



HyperGES

The ESA Large Diameter Centrifuge (LDC)

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1975 Signing of ESA Convention

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MEMBER STATES



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MEMBER STATES



ESA Establishments (1)



Headquarters

Located in Paris, home to the main programme directorates that steer and formulate ESA policy.

ESRIN

ESA's centre for Earth observation activities, near Rome, Italy, also develops information systems and hosts the Vega launcher project.

ESTEC

The European Space Research and Technology Centre, Noordwijk, the Netherlands, is the largest site and the technical heart of ESA.

ESOC

The European Space Operations Centre, Darmstadt, Germany, tracks and controls European spacecraft.

EAC

The European Astronaut Centre, Cologne, Germany, trains astronauts for missions to the International Space Station and beyond.





ESAC

The European Space Astronomy Centre, near Madrid, Spain, hosts the science operation centres and archives for ESA's astronomy and planetary missions.



Harwell (ECSAT)

Harwell Centre, in Oxfordshire, UK, is focusing on commercialisation and partnerships in space activities.



Redu

Redu Centre in Belgium is part of ESA's ground station network and is also home to ESA's Space Weather Data Centre.



Guiana Space Centre

ESA's launchers lift off from Europe's Spaceport in Kourou, French Guiana. It is jointly operated by the French space agency (CNES) and Arianespace with the support of European industry.



ESA-ESTEC, Noordwijk, NL



the 'Center of Gravity'

TEC-MMG Lis Lab @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



Jack van Loon



Alan Dowson



Francois Gaubert



Robert Lindner

flow benches

meeting room

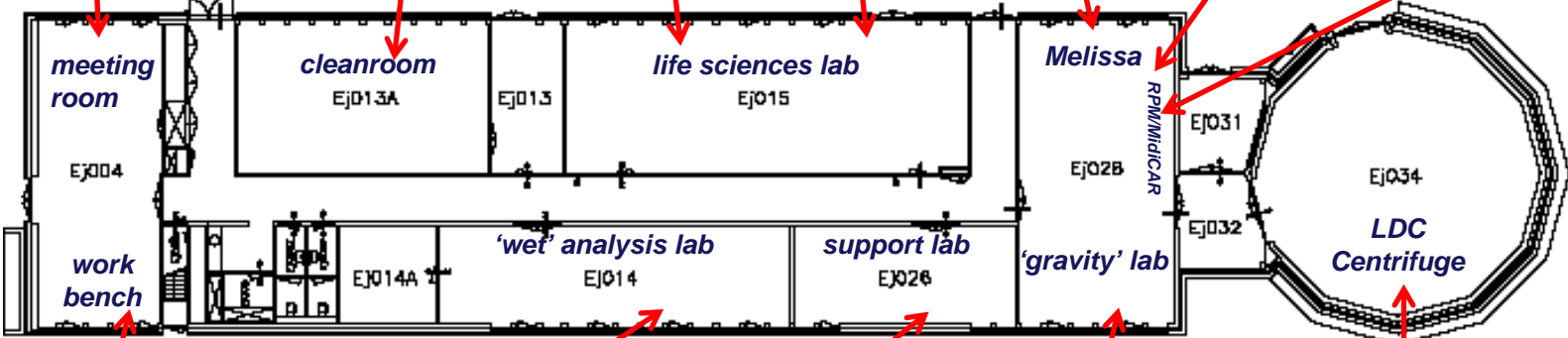
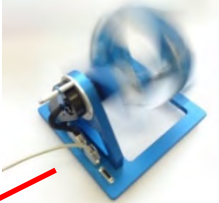
clean room

(fluor.) mic.s

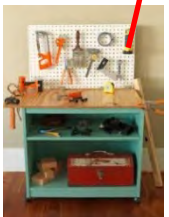
plant chamber

MidiCAR

RPMs



+ other ESTEC labs !!



workbench



LC/MS



e.g. autoclaves



clinostats



LDC

LisLab – LDC Facilities @ ESA-ESTEC

Life- and Physical Science Instrumentation Laboratory (LIS)



main lab



support lab



LDC control room



meeting room



small 'workshop'



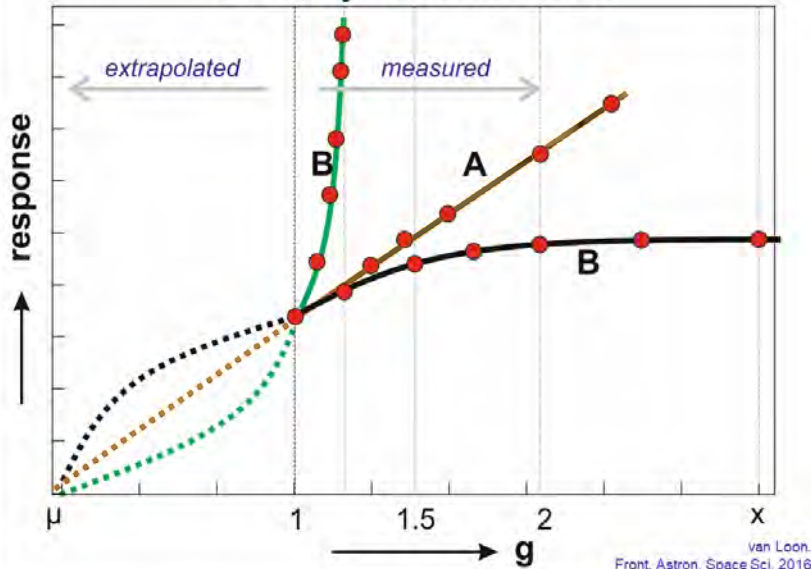
LDC prep lab



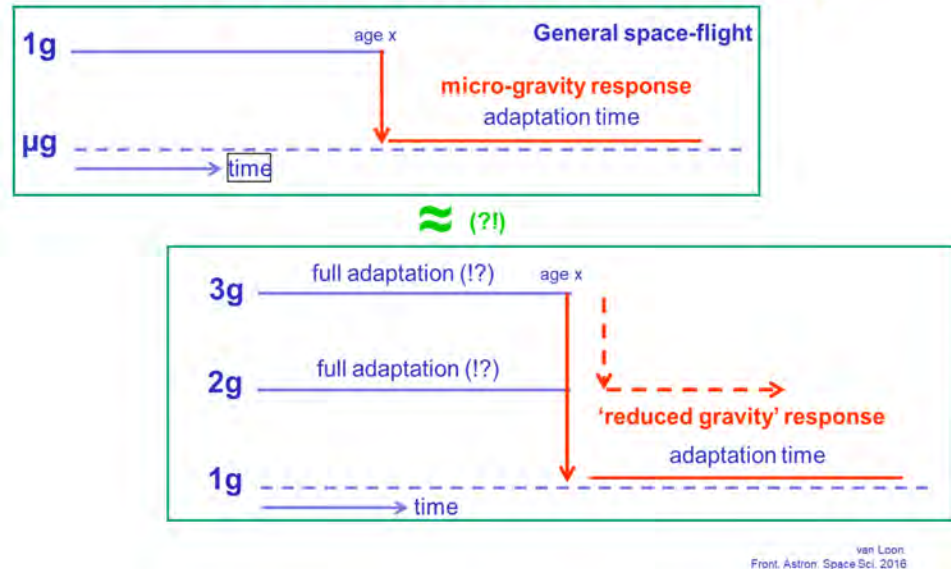
'wet lab'

Large Diameter Centrifuge

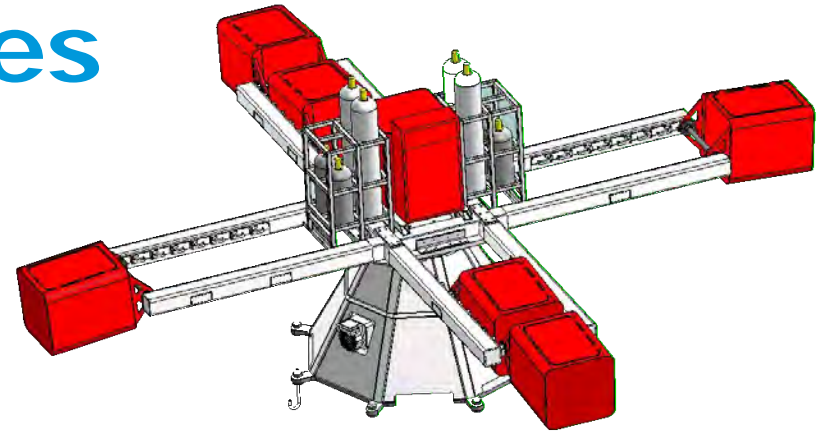
Gravity Continuum



The 'Reduced Gravity Paradigm' (RGP)



LDC Main Properties



diameter : ~ 8 meter

arms : 4

g levels : various (8 locations / arm)



exp. Volume : 7 'gondolas' ; 6 rotating (60×60×80 cm)

center gondola : control / g-sensitive materials

g vector : swing-out:

payload : 80 kg per gondola (total 210 kg incl. gondola)

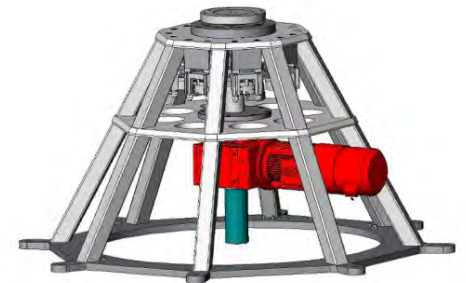
g load : 20×g fully loaded

motor : 22 kW (Siemens)

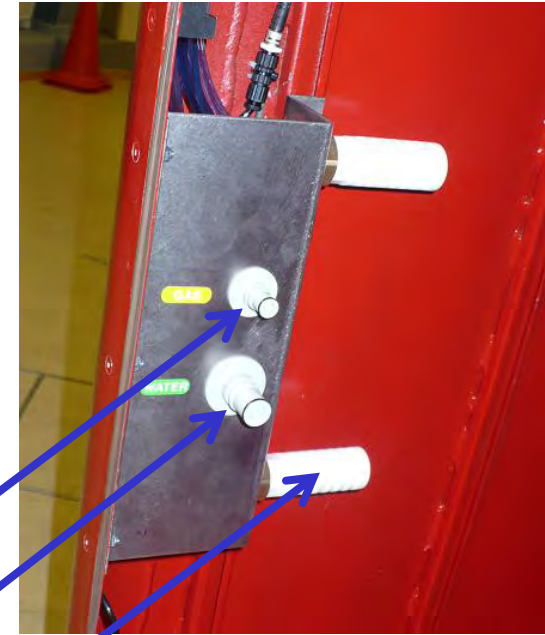
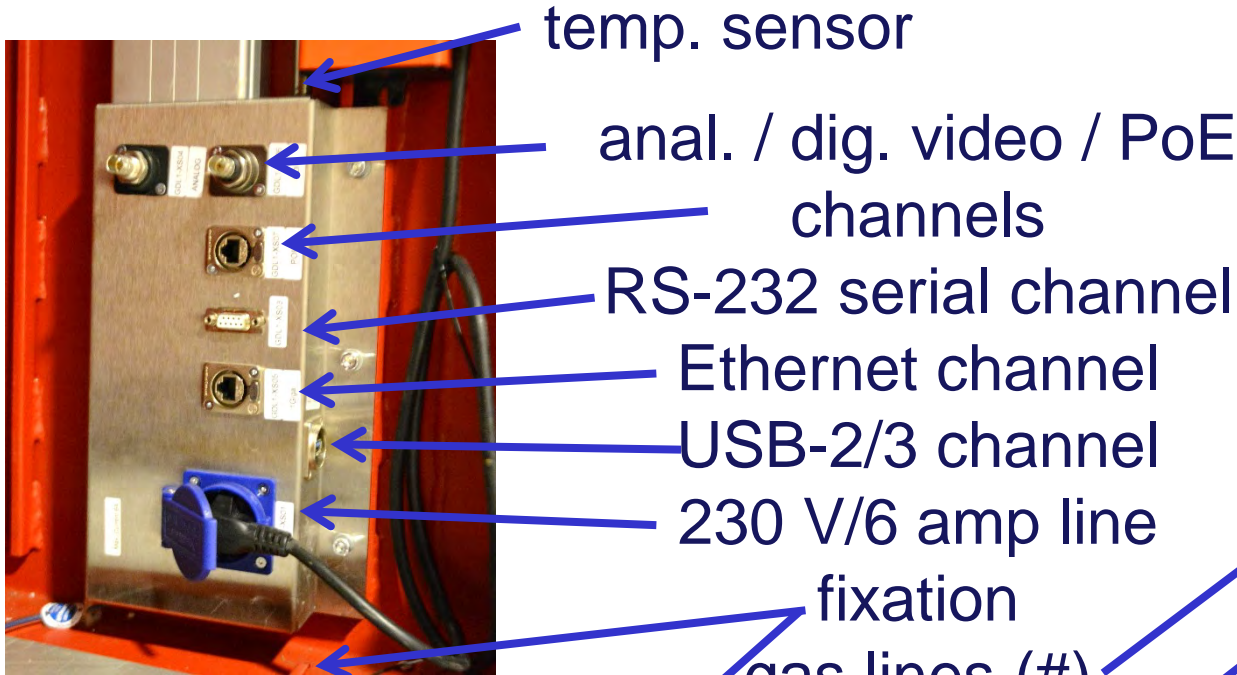
Run Time: 8817.9 h

Revolutions: 13938224

(Dec 2017)



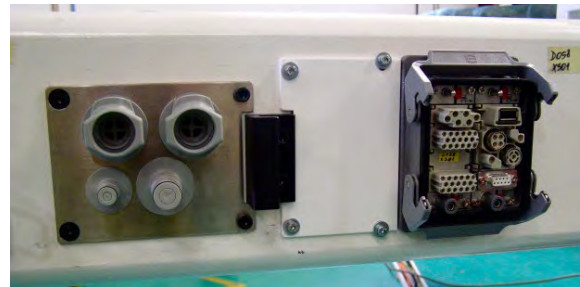
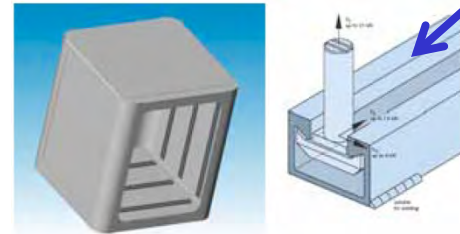
The Gondola : Main Properties



gas lines (#)

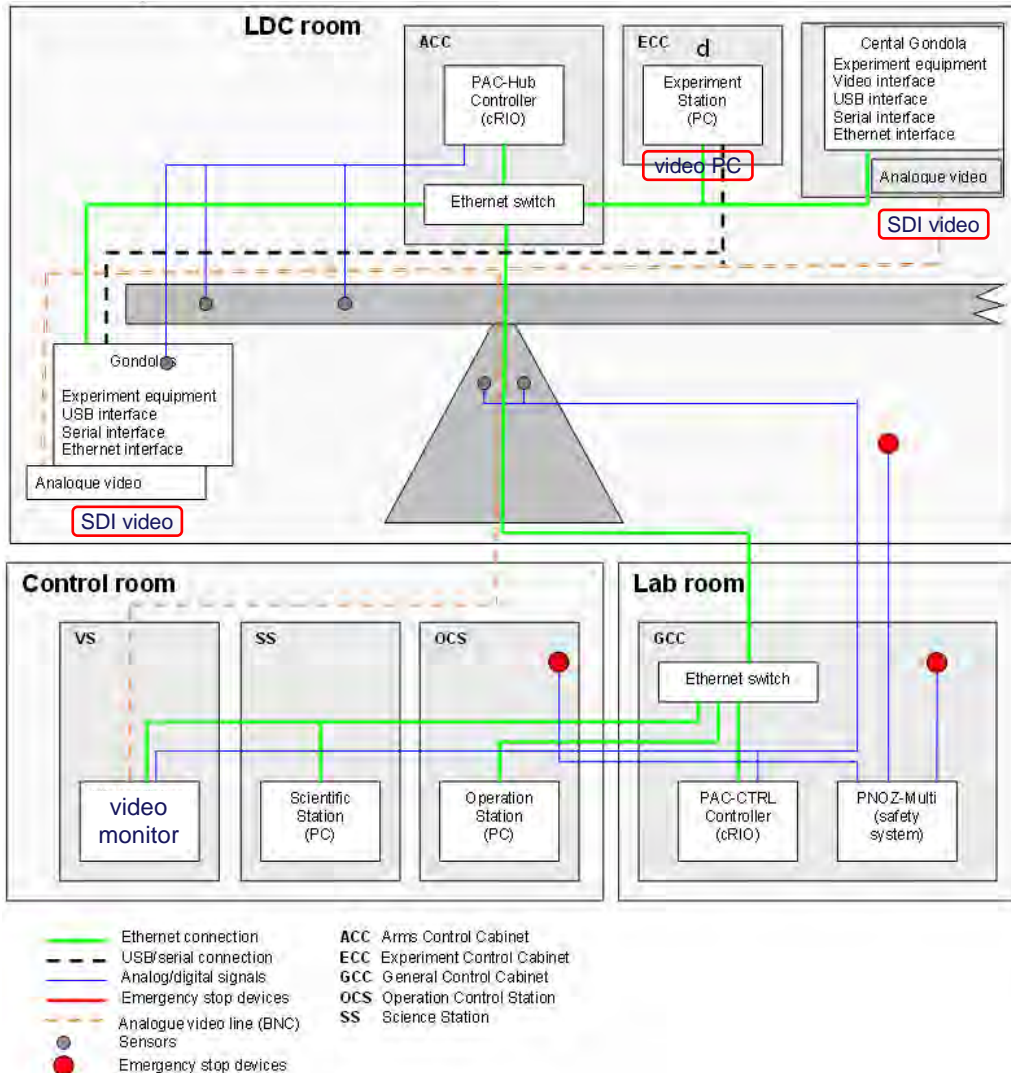
water supply

forced ventilation

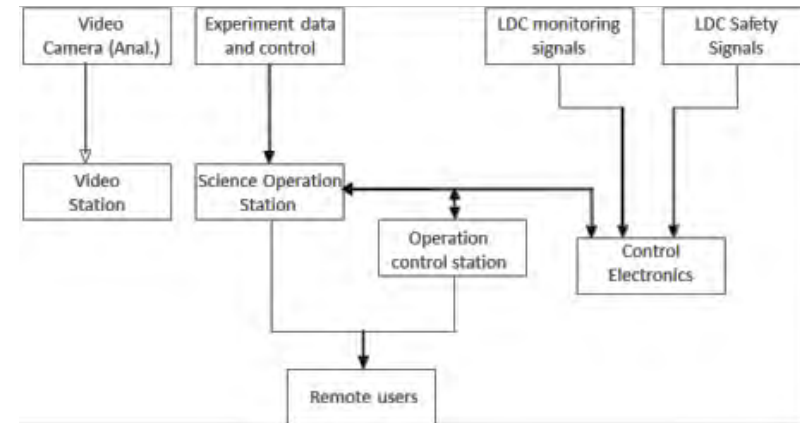


LDC Data / Electronics Interfaces

Operation Electronics Scheme



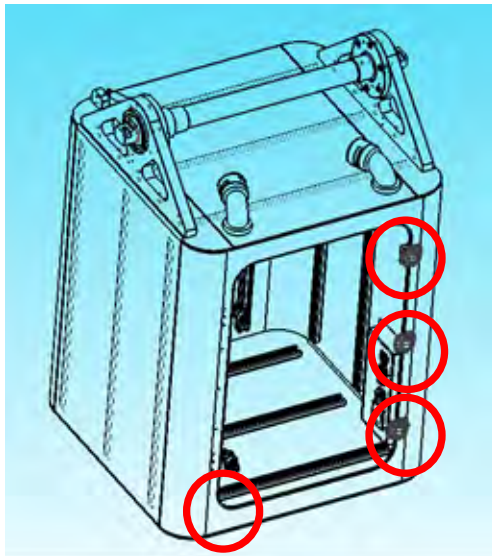
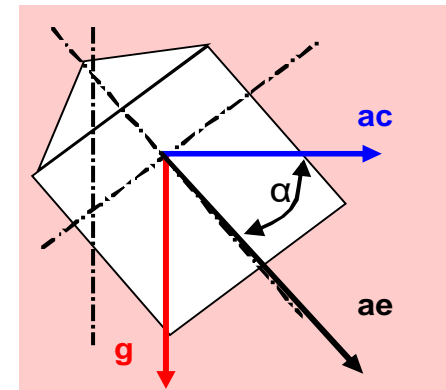
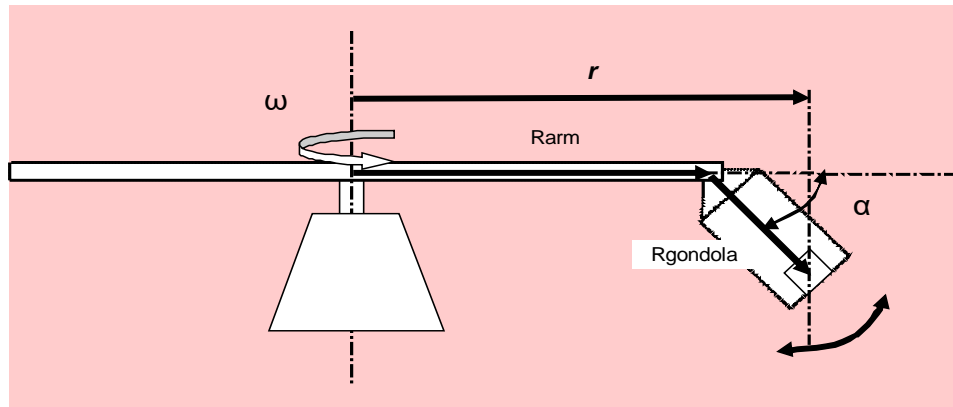
Operation Data Flow Scheme



Data / Communication:

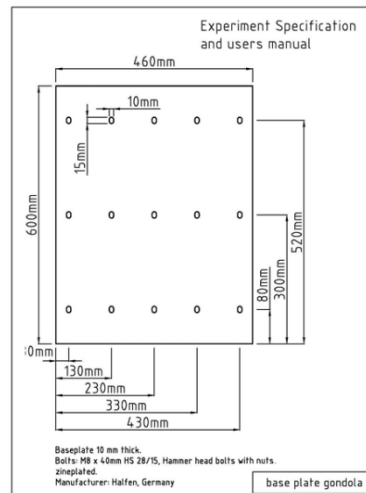
- Remote PC (Win10 / (Win7/XP!), non-Win systems)
(administrator rights!!)
- (TeamViewer)
- Exp. dedicated

LDC Swing-Out / Integration



Door clearance: 450x 710 mm (WxH)
(max. approximately; round corners,
hinges)

Working space inside: 500x500 x 720 mm



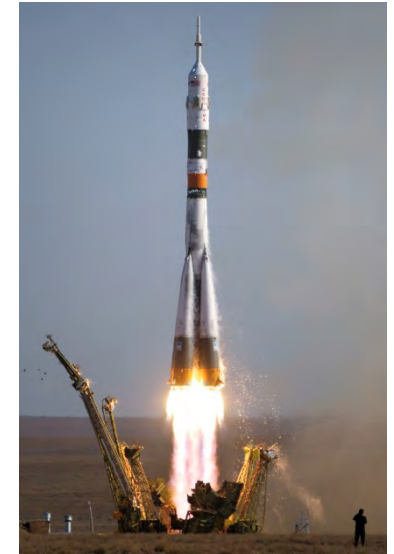
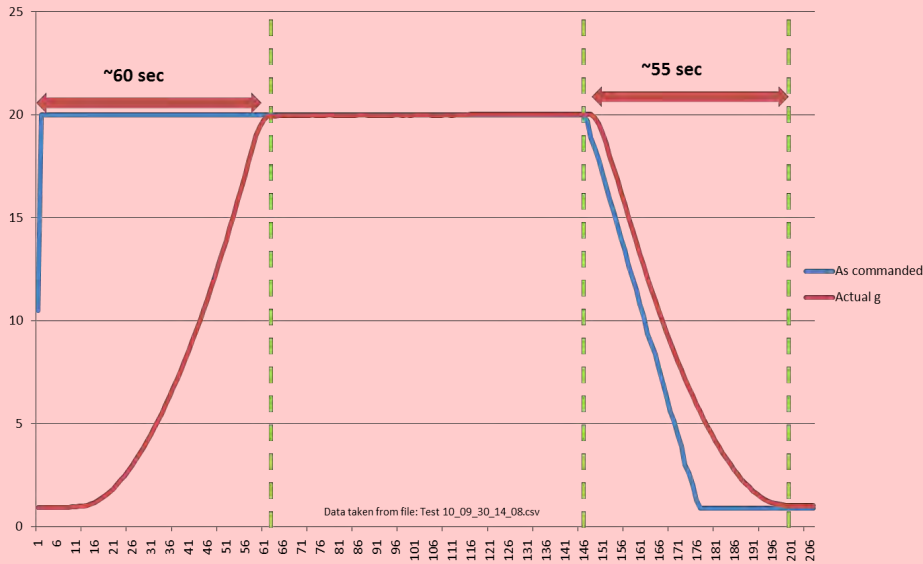
Base plate
(mostly not
needed)



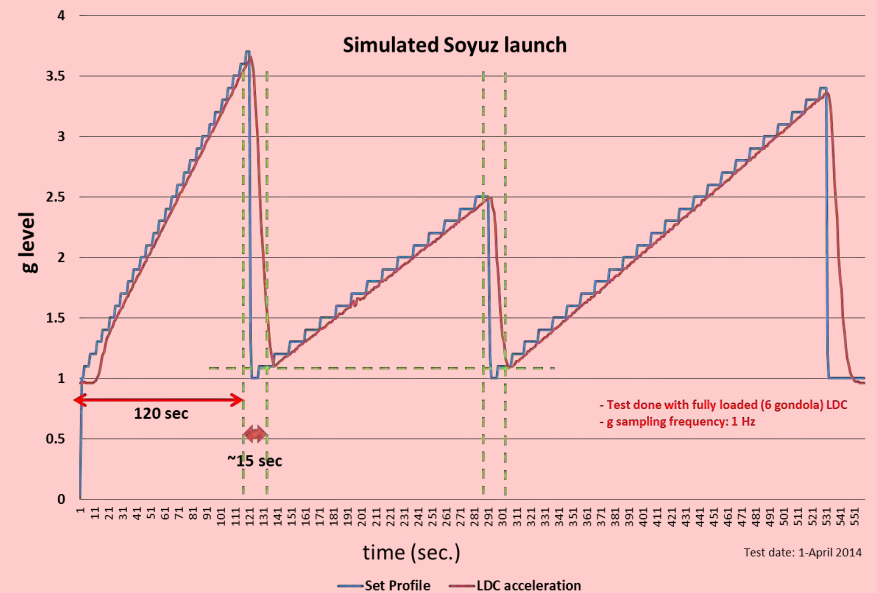
Gas / fluid containers

LDC Start-up & Profiles

Immediate spin up to 20 g and spin down to 1 with fully loaded LDC (6 gondola's).



Simulated Soyuz launch



The Gondola : Gravity Profile / Inertial Shear

total load distribution due to rotation
(no Earth 1g)

(19.515 – 19.690)

bottom of gondola

place sample @
center !



20g, longest arm
total surface area
600×600 mm

max. gradient / inertial
shear over full surface
area:

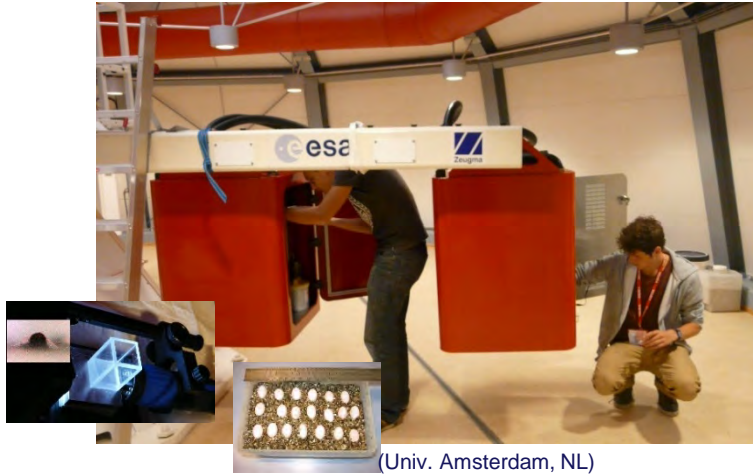
- @ 80 cm: **0.6%**
- @ 40 cm: **0.7%**
- @ 0 cm: **0.9%**

gradient over gondola
height: **10.3%**

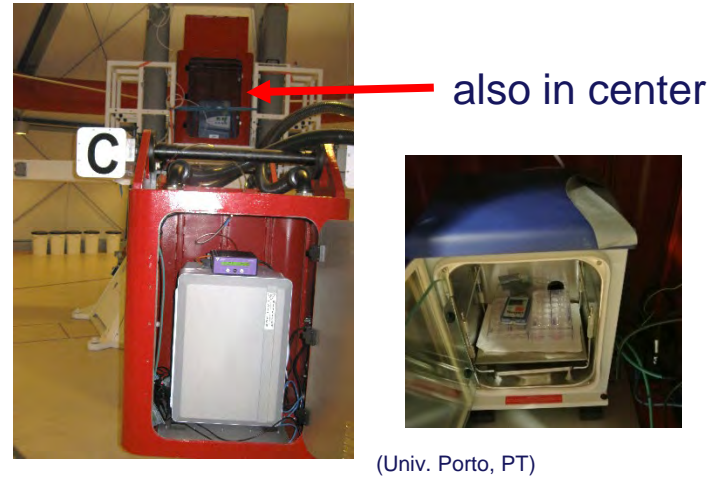
Place sample in center of gondola !!

LDC Experiment Capacity

Multiple g-levels (~factor 2)

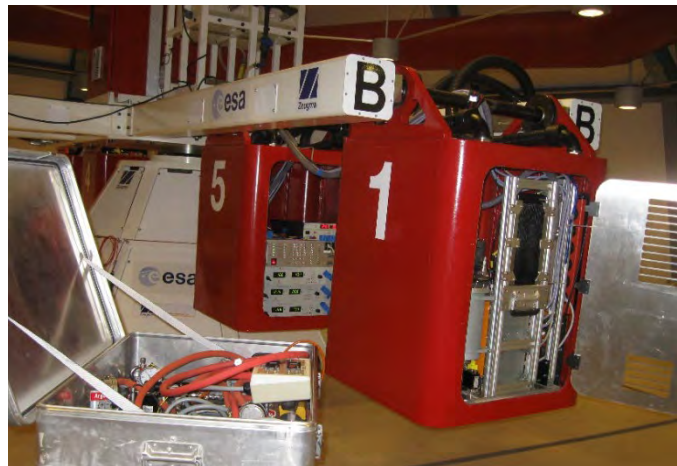


Different temperatures (~4-40 °C)



increase exp. n !

Multiple Gondolas



(MAP: Aachen et al. DE)

Lab Pre-integration



(ASML/TU/e, NL)

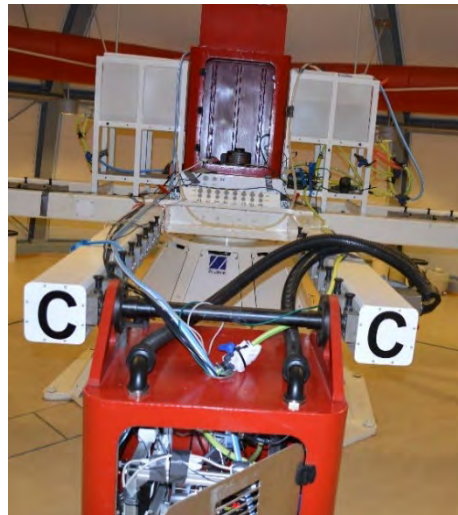
Some Experiment Configurations



Impact
(Glasgow, UK)



Crab/Neurovestibular
(Aberdeen, UK)



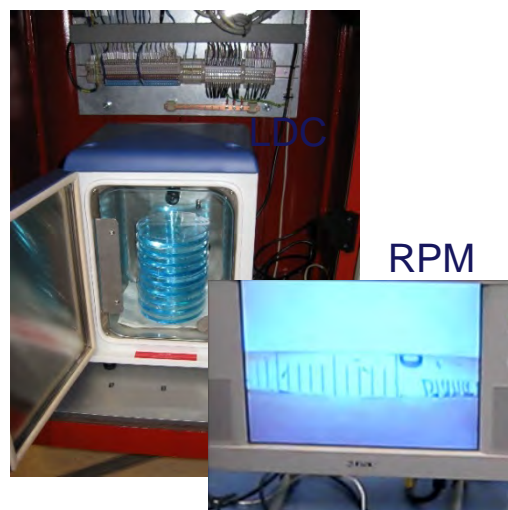
Mass & Heat Transfer
(Thessaloniki, GR)



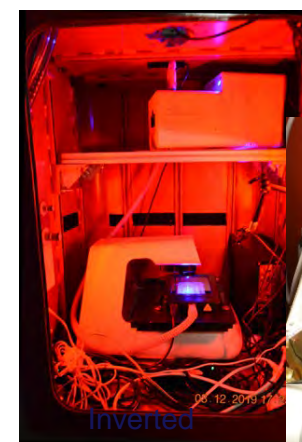
Planetary/Glacier
(Amsterdam, NL)



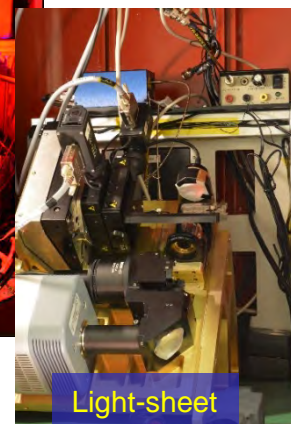
Bubble Generation
(Thessaloniki, GR)



(Liege, BE)



EVOS M7000



Fluorescence Mics

light sheet
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The HyperGES Proposal : what should be clearly addressed?!

Why to use the LDC?

- Use LDC for 'regular' hypergravity studies / launch simulations / low gravity extrapolations / microgravity simulations (Reduced Gravity Paradigm)
- Science / application background / rationale (Preliminary data (own / from literature) / References! ...)

How to use the LDC?

- Identify what parameters to measure and how (either on-line or post exposure) – Expected outcome
- Show a (preliminary) hardware configuration
- Think about schedule / logistics
- How to communicate your results (report / peer reviewed science paper / conference presentation, local and social media)

Before upload.....

- (re-)Check if ALL parts of the proposal are completed
-

Any question / remarks ?!

Don't wait asking !!

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TEC-MMG LIS Lab web URL:

http://m.esa.int/Our_Activities/Space_Engineering_Technology/Life_Physical_Sciences_and_Life_Support_Laboratory

Some peer reviewed papers from previous LDC studies (non-exhaustive list) on general, **cell biology**, **plant biology**, **animal physiology**, **fluid physics**, **plasma physics**, **geology/planetary**, **technology**, **material sciences** and other topics:

fluid physics

- <https://link.aps.org/doi/10.1103/PhysRevLett.123.244501>
- [doi:10.1007/s12217-019-09740-8](https://doi.org/10.1007/s12217-019-09740-8).
- doi.org/10.1016/j.ijmultiphaseflow.2019.03.029.
- DOI: doi.org/10.1016/j.ijheatmasstransfer.2018.12.086
- <https://doi.org/10.1016/j.fbp.2017.02.001>
- <https://doi.org/10.1103/PhysRevE.91.053009>
- DOI: [10.1209/0295-5075/110/24001](https://doi.org/10.1209/0295-5075/110/24001)
- DOI [10.1007/s10035-013-0403-2](https://doi.org/10.1007/s10035-013-0403-2)
- <https://doi.org/10.1016/j.expthermflusci.2015.01.011>
- <https://doi.org/10.1016/j.foodres.2013.10.044>.
- <https://doi.org/10.1007/s12217-012-9323-8>

plasma physics

- doi.org/10.1088/1361-6595/aa5ee8.
- [doi:10.1088/0963-0252/24/2/022002](https://doi.org/10.1088/0963-0252/24/2/022002)
- <http://dx.doi.org/10.1016/j.materresbull.2014.03.013>
- DOI: [10.1140/epid/e2013-40408-7](https://doi.org/10.1140/epid/e2013-40408-7)

cell biology:

- DOI: [10.1016/j.ejpb.2021.03.013](https://doi.org/10.1016/j.ejpb.2021.03.013).
- DOI: [10.1002/jbm.a.37215](https://doi.org/10.1002/jbm.a.37215)
- doi: [10.1016/j.bpj.2021.01.021](https://doi.org/10.1016/j.bpj.2021.01.021)
- doi: [10.1016/j.bpj.2021.01.021](https://doi.org/10.1016/j.bpj.2021.01.021).
- doi: [10.3390/ijms21072354](https://doi.org/10.3390/ijms21072354).
- <https://doi.org/10.1016/j.bpj.2019.03.038>
- doi: [10.1089/scd.2017.0206](https://doi.org/10.1089/scd.2017.0206)
- DOI: [10.1098/rsif.2016.0688](https://doi.org/10.1098/rsif.2016.0688).
- doi: [10.2147/IJN.S76329](https://doi.org/10.2147/IJN.S76329)
- DOI: [10.1371/journal.pone.0144269](https://doi.org/10.1371/journal.pone.0144269).
- DOI: [10.1089/ten.tea.2012.0267](https://doi.org/10.1089/ten.tea.2012.0267)
- <https://doi.org/10.1016/j.jbiosc.2011.09.025>

plant biology

- [doi:10.1038/s41598-018-24942-7](https://doi.org/10.1038/s41598-018-24942-7).
- <https://doi.org/10.1007/s12217-016-9531-8>
- <http://dx.doi.org/10.3389/fspas.2016.00002>
- [doi:10.1038/srep07730](https://doi.org/10.1038/srep07730)
- <http://dx.doi.org/10.1155/2014/964203>
- [doi:10.1371/journal.pone.0058246](https://doi.org/10.1371/journal.pone.0058246)
- [doi:10.1007/s12217-012-9301-1](https://doi.org/10.1007/s12217-012-9301-1)

animal physiology

- doi: [10.1302/2046-3758.102.BJR-2020-0239.R1](https://doi.org/10.1302/2046-3758.102.BJR-2020-0239.R1)
- doi: [10.1038/s41526-020-00115-7](https://doi.org/10.1038/s41526-020-00115-7)
- DOI [10.7717/peerj.6055](https://doi.org/10.7717/peerj.6055).
- <https://doi.org/10.3390/ijms20030720>
- DOI: [10.1371/journal.pone.0126928](https://doi.org/10.1371/journal.pone.0126928)
- DOI: [10.1155/2014/679672](https://doi.org/10.1155/2014/679672).
- DOI [10.1007/s12217-012-9334-5](https://doi.org/10.1007/s12217-012-9334-5)

Geology/planetary

- doi: [10.1098/rspa.2016.0673](https://doi.org/10.1098/rspa.2016.0673)

Technology

- doi: [10.1016/j.bpj.2021.01.021](https://doi.org/10.1016/j.bpj.2021.01.021)
- DOI: [10.1002/adv.21937](https://doi.org/10.1002/adv.21937)
- ISBN [978-1-68108-499-2](https://doi.org/10.1016/j.bpj.2021.01.021)

material sciences

- <https://doi.org/10.1016/j.ijheatmasstransfer.2018.05.151>

Other topics / background

- doi: [10.3389/frspt.2020.00003](https://doi.org/10.3389/frspt.2020.00003).
- DOI [10.1007/s12217-015-9462-9](https://doi.org/10.1007/s12217-015-9462-9)