

# SPACE CHEMISTRY AND GLOBAL HEALTH: DRUG DEVELOPMENT AGAINST COVID-19 IN SPACE

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# Global health issues to be solved - in space

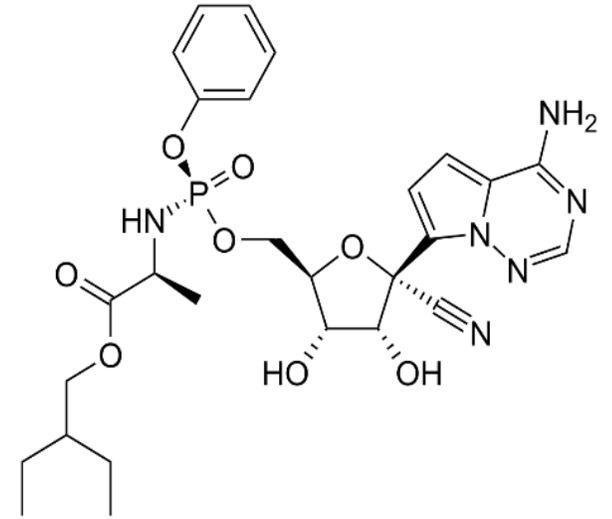
- **Performing drug discovery and chemistry in space offers a huge opportunity for developing health of human mankind**
- Novel APIs (active pharmaceutical ingredients) development: here microgravity can ensure faster, more efficient reaction routes, even novel reaction products which are difficult to synthesize on earth. API production in space: needed also by long-term space traveling
- Large number of other important chemical applications, e.g. CO<sub>2</sub> transformation into valuable materials, like plastics, on-site propellant production on space objects....
- Effects in space: microgravity, low temperature, radiation, unknown effects

Jones, R.; Darvas, F. & Janáky, Cs. (2017), *Nature Rev. Chem.*, 1, Article number: 0055  
Braddock, M. (2020), *Curr. Drug Discov. Technol.*, 17(1), 45-56.

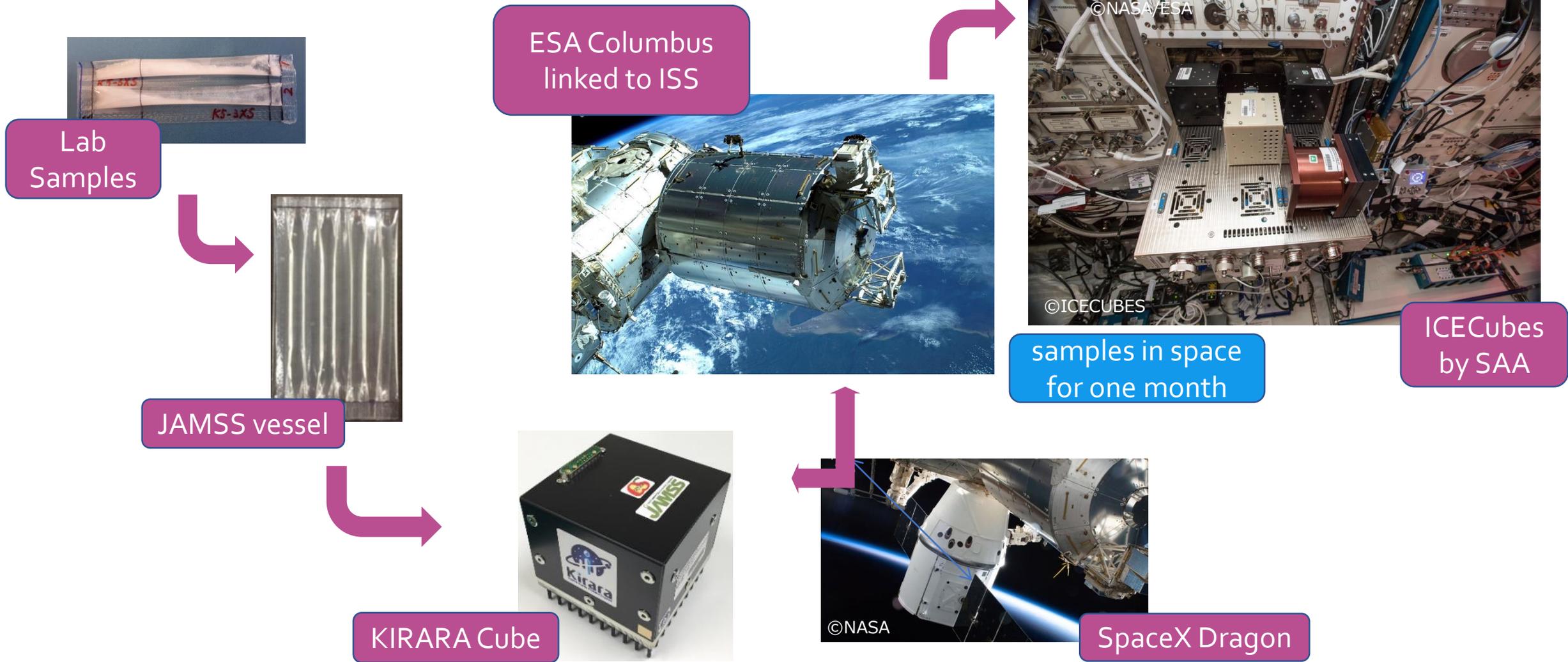


# Remdesivir, the targets of our experiments on ISS

- One of the most important and most widely used drug against COVID-19
- Marketed as Veklury®, in form of a cyclodextrin complex. It is the very first approved anti-COVID drug
- Has serious limiting factors in its application, like it accumulates in patients with decreased renal function. It cannot be used in a wide group of COVID patients ....
- **An improvement of the REM/cyclodextrin (R/C) ratio would allow in increasing the treatable client group.** Unfortunately, increase of R/C could not yet been achieved > **research in space justified**
- It is the first time that an anti-COVID research went to space
- It is the first time that effect on a drug-cyclodextrin complex was studied in the space
- Our venture created a world-wide interest: <https://finance.yahoo.com/news/innostudio-launches-consortium-developing-coronavirus-144909829.html>



# Going to ISS and returning to Earth

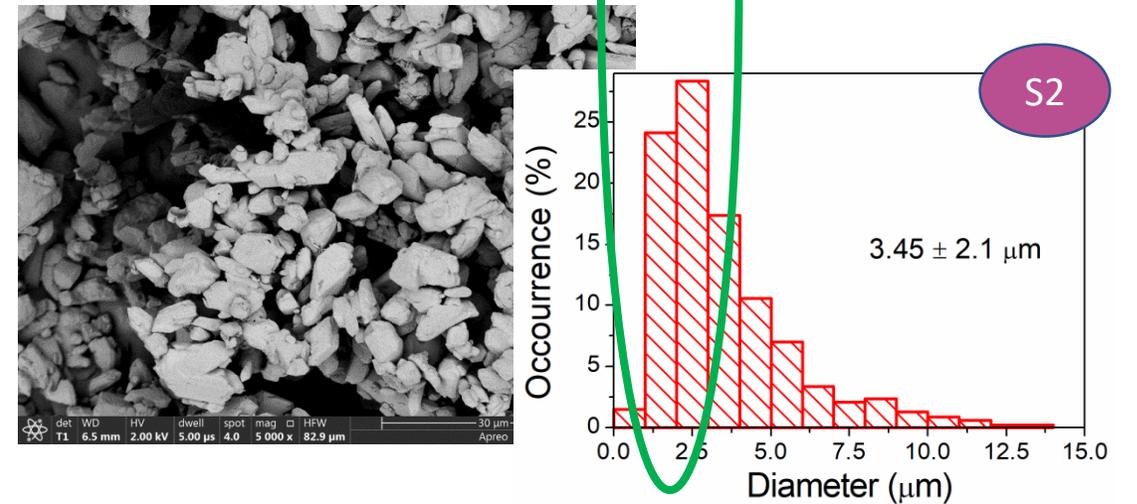
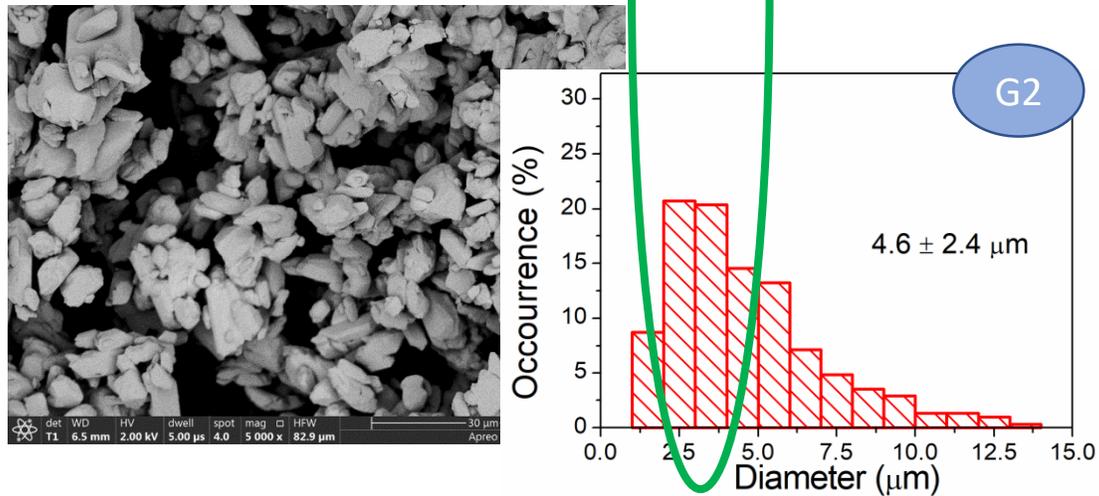
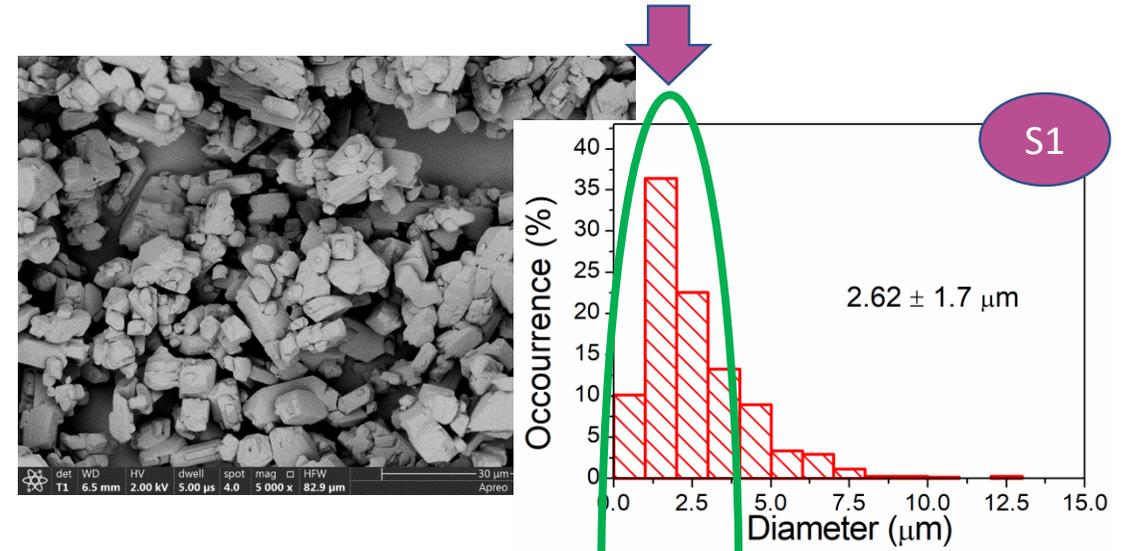
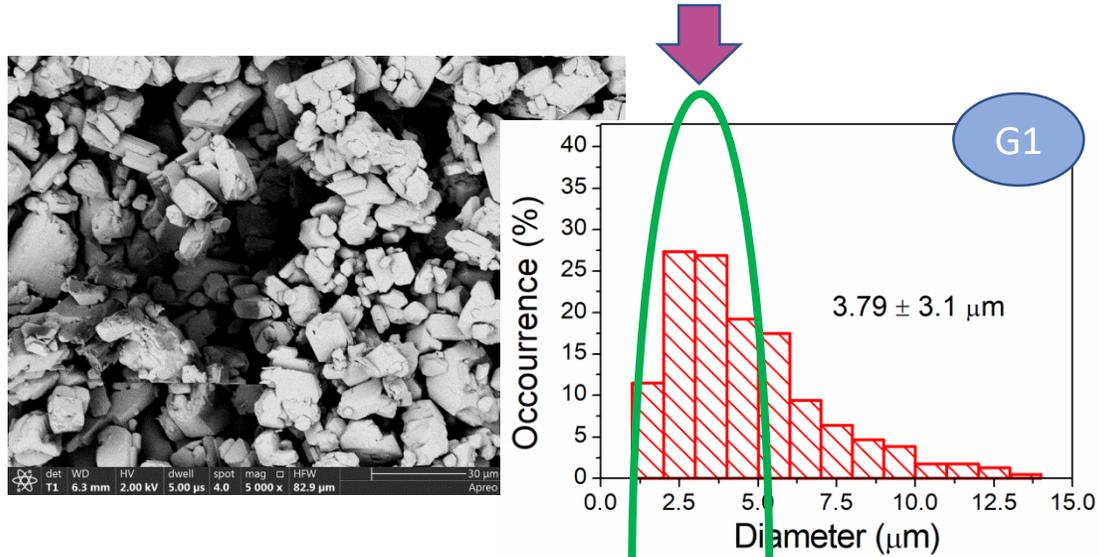


# After return from space: processing of samples

## Complex instrumental analysis, including:

- Rapid visual comparison of samples by optical microscopy
- Determination of particle size distribution by Field Emission Scanning Electron Microscopy (FE-SEM)
- REM crystal structures by X-ray Powder Diffraction (XRD)
- Analysis of REM polymorphy and crystallinity by Raman Spectroscopy
- Determination of dissolved REM by HPLC (from supernatant)
- Detection of contingent degradation products of REM and SBECD by HPLC fingerprint (from supernatant)
- **Chemometrical evaluation of the instrumental results is still ongoing**

# Morphological Investigation: FE-SEM

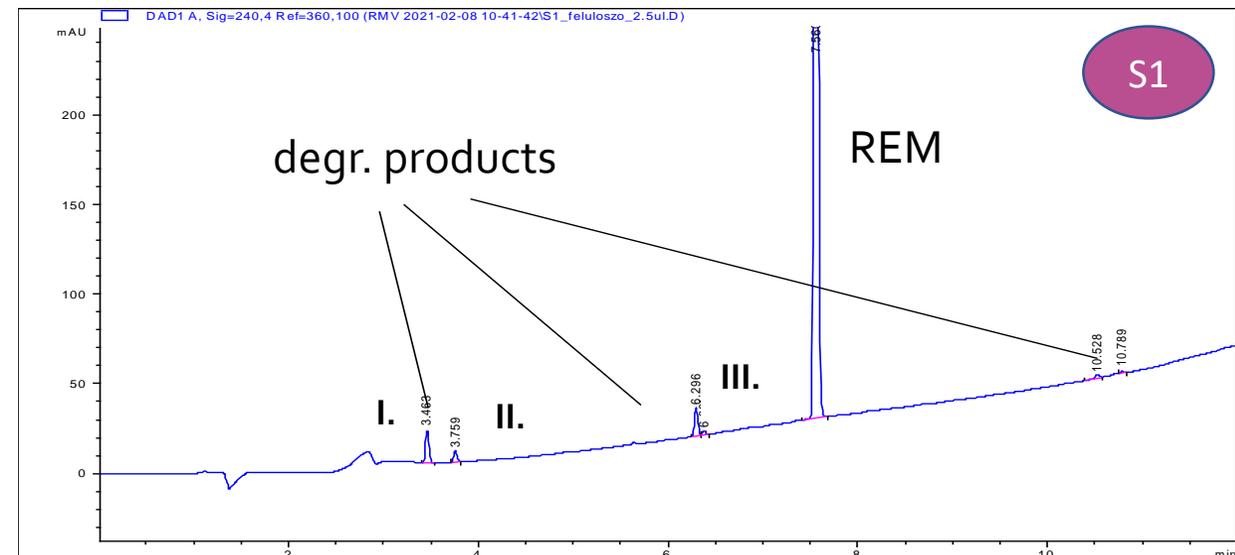
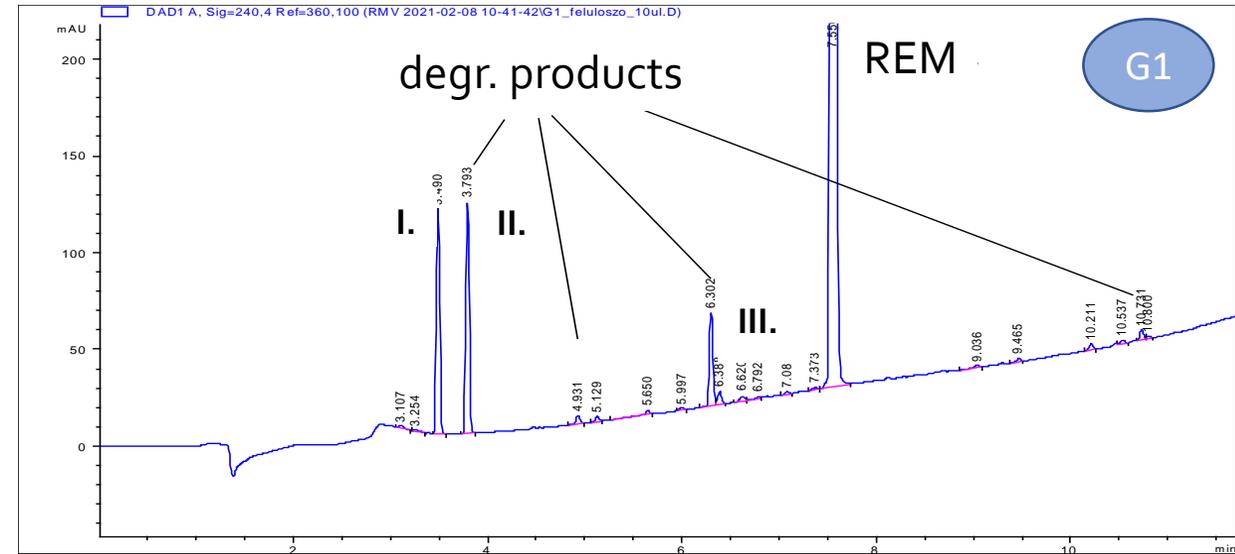


6  
Visible and statistical differences among reference (G) and space (S) samples

# Chromatography (HPLC) – unexpected results

Sample	pH	REM (mg/ml)	REM <sub>AV</sub> (mg/ml)	SD (mg/ml)	REM/SBECD (w%)
G1_1	7.0	0.97	1.02	0.04	0.5
G1_2		1.04			
G1_3		1.04			
G2_1	3.5	5.65	5.66	0.01	2.8
G2_2		5.65			
G2_3		5.66			
S1_1	7.0	0.97	1.01	0.04	0.5
S1_2		1.05			
S1_3		1.01			
S2_2	3.5	5.48	5.47	0.01	2.7
S2_3		5.46			
S2_4		5.45			

- REM (at pH neutral) in space and reference samples degraded unproportionally and in different manner;
- **Stability for one REM sample in space increased, relative to reference.**
- **This is an unexpected and important result.**
- No demonstrable product with higher REM/cyclodextrin ratio.
- Cyclodextrin was not degraded in either samples.



# Main results so far - Ongoing efforts

REM stability unexpectedly increased in space for samples with neutral pH. **This result may have clinical significance.** Decomposition routes modelling by computer will follow. Decomposition mechanism may differ in space.

Complex formation with cyclodextrin might occur via an altered mechanism. **Continuation: Complex formation modelling by computer.**

Received morphologically different, and, by decomposition, chemically modified samples in space - **Experimental IC<sub>50</sub> evaluation is the logical next step against living SARS-CoV-2 virus.** **This result may have clinical significance.**

No success in preparing a remdesivir-cyclodextrin complex with higher REM ratio.

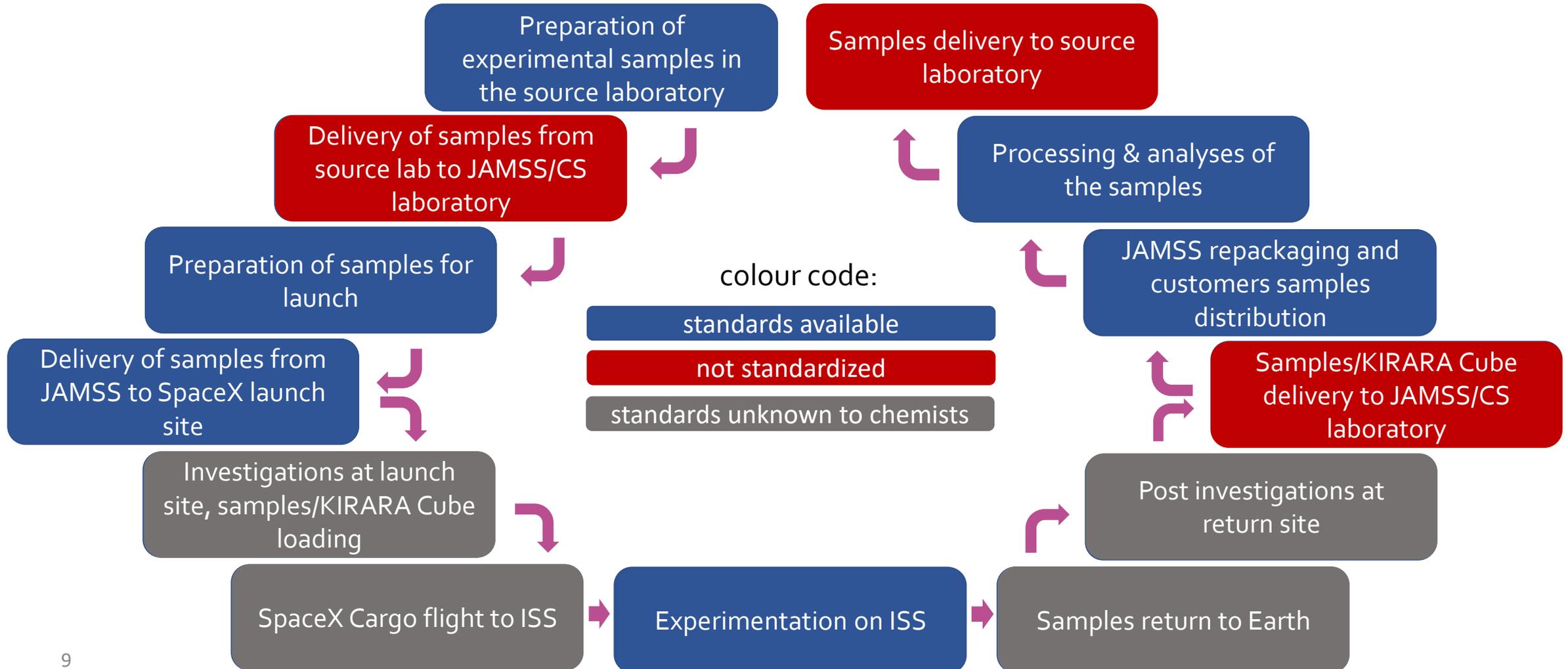
*Any collaborative idea? Clinical capacity? Please contact us.*

*Results of this study are protected by submitted patent applications.*



# Still worths mentioning: integrated standardization efforts

No appropriate standards encompassing the entire procedure



# About InnoStudio, Inc.

- One of the world leaders in **space chemistry**
- Established in 2005, member of one of the largest upstream technology networks (ThalesNano/Darholding) in Central Europe, in Budapest
- Substantial discovery related results on ISS (nanoformulation, co-crystal formulation, protein crystallization, besides present remdesivir project), **all related to improvement of global health**
- Design & development of **flow synthesis instruments for space research** together with holding members **ThalesNano, Inc.** and **ThalesNano Energy, Inc.**
- Teaming in anti-COVID research also with **ComInnex, Inc.**, an another holding member
- Teaming in CO<sub>2</sub> conversion to polymers in space with **ThalesNano Energy**
- Promotes self-organization of the Space Chemistry Community: **organizing consortiums, symposiums (6), publication forums**



# About CycloLab Ltd. (Budapest)

- The world's only all-round cyclodextrin company with over 40-year experience of cyclodextrin technology
- Pioneer in cyclodextrin technology hosting the first International Cyclodextrin Symposium in 1981 (since then, the Symposium has been organized 19 times)
- Main fields of expertise: pharmaceutical-, cosmetics, food-, environmental- and analytical applications
- Producer of 200 different cyclodextrin derivatives, amongst which betadex sulfobutyl ether sodium (SBECD) is produced in multiple ton scale per annum under GMP conditions in parenteral grade
- Over 490 peer reviewed scientific papers in cyclodextrin field, with over 20.000 citations



**Thank you for  
your attention!**

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