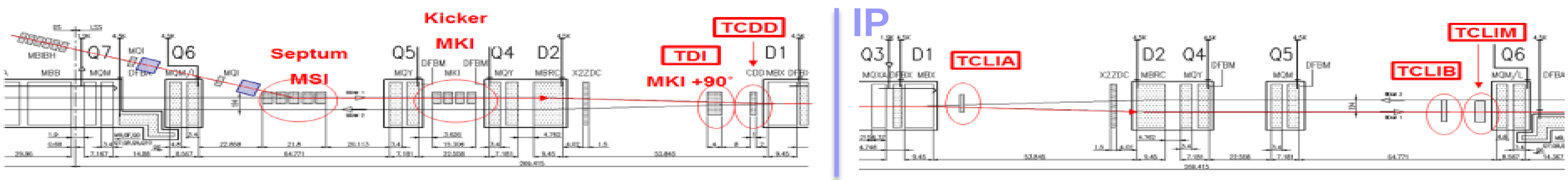
WP14 Overview

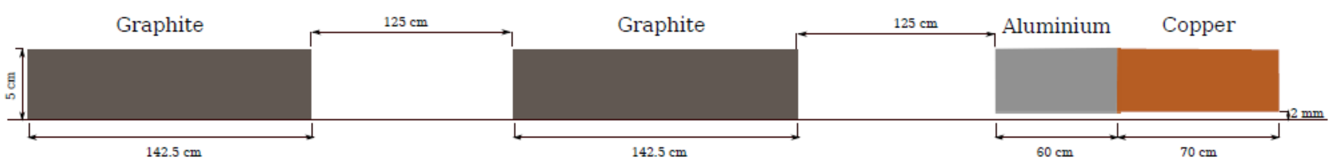
Jan Uythoven, Anton Lechner

HL-LHC Annual meeting @ KEK
17 – 21 November 2014

WP14: Injection protection upgrade



- Injection protection IP2 and IP8 : to be installed in LS2
- Absorber design taking into account
  - Protection of downstream elements (D1, Q6 etc.)
  - Survival of absorber, especially the TDIS
  - Impedance considerations
  - Experiments: opening angle for ALICE ZDC
- TDI → Segmented TDIS
  - Most important and complicated element for injection protection
  - Decided to go for 3 x 1.5 m modules
    - 2 x low Z (graphite) + 1 x high Z (materials to be optimised)
  - Integration to be formally approved (800 mm chamber)



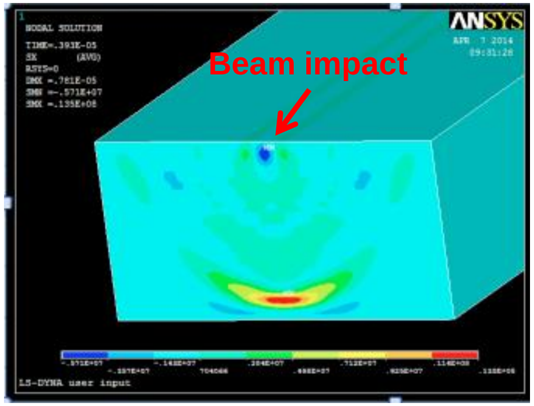
High Luminosity LHC

TDIS – Most critical

- Protection of downstream elements
  - **TDIS** can have about same integrated absorber length as present TDI
    - Critical case is grazing impact, about 1 σ impact, almost independent of absorber length
    - Full impact of HL-LHC beams is fine with present length

A. Lechner, N. Shetty, G. Steel, F. Lorenzo Maciariello, A. Perillo Marcone

- Survival of absorber: TDIS
  - Critical is again grazing case, about 1 σ impact
    - Presently assume graphite as low Z absorber
    - Research on materials like **3D Carbon/Carbon**
    - Material can be ‘exchanged’ during design phase
    - HiRadMat tests foreseen in 2015



Beam	Emit. x,y [µm]	N_b [p/bunch]	# bunches	M-C Safety Factor
Standard	**2.0**	**2.3e11**	**288**	**1.01**
BCMS	**1.3**	**2.0e11**	**288**	**0.90**
BCMS	**1.3**	**2.0e11**	**240**	**1.43**

Considering no error from energy deposition calculations.

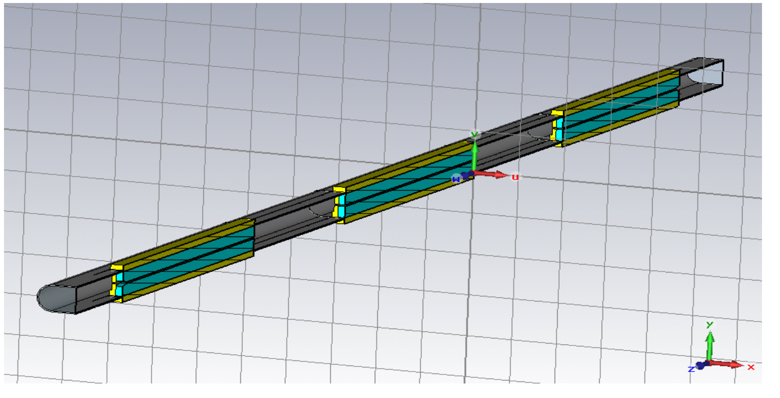
- Deliverable D2.6: Specification of Machine and Beam Parameters:

It must be noted that the feasibility of a design of the injection absorber TDIS to absorb safely the nominal and especially BCMS beam with the bunch population listed in Table 1 and small emittances is very challenging and it is presently under study.

2.3×10^{11} p+/b

TDIS impedance

- Present TDI impedance is critical due to beam induced heating causing damage to the TDI and outgassing
- Many differences with standard collimator
  - Two beams, large volume required for non-injected beam → optimised design of the current secondary collimator cannot be used
  - Large front phase for beam impact in case of MKI failure, no RF fingers.
  - Large clearance in stable beams, large excursion between injection and pre-ramp settings
- Addressed with priority in the new design
  - Improve the cooling, ensure it is cooling what and where it should
  - Surface coating
  - Closure of gap between the jaw and the beam screen for different jaw positions
  - Evaluation of impedance of the interconnections for different jaw positions
- Baseline design with 3 separate jaws and tanks → **Additional transitions will add impedance. Tapering adds length**



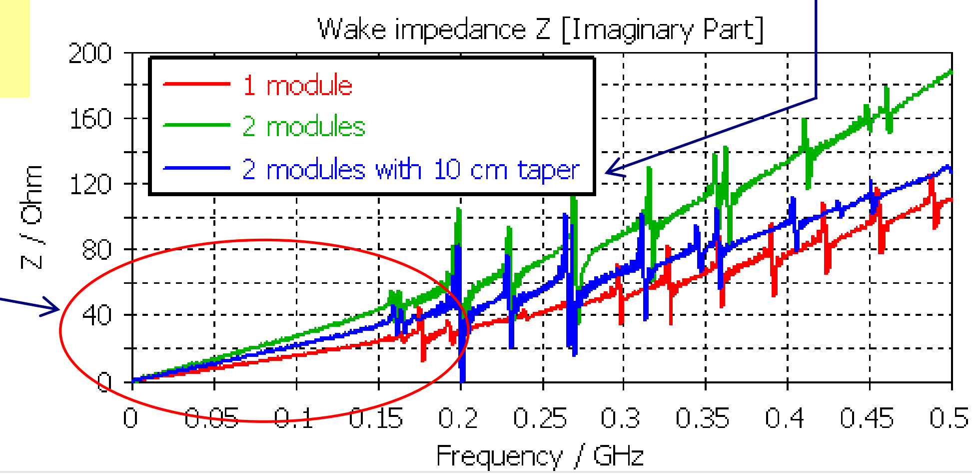
B.Salvant, N.Biancacci, E.Metral, A.Danisi, O.Frasciello (INFN), M.Zobov (INFN)

TDIS Impedance

- Large parameter space to optimise including tapering of the absorbers
  - First simulations made, positive effect of 10 cm taper
  - Beginning of next year second iteration with preliminary design, many other parameters to optimise
    - Taper length, taper height, transition length, transition height, non-linearity of tapers, jaw materials / coating, beam screen material

- Longitudinal and transverse effective impedance for beam stability
- Longitudinal and transverse resonant modes for beam stability
- Longitudinal real impedance for beam induced heating

Lower frequencies most important for the beam



MKI Failure Studies

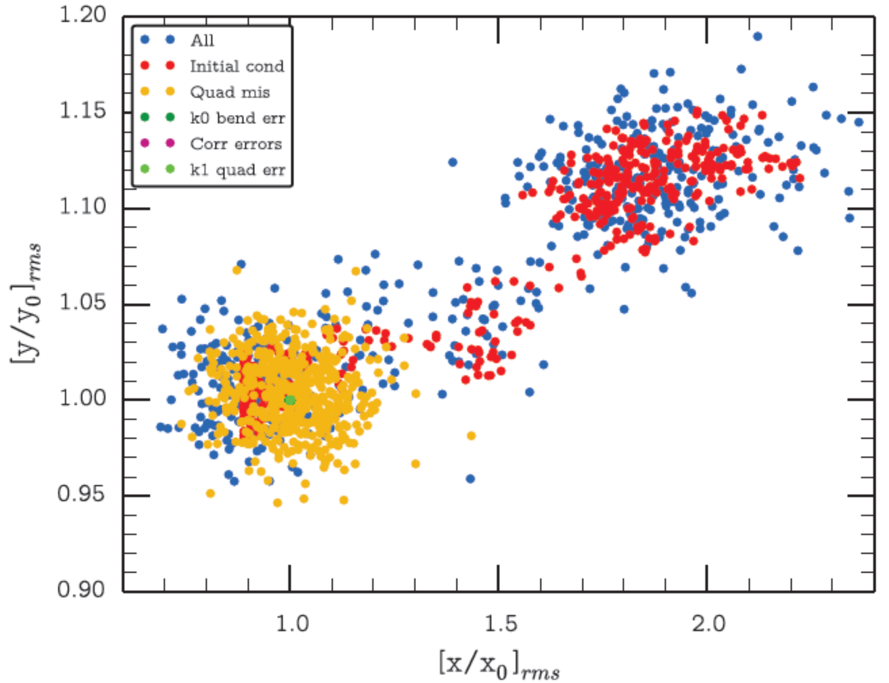
F.Velotti

- MKI strength between +/- 20%
- LIU-BCMS beam
- TDI aperture 6.8 σ (ε_{nom})
- TCLIA/B aperture 6.8 σ (ε_{nom})

- MKI strength of +/- 10% gives the: *grazing impact* on the TDI
- Evaluate the expected beam impacting on the TCLIA/B in case of MKI failures
  - Single particle emittance considered
  - 5 σ extension in *y* and y'

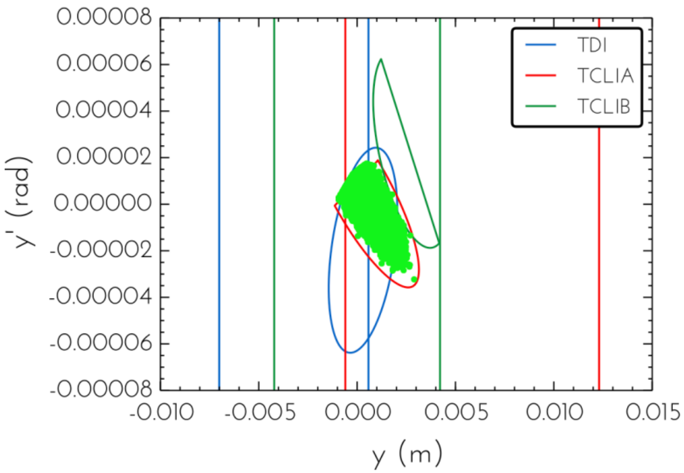
$$y = y_0 + 5\sqrt{\epsilon_y \beta_y}\cos(\psi_y)$$

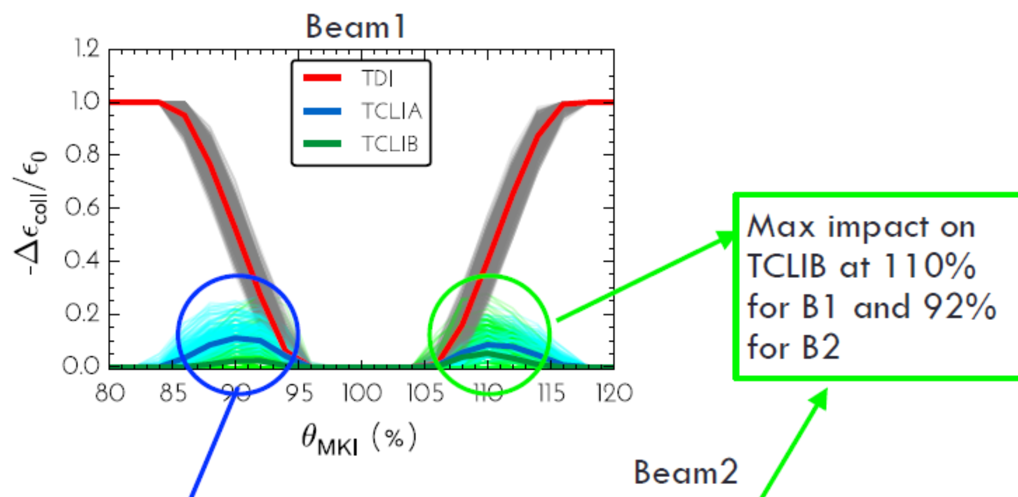
$$y' = y_0' - 5\sqrt{\epsilon_y / \beta_y}(\alpha_y \cos(\psi_y) + \sin(\psi_y))$$

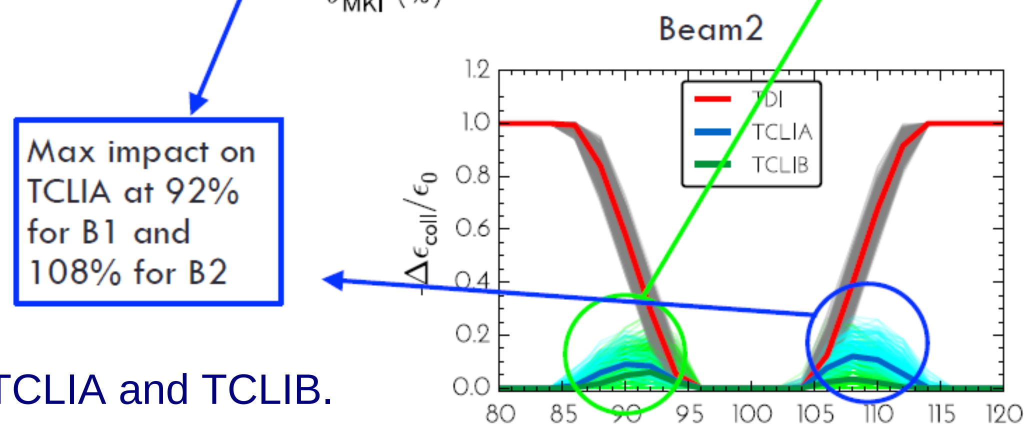


Consider realistic machine failures in magnetic fields and orbit, co_{rms} of 0.24 mm.

TCLIA and TCLIB



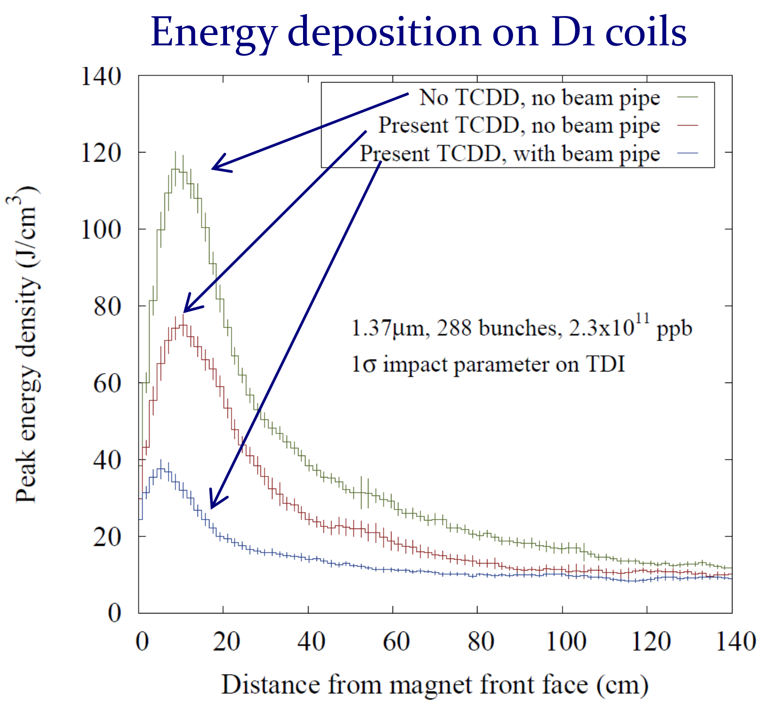




- Max 28 % area cut by TCLIA/B
- Being repeated with realistic particle distributions in phase space → expect much lower values

- Likely not necessary to be replaced TCLIA and TCLIB.
- Final decision before the end of 2014
- However, opening angle TCLIA might need to be enlarged for ALICE ZDC. Follow-up TREX & WP8
  - Sufficient argument to replace TCLIA in IP2?
- Damage levels of downstream Q6 should not be reached

TCDD: mask in front of D1

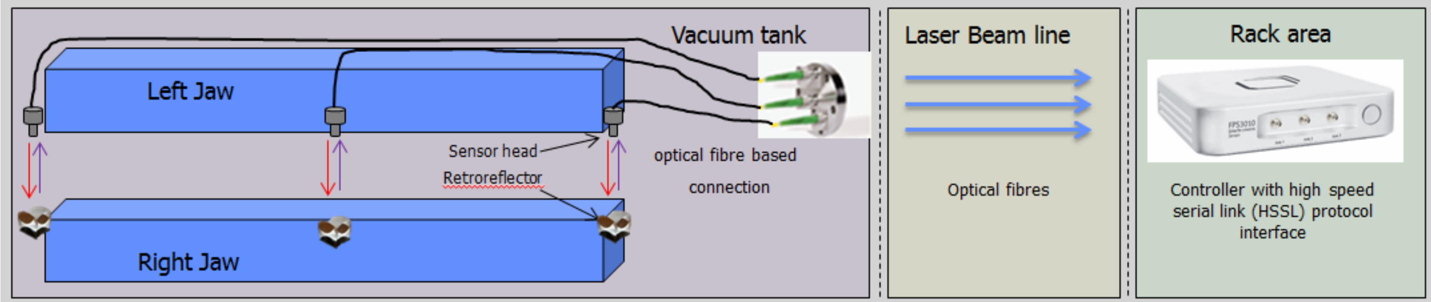


- Results depend strongly on geometry
- Beam pipe is shielding as much at the TCDD
- Improvements – of about a factor 2 – can be obtained by reducing TCDD aperture and bringing TCDD closer to the D1.
- Study mask within the D1 cryostat

- Protection of D1 against damage. Quench cannot be avoided
- Grazing impact on TDI
  - Effect on D1 rather independent on beam size
- Peak power deposition of **37 J/cm^3**
- What is the damage limit of the D1?
  - Previously published value of 50 J/cm^3 not correct
  - Need at least a safety margin of factor 3
  - **Beginning of December meeting with magnet expert and one needs to decide upon a damage threshold**
  - **This will then decide if the TCDD needs to be adapted or not**

See A. Lechner, parallel session WP5/7/14
Next talk

TDI(S) interferometric system



- Interferometry very important for safety as to guarantee the correct positioning of the TDI jaws in combination with the Beam Energy Tracking System.
- To be installed on spare TDIs for Run II, installation during Run II. Test bench developments, new sensor heads, feed through tests: so far so good.

 = - Custom, high alignment tolerance, radiation hard, interferometric position sensor head with metal FC/PC connectors

- Vacom rad-hard, UHV, aluminium coated optical fibre with stainless steel 304, FC/PC connectors and bakeable @ 300 °C

 = - Corner cube retroreflector (+/- 50 mrad, +/- 2 mm, bakeable @ 300 °C)

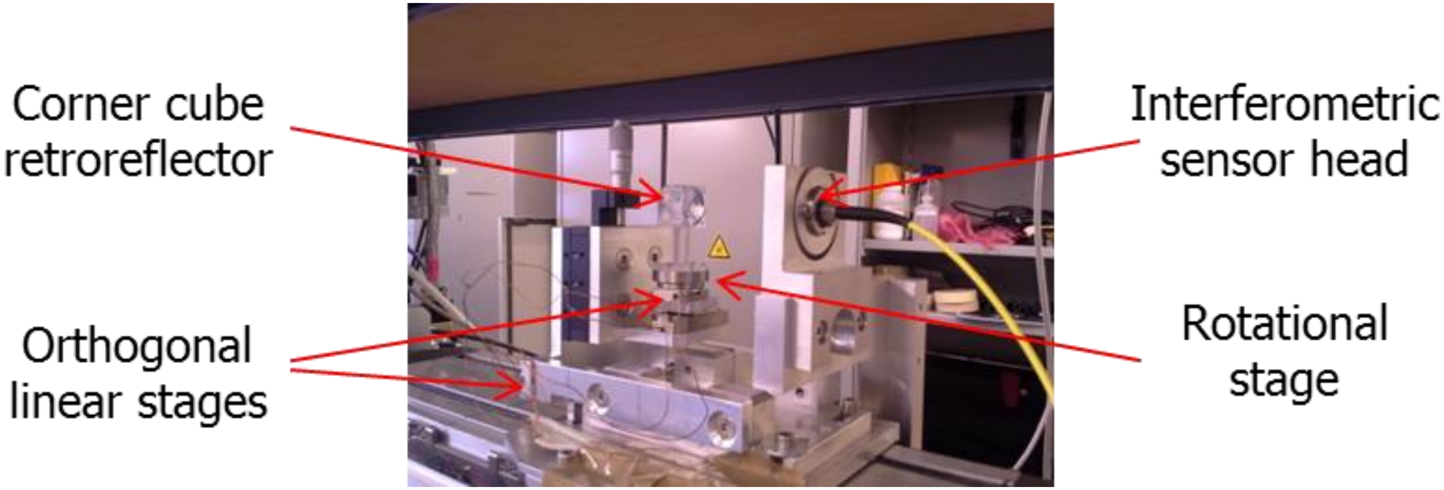
 = - Fibre Design, Stainless Steel 316L, vacuum feedthrough (3 channels) with FC/PC connectors , bakeable @ 300 °C

 = - Fujikura, "UV-acrylate" coated, rad-hard fibre (RIA ≈ 30 db/km @ 10 MGy, max working temperature = 85 °C)

 = - Attocube FPS3010, 3 channel interferometer controller with 500 kS/s, 48 bit position output with 1pm resolution

A. Masi, M.Butcher

Interferometric Test Bench



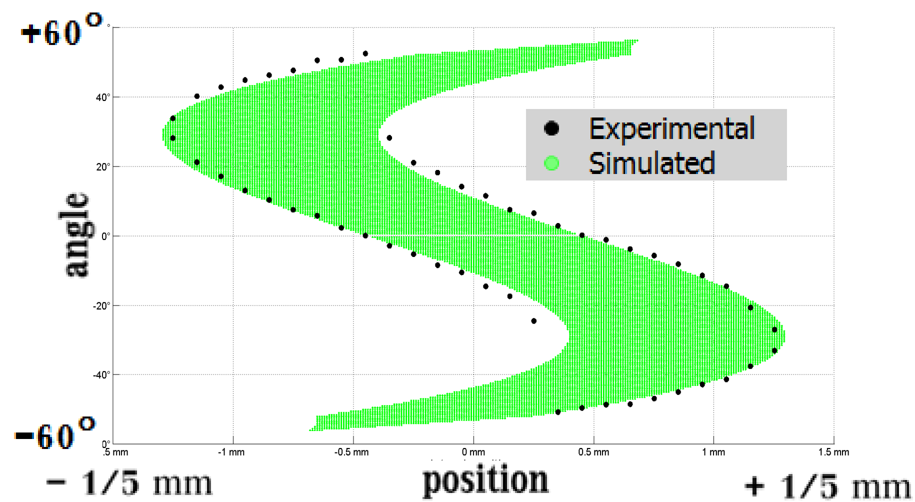
Tolerance for **Standard head** + Retroreflector at 60 mm working distance and centre of rotation at 7.5 mm from retroreflector vertex:

+/- 2 deg AND +/- 0.3 mm

↓

Ordered **Wide Angle Head** :

+/- 2 deg AND +/- 1.5 mm

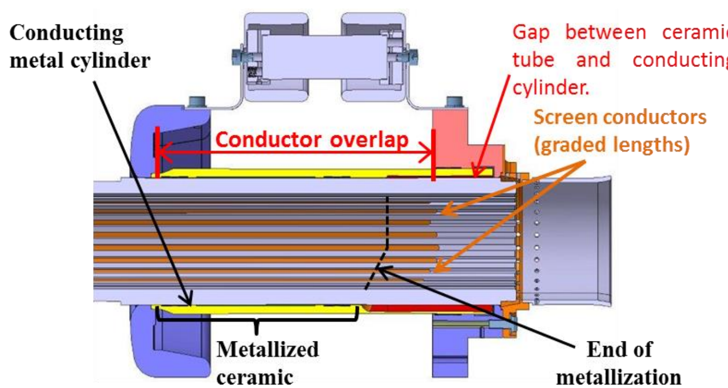


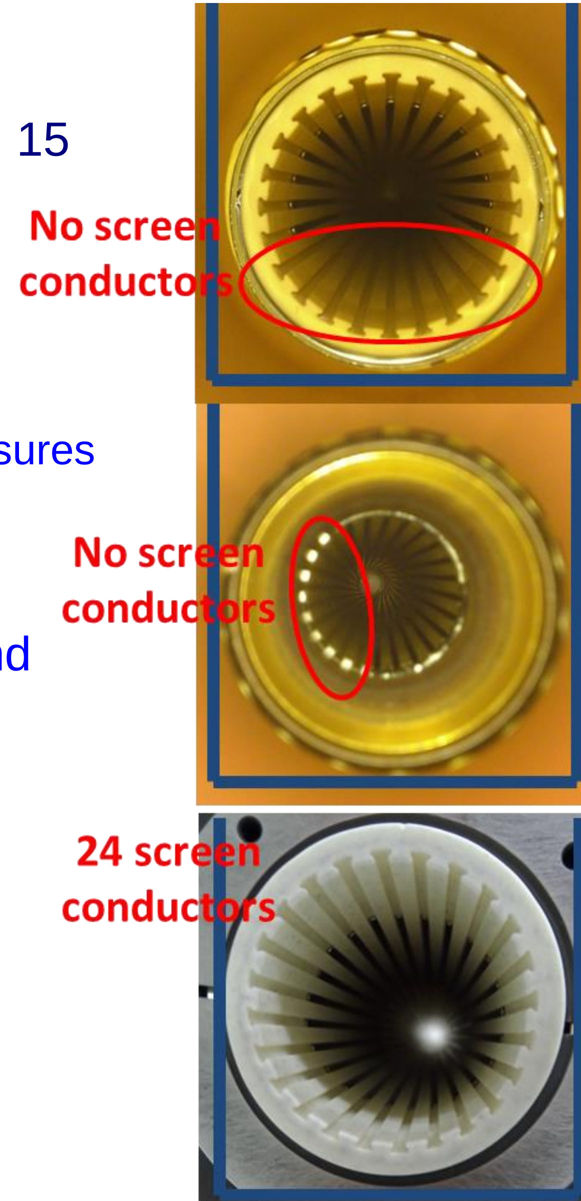
Comparison theoretical and measured tolerances

Injection kicker magnet MKI: heating

M.Barnes

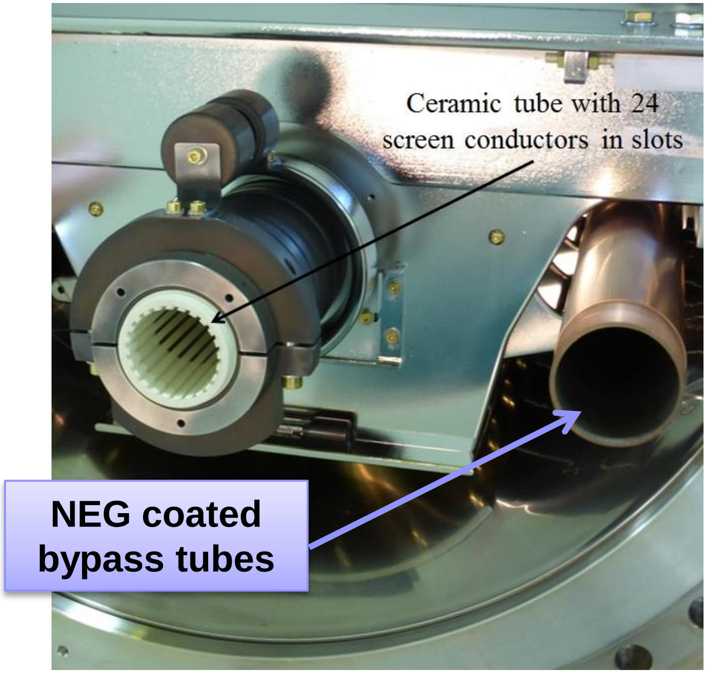
- In LS1 increased number of screen conductors from 15 to 24 screen conductors
- Experience from LS1 with ‘rotated’ conductors: operational limit at power deposition of 160 W/m
  - Run II expect about 50 W/m: OK
  - HL-LHC expect **UP TO** 190 W/m → need further measures
  - Proto-type part of HL-LHC baseline, not the series
- New developments
  - Further ‘overlap’ studies capacitively coupled end
  - Radiation cooling
  - Liquid cooling
  - Ferrite with higher Curie temperature

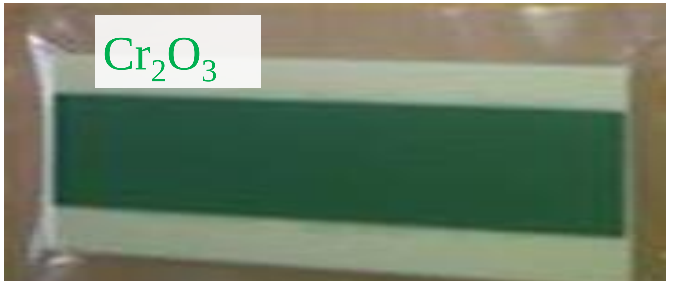


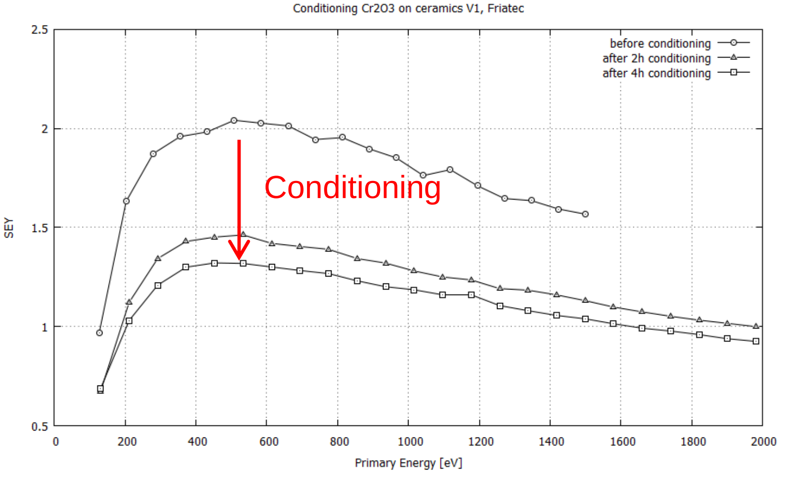


Injection kicker magnet MKI: ecloud

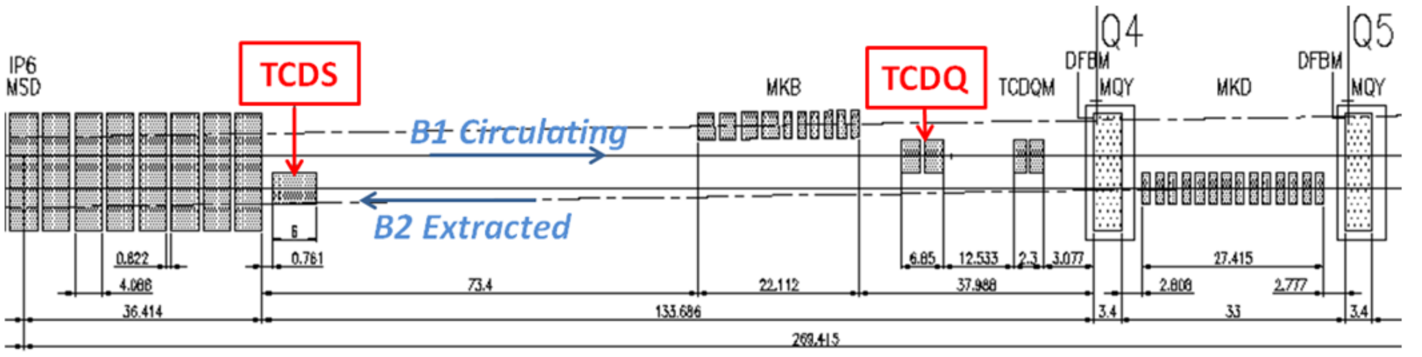
- LS1 MKI bypass tubes NEG coated, as nearby equipment.
- Ceramic tube can still be an issue with SEY values 6 – 10. Required SEY < 1.4
- Cr_2O_3 coated ceramics SEY ≈ 2, conditioned to < 1.4
- Contract placed to develop application method for Cr_2O_3 coating of MKI ceramic chamber to reduce SEY. If successful apply on prototype magnet.
- Looking for position in machine for passive prototype







LHC Beam Dumping System



- Any changes to be made in LS3
  - Verification of TCDS for HL-LHC beams. Will likely need to be upgraded.
  - Check the already modified TCDQ. Further upgrade not foreseen in the baseline.
  - Check TDE heating after multiple dumps – nitrogen venting.
  - Check TDE window – if this is an issue, might need to change dilution pattern. This is not part of the HL-LHC baseline.