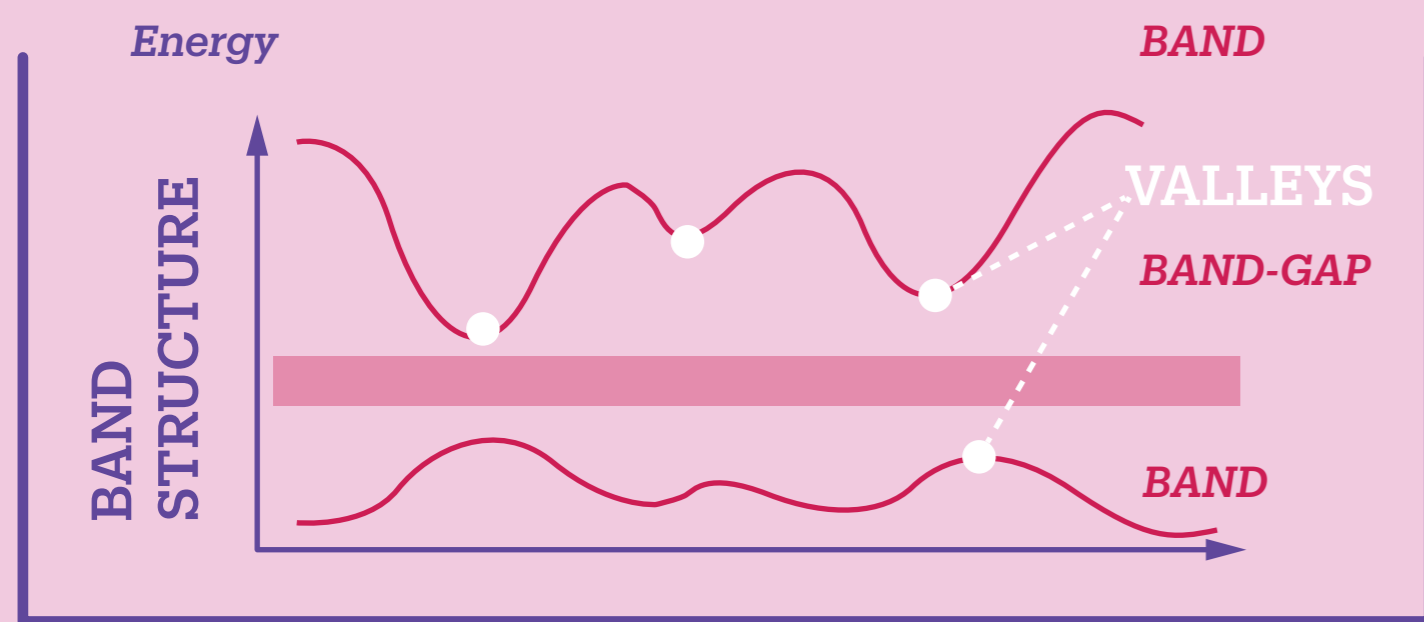


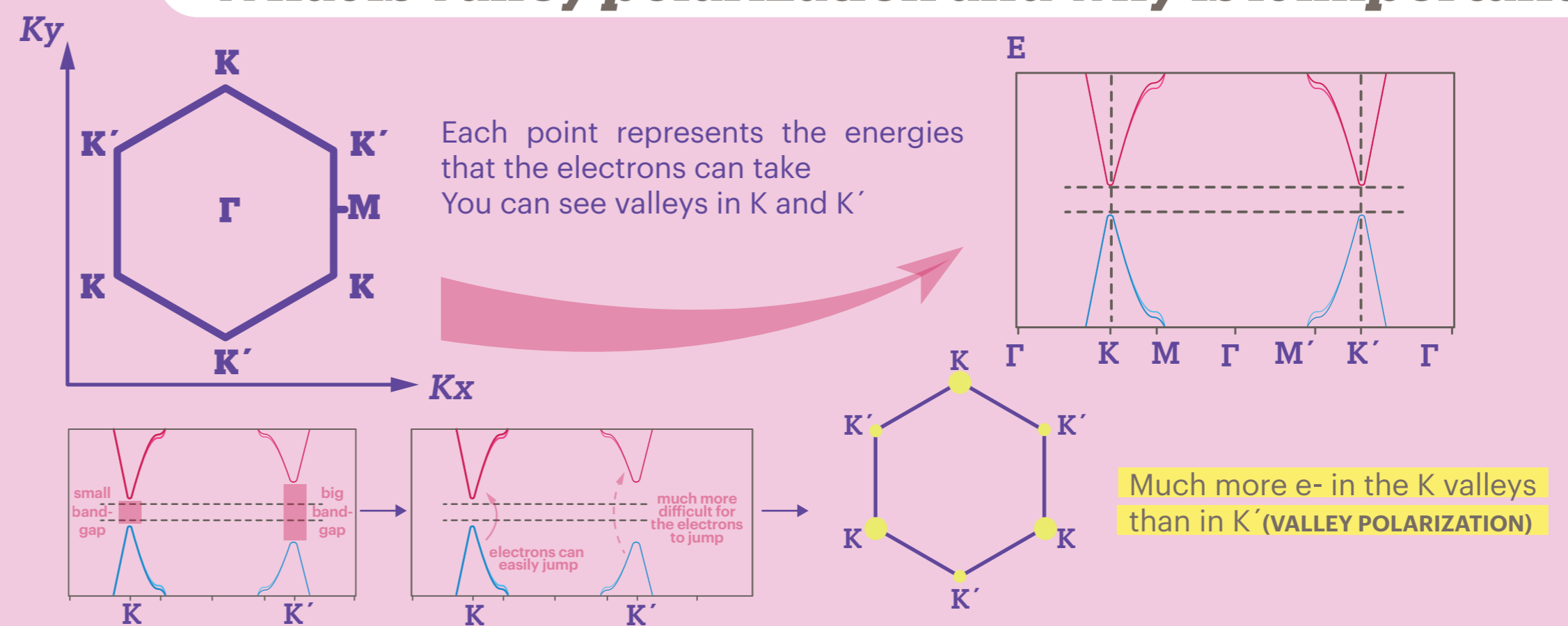
# VALLEY POLARIZATION

## What is a valley?



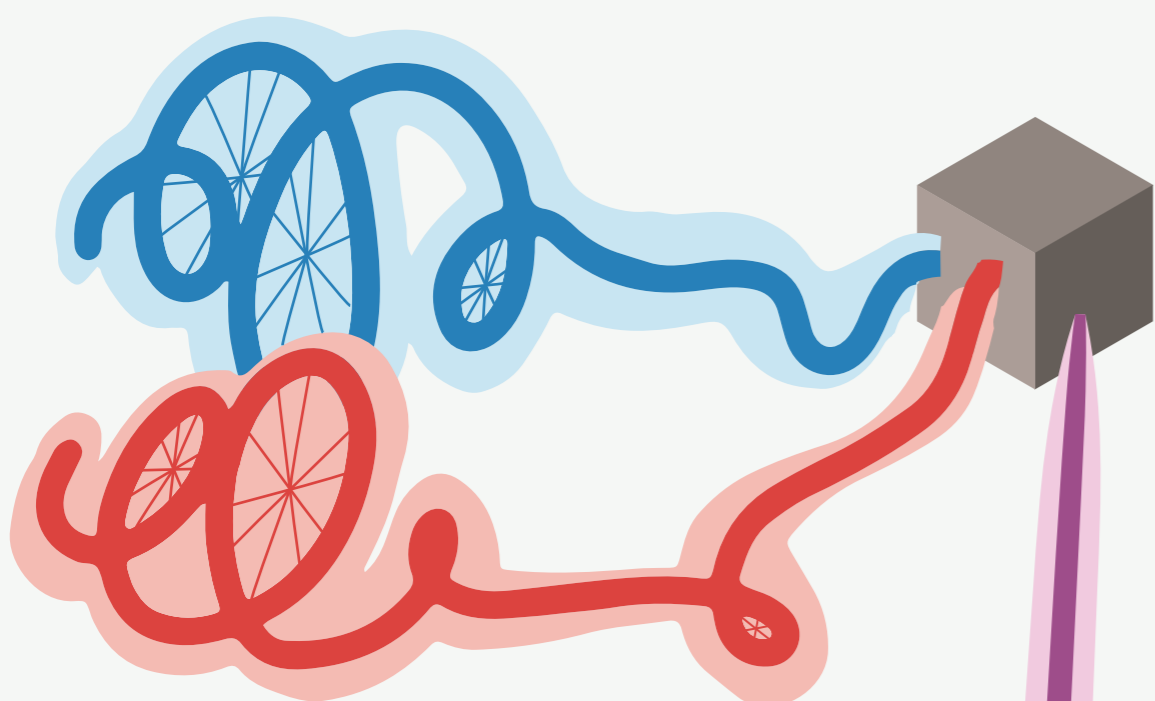
The electrons inside solid materials can only take certain values of energy. The allowed energies are called “bands” and the space between them, the forbidden ones, are the “band-gaps”. Together, they constitute the “band structure”, which is characteristic of each specific material. A local energy maximum or minimum in the bands is a “valley”.

## What is valley polarization and why is it important?



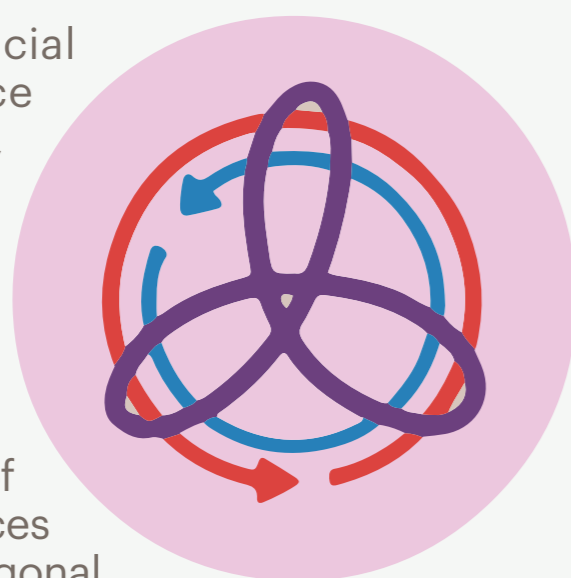
Valley polarization is the scenario where the electrons are not equally distributed among all the valleys, so that some energy-momentum configurations are more frequent than others. Reaching control over valley population in materials could be used to create quantum gates and bits for classical and quantum computing and information processing. It could also lead to a discovery of new properties for a wide range of materials.

## Generate trefoil



The trefoil field is a combination of a **left-handed** circularly polarized light beam with its second harmonic circularly polarized **in the opposite direction**. By superimposing them, a new light beam with a mixed polarization, which over time draws a trefoil shape, is created.

## Trefoil



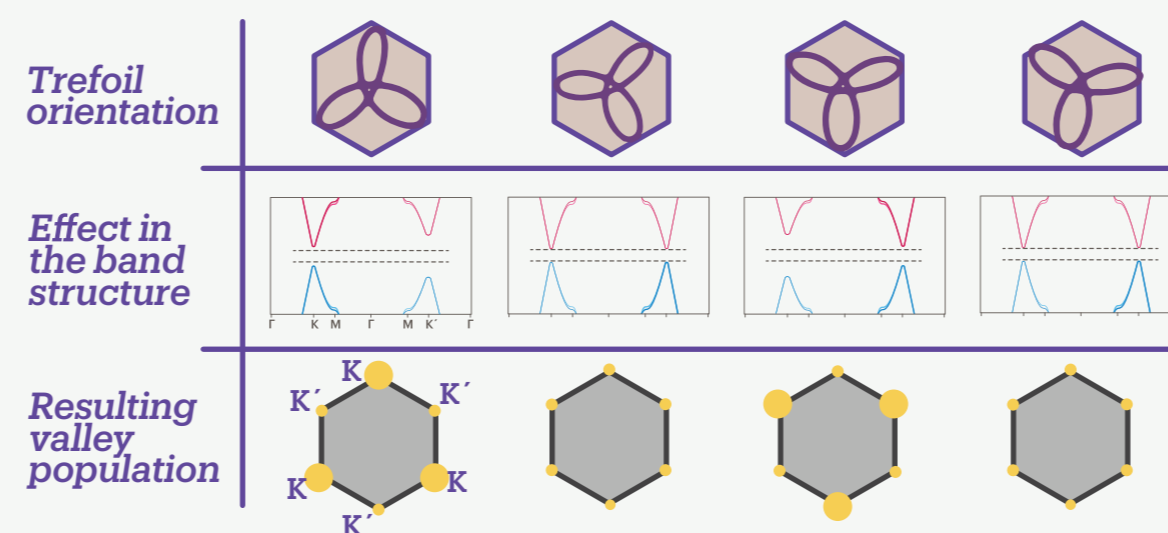
The trefoil shape is crucial to break time and space symmetry in the sample, an essential condition to achieve **VALLEY POLARIZATION**. The reason is that the **three** polarization “leaves” match the material’s internal structure made of two **triangular** sub-lattices that create a hexagonal geometry.

## Probe

The **probe** field, a much weaker pulse than the **trefoil pump** field, is used to monitor the effects induced by the trefoil field on the sample

## Direct them to the sample

### Valley polarization

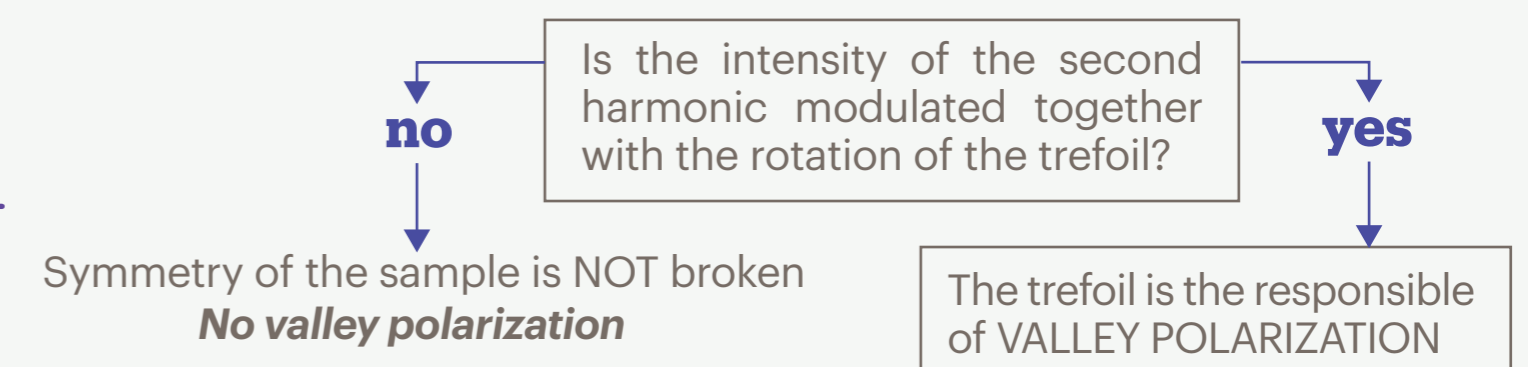


The material used in the experiment was BULK MoS<sub>2</sub>. Its key features are:  
**Central symmetry:** Its hexagonal internal structure (a symmetric figure) allows the trefoil field to actively change the electronic population, by matching this shape.  
**Bulk:** Instead of the much more difficult to engineer single 2D layers, valley polarization is induced in a 3D material (many 2D layers stuck together).

**UNIVERSALITY:** The method does not depend on the specific chosen material, as long as the incoming pump matches the internal symmetry structure of the material.

## Signal analysis

Measuring the probe’s second harmonic:



## Probe 2nd harmonic

When the probe reaches the sample, its second harmonic should be emitted and then analyzed by the equipment.

In ICFO’s experiment, the answer was affirmative: the incident trefoil field causes valley polarization, which can be controlled by rotating it with respect to the material.

## CONCLUSION

A new **UNIVERSAL** method of **VALLEY POLARIZATION** is possible for

**BULK CENTROSYMMETRIC** materials

By **UNIVERSAL** we mean that it does not depend on any specific properties of the material and can be used for 3D and 2D materials.