

## Preamble Sequence For Fast Cell Search, Low Computational Complexity, and Low PAPR

### IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number: IEEE S802.16e-04/265r1

Date Submitted:2004-08-28

#### Source:

Jason Hou Jing Wang Sean Cai  
Dazi Feng Yonggang Fang

Voice: 858-554-0387

ZTE San Diego Inc  
10105 Pacific Heights Blvd  
San Diego, CA 92121., USA

Fax: 858-554-0894

E-mail: [jhou@ztesandiego.com](mailto:jhou@ztesandiego.com)

#### Venue:

Session #33

#### Base Document:

IEEE C802.16e-04/265r1

#### Purpose:

Assist in clarifying C802.16e-04/265r1 contribution document.

#### Notice:

This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.

#### Release:

The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.

#### IEEE 802.16 Patent Policy:

The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <<http://ieee802.org/16/ipr/patents/policy.html>>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <<mailto:chair@wirelessman.org>> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <<http://ieee802.org/16/ipr/patents/notices>>.

# Preamble Sequence for Fast Cell-searching, Low Computational Complexity, and Low PAPR

Jason Hou  
ZiMAX-USA Team

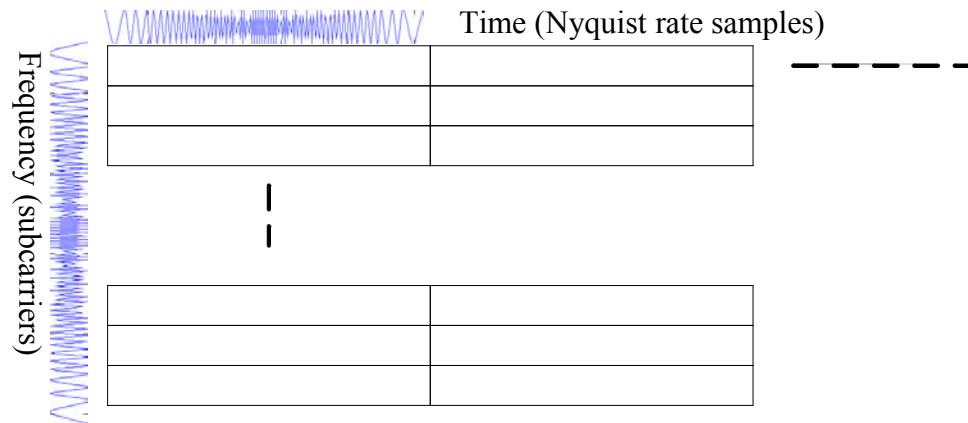
August 24, 2004

# *Addresses the Needs for Mobile Devices*

- **Single preamble sequence needed for an entire network**
- **Different code phases represent IDcell, very low computational complexity**
- **Inherently low PAPR .**
- **Provide a mechanism for fast-cell searching during HO.**
- **Reduced processing power to extend battery standby time.**
- **One preamble scan operation process provides DL channel information of all segments such as CIR, TOA, CQI, IDcell, etc.**
- **Allow MSSs to automatically adjust for DL RX timing to reduce ISI and UL TX timing to maintain subchannel slot timing orthogonality due to the readily available TOA info.**
- **Reduce the need for frequent ranging requests.**

# CAZAC Frequency-Time Duality

- **CAZAC: Constant Amplitude Zero Auto-correlation Coefficients.**
- **Main mathematical properties**
  - All cyclic shifts of the sequence form an orthonormal basis of  $\mathbb{C}^N$ .
  - CAZAC in time domain if and only if CAZAC in frequency domain (see contribution for details).

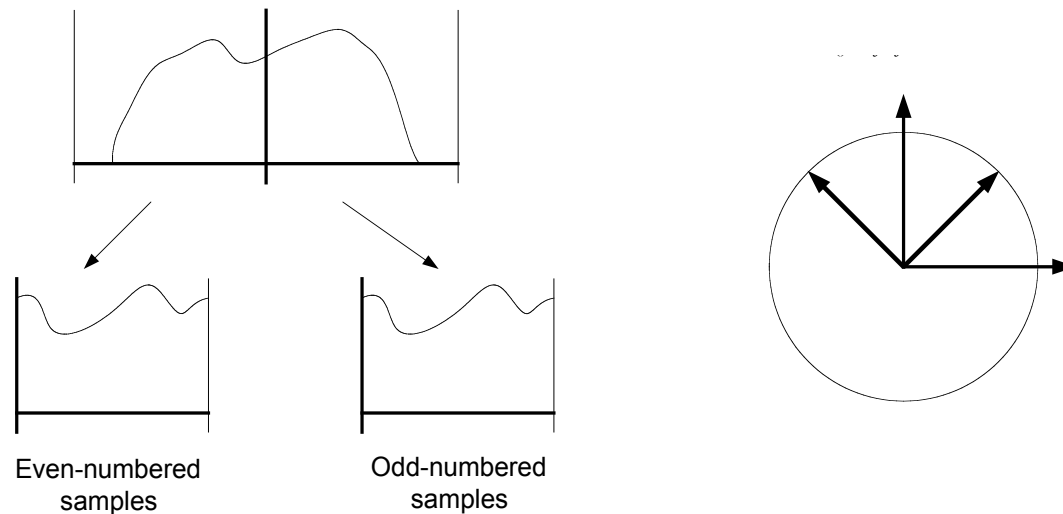


# CAZAC Sequences

- **Chu sequence (L=8,32,128,512,...)**
- **Frank-Zadoff sequence (L=16,64,256,1024,...)**
- **Frequency-time offset ambiguity**
  - Chu sequence
    - Frequency offset of
    - Frequency offset of  $k$  subcarriers ( $k/(LT_s)$ )->time offset of  $-k$  Nyquist samples.
  - Frank-Zadoff sequence
    - Exhibits Chu-like frequency-time ambiguity (not exact).
    - Frequency offset of  $k$  subcarriers->time offset of  $-k$  Nyquist samples.

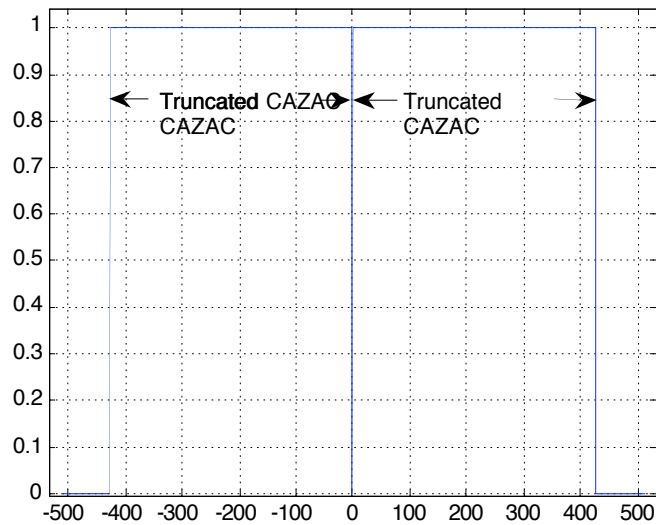
# *Construction of Low PAPR Sequences*

- **Straight adoption of CAZAC sequences cannot be done due to guard bands in OFDMA.**
- **Utilize spectrum folding to inherit CAZAC properties with moderate rise of PAPR due to exclusion of guard bands.**

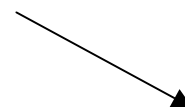


# Principles of Constructing Low PAPR Sequences

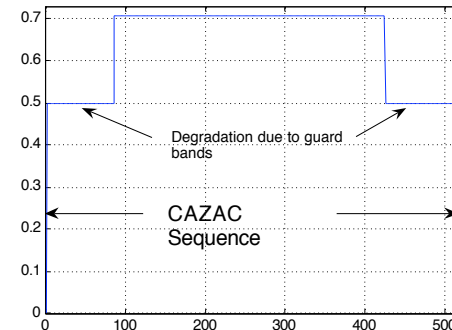
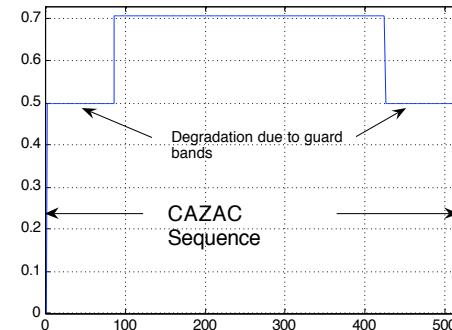
- Method to construct constant-amplitude frequency sequence and low PAPR time waveform



Spectrum of even-numbered time samples

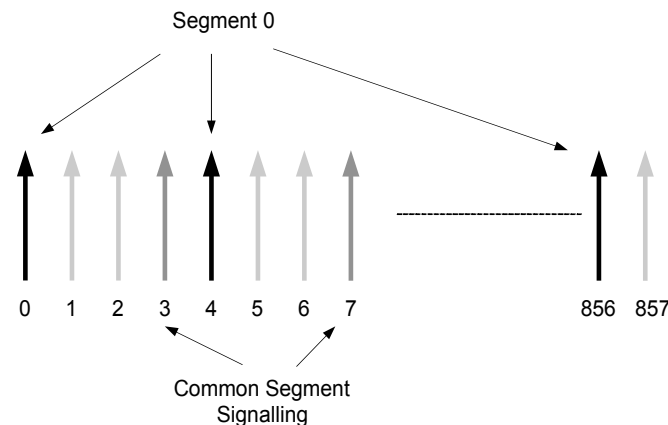


Spectrum of odd-numbered time samples



# Preamble Sequences for PUSC

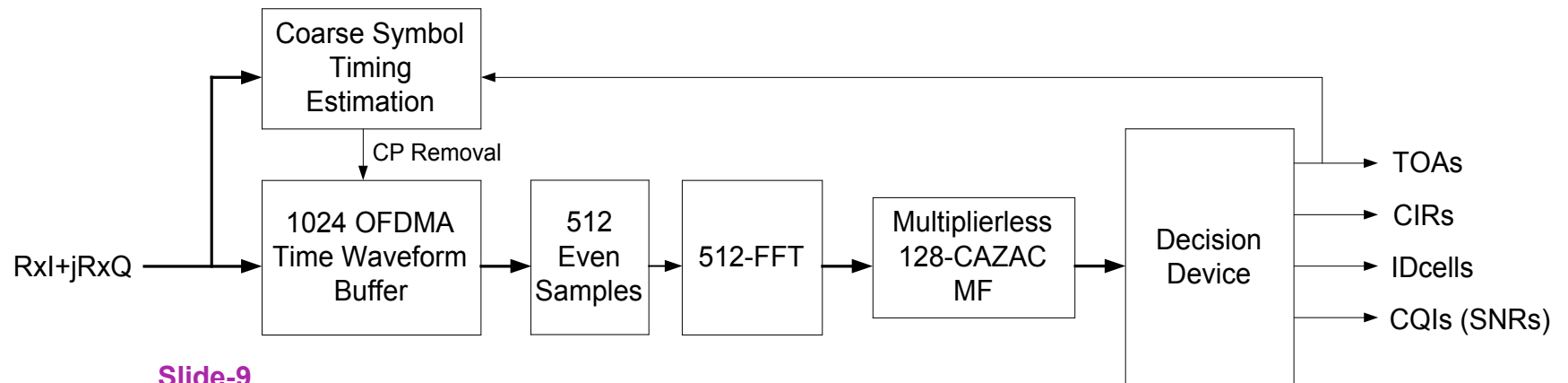
- **Subcarriers are divide into four carrier-sets**
  - Segment 0 uses set 0, segment 1 uses set 1, segment 2 uses set 2
  - All sets use the same CAZAC sequence. *IDcell* is characterized by the code-phase (number of cyclic shifts) of the CAZAC sequence.
- **Carrier-set 3 is used for common segment signaling without boosting by all segments.**
  - For 1024-FFT with 128-Chu, segment 0 sends 0-shifted CAZAC, segment 1 sends 42-shifted CAZAC, and segment 2 sends 84-shifted CAZAC.
  - Used for establishing a timing reference and not for channel estimation.
  - Non-boosted to reduce PAPR degradation





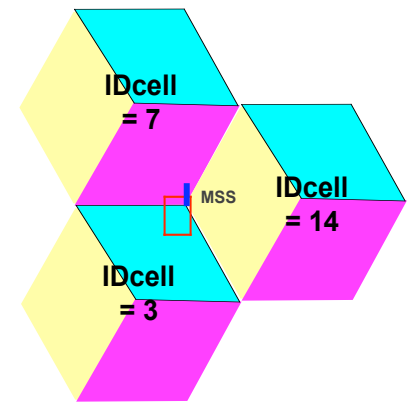
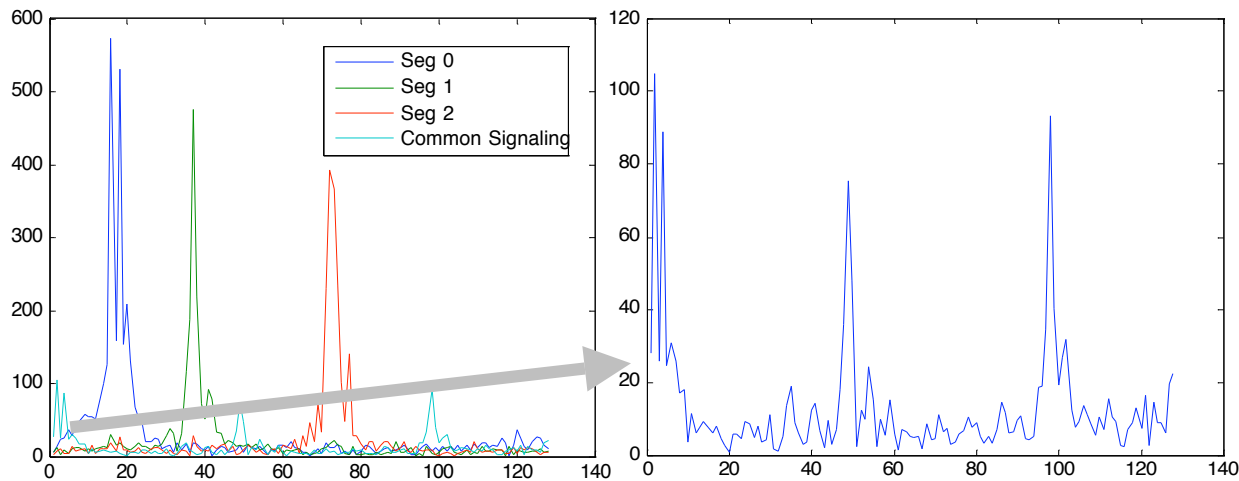
# *Low Computational Complexity*

- **Operation can be done solely in frequency domain.**
- **CAZAC MF can be implemented as a multiplierless tap-delay line filter with reduced taps (CORDICs and adders).**
- **CORDICs can be shared with channel estimators.**
- **Further hardware complexity reduction by exploring CAZAC symmetry (for example, 16-element Frank-Zadoff are  $\pm 1$  and  $\pm j$ ).**



# Example of PUSC In SUI-3 With the 3 Adjacent Sectors of 3 BSs

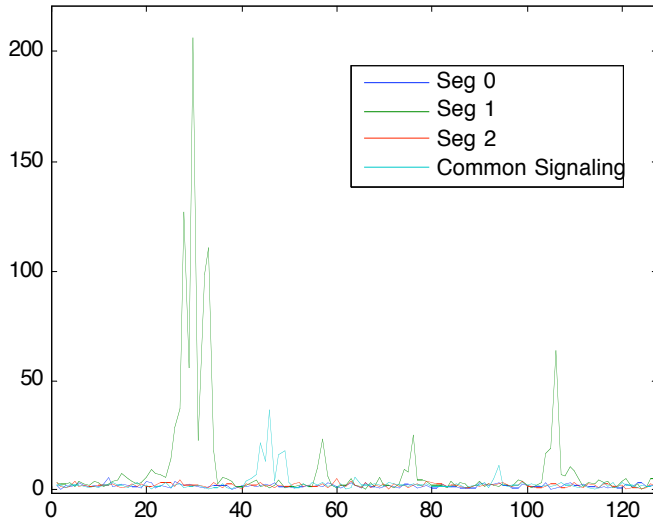
- **1024-FFT PUSC (frequency locked)**
- **Robust *IDcell* identification of all segments**



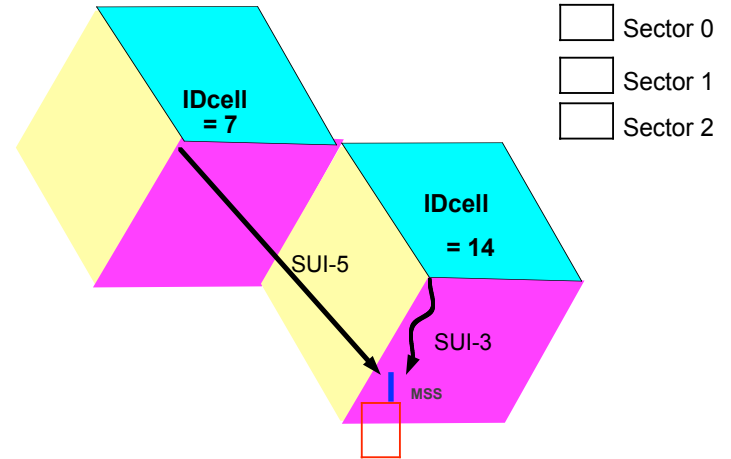
- Sector 0
- Sector 1
- Sector 2

# Example of Same Segment Interference In PUSC, Scenario 1

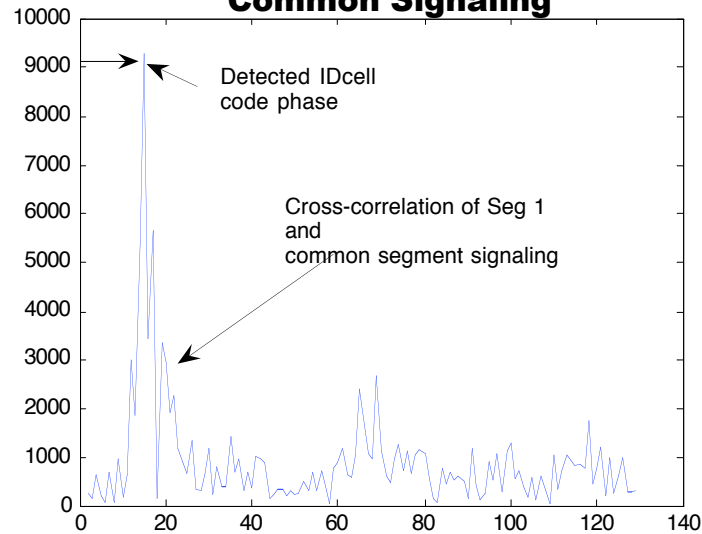
**Results of CAZAC Matched Filtering In Frequency Domain**



*IDcell* detection using cross-correlation of CAZAC MF outputs of Seg 0 and common segment signaling

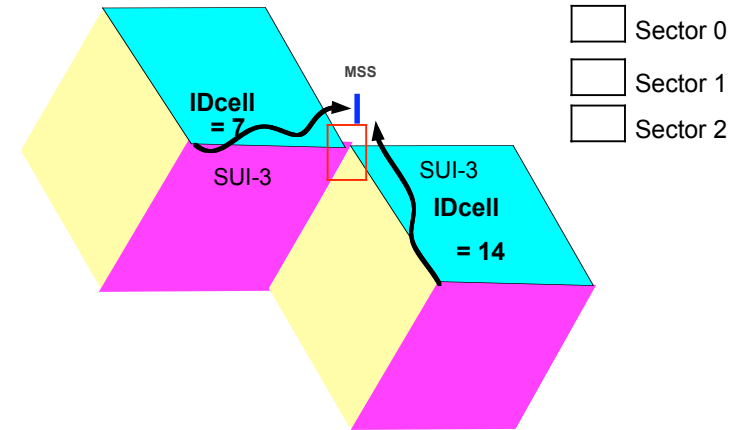
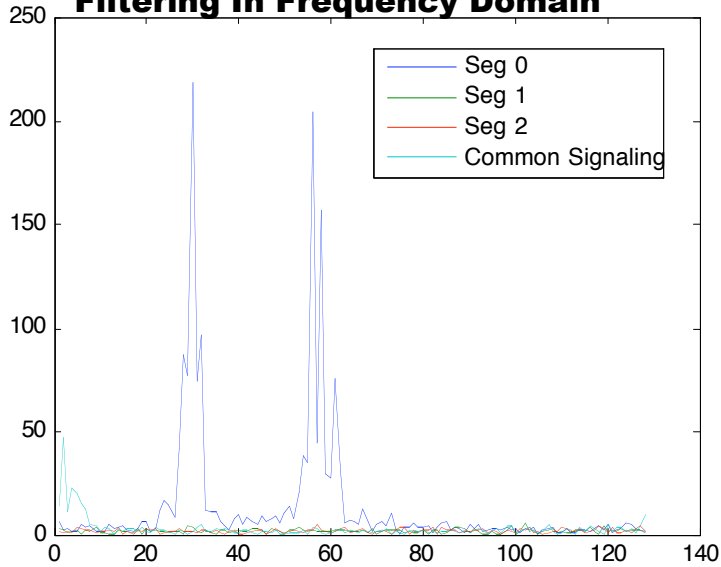


**Cross-correlation of Seg 0 and Common Signaling**

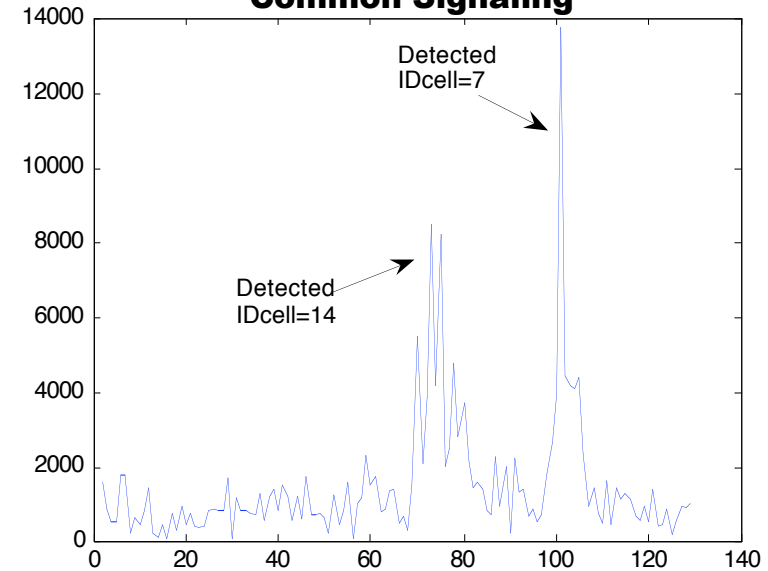


# Example of Same Segment Interference In PUSC, Scenario 2

**Results of CAZAC Matched Filtering In Frequency Domain**

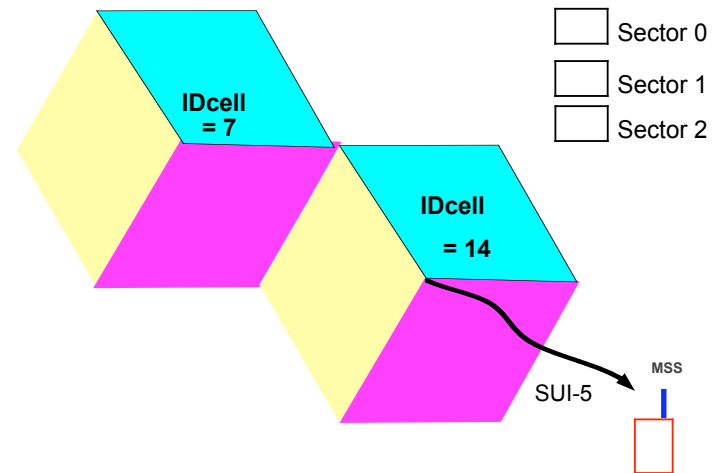
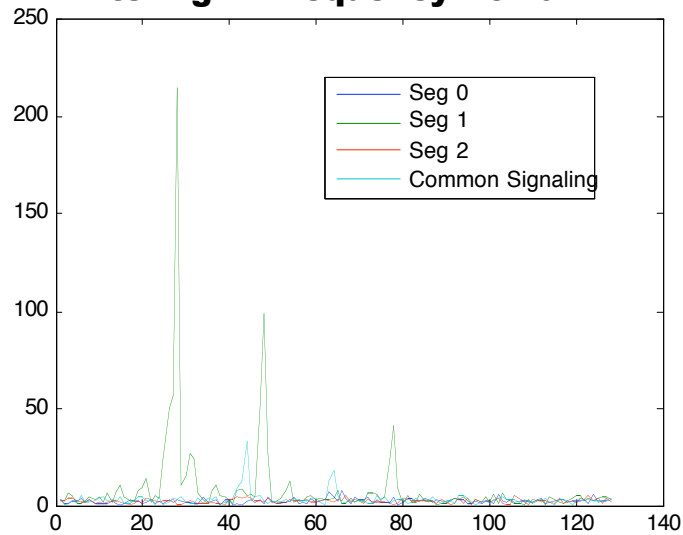


**Cross-correlation of Seg 0 and Common Signaling**

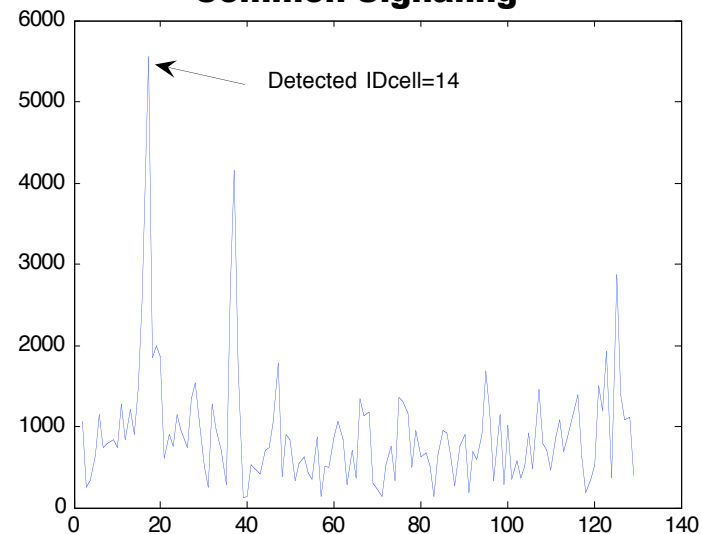


# Example of Severe Multipath SUI-5 in PUSC, Scenario 3

### Results of CAZAC Matched Filtering In Frequency Domain



### Cross-correlation of Seg 1 and Common Signaling



## *Conclusion*

- **Addresses the needs of MSSs where fast cell-searching is essential.**
- **Allows for extended battery time where neighbor and other frequency BS scanning can be done quickly and reliably and hardware complexity is very low.**
- **Allows for accurate adjustment of RX and TX timing to reduce RX ISI and TX multi-user interference in high-speed vehicular mobile environment even during HO.**