



Simultaneous Measurement of Local Cortical Blood Flow and Tissue Oxygen Saturation by Near infra-red Laser Doppler Flowmetry and Remission Spectroscopy in the Pig Brain

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Introduction

Optical properties of the brain allow noninvasive monitoring with high temporal resolution:

- Red blood cell concentration and velocity - dynamic light scattering (LDF)
- Ratio of oxygenated and deoxygenated Hb - Absorption - oxygen saturation (Absorption / Remission Spectroscopy)

Aim

To evaluate the combined use of NiLDF and RS for measurement of regional perfusion and oxygen saturation of the cerebral cortex during controlled decrease of cerebral perfusion pressure (CPP), ischemia and reperfusion.

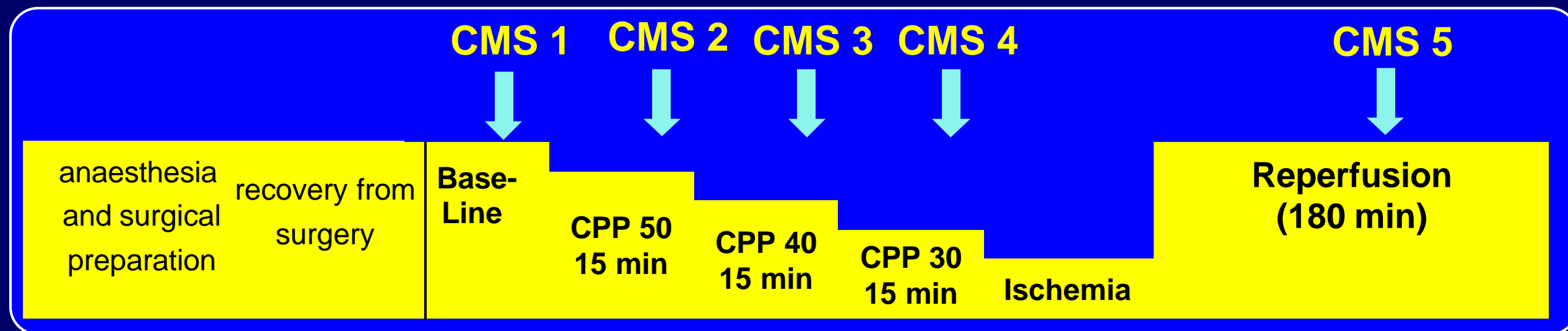
Material and Methods

mixed breed juvenile pigs (n=8; body weight = 17.2 ± 2.2 kg)

- anaesthesia: a - Chloralose (50mg kg^{-1} bolus ; $5\text{mg kg}^{-1} \text{h}^{-1}$ infusion); $\text{N}_2\text{O} / \text{O}_2$
- immobilization (pancuroniumbromide $0.2 \text{ mg kg}^{-1} \text{h}^{-1}$)
- ventilation: volume controlled (Servovent 900C, Siemens Elma, Sweden)

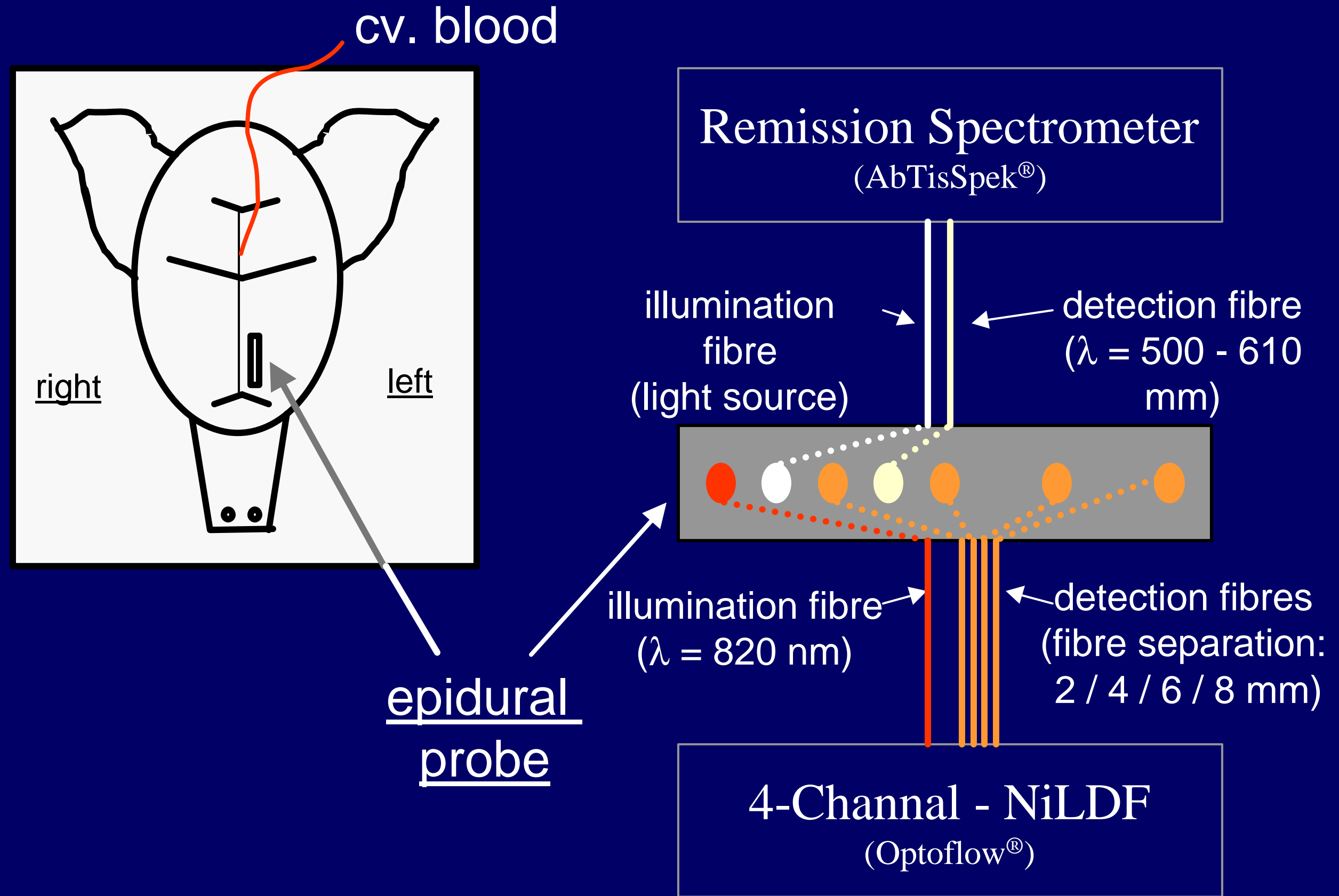
**Cerebral perfusion pressure
(CPP)**
CPP = MABP - ICP

Manipulation of CPP
intracisternal infusion of aCSF
cuff around pulmonary artery



- regional cerebral blood flow (coloured microspheres, reference blood method)
- ICP measurement (CaminoV420, San Diego, CA, USA)
- cardiovascular monitoring (MABP, CVP, HR)
- arterial and cerebral venous (sagittal sinus) blood gas analysis

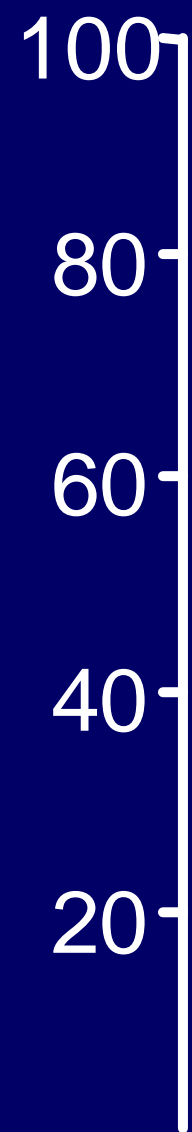
Head Instrumentation: NiLDF & Remission Spectroscopy (RS)



Results: Cerebral Blood Flow (CBF)

n = 9
mean ± SD

CBF [mL 100g⁻¹ min⁻¹]



■ regional CBF

■ forebrain CBF

* signif. vs. baseline (p <0.05)

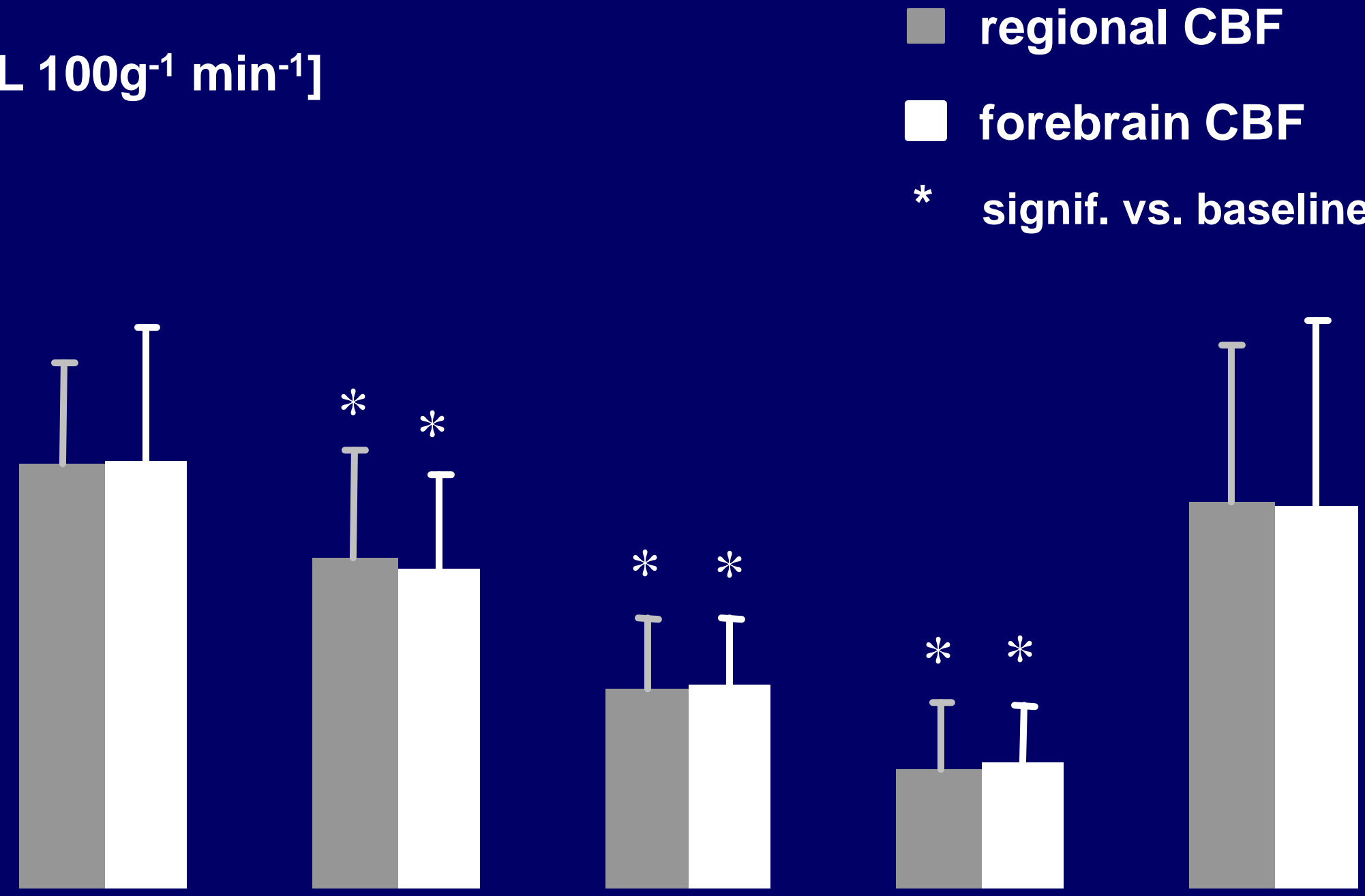
baseline

CPP 50

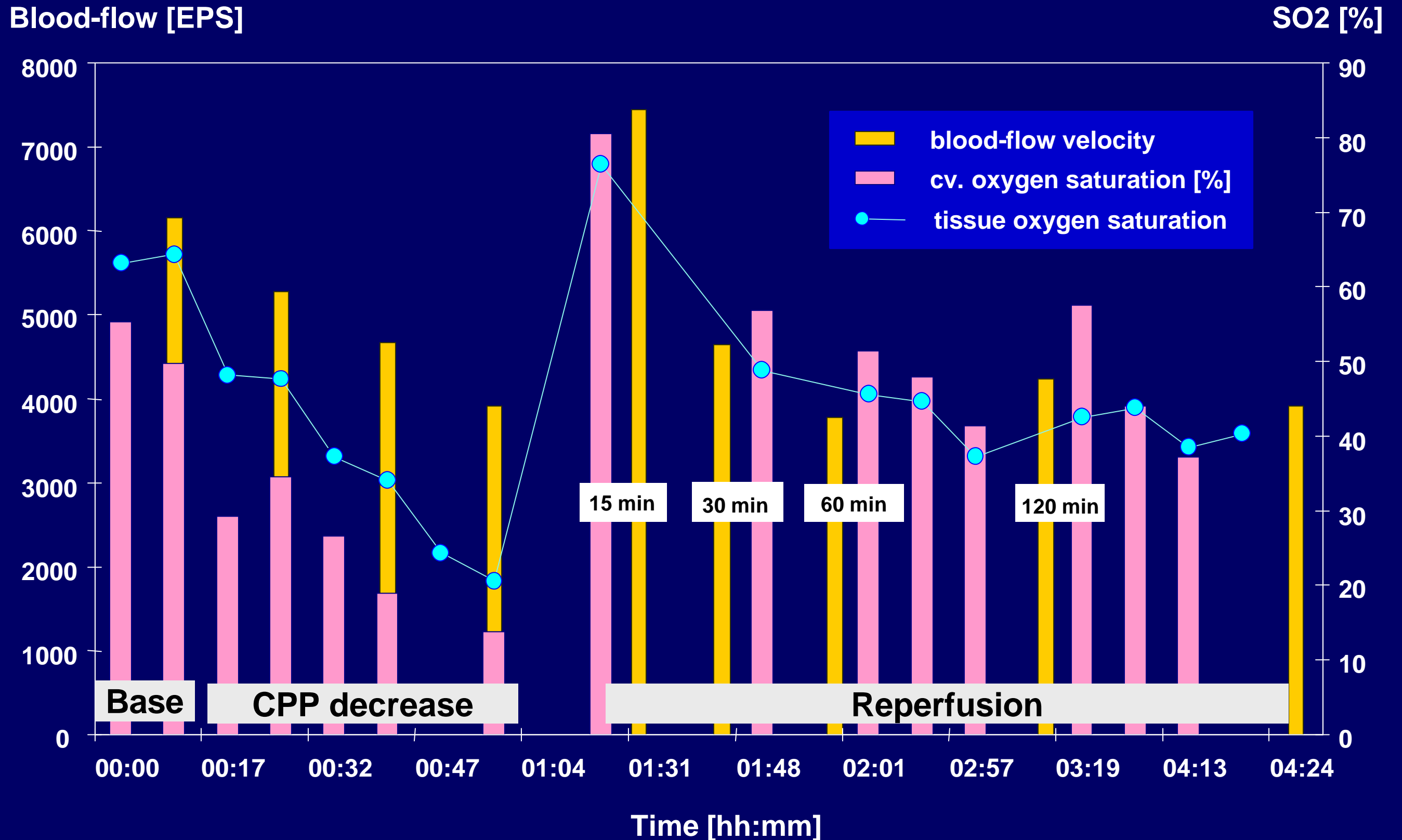
CPP 40

CPP 30

Reperfusion

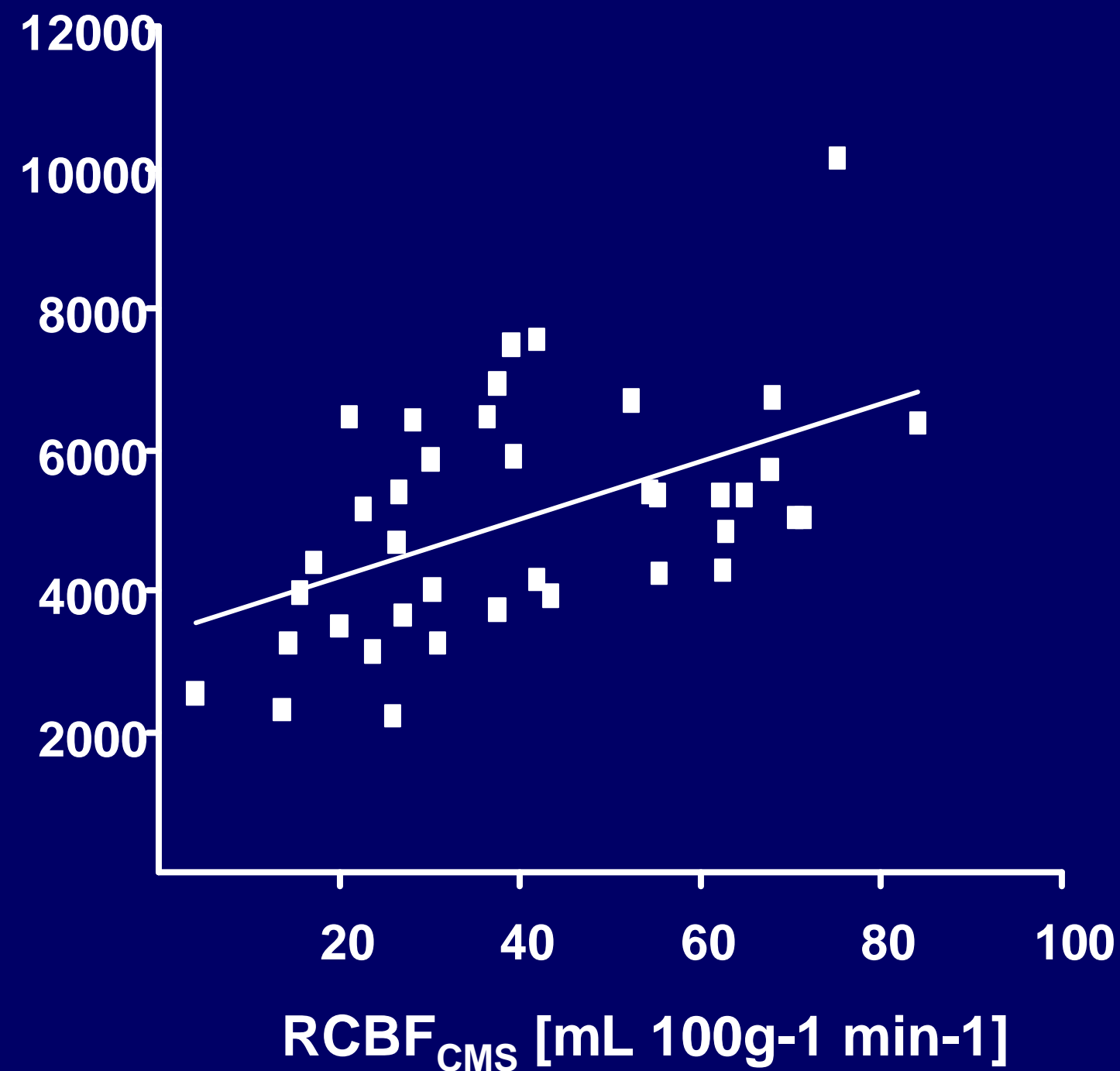


Blood-flow velocity and tissue oxygen saturation in the cerebral cortex of an anesthetized pig during progressive CPP reduction, ischemia and reperfusion (example registration)



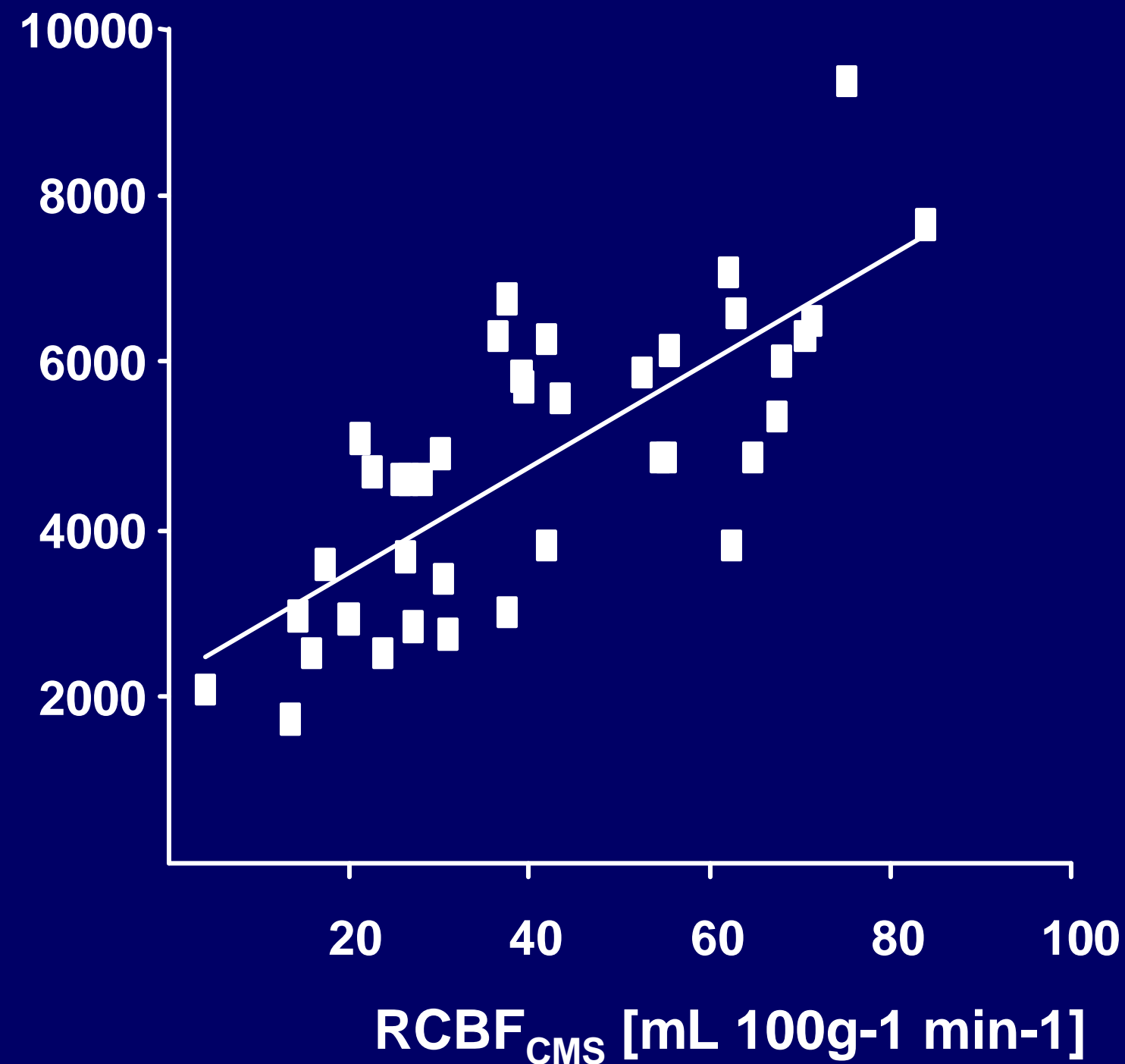
Local $\text{CBF}_{\text{NiLDF}}$ and Regional CBF_{CMS} (absolute values) $n = 9$

$\text{LCBF}_{\text{NiLDF}}$ [AU]



Local CBF_{NiLDF} and Regional CBF_{CMS} (absolute values) n = 9

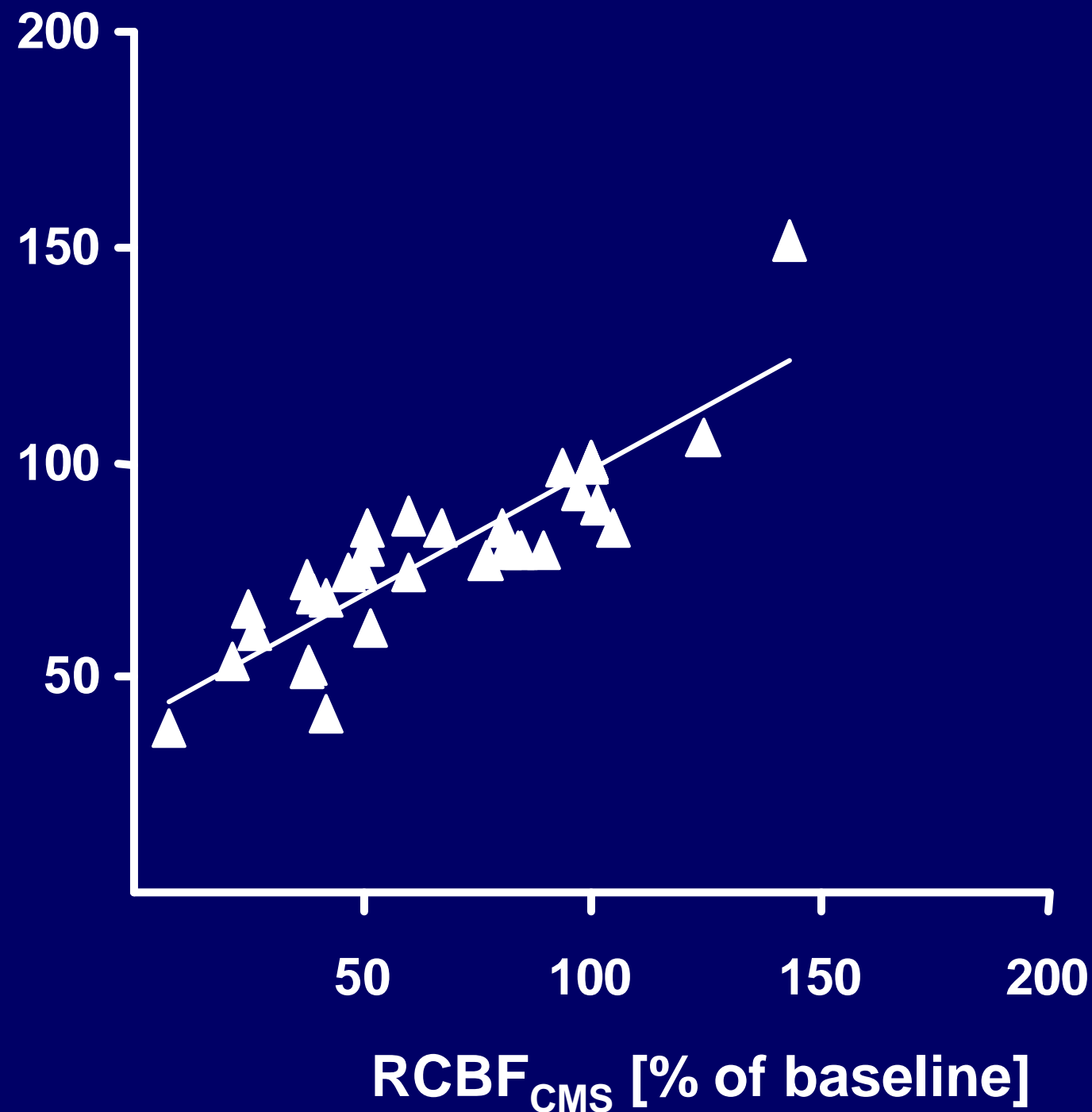
LCBF_{NiLDF} [AU]



Changes of Local $\text{CBF}_{\text{NiLDF}}$ and Regional CBF_{CMS} (% of baseline)

n = 9

$\text{LCBF}_{\text{NiLDF}}$ [% of baseline]



fibre separation: 2 mm

$$y = 0.59x + 39.8$$

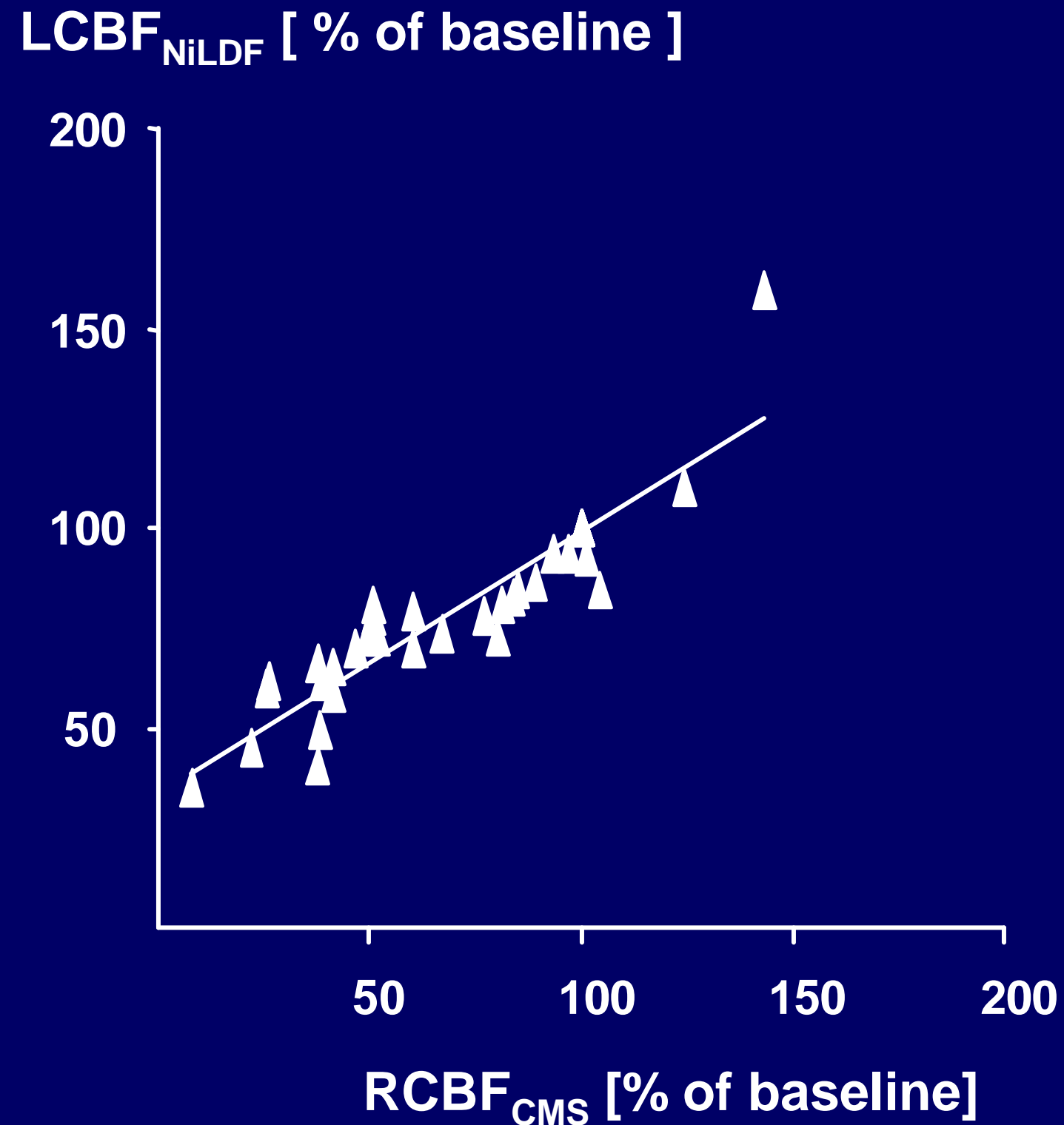
$$R^2 = 0.79$$

$$n = 39$$

$$p < 0.001$$

Changes of Local $\text{CBF}_{\text{NiLDF}}$ and Regional CBF_{CMS} (% of baseline)

n = 9



fibre separation: 4 mm

$$y = 0.66x + 33.6$$

$$R^2 = 0.85$$

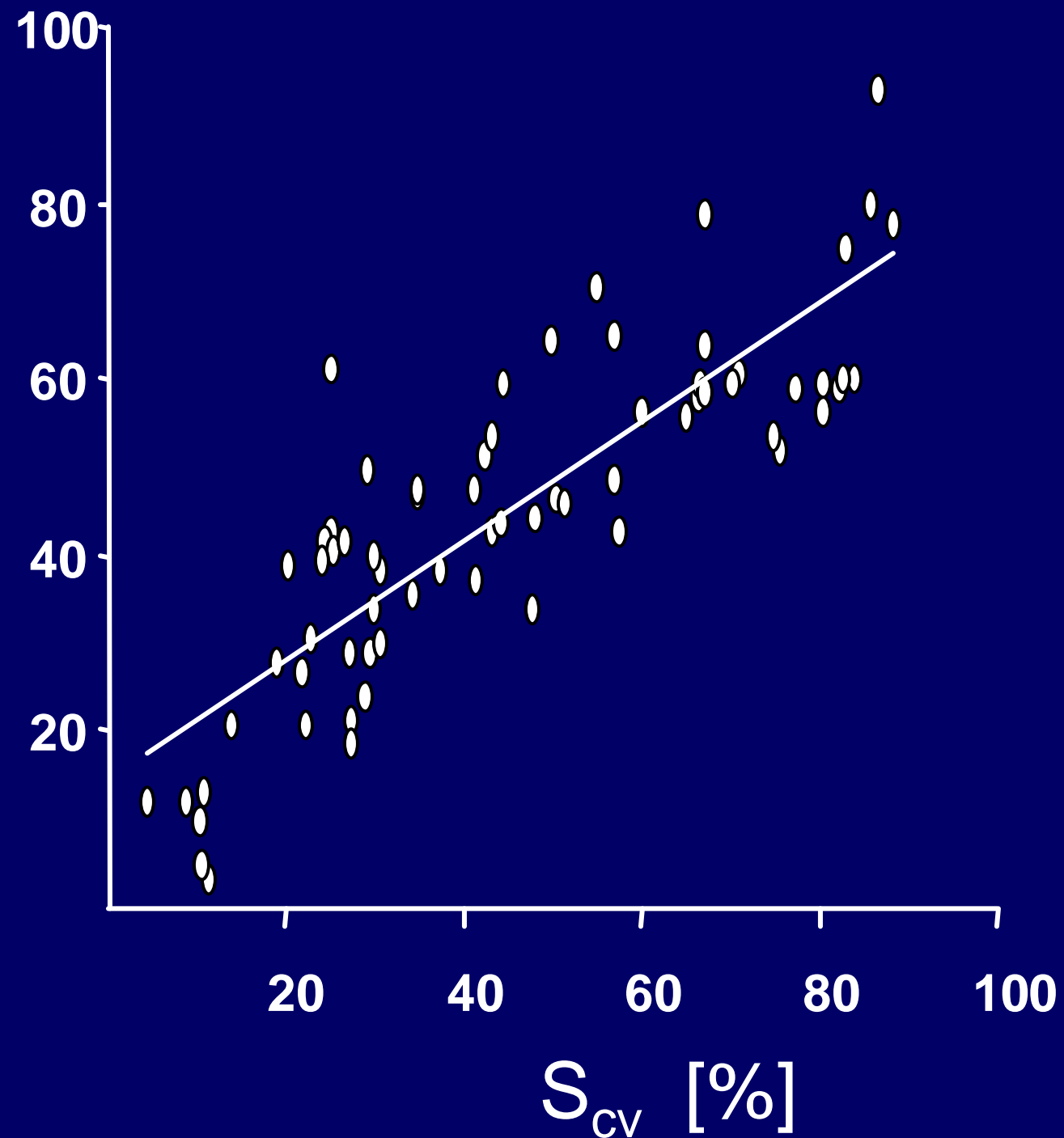
$$n = 39$$

$$p < 0.001$$

Tissue Oxygen Saturation (S_{ti}) and Cerebral Venous Oxygen Saturation (S_{cv})

S_{ti} [%]

$n = 5$



$$y = 0.68x + 14.4$$

$$R^2 = 0.72$$

$$n = 67$$

$$p < 0.001$$

- **The combined use of NiLDF and RS allows continuous optical monitoring of the key parameters of oxygen metabolism within the cerebral cortex under clinically relevant conditions**
- **A fibre separation of 4 mm results in a better correlation of LDF signal and absolute CBF (reduced local variability?)**

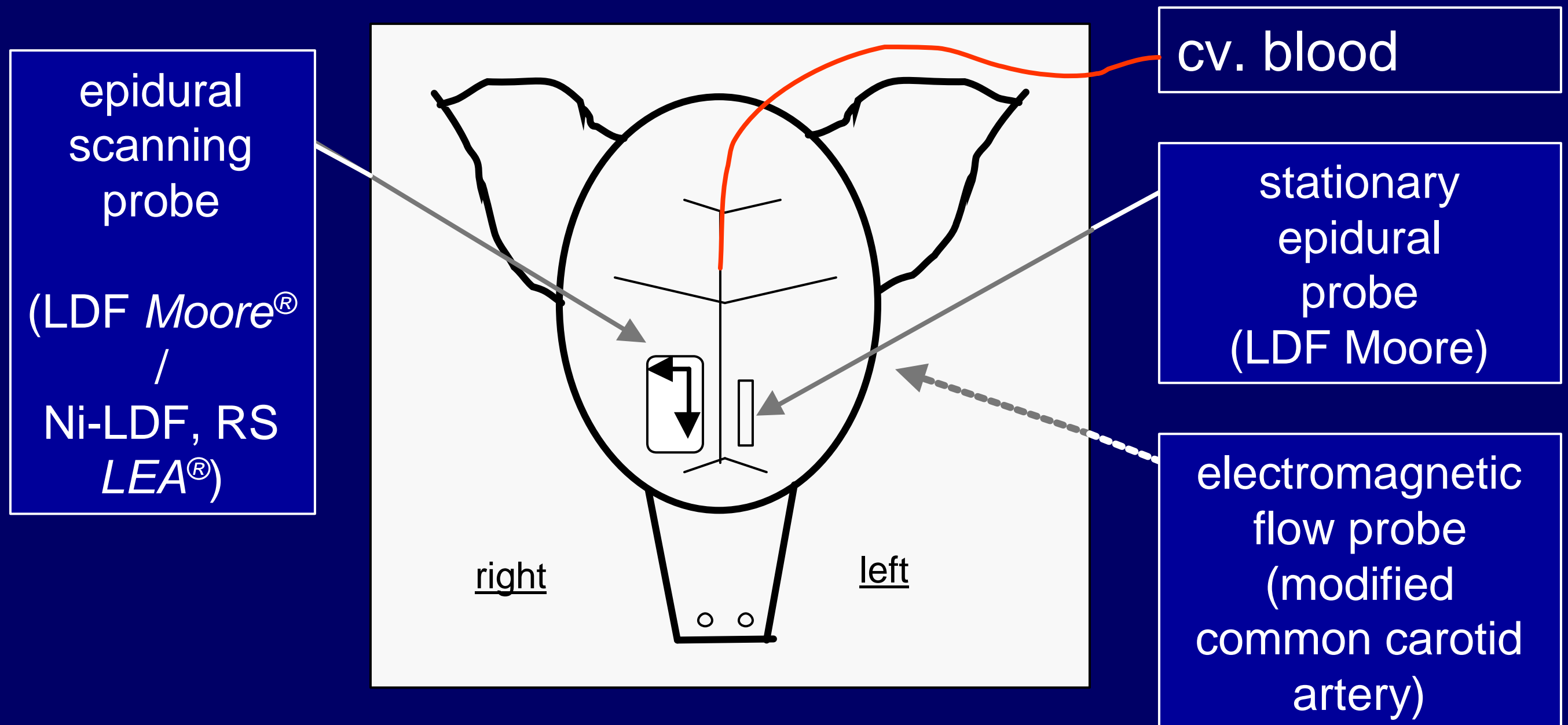
However:

- **biological zero of NiLDF**
- **local variability (measurement of absolute values)**
- **calculation of regional CMRO_2 ® neuro-vascular coupling on a regional level**

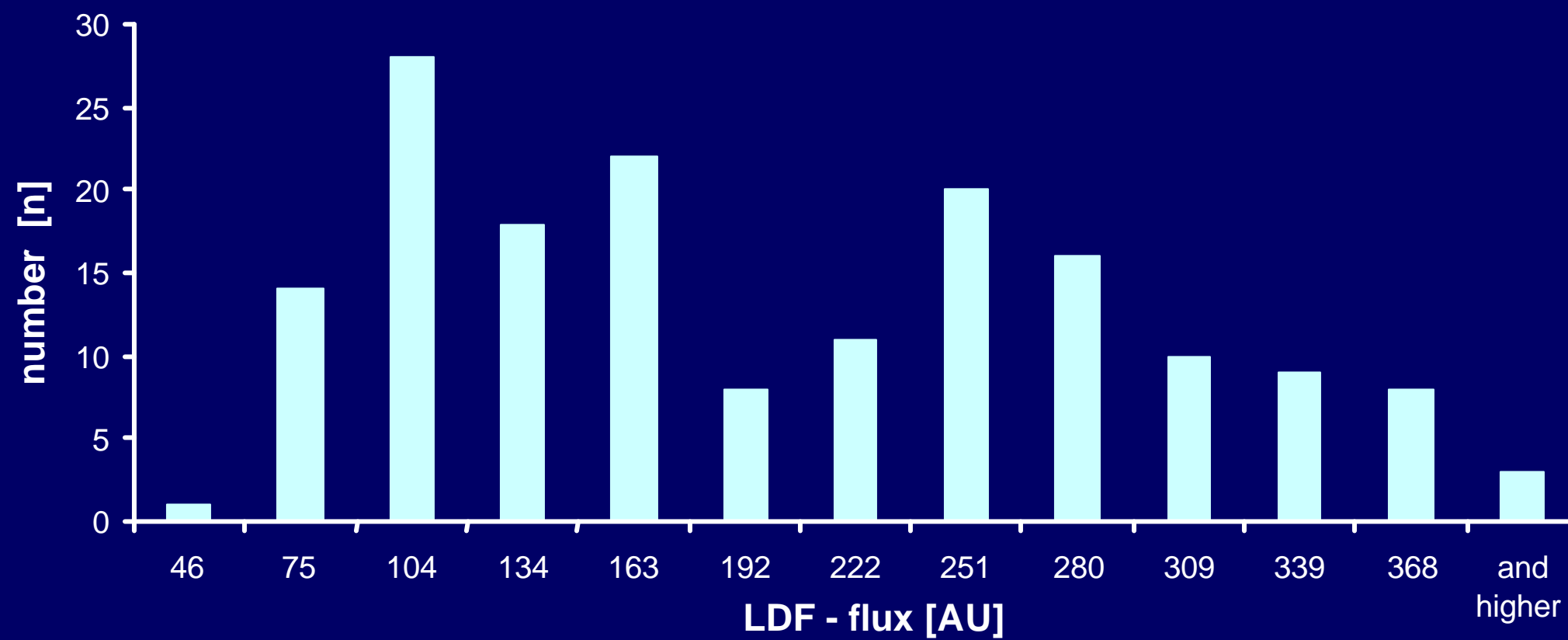
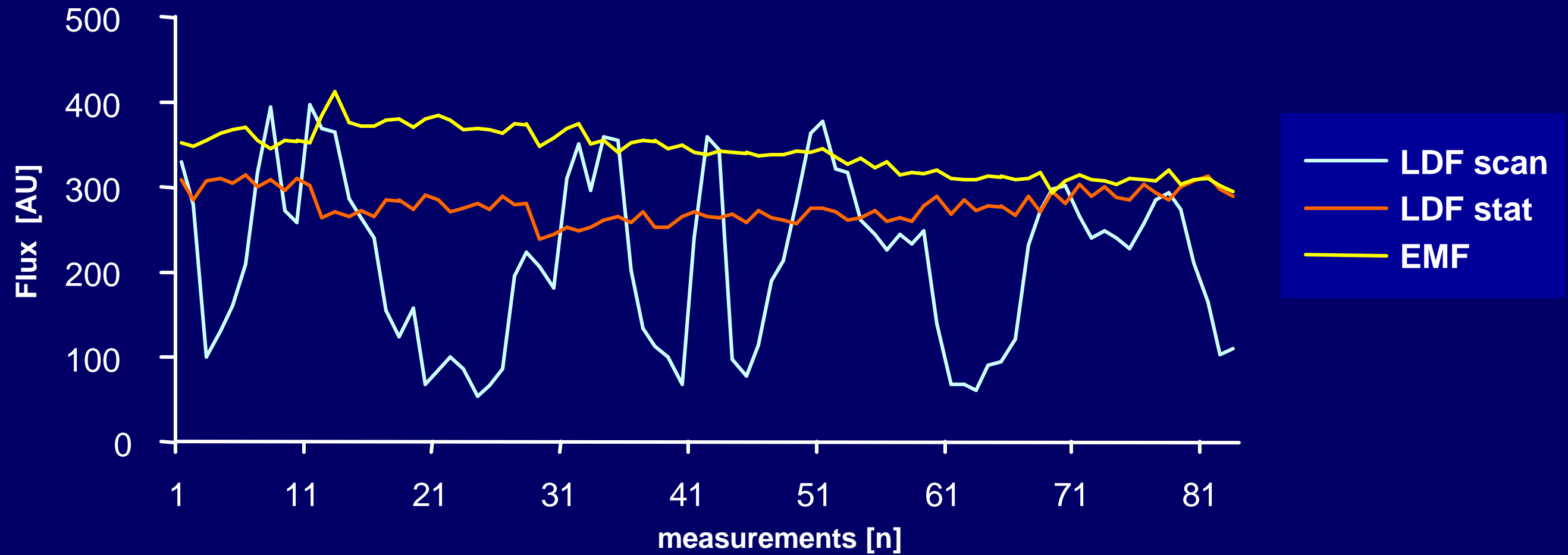
Spatial variability

2 pigs (8 Weeks old)

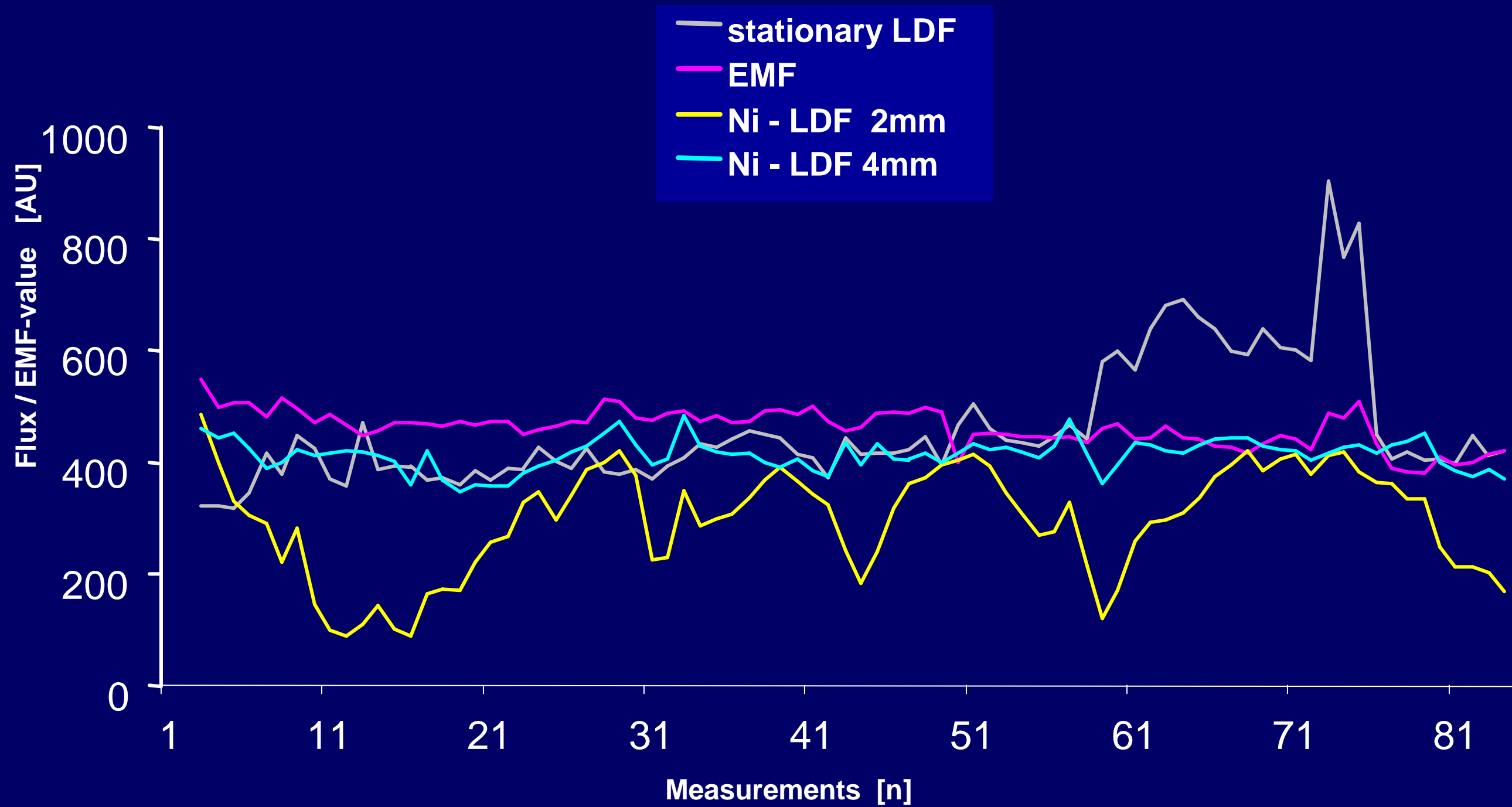
- anaesthesia: Isoflurane (1%) N₂O / O₂
- immobilization (pancuroniumbromide 0.2 mg kg⁻¹ h⁻¹)
- ventilation: volume controlled (Servovent 900C, Siemens Elma, Sweden)



Spatial variability (LDF, Moore[®])

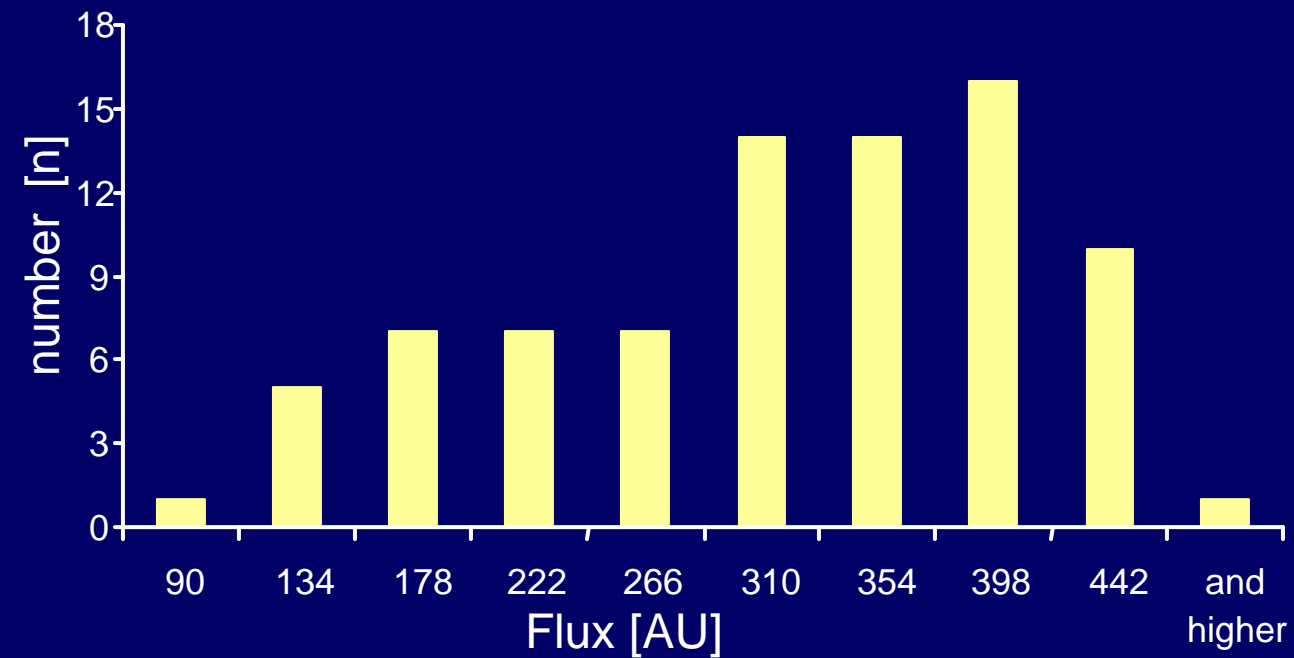


Spatial variability (Ni-LDF, *LEA*[®])

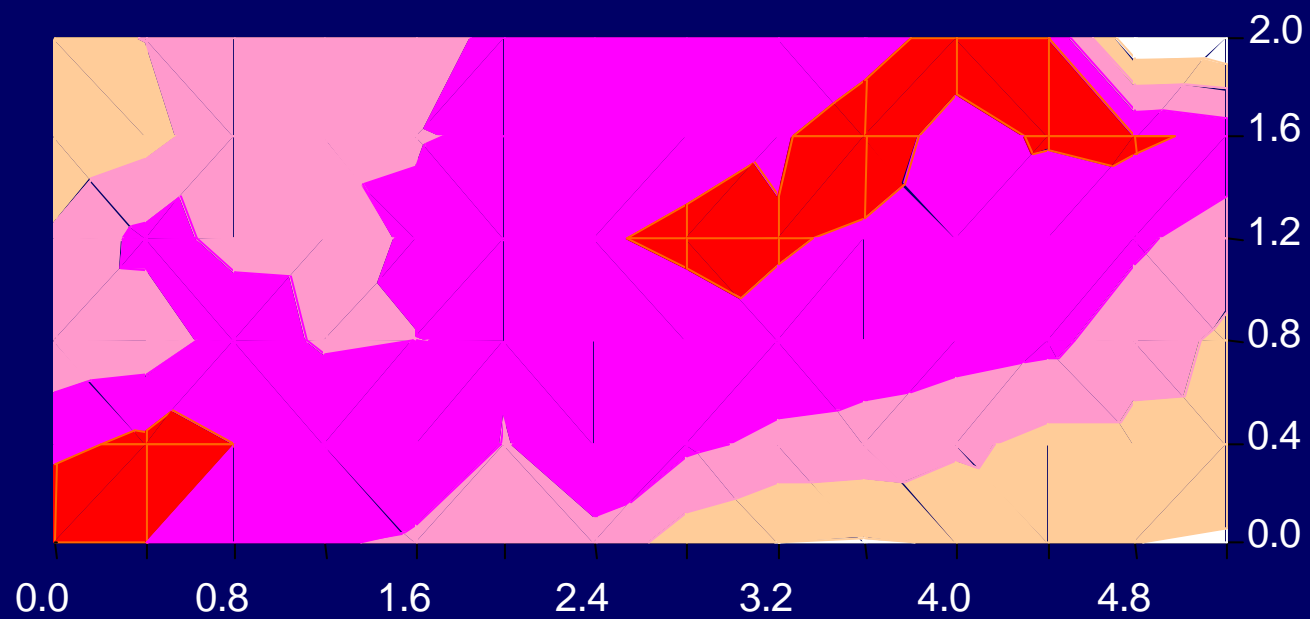
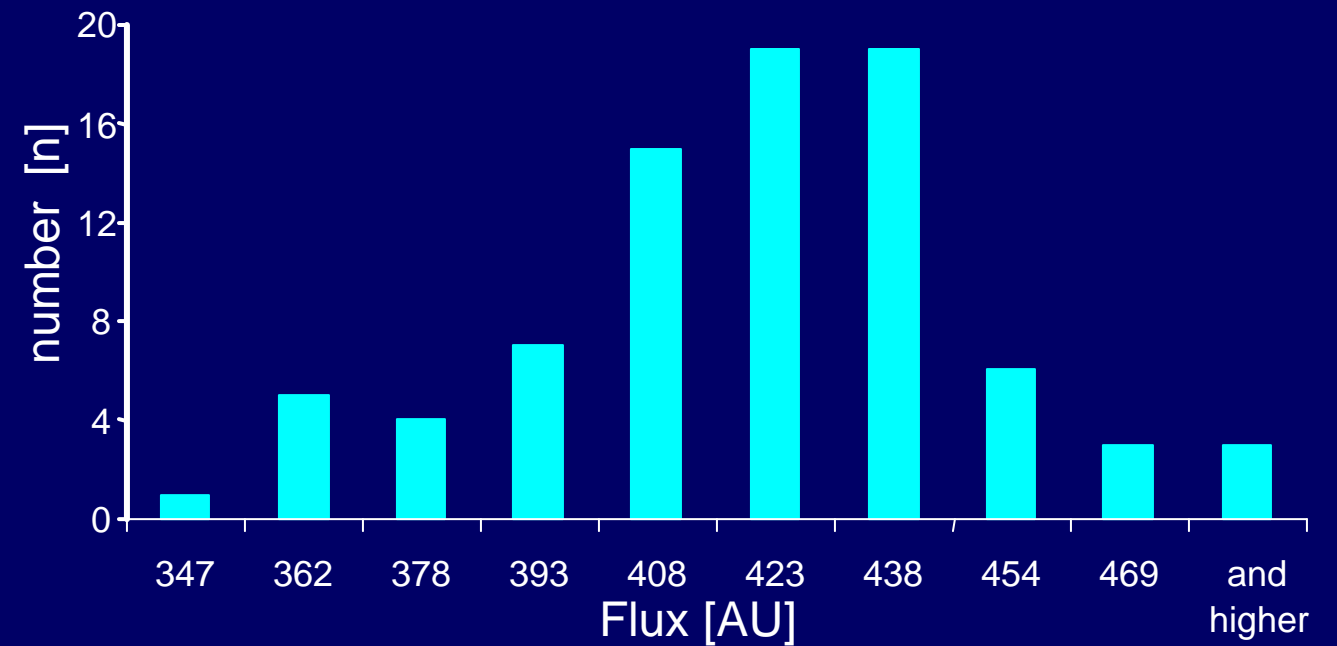


Spatial variability (Ni-LDF, *LEA*[®])

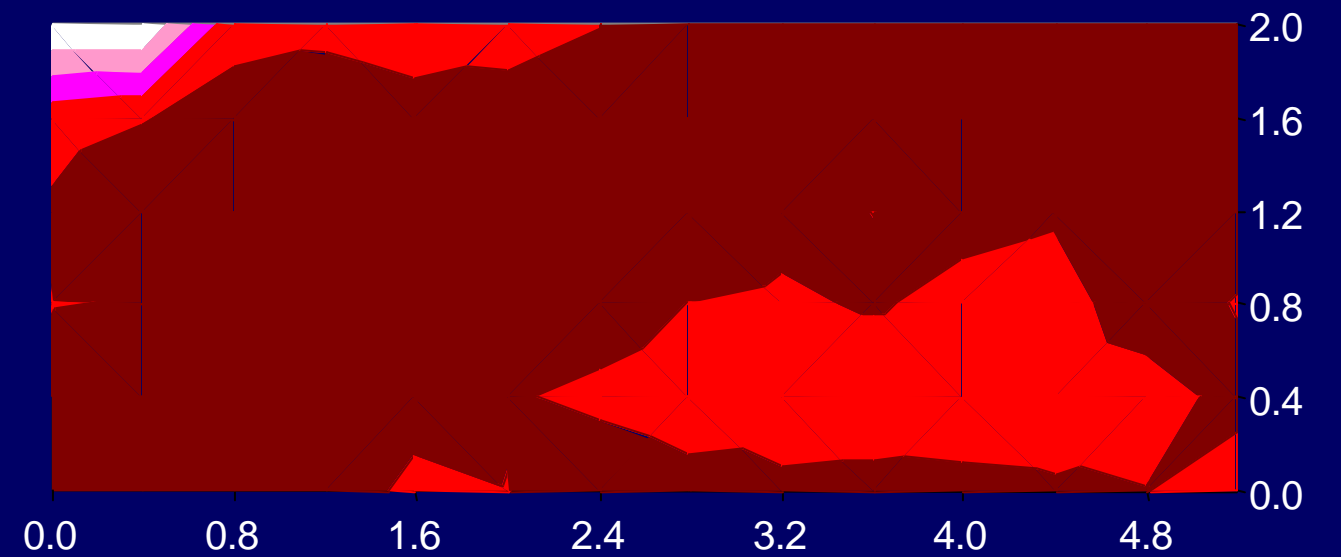
Ni LDF 2mm fibre separation



Ni LDF 4mm fibre separation



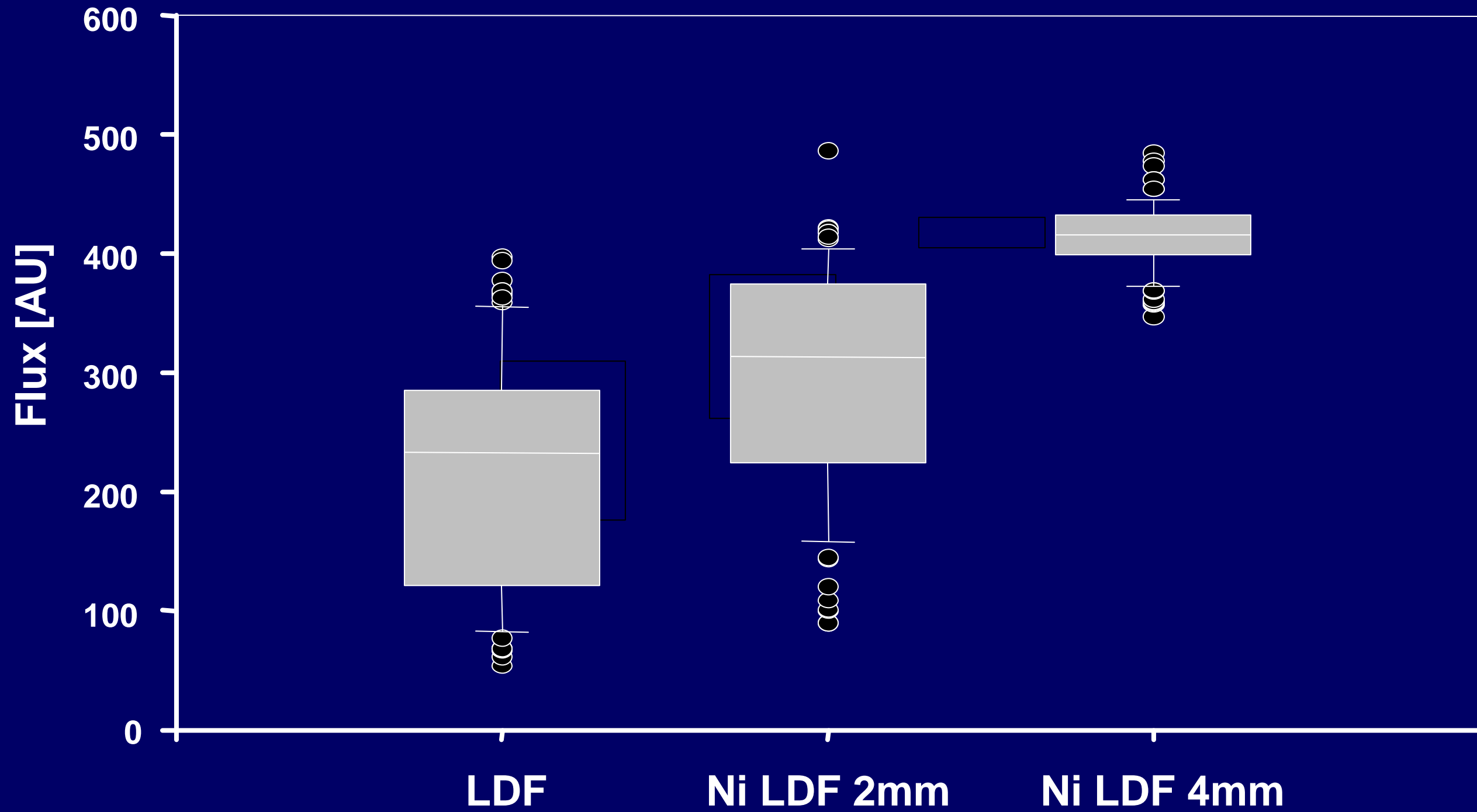
Flux [AU]



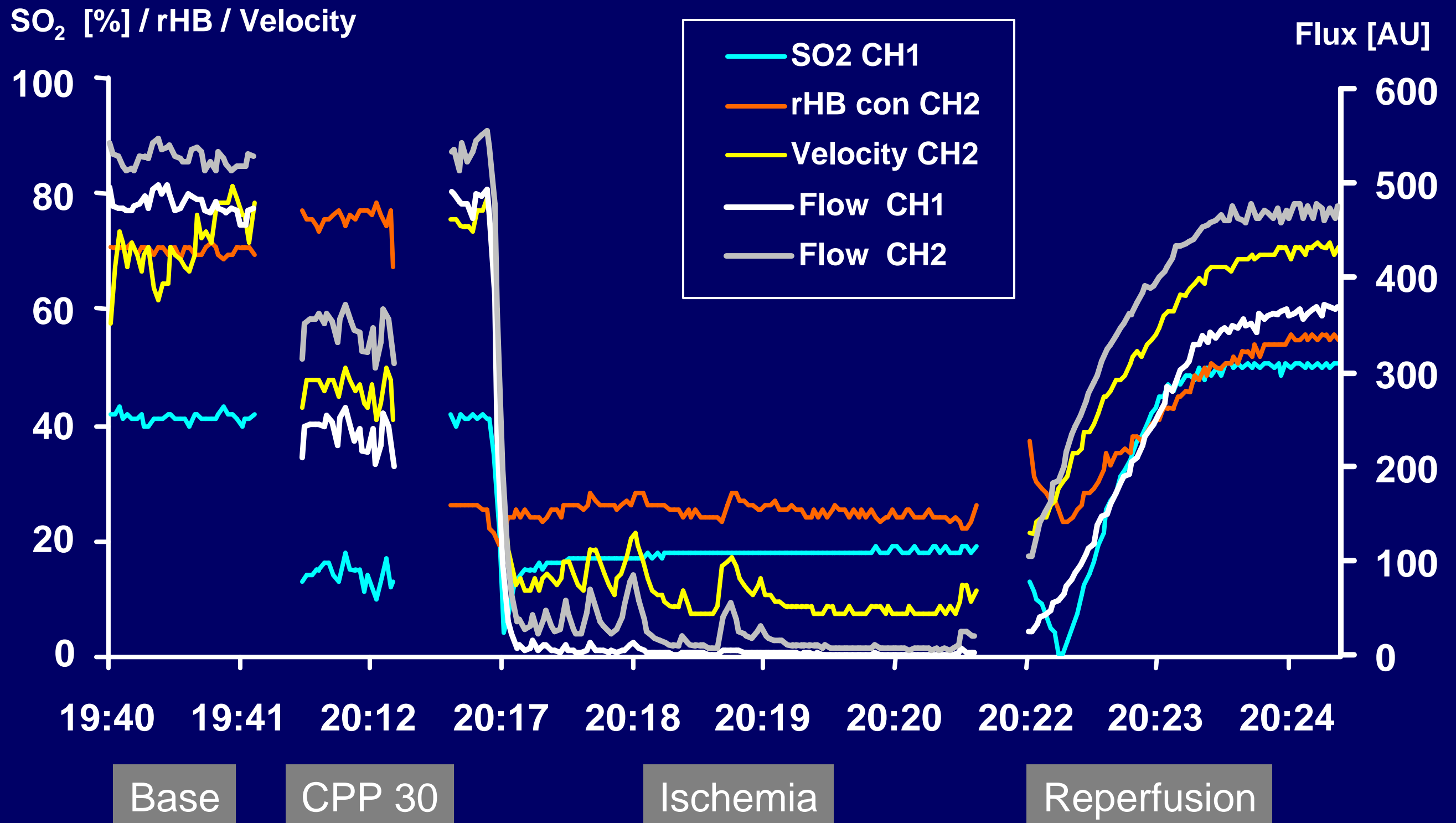
Flux [AU]



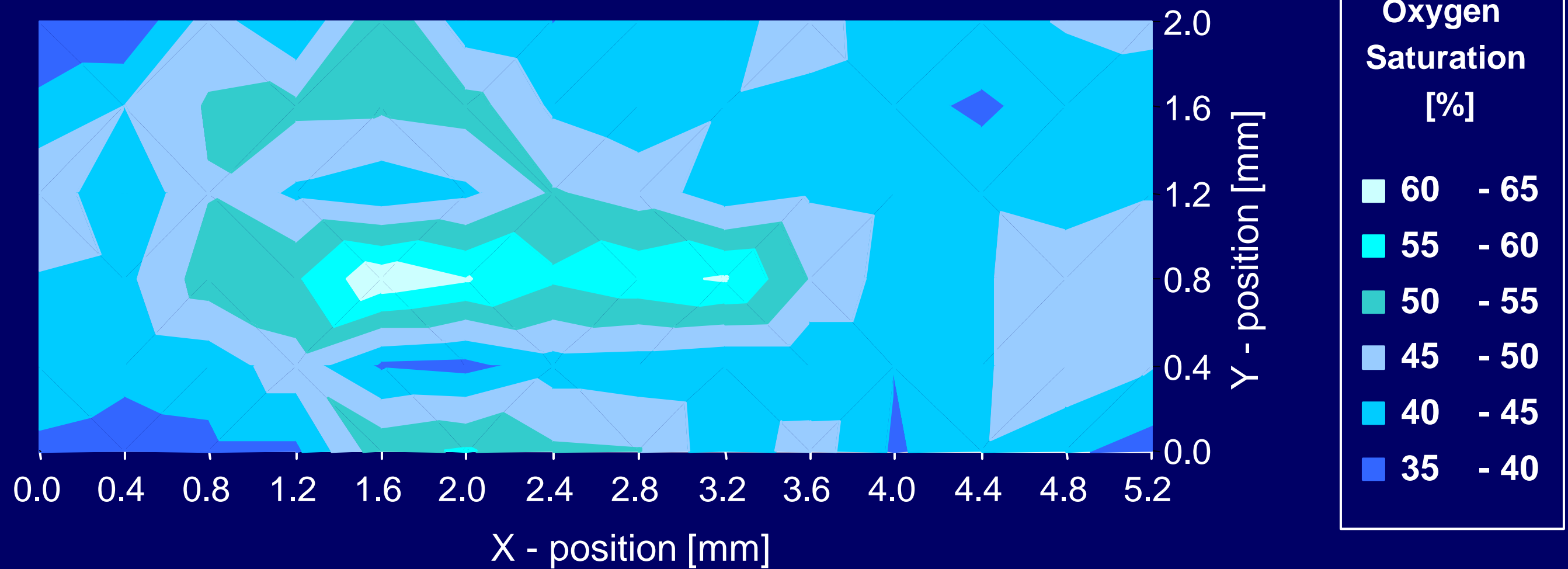
Comparison of blood flow variability



Biological zero (example registration „P690“)



Spatial Variability of Tissue Oxygen Saturation (visible light RS)



Summary

- The combined use of NiLDF and RS allows continuous optical monitoring of the key parameters of oxygen metabolism within the cerebral cortex under clinically relevant conditions
- NiLDF value is near to biological zero during ischemia
- Reduced spatial variability with increasing fibre separation
- \Rightarrow measurement of total values with limited number of measuring points (multiple fibre probes in humans)
- additional information of redox state of cytochromes during ischemia (in vitro, transplanted organs)