

# Accelerator Science at the Australian Synchrotron

On behalf of the Accelerator Science and Operations Group

Dr Mark Boland  
Principal Scientist  
Accelerator Physics

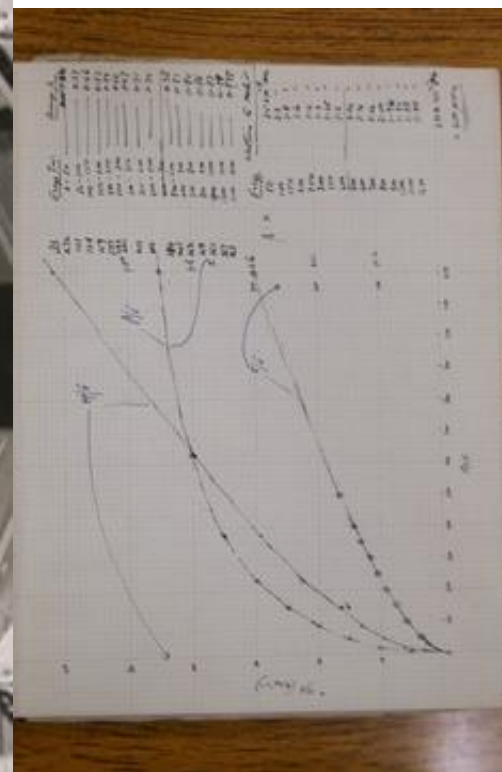
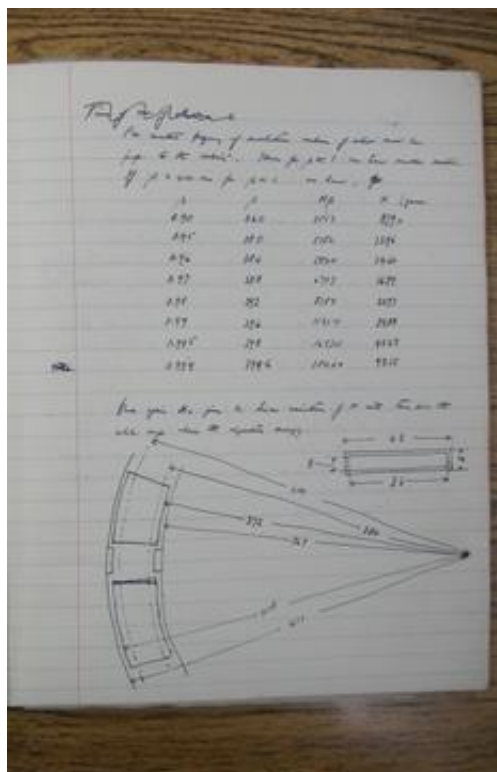


## Australian Synchrotron

# The Synchrotron Light Source World Map



# Building on the past



## Sir Mark Oliphant – synchrotron co-inventor

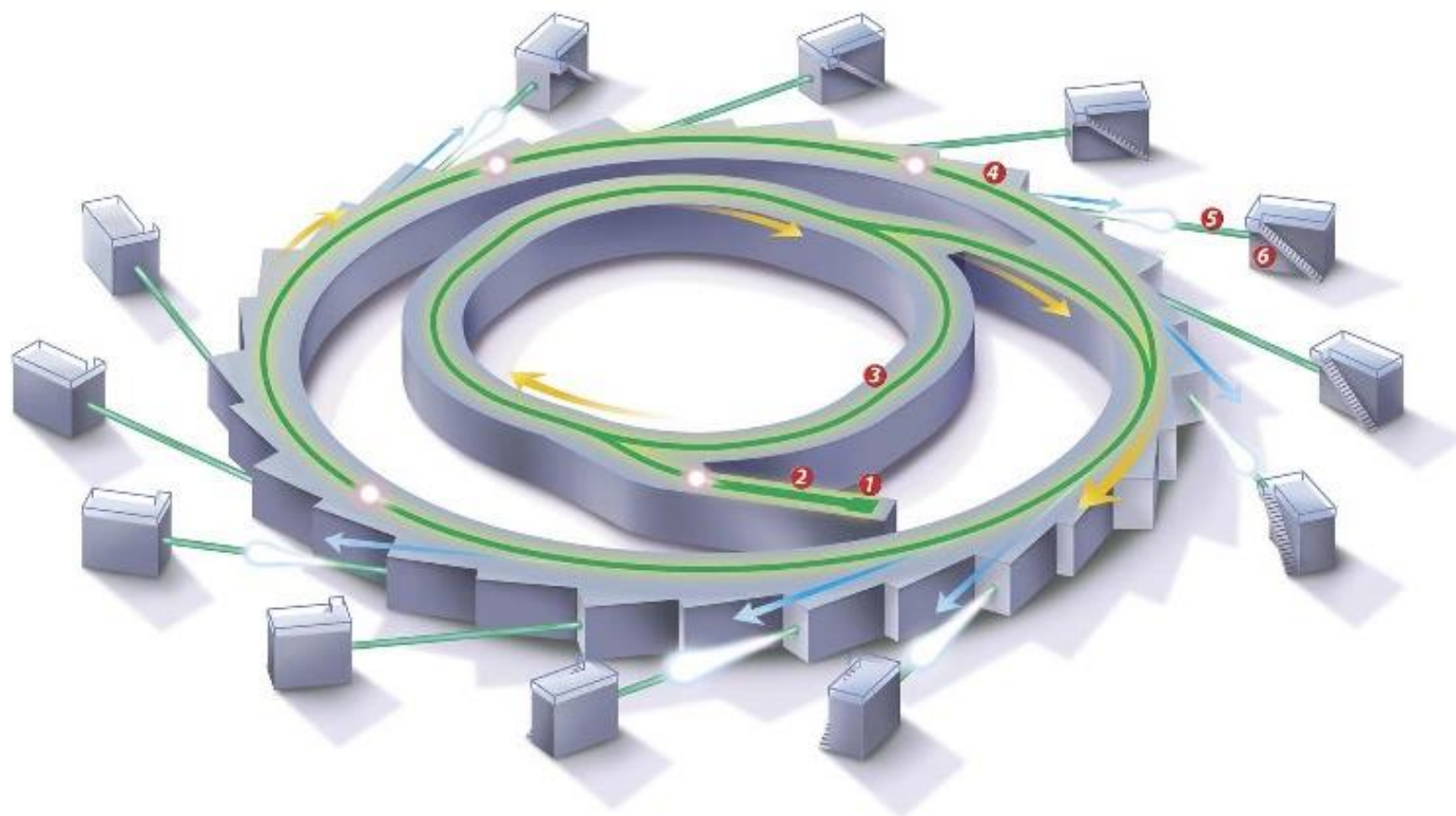


# Australian Synchrotron Light Source

2003-05-15

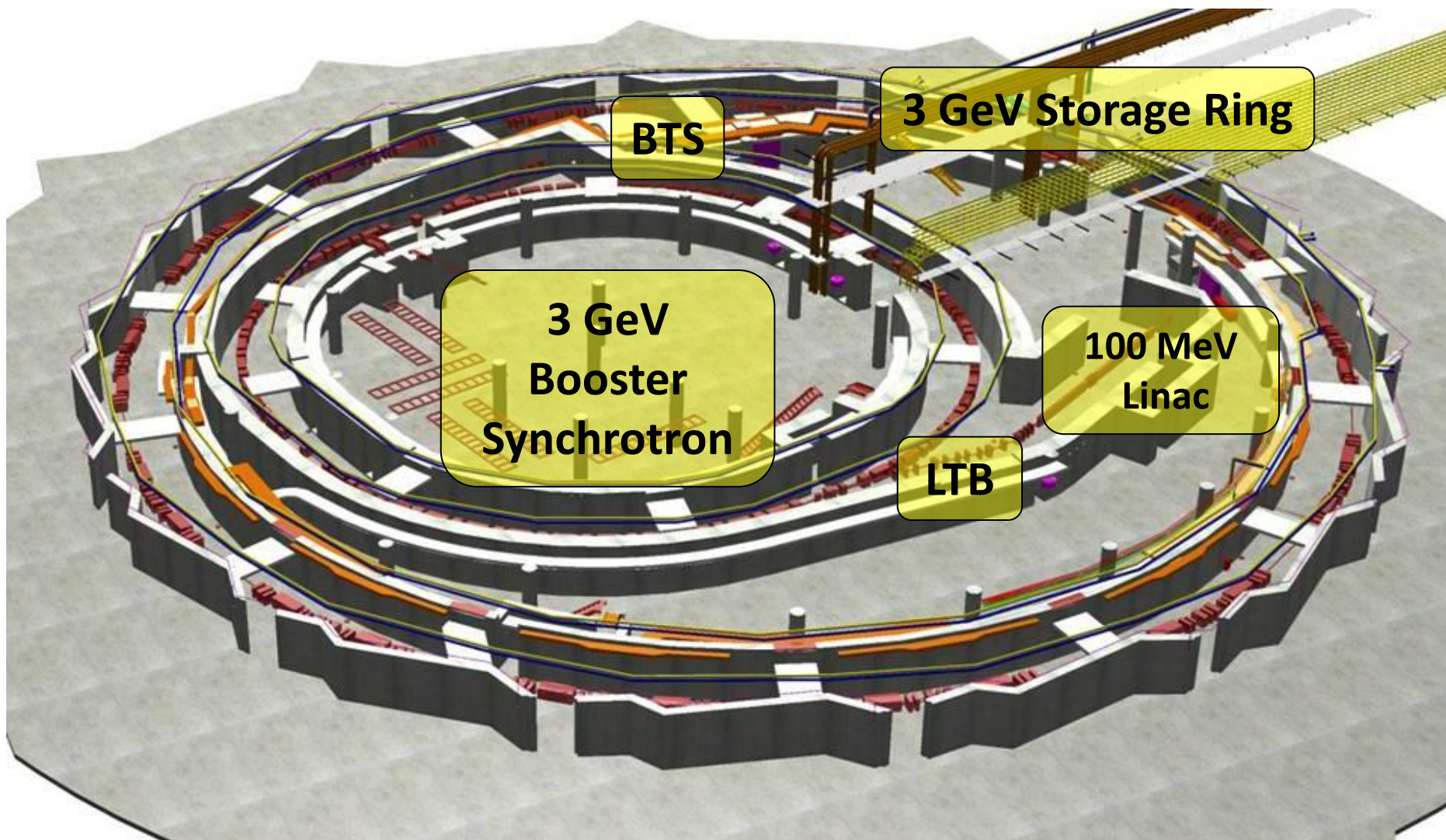


# ASLS Cartoon





# Machine Overview



# Linac

- Accelerates electrons to 100 MeV
- Injects electron beam into the booster ring
- Pulsed at 1 Hz





# Booster

- Accelerates electrons to 3 GeV
- Injects electrons into the storage ring
- Only “real synchrotron” in the lab





# Storage Ring

- 10 photon beamlines
- Continues top-up injection operation



# User Beam Available since 2007

## 16 Week Availability

Click and drag in the plot area to zoom in





# Buildings construction completed 2012

National Synchrotron  
Science Centre

Medical Imaging  
Beamline

Offices

User  
Accommodation

Engineering Workshop  
Metrology Laboratory  
RF Laboratory

Storage

# 2012 New National Centre for Synchrotron Science





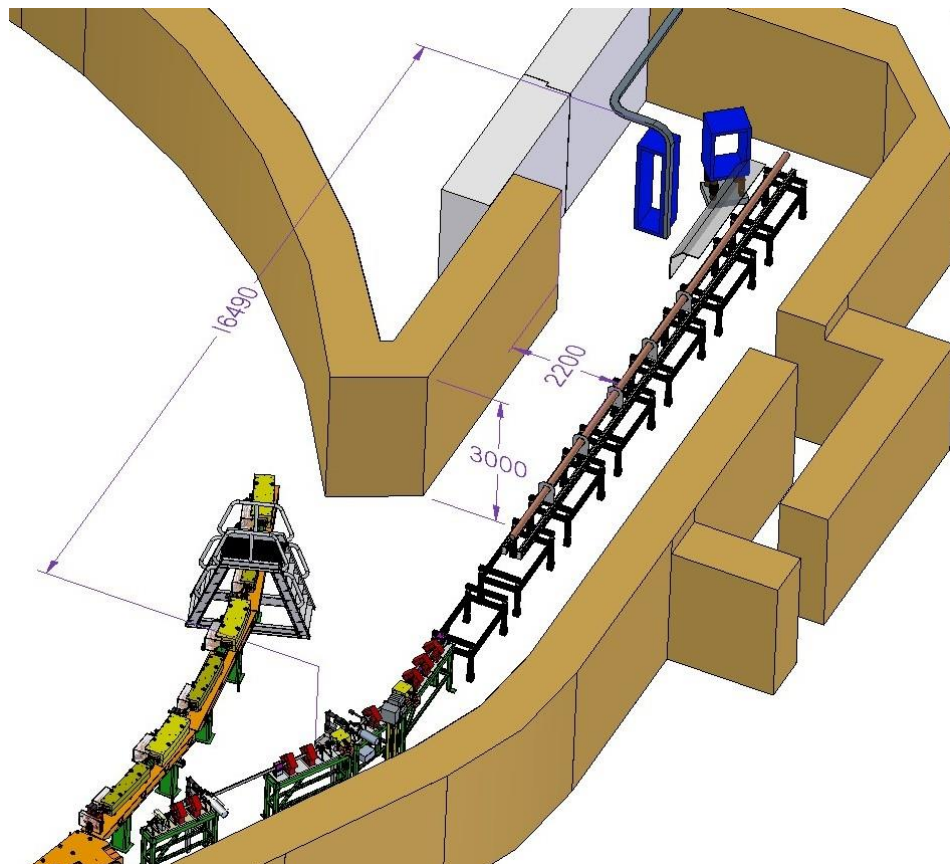
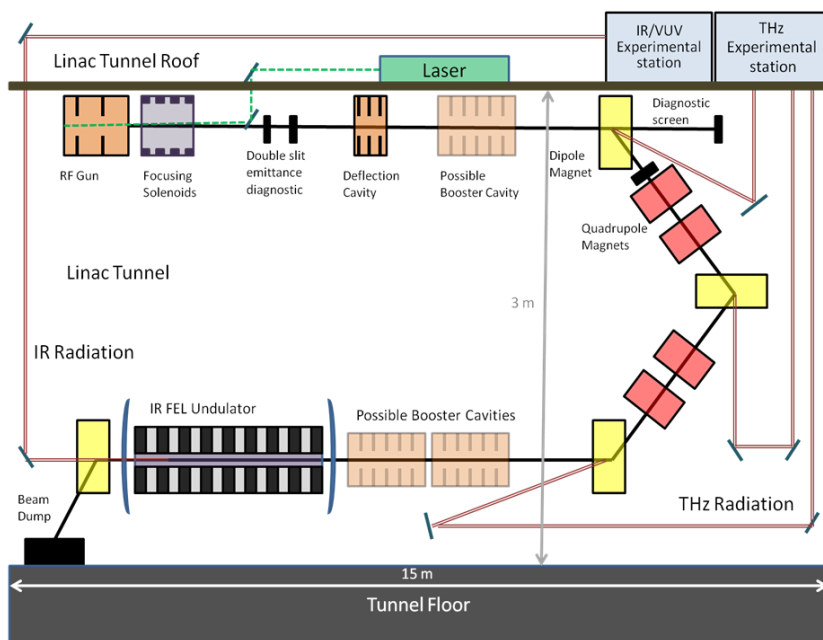
# Plans for light sources in Australia

- Accelerator development included in strategic plans



# CLEAR (Coherent Low Emittance Accelerator Radiation)

- CDR in progress
- Unfunded
- Using existing tunnel space
- PhD working on RF photocathode
- PhD worked on undulator characterisation

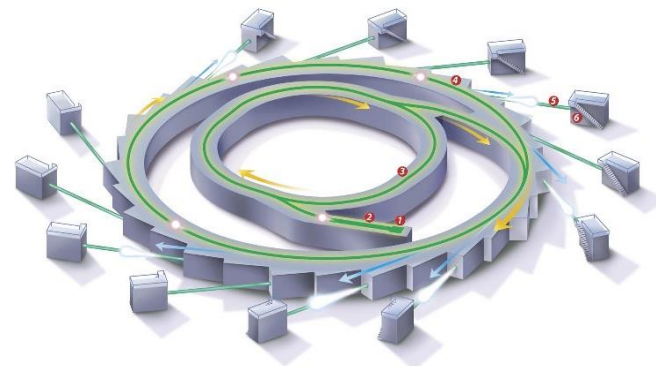
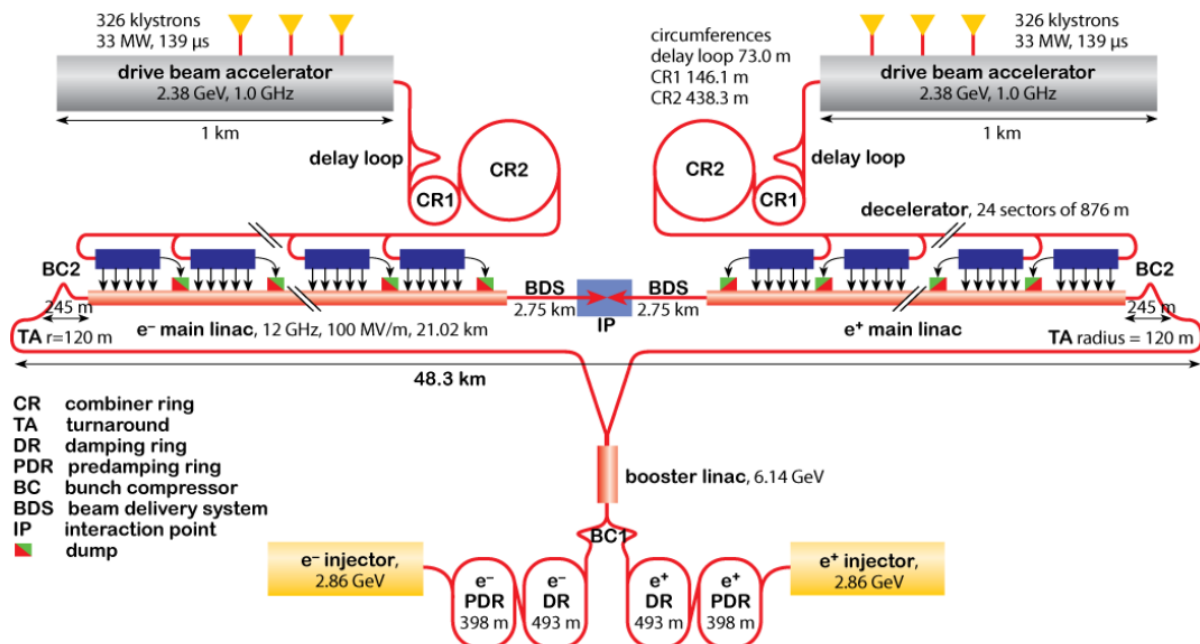




# Possible FEL site



# Australian Synchrotron as a test bed



## •CLIC damping require:

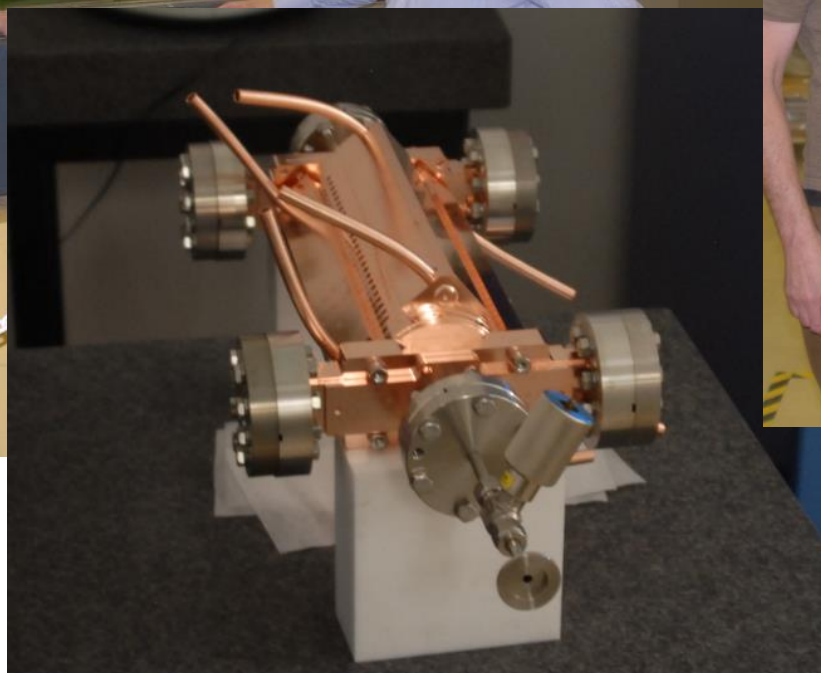
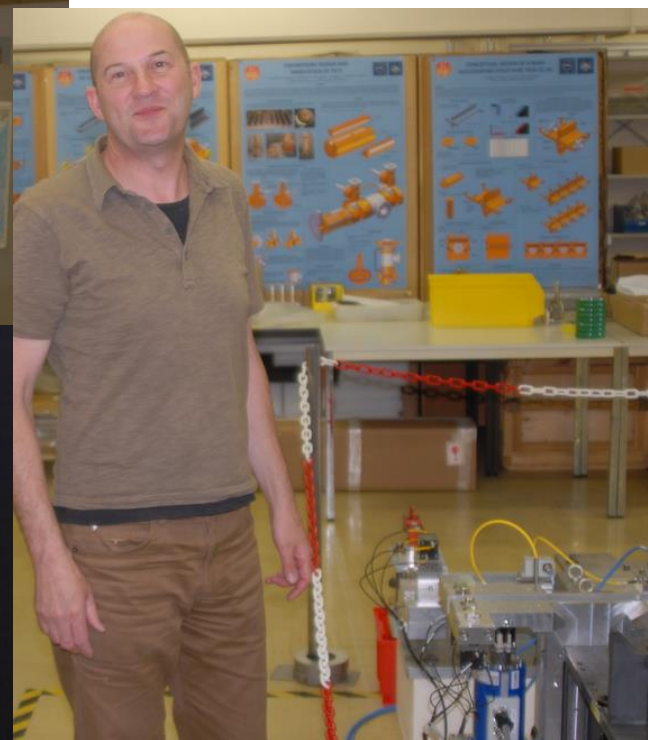
- 2.86 GeV
- $\varepsilon_y = 1$  pm vertical emittance
- $4.3 \times 10^9$  e<sup>-</sup> per bunch
- $1.3 \times 10^{12}$  e<sup>-</sup> total charges

## •ASLS storage ring

- 3 GeV (have injected 1.5 to 3 GeV)
- Achieved  $\varepsilon_y < 1$  pm
- For MD use up to  $4.5 \times 10^{10}$  e<sup>-</sup> per bunch
- $0.9 \times 10^{12}$  e<sup>-</sup> total charges for user beam

**Significant MD time for research!**

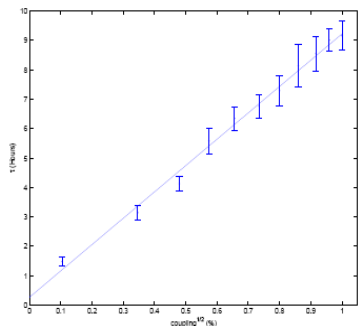
# Workshop staff trained in x-band at CERN



- Uni. Of Melb. Workshop staff
- CERN associate for one year



# Body of evidence for ultralow emittance



PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **14**, 012804 (2011)

## Achievement of ultralow emittance coupling in the Australian Synchrotron storage ring

R. Dowd, M. Boland, G. LeBlanc, and Y-R. E. Tan

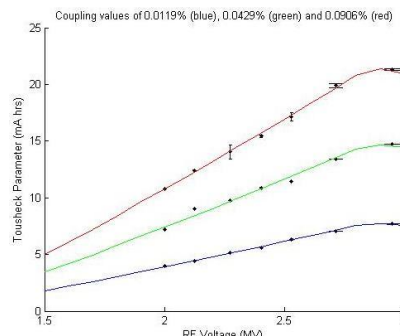
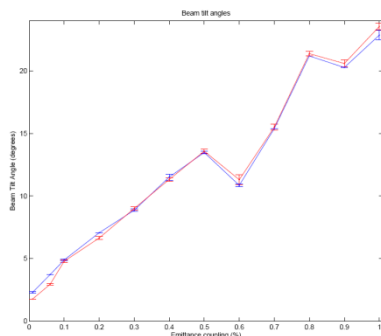
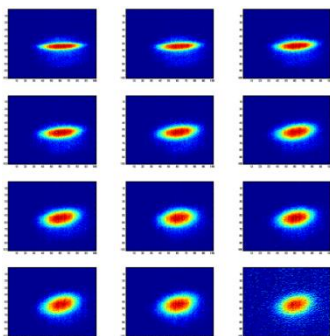
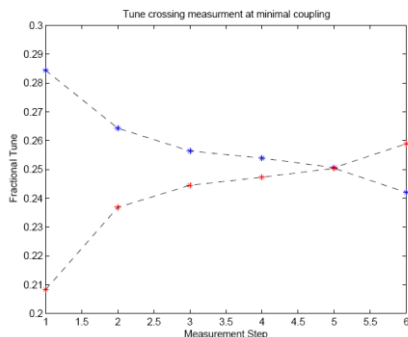
Australian Synchrotron, 800 Blackburn Road, Clayton, 3168, Australia

(Received 16 April 2010; published 29 January 2011)

Investigations into producing an electron beam with ultralow vertical emittance have been conducted using the Australian Synchrotron 3 GeV storage ring. A method of tuning the emittance coupling ( $\epsilon_y/\epsilon_x$ ) has been developed using a machine model calibrated through the linear optics from closed orbits method. Direct measurements of the beam emittance have not been possible due to diagnostic limitations, however two independent indirect measurements both indicate a vertical emittance of 1.2–1.3 pm rad ( $\epsilon_y/\epsilon_x = 0.01\%$ ). Other indirect measurements support the validity of these results. This result is the smallest vertical emittance currently achieved in a storage ring.

DOI: [10.1103/PhysRevSTAB.14.012804](https://doi.org/10.1103/PhysRevSTAB.14.012804)

PACS numbers: 29.27.Fh, 41.75.Ht



$$\epsilon_y = 1.24 \pm 0.4 \text{ pm}$$

World low at the time

SLS has now achieved 0.9 pm

Our new results are indicating

$$\epsilon_y < 0.5 \text{ pm}$$

# Vertical Undulator Spectrum

PRL **109**, 194801 (2012)

PHYSICAL REVIEW LETTERS

week ending  
9 NOVEMBER 2012

## Observation of Picometer Vertical Emittance with a Vertical Undulator

K. P. Wootton,<sup>1,\*</sup> M. J. Bolland,<sup>1,2</sup> R. Dowd,<sup>2</sup> Y.-R. E. Tan,<sup>2</sup> B. C. C. Cowie,<sup>2</sup> Y. Papaphilippou,<sup>3</sup>  
G. N. Taylor,<sup>1</sup> and R. P. Rassool<sup>1</sup>

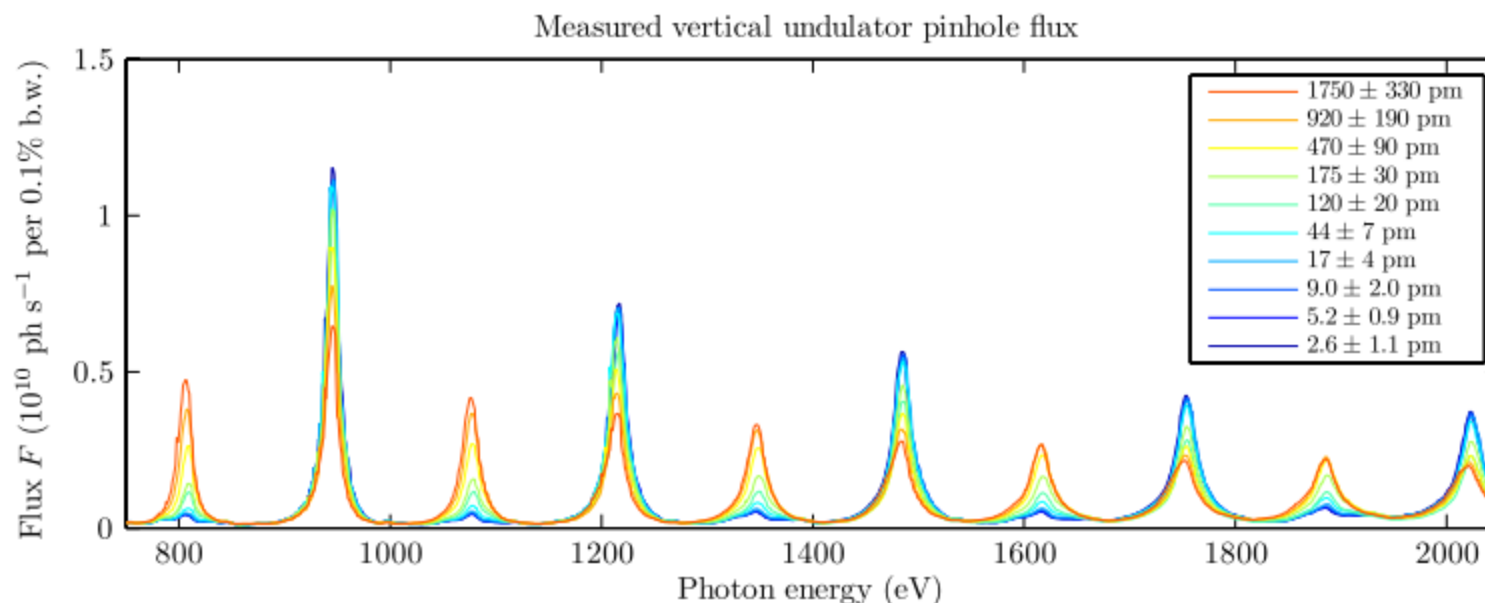
<sup>1</sup>*School of Physics, The University of Melbourne, Melbourne VIC 3010, Australia*

<sup>2</sup>*Australian Synchrotron, 800 Blackburn Road, Clayton VIC 3168, Australia*

<sup>3</sup>*European Organization for Nuclear Research (CERN), BE Department, 1211 Geneva 23, Switzerland*

(Received 11 July 2012; published 8 November 2012)

Using a vertical undulator, picometer vertical electron beam emittances have been observed at the Australian Synchrotron storage ring. An APPLE-II type undulator was phased to produce a horizontal magnetic field, which creates a synchrotron radiation field that is very sensitive to the vertical electron beam emittance. The measured ratios of undulator spectral peak heights are evaluated by fitting to simulations of the apparatus. With this apparatus immediately available at most existing electron and positron storage rings, we find this to be an appropriate and novel vertical emittance diagnostic.



# Formation of ACAS in 2010



ACAS Institutes

Australian Synchrotron

Australian Nuclear Science and Technology Organisation

The University of Melbourne

The Australian National University



# ICHEP 2012 in Melbourne, accelerator based science on the map



20 September 2013

Workshop - X-band technology for FELs -  
Mark Boland



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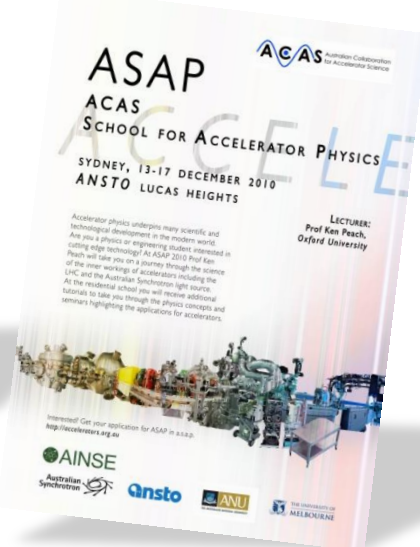




**International Beam Instrumentation  
Conference 2015**  
Melbourne, Australia  
14–17 September, 2015

# ASAP - ACAS School for Accelerator Physics

- 2008 Ted Wilson, CERN/Oxford Uni.
- 2010 Ken Peach, CERN/Oxford Uni.
- 2012 Emmanuel Tsesmelis, CERN/Oxford Uni.
- 2014 Phil Burrows, JAI/Oxford Uni. – 13-24 January 2014, Melbourne



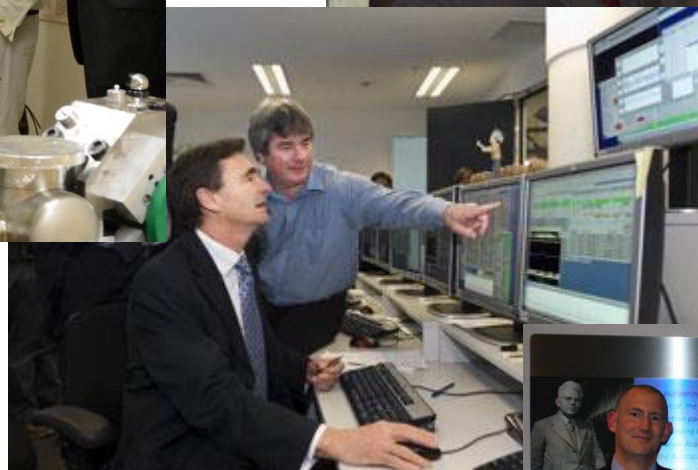


# ACAS – Building the future

- Nurture students into accelerator physics
- Graduates now working with medical accelerators
- Willing to contribute to ambitious science projects
- Strong desire to collaborate



# Healthy democracy since 2007







**Australian Synchrotron**