SoLID SIDIS-NH_3 Studies (update)

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Reminder on our SIDIS-NH_3 studies

- The SoLID SIDIS program includes He^3 and NH_3 target-based experiments
  - The overall background rates in the transversely polarized NH_3 target experiment are expected to be smaller compared to those of the He^3 target experiment
  - But due to the large magnetic field in the transverse direction, the high rate particles form a sheet-of-flame type background in the NH_3 experiment

- Our purpose was to study the single electron trigger rate in the NH_3 experiment
  - to find out whether we can obtain 100 kHz (or less) total single particle trigger threshold
  - by studying the particle rate in detectors with all material budget
  - by controlling the sheet-of-flame type background properly

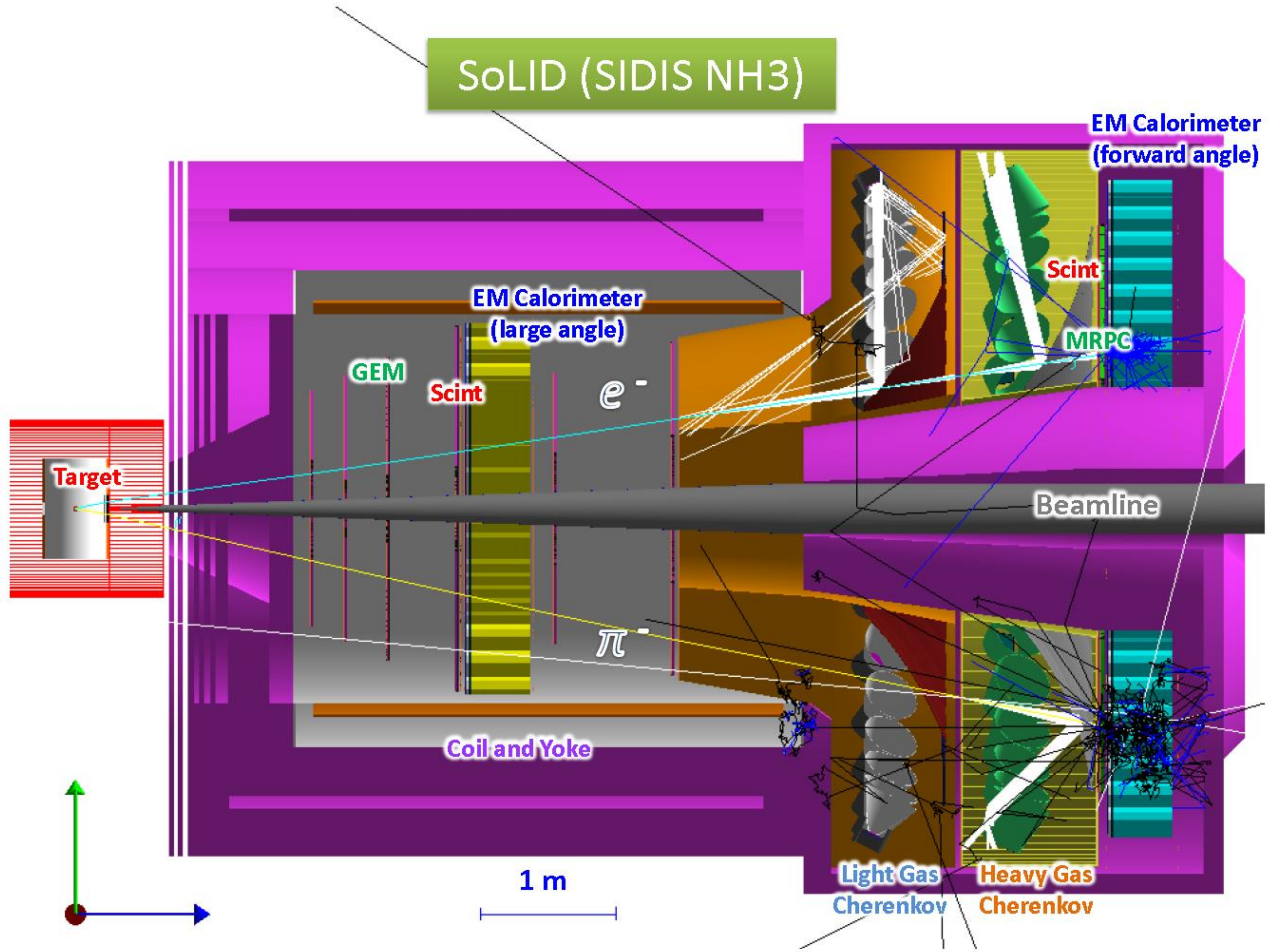
- In general we carried out trigger, background and acceptance studies
  - using eDIS and Wiser generators
  - and full Geant4 simulations

- During the Collaboration Meeting in June, I showed some preliminary results on the trigger rates
  - Today I will show updated new results
  - We will see rate numbers from the combined response of three FA and two LA sub-detectors

Reminder on the SIDIS-NH_3 setup

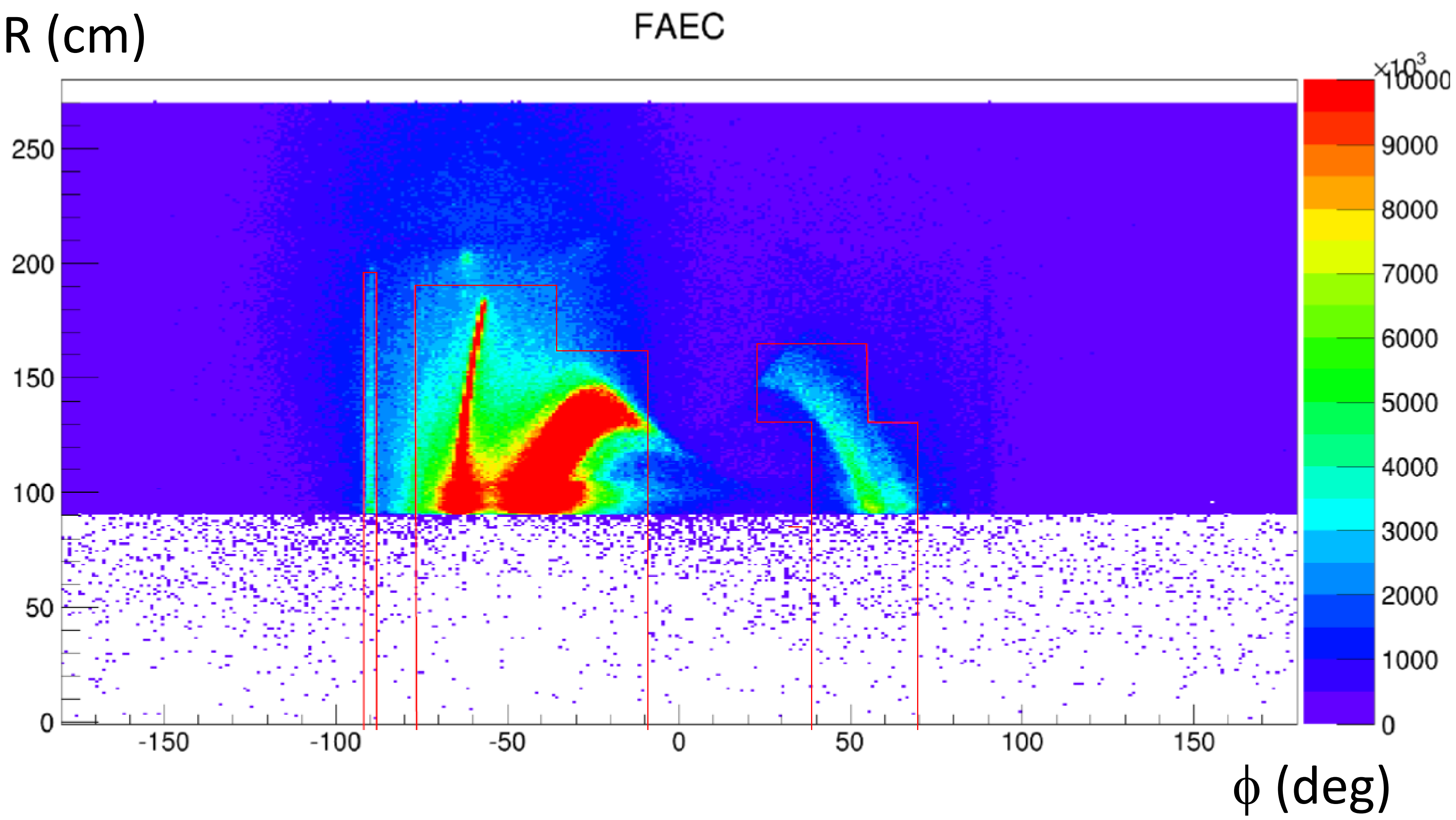
$$e + p \to e' + \pi^{+/-} + X$$

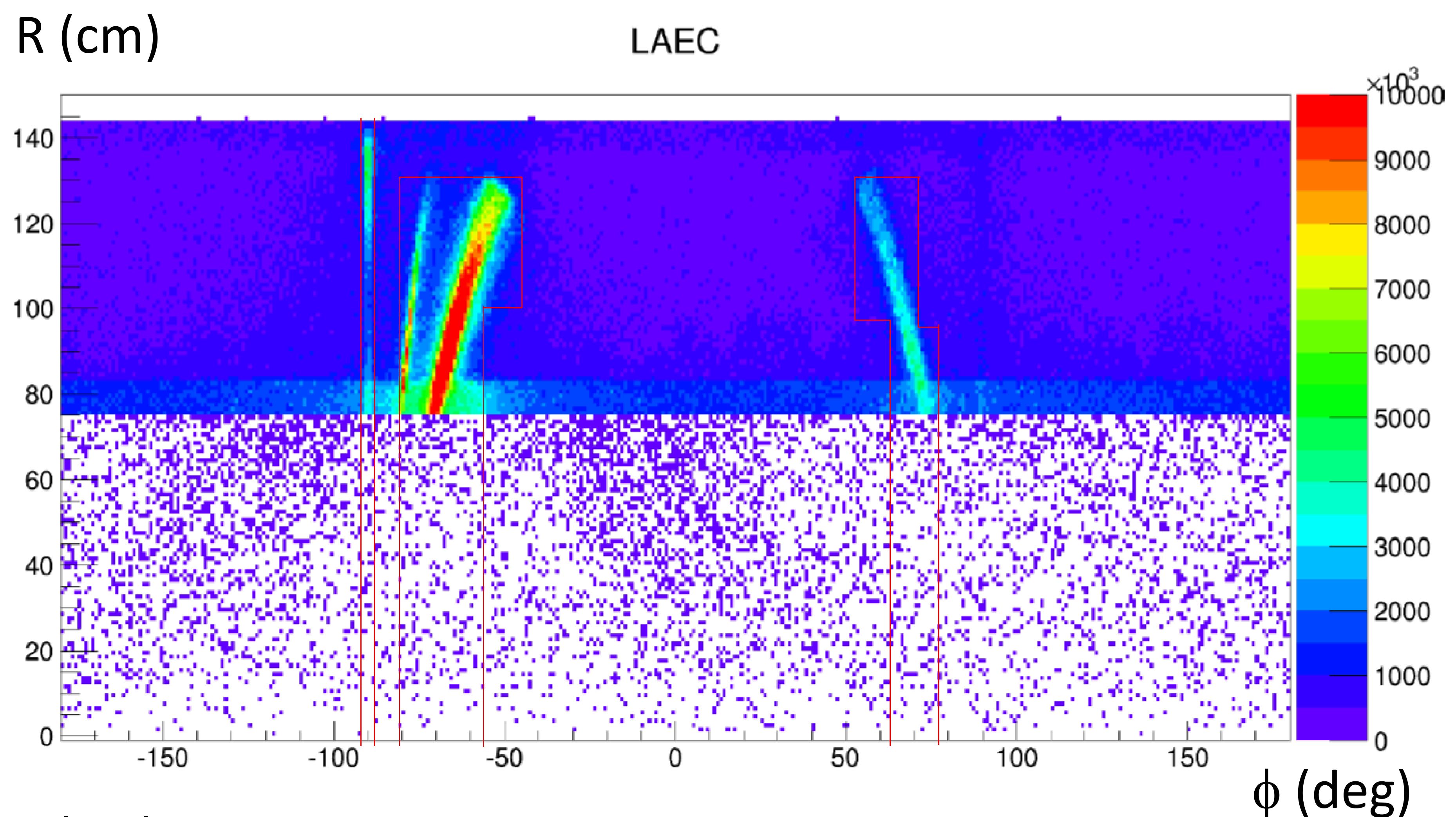
- The NH_3 target polarization is required to be higher than 70% with the spin flip in every few hours.
- Two Beam energies: 11 GeV and 8.8 GeV
- Total luminosity $5.95 \cdot 10^{35}\ cm^{-2}\ s^{-1}$
- Beam current: 100nA
- The beam goes through 5T target magnetic field
- Density of the NH_3 target is $0.819\ g\ cm^{-3}$
- NH_3 target thickness is 2.826 cm
- The target is immersed in liquid He^4

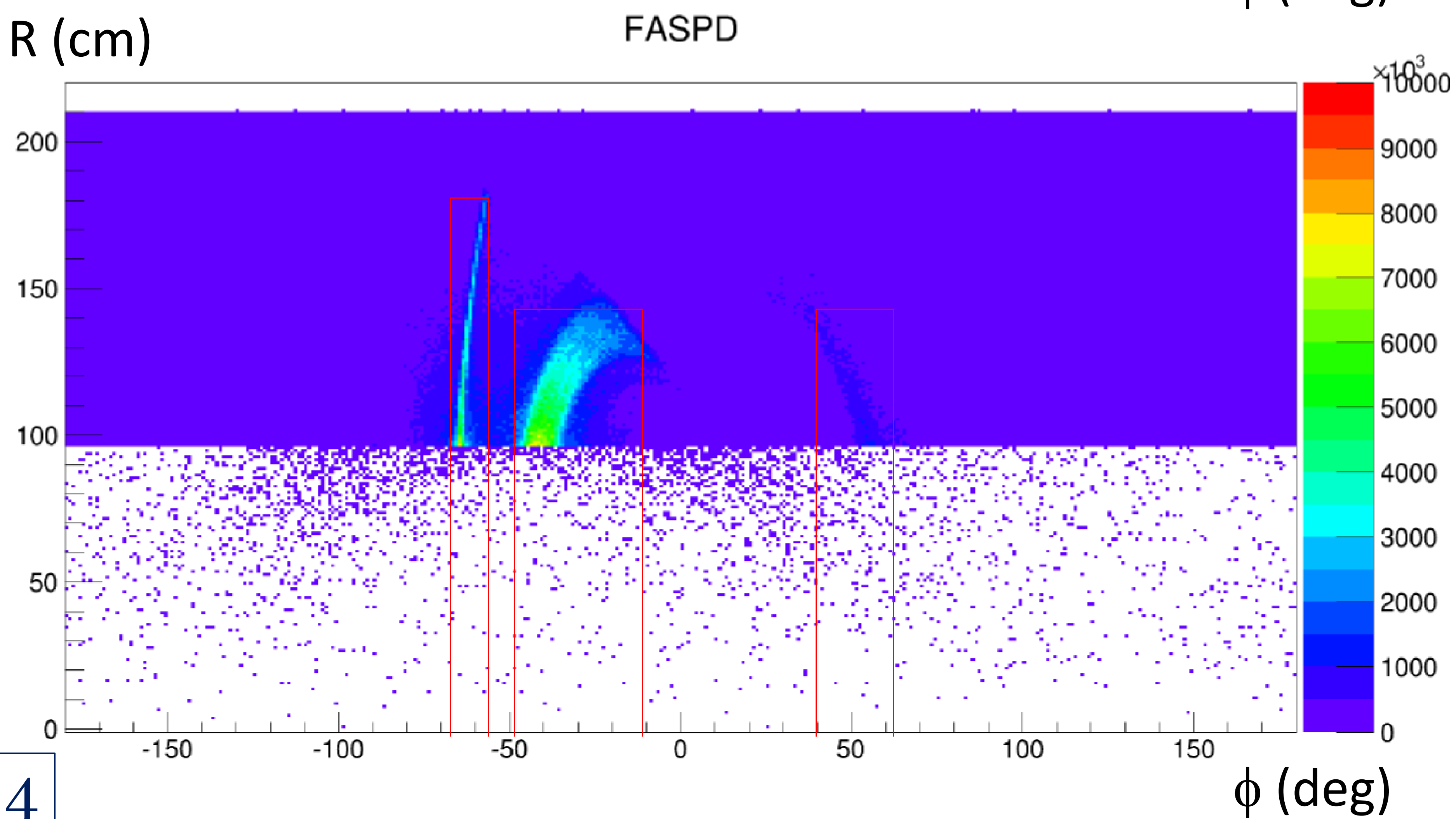


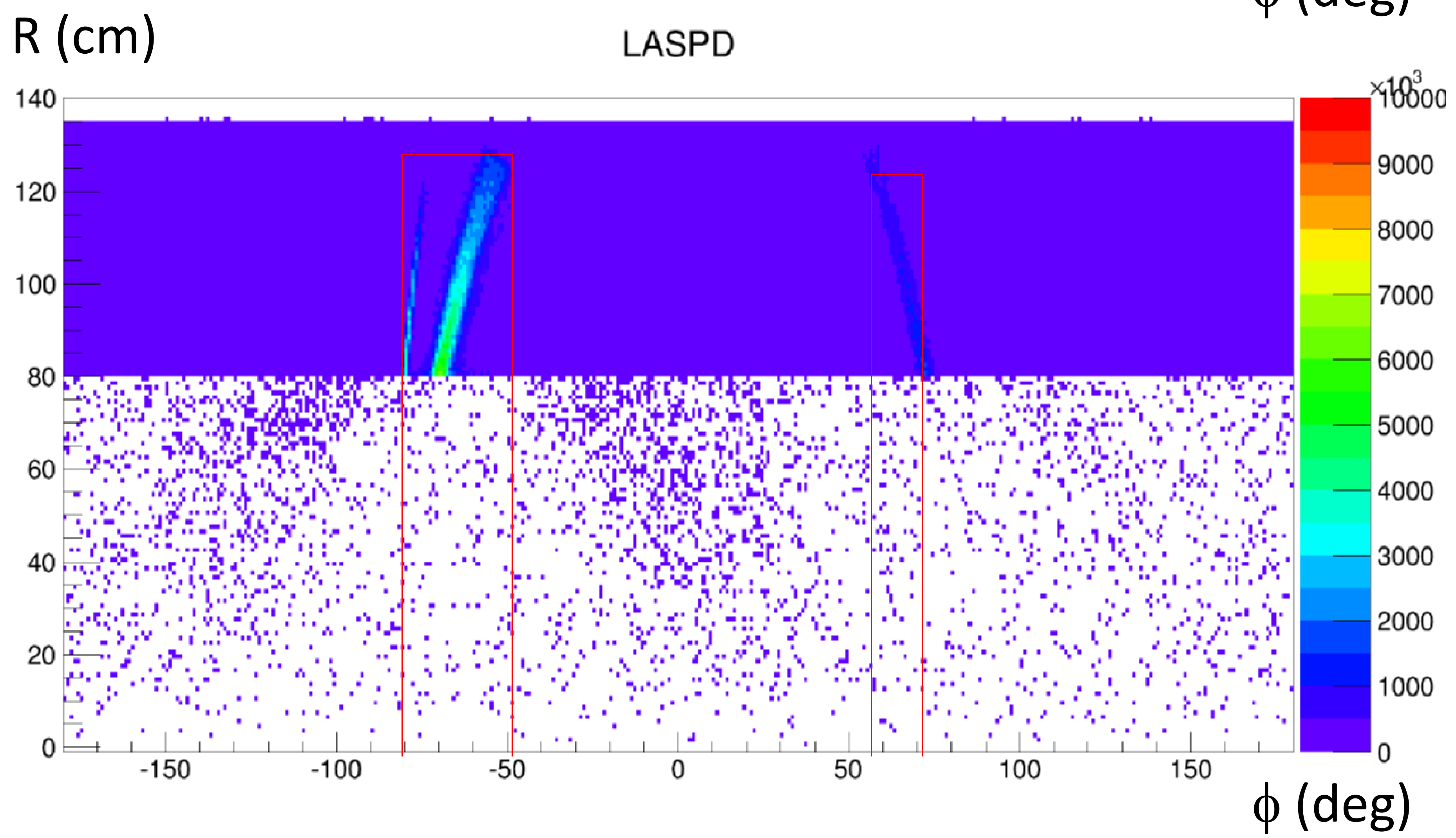
Reminder on the sheet-of-flame (sof) cuts

- Here are the sheet-of-flame cuts for FAEC/FASPD as well as for LAEC/LASPD
  - The lower part has no detector
  - The fake hits are from average hit positions of low energetic particles spirally passing one plane multiple times





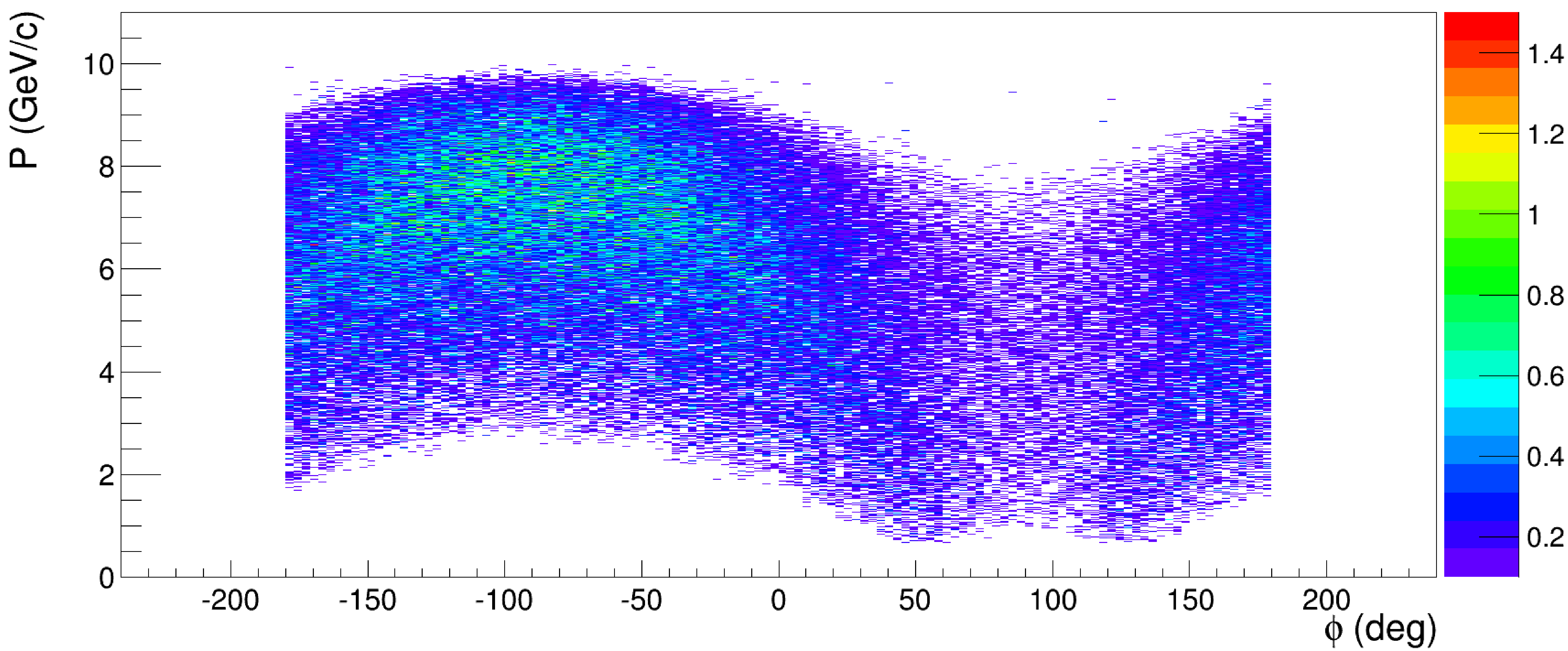




Electron momentum – azimuthal angle dependence for FAEC after sof cuts

- We have determined
  - the FAEC trigger condition: $Q^2 > 1$ (GeV/c)^2
  - the LAEC trigger condition: $E > 3$ GeV
- Let's now look at the momentum P (in GeV/c) of electrons (reaching FAEC and GEM) vs. the azimuthal ϕ angle
- The plot below shows what the particle hit pattern looks like because of the asymmetric field

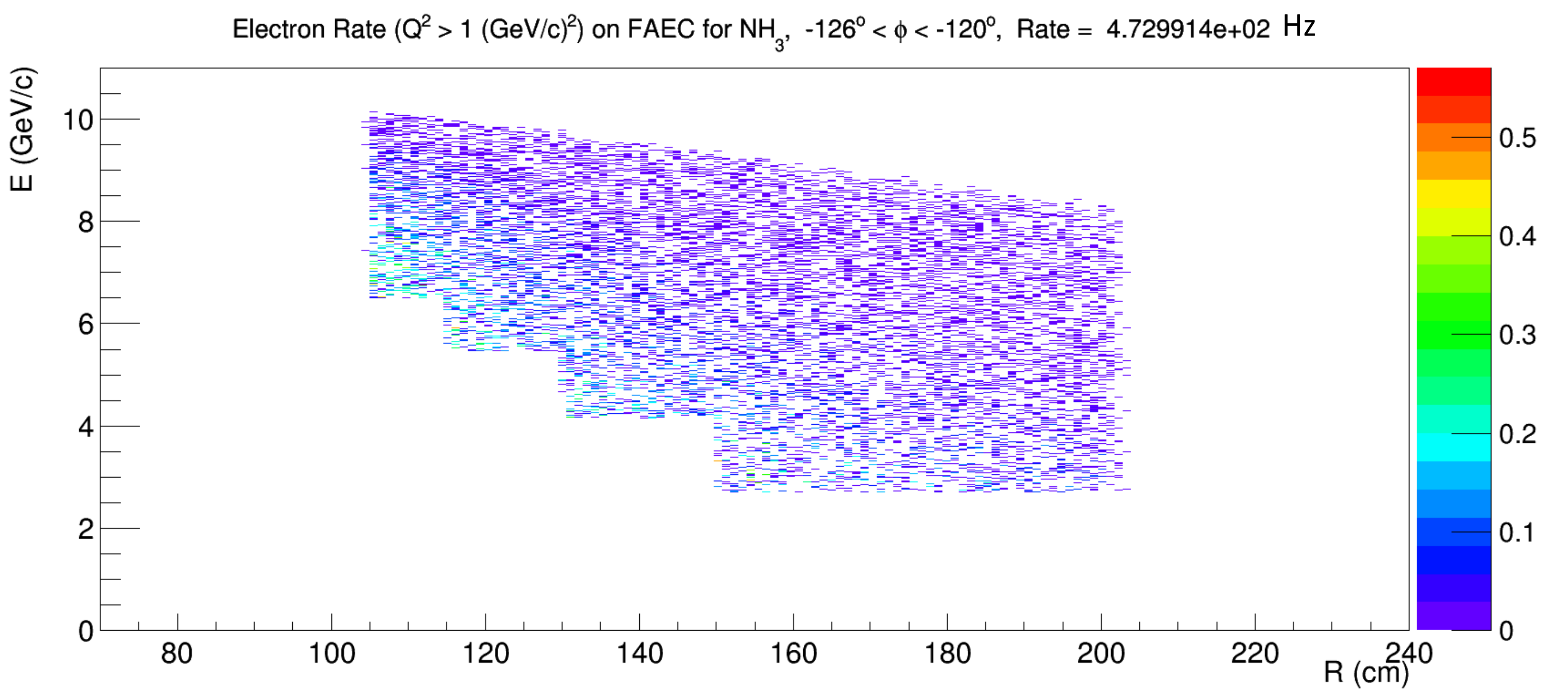
All electrons at $Q^2 > 1$ (GeV/c)^2 reach FAEC and GEM

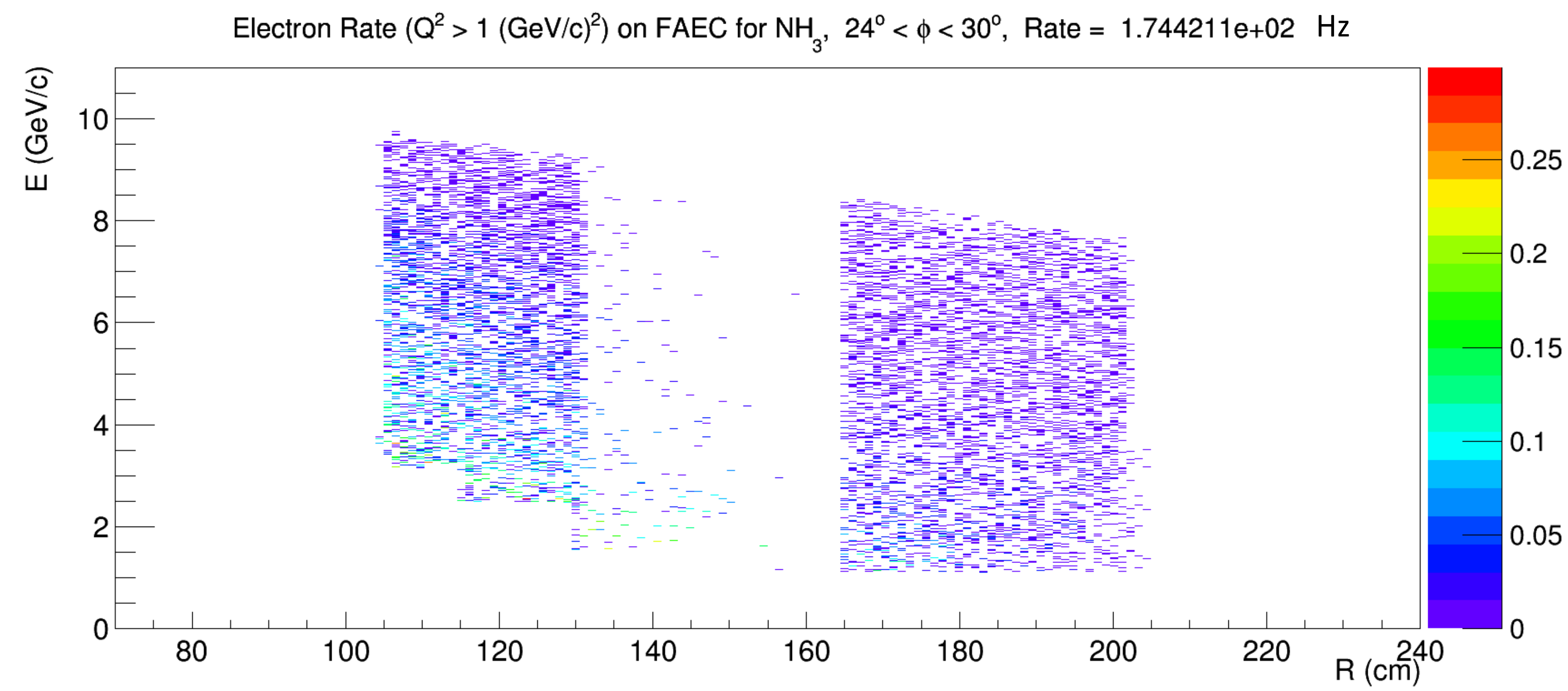


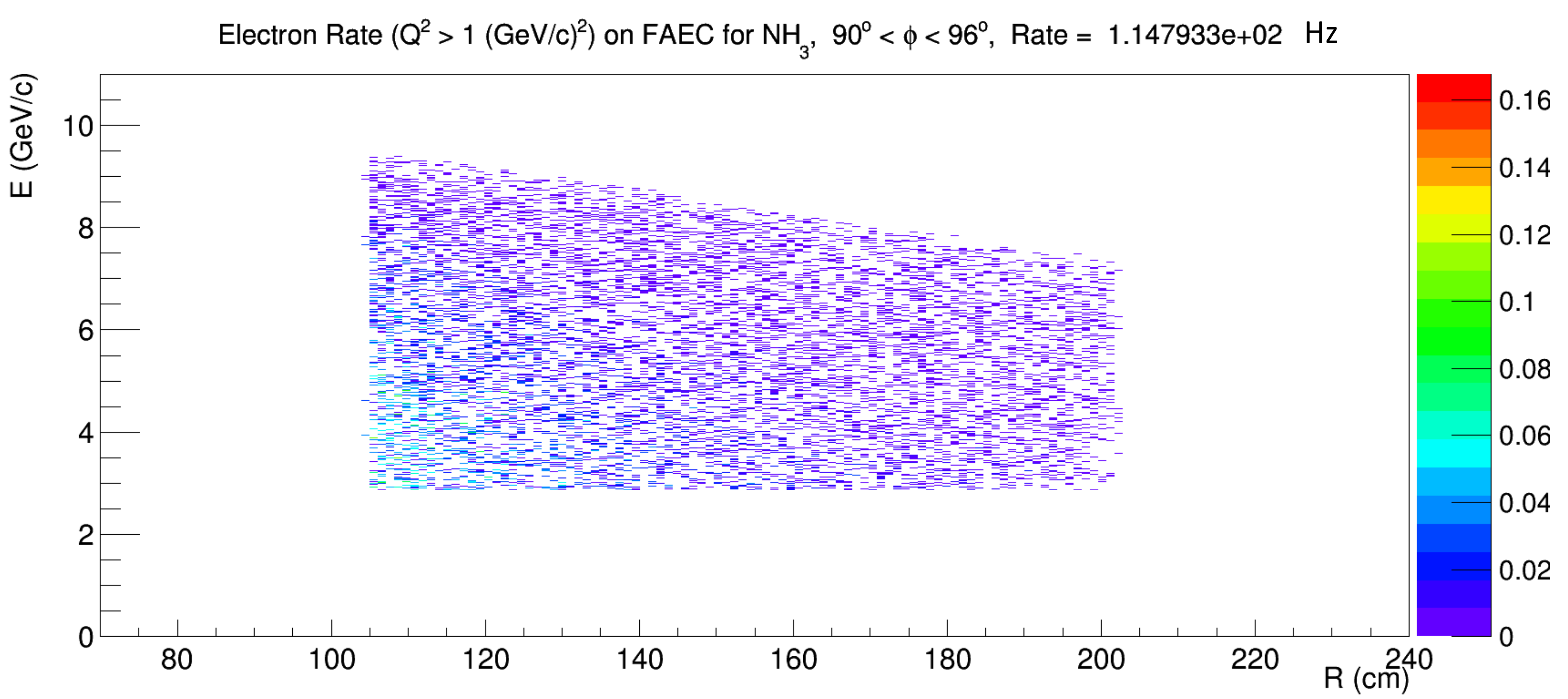
(for LAEC the physics cut E = 3.5 GeV has been used for the SIDIS-proton proposal E12-11-108)

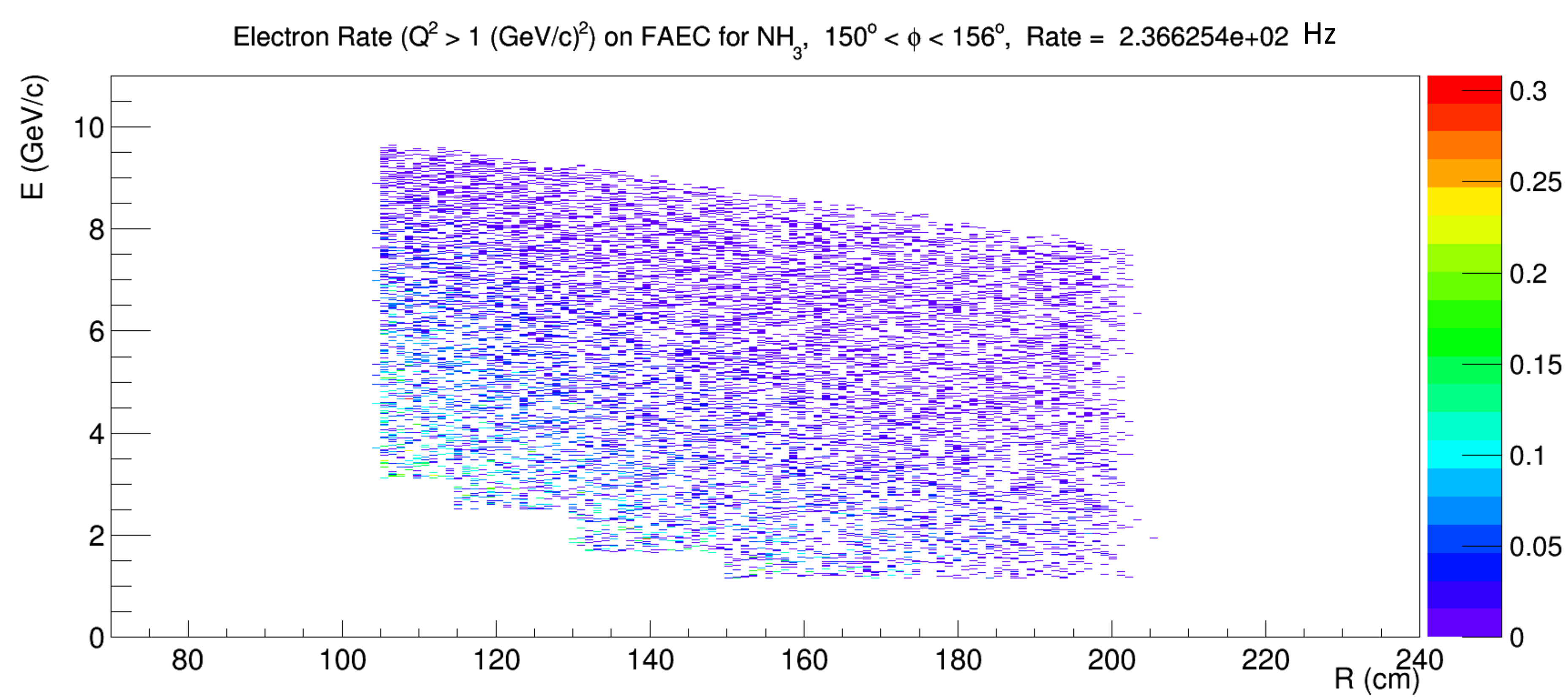
Electron energy – radius dependence for FAEC after sof cuts

- Four plots for the Energy (in GeV) of electrons vs. the radius R (in cm) on the surface of FAEC
- The Q^2 = 1 $(GeV/c)^2$ lines are implemented as step functions in ϕ = 6° bins from -180° to 180°
- Totally there are sixty ϕ bins for FAEC









New results on the particle hit rate for FA sub-detectors

- Here we show single rates for different particles with 11 GeV beam
  - from the forward angle EC
  - from the combined response of the forward angle EC + LGC
  - from the combined response of the forward angle EC + LGC + SPD

e _FA (kHz)	EC	EC+LGC	EC+LGC+SPD
Electron (primary + secondary)	9.53	8.56	7.88
Electron (primary)	8.15	7.72	7.20
π^- (primary + secondary)	290.91	4.75	4.46
π^- (primary)	239.16	4.40	4.14
π^+ (primary + secondary)	460.31	4.92	4.33
π^+ (primary)	393.46	4.49	3.98
π^0, γ / π^0, e (primary + secondary)	490.44 / 37.77	10.52 / 7.80	6.56 / 7.18
Proton (primary + secondary)	166.57	0.0015	0.00052
Proton (primary)	150.78	0.000135	0.000135
Sum of each column (primary + secondary)	1.456e+03	36.55	30.41
Sum of each column (primary)	791.55	16.61	15.32

The electron trigger cuts, $Q^2 > 1$ (GeV/c)^2, are applied; the EC, LGC and SPD sof cuts are applied

New results on the particle hit rate for LA sub-detectors

- Here we show single rates for different particles with 11 GeV beam
  - from the forward angle EC and from the combined response of the forward angle EC + SPD

e_LA (kHz)	EC	EC+SPD
Electron / Proton (primary + secondary)	0.84	0.75
Electron / Proton (primary)	0.82	0.74
π^- (primary + secondary)	14.45	12.90
π^- (primary)	13.47	12.15
π^+ (primary + secondary)	17.87	16.68
π^+ (primary)	16.55	15.51
π^0, γ / π^0, e (primary + secondary)	22.27 / 0.28	1.41 / 0.28
Proton (primary + secondary)	17.76	16.77
Proton (primary)	17.35	16.40
Sum of each column (primary + secondary)	73.47	48.79
Sum of each column (primary)	48.19	44.80

The flat LAEC electron trigger cut, E = 3.0 GeV, is applied; the EC and SPD sof cuts are applied

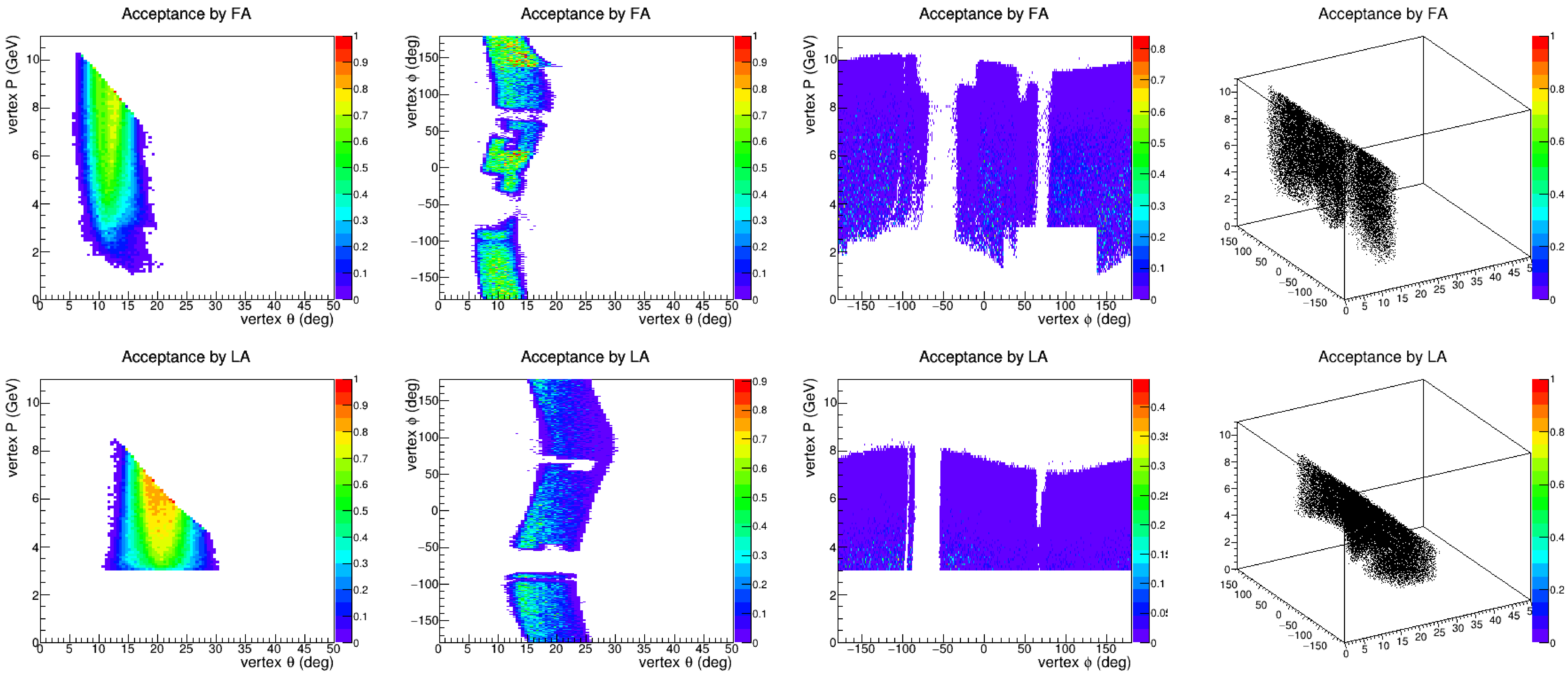
- For FA and LA EC, LGC, SPD we turn off some sectors/modules, due to the sof's presence
- The largest effect comes from the EC sof cuts
- The LGC and SPD sof cuts are in the same kinematics and we don't lose much physics events

Total single rate and Acceptance

- In summary, we are interested in

Total sum of (primary + secondary) FA EC+LGC+SPD and LA EC+SPD	= 79.2 kHz

- And here are the new acceptance plots for the NH_3 target experiment



The new acceptance plots by FA and LA sub-detectors

Summary and outlook

- For determining the total trigger rate of the SoLID SIDIS-NH_3 experiment, we used the combined trigger response
  - from the forward angle EC + LGC + SPD
  - from the large angle EC + SPD

- Detailed study of detector rate, occupancy and relation with the sheet-of-flame would need help from all sub-detector groups

- Improve the results of the studies reported in this presentation
  - using the longer endcap
  - using the generator solid_bggen for hadrons, instead of the currently used Wiser generator
  - using more realistic EC trigger function

- Revisit the physics projection for SIDIS-"p" and update where necessary, using the new acceptance information

Backups

Sub-detector sof cuts

The FAEC sof cuts

(-92° < ϕ <-88°, R<196cm) and (-78° < ϕ <-35°, R<190cm) and (-35° < ϕ < -9°, R<162cm) and (23° < ϕ <39°, 131cm<R<165cm) and (39° < ϕ <55°, R<165cm) and (55° < ϕ < 70°, R<131cm)

The LAEC sof cuts

(-92° < ϕ <-88°, R<196cm) and (-81° < ϕ <-56°, R<31cm) and (-56° < ϕ < -47°, 100cm<R<31cm) and (53° < ϕ <63°, 97cm<R<131cm) and (63° < ϕ <71°, R<131cm) and (71° < ϕ < 77°, R<96cm)

The LGC sof cuts

(-82° < ϕ <-40°, R<115cm) and (55° < ϕ <77°, R<103cm), which corresponds to the LGC sector - 17, 18, 19, 28, 29

The FASPD sof cuts

(-67° < ϕ <-56°, R<181cm) and (-49° < ϕ <-11°, R<143cm) and (40° < ϕ < 62°, R<143cm), which corresponds to the FASPD sector/module – 35/1, 35/2, 35/3, 37/1, 37/2, 38/1, 38/2, 39/1, 39/2, 40/1, 40/2, 41/1, 41/2, 42/1, 42/2, 43/1, 43/2, 52/1, 52/2, 53/1, 53/2, 54/1, 54/2, 55/1, 55/2

The LASPD sof cuts

(-81° < ϕ <-49°, R<127cm) and (57° < ϕ <73°, R<124cm), which corresponds to the LASPD sector – 32, 33, 34, 35, 36