Burst Marker Analysis

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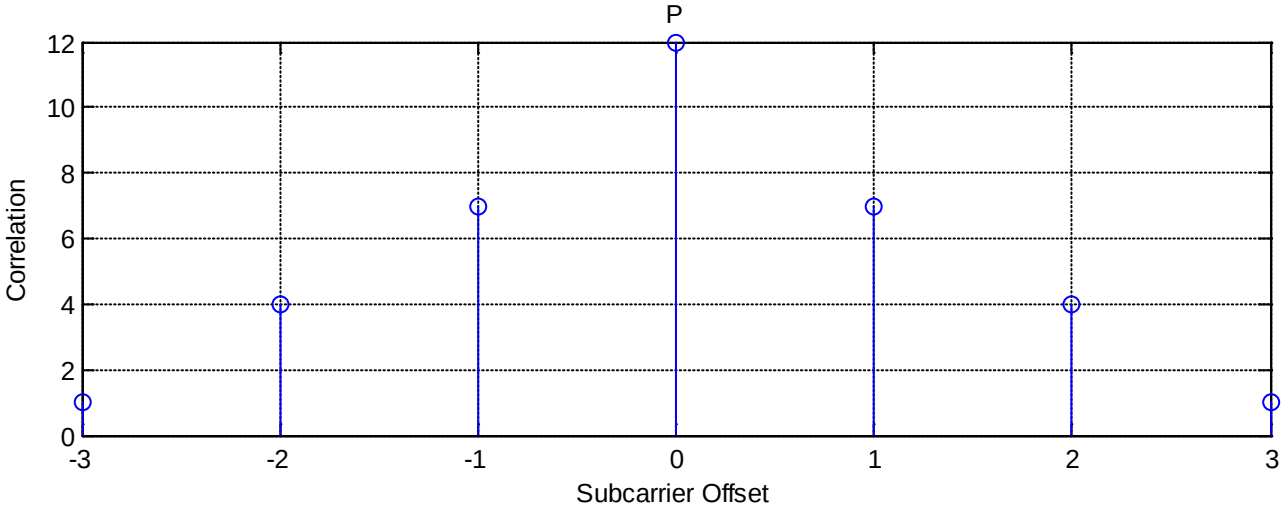
TERNARY SEQUENCES AUTO AND CROSS-CORRELATION

Baseline Ternary Burst Marker Detection [1,2]

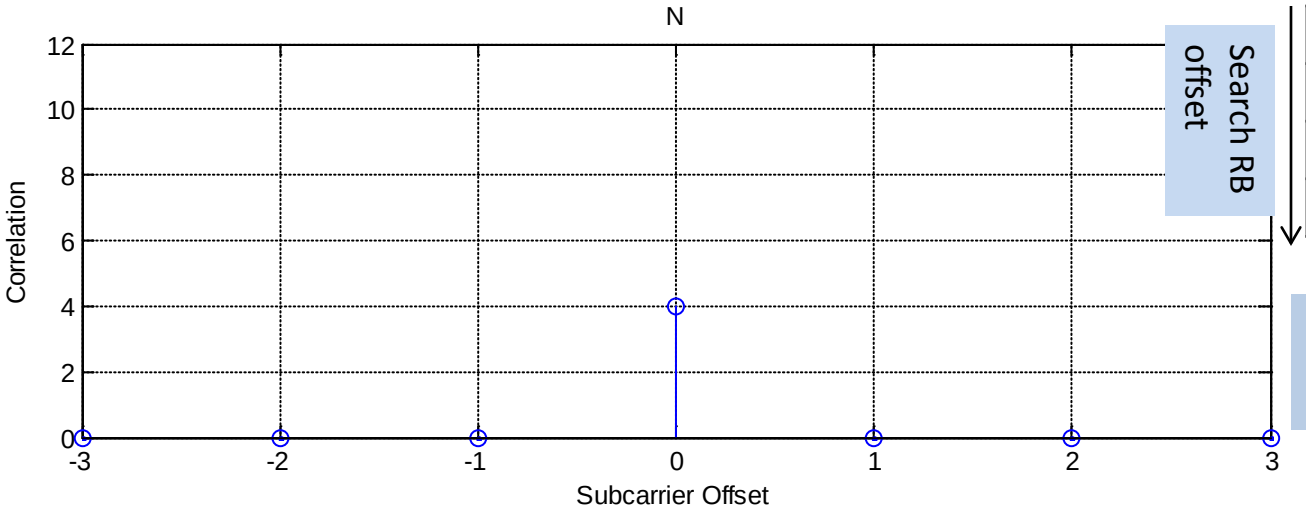
- Four profiles identified by N location.
- BM detector use energy detection:
  - **P** detector is sum power at P locations
  - **N** detector is sum power at N locations
- Threshold is scaled **P** detector output
- BM detection relies on the ratio of N to P energy, N to P ratio is 1/3.
- BM is interleaved with data and pilots.

[1] Dallas, November 2013, rahman_syed_3bn_03_1113.pdf
[2] Dallas, November 2013, rahman_syed_3bn_01_1113.pdf

BM #3,length=16, RB=1x8



Note: Table list BM elements, interleaved data RE not shown.



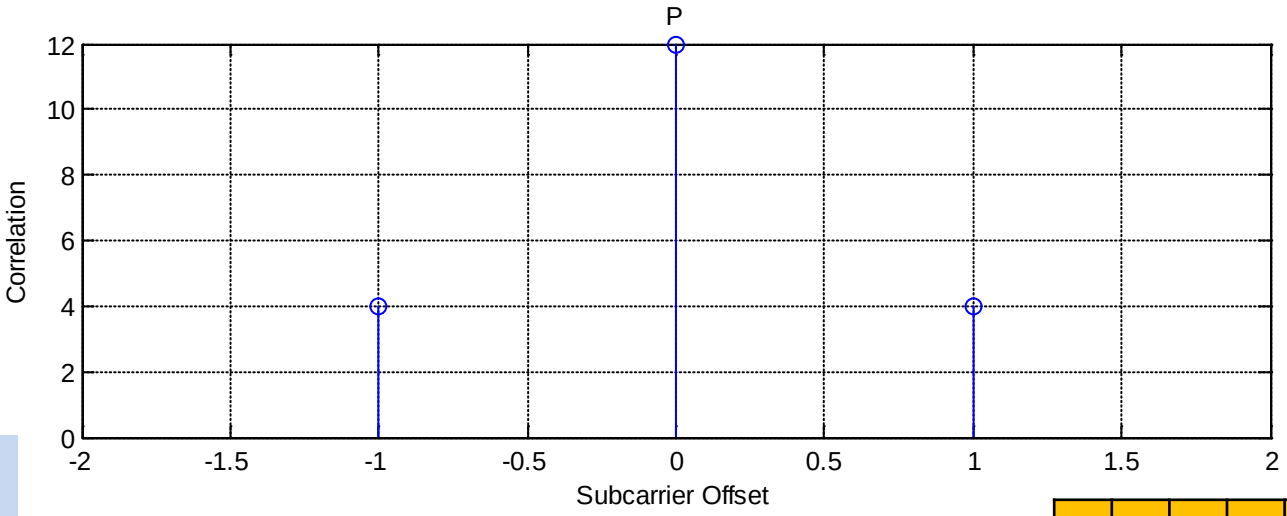
Search RB offset

1	1	0	1
1	0	1	1
1	1	1	1
0	1	1	0

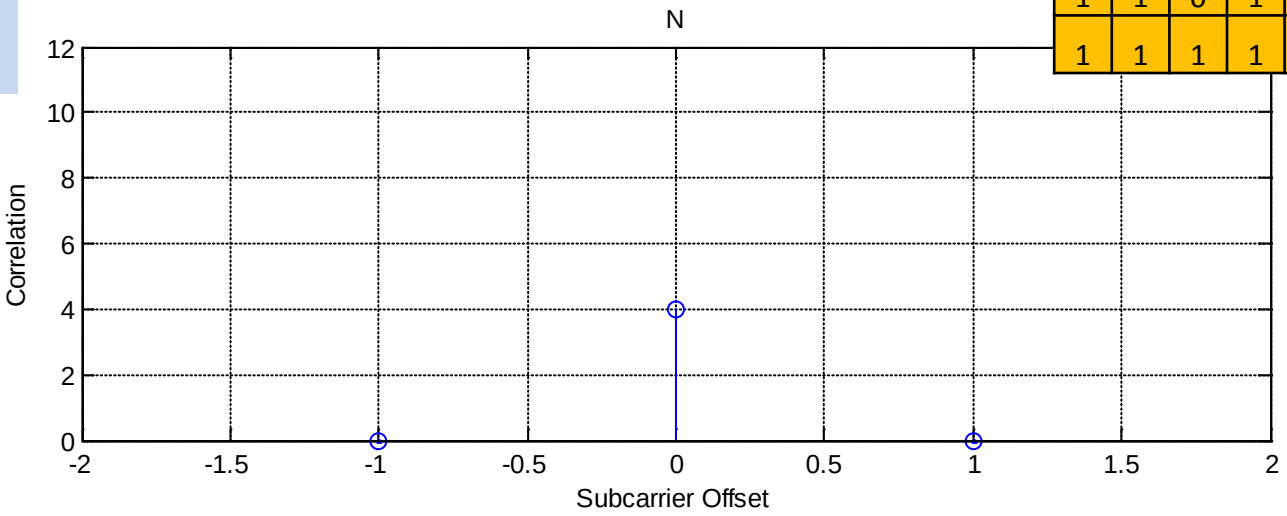
1 : P location
0 : N location
- : do not care

BM #3,length=16, RB=1x16

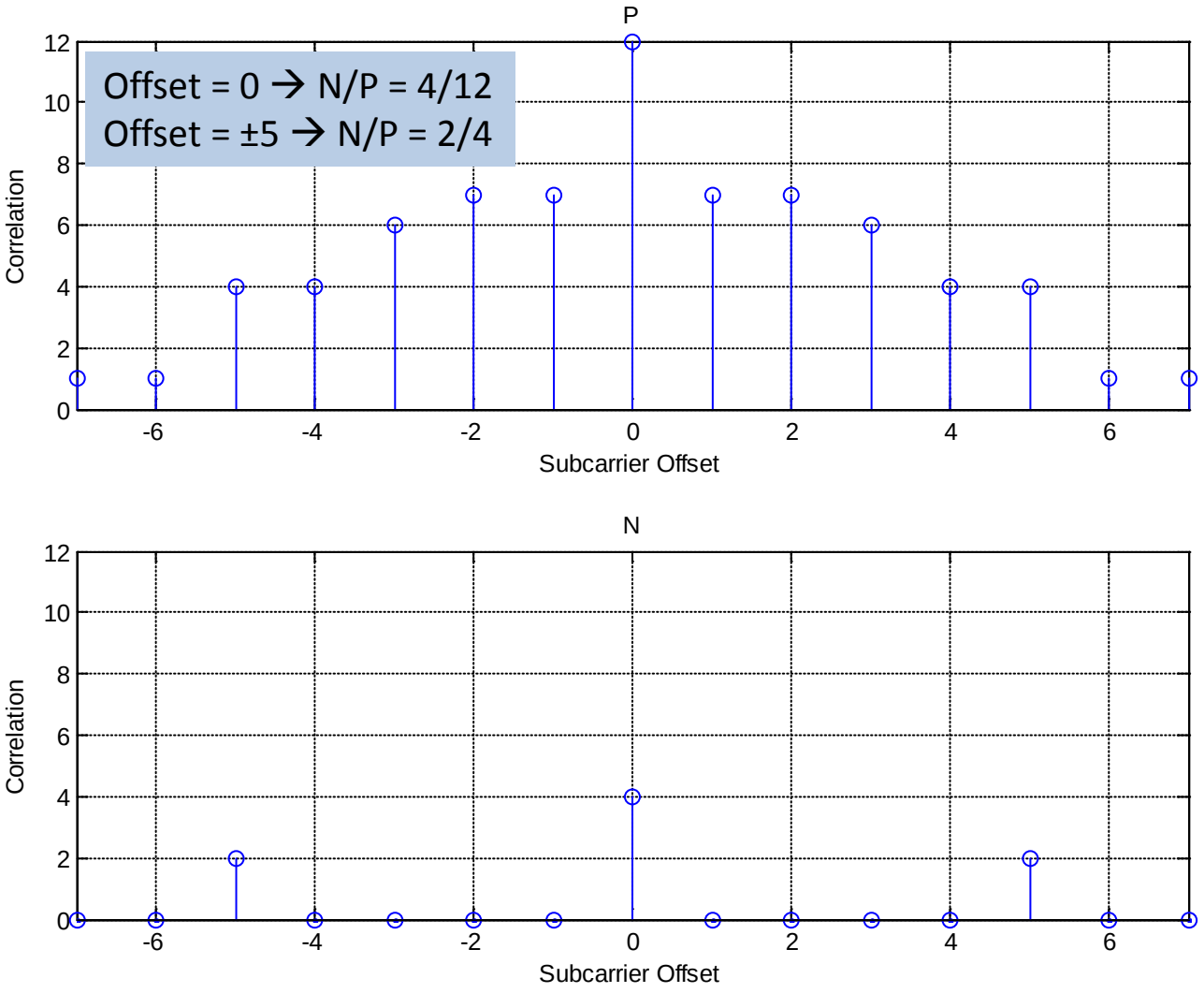
Good contrast between N & P



1	1	0	1	1	0	1	1
1	1	1	1	0	1	1	0

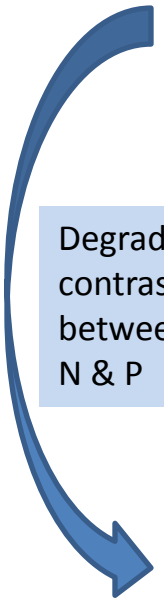


BM #3,length=16, RB=1x4

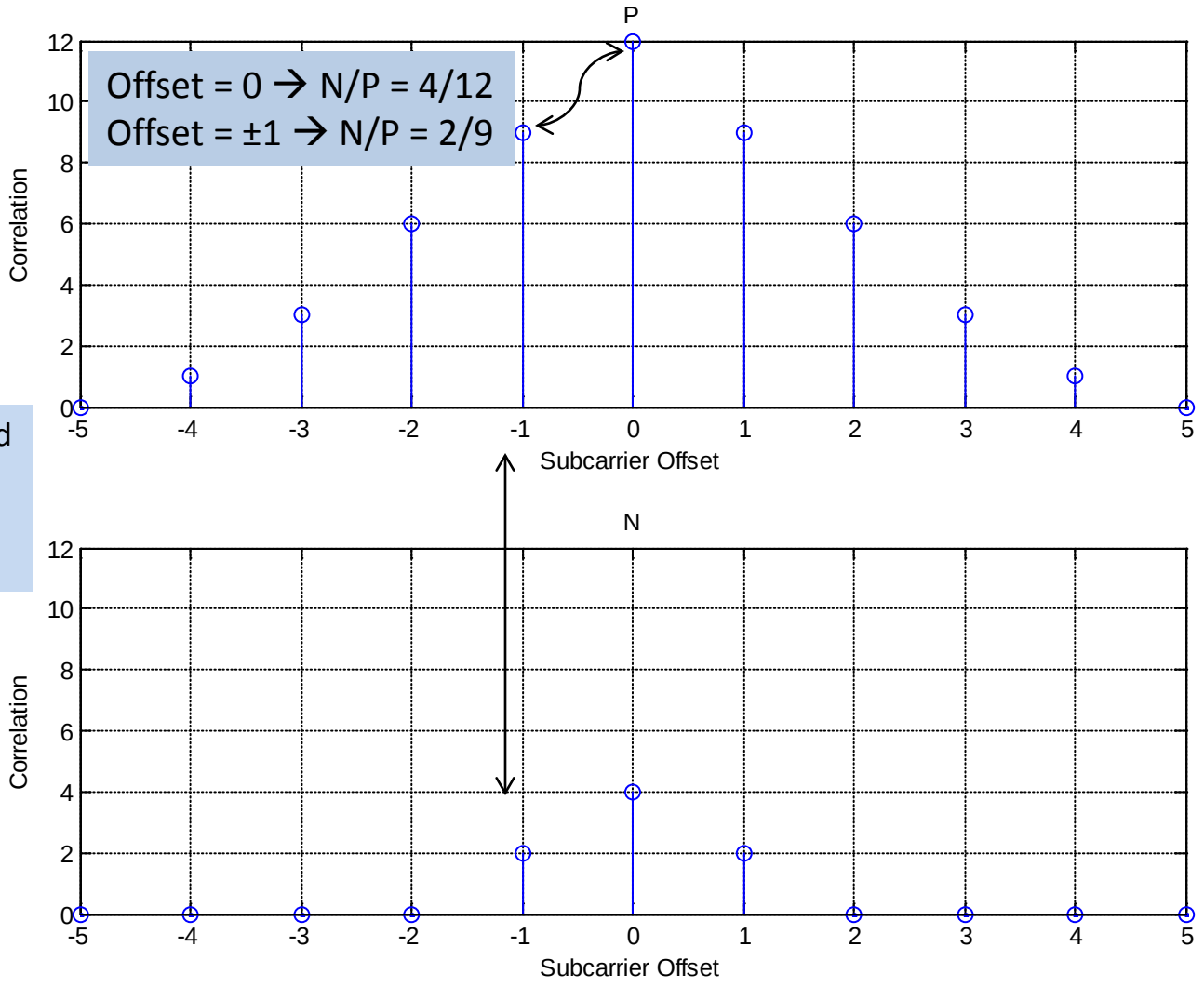


1	1
0	1
1	0
1	1
1	1
1	1
0	1
1	0

BM #3,length=16, RB=1x6



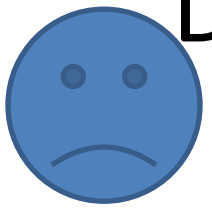
Degraded contrast between N & P

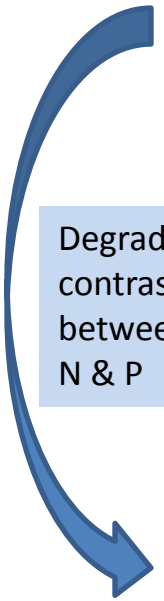


1	1	0
1	1	0
1	1	1
1	1	1
0	1	1
0	X	X

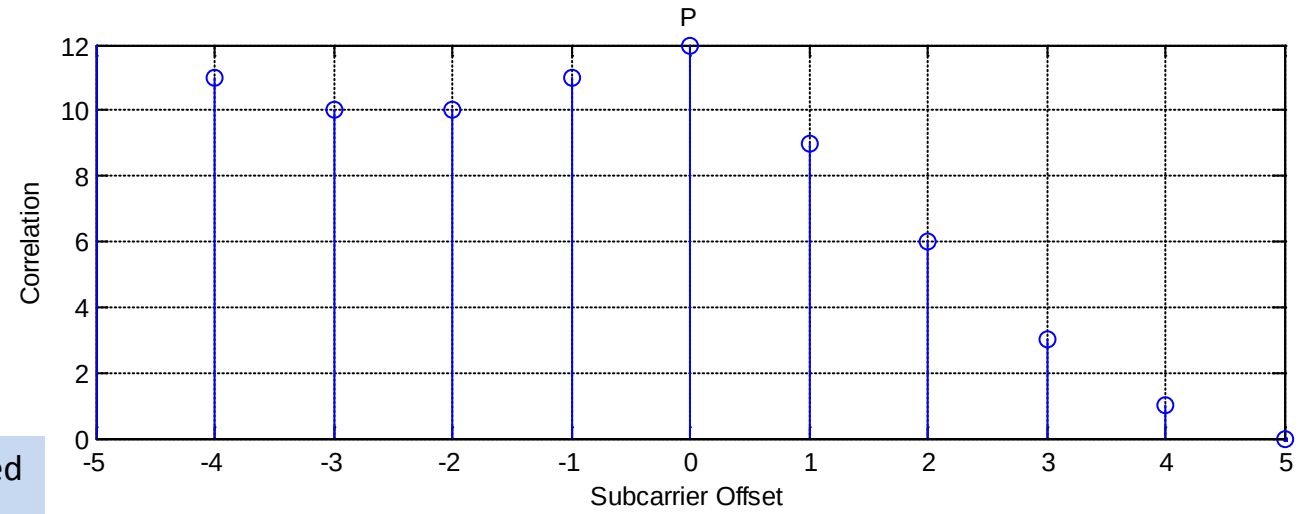
1 : P location
0 : N location
X : do not care

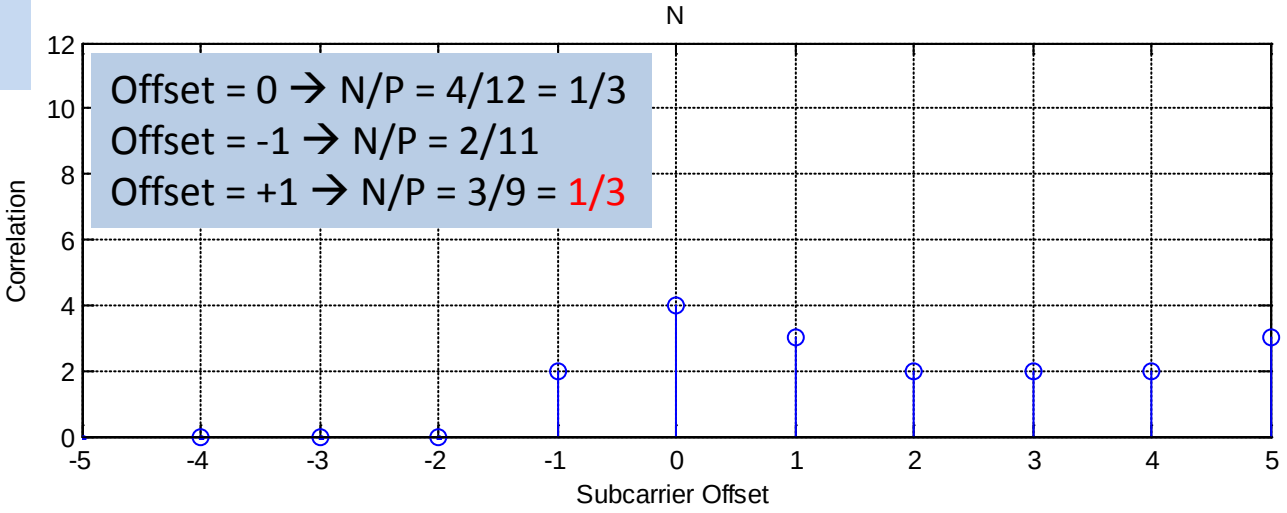
BM #3,length=16, RB=1x6
Data and Idle prior and after BM





Degraded contrast between N & P



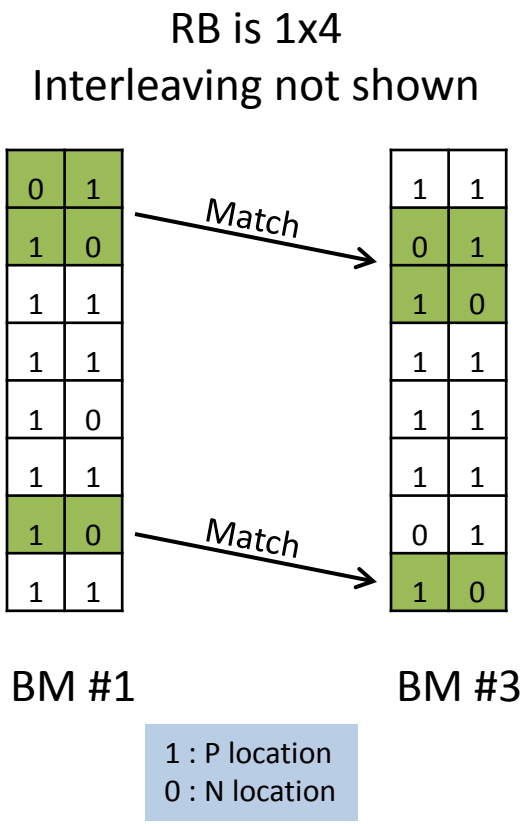


Offset = 0 → N/P = 4/12 = 1/3
Offset = -1 → N/P = 2/11
Offset = +1 → N/P = 3/9 = 1/3

D	D	D
D	D	D
D	D	D
D	D	D
1	1	0
1	1	0
1	1	1
1	1	1
0	1	1
0	S	S
S	S	S
S	S	S
S	S	S
S	S	S

1 : P location
0 : N location
- : do not care
S : Idle
D : Data or Pilots

Burst Marker Cross-Correlation, RB = 1 subcarrier by 4 symbols



- For RB size other than 1x8 or 1x16 cross-correlation between profile is poor.
- Example: BM #1 and BM #3 have 3 out of 4 N at same location for 1 RB offset.

Comments on Baseline Burst Marker Auto and Cross-Correlation

- The four sequence are orthogonal only if RB = 1x8, 1x16,….
- For RB size not multiple of 8 symbols in time, correlation and cross-correlation is poor. Lead to large misdetection and false detection rate.
- Correlation is degraded (by false detection) when BM is preceded or followed by silence (idle)
- Three examples provided but many more cases are problematic.

MISDETECTION AND FALSE DETECTION RATE IN PRESENCE OF NOISE

Calculation of Missing and False Detection of Burst Marker

- PDF and CDF of **P** and **N** detectors is computed.

  Note: H axis is threshold level, not power.
- **BM present**, Missing probability is:

  Prob(**N** > Thresh) OR Prob(**P** < Thresh)
- **Data present**, False detect probability is:

  Prob(**N** < Thresh) AND Prob(**P** > Thresh)
- **Silence present**, False detect probability is:

  Prob(**N** < Thresh) AND Prob(**P** > Thresh)

Packet Error Rate from Burst Marker Missing and False Detection

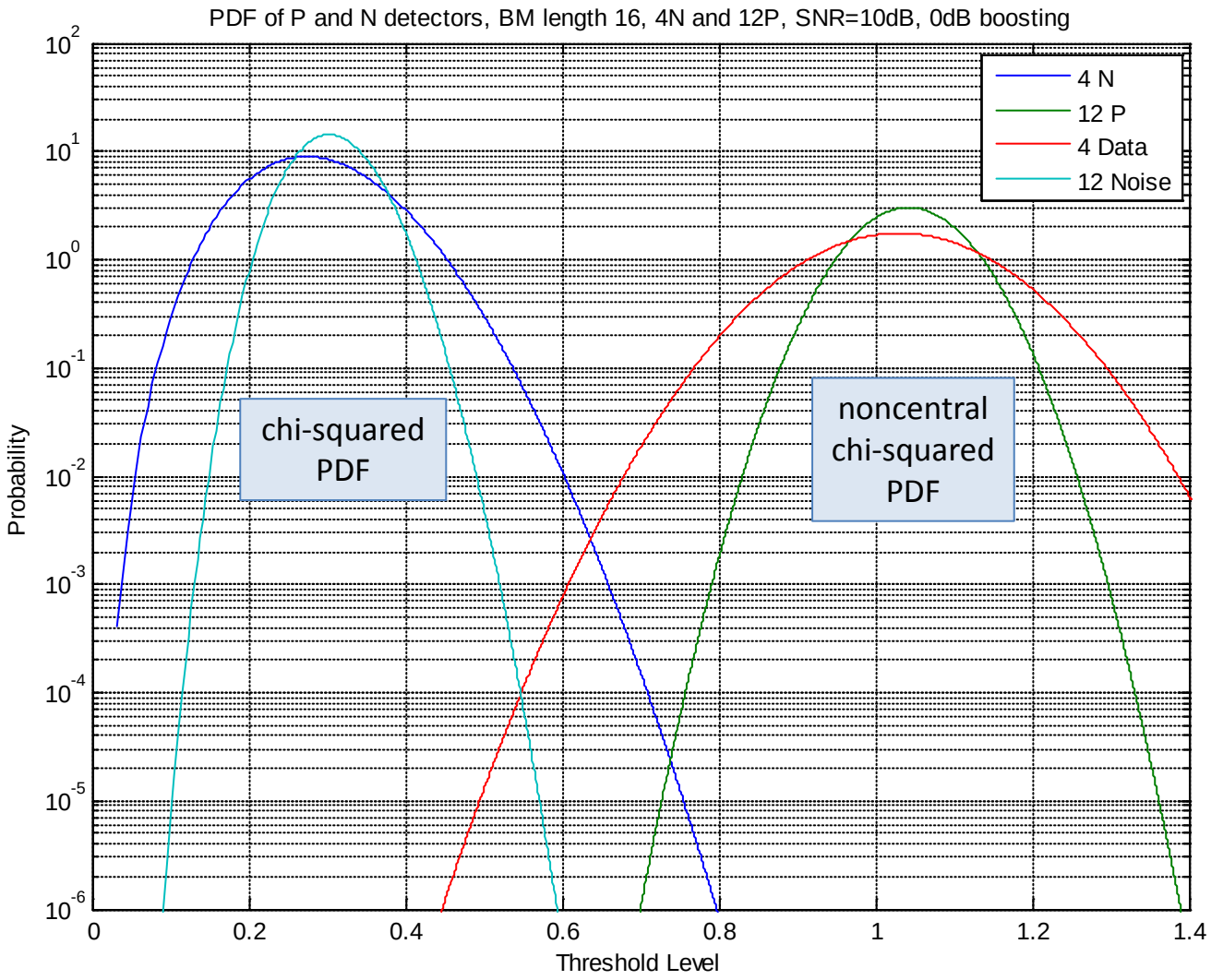
- **Packet Error Rate =**

  Prob(Missing Start) + Prob(Missing Stop) + M*Prob(False detection)

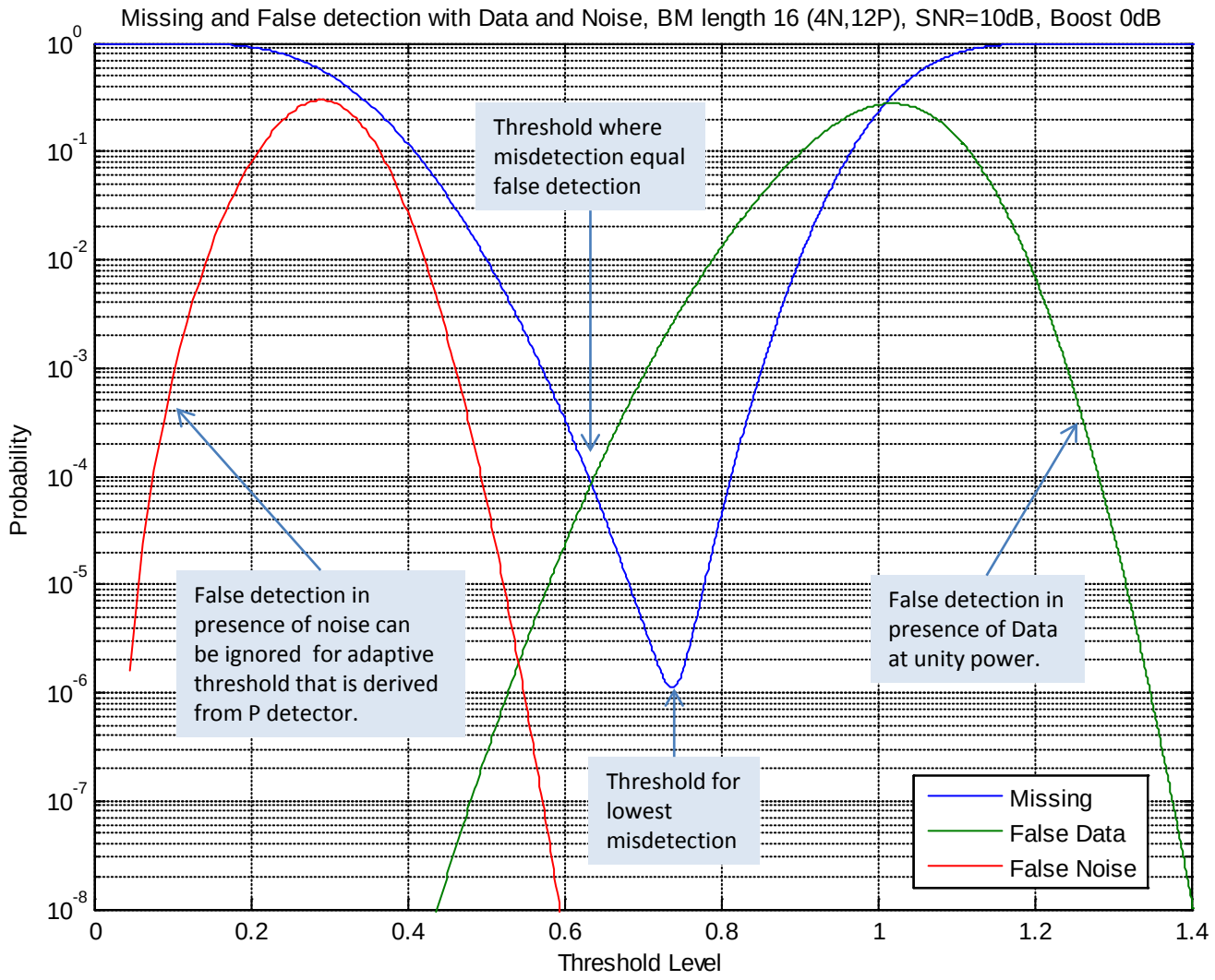
  M is the number of search of BM in the packet

  1500 Byte packet example: QPSK modulation and RB of 1 subcarrier by 8 symbols. M = 863 because data use 863 RB (or 6900 RE).

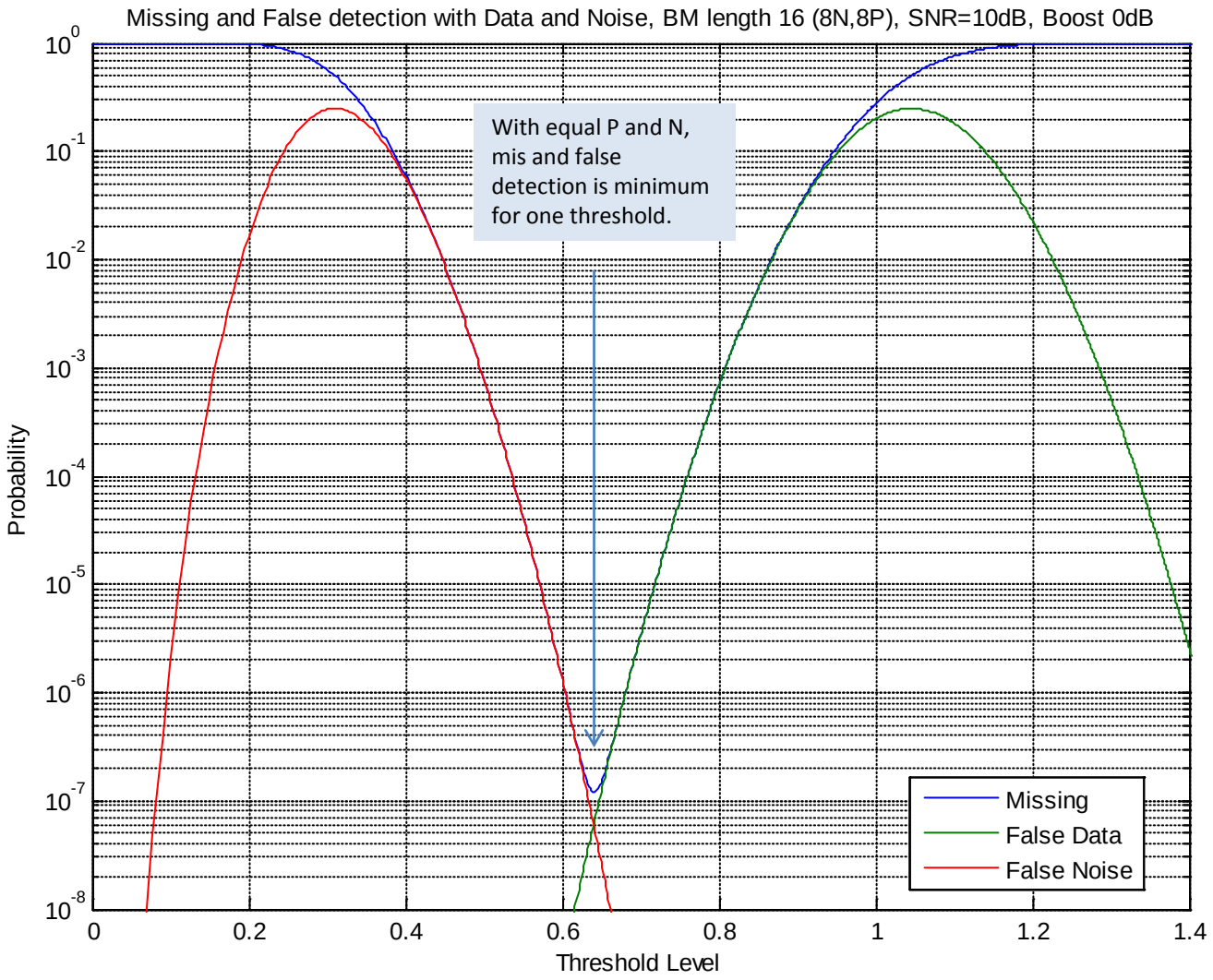
P and N detectors PDF in presence of: Burst Marker, Data and Silence



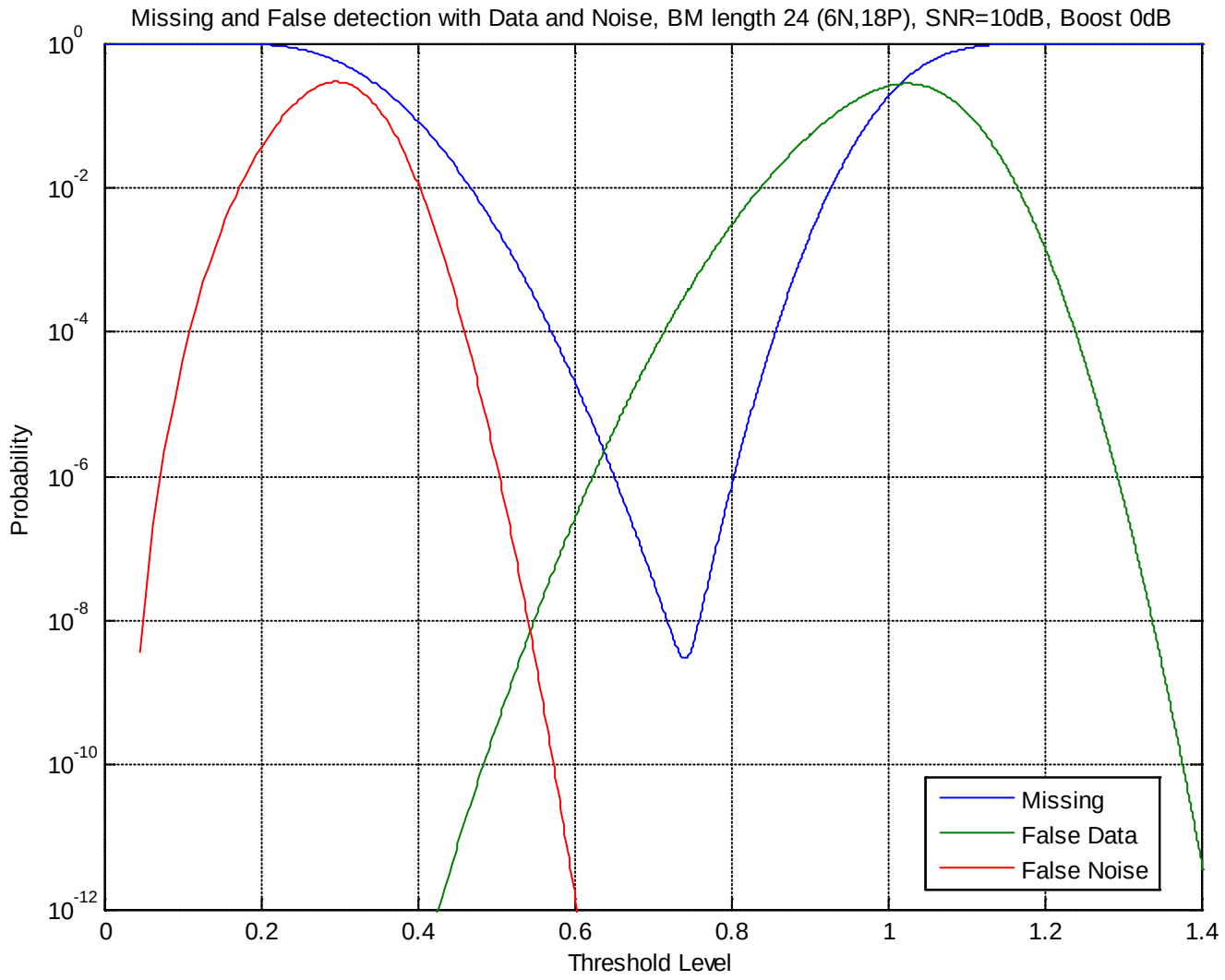
Mis and False Detection vs Threshold, BM 16 (4N,12P), SNR=10dB



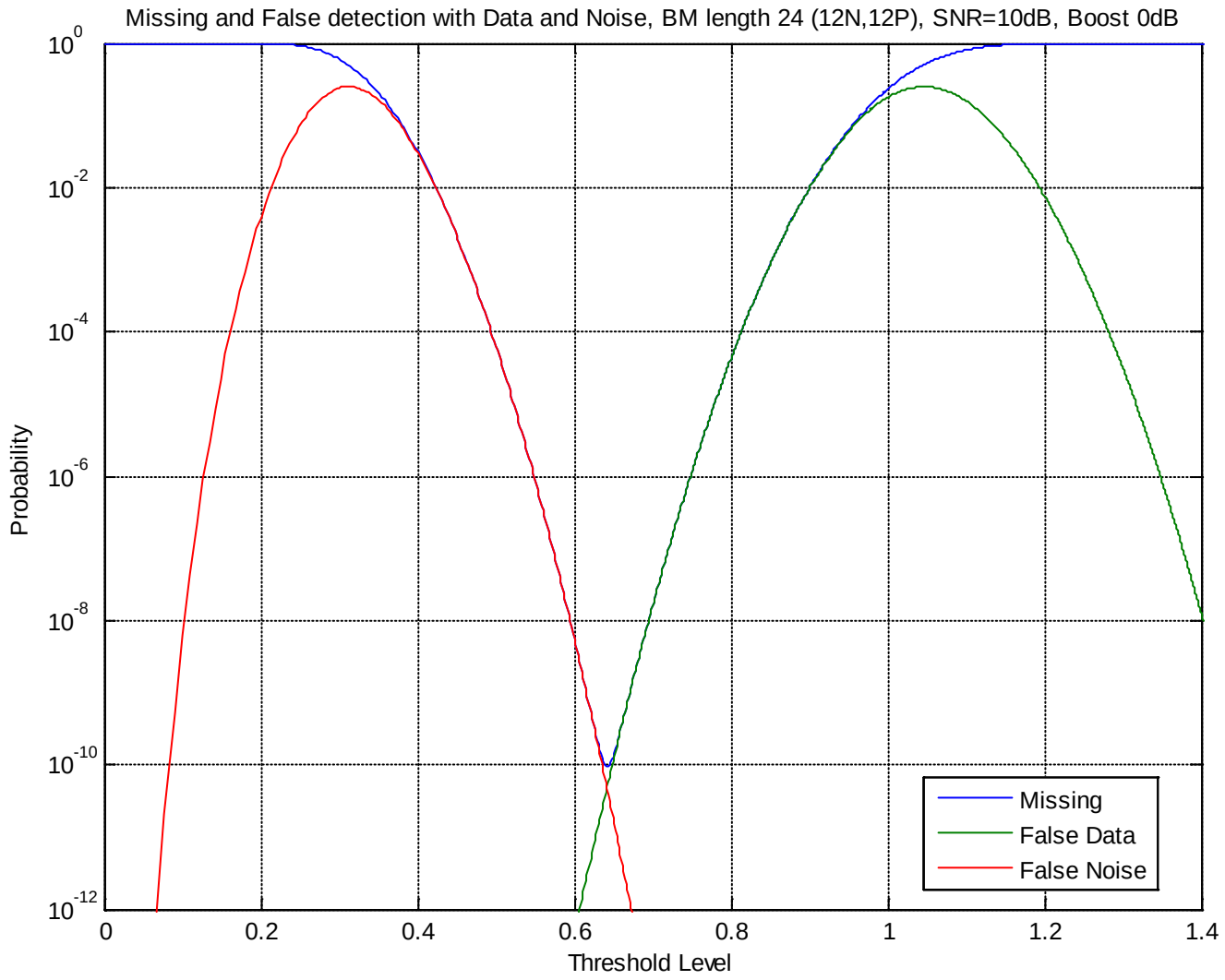
Mis and False Detection vs Threshold, BM 16 (8N,8P), SNR=10dB



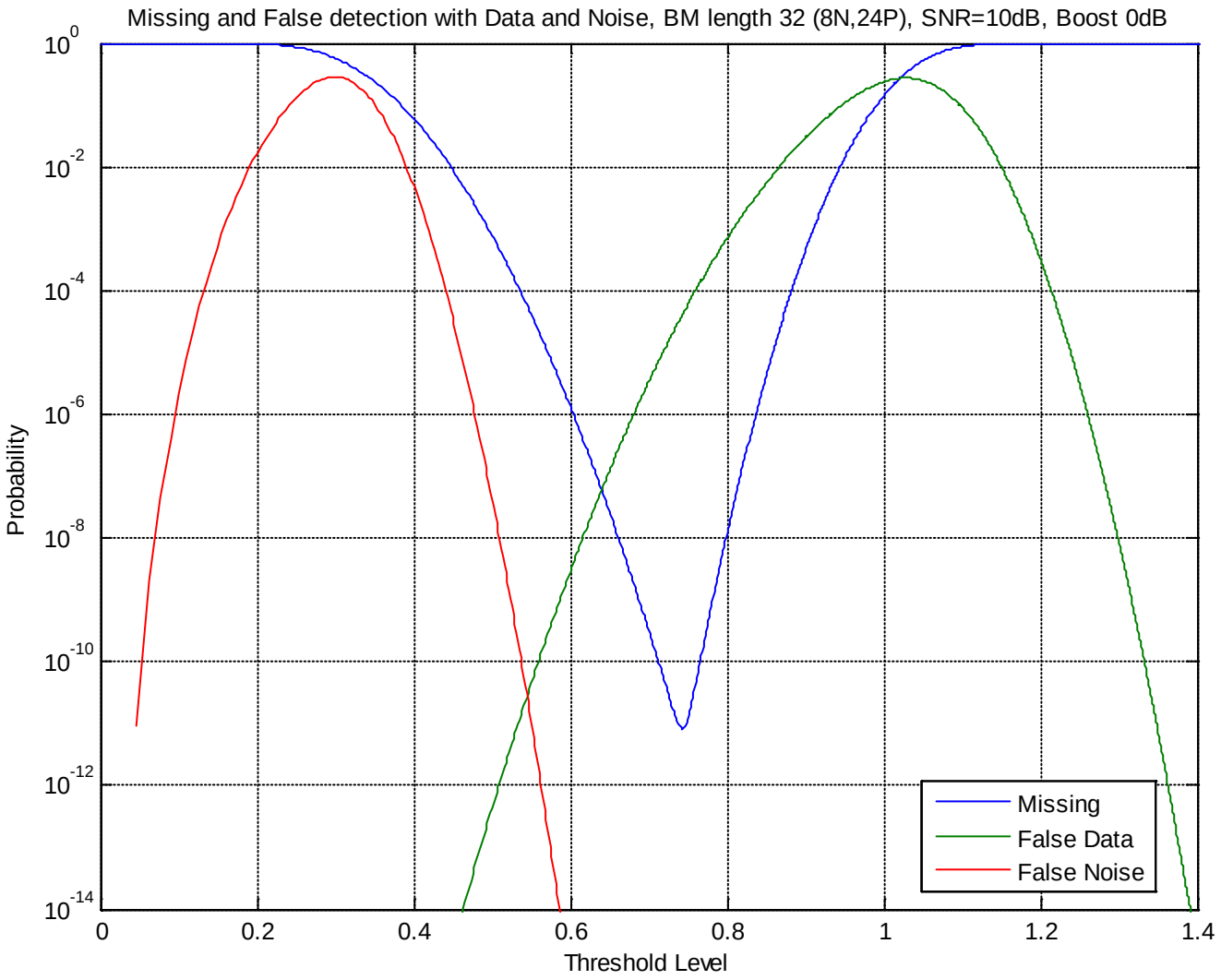
Mis and False Detection vs Threshold, BM 24 (6N,18P), SNR=10dB



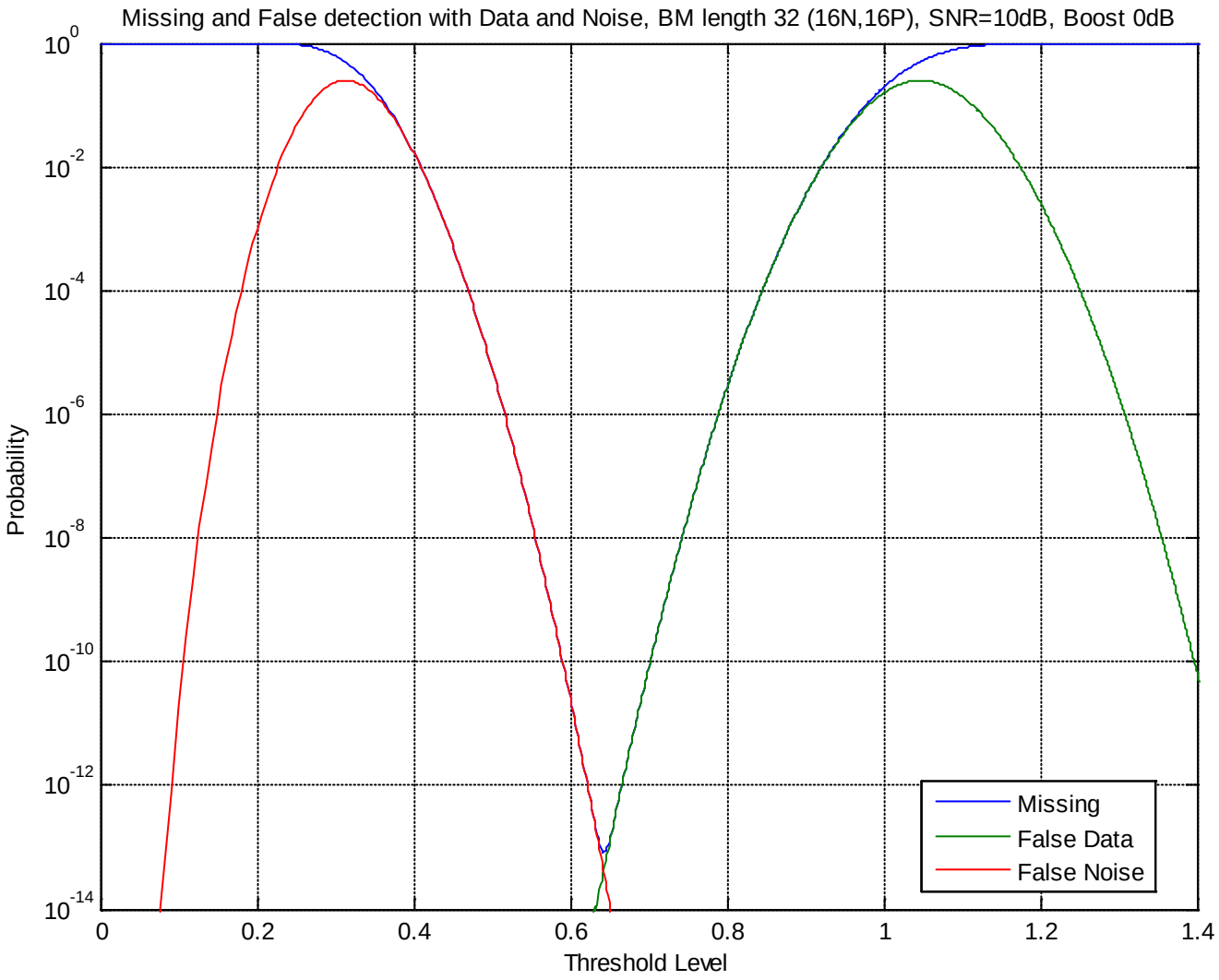
Mis and False Detection vs Threshold, BM 24 (12N,12P), SNR=10dB



Mis and False Detection vs Threshold, BM 32 (8N,24P), SNR=10dB



Mis and False Detection vs Threshold, BM 32 (16N,16P), SNR=10dB



Comments on Baseline Burst Marker Mis and False Detection in Noise

- Ternary sequences are useful at differentiating the BM from the data.
- In noise, false detection rate is the limiting factor.
- False detection rate could be reduced (<1/1000) by selecting a N/P ratio of 1.
- A N/P ratio of 1 allow a power boosting of 3 dB.

Burst Marker Questions?

- What is the minimum SNR requirements?
  - BM should be reliable for SNR >= 12 dB (16-QAM FEC threshold)
  - 10 dB is proposed in [1] is also a good target
- What is the target misdetection and false detection rate?
  - For a target packet error rate is 5e-5, misdetection rate (start + end BM) should be less than 5e-6 as recommended in [3]
  - False detection rate depend on packet and RB size. RB size has not been decided. Preliminary guideline could be 1/100 to 1/1000 the packet error rate. This is different from [3].
  - Rate should decrease for increasing SNR, **no error floor**. BM error rate should not limit the packet error rate at high SNR.
- Is the BM aligned with Resource Block?
  - Yes, but it introduce jitter. Jitter has to be removed in the 1-D to 2-D mapping by padding front and back of packet with idle.

[3] Geneva, July 2013 rahman_syed_3bn_01_0713.pdf

Burst Marker Questions?

- Could the BM span over multiple Resource Blocks?
  - Yes, if BM size larger than one RB (see next presentation)
- Could the BM span over 2 OFDMA frame?
  - Yes, if BM size larger than one RB
- How many profiles?
  - Unknown. We need proposals and decisions in this area
- Could the profiles be encoded in the BPSK signal instead of the N pattern?
  - Yes, it is possible (see next presentation)
- Are two type of signaling for the BM (BPSK and ternary) needed?
  - No, we should use one type if all requirements are met