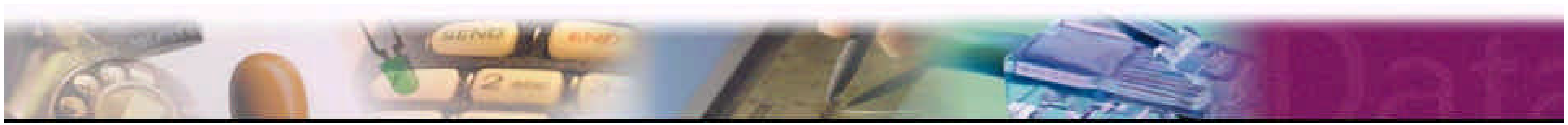
Proposal for a Spatial Channel Model in 3GPP RAN1/RAN4

Contribution WG1#20(01)579 of Lucent Technologies to 3GPP-WG1
Busan, May 21st 2001

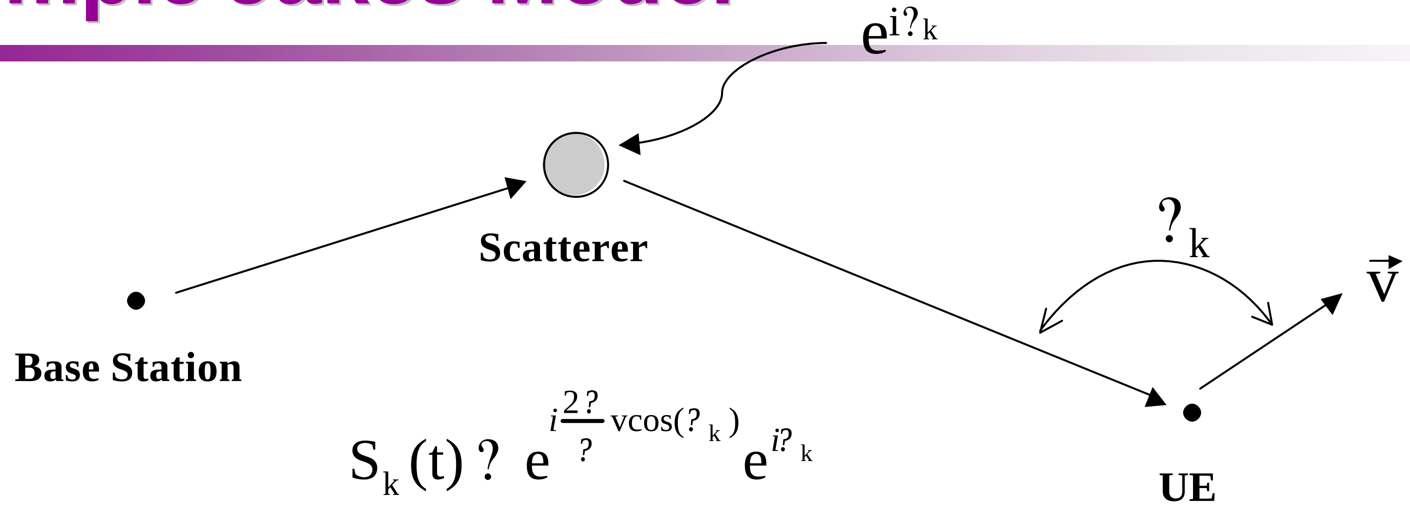
Lucent Technologies
Bell Labs Innovations



Basic Approach

- Implement the channel as an extended Jakes' model
- Incorporate the recommendations of COST 259.
- Include spatial knowledge of the basestation, UE, and scatterer positions.
- Use a common set of scatterers for uplink and downlink.
- Include provisions for antenna patterns and mobile movement through the cell.

Simple Jakes Model

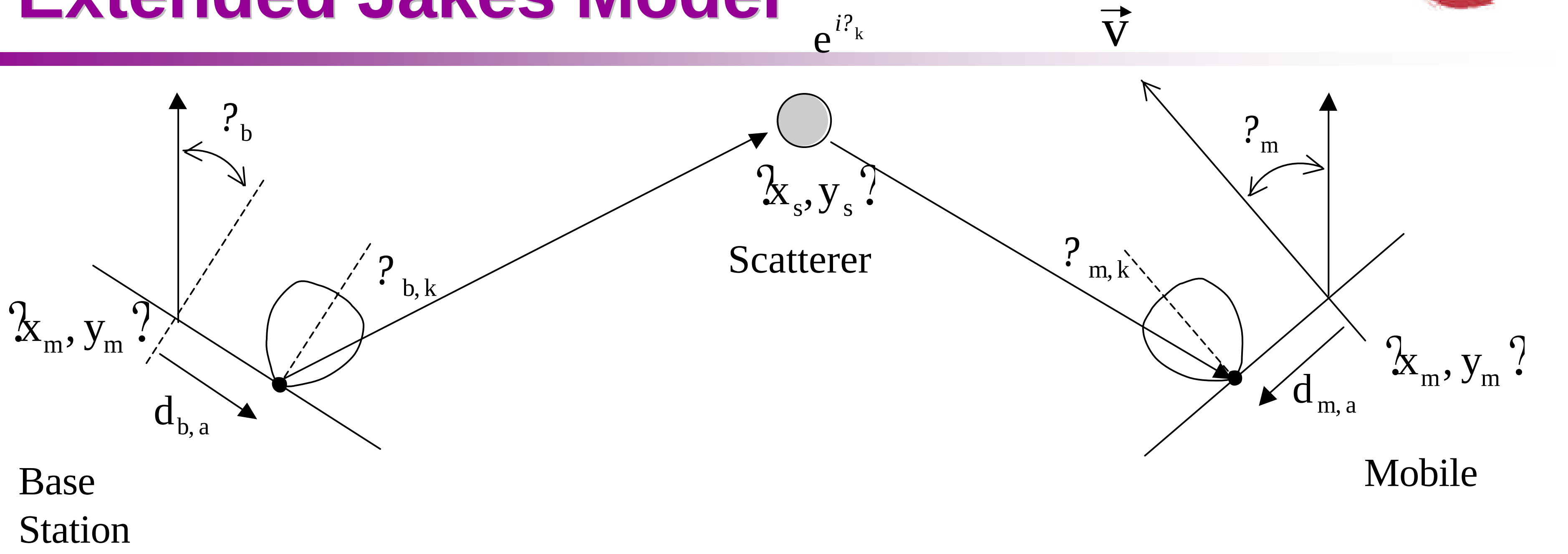


$$S_k(t) ? \; e^{i\frac{2?}{?}v\cos(?_k)} e^{i?_k}$$

The contribution from each scatterer is summed to get the fading channel

$$C(t) ? \frac{E_o}{\sqrt{N}} \sum_k S_k(t)$$

Extended Jakes Model



$$S_k(t) ? G_b(?_{b,k}, f) e^{i\frac{2?}{?} d_{b,k} \cos(?_{b,k})} ?? e^{i\frac{2?}{?} v\cos(?_{m,k})t} e^{i?_k} ?? e^{i\frac{2?}{?} d_{m,k} \cos(?_{m,k})} G_m(?_{m,k}, f)$$

$$?_{b,k} ? ?_{b,k} ? ?_b$$

$$?_{m,k} ? ?_{m,k} ? ?_m$$

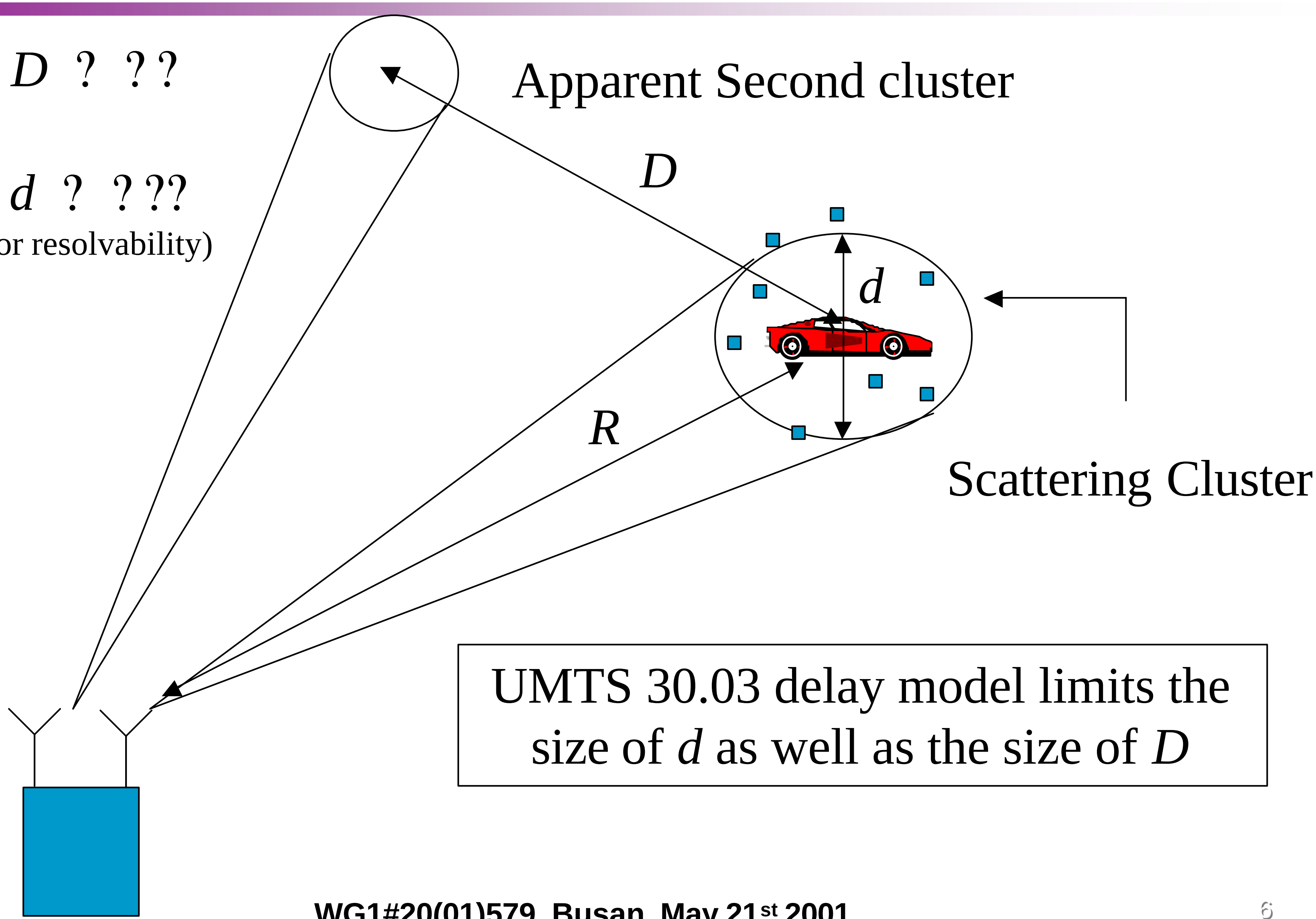
Goals of Spatial Channel Model

- Self-consistent modeling of:
  - Temporal Fading / Doppler Spread
  - Frequency Fading / Delay Spread
  - Spatial Fading / Angle Spread
  - i.e., cannot have arbitrary statistics
- Collapses to known 2-D model (e.g. Jake's Model)
- Limited number of possible parameter assignments - repeatability!
- Self-consistent in both uplink and downlink channels (i.e. reciprocity while allowing for upling/downlink frequency differences)
- Allows for time evolution (i.e., continuous from frame to frame)
  - useful in beam-steering performance evaluation

Relationship Between Scatterers and Parameters (1/2)

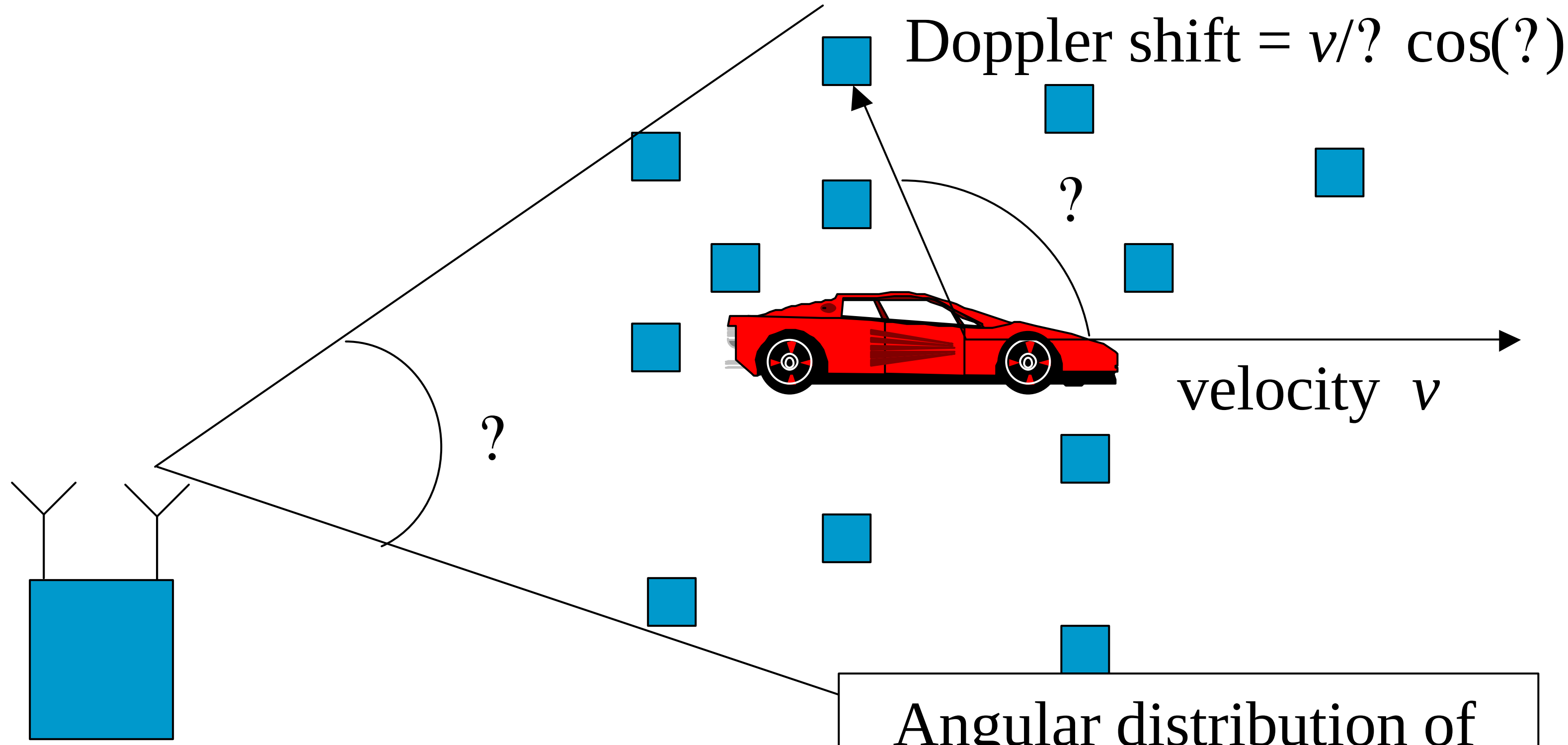
D ? ??

d ? ???
(for resolvability)



UMTS 30.03 delay model limits the size of *d* as well as the size of *D*

Relationship Between Scatterers and Parameters (2/2)



Position of scatterers relative to receiver determines Angle-of-Arrival distribution

Angular distribution of *illuminated* scatterers relative to mobile velocity determines Doppler spectrum

Options for Scatterer Distribution

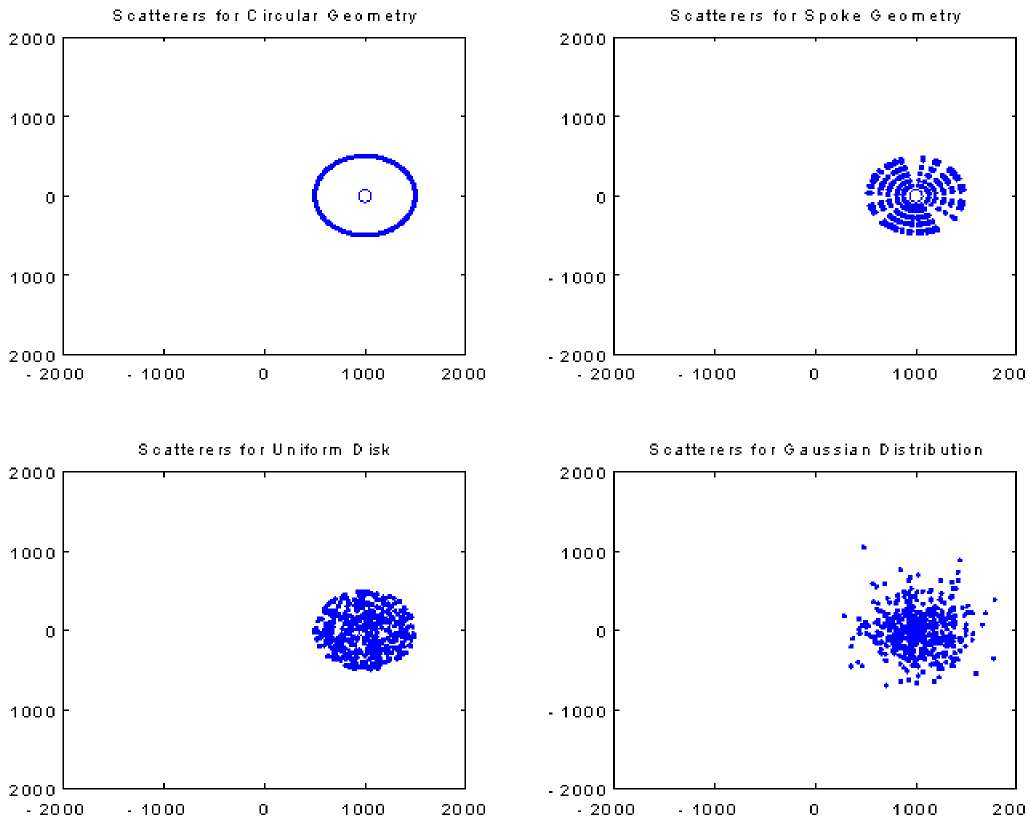
- Options for Macro-cell models - scatterers around mobile:
  - uniform on circle about mobile
  - uniform in disk about mobile
  - uniform on spokes emanating from the mobile
  - Bivariate Gaussian about mobile
- Options for Micro-cell models - scatterers surround both mobile and base
  - uniform on circles about mobile and base
  - on ellipse with mobile and base at foci
- Each has its own AOA/TOA/Doppler statistics
- We have decided to ignore the TOA statistics within a cluster for macro-cell model assuming that each cluster is a single resolvable path (i.e., a UMTS 30.03 tap)
  - limits the cluster size
  - TOA statistics determine the number and size of the clusters

Macro-cell Models - Scatterer Distribution

Lucent Technologies
Bell Labs Innovations

Circle

Spoke



Disk

Gaussian

Scatter Distributions Selection

- All macro cell distributions provide classic Doppler spectrum since they are uniform in angle about the mobile (assuming mobile uses omni-directional antenna and base station illuminates entire scattering radius)
- Gaussian distribution matches best with limited AOA measurement data available
- Thus, we choose Gaussian distribution of scatterers about mobile for macro/mid size cell model
- Elliptical model allows separate scattering ellipses to represent different taps in UMTS 30.03 model
- Other microcell models represent problematic relationships between AOA and TOA.
- Thus, we choose Elliptical distribution of scatterers for micro-cell model

UMTS 30.03 Channel Models

Lucent Technologies
Bell Labs Innovations

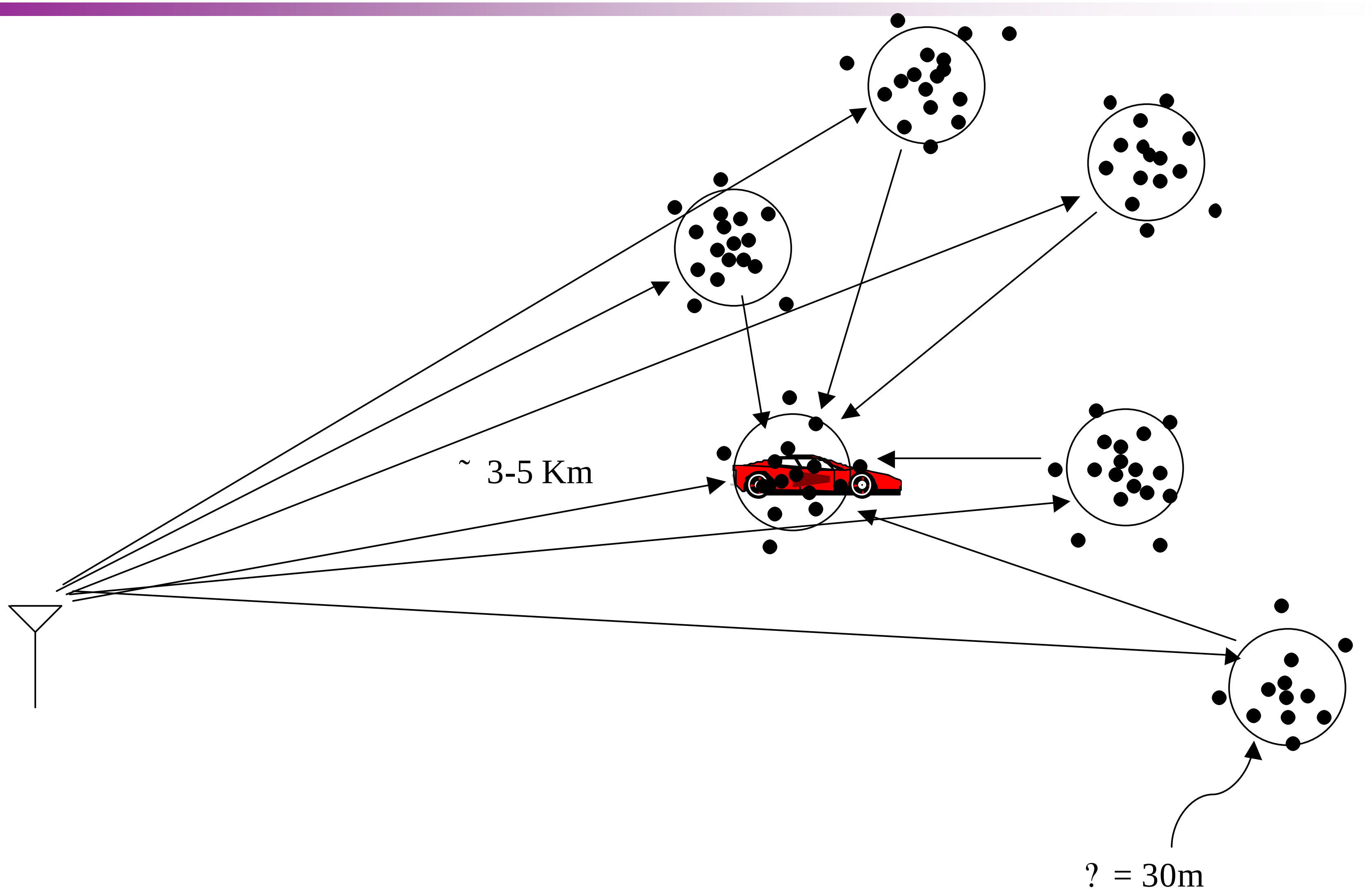
Pedestrian

Tap	Channel A		Channel B	
	Relative Delay (ns)	Average Power (dB)	Relative Delay (ns)	Average Power (dB)
1	0	0	0	0
2	110	-9.7	200	-0.9
3	190	-19.2	800	-4.9
4	410	-22.8	1200	-8.0
5			2300	-7.8
6			3700	-23.9

Vehicular

Tap	Channel A		Channel B	
	Relative Delay (ns)	Average Power (dB)	Relative Delay (ns)	Average Power (dB)
1	0	0	0	-2.5
2	310	-1.0	300	0
3	710	-9.0	8900	-12.8
4	1090	-10.0	12900	-10.0
5	1730	-15.0	17100	-25.2
6	2510	-20.0	20000	-16.0

Example Scenario for Veh-A



UMTS 30.03 Spatial Channel Models (1/2)

- Vehicular A
  - 6 clusters of scatterers (5 due to reflectors)
  - each cluster bi-variate Gaussian - sigma = 30m
  - cluster separations 90m - 750m
  - mobile distance of 3-5km (macro cell)
  - moderate/low delay spread (rms = 370 ns)
  - low angle spread (rms = ~2 degrees)
- Vehicular B
  - 6 clusters of scatterers (5 due to reflectors)
  - each cluster bi-variate Gaussian - sigma = 40m
  - cluster separations 90m - 6000m
  - mobile distance of 3-5km (macro cell)
  - high delay spread (rms = 4000 ns)
  - low-moderate angle spread (rms = ~10 degrees)

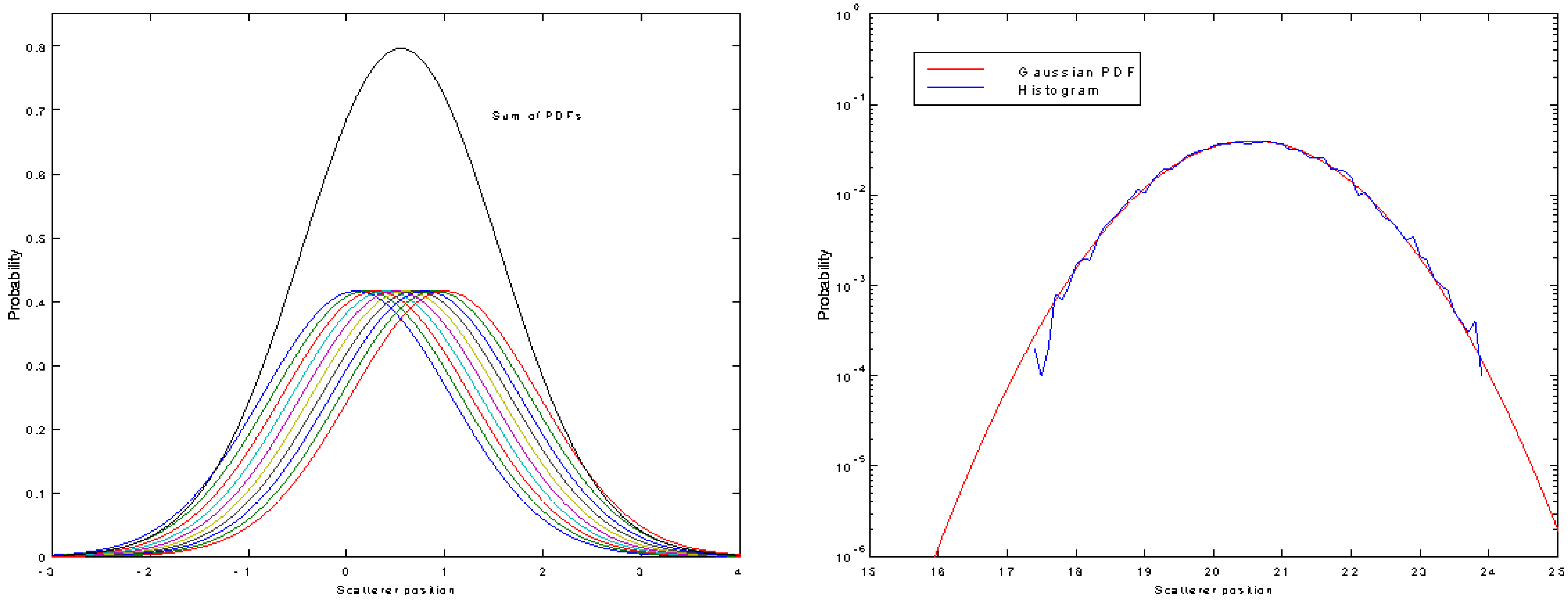
UMTS 30.03 Spatial Channel Models (2/2)

- Pedestrian A (Macro)
  - 4 clusters of scatterers (3 due to reflectors)
  - each cluster bi-variate Gaussian - sigma = 5m
  - cluster separations 35m - 125m
  - mobile distance of 300-500m (micro/mid cell)
  - low delay spread (rms = 45 ns)
  - low angle spread (rms = ~2 degrees)
- Pedestrian B (Macro)
  - 6 clusters of scatterers (5 due to reflectors)
  - each cluster bi-variate Gaussian - sigma =10m
  - cluster separations 60m - 1000m
  - distance of 300-500m (micro/mid cell)
  - moderate delay spread (rms = 750 ns)
  - moderate/high angle spread (rms = ~20 degrees)

Time Evolution

- The preceding model varies with time but does not account for larger scale movement of the mobile
- We may wish to examine the ability to track mobile movement (e.g., for beamforming)
- To accomplish this we allow the scattering clusters to move at fixed intervals.
- We add/delete scatterers by creating “composite distributions” to create overall Gaussian pdf.
- The larger the time between changes the more the mobile moves and thus the more scatterers which will be added and deleted.
- Increasing the number of scatterers to be changed increases the phase discontinuities experienced.

Time Evolution - Method



Super-position of Gaussians to produce a Gaussian

Model Validation

Lucent Technologies
Bell Labs Innovations

- Channel measurements were taken to aid in the creation of an appropriate channel model
- Measurements taken in suburban (Whippany, NJ) and urban (Newark, NJ) settings. Whippany and Newark show moderate/narrow angle spread environments.
- Details of the measurement campaign results can be shared within 3GPP if a discussion forum is established.
- Sharing of channel sounding results within 3GPP is the only way forward for a realistic parameterization of the channel model.

References

[1] R.M. Buehrer, S. Arunachalam, K. Wu and A. Tonello, "Spatial Channel Model and Measurements for IMT-2000 Systems", Proc. of Vehicular Technology Conference, Rhodes, Greece, May 2001.