

LHC Beam-Beam Compensator Prototype

– Update –

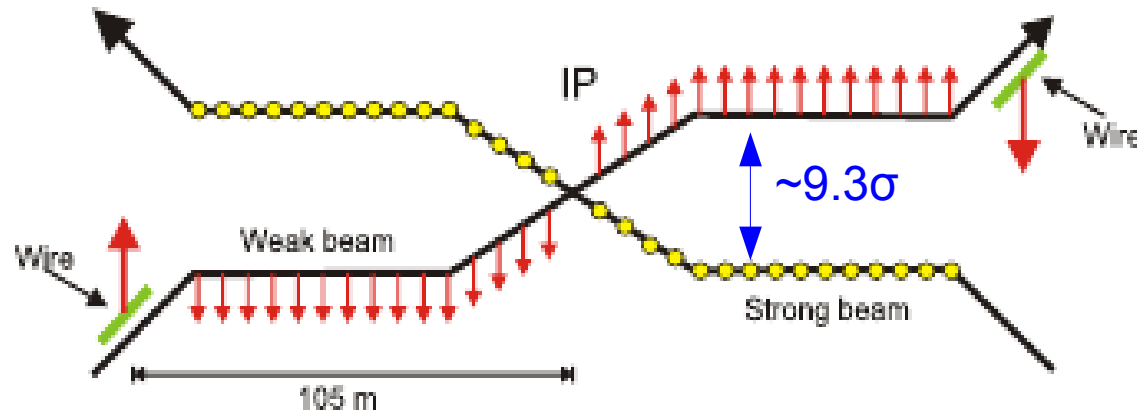
Ralph J. Steinhagen

for and with input from:

O. Aberle, R. Assmann (Collimation), A. Bertarelli, A. Dallocchio,
S. Fartoukh, R. Jones, J.-P. Koutchouk, F. Bertinelli, D. Perini,
A. Ravni, T. Rijoff, S. Redaelli (Collimation), R. Veness,
J. Wenninger (MPP), F. Zimmermann (ABP lead), M. Zerlauth

Motivation for Installing a BBC Prototype in the LHC I/II - Passed several Milestones

- Initial proposal based on to J.-P. Koutchouk's note: CERN-SL-2001-048-BI



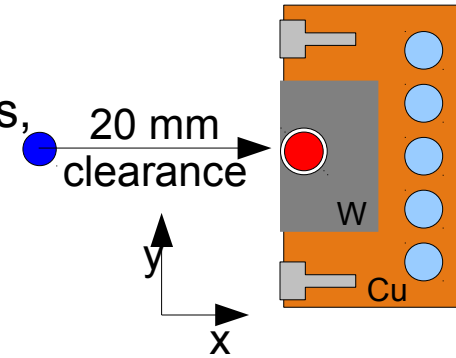
- Since, SPS wire-wire and RHIC beam-wire experiments demonstrated that:
 - “detrimental wire effect on life-time can be compensated by another wire”*
 - Benchmark of numerical tool chain → indication of what to expect at LHC*
- Further tests require a true long-range beam-beam limited machine...
→ proof-of-principle requires BBC prototype into machine before HL-LHC

- Reservations around IR1&IR5, LHC-BBC-EC-0001:
 - Min. LRBB → BBC phase advance: $\Delta\mu \approx 2.6^\circ$ (→ 3.1°)
 - Symmetric beta-function: $\beta_{x/y} \approx 1000$ m (for $\beta^* = 0.55$ m)
 → Prototype with nominal parameters not feasible during LS-1 (MPP, Cleaning,...).

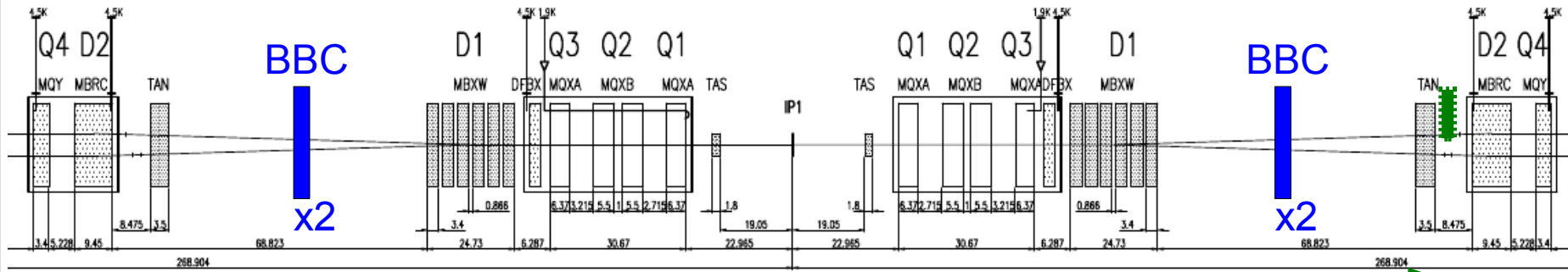
- Compromises in favour of an early proof-of-concept tests to guide and to gain lead-time for nominal system at HL-LHC:
 1. Operation close to MP envelope:
 - a) need to embed wire in collimator jaw-type structure – preferred
 - b) Operate within shadow of TCTs → ineffective w.r.t. beam-physics
 2. Limit nominally 8 BBC units to two:
 BBC.B1-H replacing TCL.xR1.B1 & BBC.B1-V replacing TCT(P).xL5.B1
 3. Wire parameters:
 - Solid wire radius of ~ 1 mm → 1kW power dissipation
 - sub- σ level of hor./ver. position control
 - Nominal scheme: $I = I_{\text{peak}} \cdot \sqrt{2\pi} \cdot \sigma_s \cdot n_{\text{parasitic}} = 72 \dots 350$ Am (max.)
 - Pulsed wire to accommodate differences for PACMAN bunches
 → not practical at this stage → stick to DC compensation only

Proposed Prototype Layout after LS-1

- Choice of replacing TCTP/TCL...
 - minimises the MP risk w.r.t. asynchronous beam dumps,
 - reuses existing collimation infrastructure, and
 - allows testing with nominal (/ATS) optics after LS-1.



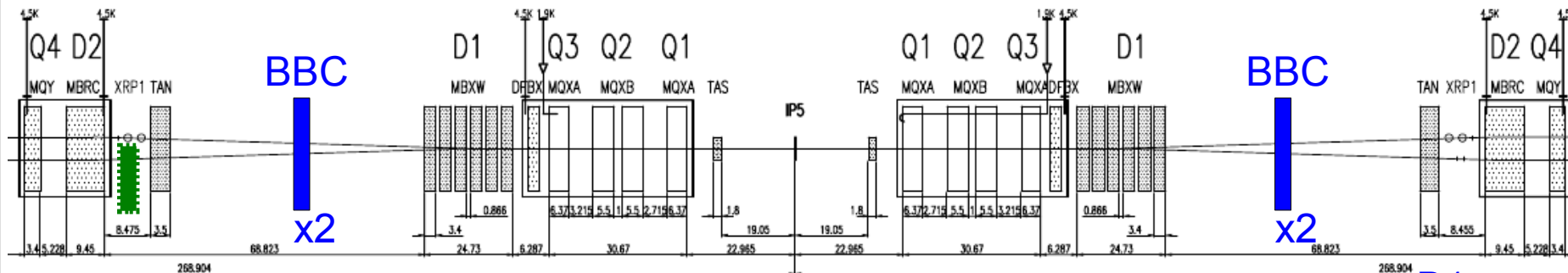
ATLAS



Nominal
Prototype

TCL.B1 (Cu)

CMS

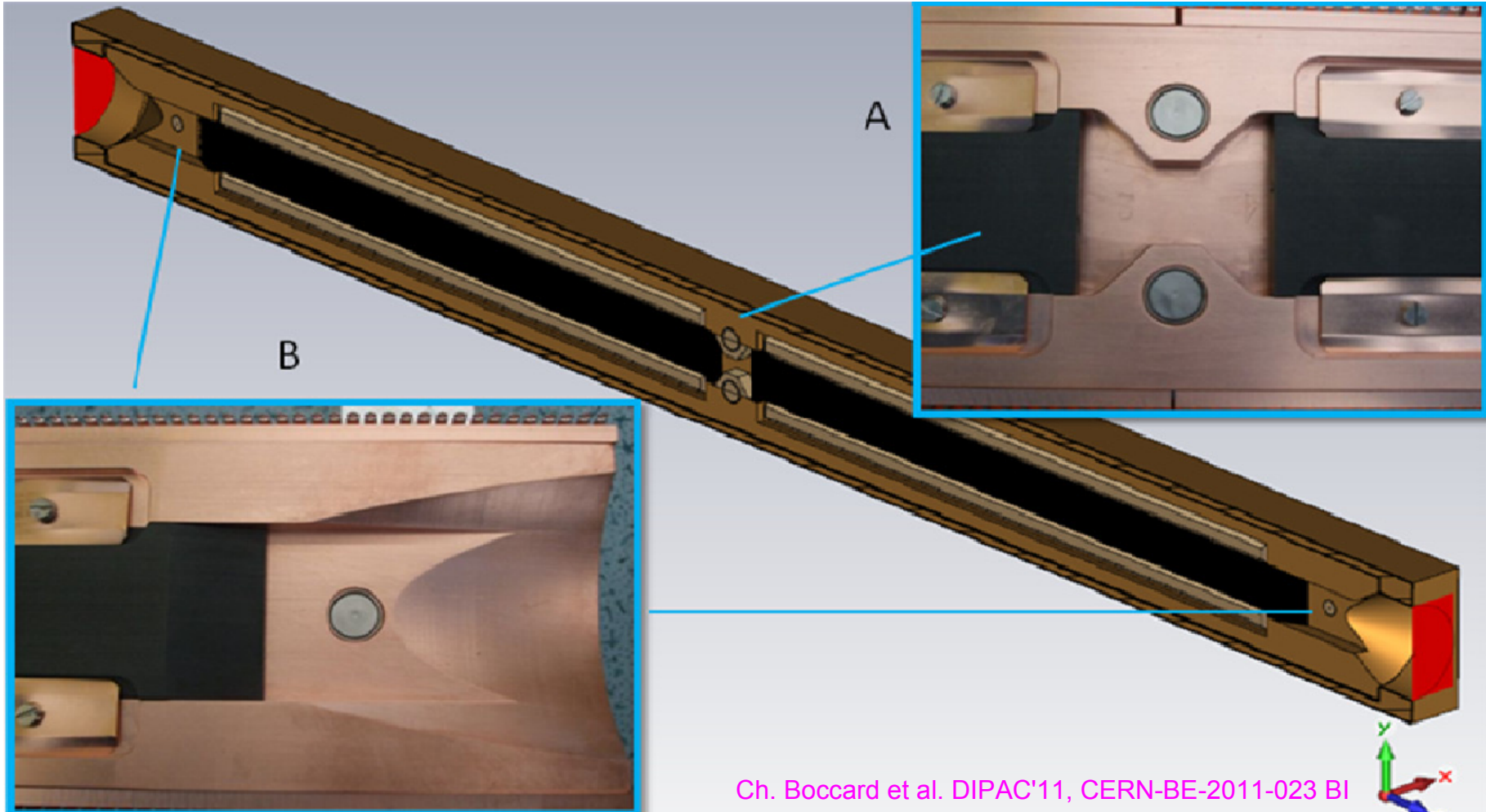


TCT(P).B1 (W)

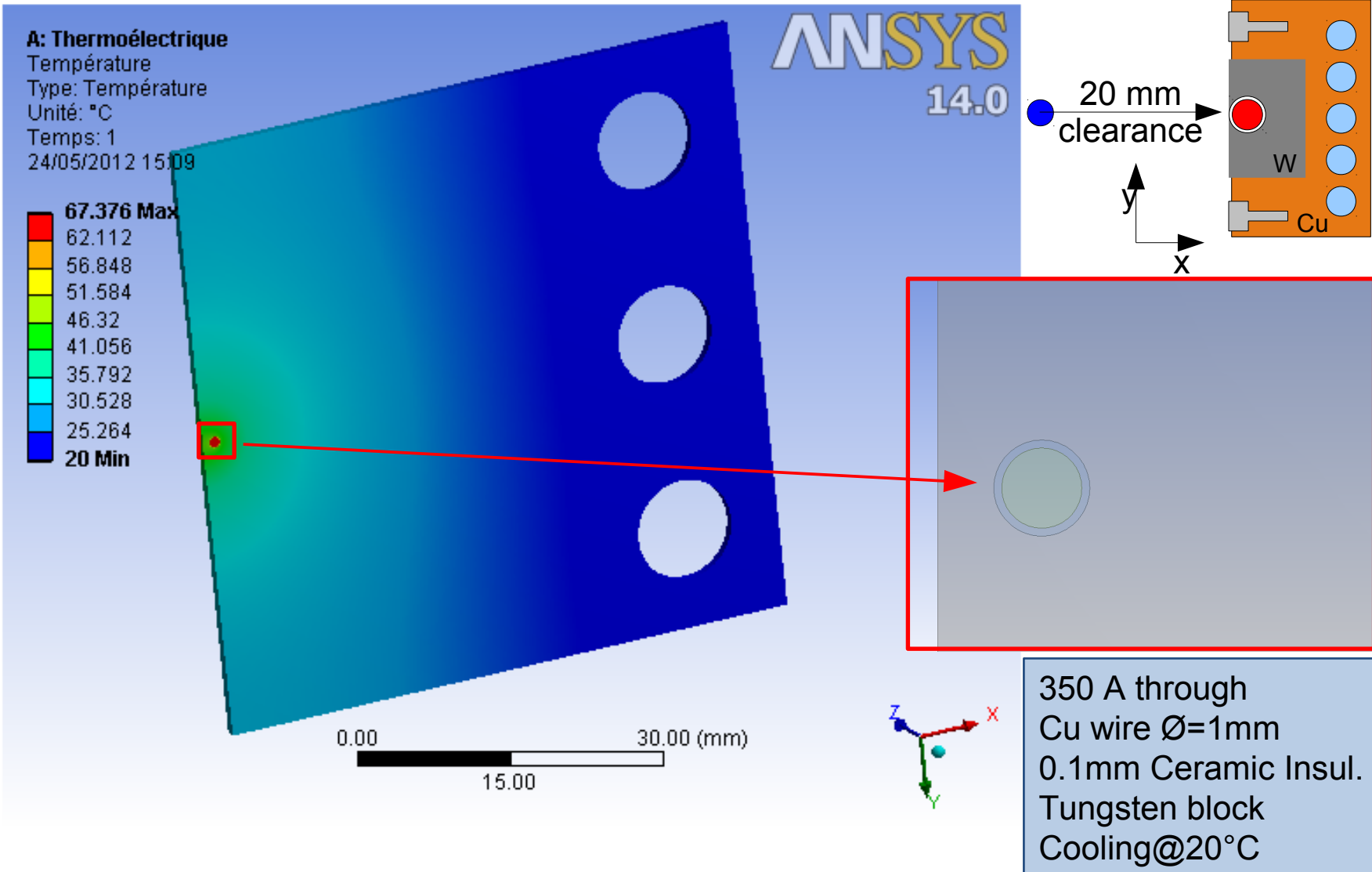
~105 m

B1
B2

- Design functionally tested w.r.t. BPM response, integration etc.



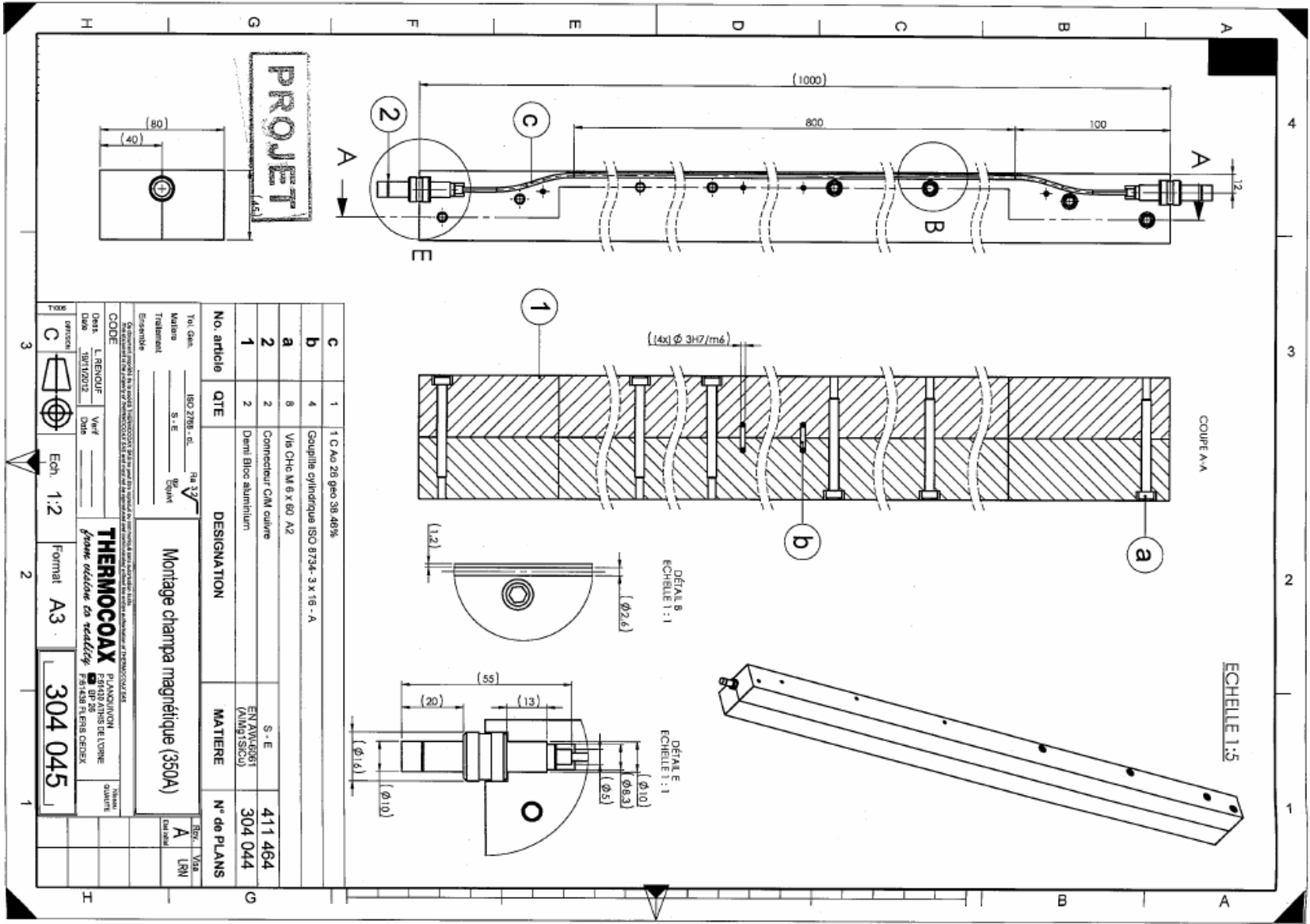
- Main required modifications: wire-in-jaw, larger buttons → cable/water routing



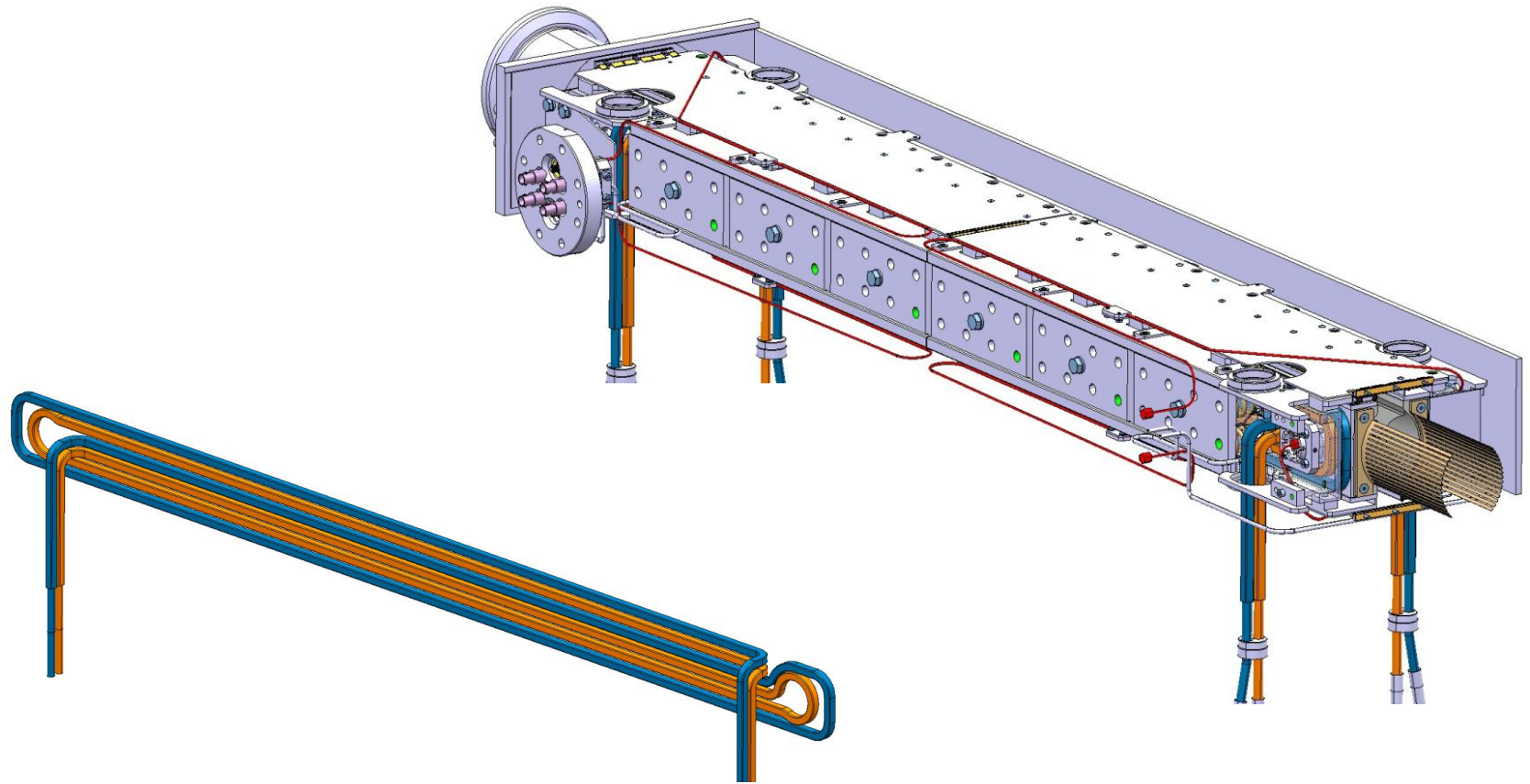
Finite-Element and analytic estimates agree for given (perfect) conditions
to be further studied → more specific model and lab-prototype test in progress.



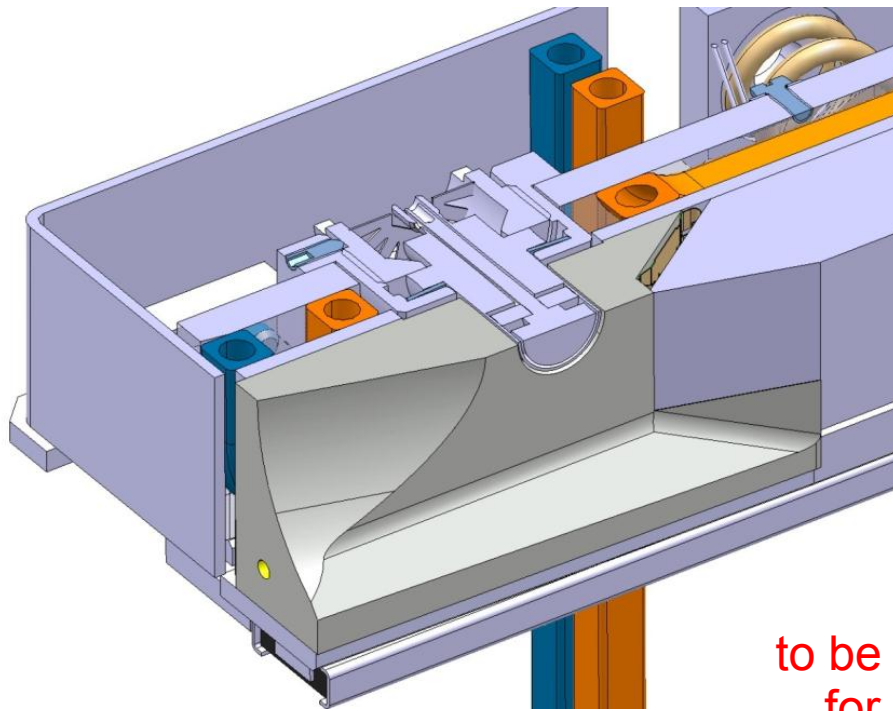
Proof-of-Concept: Wire-in-Jaw Embedding & Cooling using commercially available THERMOCOAX solution (A. Ravni)



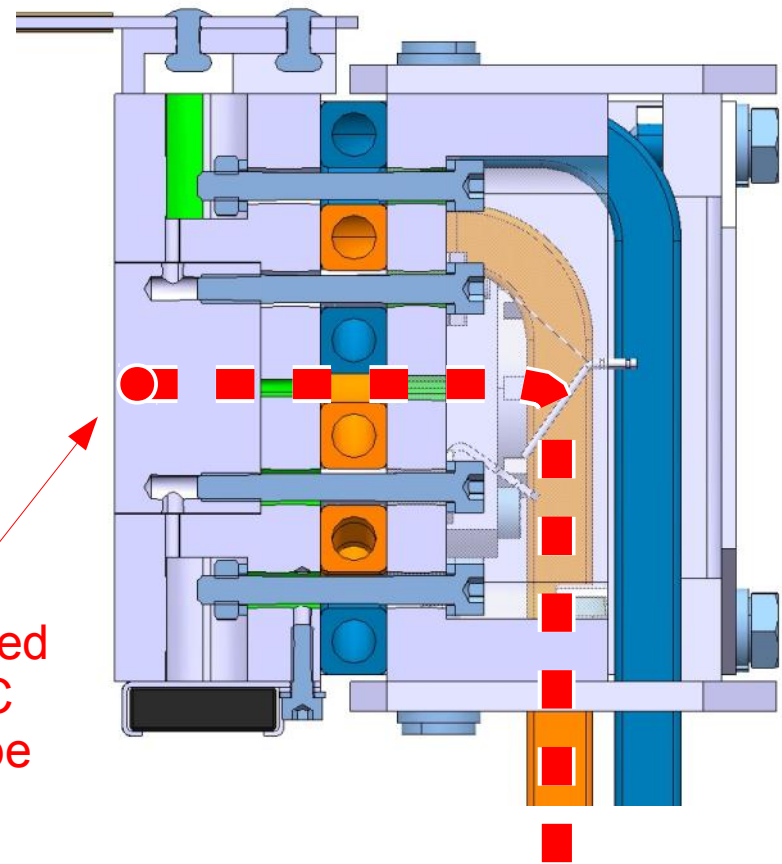
Prototype to be tested in March → then in || integration into W-jaw of TCTP&TCL



- Can re-use nearly 100% of existing TCTP design.
- Remaining challenge: finding space for the wire current feed-through amongst the cooling circuits and BPM button feed-throughs.



TCTP cross-section



to be added
for BBC
Prototype

- Gretchen Frage: do we wait until the lab prototype tests are conclusive or do we start with the design/production right away in March?

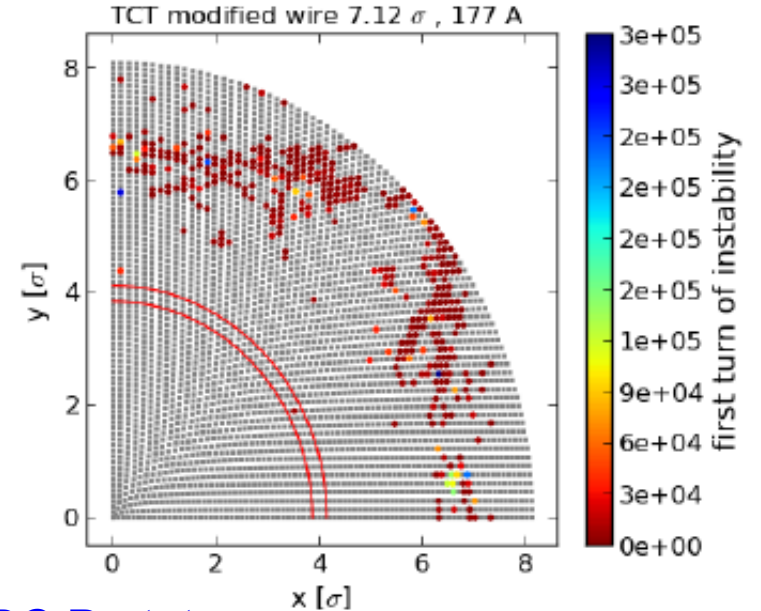
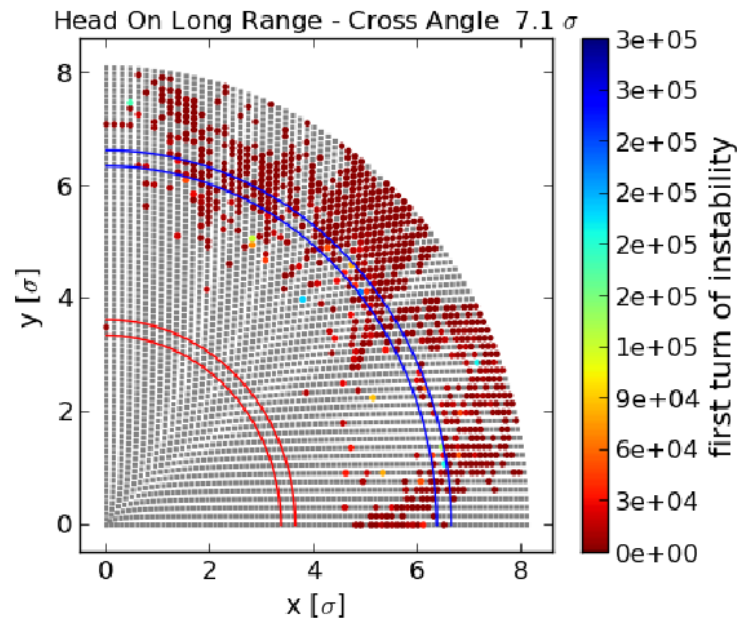
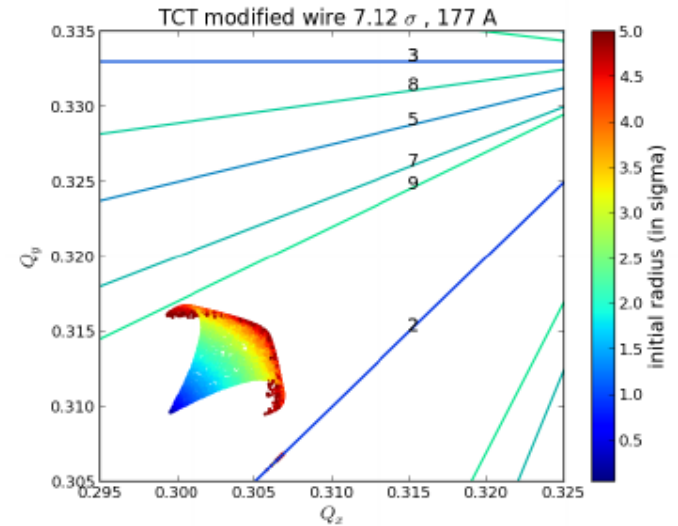
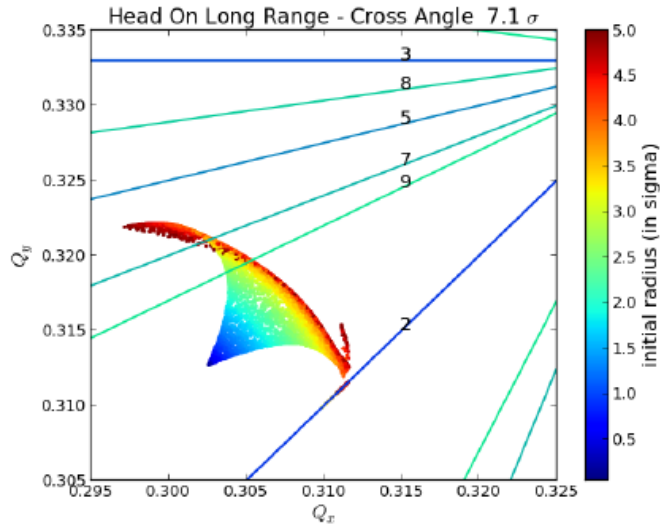
- Necessary technical infrastructure planned to be installed during LS-1 (powering, girders, water, cables, etc.) → ECR and integration in progress

- Mechanical feasibility, material and vacuum compatibility tests
 - mechanical and electrical constraints, vacuum compatibility
→ lab mock-up test to validate design (Axel Ravni, BI-ML) → March'13
- After/in || wire-in-jaw prototype mods of existing TCTP design (A. Bertarelli)?

- Impact on machine impedance (E. Metral et al.)
→ BBC is similar/the same as the TCTP from an RF point of view
- Beam cleaning and robustness simulations (FLUKA) – not started yet, tbd.
- Medium term action items that are not scheduled yet:
 - Add. R&D and beam instrumentation
 - BBC prototype construction
 - Pre-installation prototyping and HW integration tests (Lab-cycling)



Reserve slides



BBC Prototype

- Crossing angle with average separation of 12 (nom. LHC) → 7.1σ (LR-limited)

Transverse position [σ]	Current A	Unstables Particles [%]	Minimum Radius [σ]
HoLr		0	3.2
12	177	0	4.6
14	177	0	4.4
14	237	0	4.0

present LHC

Table 4.14: Summary of the stability test for TCT opt β , using nominal LHC optics and making the tests for differents transverse positions and current values, crossing angle 12 σ .

Transverse position [σ]	Current A	Unstables Particles [%]	Minimum Radius [σ]
HoLr		22	3.5
7.1	177	11	4.0
8.25	177	20	3.5
8.25	237	16	3.8

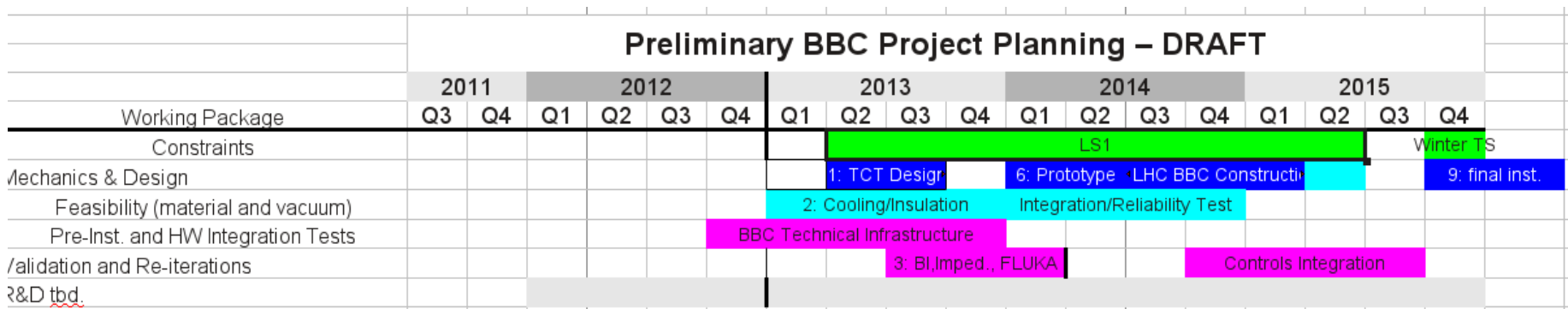
proof-of-concept

Table 4.16: Summary of the stability test for TCT opt β , using nominal LHC optics and making the tests for differents transverse positions and current values, crossing angle 7.1 σ .



Preliminary Cost Estimates and Planning - DRAFT

LHC Long-Range Beam-Beam Compensator Planning				DRAFT – TO BE DISCUSSED			
Item	Description	FTE	Costs [kCHF]	Time [y]	Comments/Resources		
1	Re-design and re-validation of TCT wire-in-jaw design	0.2	99	1	last updated: 2011-10-25, rstein		
2	Feasibility, material and vacuum compatibility tests	1.0	412	1	EN-MME, BE-BI-ML (fellow)		
3	Evaluation of pick-up response and impact on machine impedance Impact on beam cleaning and robustness studies (FLUKA)	1.5	0	0	BE-BI-QP, BE-ABP-ICE EN-STI?		
4	Preparation of technical infrastructure in LS1	0.2	195	0			
5	Additional R&D and beam instrumentation	2.0	120	0	BE-BI		
6	BBC prototype construction	0.1	396	1.5	EN-STI, 1 + 2 prototypes, tbc. (O. Aberle)		
7	Pre-Installation and HW Integration Tests	0.1	20	0.5	EN-STI, BE-BI		
8	Controls integration	1.0			BE-CO?		
9	Final installation of TCT with wire-in-jaw design		20	0.1			
10	Future R&D and physics potential evaluation	1.0			ABP-LCU		
11	Final operational design, deployment and coordination						
Total:		7.1	1262	2.6	no contingency/delays included (e.g. SPS prototype)		
Costs for 2013:			367				
Costs for 2014/2015:			734.736 (approx)				
primary item							
conditional activity, can only proceed if primary item is achieved							
parallel activity							





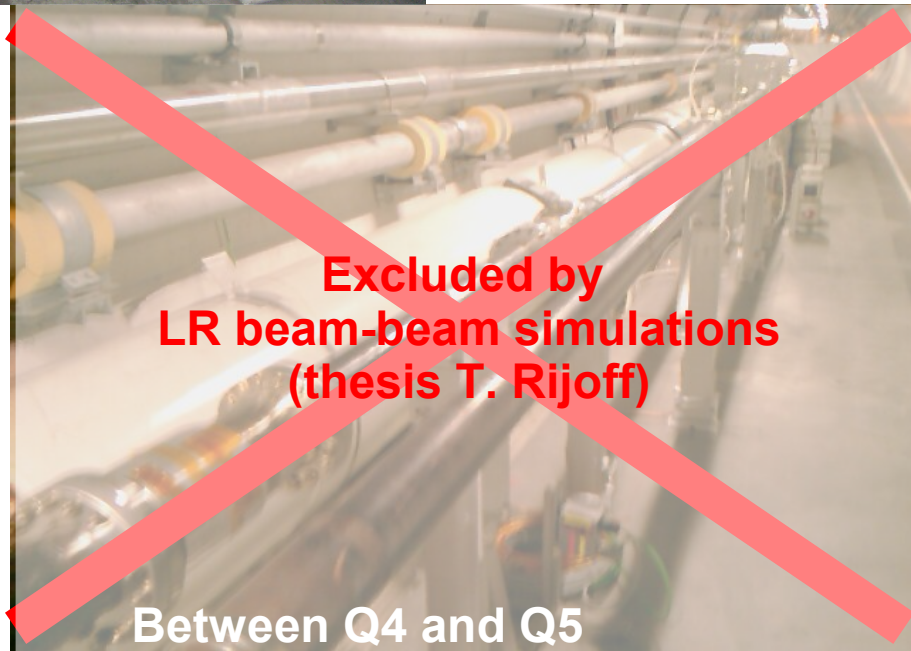
Physical Space IR5 Requires Horizontal BBC



reserved location IP → 105 m



TCT and roman pots



**Excluded by
LR beam-beam simulations
(thesis T. Rijoff)**

Between Q4 and Q5