7th International Conference
Charged & Neutral Particles Channeling Phenomena

7th International Conference "Charged & Neutral Particles Channeling Phenomena Channeling 2016“, Sirmione-Desenzano Del Garda (Italy), 25 September 2016

from LHC to FCC

Frank Zimmermann

thanks to Michael Benedikt, Oliver Brüning, Mirko Pojer, Stefano Redaelli

PS
FCC
LHC
SPS
HL-LHC

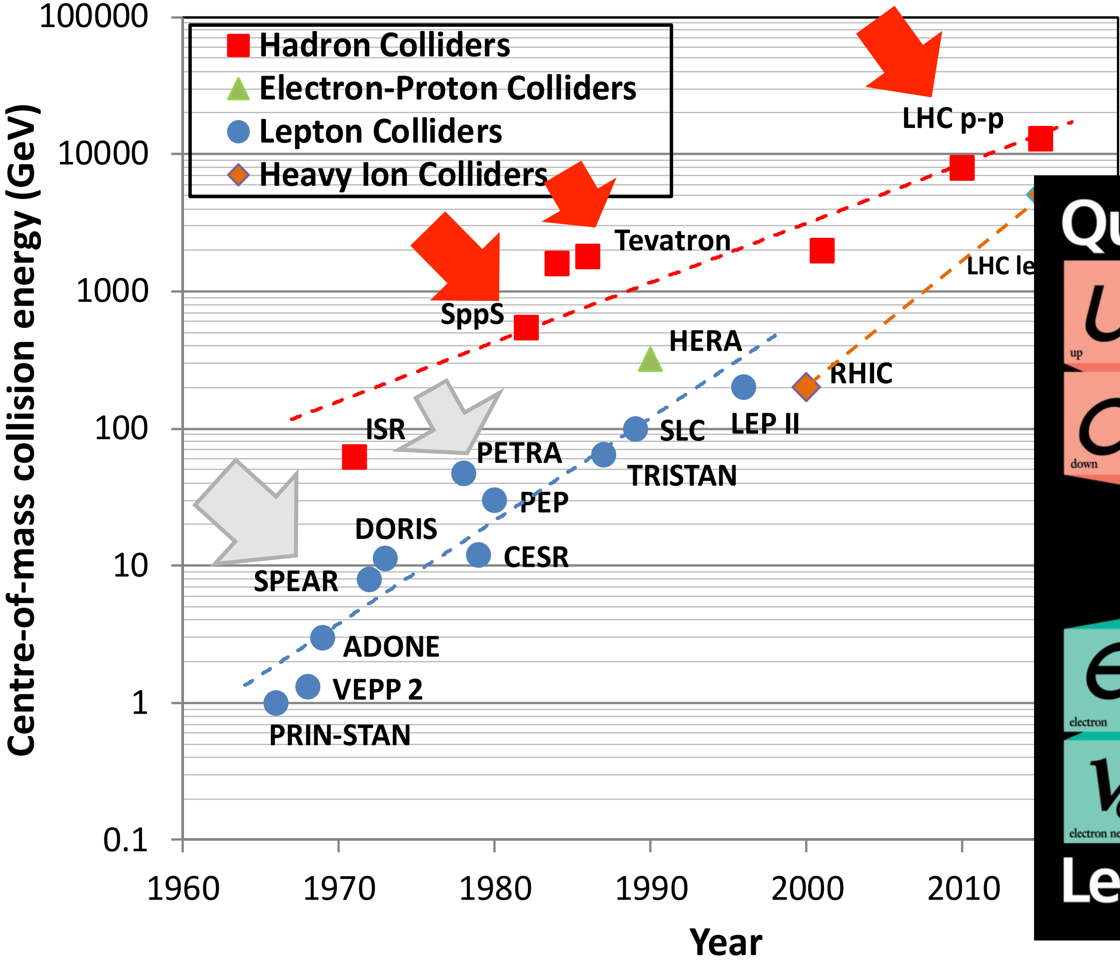
FCC hh ee he
EuroCirCol
EuCARD²
XBEAM EXTREME

http://cern.ch/fcc

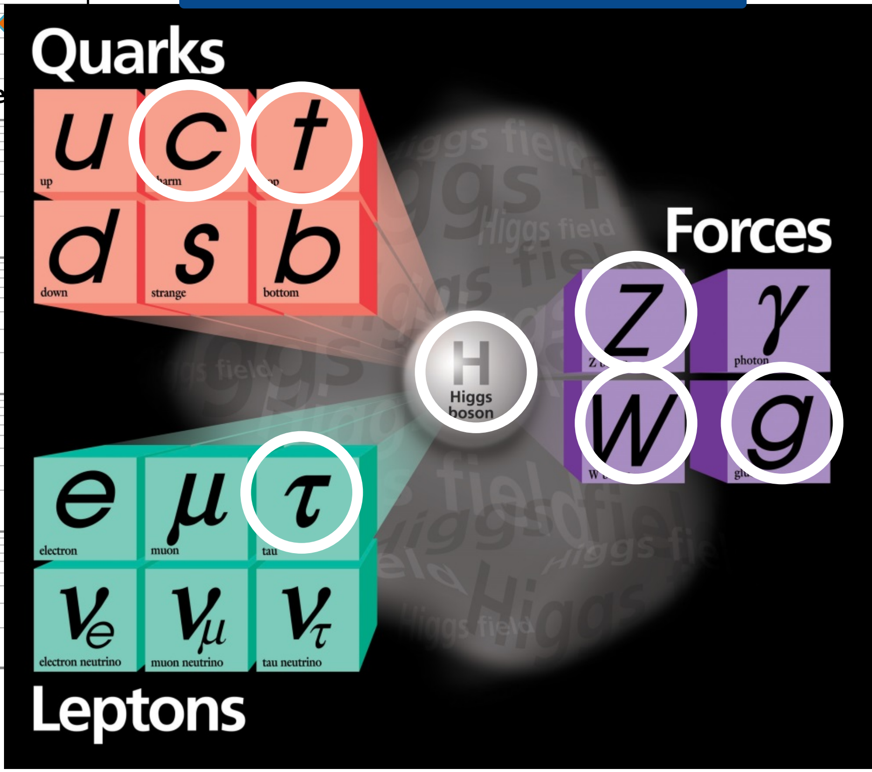
*Work supported by the **European Commission** under Capacities 7th Framework Programme project EuCARD-2, grant agreement 312453, and the HORIZON 2020 project EuroCirCol, grant agreement 654305*

J. Wenninger

colliders and discoveries



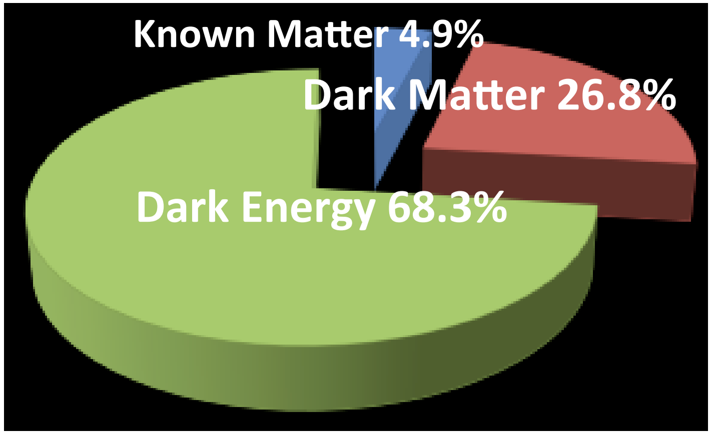
Standard Model Particles and forces

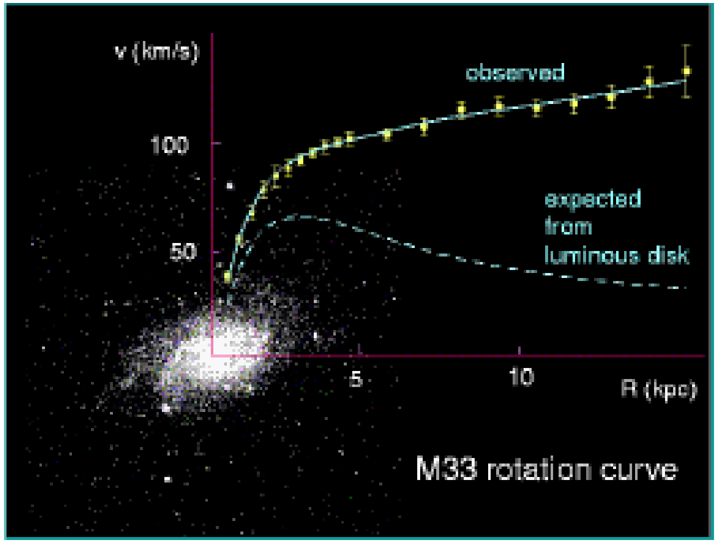


powerful instruments for discovery and precision measurement

many open questions remain

➢ Standard Model describes known matter, i.e. 5% of the universe!

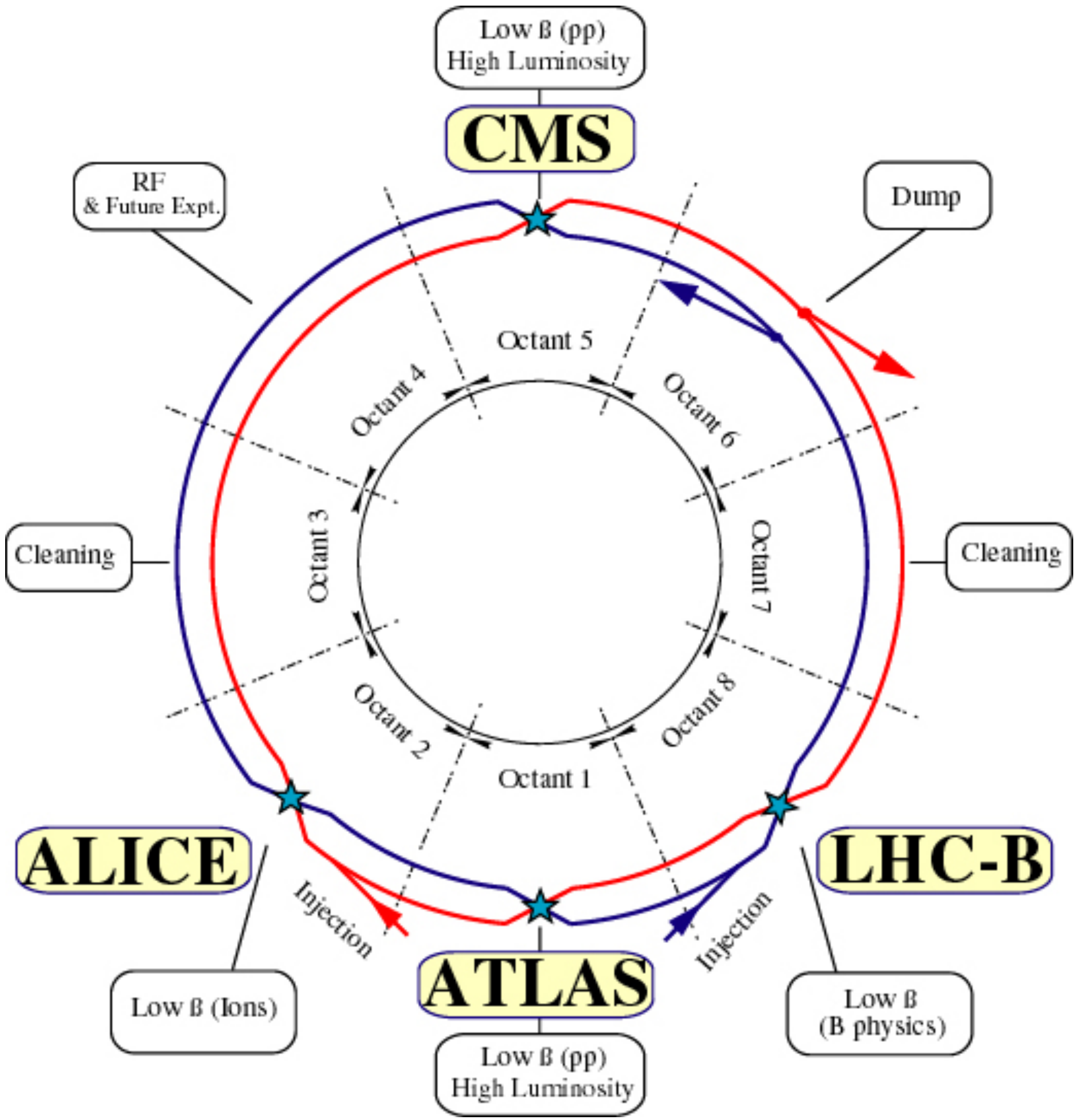




galaxy rotation curves, 1933 - Zwicky

➢ what is dark matter?
➢ what is dark energy?
➢ why is there more matter than antimatter?
➢ why do the masses differ by more than 13 orders of magnitude?
➢ do fundamental forces unify in single field theory?
➢ what about gravity?
➢ is there a "world equation – theory of everything"? …

LHC: highest energy *pp*, *AA*, and *pA* collider



design parameters

c.m. energy = 14 TeV (*p*)
luminosity =10^{34} $cm^{-2}s^{-1}$

1.15×10^{11} p/bunch
2808 bunches/beam

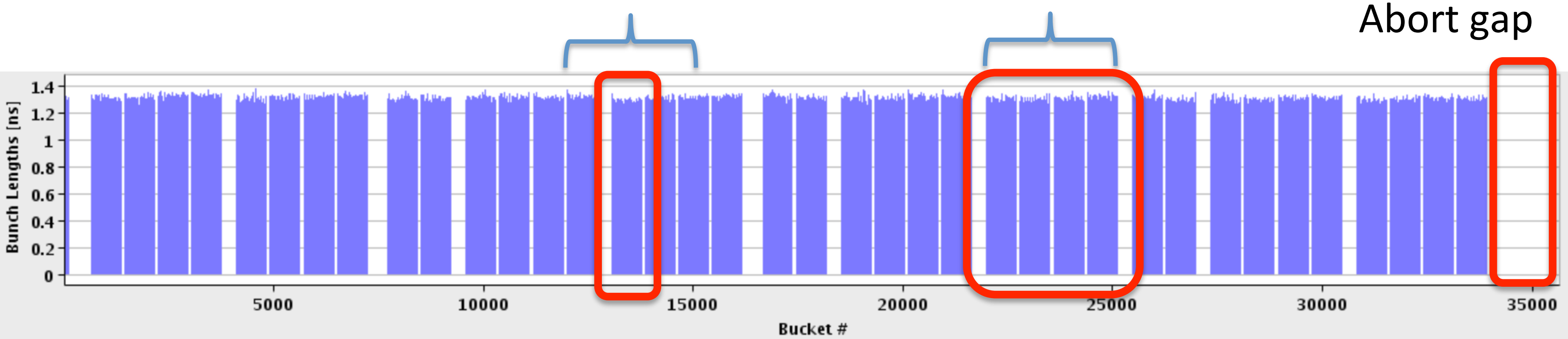
360 MJ/beam

ge=3.75 mm
b*=0.55 m
q_c=285 mrad
s_z=7.55 cm
s*=16.6mm

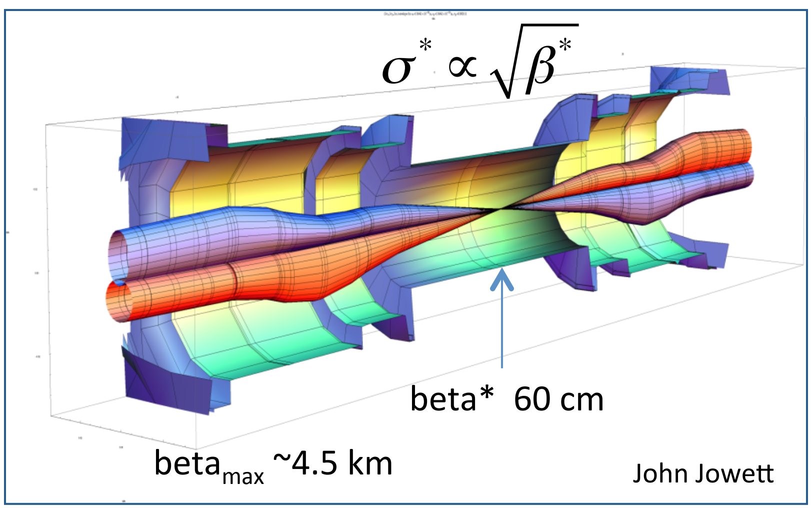
1 PS batch
(36 bunches)

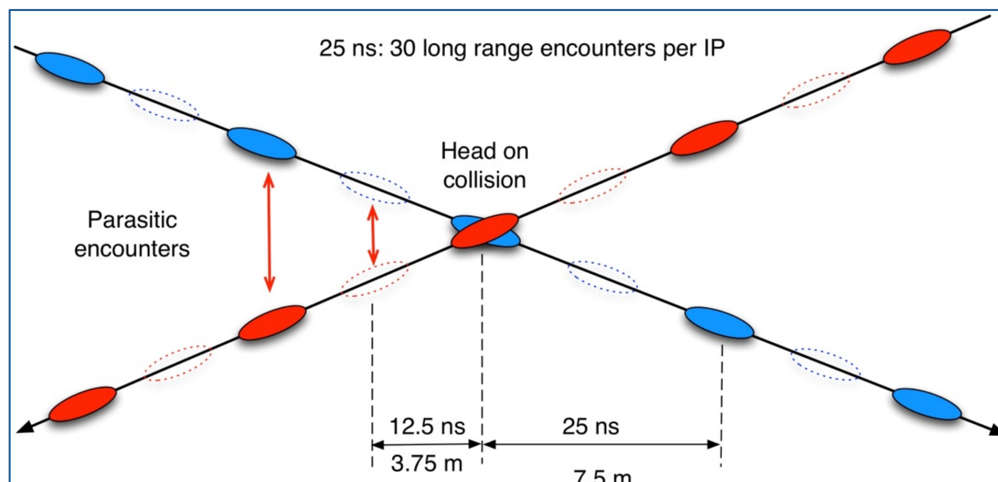
1 SPS batch
(144 bunches)

Abort gap



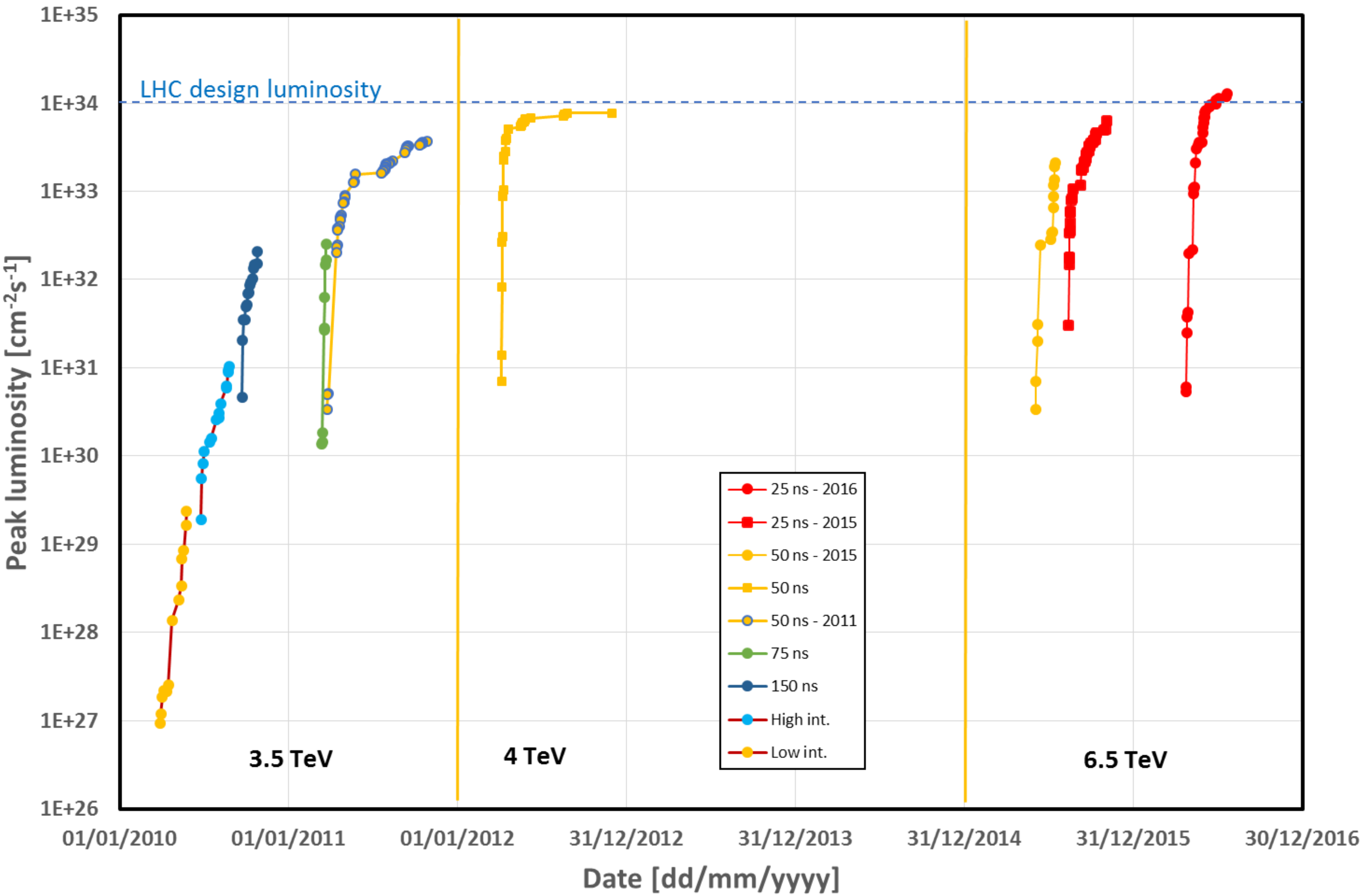
26.7 km - 1380 bunches in 2012, ~2800 in 2015



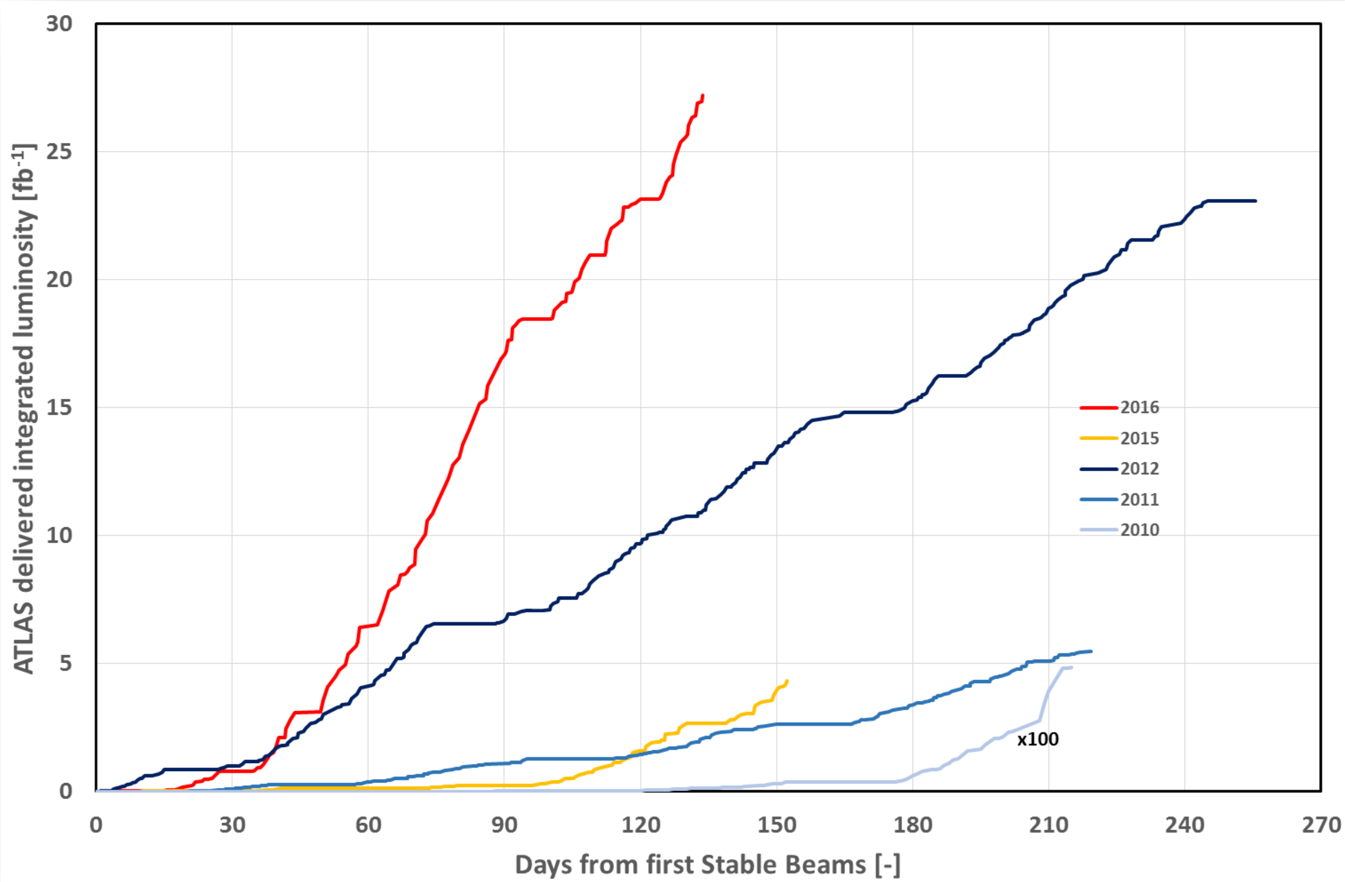


M. Lamont

this summer LHC reached its design luminosity



integrated luminosities



2016 delivered integrated Luminosities

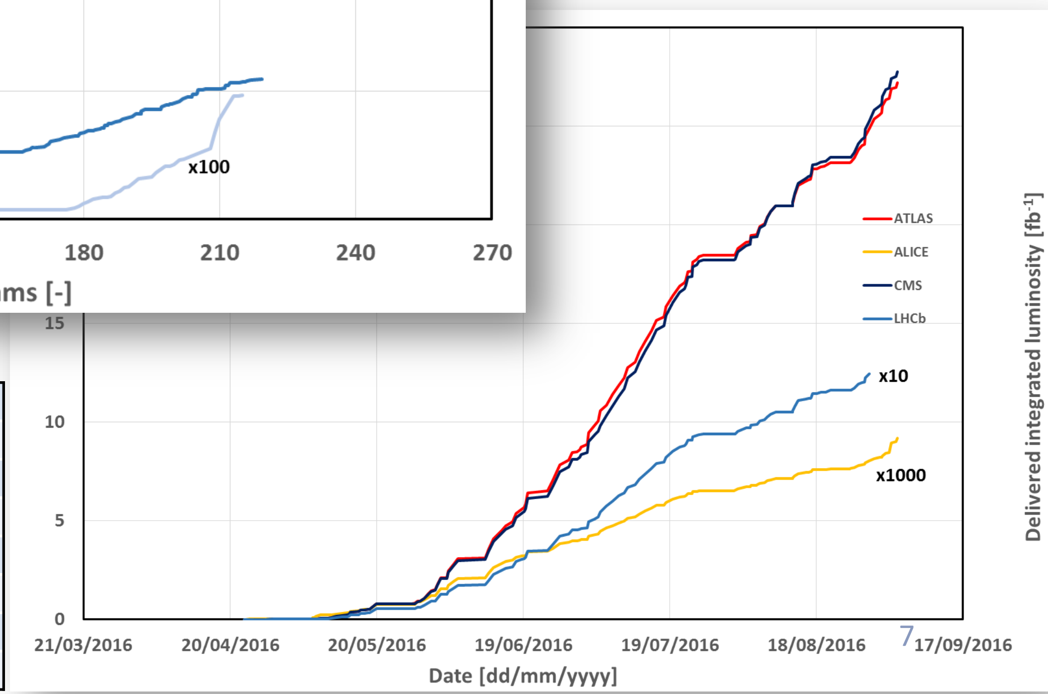
(update 30/08)

ATLAS: 27.2 fb^{-1}

ALICE: 9.2 pb^{-1}

CMS: 27.8 fb^{-1}

LHCb: 1.4 fb^{-1}



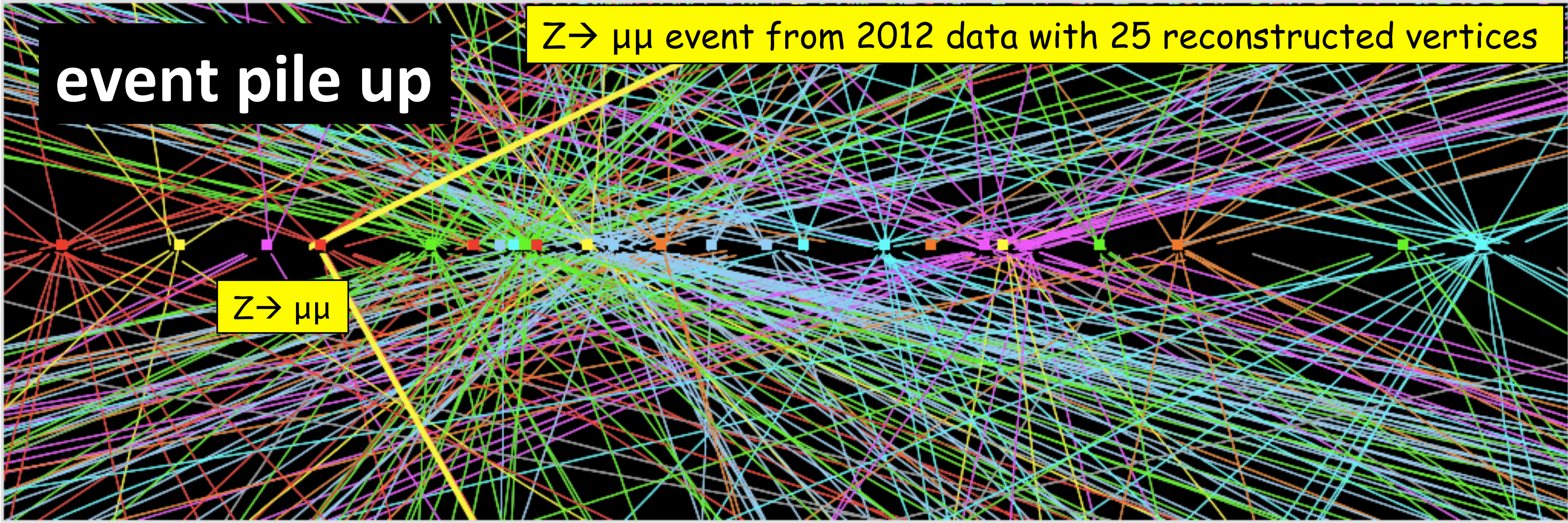
2016 parameters

Energy	6.5 TeV
Bunch spacing	25 ns
Bunch population	~1.1-1.2e11 p/b
Max bunches/injection	72/96
Max. number bunches	2220
Nc GPDs	2208
Beta* GPDs	40 cm
Crossing angle GPDs	185 mrad

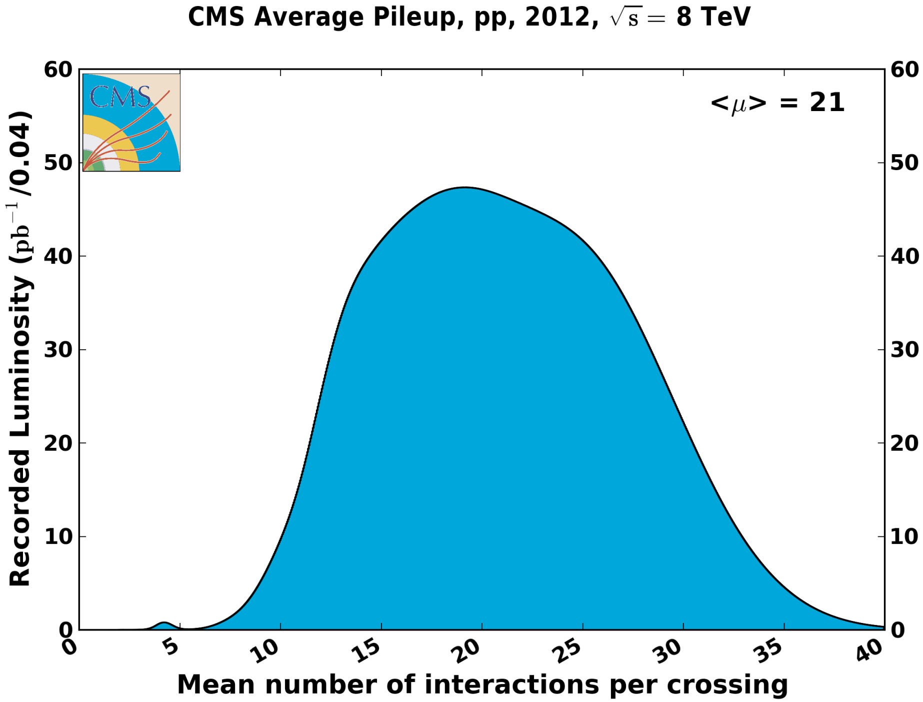
LHC parameters – achieved versus design

parameter	unit	LHC design (2004)	LHC July 2016
beam energy	TeV	7	**6.5**
bunch population N_b	10^{11}	1.15	**1.18**
bunch spacing	ns	25	25
no. bunches / beam	mm	2808	**2076** (limited by SPS beam dump)
beam current	A	0.58	**0.44**
norm. rms emittance ge$_{x,y}$ at start of physics		3.75	**2.6**
IP beta function b$_{x,y}$ (1/2/5/8)	m	0.55/ 10 / 0.55 / 1-50	**0.4** / 10 / **0.4** / 3
rms IP beam size	mm	16.6	**12.3**
rms bunch length	cm	7.55	7.88
full crossing angle (IPs 1 and 5)	mrad	285	**370**
luminosity	10^{34} cm^{-2} s^{-1}	1.0	**1.1**
events / crossing (pile up)		19	**27**
average luminosity lifetime	h	15	**24**

event pile up



2012:
50 ns
bunch
spacing



M. Lamont, IPAC'13

for 25 years many experts told me LHC would never work because of this or because of that …

but it does work beautifully!

lessons from the LHC

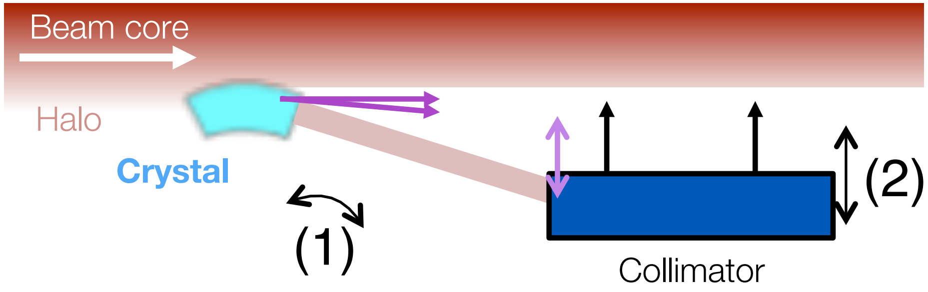
O. Brüning

- **combined experimental interaction and injection regions** (risks & constraints) ***OK***
- **radiation to electronics** → SC links and new caverns for HL-LHC
- **powering in 8 separate sectors** ***OK***
- **noise from klystron driven RF & from power converters** ***OK***
- **field quality, magnet sorting and dynamic aperture** ***OK***
- **"snap back" and dynamic magnet effects under control** ***OK***
- **e-cloud** conditioning works, no show stopper, but heat near limit
- **emittance growth** under control ***OK***
- **maximum beam-beam tune shift higher than expected** ***OK***
- **UFO effects** unexpected, but UFO rate decreases with time
- **excellent machine reproducibility from day to day, and year to year**
- **first experience with crystal collimation**

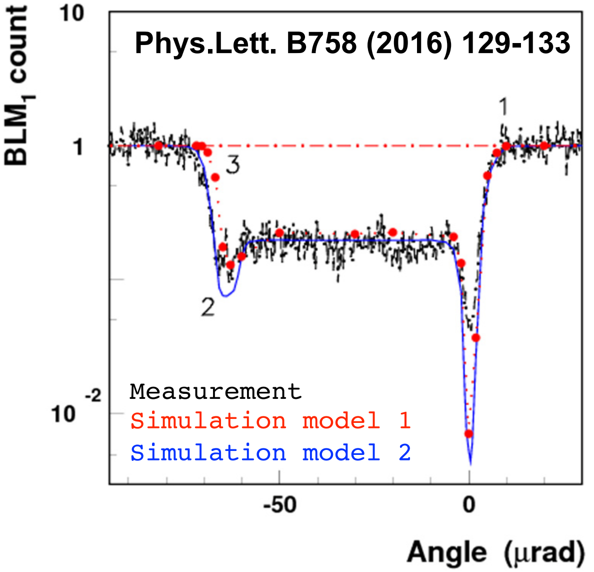
all these lessons are exploited in the design of future hadron colliders

first proton channeling at 6.5 TeV

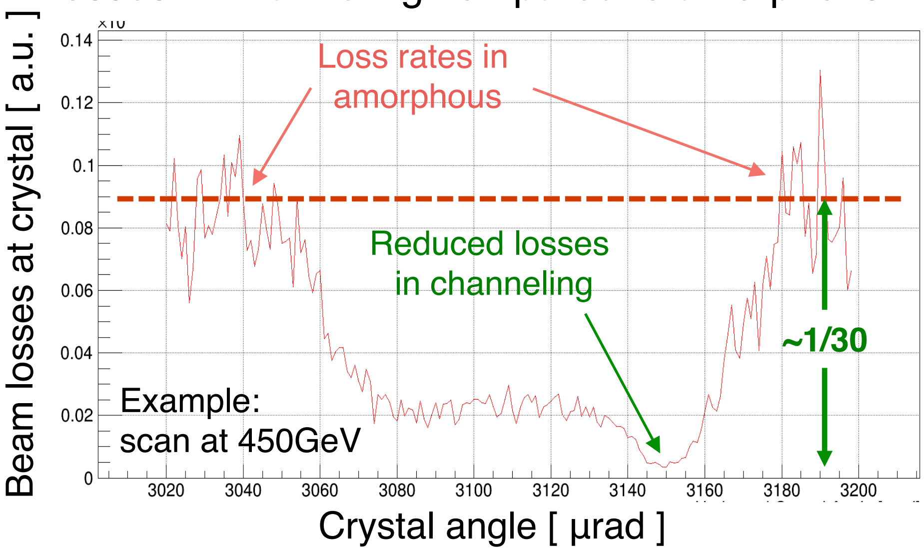
S. Redaelli



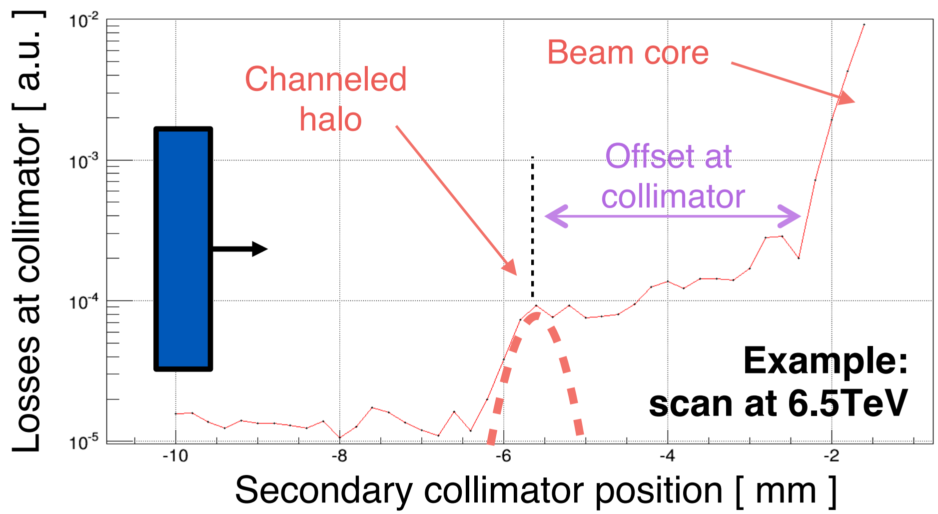
important: achieved required angular control of <1 μrad (A. Masi *et al.*)



(1) **angular scan**: strong reduction of local losses in channeling compared to amorphous



(2) **linear collimator scan**: measures the profile of the channeled halo.



time line for LHC crystal collimation

S. Redaelli

- 2015-2016 (start of Run II): crystal test stand on beam 1

  two crystals, one per plane. Different technologies (quasi-mosaic / strip)

- 2017-2018 (last 2 years of Run II): New crystal test stand also on beam 2

  plan an installation during this end-of-year technical stop (EYETS2016): <u>2 crystals</u>
  aim at testing new technology for goniometer; need better control of bending angles
  want 50.0 ± 2.5 mrad, for first installation got ~40mrad (quasi-mosaic) and ~65mrad (strip)

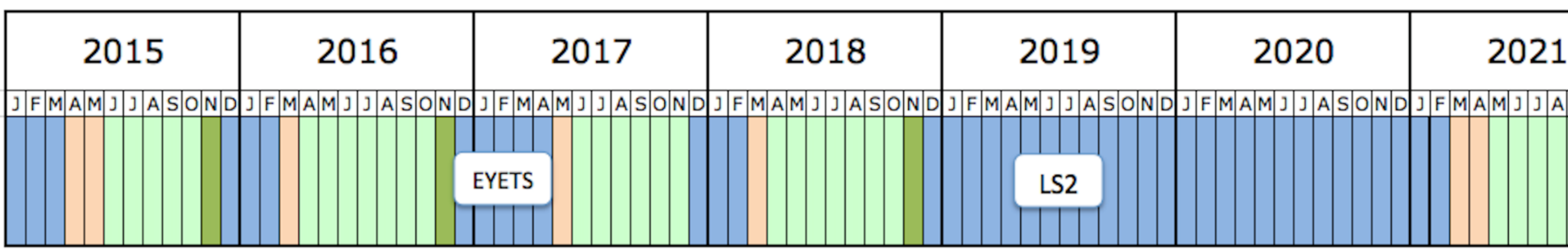
- EYETS2017: possible upgrade of "old" beam 1 goniometers.

  <u>if</u> beam experience indicates need for testing the new goniometers on both beams

- LHC second long shutdown (LS2): 4 new crystals for ion collimation

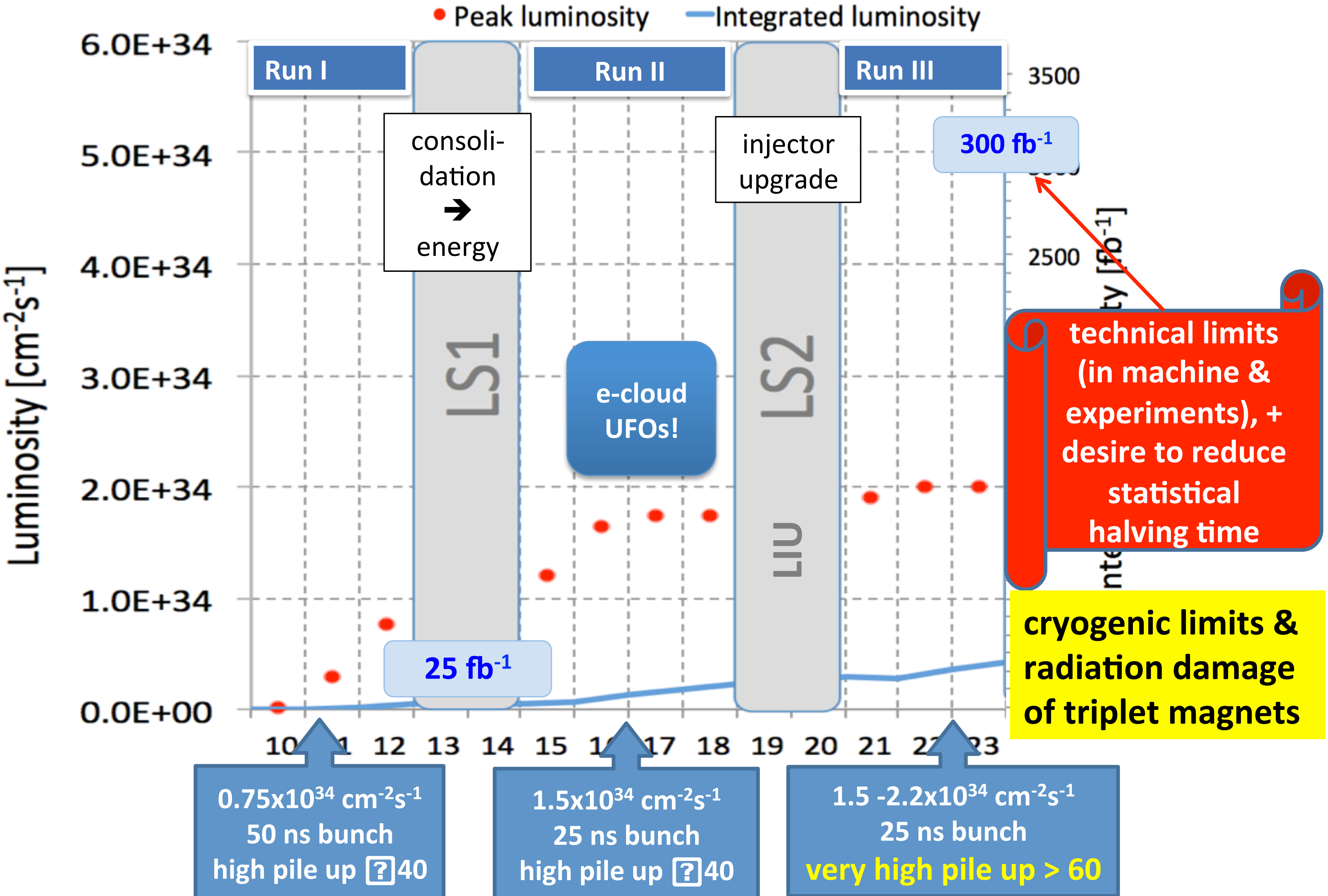
  NOT a baseline *within the HL-LHC project, but R&D funding available to prepare for this; use of 4 crystals requires production of ~10 units (including spares).*

- crystals for LHC fixed target experiment – larger angles above 200 mrad – waiting for feedback from recent "Physics Beyond Colliders" workshop



Y. Papaphilippou

LHC upgrade: HL-LHC



HL-LHC Goals

- prepare machine for operation beyond 2025 and up to **2035**
- beam parameters and operation scenarios for

  total integrated luminosity of **3000 fb^{-1}**

implying an integrated luminosity of **250 fb^{-1} per year**,

limit **m→140** (➔ peak luminosity **5x10^{34} cm^{-2} s^{-1}**)

➔ operation with levelled luminosity!

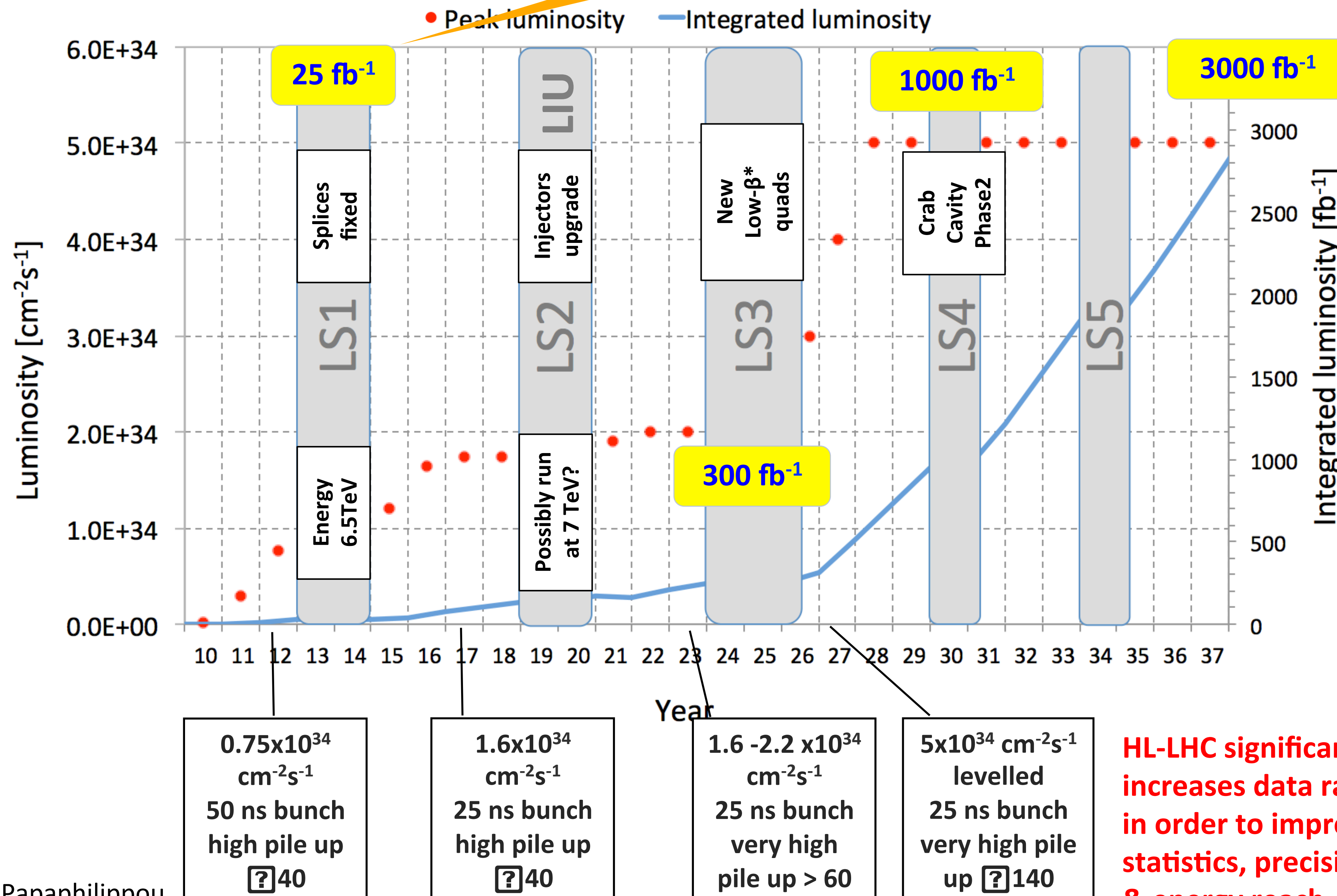
➔10 times luminosity of first 10 years of LHC operation

HL-LHC parameters with latest update

parameter	**nominal LHC**	**HL-LHC original**	**HL-LHC (2016)**
bunch population N_b $[10^{11}]$	1.15	2.2	2.2
number of bunches	2808	2748	2748
beam current [A]	0.58	1.12	1.12
stored Beam Energy [MJ]	362	677	677
full crossing angle [mrad]	285	590	512
crossing angle with crab cavities [mrad]	-	0	150
beam separation [s]	9.9	12.5	12.5
b^* [m]	0.55	0.15	0.2
normalized emittance e_n [mm]	3.75	2.5	2.5
r.m.s. bunch length [cm]	7.55	8.1	8.1
virtual luminosity (w/o CC) $[10^{34}\ cm^{-2}s^{-1}]$	1.2 (1.0)	21.3 (7.2)	13.8 (6.95)
max. luminosity $[10^{34}\ cm^{-2}s^{-1}]$	1	5.3	5.3
levelled pile-up/pile-up density [evt. | evt./mm]	26/0.2	140/1.2	140/1.2

Y. Papaphilippou, Thessaloniki, 4 September 2016

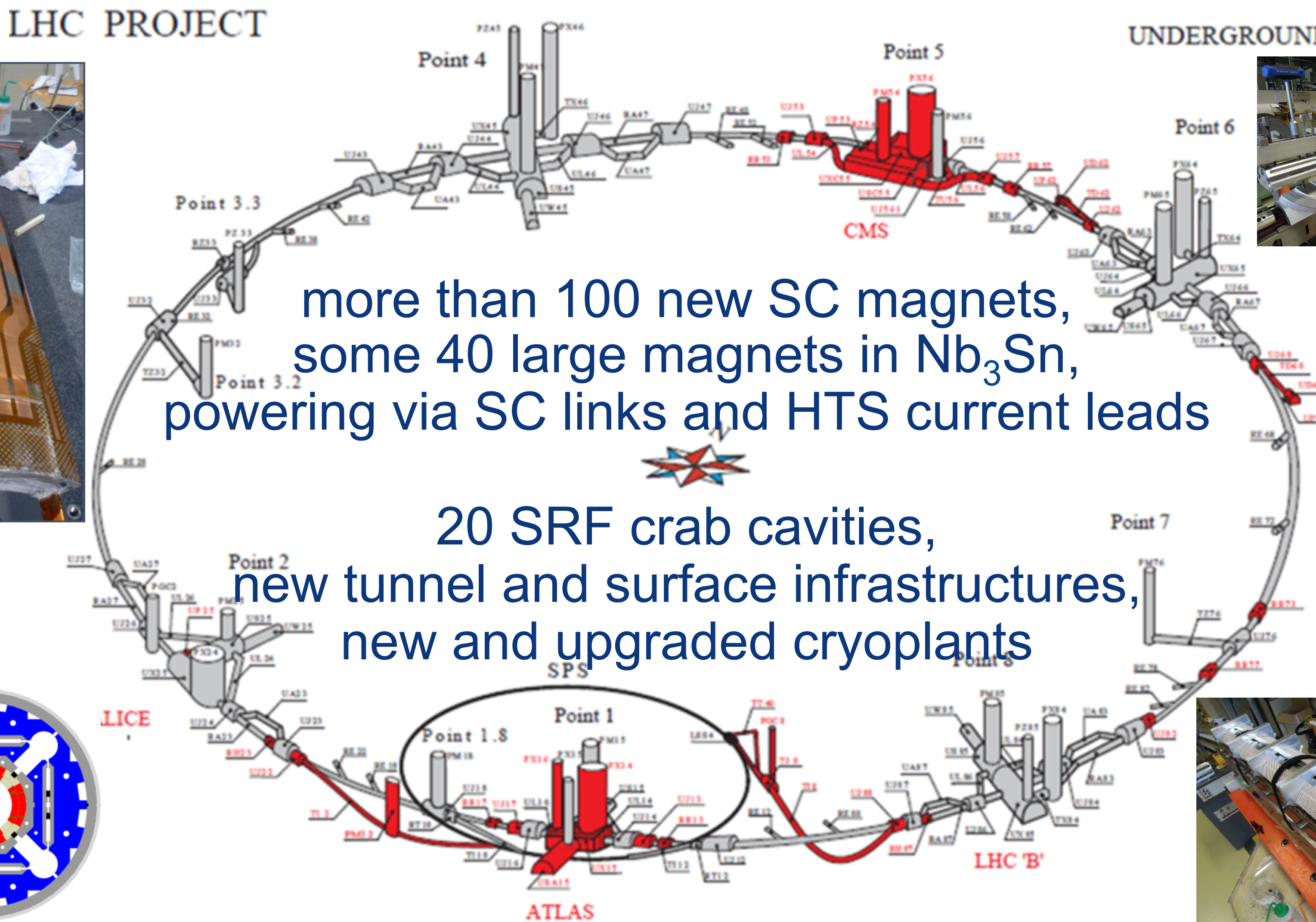
HL-LHC projections



Y. Papaphilippou

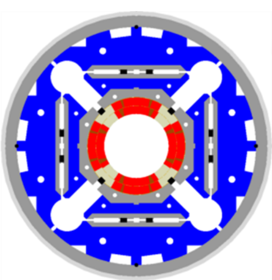
HL-LHC significantly increases data rate in order to improve statistics, precision, & energy reach

High Luminosity LHC project



more than 100 new SC magnets,
some 40 large magnets in Nb_3Sn,
powering via SC links and HTS current leads

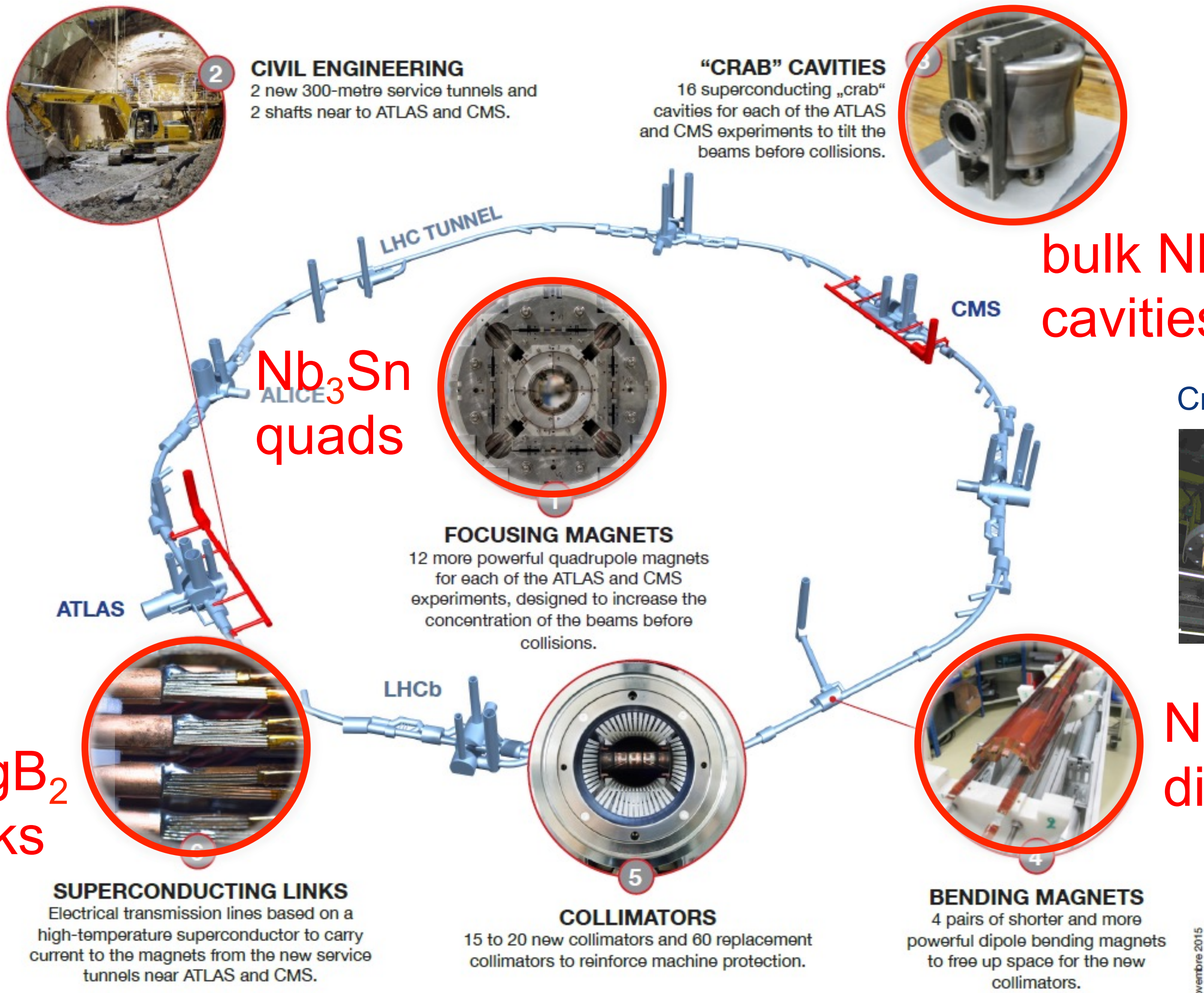
20 SRF crab cavities,
new tunnel and surface infrastructures,
new and upgraded cryoplants



L. Rossi

HL LHC project landmarks

Cryo@P4



bulk Nb cavities

Nb_3Sn quads

Cryo@P1-P5

MgB_2 links

Nb_3Sn dipoles

Nb_3Sn for the first time in a hadron accelerator (? 30 tons)

short LHC history

1983 *LEP Note 440* - S. Myers and W. Schnell propose twin-ring *pp* collider in LEP tunnel with 9-T dipoles

1991 CERN Council: LHC approval in principle

1992 EoI, LoI of experiments

1993 SSC termination

1994 CERN Council: LHC approval

1995-98 cooperation w. Japan, India, Russia, Canada & US

2000 LEP completion

2006 last s.c. dipole delivered

2008 first beam

2010 first collisions at 3.5 TeV beam energy

2016 collisions at ~design energy and design luminosity

>30 years!

now is the time to plan for 2040

LEP Note 440
11.4.1983

PRELIMINARY PERFORMANCE ESTIMATES FOR A LEP PROTON COLLIDER

S. Myers and W. Schnell

beyond LHC/HL-LHC

- **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,…."

- **U.S. Strategy and "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 of physics results that can be acquired in the P5 time window…."

- **ICFA statement 2014:**

  "…. ICFA supports studies of energy frontier circular colliders and encourages global coordination.…."

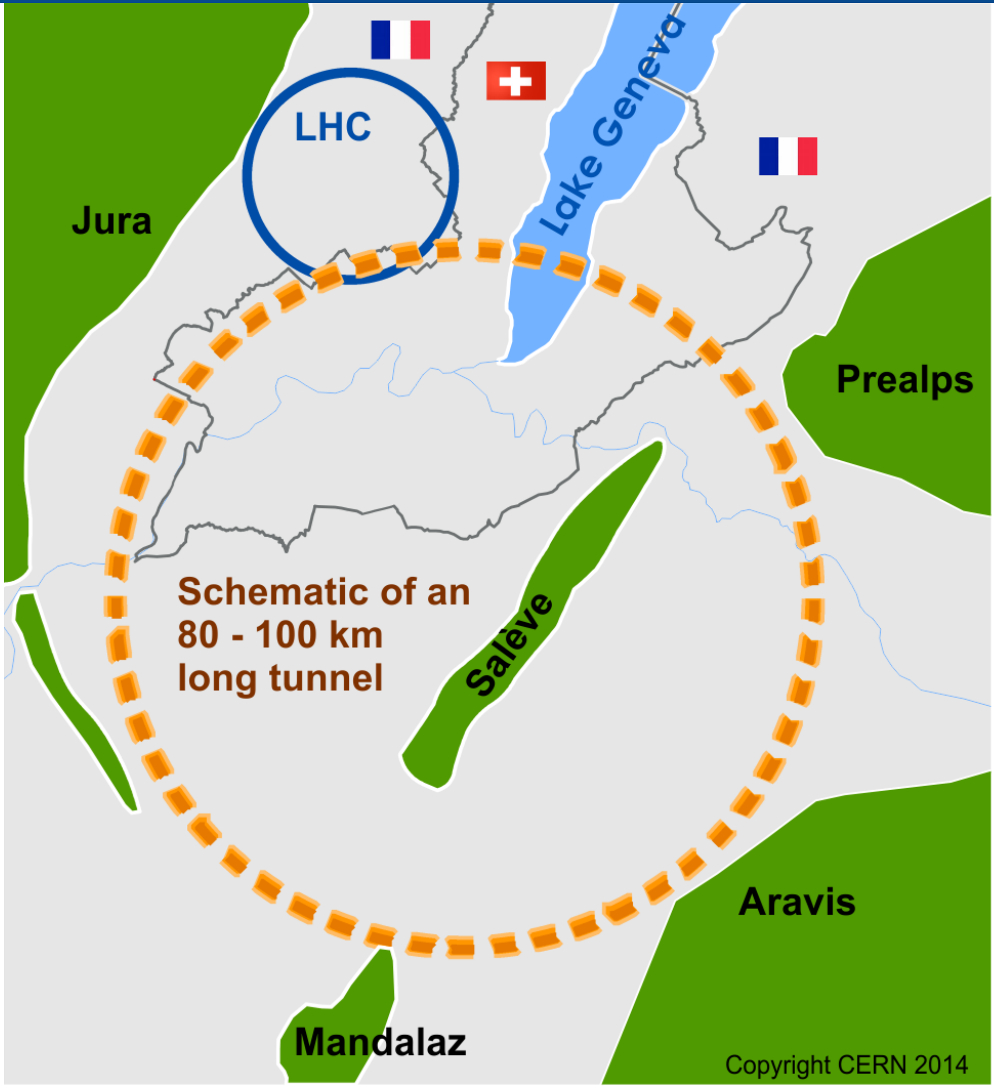
Future Circular Collider Study
GOAL: CDR and cost review for the next ESU (2019)

international FCC collaboration (CERN as host lab) to study:

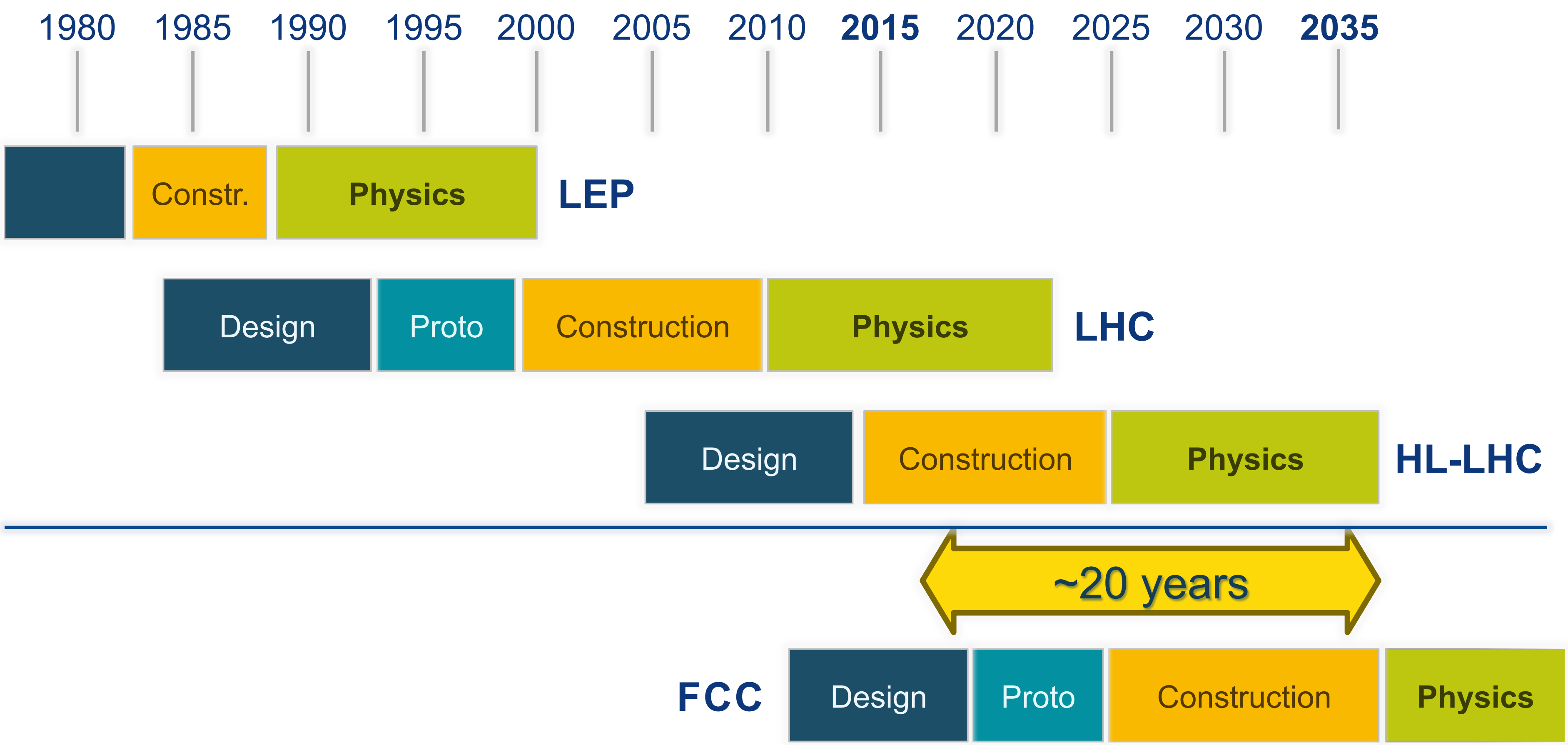
- ***pp*-collider (*FCC-hh*)**
  → main emphasis, defining infrastructure requirements

~16 T ? 100 TeV *pp* in 100 km

- **80-100 km tunnel infrastructure** in Geneva area, site specific
- ***e*⁺*e*⁻ collider (*FCC-ee*),** as potential first step
- ***p-e* (*FCC-he*) option,** integration one IP, FCC-hh & ERL
- **HE-LHC** with *FCC-hh* technology



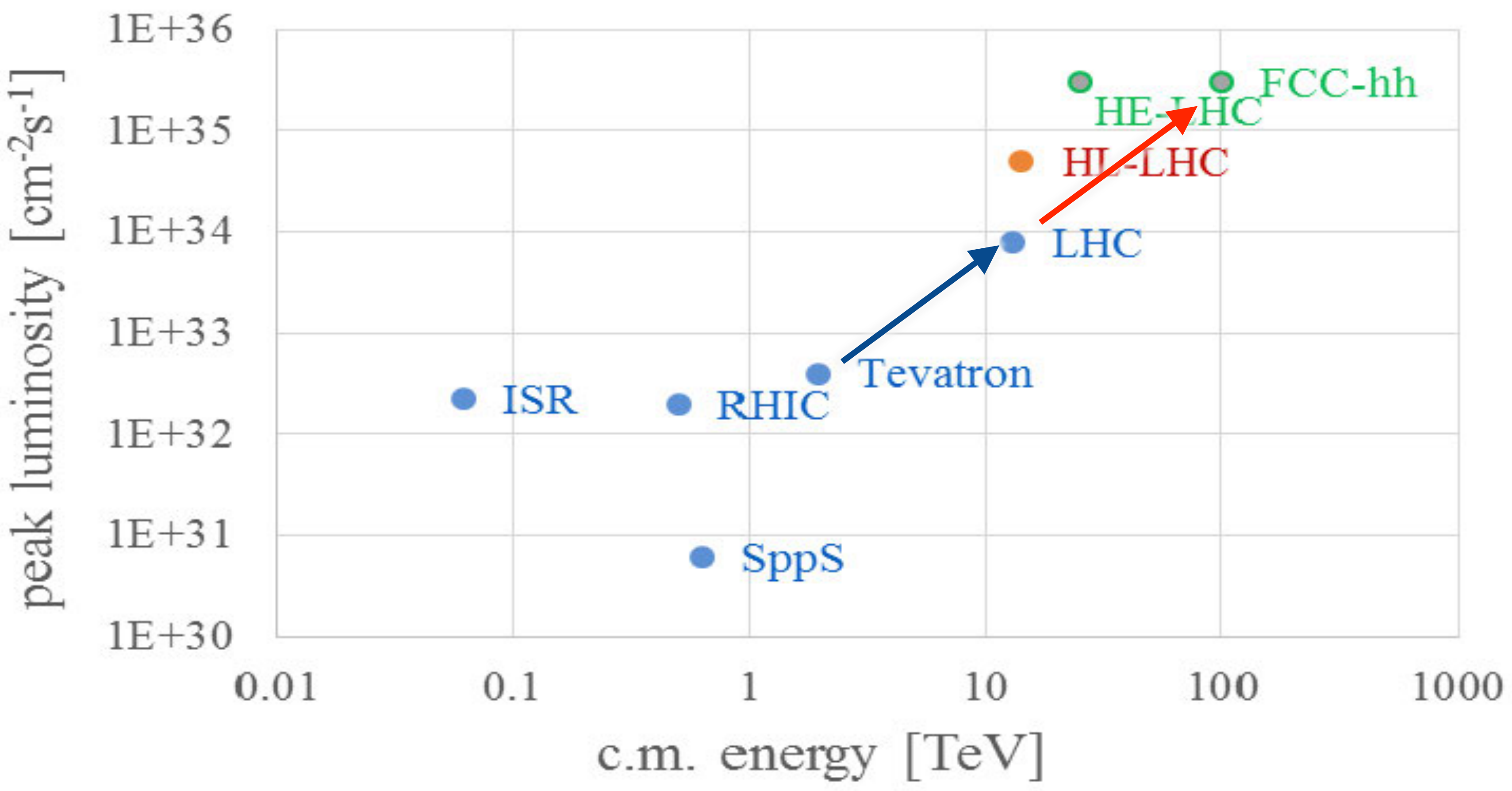
CERN circular colliders & FCC



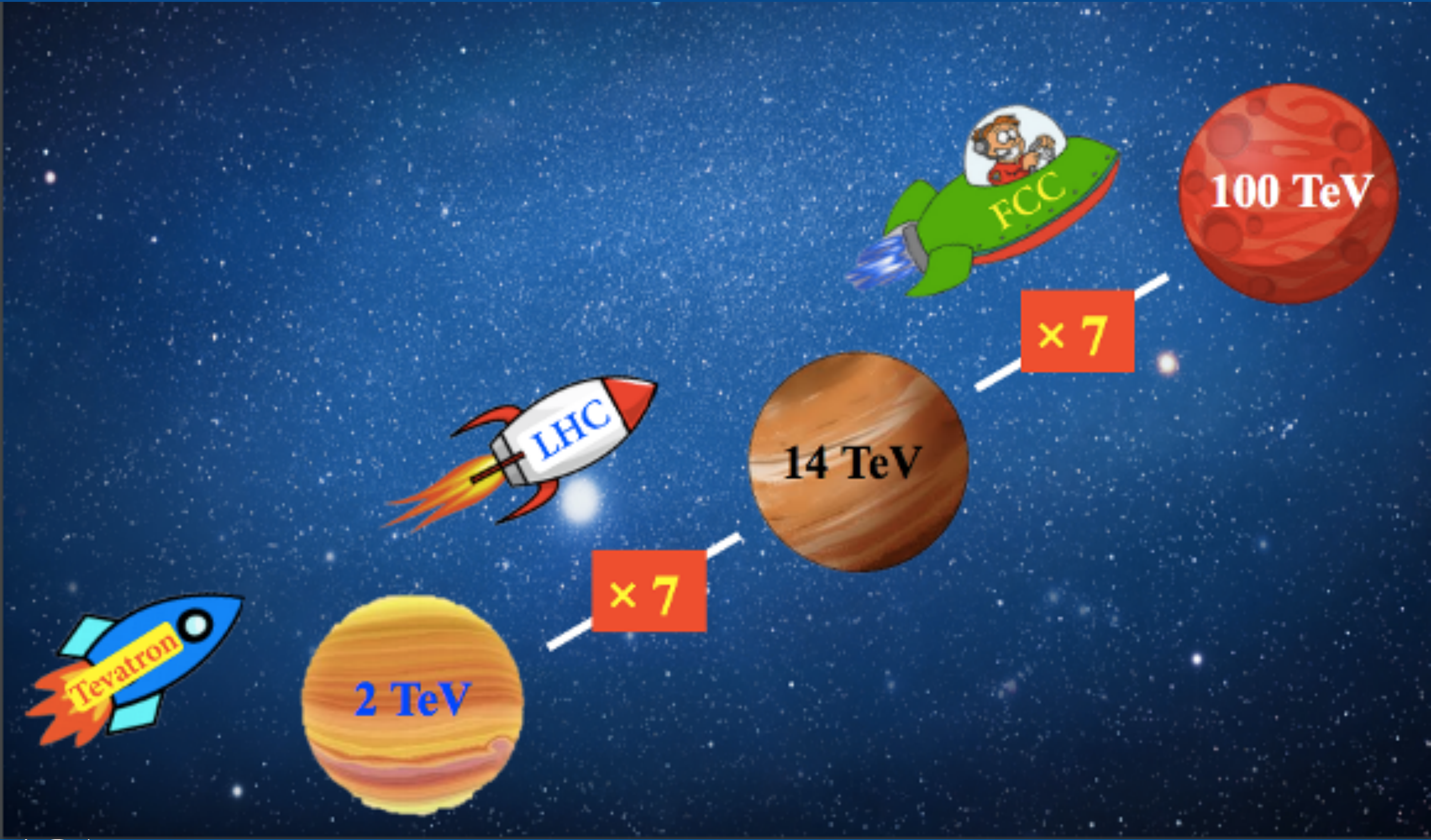
must advance fast now to be ready for the period 2035 – 2040;
goal of phase 1: CDR by end 2018 for next update of European Strategy

M. Benedikt,
F. Gianotti

pp/p-pbar in the *L-E* plane



unravelling the universe with a sequence of hadron colliders



G. Giudice

site investigations

Alignment | Shafts | Query

Choose alignment option

100km quasi-circular

Tunnel elevation at centre:261mASL

Grad. Params

Azimuth (°): -20

Slope Angle x-x(%): 0.65

Slope Angle y-y(%): 0

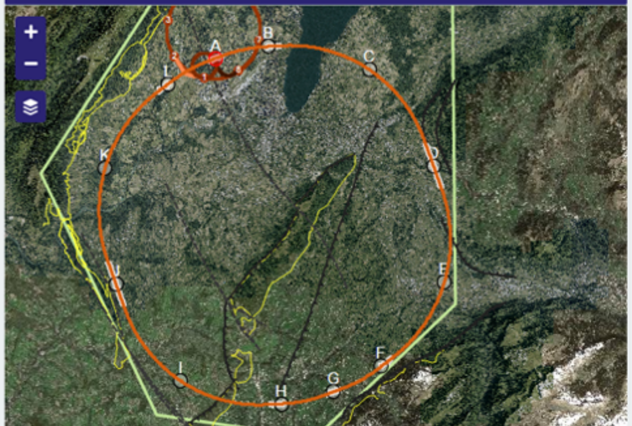
LOAD | SAVE | CALCULATE

Alignment centre

X: 2499731 Y: 1108403

	CP 1		CP 2	
	Angle	Depth	Angle	Depth
LHC	-64°	220m	64°	172m
SPS		242m		241m
TI2		235m		241m
TI8		242m		170m

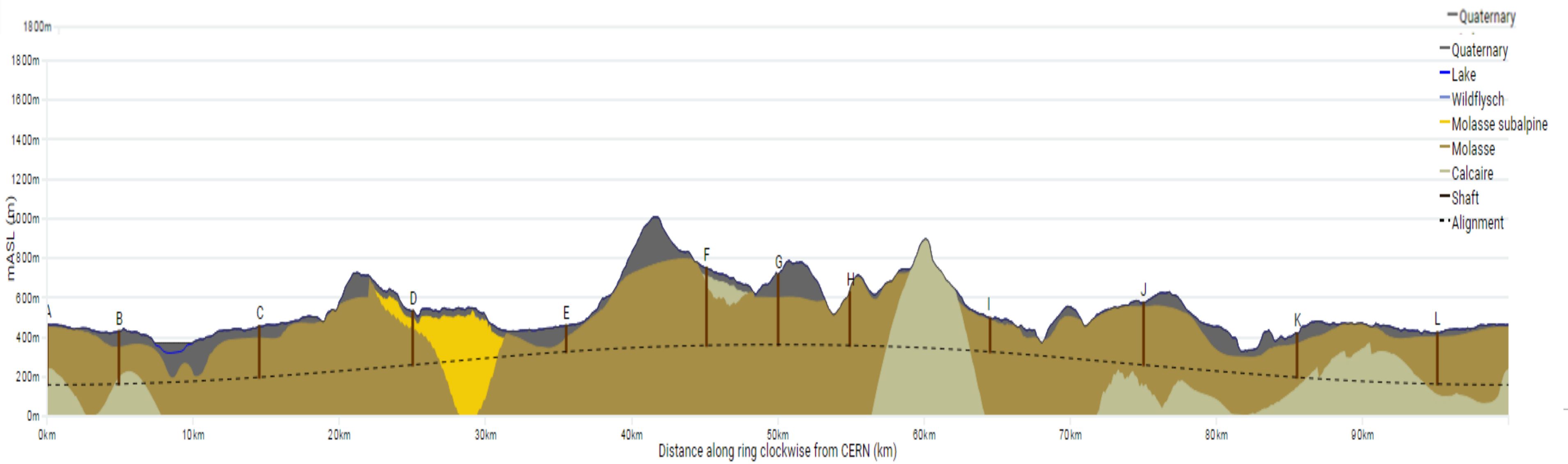
Alignment Location



Geology Intersected by Shafts | Shaft Depths

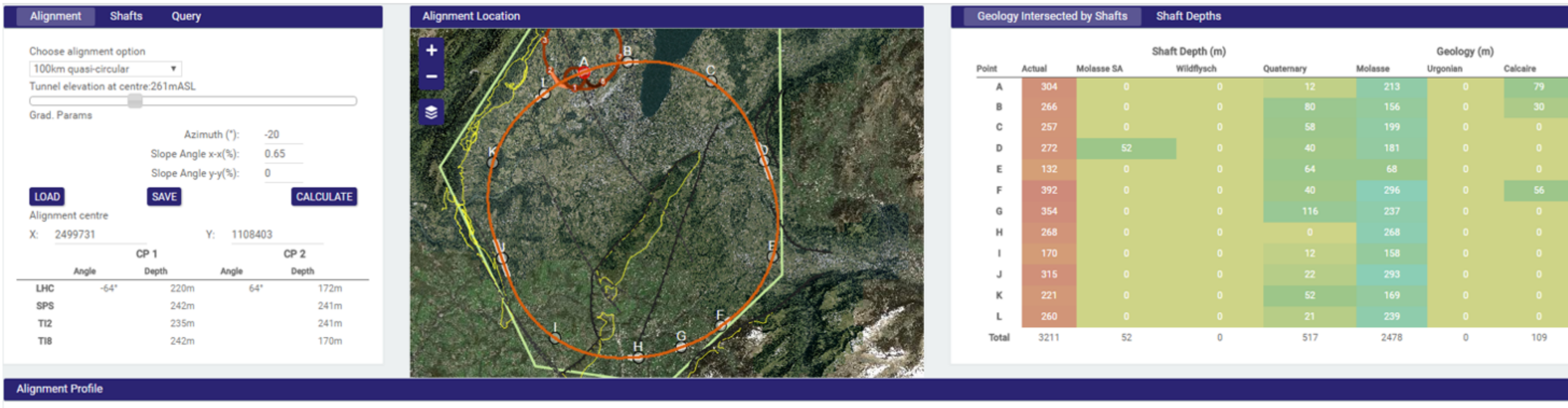
	Shaft Depth (m)			Geology (m)			
Point	Actual	Molasse SA	Wildflysch	Quaternary	Molasse	Urgonian	Calcaire
A	304	0	0	12	213	0	79
B	266	0	0	80	156	0	30
C	257	0	0	58	199	0	0
D	272	52	0	40	181	0	0
E	132	0	0	64	68	0	0
F	392	0	0	40	296	0	56
G	354	0	0	116	237	0	0
H	268	0	0	0	268	0	0
I	170	0	0	12	158	0	0
J	315	0	0	22	293	0	0
K	221	0	0	52	169	0	0
L	260	0	0	21	239	0	0
Total	3211	52	0	517	2478	0	109

Alignment Profile



C. Cook, J. Osborne

site investigations



Point	Shaft Depth (m) Actual	Molasse SA	Wildflysch	Quaternary	Geology (m) Molasse	Urgonian	Calcaire
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J	315	0	0	22	293	0	0
K	221	0	0	52	169	0	0
L	260	0	0	21	239	0	0
Total	3211	52	0	517	2478	0	109

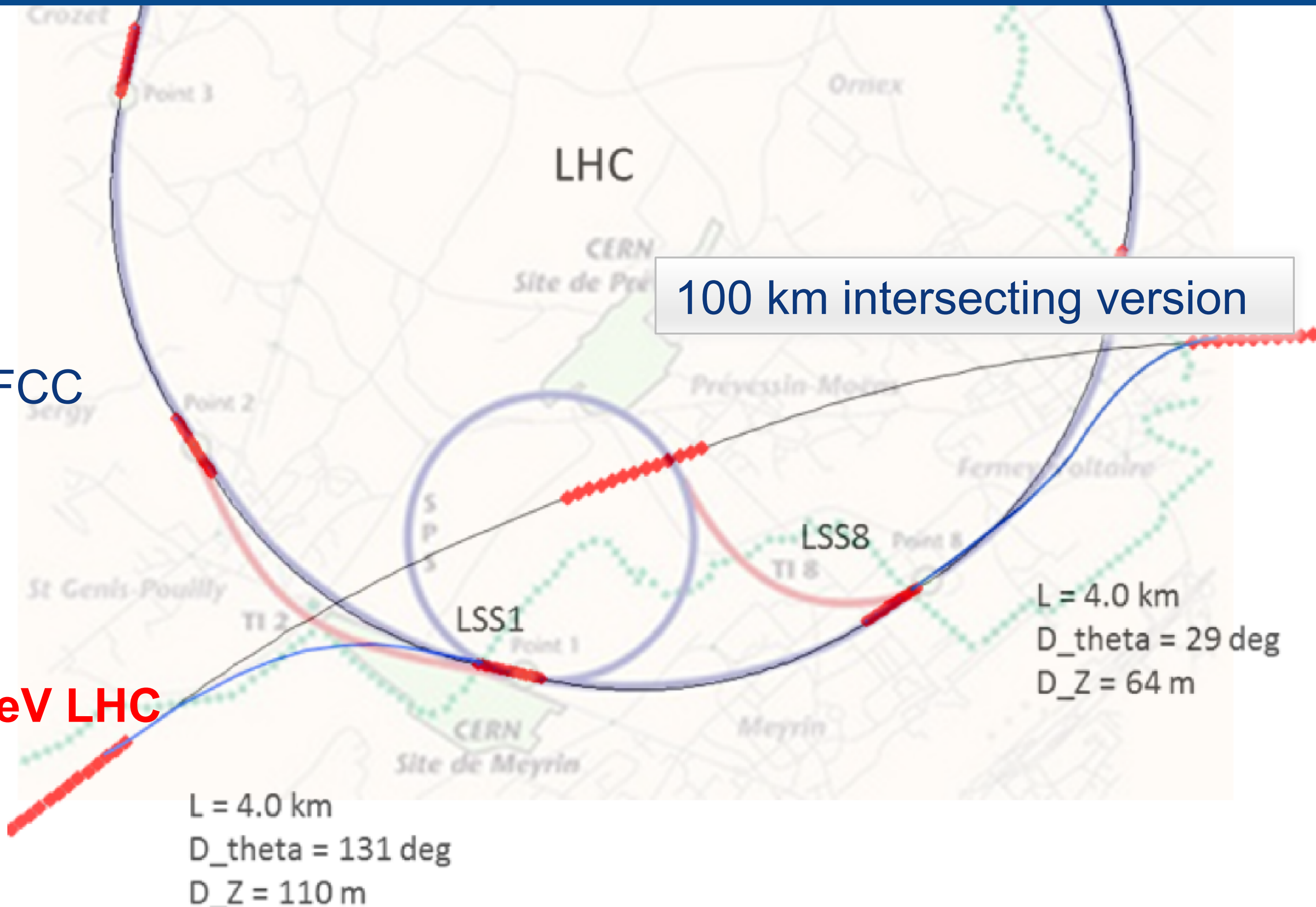
- 90 – 100 km fits geological situation well
- LHC suitable as potential injector
- the 100 km version, intersecting LHC, is now being studied in more detail

C. Cook,
J. Osborne

FCC-hh injector studies

injector options:

- **SPS → LHC → FCC**
- SPS/SPS$_{upgrade}$ → FCC
- SPS -> FCC booster → FCC



current baseline:

- **injection energy 3.3 TeV LHC**
- confirmed by review

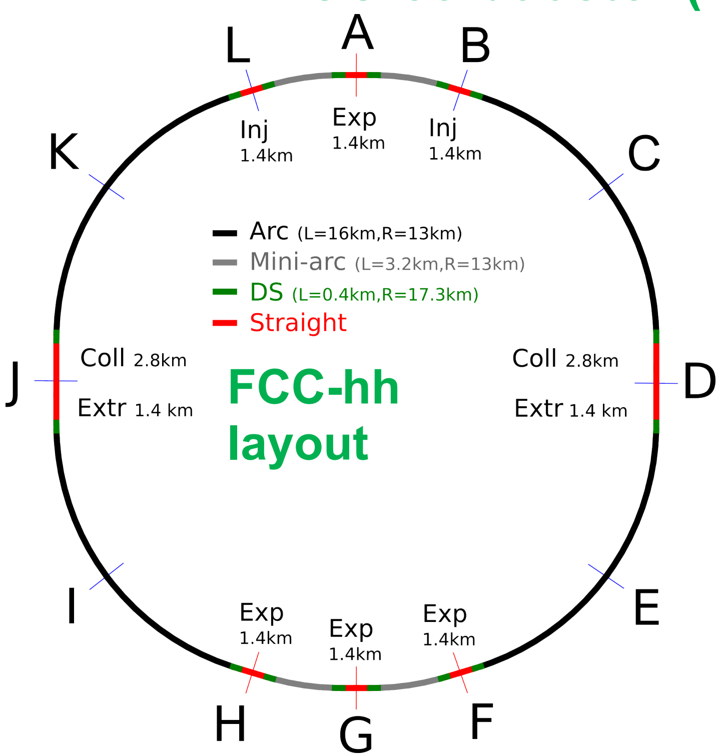
alternative options:

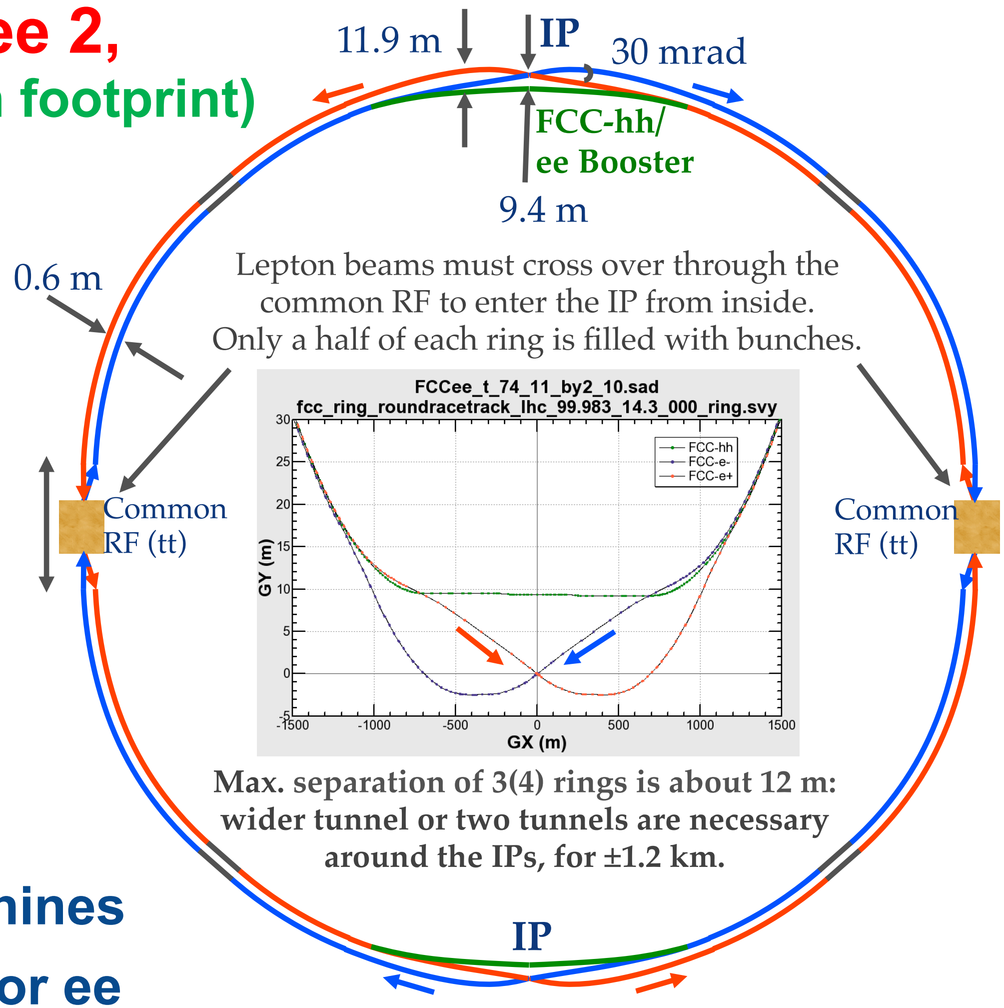
- injection around 1.5 TeV
- **compatible with: SPS$_{upgrade}$, LHC, FCC booster**

W. Bartmann, B. Goddard

common layouts for hh & ee

FCC-ee 1, FCC-ee 2, FCC-ee booster (FCC-hh footprint)

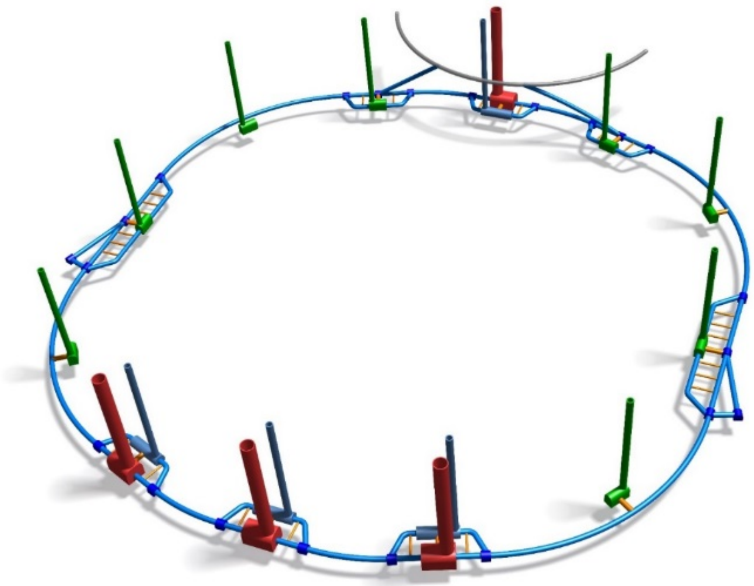


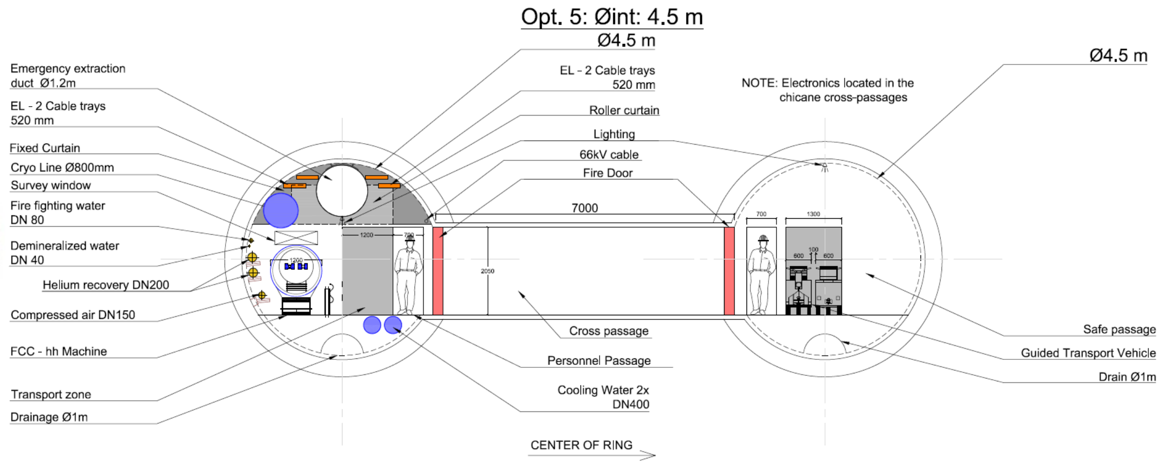


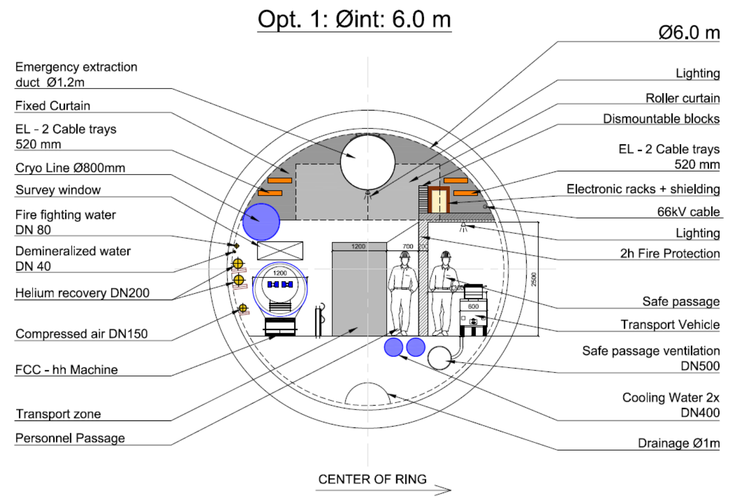
- 2 main IPs in A, G for both machines
- asymmetric IR optic/geometry for ee to limit synchrotron radiation to detector

D. Schulte, K. Oide

CE and TI optimization







more detailed studies launched on

- CE: single vs. double tunnels
- CE: caverns, shafts, underground layout
- technical infrastructures
- safety, access
- transport, integration, installation
- operation aspects

J. Osborne

hadron collider parameters

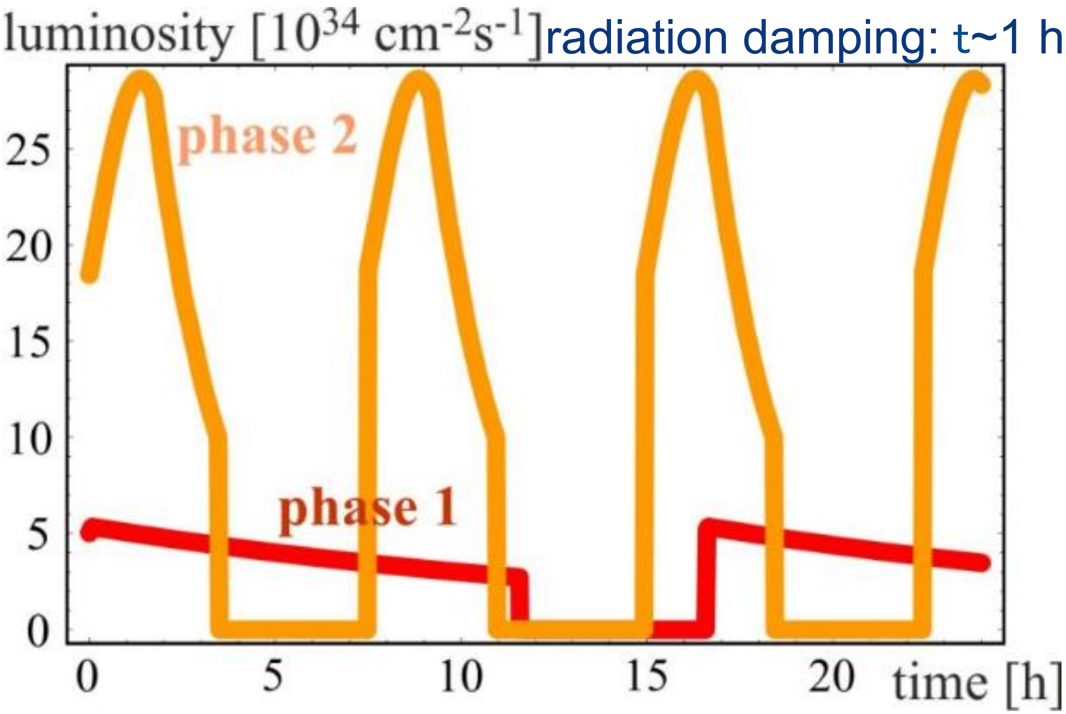
parameter	FCC-hh		SPPC	HE-LHC* *tentative	(HL) LHC
collision energy cms [TeV]	**100**		71.2	**>25**	14
dipole field [T]	**16**		20	**16**	8.3
circumference [km]	**100**		54	**27**	27
# IP	**2 main & 2**		2	**2 & 2**	2 & 2
beam current [A]	**0.5**		1.0	**1.12**	(1.12) 0.58
bunch intensity [10^{11}]	**1**	**1 (0.2)**	2	**2.2**	(2.2) 1.15
bunch spacing [ns]	**25**	**25 (5)**	25	**25**	25
beta* [m]	**1.1**	**0.3**	0.75	**0.25**	(0.15) 0.55
luminosity/IP [10^{34} $cm^{-2}s^{-1}$]	**5**	**20 - 30**	12	**>25**	(5) 1
events/bunch crossing	**170**	**<1020 (204)**	400	**850**	(135) 27
stored energy/beam [GJ]	**8.4**		6.6	**1.2**	(0.7) 0.36
synchrotr. rad. [W/m/beam]	**30**		58	**3.6**	(0.35) 0.18

FCC-hh luminosity phases

phase 1: b*=1.1 m, DQ_{tot}=0.01, t_{ta}=5 h, 250 fb^{-1} / year

phase 2: b*=0.3 m, DQ_{tot}=0.03, t_{ta}=4 h, 1 ab^{-1} / year

Transition via operational experience, no HW modification



Total integrated luminosity over 25 years operation:

O(20) ab^{-1}/experiment

consistent with physics goals

PRST-AB 18, 101002 (2015)

physics prospects

Physics at the FCC-hh

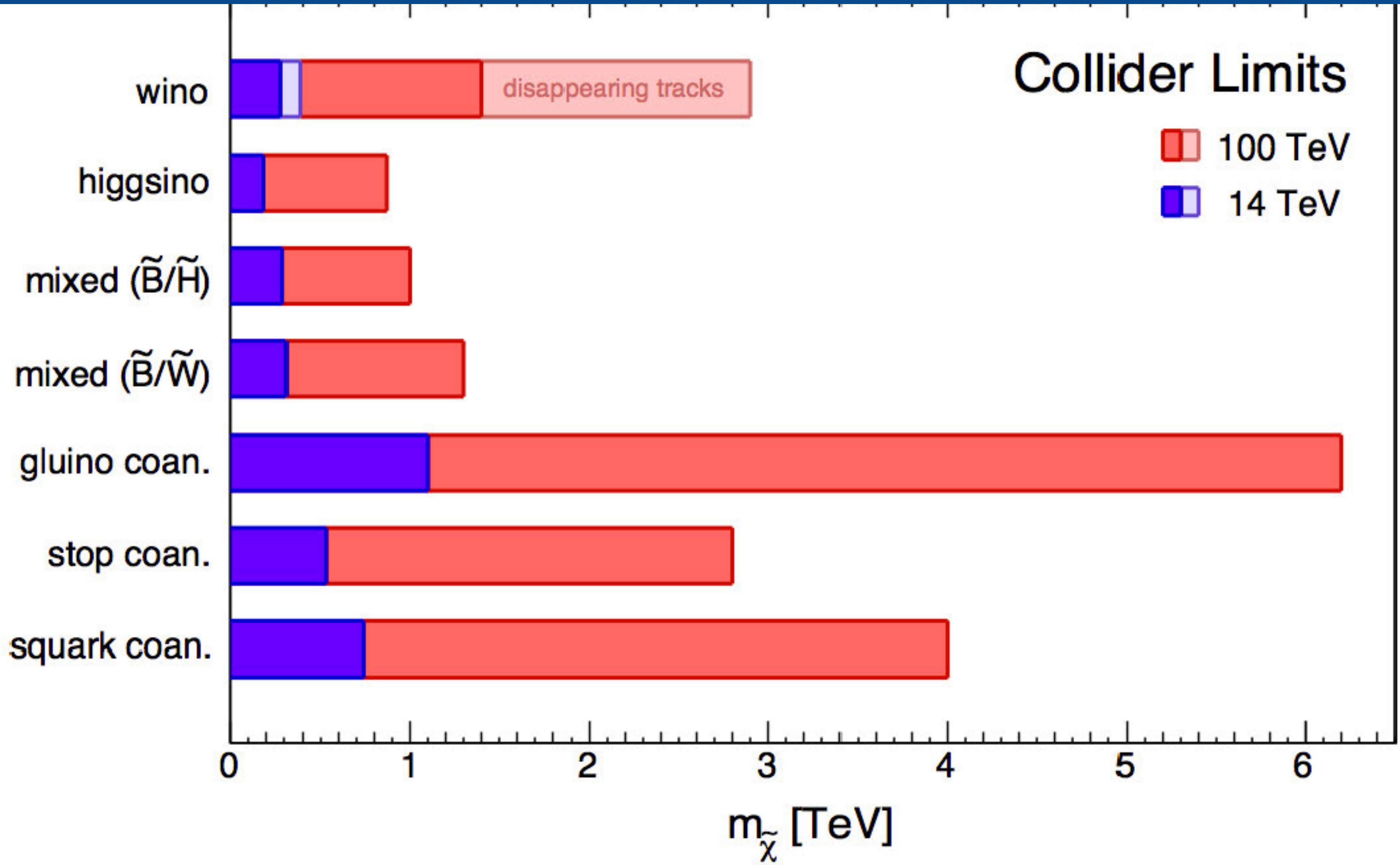
https://twiki.cern.ch/twiki/bin/view/LHCPhysics/FutureHadroncollider

- **Volume 1: SM processes** (238 pages)
- **Volume 2: Higgs and EW symmetry breaking studies** (175 pages)
- **Volume 3: beyond the Standard Model phenomena** (189 pages)
- **Volume 4: physics with heavy ions** (56 pages)
- **Volume 5: physics opportunities with the FCC-hh injectors** (14 pages)

- **being published as CERN yellow report**

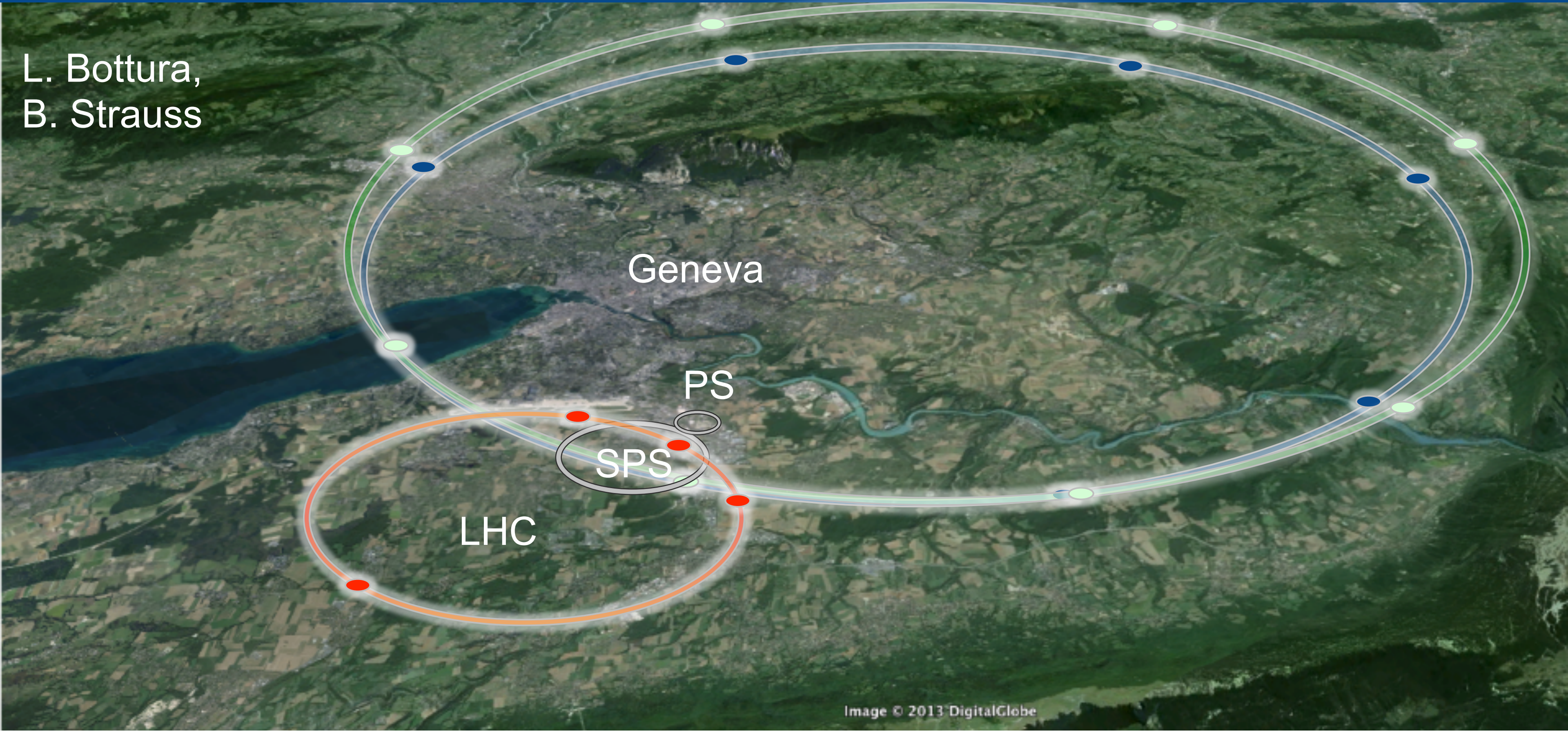
M. Mangano

FCC-hh physics perspectives



G. Giudice

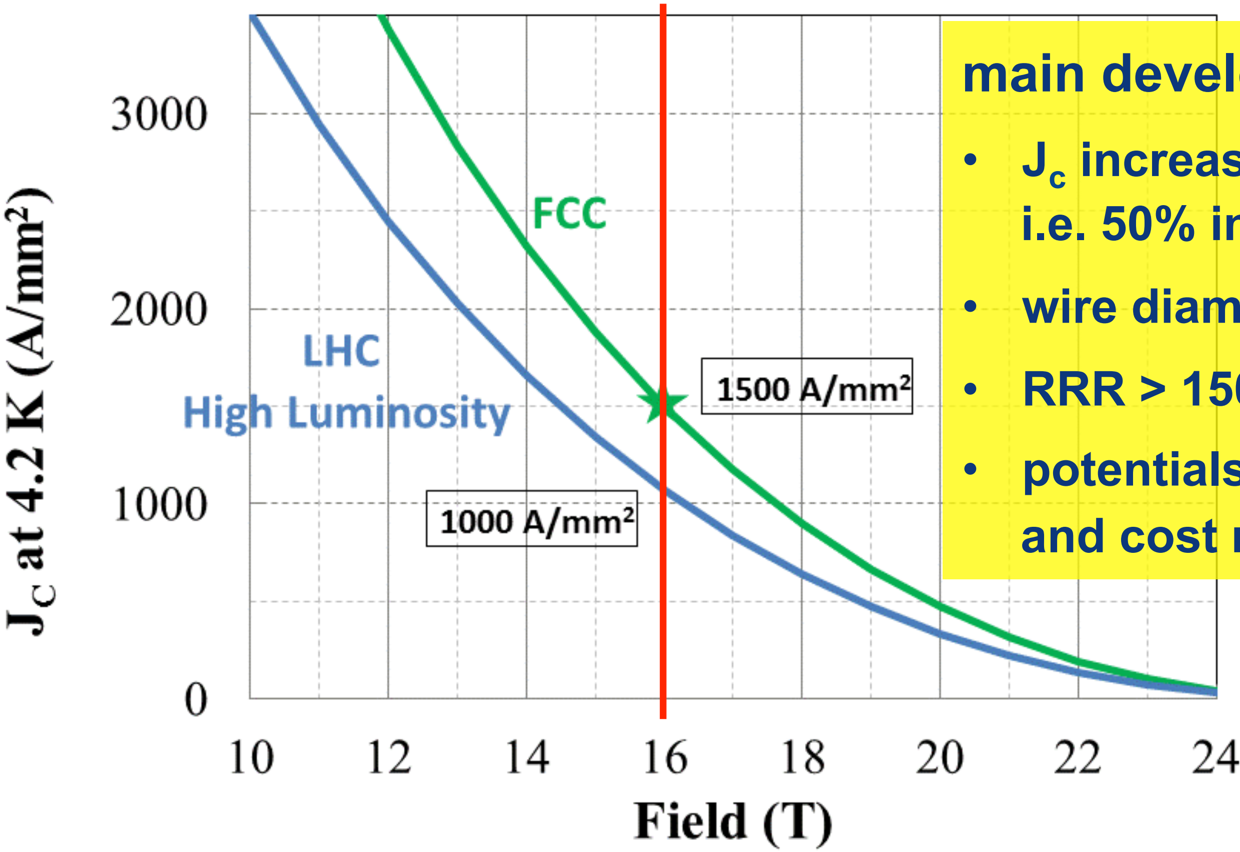
FCC SC main magnet options and requirements



LHC	HE-LHC baseline	FCC-hh baseline	FCC-hh
27 km, 8.33 T	**27 km, 16 T**	**100 km, 16 T**	80 km, **20 T**
14 TeV (c.o.m.)	26 TeV (c.o.m.)	100 TeV (c.o.m.)	100 TeV (c.o.m.)
1300 tons NbTi	**1600 tons Nb_3Sn**	**6000 tons Nb_3Sn**	2000 tons HTS
0.3 tons HTS	**800 tons Nb-Ti**	**3000 tons Nb-Ti**	9000 tons LTS

Nb_3Sn conductor program

Nb_3Sn is one of the major cost & performance factors for FCC-hh and must be given highest attention



main development goals till 2020:

- J_c increase (16T, 4.2K) > 1500 A/mm² i.e. 50% increase wrt HL/LHC wire
- wire diameter 1 mm
- RRR > 150
- potentials for large scale production and cost reduction

D. Schoerling, D. Tommasini

FCC Nb_3Sn program

Conductor developments with regional industries:

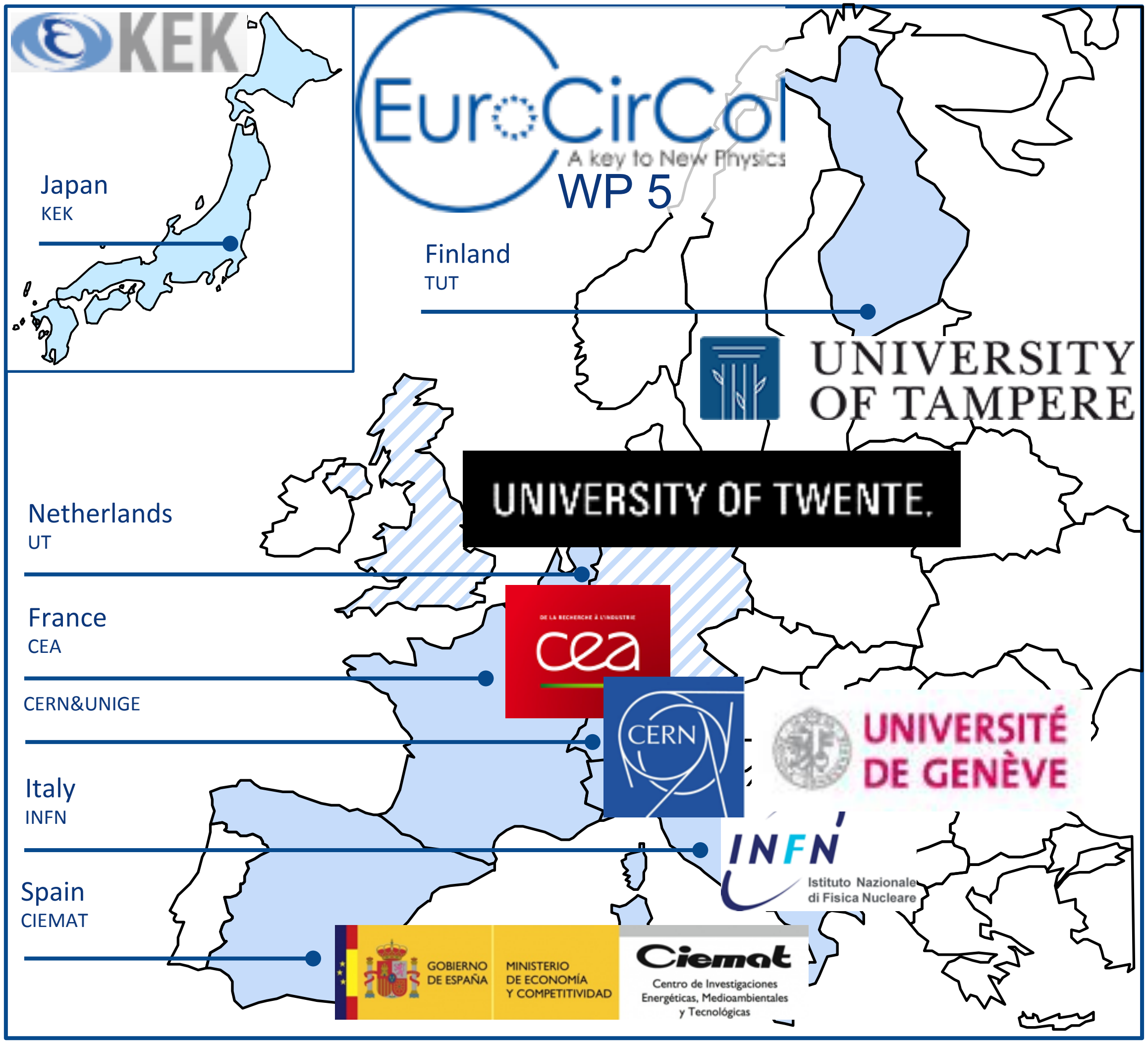
- **CERN/KEK** – **Japanese** contribution. Japanese **industry** (JASTEC, Furukawa, SH Copper) and laboratories (Tohoku Univ. and NIMS).
- **CERN/Bochvar High-technology Research Inst.** – **Russian** contribution. Russian **industry** (TVEL) and laboratories
- **US DOE MDP program** – **US** activity with **industry** (OST) and labs
- **CERN/KAT** – **Korean** **industrial** contribution
- **CERN/Bruker**– **European** **industrial** contribution

Characterisation of conductor & research with universities:

- Collaboration agreement with **Technical University of Vienna**
- Collaboration agreement with **Applied Superconductivity Centre** at Florida State University

M. Benedikt,
L. Bottura

16 T dipole design – CERN-EU program

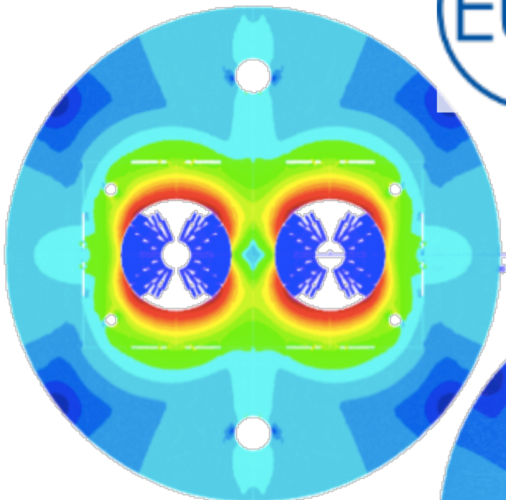


GOAL:
design a 16 T accelerator-quality model dipole magnet by 2018

M. Benedikt, D. Tommasini

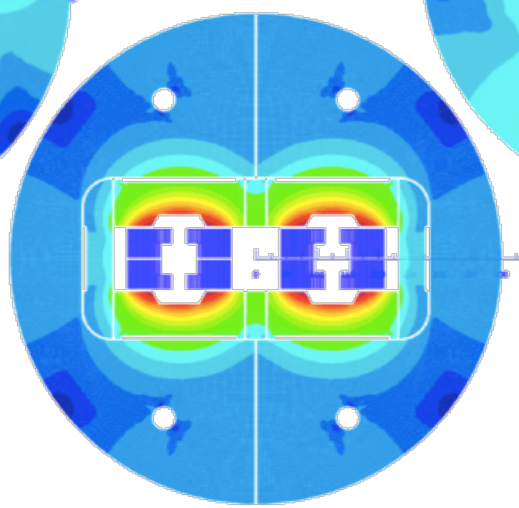
16 T dipole options under consideration

Cos-theta

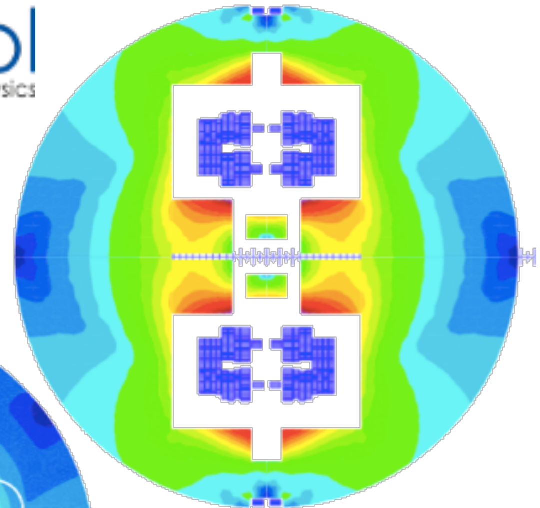


EuroCirCol
A key to New Physics

Blocks

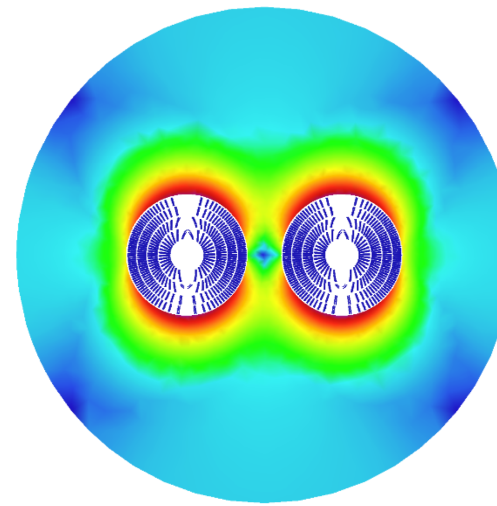


Common coils



Swiss contribution
via PSI

Canted Cos-theta

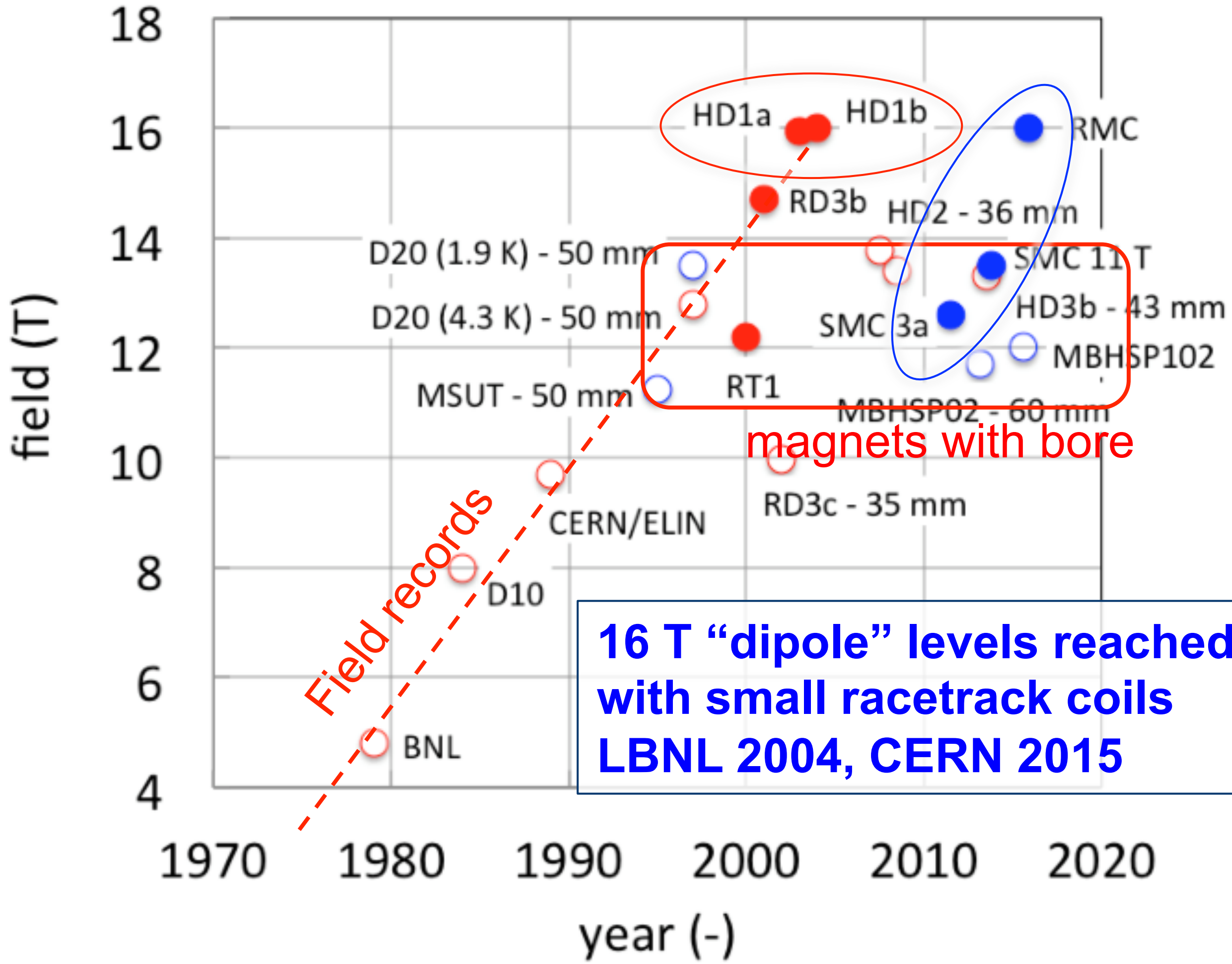


end 2016: down-selection of options for more detailed design work

L. Bottura,
D. Tommasini

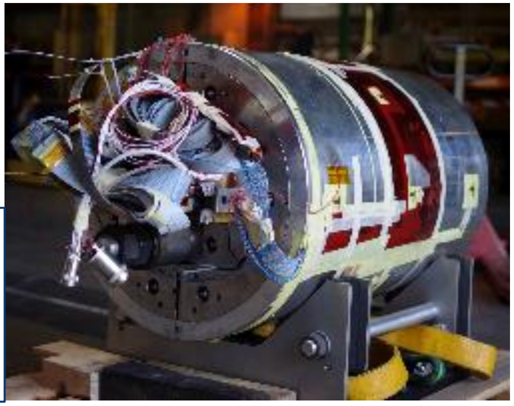
towards 16 T magnets

record fields for SC "dipole" magnets



16 T "dipole" levels reached with small racetrack coils LBNL 2004, CERN 2015

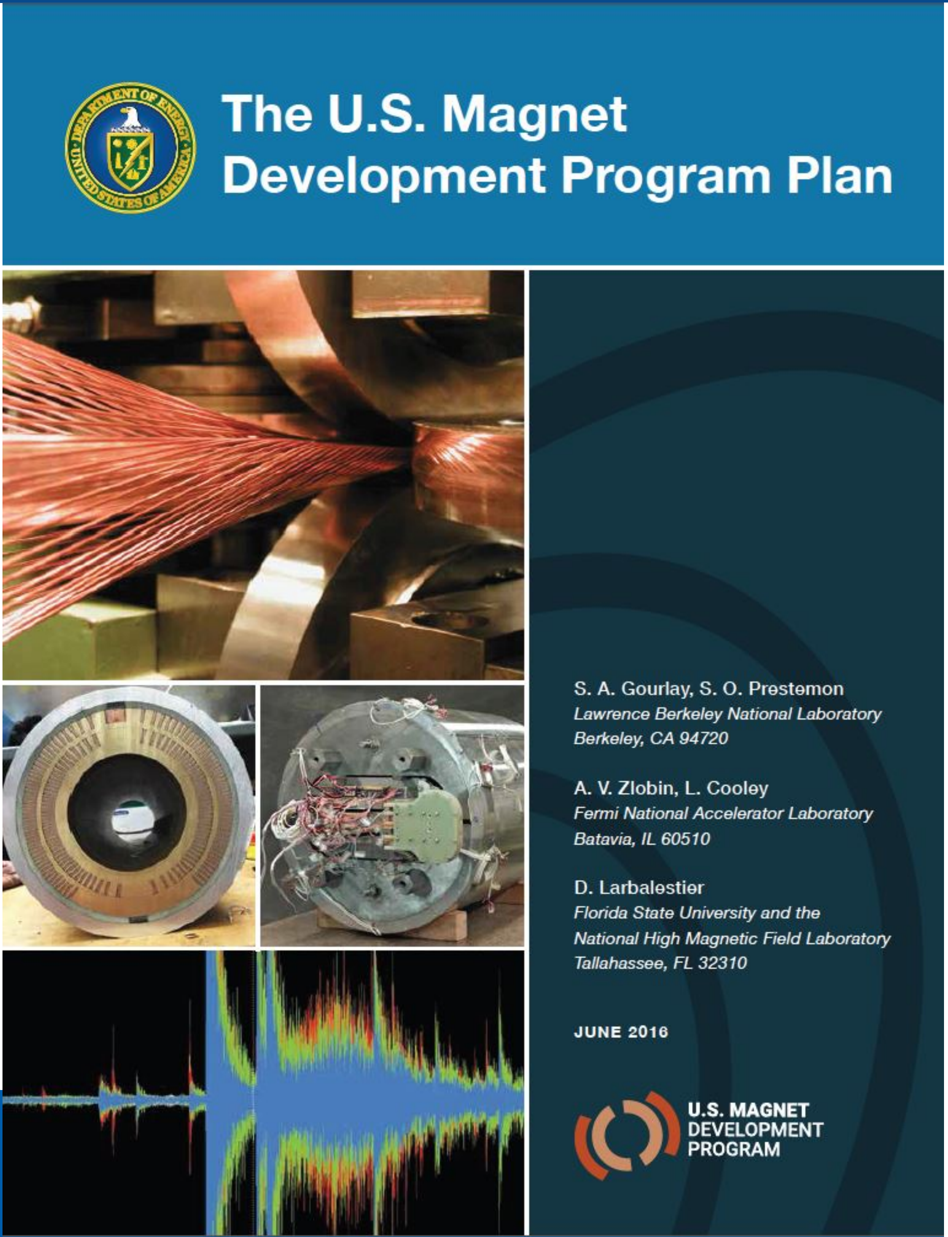
LBNL HD1



CERN RMC

L. Bottura, D. Tommasini

US magnet program



The U.S. Magnet Development Program Plan

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Berkeley, CA 94720

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Florida State University and the
National High Magnetic Field Laboratory
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JUNE 2016

U.S. MAGNET DEVELOPMENT PROGRAM

Program (MDP) Goals:

GOAL 1:

Explore the performance limits of Nb_3Sn accelerator magnets with a focus on minimizing the required operating margin and significantly reducing or eliminating training.

GOAL 2:

Develop and demonstrate an HTS accelerator magnet with a self-field of 5 T or greater compatible with operation in a hybrid LTS/HTS magnet for fields beyond 16 T.

GOAL 3:

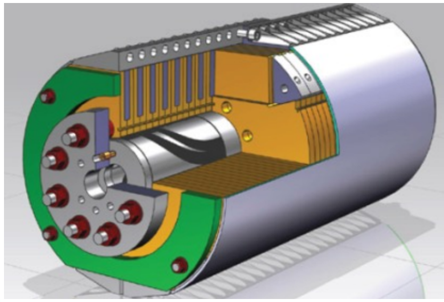
Investigate fundamental aspects of magnet design and technology that can lead to substantial performance improvements and magnet cost reduction.

GOAL 4:

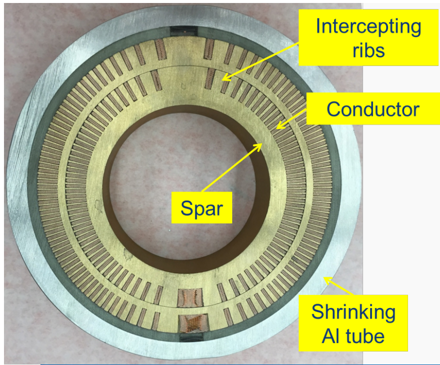
Pursue Nb_3Sn and HTS conductor R&D with clear targets to increase performance and reduce the cost of accelerator magnets.

Under Goal 1:

16 T cos theta dipole design



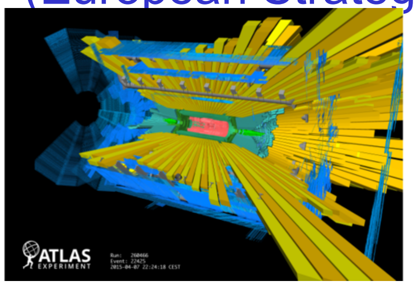
16 T canted cos theta (CCT) design

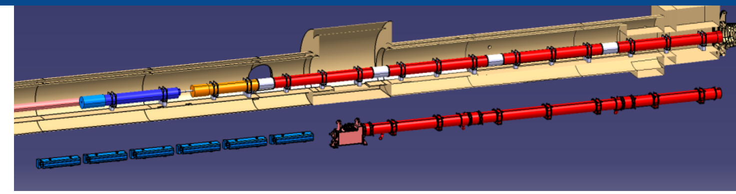


HEP & magnet time line

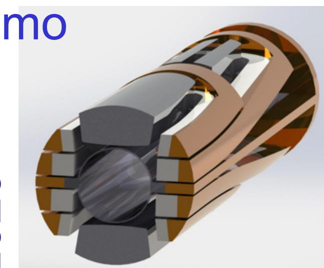
G. de Rijk

LHC Run-II provides results to define future HEP roadmap (European Strategy 2018)





Accelerator-grade HTS 5 T demo

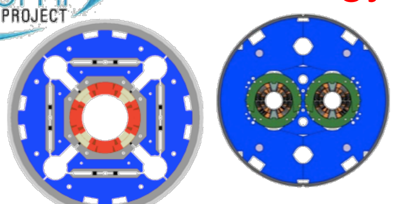


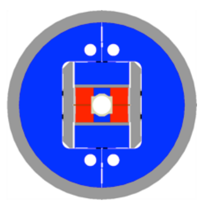
HL-LHC demonstrates large-scale use of Nb_3Sn

End of LHC useful life

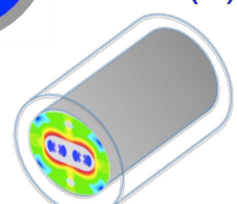
2015 2016 2017 2018 2019 2020 2025 2030 2035 2040

12 T accelerator technology



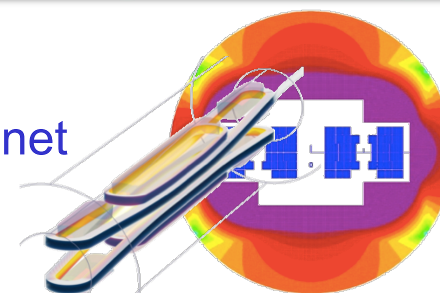


16 T magnet model(s)



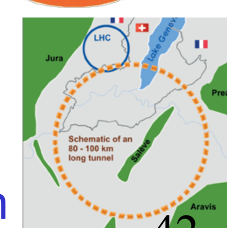
16 T accelerator technology

20 T magnet model(s)



FCC CDR (EuroCirCol) propose a new energy frontier accelerator

FCC construction decision



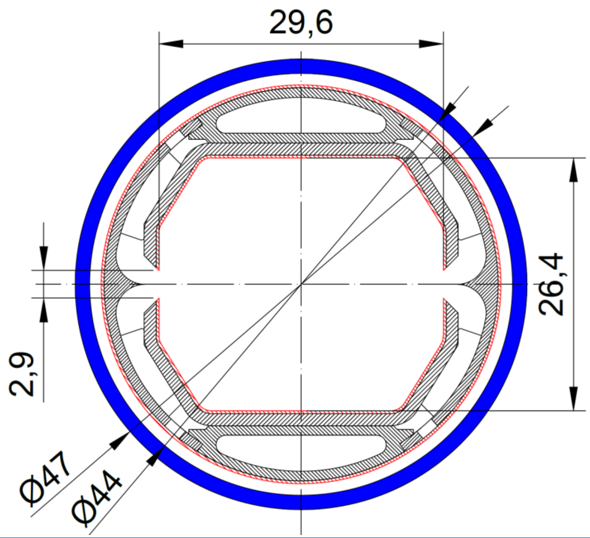
proton synchrotron radiation: FCC beam screen prototype

high synchrotron radiation load of protons @ 50 TeV:

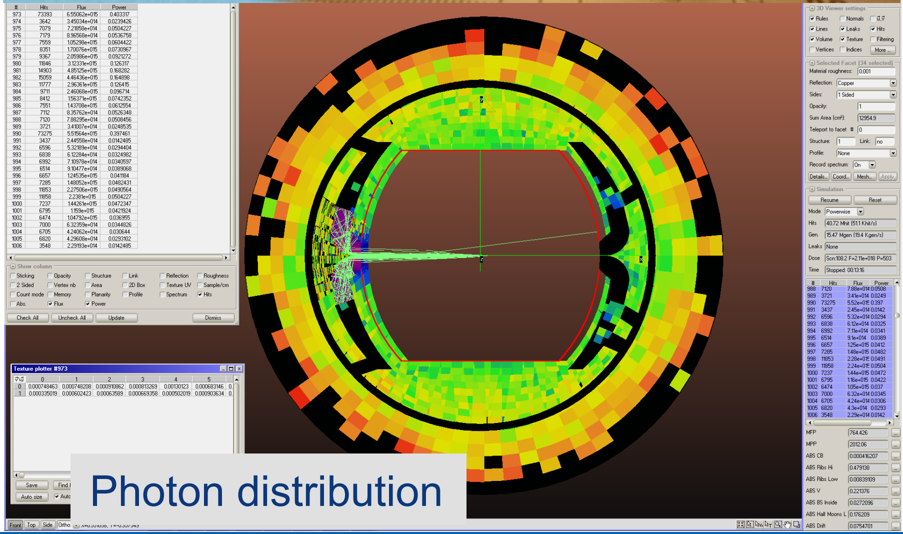
- **~30 W/m/beam (@16 T)** (LHC <0.2W/m)
- **5 MW total in arcs**

new beam screen with ante-chamber

- absorption of synchrotron radiation at 50 K to reduce cryogenic power
- avoids photo-electrons, helps vacuum



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

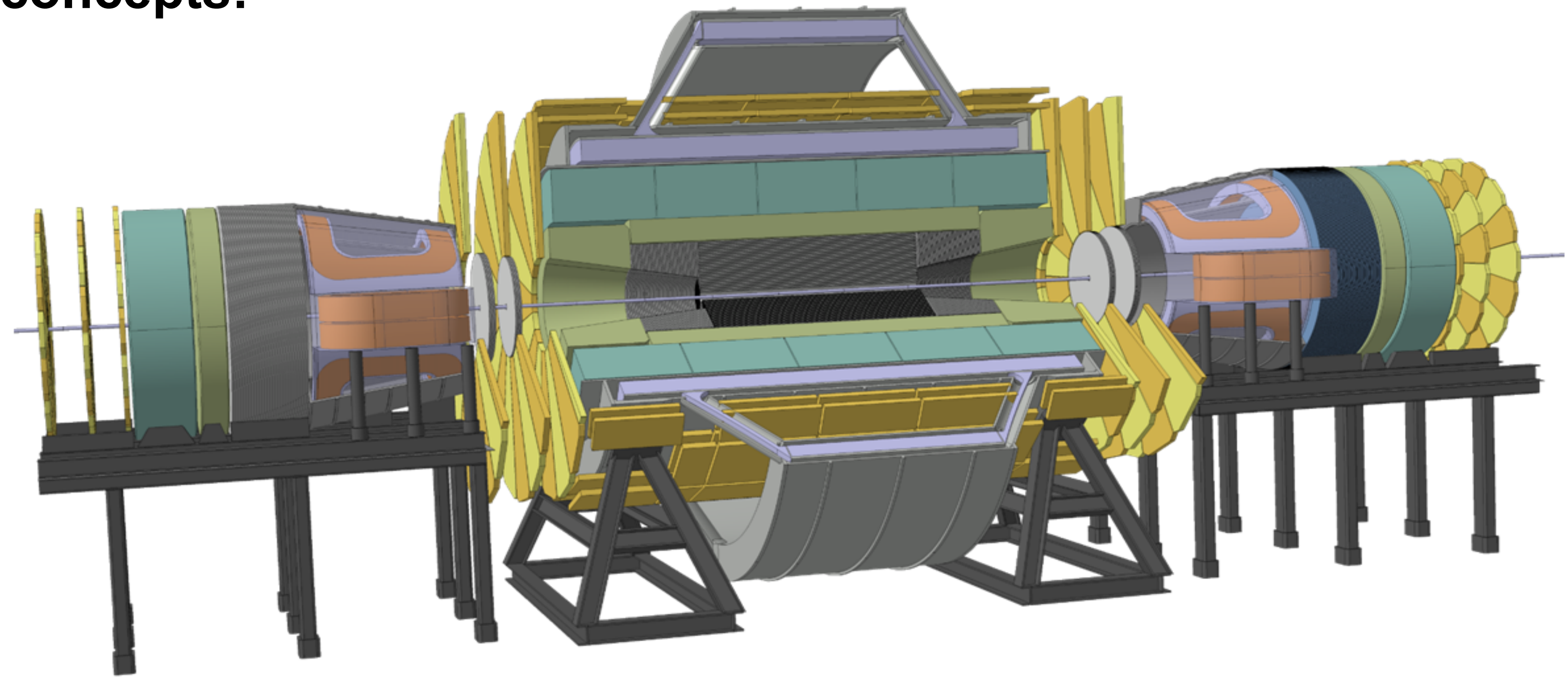


Photon distribution

R. Kersevan, C. Garion

FCC-hh detector developments

first concepts were based on extension of LHC detector concepts:

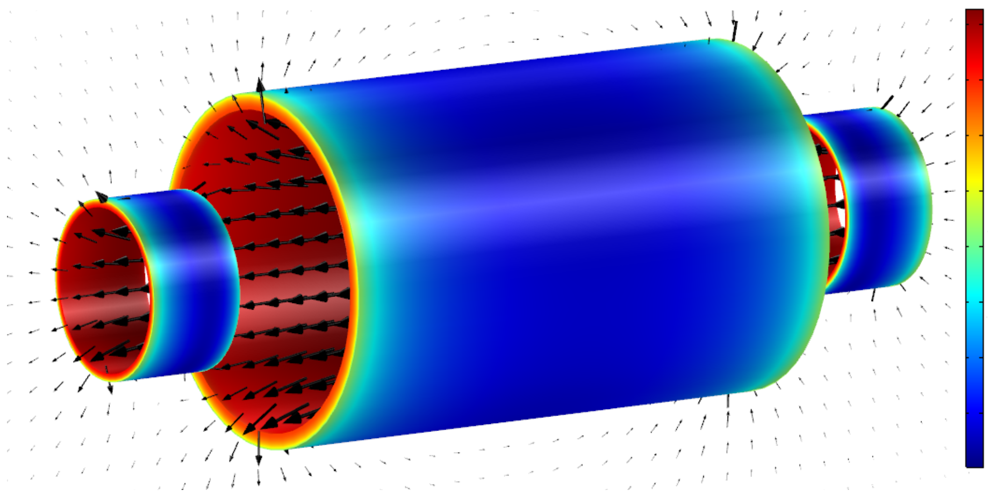


***B*=6 T, 12 m bore, solenoid with shielding coil and 2 dipoles 10 Tm; length 64 m, diam. 30 m, magnet 7000 tons, stored energy 50 GJ**

H. ten Kate, M. Benedikt

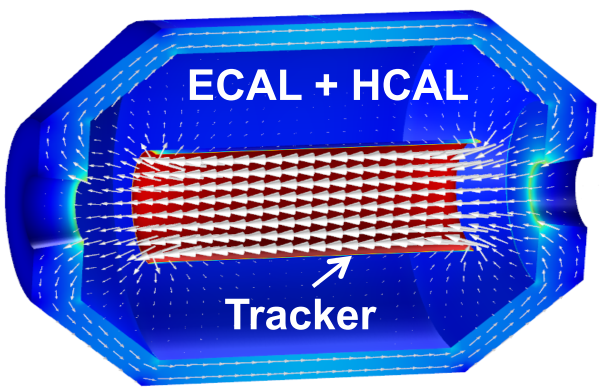
detector magnet studies

new designs for physics-enabling & cost-efficient magnet systems



today's baseline:

4 T/10m bore 20m long Main Solenoid
4 T Side Solenoids – all unshielded
14 GJ stored energy, 30 kA and
2200 tons system weight



alternative challenging design:

4T / 4 m Ultra-thin, high-strength Main Solenoid
allowing positioning inside the e-calorimeter,
280 MPa conductor (side solenoids not shown)
0.9 GJ stored energy, elegant, 25 t only,
but needs R&D!

H. ten Kate, M. Benedikt

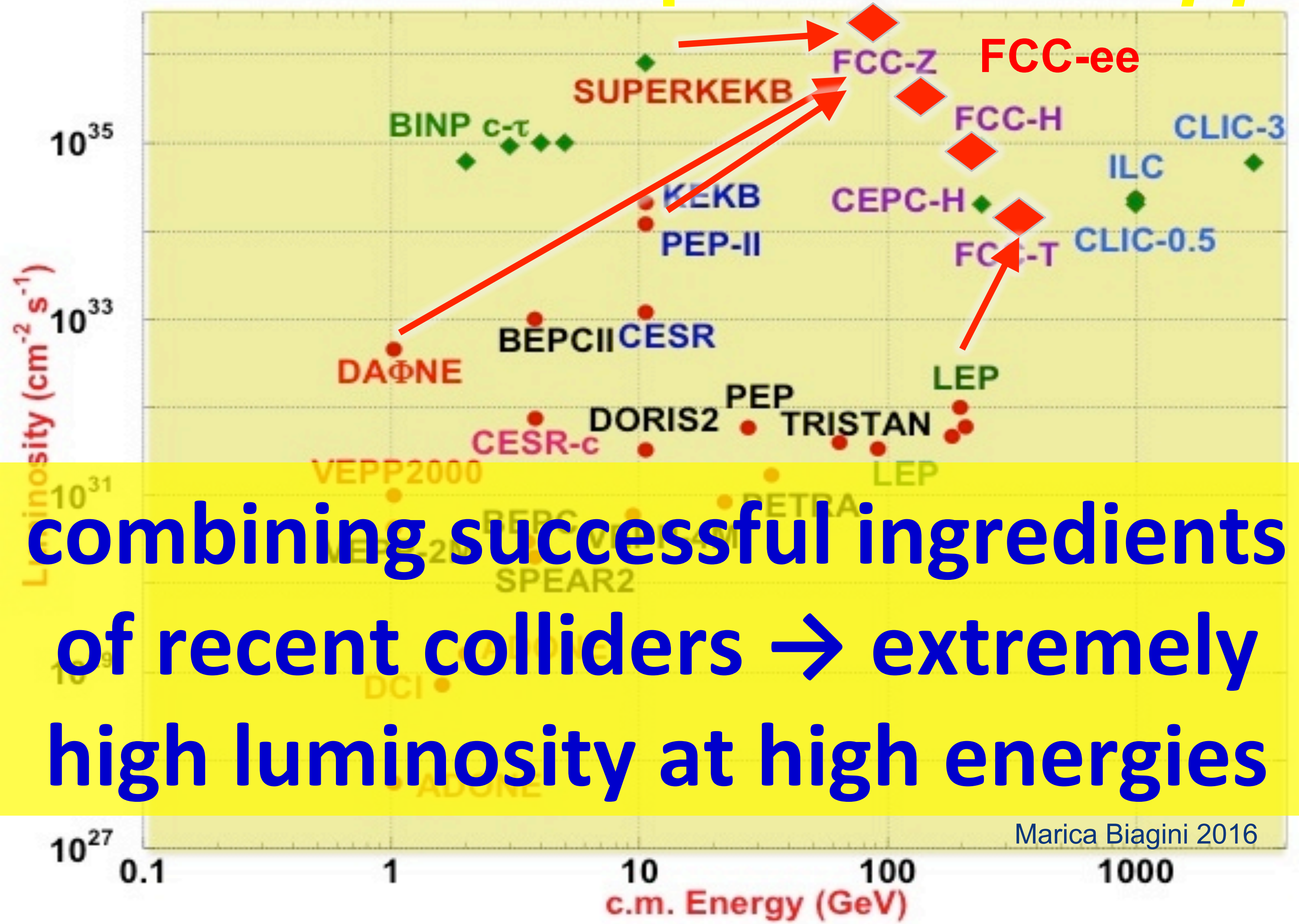
lepton collider parameters

parameter	FCC-ee (400 MHz)					CEPC	LEP2
Physics working point	Z		WW	ZH	tt_{bar}	H	
energy/beam [GeV]	45.6		80	120	175	120	105
bunches/beam	30180	91500	5260	780	81	50	4
bunch spacing [ns]	7.5	2.5	50	400	4000	3600	22000
bunch population [10^{11}]	1.0	0.33	0.6	0.8	1.7	3.8	4.2
beam current [mA]	1450	1450	152	30	6.6	16.6	3
luminosity/IP x $10^{34}cm^{-2}s^{-1}$	210	90	19	5.1	1.3	2.0	0.0012
energy loss/turn [GeV]	0.03	0.03	0.33	1.67	7.55	3.1	3.34
synchrotron power [MW]	100					103	22
RF voltage [GV]	0.4	0.2	0.8	3.0	10	6.9	3.5

identical FCC-ee baseline optics for all energies

FCC-ee: 2 separate rings CEPC, LEP: single beam pipe

exploiting lessons & recipes from past e^+e^- and *pp* colliders



combining successful ingredients of recent colliders → extremely high luminosity at high energies

LEP:
- high energy
- SR effects

B-factories:
KEKB & PEP-II:
- high beam currents
- top-up injection

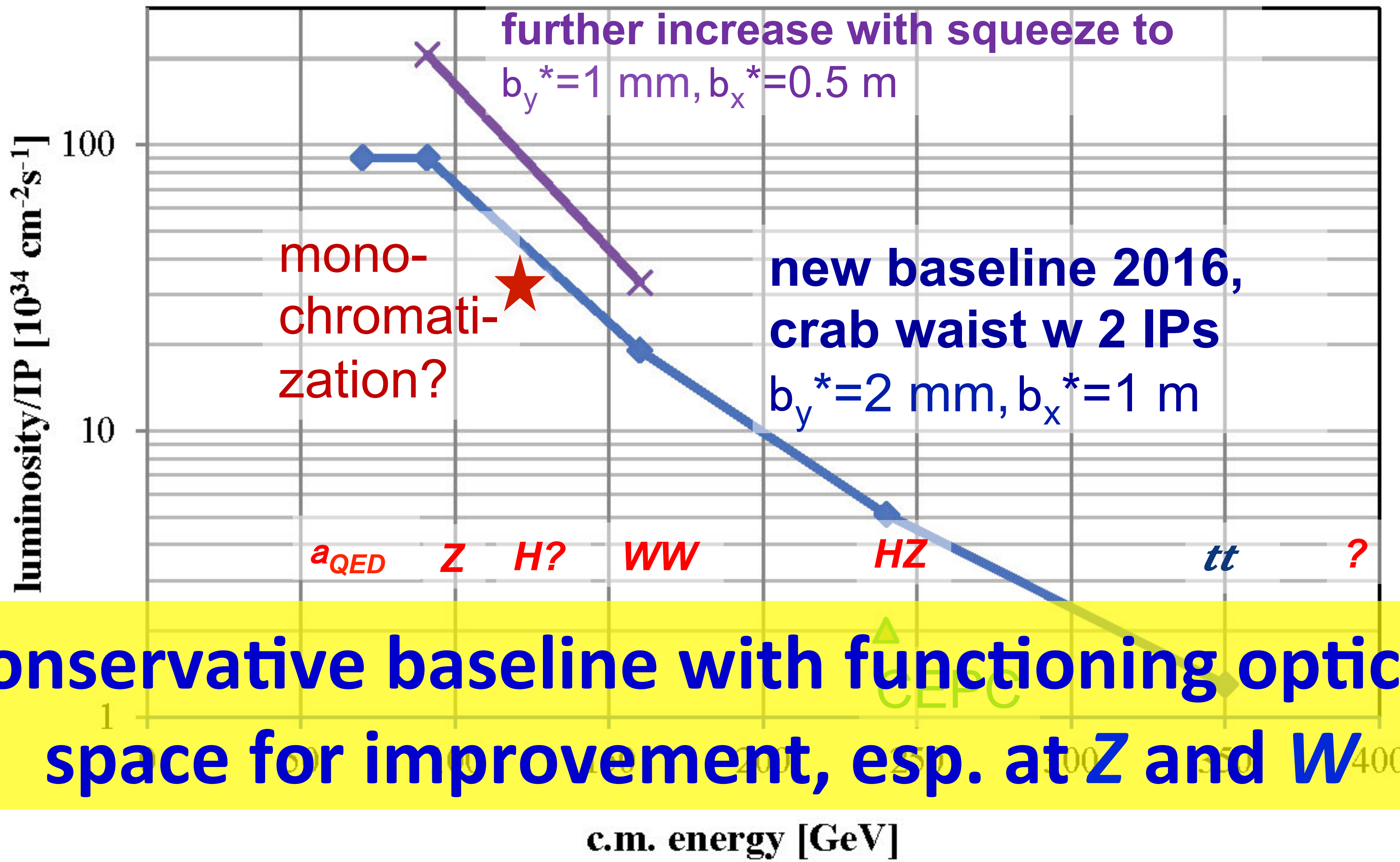
DAFNE: crab waist

Super B-factories
S-KEKB: low b_y*

KEKB: *e*$^+$ source

HERA, LEP, RHIC:
- spin gymnastics

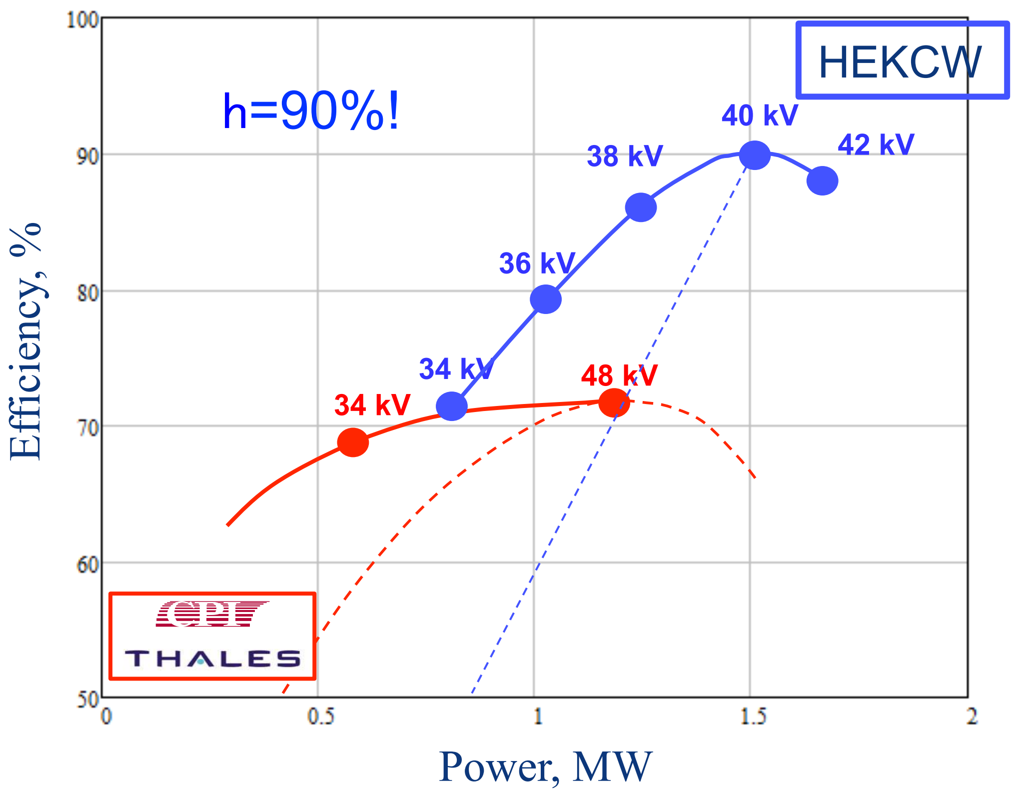
FCC-ee luminosity per IP



conservative baseline with functioning optics, space for improvement, esp. at *Z* and *W*

after 80 years a breakthrough in klystron efficiency!

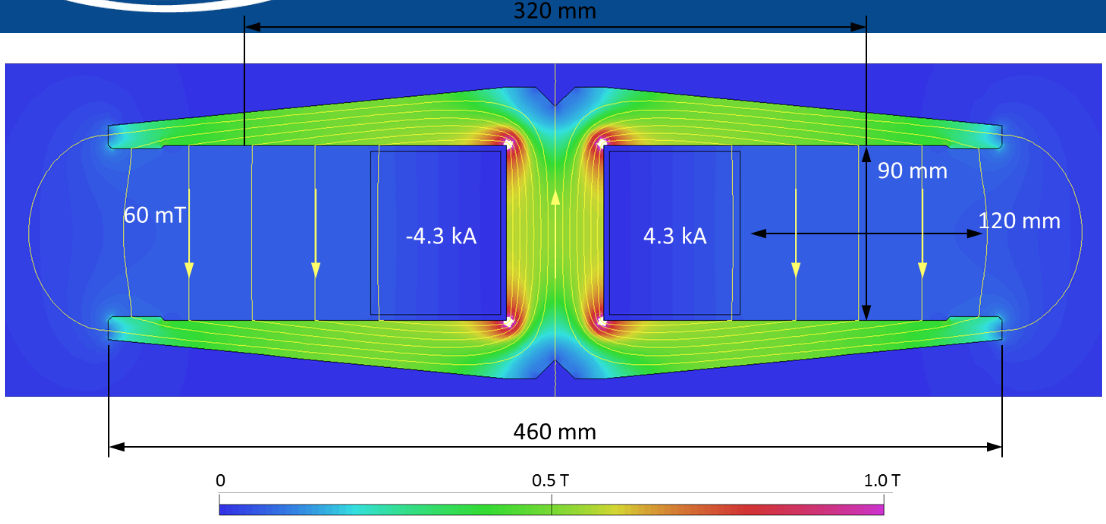
comparing simulated performances of MBIOT and HEKCW MBK



A 40-beam prototype "BAC" klystron has been built and successfully tested at VDBT, Moscow, this year!

I. Syratchev

efficient 2-in-1 arc magnets

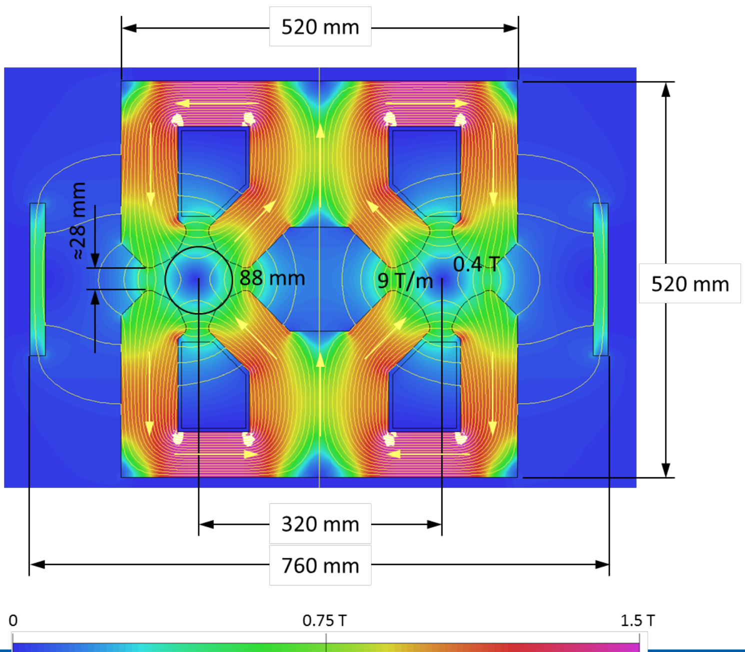


FCC-ee 500 G dipole based on twin aperture yoke and single busbars as coils

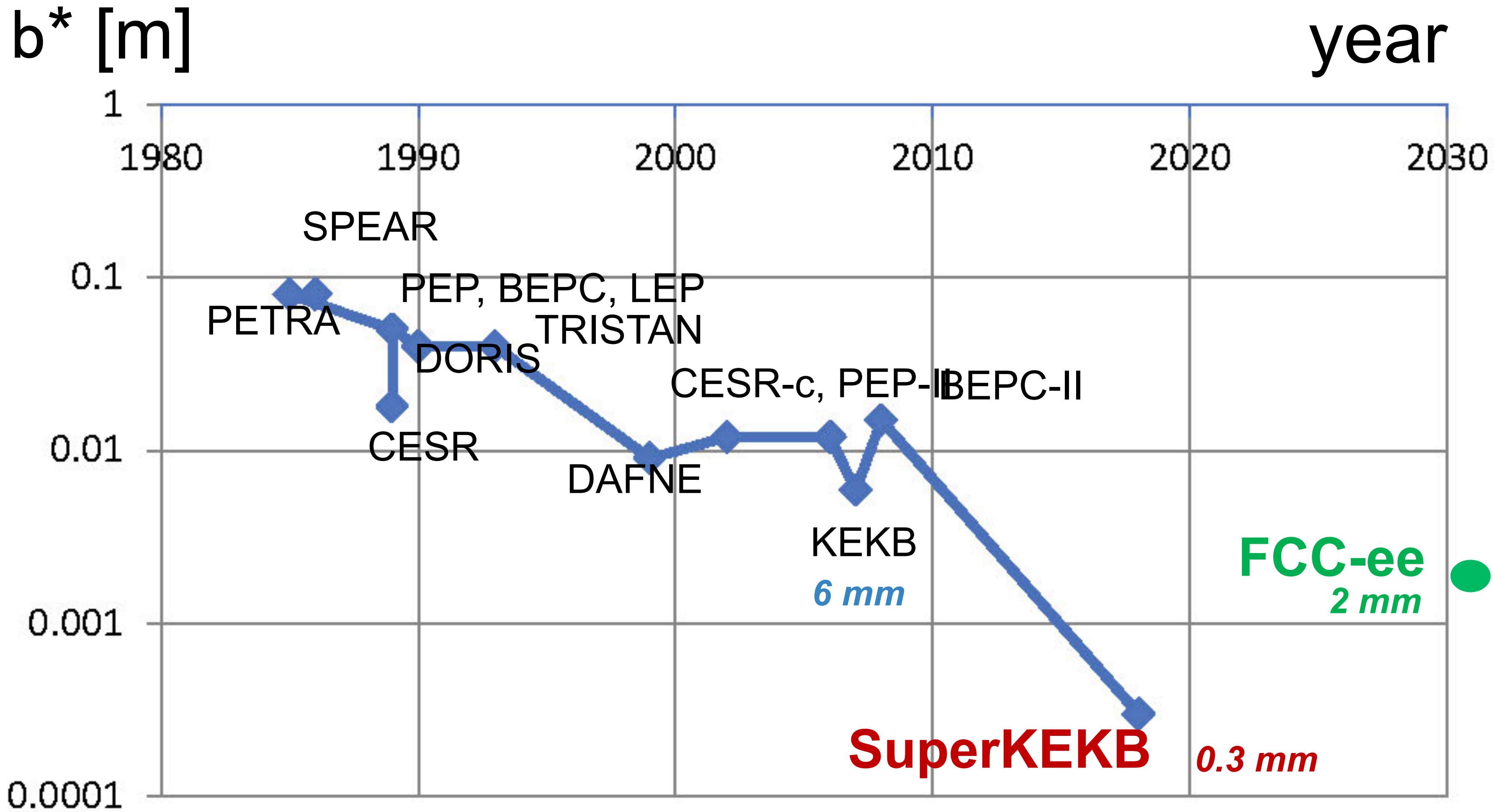
twin 2-in-1 quadrupole

the novel arrangements of the magnetic circuit allow for considerable savings in Ampere-turns and power consumption, less units to manufacture, transport, install, align, remove,…

midplane shield for stray field



b_y* evolution over 40 years



SuperKEKB will pave the way towards b*≤2 mm

FCC International Collaboration

- 87 institutes
- 28 countries + EC

Status: August, 2016

FCC Collaboration Status

87 collaboration members + EC + CERN as host

ALBA/CELLS, Spain
Ankara U., Turkey
Aydin U, Istanbul, Turkey
U Belgrade, Serbia
U Bern, Switzerland
BINP, Russia
CASE (SUNY/BNL), USA
CBPF, Brazil
CEA Grenoble, France
CEA Saclay, France
CIEMAT, Spain
Cinvestav, Mexico
CNRS, France
CNR-SPIN, Italy
Cockcroft Institute, UK
U Colima, Mexico
UCPH Copenhagen, Denmark
CSIC/IFIC, Spain
TU Darmstadt, Germany
TU Delft, Netherlands
DESY, Germany
DOE, Washington, USA
TU Dresden, Germany
Duke U, USA
EPFL, Switzerland
UT Enschede, Netherlands
ESS, Sweden
U Geneva, Switzerland
Giresun U. Turkey
Goethe U Frankfurt, Germany
GSI, Germany
GWNU, Korea
U. Guanajuato, Mexico
Hellenic Open U, Greece
HEPHY, Austria
U Houston, USA
ISMAB-CSIC, Spain
IFAE, Spain
IFIC-CSIC, Spain
IIT Kanpur, India
IFJ PAN Krakow, Poland
INFN, Italy
INP Minsk, Belarus
U Iowa, USA
IPM, Iran
UC Irvine, USA
Isik U., Turkey
Istanbul University, Turkey
JAI, UK
JINR Dubna, Russia
Jefferson LAB, USA
FZ Jülich, Germany
KAIST, Korea
KEK, Japan
KIAS, Korea
King's College London, UK
KIT Karlsruhe, Germany
KU, Seoul, Korea
Korea U Sejong, Korea
U Liverpool, UK
U Lund, Sweden
U Malta, Malta
MAX IV, Sweden
MEPhI, Russia
UNIMI, Milan, Italy
MIT, USA
Northern Illinois U, USA
NC PHEP Minsk, Belarus
OIU, Turkey
Okan U, Turkey
U Oxford, UK
PSI, Switzerland
U. Rostock, Germany
RTU, Riga, Latvia
UC Santa Barbara, USA
Sapienza/Roma, Italy
U Siegen, Germany
U Silesia, Poland
Stanford U, USA
U Stuttgart, Germany
TAU, Israel
TU Tampere, Finland
TOBB, Turkey
U Twente, Netherlands
TU Vienna, Austria
Wigner RCP, Budapest, Hungary
Wroclaw UT, Poland


FCCWEEK 2016
International Future Circular Collider Conference
ROME 11-15 APRIL
fccw2016.web.cern.ch
http://cern.ch/fccw2016
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B. Rimmer (JLAB)
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D. Schulte (CERN)
M. Seidel (PSI)
A. Seryi (JAI)
B. Strauss (DOE)
M. Syphers (FNAL)
L. Tavian (CERN)
R. Tenchini (INFN Pisa)
D. Tommasini (CERN)
G. Tonelli (U. Pisa)
P. Vedrine (CEA)
A. Weiler (TU München)
J. Wenninger (CERN)
F. Zimmermann (CERN)
F. Zwirner (U. Padova)


Other Regions
Asia
U.S.
Middle East
Europe
468
Participants
168
Institutes
24
Countries

summary

- LHC is running extremely well thanks to 30 years of worldwide efforts
- LHC upgrade HL-LHC will support frontier physics program till ~2035/2037
- now it is time to prepare for the post-LHC era: FCC study is developing design of large circular accelerator complex, technology developments in key areas (high-field magnets, RF, SR handling …)
- rapidly growing global FCC collaboration (now ~100 institutes), next milestone: FCC Week 2017
- what can channeling do for FCC or FCC upgrade?


FCCWEEK2017
Future Circular Collider Conference
BERLIN, GERMANY
29 MAY - 02 JUNE
fccw2017.web.cern.ch
IEEE CSC
DPG
DESY