

Visualizing Statistics of Brain Perfusion Data



Helwig Hauser
(in coop. with **Sylvia Glaßer** et al.),
MedViz Seminar 2010-10-08



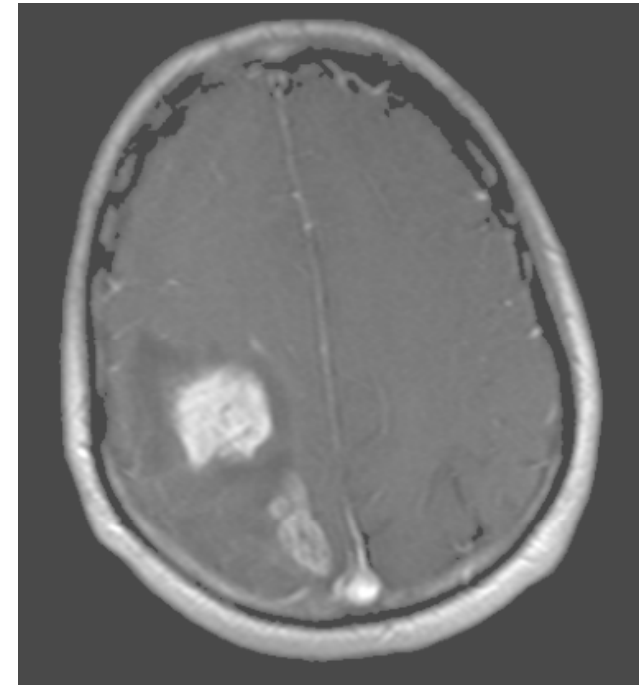
Project Overview



- Next “act” in an on-going cooperation between
 - the Univ. of Magdeburg (group of Prof. Preim)
 - the Univ. of Bergen (myself et al.)
 - others (Arvid, Atle Bjørnerud from Rikshospitalet, ...)
- Follow-up research wrt. Steffen Oeltze’s work
 - was here in Bergen, too
 - we worked out an interactive visual analysis approach for medical perfusion data [TVCG 2007, ...]
 - defended his PhD this year (magna cum laude!)
- Sylvia’s project (on-going!)
 - own work (best paper of VMV 2009, ...)
 - here on brain tumor data from Atle Bjørnerud

- **Glioblastoma:**
most common and most aggressive type of primary brain tumor

- **Tumor Distinction:**
 - **low-grade** tumors:
well-differentiated;
not really benign, but still better prognosis for patient
 - **high-grade** tumors:
undifferentiated;
malignant, worse prognosis



example of a high grade glioblastoma (T1 image sequence, image courtesy A. Bjørnerud)

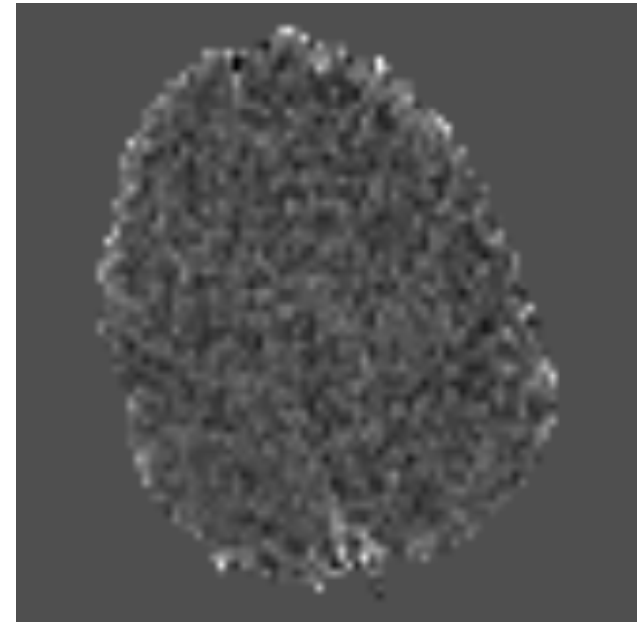
Motivation & Medical Background



- Dynamic susceptibility contrast MRI (DSC-MRI) for perfusion imaging \Rightarrow physiologic information

- **Current focus:**

- \rightarrow **tumor heterogeneity**
(to differentiate between low-grade and high-grade, if possible)
- \rightarrow **interactive visual analysis**
based on quantitative and descriptive perfusion parameters (data-near)



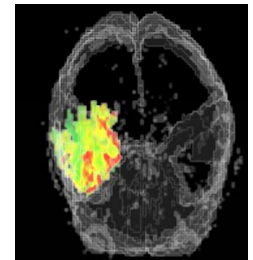
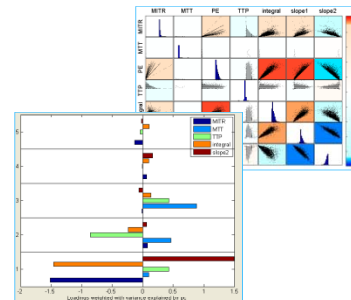
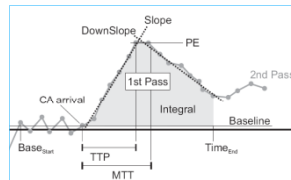
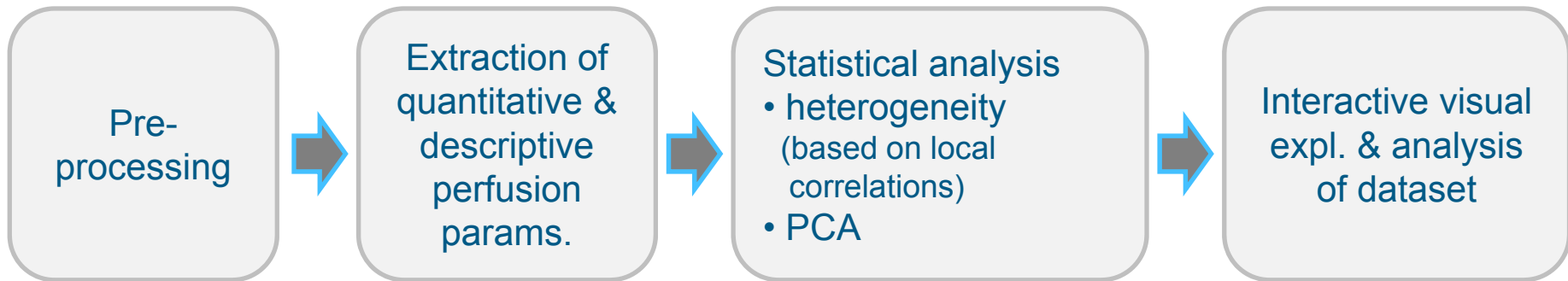
T2* image with glioblastoma
(image courtesy : A. Bjørnerud)

Visualization Pipeline



■ Integrating

- **statistical analysis**
(correlation analysis, PCA, etc.)
- **interactive visualization**



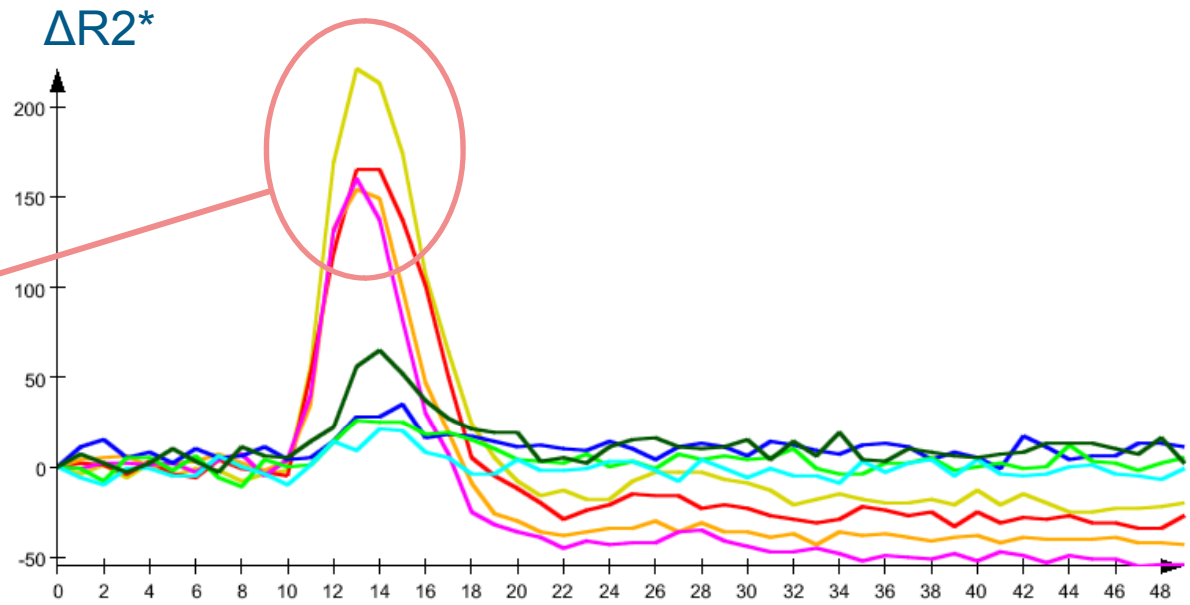
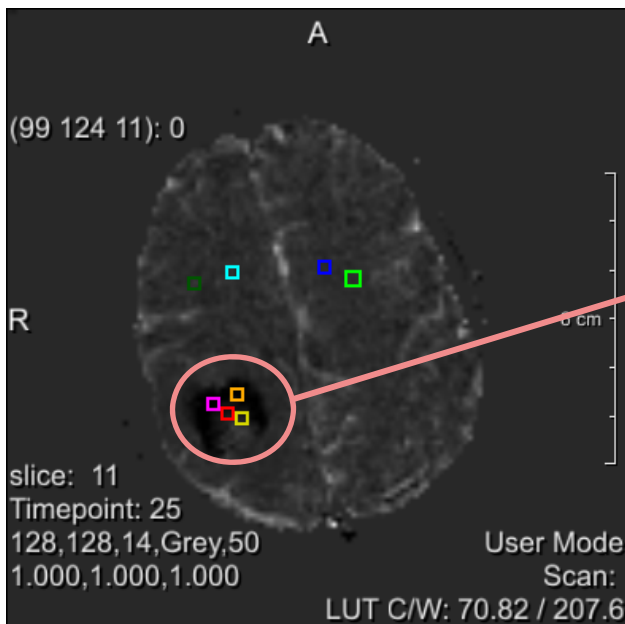
Quantitative Perfusion Parameters



- **Cerebral blood volume (CBV)**
 - total volume of blood traversing a given region of brain [ml of blood per 100 grams of brain tissue]
- **Cerebral blood flow (CBF)**
 - volume of blood traversing a given region of brain per unit time [ml of blood per 100 gr of brain tissue per minute]
- **Mean transit time (MTT)**
 - $MTT = CBV / CBF$
 - average time for blood to traverse between arterial inflow and venous outflow [s]
- **Derived with NordicICE software**
- **CBF and MTT not yet so much studied in the context of oncologic imaging (even though much used in stroke imaging)**

Descriptive Perfusion Parameters

- Derived from the $\Delta R2^*$ -Curve, $\Delta R2^*$: relative concentration time curves
- Example of $\Delta R2^*$ dataset with markers and corresponding curves for tumor and brain tissue

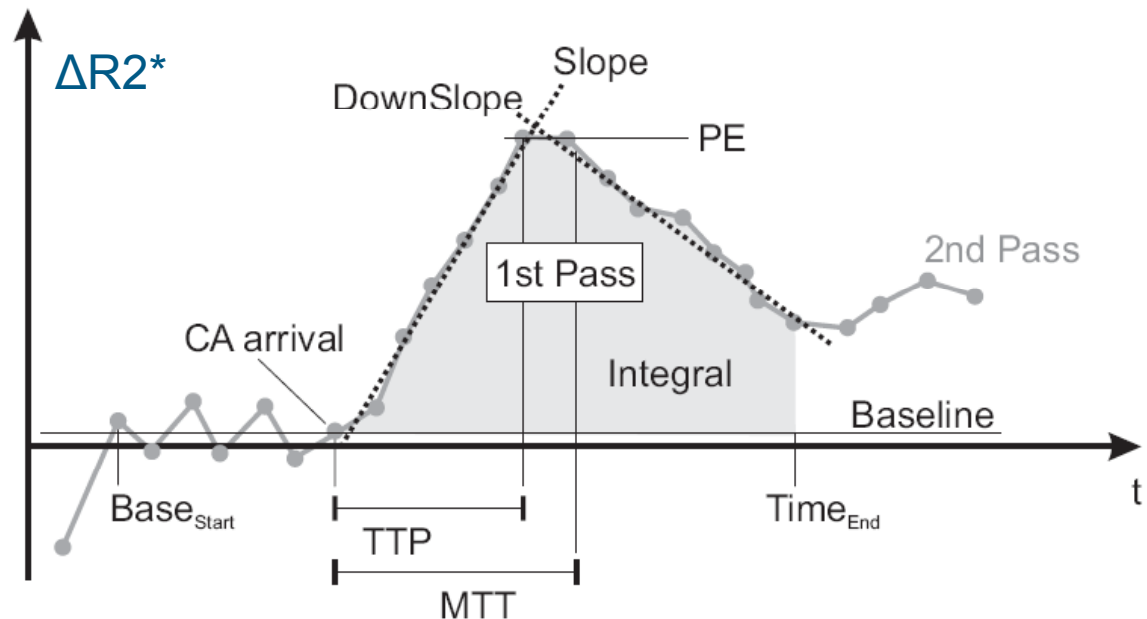


Descriptive Perfusion Parameters



Most common descriptive perfusion parameters

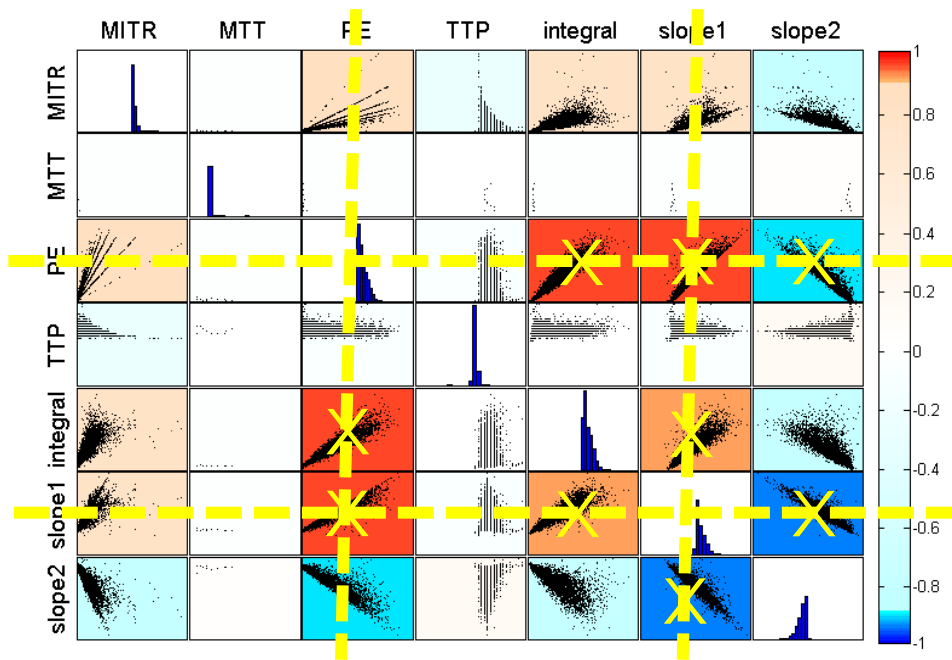
- **PE** ... maximum value of the curve
- **TTP** ... point in time where PE occurs
- **Integral** ... the approximated area between curve and baseline
- **Mean Transit Time (MTT)** ... the 1st moment of the curve
- **Slope** ... steepness of ascending curve during 1st pass
- **Maximum Intensity-Time Ratio (MITR)** ... steepness of ascending curve, ratio of PE and TTP
- **DownSlope** ... steepness of descending curve during 1st pass



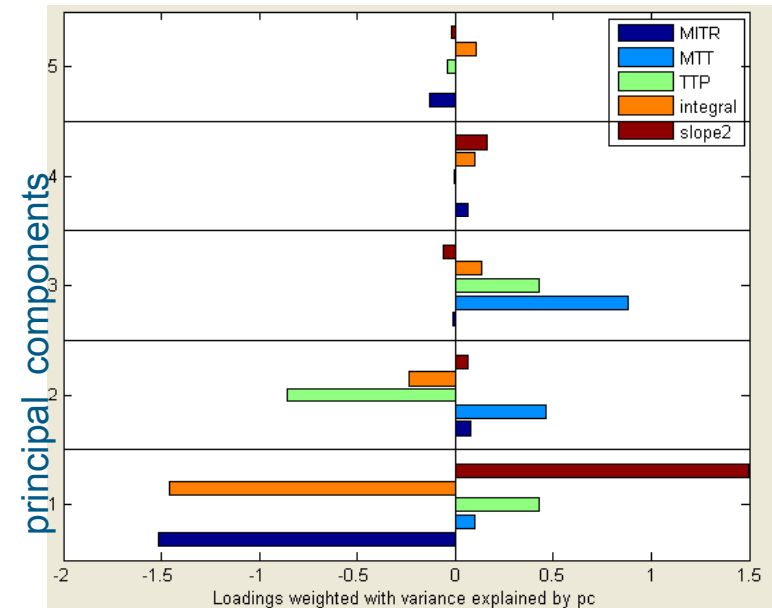
Statistical Analysis of Descr. Perf. Params.



- Reduce no. of params. via correlation analysis
- Trends via principal component analysis (PCA)



saturated colors indicate high correlation between parameters



each principal component represents a trend of the data

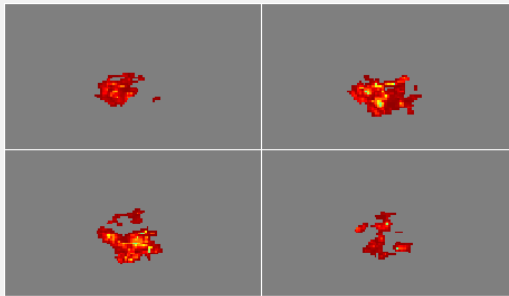
Statistical Analysis – work in progress



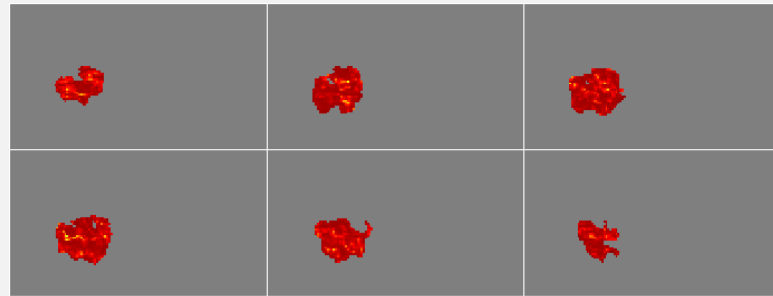
■ Correlation of **quant. parameters CBF & CBV**

→ first results indicate higher correlation for low-grade tumors

examples of
low-grade
tumors

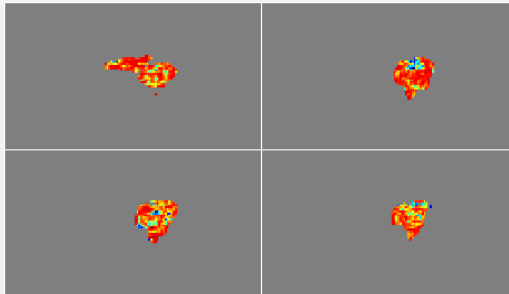


representative slices of
tumor case 009

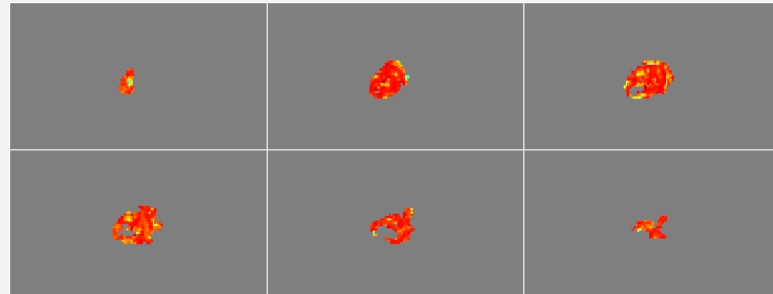


representative slices of tumor case 050

examples of
high-grade
tumors

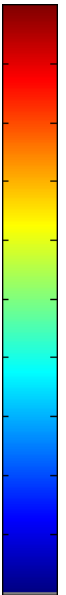


representative slices of
tumor case 017



representative slices of tumor case 052

high
correl.

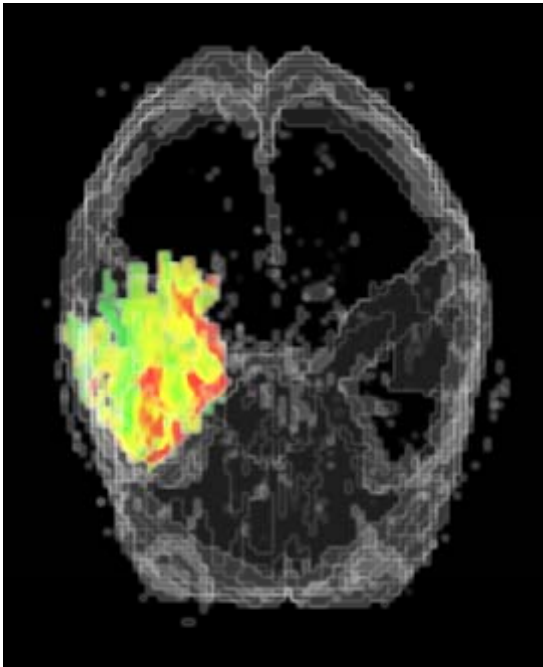


low
correl.

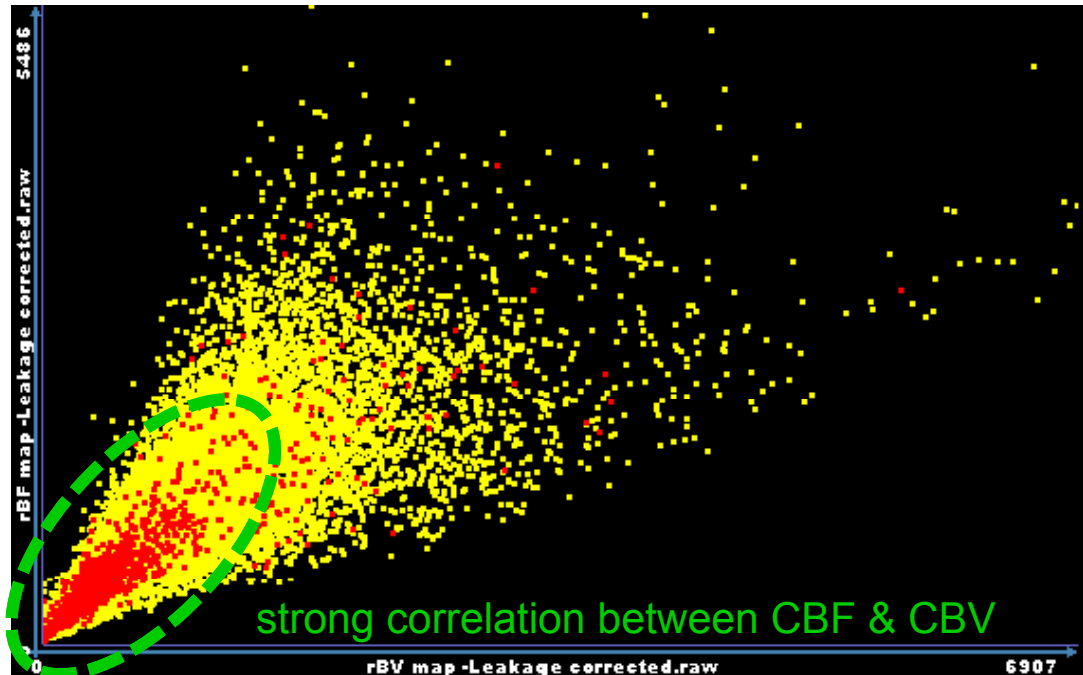
Statistical Analysis – work in progress



- Visual analysis of the correlation with SimVis
- Starting point: quantitative perfusion parameters of **low-grade tumor**



3D view of brain (gray) and tumor (color is assigned to integral)

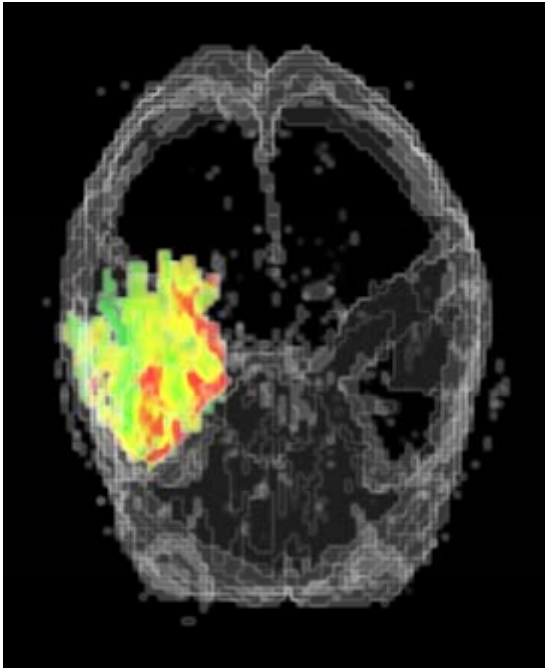


scatterplot of rCBV and rCBF, tumor voxels are highlighted in red

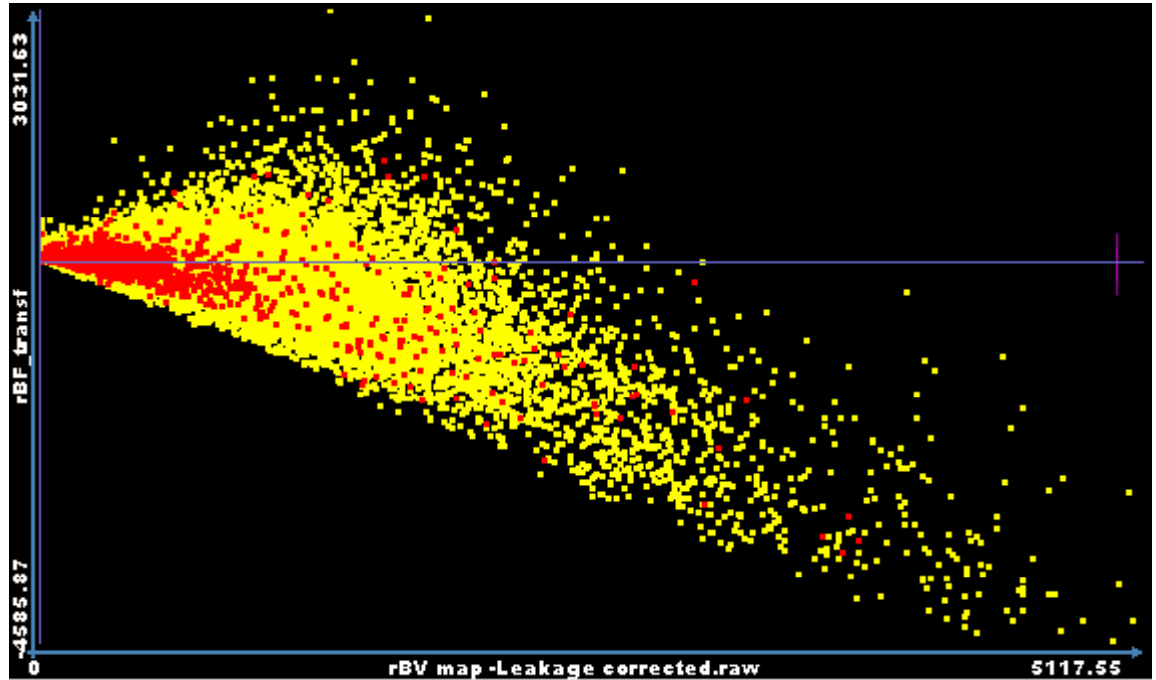
Statistical Analysis – work in progress



- Transformation (shear) of scatterplot rCBV–rCBF



3D view of brain (gray) and tumor (color is assigned to integral)



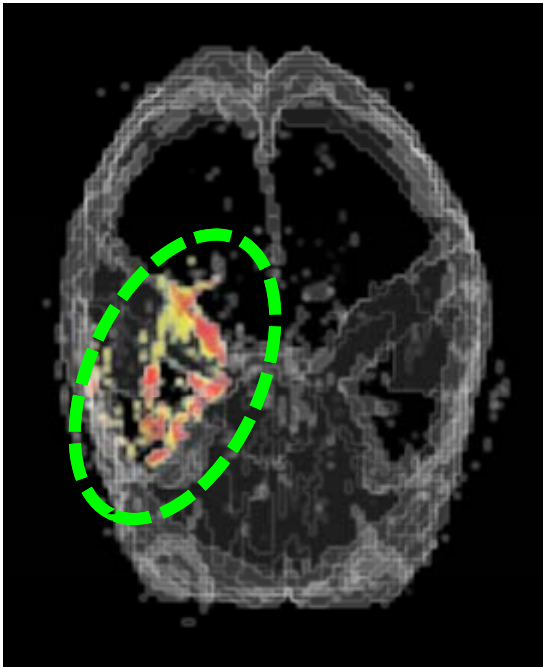
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Statistical Analysis – work in progress

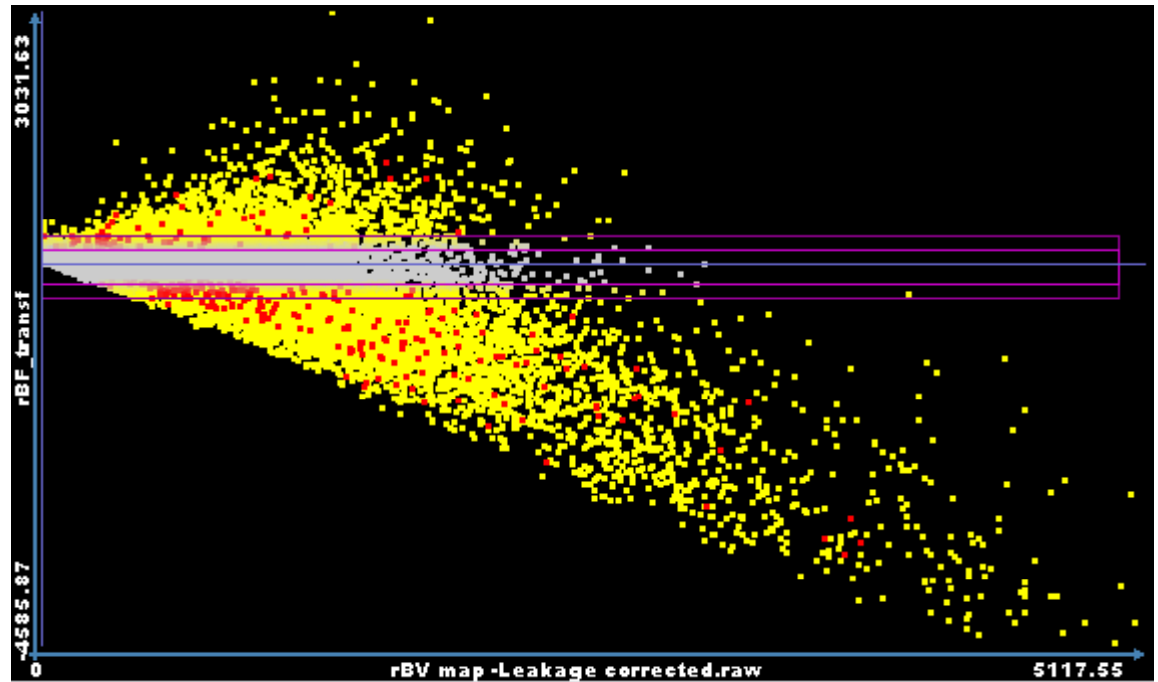


■ Exclude highly correlated values

A tumor part at the right boundary with high integral values remains
→ possible indication for high neoangiogenetic activity at boundary



3D view of brain (gray) and tumor (color is assigned to integral)

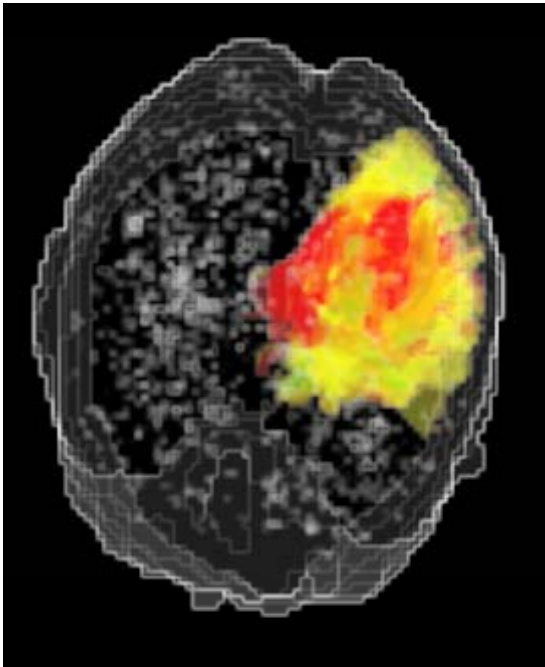


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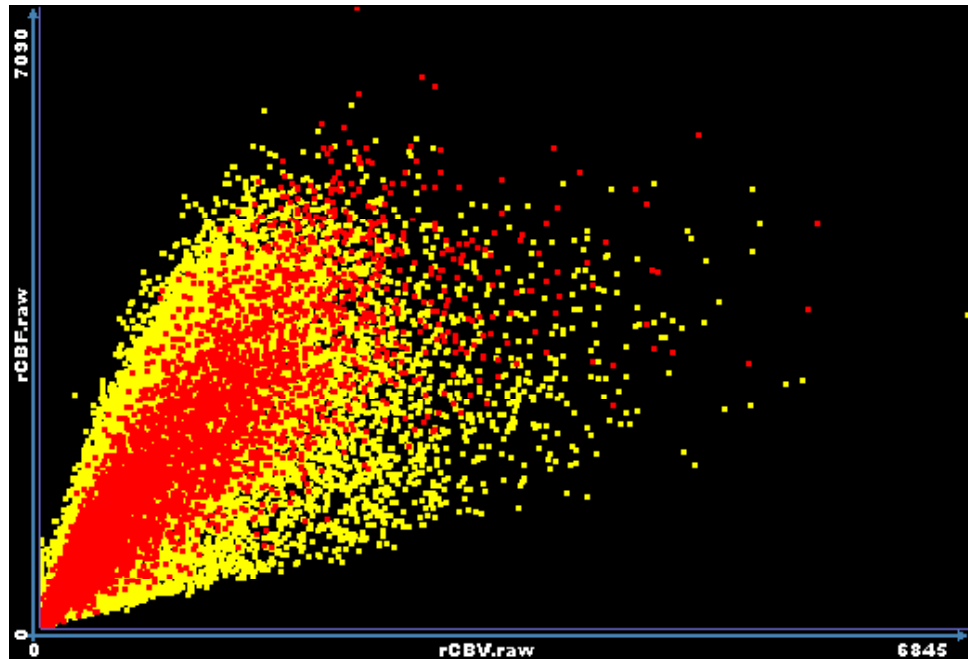
Statistical Analysis – work in progress



- Example of high-grade tumor, scatterplot of quantitative parameters



3D view of brain (gray) and tumor (color is assigned to integral)

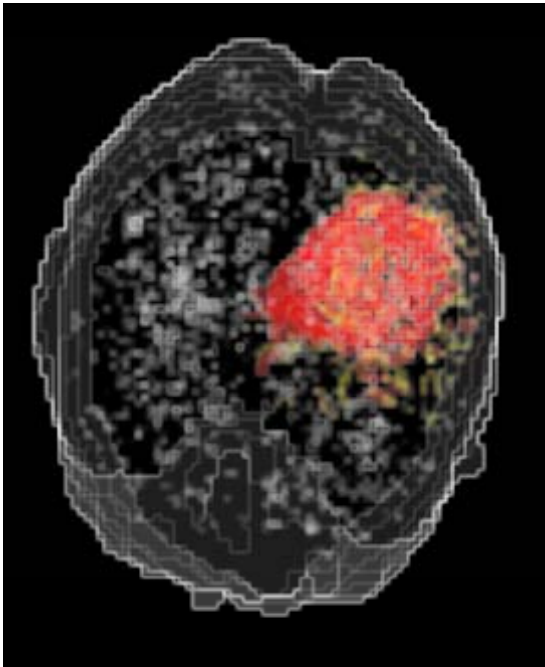


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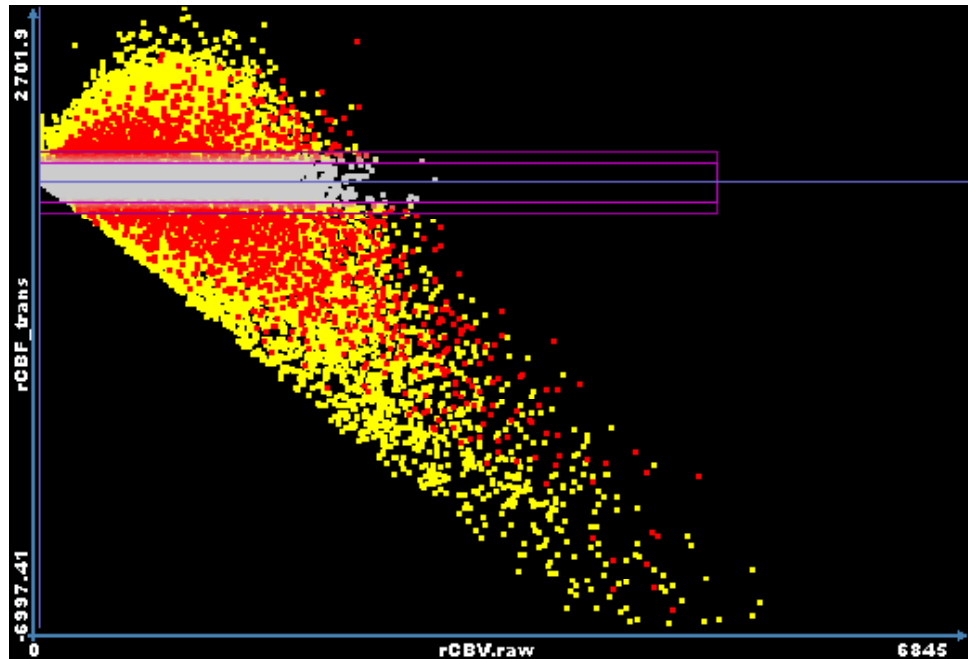
Statistical Analysis – work in progress



- Transformation of scatterplot of rCBV and rCBF
- Exclude highly correlated values



3D view of brain (gray) and tumor (color is assigned to integral)



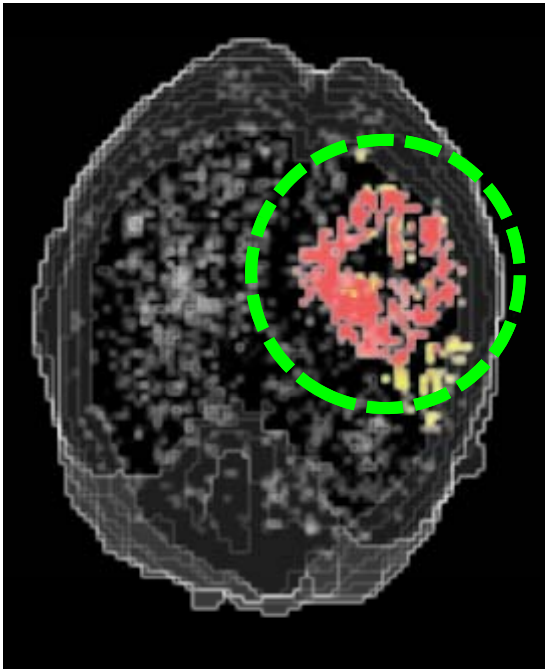
scatterplot of rCBV and rCBF, tumor voxels are highlighted in red

Statistical Analysis – work in progress

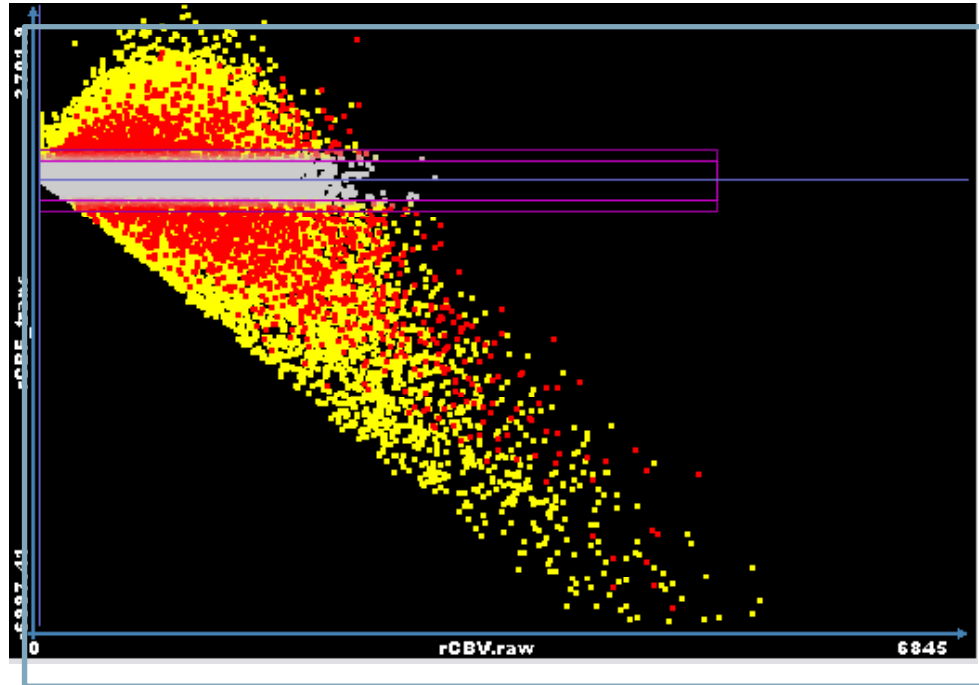


■ Restrict visualization to a slice

A ring-shaped tumor part with high Integral values remains
→ bigger areal with high neoangiogenetic activity



3D View of brain (gray) and tumor (color is assigned to Integral)



Scatterplot of rCBV and rCBF, tumor voxels are highlighted in red

Next Steps



- Adaption of the visual analysis to descriptive perfusion parameters and PCA trends
 - model-free approach
- Comparison of all results for low-grade and high-grade tumors to learn about tumor's heterogeneity
- Additional comparison with longitudinal study involving brain datasets that develop from low-grade into high-grade tumors

Acknowledgements



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- **Fraunhofer MeVis**

References from Steffen & Sylvia



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