FVTX Trigger

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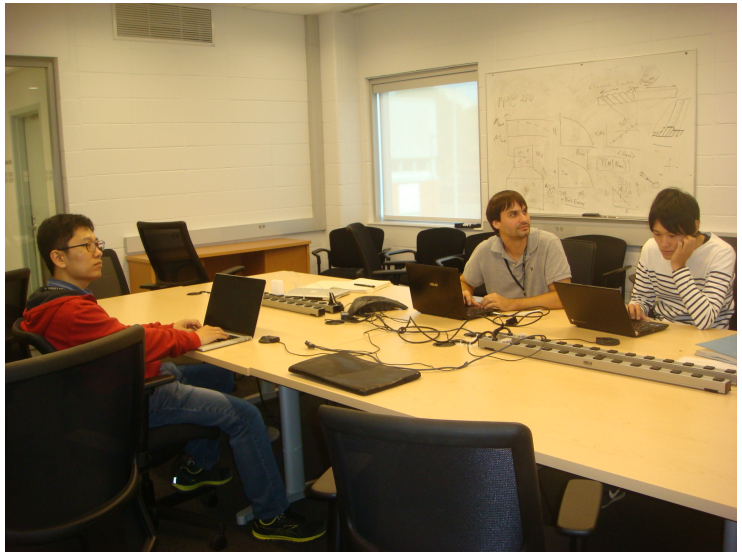
RIKEN
and
FVTX Group

Outline

1. Statistical Goal (of high multiplicity events for pp)
2. Trigger Performance
3. Hardware status



pA vs. pp

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Physics Letters B

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Observation of long-range, near-side angular correlations in pPb collisions at the LHC ☆

CMS Collaboration *

CERN, Switzerland

ARTICLE INFO

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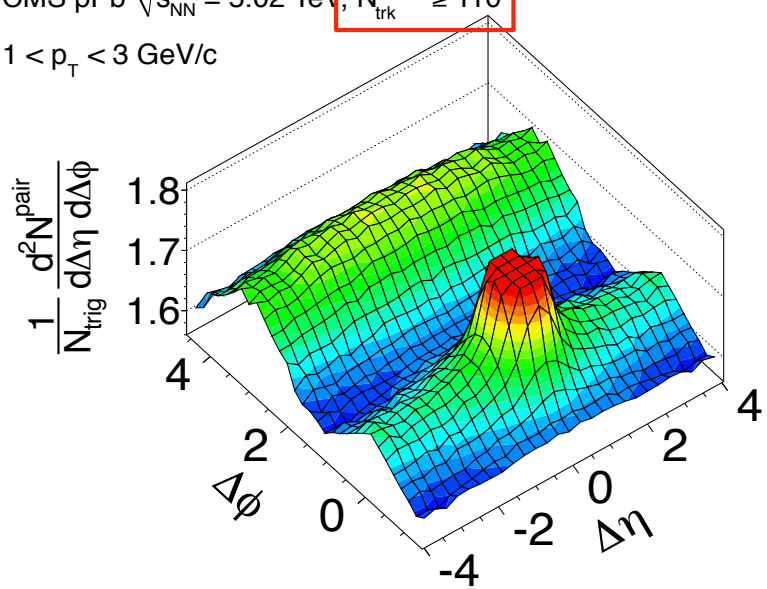
ABSTRACT

Results on two-particle ang
nucleon center-of-mass energy of 5.02 TeV are presented. The analysis uses two million collisions
collected with the CMS detector at the LHC. The correlations are studied over a broad range of

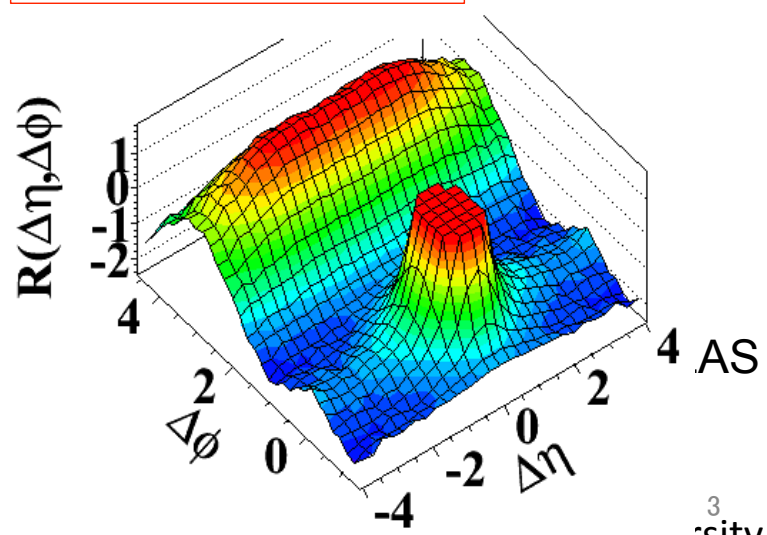
Signal is expected to be smaller in pp.
Requires more statistics than pA.
Requires more statistics than pA

CMS pPb $\sqrt{s_{NN}}$ = 5.02 TeV, $N_{trk}^{offline} \geq 110$

$1 < p_T < 3$ GeV/c

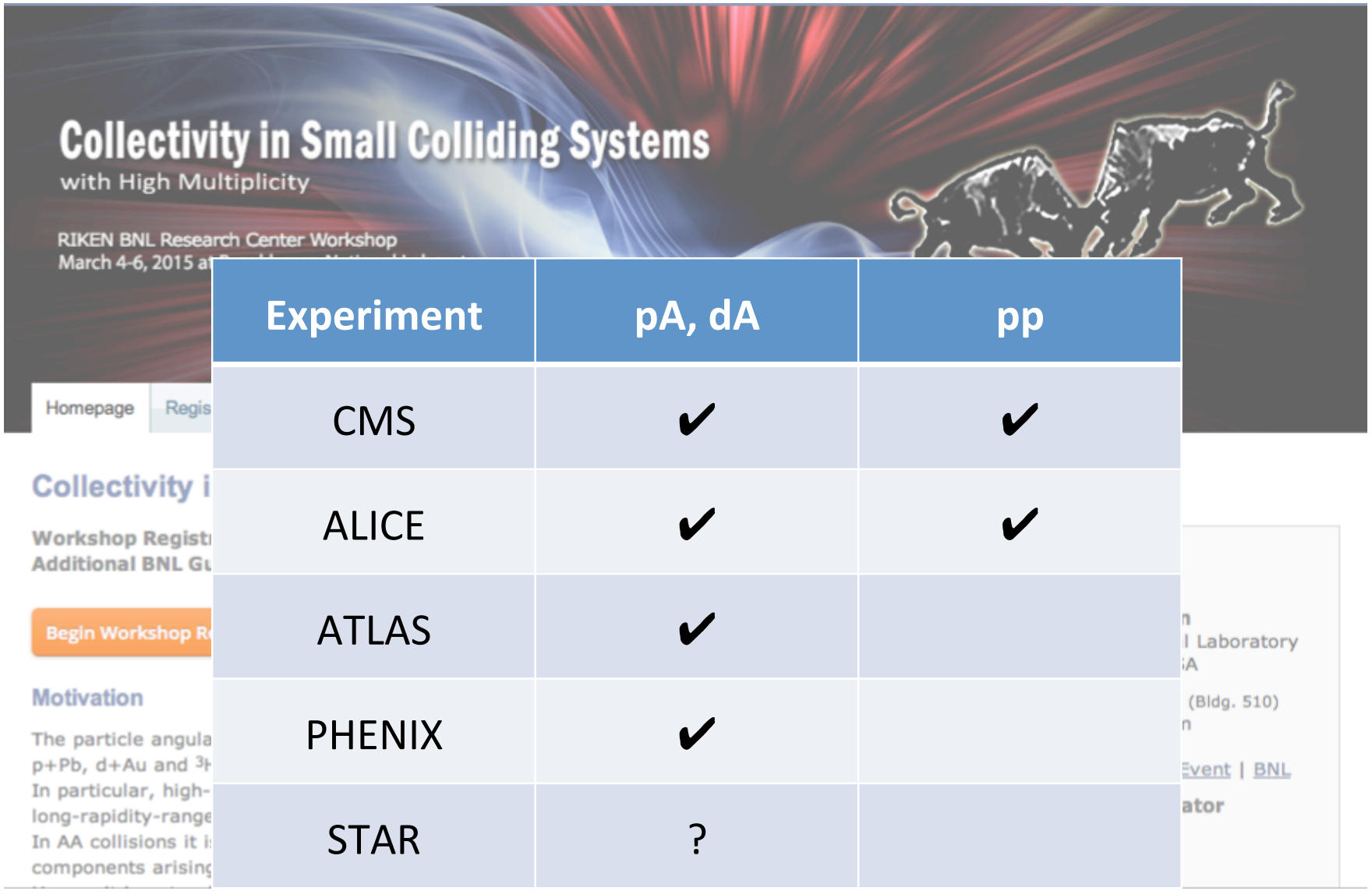


pp N>110, $1<p_T<3$ GeV/c



AS

sity



Experiment	pA, dA	pp
CMS	✔	✔
ALICE	✔	✔
ATLAS	✔	
PHENIX	✔	
STAR	?	

PPG161

In preparation for PRL

Measurement of long-range angular correlation and quadrupole anisotropy of pions and (anti)protons in central d+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

A. Adare,[13] C. Aidala,[38,42,43] N.N. Ajitanand,[60] Y. Akiba,[55,56] R. Akimoto,[12] H. Al-Bataineh,[49] H. Al-Ta'ani,[49]
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R. Armendariz,[8] E.C. Aschenauer,[7] E.T. Atomssa,[35] R. Averbeck,[61] T.C. Awes,[51] B. Azmoun,[7] V. Babintsev,[24]
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Dec.18 (Thusday) I will present the FVTX trigger in PLHF PWG meeting.

M. Chiu,[7] I.J. Choi,[25,69] J.B. Choi,[10] R.K. Choudhury,[4] P. Christiansen,[40] T. Chujo,[64] P. Chung,[60] O. Chvala,[8]
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T. Dahms,[61] S. Dairaku,[34,55] I. Danchev,[65] K. Das,[20] A. Datta,[42] G. David,[7] M.K. Dayananda,[21] A. Denisov,[24]
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D.E. Fields,[48] M. Finger,[9] M. Finger, Jr.,[9] F. Fleuret,[35] S.L. Fokin,[33] Z. Fraenkel,[67,*] J.E. Frantz,[50,61] A. Franz,[7]
A.D. Frawley,[20] K. Fujiwara,[55] Y. Fukao,[55] T. Fusayasu,[47] C. Gal,[61] I. Garishvili,[62] A. Glenn,[37] H. Gong,[61]
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H. Iinuma,[31] Y. Ikeda,[64] K. Imai,[29,34,55] M. Inaba,[64] A. Iordanova,[8] D. Isenhower,[1] M. Ishihara,[55] M. Issah,[65]
D. Ivanischev,[54] Y. Iwanaga,[23] B.V. Jacak,[61] J. Jia,[7,60] X. Jiang,[38] J. Jin,[14] D. John,[62] B.M. Johnson,[7]
T. Jones,[1] K.S. Joo,[46] D. Jouan,[52] D.S. Jumper,[1] F. Kajihara,[12] J. Kamin,[61] S. Kaneti,[61] B.H. Kang,[22]
J.H. Kang,[69] J.S. Kang,[22] J. Kapustinsky,[38] K. Karatsu,[34,55] M. Kasai,[55,57] D. Kawall,[42,56] M. Kawashima,[55,57]
A.V. Kazantsev,[33] T. Kempel,[28] A. Khanzadeev,[54] K.M. Kijima,[23] J. Kikuchi,[66] A. Kim,[18] B.I. Kim,[32] D.J. Kim,[30]
E.-J. Kim,[10] Y.-J. Kim,[25] Y.K. Kim,[22] E. Kinney,[13] Á. Kiss,[17] E. Kistenev,[7] D. Kleinjan,[8] P. Kline,[61]
L. Kochenda,[54] B. Komkov,[54] M. Konno,[64] J. Koster,[25] D. Kotov,[54] A. Král,[15] A. Kravitz,[14] G.J. Kunde,[38]

1v1 [nucl-ex] 29 Apr 2014

PPG Chair: Shengli Huang (Vanderbilt) PPG Members: PPG Members: John Chin-Hao Chen(RBRC), ShinIchi Esumi(Tsukuba), Jiangyong Jia(Stony), Anne Sickles(BNL), Julia Velkovska(Vanderbilt), Paul Stankus (ORNL)

Observed v2 in dAu @ PHENIX

Minimum bias : dAu

Minimum bias : pp

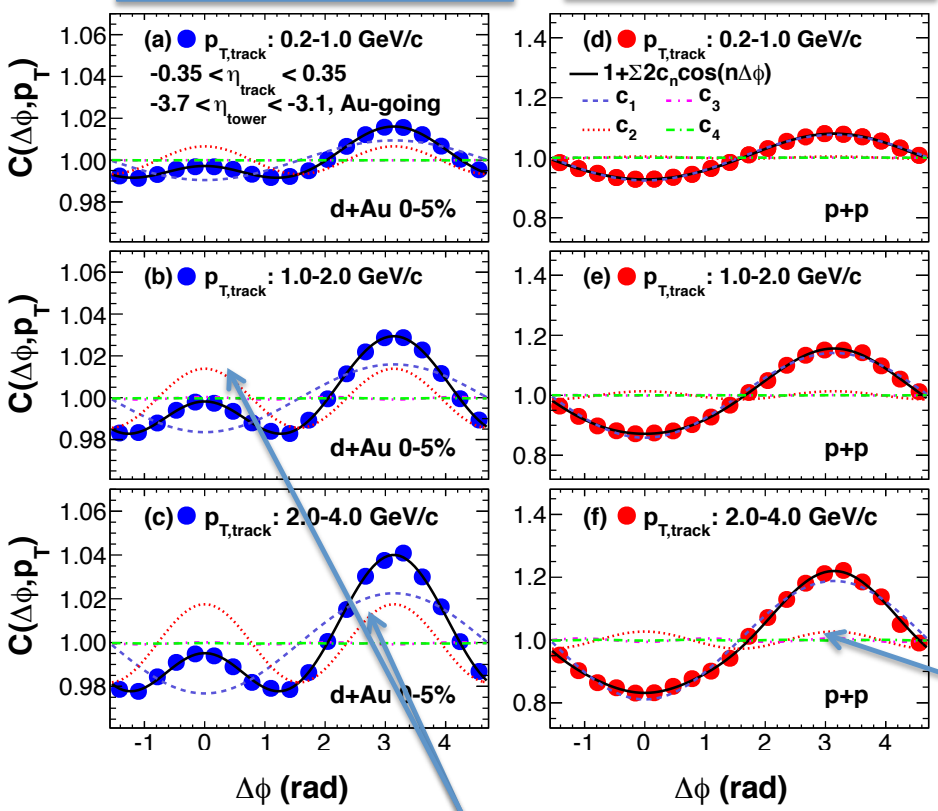
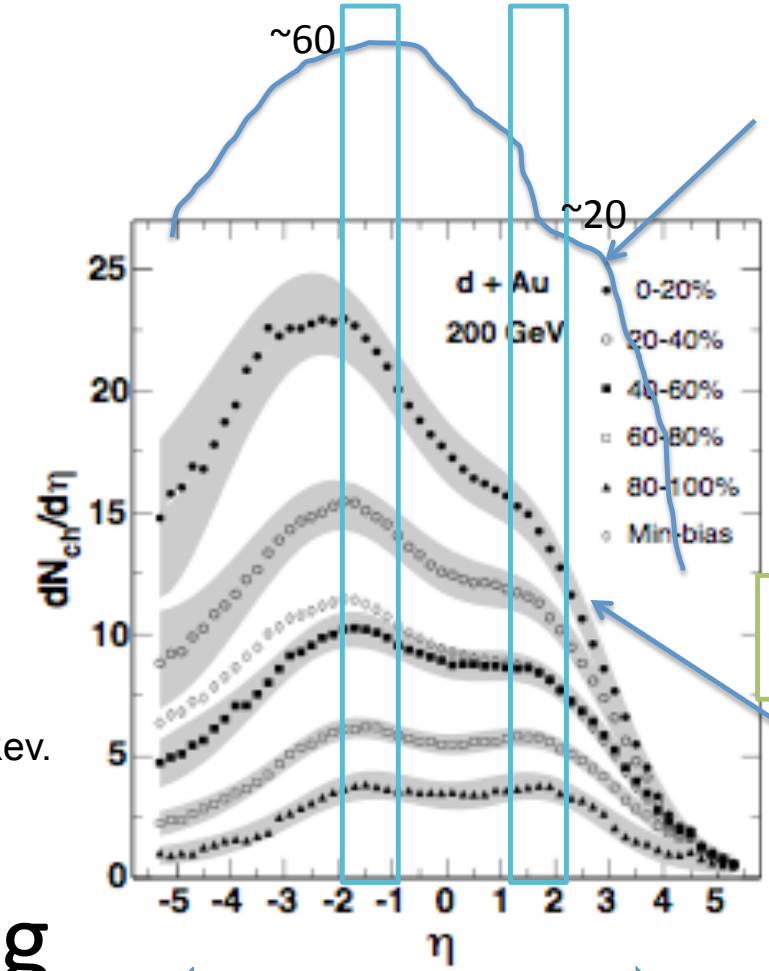


FIG. 1: The azimuthal correlation functions $C(\Delta\phi, p_T)$, as defined in Eq. 2, for track-tower pairs with different track p_T selections in 0%–5% central d+Au collisions (left) and minimum bias p+p collisions (right) at $\sqrt{s_{NN}} = 200$ GeV. From top to bottom, the track p_T bins are 0.2–1.0 GeV/c, 1.0%–2.0 GeV/c and 2.0%–4.0 GeV/c. The pairs are formed between charged tracks measured in the PHENIX central arms at $|\eta| < 0.35$ and towers in the MPC-S calorimeter ($-3.7 < \eta < -3.1$, Au-going). A near-side peak is observed in the central d+Au which is not seen in minimum bias p+p. Each correlation function is fit with a four-term Fourier cosine expansion; the individual components $n = 1$ to $n = 4$ are drawn on each panel, together with the fit function sum.

Elementary process (not flow)

v2 component (red curve)

Track Multiplicity vs. rapidity



For 0 ~ 5% centrality, track multiplicity is 20 in d-going and 60 in Au-going side in FVTX rapidity region.

For pp ~ 40 ?
We set trig threshold to be 30.

PHOBOS Phys. Rev. C72, 031901

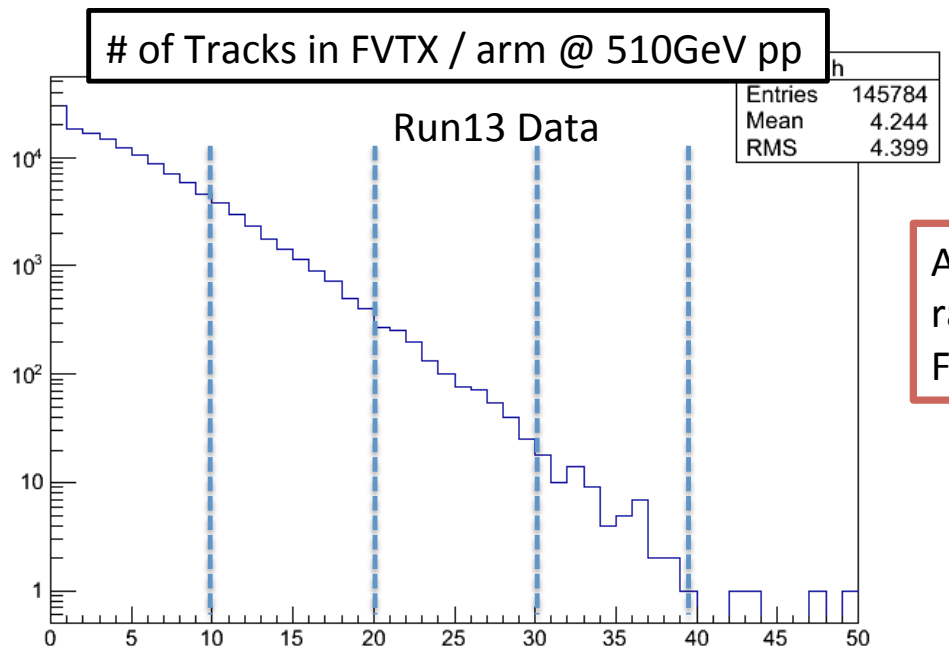
Au-going

d-going

Larger v_2 smaller

Required Rejection Power

# of Tracks / arm	> 0	> 10	> 20	> 30	> 40
Fraction in MB	100%	10%	0.7%	0.04%	0.008%
Rates in MB	1MHz	100kHz	7kHz	400Hz	80Hz
Required Rejection Power	1	10	142	2,500	12,500



Assuming BBC rate of 1MHz, rates for # of tracks > 30 in FVTX is about 400Hz at 500GeV.

Key Features to observe Ridge

- 0 ~ 5% centrality => **20 ~ 60 tracks** / rapidity unit
- pp is symmetric collision, so take average 40 as the signal region.
- The higher the multiplicity, collective motion effect expected to be larger.
- **80 Mevents** Cental dA Events in Run8

Key Features to observe Ridge

- 0 ~ 5% centrality => **20 ~ 60 tracks** / rapidity unit
- **80 Mevents** Cental dA Events in Run8

Goal of Run 15

- FVTX North and South separate trigger bits
- Assuming 100Hz per arm (Total 200Hz)
- 200Hz x 3600s x 24h x 7days x 9 weeks x 30% DAQ time ~ 300M high multiplicity events

$$\#\,trigger(\#\,track > 30) = \#\,trigger \times purity$$

-> Purity of the trigger is the issue

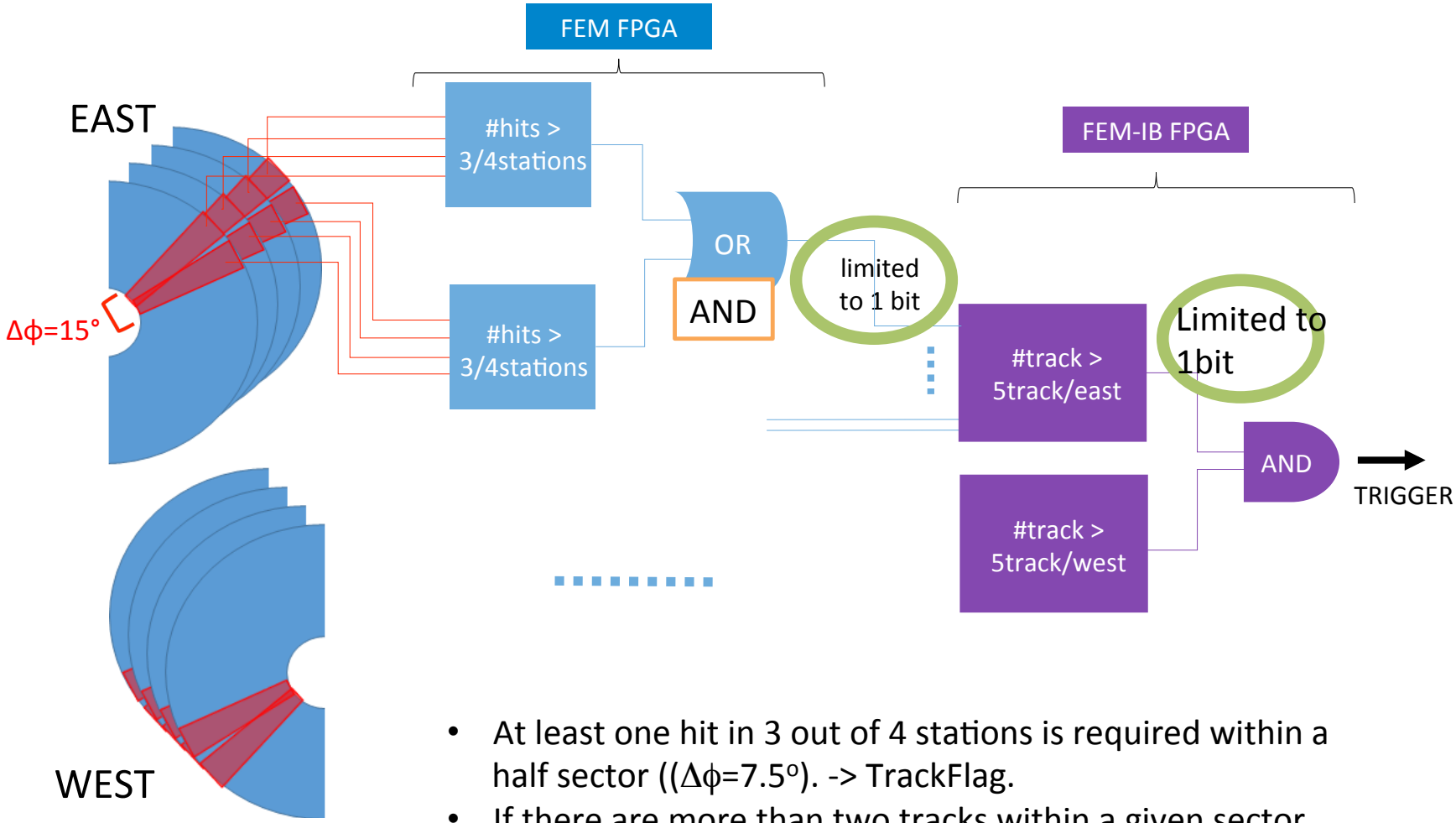
Note

- Trigger efficiency, rejection power and prescale factor do not affect on this total triggered event estimation, because constant 100Hz is assumed.

Goal of Run 15

- FVTX North and South separate trigger bits
- Assuming 100Hz per arm (Total 200Hz)
- 200Hz x 3600s x 24h x 7days x 9 weeks x 30% DAQ time ~ 300M high multiplicity events

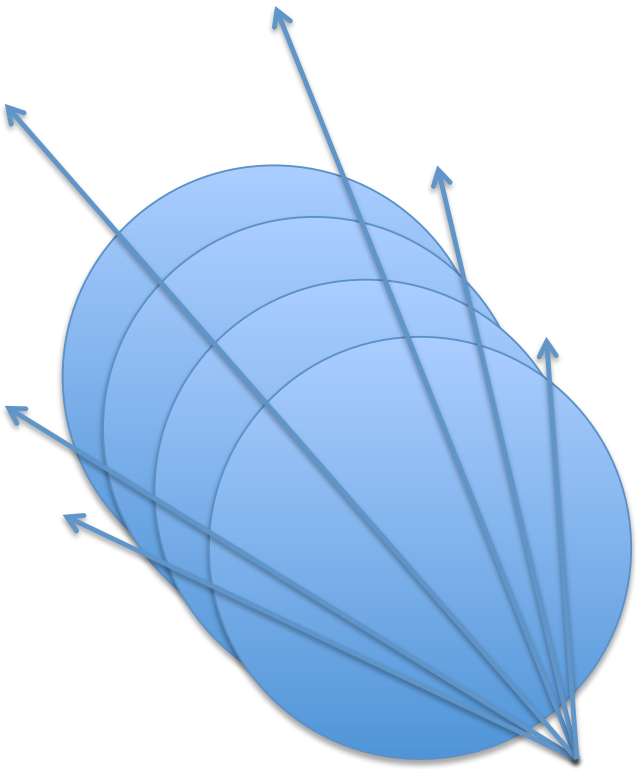
FVTX TRIGGER TERMINOLOGY



- At least one hit in 3 out of 4 stations is required within a half sector ((Δϕ=7.5°). -> TrackFlag.
- If there are more than two tracks within a given sector (Δϕ=15°), the second one won't be counted.

We Request Two Trigger bits (one per arm) for FVTX trigger.

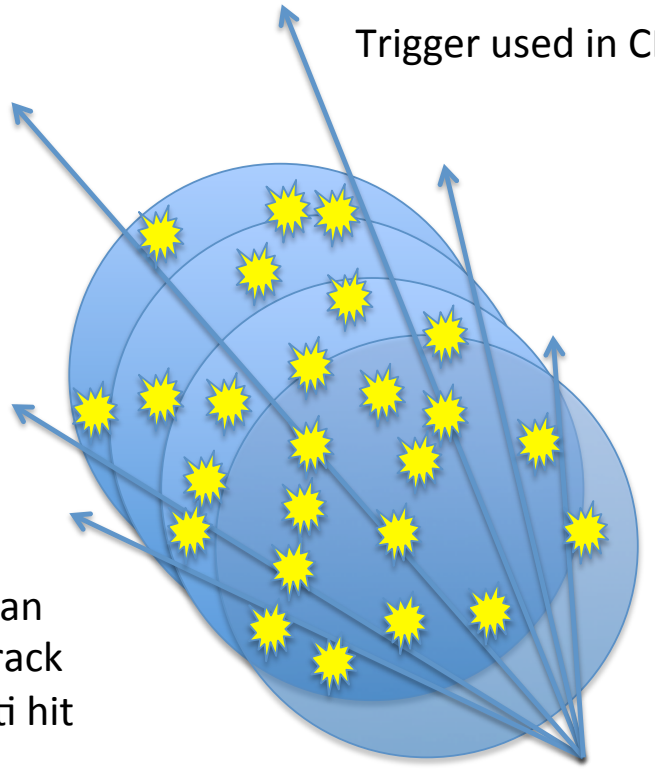
Trigger Concept



Multi Track

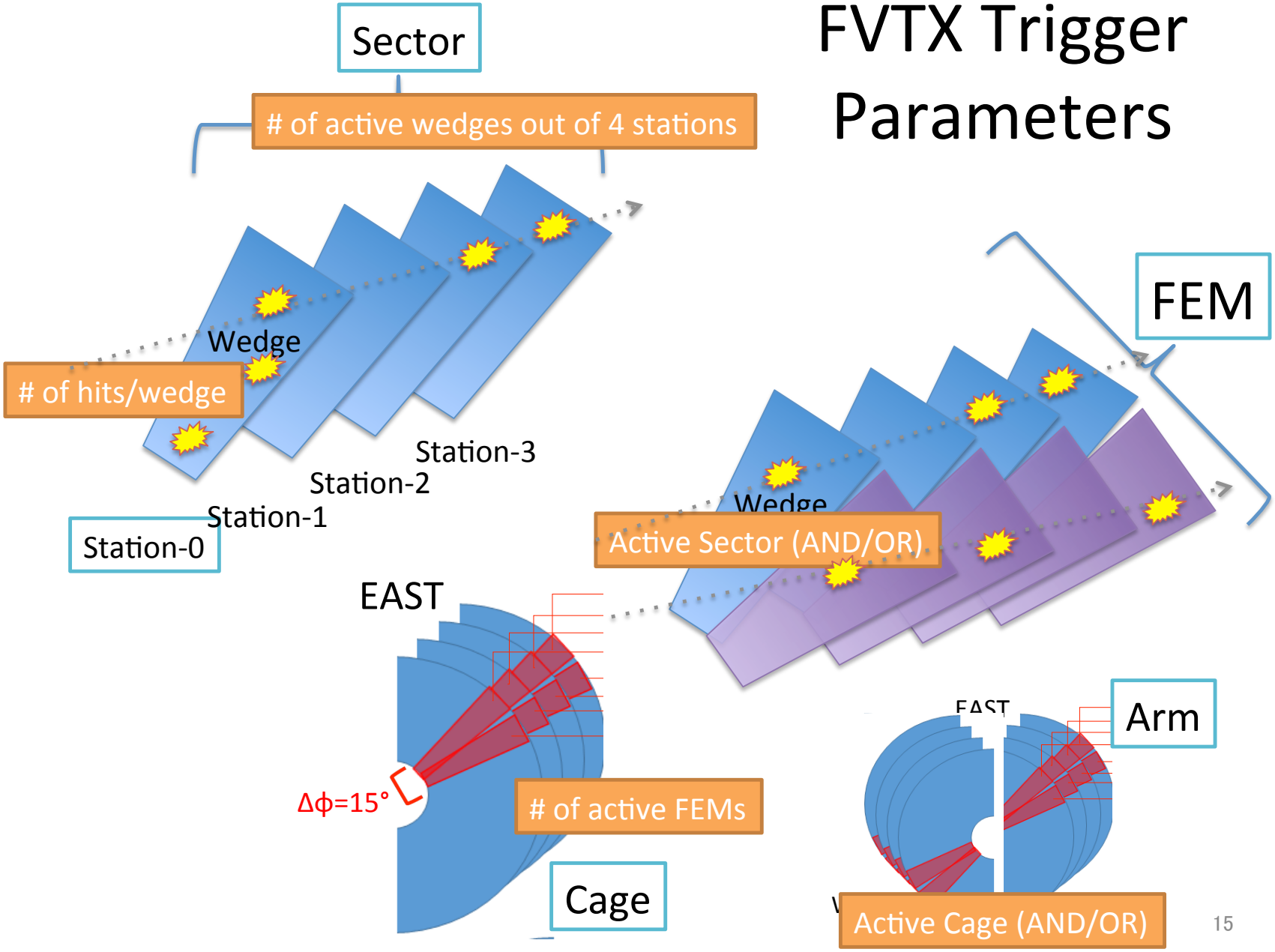
How well we can trigger multi track events by multi hit algorithm?

Trigger used in CMS

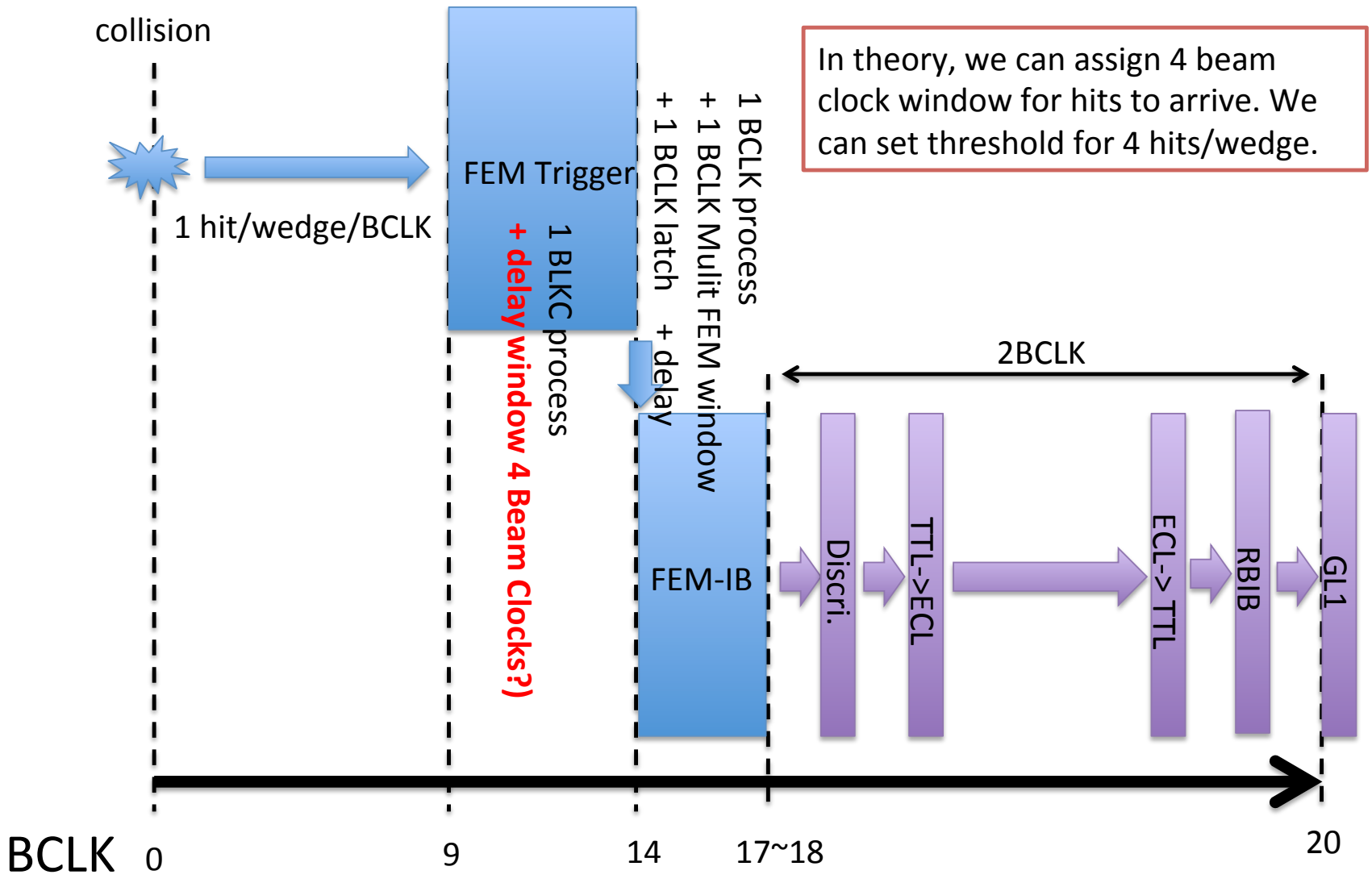


Multi Hit

FVTX Trigger Parameters



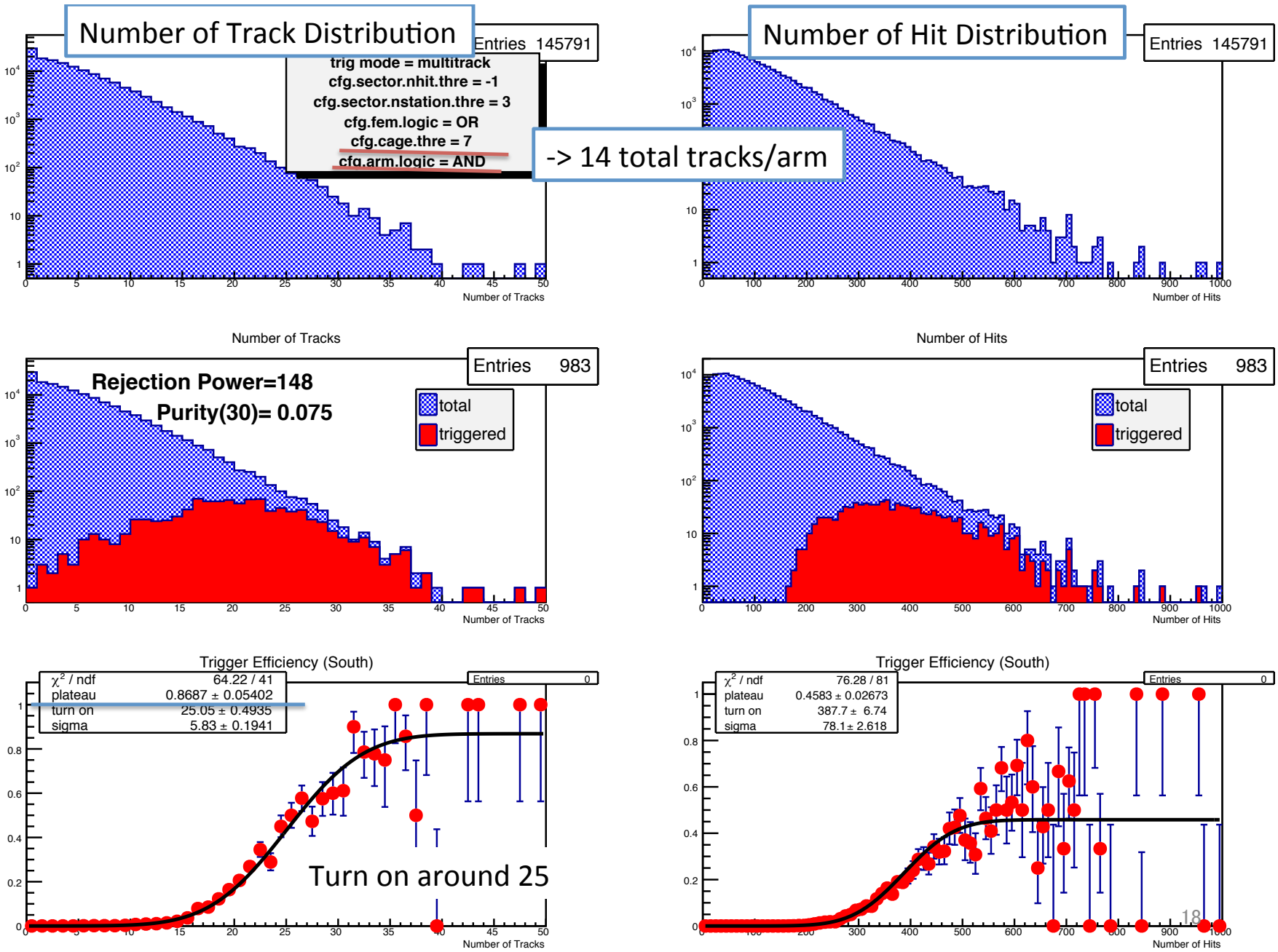
FVTX Trigger Timing Chart

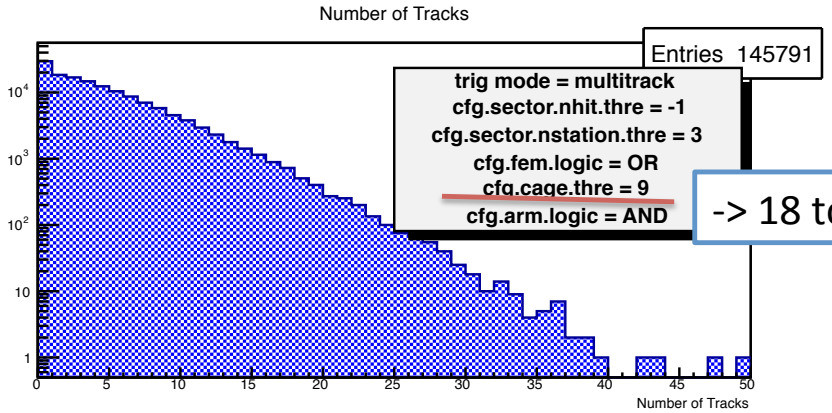


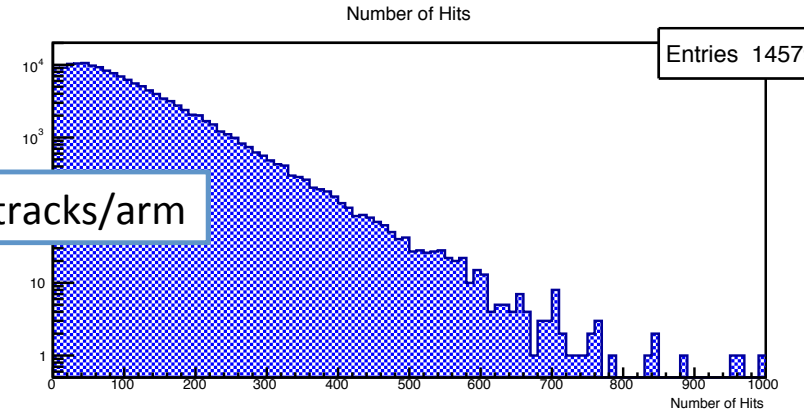
In theory, we can assign 4 beam clock window for hits to arrive. We can set threshold for 4 hits/wedge.

Run13 pp data was used. #of tracks could be lower in 200GeV.

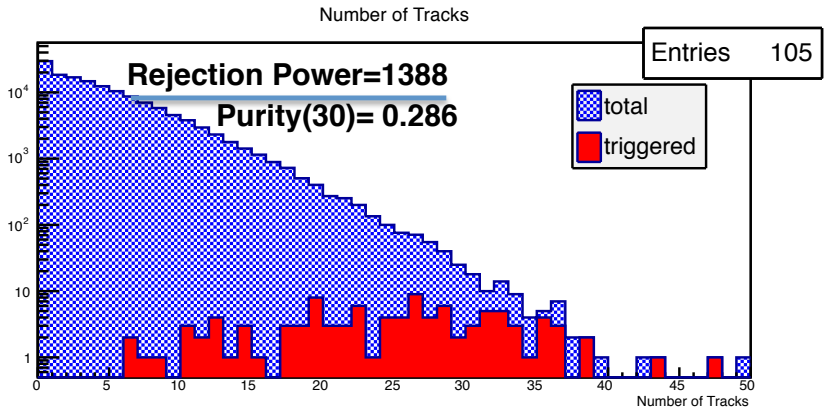
TRIGGER PERFORMANCE

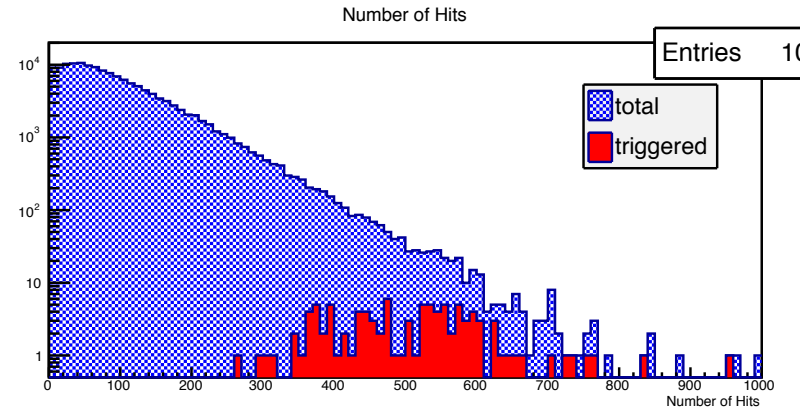

Number of Track Distribution
Entries 145791
trig mode = multitrack
cfg.sector.nhit.thre = -1
cfg.sector.nstation.thre = 3
cfg.fem.logic = OR
cfg.cage.thre = 7
cfg.arm.logic = AND
-> 14 total tracks/arm
Number of Hit Distribution
Entries 145791
Number of Tracks
Number of Hits
Entries 983
Rejection Power=148
Purity(30)= 0.075
total
triggered
Trigger Efficiency (South)
χ² / ndf 64.22 / 41
plateau 0.8687 ± 0.05402
turn on 25.05 ± 0.4935
sigma 5.83 ± 0.1941
Turn on around 25
χ² / ndf 76.28 / 81
plateau 0.4583 ± 0.02673
turn on 387.7 ± 6.74
sigma 78.1 ± 2.618

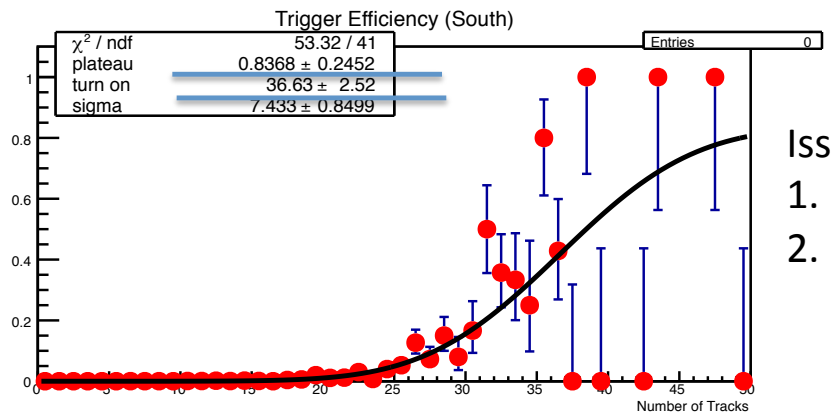




-> 18 total tracks/arm

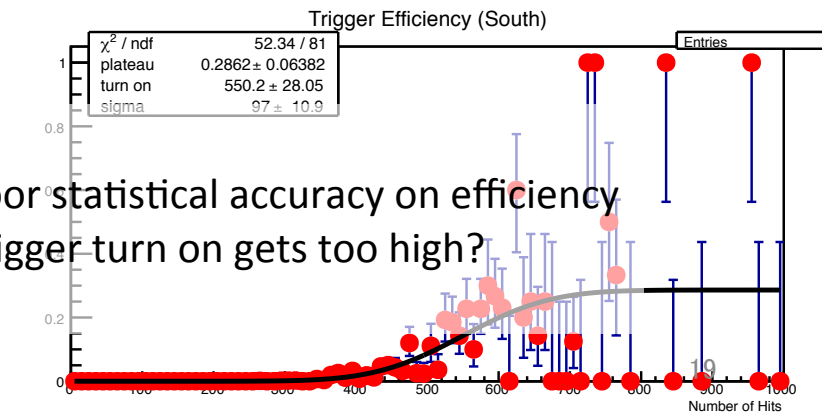






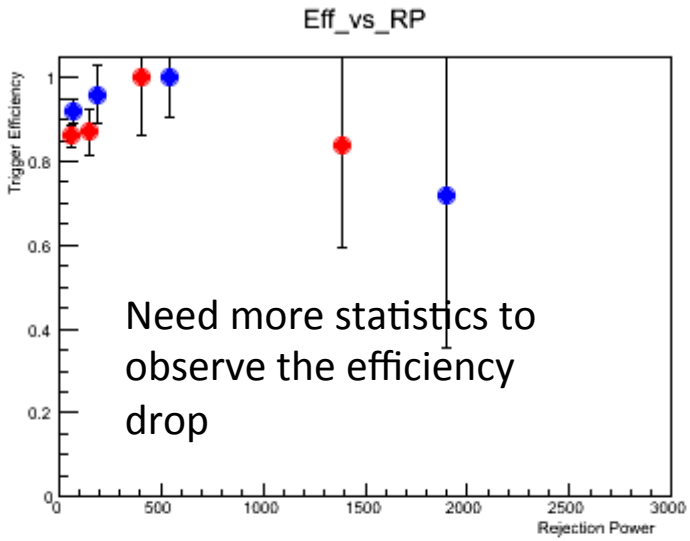
Issues

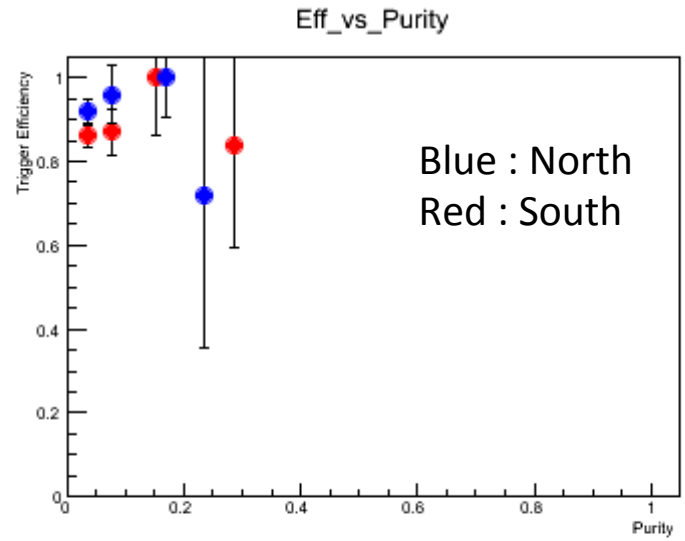
1. Poor statistical accuracy on efficiency
2. Trigger turn on gets too high?

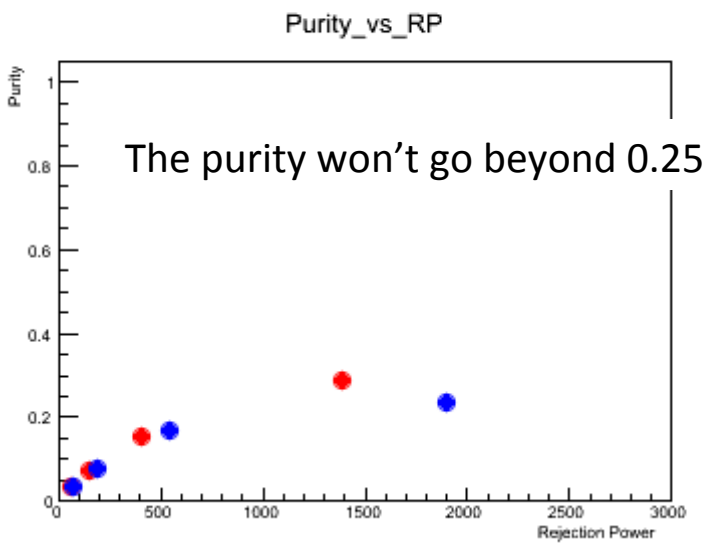


Performance

	South					North				
*cage_thre	Eff	dEff	RP	Purity	FOM	Eff	dEff	RP	Purity	FOM
6	0.86	0.026	61	0.037	1.92	0.92	0.028	70	0.035	2.25
7	0.87	0.054	148	0.075	9.68	0.96	0.067	185	0.076	13.54
8	1.00	0.136	404	0.153	61.7	1.00	0.097	541	0.171	92.51
9	0.84	0.245	1388	0.286	331	0.72	0.363	1893	0.234	317

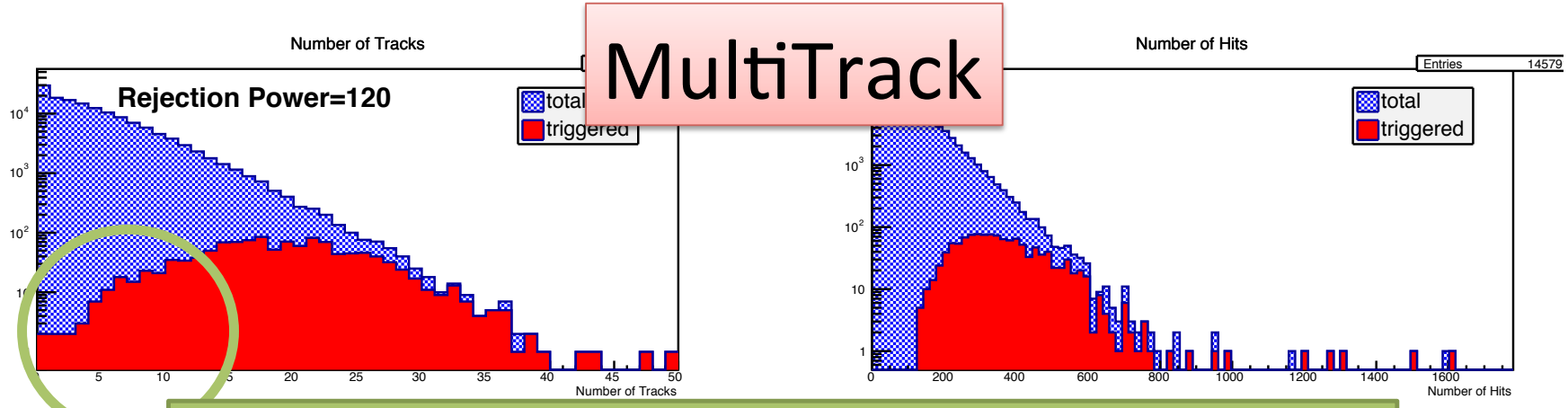






trig mode = multitrack
cfg.sector.nhit.thre = -1
cfg.sector.nstation.thre = 3
cfg.fem.logic = OR
cfg.cage.thre = 6 ~ 9
cfg.arm.logic = AND

Multi-Track vs. Multi-Hit Algorithm



Low track events are more suppressed in Multi-Track than Multi-Hit Mode

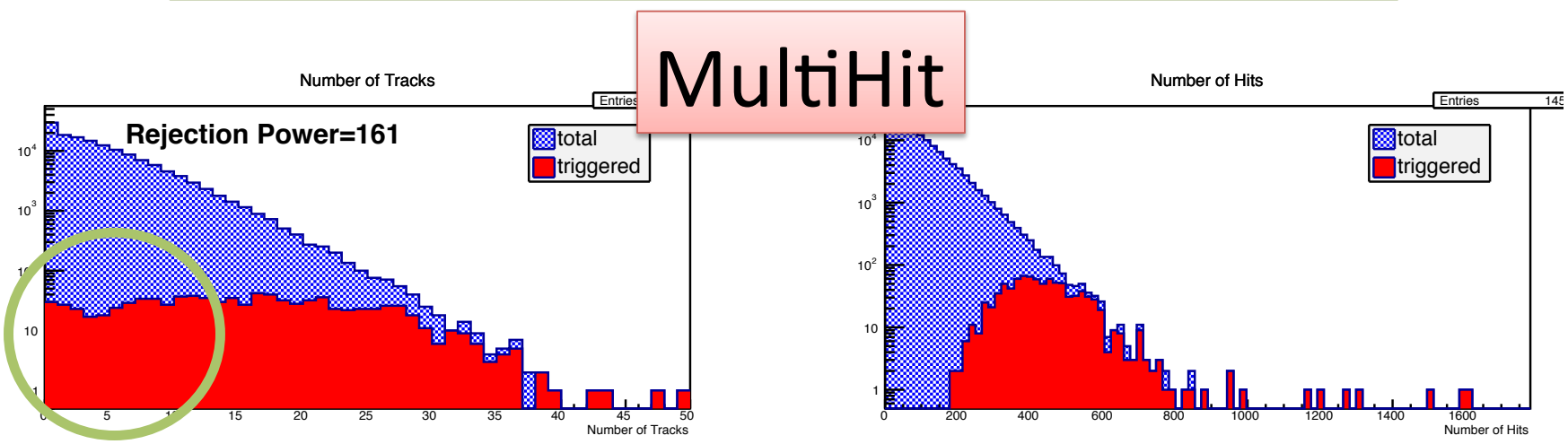
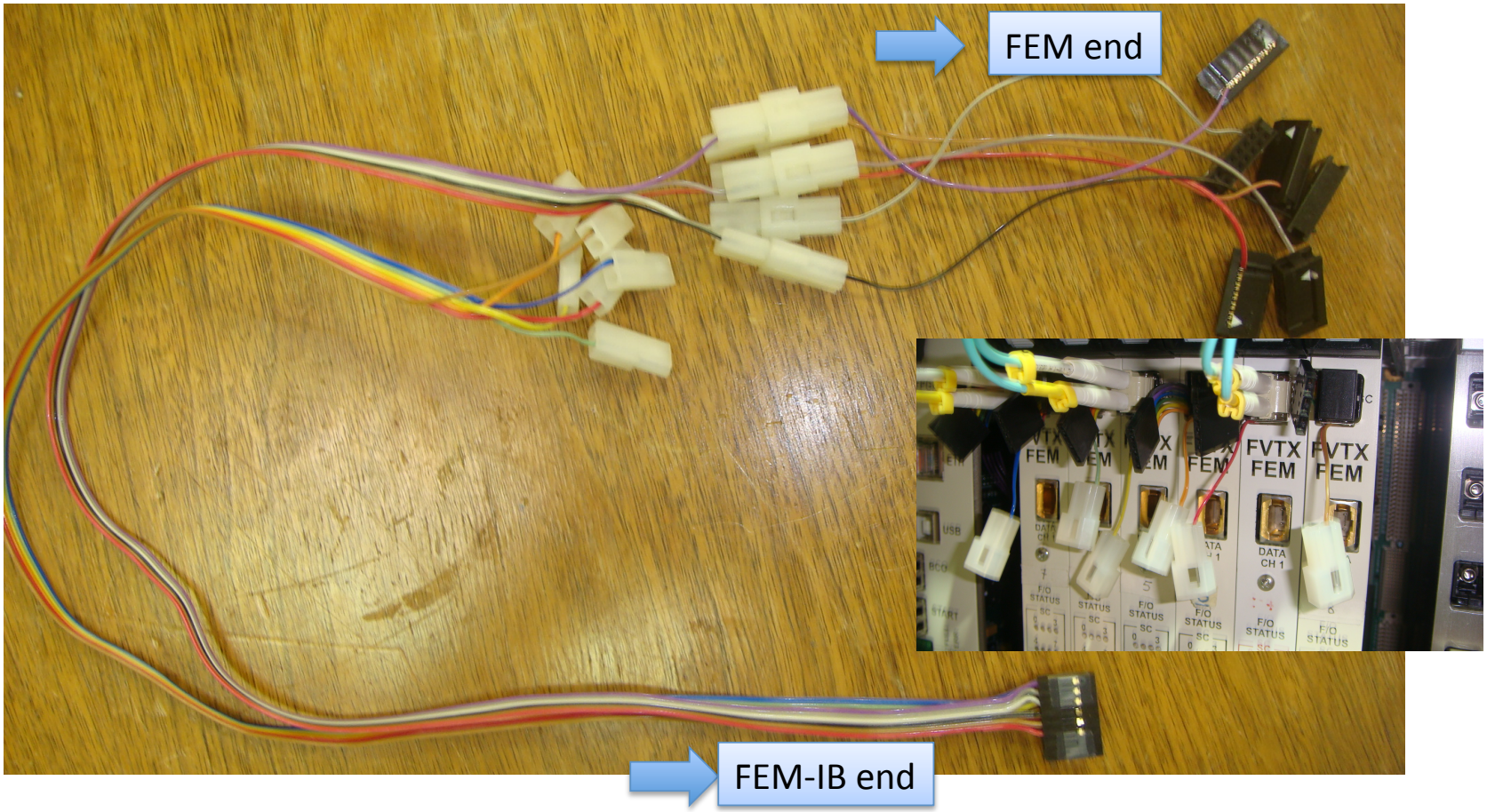


Figure of Merit

- There is some correlation between purity and rejection power. The higher the rejection power, the higher the purity.
- The present purity 0.25 scales down expected total events from 300M to 80M.
- So far, the best performance is provided by tighter condition with higher rejection power with smaller prescale.
- Need to explore even tighter condition with high statistics data sample. (x10 stat data production is completed).
- Combination trigger with multi-track and multi-hit algorithm will be explored.

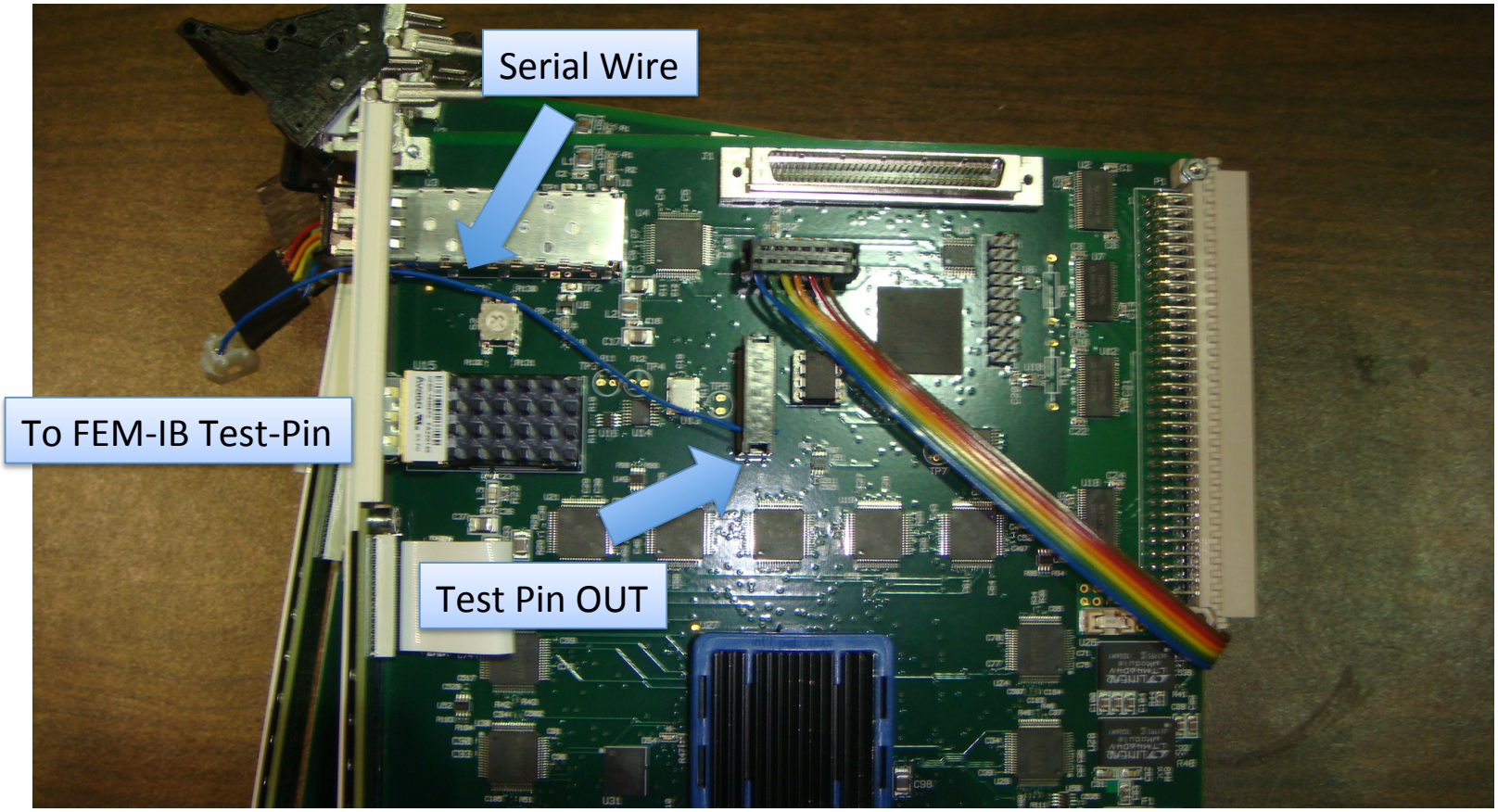
HARDWARE STATUS

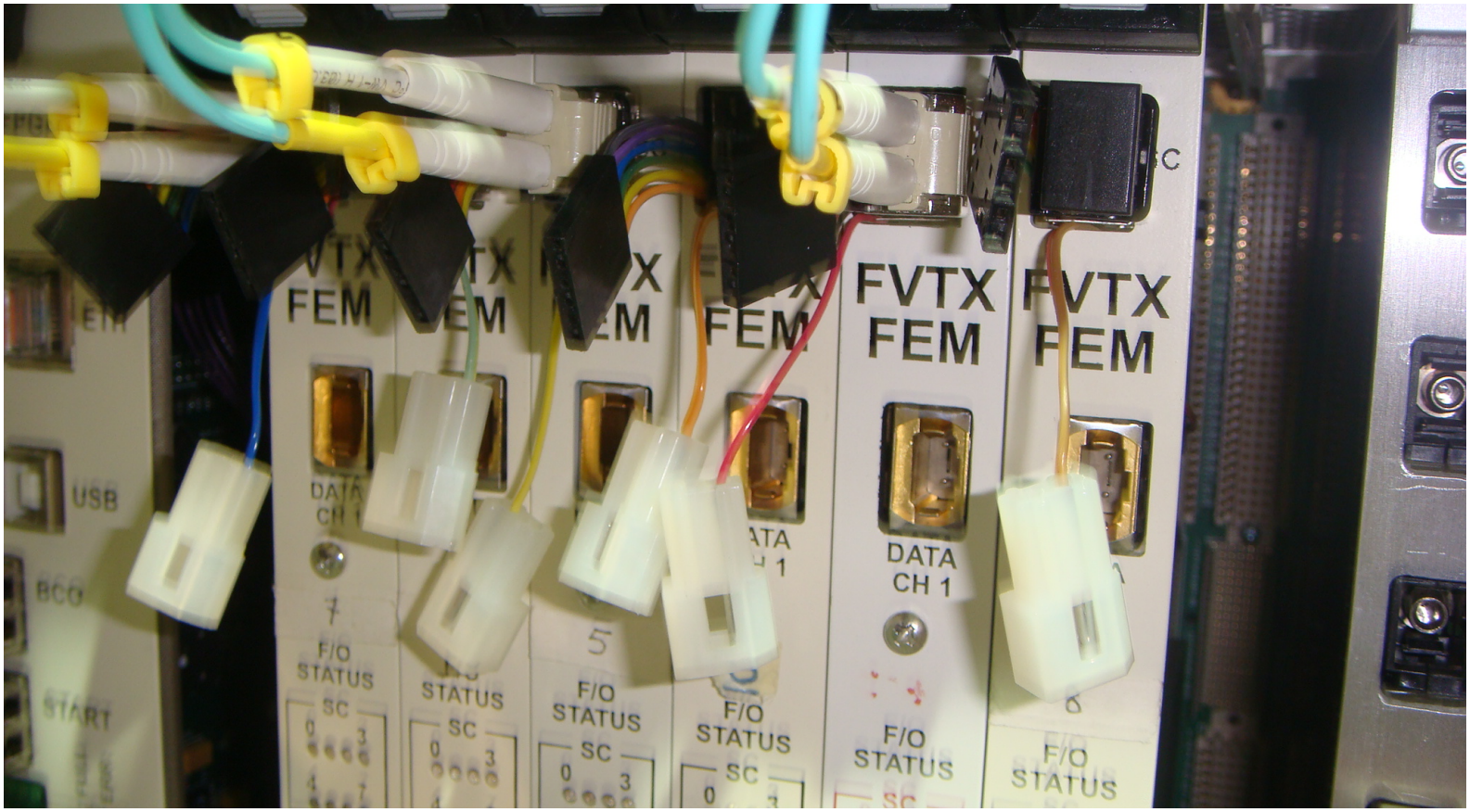
FEM-IB Cable



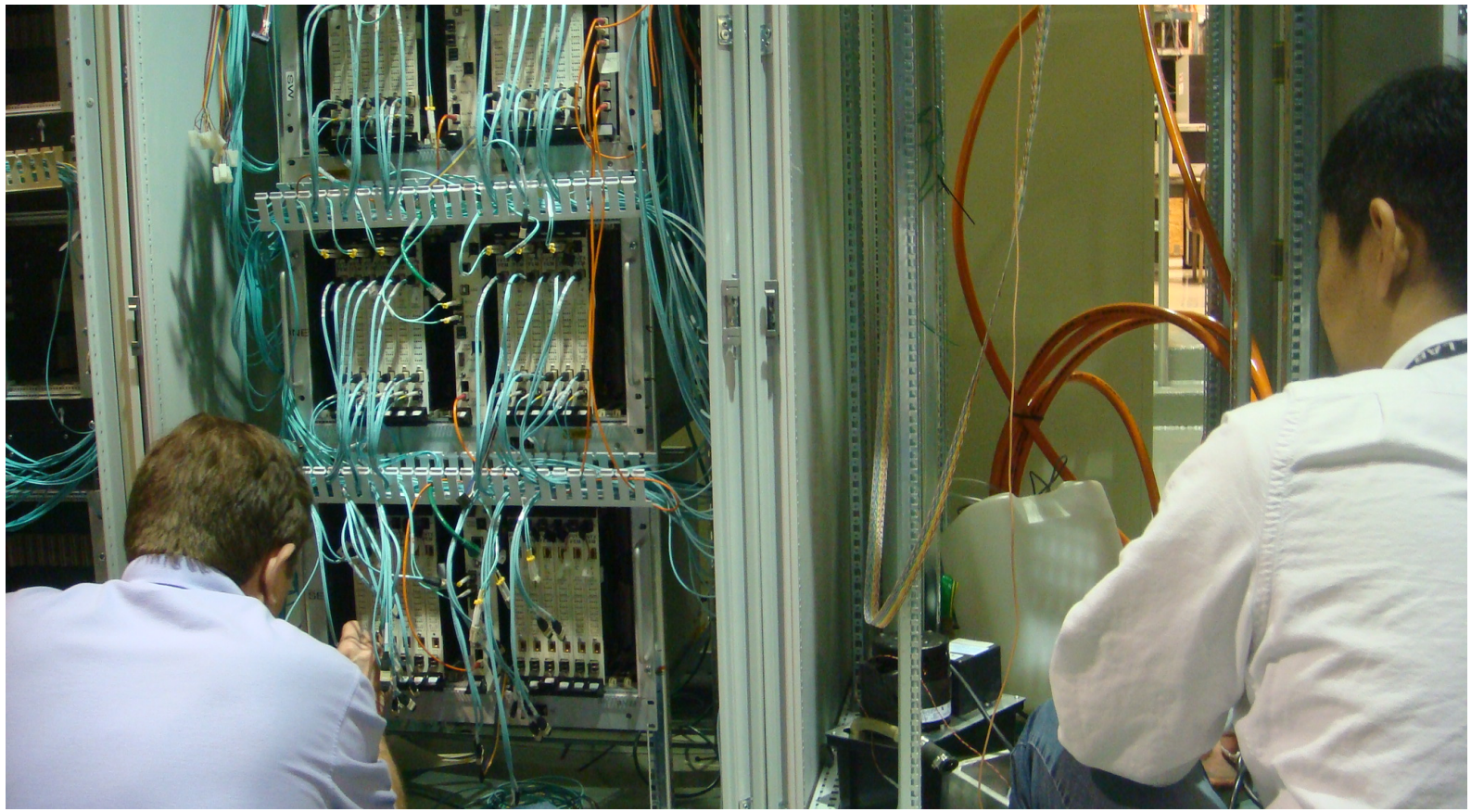
4 FEM-IB cables were made and they are ready to be installed.
Better wait until January when Eric comes back?

Trigger Cable @ FEM Board



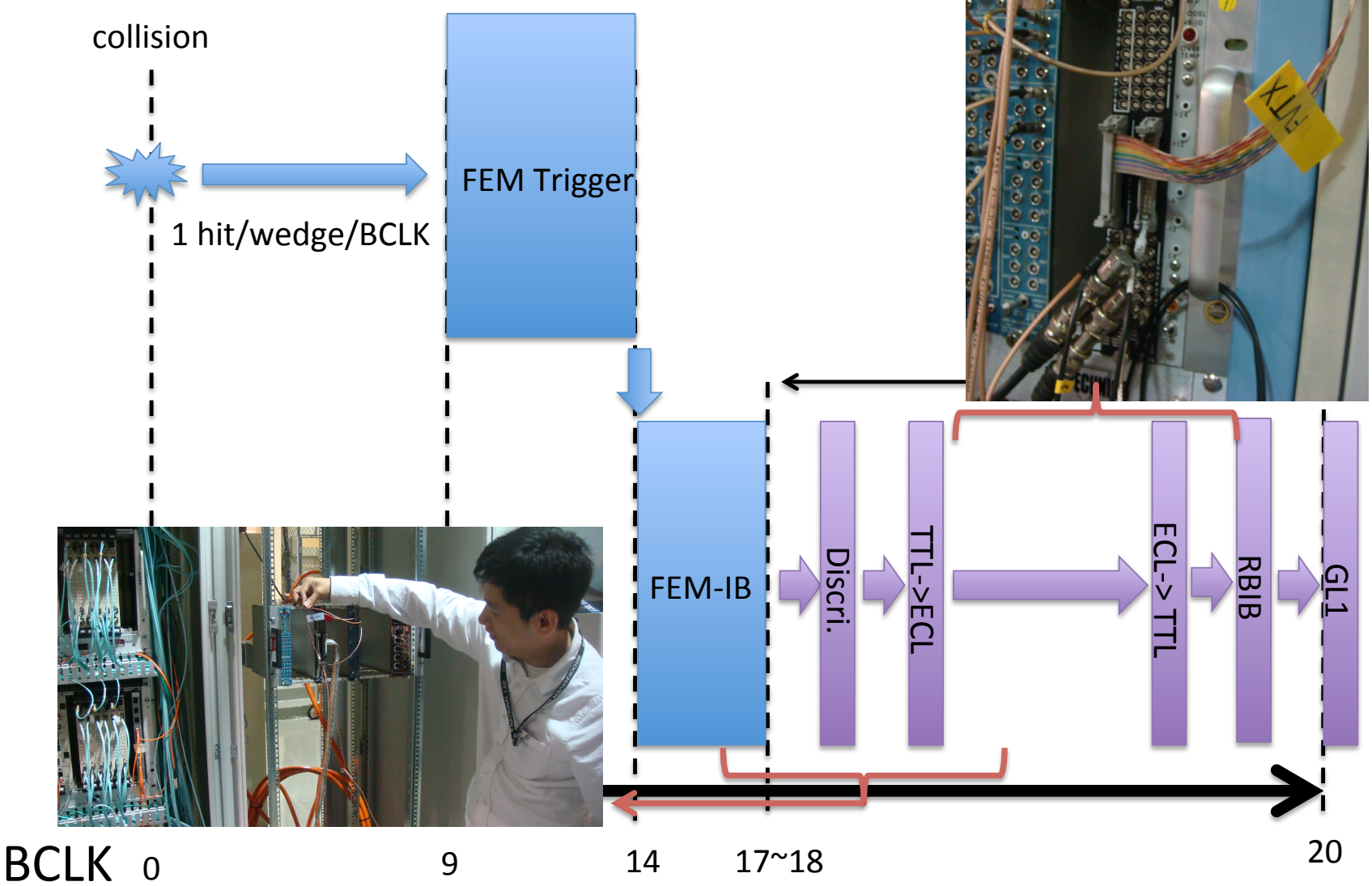

FVTX
FEM
FVTX
FEM
DATA
CH 1
F/O
STATUS
SC
USB
BCO
START

FEM -> FEM-IB Installation



November 5th, 2014

FEM-IB -> GL1


collision
1 hit/wedge/BCLK
FEM Trigger
FEM-IB
Discri.
TTL->ECL
ECL-> TTL
RBIB
GL1
BCLK
0
9
14
17~18
20

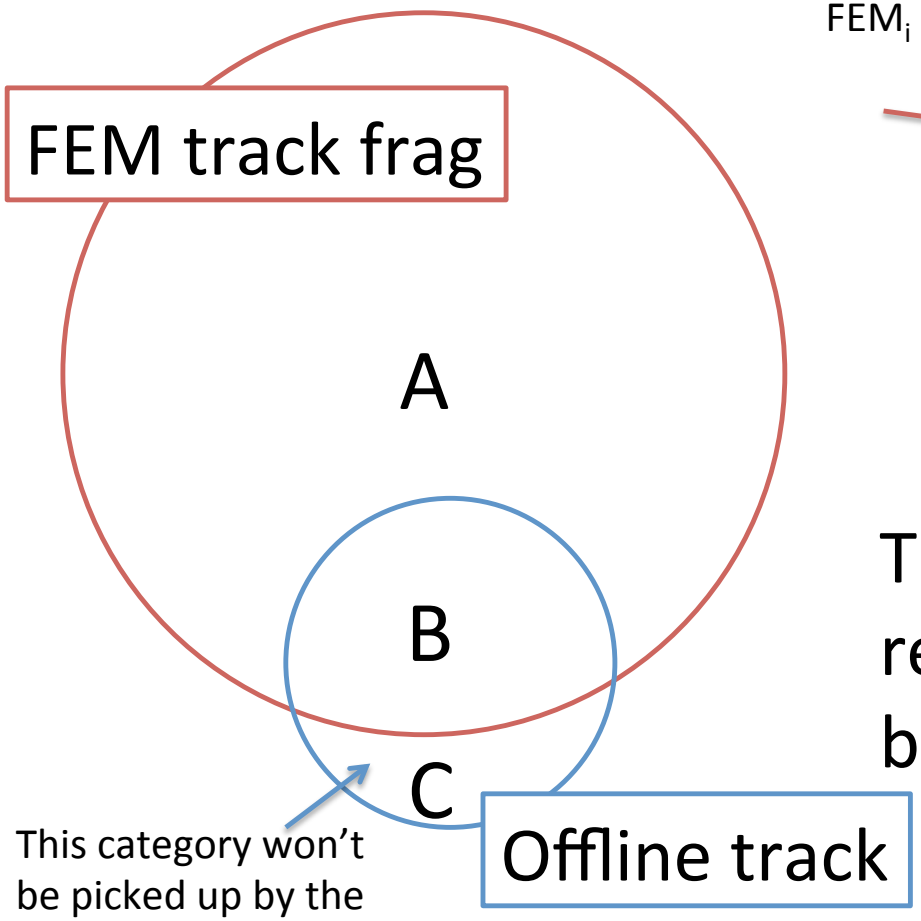
Works to be done

- Optimization of trigger parameters.
- Trigger parameters control via slow control (Aaron).
- Trigger efficiency measurement at test bench (Toru)
- Chain test with multiple FEMs at 1008.
- Trigger Timing measurement with cosmic.

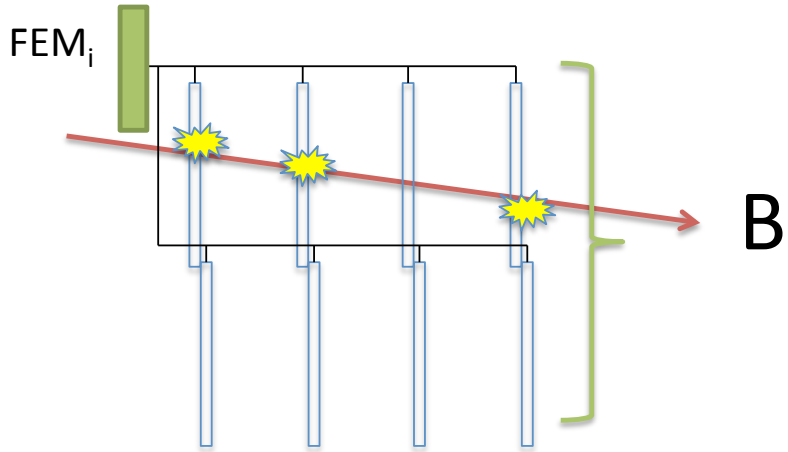
BACKUPS

DIFFERENCE BETWEEN ONLINE AND OFFLINE TRACK

Difference in Track Criteria

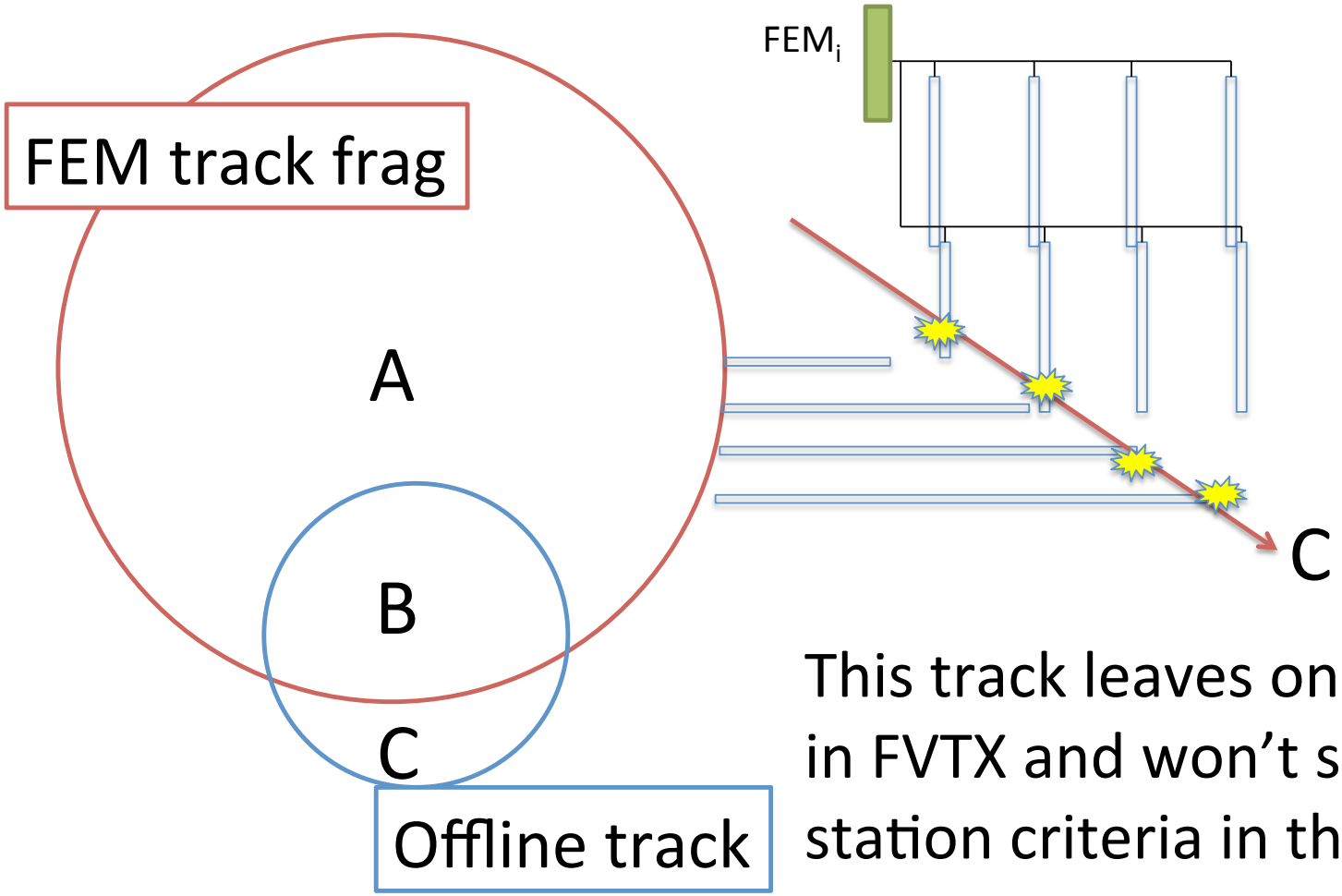


This category won't be picked up by the trigger -> cause of survival tracks



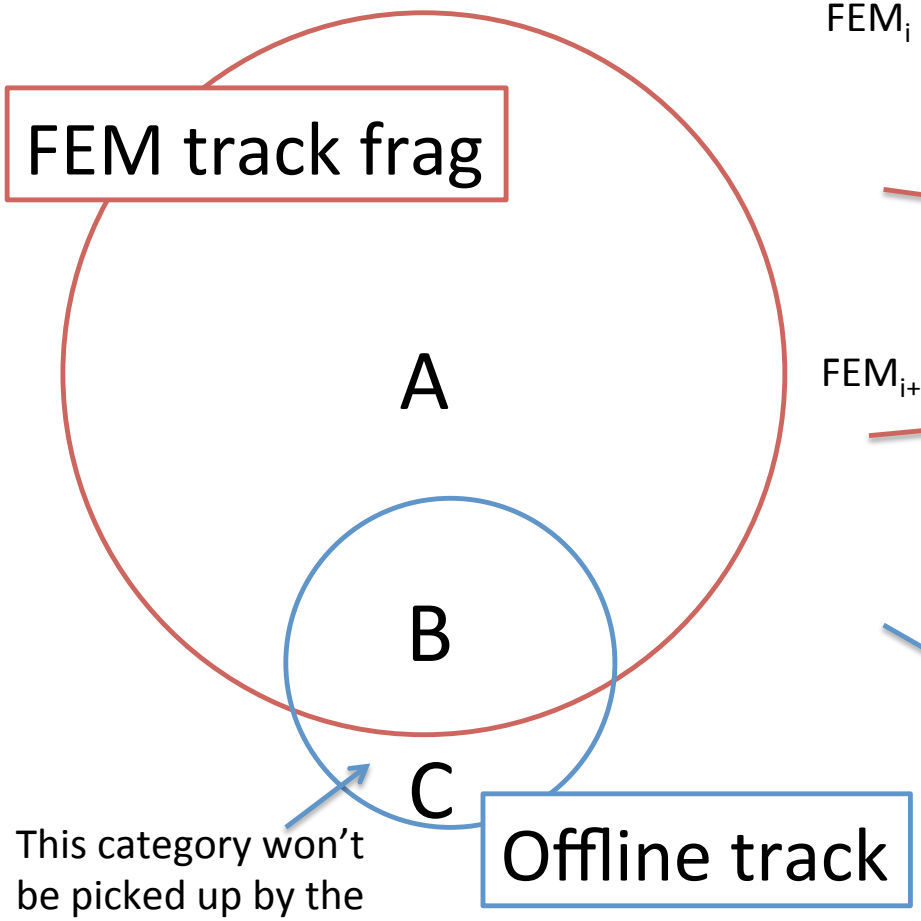
This track will be recognized as track in both online and offline.

Difference in Track Criteria

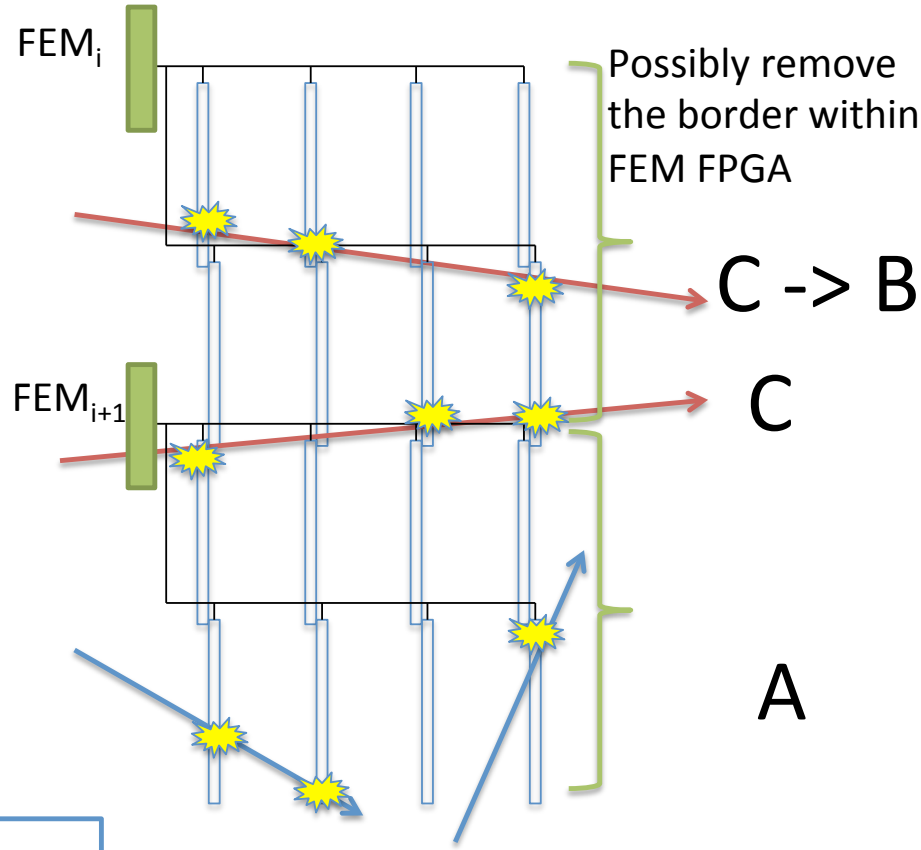


This track leaves only 2 hits in FVTX and won't satisfy ¾ station criteria in the trigger

Difference in Track Criteria

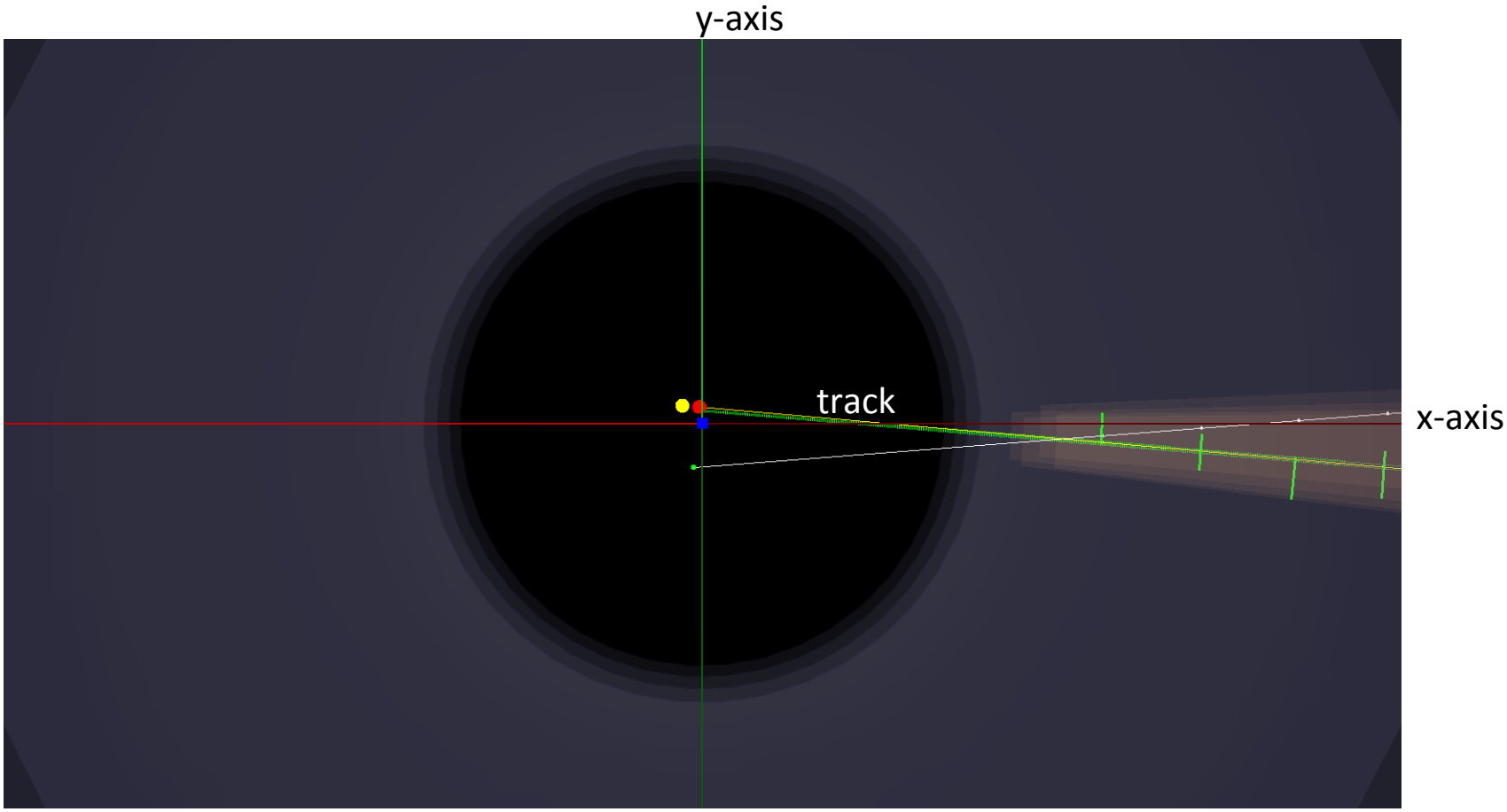


This category won't be picked up by the trigger -> cause of survival tracks

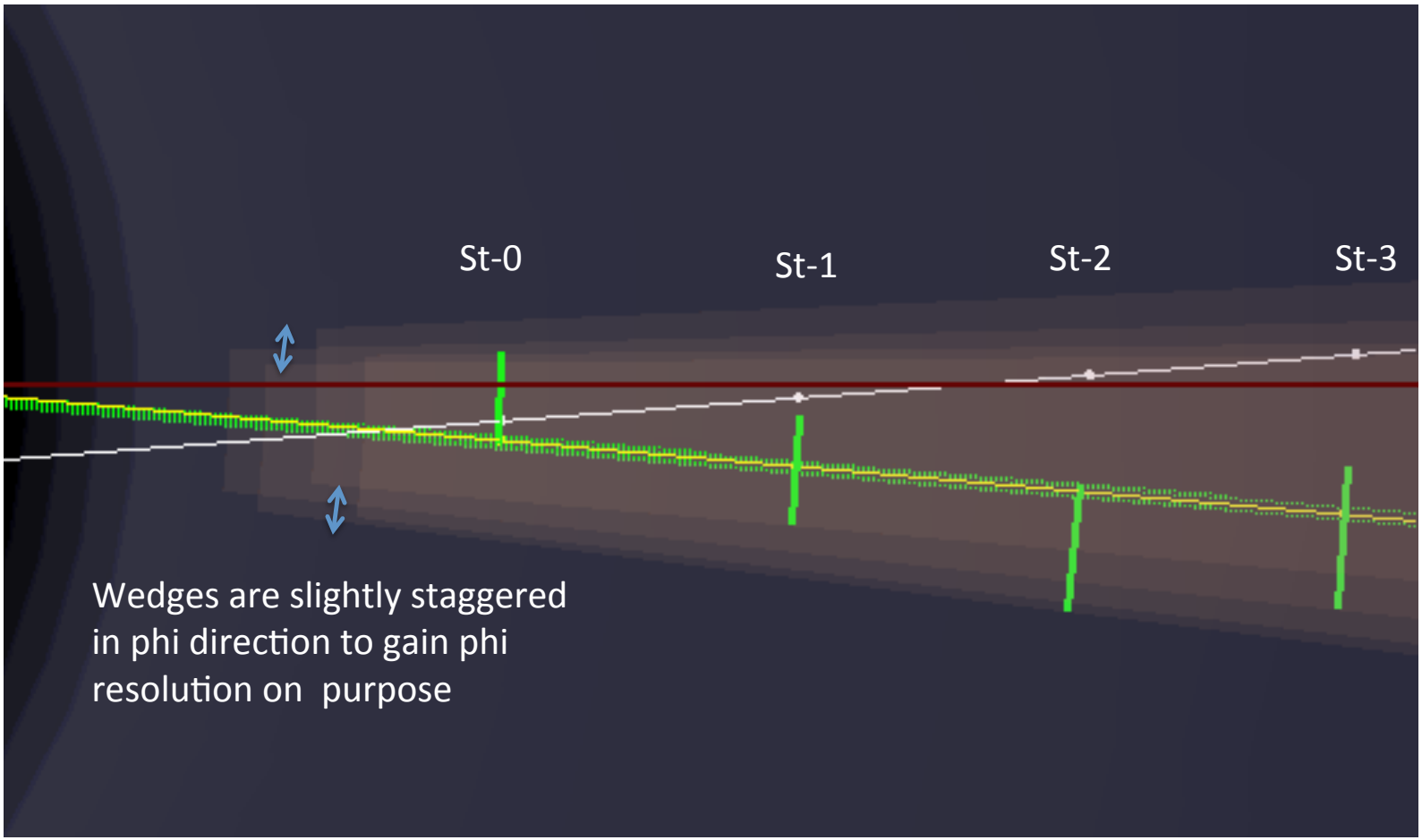


- This differences can cause small fraction survives FEM track frag>*x* trigger condition

FVTX Alignment



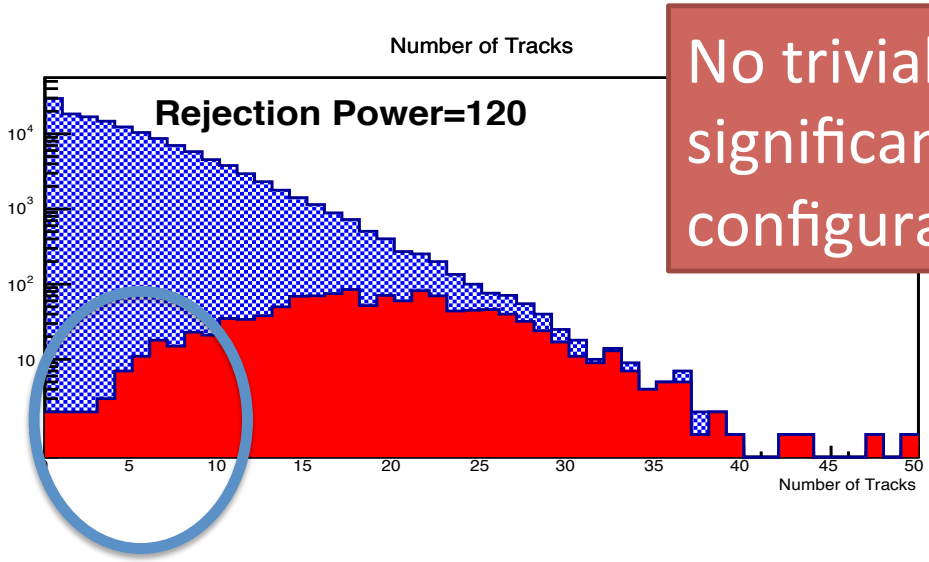
FVTX Event Display



This mismatch of phi angle between stations enhances “category C”

Low # Track Leak Cause Summary

1. Online trigger won't recognize track which crosses boarder between sectors
2. Online trigger won't have VTX hit information.
3. FVTX stations are staggered by a little bit in phi direction



No trivial solutions without significant revise in hardware configuration

Figure of Merit

Signal = number of high multi-track events

$$RP = \frac{BBC}{trigger}$$

$$\frac{BBC}{RP \times prescale} = trigger = 150Hz$$

$$prescale = \frac{BBC}{150Hz \times RP} = \frac{1.5MHz}{150Hz \times RP} = \frac{10^4}{RP}$$

Figure of Merit

$$Signal = \frac{trigger \times efficiency \times purity}{prescale} = \frac{trigger \times effiicency \times purity \times RP}{10^4}$$

Assuming "trigger" rate is fixed to be 100 ~ 200Hz/arm, then the number of signal is defined as multiplicative function of the efficiency, purity, and RP.