ALICE ZDC and TCTTVB Tertiary Collimators

Zero-degree calorimeters in ALICE are crucial for physics measurements

- D1 separator magnet separates spectator protons and neutrons to two distinct calorimeters 92 m from IP
- Neutron calorimeter also measures neutrons from electromagnetic dissociation (1 and 2 n)
- Problem is that neutrons may be intercepted by the tertiary collimators (TCTV) which are there to protect the low-beta triplet quadrupoles
 - Depends on setting of TCTV jaws
 - Assume that TCTV.4L2.B1 on left is centred on closed orbit of incoming Beam 1
 - Assume that TCTV.4R2.B2 on left is centred on closed orbit of incoming Beam 2
- Closed orbit is superposition of *fixed ALICE spectrometer bump* and *variable crossing angle bump*
- Angular spread of spectator neutrons from nuclear Fermi momentum taken from ALICE simulations to be 51 μrad

Reminder of layout details

NAME 💌	S 💌	L 💌	XC 💌	YC 💌	PXC 💌	PYC 💌	BETX 💌	BETY 💌	ALFX 💌	ALFY 💌	MUX 💌	MUY
IR2\$START	3215.464	0	-8.75E-11	0.002093	-9.84E-13	7.38E-06	1269.003	1369.512	-16.446	-4.80475	8.229828	7.231967
X2ZDC.4L2	3217.839	1.5	-8.99E-11	0.00211	-9.84E-13	7.38E-06	1348.328	1392.434	-16.9541	-4.84652	8.230117	7.232241
TDI.4L2.B1	3253.696	4.185	-1.25E-10	0.002375	-9.84E-13	7.38E-06	2839.25	1762.615	-24.625	-5.47714	8.233034	7.235884
TCTV.4L2.B1	3259.449	1	-1.31E-10	0.002417	-9.84E-13	7.38E-06	3129.639	1826.211	-25.8556	-5.57831	8.233341	7.236394
TCDD.4L2	3261.709	1	-1.33E-10	0.002434	-9.84E-13	7.38E-06	3247.599	1851.515	-26.339	-5.61806	8.233454	7.23659
MBX.4L2	3274.054	9.45	-1.17E-10	0.002525	-9.42E-13	7.38E-06	3930.512	1992.901	-28.98	-5.83468	8.234004	7.237612
DFBXC.3L2	3277.555	2.853	-1.20E-10	0.002551	-9.42E-13	7.38E-06	4136.052	2033.971	-29.7289	-5.89624	8.234142	7.237889
IP2	3332.437	0	-3.59E-12	5.77E-12	2.63E-12	-1E-05	0.5	0.500001	-1.38E-06	-1.04E-06	8.483795	7.48639
DFBXD.3R2	3390.172	2.853	8.12E-11	-0.00356	-1.24E-13	2.61E-05	2000.473	3968.153	5.846085	29.11853	8.73252	7.736155
MBX.4R2	3400.27	9.45	2.15E-10	-0.0033	-6.47E-13	2.61E-05	1884.199	3401.88	5.668519	26.95916	8.733348	7.736592
TCTV.4R2.B2	3406.425	1	2.11E-10	-0.00314	-6.47E-13	2.61E-05	1815.086	3078.118	5.560289	25.64236	8.733878	7.736895
TCLIA.4R2	3408.685	1	2.09E-10	-0.00308	-6.47E-13	2.61E-05	1790.043	2963.307	5.520549	25.15886	8.734077	7.737014
X2ZDC.4R2	3448.535	1.5	1.83E-10	-0.00204	-6.47E-13	2.61E-05	1377.979	1297.887	4.819819	16.63337	8.738116	7.740248
IR2\$END	3449.41	0	1.83E-10	-0.00201	-6.47E-13	2.61E-05	1369.558	1268.942	4.804432	16.44618	8.738218	7.740357

Nominal ion collision optics ($\beta^*=0.5 \text{ m}$, 10 μ rad crossing angle)

•Black lines show $\pm 0,1,2,3\sigma$ of neutron beam (3σ includes 98.9% of flux).

•Blue is vertical beam (8.3σ) envelope of Beam 1 (L \rightarrow R), pink $[2DCplot \rightarrow 4]$ 0.00 is Beam 2 (R \rightarrow L).

•Closed orbit tolerance is hollowed out around closed orbit line in centre of beam envelope (about 1σ).

•TCTV collimators shown in red, jaws are centred on closed orbit, at 13σ in this case (previously 8.3).

•Planes of ZDC detectors shown in green.



CrossingAngles $\rightarrow \{2.62512 \times 10^{-12}, -0.00001, 5.49839 \times 10^{-12}, 0.00001\},\$ nsigmaTCT $\rightarrow 15., jawTCT \rightarrow$

{{TCTV.4L2.B1, {0.016789, -0.0119541}}, {TCTV.4R2.B2, {0.0167375, -0.0119175}}}

Neutron envelope

Beam envelopes calculated from optics and closed orbits.

Neutron envelopes using intrinsic RMS angular spread + spread in beam crossing angle around slope of closed orbit + source size.

Neutron envelope in vertical plane, at $n_y \sigma$ of distribution

$$p_{yc}(s-s_{\rm IP}) + n_y \sqrt{\left(\frac{\epsilon\beta^*}{2\gamma} + \left(\frac{\epsilon}{2\gamma\beta^*} + \sigma_{p_y {\rm Fermi}}^2\right)(s-s_{\rm IP})^2\right)}$$

where $\sigma_{p_v \text{Fermi}} = 51 \, \mu \text{rad}$

Early ion collision optics ($\beta^*=1$. m, zero crossing angle)



Because beam is smaller, a $\pm 13s$ collimator gap is not enough to let the neutron beam pass.

As in the nominal optics, the neutrons are not centred on the collimator gap.

J.M. Jowett, TCTVB & ALICE Meeting, 10/3/2008



 $\begin{aligned} & \text{CrossingAngles} \rightarrow \left\{ 8.71787 \times 10^{-13}, \ 0.000102, \ 7.25118 \times 10^{-12}, \ -0.000102 \right\}, \ \text{nsigmaTCT} \rightarrow 13, \\ & \text{jawTCT} \rightarrow \left\{ \left\{ \text{TCTV}.4L2.B1, \ \left\{ 0.0114882, \ -0.0134222 \right\} \right\}, \ \left\{ \text{TCTV}.4R2.B2, \ \left\{ 0.0114532, \ -0.0133812 \right\} \right\}, \\ & \text{MADfile} \rightarrow \text{CollisionIons}-40.\text{madx}, \ \text{LHCB1opticsFile} \rightarrow \text{LHCB1collisionIons}-40.\text{tfs}, \\ & \text{LHCB2opticsFile} \rightarrow \text{LHCB2CollisionIons}-40.\text{tfs}, \\ & \text{MADXterminalOutputFile} \rightarrow \text{CollisionIons}-40.\text{mou}, \ \text{ON}_X2 \rightarrow -0.4 \\ \end{aligned}$

Optimum for Nominal Ion Collision Optics at $\sim 20 \ \mu$ rad



 $\begin{aligned} & \text{CrossingAngles} \rightarrow \left\{1.28934 \times 10^{-12}, \ 0.000022, \ 6.83363 \times 10^{-12}, \ -0.000022\right\}, \ \text{nsigmaTCT} \rightarrow 13, \\ & \text{jawTCT} \rightarrow \left\{\{\text{TCTV.4L2.B1, } \{0.0139058, \ -0.0110049\}\}, \ \{\text{TCTV.4R2.B2, } \{0.0138632, \ -0.0109711\}\}\right\}, \\ & \text{MADfile} \rightarrow \text{CollisionIons60.madx, LHCBlopticsFile} \rightarrow \text{LHCB1CollisionIons60.tfs,} \\ & \text{LHCB2opticsFile} \rightarrow \text{LHCB2CollisionIons60.tfs,} \\ & \text{MADXterminalOutputFile} \rightarrow \text{CollisionIons60.mou, ON}_{X2} \rightarrow 0.6\right\} \end{aligned}$

Optimum for Early Ion Collision Optics at $\sim 20 \ \mu$ rad



But larger gap in terms of $\boldsymbol{\sigma}$

Conclusions

- With the assumptions on collimator gap settings, there are new optimum crossing angles, depending only weakly on β^* , that will allow a maximum neutron flux to pass
 - Re-consider running configuration for heavy-ions in ALICE
 - Can we use ZDC data in setting up collision conditions?
- Although the gaps have to be widened they appear to still fulfil their protection role (see Ralph's talk)
- Effect on collimation efficiency and losses in the triplets in stable beam conditions can be evaluated (see Giulia's talk)