

# **A ROBUST FETAL ECG DETECTION METHOD FOR ABDOMINAL RECORDINGS**

Biomedical Signal Processing Project

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# INTRODUCTION

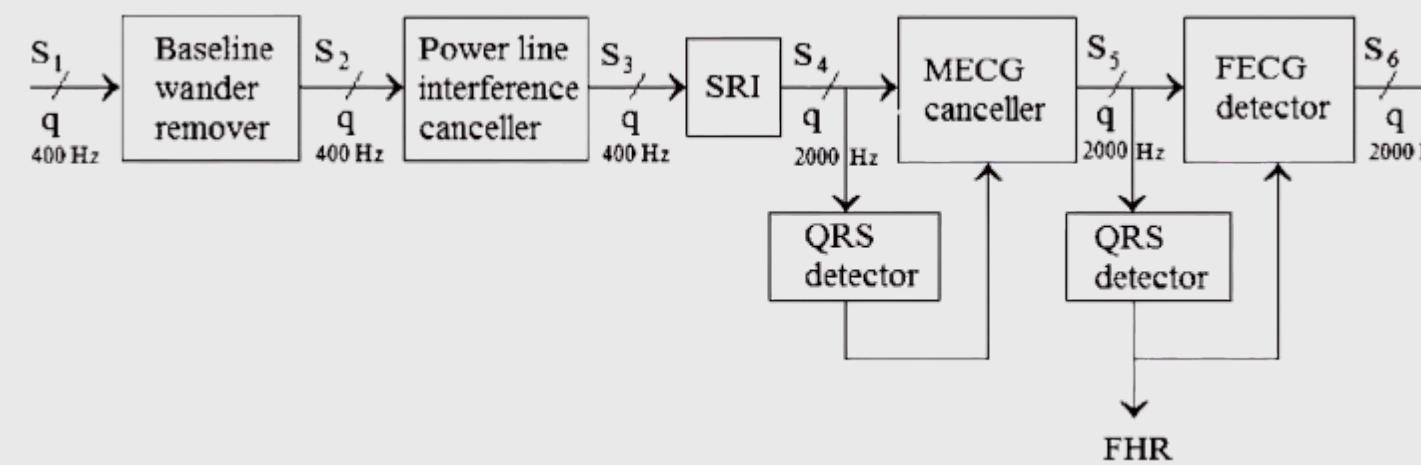
Monitoring the fetal cardiac activity can provide important information to obstetricians for the assessment of the **fetal well-being**.

**Abdominal FECG** provide a **non-invasive** diagnostic tool to do so.

However, the **fetal signal** has **small amplitude** and it's **overwhelmed by** a large number of **interference signals** such as baseline drift, power-line interference, motion artifacts and the mother's ECG itself

The paper proposes a non-blind method for FECG detection in abdominal recordings during pregnancy and labour.

# METHOD



The method proposed detects the FECG by estimating and removing the inference signals step-by-step:

- 1.** Baseline wander remover
- 2.** Power-line interference canceller
- 3.** Sampling-rate increaser
- 4.** Mother QRS detector → MECG canceller
- 5.** Fetal QRS detector → FECG extractor

# BASELINE WANDER REMOVER

**Adaptive filtering and Polynomial or Cubic Spline Subtraction are rejected**

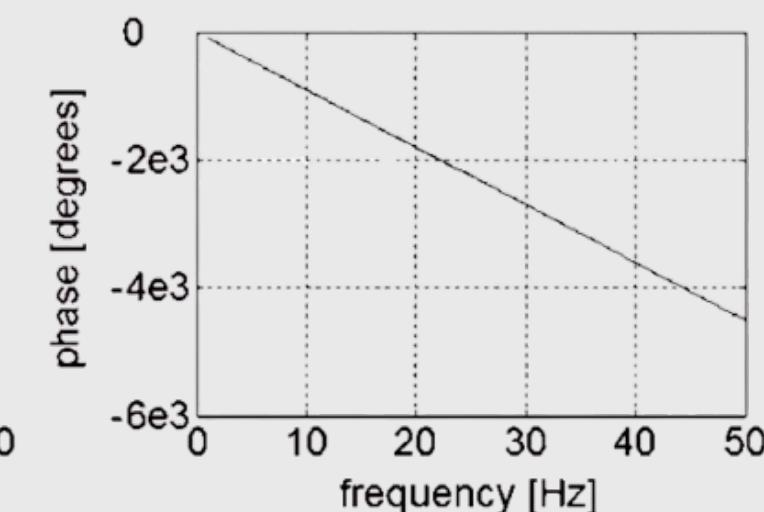
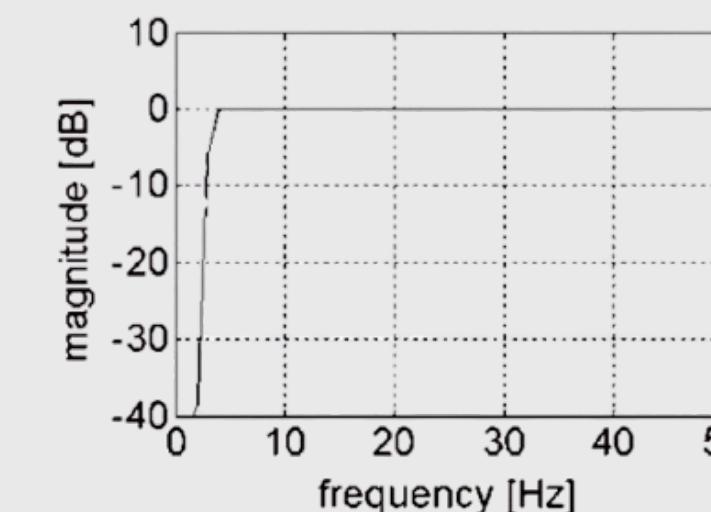
**SOLUTION → Linear-phase high pass FIR filter**

It attenuates the large amount of baseline wander though it may cause a slight FECG distortion

**Cut-off frequency:** 3Hz

**Filter Order:** 1000 (+1)

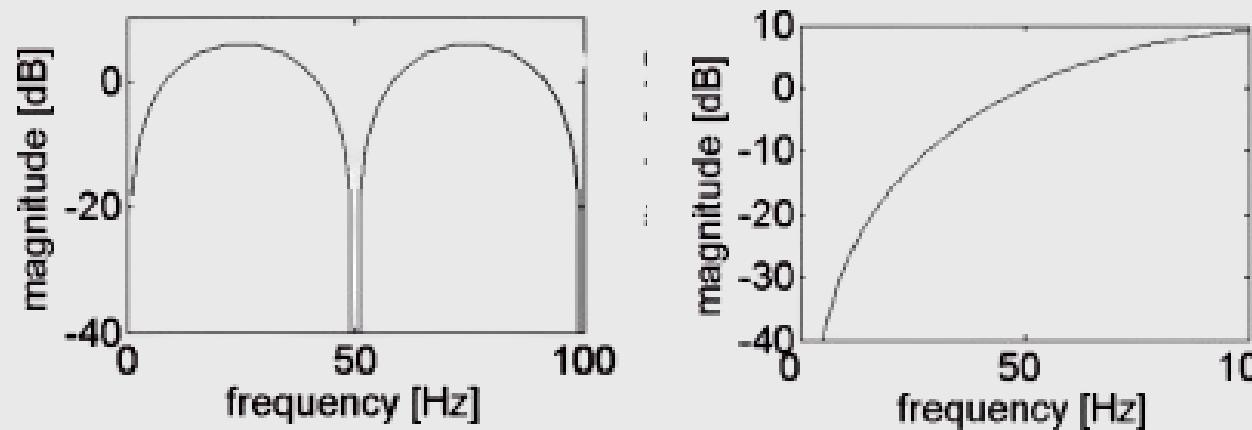
**Window:** Hamming



# ADAPTIVE PLI CANCELLER

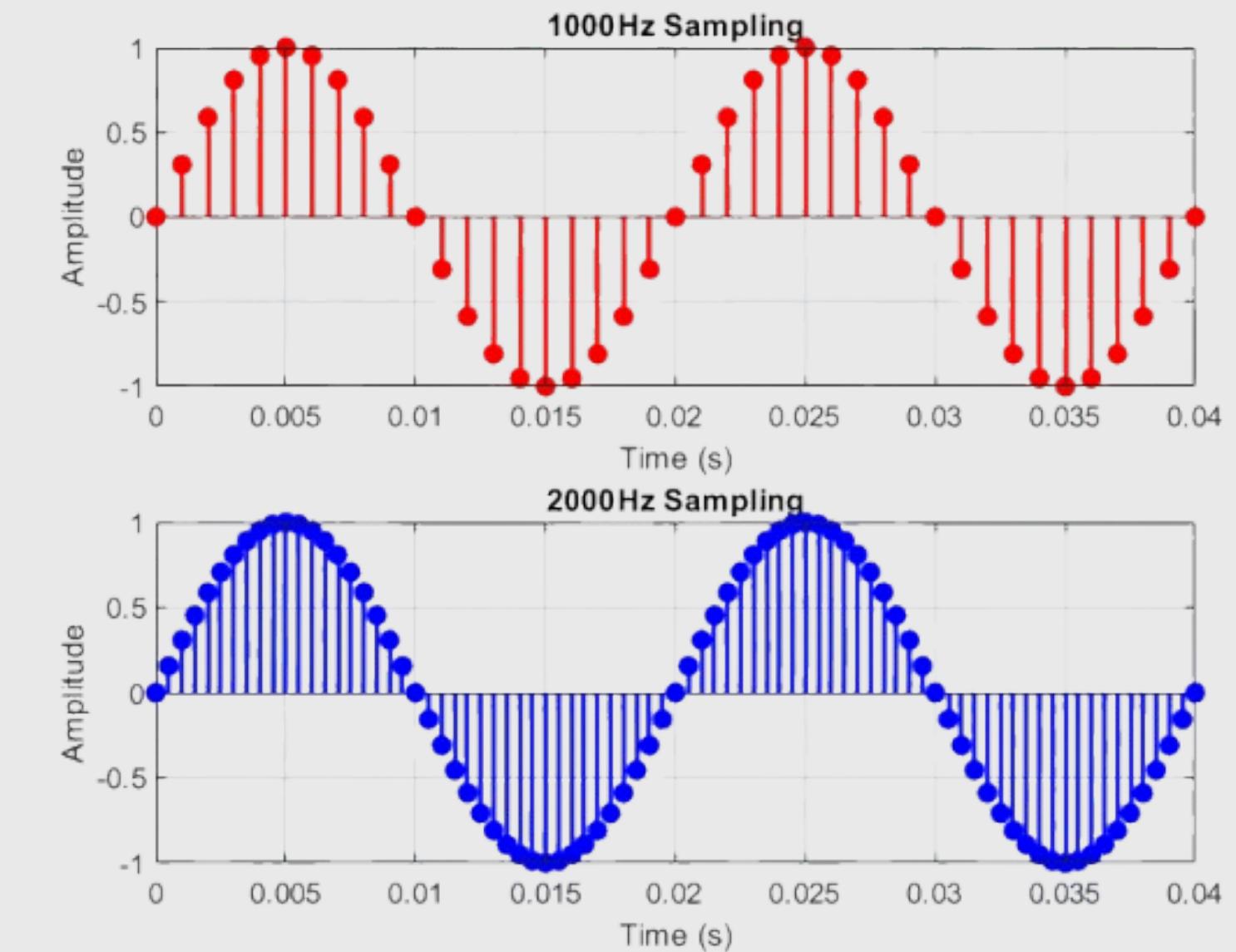
**Blocking detection** to protect QRS complexes:  
Comb Filtering → Threshold Detection → Mask Generation

**Adaptive Cancellation Loop:**  
Reference Generation → Error Calculation → Error Filtering  
Reference Generation parameters Update using LMS



# SAMPLING RATE INCREASER

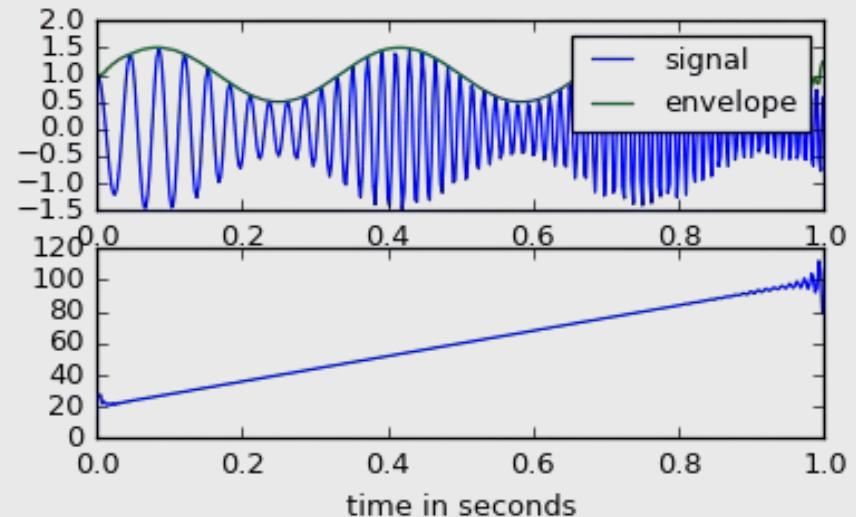
Sampling rate increased to **2000 Hz**  
for removing MECG with high  
precision



# MECG CANCELLER

## MQRS DETECTOR:

1. PCA
2. Detection with Hilber Envelope and Dynamic Thresholding
3. Perfect Template Overlap via Cross-Correlation



## MECG CANCELLER:

1. Average Beat Template
2. Beat Segmented into P Wave, QRS complex and T wave
3. Adaptive Fitting with Ridge Regression

$$M = \begin{pmatrix} | & 0 & 0 \\ \underline{\mu}_P & 0 & 0 \\ | & 0 & 0 \\ 0 & | & 0 \\ 0 & \underline{\mu}_{QRS} & 0 \\ 0 & | & 0 \\ 0 & 0 & | \\ 0 & 0 & \underline{\mu}_T \\ 0 & 0 & | \end{pmatrix}. \quad \underline{a} = (M^T M)^{-1} M^T \underline{m}.$$

# FECCG EXTRACTOR

## FQRS DETECTOR

2 different approaches:

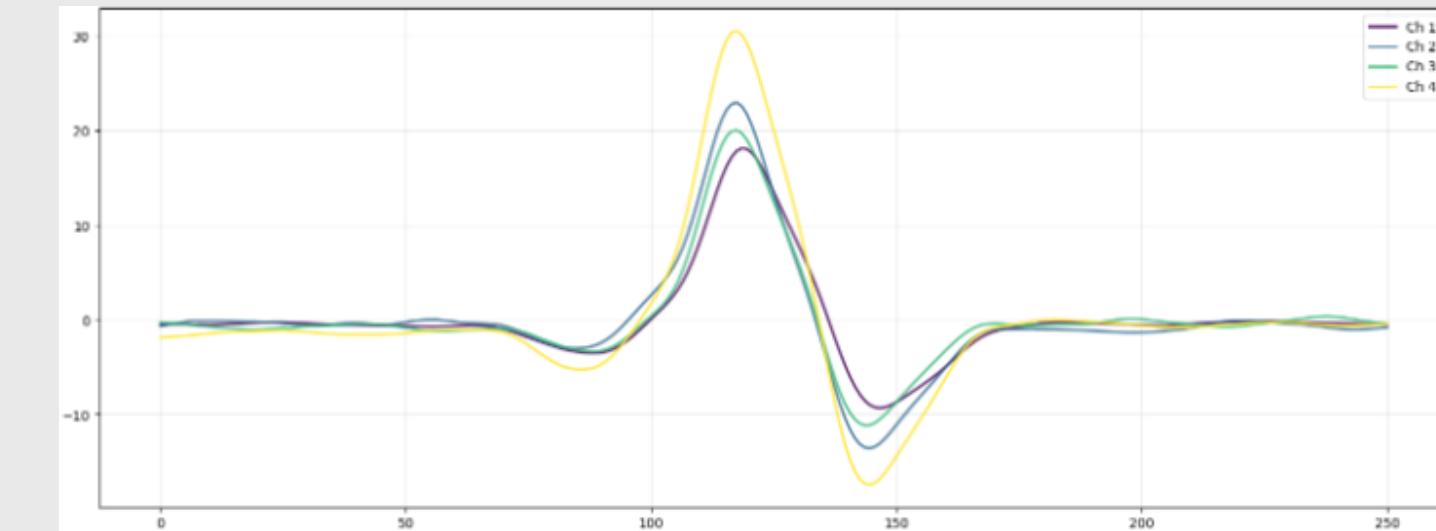
1. PCA-Hilbert
2. Energy-Based

## ENERGY BASED DETECTION

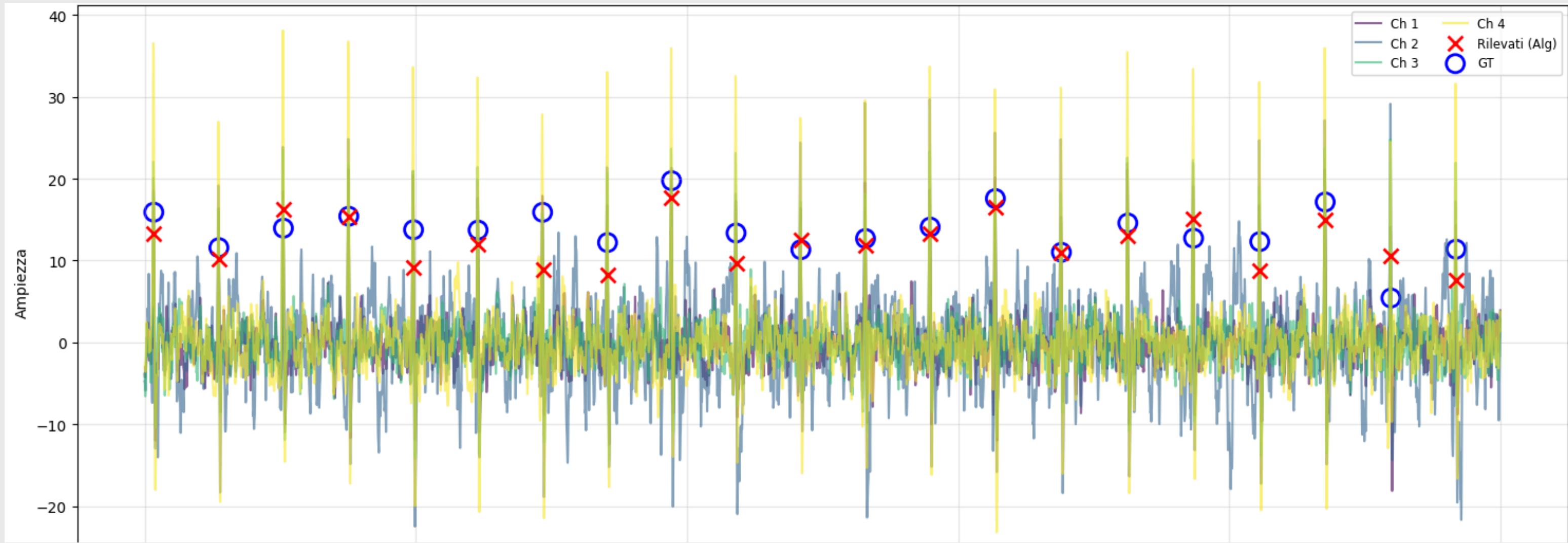
- Compute Cubic Energy to enhance peaks
- Percentile Threshold

## FETAL BEAT RECONSTRUCTION

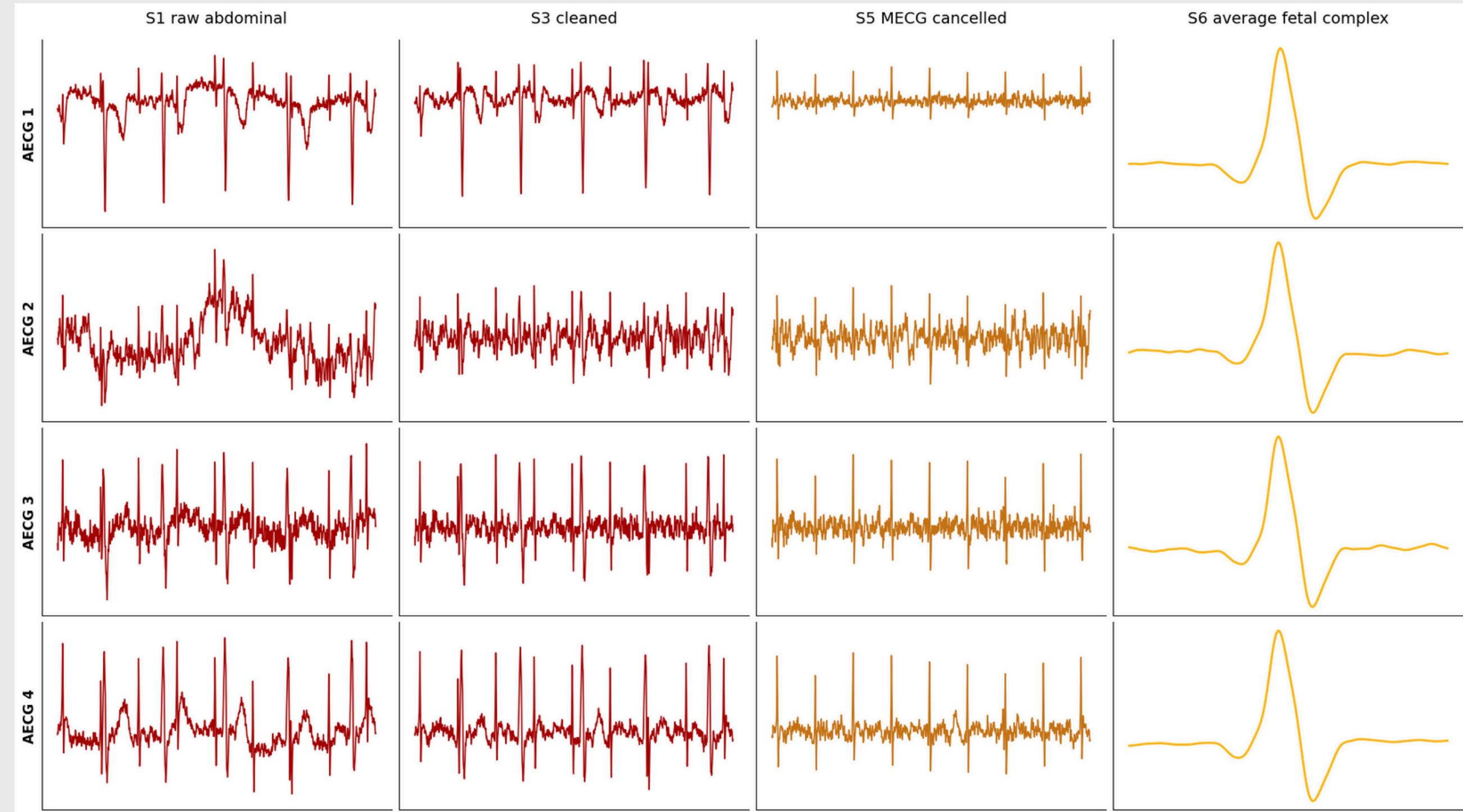
- Synchronization
- Averaging of ALL beats



# FECCG EXTRACTOR



# PIPELINE OUTPUT



# METRICS

$$Reliability = 1 - \frac{N_{outliers}}{N_{total}}$$

$$\text{SNR}_j = \frac{P_{F_j}}{P_{M_j}} = \frac{P_{S_{6,j}}}{P_{S_{5,j} - S_{6,j}}},$$

$$\text{SIR}_j = \frac{P_{F_j}}{P_{N_j}} = \frac{P_{S_{6,j}}}{P_{S_{4,j} - S_{5,j}}}.$$

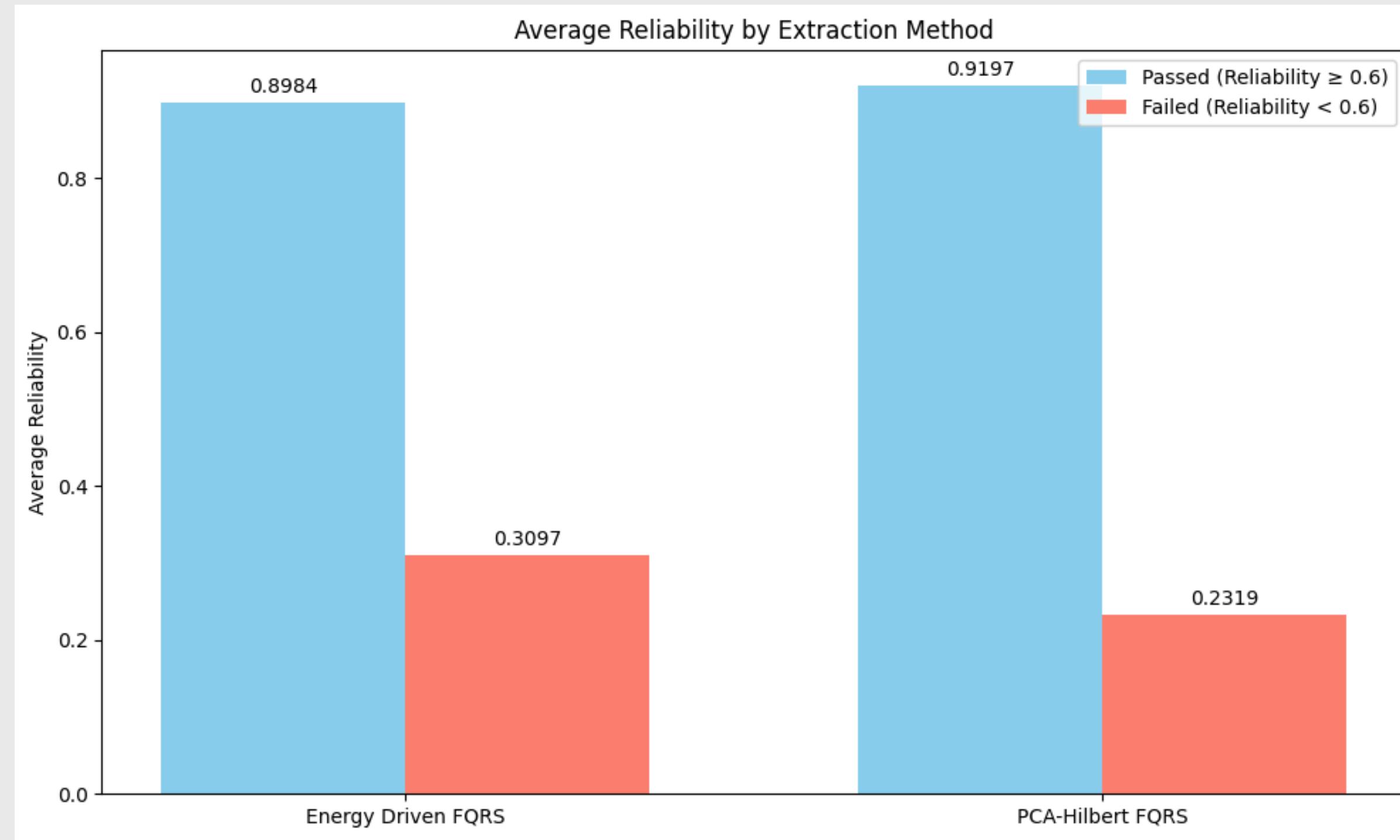
$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Sensitivity} = \frac{TP}{TP + FN}$$

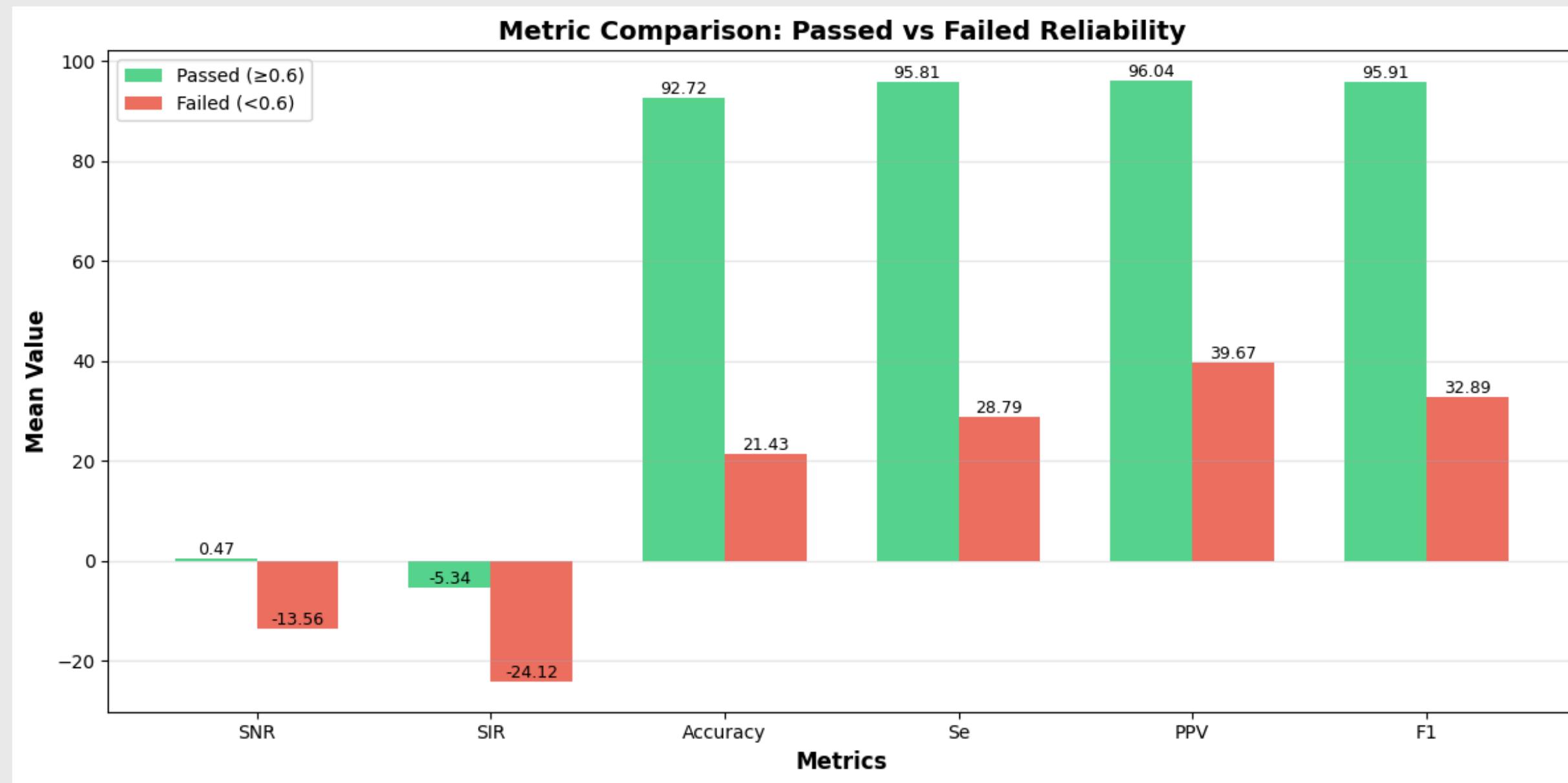
$$\text{PPV (Precision)} = \frac{TP}{TP + FP}$$

$$\text{F1 Score} = \frac{2 \cdot TP}{2 \cdot TP + FP + FN}$$

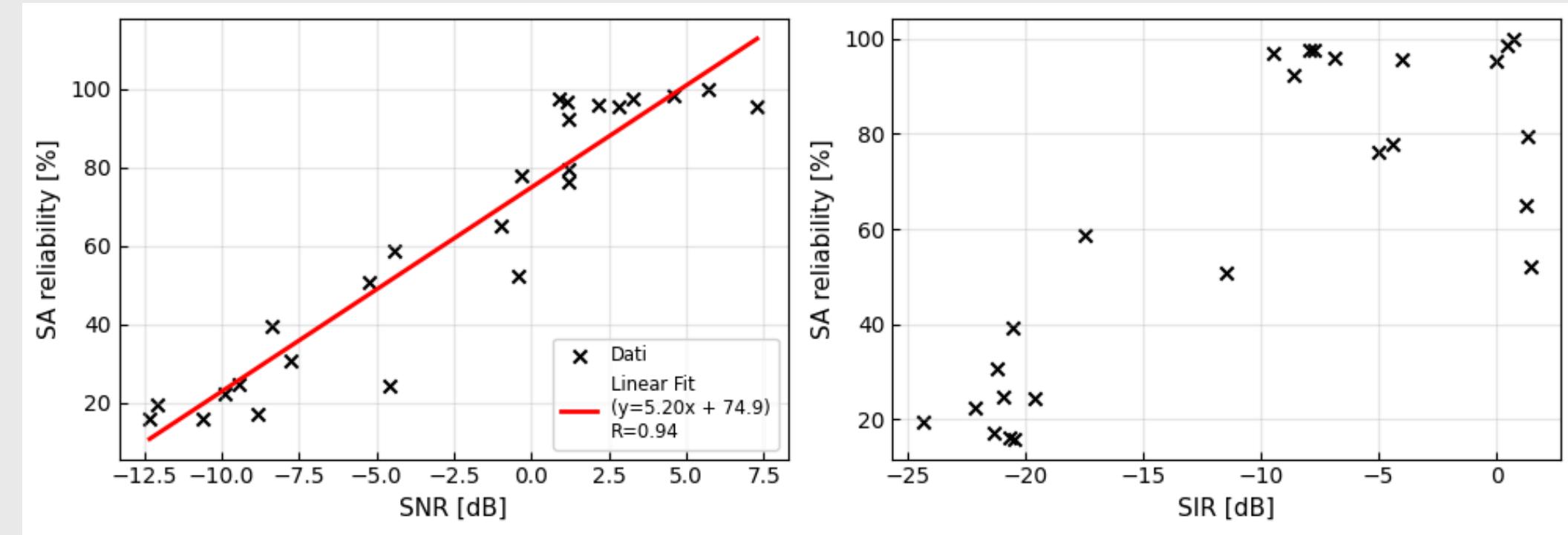
# RESULTS



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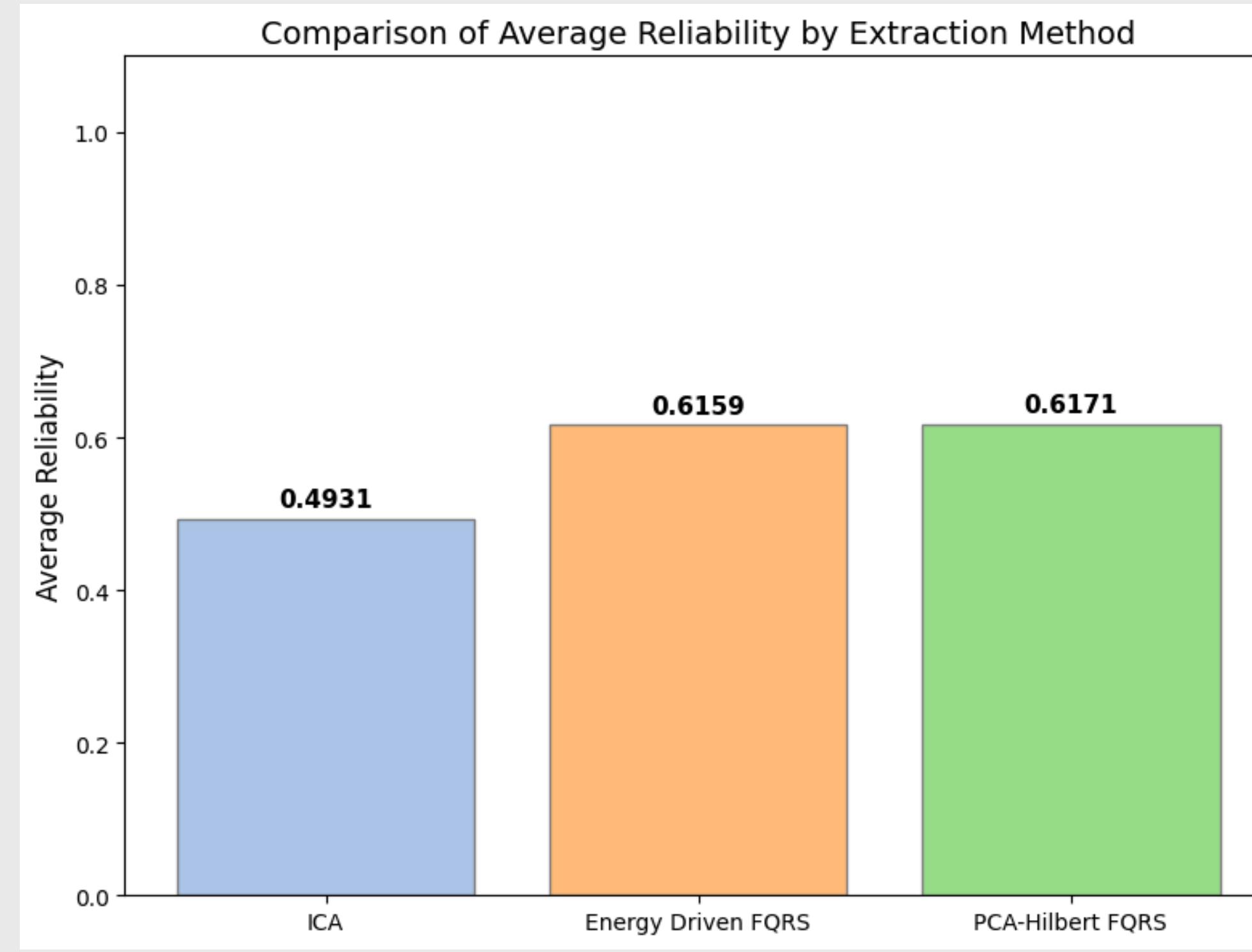
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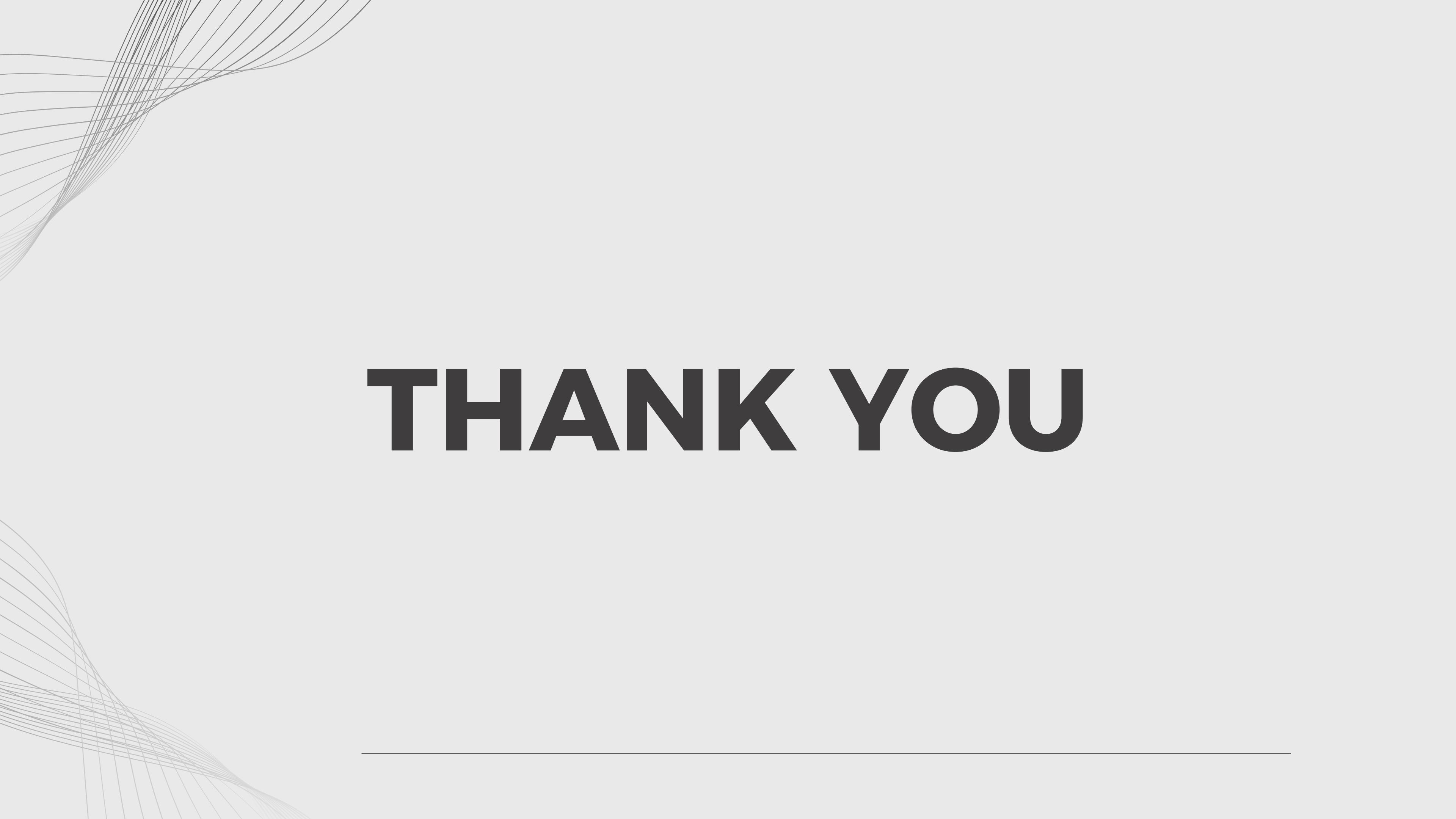


## PEARSON CORRELATION MATRIX

	Reliability	SNR	SIR
Reliability	1	0.94	0.81
SNR	0.94	1	0.89
SIR	0.81	0.89	1

# ICA COMPARISON





# **THANK YOU**

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