Cryogenic BLMs

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with input from: Bernd Dehning, Belen Salvaucha , Francesco Cerutti, Luigi Esposito, Alessio Mereghetti, Christoph Kurfuerst , Marcin Bartosik, Vittorio Parma, Nicolas Bourcey, Jean-Phillipe Tock, Thierry Renaglia, Erich Griesmayer (CIVIDEC), Vladimir Eremin (IOFFE), Thomas Eisel, Johan Bremer and other colleagues.

LSC, October 11th, 2013

Outlook

- Motivation for Cryogenic BLMs.
- Results of beam-test and irradiation studies.
- Motivation for LS1 installation on the cold mass.
- Proposal.
- Installation setup.
  - Safety considerations.
- Who is on the project (now).
- Conclusions.

Motivation for Cryogenic BLMs

- Simple idea:
  measure beam loss signals closer to the coils.
- The case was investigated for new triplet magnets but can be applied to other losses/locations.
- Triplet magnets difference between debris and losses:
  - Different loss pattern.
  - Different particles (e.g. debris: 1 TeV pions).
  - As a result different ratios S_{BLM}/E_{coil}

Motivation – existing documentation

FLUKA Simulations for Assessing Thresholds of BLMs Around the LHC Triplet Magnets

A. Mereghetti[1], on behalf of the FLUKA Team
M. Sapinski[2], on behalf of the BLM Team

[1]EN/STI/EET

[2]BE/BI/BL

October 18^{th}, 2011

For current BLMs and preliminary study for CryoBLMs

http://indico.cern.ch/event/CryoBLM2011

CERN-ATS-Note-2012-014 TECH , CERN-ATS-2012-093, IPAC12

Motivation – loss scenario

FLUKA Simulations

Aim

Relate the energy deposited in the superconducting coil of the *inner triplet* to the signal read by BLMs all around: **assessment of the signal thresholds**.

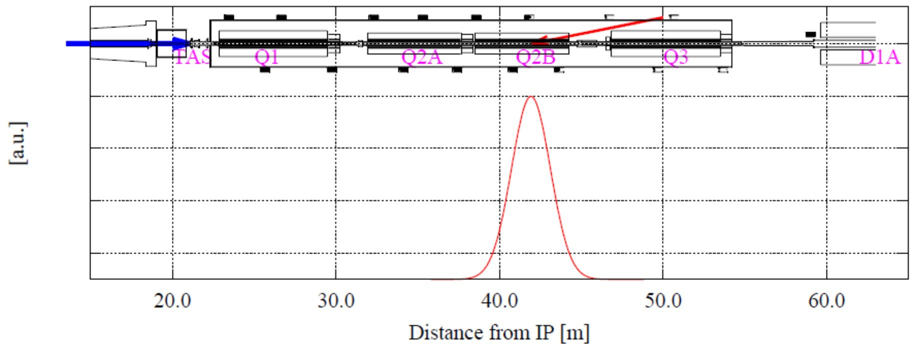
FLUKA simulations of the *Inner Triplet* presently installed on the right side of Point 1 of LHC (ATLAS). Considered scenarios:

pp-collision debris

- $L_0 = \mathbf{10^{34}\ cm^{-2}\ s^{-1}}$ [1];
- **80 mb** as pp inelastic cross section at 14 GeV centre-of-mass energy;

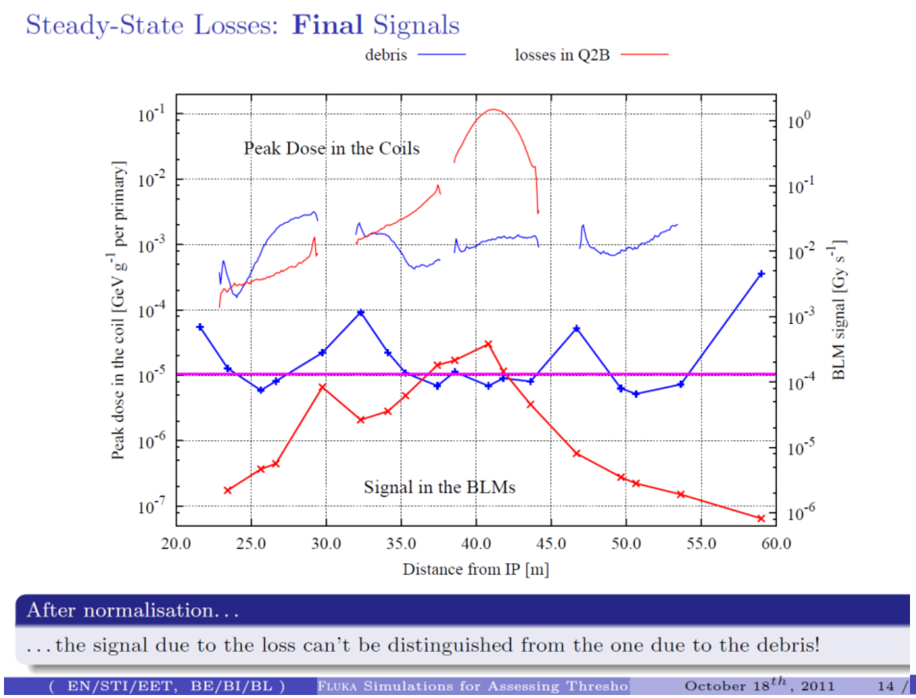
direct losses in Q2B (MQXB.2BR1)

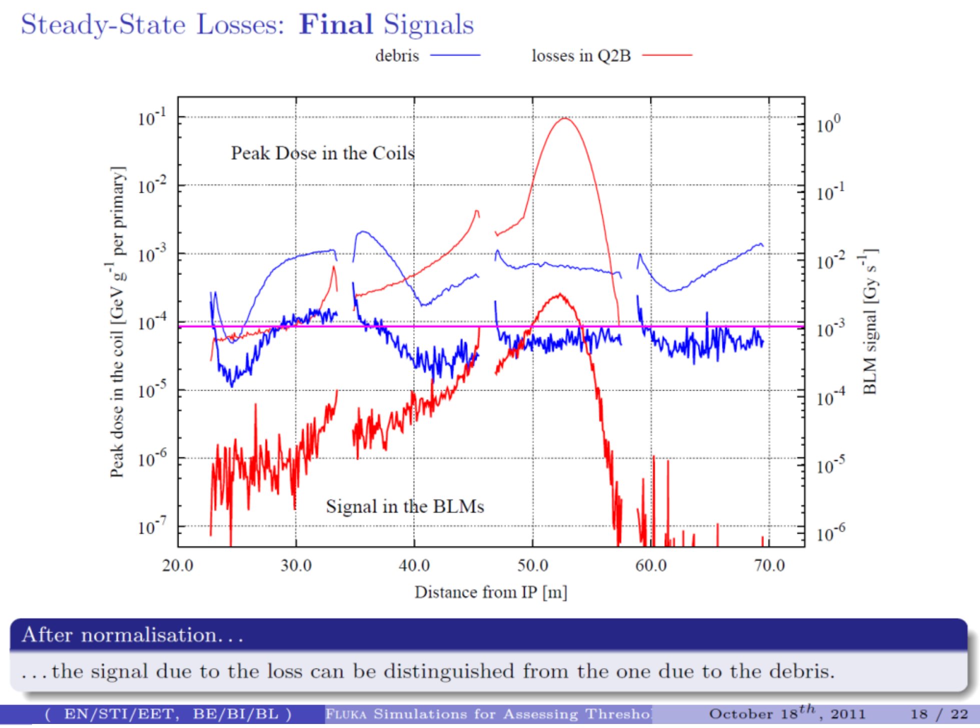
7.0 TeV protons on Q2B magnet, due to wrong settings of collimators;



For other scenarios: EDMS doc in preparation.

Motivation – loss versus debris

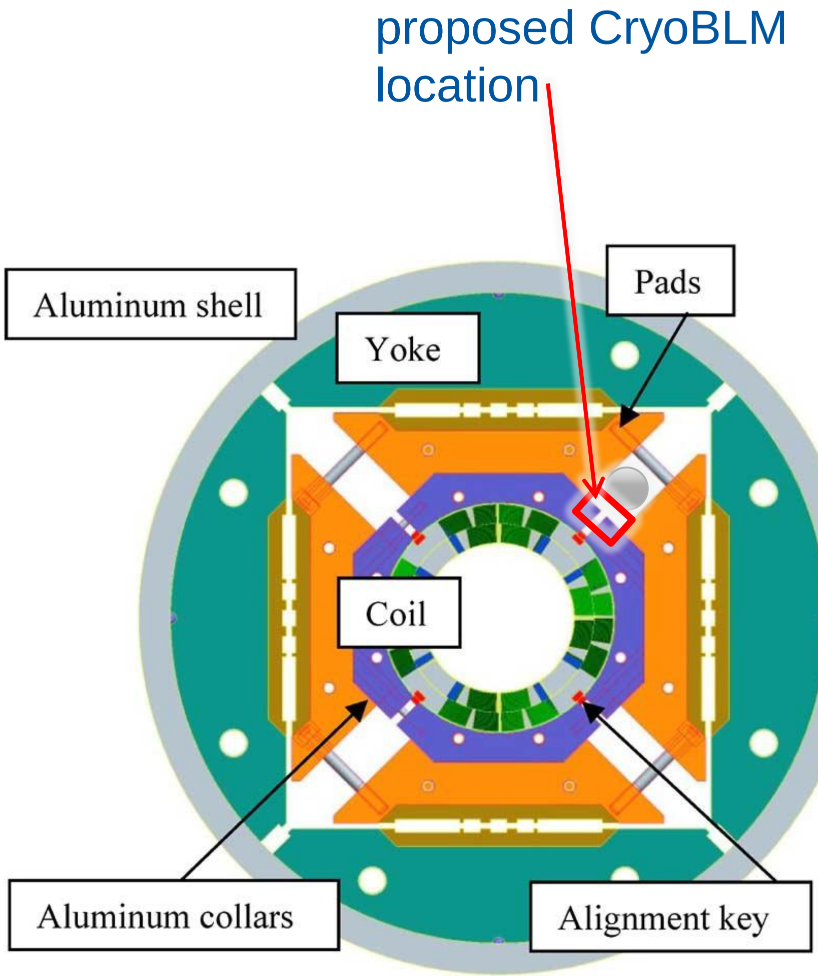




- For HL-LHC luminosity losses in triplets will be close to quench limit.
- Now BLM thresholds are factor 3 below quench level.
- It will not be possible for HL-LHC. Need more precise measurement.
- CryoBLMs give 2-3 times better separation debris/loss.
- Similar need for other losses: collimation, injection…

New simulations - ongoing

- Work of Francesco Cerutti and Luigi Esposito.
- Real new triplet geometry.
- For debris: done.
- For loss scenario: ongoing investigation, probably new Sixtrack studies needed.
- Motivation for CryoBLMs not expected to change.

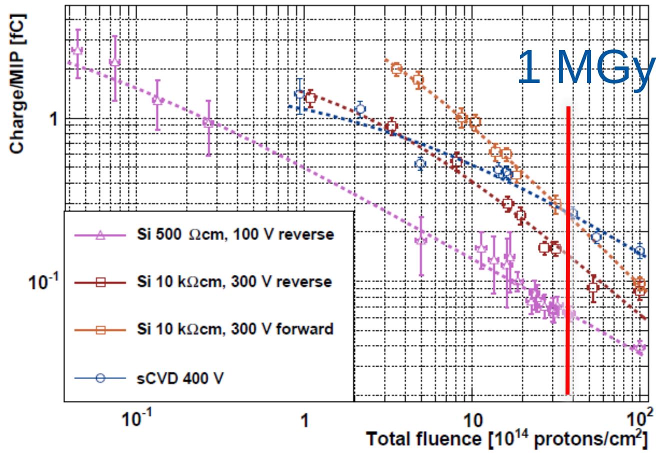


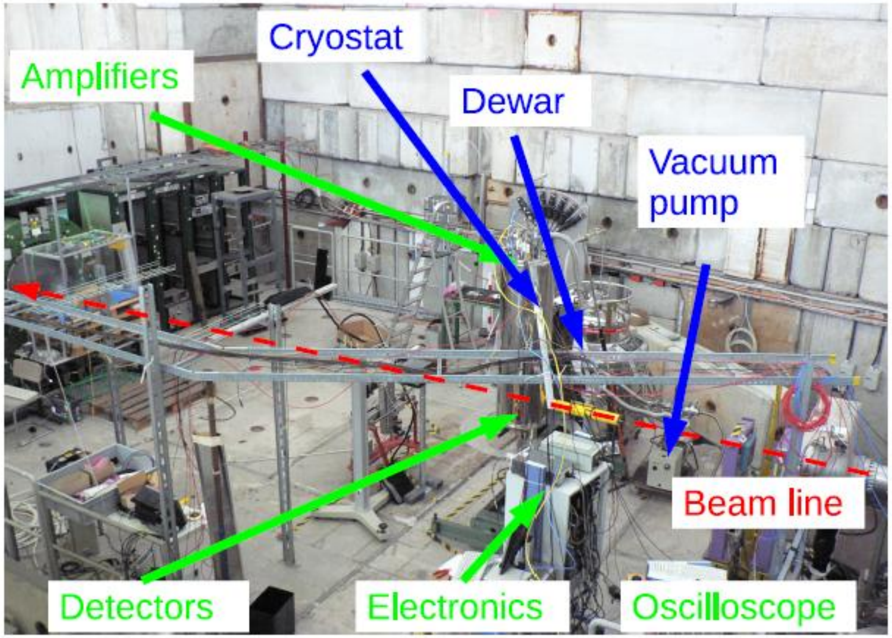
Results of beam-tests

- Detectors were studied and tested on the beam
- Rich documentation:
  - Ch. Kurfuerst et al., Radiation Tolerance of Cryogenic Beam Loss Monitor Detectors , Proceedings of IPAC13
  - M. Bartosik et al., Characterisation of Si Detectors for the Use at 2 K, Proceedings of IPAC13, MOPME071, CERN-ATS-2013-058
  - Ch. Kurfuerst, PhD thesis, November 2013
- In LHe: shorter signals, higher amplitude
- Good radiation hardness

Investigated technologies:

- x He3 chamber
- ✓ Silicon
- x scintillators
- x scintillation in LHe
- ✓ Diamond
- ✓ LHe ionization chamber
- x thermal equilibrium cal
- x transition edge sensors





Motivation for LS1 installation on the cold mass

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- Investigate long-term performance of the system (stability, reliability, availability – as the current system).
- Measure relation of signals between current detectors and new ones.
- Evaluate Rradiation hardness of other prototype elements (holder, cables).
- Gain experience in operation.
- Perform interesting physics measurements.

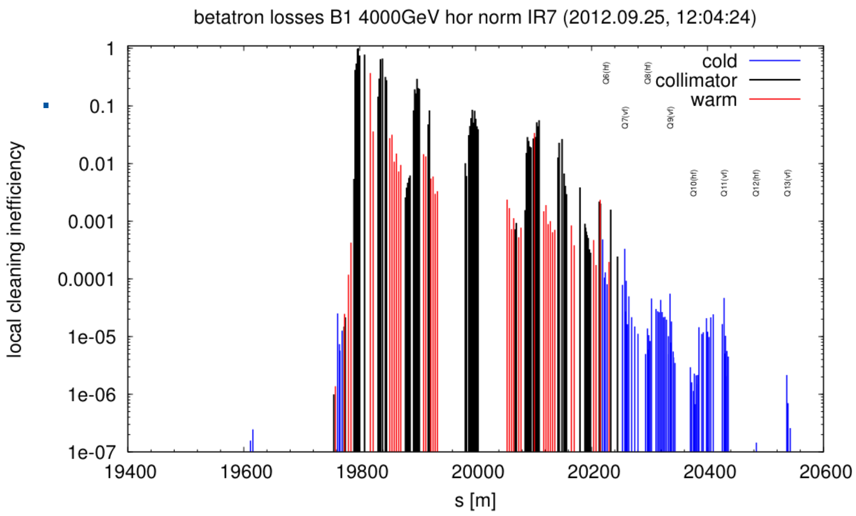
Proposal

- Triplet magnets not accessible during LS1.
- MQ cold mass is difficult to access.

Install detectors on MBs where large signals expected:

- Two locations: 11R1 and 9R7.
- Each location: 4 detectors (probing the radiation field).
- Connect to standard BLM electronics
  (special crates, not affecting the current system).
- Keep possibility of measuring fast signals (bunch-by-bunch).
- Make sure this test installation will not affect magnets.

Location R7



BLM signals during 4 TeV loss map 2012-09-25.

Monitor	loss rate [Gy/s]
BLMQI.08R7.B1E30_MQ	$4.6\cdot10^{-5}$
BLMEI.09R7.B1E30_MBA	$4.3\cdot10^{-5}$

- Purpose: observation of collimation losses.
- Maybe particularly interesting for next quench test.
- Choice made based on dose measured during collimation loss maps (data from Belen Salvachua, collimation).
- Normal signals scale down, small differences between various loss maps.
- Two locations seem to be equally good: MBA and MBB between Q8 and Q9 – in both cases end cap facing the IP

Location R7 – cell 9R7

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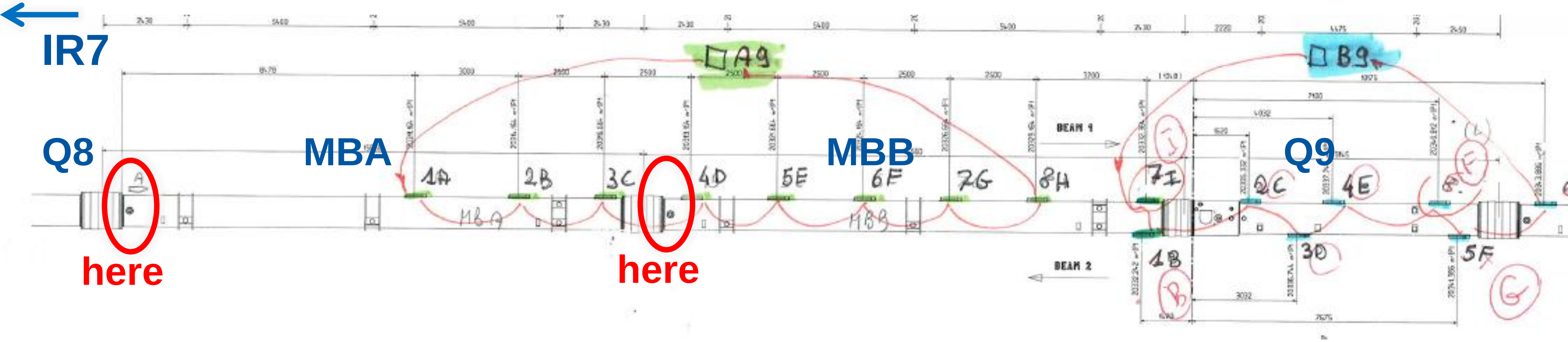
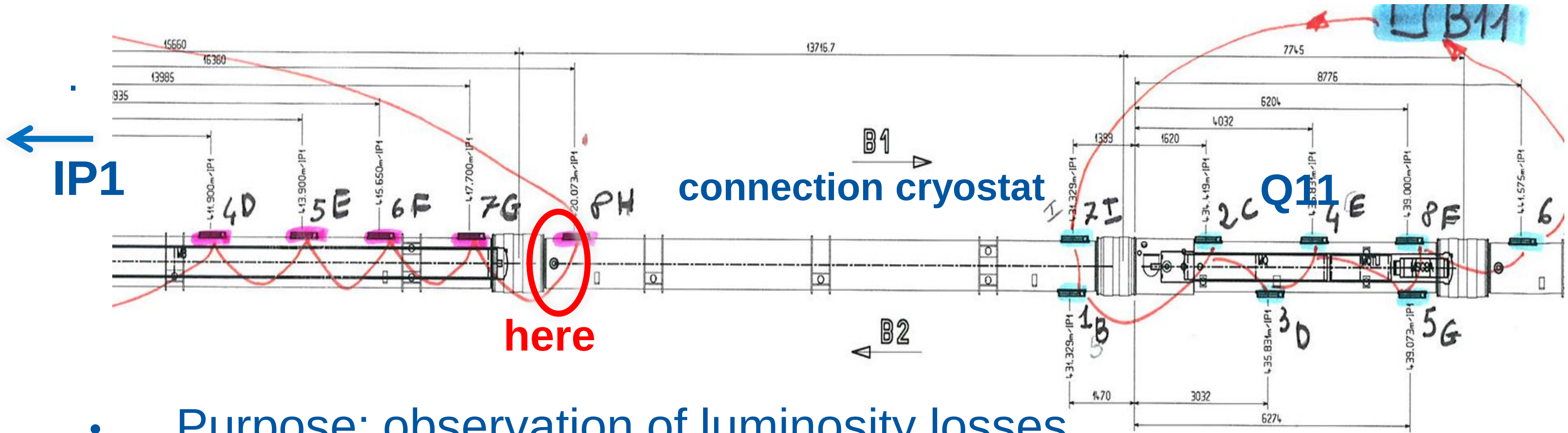


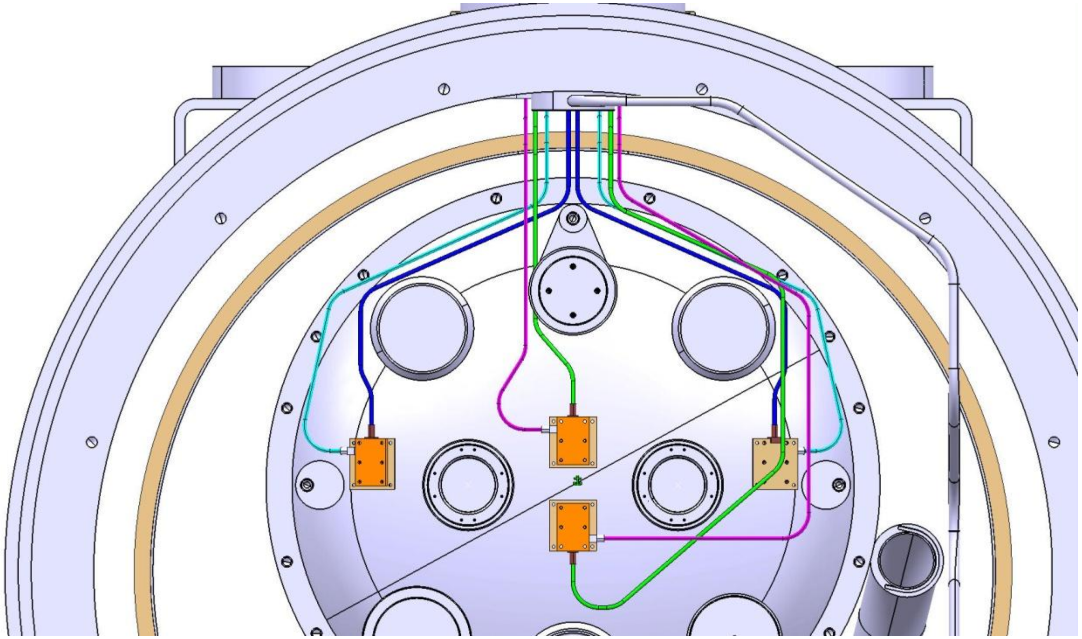
Location R1 – cell 11R1



- Purpose: observation of luminosity losses.
- Connection cryostat end cap facing the IP is proposed.
- Choice made based on total dose due to luminosity production measured by current BLM system.
- BLMEI.11R1.B1E30_MBB - integrated dose of 2.5 Gy (in November 2012 – largest in the area)
- Expected about 5 times larger rate because closer to beam

Installation setup

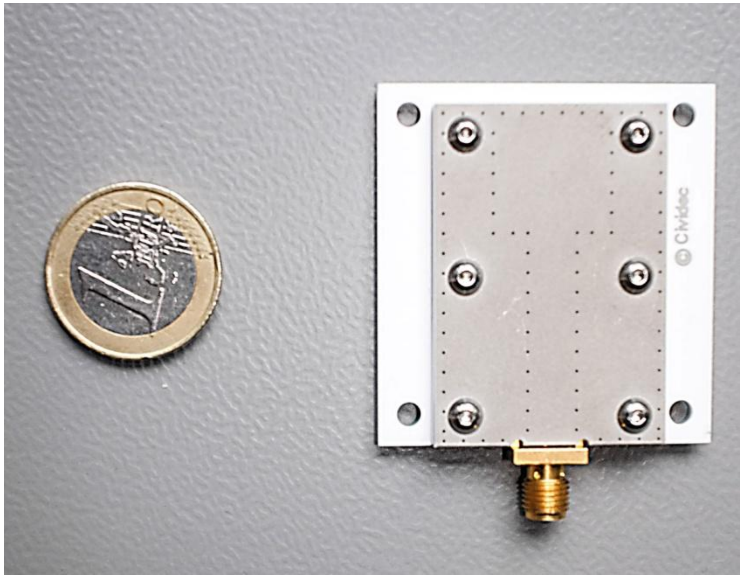
- Support plates attached to the front of the magnet
- (see LHCQQA_S0273 by Thierry).
- Detectors on special holders screwed to the plates.



drawing by Thierry

Installation setup

- In each location: one diamond and 3 silicon detectors
- Materials:
  - Cables the same as for BPMs (vacuum, cryogenic),
  - Ceramic PCBs (Diamond), FR-4 for Silicon
  - SMA connectors with ceramic instead of teflon.
- HV: maximum 500 V (Diamond)
- Each detector is independent (separate HV)
- Heat dissipated by working detector ~ 1 mW



Who is on the project

- CERN: Bernd Dehning, myself
- PhD students:
    - Christoph Kurfuerst – finished
    - Marcin Bartosik
- External collaborators:
    - Vladimir Eremin (IOFFE, St. Petersburg, Si detectors, holders)
    - Erich Griesmayer (CIVIDEC, Diamond detectors, holders)
    - Chris Fabjan (expert for LHe chamber – not for LS1 test)
- FLUKA simulations: Francesco Cerutti, Luigi Esposito
- Many people from CERN to help: Vittorio Parma, Nicolas Bourcey, Jean-Phillipe Tock ,Thierry Renaglia, CryoLab team, Christian Boccard - thank you!

Conclusions

- An installation of beam loss detectors on the cold mass of LHC magnets is proposed in two locations.
- It is an important development towards HL-LHC.
- Materials and detectors have been carefully chosen.
- Most of the elements are produced.
- ECR will be circulated soon.

Thank you for your attention!

Additional slides

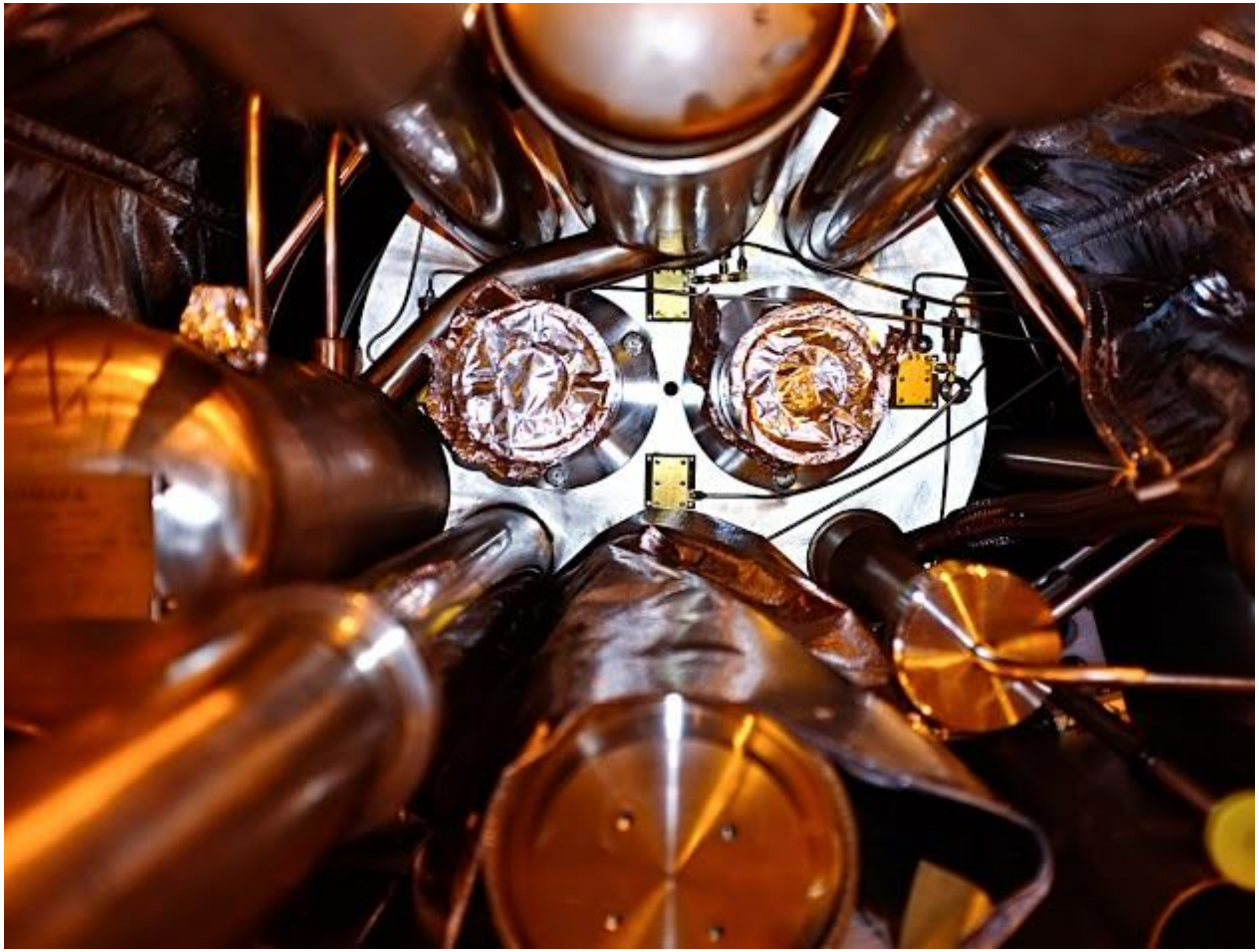
Loss map data

Monitor	dcum [m]	loss RS09 [Gy/s]
BLMQI.06R7.B1E10_MQTL	20219.17	0.000484443
BLMQI.07R7.B1E10_MQ	20257.2	0.000333014
BLMQI.06R7.B1E20_MQTL	20223.47	0.0001299324
BLMQI.06R7.B2I20_MQTL	20222.27	0.0001057081
BLMQI.07R7.B1E20_MQ	20259.77	9.27885E-05
BLMQI.06R7.B2I10_MQTL	20226.9	8.08849E-05
BLMQI.07R7.B2I30_MQ	20253.23	7.88157E-05
BLMQI.09R7.B1E10_MQ	20335.33	5.54319E-05
BLMQI.07R7.B1E30_MQ	20264.32	4.98616E-05
BLMQI.11R7.B1E10_MQ	20428.58	4.67632E-05
BLMQI.08R7.B1E30_MQ	20303.42	4.5806E-05
BLMEI.09R7.B1E30_MBA	20319.16	4.32588E-05
BLMEI.09R7.B1E21_MBA	20311.16	3.00738E-05
BLMEI.09R7.B1E22_MBA	20314.16	2.73749E-05
BLMQI.07R7.B2I20_MQ	20258.57	2.716E-05

Luminosity data

Monitor	dcum [m]	loss RS09 [mGy]
BLMEI.11R1.B1E22_MBB	413.9	1189.962
BLMEI.11R1.B1E23_MBB	415.65	1108.671
BLMEI.11R1.B1E24_MBB	417.7	1283.256
BLMEI.11R1.B1E30_MBB	420.073	2549.128
BLMQI.11R1.B2I30_MQ	431.326	1574.25
BLMEI.11R1.B1E21_LEHR	431.34	3073.741
BLMQI.11R1.B1E10_MQ	434.416	2634.265

Pictures from installation on Q7



Pictures from installation on Q7