

The African Light Source Project

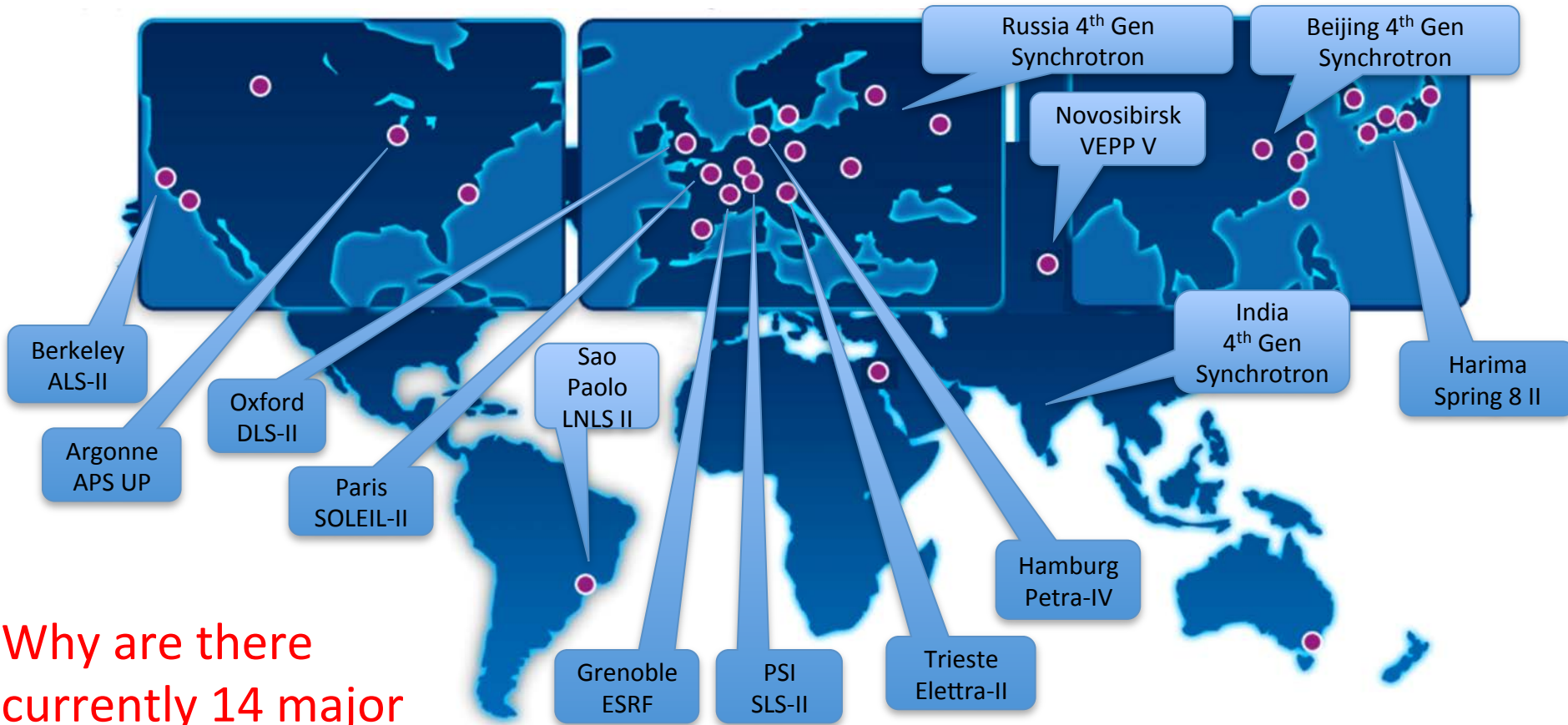


There are about 31
3rd generation **Light Sources** as at
October 2017 ...

What are they ?
Why are they distributed like this ?

Graphic adapted from ESRF source

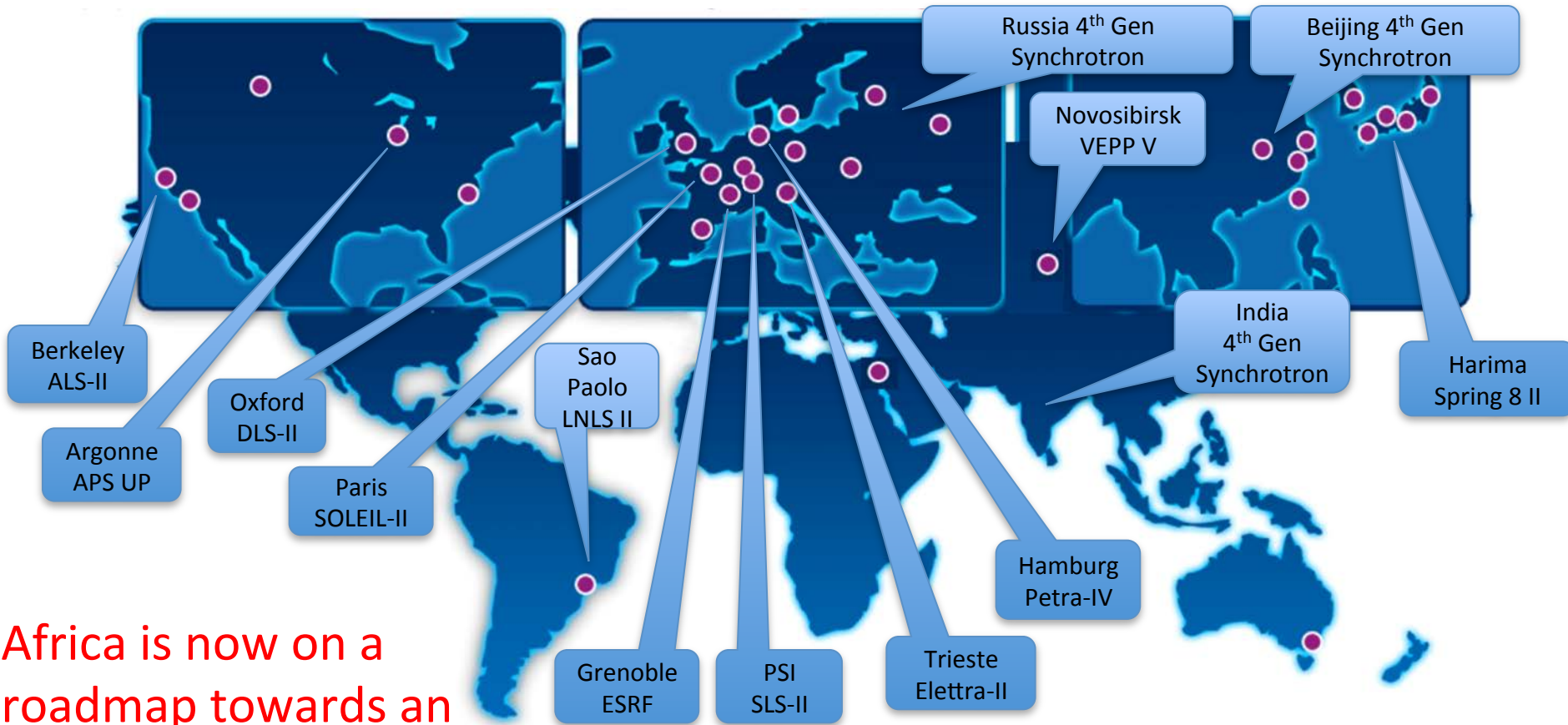
The African Light Source Project



Why are there currently 14 major upgrades / new builds ?

Graphic adapted from ESRF source

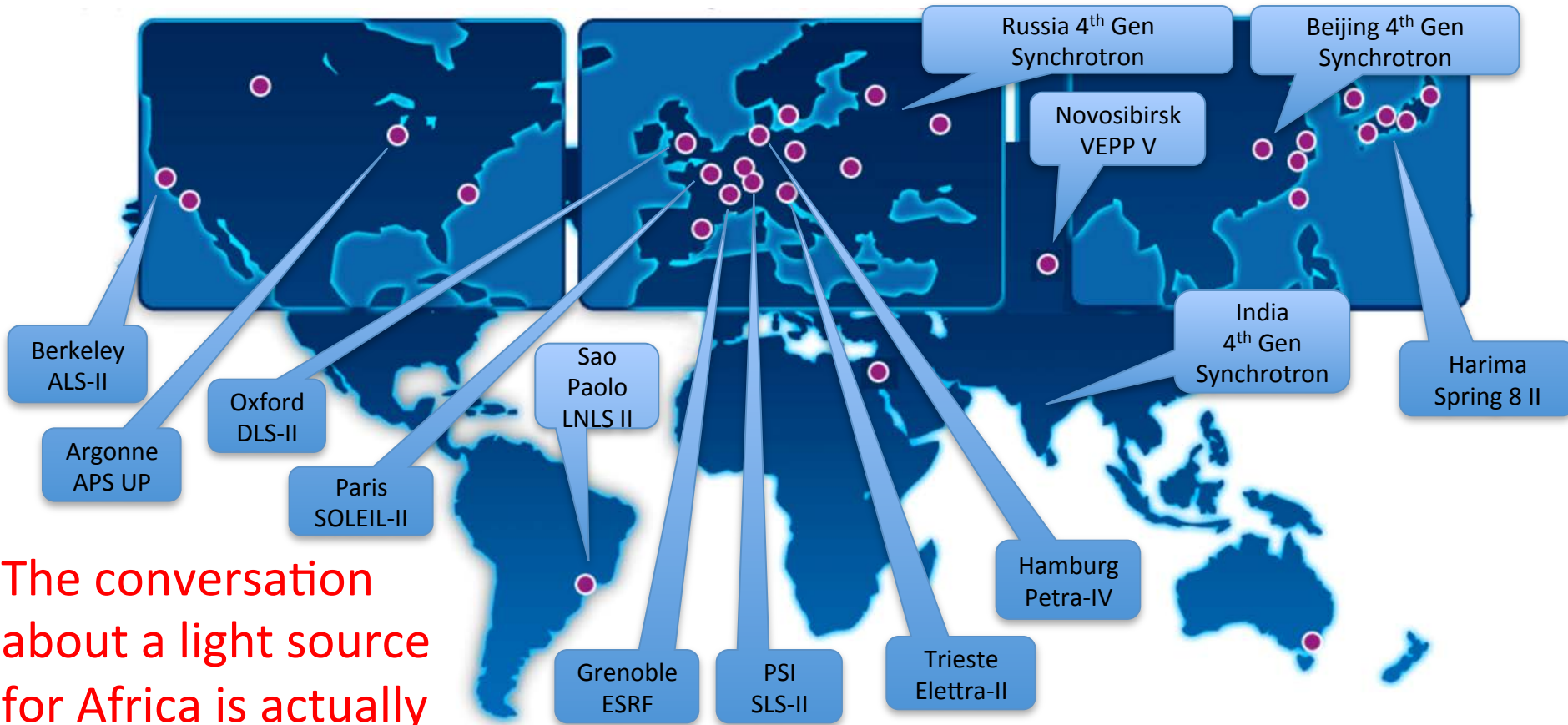
The African Light Source Project



Africa is now on a roadmap towards an African Light Source

Graphic adapted from ESRF source

The African Light Source Project



The conversation about a light source for Africa is actually some decades old.

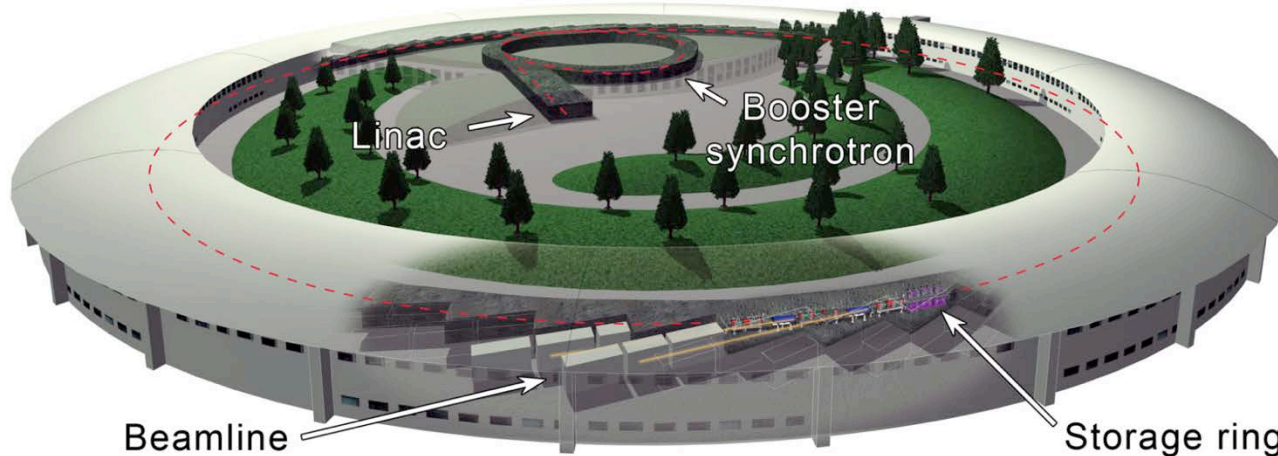
Graphic adapted from ESRF source

The African Light Source Project



What is a Light Source (synchrotron / FEL) transformative scientific instruments similar to the invention of conventional lasers and computers ...
premier research tool for

- Bio science, materials science, geo science, paleontology, archeology, environmental science, energy science, chemistry, industry





The African Light Source Project



Socio-economic benefits

- Boost African Scientific Research, Research Capacity (Continent, regions, Institutes), Capacity Building - African Science Renaissance
- Global Research Community
- Tackling Diseases (Malaria, TB, Aids, Ebola)
- Unique African Research Opportunities attracting international collaboration : Energy opportunities, African Environment, Cradle of Humankind, Cradle of Culture, Mineral beneficiation, Agriculture.
- Mobility, Conferences, Schools, International Mentoring partnerships in student training, Regional Centres of Excellence, Local feeder instrumentation
- Build Research capacity in Industry, competitive industry
- **Science for Peace (eg SESAME – discussed this week)**
- Return of the African Science Diaspora - new opportunities for young excellent scientists
- For African countries to take control of their destinies and become major players in the international community

The African Light Source Project

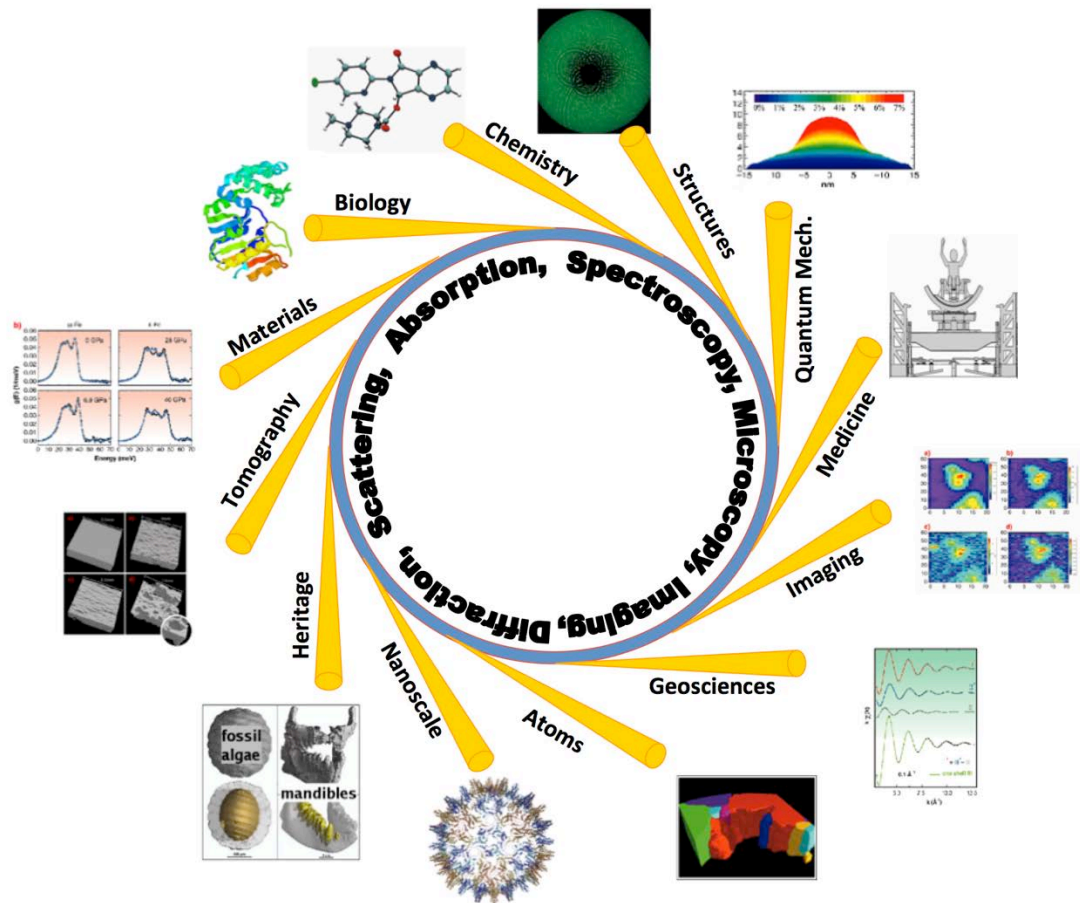


Some examples of Science with Synchrotrons

Multidisciplinary

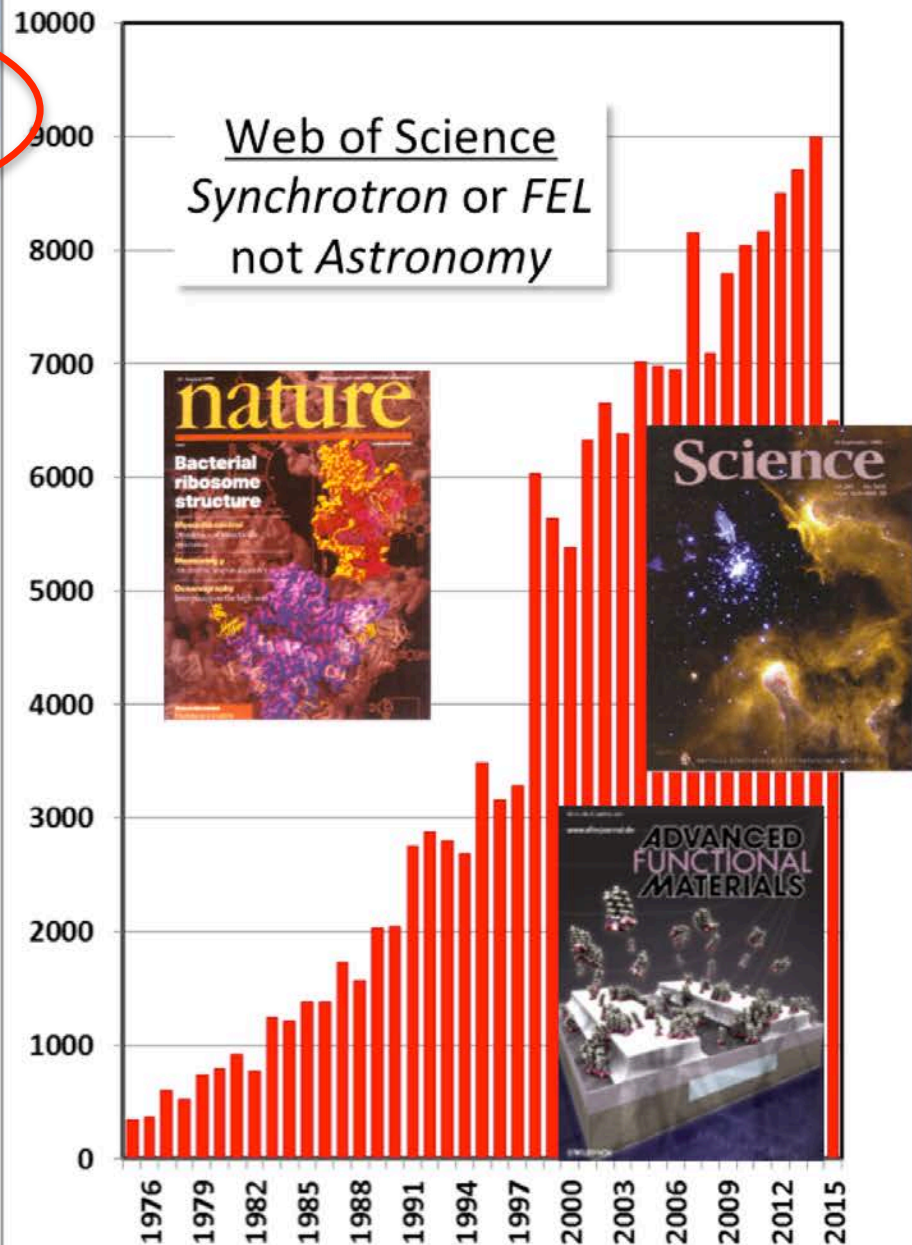
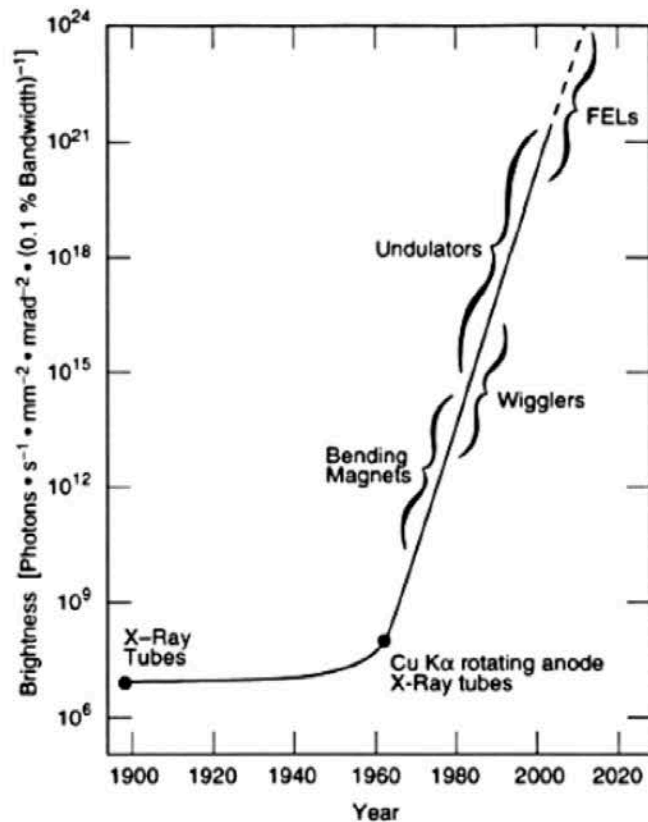
- Research
- Technology
- Industry

* Credit inferred from each slide



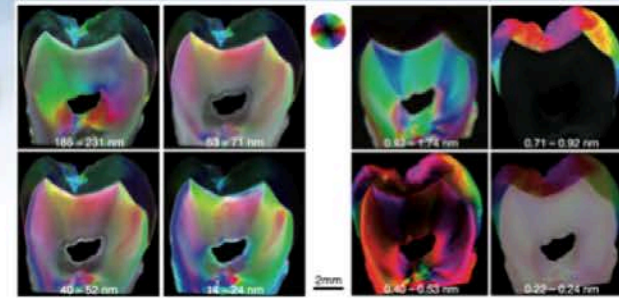
Growth in Synchrotron Science

- Steady growth in past four decades – big jump in late 1990's fueled by 3rd-SRs

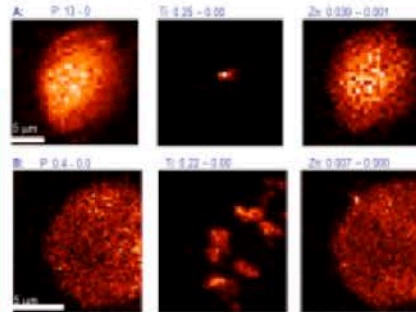
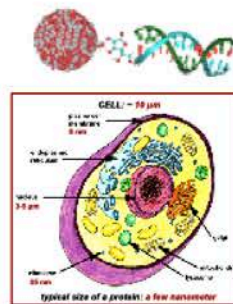


Integrated Tools for Multi-scale Bioscience

.... actually MANY areas !

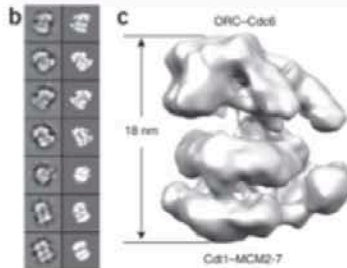


X-ray Imaging (<math>< 1 \mu\text{m}</math> scale)



X-ray Microscopy (10-100nm scale)

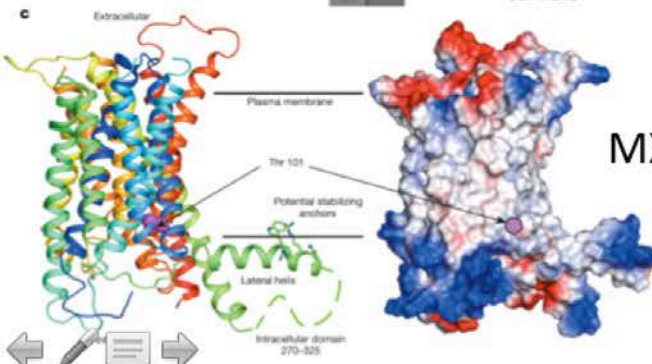
Cryo-EM (nm scale)



SAXS/WAXS (nm scale)



MX (atomic scale)



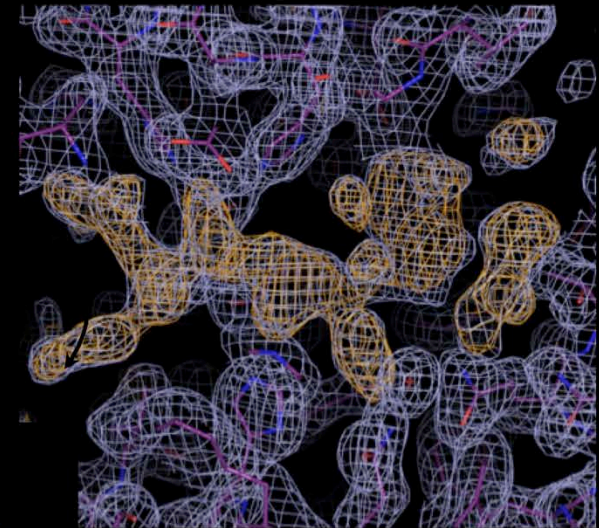
Multiscale Biosciences at NSLS-II:

- Develop & provide integrated X-ray and complementary tools across multiple length scales along with tools for data handling and integration

Drug design for hypertension

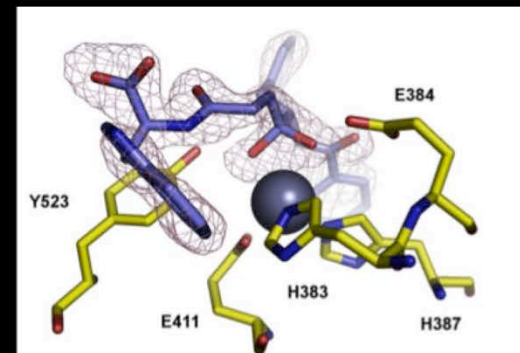
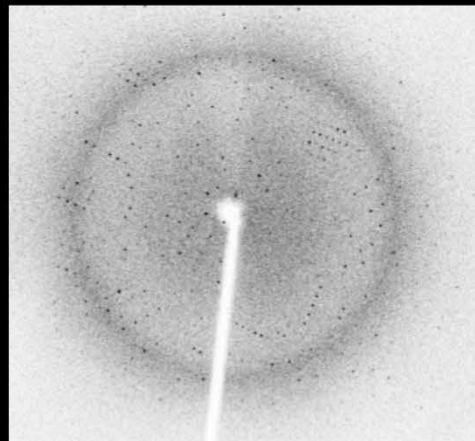
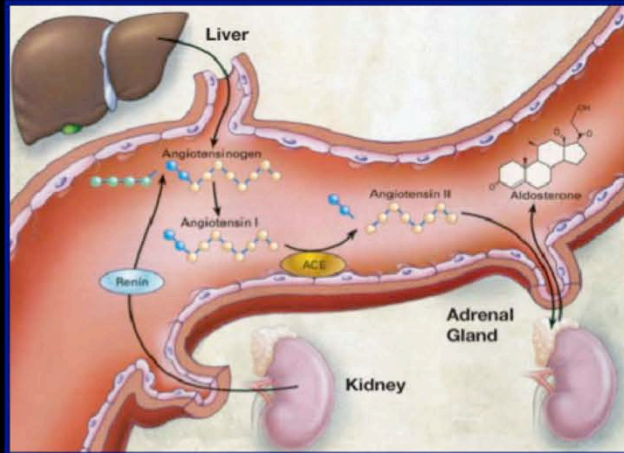


Dr. Jean Watermeyer



High blood pressure is treated using inhibitors of angiotensin-converting enzyme.

X-ray crystallography allows visualisation of locally-designed, novel inhibitors binding to the enzyme.

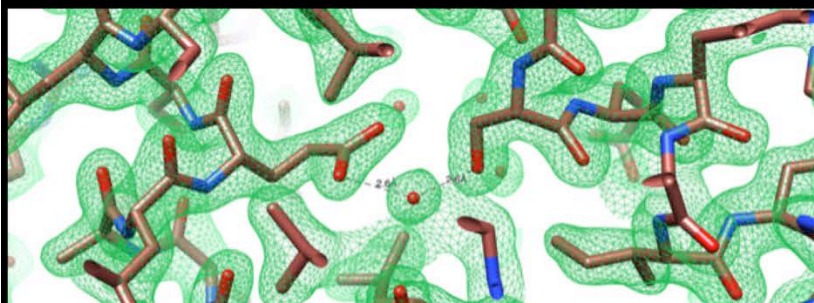


Water purification is achieved through polyacrylamide flocculation
Acrylamide is made in kiloton quantities using nitrile hydratase



Dr Jennifer van Wyk

Naturally occurring nitrile hydratase



Enzyme modified for greater thermostability

Better enzymes for acrylamide manufacture are designed using structural knowledge





THE AFRICAN LIGHT SOURCE CONFERENCE AND WORKSHOP

16 - 20 NOVEMBER 2015, ESRF GRENOBLE FRANCE



INSTITUT MAX VON LAUE - PAUL LANGEVIN



Structural biology: A powerful tool to gain insight into the biology of the malaria parasite, *Plasmodium falciparum*

Theresa L. Coetzer^a, Manuel Blanc^b, Daniel R Meyersfeld^a, Juliette Devos^b, Kubendran Naidoo^a, Malene Ringkjøbing Jensen^c, Sonja B Lauterbach^a, Martin Blackledge^c, Michael Haertlein^b, V. Trevor Forsyth^{b,d}, Edward P. Mitchell^e

^a WITS Medical School, NHLS, Johannesburg, Republic of South Africa.

^b Life Sciences Group, Institut Laue-Langevin, 71 Avenue des Martyrs, 38000 Grenoble, France.

^c IBS, 71 Avenue des Martyrs, 38000 Grenoble, France.

^d Faculty of Natural Sciences, Keele University, Staffordshire, ST5 5BG, United Kingdom.

^e ESRF, 71 Avenue des Martyrs, 38000 Grenoble, France.



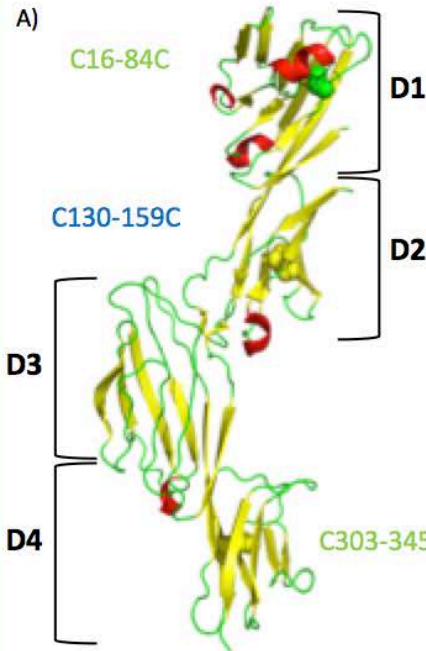
Structural studies of dynamic CD4 changes relevant to HIV infection

J.A. Channell^{1,2,4,5}, N. Cerutti³, M. Moulin¹, T. Forsyth^{1,4}, M. Haertlein¹, E. Mitchell^{2,4}, A. Capovilla³, M. Papathanasopoulos³

From the ILL Life Sciences Group¹ and the ESRF Business Development Office², Grenoble, France, the HIV Pathogenesis Research Unit in the Department of Molecular Medicine and Haematology at the University of the Witwatersrand, Johannesburg, South Africa³, EPSAM, Keele University, UK⁴ and the South African Medical Research Council⁵.

CD4 is the primary receptor for HIV-1 surface glycoprotein, gp120. Preliminary data suggests that gp120 binds a specific redox isomer of CD4 in which its second domain, metastable allosteric disulphide bond is reduced. A collaboration exists between the ILL, ESRF and HPRU to use high and low-resolution X-ray and neutron scattering techniques to determine the structural implications of CD4 redox biology on gp120 binding and will thus aid in rational design of HIV-1 entry inhibitors.

Scientific Background



HIV is the causative agent of AIDS infecting CD4⁺ and CCR5/CXCR4⁺ cells of the innate and adaptive immune systems of more than 35million people, worldwide. CD4 is the primary receptor of trimeric HIV-1 surface antigen (env) and specifically binds gp120. CD4 has a transmembrane (TM), a cytosolic tail (CT) and 4 ecto-domains (D1-4) of which D1,2 & 4 contain disulphide bonds (fig. 1A,B)². D2 contains a non canonical configuration of disulphide bond (-RHStaple) which is metastable and associated with an unusual class of disulphide bonds called the allosteric disulphides. Biochemical analyses show that CD4 can only bind gp120 when its D2 disulphide bond is reduced³ (fig.1C). Physiologically, CD4's function is involved in the adaptive immune response and can be found on resting T-cells in fully oxidised monomers and on active T-cells in D2 swapped disulphide dimers. Therefore, the partially reduced CD4 redox isomer (2dCD4^{R1}) is a functionally and therefore a potentially structurally unique CD4 species able to bind gp120.

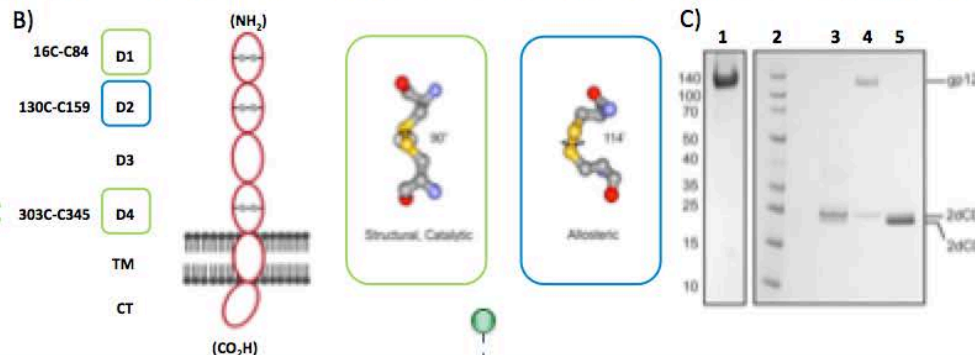


Figure 1: A) Ecto-domains of CD4 1-4. The disulphide bonds in D1, 2 and 4 are shown in space filling mode. (generated using PyMOL from PDB ID 1W1Q)¹. B) Schematic depicting full-length, oxidised, monomeric CD4 as found on the resting T-cell. The D1 and 4 disulphides are structural whereas the D2 disulphide bond belongs to the allosteric family of disulphide bonds. C) 1=gp120 control, 2=molecular weight marker, 3=pre-bound CD4 redox isomers, 4=gp120-CD4 bound fraction, 5=unbound CD4 fraction. SDS-PAGE showing that only the partially reduced 2dCD4^{R1} species is capable of binding CD4³.



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16 - 20 NOVEMBER 2015, ESRF GRENOBLE FRANCE



MAPPING THE EPITOPE: DEFINING THE STRUCTURE OF THE HIGHLY IMMUNOGENIC ENV-CD4 COMPLEX

Gavin Owen, Nichole Cerutti, Mark Killick, Edward Mitchell,
Michael Haertlein, Trevor Forsyth, Maria Papathanasopoulos



INTRODUCTION

Despite recent advances in the design of HIV-1 Env-based vaccine immunogens, such immunogens have not yet elicited broadly cross-reactive neutralizing antibodies against circulating primary HIV (Fig. 1). A major research aim of the HIV Pathogenesis Research Unit (HPRU) at the University of the Witwatersrand in South Africa is the evaluation of vaccine design strategies to identify Envelope(HIV)-CD4(human host) (Fig. 2) vaccine immunogens capable of inducing potent, durable, and broadly protective neutralizing antibodies responses against clinically relevant HIV-1 subtype C.

The HPRU has focused on the development of an effective prophylactic HIV vaccine which utilizes a novel immunogen called Env-2dCD4^{S60C} that consists of a human two domain CD4 with an S60C mutation (2dCD4^{S60C}) covalently bound to monomeric gp120 (Fig. 3). We have designed, expressed, and purified sufficient quantities of the recombinant gp120 monomers, the 2dCD4^{S60C} capable of forming a covalent interaction with Env, and have subsequently generated, isolated, and performed functional analyses on the novel covalent complex (reported in [1]).

HIV and its interaction with CD4

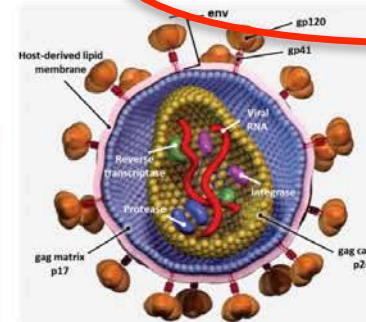


Fig. 1: A model representation of the structural organization of the HIV-1 virion and its associated proteins [2].

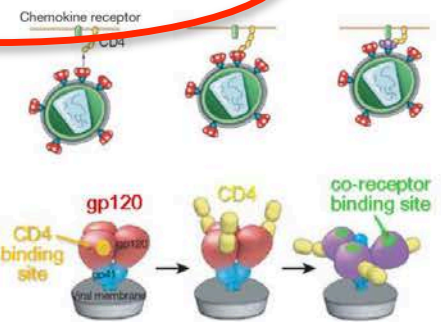
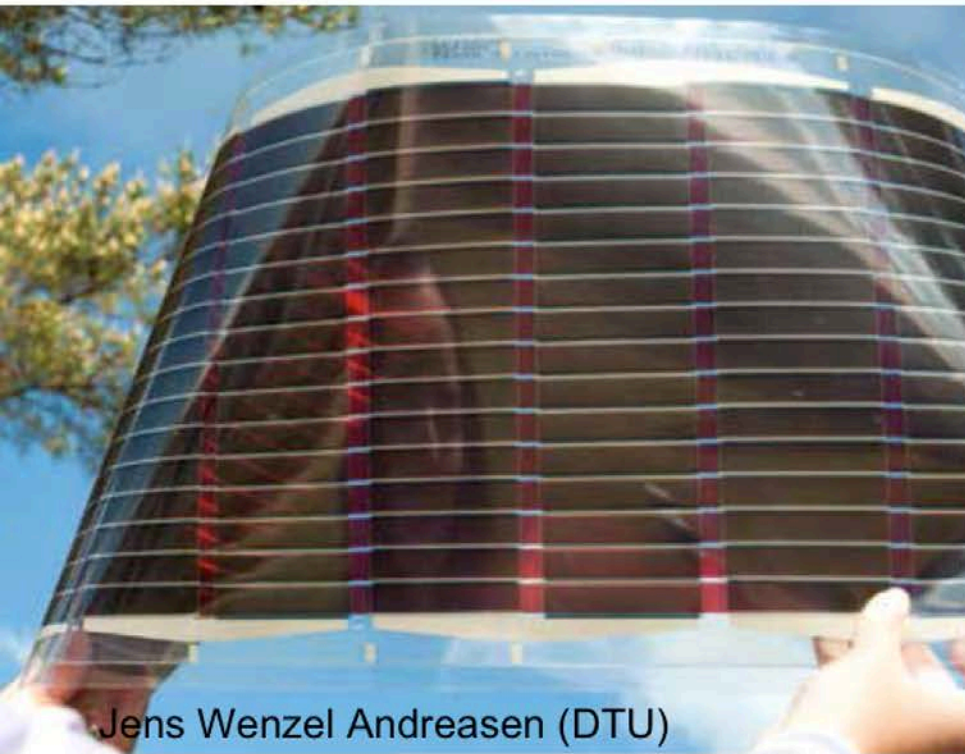


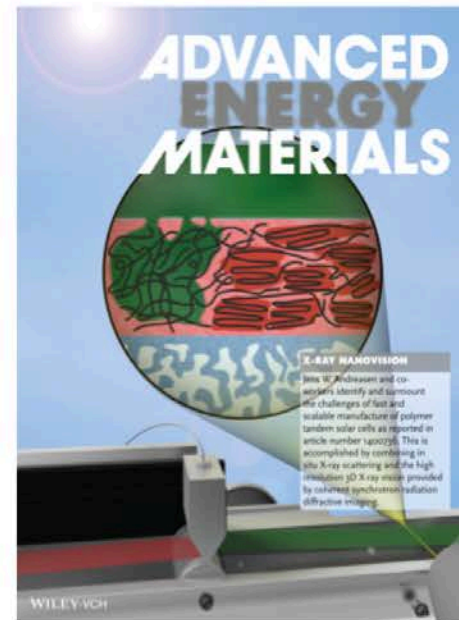
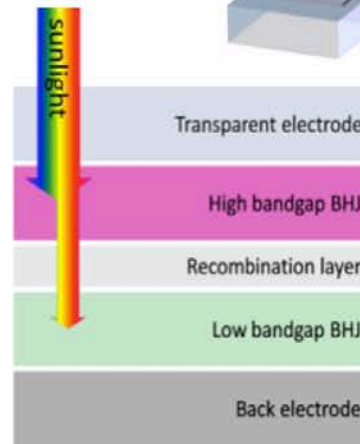
Fig. 2: Conformational changes in the gp120 trimeric spike induced by CD4 binding and the associated consequences for viral attachment to the target cell [3].

Organic Solar cells @ PETRA III

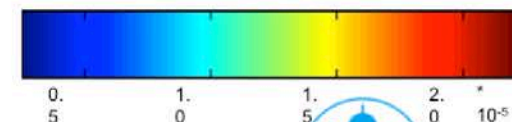
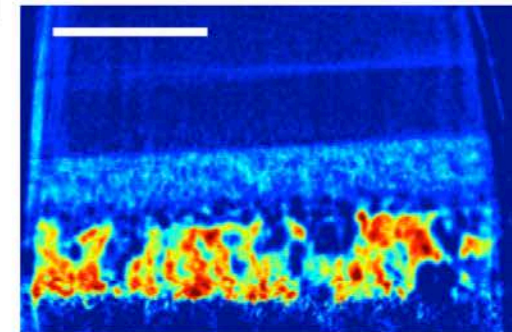
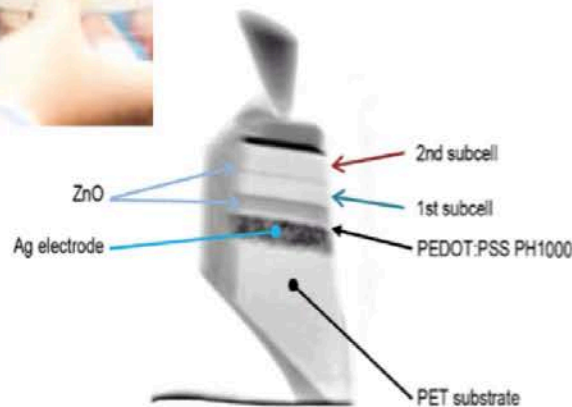
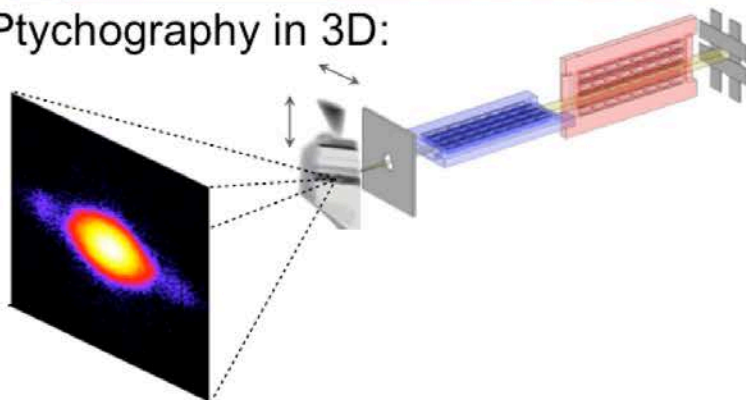
The Danish Technical University project on organic solar cells



Jens Wenzel Andreasen (DTU)



Ptychography in 3D:



Why do palaeontologists are interested in X-rays?

200 Mys old dinosaur embryo



165 Mys old cephalopod



Fragile and unique fossils limit physical preparation



Some sediment must be kept

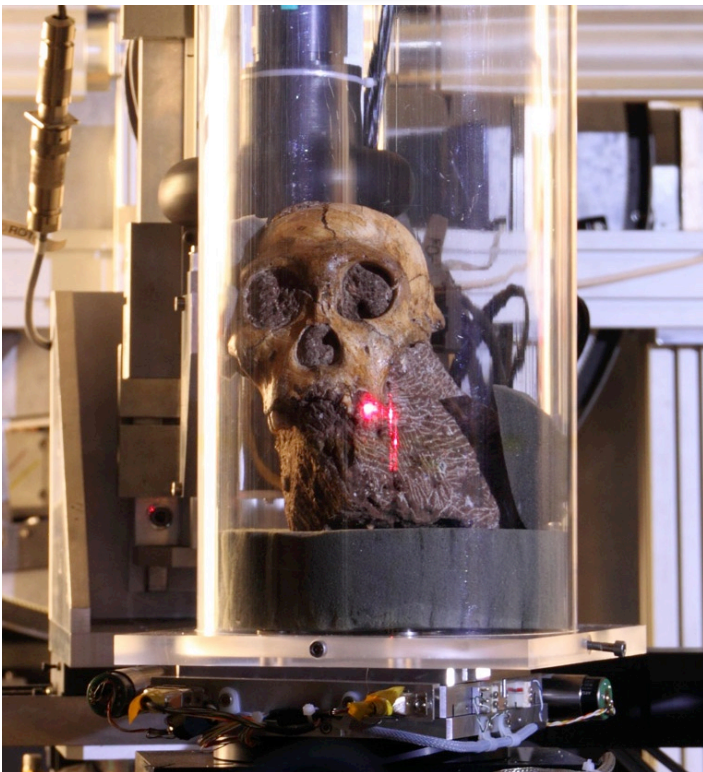


Micro-jack-hammer

The African Light Source Project



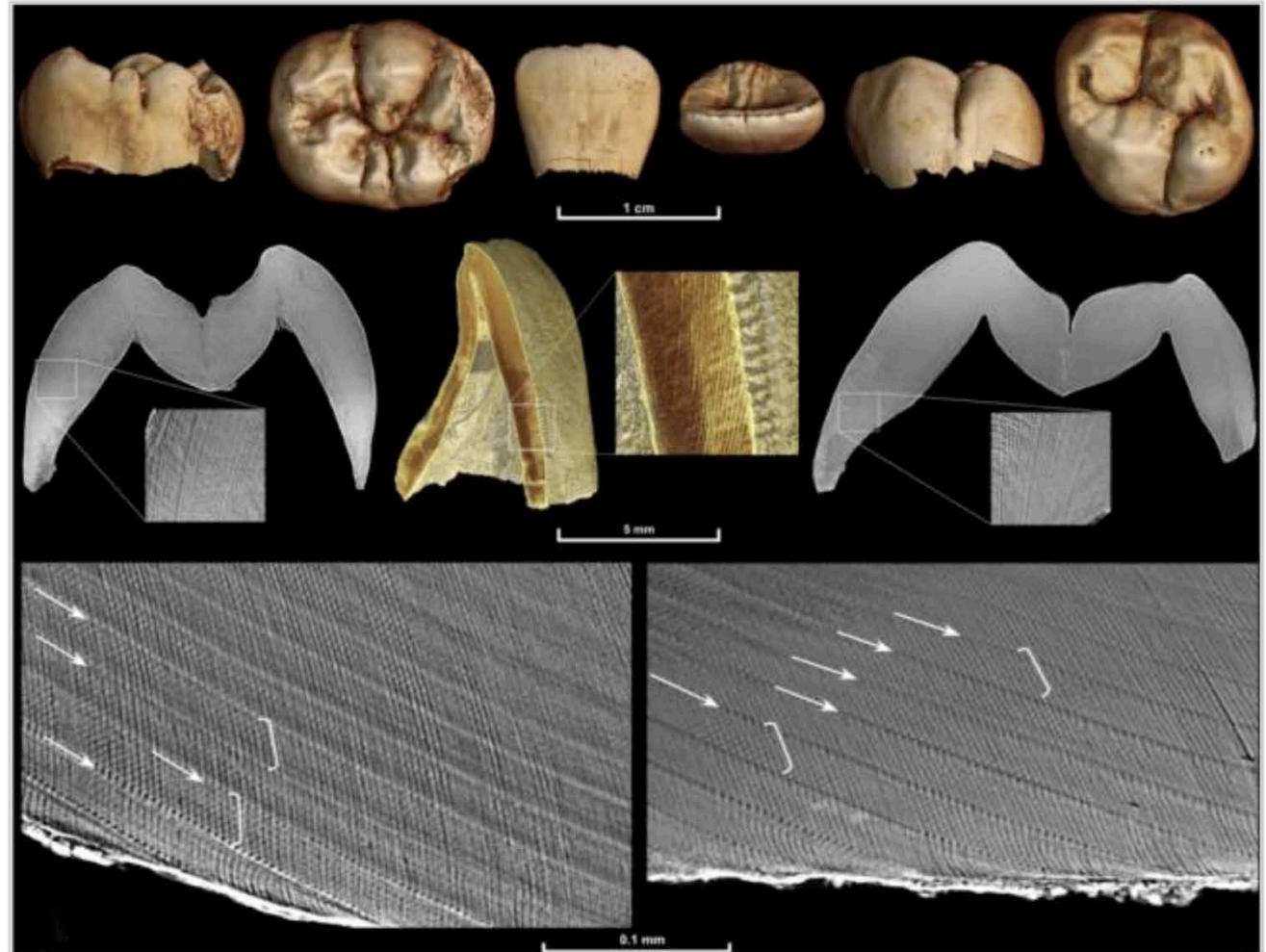
Paleontology



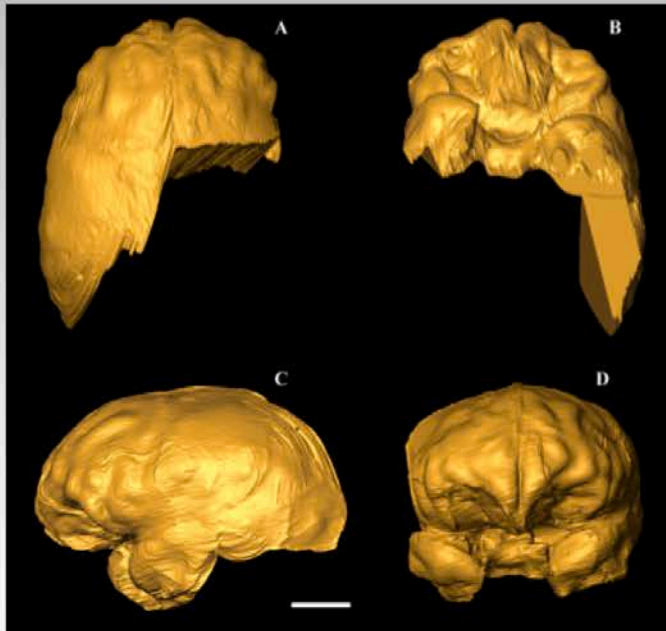
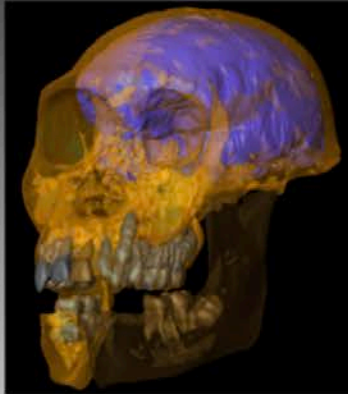
Dental Ontogeny in Pliocene and Early Pleistocene Hominins

T.M. Smith, P. Tafforeau,
A. Le Cabec, A. Bonnin,
A. Houssaye, J. Pouech,
J. Moggi-Cecchi,
F. Manthi, C. Ward,
M. Makaremi &
C.G. Menter

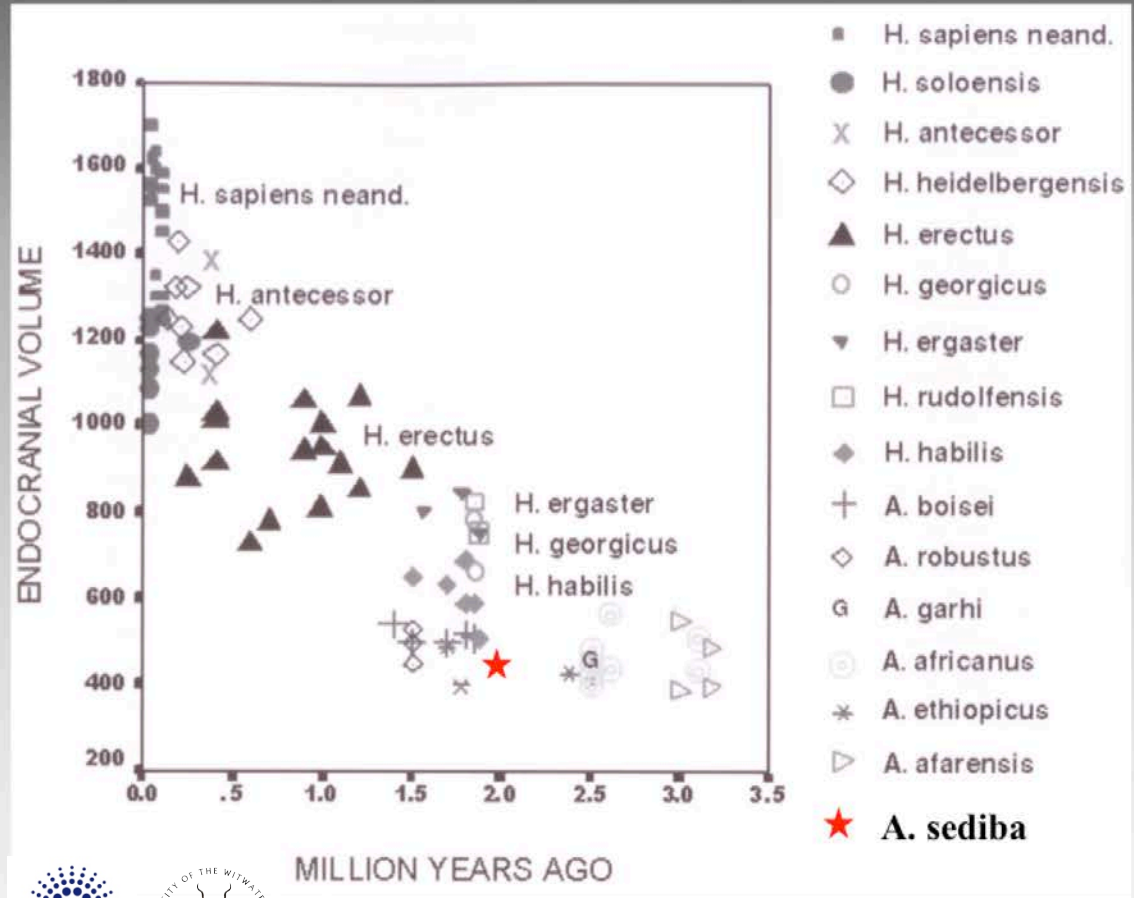
Phase contrast X-ray
synchrotron
microtomography,
Submicron
resolution,
unprecedented
contrast



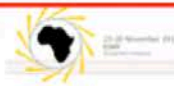
Human brain evolution



Carlson et al. (2011)



Modified from Holloway et al. (2004)



Fossilized burrow: 251 million years old

OPEN ACCESS Freely available online

PLOS ONE

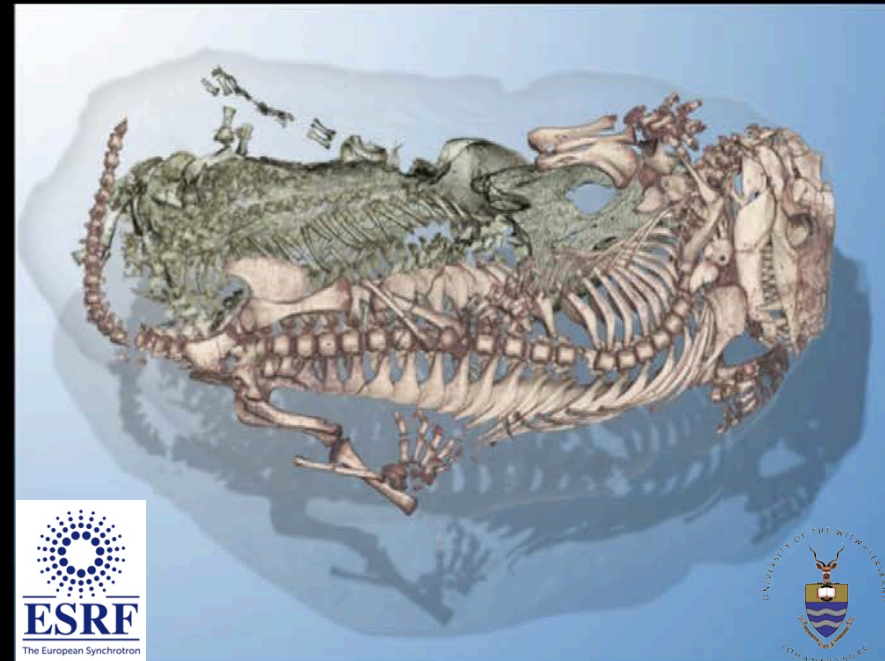
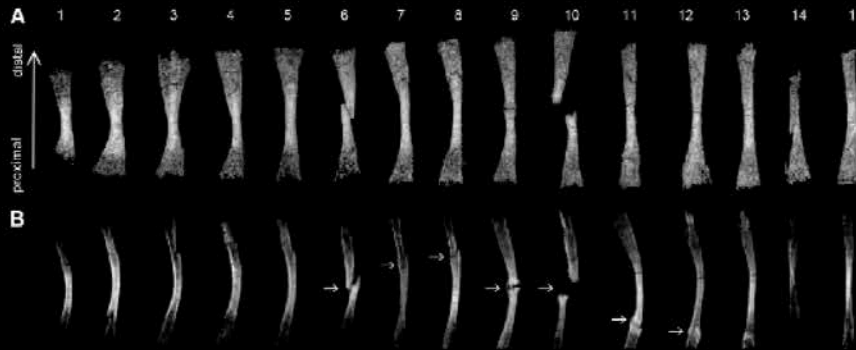
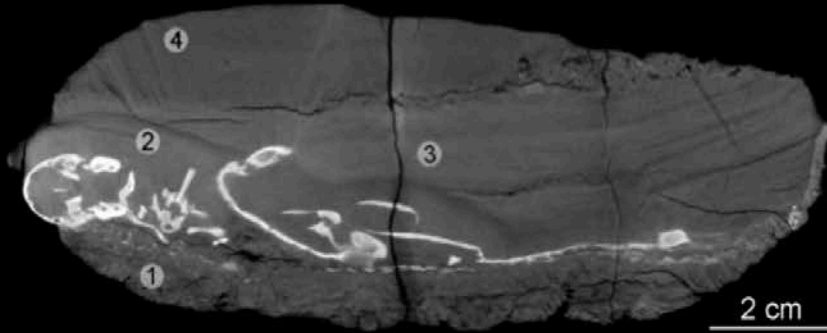
Synchrotron Reveals Early Triassic Odd Couple: Injured Amphibian and Aestivating Therapsid Share Burrow

Vincent Fernandez^{1*}, Fernando Abdala¹, Kristian J. Carlson^{1,2}, Della Collins Cook², Bruce S. Rubidge¹, Adam Yates^{1,3}, Paul Tafforeau⁴

Fernandez et al. (2013) PLoS ONE

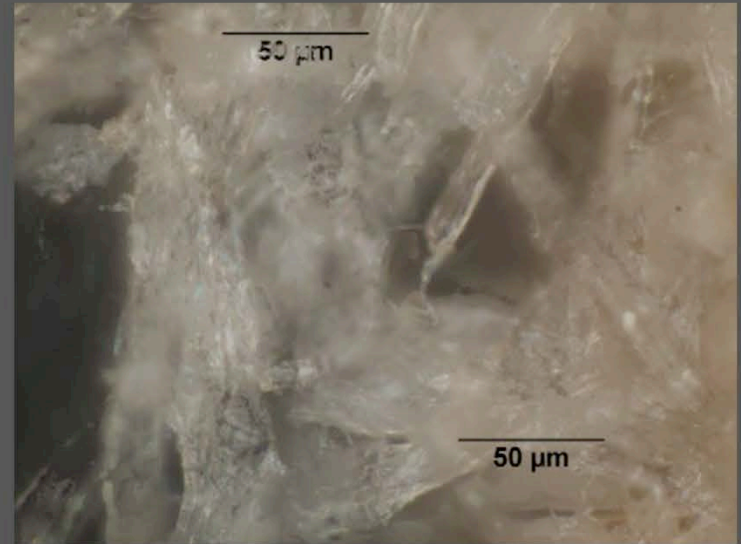
Broomistega putterilli

Thrinaxodon liorhinus



Investigation of the **manufacturing technologies** used to produce historical documents in the southern African region
Chemical composition and degradation pathways of African historical documents
Ink, fibre and sizing analysis of African historical documents

Collaboration with institutions that deal with archaeological objects for resource sharing



Historical documents : Timbuktu

Research stay of Kaitano Dzinavatonga to work on proposals, start preparing samples and perform preliminary tests

African Light Source Conference
Loïc Bertrand 17 November 2015

IPANEMA | ARCHAEOLOGY
CONSERVATION SCIENCES
PALAEOANTHROPOLOGY
PALAEO-ENVIRONMENTS | ANCIENT MATERIALS
RESEARCH PLATFORM



South African rock art

St. Hoerlé, S. Mguni, D. Pearce, C. Sandt, L. Jacobson, L. Bertrand...



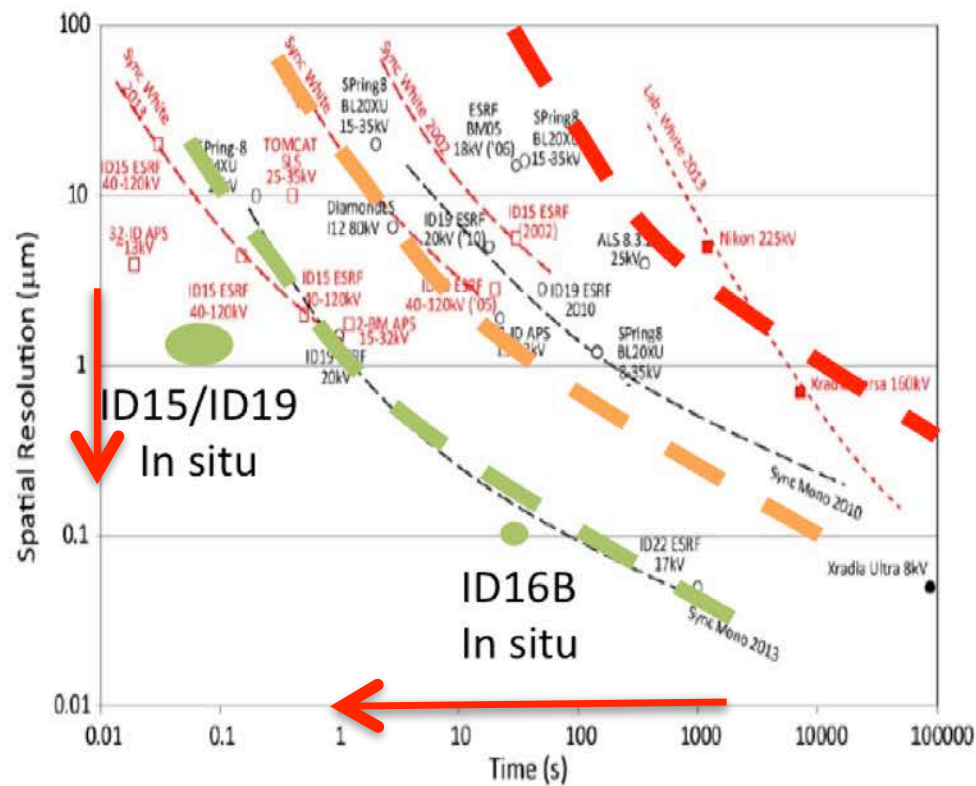
McGregor museum



AHRI

Technological Advance:

1 measured point \rightarrow 4D data (3 space and time) - improvements of 10^4



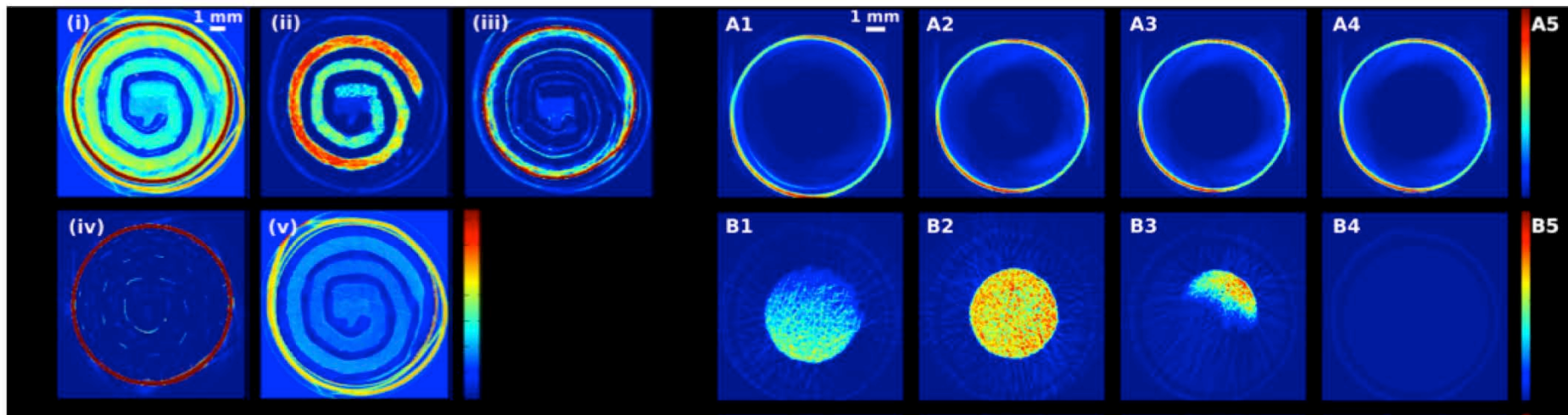
- 4D tomography helps understanding material science phenomena if you like to see things !!
- Scans in less than 1s with 1µm resolution can be done
- Scans in less than 30s with 100nm resolution can be done
- It can help to validate numerical modelling
- Various set up have been developed for thermal treatment or mechanical testing
- Trends : faster and / or higher spatial resolution and multi resolution



The African Light Source Project



ctPDF of Battery materials



10,000 2D datasets per image, 30 mins per image ~10Tb/day
Jensen, Corr, Di Michiel, SJLB et al., *J. Electrochem. Soc.* (2015)



The African Light Source Project



After a consultative process and an digital election, the Interim Steering Committee for the African Light Source was formed

Launch of the Interim Steering Committee for the African Light Source

Launched electronically on the 16th August 2014

Coinciding with the ASP2014 Forum Day

Initial members of the Interim Steering Committee of the African Light Source

These members nominated following communications sent to all available mailing lists and records of interested parties.

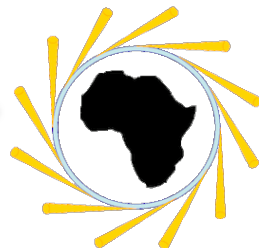
Herman Winick,	SSRL (SLAC) USA
Sekazi Mtingwa	TriSEED, IUPAP
Simon Connell	UJ, SA
Tshepo Ntsoane	Necsa, SA
Jonathan Dorfan	OIST, Japan
Mohammad S. Yousef	Cairo University, Egypt
Tarek Hussein	Cairo University, Egypt
Kennedy Reed	LLNL, USA
Brian Masara	SAIP, SA (Zimbabwean)
Ken Evans-Lutterodt	BNL, USA
Sverker Werin	MAX IV, Sweden
Francesco Sette / ESRF representative	ESRF, Europe
Ahamadou Wague	Universite Cheikh Anta Diop, Senegal
Krystle J. McLaughlin	Lehigh University, USA
Philip Oladijo	Wits, SA (Nigerian)

2014/08/16

Launch : Interim Committee for the African Light Source

1

Plan 1st African Light Source Conference and Workshop in Nov 2015





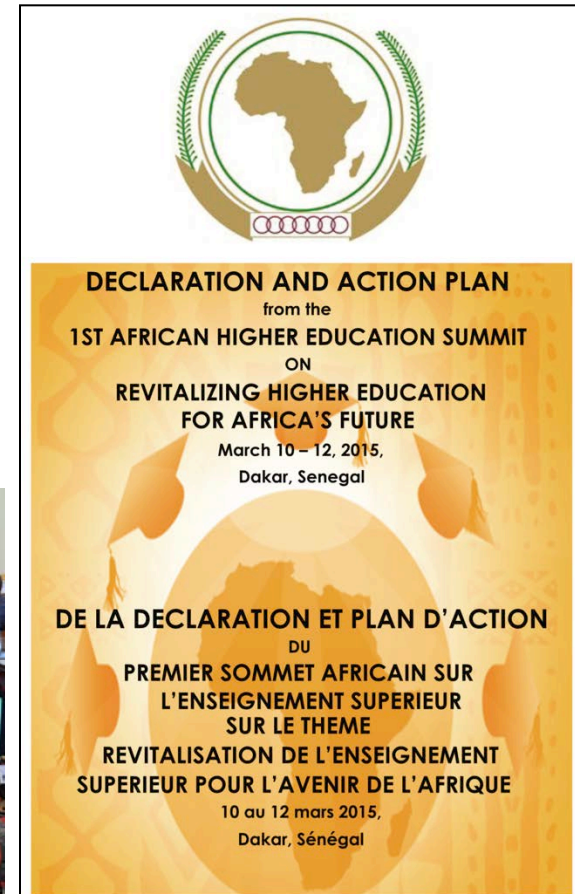
The African Light Source Project



Declaration and Action Plan

1st African Higher Education Summit on Revitalizing Higher Education for Africa's Future,
10-12 March 2015, Dakar, Senegal.

Article 5.3.2 p 22 : Recommends establishing a Synchrotron as a centralized African scientific facility.





THE AFRICAN LIGHT SOURCE CONFERENCE AND WORKSHOP

16 - 20 NOVEMBER 2015, ESRF GRENOBLE FRANCE



Towards the African Light Source

<http://www.saip.org.za/AfLS2015/>





THE AFRICAN LIGHT SOURCE CONFERENCE AND WORKSHOP

16 - 20 NOVEMBER 2015, ESRF GRENOBLE FRANCE



- After a consultative process and an election, the Interim Steering Committee for the African Light Source was formed in August 2014 to organise this event.



- The conference had an assessment phase and an outcomes phase.

A Synchrotron Light Source for Africa

Sekazi K. Mtingwa

After many discussions both within Africa and globally Three major outcomes emanated from the highly suc-



NEWS

Home Video World UK Business Tech Science Magazine Entertainment

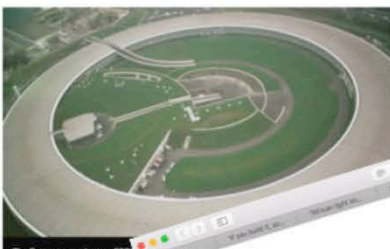


Science & Environment

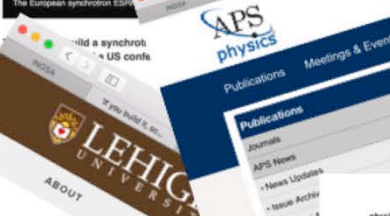
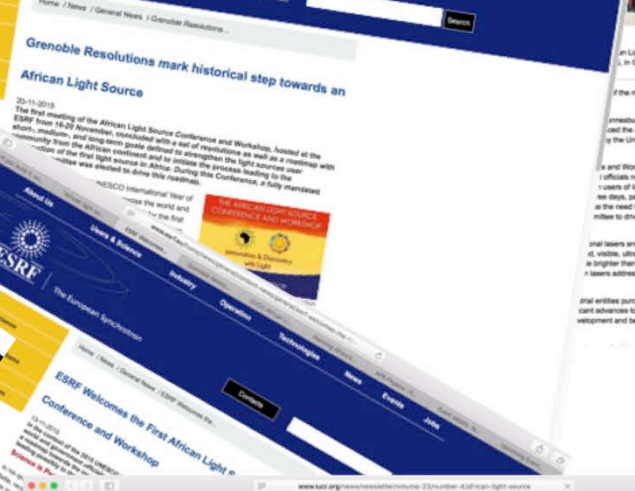
African synchrotron bid gathers pace

By Jonathan Webb
Science reporter, BBC News, San Antonio

5 March 2015 | Science & Environment



The European synchrotron ESRF



physicsworld.com Comment: Forum

A shining light for African science

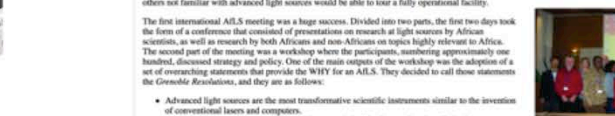
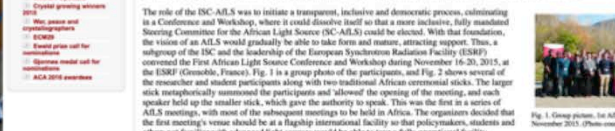
Sekazi Mtingwa calls for physicists to get behind African plans to build the continent's first ever light source

Light sources such as synchrotrons or free-electron lasers have been among the most transformative scientific instruments since the invention of traditional lasers and computers. They embrace almost all spectroscopy, scattering and imaging techniques, using radiation from the infrared to the X-ray and even soft gamma rays. They are also orders of magnitude brighter than traditional lasers. Though costly to build, light sources have resulted in thousands of published papers, provided graduate student training and driven technological innovation.

The extremely high photon flux that light sources provide has allowed big advances to be made in many applications, including drug development, data storage and – based upon the deciphering of protein, bacterial and viral structures – disease



A light source... Africa would e... thousands of A... scientists, engin... and students to g... access to a superh...

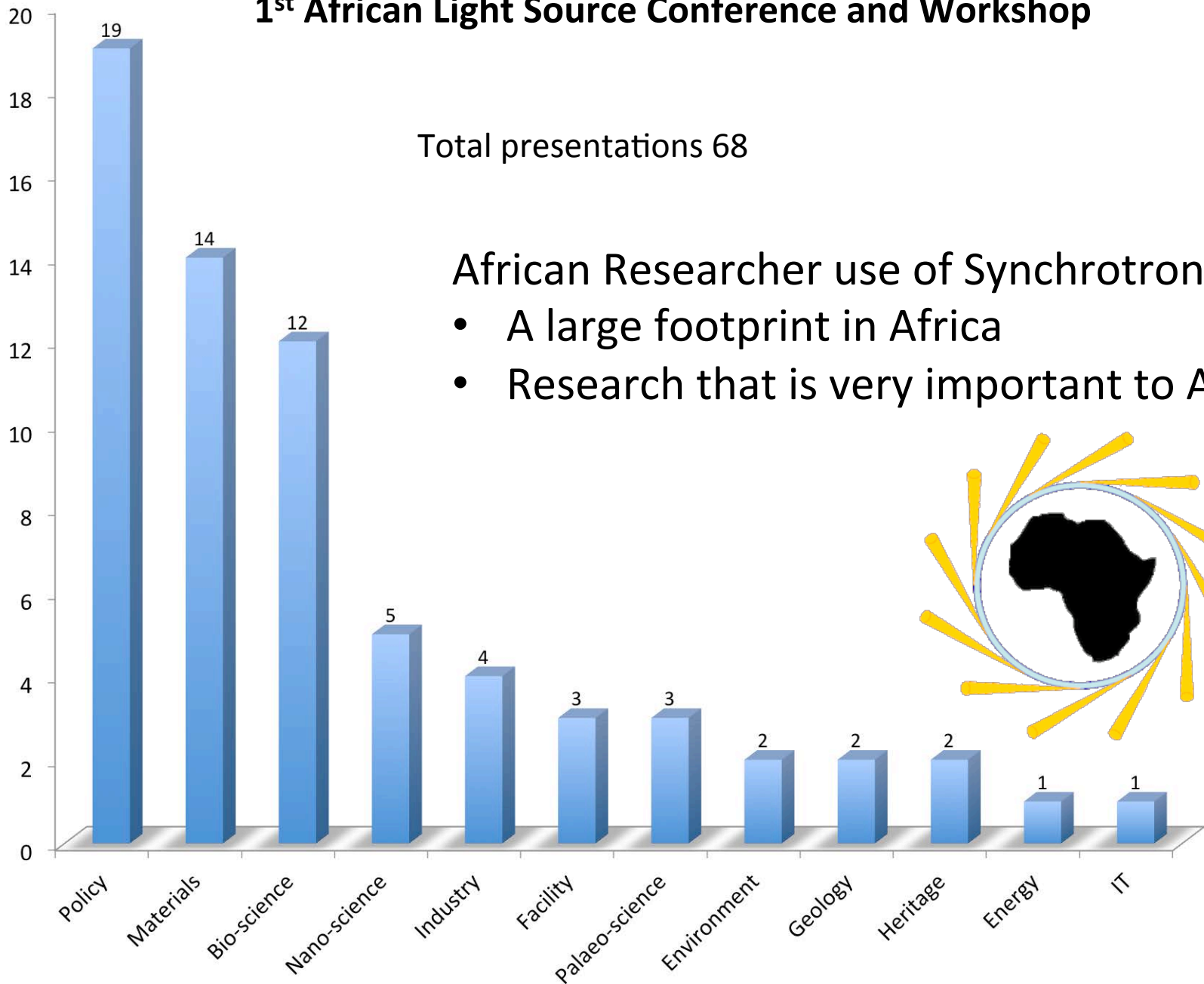


The first international A.L.S. meeting was a huge success. Divided into two parts, the first two days took the form of a conference that consisted of presentations on research at light sources by African scientists, as well as research by both Africans and non-Africans on topics highly relevant to Africa. The second part of the meeting was a workshop where the participants, numbering approximately one hundred, discussed strategy and policy. One of the main outputs of the workshop was the adoption of a set of overarching statements that provide the WHY for an A.L.S. They decided to call those statements the *Grenoble Resolutions*, and they are as follows:

- Advanced light sources are the most transformative scientific instruments similar to the invention of conventional lasers and computers.
- Advanced light sources are revolutionizing a myriad of fundamental and applied sciences, including agriculture, biology, bioelectronics, chemistry, climate and environmental eco-systems science, cultural heritage studies, energy, engineering, geology, materials science, nanotechnology, paleontology, pharmaceutical discoveries, and physics, with an accompanying impact on sustainable living.
- The community of researchers around the world is striving collaboratively to construct ever more intense sources of electromagnetic radiation from synchrotron light sources and X-ray free-electron lasers (XFELs), to address the most challenging questions in biology and condensed matter physics.
- The African Light Source is expected to contribute significantly to the African Science Renaissance, the ethos of the African Science & Technology University Education, the training of a new generation of young researchers, the growth of competitive African industries, and the advancement of science, technology, engineering and innovation in Africa.
- For African countries to take control of their destinies and become major players in the international community, it is inevitable that a construction somewhere on the African continent in the near future, which will promote peace and collaborations among African nations and the global community.

Several of the researcher and student participants who numbered close to a hundred. Two attendees held traditional African ceremonial sticks. The larger stick metaphorically summoned the participants and "allowed" the African leadership to progress the light source to the next stage of development. During the workshop, the participants and "allowed" the African leadership to progress the light source to the next stage of development.

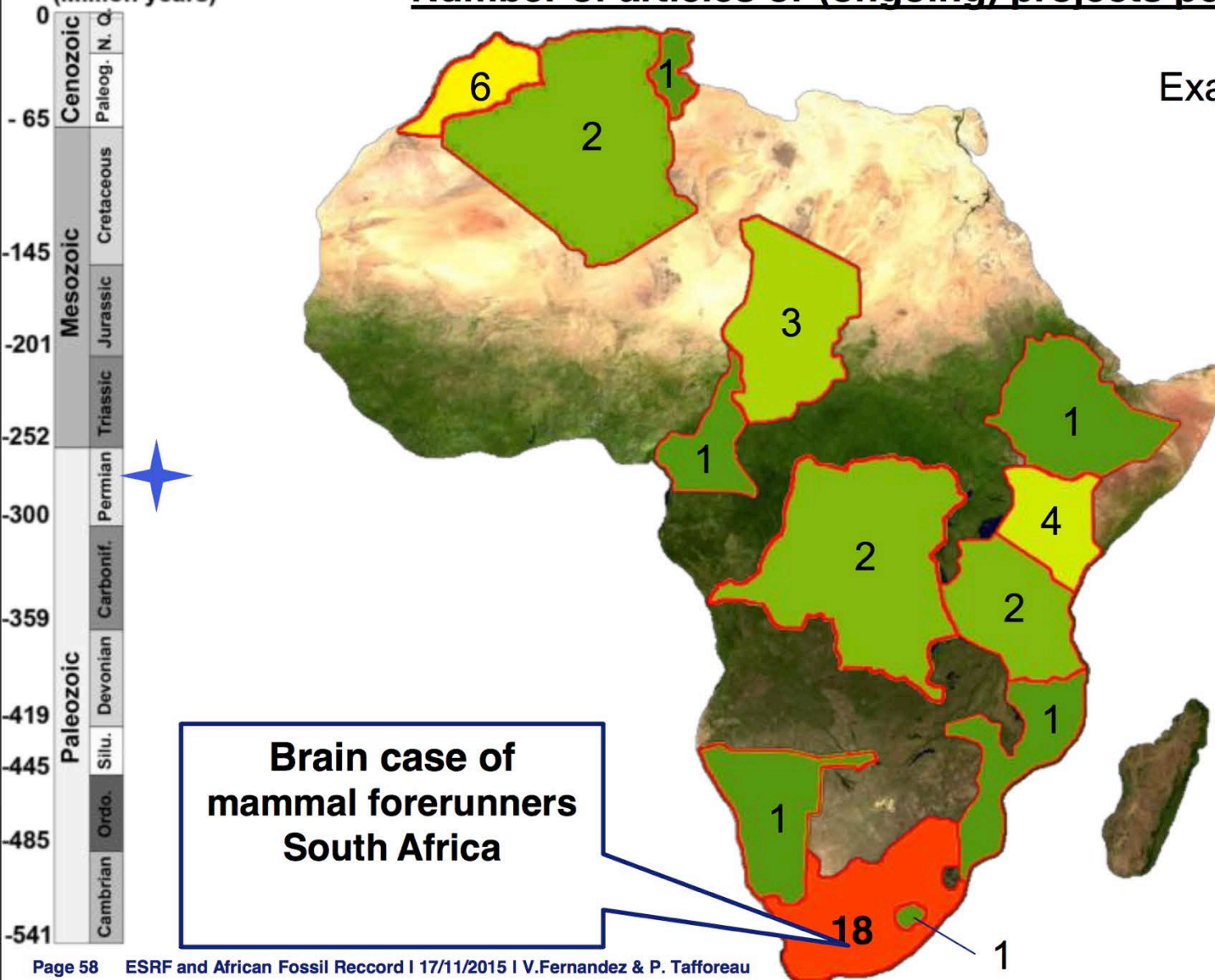
1st African Light Source Conference and Workshop



Age
(Million years)

Number of articles or (ongoing) projects per country

Example of ongoing projects



**Brain case of
mammal forerunners
South Africa**

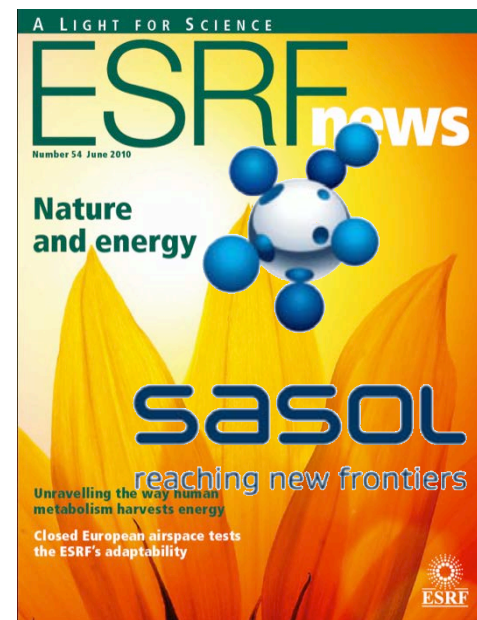
The African Light Source Project



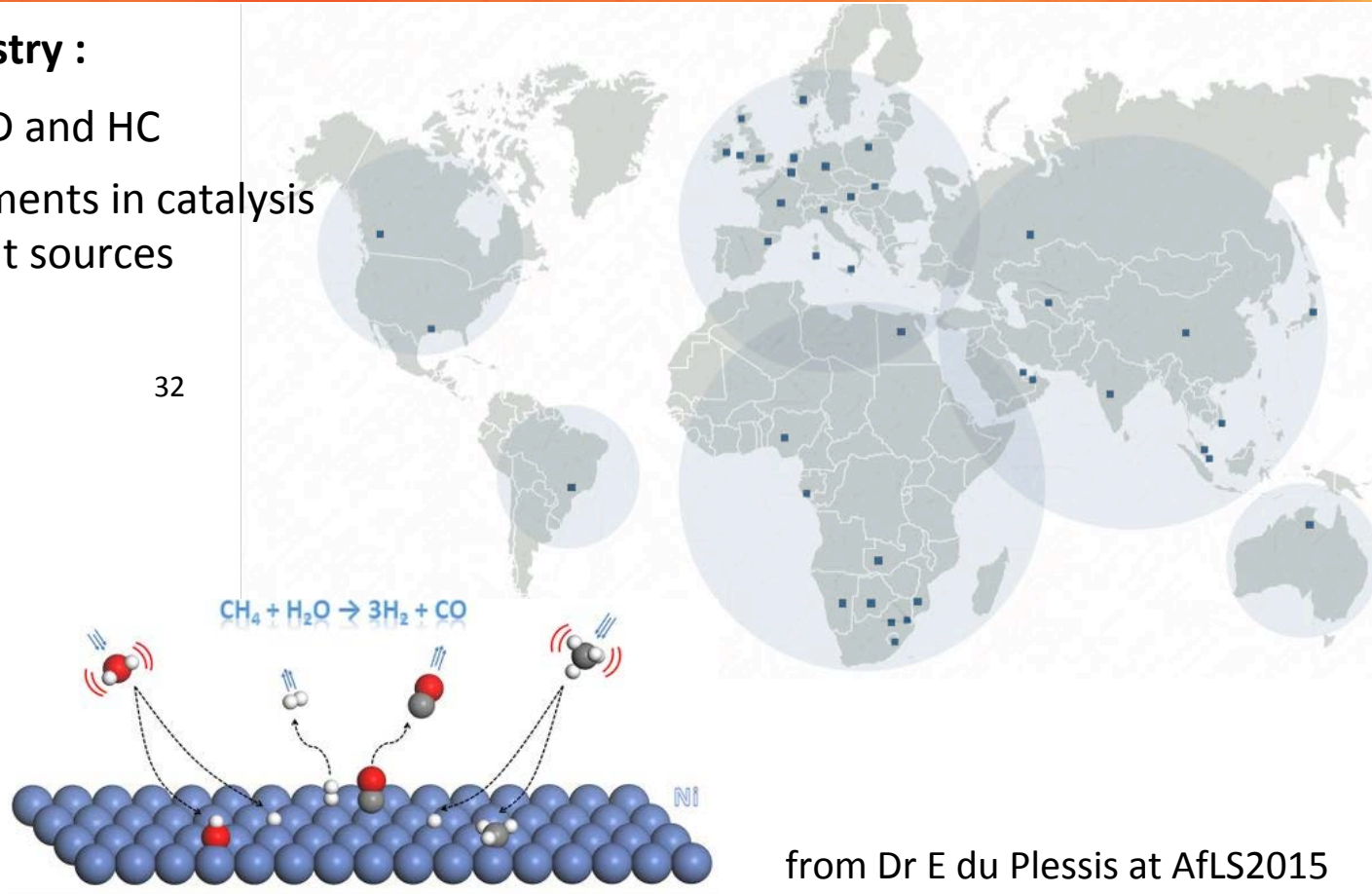
Example of African Industry :

SASOL investment in R&D and HC

SASOL capacity, achievements in catalysis studies – local and at light sources



32



from Dr E du Plessis at AfLS2015



THE AFRICAN LIGHT SOURCE CONFERENCE AND WORKSHOP

16 - 20 NOVEMBER 2015, ESRF GRENOBLE FRANCE



Discovery :

African participation and potential larger than anticipated

1. User base is bigger and stronger than originally perceived.
2. Industry already engaged (SASOL)
3. Paleo- with a huge African footprint
4. Bio- already onto African diseases
5. Materials Experienced Users
6. Beginnings of a local infrastructure in some countries.
7. Synergies with SKA in IT support
8. Potential for growth based on the User base of feeder instrumentation

Grenoble Resolutions towards the African Light Source

- 1. Advanced light sources are the most transformative scientific instruments similar to the invention of conventional lasers and computers.**
- 2. Advanced light sources are revolutionizing a myriad of fundamental and applied sciences, including agriculture, biology, biomedicine, chemistry, climate and environmental eco-systems science, cultural heritage studies, energy, engineering, geology, materials science, nanotechnology, palaeontology, pharmaceutical discoveries, physics, with an accompanying impact on sustainable industry.**
- 3. The community of researchers around the world are striving collaboratively to construct ever more intense sources of electromagnetic radiation, specifically derived from synchrotron light sources and X-ray free-electron lasers (XFELs), to address the most challenging questions in living and condensed matter sciences.**
- 4. The African Light Source is expected to contribute significantly to the African Science Renaissance, the return of the African Science Diaspora, the enhancement of University Education, the training of a new generation of young researchers, the growth of competitive African industries, and the advancement of research that addresses issues, challenges and concerns relevant to Africa.**
- 5. For African countries to take control of their destinies and become major players in the international community, it is inevitable that a light source must begin construction somewhere on the African continent in the near future, which will promote peace and collaborations among African nations and the wider global community.**



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AfLS meeting : Part II - Concrete outcomes.

1. Grenoble Resolutions.

- See <http://events.saip.org.za/conferenceDisplay.py/getPic?picId=70&confId=61>

2. Terms of Reference.

- See <http://events.saip.org.za/conferenceDisplay.py/getPic?picId=67&confId=61>

3. Roadmap summary.

- See <http://events.saip.org.za/conferenceDisplay.py/getPic?picId=66&confId=61>

4. Steering Committee to drive this roadmap forward.

- fully mandated
- globally elected
- See <https://docs.google.com/spreadsheets/d/1NlULgrE7Bu9t2aeiKIYd3zgFALoLbksfEFTqNC8p0q0/edit#gid=0>



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**AfLS Steering Committee
Regions represented ...
55 members**





The African Light Source Project



See <http://www.africanlightsource.org>

A Roadmap to the African Light Source

We are concerned with capacity building in terms of human resources, local laboratory support infrastructure and regions of excellence. We are building networks, identifying partners, training, mobility, workshops, schools and conferences and optimising the use of existing funding instruments. By degrees we will be building, on strong foundations, a massive campaign for a strong researcher user base with an aware policy-maker cohort, across Africa, and globally linked.

Auditing the progress in terms of Science and Capacity.

Ultimately there will be a feasibility study, business plan, governance model and Technical Design Report, leading to an African Light Source.



The African Light Source Project



Current Activities

- Pan African Governmental Programme
- Conferences / Meetings
 - SFSA, ICRI, APS, ICSU Board, IBSP Board, HBB, many others by SCC members
- Stakeholder Organisations / partners to be identified which welcome the AfLS programme
- Exchanges, Collaborations, Networks : Applications for existing funding instruments (successful / in preparation)
 - **Severall** ... Sister, RCUK, GDRF, EU funds, participation in various Light Source internal projects
 - **IUPAP-IUCr** “Utilisation of Light Source and Crystallographic Sciences to Facilitate the Enhancement of Knowledge and Improve the Economic and Social Conditions in Targeted Regions of the World” Now running.
- Capacity Building
 - Training, Exchanges, Post Docs



The African Light Source Project



Specialized Technical Committee on Education, Science and Technology Africa Union : STC-EST

20 October 2017 Egypt

H.E. Prof. Sarah Anyang Agbor

AU Commissioner for Human Resources, Science and Technology.

African Academy of Science

President **Prof. Felix Dapare Dakora**

Presentation on African Light Source



The African Light Source Project



Partnership:  African Academy of Science



Royal Society UK



AfLS Steering Committee



The Call to support the creation of an Africa Synchrotron project

See the AAS website

- Build the case for the AfLS
- Letter of support / endorsement
- Online petition



The African Light Source Project



Announcement :

2nd African Light Source Conference and Workshop

Schedule : 1 week in November 2018

Venue : Somewhere in Africa !

TBA



The 2nd African Light Source Conference and Workshop



The African Light Source Project



Backup

The African Light Source Project

