Decomposition Method for Cerebral Oxygenation to Improve Detection of Brain Injury in Preterm Infants

Infant

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Background and Aims

Challenges in brain monitoring for preterm infants:

- Up to 30% of preterm infants <32 weeks of gestation develop intra-ventricular haemorrhages (IVH)
- Cranial ultrasound will detect IVH, but 1) required handling can compromise stability of infant and 2) serial measurements only

Near Infrared Spectroscopy (NIRS):

- Measures regional cerebral oxygenation ($rcSO_2$)
- Continuous, long-duration (days) measurements of $rcSO_2$ possible
- Minimal handling required (initial application of probe only)
- Can automated (computer) analysis of $rcSO_2$ detect IVH?

NIRS device

NIRS probe

AIM 1: Remove noise: develop automated method to extract transients and baseline shifts from $rcSO_2$ signal
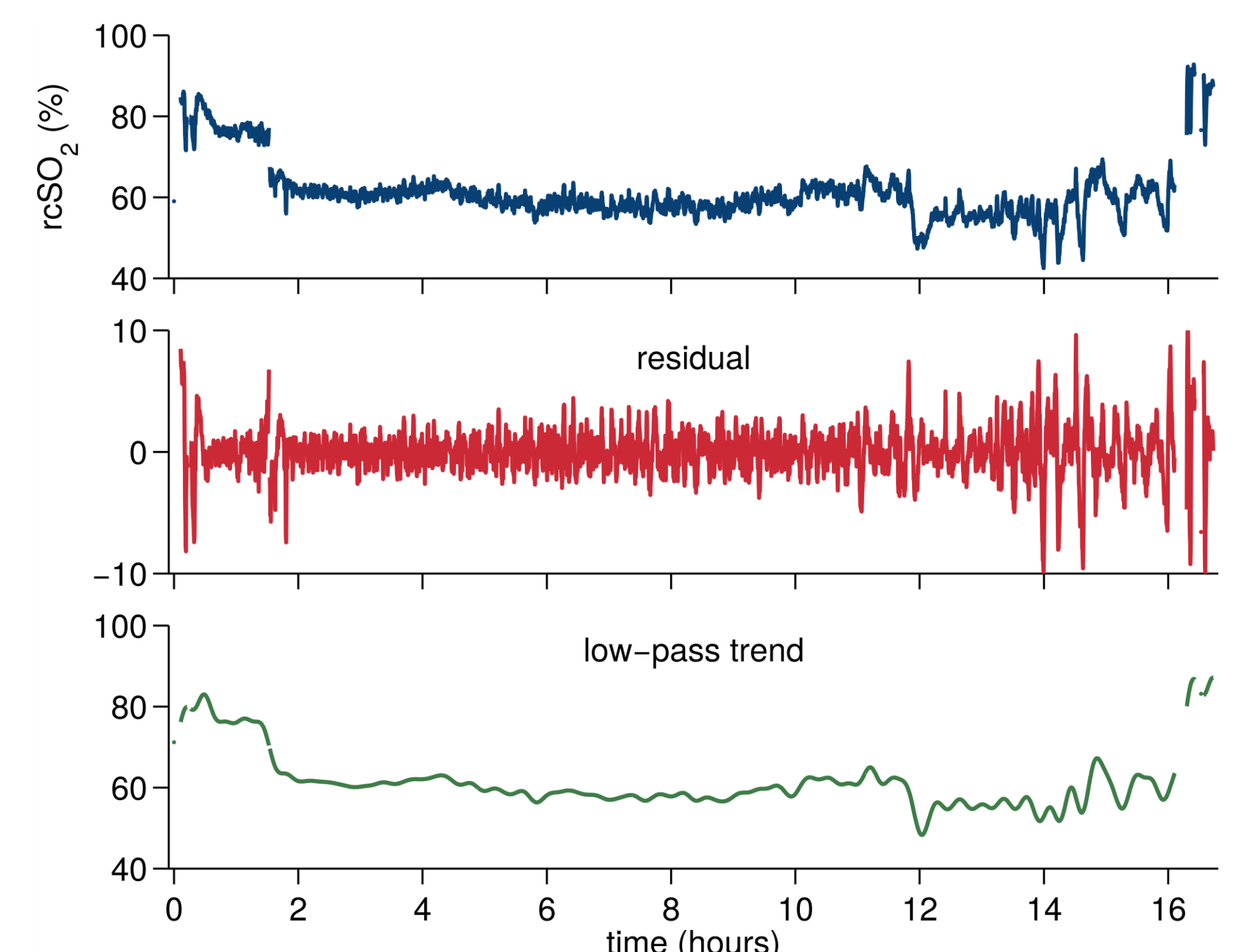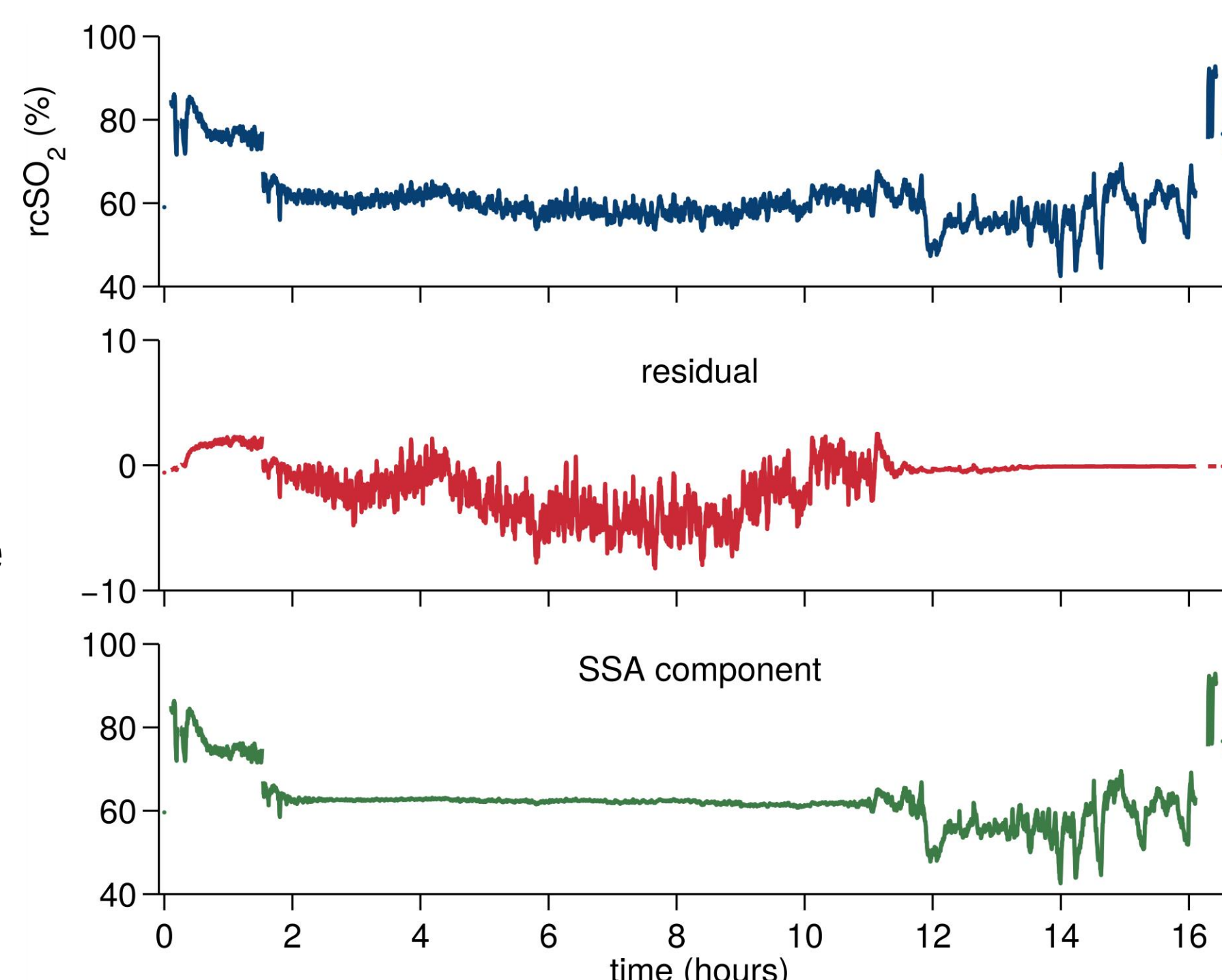
AIM 2: Extract features from signal to detect IVH

Methods

Patients $rcSO_2$ Data

- Recorded continuously for up to 48 hours of life *(INVOS 5100c NIRS device with neonatal probe)*
- Adverse outcome: any grade of IVH or PVL
- Good outcome: absence of IVH/PVL

SSA Decomposition Method

1. Rotate signal 90° in time–frequency domain (use discrete cosine transform, DCT)
2. Decompose signal using singular spectrum analysis (SSA); remove noise [1]
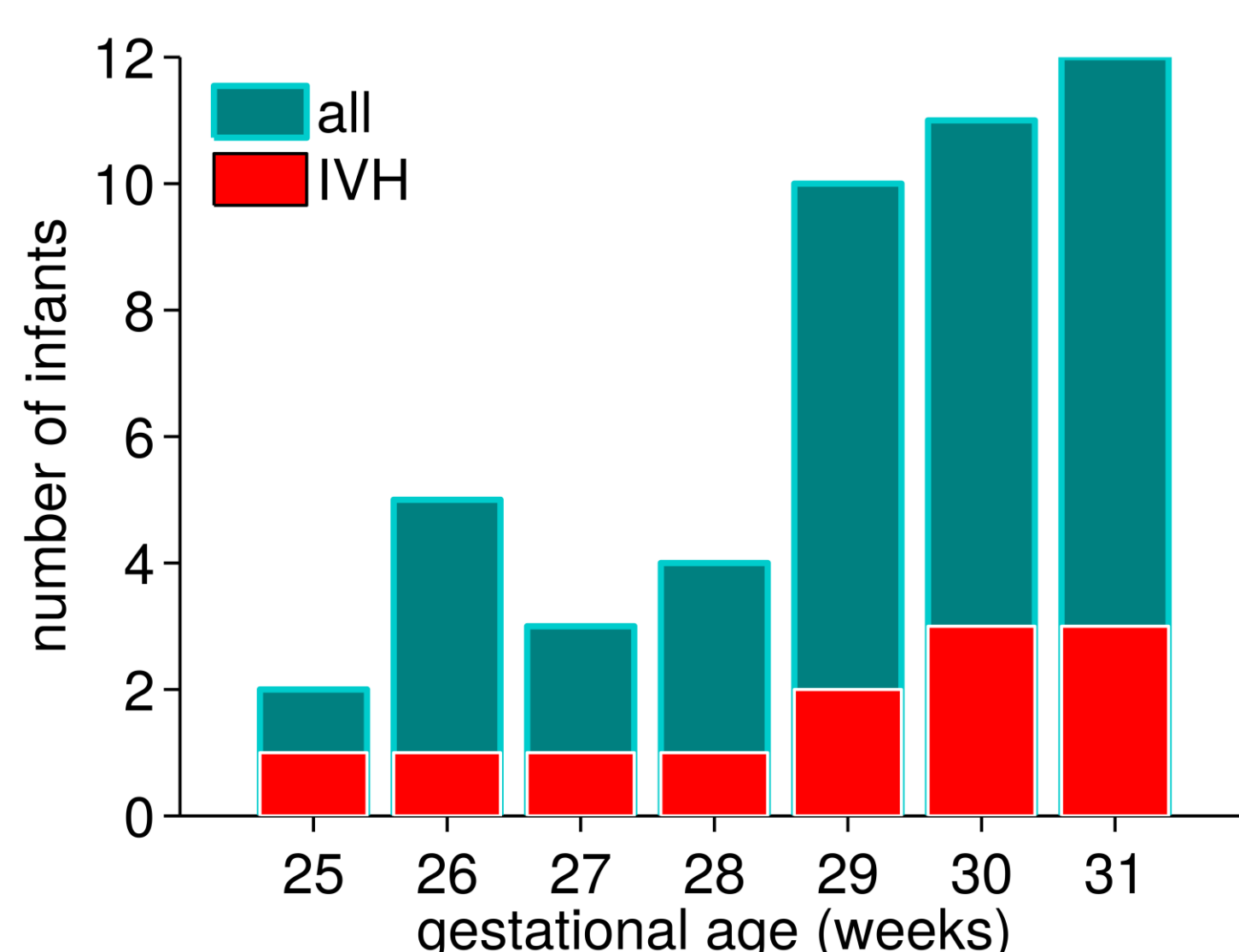3. Rotate back in time–frequency domain (inverse DCT)

Feature Set

- Filter with dyadic filter bank
- Amplitude modulated (AM) features; frequency modulated (FM) features; and fractal dimension (FD); see [2] for details.

SSA decomposition method (left) differs to low-pass filtering approach (right)

Results and Conclusions

47 preterm infants; 12 with IVH

Top 3 features from 3 signals
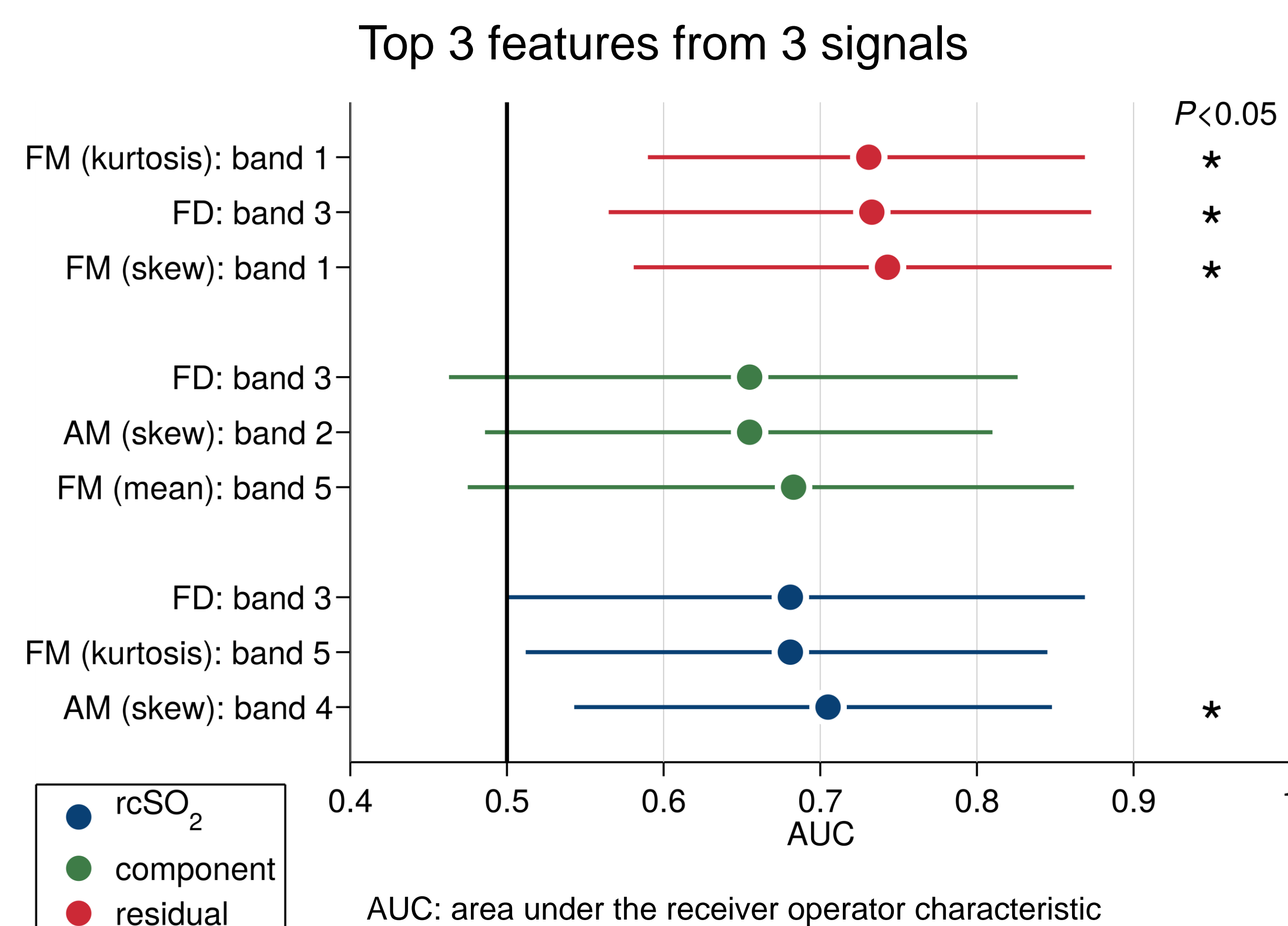
AUC: area under the receiver operator characteristic

Conclusions:

- New decomposition method able to extract components from $rcSO_2$ with transients and baseline shifts.

- Features from residual signal discriminates between those infants with and without IVH

- Automated analysis of cerebral oxygenation could aid early detection of IVH and help improve outcomes for preterm infants

REFERENCES:
[1] Vautard R, Yiou P, & Ghil M (1992). Singular-spectrum analysis: A toolkit for short, noisy chaotic signals. Physica D: Nonlinear Phenomena, 58(1–4), 95–126.
[2] O'Toole JM, Kenosi M, Finn D, Boylan GB, & Dempsey EM. (2016). Features of cerebral oxygenation detects brain injury in premature infants. In IEEE 38th Int Conf EMBC, Aug. (pp. 3614-3617).

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