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Mark III Mobile Nose – A Stereo Electronic Nose for a Mobile Inspection Robot

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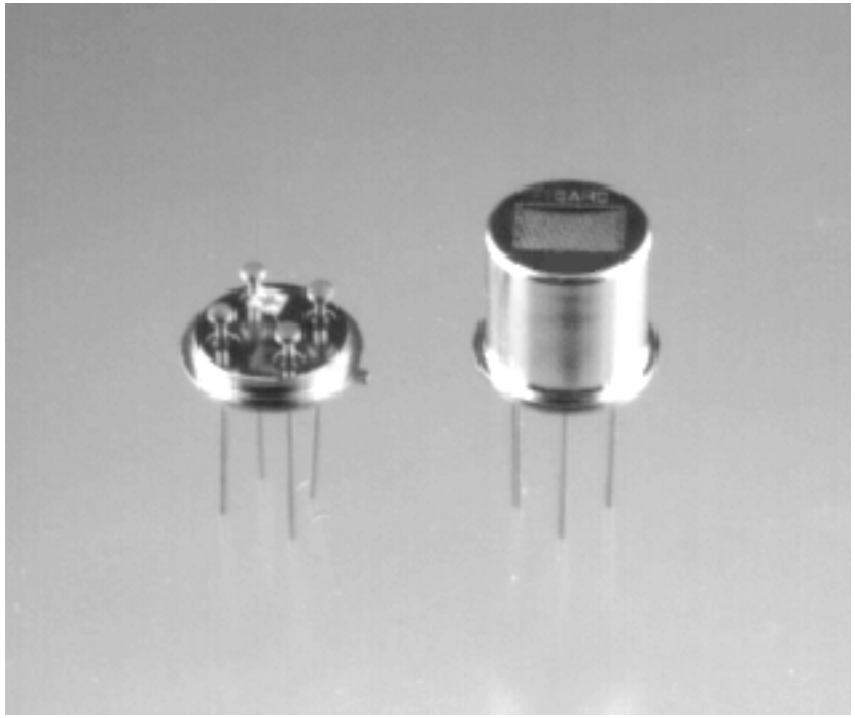
Contents

1) Introduction

- Mobile Nose
  - cover larger scale environments
  - electronic watchman with smelling ability, …
  - use in rescue robots
  - detection
  - localisation
  - identification

2) Set-Up of the Mark III Mobile Nose

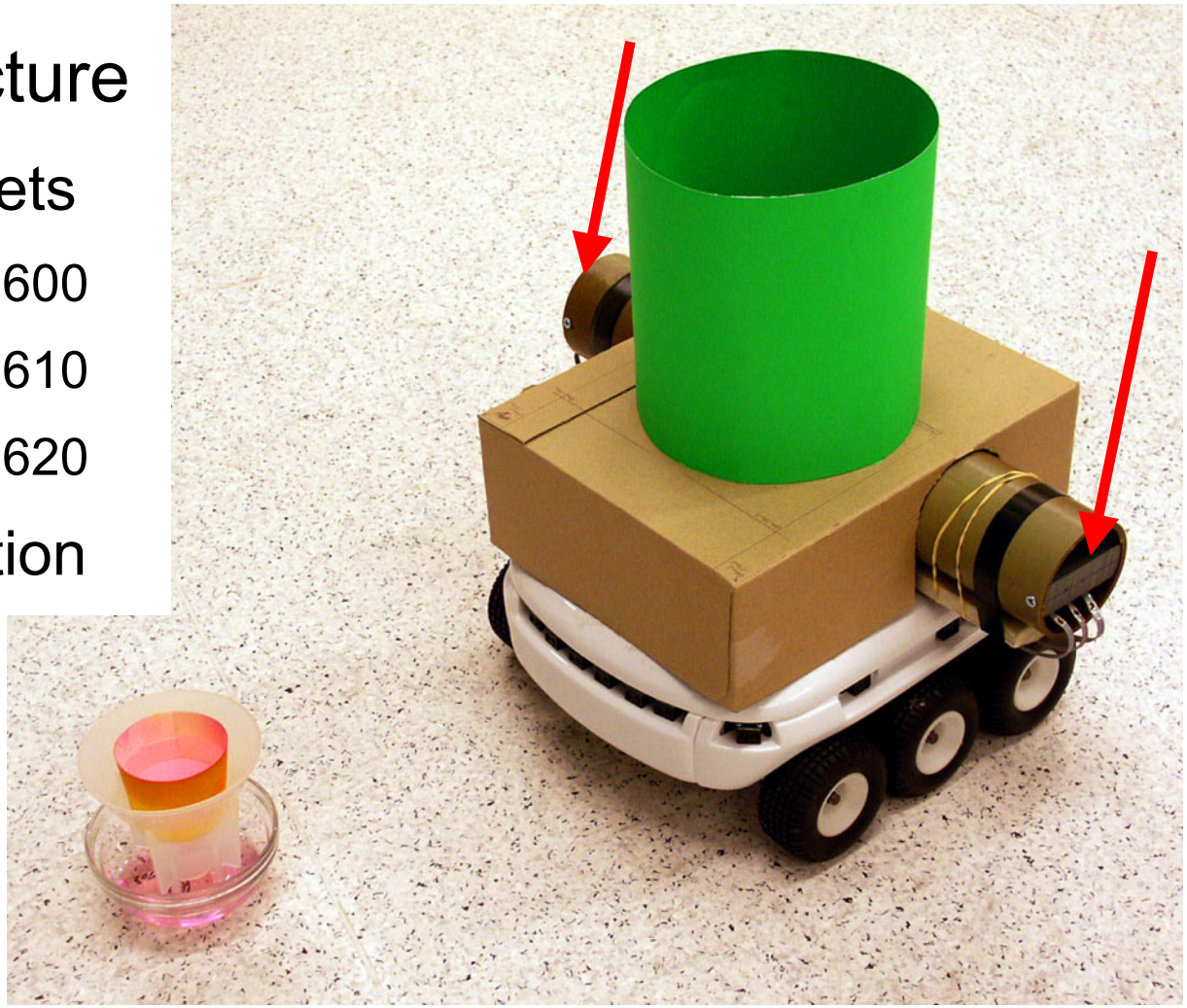
- metal oxide gas sensors
  - doped semiconducting surface layer
  - heating element



- pros and cons
  - high sensivity
  - inexpensive
  - low selectivity
  - long recovery

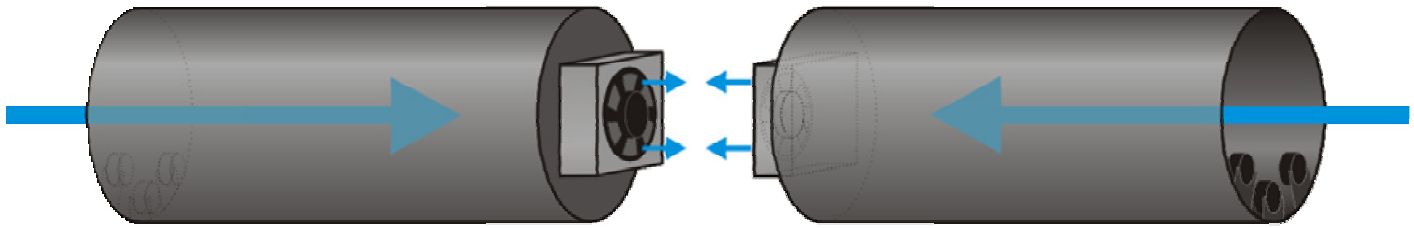
2) Set-Up of the of the Mark III Mobile Nose

- stereo architecture
  - 2 equivalent sets
    - Figaro TGS 2600
    - Figaro TGS 2610
    - Figaro TGS 2620
  - 40 cm separation



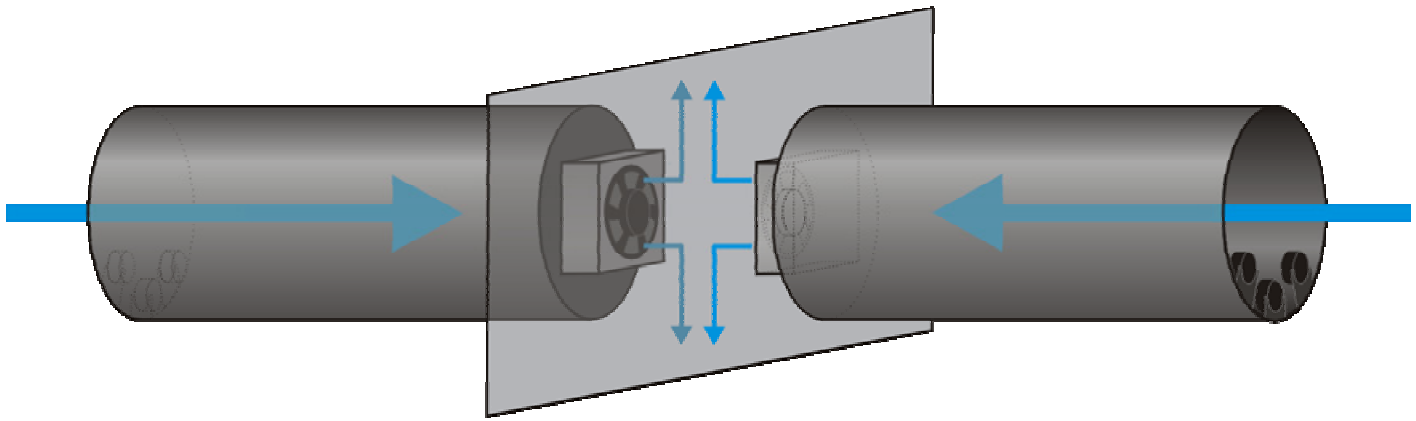
2) Set-Up of the of the Mark III Mobile Nose

- use of suction fans
  - Papst 405F (8 m^3/h)
  - sensors behind a covering bar



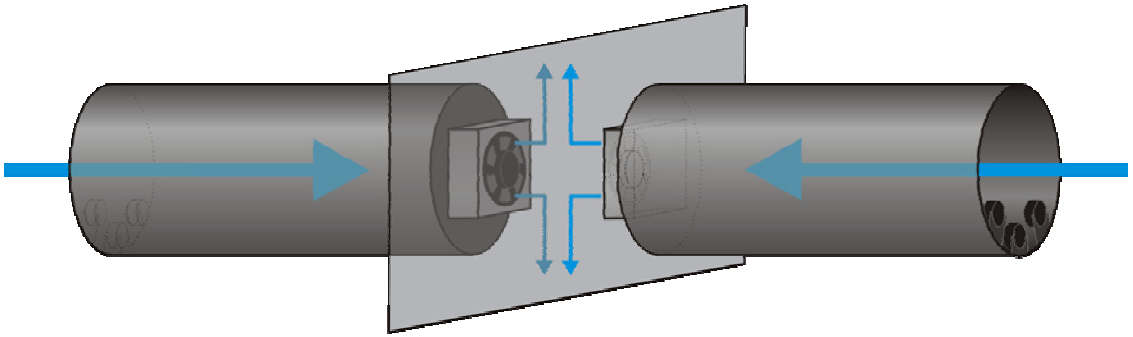
2) Set-Up of the of the Mark III Mobile Nose

- use of a "septum"
  - fans directed against each other
  - decrease the rate of air exchange



3) Dynamic Response Experiment

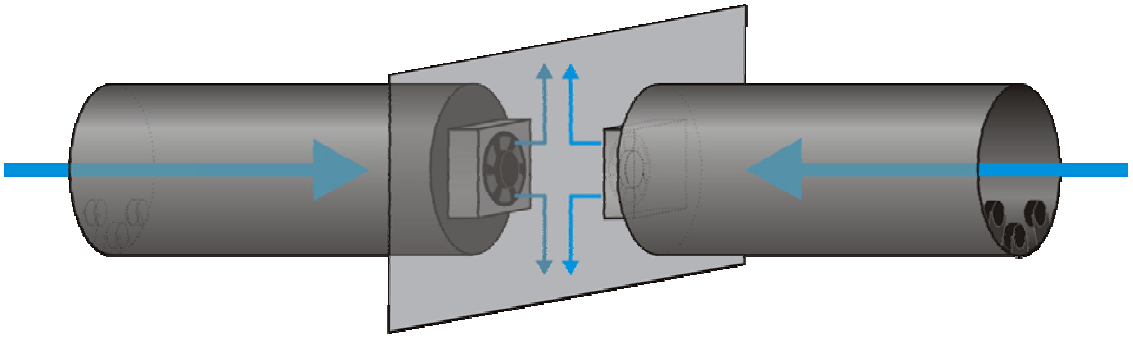
- dynamic response of the mobile nose
- step stimulus by opening a bottle



3) Dynamic Response Experiment

- dynamic response of the mobile nose
- step stimulus by opening a bottle

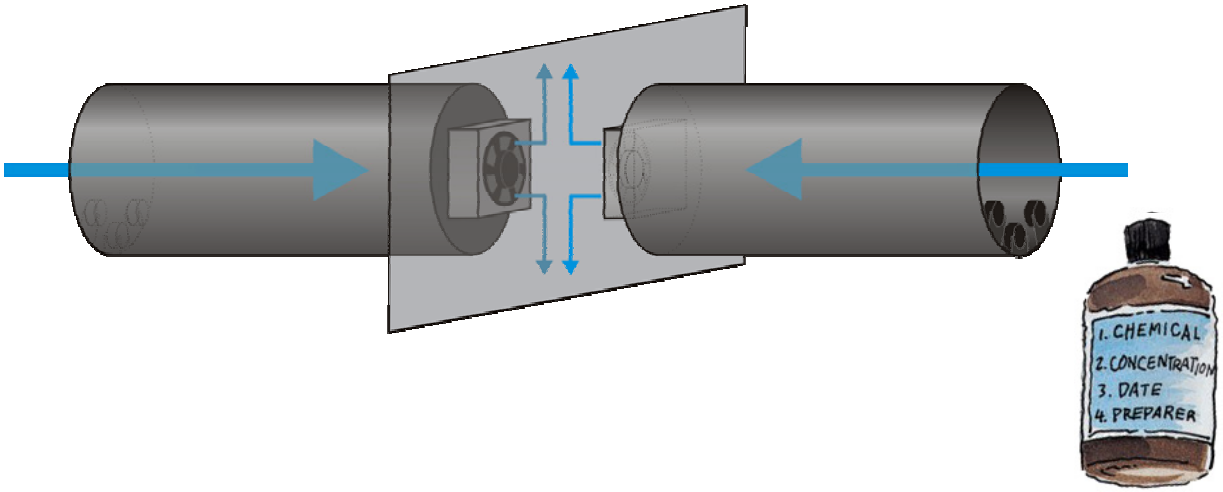
wait for 20s



3) Dynamic Response Experiment

- dynamic response of the mobile nose
- step stimulus by opening a bottle

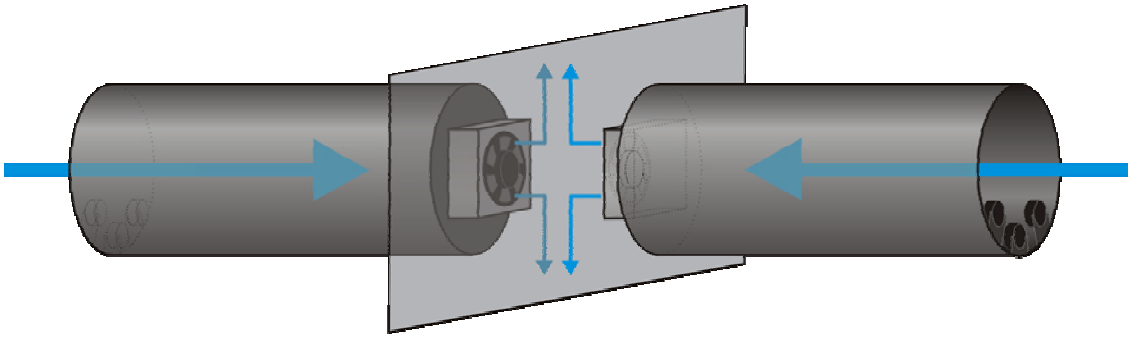
open the bottle for 10 s



3) Dynamic Response Experiment

- dynamic response of the mobile nose
- step stimulus by opening a bottle

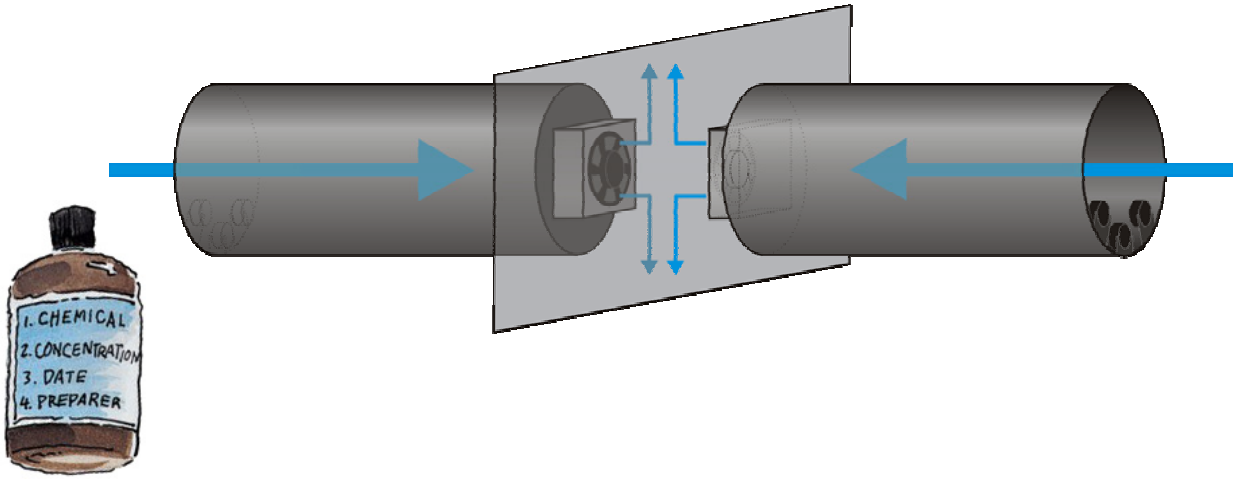
wait for 120s



3) Dynamic Response Experiment

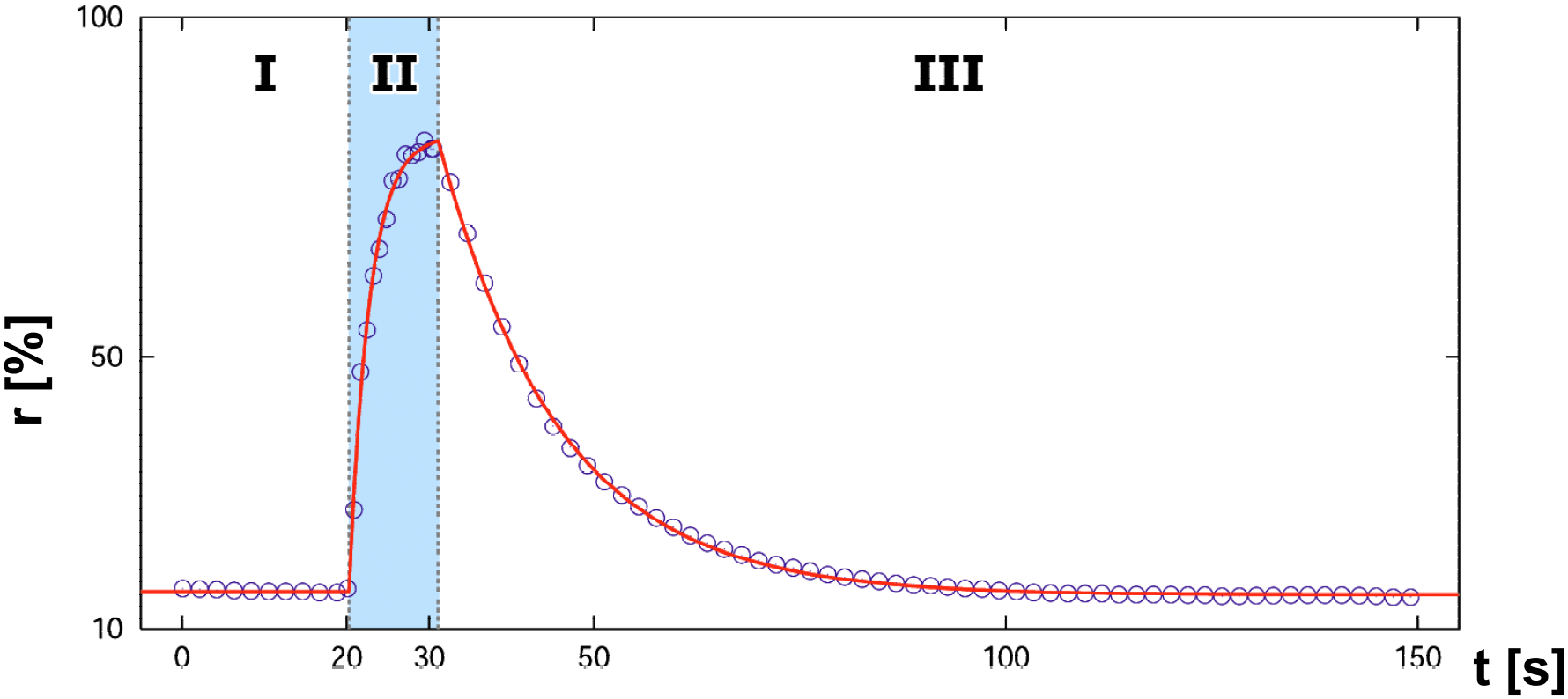
- dynamic response of the mobile nose
- step stimulus by opening a bottle

repeat on other side



4) Sensor Model

- assume first-order sensor model
- exponential rise and decay



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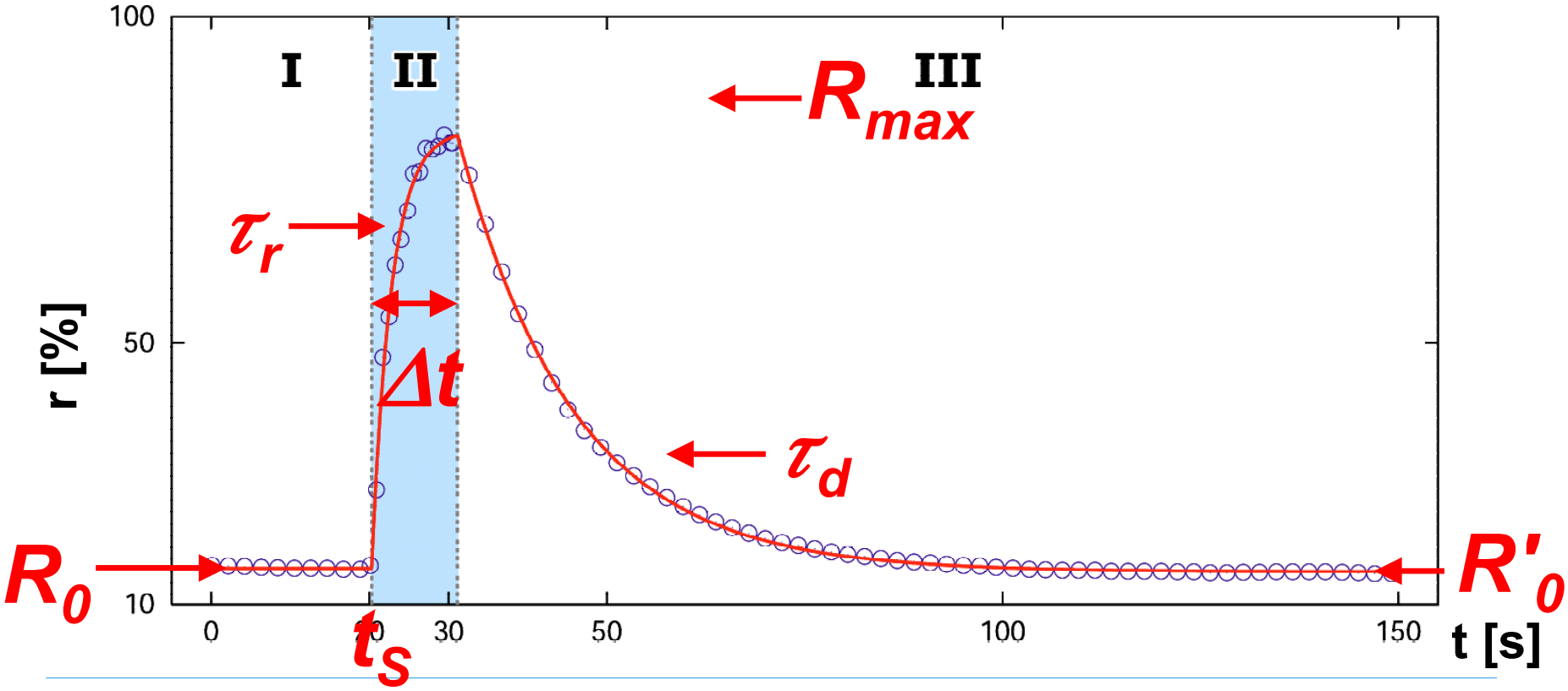
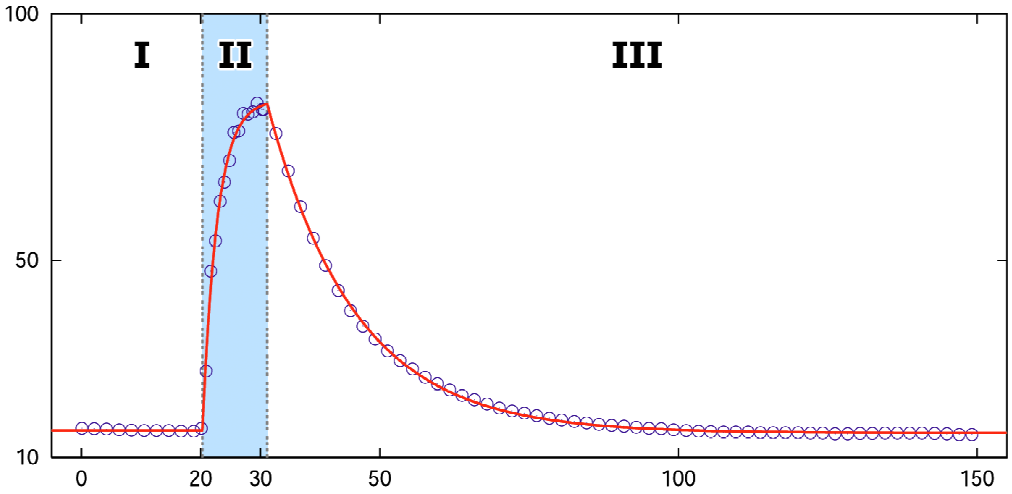


5) Evaluation

- non-linear fitting: Marquardt-Levenberg
  - gnuplot implementation can be used
  - parameter values
  - asymptotic standard error



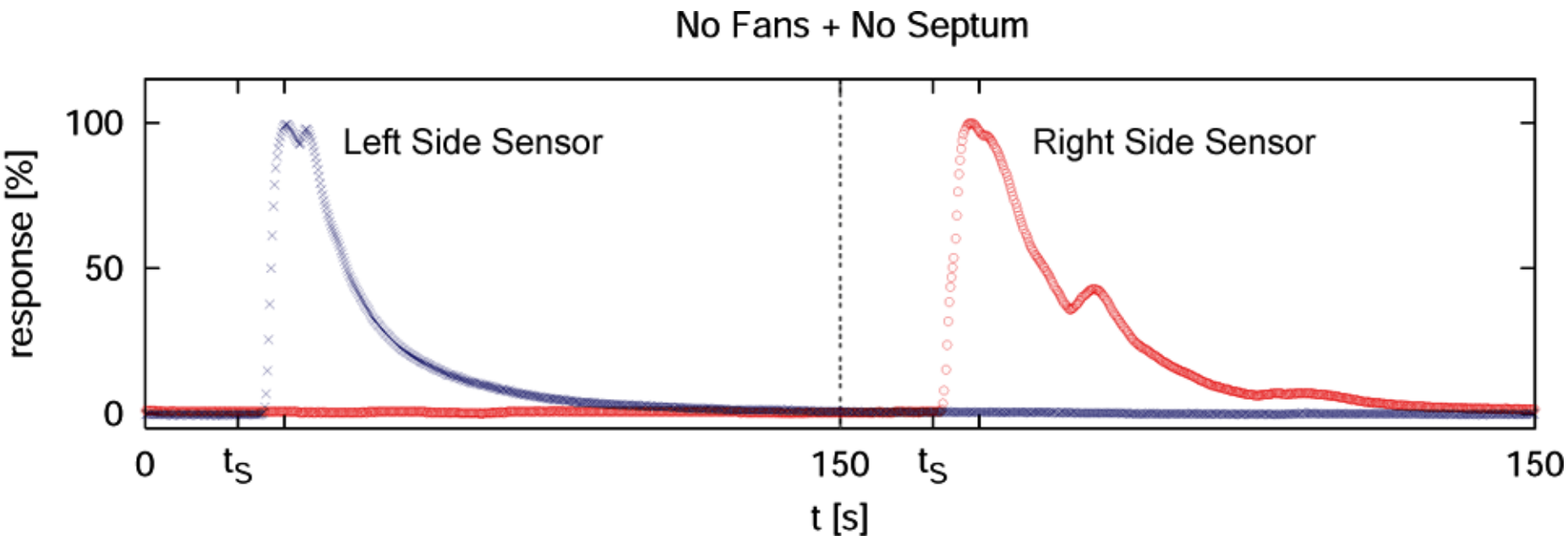
5) Evaluation

- combining individual fits
  - assuming Gaussian distribution with different σ_i
  - maximum likelihood estimator
  - weighted averaging

$$\bar{x} = \frac{\sum \omega_i \, x_i}{\sum \omega_i} \qquad \omega_i = \frac{1}{\sigma_i^2}$$

$$\bar{\sigma}^2 = \frac{\sum \omega_i}{(\sum \omega_i)^2 - \sum \omega_i^2} \sum \omega_i \, (x_i - \bar{x})$$

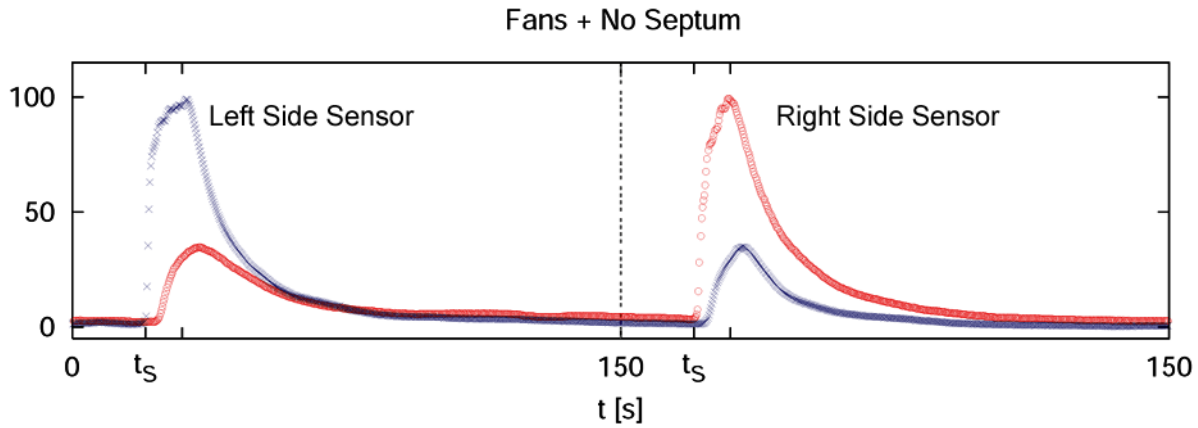
6) Results - No Fans



- $\tau_r \approx 1.93 \pm 1.18$ s
- $\tau_d \approx 28.88 \pm 6.02$ s

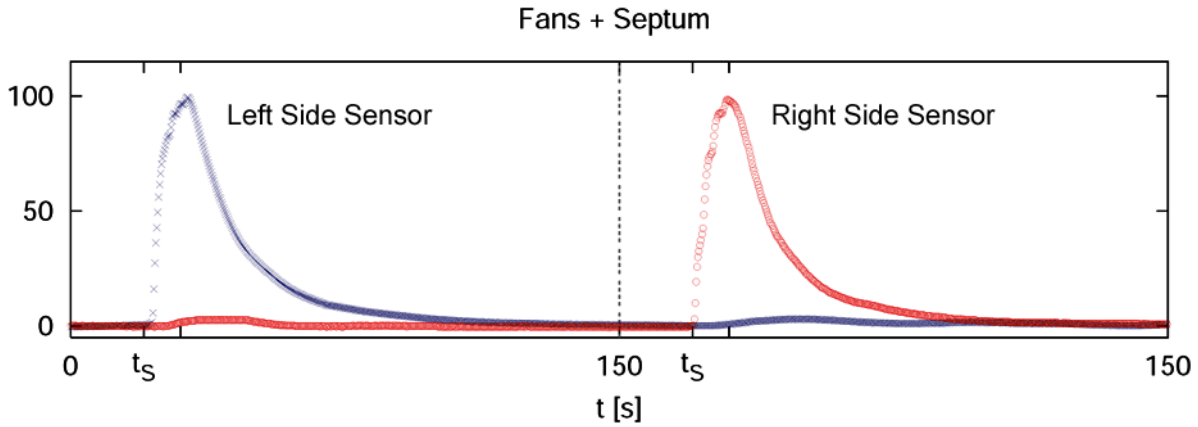
TGS 2620, 2×6 trials

6) Results - Fans



$\tau_r \approx 1.85 \pm 0.71$ s

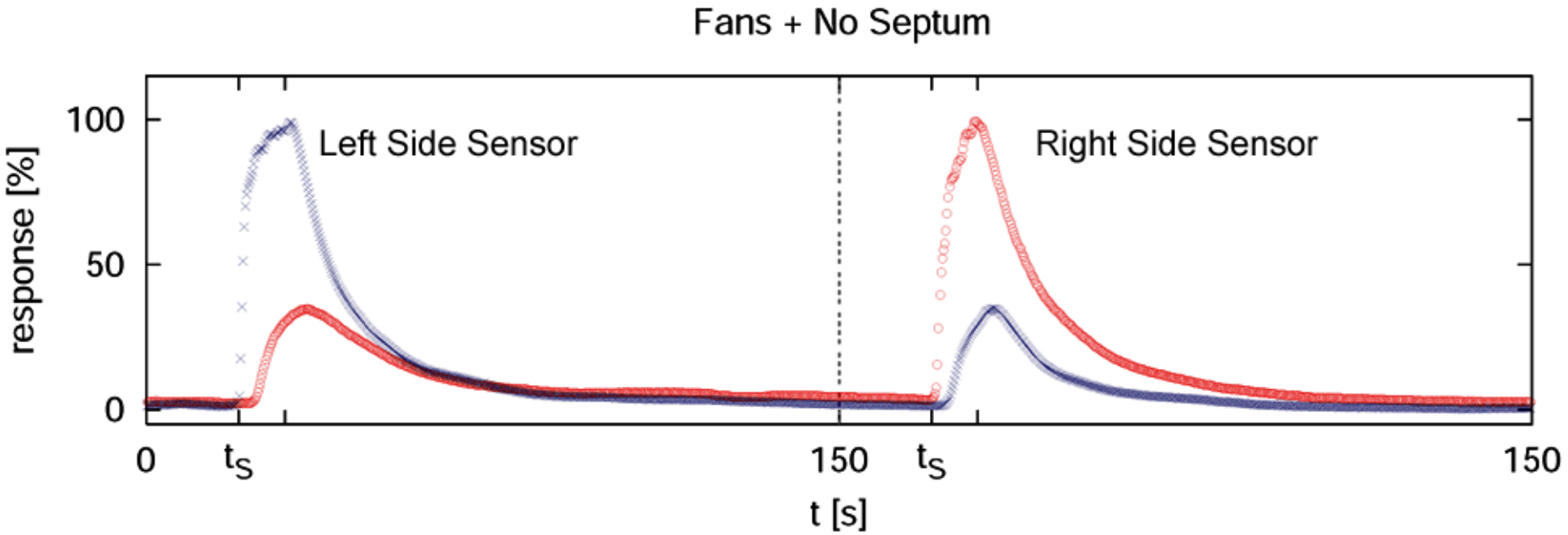
$\tau_d \approx 9.90 \pm 2.14$ s



$\tau_r \approx 1.91 \pm 0.96$ s

$\tau_d \approx 10.20 \pm 0.75$ s

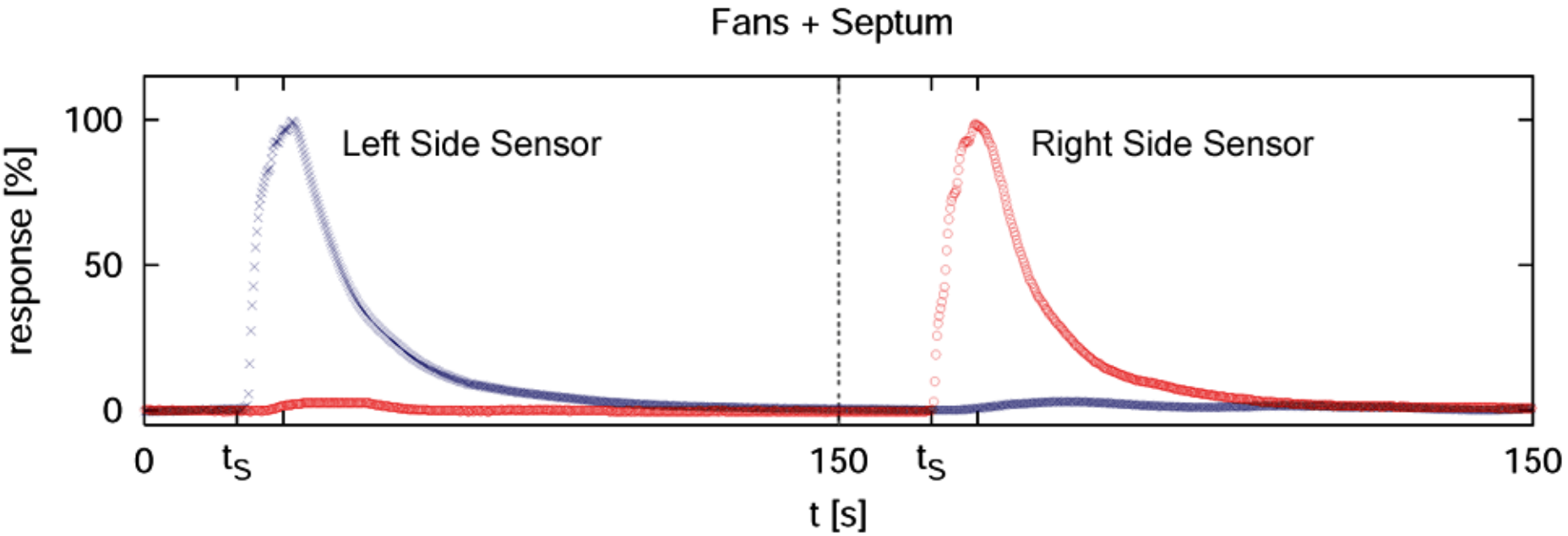
6) Results - Fans



- $\tau_r \approx 1.85 \pm 0.71$ s
- $\tau_d \approx 9.90 \pm 2.14$ s

TGS 2620, 2×6 trials

6) Results - Fans and Septum

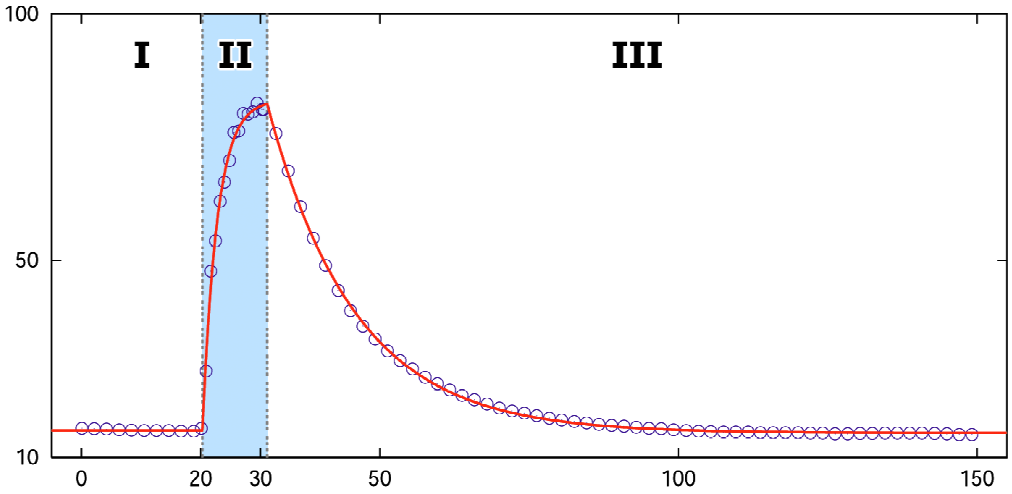


- $\tau_r \approx 1.91 \pm 0.96$ s
- $\tau_d \approx 9.90 \pm 2.14$ s

TGS 2620, 2×9 trials

7) Conclusions

- method to determine dyn. response parameters
  - experiment
  - evaluation
- first-order sensor model is appropriate



7) Conclusions

- design of the Mark III Mobile Nose introduced
- using fans doesn't change response time …

$$\tau_r \approx 2\ \mathrm{s}$$

- … but rather speeds up recovery

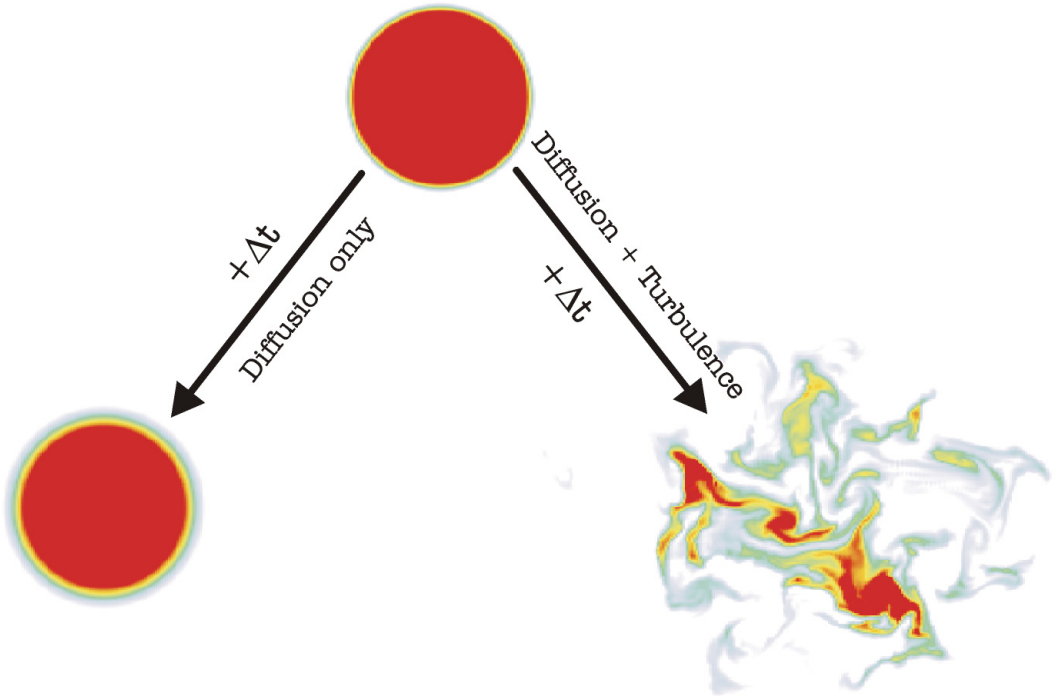
$$\tau_d^{(\text{no fans})} \approx \text{"20 s"}$$

$$\tau_d^{(\text{fans})} \approx 11\ \mathrm{s}$$

- separation of airstreams is needed

8) Applications - Turbulence

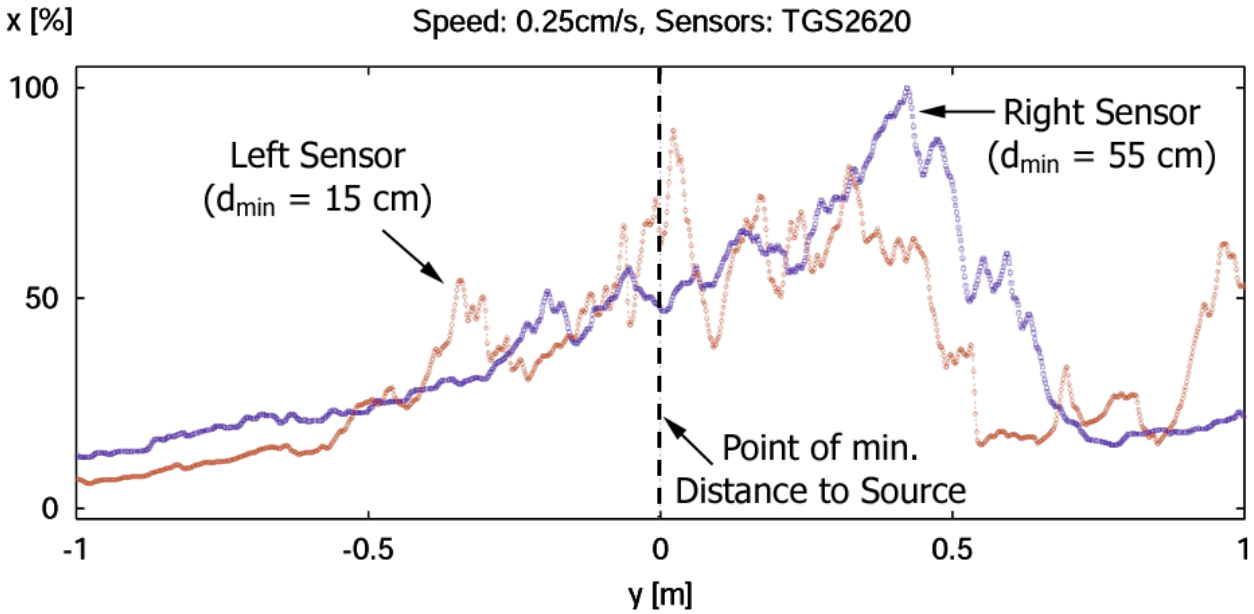
- problem of turbulence

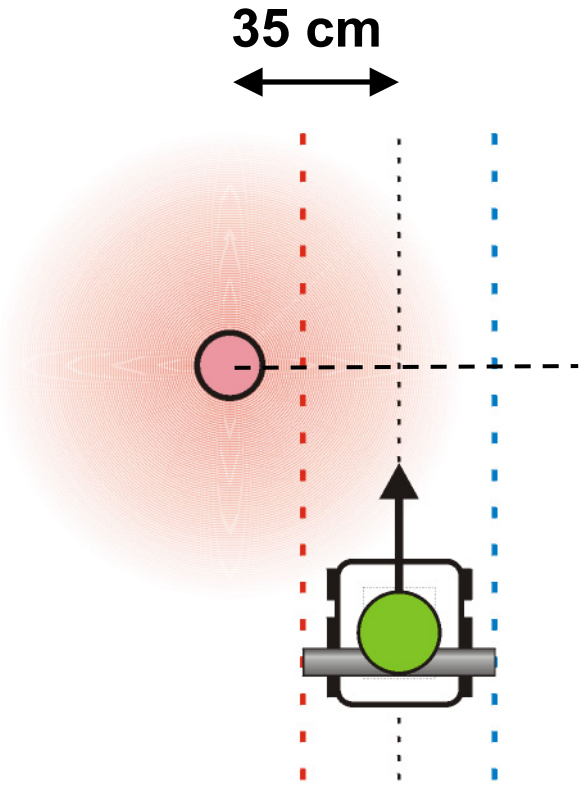


Smyth & Moum 2001

8) Applications - Turbulence

- instantaneous distribution





8) Applications - Gas Concentration Mapping

- mapping algorithm to combine gas sensor readings

10 min

8) Applications - Gas Concentration Mapping

- mapping algorithm to combine gas sensor readings

15 min

8) Applications - Gas Concentration Mapping

- mapping algorithm to combine gas sensor readings

30 min

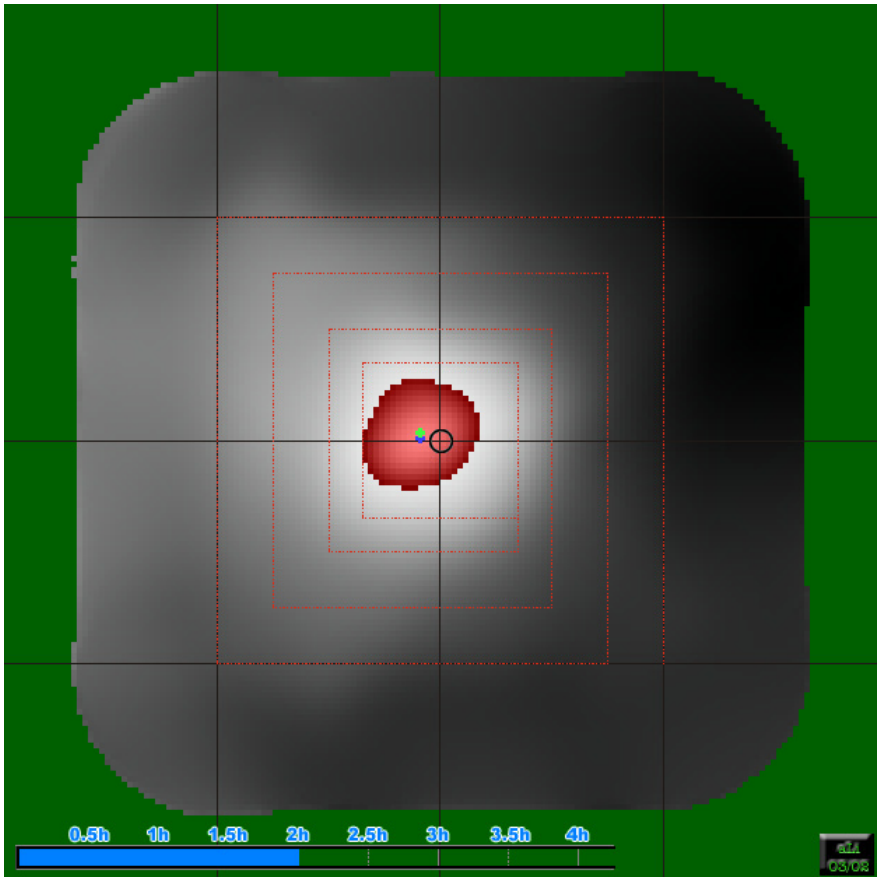
8) Applications - Gas Concentration Mapping

- mapping algorithm to combine gas sensor readings

60 min

8) Applications - Gas Concentration Mapping

- mapping algorithm to combine gas sensor readings



120 min

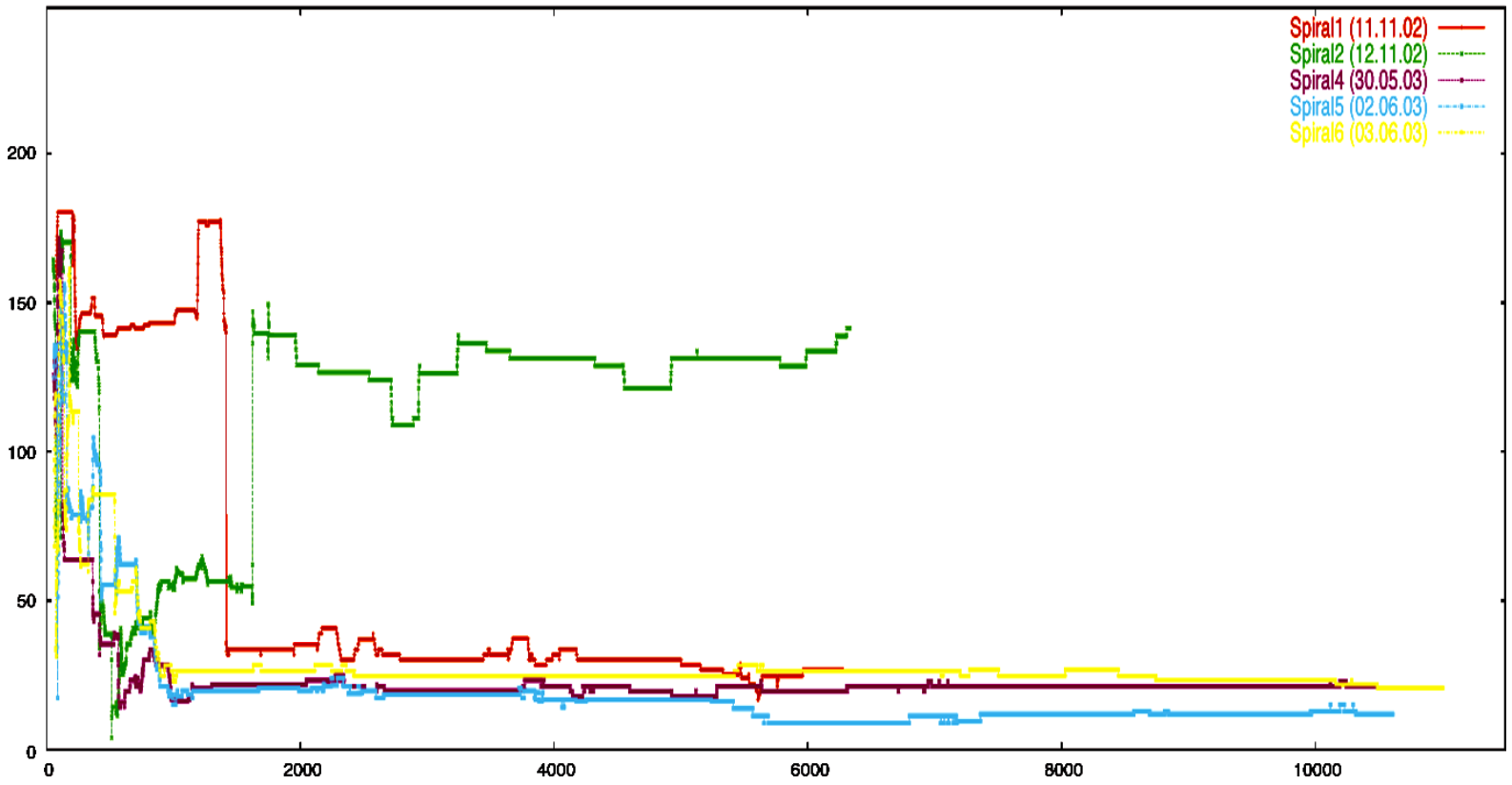
8) Applications - Gas Concentration Mapping

- mapping algorithm to combine gas sensor readings

178 min

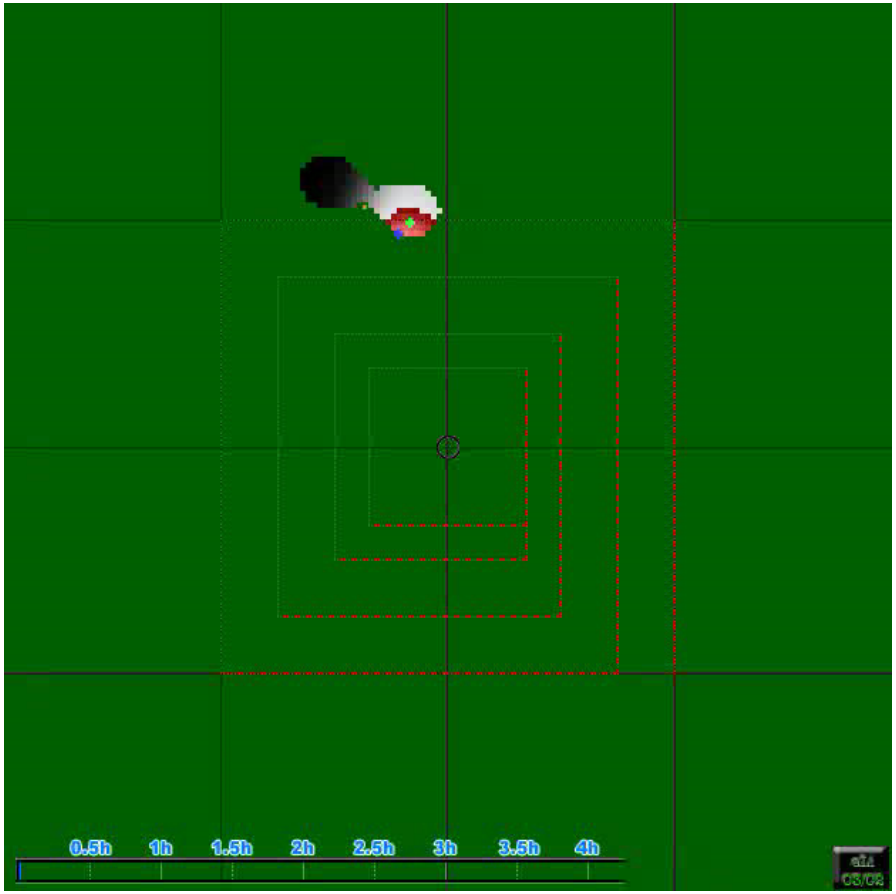
8) Applications - Gas Concentration Mapping

- " av. max. concentration - source" distance



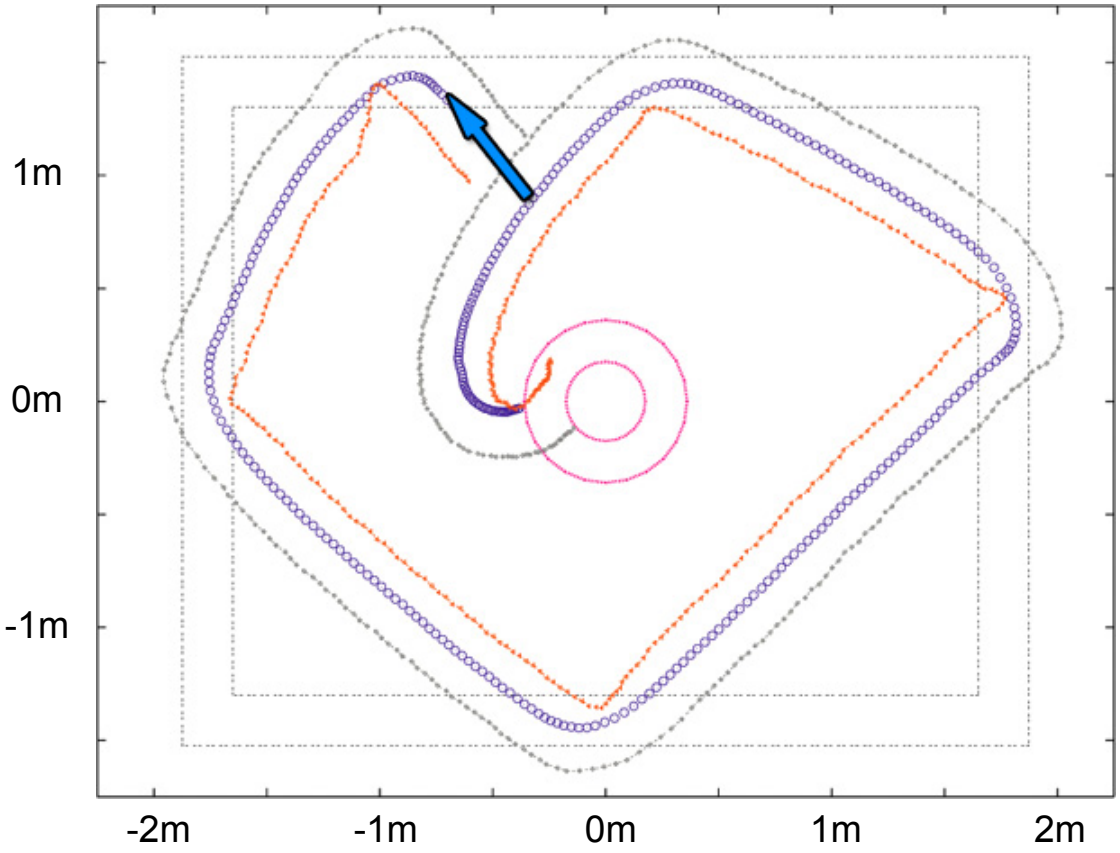
8) Applications - Gas Concentration Mapping

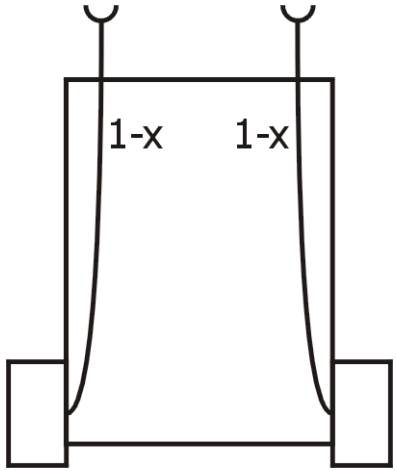
- evolution



8) Applications - Reactive Gas Source Localisation - PL

- smelling Braitenberg vehicle

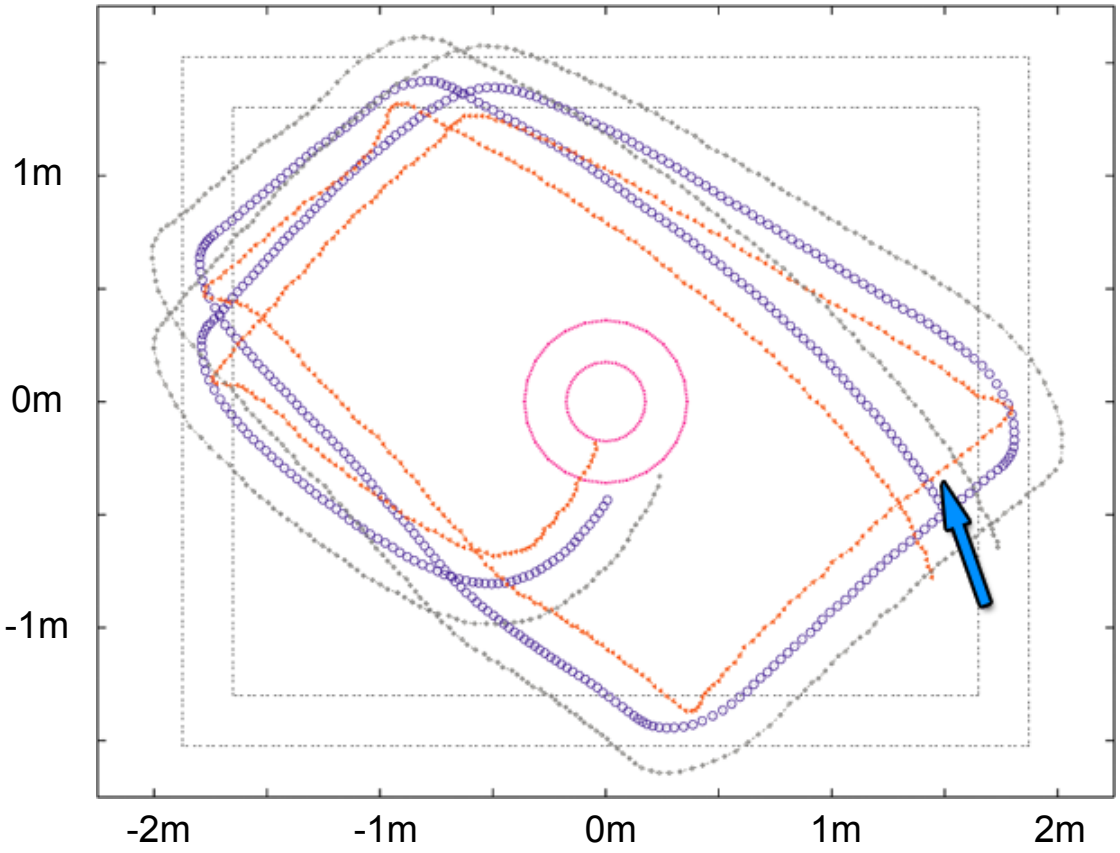


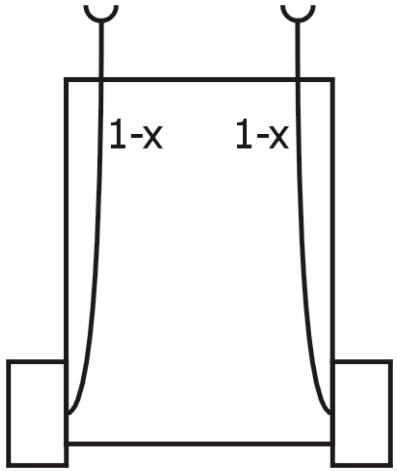


"Permanent Love"

8) Applications - Reactive Gas Source Localisation - PL

- smelling Braitenberg vehicle

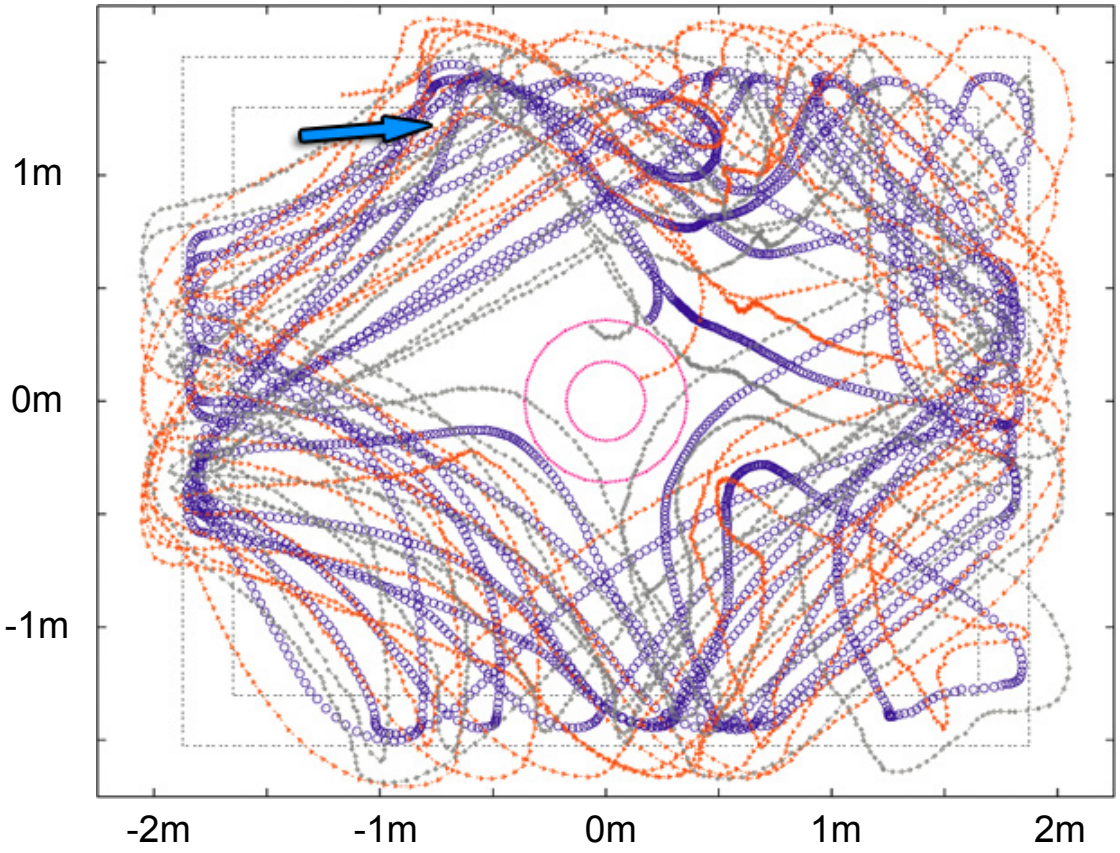


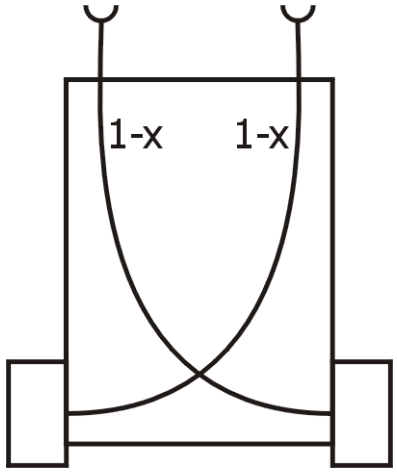


"Permanent Love"

8) Applications - Reactive Gas Source Localisation - EL

- exploration & gas concentration peak avoiding

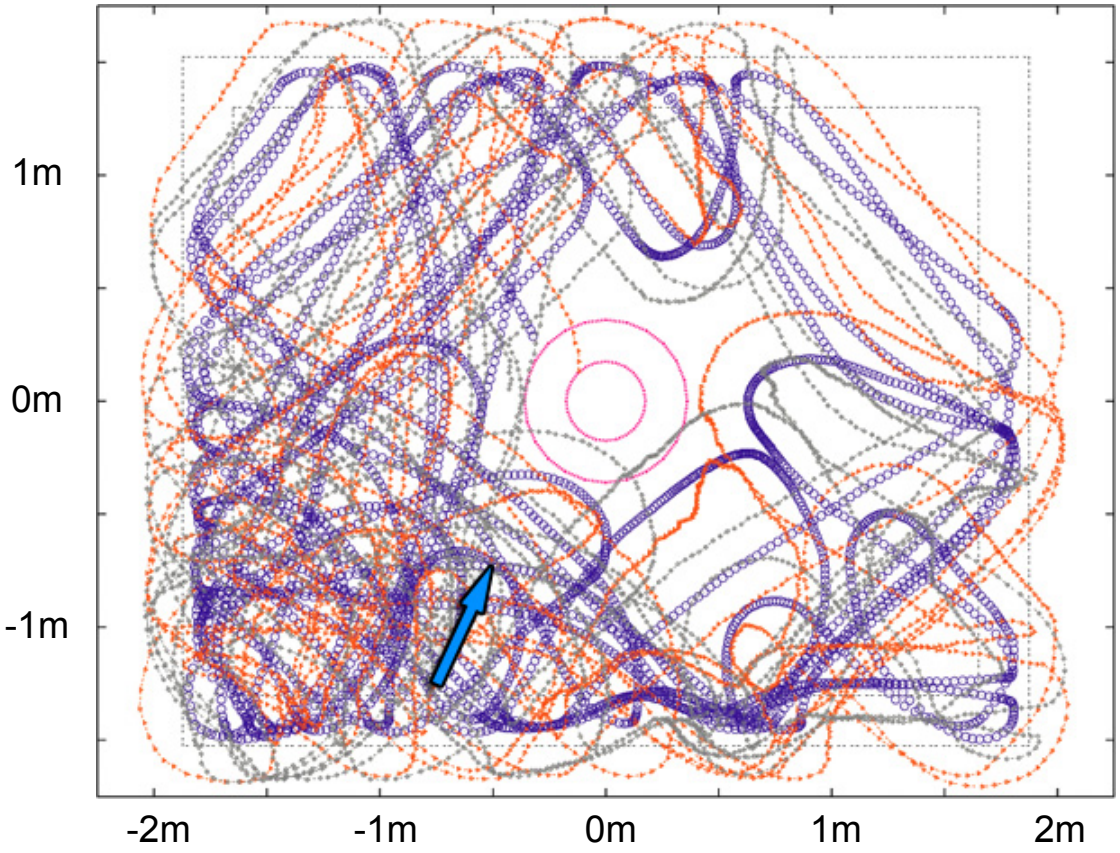


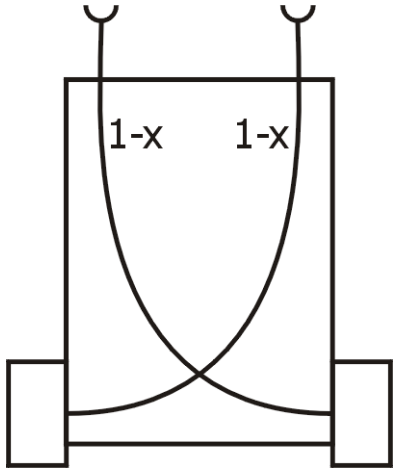


"Exploring Love"

8) Applications - Reactive Gas Source Localisation - EL

- exploration & gas concentration peak avoiding





"Exploring Love"

8) Applications - Curvature Mapping

- curvature mapping
  - use current tangent
  - increase grid cells the robot turns away from
    - by a fixed amount
    - proportional to the curvature of the path

8) Applications - Curvature Mapping