Global Reconstruction Logic (GRL)

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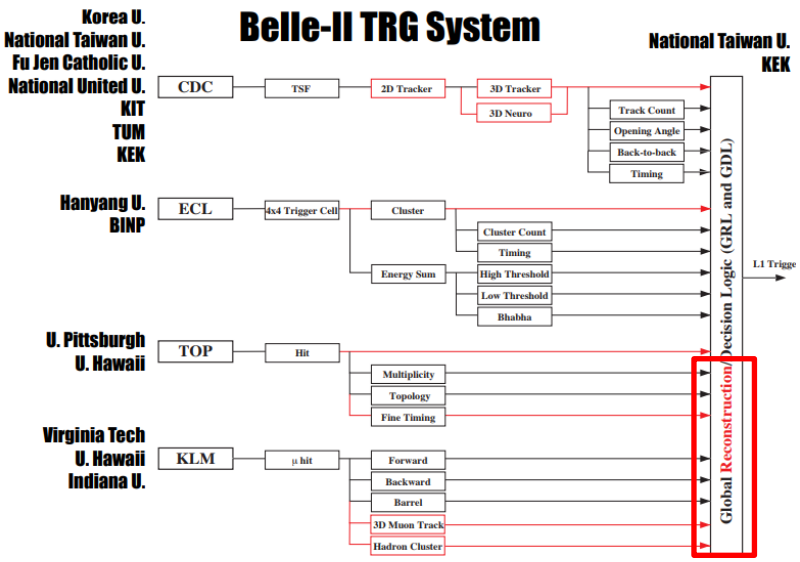
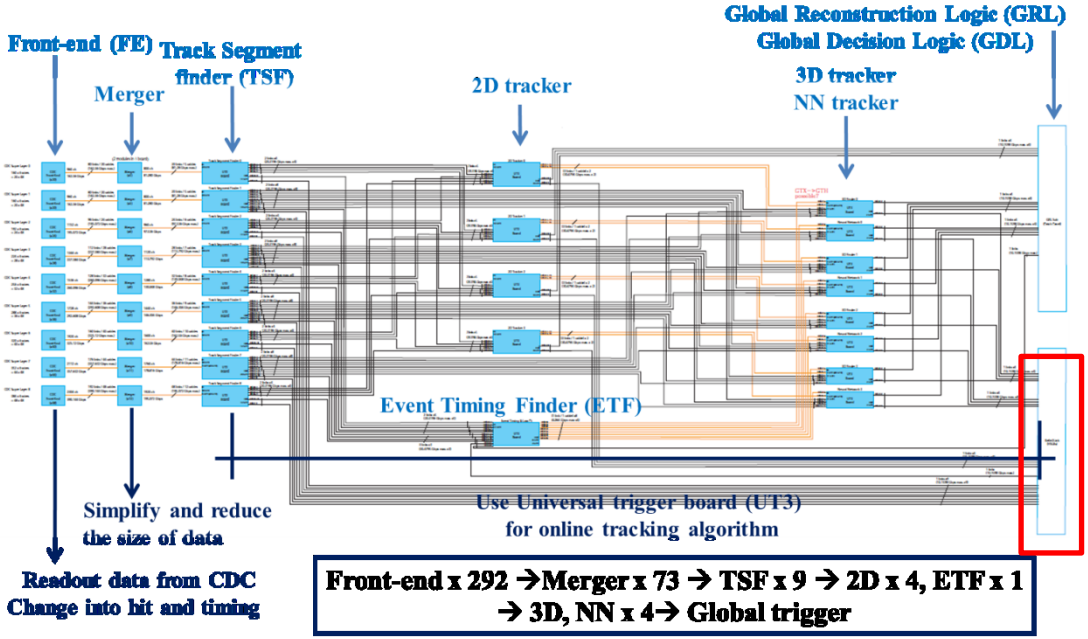
Introduction to GRL

- Belle II TRG and CDCTRG system.





  - Master of CDCTRG
  - Detailed information of each sub-trigger.

- GRL's strategic location in the entire hardware system has good flexibility to develop any kinds of special logic.

GRL's functionalities

- GRL receives detailed information of physics objects (track, cluster…) for reconstruction, and also provides summary information to GDL.

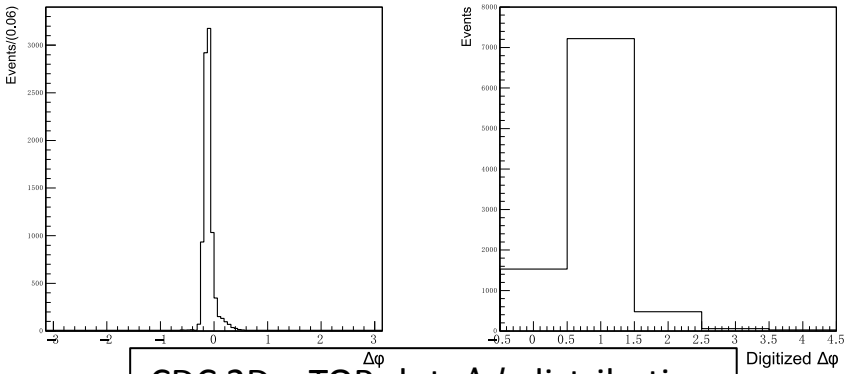
- Master of CDCTRG: inputs from TSF, 2D, 3D, and NN.
  - Track counting for 2D, **3D, NN (z0 cut)**.
  - **Short tracking.**
  - **Track counting reduction.**
  - **CDCTRG event timing from 2D/NN.**
  - b2b between 2 tracks, opening angle.
  - CDCTRG flow control.

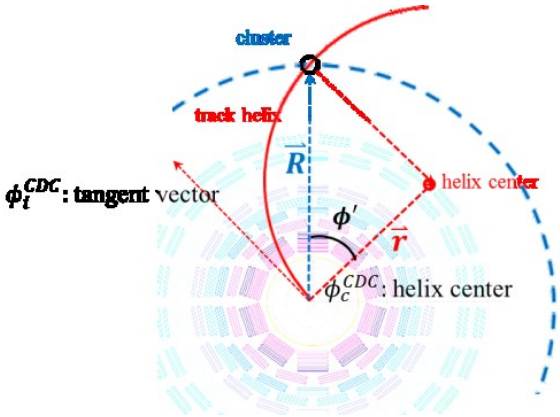
- Matching between the CDC 2D track and outer detector hit in barrel.
  - CDC-ECL (cluster position and energy)
  - CDC-KLM (KLM sector ID).
  - CDC-TOP (TOP slot ID).
  - b2b between 1trk-1cluster and 2 clusters, samehem, opphem.

Matching algorithm in GRL

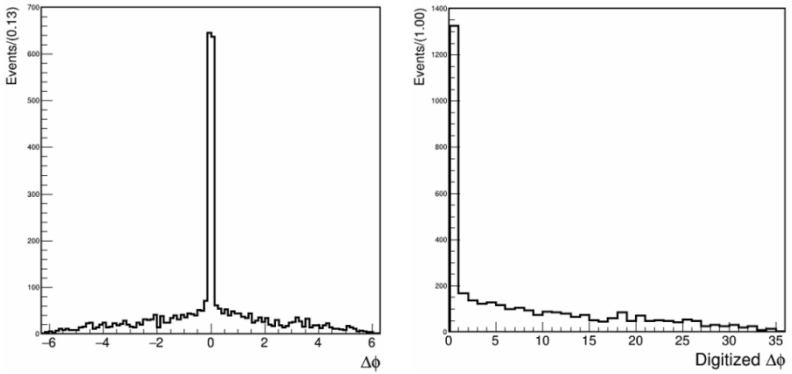
- Matching between CDC 2D full track and outer detector (ECL, KLM, TOP):
  - Extrapolate the track with the Hough finder output (r and ϕ) up to a fixed R, then check the ϕ between it and outer detector hit.

CDC 2D – ECL cluster: $\Delta\phi$ distribution

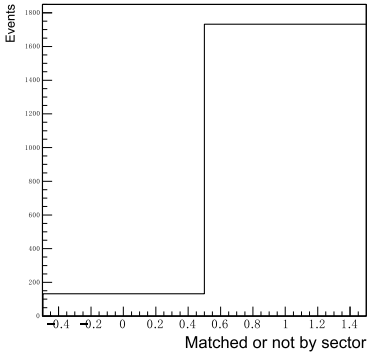


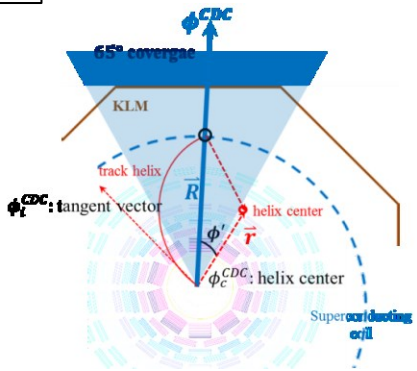


CDC 2D – TOP slot: $\Delta\phi$ distribution
Using TOPBarHit in TOP basf2



CDC 2D – KLM sector:
Matched or not





GRL Output to GDL

- https://confluence.desy.de/pages/viewpage.action?pageId=75106458

- N(2D/3D/NN) in 500 ns
- N(2D-ECL matched cluster)
- N(1 GeV, 2 GeV photon)
- N(matched 1 GeV, 2 GeV cluster)
- N(2D-KLM matched sector)
- N(2D-TOP matched sector)

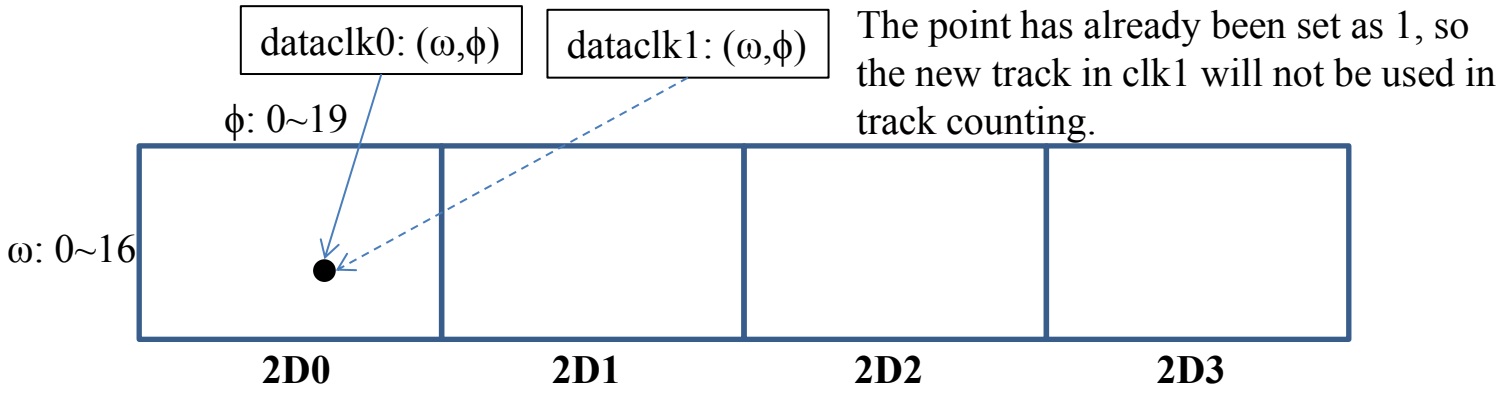
Those "number" (N) are sent to GDL in terms of exclusive bits for the cases: N = 1, N = 3, N = 3, and N > 3, in which N is the max value within the timing window (event).

- b2b: 1to3, 1to5, 1to7, 1to9 (1 digit = 10 degrees)
  - 2 tracks, 2 clusters, 1track-1cluster, TSF
- cdc_open90 = b2b_1to19 of 2 tracks
- samehem: 1track-1cluster at the same hemisphere
- opphem: 1track-1cluster at the opposite hemisphere

- CDC timing from 2D/NN.
- Short tracking result: to be determined.

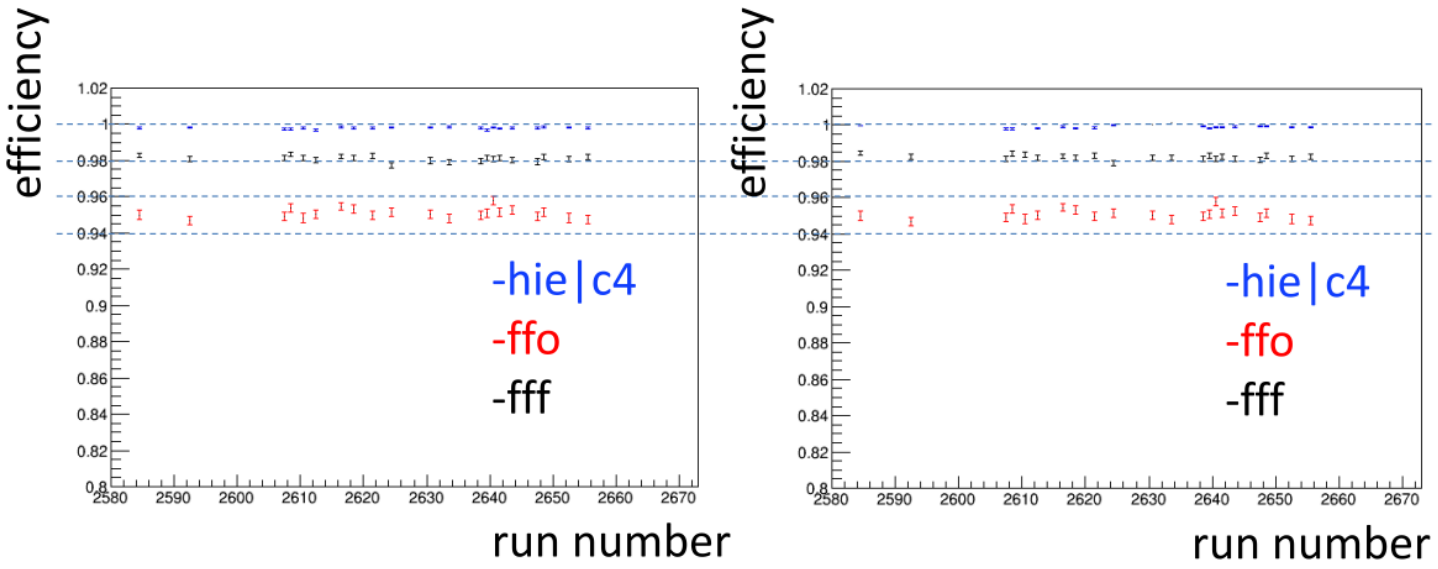
Track counting reduction in GRL: a

- One reason of high fff rate: clone 2D tracks with similar value of ω and ϕ.
- To suppress the clone track by comparing the ω and ϕ, those information have to be kept. → A ω and ϕ 2D map is used in GRL to persist the information.
- ω: -33 ~ 33, ϕ: 0~79.
  - A 17*20*4 map is used for now. Mesh size: 2*2. (2 bits in LSB are ignored.)
  - Even larger mesh size is worth trying: https://confluence.desy.de/download/attachments/98077342/koga_reducedtrack_2019_7_11.pdf?version=2&modificationDate=1565161472524&api=v2



Track counting reduction in GRL: a (cont'd)

- Compared with fff, aaa rate is reduced by 20%.
- eff check for a/f:
  - Done for both dimuon skim and hadronic skim
  - fff/aaa eff. for hadronic skim:
- Conclusion: aaa performs well to replace fff. Will try larger mesh size for a.



Short tracking (ST)

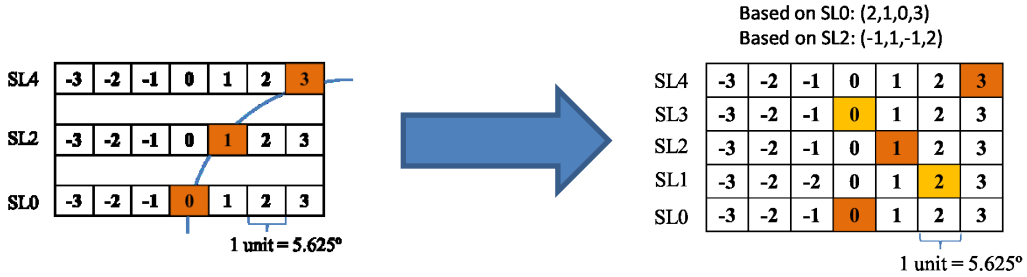
- Original short tracking scheme in CDCTRG: Hough finder without TSF8.
  - ETF and short tracking in the same UT3. → Can't do it due to resource issue.

- A simple temporary scheme for phase3:
  - GRL has enough resource and spare GTX ports.
  - Inner TSFs can send the TS hit map to GRL through GTX.
  - Simple pattern recognition algorithm by $\Delta\phi$.
  - Output: position of TSF0 (ϕ_0) of tracks.

- Expected improvement:
  - Even if the number of short track might not be precise, existence of short track can enhance various types of trigger.
  - Hadronic trigger (fff), Bhabha/$\gamma\gamma$ separation.
  - Matching between short track and endcap ECL/KLM info.

Performance check

- The following slides will go through the history and performance of the GRL ST in different stages.
  - 3 SL
  - 5 SL
  - Upgraded 5 SL



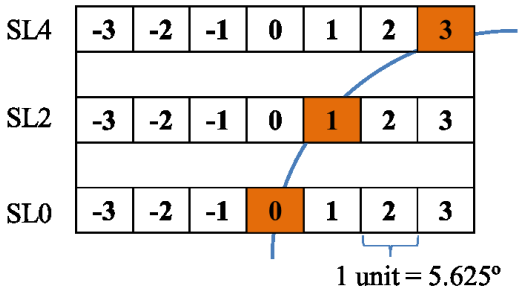
- How to judge the performance of ST in different stages?

- **Correctness** = (# of matched TRG ST)/(# of TRG ST)
  - Highly depends on the noise or background CDC hits.

- **Tracking rate** = (# of matched TRG ST)/(# of CDC tracks)
  - # of CDC tracks: with requirements.
  - Depends on the completeness of the algorithm.

3 SL: exp7 cosmic run 2103 and 2104

- First look of the ST logic (3 SL) with cosmic run
- Correctness: ~88%.



Pattern (1,3)

SL0	SL2	SL4	GRL ST
O			11491 (87.9%)
O	O	O	10612 (81.2%)
X			1577 (12.1%)
X	X	X	297 (2.3%)
X	at least 1 matched		1280 (9.8%)
X	both matched		782 (6.0%)

3 SL: exp7 beam run 3870

- Exp7 run 3870.

- Correctness:
  - CDC tracks: All CDC tracks not found by TRG 2D.
  - SL0: 20.5%
  - SL2: 27.1%
  - All 3 SL: 13.0%

- Lots of wrong ST are found due to background and noise (beam condition).

SL0	SL2	SL4	GRL ST
O			20.5%
	O		27.1%
O	O	O	10.3%
X			79.5%
	X		72.9%
X	X	X	57.9%

3 SL: Cross-check with different beam conditions

- The background on CDC depends on the beam condition. The situation is worse right after beam injection is done.

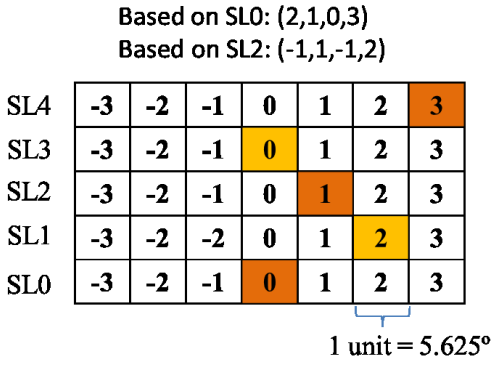
- Here I pick up some of the long runs and check the result for the first and the last output files.
  - 3924: debug run with higher CDC threshold

r03924 head	r03877 head	r03878 head	r03879 head	r03886 head	r03903 head
Tracking rate: 26.9%	Tracking rate: 27.3%	Tracking rate: 28.6%	Tracking rate: 26.2%	Tracking rate: 28.6%	Tracking rate: 28.9%
Correctness: 25.0%	Correctness: 12.5%	Correctness: 9.5%	Correctness: 23.9%	Correctness: 9.9%	Correctness: 8.9%
r03924 tail	r03877 tail	r03878 tail	r03879 tail	r03886 tail	r03903 tail
Tracking rate: 23.7%	Tracking rate: 22.3%	Tracking rate: 26.5%	Tracking rate: 24.1%	Tracking rate: 22.0%	Tracking rate: 23.2%
Correctness: 50%	Correctness: 44.7%	Correctness: 16.3%	Correctness: 45.2%	Correctness: 41.1%	Correctness: 43.0%

5 SL: exp8 beam run 2165

- Part of exp8 run 2165.
- ~40 patterns from TSIM.
- Tracking rate:

Match	Requirement	Tracking rate (%)
SL2	All 5 SL hit && !veto	44.7
SL2 && 4 SL matched	All 5 SL hit && !veto	44.3
SL2 && 5 SL matched	All 5 SL hit && !veto	42.2



- Correctness = 63.2%
  - "Matched": At least SL2 hit is matched.
  - 60%~70%: improved from 3 SL ST.

- Main reasons for the missing ST in TRG:
  - **Many missing patterns from TSIM study. → Track rate can be further improved after including more patterns.**

5 SL: updated patterns, cosmic runs in the end of phase3

- 40 → 137 patterns are included in total.
  - By using exp8 r2165.

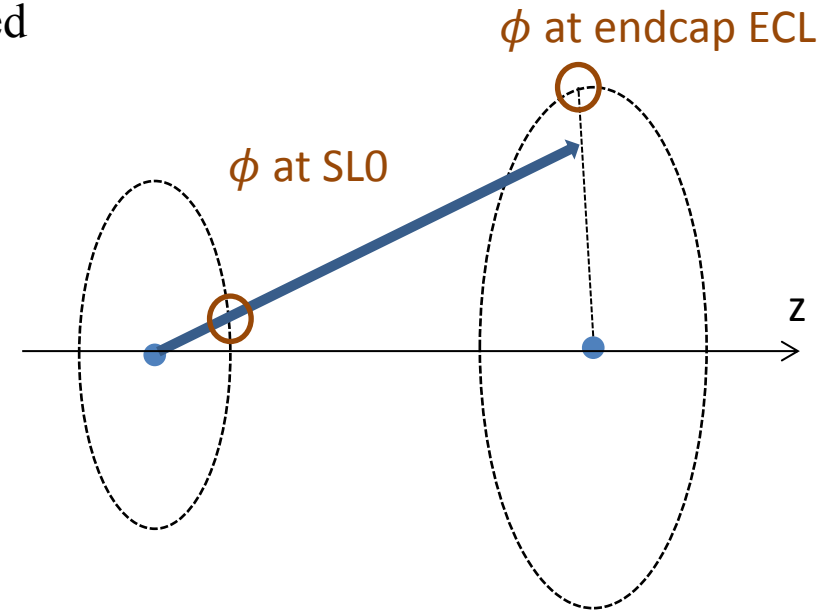
Run	Description, conf	Tracking rate (%)	Correctness (%)	
e8 r2165, beam run	Beam run, BEAM conf.	44.7	63.2	
e8 r3420~3421	Solenoid+QCS, BEAM conf.	44.8	92.7	
e8 r3451	OCS off, BEAM	44.1	91.5	
e8 r3467	Both Solenoid QCS off, BEAM	44.9	89.2	
e9 r0081	Both Solenoid QCS off, BEAM	83.2	89.7	with updated patterns
e9 r0082	Both Solenoid QCS off, COSMIC	86.4	89.7	

- By comparing the cosmic runs' results, tracking rate is improved and correctness is the same.

- Waiting for next beam run for further selection.

New features: matching with ECL cluster in endcap

- Investigation on possibility of matching between short track and ECL cluster in endcap region.
- For each short track, we know the ϕ at SL0 and its pattern.
- We can get the extrapolated ϕ of the track at endcap ECL region by using data.
  - If the $\Delta\phi$ distribution for specific patterns is significant, the ϕ of endcap can be obtained in firmware.
- Using the tracks in exp8 run 2165, and the extrapolated track positions on ECL entrance.



Possibility of each pattern reaching each endcaps

- By beam run e8 run2165.
- $|z0| < 10$ cm

				Back	For
0	0	0	0	0.839	0.000
0	-1	0	0	0.680	0.000
0	-1	1	0	0.008	0.000
0	-1	-1	0	1.000	0.000
0	-2	0	0	0.000	0.000
0	-2	1	0	0.000	0.006
0	-2	2	0	0.000	0.923
0	-2	3	0	0.000	1.000
0	-3	1	0	0.000	0.780
0	-3	2	0	0.000	0.997
0	-3	3	0	0.000	1.000
0	-4	2	0	0.000	1.000
0	-4	3	0	0.000	1.000
0	0	0	1	0.895	0.000
0	0	1	1	0.821	0.000
0	-1	0	1	1.000	0.000
0	-1	1	1	0.382	0.000
0	-1	2	1	0.000	0.000
0	-2	2	1	0.000	0.854
0	-2	3	1	0.000	1.000
0	-3	2	1	0.000	0.997
0	-3	3	1	0.000	1.000
0	0	0	-1	0.887	0.000
0	0	-1	-1	0.962	0.000
0	-1	0	-1	0.576	0.000
0	-1	-1	-1	0.888	0.000
0	-2	0	-1	0.000	0.000
0	-2	1	-1	0.000	0.262
0	-3	1	-1	0.000	0.947
0	-3	2	-1	0.000	1.000
-1	-1	0	0	0.786	0.000
-1	-1	1	0	0.000	0.000
-1	-2	0	0	0.200	0.000
-1	-2	1	0	0.000	0.000

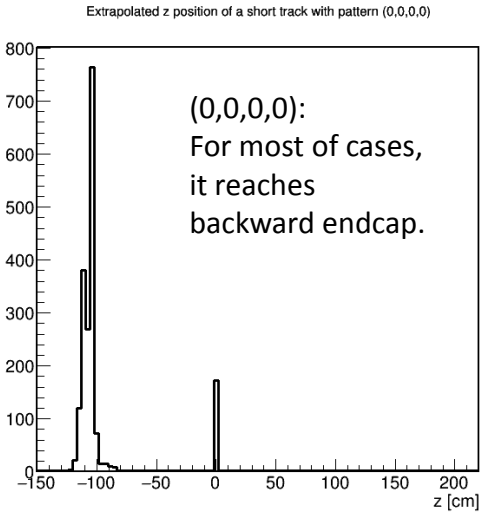
				Back	For
-1	-3	1	0	0.000	0.711
-1	-3	2	0	0.000	0.996
-1	-3	3	0	0.000	1.000
-1	-4	2	0	0.000	1.000
-1	-4	3	0	0.000	1.000
1	0	1	0	0.463	0.000
1	0	0	0	0.877	0.000
1	0	-1	0	1.000	0.000
1	-1	0	0	0.406	0.000
1	-1	1	0	0.007	0.000
1	-2	2	0	0.000	0.974
1	-2	3	0	0.000	1.000
1	-3	2	0	0.000	1.000
1	-3	3	0	0.000	1.000
-1	-1	0	1	0.929	0.000
-1	-1	1	1	0.696	0.000
-1	-2	0	1	0.647	0.000
-1	-2	1	1	0.066	0.000
-1	-2	2	1	0.000	0.000
-1	-3	1	1	0.000	0.000
-1	-3	2	1	0.000	0.926
-1	-3	3	1	0.000	1.000
-1	-4	2	1	0.000	1.000
-1	-4	3	1	0.000	1.000
1	0	-1	-1	0.867	0.000
1	0	0	-1	0.568	0.000
1	-1	-1	-1	0.719	0.000
1	-1	0	-1	0.109	0.004
1	-1	1	-1	0.000	0.092
1	-2	1	-1	0.000	0.766
1	-2	2	-1	0.000	0.990
1	-3	1	-1	0.000	0.989
1	-3	2	-1	0.000	1.000

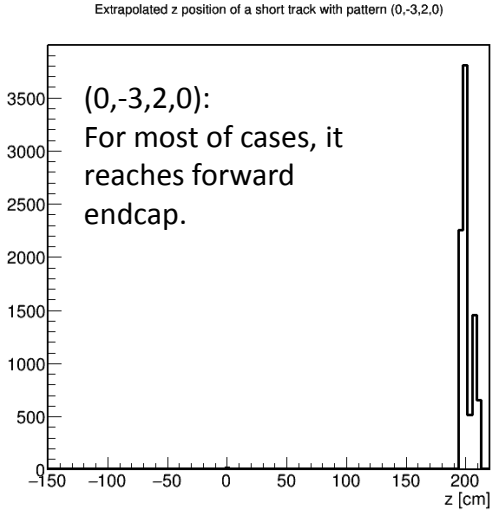
				Back	For
-1	-1	1	2	0.797	0.000
-1	-1	2	2	0.300	0.000
-1	-2	1	2	0.316	0.000
-1	-2	2	2	0.027	0.016
-1	-2	3	2	0.000	0.467
-1	-3	2	2	0.000	0.396
-1	-3	3	2	0.000	0.969
-1	-3	4	2	0.000	1.000
1	0	-1	-2	0.508	0.000
1	0	0	-2	0.077	0.000
1	-1	1	-2	0.000	0.300
1	-1	0	-2	0.005	0.050
1	-1	-1	-2	0.126	0.000
1	-2	0	-2	0.006	0.326
1	-2	1	-2	0.000	0.874
-2	-2	0	1	0.806	0.000
-2	-2	1	1	0.271	0.000
-2	-3	1	1	0.000	0.015
-2	-3	2	1	0.000	0.341
-2	-4	2	1	0.000	1.000
-2	-4	3	1	0.000	1.000
-2	-5	3	1	0.000	1.000
2	1	0	-1	0.565	0.000
2	0	1	-1	0.000	0.087
2	0	0	-1	0.186	0.005
2	0	-1	-1	0.837	0.000
2	-1	1	-1	0.000	0.418
2	-1	0	-1	0.000	0.015
2	-2	2	-1	0.000	1.000
2	-2	1	-1	0.000	0.918
-2	-2	1	2	0.620	0.000
-2	-2	2	2	0.177	0.040
-2	-3	1	2	0.200	0.020
-2	-3	2	2	0.005	0.481
-2	-3	3	2	0.000	0.988
-2	-4	2	2	0.000	0.928
-2	-4	3	2	0.000	1.000
-2	-4	4	2	0.000	1.000

				Back	For
2	1	0	-2	0.613	0.000
2	1	-1	-2	0.818	0.000
2	0	1	-2	0.037	0.481
2	0	0	-2	0.140	0.041
2	0	-1	-2	0.619	0.000
2	0	-2	-2	1.000	0.000
2	-1	2	-2	0.000	1.000
2	-1	1	-2	0.000	0.775
2	-1	0	-2	0.000	0.276
2	-1	-1	-2	0.042	0.000
2	-2	0	-2	0.000	0.846
2	-2	1	-2	0.000	0.981
-2	-2	1	3	0.842	0.000
-2	-2	2	3	0.530	0.012
-2	-3	2	3	0.042	0.292
-2	-3	3	3	0.000	0.870
-2	-3	4	3	0.000	1.000
-2	-4	3	3	0.000	0.900
-2	-4	4	3	0.000	1.000
2	1	-1	-3	0.643	0.000
2	0	-1	-3	0.571	0.000
2	0	-2	-3	1.000	0.000
2	-1	0	-3	0.000	0.790
2	-2	0	-3	0.000	0.981
2	-2	1	-3	0.000	1.000
-2	-2	2	4	0.400	0.000
-2	-3	3	4	0.000	0.563
-2	-3	4	4	0.000	0.889
-2	-4	4	4	0.000	1.000
2	-1	0	-4	0.000	1.000
2	-1	-1	-4	0.000	0.143
2	-2	0	-4	0.000	0.923

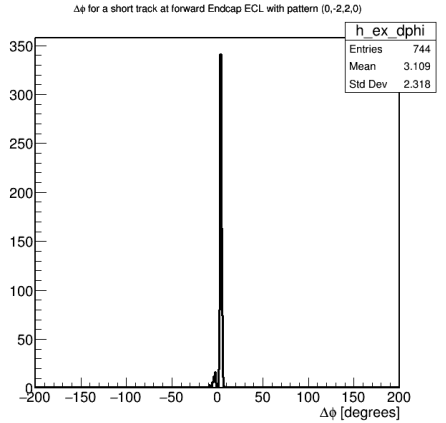
Extrapolated z position and $\Delta\phi$ for each patterns

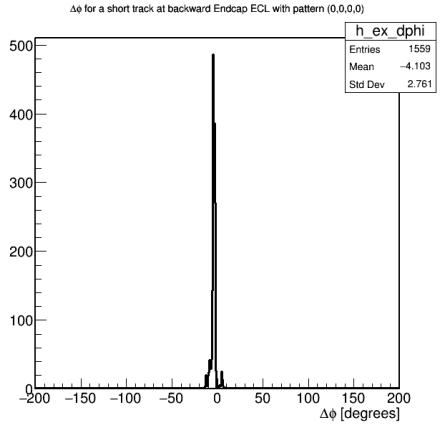
- Demonstration plots of the extrapolated z distribution.
  - Peak at 0: doesn't reach ECL.
  - z < -102: Reaching backward endcap.
  - z > 196: Reaching forward endcap.
  - Else: Reaching barrel.





- $\Delta\phi$ distribution for the patterns with good extrapolated z distribution.
  - Looks good (narrow) enough to utilize.





Alternative CDCTRG timing by 2D/NN

- The original plan of CDCTRG timing is ETF, which utilizes histogram method on the fastest timing of all TS.
  - Not working properly with large background.

- A temporary alternative way:
  - Each 2D (NN) track has 4~5 (8~9) associated TS and their priority timing.
  - We just puck up the fastest priority timing among all the 2D/NN tracks in GRL.

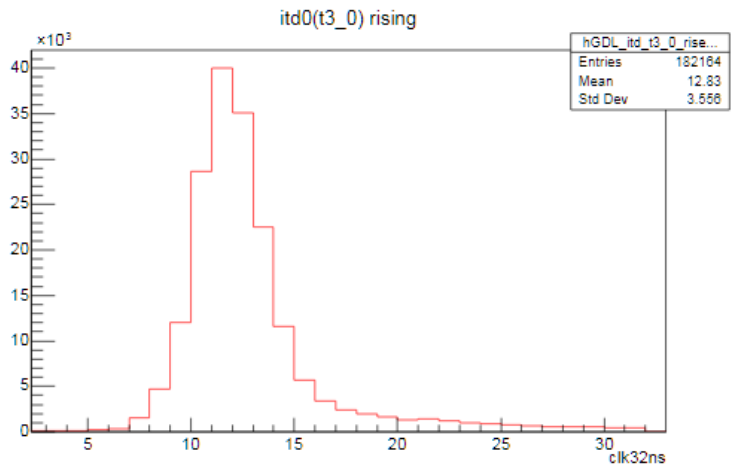
- This fastest priority timing scheme will be tested next week.

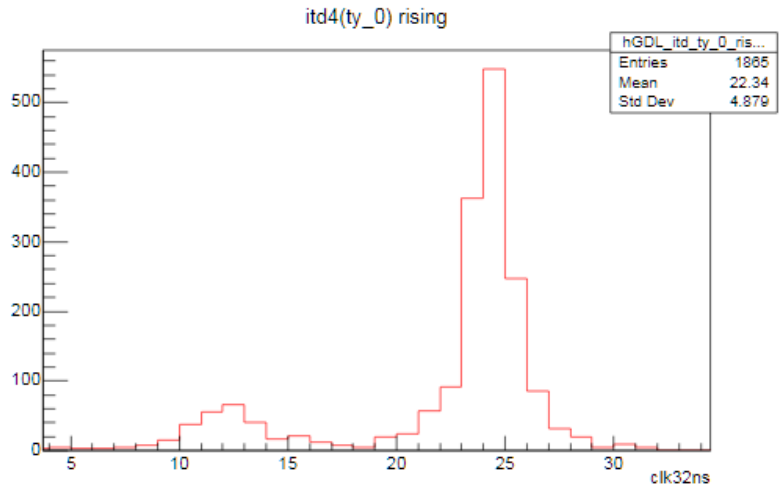
3D/NN track counting

- GRL received the 3D/NN result, and provides the track counting result with z0 cut.

- Both are in debugging stage:
  - 3D: needs the commissioning of 2D fitter.
  - NN: commissioning soon.

- 3D/NN input bit timing in GDL:
  - L1 limit: a 21st clock





- Will try to use lemo/LVDS between 3D/NN and GRL instead of GTH.

Summary & To do

- Recent focus/thing under development:

- Short tracking:
  - 60~70% of correctness and ~90% od tracking rate.
  - Updated version: to be tested in the next beam run.
  - Prospect: matching between short track and endcap info (ECL/KLM).

- 2D full track counting reduction: a
  - With a 2*2 mesh size on ω and ϕ map, aaa (fff) rate is reduced by 20% and the performance is the same.
  - Will try larger mesh size.

- Alternative CDCTRG timing with 2D/NN: to be testes soon.

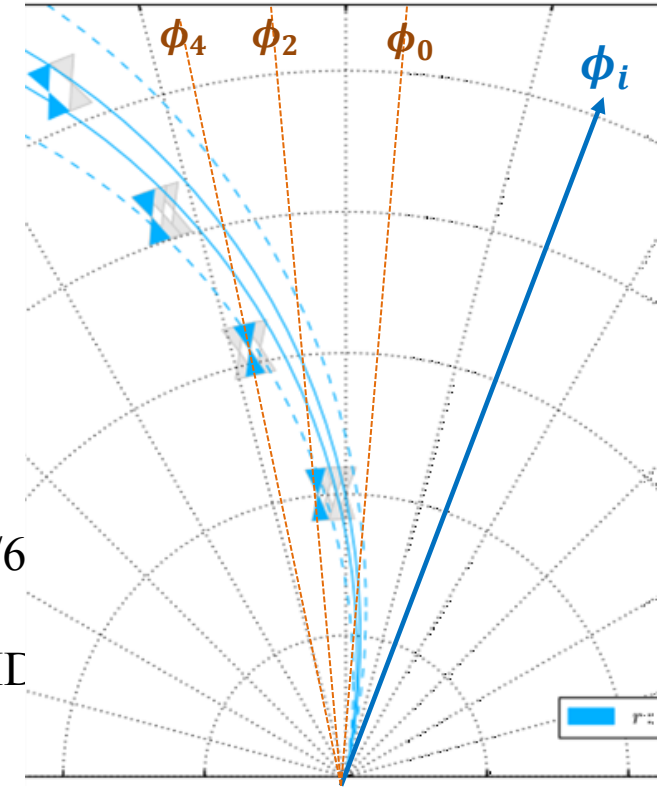
- 3D/NN track counting: still under development. Latency limit is a problem.

Backup

Algorithm

- TSF0, 2, and 4 would send TS hit map to GRL. → position (ϕ).

- For tracks with certain momentum value, we should be able to find relations in $\Delta\phi_{0,2}$ and $\Delta\phi_{0,4}$.



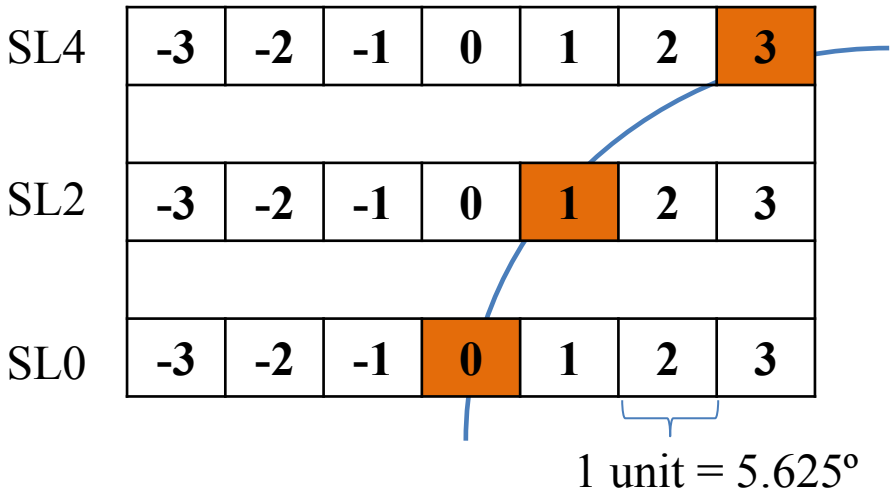
- TSF0: 32*5 = 160 TS. $d\phi_0$ = 2.25º.
- TSF2: 32*6 = 192 TS. $d\phi_2$ = 1.875º.
- TSF4: 32*8 = 256 TS. $d\phi_4$ = 1.4065º.
  - It's difficult to calculate $\Delta\phi_{0,2}$ and $\Delta\phi_{0,4}$ with different digits.
    EX: $\Delta\phi_{0,2} = \frac{9}{4} ID_0 - \frac{15}{8} ID_2$. LUT is needed.
  - For $d\phi$, we use a common factor 5.625º (=360/6
    → 2.5 TS in SL0, 3 TS in SL2, 4 TS in SL4.
    Then, $\Delta\phi$ info can be simply obtained by new ID

Algorithm (cont'd)

- $\Delta\phi_{0,2}$ and $\Delta\phi_{0,4}$ can be simply utilized by new ID with new unit = 5.625°.

- For a certain value of pt, ($\Delta\phi_{0,2}$, $\Delta\phi_{0,4}$) would be some fixed patterns.
  - Check the patterns for different pt value by TSIM.
  - In firmware, track finding can be simple implemented by pattern recognition.

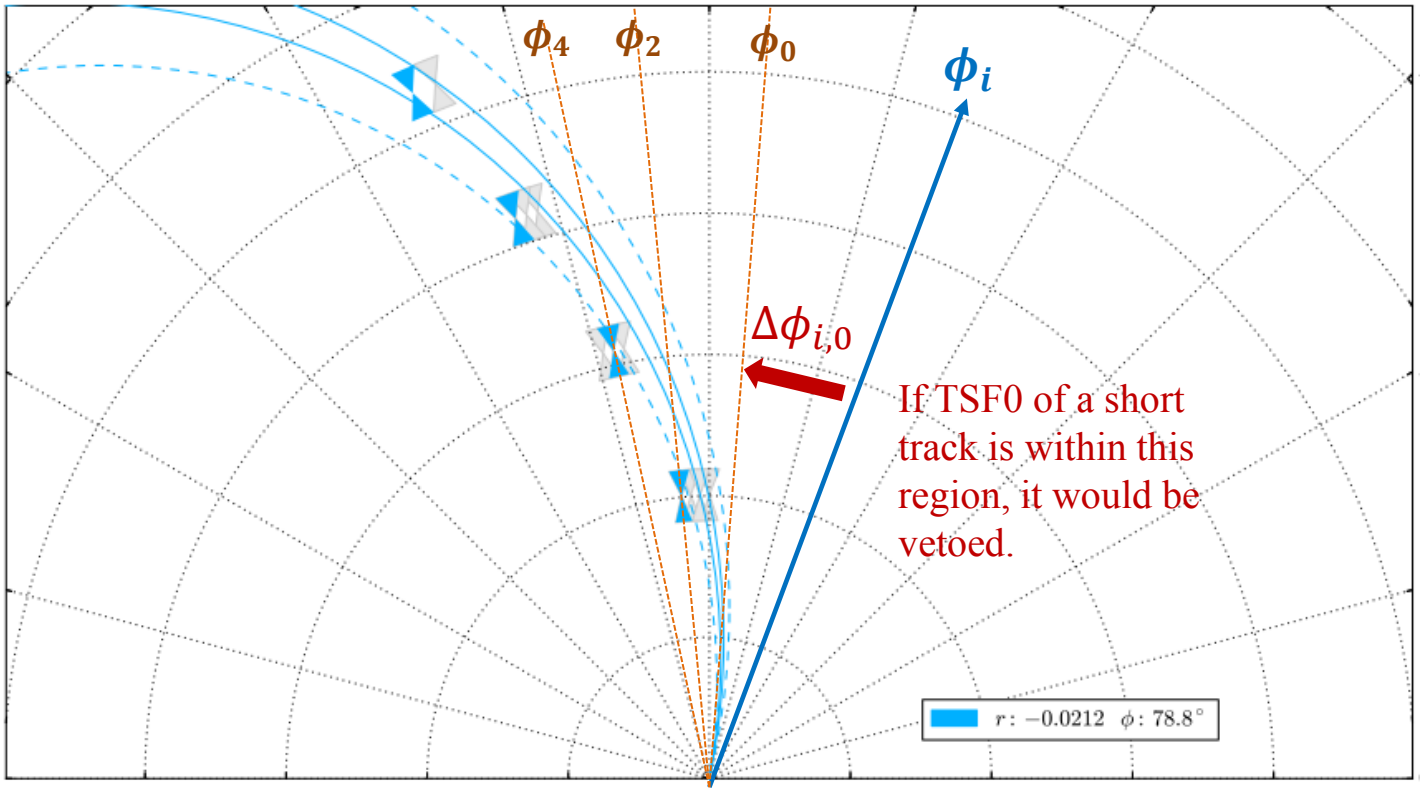
- In the below case, the ($\Delta\phi_{0,2}$, $\Delta\phi_{0,4}$) pattern is noted as (1,3).



Full track veto

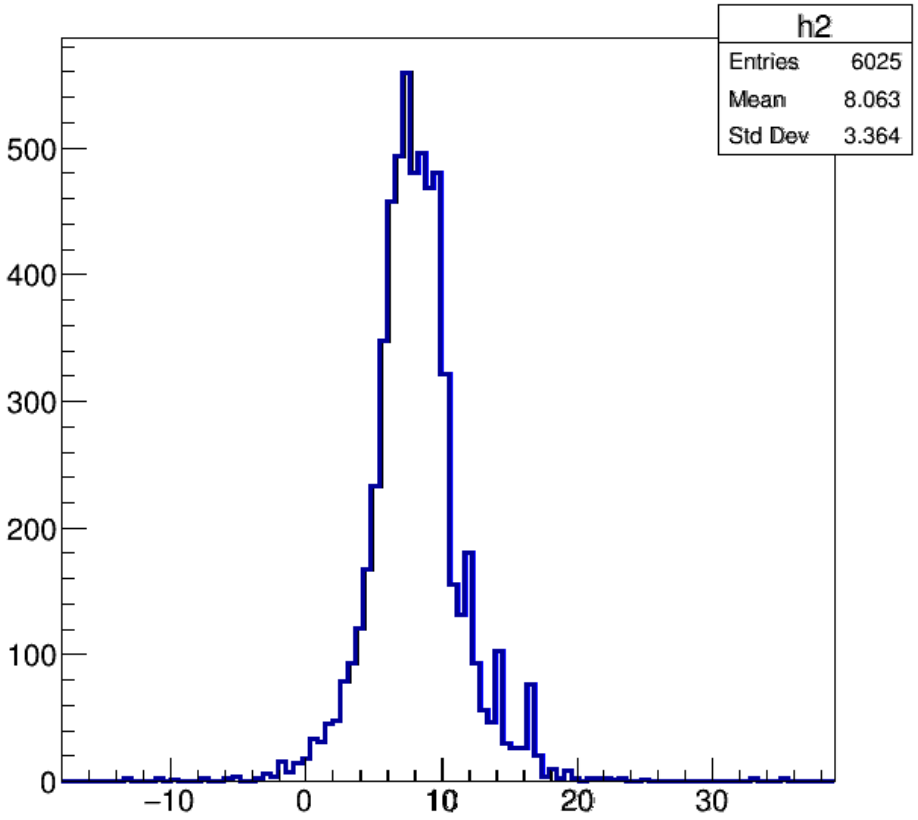
- The full tracks info from 2D (w, ϕ_c) would arrive GRL later.

- For a full track, the value of $\Delta\phi_{i,0}$ should also have relation to w, then we can veto the found short track within the region of $\Delta\phi_{i,0}$.



Full track veto (cont'd)

- The veto range for each w value.



$\Delta\phi_{i,0}$ of w = 30.

pt	w	L (°)	R (°)	mean (°)
10.20	**1**	-2.0	3.0	0.45
5.10	**2**	-2.2	3.4	0.59
3.40	**3**	-2.2	4.0	0.84
2.55	**4**	-2.0	4.5	1.14
2.04	**5**	-2.0	4.6	1.38
1.70	**6**	-2.0	6.0	1.66
1.46	**7**	-2.0	6.5	1.93
1.28	**8**	-2.0	6.5	2.15
1.13	**9**	-2.0	7.5	2.40
1.02	**10**	-2.0	8.0	2.72
0.93	**11**	-2.0	9.0	2.96
0.85	**12**	-2.0	10.0	3.22
0.78	**13**	-2.0	10.0	3.45
0.73	**14**	-2.0	10.0	3.73
0.68	**15**	-2.0	11.0	3.97
0.64	**16**	-3.0	13.0	4.19
0.60	**17**	-3.0	12.0	4.43
0.57	**18**	-3.0	13.0	4.72
0.54	**19**	-2.0	13.0	4.99
0.51	**20**	-3.0	15.0	5.27
0.49	**21**	-3.0	16.0	5.50
0.46	**22**	-5.0	16.0	5.79
0.44	**23**	-5.0	16.0	6.14
0.43	**24**	-4.0	16.0	6.36
0.41	**25**	-5.0	19.0	6.60
0.39	**26**	-5.0	20.0	6.91
0.38	**27**	-5.0	20.0	7.07
0.36	**28**	-8.0	22.0	7.47
0.35	**29**	-10.0	22.0	7.70
0.34	**30**	-8.0	20.0	8.06
0.33	**31**	-6.0	26.0	8.68
0.32	**32**	-10.0	28.0	10.00
0.31	**33**	-4.0	30.0	10.76

5 SL: updated patterns

- By beam run e8 run2165. 137 in total.

				eff. (z0)	Ratio
0	0	0	0	93.5%	4.5%
0	-1	0	0	92.4%	8.2%
0	-1	1	0	62.7%	0.6%
0	-1	-1	0	92.9%	0.5%
0	-2	0	0	42.1%	0.1%
0	-2	1	0	27.8%	0.4%
0	-2	2	0	90.7%	2.0%
0	-2	3	0	93.5%	0.1%
0	-3	1	0	34.0%	0.1%
0	-3	2	0	96.9%	21.7%
0	-3	3	0	95.3%	4.6%
0	-4	2	0	94.7%	1.6%
0	-4	3	0	92.3%	0.0%
0	0	0	1	95.0%	0.0%
0	0	1	1	88.1%	0.1%
0	-1	0	1	57.6%	0.0%
0	-1	1	1	55.2%	0.3%
0	-1	2	1	26.5%	0.0%
0	-2	2	1	83.6%	1.4%
0	-2	3	1	96.3%	1.9%
0	-3	2	1	75.2%	0.8%
0	-3	3	1	95.2%	6.9%
0	0	0	-1	20.4%	0.1%
0	0	-1	-1	36.4%	0.0%
0	-1	0	-1	51.0%	2.2%
0	-1	-1	-1	71.4%	1.1%
0	-2	0	-1	3.1%	0.1%
0	-2	1	-1	2.1%	0.1%
0	-3	1	-1	11.6%	0.2%
0	-3	2	-1	64.1%	0.3%
-1	-1	0	0	71.5%	0.3%
-1	-1	1	0	8.2%	0.0%
-1	-2	0	0	27.6%	0.1%
-1	-2	1	0	27.4%	0.1%

				eff. (z0)	Ratio
-1	-3	1	0	47.5%	0.3%
-1	-3	2	0	94.5%	4.9%
-1	-3	3	0	91.9%	0.2%
-1	-4	2	0	92.5%	1.8%
-1	-4	3	0	89.6%	0.2%
1	0	1	0	76.7%	0.7%
1	0	0	0	83.8%	4.6%
1	0	-1	0	50.0%	0.0%
1	-1	0	0	39.5%	0.4%
1	-1	1	0	28.1%	0.3%
1	-2	2	0	54.7%	0.5%
1	-2	3	0	80.0%	0.0%
1	-3	2	0	59.4%	0.1%
1	-3	3	0	80.0%	0.1%
-1	-1	0	1	65.4%	0.1%
-1	-1	1	1	35.6%	0.2%
-1	-2	0	1	24.6%	0.0%
-1	-2	1	1	24.0%	0.3%
-1	-2	2	1	20.7%	0.1%
-1	-3	1	1	4.2%	0.0%
-1	-3	2	1	51.5%	0.9%
-1	-3	3	1	83.5%	1.4%
-1	-4	2	1	53.2%	0.4%
-1	-4	3	1	77.3%	0.5%
1	0	-1	-1	28.7%	0.2%
1	0	0	-1	13.8%	0.4%
1	-1	-1	-1	6.6%	0.1%
1	-1	0	-1	6.6%	0.5%
1	-1	1	-1	6.3%	0.2%
1	-2	1	-1	5.3%	0.2%
1	-2	2	-1	31.9%	0.4%
1	-3	1	-1	32.3%	0.2%
1	-3	2	-1	49.1%	0.2%

				eff. (z0)	Ratio
-1	-1	1	2	34.1%	0.2%
-1	-1	2	2	10.5%	0.0%
-1	-2	1	2	14.3%	0.1%
-1	-2	2	2	22.0%	0.3%
-1	-2	3	2	14.3%	0.0%
-1	-3	2	2	6.4%	0.1%
-1	-3	3	2	49.0%	0.5%
-1	-3	4	2	44.4%	0.0%
1	0	-1	-2	19.5%	0.3%
1	0	0	-2	7.7%	0.1%
1	-1	1	-2	8.4%	0.1%
1	-1	0	-2	10.9%	0.9%
1	-1	-1	-2	8.3%	0.3%
1	-2	0	-2	4.2%	0.3%
1	-2	1	-2	12.1%	0.3%
-2	-2	0	1	36.1%	0.1%
-2	-2	1	1	22.3%	0.2%
-2	-3	1	1	12.9%	0.1%
-2	-3	2	1	25.5%	0.2%
-2	-4	2	1	20.2%	0.1%
-2	-4	3	1	65.2%	0.2%
-2	-5	3	1	42.9%	0.0%
2	1	0	-1	12.7%	0.1%
2	0	1	-1	11.4%	0.2%
2	0	0	-1	10.9%	0.8%
2	0	-1	-1	9.7%	0.1%
2	-1	1	-1	8.1%	0.5%
2	-1	0	-1	1.7%	0.1%
2	-2	2	-1	25.7%	0.2%
2	-2	1	-1	3.5%	0.1%
-2	-2	1	2	31.9%	0.4%
-2	-2	2	2	18.4%	0.2%
-2	-3	1	2	10.7%	0.1%
-2	-3	2	2	18.5%	0.5%
-2	-3	3	2	35.1%	0.2%
-2	-4	2	2	15.2%	0.1%
-2	-4	3	2	45.5%	0.3%
-2	-4	4	2	54.8%	0.0%

				eff. (z0)	Ratio
2	1	0	-2	20.9%	0.1%
2	1	-1	-2	25.3%	0.0%
2	0	1	-2	8.3%	0.0%
2	0	0	-2	13.4%	0.6%
2	0	-1	-2	20.8%	0.5%
2	0	-2	-2	25.0%	0.0%
2	-1	2	-2	30.4%	0.0%
2	-1	1	-2	18.9%	0.5%
2	-1	0	-2	7.5%	0.7%
2	-1	-1	-2	2.1%	0.0%
2	-2	0	-2	1.9%	0.1%
2	-2	1	-2	13.4%	0.2%
-2	-2	1	3	44.1%	0.0%
-2	-2	2	3	23.4%	0.2%
-2	-3	2	3	6.2%	0.0%
-2	-3	3	3	35.0%	0.2%
-2	-3	4	3	56.5%	0.0%
-2	-4	3	3	28.3%	0.1%
-2	-4	4	3	43.9%	0.0%
2	1	-1	-3	18.8%	0.0%
2	0	-1	-3	21.8%	0.2%
2	0	-2	-3	17.0%	0.0%
2	-1	0	-3	21.8%	0.2%
2	-2	0	-3	16.4%	0.1%
2	-2	1	-3	21.1%	0.0%
-2	-2	2	4	26.0%	0.0%
-2	-3	3	4	14.8%	0.0%
-2	-3	4	4	33.3%	0.0%
-2	-4	4	4	37.5%	0.0%
2	-1	0	-4	25.7%	0.0%
2	-1	-1	-4	8.5%	0.0%
2	-2	0	-4	43.5%	0.0%