UNIVERSITÀ DEGLI STUDI DI PADOVA

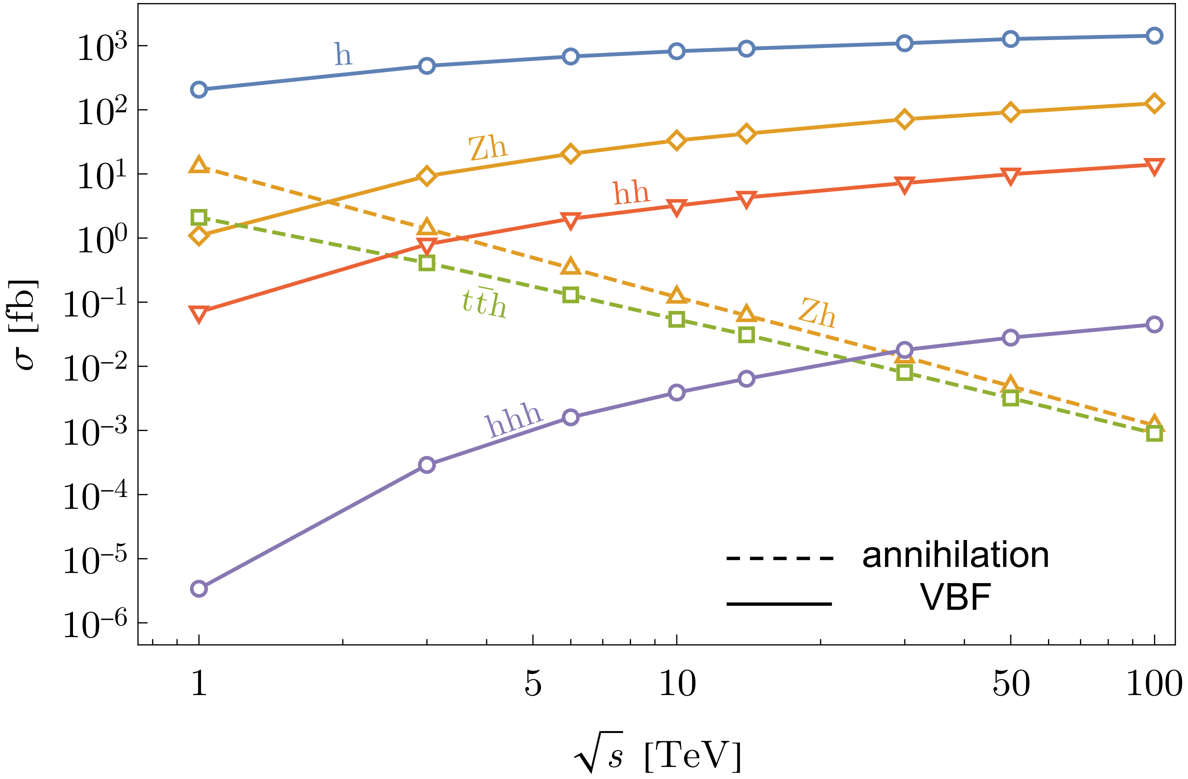
INFN PADOVA

MuC and demonstrator facility

D. Lucchesi for MuC Padova

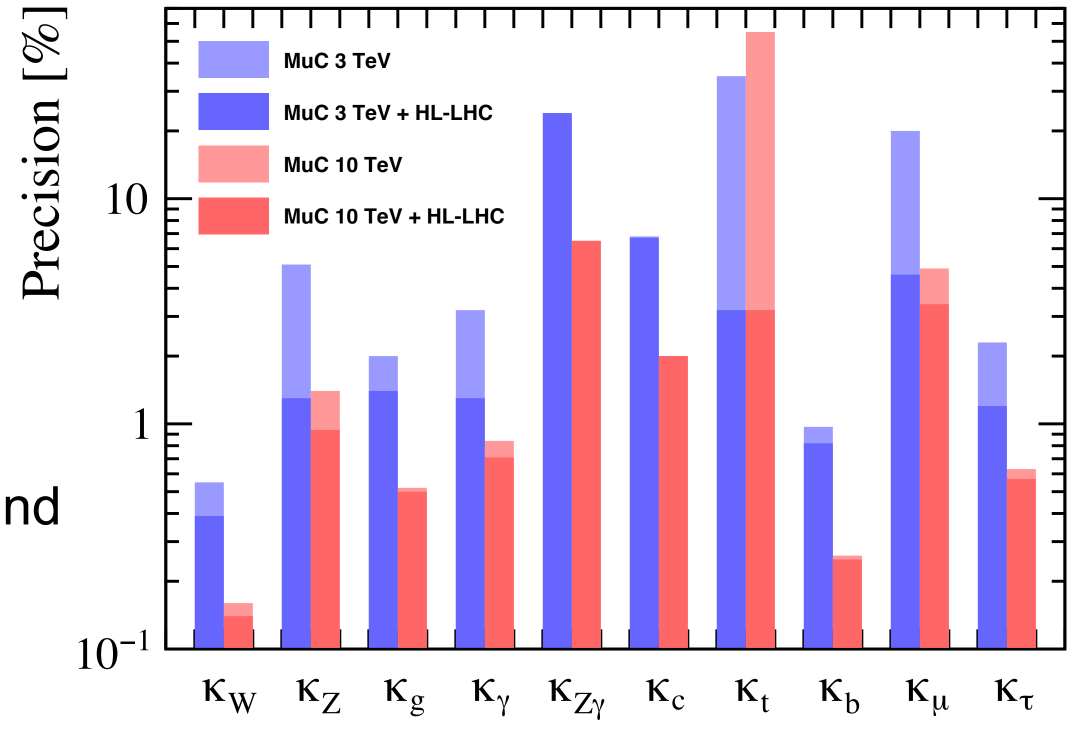
Riunione per la EPPS Padova

Why MuC? Higgs physics



5 years one experiment

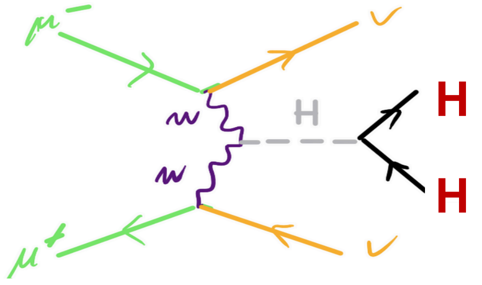
	cross section [fb]		expected events	
	3 TeV	10 TeV	1 ab^{-1} at 3 TeV	10 ab^{-1} at 10 TeV
H	550	930	5.5×10^5	9.3×10^6
ZH	11	35	1.1×10^4	3.5×10^5
$t\bar{t}H$	0.42	0.14	420	1.4×10^3
HH	0.95	3.8	950	3.8×10^4
HHH	3.0×10^{-4}	4.2×10^{-3}	0.30	42

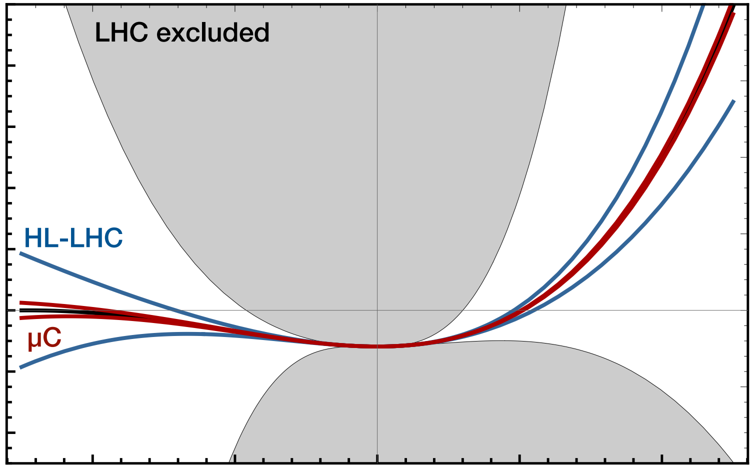


Higgs couplings to elementary bosons and fermions could be measured at% level

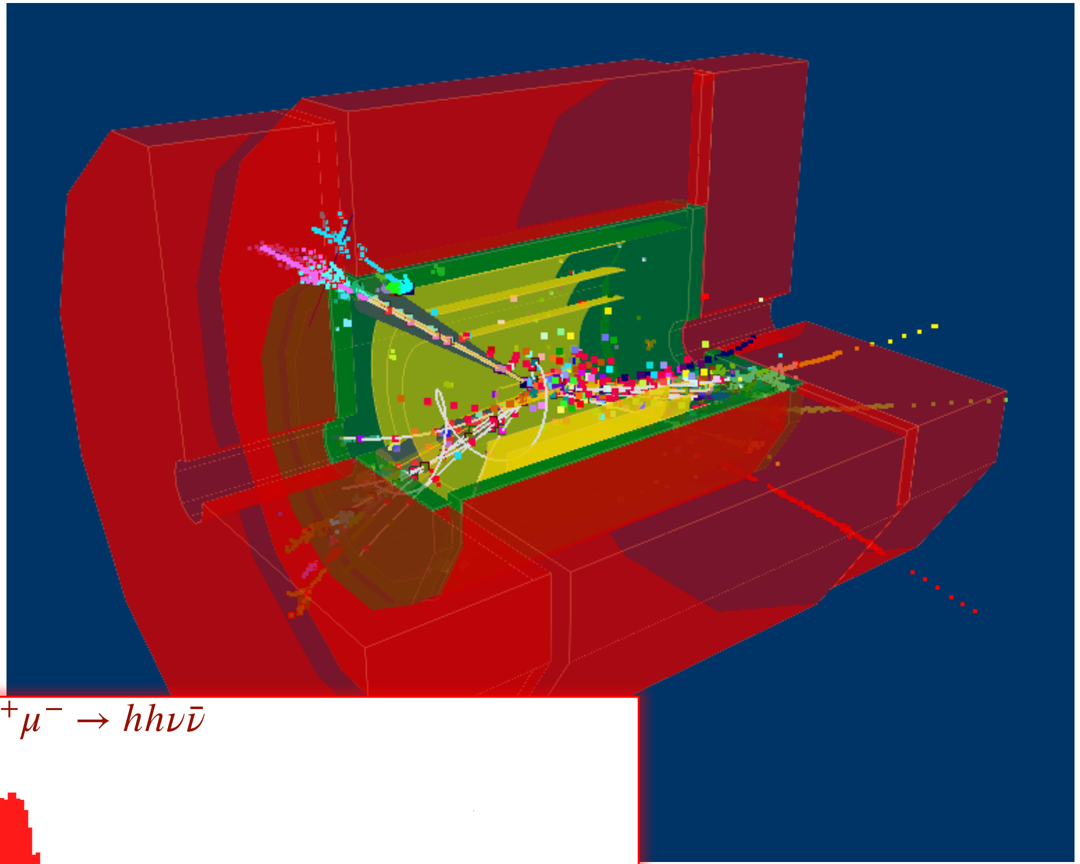
Why MuC? Higgs potential

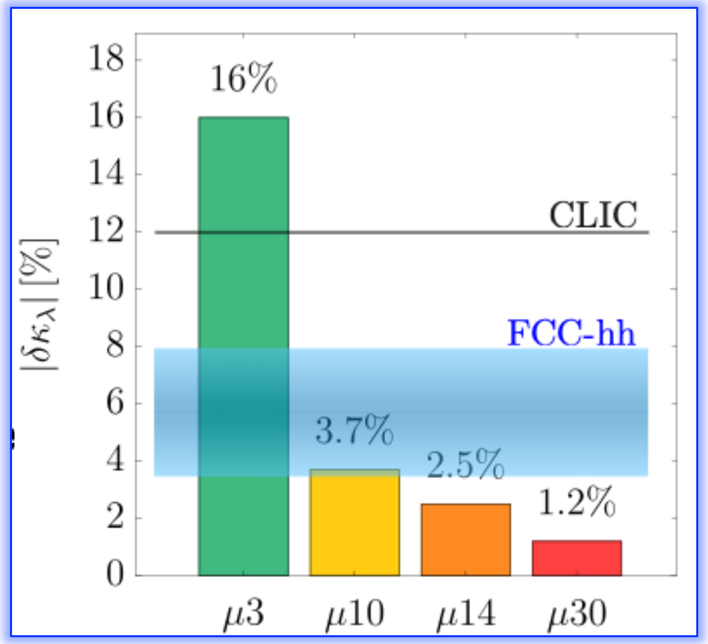
Measurement of trilinear coupling gives access to the Higgs potential





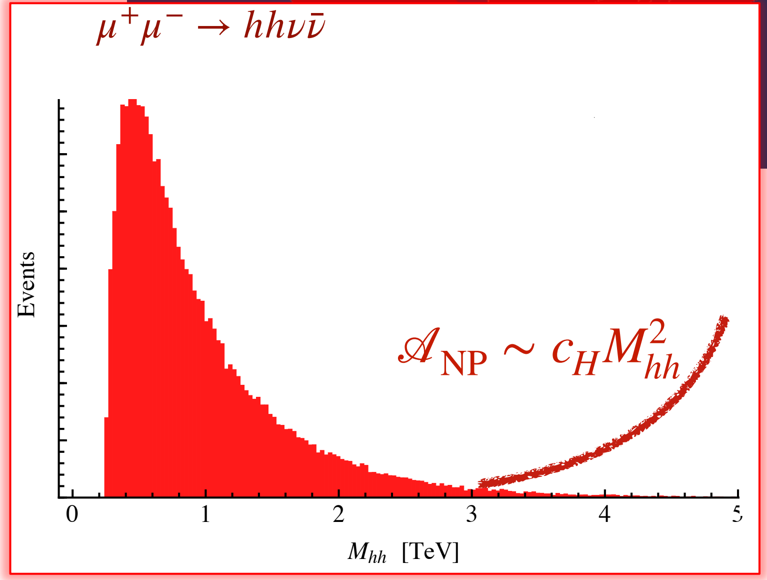
credits: Craig, Petrossian-Byrne





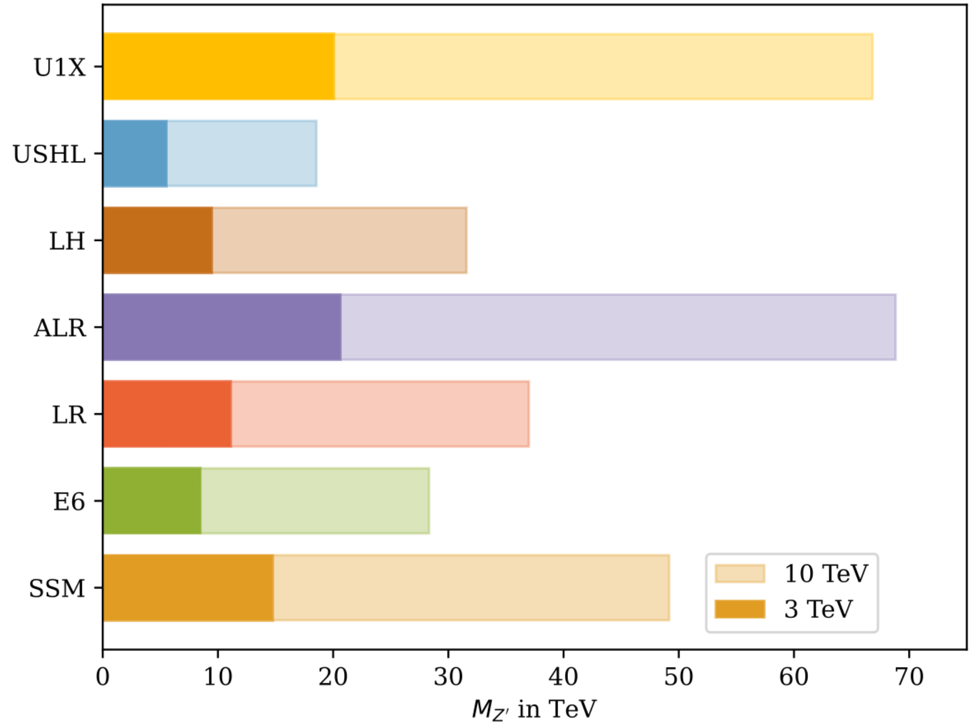
Muon collider allows the most precise measurement with 10 ab^{-1} ~5 years of data taking (FCC-hh 30 ab^{-1} ~50 years)
HL-LHC will reach 50% precision SM value

New Physics effects can appear at high double Higgs invariant mass



Why MuC? Zillions of other physics searches

Effective Z'-model with new gauge boson couplings to the SM fermions



Excluded masses at 95% CL:
MuC: up to 70 TeV
LHC: 5 TeV, HL-LHC: 8 TeV
Future e^+e^-: 20 TeV

Heavy neutrino

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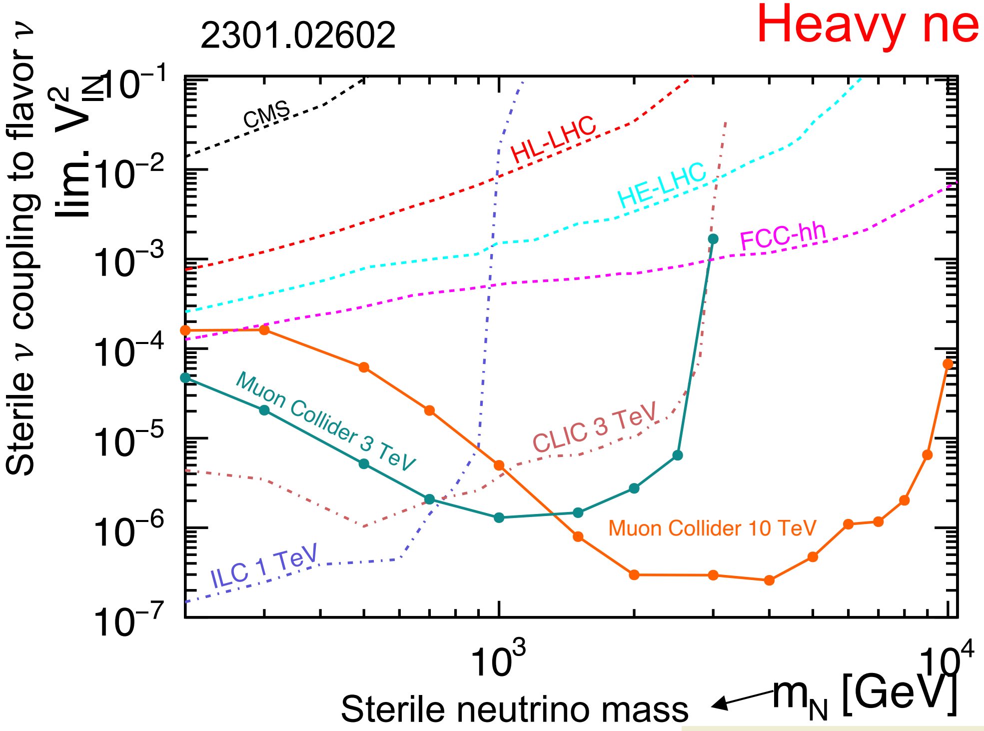

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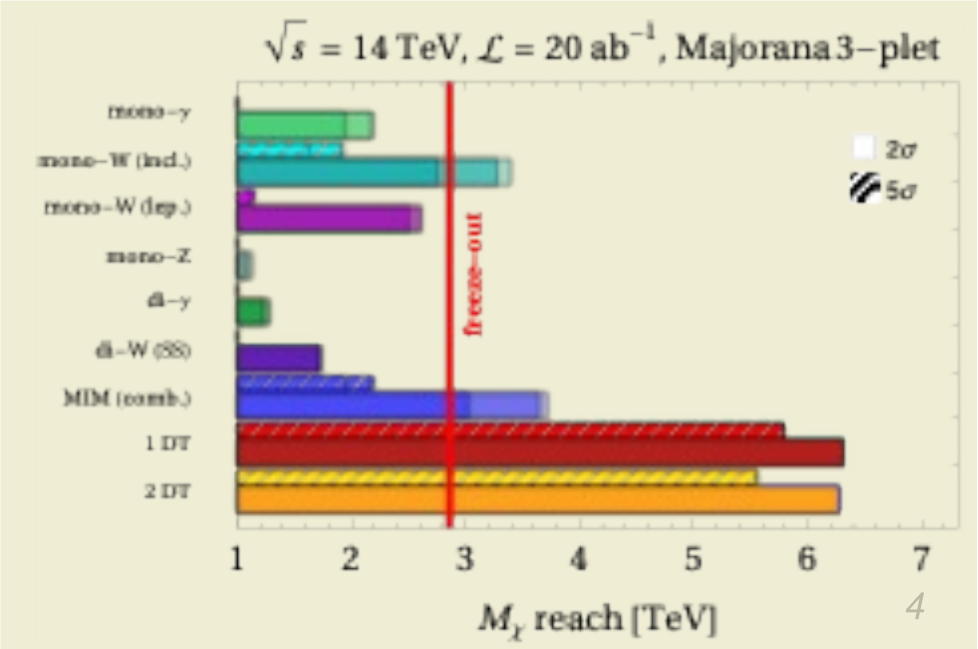
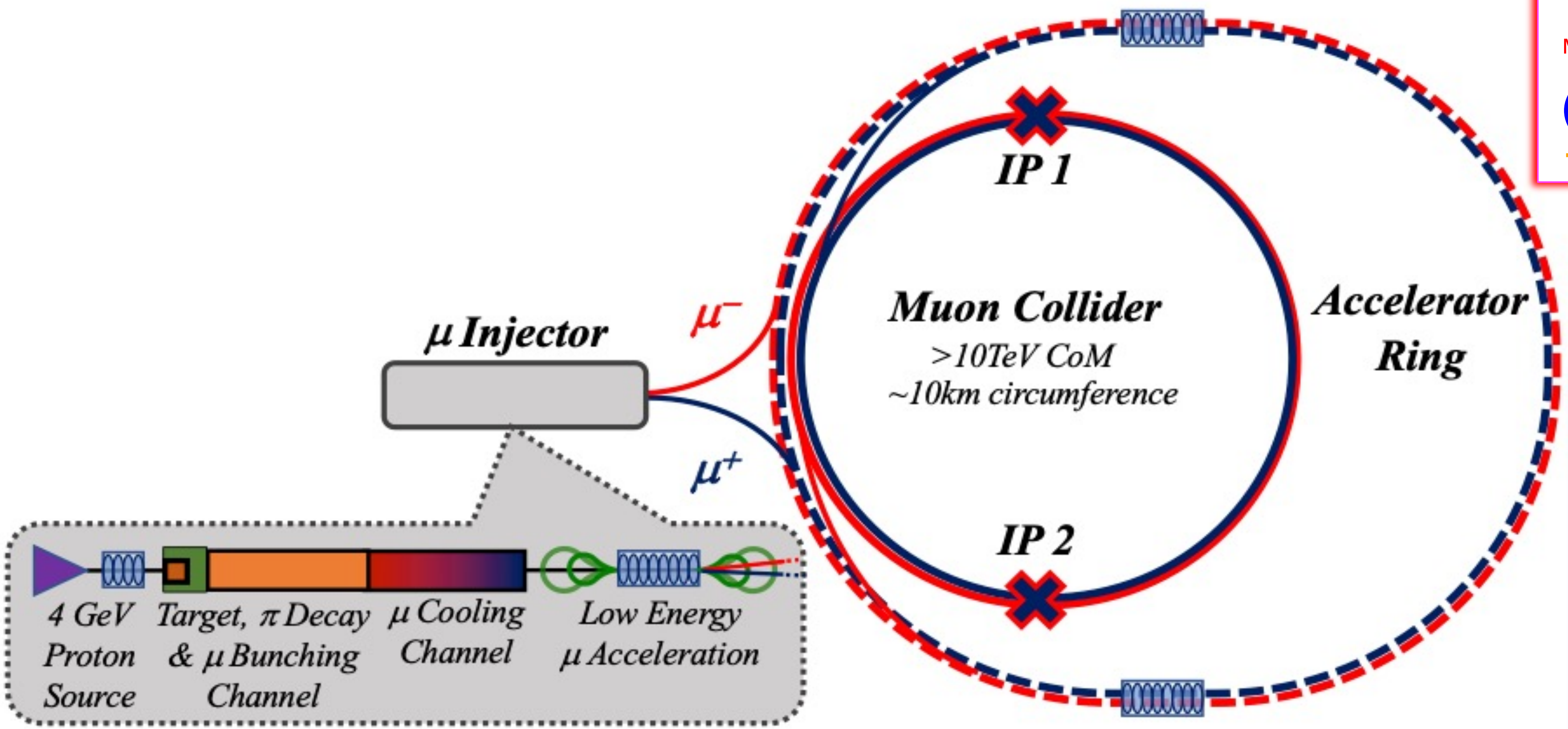
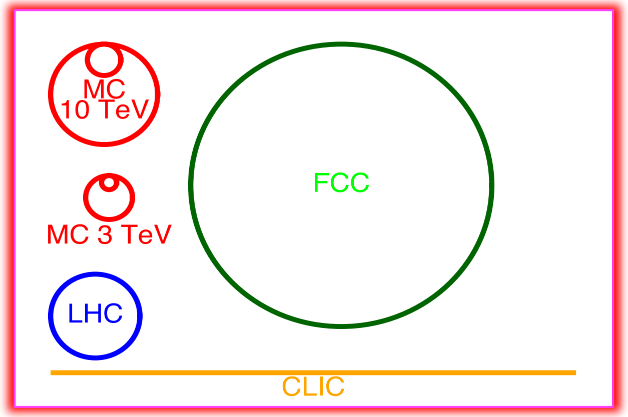


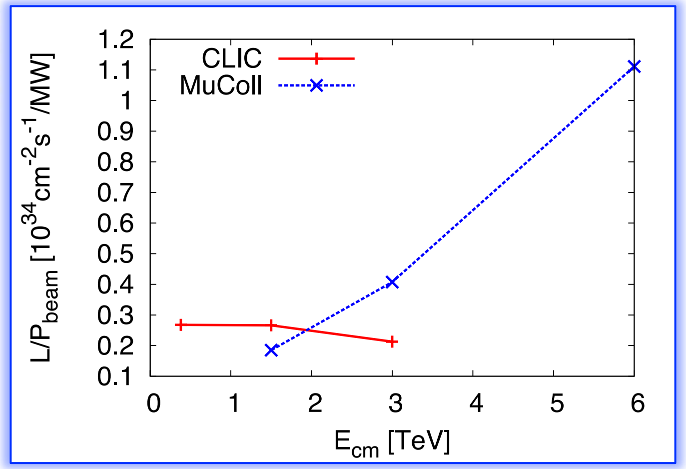
MuC facility



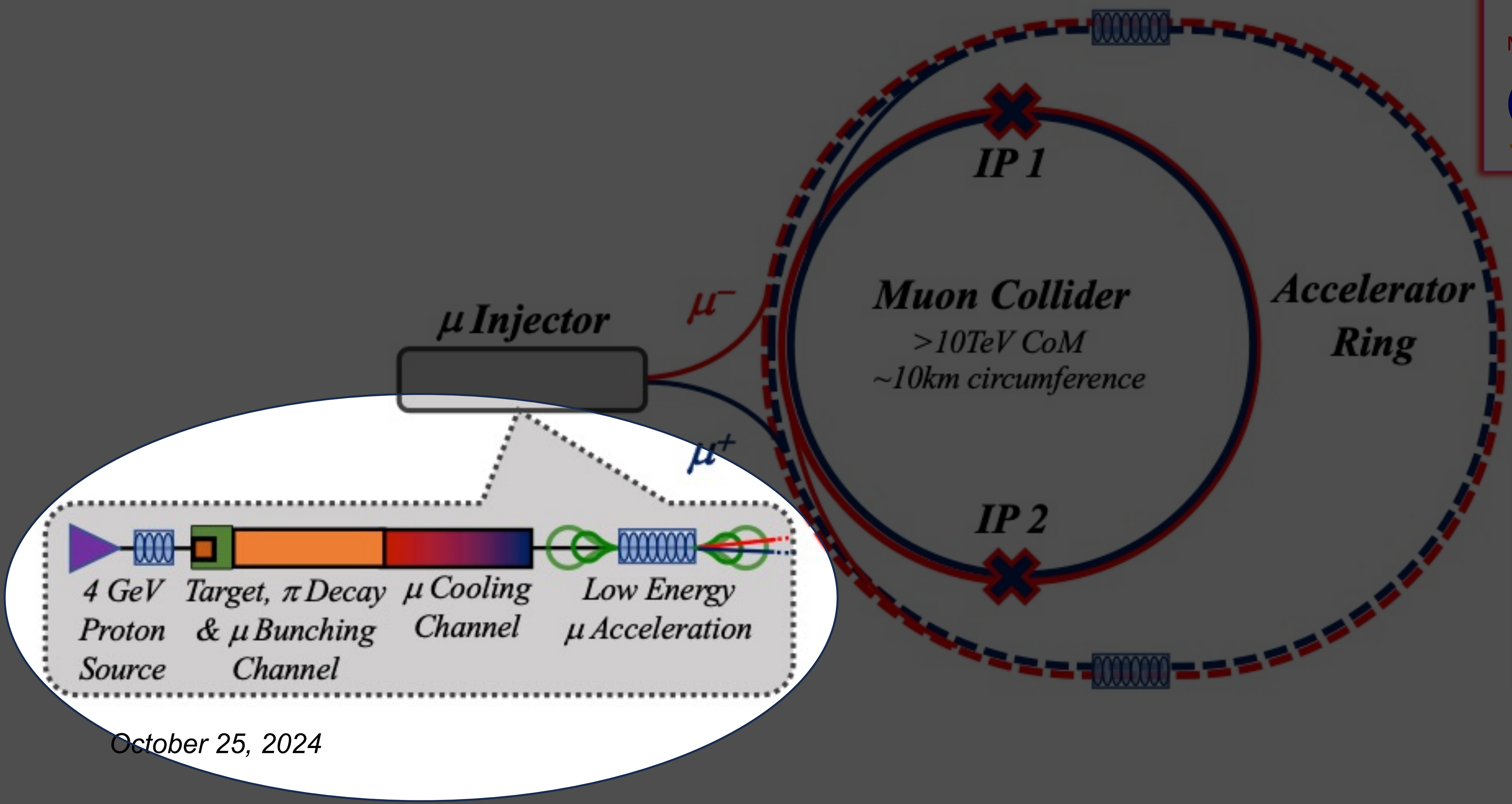
"small" rings



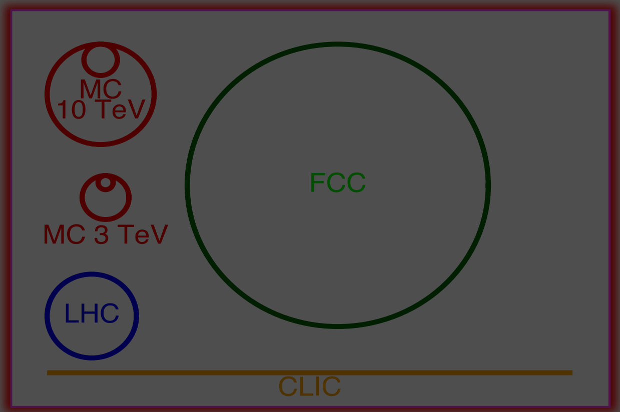
Not so expensive



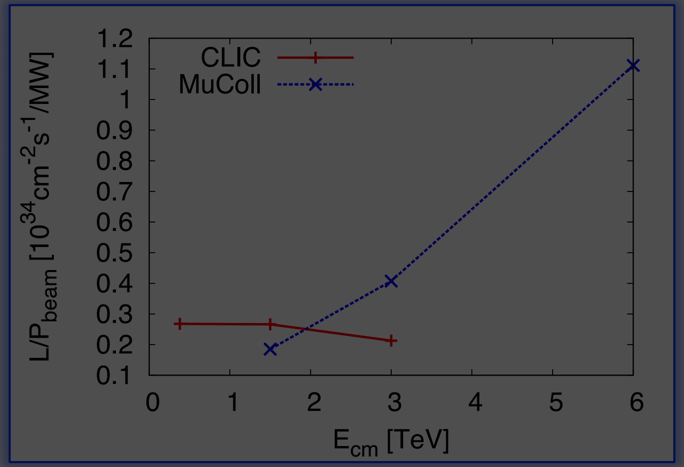
MuC facility



”small” rings



Not so expensive



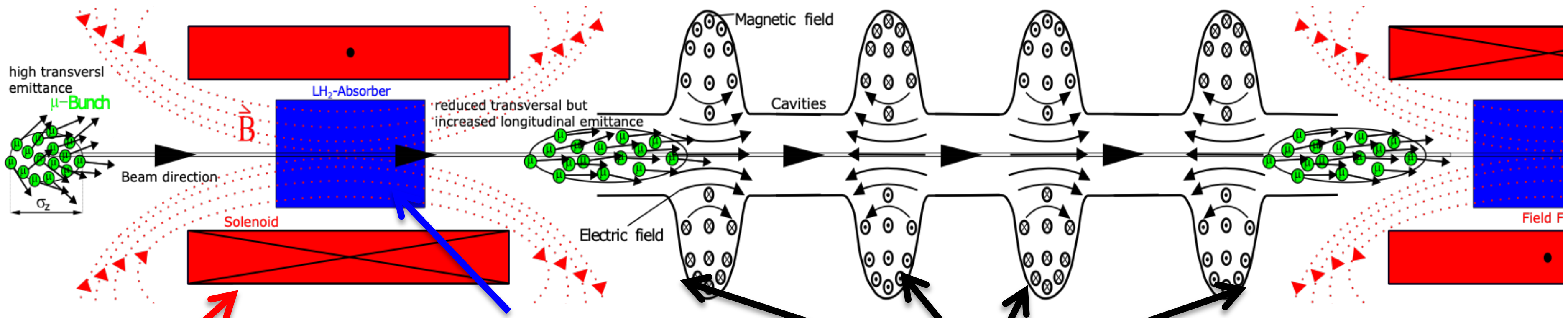
Demonstrator facility motivation

Demonstrate 6D reduction of muon beam emittance by a factor 2 by using ionization cooling

- Study and test high power target materials
- Test solenoid magnets for target
- Identify new strategy for beam dump
- High temperature superconducting magnets (10-20K)
- Construct and test cooling cells:
  - reliable RF in magnetic fields
  - absorber materials (LiH to start)
- Develop new beam dump detectors, Si based?

Depending on the resources available the muon beam could be re-accelerated and used for muon and neutrino physics.

Muon ionization cooling principle



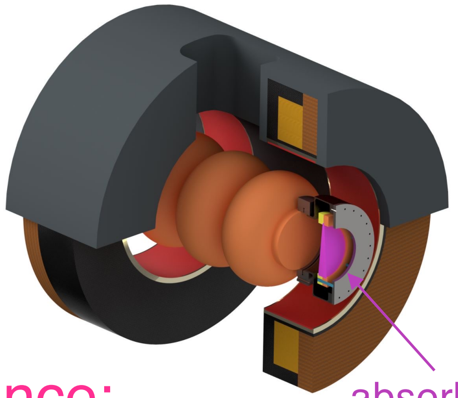
High-field, superconducting solenoid to minimize multiple scattering effect

Absorbers, Low Z material: Lithium hydride, liquid H

High-gradient normal-conducting RF cavities

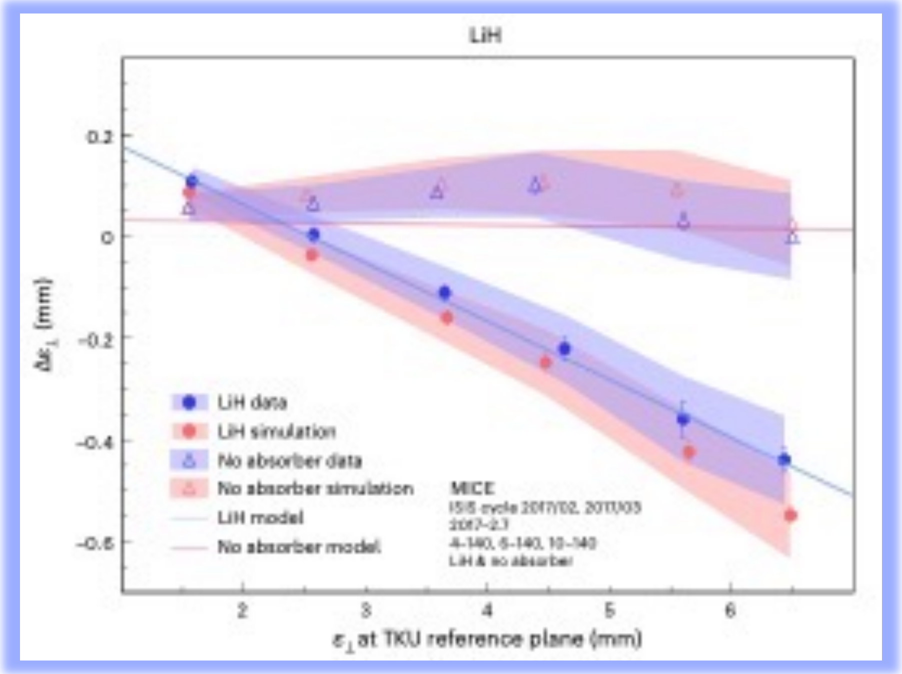
IMCC new activities:

- systematic design of the different cells



Improvement on expected simulated emittance: from 55 μm (MAP, Muon Accelerator Program) to 33 μm

Goal of the final emittance: 25 μm



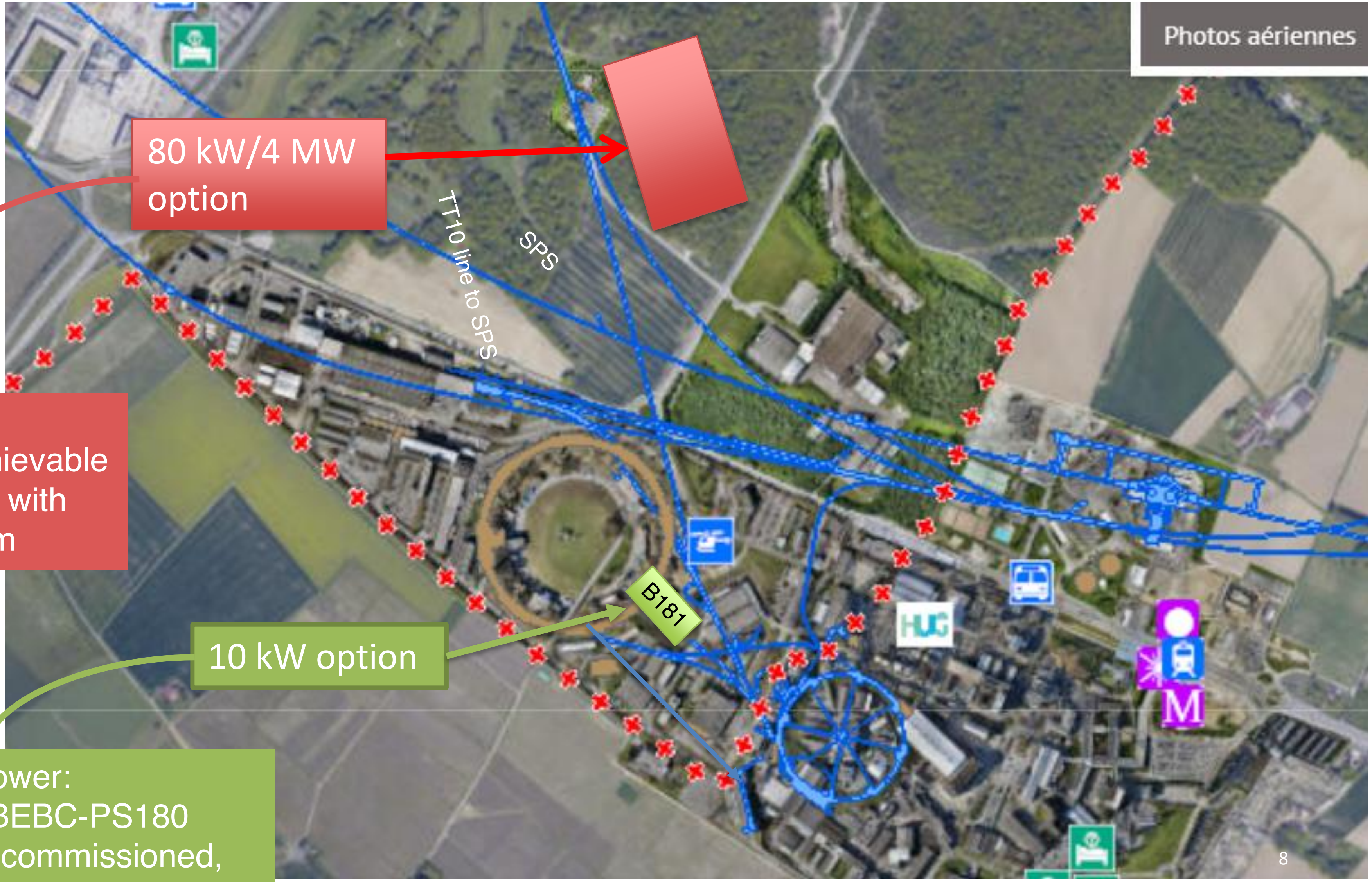
Simulation of transverse emittance well reproduced by MICE data

Demonstrator possibilities

Both use maximum intensity per pulse ~10^{13} ppp (or more) in pulses of few ns at 20+ GeV.

Different repetition rate:

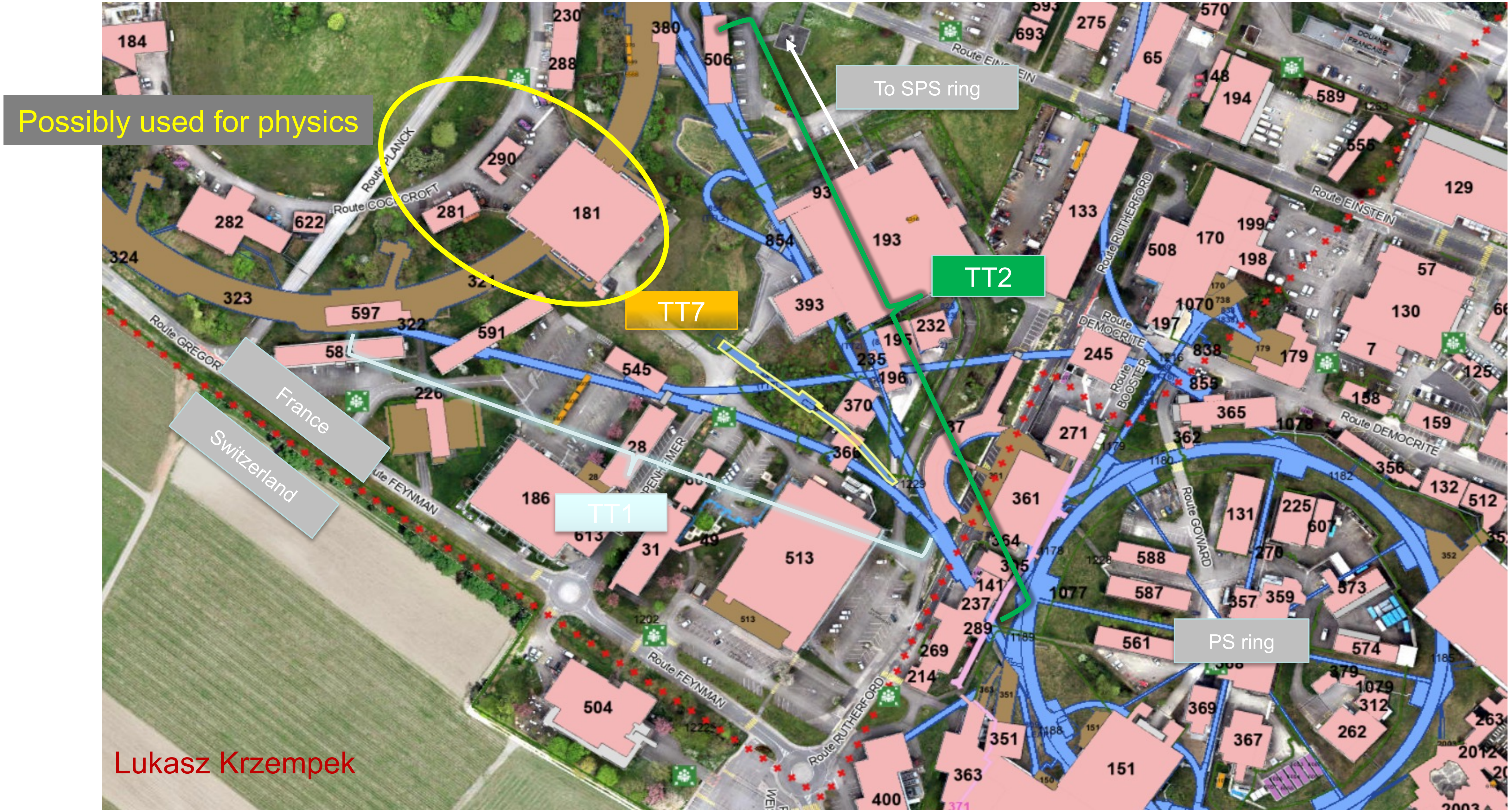
- 1 pulse/few second
- 1÷2 pulse/per minute



High power
O(80kW) on target easily achievable
No showstopper for 4 MW with beam at a depth of 40 m

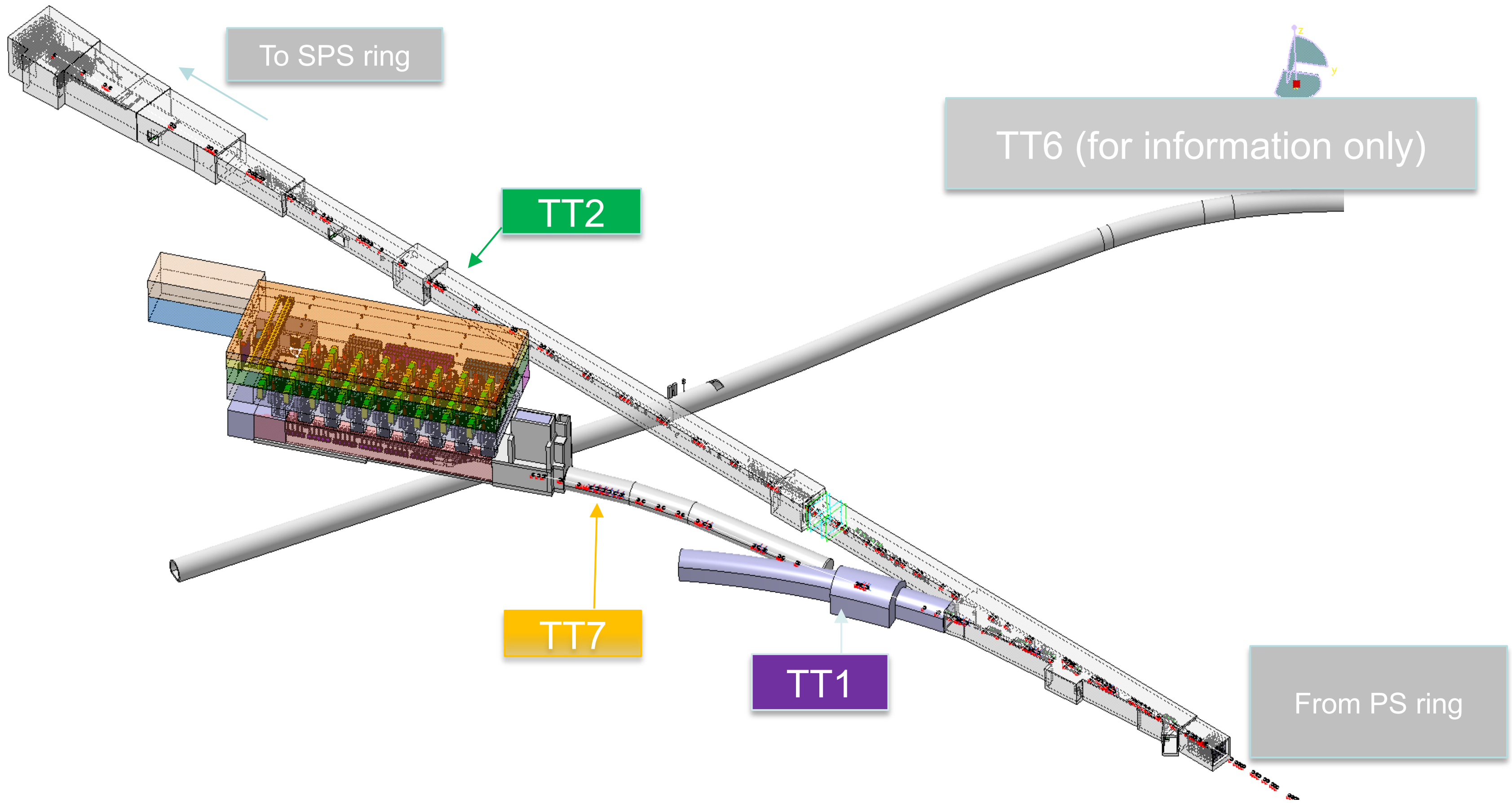
Low power:
Reuse line of BEBC-PS180 Collaboration, decommissioned, extending it towards B181 (now magnet factory)

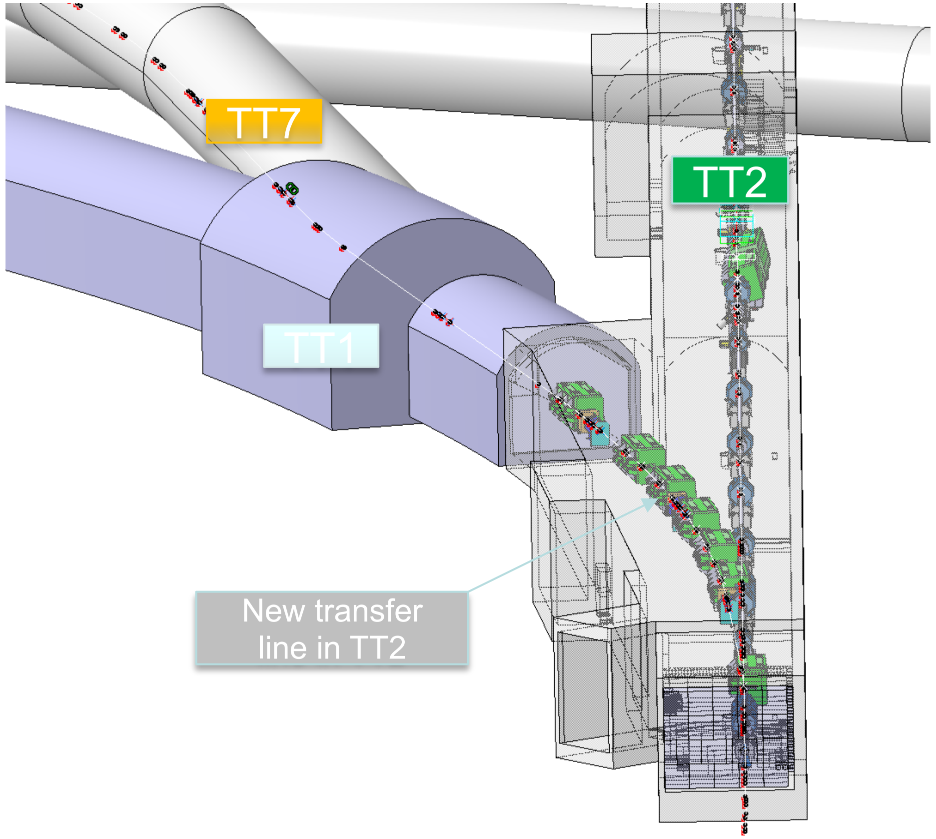
Low power option: use PS and TT7 line



TT7 line

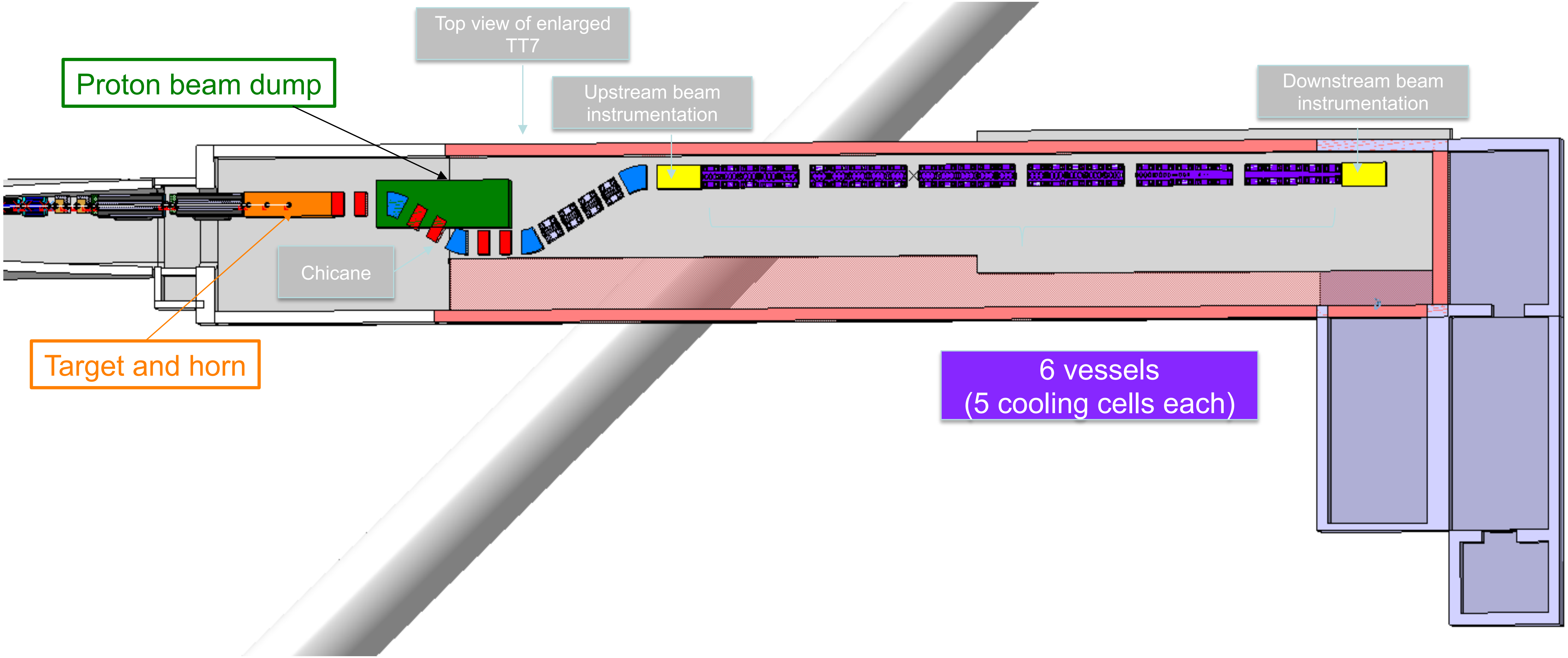
Lukasz Krzempek





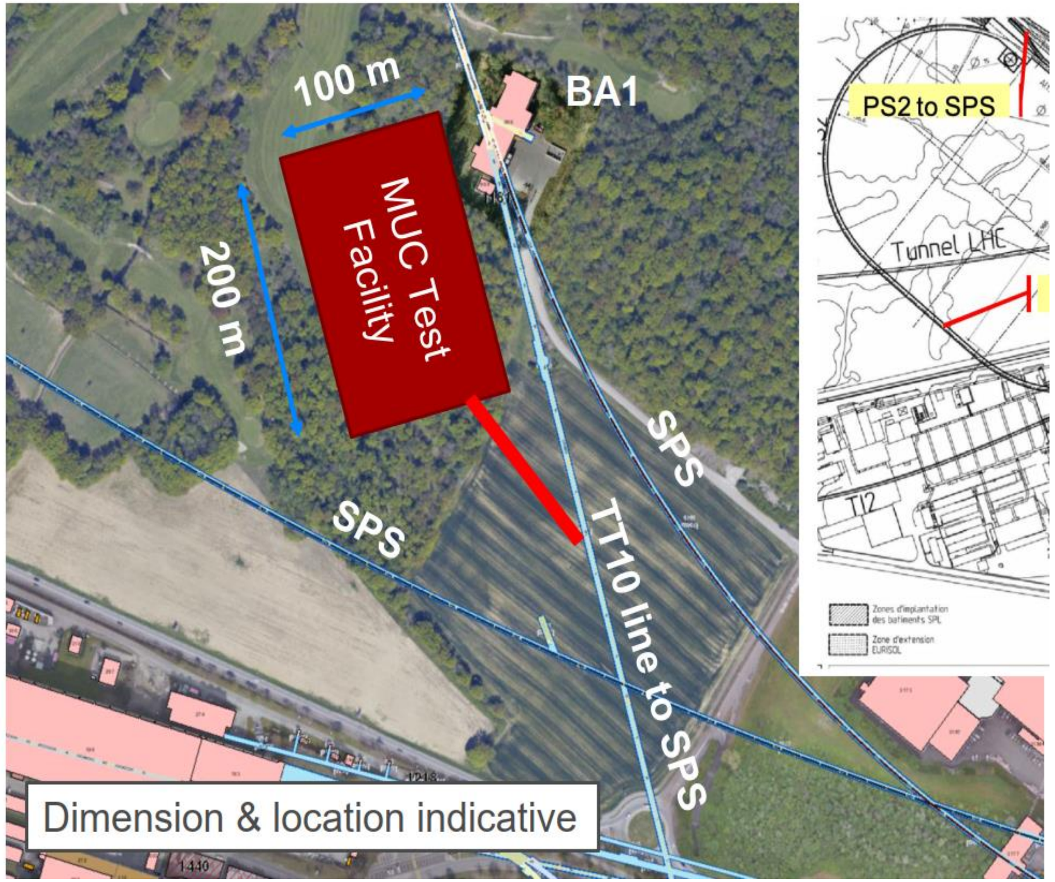
Demonstrator layout

Lukasz Krzempek



High power option

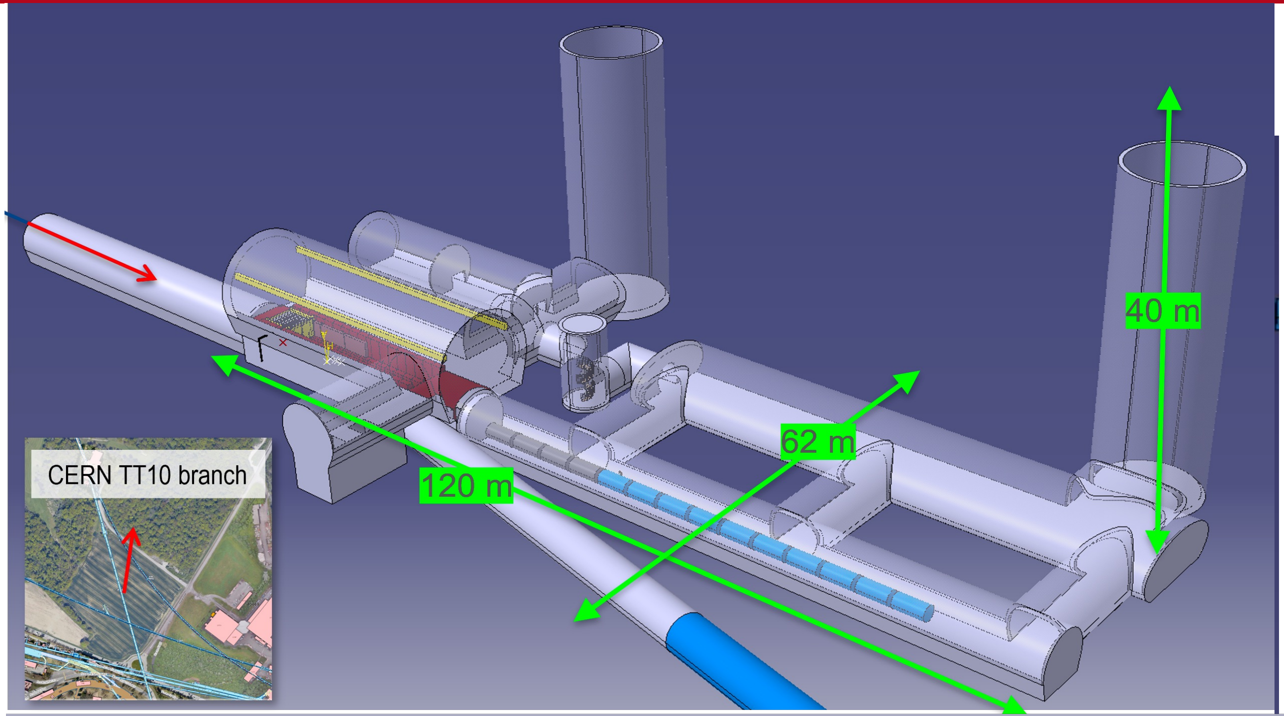
- TT10 is the transfer line from the CERN PS (≤26 GeV) to the CERN SPS.
  - O(80kW) on target can easily be achieved.
  - >10^{13} protons can be sent on a target at 20GeV+ in pulses of few nsec (n_TOF beam).
  - 4 MW does not appear to be a showstopper in this layout with beam at a depth of 40 m (detailed studies will have to be performed).
  - Future upgrades towards a collider and HP-SPL are in principle compatible with this layout.

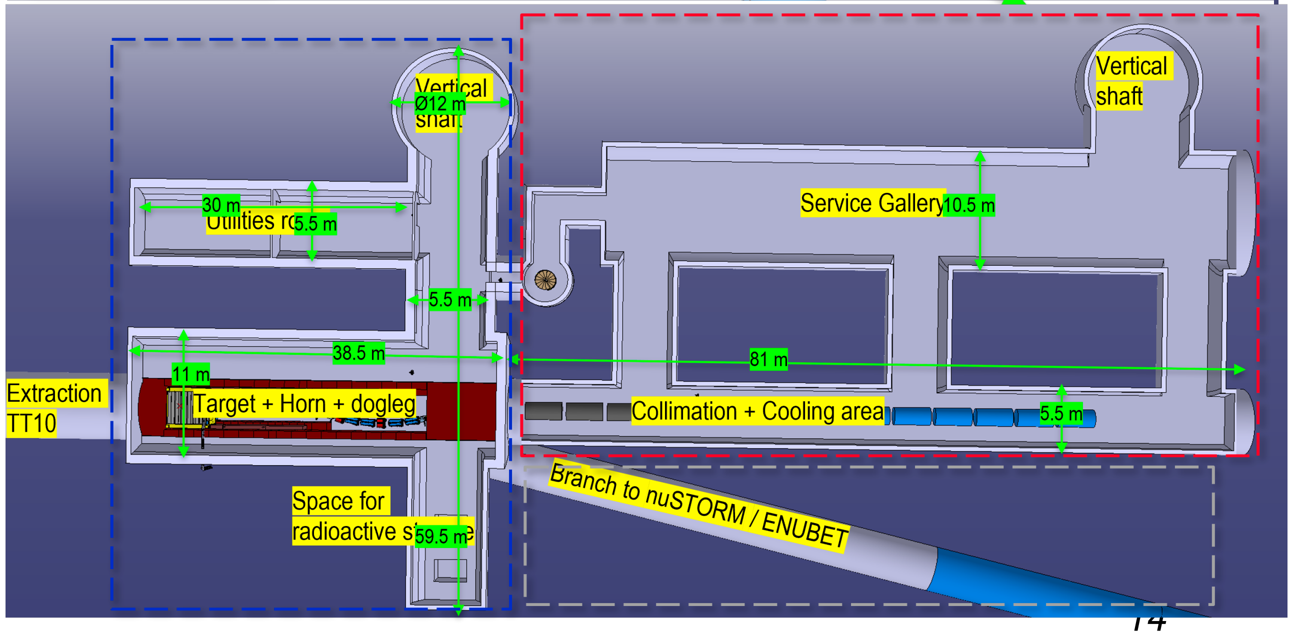


High power option

MUC Demonstrator VERY Conceptual layout

- The Facility is flexible enough to accommodate other experiments.
- nuSTORM and potentially ENUBET could be branched from the MUC Demonstrator Facility.
- The same target complex would be used profiting from its shielding and general target systems infrastructure, utilities, and accesses.
- The double deflection of the beamline could reduce radiation streaming towards the nuSTORM ring.
- Synergies between experiments would reduce costs on both sides.
- 26 GeV/c beam from the PS is appropriate for nuSTORM



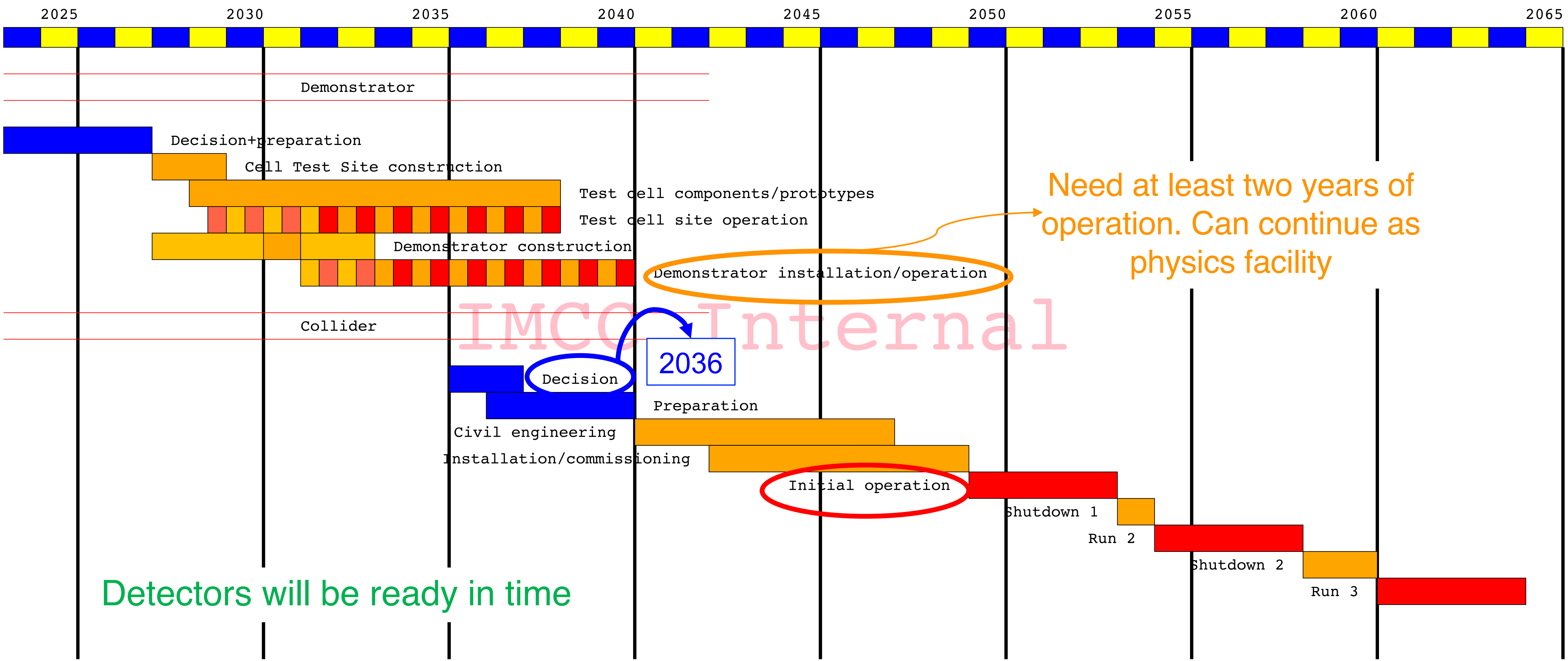


It is super important to have support for these activities

BACKUP

Tentative Timeline (Fast-track for $\sqrt{S}$=10 TeV)

IMCC Internal means "it is only a basis to start the discussion, it will be reviewed soon"



Possible implementations

Energy staging: Start at lower center-of-mass energy, e.g. $\sqrt{S}$= 3 TeV or more suited energy, move later at higher energy

Luminosity staging: Start $\sqrt{S}$=10 TeV with low luminosity, upgrade later to high luminosity as in HL-LHC

Expected integrated luminosity in 5 years one experiment

$\sqrt{s} = 3$ TeV 1 ab^{-1}

$\sqrt{s} = 10$ TeV 10 ab^{-1}

Parameter	Symbol	unit	Scenario 1		Scenario 2	
			Stage 1	Stage 2	Stage 1	Stage 2
Centre-of-mass energy	E_{cm}	TeV	3	10	10	10
Target integrated luminosity	$\int \mathcal{L}_{\mathrm{target}}$	ab^{-1}	1	10	10	
Estimated luminosity	$\mathcal{L}_{\mathrm{estimated}}$	$10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$	2.1	21	tbc	14
Collider circumference	C_{coll}	km	4.5	10	15	15
Collider arc peak field	B_{arc}	T	11	16	11	11
Luminosity lifetime	N_{turn}	turns	1039	1558	1040	1040
Muons/bunch	N	10^{12}	2.2	1.8	1.8	1.8
Repetition rate	f_{r}	Hz	5	5	5	5
Beam power	P_{coll}	MW	5.3	14.4	14.4	14.4
RMS longitudinal emittance	$\varepsilon_{\parallel}$	eVs	0.025	0.025	0.025	0.025
Norm. RMS transverse emittance	$\varepsilon_{\perp}$	µm	25	25	25	25
IP bunch length	σ_z	mm	5	1.5	tbc	1.5
IP betafunction	β	mm	5	1.5	tbc	1.5
IP beam size	σ	µm	3	0.9	tbc	0.9

Study on how to use LHC tunnel and/or other infrastructures