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COMPASS luminosity for 2002-2004

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A preliminary determination of the luminosity at the COMPASS experiment has been performed for the years 2002 to 2004. The resulting luminosities are available for each run and serve as a basis for the determination of cross sections.

This note describes the main ingredients of the luminosity determination. Run by run files are available in ~shellwig/public/stab/lumi*.

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1 Overview

The luminosity integrated over the life time of the experiment is calculated according to:

$$\mathcal{L} = N_T N_\mu \epsilon_{\mathrm{DAQ}},$$

where N_T is the number of target nucleons per area, N_μ the number of muons which enter the target according to standard analysis cuts (may pass through both cells, within 1.4 cm radius and $y < 1\,\mathrm{cm}$) and ϵ_{DAQ} is the live time of the DAQ.

Please note that the calculated number does not include the beam reconstruction efficiency, neither does the Monte Carlo simulation include a beam simulation. The beam reconstruction efficiency is 0.96 ± 0.01 for beam particles passing the target [1].

Cross sections can be calculated with the given integrated luminosity $\mathcal{L}$ according to

$$\sigma = \frac{N_{rec.events}}{\mathcal{L} \cdot \epsilon_{rec.}},$$

where the reconstruction efficiency includes beam reconstruction, trigger efficiencies (including veto dead time) and particle reconstruction efficiencies.

For each run the muon flux and integrated luminosity has been calculated for all reconstructed spills and for the spill which pass the bad spill lists.

The files are available in ~shellwig/public/stab/lumi*.

2 Target density

The target is filled with ^6LiD and other elements, mainly ^4He. The relevant number is the number of nucleons per cm^2. It can be calculated from the known mol mass of the different materials in the target [2, 3]. Here we assume that the distribution is homogeneous within the target cell diameter of 3 cm (Tab. 1).

The target density N_T in units of number of nucleon is N_A times the target density ρ_T in units of g/cm^2. The latter is calculated from the mol mass of the different materials within the target cell $\rho_T = \frac{\mathrm{mol}}{\pi r^2}$; $r = 1.5\,\mathrm{cm}$.

Table 1: Target thickness.

year	density N_T N/cm^2	density g/cm^2	^6LiD mol	other mol
2002	$3.46 \cdot 10^{25}$	57.5	333.9	72.5
2003	$3.49 \cdot 10^{25}$	58.0	337.2	72.8

3 Muon flux

The relevant number to determine the luminosity is the number of muons which enter the target volume. The number of muons passing SciFi station 2, which is mounted in front of the target, is counted by six scalers which are available in PHAST in the method of PaEvent class

```
const vector<UInt_t> & vScaler () const {return vecScaler; }
```

These scalers are not gated and include no DAQ dead time. There are muons, which pass the SciFi station, but do not cross the target, only a fraction of the beam tracks are reconstructed (about 96 %) and the logical or combination of the SciFi channels is not fully efficient. All that is taken into account in the ratio r of reconstructed beam tracks in target to counted particles in the scaler: $r = N_{tracks}/N_{scaler} = 0.58$ (the value has been determined for 2004 from random trigger runs to be 0.597 ± 0.025 [4] or 0.572 [5]).

4 Dead time

The dead time of the data acquisition system is generated inside the trigger control system based on user input. It allows to set a minimum dead time between two triggers, and two ranges, where a certain number of triggers are allowed within a specified time. Due to that algorithm no simple equation is available to calculate the dead time for a given trigger rate.

Improvements at the front-end level decreased the dead time every year.

Table 2: Dead time, trigger rate and dead time settings.

Time or run	dead time	trigger rate	TCS dead time settings fixed	variable 1	variable 2
2002					
run <21687	17 %	4 kHz	13 μs	3 trigger in 300 μs	
run $\geq$ 21687	7 %	4 kHz	13 μs	5 trigger in 300 μs	
2003					
P1A start	x %	x kHz	10 μs	3 trigger in 75 μs	10 trigger in 250 μs
P1A 15.6. 20:08	x %	x kHz	10 μs	3 trigger in 75 μs	10 trigger in 300 μs
P1A 15.6. 20:43	x %	x kHz	10 μs	3 trigger in 75 μs	8 trigger in 300 μs
P1A 17.6. 21:10	x %	x kHz	5 μs	3 trigger in 75 μs	6 trigger in 225 μs
P1A 25.6. 18:23	6.7 %	x kHz	10 μs	3 trigger in 75 μs	6 trigger in 225 μs
2004					
	5 %	10 kHz	5 μs	3 trigger in 75 μs	6 trigger in 225 μs

5 Luminosity at COMPASS

While the run by run luminosities calculated above is for recorded and reconstructed beam track events one can also calculate the luminosity for the muons on target.

With $2 \cdot 10^8/16.8\,\mathrm{s}$ muons, a target density of $58\,\mathrm{g/cm^2}$ and a target diameter of 3 cm one gets a luminosity of $3.8 \cdot 10^{32}\,\mathrm{cm^{-2}s^{-1}}$. Here we assume σ_x and σ_y of the beam 8 mm, where about 8% of the muons do not hit the target.

Including standard target cuts (1.4 cm diameter, $y < 1$cm, muon passes both target cells) reduces the luminosity by $0.80/0.92 \cdot 0.95$ to $3.1 \cdot 10^{32}\,\mathrm{cm^{-2}s^{-1}}$.

Further factors (DAQ dead time, beam reconstruction efficiency, trigger dead time, inefficiencies and other effects) of about 0.65 reduce the luminosity of recorded and reconstructed events to about $2 \cdot 10^{32}\,\mathrm{cm^{-2}s^{-1}}$.

References

[1] M. von Hodenberg, *private communication*.

[2] N. Doshita et al., *Target material data of run 2002*, COMPASS note 2003-5, `http://wwwcompass.cern.ch/compass/notes/2003-5/2003-5.ps`.

[3] N. Doshita et al., *Target material data of run 2003*, COMPASS note 2003-8, `http://wwwcompass.cern.ch/compass/notes/2003-8/2003-8.ps`, 20.1.2004.

[4] S. Trippel, *Aufbau einer Messeinrichtung zur Bestimmung des Myonenflusses bei COMPASS*, `http://wwwcompass.cern.ch/compass/publications/ps/2005_dpl_trippel.ps.gz`, diploma thesis, Universität Freiburg, March 2005.

[5] R. Hermann, COMPASS analysis meeting, `http://wwwcompass2.cern.ch/compass/software/analysis/transparencies/2005/am_050630/hermann_050630.pdf`, June 2005.

6 Appendix: Scaler naming in 2002–2004

Table 3: Naming of gated and ungated scalers.

name	gate
P1	ungated
P2	V_{tot}
P3	V_{prime}
P4	V_{tot}& DAQ
P5	V_{prime}& DAQ
P6	DAQ

Table 4: Scaler 190 in 2003, 2004. These are without any veto. SC02P1sf is also known as SC99P2 for compatibility to 2002 naming in coral.

name	offset	validity	channel	description
SC01P1sf	0	24885-32832	0	SF1 1
SC02Y1sf	0	32833-	0	SF1 1
SC01P1sf	1	24885-32832	1	SF1 2
SC02Y1sf	1	32833-	1	SF1 2
SC01P1sf	2	24885-32832	2	SF1 3
SC02Y1sf	2	32833-	2	SF1 3
SC01P1sf	3	24885-32832	3	SF1 4
SC02Y1sf	3	32833-	3	SF1 4
SC01P1sf	4	24885-32832	4	SF1 5
SC02Y1sf	4	32833-	4	SF1 5
SC01P1sf	5	24885-32832	5	SF1 6
SC02Y1sf	5	32833-	5	SF1 6
SC02P1sf	0	24885-32832	6	SF2 1
SC02X1sf	0	32833-	6	SF2 1
SC02P1sf	1	24885-32832	7	SF2 2
SC02X1sf	1	32833-	7	SF2 2
SC02P1sf	2	24885-32832	8	SF2 3
SC02X1sf	2	32833-	8	SF2 3
SC02P1sf	3	24885-32832	9	SF2 4
SC02X1sf	3	32833-	9	SF2 4
SC02P1sf	4	24885-32832	10	SF2 5
SC02X1sf	4	32833-	10	SF2 5
SC02P1sf	5	24885-32832	11	SF2 6
SC02X1sf	5	32833-	11	SF2 6
SCicP1	0	27917-32832	12	Ion Chamber
SCicP1	1	27917-32832	13	Deadtime measurement clock
			14	
SCSM2	0	36335-	15	SM2 NMR frequency
SCsum	0	27917-32832	16	VSum 0 VTot
SCsum	0	27917-32832	17	VSum 1 Vprime
SCsum	0	27917-32832	18	VSum 2 VI1
SCsum	0	27917-32832	19	VSum 3 VI2
SCsum	0	27917-32832	20	VSum 4 VO1
SCsum	0	27917-32832	21	VSum 5 Vbl
SCsum	0	27917-32832	22	VSum 6 Vscifi
SCsum	0	27917-32832	23	VSum 7 VUpDoen
SCsum	0	27935-32832	24	VSum 8 NotVTot
SCsum	0	27935-32832	25	VSum 9 NotVprime
SCsum	0	-32832	26	VSum 10 HCAL1 th2 layer 3
SCsum	0	-32832	27	VSum 11 HCAL1 th2 layer 4
SCsum	0	-32832	28	VSum 12 HCAL1 th1 layer 1
SCsum	0	-32832	29	VSum 13 HCAL1 th1 layer 2
SCsum	0	-32832	30	VSum 14 HCAL1 th1 layer 3
SCsum	0	-32832	31	VSum 15 HCAL1 th1 layer 4

Table 5: Scaler 191 as used 2002 in coral. Offsets 16-21 are available in coral.

name	offset	validity	channel	description
SC99P2	0	18815-24884	0	VO1 33
SC99P2	2	18815-24884	1	VO1 34
SC99P2	4	18815-24884	2	VO1 35
SC99P2	6	18815-24884	3	VO1 36
SC99P2	8	18815-24884	4	VI1 1
SC99P2	10	18815-24884	5	VI1 1
SC99P2	12	18815-24884	6	VI1 1
SC99P2	14	18815-24884	7	VI1 4
SC99P2	16	18815-24884	8	VI2 1
SC99P2	18	18815-24884	9	VI2 2
SC99P2	20	18815-24884	10	VI2 3
SC99P2	22	18815-24884	11	VI2 4
SC99P2	24	18815-24884	12	Vbl 1
SC99P2	26	18815-24884	13	Vbl 2
SC99P2	28	18815-24884	14	Vbl 3
SC99P2	30	18815-24884	15	Vbl 4
SC99P2	1	18815-24884	16	Sf1 1
SC99P2	3	18815-24884	17	Sf1 2
SC99P2	5	18815-24884	18	Sf1 3
SC99P2	7	18815-24884	19	Sf1 4
SC99P2	9	18815-24884	20	Sf1 5
SC99P2	11	18815-24884	21	Sf1 6
SC99P2	13	18815-24884	22	Sf2 1
SC99P2	15	18815-24884	23	Sf2 2
SC99P2	17	18815-24884	24	Sf2 3
SC99P2	19	18815-24884	25	Sf2 4
SC99P2	21	18815-24884	26	Sf2 5
SC99P2	23	18815-24884	27	Sf2 6
SC99P2	25	18815-24884	(28	vo1 sum until 11.6.02)
SC99P2	27	18815-24884	(29	vi1 sum ")
SC99P2	29	18815-24884	(30	vi2 sum ")
SC99P2	31	18815-24884	(31	vtot ")