Long run

MOCK-UP CALIBRATION AT CERN

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The Mock-up

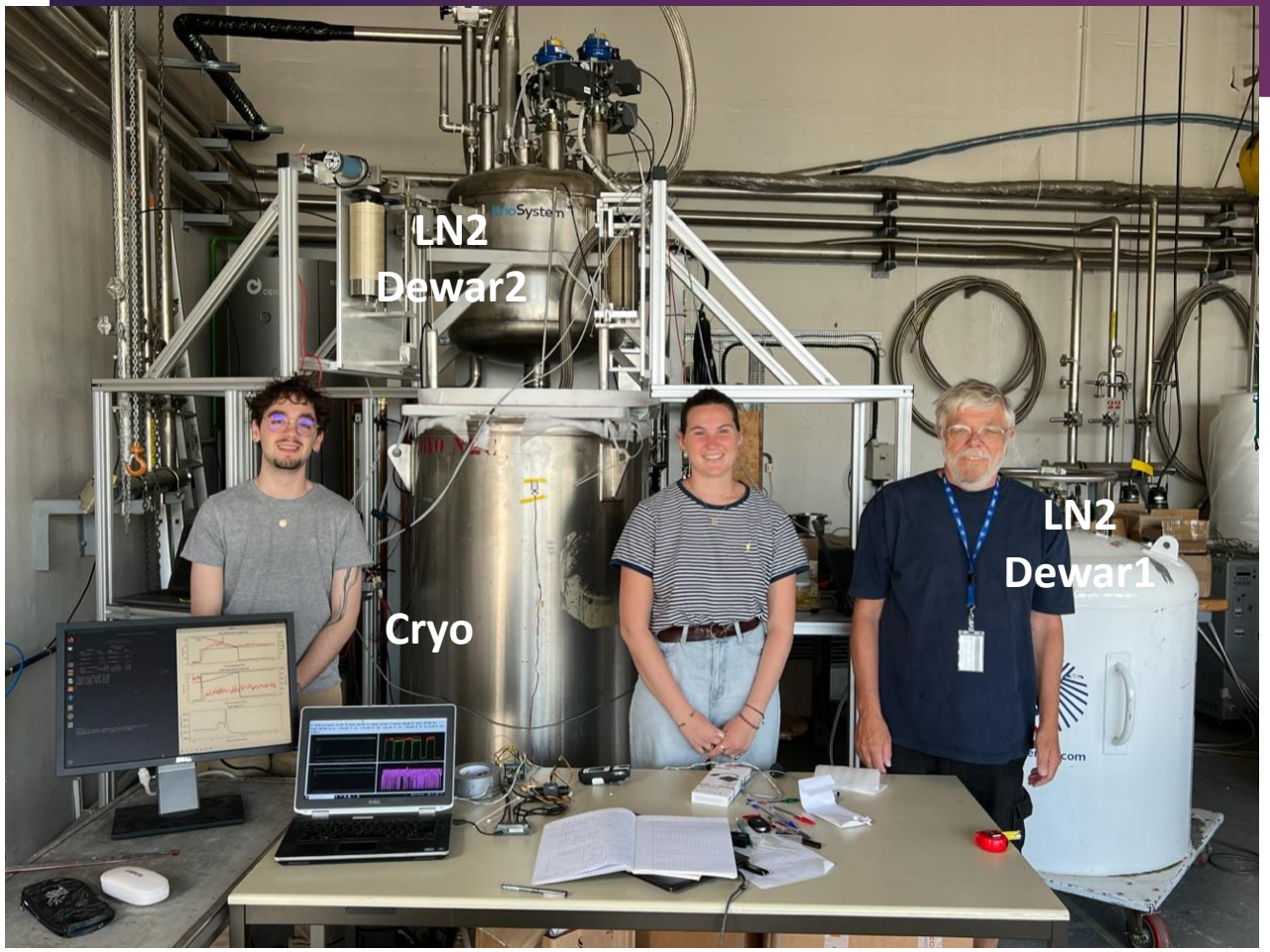
INTRODUCTION

Determine if a cold environment can cause issues on a long run, firstly with LN2 and then with LAr.

	MU_CShort	MU_CLong	MU_Warm
Purpose	Robustness of the cold behaviour for ice formation, source blocked, bend, pipe leak		Behaviour in bends, DS20k length, source size
Temp. (K)	LN2 (77)		Room (290)
Location	CPPM	CERN	CPPM
Pipe lgth (m)	4	2	15** (~DS-20k)
Nb bends*	2	1	15 (11, 7)
Runs	09+11/22, **03/23**	***1 month @ June 23***	**03-04/23**

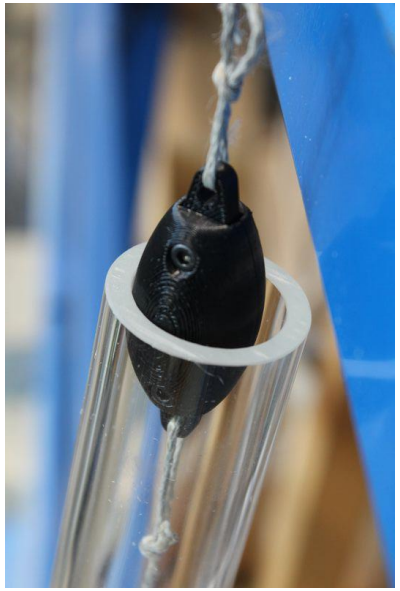
The Mock-up

PRESENTATION OF THE MOCK-UP AND PSEUDO-SOURCE



Pseudo–source

- L = 5.5cm
- ϕ = 2.5 cm
- M= O(100) g

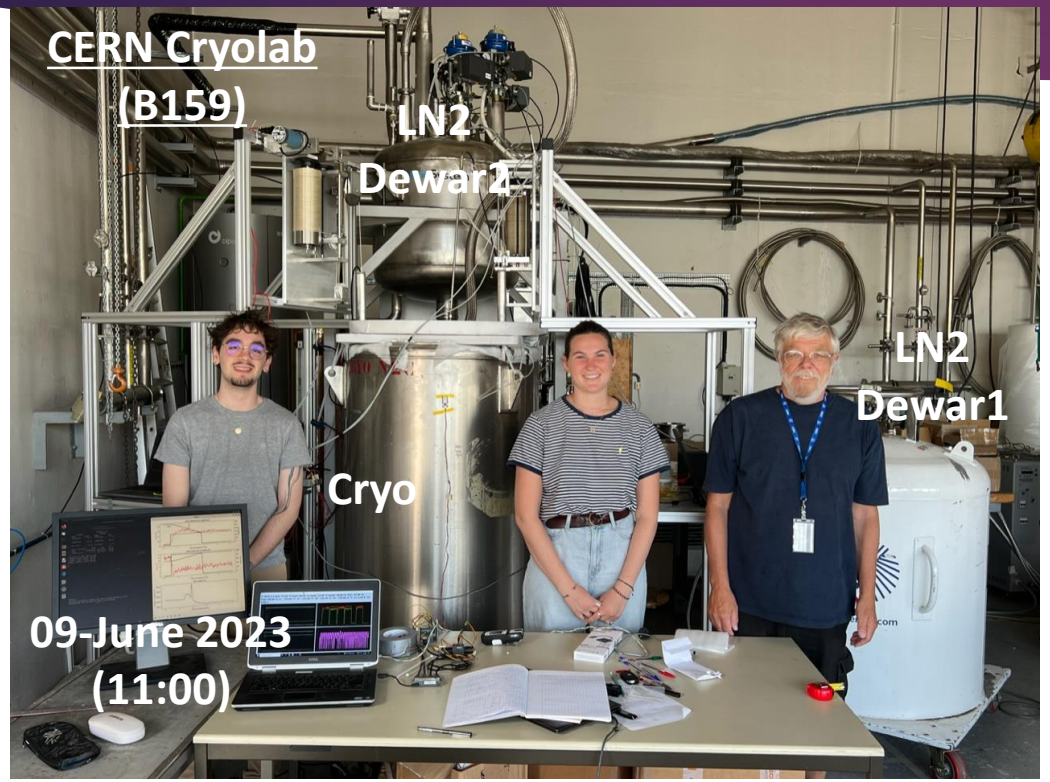


<u>In CERN Cryolab, building 159</u>

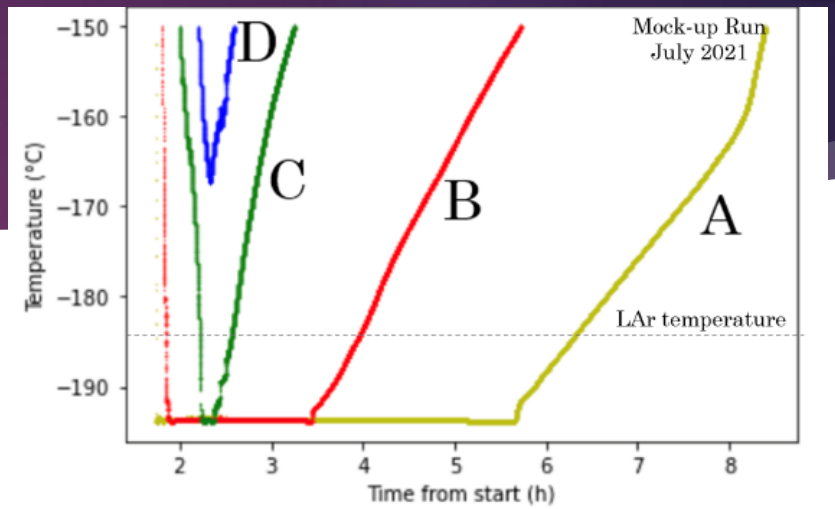
- **30/05-2/06 : Installation**
- **5-9/06 : Settings and Warm run**
- **9-26/06 : LN2 tests**
- **26/06-03/07 : Warming up Cryo to put LAr**
- **03-10/07 : LAr tests (TBD)**

The Mock-up

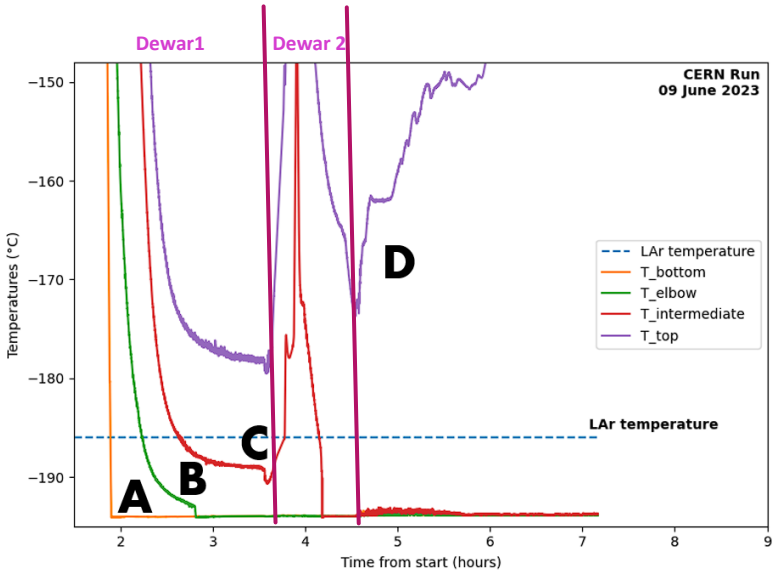
COMPARING MOCK-UPS AT COLD (1/2)



- Cryostat >90% filled with LN2 in 4 hours
- Left gN2 flushing at 60 L/h *(240 L/h during cooling)*
- 3 lowest temperatures at -194^{O}C for 4 hours



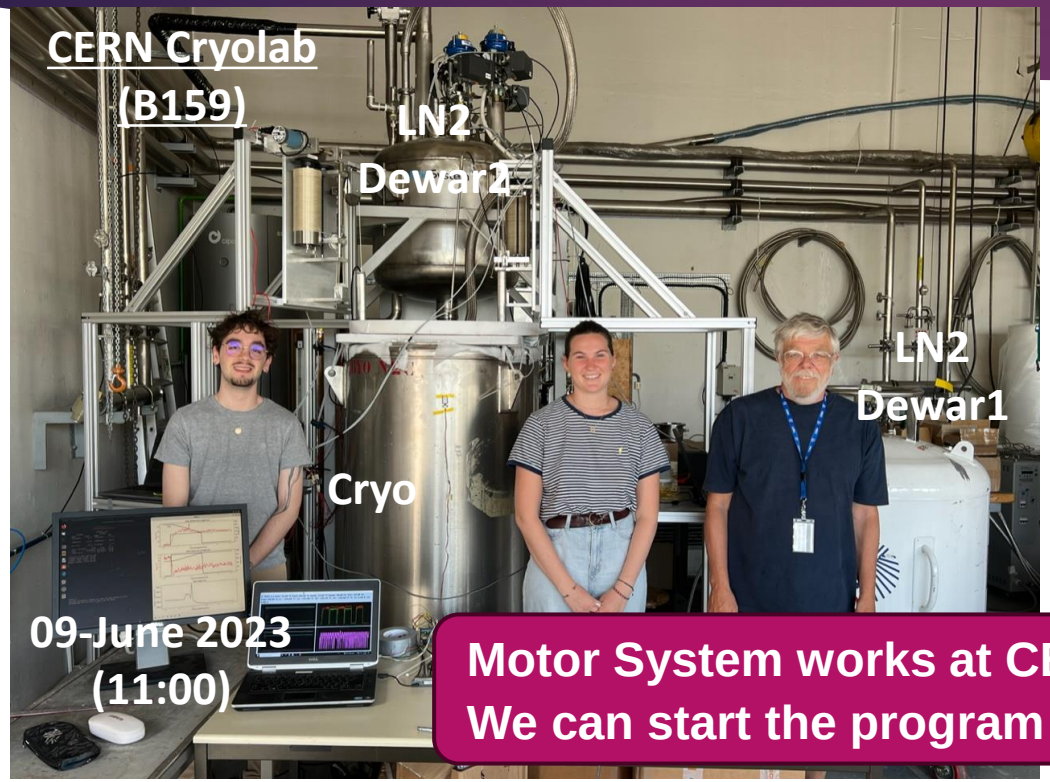
Short Run (0.4 m^3)



Long Run (1.6 m^3)

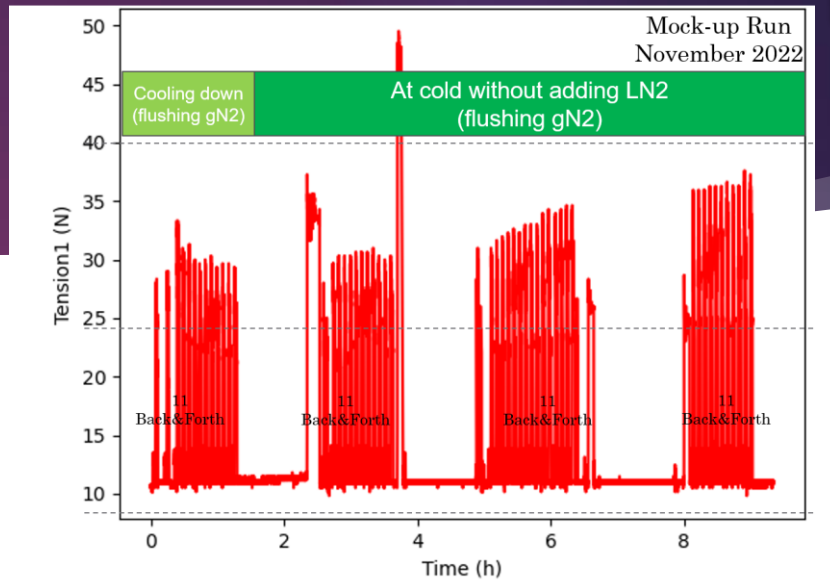
The Mock-up

COMPARING MOCK-UPS AT COLD (2/2)



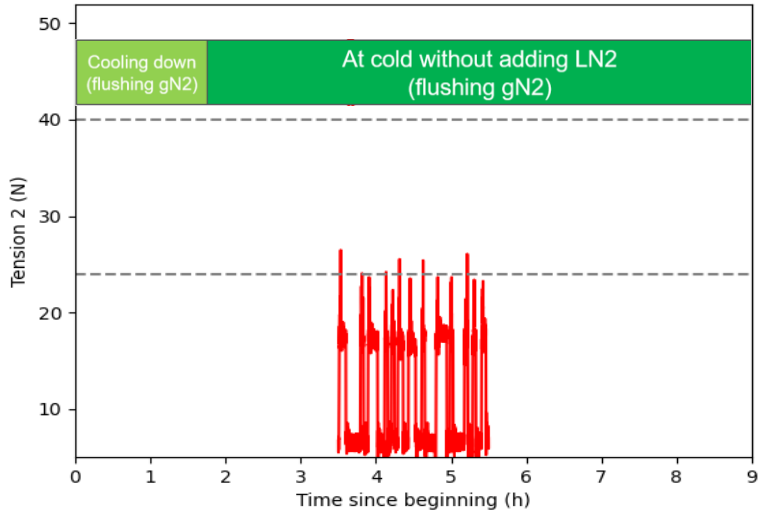
Motor System works at CERN.
We can start the program

- Cryostat >90% filled with LN2 in 4 hours
- Left gN2 flushing at 60 L/h *(240 L/h during cooling)*
- 3 lowest temperatures at -194^{O}C for 4 hours



Short Run (November 2022)

Dewar1

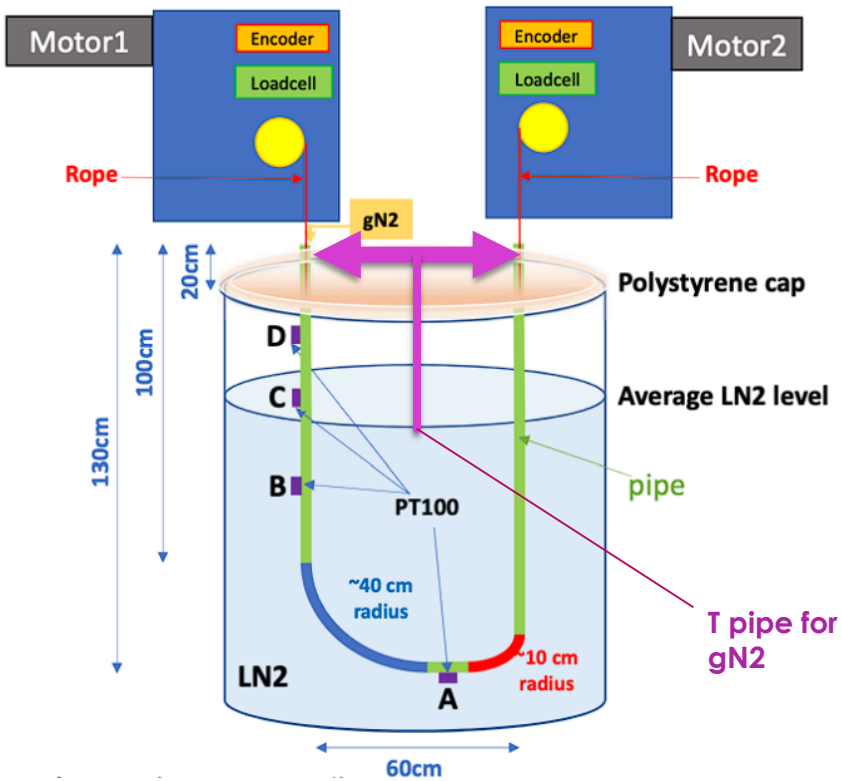


Long Run (June 2023)

Preparation : stable conditions

GENERAL DATA

Date	Hour	Temperature (°C)	%LN2 in tank	gN2 flow (L/h)
Fri – 06/09	18:00	A,B,C LN2 and D ~ -170 °C	98%	>250 on left side (no T)
Sat – 06/10	14:31	A,B,C LN2 and D ~ -127 °C	92%	250 on left side (no T)
Sun – 06/11	14:53	A,B,C LN2 and D ~ -108 °C	86%	120 on left side (no T)
Mon – 06/12	09:10	A,B,C LN2 and D ~ -100 °C	81%	120 on right side (no T)
Tue – 06/13	11:06	A,B,C LN2 and D ~ -177 °C	90% (refilled)	250 (T placed)



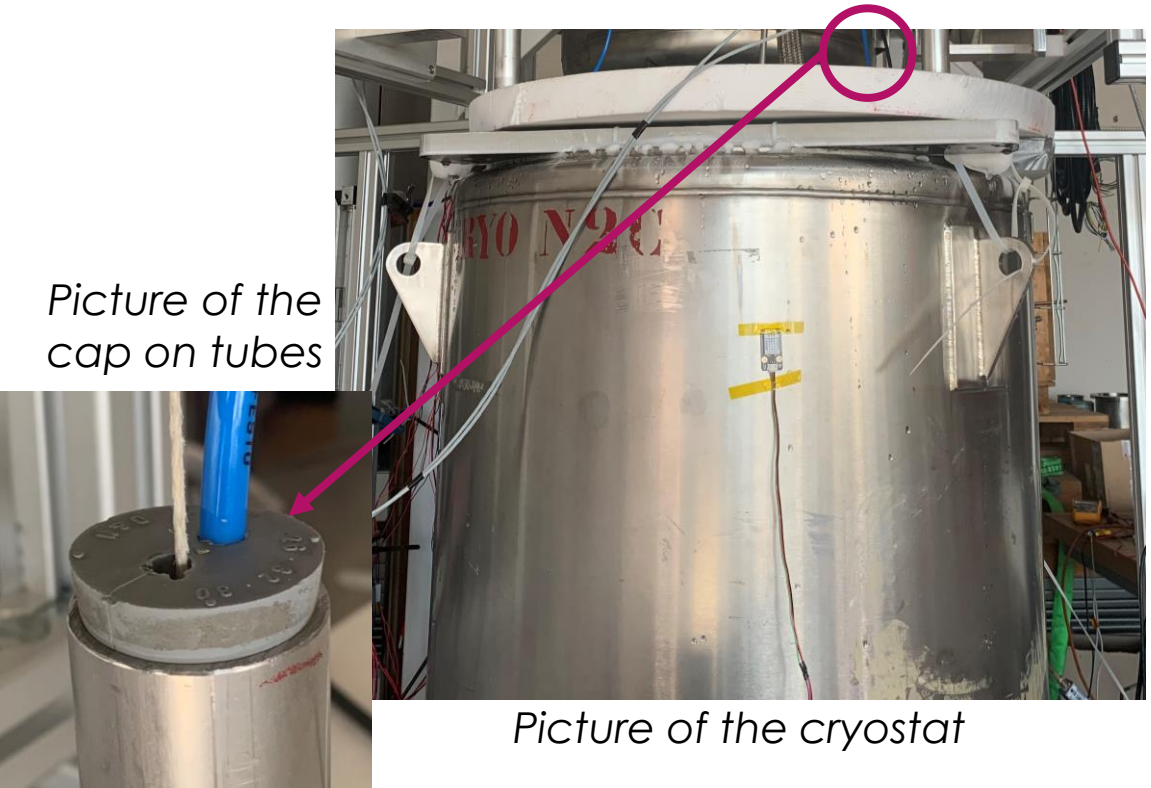
DS4 (left) | DS2 (right)

Stable conditions reached after 4 days : %LN2 in tank is automatically readjusted and gas N2 flow is set to 120 L/h with the T shaped pipe added.

Preparation : stable conditions

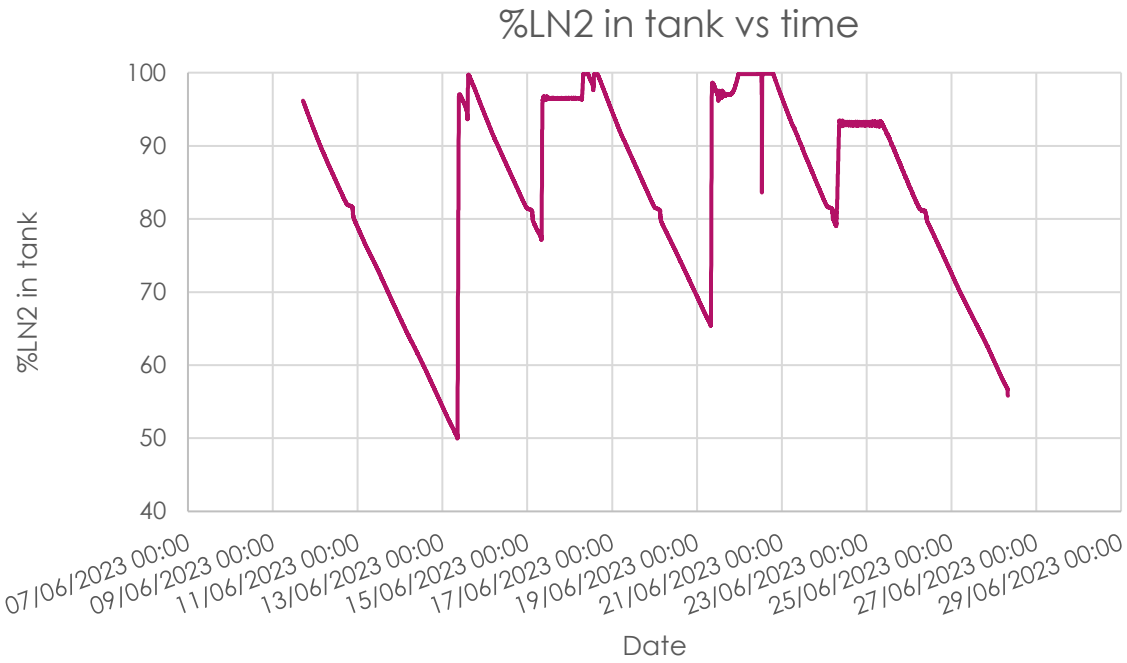
TEMPERATURE OF PT100 STEPS AND TANK FILLING

The cryostat is not fully hermetic, nor adiabatic.
We lose almost 0.5%/h of LN2 in the tank.



Picture of the cap on tubes

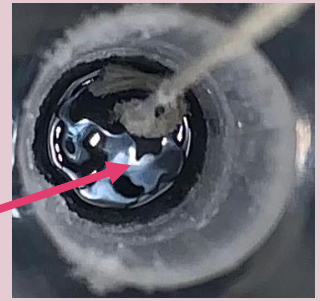
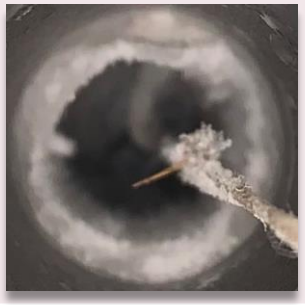
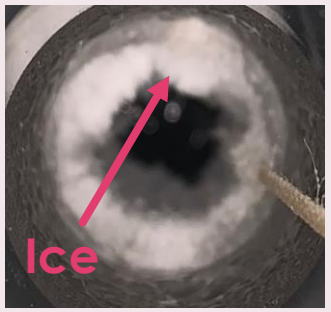
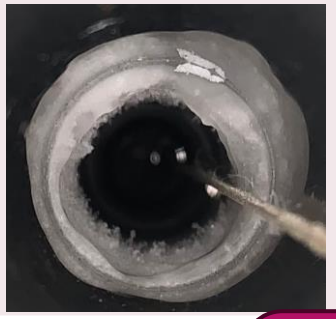
Picture of the cryostat



Then the filling process is now automatic, we just let the cryostat without auto-filling on the weekends and on Wednesday.

Preparation : stable conditions

ICE FORMATION AND GN2 FLOW IN TUBE

Date	09/06	10/06	12/06	13/06	26/06
Left Side (DS4)					
Right Side (DS2)					

Pictures are cropped to be visible so do not pay attention on sizes, more on shapes.
The rope on the corner of tube to take the picture, in center usually

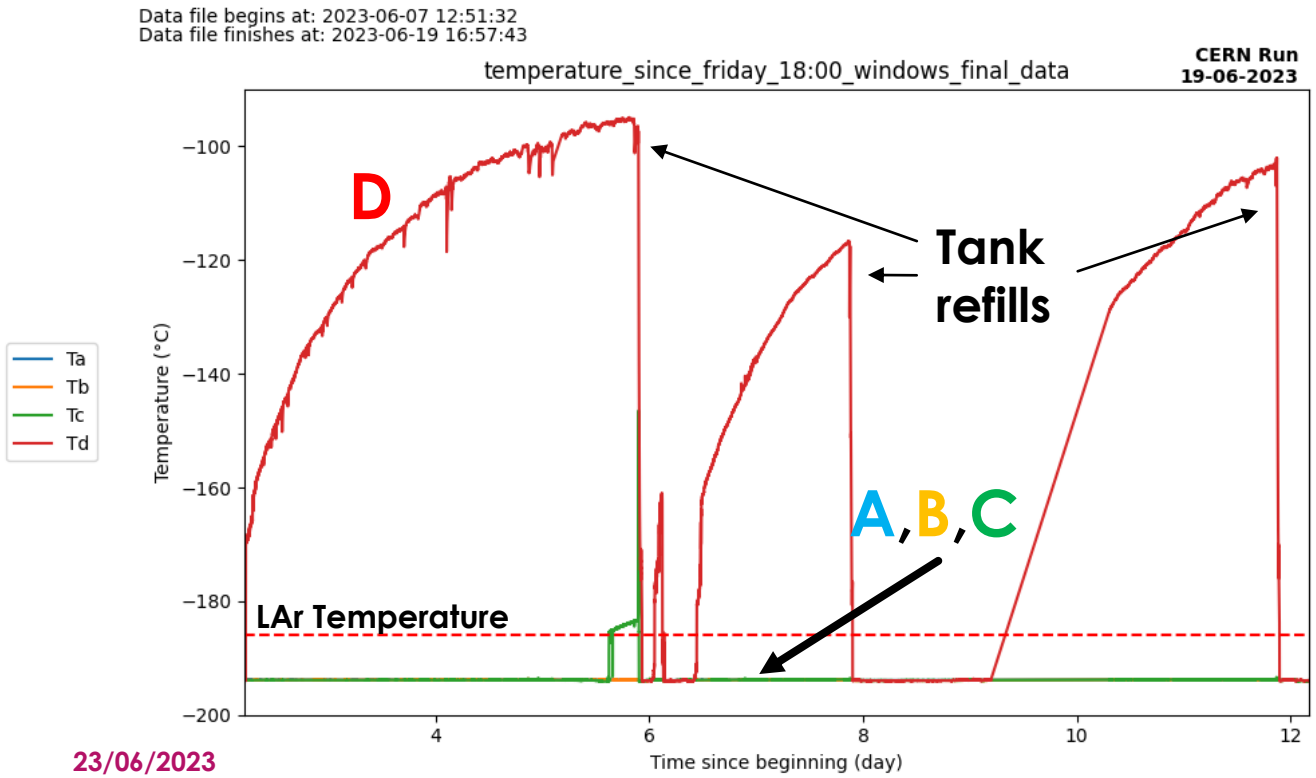
Ice formation stable ➔ No issues with it.
LN2 in the tube, should not happen with LAr

- Ice formation on both sides
  ➔ **flush gN2 on left at 250L/h**
- Left side ice decreased but LN2 visible inside tube (pos 570), blocking gN2 on right side
  ➔ place the T pipe to flush left and right (250L/h)
- Ice on right side went into frost
  ➔ gN2 at 120L/h, **stable conditions**

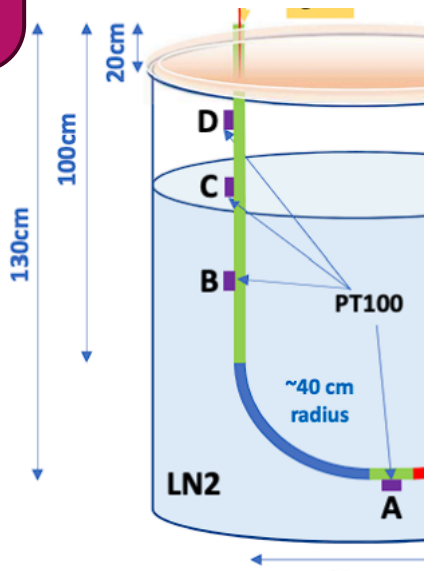
Preparation : stable conditions

TEMPERATURE OF PT100 STEPS AND TANK FILLING

During almost 18 days **A, B, C are at LN2 temperature** (except few hours to set the new filling process).



Ice formation stable, temperature sufficiently constant.
Conditions are stable.

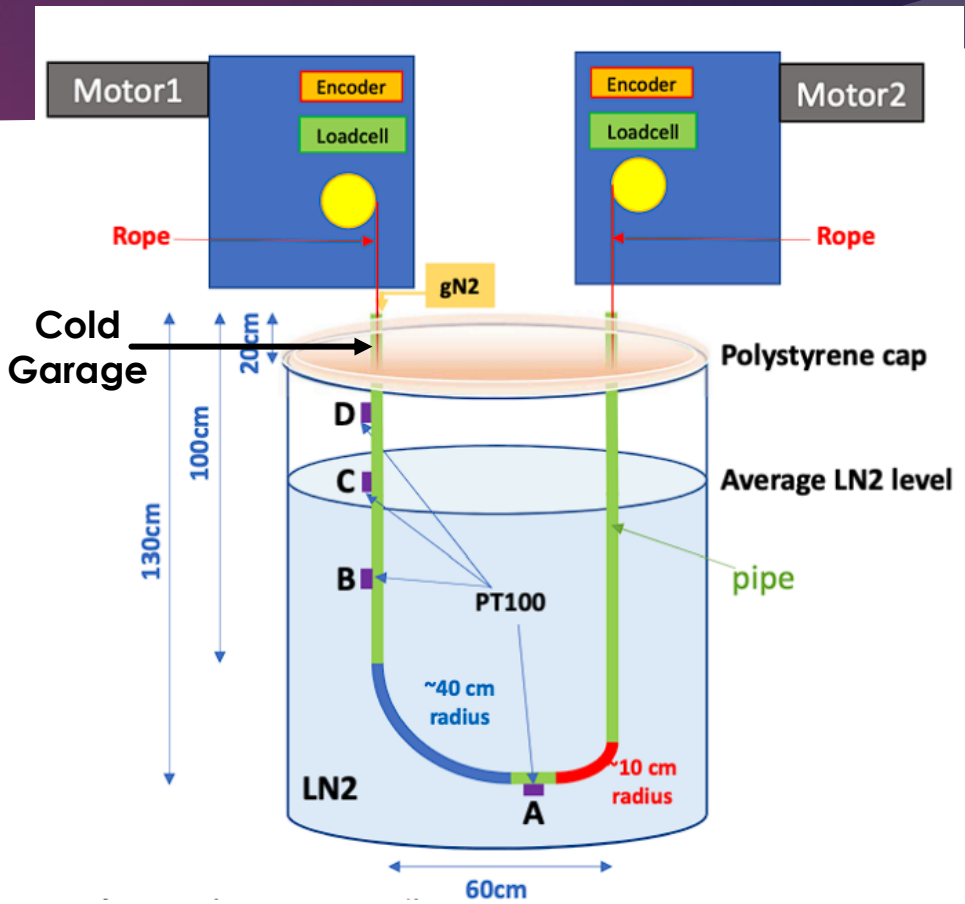


Stress test with LN2

PROGRAM FOR THE TEST

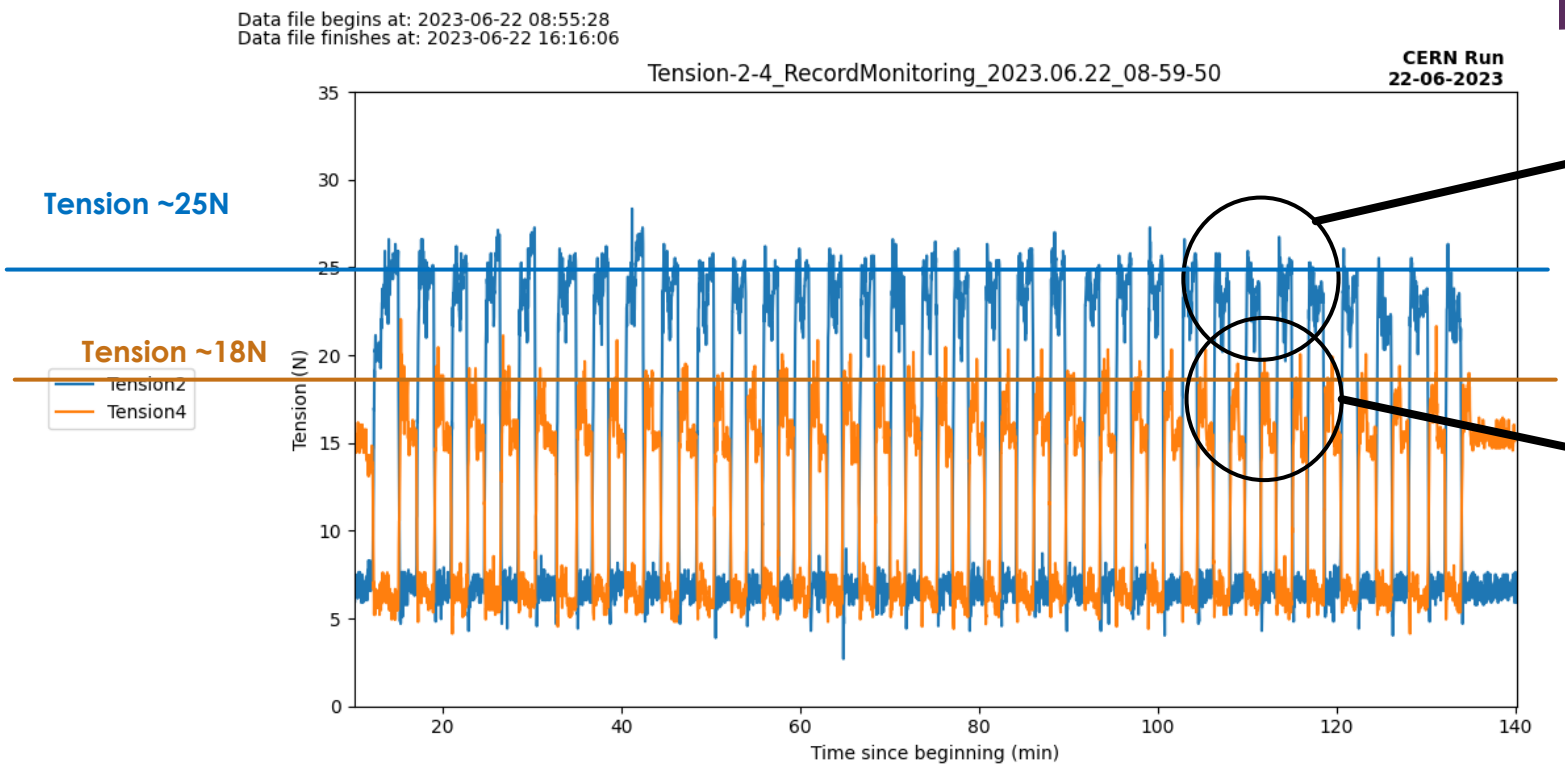
The goal is to check robustness of the Mock-up

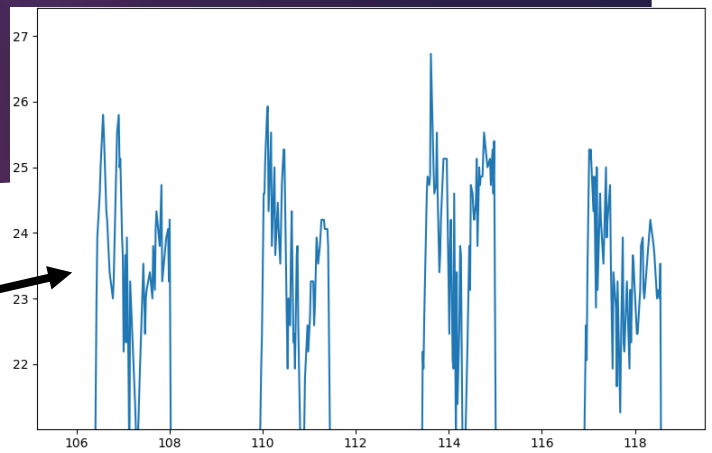
- **Back and forth from the cold garage to PT100 A with a ~1min stop at the edges** (~2 cm/s)
- **35 times every morning → ~100m** (~3h)
- **Do this for 8 mornings → ~800m**



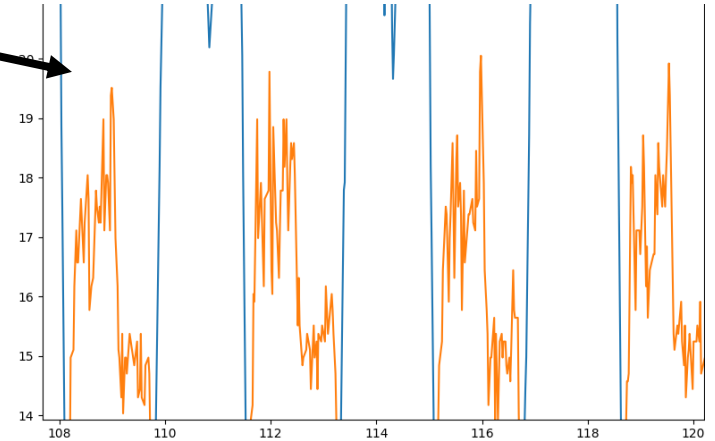
Stress test with LN2

TYPICAL RUN FOR DS2





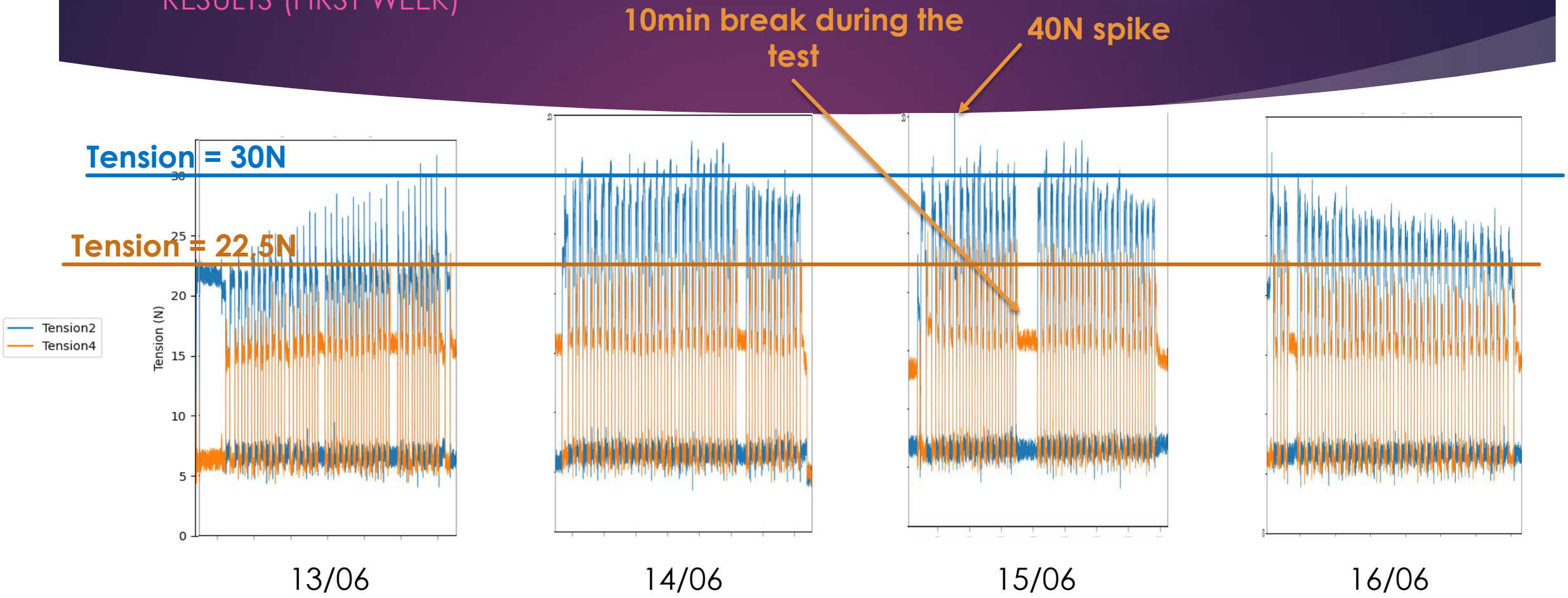
Typical tension for DS2



Typical tension for DS4

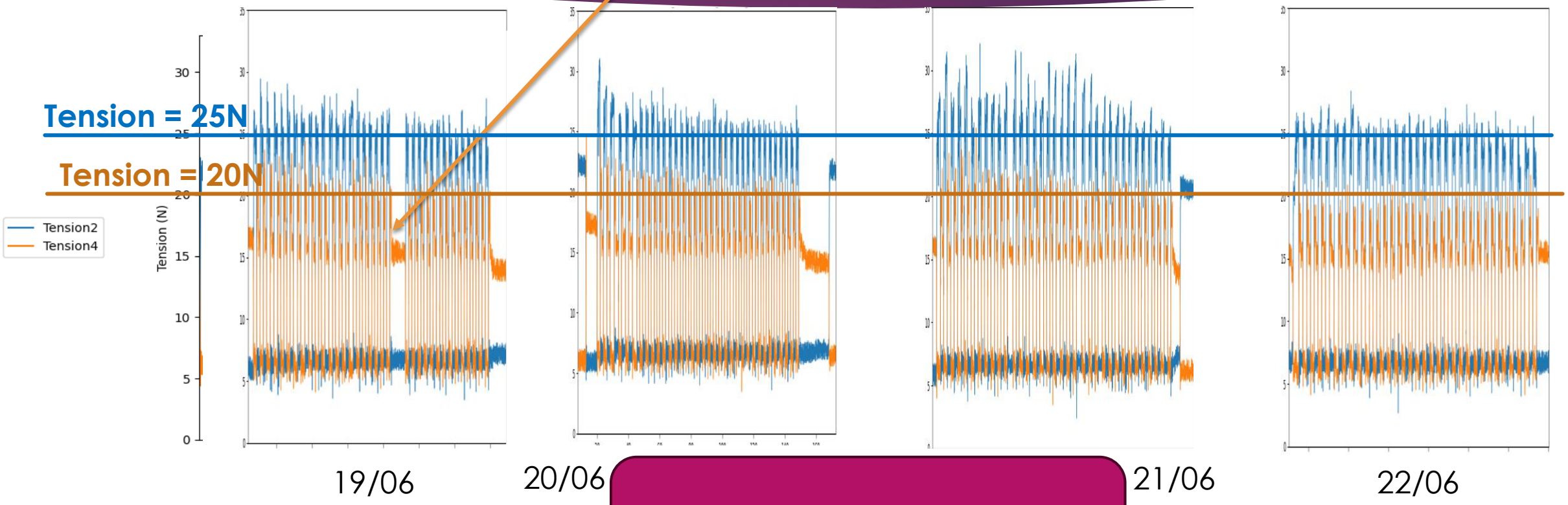
Stress test with LN2

RESULTS (FIRST WEEK)



Stress test with LN2

RESULTS (SECOND WEEK)



The tension is around 20-30N

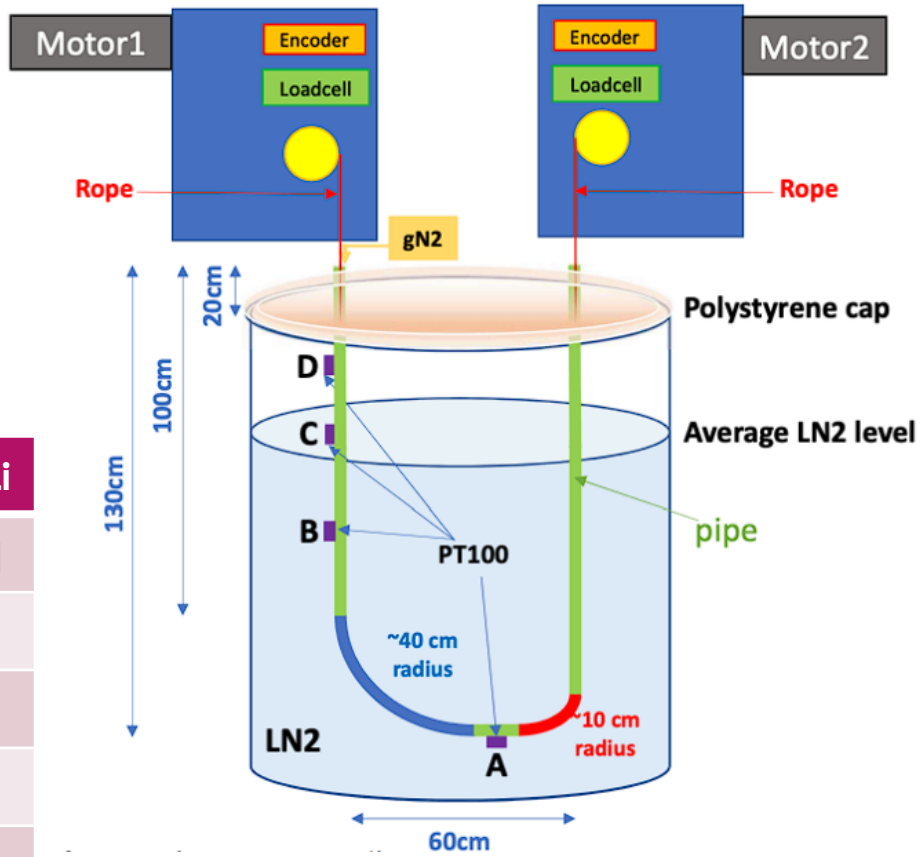
Calibration test with LN2

PROGRAM FOR THE TEST

The goal is to check **how the motors react when the source is left for a long time** at a PT100 step.

We left the source at different spot for different periods of time (1min, 10min, 30min, 1h, 2h, a night, a weekend)

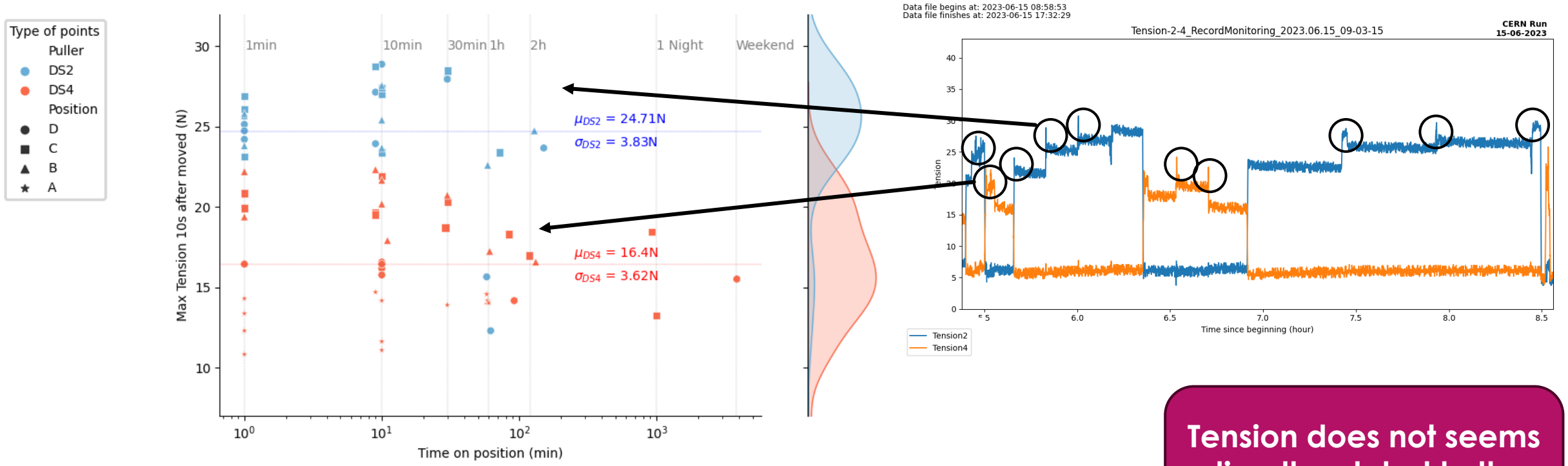
Source	^{57}Co	^{133}Ba	^{22}Na	^{137}Cs	^{60}Co	AmBe	AmC	AmLi
Energy (keV)	122	356	511	662	1173	[0.2, 12]	[2, 7]	[0, 2]
Activity (side) (kBq)	18	1,9	0,36	2,2	0,36	0,14	0,15	-
Activity (bottom) (kBq)	100	5	0,67	4,6	0,6	0,18	0,18	-
Duration of calibration (h)	3,84	18,72	23,52	36	74,4	8	8	-
Time on each spot	**12'**	**1h50'**	**2h20**	**3h45'**	**8h**	**40'**	**40'**	**-**



Then, we know we'll be able to calibrate DarkSide with different radioactive sources

Calibration test with LN2

GENERAL LOOK OF THE RESULTS



When the source is moved from its staying position, we get the maximal tension 10s after the start of the move.

Tension does not seems directly related to the time left at same place

Conclusion

LN2 MOCK-UP TEST CONCLUSION, DISCUSSION FOR LAR

- **Run at CERN at LN2 for 18 days (1,3m of useful tube)**
  - ✓ **Liquid in the tube 50cm from top → T pipe**
  - ✓ **Ice formation mitigated using gN2**
  - ✓ **Average tension 20-30N during stress test**
  - ✓ **No impact on tension when stopping (from 1min to 2 days)**

- **Next test : LAr for 5 days**
  - ➢ **No liquid in tube → gN2 60L/h**
  - ➢ **Redo stress and calib tests**

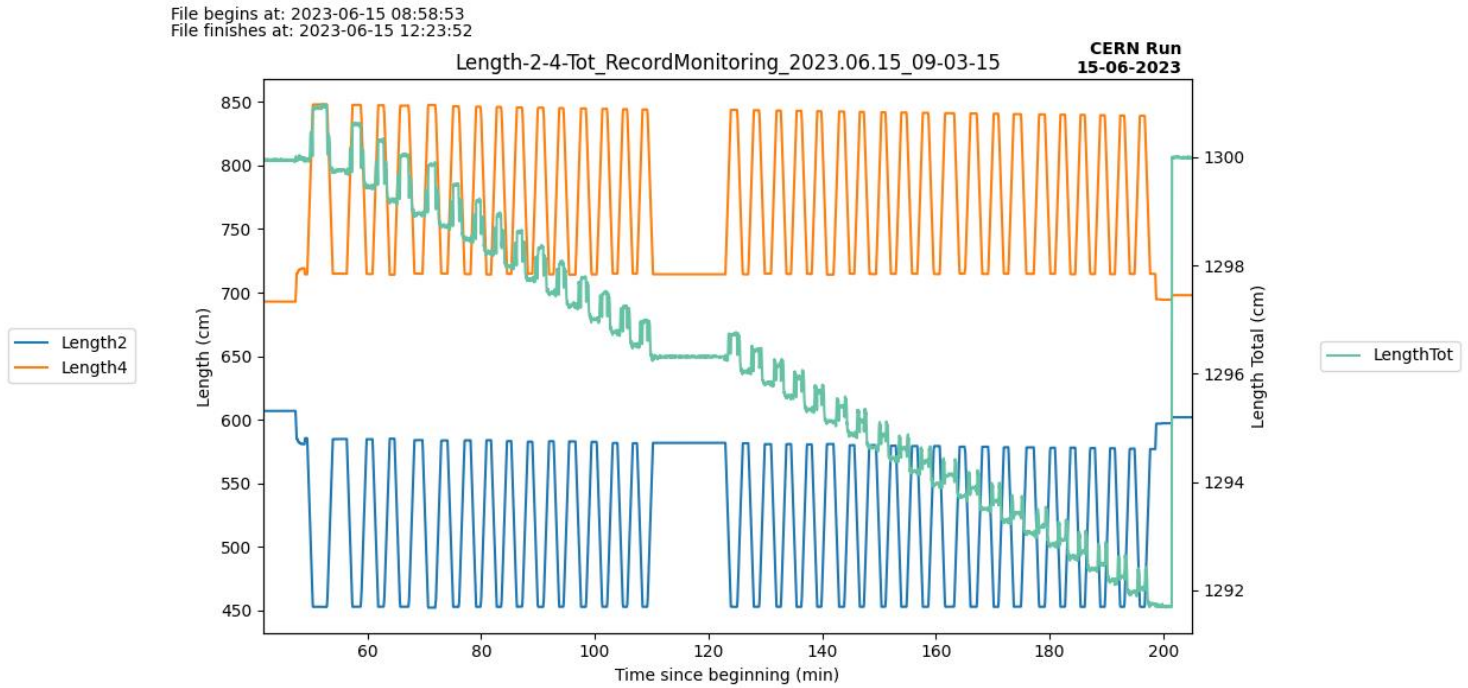
Liquid in tank	LN2	LAr
Speed of the source (cm/s)	2	-
Position Accuracy (cm)	±1	-
Tension (N)	15-30	-
Ice formation (block)	Not huge	-
Total Length for one source (m)	?	-
Total nb of back&forth / pipe	?	-

	DS-20k	MU_CS	MU_CL		MU_W
	General				
Goals	NA	Cold behav.	Robust at cold		bends scale 1:1
Availability	10/24	09/22	05/23		02/23
Runs	>02/26	2022-23	2023		2023
	Conditions				
Temperature (K)	88	**77**	**77**	**88**	290
Usage time / run (days)	30	0.3	18	5	0.3
Location	LNGS	CPPM	CERN		CPPM
	Mechanics				
Pipe Total length (m)	20	~ 4	~ 2		~15
Pipe thickness (mm)	1.5	1.65	1.5		1.5
Pipe internal Diameter (mm)	30	30	33		30
Pipe Material	SS	Ti, SS	SS		Plastic
Nb of Bends / pipe (ϕ=30cm)	14, 15	2	1		**15**
Source length (cm)	TBD	3	5		5
Source diameter (cm)	TBD	1	2.5		2.5
	Requirements / Performance				
Speed of the source (cm/s)	> 1	2	–	–	2
Position Accuracy (cm)	±1	±1	–	–	±1
Tension (N)	< 150	25-40	–	–	60-90
Ice formation (block)	No	No	–	–	NA
Total Lenght for one source (m)	100	> 100	–	–	> 100
Total nb of back&forth / pipe	10	44	–	–	>6

BACK UP

Stress test with LN2

LENGTH GRAPH AND USUAL CHANGE ON TOTAL LENGTH



The **total length always decrease by ~10cm**

Correspond to 0.1% of the total run distance