Speck NET

Centre for Speckled Computing

Remote Monitoring of COPD Patients using Speckled Computing – the Elgin Experience

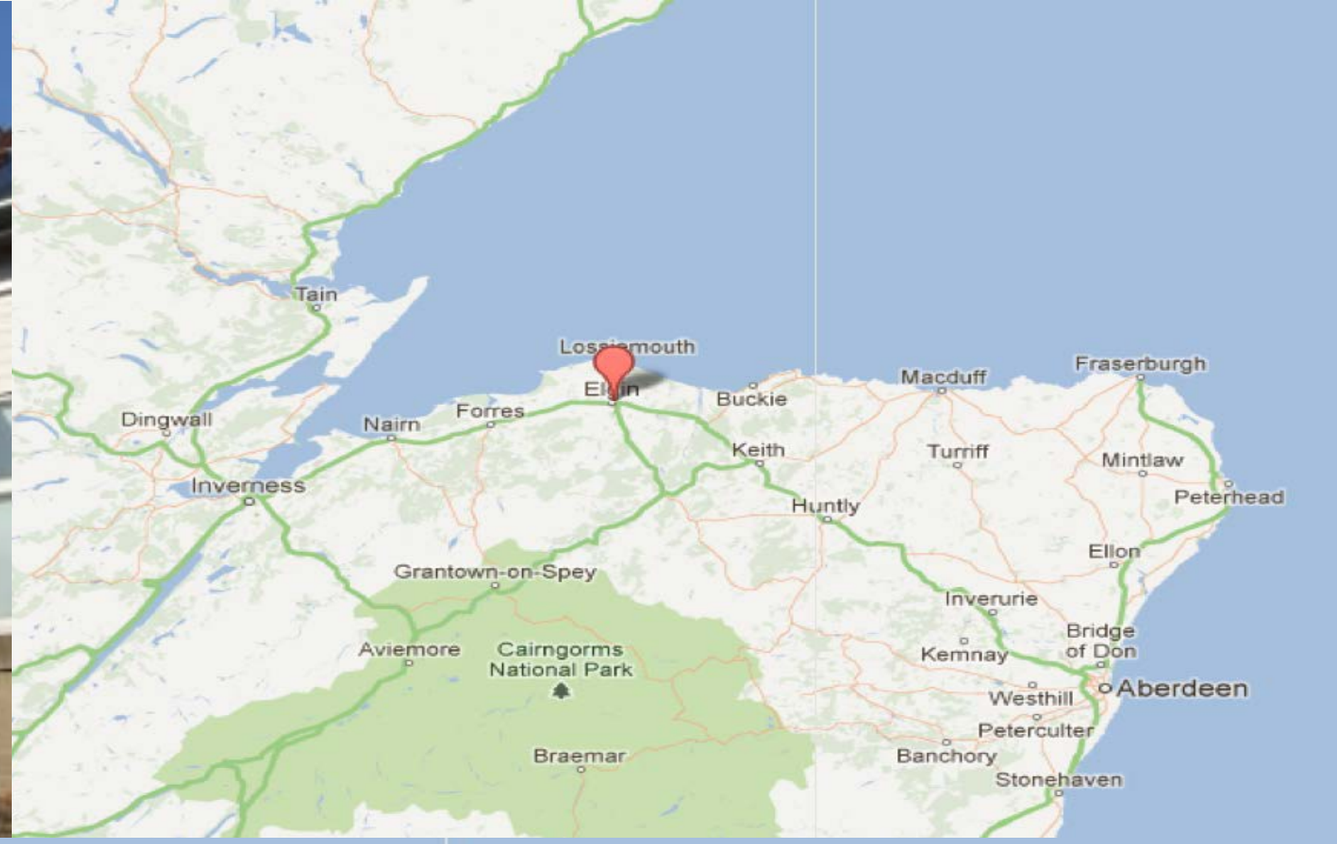
Prof. D K Arvind

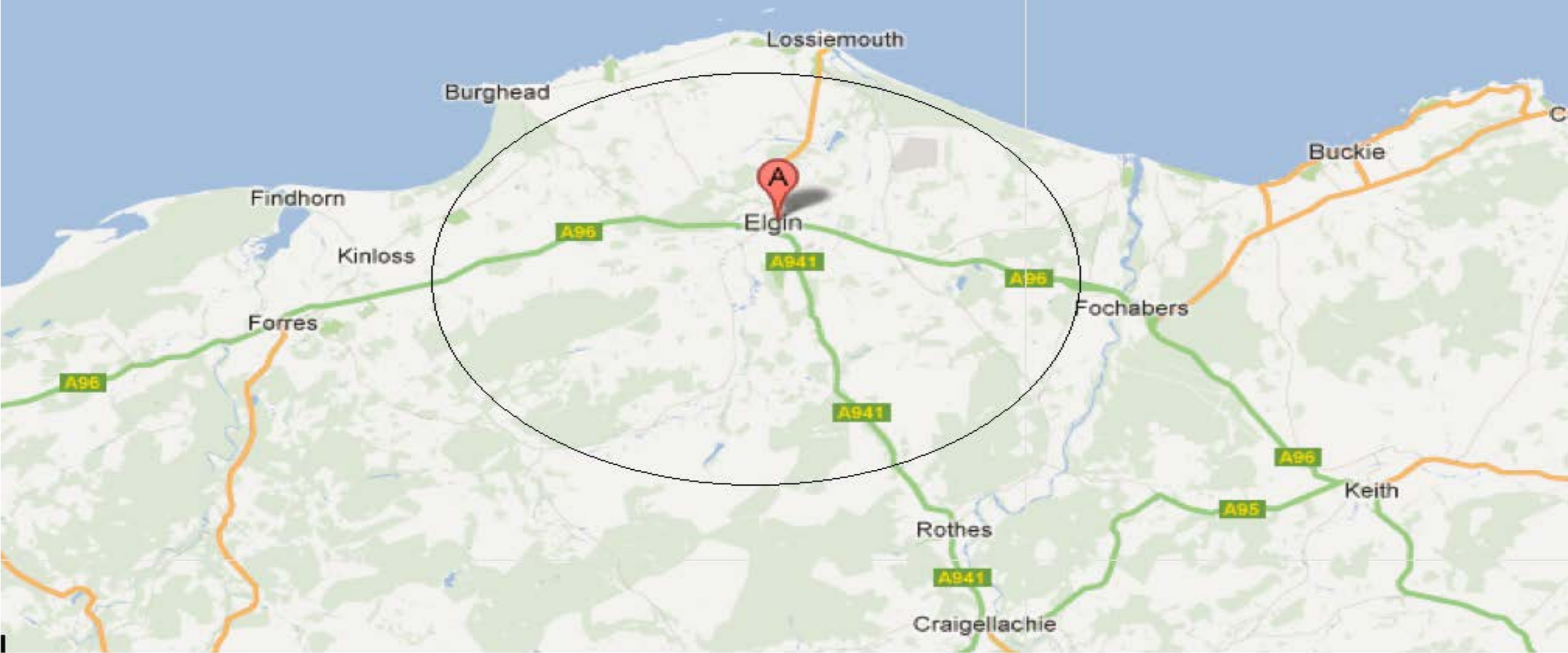
School of Informatics, University of Edinburgh

Specknet

Partners

- The Moray Council
- NHS Grampian
- The Maryhill GP Practice, Elgin
- Centre for Speckled Computing, University of Edinburgh


Tain
Lossiemouth
Elgin
Dingwall
Nairn
Forres
Buckie
Macduff
Fraserburgh
Keith
Turriff
Mintlaw
Inverness
Huntly
Peterhead
Ellon
Grantown-on-Spey
Inverurie
Aviemore
Cairngorms
National Park
Kemnay
Bridge
of Don
Aberdeen
Westhill
Peterculter
Banchory
Braemar
Stonehaven


Lossiemouth
Burghead
A
Findhorn
Elgin
Kinloss
A96
A941
Forres
Fochabers
Buckie
Rothes
Keith
A95
Craigellachie

Centre for Speckled Computing

End-users → Potential Customers

Ideas
Algorithms

Platforms
Software

Proof-of-Concept,

Demonstrators

Commercialisation

Application Products

Informatics Forum

Research

Appleton Tower

Evangelism,
Partnerships

Specknet

COPD

- 7% of world population and growing
- 3.7 million in the UK; 100,000 in Scotland
- Most common reason for hospital admissions in Scotland
- £100M - Direct cost to NHS in Scotland in 2004-5

"COPD is the mother of long term conditions"

Managing COPD

- Patients reported symptoms – unreliable and inaccurate
- Indicators of exacerbation
  - Increase in breathlessness
  - Changes in respiratory rate and breathing pattern
  - Reduction in activity
- Pulmonary rehabilitation to reduce recurrence of exacerbation

Continuous remote monitoring of Respiration and Activity

Unmet Healthcare Need

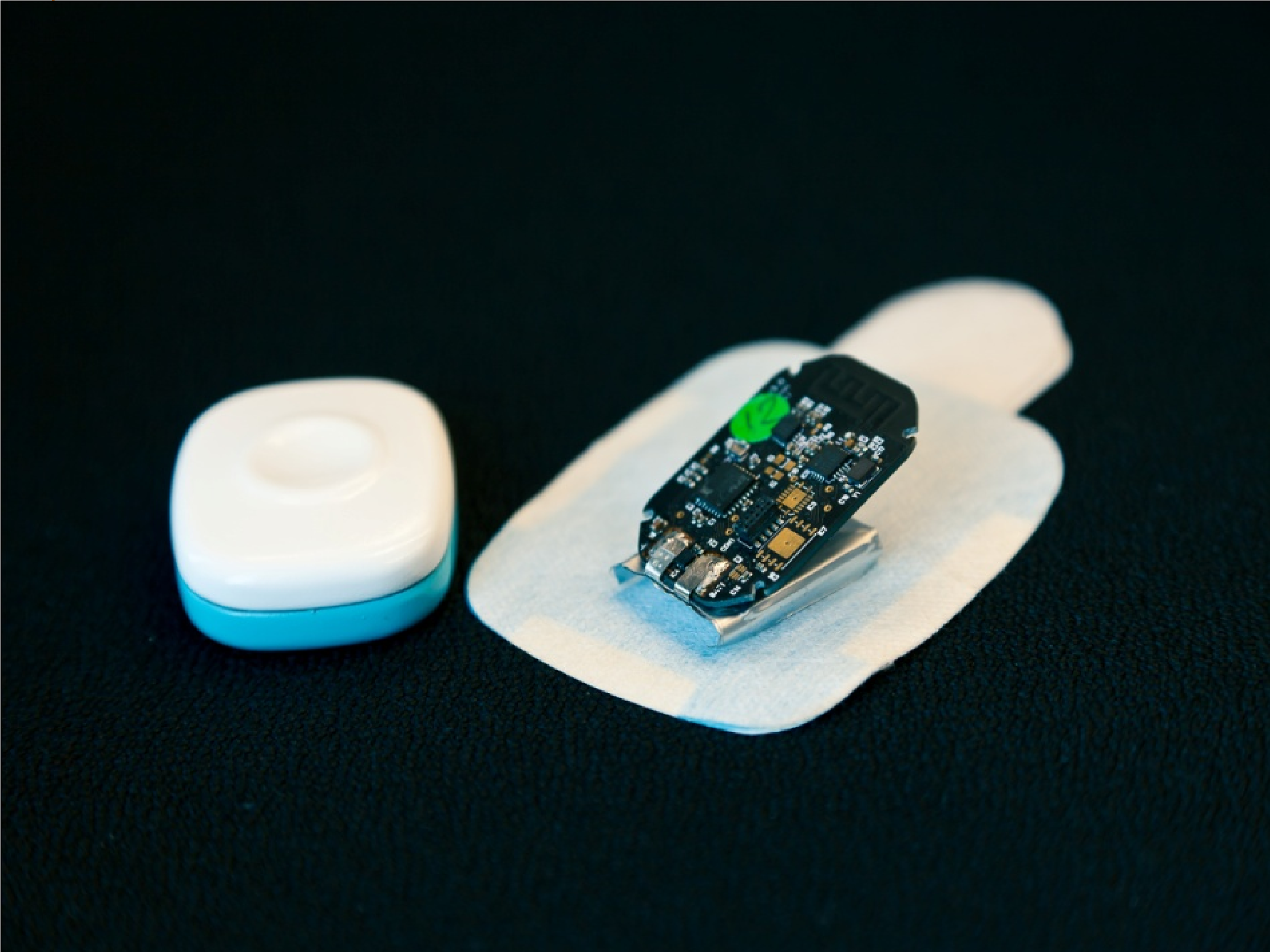
- Respiration – one of the four vital signs monitored in a SEWS chart
- Identify early exacerbation in COPD
- Support pulmonary rehabilitation post exacerbation

"Monitoring of patients with COPD at home may help NHS boards avoid costs of £1,000 per patient per year"

Source : A Review of Telehealth in Scotland, 2011

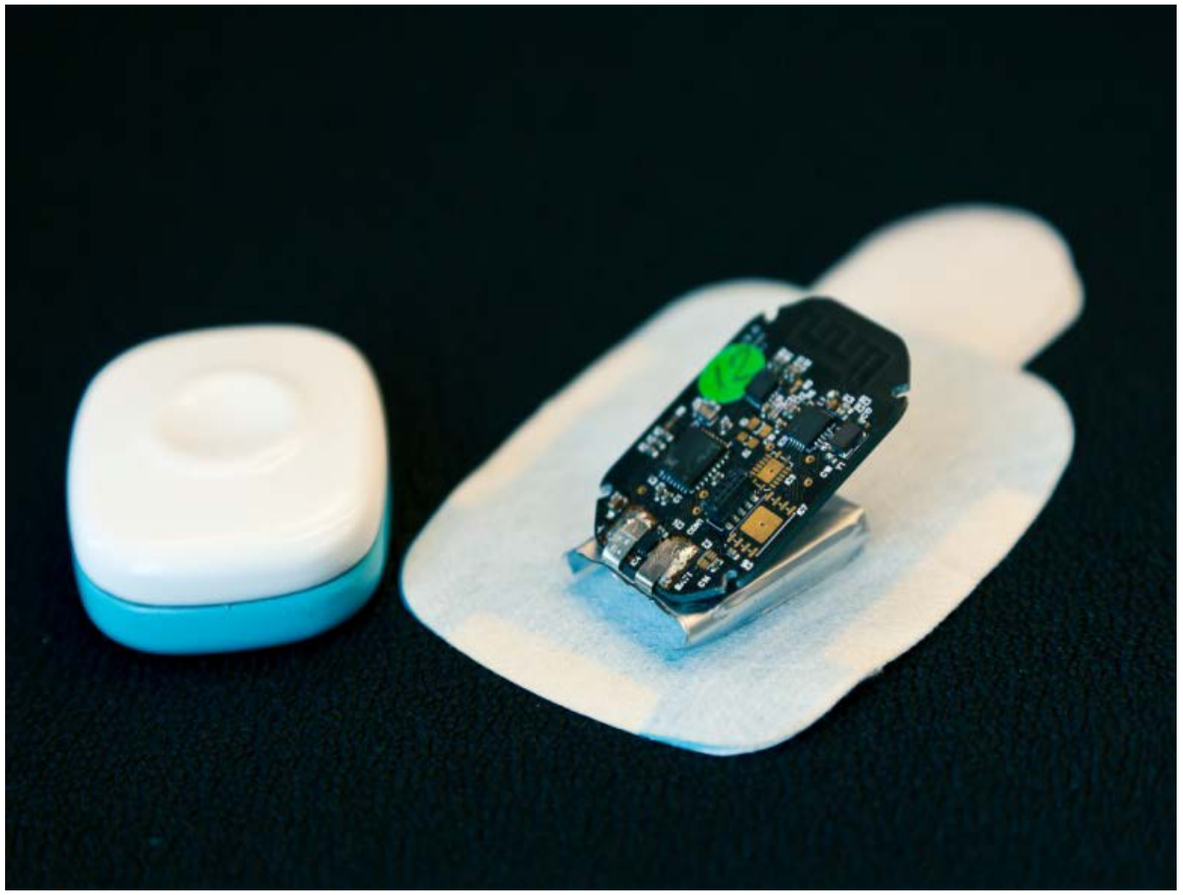
Specknet

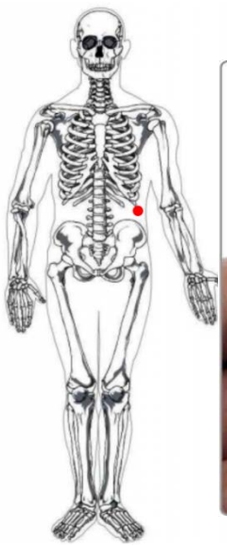
- Specks: miniature devices combine sensing, processing and wireless networking
- Wireless patch for measuring respiratory rate, respiratory effort and activity
- Continuous remote monitoring which transmits data via a base-station to a secure server via a broadband interconnection



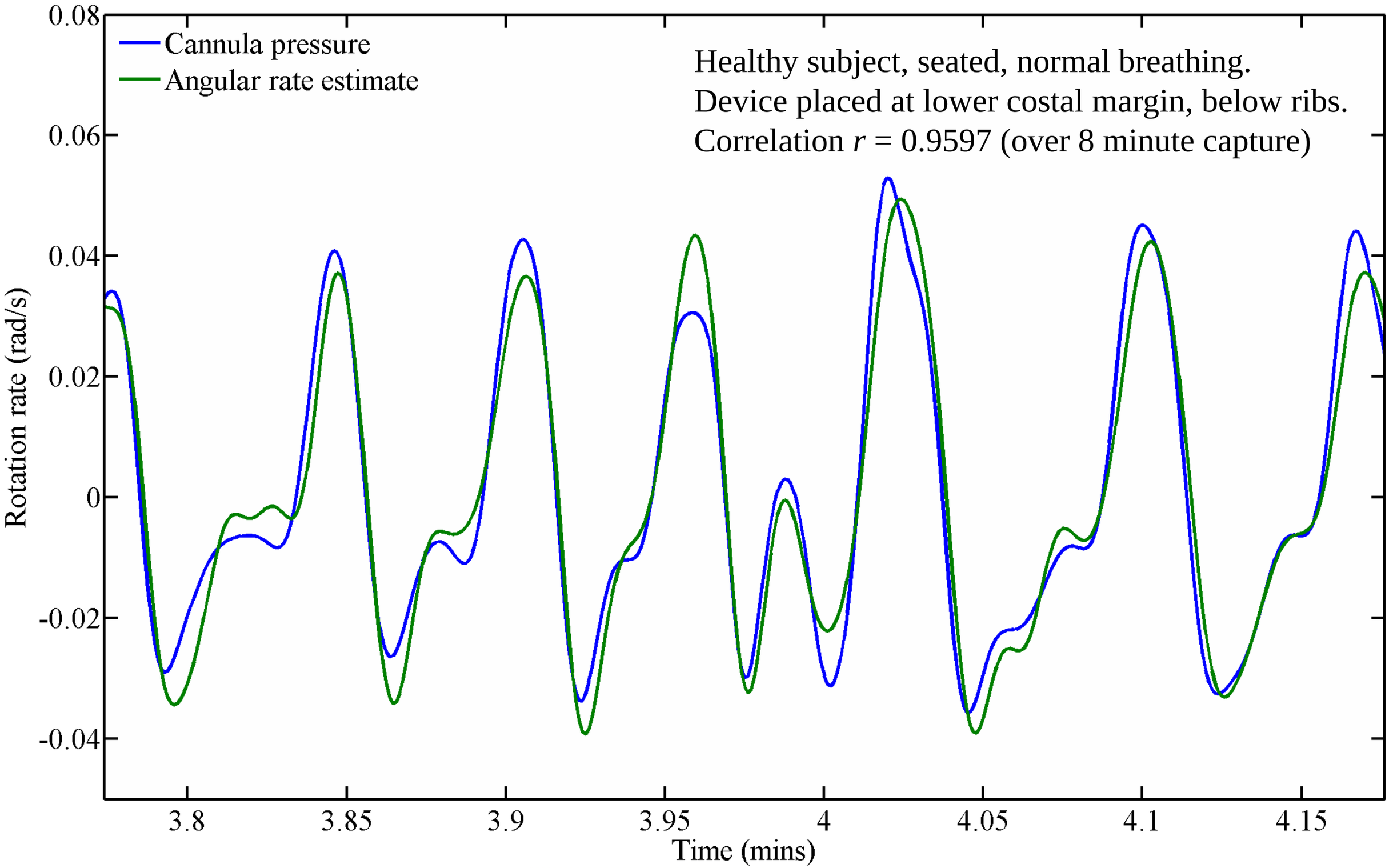
RESpeck Device

- Wireless patch with a three-axis accelerometer
- Sealed case and self-adhesive pouch
- Measures chest wall rotations as the wearer breathes
- Provides a respiratory effort waveform, respiratory rate and patient activity data

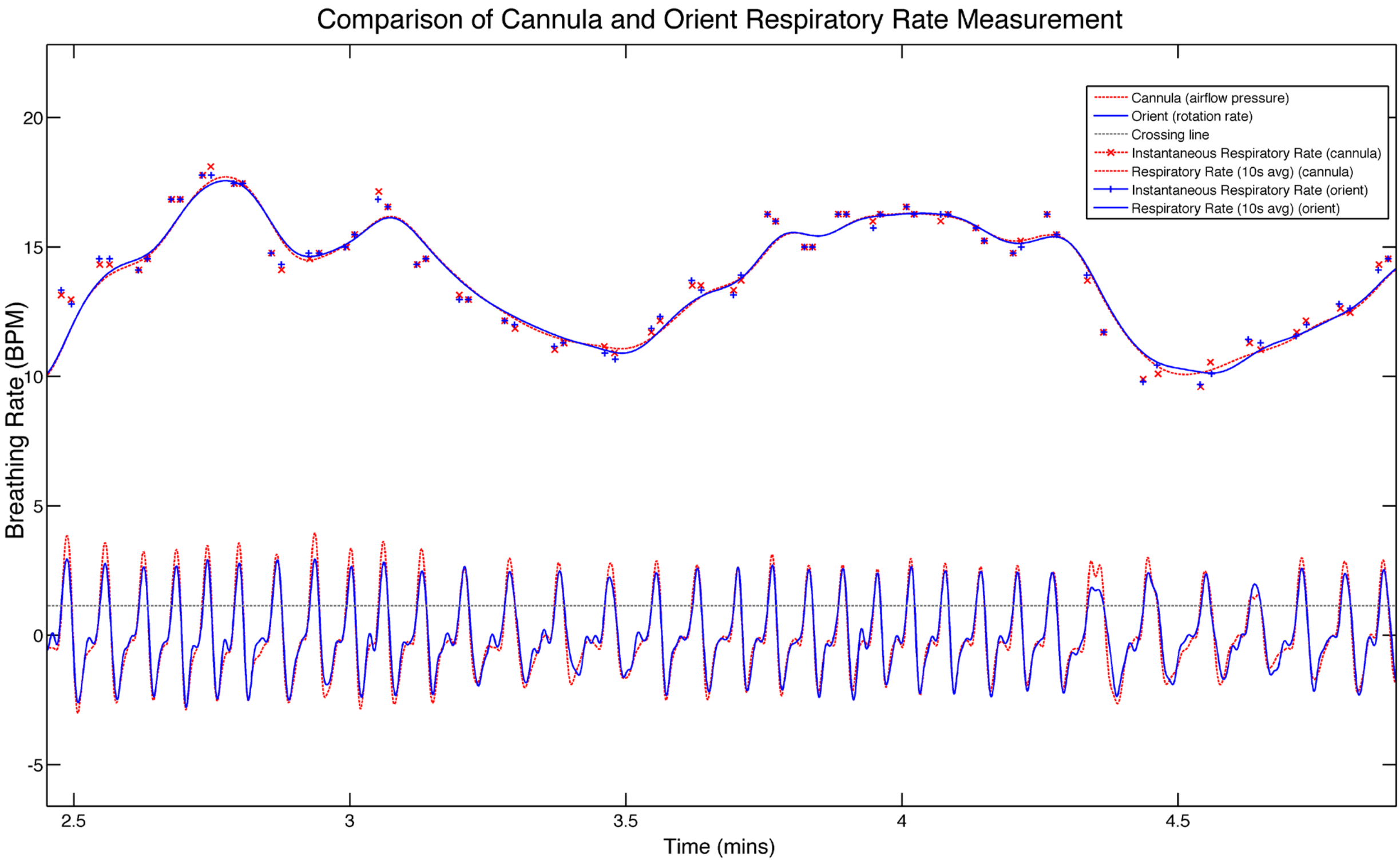




Recovery of flow rate waveforms



Specknet


Comparison of Cannula and Orient Respiratory Rate Measurement
Cannula (airflow pressure)
Orient (rotation rate)
Crossing line
Instantaneous Respiratory Rate (cannula)
Respiratory Rate (10s avg) (cannula)
Instantaneous Respiratory Rate (orient)
Respiratory Rate (10s avg) (orient)
Breathing Rate (BPM)
20
15
10
5
0
-5
2.5
3
3.5
4
4.5
Time (mins)

Specknet

Wireless Healthcare of COPD

- Wireless patch worn on the torso
- Re-useable wireless sensor module
- Contained in a single-use sleeve for hygienic attachment to the torso
- Data collection and processing in a base-station via ultra low power wireless link
- Transmitted via broadband internet or via GPRS to server
- Remote respiratory monitoring service

Respiratory Monitoring Service

- Daily reports summarising hourly trends
- Option to access historical data
- Respiratory rate, respiratory effort/flow, activity, heart rate, cough frequency, speech episodes
- Remote examination of patient’s breathing in real-time

Patient-centric design

- Long-term wear
  - Light-weight - 17gms (incl. battery)
  - Unobtrusive - 4.5 x 3.7 x 1.3 cm
  - Battery lifetime - 12 months
- Ease of use
  - No recharging of batteries
  - Data stored on wireless patch and downloaded to the base-station when within range – no manual intervention
- Remote monitoring of performance of sensor devices for scalable deployment
  - Diagnostic data on sensor performance
  - Wireless patch replaced due to malfunction or before the battery runs out

Validation on postoperative subjects

with Dr Gordon Drummond (Royal Infirmary of Edinburgh & University of Edinburgh) 2010

- 19 gynaecological patients, who received Patient Controlled Analgesia
- Analysis performed over 5 minute epochs of synchronised accelerometer and nasal pressure signals
- Breaths were identified in the nasal pressure signal, which were then matched to a breath from the corresponding orient signal
- The instantaneous respiratory rate of these matched breaths were compared

Summary of results

- 248 hours of breathing were studied
- Successful transmission 94% of the time
- 119,765 valid cannula breaths
- 105,416 matched to Orient breaths
- Instantaneous respiratory rates agree to within 2BPM for 86% of matched breaths
- Mean absolute difference: 0.6BPM
- A reliable measure of respiratory rate was possible in 95.4% of the 5-minute epochs

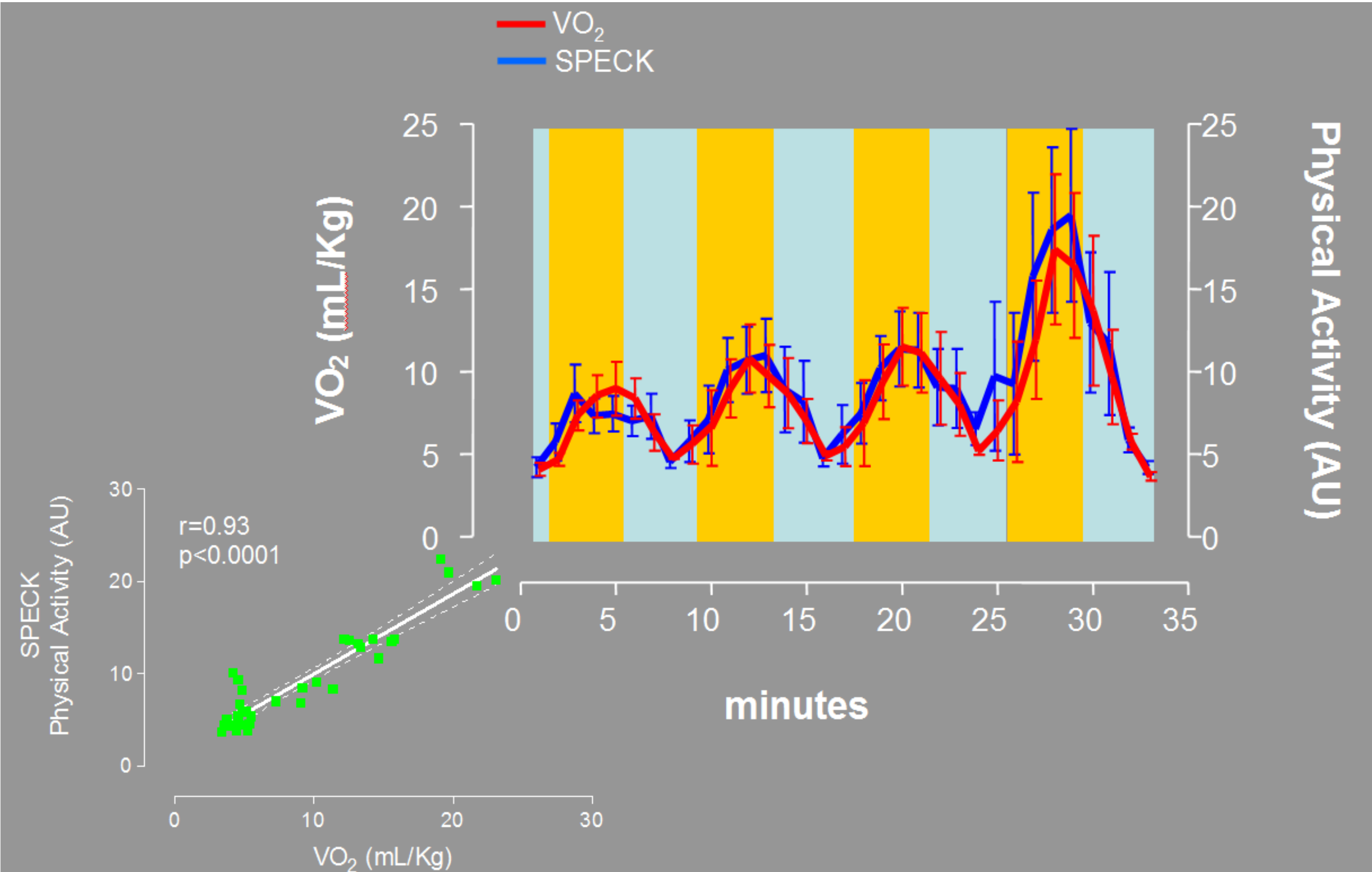
with McNee & Rabinovich 2010 (RIE/UoE)

Simultaneous oxygen usage and acceleration data were obtained for 4 healthy subjects

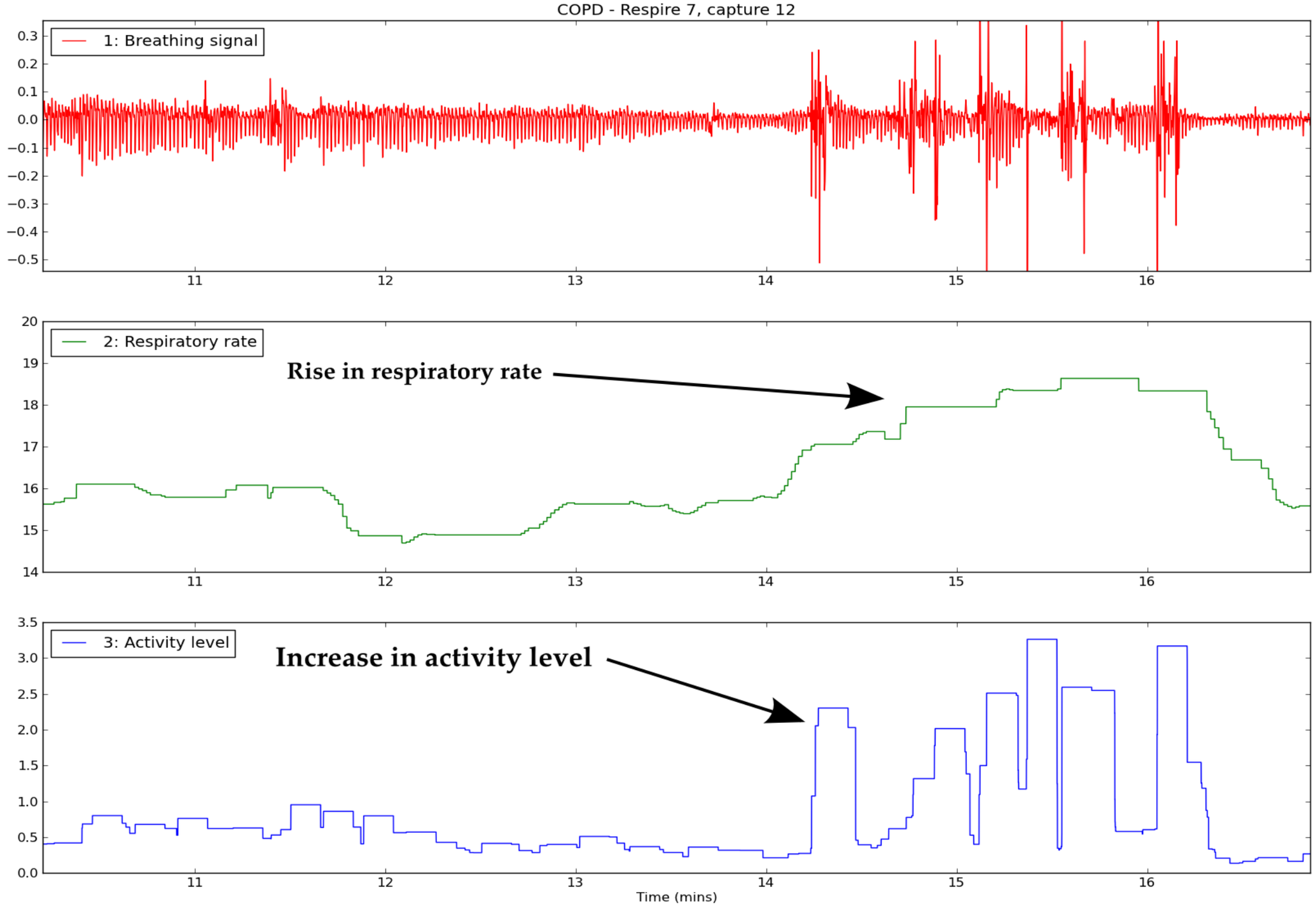
The rate of change of acceleration provides a good estimate of energy expenditure

Type of Activity	Time	Type of Activity	Time
Lying	4 min	Sitting	2 min
Sitting	2 min	Standing and walking	1 min
Standing	1 min	Climbing stairs	1 min
Slow walking (<60% of 6MWT speed)	6 min	Sitting	5 min
Sitting	3 min	Standing and walking	1 min
Fast walking (approximately 6MWT speed)	6 min	Treadmill (flat walking)	4 min
Sitting	5 min	Treadmill (4% slope)	4 min
Sweeping	4 min	Standing and walking	1 min
Sitting	2 min	Sitting	2 min
Lifting objects	3 min		

Oxygen consumption v/s physical activity



Simultaneous RR/Activity in COPD patient



- Wireless patch with 3-axis accelerometer measures rotation of the chest wall – a good proxy for respiratory flow

  A. Bates, M. J. Ling, J. Mann and D. K. Arvind *"Respiratory Rate and Flow Waveform Estimation from Tri-axial Accelerometer Data", Proc. Int. Conf. on Wearable and Implantable Body Sensor Networks, pages 144-150, Singapore, June 2010*

- Validated against nasal pressure in clinical trials – a good match in respiratory rate

  G.B. Drummond, A. Bates, J. Mann and D.K. Arvind *"Validation of a new non-invasive automatic monitor of respiratory rate for postoperative subjects", British Journal of Anaesthesia, 107:462-469, 2011*

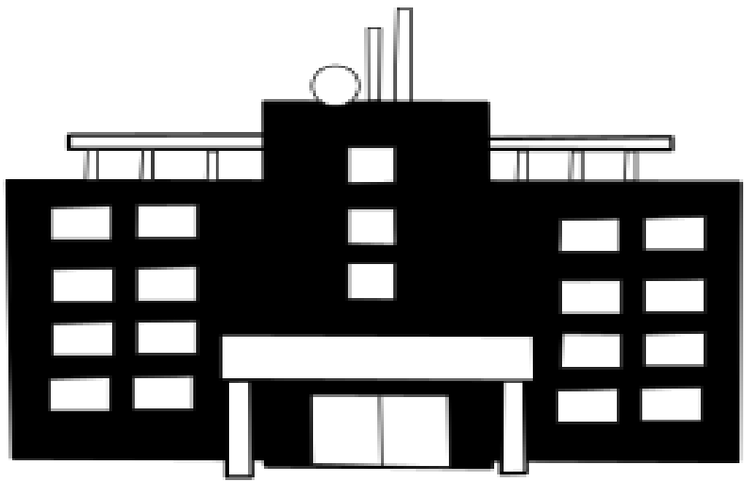
- Accelerometer and nasal pressure used in tandem to monitor *central nervous system respiratory depression* and *upper airway obstruction*

  A. Bates, D. K. Arvind, and J. Mann *:"*Wireless Monitoring of Post-operative Respiratory Complications" *Proc. ACM 2011 Int. Conf. on Wireless Health, San Diego, CA, Oct. 2011*

The Moray Study

- Study use of wireless respiratory and activity monitoring in a community setting
- Evaluate impact on the stakeholders: patients, clinicians, nurses, health authority
- Confirm usefulness of data in Primary care setting

Home Monitoring Data Flow



Patient leaves hospital with
RESpeck monitor

Acceleration data via
secure Internet connection

Respiratory rate and
activity report

Maryhill Health Centre
Elgin

Centre for Speckled Computing
University of Edinburgh

Acceleration, Breathing signal, Respiratory rate and Activity, Magenta, 7 June 2012

1: Acceleration(y)
2: Acceleration(x)
3: Acceleration(z)

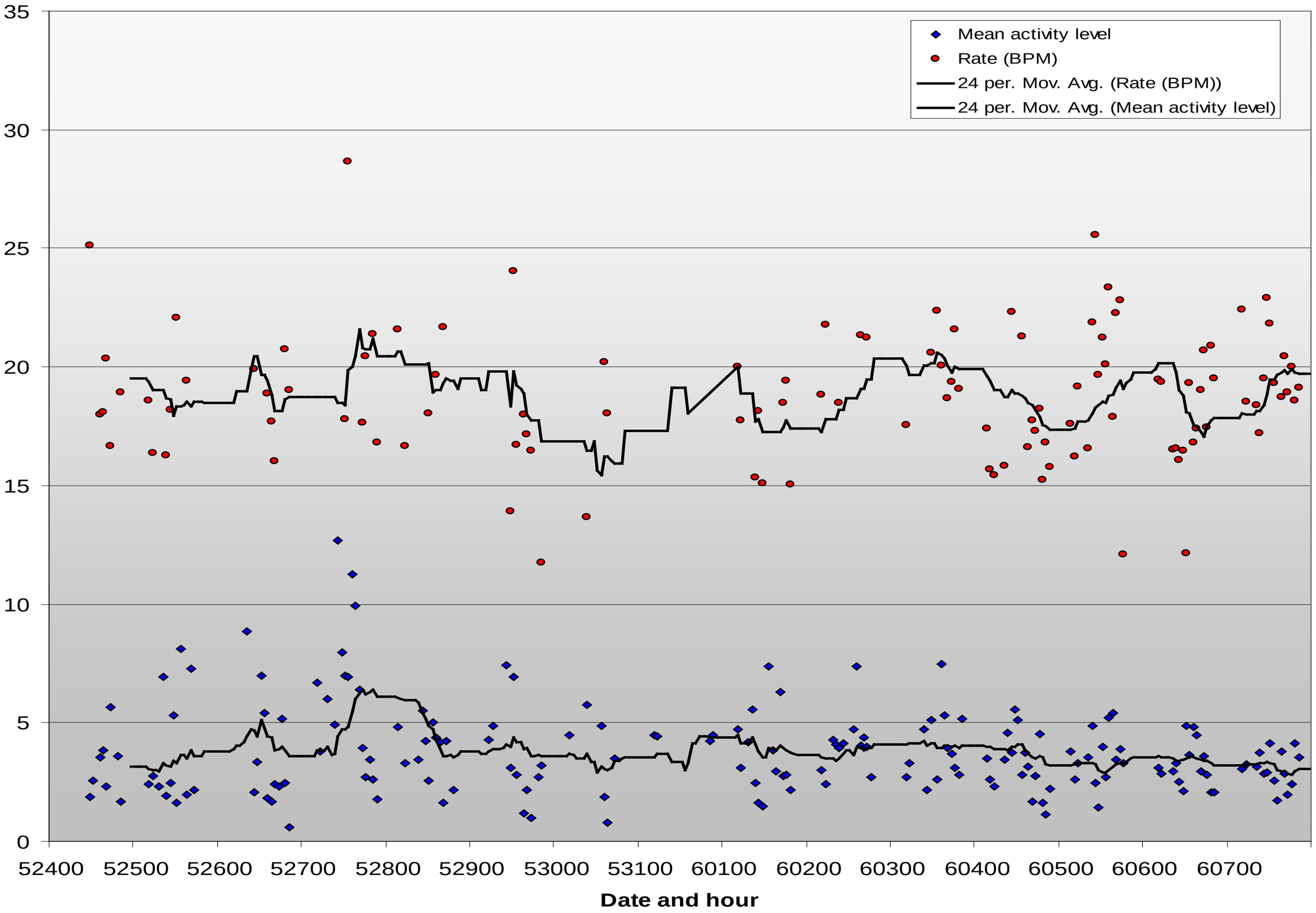
4: Breathing signal

5: Respiratory rates

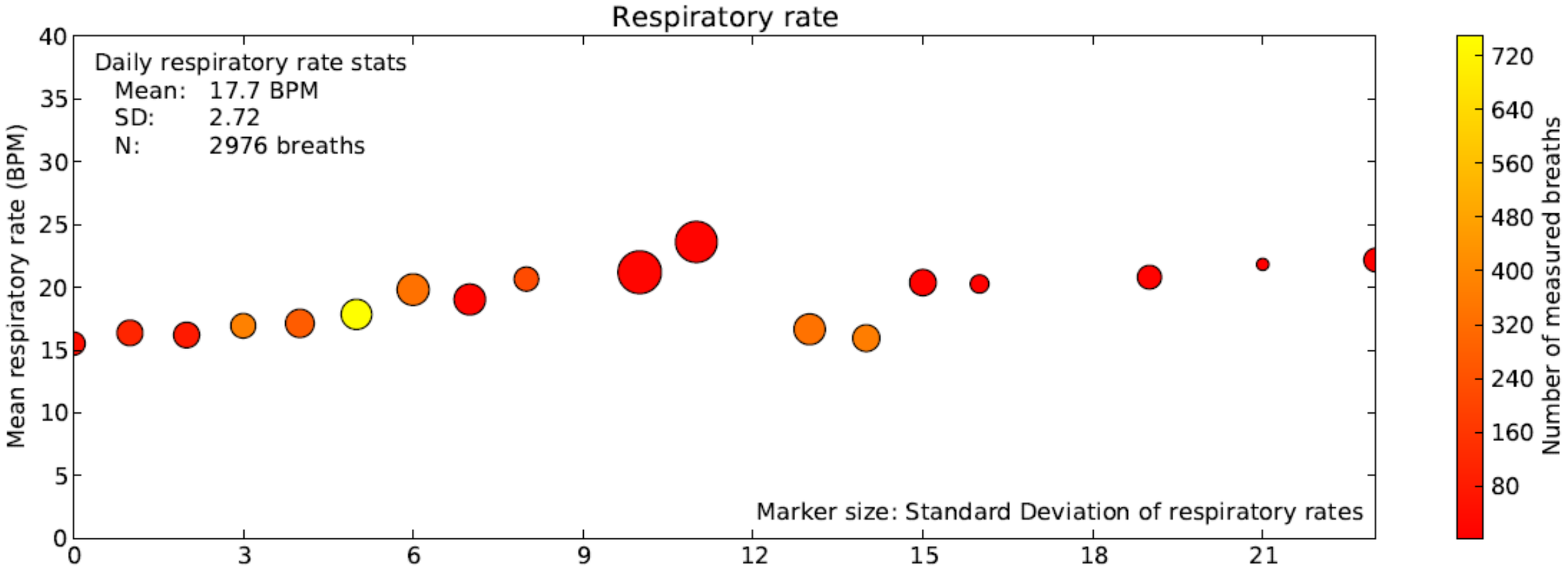
6: Activity

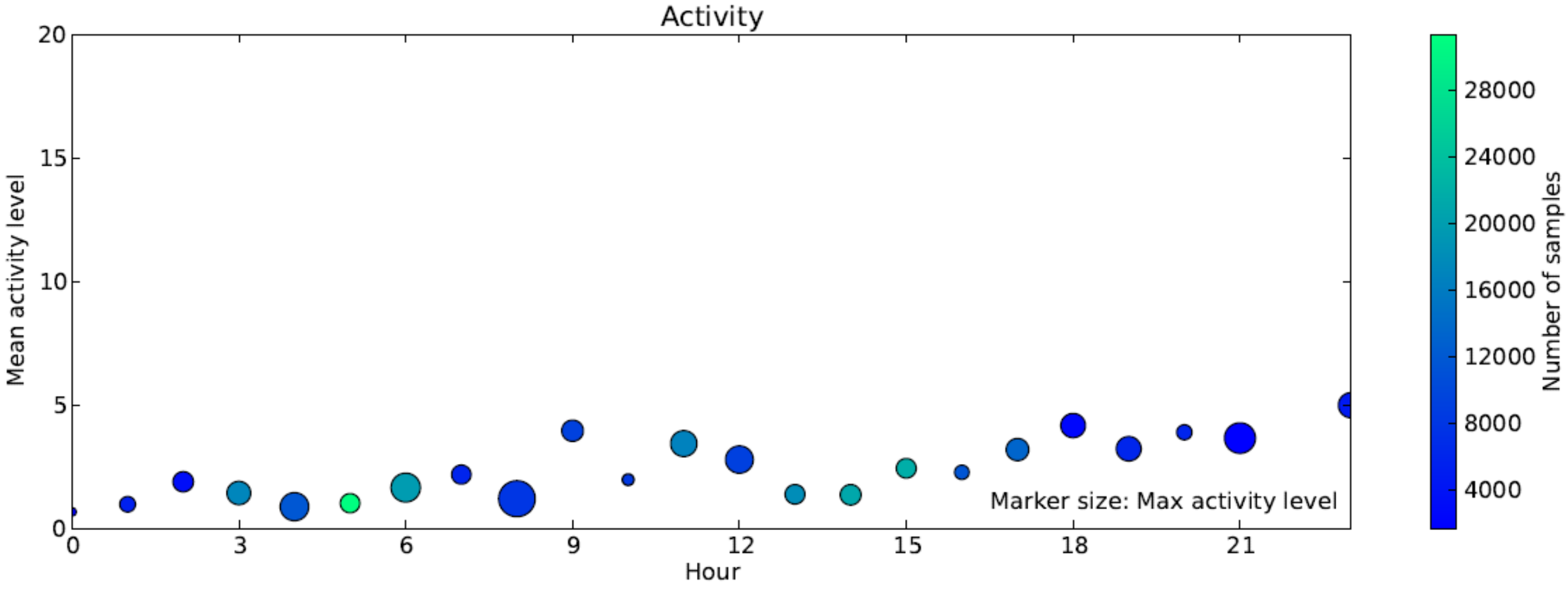
Time (mins)

Respiratory Rate and Activity
Magenta, *24 May - 7 June*



Daily report: Yellow, Sunday 08 July 2012





Evaluation

- Detect early onset of exacerbations to avoid hospital admissions
- Facilitate early discharge from hospital
- Reduce patient anxiety
- Clinical view on usefulness of data
- Health economics – including clinical time saved, hospital admissions prevented (comparison with previous position)
- Patient view – general feelings/reduced anxiety
- Carbon footprint – extending the reach of the Practice

Scotsman 30.viii.2012

Patch that lets GP give you a check-up from miles away

By FRANK URQUHART
Published on **Thursday 30 August 2012 00:00**

PATIENTS suffering from respiratory problems are taking part in a groundbreaking and potentially life-saving project which allows doctors to monitor them remotely through a body patch.

• Device allows GPs to measure respiratory flow and rate of patients remotely

• Patch is being piloted in community setting after successful hospital trials

The small electronic patch, worn on the patient's chest, measures respiratory flow and rate and sends the data through wireless technology to a GP practice in Elgin, enabling the patients in Moray to be constantly monitored in the comfort of their own homes.

The system, developed by the Centre for Speckled Computing at Edinburgh University, has already been successfully tested at trials in hospitals in the city, but it is now being piloted for the first time with patients in a community setting.

In a separate development, patients at the same Moray health practice are testing another revolutionary remote healthcare system which allows them to send daily readings of their blood pressure, oxygen levels, temperature and pulse to doctors. It is hoped the two pilot schemes will lead to the early identification of problems, help reduce hospital admissions and ultimately save lives.

Ian Cameron, 58, a patient at the Maryhill practice in Elgin, has already used both devices and praised the initiative.

Mr Cameron, a former demolition worker, suffers from chronic obstructive pulmonary disorder (COPD), which affects his breathing.

He said: "I was happy to try anything which could help me to stay well and it's good to know I'm being so closely monitored. I wore the patch for a month. It's only about one and half inches square. I thought it might bother me, especially at night, but I quickly stopped noticing it."

He added: "I have now started using the other device. I connect up to a machine like a laptop and it takes readings of my blood pressure, oxygen levels, temperature and pulse every morning.

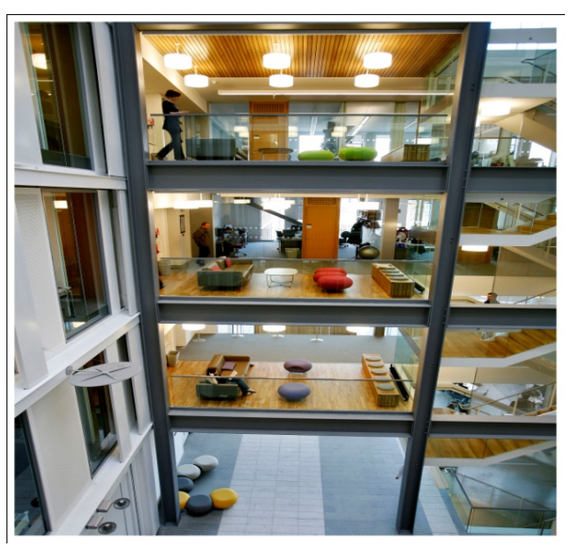
TOP STORIES
New Scottish health secretary Alex Neil targets NHS booze 'nightmare'
Rethink on MS pill gives hope to Scots sufferers
Frankenstein treatment 'to regrow limbs'
Fat children eat less than skinny peers
Jane Devine: There is no such thing as a safe amount of booze when driving, so let's set the limit at zero

NEWS
Scottish news
UK
International
Politics
Opinion
Holyrood live
Transport
Education

Mr Cameron, a former demolition worker, suffers from chronic obstructive pulmonary disorder (COPD), which affects his breathing.

He said: "I was happy to try anything which could help me to stay well and it's good to know I'm being so closely monitored. I wore the patch for a month. It's only about one and half inches square. I thought it might bother me, especially at night, but I quickly stopped noticing it."

Centre for Speckled Computing
10 Crichton Street
Edinburgh EH8 9AB



Scotland, United Kingdom
+44 (0)781 765 4055
dka@inf.ed.ac.uk