DDVCS with SuperBigBite

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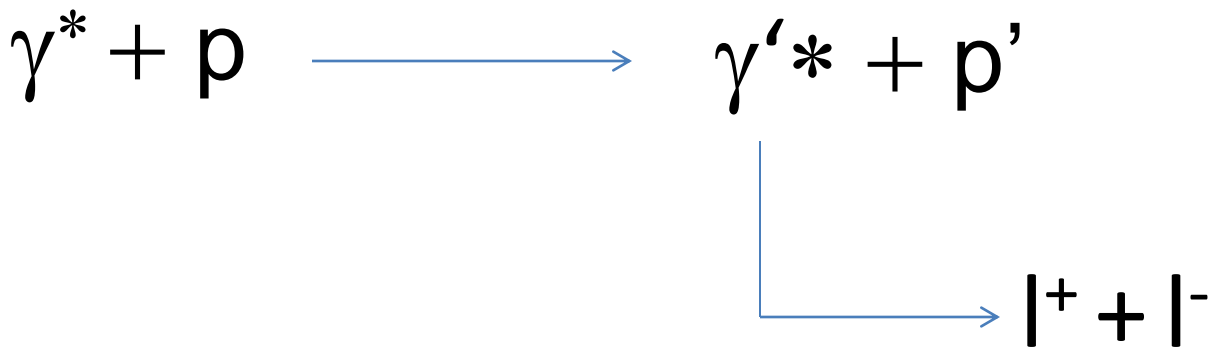
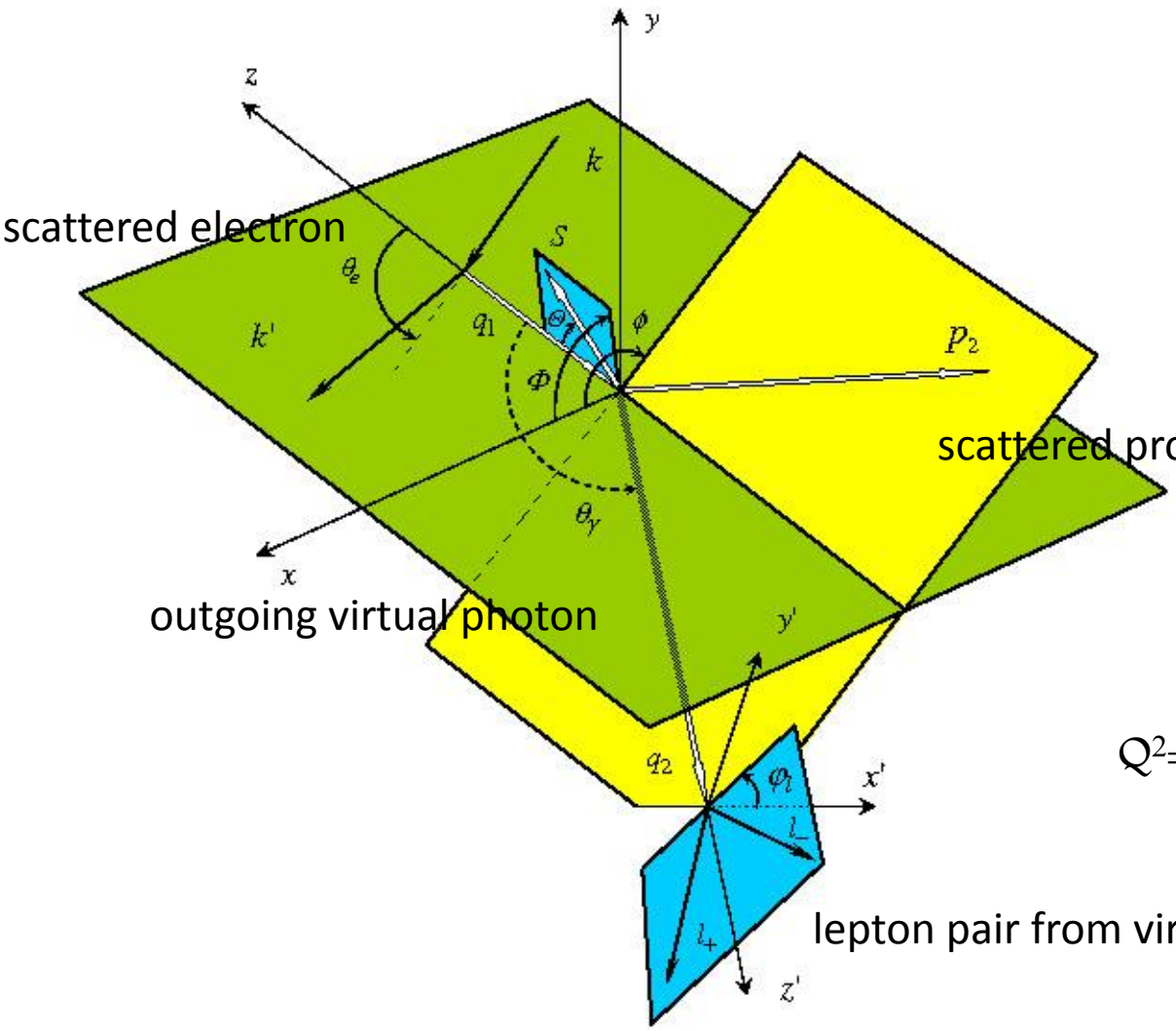
December 20th 2013

Double DVCS



Guidal and Vanderhaegen : Double deeply virtual Compton scattering off the nucleon (arXiv:hep-ph/0208275v1 30 Aug 2002)
Belitsky Radyushkin : Unraveling hadron structure with generalized parton distributions (arXiv:hep-ph/0504030v3 27 Jun 2005)

Double Deeply Virtual Compton Scattering



Δ = p1-p2 = q2-q1

p = p1+p2

q = ½ (q1+q2)

$Q^2 = -q^2$

$$\xi = \frac{Q^2}{2p.q}$$

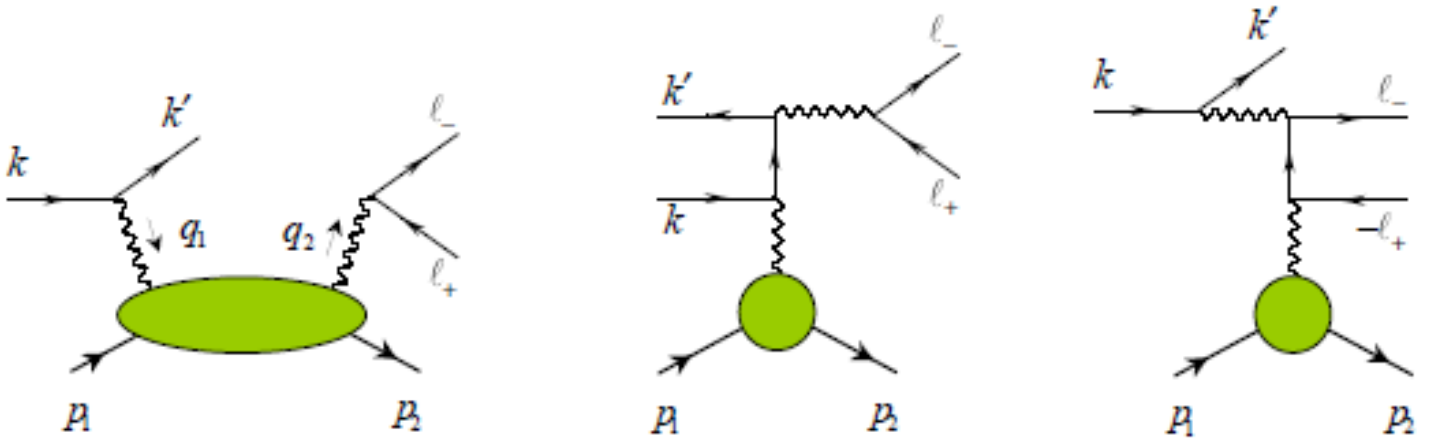
$$\eta = \frac{\Delta.q}{p.q}$$

$Q^2 = -(k-k')^2$ $\qquad$ $x_{bj} = \frac{Q^2}{2p_1q_1}$

Double DVCS

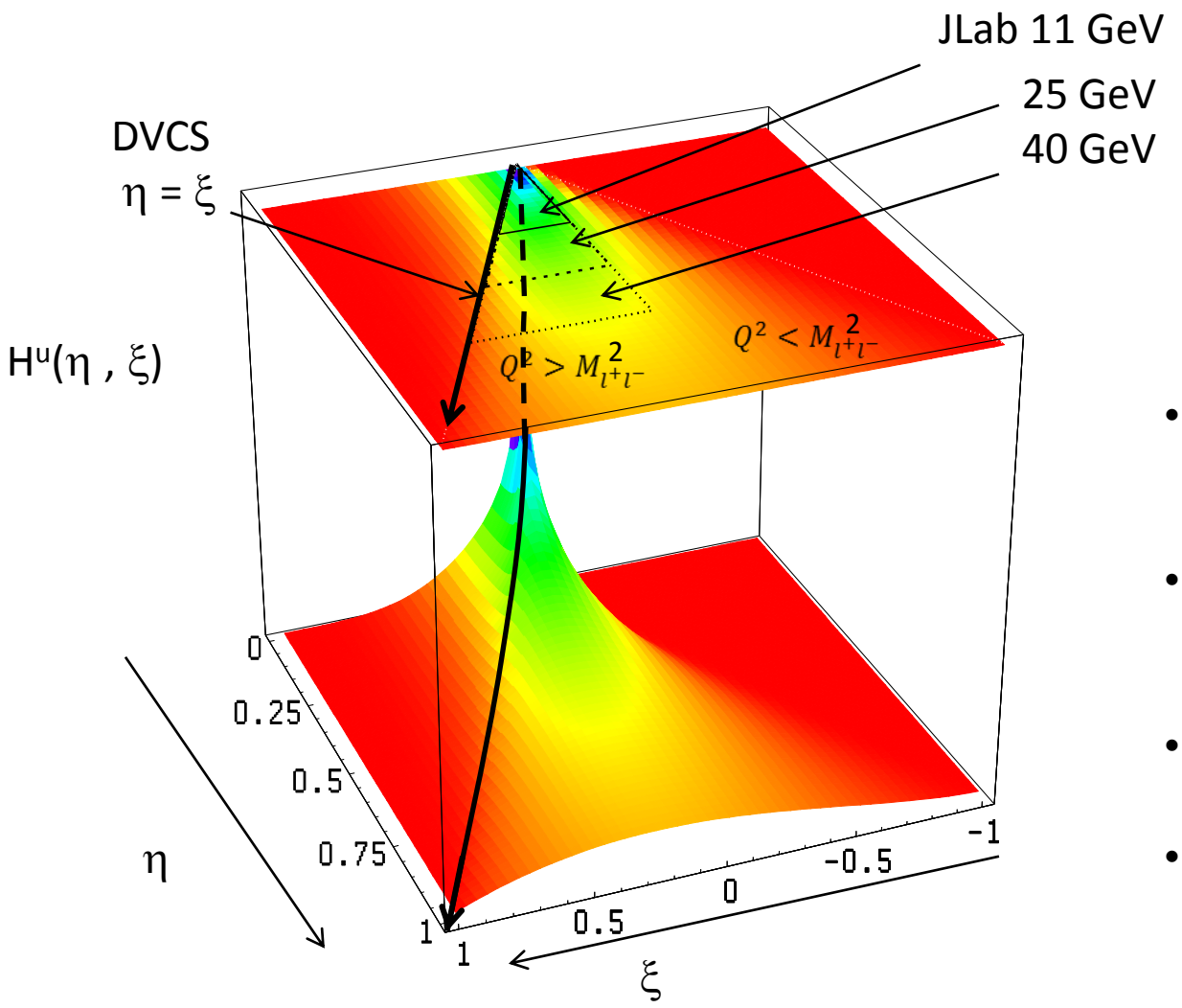
- Detect dilepton pair instead of real photon
- Allow to vary skewness η of the reaction
- Charged particle in final state can use spectrometer to measure momentum (less requirement on calorimeter energy resolution)

Double DVCS and Virtual Bethe Heitler



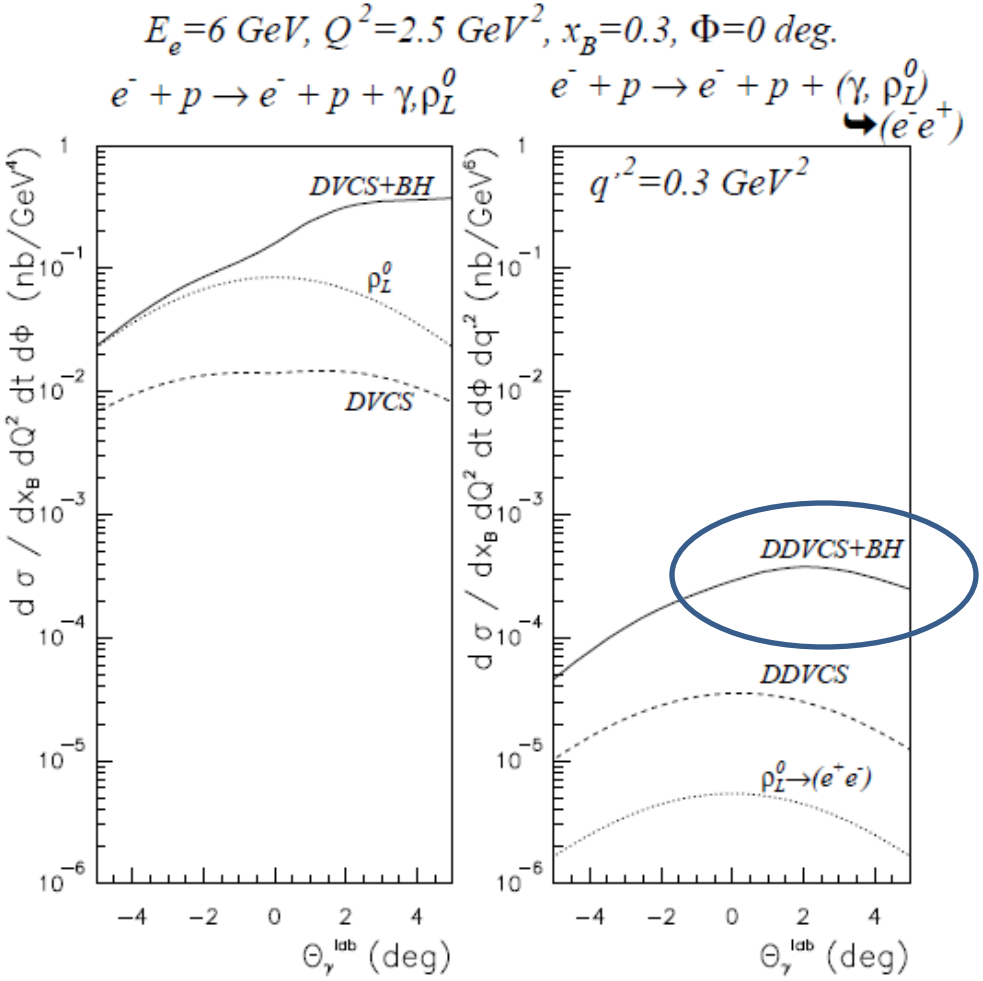
- Interference of Double DVCS and virtual Bethe Heitler

Kinematical coverage



- DVCS only probes $\eta = \xi$ line
- Example with model of GPD H for up quark
- Jlab : $Q^2>0$
- Kinematical range increases with beam energy (larger dilepton mass)

DDVCS cross section



- VGG model
- Order of ~0.1 pb = 10^{-36}cm^2
- Virtual Beth and Heitler
- Interference term enhanced by BH
- Contributions from mesons small when far from meson mass

DDVCS measurement

- Need high luminosity
  - Hall B : 10^{35}- 10^{36} $cm^{-2}s^{-1}$
  - mEIC : 1.5x 10^{34} $cm^{-2}s^{-1}$
  - Want $10^{38}cm^{-2}s^{-1}$ ideally 10^{39} $cm^{-2}s^{-1}$

- Pair detection : clean trigger

- Ideally look at muons channel to avoid ambiguity with initial electron
  (muon source low luminosity)

DDVCS measurement

- Large acceptance to get the whole angular coverage of the pair

- Forward angle for increase of Bethe and Heitler interference

Cinematique

$$q_1 + p_1 \to q_2 + p_2$$

$$q = \frac{1}{2}(q_1 + q_2)\,, \qquad p = p_1 + p_2\,, \qquad \Delta = p_1 - p_2 = q_2 - q_1$$

$$\xi = \frac{Q^2}{p \cdot q} \qquad \eta = \frac{\Delta \cdot q}{p \cdot q}$$

$$\xi = \frac{\mathcal{Q}^2 - M^2_{\ell\bar{\ell}} + \Delta^2/2}{2\mathcal{Q}^2/x_{\rm B} - \mathcal{Q}^2 - M^2_{\ell\bar{\ell}} + \Delta^2}\,, \qquad \eta = \frac{\mathcal{Q}^2 + M^2_{\ell\bar{\ell}}}{2\mathcal{Q}^2/x_{\rm B} - \mathcal{Q}^2 - M^2_{\ell\bar{\ell}} + \Delta^2}$$

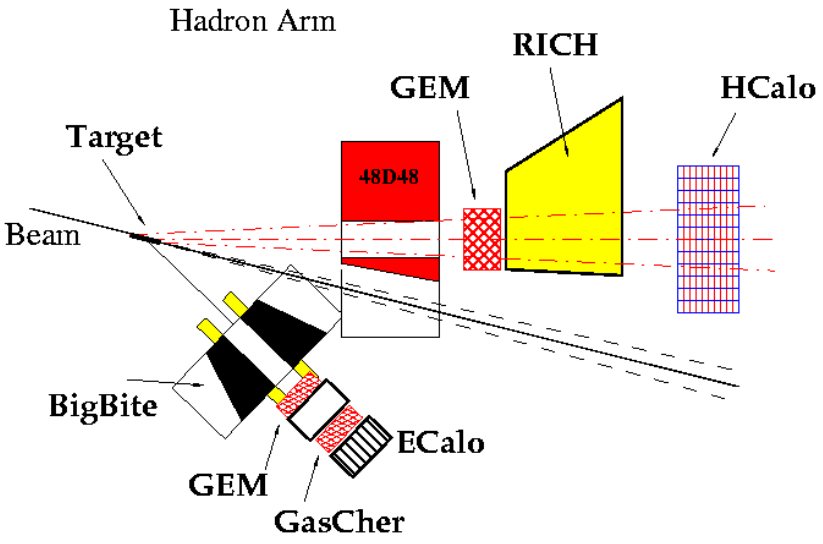
Spectrometre SuperBigBite

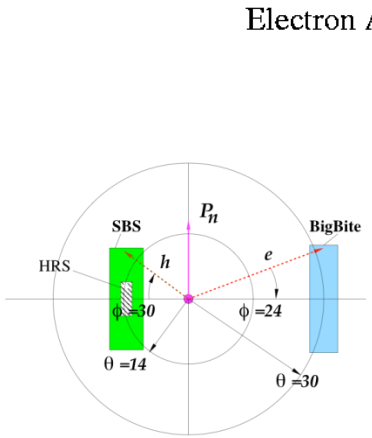
Large Dipole 48 in x 48 in

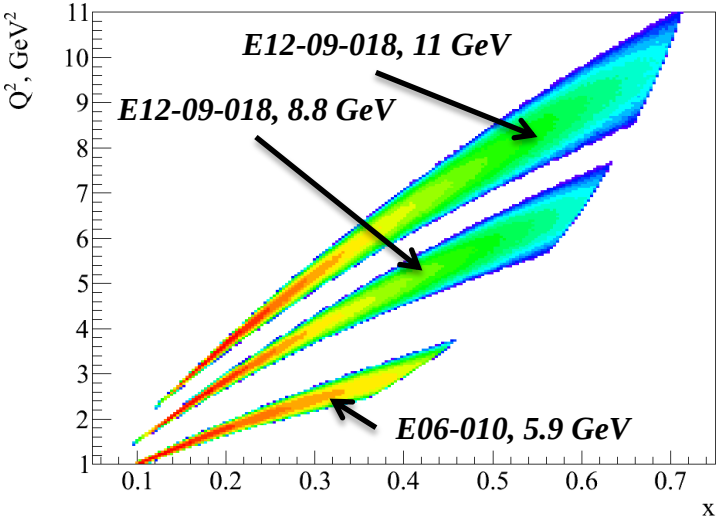
Gem trackers

Calorimetre hadronique
20 cm x 20 cm x 100 cm

E12-09-018: SIDIS on polarized ^{3}He @ 12 GeV



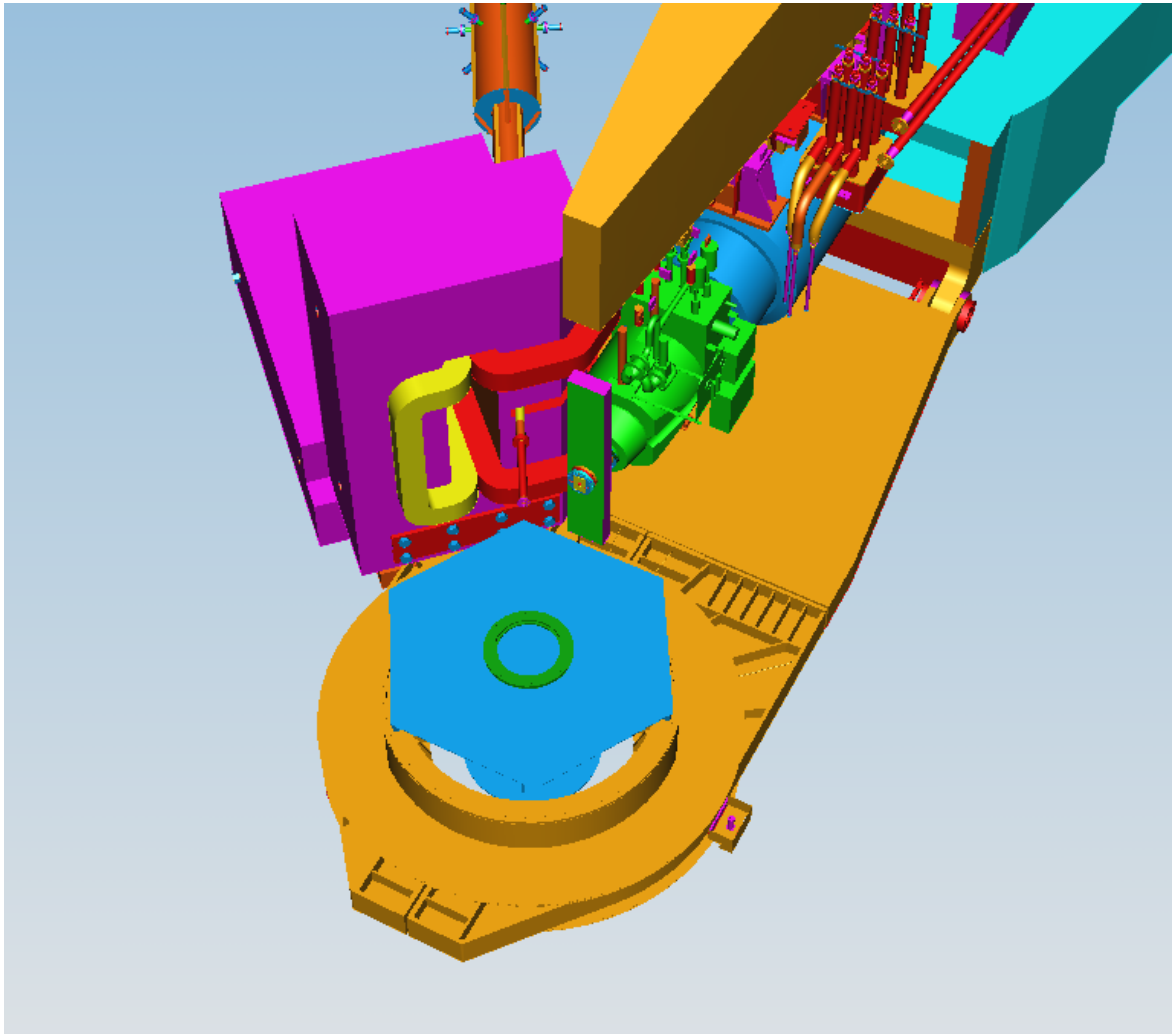




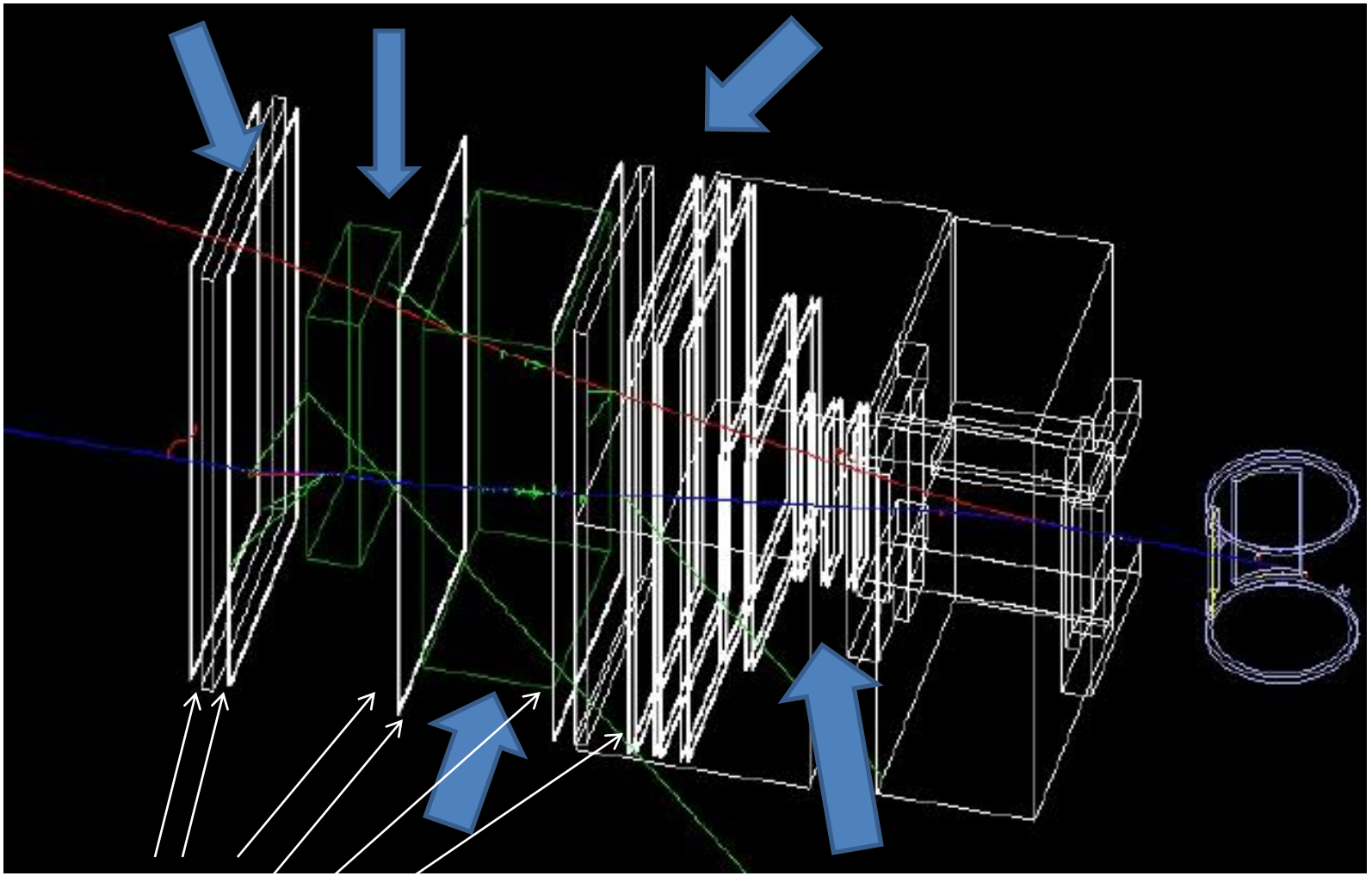
Experiment E12-09-018

- ***Approved by JLab PAC38 (August 2011), 64 days, A- rating***
- ***Spokespersons:***
  - ***G. Cates (UVA)***
  - ***E. Cisbani (INFN)***
  - ***G. Franklin (CMU)***
  - ***A. Puckett (LANL—currently JLab, near future UConn)***
  - ***B. Wojtsekhowski (JLab)***
- In two-months production run, E12-09-018 will reach ~1000X statistical FOM of E06-010 n, ~100X HERMES p
- ***Electron arm: BigBite at 30 deg as in E06-010 + A_1^n detector upgrades***
- ***Hadron arm: Super BigBite (SBS) at 14 deg.***
- Target: high-luminosity polarized Helium-3

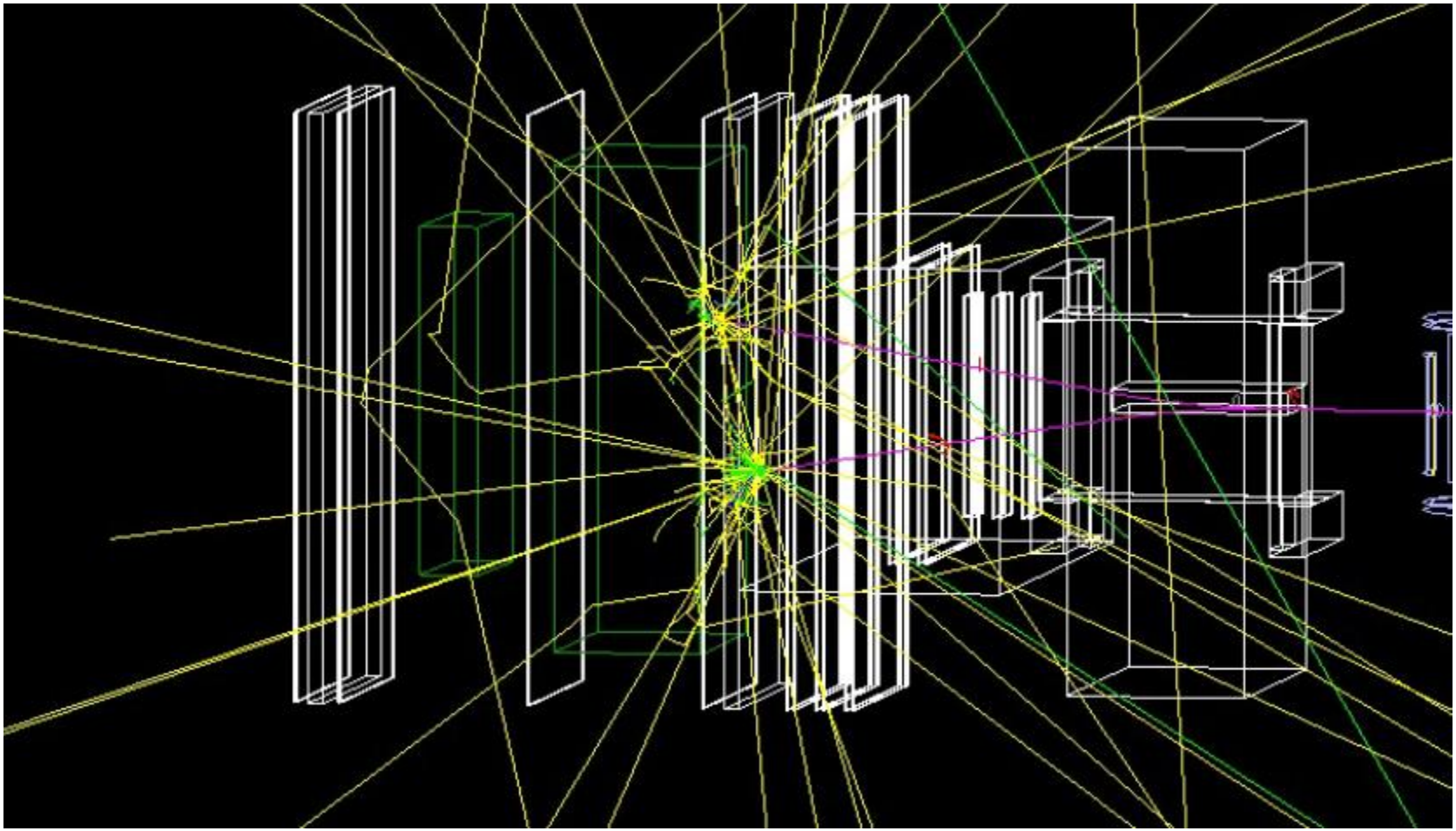
Possible HRS/SBS layout



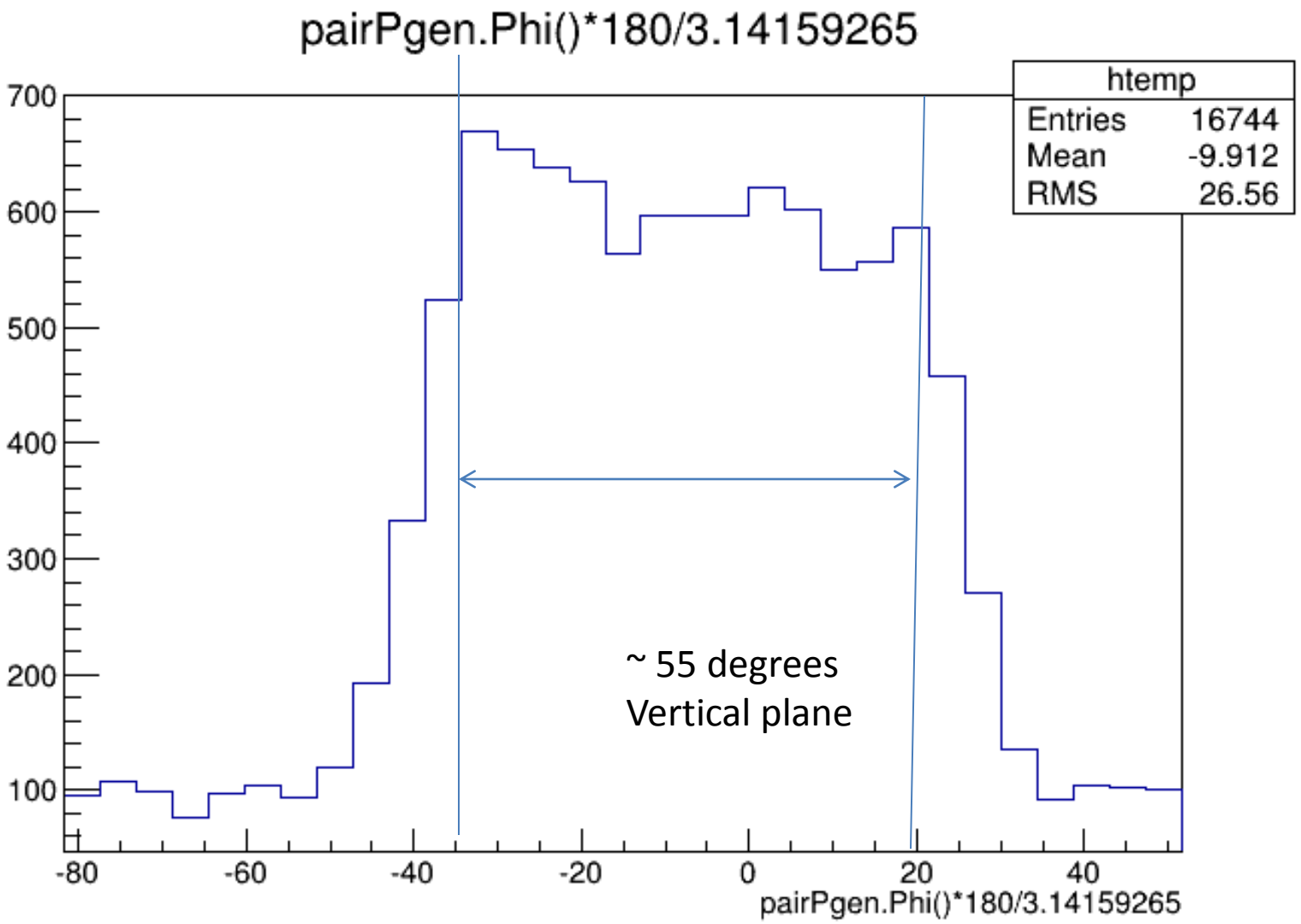
Experimental setup



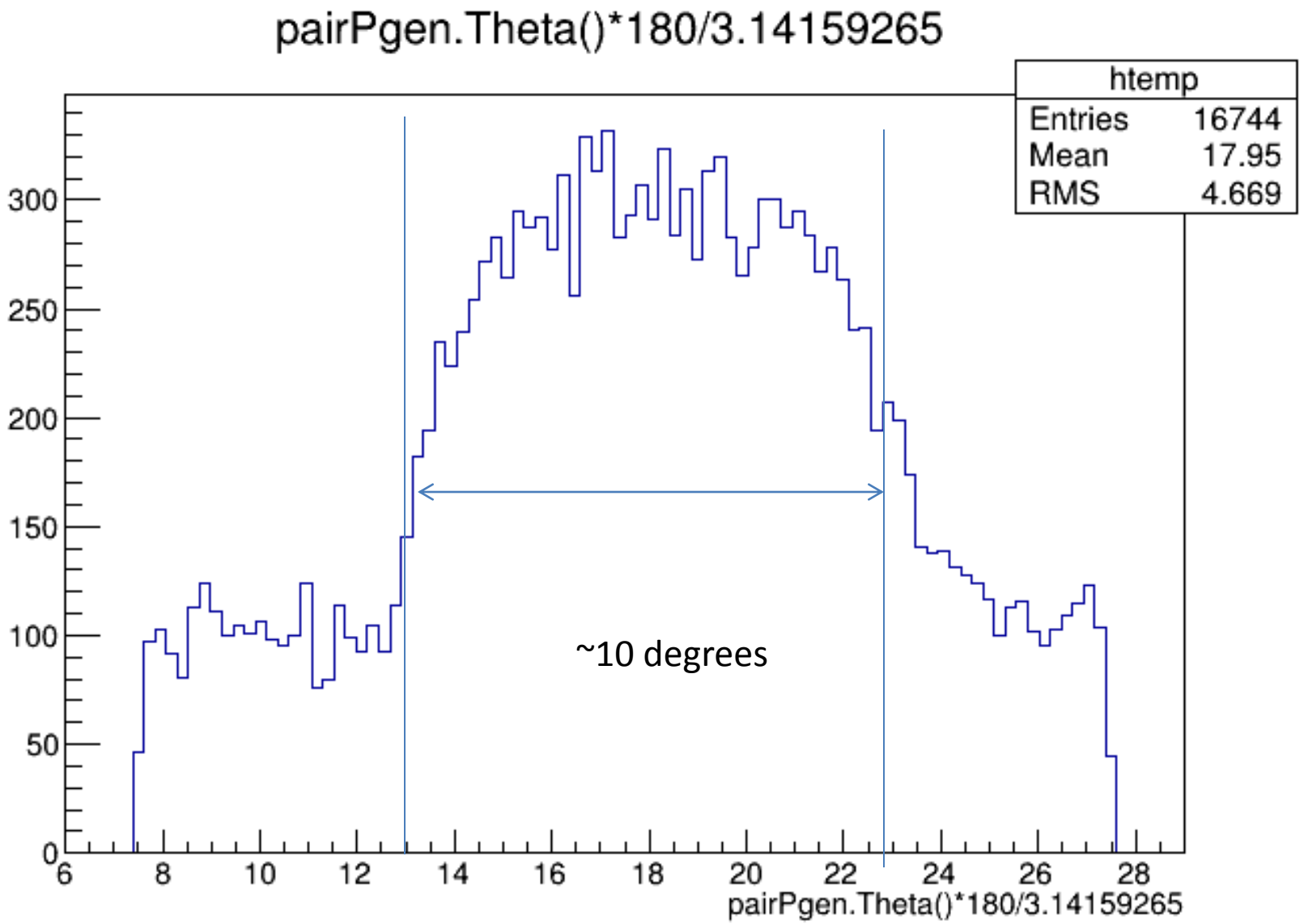
Pion event



Acceptance


pairPgen.Phi()*180/3.14159265
htemp
Entries 16744
Mean -9.912
RMS 26.56
700
600
500
400
300
200
100
-80
-60
-40
-20
0
20
40
pairPgen.Phi()*180/3.14159265
~ 55 degrees
Vertical plane

Acceptance

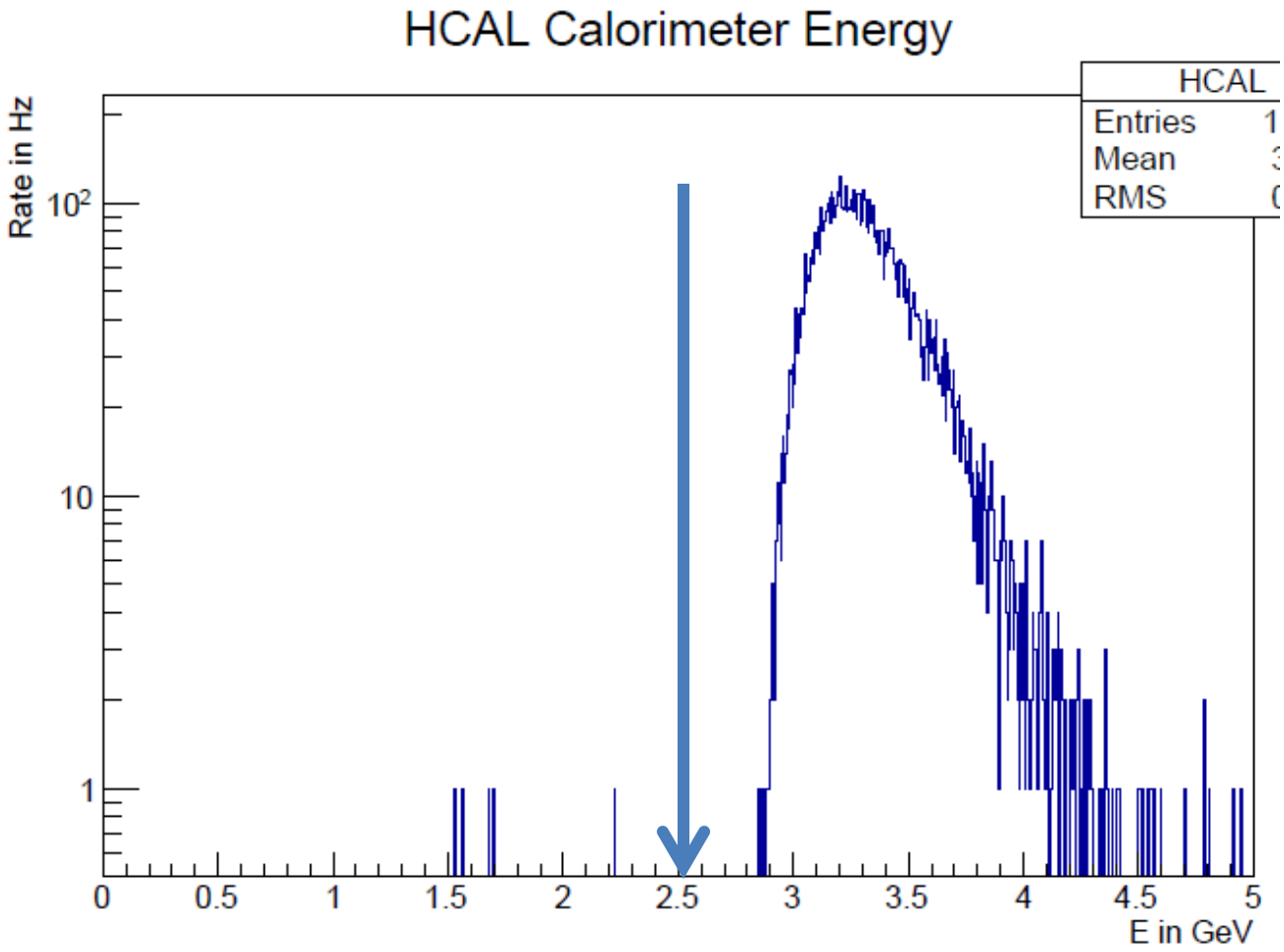

pairPgen.Theta()*180/3.14159265
htemp
Entries 16744
Mean 17.95
RMS 4.669
~10 degrees
pairPgen.Theta()*180/3.14159265

Q’2 range

- Assume 3 GeV muons
- Q’2 = 4 * 3 * 3 * $\sin^2$(theta/2)
- Q’2>1 GeV 2  theta > 19.2 degrees
- Reduce acceptance to event closer to vertical plane (about 50 %)

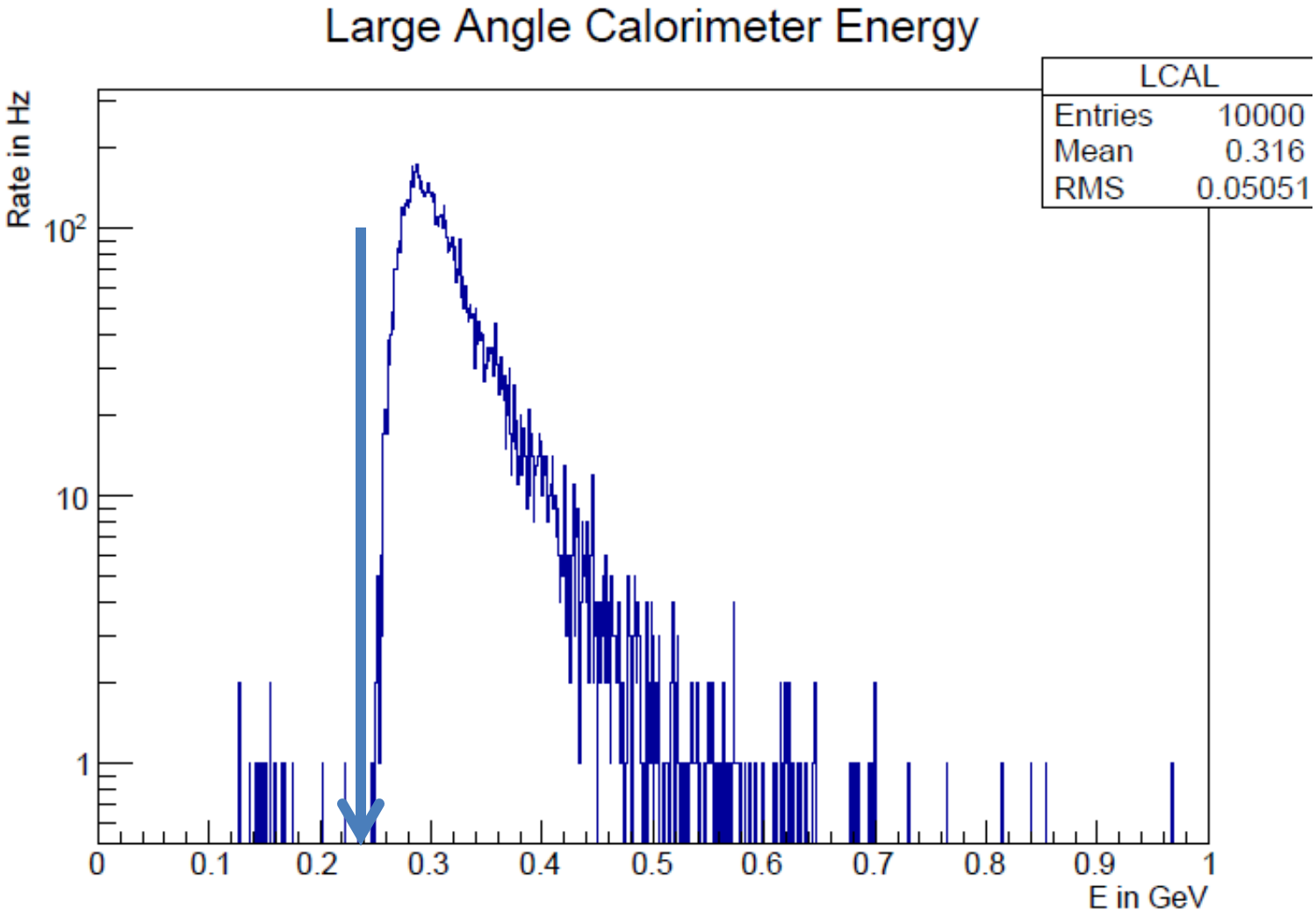
Energy deposit muons in HCAL

2 x 3 GeV muons

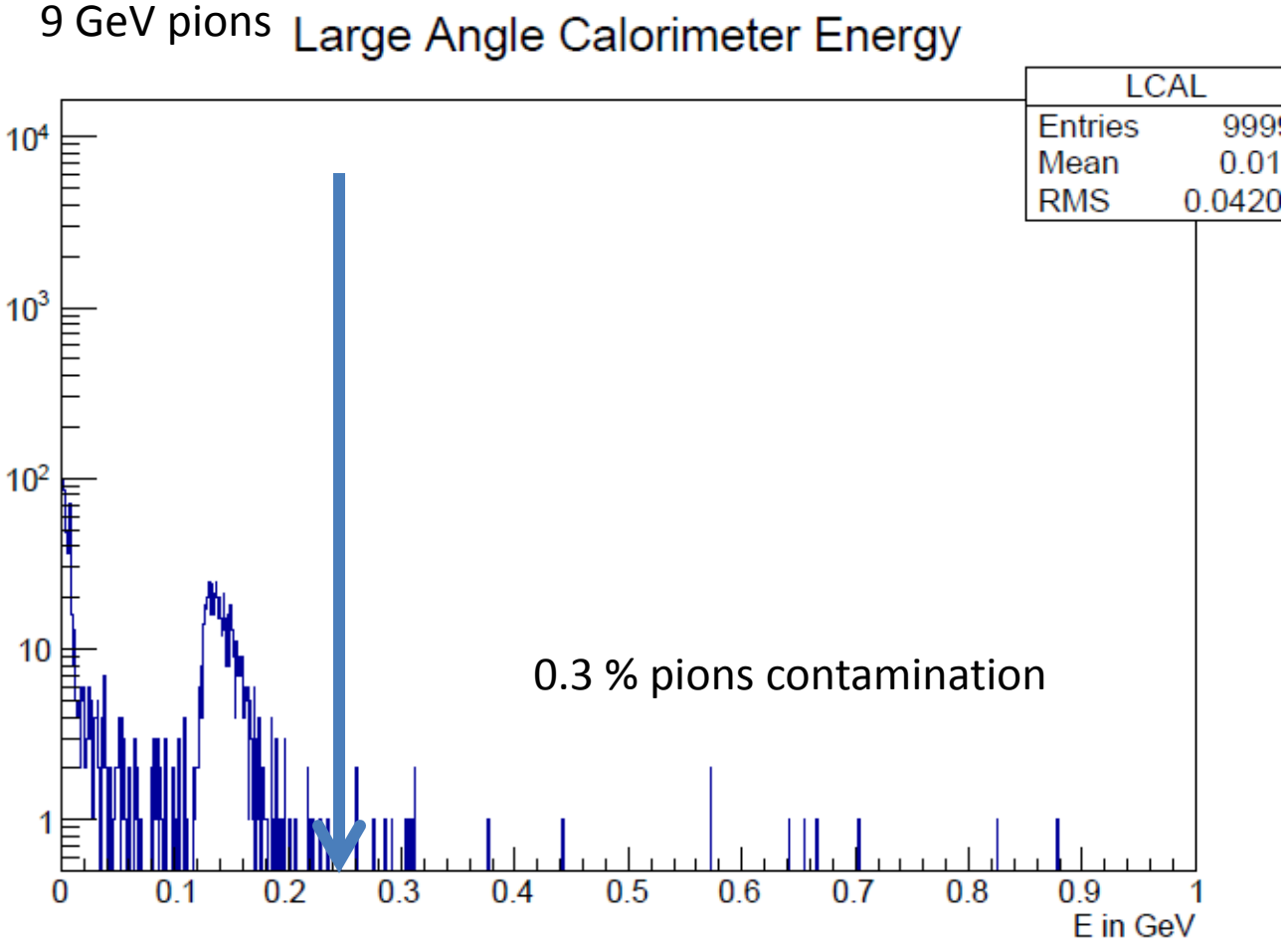


Energy deposit muons in LAC

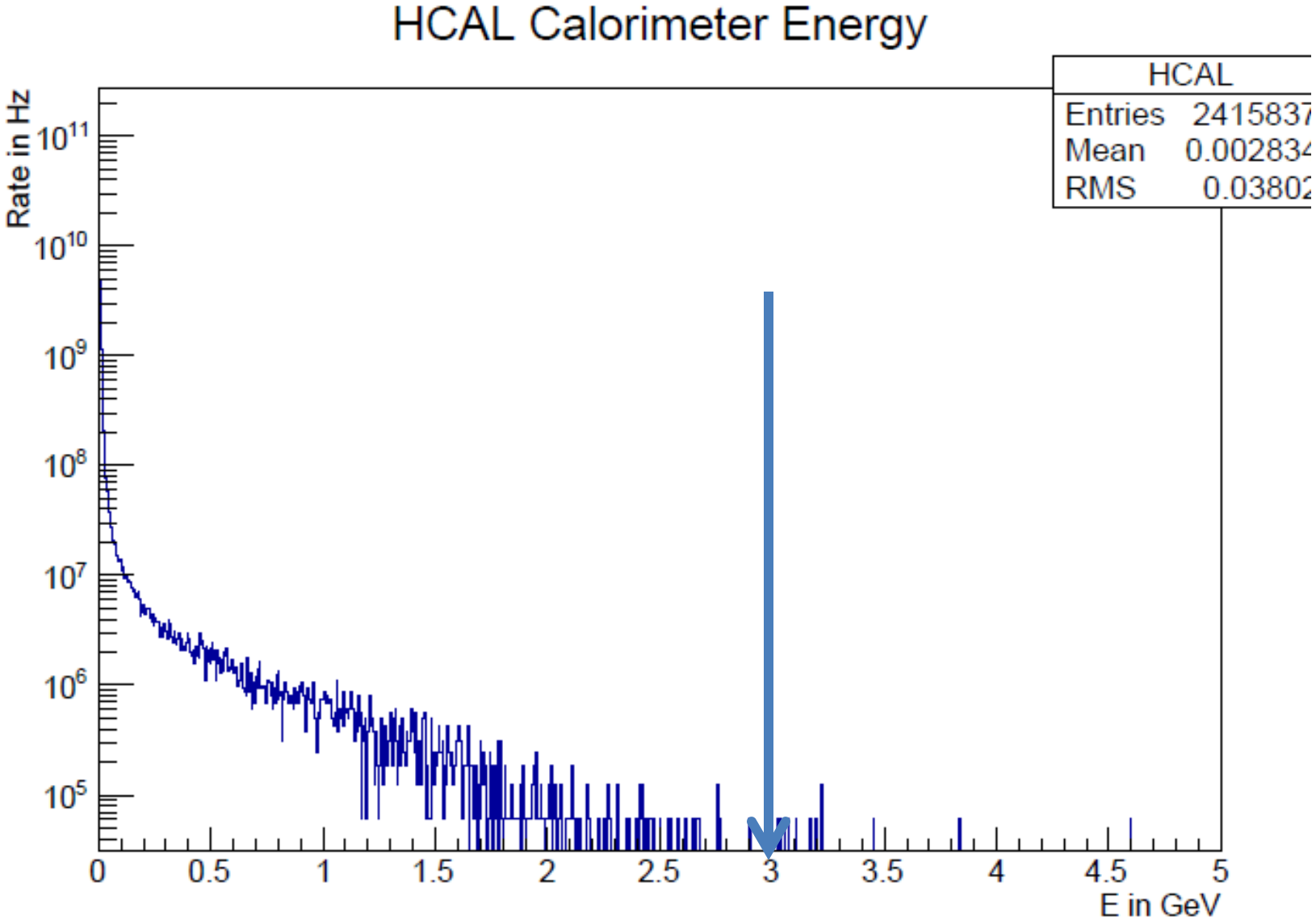
2 x 3 GeV muons



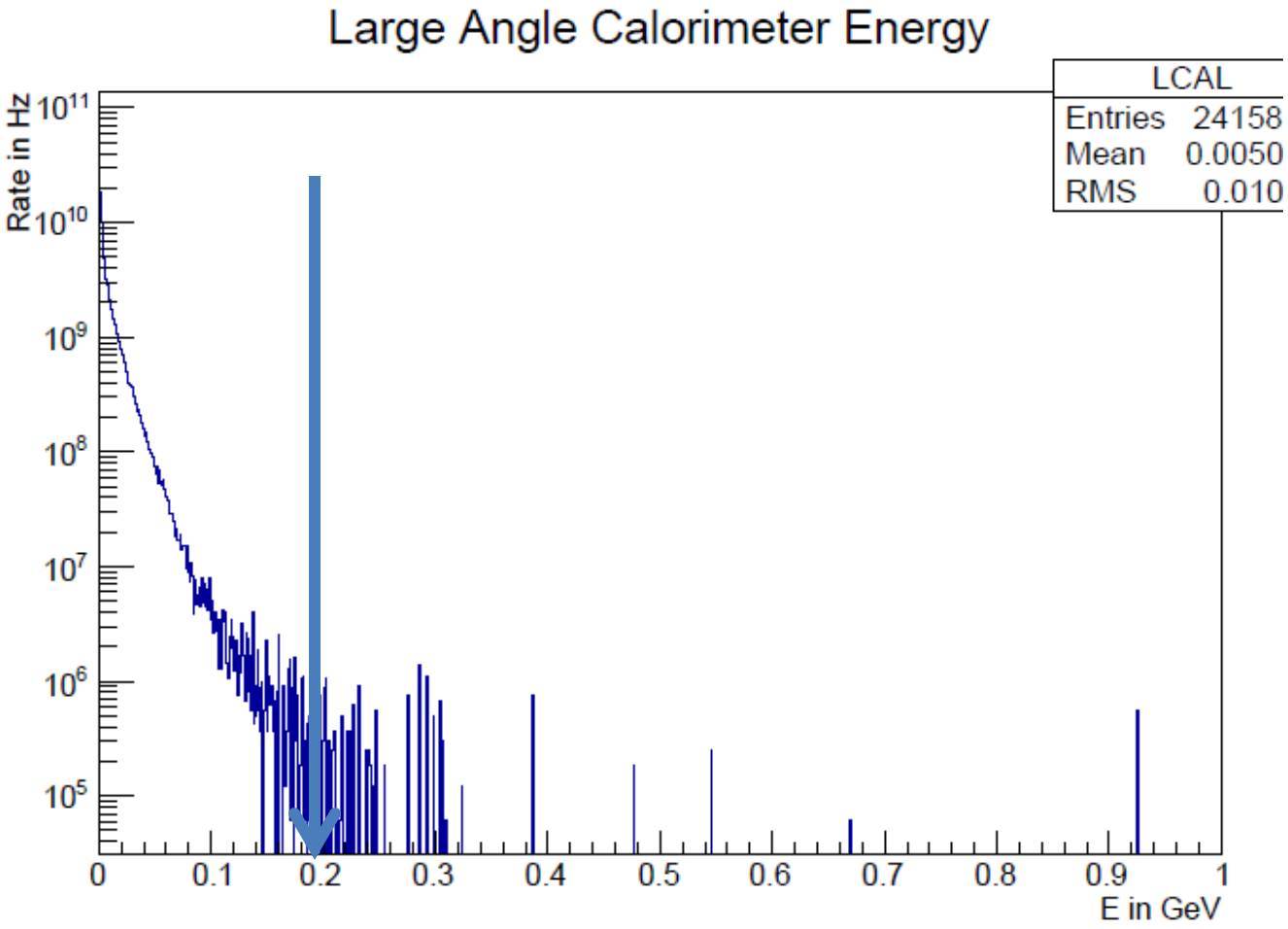
Pion spectrum



Background


HCAL Calorimeter Energy
HCAL
Entries 2415837
Mean 0.002834
RMS 0.03802
Rate in Hz
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
E in GeV

Background

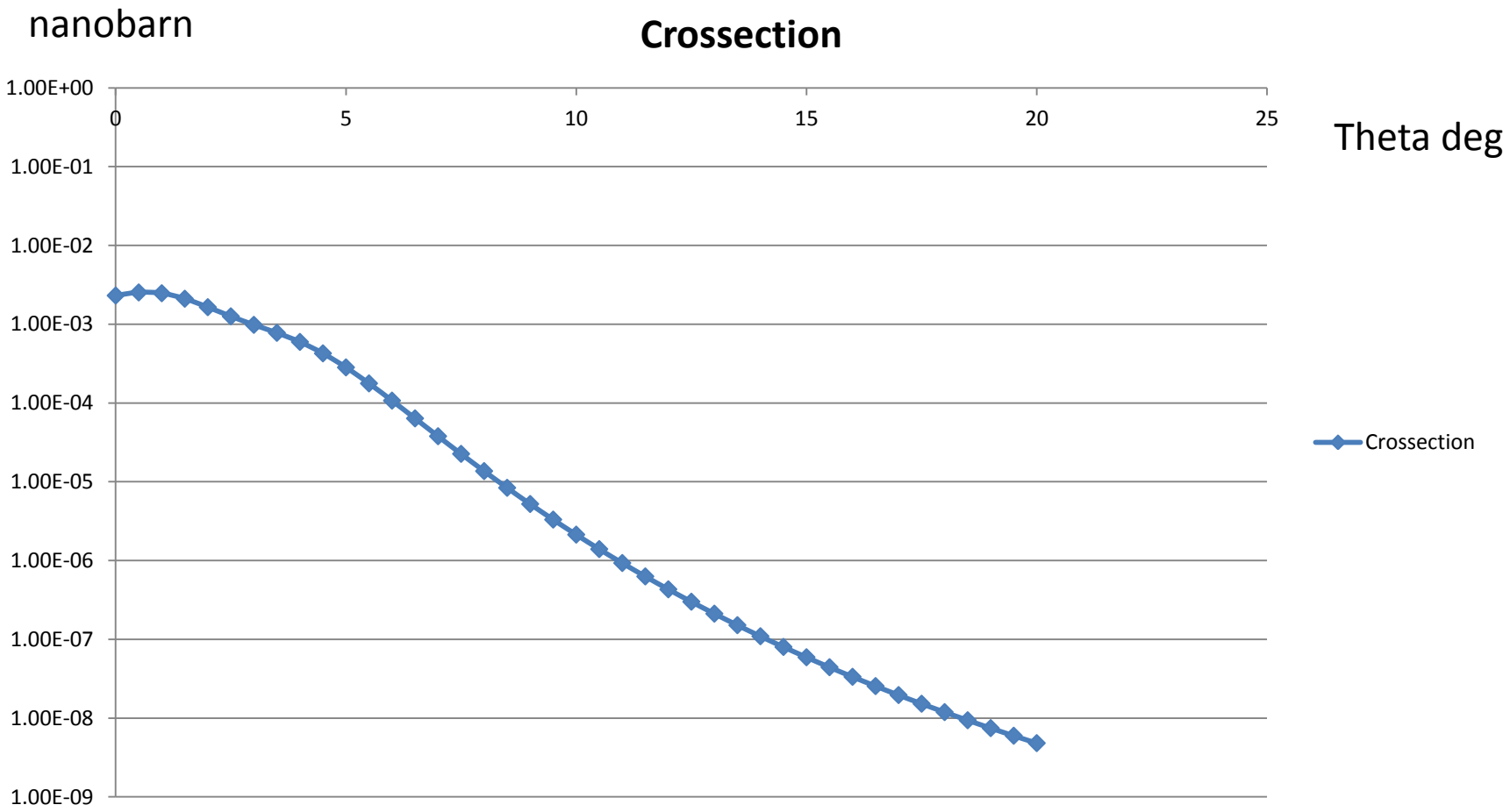

Large Angle Calorimeter Energy
LCAL
Entries 24158
Mean 0.0050
RMS 0.010
Rate in Hz
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
E in GeV

Trigger rate

- LAC accidental : 7 MHz
- Electron DIS rate ~ 2 KHz
- 420 Hz with 30 ns coincidence

Cross section DDVCS VGG

E=8.8 GeV Q2=2.96 GeV2 xbj=0.2 Q'2 = 1 GeV2



To do list

- Finish event generator
- Look at event distribution
- Look at rates and performance of detector
- Look at rates in trackers
- Optimize kinematics
  - Maybe workshop Mid March : dimuon physics

Conclusion

- Pion rejection seems reasonable
- Reuse of existing detectors

- Crosssection if order of picobarn

- Need to finish event generator and look at physics rates but seems feasible