

PostgreSQL in Research and Development Three Success Stories



Roland Sonnenschein
Hesotech GmbH
automatisieren – visualisieren

<http://www.hesotech.de>

Wilhelm-von-Nassau-Park 11
D-65582 Diez
Germany

Hesotech: (Software) Engineering

- Technical Processes
 - Documentation
 - Control
- Customers
 - Industry: testing, development, production
 - Science
- PostgreSQL is core for storage of
 - Measurements (simple and complex)
 - Administration data
 - Metadata



Our Projects

- No special server hardware
- Windows OS
- Small number of clients with high load
- Normally no internet, only intranet



Project Stories with PostgreSQL

▶ Bearings of Wind Turbines

- Huge amount of measurements



▶ Corrosion Protection

- + Complex Administration-Data



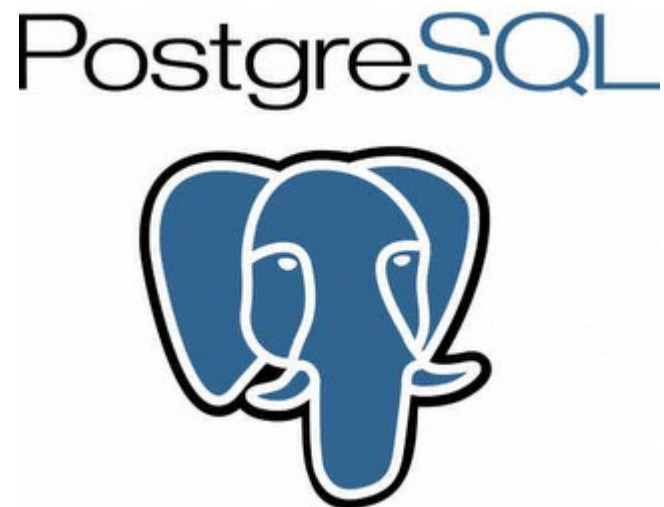
▶ Plant Genetics

- + Image Storage and Processing



Agenda Each Story

1. Technical background explanations
2. Point, where our champion enters the arena

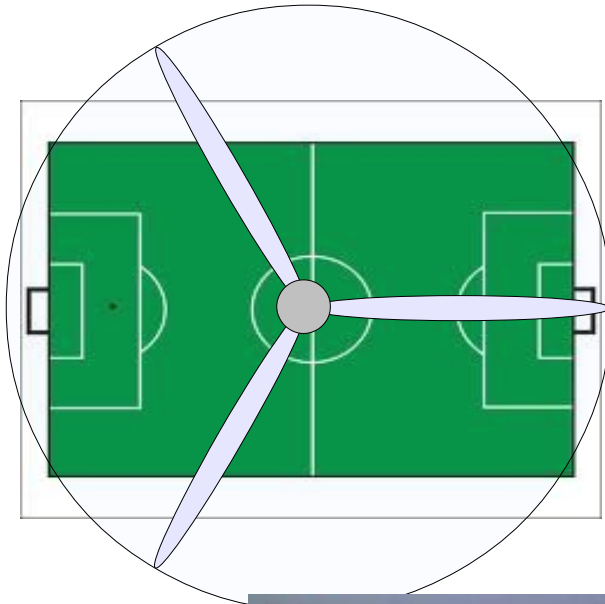


1. Bearings of Wind Turbines

Schaeffler, Schweinfurt (Germany)



Dimensions of Modern Wind Turbins

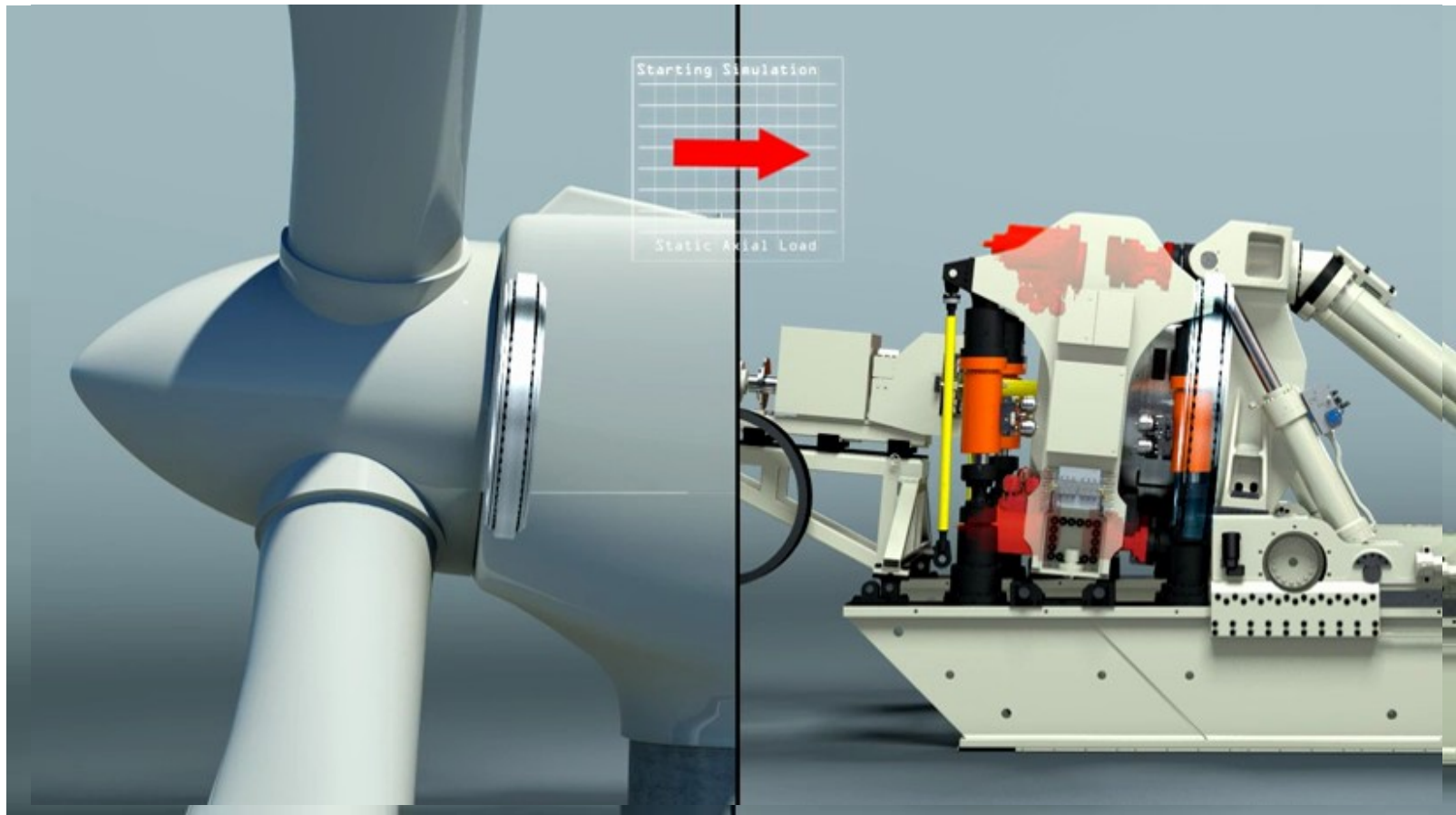


Live Time
> 20 Years



ASTRAIOS: Simulation of Forces

4 Radial + 4 Axial Hydraulic Cylinders



ASTRAIOS

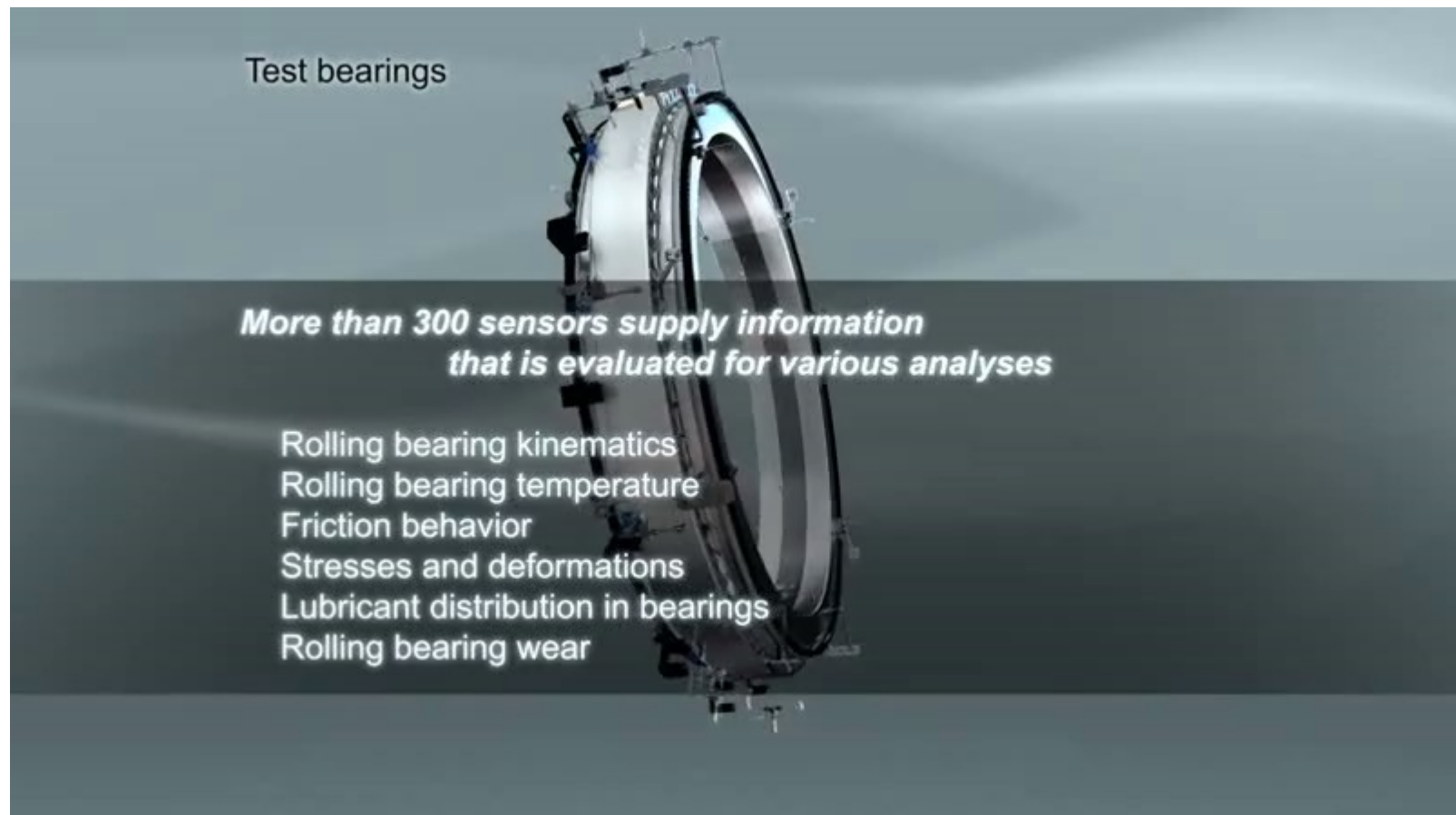


ASTRAIOS

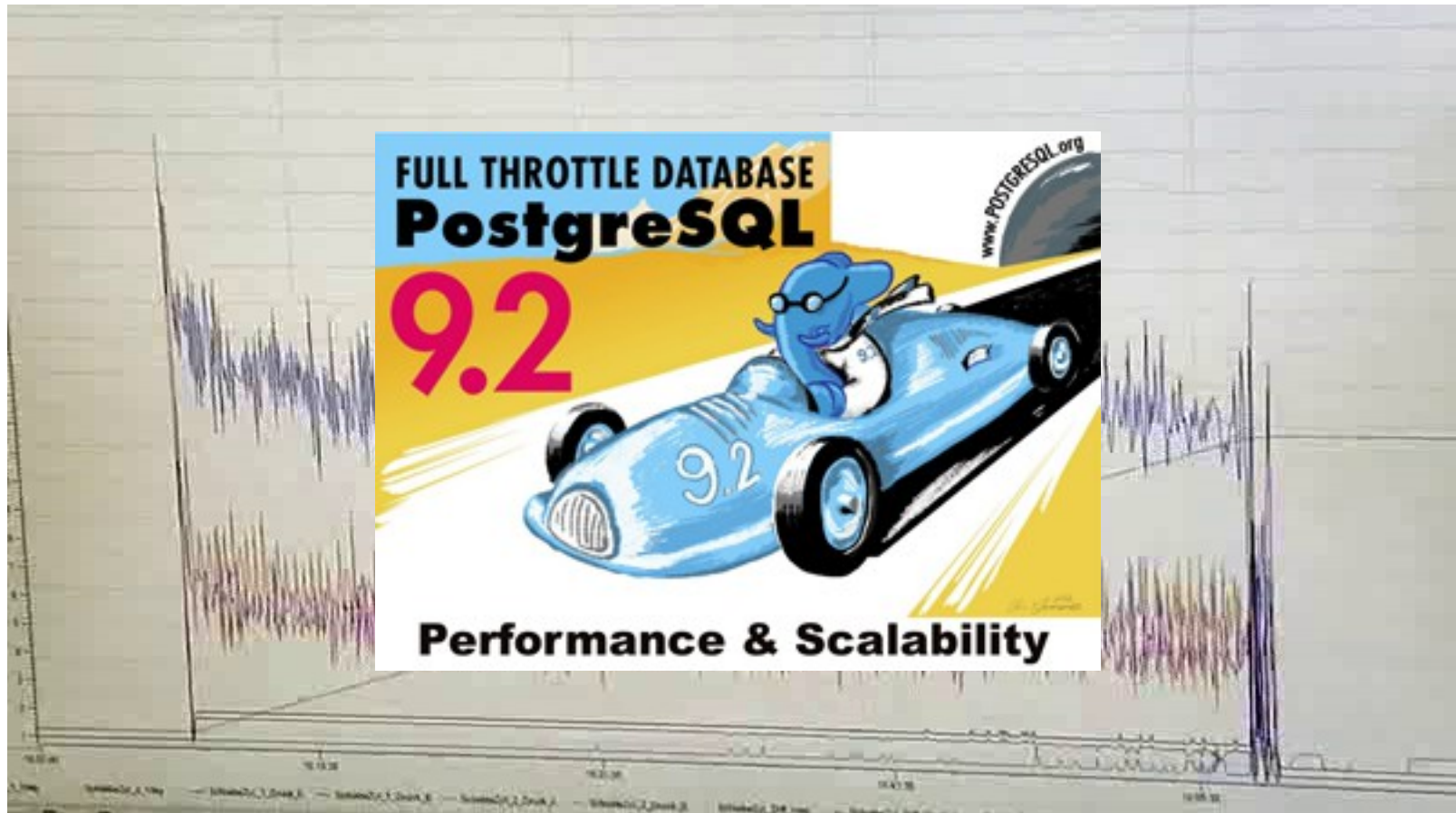


Sensors, Charts

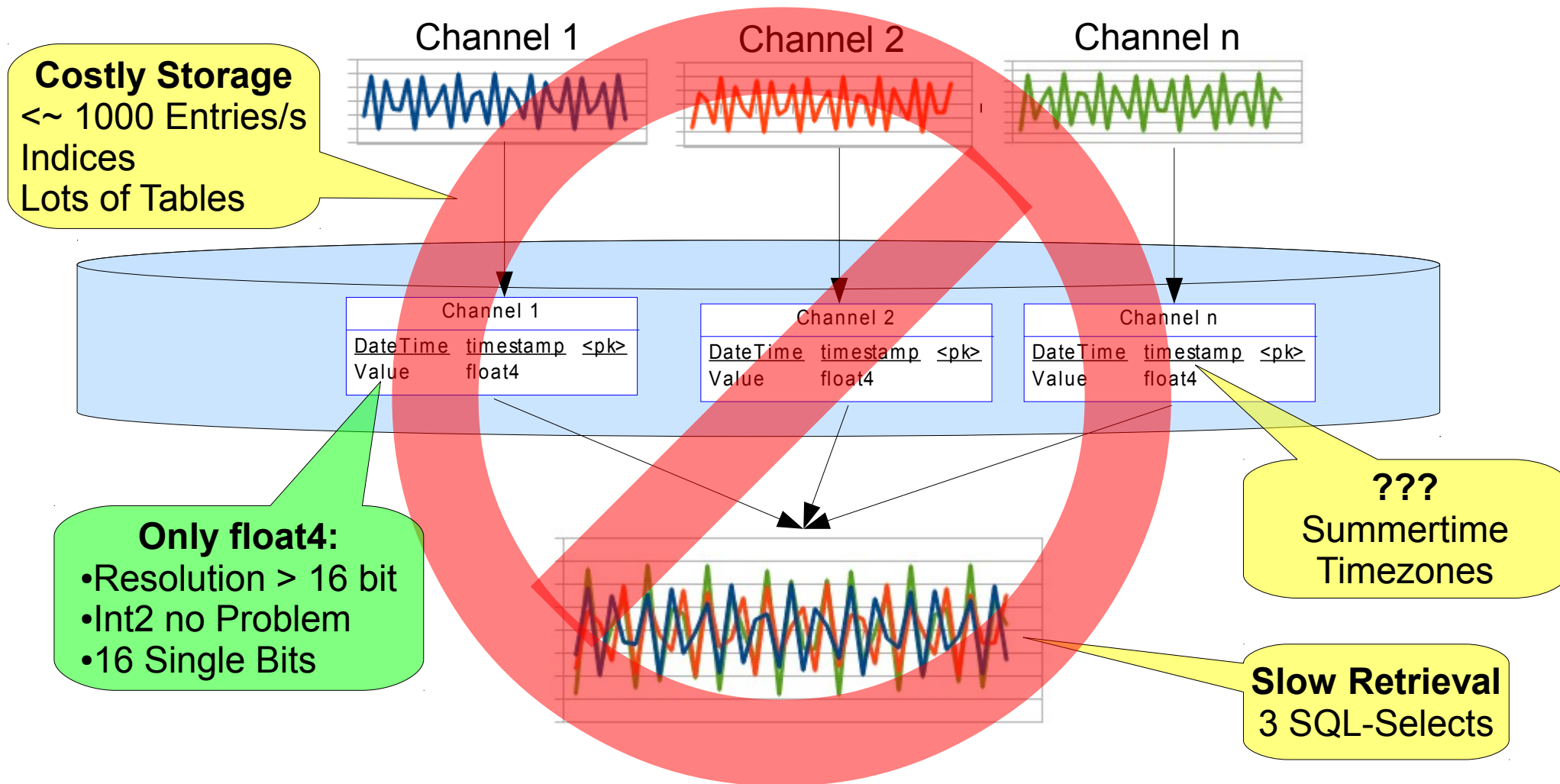
>300 Sensors: 1 kHz



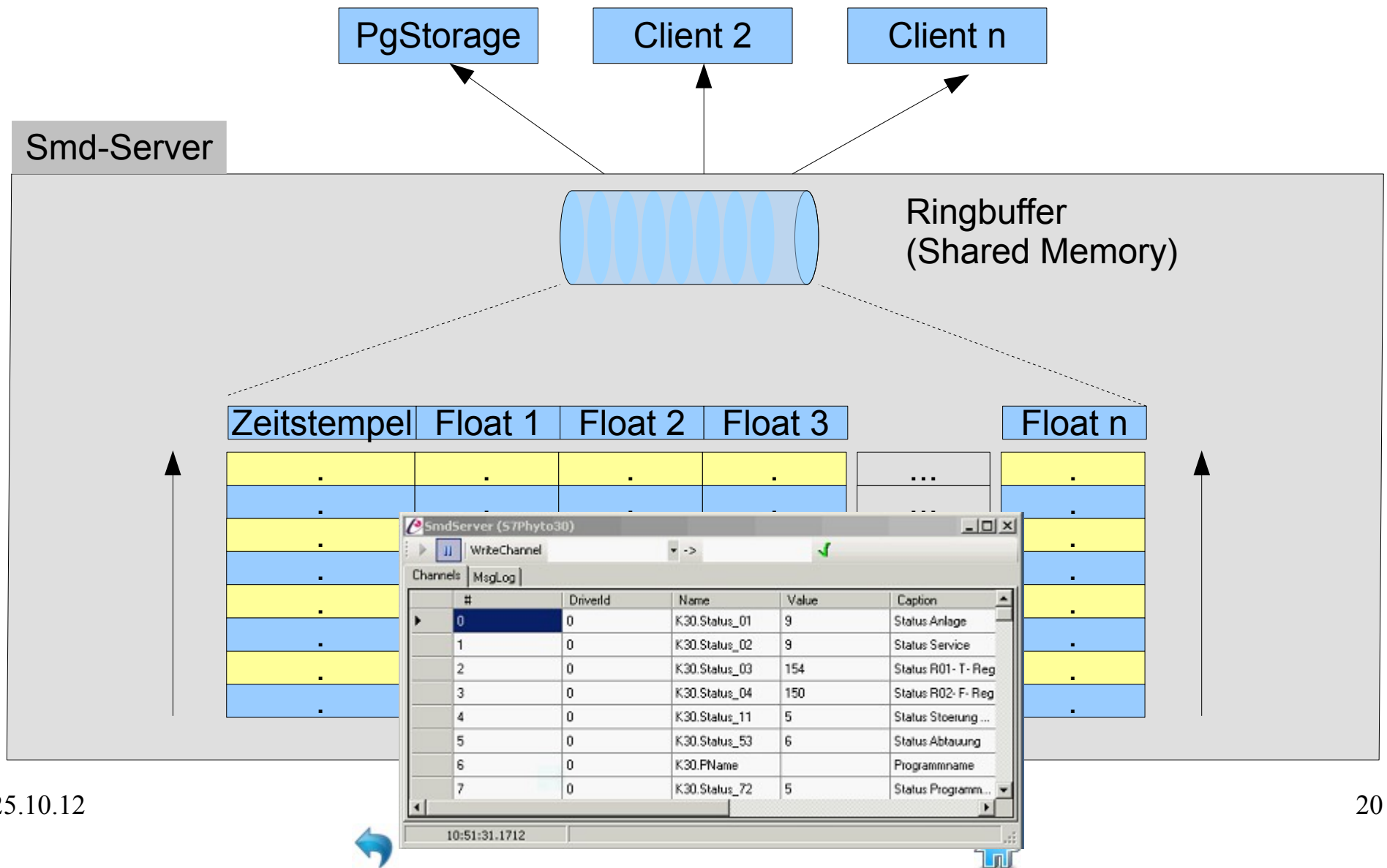
The Champion Enters the Arena



Storing Measurements (Simplest Way)



Storage: Ringbuffer



Storage: Packaging

DateTime	Float 1	Float 2	Float 3	...	Float n
t_n . (b)	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
(L) .	.	(M)	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.

DateTime	Float 1	Float 2	Float 3	...	Float n
$t_{(n-1)}$.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.
.	.	.	.	...	.

(b) •DateTime of Package

(c) • $dwell = t_n - t_{(n-1)}$

(d) •Count Of Measurements in Package

(e) • $[\min(\text{Float } 1), \min(\text{Float } 2), \dots, \min(\text{Float } n)]$

(f) • $[\max(\text{Float } 1), \max(\text{Float } 2), \dots, \max(\text{Float } n)]$

(g) • $[\text{avg}(\text{Float } 1), \text{avg}(\text{Float } 2), \dots, \text{avg}(\text{Float } n)]$

(h) • $[\text{cur}(\text{Float } 1), \text{cur}(\text{Float } 2), \dots, \text{cur}(\text{Float } n)]$

(L) •List of DateTimes in Package

(M) •Matrix of Measurements in Package

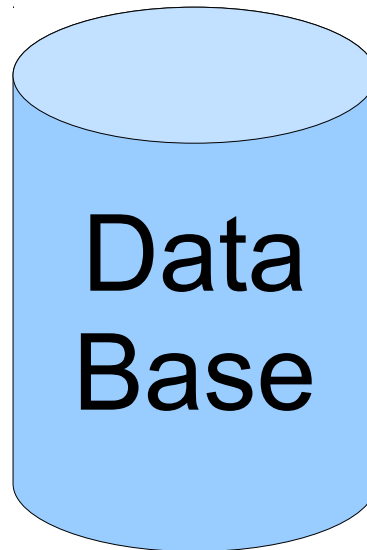
hischnset		
entry	bigserial	<pk>
status	INT4	
chnsetid	INT4	
dt_package	TIMESTAMP WITH TIME ZONE	
dwell	INTERVAL	
cnt_mv	INT4	
min_mv	FLOAT4[]	
max_mv	FLOAT4[]	
avg_mv	FLOAT4[]	
cur_mv	FLOAT4[]	
dt_list	bytea	
mv_array	bytea	

Sectioning of Database

Overflow
must be avoided

Backup of Data
> 100 Gbyte is a
Time Consuming
Job

Fast
Deletion of Data



•Storage of Data into
different **Schemas**
according to Timestamp

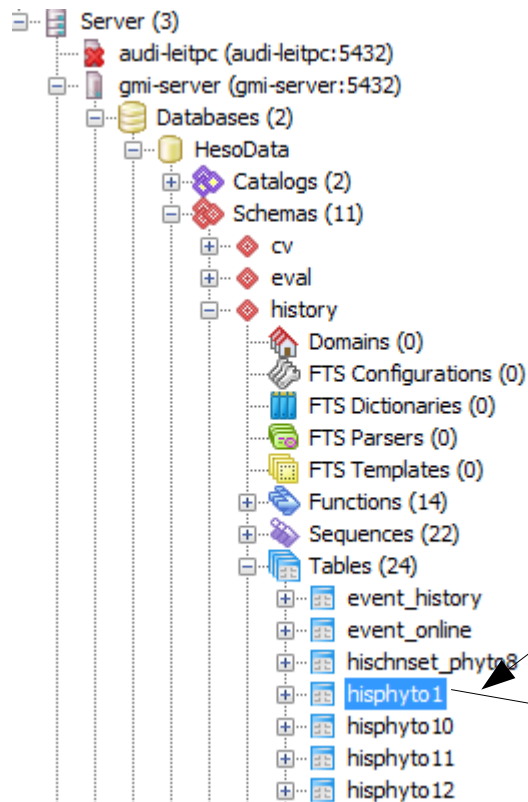
All Measurements of one
year (month, week, day, ...)
•into one separate Schema

•Per Schema
- Backup
- Restore
- Delete

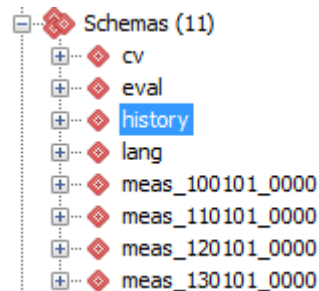


Sectioning of Database

One Table per Channel-Set



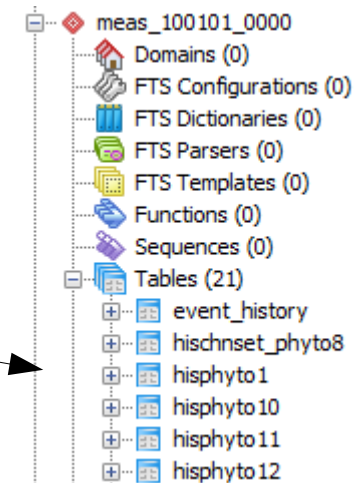
One Schema per Time-Period



Schemas for Measurements

- Starting 2010-01-01
- Starting 2011-01-01
- Starting 2012-01-01
- Starting 2013-01-01

Tables in Schema of Time-Period are Inherited



Empty Parent Tables

Inheritance

Sectioning of Database

- Parent Schema: History
 - Each ChannelSet $\rightarrow$ One History-Table
- Each Time-Period $\rightarrow$ One Schema
 - Tables inherited from History-Schema
- Automatic Generation of Schemas
- Automatic Generation of Rules for Update, ...



Aggregation in SQL Query Template

```

select min(entry), min(dt_package),
#ARRAY[,,,]#           -- e.g. ARRAY[ min(min_mv[1], max(max_mv[1]))
From {0}                -- e.g. history.Data
where status>0           -- is Valid
and chnsetid={1}        -- Same Channel-Config
and dt_package >='{2}'::timestampz -- From
and dt_package < '{3}'::timestampz -- To
group by floor(EXTRACT(EPOCH FROM dt_package)/#GroupRangeSec#)
order by 2
    
```

hischnset		
<u>entry</u>	<u>bigserial</u>	<u><pk></u>
status	INT4	
chnsetid	INT4	
dt_package	TIMESTAMP WITH TIME ZONE	
dwel	INTERVAL	
cnt_mv	INT4	
min_mv	FLOAT4[]	
max_mv	FLOAT4[]	
avg_mv	FLOAT4[]	
dt_list	bytea	
mv_array	bytea	

Retrieve requested Data
as an Array.

Meaning of Array-Indizes
in ChnSetId



Aggregation: GroupRangeSec

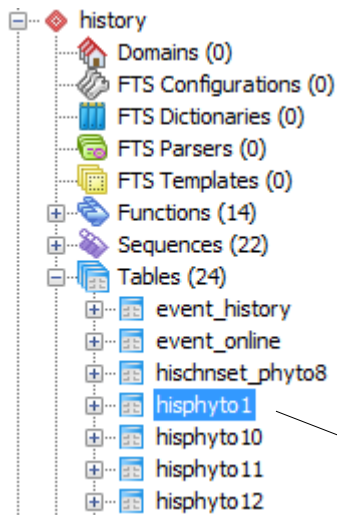
```
SELECT entry,  
       dt_package, EXTRACT(EPOCH FROM dt_package), floor(EXTRACT(EPOCH FROM dt_package)/600)  
FROM history.hisphyto1  
where dt_package between '2011-02-01 00:00:00' and '2011-02-02 01:00:00'  
order by 4
```

	entry bigint	dt_package timestamp with time zone	date_part double precision	floor double precision
1	235338	2011-02-01 00:00:00+01	1296514800	2160858
2	235339	2011-02-01 00:02:00+01	1296514920	2160858
3	235340	2011-02-01 00:04:00+01	1296515040	2160858
4	235341	2011-02-01 00:06:00+01	1296515160	2160858
5	235342	2011-02-01 00:08:00+01	1296515280	2160858
6	235343	2011-02-01 00:10:00+01	1296515400	2160859
7	235344	2011-02-01 00:12:00+01	1296515520	2160859
8	235345	2011-02-01 00:14:00+01	1296515640	2160859
9	235346	2011-02-01 00:16:00+01	1296515760	2160859
10	235347	2011-02-01 00:18:00+01	1296515880	2160859
11	235348	2011-02-01 00:20:00+01	1296516000	2160860
12	235349	2011-02-01 00:22:00+01	1296516120	2160860
13	235350	2011-02-01 00:24:00+01	1296516240	2160860
14	235351	2011-02-01 00:26:00+01	1296516360	2160860
15	235352	2011-02-01 00:28:00+01	1296516480	2160860
16	235353	2011-02-01 00:30:00+01	1296516600	2160861
17	235354	2011-02-01 00:32:00+01	1296516720	2160861

GroupRangeSec
= 10 min



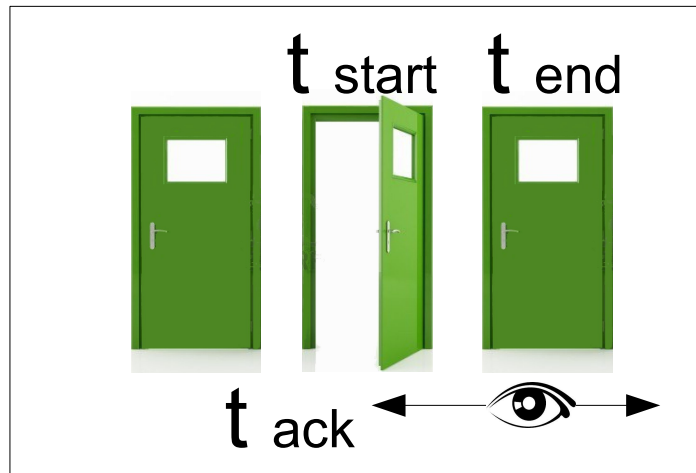
Definition of Retrieval-Strategy XML in Comment of Table



```
<Parameters>
  <!--TimeSpan in C#-Notation -->
  <!-- Timespan, to split SQL-Queries -->
  <Parameter Name="QuerySplitTime" TimeSpan="10.00:00:00" />
  <!-- Timespan between 2 entries in Detail-Data -->
  <Parameter Name="DetailReadInterval" TimeSpan="00:00:00.010" />
  <!-- Below this Timespan, Access to Detail-Data -->
  <Parameter Name="ThresholdOfDetailMode" TimeSpan="00:10:00" />
  <!-- Above this Timespan, Acces to additional Aggregated Table -->
  <Parameter Name="ThresholdOfAggregatedTable"
    TimeSpan="2.00:00:00" Table="#this#_l300"/>
  <!-- Additional Threshold for aggregated tables of higher level -->
</Parameters>
```



Trigger Driven Alarm System



event_online		
<u>event_id</u>	INT4	<pk>
event_name	varchar(80)	
priority	INT4	
his_entry	bigint	
description	TEXT	
start_time	TIMESTAMP WITH TIME ZONE	
end_time	TIMESTAMP WITH TIME ZONE	
ack_time	TIMESTAMP WITH TIME ZONE	

TRIGGER: BEFORE UPDATE

- Depending on
- (OLD.--- , NEW.---) = (null, not null)
 - insert into event_history ..
 - update event history ...

event_history		
<u>entry</u>	bigserial	<pk>
event_name	varchar(80)	
description	TEXT	
start_time	TIMESTAMP WITH TIME ZONE	
end_time	TIMESTAMP WITH TIME ZONE	
ack_time	TIMESTAMP WITH TIME ZONE	

2. Corrosion Protection Audi, Ingolstadt (Germany)

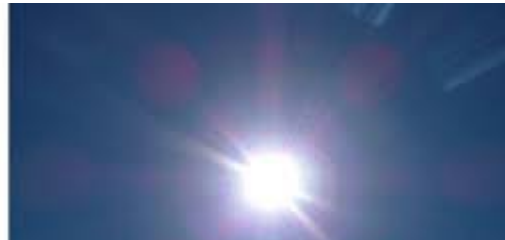


Reproducible Simulation of Enviromental Stress

Heat and Humidity



Sun (Vis + UV)



Frost



Rain



Stone Chips

Salt



Road Holes



Corrosion Center: 12 Years within 19 Weeks



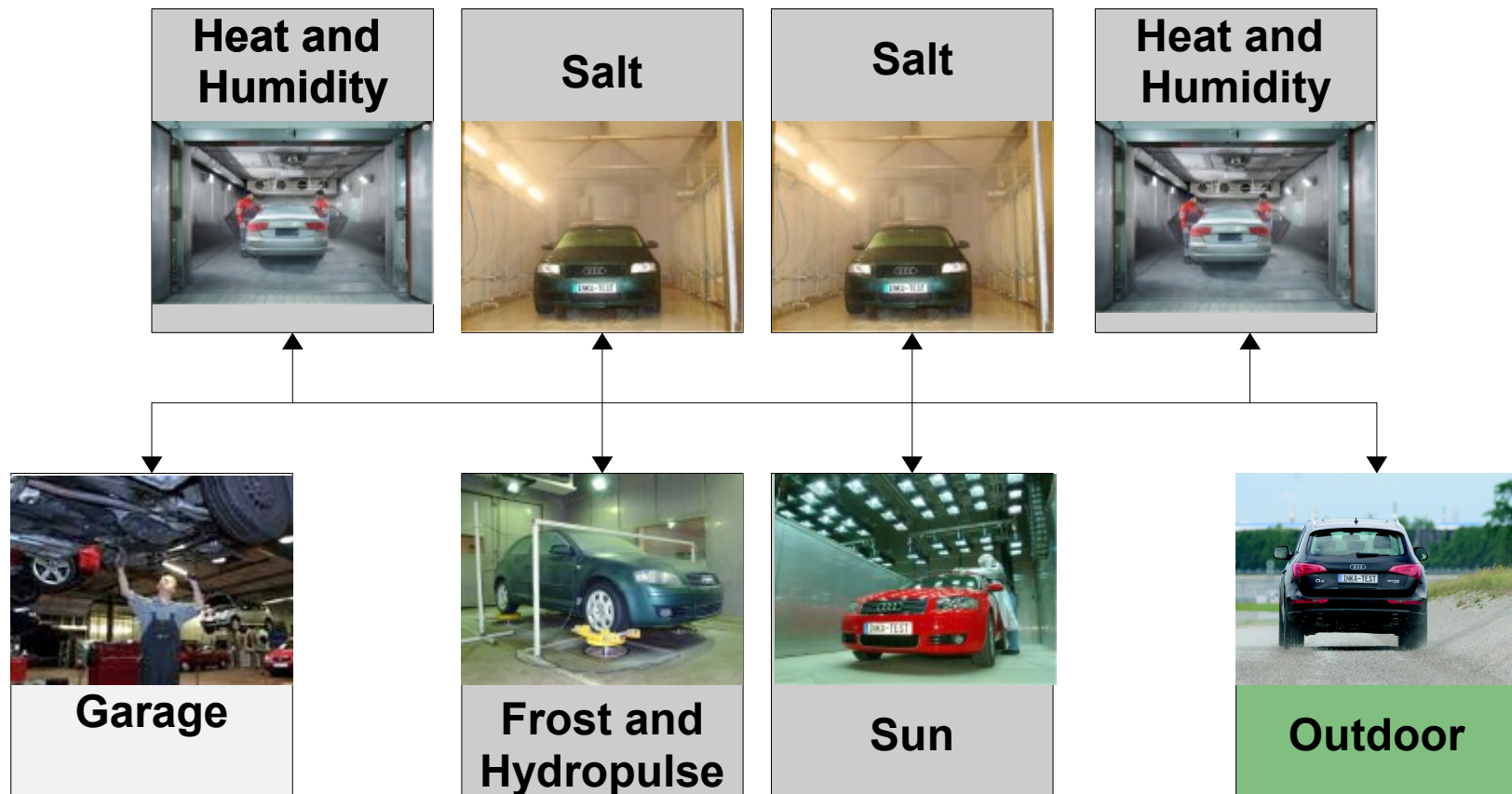
25.10.12

© Hesotech GmbH / R. Sonnenschein

33



Changeover of Cars



12 Years within 19 Weeks

- Equal and reproducible treatment of all cars
 - 12 cars simultaneous under test
 - 8 different environmental facilities
 - 10 different treatment types
 - 3 changeovers per car and day
 - 250 changeovers per car
 - 2 different chamber profiles:
 - workday, weekend
- **Everything well scheduled and documented**



The Champion Enters the Arena



Schedule for Changeover of Cars

Working Day

Enviromental Chamber

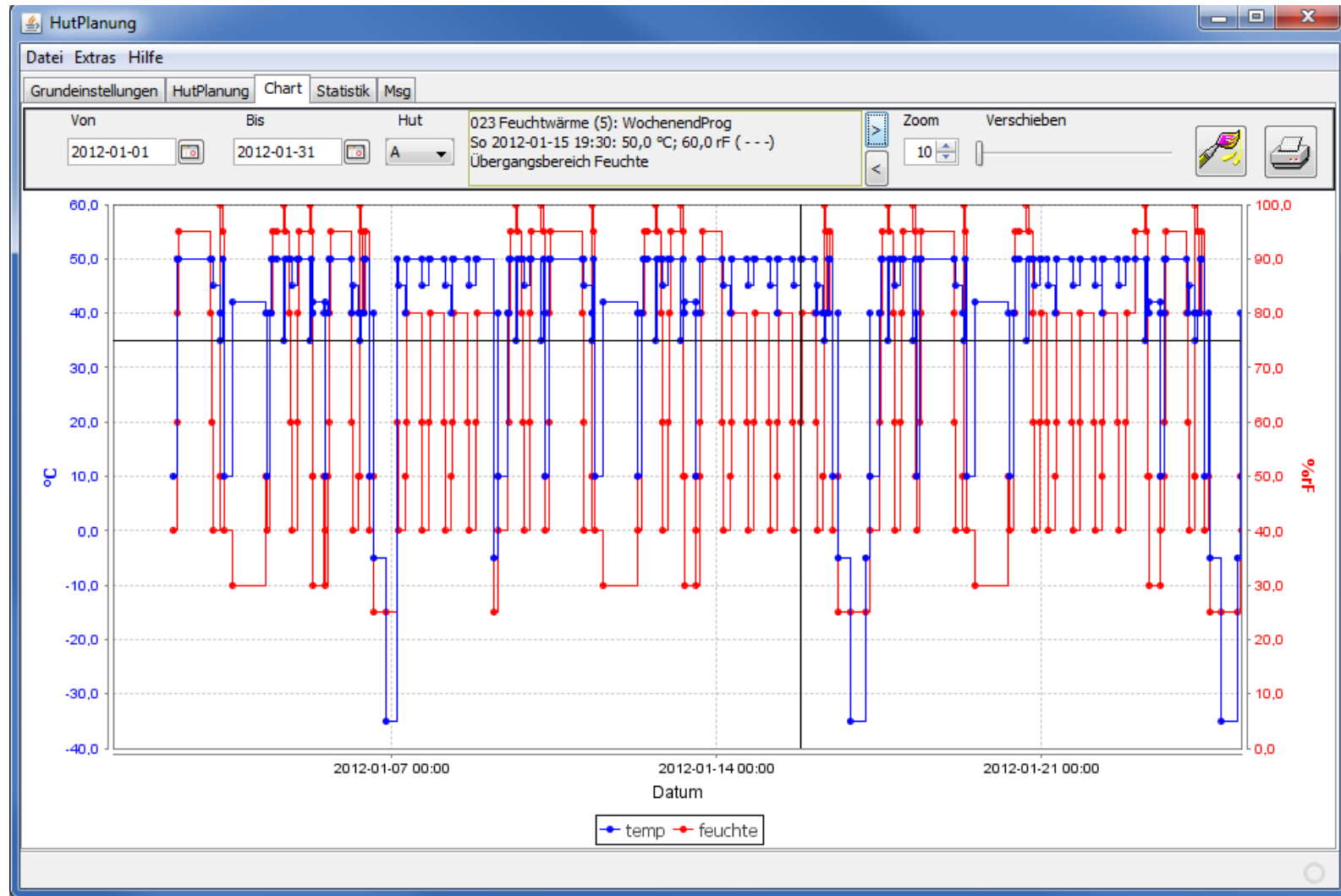
Weekend

Changeover of Cars

Datum	007 Feuchtwärme	011 Salzsprüh	015 Salzsprüh	019 Salzsp...	023 Feuchtwärme	032 Sonne	018 Kälte	Teststrecke
2012-01-06	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg
-> 1		G: 07:15 H: 07:15	A: 07:15 B: 07:15			K: 07:15 L: 07:15		C: 07:15 D: 07:15
-> 2								E: 07:20 F: 07:20
-> 3	E: 09:15 F: 09:15		I: 09:15 J: 09:15					I: 07:25 J: 07:25
-> 4								G: 09:15 H: 09:15
-> 5		C: 12:15 D: 12:15						A: 12:15 B: 12:15
-> 6						G: 13:30 H: 13:30		K: 13:30 L: 13:30
-> 7					K: 15:15 L: 15:15		A: 14:30 B: 14:30	
2012-01-07	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg
2012-01-08	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg	WochenendProg
2012-01-09	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg
-> 1		E: 07:15 F: 07:15	K: 07:15 L: 07:15			I: 07:15 J: 07:15		A: 07:15 B: 07:15
-> 2								C: 07:20 D: 07:20
-> 3	C: 09:15 D: 09:15		G: 09:15 H: 09:15					G: 07:25 H: 07:25
-> 4								E: 09:15 F: 09:15
-> 5		A: 12:15 B: 12:15						K: 12:15 L: 12:15
-> 6						E: 13:30 F: 13:30		I: 13:30 J: 13:30
-> 7					I: 15:15 J: 15:15		K: 14:30 L: 14:30	
2012-01-10	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg	ArbeitstagProg
-> 1		C: 07:15 D: 07:15	I: 07:15 J: 07:15			G: 07:15 H: 07:15		K: 07:15 L: 07:15
-> 2								A: 07:20 B: 07:20



Scheduled Treatments: Chart



Scheduled Treatments: Crosstab

HutPlanung

Datei Extras Hilfe

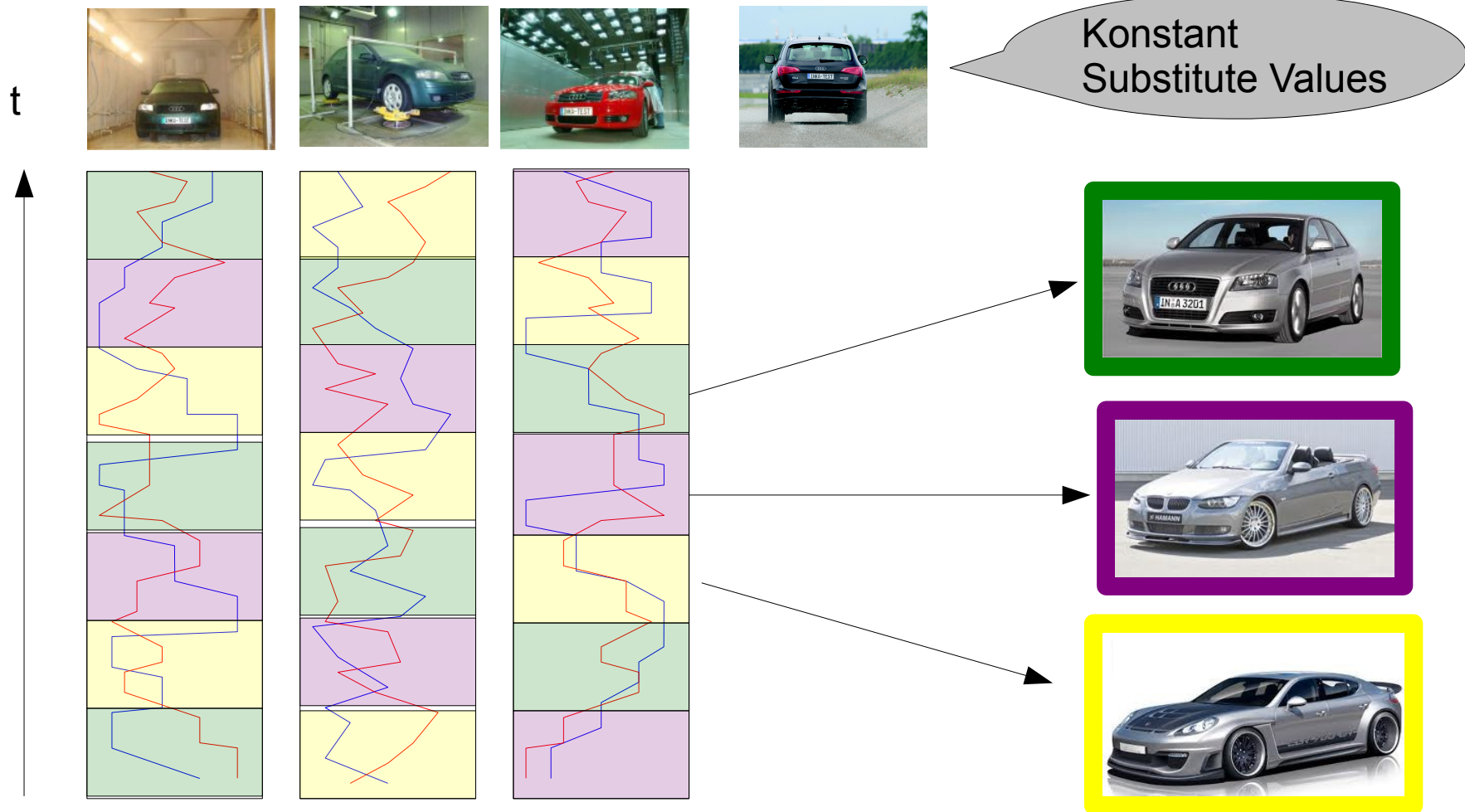
Grundeinstellungen HutPlanung Chart Statistik Msg

Von 2012-01-02 Bis 2012-01-31

696,0 Stunden = 29,00 Tage

	Soll %	A		B		C		D		E		F	
		Anzahl	Stunden	Anzahl	Stunden	Anzahl	Stunden	Anzahl	Stunden	Anzahl	Stunden	Anzahl	Stunden
		Tage	%	Tage	%	Tage	%	Tage	%	Tage	%	Tage	%
1: Salzsprühen	3,0	20	20,0	20	20,0	21	21,0	21	21,0	21	21,0	21	21,0
		0,8	2,9	0,8	2,9	0,9	3,0	0,9	3,0	0,9	3,0	0,9	3,0
2: Trocknen ohne Sonne	19,5	30	102,0	30	102,0	29	97,3	29	97,3	30	100,3	30	100,3
		4,3	14,7	4,3	14,7	4,1	13,9	4,1	13,9	4,2	14,3	4,2	14,3
3: Trocknen mit Sonne	11,1	10	88,5	10	88,5	12	100,0	12	100,0	11	82,5	11	82,5
		3,7	12,7	3,7	12,7	4,2	14,3	4,2	14,3	3,4	11,8	3,4	11,8
4: Kälte -5°C	3,8	6	24,0	6	24,0	6	24,0	6	24,0	7	30,0	7	30,0
		1,0	3,5	1,0	3,5	1,0	3,4	1,0	3,4	1,3	4,3	1,3	4,3
5: Kälte -35	3,7	3	22,0	3	22,0	3	22,0	3	22,0	4	30,0	4	30,0
		0,9	3,2	0,9	3,2	0,9	3,1	0,9	3,1	1,3	4,3	1,3	4,3
6: Feuchtwärme 95	27,3	44	185,5	44	185,5	46	185,3	46	185,3	46	186,8	46	186,8
		7,7	26,7	7,7	26,7	7,7	26,5	7,7	26,5	7,8	26,7	7,8	26,7
7: Feuchtwärme 80	20,7	54	141,0	54	141,0	53	136,5	53	136,5	55	137,0	55	137,0
		5,9	20,3	5,9	20,3	5,7	19,5	5,7	19,5	5,7	19,6	5,7	19,6
8: Teststrecke	3,4	21	59,0	21	59,0	21	58,8	21	58,8	21	56,8	21	56,8
		2,5	8,5	2,5	8,5	2,5	8,4	2,5	8,4	2,4	8,1	2,4	8,1

Stitching Measured Curves of Stress



Car under Test: Treatments

FzgAuswertung

File

Auswertung Einstellungen Meldungen

☒ Nur aktuelle FZG Fz-Typ von 2010-08-24 15:15 Auftrag I/EG-72Nr.254

Hut D SerienNr. 98ZCS120029 Bis 2011-01-31 07:15 Kunde NULL

Behandlungen Statistik Histogramme Diagramme

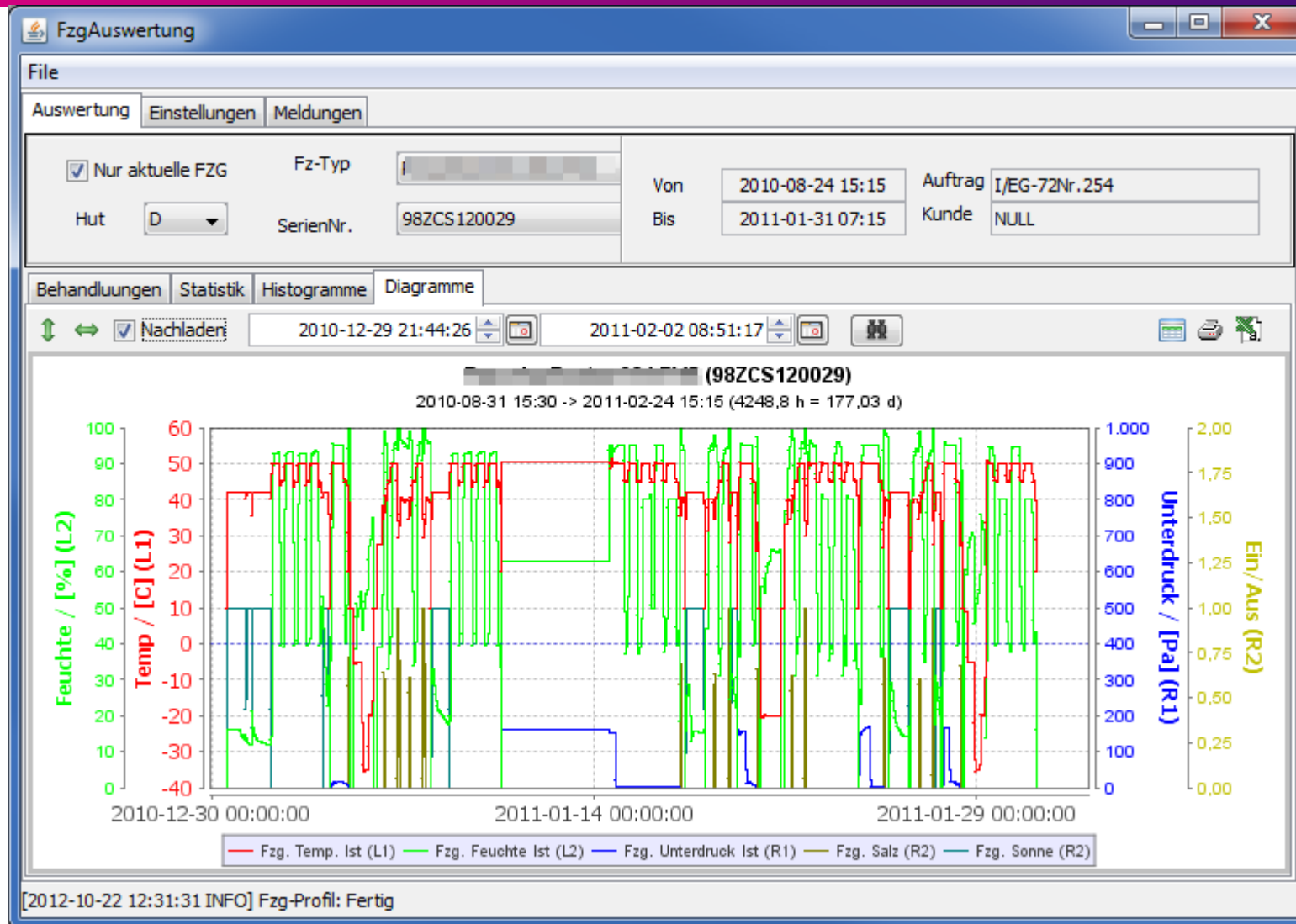
Alle 98ZCS120029.1 2010-08-31 15:30 --> 98ZCS120029.271 2011-02-24 15:15

	Kammer	FZW	Position	Startzeit	Endezeit	Zus
⊖	011 Salzsprüh	98ZCS120029.259	Rechts	2011-01-25 07:15	2011-01-25 12:15	
⊖	Teststrecke	98ZCS120029.260	-/-	2011-01-25 12:15	2011-01-25 13:30	
⊖	032 Sonne	98ZCS120029.261	Rechts	2011-01-25 13:30	2011-01-26 07:25	
⊖	Teststrecke	98ZCS120029.262	-/-	2011-01-26 07:25	2011-01-26 09:15	
⊖	015 Salzsprüh	98ZCS120029.263	Rechts	2011-01-26 09:15	2011-01-27 07:15	
⊖	032 Sonne	98ZCS120029.264	Rechts	2011-01-27 07:15	2011-01-27 13:30	
⊖	Teststrecke	98ZCS120029.265	-/-	2011-01-27 13:30	2011-01-27 15:15	
⊖	023 Feuchtwärme	98ZCS120029.266	Rechts	2011-01-27 15:15	2011-01-28 07:15	
⊖	015 Salzsprüh	98ZCS120029.267	Rechts	2011-01-28 07:15	2011-01-28 09:15	
⊖	Teststrecke	98ZCS120029.268	-/-	2011-01-28 09:15	2011-01-28 11:15	
⊖	Werkstatt	98ZCS120029.269	-/-	2011-01-28 11:15	2011-01-28 14:30	
⊖	018 Kälte	98ZCS120029.270	Rechts	2011-01-28 14:30	2011-01-31 07:15	
⊖	Werkstatt	98ZCS120029.271	-/-	2011-01-31 07:15	2011-02-24 15:15	

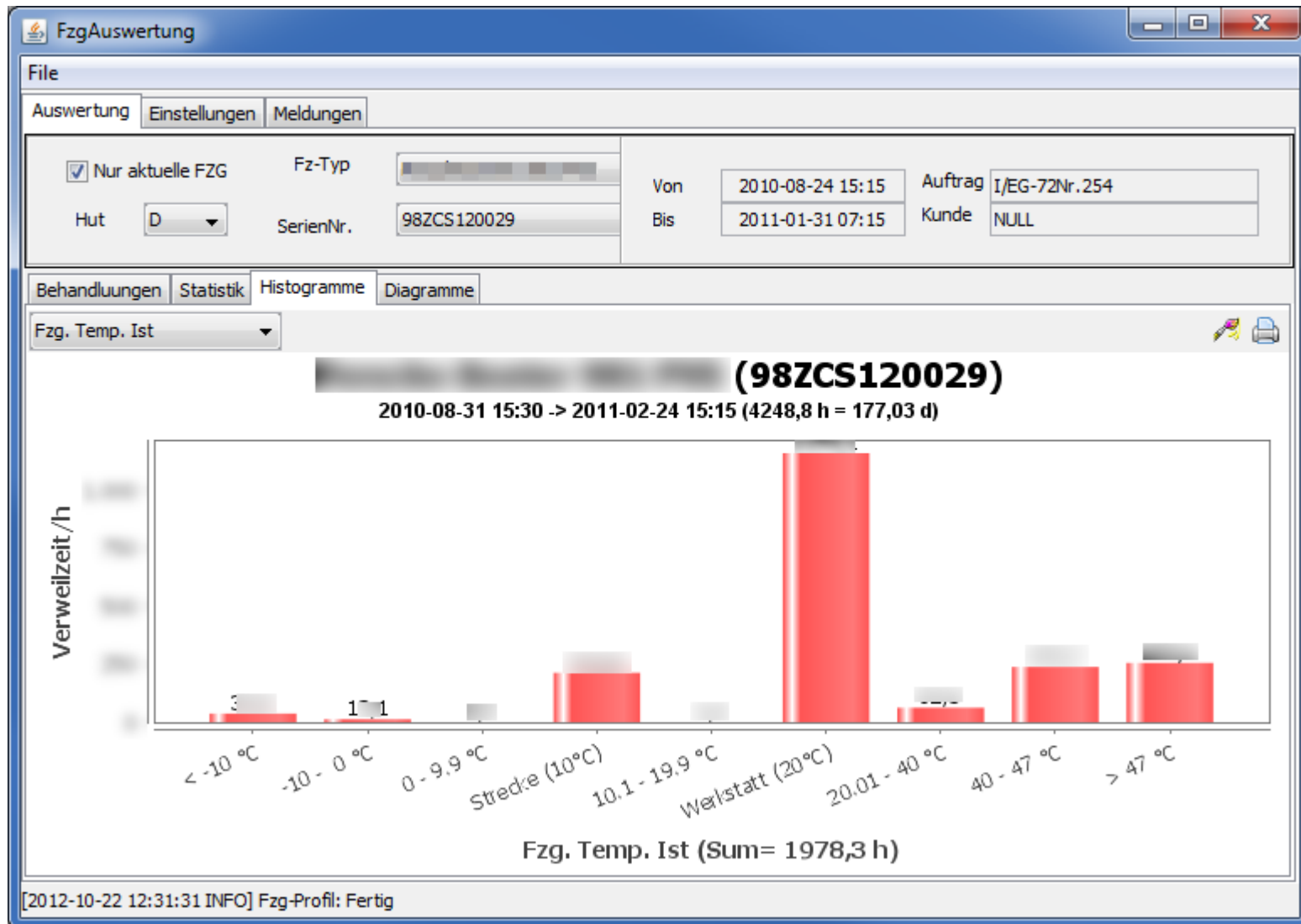
[2012-10-22 12:31:31 INFO] Fzg-Profil: Fertig



Car under Test: Chart

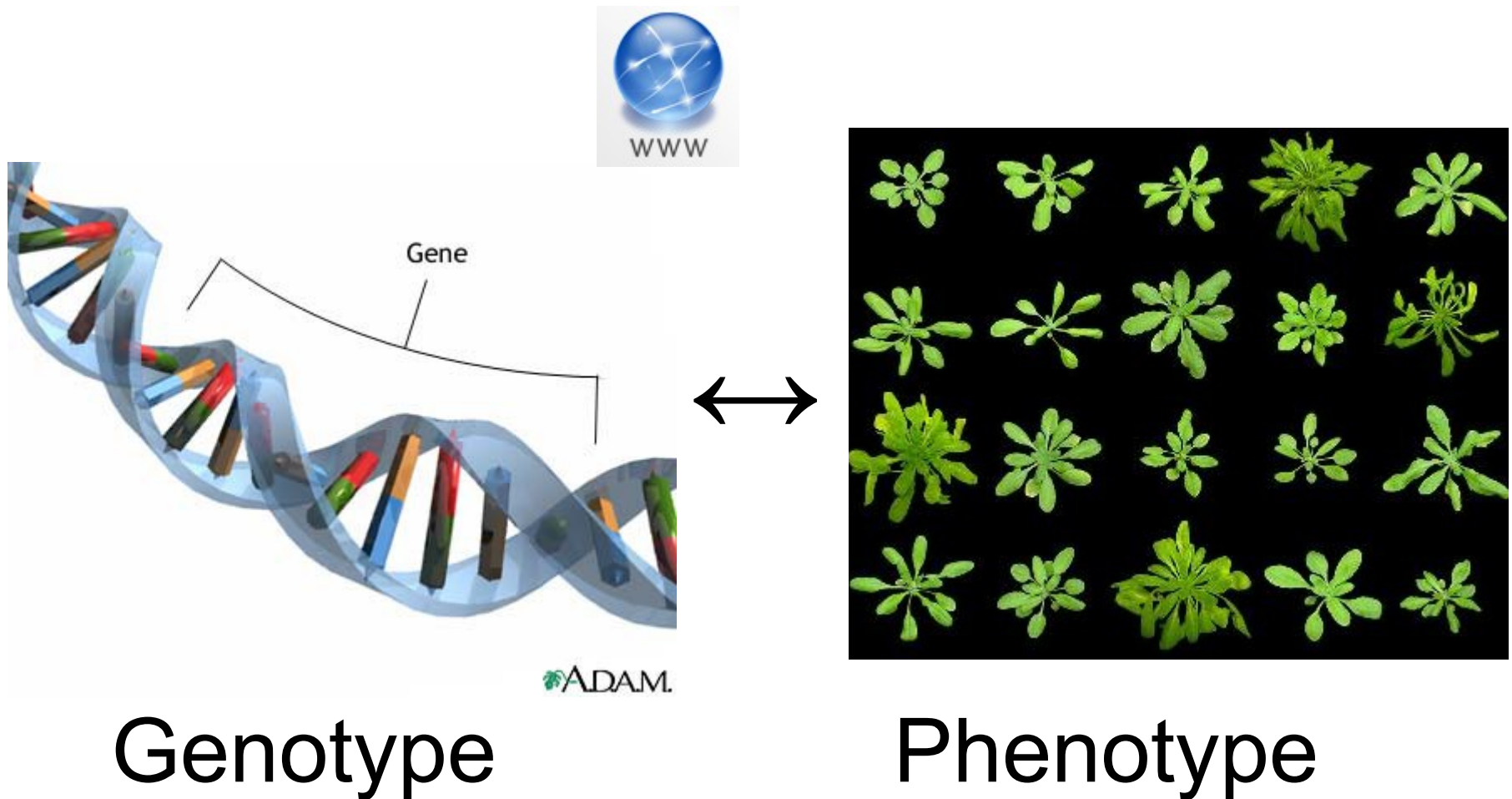


Car under Test: Statistics



3. Plant Genetics

Gregor-Mendel-Institute, Vienna



Phyto-Chambers at the GMI



Mass Phenotyping Image Scan



Mosaik + Tile

- Total shelf is recorded
- Mosaic = Matrix of Tiles
- Region Of Interest (ROI) = Rectangle on mosaic
 - Region of plant
 - Stitched on demand

(0,0)	(1,0)	(2,0)	(3,0)
(0,1)	(1,1)	(2,1)	(3,1)
(0,2)	(1,2)	(2,2)	(3,2)
(0,3)	(1,3)	(2,3)	(3,3)
(0,4)	(1,4)	(2,4)	(3,4)
(0,5)	(1,5)	(2,5)	(3,5)

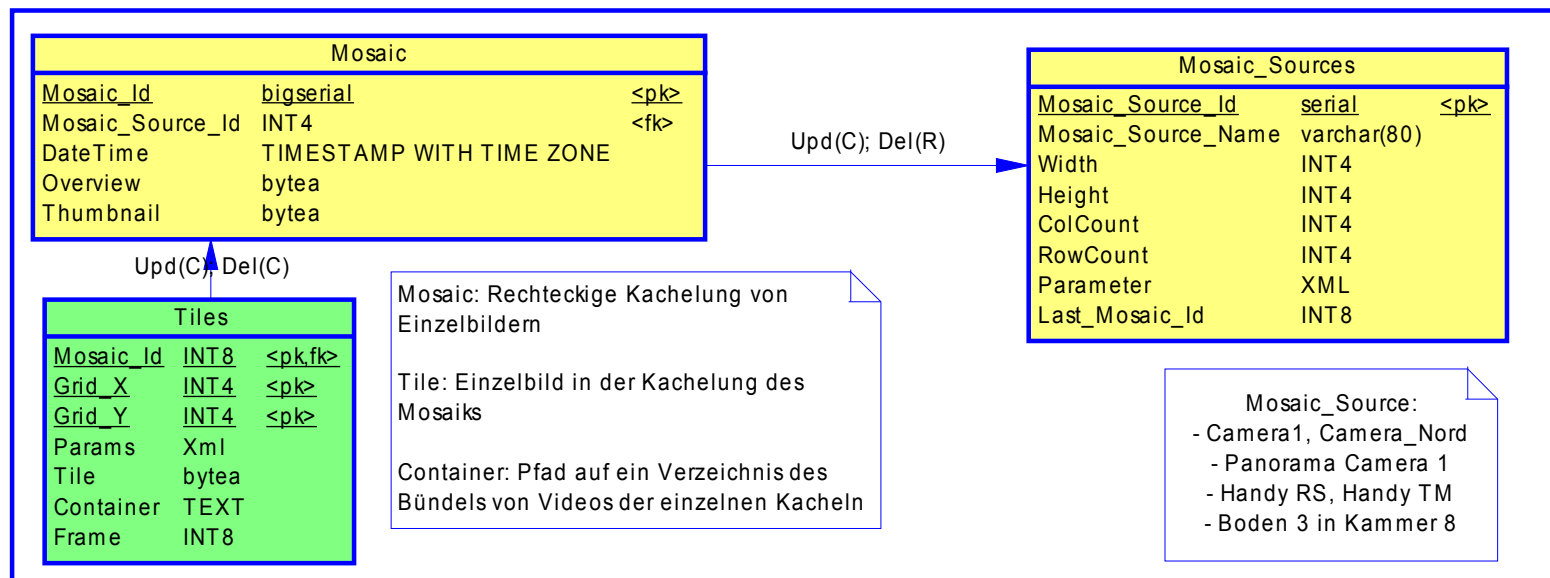


The Champion Enters the Arena



Storing Mosaic + Tiles

DB-Function: getMosaicOfRoi(mosaicId, roi)

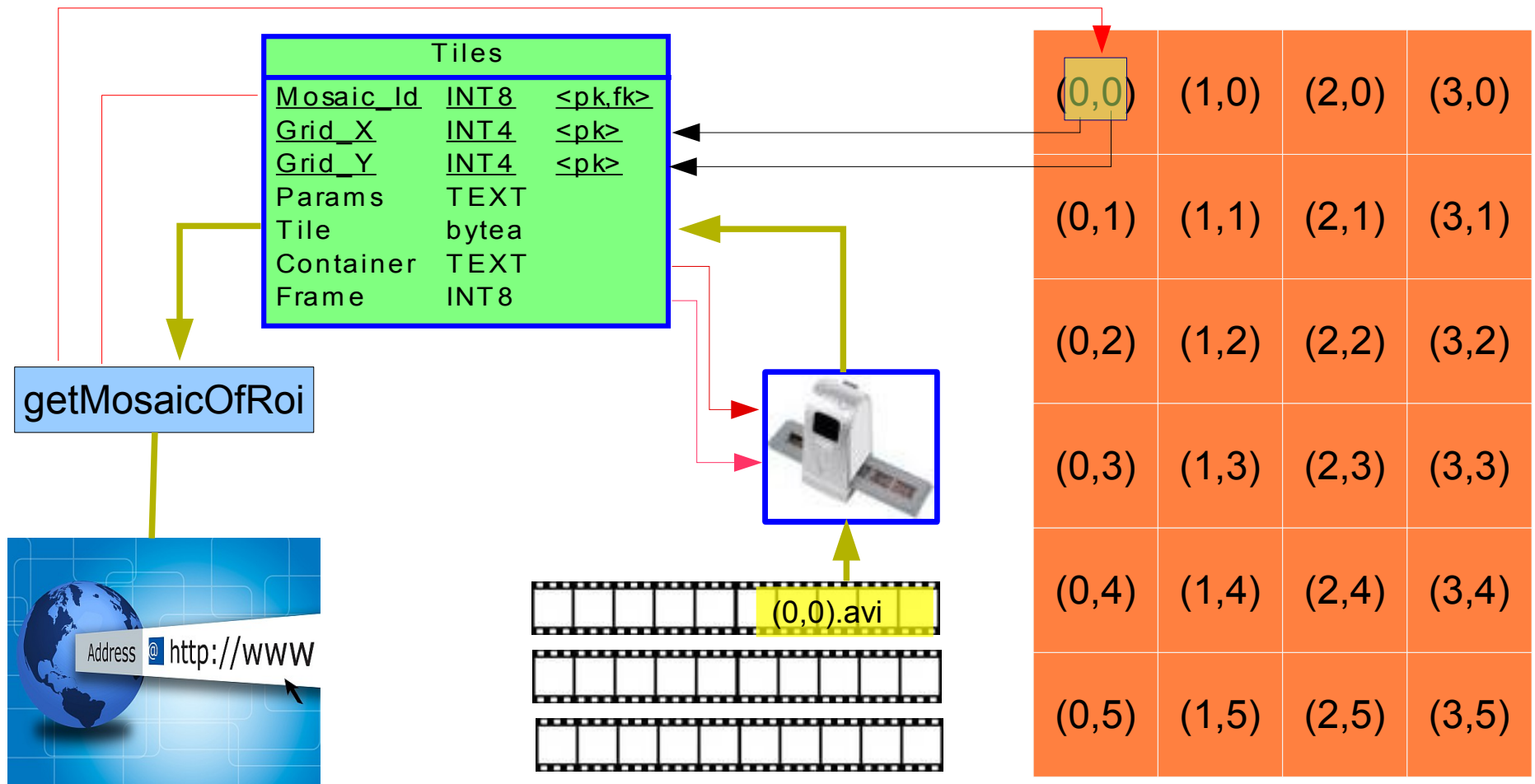


Long term storage of tile in Video

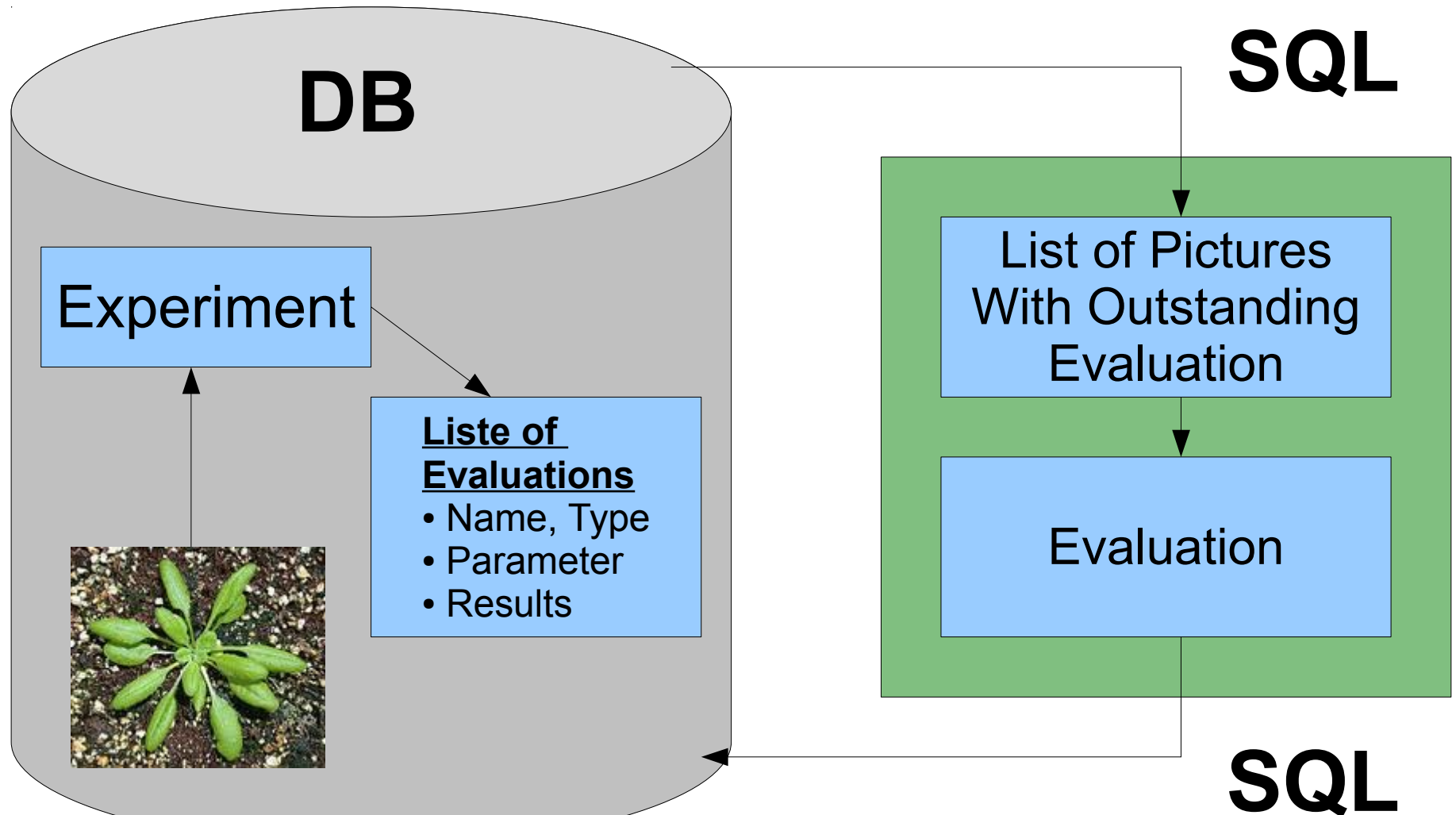
- Mosaic-Video = Bundle of Tile-Videos

Lots of Images!

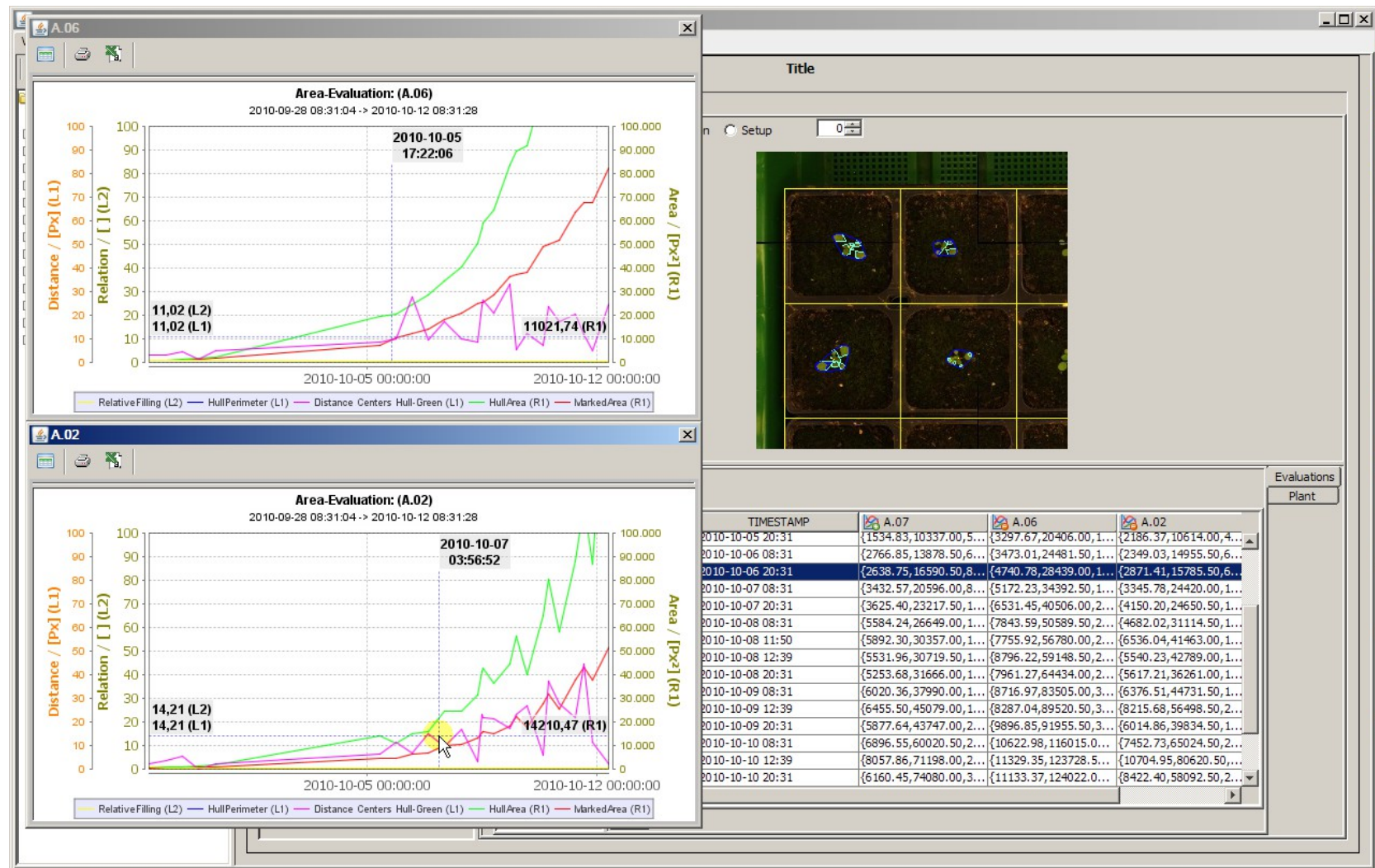
Bundle of Videos



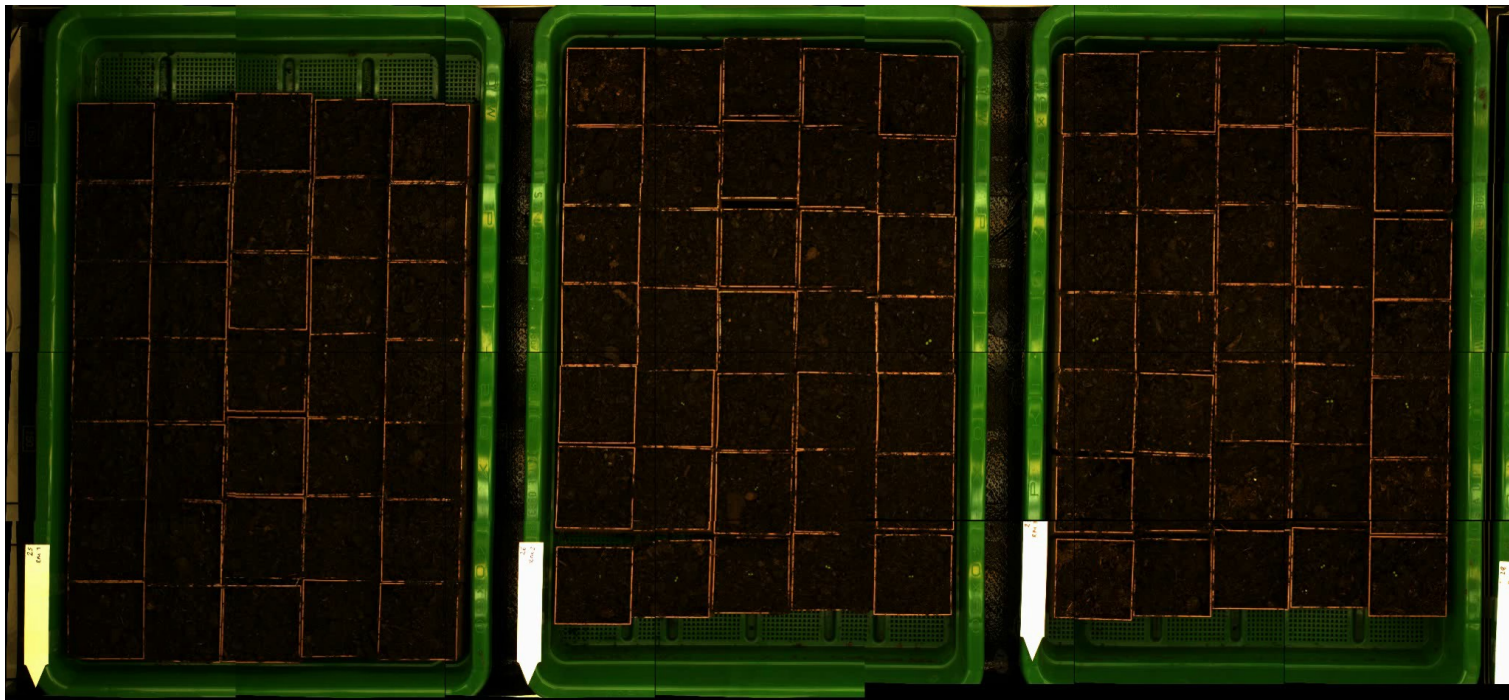
External Evaluation (Principles)



Graphical User Interface



Video of Plant Growth: Overview



PostgreSQL Experiences

- PostgreSQL is much more the the backend of a persistence framework
 - Be careful using Hibernate
- PostgreSQL makes live easier
 - Referential integrity,
 - Triggers
 - Procedures
 - C-Functions
 - Complex Datatypes



PostgreSQL Experiences

- Excellent Stability
- Very good functionality
 - Procedural languages
 - PgSql, Java, Perl, V8, ...
 - Debug ability
 - Expandable with own C-Functions
 - Complex datatypes (Xml, JSON, HStore, ...)
- Very good documentation
- pg_backup, pg_restore very slow



References

- **Wind Turbines**

- http://www.fag.de/content.fag.de/en/branches/industry/wind_energy/wind_energy_service/largesizebearingteststand/ast-raios.jsp
- <http://www.land-der-ideen.de/presse/meldung/365-orte-im-land-ideen-empfang-bundes-und-publikumssieger-2012>
- <http://www.br.de/radio/bayern2/sendungen/regionalzeit-franken/teststand-fuer-windkraftanlagen100.html>

- **Corrosion Prevention**

- <http://www.umweltsimulationen.com/anwendungsberichte/korrossionskammern.html>
- <http://www.hesotech.de/anwendungsberichte/phaenotypisierung.html>
- http://www.focus.de/fotos/der-inka-test-verlangt-dem-auto-alles-ab-unter-den-extrembedingungen_mid_493179.html
- <http://www.autobild.de/artikel/korrosionsschutz-49074.html>
- <http://www.motor-talk.de/videos/audi-perfektion-audi-qualitaet-ist-einzigartig-v6842.html>
- <http://youtu.be/mwUp6RDNo-I>

- **Plant Genetics**

- <http://www.gmi.oeaw.ac.at>
- <http://www.gmi.oeaw.ac.at/documents/media-files/growth-chamber-video>



Feedback

<http://2012.pgconf.eu/feedback/>

