

FCS Trigger Status

Web document :	https://www.star.bnl.gov/protected/spin/akio/fcs/index.html
Mapping :	https://www.star.bnl.gov/protected/spin/akio/fcs/index.html#mapping
Triggering :	https://www.star.bnl.gov/protected/spin/akio/fcs/trigger.html
EPD as PRS :	https://www.star.bnl.gov/protected/spin/akio/fcs/epd.htm

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FCS Trigger Algorithm

1 DEP=32ch=4x8 tower

Stage-0 Time bin sum, Ped Sub,
Apply ET and SiPM/FEE gain

Stage-1 makes 8 of 2x2 sums

Stage-2 makes overlapping 4x4 sums

Match Ecal4x4 – Hcal4x4

Match Ecal4x4 – EPD with mask

EM Trigger = $H_{4x4} < E_{4x4} * \text{RATIO_THR}(=0.25)$

Had Trigger = $H_{4x4} > E_{4x4} * \text{RATIO_THR}(=0.25)$

ELE Trigger = EM Trigger * (PRES * Mask)

GAM Trigger = EM Trigger * !(PRES * Mask)

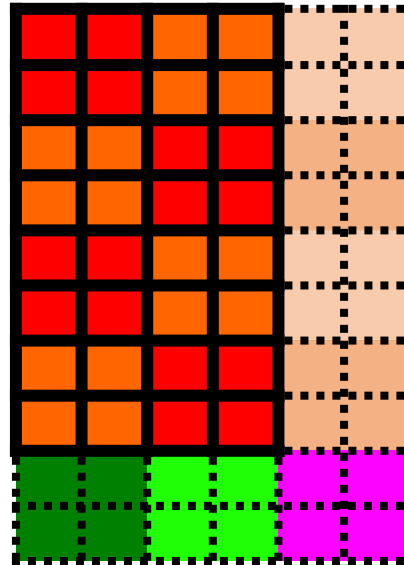
JET trigger = Ecal + Hcal Jet Pacht

Cosmic = Total sum of Ecal and Hcal separately

Apply thresholds on those 6 triggers

Stage-3 North OR South for singles triggers

North AND South for doubles triggers



Possible Further Optimizations

- Ecal4x4 – Hcal4x4 match
 - Closest (current)
 - Best of 4 nearby Hcal 4x4?
- EPD Mask (see later slides)
- North-South coincidence
 - Simple N&S (current)
 - Divide by geometry to avoid triggering on jet heading N-S gap
- Jet trigger
 - 3 (Top, Mid, Bottom) JP (current)
 - Eta division?
- How many thresholds for each trigger?

We have both **C++** and **VHDL** codes in CVS:

https://www.star.bnl.gov/cgi-bin/protected/cvsweb.cgi/StRoot/RTS/src/TRG_FCS/

This will be the document & bit checker & trigger emulator for MC

Selecting bit ranges at trigger stages

Stage	# of bit (Max)	E [GeV/cou nt]	ET @ near beam [MeV / Count]	ET @ far corner [MeV / Count]
Total Pulse (16 time bin) (100% integral)	16 bit (65k) 32k <= 180GeV	0.0053		
Peak Time bin (1/8 integral)	12 bit (4k) 4k == 180GeV	0.045		
8 Time bin Sum (~75% integral)	15 bit (33k) 26k <= 180GeV	0.0070	0.24711 (26k= 6.4GeV)	1.47035 (26k=38.2GeV)
4.6 bit ET*GainCorr	19 bit (524k)		0.24711 (26k= 6.4GeV)	0.24711 (156k=38.2GeV)
2x2 Sum	21 bit (2097k)		0.24711 (26k=6.4GeV)	0.24711 (156k=38.2GeV)
Cut top 6 bit And bottom 7 bit	8 bit (255)		31.6 MeV/count (202= 6.4GeV)	31.6 MeV/count (255=8.0 GeV)
Cut top 4 bit And bottom 5 bit	12 bit (4k)		7.9MeV / count (808 = 6.4GeV)	7.9MeV / count (4k = 32 GeV)

EPD numbering :

PP = 1~12

TT = 1~31 (0 has no tile)

FCS numbering :

NS = 0 (north) ~ 1(south)

Row = 1 (top) ~ 12(bottom)

Col = 1 (inside) ~ 16 (outside)

DEP = 0 (Row1&2) ~ 5(Row11&12)

Id = (Row-1)*16 + Col-1

= DEP*32 + ch

One PP-Odd(16ch) or PP-Even (15ch)

= FEEBd(16ch)

= Signal Cable(16ch)

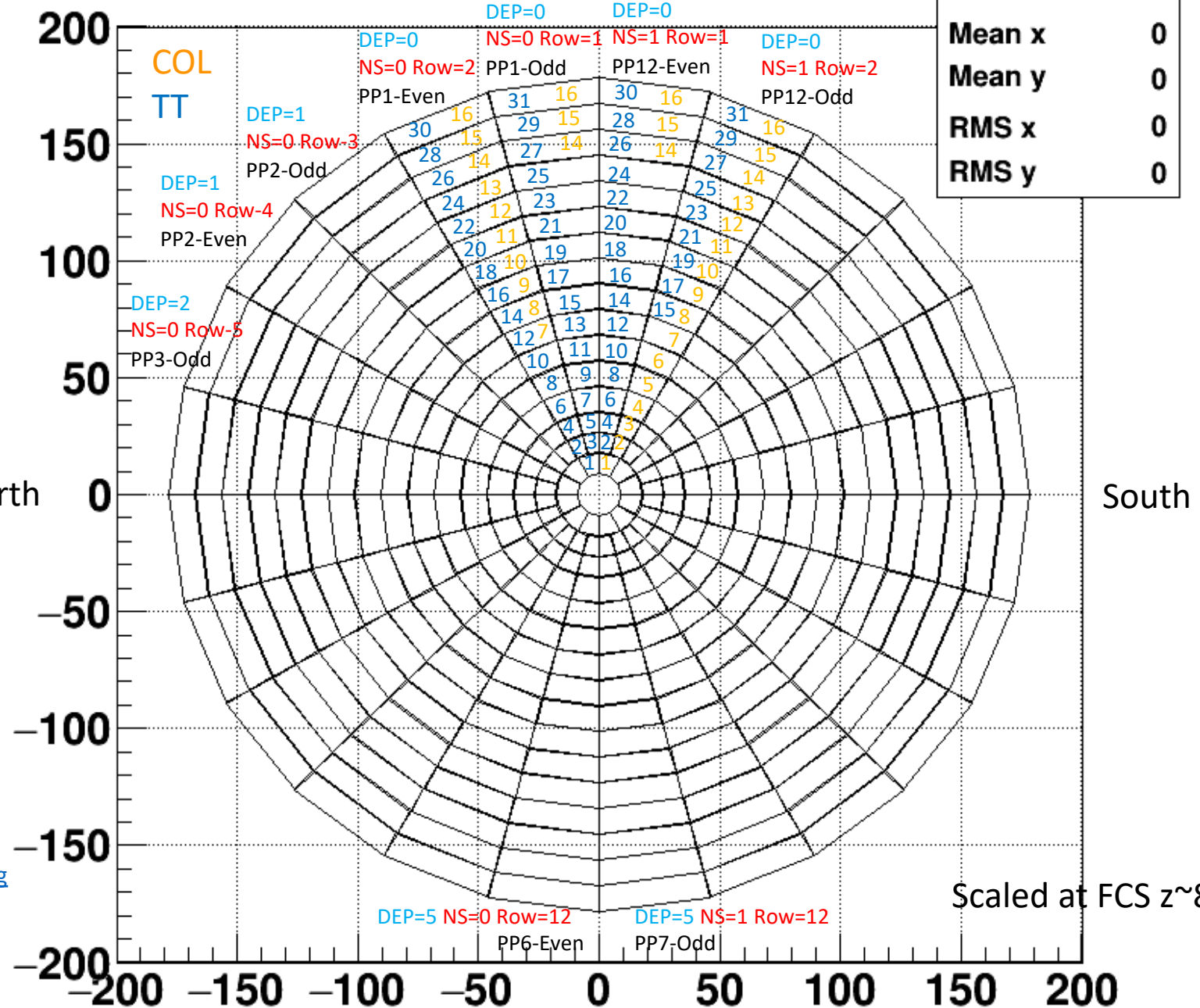
= 1/2 DEP

FCS-EPD

EPD West

FCS-EPD

looking from outside (looking towards east)

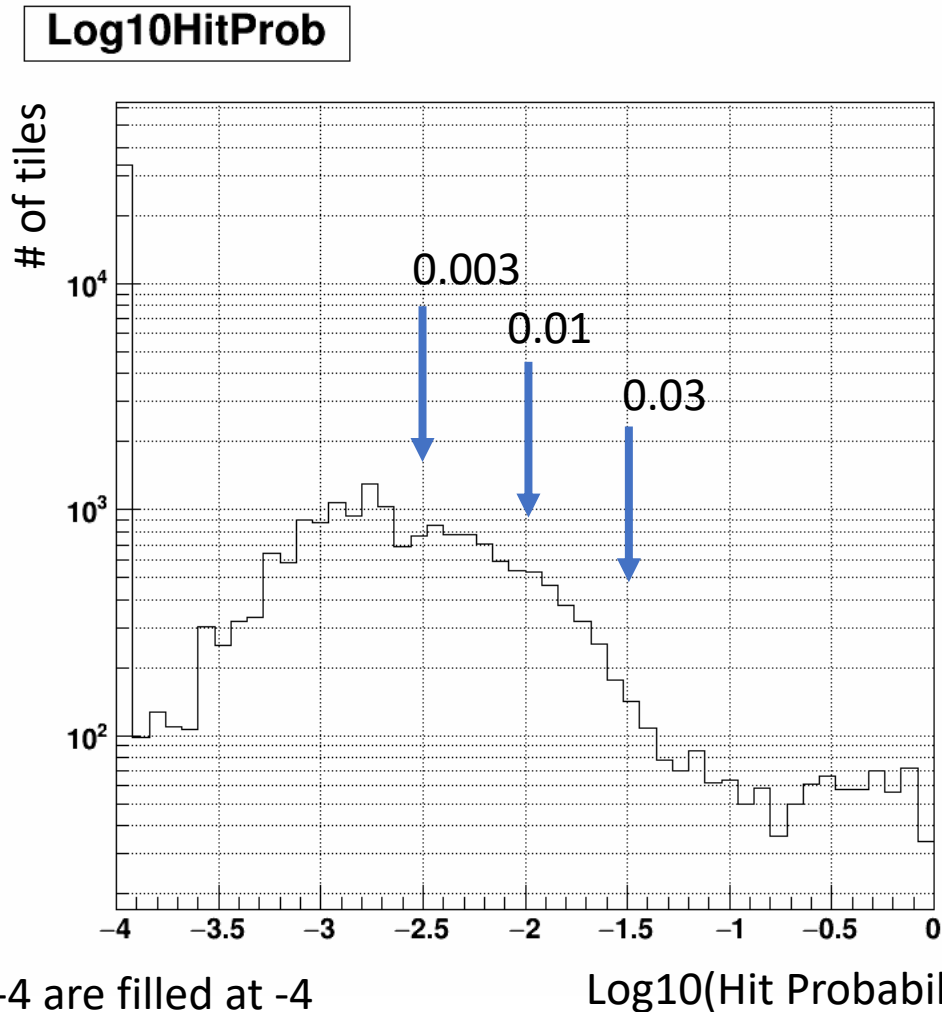


<https://drupal.star.bnl.gov/STAR/subsys/epd/operations-2018/what-supersector-fiberbundle-fee-and-sipm-where>

<https://www.star.bnl.gov/protected/spin/akio/fcs/index.html#mapping>

<https://www.star.bnl.gov/protected/spin/akio/fcs/fcsEpdMap.txt>

EPD Hit probability distribution for ET=0.6GeV Single Electron



Ecal 4x4 are $9\text{col} * 15\text{row} = 135$ per side
EPD has $31\text{ch} * 6\text{dep} = 186$ tiles per side
This histogram has $135 * 186 * 2 = 50\text{k}$ entries

North-South mask ORed
→ take care charge positive/negative

Input electron ET=0.6GeV
→ ET = 0.8 and 1.0GeV available

Vertex z position is 0
→ vertex at $\pm 50\text{cm}$ available

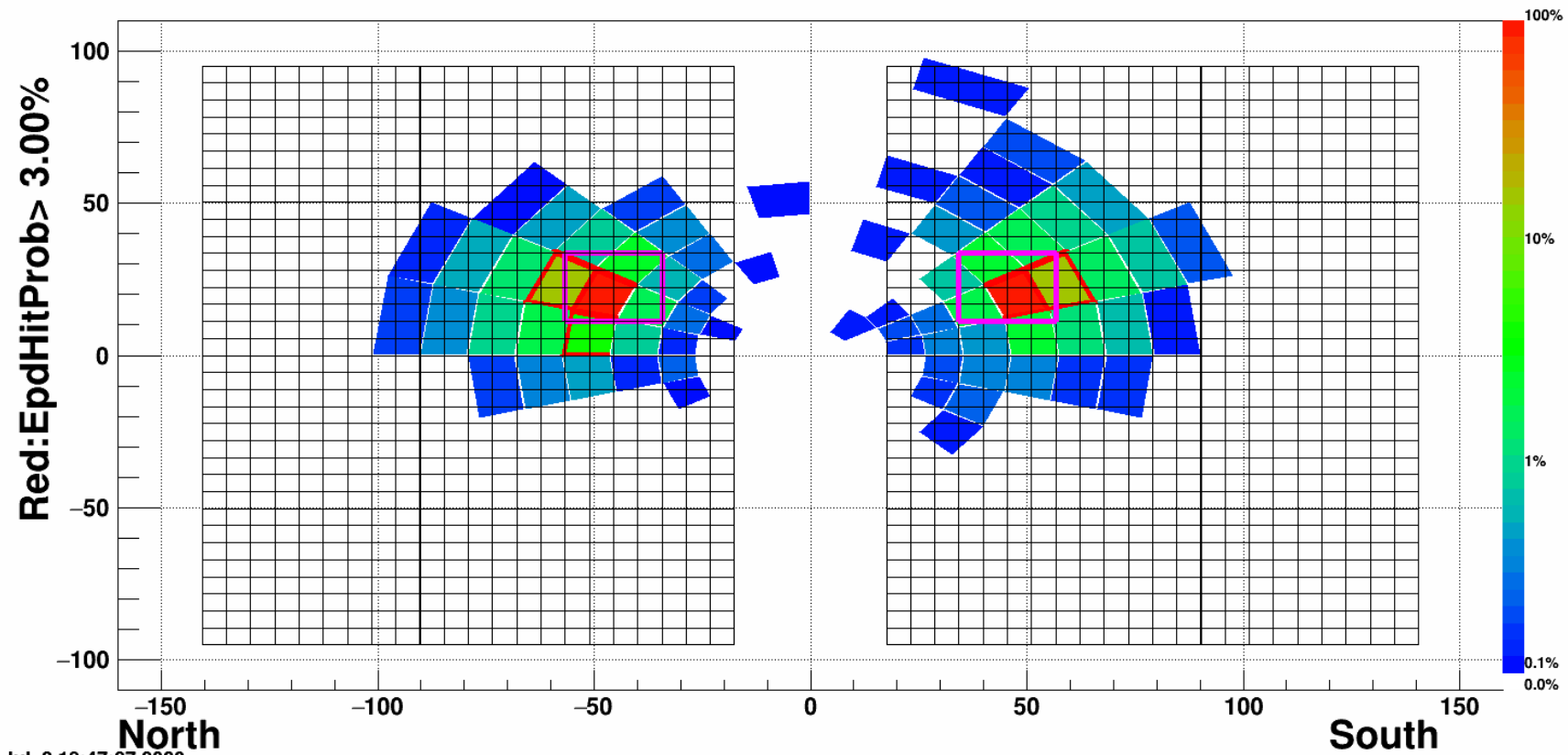
More plots for different ET, Z Vertex, etc and actual mask, code location & howto documents are at
<https://www.star.bnl.gov/protected/spin/akio/fcs/epd.html#mask>

Single electron Hit Probability > 0.03

Triggered Ecal 4x4 (highest ET > 0.5GeV)

Selected EPD Mask with hit probability threshold

FCSEcal4x4 Col2RoI6-EPD



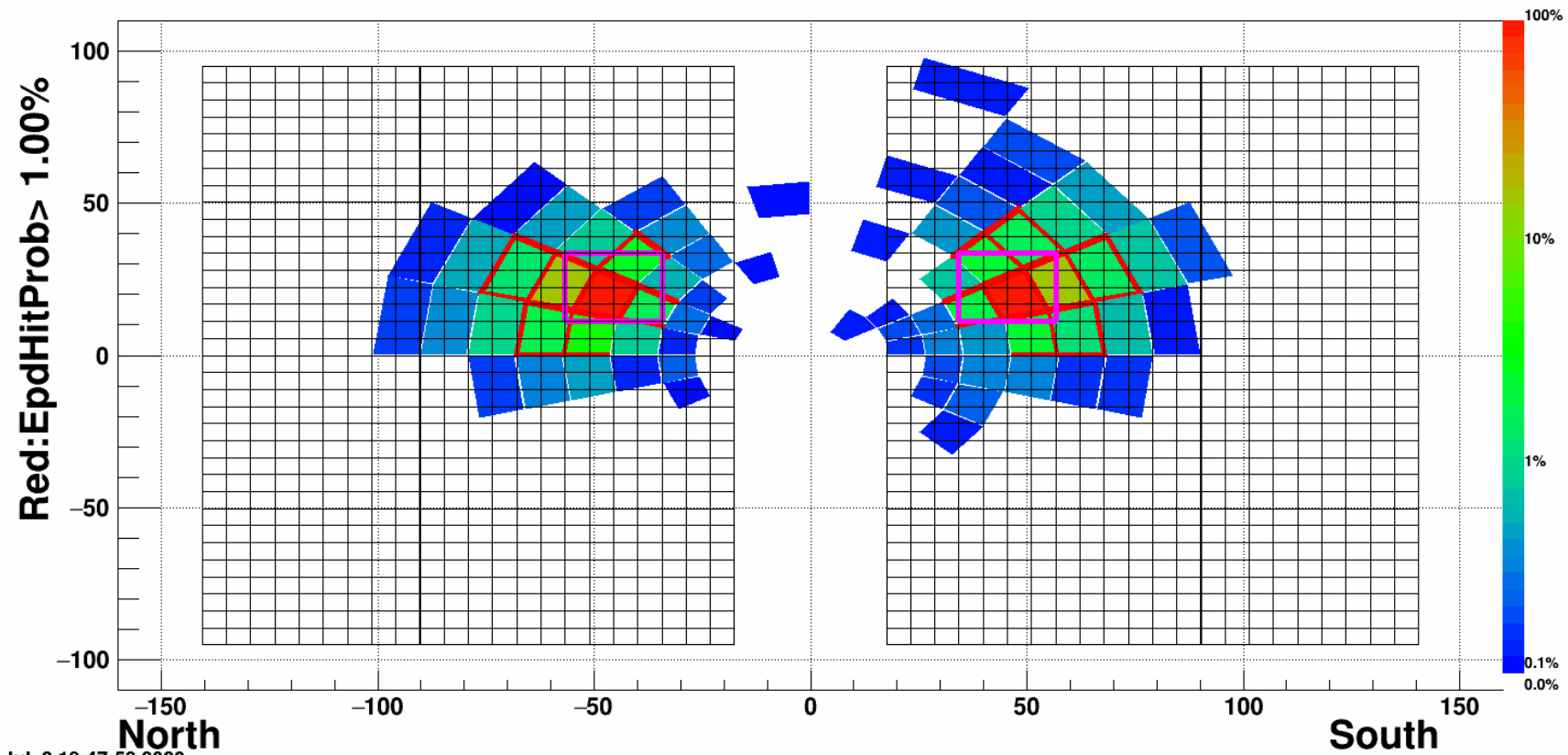
Thu Jul 2 18:47:27 2020

Single electron Hit Probability > 0.01

Triggered Ecal 4x4 (highest ET > 0.5GeV)

Selected EPD Mask with hit probability threshold

FCSEcal4x4 Col2RoI6-EPD



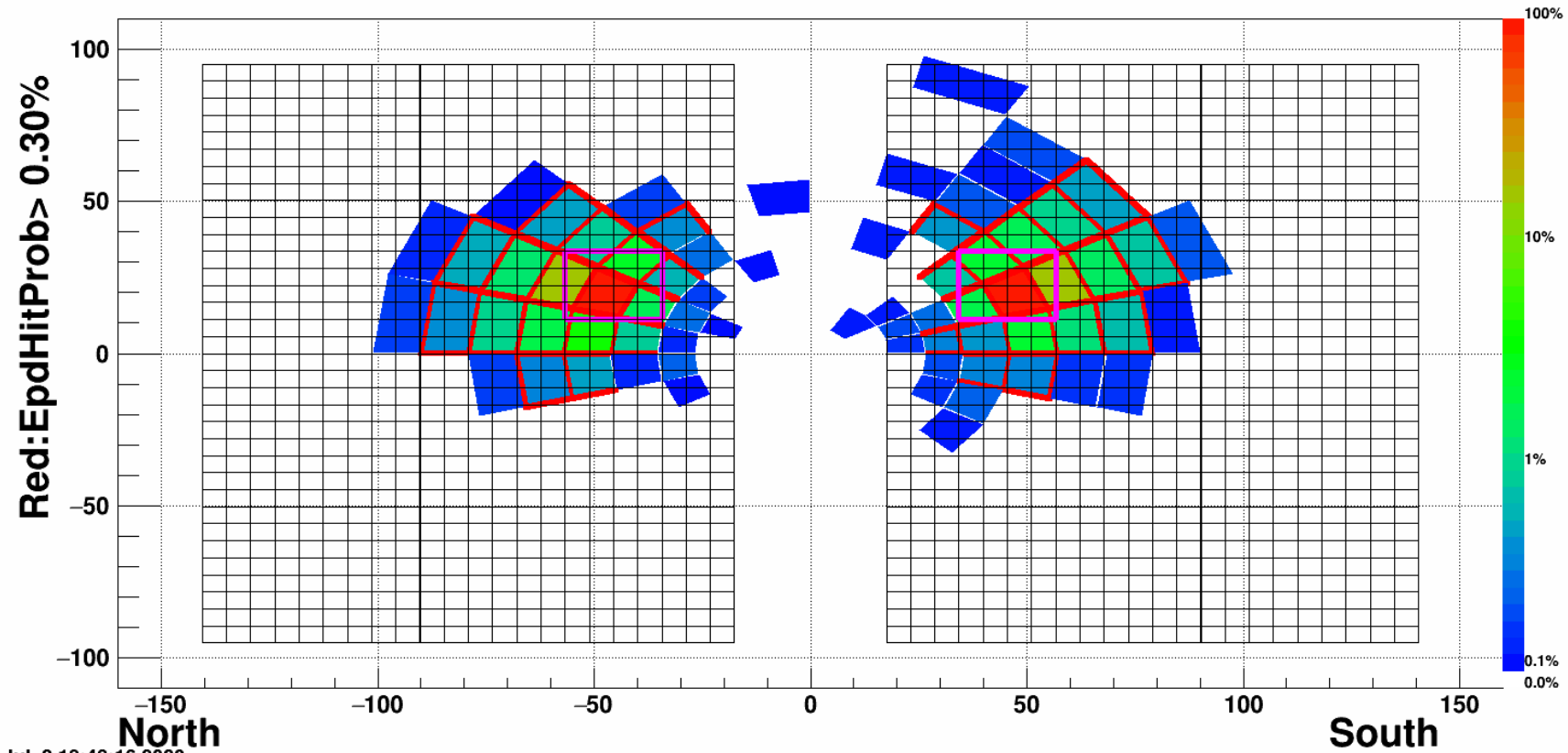
Thu Jul 2 18:47:52 2020

Single electron Hit Probability > 0.003

Triggered Ecal 4x4 (highest ET $> 0.5\text{GeV}$)

Selected EPD Mask with hit probability threshold

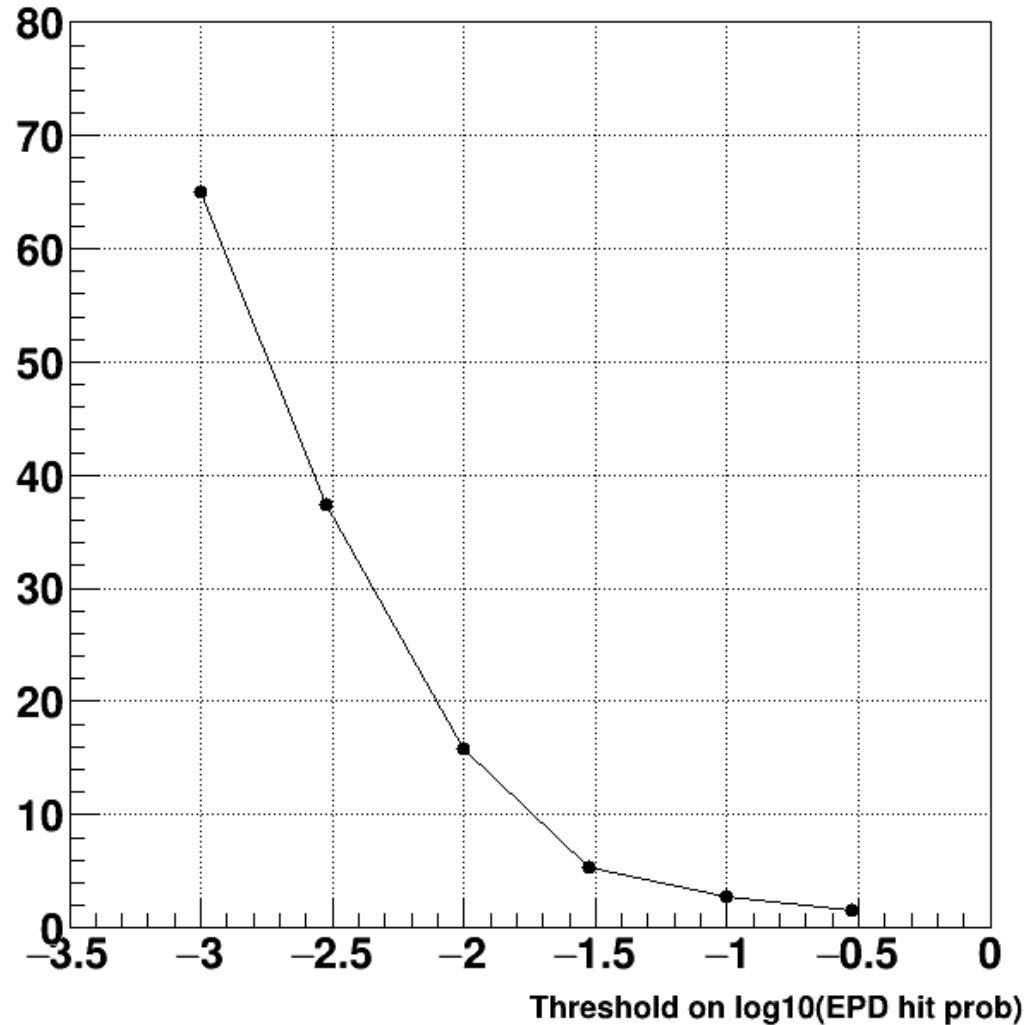
FCSEcal4x4 Col2RoI6-EPD



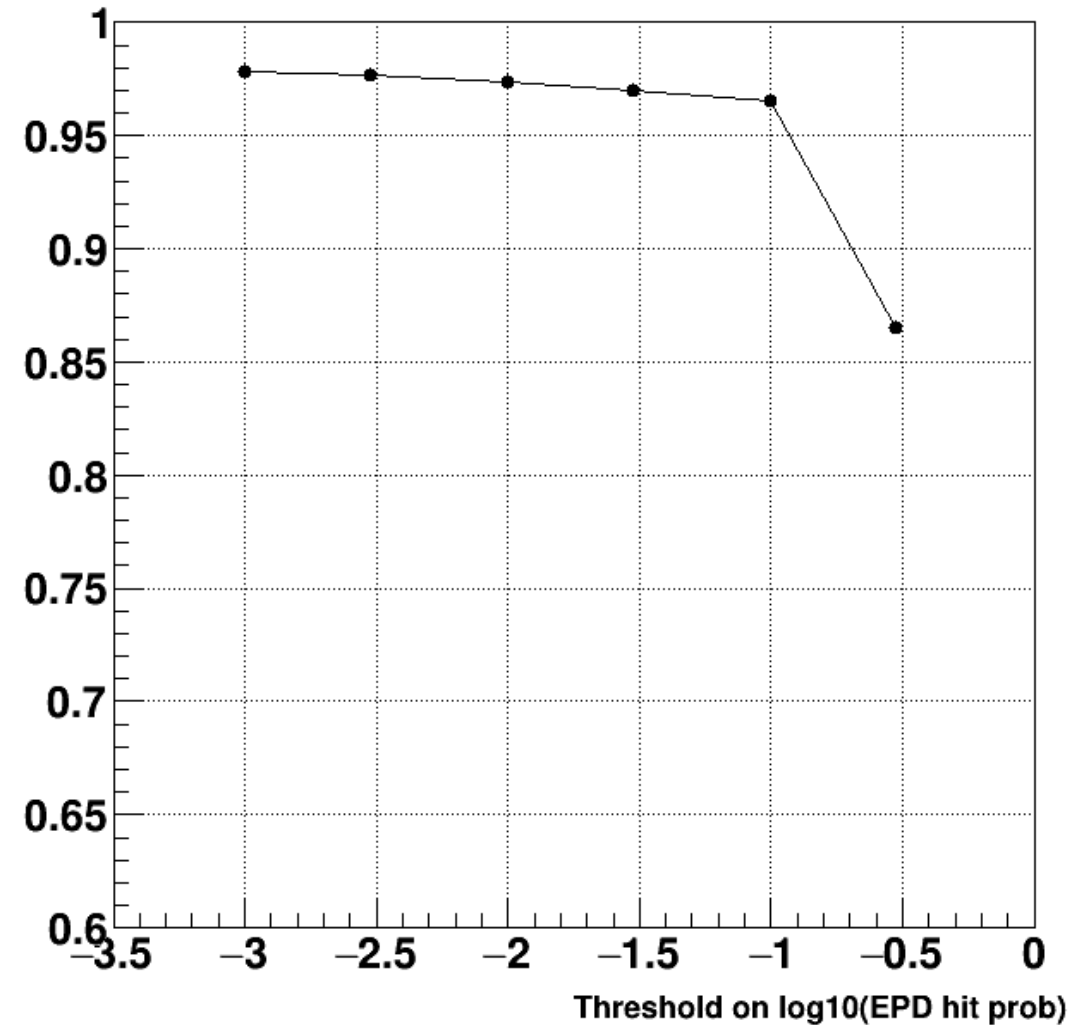
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Masks made with varying threshold on hit probability

Average nMask EPD tile per Ecal4x4



Trg Eff for single electron



PYTHIA Sample @ RCAS, 400 jobs done in few hours

PYTHIA	DY	Minbias
Cross Section	2.23D-04	3.15D+01
# of Run	200	200
Pythia generated Evt/Run	~100k	~5k
Total generated	~20M	~1M
Equiv. run time @ 1MHz collision	~3e6sec (~36days)	~1sec
Filter	FcsDYFilter.cxx	FcsDYBGFilter.cxx
Filter rejection power	~1/200	~1/10
After Pythia Filter/Run	500	500
After Pythia Filter total	100k	100k
EM N*S Triggered (ET>0.5GeV)	67k (67%)	16k (16%)
ELE N*S Triggered (ET>0.5GeV, 0.003 mask)	55k (55%)	7k (7%)
CPU time/run	~3hour	~2hour
CPU time/event	~20sec	~14sec

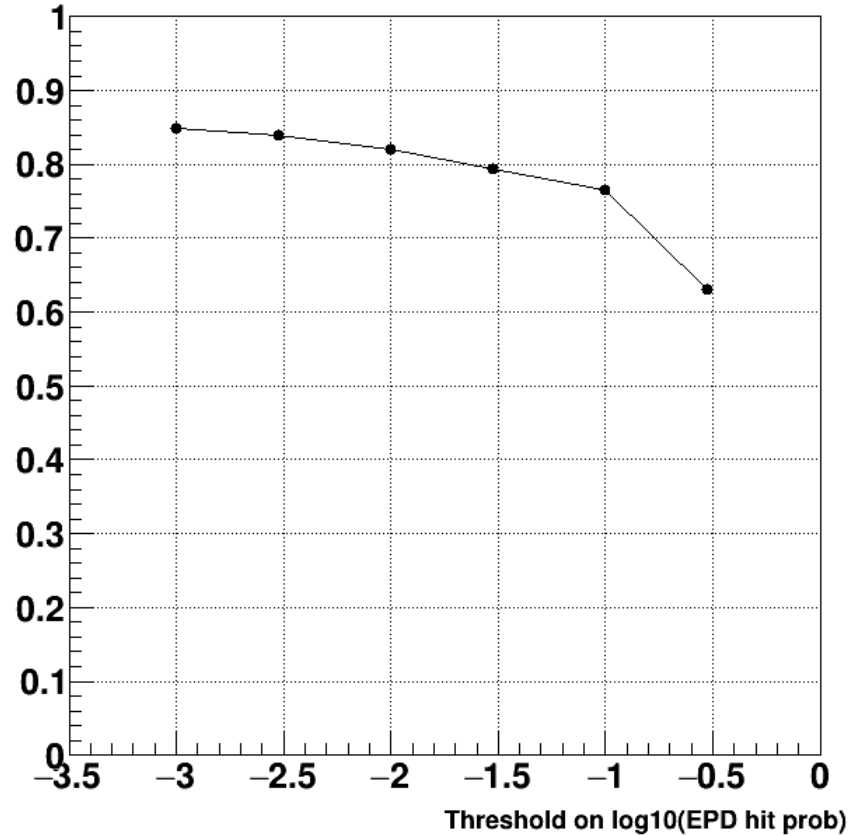
StRoot/StarGenerator/FILT/FcsDYFilter.cxx
 e+ and e- with ET>1GeV heading Ecal box
 mass > 2.5GeV

StRoot/StarGenerator/FILT/FcsDYBGFilter.cxx
 2 of any stable particle with ET>1GeV heading Ecal box
 mass (any combination from above) > 2.5GeV

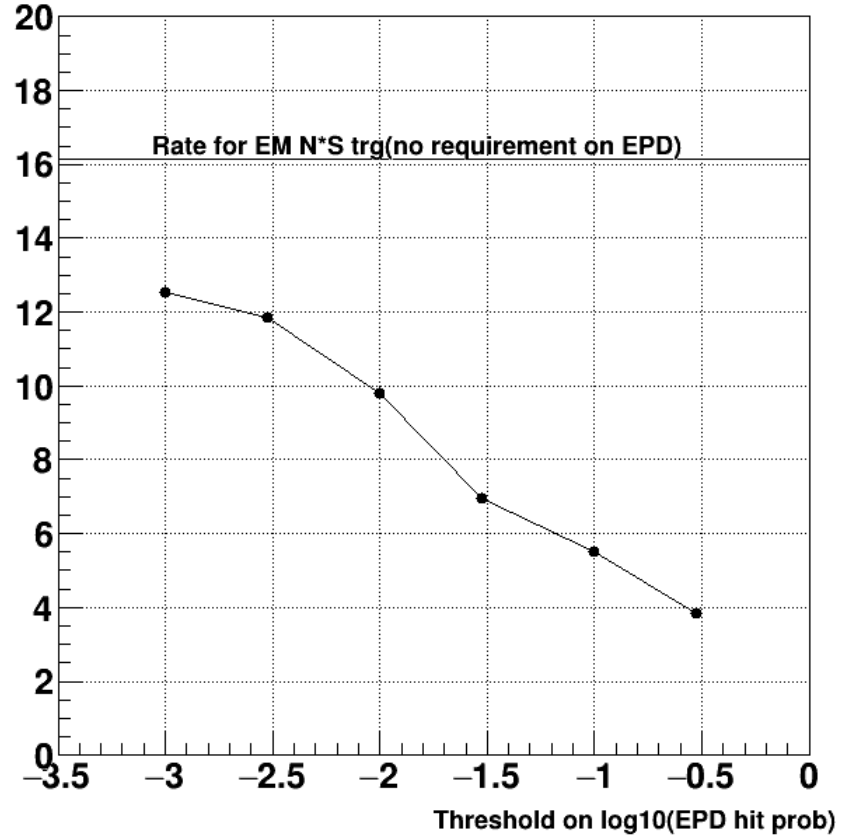
DY trigger efficiency for PYTHIA DY events and DY trigger Rate from PYTHIA QCD events

Trg Eff for DY

ELE N*S / EM N*S



BG trg rate [kHz] @ 1MHz collision



EMTHR1 = 16 $16 * 0.0316 \text{ GeV/count} = 0.5 \text{ GeV}$
 Nominal threshold is 32 = 1 GeV

FCS Trigger code

- <https://www.star.bnl.gov/protected/spin/akio/fcs/trigger.html>
 - has links to VHDL code by Tonko (used for run19, need to be evolved to run22 algo)
 - And C++ emulation codes
 - Now with all run22 base triggers, including ETOT/cosmic trigger
 - Switchable (.h file or reading from text) EPD mask for ELE trigger
- **StFcsDbMaker** gives proposed EPD mapping (and reverse mapping to EPD numbering)
- **StFcsFastSimulatorMaker**
 - It now reads EPD g2t hit table and make StFcsHit with proposed map
 - It is based on StEpdFastSimMaker provided by EPD group
 - Still need mapping verification → FIXED and DONE
- **StFcsTriggerSimMaker**
 - Now it run with Tonko's wrapper class and DAQ code
 - StRoot/RTS/src/FCS_DAQ
 - StRoot/RTS/src/FCS_TRG
 - Added hooks for QA
- **StFcsEventDisplay** now shows EPD hits
- **StFcsTrgQaMaker** has trigger QA and should evolved to online trigger QA

FCS trigger & software

1. GEANT geometry, g2t and fast simulator
2. Mmapping & calibration tables
3. DST data model Usable interface to trigger data from DEP
4. Raw data reader
5. Ecal Cluster Finder
6. Ecal Photon Fit
7. 2D and 3D Event Displays
8. Analysis of run19 AuAu200 test data
 1. Ecal : Reconstruction of pi0 put in CVS
 2. Ecal : Finding MIP peaks put in CVS
9. Trigger Algorithm overall design and Emulation in C++ for bit checker and for MC
 - EPD as PRES – Mask for electron trigger June2020 Almost DONE
 - 4x4 Ecal – best of four 4x4 Hcal correlation map for EM/Hadron trigger Aug2020
 - North-South coincidence geometry?
 - Jet trigger optimization?
10. Update VHDL code for stage2 & 3 - Need Eleanor's help Winter 2021
11. Robust (accidental hits proof) signal fitting vs time-bins & signal simulator Summer 2021
12. Hcal hadronic shower characterization (Hcal cluster finder?) Fall2020
13. Hcal calibration using cosmic muon pre beam time MC(see Navagyan's) & cosmic trigger Data taking summer 2021
14. Integration and matching with Tracking Fall 2020
15. PYTHIA level event filter for DY/QCD for MC
 1. During/After GEANT filter for QCD background for DY Early 2021
 2. Large scale MC sample for Jpsi, DY, QCD background for DY, and jets Fall 2020
16. Physics analysis code Early 2021
 - Finding J/Psi and DY
 - Jet finder and high pT charged hadron reconstruction
17. jEVP and online QA Summer 2021
18. GEANT4 for STAR ???

Done

Working on

To do

Possible timescale