



# FEMFAT LAB

## LOAD DATA ANALYSIS

Damage equivalent test time  
reduction

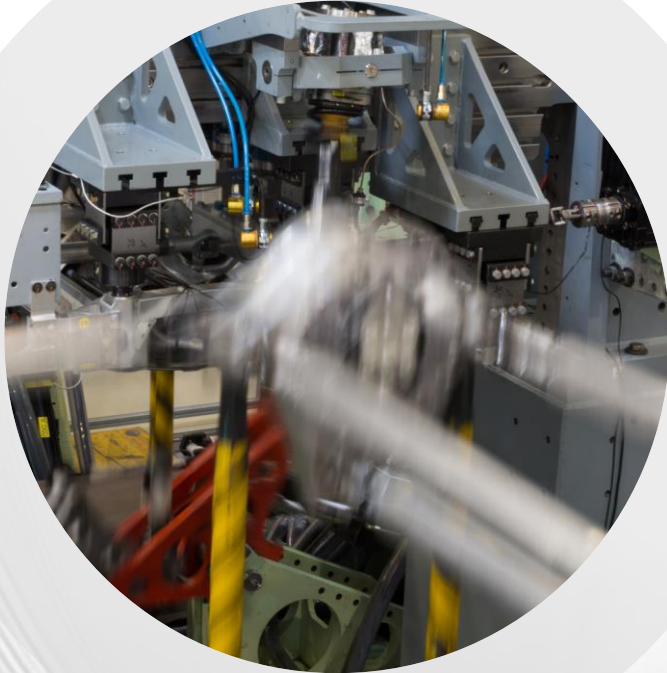
September 22 | XF-T Markus Baumann

# Motivation



In the early development process, you want to get results fast with very short computing time.

Long load - time histories prevent this.



With consideration of

- Phase relationship of the input channels must be preserved
- Extreme values should occur
- Damage should be the same

# Workflow

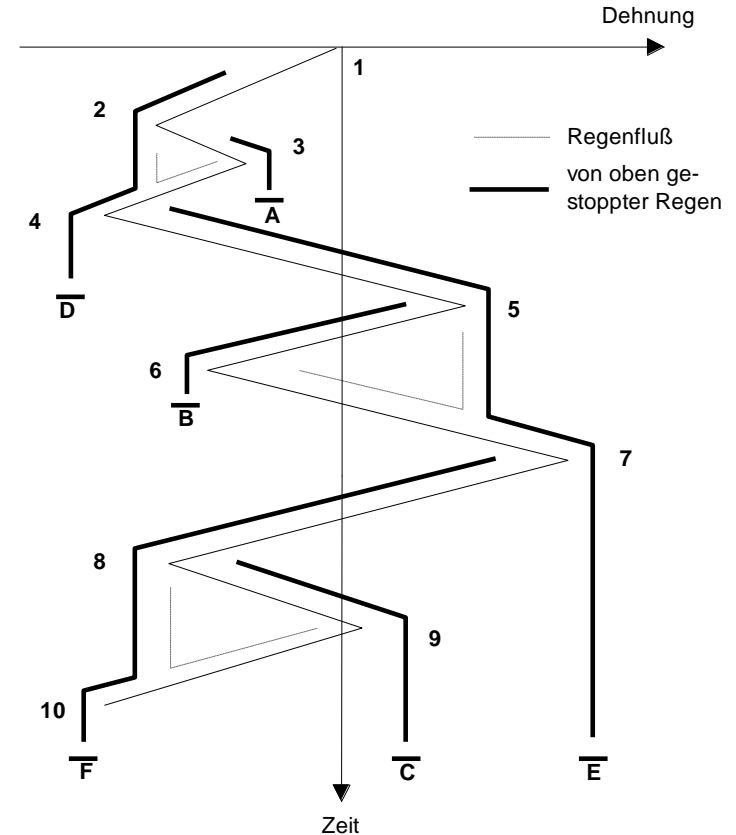




# Background

# Background rainflow counting

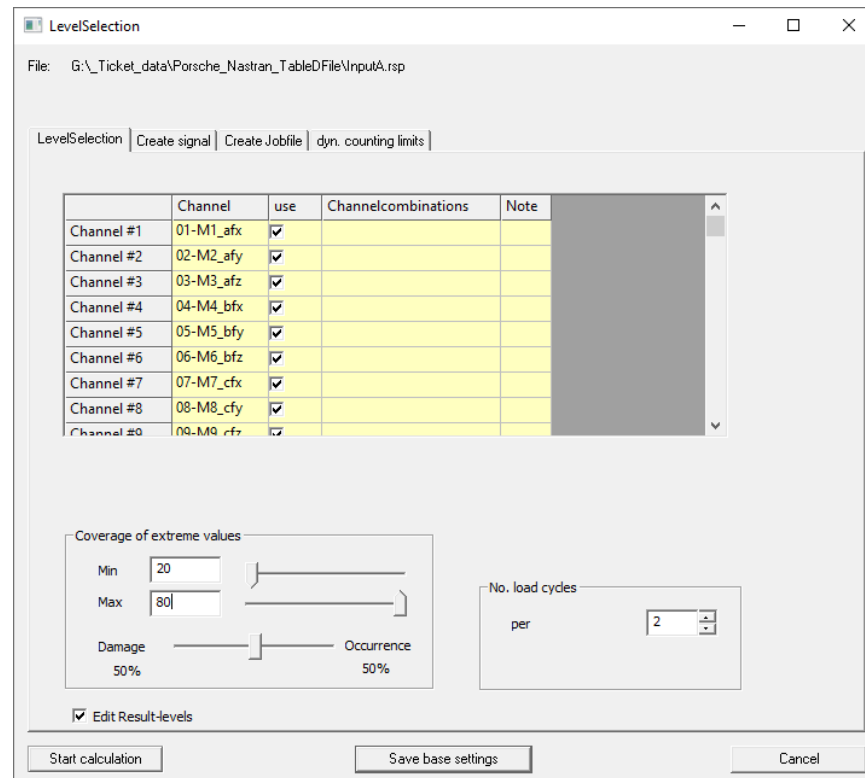
- FEMFAT LAB offline rainflow counting:
  - Starts at biggest minimum  
Sequenzshift: load data before minimum shifted to the end of time data
  - Results closed cycles – no residuum





# Background level selection

- FEMFAT LAB level selection
  - Based on rainflow counting
  - Selection of “from / to” values with biggest amplitude (highest damage) or with occurrence counts (edit with slider control)



LevelSelection

File: G:\Ticket\_data\Porsche\_Nastran\_TableDFile\InputA.rsp

LevelSelection | Create signal | Create Jobfile | dyn. counting limits |

	Channel	use	Channelcombinations	Note
Channel #1	01-M1_afx	<input checked="" type="checkbox"/>		
Channel #2	02-M2_afy	<input checked="" type="checkbox"/>		
Channel #3	03-M3_afz	<input checked="" type="checkbox"/>		
Channel #4	04-M4_bfx	<input checked="" type="checkbox"/>		
Channel #5	05-M5_bfy	<input checked="" type="checkbox"/>		
Channel #6	06-M6_bfz	<input checked="" type="checkbox"/>		
Channel #7	07-M7_cfx	<input checked="" type="checkbox"/>		
Channel #8	08-M8_cfy	<input checked="" type="checkbox"/>		
Channel #9	09-M9_cfz	<input checked="" type="checkbox"/>		

Coverage of extreme values

Min: 20 Max: 80

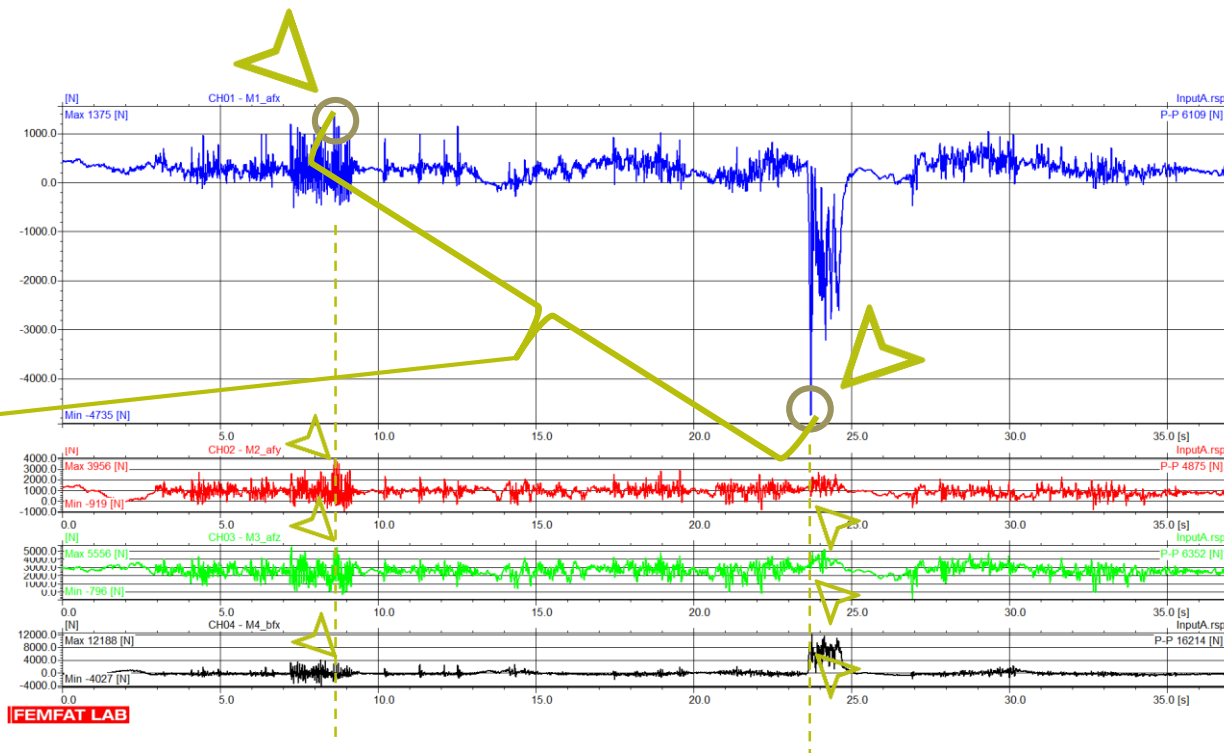
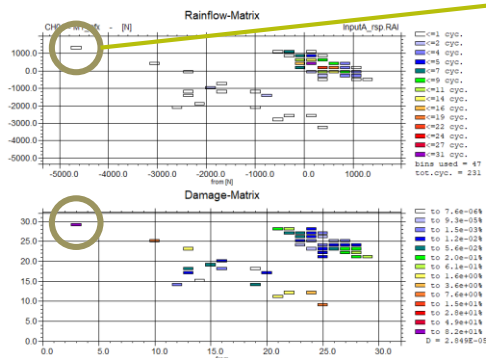
Damage 50% Occurrence 50%

No. load cycles per: 2

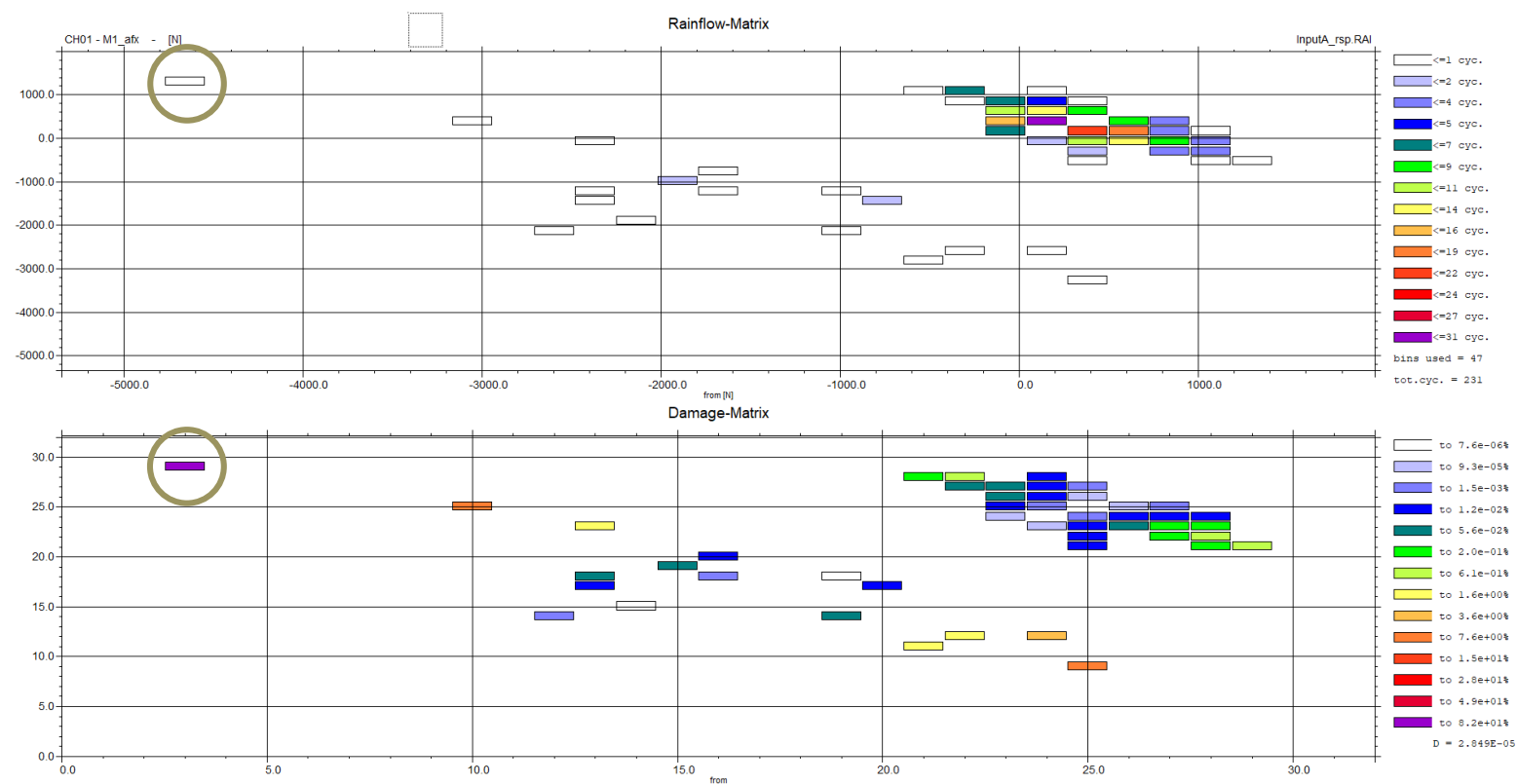
☒ Edit Result-levels

Start calculation Save base settings Cancel

- FEMFAT LAB level selection
  - Level selection for each channel and save level for all channels at the same time



# Background level selection



- FEMFAT LAB mixing track
  - Generate a usable test procedure
  - Correlation by means of damage comparison
  - Constraints: target damage values, target time interval, min./max. repetitions

Track mixing PG				
Manoeuvre	Rep.	ACC_X	ACC_Z	.....
Potholes	?	D <sub>PH_AX</sub>	D <sub>PH_AZ</sub>	.....
Rough road	?	D <sub>RR_AX</sub>	D <sub>RR_AZ</sub>	.....
Fast 8	?	D <sub>BR_AX</sub>	D <sub>BR_AZ</sub>	.....
Groove	?	D <sub>F8_AX</sub>	D <sub>F8_AZ</sub>	.....
.....	...	.....	.....	.....
Target		D <sub>total_AX</sub>	D <sub>total_AZ</sub>	.....
Opti.		D <sub>opti_AX</sub>	D <sub>opti_AZ</sub>	.....

Example (user input):  
Factor: 100  
Min. test-time :110h  
Max. test-time :130h  
Min./Max. repetitions per maneuver  
Only relevant channels selected

Track mixing PG				
Manoeuvre	Rep.	ACC_X	ACC_Z	.....
Potholes	0	D <sub>PH_AX</sub>	D <sub>PH_AZ</sub>	.....
Rough road	700	D <sub>RR_AX</sub>	D <sub>RR_AZ</sub>	.....
Fast 8	400	D <sub>BR_AX</sub>	D <sub>BR_AZ</sub>	.....
Groove	300	D <sub>F8_AX</sub>	D <sub>F8_AZ</sub>	.....
.....	...	.....	.....	.....
Target		D <sub>total_AX</sub>	D <sub>total_AZ</sub>	.....
Opti.		D <sub>opti_AX</sub>	D <sub>opti_AZ</sub>	.....

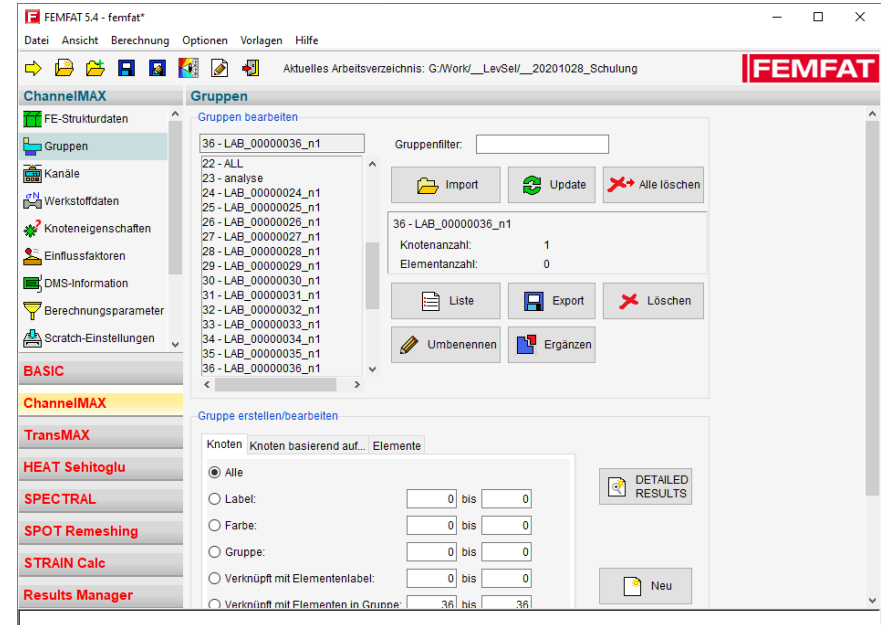
Overview of results	
Result	Value
Calc. time in h:	112
used files	6
Min	0.972
Max	1.02
Mean	0.994
Std. dev:	0.0149
Coverage EV %	91
Good/better condition	0.0149

Result:

- Good damage correlation with target
- Testing time as planned
- Maneuver count in sensible range

# Preperation

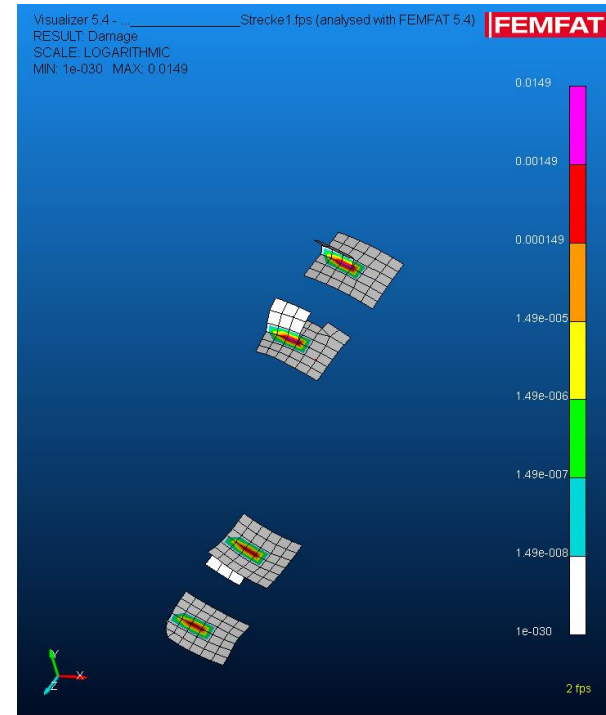
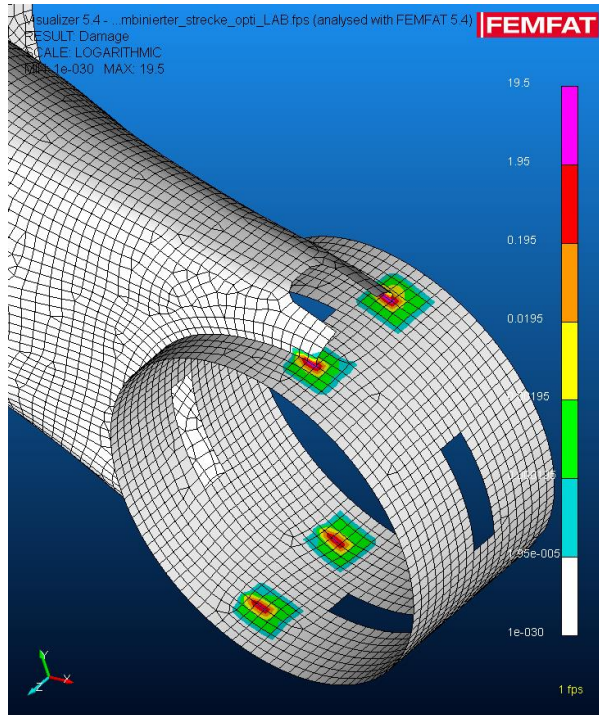
- FEMFAT
  - Reference calculation
  - Define calculation groups around high damage notes
    - Name „lab.....“ or „ecs....“
    - This averaged group damage is mixed
  - Save a sample job file
    - FEMFAT LAB will generate the batchfile





# Preperation FEMFAT calculation groups

- In this example we reduced to 27 node groups



# FEMFAT LAB level selection

- Reference time histories

- 3 Tracks

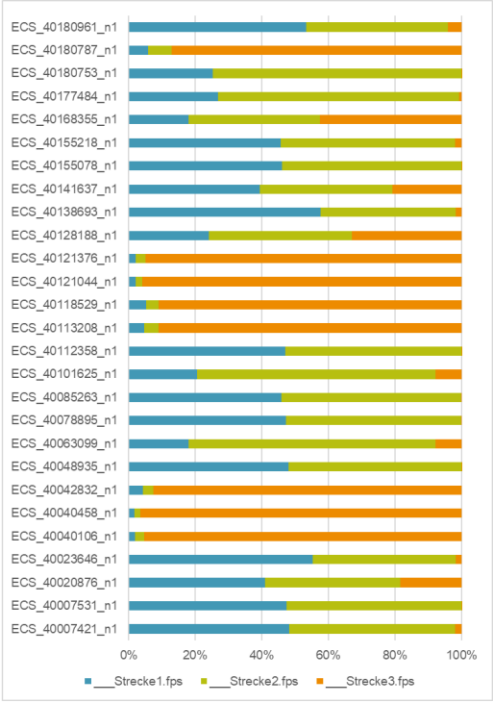
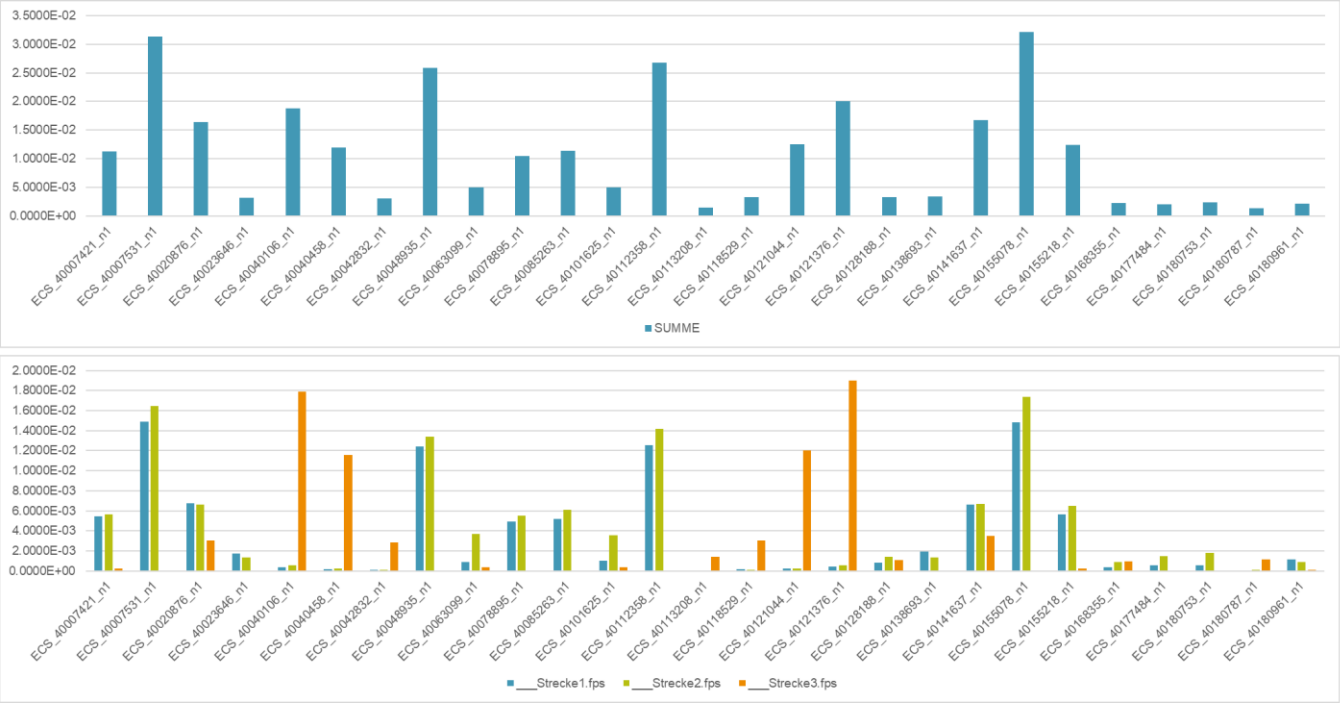
no.	name	samples	time [sec]
1	Track_01.rsp	22528	22528
2	Track_02.rsp	1097728	2196
3	Track_03.rsp	193536	960

- Different sample rate

- 90 Channels

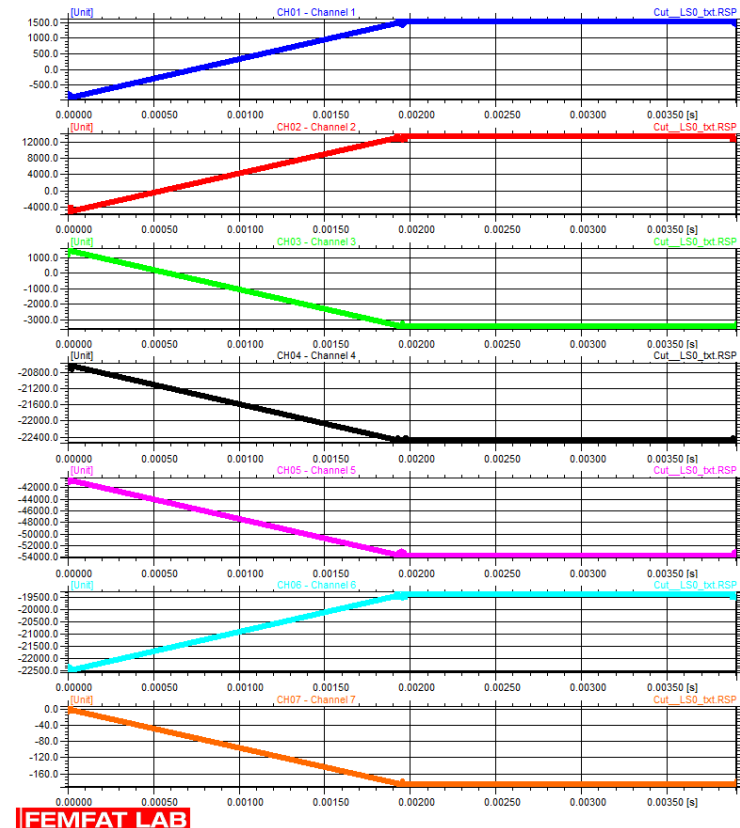
- In summary 1313792 samples and 25684 seconds

- Reference (target) damage



# Level selection

- Output level selection (interface to FEMFAT)
  - ~ 4000 level files
    - For each channel one from - to level
  - FEMFAT job file
  - Batch file



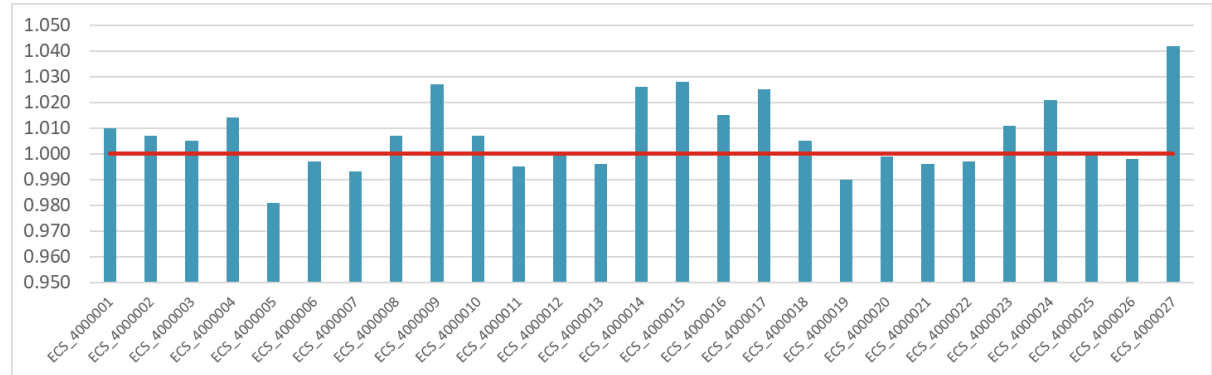
# FEMFAT LAB mixing track



- Loop 1
  - Determine mathematical optimum
    - Result:
      - Reduction from 1313792 samples to 3178 (413 / 1)
      - 296 different level pairs
      - Rel. damage between reference and result:
        - max: 1.040
        - min: 0.981
        - Mean 1.010

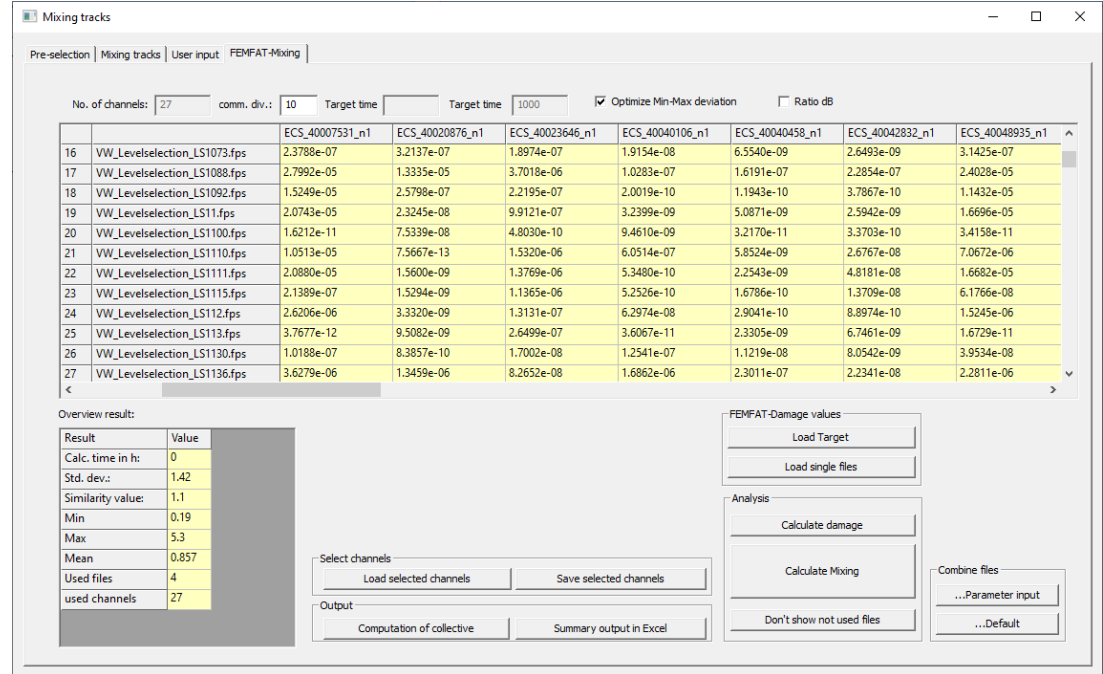
Overview result:

Result	Value
Calc. time in h:	0
Std. dev.:	0.0137
Similarity value:	0.0141
Min	0.981
Max	1.04
Mean	1.01
Used files	296
used channels	27



# Mixing track

- Loop 2
  - File selection
  - Extrem value coverage
  - Channel weighting
  - Limit time (samples)
  - Change number of file repetition
  - Insert common divisor



The screenshot displays the 'Mixing tracks' application window. At the top, there are tabs for 'Pre-selection', 'Mixing tracks', 'User input', and 'FEMFAT-Mixing'. Below these, a table lists 27 channels with columns for file names and numerical values. The table is scrollable, showing rows 16 through 27. Below the table, there is an 'Overview result:' section with a table of statistics. To the right of the overview, there are several control panels: 'FEMFAT-Damage values' with 'Load Target' and 'Load single files' buttons; 'Analysis' with 'Calculate damage' and 'Calculate Mixing' buttons; and 'Combine files' with '...Parameter input' and '...Default' buttons. At the bottom, there are 'Select channels' and 'Output' sections with buttons for loading, saving, and computing data.

No. of channels:	27	comm. div.:	10	Target time	Target time	1000	<input checked="" type="checkbox"/> Optimize Min-Max deviation	<input type="checkbox"/> Ratio dB
16	VW_Levelselection_LS1073.fps	2.3788e-07	3.2137e-07	1.8974e-07	1.9154e-08	6.5540e-09	2.6493e-09	3.1425e-07
17	VW_Levelselection_LS1088.fps	2.7992e-05	1.3335e-05	3.7018e-06	1.0283e-07	1.6191e-07	2.2854e-07	2.4028e-05
18	VW_Levelselection_LS1092.fps	1.5249e-05	2.5798e-07	2.2195e-07	2.0019e-10	1.1943e-10	3.7867e-10	1.1432e-05
19	VW_Levelselection_LS111.fps	2.0743e-05	2.3245e-08	9.9121e-07	3.2399e-09	5.0871e-09	2.5942e-09	1.6696e-05
20	VW_Levelselection_LS1100.fps	1.6212e-11	7.5339e-08	4.8030e-10	9.4610e-09	3.2170e-11	3.3703e-10	3.4158e-11
21	VW_Levelselection_LS1110.fps	1.0513e-05	7.5667e-13	1.5320e-06	6.0514e-07	5.8524e-09	2.6767e-08	7.0672e-06
22	VW_Levelselection_LS1111.fps	2.0880e-05	1.5600e-09	1.3769e-06	5.3480e-10	2.2543e-09	4.8181e-08	1.6682e-05
23	VW_Levelselection_LS1115.fps	2.1389e-07	1.5294e-09	1.1365e-06	5.2526e-10	1.6786e-10	1.3709e-08	6.1766e-08
24	VW_Levelselection_LS112.fps	2.6206e-06	3.3320e-09	1.3131e-07	6.2974e-08	2.9041e-10	8.8974e-10	1.5245e-06
25	VW_Levelselection_LS113.fps	3.7677e-12	9.5082e-09	2.6499e-07	3.6067e-11	2.3305e-09	6.7461e-09	1.6729e-11
26	VW_Levelselection_LS1130.fps	1.0188e-07	8.3857e-10	1.7002e-08	1.2541e-07	1.1219e-08	8.0542e-09	3.9534e-08
27	VW_Levelselection_LS1136.fps	3.6279e-06	1.3459e-06	8.2652e-08	1.6862e-06	2.3011e-07	2.2341e-08	2.2811e-06

Overview result:

Result	Value
Calc. time in h:	0
Std. dev.:	1.42
Similarity value:	1.1
Min	0.19
Max	5.3
Mean	0.857
Used files	4
used channels	27

Select channels: Load selected channels Save selected channels

Output: Computation of collective Summary output in Excel

FEMFAT-Damage values: Load Target Load single files

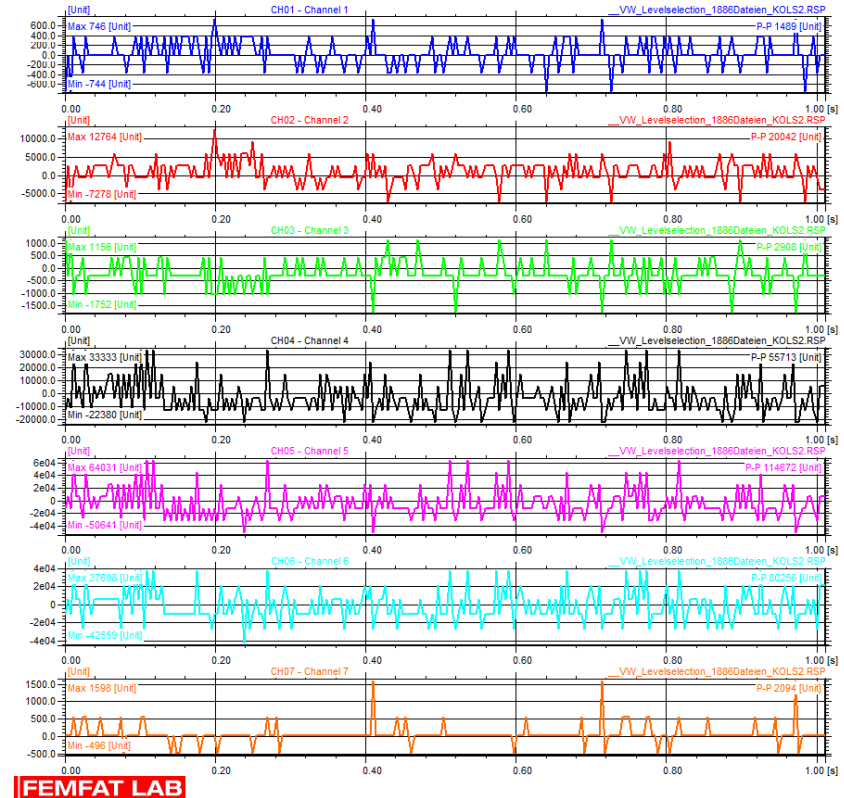
Analysis: Calculate damage Calculate Mixing

Combine files: ...Parameter input ...Default

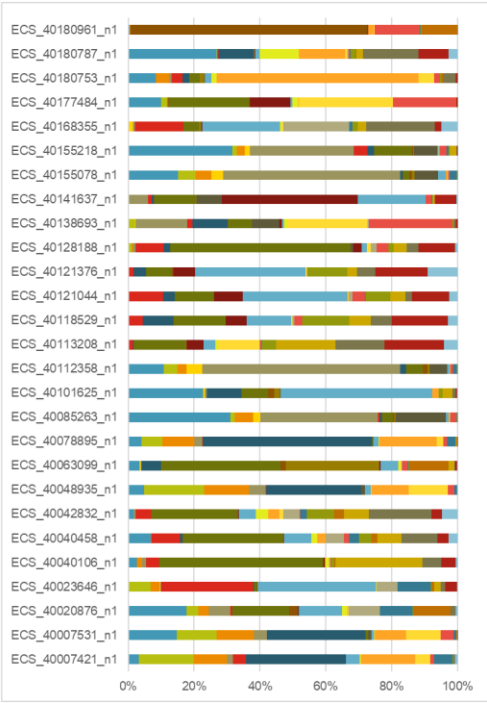
Don't show not used files

- Result

- Reduction from 1313792 samples to 2598 (506 / 1)
- 25 different level pairs
- Rel. damage between reference and result:
  - max: 1.000
  - min: 0.94



- Result damage abs. / rel.



# Conclusion

- FEMFAT compare calculation
  - The combination of different levels returns an increase in the damage. Amplitudes (the from of one level pair to one to of another level pair is typically higher then the highest from - to level in single level pairs)
  - A higher reduction of input level pairs results in a higher damage in the selected nodes
  - Typical time reduction factor between 500 and 1000 in stochastic time histories





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INSPIRING **INNOVATION.**