Mid-Term Review
10th of December 2018, Brussels

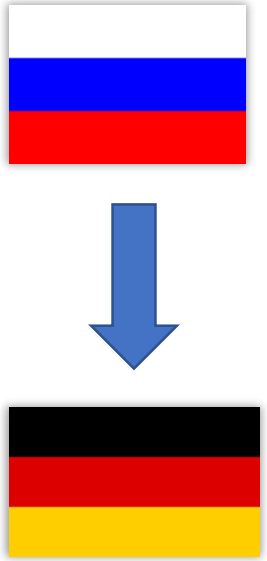
Sofiya Savelyeva
ESR11, WP4

Institution: Technical University of Dresden
Supervisor: Prof. Dr. Christoph Haberstroh

EASITrain – European Advanced Superconductivity Innovation and Training. This Marie Sklodowska-Curie Action (MSCA) Innovative Training Networks (ITN) has received funding from the European Union's H2020 Framework Programme under Grant Agreement no. 764879

Background & Recruitment

- **Home country:** Russia
- **Field:** Cryogenics
- **Education:** Bauman Moscow State Technical University
- **Work experience:** Engineer in the cryogenic laboratory of Bauman University, 2014-2017



- **Hosting country:** Germany
- **Host institute/PhD University:** Technische Universität Dresden
- **EASITrain Supervisor/PhD Supervisor:** Prof. Dr. Christoph Haberstroh
- **Contract start - end date:** 01.02.2018 – 31.01.2021
- **Current employment period:** 10 months
- **EASITrain Project title:** "Development and efficiency assessment of a Nelium refrigeration cycle"

Georg-Schumann-Bau of the TU Dresden

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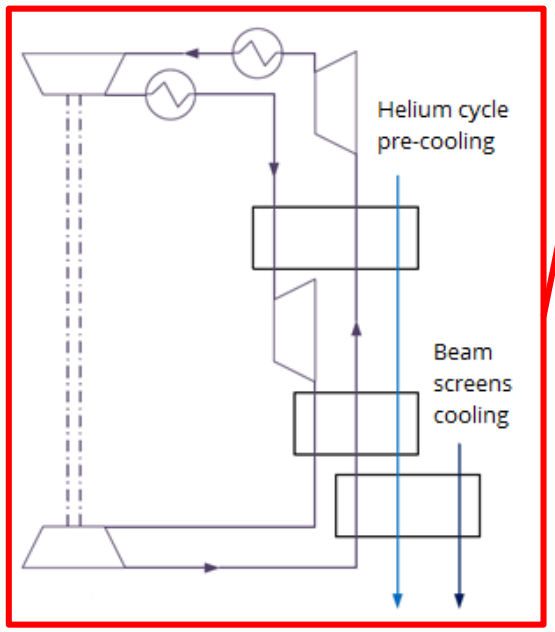
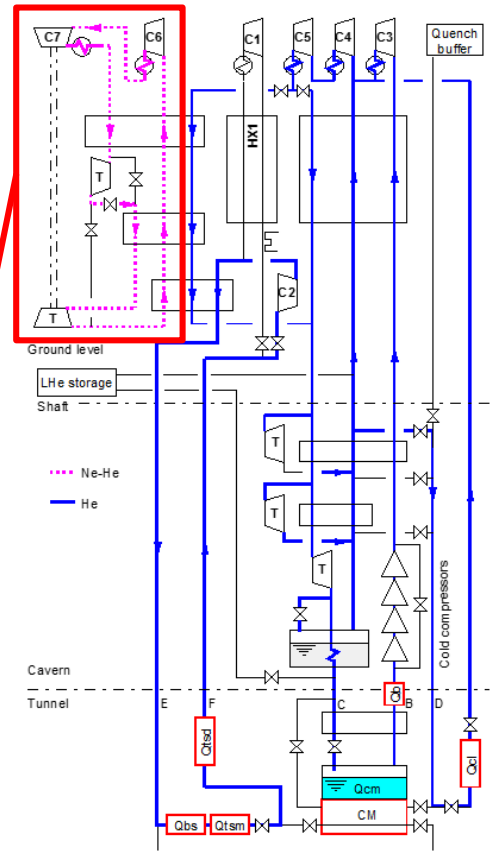
Project subject

- **Subject:** Nelium (neon-helium) Turbo-Brayton cycle
- **Application:** part of the FCC cryogenic system (the beam screens and thermal shield cooling and Helium cycle pre-cooling)
- **Reasons for research:**
  - unconventionally high cooling capacity required at 40 K temperature level: ***680 kW***
  - development of new promising cryogenic technology: more efficient than the conventional helium cycle thanks to turbo-compressors application (**10 % higher Carnot efficiency**)
  - **industrial application:** superconducting cables cooling (40-77 K)

Nelium cycle





FCC-hh cryogenic layout
(L. Tavian, S. Klöppel)

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Project Objectives

- **Improving the cooling system** for beam screens, thermal shields and the Helium cycle pre-cooling, using Nelium Turbo-Brayton cycle – *in cooperation with CEA **(ESR 4)**, CERN*

- **Industrial applications** of cryogenic mixture cycles below 80 K – *in cooperation with Linde AG (München), Linde Kryotechnik (Pfungen) – **secondment in 2019***

- Development of **turbo-compressors** for the light gases – *in cooperation with University of Stuttgart **(ESR 15)***

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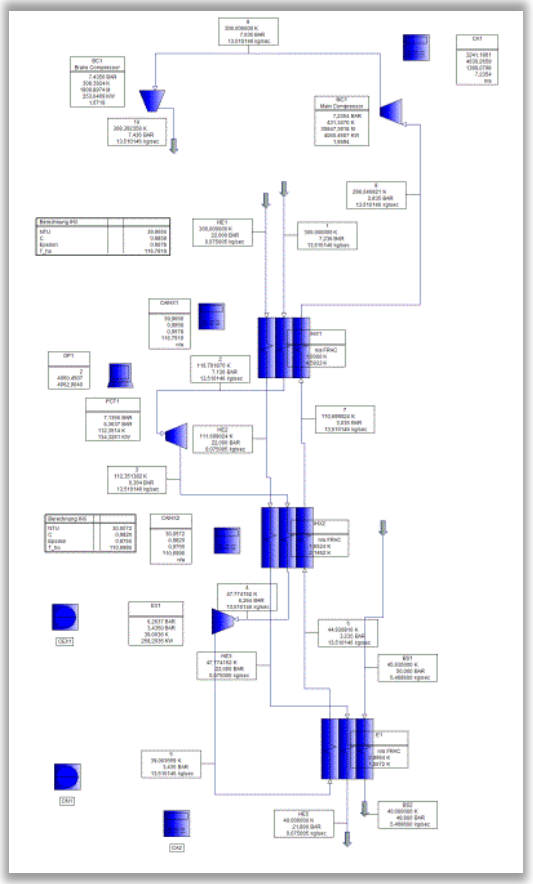
Current status - Research

Work performed:

- Review of literature and previously done work
- **Cycle simulation** in PRO II
- **Neon market analysis** and **fluid composition** improvement
- **Neon production process study** – possible alternative mixture composition found
- **Neon-helium mixture composition influence on the cycle** parameters and components (in progress)

Screenshot of the cycle simulation in PRO II



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Current status - Research

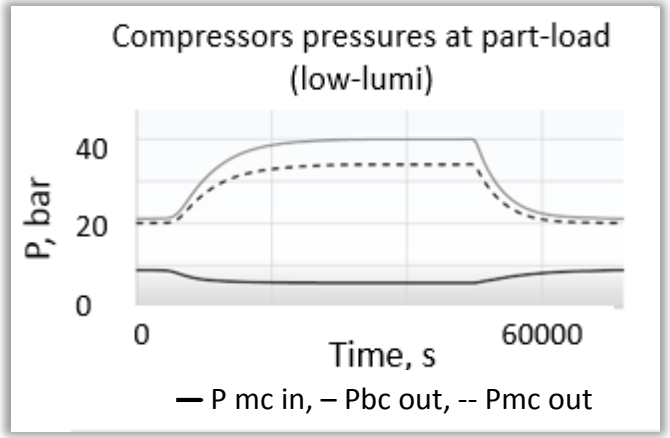
Part-load operation model – for updated mixture composition and Helium cycle precooling

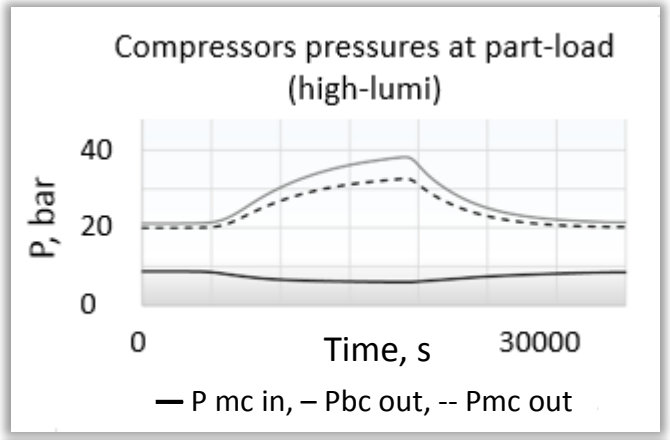
Compressor model

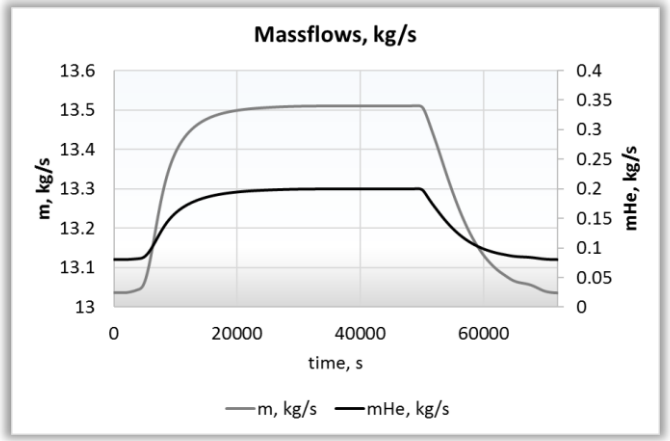
Cycle model in PRO II

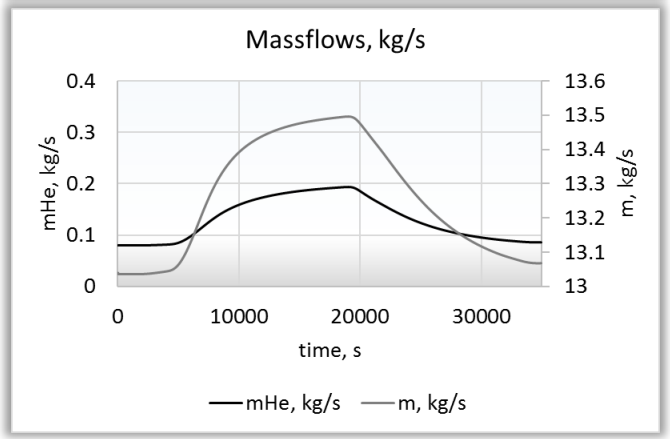
Cycle parameters for components design

Inputs for ESR 15
(compressor design)









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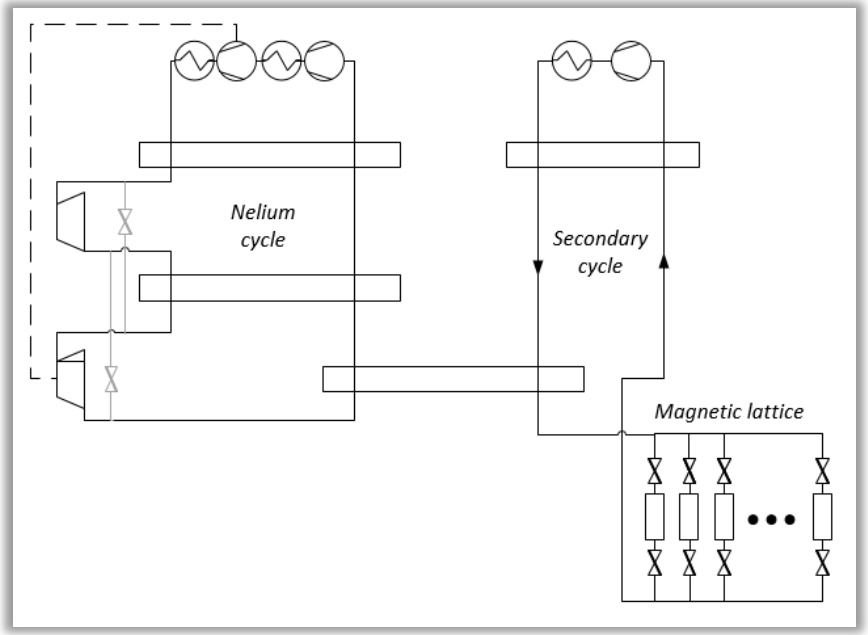
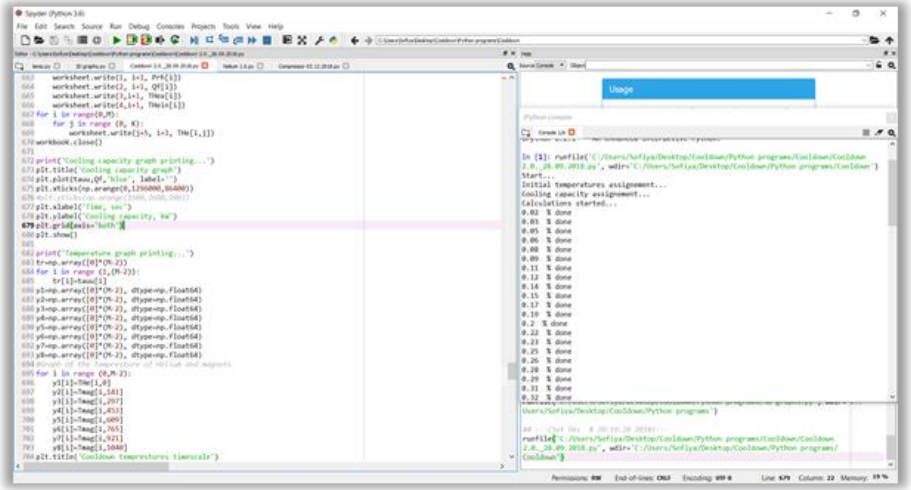
Current status - Research

- **Cool-down operation model** in Python – for magnets and secondary cycle (for the Nelium cycle – in progress)

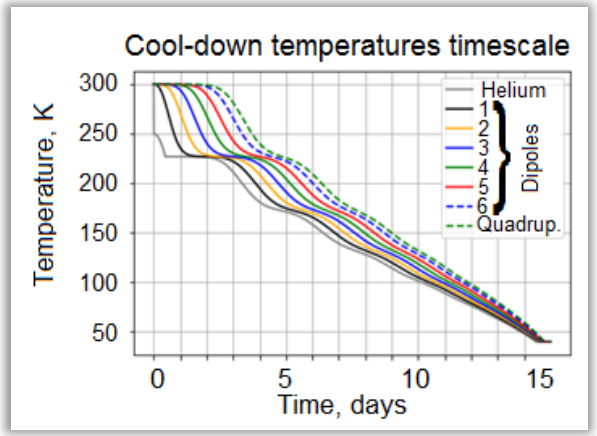
Cool-down operation flow diagram

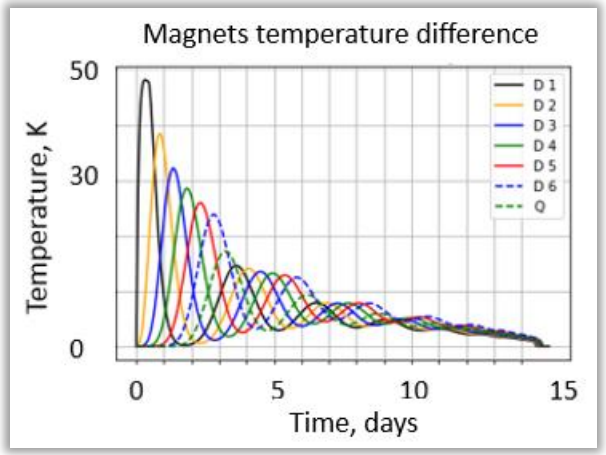


Programming in Python



Simulation results





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Current status - Cooperation

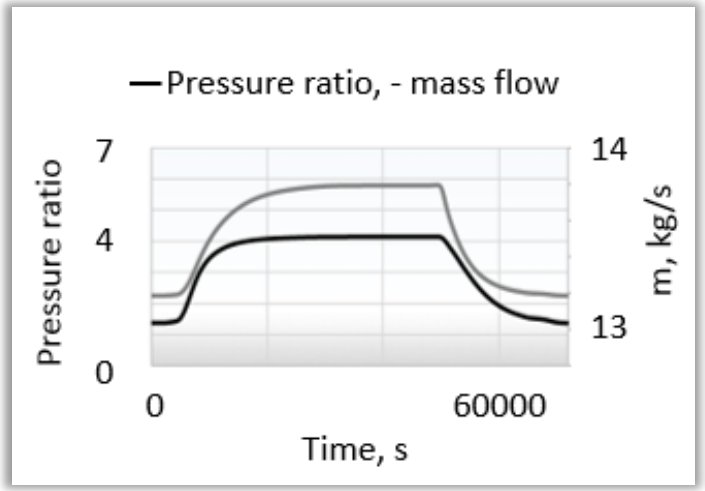
University of Stuttgart (ESR 15)

- ✓ preparation for the compressor **test rig** setup and common experiment from March 2019
- ✓ **inputs** for the main compressor design
- ✓ email correspondence; Skype meetings

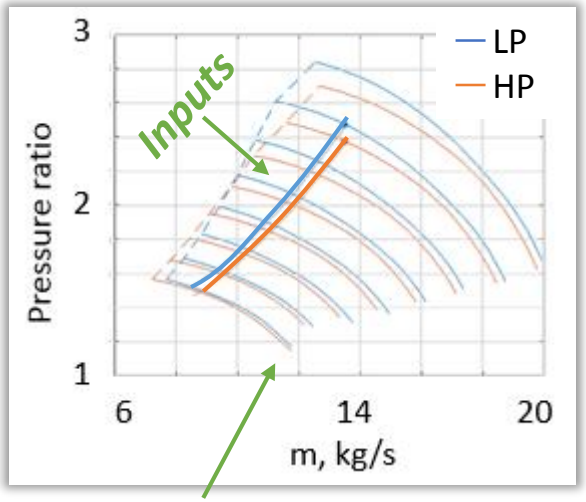
Linde AG, Munich/Linde Kryotechnik, Pfungen

- ✓ industrial conventional and turbo Brayton cycles comparison;
- ✓ neon production process study – ***common paper*** *is planned for Cryogenics 2019 conference*;
- ✓ regular internal Skype meetings (once per month)
- ✓ **secondment**

Main compressor pressure ratio and massflow (low-lumi)



Main compressor operation map



M. Podeur (ESR 15)

Industrial conventional and Turbo-Brayton cycles compared

Unit name	LIPA I	Mayekawa	NeoKelvin		Air Liquide
Cooling power	4 kW	5 kW	2 kW	10 kW	7-150 kW
Fluid	He	Ne	Ne	Ne	*Ne*
Power consumptions	41 kW	52 kW	55 kW	170 kW	85-1200 kW

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Next steps

- Further cycle design and operational modes improvements
- Hardware specification
- Industrial approach – cycle scaling for different mixtures and temperatures below 80 K – **secondment at Linde Kryotechnik** in 2019
- Study of turbo-compressor performance in cryogenic cycles with the light gases:
  - **common work on the test rig** (~15 kW) with **ESR 15** at the **University of Stuttgart** from March 2019 (sensors installation, getting system running, data analysis)
  - implementation of the turbo-compressor model to cycle calculations

repeated stays at USTUTT

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Training, Conferences & Workshops

Trainings:

✓ EASITrain lectures spring 2018	CERN, Geneva	03.03.-23.03.2018

Workshops on superconducting cables, magnet testing, treatment surface chemistry, cryogenics, manufacturing, project management

✓ EASIschool 2018	Vienna	03.09.-14.09.2018

Course on applied superconductivity, project management course, media training, innovation management

✓ LabView course	TU Dresden	16.04.-18.04.2018
✓ German, upper-intermediate	TUDIAS, Dresden	04.04.-25.07.2018
✓ German, pre-advanced	Goethe Institute, Dresden	18.09.-30.11.2018

Conferences/Workshops:

✓ FCC Week 2018	Amsterdam	09.04.-13.04.2018
✓ PhD Seminar	Bad Schandau	21.10.-23.10.2018
✓ DKV Conference	Aachen	21.11.-23.11.2018

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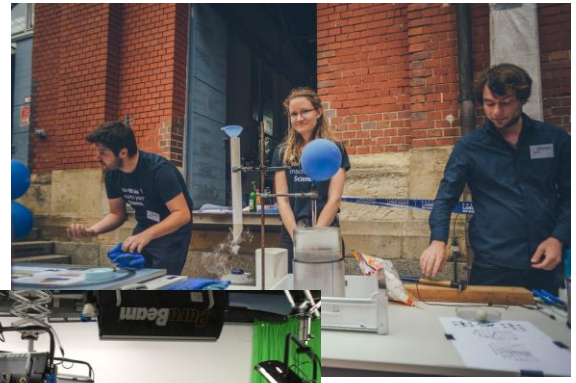
Outreach, Dissemination & Networking

- **Outreach activities**
  - ✓ Video Interview, CERN, March 2018
  - ✓ International Refrigeration and Compressor Course, TU Dresden, 21.05. - 25.05.2018
  - ✓ Long Night of Science, TU Dresden, 14.06.2018
- **Presentations:**
  - ✓ FCC Week 2018, Amsterdam, 12.04.2018
  - ✓ PhD seminar, TU Dresden, 21.10.-23.10.2018
- **Networking activities**
  - ✓ FCC meetings, meetings with companies, conferences, EASITrain meetings incl. social events
  - ✓ Project cooperation with other ESRs and industry

Lond Night of Science



CERN Video Interview

FCC Week 2018

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Impact

- Personal impact of MSCA fellowship :
  - ✓ Open the border to the research society of Europe
  - ✓ PhD project in cooperation with research institution + industry
  - ✓ Technical/non-technical trainings
  - ✓ Mobility (secondments, schools, scientific events attendance)
  - ✓ Access to facilities closed for public
  - ✓ Scientific Network
  - ✓ Multicultural environment
- Future career plans:
  - ✓ Research & Development in industry
    or
  - ✓ Academic career

TUD team

EASITrain team

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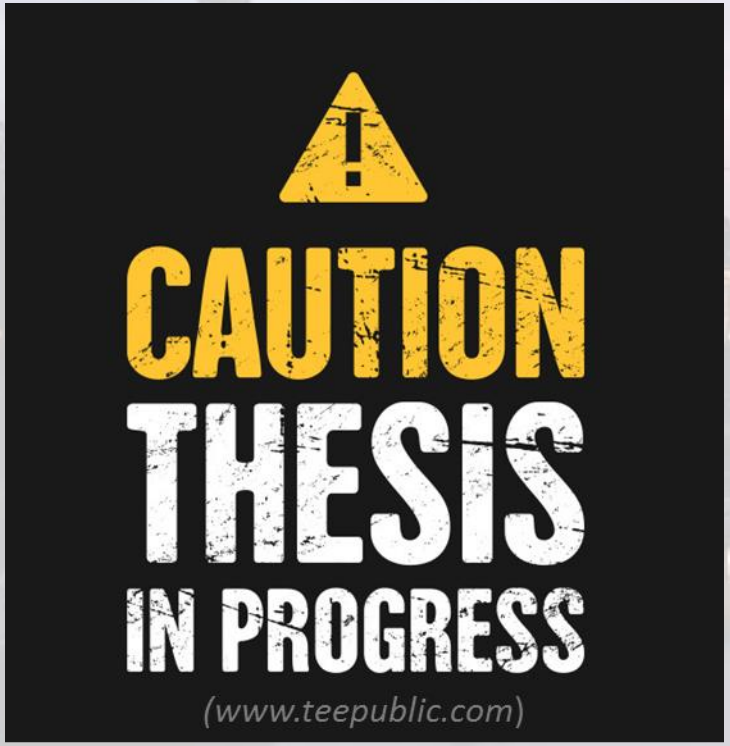

Thank you for your attention!

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