

Irregular Turbo-Like Codes

Brendan J. Frey

David J. C. MacKay

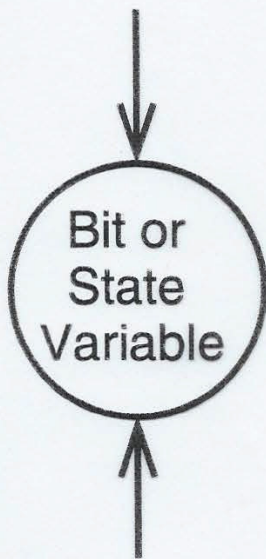
Apple 1113

Suppose you are *told* the values of
some bits[✓] in a transmitted codeword
(or states)

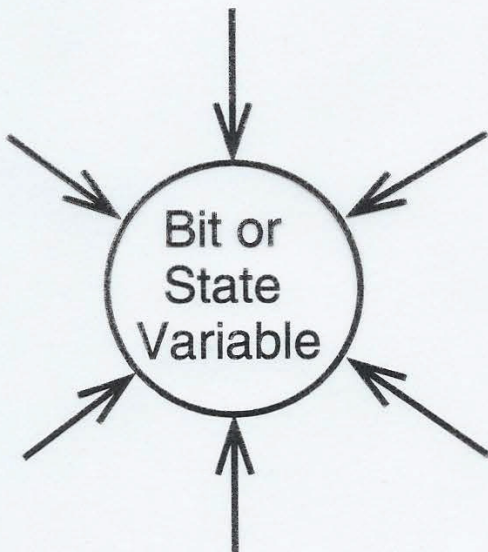
This effectively decreases the rate of
the remaining code, making decoding
easier

Can we get a free lunch
out of this?

Irregular codes: A free bite of lunch



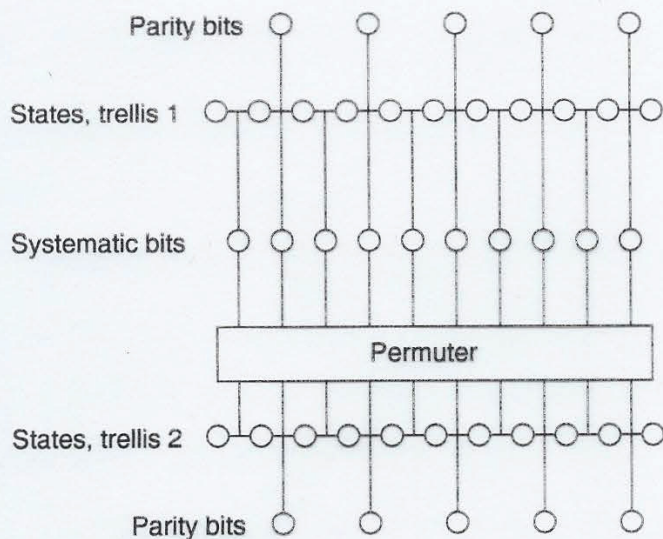
Pinned down SLOWLY



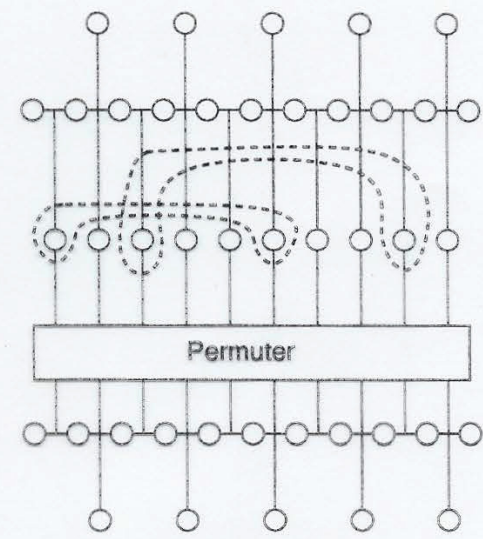
Pinned down QUICKLY!

"Irregularizing" a turbocode

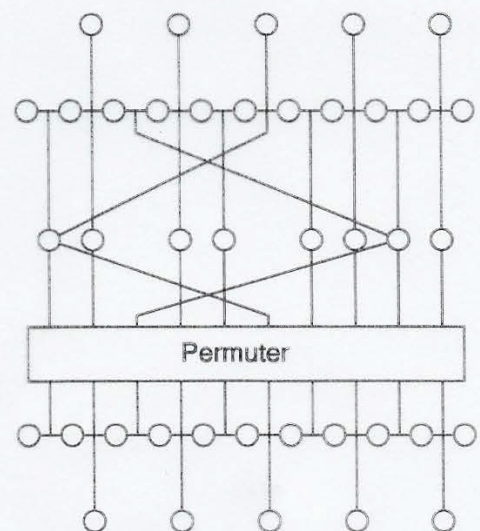
Regular turbocode $R=10/20$



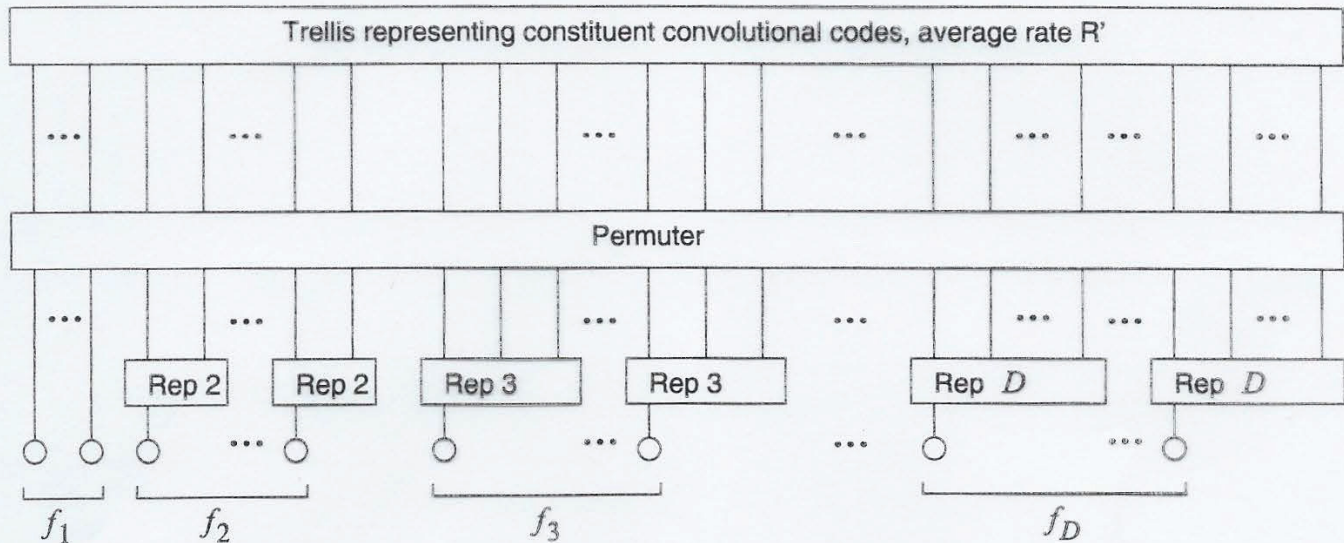
"Irregularization"



Irregular turboencoder $R=8/18$



Rate-degree relations



$\bar{d}$ = Avg degree of codeword bits

$\bar{R}$ = Avg rate of convolutional codes

R = Rate of irregular turbocode

Avg # constraints per bit: $\bar{d}(1 - \bar{R})$

$$1 - R = \bar{d}(1 - \bar{R})$$

Simplified degree profiles

Degree 1

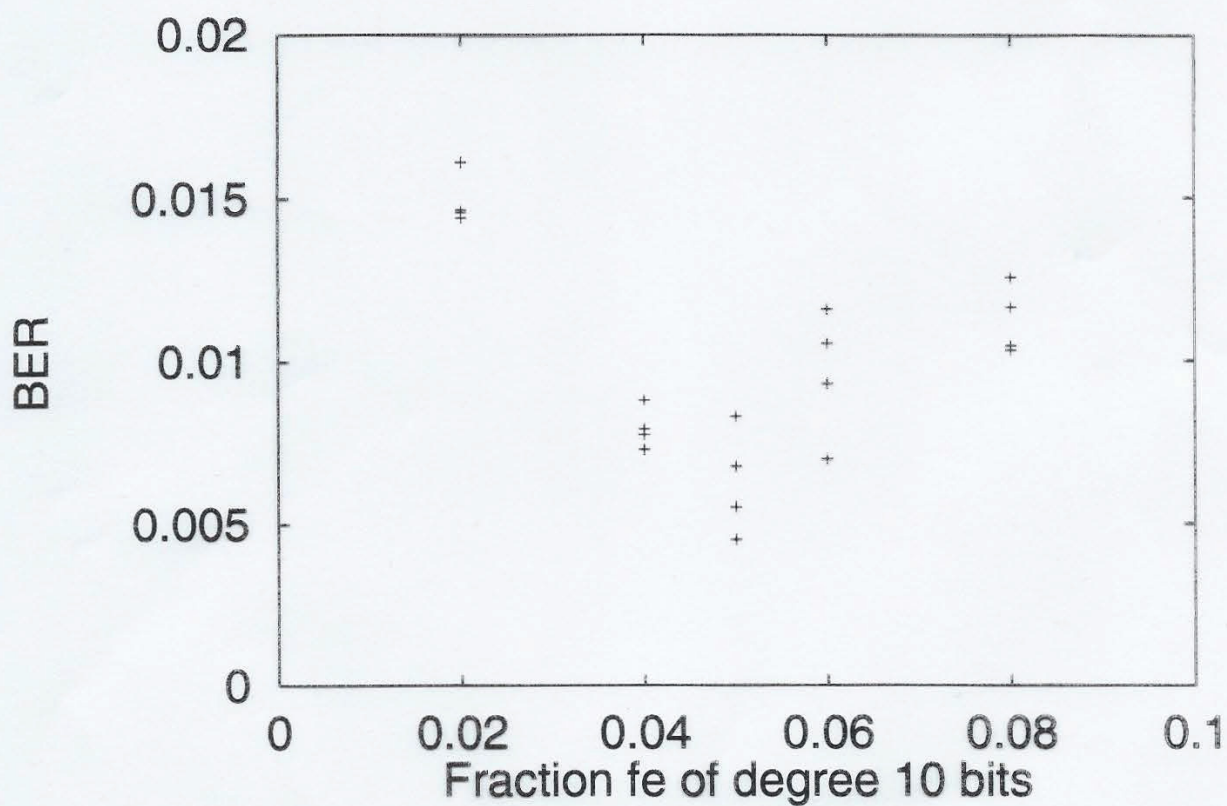
Degree 2

Degree d_e : Fraction f_e “elite” bits have degree d_e

$$\bar{d} = (1 - R) + 2(R - f_e) + d_e f_e$$

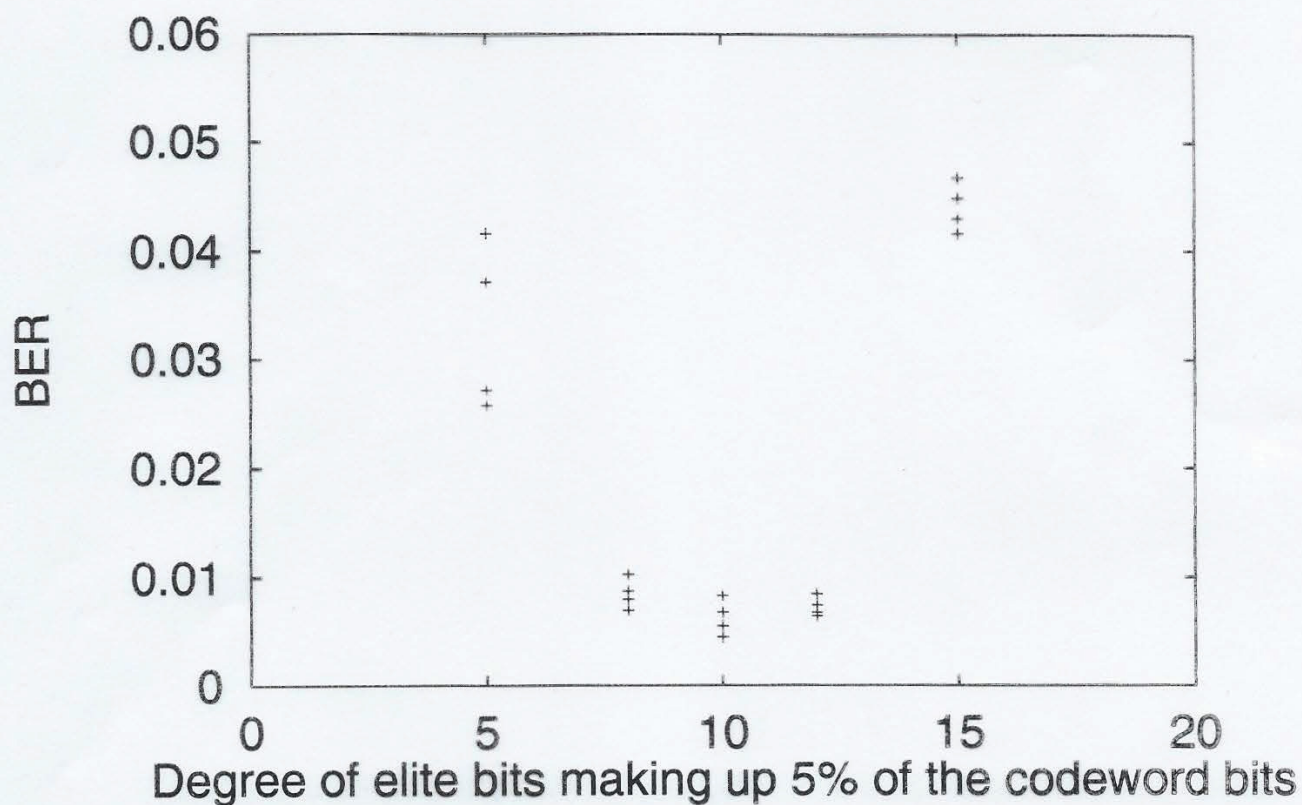
$$1 - \bar{R} = \frac{1 - R}{(1 - R) + 2(R - f_e) + d_e f_e}$$

$K=65536$, $R=1/2$:
Optimizing f_e with $d_e = 10$

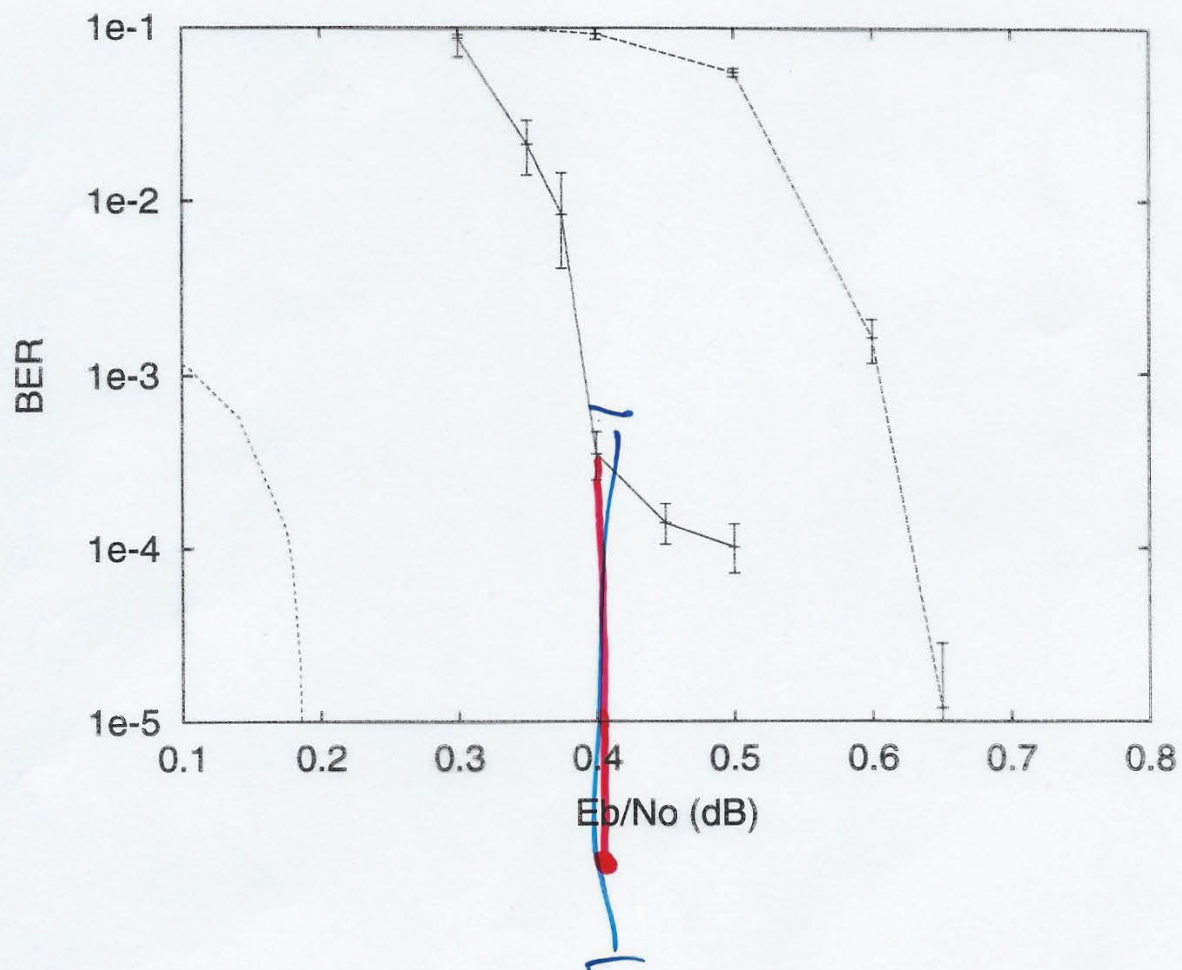


$K=65536$, $R=1/2$:

Optimizing d_e with $f_e = .05$

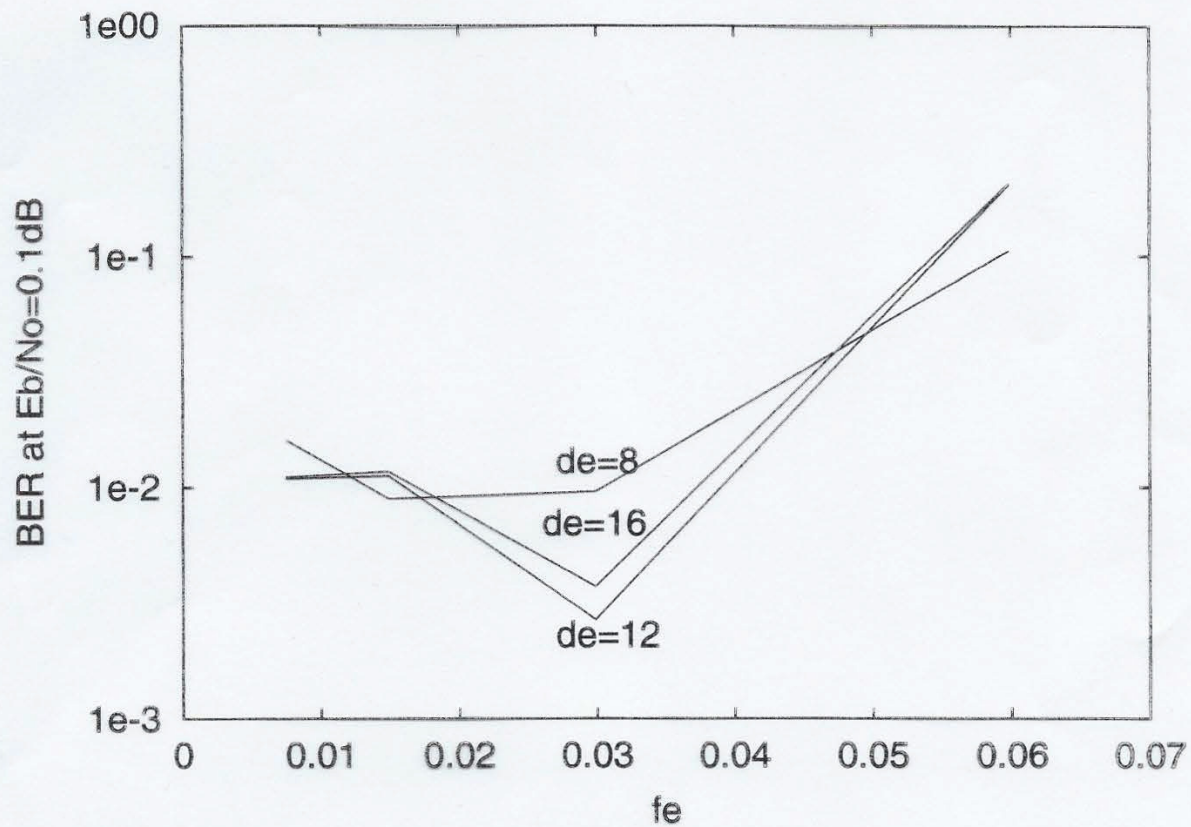


$K=65536$, $R=1/2$:
Measured bit error rate



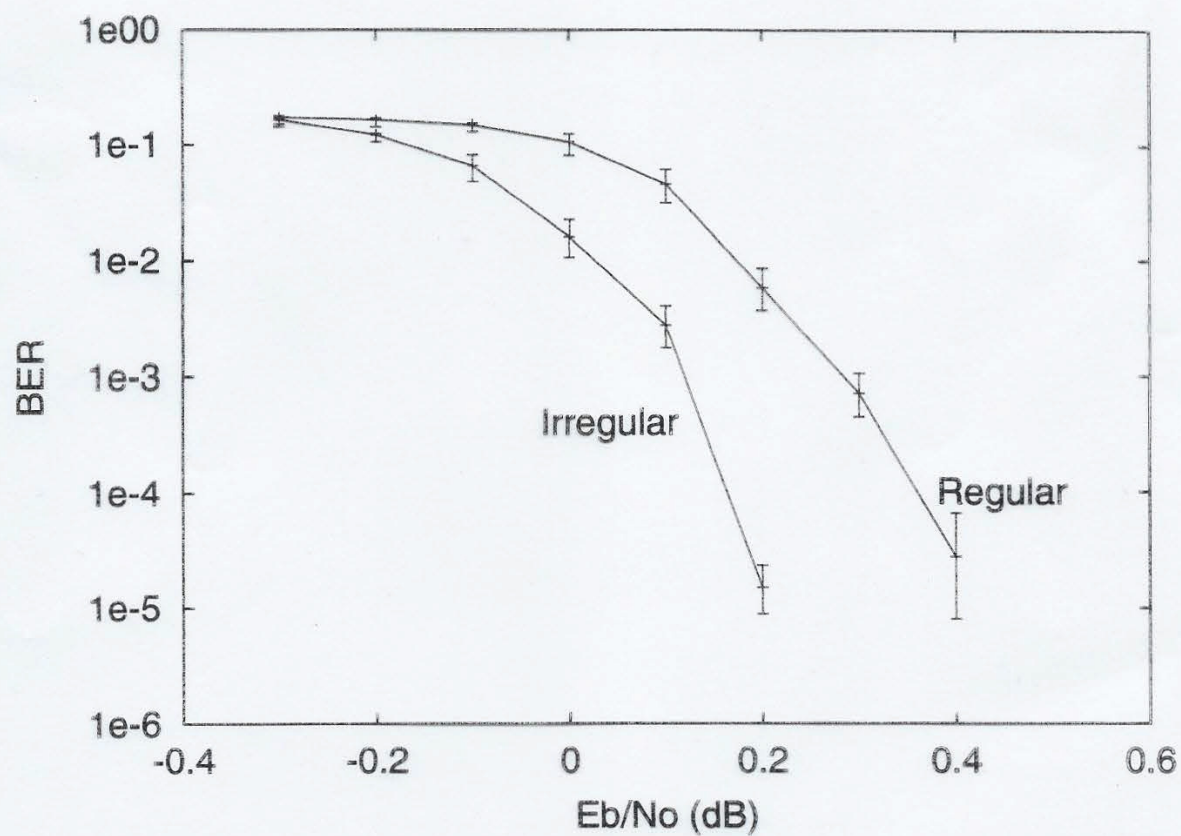
$K=8920$, $R=1/3$, CCSDS:

Optimizing d_e and f_e



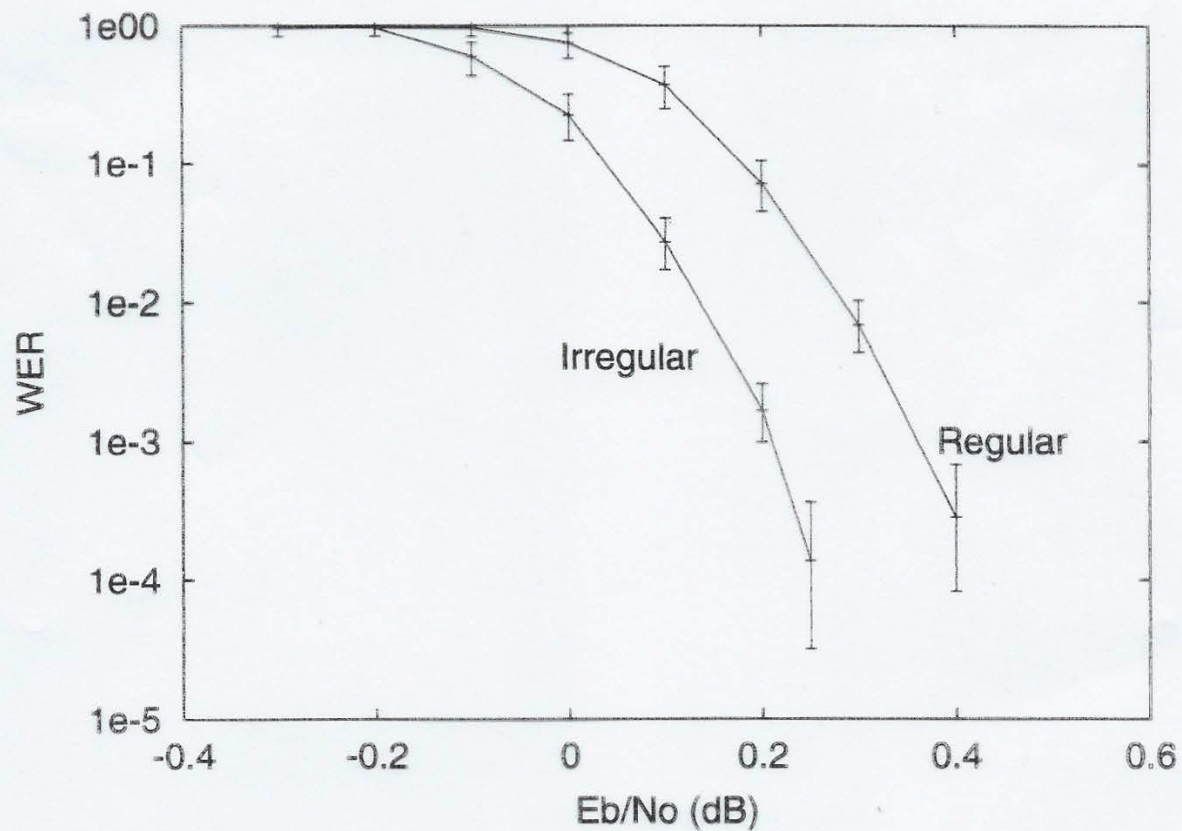
$K=8920$, $R=1/3$, CCSDS:

Measured bit error rate



63,000 blocks simulated

$K=8920$, $R=1/3$, CCSDS: Measured word error rate



Summary

Irregular turbocodes are a good idea!

Gain of 0.23 dB for irregular $K=65536$, $R=1/2$ Berrou et al turbocode

... But, “irregularization” introduces low-weight codewords at rate $1/2$

Gain of 0.2 dB for irregular $K=8920$, $R=1/3$ CCSDS turbocode – no weight problem

For long block lengths: Use density evolution

For short block lengths: Search is probably better