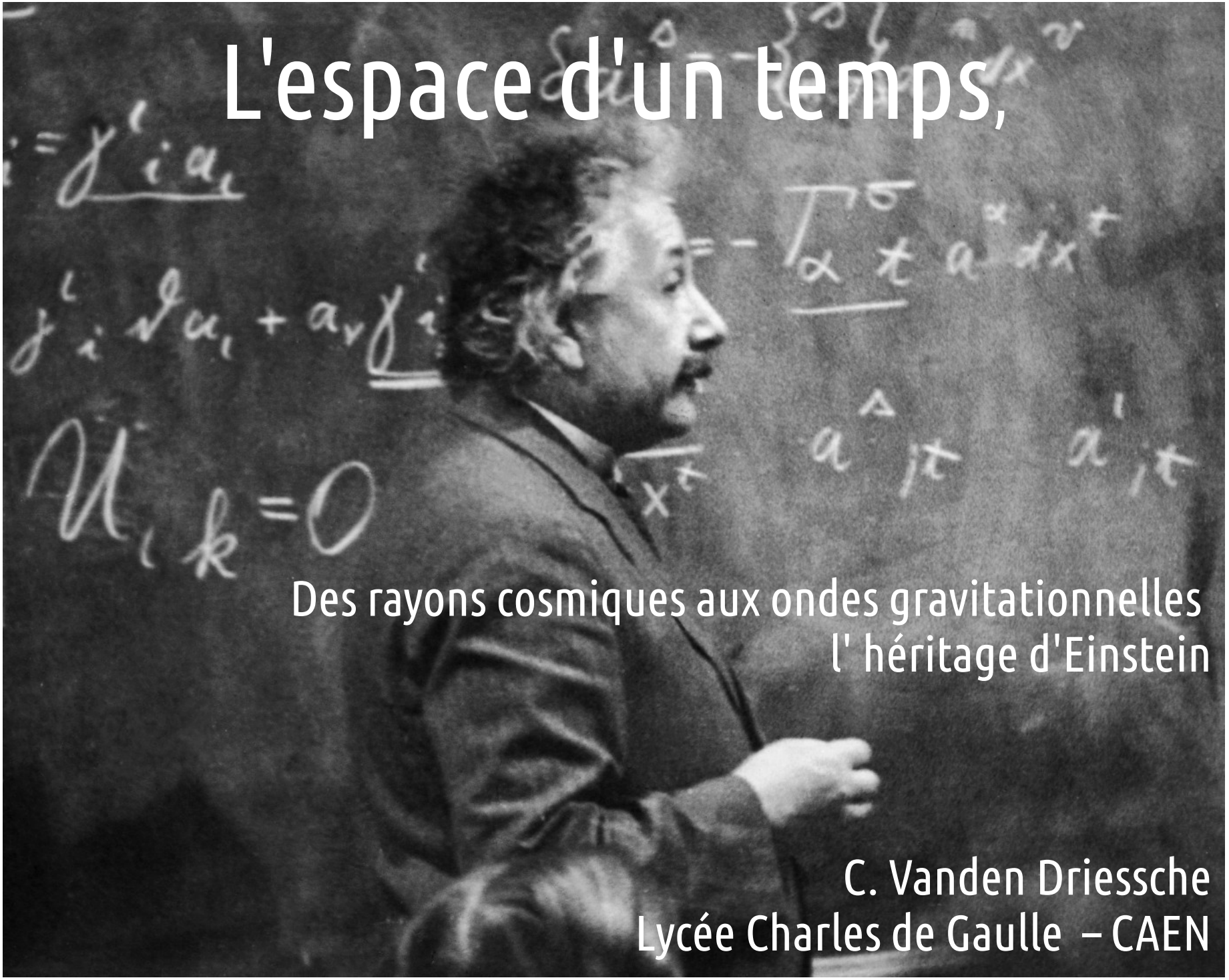
# L'espace d'un temps,

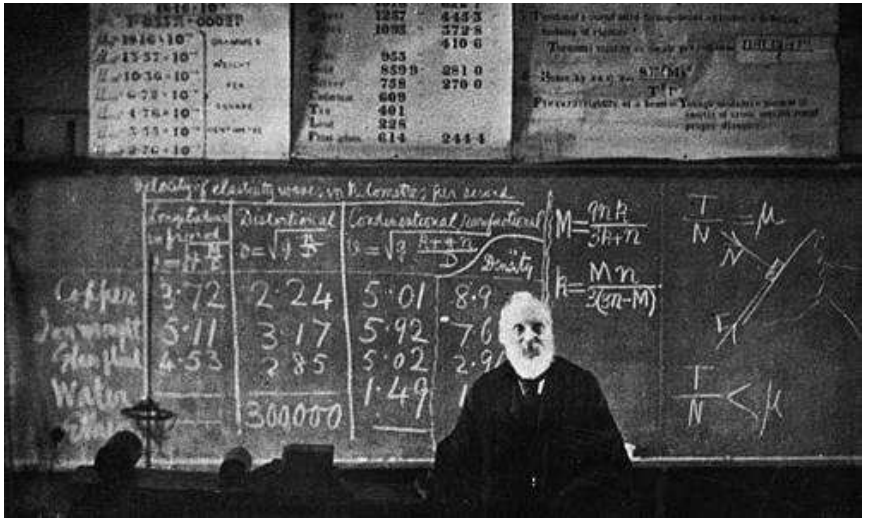


## Des rayons cosmiques aux ondes gravitationnelles
## l' héritage d'Einstein

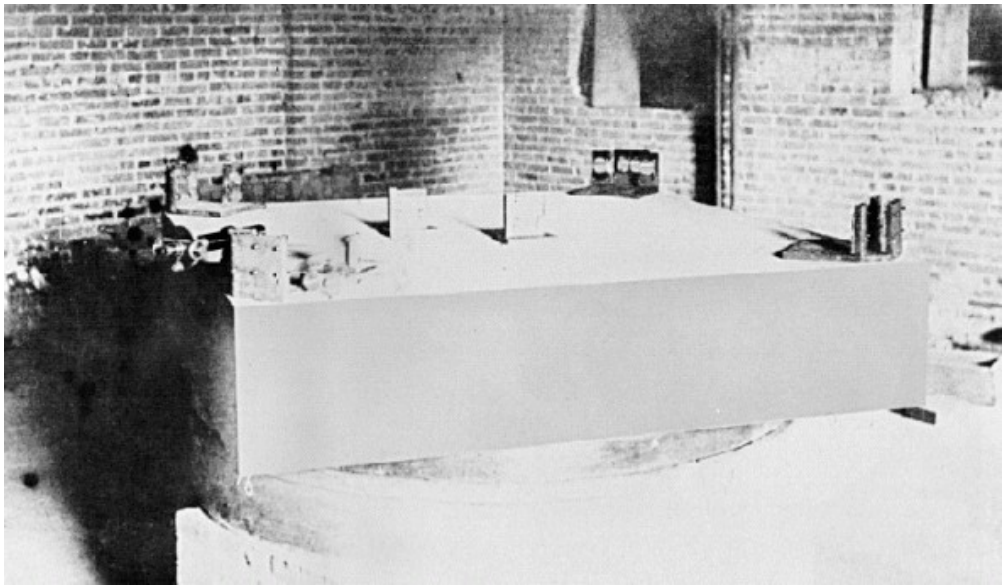
C. Vanden Driessche
Lycée Charles de Gaulle – CAEN

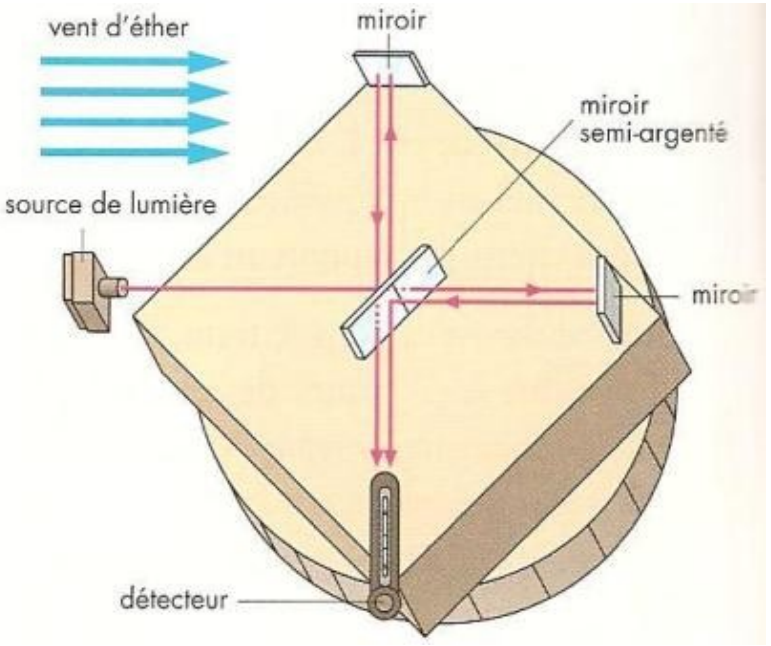

Rubrique à Brac © Gotlib – Dargaud

# De Newton à Lord Kelvin ...

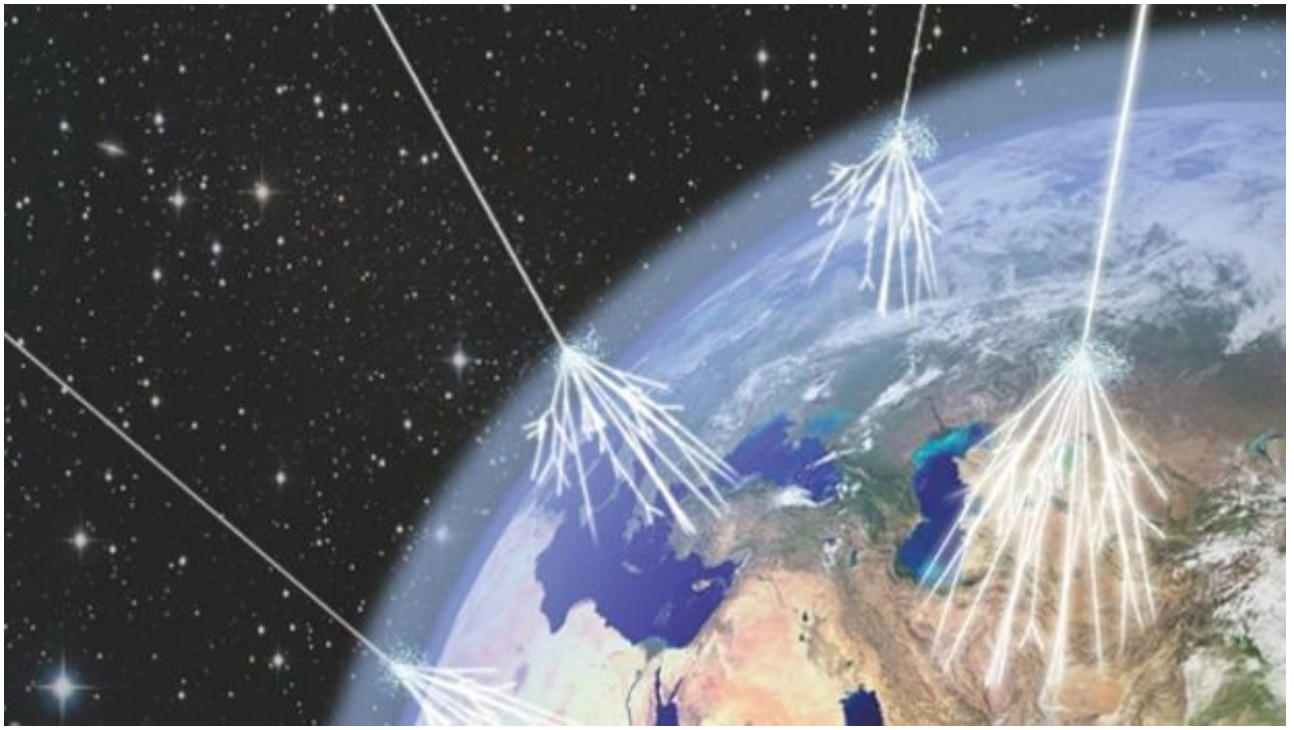
# Michelson et Morley

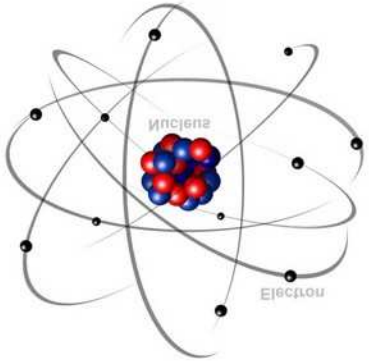




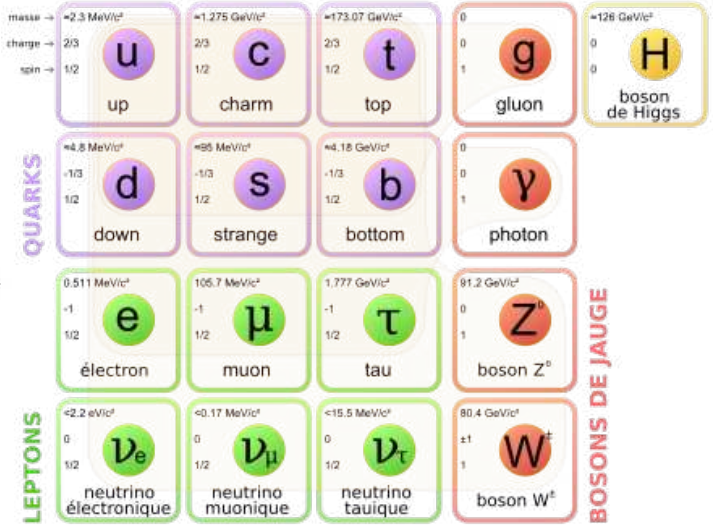
# La relativité restreinte

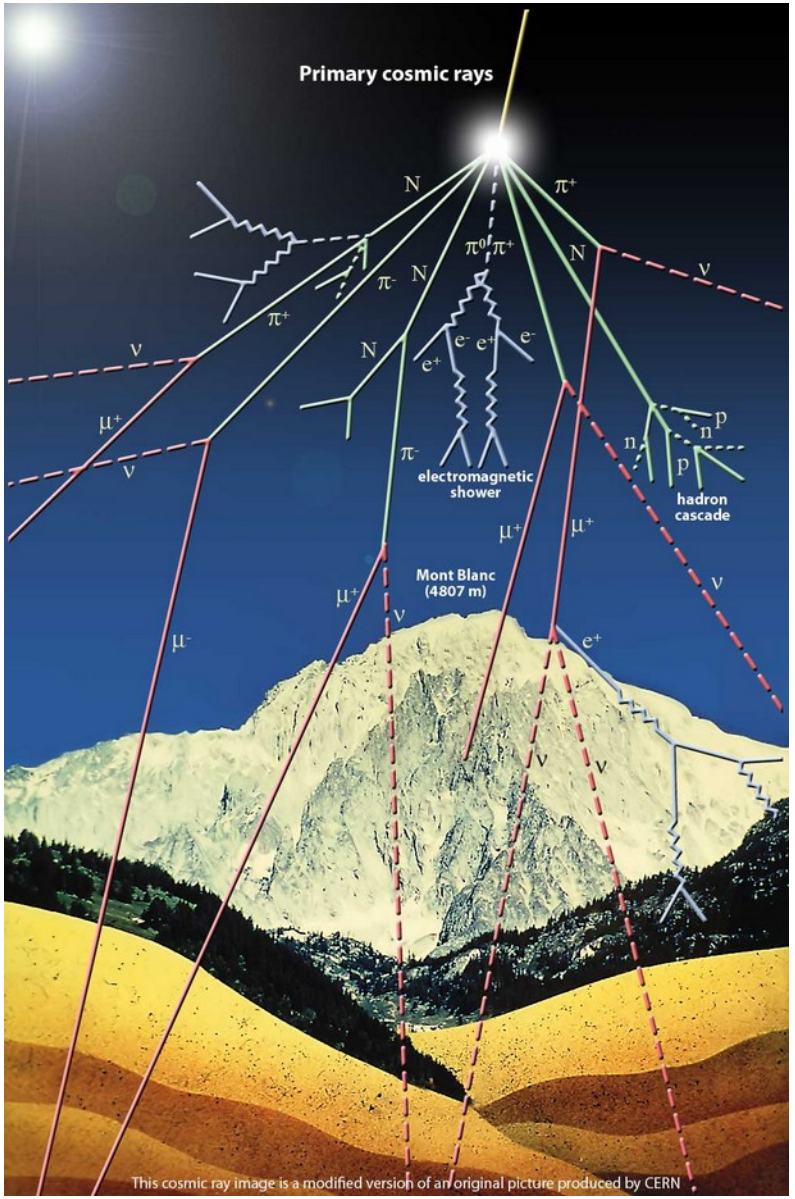
# Les rayons cosmiques






| Properties of Protons, Neutrons, and Electrons | | | |
|---|---|---|---|
| | Electron | Proton | Neutron |
| Symbol | e− | p | n |
| Charge | 1− | 1+ | 0 |
| Location | electron cloud around the nucleus | nucleus | nucleus |
| Relative mass | 1/1,840 | 1 | 1 |



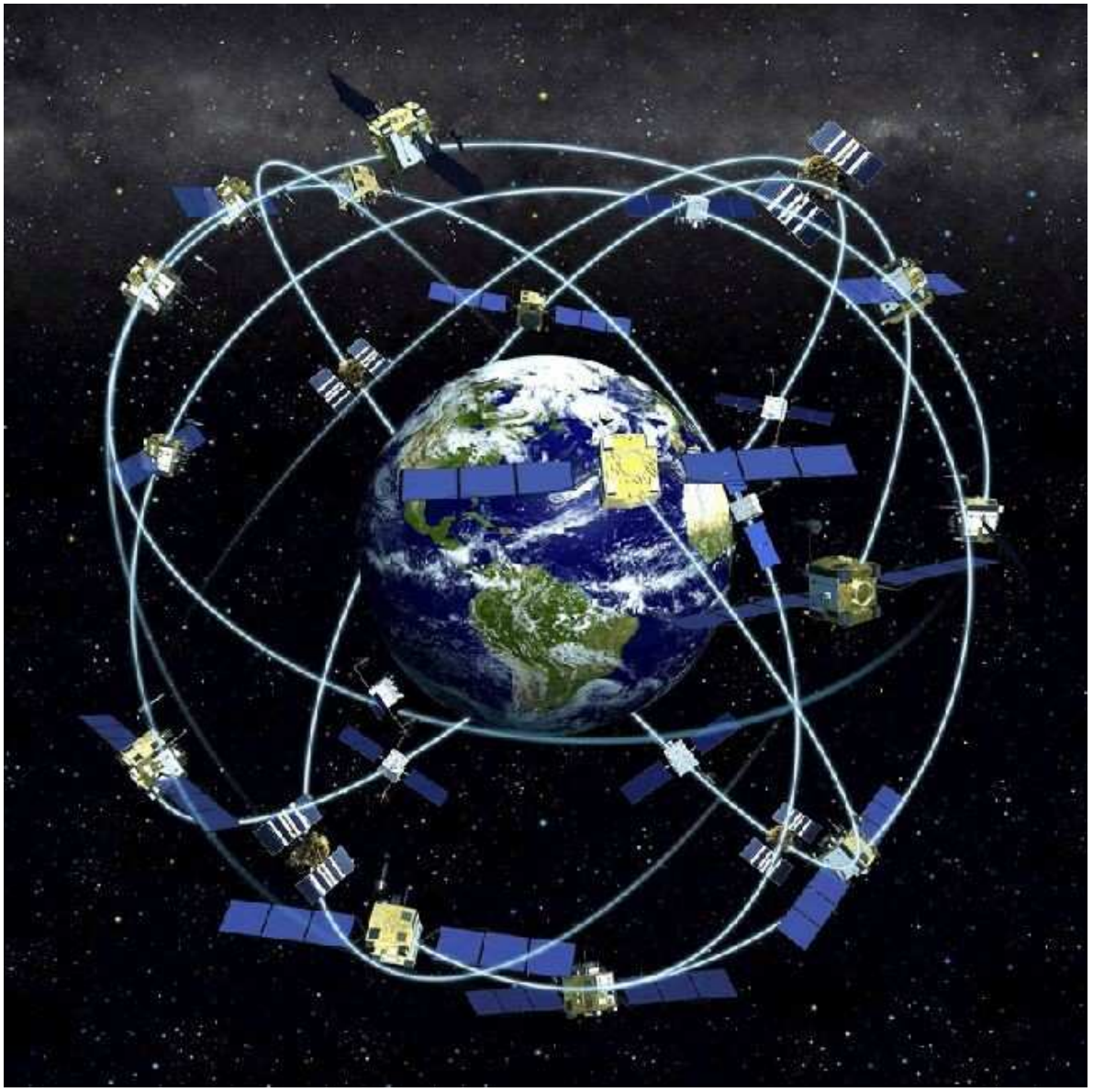



2.2 µs

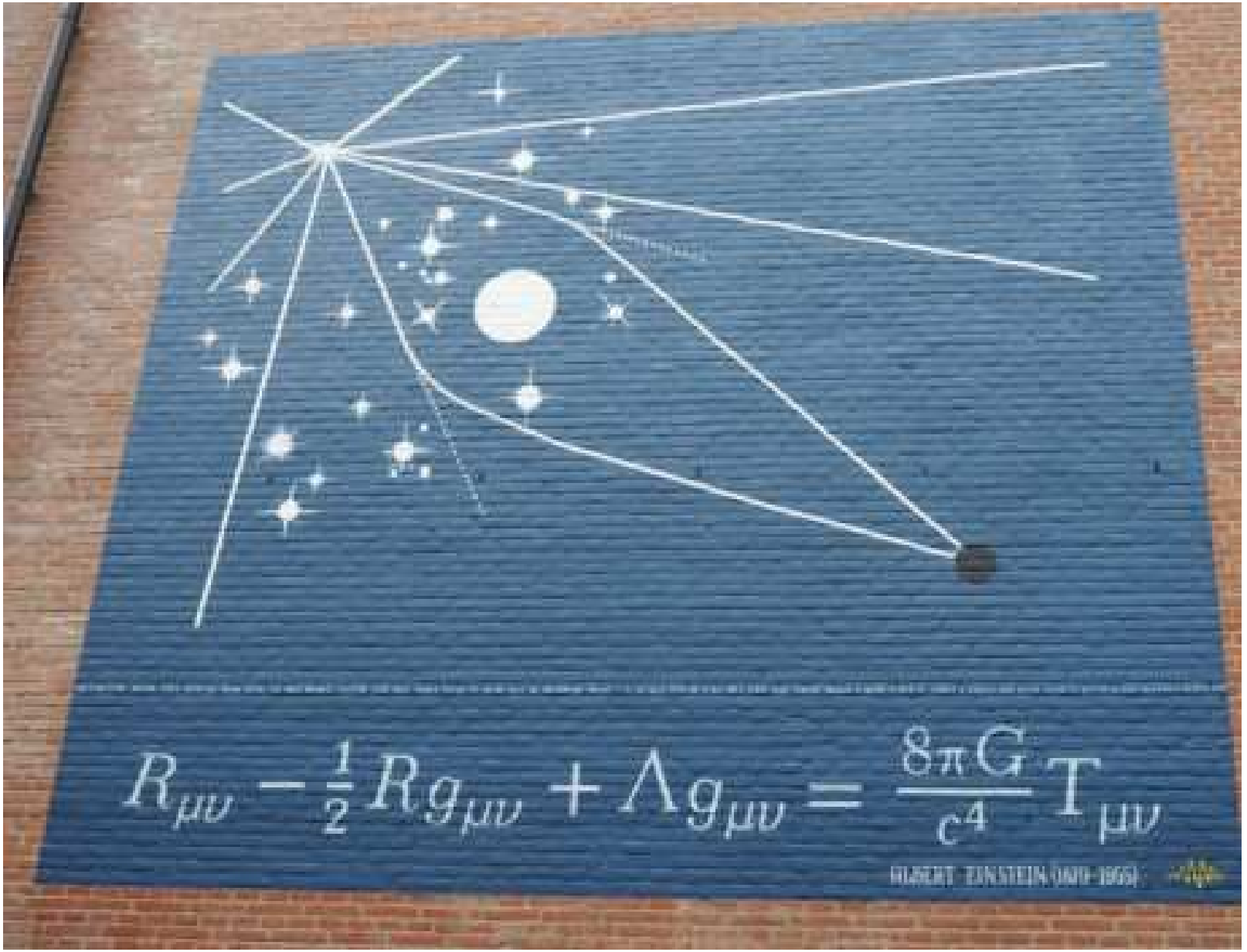
600 m


# La dilatation du temps

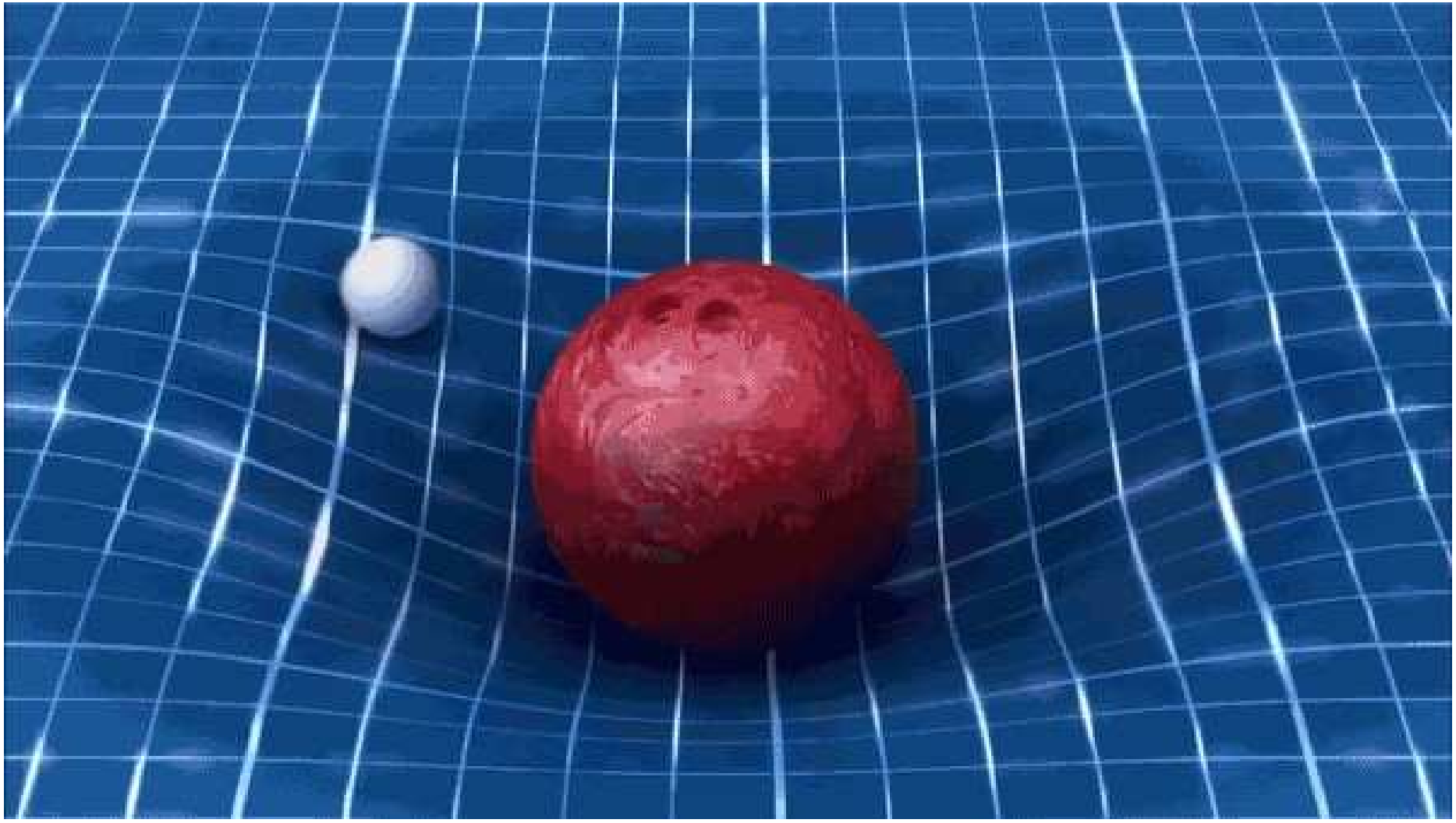
# La relativité au quotidien : le GPS



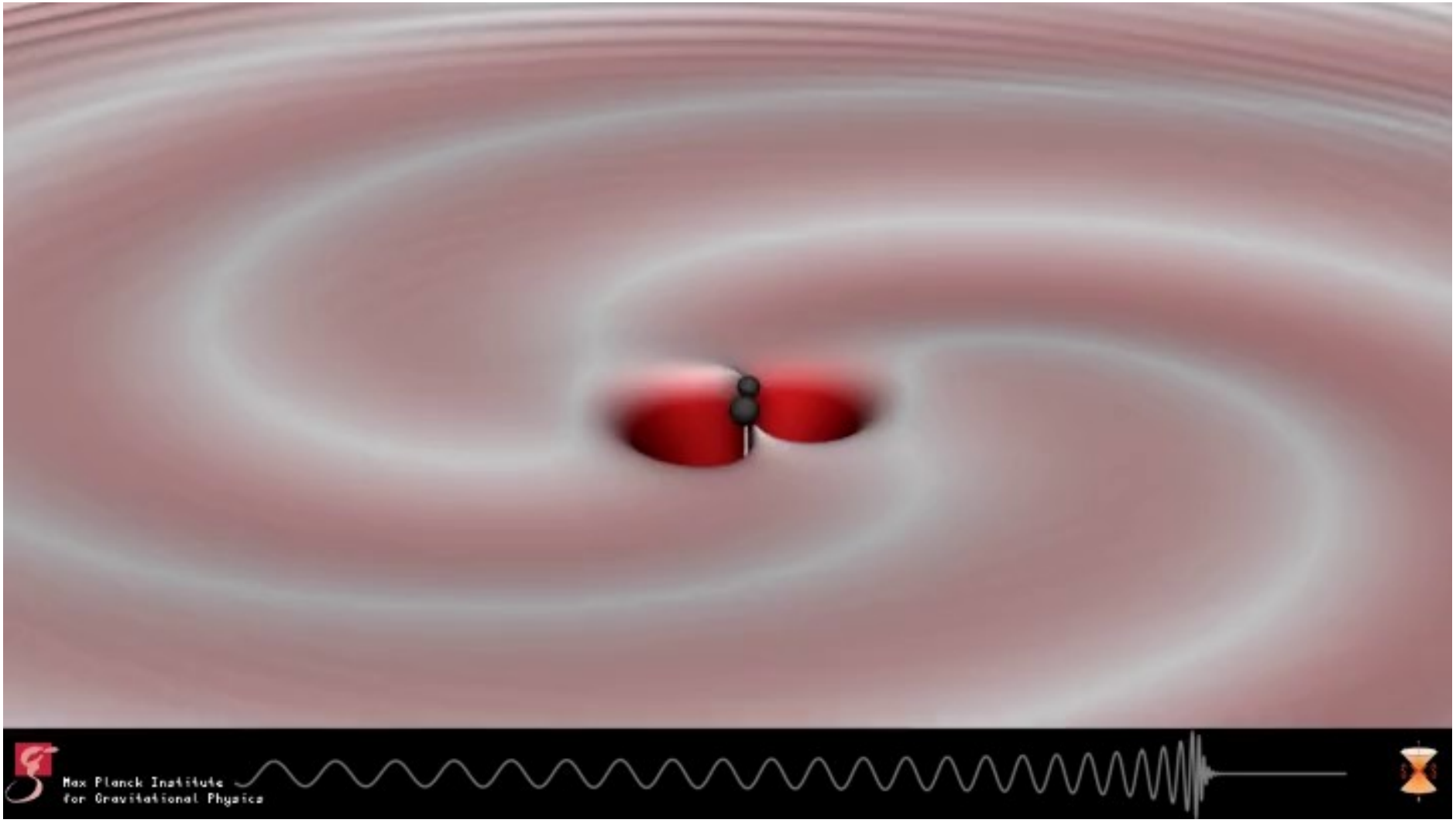
# La relativité générale

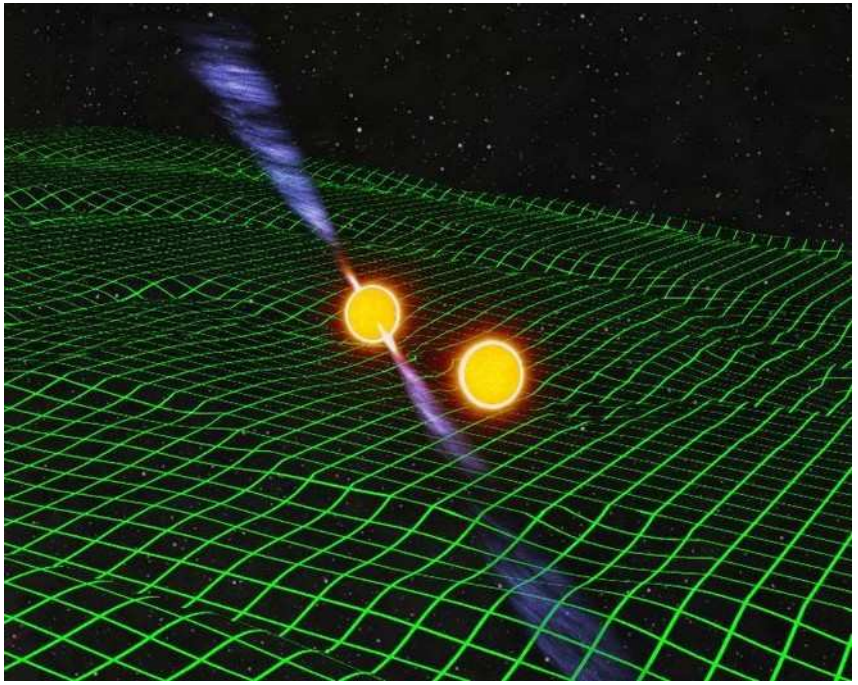


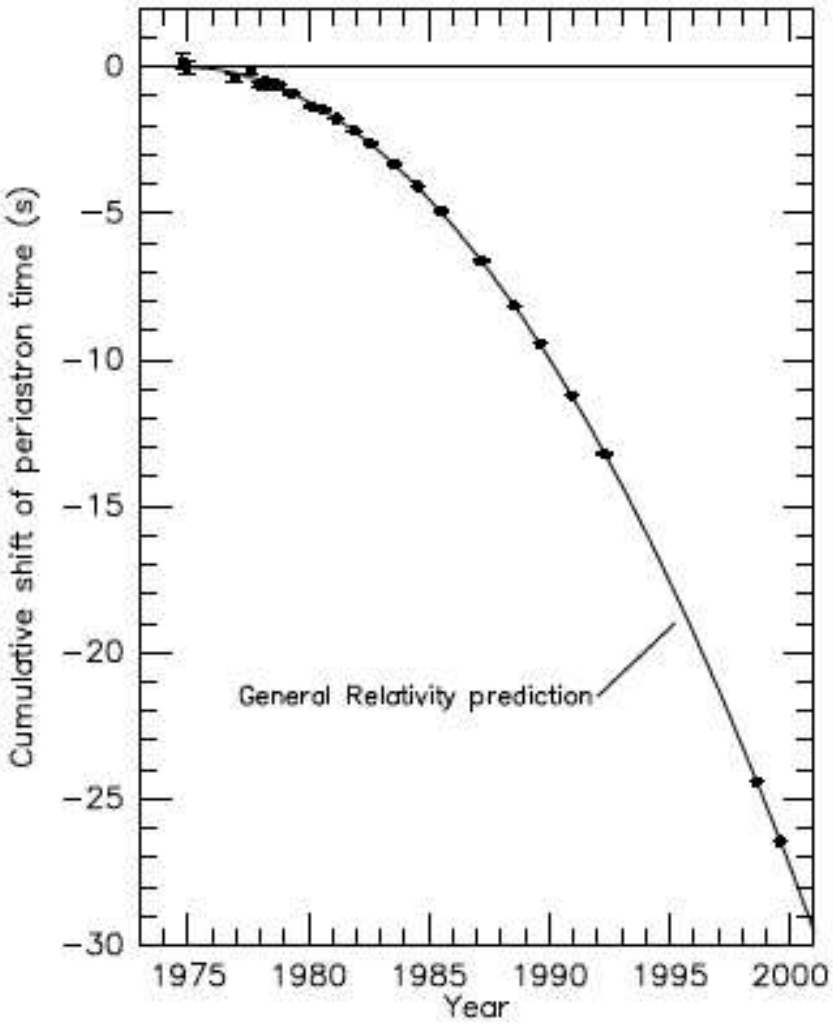
# L'espace temps ...



# Prédiction





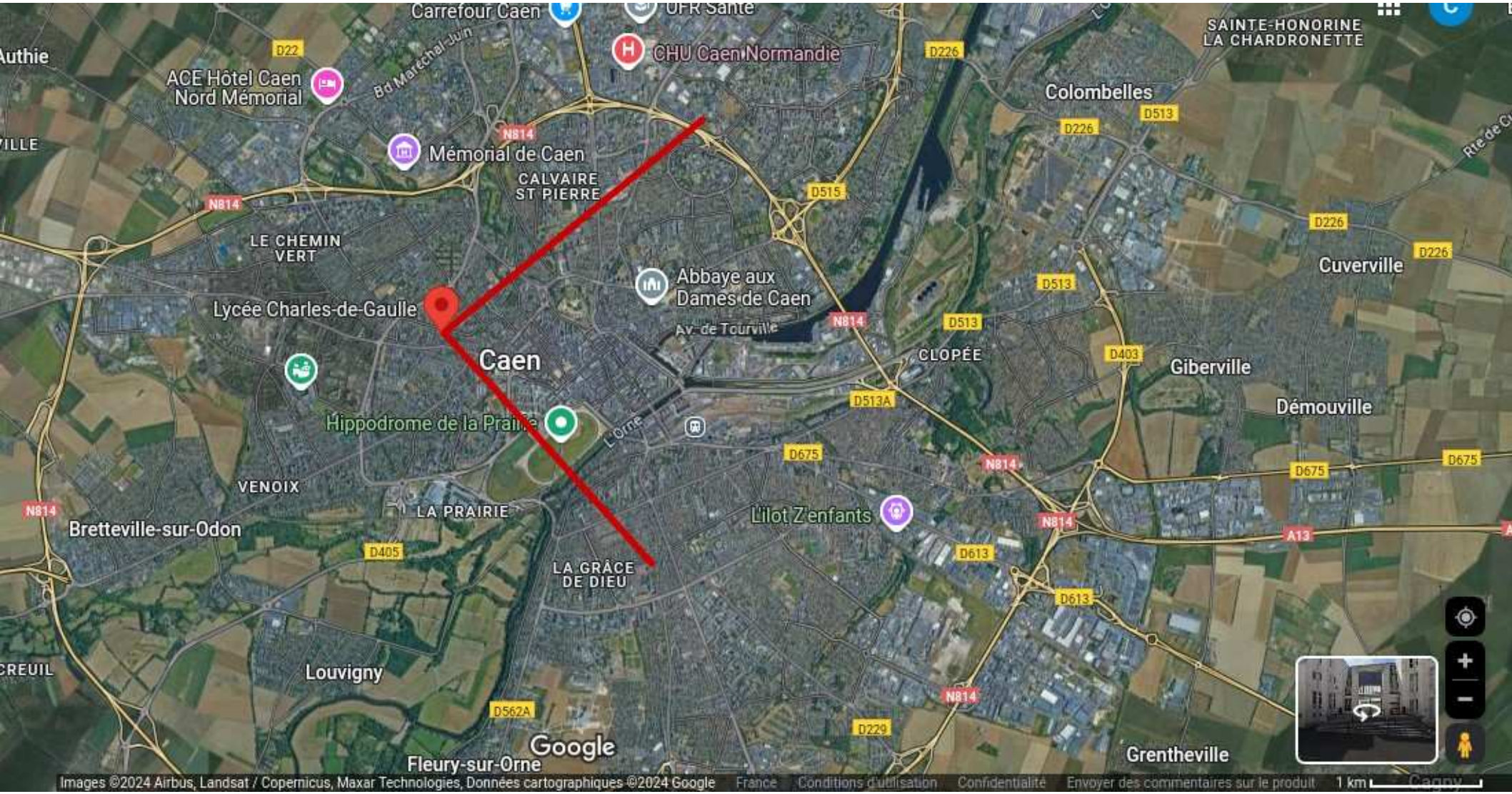



# Détection indirecte
# Nobel 1993

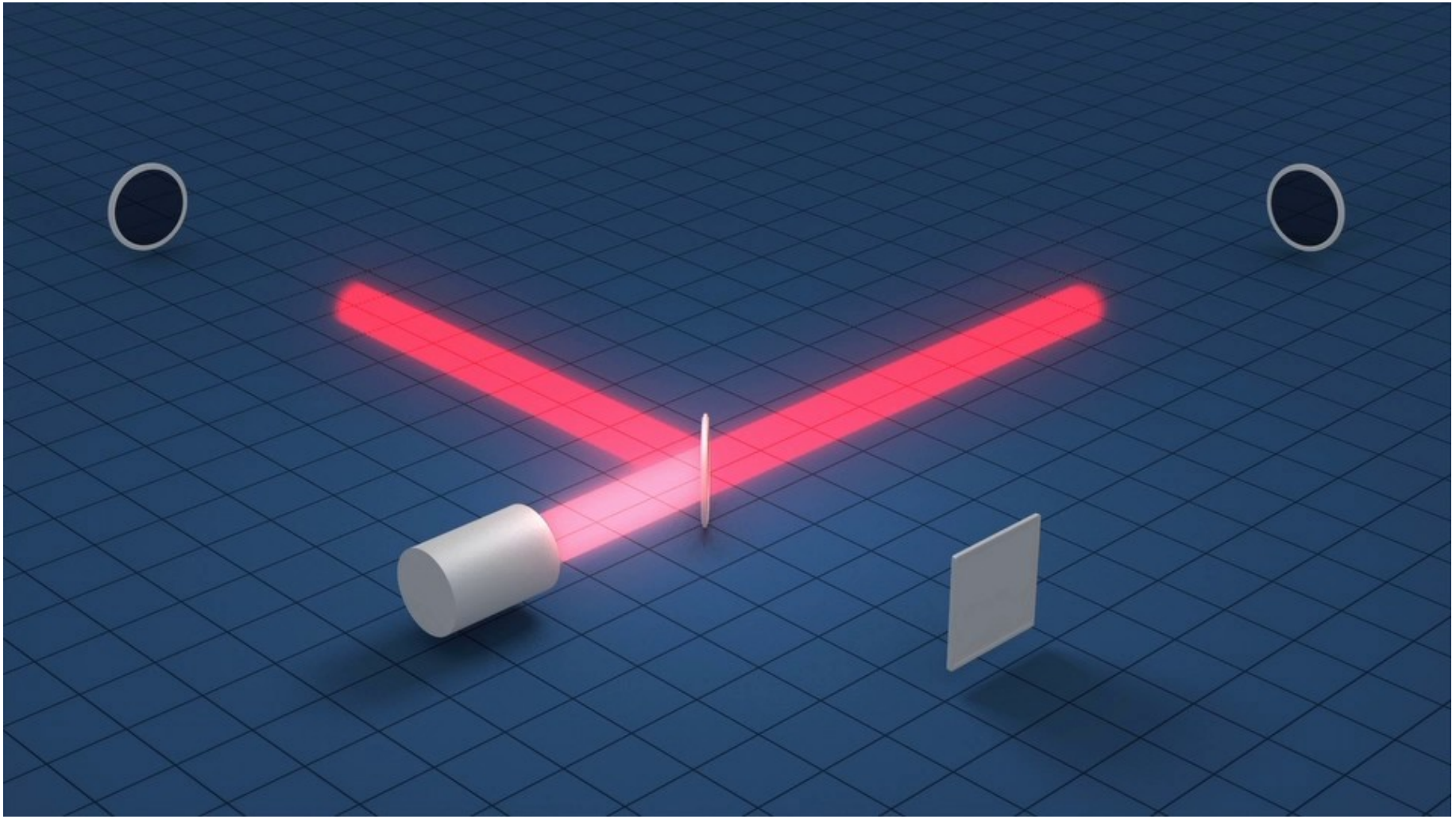
# Détection directe : les barres de Weber

# Détection directe : LIGO / VIRGO

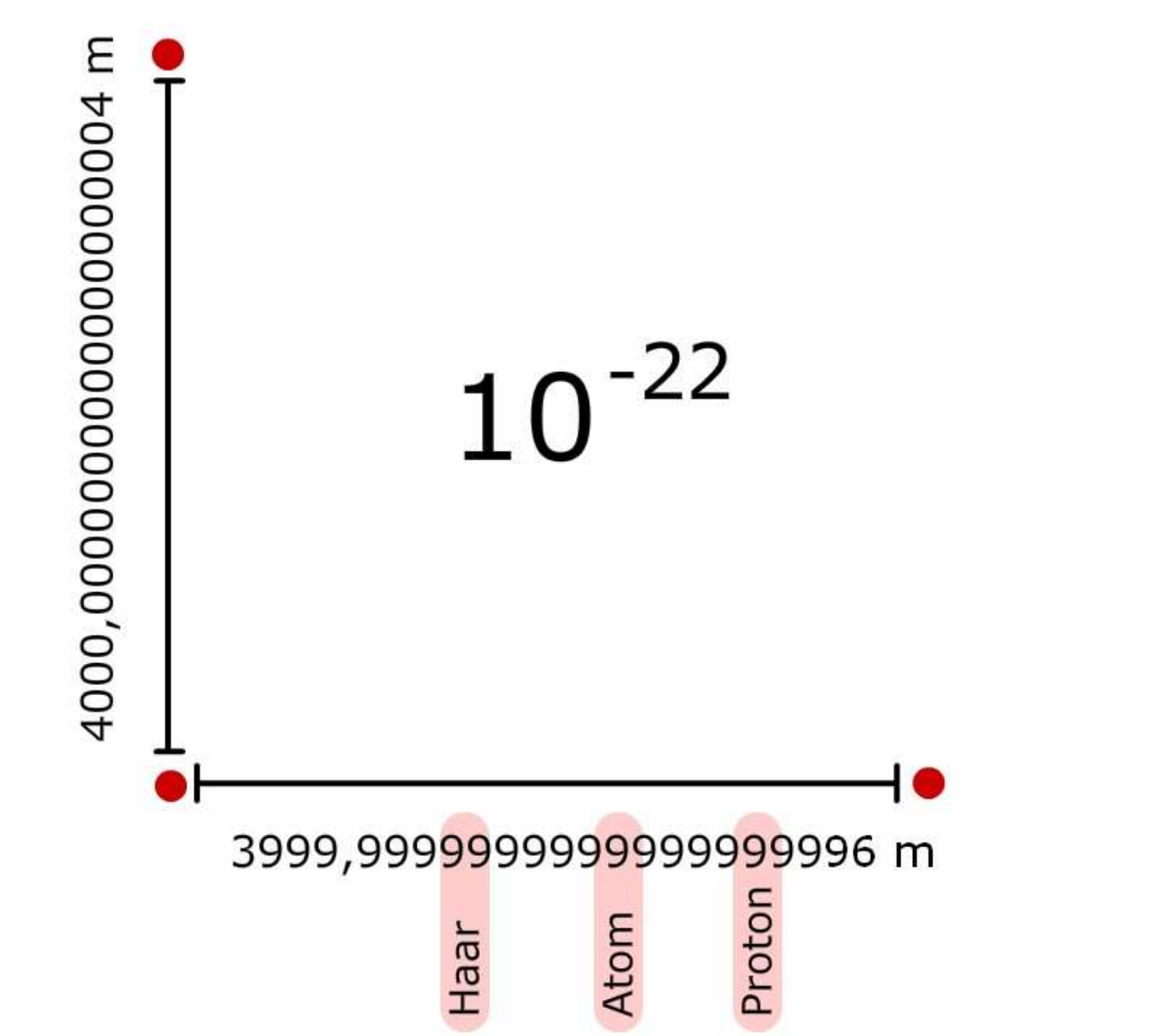
# Si Virgo était à Caen ...

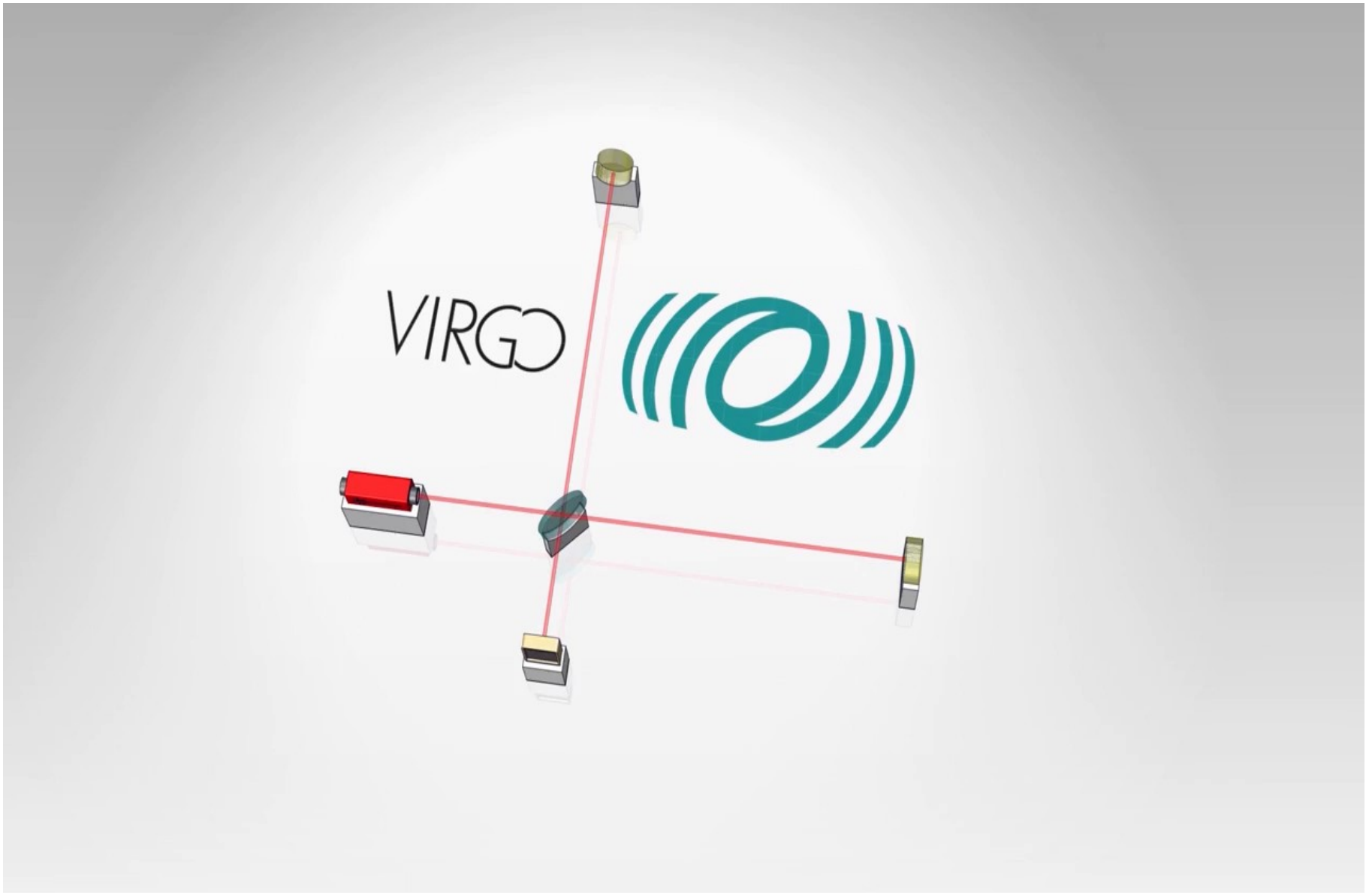


# Le principe

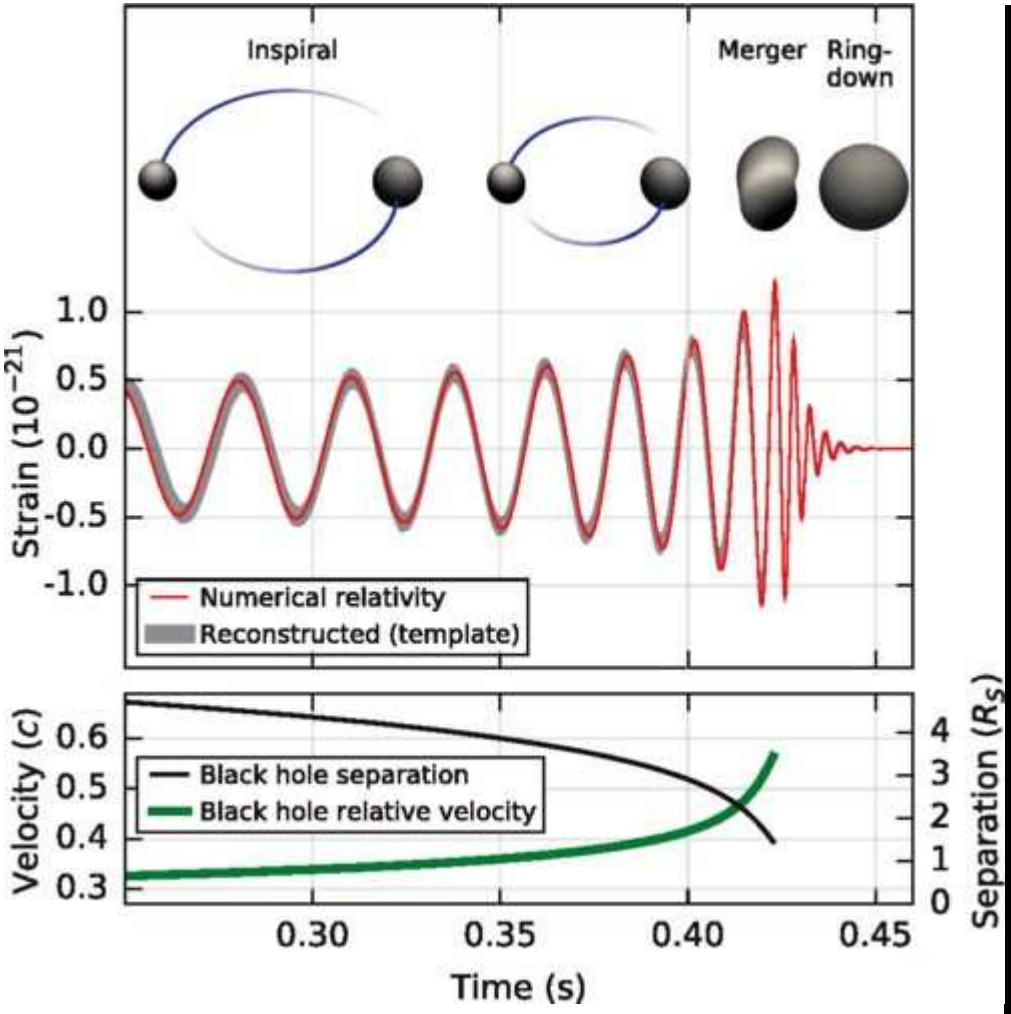


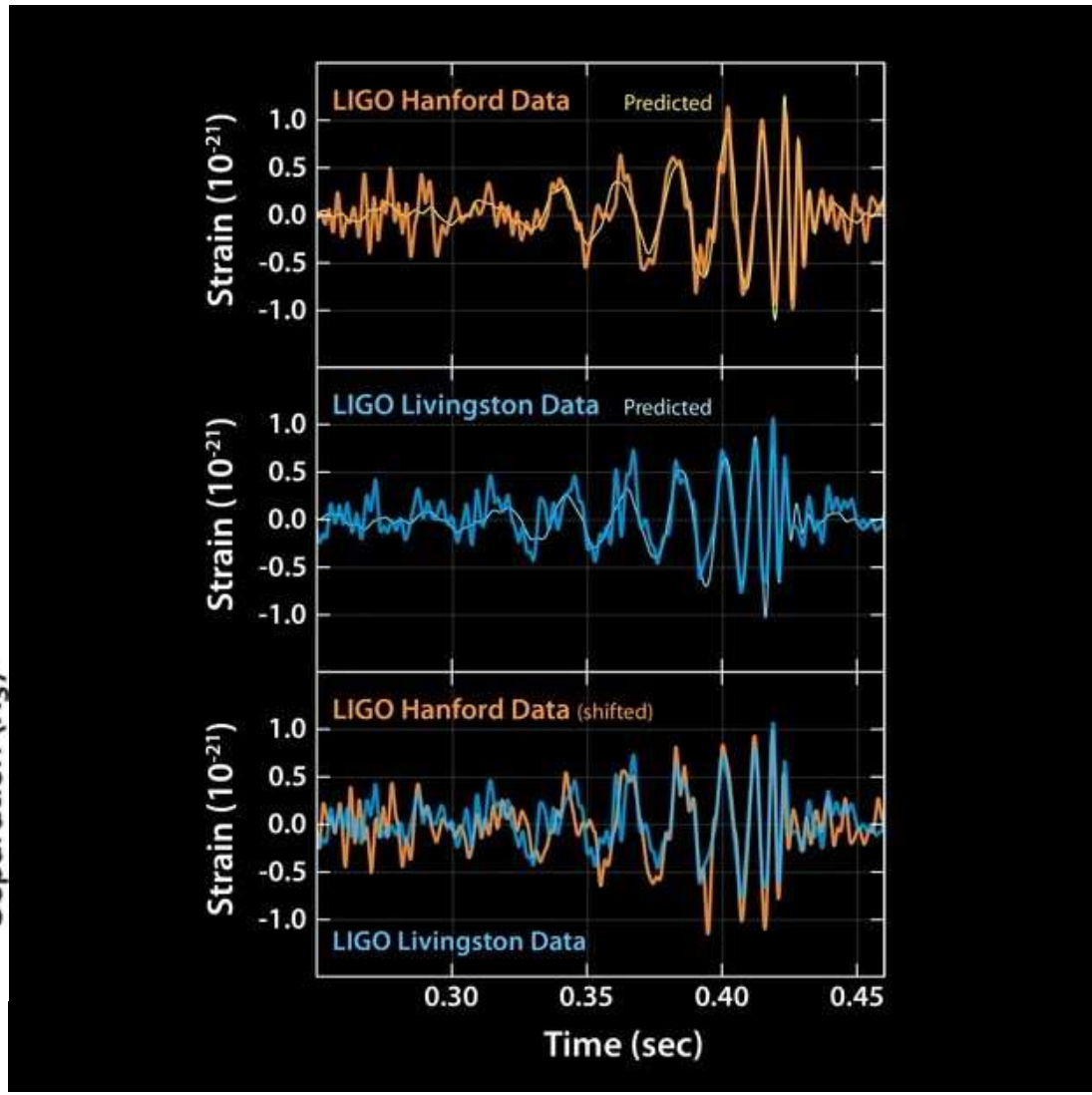
# Un problème de taille ...




VIRGO

# GW150914


Inspiral
Merger
Ring-down
Strain ($10^{-21}$)
1.0
0.5
0.0
-0.5
-1.0
Numerical relativity
Reconstructed (template)
Velocity (c)
0.6
0.5
0.4
0.3
Black hole separation
Black hole relative velocity
Separation ($R_S$)
4
3
2
1
0
0.30
0.35
0.40
0.45
Time (s)


LIGO Hanford Data
Predicted
LIGO Livingston Data
Predicted
LIGO Hanford Data (shifted)
LIGO Livingston Data
Strain ($10^{-21}$)
1.0
0.5
0.0
-0.5
-1.0
0.30
0.35
0.40
0.45
Time (sec)

# Astronomie multi messagers