PostgreSQL in Research and Development

Three Success Stories

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automatisieren – visualisieren

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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**
  - Hugh amount of measurements

SCHAEFFLER
LuK INA FAG

- **Corrosion Protection**
  - **+** Complex Administration-Data

Audi

- **Plant Genetics**
  - **+** Image Storage and Processing

GMI

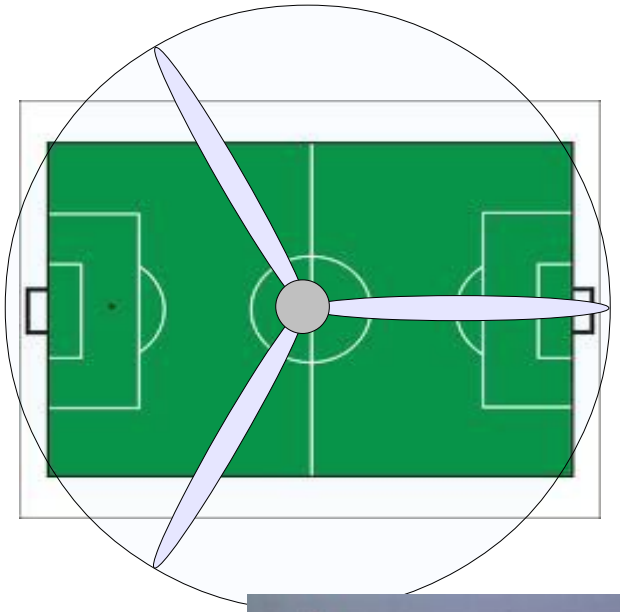
Agenda Each Story

1. Technical background explanations

2. Point, where our champion enters the arena

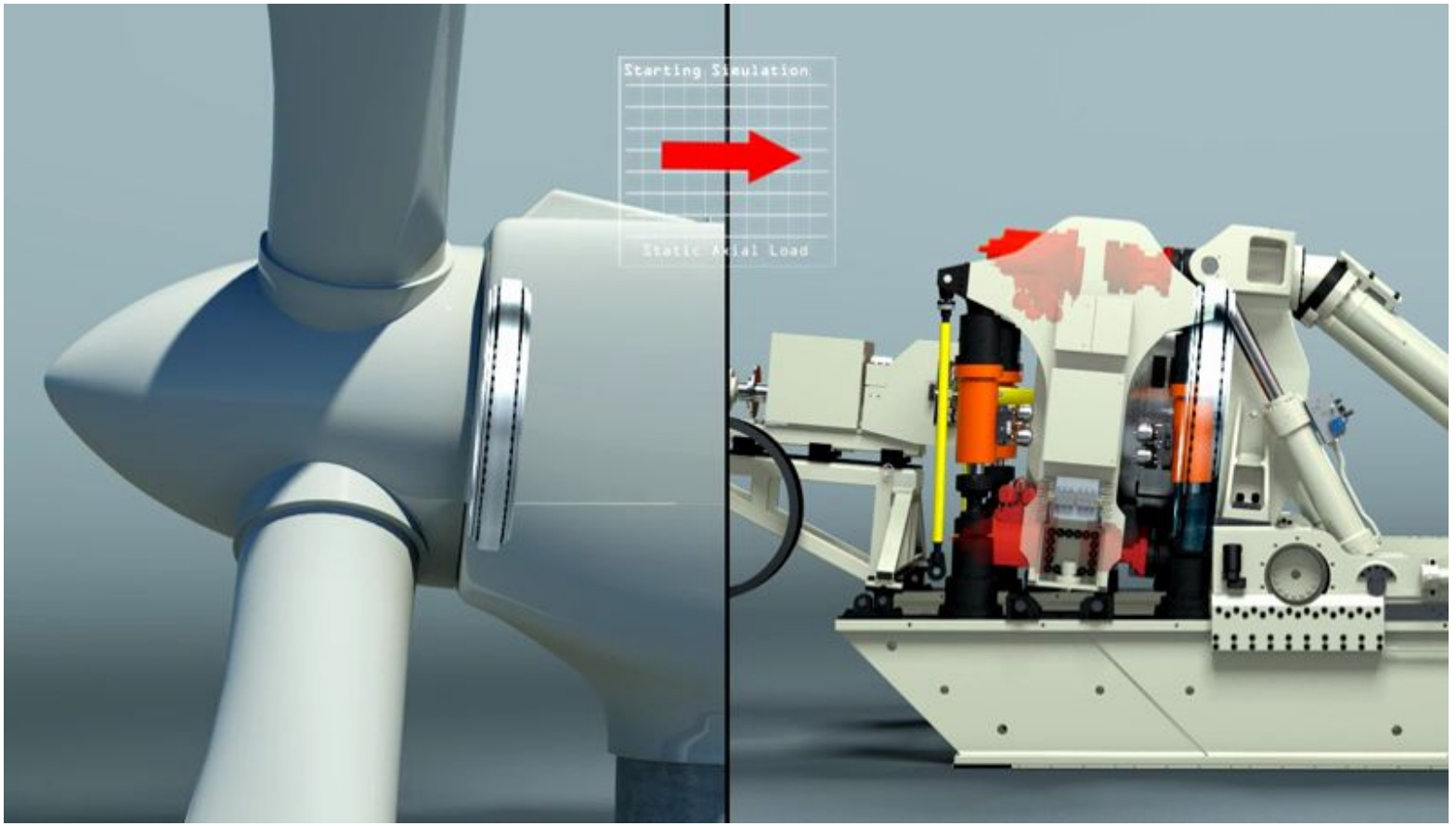
1. Bearings of Wind Turbines
Schaeffler, Schweinfurt (Germany)

Dimensions of Modern Wind Turbins



Live Time
> 20 Years

ASTRAIOS: Simulation of Forces 4 Radial + 4 Axial Hydraulic Cylinders

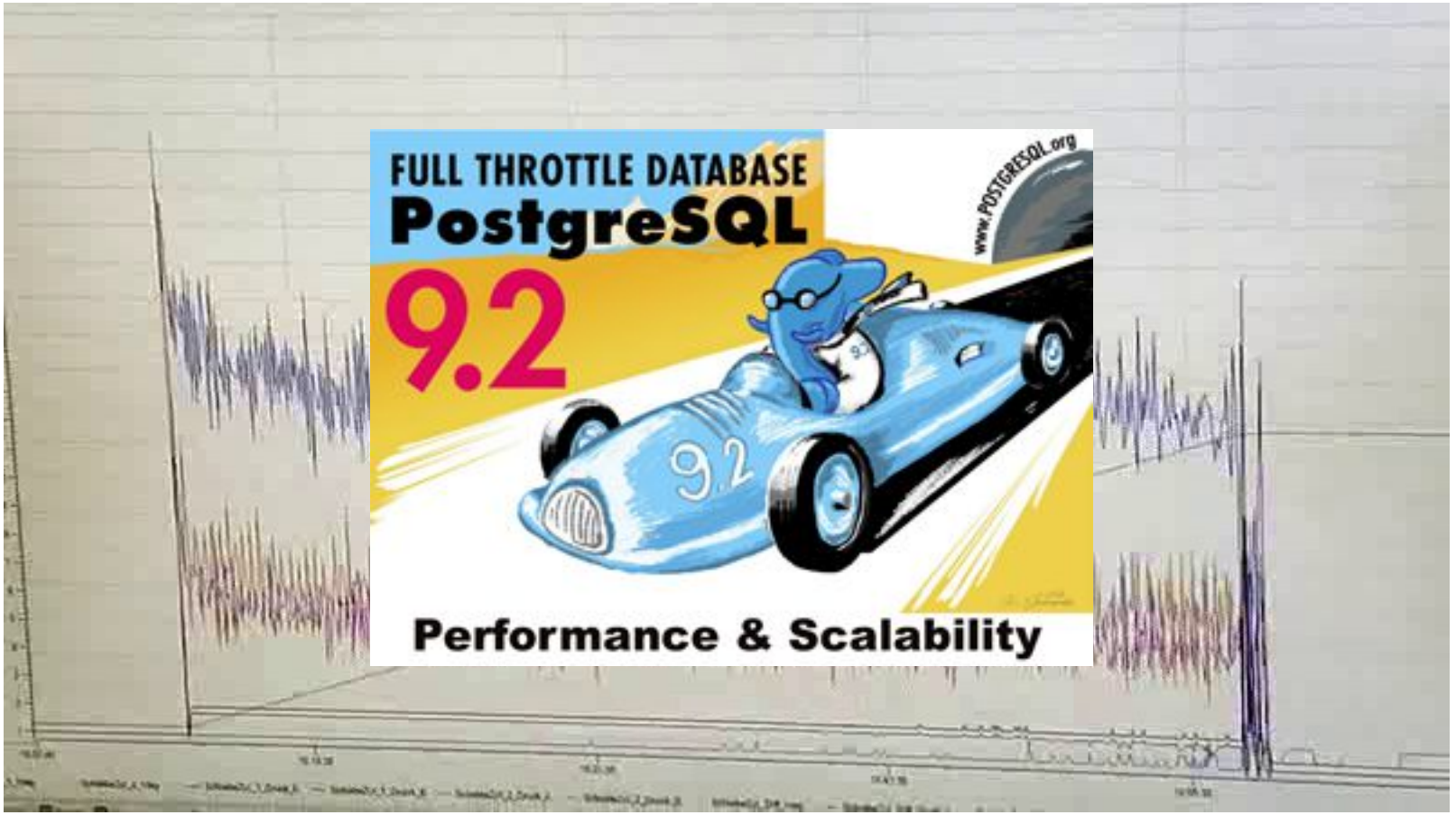


ASTRAIOS

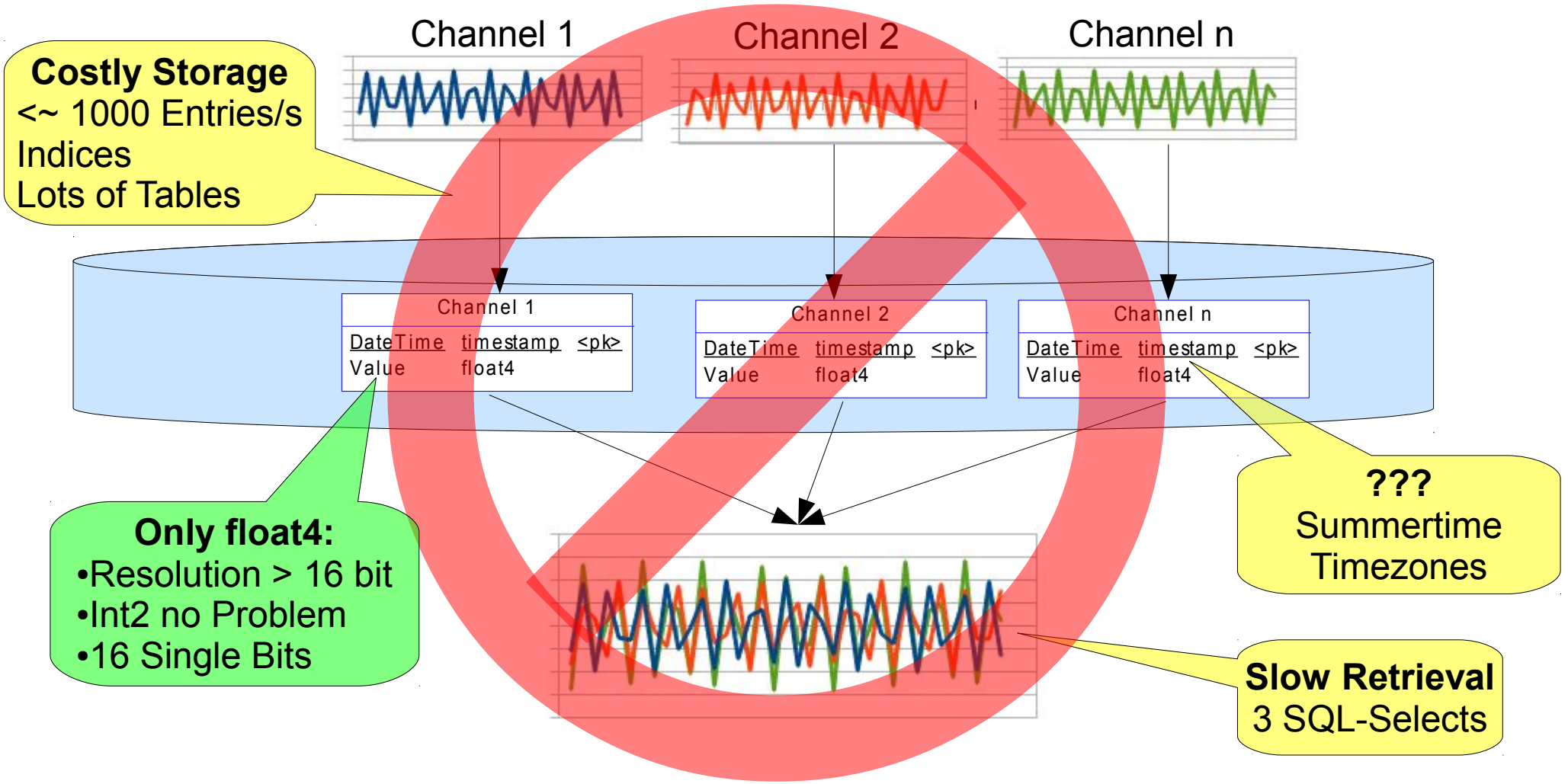
ASTRAIOS

Sensors, Charts
>300 Sensors: 1 kHz

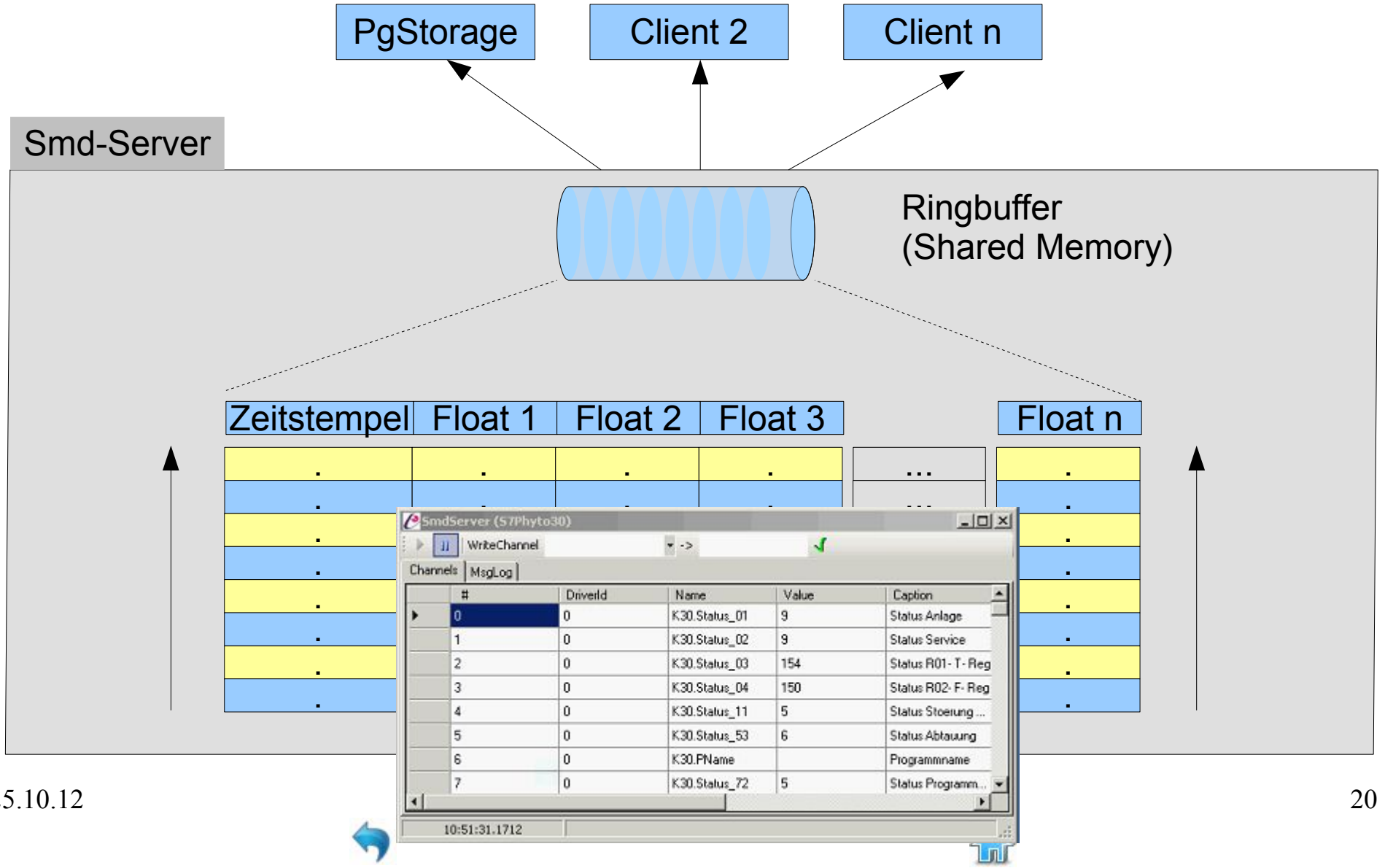
The Champion Enters the Arena



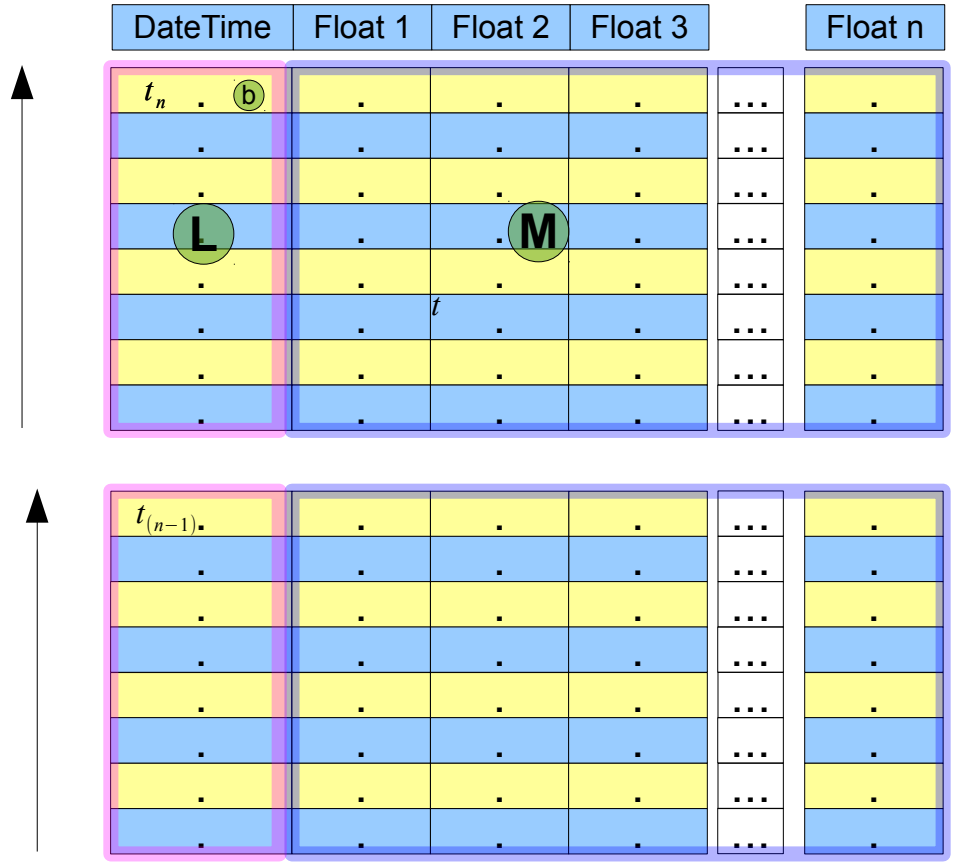
Storing Measurements (Simplest Way)



Storage: Ringbuffer



Storage: Packaging



- b •DateTime of Package
- c • $dwell = t_n - t_{(n-1)}$
- d •Count Of Measurements in Package
- e •[**min**(*Float 1*), **min**(*Float 2*), …, **min**(*Float n*)]
- f •[**max**(*Float 1*), **max**(*Float 2*), …, **max**(*Float n*)]
- g •[**avg**(*Float 1*), **avg**(*Float 2*), …, **avg**(*Float n*)]
- h •[**cur**(*Float 1*) **cur**(*Float 2*), …, **cur**(*Float n*)]
- L •List of DateTimes in Package
- M •Matrix of Measurements in Package

hischnset		
entry	bigserial	<pk>
status	INT4	
a chnsetid	INT4	
b dt_package	TIMESTAMP WITH TIME ZONE	
c dwell	INTERVAL	
d cnt_mv	INT4	
e min_mv	FLOAT4[]	
f max_mv	FLOAT4[]	
g avg_mv	FLOAT4[]	
h cur_mv	FLOAT4[]	
L dt_list	bytea	
M mv_array	bytea	

Sectioning of Database

Overflow
must be avoided

Backup of Data
> 100 Gbyte is a
Time Consuming
Job

Fast
Deletion of Data

Data
Base

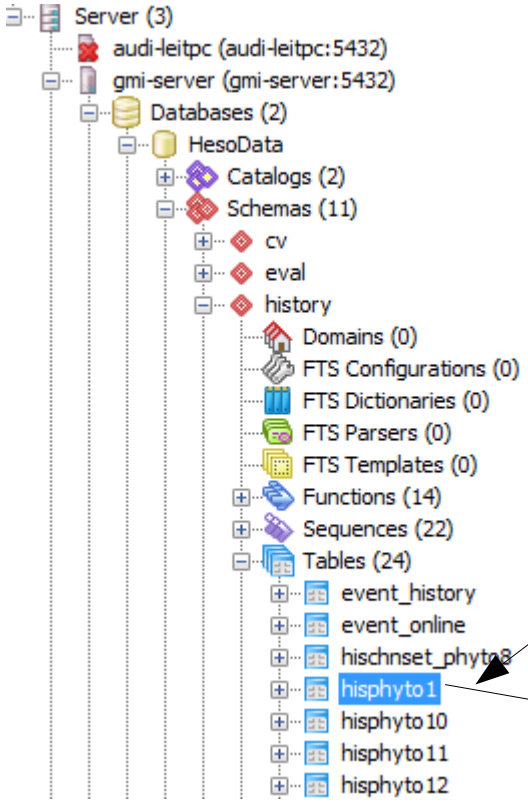
•Storage of Data into
different **Schemas**
according to Timestamp

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

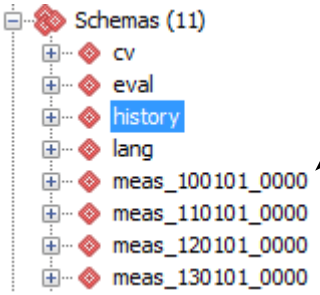
•Per Schema
- Backup
- Restore
- Delete

Sectioning of Database

One Table per Channel-Set



One Schema per Time-Period

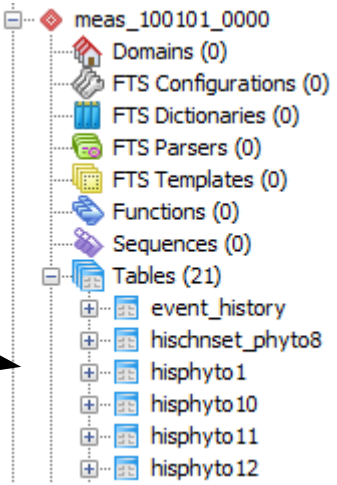


Schemas for Measurements
- Starting 2010-01-01
- Starting 2011-01-01
- Starting 2012-01-01
- Starting 2013-01-01

Empty Parent Tables

Inheritance

Tables in Schema of Time-Period are Inherited



Sectioning of Database

- Parent Schema: History
  - Each ChannelSet → One History-Table
- Each Time-Period → 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}'::timestamptz               – From
and dt_package < '{3}'::timestamptz               – To
group by floor(EXTRACT(EPOCH FROM dt_package)/#GroupRangeSec#)
order by 2
```

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[]	
dt_list	bytea	
mv_array	bytea	

Retrieve requested Data
as an Array.

Meaning of Array-Indizes
in ChnSetId

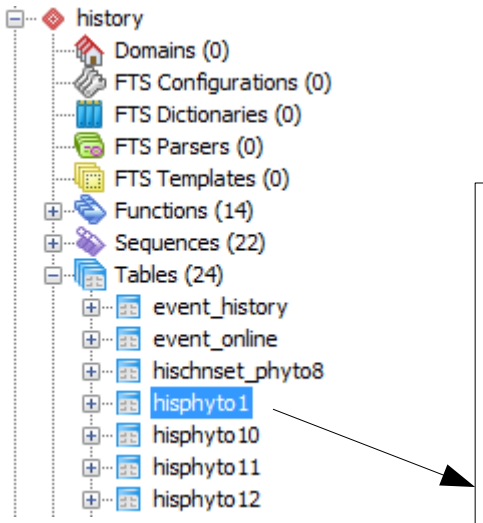

Aggregation: GroupRangeSec

```
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

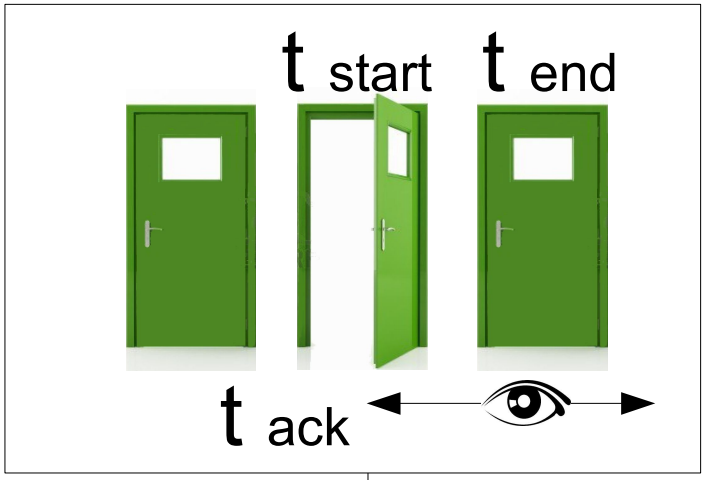
GroupRangeSec = 10 min

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



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

event_online

event_id	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	

event_history

entry	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)

Reproduceable Simulation of Enviromental Stress

Heat and Humidity

Sun (Vis + UV)

Frost

Rain

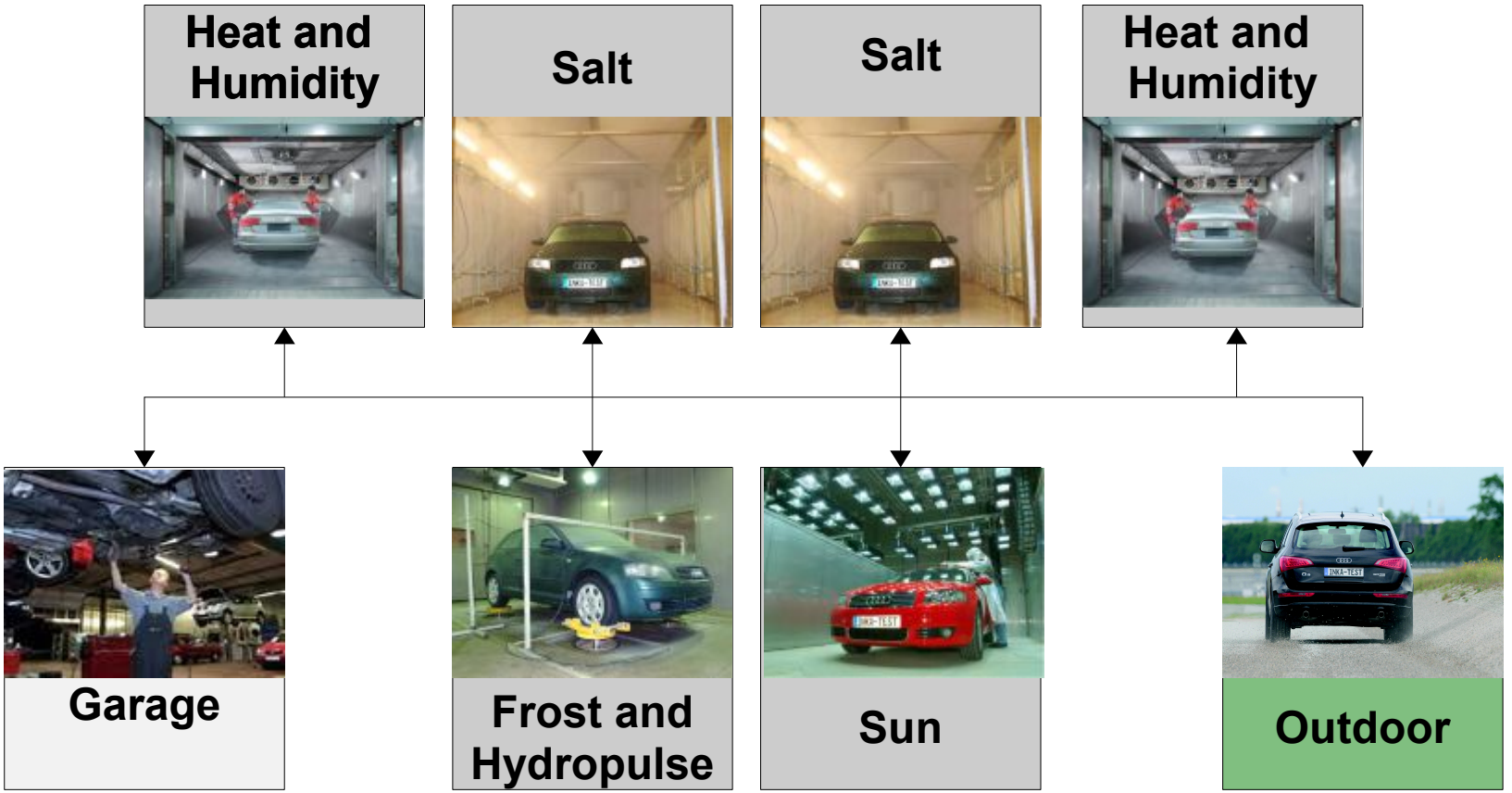
Salt

Stone Chips

Road Holes

Corrosion Center:
12 Years within 19 Weeks

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

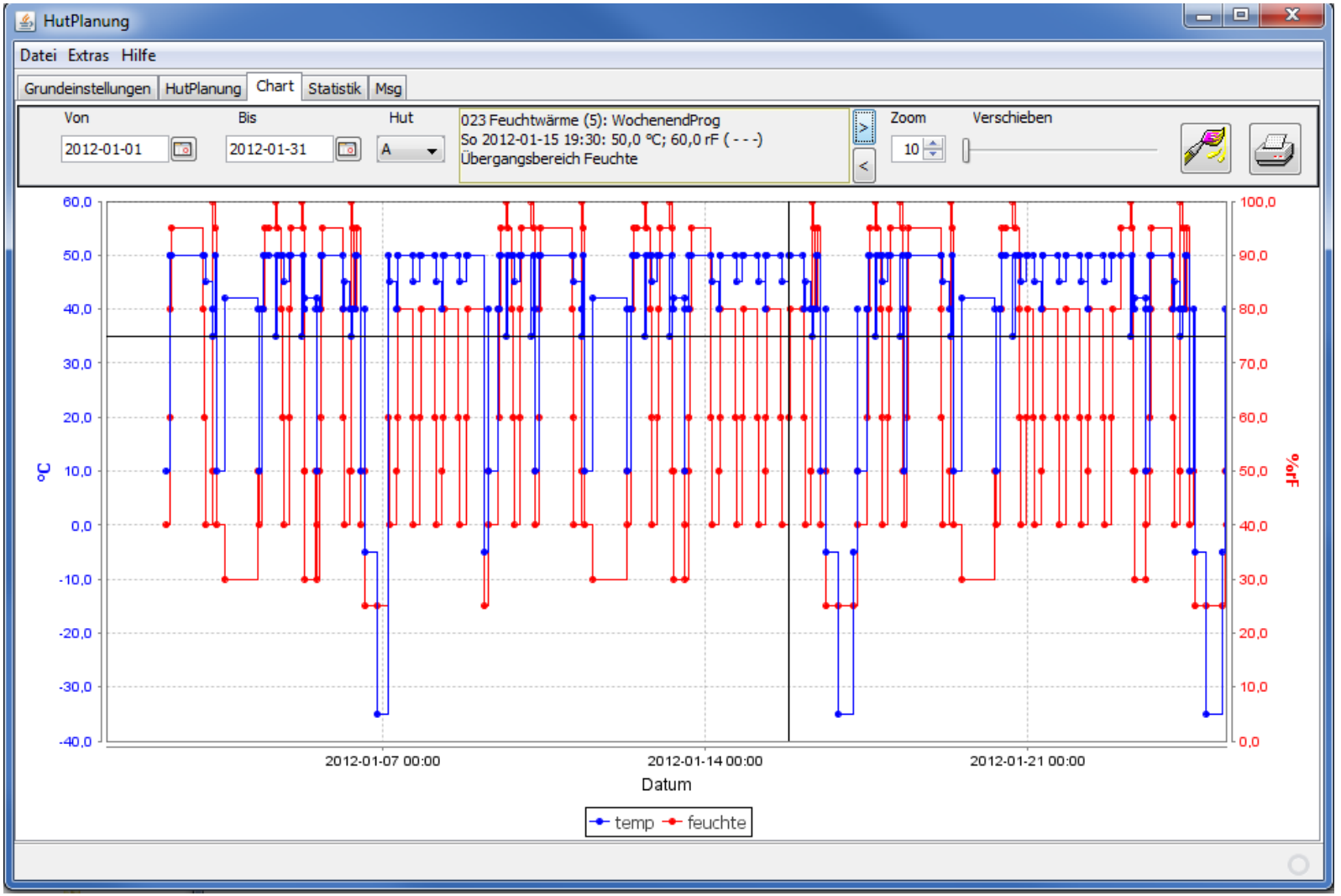
Weekend

Enviromental Chamber

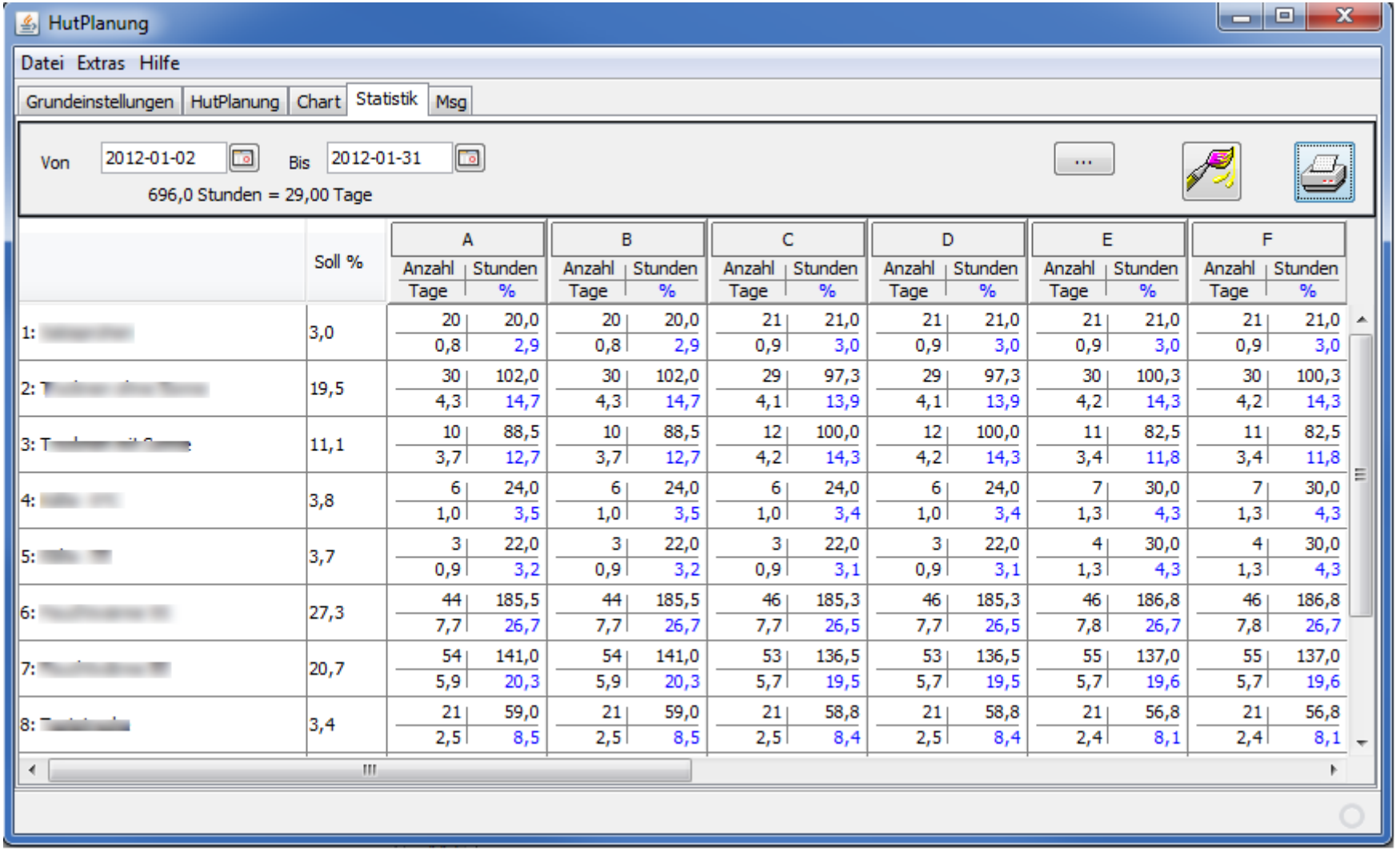
Changeover of Cars

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

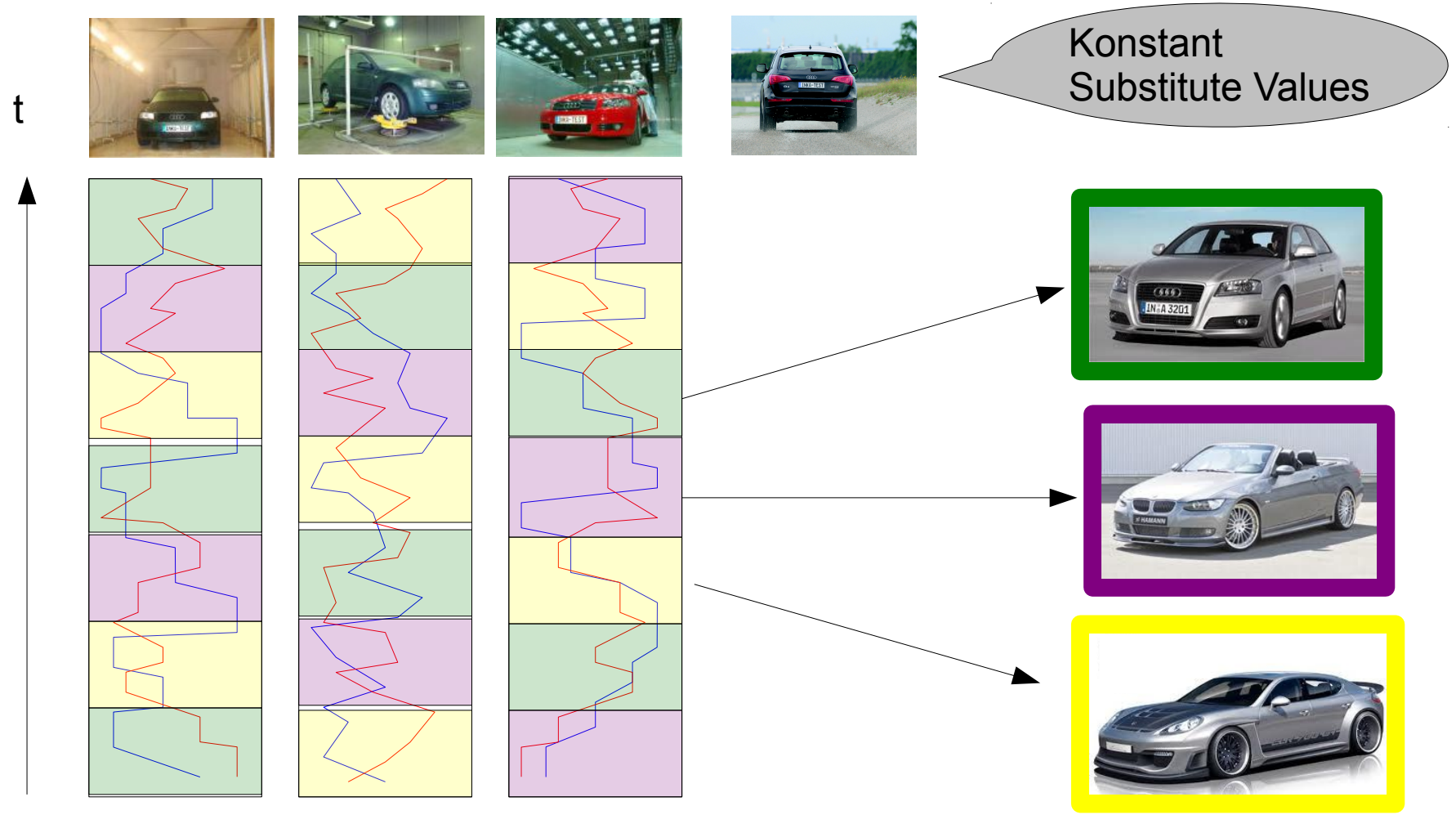


Scheduled Treatments: Crosstab

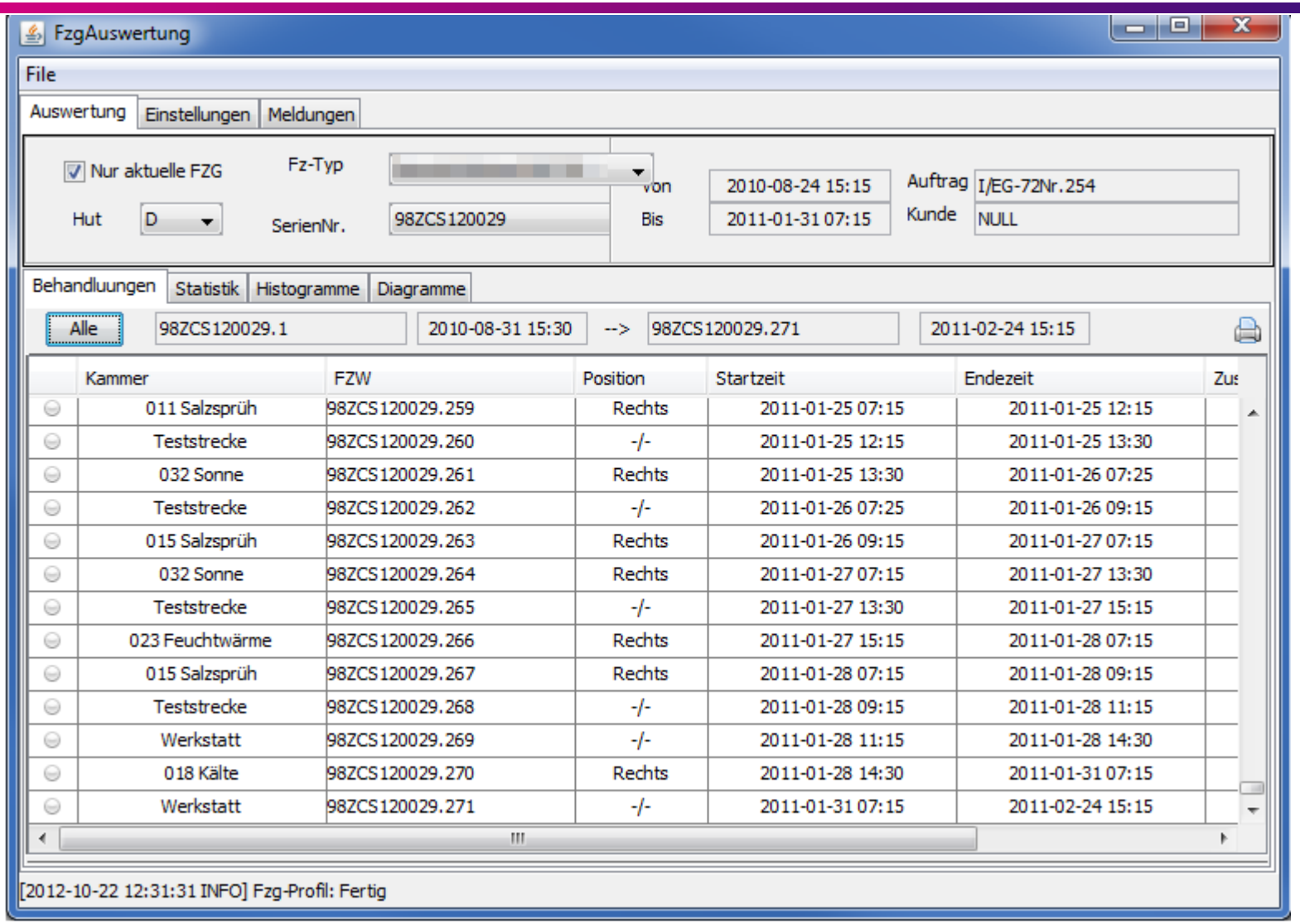


	Soll %	A		B		C		D		E		F	
		Anzahl Tage	Stunden %	Anzahl Tage	Stunden %	Anzahl Tage	Stunden %	Anzahl Tage	Stunden %	Anzahl Tage	Stunden %	Anzahl Tage	Stunden %
1:	3,0	20	20,0	20	20,0	21	21,0	21	21,0	21	21,0	21	21,0
		0,8	2,9	0,8	2,9	0,9	3,0	0,9	3,0	0,9	3,0	0,9	3,0
2:	19,5	30	102,0	30	102,0	29	97,3	29	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:	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:	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:	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:	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:	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:	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

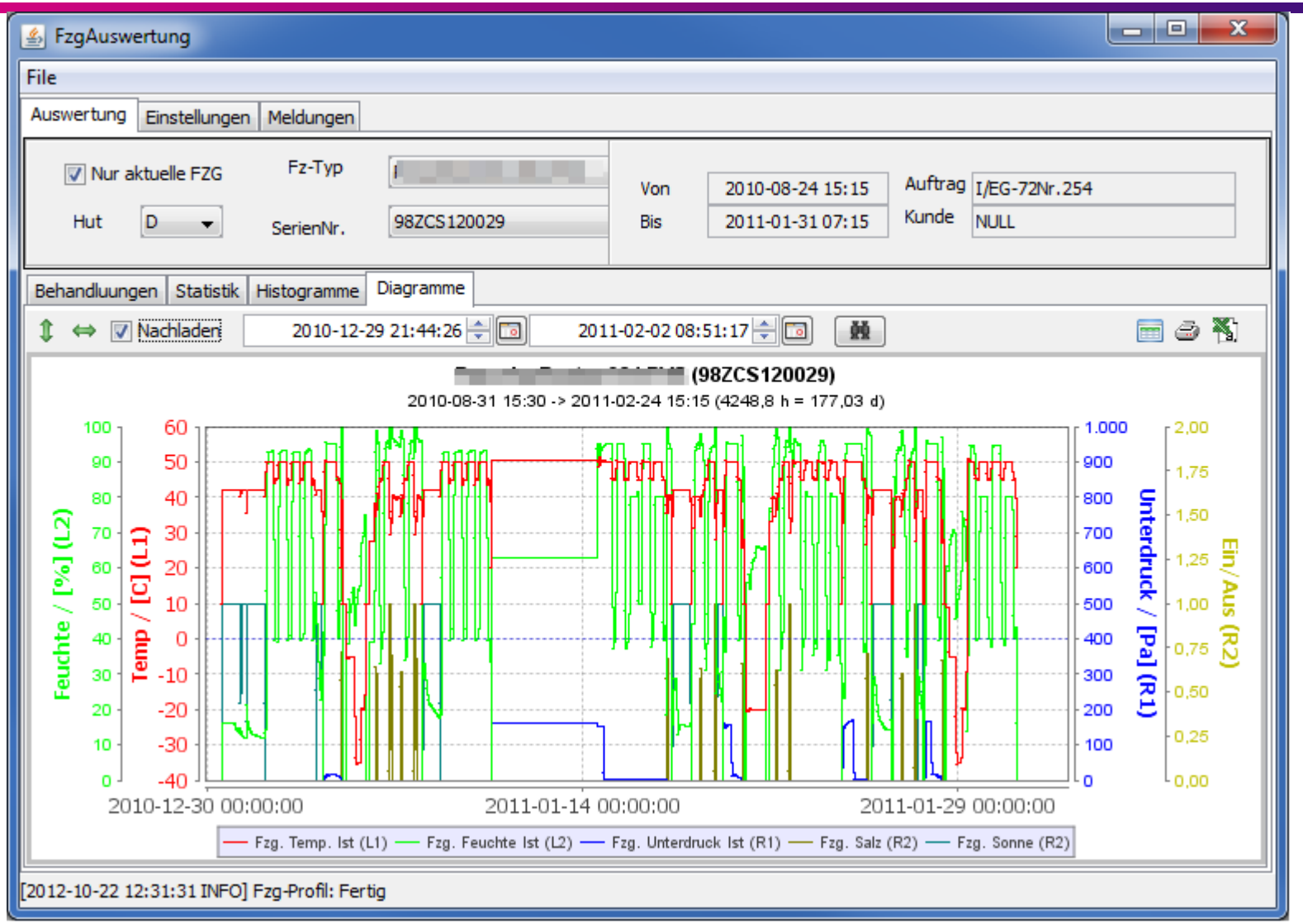
Stitching
Measured Curves of Stress



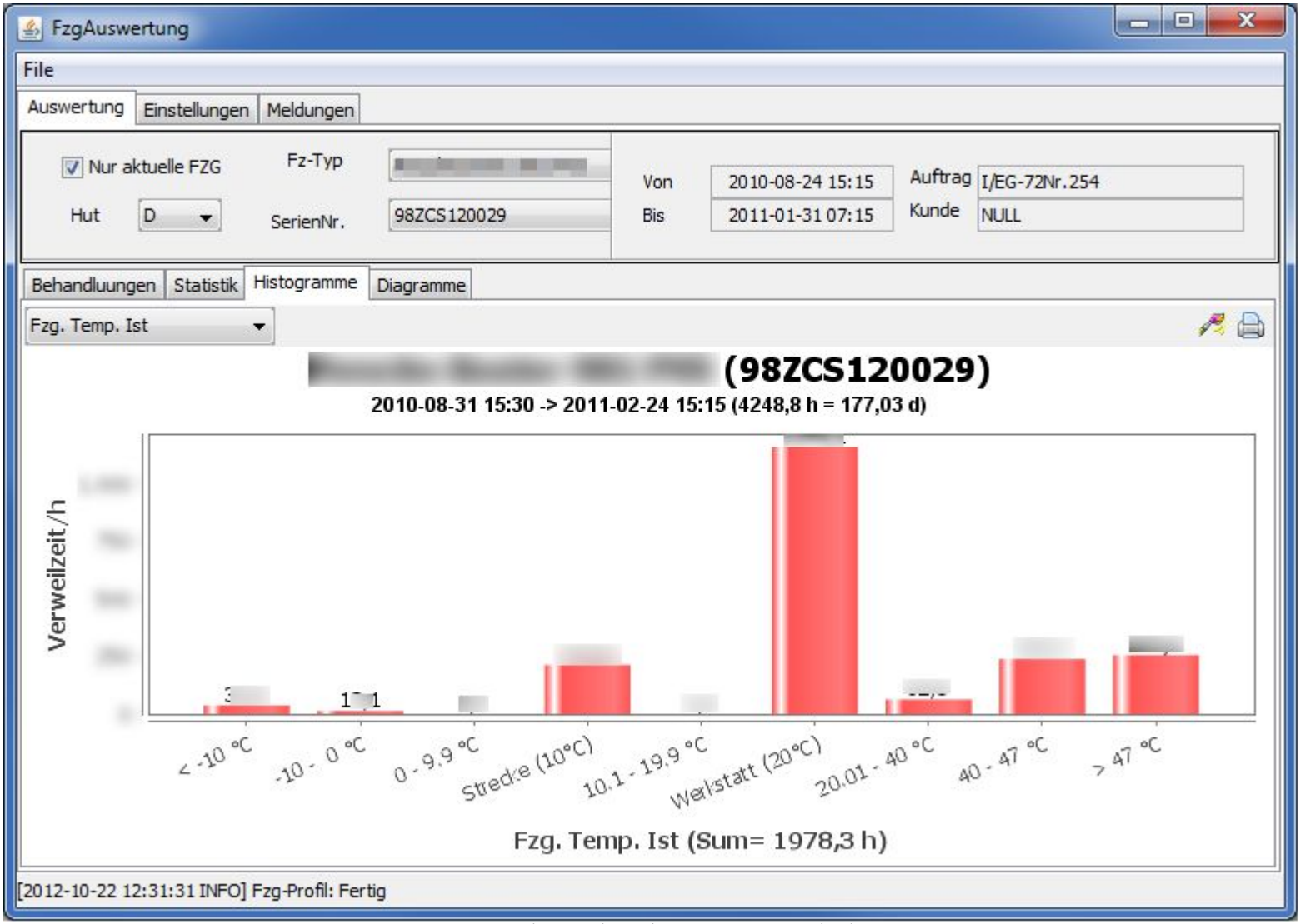
Car under Test: Treatments



Car under Test: Chart



Car under Test: Statistics



3. Plant Genetics
Gregor-Mendel-Institute, Vienna

Genotype

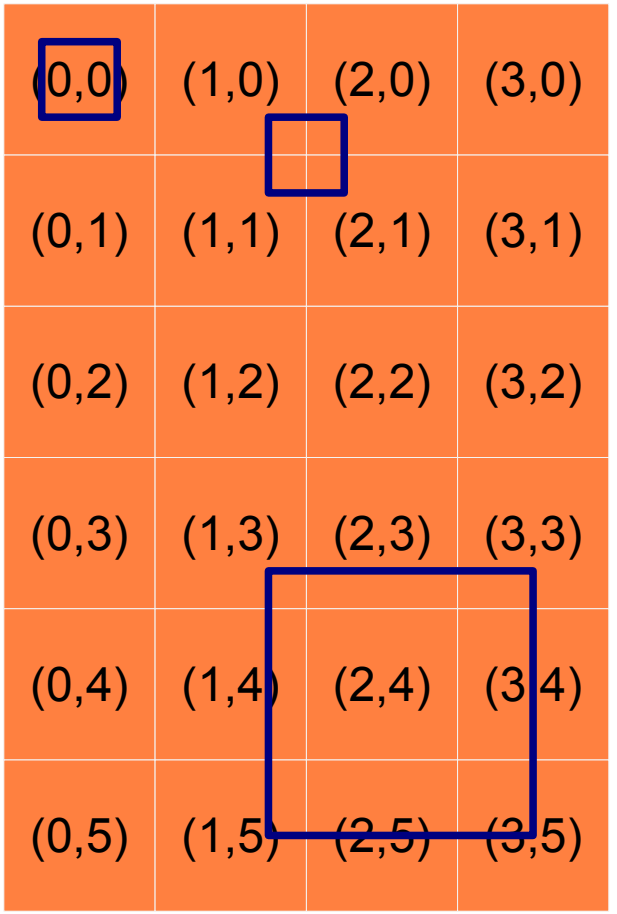
Phenotype

Phyto-Chambers at the GMI

Mass Phenotyping
Image Scan

Mosaik + Tile

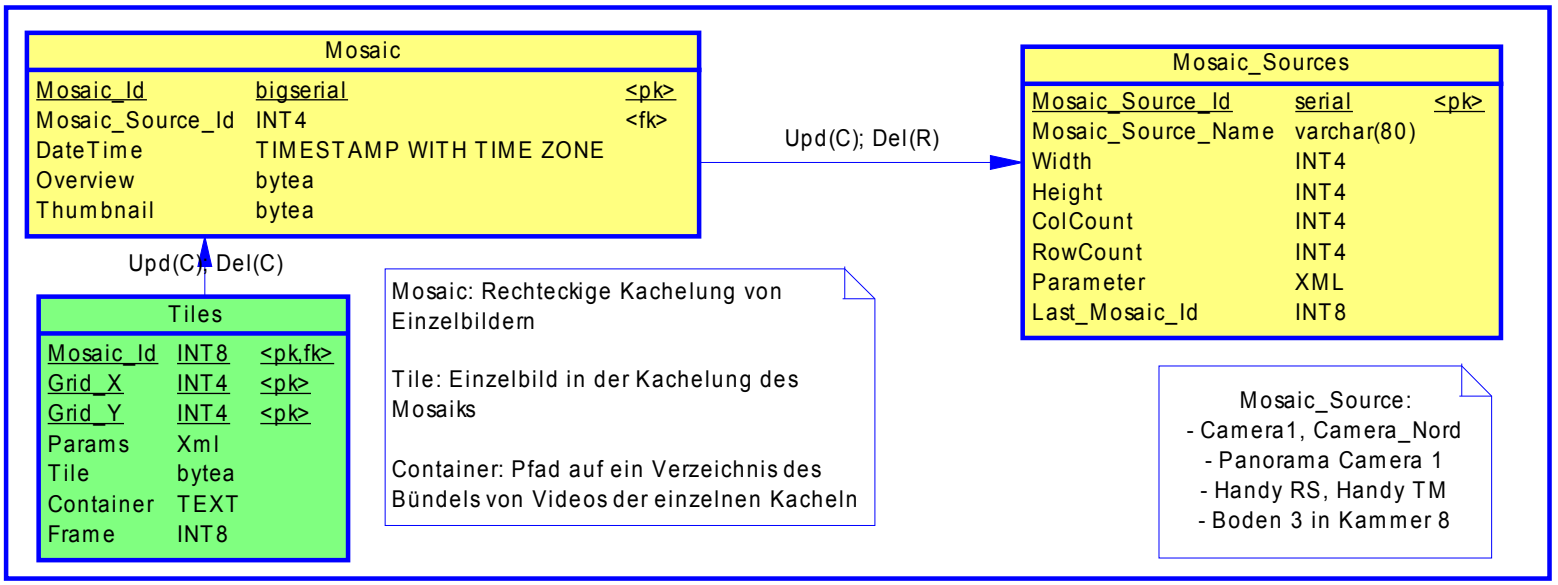
- Total shelf is recorded
- Mosaic = Matrix of Tiles
- Region Of Interest (ROI) = Rectangle on mosaic
  - Region of plant
  - Stitched on demand



The Champion Enters the Arena

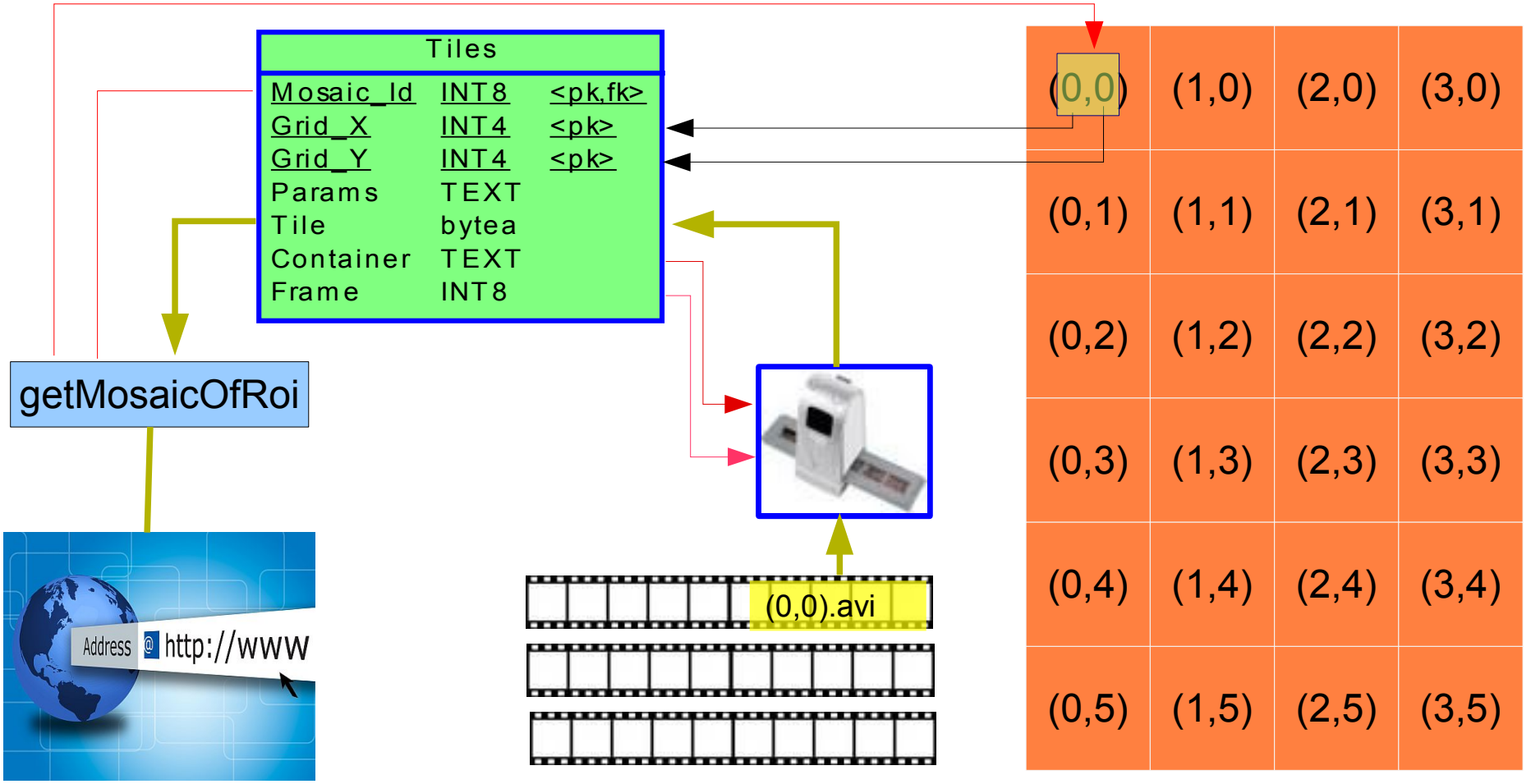
Storing Mosaic + Tiles

DB-Function: getMosaicOfRoi(mosaicId, roi)

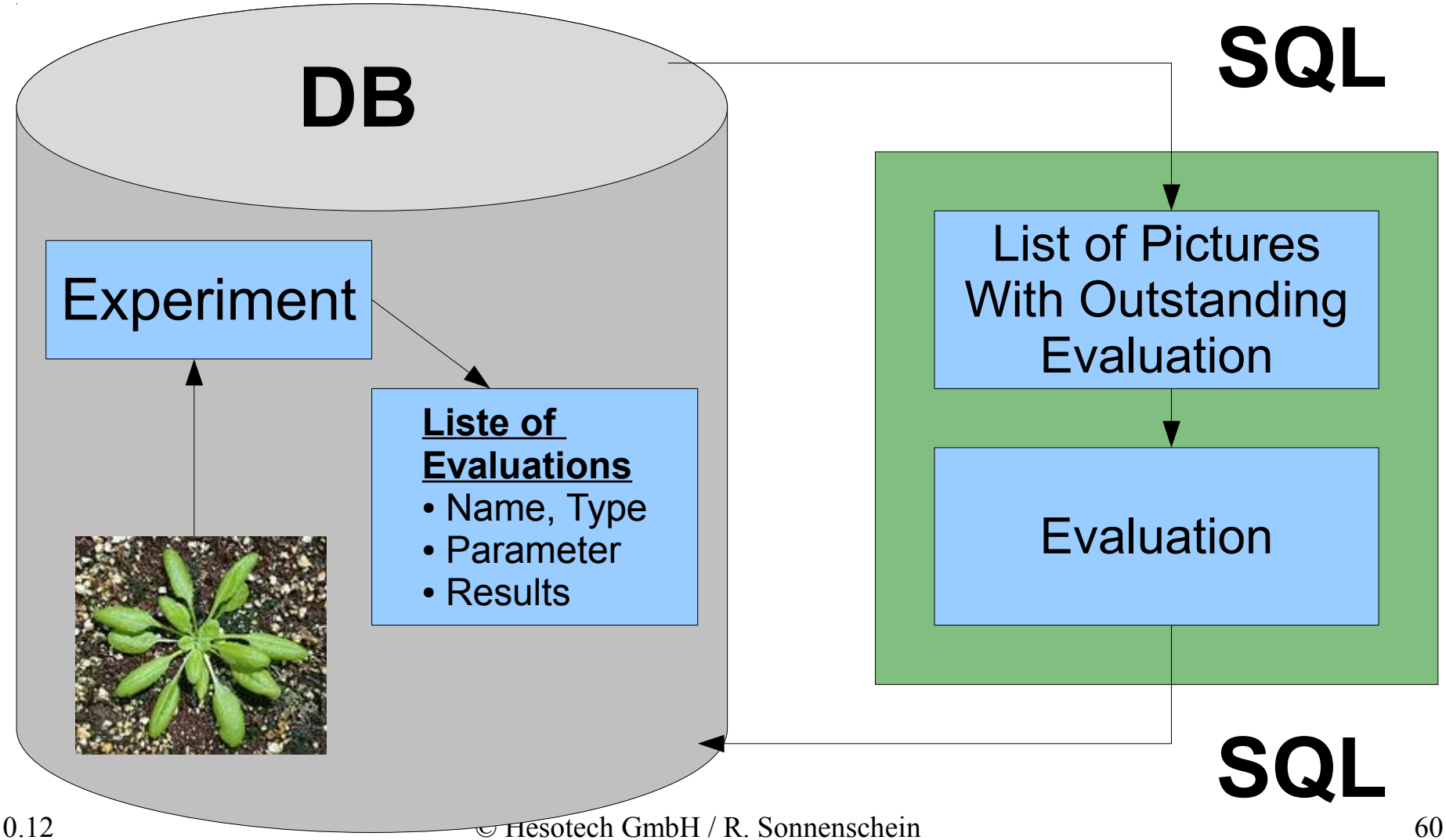


Long term storage of tile in Video
- Mosaic-Video = Bundle of Tile-Videos

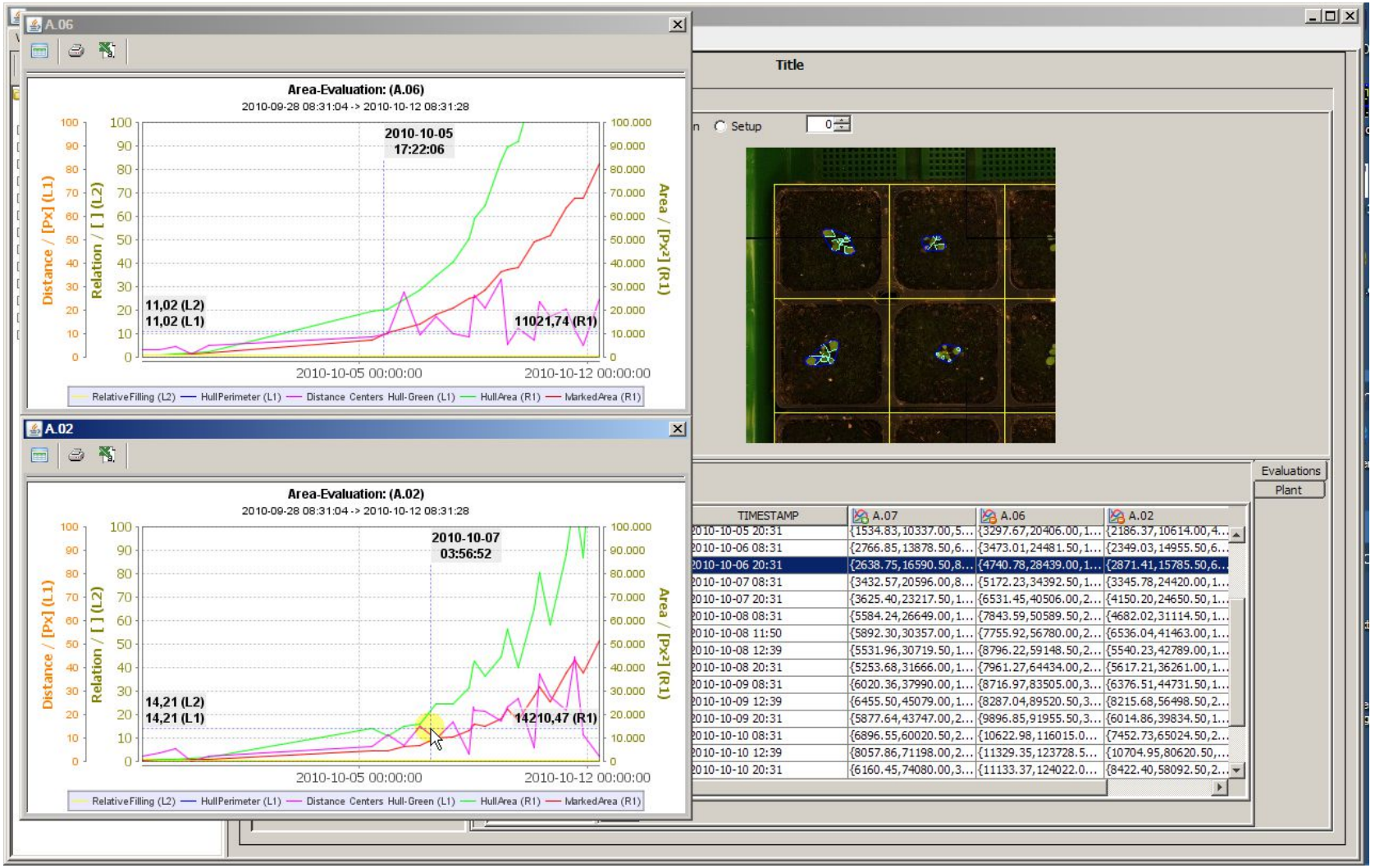
Lots of Images!
Bundle of Videos



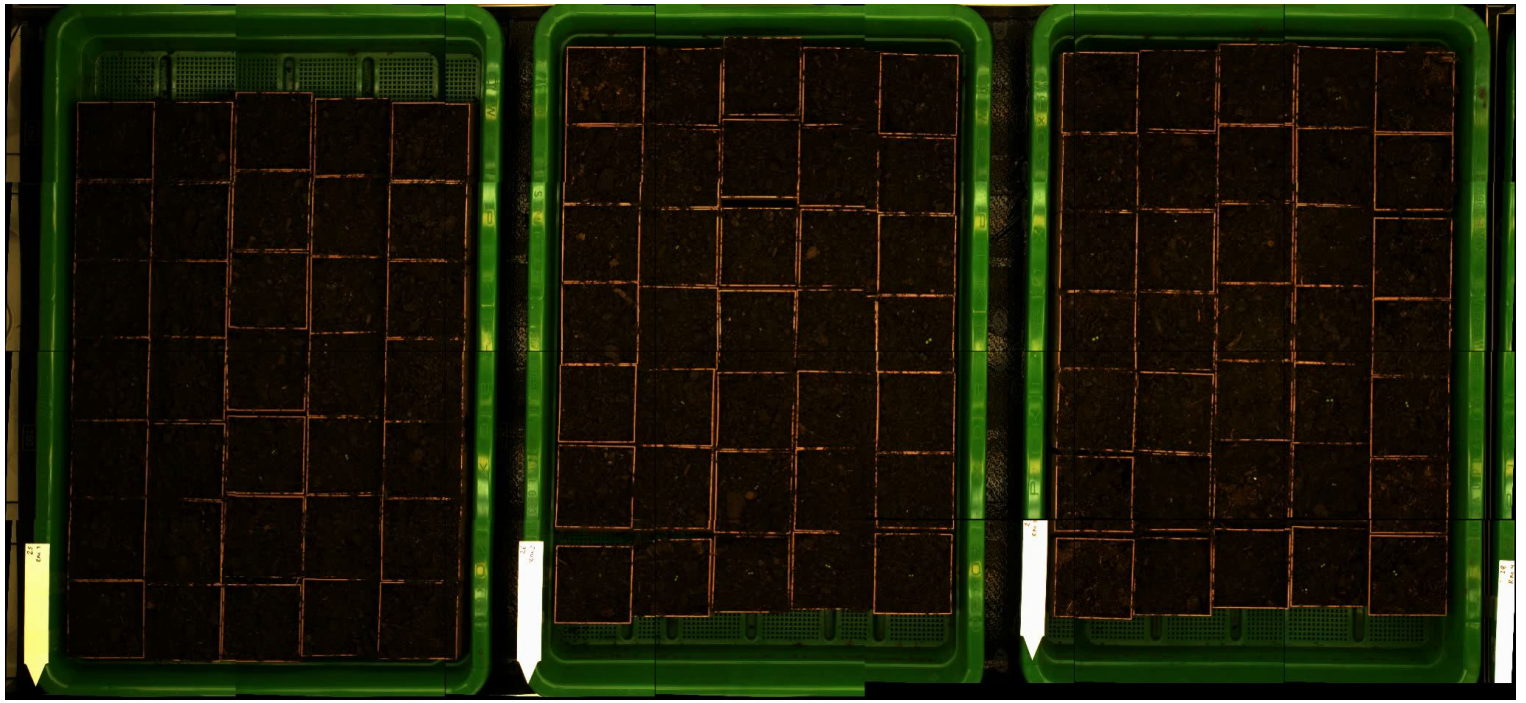
External Evaluation (Principles)



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/astraios.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
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Feedback

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