Engineering Research and Technology : SA - ESRF

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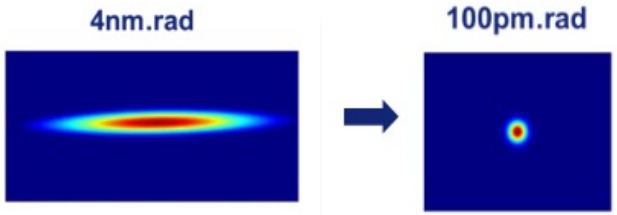
2. Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME),
4. Grenoble Institute of Technology (Grenoble-INP)

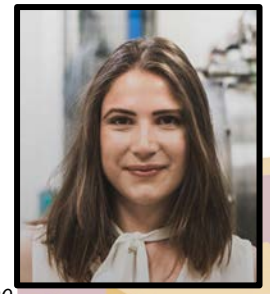
Note :

1. Frontier Level and High-Tech Opportunities,
2. Leveraging increased supervision and mentorship
3. International benchmarking and networking

ESRF – part of an Eco-system for Innovation

A Potgieter : Cooling and extreme mechanical stability

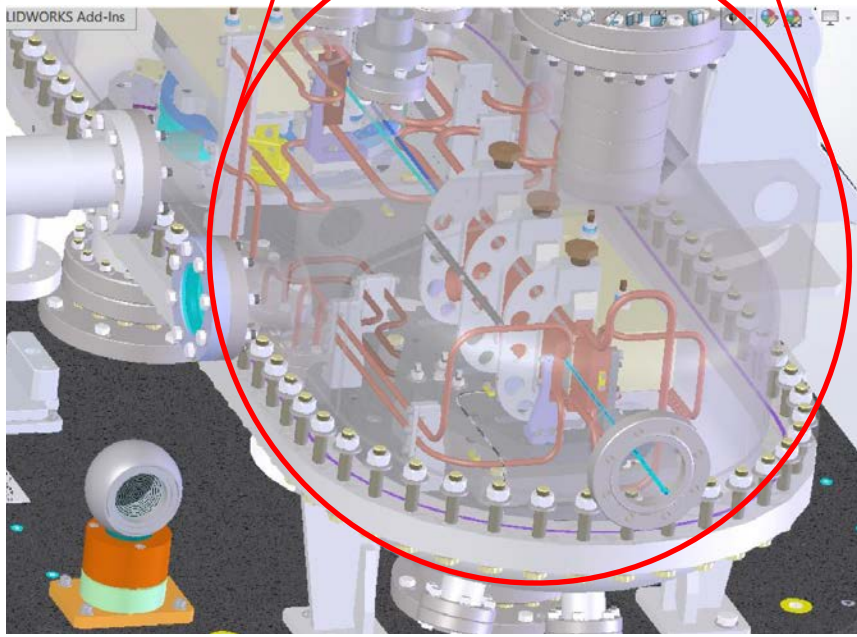




Alicia (UJ+ESRF+UG) is a PhD student in Engineering.

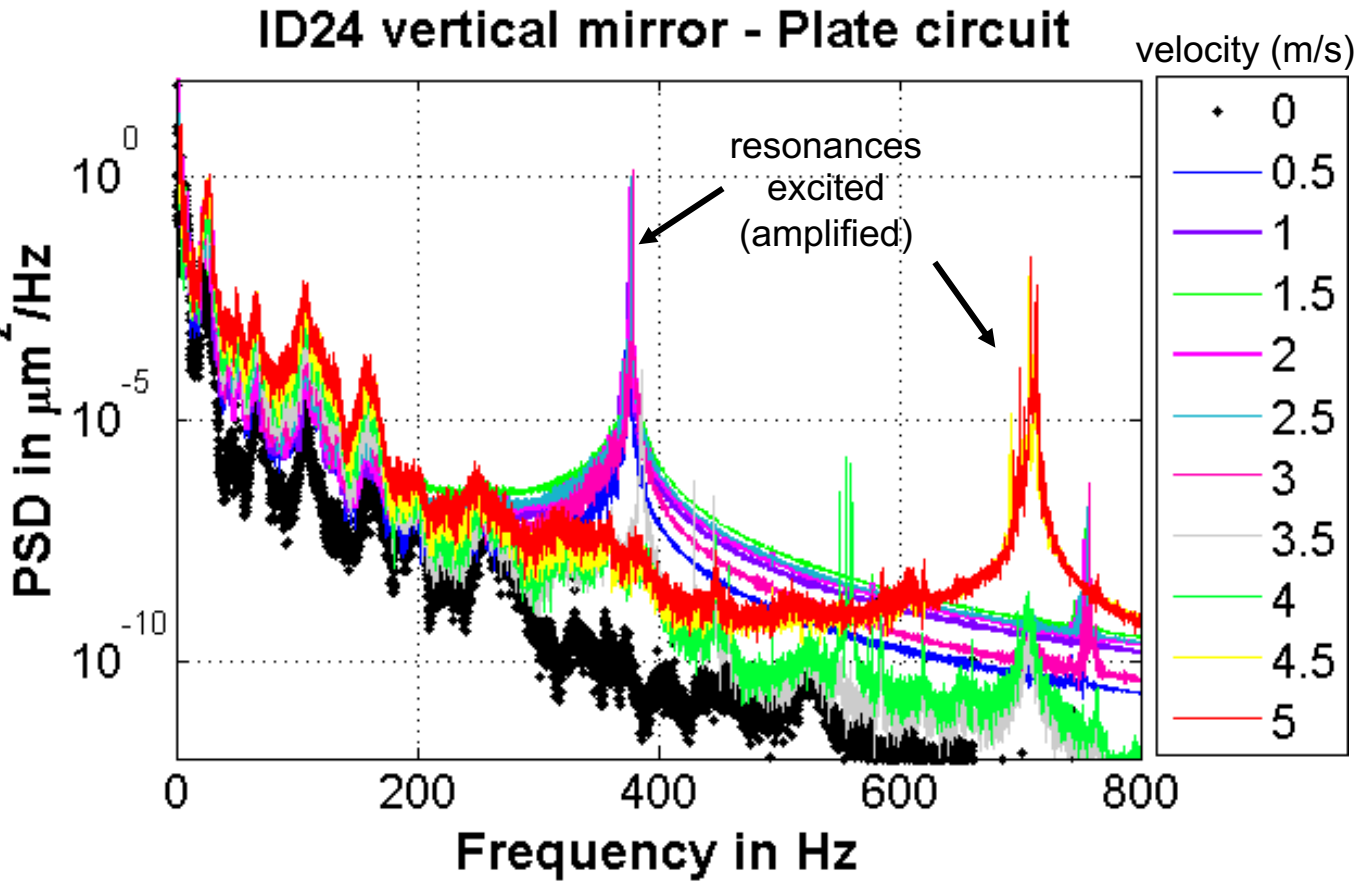
http://intranet.esrf.fr/files/live/sites/intranet/files/Experiments/BAG%20meeting/BAG%20Meeting%202020/Intro_BAGMeeting2020.pdf

- **Extremely Brilliant Source (EBS)**
  4th Generation Synchrotron
- **45 x Decreased Emittance,**
  finer focus and 100 x brightness
- **Need better cooling**
  Need better stability
- **New design for fluid flow**
  (colling systems : pumps, valves, pipes ….)
- **Singularities (bends, curves, sudden changes ….)**
- **Turbulence, vortices, chaotic flow**
  High Reynolds numbers – large local pressure changes → vibrations



Complex Cooling circuits: Mirrors of ID24
S. Jarjayes, FSI PhD Meeting, 03/11/2020

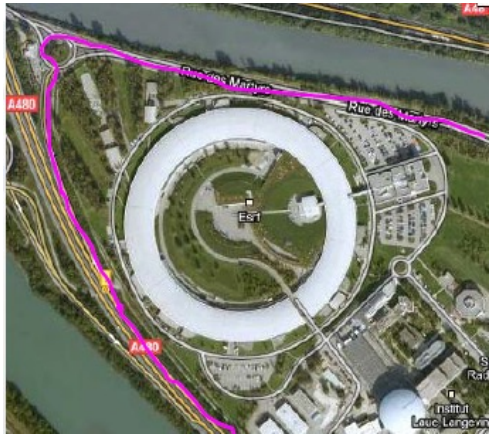
Cooling and extreme mechanical stability



Cooling flow induced vibrations on ID 24 mirror
These vibration amplitudes must be minimized to improve imaging performance

https://www.esrf.fr/files/live/sites/www/files/Instrumentation/friday-lectures-slides/Talk_L.Zhang.pdf

Peaks due to vacuum pumps



Traffic, River, Tram

Vibration and Mechanical Stability study
L. Zhang, M. Lesourd. (2010)

Simulation Benchmarked to Experiments → Design

Fluid-Structure Interactions

FSI

Pipe network

Fluid Dynamics

Structural Mechanics

Particle induced vibration

Continuum Fluid Dynamics

PIV

LEGI- Experiment

CFD

Simulations

FEA

Simulations

Vibrations

ESRF-Experiment

Finite Element Analysis

BFS

Elbow

Backwards facing step

Reynolds Av Nav-Stokes

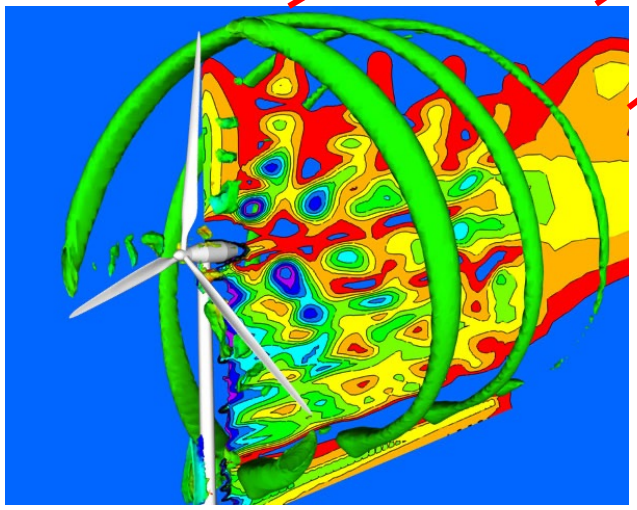
RANS

LES

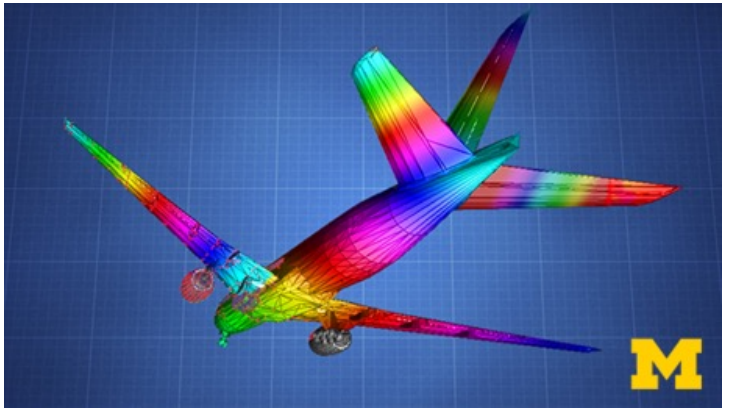
URANS

Large Eddy Simulation

Unsteady Reynolds Av Nav-Stokes

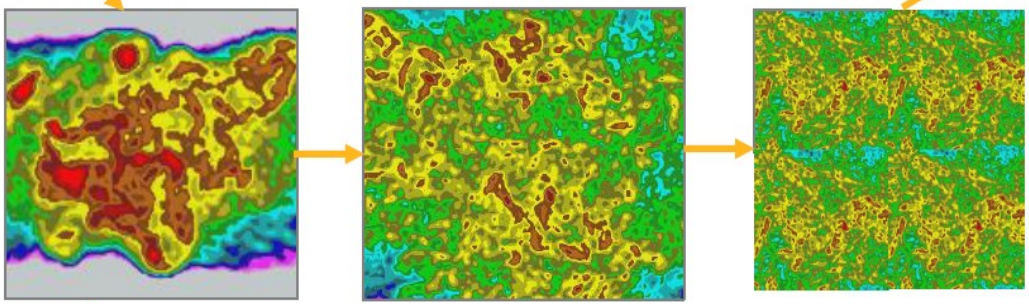


Simulation benchmarked to experiments inform design

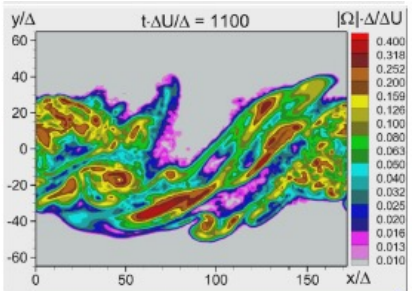


Simulation parodyme

Creation of Large Scales | Energy transfer – Inertial Range | Dissipative Range – conversion to Heat

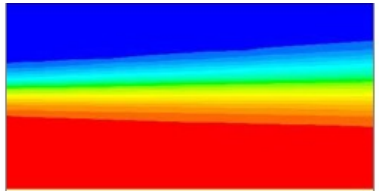


LES



LES | Resolved | Δ_{LES} | Modeled

RANS



RANS | Modeled

Ansys Learning Hub- L1: Turbulence
NAFEMS Turbulence online session 2

Simulation parodyme

Simulations – benchmarked to first approximation of PIV results.

Time-average momentum and energy equation results in additional unknowns.

Define Reynold stresses in terms of known quantities

Eddy Viscosity Models- Boussinesq hypothesis

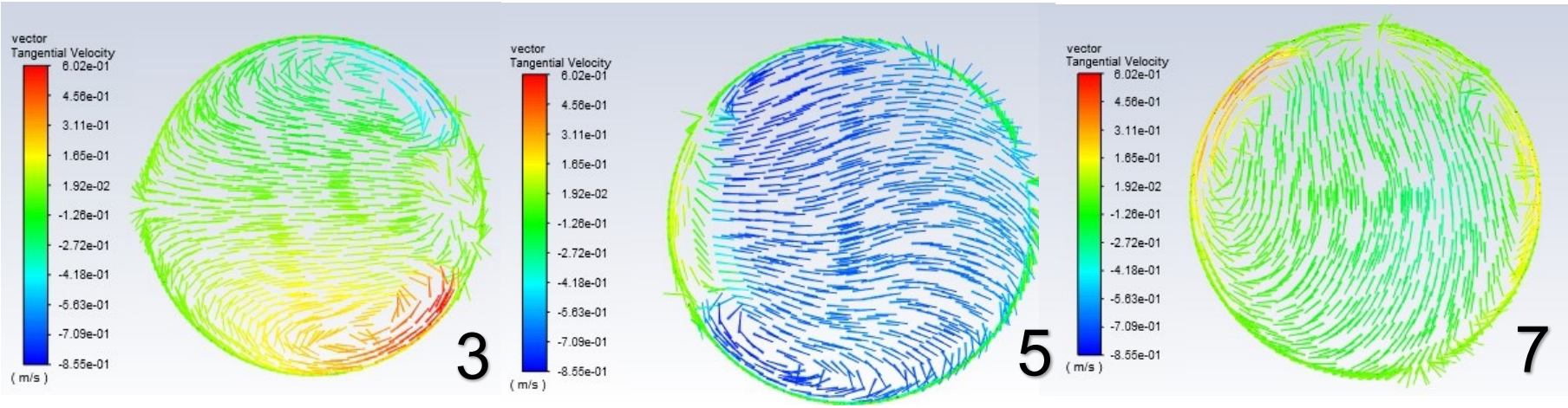
- Simple relationship between Reynolds stresses and velocity gradient through eddy viscosity.
- Relies on dimensional analysis
- Isotropic (eddy viscosity is a scalar- same in all directions)
- Reasonable for simple turbulent shear flows
- 1-4 eq to account for the unknowns

- Realizable k-epsilon
- RNG k-epsilon (renormalization group)
- Standard k-omega
- SST k-omega (Shear Stress Transport)

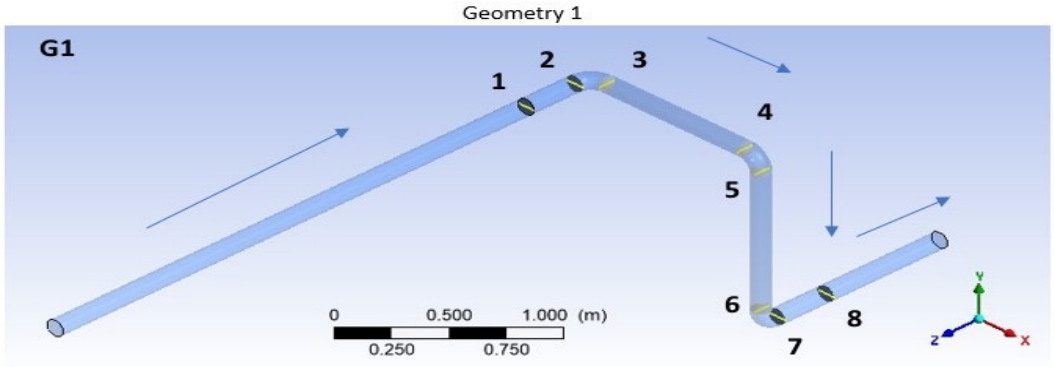
Reynolds-stress Models (RSM)

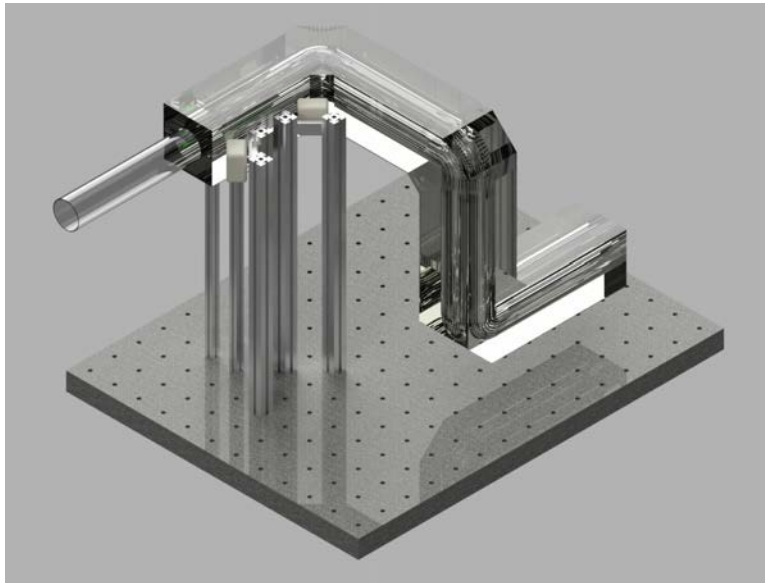
- Eq specifically to each Reynold stress (7 Equations)
- No isotropic assumption
- More complicated and computational intense

Simulation Benchmarked to Experiments → Design



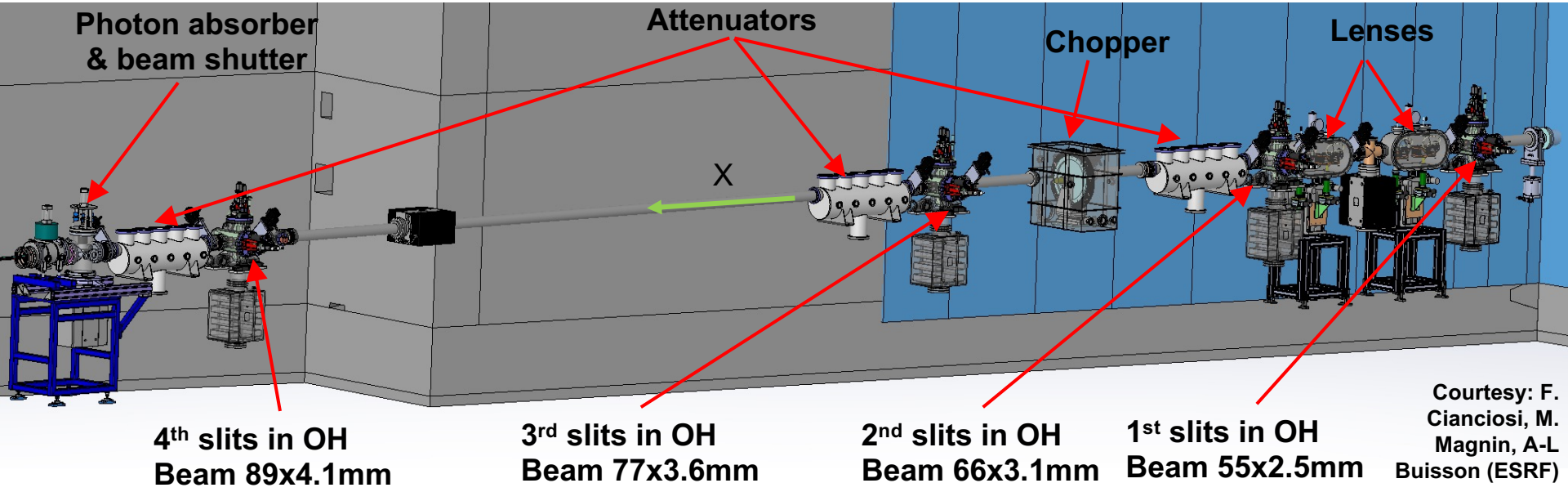
Advanced Simulation and benchmarking with





BM18 – typical tomo beamline at the ESRF

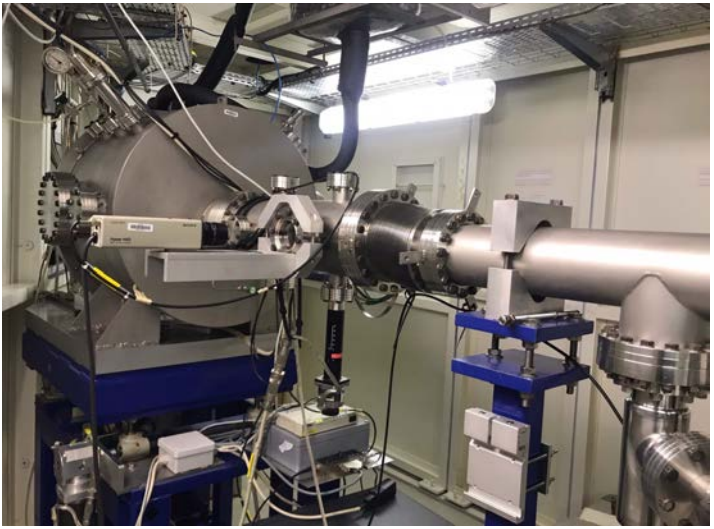
Fortune Mokoene (UJ+ESRF) is a MSc student working within the European Horizon 2020 project BEAmline for Tomography at SESAME (BEATS) has the objective to design, procure, construct and commission a beamline for hard X-ray full-field tomography at the SESAME synchrotron in Jordan

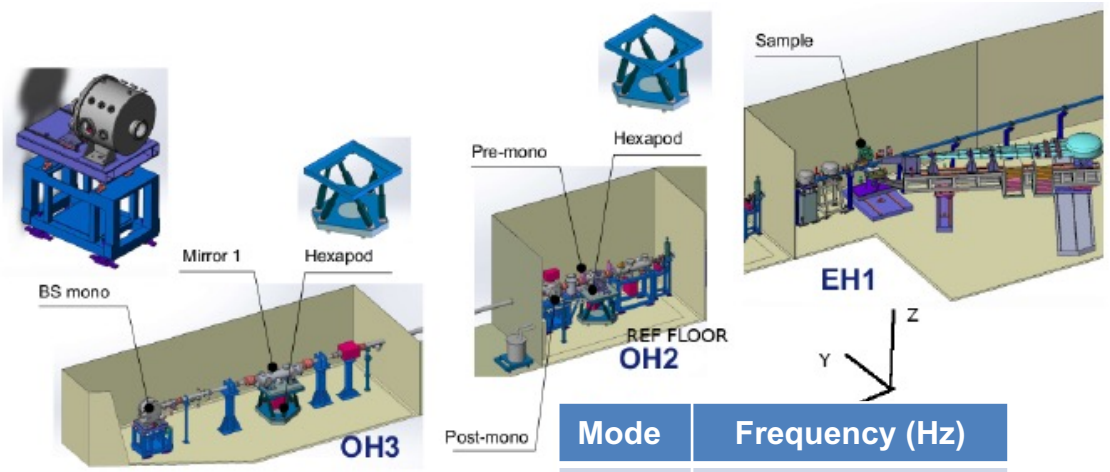


Exposure to a Beamline Layout, design and deep training in certain elements

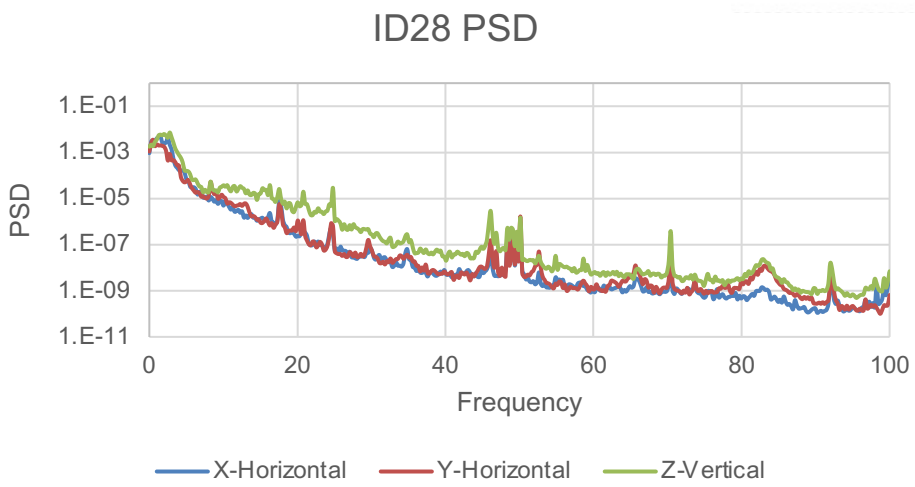
1. Design : Sample and detector support system
2. Vibration simulation and analysis
3. Sample environment (thermal)
4. Sample environment (Strain)
5. Sample environment simulation (thermal)

Measurement at ID28 Chamber for benchmarking





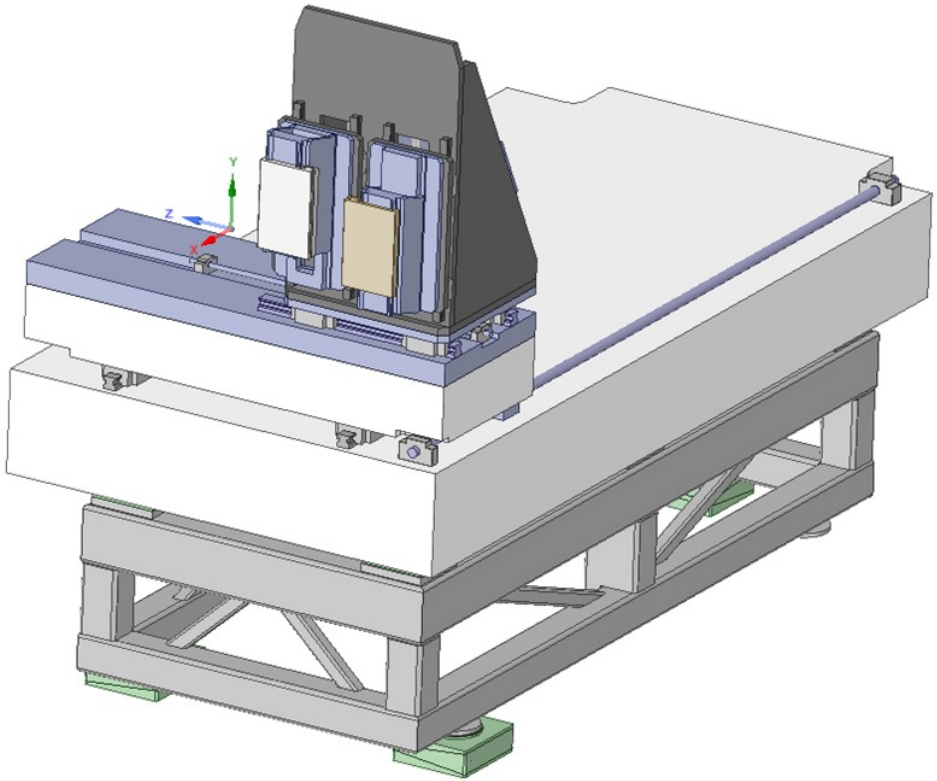
Mode	Frequency (Hz)
1	18
2	19
3	25
4	28
5	45

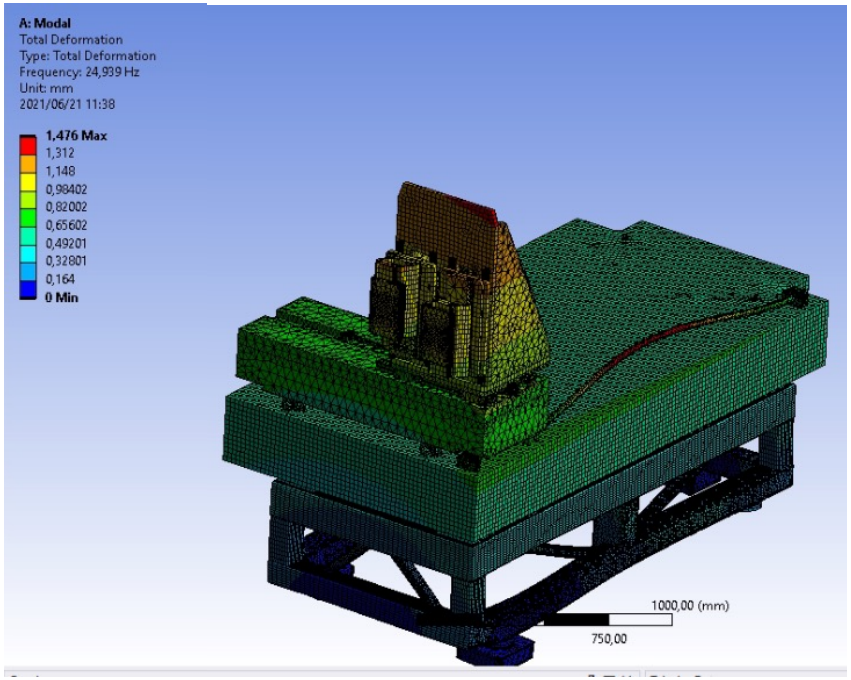


Direction	Input RMS Displacement (nm)	RMS displacement (nm)
X	101	116
Y	76	96
Z	127	137

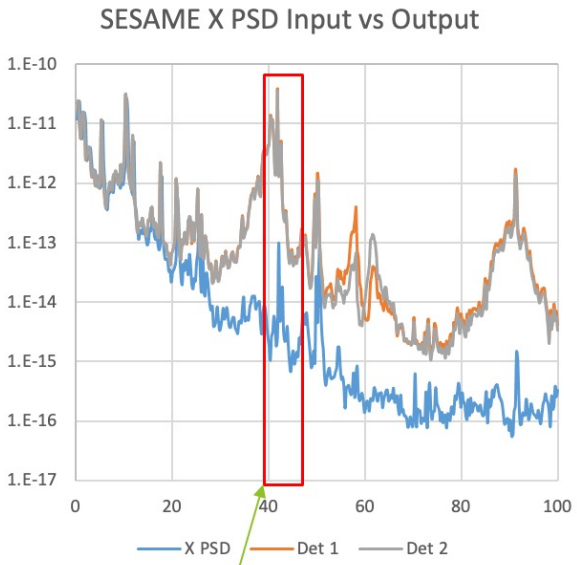
Design of various components for BEATS

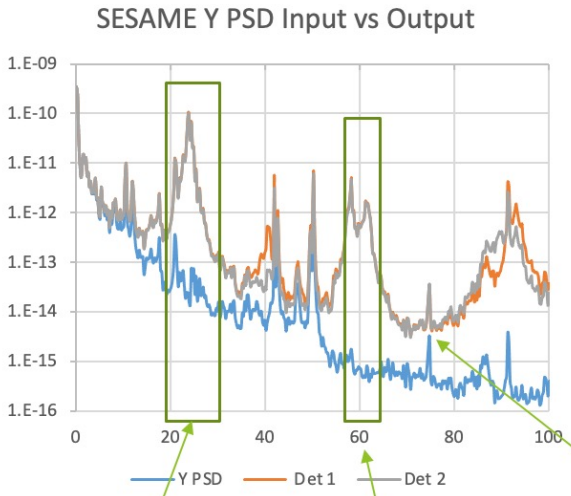
Design of the sample and detector stage.
Mechanical design and FEA of vibrations (simulation benchmarked to a similar instrument)

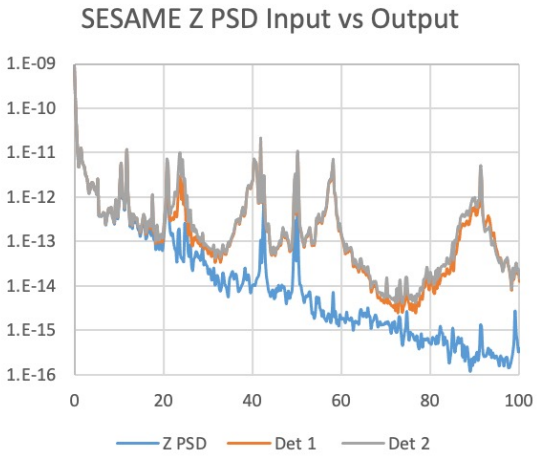




Design of various components for BEATS







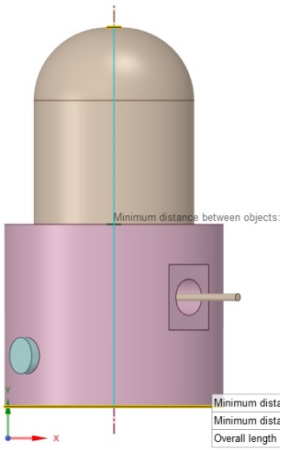
Mode 4

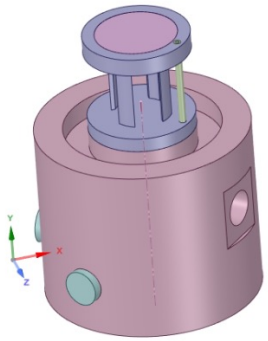
Mode 1

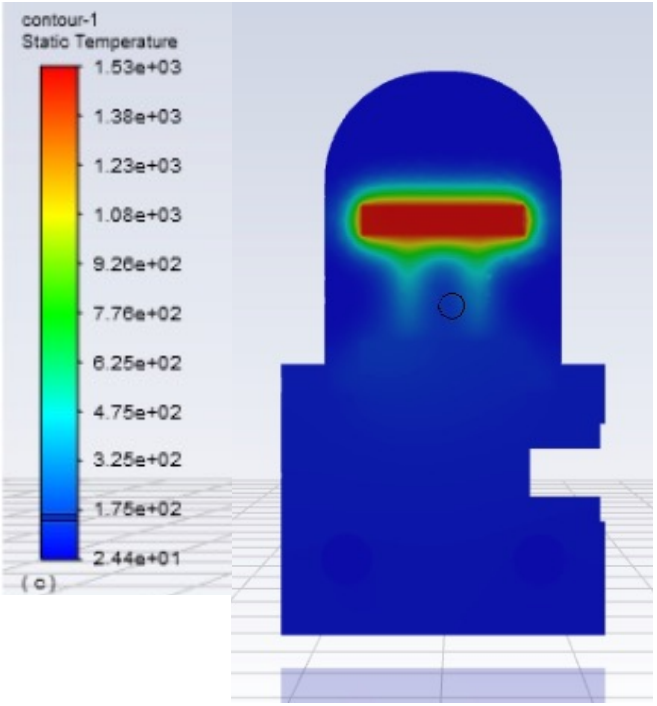
Mode 5

Mode 6

Design of various components for BEATS







Sample Environment

High temperature furnace

Design and simulation

ESRF role in the AfLS

First publications from Egypt then SA

1st formal Pan-African call. AfLS is in the ALC launch docs

Global conversations about the AfLS

Formation of AfLS Interim Steering Committee

AfLS1 Conference and AfLS SC

AfLS2020 IAC, LoS/MoU CDR Process

AfLS2 Conference

1990 1995 2000 2005 2010 2015 2020

Letter to SA-NRF

SA Synchrotron Initiative

1st African HE Summit : AfLS in the Declaration

AU: STC-EST, AAS call to support AfLS as a Pan African initiative

Many AfLS Roadmap related activities

AU: Exec Council call to support AfLS as a Pan African initiative

AfLS Foundation Legal Entity

Ghana Govt support

MoUs and LoSs

International Advisory Committee

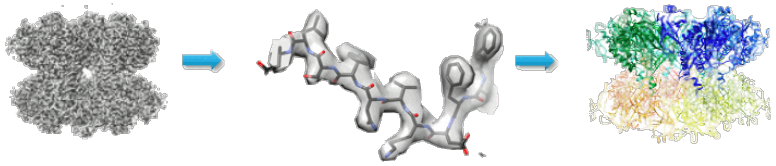
Conceptual Design Report Process

1. ESRF long term partner of SA : part of Science@Synchrotrons (from 2003), SRRIC, AfLS meetings
2. Towards Pan African Scientific Associateship of the ESRF.
3. Enable African Government experience in governance of RIs

ESRF role in the AfLS

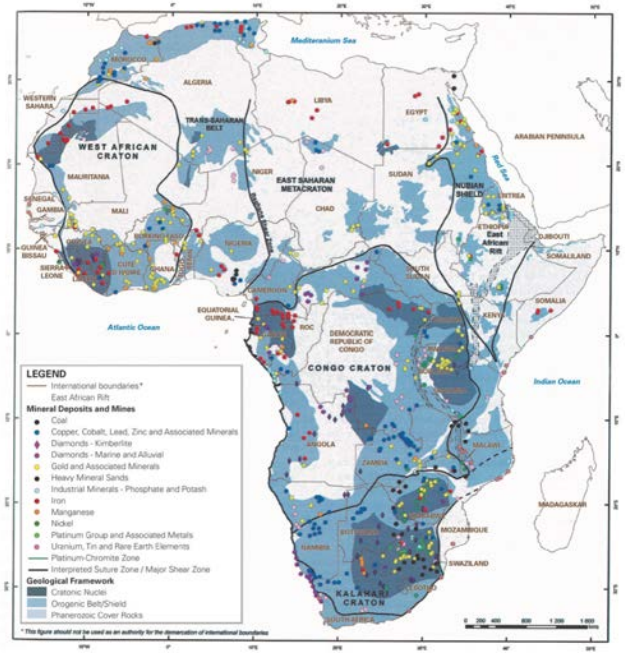
Global and Africa relevant Research and Innovation – by Africans and partners

African Cultural and Paleo Heritage



Developing medical interventions for Africa's disease burden, Malaria, HIV, TB, Ebola ….

Beneficiating Africa's mineral wealth: Mining Review Africa



AfLS-CDR Conceptual Design Report

Energy Materials

Innovations

….. and much more

ESRF Membership – Taking stock in this case

1. **Achievements**
   - Broaden footprint from Science to Engineering
   - Include beamline instrumentation engineering and technology
2. **Successes**
   - Simulation + benchmarking → Design
   - New cohort towards African Light Source
3. **Challenges**
   - COVID conditions
   - Develop VISA process for MSc Engineering (EU labor law)
   - Funding
4. **New opportunities**
   - Transfer Advanced Design skills to SA
   - Capacity for SA to develop Instrumentation for Science
   - Breakthrough Science, technology Driver

Significance of the continued access to the ESRF synchrotron.

1. ESRF is an International large-scale infrastructure – world leader – CERN of synchrotrons
2. Capacity development - Examples of Engineering the focus of this presentations
   - Frontier level and High-Tech Opportunities,
   - Leveraging increased supervision and mentorship
   - International benchmarking and networking
3. Diversity – exhibited here.
4. Succession development project /programme leadership.
   - Students, Emerging Researchers