

CERN Mock-up test results

LONG RUN AT LN2

DarkSide20K Calibration
Meeting 28/06/2023

1. Setting up the Mock-up
2. Overall conditions of the test
3. Stress test
4. Long stay test
5. Conclusion
6. Next step

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Mock-up

INTRODUCTION

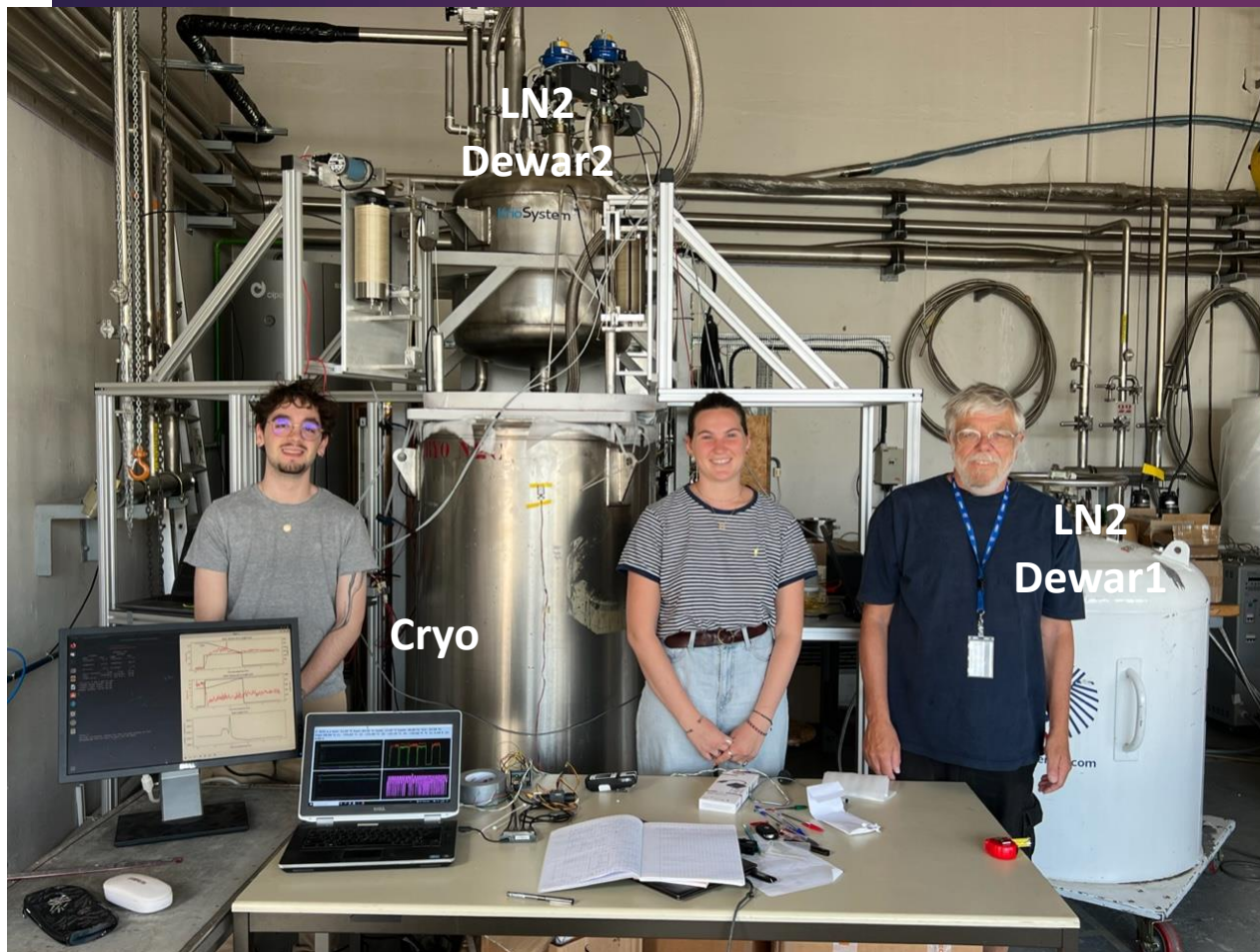
Determine robustness of calibration system at cold, and during a long period (LN2 then LAr).

	MU_CShort	MU_CLong	MU_Warm
Purpose	Robustness against ice formation, source blocked, bend, pipe leak		Behaviour in bends, DS20k Length
Temp. (K)	LN2 (77)	LN2 (77), LAr (88)	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

Huge thanks to the CERN Cryolab for providing and running the Cryostat, the LN2 and the LAr

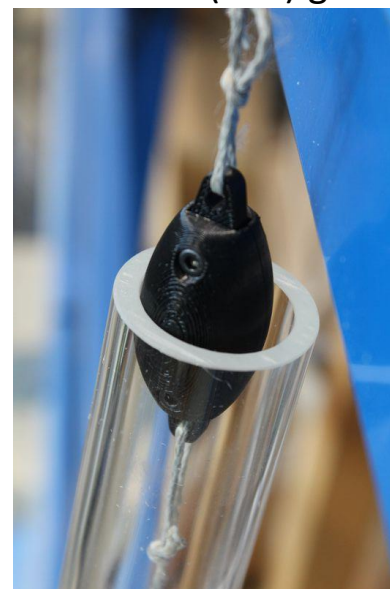
Mock-up

TEST'S SCHEDULE



Pseudo-source

- $L = 5.5\text{cm}$
- $\phi = 2.5\text{ cm}$
- $M = O(100)\text{ g}$



In CERN Cryolab, building 159

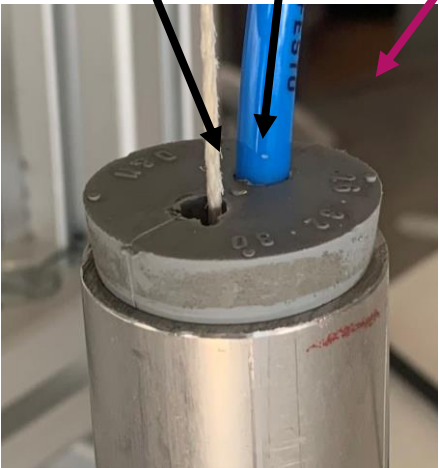
- 30/05-2/06 : Installation
- 5-9/06 : Settings
- 9-26/06 : LN2 tests
- 26/06-03/07 : Warming up Cryo to put LAr
- 03-10/07 : LAr tests (TBD)

Mock-up

SETUP

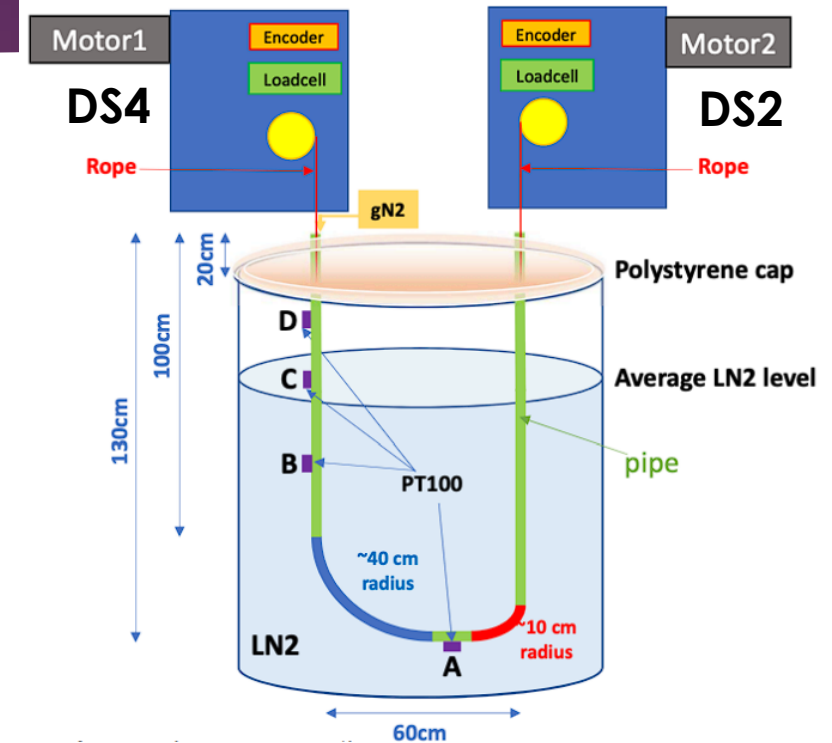


Rope
gN2 flush



The tube cap is **not fully hermetic** because of rope and gN2 flushing

The cryostat is **not fully adiabatic**
→ **Need constant refill with LN2**



- 4 PT100 probes (A, B, C, D)
- 1.3 meter of useful tube (from A to D)

Mock-up

COMPARISON WITH CPPM MOCK-UP (FIRST 8 HOURS)

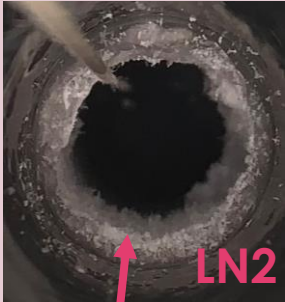
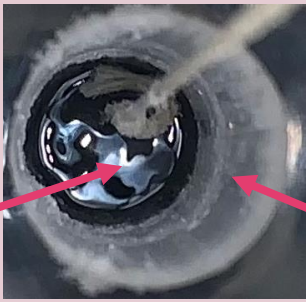


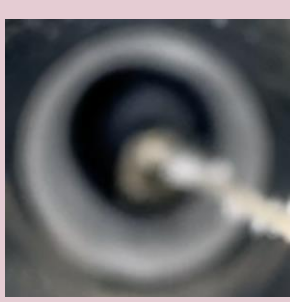

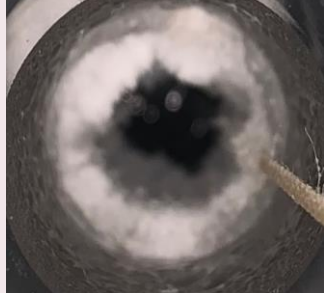
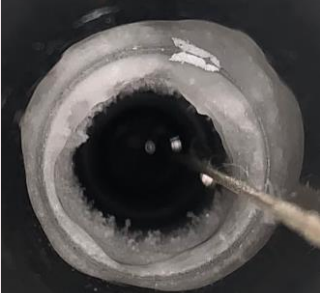
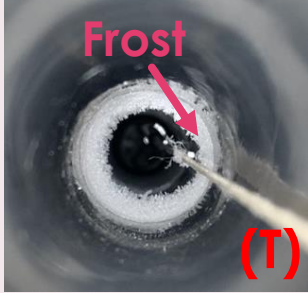

RUN	Temperature of A, B, C, D	Tension	Conclusion
CPPM short run, Poorly isolated cryostat (0.16 m³)	<p>Mock-up Run July 2021</p>	<p>Mock-up Run November 2022</p>	<ul style="list-style-type: none"> Left gN2 flushing at 60L/h $T_A \leq T_{LAr}$ for only 5h after filling <ul style="list-style-type: none"> Tension 12-40N
CERN long run, Vacuum isolated cryostat (0.4 m³)	<p>CERN Run 09 June 2023</p>		<ul style="list-style-type: none"> Left gN2 flushing at 60L/h T_A, T_B, T_C always below T_{LAr} once filled <ul style="list-style-type: none"> Tension 5-25N

**Motorized Systems
work at CERN.**

Overall conditions of the test

ICE FORMATION MITIGATION

6

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

1- Ice formation on both sides (09/06)

→ Flush hot gN2 on left at 250L/h (4x nominal)

→ Left side ice turns into frost

2- LN2 inside (-50cm) tube prevent gN2 to reach right side

→ T pipe to flush left and right (250L/h)

→ Ice on right side turn into frost

Pictures are cropped to be visible so do not pay attention on sizes, more on shapes.

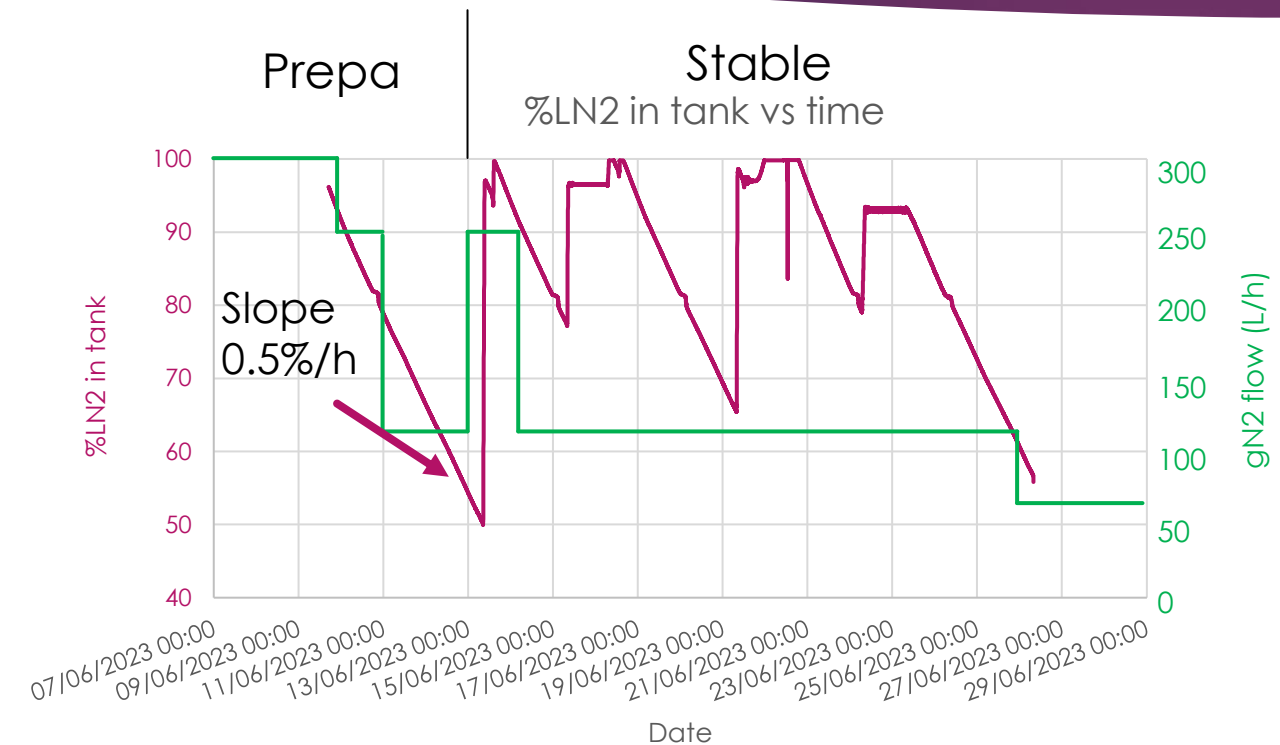
The rope on the corner of tube to take the picture, in center usually

Ice turns into frost after 1 day of large gN2 flush on both sides → Stable conditions for test

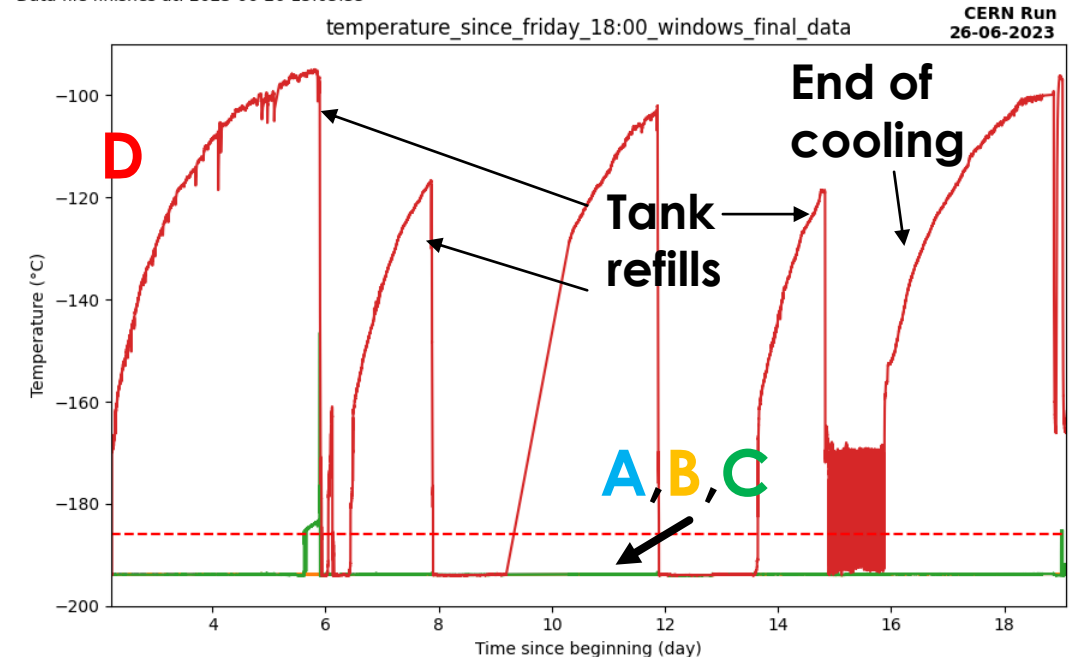
Test conditions (18 days)

TEMPERATURE OF PT100 AND TANK FILLING

7



Data file begins at: 2023-06-07 12:51:32
Data file finishes at: 2023-06-26 15:05:35



- **Filling process is automatic** (no auto-filling on the weekends and on Wednesday)
- Flushing at 120L/h (2x60 with T)

- T_A, T_B, T_C always below T_{LAr} for 18 days
- $T_D \in [-190, -100] \text{ } ^\circ\text{C}$

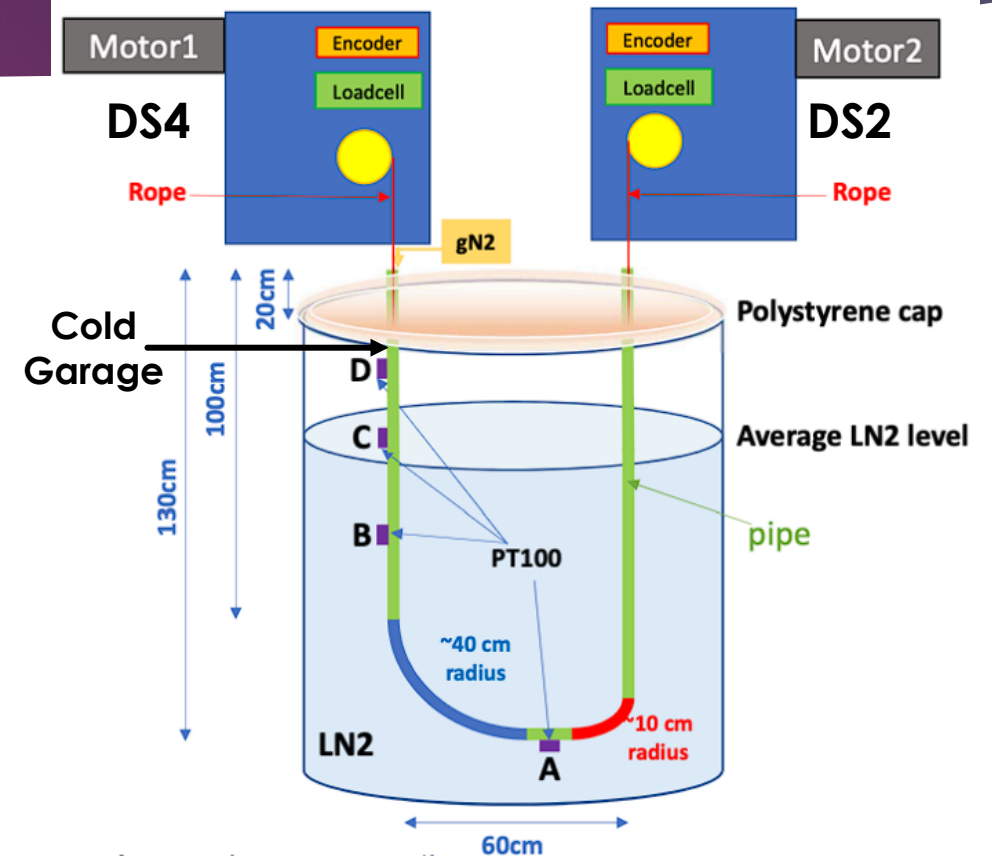
Stress test with LN2

PROGRAM

8

The goal is to check robustness of the Mock-up

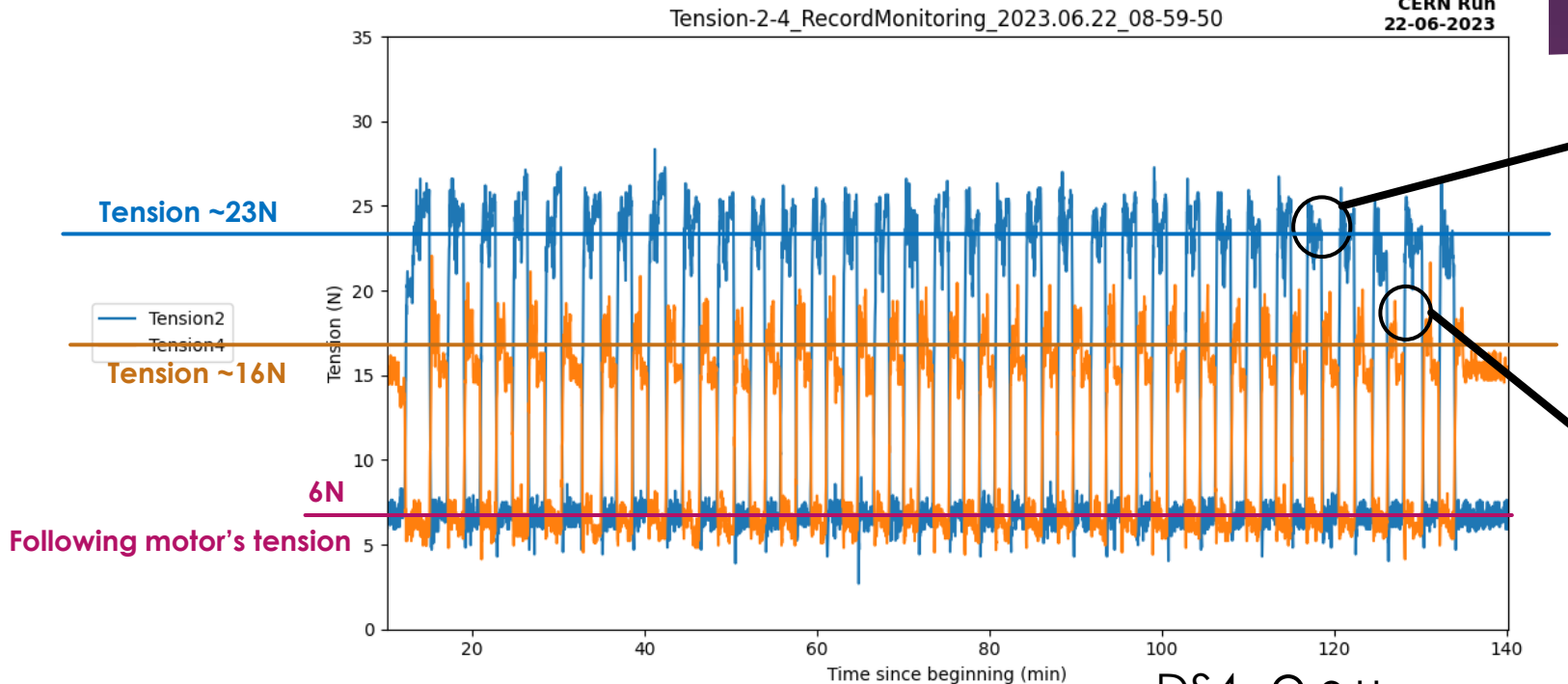
- **Back and forth (b&f) from the cold garage to PT100 A** (2x 1,3m) with a ~1min stop at the edges (~1 cm/s)
- **35 b&f/day (~3h) for 8 days**
In DS20K, 8 sources so 4b&f and 20m tube
→ 280 b&f → **70x DS20k**
→ ~740m → **5x DS20k**



Stress test with LN2

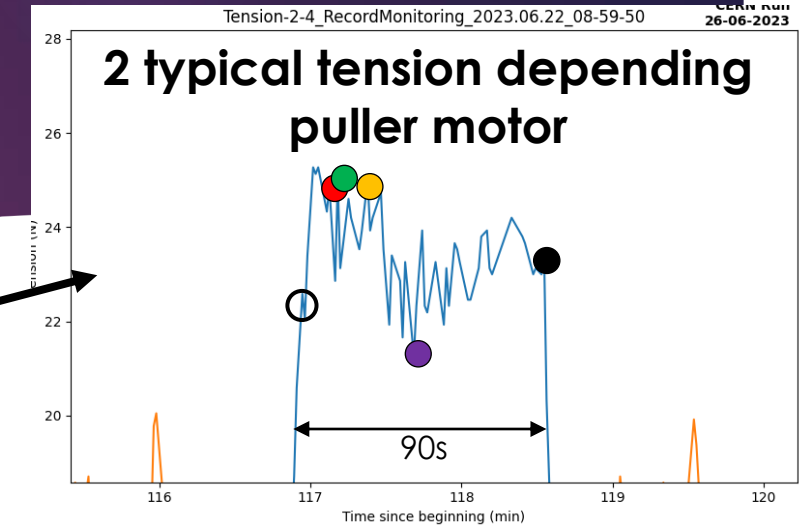
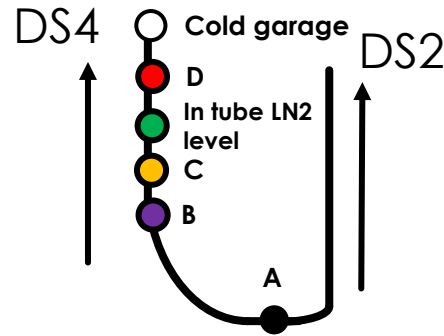
TYPICAL RUN

Data file begins at: 2023-06-22 08:55:28
Data file finishes at: 2023-06-22 16:16:06



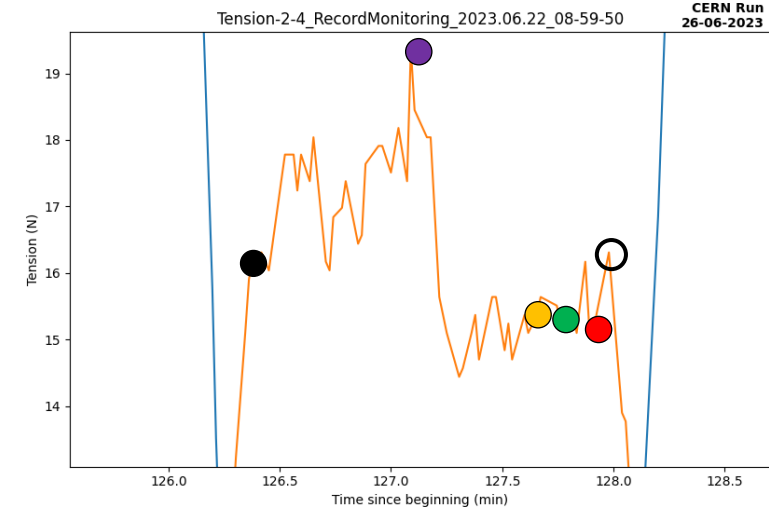
- DS2 tension around 24N, no visible impact of tube geometry
- DS4 tension lower, and reflects the tube geometry

28/06/2023



Typical tension for DS2

Data file begins at: 2023-06-22 08:55:28
Data file finishes at: 2023-06-22 16:47:14



Typical tension for DS4

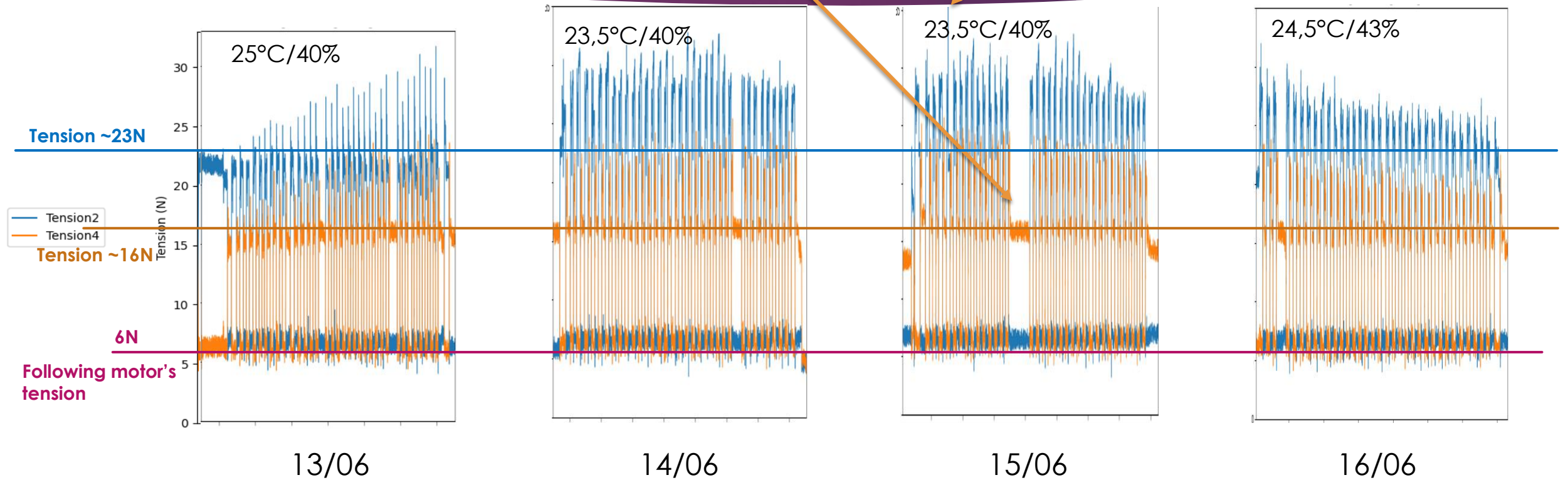
Stress test with LN2

RESULTS (FIRST WEEK)

10

10min break during the test

40N spike

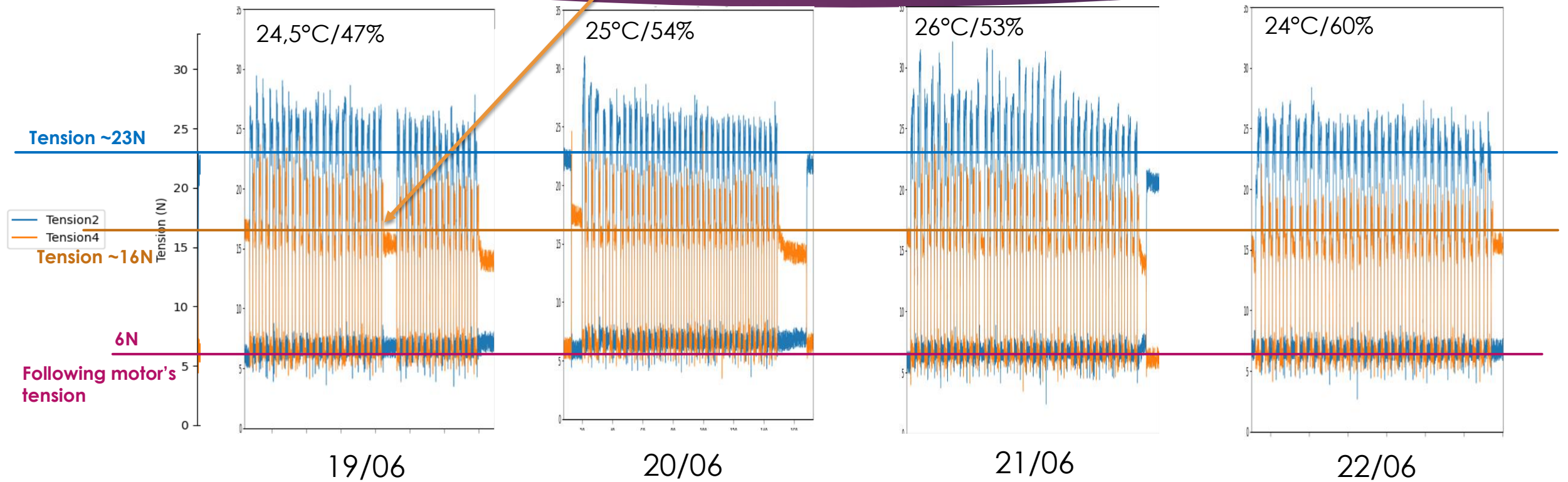


DS2 tension : two days at 25-30N at worst

Stress test with LN2

RESULTS (SECOND WEEK)

10min break during the test



The tension is stable

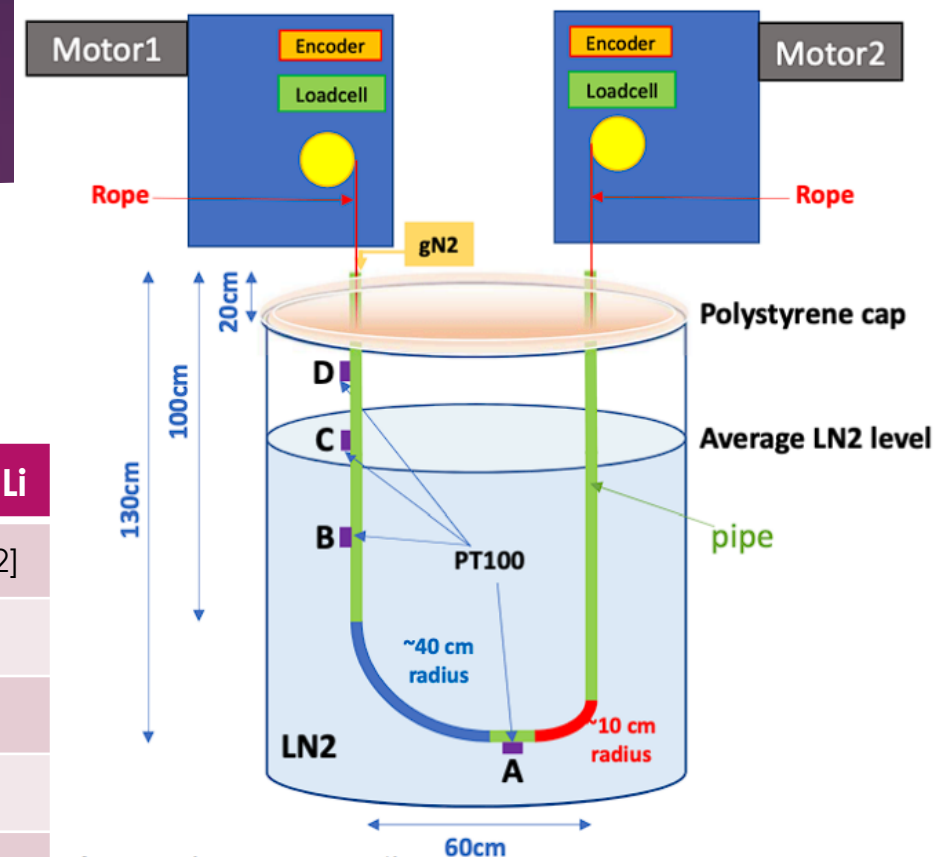
Long stay test with LN2

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.

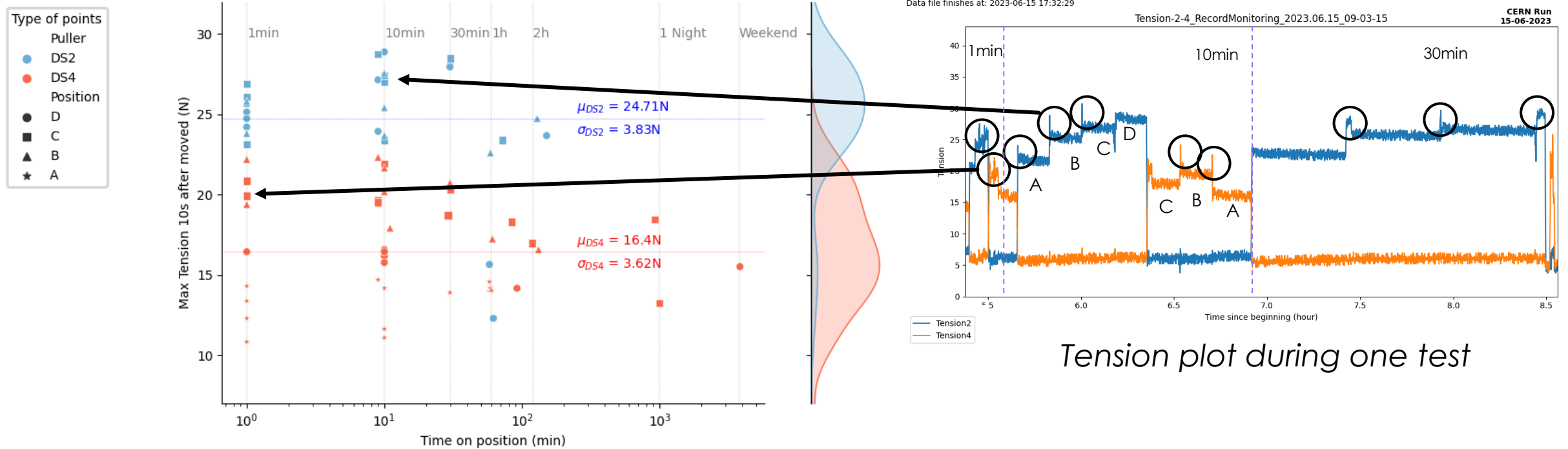
We left the source at different spots for different periods of time (1min, 10min, 30min, 1h, 2h, a night, a weekend)

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	200	200	-
Time on each spot	12'	1h50'	2h20	3h45'	8h	22h	22h	-



Long stay test with LN2

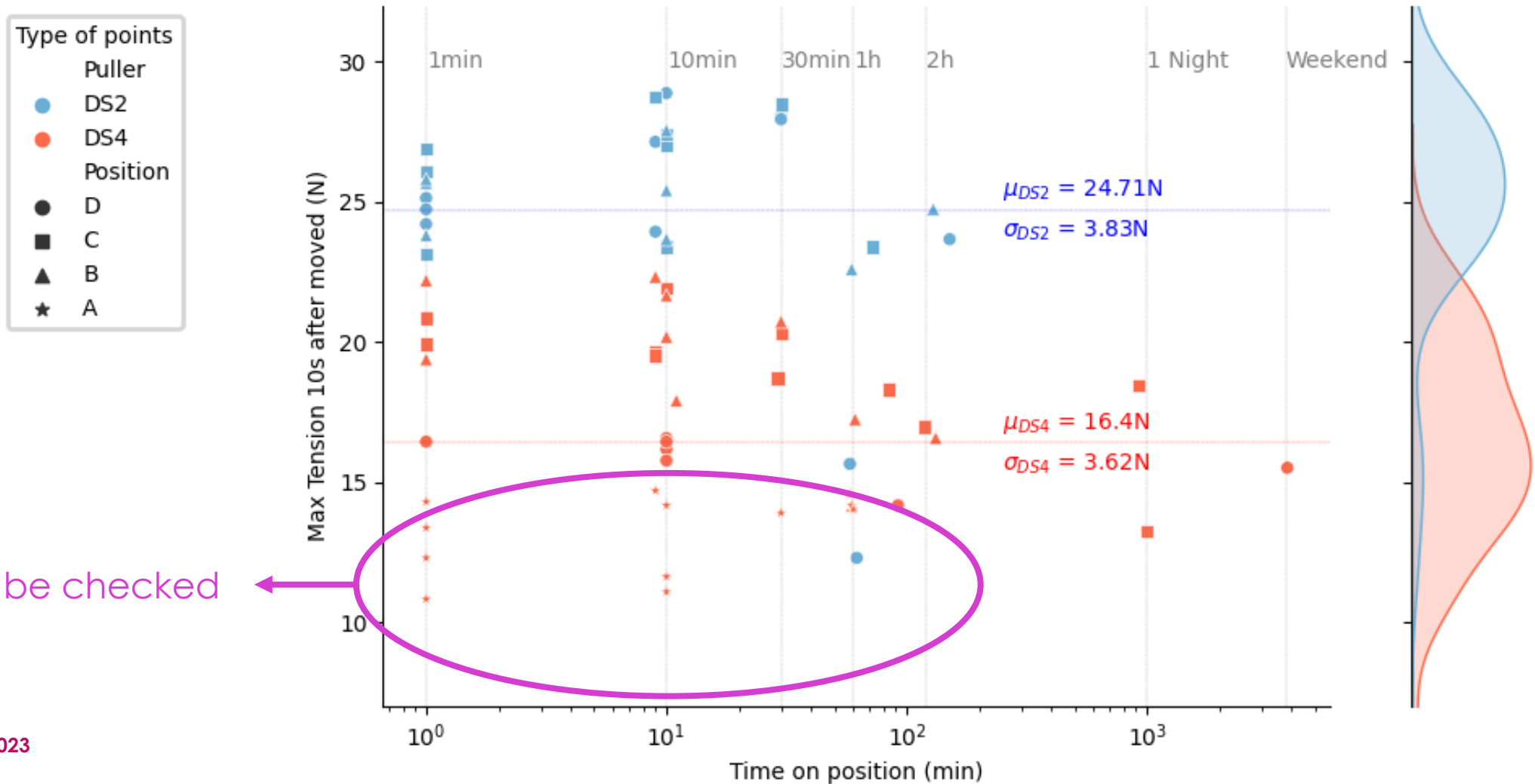
TENSION AFTER STOP



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

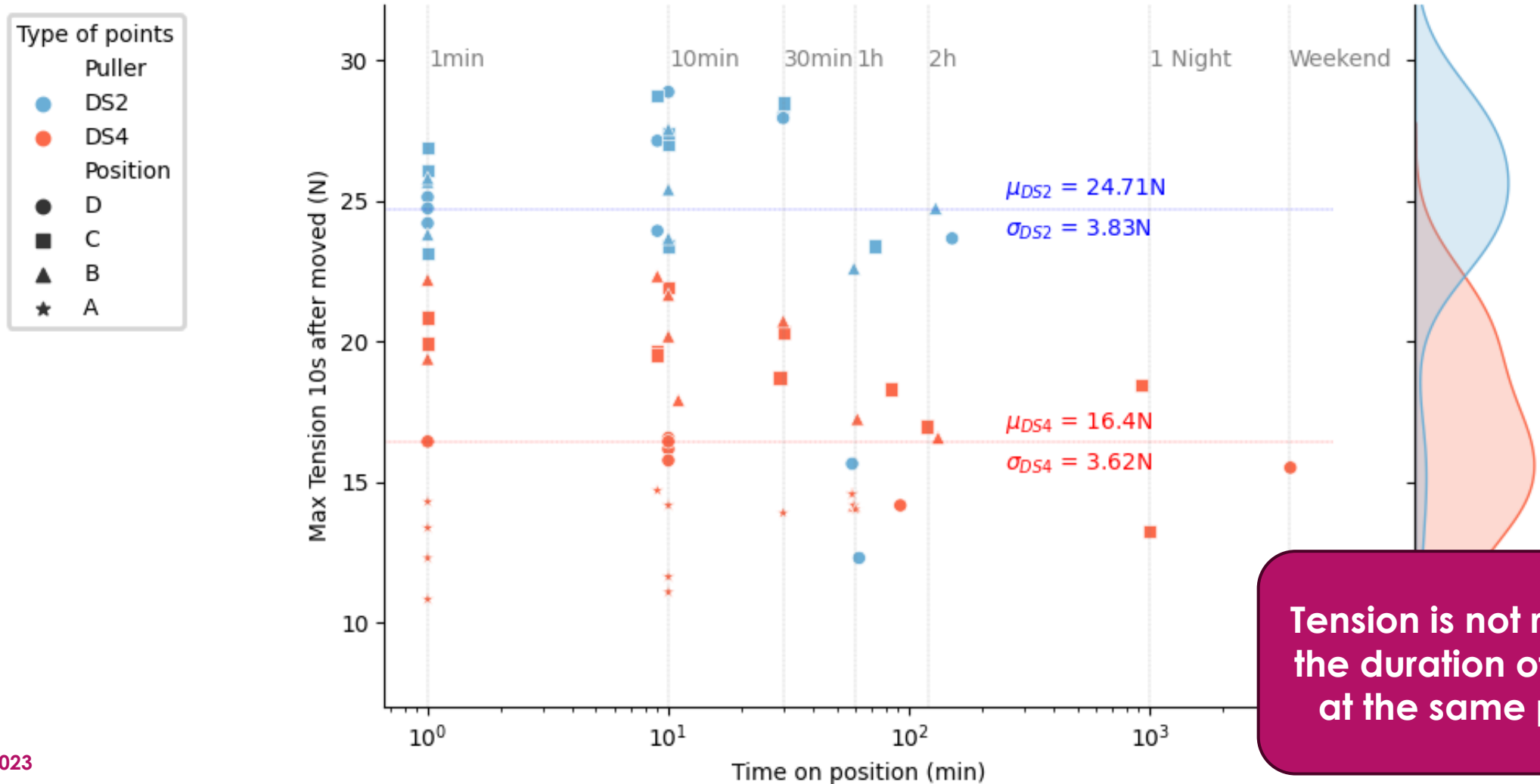
Long stay test with LN2

TENSION AFTER STOP



Long stay test with LN2

TENSION AFTER STOP



Conclusion

LN2 MOCK-UP TEST

- **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 → Frost
 - ✓ Average tension 15-30N during stress test
 - ✓ No impact on tension when stopping (from 1 min to 2 days)

Robust behavior of calib system at LN2 temperature for 2 weeks

Liquid in tank	LN2
Speed of the source (cm/s)	1
Position Accuracy (cm)	±1
Tension (N)	15-30
Ice formation (block)	Mitigated with gN2
Total Length for one source (m)	800
Total nb of back&forth / pipe	280

	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
Usage time / run (days)	30	0.3	18	5
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 ($\phi=30$ cm)	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	3	—	2
Position Accuracy (cm)	±1	±1	—	±1
Tension (N)	< 150	25-40	—	60-90
Ice formation (block)	No	No	—	NA
Total Length for one source (m)	100	> 100	—	> 100
Total nb of back&forth / pipe	10	44	—	>6

Next test :

LAR FOR 5 DAYS

- Warming up the cryostat for 7 days : from LN2 temperature to above LAr.
- We expect to start 3rd of July :
 - No liquid in tube → gN2 60L/h
 - Redo stress and calib tests

Liquid in tank	LAr
Speed of the source (cm/s)	?
Position Accuracy (cm)	?
Tension (N)	?
Ice formation (block)	?
Total Length for one source (m)	?
Total nb of back&forth / pipe	?