SESAME

Using Force Sensitive Resistors to Monitor Foot Contact Events in Sprint Running

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Context

- Sensors are getting smaller, lighter, cheaper, wireless
- Analysis can be undertaken in training
- Allows quantitative assessment of training and sharing of data

Sprint Biomechanics

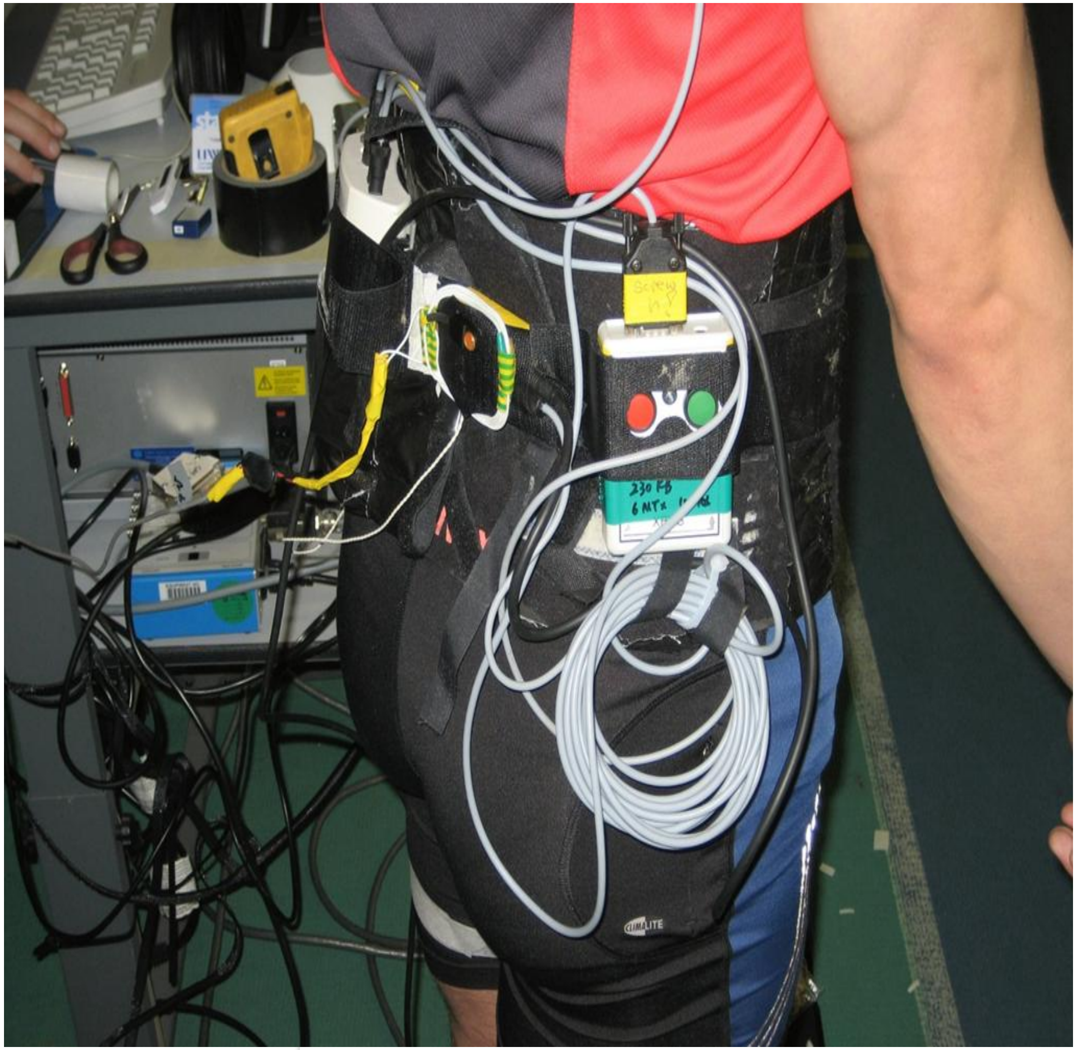
- Ground contact time (CT) is an important measure in sprinting
- CT is a variable that elite coaches are interested in monitoring
- CT is linked to force production
  - Force production allows CT to be minimised (Mann, 1985)
  - Negative relationship between CT and velocity (Weyand *et al.*, 2000)

Ecological Validity

Ecological Validity

- Use sensors with athletes in ‘normal’ training
    - *sprinters don’t want to wear anything extra*
- Disturb the environment as little as possible
- Capture and store data automatically
- Provide feedback as soon as possible

Unobtrusiveness?!



Considerations

- Measurement of CT requires a high sampling rate
  - Ideally ~ 1000 Hz
- A simple method of detecting touchdown and take-off is necessary
  - CODA marker vertical acceleration

(Bezodis *et al.*, 2007)

- Data capture volume is constrained with automatic motion analysis

Why Use In-Shoe Measures?

- Facilitates collection of data for all steps of a sprint run
  - Combines high-resolution quantitative measurement with large capture volume

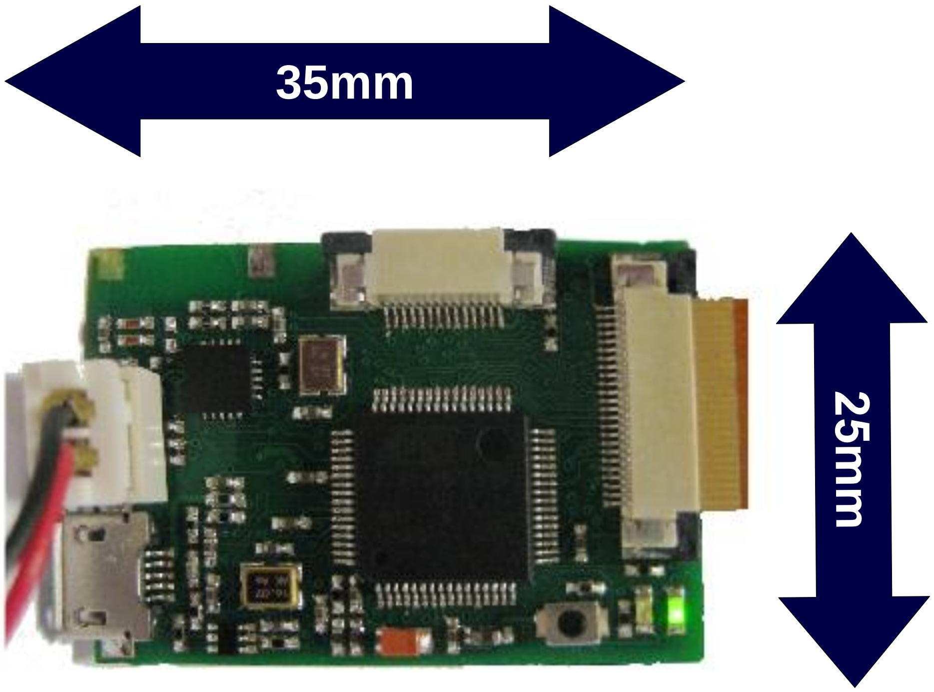
- Can be engineered so system is comfortable and unobtrusive

Aims

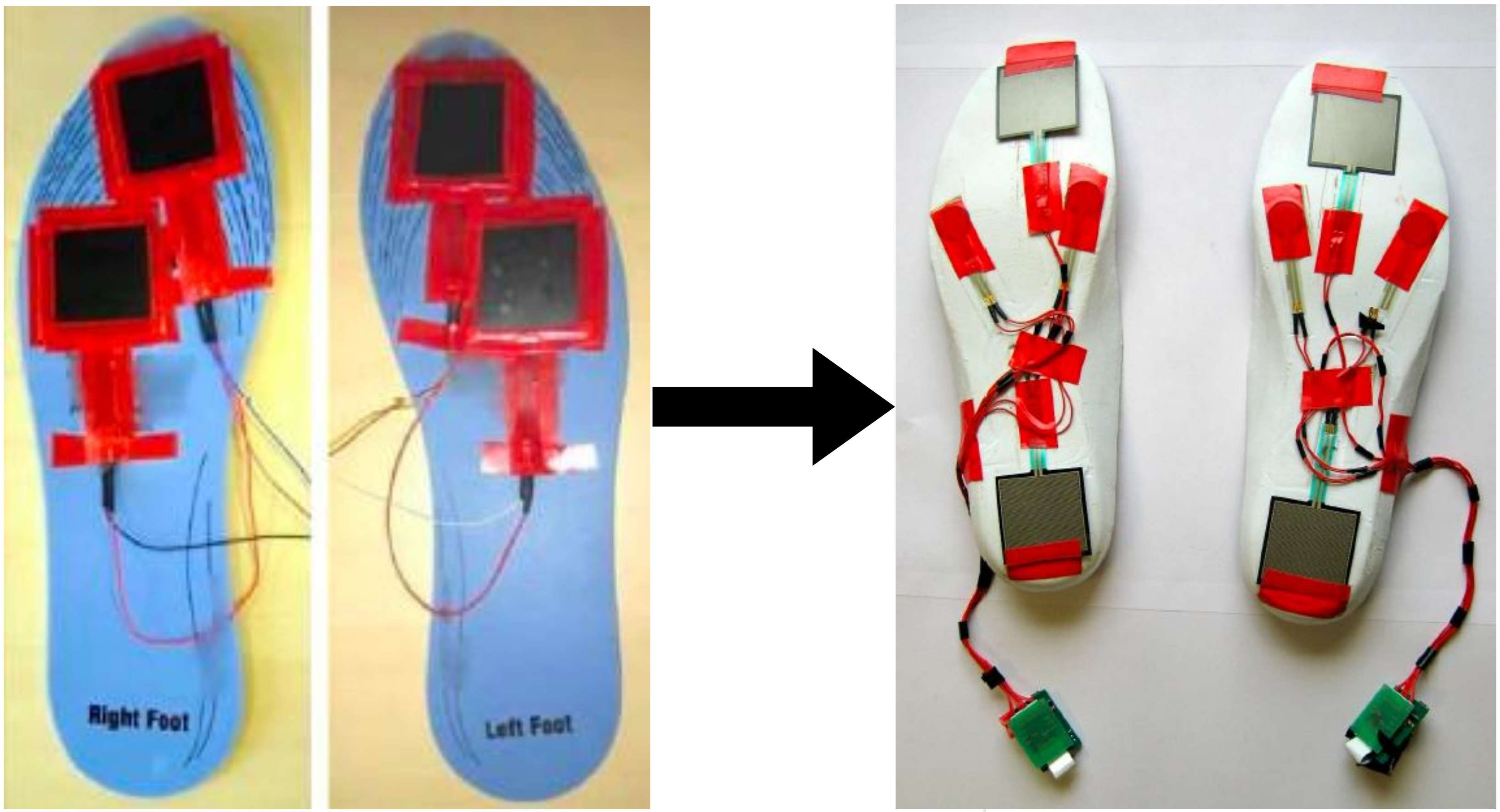
- To develop and evaluate an in-shoe method of obtaining contact times during a sprint run
- To use data for research and feedback purposes
- To integrate this system into an on-athlete wireless network of data collection devices

System Specifications

- Tiny sensing node
- Weighs 8 g (with battery)
- Multiple nodes sync
- Tens of pounds



Force Sensitive Resistors (FSR)



Force Sensitive Resistors (FSR)

Shoe to shoe wireless
synchronisation errors:
mean = 0.1 ms
max = 1.0 ms
capture duration (3 mins)

Twin Force Plate criterion

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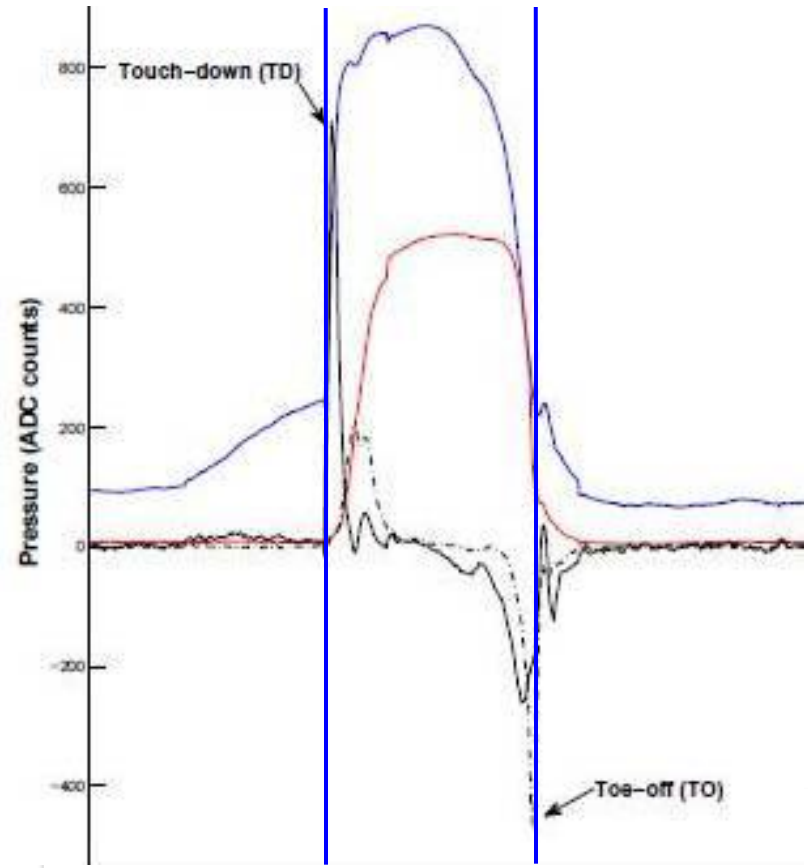
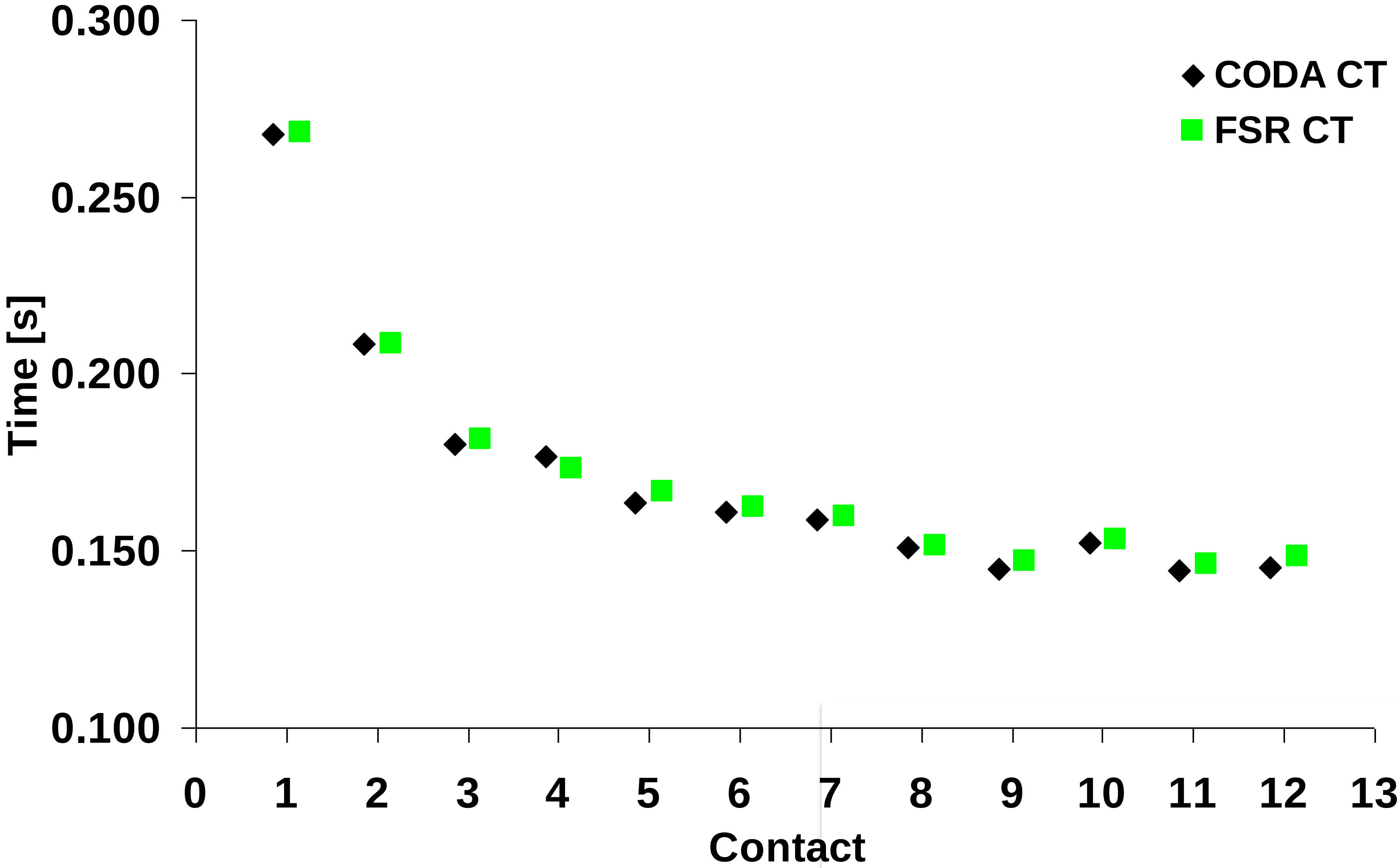
ION board
Small, lightweight sensing node, on-board storage wire-less communications, sampling rate = 1kHz. [Atmel AT91SAM7S256 processor Nordic nRF24L01+ 2 Mbps radio, 16 MBytes of flash, 12 bit external ADC and a 16 g 3D accelerometer]. SMD radio antenna edge of ION board, all outside shoe

System Validation

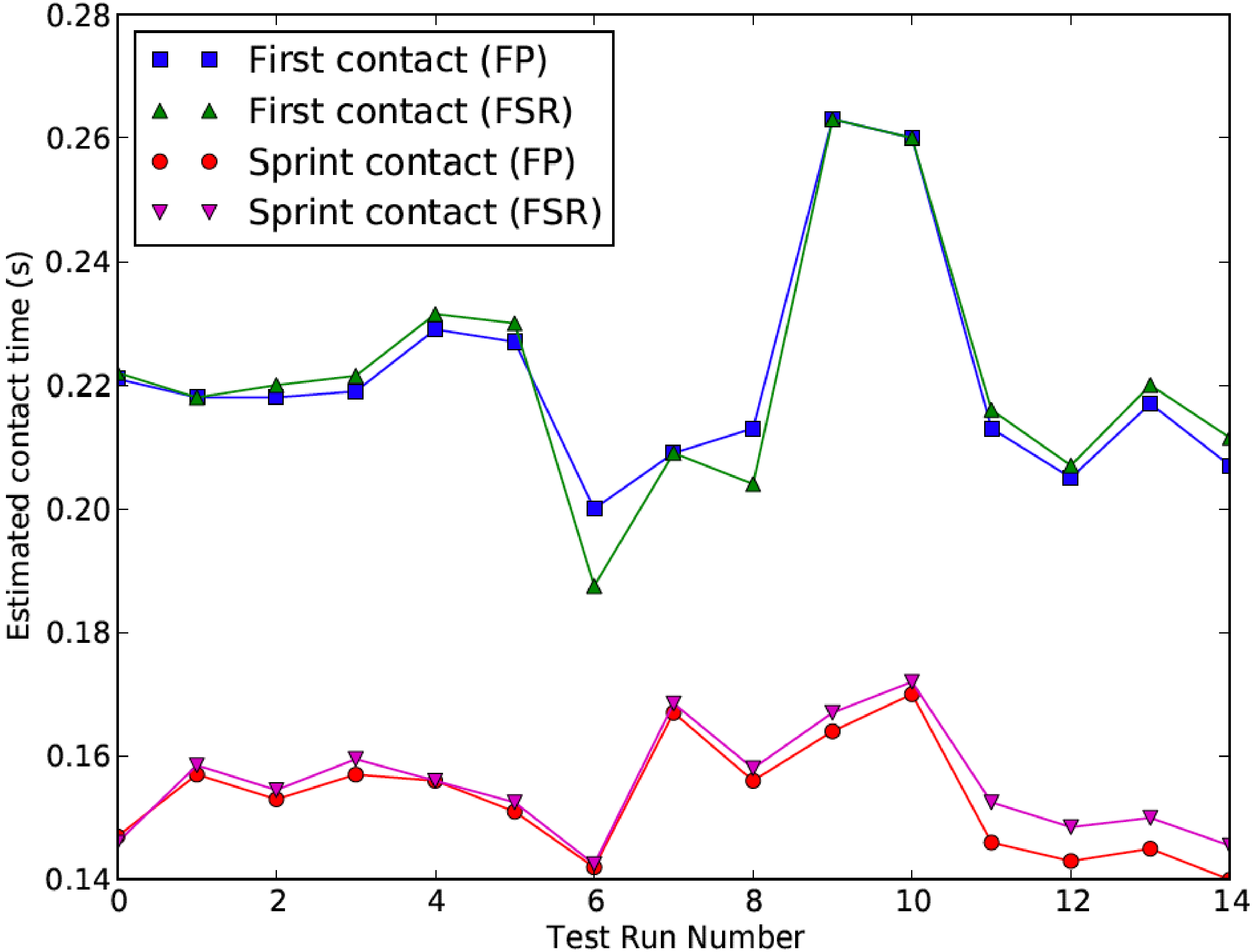
- Validate CT against criterion measures
  - CODA motion analysis
  - Kistler force plate
- Contact time (FSR)
  - Automated algorithm
  - First derivates of FSR signal



Validity (FSR v CODA)

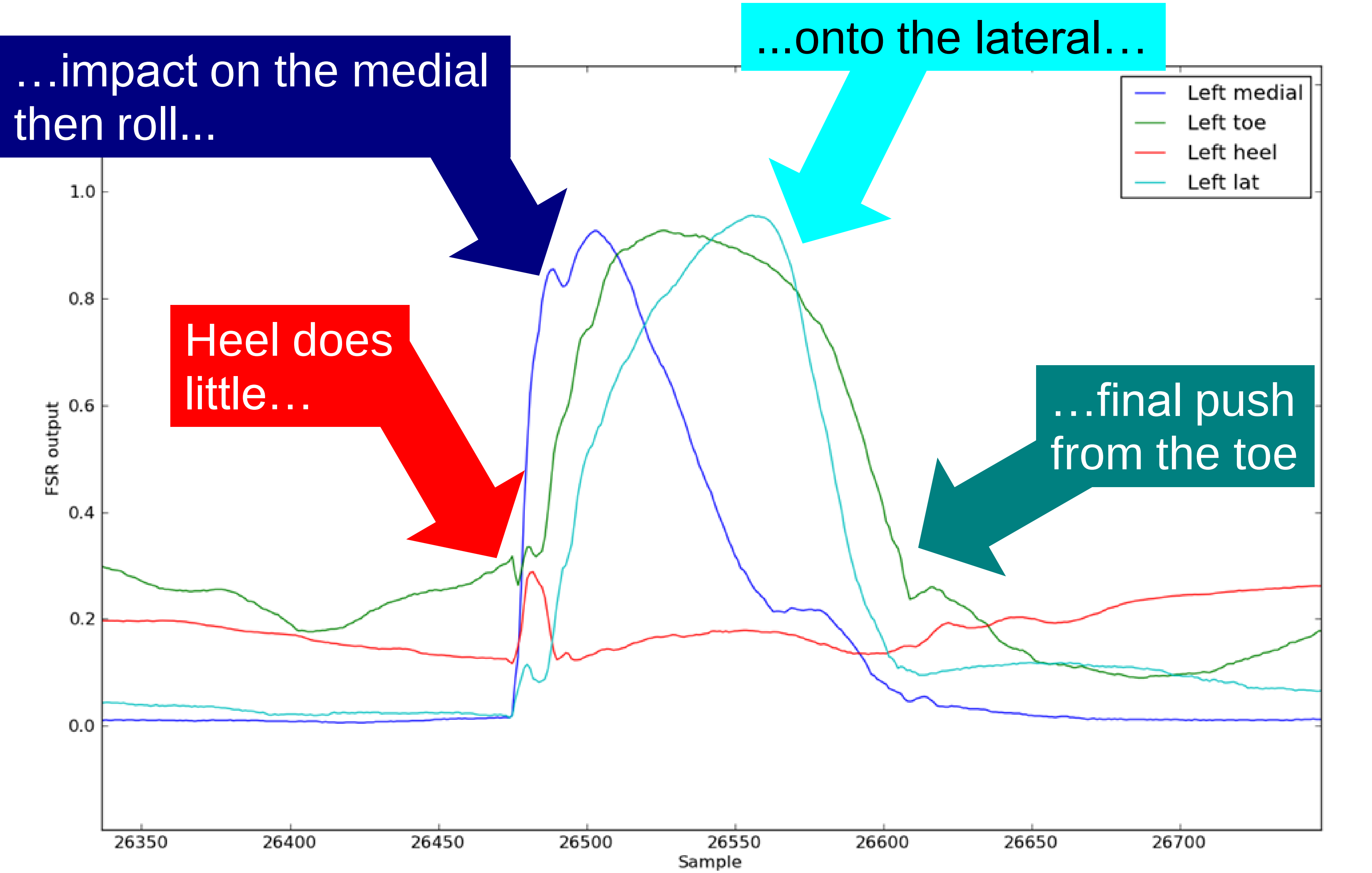


Validity (FSR v FP)

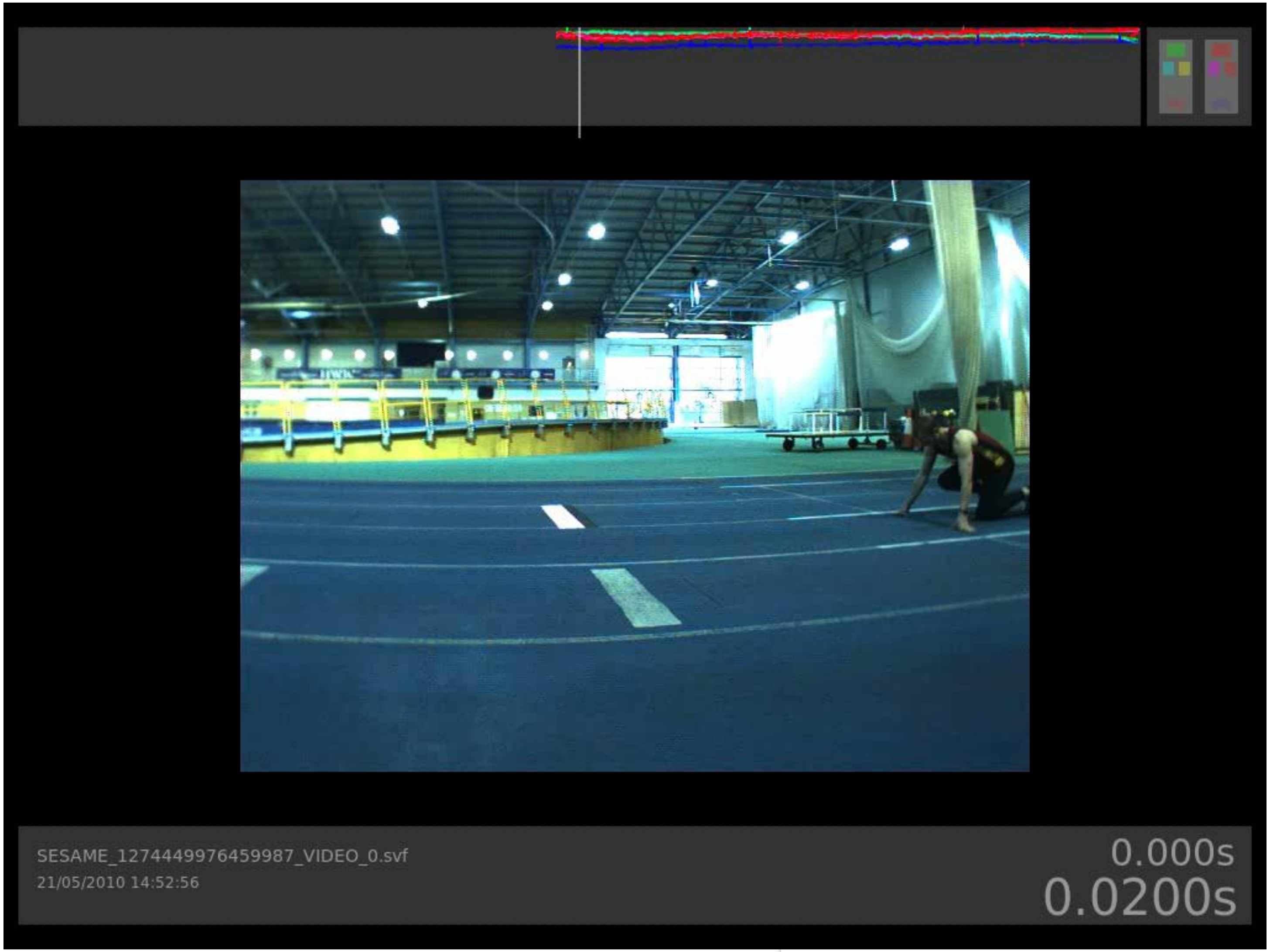


System Validation

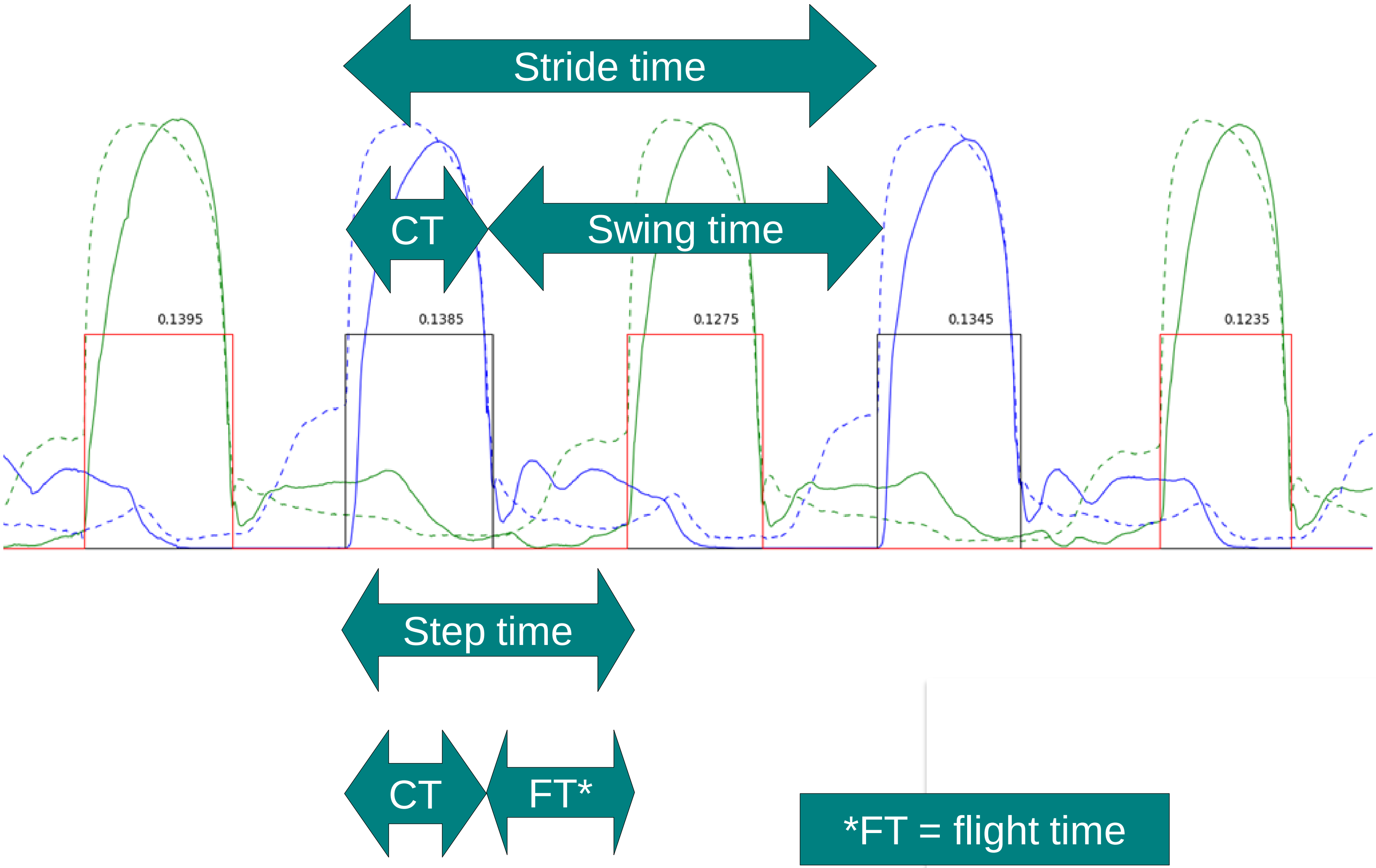
- Comparison to criterion motion analysis and force plate data
- Motion Analysis (CODA): 0.0033 s, 1.2%
- Force plate: 0.0025 s, 1.4%


…impact on the medial then roll...
...onto the lateral…
Heel does little…
…final push from the toe
Left medial
Left toe
Left heel
Left lat
1.0
0.8
0.6
0.4
0.2
0.0
FSR output
26350
26400
26450
26500
26550
26600
26650
26700
Sample

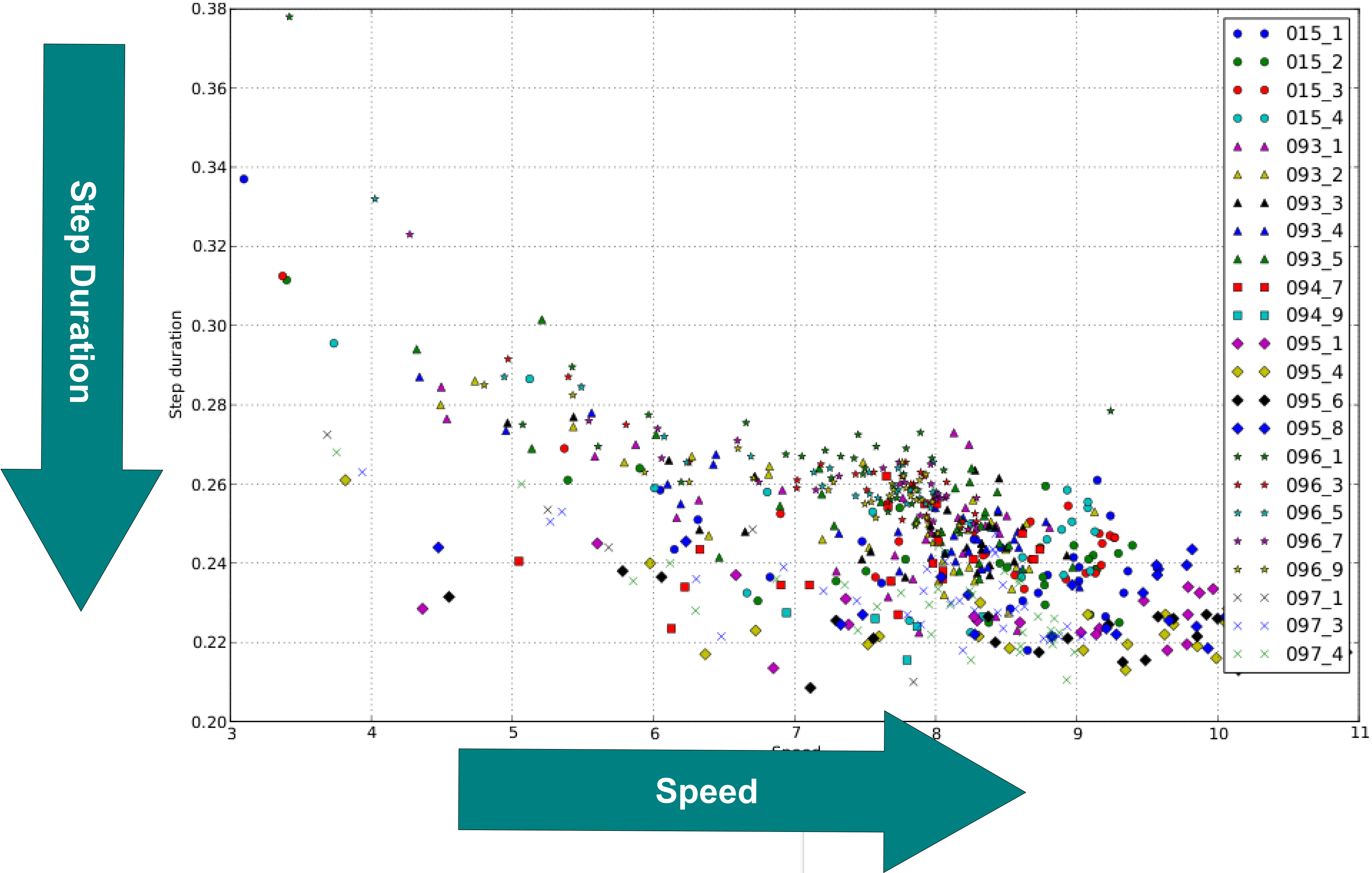
Can sync to video…

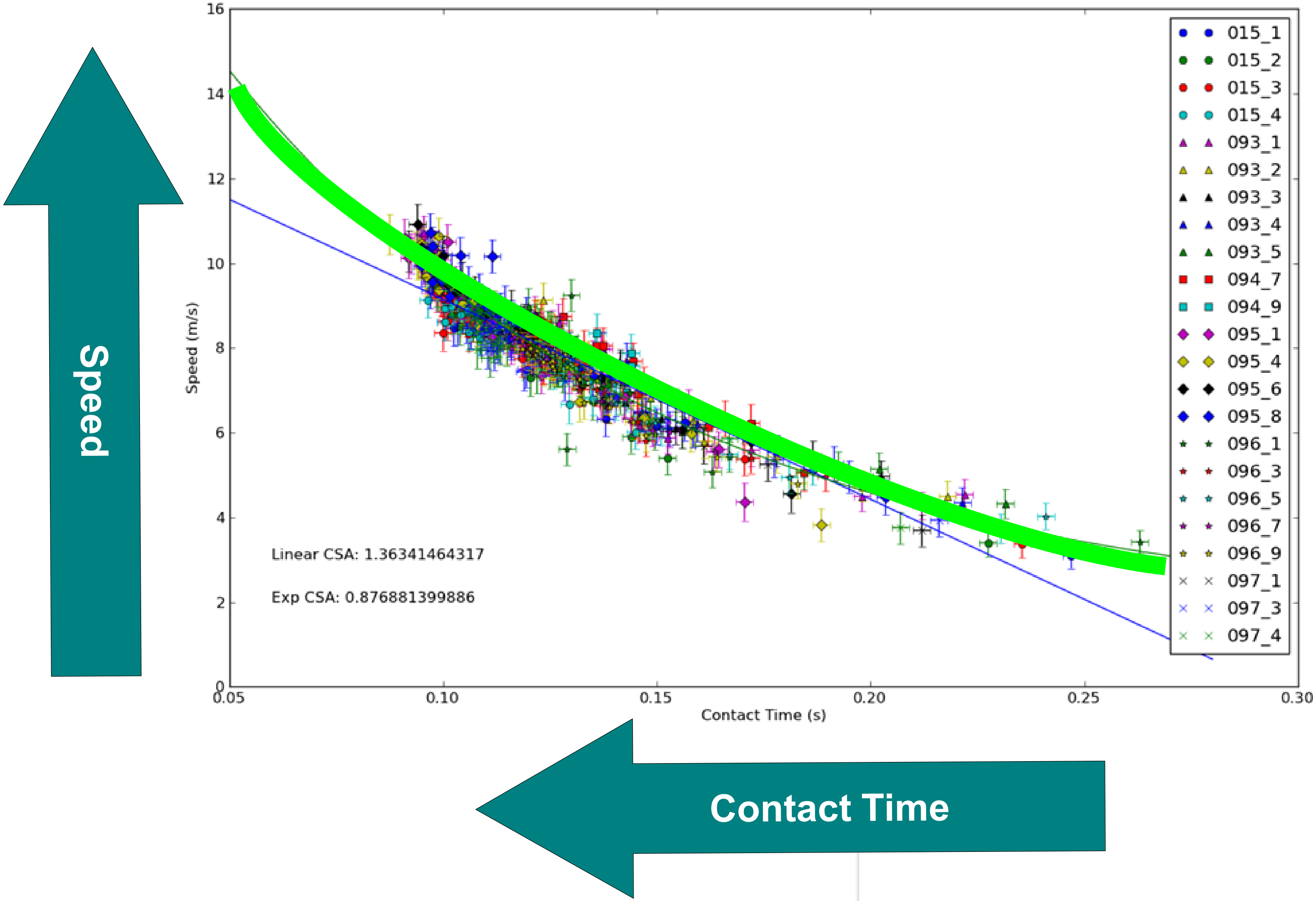


Compute the stride/step times, flight/swing times, contact times

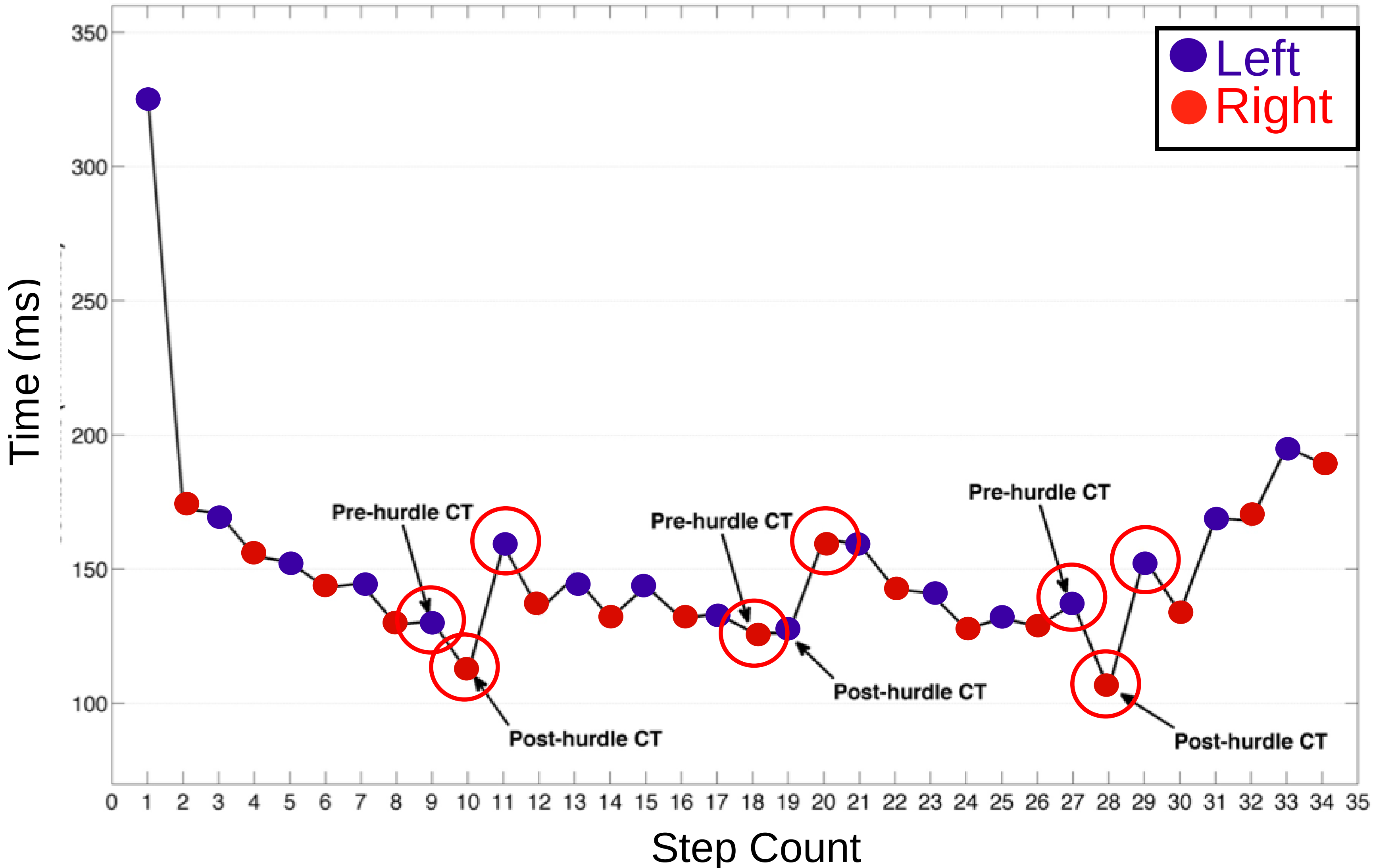


*FT = flight time

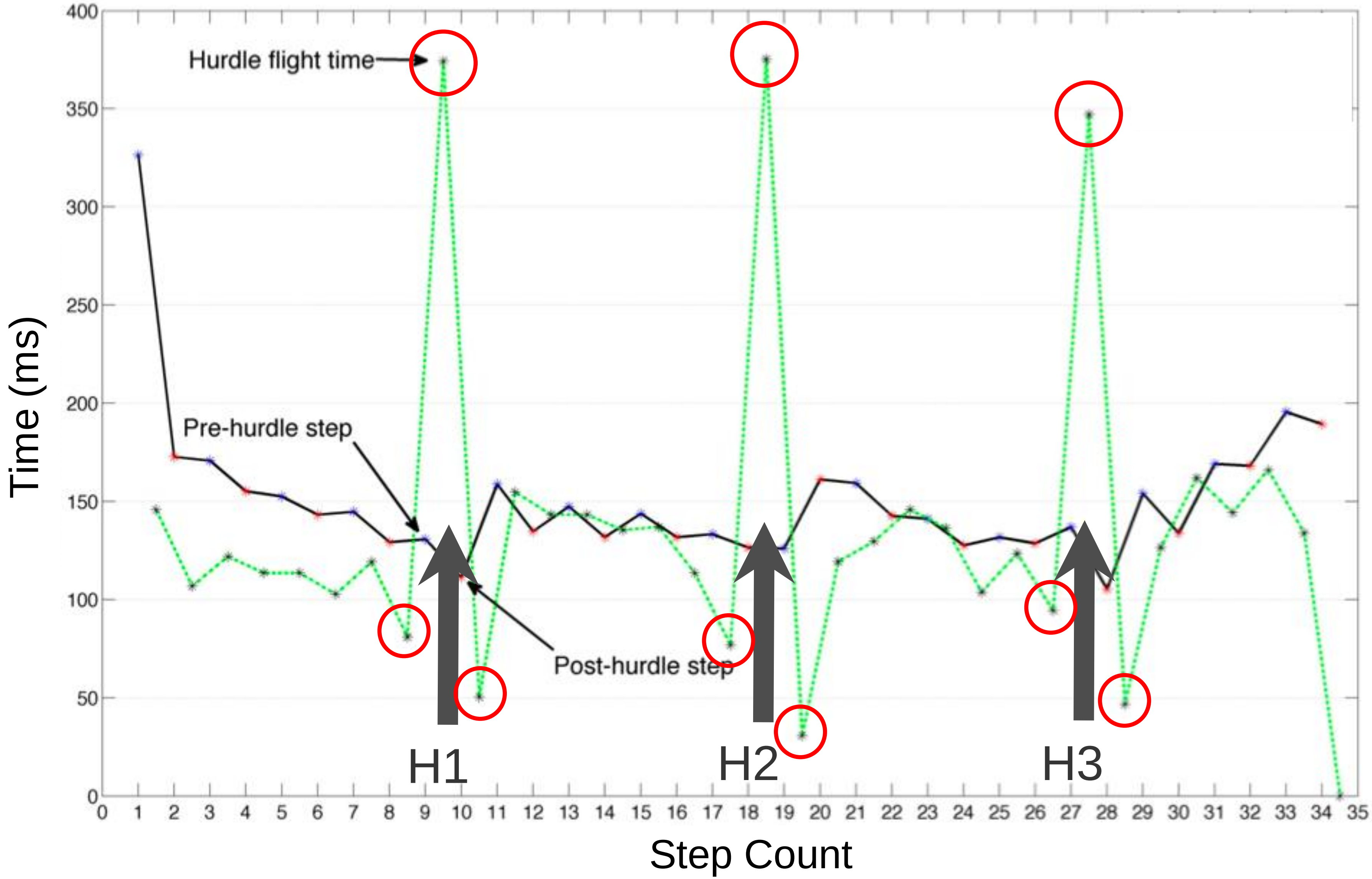

Step Duration
Step duration
Speed
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
3
4
5
6
7
8
9
10
11
015_1
015_2
015_3
015_4
093_1
093_2
093_3
093_4
093_5
094_7
094_9
095_1
095_4
095_6
095_8
096_1
096_3
096_5
096_7
096_9
097_1
097_3
097_4


Speed
Speed (m/s)
16
14
12
10
8
6
4
2
0
0.05
0.10
0.15
0.20
0.25
0.30
Contact Time (s)
Linear CSA: 1.36341464317
Exp CSA: 0.876881399886
015_1
015_2
015_3
015_4
093_1
093_2
093_3
093_4
093_5
094_7
094_9
095_1
095_4
095_6
095_8
096_1
096_3
096_5
096_7
096_9
097_1
097_3
097_4
Contact Time

System Application: Hurdling



Contact & Flight Times



Athlete & Coach Feedback

- Worn in both training and competition
- "Forget it's there"
- Useful data to facilitate and support the coaching process

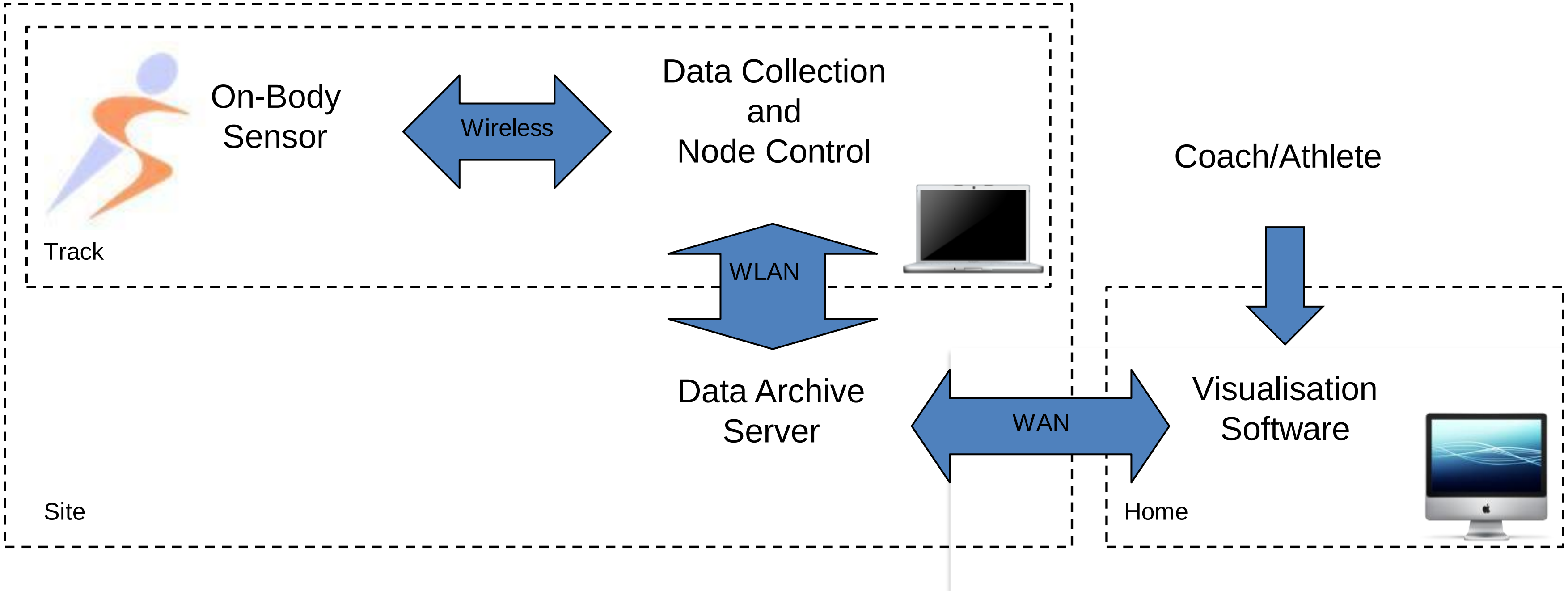
Future Work

- Establish link between contact time and performance

- Integrate system with other wireless monitoring devices

Summary

- On-body sensor system for foot/ground interaction in elite sprinting and sprint hurdling
- Domain specific demands, coach information, scientific tool



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Thank you for your attention

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