EuroCirCol
A key to New Physics

FCC hh ee he

Co-funded by the European Commission

# INFRADEV: EuroCirCol

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INFN

Giornata Informativa Bandi H2020
Frascati, 25 Maggio 2016

CERN

# Outline

**EuroCirCol**: **Euro**pean **Cir**cular Energy-Frontier **Col**lider Study

**INFRADEV: DESIGN STUDY H2020**

- EuroCirCol & The Future Circular Collider Study
- Work Packages & INFN involvement
- Partners
- Project Budget
- Final remarks on the organization

# EC Evaluation Results


15/15

Quotes

- Science is excellent
- Project is ambitious and shows innovation potential
- Objectives are clear and approach is credible
- Will have impact on other disciplines and industry
- Key element of European Strategy on Particle Physics

**Recognition of FCC Study by European Commission**

# Future Circular Collider Study
# GOAL: CDR and cost review for the next ESU (2018)

**LHC evolution**

**1983** first LHC proposal, launch of design study

**1994** CERN Council: LHC approval

**2010** first collisions at 3.5 TeV beam energy

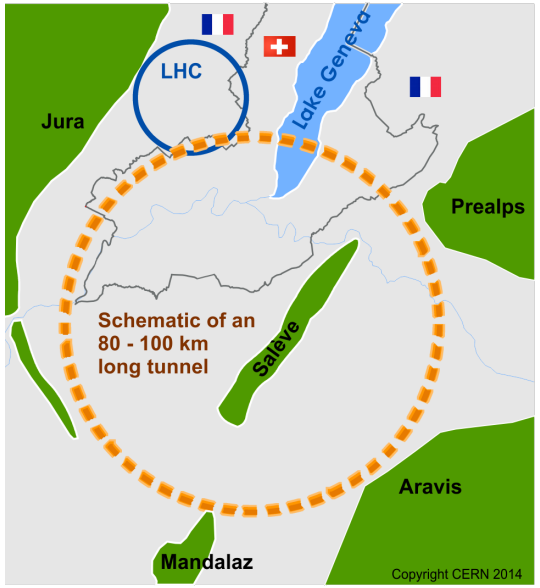
**2015** collisions at ~ design energy

**now is the time to plan for ~ 2040!**

## FCC Strategic Motivation

- **European Strategy for Particle Physics 2013:**
  "…to propose an **ambitious post-LHC accelerator project…,** CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines…coupled to a **vigorous accelerator R&D programme**, including **high-field magnets** and **high-gradient accelerating structures**
- **ICFA statement 2014:**
  "…ICFA supports studies of energy frontier circular colliders and encourages global coordination…"
- **US P5 recommendation 2014:**
  "…A very high-energy proton-proton collider is the most powerful tool for direct discovery of new particles and interactions under any scenario oh physics results that can be acquired in the P5 time window…"

# FCC motivation and scope




## Pushing the energy frontier

A very large circular hadron collider seems the only approach to reach 100 TeV c.m. collision energy in coming decades

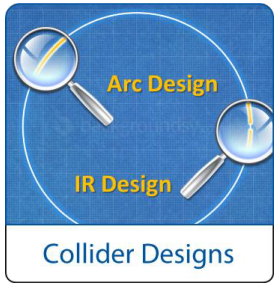
- access to new particles (direct production) far beyond LHC reach
- much increased rates in the sub-TeV mass range

The name of the game of a hadron collider is energy reach

$$E \propto B_{dipole} \times \rho_{bending}$$

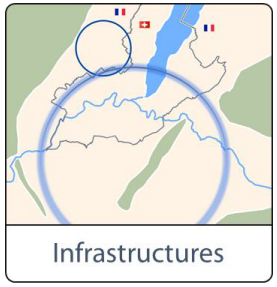
LHC: factor ~4 in radius
factor ~2 in field
→O(10) in Ecm

## FCC scope

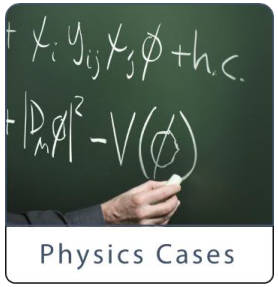


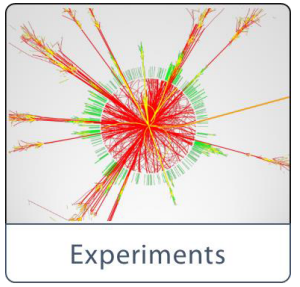

FCC-hh (100TeV in 100km)
FCC-ee
FCC-he

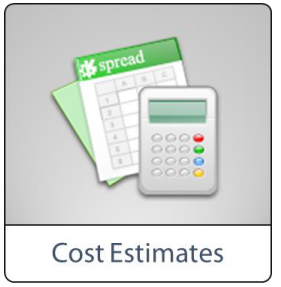

**key technologies**
**dedicated R&D,**
**16 T magnets**
**SRF technologies**
**RF power sources**




tunnel in Geneva area, linked to CERN accelerator complex, site-specific



# EuroCirCol EU Horizon 2020 Grant

EC contributes with funding to **FCC-hh** study

- **Main aspects of hadron collider design: arc & IR optics design, 16 T magnet program, cryogenic beam vacuum system**
- Recognition of FCC Study by European Commission.

**H2020 EuroCirCol**

Hadron Collider

Key Technologies

Resources provided **by research institutes and universities with H2020 grant support.**

Future Circular Collider study **without** H2020 Support Requests

Infrastructure

Implementation


Cost Baseline

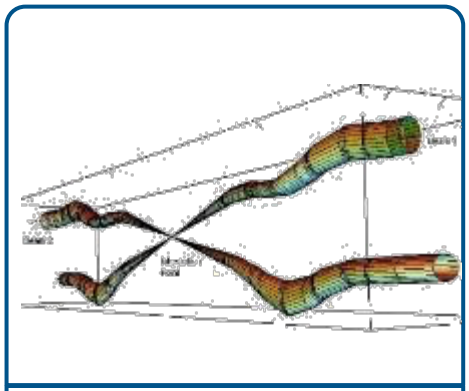
**Resources provided** and work carried out **by worldwide collaboration.**

4 years project, started on June 1st 2015

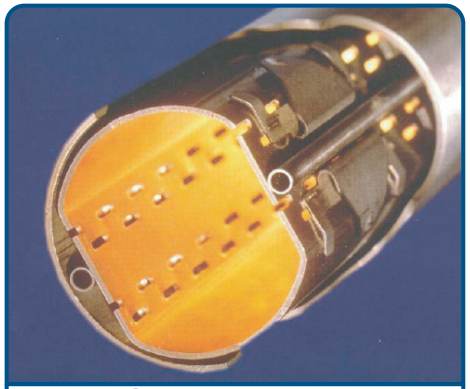
# EC Funded Scope


Management

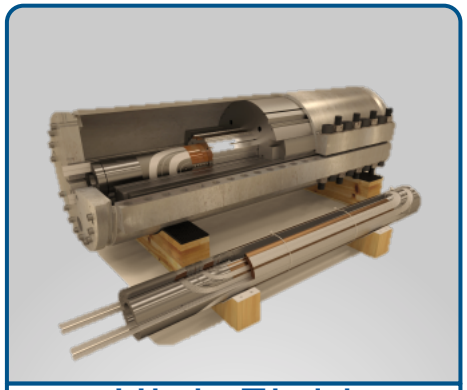

Arc Design



EIR Design



Cryo Beam Vacuum



High Field Magnet

core activities for FCC-hh

# EuroCirCol Workpackages

WP 5:
Develop a viable and cost optimised dipole magnet conceptual design

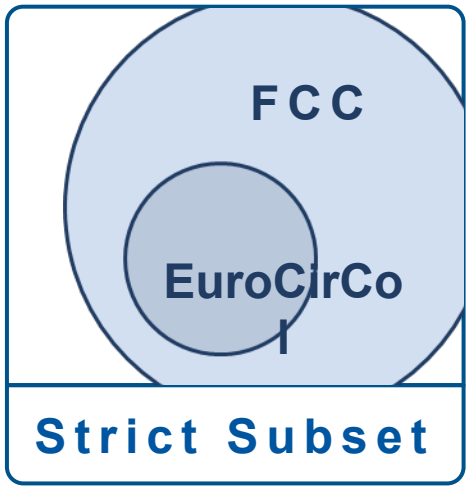
WP 4:
Develop the beam screen conceptual design and perform tests

WP 2:
Ensure that the beam screen and magnet design lead to good beam performance

WP 3:
Ensure that the beam can be used to produce the desired luminosity in the experiments

# EuroCirCol is Subset of FCC

**Funding Instrument**




**Strict Subset**

**Matching Resources**

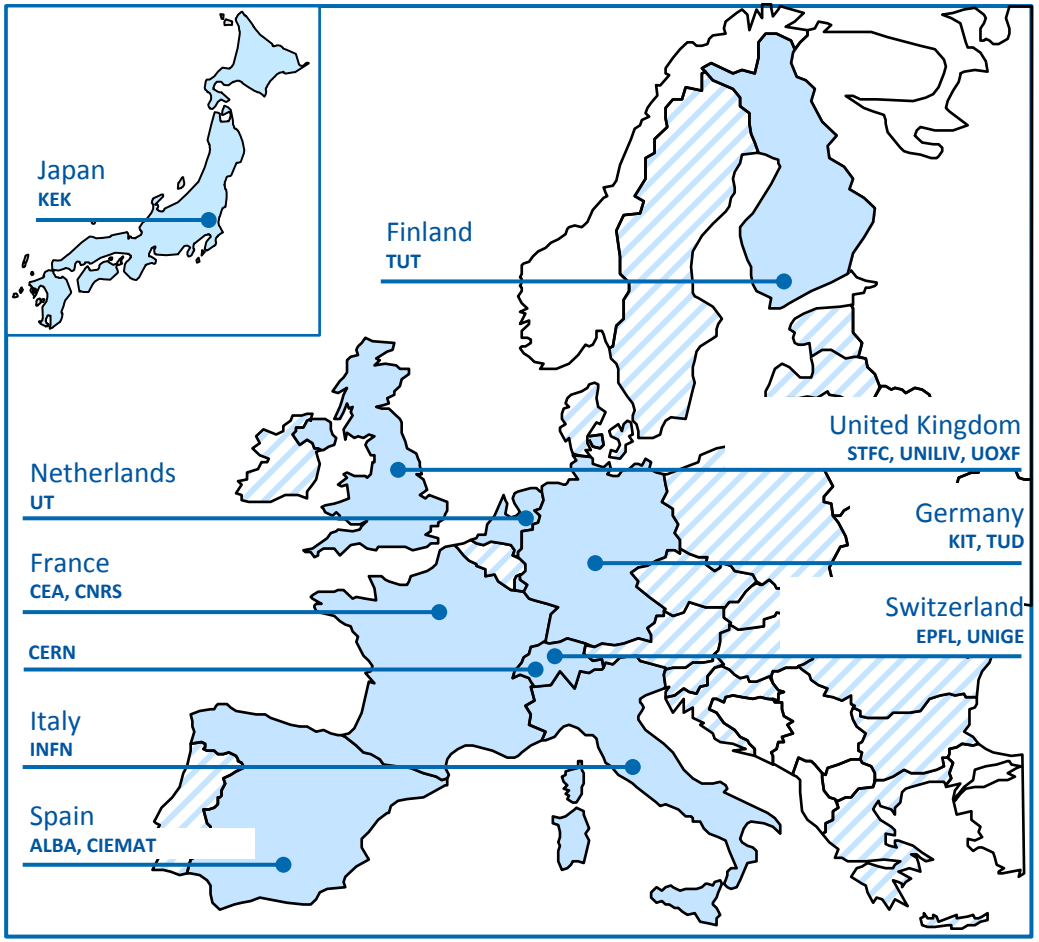
- Helps subset of FCC Participants performing their work efficiently
- Consortium Agreement is extension to FCC MoU
- Establishes compliance with EC H2020 rules
- Limits duplication of management / governance
- Quantify and track matching resources
- Support fundraising of matching resources

# Organisation Aspects

- **FCC** Study is a Collaboration based on a **Memorandum of Understanding** by which Participants commit
  - to study circular post-LHC machines
  - on best effort contributions
- **EuroCirCol** is a Consortium of Participants tied together via a **H2020 Grant Agreement** (GA) with the EC **and a Consortium Agreement** (CA)

# EuroCirCol Consortium + Associates

| | |
|---|---|
| **CERN** | IEIO |
| **TUT** | Finland |
| **CEA** | France |
| **CNRS** | France |
| **KIT** | Germany |
| **TUD** | Germany |
| **INFN** | Italy |
| **UT** | Netherlands |
| **ALBA** | Spain |
| **CIEMAT** | Spain |
| **STFC** | United Kingdom |
| **UNILIV** | United Kingdom |
| **UOXF** | United Kingdom |
| **KEK** | Japan |
| **EPFL** | Switzerland |
| **UNIGE** | Switzerland |
| **NHFML-FSU** | USA |
| **BNL** | USA |
| **FNAL** | USA |
| **LBNL** | USA |




Consortium Beneficiaries, signing the Grant Agreement

# INFN contributions to **FCC accelerator studies**

## FCC-hh via EuroCirCol:

- WP3: Experimental insertion region design (LNF)
- WP4: Cryogenic beam vacuum system (LNF)
- WP5: High field (16 T) magnet R&D (Ge, Lasa)

EuroCirCol
A key to New Physics

in the framework of
**EU H2020 Grant EuroCirCol**

## FCC-ee:

- Machine Detector Interface (LNF)
- Thin film technology for SRF cavities (Legnaro)
- Impedance Evaluation (Sapienza & INFN-Rm1)

in the framework of
consortium of partners
based on **MoU**

# WP5: High-field accelerator Magnet Design

INFN Genova

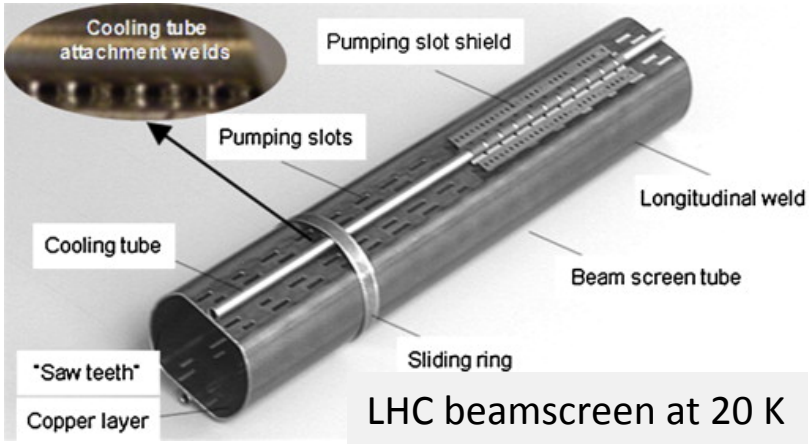
INFN Milano (LASA)

## Challenges

- **Field strengths** in the order of **16 T** as required for an energy frontier hadron collider **are much beyond the highest field** reached by a magnet with significant aperture available today.
- The target field strength requires:
  - ***novel concepts*** for conductor configurations (large current, stable, good winding properties)
  - ***suitable coil shape*** (efficient, precise and with acceptable stress level)
  - ***compact structures***, which are compatible with a four-fold increase in the electromagnetic force with respect to present state-of-the-art

# Vacuum technology challenges

INFN-LNF



LHC beamscreen at 20 K

| FCC-hh Key Parameters | FCC-hh | LHC |
|---|---|---|
| Energy [TeV] | 100 c.m. | 14 c.m. |
| Dipole field [T] | 16 | 8.33 |
| # IP | 2 main, +2 | 4 |
| Luminosity/IP$_{main}$ [cm$^{-2}$s$^{-1}$] | 5-10 x 10$^{34}$ | 1 x 10$^{34}$ |
| Energy/beam [GJ] | 8.4 | 0.39 |
| **Synchr. rad. [W/m/apert.]** | **28.4** | **0.17** |
| Bunch spacing [ns] | 25 (5) | 25 |

**SR power ~30W/m/beam** in arcs ($E_{crit}$=4.3 keV), total 5 MW (LHC 7kW)

⇒ Cooling challenge

⇒ Vacuum challenge

⇒ Impedance challenge

⇒ Mechanical challenge

⇒ Electron cloud

⇒ Cost challenge

- Dipole Cold bore at 1.9 (or 4.2?) K
- Beamscreen temperature at 50K
- **5MW SR => 100MW of cooling power**
- Need good vacuum between 40-60K
- Need to reduce Impedance budget

**Wide and highly technologically and scientifically challenging R&D required**

# WP3 Experimental Insertion Region Design

INFN-LNF in close collaboration with CERN

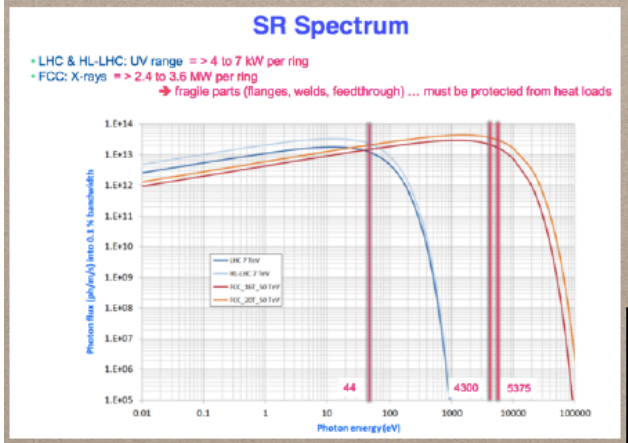
Study impact of **synchrotron radiation emitted by protons** on detector and machine components and develop mitigation techniques

motivation

tool: MDIsim

## SYNCHROTRON RADIATION FOR PROTONS

- Energy distribution of synchrotron radiation photons for LHC and FCC-hh:




$$E_{FCC_{hh}} \propto 7 \times E_{LHC}$$

$$P_{SR_{FCC_{hh}}} \propto 170 \times P_{SR_{LHC}}$$

$$E_{Crit_{FCC_{hh}}} \propto 100 \times E_{Crit_{LHC}}$$

X-Rays

U.V.

The total radiated power will probably be still low, but the much greater photon energy demands for a careful evaluation

More, and more energetic photons!

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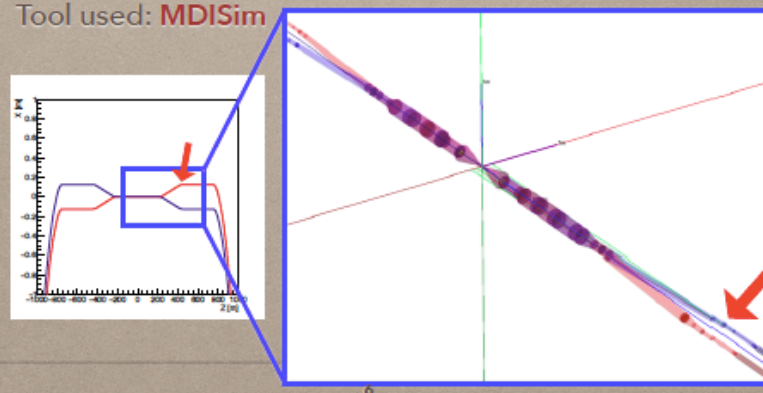
- My (current) task is to **evaluate the contribution of synchrotron radiation** photons emitted in the last bending magnets **into the interaction region**
- Tool used: MDISim



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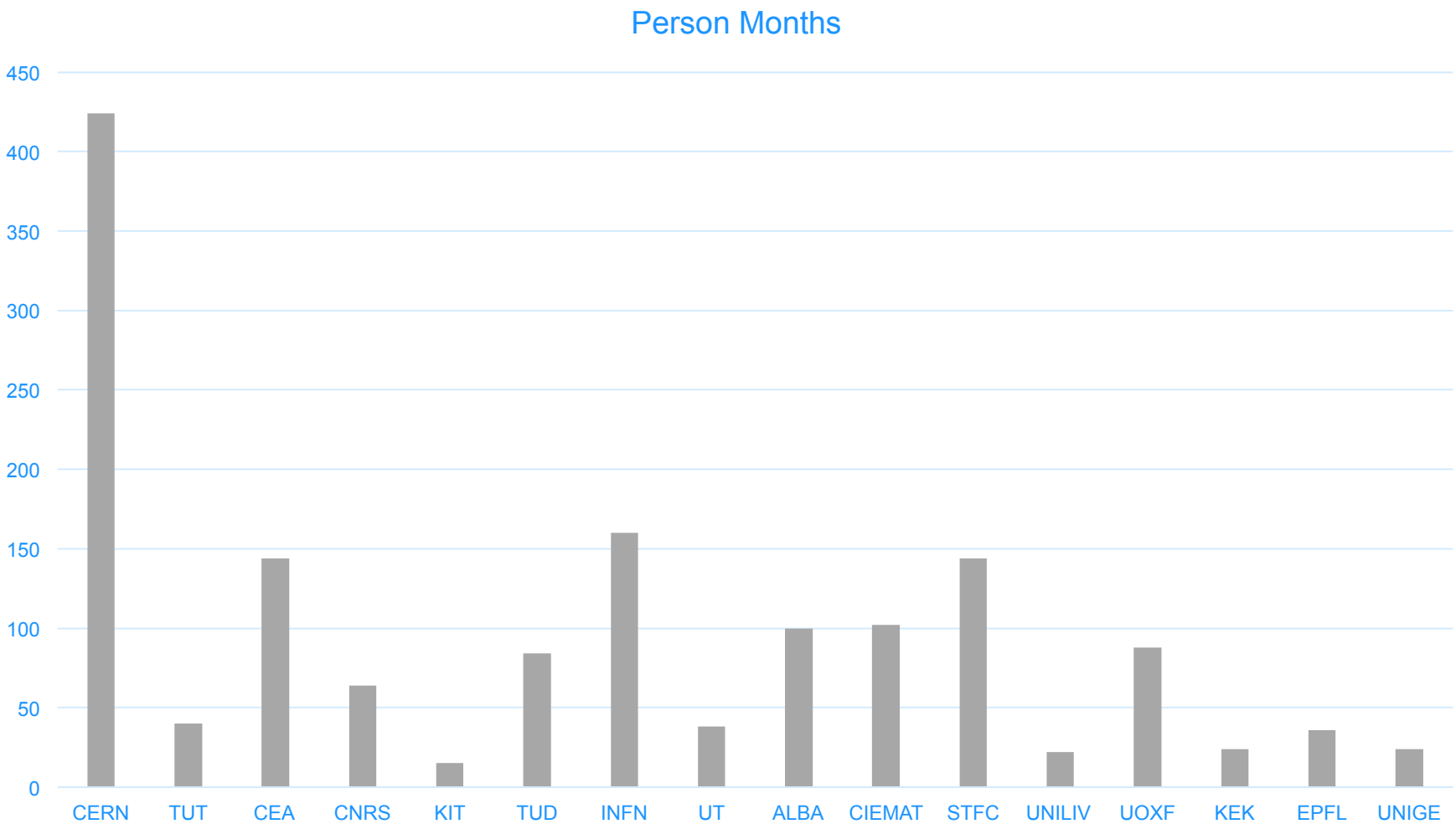
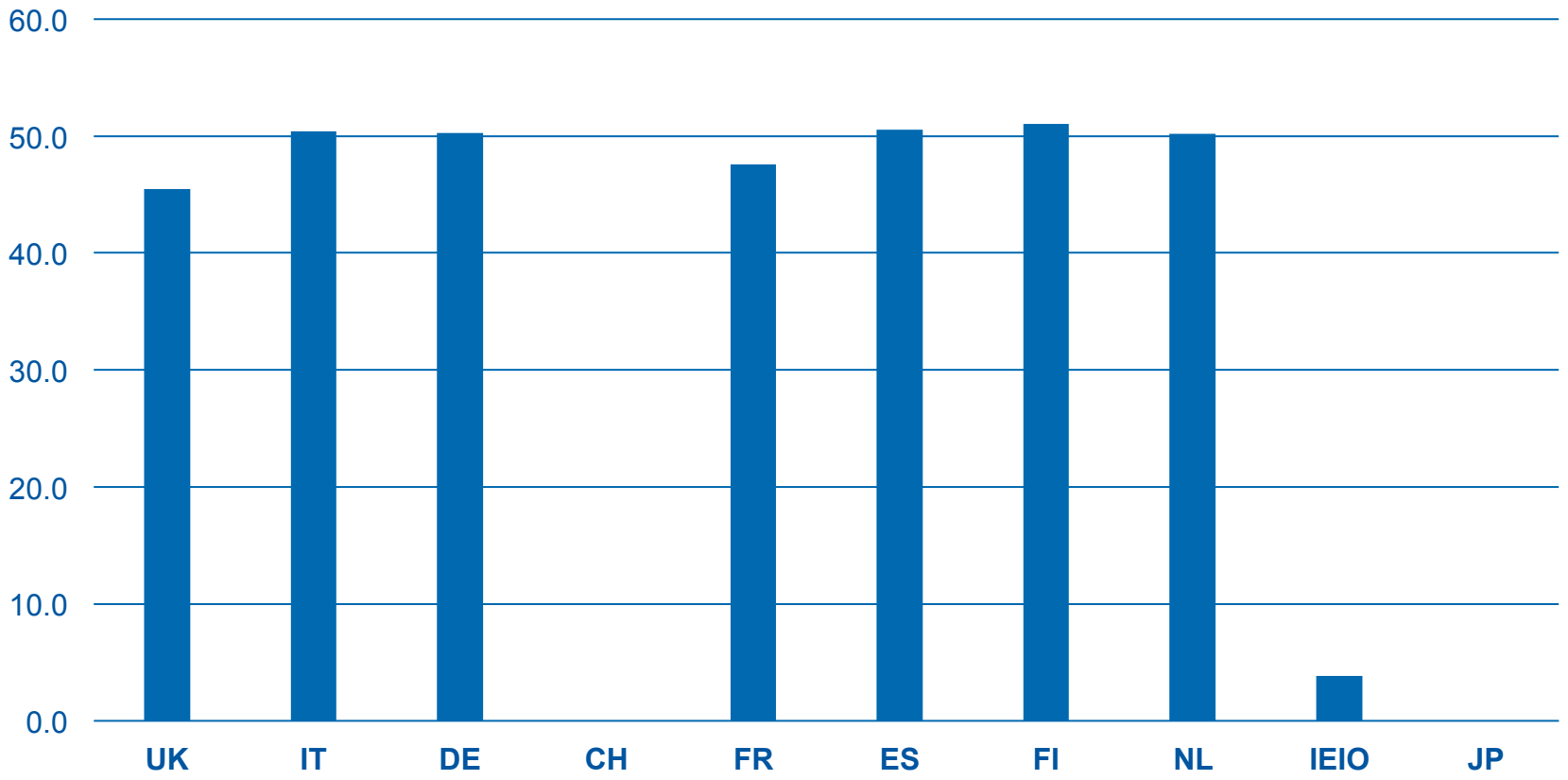
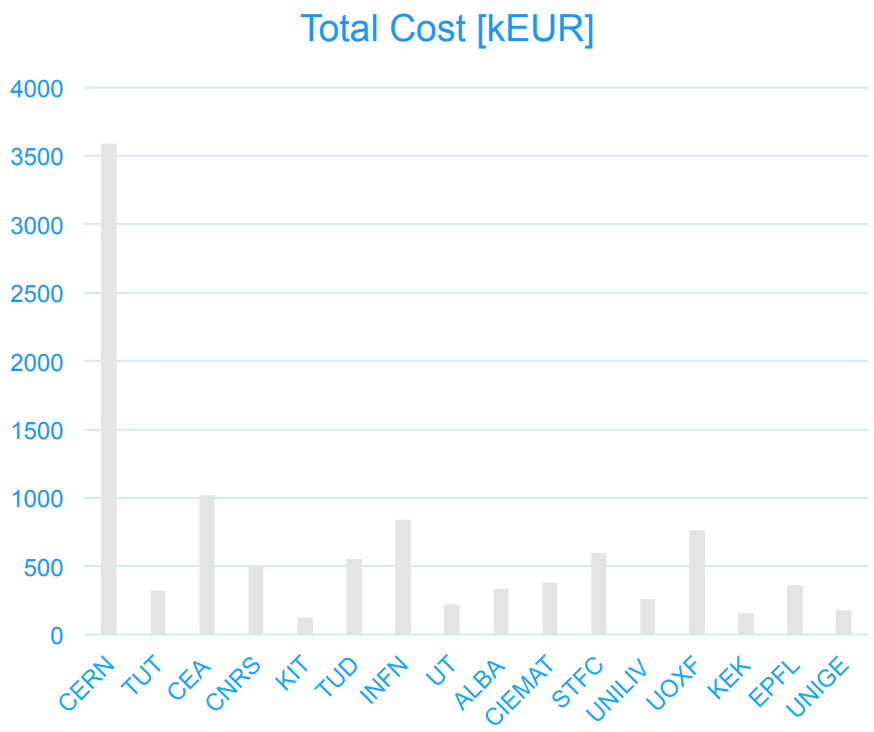
# Total Effort Overview

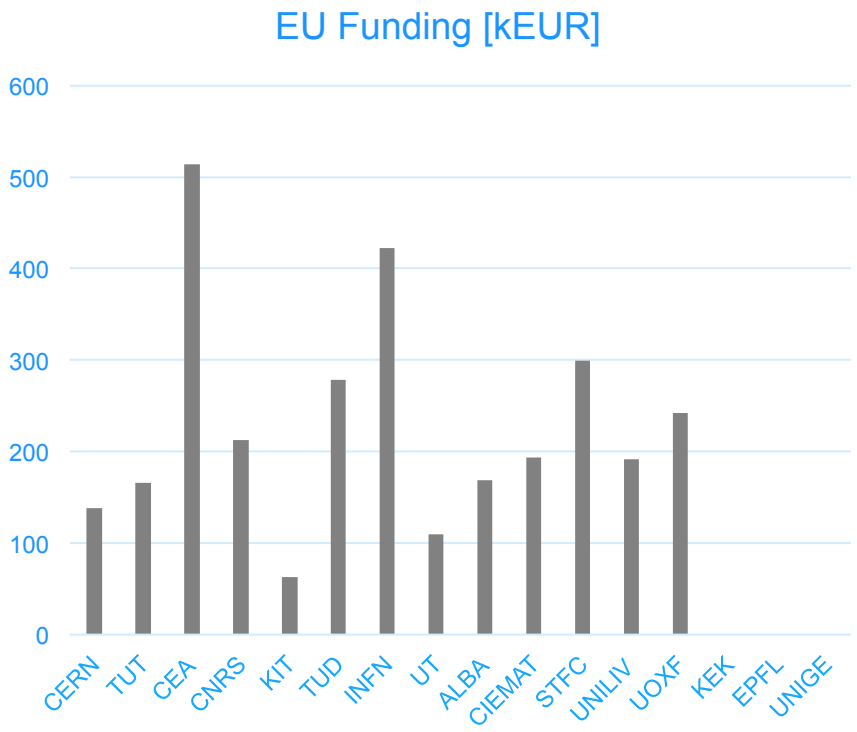


# Funding Ratio in % per Country



# Cost and Funding Overview



# Practical Steps STEPS as the project starts:

- Identification of Administrative & Technical personnel
- Scientific Team definition, team database
- Administration Support Roles
- Reporting dates, Milestones & Deliverables
- Establish governance structure
- Schedule governance meetings
- Schedule WP meetings

# Project Personnel Database

**As the project is approved the following figures need to be defined:**

- Administrative
  - Contact for EC project matters (done)
  - Roles for administration support tasks
- Technical
  - WP leaders
  - WP deputies
  - WP technical contact per WP at Beneficiary
  - Science and engineering team members at Beneficiaries (task leaders, researchers)

# Administration Support Roles

## Names per Beneficiary for:

| | |
|---|---|
| **Administrative Coordination Officer** | Collects, compiles and re-distributes technical and financial input<br>(Examples: EU offices, dedicated WP coordination assistants) |
| **Finance Service Officer** | Personnel and material resource planning and tracking<br>Preparing Internal Resource Utilisation Summaries and financial reporting to the EC<br>(Examples: finance departments or EU offices) |
| **Communication Officer** | Collect, prepare and disseminate information intended for the public<br>(Examples: press offices, outreach groups) |
| **Knowledge and Innovation Officer** | Assess background of beneficiaries in the work package<br>Collect and compile IP and technologies with innovation and exploitation potentials<br>Interact with communication offices<br>Liaise with the Coordinator's Knowledge Transfer office |
| **Gender Equality Officer** | Monitors gender aspects<br>Assists in identifying and documenting support instruments<br>Work with other Beneficiaries on improvement actions |

# Compile Team Database

Example!

**WP leaders send tables** with list of persons and work descriptions as input to milestone reports.

| **WP :** | | | |
|---|---|---|---|
| **Lead:** | | **Co Lead:** | |
| | | | |
| **Participants:** | **Person (name, email, phone)** | **Task:** | |
| CERN | Person 1 | *Work description …* | |
| | Person 2 | … | |
| INFN | Person 3 | … | |
| | Person 4 | … | |
| … | … | … | |
| … | … | … | |
| …. | … | … | |

# Reporting

Example!

| Report | Date at which information reaches Coordinator | |
|---|---|---|
| Internal Activity Report 1 | M 10 | |
| Internal Resource Utilisation 1 | M 10 | |
| Internal Resource Utilisation 2 | M 18 | |
| Periodic Report 1 to EC | M 18 + 10 calendar days | |
| Internal Resource Utilisation 3 | M 25 | |
| Internal Activity Report 2 | M 25 | |
| Internal Resource Utilisation 4 | M 36 | |
| Periodic Report 2 to EC | M 36 + 10 calendar days | |
| Internal Resource Utilisation 5 | M 48 | |
| Periodic Report 3 to EC | M 48 + 10 calendar days | |

… to conclude:

# Sample messaging

**Key message:**

The FCC study is needed now to ensure continuity in the field.

**Proof point:**

R&D, large-scale technical developments at industrial scale and construction is will require over 20 years, comparable to the operational lifetime of the LHC.

**slide from: James Gillies, Head of Communications, CERN**
**EuroCirCol kick-off meeting, 2 June 2015**

# Sample messaging

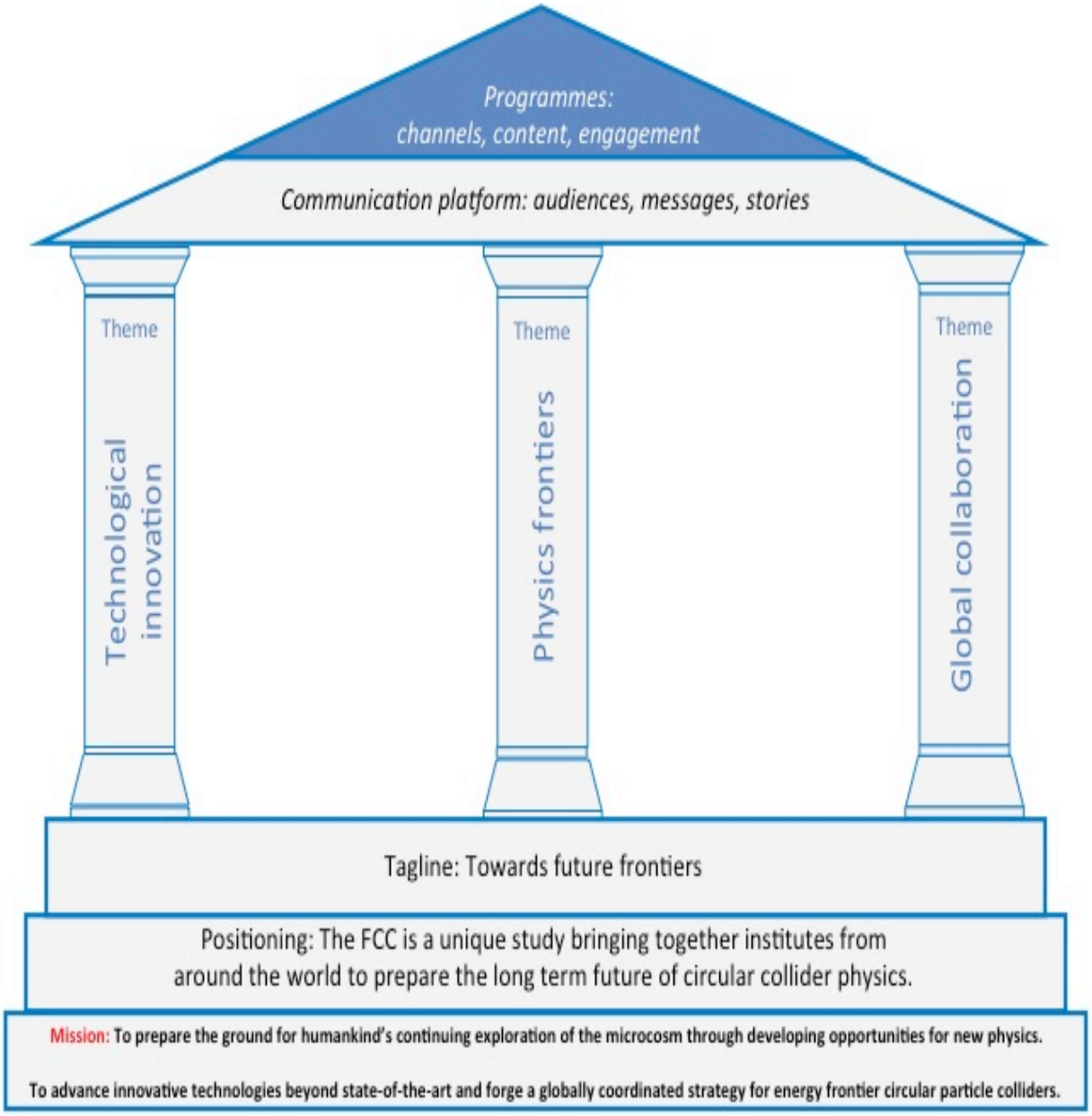
**Key message:**

The FCC study is a strong example of what can be achieved when people from around the world work together.

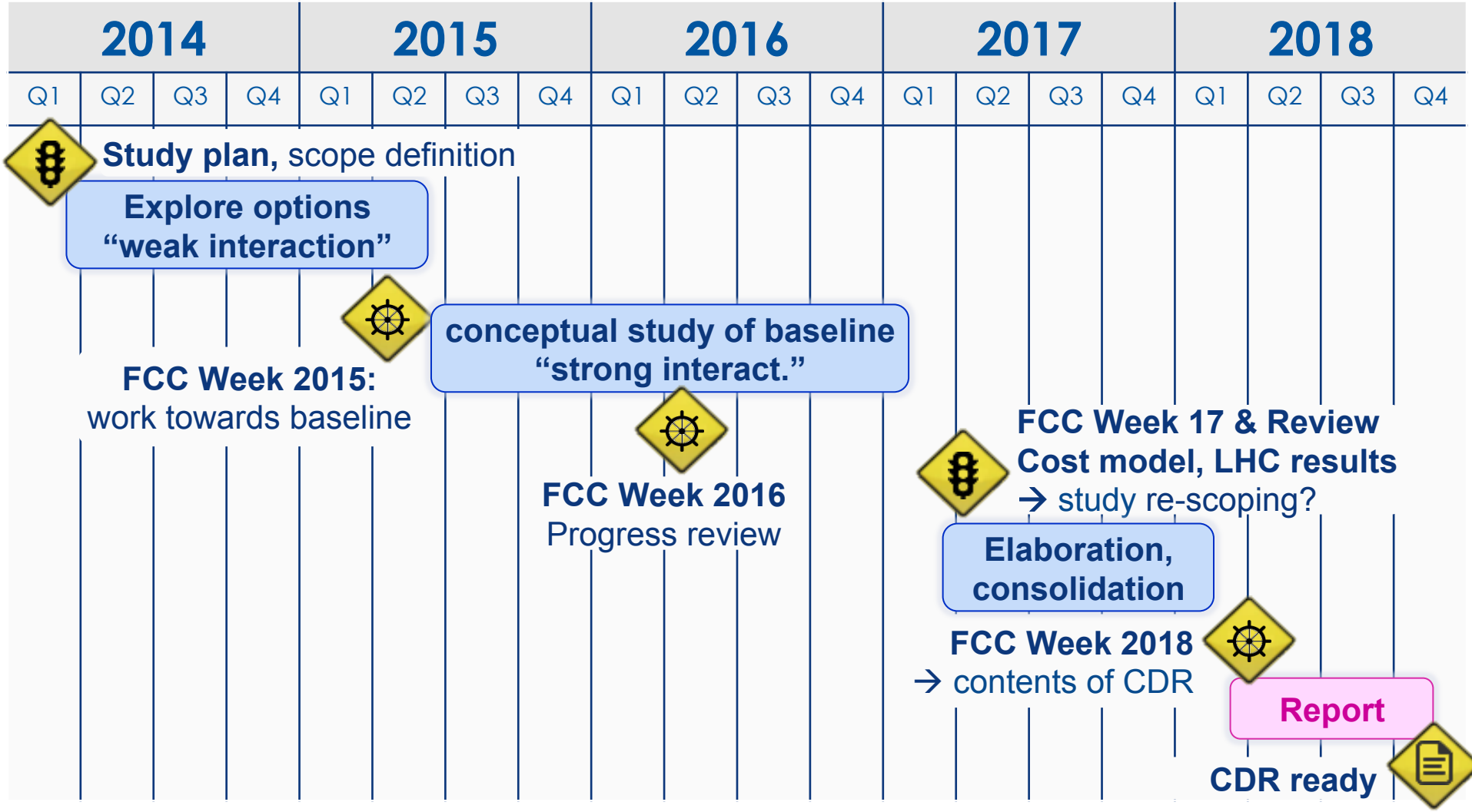
**Proof point:**

51 institutes from 19 countries are involved in the FCC study

**slide from: James Gillies, Head of Communications, CERN**
**EuroCirCol kick-off meeting, 2 June 2015**


Programmes:
channels, content, engagement
Communication platform: audiences, messages, stories
Theme
Technological innovation
Theme
Physics frontiers
Theme
Global collaboration
Tagline: Towards future frontiers
Positioning: The FCC is a unique study bringing together institutes from around the world to prepare the long term future of circular collider physics.
Mission: To prepare the ground for humankind's continuing exploration of the microcosm through developing opportunities for new physics.
To advance innovative technologies beyond state-of-the-art and forge a globally coordinated strategy for energy frontier circular particle colliders.

# FCC Study time line towards CDR





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# Strategic Goals

Create awareness of strategic and funding needs for particle-physics

Provide decision baseline for physics research infrastructure roadmap

Confirm Europe as preferred area for next large scale collider facility

## Work towards inclusion of EuroCirCol in the ESFRI roadmap (European Strategy for Research Infrastructures)