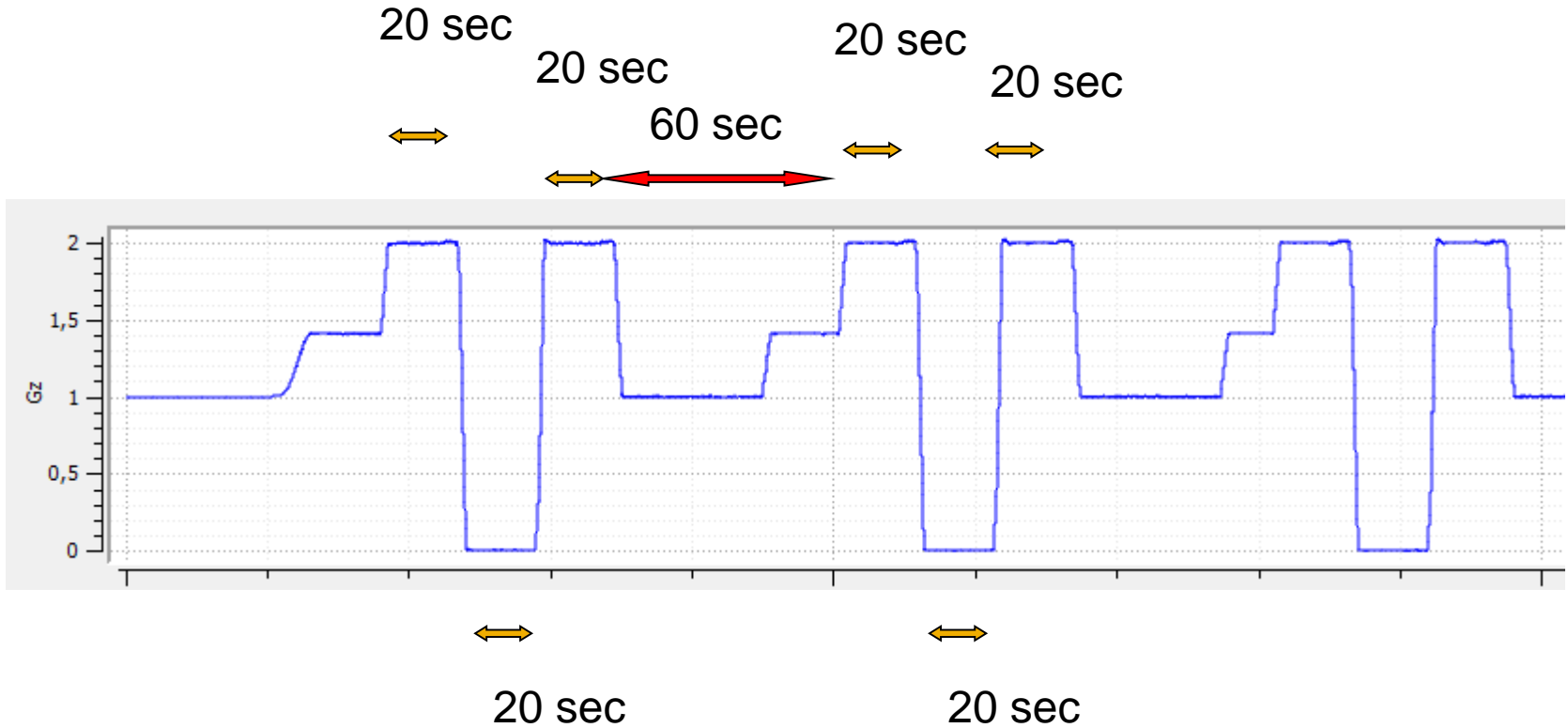
# HTC - EQUIPMENT



## Medical Monitoring

- **ECG (1ch) & HR**
- Breathing
- Blood pressure
- **Blood O<sub>2</sub> saturation**
- **Earlobe blood flow**
- Body temperature

# Acceleration profile



Intended repetition 20 times

# Participants

- European Space Agency
  - Automation and Robotics Section (TEC-MMA)  
European Space research and Technology Centre, ESA
- 4 future engineer – astronauts
  
- MIAM
  - 1 instructor pilot

# Procedure

- ENT examination:
  - Rotary Chair Test (Barany Chair Test);
  - Rotary test and spontaneous and evoked nystagmus;
  - ENT consultation.
  
- Preflight check

# Procedure

- Centrifugation 20 cycles: duration 20 sec., acceleration range 2 Gz, 0 Gz, 2 Gz, 1 Gz
- Manual attempt to check the eye-hand coordination of candidates during centrifugation;
- Orientation tests and Romberg attempt.
- Precision tasks – pressing HUD panel buttons

# HUD keypad



# Key pressing

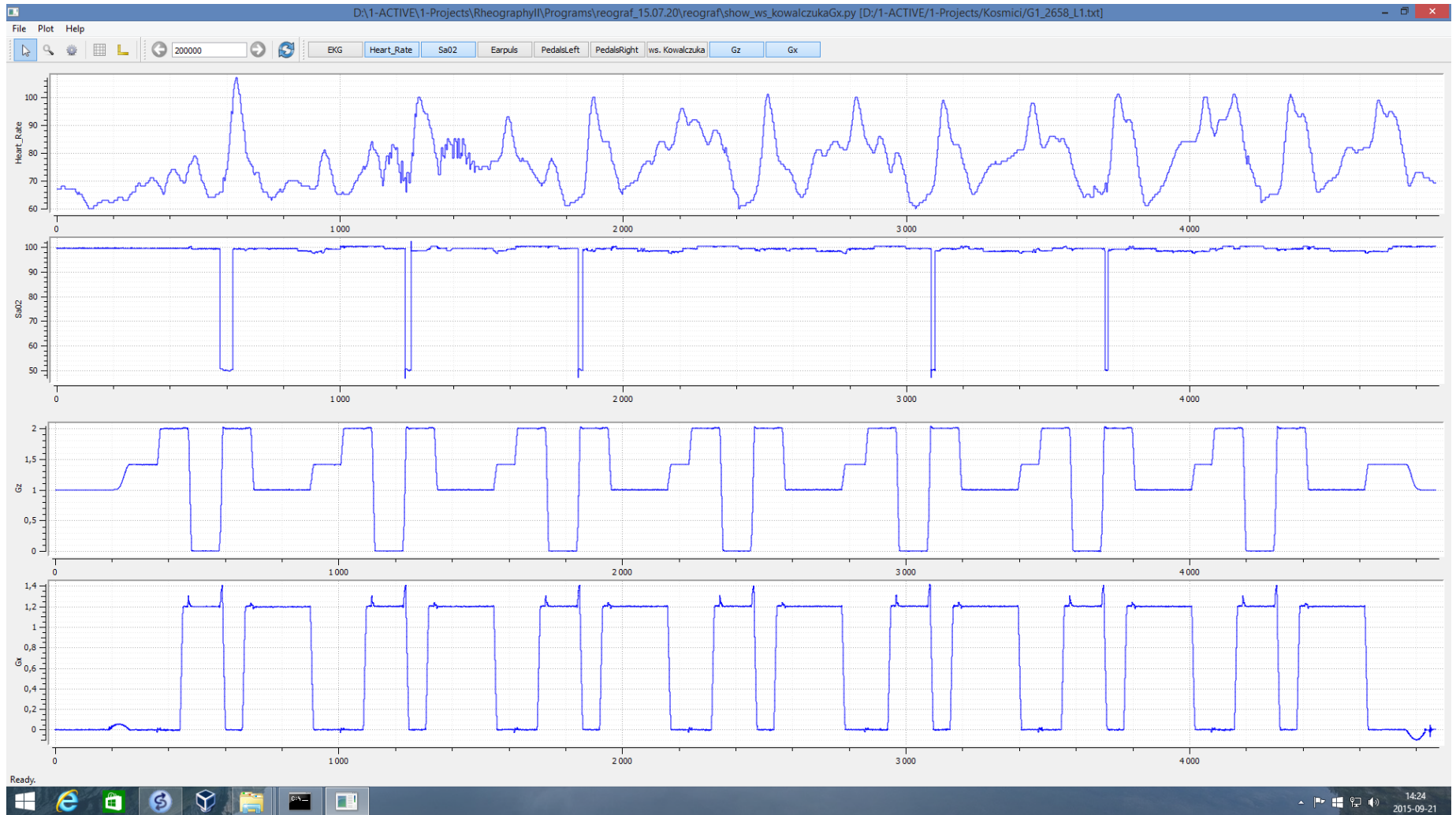




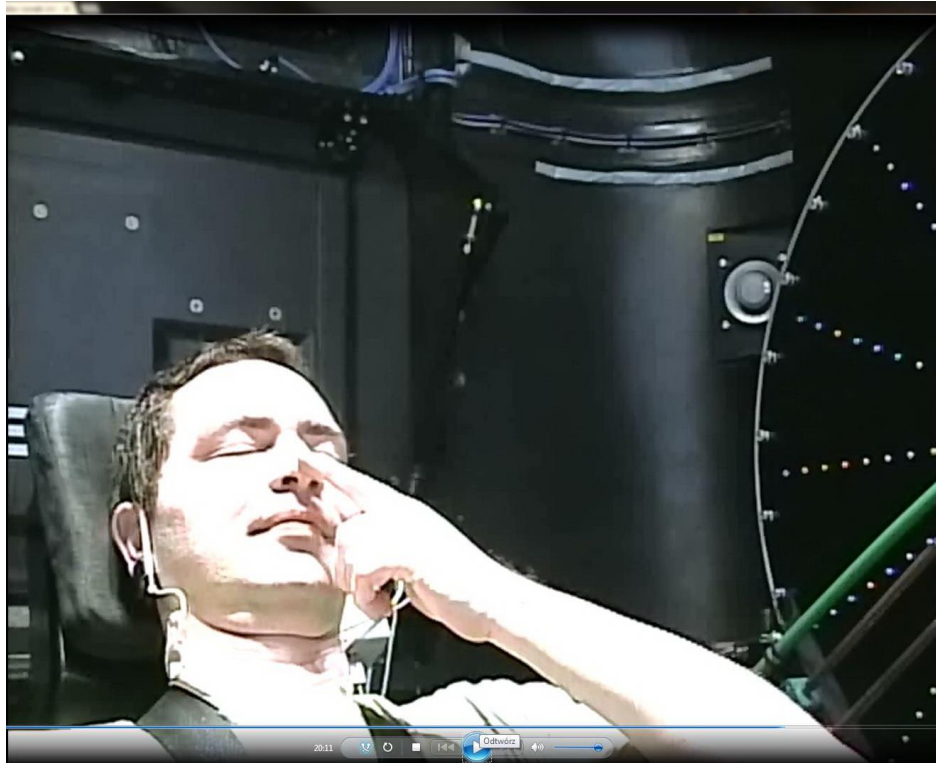
# Procedure

- Expositions repeated at 2 consecutive days
- ~20h break between expositions

# Data registered (example)



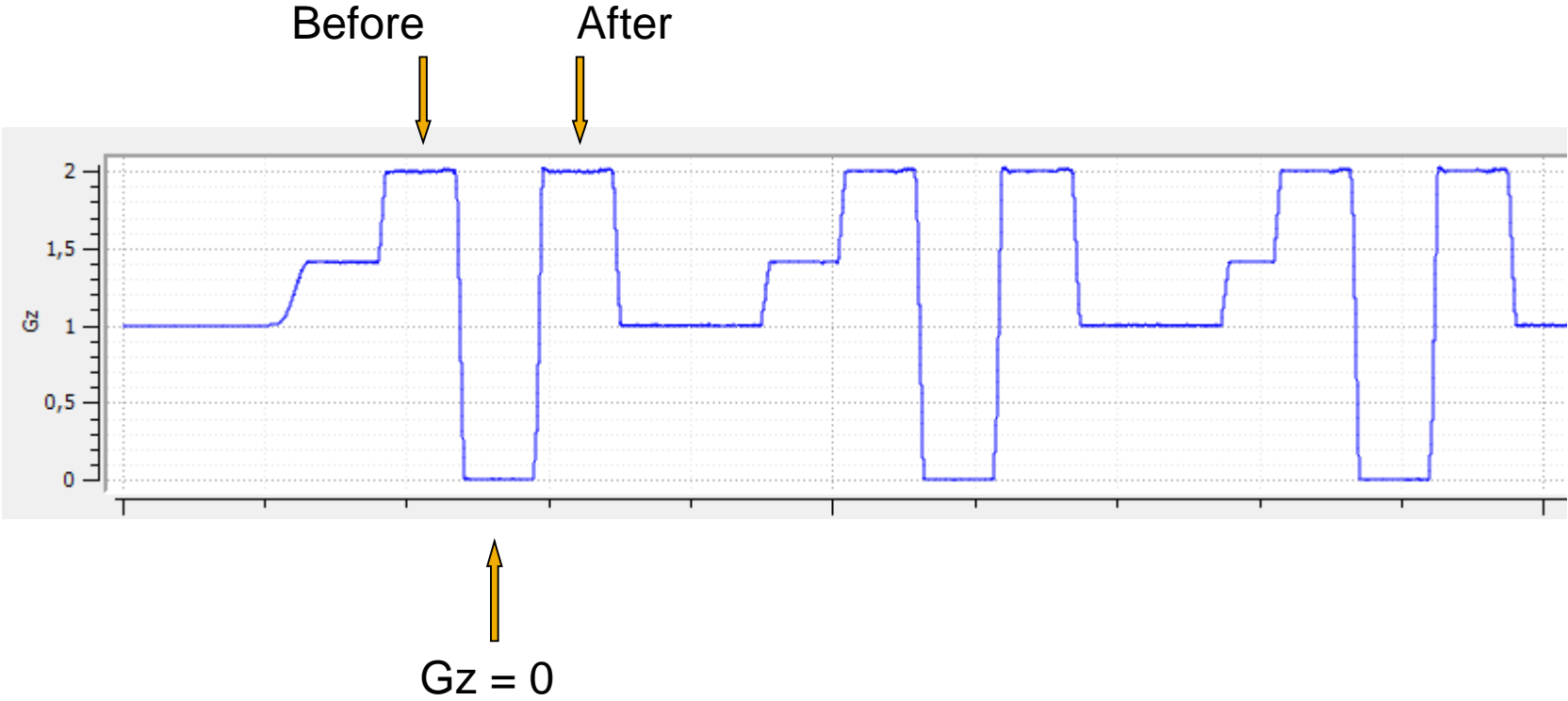
# Romberg attempt



# No of repetitions $(32+66=98)$

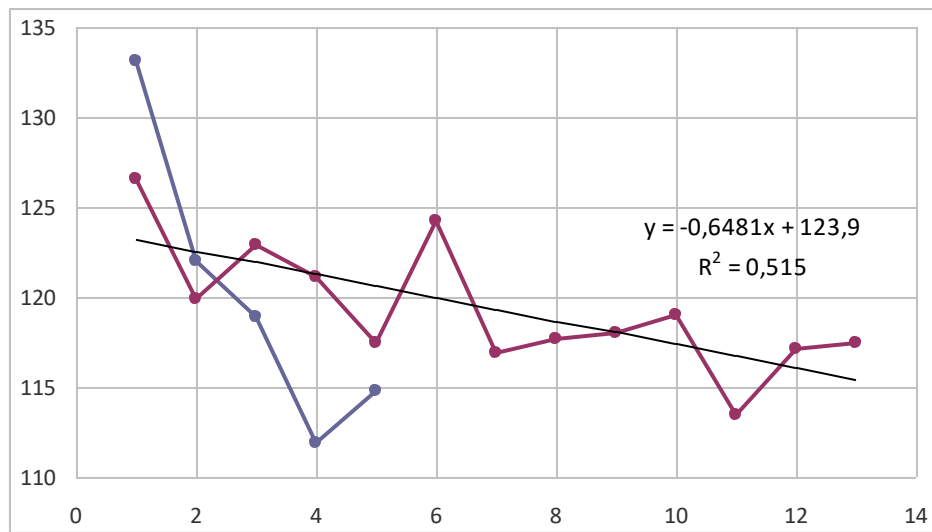
Day/ participant	1	2	3	4	5
1	6	3	7	5	11
2	11	13	14	13	17

# Acceleration profile measurements



# Results

## Heart rate



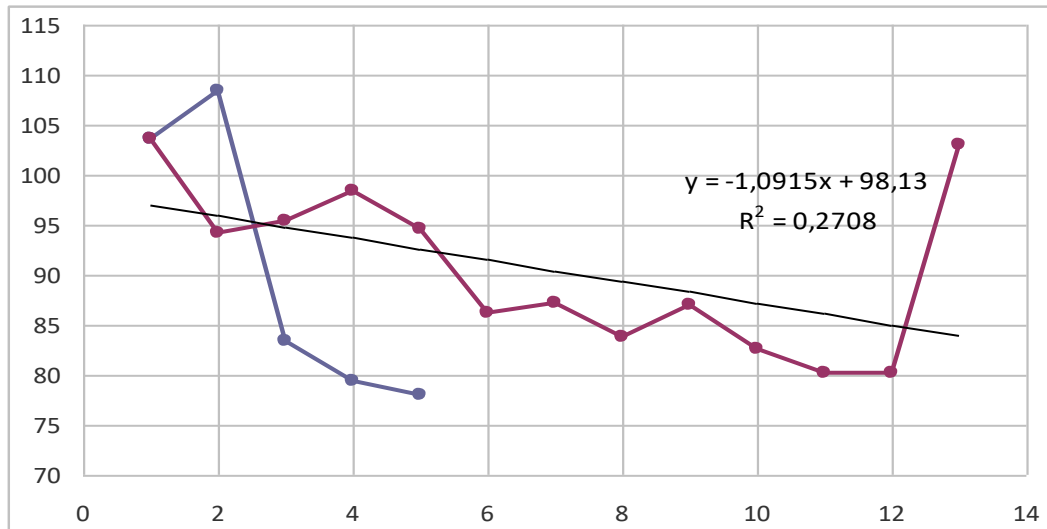
Blue 1st day

Red 2nd day

Before 0Gz

# Results

Heart rate Gz=0



Blue 1st day

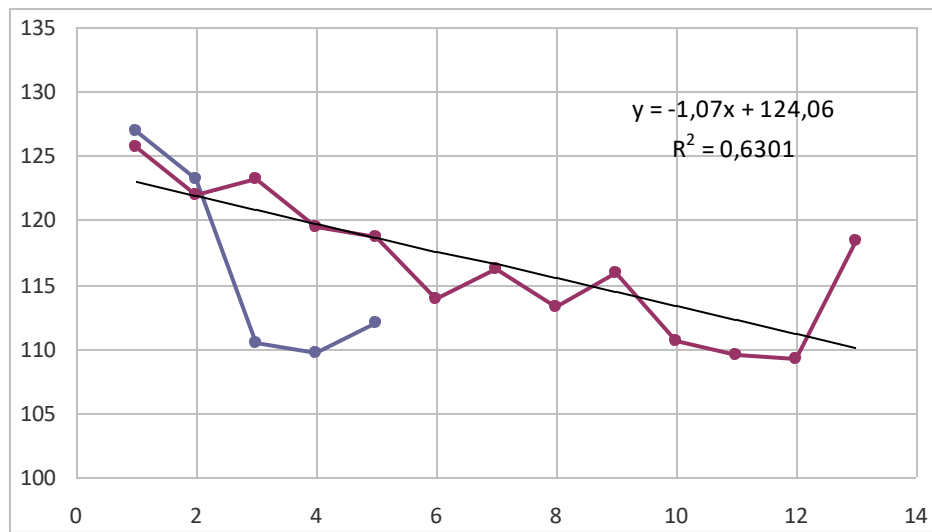
Red 2nd day

During 0Gz

# Results

Heart rate

after Gz=0



Blue 1st day

Red 2nd day

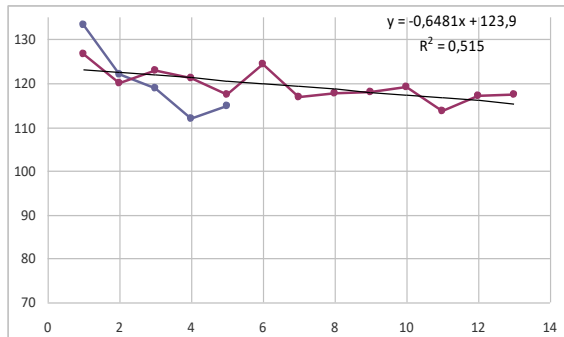
Before 0Gz



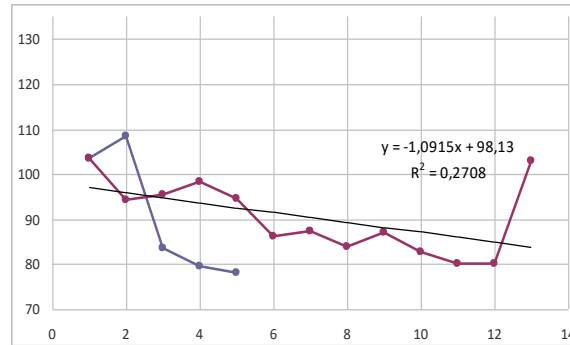
# Results

## Heart rate

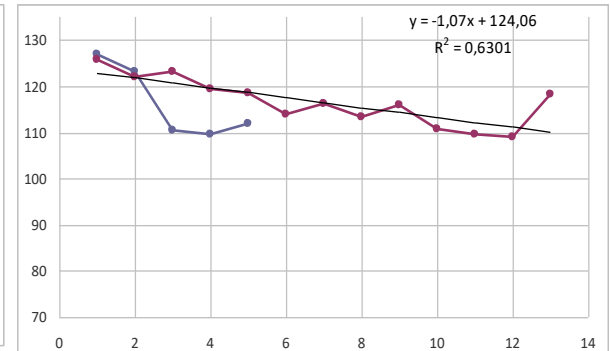
### Before



### Gz = 0



### After



Blue 1st day

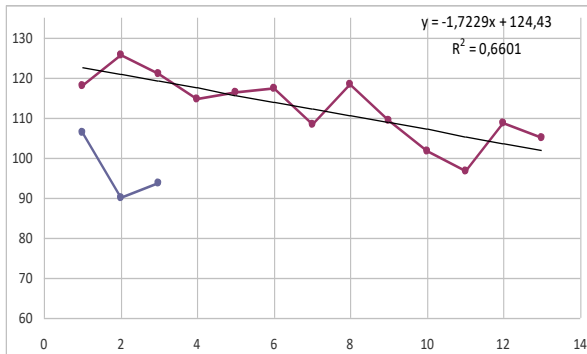
Red 2nd day

Before 0Gz

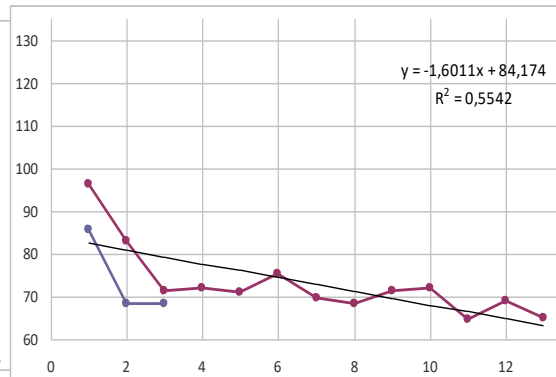
# Results

## Heart rate (another candidate)

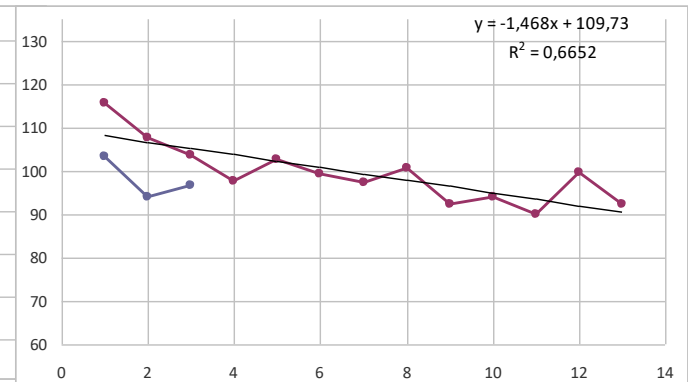
Before



Gz = 0



After



Blue 1st day

Red 2nd day

Before 0Gz

# Results - summary

- SaO<sub>2</sub> – no statistically significant changes
- HR – decrease at 0Gz ( $p < 0,05$ )
- Increase both in speed and precision of tasks
- High incidence of MS symptoms
- Only one „full blown” MS
- Much better results at 2nd day
- Preliminary motion habituation is important – MIAM pilot

# Discussion

- Comparison with previous data
- **CLASSICS IN SPACE MEDICINE** *Aviation Medicine*. Edited by Mark R. Campbell, M.D.
- *Aviation, Space, and Environmental Medicine*  
Vol. 80, No. 12 December 2009

# Discussion

- Neurovestibular symptoms decreasing
- Incidence of MS subsiding
- Similar results as in „Vomit comet”
- HR changes of statistical significance – maybe low no of participants

# Conclusions / recommendations

Centrifuge can be used for some parts of astronauts training in two modes:

Classic – check / improve G tolerance

before flight – either in +Gz and +Gx axes

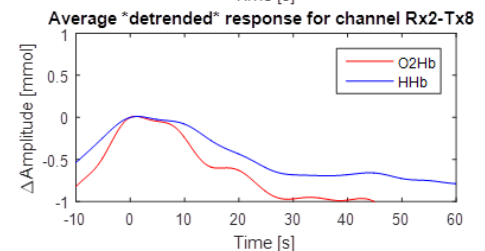
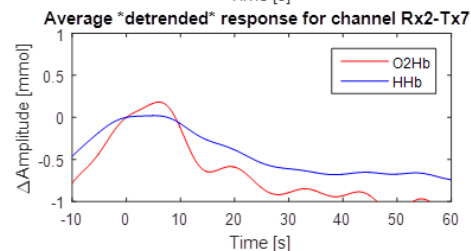
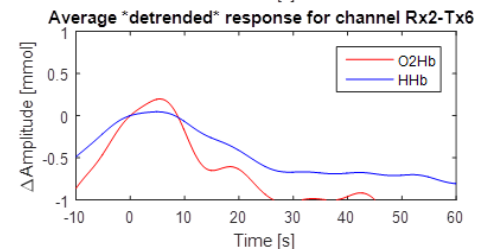
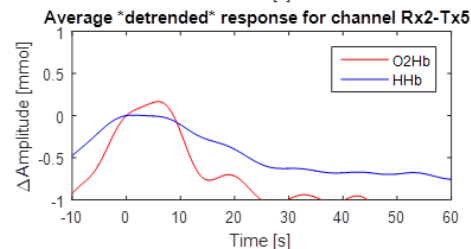
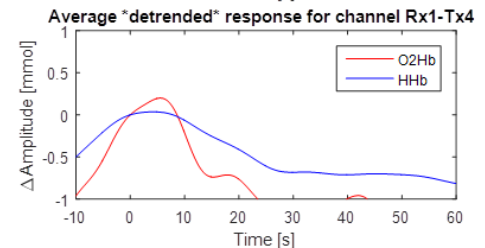
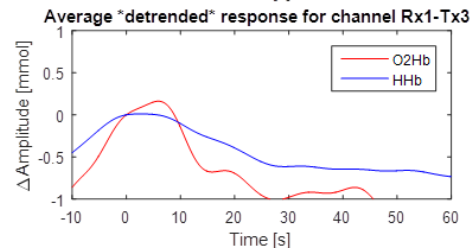
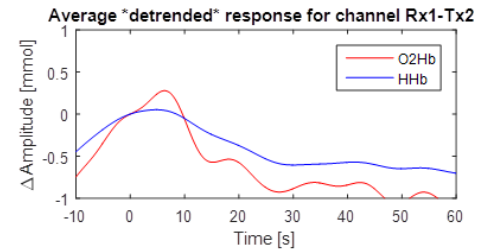
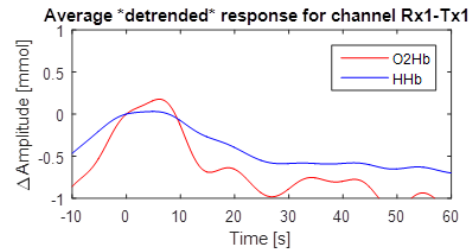
New – training of precise movement in simulated 0Gz environment

# Room for improvements

- Slower change of gondola position
- More diverse tasks
- Longer time on zero Gz (almost unlimited)
- Longer training program (in MS desensitization program we do 3x5 days)

# Follow-up: Cognitive studies in simulated microgravity

- Executive functions  
With use of fNIRS





**Thank you for the attention!**

