

Optical Triangulation

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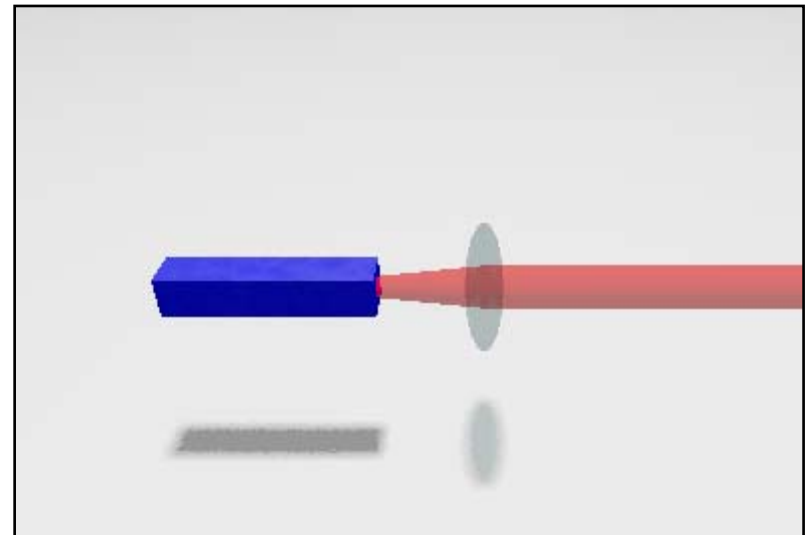
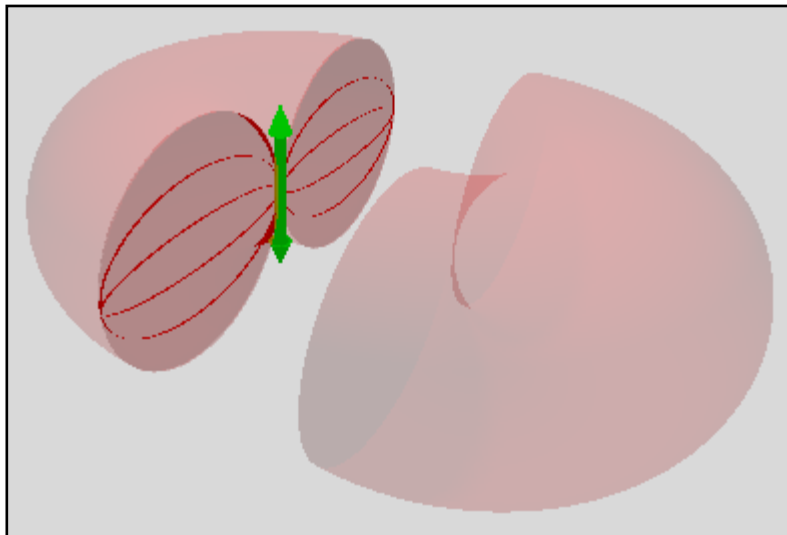
Outline

- Problem and Motivation
- System Design
- Initial Proposed Solution (Analogue)
 - Received Signal Strength Information Design
 - Evaluation
- Second Proposed Solution (Digital)
 - Probabilistic Design
 - Evaluation
- Implementation of Methods
- Conclusions



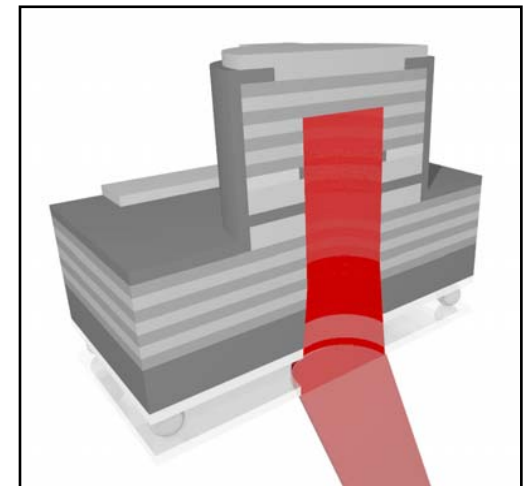
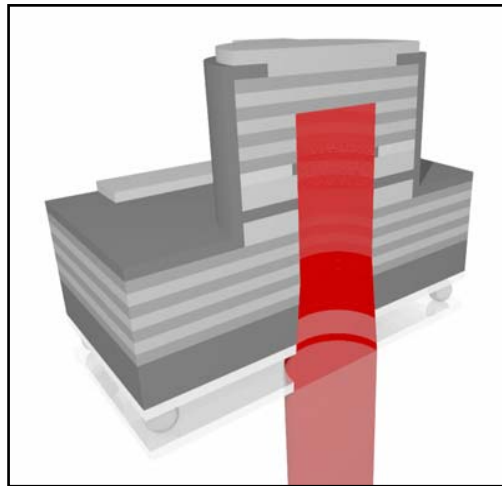
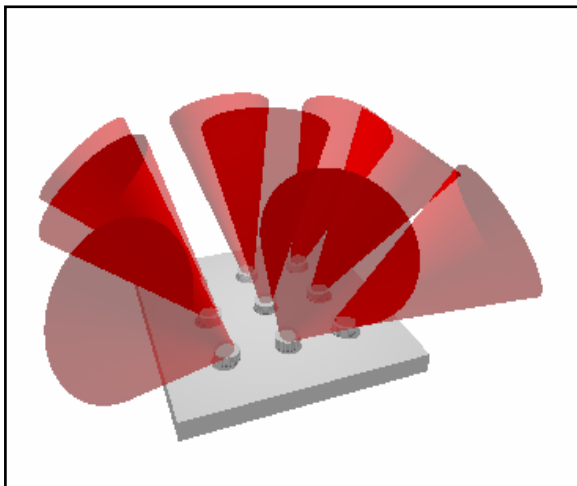
Problem and Motivation

- Problem
 - To provide localisation between individual Specks using Optical elements. Thus leading to Optical communication between Specks
- Motivation
 - The improved efficiency with Optical communication rather than Radio communication once the SpeckNet has been defined.
 - Increased Localisation accuracy.



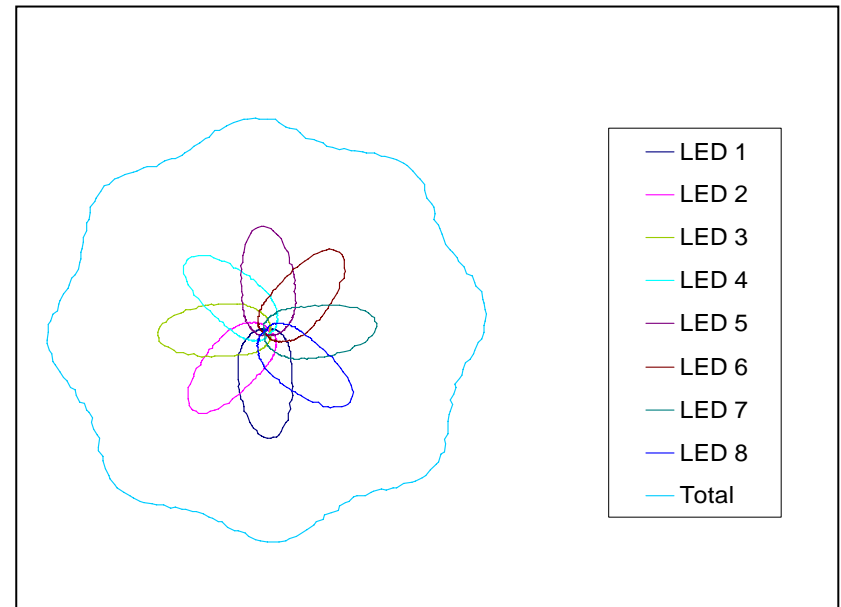
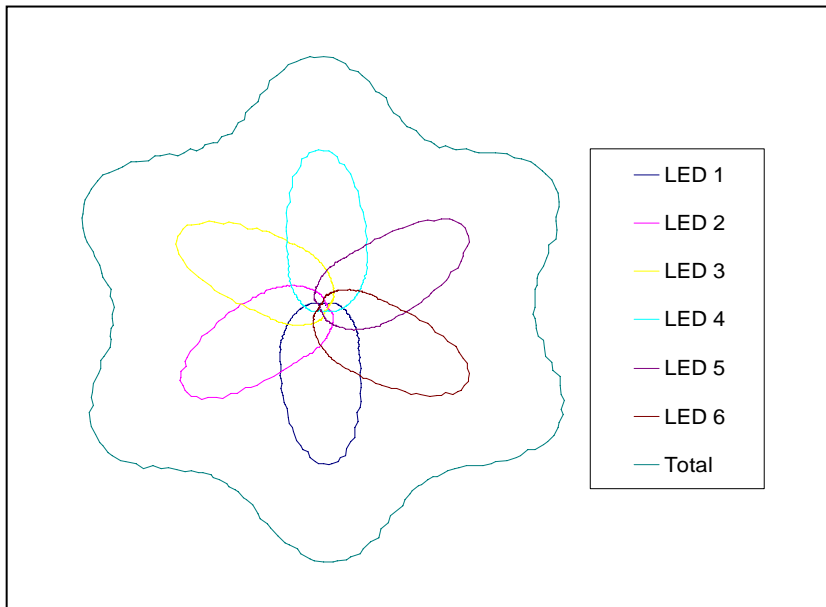
System Design

- The greatest communication efficiency increase is possible when using Lasers - producing collimated pencil-like beams.
- Therefore to cover the same communication volume as Radio we require:
 - Multiple Lasers
 - “Steerable” Lasers



Initial Proposal (Analogue)

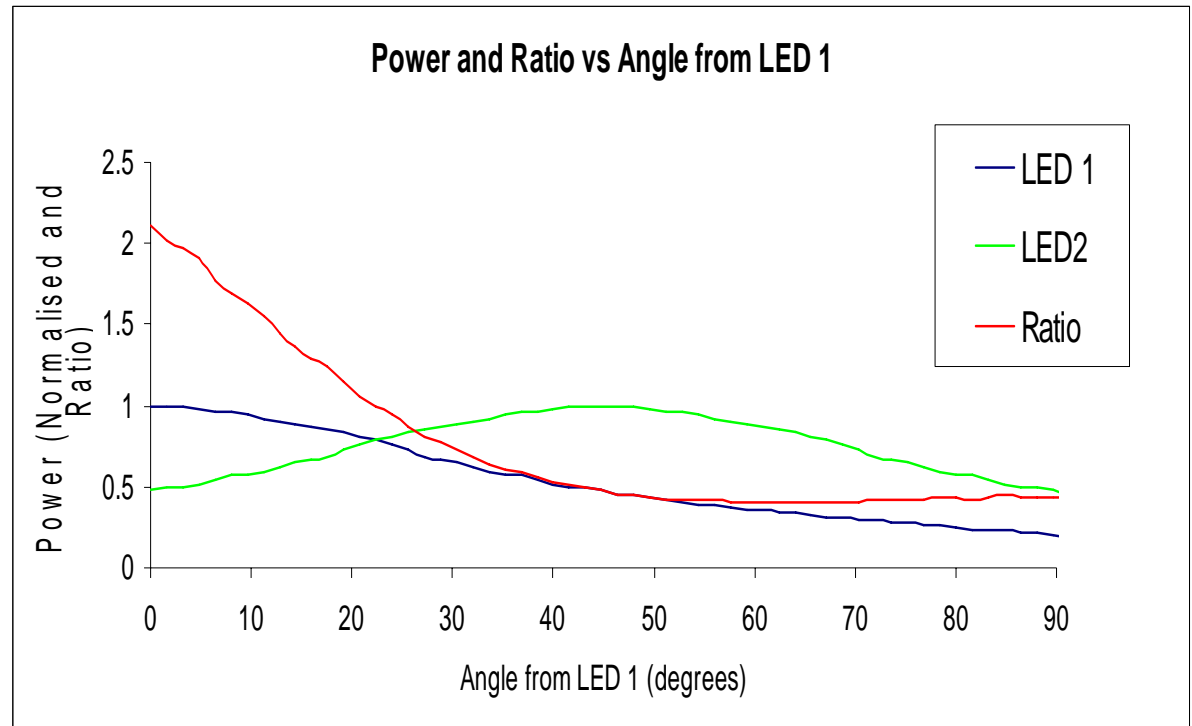
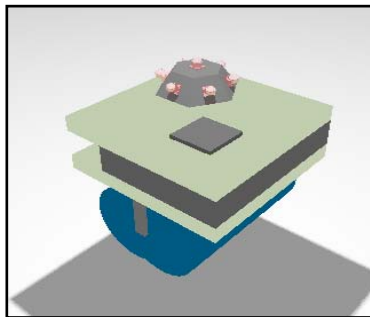
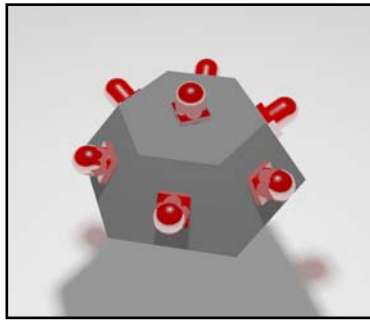
- Initially the Multiple Emitters solution is used – having six emitters (off the shelf LEDs to begin).
- Distance via RSSI
 - Measurement of total received power.
 - The more volume covered (i.e. the more emitters) leads to greater distance measurement accuracy



Initial Proposal (Analogue)

Angle via RSSI

- Comparison of received power from two emitters, belonging to the same transmitting Speck.



Evaluation

- Received Signal Strength Information
 - Simple Algorithm implementation.
 - Hardware requires Analogue IO Ports
 - Relies on Line-of-Sight.
 - Signal strength depends on:
 - Environment
 - Hardware

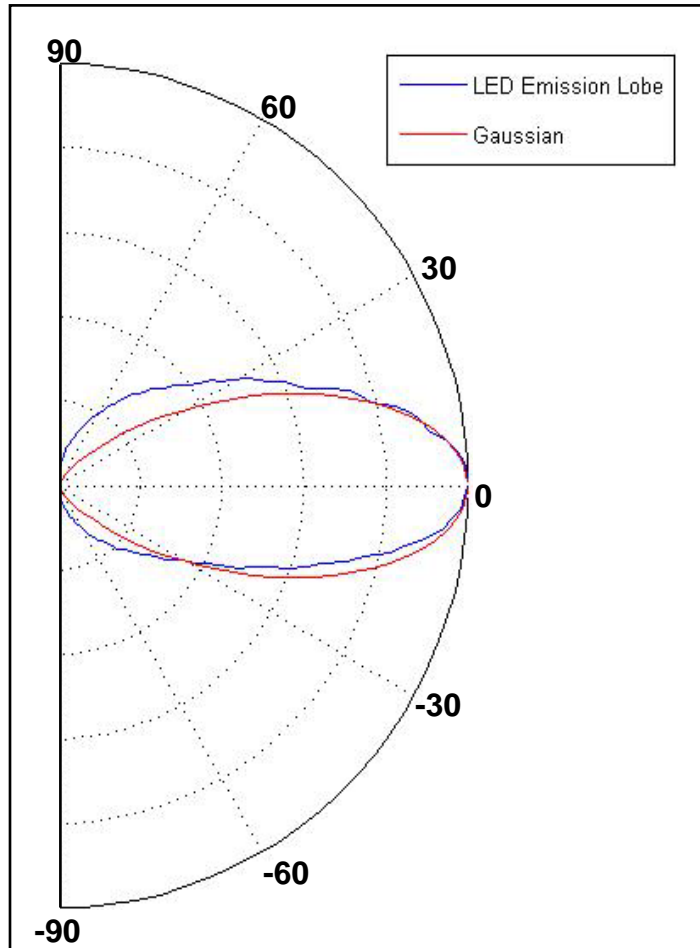


Second Proposal (Digital)

- Probabilistic Localisation
 - Use of Gaussian Distributions.
 - Communication of emission description.
 - Combined position probability is obtained through multiplication of individual probabilities received from transmitting Specks.
 - Transmitted probabilities calculated by the convolution of the Speck's position distribution and emission probability.



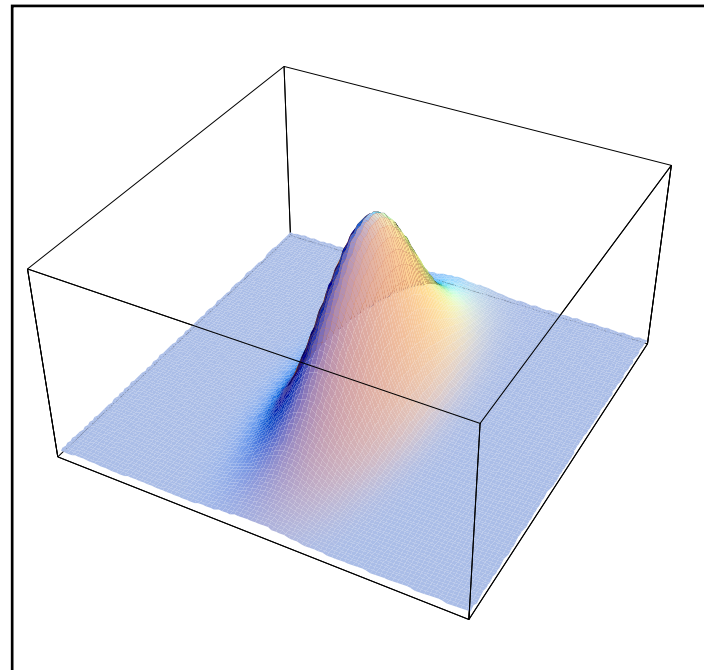
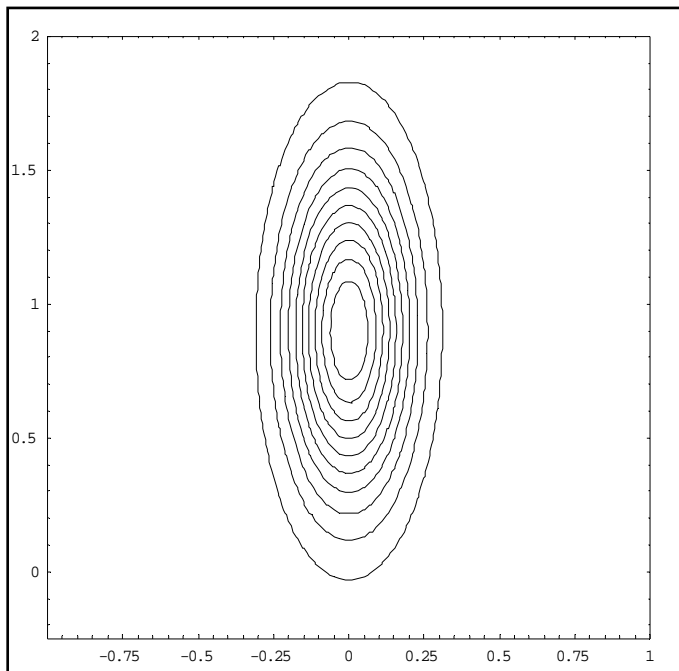
Gaussian Distribution



- First order Gaussians with elliptical cross-section used to describe LED emission.
- Higher order Gaussians can be used to describe more complex emission.

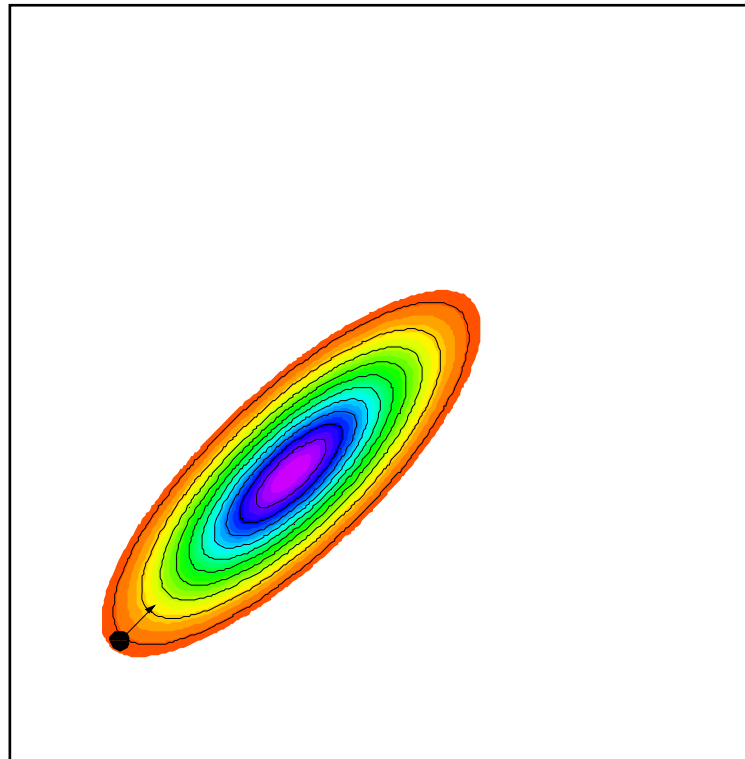
Gaussian Distribution

- Multiplication of Gaussians result in a Gaussian.
- Convolution of Gaussians result in a Gaussian.



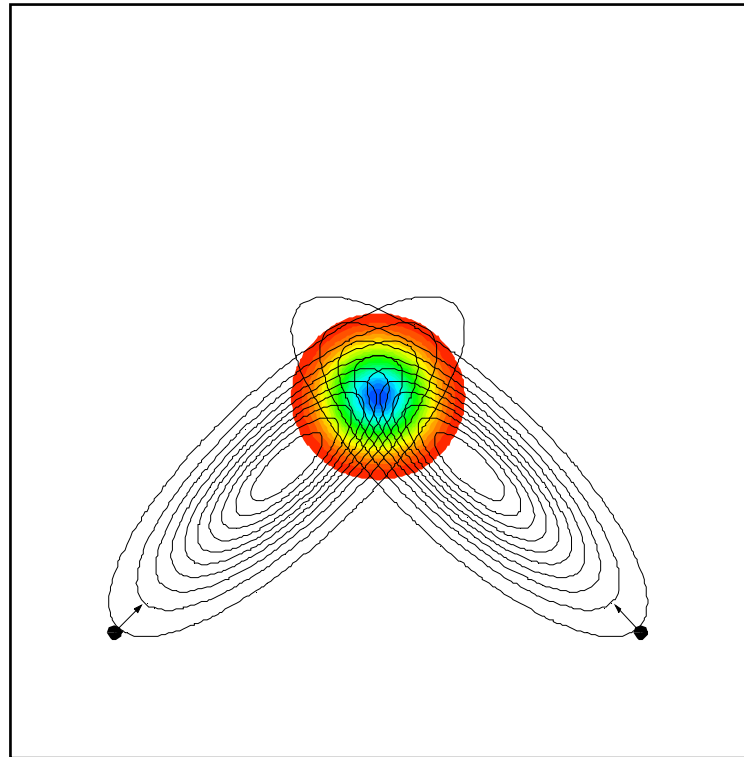
Gaussian Interception

- Speck location is more tightly constrained the more information the Speck receives.



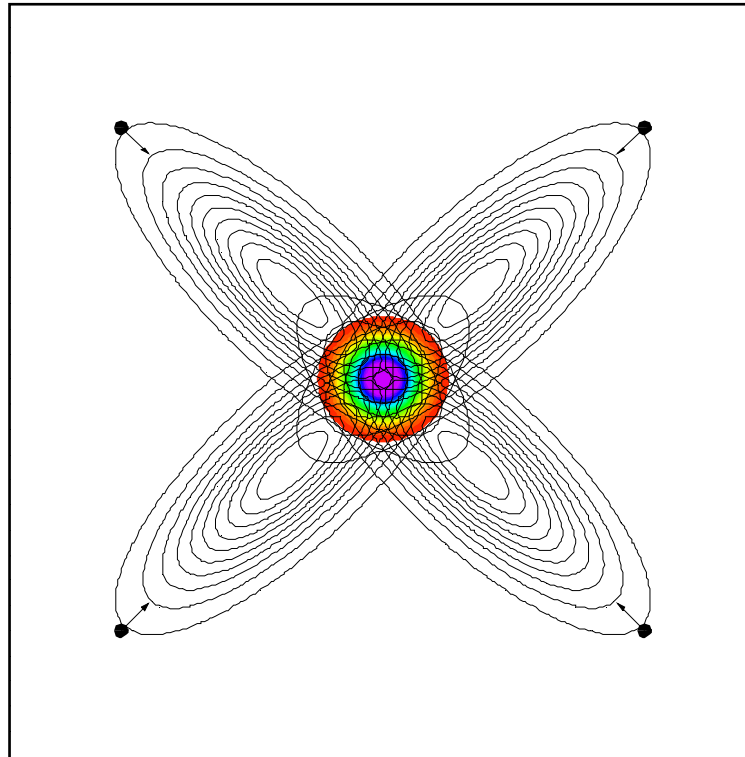
Gaussian Interception

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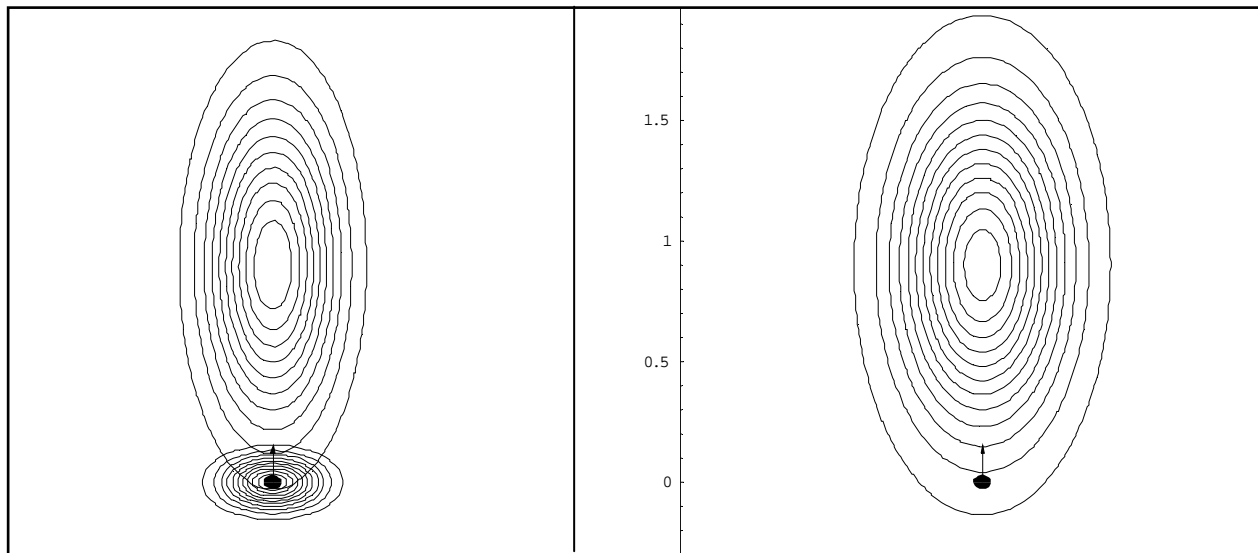
Gaussian Interception

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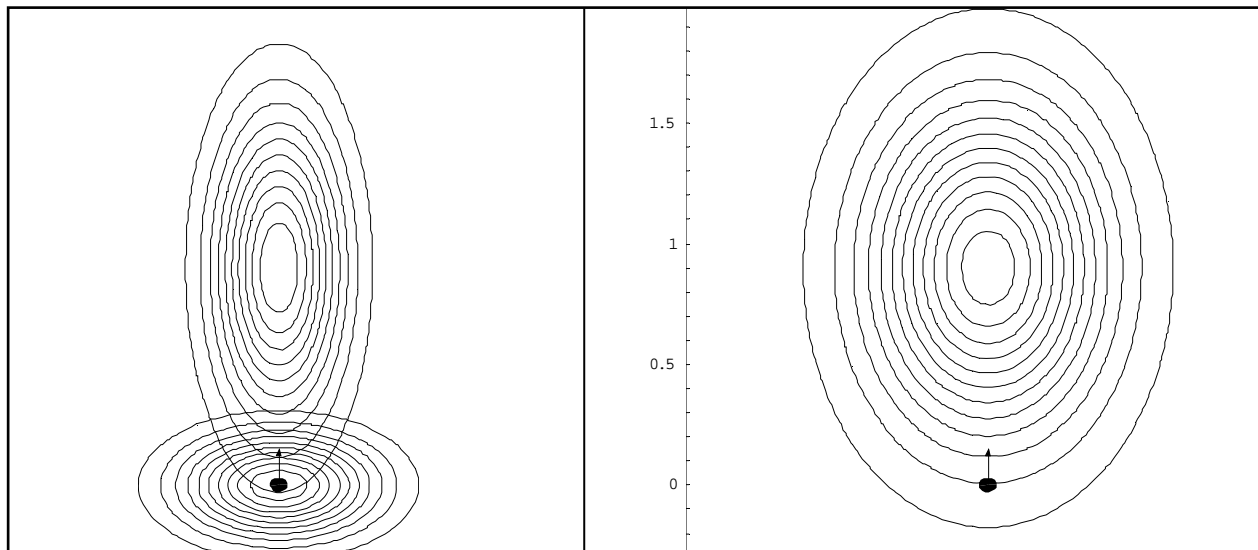
Gaussian Convolution

- Speck position is included within emission using the convolution of the Specks position probability and its emission profile.



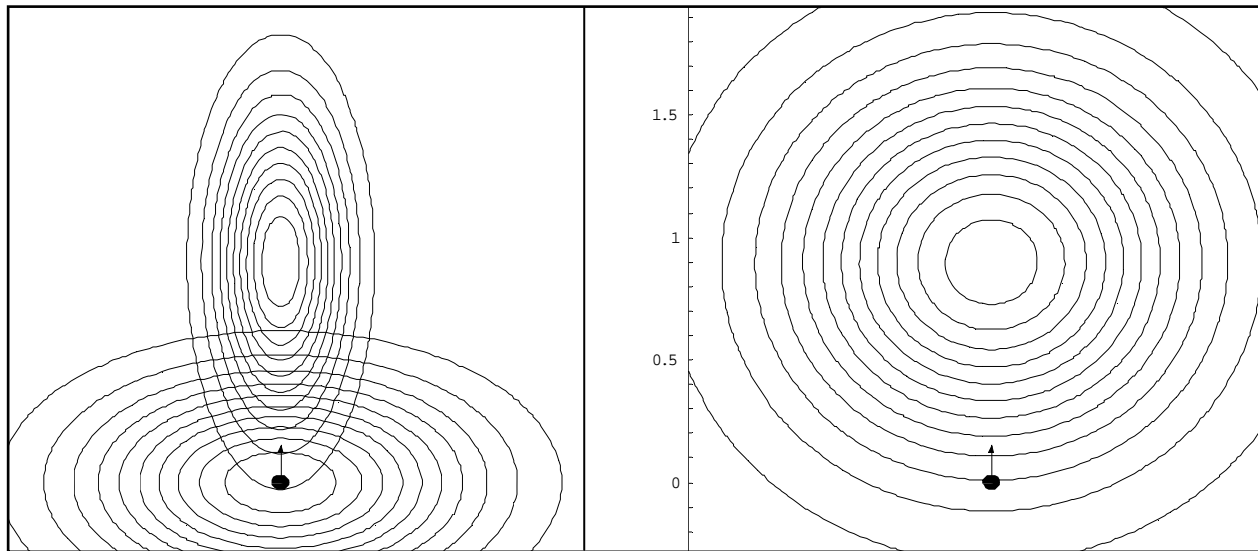
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Gaussian Convolution

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Evaluation

- Probabilistic Localisation
 - Simple hardware implementation.
 - Algorithm takes signal strength into account automatically and as such could be dynamic
 - Speck Level Self-calibration
 - Relies on Line-of-Sight.
 - Algorithm is processor intensive



Implementation of both Methods

1. Model that can test different SpeckNet Densities
 - Optimise emitter configuration
 - Optimise required transmission strength
2. Model random Speck positioning and directions.
 1. Uniformly Random
 2. Gaussian Random
 3. Mesh with Random Orientations
3. 10% of Specks choose to become an Origin on first iteration.
4. Origin Specks transmit information and then wait for replies, this continues throughout the SpeckNet.
5. Special Case:
 - Nth level Specks receiving data from more than one Origin join the Origin that provides the tightest constraints.
6. “Re-Origination”
 - If left it is possible that one Origin will become dominant, due to the higher constraints it lays out.
 - Otherwise, the connectivity of each Speck could be transmitted leaving the Speck with the highest connectivity to become the SpeckNets Origin



Conclusions

- System Design
 - Multiple Emitters
 - “Steerable” Emitters
- RSSI Method
 - + Received power comparison
 - High level of accuracy
 - Angle and Distance measurements between two Specks
 - Simple software implementation
 - Environment dependent emission profiles
 - LED damage
 - Power fluctuations
- Probabilistic Method
 - + Dynamic emission profiles
 - Speck level calibration
 - Gaussian described emission profiles
 - Processor intensive

