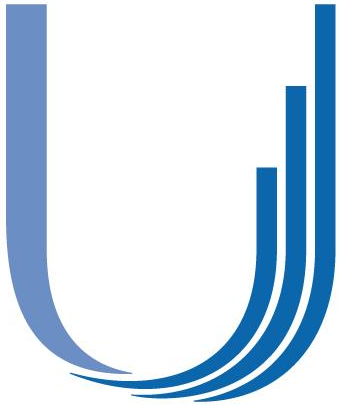
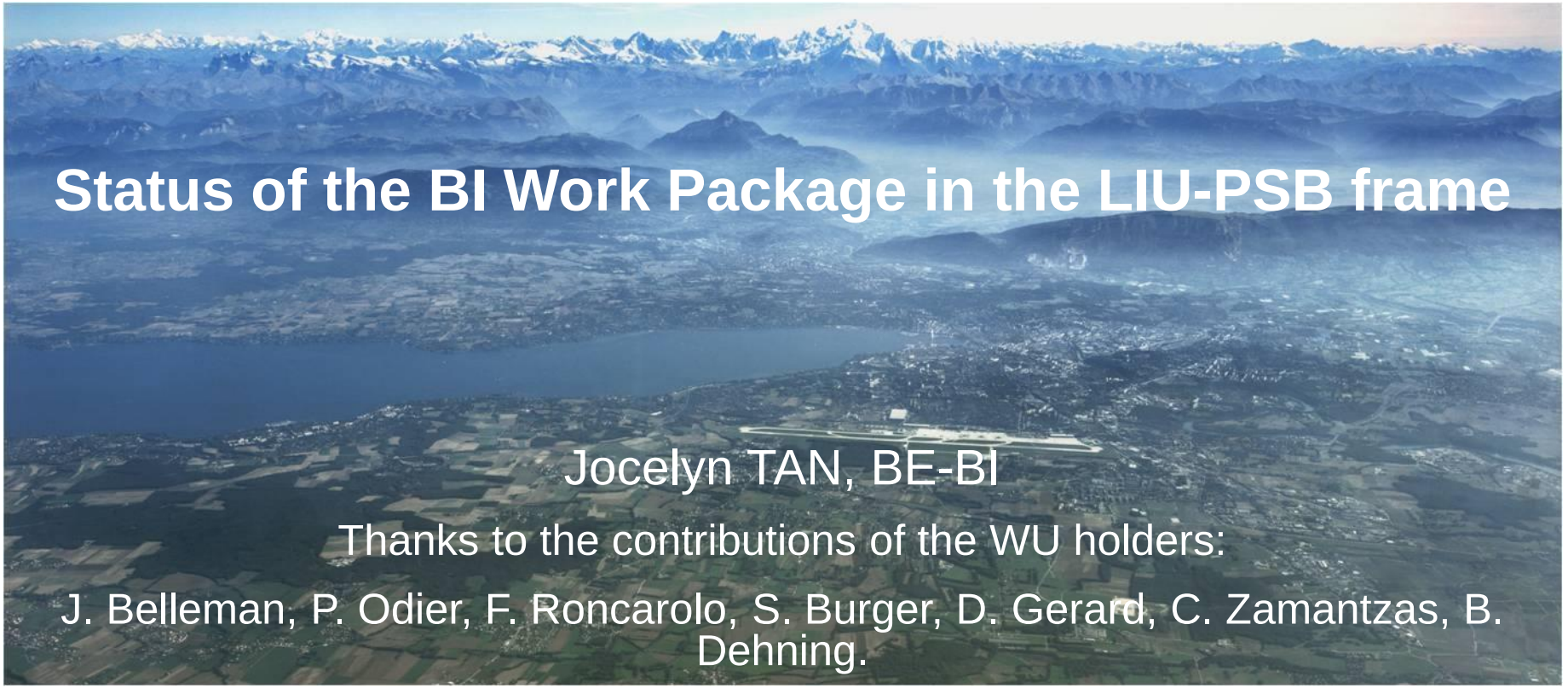


LHC Injectors Upgrade

LHC Injectors Upgrade



Status of the BI Work Package in the LIU-PSB frame

Jocelyn TAN, BE-BI

Thanks to the contributions of the WU holders:

J. Belleman, P. Odier, F. Roncarolo, S. Burger, D. Gerard, C. Zamantzas, B. Dehning.

CERN

Outline

- Foreword
- Relevant Observables
- H^- injection System & Half Sector Test
- Conclusion

LIU-PSB-BI Work Package

- Total budget: 3635 kCHF
- 5 budget codes

Machine sector	Total: 20 Work Units
BI line	2
H^- Injection & Half Sector Test	6 + 3
Ring	5
Extraction lines	4

- 4 cost drivers represent 79.8 % of the WP budget
  - Wire Scanners: 970 kCHF
  - Booster TMS: 750 kCHF
  - Upgrade for L4: 648 kCHF
  - BLMs: 532 kCHF

LIU-PSB Milestones

- Half Sector Test
  - Part 1 Q3 2015
  - Part 2 Q1 2016

- EYETS = Extended-Year-End Technical Stop
  - 16 weeks, from Dec. 2016 to March 2017
  - All WPs related to Linac4 connection: end 2016, should Linac2 fail all of a sudden.

- LS2
  - 1.5 year, from Q2 2018 to Q4 2019
  - All WPs related to PSB energy upgrade
  - Linac4 connection to PSB *if not done during EYETS*

- Presently there is no management decision to relax on the end-2016 deadline for the Linac4 connection to the PSB. Therefore this has to stay the baseline for our planning.

Outline

- Foreword
- Relevant Observables
  - Beam intensity
  - Beam profile
  - Beam loss
  - Beam position
- H^- injection System & Half Sector Test
- Conclusion

Relevant Observables

- Beam Intensity
  - Injection efficiency (Slow)
  - Acceleration efficiency (DC)
- Beam Profile
  - Transfer-lines: septum position plates
  - Injection matching
  - Transverse emittance
- Beam Loss
  - Ring and transfer lines : Monitoring
- Beam Position
  - Orbit and trajectory
  - Transverse instabilities between PSB and PS

BEAM INTENSITY
Measurement of injection efficiency with Linac4

Summary

- ***Needed for Linac4 connection → EYETS***
- Four monitors **BR.TMD in 8L1,** installed in '72, un-used since early 80s'
- Analog turn by turn acquisition, up to 100 turns
- **Watchdog** : comparison with BI.BCT20 after 100 turns

Status after LS1

- One BCT available (without shielding) in the laboratory

Plans for 2015-2016

- Study of the electronics, test of a prototype in the machine
- Manufacturing of a ceramic vacuum chamber. **There is no spare!**
- Manufacturing of the Front and Back End Electronics
- Specification of the SW for the acquisition chain based on the TRIC card

Plans for EYETS 2016-2017

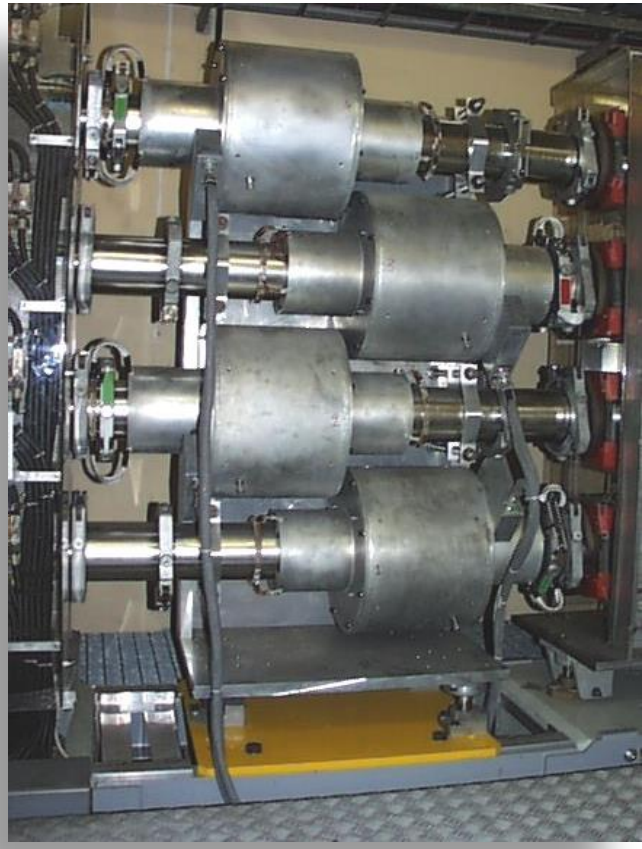
- New cables pulling
- Reshuffle the monitors in the BI radioactive workshop: **ALARA to be checked**
- Installation : monitors & Electronics
- Full system commissioning

Courtesy: P. Odier

BEAM INTENSITY
Quantify total intensity transmission during PSB cycle

Summary

- ***Needed for Linac4 connection → EYETS***
- Four monitors BR.BCTDC in section 9 (DCCT)



Status after LS1

- **Acquisition chain upgraded**
  - 12 bit ADC replaced by 16 bit ADC (VD80)
  - Simplification of the HW (intervalometers for the hot spots replaced by markers acquired with the ADC)
  - Common Expert GUI for the DCCTs in the injectors ☺
- **Front End Electronics assembled** : Not installed due to higher priorities
- **Front End housing:** manufacturing launched (BI-ML)

Plans for 2015

- **Test of the new B Train Receiver** (White Rabbit, SVEC VME card) in // with the current ß Normalizer based on the old B Train
- **Share the firmware and the mezzanine**: contact H. Damerau (RF)
- **Installation of the new Front End Electronics** (TS 2015-2016)

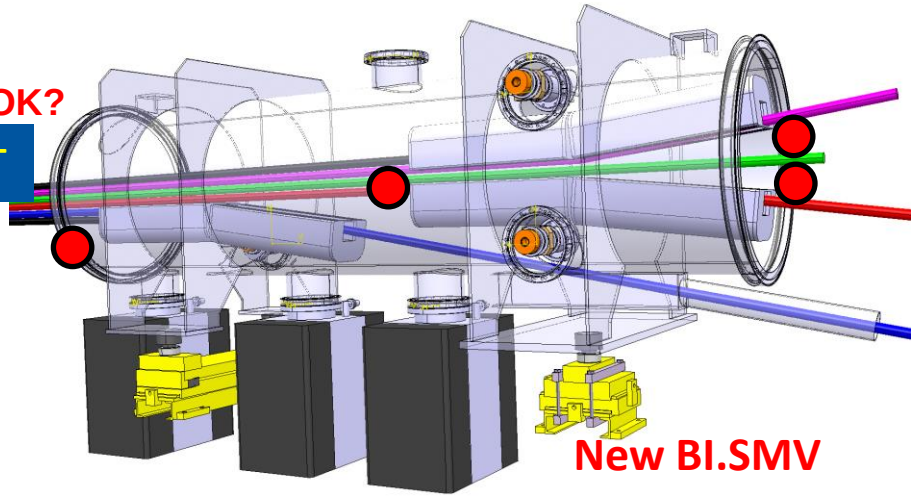
Plans for EYETS 2016-2017

- **Installation of the new B train** (White Rabbit) Receiver
- **Adaptation for Linac4 intensities:** Front and Back End for Linac 4

Courtesy: P. Odier

BEAM PROFILE
BI.SMV position measurement plates w/ Linac4

- **New WU created in 2014, baseline End 2016. Still OK?**
  Should be aligned with the work done by ABT
- **New INJECTION SEPTUM for 160 MeV beams**
- **Based on existing system**
- **Specifications under discussion w/ Bettina**
  - Ensure the **distributed beams** are centered in their respective apertures.
    - @ input plates: stripped electrons charge deposition
    - @ output plates: secondary emission, expected to be very weak!
  - Linear, 10^4 dymanic range, large bandwith (min 50ns beam pulse), Direct signals on OASIS
  - No interlock, no aperture restriction



Courtesy: M. Hourican

- **Planning for 2015** (in agreement with TE-ABT Team)
  - April-June: Design
  - Mid- Sept: Procurement of parts: Ti plates 1mm thick
  - October: Installation in BI.SMV

Courtesy: F. **Roncarolo, D. Gerard**

BEAM PROFILE
Turn by turn meas. for injection matching w/ Linac4

- **Specifications**:

- ***Needed for Linac4 connection → EYETS***
  - injection of half a PSB turn (i.e. 0.5 μs, 2x10^{11} protons) to well separate turn-by-turn profiles. Only Ring 3 H+V planes
  - acquisition of – **say up to 20** – consecutive profiles
  - **External condition interlock :** to shorten the Linac4 pulse (max 1-turn-injection)
  - NOT PPM In/Out
  - Permament implementation for commissioning, MDs and operation
  - **Compact SEM grids**, grid size : 26mm, 64 graphite wires (∅= 33 μm)
  - Thick frame for stopping scattered protons

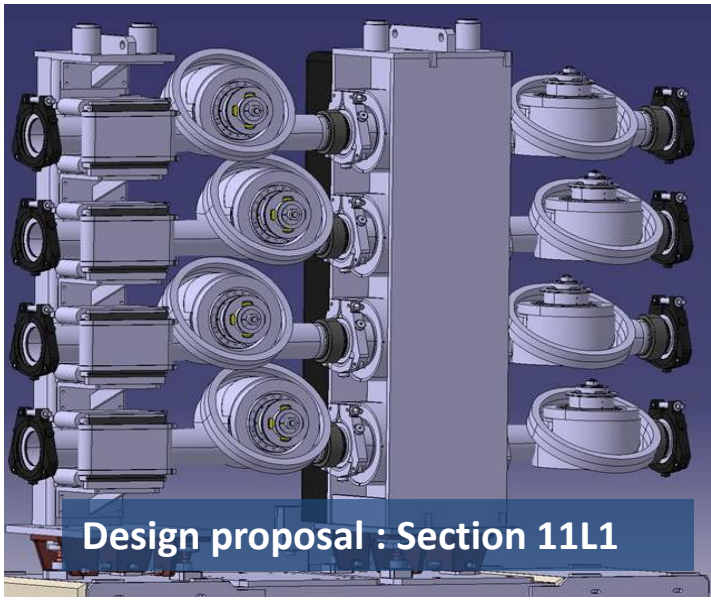
- **Status**
  - Mechanics designs: not started
  - Electronics : conceptual design started
  - Proposed SEM's integration: **section 4L1**
  - To do : Space Reservation Request for 4L1+ ECR

Courtesy: F. Roncarolo

BEAM PROFILE
Wire Scanner

- **Baseline: LS2**
- **Aim**: adaption of the scanner design for the PS and SPS to the limited space in the PSB
- **Status**
  - Mechanical design proposals are under discussion:
  - Development of control end acquisition electronics advancing
  - Proposed BWS' integration: **section 11L1 + 16L1 ?**
  - To do : Space Reservation Request for 11L1 and 16L1+ ECR
- **2015**
  - Two prototypes (SPS + Lab) are used for optimisation and development of control electronics
  - If PSB study shows that integration is possible, then we can finalize the design (mechanics)
  - **Budget update**
- **2016**
  - production prototype scanner for installation YETS16-17
- **2017**
  - commissioning of prototype
- **Aim: Completion during LS2**
- **but we are on the critical path**

Courtesy: B. Dehning

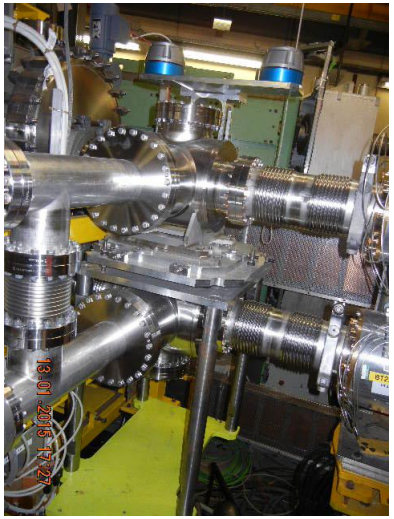


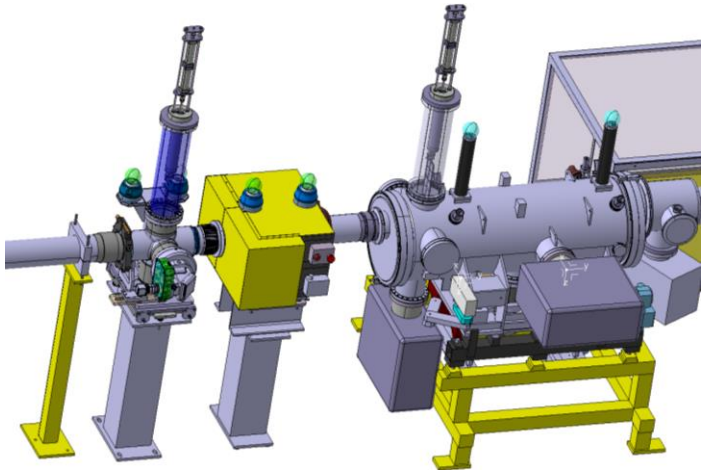
BI is in favor having 2 sections: **could be 16L1**

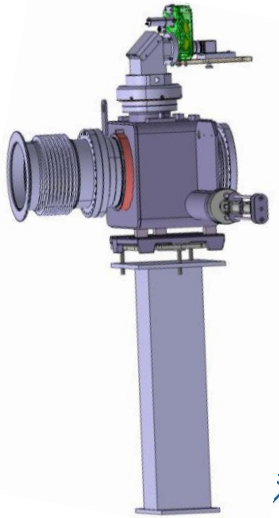
BEAM PROFILE
New Housings for BI.BTV30, BT.BTV10 and 30

MOTIVATION:
The need of longer magnetic length for Septa induced by increased beam energy

Monitor	BT.BTV10	BT.BTV30	BI. BTV30
Status	Tanks installed	Design in good progress	
Plan for 2015	Production of optical mechanical part and of support		
	Production of transition pipes	Tank production	
		SRR + ECR Modification of adjacent pipes	
Baseline	**LS2**: Monitors installation		EYETS:Modification of existing tank







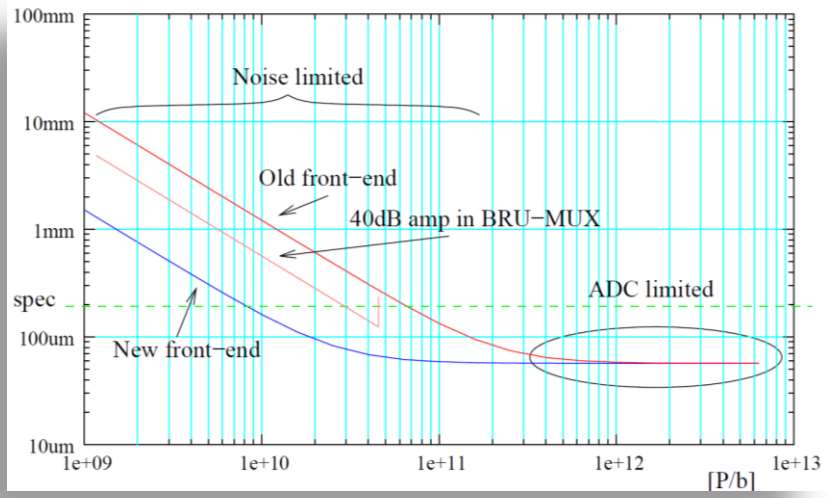
Courtesy: D. Gerard

BEAM LOSS
PBS and Transfer lines BLM system

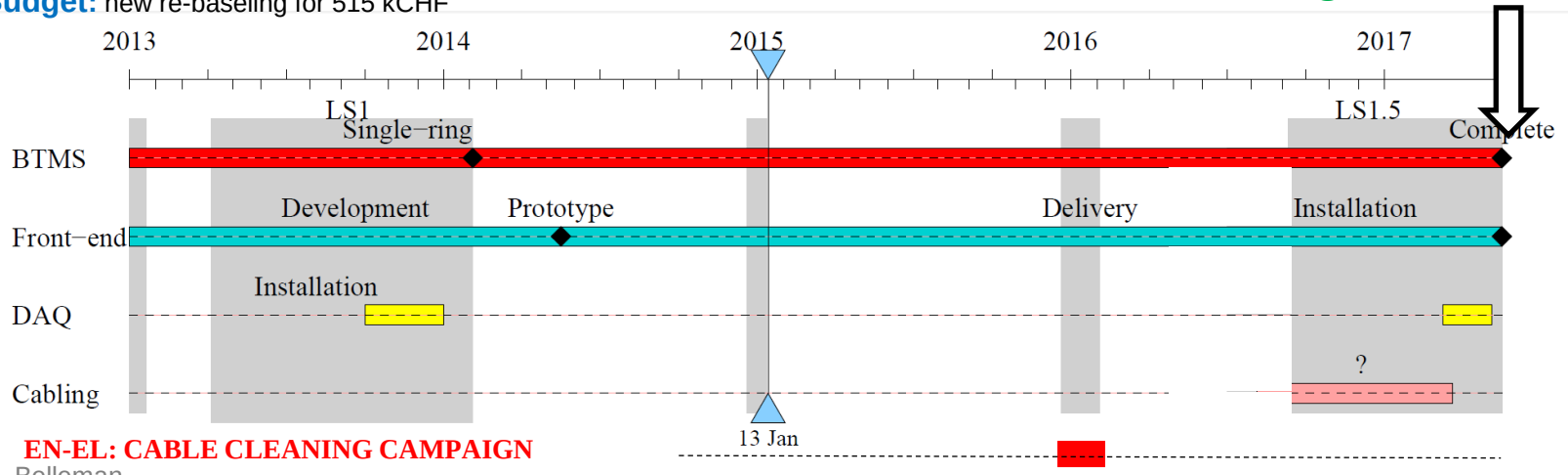
- **Baseline: End 2016**
- **Ionization Chambers (ICs): from LHC, for free**
- **Status**
  - **ICs in L2 sections**
    - WU completed during LS1: Cable pulling
  - **Flat ICs in L3 sections**
    - 2014-15: monitors' procurement
    - YETS16-17: cable pulling ECR
    - 2017: commissioning/operation
  - **ICs for injection and extraction lines**
    - 2014-15: Electronics procurement
    - YETS16-17: cable pulling
    - 2017: commissioning/operation
- **All systems should be ready for the 2017 start-up if cabling is granted**

BEAM POSITION
Ring Trajectory Measurement System

- **Specifications**
  - ***Needed for Linac4 connection → EYETS***
  - Bunch-by-bunch, turn-by-turn trajectories over the whole cycle
  - Various derived averages (Orbits, M[RV]P)
  - Position resolution 200µm
  - No more multiplexing over the four rings
  - New front-end electronics with settable gain
- **Status**
  - One full ring can be acquired, multiplexed, Design target resolution of 0.2mm
  - Software: FESA interface, with hooks for YASP and the Sampler + Expert GUI
  - We're still using the old front-end electronics, without VGAs
  - Interference on analogue signals is a real nuisance
- **2015-16: Qualify the acquisition system**
- **Start-up 2017: *Project COMPLETION***
- **Budget:** new re-baseling for 515 kCHF



New baseline: FEASIBLE for 2017 if we can get cables in BOR

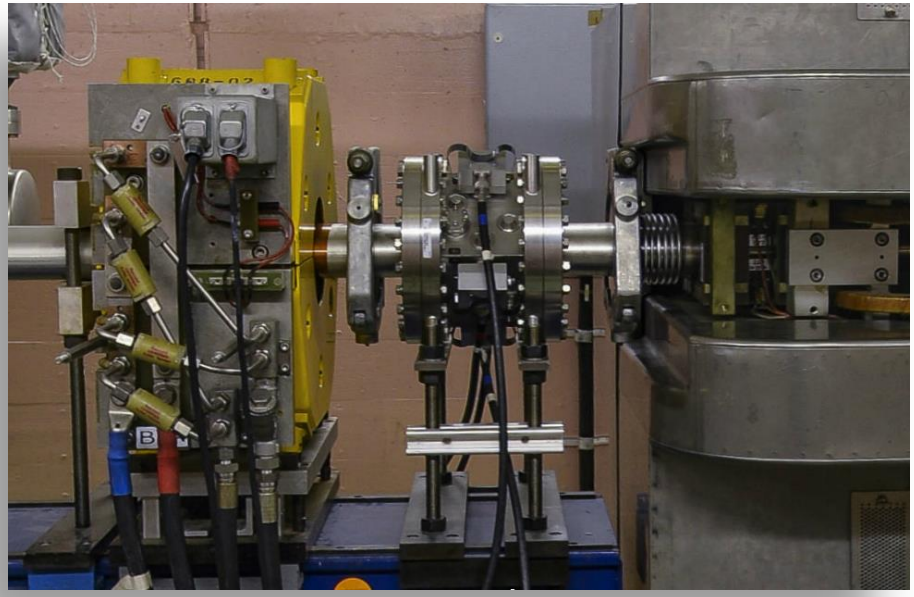


Courtesy J. Belleman

BEAM POSITION
Wide Band BPM in the BTP line

- **Baseline: End 2016**

- **Specifications**
  - Spot transverse instabilities during beam transfer between PSB ans PS
  - Based on existing PS design (section 94)



- **Status**
  - Not started

- **Plans for 2015**
  - Design + production
  - DIC
  - Space reservation Request in BTP + ECR

- **Plans for 2016**
  - Installation and commissioning
  - Acquisition : OASIS

Courtesy J. Belleman

BEAM POSITION
Inductive BPMs in the extraction lines

- **Baseline: LS1**
- **Upgrade**
  - 8 monitors + 2 spares
  - New front and back end electronics for compatibility with Linac4 beams
  - New lab test bench
- **BTP and BTM lines: LIU budget**
- **Status**
  - **WU completed during LS1**
  - Some interference noise with beam being investigated

Outline

- Foreword
- Relevant Observables
  - Beam intensity
  - Beam profile
  - Beam loss
  - Beam position
- H^- injection System & Half Sector Test
- Conclusion

Beam Diagnostics for the new H- charge-exchange injection system in section 1L1

H0/H- current monitor

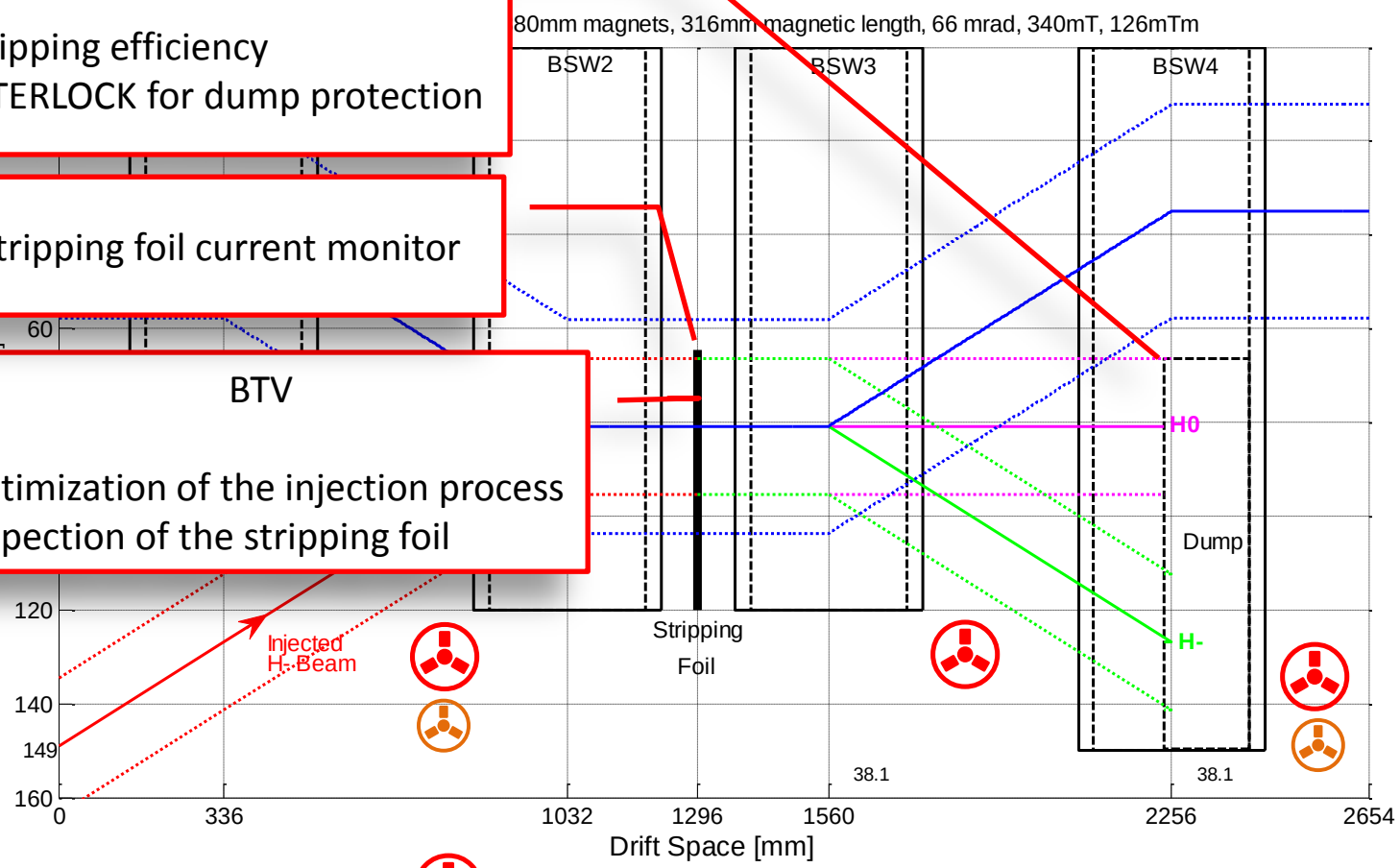
Stripping efficiency
INTERLOCK for dump protection

Stripping foil current monitor

BTV

Optimization of the injection process
Inspection of the stripping foil

Baseline: end 2016
All four rings



ICs for beam loss monitoring

Diamond detectors : for observation of fast losses and foil degradation

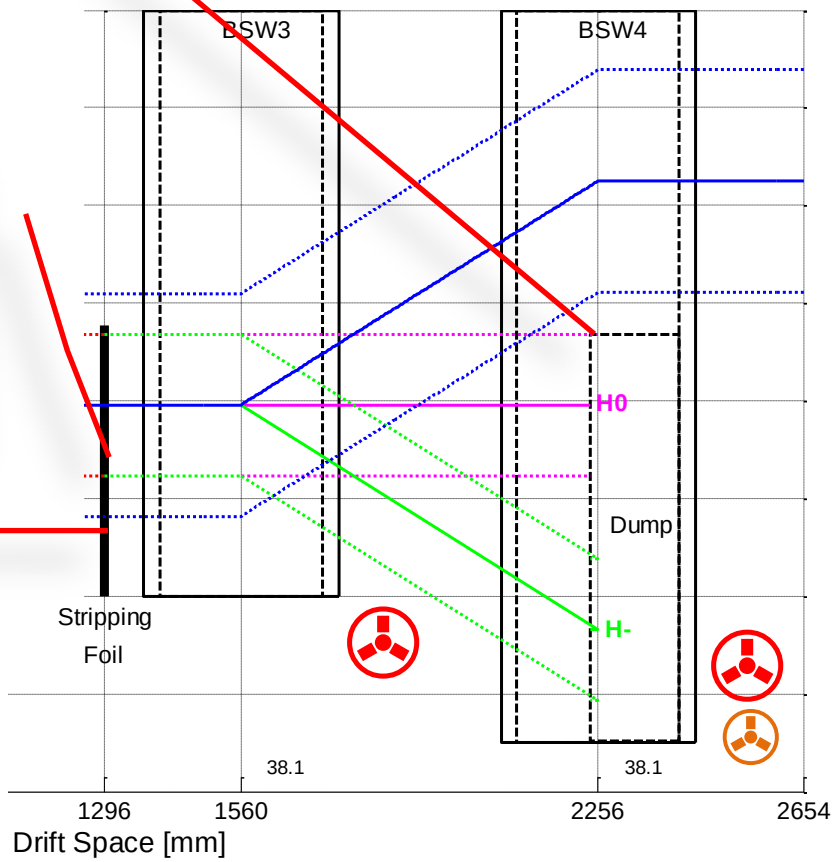
Courtesy: W. Weterings

Beam Diagnostics for the new H- charge-exchange injection system: HST in Linac4 tunnel

H0/H- current monitor
Baseline: Q1 2016
Stripping efficiency
INTERLOCK for dump protection

BTV
Baseline: *1 BTV Q3 2015, the other one Q1 2016*
Optimization of the injection process
Inspection of the stripping foil

Stripping foil current monitor
Baseline: Q3 2015

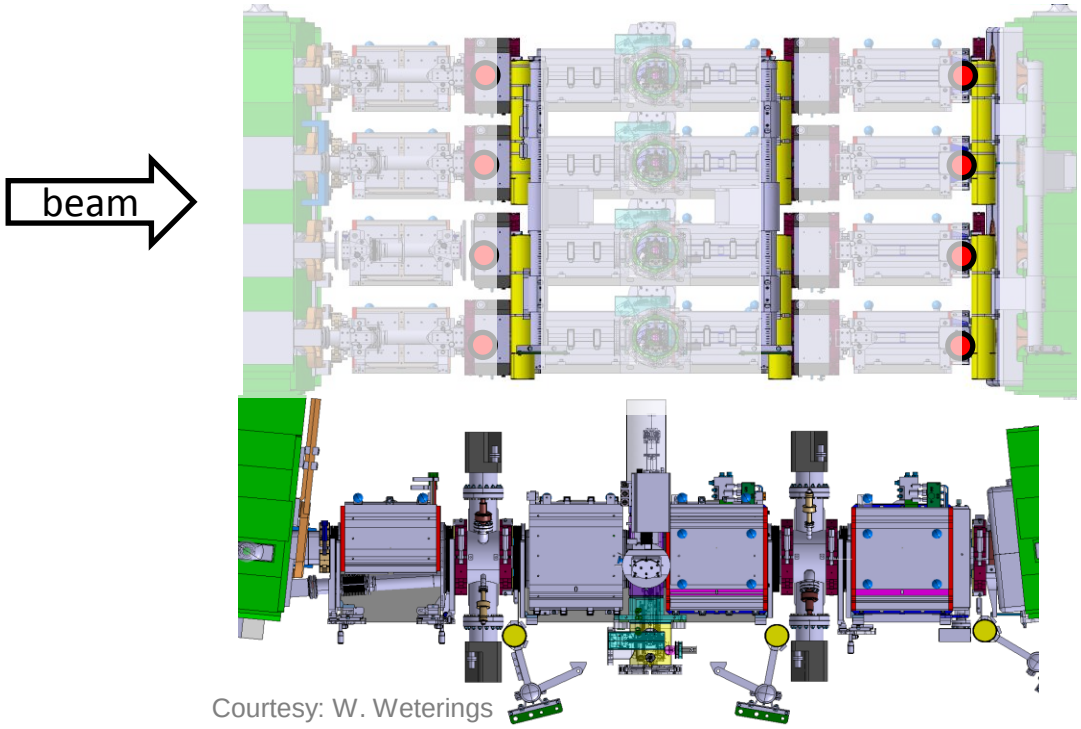


ICs for beam loss monitoring

Diamond detectors : for observation of fast losses and foil degradation

Courtesy: W. Weterings

New H^- charge-exchange injection system
Beam Loss and Interlock Systems



Courtesy: W. Weterings

Ionization chambers : x6
Monitoring foil degradation
Machine protection ($H0/H^-$ dump)
Interlock

Diamond: x8
Monitor fast losses & foil degradation
Optimize stripping efficiency

Both detectors share the same support system

	Monitoring	Observation	Half Sector Test
Status	**BLM support design and integration done**		
2015	Acquisition chain	Acquisition chain Diamond detector	Installation + cabling
2016			Commissioning
YETS 16-17	Cabling	Cabling	

New H- charge-exchange injection system

H0/H- Current Monitor

LINAC4 Project Document No.
L4-T-EP-0003 rev 1.0
CERN Div./Group or Supplier/Contractor Document No.
TE/ABT
EDMS Document No.
1069244

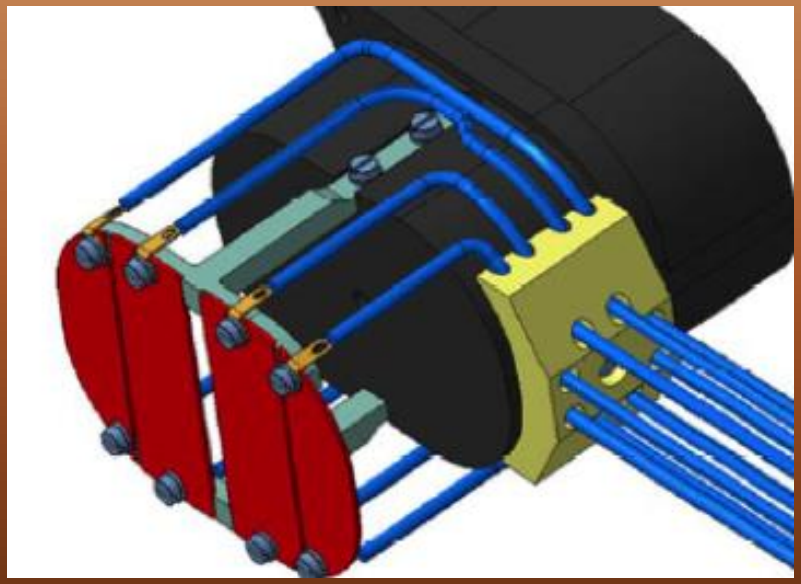
Mechanical Design Completed

Monitor to be installed in front of each H0/H- dump.

- low-Z material, low activation: Titanium plates
- medium-level conductivity (best compromise between read-out of the deposited charge and the presence of a pulsed magnetic field)

Fabrication can be launched

- **BI wants to approve the production drawings**
- B.Riffaud (MME) (via BI-ML ?)
  - 1 system will be ready for HST part 2



Electronics Design Ongoing

- 1 VME per ring, with following outputs
  - Interlock
  - 4xOasis (fast Amplifier)
  - 4xIntegrator (from 50ns to 1us)
  - 1xStripping foil current (next slide)
- 1 MHz ADC
  - Interlock
  - Sampling of integrator @ 1us → time signal
- DAC for interlock reference

- Will be ready for HST
  - Part1: only stripping foil current
  - Part2: first H0-H- current system

Courtesy: F. Roncarolo

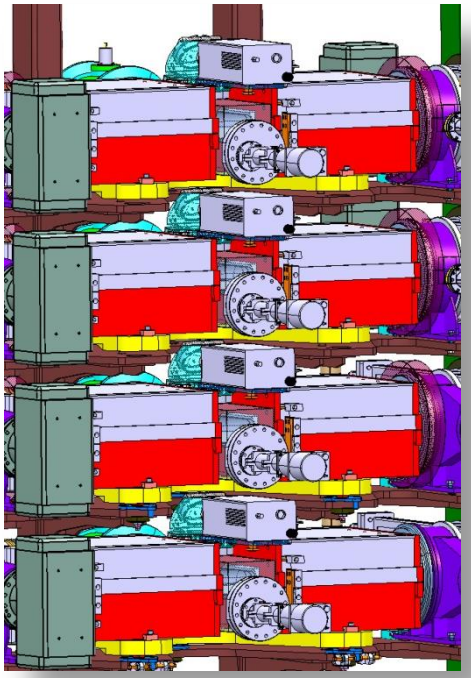
New H^- charge-exchange injection system
$H0/H^-$ Stripping Foil Current

- Signal cable feed through included in mechanical design
- BI is responsible from signal feedthrough
- Electronics design on going
  - Included in H0-H- VME, same readout
  - BIAS +-10V via DAC likely envisaged (if compatible with magnetic fields
- Will be ready for HST part 1

New H^- charge-exchange injection system
Beam Profile and Foil Inspection

BTV Stripping Foil			
Project	**Number**	**Permanent**	**Installation**
L4T	1	Yes	Q3 2015
HST	1	No	Q1 2016
BOOSTER	4	Yes	2018-2019
Spare	2	-	-
Status			
Design	Done	In collaboration with EN-MME and ABP-FPS	
Integration	Done	In collaboration with EN-MME and ABP-FPS	
Production	Done	All movement and 'cloche' mechanics	
Assembly/Test	Validation of production by Q2		
Interlock	Between Screen and Foil movements to avoid collision Interface and test to be done		

3D view of BTV_SF in the 4 rings of the BOOSTER



BTV in front of proton dump			
Project	**Number**	**Permanent**	**Installation**
HST	1	No	Q1 2016
Status			
Use of available spare BTV AD/BASE type (pneumatic)			

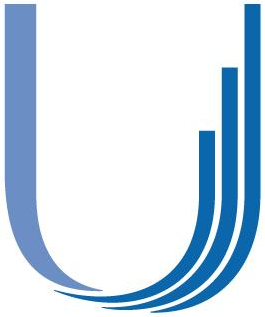
Pneumatic BTV AD/Base type will be used for the BTV dump of the HST

Special Rad Hard ThermoFisher cameras (CID8726DX7) and dedicated cabling have been received for the L4T and the HST installation.

Courtesy: S. Burger

Conclusion

- Two WUs completed during LS1
- HST: on time Part 1 Q3 2015 & Part 2 Q1 2016
- BLMs & BTMS: A large cabling effort for YETS 16-17
- H^- injection: on time for Linac4 connection
- BWS: on the critical path
- Other BI Work Units: No showstopper
- Can LIU provide a wishlist of monitors which might be installed before LS2 ?



LHC Injectors Upgrade

THANK YOU FOR YOUR ATTENTION!

Cost Breakdown

LIU-PSB	Budget Code	Section	Description	Type	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL LIU (kCHF)
PSB BLM System w/ IC in L2 sections	64020	BL	LIU-PSB BLM Upgrades	Ring - L2 section			127						127
PSB BLM System w/ FIC in L3 sections				Ring - L3 section				11	30	123			164
BLM for Extraction line w/ IC				Extraction					70	80			150
BLMs for H- injection				BI line and H- injection				3	40	48			91
Fast BLMs at injection dump				H- injection					100	37			137
New Orbit System	64021	PI	LIU-PSB PU & BCT Upgrades	Cables in LS2		25	210	0	10	78	77	350	750
Watchdog (BR8.TMD)				4 Monitors		16	13	0	19	50	50	50	198
DCCT Upgrade						9	15	20	50	10	10		114
BTP Line Inductive Pus					10	131	103	20					264
Wideband PU for BTP Line									35	40			75
Screens at extraction BT.MTV10+30	64022	PM	LIU-PSB Profile Measurement Upgrades		9	8	11	4	45			7	84
H0/H- Meas at injection dump				H- injection				10	31	9			50
BTV screen at stripping foil				H- injection		14	3	48	13	32			110
New tank for BI.MTV30				H- injection			3	4	33			20	60
T by T profile at injection				Based on fast SEM readout					10	90	20	15	135
BI.SMV position plates				H- injection				0	40	10			50
BWS Upgrade	64023	BL	LIU-PSB Wirescanner Upgrade					12	100	548	200	110	970
Half Sector test	64025	BL+PM	LIU-PSB HST	H0/H- monitor				0	10				10
				Screen + camera system				27	40	24			91
				Stand & diamond BLMs				0	5				5
	TOTAL LIU (kCHF)				19	203	485	159	681	1179	357	552	3635