



EXCELENCIA
SEVERO
OCHOA

25
years
1991-2016

Institut de Física
d'Altes Energies



Barcelona Institute of
Science and Technology

Welcome to IFAE

From Particles to the Cosmos

July 19, 2022

Fundat per | Founded by



Membre de | Member of



Amb el suport de | Supported by



consortium between the **Catalan Government** and **UAB**

founded in **1991**: celebrated our 30th birthday in 2021.

160 people

three divisions: theory, experimental, technical + administration

basic research in fundamental physics and

applied research in instrumentation and medical applications

research lines: Particle Physics, Astroparticle Physics, Cosmology, Medical Imaging, Physics Instrumentation, Quantum Computing

collaboration in **10 international experiments** in high impact / leadership positions (ATLAS, T2K, Hyper-K, MAGIC, CTA, **HERD**, DES, PAU, DESI, Euclid, LSST, Virgo, **Einstein Telescope**)

one large **engineering** group (30+ engineers and technicians)

facilities: chip packaging & assembly, clean rooms, shielded room, electronics labs, optical lab, cryogenic lab, mechanical workshop (300 m²)

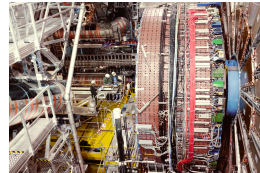
one massive data processing center: **PIC** (LHC Tier-1)



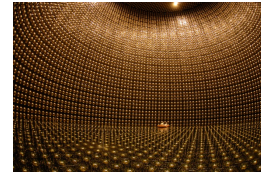
Experimental division

particle physics

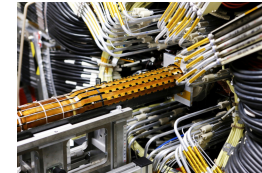
Higgs, dark matter,
antimatter



ATLAS



T2K



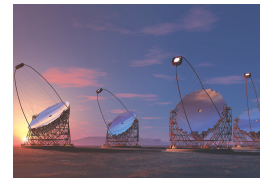
ATLAS PIXELS

particle astrophysics

dark matter,
extreme universe



MAGIC



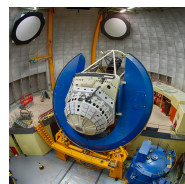
CTA



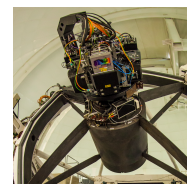
VIRGO

cosmology

dark energy,
dark matter



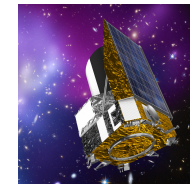
DES



PAU



DESI

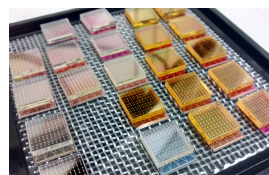


EUCLID

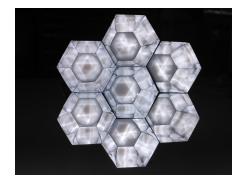
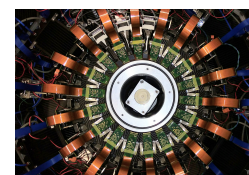


LSST

applied physics



MEDICAL IMAGING



NEW DETECTORS

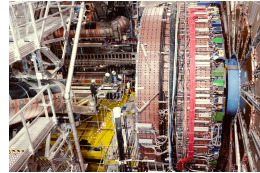


QUANTUM COMPUTING

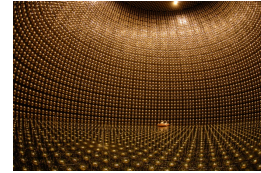
Experimental division

particle physics

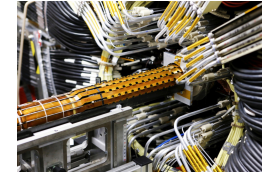
Higgs, dark matter,
antimatter



ATLAS



T2K



ATLAS PIXELS

particle astrophysics

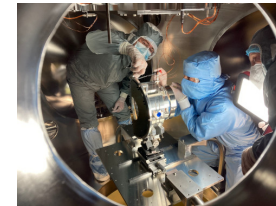
dark matter,
extreme universe



MAGIC



CTA



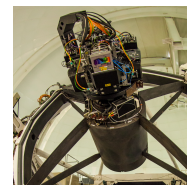
VIRGO

cosmology

dark energy,
dark matter



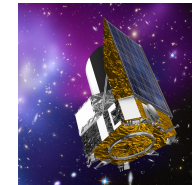
DES



PAU



DESI

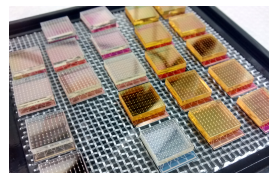


EUCLID

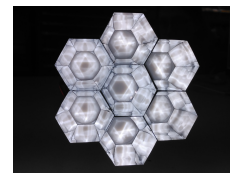
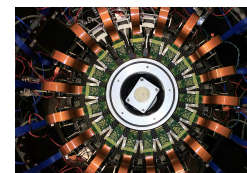


LSST

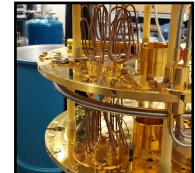
applied physics



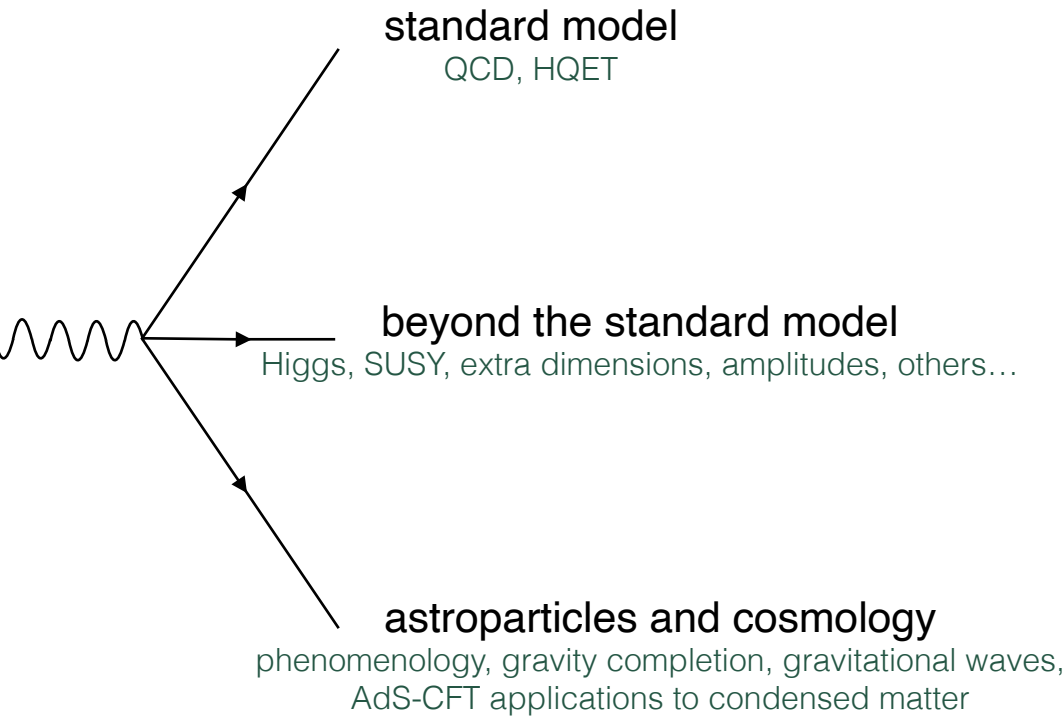
MEDICAL IMAGING



NEW DETECTORS

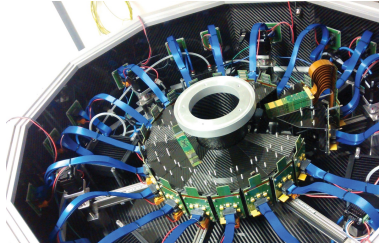


QUANTUM COMPUTING

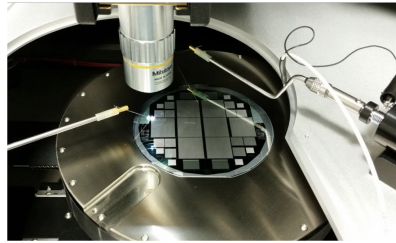


$$\begin{aligned}
 & W_\nu^+ W_\mu^-) - 2A_\mu Z_\mu^0 W_\nu^+ W_\nu^-] - g\alpha_1 \\
 & \frac{1}{8}g^2\alpha_h[H^4 + (\phi^0)^4 + 4(\phi^+\phi^-)^2 + 4(\phi^0)^2\phi^+\phi^- + \\
 & gMW_\mu^+ W_\mu^- H - \frac{1}{2}g\frac{M}{c_w^2}Z_\mu^0 Z_\mu^0 H - \frac{1}{2}ig[W_\mu^+ (\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0) + \\
 & W_\mu^- (\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0)] + \frac{1}{2}g[W_\mu^+ (H\partial_\mu\phi^- - \phi^-\partial_\mu H) + \\
 & \phi^+\partial_\mu H)] + \frac{1}{2}g\frac{1}{c_w}(Z_\mu^0(H\partial_\mu\phi^0 - \phi^0\partial_\mu H) - ig\frac{s_w^2}{c_w}L \\
 & igs_wMA_\mu(W_\mu^+\phi^- - W_\mu^-\phi^+) - ig\frac{1-2c_w^2}{2c_w}Z_\mu^0(\phi^+\partial_\mu\phi^- - \\
 & igs_wA_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) - \frac{1}{4}g^2W_\mu^+ W_\mu^- [H^2 + (\phi^0)^2 + 2(2s_w^2 - 1)^2\phi^+\phi^-] \\
 & \frac{1}{4}g^2\frac{1}{c_w^2}Z_\mu^0 Z_\mu^0 [H^2 + (\phi^0)^2 + 2(2s_w^2 - 1)^2\phi^+\phi^-] \\
 & W_\mu^-\phi^+) - \frac{1}{2}ig^2\frac{s_w^2}{c_w}Z_\mu^0 H(W_\mu^+\phi^- - W_\mu^-\phi^+) + \\
 & W_\mu^-\phi^+) + \frac{1}{2}ig^2s_wA_\mu H(W_\mu^+\phi^- - W_\mu^-\phi^+) - g^2\frac{s_w^2}{c_w} \\
 & g^1s_w^2A_\mu A_\mu\phi^+\phi^- - \bar{e}^\lambda(\gamma\partial + m_e^\lambda)e^\lambda - \bar{\nu}^\lambda\gamma\partial\nu^\lambda \\
 & \bar{d}_j^\lambda(\gamma\partial + m_d^\lambda)d_j^\lambda + igs_wA_\mu[-(\bar{e}^\lambda\gamma^\mu e^\lambda) + \frac{2}{3}(\bar{u}_j^\lambda \\
 & \frac{ig}{4c_w}Z_\mu^0[(\bar{\nu}^\lambda\gamma^\mu(1 + \gamma^5)\nu^\lambda) + (\bar{e}^\lambda\gamma^\mu(4s_w^2 - 1 - \\
 & 1 - \gamma^5)u_j^\lambda) + (\bar{d}_j^\lambda\gamma^\mu(1 - \frac{8}{3}s_w^2 - \gamma^5)d_j^\lambda)] + \frac{ig}{2\sqrt{2}} \\
 & (\bar{u}_j^\lambda\gamma^\mu(1 + \gamma^5)C_{\lambda\kappa}d_j^\kappa)] + \frac{ig}{2\sqrt{2}}W_\mu^-[(\bar{e}^\lambda\gamma^\mu(1 + \gamma^5) \\
 & \gamma^5)u_j^\lambda)] + \frac{ig}{2\sqrt{2}}\frac{m_e^\lambda}{M}[-\phi^+(\bar{\nu}^\lambda(1 - \gamma^5)e^\lambda) + \phi^-(\bar{e}^\lambda(1 - \gamma^5)\nu^\lambda) \\
 & \frac{g}{2}\frac{m_e^\lambda}{M}[H(\bar{e}^\lambda e^\lambda) + i\phi^0(\bar{e}^\lambda\gamma^5 e^\lambda)] + \frac{ig}{2M\sqrt{2}}\phi^+[-m_u^\lambda(\bar{u}_j^\lambda C_{\lambda\kappa}(1 + \gamma^5)d_j^\kappa) \\
 & m_u^\lambda(\bar{u}_j^\lambda C_{\lambda\kappa}(1 + \gamma^5)d_j^\kappa) + \frac{ig}{2M\sqrt{2}}\phi^-[m_d^\lambda(\bar{d}_j^\lambda C_{\lambda\kappa}^\dagger(1 + \gamma^5)u_j^\lambda) \\
 & \gamma^5)u_j^\lambda] - \frac{g}{2}\frac{m_u^\lambda}{M}H(\bar{u}_j^\lambda u_j^\lambda) - \frac{g}{2}\frac{m_d^\lambda}{M}H(\bar{d}_j^\lambda d_j^\lambda) +
 \end{aligned}$$

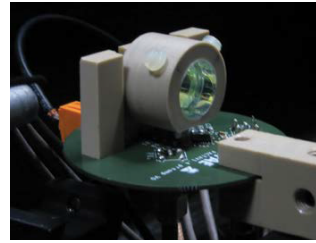
Technology and infrastructure



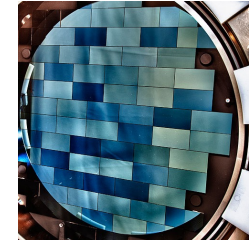
Medical imaging:
high resolution PET



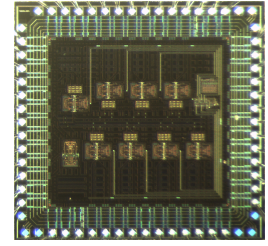
Novel 3D pixel silicon
detectors for LHC



Silicon
photomultipliers



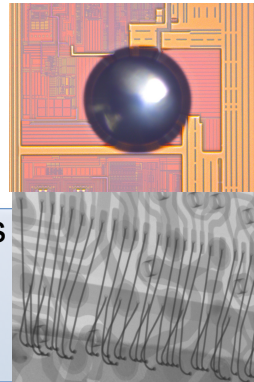
Large area
CCD readout



ASIC design



Clean rooms



Microelectronics
integration:
bump & wire
bonding



Precision
mechanics:
design and
manufacturing

Massive data
processing
center

