First Results From Emulsion Test Beam

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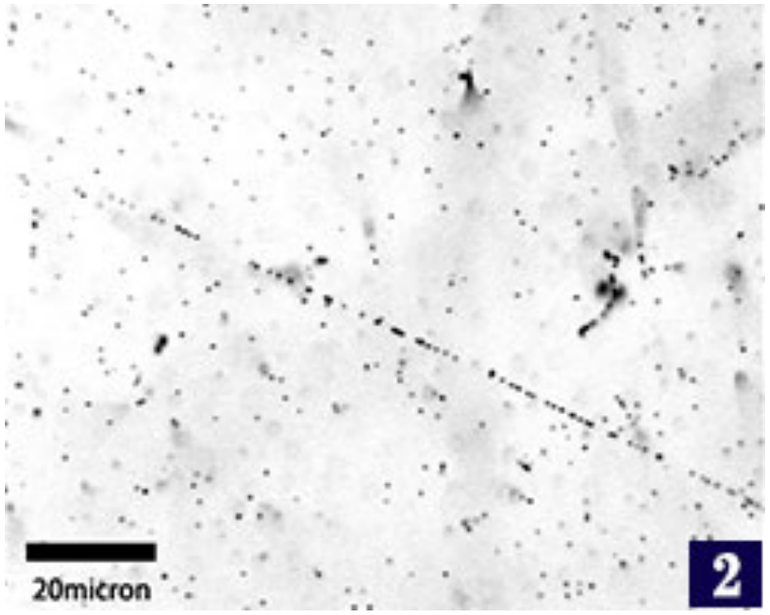
MOTIVATION

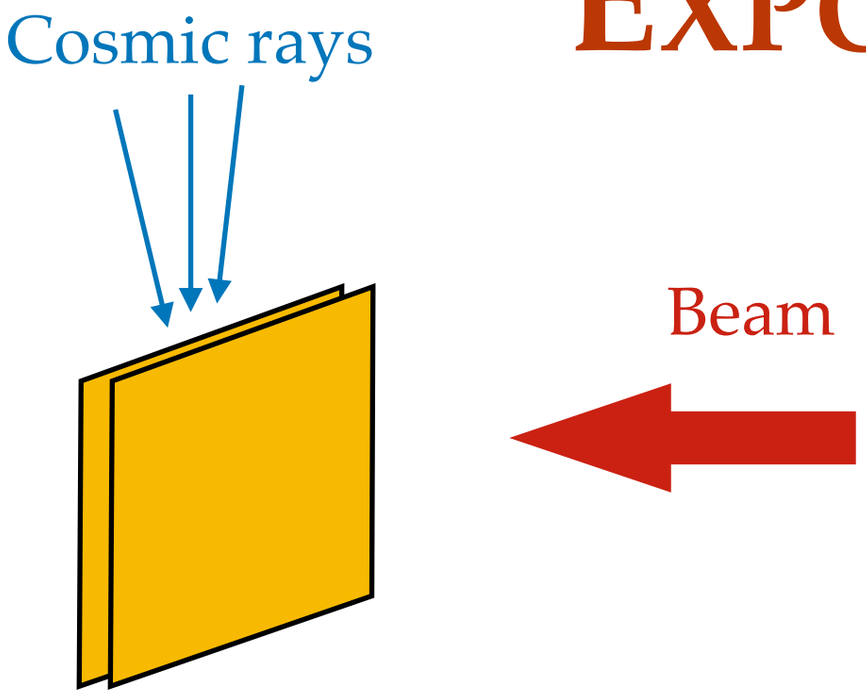
- The grain density of a track in emulsion is approximately proportional to the energy loss of charged particle
- The response of nuclear emulsion saturates for ions with Z>=1
- Refreshing procedure: partial cancelation of tracks in order to extend dynamic range of emulsions

- New nuclear emulsions (Nagoya production) will be used in the FOOT experiment, never used for particle identification
- Test beam performed at LNS in July 2017: exposure of newly produced emulsion films to H, D, He, C beams
- Test of different refreshing procedures to define the working point for particle identification



$$\text{Grain density} \propto \frac{dE}{dx} \propto \frac{Z^2}{E}$$

EXPOSED SAMPLES



- Surface of emulsion samples: 5x4 cm^2
- Beam particles orthogonal to emulsion surface
- Four particle beams (H, D, He, C) @80 MeV/u
- Four exposures per beam, each treated with different refreshing procedure

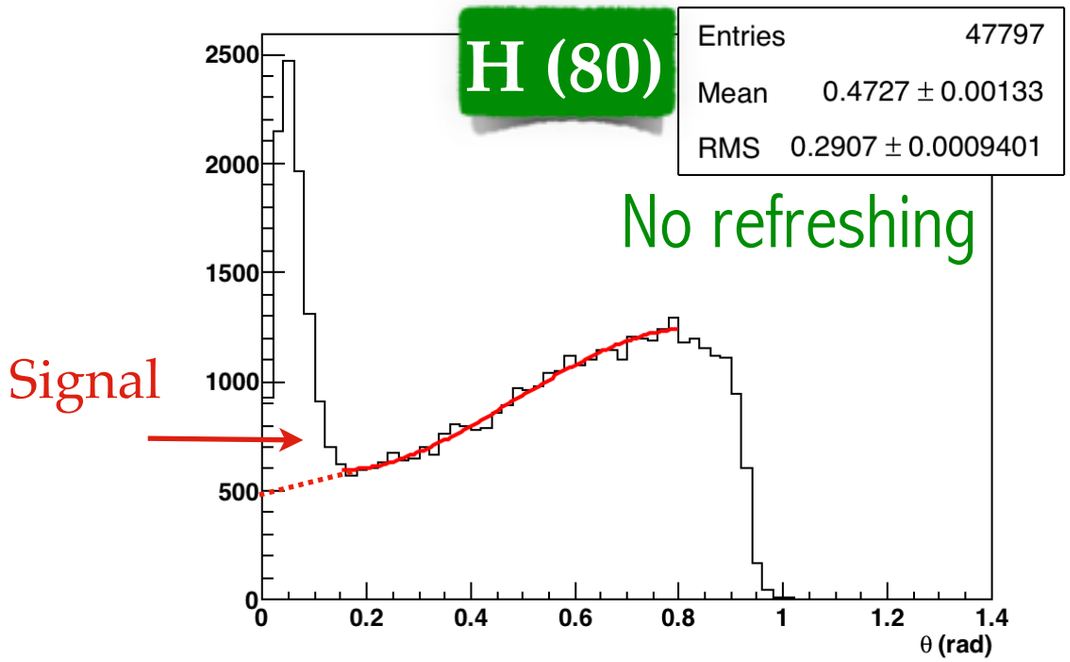
	No refreshing	28°C	34°C	36°C	38°C
H (80 MeV/u)	✓	✓	✓	✓	
D (80 MeV/u)	✓	✓	✓	✓	
He (80 MeV/u)	✓	✓	✓	✓	
C (80 MeV/u)	✓	✓	✓	✓	

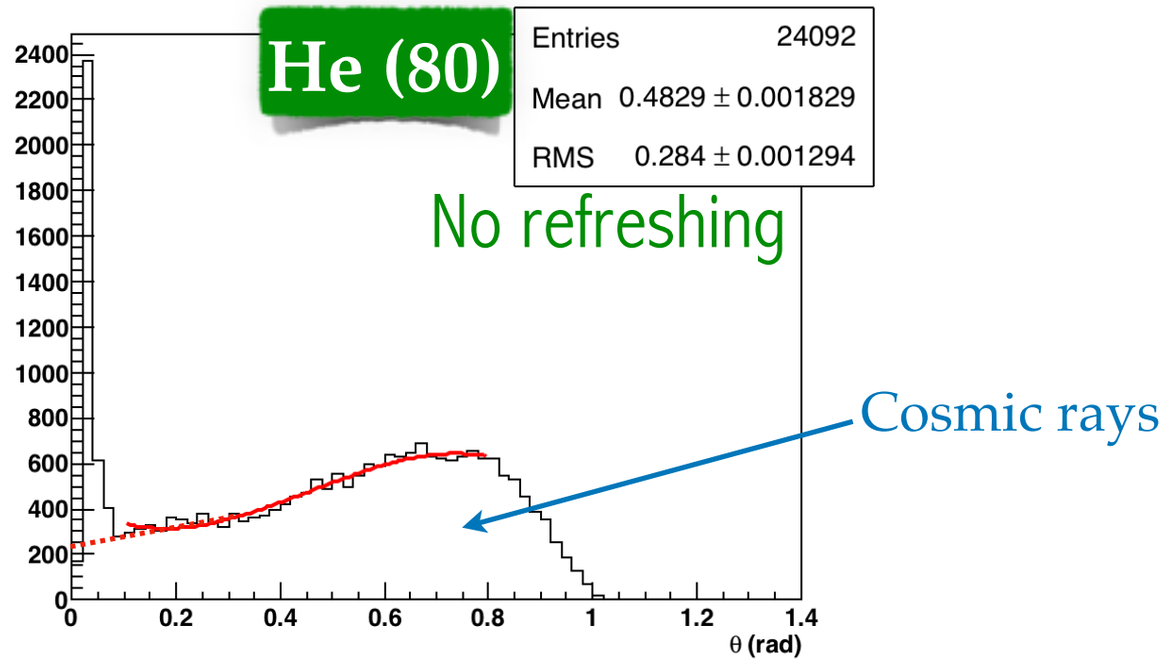
*same ionization as Li (200 MeV/u)

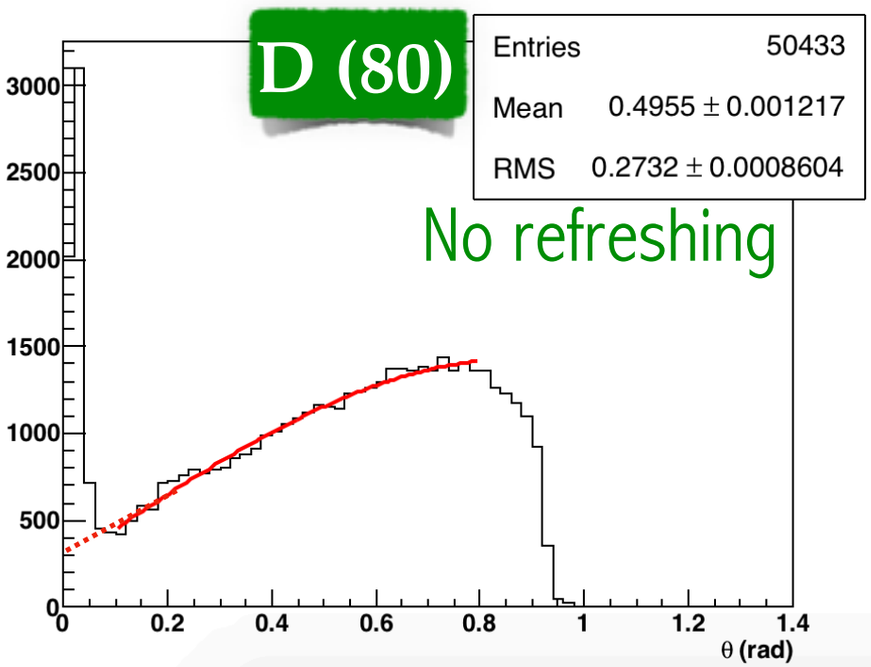
✓Analysed

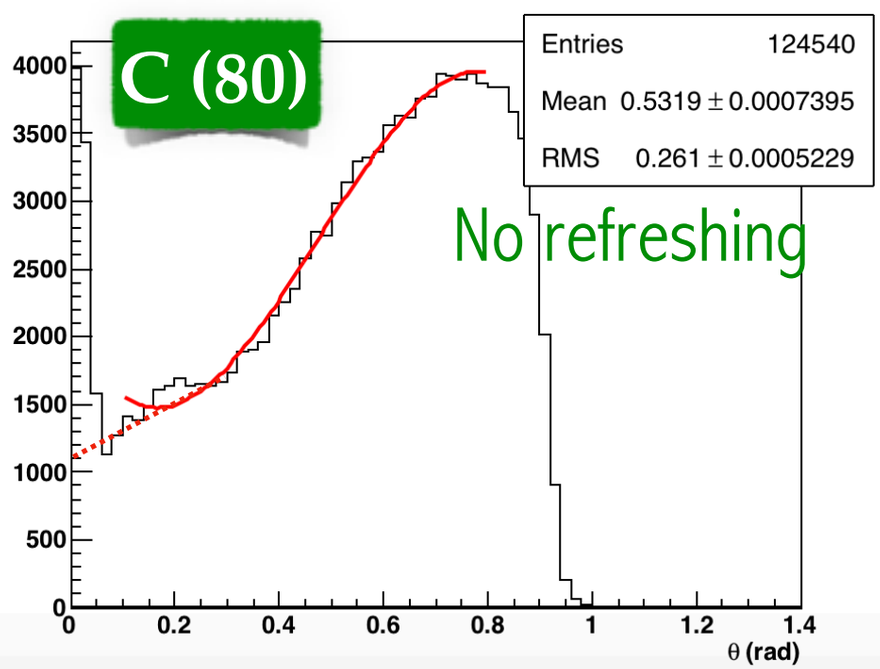
SIGNAL SELECTION

- Emulsion films integrates cosmic rays passing through them from production to development (~2 months)
- Signal tracks perpendicular to emulsion films (θ<0.1 rad)
- Angular acceptance for the present analysis: θ<1 rad



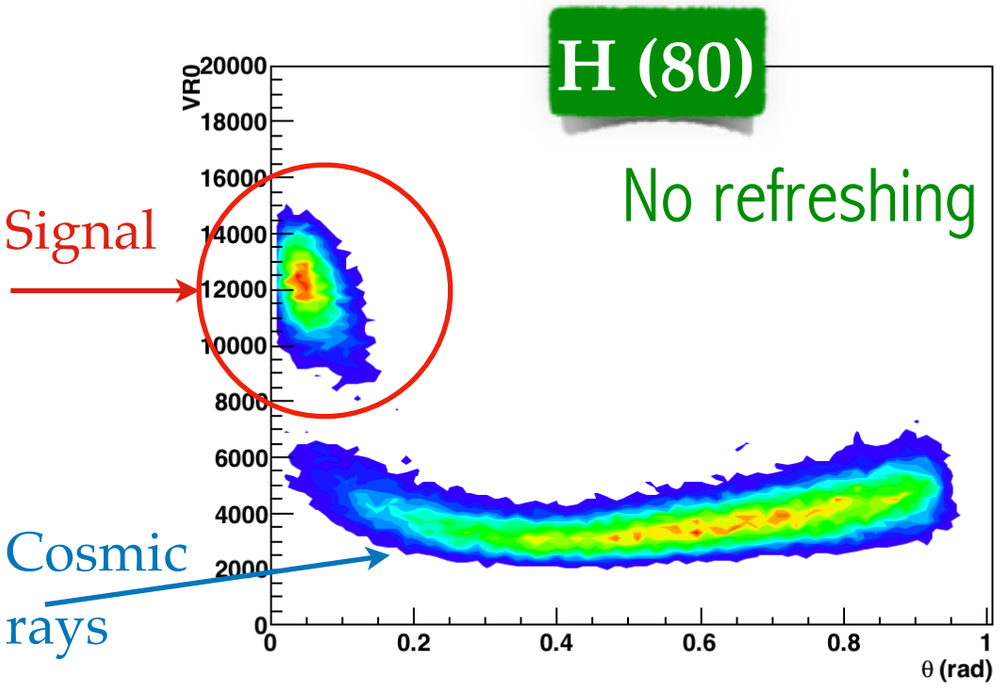


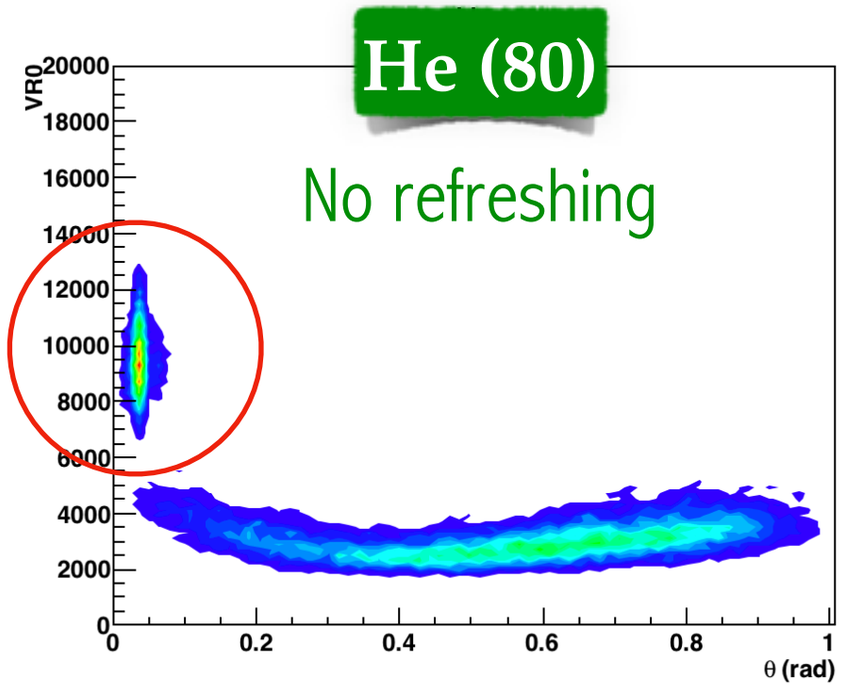


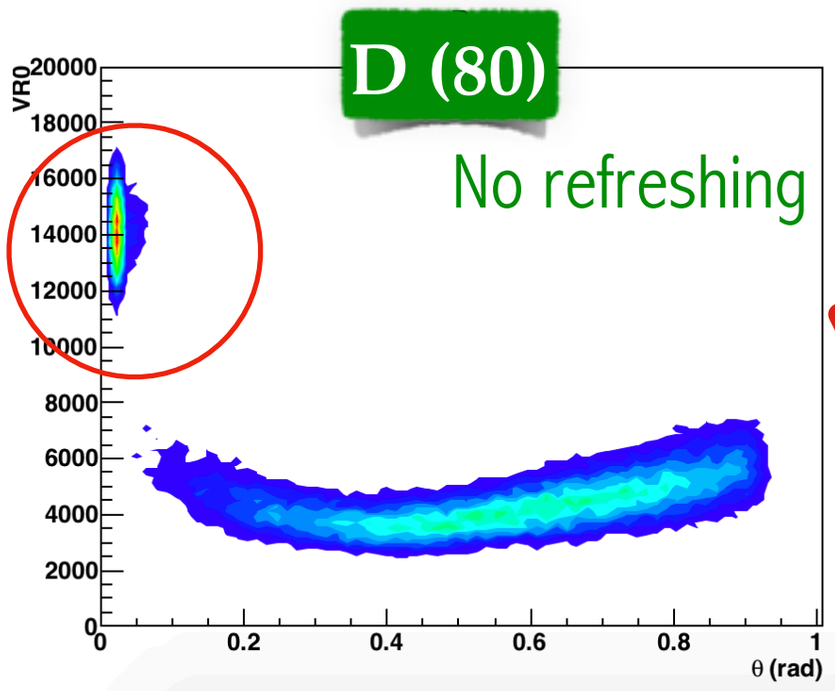


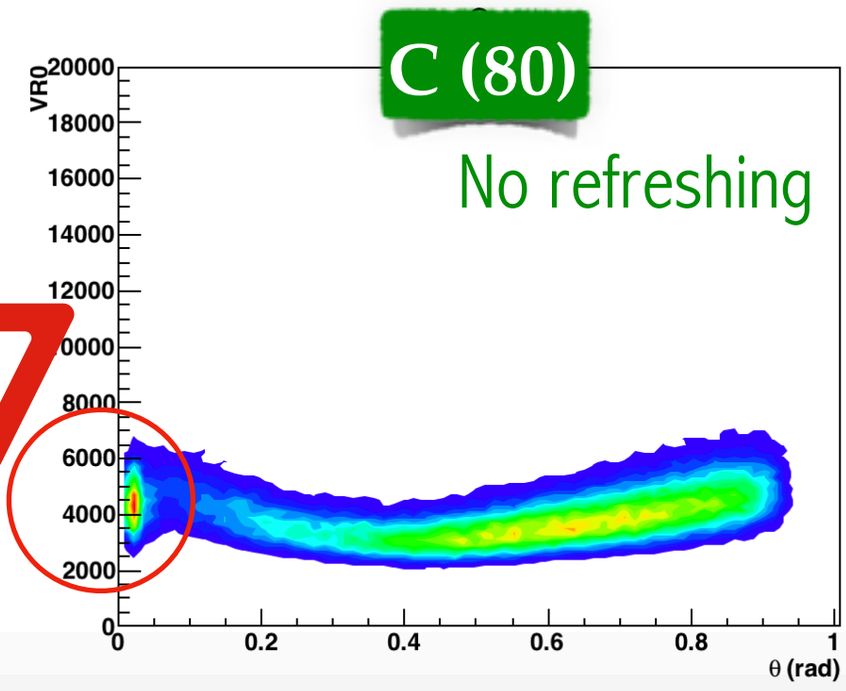
SIGNAL SELECTION

- Signal tracks from H, He and D show ionization (VR0) larger than cosmic rays
- **Unexpected** behavior for Carbon: same ionization of cosmic rays



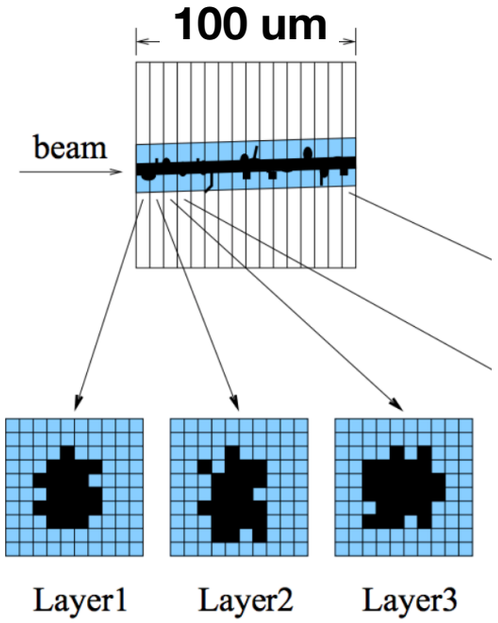






VR0

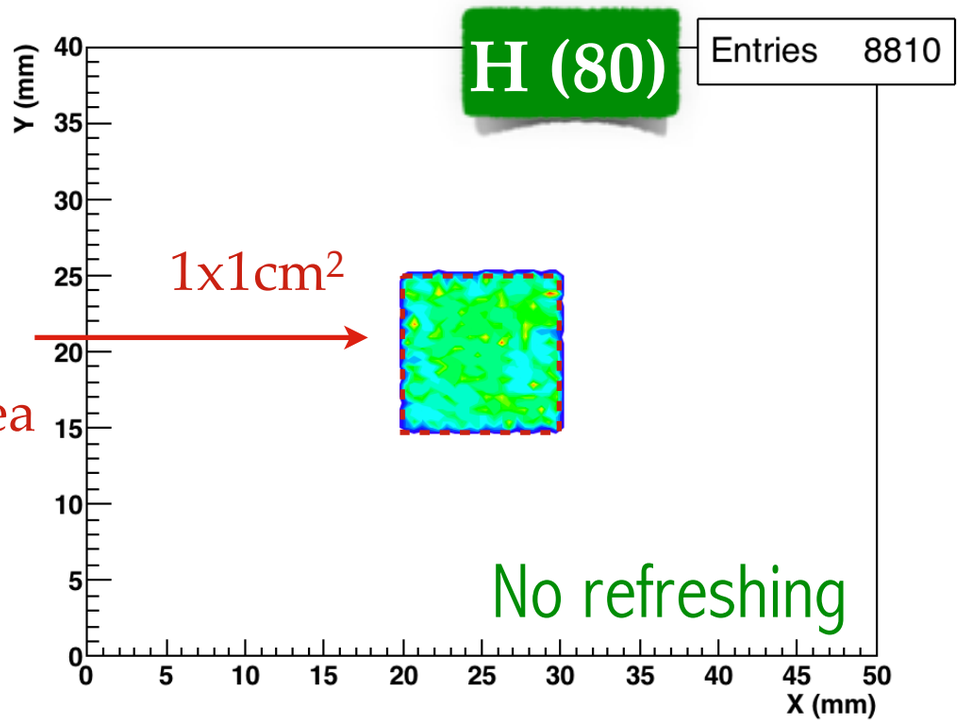
Sum of the number of pixels associated with each recognized tracks

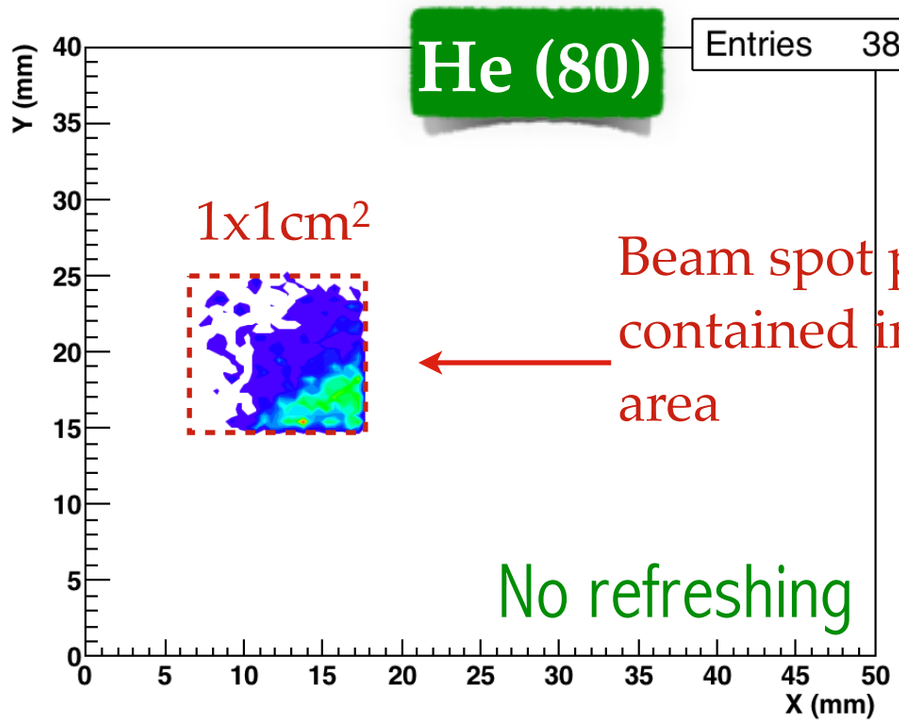


Scanned Area

- Signal selection: $\theta<0.1$ rad

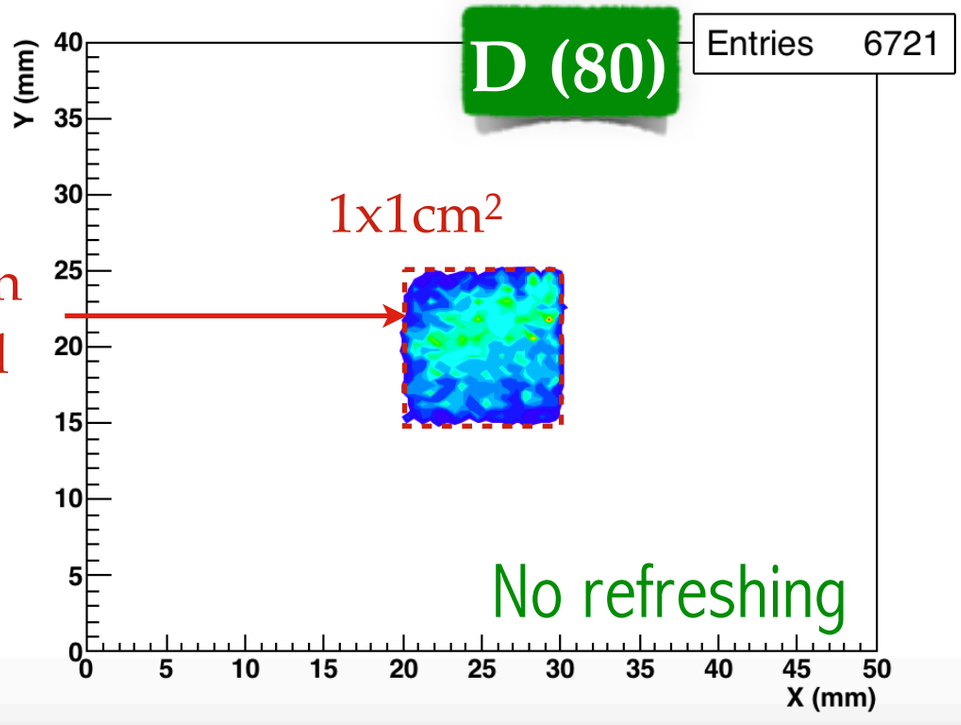
Beam size wider than scanned area

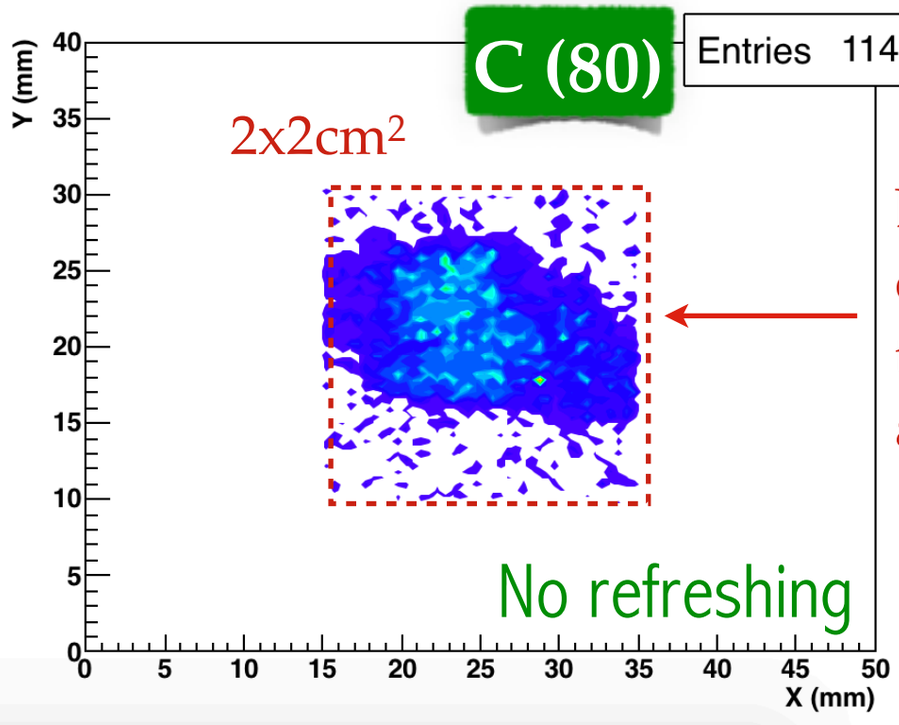




Beam spot partially contained in scanned area

Beam spot contained in the scanned area

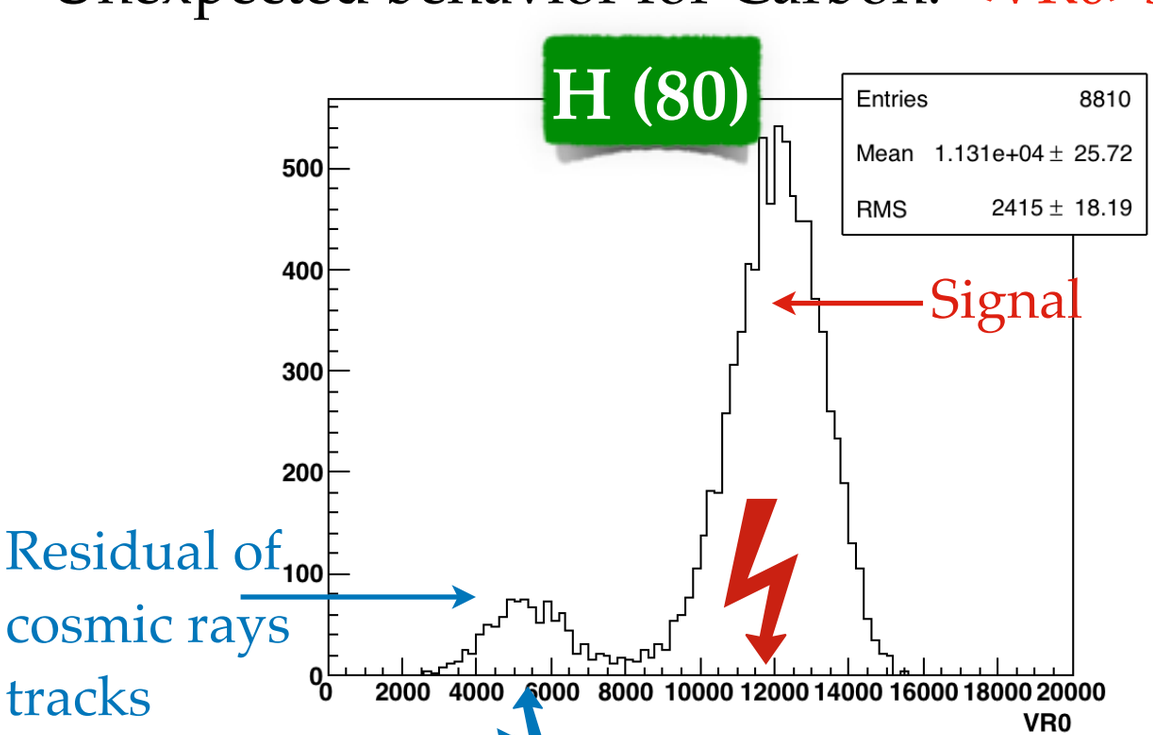


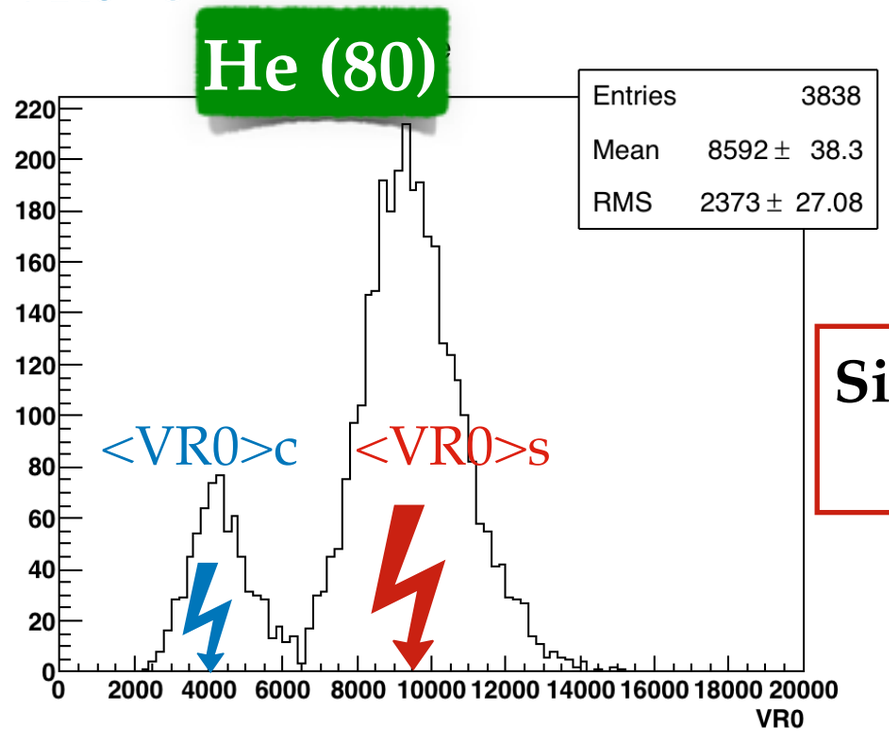


Beam spot contained in the scanned area

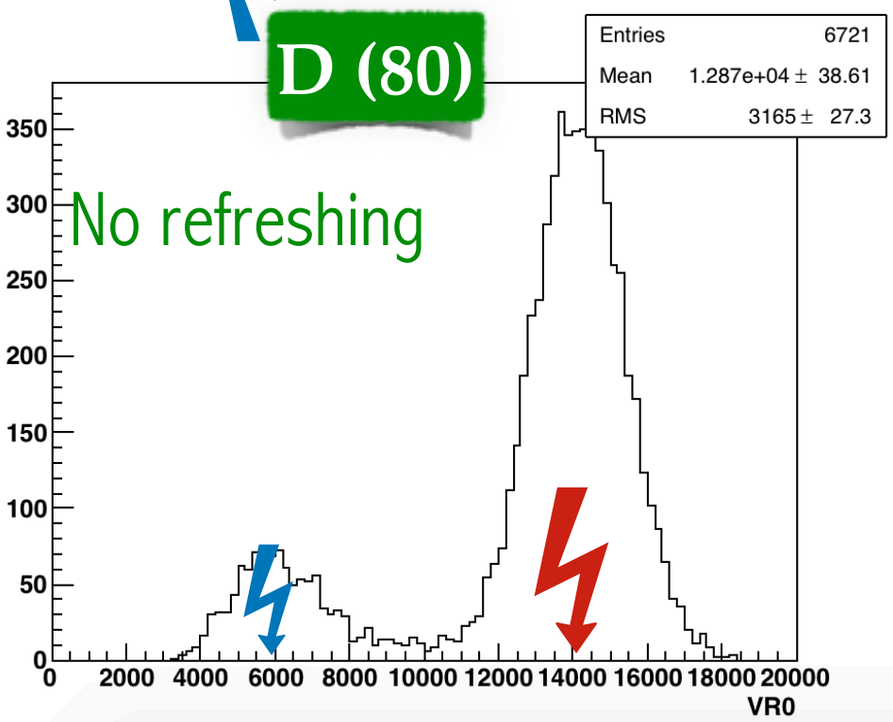
IONIZATION

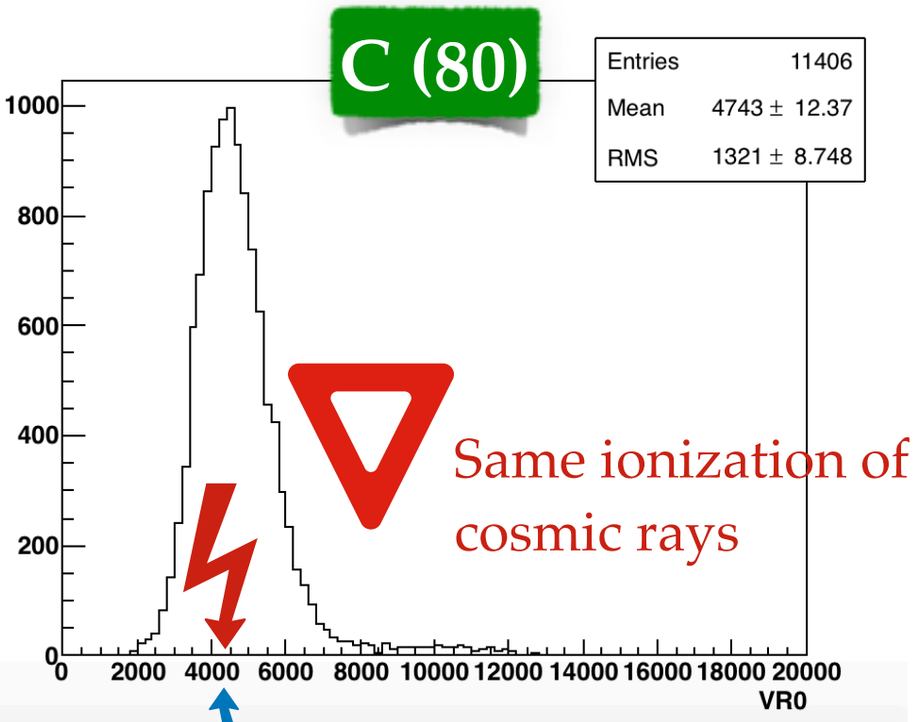
- Particle ionization relative to cosmic rays constant for H, D, He: <VR0>s/<VR0>c ~2.3
- Saturation observed in case of No refreshing
- Unexpected behavior for Carbon: <VR0>s=<VR0>c





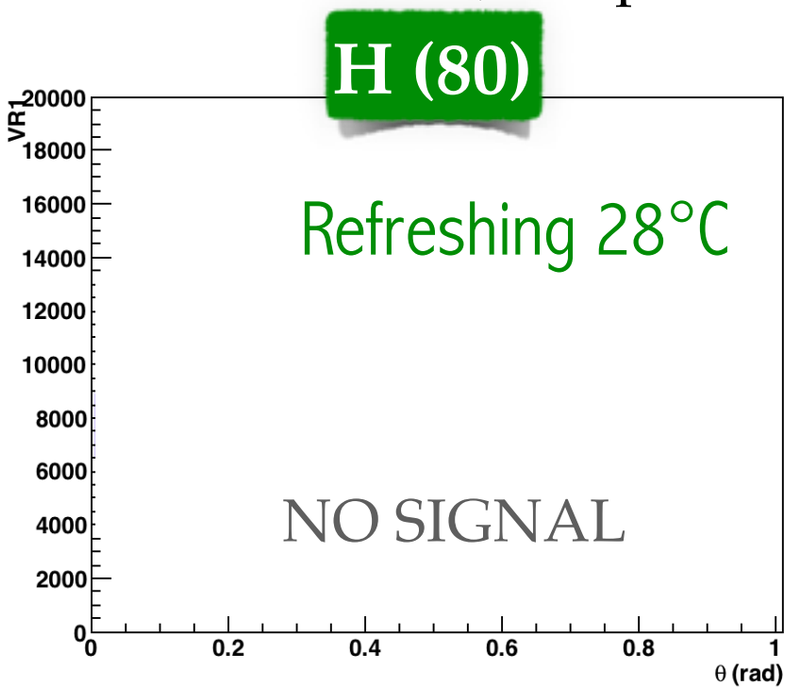
Signal selection: θ<0.1 rad

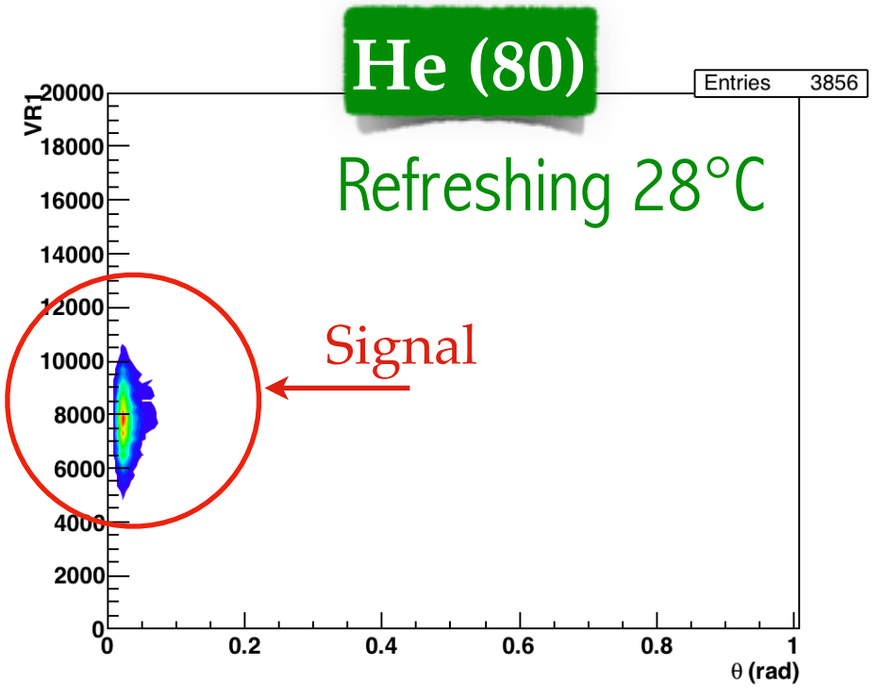


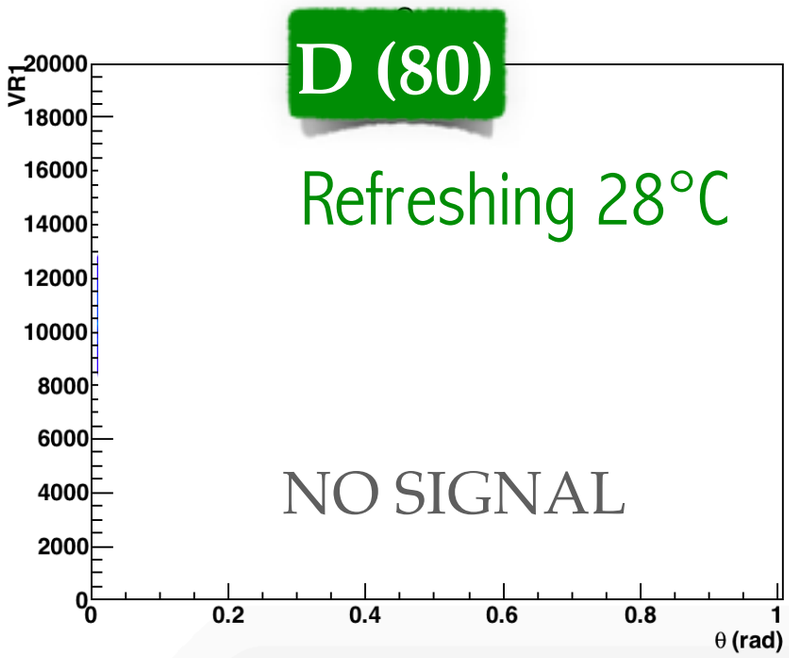


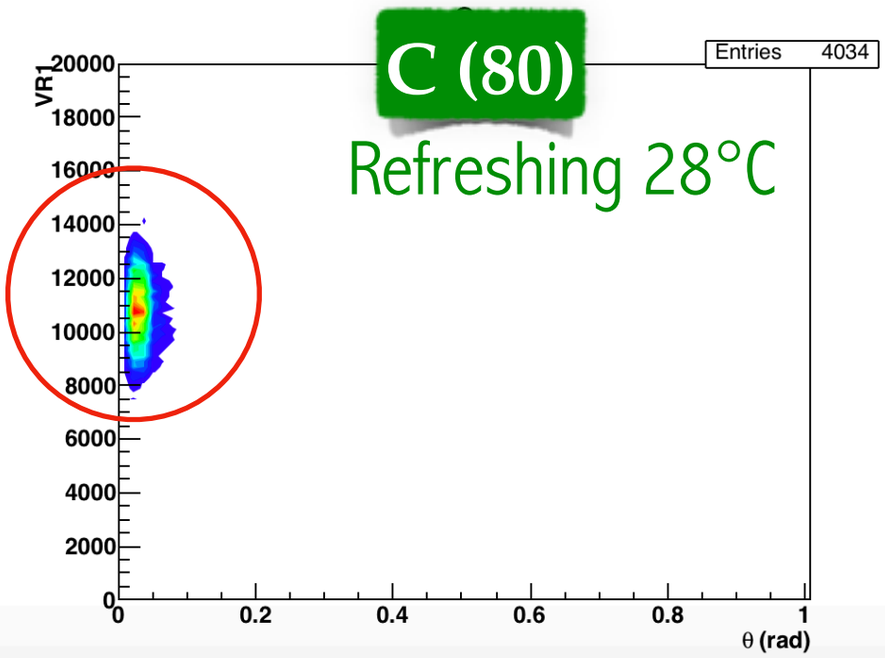
REFRESHING 28°C

- Cosmic rays cancelled
- H and D tracks cancelled
- Degradation of ionization for He tracks
- High ionization for C tracks (as expected)



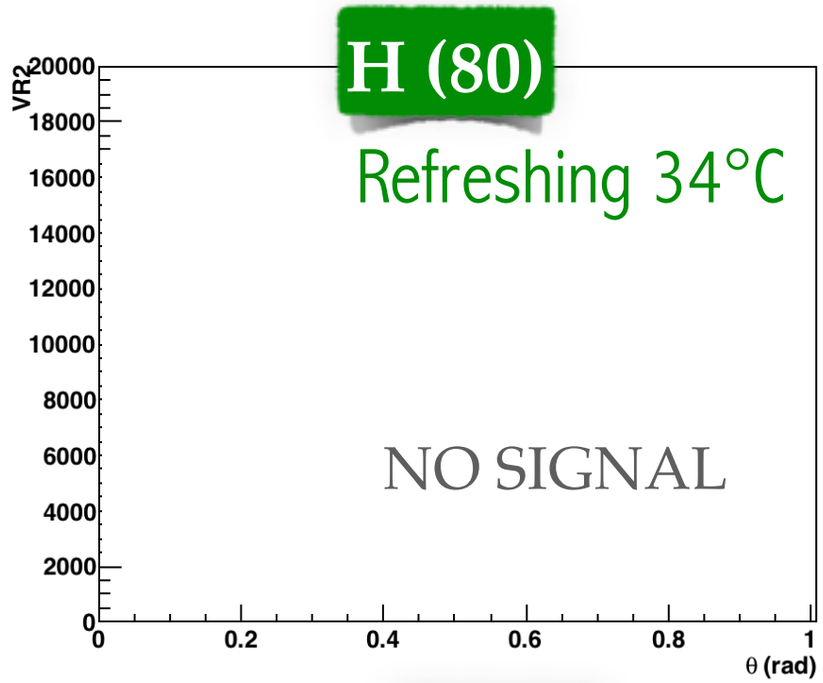


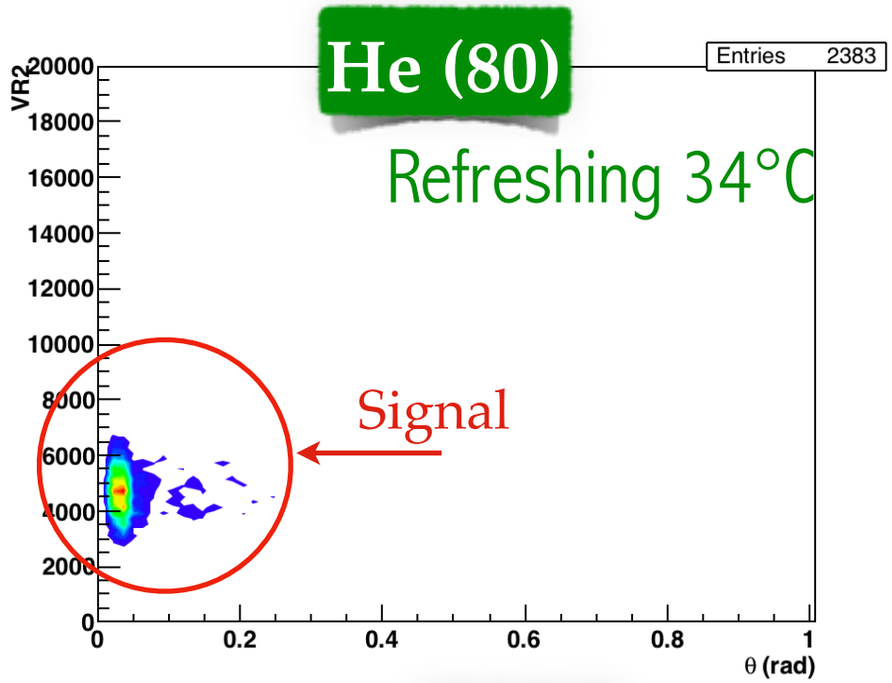


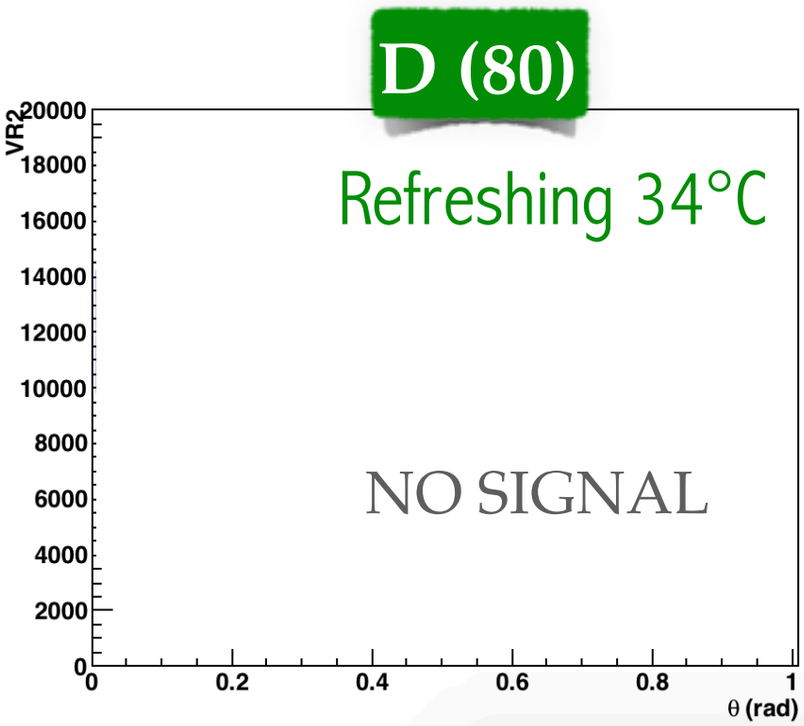


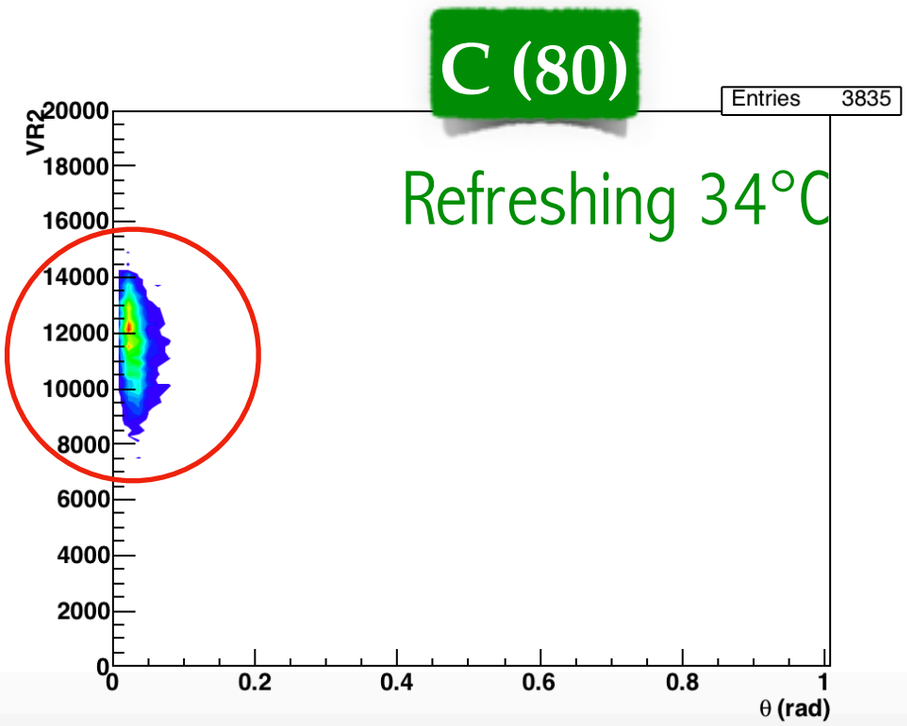
REFRESHING 34°C

- Cosmic rays cancelled
- H and D tracks cancelled
- Partial cancellation of He tracks
- No degradation of C ionization



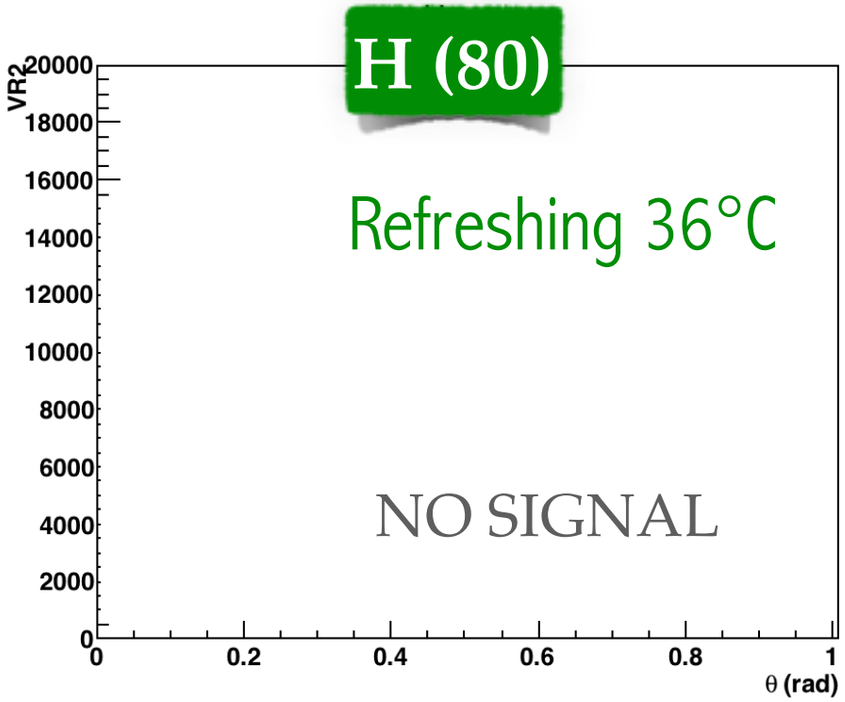


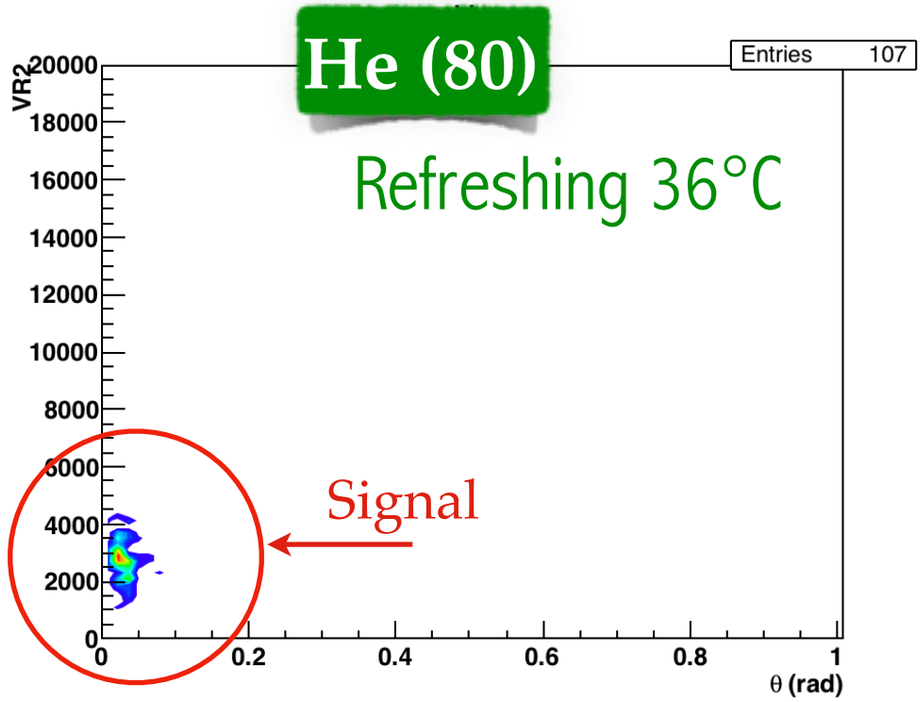


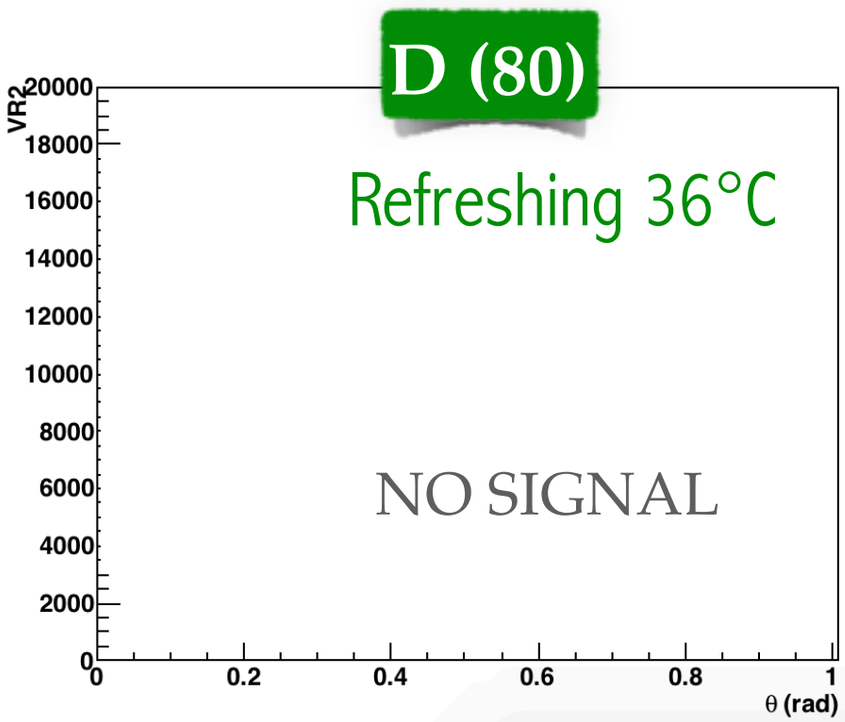


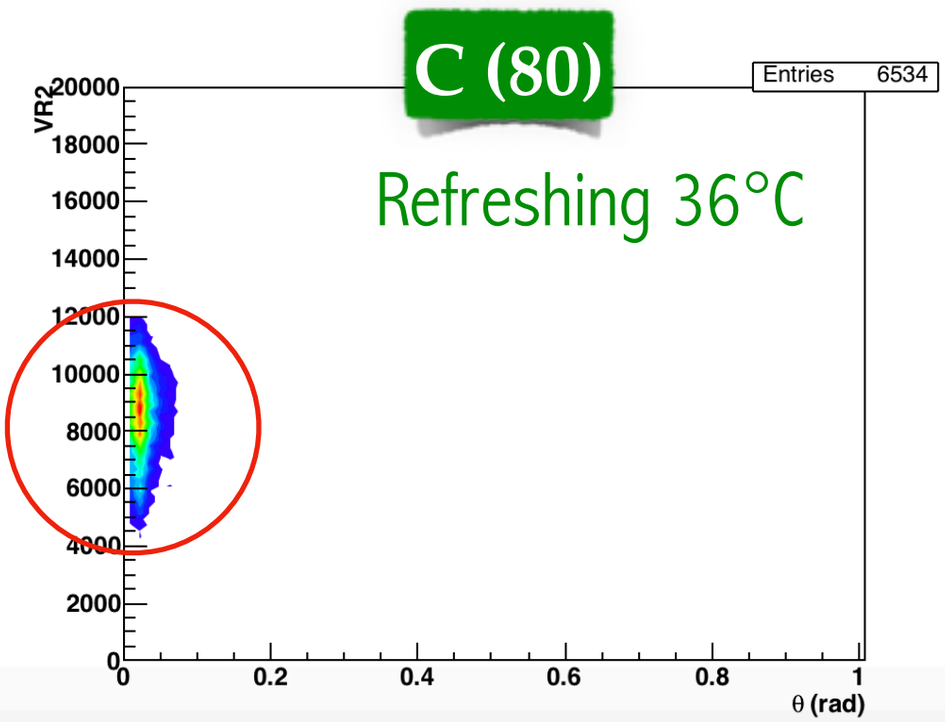
REFRESHING 36°C

- Cosmic rays cancelled
- H and D tracks cancelled
- Further cancellation of He tracks
- Degradation of ionization for C tracks



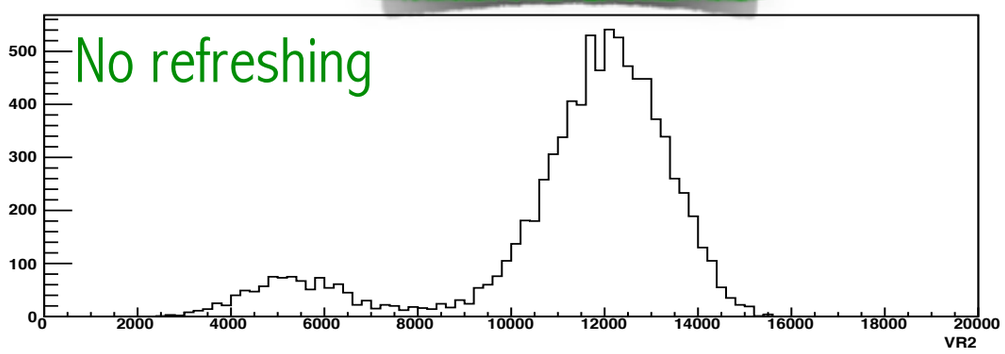


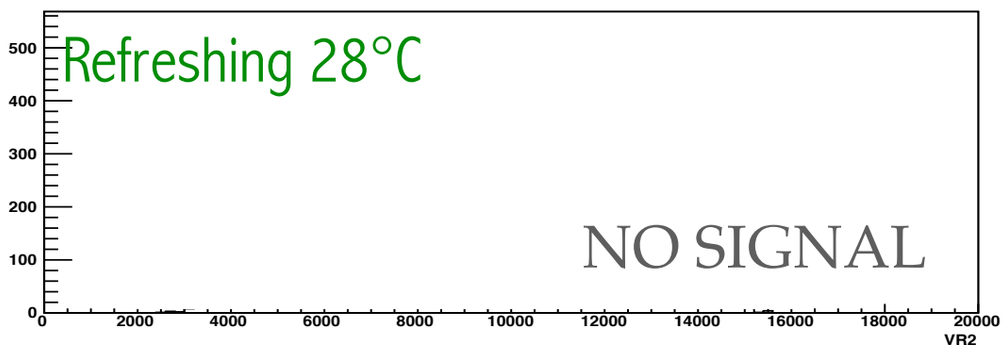


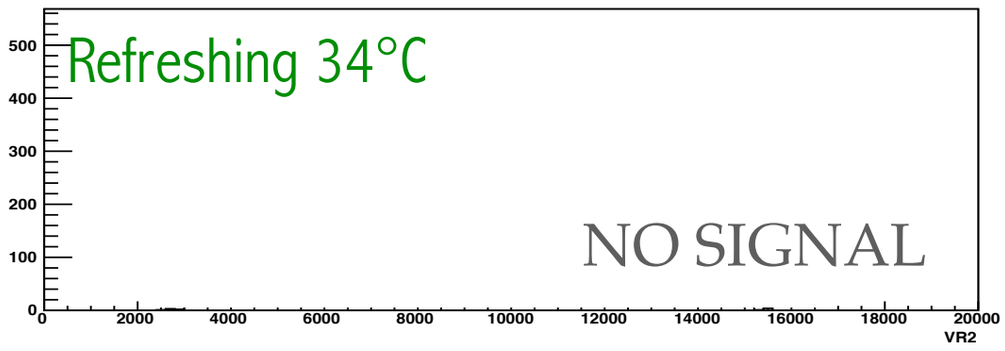


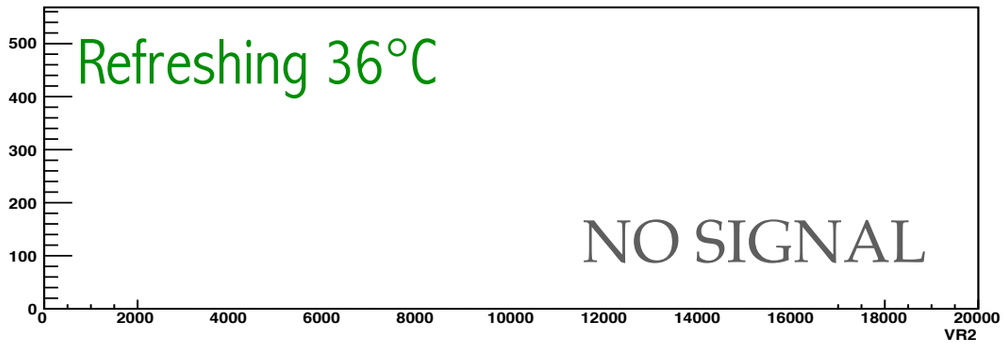
RESULTS

H (80 MeV)

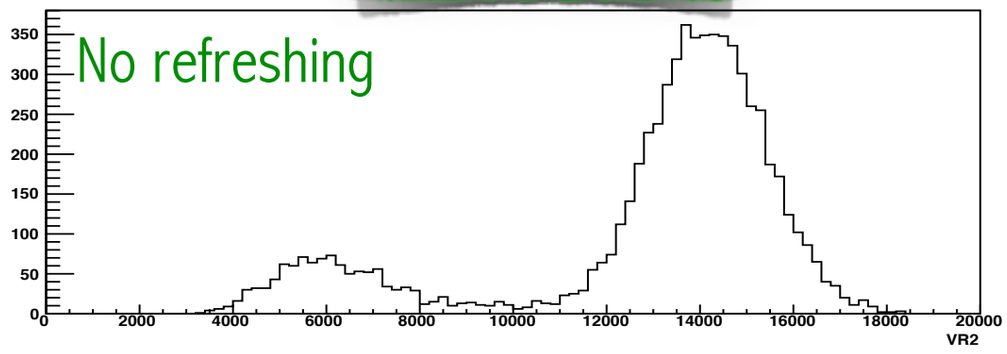


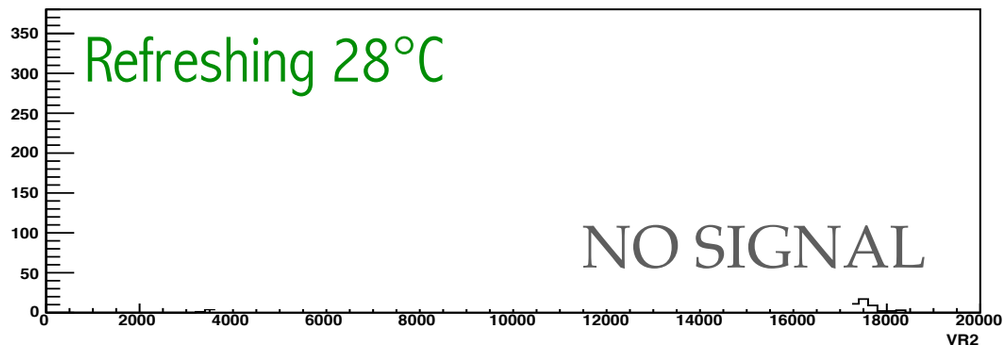


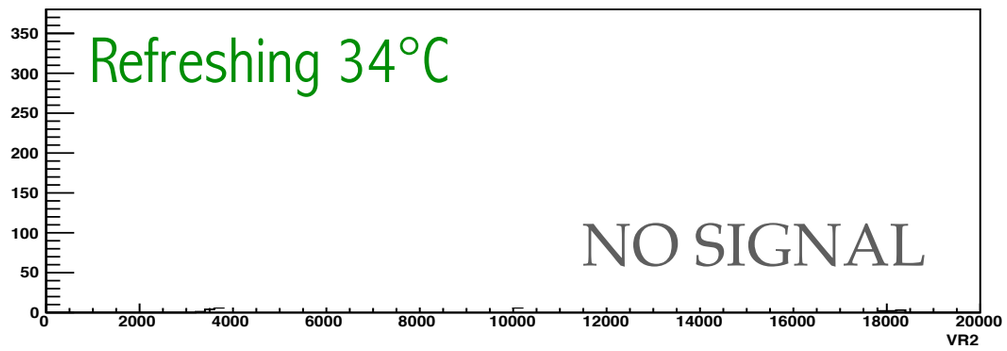


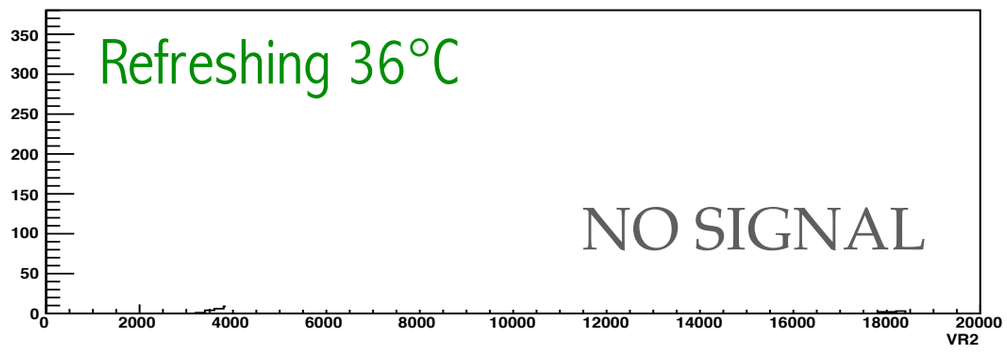


D (80 MeV)



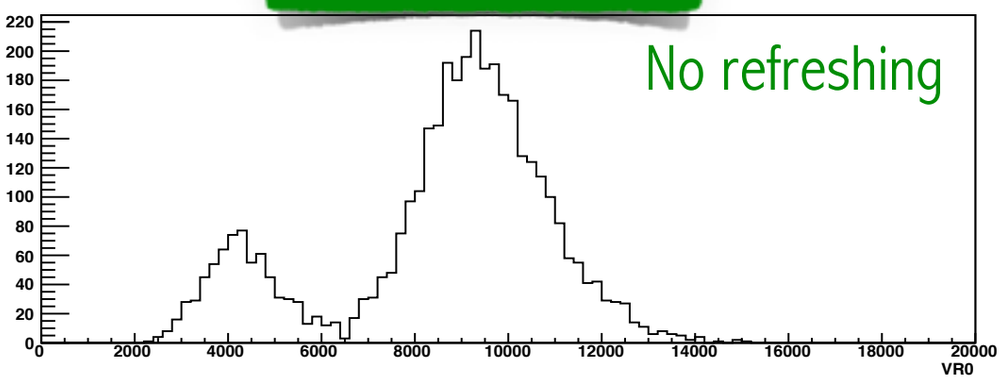


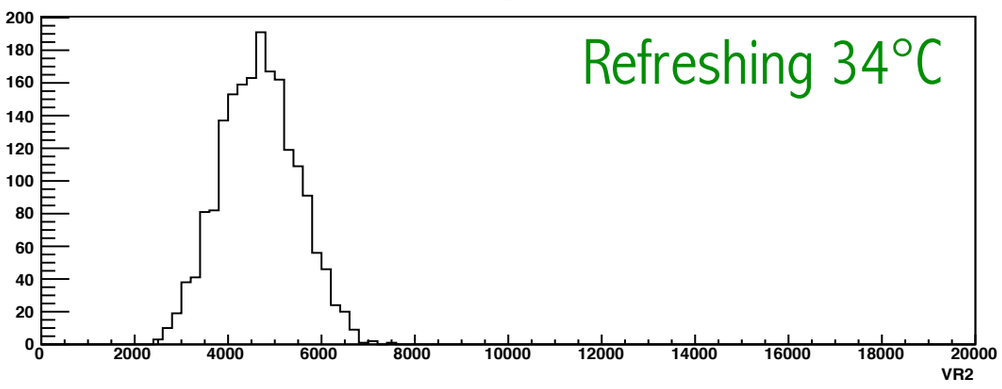


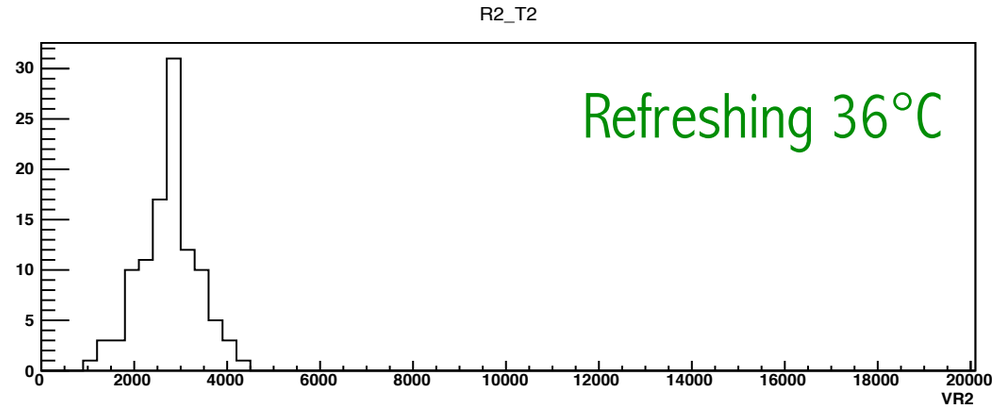


RESULTS

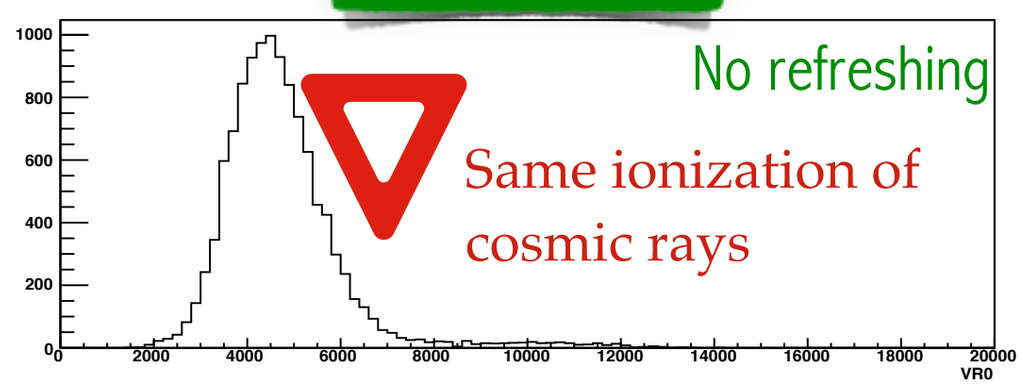
He (80 MeV)

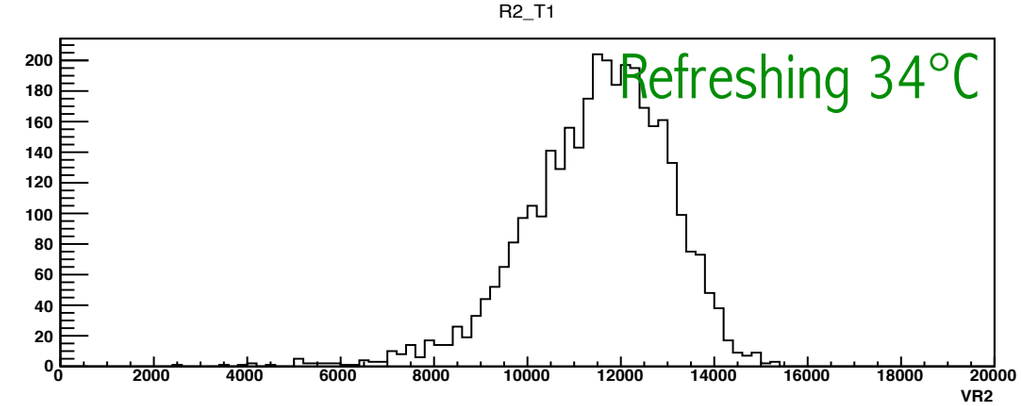


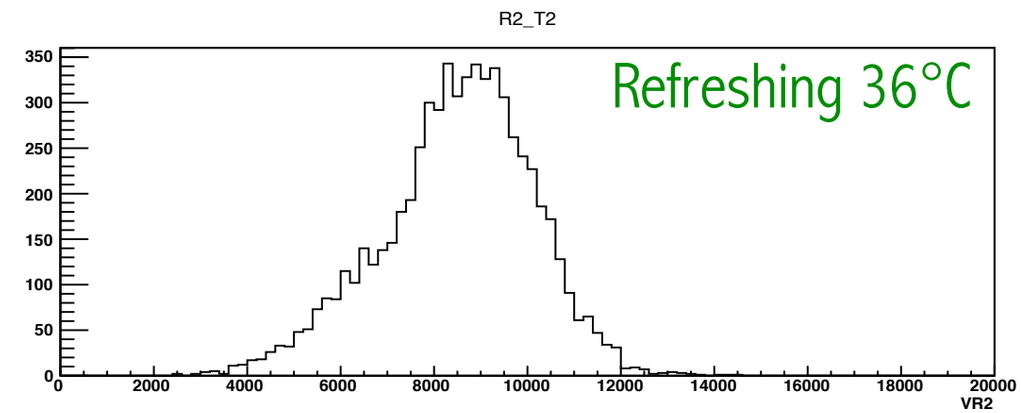




C (80 MeV)







Conclusion

- First results of refreshing procedure performed to new nuclear emulsions produced in Nagoya exposed to H, D, He, C (80 MeV/u) @LNS in July
- Scanning of a small area of several samples performed in Napoli Emulsion Laboratory
- In the samples **without refreshing** signal tracks show higher ionization wrt cosmic rays, but they saturate
- Unexpected behavior observed for C beam: same ionization as cosmic rays
- The **28°C refreshing** completely removes cosmic rays, H(80 MeV/u) and D(80 MeV/u)
- The **34°C refreshing** partially cancels He(80 MeV/u) and does not affect C(80 MeV/u)
- The **36°C refreshing** strongly reduces He(80 MeV/u) component and slightly reduces the C(80 MeV/u) volume

Perspectives

- Perform a new scanning campaign of all samples with larger area
- Test beam in Trento in December to test refreshing procedure with
  - H(200 MeV/u)
  - H(50 MeV/u) simulating He(200 MeV/u)
  - H(80 MeV/u) for comparison with LNS measurements