LHC Injectors Upgrade

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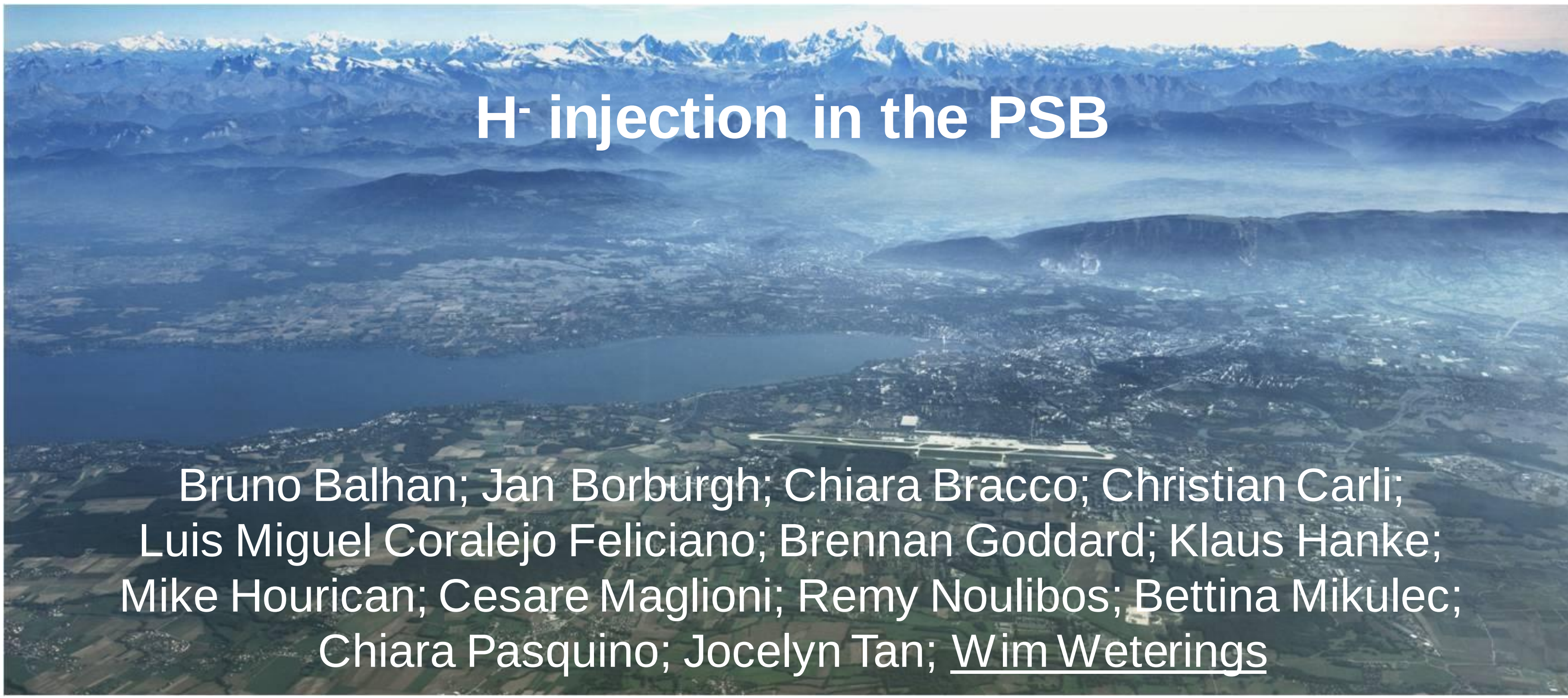


H$^-$ injection in the PSB

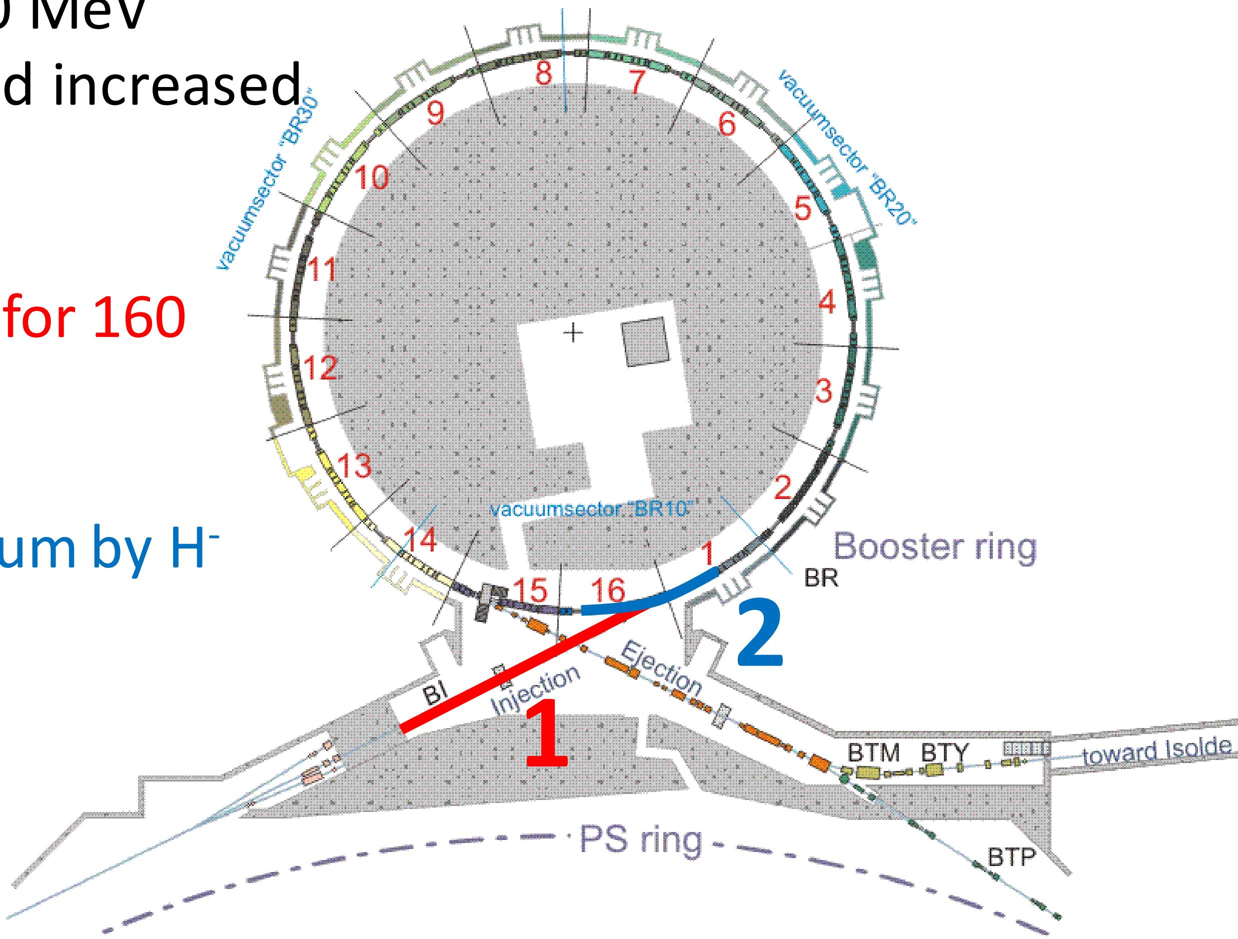
Bruno Balhan; Jan Borburgh; Chiara Bracco; Christian Carli; Luis Miguel Coralejo Feliciano; Brennan Goddard; Klaus Hanke; Mike Hourican; Cesare Maglioni; Remy Noulibos; Bettina Mikulec; Chiara Pasquino; Jocelyn Tan; Wim Weterings

Scope of the injection upgrade

Injection upgrade from 50 MeV protons to 160 MeV H^- and increased intensity*:

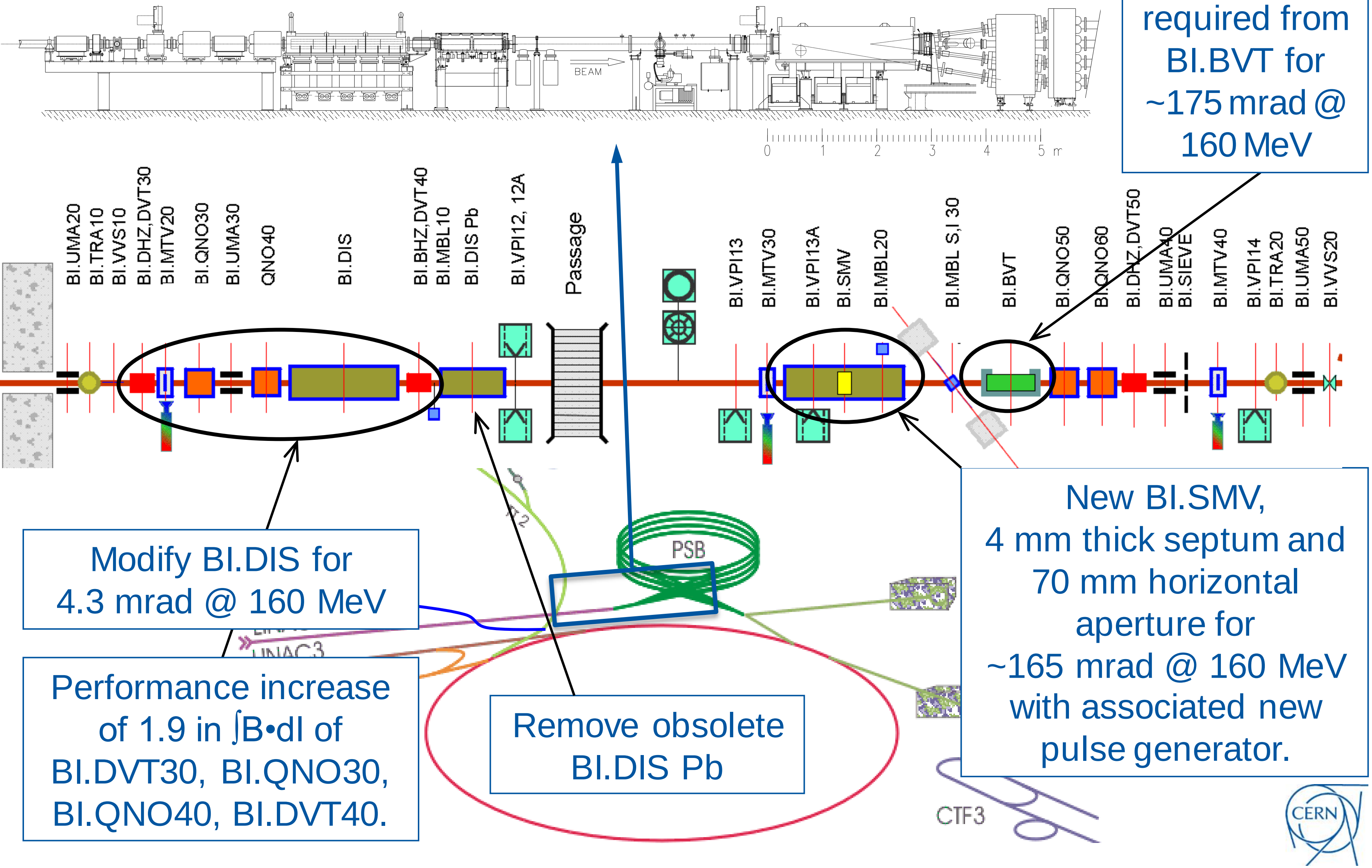
1. re-build injection line for 160 MeV;

2. replace injection septum by H^- injection system.



* although LIU aims at LHC-type beams, all equipment must be compatible with the highest intensities that can be expected.

Injection line for 160 MeV



~0.36 Tm required from BI.BVT for ~175 mrad @ 160 MeV

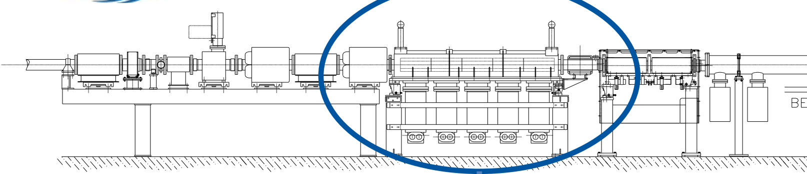
New BI.SMV, 4 mm thick septum and 70 mm horizontal aperture for ~165 mrad @ 160 MeV with associated new pulse generator.

Modify BI.DIS for 4.3 mrad @ 160 MeV

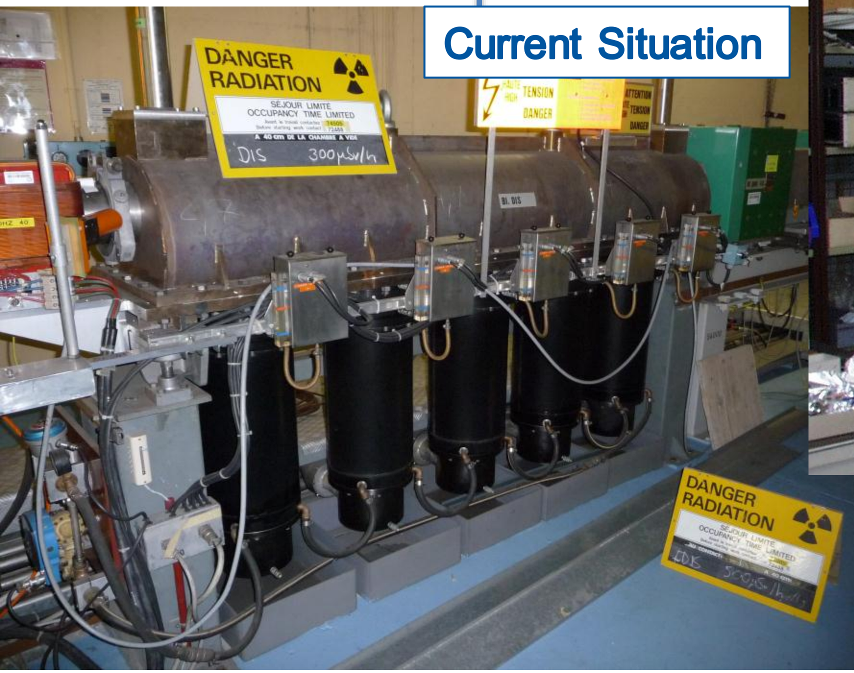
Performance increase of 1.9 in ∫B•dl of BI.DVT30, BI.QNO30, BI.QNO40, BI.DVT40.

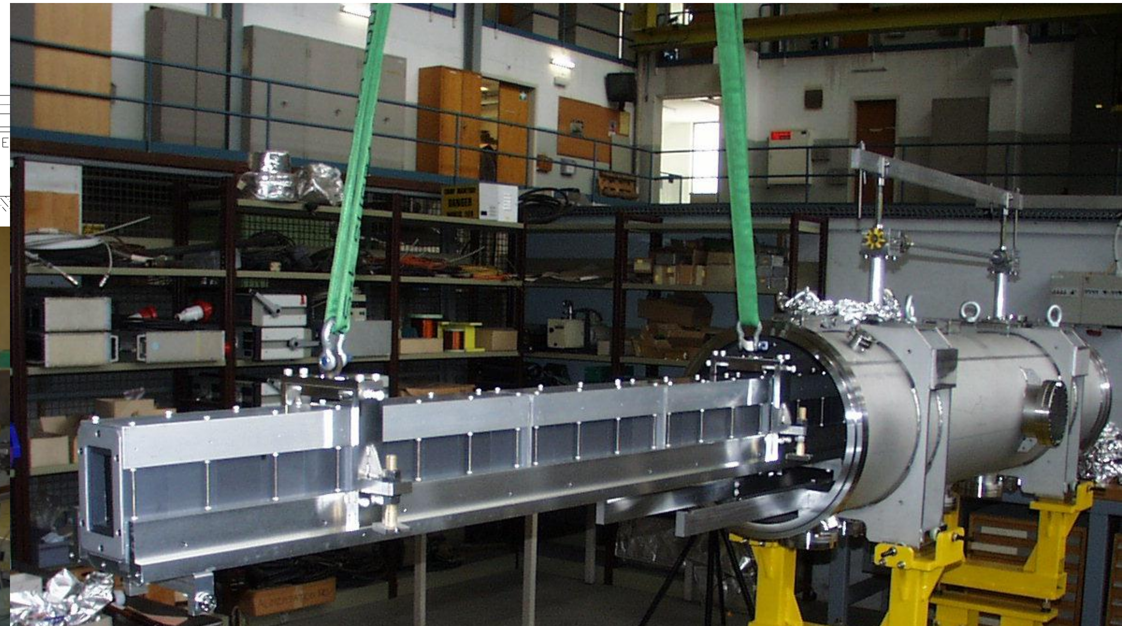
Remove obsolete BI.DIS Pb

Proton Distributor BI.DIS



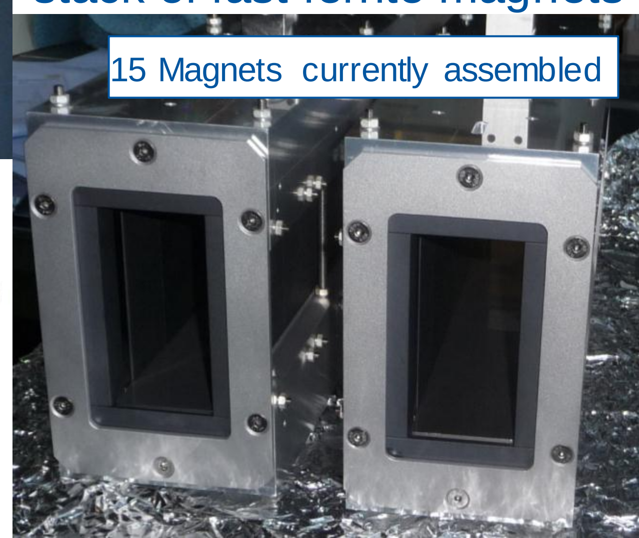
Current Situation

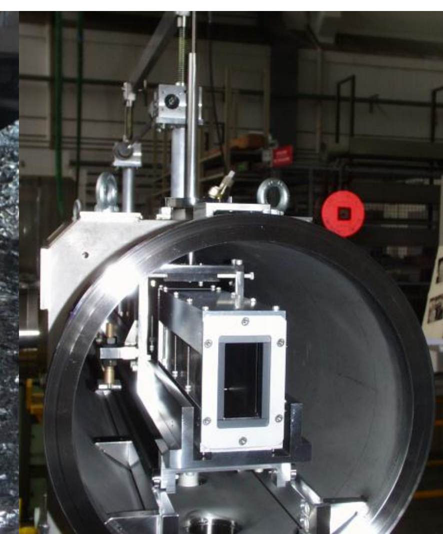




New system with rapid exchange “Plug n Play” stack of fast ferrite magnets

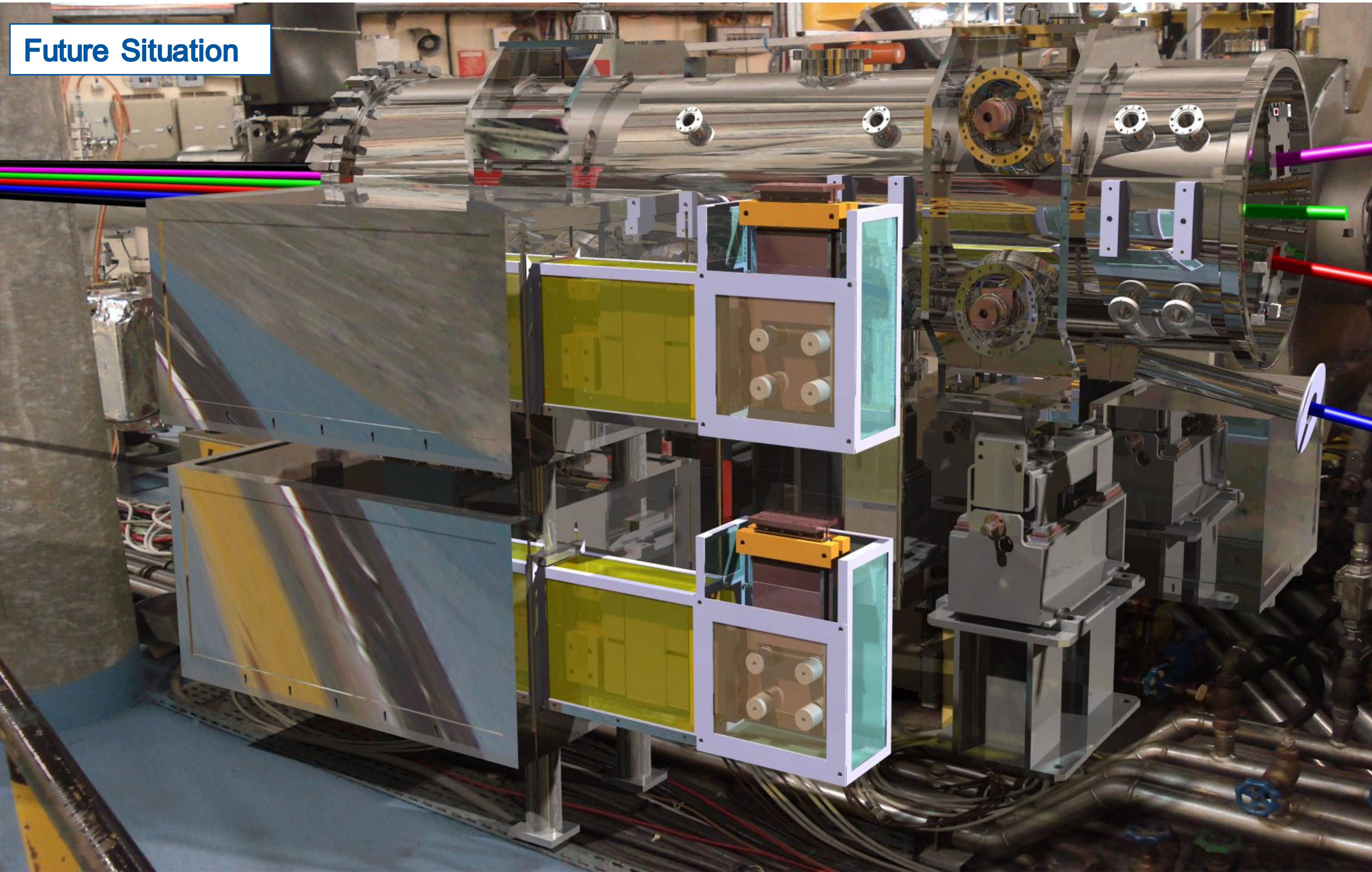
15 Magnets currently assembled





Development on new compact UHV 12 kV feedthrough

Vertical Septum BI.SMV

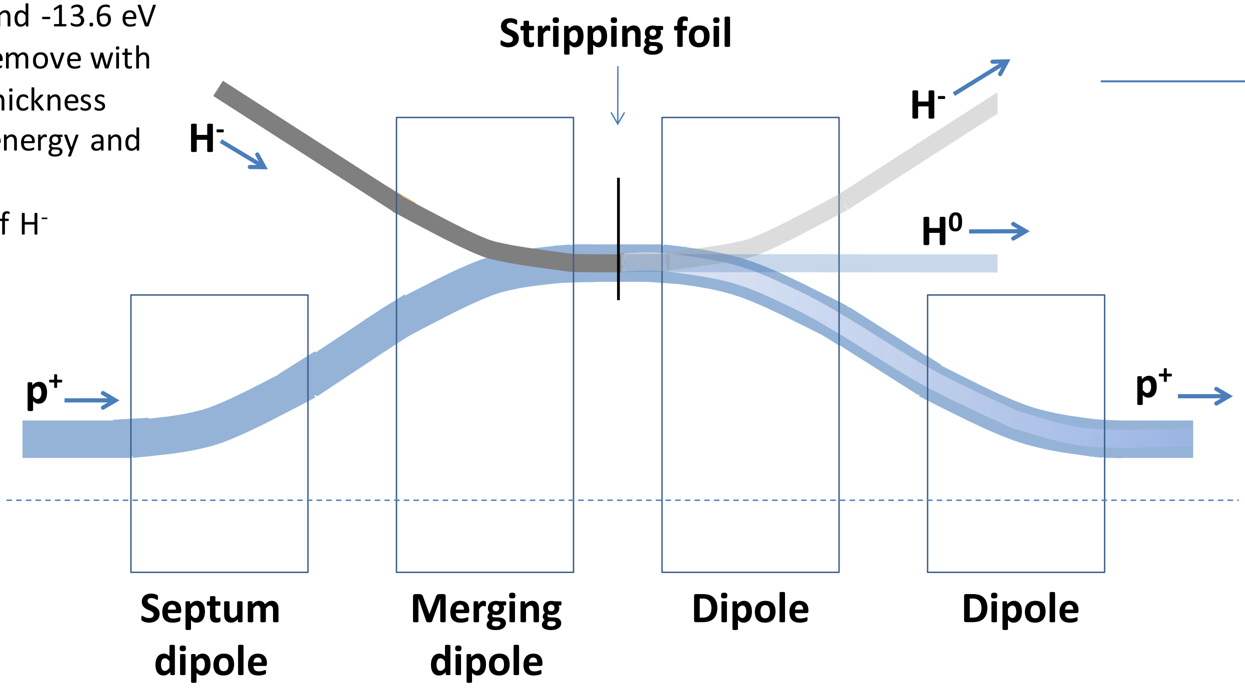


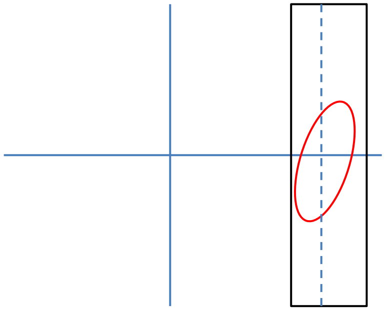
H$^-$ injection concept

Crucial features are merging dipole (part of injection "chicane") and stripping foil

H- is a negative ion of hydrogen

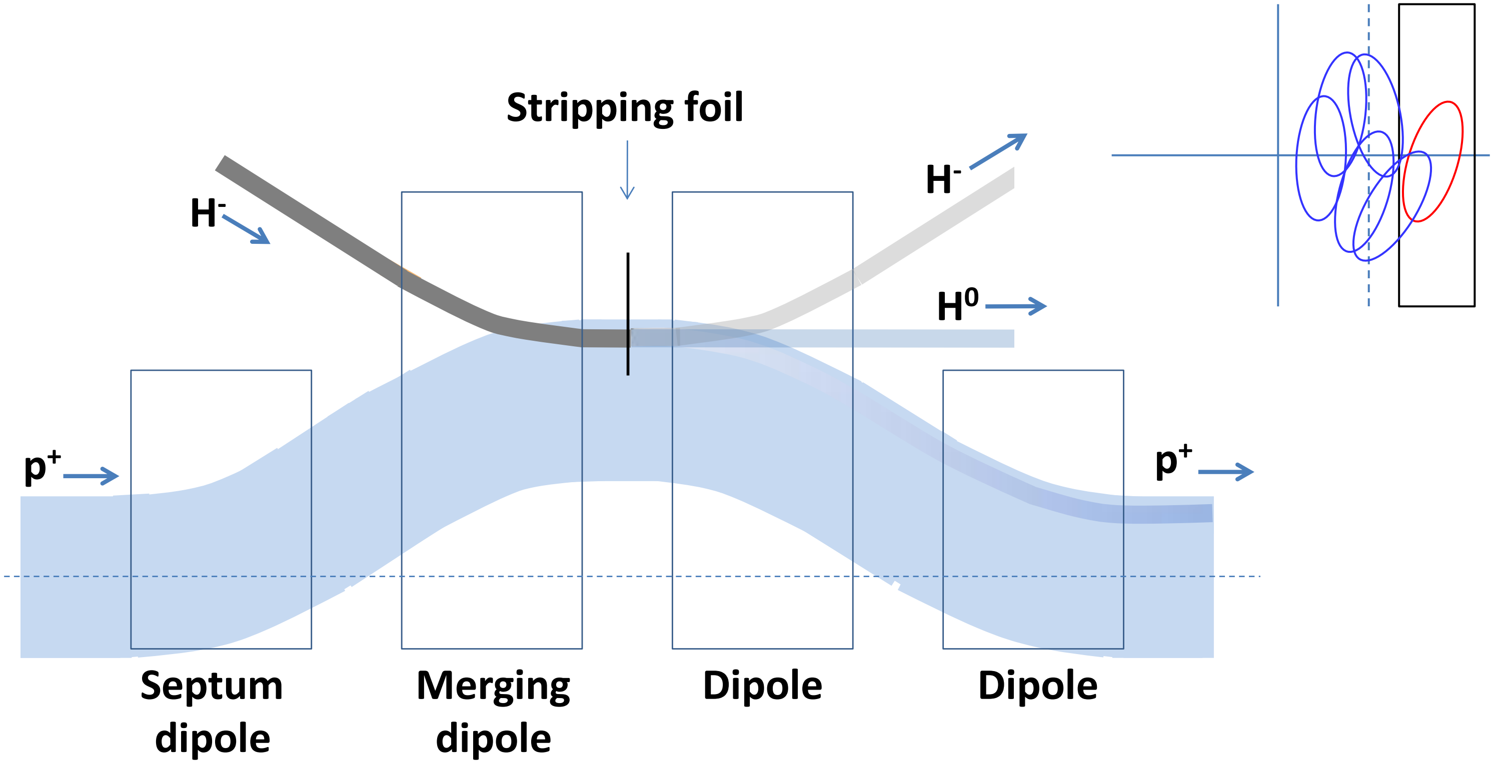
- Two electrons attached to proton: binding energies -0.75 and -13.6 eV
- Electrons are 'easy' to remove with a thin foil of some **μm** thickness (efficiency depends on energy and foil thickness).
- Typically 1% of H^0, 10^{-6} of H^-





H^- injection concept

Shifting the machine orbit with respect to foil (painting) fills machine aperture with beam

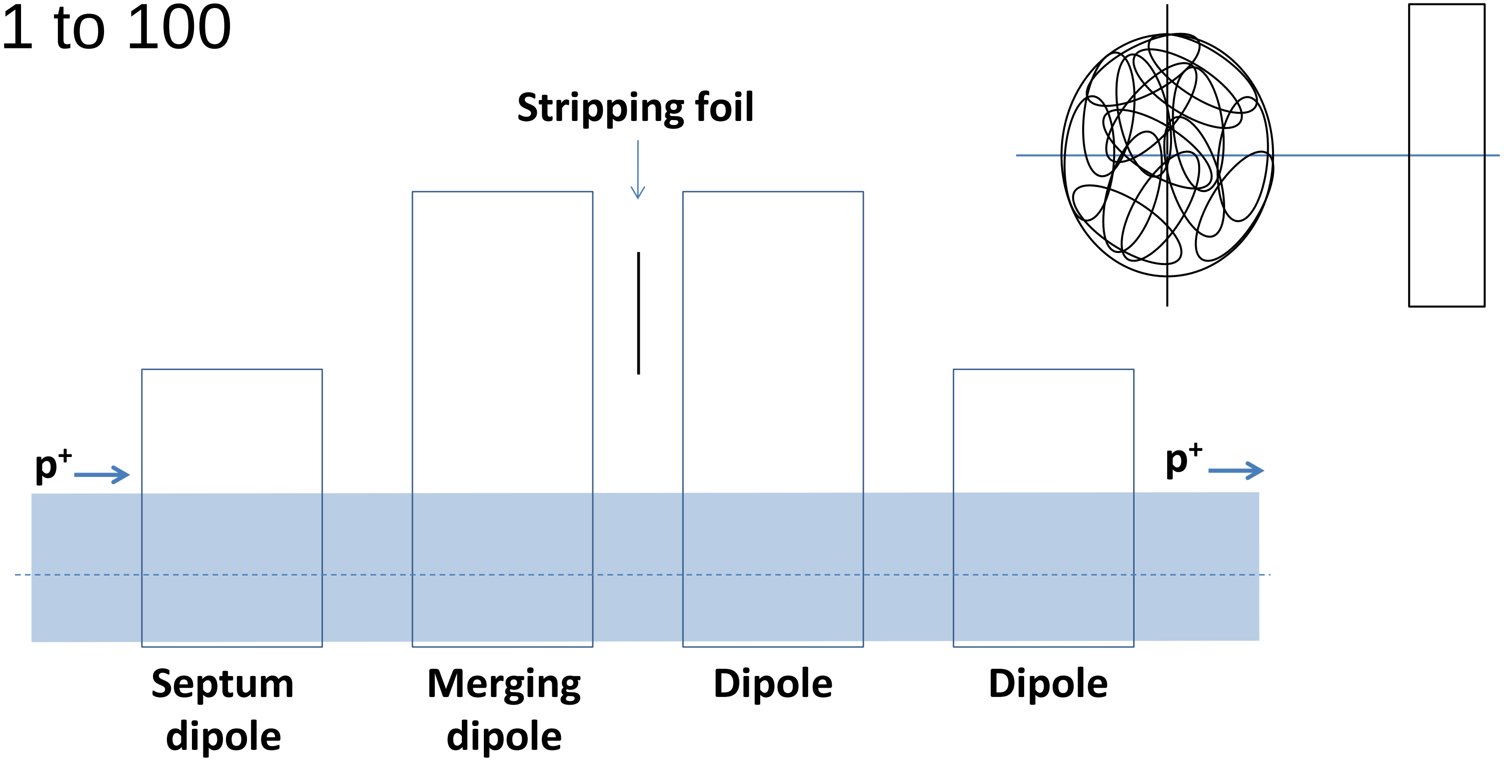


H^- injection concept

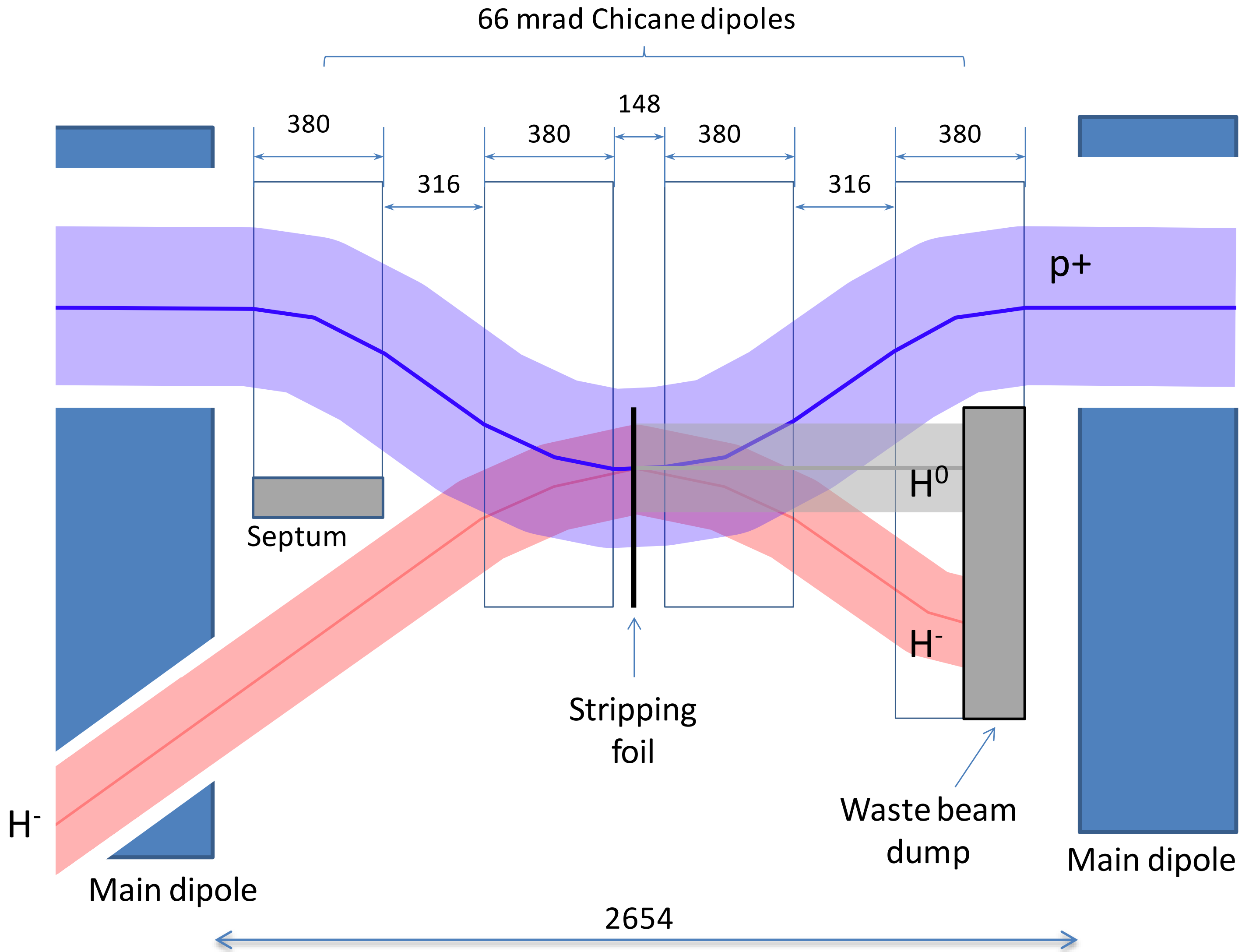
Chicane switches off to zero amplitude after injection

Intensities/emittances → number of injected turns

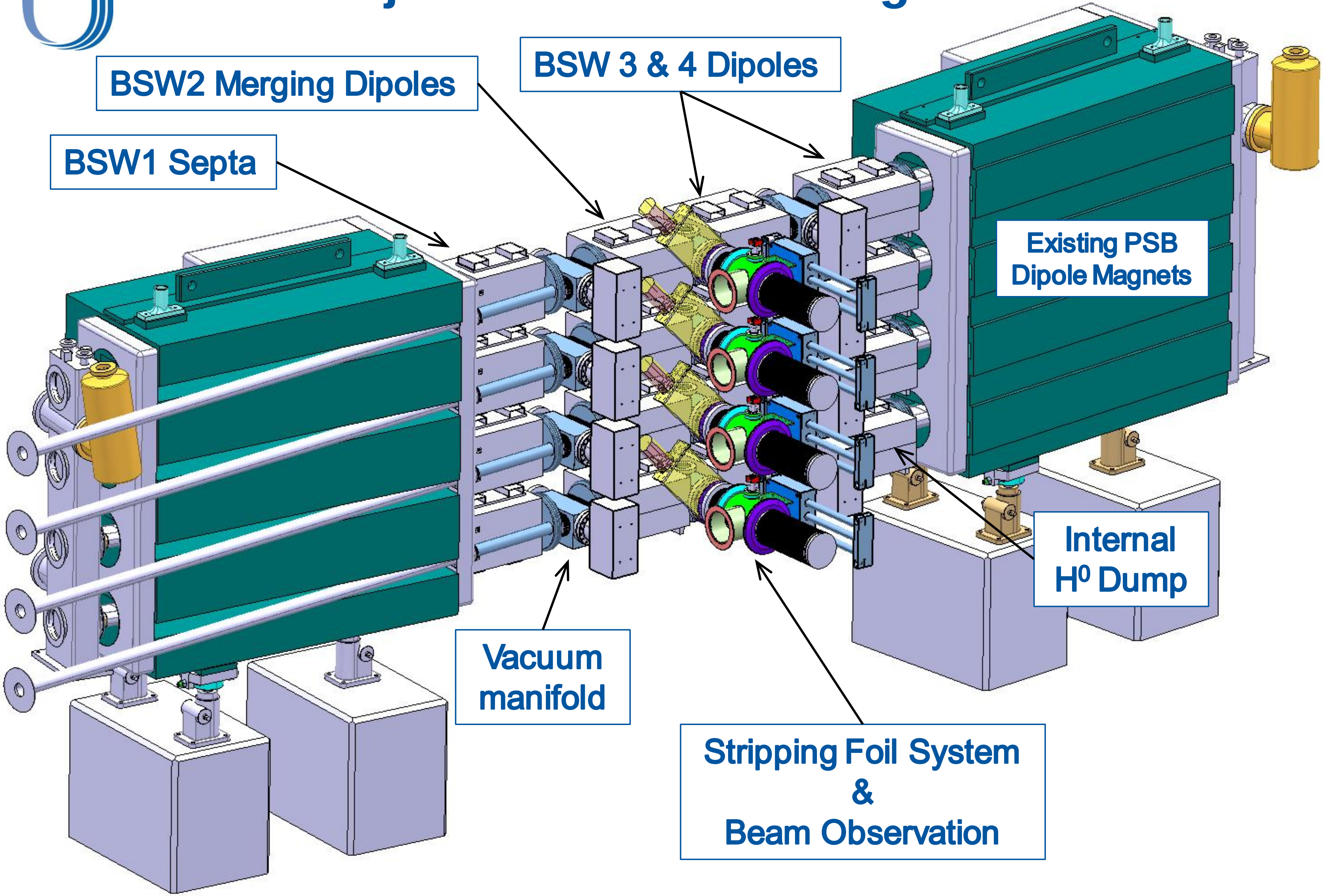
- From 1 to 100



PSB H^- injection chicane concept



PSB H$^-$ injection chicane design

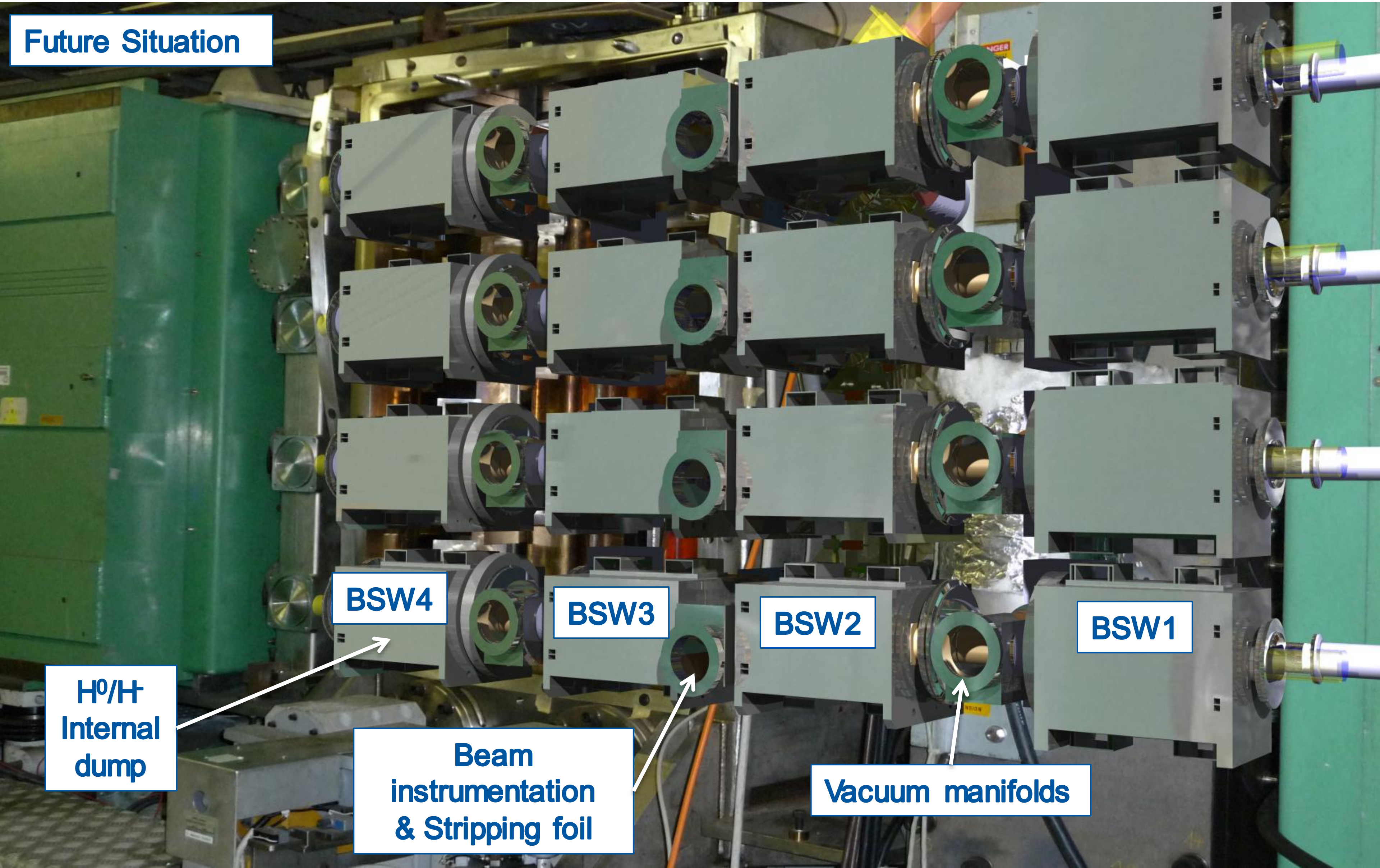


BI.BSW Baseline magnet parameters

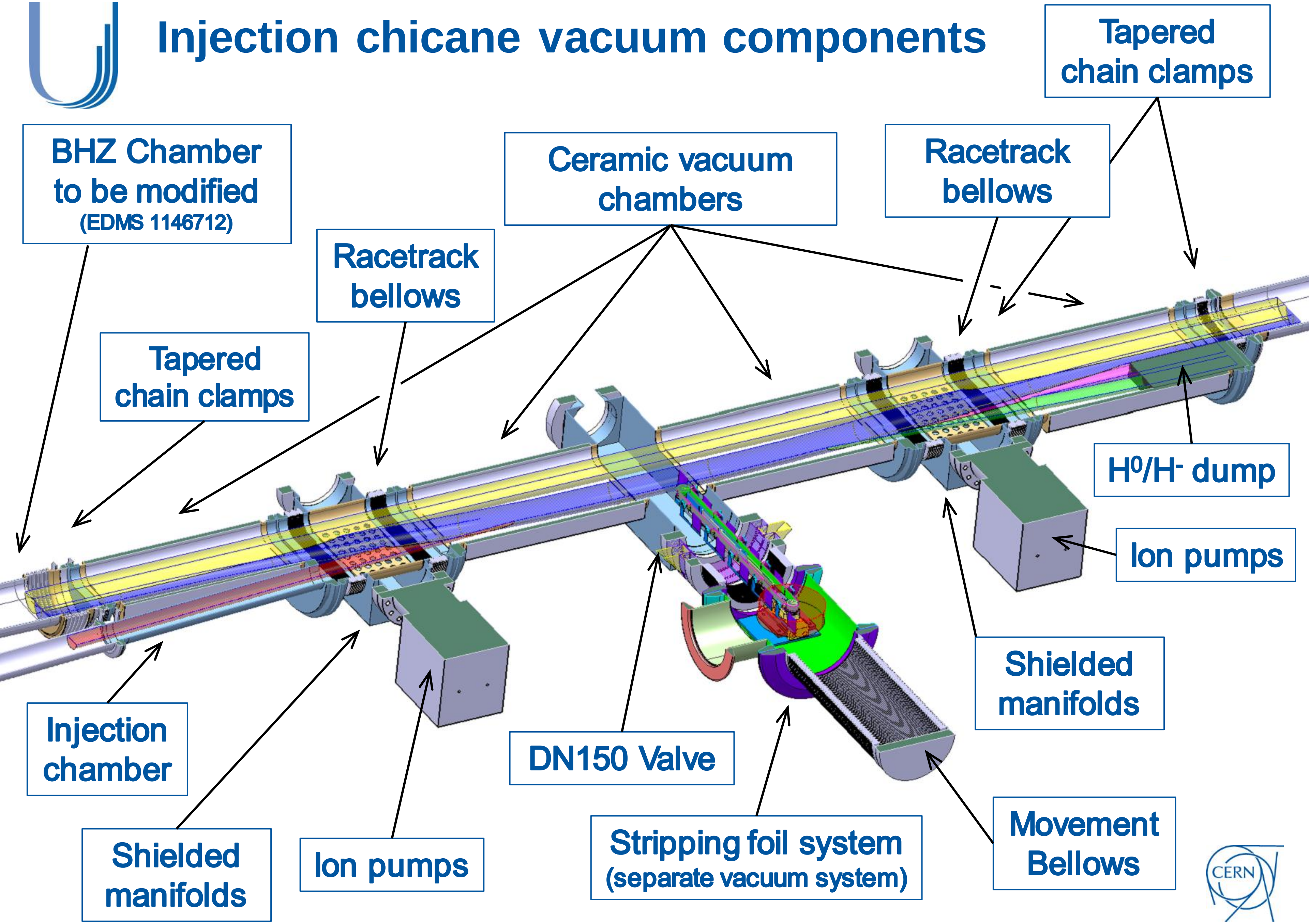
For 316mm magnetic length

Magnetic Properties	BSW1	BSW2/BSW3	BSW4
Field in the center of the magnet [T]	0.399	0.399	0.399
$\int B_y dl$ at magnet centre [m.Tm]	126	126	126
Electric current [kA]	13.5	13.5	13.5
Field homogeneity [%]	1	1	1
Good field region (h x v) [mm]	85x140	85x196	85x220
R (mΩ)	0.3	0.3	0.32
L (μH)	3.3	4.2	4.7
Number of turns	2	2	2
Mechanical properties			
Physical length [mm]	373	380	380
Septum conductor thickness [mm]	7	n.a.	n.a.
Pole face length [mm]	297.8	301	296
Endplate thickness [mm]	13.6	15.5	12
Yoke cross section [mm]	260x260	390x220	390x220
Aperture [mm]	162x85	218x85	242x85
Water cooling [l/min.]	4	3.4	3.3
Water cooling pressure [bar]	12	12	12

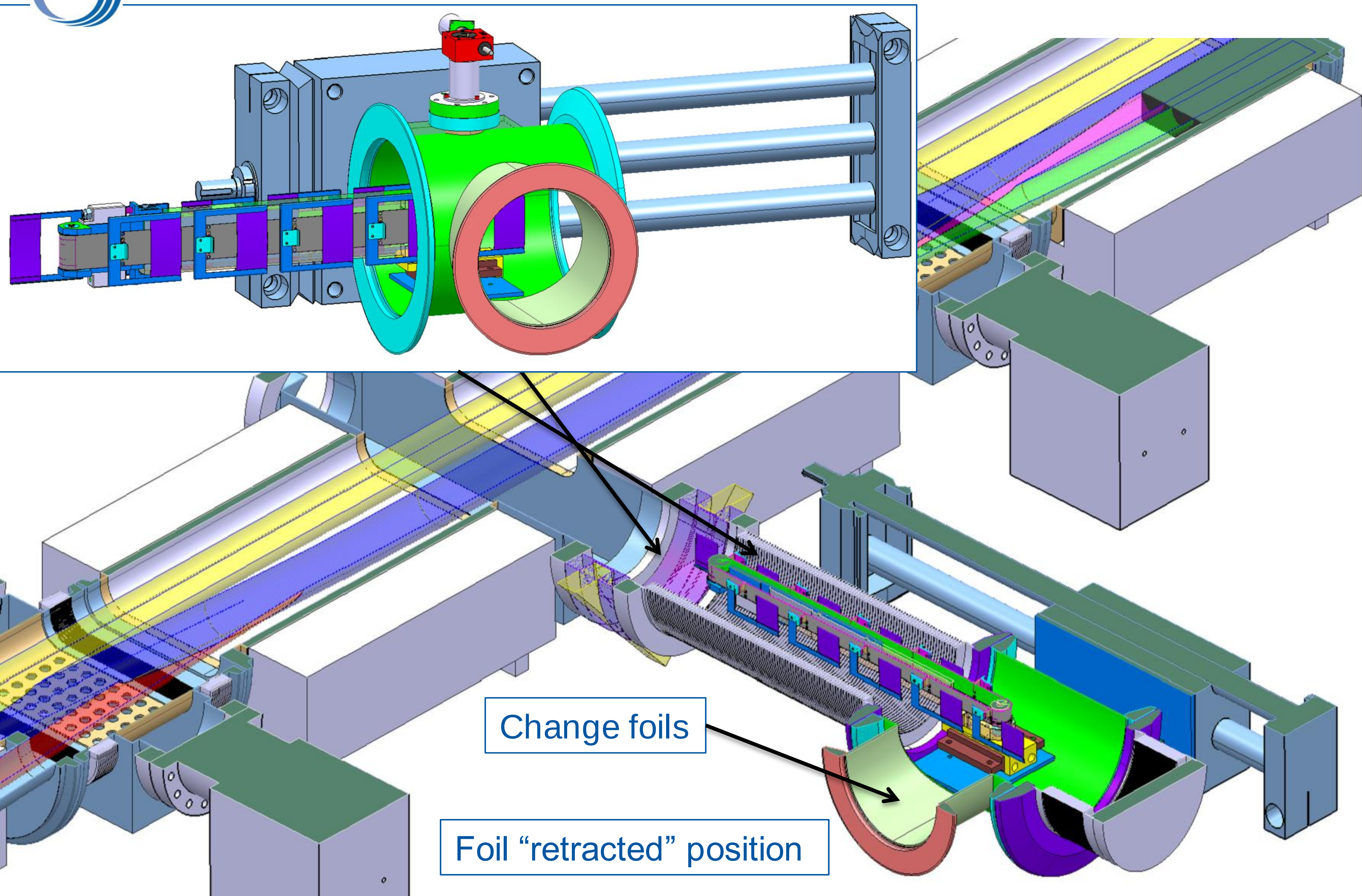
Mechanical integration BI.BSW



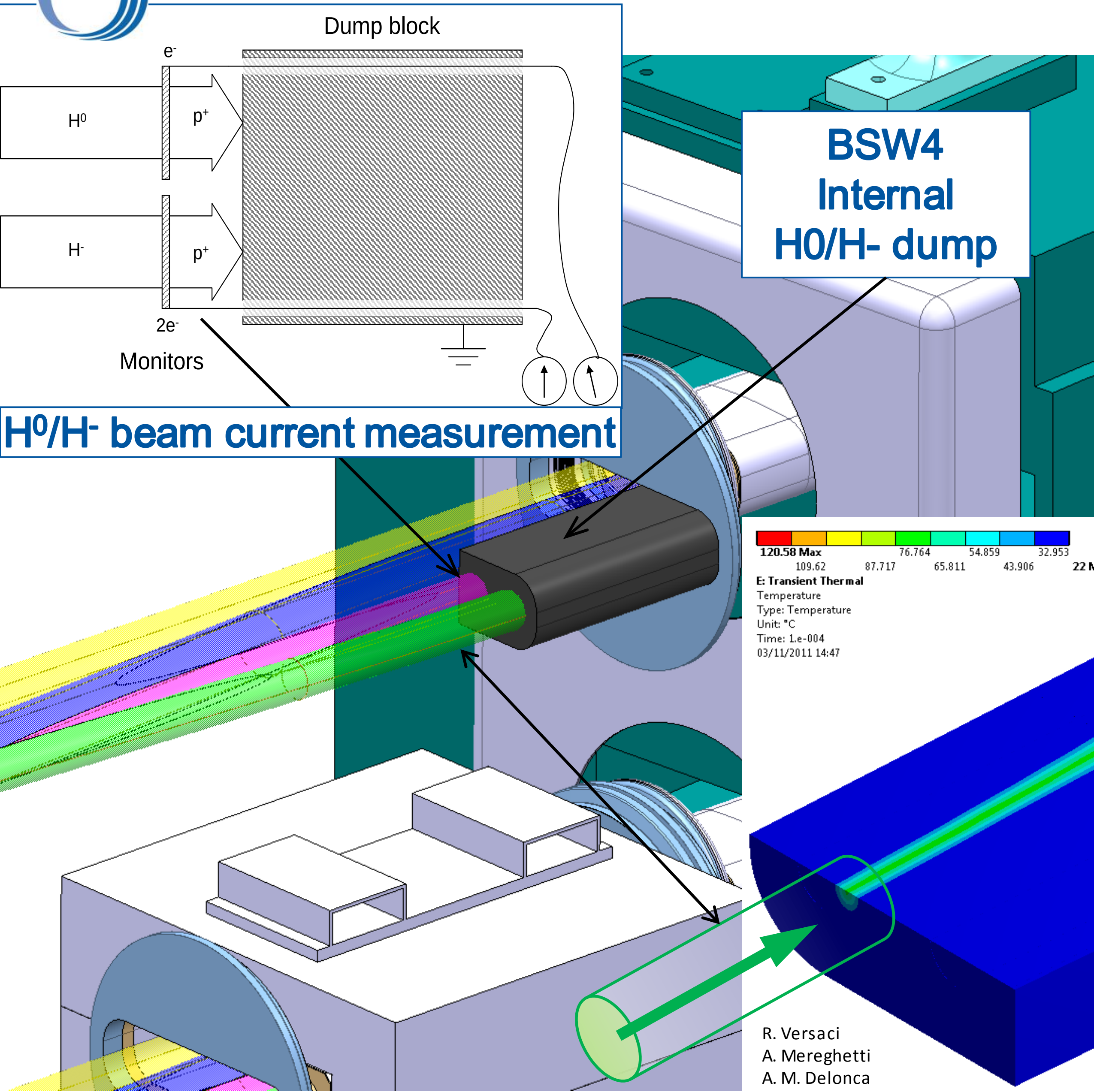
Injection chicane vacuum components



Stripping foil mechanism BI.STR



Internal H^0/H^- dump TDISA

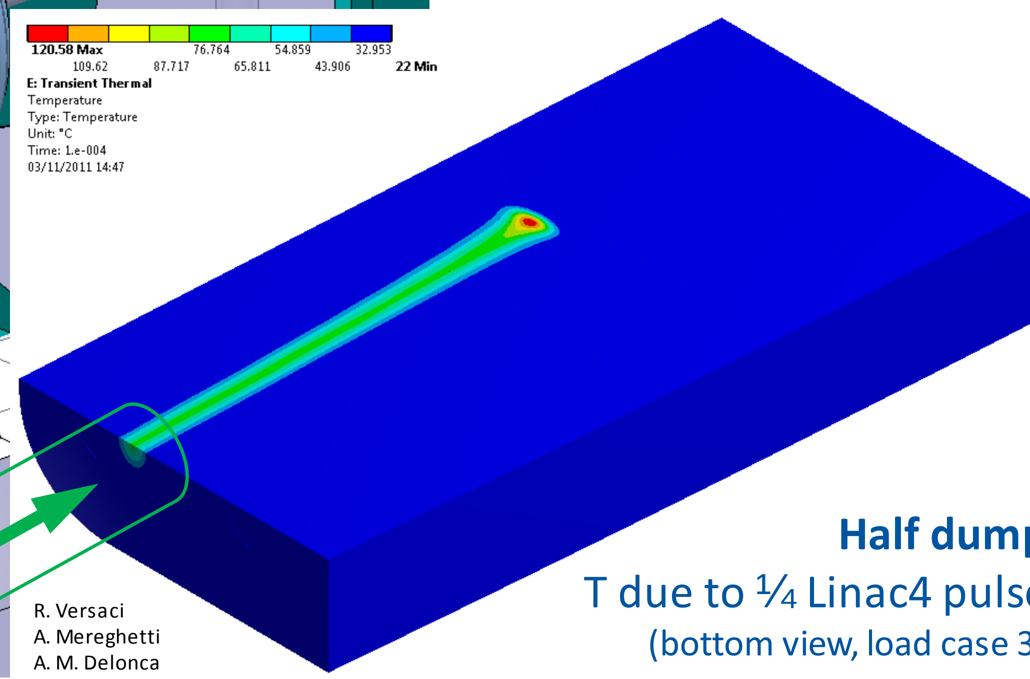


Three loading cases:
(depending on stripping efficiency)

1) 98% (foil operational)
   Steady-state;
   2% H^0, 0.8mA, ~14.2W

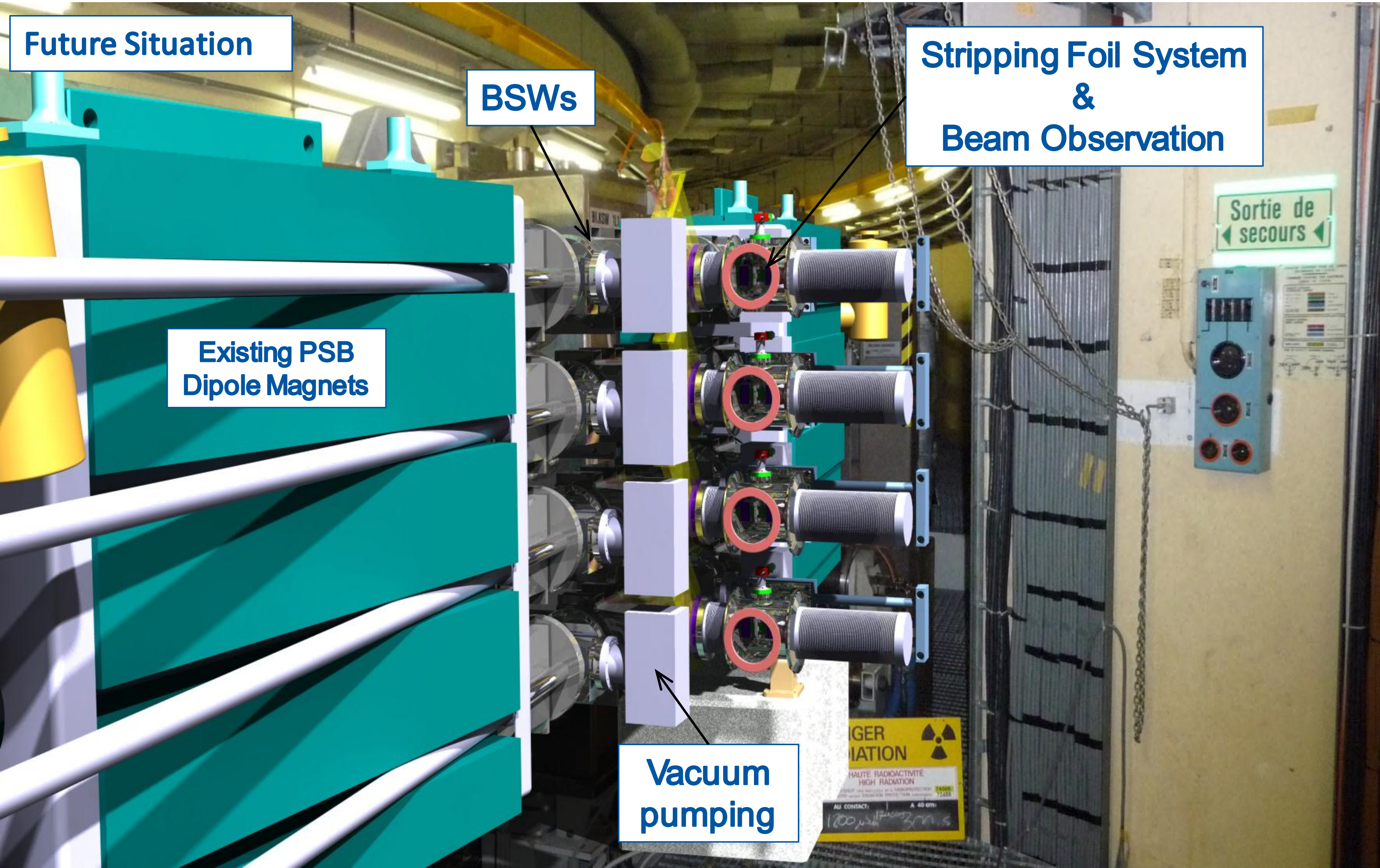
2) 90% (foil degraded)
   Steady-state;
   10% H^0 , 4mA, ~8h, ~71W

3) 0% (foil accident)
   Transient;
   ¼ Linac4 pulse; 40mA, 100% H^-, ~500J (interlock after 1 pulse)



Half dump
T due to ¼ Linac4 pulse
(bottom view, load case 3)

Mechanical integration BI.STR



Summary

- The PSB injection needs to be upgraded from 50 MeV protons to 160 MeV H^- operation.
- The injection line components have to be modified, or newly built, for a performance increase of 1.9 in $\int B \cdot dl$.
- The current SMH septum will be replaced by a H^- injection system, consisting of:
  - ➢ 16 newly built BSW injection chicane magnets and powering system;
  - ➢ 4 stripping foil mechanism and motorisation system;
  - ➢ Adequate beam instrumentation: - Beam-profile measurement at the foil
    - Visual inspection of the foil
    - H^0/H^- population measurement at the dump
    - Beam Loss Monitors
  - ➢ Internal H^0/H^- dump with cooling system.

Conclusion

from the closing remarks of

Review on PSB 160 MeV H- Injection

9-10 November 2011

"The world's most complex ring injection system is about to become more complex…"

"But if anyone can do it, CERN can"

Review board :

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B. Pine, STFC/RAL/ISIS
B. Jones, STFC/RAL/ISIS
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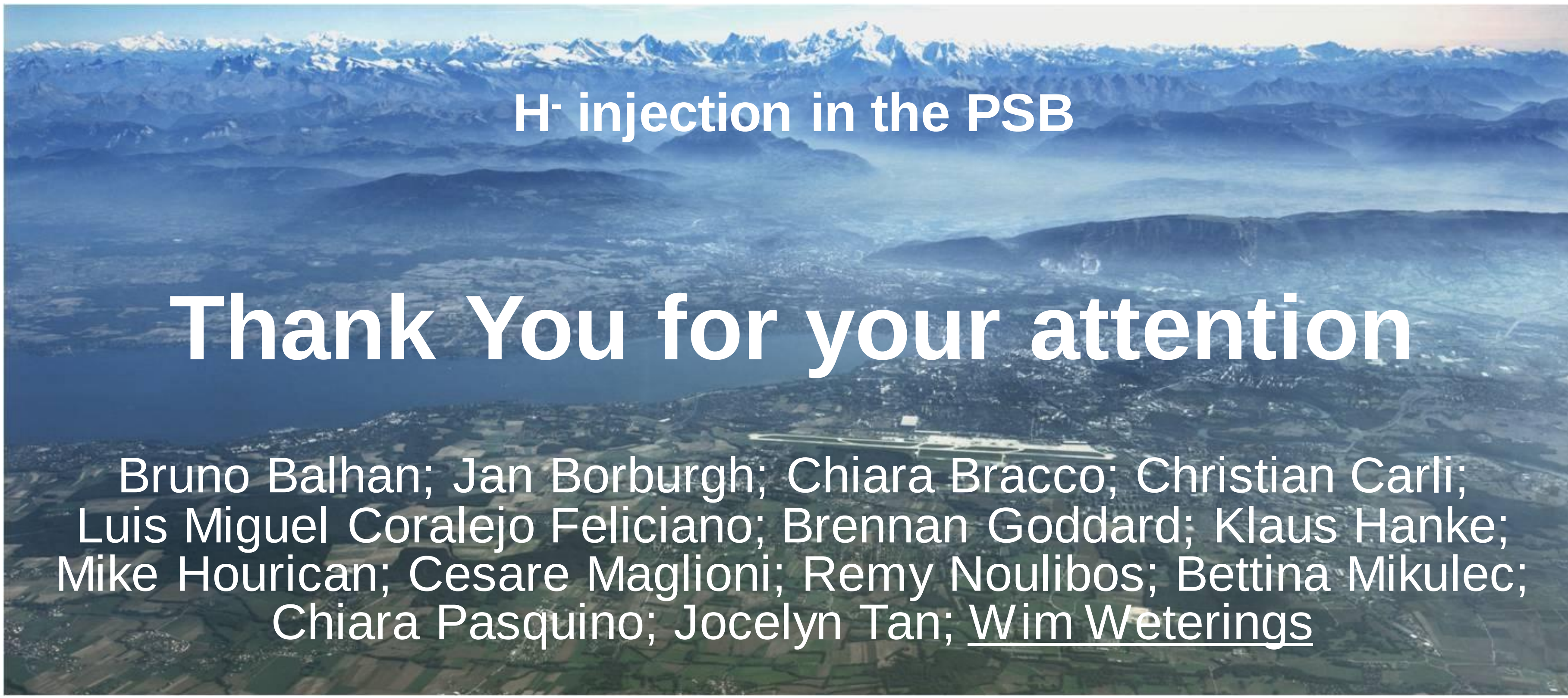

H^- injection in the PSB

Thank You for your attention

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