Calibration Measurements

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Procedure

- In case of **"real" asynchronous beam dump** we will need to **check possible damage of the TCDQ/TCSP.**

- A procedure has been worked out and relies on **calibration measurements** to be performed during re-commissioning and to be used as **reference.**
  - HW checks and local inspection
  - Measurements with beam:
    - Aperture measurements
    - Standard asynchronous beam dump check ➔ comparison of loss patterns
    - Transmission measurements
    - Recheck TCDQ and TCSP alignment (beam centre position)

HW Checks and Local Inspection

- Cooling water connections and feed-through
- Jaw movements and sensor response
- Vacuum bellows
- **Local activation** on diluters and downstream elements (**reference measurements following regular operation** are needed)
- **Vacuum pressure** during jaw movements (no changes should be apparent, **reference measurement** needed) ➔ **no activity observed while moving jaws without beam**

RP Survey

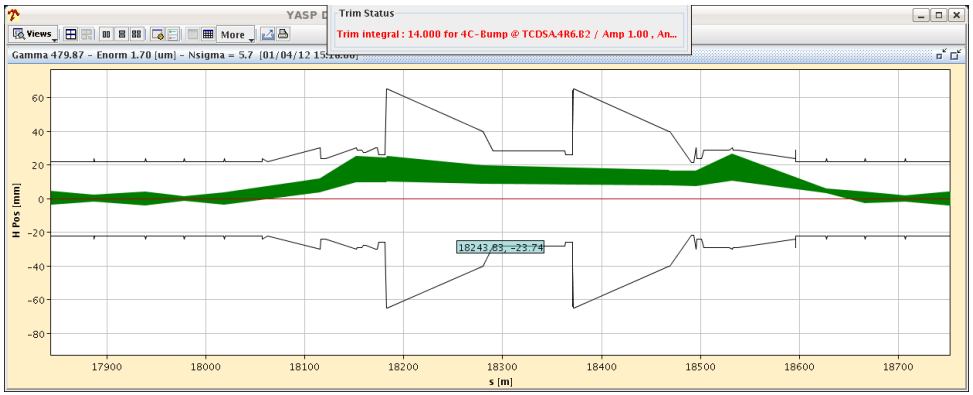
Stored intensity: TS1 ~4e13 p+, TS2 ~9e15

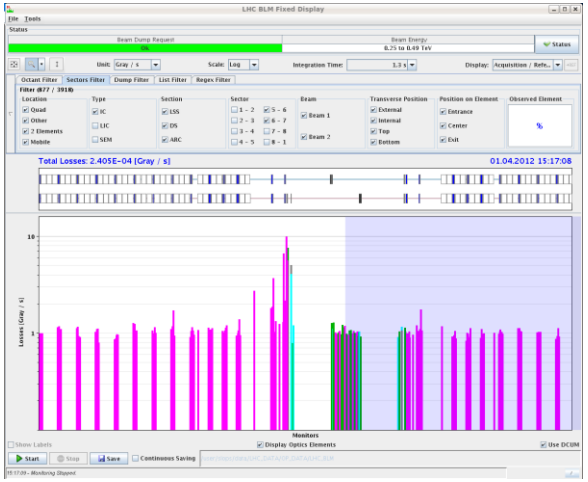
			TS1 (W25)		TS2 (W36)	
			BGO (cps)	AD6 (uSv/h)	BGO (cps)	AD6 (uSv/h)
LEFT	TCDSD.4L6.B1	left	800		1500	1.8
		right	550		800	1
		top	350		800	0.85
		bottom	450		500	0.5
	TCDSU.4L6.B1	left	800		150	0.2
		right	700		1500	1.7
		top	700		1400	1.5
		bottom	750		750	0.6
	TCDQI.4L6.B2	left	700		1400	1.2
		right	1100	0.9	1200	1.2
		top	400		800	1.8
		bottom	500		450	0.4
	TCDQD.4L6.B2	left		1.5	1600	2.5
		right		0.6	1400	1.3
		top		0.7	1100	1
		bottom		0.8	500	1.45
	TCSP.4L6	left	650		2000	2
		right	480		400	0.35
		top	500		1400	1.2
		bottom	520		800	0.7
	TCDQM.A4L6	left	500		700	0.7
		right	660		800	0.8
		top	1000	0.8	1600	1.7
		bottom	550		1400	1
	TCDQM.B4L6	left	170		350	0.25
		right	400		650	0.45
		top	250		400	0.35
		bottom	200		350	0.3

			TS1 (W25)		TS2 (W36)	
			BGO (cps)	AD6 (uSv/h)	BGO (cps)	AD6 (uSv/h)
RIGHT	TCDQM.B4R6	left	340		500	0.4
		right	150		250	0.2
		top	200		300	0.35
		bottom	230		350	0.35
	TCDQM.A4R6	left	500		800	0.9
		right	480		650	0.55
		top	460		550	0.6
		bottom	600		850	0.8
	TCSP.4R6.B1	left	300		300	0.25
		right	500		700	0.7
		top	450		700	0.75
		bottom	300		550	0.6
	TCDQD.4R6.B1	left	800		550	0.5
		right	520		400	0.4
		top	350		350	0.35
		bottom	350		350	0.35
	TSDQI.4R6.B1	left	1300	0.9	1100	1.2
		right	450		600	0.65
		top	450		600	0.7
		bottom	350		550	0.6
	TCDSU.4R6.B2	left	900		1100	1.2
		right	850		100	0.15
		top	550		800	0.9
		bottom	350		550	0.5
	TCDSD.4R6.B2	left	350		500	0.5
		right	680		1000	1.1
		top	370		500	0.6
		bottom	350		350	0.4

Measurements with Beam

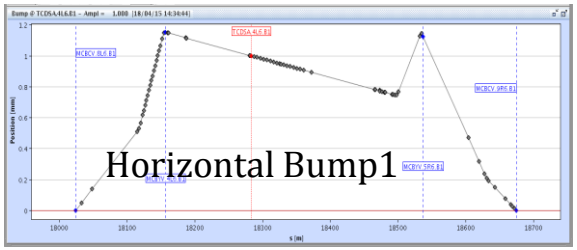
- Reference aperture measurement at the diluters:
  - Orbit corrected, interlocks masked (BPMs, collimator thresholds open)
  - **Aperture scans** with circulating beam (pilot) with TCDQ/TCSP **IN** (injection position) and **OUT** (parking position):
    - Beam moved in steps (1 sigma) towards jaw and record losses at TCDQ, TCSP, TCDQM, Q4, (TCP.IR7 defines beam envelope)
    - Repeat moving beam to other direction
    - Define a reference loss pattern

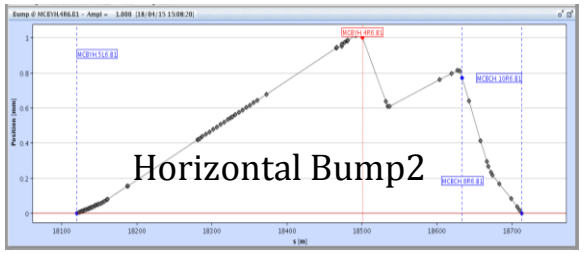


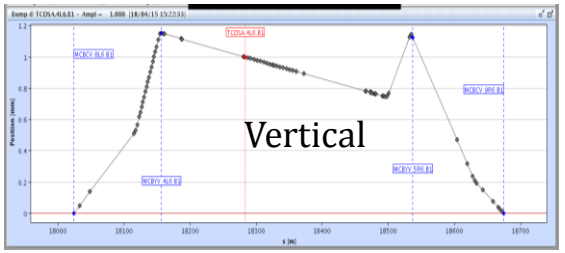


- In case of asynchronous beam dump with given beam intensity, repeat the test and check that no unexpected losses appear ➔ no unforeseen obstacles sticking into the beam

Reference Aperture Measurements





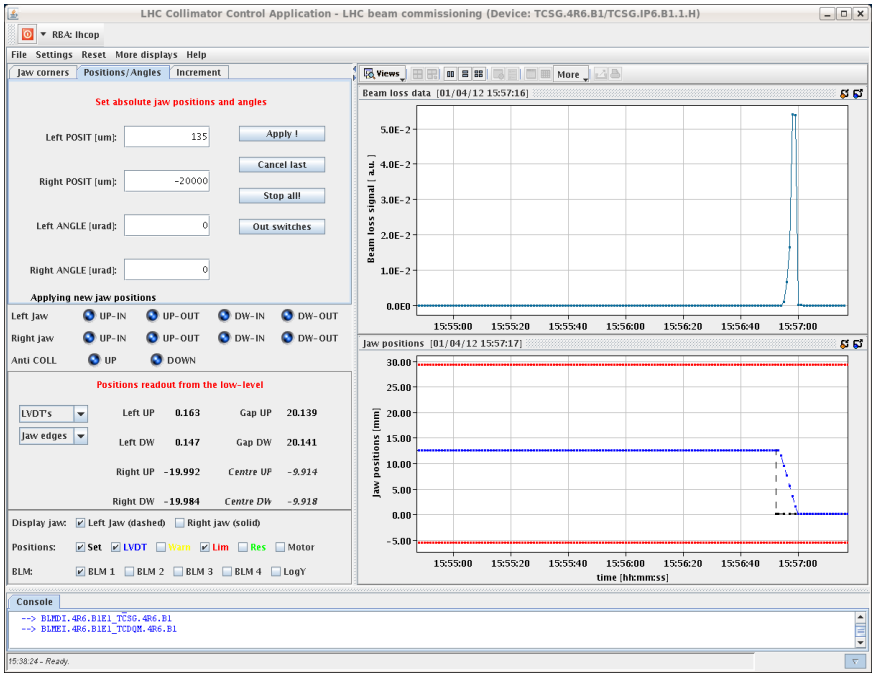


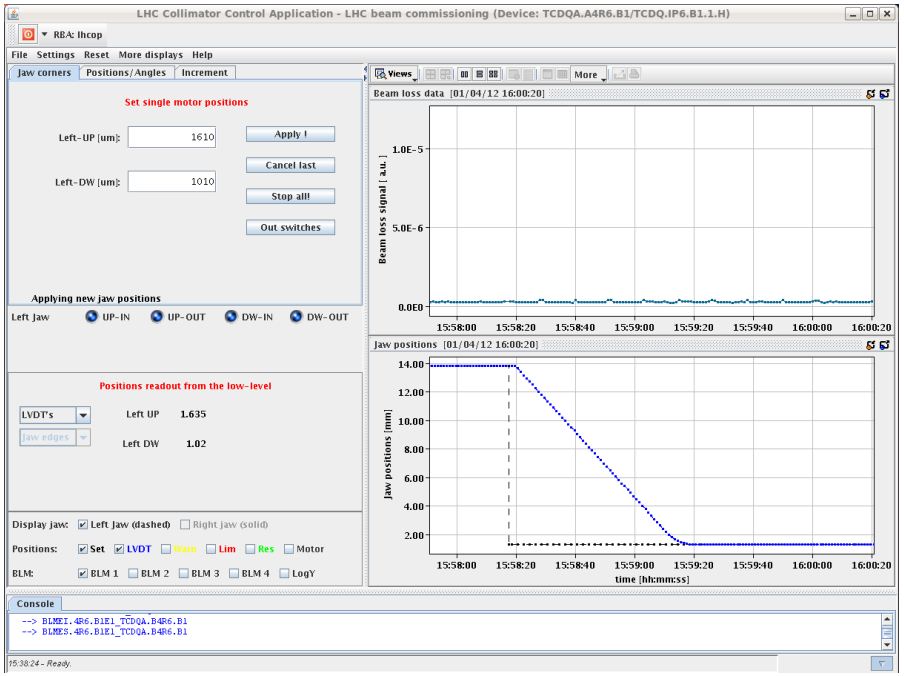
Beam 1		
Bump H 1	+9 mm @ TCDS.4L6	-14 mm @ MQY.4R6
Bump H 2	+14 mm @ TCDQM.4R6	-15 mm @ @ MQY.4R6
Bump V	+10 mm @ MQY.4L6	-11 mm @ MQY.4L6
Beam 2		
Bump H 1	+11 mm @ MQY.4L6	-12 mm @ TCDQM.4L6
Bump H 2	+12 mm @ MQY.4L6	-11 mm @ TCDS.4L6
Bump V	+10 mm @ MQY.4R6	-12 mm @ MQY.4R6

TCPs set at 8 sigma: larger beam than nominal (5.7 sigma) ➔ if measurements repeated with 5.7 sigma ~ 4 mm larger aperture expected

Transmission Measurements

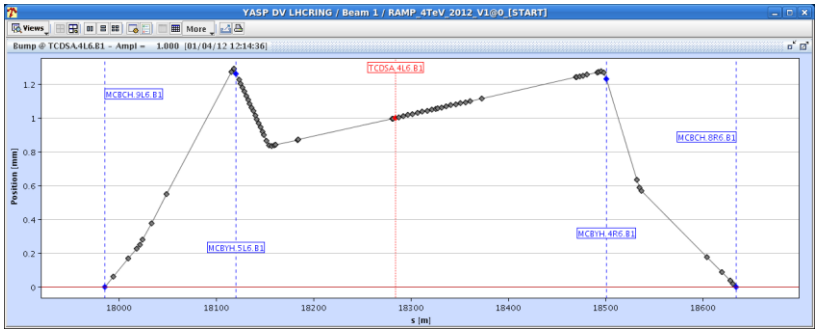
- TCDQ and TCSG closed (TCSG left jaw at collimator centre, TCDQ jaw retracted by 1 sigma)





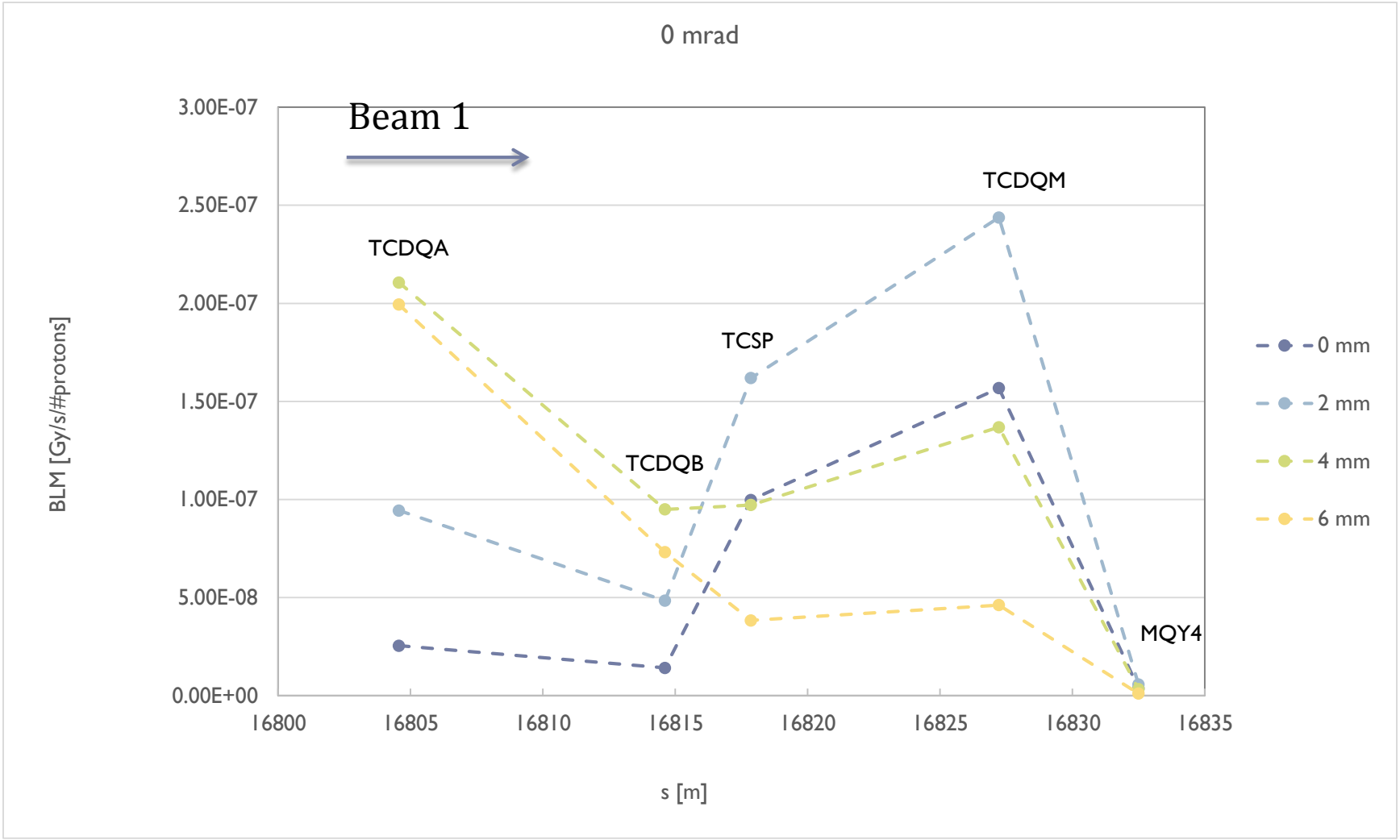
Transmission Measurements

- TCDQ and TCSG closed (TCSG left jaw at collimator centre, TCDQ jaw retracted by 1 sigma)
- Bump at TCDQ (the one used for asynchronous dump tests but in direction of the jaw)
- I&D 1 turn with probe beam

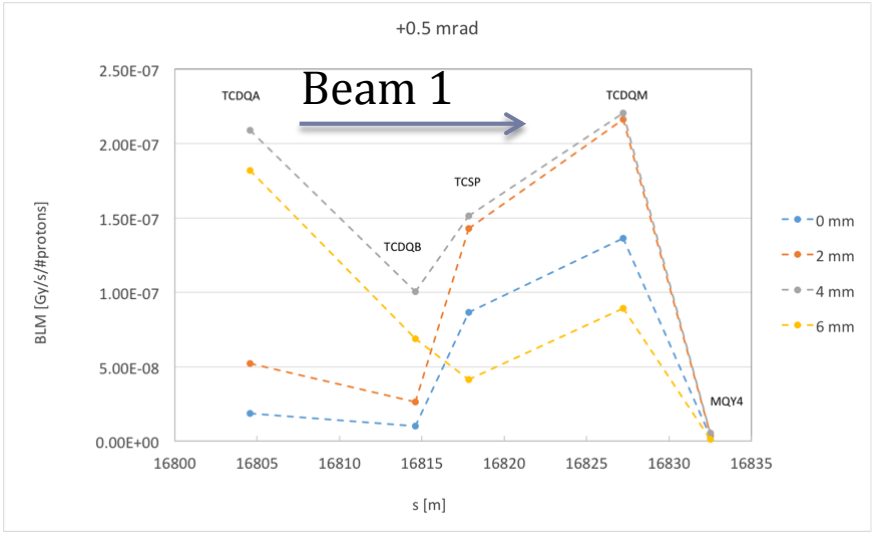


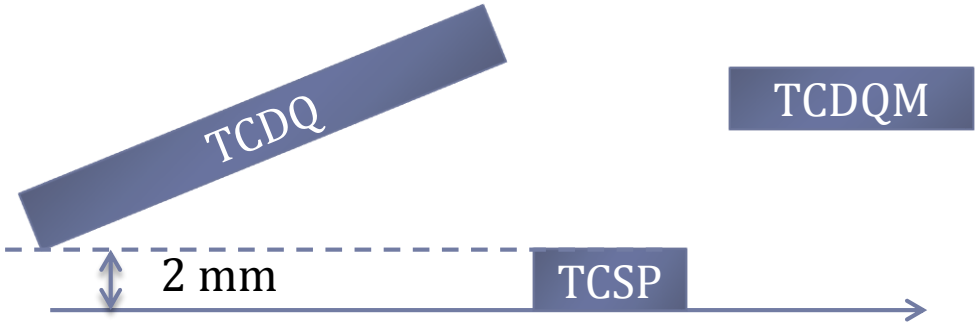
- Inject with bump amplitudes of 0, 2 and 6 mm for TCDQ angles of 0 and ±1 mrad (possibly intermediate angles) around actual position ➔ check loss pattern

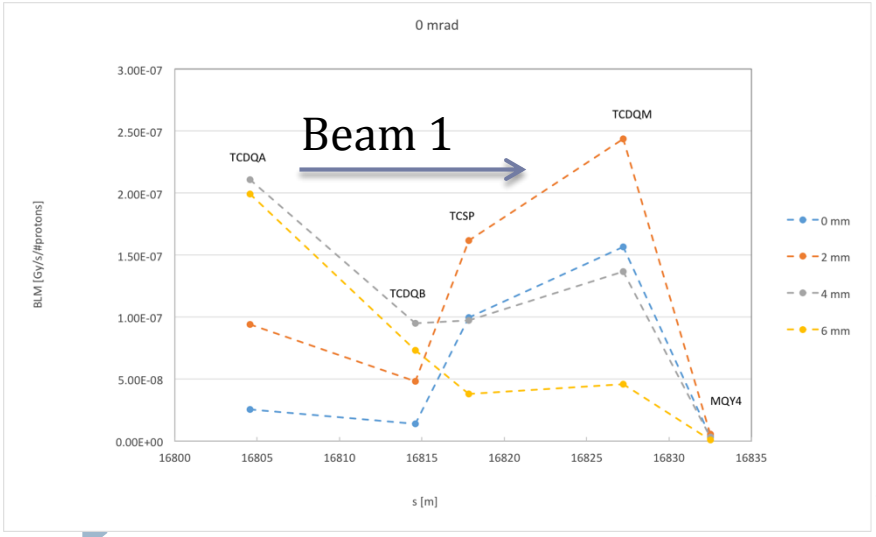
Reference Loss Patterns B1



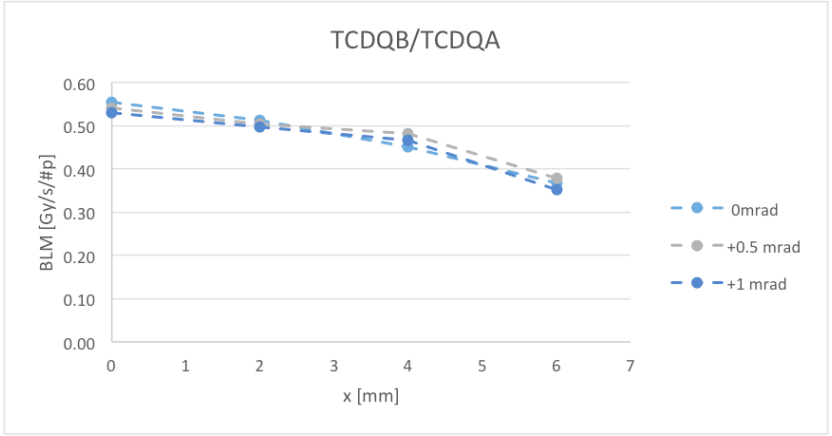
Reference Loss Patterns B1





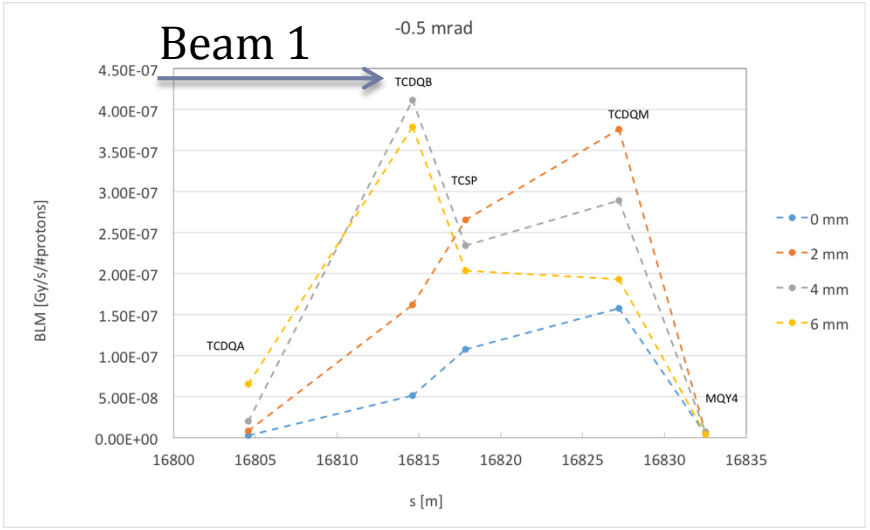


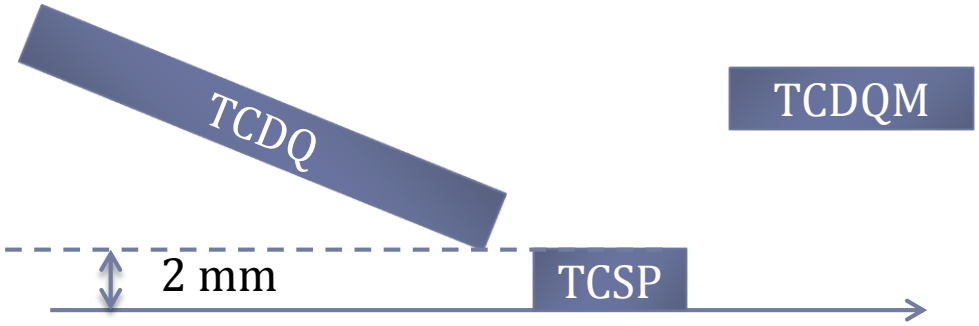
TCDQM



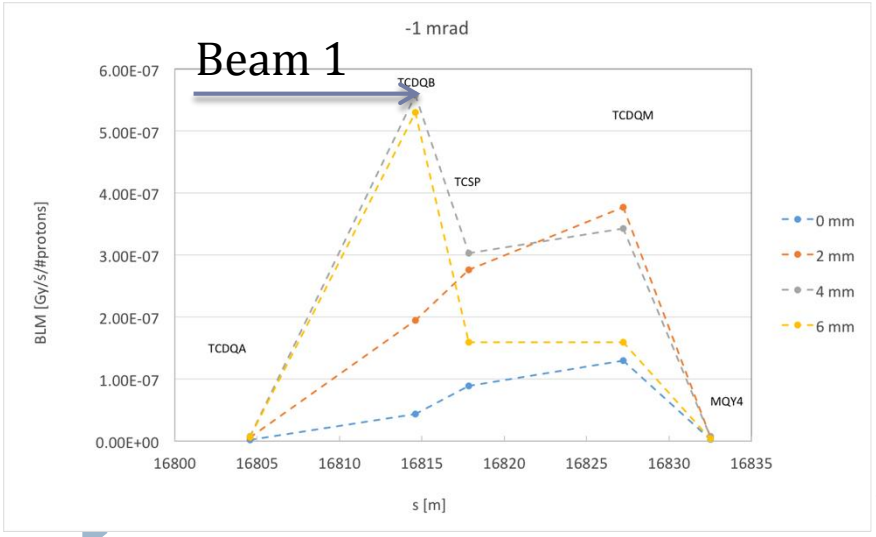
Upstream corner intercepts the beam and the full jaw absorbs the produced showers

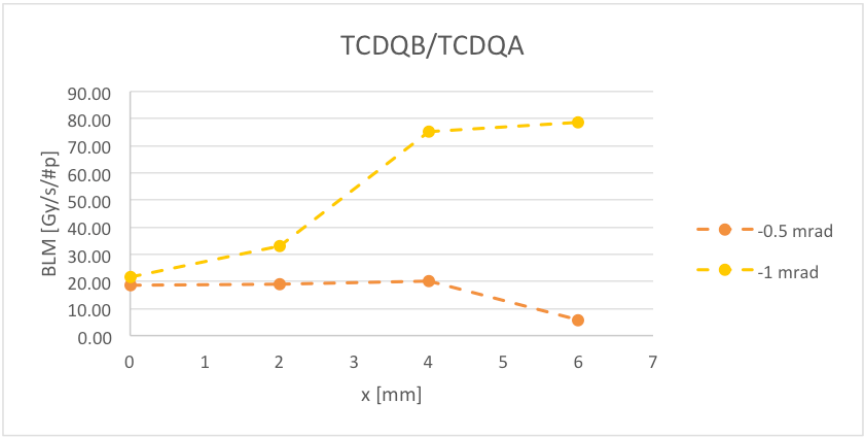
Reference Loss Patterns B1





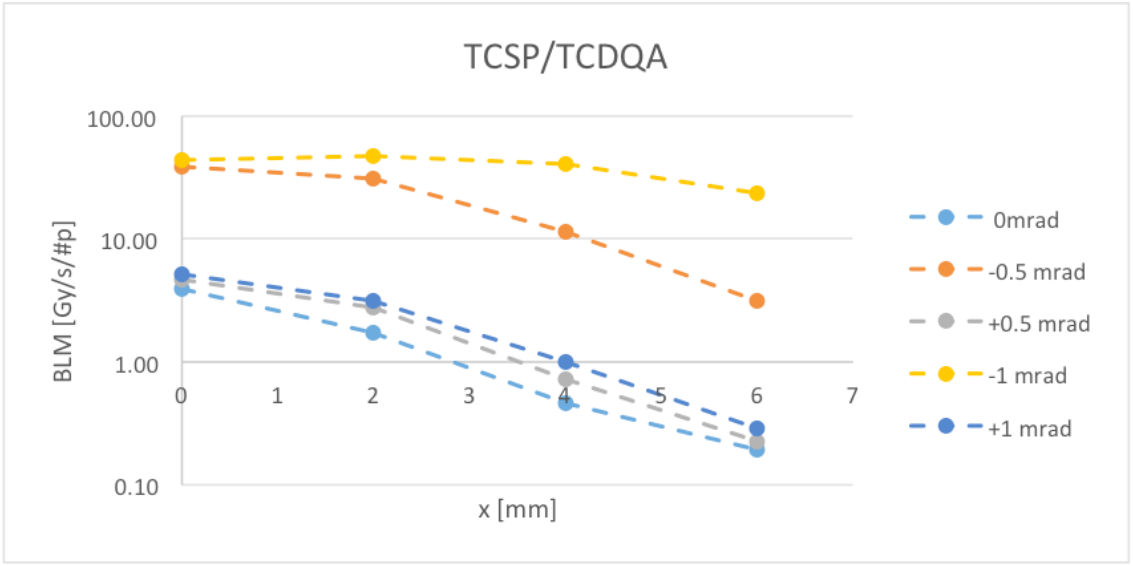
TCDQM



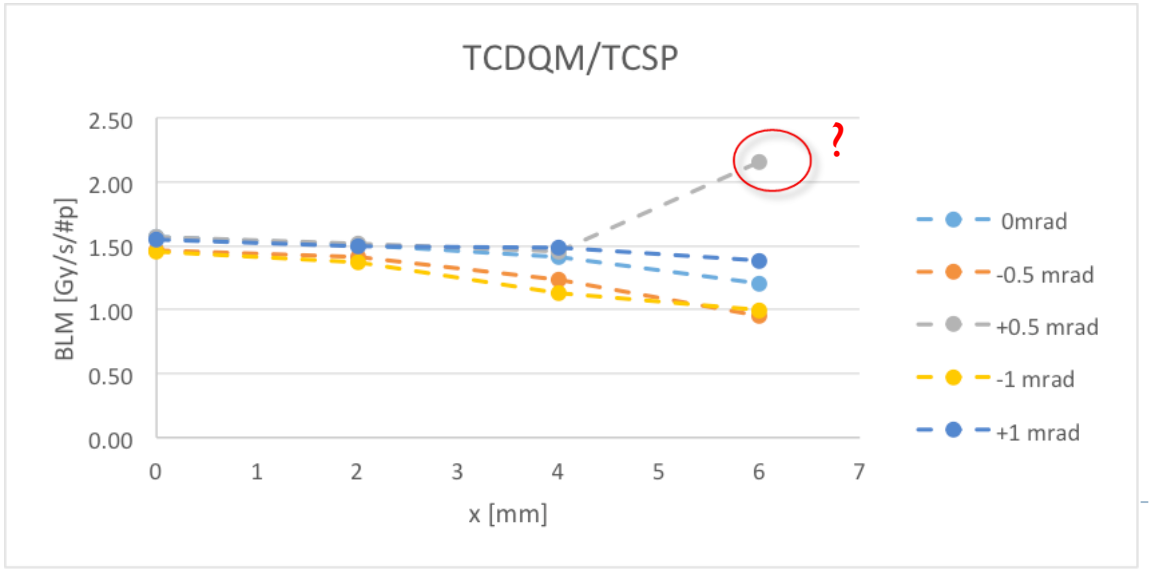


Downstream corner intercepts the beam and the showers are not stopped in the TCDQ

Reference Loss Patterns B1

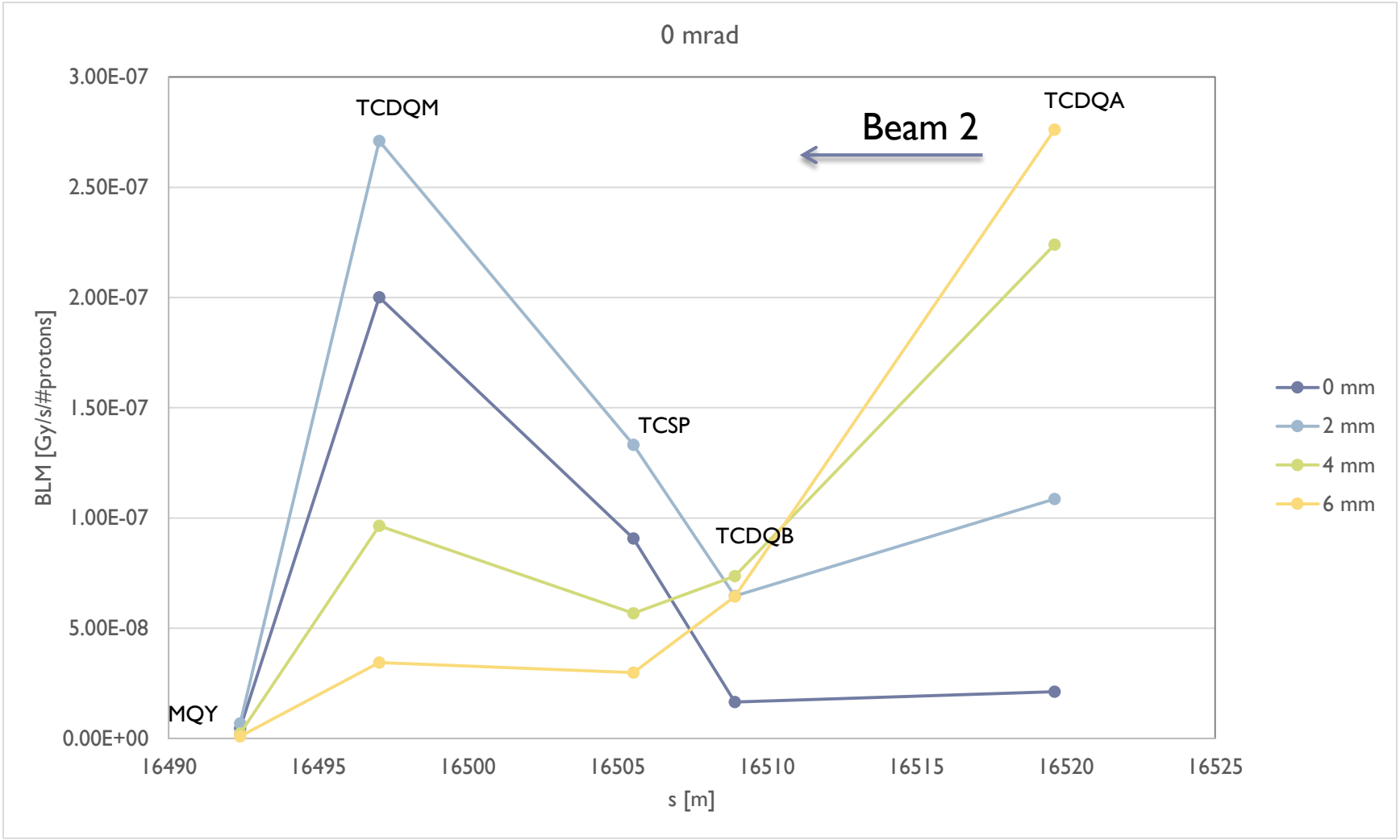


As expected higher losses for negative TCDQ angle. When the bump >2 mm ➔ lower losses since TCDQ intercepts first the beam

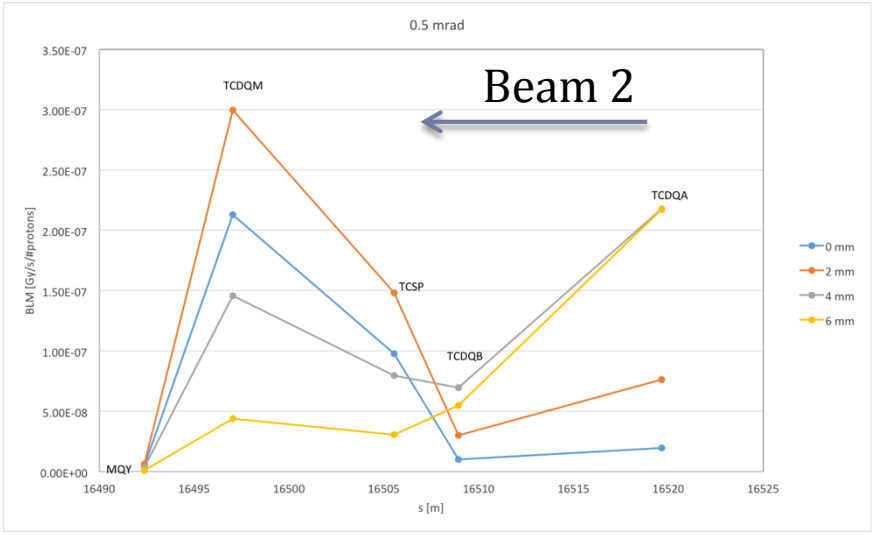


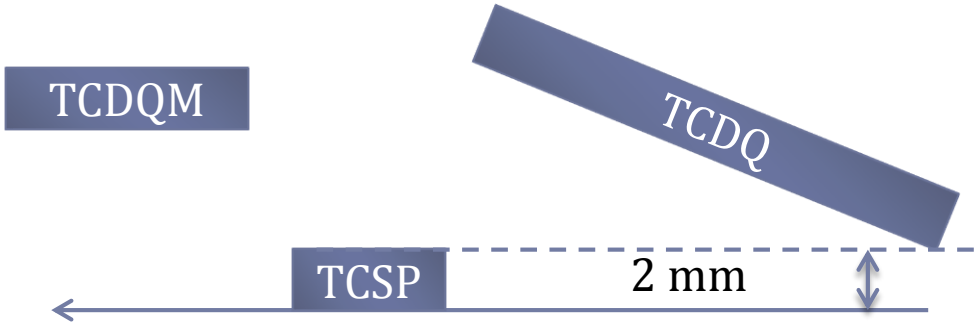
Losses at TCDQM mainly due to showers from the TCSP (1m long graphite).

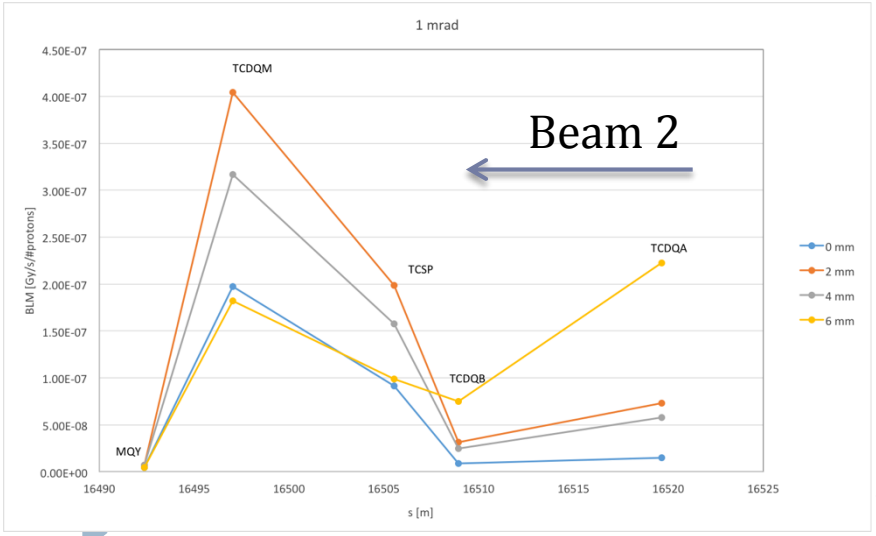
Reference Loss Pattern B2



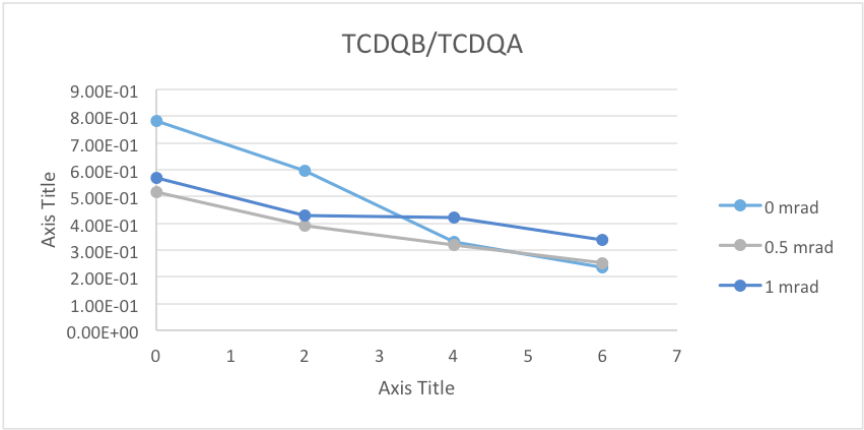
Reference Loss Patterns B1





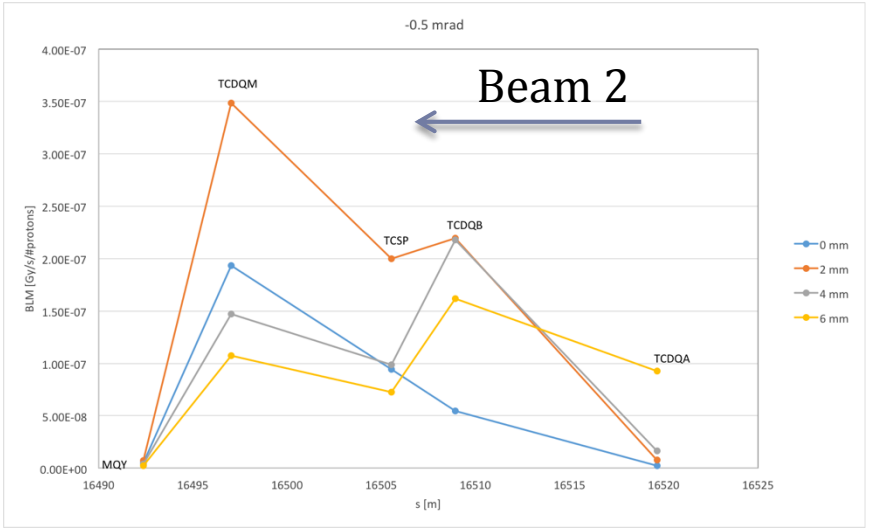


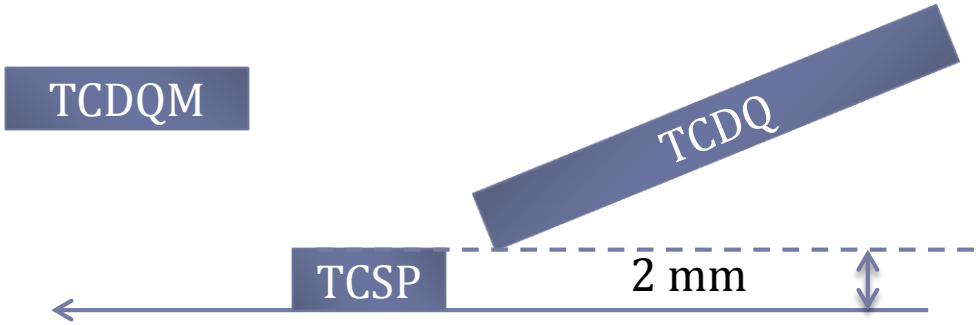
TCDQM

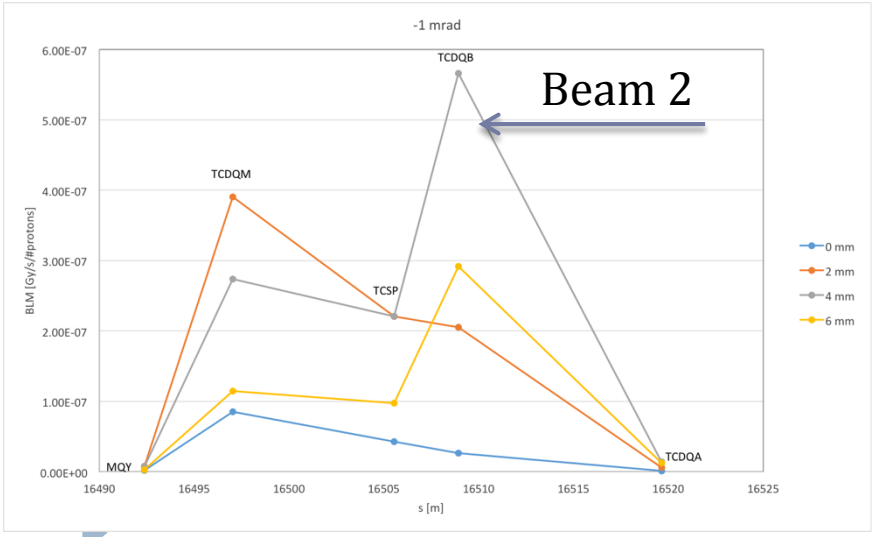


Upstream corner intercepts the beam and the full jaw absorbs the produced showers

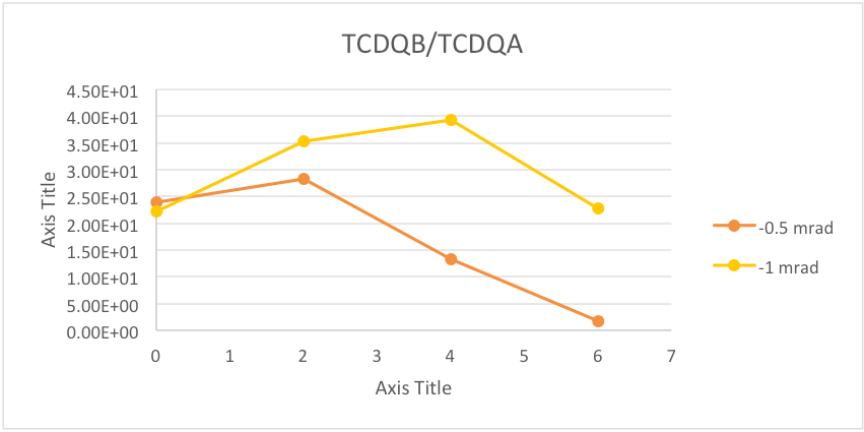
Reference Loss Patterns B1





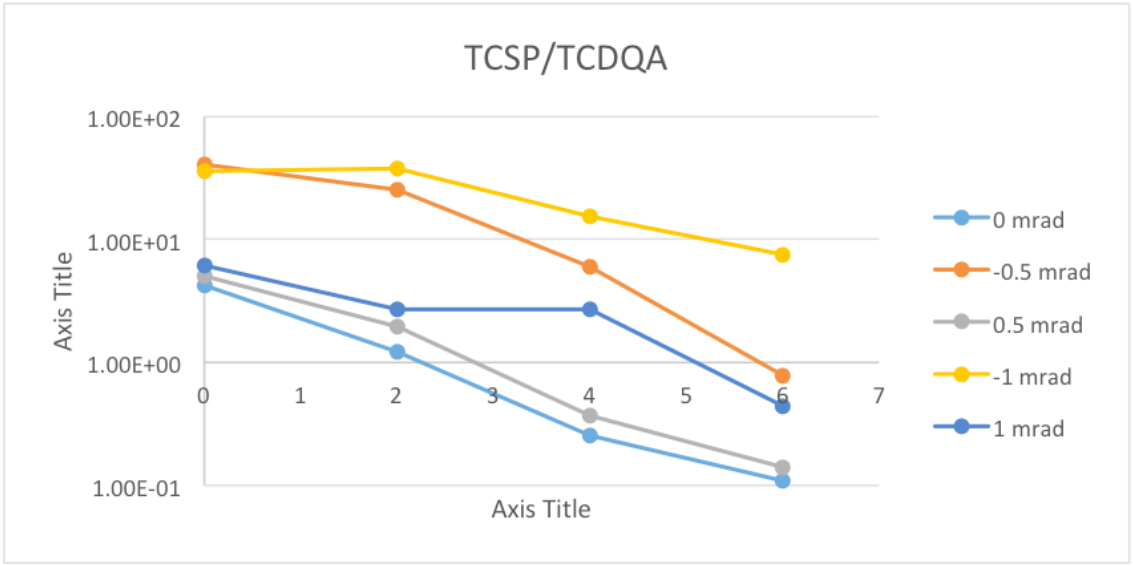


TCDQM

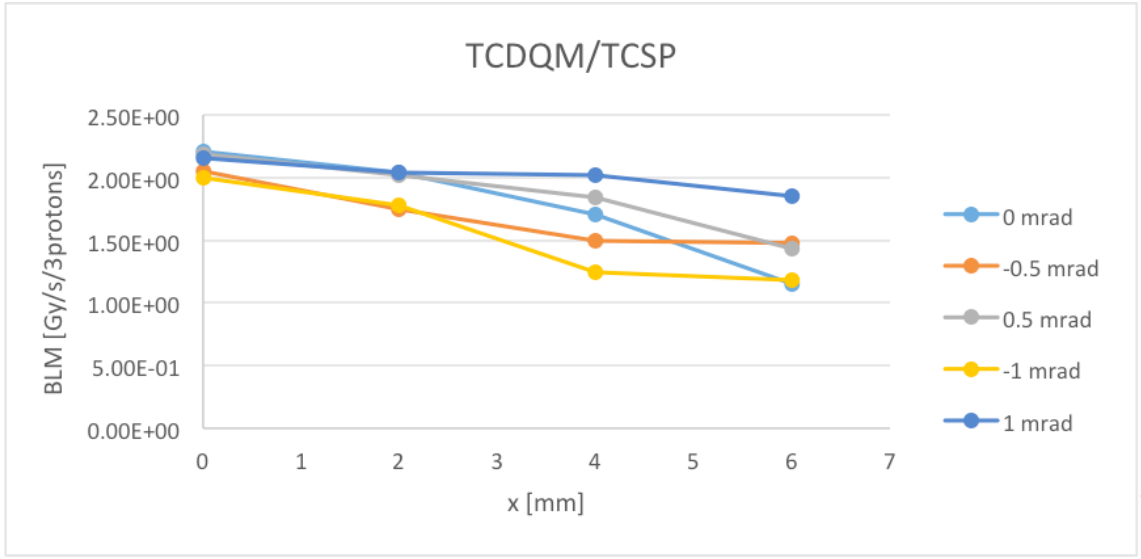


Downstream corner intercepts the beam and the showers are not stopped in the TCDQ

Reference Loss Patterns B1



As expected higher losses for negative TCDQ angle. When the bump >2 mm ➔ lower losses since TCDQ intercepts first the beam



Losses at TCDQM mainly due to showers from the TCSP (1m long graphite).

Next Step

- Repeat RP survey measurements
- Simulations (MADX+PYCOLLIMATE+FLUKA) ➔ check if any qualitative and/or quantitative change can be appreciated in case of jaw damage (higher losses at downstream elements?)
- Repeat calibration measurements after Xmas stop to compare the loss patterns with previous references
- Repeat same studies for TCDS:
  - Use data from MKD waveform (need to mask BETS to inject in abort gap)
  - Use 14/15 MKD knob