Report from WAMHTS-1 in Hamburg @ EuCARD2 CM

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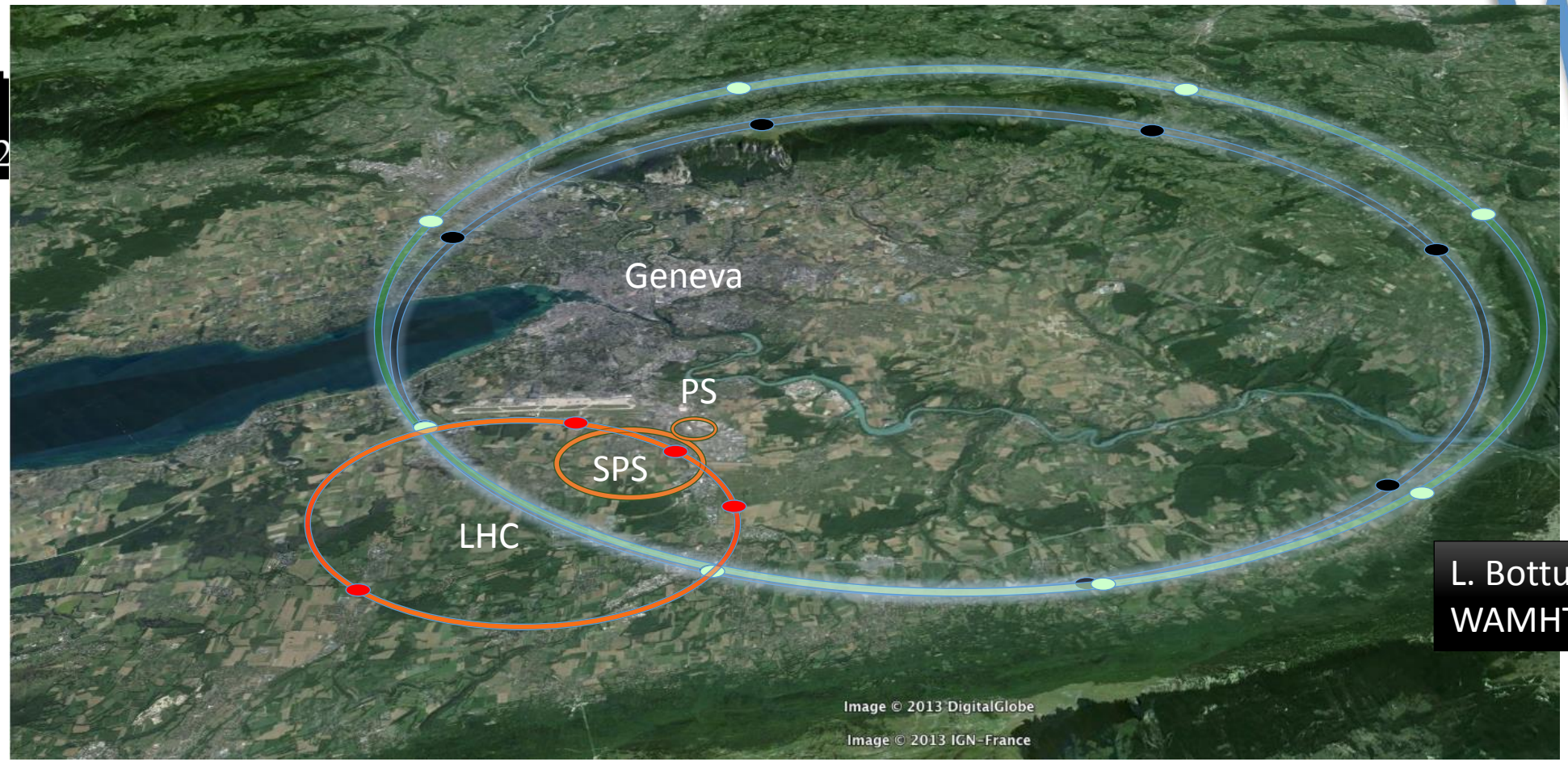
With contribution from L. Bottura and L. Cooley and other participants

WAM HTS – 1 General

- Triggered by HE-LHC, alter FCC-hh
  - EuCARD^2
- Following tradition of WAMS and WAMSD, it has been the 1st dedicated to HTS technology for Accelerator Magnets.
- Aim was to provide a forum where material scientists, conductor designers, and magnet engineers, all meet, also with Industry.
- 57 participants in WAMHTS-1 in Hamburg

The FCC-hh is the main goal (but not the only one)



L. Bottura at WAMHTS-1

LHC	HE-LHC	FCC-hh	FCC-hh
27 km, 8.33 T	27 km, **20 T**	80 km, **20 T**	100 km, **16 T**
14 TeV (c.o.m.)	33 TeV (c.o.m.)	100 TeV (c.o.m.)	100 TeV (c.o.m.)

A summary

L. Bottura at WAMHTS-1

- HTS for field (MB)
  - Attain o(20) T, reducing length and civil engineering in the main dipoles, and providing ad-hoc solutions for specific regions (e.g. function similar to the LHC 11 T Nb_3Sn dipole). Only HTS can do this
- HTS for operating margin (D1)
  - The FCC IR and collimator regions will be a “hell of a place”, with particles and energies never experienced before. Radiation tolerance, heat removal and temperature margin will be paramount to reliable operation. HTS can do this
- HTS for low consumption (booster/injector)
  - The FCC injector complex requires high energy efficiency to maintain the installed power at a reasonable level (e.g. the LHC SPS uses today o(50) MW). HTS at 20…77 K is a good candidate for this
- HTS for power transmission
  - The scale of the accelerator requires high-current lines over km lengths. HTS, combined with advances in cryogenic distribution, would be the ideal solution

HEP & HTS

- HEP has never been a driver for HTS
- Since a few years it is
- WAMHTS-1 hs enhanced this positive dynamism
  - Stared in USA af ew years ago
  - Boosted by HE-LHC and FCC
  - Other projects in Japan and elsewhere
- Company are looking at us with interest
  - 8 superconductor companies attended WAMHTS-1 !!
  - We need not deceive them

Results of the HEP - HTS

- Return of interest toward
- High Field (say > 10 T)
- Low temperature 4-20 K regime
- For us they are not HTS : they are HFS **High Field Superconductors**

- Now many reputed companies (except one) have optimization program for high field; laboratories are studying how to relate characterizion at 77 K s.f. (easy and continuous) to properties at 4.2 K – 20 T
- This interest $\Rightarrow$ indicator of difficulties in penetrating the real marked
  - for us economics is important but not a barrier – to a certain extend
  - We are a good partner, willing to test with perseverance

Compilation producers by Lance Cooley and Luca Bottura

Region	Vendor	Material and Route*
E.U.	Bruker (internal use)	REBCO (ABAD+PLD)
	SuperOx	REBCO (IBAD+PLD)
	Theva (not attending)	YBCO (ISD+RCE)
U.S.A.	SuperPower	YBCO (IBAD+MOD)
	AmSC (internal; not attending)	REBCO (RABiTS+MOD)
Asia	Fujikura (also Europe)	REBCO (IBAD+PLD)
	Sunam	REBCO (IBAD+RCE/DR)
	Sumitomo	DI Bi-2223

To add :
OST for Bi-2212
(in other session)

There are more HTS producer than Nb-Ti !

* REBCO = rare-earth (usually Gd) doped YBCO, where YBCO = $YBa_2Cu_3O_{7-x}$; IBAD/ABAD = Hastelloy C or stainless steel substrate with MgO buffer layer textured by ion/alternating beam assisted deposition; PLD = pulsed laser deposition; RCE = reactive combination of elements; ISD = inclined substrate deposition; MOD = metal-organic chemical vapor deposition; RABiTS = rolling assisted bi-axial textured substrates; DR = diffusion reaction.

Recommendation following tape session

- Unification of terminology :
  - lift factor… (ratio between performance at different temperature – field…)
- Increasing the YBCO thickness is a direct route for increasing the overall current density.
- Process optimization should maintain or improve the critical current variation along the unit length to 2.5%.
- Batch-to-batch consistency of critical current should be maintained at 5% level among unit lengths.
- Kilometer unit lengths should be achieved.
- Conductor thickness should be controlled to better than 5 mm, and width to better than 50 mm, including copper coating, to avoid stress concentration during winding or cabling.

Conductor

- CORC is certainly making competition to Roeble
- Other configuration (stacked tape) are also considered, with different problem
- We do not have an ideal cable – conductor - today…
  - Je tape is now not far for our goal!
  - Need UNIFORMITY and long lengths & cost reduction
- **How to transform the good tape perfomance int a good conductor?**
- Except Bi-2212:
  - Rutherford cable is a gift
  - However the 1 producer; the overpressure in O2 atmosphere and the transverse pressure needs to be addressed and demonstrated to be not a practical show-stopper

Points of reflection (provocations) to Magnet Designer and Engineers

- Industry needs orders…
- Industy need continuous orders…
- The downselection today is too early: we do not not know which of the variou processes will be the best for industrial production
- HTS Conductor is not yet mature to make good magnets
- Magnet manufatcurer must use the HTS as it is now
  - Built devices that reach a single goal (single goal demo, rather than final demo) even if the **whole set of parameters for the application is not met, yet**
  - Are we ready to use a conductor not good enough?
- **HTS means HIGHER STABILITY, evn at 4.2 K: how we use this characteristic?**
- **Are we ready to rediscuss margins and other categories?**
  Mantras are not good for accommodate novelties