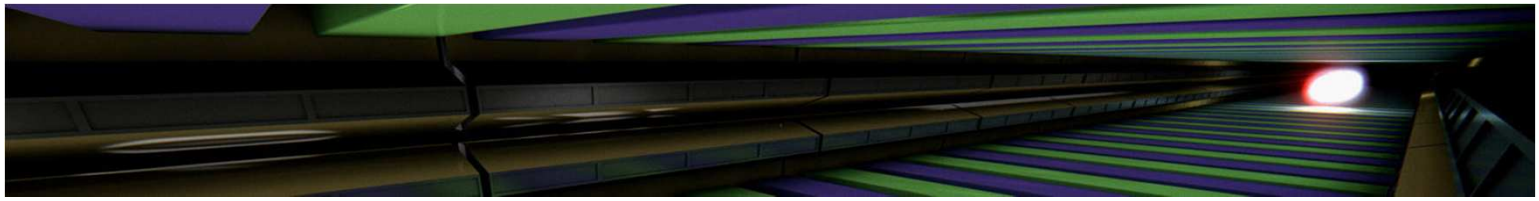
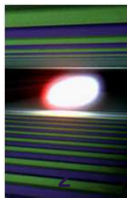


XFEL cryomodule transportation

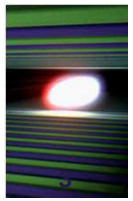
S. Barbanotti, O. Sawlanski, K. Jensch

Summary



- Previous experiences of cryomodule transportation
- XFEL cryomodule transportation system
- First tests (M8 and PXFEL2)
- PXFEL3_1 results
- Future plans

Previous experiences on cryomodule transportation

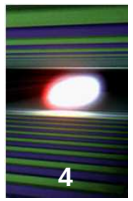


- All SNS cryomodules were transported from Jefferson Lab to Oak Ridge.

- FNAL CM1 cryomodule was transported between two buildings inside Fermilab (from ICB to NML).
- FLASH 3.9 GHz module flew from Fermilab to Paris and “drove” all the way to Desy.

- Many TTF cryomodules were transported on a regular truck inside DESY (from Halle 3 to CMTB to the FLASH tunnel)

Previous experiences on cryomodule transportation



- **Shipping and alignment for the SNS cryomodule,**
  T. Whitlatch, et al., TPAH119, PAC01, Chicago
  - Performed road test using CEBAF cryomodule
  - Module cradled in a stiff frame with rubber pads
  - Alignment check after road test: a 0.3mm downward shift of one of the flanges; all other measurements were within instrument tolerances.
  - Maximum accelerations of the beamline were 0.9, 1.3 and 1.4 g (vertical, axial, and transverse direction).

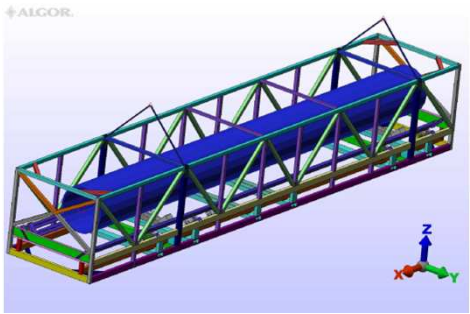
- **1.3 GHz Cryomodule (CM1) Transport to New Muon Lab (NML)**,
  M. McGee (AD/MS), August 11, 2008, MSDN-ME-000076
  - Module on a frame damped with shock absorbers.
  - Very slow ride, no abrupt acceleration / deceleration.
  - Acceleration values on the rigid frame up to 1.7 / 2.1 g (vertical / transverse); below 0.5 g on the cavity string.

European XFEL

XFEL cryomodule transportation system

- Industrial study fixed **maximum allowable acceleration** on the cryomodule to **1.5 g** (to avoid coupler damages) and recommended use of **end caps** to fix the GRP to the VV
- Design of the frame included extended analysis and testing







DESY HELMHOLTZ ASSOCIATION

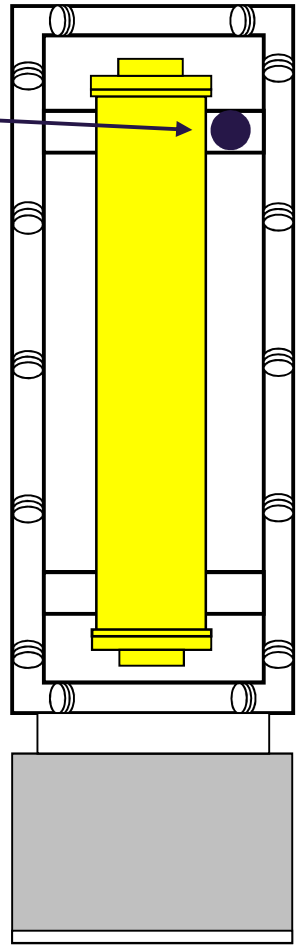
Transportation monitoring system

- 2 independent x, y, z accelerometers, with synchronized time stamps (set at the beginning from the computer)

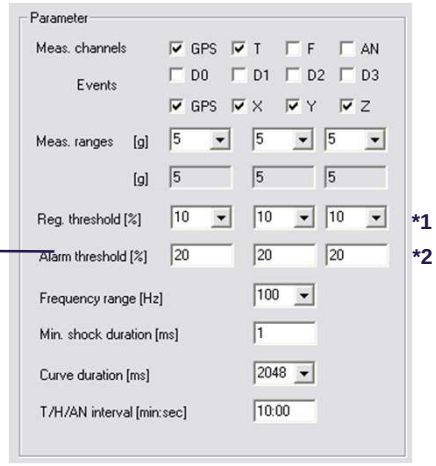
- GPS recording

- Values to be set:
  - Record (record of time and x, y, z values)
  - Alarm (detailed record of the next 2s)

MoniLog measurement system



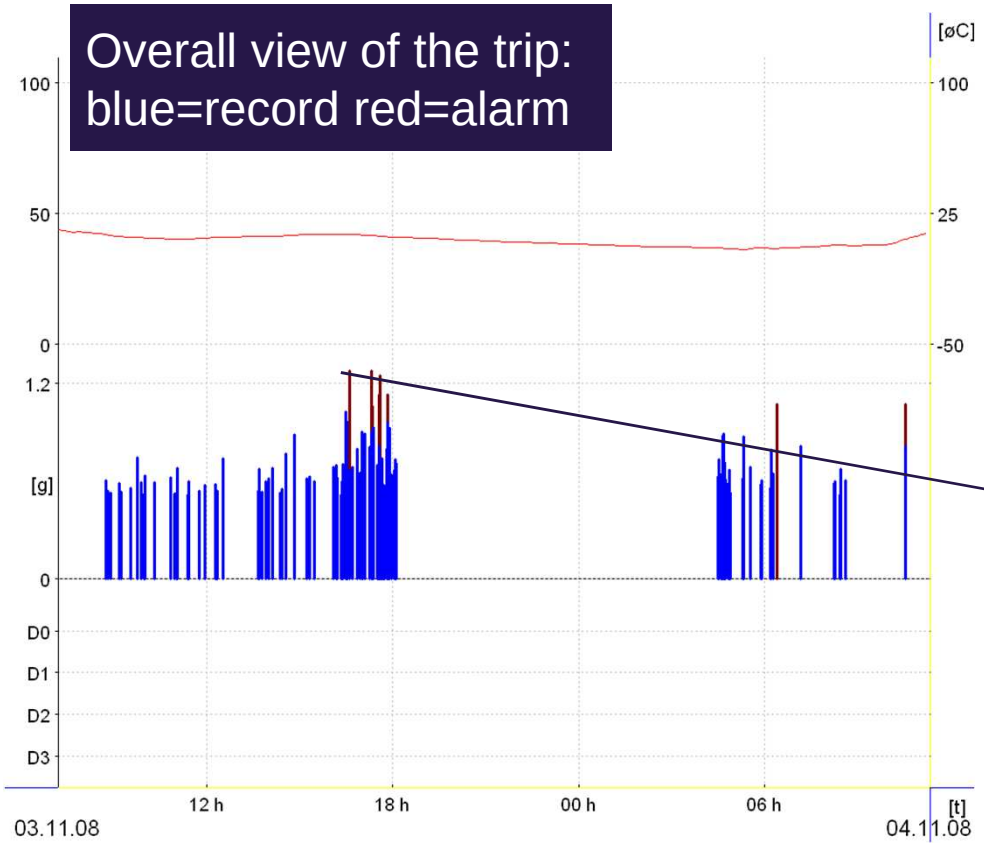
Transportation monitoring system

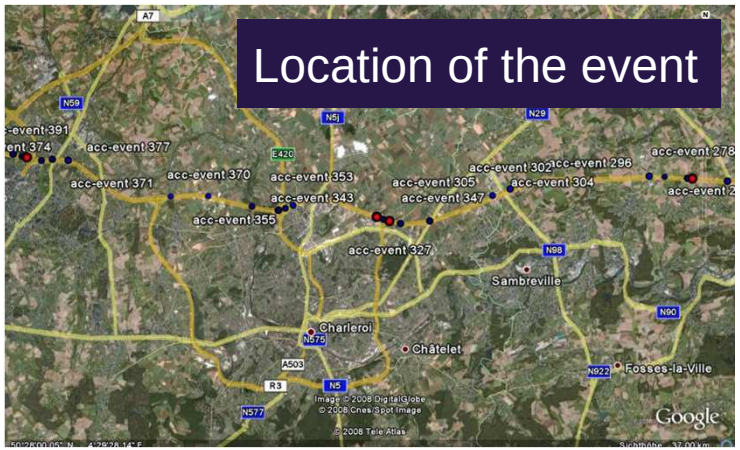


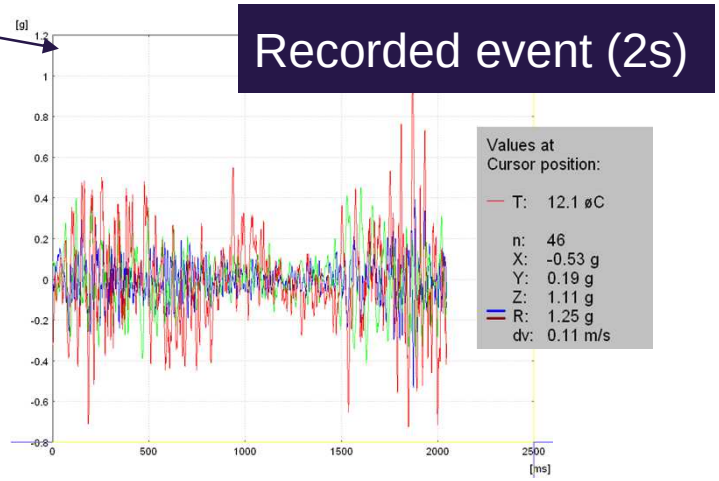
	Hamburg - Saclay		Saclay – Hamburg	
	inside frame	***outside frame***	***inside frame***	***outside frame***
Record (***1**)	0,5 g	1,0 g (PXFEL) 2,0 g (M8)	0,5 g	1,0 g
Alarm (***2**)	1,0 g	1,5 g (PXFEL) 2,0 g (M8)	1,0 g	1,5 g

Example of recorded values

- Module 8 transportation from Desy to CEA



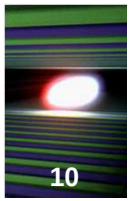




Monitored transportation

- Monitored transportation:
  - Module 8 (M8): DESY – CEA and CEA – DESY
  - PXFEL2: DESY – CEA and CEA – DESY (11/09)
  - PXFEL2: DESY – CEA (07/10)
  - PXFEL2_1: CEA – DESY (spring 2011, data not recorded)
  - PXFEL3_1: CEA – DESY

M8 and PXFEL2



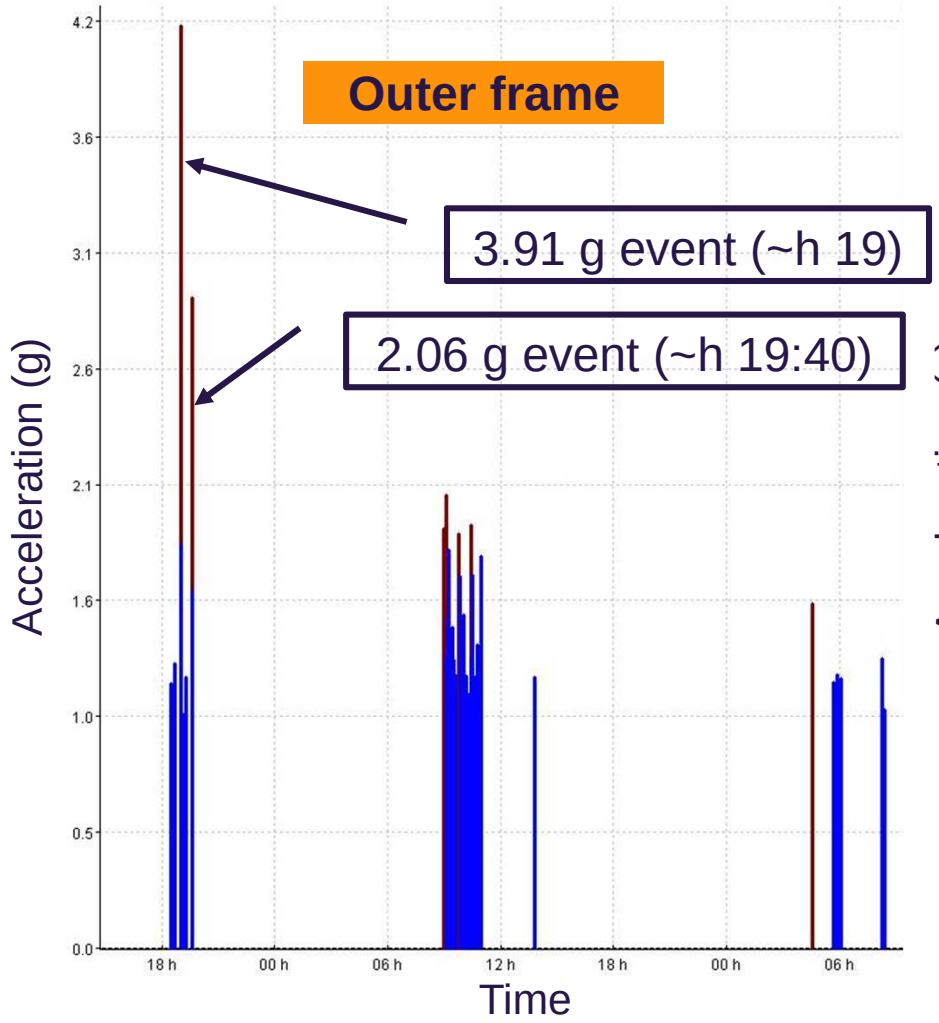
- aX, aY, aZ at maximum $aR = \sqrt{aX^2 + aY^2 + aZ^2}$

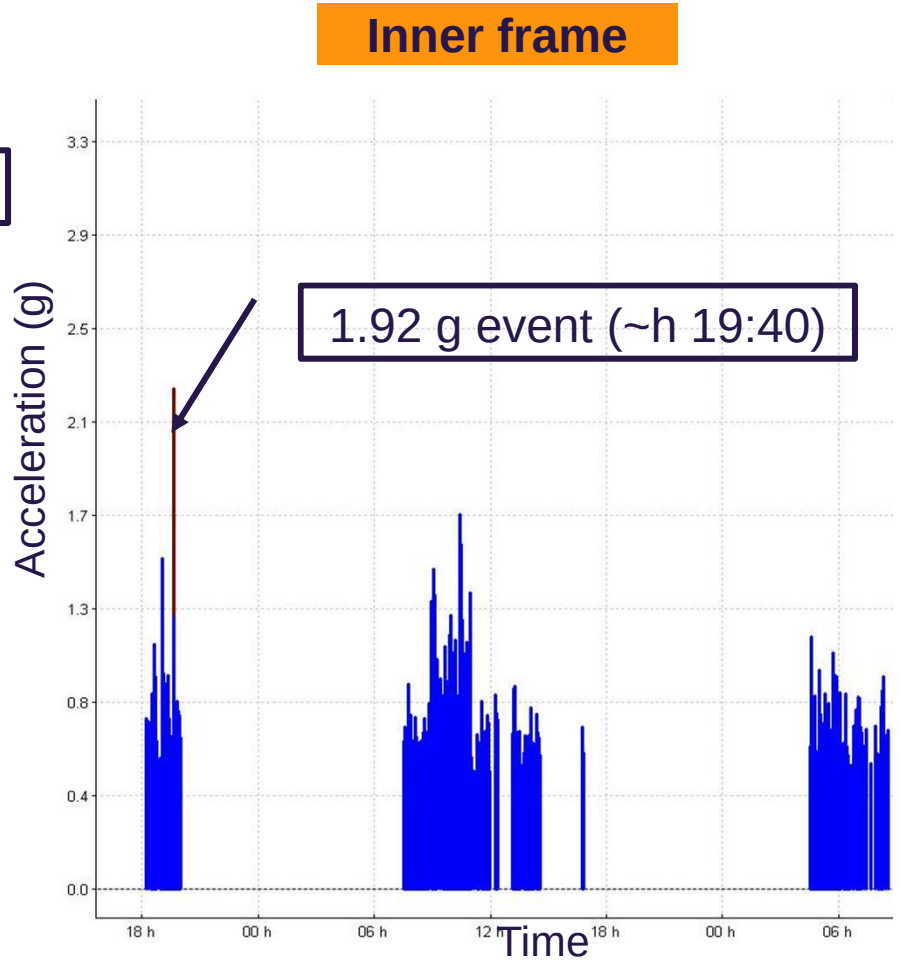
	Hamburg - Saclay					
	inner frame			*outer frame*		
	aX [g]	aY [g]	aZ [g]	aX [g]	aY [g]	aZ [g]
Module 8	0.55 / -0.59	0.62 / -0.58	1.11 / -1.18	no data, limit was to high (2g)		
Module PXFEL2 (11/09)	0.69 / - 0.78	0.84 / -0.82	1.38 / -1.08	0.82 / -0.55	1.45 / -1.44	2.34 / -1.95

	Saclay - Hamburg					
	inner frame			*outer frame*		
	aX [g]	aY [g]	aZ [g]	aX [g]	aY [g]	aZ [g]
Module 8	0.55 / -0.47	0.86 / -0.87	1.42 / -1.30	0.5 / -0.43	1.26 / -1.4	1.95 / -1.25
Module PXFEL2 (11/09)	0.54 / -0.42	0.69 / -0.55	1.07 / -0.92	0.49 / -0.42	0.92 / -1.11	1.97 / -1.62

PXFEL3_1 results

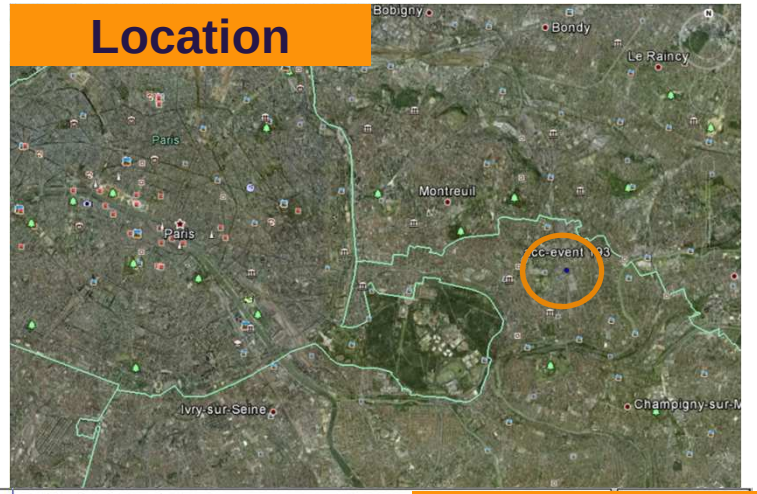
- 2 main event, one on the outer and one on the inner frame



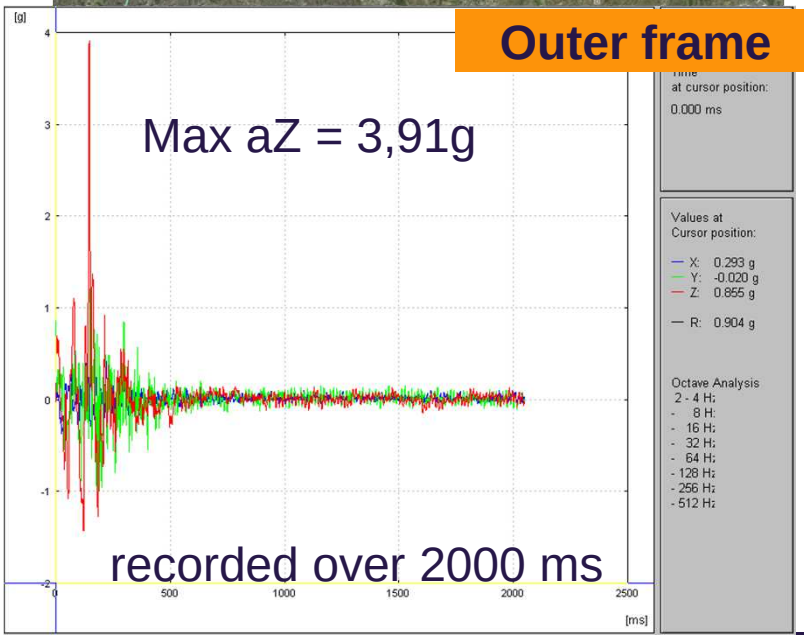


First event on PXFEL3_1

Location

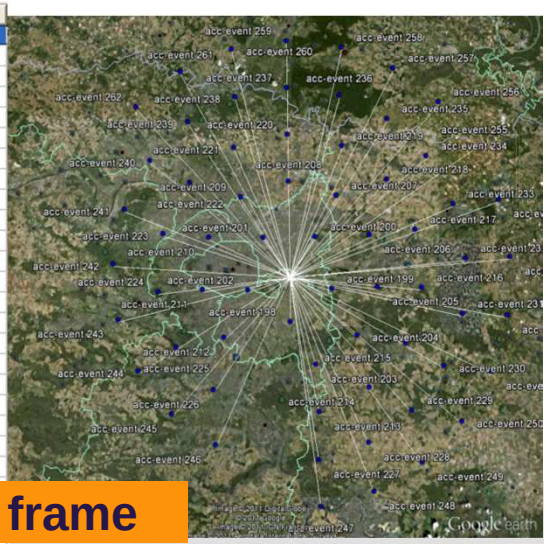


Outer frame



Number	Date	X [g]	Y [g]	Z [g]
192	26.10.11 19:00:42	-0.15	0.06	0.52
193	26.10.11 19:01:32	0.14	0.19	0.61
194	26.10.11 19:01:32	-0.14	0.44	0.59
195	26.10.11 19:01:32	0.19	-0.34	-0.86
196	26.10.11 19:01:32	0.07	-0.12	-0.67
197	26.10.11 19:01:32	0.54	0.49	0.93
198	26.10.11 19:01:32	-0.30	0.57	1.04
199	26.10.11 19:01:32	0.38	-0.53	-1.25
200	26.10.11 19:01:32	0.30	0.60	1.02
201	26.10.11 19:01:32	-0.29	0.07	-0.73
202	26.10.11 19:01:32	0.24	0.25	0.68
203	26.10.11 19:01:32	0.37	0.34	0.73
204	26.10.11 19:01:32	-0.17	-0.23	-0.54
205	26.10.11 19:01:32	-0.58	0.40	0.59
206	26.10.11 19:01:32	0.39	-0.50	-0.90
207	26.10.11 19:01:32	0.49	-0.26	-0.52
208	26.10.11 19:01:32	-0.23	0.62	0.89
209	26.10.11 19:01:32	-0.24	-0.32	-0.80
210	26.10.11 19:01:32	0.57	-0.57	-1.13
211	26.10.11 19:01:32	0.45	-0.22	0.84
212	26.10.11 19:01:32	-0.19	0.23	0.65
213	26.10.11 19:01:32	-0.24	-0.32	-0.60
214	26.10.11 19:01:32	0.15		
215	26.10.11 19:01:32	-0.08		
216	26.10.11 19:01:32	-0.19		
217	26.10.11 19:01:32	-0.23	-0.21	-0.63
218	26.10.11 19:01:32	-0.25	-0.13	-0.56
219	26.10.11 19:01:32	0.21	-0.03	0.54
220	26.10.11 19:01:40	0.15	-0.19	-0.50
221	26.10.11 19:01:40	-0.21	-0.15	-0.52
222	26.10.11 19:01:40	0.20	-0.46	-0.50
223	26.10.11 19:01:40	0.07	0.26	0.71
224	26.10.11 19:01:40	0.17	-0.26	-0.59
225	26.10.11 19:01:40	-0.15	-0.23	-0.52
226	26.10.11 19:01:40	-0.13	0.34	0.65
227	26.10.11 19:01:40	-0.34	0.48	0.59
228	26.10.11 19:01:40	0.49	-0.48	-0.66
229	26.10.11 19:01:40	0.27	-0.28	0.55
230	26.10.11 19:01:40	0.26	0.14	0.82
231	26.10.11 19:01:40	-0.53	-0.32	0.52
232	26.10.11 19:01:40	0.12	0.17	0.72
233	26.10.11 19:01:40	0.27	0.29	0.55
234	26.10.11 19:01:40	0.20	-0.22	0.57
235	26.10.11 19:01:40	0.21	-0.51	-0.40
236	26.10.11 19:01:40	0.19	0.15	0.54
237	26.10.11 19:01:40	-0.10	-0.20	-0.50
238	26.10.11 19:01:49	-0.20	-0.36	-0.64
239	26.10.11 19:01:49	0.25	0.77	0.84
240	26.10.11 19:01:49	-0.32	-0.46	-0.95
241	26.10.11 19:01:49	0.12	-0.62	-1.21
242	26.10.11 19:01:49	0.31	0.25	0.55

Inner frame



64 events between 0,5 g and 1,0 g after the 3,91 g at the outer frame.

The time between the first and the last event was 20 sec.

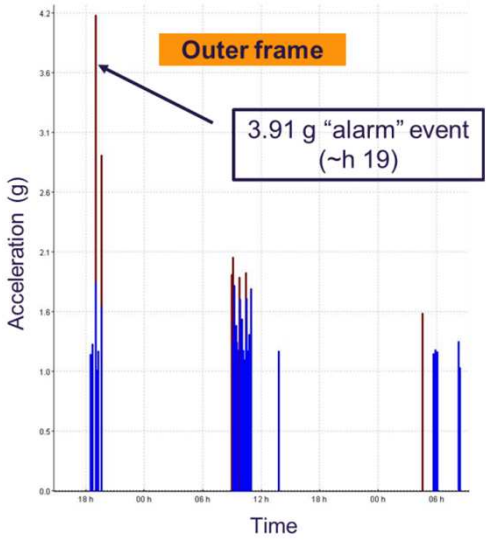
Event 1 on PXFEL3_1

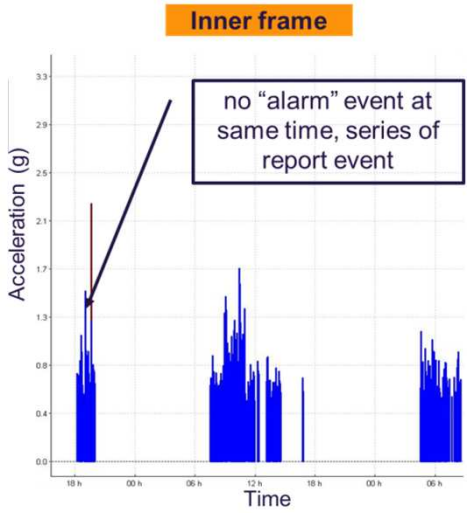
- High value only on outer frame; acceleration on the inner frame below “record” limit

- Time behavior looks similar to other “shock” events (potholes, rough roads, ...)

- 4 g acceleration is an expected load during transportation on semitrailer lorries with air suspension

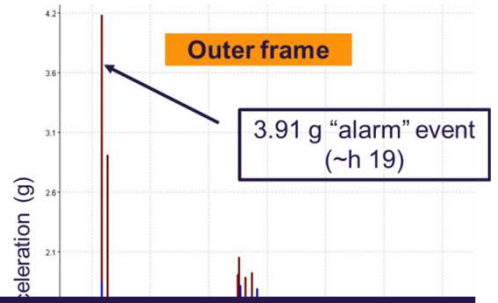
http://www.smt-hybrid.de/fileadmin/PDF/Handbook.pdf, “Making the transportation of susceptible goods transparent”, by SMT & Hybrid GmbH, page 9





Event 1 on PXFEL3_1

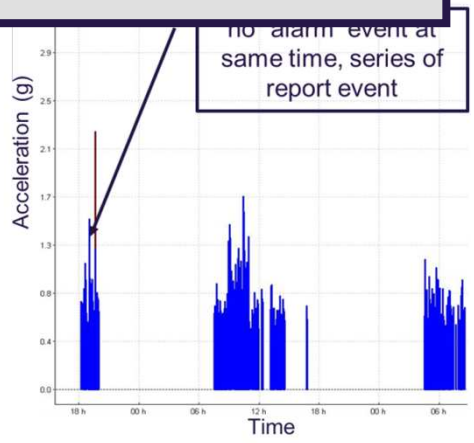
- High value only on outer frame; acceleration on the inner frame below “record” limit



This seems a normal event, well damped by the frame

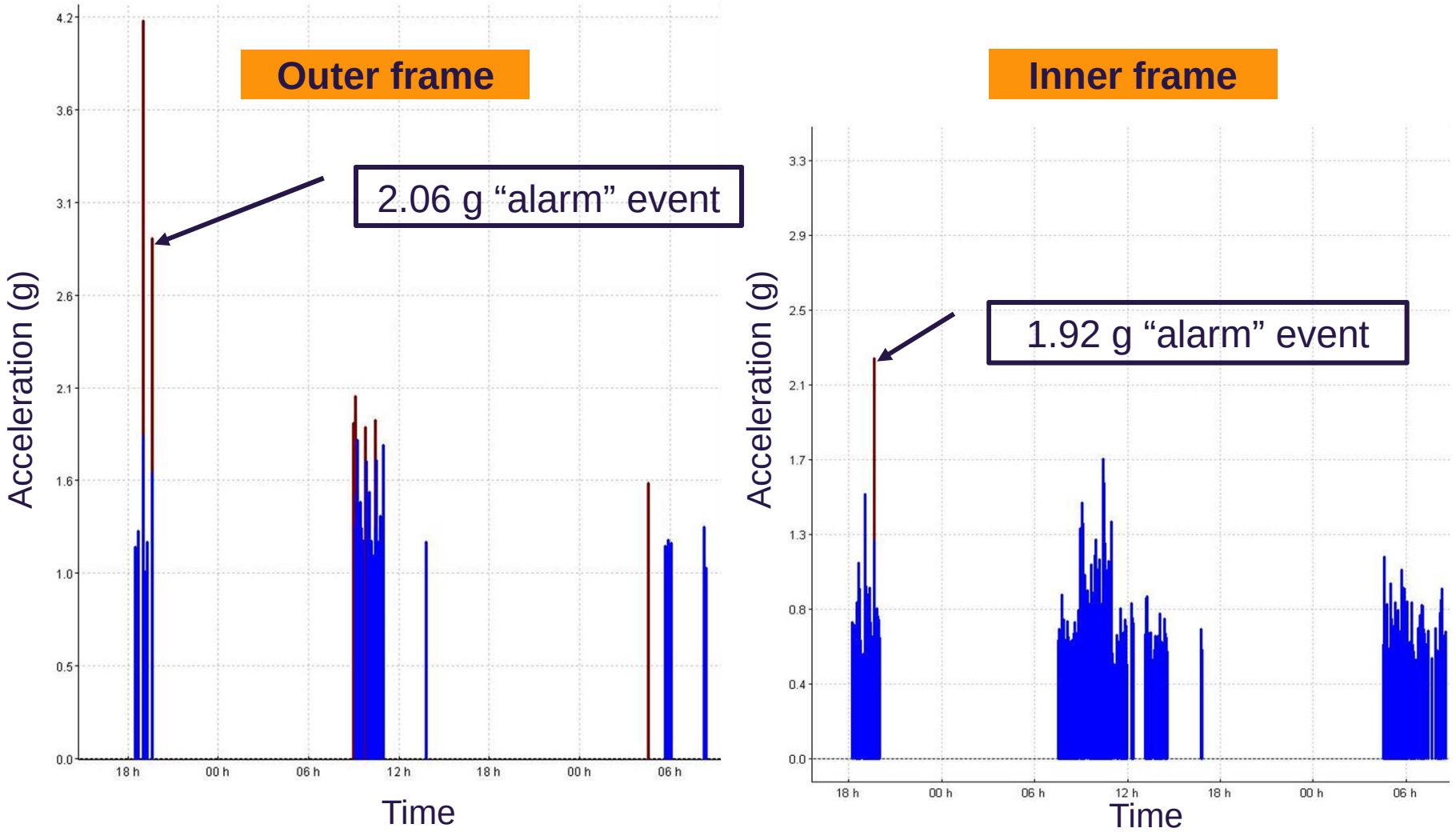
No need of additional investigation

- 4 g acceleration is an expected load during transportation on semitrailer lorries with air suspension



http://www.smt-hybrid.de/fileadmin/PDF/Handbook.pdf, “Making the transportation of susceptible goods transparent”, by SMT & Hybrid GmbH, page 9

Second event on PXFEL3_1

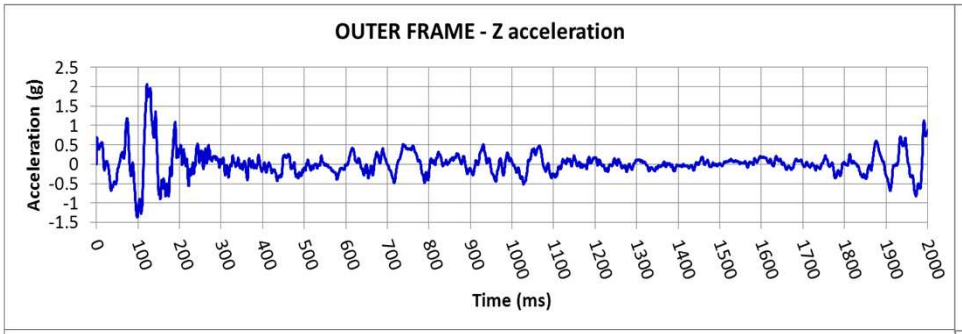


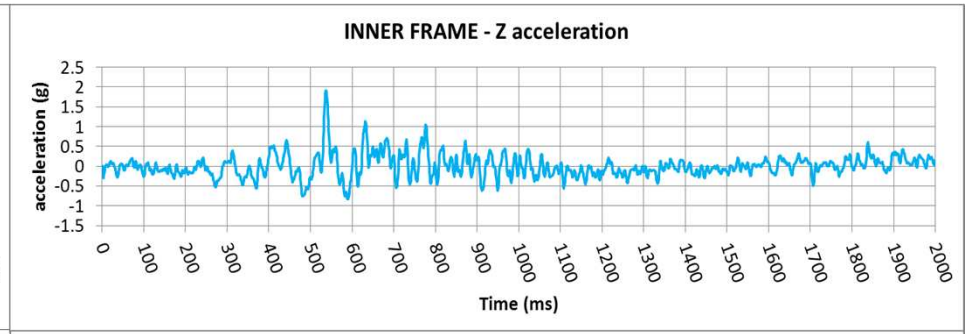
European XFEL

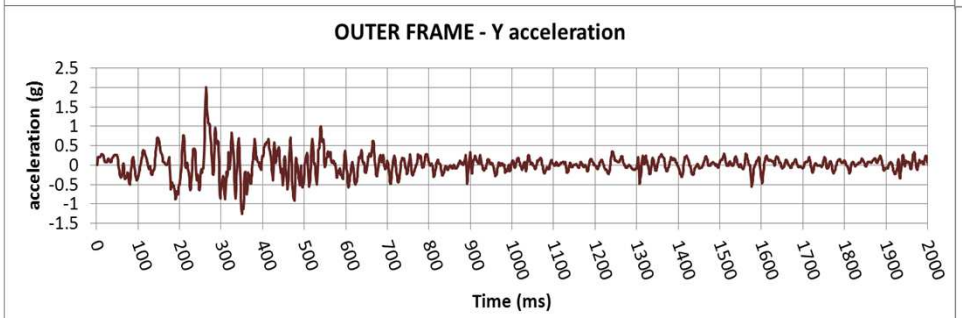
Second event on PXFEL3_1

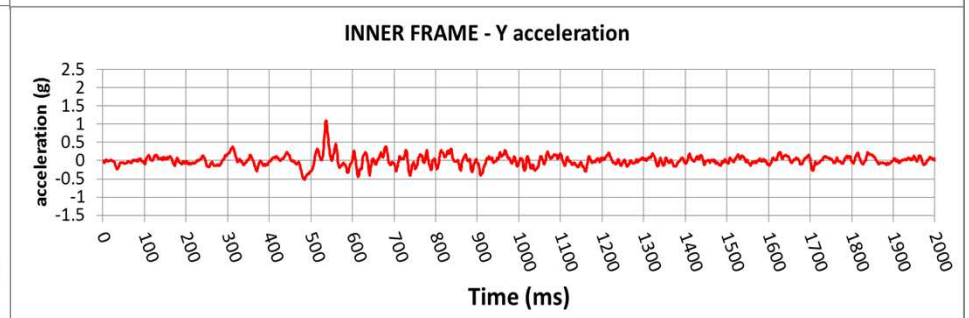
inner frame		
aX [g]	aY [g]	aZ [g]
-0.35	1.1	1.92

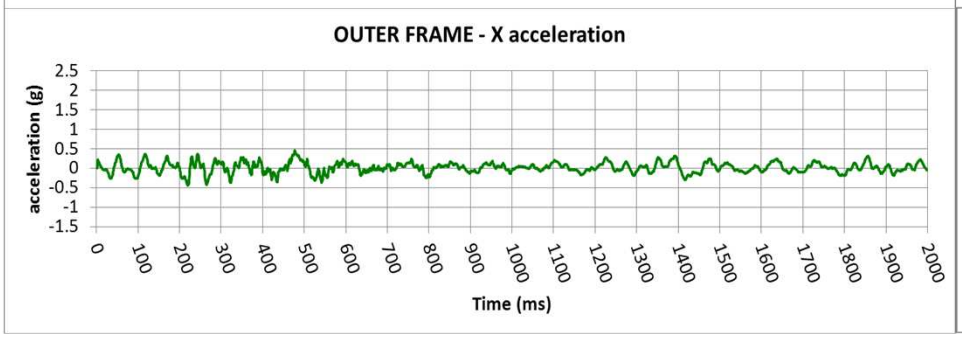
outer frame		
aX [g]	aY [g]	aZ [g]
-0.42	2.02	2.06

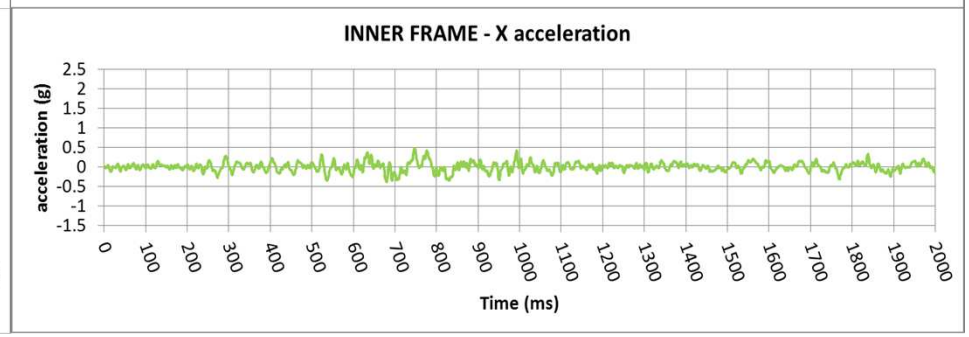












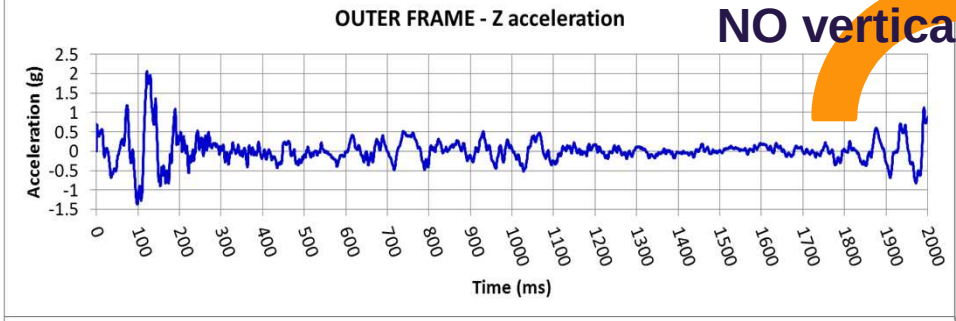
European XFEL

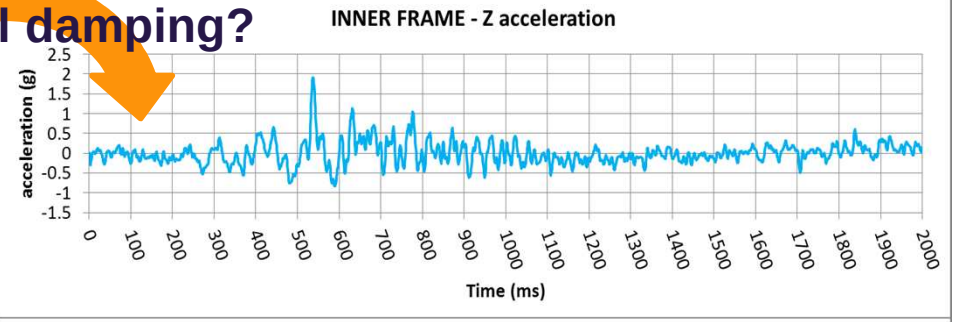
Second event on PXFEL3_1

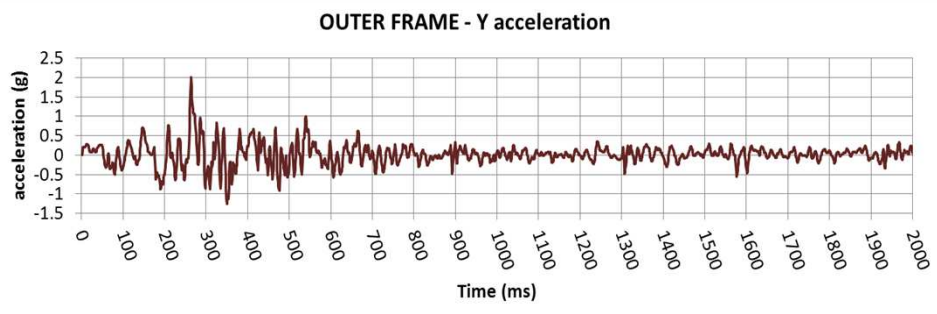
inner frame		
aX [g]	aY [g]	aZ [g]
-0.35	1.1	1.92

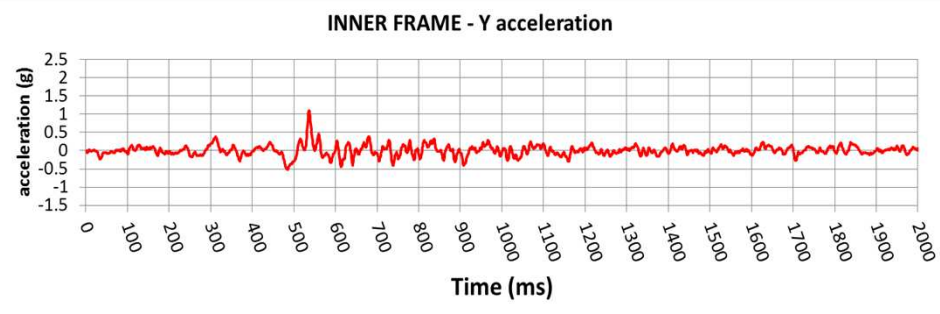
outer frame		
aX [g]	aY [g]	aZ [g]
-0.42	2.02	2.06

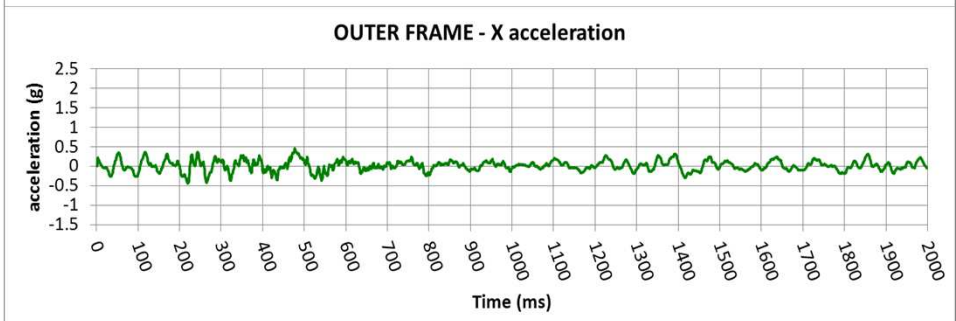
NO vertical damping?

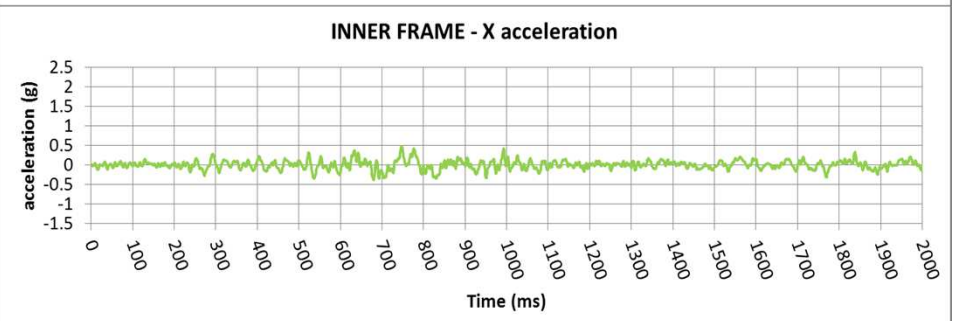










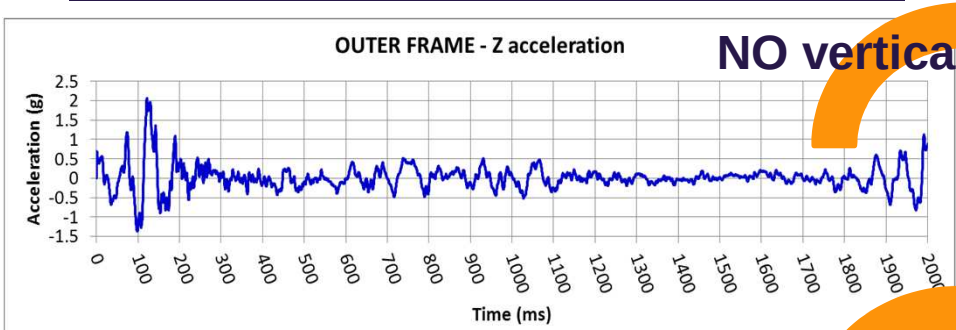


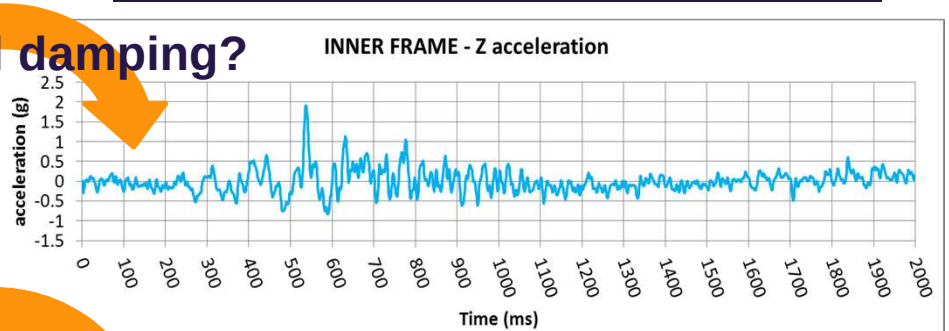
Second event on PXFEL3_1

inner frame		
aX [g]	aY [g]	aZ [g]
-0.35	1.1	1.92

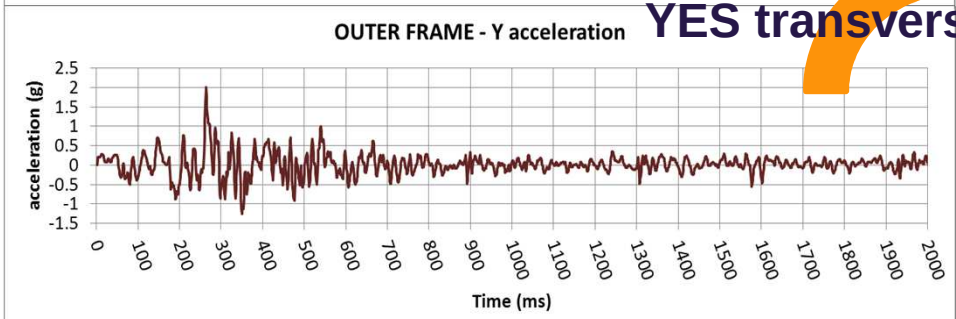
outer frame		
aX [g]	aY [g]	aZ [g]
-0.42	2.02	2.06

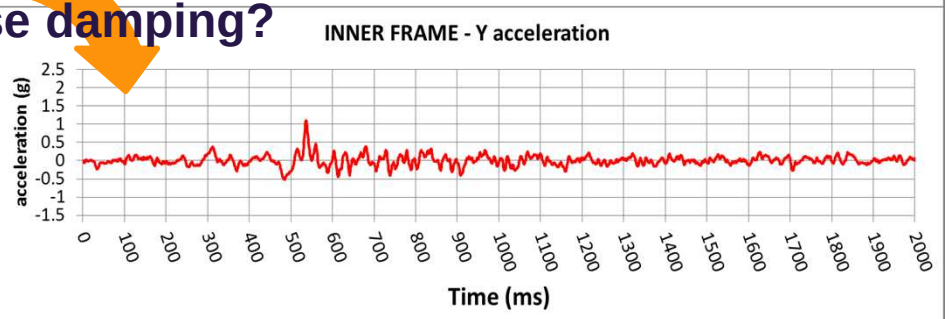
NO vertical damping?

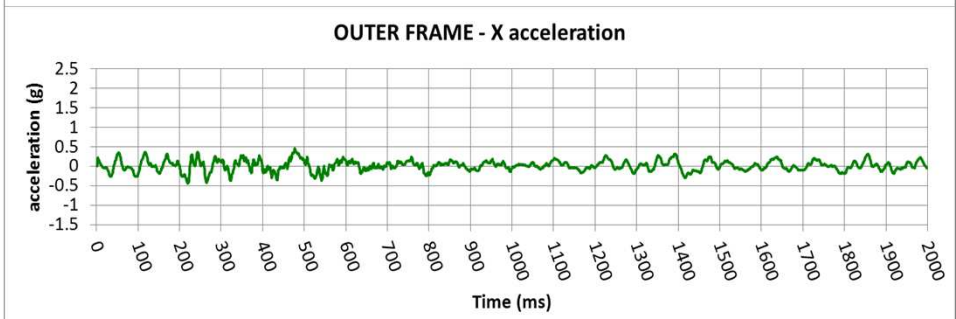


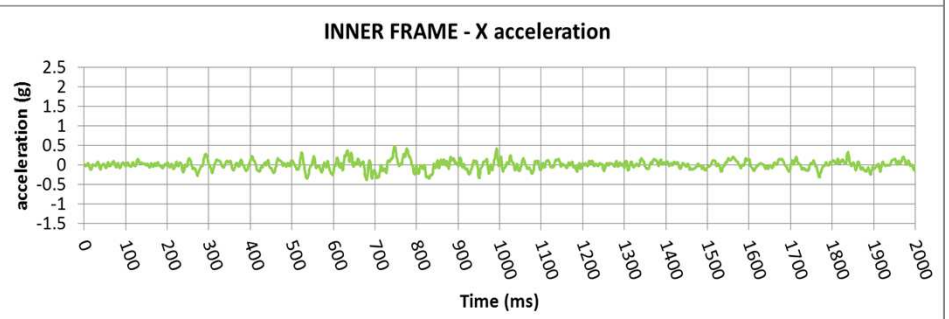


YES transverse damping?







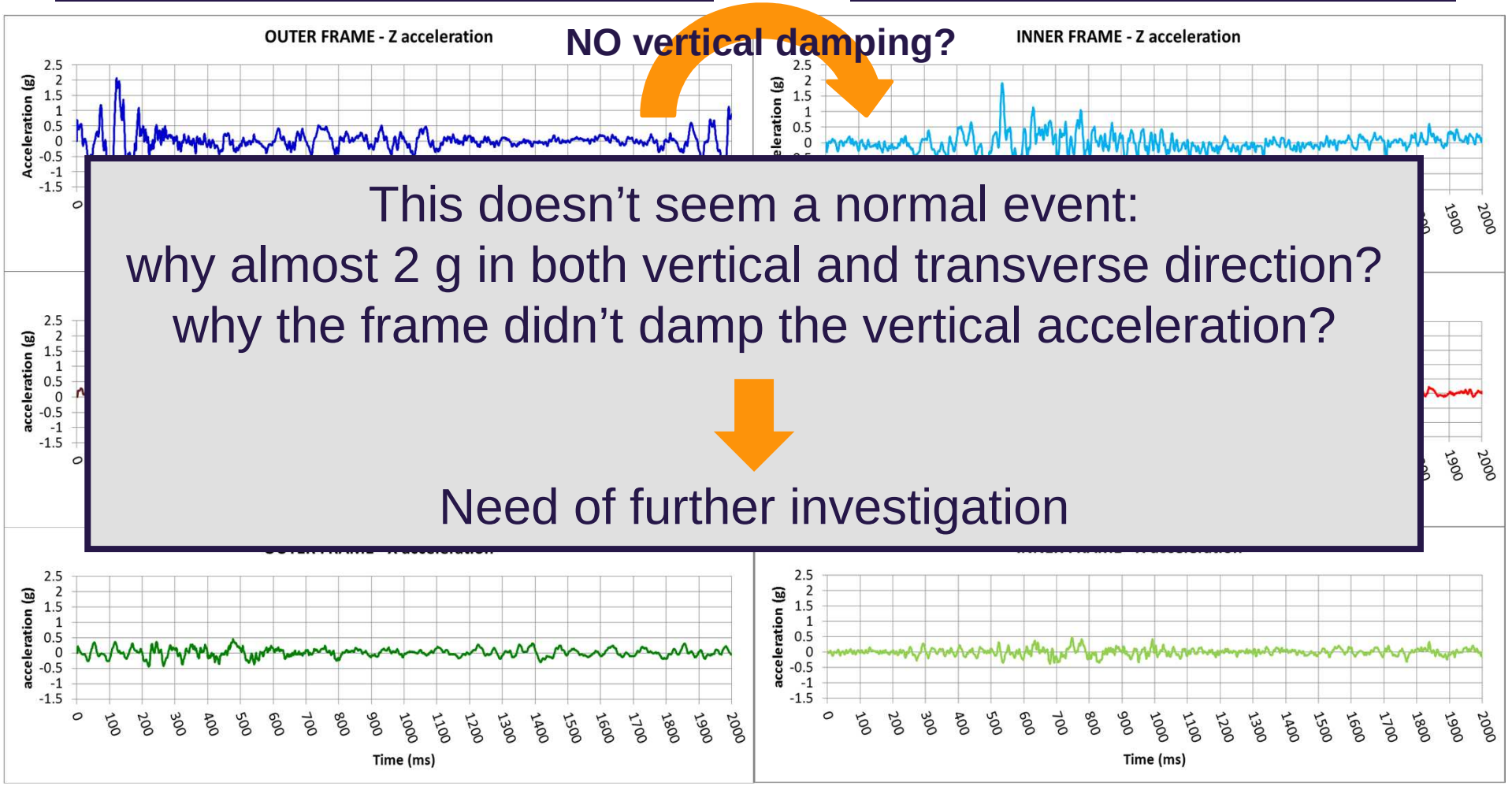


Second event on PXFEL3_1

inner frame		
aX [g]	aY [g]	aZ [g]
-0.35	1.1	1.92

outer frame		
aX [g]	aY [g]	aZ [g]
-0.42	2.02	2.06

NO vertical damping?



This doesn't seem a normal event:
why almost 2 g in both vertical and transverse direction?
why the frame didn't damp the vertical acceleration?

Need of further investigation

Present and future actions

- Additional investigation is needed on the second event; contact also the company that produced the frame
- 6 additional monitoring devices (Sensr accelerometers) procured for next module transportation, to be positioned at the other side of the frame on the fixed and damped structures
- Comparative test between different devices (Monilogs, Sensr, Shocklog)
- Additional GPS transponder procured (we can localize the truck during the trip)
- Further analyses on the frame: test of the whole assembly? Additional tests on the coils? ...

Thank you to all the colleagues from Fermilab, INFN and Desy who helped in this work

Thank you for your attention!