Simulation update

Giulia D'Imperio for the simulation working group

CYGNO general meeting 29/10/20

cygno-login

- Virtual machine for cygno analysis and simulation
- CENTOS 8 operating system, with python 3.8, ROOT and Geant4 installed
- Tested with cygno codes (background simulation, toy MC, noise simulation, reconstruction)
- Ask an account to Giovanni Mazzitelli
- Double login:
  - first login to `linux.lngs.infn.it`
  - then `ssh cygno-login` (same credentials)
  - create your user workspace in `/nfs/cygno/users`
  - use setup script: `source /nfs/cygno/setup_cygno_login.sh`
  - PBS batch system, use `cygno` queue

cygno wiki page in progress

Each code repository has a README file, but we plan to use also a wiki page on github for instructions:
https://github.com/CYGNUS-RD/WIKI-documentation/wiki

This wiki is independent from the INFN wiki used by the editorial board.

Quenching factor calculations with SRIM

New calculations of QF

- Quick calculation mode, 1000 ions per run
- IONIZ.TXT: primary and secondary ionization energy loss
  - Integrating over whole range results in the total ionization energy loss
  - $QF=(E_{ioniz,e}+E_{ioniz,recoil})/E$

Previous calculations of QF

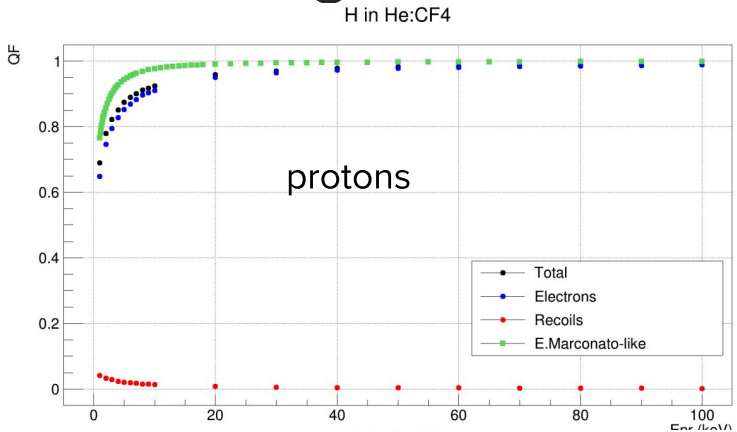
- E.Marconato used the *Tables of Stopping Powers and Ion Ranges*

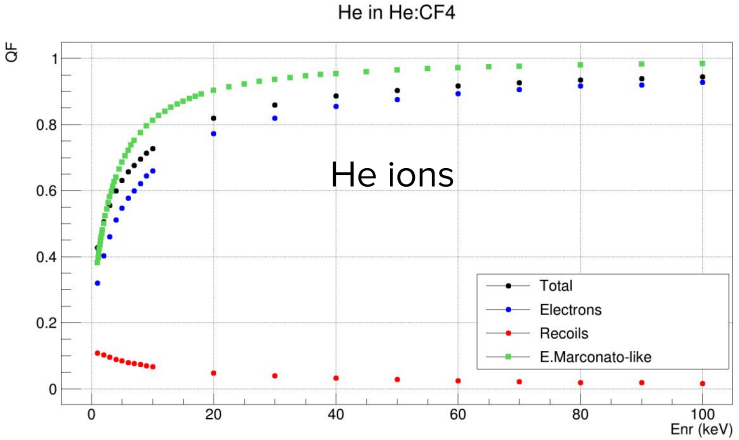
$$QF=(dE/dx)_{elec}/[(dE/dx)_{elec}+(dE/dx)_{nuclear}]$$

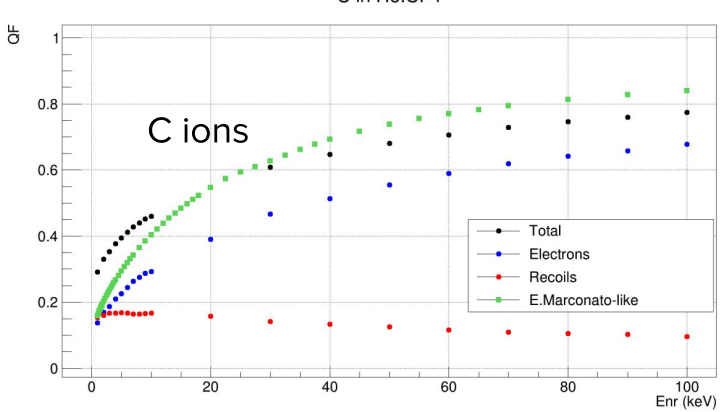
$$(dE/dx)_{elec}=(dE/dx)_{ioniz,e}+(dE/dx)_{other,e}$$

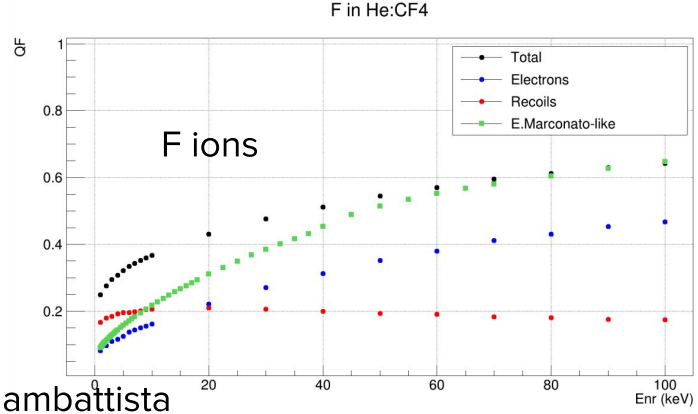
The definition of QF in the previous calculations is not what we need.
New calculations should use the “correct”definition for our purpose (i.e. fraction of energy deposited through ionization process w.r.t. total energy deposited)

Quenching factor calculations with SRIM



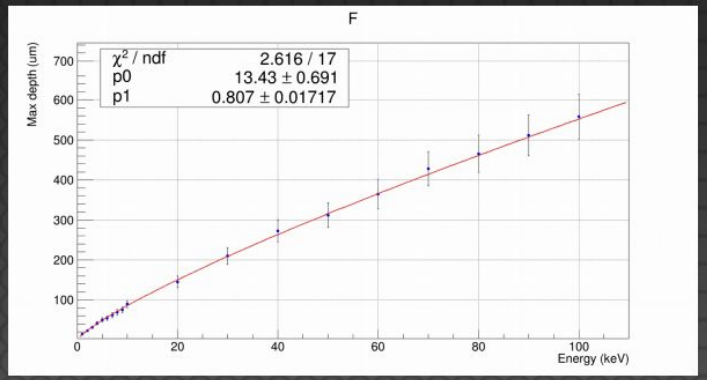


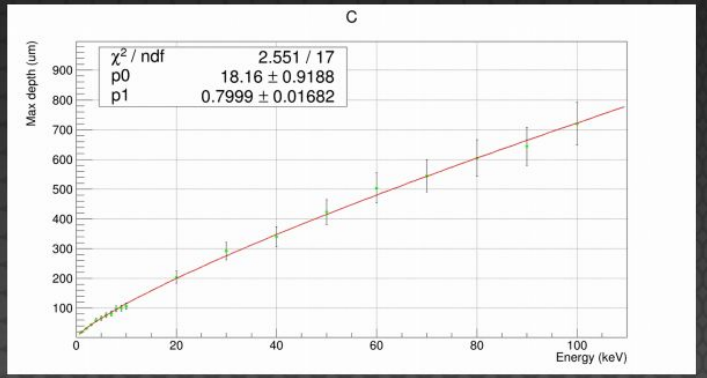


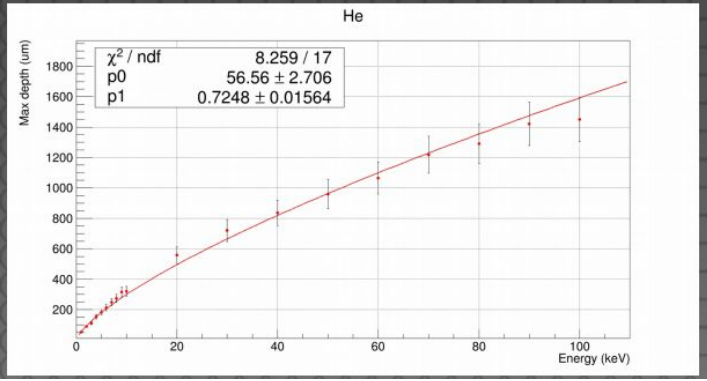


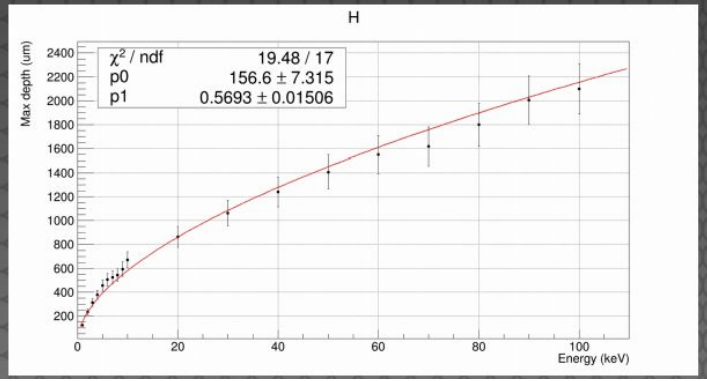
Pysrim – target width

From the data of the quick calculation we estimated the target width necessary to fully contain the events; fit function $p_0 E^{p1}$









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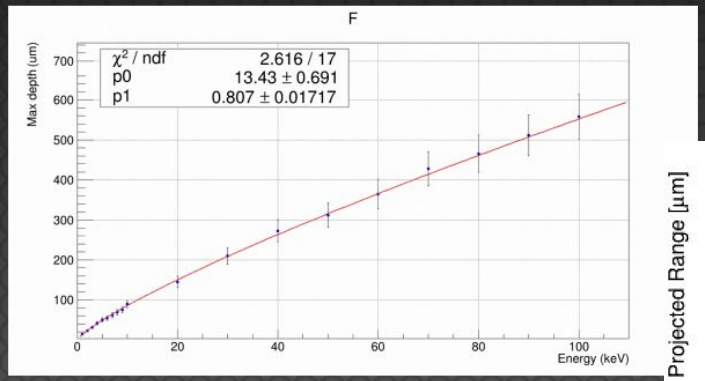
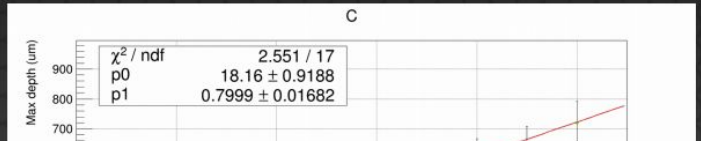
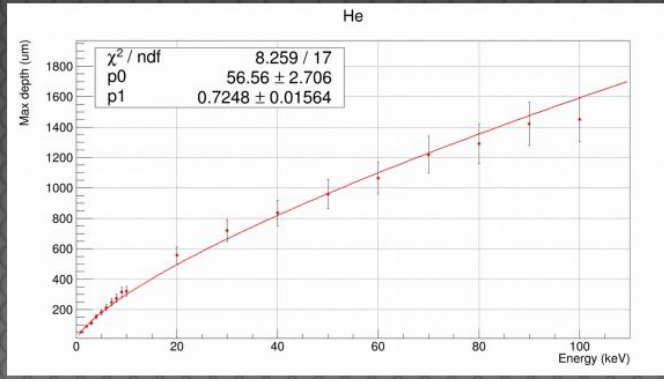
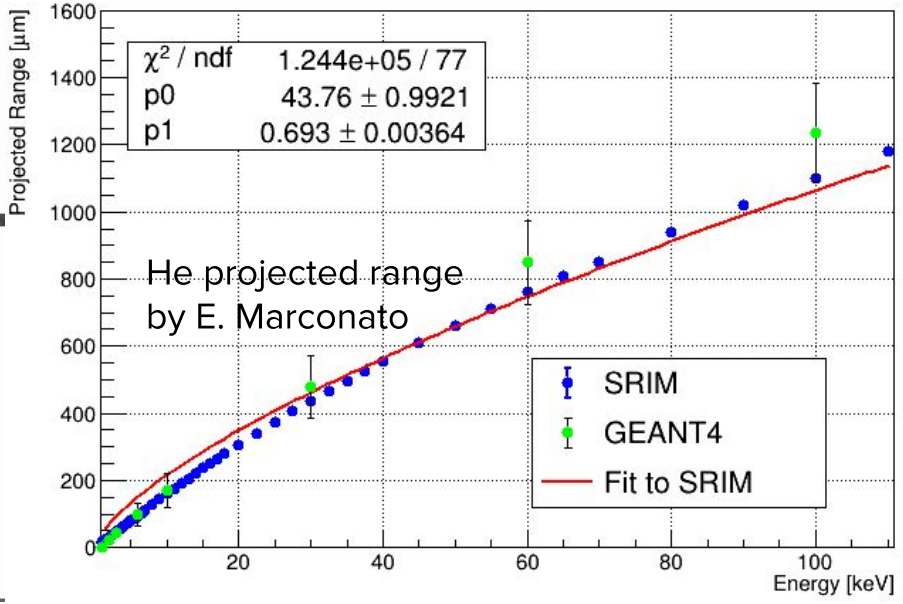


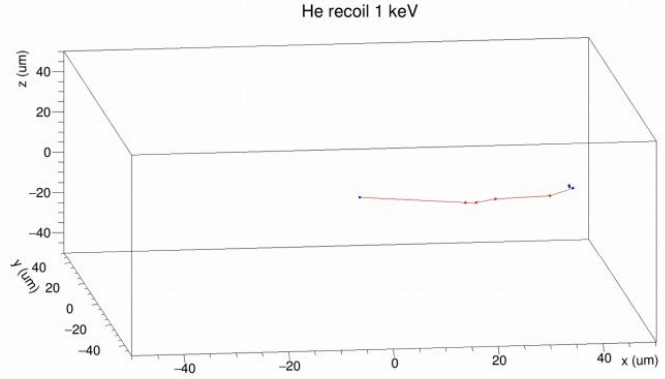


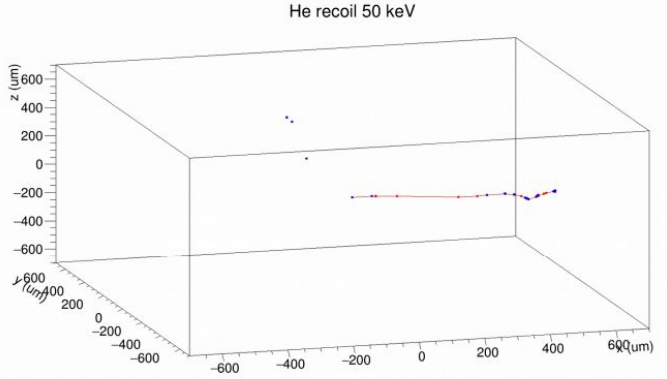




He projected range by E. Marconato

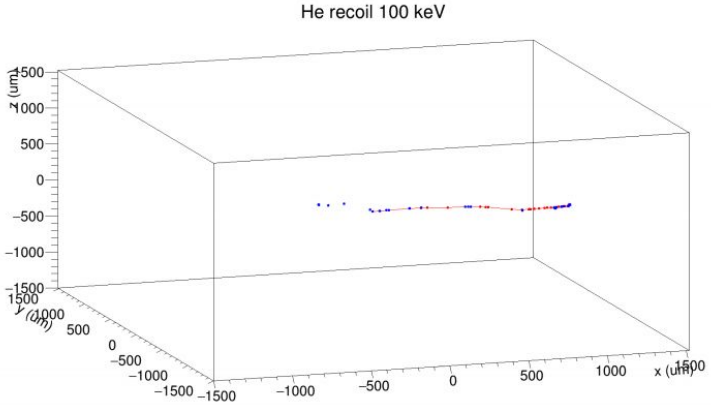
Track reconstruction (He)





Data from COLLISON.TXT

- Red dots are recoils produced by the primary ion
- Blue dots are secondary recoils, produced by primary recoils



The main problem at the moment is to combine the 2 output files of SRIM:
- x,y,z, tot energy
- depth, ionization energy

➜ x,y,z, ionization energy

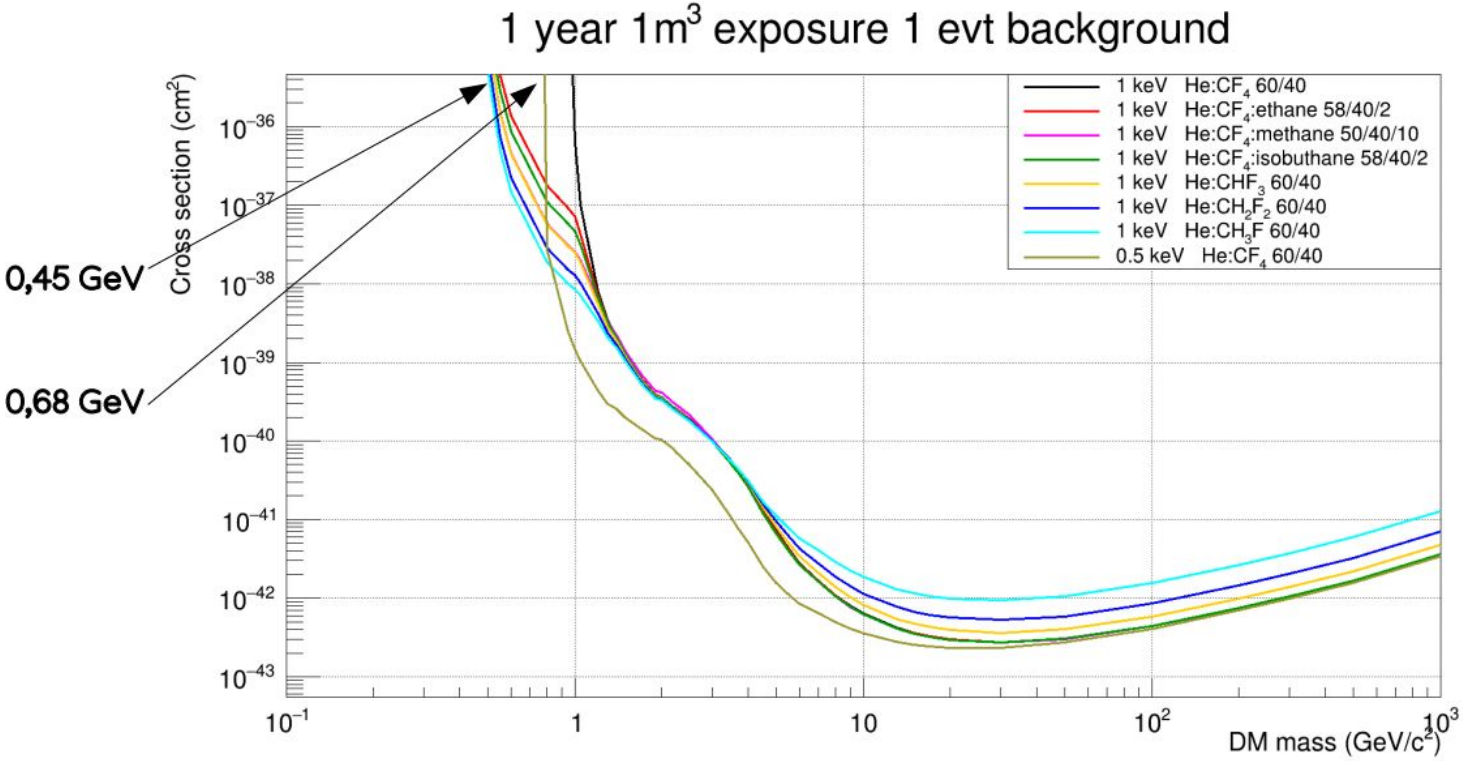
Can we just multiply the total energy deposit by the average QF?

SENSITIVITY

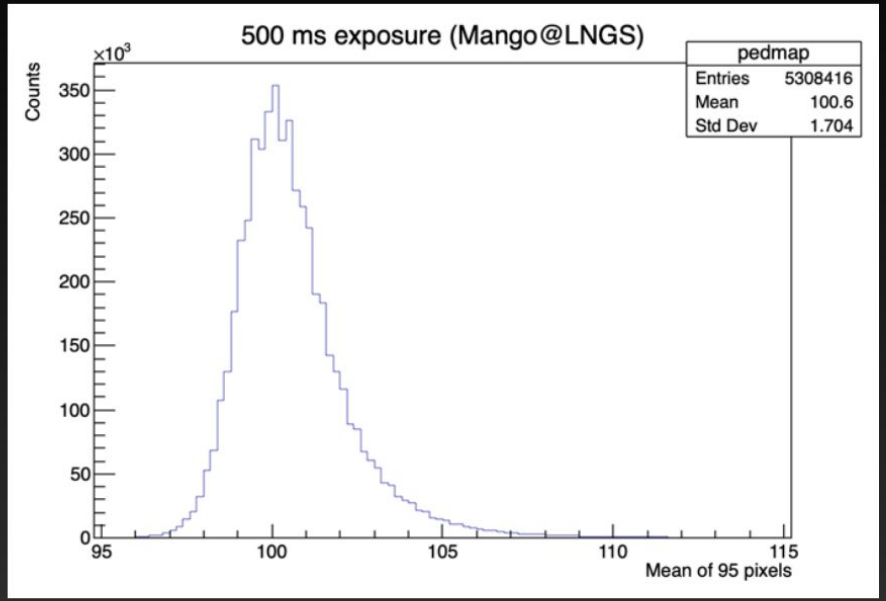
- New gas mixtures tried

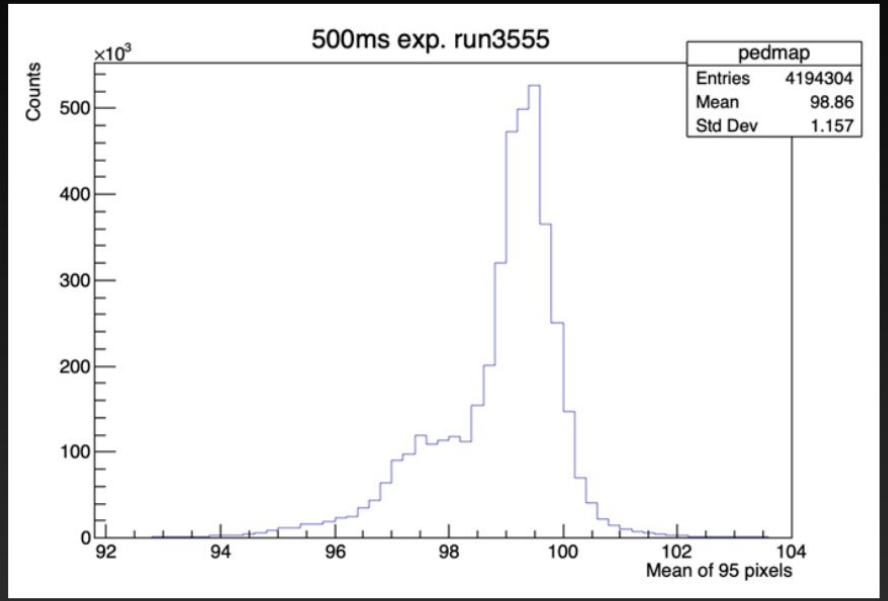
Gas mixture	Percentage	Density (kg/cm^3)
He:CF_4	60/40	1,588
He:CF_4:ethane	58/40/2	1,611
He:CF_4:methane	50/40/10	1,637
He:CF_4:isobuthane	58/40/2	1,635
He:CHF_3	60/40	1,278
He:CH_2F_2	60/40	0,972
He:CH_3F	60/40	0,676

SENSITIVITY



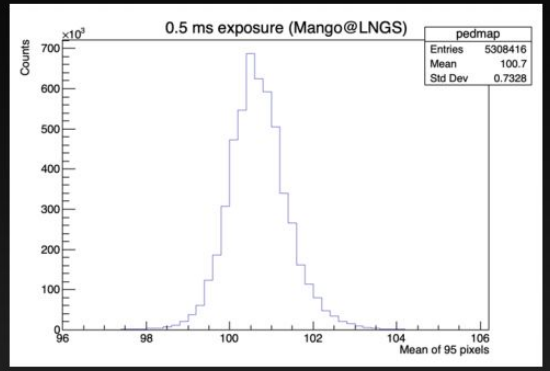
Comparison of noise of Flash and Fusion

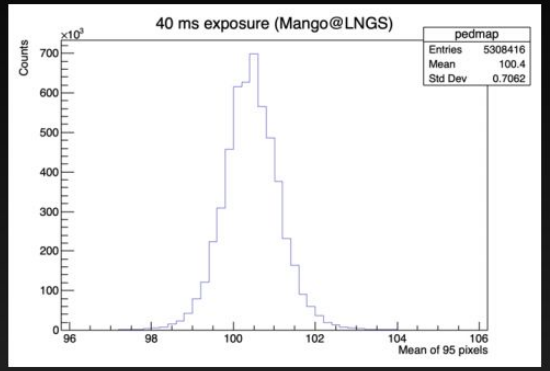


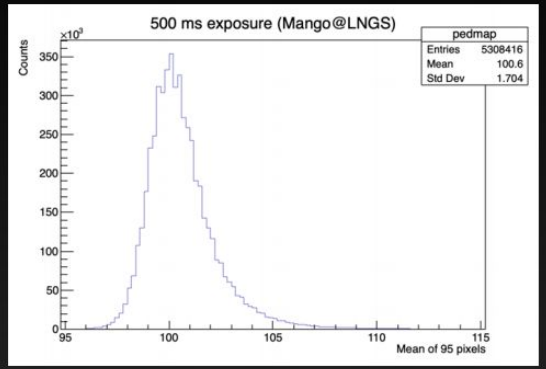


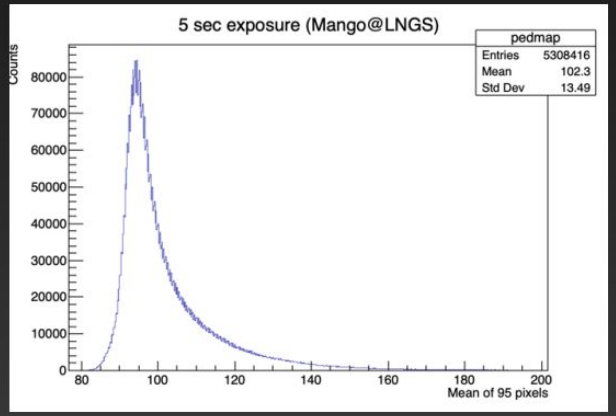
- Data at LNGS is collected with ORCA Fusion and Run 3555 was collected with ORCA Flash.

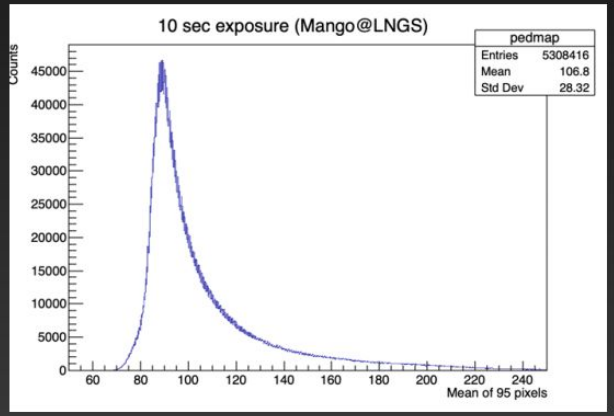
ORCA Fusion with Different exposure











- All the data was collected with Orca Fusion and cap on.

Conclusions

- The new definition of the QF should be the “right” one
- New QF calculations should be included in the sensitivity study
  - improvement of the QF for C and F ions
  - slightly lower QF for H and He ions
- 3D track reconstruction + ionization energy information is not produced by SRIM
  - we could redo some comparison with Geant4
- Sensitivity calculations for gas mixtures containing H show a larger improvement for the low-mass DM w.r.t. lowering the threshold to 0.5 keV
- Noise studies with ORCA Fusion and comparisons with ORCA Flash ongoing, Rafael and Igor will prepare a presentation in one of the next meetings