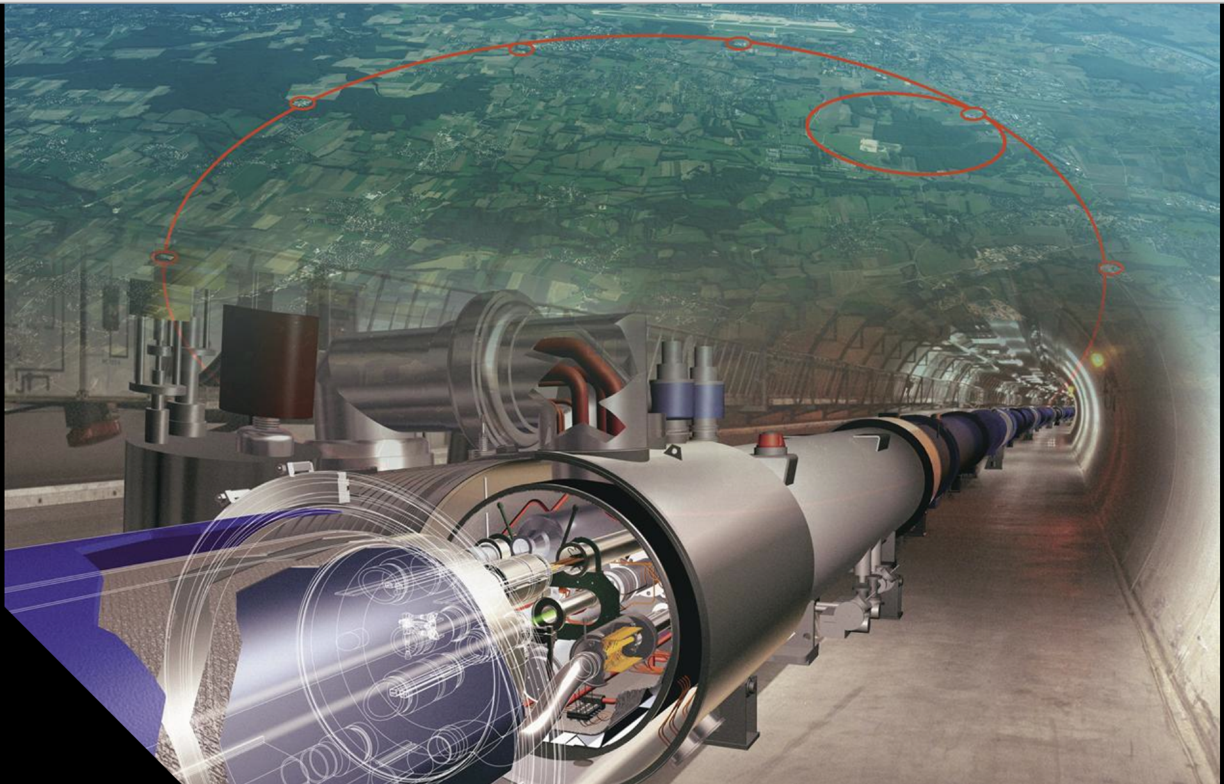
Road to an update of the European HEP Strategy

Jorgen D'Hondt
Vrije Universiteit Brussel
ECFA chairperson
(https://ecfa.web.cern.ch)

FCC week
24-28 June 2019
Brussels, Belgium



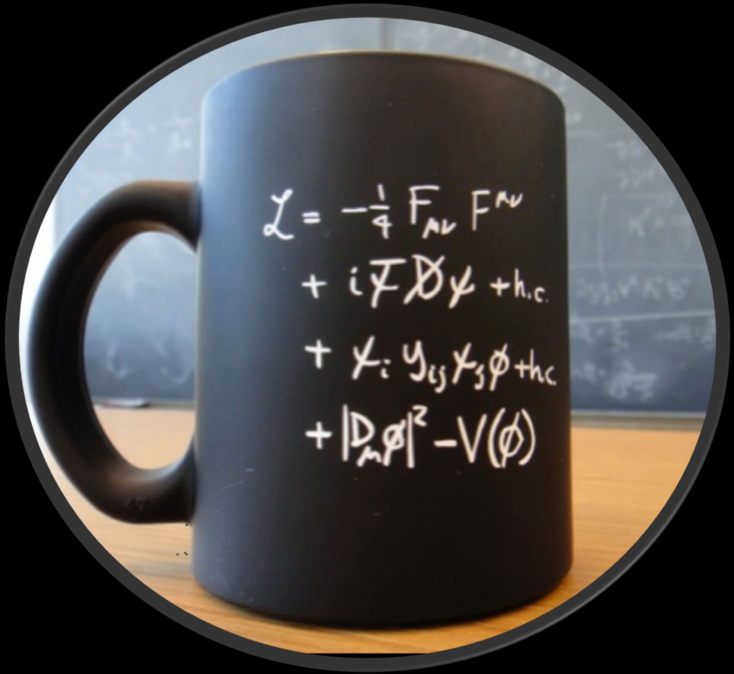
HEP@VUB BRUSSELS

VUB

iihe BRUXELLES BRUSSEL

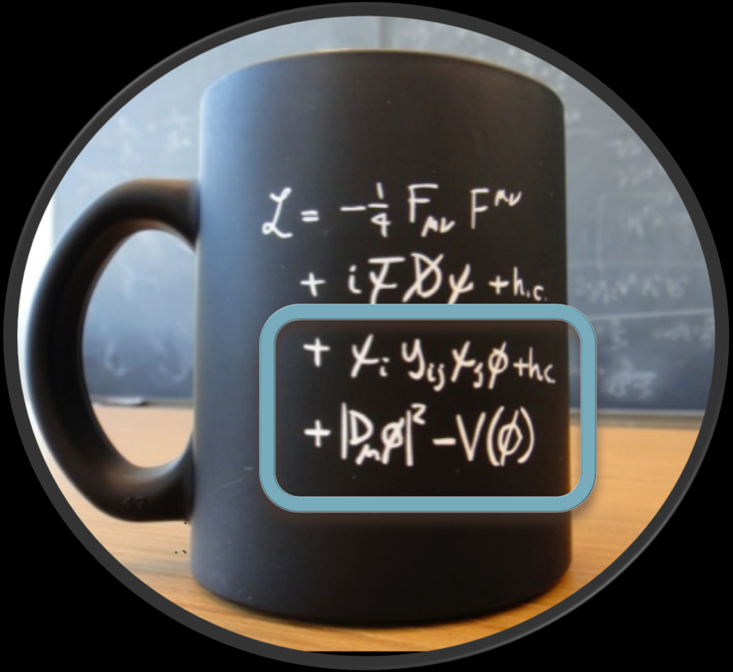
understand nature at the
largest and the smallest scales

Particle Physics today



enormous success in describing matter at the smallest scales

Particle Physics today



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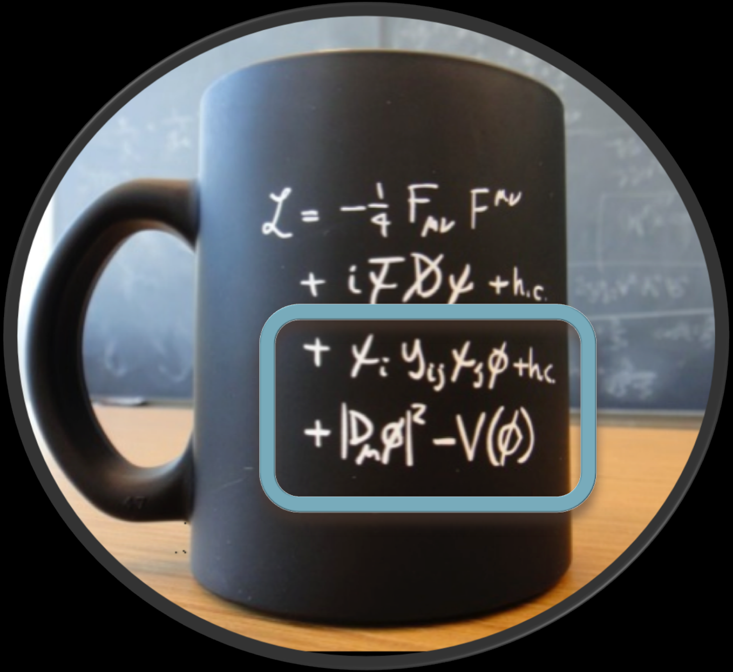
Particle Physics today



enormous success in describing matter at the smallest scales

describing $\neq$ understanding

Key open questions for particle physics?

Riccardo Rattazzi
@ Granada

Problems vs Mysteries

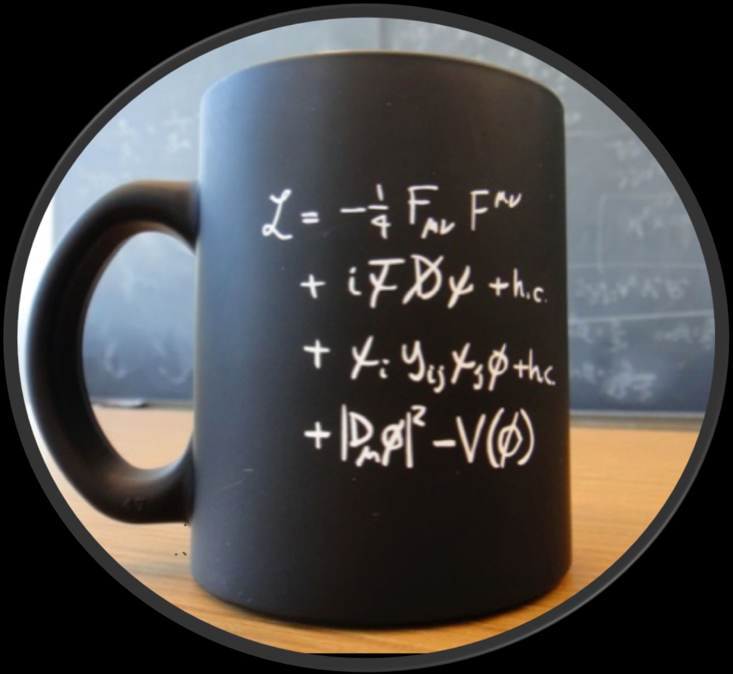
- Dark Matter
- Baryogenesis
- Strong CP
- Fermion mass spectrum & mixing

Plausible EFT solutions exist

- Cosmological Constant
- EW hierarchy
- Black Hole information paradox
- very Early Universe

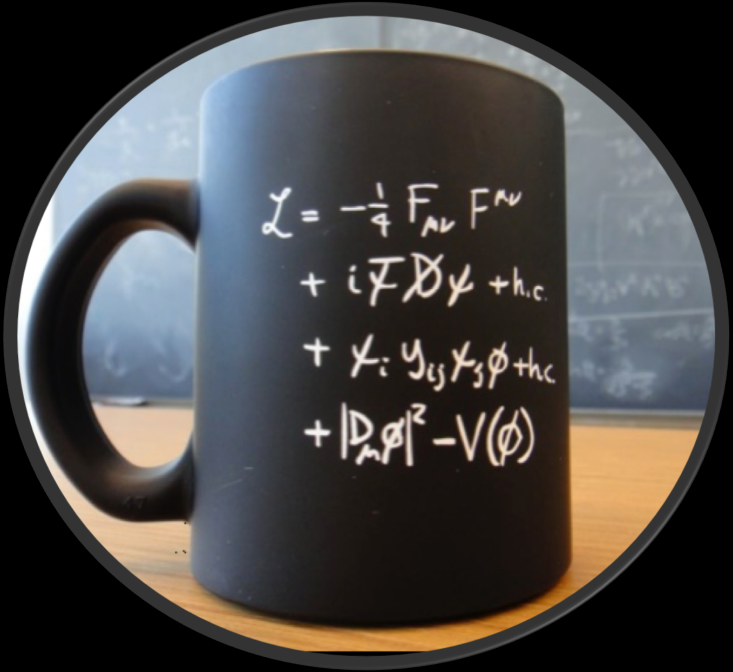
Challenge or outside EFT paradigm

Particle Physics today



new physics

Particle Physics today

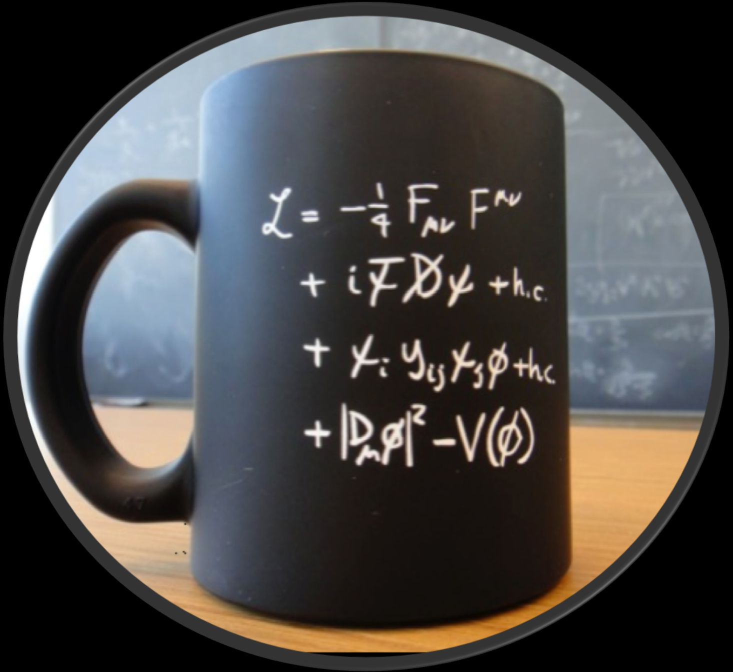


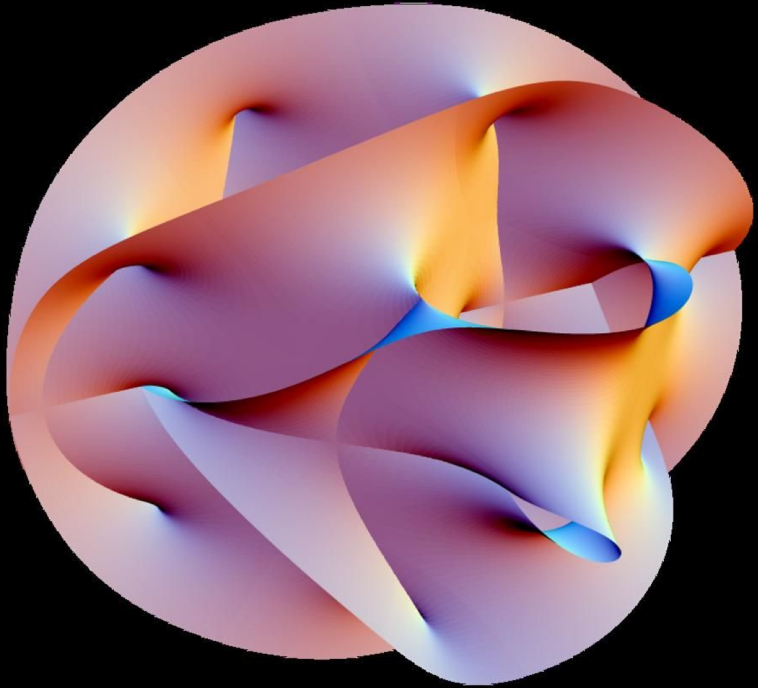
a simple design?

new physics

Particle Physics today

or more elegant ?

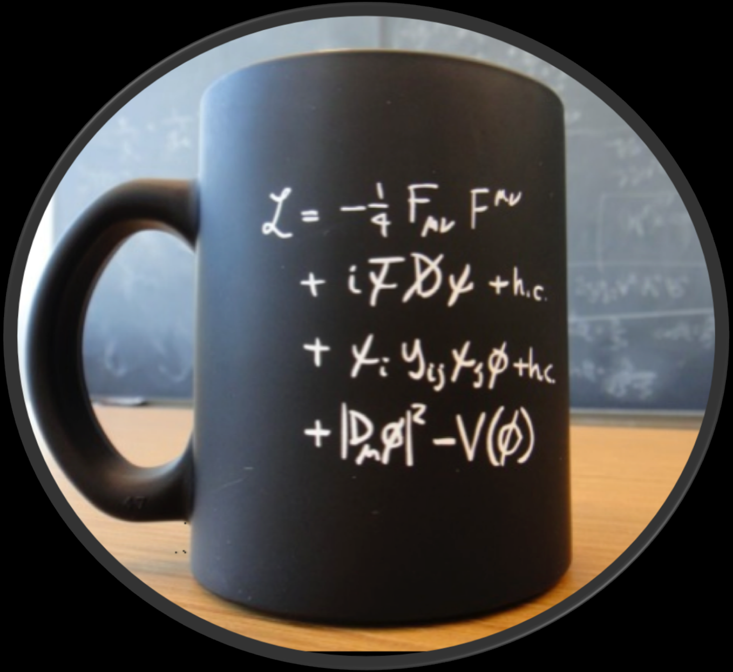




new physics

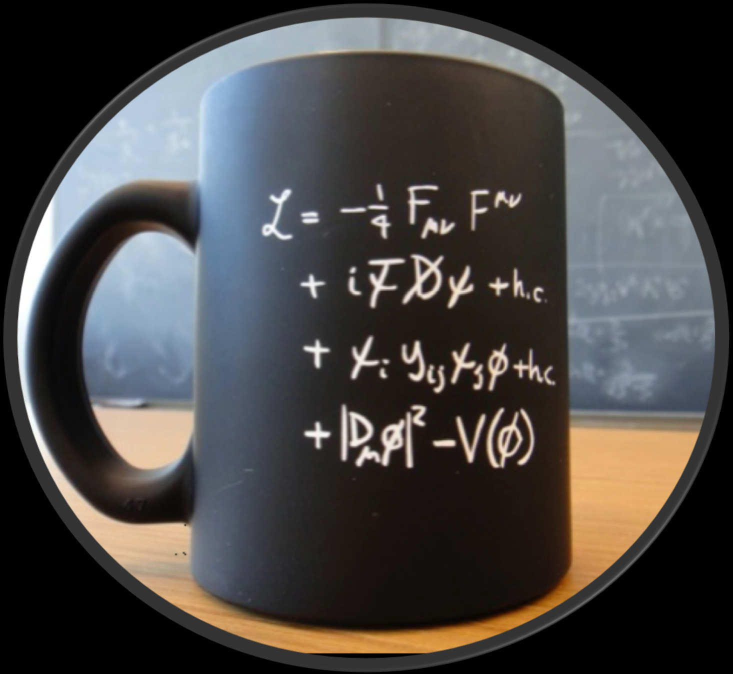
Particle Physics today

or more surreal?



new physics

Particle Physics today



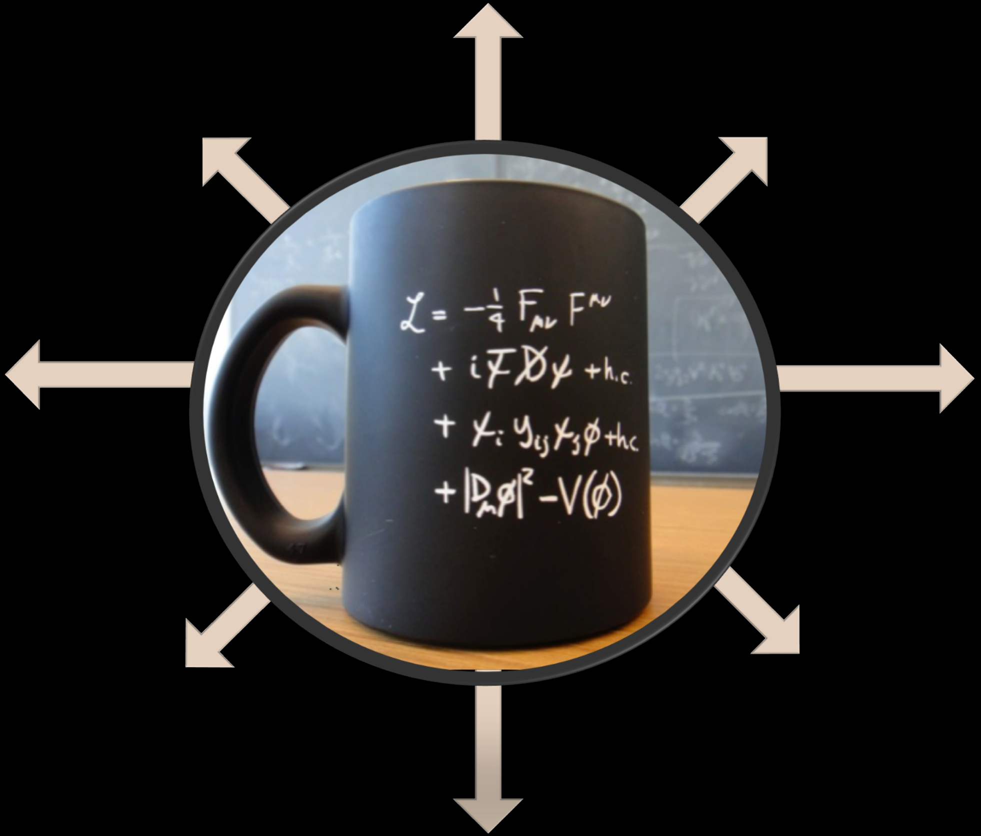
connection

new physics

although there is no lack of novel theoretical ideas, there are no clear indications where new physics is hiding although there is no lack of novel theoretical ideas, there are no clear indications where new physics is hiding

an argument for a strong and diverse, yet coherent and concerted empirical exploration higher energy interactions in the lab

earlier universe



rarer processes

higher energetic phenomena in the universe higher energy interactions in the lab

earlier universe

rarer processes

higher energetic phenomena in the universe

What is out there on our accelerator/collider technology front?

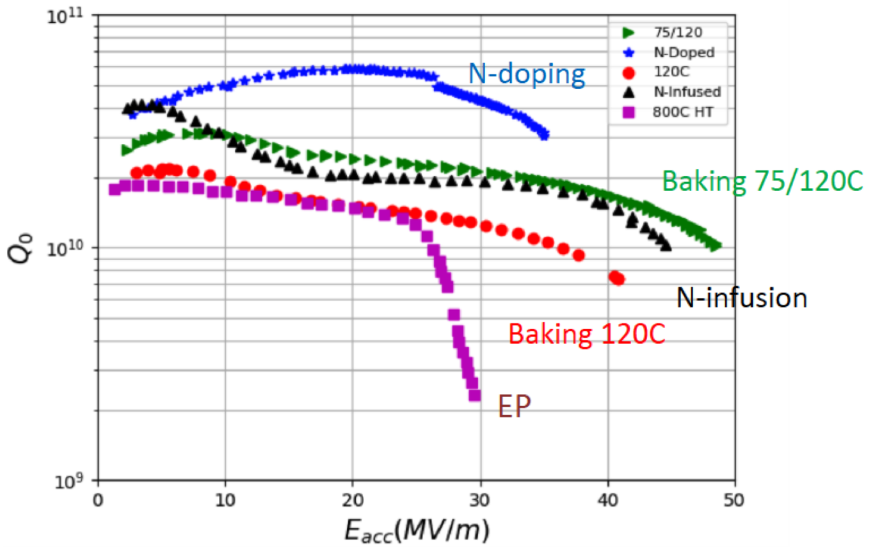
(only a very brief snapshot)

RF cavity R&D – *~50MV/m within reach while XFEL@DESY has ~30MV/m*

Akira Yamamoto
@ Granada

State of the Art in High-Q and High-G (1.3 GHz, 2K)

Courtesy: Anna Grassellino
- TTC Meeting, TRIUMF, Feb., 2019



- **N-doping** (@ 800C for ~a few min.)
  - Q >3E10, G = 35 MV/m
- **Baking w/o N** (@ 75/120C)
  - Q >1E10, G =49 MV/m (Bpk-210 mT)
- **N-infusion** (@ 120C for 48h)
  - Q >1E10, G = 45 MV/m
- **Baking w/o N** (@ 120C for xx h)
  - Q >7E9, G = 42 MV/m
- **EP** (only)
  - Q >1.3E10, G = 25 MV/m

- **High-Q** by **N-Doping** well established, and
- **High-G** by N-infusion and **Low-T baking** still to be understood and reproduced, worldwide.

SC Magnet R&D – *16 T magnets would allow to reach much higher pp collision energies*

FRESCA2 @ CERN

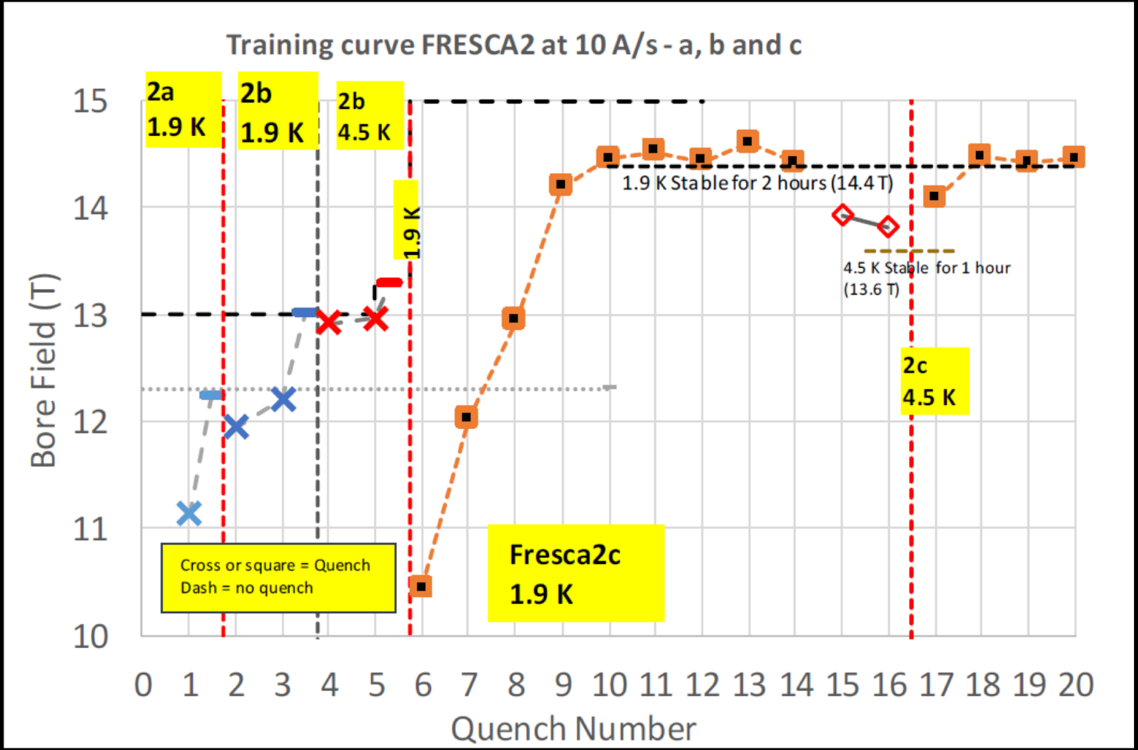
Test new superconductive cables (Nb_3Sn)

Dipole magnet
1.5 m long, 1 m diameter, 10 cm aperture

Nominal 13 T design, with an ultimate goal of 15 T, and reached 14.6 T (April 2018), a record for a magnet with a “free” aperture, and with only few quenches

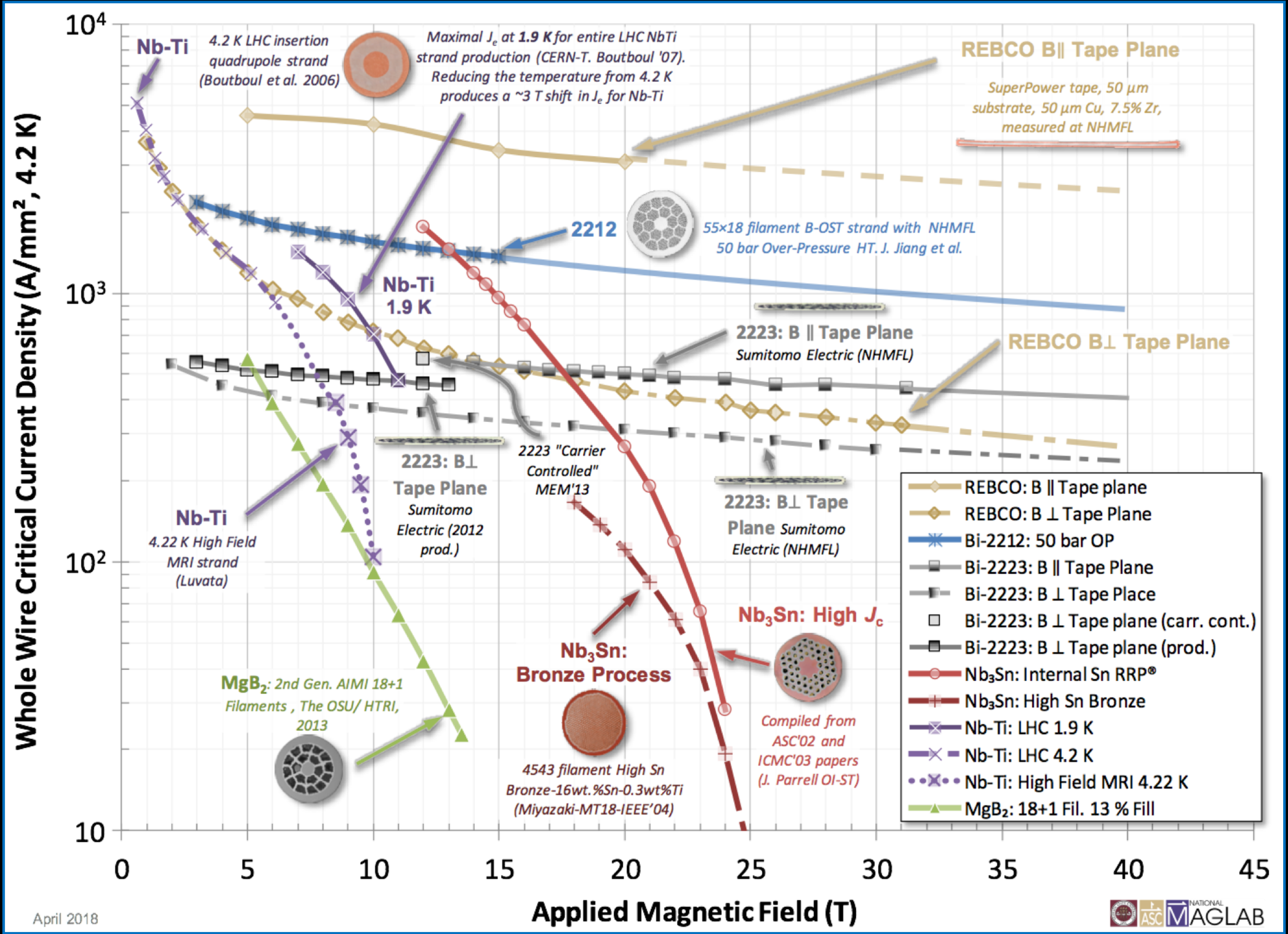
SC Magnet R&D – *16 T magnets would allow to reach much higher pp collision energies*

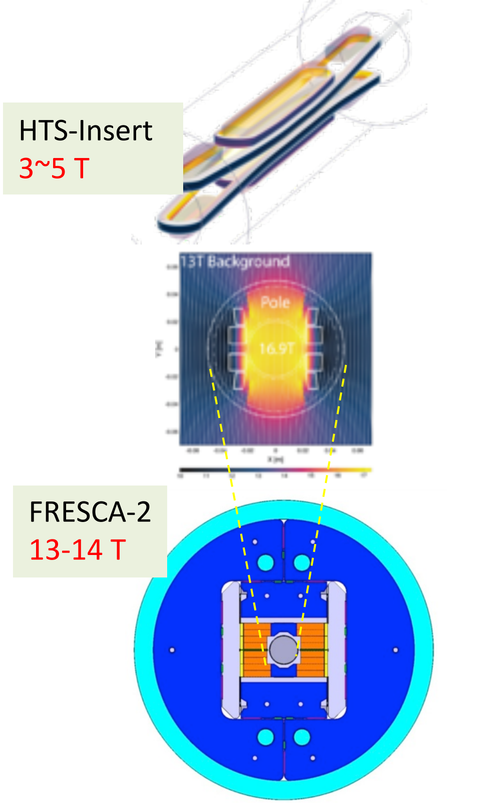
FRESCA2 @ CERN



F. Toral @ Plenary ECFA meeting Nov 2018

SC Magnet R&D – *alternative materials for high-J_c at high magnetic field*





Eucard2: HTS-insert to be tested in 2019
(3-5) + (13-14)T : > 16 T

Timelines

Akira Yamamoto
@ Granada

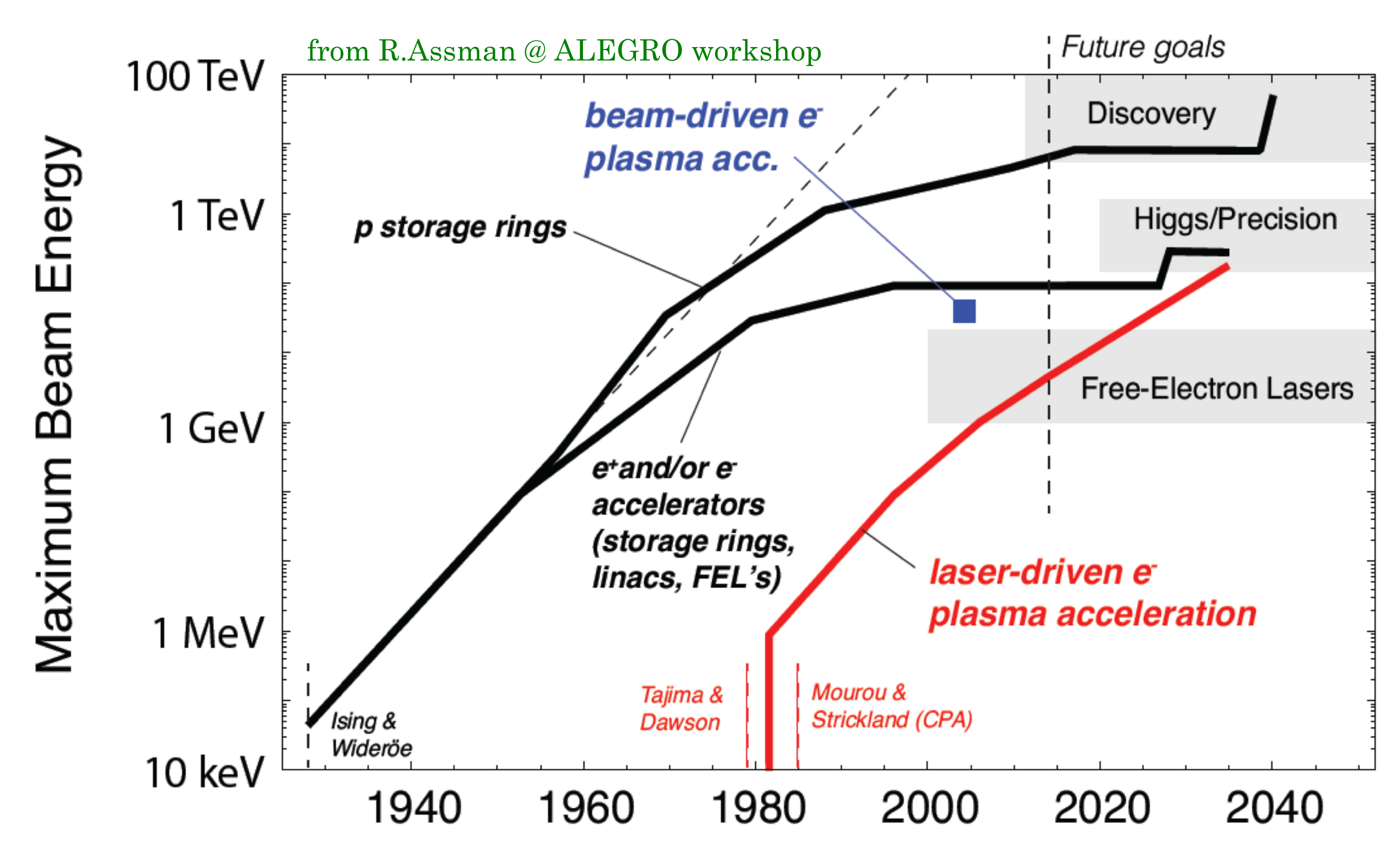
Personal View on Relative Timelines

Timeline	~ 5	~ 10	~ 15	~ 20	~ 25	~ 30	~ 35
Lepton Colliders							
SRF-LC/CC	Proto/pre-series	Construction		Operation		Upgrade	
NRF—LC	Proto/pre-series	Construction		Operation		Upgrade	
Hadron Collier (CC)							
8~(11)T NbTi /(Nb3Sn)	Proto/pre-series	Construction			Operation		Upgrade
12~14T Nb_3Sn	Short-model R&D		Proto/Pre-series		Construction	Operation	
14~16T Nb_3Sn		Short-model R&D		Prototype/Pre-series		Construction	

Accelerator R&D – Advanced Novel Accelerators (ICFA Panel)

ALEGRO (Advanced LinEar collider study GROup, for a multi-TeV Advanced Linear Collider)
Workshop (March 2018 in Oxford): http://www.physics.ox.ac.uk/confs/alegro2018/index.asp

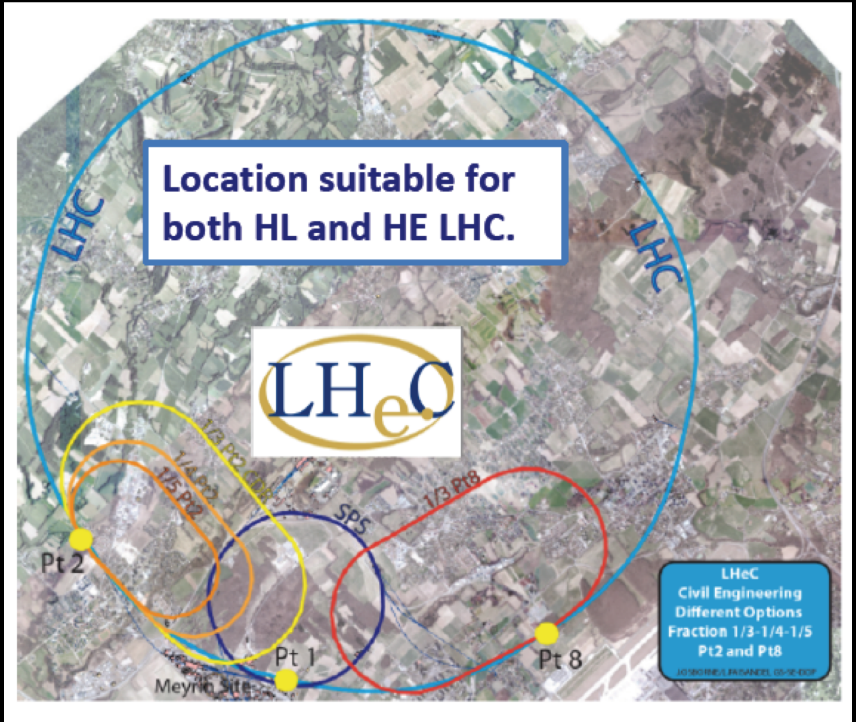
ALEGRO delivered a document detailing the international roadmap and strategy of Advanced Novel Accelerators (ANAs).



Concrete collider options studied at CERN

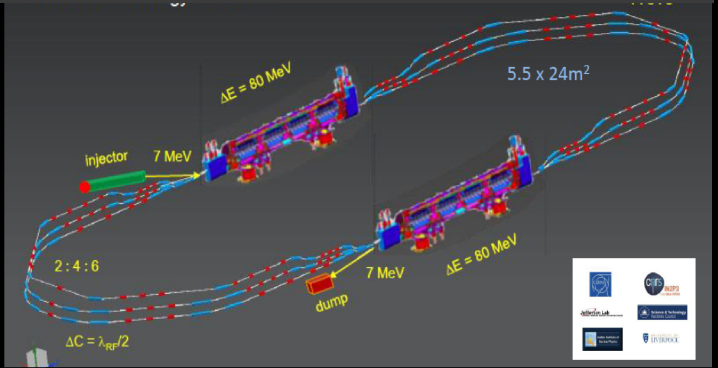
LHeC (ep), http://lhec.web.cern.ch

J. Phys. G: Nucl. Part. Phys. 39 (2012) 075001 [arXiv:1206.2913]



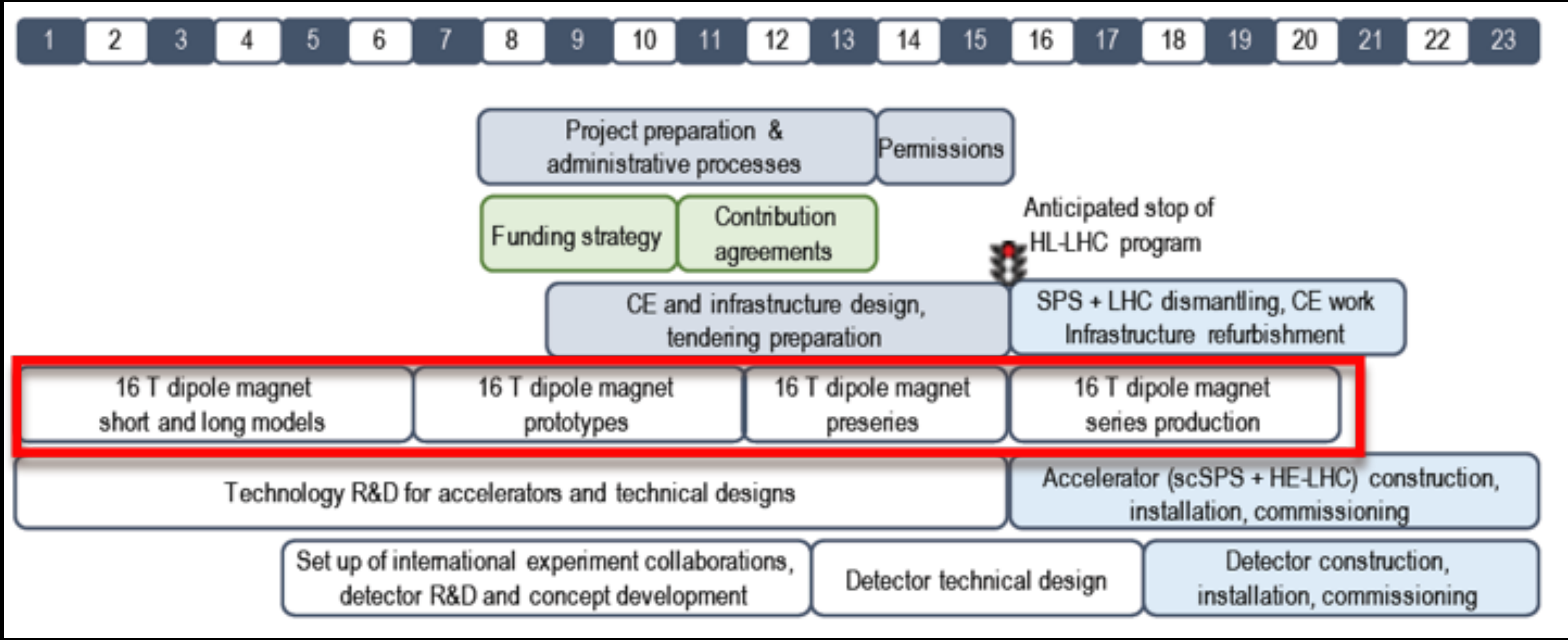
LHeC (60 GeV e- from ERL)
E_{cms} = 0.2 – 1.3 TeV
run with the HL-LHC (≳ Run5)

Energy Recovery Linac (ERL)
R&D demonstrator at Orsay, PERLE



Concrete collider options studied at CERN

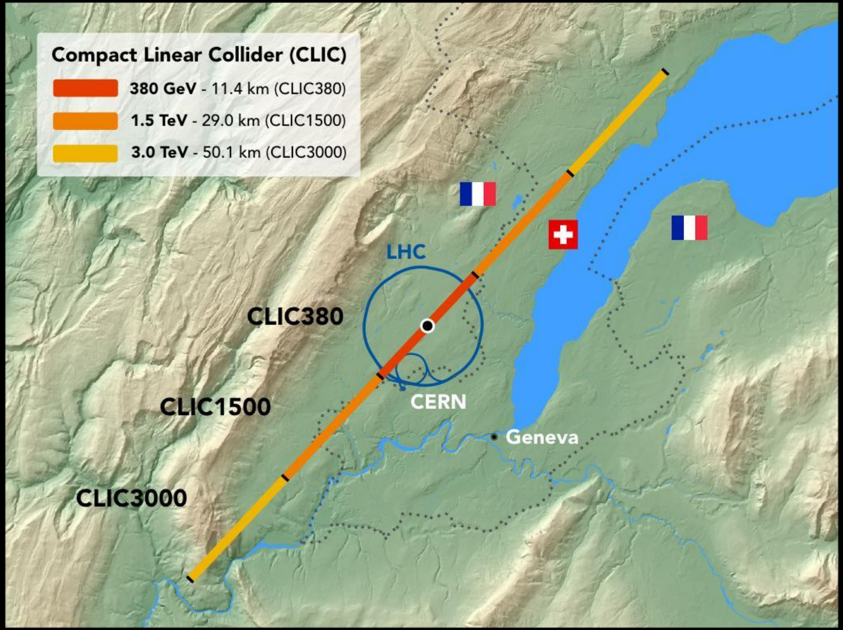
HE-LHC (pp, pA, AA, ep), https://fcc-cdr.web.cern.ch/

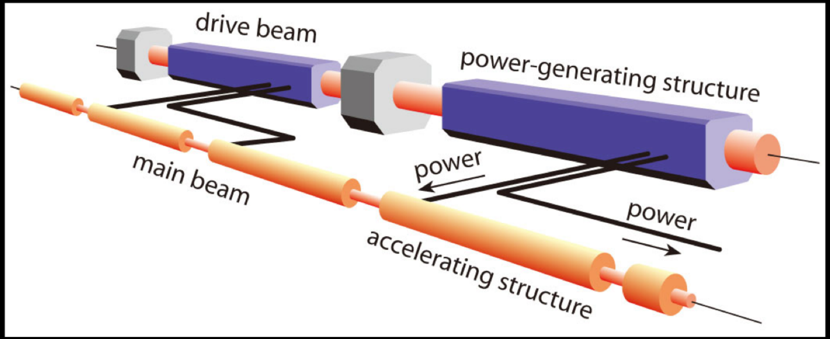


Technical schedule for HE-LHC with 16 T magnets

Concrete collider options studied at CERN

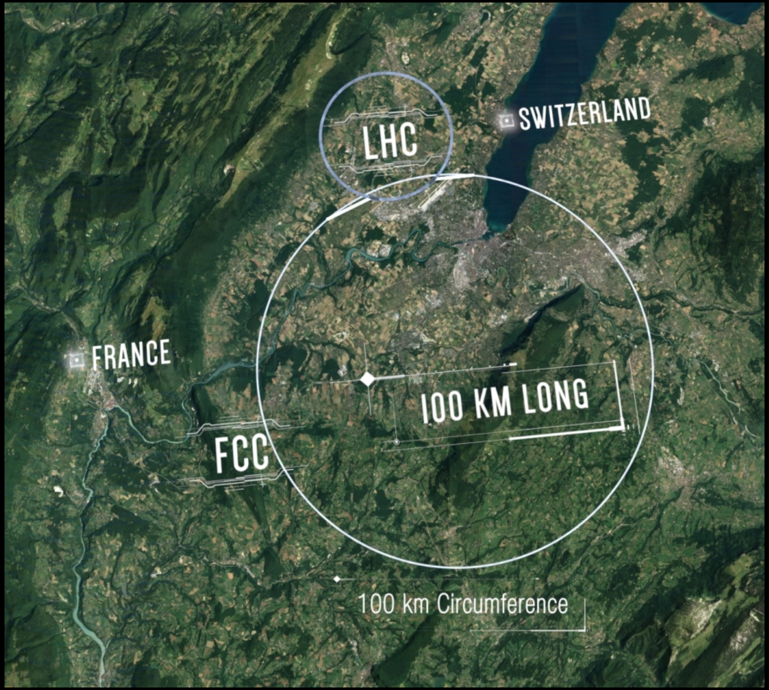
CLIC (ee), http://clic-study.web.cern.ch/





Concrete collider options studied at CERN

FCC (ee, ep, pp, pA, AA, eA), https://fcc-cdr.web.cern.ch/

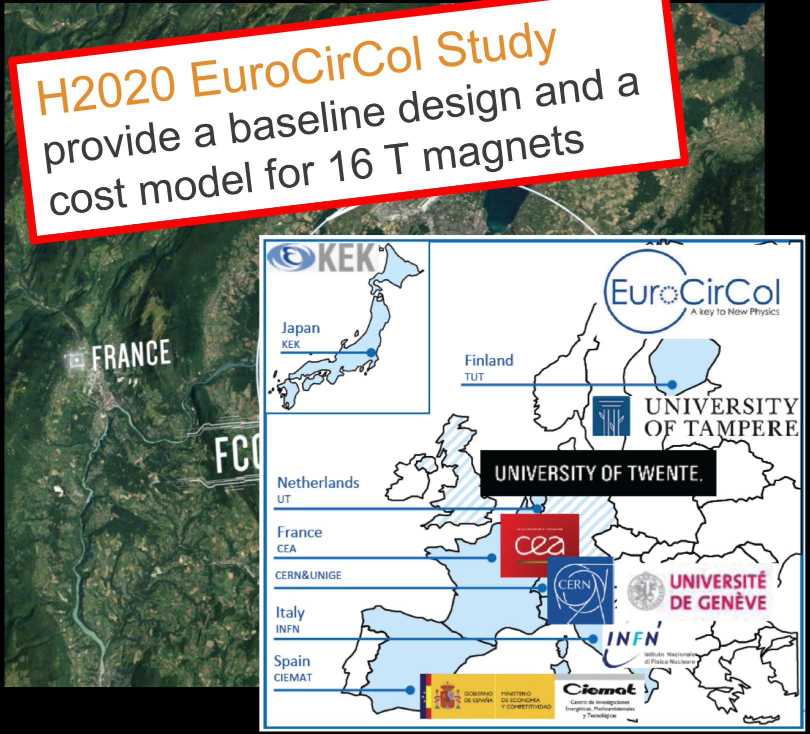


- **e^+e^- collider (*FCC-ee*)** **@ 90-365 GeV** as potential first step
- ***pp*-collider (*FCC-hh*)** **@ 100 TeV**
- ***p-e* collider (*FCC-he*)**
- **HE-LHC** with *FCC-hh magnets*
- ***$\mu\mu$* colider (*FCC-$\mu\mu$*)** option
- AA, Ap, Ae options

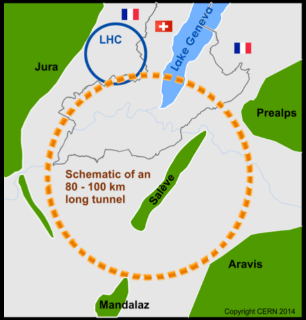
Concrete collider options studied at CERN

FCC (ee, ep, pp, pA, AA, eA), https://fcc-cdr.web.cern.ch/

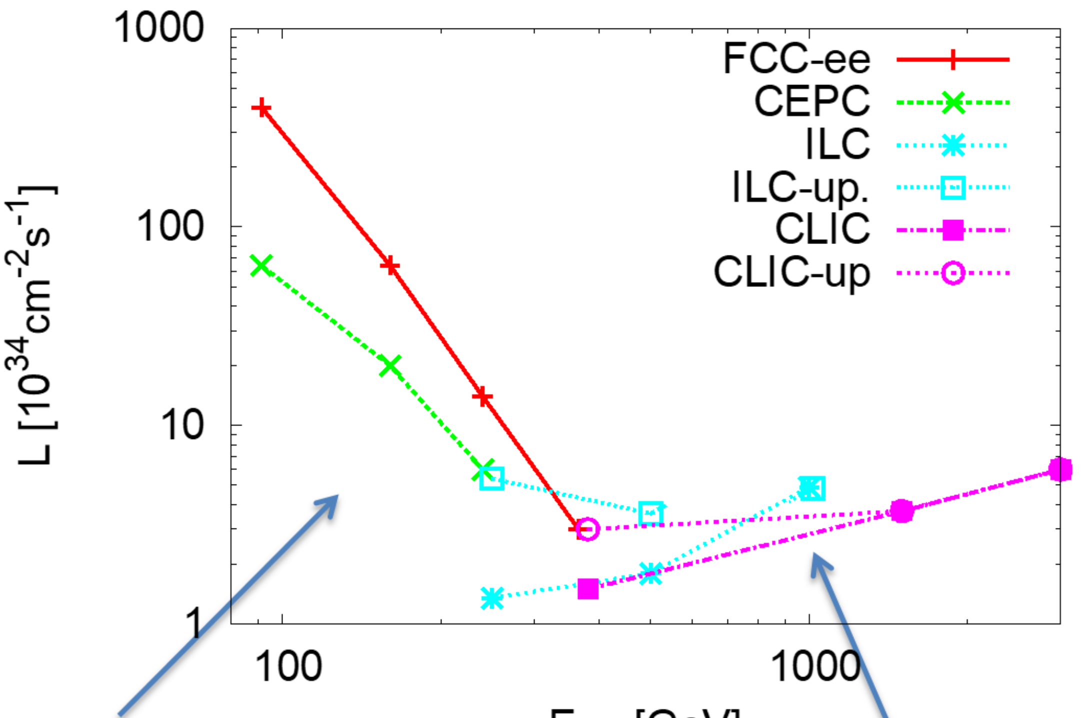
H2020 EuroCirCol Study
provide a baseline design and a cost model for 16 T magnets



- **e^+e^- collider (*FCC-ee*)** **@ 90-365 GeV** as potential first step
- ***pp*-collider (*FCC-hh*)** **@ 100 TeV**
- ***p-e* collider (*FCC-he*)**
- **HE-LHC** with *FCC-hh magnets*
- ***μμ* colider (*FCC-μμ*)** option
- AA, Ap, Ae options

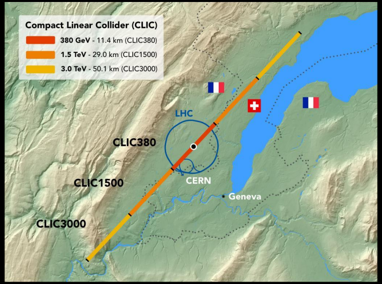


Luminosity per facility



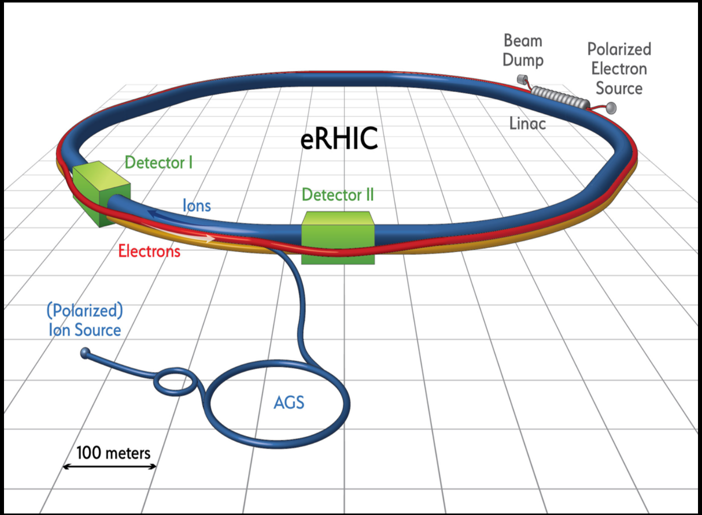
$$L \propto P_{synrad} E_{cm}^{-3.5}$$

$$L \propto P_{RF} E_{cm}$$

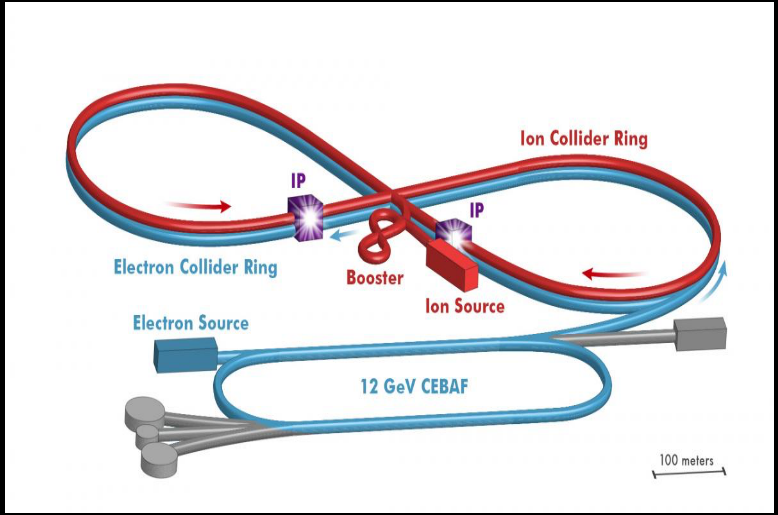


Other concrete collider options

EIC (eA, ep), http://www.eicug.org



Brookhaven NL



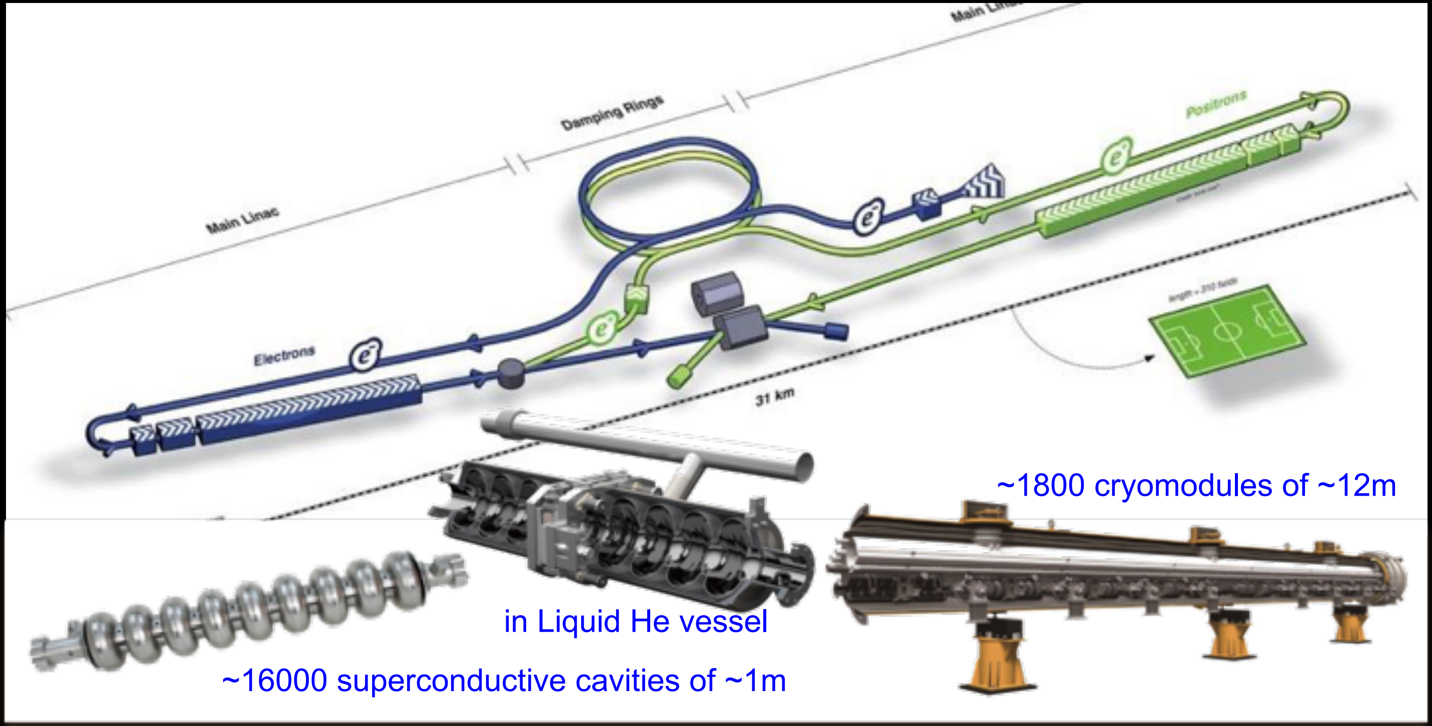
Jefferson Lab

EIC (3-20 GeV e-)

$E_{cms} = 0.02 - 0.13$ *TeV*

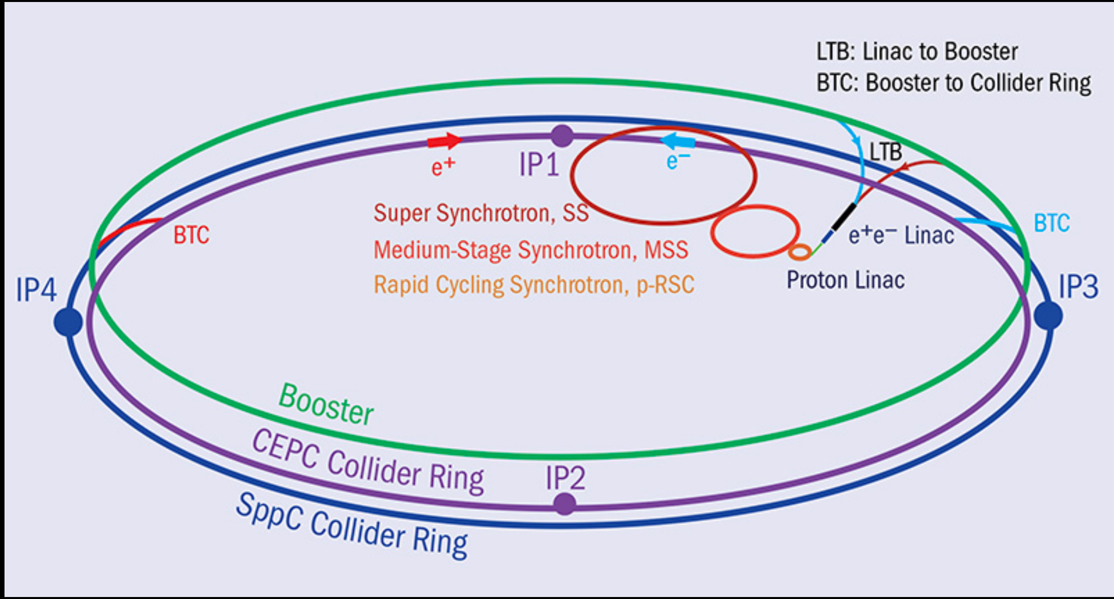
Other concrete collider options

ILC (ee), http://newsline.linearcollider.org



Other concrete collider options

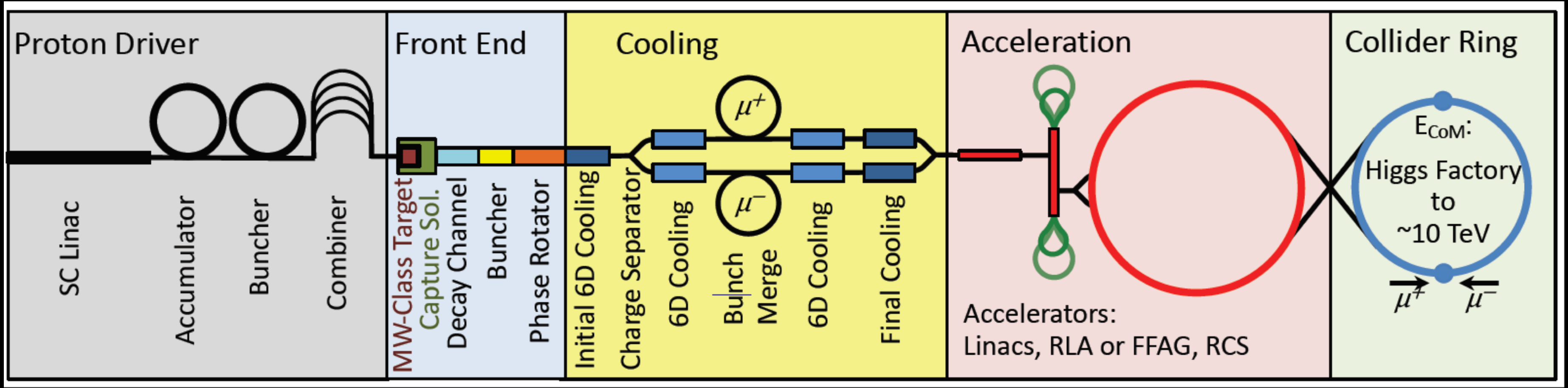
CEPC (ee), http://cepc.ihep.ac.cn



Other concrete collider options

Muon Collider, https://indico.cern.ch/event/801616/

need for a strong, concerted and global R&D effort



Short, intense proton bunches to produce hadronic showers

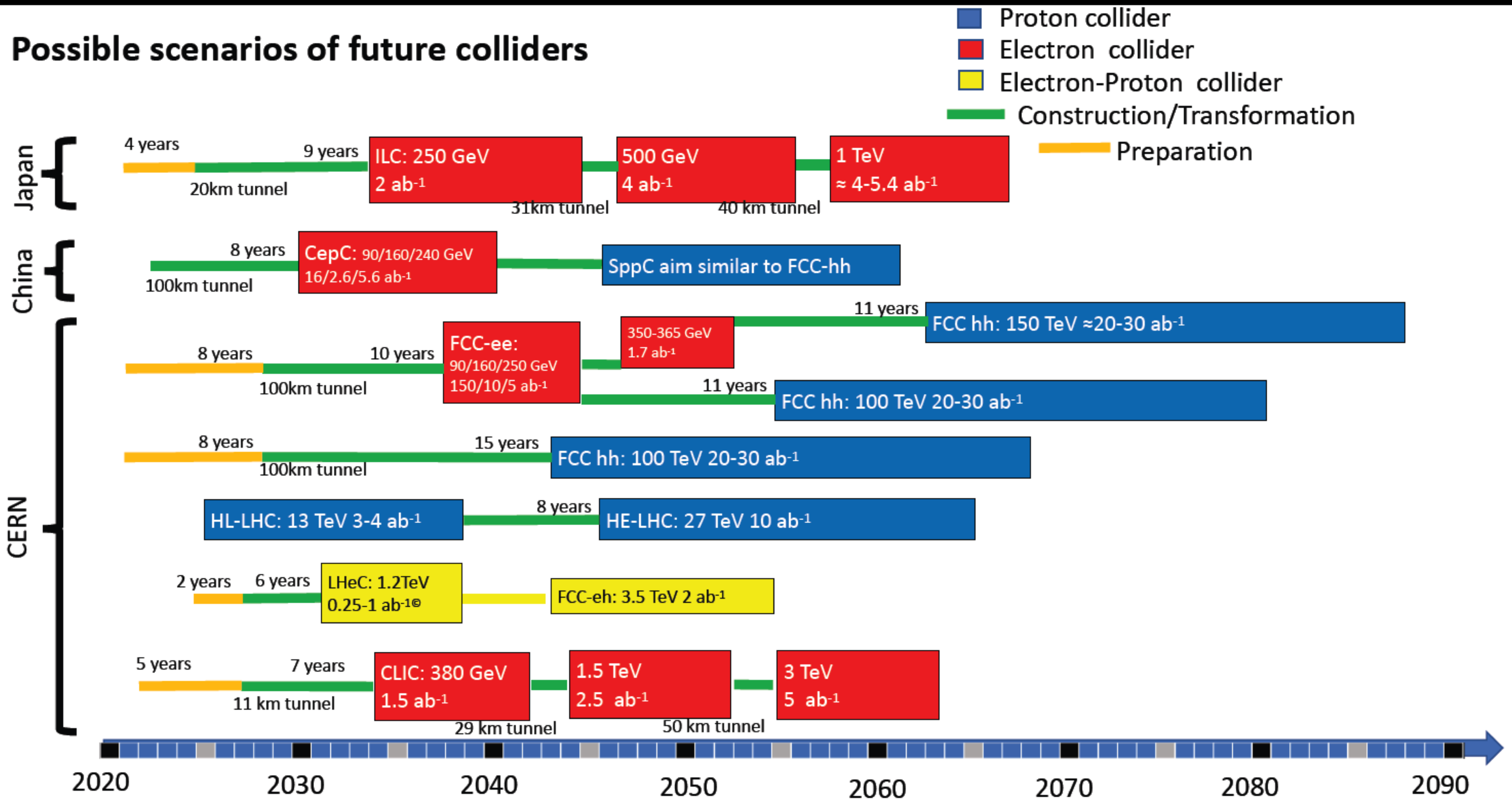
Muon are captured, bunched and then cooled

Acceleration to collision energy

Collision

Pions decay into muons that can be captured

Possible scenarios of future colliders



we can only explore our aspirations
when we innovate technology

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our field of high-energy physics is
driven by our innovations in
technology

from challenges to opportunities

foster the most talented researchers with aspirations in instrumentation, computing and software

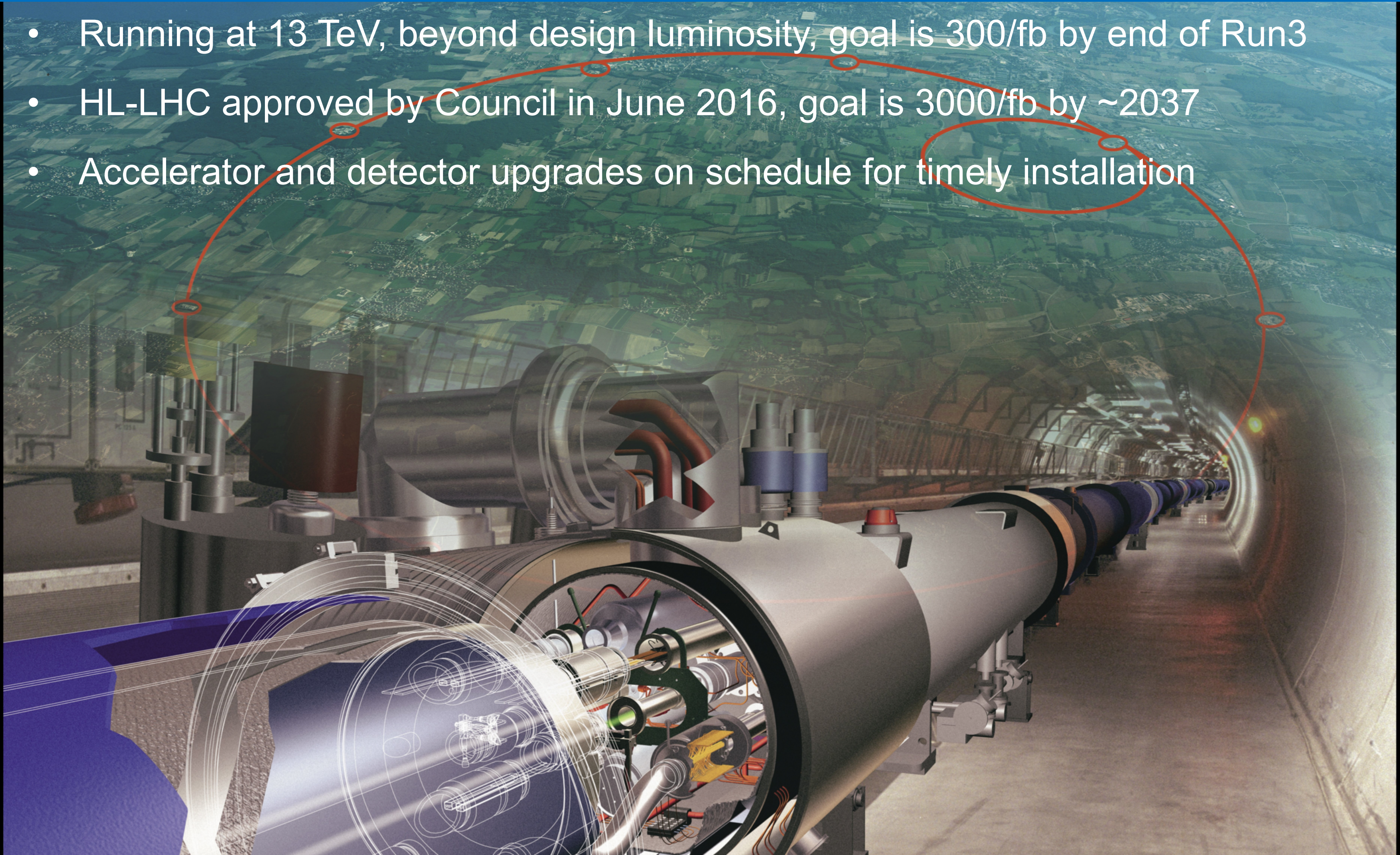
from challenges to opportunities

foster the most talented researchers with aspirations in instrumentation, computing and software

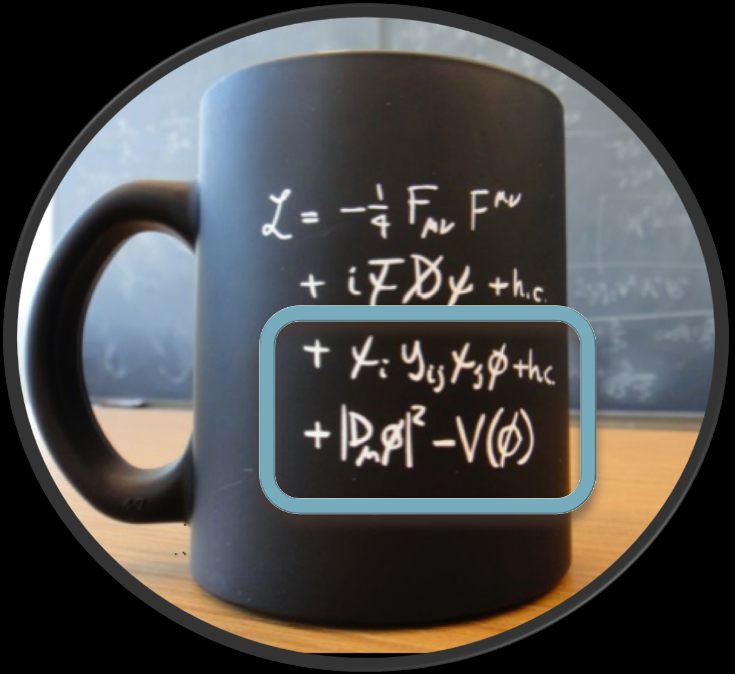
foster global R&D programs for technology and synergies with disciplines facing equivalent challenges

The (HL-)LHC at the frontline – colliding protons & ions

- Running at 13 TeV, beyond design luminosity, goal is 300/fb by end of Run3
- HL-LHC approved by Council in June 2016, goal is 3000/fb by ~2037
- Accelerator and detector upgrades on schedule for timely installation

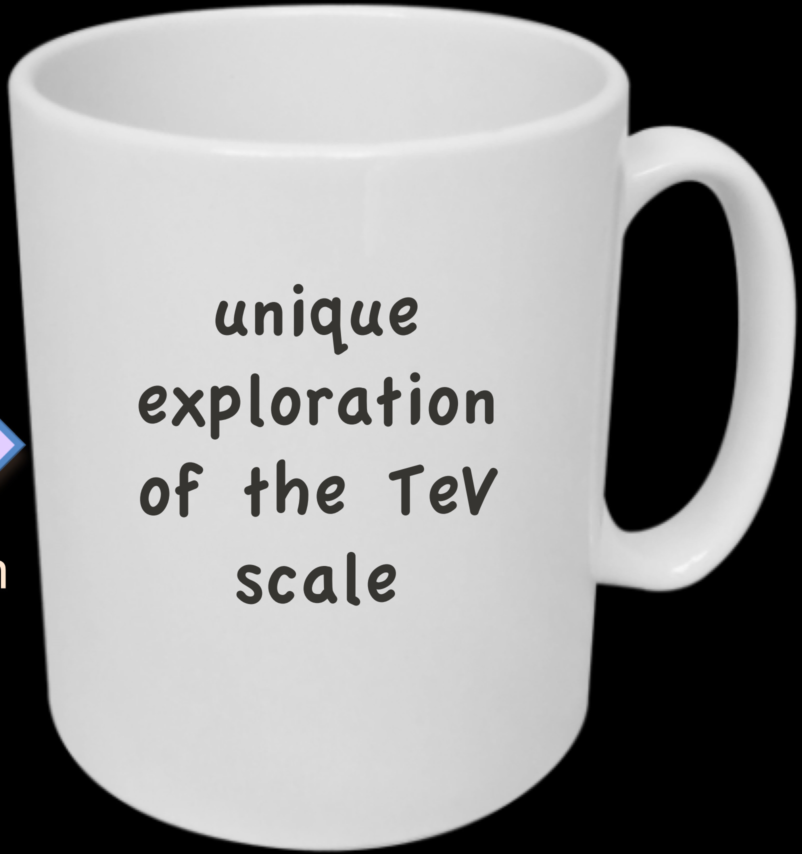


The impact of the LHC



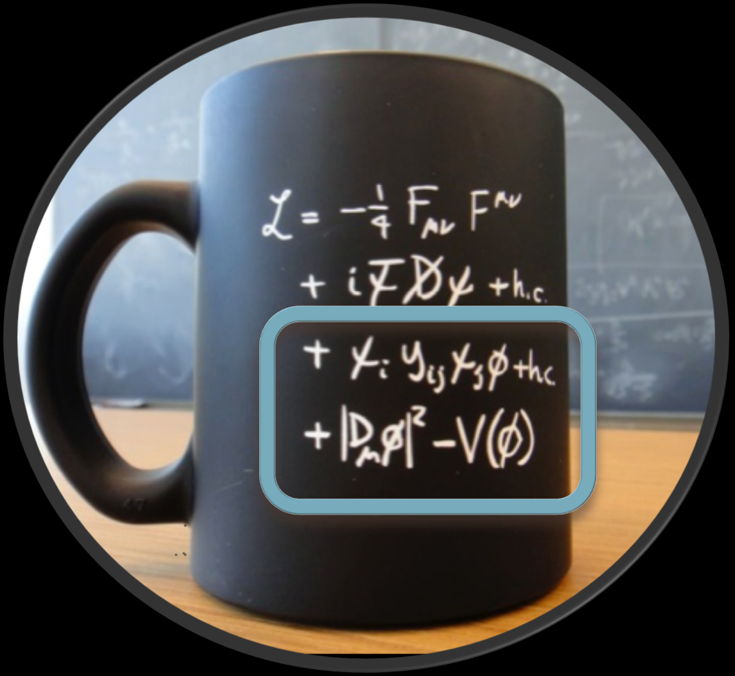
a MORE PRECISE and more COMPLETE description

connection



new physics

The impact of the LHC

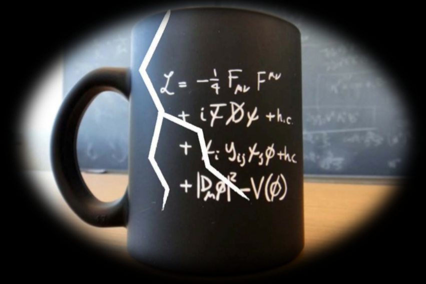


a MORE PRECISE and more COMPLETE description

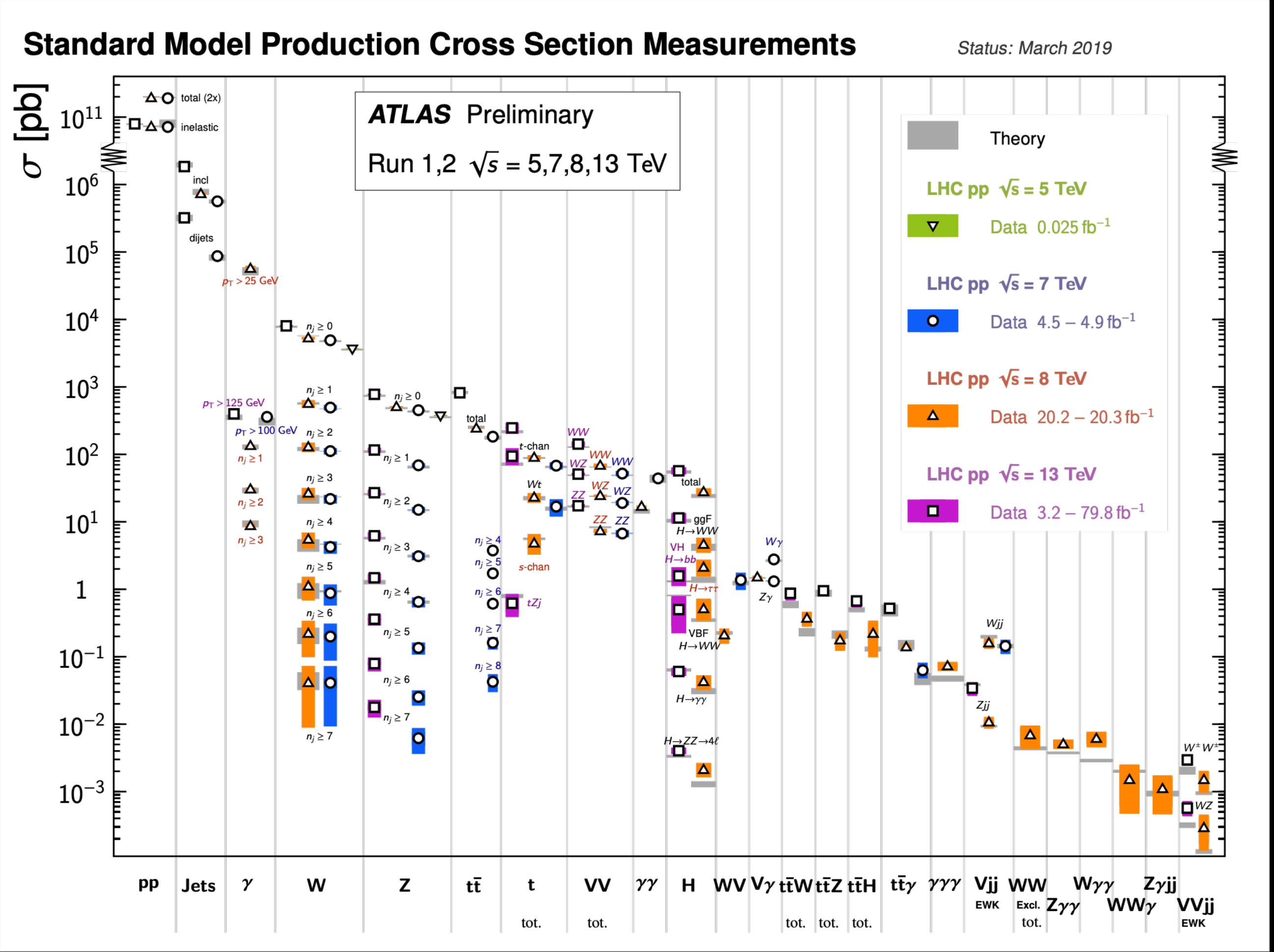
connection

new physics

Some physics results of the LHC – Standard Model



the cup doesn't break over many orders of magnitude



more data is needed

and due to our innovations in technology

more data is coming

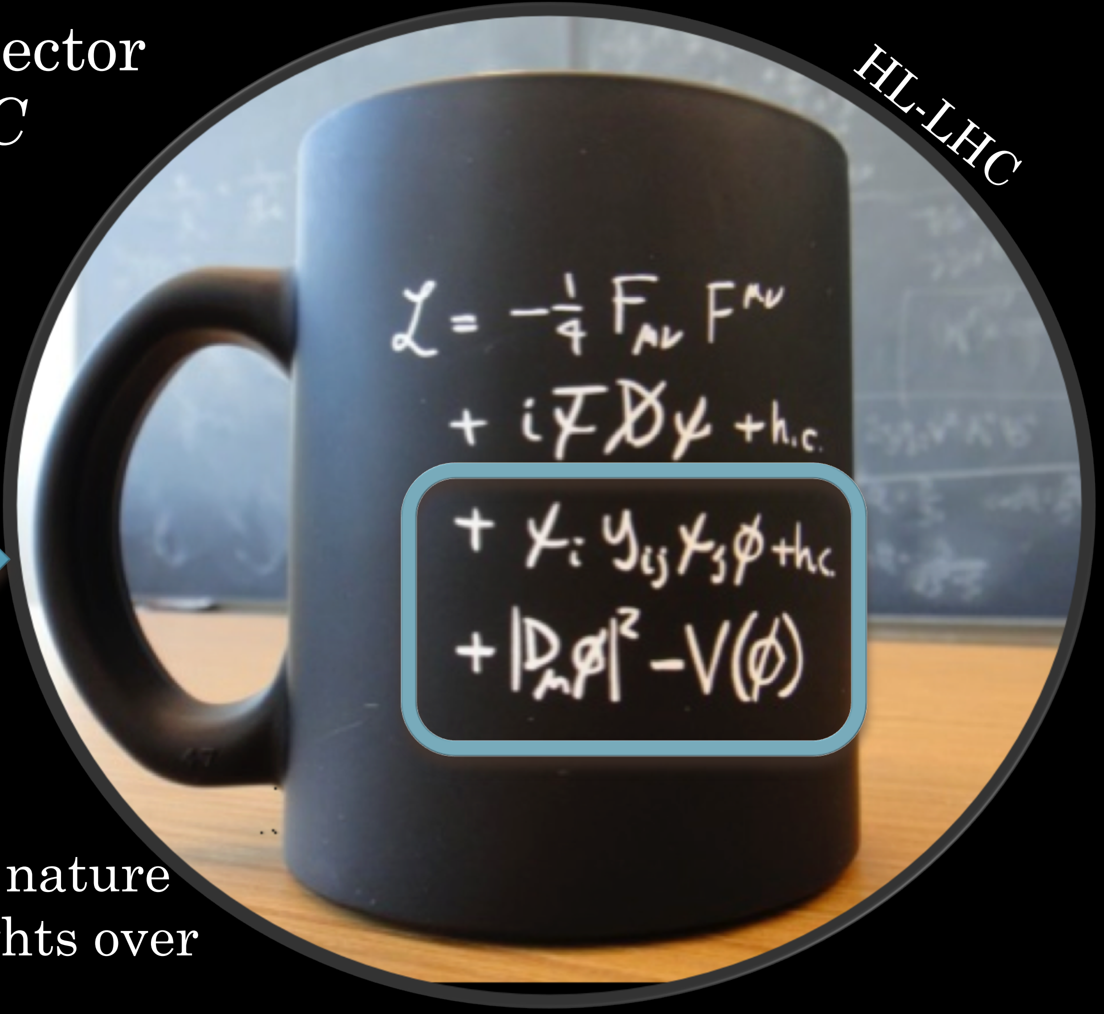
ALICE – Upgrade LS2 – study Quark-Gluon Plasma formed in nuclear collisions
Monolythic-pixel Inner Tracking System
→ x3-5 better tracking precision
Pixel Muon Forward Tracker
→ non-prompt muons from B decays
GEM-based TPC readout
→ x100 readout rate in Pb-Pb
ΔV = 270 V
ΔV = 800 V
ΔV = 230 V
ΔV = 800 V
ΔV = 288 V
ΔV = 20 V
ΔV = 359 V
ΔV = 800 V
pad plane
• Low-pT heavy-flavour mesons/baryons:
• Low-pT charmonia: c-cbar melting and
• Low-mass di-electrons: QGP thermal r
LHCb – Upgrade LS2
Construction well advanced
Will collect 50 fb-1 at instantaneous lumi of 2x10³³cm-2s-1
Full software trigger
New tracking detectors
New RICH photon detectors
New electronics read out at 40 MHz
Prototypes of DAQ board (PCIe40)
VELO RF-foil (250 um thick machined aluminum foil)
Machining and light scan of the scintillating fiber mats for the fibre tracker
Cherenkov ring from a full RICH MaPMT module
ream Tracker silicon or module under test
First scintillating fibre modules arriving at CERN
Calorimeter front-end board
Muon system readout ASIC
High-Luminosity LHC: 300/fb (by 2023) → 3000/fb (by 2037)
HiLumi HL-LHC PROJECT
CIVIL ENGINEERING
"CRAB" CAVITIES
LHC TUNNEL
CMS
ALICE
ATLAS
FOCUSING MAGNETS
LHCb
SUPERCONDUCTING LINKS
COLLIMATORS
BENDING MAGNETS
New IR-quads Nb3Sn (inner triplets)
New 11 T Nb3Sn (short) dipoles
Collimation upgrade
Cryogenics upgrade
Crab Cavities
Cold powering
Machine protection
Civil engineering
Formal approval by CERN Council (June 2016)
Cost to Completion : 950 MCHF (material)
Detector
plann
ATLAS – Upgrade Phase II (LS3)
NEW ALL-SILICON INNER TRACKER (ITK) WITH ETA COVERAGE UP TO 4
HIGH GRANULARITY TI IN FORWARD R
TDAQ OFF-DETECTOR ELECTRONICS:
• L0 HARDWARE TRIGGER:
• L0 CALORIMETER
• L0 TOPOLOGICAL
• L0 MUON
• L0 GLOBAL
• L1 HARDWARE TRIGGER (OPTION):
• L1 GLOBAL
• L1 TRACK TRIGGER
• READOUT SYSTEM
• HLT
NEW MUON CHAMBERS IN THE INNER BARREL REGION
FORWARD MUON TAGGER (OPTION)
64
CMS – Upgrade Phase II (LS3)
Trigger/HLT/DAQ (interim TDR submitted)
• Track information in trigger at 40 MHz
• 12.5 μs latency
• HLT input/output 750/7.5 kHz
Barrel EM calorimeter
• New FE/BE electronics for full granularity readout at 40 MHz - with improved time resolution
• Lower operating temperature (8°)
Muon systems
• New DT & CSC FE/BE electronics
• New station to complete CSC at 1.6 < η < 2.4
• Extended coverage to η ≃ 3
New Endcap Calorimeters
• Rad. tolerant - High granularity transverse and longitudinal
• 4D shower measurement including precise timing capability
Beam radiation and luminosity
Common systems and infrastructure
New Tracker
• Rad. tolerant - increased granularity - lighter
• 40 MHz selective readout (strips) for Trigger
• Extended coverage to η ≃ 3.8
MIP precision Timing Detector
• Barrel layer: Crystal + SiPM
• Endcap layer: Low Gain Avalanche Diodes

Beyond the potential of the LHC data (2010-2023), with the HL-LHC data (2026-2037) important progress can be expected on

Standard Model physics
Higgs physics
Beyond the Standard Model physics
Flavour physics
High-density QCD

HL-LHC and HE-LHC Physics reports (Dec 2018):
https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HLHELHCWorkshop

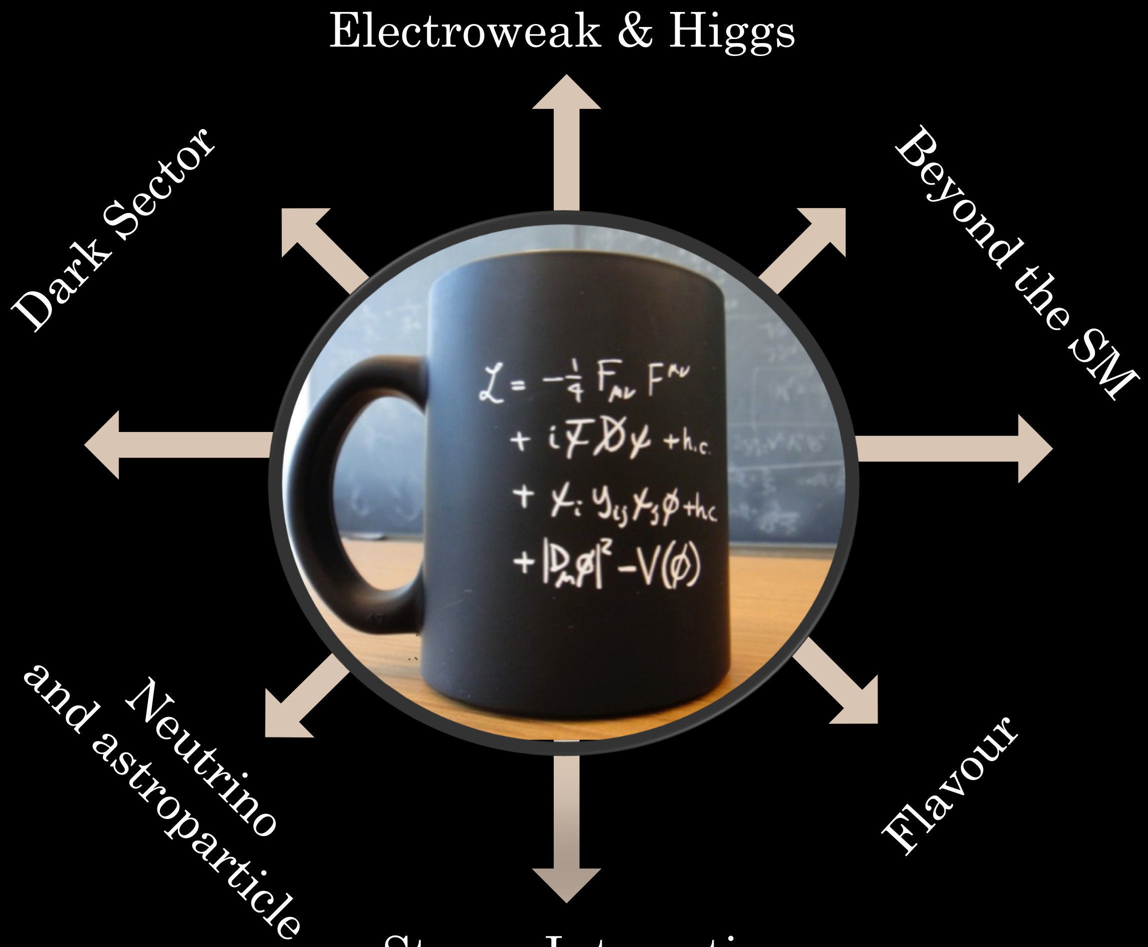
Zooming into the scalar sector *from LHC to HL-LHC*



Ample opportunities to explore nature and to pursue innovative thoughts over the next 20 years

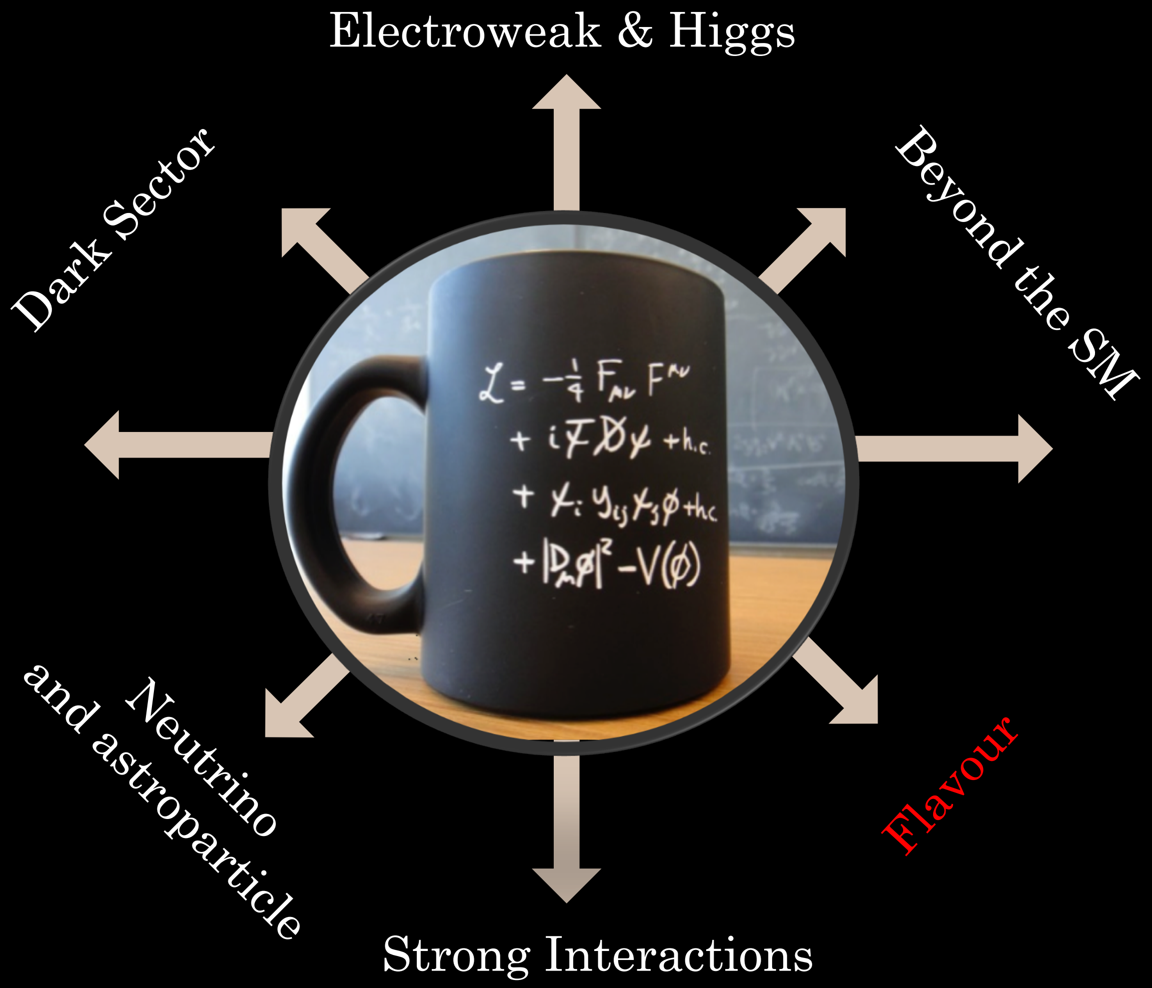
Open Symposium
Towards updating the European Strategy for Particle Physics
May 13-16, 2019, Granada, Spain
https://cafpe.ugr.es/eppsu2019/

The Granada themes



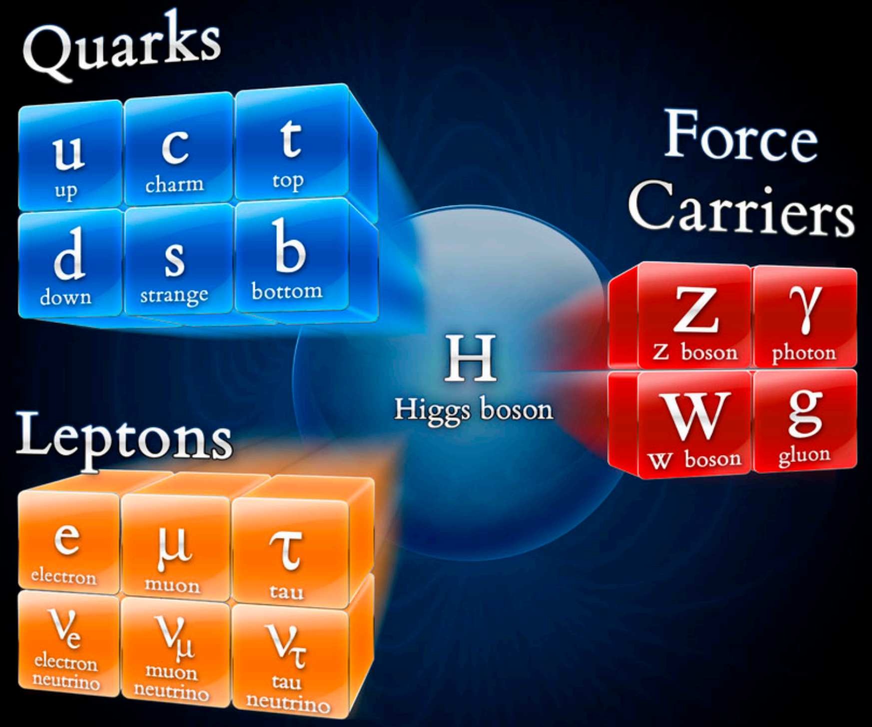
The Granada themes

Flavour & CP



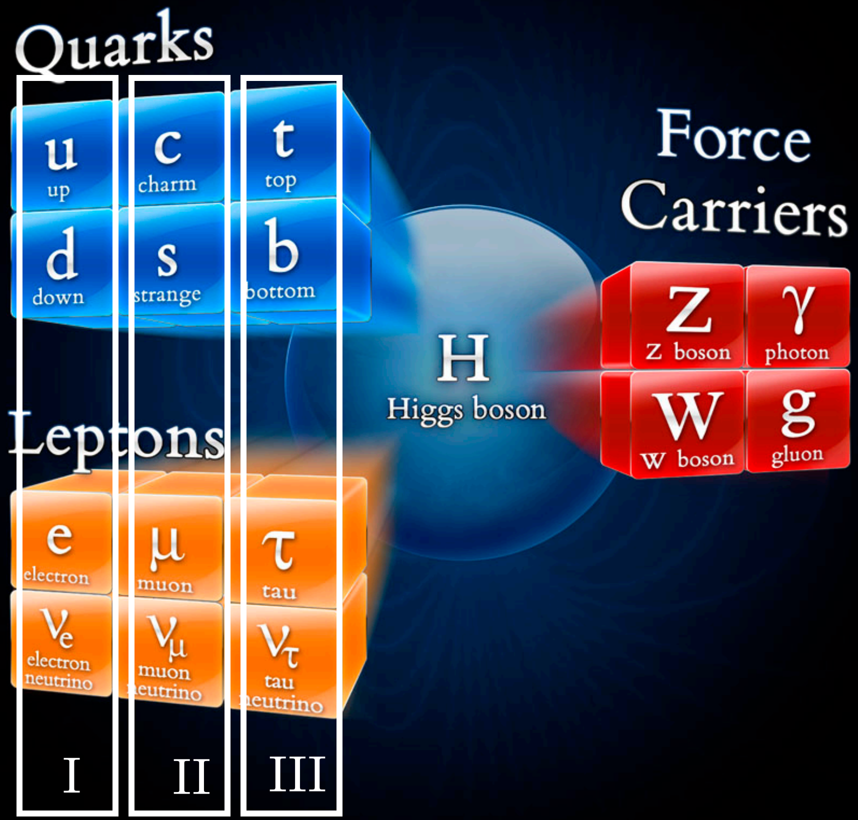
The Granada themes

Flavour & CP



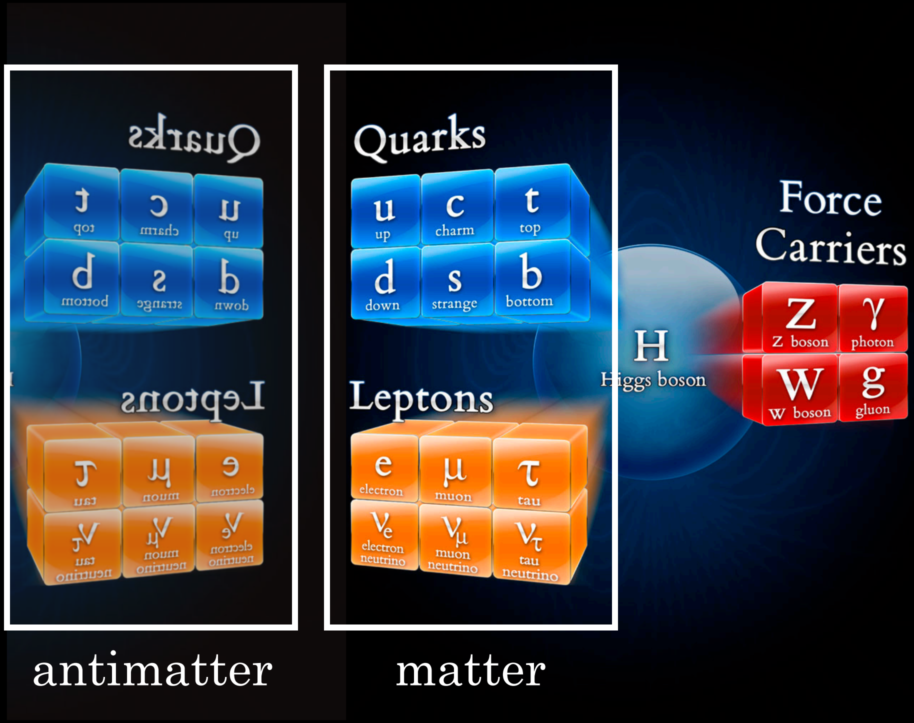
The Granada themes

Flavour & CP



The Granada themes

Flavour & CP



The light sector (u,d,s + e,μ)

Three "clear" cases calling for diversity in the short/mid-term:

1. EDMs [d_e, d_n, d_N,.]	Strong CP EW CP	new: Storage rings
2. μ→e processes	1 → 2 Gen Lep. Mix.	Intense μ beams
3. Rare K decays	1 → 2 Gen. Quark Mix.	Intense K beams

$\Lambda > 10^3$ TeV for O(1) couplings
Storage ring JEDI/CPEDM start construction in 2027

Antonio Zoccoli @ Granada

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$\Lambda > 10^4$ TeV for O(1) couplings
Mu2e@FNAL, MEG@PSI, COMET@J-PARC, …
Sensitivity improvement x10000

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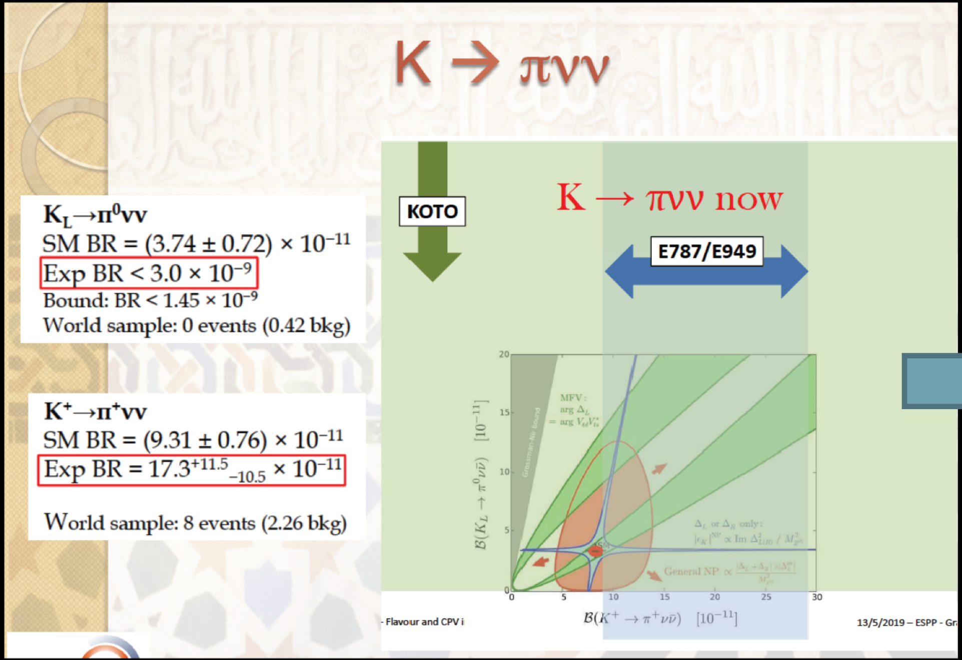
Sensitivity improvement x10000

Great potential
Difficult experiments

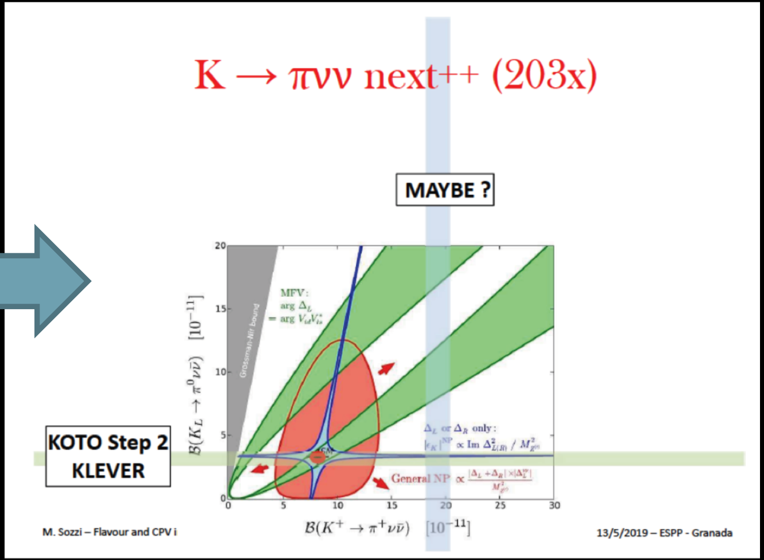
Antonio Zoccoli @ Granada

The light sector (u,d,s + e,μ): rare K decay evolution

NA62@SPS & KOTO@J-PARC

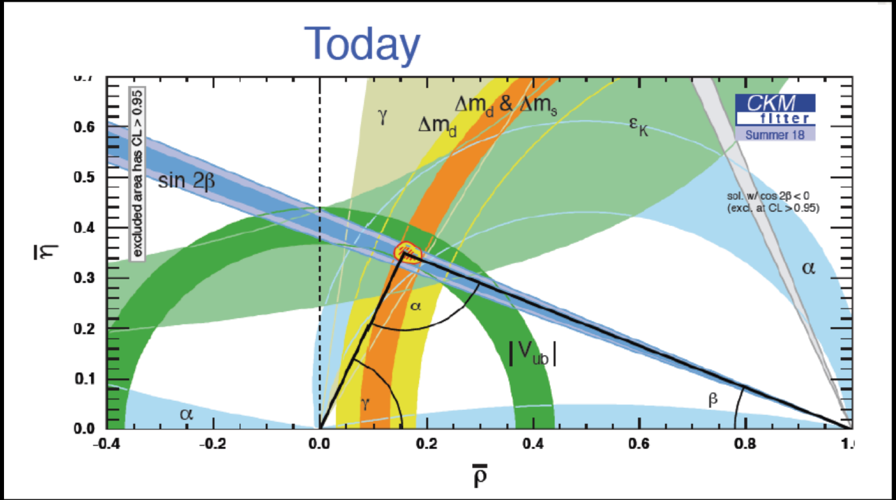


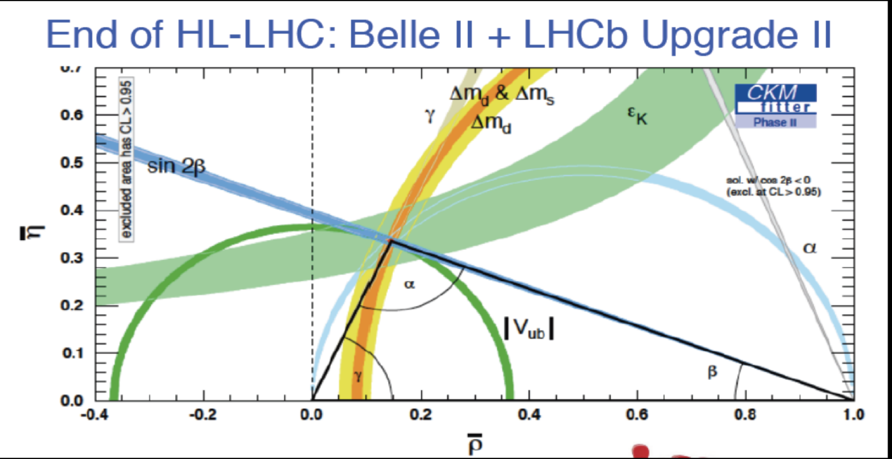
KOTO-Step2 & KLEVER@CERN



Antonio Zoccoli @ Granada

The heavy sector (b,c,t + τ + h)





Belle II+1= Belle III

Just started within Belle II

Goal: x5 increase in peak luminosity

- ❑ Doable from a machine perspective ?
- ❑ Detectors issues running at 4 10^{36} cm^{-2} s^{-1}
- ❑ Physics case

Under study, more before the end of 2019

Z^0 factories

Goal: 10^{11} – 10^{12} Z^0 (CEPC)
5. 10^{12} Z^0 (FCCee)
$BR(Z^0 \rightarrow b\bar{b}) = 15\%$

ILD-like detector + charged hadron PID.

FCC-pp a dedicated experiment (à la LHCb)

e^+e^- Super Charm-Tau Factories:
SCT (BINP, Novosibirsk) and STCF/HIEPA (China)
E: 2 to 6 GeV
Peak Luminosity (> 4 GeV) 10^{35} cm^{-2} s^{-1}

“Flavour is the usual graveyard for BSM electroweak theories”

Antonio Zoccoli

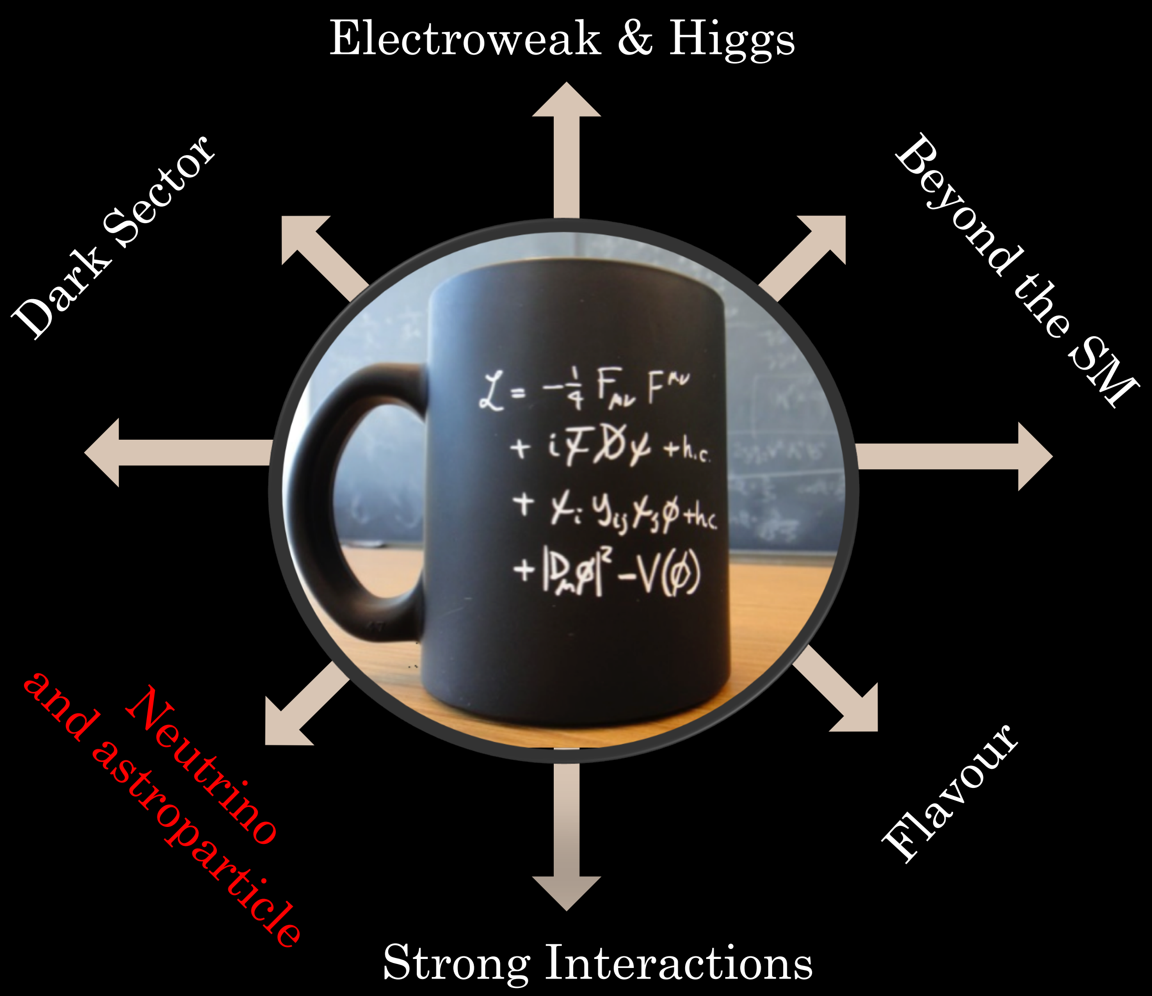
The Granada themes

Flavour & CP

- Challenging experiments, but a must-have in our experimental portfolio
- Outstanding BSM scale reach: $\Lambda > 10^2$-10^5 TeV
- Particle-ID should be part of any future collider program at high energies
- Different environments (ee and pp) are complementary
- A Z^0-factory is a fantastic tool for flavour physics

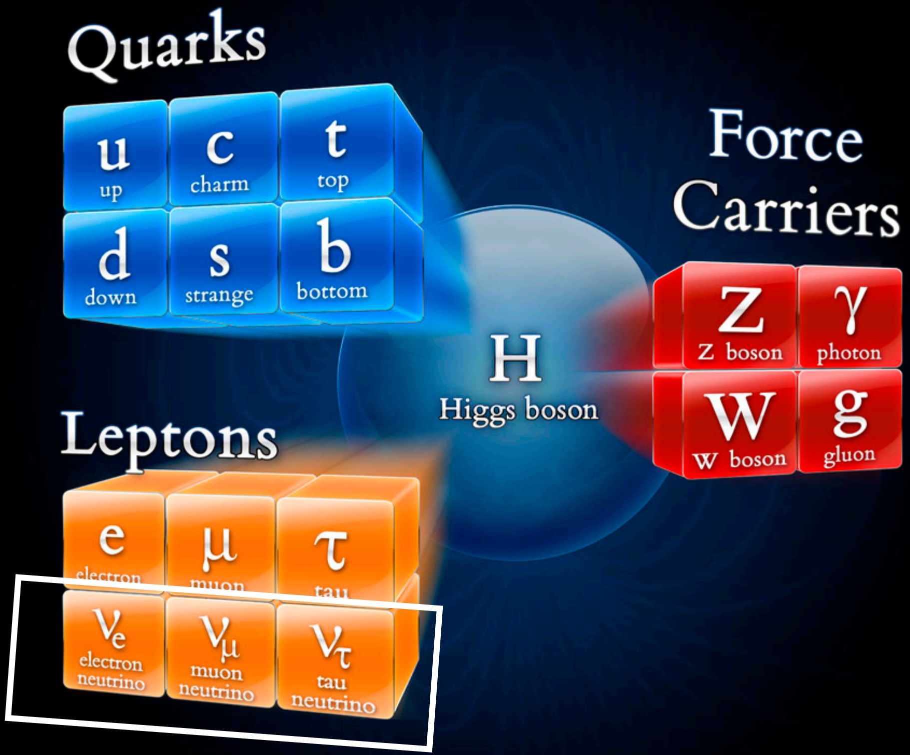
The Granada themes

Neutrino and astroparticle



The Granada themes

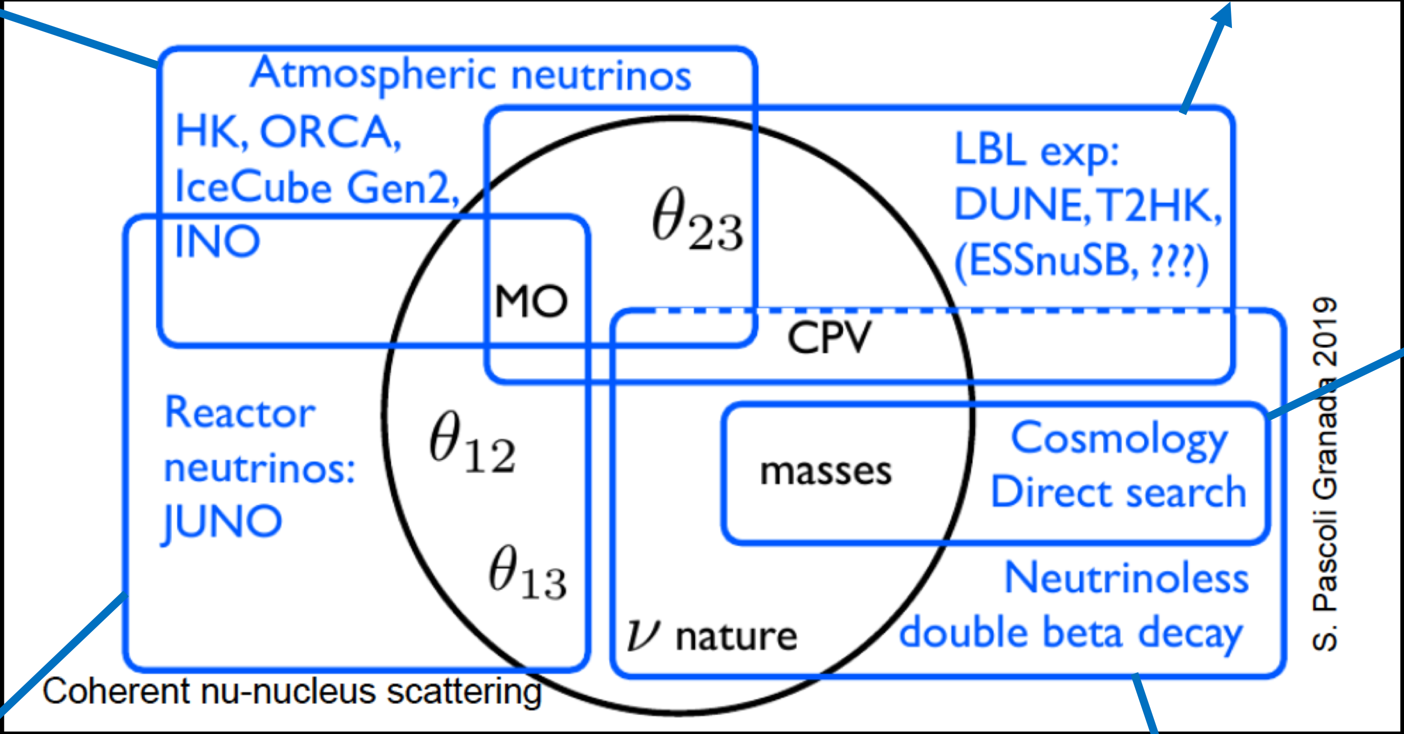
Neutrino and astroparticle



Need for a diverse approach – *every neutrino source counts*

Complementary for mass ordering and sterile neutrinos

Collaboration with QCD/nuclear models (NA61) CERN Neutrino Platform essential



Euclid, DESI, …

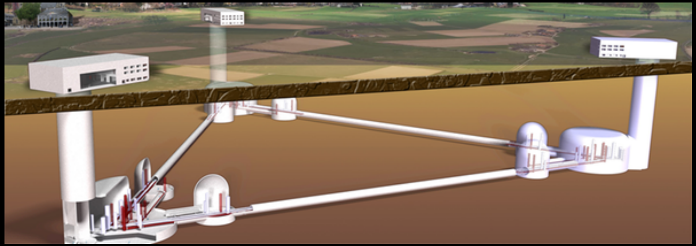
Sterile neutrinos

Upcoming experiments: LEGEND, CUPID, NEXT, …

The Granada themes

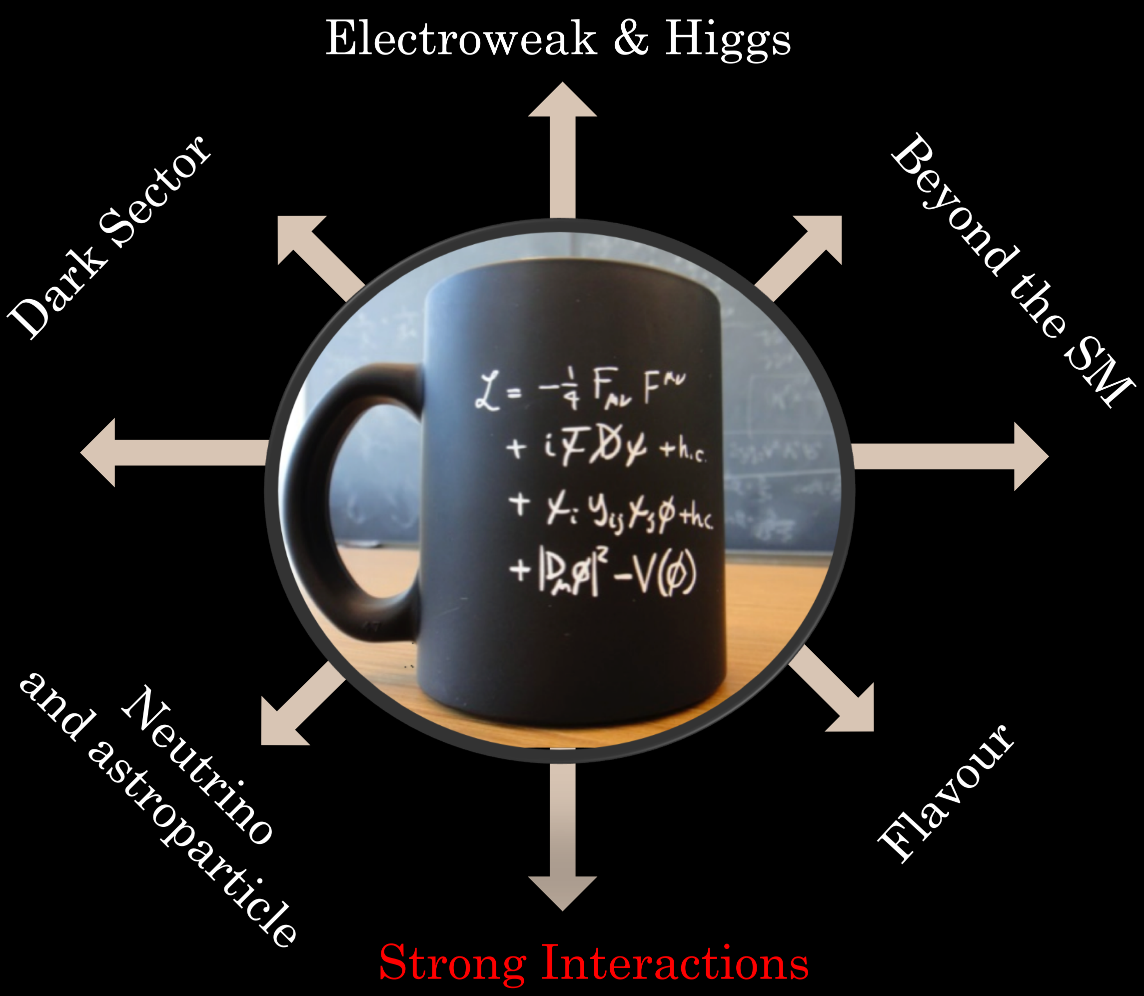
Neutrino and astroparticle

- A challenging experimental program is being prepared to measure masses, mixing and nature
- Neutrino physics might be an essential portal to new physics
- Important information will emerge in the coming years on our search for sterile neutrinos
- While we have little guidance for our search for new physics, an opportunity emerge to explore the synergies with astroparticle physics and gravitational waves physics



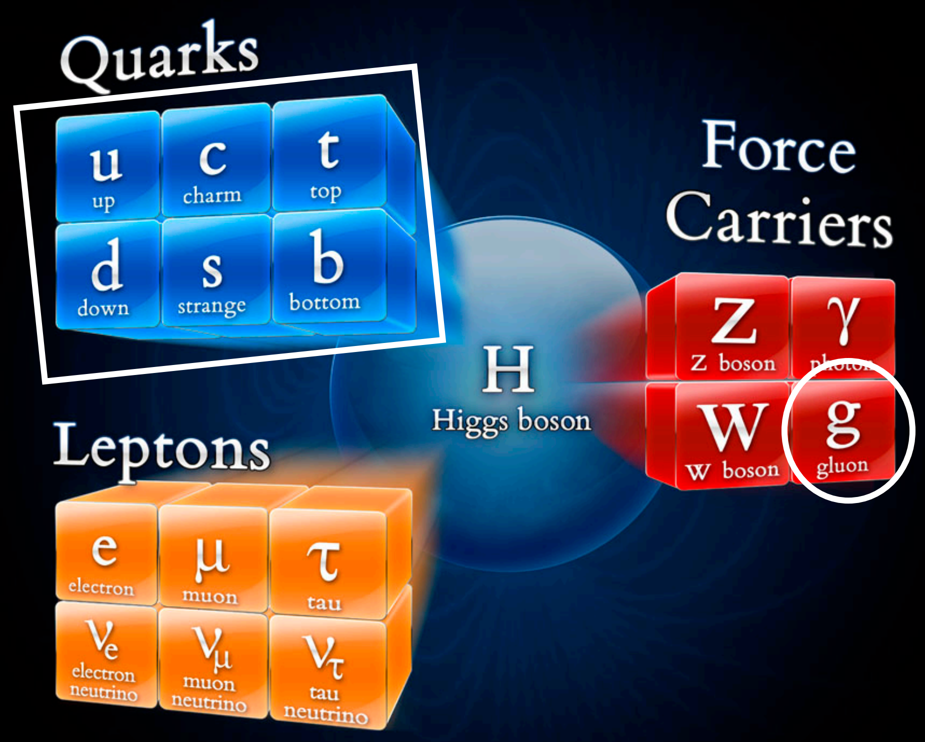
The Granada themes

Strong Interactions



The Granada themes

Strong Interactions



Strong interactions

QCD theory: $\mathcal{L}_{\text{QCD}} = -\frac{1}{4} F^a_{\mu\nu} F^{\mu\nu}_a + \bar{\psi}(i\not{D} - m)\psi$

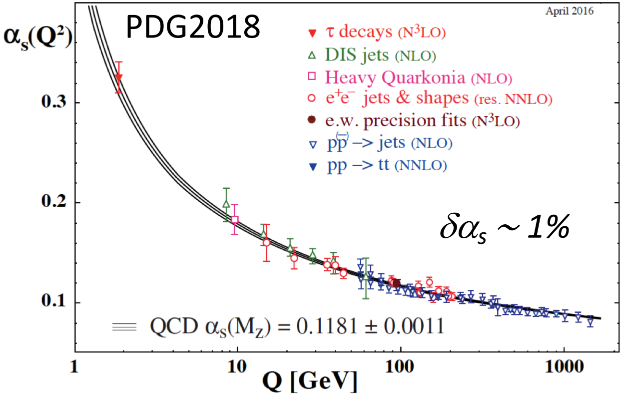
key phenomena
(non-Abelian gauge group)

colour confinement
α_s (Q^2 low) ~ 1

"hot and dense QCD"
(low energy domain)
(lattice calculations)

asymptotic freedom
α_s (Q^2 high) << 1

"vacuum QCD"
(high energy domain)
(perturbative calculations)



$\alpha_{EW} << \alpha_s$

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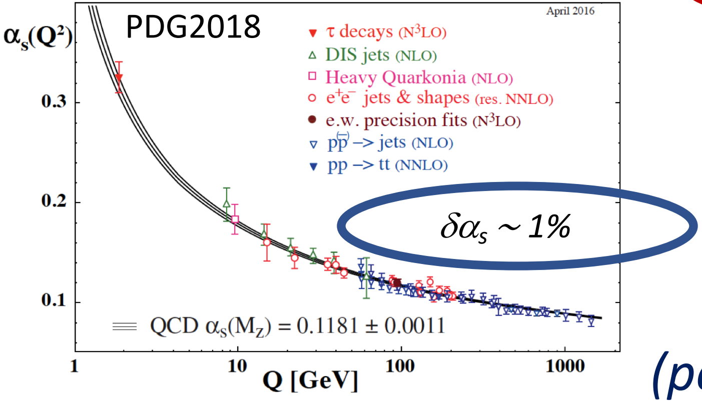

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European Strategy Update

Strong interactions

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(low energy doma
(lattice calculatio

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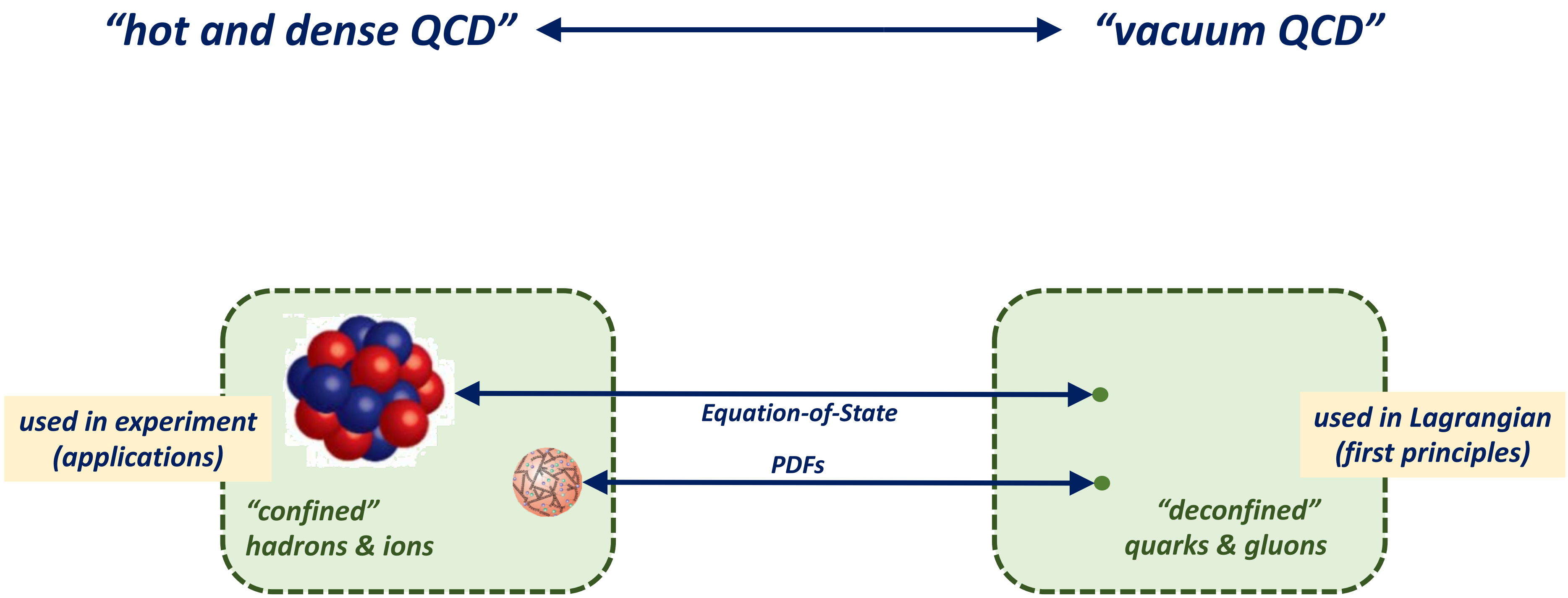
turbative calculations)

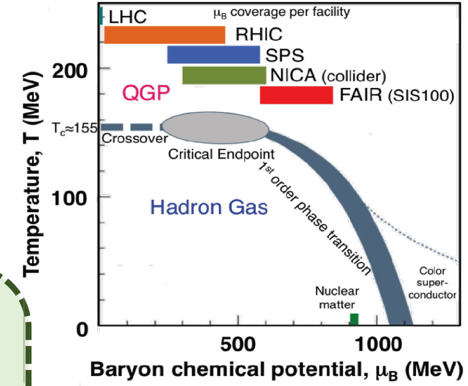
Today	$\delta\alpha_s$~1%
FCC-ee	$\delta\alpha_s$~0.1%
LHeC/FCC-eh	$\delta\alpha_s$~0.1%
FCC-hh	*up to 25 TeV*
Lattice-QCD	$\delta\alpha_s$~0.3%

for EW&H physics need $\delta\alpha_s$~0.1%


“hot and dense QCD”
“vacuum QCD”
used in experiment
(applications)
“confined”
hadrons & ions
Equation-of-State
PDFs
used in Lagrangian
(first principles)
“deconfined”
quarks & gluons

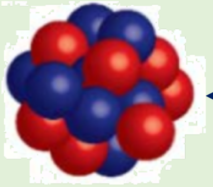
“hot and dense QCD” ⟷ “vacuum QCD”

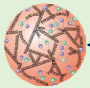
How do properties of the QGP emerge from the fundamental QCD interactions as a function of system size and under varying conditions of initial energy density and baryon chemical potential?



From LQCD: T_c (μ_B=0) = 156.5 ± 1.5 MeV

From experiment: determination of chemical freeze-out temperature





used in experiment (applications)

“confined” hadrons & ions

Equation-of-State

PDFs

used in Lagrangian (first principles)

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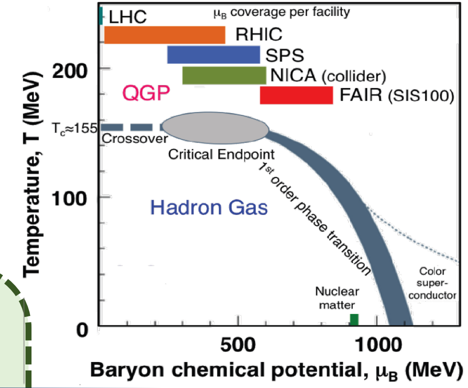

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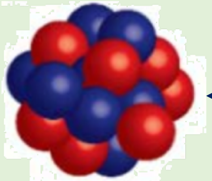

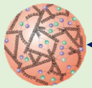

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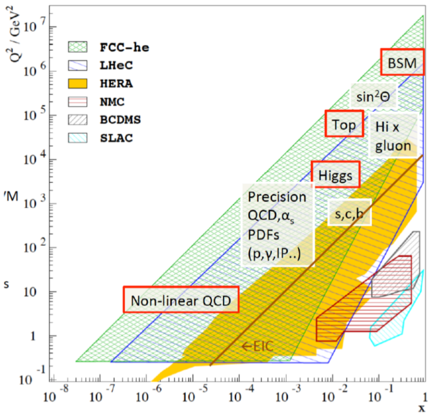
What are the experimental and theoretical pre-requisites to reach an adequate precision of perturbative and non-perturbative QCD predictions at the highest energies?



From QCD: evolution equations of PDFs

From experiment: PDF parameters values themselves

"hot and dense QCD" ⟷ *"vacuum QCD"*

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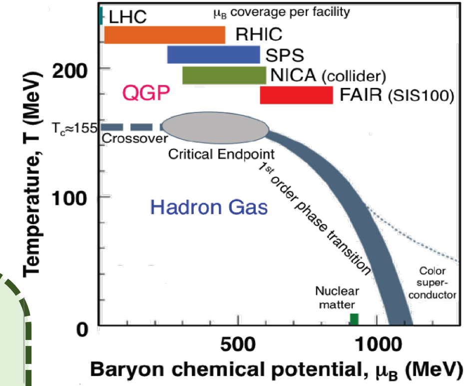
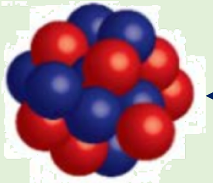
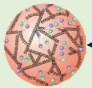


Key facilities involve collisions with heavy ions





used in experiment (applications)

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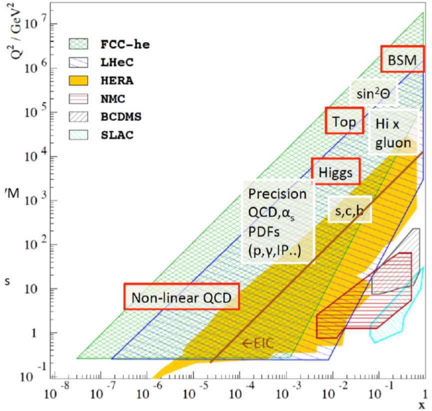

What are the experimental and theoretical pre-requisites to reach an adequate precision of perturbative and non-perturbative QCD predictions at the highest energies?

Key facilities involve collisions with protons

"hot and dense QCD" ⟷ *"vacuum QCD"*

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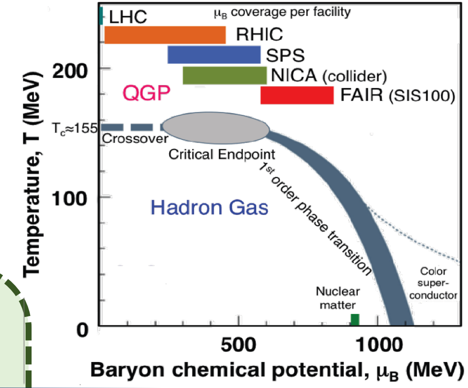
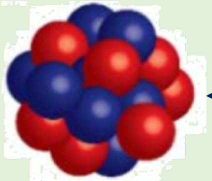


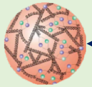
HL-LHC: increased luminosity, low-μ_B

HE-LHC/FCC: new probes

Fixed-target@SPS: high-μ_B

Fixed-target@(HL-)LHC: medium-μ_B





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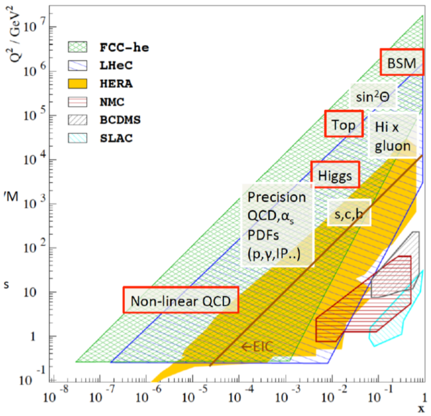


HL-LHC: mid-x (up to x2 improvement)

Fixed-target@(HL-)LHC: high-x

ep:
- EIC: first steps beyond collinear model
- LHeC: high-x & highest-Q^2 coverage
- FCC-ep: O(1%) on σ(W,Z,H) at FCC-pp

ERL system for electron beam at 60 GeV

The Granada themes

Strong Interactions

- A hadronic structure program with ep/pp/eA colliders provides vital ingredients for the high precision exploration

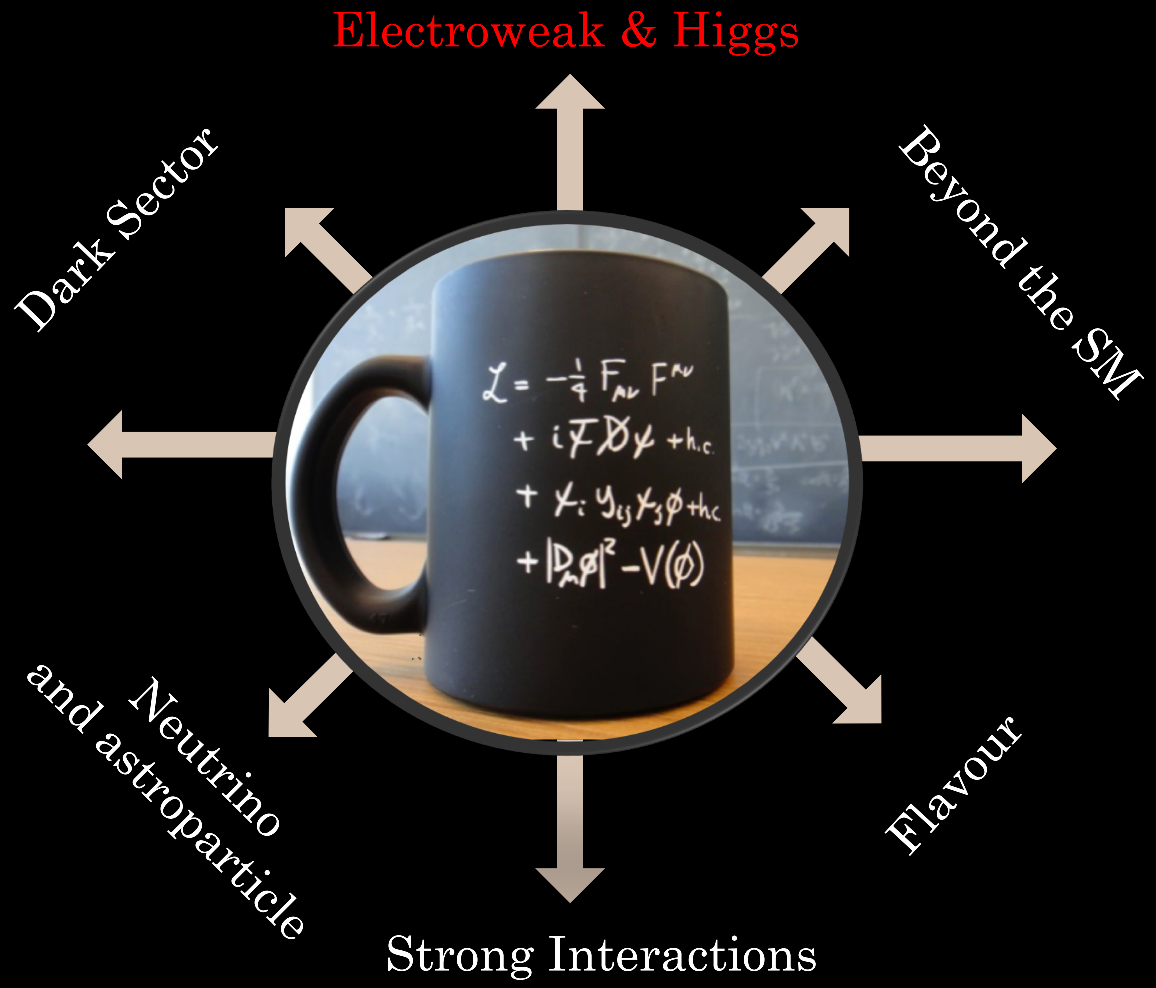
- A hot & dense QCD program at the SPS, is complementary to other emerging facilities worldwide, and brings unique contributions in the exploration of the QCD phase diagram

- A high-energy AA/pA/fixed-target program at the LHC, HL-LHC, HE-LHC and FCC is unique and provides essential science towards a profound understanding of nuclear and particle physics

- A high-luminosity e^+e^- collider at the EW scale provides a unique environment for high-precision QCD

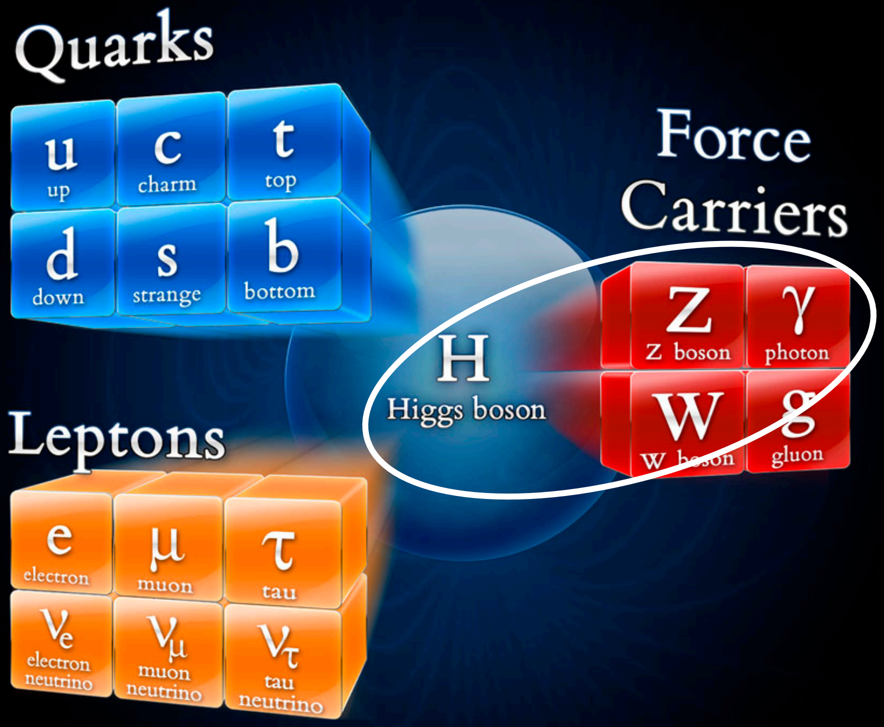
The Granada themes

EW & Higgs



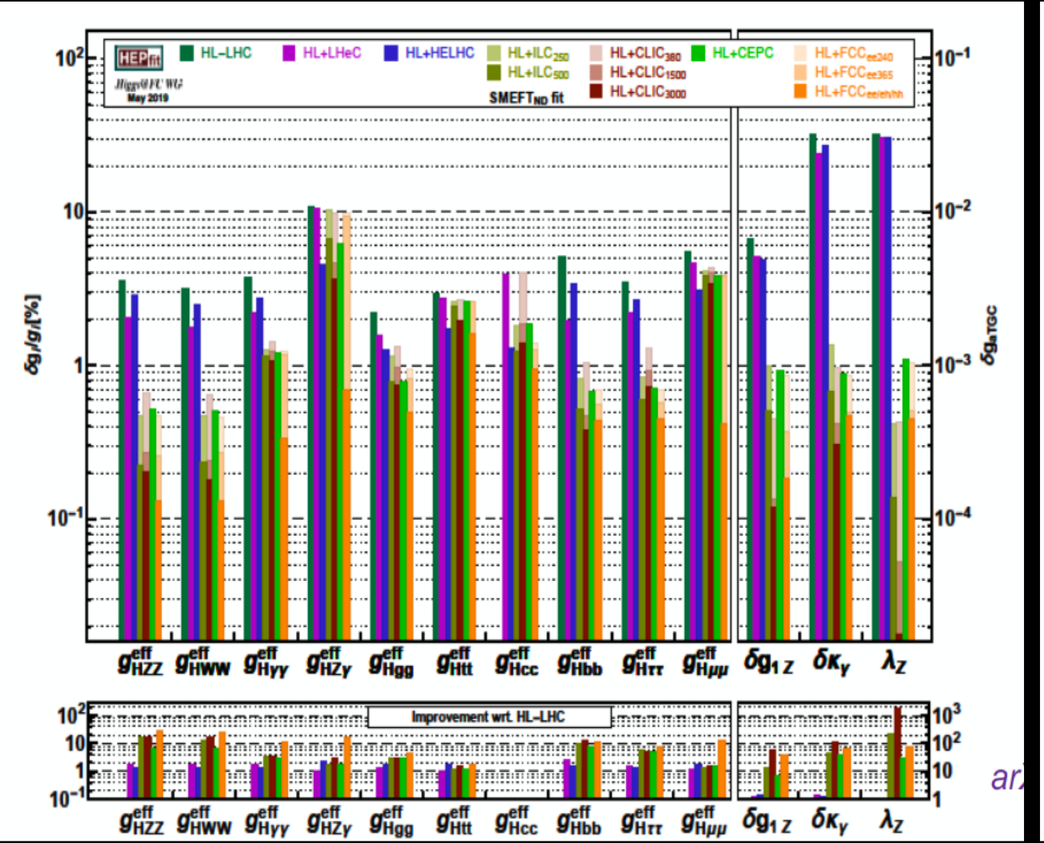
The Granada themes

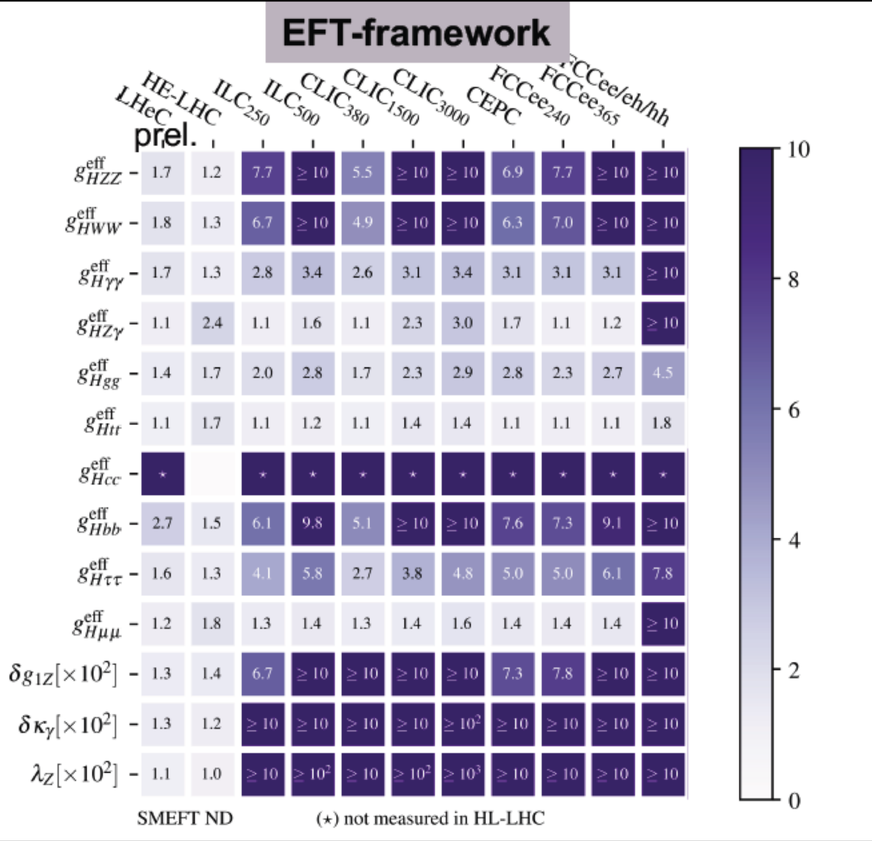
EW & Higgs



Potential to measure Higgs couplings

improvements wrt HL-LHC





arXiv:1905.03764

Beate Heinemann @ Granada

of "largely" improved H couplings (EFT)

		Factor ≥2	Factor ≥5	Factor ≥10	Years from T_0
Initial run	CLIC380	9	6	4	7
	FCC-ee240	10	8	3	9
	CEPC	10	8	3	10
	ILC250	10	7	3	11
2nd/3rd Run ee	FCC-ee365	10	8	6	15
	CLIC1500	10	7	7	17
hh	HE-LHC	1	0	0	20
2nd/3rd Run ee	ILC500	10	8	6	22
	CLIC3000	11	7	7	28
ee,eh & hh	FCC-ee/eh/hh	12	11	10	>50

13 quantities in total

NB: number of seconds/year differs: ILC 1.6×10^7, FCC-ee & CLIC: 1.2×10^7, CEPC: 1.3×10^7

The Granada themes

EW & Higgs

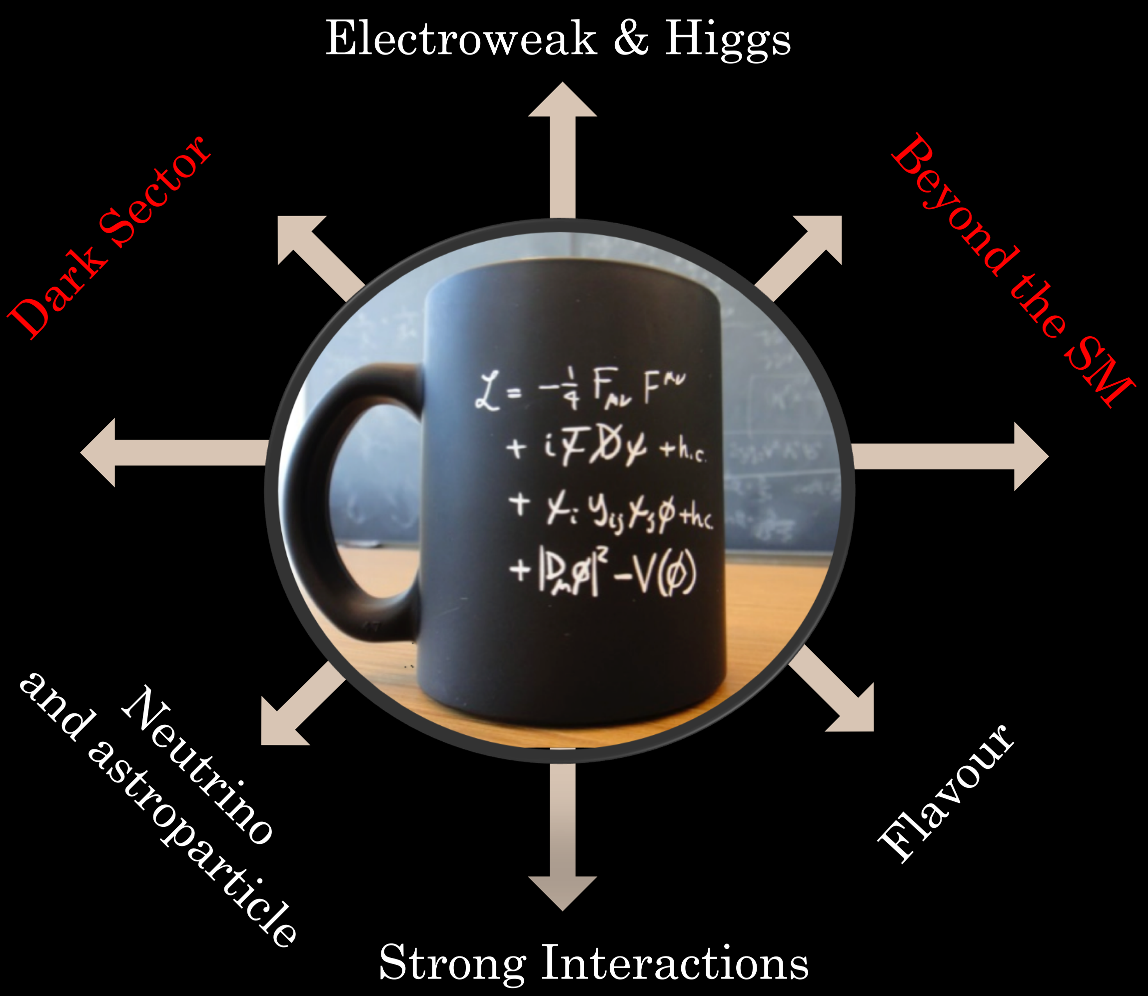
- Measuring Higgs couplings is perceived as one of the prime avenues in our search for new physics
- With the HL-LHC one can probe many Higgs couplings to the few percent level
- Additional to the HL-LHC sensitivity, all proposed e^+e^- colliders can achieve major and comparable improvements in their first stages
- In a second stage, a higher energy e^+e^- collider or hadron collider are important to reach the ultimate sensitivity

The Granada themes

Beyond the SM

&

Dark Sector



The Granada themes

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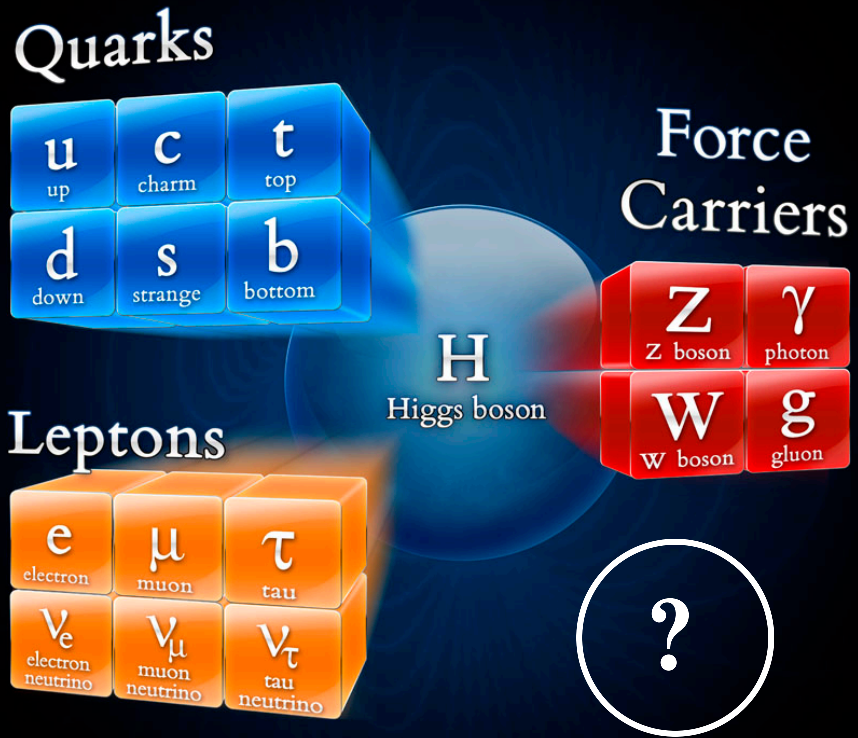
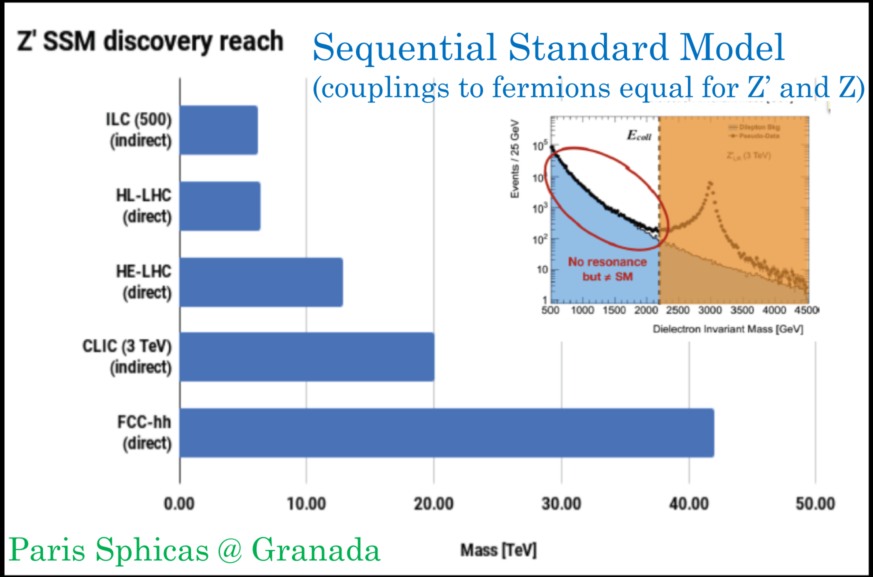
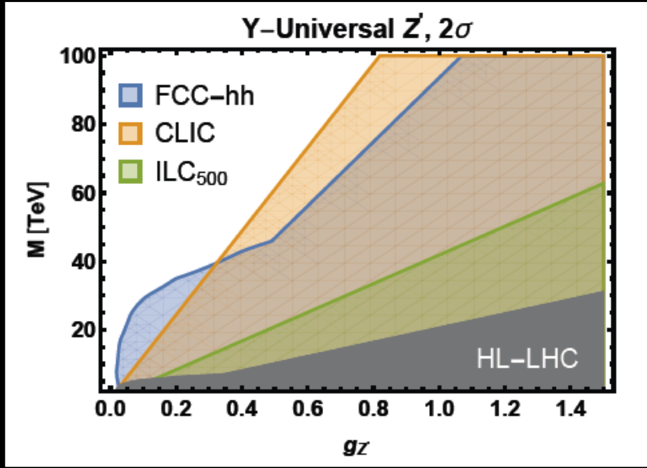


Are there new interactions or new particles around or above the electroweak scale?



- In general, if the couplings become large the sensitivity at lepton colliders is enhanced
- For weak couplings the direct search at hadron colliders dominates the picture

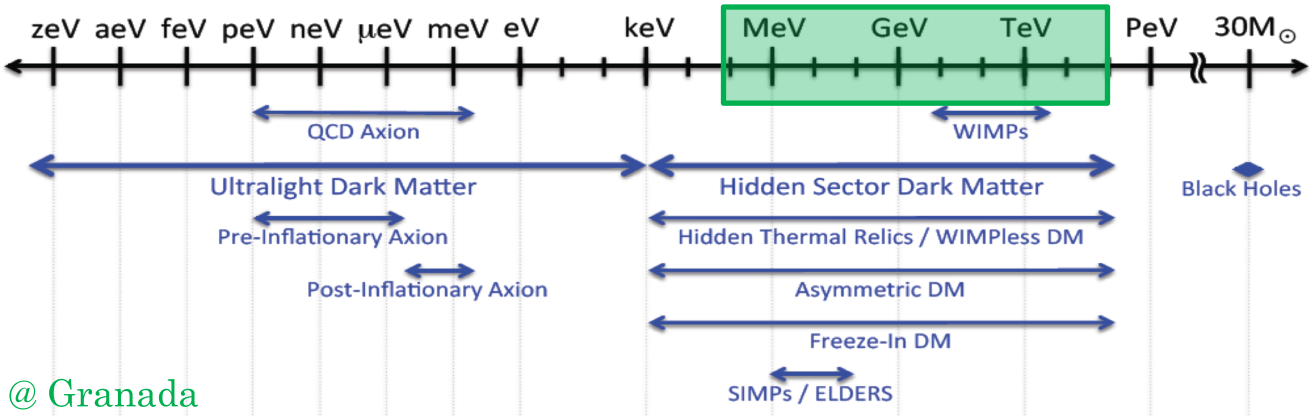


Paris Sphicas @ Granada

Many more models are compared…

Dark Matter: Where to start looking? Very little clue on mass scale…

Too small mass
⇒ won't "fit"
in a galaxy!

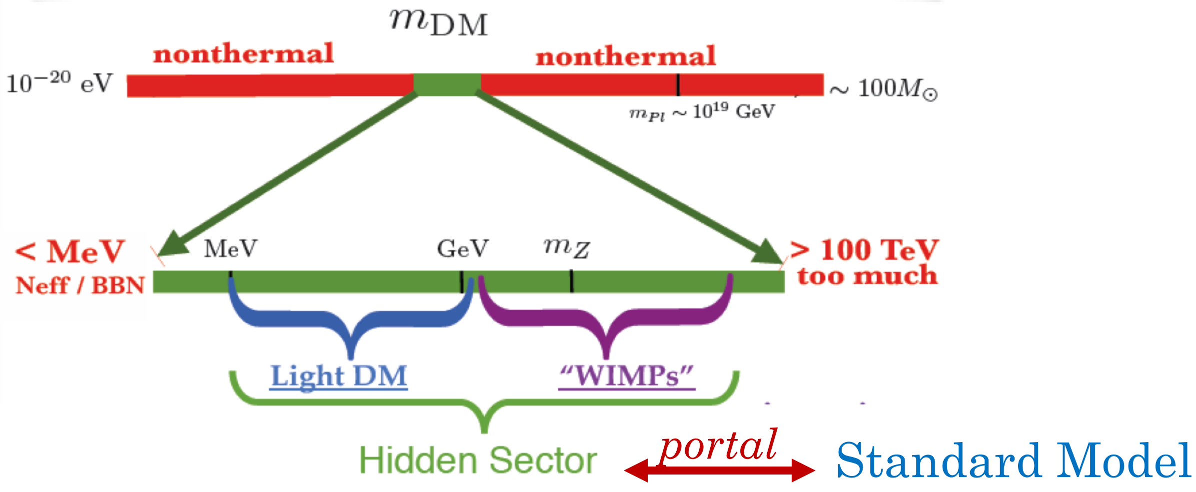


From MACHOs
searches

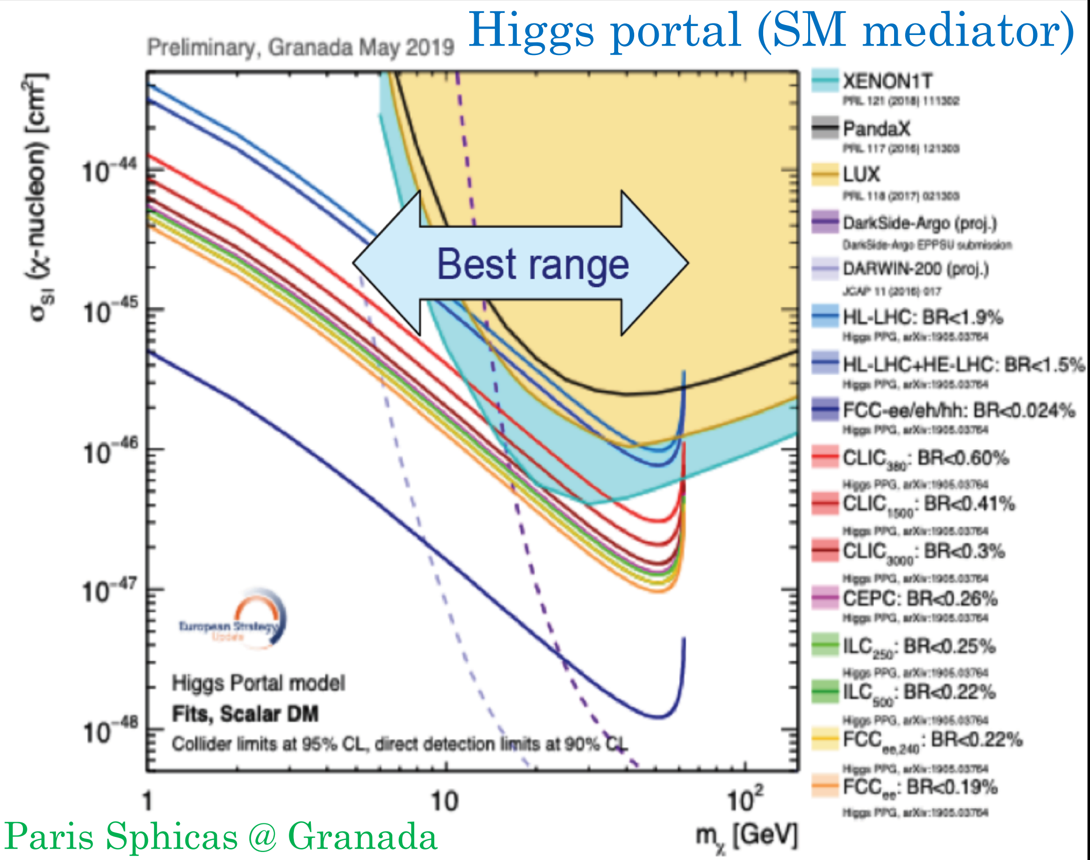
Marcela Carena @ Granada

The assumption of Thermal Equilibrium in the early Universe narrows the viable mass range.

Interesting phenomena like long-lived particles and feebly interacting particles.



What cases of thermal relic WIMPs are still unprobed and can be fully covered by future collider searches?



A collider discovery will need confirmation from DD/ID for cosmological origin

A DD/ID discovery will need confirmation from colliders to understand the nature of the interaction

A future collider program that optimizes sensitivity to invisible particles coherently with DD/ID serves us well. Need maximum overlap with DD/ID.

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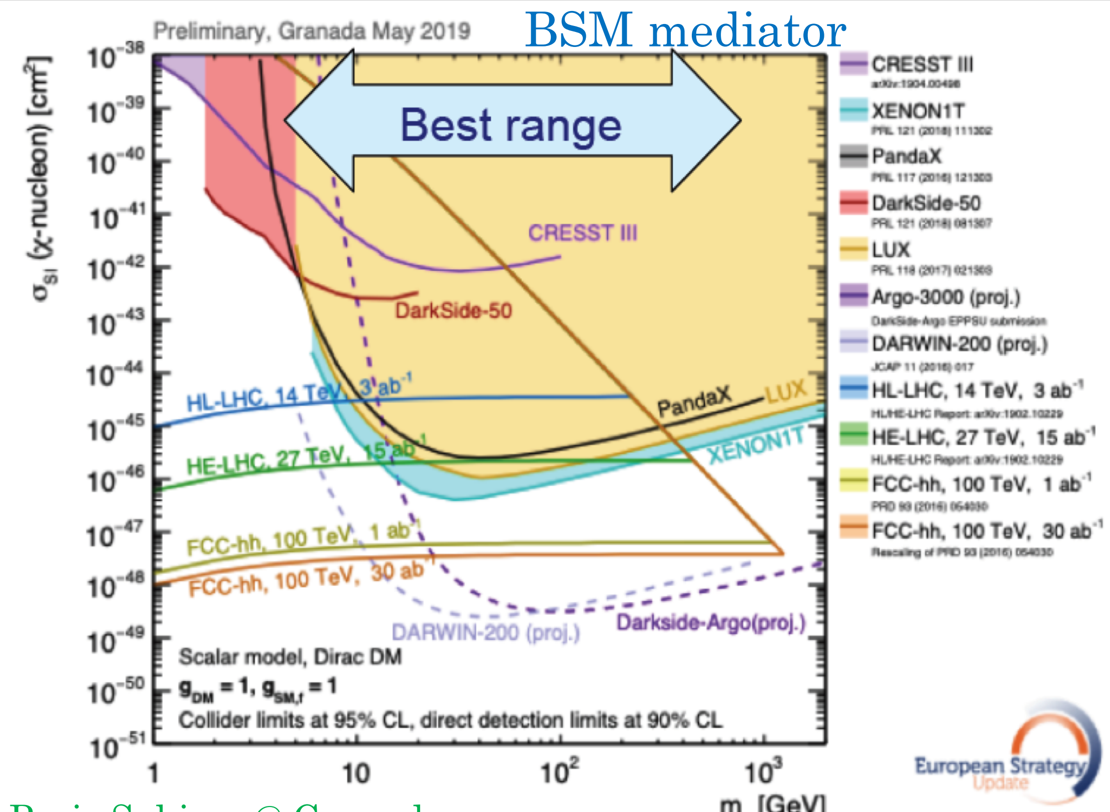

Paris Sphicas @ Granada

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A DD/ID discovery will need confirmation from colliders to understand the nature of the interaction

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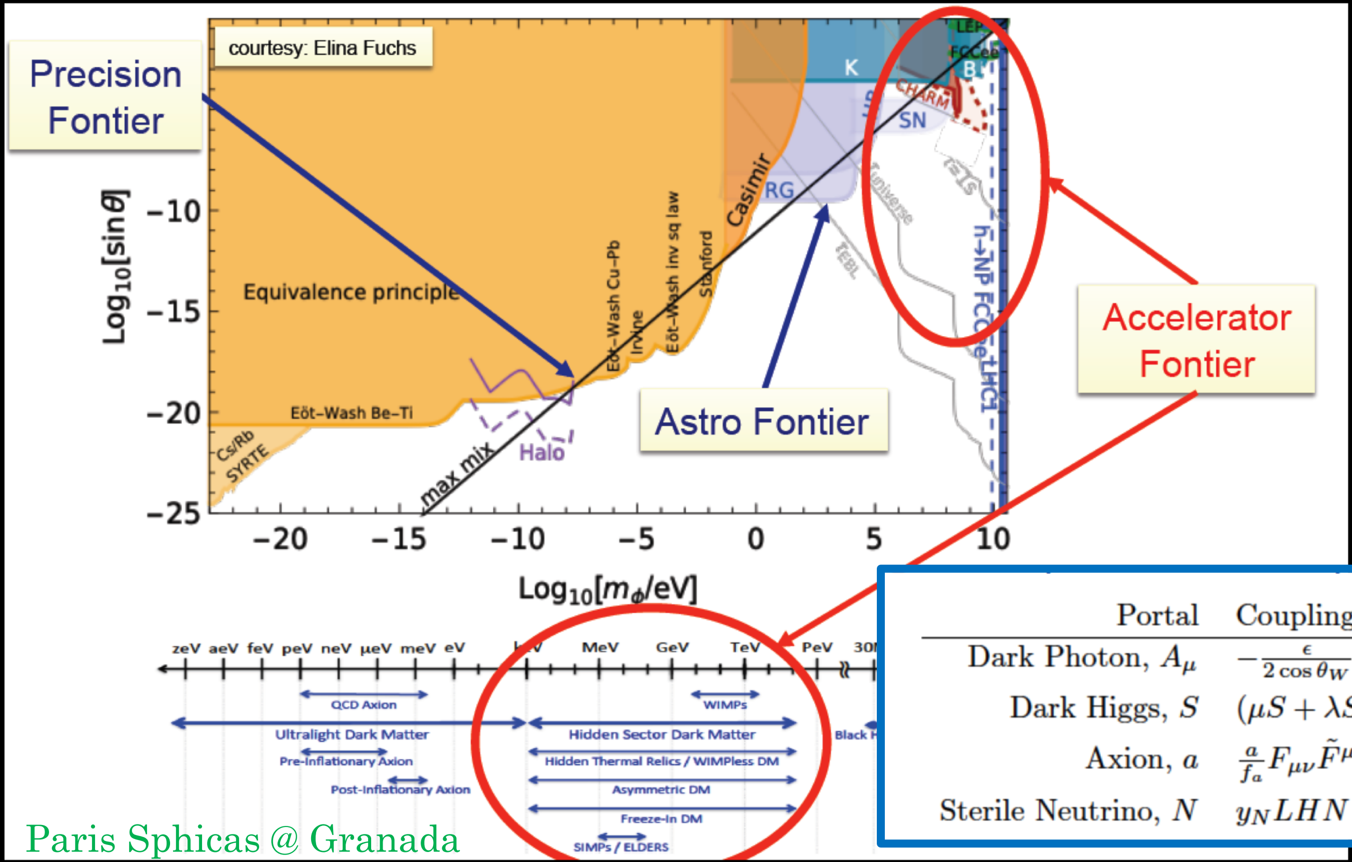
To what extent can current or future accelerators probe feebly interacting sectors?



PBC report, arXiv:1901.09966

Portal	Coupling
Dark Photon, A_μ	$-\frac{\epsilon}{2\cos\theta_W} F'_{\mu\nu} B^{\mu\nu}$
Dark Higgs, S	$(\mu S + \lambda S^2) H^\dagger H$ (Relaxion toy model, mixes \w Higgs)
Axion, a	$\frac{a}{f_a} F_{\mu\nu}\tilde{F}^{\mu\nu}$, $\frac{a}{f_a} G_{i,\mu\nu}\tilde{G}_i^{\mu\nu}$, $\frac{\delta_\mu a}{f_a}\overline{\psi}\gamma^\mu\gamma^5\psi$
Sterile Neutrino, N	$y_N L H N$

Use four simplified models ("portals") from which benchmarks are identified to evaluate experimental sensitivity

The Granada themes

Beyond the SM
&
Dark Sector

- In the absence of concrete guidance, the parameter space for new physics is vast…
- Exploring synergies and coordination with adjacent fields is necessary, e.g. with the direct and indirect dark matter detection communities for common interpretation of results
- Complementarity between lepton and hadron colliders for dark matter searches with the combined FCC program providing the best sensitivity for the benchmarks
- Complementarity between beam dump and collider experiments for feebly interacting particles

Synergies

Coordination

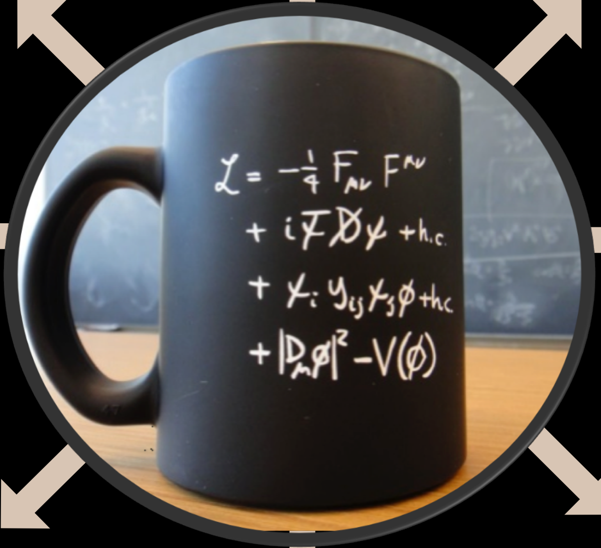
Collaboration

Signals for new (particle) physics can appear anywhere, also in adjacent fields.

Electroweak & Higgs

Dark Sector

Beyond the SM

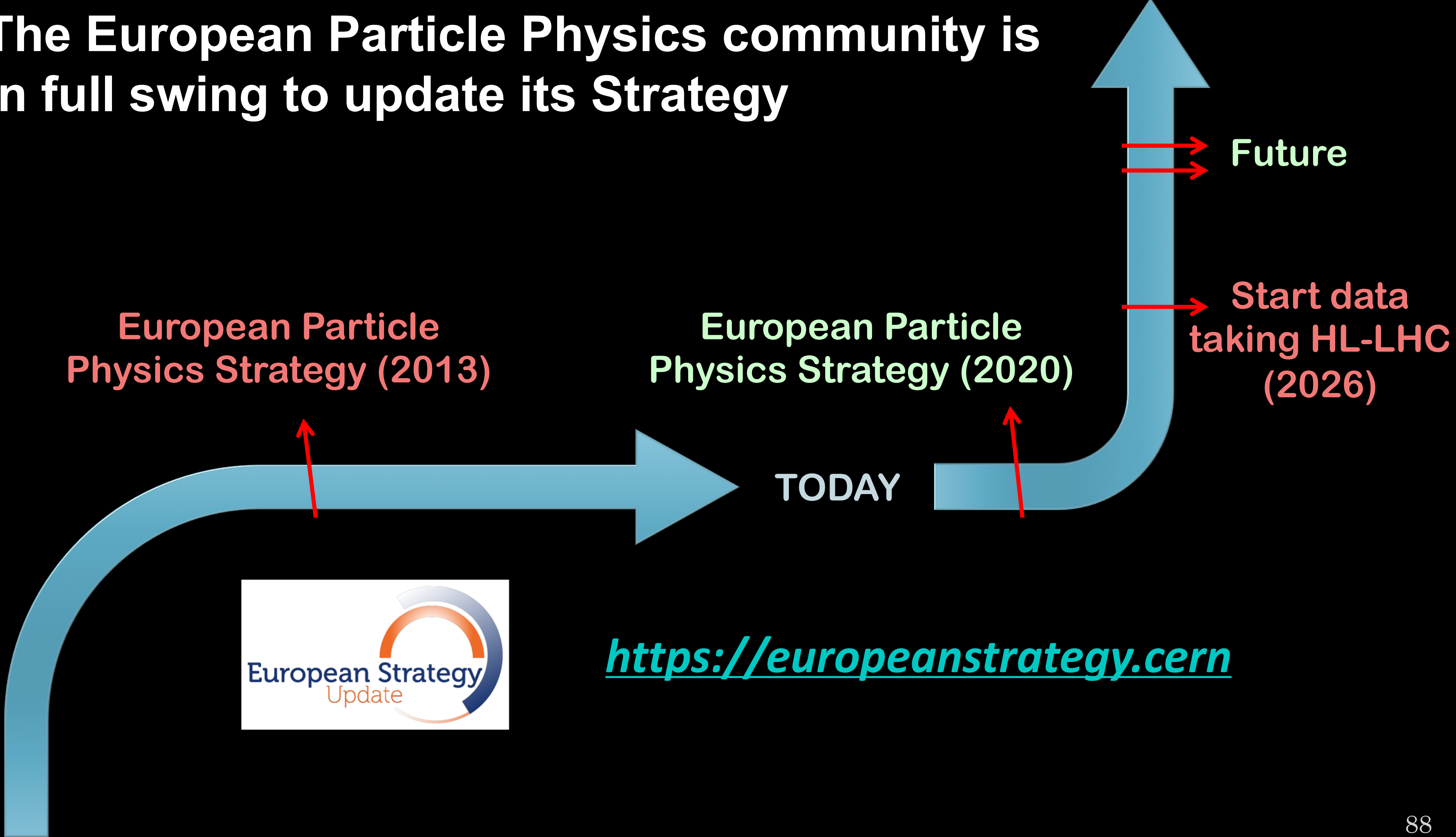


Neutrino and astroparticle

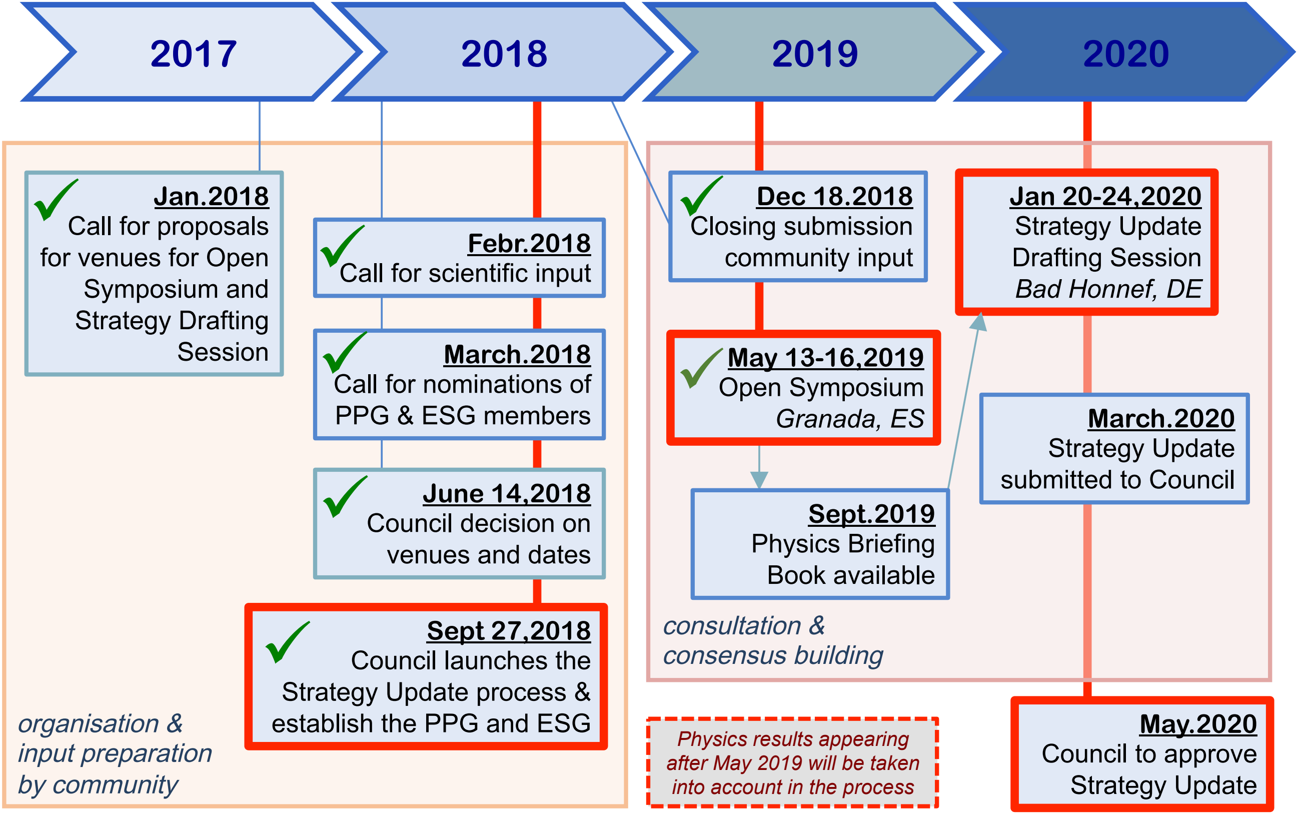
Flavour

Strong Interactions

The European Particle Physics community is in full swing to update its Strategy



https://europeanstrategy.cern


2017
2018
2019
2020
Jan.2018
Call for proposals for venues for Open Symposium and Strategy Drafting Session
Febr.2018
Call for scientific input
March.2018
Call for nominations of PPG & ESG members
June 14,2018
Council decision on venues and dates
Sept 27,2018
Council launches the Strategy Update process & establish the PPG and ESG
organisation & input preparation by community
Dec 18.2018
Closing submission community input
May 13-16,2019
Open Symposium
Granada, ES
Sept.2019
Physics Briefing Book available
Jan 20-24,2020
Strategy Update Drafting Session
Bad Honnef, DE
March.2020
Strategy Update submitted to Council
consultation & consensus building
Physics results appearing after May 2019 will be taken into account in the process
May.2020
Council to approve Strategy Update

A personal thought

- There is new physics to be discovered, but no guaranteed discovery path

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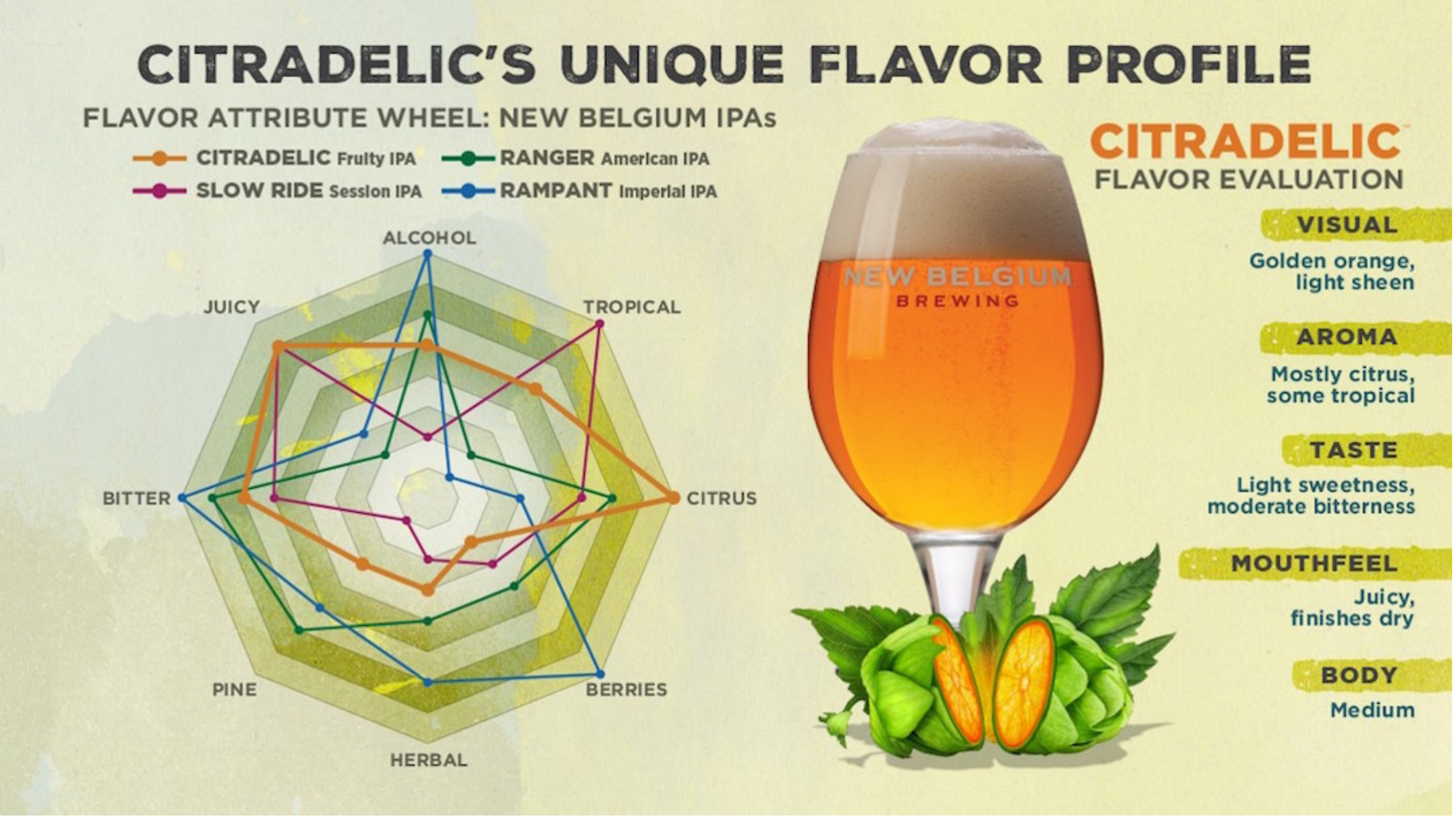
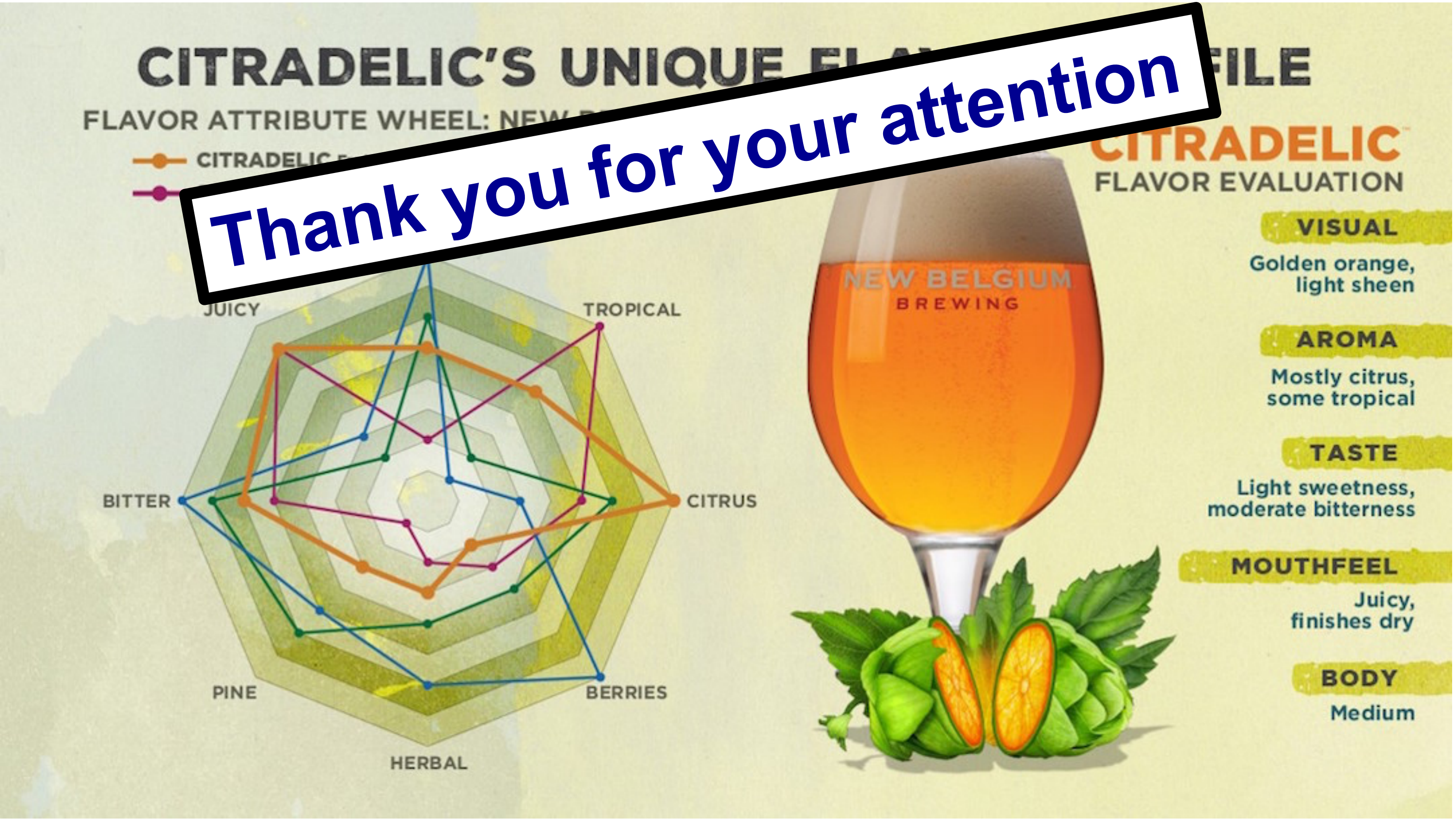


If you want to discover a great taste, you will have to sample several

- There is new physics to be discovered, but no guaranteed discovery path



Thank you for your attention

If you want to discover a great taste, you will have to sample several