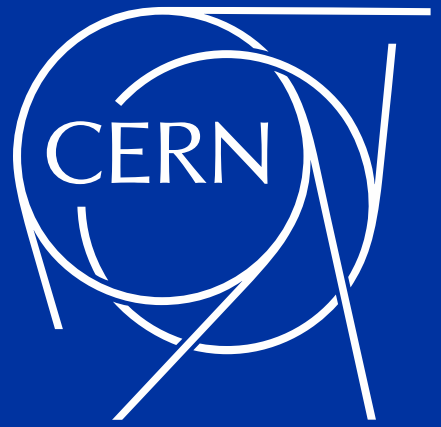


LHC integration of the double-crystal set up

K.A. Dewhurst on behalf of NDC section

12 December 2023

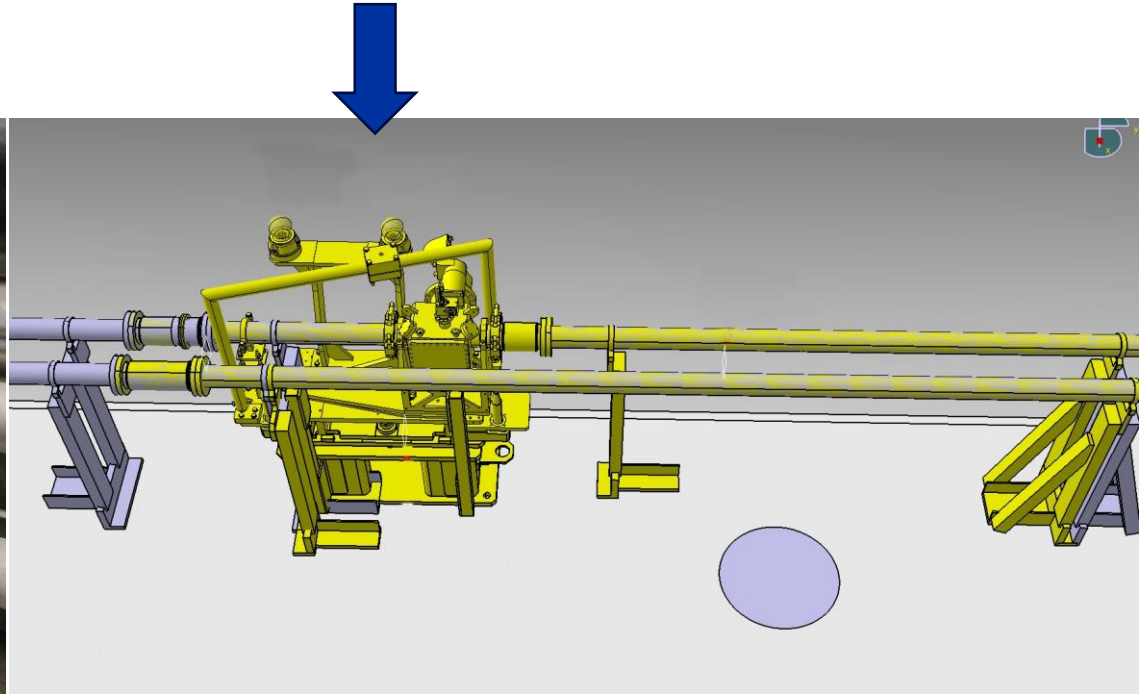
3rd workshop on electromagnetic dipole moments of unstable particles at IJCLab

Contents

1. The proposed layout uses beam 2

Positions decided for the TWOCRYST experiment; chosen to be compatible with the HL-LHC experiment layout.

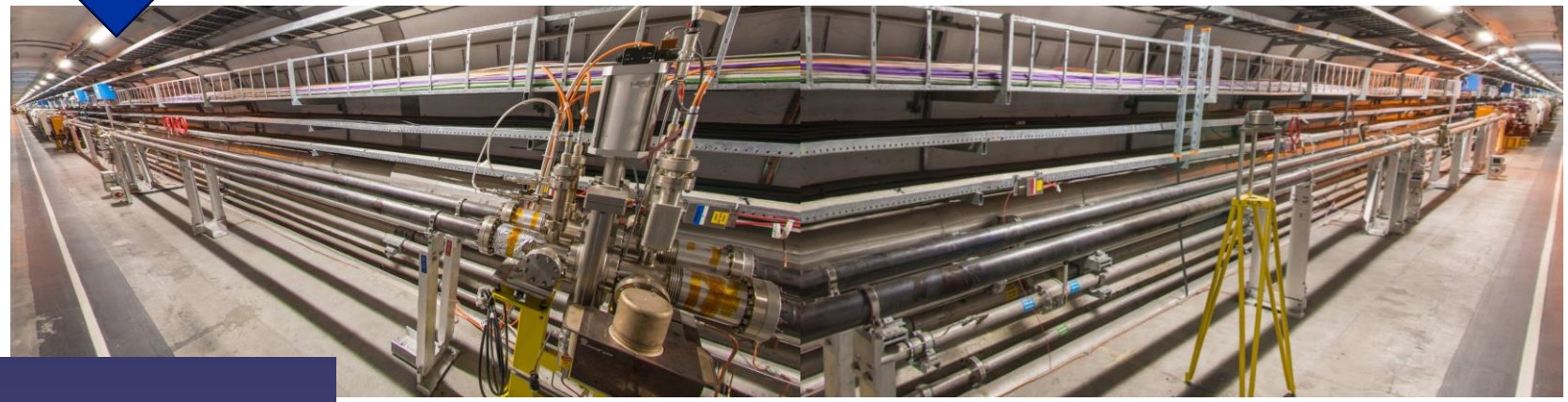
Crystal 1: TCCS at 6773.9 m



1. The proposed layout uses beam 2

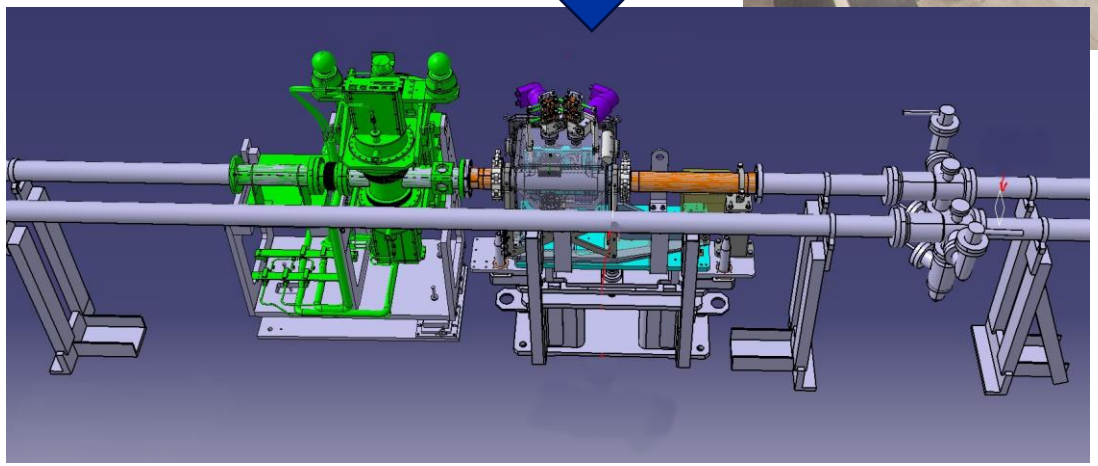
Positions decided for the TWOCRYST experiment; chosen to be compatible with the HL-LHC experiment layout. TCCP is located close to IP3.

Crystal 2: TCCP at 6653.3 m



TCCP

Roman pot station for TWOCRYST

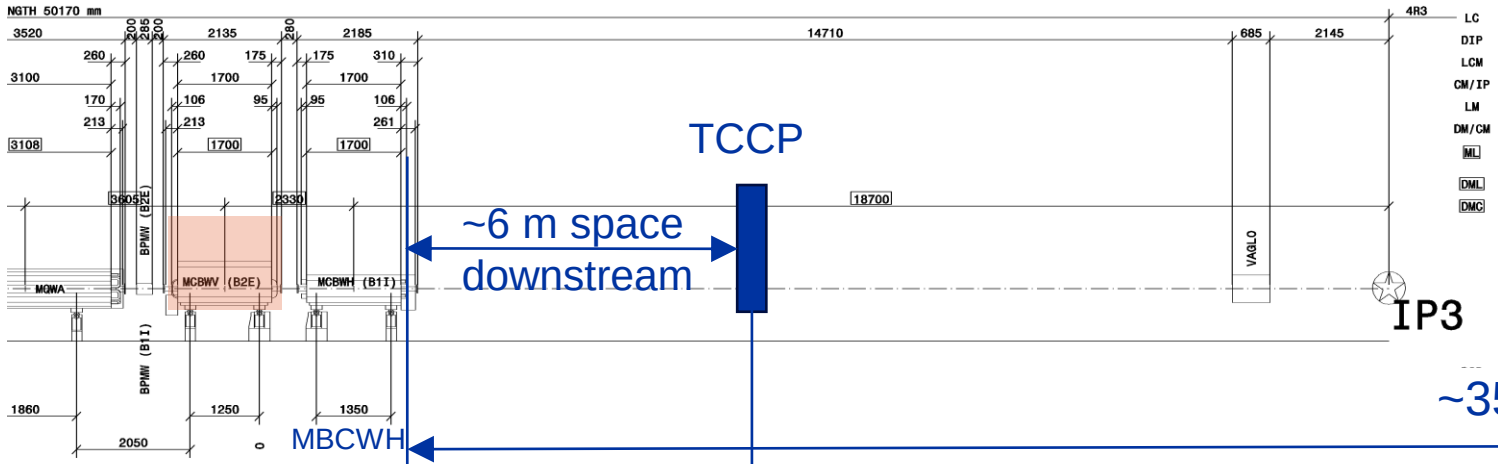


HL-LHC layout requires more components, to be decided, potentially including:

- Spectrometer magnet (2 m)
- Second detector (RP) (1.5 m)
- Additional collimators

1. Available space

Overview of the momentum collimation region (IP3)



TCCP

~6 m space downstream

IP3

~35 m space in total

~6682 m

MBCWH B2

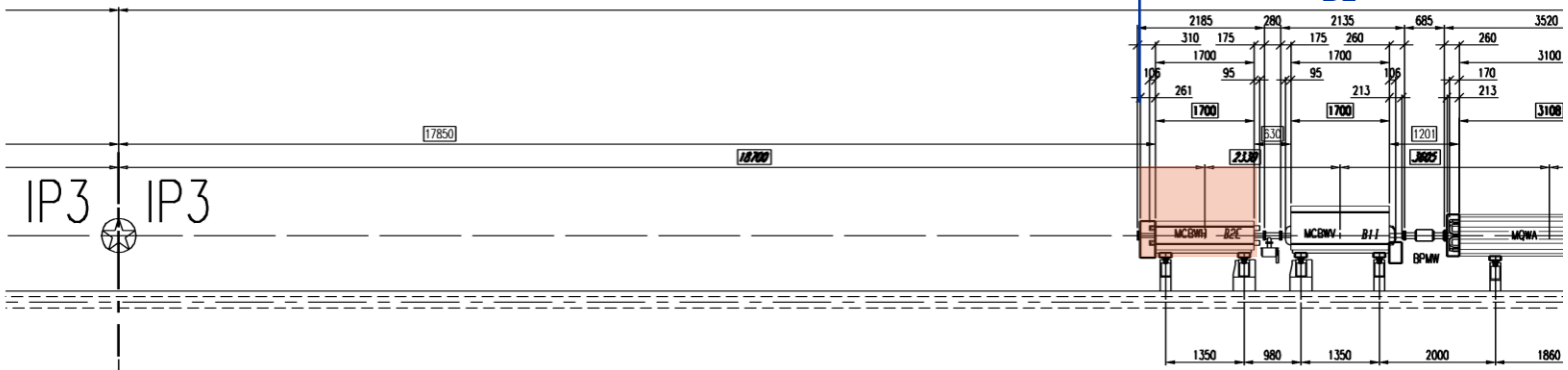
MBCWV B1

MBCWH B1

MBCWV B2

~6647 m

6653.3 m



Conclusions

6m space available immediately downstream of the TCCP.

More space available in the region if needed (move the TCCP upstream).

However, moving the TCCP upstream reduces the separation with the main beam (next slide).

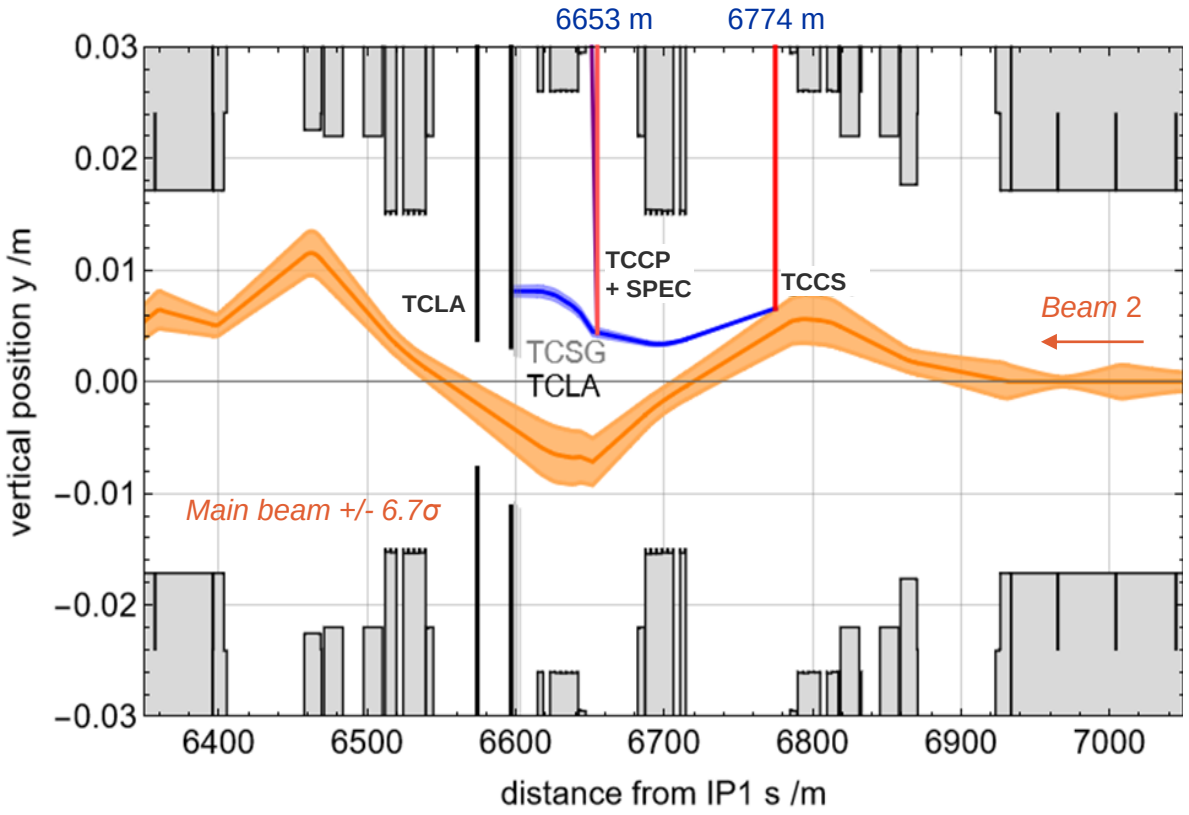
2. Beam size and aperture constraints

Require N1 ≥ 12σ

Inclusion of a spectrometer magnet with field of 4 Tm. The orbit bump caused by this magnet was matched back to the nominal closed orbit by local vertical corrector magnets in MADX.

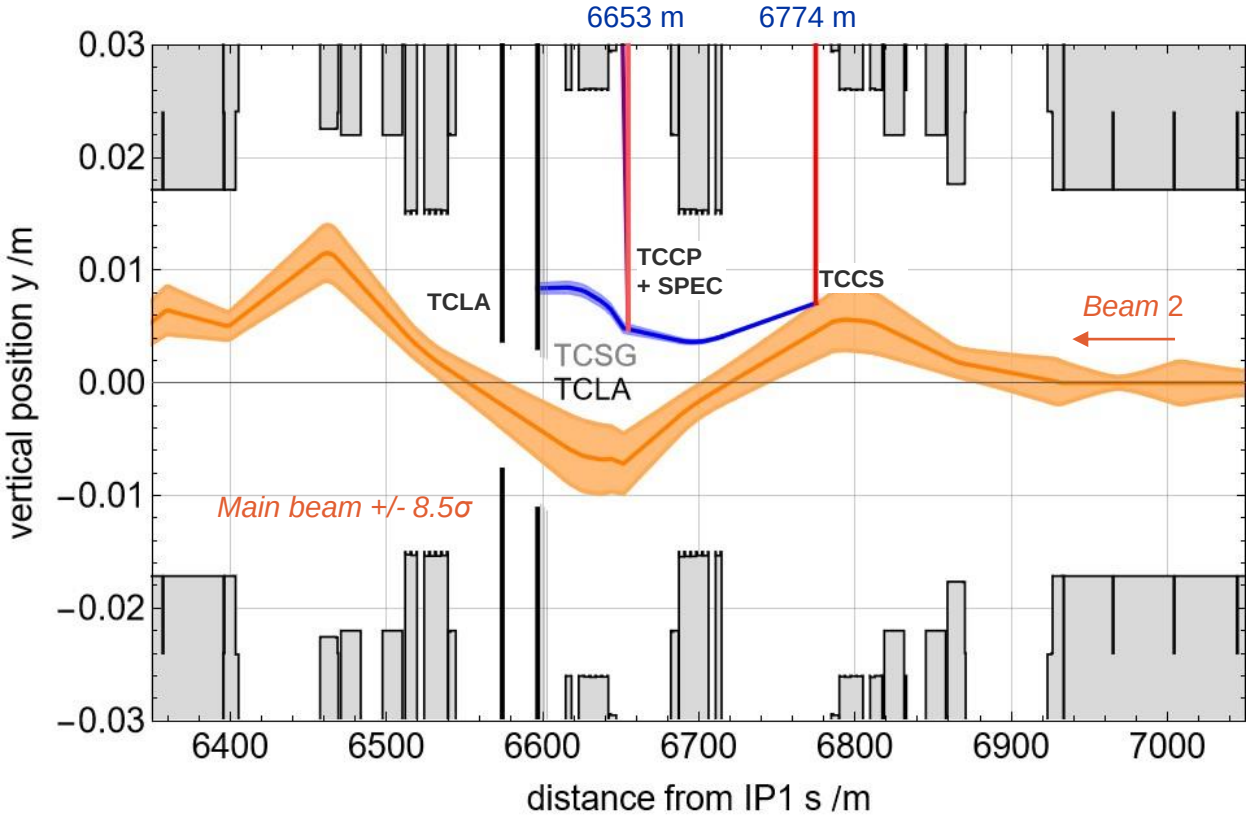
Tight collimator settings

Main beam +/- 6.7 σ.
Aperture limit at 6471 m, N1: 18.2 σ. (diff 11.5)



Relaxed collimator settings

Main beam +/- 8.5 σ.
Aperture limit at 6471 m, N1: 18.2 σ. (diff 9.7)



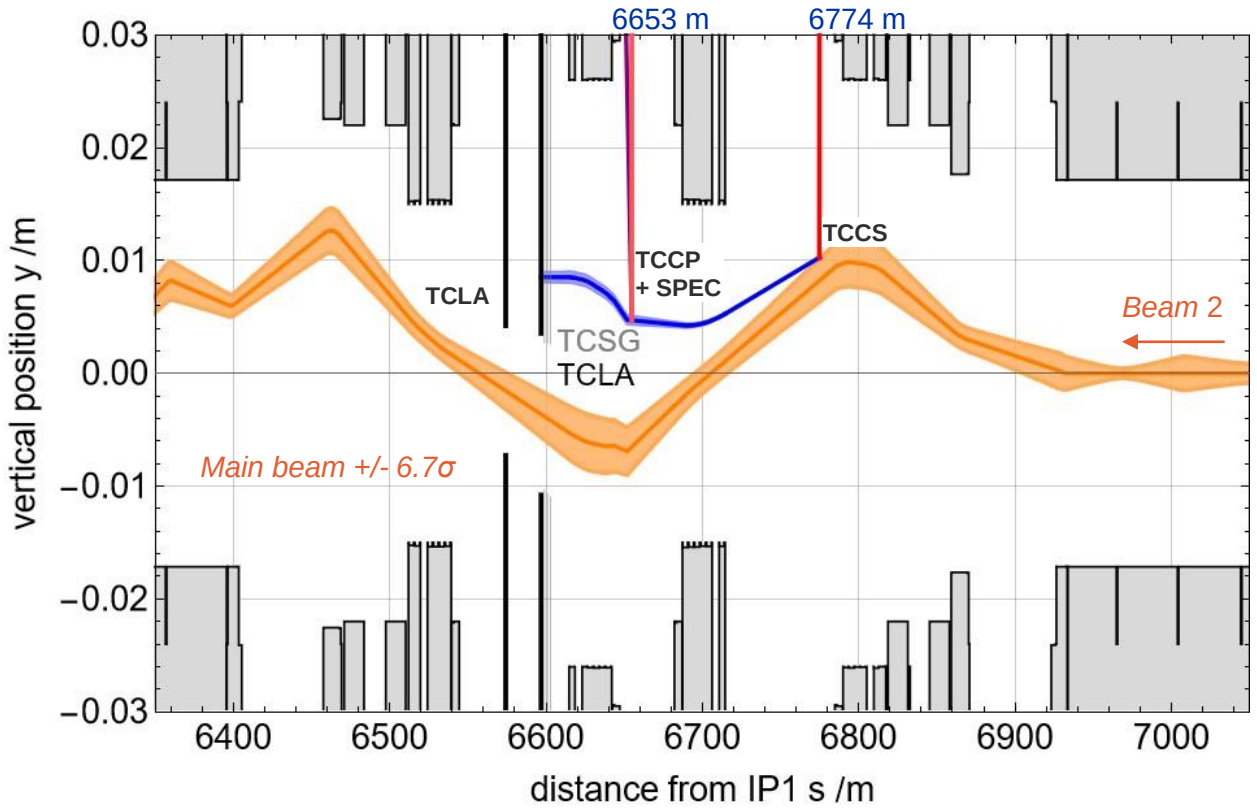
3. Magnet strength: spectrometer settings

Require N1 ≥ 12σ

Orbit bump caused by the spectrometer magnet is matched back to the nominal closed orbit by local vertical corrector magnets in MADX.

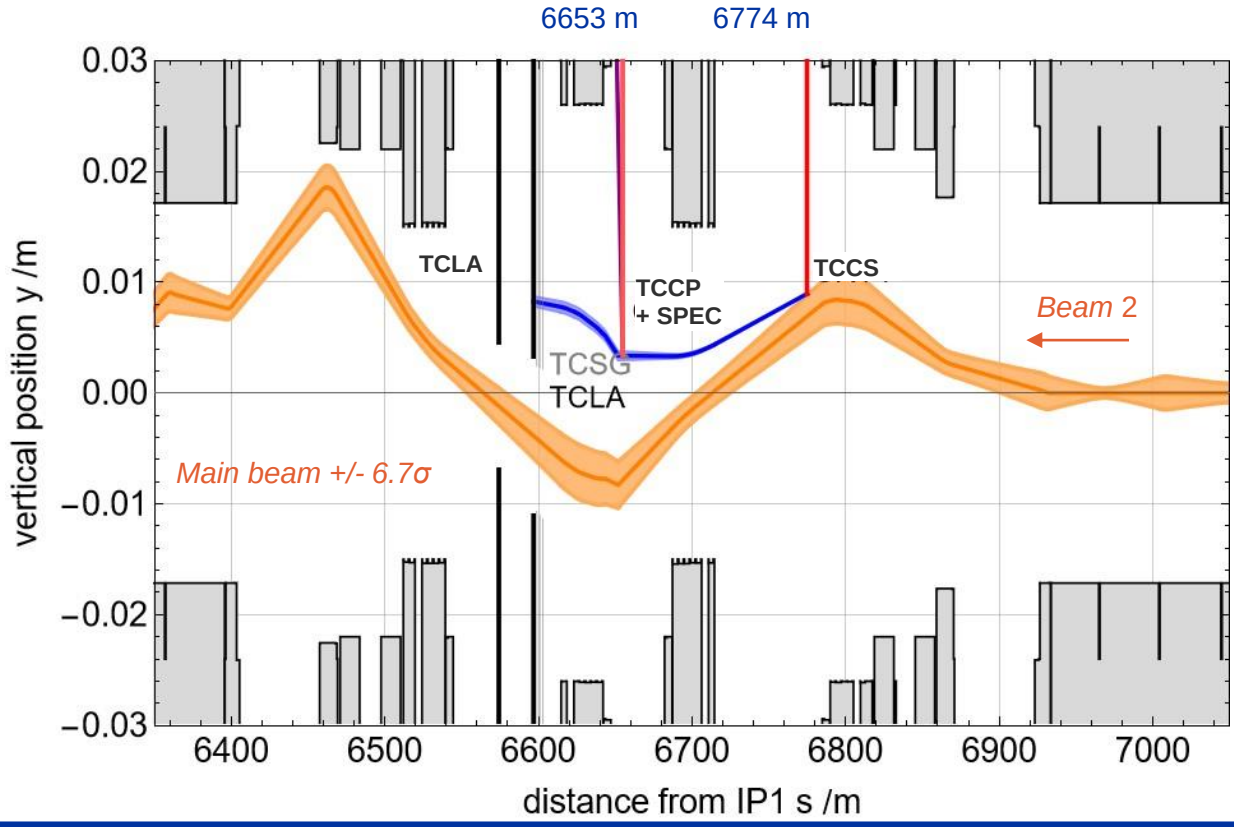
4.5 Tm magnet: matched to closed orbit

Aperture limit at 6471 m, N1: 14.5 σ.



5.0 Tm magnet: good match not found

Aperture limit at 6471 m, N1: <<10 σ.



3. Magnet strengths: spectrometer settings

Kicker magnets near IP3	4.0 Tm case – Strength (Tm)	4.5 Tm case – Strength (Tm)	5.0 Tm case – Strength (Tm)
mcbcv9.r3.b2	0.0	0.0	0.0
mcbcv7.r3.b2	0.70	1.23	1.05
mcbwv5.r3.b2	-1.29	-1.68 (90% of max)	-1.68 (90% of max)
mcbwv4.l3.b2	-1.68 (90% of max)	-1.68 (90% of max)	-1.68 (90% of max)
mcbcv6.l3.b2	-0.90	-0.74	-1.38
mcbcv8.l3.b2	0.09	-0.19	0.46
mcbcv10.l3.b2	1.32	1.68	1.86

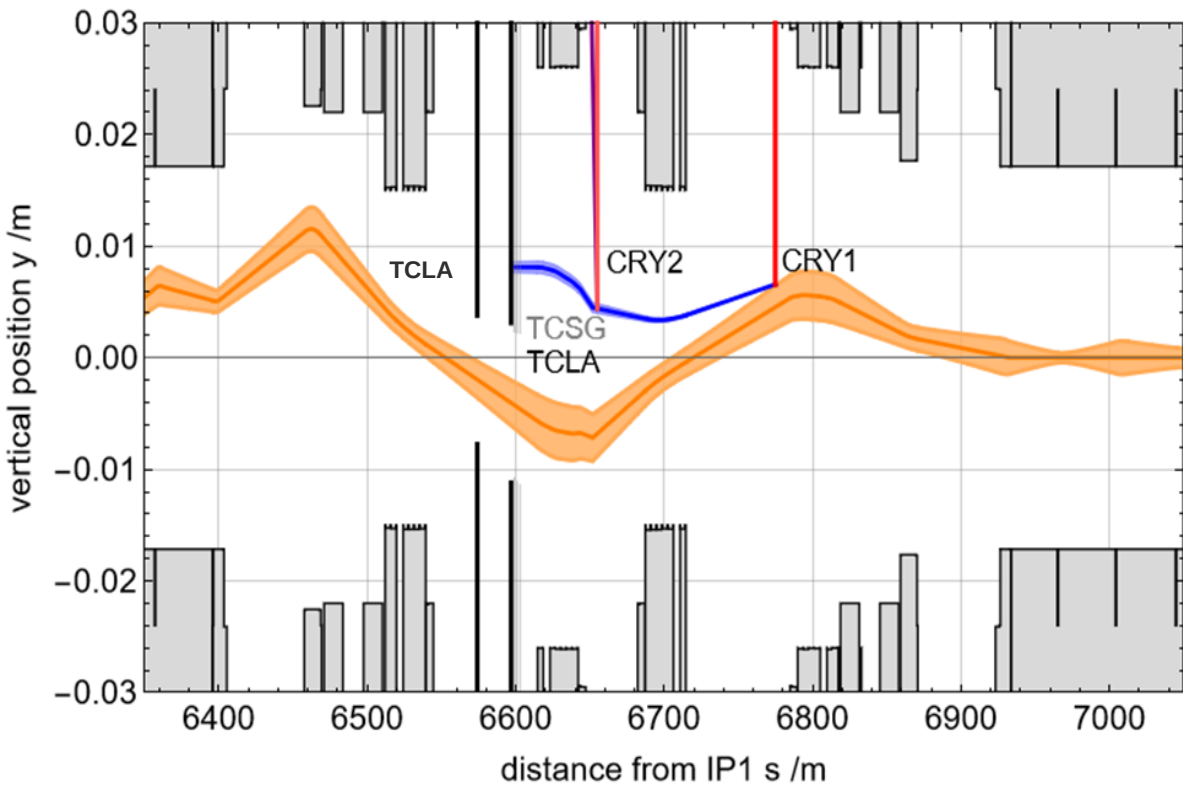
Note: The operational margin with the orbit correctors needs to be confirmed by LHC OP team.
Higher spectrometer magnetic field goes inversely with the aperture.
Further work: consider the aperture inside the spectrometer magnet.

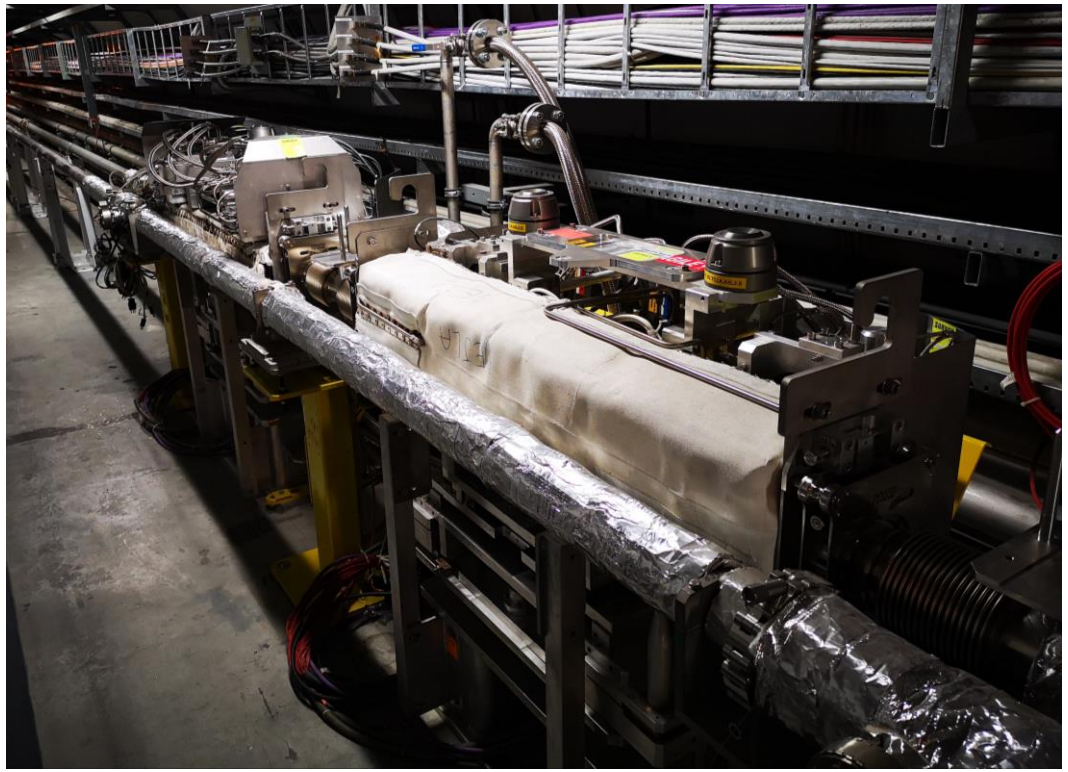
Conclusions

A 4 Tm spectrometer can be incorporated: correction by existing magnets and within aperture limits.
A maximum field is <5 Tm, likely close to 4.5 Tm.
Increasing the magnetic field decreases the available aperture.

4. Clean up: additional collimators

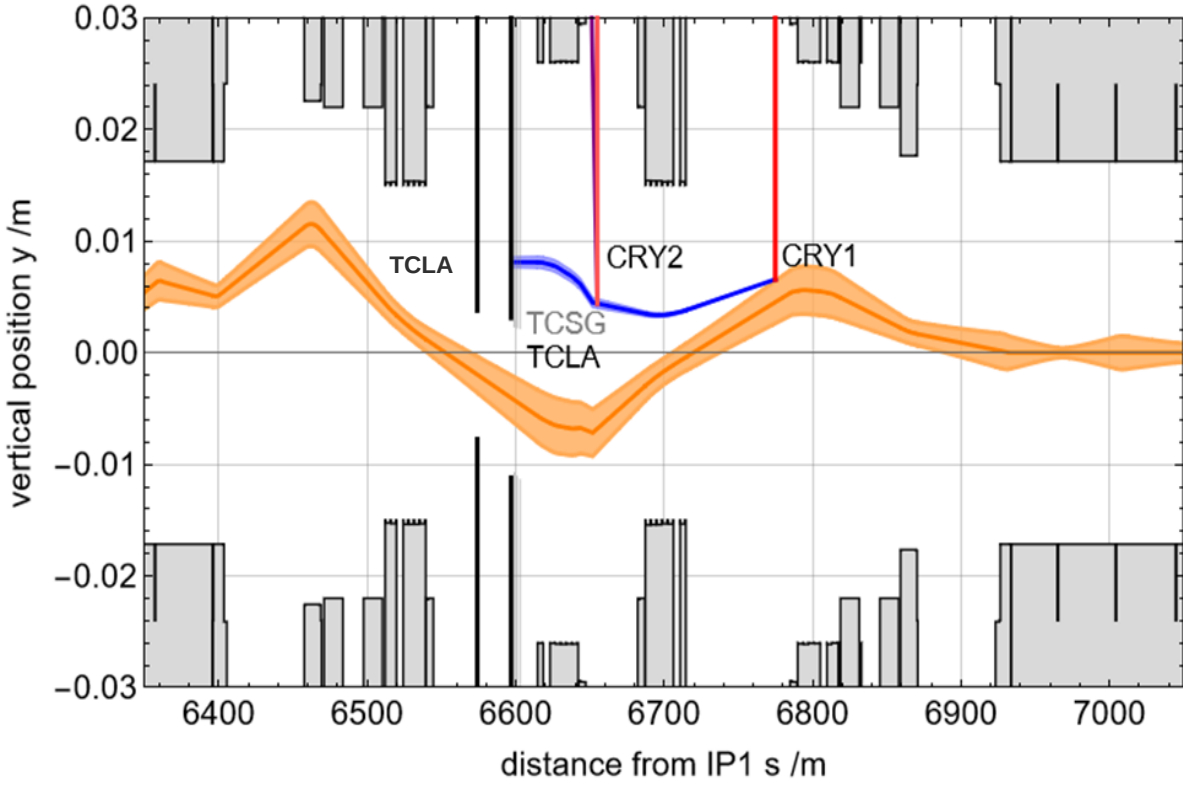
The current vertical TCLA in IR3 (TCLA.A5L3.B2) will intercept the channelled beam from the TCCS with 23.7 σ.





4. Clean up: additional collimators

Additional collimators with a hierarchy; 3 TCSGs and 1 TCLA could be installed. The current suggested positions still need to be checked (e.g. physical restrictions in the tunnel).

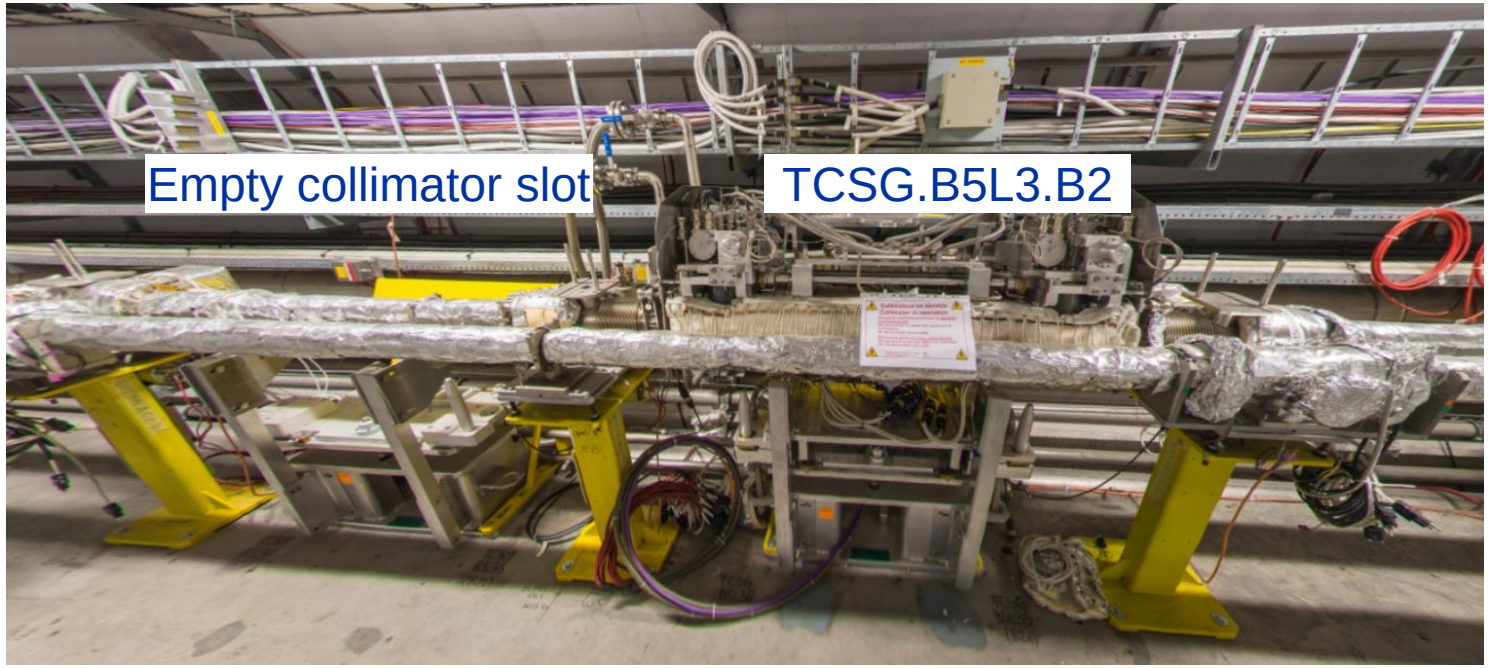


New collimators for HL	Potential position / m	Setting / σ
TCSG.A	6602.9	21.3
TCSG.B	6600.9	21.3
TCSG.C	6598.9	21.3
TCLA	6596.9	23.7

4. Clean up: additional collimators

Can we make use of existing empty collimator slots in IR3 for the new collimators?
Each existing (horizontal) TCSG in Region 3 is alongside an empty collimator slot (with existing connections).

For example, TCSG.B5L3.B2 at position 6604.7 m, has an empty collimator slot just downstream.



Current collimator	Position / m
TCSG.4L3.B2	6627.7
TCSG.5L3.B2	6610.5
TCSG.B5L3.B2	6604.7

New TCSGs can be placed in the available slots alongside existing TCSGs. Only 1 new installation (new TCLA) needed.

4. Clean up: additional collimators

Suggested collimator positions: use existing slots where available.

New collimator	Position / m
TCSG.A	6626.2
TCSG.B	6609.0
TCSG.C	6603.2
TCLA	6596.9

Further work: assess the effectiveness of the proposed new collimators with particle-matter interaction simulations.

Conclusions

The current TCLA will intercept the channelled beam from the TCCS.

Additional vertical collimators are being considered.

Further work is needed to assess their performance.

5. Summary

Further work: consider the aperture inside future components; spectrometer magnet and roman pots. Assess effectiveness of proposed new collimators with particle-matter simulations.

TWOCRYST positions decided, installation will begin on B2.
6m available downstream of the TCCP for spectrometer and detectors.
35m space available in the region of IP3.

We can incorporate a 4 Tm spectrometer with acceptable aperture for the main beam with an orbit bump.

Maximum possible spectrometer field is ~4.5 Tm (less than 5 Tm).
Compromise between aperture and magnet strength.

Current TCLA will intercept the channelled particles from the TCCS.
Additional vertical collimators are being considered; assess proposed positions and performance.

Good progress on experiment planning, more details to be explored.

5. Summary of positions

Current values (tbc)

Element (PoP)	Position / m
TCCS	6773.9
TCCP	6653.3
TCLA (TCLA.A5L3.B2)	6574.2

New elements for HL	Position / m
Spectrometer	6650.3
TCSG.A	6626.2
TCSG.B	6609.0
TCSG.C	6603.2
TCLA	6596.9