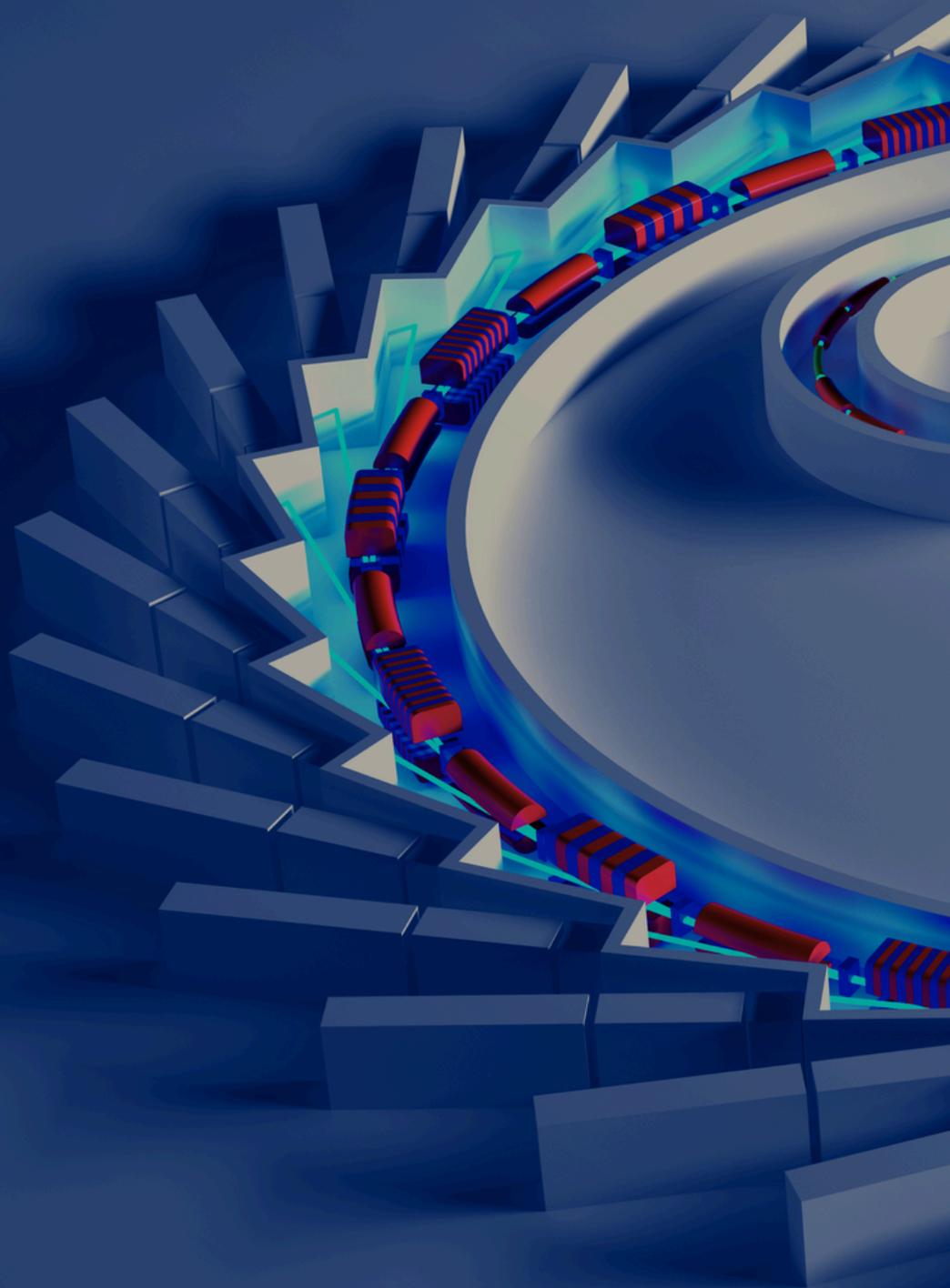




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Empowering Africa through Synchrotron Science

Toolkit

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SHORT SUMMARY

Bridging the Synchrotron Divide for African Scientific and Diplomatic Empowerment

Synchrotron light sources are critical tools for addressing development challenges in health, agriculture, energy, materials, and cultural preservation. While more than **60 synchrotron facilities** operate worldwide, **Africa remains the only inhabited continent without one**. African scientists currently account for **less than 1% of global synchrotron usage**.

This toolkit proposes a practical and inclusive solution: the development of a **dedicated African beamline at SESAME**, a UNESCO-supported synchrotron facility in Jordan. This initiative would provide African countries with cost-effective access to cutting-edge infrastructure while simultaneously advancing **science diplomacy** and **regional integration**.

For an investment of **\$6–10 million** over **3–5 years**, the beamline could:

- Train **200+ scientists annually**
- Serve as a neutral platform for international cooperation
- Enable African research across **health, food security, and clean energy**
- Strengthen Africa's voice in global scientific governance

This publication offers actionable guidance for African Member States to engage at multiple levels, from entry-tier participation to full governance roles, supported by national and regional science diplomacy frameworks.

With only
\$ 6-10 million
over **3-5 years**,
the beamline could
train **200+** scientists
annually



"Since wars begin in the minds of men and women, it is in the minds of men and women that the defences of peace must be constructed"

Empowering Africa through Synchrotron Science

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Executive Summary

A synchrotron facility represents a cornerstone of modern scientific infrastructure, enabling breakthroughs across disciplines such as health, agriculture, energy, materials science, and cultural preservation, many of which directly support the 17 Sustainable Development Goals (SDGs) and address Africa-specific challenges. Establishing such a facility in Africa would fill a critical infrastructure gap, empowering researchers, educators, and innovators across the continent to fully participate in and contribute to global scientific progress.

Beyond scientific advancement, synchrotron access serves as a powerful instrument of science diplomacy, creating neutral platforms for international cooperation, fostering regional integration, and elevating Africa's position in global scientific governance. Through collaborative engagement with synchrotron science, Member States can strengthen diplomatic ties, address shared challenges, and build lasting partnerships that transcend political differences.

Constructing a full synchrotron in Africa would cost over \$500 million and take more than a decade. A more immediate and cost-effective solution is for African countries to support the development of a dedicated African beamline at SESAME (Jordan), a UNESCO-supported synchrotron. This beamline would:

- Cost \$6–10 million to build and operate over 3–5 years.
- Provide access to world-class research tools.
- Enable training of over 200 African scientists annually.
- Contribute to local innovation and scientific capacity-building.
- Create a diplomatic bridge between Africa and the Middle East region.
- Establish a foundation for multilateral scientific cooperation.

This toolkit provides governments and stakeholders with a comprehensive roadmap for engaging in this strategic initiative, including diplomatic frameworks, governance models, and policy alignment strategies tailored to different Member State contexts.

Key Messages

- Establishing an African beamline at the SESAME synchrotron facility in Jordan represents a cost-effective way to access cutting-edge scientific infrastructure while strengthening African Member States' international partnerships.
- Participation demonstrates African Member States' commitment to both scientific excellence and regional integration in line with Agenda 2063.
- The flexible governance model ensures that countries of all sizes and capacities can meaningfully participate and benefit.
- Beyond scientific returns, this project creates new diplomatic channels and enhances African Member States' voice in global scientific governance.

- The participation structure allows African Member States to engage at a level appropriate to their current capacity while leaving room for increased involvement as the scientific ecosystem develops.

Introduction to Synchrotrons

What is a Synchrotron?

In simple terms, a synchrotron is like a giant microscope that uses powerful light beams, including X-rays, ultraviolet, and infrared, to explore the structure of materials at the atomic and molecular levels. It is an essential tool in modern science and technology.

A beamline is a research station inside a synchrotron, equipped to perform specific experiments using the synchrotron's light. Each beamline is specialized for particular types of research, such as protein crystallography or materials analysis.

Why It Matters

The myriad applications of synchrotrons have direct implications for Africa's development needs and scientific advancement. Synchrotrons also provide opportunities for diplomatic engagement through shared scientific priorities. The diagram below summarizes the applications and the potential impacts of these facilities.

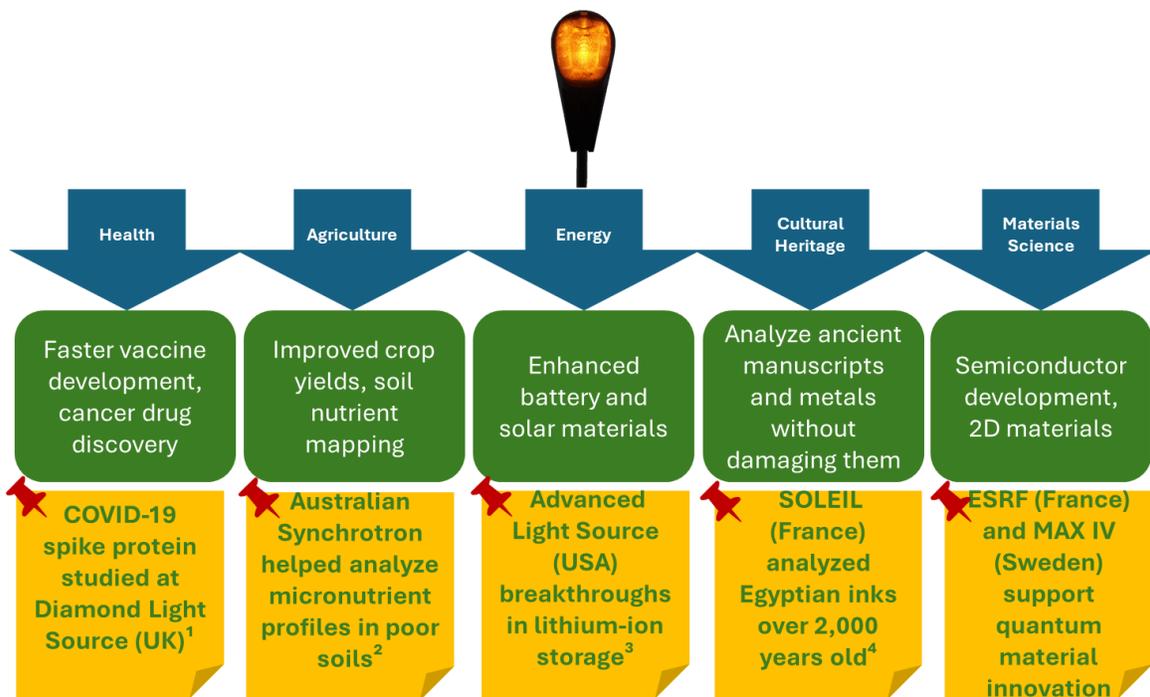


Diagram 1: Applications and Impacts of Synchrotron Research Facilities

Synchrotrons as Science Diplomacy

Synchrotrons frequently function as instruments of science diplomacy, the use of scientific collaboration to build international relationships and to address shared challenges. Science diplomacy enables countries to come together to finance the high cost of building a synchrotron and to source the highly specialized expertise required to build and operate the facility from across borders. Additionally, international synchrotrons strengthen regional collaboration on science and technology and can provide a more neutral space for engagement between countries whose formal diplomatic relations are strained.

Examples of synchrotron collaboration serving as a bridge between nations include:

- SESAME brings together Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine, and Turkey despite regional tensions,
- European synchrotrons maintained Russian scientific access during political sanctions through science exemptions,
- Brazilian Synchrotron Light Laboratory (LNLS) serves as regional hub for South American scientific cooperation and capacity building,
- Australian synchrotron hosts dedicated beamlines for Southeast Asian partners, strengthening regional ties.

Africa's Challenge: The Synchrotron Gap

Over 60 synchrotrons exist globally⁵, located in North America, Europe, Asia, Latin America, and Australia. Africa remains the only inhabited continent without one, and less than 1% of global beamtime is used by African scientists⁶.

Barriers to access include:

- High travel and accommodation costs.
- Complicated application processes.
- Limited institutional support for proposal development.
- Insufficient diplomatic frameworks to facilitate access.

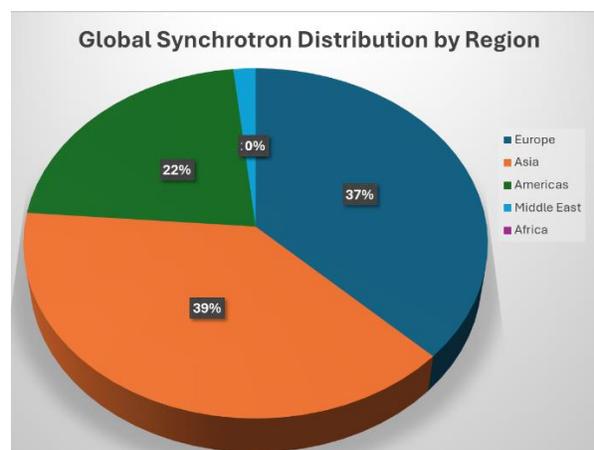


Fig. 1: Global Synchrotron Distribution by Region

Consequently, Africa misses out on advances in clean energy, disease diagnostics, crop resilience, and other critical areas. This scientific exclusion also limits Africa's voice in global scientific governance and policy-making forums.

Key Statistics:

- ESRF (France) has hosted >80 experiments involving South African institutions⁸.
- African users at SESAME (Jordan) <5%⁹.
- LNLS (Brazil) trains over 300 local users per year¹⁰.

Immediate Solution: An African Beamline at SESAME

SESAME, located in Jordan, is a regional synchrotron developed under the auspices of UNESCO, with other partners such as CERN and the IAEA. It is accessible to Africa and designed for international cooperation, serving as a model of successful science diplomacy in a complex geopolitical region. Constructing a beamline at SESAME dedicated to use by African scientists offers a relatively fast, cost-effective and pragmatic solution to Africa's synchrotron gap.

Why a Beamline at SESAME?

- **Proximity:** Jordan is geographically close to North and East Africa.
- **Cost-Effective:** A beamline costs only 1–2% of a full synchrotron.
- **Quick Implementation:** Can be operational within 3–5 years.
- **Capacity:** SESAME hosts international training; has supported over 1,000 researchers from MENA⁷.
- **Infrastructure Ready:** Room for up to 16 beamlines; currently has 5 operational.
- **Diplomatic Value:** SESAME already demonstrates how scientific cooperation transcends political differences, bringing together countries that may not otherwise collaborate.

Economic and Development Benefits

- **Pharmaceutical R&D:** Accelerate development of malaria and tuberculosis drugs.
- **Agricultural Research:** Address food insecurity and drought through soil and plant studies.
- **Clean Energy:** Innovate in storage and solar technologies.
- **Job Creation:** Foster homegrown industries in biotech and nanotech.
- **Diplomatic Returns:** Generate soft power and influence through scientific leadership.

Capacity Building Opportunities

- Train 200+ scientists annually in spectroscopy, imaging, and data analysis.
- Establish regional research hubs and a Pan-African Synchrotron Users Network.
- Develop diplomatic and science policy expertise among government officials.
- Create a cadre of “science diplomats” who can represent African interests in global forums.

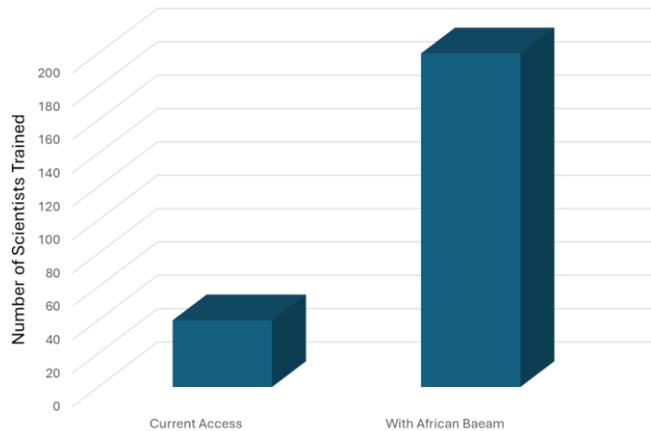


Fig. 2: Projected Annual Training Capacity for African Scientists

Diplomatic and Strategic Benefits

Science Diplomacy

The African beamline at SESAME represents a strategic opportunity for science diplomacy, offering a space for diplomatic and scientific exchange and collaboration. It would create formal and informal channels for international cooperation, provide a neutral ground for collaboration, build trust through joint scientific endeavors, and increase Africa’s representation in global scientific forums.

Scientific Exchange

Enabling collaboration between incoming African countries as well as with current SESAME members, the beamline facilitates people-to-people connections through:

- Researcher exchanges and joint publications
- Academic partnerships between African and Middle Eastern institutions
- Shared training programs and workshops
- Development of Pan-African scientific networks

Diplomatic Opportunities

Member States participating in the African beamline initiative will gain:

- Representation on the SESAME Council
- Coordinated positions in UNESCO and other multilateral forums
- Strengthened bilateral relations with Jordan and other SESAME members
- Increased influence in global scientific governance structures
- Platforms to address shared challenges through scientific collaboration

Alignment with African Goals

- **Supports Agenda 2063:** Emphasizes science, technology, and innovation as drivers of African integration and development.
- **Contributes to SDGs:** Especially Goals 3 (Health), 4 (Education), 9 (Industry), 13 (Climate), and 17 (Partnerships).
- **Achieves scientific equity:** Only 3 countries (South Africa, Egypt, Morocco) are regular users of synchrotron facilities⁸. A shared beamline would democratize access for the entire continent.
- **Promotes regional integration:** Creates a platform for Pan-African scientific collaboration and knowledge sharing.
- **Strengthens Africa's global scientific voice:** Increases representation in international scientific bodies and decision-making forums.

Toolkit

Key Action Areas for African Governments

Political Support

- Integrate beamline participation into national science, innovation, and higher education policies.
- Raise the issue at the African Union STC and UNESCO platforms.
- Appoint science diplomacy focal points within foreign ministries.
- Leverage existing diplomatic missions in Jordan to support SESAME engagement.

Financial Commitment

- Explore flexible contribution models based on tiered participation:
 - Tier 1 (Core Members): \$400,000-500,000 per country
 - Tier 2 (Associate Members): \$200,000-300,000 per country
 - Tier 3 (Participating Members): \$50,000-100,000 per country
- Leverage support from AfDB, EU Horizon Europe, and World Bank Science Funds.
- Explore innovative financing mechanisms such as regional pooled funds or public-private partnerships.
- Consider in-kind contributions (equipment, expertise, training facilities), from other synchrotron facilities to supplement financial commitments.

Research and Innovation Strategy

- Focus research funding calls on local needs: infectious disease, drought tolerance, and climate materials.
- Promote inter-university collaboration to shape experimental proposals.
- Align research priorities with national development plans and diplomatic objectives.
- Create mechanisms to translate research findings into policy recommendations.
- Establish knowledge-sharing platforms between scientific and diplomatic communities.

Human Resource Development

- Support MSc/PhD programmes in synchrotron-based science.
- Offer fellowships for access to SESAME or other synchrotrons such as MAX IV, ESRF.
- Train technical staff to operate and maintain experimental instruments.
- Develop science diplomacy training programs for researchers and diplomats.
- Create exchange programs between scientific institutions and foreign ministries.

Policy Alignment Framework

Effective engagement with the African beamline initiative requires alignment between scientific and diplomatic policies on national, regional and international levels. Member States should consider:

National Level Alignment

- 1. Interministerial Coordination Mechanisms**
 - Establish formal coordination between ministries of science/education, foreign affairs, and development
 - Create joint working groups to develop coherent positions on synchrotron access
 - Align national research priorities with diplomatic objectives
- 2. Science Diplomacy Strategies**
 - Develop explicit science diplomacy strategies that include synchrotron access
 - Train diplomats in scientific matters and scientists in diplomatic engagement to enable harmonized advocacy for the African beamline
 - Include scientific cooperation in bilateral relationship frameworks

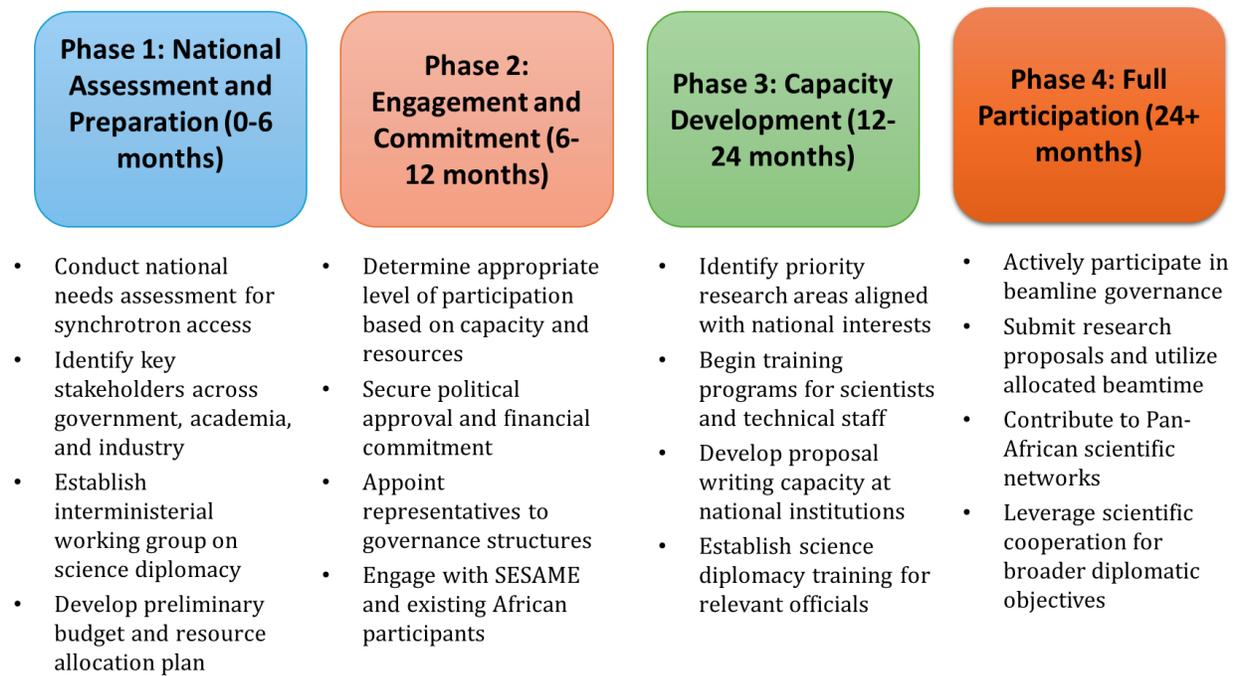
Regional Level Alignment

- 1. African Union Framework**
 - Integrate synchrotron access into AU science and technology strategies
 - Use Regional Economic Communities as coordination platforms
 - Develop common positions for engagement with international partners
- 2. Pan-African Scientific Networks**
 - Support the African Light Source Foundation as a coordinating body
 - Establish regional centers of excellence linked to the beamline
 - Create mechanisms for sharing expertise across the continent

International Level Alignment

- 1. Multilateral Engagement**
 - Coordinate African positions in UNESCO, IAEA, and other relevant forums
 - Leverage diplomatic missions to international organizations
- 2. Partnership Development**
 - Establish strategic partnerships with other synchrotron facilities
 - Engage diaspora scientists as bridges to international facilities
 - Develop South-South cooperation frameworks focused on shared infrastructure

Roadmap for Implementation



Investing in science diplomacy strategies and capacities can support the realization of the initiative

Diagram 1: Applications and Impacts of Synchrotron Research Facilities

FAQs

Q1: Why not build a synchrotron in Africa?

It remains a strategic goal, to be achieved within the coming 15-20 years, however it is expensive and time-consuming. A beamline offers faster, more achievable access while building the diplomatic and scientific foundations for a future African synchrotron.

Q2: Will contributors benefit directly?

Yes, through guaranteed access rights, capacity-building programs, co-governance of the initiative, and enhanced diplomatic relationships. The tiered participation model ensures benefits are proportional to contribution while maintaining inclusivity.

Q3: What return on investment can be expected?

Both scientific returns (increased publications, patents, improved health outcomes, and resilient food and energy systems) and diplomatic returns (enhanced international prestige, new partnership channels, increased influence in scientific governance bodies).

Q4: Can smaller countries with limited scientific capacity meaningfully participate?

Yes, the different-level participation model specifically accommodates countries with varying levels of scientific capacity and resources. Tier 3 participation focuses on capacity building and training while providing a pathway to increased engagement over time.

Q5: How does this initiative relate to other regional integration efforts?

The African beamline complements existing regional integration frameworks by creating practical cooperation mechanisms around shared scientific infrastructure. It can serve as a model for other shared resource initiatives and strengthen the implementation of AU science and technology strategies.

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Annexes

Annex 1: SESAME Technical Factsheet

Energy: 2.5 GeV (Giga-electron Volts)

What It Means: The electrons in SESAME's storage ring are accelerated to 2.5 billion electron volts, enough energy to produce bright X-rays and infrared light for advanced experiments.

Comparison: Similar to Brazil's LNS (2.15 GeV) and India's Indus-2 (2.5 GeV). Lower than Europe's ESRF (6 GeV) but sufficient for most materials, biological, and environmental research.

Beam Current: 250 mA (Milliamperes)

Why It Matters: Higher beam current = more intense light = sharper imaging and faster experiments.

Example: SESAME's beam can analyze protein structures in hours, not days.

Operational Beamlines

Beamline	Acronym	Purpose	Real-World Use
XAFS/XRF	XAS/XRF	Chemical analysis of materials, environmental samples, and ancient artifacts	Soil nutrient mapping, pollution detection
Infrared (IR)	IR	Studying molecular vibrations in biomolecules and materials	Malaria drug research, cancer cell analysis
MX	MX	Protein crystallography for drug design	COVID-19 spike protein imaging (like Diamond, UK)
BEATS	BEATS	3D imaging of materials and biological samples	Fossil studies, battery material defects
HESEB	HESEB	Hard X-rays for energy and environmental research	Solar panel efficiency, water purification tech

Expansion Capacity: 16 Beamlines

SESAME's facility can host 11 additional beamlines as demand grows, allowing African nations to propose new research stations tailored to regional needs (e.g., drought-resistant crops, malaria vaccines).

User Access

- Peer Review: Proposals are reviewed by international scientists for scientific merit.
- Training: SESAME offers workshops and fellowships (e.g., 200+ researchers trained annually from the Middle East and Africa).

- Regional Priority: African projects receive dedicated support to overcome logistical barriers.
- Diplomatic Channels: Member State status facilitates access through formal diplomatic agreements.

Annex 2: Case Studies with Diplomatic Context

1. South Africa at ESRF (France)

Scientific Collaboration: - Over 80 experiments since 2005. - Key Projects: - Battery Tech: Improved lithium-ion battery lifespan by 20% (used in South African solar startups). - Paleontology: Analyzed 200-million-year-old fossils, contributing to global climate change models.

Diplomatic Outcomes: - Strengthened France-South Africa bilateral relations through formal science cooperation agreement - Created pathway for South African representation on ESRF advisory committees - Facilitated technology transfer agreements between European and South African institutions - Supported joint positions on climate science in multilateral forums

2. Kenya at MAX IV (Sweden)

Scientific Program: - ICTP-funded fellowships for 15 Kenyan researchers (2018–2023). - Focus: Solar nanomaterials for off-grid energy solutions. - Outcome: Developed a low-cost solar coating that boosts efficiency by 15%, piloted in rural Kenya.

Diplomatic Impact: - Established formal Kenya-Sweden partnership on sustainable energy - Created academic exchange programs between Kenyan and Swedish universities - Provided platform for Kenya's leadership in East African renewable energy initiatives - Strengthened Kenya's position in international climate negotiations through evidence-based contributions

3. Egypt at SESAME (Jordan)

Scientific Role: - Founding member; contributed \$5 million to SESAME's construction. - Usage: Egyptian researchers led 20% of SESAME's experiments (e.g., analyzing ancient papyrus inks, semiconductor materials). - Impact: Trained 150+ Egyptian scientists since 2017, fostering a local quantum materials research hub.

Diplomatic Achievements: - Maintained scientific cooperation channels with regional neighbors - Enhanced Egypt's diplomatic standing as a science leader in the Middle East and North Africa - Created a neutral forum for Egyptian scientists to collaborate with international colleagues - Demonstrated Egypt's commitment to regional stability through institutional support for SESAME

4. Morocco-France-Senegal Trilateral Cooperation

Scientific Initiative: - Joint research program on agricultural drought resistance using SOLEIL synchrotron (France) - Involved 12 researchers from three countries (2019-2022) - Resulted in drought-resistant crop varieties now being tested in all three countries

Diplomatic Outcomes: - Created new trilateral cooperation mechanism between European and African partners - Established model for North-South-South scientific collaboration - Strengthened Morocco's role as bridge between Europe and West Africa - Led to expanded cooperation in climate adaptation technologies.

Annex 3: Budget Estimate with Flexible Contribution Models

Standard Budget Framework

Category	Cost (USD)	Details
Beamline Construction	\$9M	Includes magnets, detectors, and shielding (based on SESAME's existing beamline costs).
Installation & Commissioning	\$0.5M	Labor, calibration tools, and safety certifications.
Initial Operations (3 years)	\$1M	Staff salaries (\$500K/year), maintenance (\$200K/year), user support (\$300K/year).
Contingency (10%)	\$0.8–1M	Unforeseen technical challenges or inflation.
Total	\$10–12M	

Potential Funding Sources:

- African Development Bank Science and Technology Fund –
- EU
- Africa Partnership Instruments
- World Bank research capacity building programs

Annex 4: Global Synchrotron List with Diplomatic Context

Region	Synchrotron	Country	Energy (GeV)	Beamlines	Specialization	Diplomatic Significance
Europe	ESRF	France	6.0	44	Materials, health, archaeology	19 European and world nations in governance structure; model for transnational scientific facilities
Asia	SPring-8	Japan	8.0	62	Quantum tech, energy	Hub for Asia-Pacific scientific cooperation significant science diplomacy tool for Japan
Americas	Advanced Photon Source	USA	7.0	34	Drug discovery, nanotechnology	Hosts international research partnerships; maintains scientific ties even during political tensions
Middle East	SESAME	Jordan	2.5	5	Regional collaboration, training	UNESCO-supported peace-building initiative; brings together some countries without full diplomatic relations
Africa	None	-	-	-	-	Gap represents both scientific and diplomatic opportunity for the continent

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Empowering Africa through Synchrotron Science

Africa's absence from the global synchrotron ecosystem represents both a scientific gap and a diplomatic opportunity. While over 60 synchrotrons operate globally, Africa lacks a single facility. This toolkit provides a strategic roadmap for bridging that gap through collective participation in a dedicated African beamline at the SESAME synchrotron in Jordan.

Designed for governments, diplomats, and scientific leaders, the toolkit outlines:

- Flexible participation models for Member States
- Phased implementation over 3–5 years
- Science diplomacy frameworks at national, regional, and multilateral levels
- Budget models and partnership mechanisms
- Case studies demonstrating synchrotron-enabled impact

Through this initiative, African countries can catalyze scientific innovation, strengthen diplomatic engagement, and shape a future of shared research infrastructure.

