

# Future Circular Collider Study

V. Mertens – 9 May 2017

gratefully acknowledging input from FCC coordination group,  
global design study team and all other contributors

LHC

SPS

PS

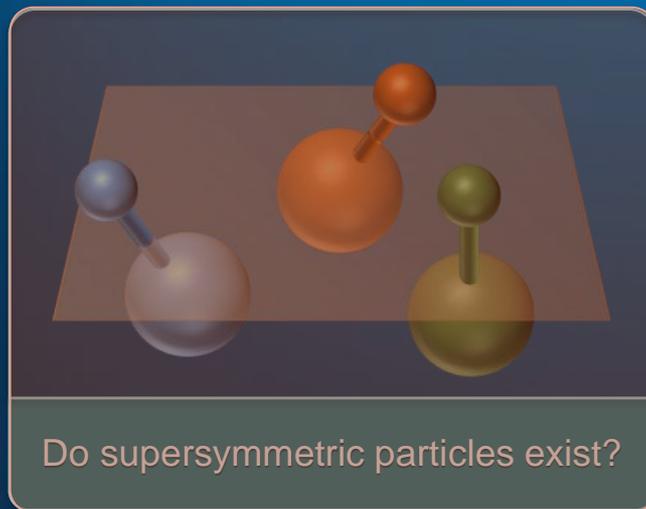
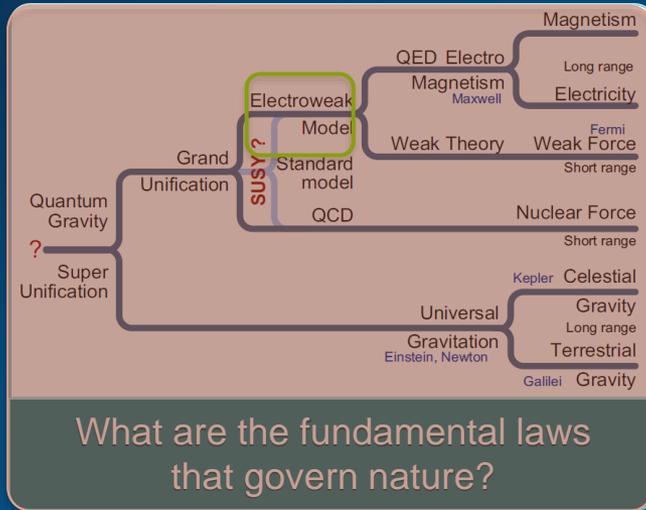
FCC



<http://cern.ch/fcc>

Material courtesy M. Benedikt

# Open Questions





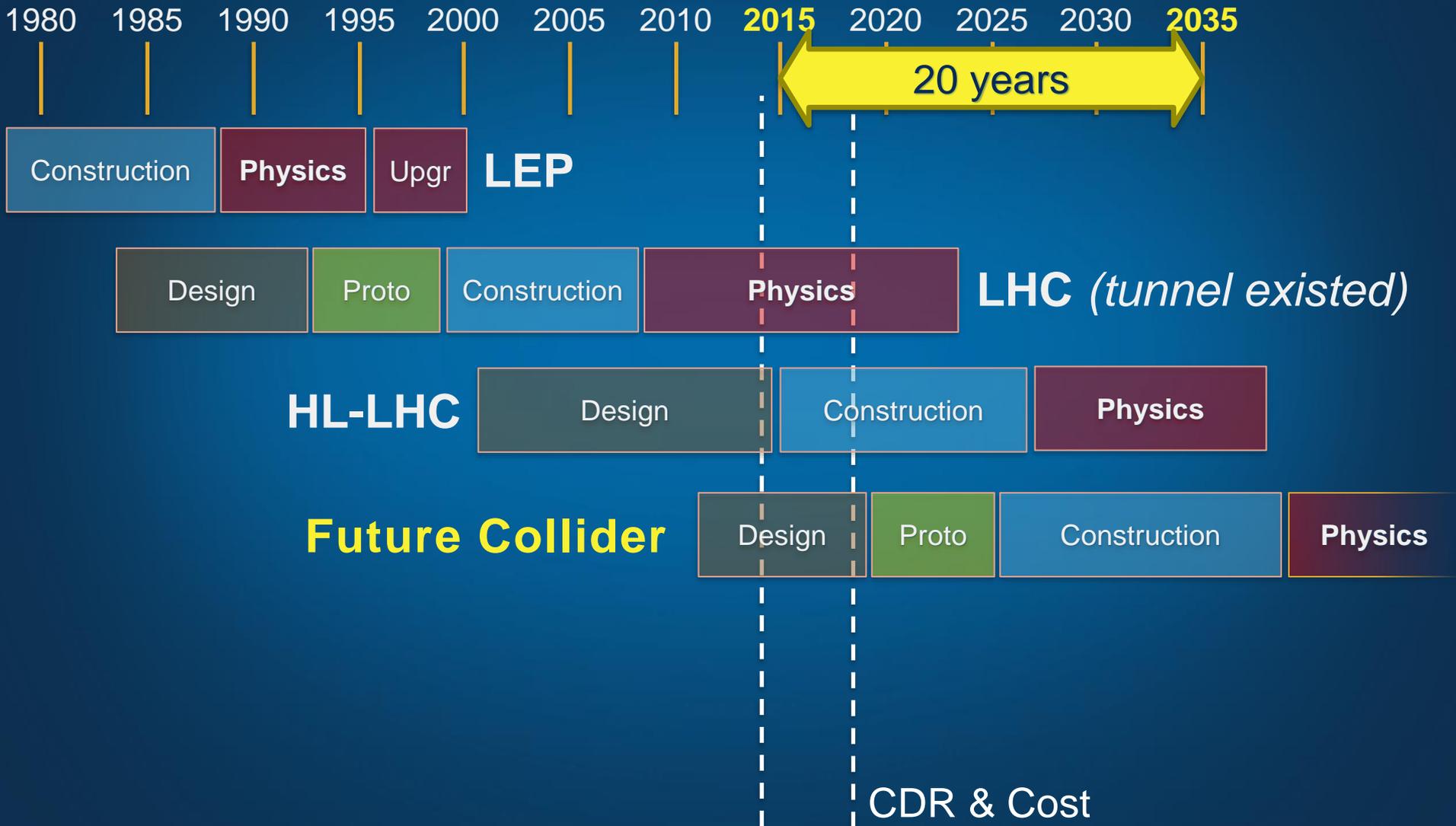
# Strategy Update 2013



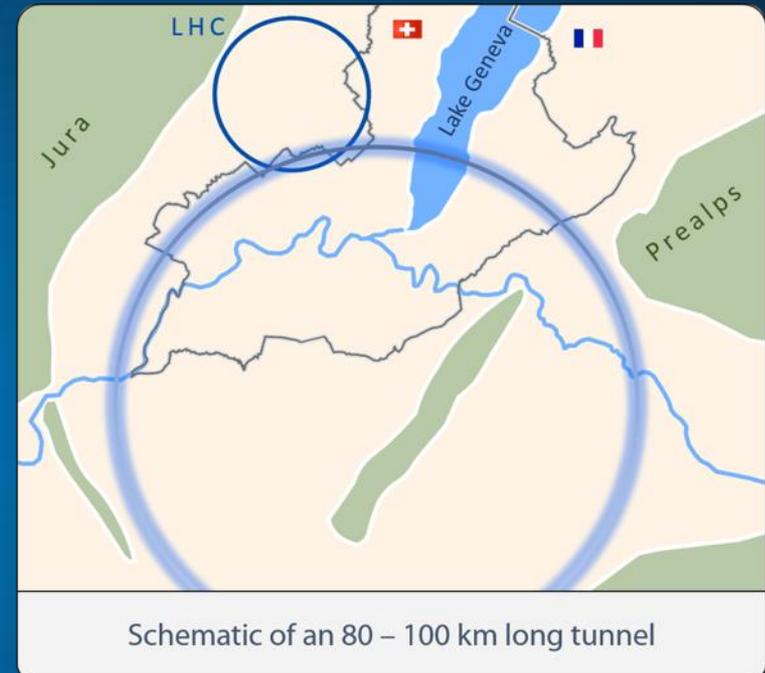
“CERN should undertake **design studies** for accelerator projects in a **global context**, with emphasis on proton-proton and electron-positron **high-energy frontier** machines.”

*The European Strategy for Particle Physics, May 2013*

Have material as sound decision support for the post-LHC era by 2019



- **pp** collider (**FCC-hh**)  
 Defines infrastructure requirements  
**16 T** magnets →
  - **100 TeV** centre of mass in
  - **100 km** long tunnel
- **e<sup>+</sup>e<sup>-</sup>** collider (**FCC-ee**)  
 Potential intermediate step  
**Extreme luminosities** at 90–350 GeV
- Infrastructures  
**Leverage** existing CERN accelerator complex, know-how and successful management of largest-scale science projects  
**Build on** a history of **international trust and collaboration** across cultures, political systems





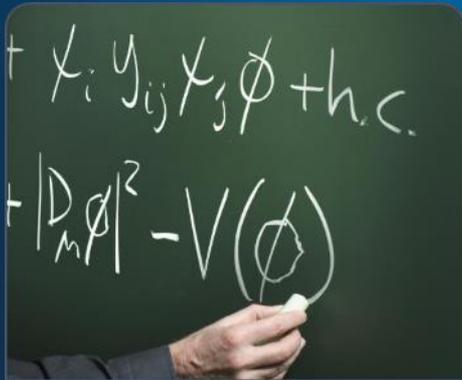
Collider Designs



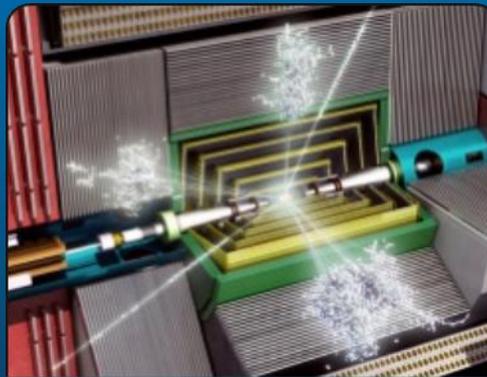
Infrastructures



R&D Programs



Physics Cases



Experiments

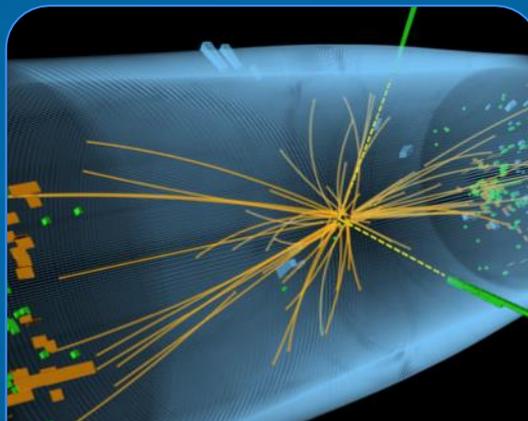


Cost Estimates

## conceive for ...



S a f e t y



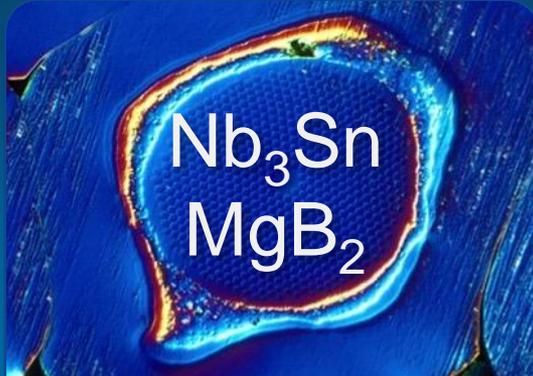
Performance



Efficiency



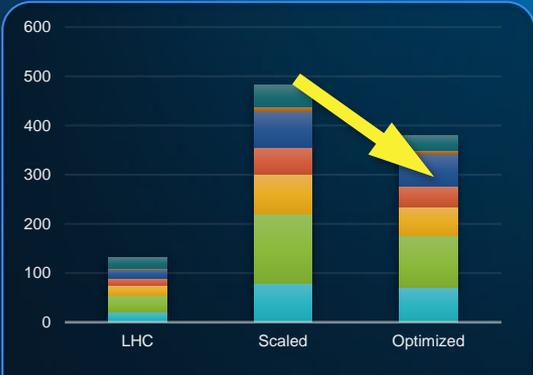
High-field Magnets



Novel Materials and Processes



Efficient Cryogenics



Power Efficiency



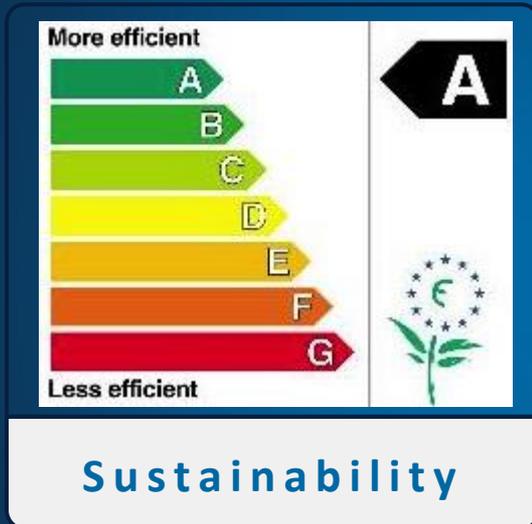
Reliability & Availability



Global Scale Computing

# Breakthroughs are needed

Naïve scale-out of today's technologies without advancement leads to unsustainable cost/performance



Only a project, which can be operated cost effectively, has chances to be funded.



Number of subsystems requires breakthrough in reliability and availability at large.



Breakthroughs in novel materials, processes, production, testing at large scale !

# FCC Week 2017 MAY 29 - JUNE 2 BERLIN, GERMANY



## FCC WEEK 2017

The annual meetings of the worldwide Future Circular Collider study (FCC) are major international events that review the progress in every domain which is relevant to develop feasible concepts for a next generation frontier particle accelerator based on high energy physics research infrastructure. This 3rd meeting is jointly organised by CERN and DESY. It is also the annual meeting of the EuroCirCol FCC Horizon 2020 Research and Innovation Action project. Previous events took place in Washington and Rome. In 2017 the FCC Week will take place in Berlin, Germany, between May 29 and June 2.

<http://cern.ch/fccw2017>



Register



Abstract Submission



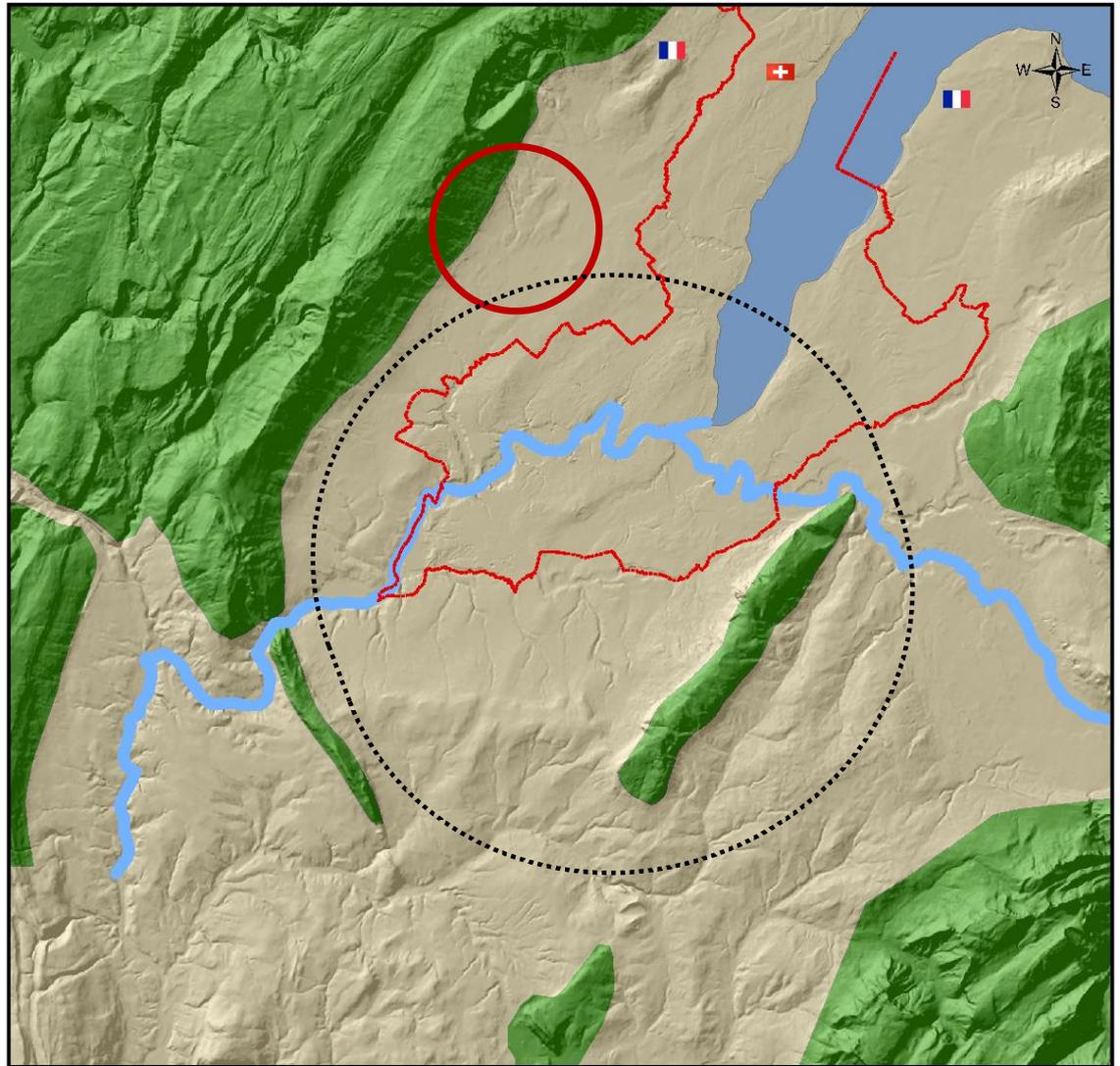
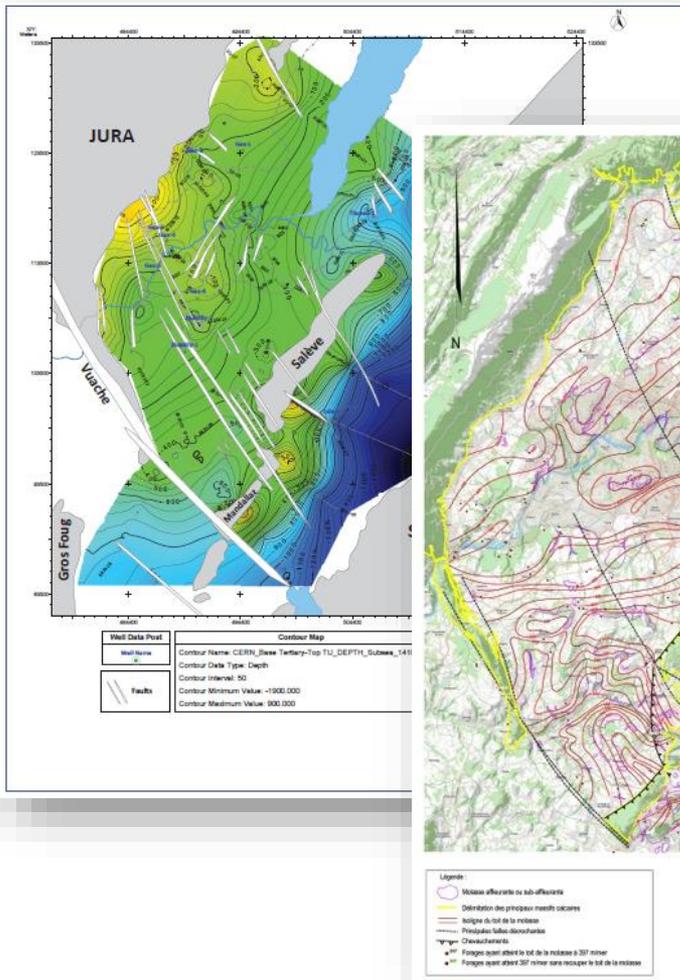
Venue

Registration will be opened on **September 1, 2016**. The early registration fee for Early Stage Researchers

Oral presentation is by invitation only and there will be the opportunity to submit for a special IEEE proceedings

A few minutes from Berlin Zoo, the **InterContinental hotel** is located at the crossroad of Mitte and City West. It

# Data Integration for CE Concepts



# 97.75 km FCC baseline tunnel

## Geology and civil engineering studies

Alignment Shafts Query

Choose alignment option  
100km quasi-circular

Tunnel elevation at centre 261mASL

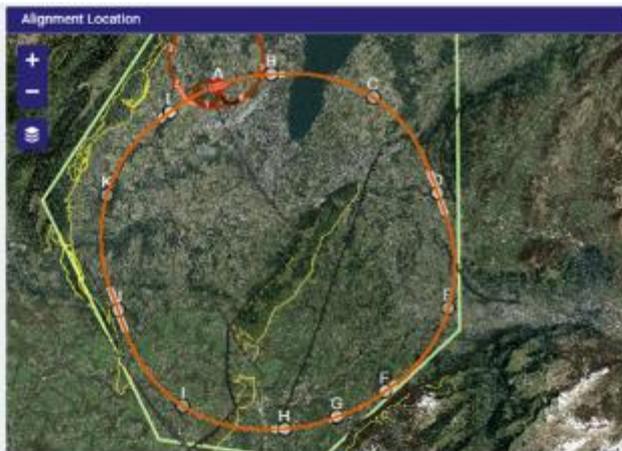
Grad. Params

Asimuth (°): -20  
Slope Angle x-x(%): 6.65  
Slope Angle y-y(%): 0

LOAD SAVE CALCULATE

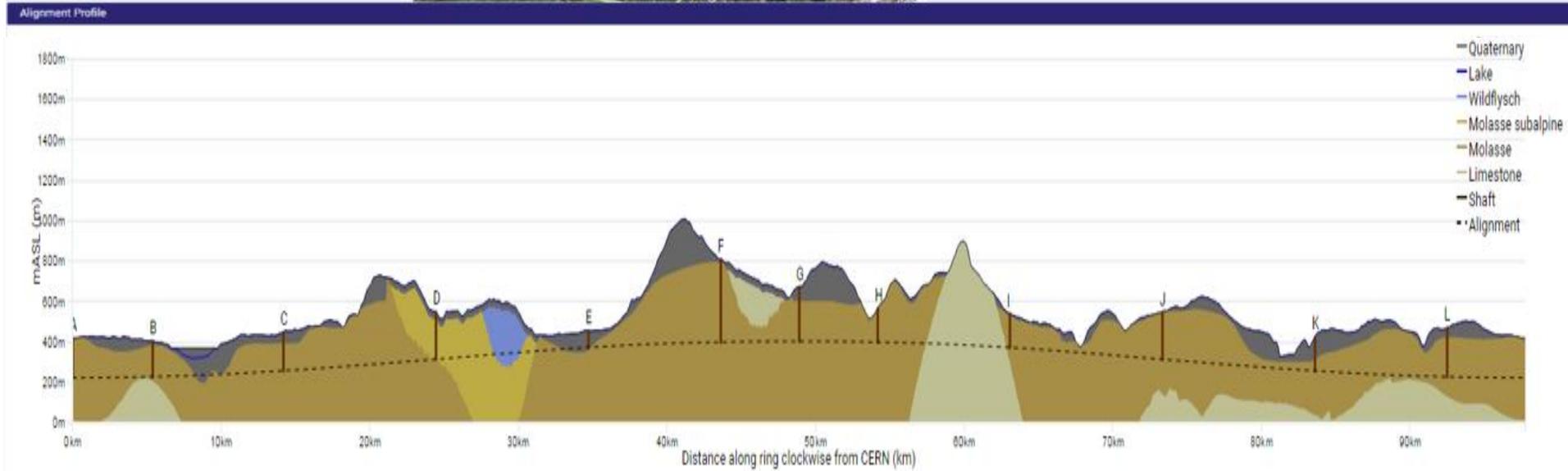
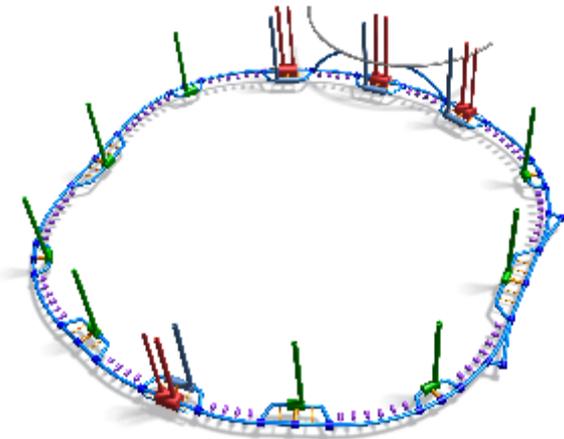
Alignment centre  
X: 2499731 Y: 1108403

	Angle	CP 1	Angle	CP 2
		Depth		Depth
LHC	-64°	229m	64°	172m
SPS		242m		241m
TIG		235m		241m
TIB		242m		170m

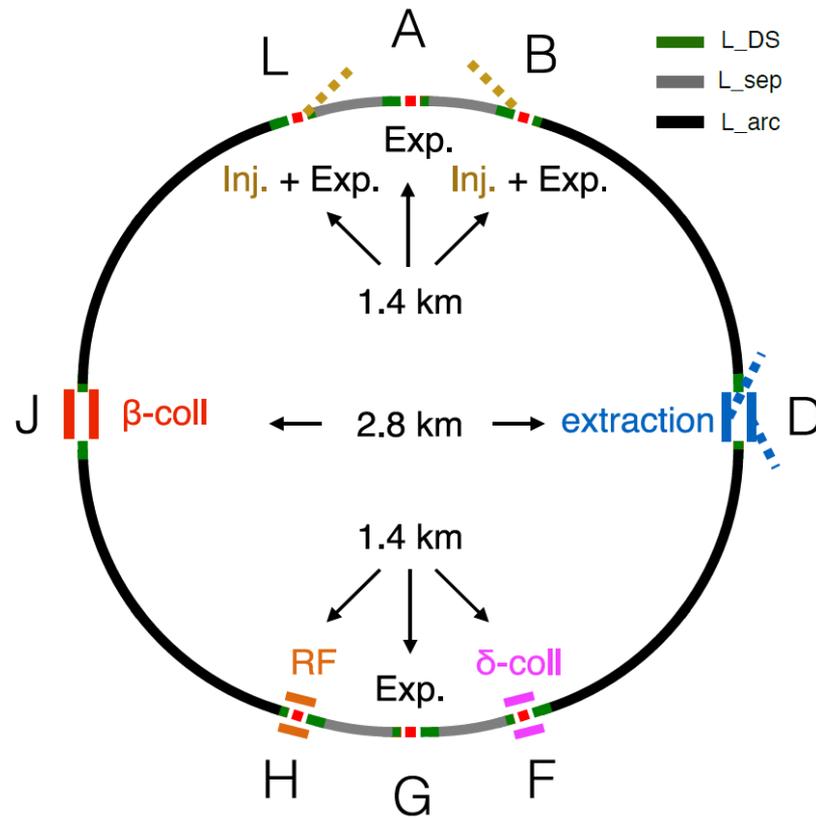


Geology intersects

Point	Actual
A	304
B	264
C	257
D	272
E	132
F	392
G	354
H	268
I	170
J	315
K	221
L	260
Total	3211



# Machine Layout





# FCC 16 T R&D program 2016-2022

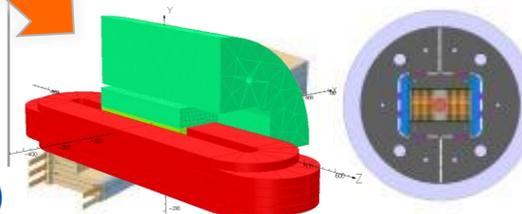
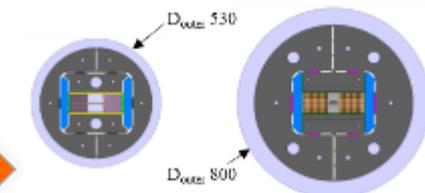
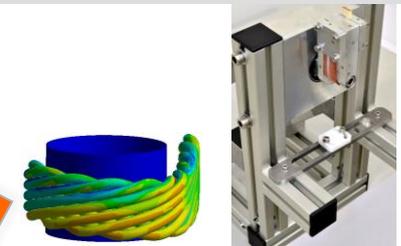
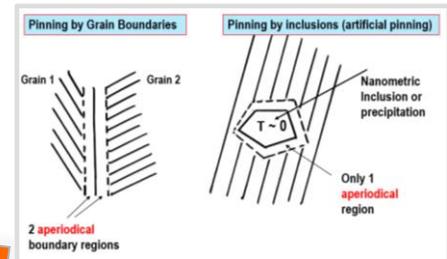
## Wire and coil modelling, structure design

FCC-ST-0001

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15 MCHF material over first 4 years (8 MCHF conductor R&D)



# FCC-hh cryo beam-vacuum system

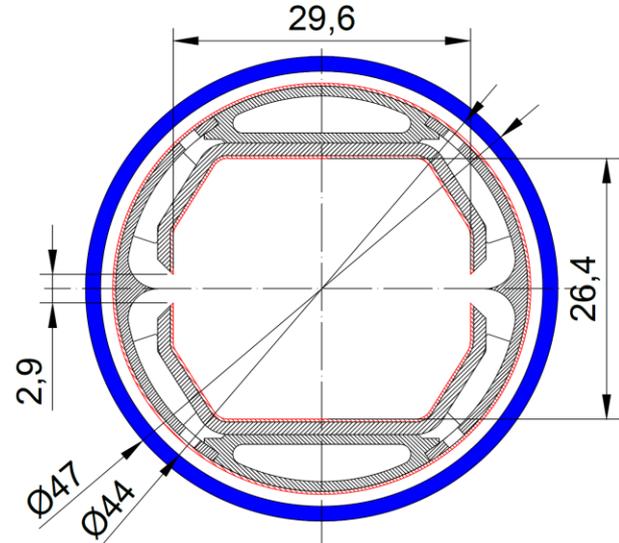
## Surface technology, production technique

**FCC-hh:  $\approx 5$  MW SR power in cold arcs**  
beam screen at 40-60 K (LHC at 5-20 K)  
better Carnot efficiency; reduces cryo power  
but higher resistance  $\rightarrow$  res. wall instability

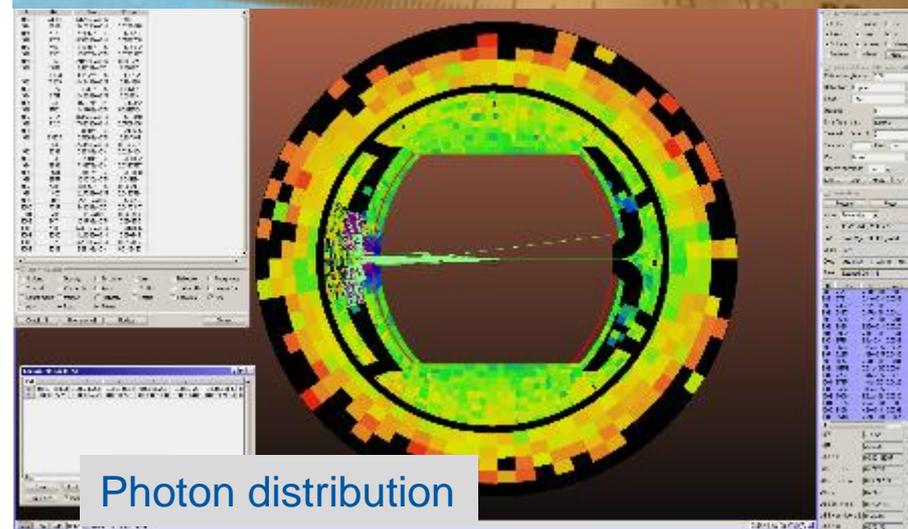
### slits & wedge

capture and hide photons  
 $\rightarrow$  no photoelectrons in beam pipe proper

**surface treatment** reduce SEY ?



**First FCC-hh beam screen prototype**  
Testing 2017 in ANKA within EuroCirCol

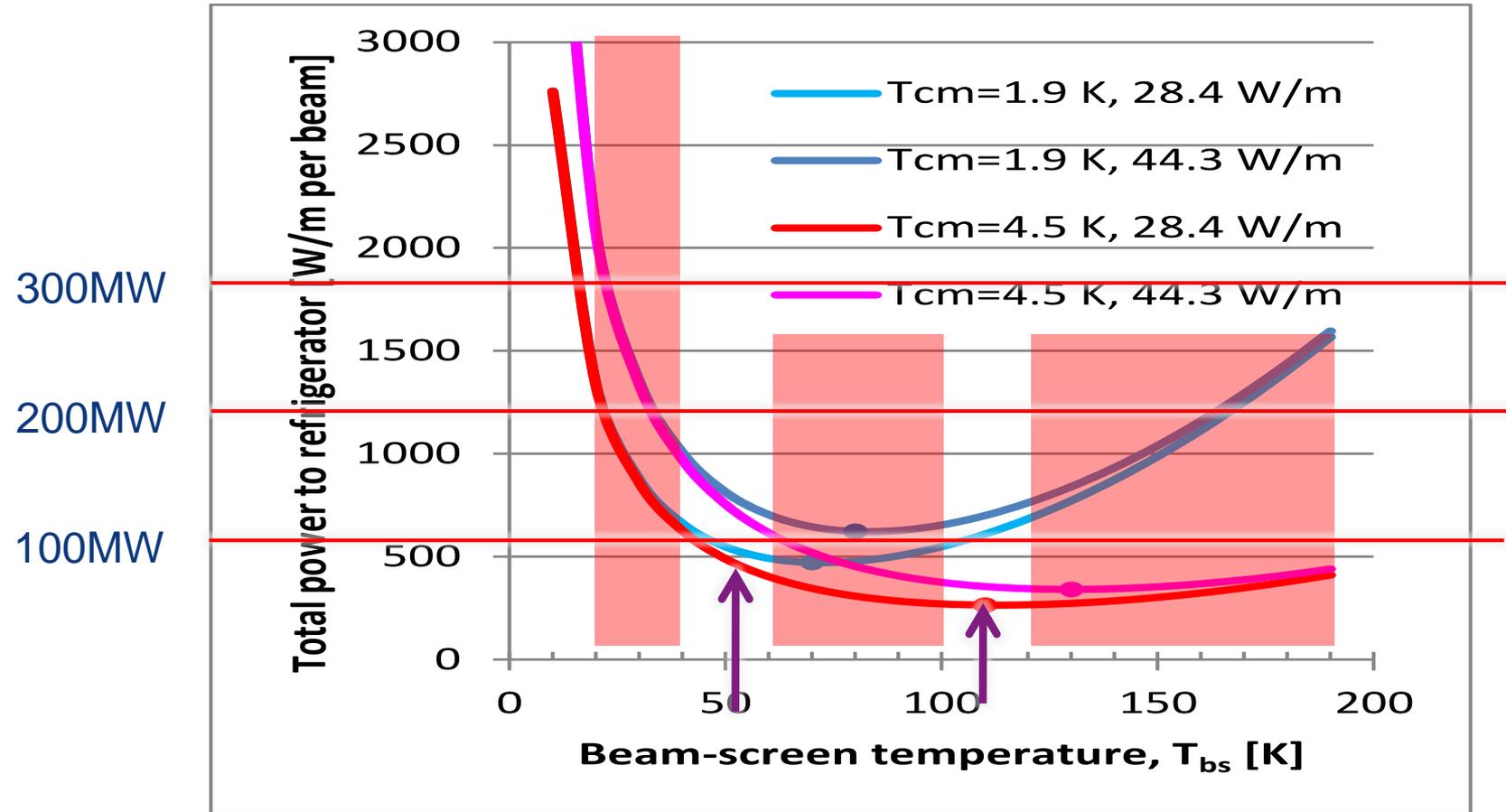


Photon distribution

# Cryogenic system

## Process optimisation, energy efficiency

Overall optimisation of cryo-power, vacuum and impedance  
 Temperature ranges: <20, 40 K-60 K, 100 K-120 K



# Beam power and beam handling

## New materials, collimators, beam dump

### Stored energy 8.4 GJ per beam

- Factor 25 higher than for LHC, equivalent to A380 (560 t) at nominal speed (850 km/h). Can melt 12 t of copper.



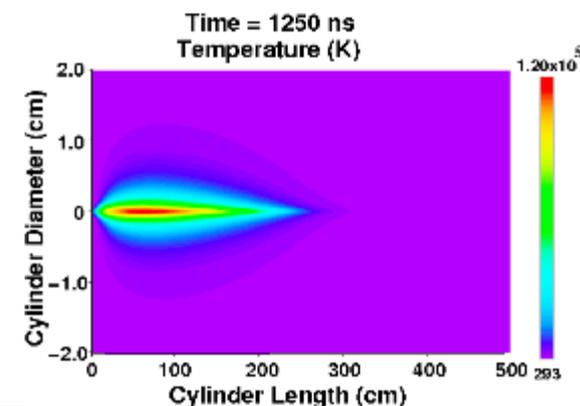
- Collimation, control of beam losses and radiation effects (shielding) are of prime importance.
- Injection, beam transfer and beam dump all critical.

**Machine protection issues to be addressed early on!**

Damage of a beam with an energy of 2 MJ



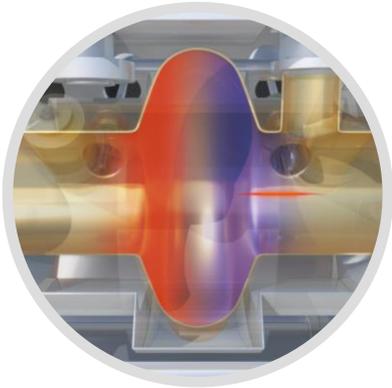
**Hydrodynamic tunneling:**  
beam penetrates ~300 m in Cu



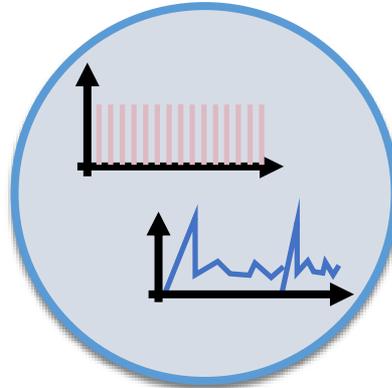


# SRF system R&D lines

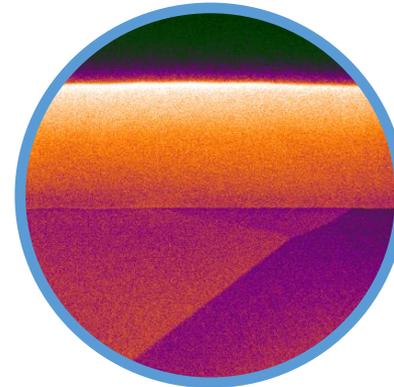
## Material performance, energy efficiency



400/800 MHz  
Nb/Cu coated



HOM spectrum  
tailoring



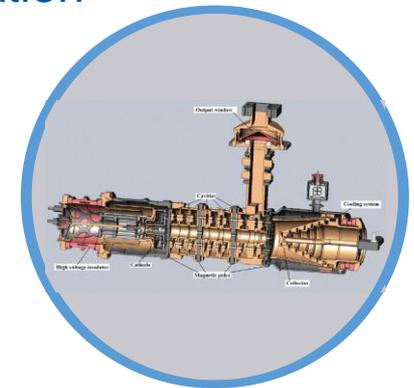
Q-slope  
mitigation



Material &  
manufacturing



Assembly & cost  
optimisation



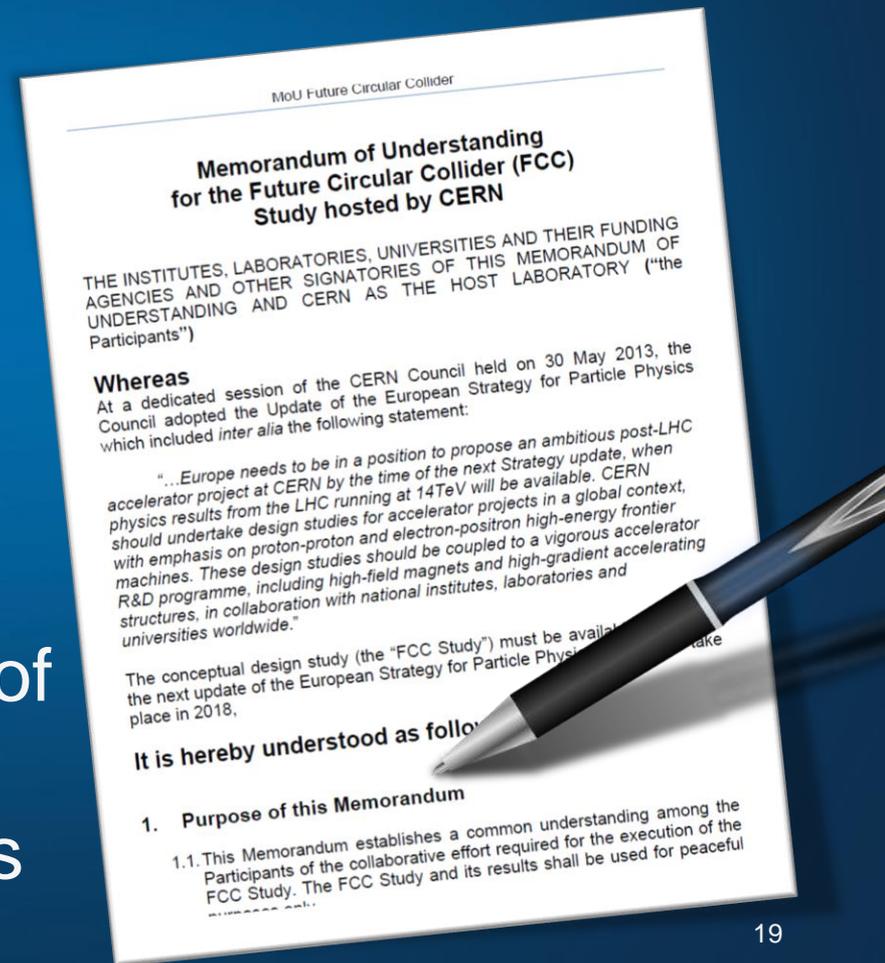
Efficient  
power sources



# Collaboration



- **Only a world-wide collaboration** can realize an infrastructure of such kind
- **Self governing**, topically **complementary** and geographically **balanced**
- Incremental & open to **academia and industry**
- Partners own commonly the infrastructure
- Catalyzing development of products based on cutting-edge technologies





# Collaboration & Industry Relations



CERN hosts the collaboration: An implementation project requires an adequate governance structure





# Summary

- FCC study is aiming at CDR for end 2018 as first milestone.
- First full iteration of geology, civil engineering, technical infrastructure studies and machine designs completed.
- Excellent progress on SC magnets and cryogenic beam vacuum system design & other key technical R&D areas.
- Next step is study review at FCC Week in Berlin.
- International collaboration is the basis to advance on all challenging subjects.