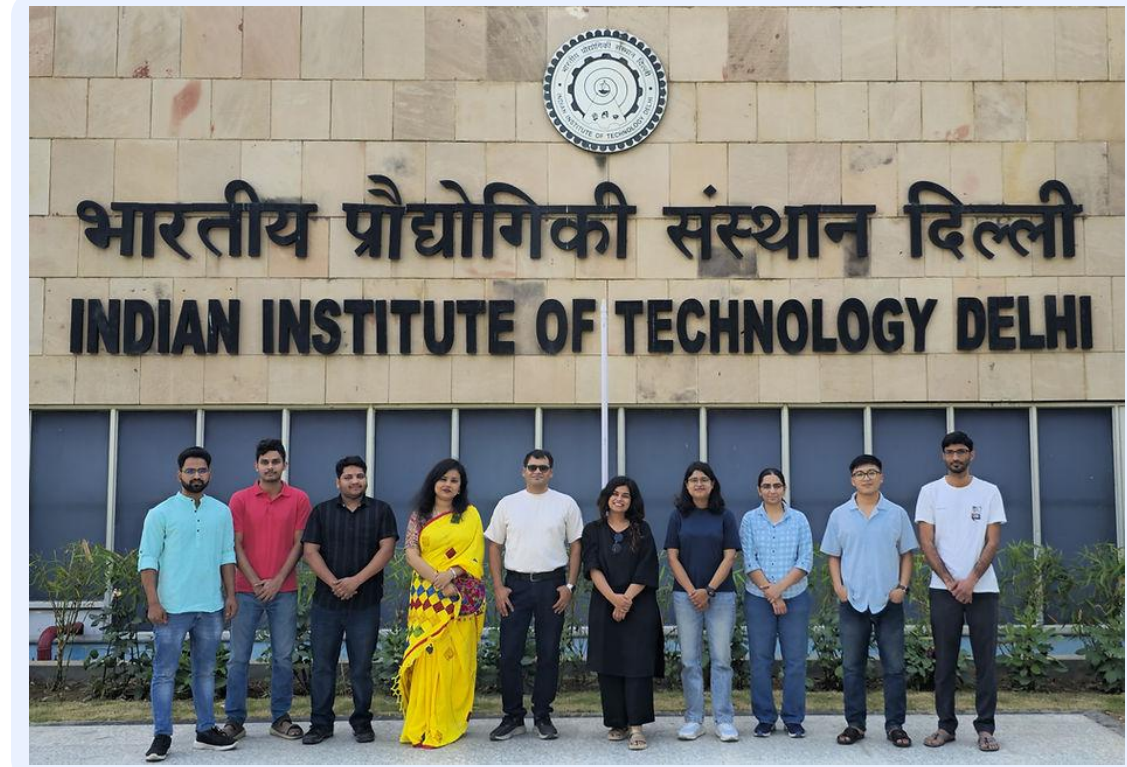


From Quantum Crystals to Quantum Capability

Building India's materials foundation for secure communication and sensing

Prof. Kaustuv Manna

Quantum Materials Magneto-Transport Laboratory

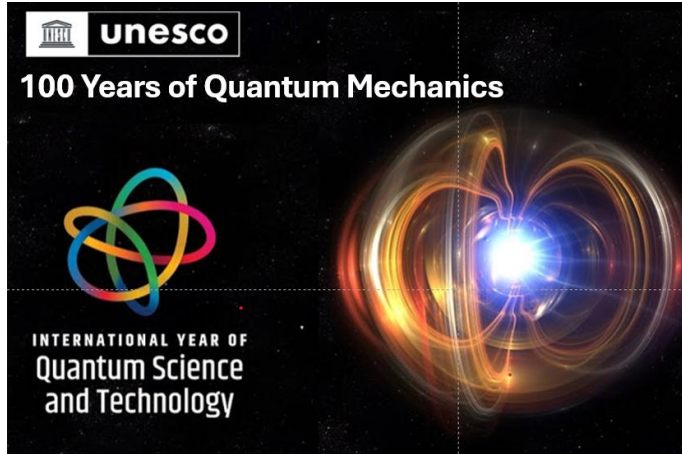


Group Webpage: <https://kaustuvmanna1.wixsite.com/my-site-1>



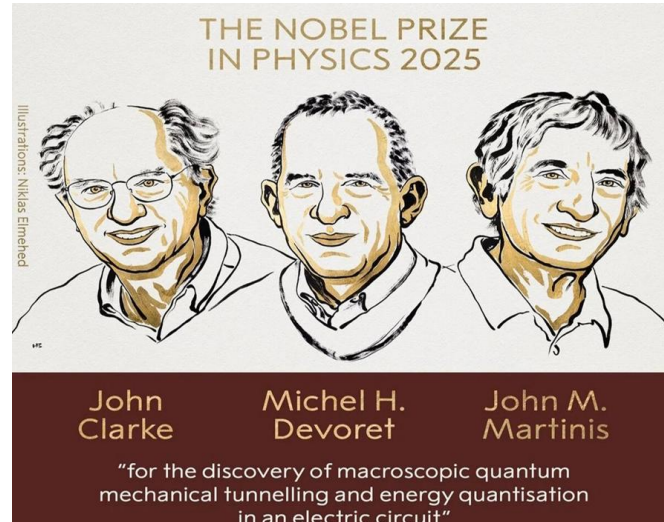
Quantum mechanics after 100 Years: From foundations to systems

In 2025, the centenary of quantum mechanics coincided with a Nobel Prize for quantum effects in an electrical circuit.



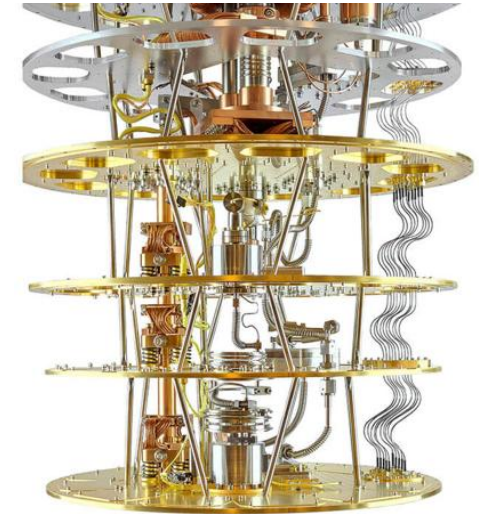
2025 CENTENARY

The UN General Assembly declared 2025 the International Year of Quantum Science and Technology, with UNESCO as lead agency.



NOBEL PRIZE IN PHYSICS 2025

John Clarke, Michel H. Devoret and John M. Martinis were honoured for macroscopic quantum tunnelling and energy quantisation in an electrical circuit.



QUANTUM COMPUTING HARDWARE

Cryogenic platforms allow superconducting circuits to preserve and control quantum behaviour at device scale.

THE LINK TO THIS TALK

Quantum effects in materials and circuits can become measurable functions and usable systems.

A quantum system begins with matter

Purity, symmetry, orientation and stability determine every downstream quantum function.

01

MATERIAL CONTROL

Composition • purity • symmetry • orientation

02

QUANTUM RESPONSE

Photons • spin • charge • heat

03

DEVICE ELEMENT

Source • detector • sensor • converter

04

SYSTEM CAPABILITY

Communication • sensing • future electronics

THE ENGINEERING TRUTH

Build the material first. Everything else inherits its quality.



Quantum materials for sensing and future electronics

An oriented crystal converts controlled stimuli into electrical and optical signals

MAGNETIC FIELD

Hall, Nernst and magnetoresistive response

HEAT GRADIENT

Thermoelectric and thermomagnetic response

LIGHT

Photogalvanic and nonlinear optical response

SPIN OR STRAIN

Spin-charge conversion and direction-dependent transport

SENSING OPPORTUNITIES

Magnetic field and current, temperature and heat flux, polarization and light

FUTURE ELECTRONICS

Spin-sensitive transport, non-reciprocal devices and multifunctional electronic elements

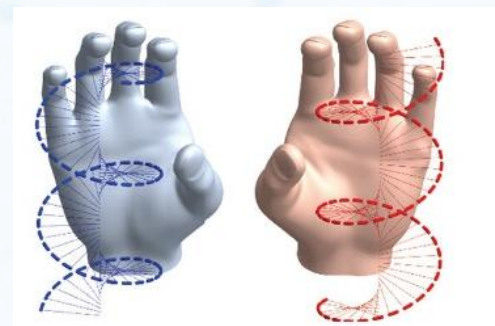
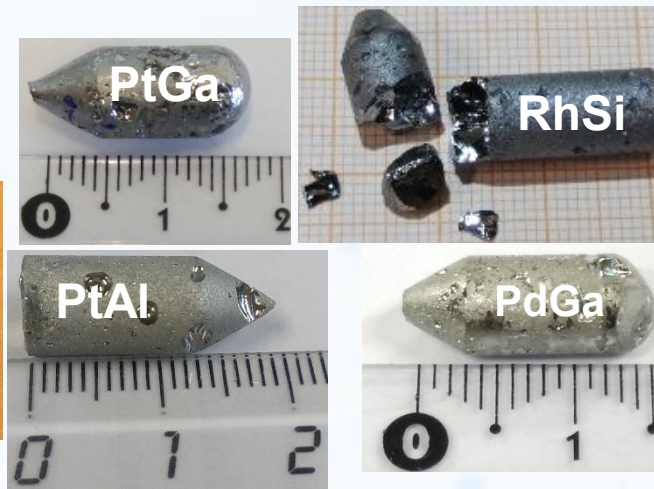


❑ Discovery of Chiral Topology

❑ Discovery of First Quantum Magnet

WORLD'S TOP 2% SCIENTISTS

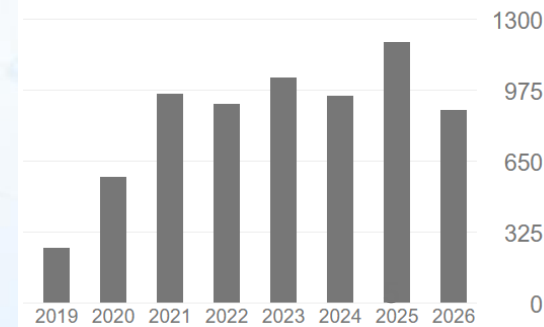
Listed from 2022



DNA, RNA, Sugars: Right Handed
Amino acids in proteins: Left Handed

Cited by	All	Since 2021
Citations	7043	5963
h-index	40	36
i10-index	64	58

[VIEW ALL](#)



90+ peer-reviewed publications

20

nature
International journal of science

3

Science
AAAS

Nature 649, 47–52 (2026);
Nature 604, 647–652 (2022);
Nature 567, 500–505 (2019);
Science 369, 179–183 (2020);
Science 365, 1278–1281 (2019)

Nat. Phys. 15, 759–765 (2019);
Nat. Phys. 18, 813–818 (2022);
Nat. Phys. 19, 682–688 (2023);
Nat. Phys. 20, 1912–1918 (2024);

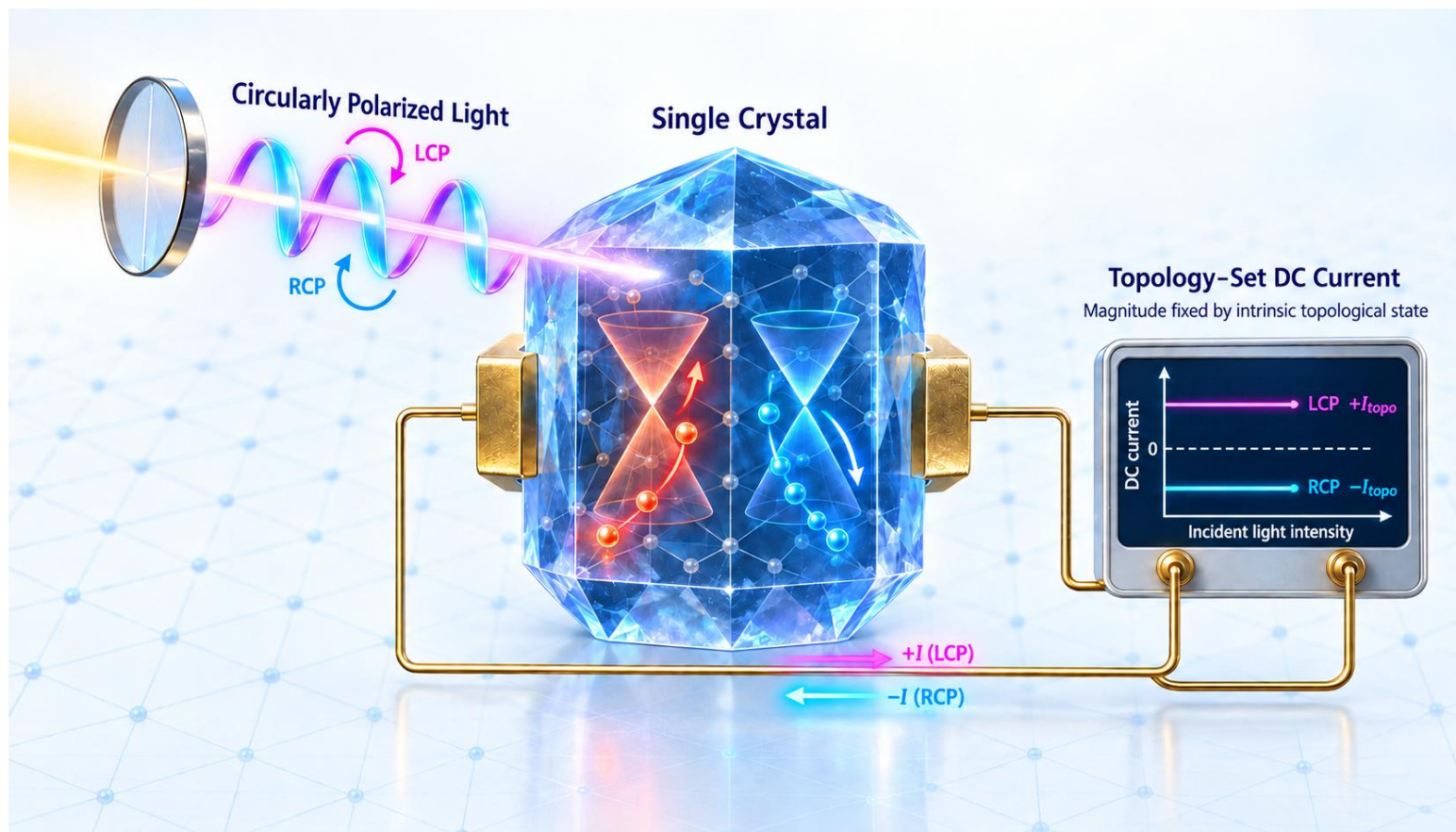
Sci. Adv. 6, eaba0509 (2020);
Proc Natl Acad Sci. 117, 27104 (2020).
npj Quantum Mater 5, 96 (2020).
Angew. Chem. Int. Ed., 62, e202303296 (2023)

Nat. Commun. 15, 3720 (2024);
Nat. Commun. 11, 2033 (2020);
Nat. Commun. 11, 3507 (2020);
Nat. Commun. 12, 154 (2021);
Nat. Commun. 12, 3994 (2021);

Phys. Rev. B 110, 224514 (2024).
Phys. Rev. B 103, 115206 (2021).

Phys. Rev. Lett. 127, 157405 (2021);
Phys. Rev. Lett. 130, 066402 (2023);
Adv. Mater. 32, 1908518 (2020);

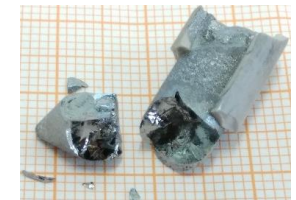
Quantized circular photogalvanic effect (CPGE)



Photocurrent that switches
depending on the sense of circular
polarization of the incident light.



RhSi



$\text{Rh}_{0.95}\text{Ni}_{0.05}\text{Si}$

Our 1st prediction: npj Quantum Mater 5, 96 (2020)

Our 1st experiment with basic characterization:
Phys. Rev. Lett. 130, 066402 (2023)

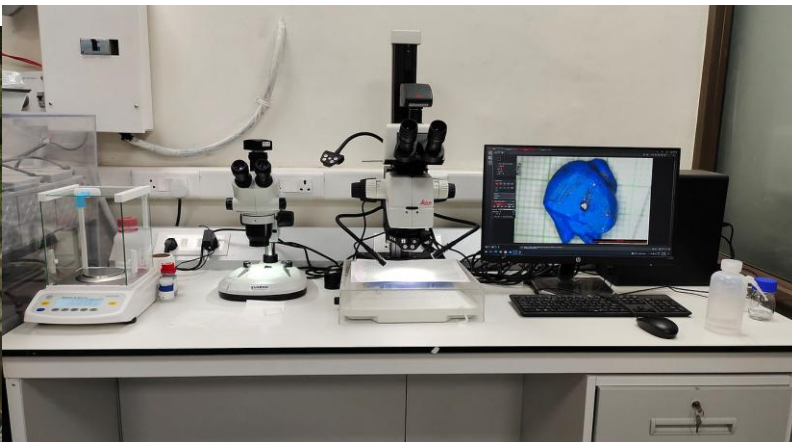
Quantized Photocurrents in Gapless Topological Matter:

arXiv:2607.12420 (2026)

Under review in **Science**



Quantum Materials Magneto-Transport Laboratory



<https://kaustuvmanna1.wixsite.com/my-site-1>

Indian Institute of Technology, Delhi



IIT Delhi Physics Department

Quantum Materials Magneto-Transport Laboratory

[Home](#)

[Profile](#)

[Publications](#)

[Projects](#)

[Research](#)

[Lab Facilities](#)

[Open Positions](#)

[Contact](#)

kaustuvmanna@physics.iitd.ac.in



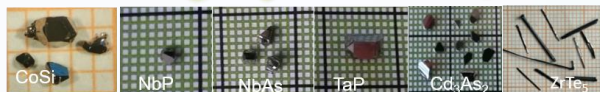
WORLD'S TOP 2% SCIENTISTS

End-to-end single-crystal capability

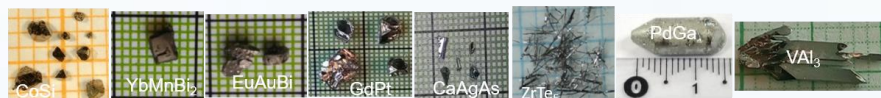
One laboratory controls the chain from synthesis to direction-specific property validation

Single Crystals of various Quantum Materials

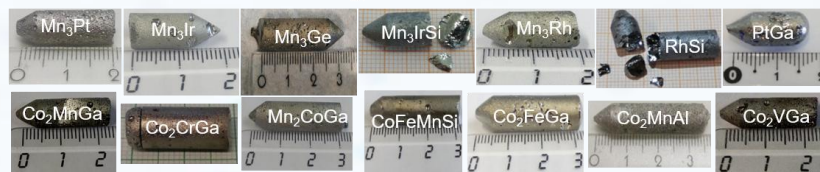
Chemical
vapor
transport



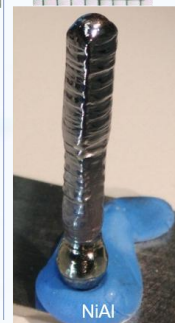
Flux
method



Bridgman
method



Optical
Floating
Zone



CONNECTED OUTPUT

Oriented specimens with direction-specific magnetic, electrical, thermal and optical property data

01



GROW

Bridgman to 1800 °C
Flux, CVT and floating zone

02



ORIENT

Laue diffraction
Select the crystallographic axis

03



CUT & PREPARE

Wire saw and diamond saw
Prepare direction-specific specimens

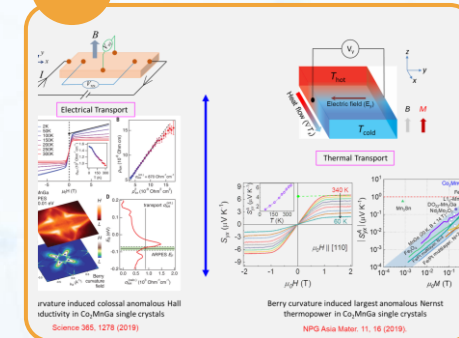
04



MEASURE

Magnetic, electrical and
thermal transport

05



VALIDATE

Anisotropy and quantum
oscillations
Link crystal direction to response

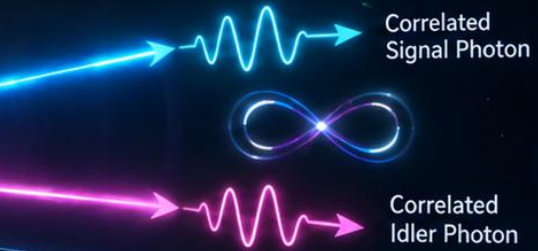
Efficient Frequency Conversion



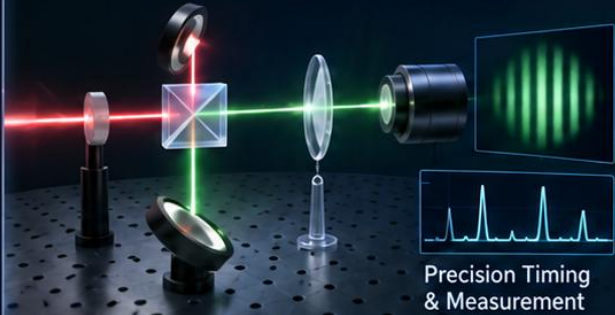
KTP



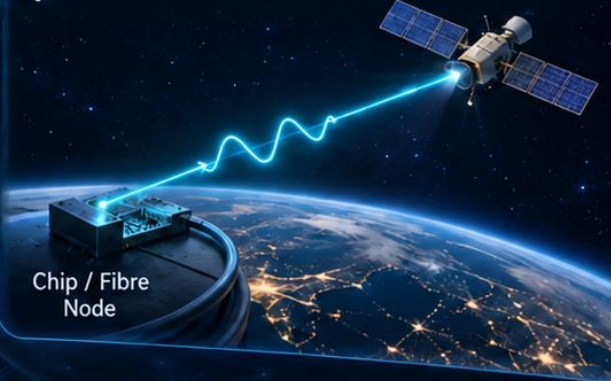
Entangled Photon Sources



Quantum Sensing & Metrology



Quantum Communication & Satellite QKD

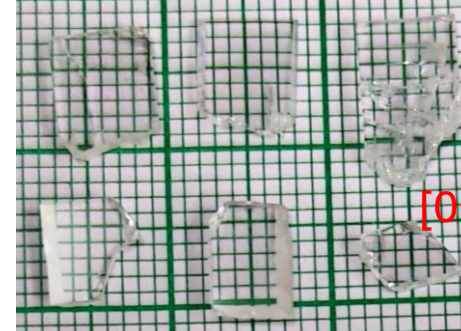


Indigenous Quantum Photonics Capability

Project with DRDO



(JATC-P2QP-17)



Permanent magnets: an adjacent strategic materials opportunity

The discipline behind quantum crystals also applies here: composition control, anisotropy and reliable performance data.

INDIA'S CURRENT POSITION

Most sintered NdFeB demand is imported

NATIONAL SCALE-UP

6,000 tonnes/year domestic rare-earth magnet capacity targeted

WHAT THE IIT DELHI PLATFORM CONTRIBUTES

- **Materials synthesis and phase control**
- Magnetic anisotropy and structure-property characterization
- Application-led performance validation with industry

COLLABORATION SOUGHT

Magnet manufacturers, motor and actuator companies, and strategic-system integrators



India's indigenous capability opportunity

Control the material platform, its performance data and the route to qualified components.

MATERIAL PLATFORM

Grow and orient functional crystals for defined optical, magnetic and electronic responses.

COMPONENT EVIDENCE

Measure direction-dependent performance and establish reproducible specifications.

QUALIFICATION PATH

Work with industry to package, test and adapt components for Indian operating needs.

STRATEGIC GAIN

Domestic know-how, performance data and a supply route that India can control.



Academia–industry collaboration model

A shared programme connects scientific capability with product ownership and qualification.



IIT DELHI

Crystal growth, orientation and physical-property validation

SHARED PROGRAMME

Application specification, prototype cycles, IP and milestones

INDUSTRY PARTNER

Device engineering, packaging, manufacture and customer qualification

Three partnership invitations

Three practical ways to engage with the IIT Delhi materials capability.

01

CO-DEVELOP

Convert a defined application need into material, geometry and test criteria.

02

VALIDATE

Sponsor measurements under operating conditions that matter to the product.

03

SCALE

License, manufacture or integrate a validated crystal or component platform.

A USEFUL FIRST DISCUSSION

Bring one target performance requirement. We will define the material and validation route.



The background of the slide features a light blue gradient with a subtle, repeating pattern of interconnected dots and lines, resembling a network or molecular structure. The dots are small and light blue, while the lines are thin and light blue, creating a mesh-like effect across the entire slide.

Thank you...