Advanced electronics for Physics detectors, Medical, Industrial and Space applications

Group for **R**adiation **I**maging and **T**racking

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Find us at: *https://web.infn.it/GRIT/*

What do we do

What we do: help solving puzzles like this

Particles position in **space**

Particles position in **time**

µm precision

ns, **ps** precision

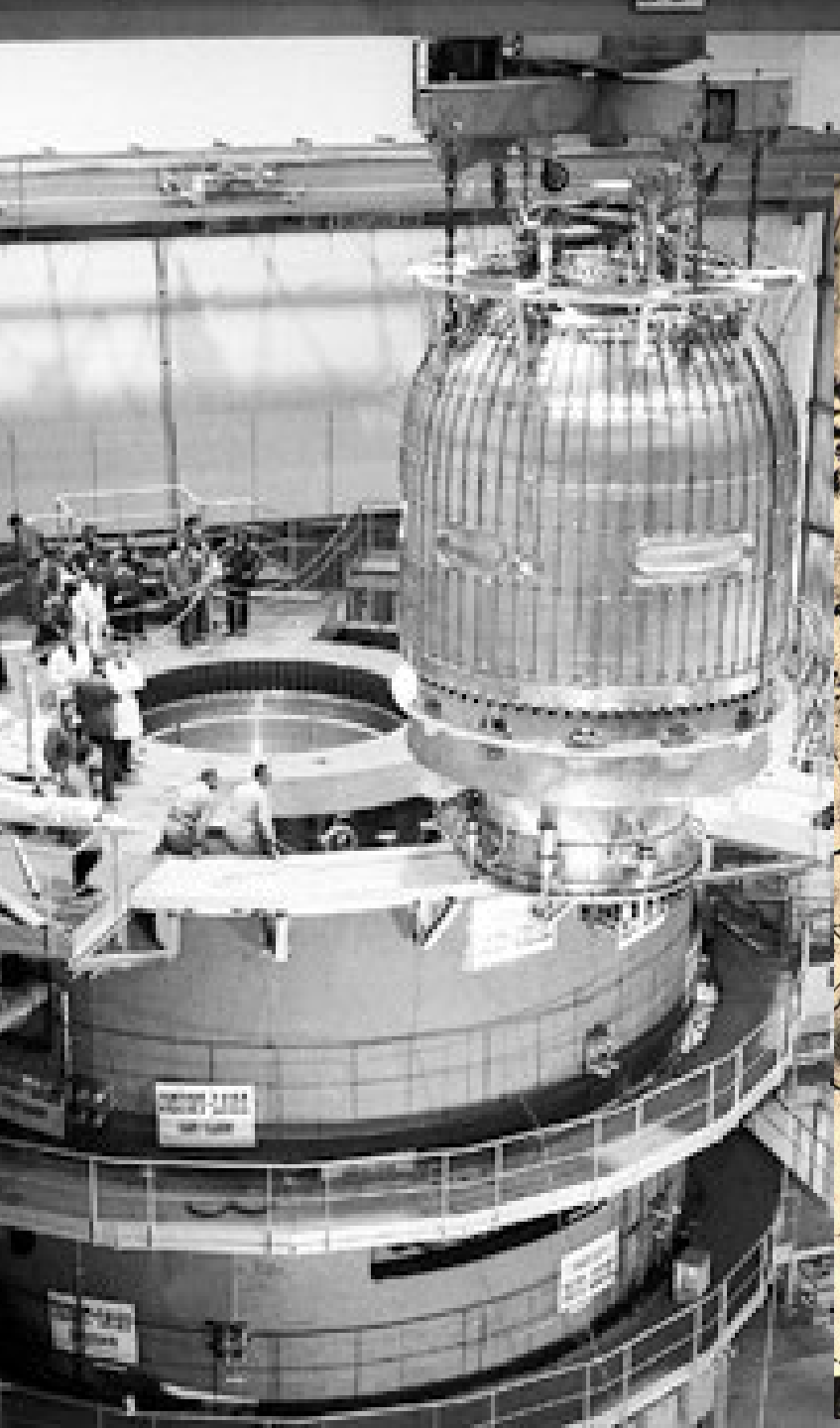
Over many **m^2**

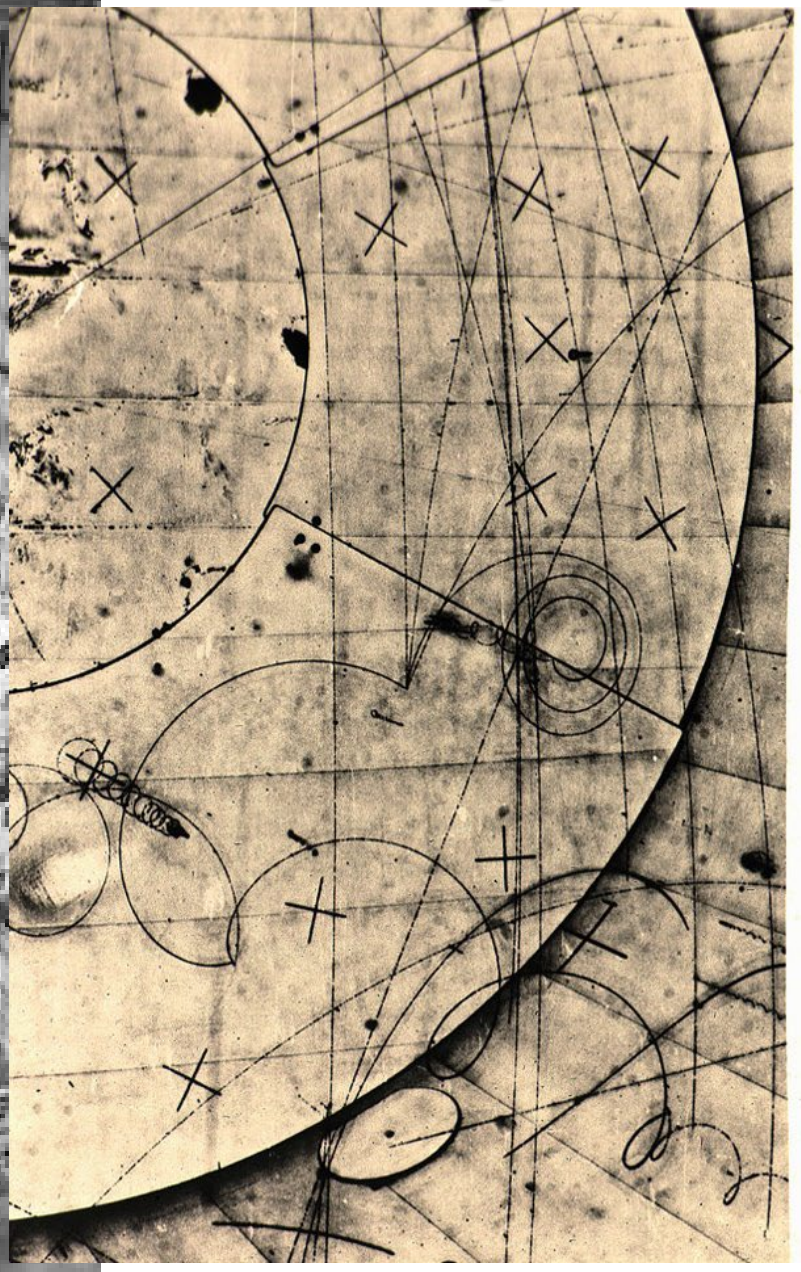
Over **years**

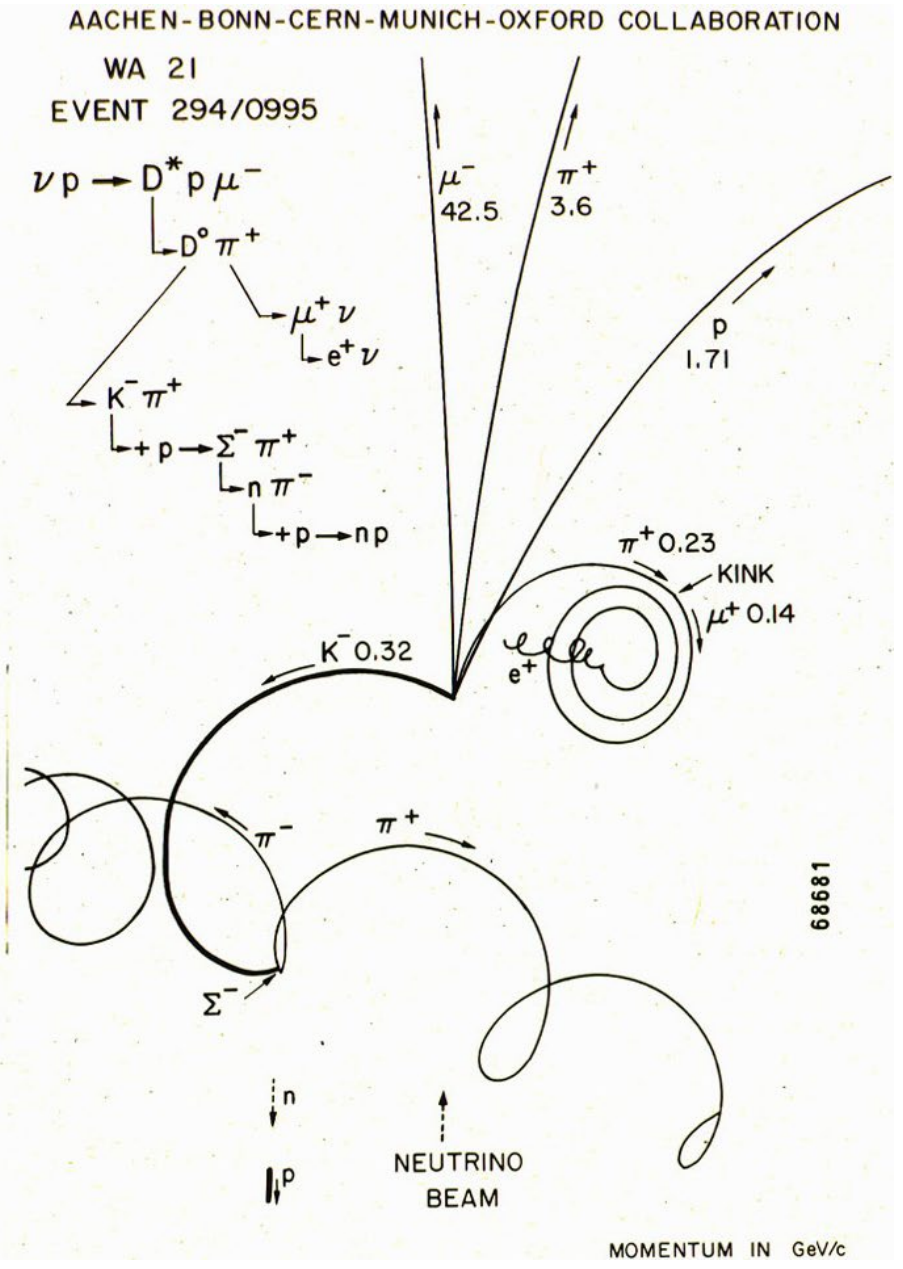
Little **power**

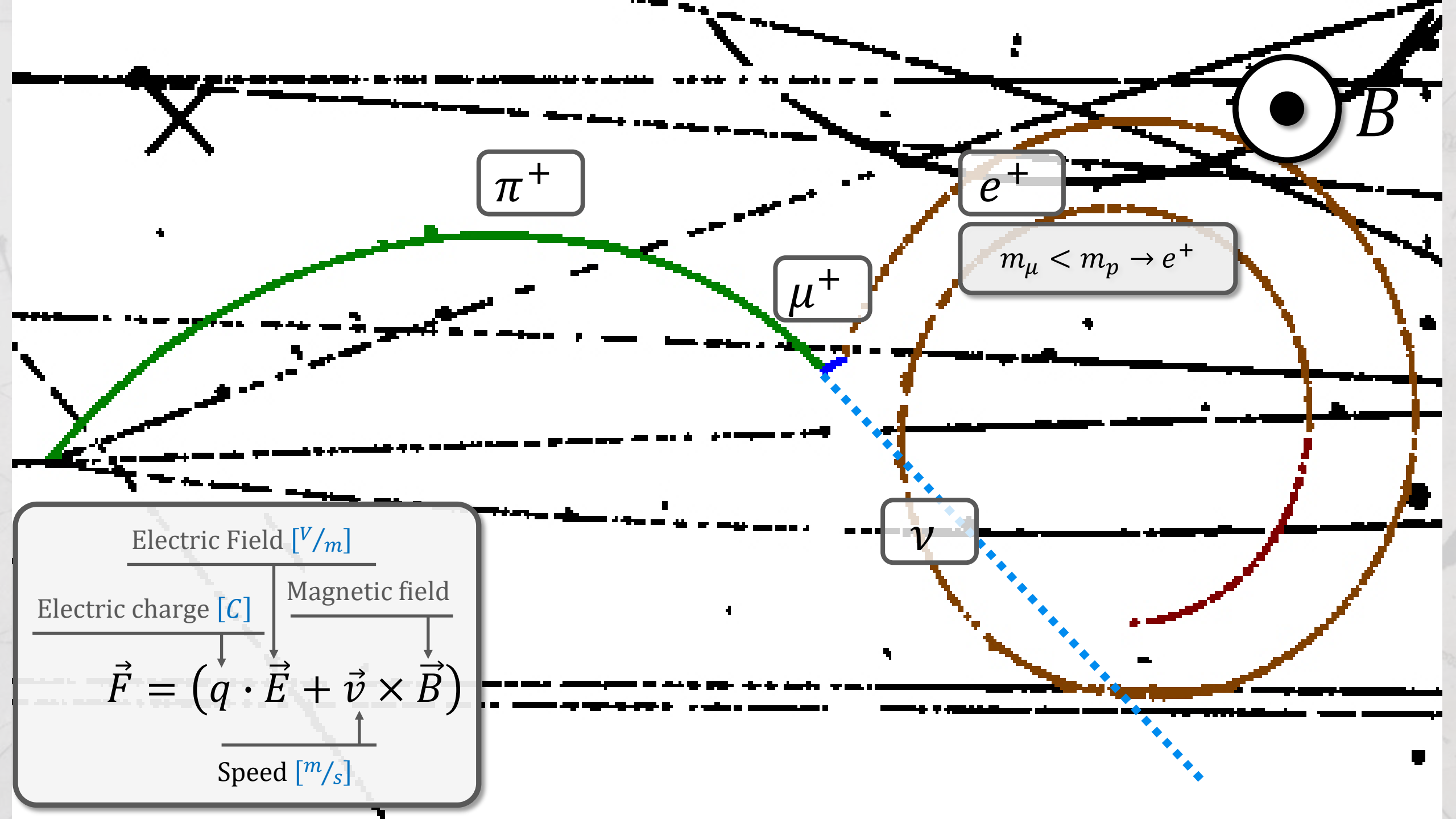
Hostile **radiation**

Once upon a time in the lab....

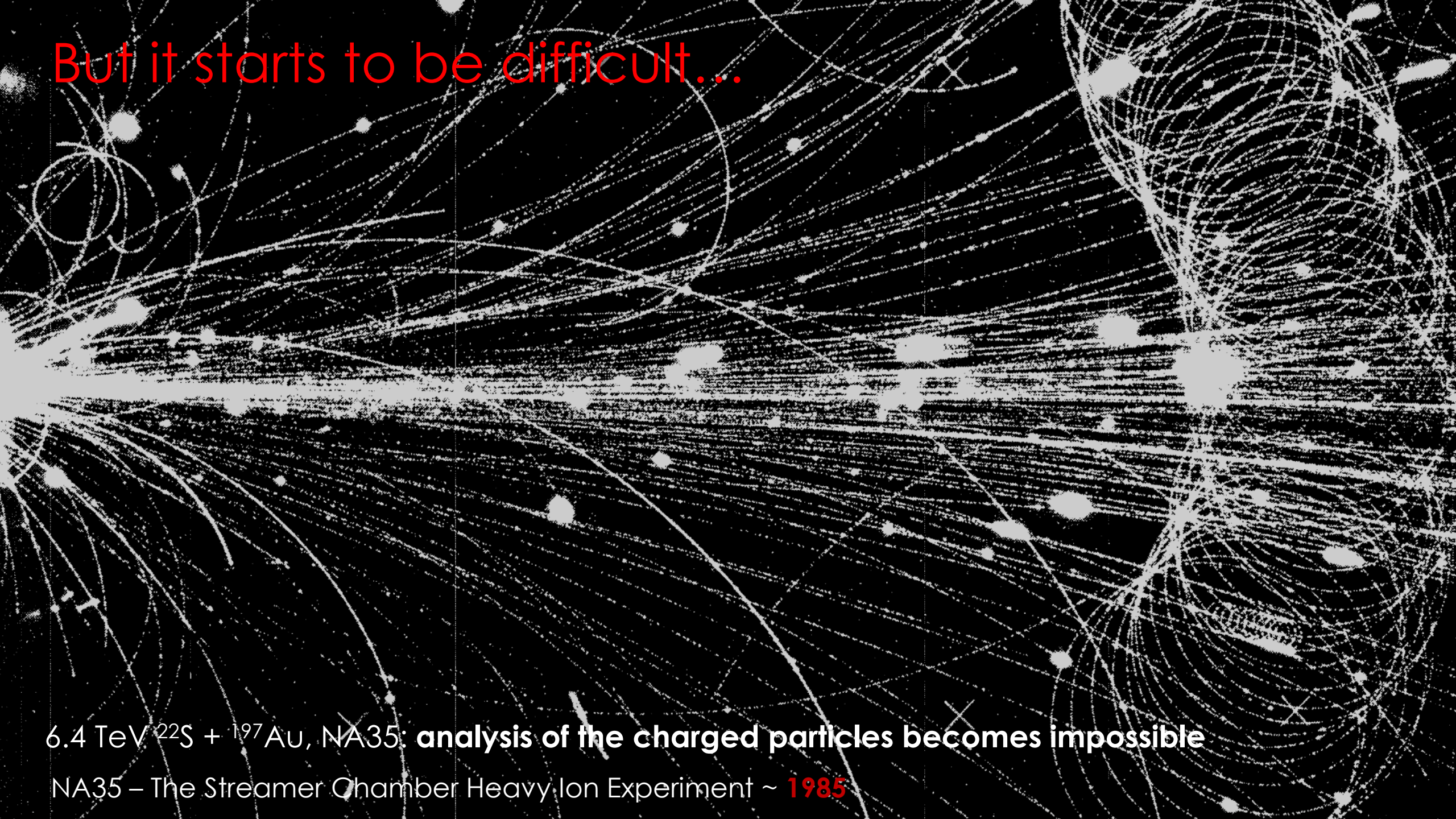






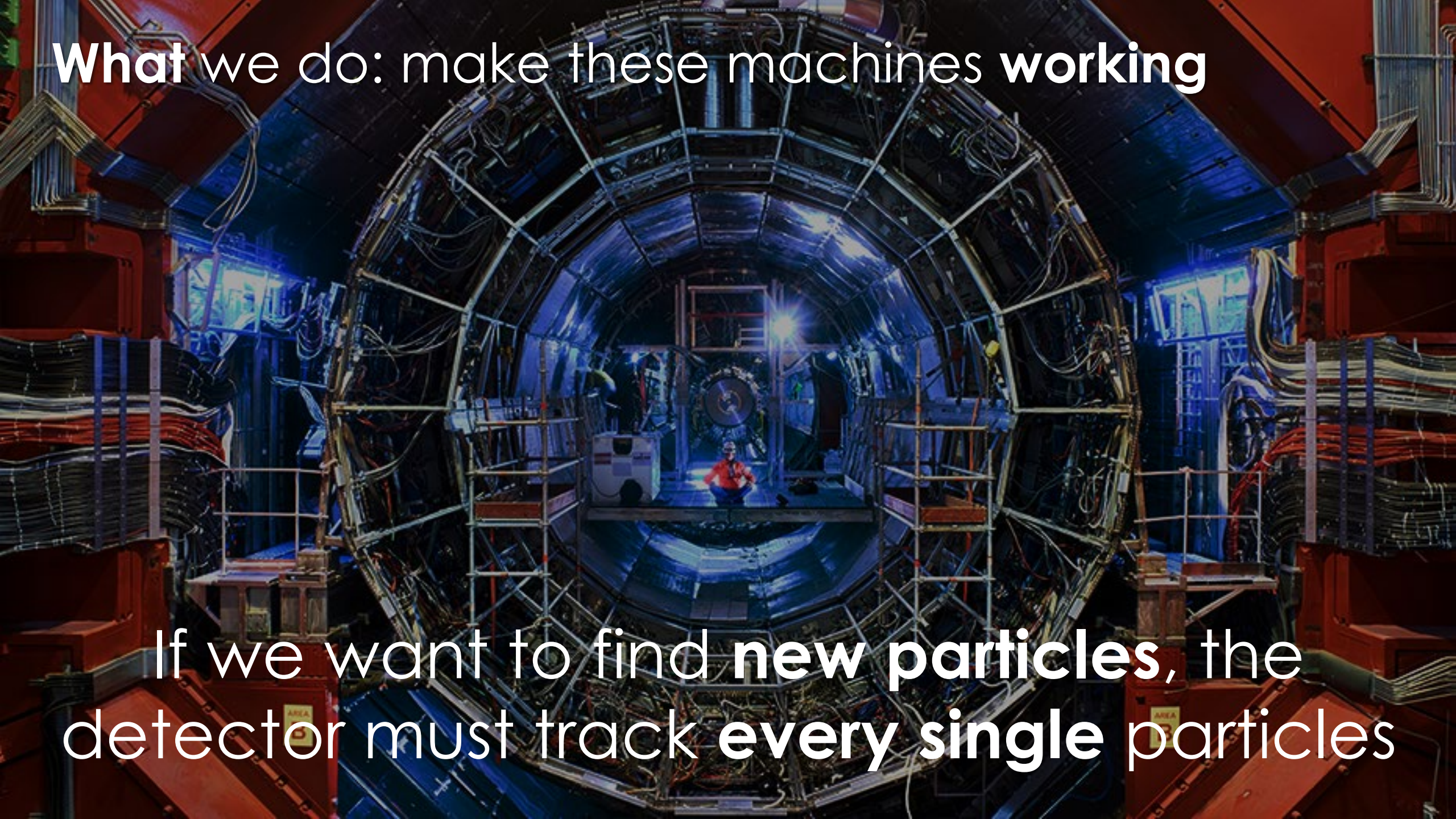

B
π^+
μ^+
e^+
$m_\mu < m_p \rightarrow e^+$
ν
Electric Field $[V/m]$
Electric charge $[C]$
Magnetic field
$\vec{F} = (q \cdot \vec{E} + \vec{v} \times \vec{B})$
Speed $[m/s]$

But it starts to be difficult…



6.4 TeV ^{22}S + ^{197}Au, NA35: **analysis of the charged particles becomes impossible**

NA35 – The Streamer Chamber Heavy Ion Experiment ~ **1985**



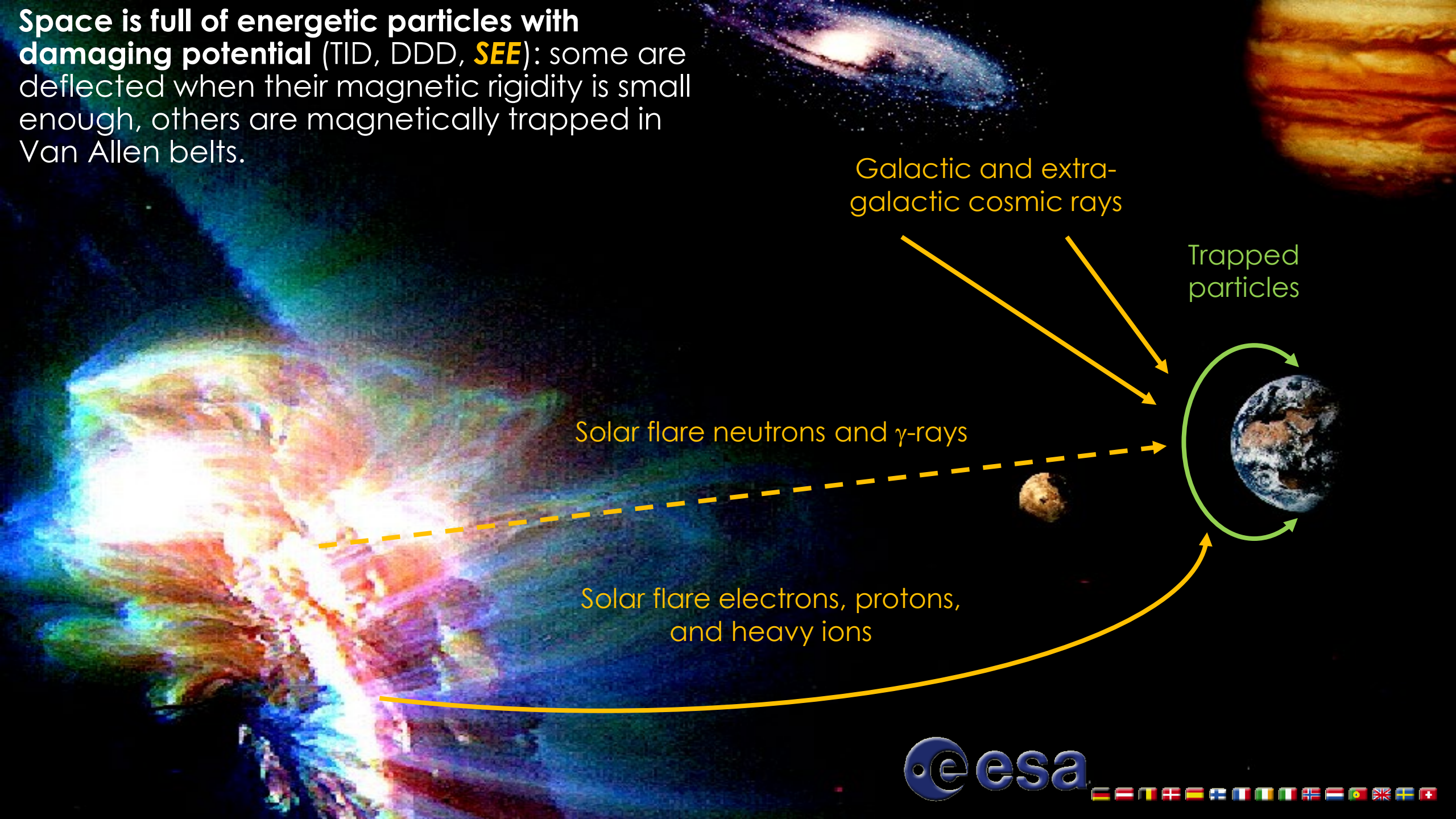
What we do: make these machines **working**

If we want to find **new particles**, the detector must track **every single** particles

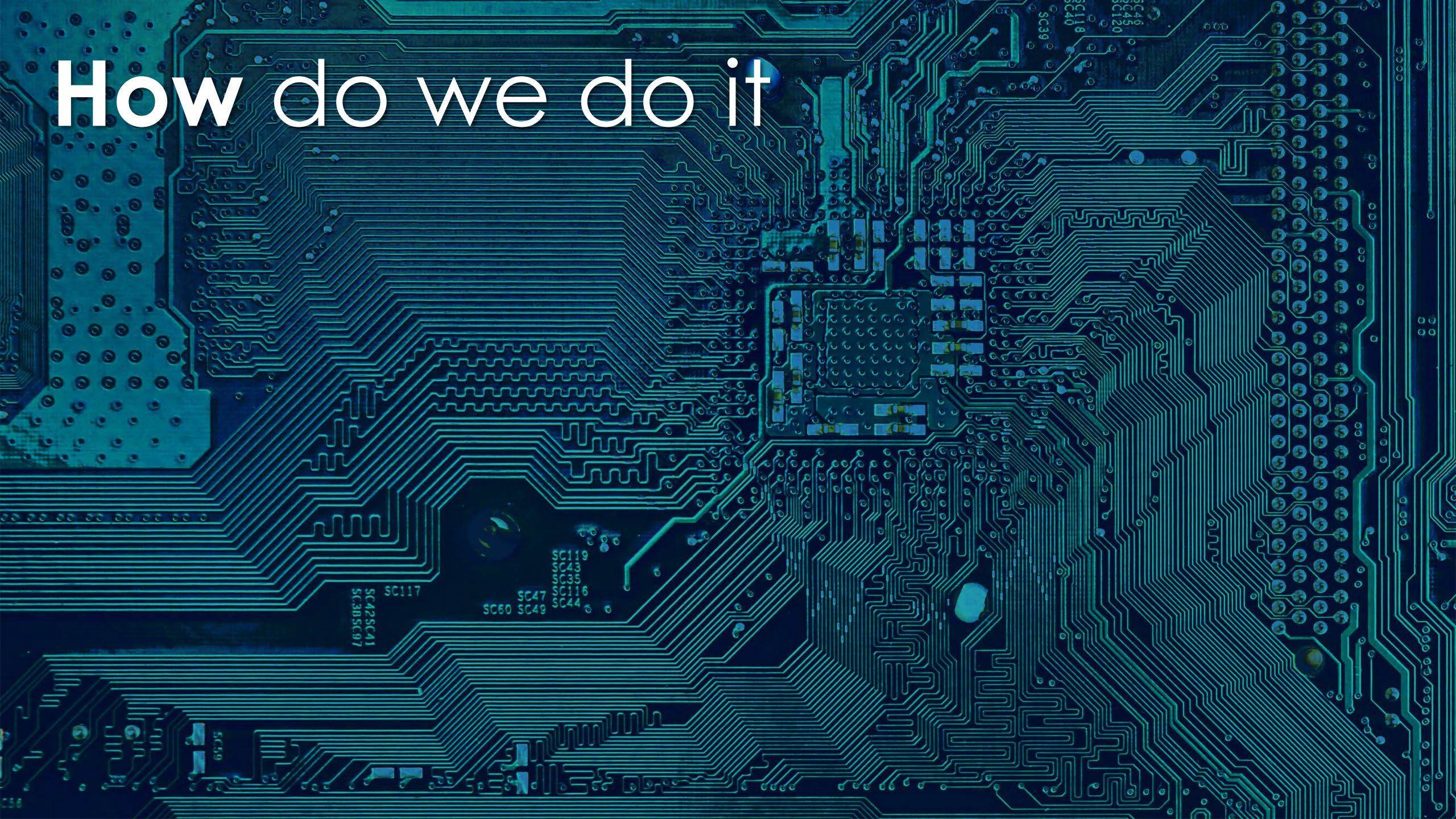
What we do: make these machines **surviving**

If we want the astronauts back to Earth,
better the spaceship survives as well!

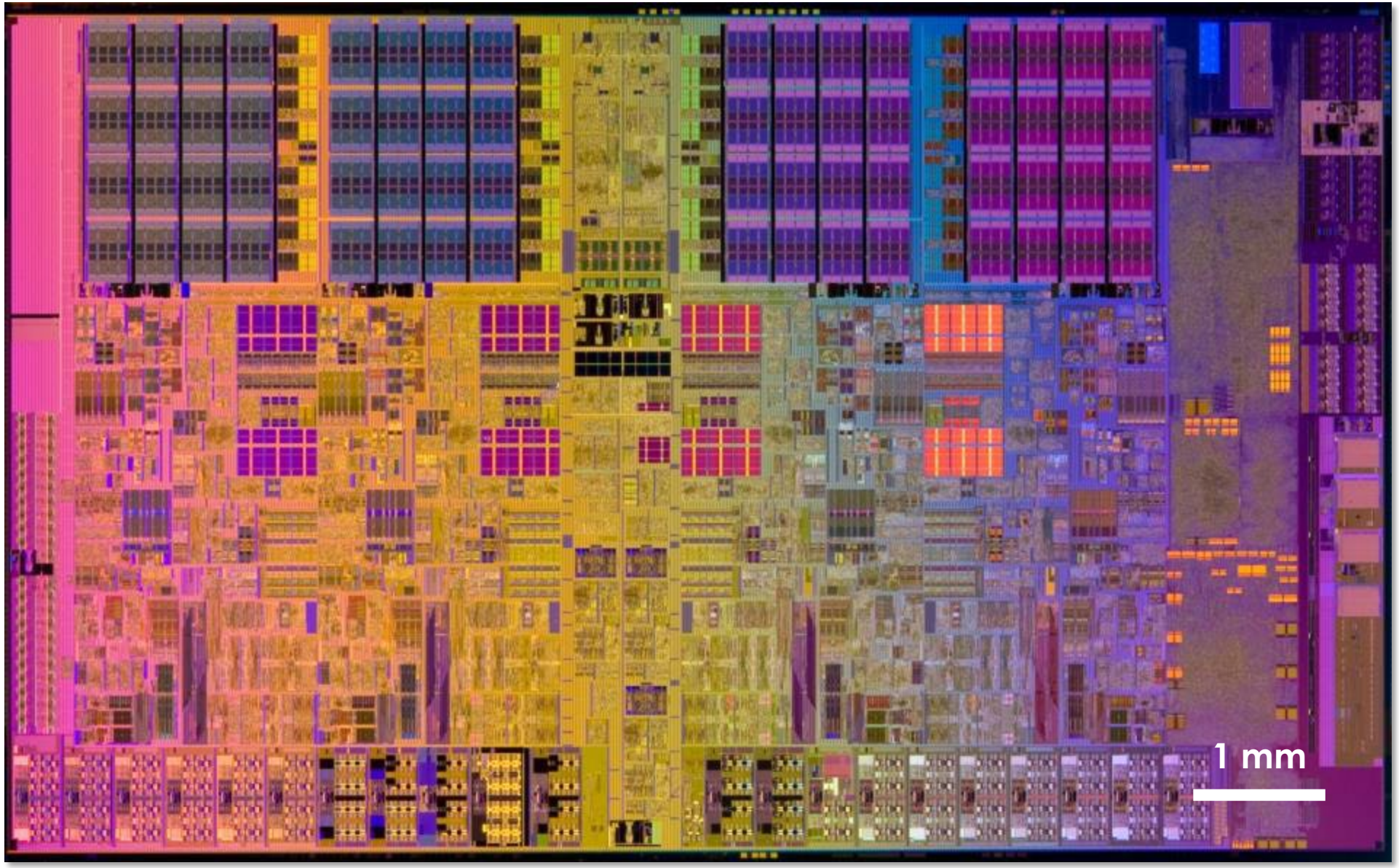
Space is full of energetic particles with damaging potential (TID, DDD, ***SEE***): some are deflected when their magnetic rigidity is small enough, others are magnetically trapped in Van Allen belts.



How do we do it

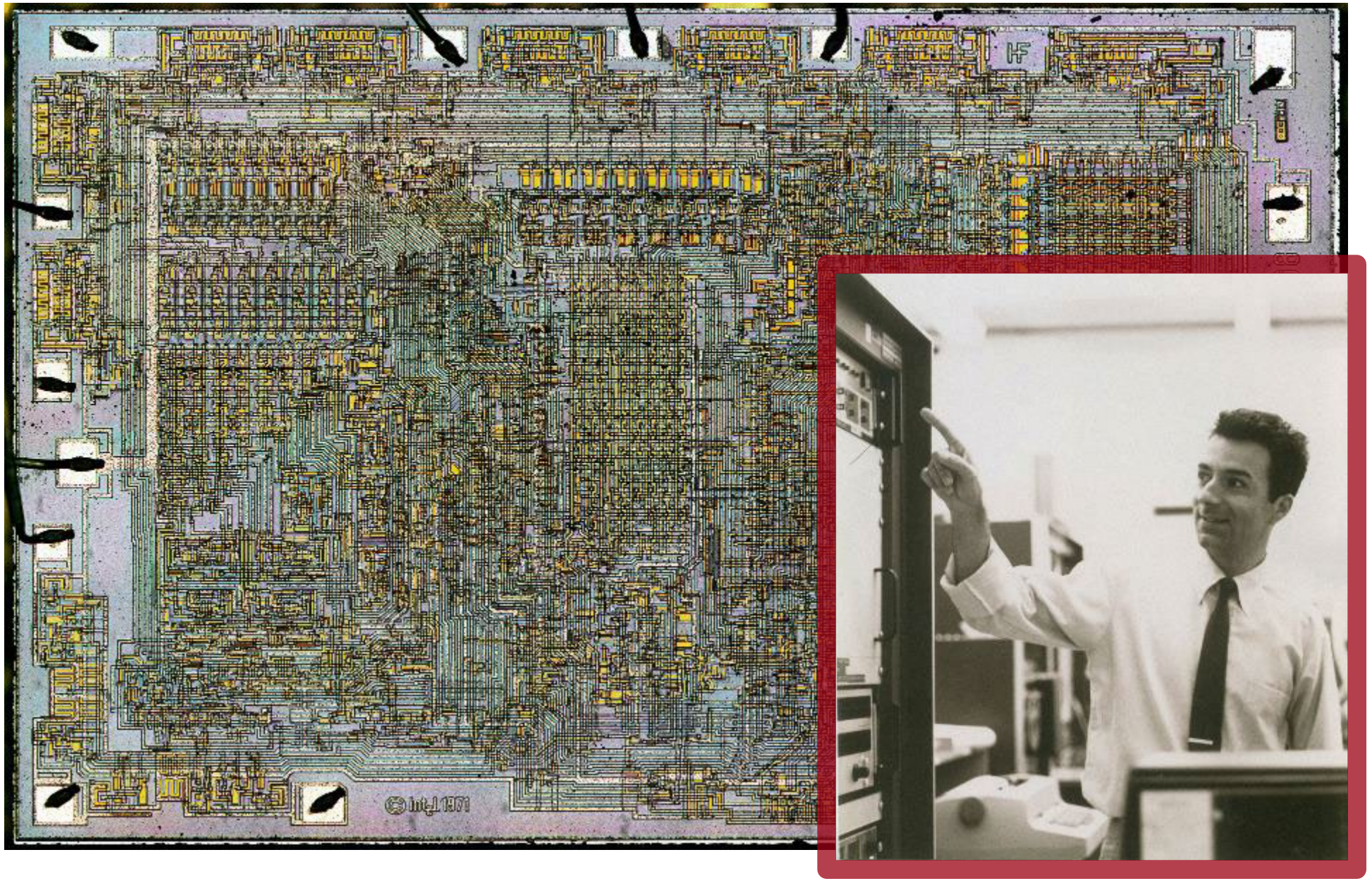


How do we do it?



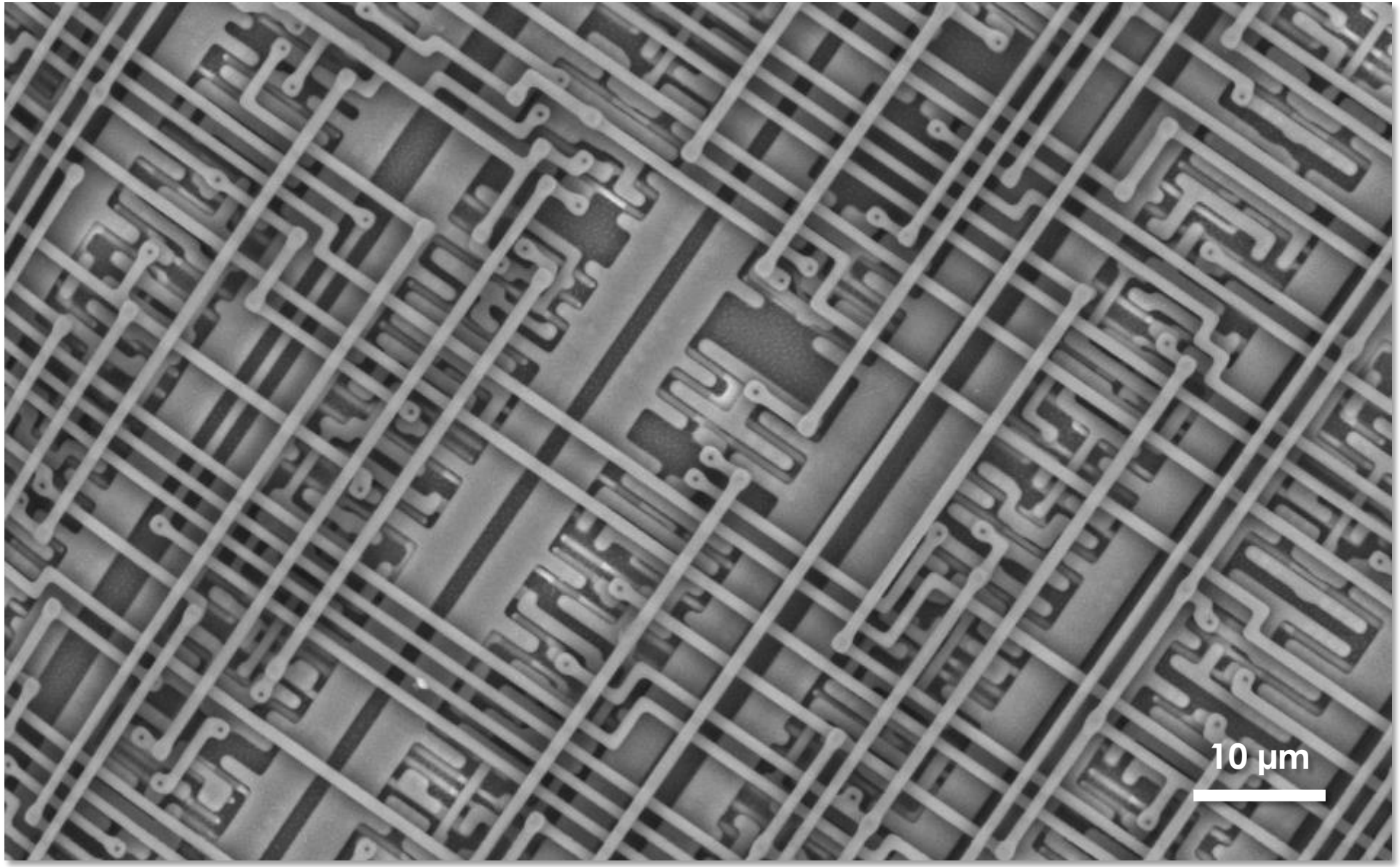
Think about **modern art**

How to measure **time** and **position**?



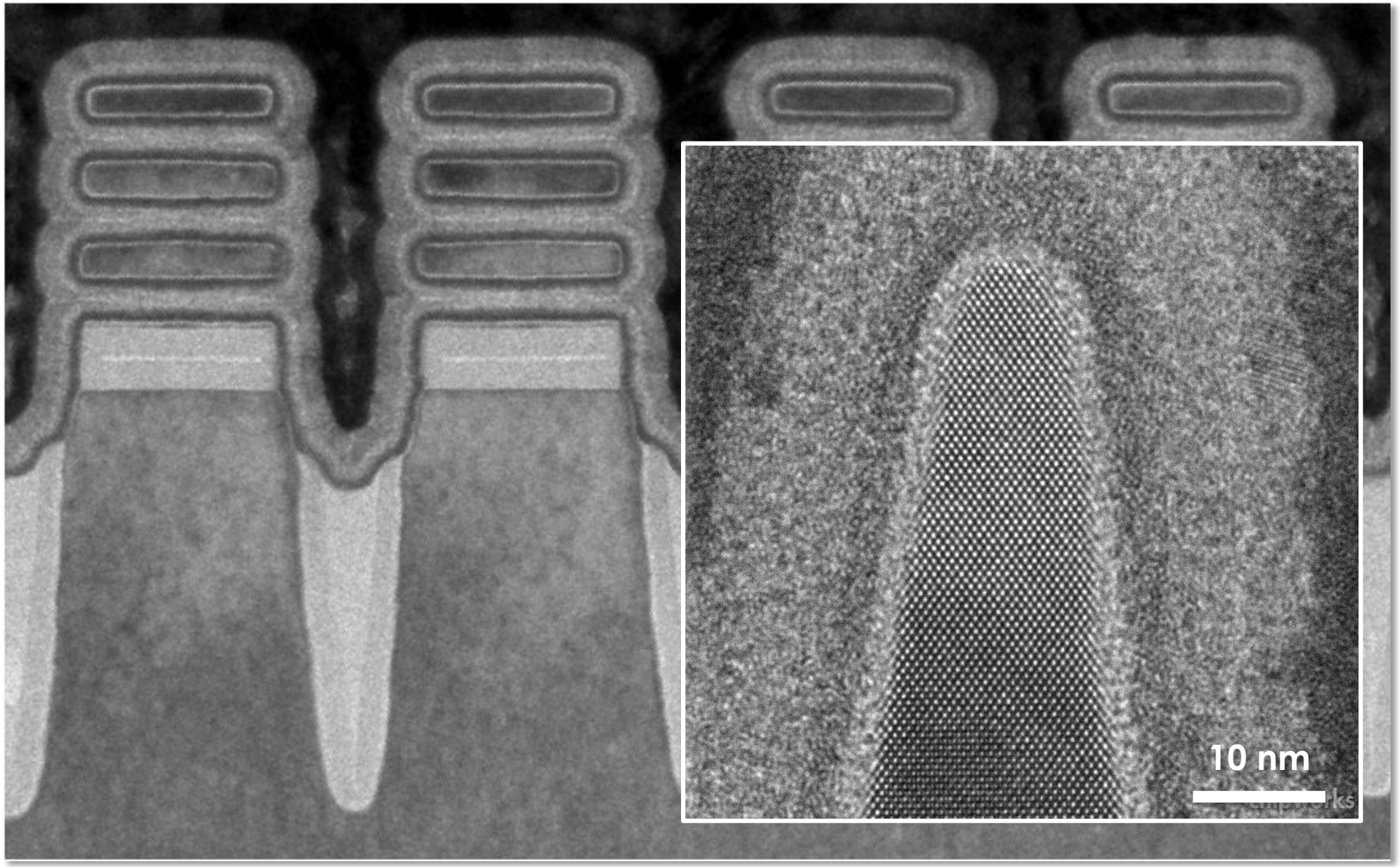
An art started by an **illustrious student from Padova**: **F. Faggin**

How do we do it?



modern art of extremely **complex systems**

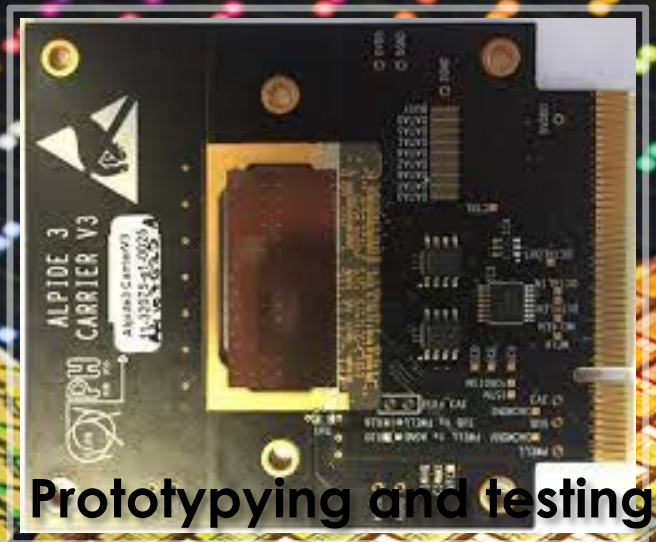
How do we do it?



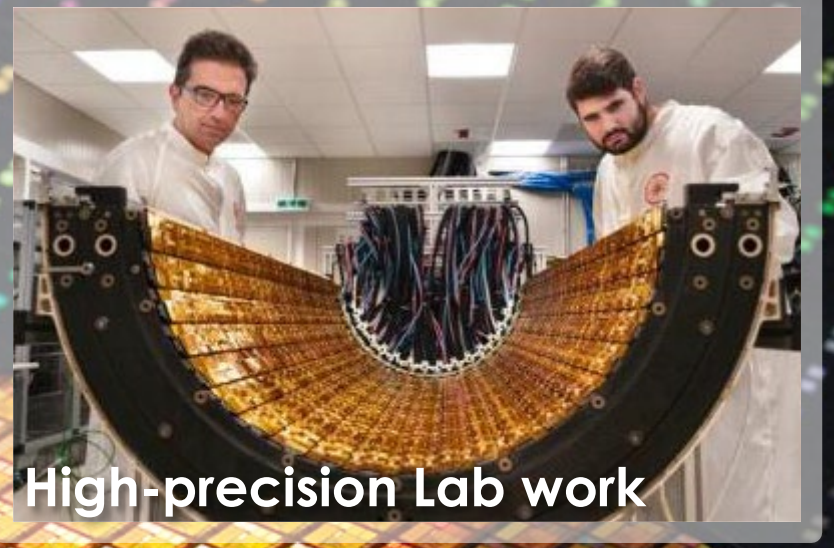
complex systems powered by **quantum physics**

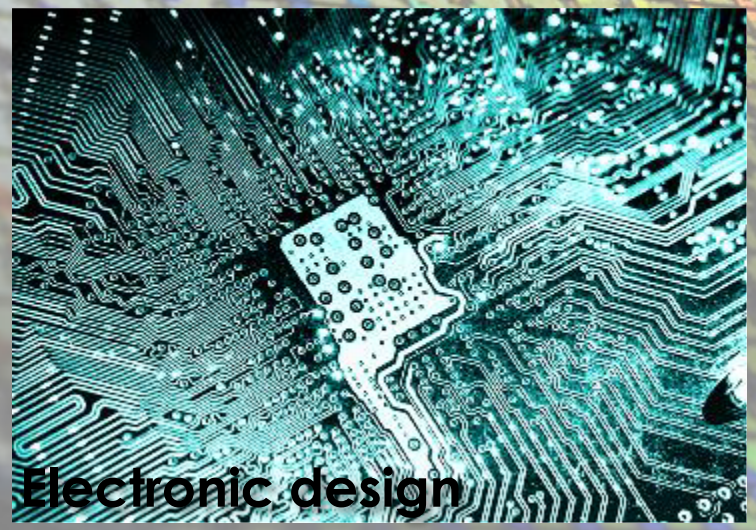
How do we do it?


Advanced computing

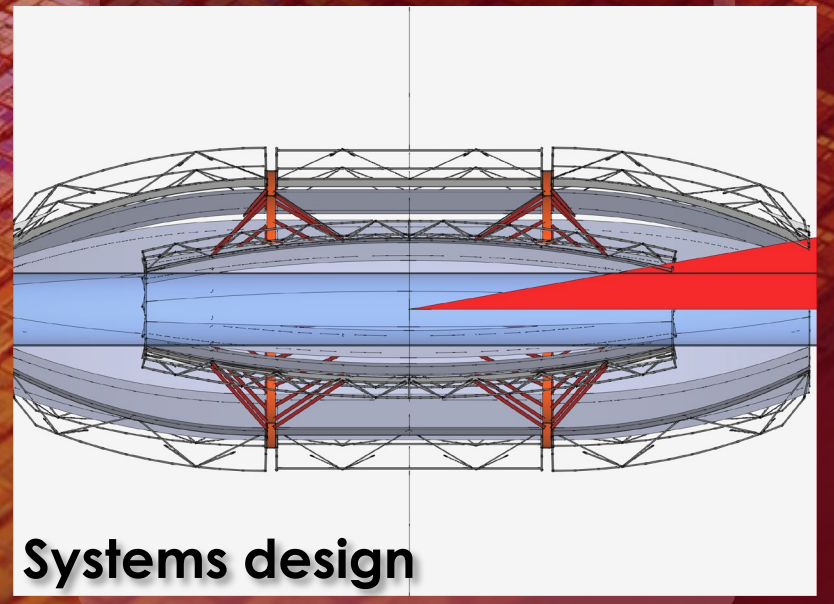


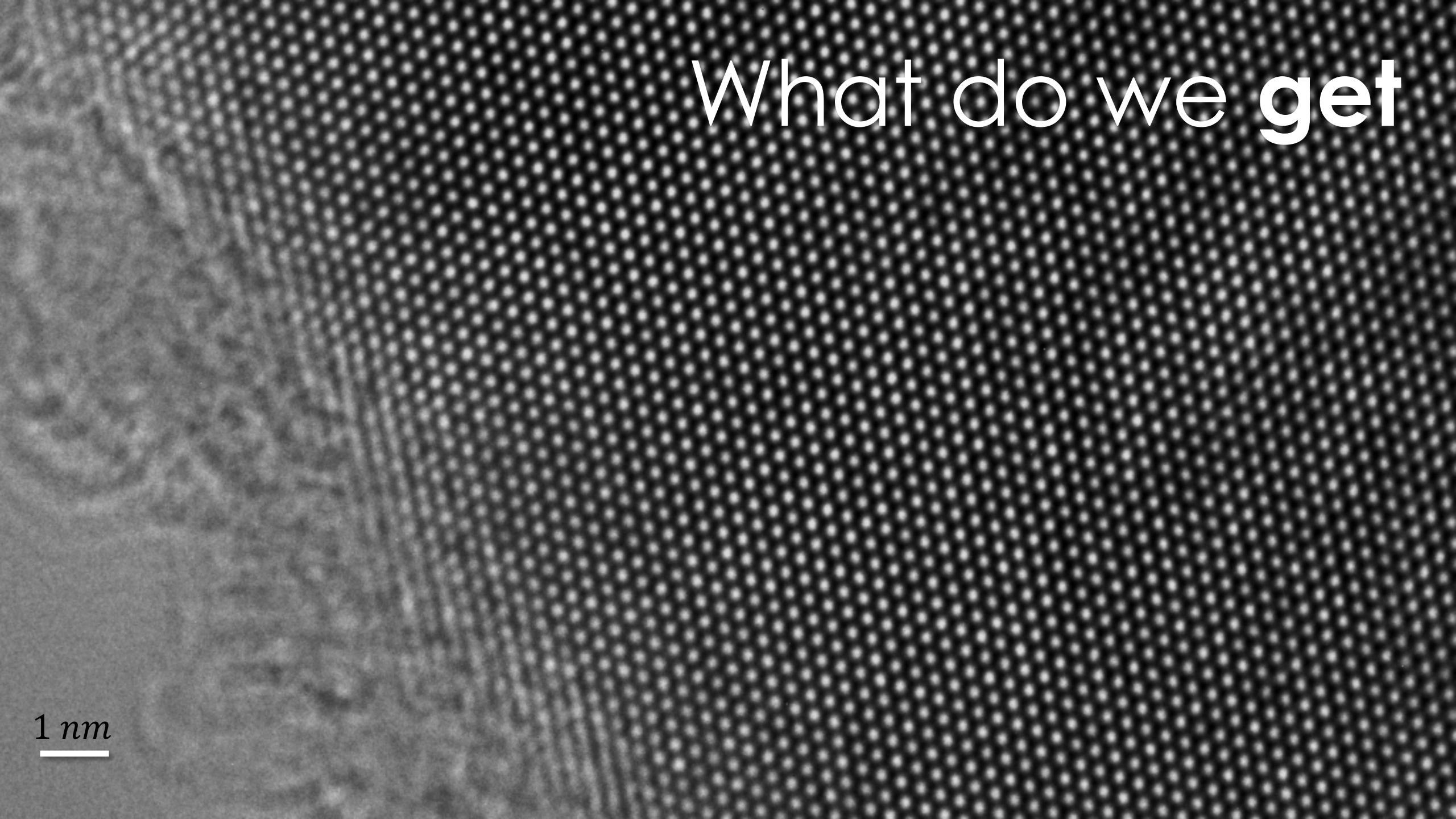
Prototypying and testing


High-precision Lab work


Electronic design


On-the-field tasks

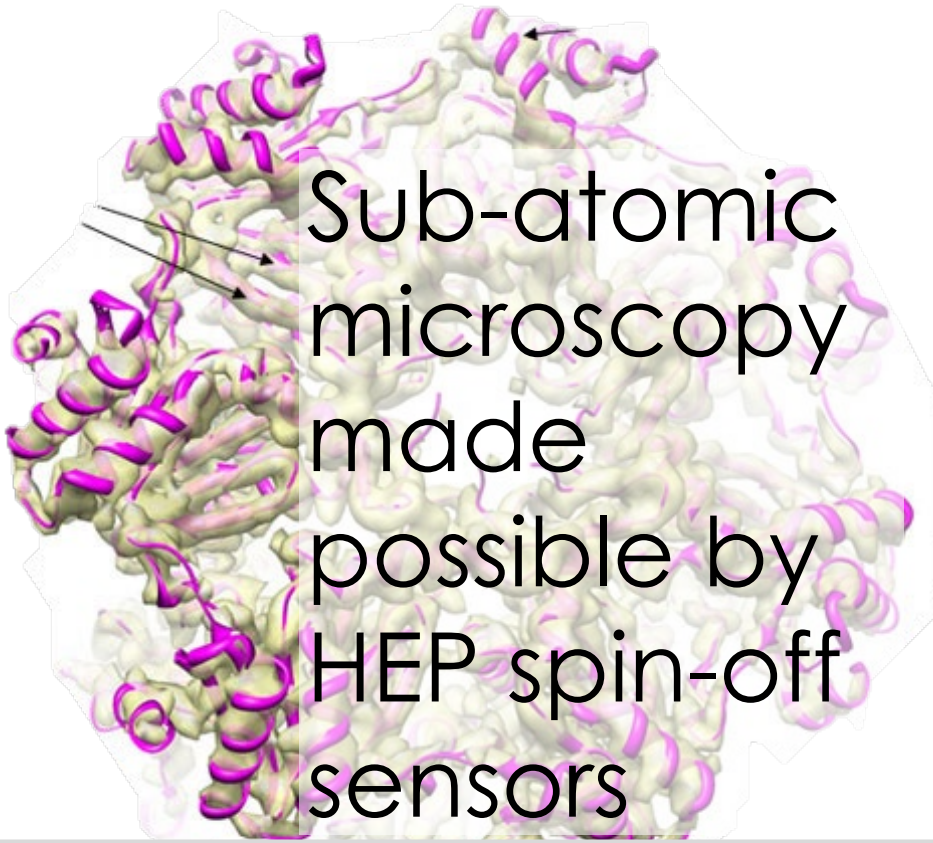

Systems design


What do we **get**
1 nm

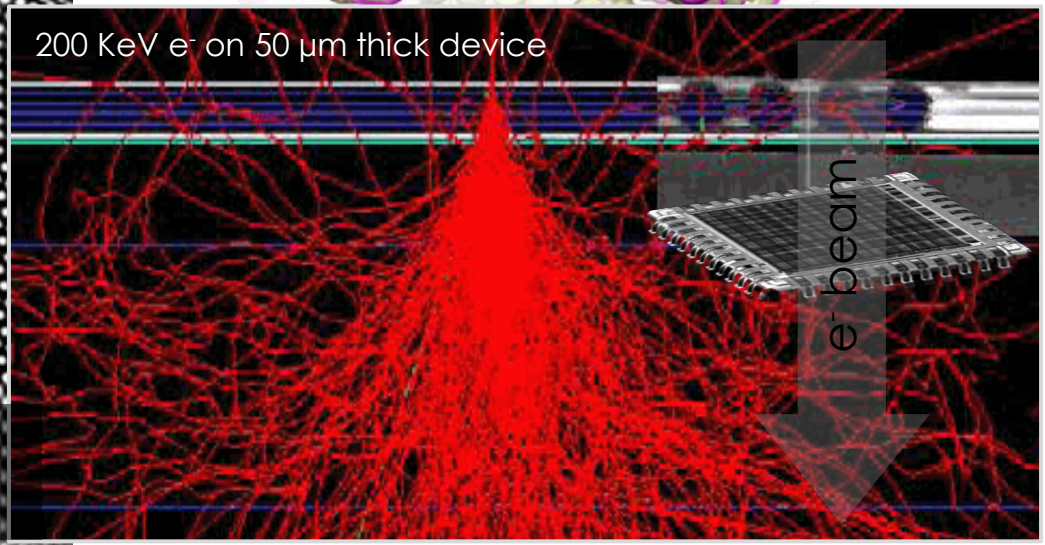
Electron Microscopy (e^-)

Si lattice – 2.5 ms integration time

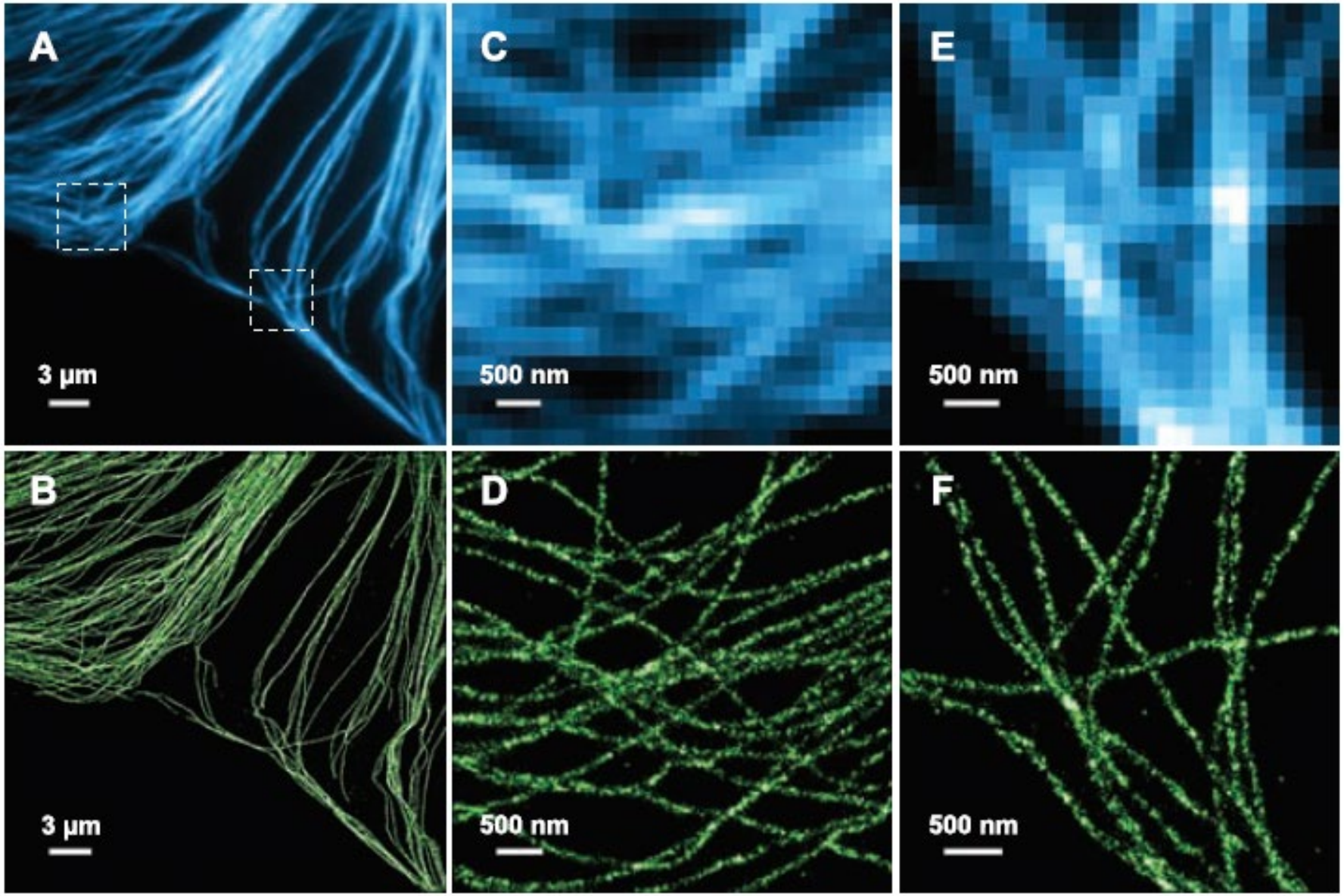
Look at:
https://www.gatan.com/products/tem-imaging-spectroscopy/k3-camera-0



Sub-atomic microscopy made possible by HEP spin-off sensors



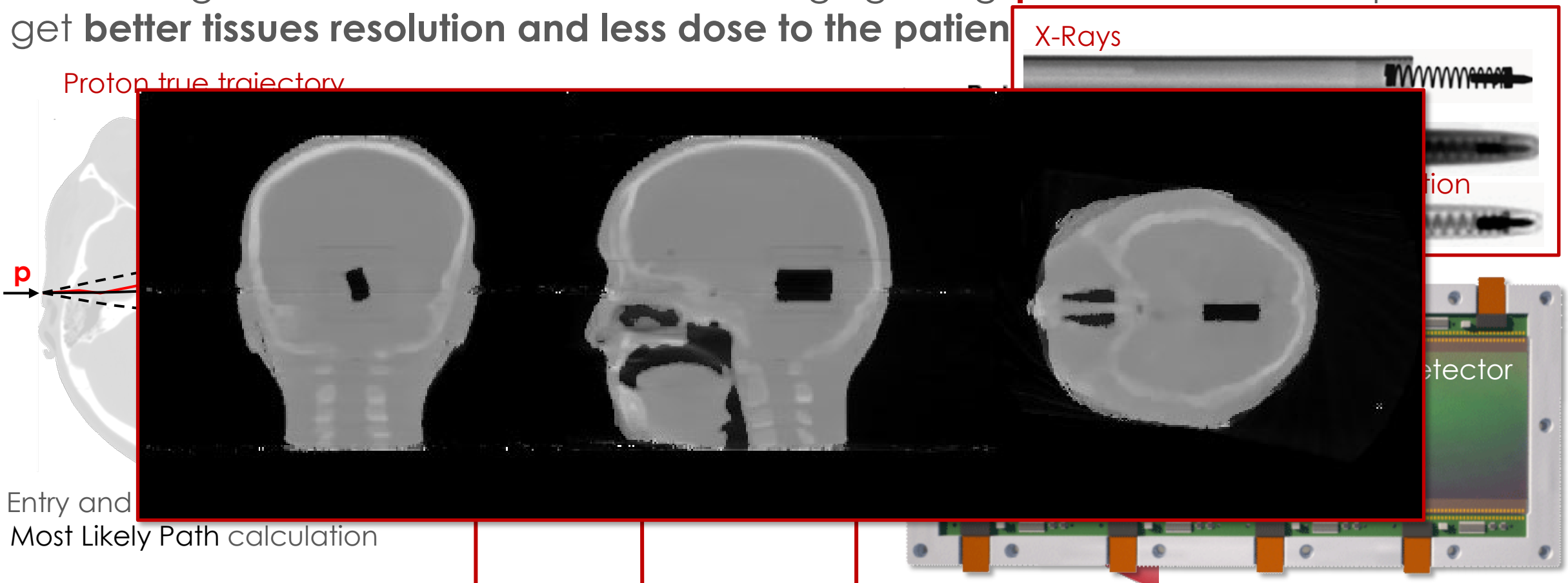
Bioscience (γ)



Photon clustering allows **breaking the diffraction limit** (Nobel Prize 2014)

Medicine (γ, p)

Advancing state-of-the-art in medical imaging using **protons** instead of photons to get **better tissues resolution and less dose to the patien**



With at least 10^8 tracks (energy loss, exit point & angle, entry point) recorded, we can reconstruct a complete 3D image.

https://mediaspace.unipd.it/media/La+tomografia+-+Percorsi+galileiani+Phd+Edition/1_d1m7vb2o

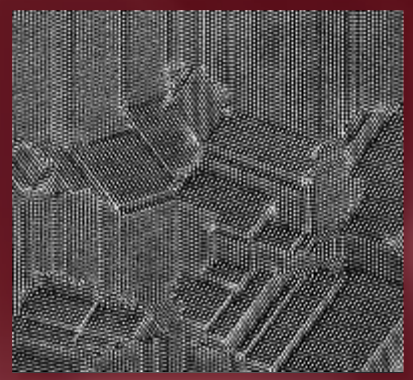
Industry (x)

X-ray **Computed Tomography** and imaging help verifying production, food quality and even sawmills!

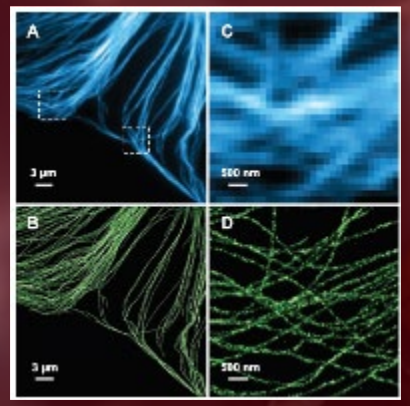
Blue-sky research helps in real-world challenges

ALICE

Nanometer (e^-)

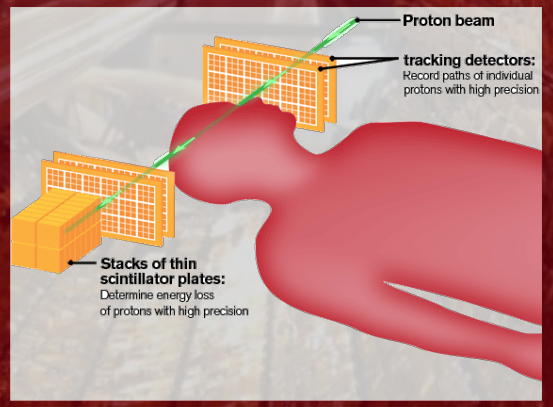


Micron (γ)



Millimetes (x)

Meter (p)

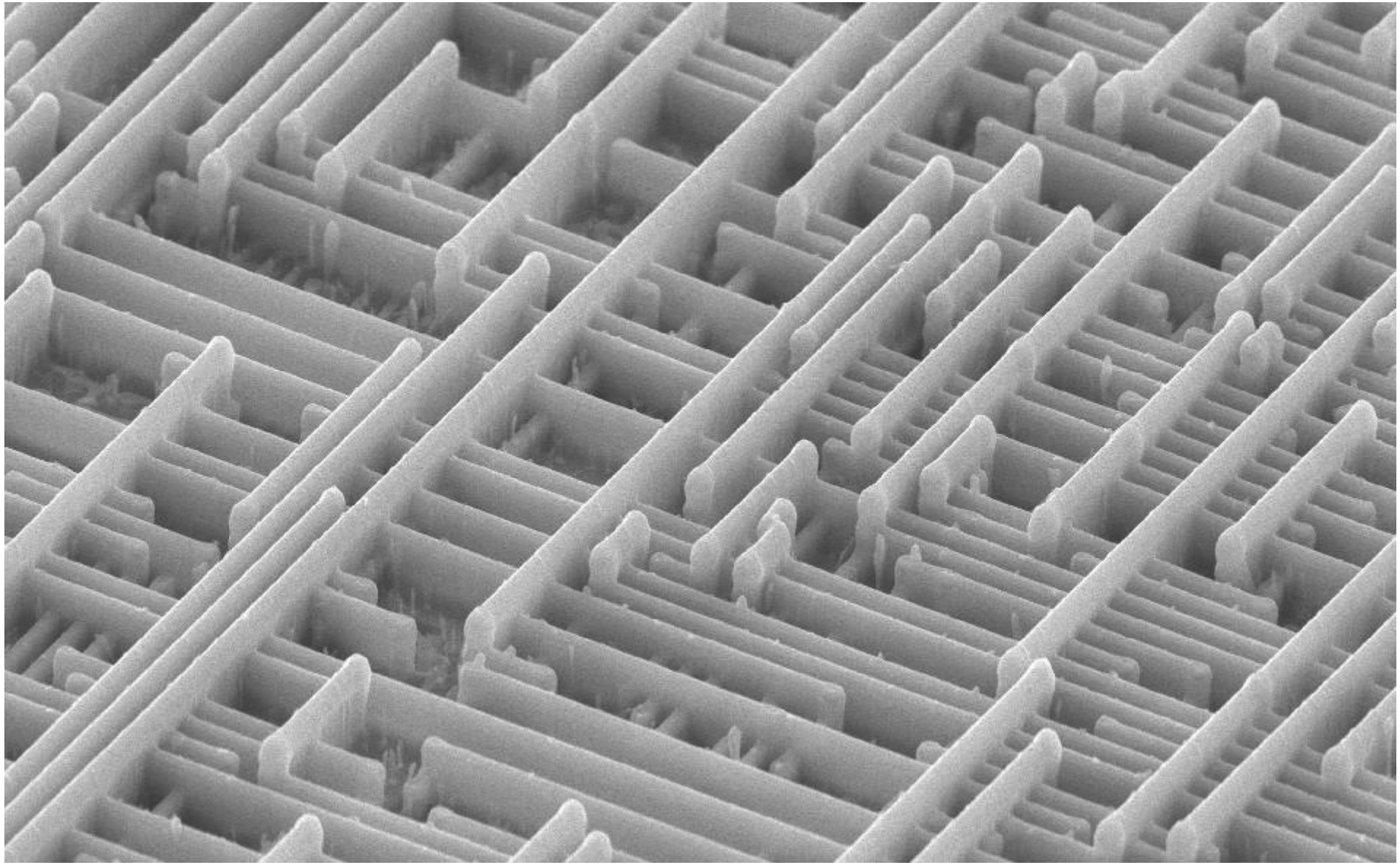


and beyond (?)

INFN

Summary

The nanoworld **allows to**…

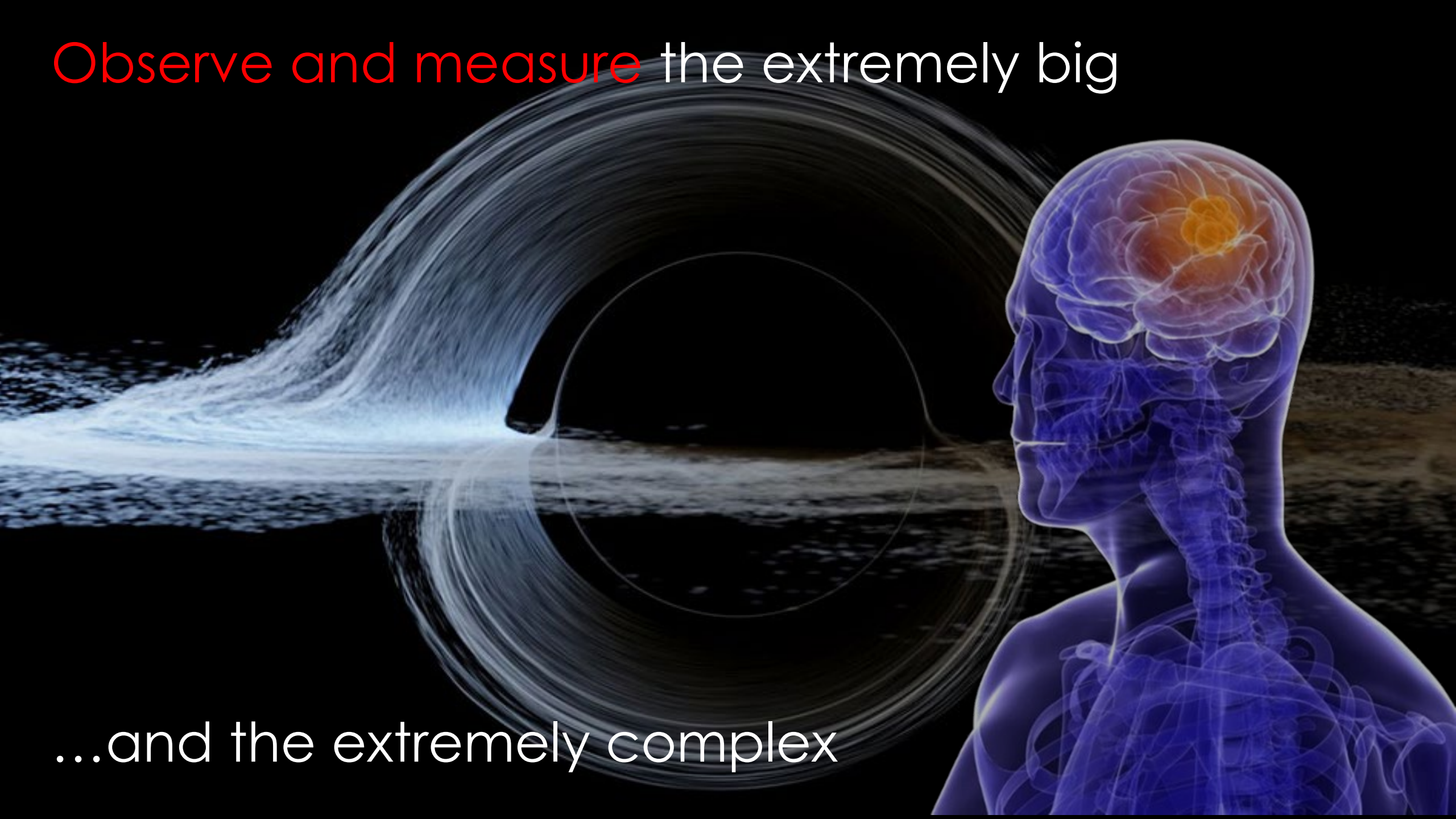


Ideas,
Theory,
Design:

Nano & micro systems

To look at the universe

Observe and measure the extremely big



…and the extremely complex

Want to play? You welcome!

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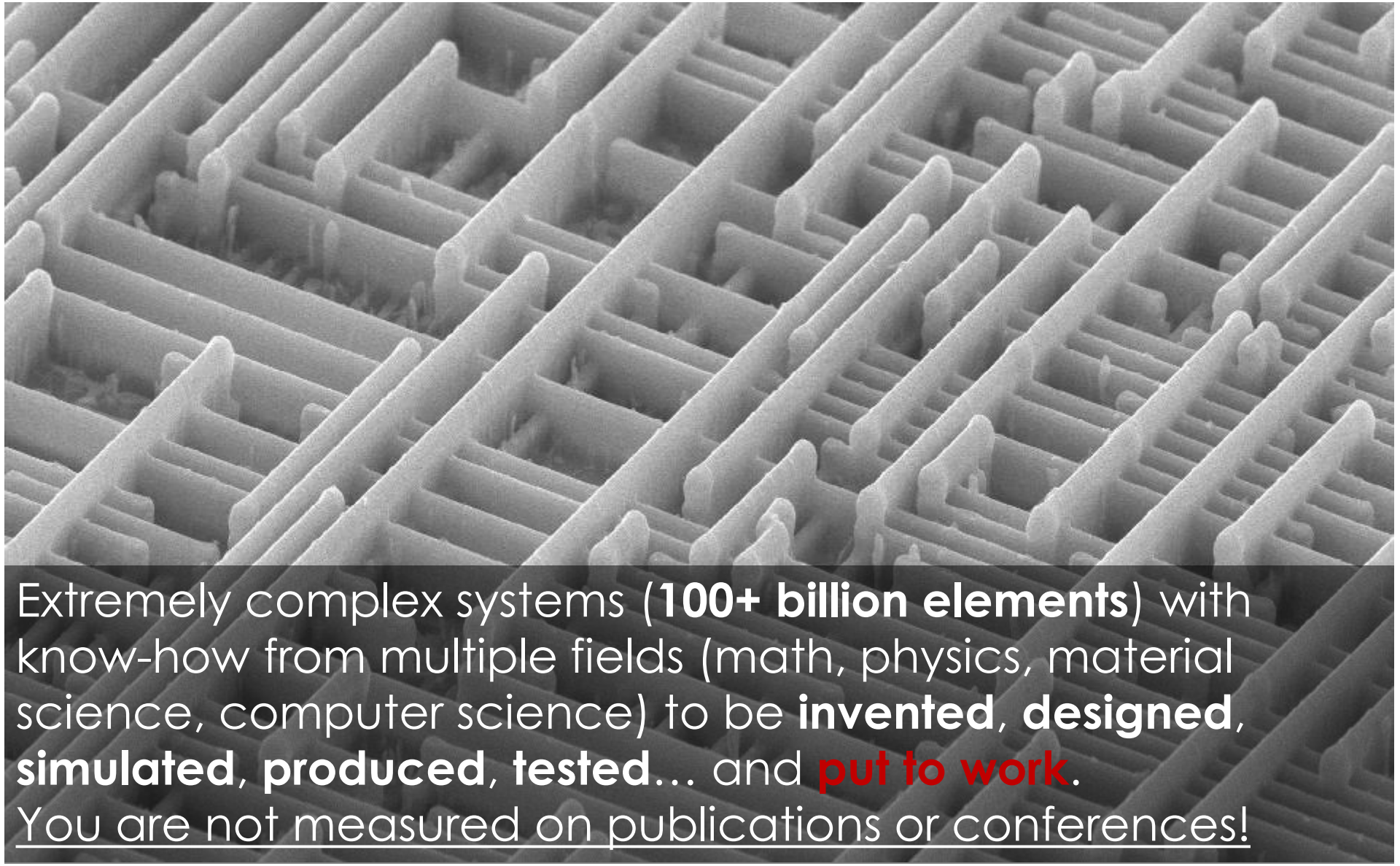
dott. ***Sabrina Ciarlantini*** *(sabrina.ciarlantini@phd.unipd.it)*
dott. ***Caterina Pantouvakis*** *(caterina.pantouvakis@phd.unipd.it)*
dott. ***Michele Rignanese*** *(michele.rignanese@phd.unipd.it)*

Backup

Is it challenging?

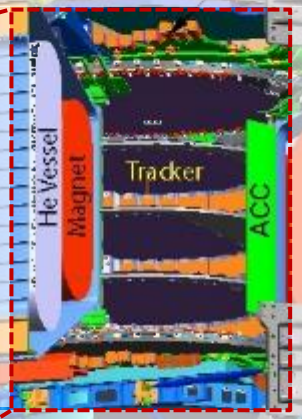


Extremely complex systems (**100+ billion elements**) with know-how from multiple fields (math, physics, material science, computer science) to be **invented**, **designed**, **simulated**, **produced**, **tested**… and **put to work**.
You are not measured on publications or conferences!

Not (only) theory, **nor** (only) simulation, **nor** (only) analysis

Must, simply, work!

In space (cosmics, γ, and beyond)

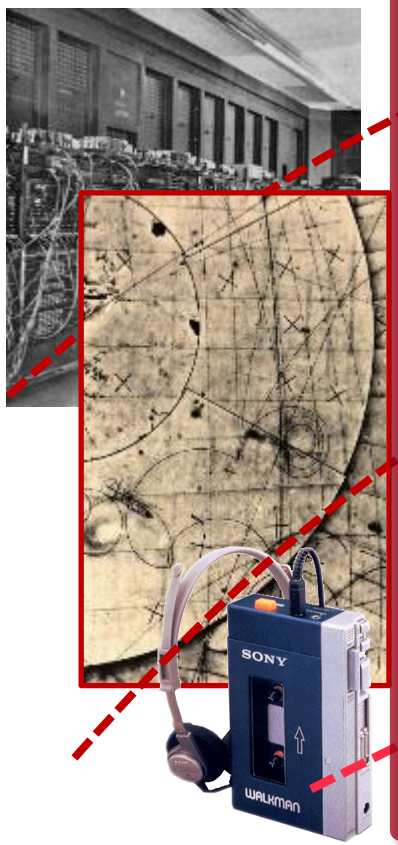


Silicon sensors onboard satellites looks at the near and deep space

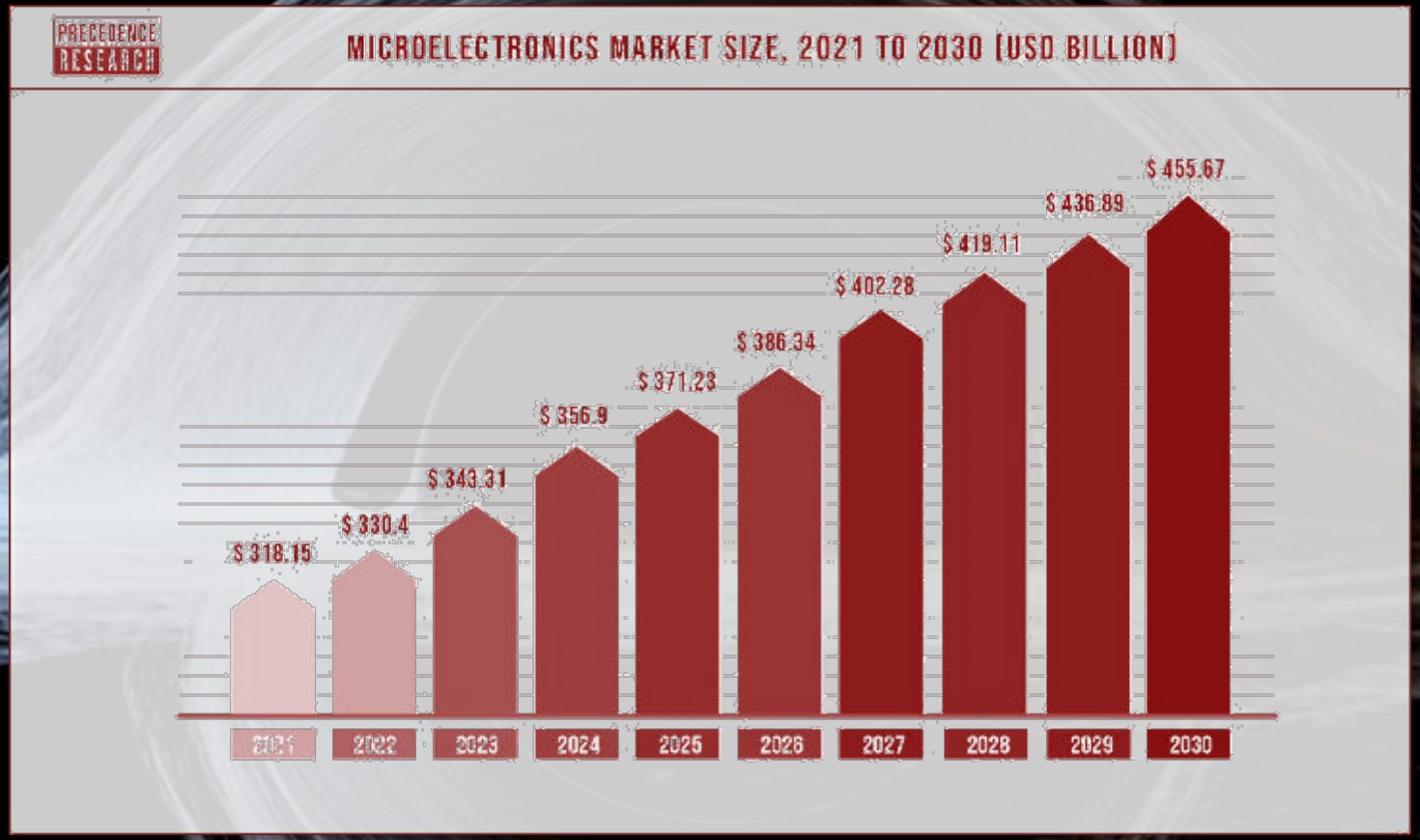
Disclaimer: that game **hurts physicist's pride**

70s 80s 90s 00s 10s

Log (Information density)



Disclaimer: it's a **bigger game** than what you think



Interstellar's black hole "Gargantua" is not scientifically accurate (as shown in the movie) but the simulation produced 800 TByte of unprecedented quality data, which lead Kip Thorne (Nobel prize 2017) to investigate some unexpected effects (which you cannot see in the movie) about the lensing effect.

Class. Quantum Grav. **32** (2015) 065001

Thorne K S 2014 The Science of Interstellar