

Beam test and Simulation

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For ECal Beam Test Group

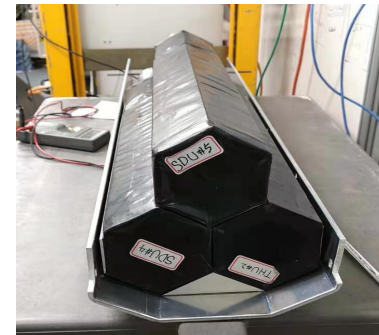
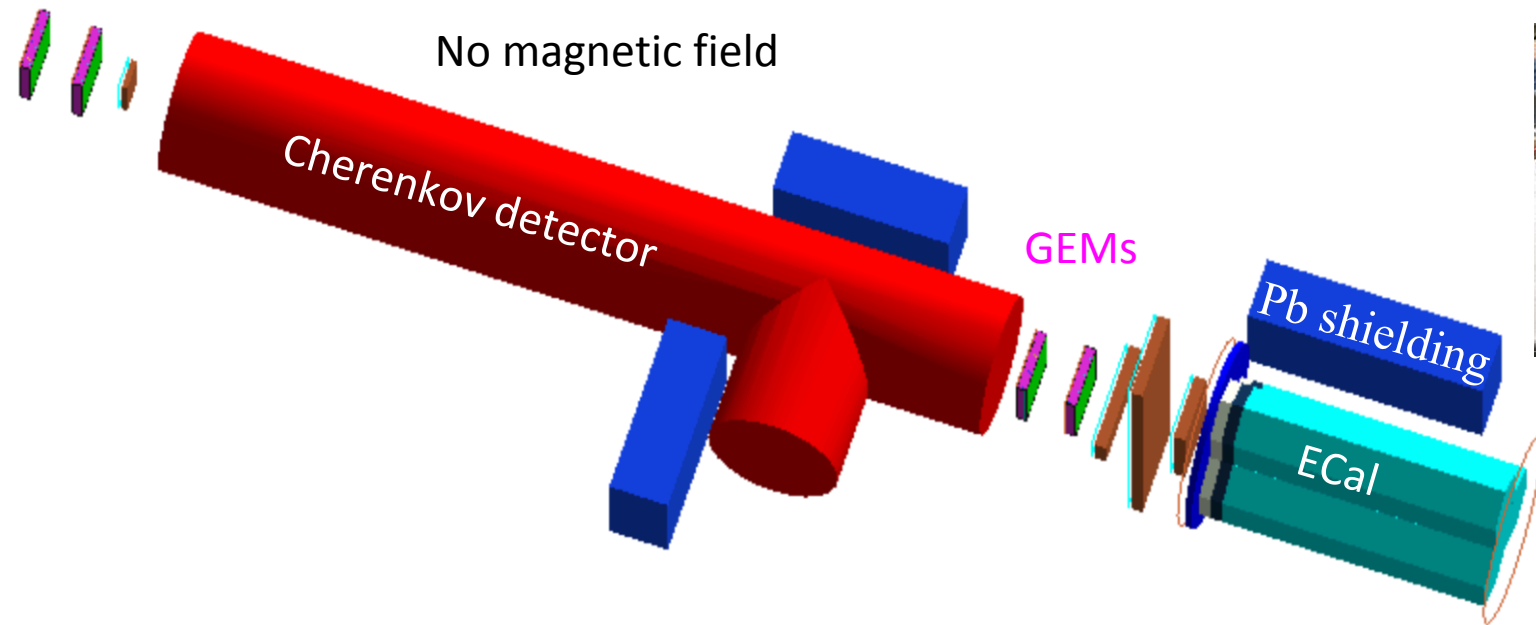
- Beam test simulation configuration
- Comparison between simulation and data
- LASPD photon rejection

Simulation for Beam Test at Jlab

- ❑ Benchmarking simulation of rate and background
- ❑ Study ECal and LASPD performance under high rate, high radiation, high background condition
- ❑ Study ECal and LASPD PID



GEMs SC_A

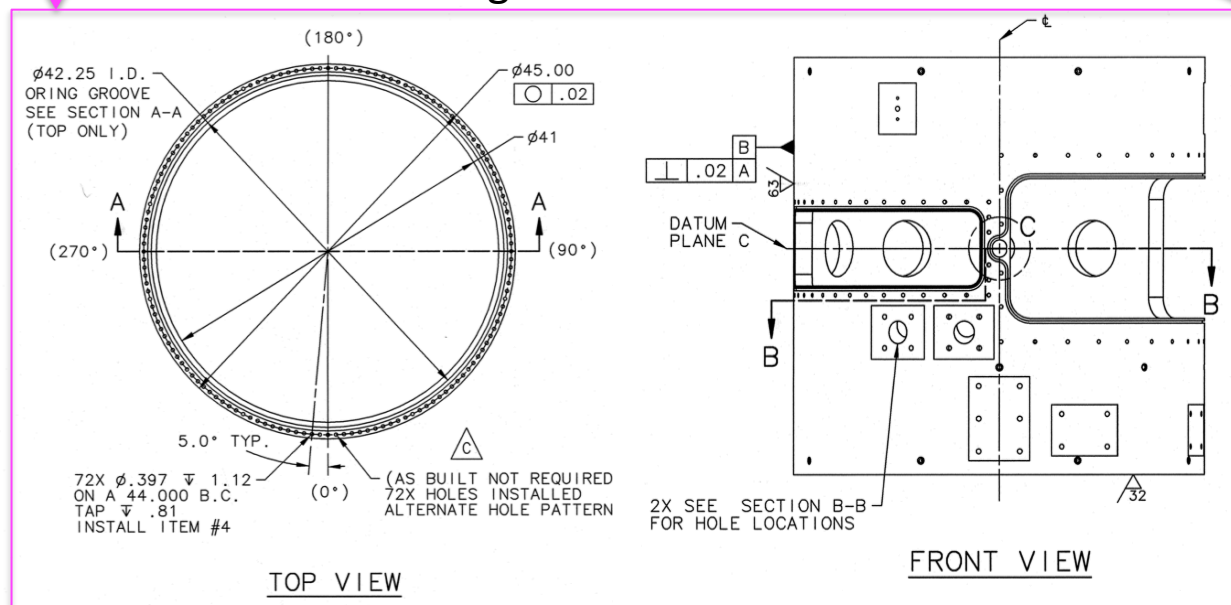
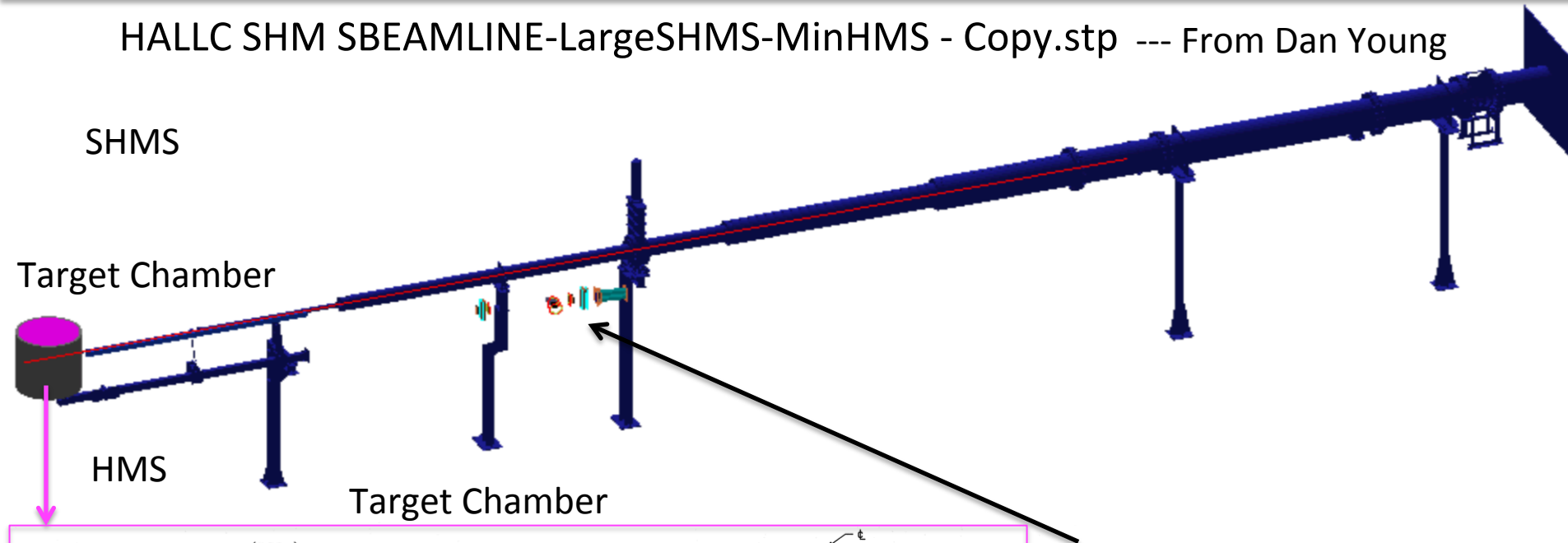


SC_B

Front to back GEM1+2, SC-A, Cer, GEM3+4, SC-C, LASPD, SC-D, Preshower, Shower, SC-B

Hall C Downstream Beam Line are included

HALLC SHM SBEAMLINE-LargeSHMS-MinHMS - Copy.stp --- From Dan Young

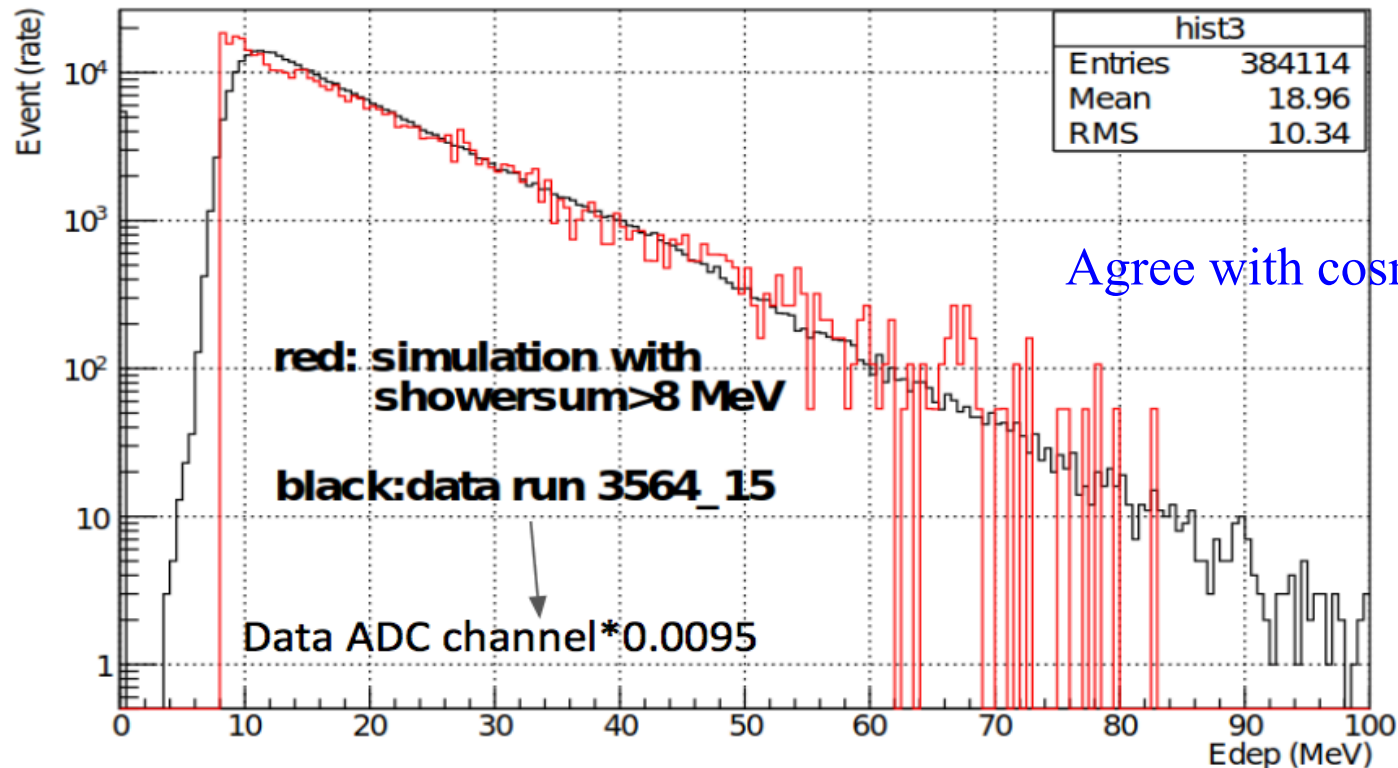


Detector position

- 82 deg: 8m SHMS
- 7 deg: 21 HMS
- 18 deg: 20m HMS

ECal Simulation for Beam Test at 82 deg

- dominant by π^0
- charged pion energy is not large enough to see the MIP at shower



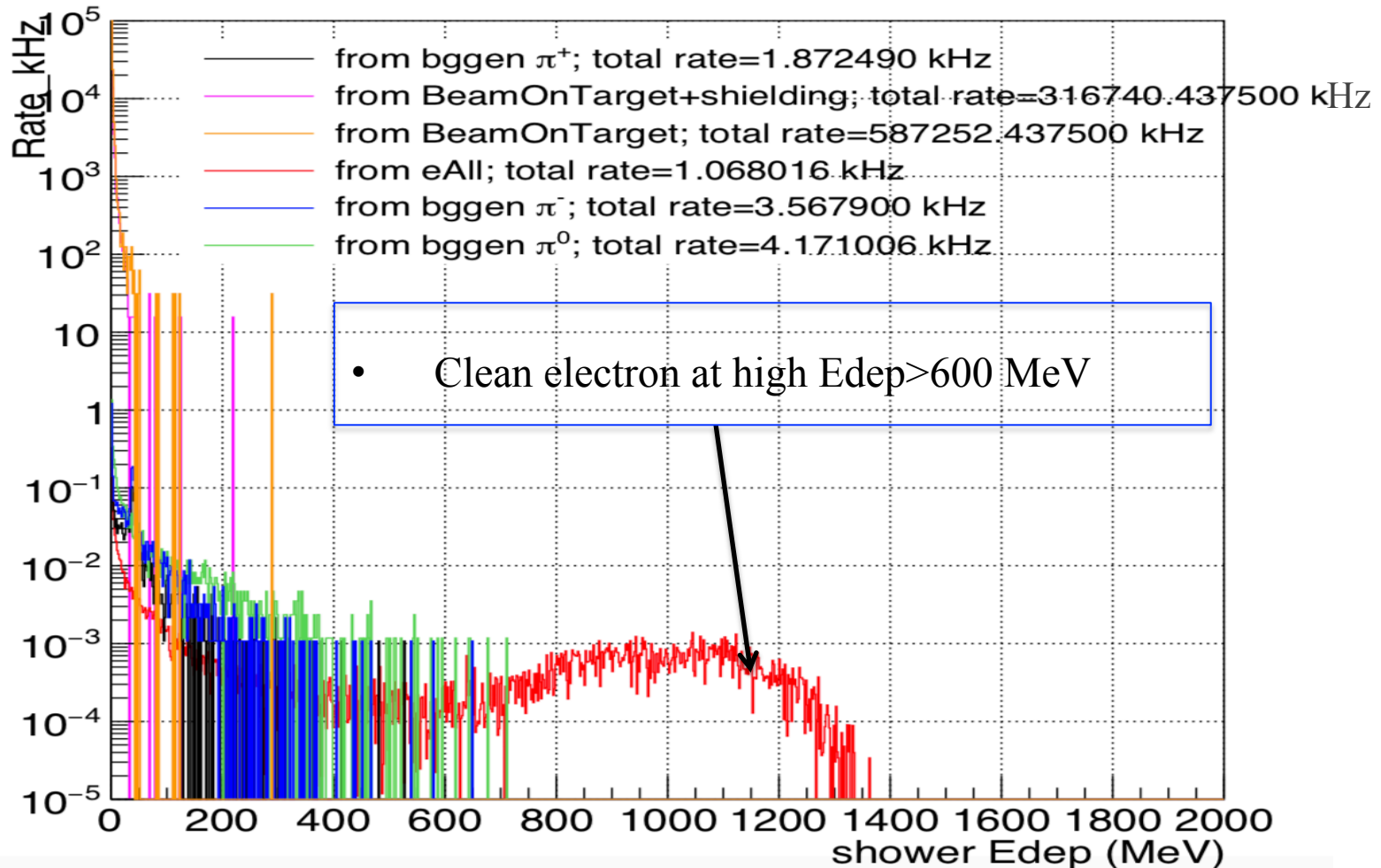
Agree with cosmic ray test !

- The shower deposit energy tail follows an exponential function for both the simulation and the data, providing an alternative method for “calibration” in the absence of MIP peaks.

ECal Simulation for Beam Test at 7 deg

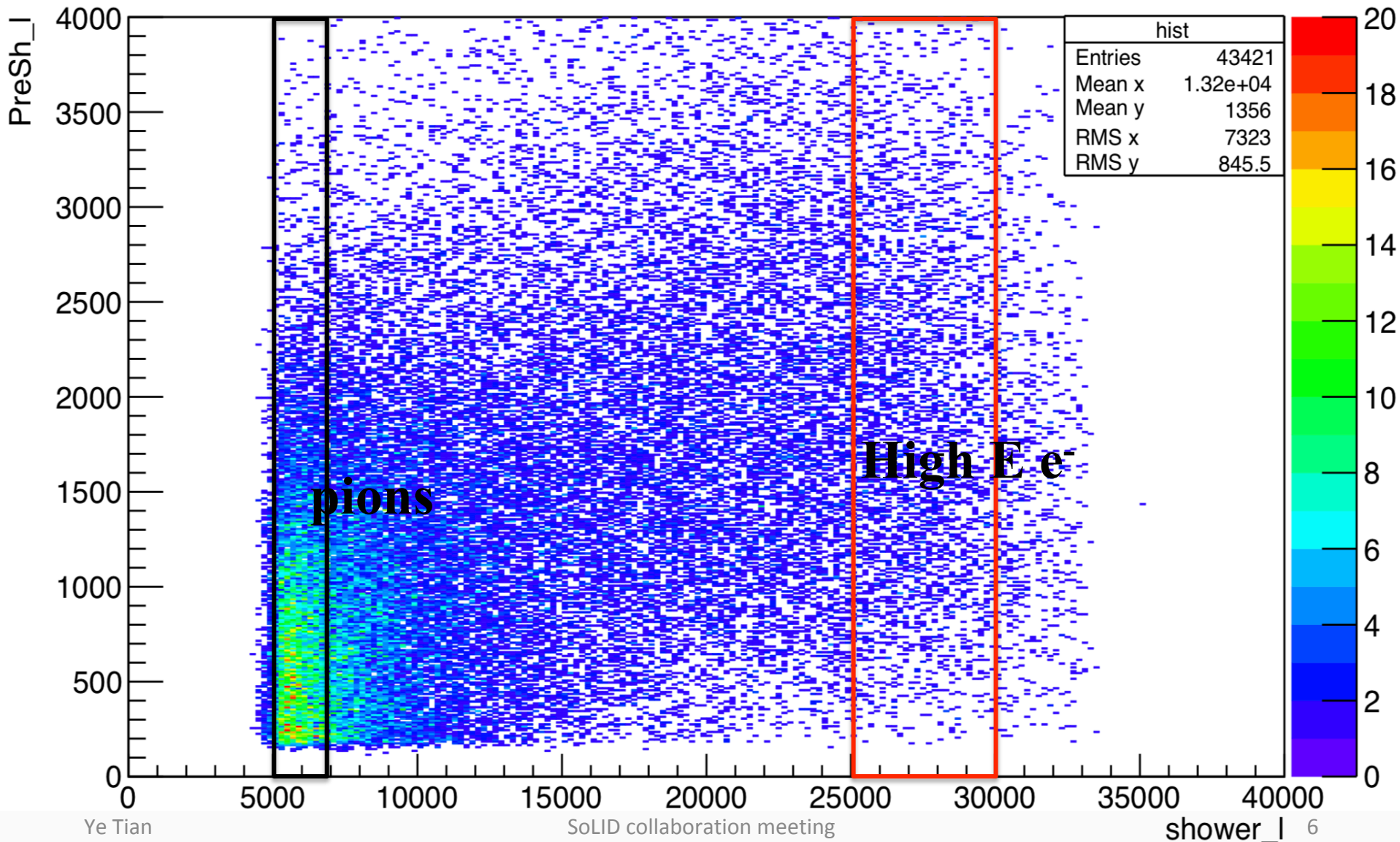
➤ 7 deg—luminosity $\sim e^{37}$

- 60 MeV Moller electron from the target
- γ from beam line (high energy photons covered the MIP at shower)



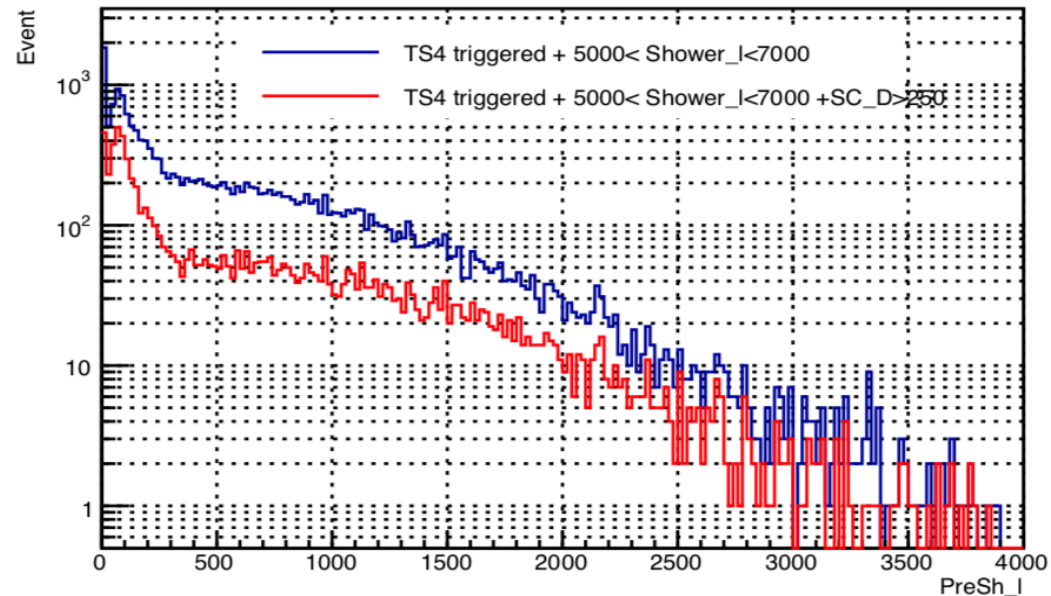
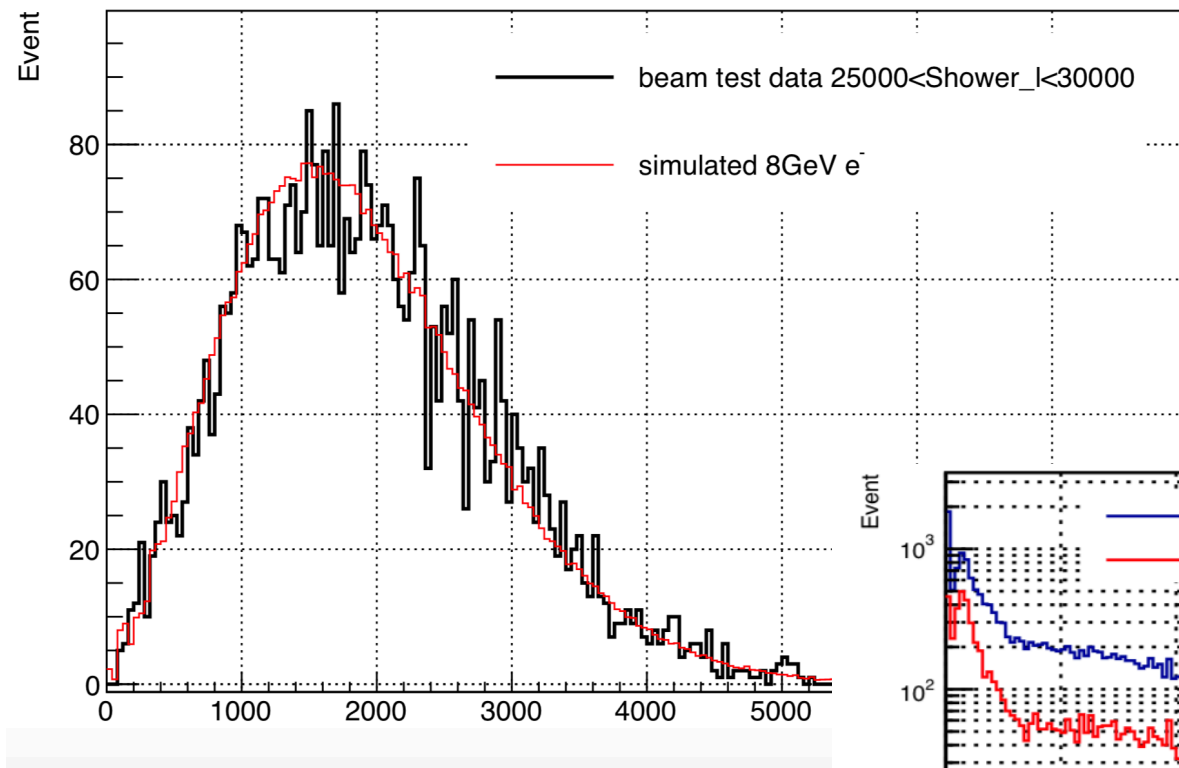
Ecal Data for Beam Test at 7 deg

- Select high energy e^- (clean signal) to test Cherenkov detector performance

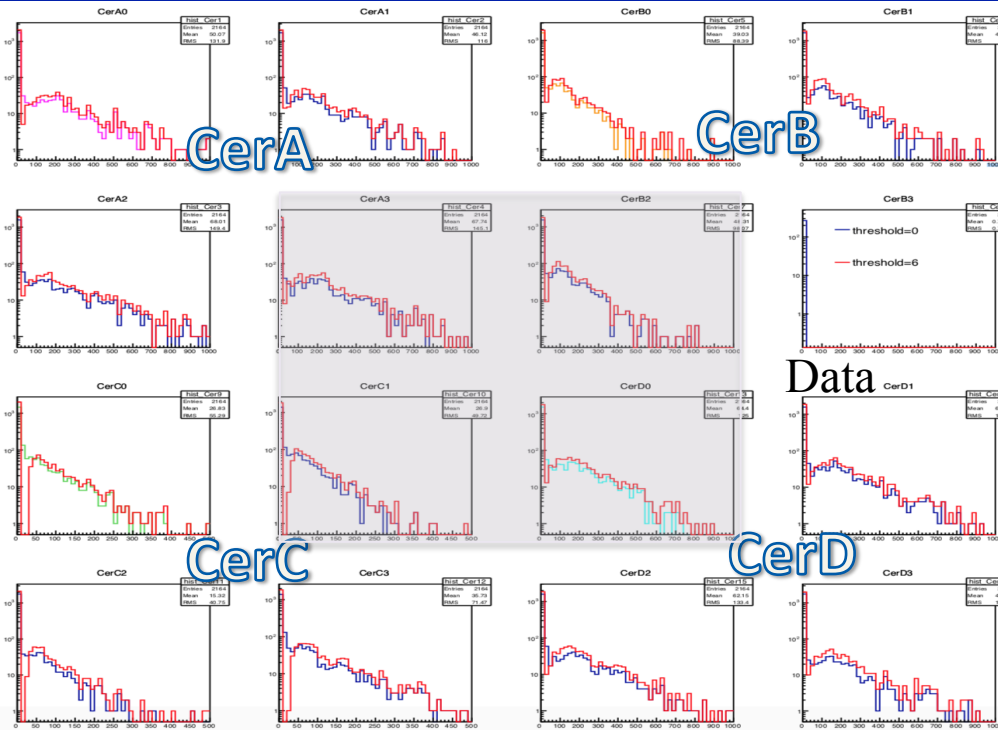


Ecal PreShower Edep for Beam Test at 7 deg

- PreShower can help on identifying high energy e^- , and it works well at the high energy region (above pion Cherenkov radiation threshold).



High Energy e^- to Test Cherenkov Detector at 7 deg

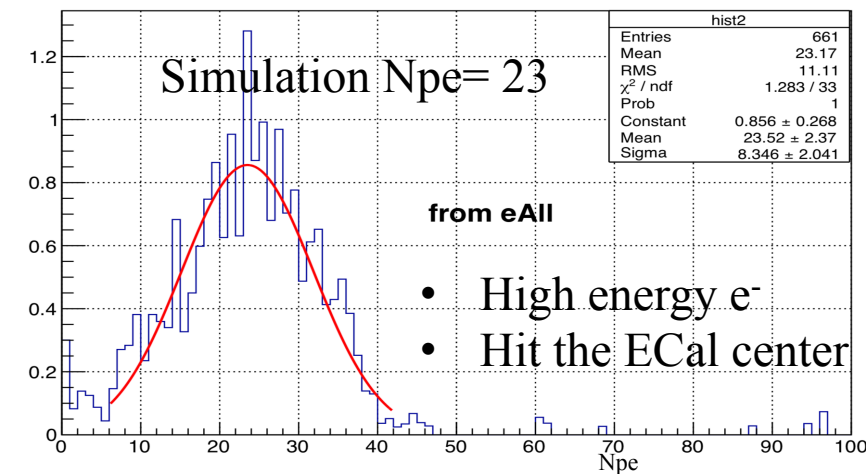


Data Npe = 11 at 7 deg

- High energy e^- cuts
- ECal center cut
- At least one PE in two diagonal modules out of the four central blocks
- Consistent with 18 deg

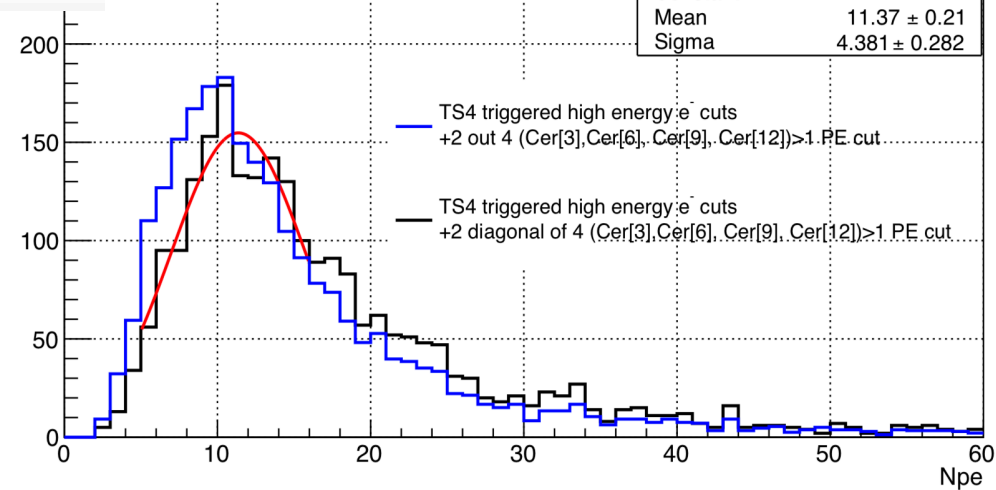
To-do:

- Add two diagonal Cherenkov modules cuts on the simulation



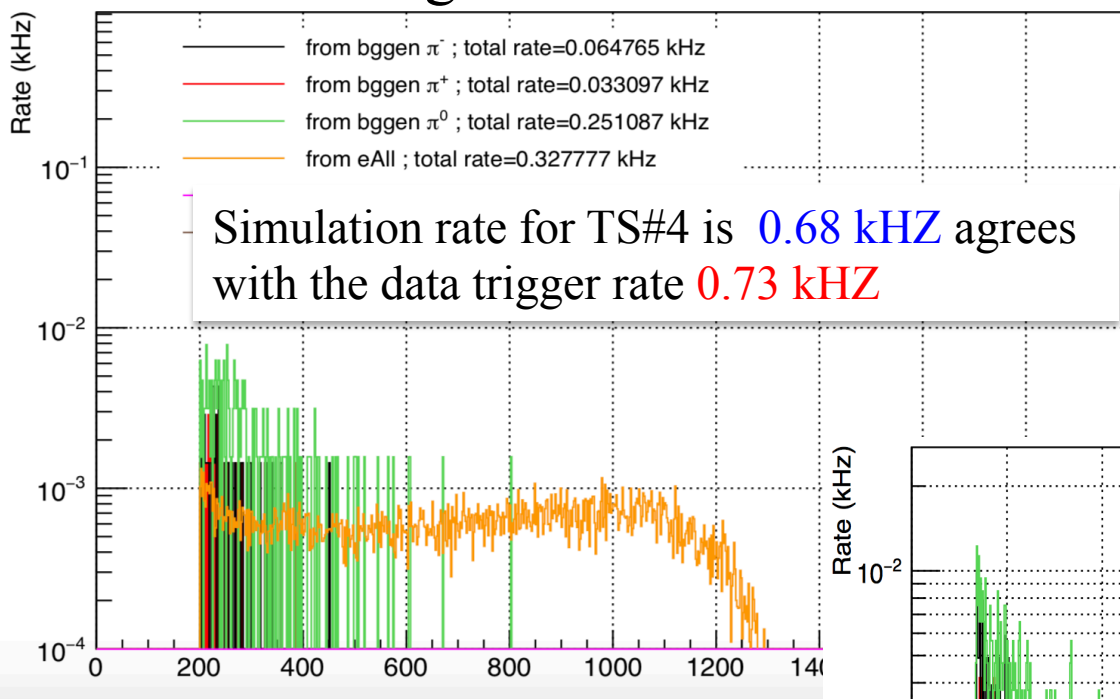
- High energy e^-
- Hit the ECal center

Data



ECal Rate Comparison at 7 deg

✓ Benchmarking simulation of rate and background



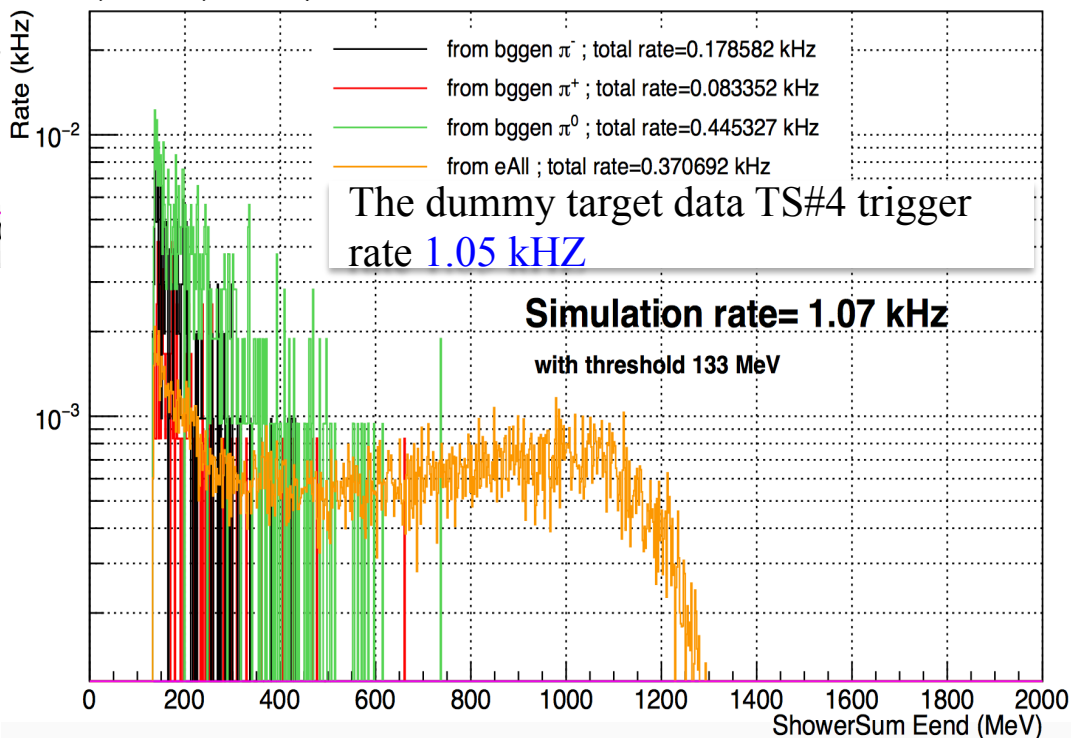
- TS#4 threshold $E_{dep}=200$ MeV calibrated from the run 4121 (3He target):

Data/simulation=1.07

- TS#4 threshold $E_{dep}=133$ MeV calibrated from the run 4206 (dummy target)

Data/simulation=0.98

- ❖ Simulation rate is consistent with the 7 deg data (<10%).



ECal Rate Comparison at 18 deg

- **18 deg**—high rate test luminosity~ $2e^{37}$ - $4.5e^{38}$
- ✓ Study ECal, LASPD performance under the condition comparable to SoLID
- It is easy to see the MIP at shower

Beam test detector rate is comparable to that of SoLID

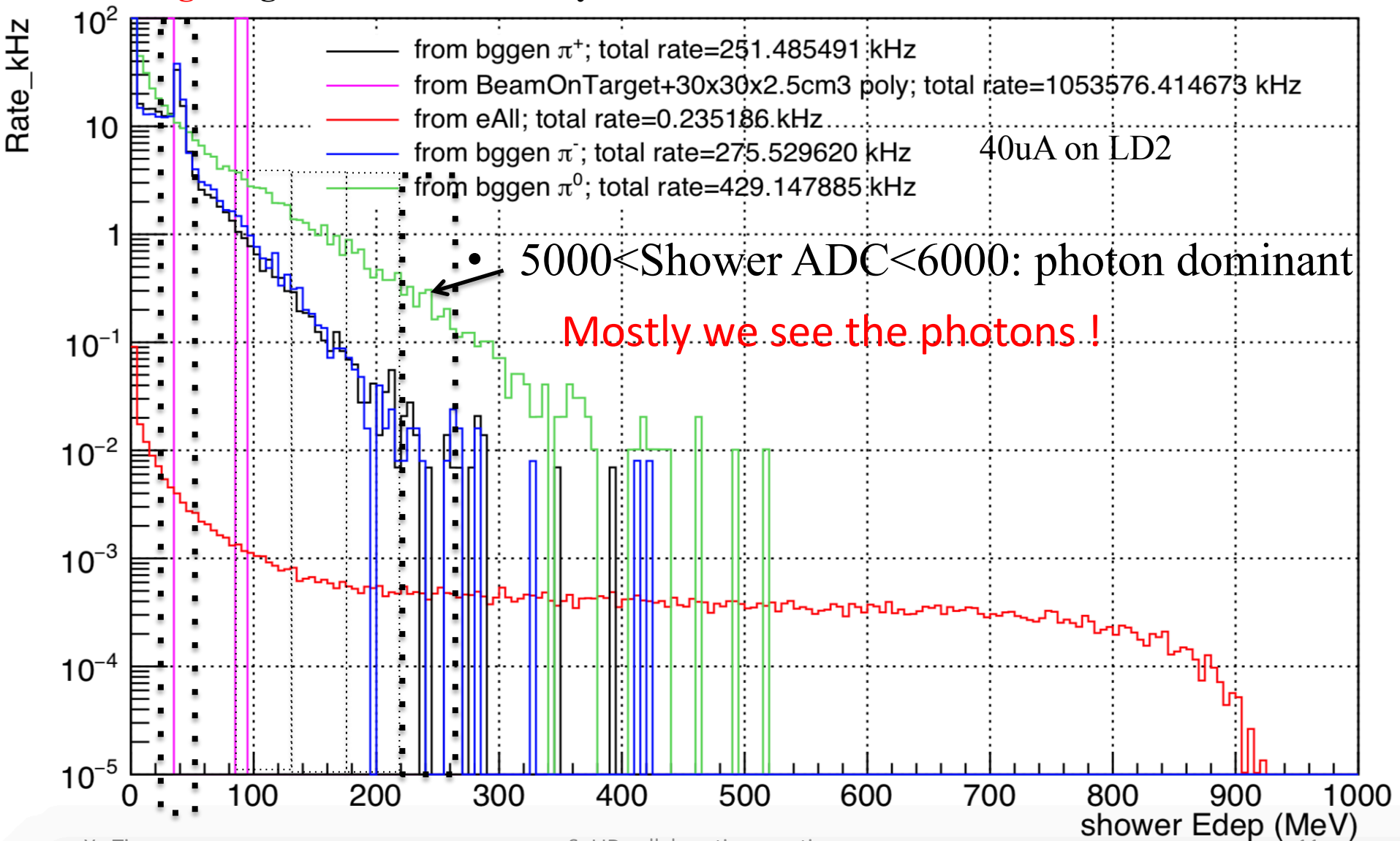
Detector Maximum Rate (MHz)	SIDIS ^3He	J/ψ	PVDIS	Beam Test	Comment
SPD_LA	4.5	9.2		10.2 (5uA)	Cut below MIP
EC_preshower_FA	3.3	7.65	9.0	10.24 (68uA)	Cut below MIP
EC_shower_FA	0.92	2.344	0.9		Cut below MIP
EC_preshower_LA	4.533	8.119			Cut below MIP
EC_shower_LA	0.482	1.894			Cut below MIP

(Table 25 from SoLID PreCDR)

- ❖ based on 5uA run 4680 waveform from https://userweb.jlab.org/~tianye/SoLID/ECAL_beamtest_simulation_2022/run4680_LASPD_rate_pulse.pdf
- ❖ based on 68 uA run4813 trigger rate

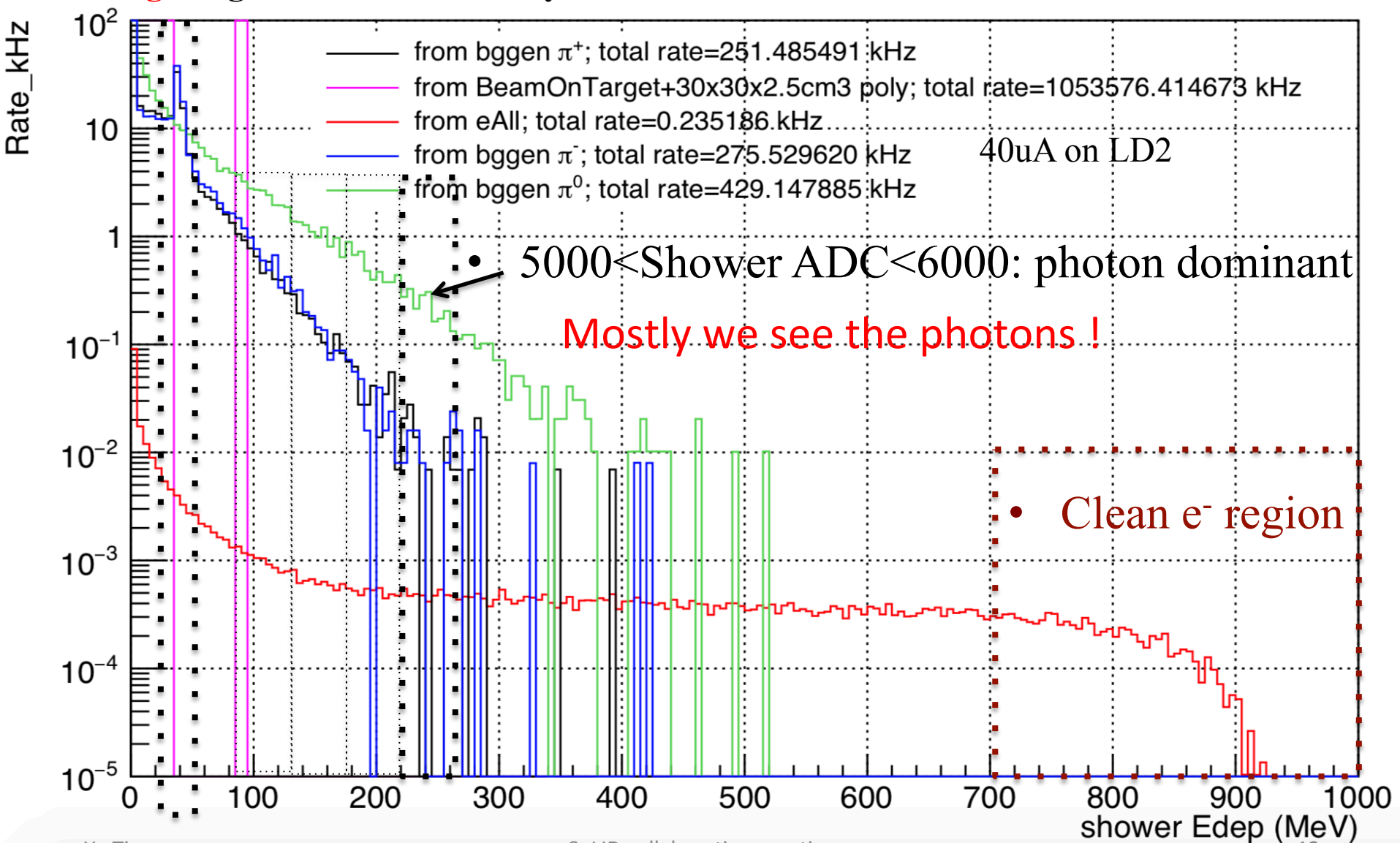
Simulation: γ , π^\pm , e^- Ratio as a Function of DepE

➤ **18 deg**—high rate test luminosity $\sim 2e^{37}$ - $4.5e^{38}$



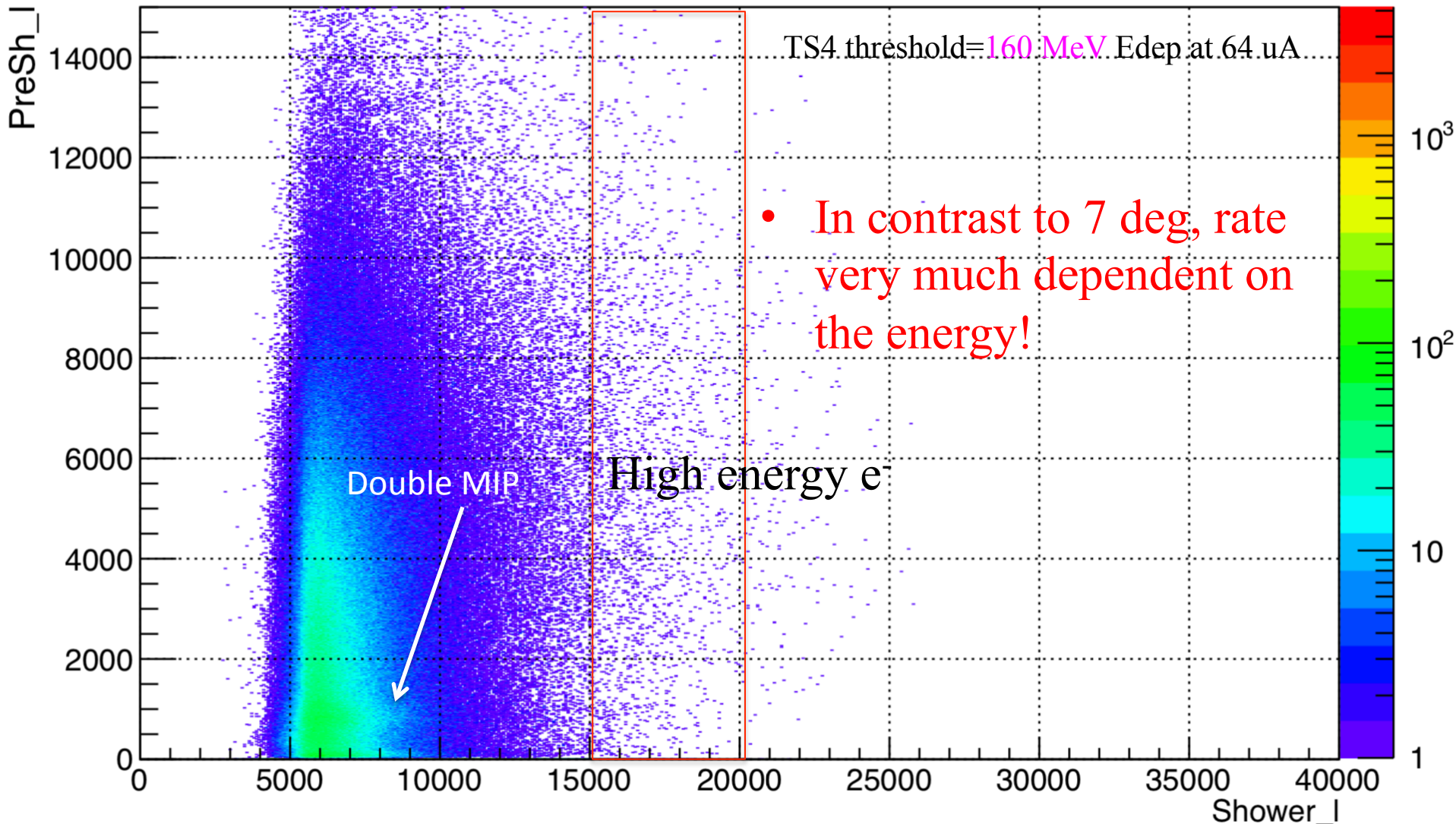
Simulation: γ , π^\pm , e^- Ratio as a Function of DepE

➤ **18 deg**—high rate test luminosity $\sim 2e^{37}$ - $4.5e^{38}$

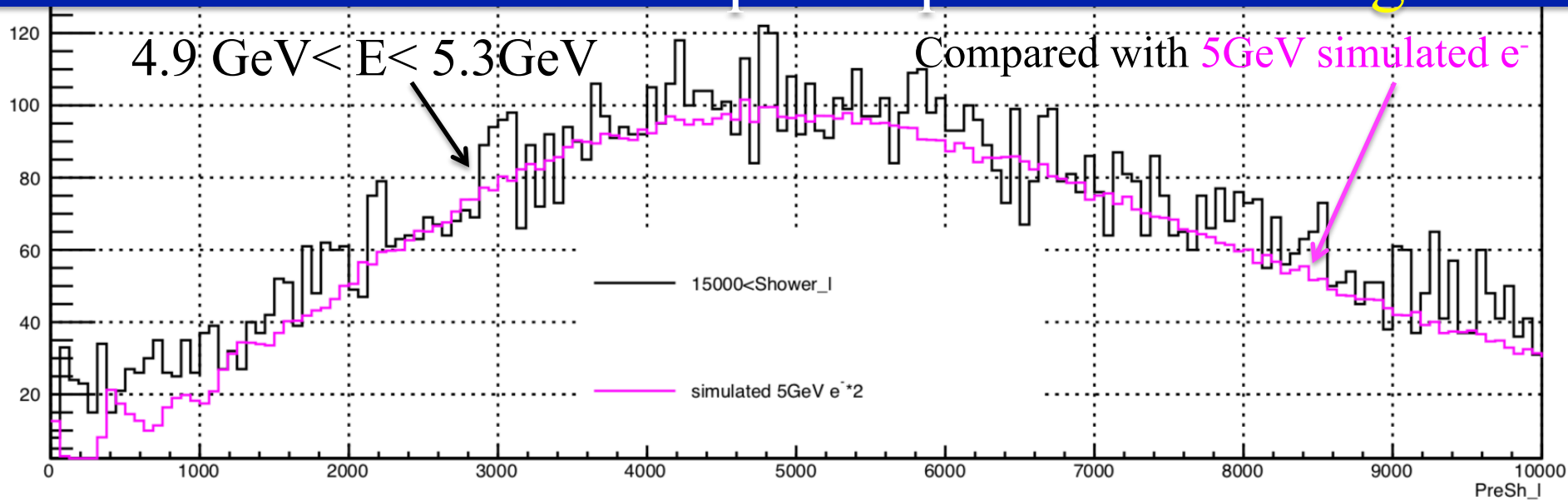


Ecal Triggered Data for Beam Test at 18 deg

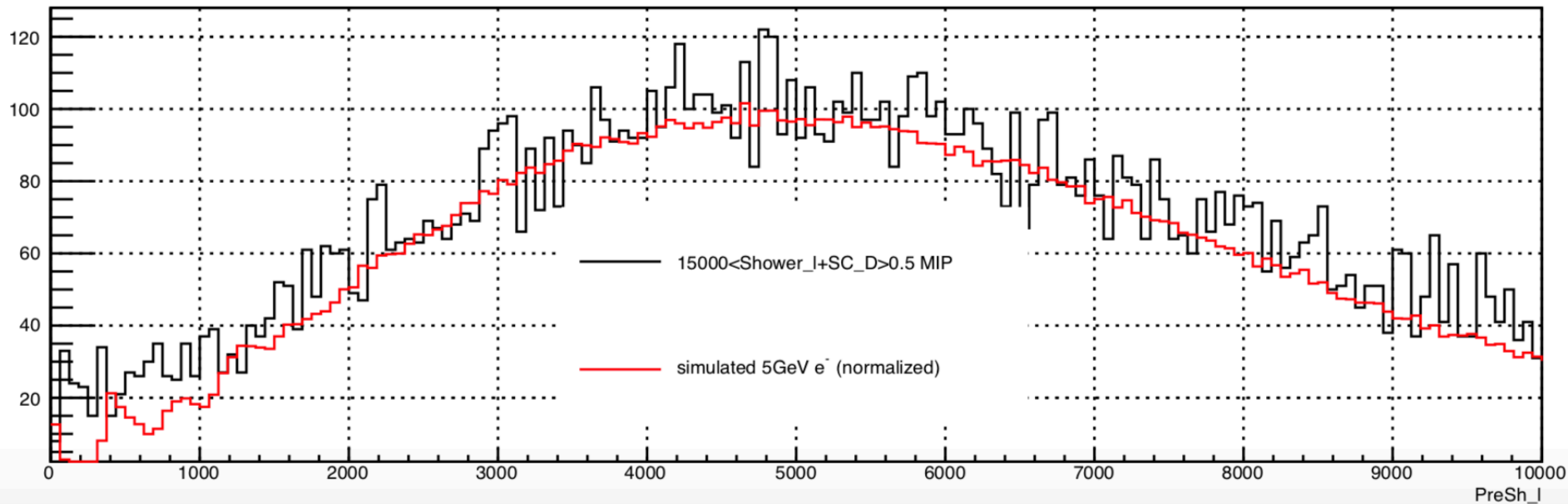
PreSh_I vs Shower_I TS4=310 mV



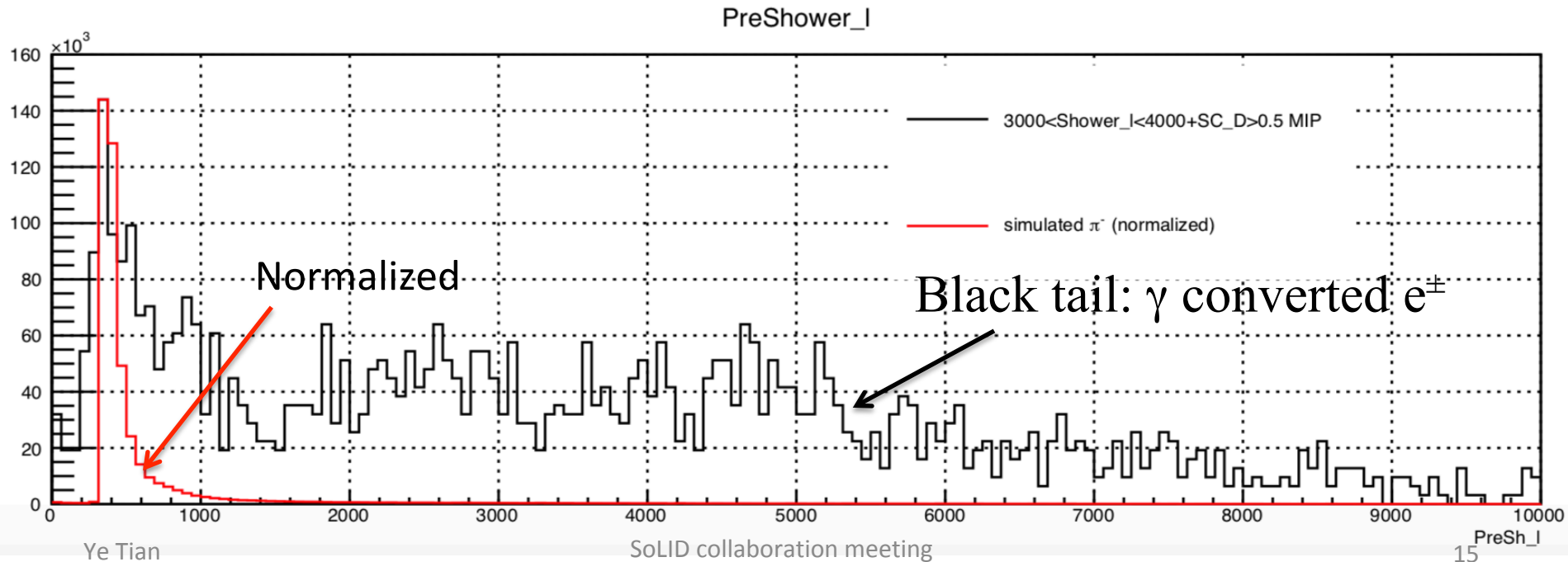
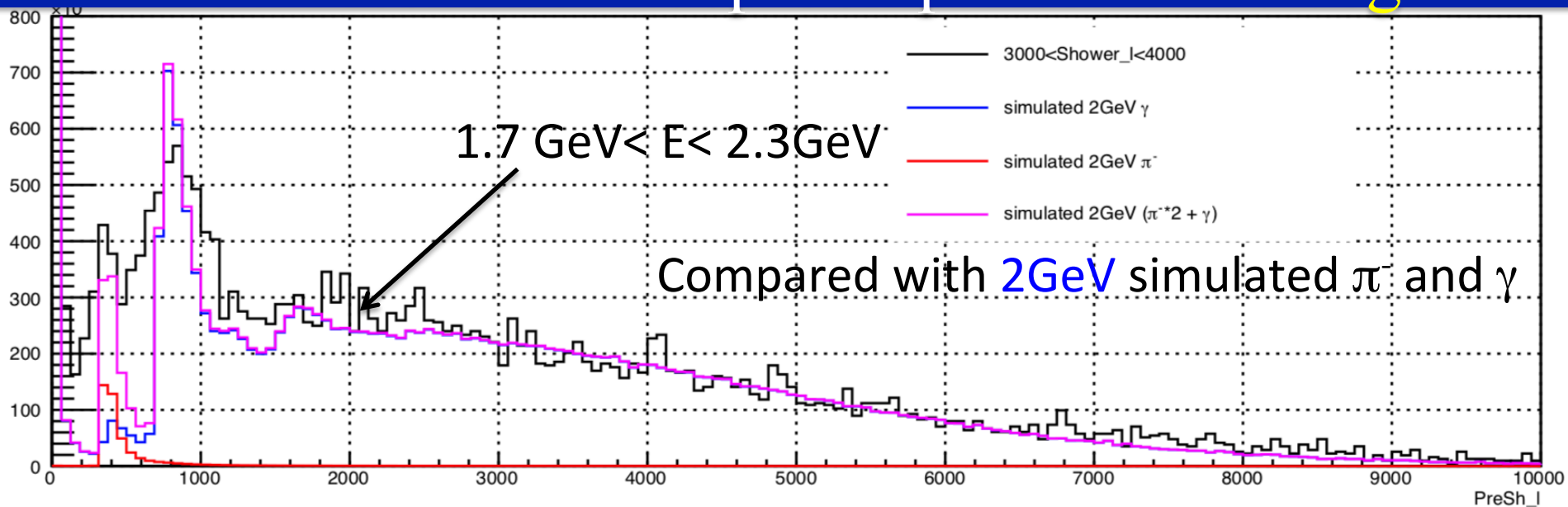
Ecal Preshower Edep Comparison at 18 deg

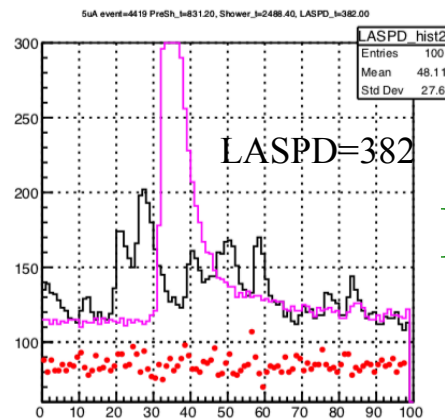
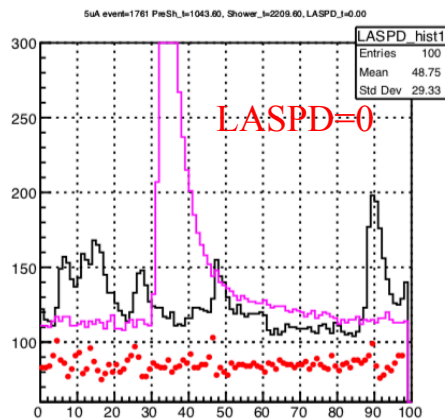
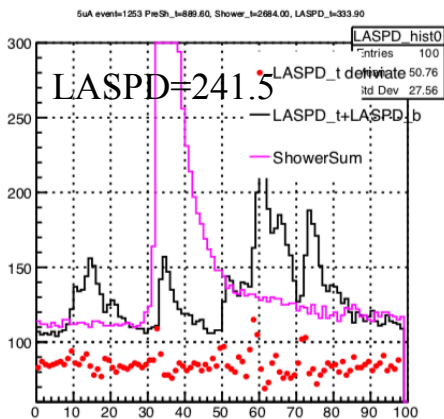


PreShower works very well for the high energy region

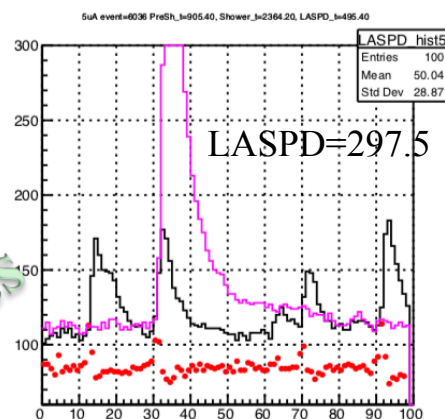
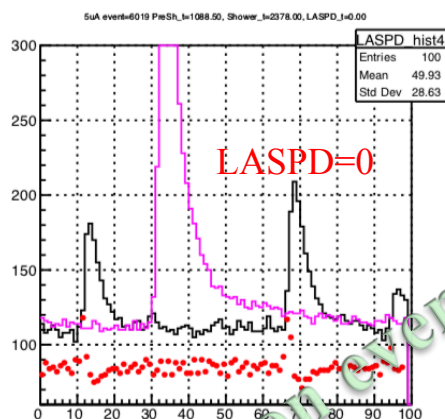
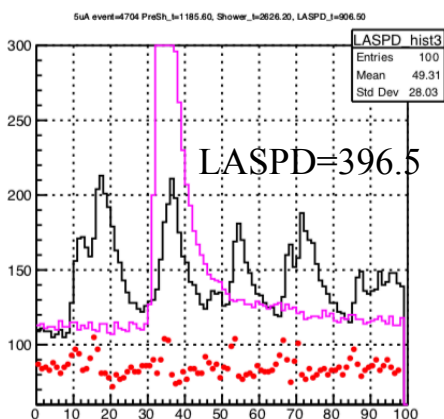


Ecal Preshower Edep Comparison at 18 deg



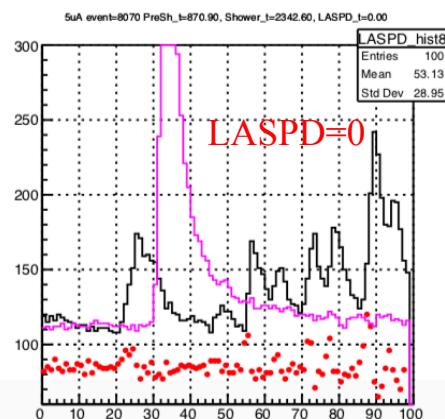
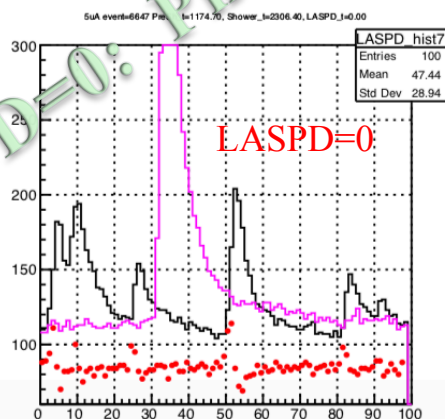
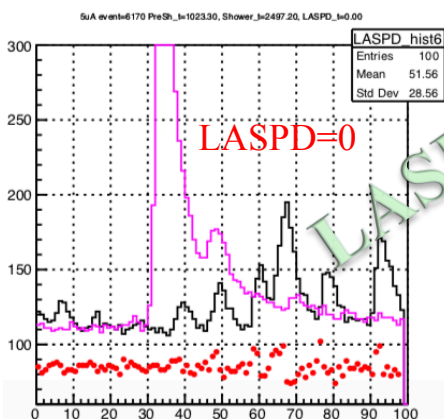


LASPD Photon Rejection Study at 18 deg



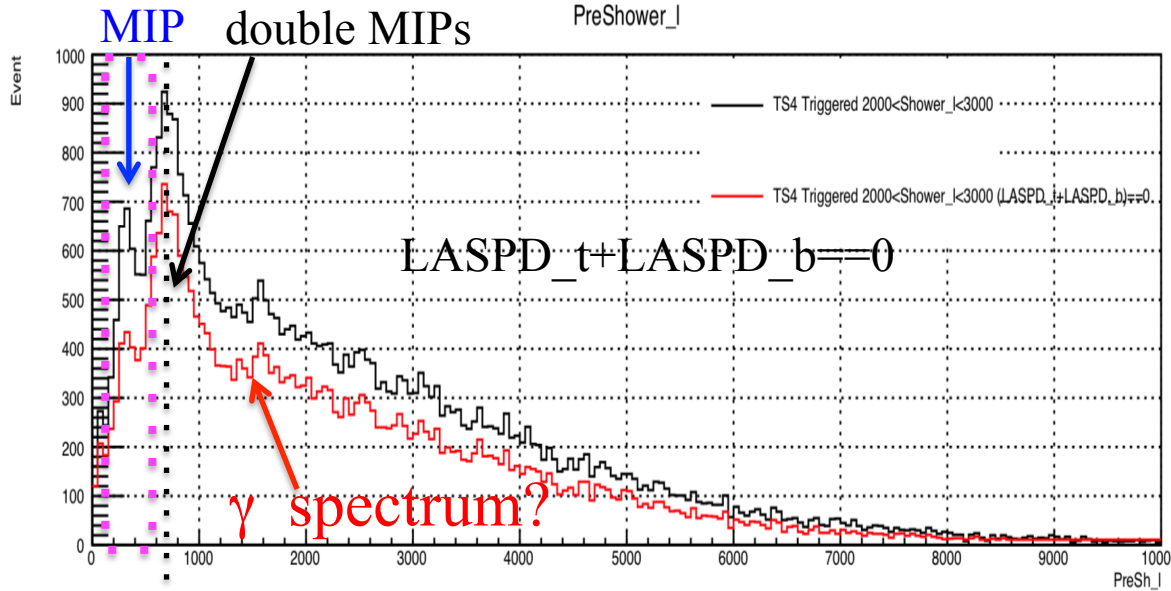
- LASPD_t derivative
- LASPD_t+LASPD_b
- ShowerSum

- Run 4680
- 5uA on LD2



- TS4
- $2200 < \text{Shower}_t < 2800$
- $800 < \text{PreSh}_t < 1200$

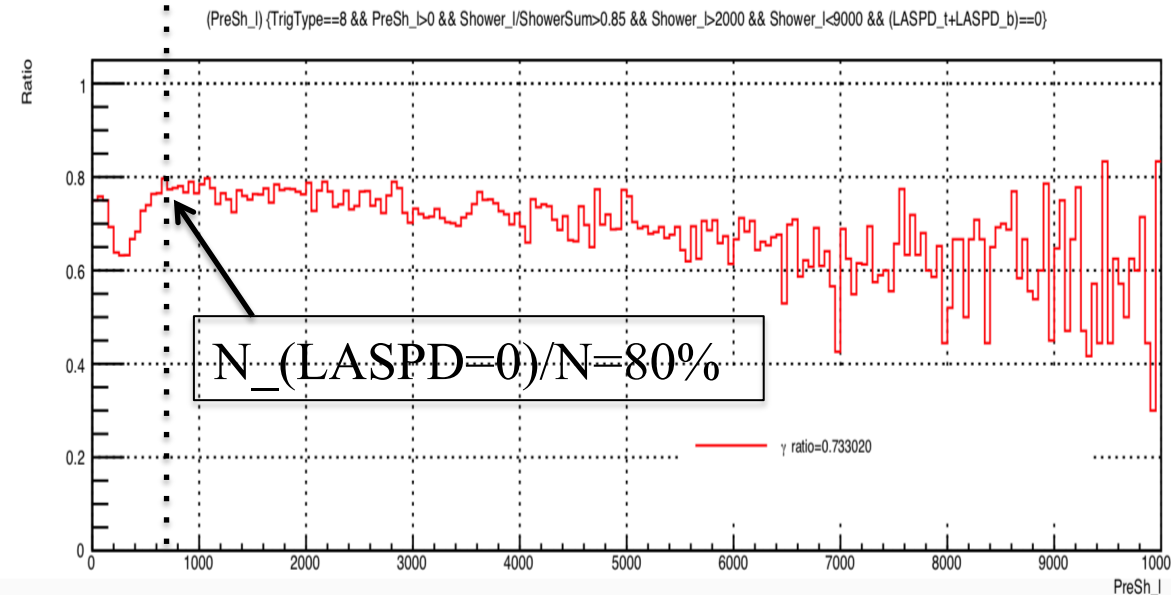
LASPD Photon Rejection Study at 18 deg



Photon rejection:
 $N/N(\text{LASPD} > 0.5 \text{ MIP})$

PreCDR LASPD photon
 rejection 10:1

- 30-ns timing window
- 60 segmentation
- ($\pi^0 \gamma$ + low energy e^- + γ bkg)



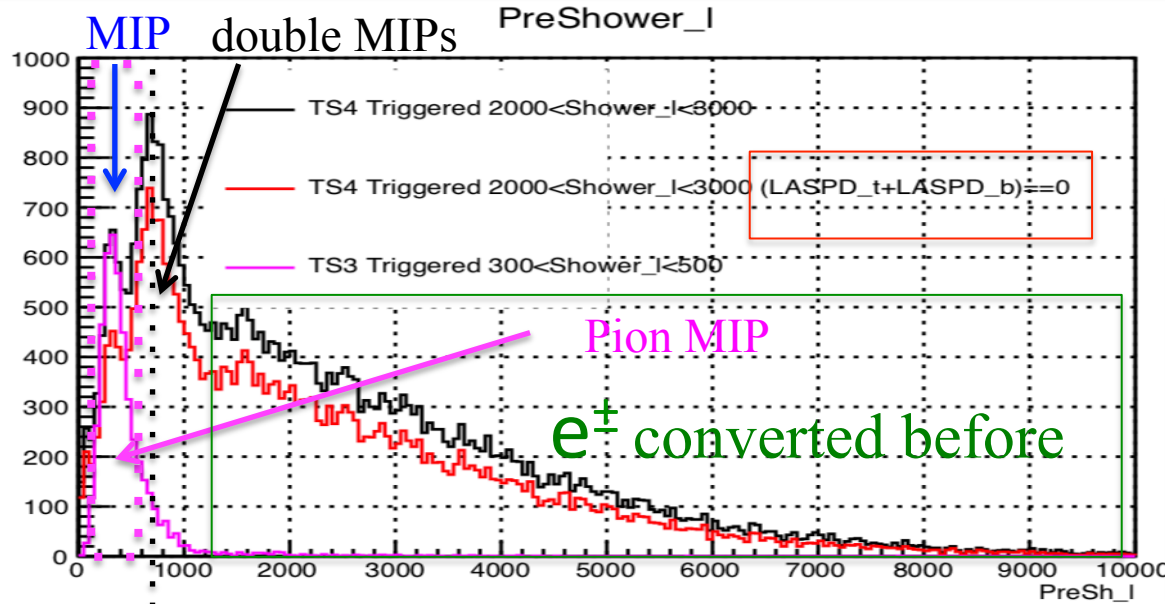
- Run 4680
- 5uA on LD2

LASPD Photon Rejection Study at 18 deg

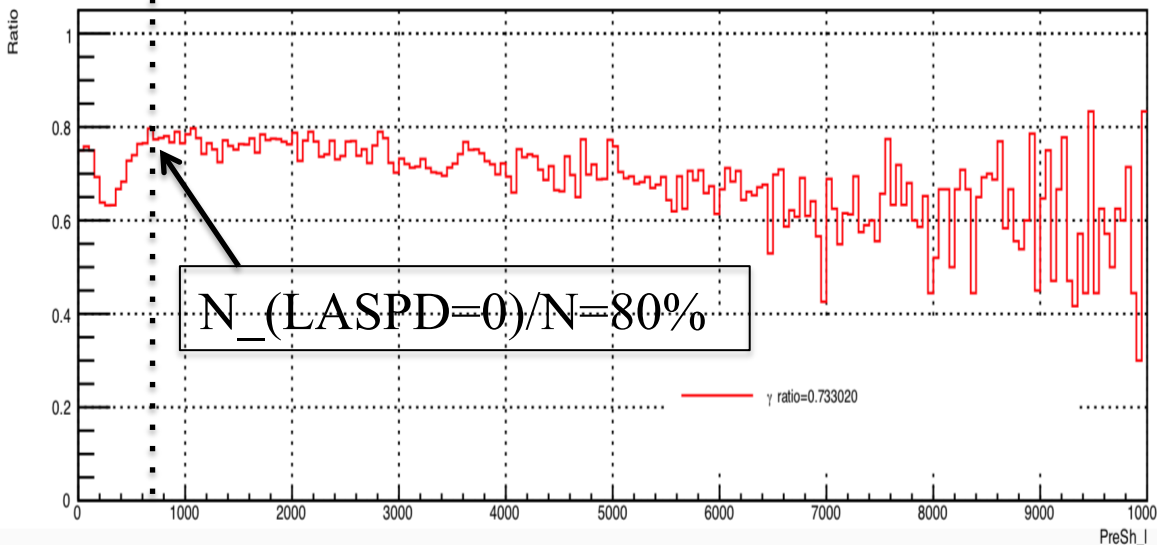
Photon rejection:
 $N/N(\text{LASPD} > 0.5 \text{ MIP})$

PreCDR LASPD photon
 rejection 10:1

- 30-ns timing window
- 60 segmentation
- (π^0 γ + low energy e^- + γ bkg)



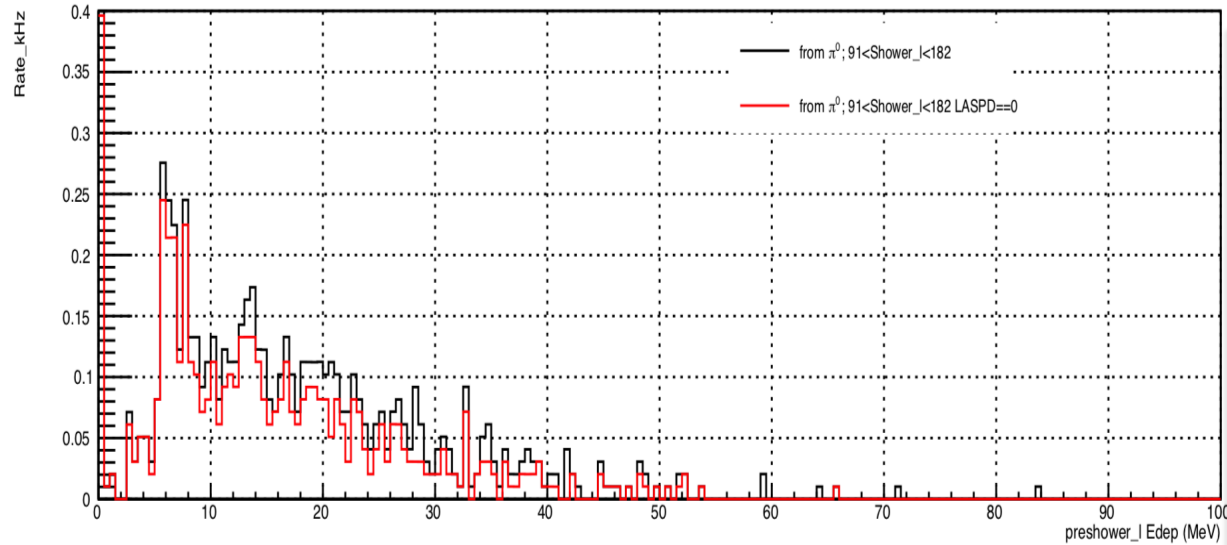
$(\text{PreSh_I}) (\text{TrigType}==8 \ \&\& \ \text{PreSh_I}>0 \ \&\& \ \text{Shower_I}/\text{ShowerSum}>0.85 \ \&\& \ \text{Shower_I}>2000 \ \&\& \ \text{Shower_I}<9000 \ \&\& \ (\text{LASPD_t}+\text{LASPD_b})==0)$



- Run 4680
- 5uA on LD2

LASPD Photon Rejection Study at 18 deg

PreSh_I {rate*(Shower_I>90.9 && Shower_I<182)}



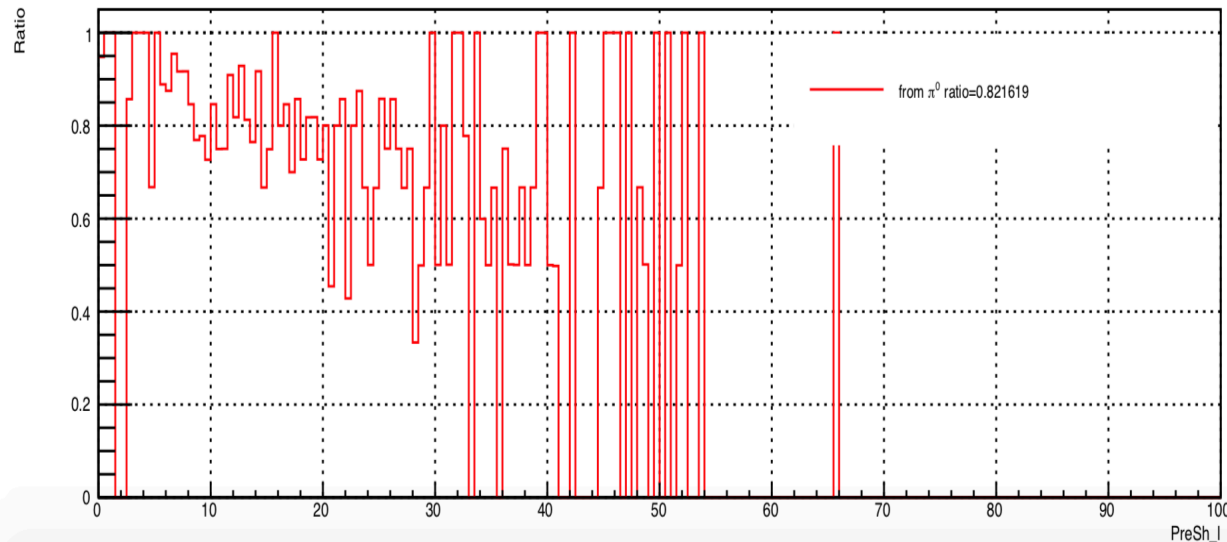
Simulation:

$N_{\text{(LASPD=0)}}/N=82.2\%$

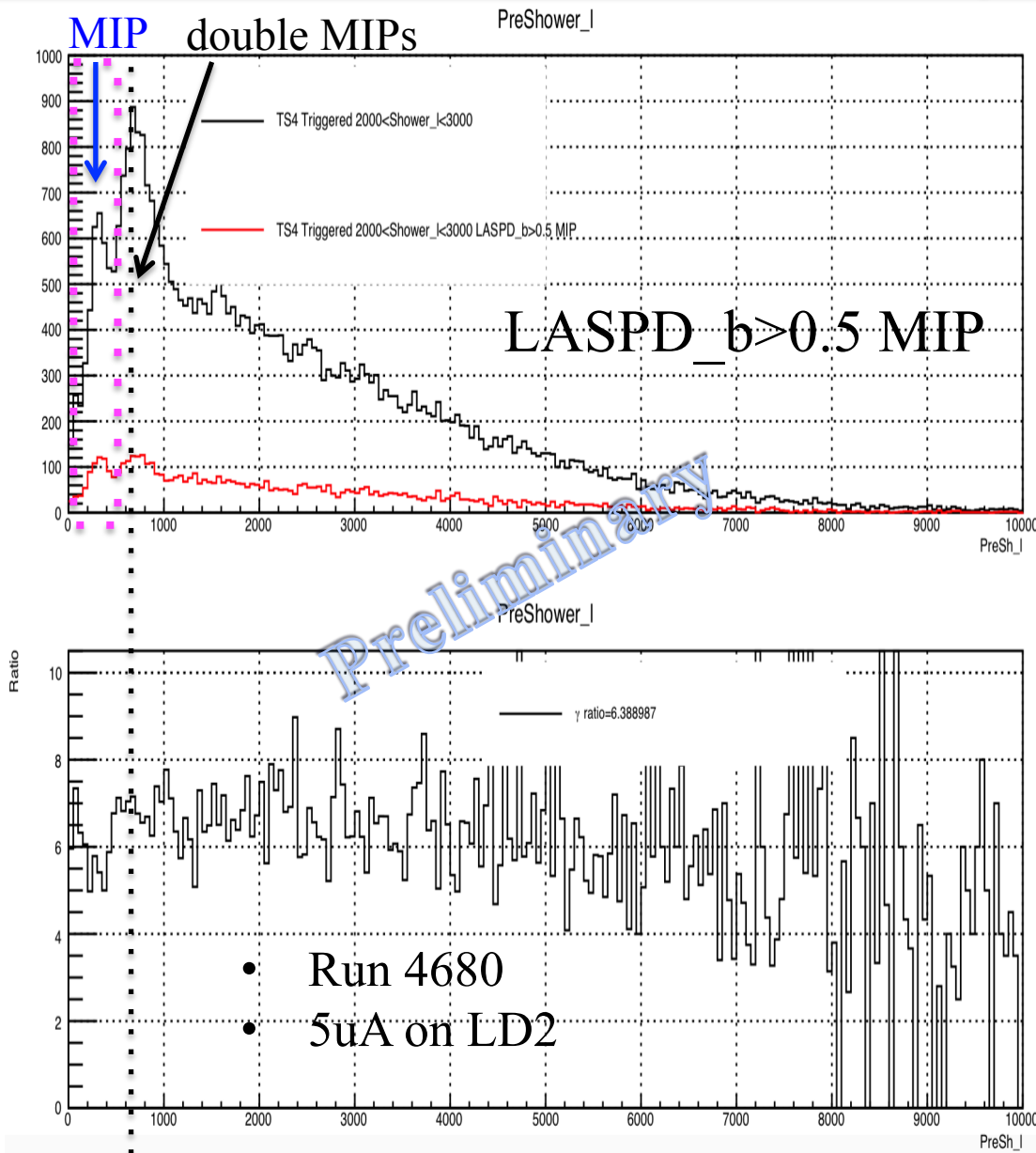
**$\sim 17.8\%$ γ converted
before LASPD**

**Consisted with the beam
test data !**

PreSh_I {rate*(Shower_I>90.9 && Shower_I<182 && LASPD_Eendsum==0)}



LASPD Photon Rejection Study



Photon rejection:
 $N/N(\text{LASPD}>0.5 \text{ MIP})$

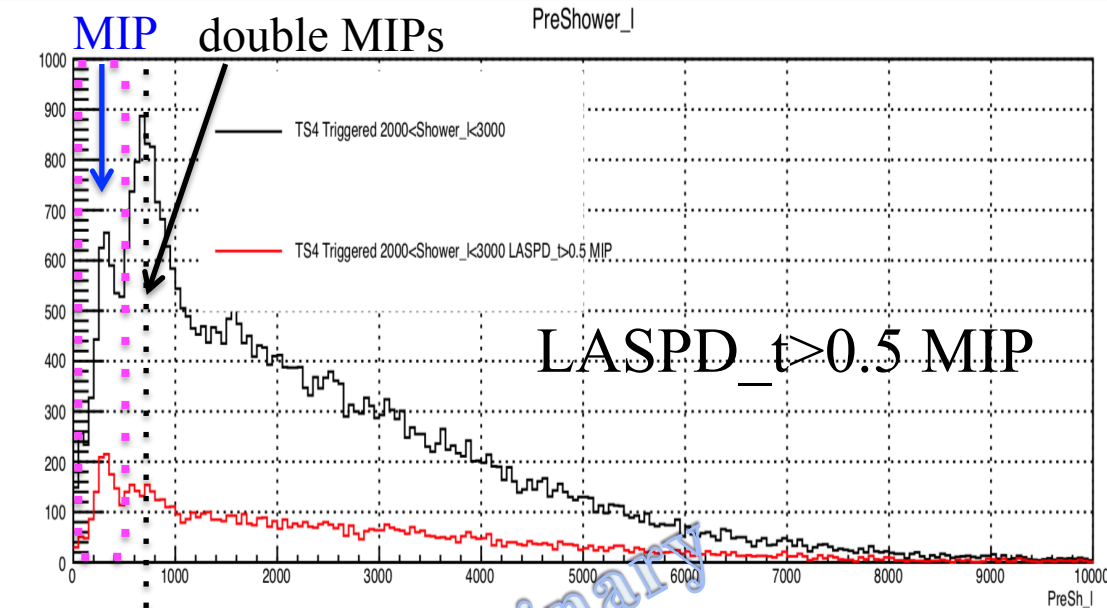
PreCDR LASPD photon
rejection 10:1

- 30-ns timing window
- 60 segmentation
- ($\pi^0 \gamma$ +low energy e^- + γ bkg)

Beam test photon rejection
factor $\sim 7:1$ at double MIPs

- LASPD_b>0.5 MIP cut

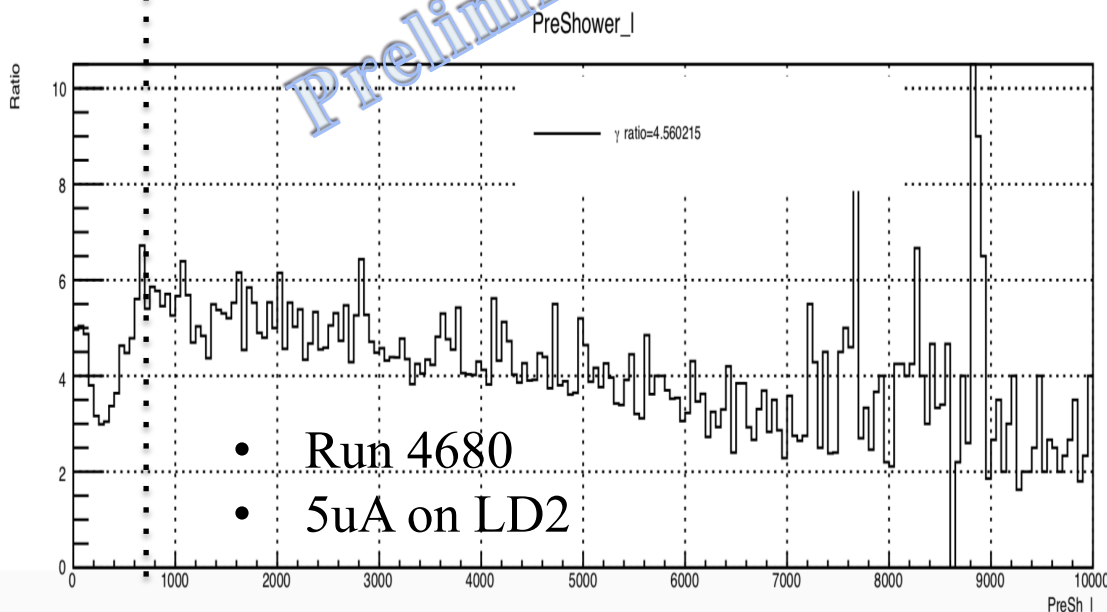
LASPD Photon Rejection Study



Photon rejection:
 $N/N(\text{LASPD} > 0.5 \text{ MIP})$

PreCDR LASPD photon
 rejection 10:1

- 30-ns timing window
- 60 segmentation
- ($\pi^0 \gamma$ + low energy e^- + γ bkg)



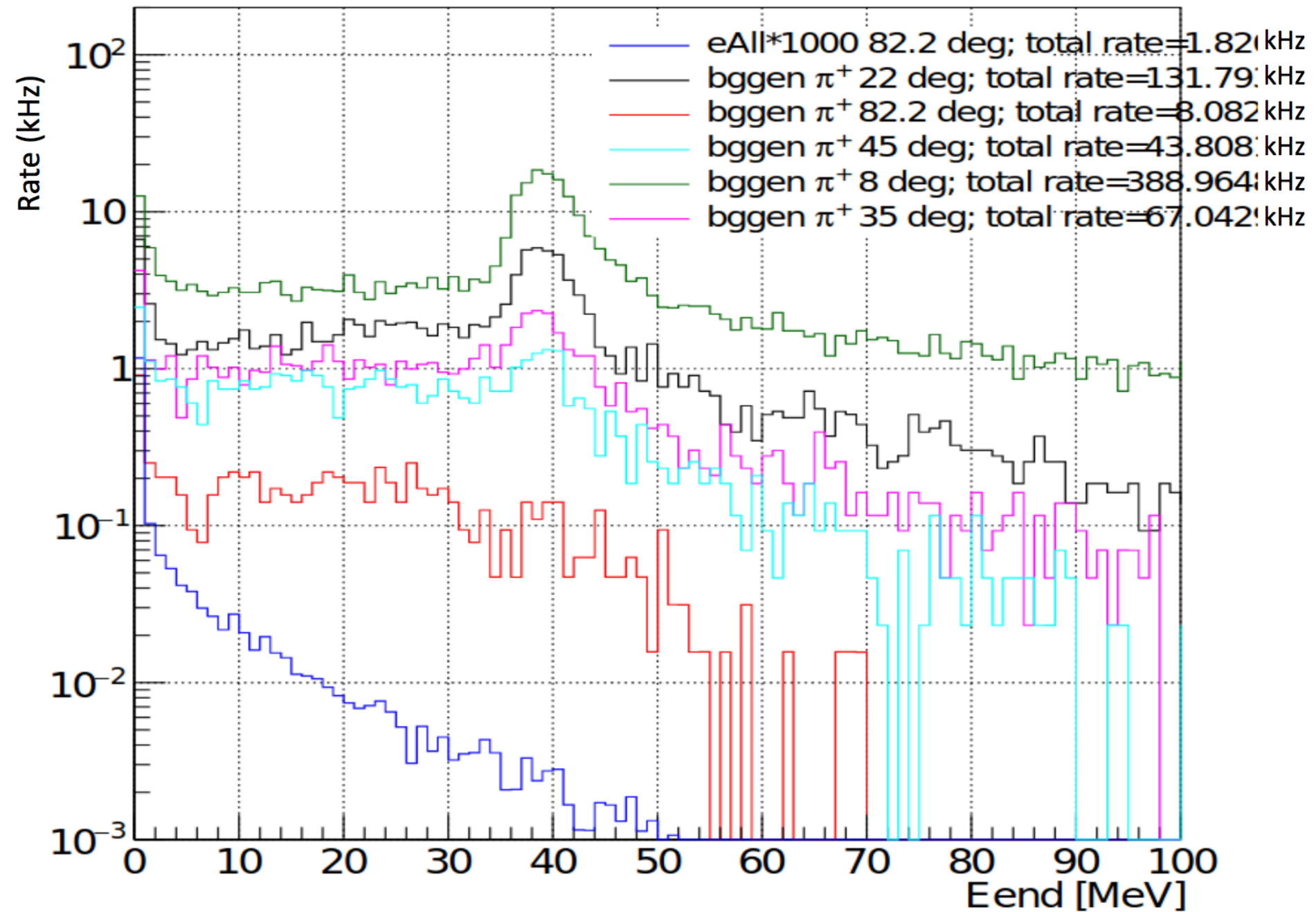
Beam test photon rejection
 factor $\sim 6:1$ at double MIPs

- LASPD_t>0.5 MIP cut

Summary

- Comparing both low and high rate test data with simulation, the rate estimations from SoLID bggen and eAll event generators are consistent with those from the 7 deg data within 10%.
- ECal prehower and shower work very well under the actual high rate, high radiation, high background SoLID running condition, and the preshower works very well on identifying e^- at high energy region (above pion Cherenkov radiation threshold $>4\text{GeV}$).
- The preliminary beam test result shows that the photon rejection factor is around 7:1 based on 5uA beam test data.
- Comparison between simulation and data and LASPD analysis are ongoing.

Backup



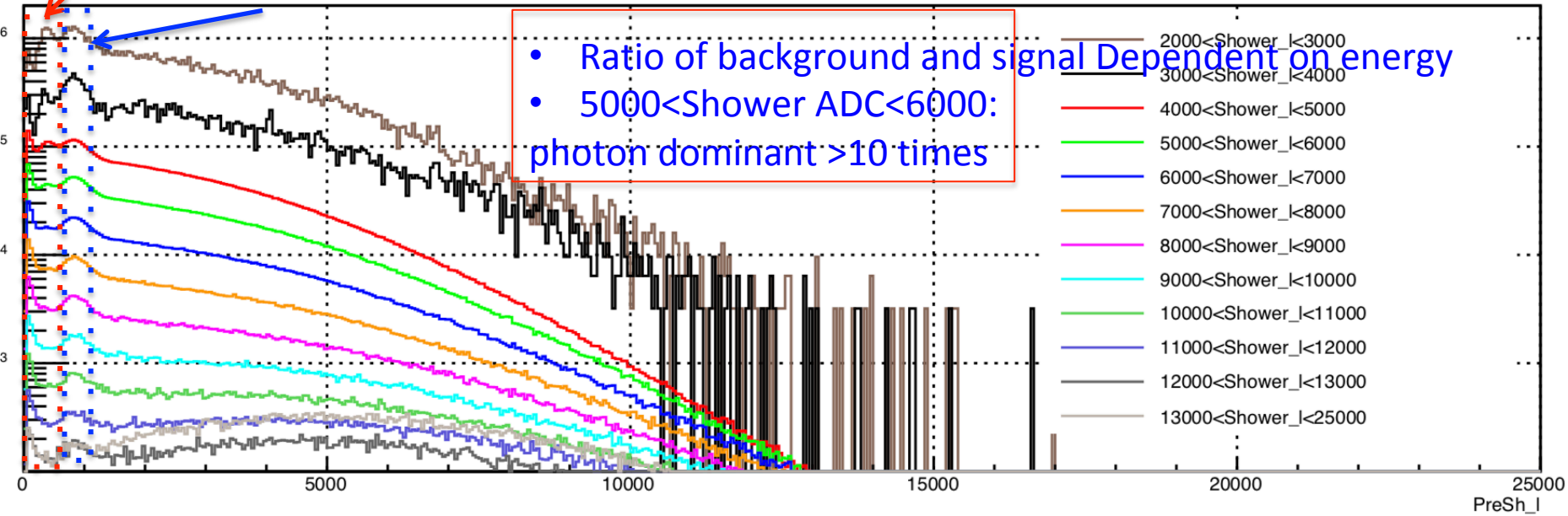
Pion MIPs

Double MIPs

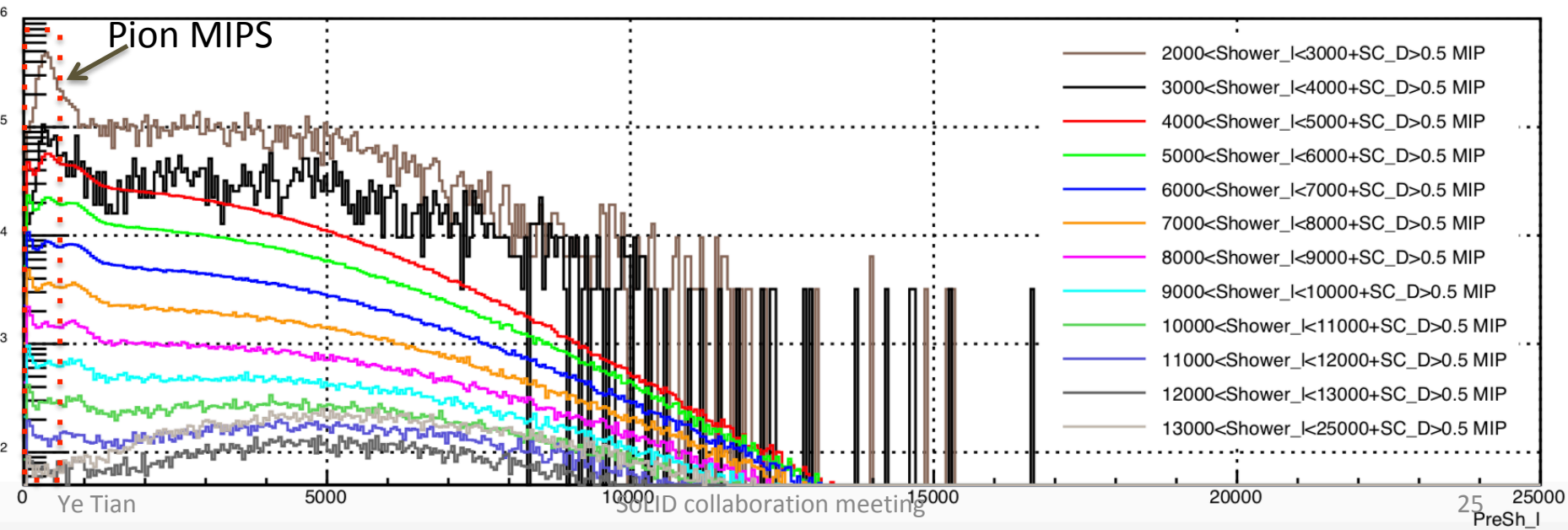
Run 4344+ Run 4577

PreShower feature

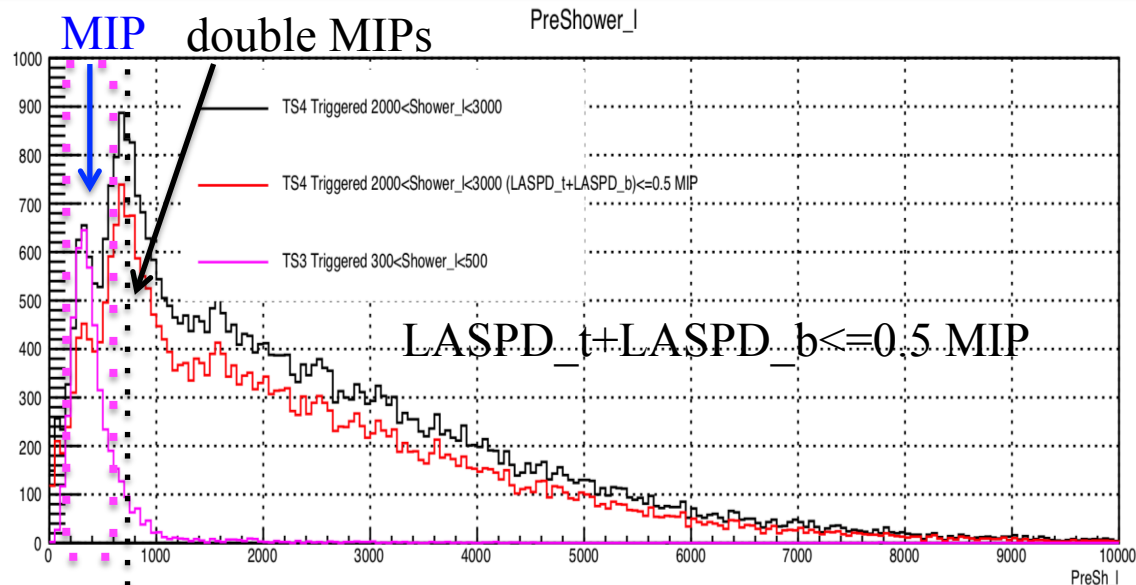
- Ratio of background and signal **Dependent on energy**
- 5000<Shower ADC<6000:
photon dominant >10 times



PreShower_I



LASPD Photon Rejection Study

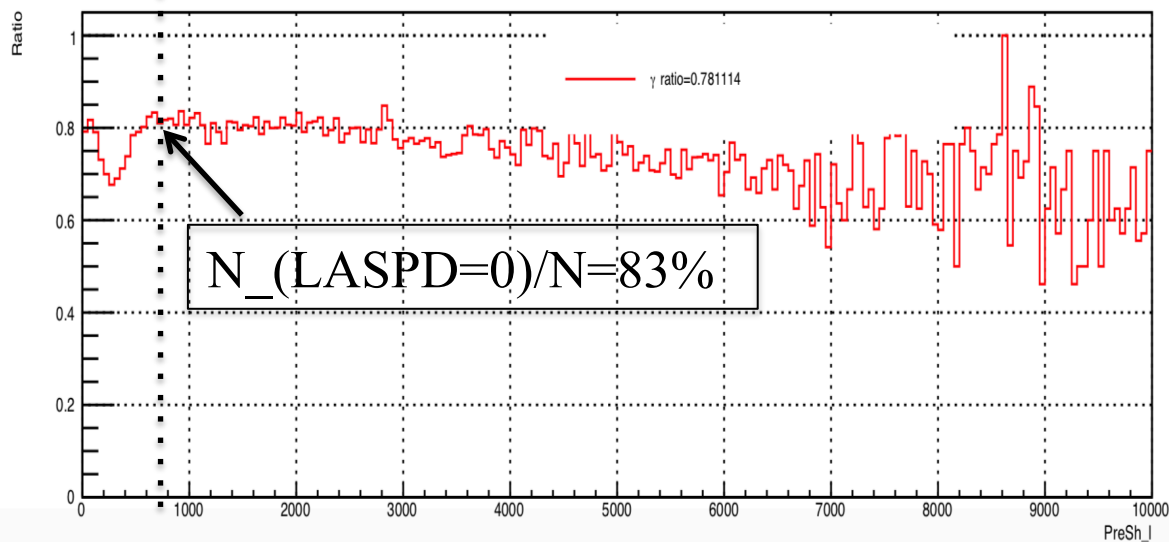


Photon rejection:
 $N/N(\text{LASPD} > 0.5 \text{ MIP})$

PreCDR LASPD photon
 rejection > 10:1

- 30-ns timing window
- 60 segmentation
- ($\pi^0 \gamma$ + low energy $e^- + \gamma$ bkg)

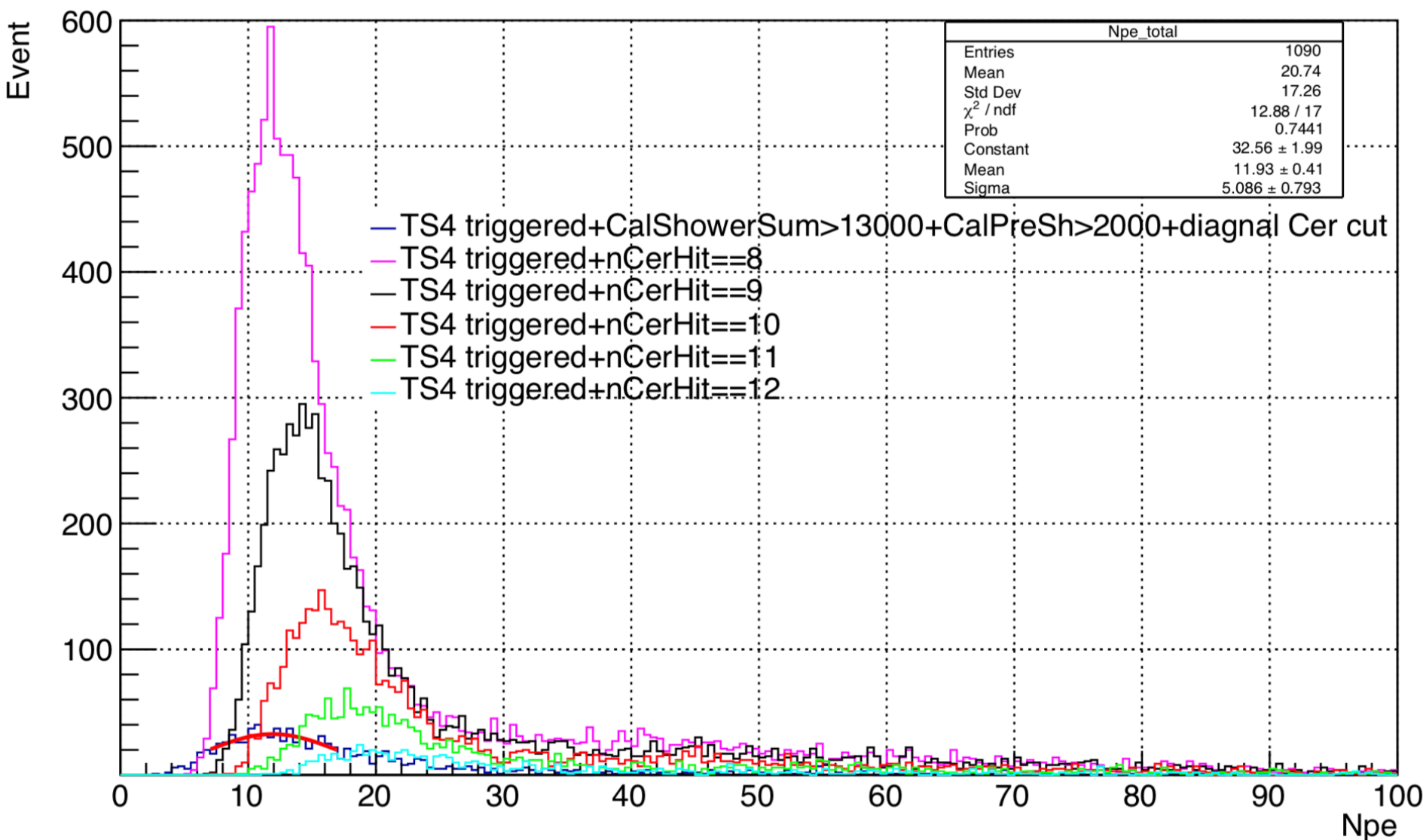
(PreSh_I) (TrigType==8 && PreSh_b>0 && Shower_I/ShowerSum>0.85 && Shower_b>2000 && Shower_I<4000 && (LASPD_t+LASPD_b)<=158)



- Run 4680
- 5uA on LD2

Consider pion background:
 $1/(1-0.91) > 10$

High Energy e^- to Test Cherenkov Detector at 18 deg



Ecal PreShower Edep for Beam Test at 7 deg

- PreShower can help on identifying high energy e^- , and it works well at the high energy region (above pion Cherenkov radiation threshold).

