innovation & entrepreneurship

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Photon Factory: Exotic laser pulses for science & high-tech industry
Photon Factory: Basic & applied research & entrepreneurship
Innovation – with companies
“We are extremely pleased with the result, and I am personally very pleased with the University’s performance ... You have demonstrated that you can deliver solutions within, and to be frank, often ahead of business time frames.”

Gareth Bell, NextWindow
2016 - Innovative Hardware Award
Hi Tech Awards

aeroQUAL

NMHC
Butane
Propane
Ethane

VOC
Formaldehyde
Methanol
Ethanol
Isopropanol

Aromatic Hydrocarbons

Hydrogen

Methane

Very wide range of VOCs.

PID
Optics and Lasers in Engineering 84:105-110.

aeroQUAL
“The Photon Factory developed an efficient alumina laser machining process that enabled the yield of Aeroqual’s gas sensor chips to be increased from 40% to >95% from non-optimum printed tiles. This increased yield contributed to Aeroqual’s 32% revenue growth in FY15. It was great to work with a top university research lab that really understood our needs.”

Geoff Henshaw
Co-founder, CTO Aeroqual (2016)
Primary industries – growing our future

Champions in the primary sector

Ministry for Primary Industries
Manatū Ahu Matua

NEW ZEALAND
How does it work?

- Input and Flow Focusing
- Orientation
- Sex Detection
- Switching
- Sorted Output
The basic idea that underpins Engender’s technology

- the interaction of light with matter generates a force (nudging)
- the interaction of light with an asymmetric particle generates a torque (orientation)
2018 Nobel Prize in Physics
scattering force vs longitudinal position
scattering force vs time
fluid velocity
Gradient force vs longitudinal position

250 pN

transverse & longitudinal velocity

80 pN
Sperm are not simple!

### Bull Dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Length (μm)</td>
<td>9.1</td>
</tr>
<tr>
<td>Head sagittal section</td>
<td></td>
</tr>
<tr>
<td>Width (μm)</td>
<td>4.7</td>
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<tr>
<td>Head profile</td>
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</tr>
<tr>
<td>Area (μm²)</td>
<td>34.5</td>
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<tr>
<td>X–Y difference (%)</td>
<td>3.8</td>
</tr>
<tr>
<td>Sorting index</td>
<td>131</td>
</tr>
</tbody>
</table>

### Fluorescent Pulse Integrals

The image shows two distributions on the chart, with a highlighted area indicating a region of interest. The x-axis represents `ch0_integral`, and the y-axis represents `ch1_integral`.
Economic impact of artificial insemination (dairy)

Unsorted semen
$4-10 per straw
>175 million straws pa

US$2+ billion pa market
Economic impact of sex-sorted semen today

$10 – 40+ per straw
~5 million straws pa

~US$220 million
Economic impact of sex-sorted semen **tomorrow**

$10 – 20 per straw

50% of total market within 5 years

>US$250 million revenue
Economic impact of sex-sorted semen tomorrow
Dairy – an amazing food

- recommended as part of a healthy diet in most countries
- contributes 134 kcal per capita per day
- contributes 8.3 g protein per capita per day
- contributes 7.6 g fat per capita per day

Global Supply

- #5 provider of energy
- #3 provider of protein, fat
Dairy – an amazing food & environmental challenge

**pollution** of our soil, waterways
manure, fertilizers

**climate change** from atmospheric pollution
greenhouse gas emissions

**biodiversity** under threat
animals, pastures, feed crops
more and more dairy cows

- India
  - 1961: 177.3 m
  - 2016: 273.8 m
- Brazil
- USA
- China
- Turkey
Figure 7.3. Annual changes in inventories of dairy herd and yields between 2017 and 2027

Note: The size of the bubbles refer to the total milk production in the base period 2015-17.

StatLink: http://dx.doi.org/10.1787/888933743480

more and more dairy products
Figure 7.3. Annual changes in inventories of dairy herd and yields between 2017 and 2027.

Note: The size of the bubbles refer to the total milk production in the base period 2015-17.

The future for Engender Technologies

~US$18m for ~45% of the company.

• Commercial-ready microfluidic chip and instruments
• IVF alpha prototype launch (Y1)
• AI alpha prototype launch (Y2)
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~US$18m for ~45% of the company.
• Commercial-ready microfluidic chip and instruments
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Lots of others along the way …
“point of cow” diagnostics – making complex solutions simple for farmers

automated milk composition “lab” in the shed
The pain

Global cost of mastitis = $35B pa

Cost of missed impregnation
  = $150k per 1000 head herd pa

Value of increased genetic gain
  = $90k per 1000 head herd pa
How does it work?

CENTRIFUGAL MICROFLUIDICS + PHOTONICS = ROBUST SENSOR PLATFORM
Development Plan

2017
- Development of fat, protein and progesterone
- Prototype instrument to operate disk and finalise tests.
- Develop mastitis (udder infection) test

2018
- MOU with a world leading milking equipment company
- PCT patent filed
- $500k POC funding in place
- Secure option to out-license to milking equipment company

2019
- Integrate into milking equipment & Field trials
- Significant upfront licensing payments on completion of MVP

2020
- Full Product Launch
- Further dairy tests (infections, nutrients, distinguishing features...)
- Review other apps: Beverage, Waste water
- Secure option to out-license to milking equipment company
Management and Directors

COLIN HARVEY  
Chairman & Investor Director

PROF. DAVID WILLIAMS  
Founding Scientist & Chair of SAB

PROF. CATHER SIMPSON  
Founding Scientist & Director

BRENT OGILVIE  
Manager

KIERAN JINA  
Operations

Founded, grew and sold one of NZ’s largest animal health companies

Led development of world’s first home pregnancy test

NZ Primary Industries Champion, CSO Engender

Proven deal-making experience with agricultural companies over five continents
where are we headed?

- Fat (total and components)
- Protein (total and components)
- Somatic cell count
- Progesterone, luteinising hormone etc.
- Ketosis (beta hydroxybutyrate)
- Bacterial identification (i.e. Gram-ve/ +ve)
- Lactose
- BVD
- Tuberculosis
- Johnes Disease
- Mycoplasma bovis
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**Sorting sperm by sex for agriculture**

<NGENDER>

**“Point of cow” diagnostics on milk**

<ORBiS MILK ON A DISK>

**Diagnose & type skin lesions with hand-held, portable device**
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**Sorting sperm by sex for agriculture**

**NGENDER**

**ORBiS MILK ON A DISK**

"point of cow" diagnostics on milk

diagnose & type skin lesions with hand-held, portable device

advanced fibre lasers for distributed manufacturing

Prostate probe

Mussel farm

"point of cow" diagnostics on milk
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- Advanced fibre lasers for distributed manufacturing
- Mussel farm
- Prostate probe
Photon Factory: Innovation & entrepreneurship

- **Sorting sperm by sex for agriculture**
- **Mussel farm**
- **“point of cow” diagnostics on milk**
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- **Advance fibre lasers for distributed manufacturing**

**NGENDER**

**ORBisS MILK ON A DISK**

*diagnoe & type skin lesions with hand-held, portable device*
Photon Factory: Innovation & entrepreneurship

- Sorting sperm by sex for agriculture
- "Point of cow" diagnostics on milk
- Diagnose & type skin lesions with hand-held, portable device
- Advanced fibre lasers for distributed manufacturing
- Mussel farm
- "Diabetes" icon
Photon Factory: Innovation & entrepreneurship

- Sorting sperm by sex for agriculture
- Skin lesion diagnosis & type with a hand-held, portable device
- Advanced fibre lasers for distributed manufacturing
- "Point of cow" diagnostics on milk
- Mussel farm
Now what??
But ... I'm just an emerging researcher!?
But ... I’m just an emerging researcher!?
Tapping the problem-rich environment ...

the cow whisperer
Hooray Moogle!
You saved Bessie!
You saved the day!
moo.

When Farmer Jones chose "find my cow" the GPS in Bessie's Moogle ear-tag activated. This data was transferred to a map on Farmer Jones' device. So Moogle (and Farmer Jones) saved Bessie!
But ... I’m just an emerging researcher!?
But ... I'm just an emerging researcher!?
listen to the problem-rich environment
come up with an idea ... then another one ...
find people who can help you succeed
the future...
the future...

genetics
robotics
vertical, indoor