Global reconstruction:
Matching of tracks between SFGD and bHAT

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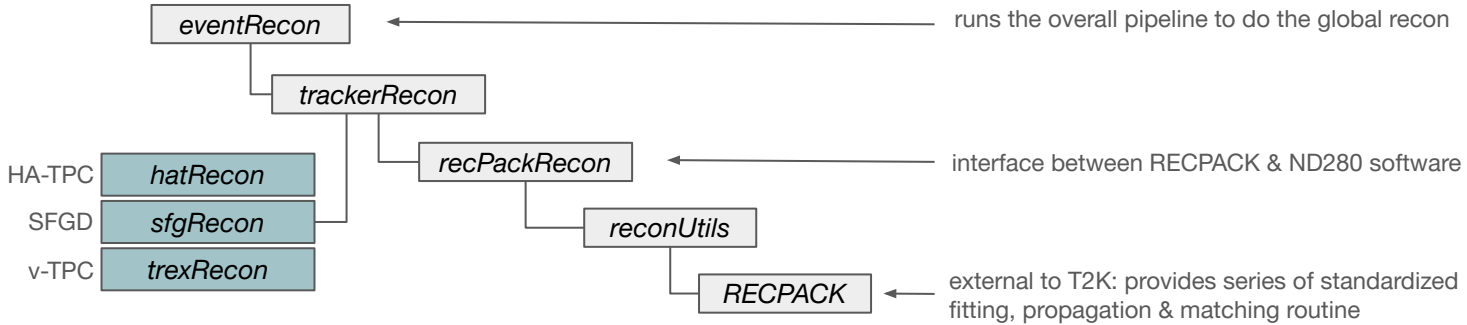
LPNHE neutrino group meeting – 15/05/2024

Introduction

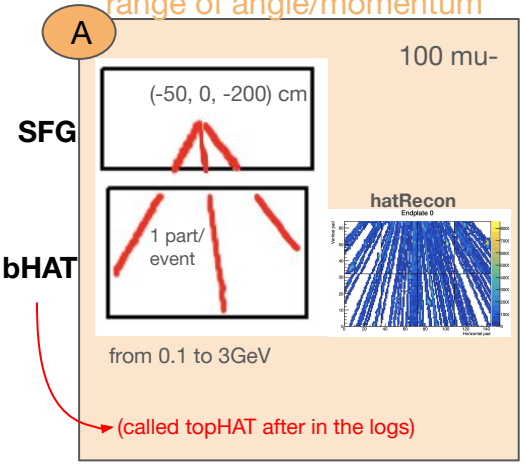
- Global reconstruction = matching tracks reconstructed in each detector into one global track in ND280
- Matching of tracks done with the ***eventRecon*** package: performs global reconstruction in ND280
  → first updated to include SFGD-bHAT matching (work of W.Saenz following what was done for SFGD-TPC1)
- Package dependences:

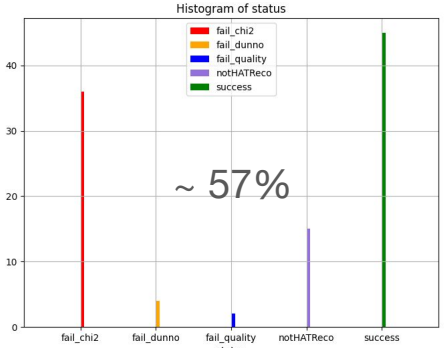


- Between SFGD and TPC1, expected matching efficiency > 90% (if no cuts) cf T2K-TN-483
- Goals:
  - find back similar matching efficiency b/n SFGD and TPC1 ✓
  - study matching efficiency b/n SFGD and bHAT ✓ : efficiency < 60% ☹
  - improve the latter: **add HAT where it's missing** and **adapt things to its specificities**

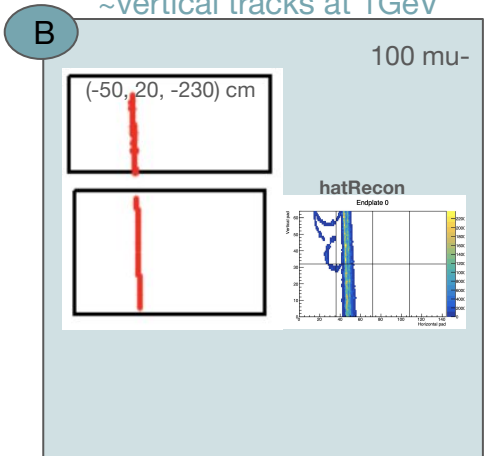
Previous status of the matching efficiency = #matched tracks / #tracks recon by both detectors

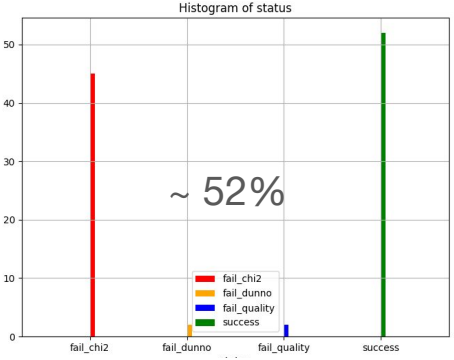
A — range of angle/momentum



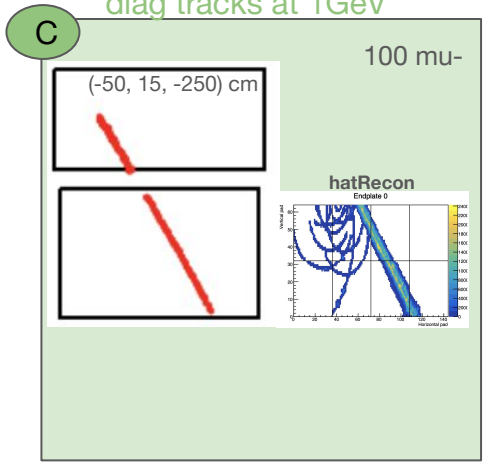


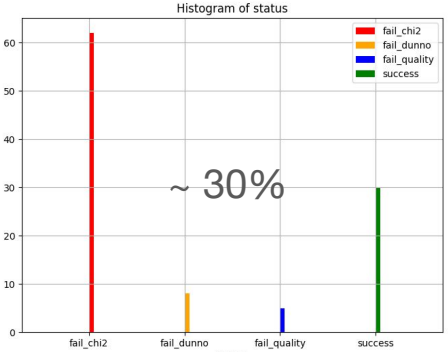
B — ~vertical tracks at 1GeV



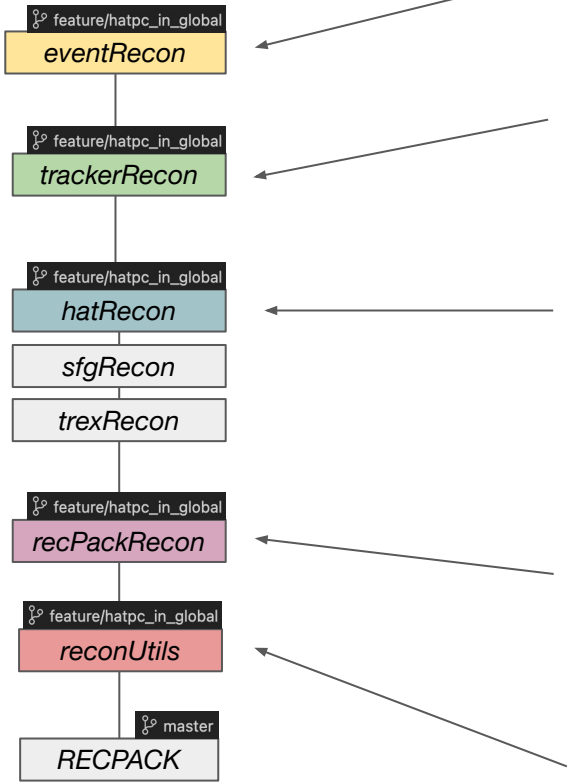


C — diag tracks at 1GeV





What was modified since



use also HAT for PID

- define a function **MergeHatSfgObjects()** similar to **MergeTpcSfgObjects()** but which do not use momentum, x and tx for matching since this gives best matching efficiency
(see next slides)

- corrected the track chi2 values (that is given as track quality)
- add track status of **ND::TReconBase::kLikelihoodFit**
- corrected how *p* and *q* parameters are set for the node states
- corrected some bug in the reconstruction of the x position

- in **TRecPackMatchingSurfaceMarker**: add HAT surface definitions similarly to TPC treatment
- in **TRecPackMatchingSurfaceMarker**: change SFG to something similar to FGD but propagates to surface in Y for HAT tracks (instead of Z with TPC tracks)
- add missing HAT in **TMergingUtils**

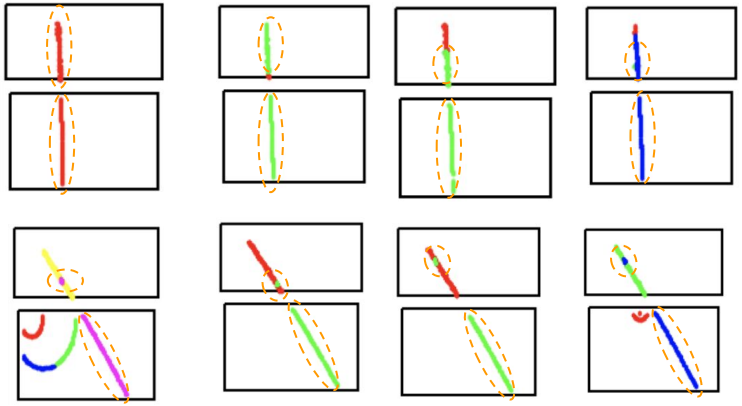
add HAT and corrected top/bottom numerotation to 1/0

Condition for tracks to be considered as matched

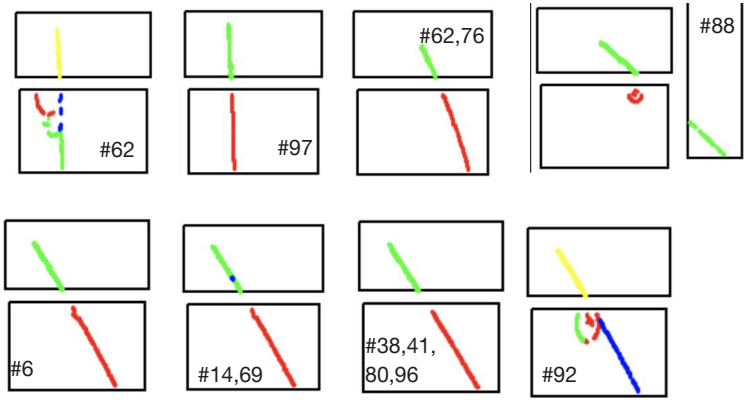
There is **at least one successful match and merge** between a SFGD and a HAT track, i.e. at leat one merged object:

```
 ---> Fit OK:  (SFG-BottomHAT) PID  (0x1d0385f0): #hits = 240, #cons = 2, #nodes = 41,
status = (success:kalman), ndof = 81, chi2 = 77.0217, p = 38.3755, q = -1, t = 8440,
PID = Electron, weight = 2.34044e-310, #alter = 0
```

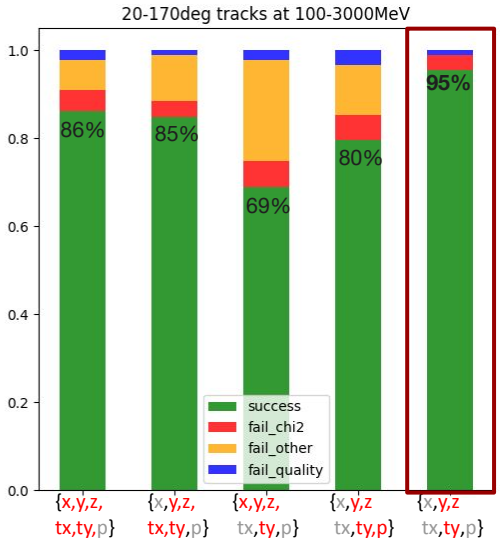
considered as matched:

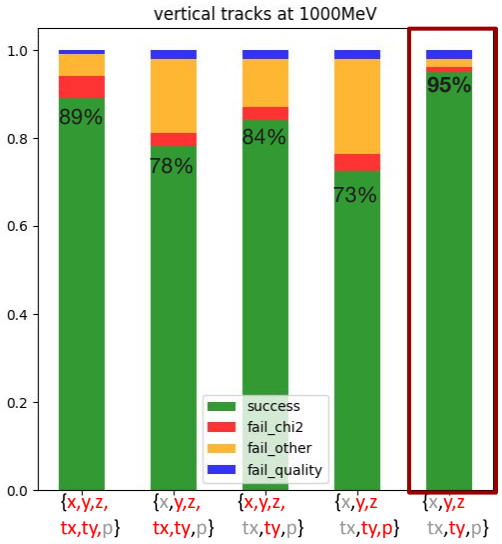


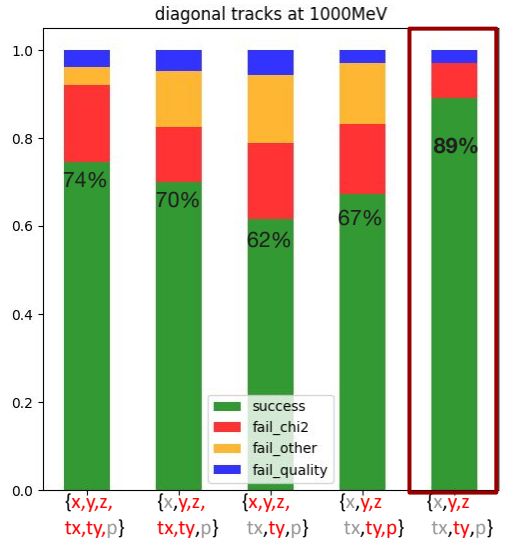
vs not matched:



Current status of the matching

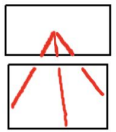




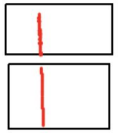


used for matching

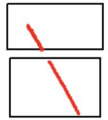
simu A



simu B

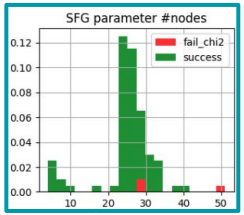


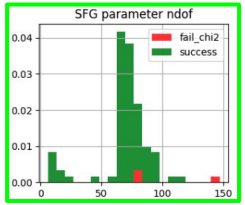
simu C

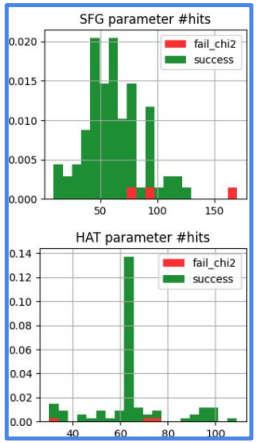


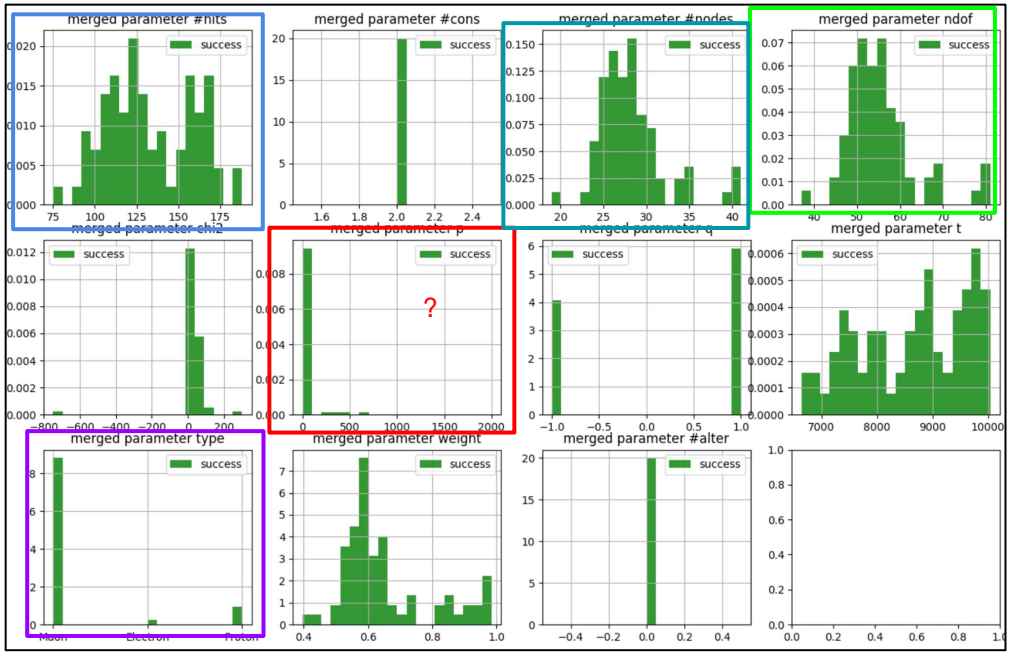
Parameters of the merged track

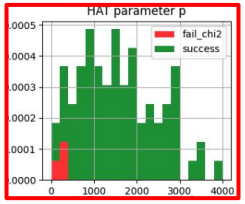
simu A

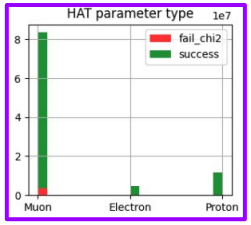












- merged param **p → need to correctly check how the object states are filled and converted in hatRecon** WIP

Conclusion

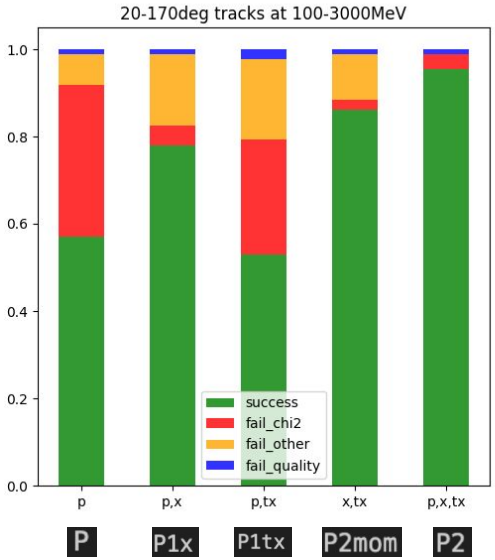
- Matching is better when not using *x*, *tx* and *p* for HAT → need to find why since we should use *x, tx*
- Some things were corrected in **hatRecon** which increased matching efficiency (track chi2, *x* recon…)

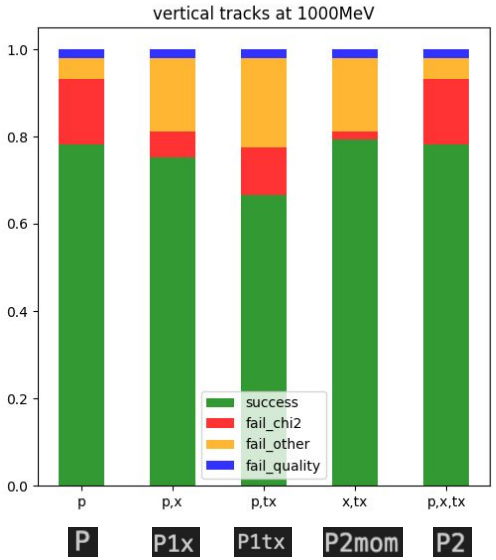
todo:

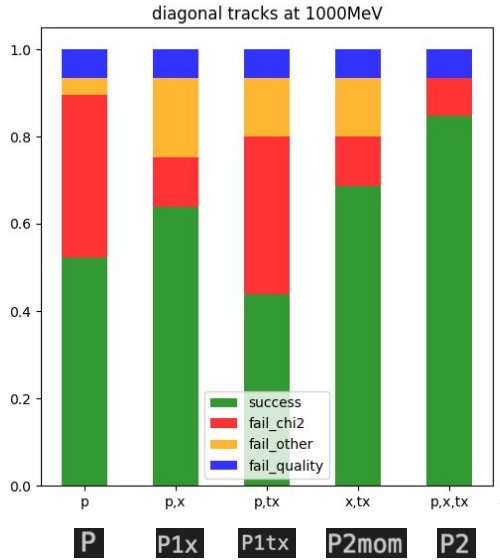
- look at the *pos* and *dir* parameters of the *(SFG)* and *(BottomHAT)* objects to understand why matching is better when excluding *x* and/or *tx*
- analyse the remaining failure cases, specially for the diagonal simulation
(→ check verbosity of **recPackRecon/src/TFittingUtils::FitObject()**)
- correct momentum and particle type values for the merged objects

Backup

Modif in **trackerRecon::TTrackerConnector**



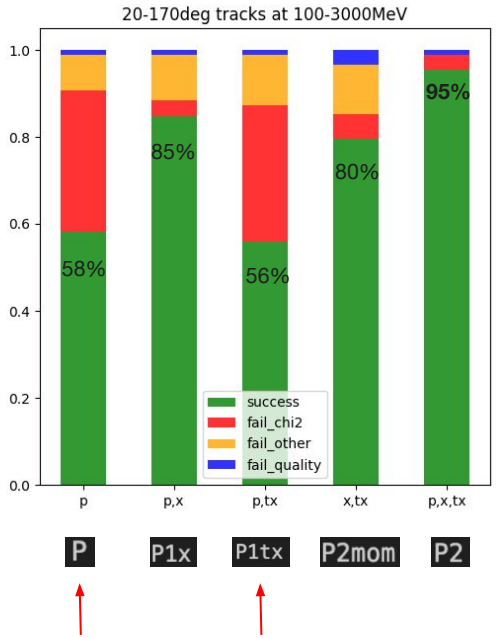


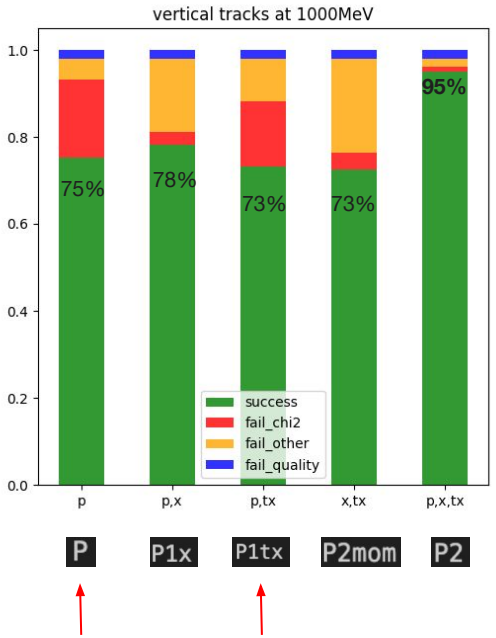


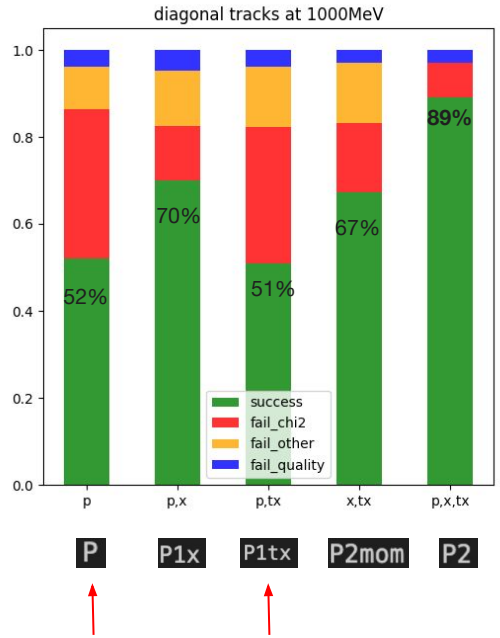
not used for matching

(before making the function)

Modif in **trackerRecon::TTrackerConnector**







not used for matching

when x is used for matching => low matching

we are looking in hatRecon, seems that x reco resolution maybe worse than expected

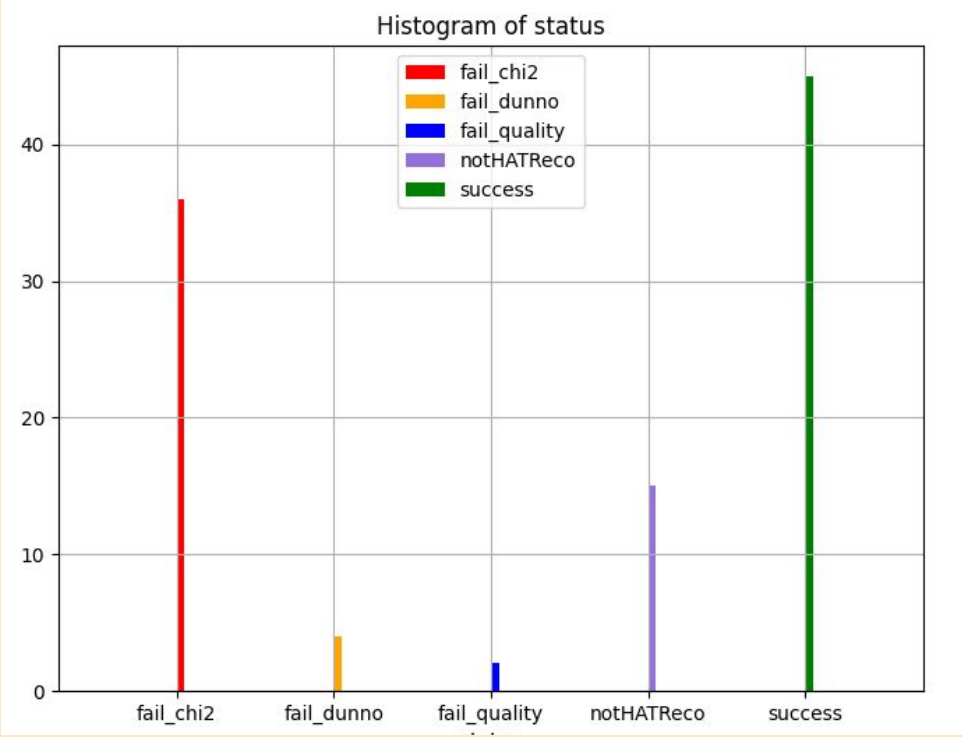
simu A

What happens when it fails: different cases

to investigate

=> failure case 'chi2'
because of chi2/ndf to large?
- should we try manually decreasing it?
- some have decent chi2 but still TMergingUtils doesn't execute? →need more prints

=> failure case unknown
- need more prints



temporarily solved

=> failure case 'track quality'
- set to 1
- need investigation in hatRecon

What happens when it fails: different cases

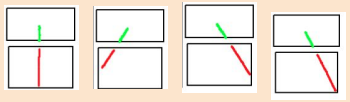
100 particles generated

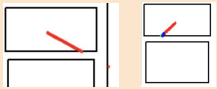
before hatRecon track quality set to 1

success: 37

fail_chi2: 28

fail_dunno: 6

fail_quality: 16 

notHATReco: 15 

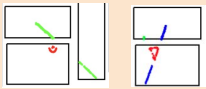
86 reco in the bHAT when running hatRecon alone (since some track are out of bHAT)

after hatRecon track quality set to 1 ⇒ ~10% improvement

success: 45 ↗️ +8

fail_chi2: 36 ↗️ +8

fail_dunno: 4 ⬇️ -2

fail_quality: 2 ⬇️ -14 

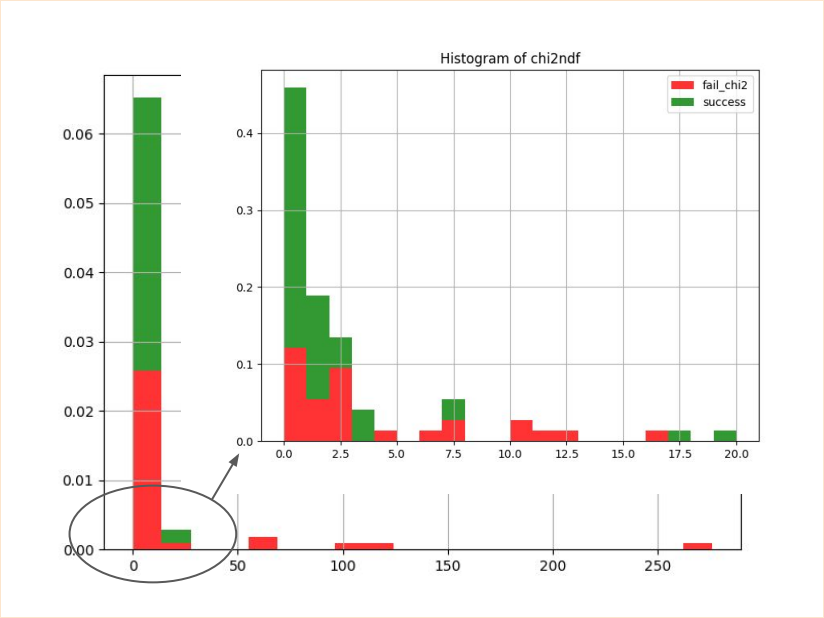
notHATReco: 15

where: CC-in2p3 (Lyon)

simu: /sps/t2k/anchalum/effGlobal/simu-area/mu-_100-3000_148_x-50y0z-200s30a20-170n100/
eventRecon out: /sps/t2k/anchalum/effGlobal/everecon_mu-_1000MeV_148_x-50y20z-230s30d0-101n100/

What happens when it fails: different cases

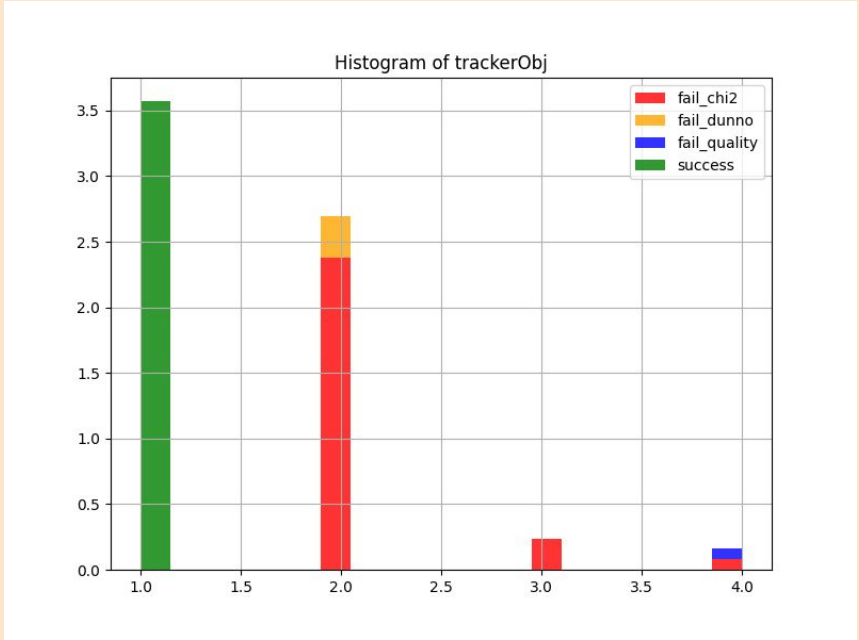
1 chi2/ndf




```
propagated parameter = -0
propagated vector = (-529.313599, -254.217743, -2182.701660, -0.002569, 0.770717, 0.637173, -0.000100)
propagated matrix = (4.283148, 0.000000, 8.033130, 0.002227, 0.004172, 0.002416, 1844.674297)
  --> chi2/ndf: 0.791944, res = (71.208725, -0.000004, 0.181106, -0.009068, 0.043768)
```

trackerRecon/src/TTrackerConnector

3 # final tracker objects




```
TrackerRecon:: TPC-FGD Object matching results:
  - Tracker Objects:     2
```

trackerRecon/src/TTrackerConnector

(details of the eventRecon logs in back up slides)

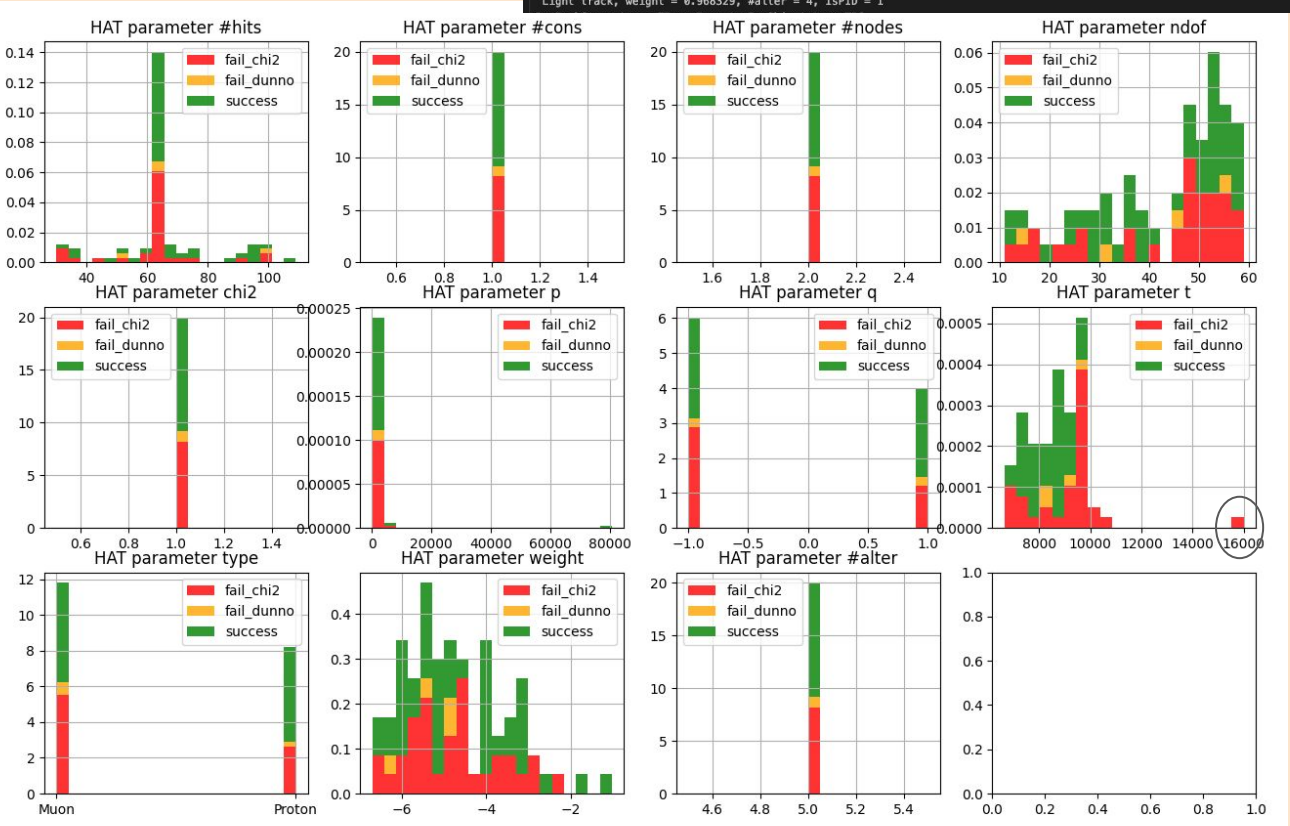
simu A

What happens when it fails: different cases

recPackRecon/src/TMatchingUtils

```
TRecPackManager::NewDirDirMatching()
  - (TopHAT) PID  (0x1da383e0): #hits = 88, #cons = 1, #nodes = 2, status = (success:chi2:likelihood), ndof = 38, chi2 = 43168.4, p = 1965.11, q =
  1, t = 8880, PID = Proton, weight = -3.95507, #alter = 5, IsPID = 1
  - (SFG) PID  (0x1d676db0): #hits = 77, #cons = 2, #nodes = 30, status = (success), ndof = 84, chi2 = 34.8715, p = 0, q = 0, t = 5095.49, PID =
  Light track, weight = 0.968329, #alter = 4, IsPID = 1
```

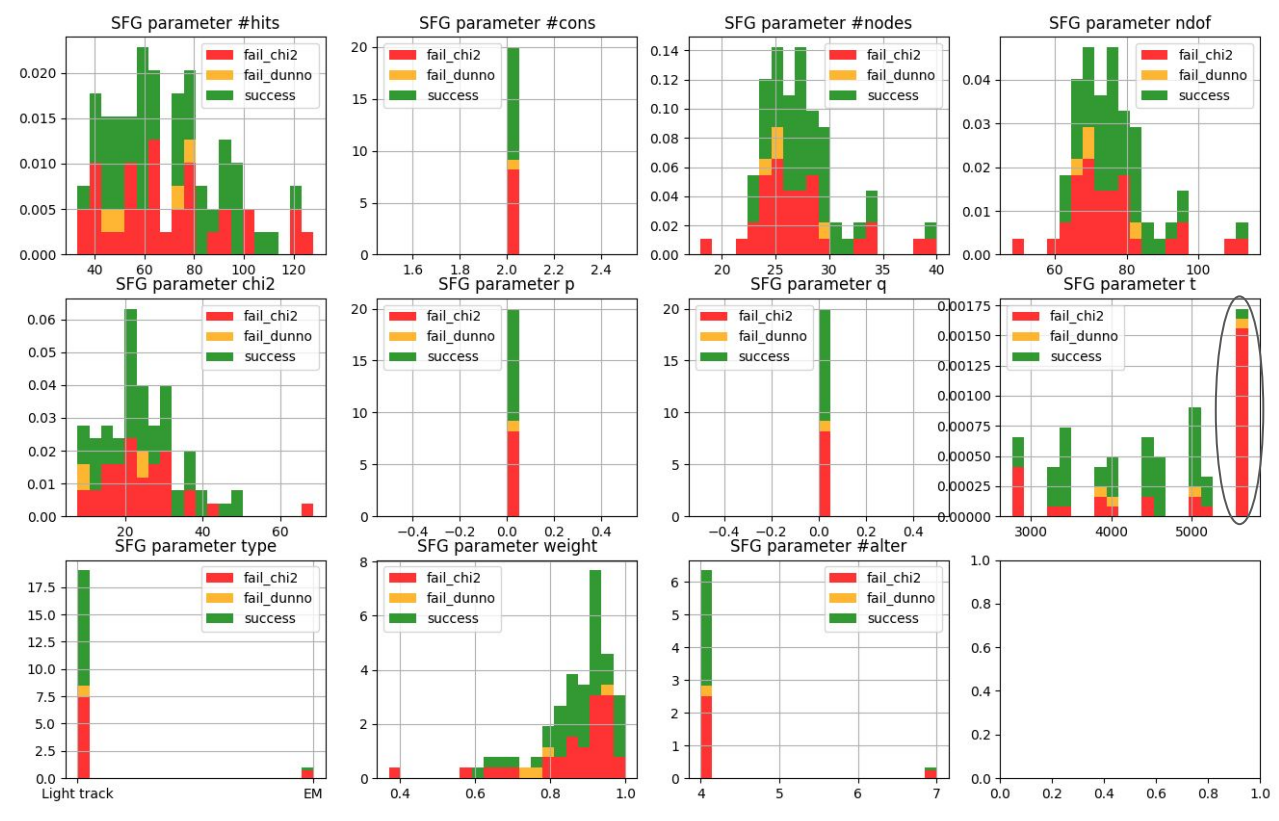
4 **#HAT parameters**



simu A

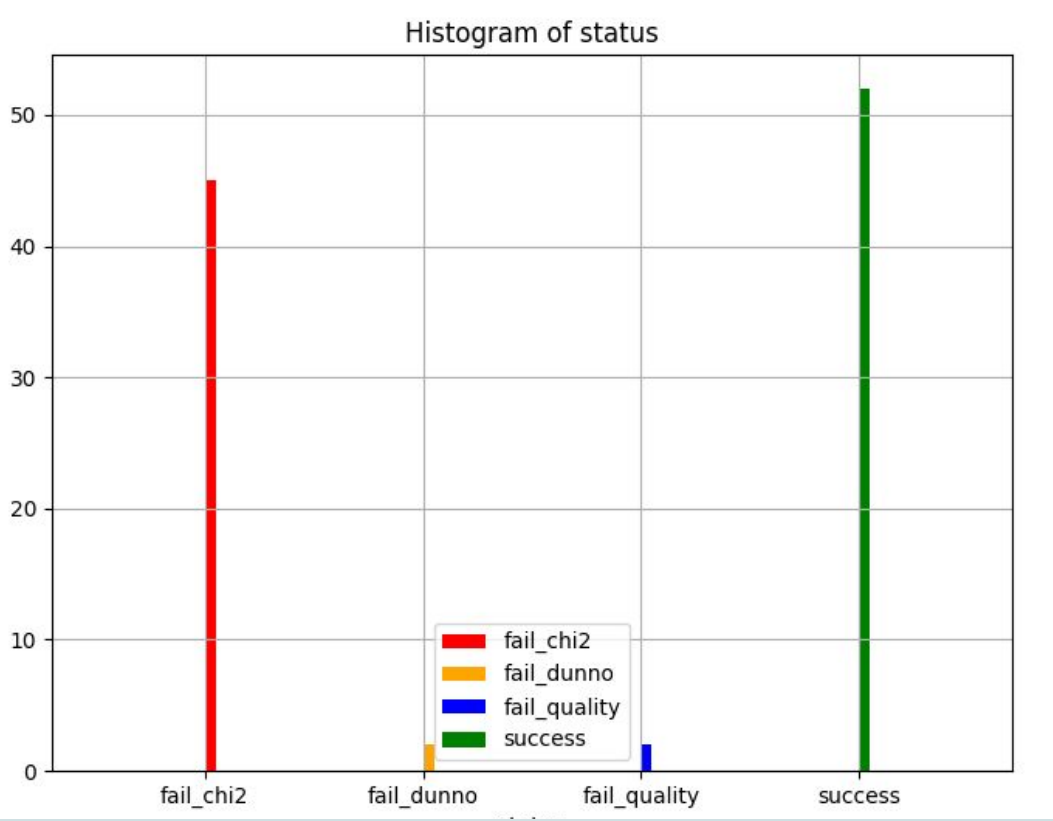
What happens when it fails: different cases

5 **#SFG parameters**



simu B

What happens when it fails: different cases



What happens when it fails: different cases

before hatRecon track quality set to 1

success: 41

fail_chi2: 30

fail_dunno: 2

fail_quality: 27

after hatRecon track quality set to 1 ⇒ ~10% improvement

success: 52 ↗️ +11

fail_chi2: 45 ↗️ +15

fail_dunno: 2

fail_quality: 2 ⬇️ -25

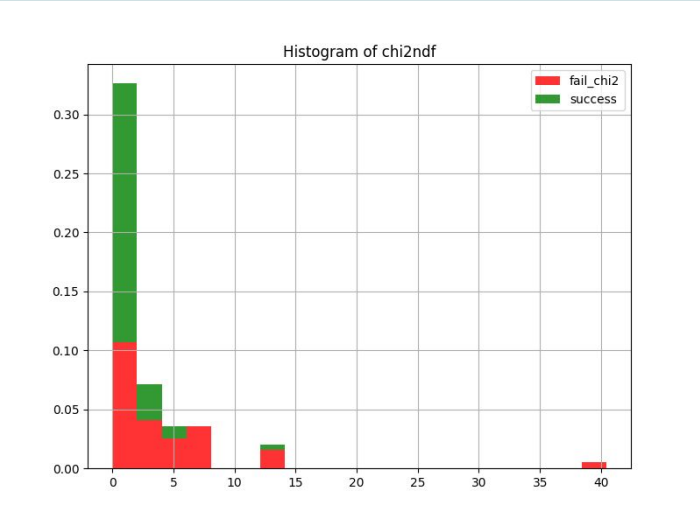
where: CC-in2p3 (Lyon)

simu: **/sps/t2k/anchalum/effGlobal/simu-area/mu-_1000MeV_148_x-50y20z-230s30d0-101n100/**
eventRecon out: **/sps/t2k/anchalum/effGlobal/everecon_mu-_1000MeV_148_x-50y20z-230s30d0-101n100/**

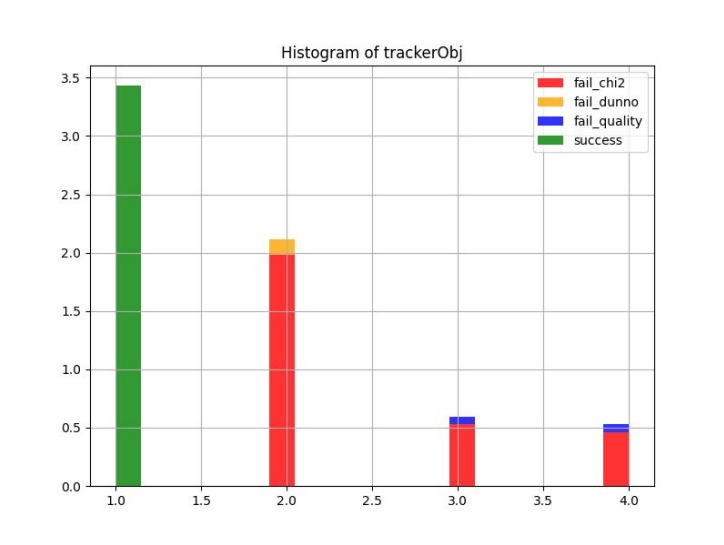
simu B

What happens when it fails: different cases

1 chi2/ndf



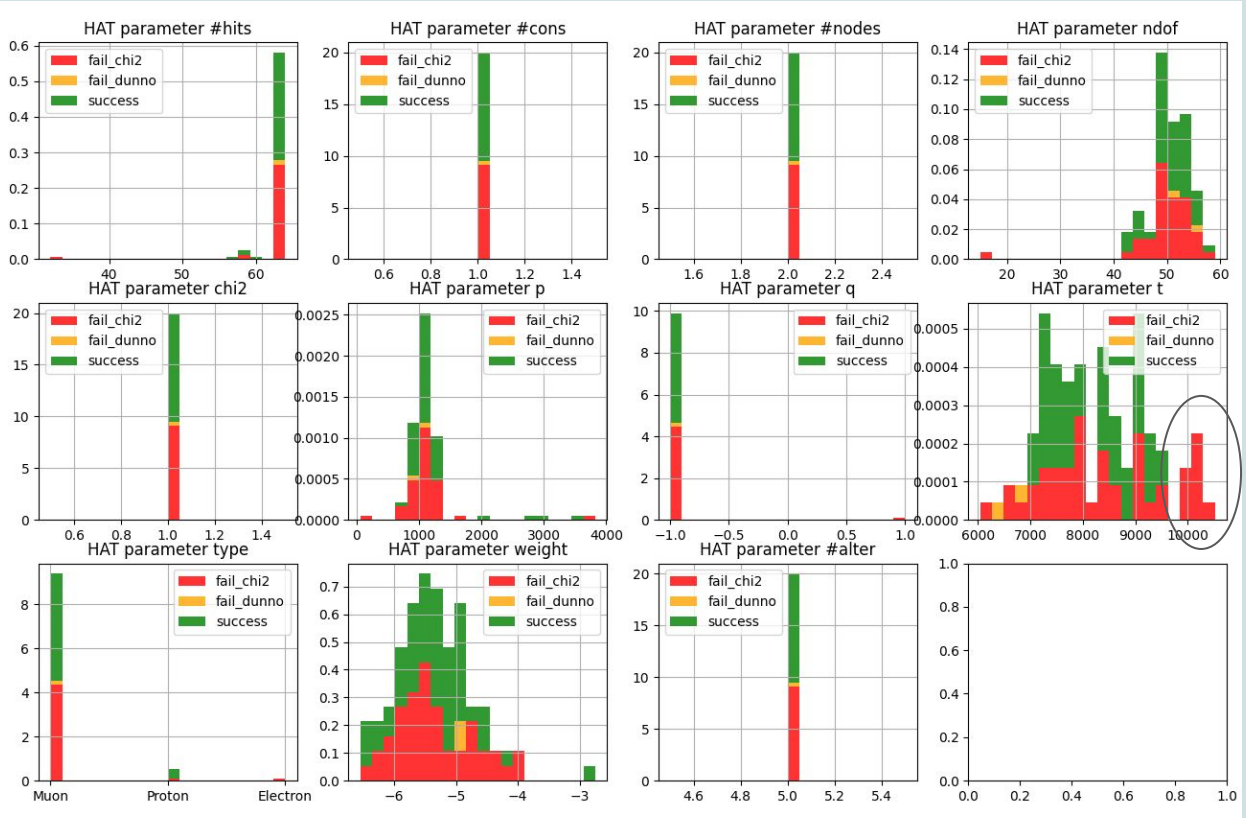
3 # final tracker objects



simu B

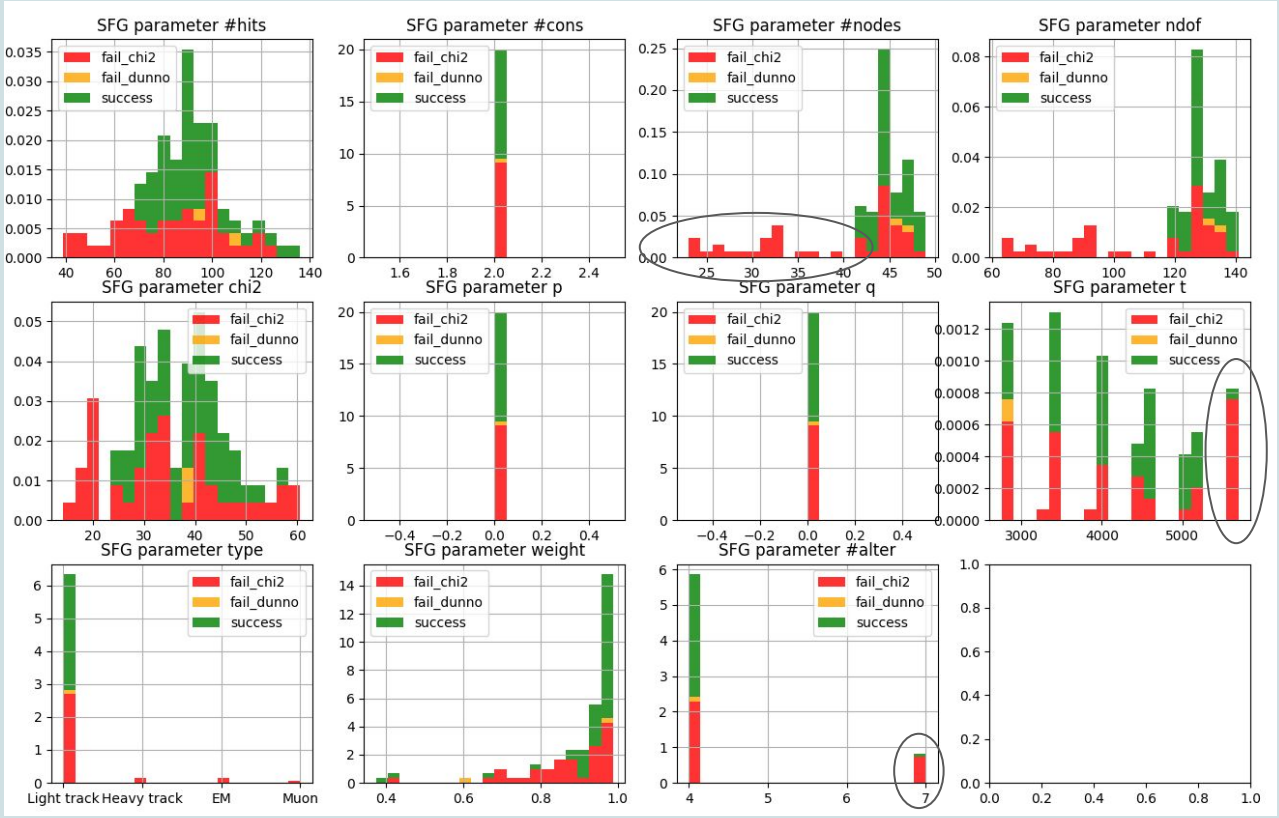
What happens when it fails: different cases

4 **#HAT parameters**



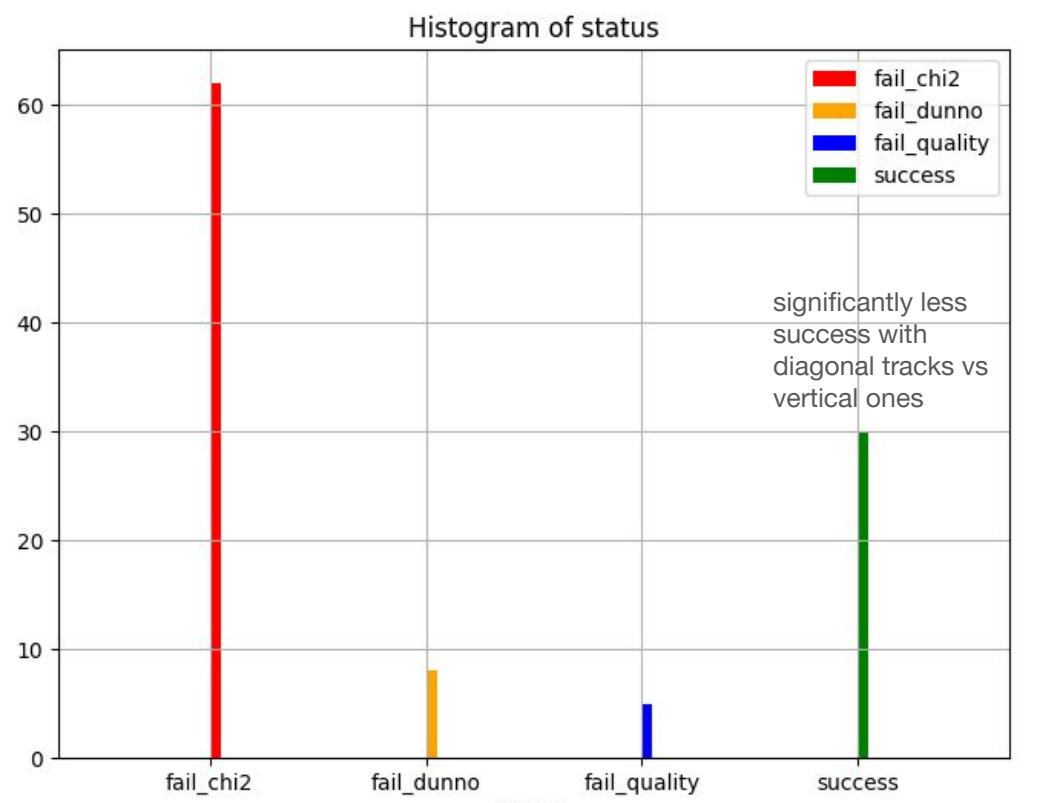
What happens when it fails: different cases

5 #SFG parameters



simu C

What happens when it fails: different cases



What happens when it fails: different cases

before hatRecon track quality set to 1

success#: 15

fail_chi2#: 39

fail_dunno#: 8

fail_quality#: 40

after hatRecon track quality set to 1 => ~15% improvement

success: 30 ↗️ +15

fail_chi2: 62 ↗️ +23

fail_dunno: 8

fail_quality: 5 ⬇️ -35

doesn't exacly add up because of unsolved eventRecon error when re-running it on original simu → a new one with a a ~10cm change in y ini position was used

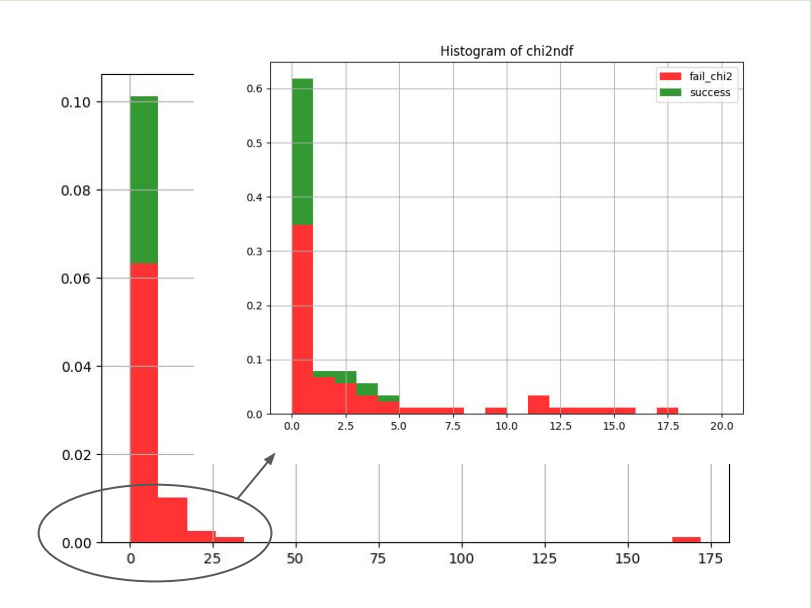
where: CC-in2p3 (Lyon)

simu: **/sps/t2k/anchalum/effGlobal/simu-area/mu-_1000MeV_148_x-50y15z-250s30d0-11n100/**
eventRecon out: **/sps/t2k/anchalum/effGlobal/everecon_mu-_1000MeV_148_x-50y15z-250s30d0-11n100/**

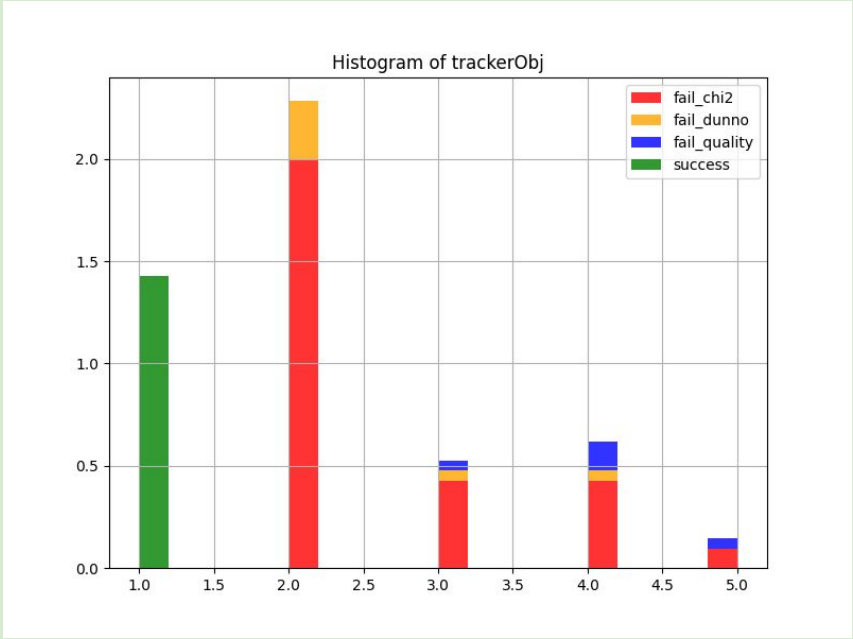
simu C

What happens when it fails: different cases

1 chi2/ndf

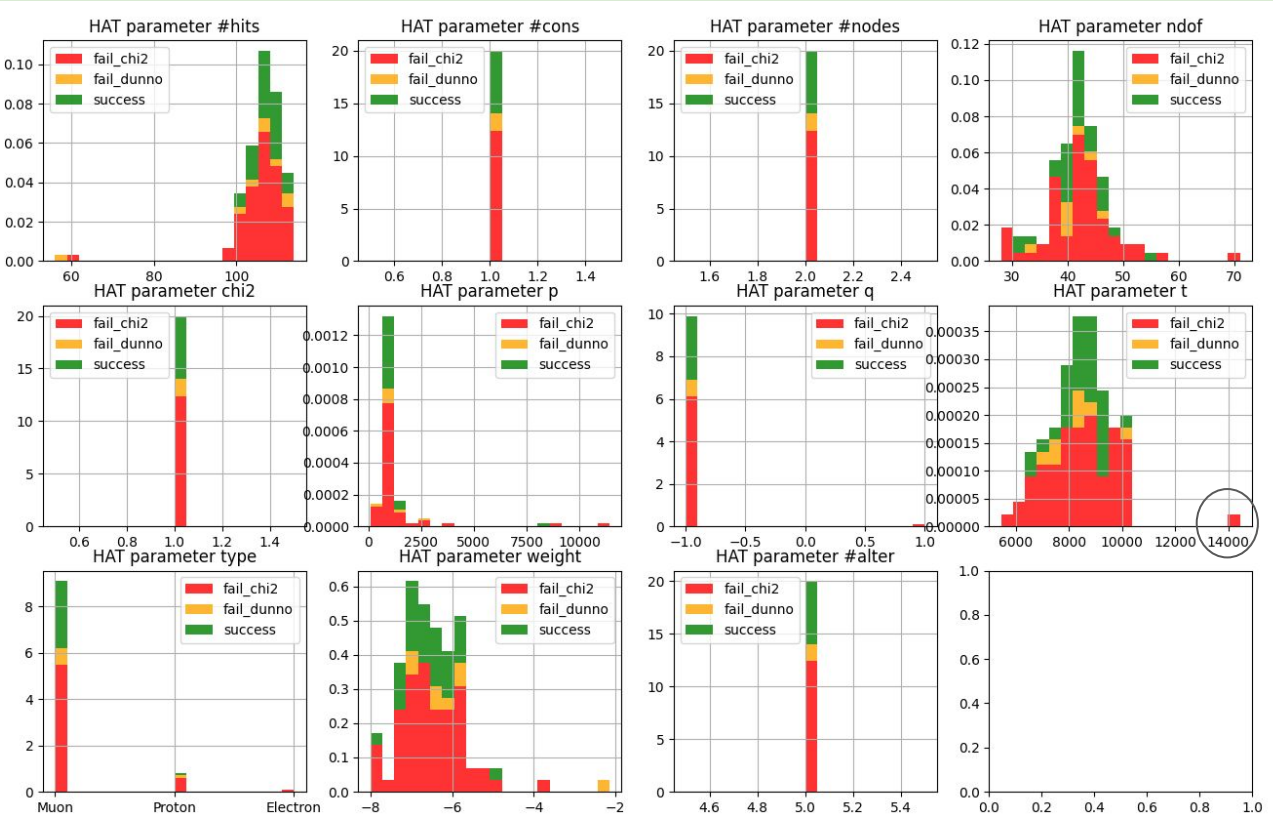


3 # final tracker objects



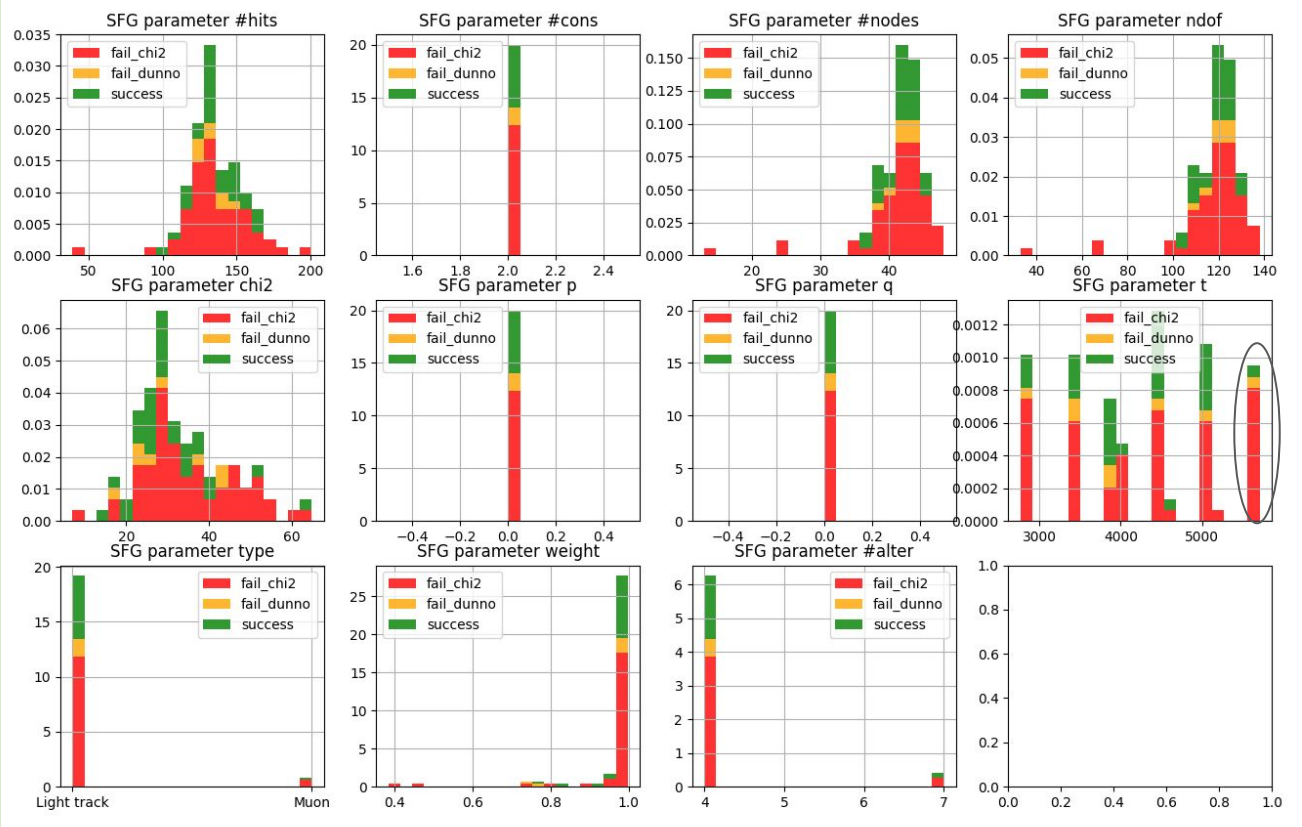
What happens when it fails: different cases

4 **#HAT parameters**



What happens when it fails: different cases

5 **#SFG parameters**



What happens when it fails: different cases

100 particles simulated
86 reco in the bHAT when running hatRecon

success: 37 ['4', '8', '10', '11', '12', '13', '17', '18', '19', '24', '25', '32', '33', '35', '46', '49', '51', '52', '55', '56', '57', '60', '61', '64', '65', '66', '70', '74', '77', '78', '83', '85', '89', '94', '95', '97', '98']

fail_chi2: 28 ['3', '6', '14', '16', '20', '30', '31', '36', '40', '44', '47', '48', '50', '59', '62', '63', '68', '69', '72', '73', '76', '80', '82', '84', '86', '88', '90', '99']

fail_dunno: 6 ['9', '23', '39', '43', '54', '79']

fail_quality: 16 ['1', '2', '7', '15', '21', '26', '28', '37', '42', '58', '67', '84', '87', '88', '91', '96']

notHATReco: 15 ['0', '5', '22', '27', '29', '34', '38', '41', '45', '53', '71', '75', '81', '92', '93']

where: CC-in2p3 (Lyon)

simu: **/sps/t2k/anchalum/effGlobal/simu-area/mu-_100-3000_148_x-50y0z-200s30a20-170n100/**
eventRecon out: **/sps/t2k/anchalum/effGlobal/everecon_mu-_1000MeV_148_x-50y20z-230s30d0-101n100/**

simu A

What happens when it fails: different cases

after hatRecon track quality set to 1 (tmp fix!) ⇒ 8% improvement

in **hatRecon/src/THATTrackFitter.cxx**
branch **anaelle_HATinGlobal**

success: 45 ['2', '4', '7', '8', '10', '11', '12', '13', '15', '17', '18', '19', '24', '25', '26', '32', '33', '35', '46', '49', '51', '55', '56', '57', '58', '60', '61', '64', '65', '66', '67', '70', '74', '77', '78', '79', '83', '85', '89', '91', '94', '95', '96', '97', '98']

fail_chi2: 36 ['3', '6', '14', '16', '20', '23', '28', '30', '31', '36', '37', '39', '40', '42', '43', '44', '47', '48', '50', '54', '59', '62', '63', '68', '69', '72', '73', '76', '80', '82', '84', '86', '87', '88', '90', '99']

fail_dunno: 4 ['1', '9', '21', '52']

fail_quality: 2 ['84', '88']

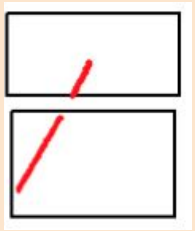
notHATReco: 15 ['0', '5', '22', '27', '29', '34', '38', '41', '45', '53', '71', '75', '81', '92', '93']
-> (tot failures: 57)

simu A

- **success**: 37

['4', '8', '10', '11',
'12', '13', '17',
'18', '19', '24',
'25', '32', '33',
'35', '46', '49',
'51', '52', '55',
'56', '57', '60',
'61', '64', '65',
'66', '70', '74',
'77', '78', '83',
'85', '89', '94',
'95', '97', '98']

e.g. for #56



```
------------------------------------------------------------------------------
--------- Do the matching between all Tracker Objects in this time bin -----------
------------------------------------------------------------------------------
t = 0 - 0
# SFG, FGD1, FGD2 hits = 0, 0, 0
TTrackerRecon:: Matching between SFG and top HAT objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 not empty
TRecPackManager::NewDirDirMatching()
 - (TopHAT) PID  (0x1da383e0): #hits = 88, #cons = 1, #nodes = 2, status = (success:chi2:likelihood), ndof = 38, chi2 = 43168.4, p = 1965.11, q =
 1, t = 8880, PID = Proton, weight = -3.95507, #alter = 5, IsPID = 1
 - (SFG) PID  (0x1d676db0): #hits = 77, #cons = 2, #nodes = 30, status = (success), ndof = 84, chi2 = 34.8715, p = 0, q = 0, t = 5095.49, PID =
 Light track, weight = 0.968329, #alter = 4, IsPID = 1
 RecPackConverters::TReconBase_to_RecObject type=TPC
RecPackConverters::TReconBase_to_RecObject(). TPC object, (0x1da383e0), #nodes = 2
RecPackConverters::TReconBase_to_RecObject(). (TopHAT) PID  (0x1da383e0): #hits = 88, #cons = 1, #nodes = 2, status = (success:chi2:likelihood),
ndof = 38, chi2 = 43168.4, p = 1965.11, q = 1, t = 8880, PID = Proton, weight = -3.95507, #alter = 5
RecPackConverters::TReconBase_to_RecObject(). base pos: (-449.839996, -912.611877, -2771.724121)
RecPackConverters::TReconBase_to_RecObject(). base cov:
  0.000591344            0            0
            0   0.000591344            0
            0            0   0.000591344

 RecPackConverters::TReconBase_to_RecObject vol_name: /t2k_1/OA_0/Magnet_0/Basket_0/BottomHAT_0/Volume_0/VacuumGap_0/Drift_0
 RecPackConverters::TReconBase_to_RecObject meastype: slopes_curv:y
 RecPackConverters::TReconBase_to_RecObject type=TPC
```

4

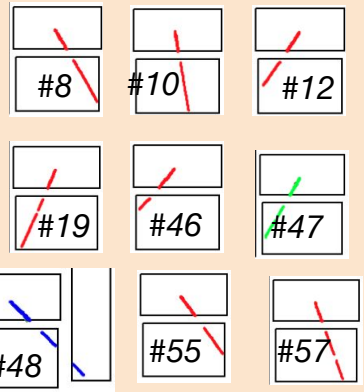
5

(...)

```
RecPackConverters::TReconBase_to_RecObject(). Cluster object, (0x1ebe9f50), Result:
  # nodes =  0
  rep =      xyz
  v =        (-528.905029, -252.425003, -2185.281006)
RecPackConverters::TReconBase_to_RecObject(). Standard object, (0x1d676db0), Result:
  # nodes =  30
  rep =      pos_dir_curv
  v =        (-527.615051, -26.948233, -1989.941040, -0.011255, -0.771869, -0.635682, 0.000100)
  TRecPackMatchingSurfaceMaker::get_surface(). (for meas) u = (-0.009354, 0.735875, 0.677053), pos = (-528.905029, -26.485001, -1990.151001)
   --> i_max, i_min = 1, 0 u[i_max], u_max = 0.735875, 0.735875
  TRecPackMatchingSurfaceMaker::get_surface(). Measurement in SFG
meas.name(): xyz
meas.name(RP::setup_volume).find('SFG'): 30
meas.name().find('slopes'): 18446744073709551615
vs std::string::npos: 18446744073709551615
  TRecPackMatchingSurfaceMaker::get_surface().u_max>fMinAngleForFgdSurfaceChange

SFG end TRecPackMatchingSurfaceMaker::get_surface(). surf =
---------- Surface (begin) -----------

  name: plane
  names:
   shape = ring

   R1 = 1e+12
   R2 = 0

(-528.905029, -26.485001, -1990.151001)
(8.789409, 8.789409, 8.789409)
(0.000000, 1.000000, 0.000000)
---------- Surface (end) -----------
 axis = (0.000000, 1.000000, 0.000000) u = (-0.009354, 0.735875, 0.677053), um = 0.001000, type = xyz
```

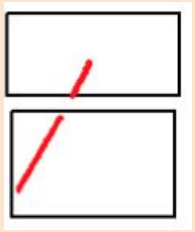
(...)

other examples



simu A

- **success**: 37
['4', '8', '10', '11',
'12', '13', '17',
'18', '19', '24',
'25', '32', '33',
'35', '46', '49',
'51', '52', '55',
'56', '57', '60',
'61', '64', '65',
'66', '70', '74',
'77', '78', '83',
'85', '89', '94',
'95', '97', '98']
e.g. for #56



(...)

```
---------- State (end) ----------

    propagated parameter = -0
    propagated vector = (-529.313599, -254.217743, -2182.701660, -0.002569, 0.770717, 0.637173, -0.000100)
    propagated matrix = (4.283148, 0.000000, 8.033130, 0.002227, 0.004172, 0.002416, 1844.674297)
      --> chi2/ndf: 0.791944, res = (71.208725, -0.000004, 0.181106, -0.009068, 0.043768)
BZH chi2/ndf: 0.791944

# matches: 1
 - (SFG)-(TopHAT) (0x1d676db0-0x1da383e0) match: chi2/ndf = 0.791944

TMergingUtils::MergeAndFitObjects(). PID merging and fitting.sfgObjects
TMergingUtils::GetBestObject(). number of hits
    1. TPC/HAT ,OTHER =0, 77
    2. TPC/HAT ,OTHER =88, 0
    1. Satisfies TPC hits&cov check1
    2. Satisfies TPC hits&cov check1
  RecPackConverters::TReconBase_to_RecObject type=TPC
```

1

usually < 1 or 2
but some are more: 2
(#48), 2.9 (#85), 23 (#97)

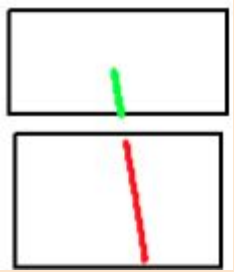
(...)

```
---------- State (end) ----------

    propagated parameter = 11.3744
    propagated vector = (-532.080459, -26.485001, -1992.079855, -0.014786, 0.772607, 0.634712, 0.001110)
    propagated matrix = (0.967496, 0.000000, 2.327143, 0.000091, 0.000065, 0.000096, 0.000000)
----> Fit OK:  (SFG-TopHAT) PID  (0x1f680e80): #hits = 161, #cons = 2, #nodes = 29, status = (success:kalman), ndof = 57, chi2 = 94.5988, p = 1.
58317, q = 1, t = 8880, PID = Electron, weight = 2.36522e-310, #alter = 0
TTrackerRecon:: Matching between SFG and bottom HAT objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empt
TTrackerRecon:: Matching between SFG and TPC1 objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empty
TTrackerRecon:: Matching between TPC1-FGD1 and TPC1-FGD1 objects
TTrackerRecon:: Matching between TPC2-FGD1-FGD2 and TPC2-FGD1-FGD2 objects
TTrackerRecon:: Matching between TPC3-FGD2 and TPC3-FGD2 objects
TTrackerRecon:: Matching between TPC1-FGD1 and TPC2-FGD1 objects
TTrackerRecon:: Matching between TPC1/TPC2-FGD1 and TPC3-FGD2 objects
TrackerRecon:: TPC-FGD Object matching results:
  - Tracker Objects:     1

--------------------------------------------------------------------------------
--------- Get the sense of the object based on time diff between FGD1 and FGD2 ---
--------------------------------------------------------------------------------
```

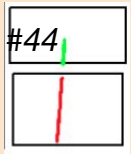
3

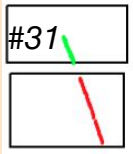
simu A

fail_chi2: 28
['3', '6', '14', '16', '20',
'30', '31', '36', '40', '44',
'47', '48', '50', '59', '62',
'63', '68', '69', '72', '73',
'76', '80', '82', '84', '86',
'88', '90', '99']
e.g. for #40



other examples






```
--------------------------------------------------------------------------------
--------- Do the matching between all Tracker Objects in this time bin ---------
--------------------------------------------------------------------------------
t = 0 - 0
# SFG, FGD1, FGD2 hits = 0, 0, 0
TrackerRecon:: Matching between SFG and top HAT objects
TrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TrackerConnector::MergeTpcSfgObjects objectContainer2 not empty
TRecPackManager::NewDirDirMatching()
  - (TopHAT) PID  (0x1e090080): #hits = 64, #cons = 1, #nodes = 2, status = (success:chi2:likelihood), ndof = 55, chi2 = 4254.99, p = 3549.62, q =
  -1, t = 9680, PID = Proton, weight = -2.74982, #alter = 5, IsPID = 1
  - (SFG) PID  (0x1cb84c90): #hits = 54, #cons = 2, #nodes = 24, status = (success), ndof = 66, chi2 = 28.7169, p = 0, q = 0, t = 5691.82, PID =
 Light track, weight = 0.855813, #alter = 4, IsPID = 1
 RecPackConverters::TReconBase_to_RecObject type=TPC
RecPackConverters::TReconBase_to_RecObject(). TPC object, (0x1e090080), #nodes = 2
RecPackConverters::TReconBase_to_RecObject(). (TopHAT) PID  (0x1e090080): #hits = 64, #cons = 1, #nodes = 2, status = (success:chi2:likelihood),
ndof = 55, chi2 = 4254.99, p = 3549.62, q = -1, t = 9680, PID = Proton, weight = -2.74982, #alter = 5
RecPackConverters::TReconBase_to_RecObject(). base pos: (-388.239990, -1043.919067, -1723.066650)
RecPackConverters::TReconBase_to_RecObject(). base cov:
   0.00307648            0            0
            0   0.00307648            0
            0            0   0.00307648

 RecPackConverters::TReconBase_to_RecObject vol_name: /t2k_1/OA_0/Magnet_0/Basket_0/BottomHAT_0/Volume_0/VacuumGap_0/Drift_0
 RecPackConverters::TReconBase_to_RecObject meastype: slopes_curv:y
 RecPackConverters::TReconBase_to_RecObject type=TPC
```

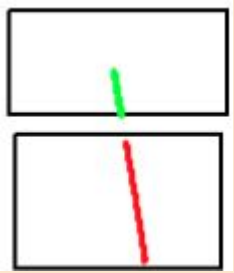
(...)

```
RecPackConverters::TReconBase_to_RecObject(). Cluster object, (0x1bf2ec40), Result:
  # nodes =  0
  rep =      xyz
  v =        (-518.896851, -247.383316, -1933.572632)
RecPackConverters::TReconBase_to_RecObject(). Standard object, (0x1cb84c90), Result:
  # nodes =  24
  rep =      pos_dir_curv
  v =        (-530.584900, -16.415239, -1990.026123, 0.039089, -0.968457, 0.246096, 0.000100)
  TRecPackMatchingSurfaceMaker::get_surface(). (for meas) u = (0.009563, 0.970271, -0.241833), pos = (-528.905029, -16.215000, -1990.151001)
    --> i_max, i_min = 1, 0 u[i_max], u_max = 0.970271, 0.970271
  TRecPackMatchingSurfaceMaker::get_surface(). Measurement in SFG
meas.name(): xyz
meas.name(RP::setup_volume).find('SFG'): 30
meas.name().find('slopes'): 18446744073709551615
vs std::string::npos: 18446744073709551615
  TRecPackMatchingSurfaceMaker::get_surface().u_max>fMinAngleForFgdSurfaceChange

SFG end TRecPackMatchingSurfaceMaker::get_surface(). surf =
---------- Surface (begin) ----------

  name: plane
  names:
   shape = ring

   R1 = 1e+12
   R2 = 0

(-528.905029, -16.215000, -1990.151001)
(8.789409, 8.789409, 8.789409)
(0.000000, 1.000000, 0.000000)
---------- Surface (end) ----------
```

(...)

simu A

fail_chi2: 28
['3', '6', '14', '16', '20',
'30', '31', '36', '40', '44',
'47', '48', '50', '59', '62',
'63', '68', '69', '72', '73',
'76', '80', '82', '84', '86',
'88', '90', '99']
e.g. for #40



(...)

```
---------- State (end) ----------
    propagated parameter = -0
    propagated vector = (-520.033752, -245.571518, -1928.904785, 0.001731, 0.965409, -0.260735, -0.000100)
    propagated matrix = (5.270027, 0.000000, 3.342878, 0.025312, 0.001345, 0.004813, 1844.674297)
      --> chi2/ndf: 5.28826, res = (139.648423, -0.000001, 12.852361, 0.008029, 0.035798)
BZH chi2/ndf: 5.28826

# matches: 1
  - (SFG)-(TopHAT) (0x1cb84c90-0x1e090080) match: chi2/ndf = 5.28826

TMergingUtils::MergeAndFitObjects(). PID merging and fitting.sfgObjects
TTrackerRecon:: Matching between SFG and bottom HAT objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empty
TTrackerRecon:: Matching between SFG and TPC1 objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empty
TTrackerRecon:: Matching between TPC1-FGD1 and TPC1-FGD1 objects
TTrackerRecon:: Matching between TPC2-FGD1-FGD2 and TPC2-FGD1-FGD2 objects
TTrackerRecon:: Matching between TPC3-FGD2 and TPC3-FGD2 objects
TTrackerRecon:: Matching between TPC1-FGD1 and TPC2-FGD1 objects
TTrackerRecon:: Matching between TPC1/TPC2-FGD1 and TPC3-FGD2 objects
TrackerRecon:: TPC-FGD Object matching results:
  - Tracker Objects:     2

--------------------------------------------------------------------------------
---------- Get the sense of the object based on time diff between FGD1 and FGD2 ---
--------------------------------------------------------------------------------
```

usually > 2 or 3
but some are less: 0.6
(#30), 2.3 (#83)

nothing more here!

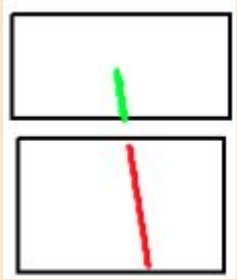
to investigate

=> failure case1 because of chi2/ndf to large?
- should we try manually decreasing it?
- why some have decent chi2 but still TMergingUtils doesn't execute? ->more prints

simu A

fail_dunno: 6
['9', '23', '39', '43', '54', '79']

e.g. for #23



other examples

```
------------------------------------------------------------------------------
--------- Do the matching between all Tracker Objects in this time bin ---------
------------------------------------------------------------------------------
t = 0 - 0
# SFG, FGD1, FGD2 hits = 0, 0, 0
TTrackerRecon:: Matching between SFG and top HAT objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 not empty
TRecPackManager::NewDirDirMatching()
  - (TopHAT) PID  (0x1db958c0): #hits = 64, #cons = 1, #nodes = 2, status = (success:chi2:likelihood), ndof = 59, chi2 = 5547.39, p = 1685.33, q =
  -1, t = 9360, PID = Muon, weight = -5.54695, #alter = 5, IsPID = 1
  - (SFG) PID  (0x1aedf270): #hits = 67, #cons = 2, #nodes = 27, status = (success), ndof = 75, chi2 = 21.2093, p = 0, q = 0, t = 5683.48, PID =
  Light track, weight = 0.890683, #alter = 4, IsPID = 1
 RecPackConverters::TReconBase_to_RecObject type=TPC
RecPackConverters::TReconBase_to_RecObject(). TPC object, (0x1db958c0), #nodes = 2
RecPackConverters::TReconBase_to_RecObject(). (TopHAT) PID  (0x1db958c0): #hits = 64, #cons = 1, #nodes = 2, status = (success:chi2:likelihood),
ndof = 59, chi2 = 5547.39, p = 1685.33, q = -1, t = 9360, PID = Muon, weight = -5.54695, #alter = 5
RecPackConverters::TReconBase_to_RecObject(). base pos: (-412.880005, -1064.380249, -1720.578491)
RecPackConverters::TReconBase_to_RecObject(). base cov:
    0.0127868            0            0
            0    0.0127868            0
            0            0    0.0127868

 RecPackConverters::TReconBase_to_RecObject vol_name: /t2k_1/OA_0/Magnet_0/Basket_0/BottomHAT_0/Volume_0/VacuumGap_0/Drift_0
 RecPackConverters::TReconBase_to_RecObject meastype: slopes_curv:y
 RecPackConverters::TReconBase_to_RecObject type=TPC
```

(...)

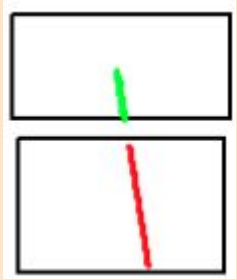
```
RecPackConverters::TReconBase_to_RecObject(). Cluster object, (0x1ca66250), Result:
  # nodes =  0
  rep =      xyz
  v =        (-528.905029, -252.425003, -1928.531006)
RecPackConverters::TReconBase_to_RecObject(). Standard object, (0x1aedf270), Result:
  # nodes =  27
  rep =      pos_dir_curv
  v =        (-528.271790, 13.683421, -1993.182739, -0.004102, -0.967192, 0.254013, 0.000100)
  TRecPackMatchingSurfaceMaker::get_surface(). (for meas) u = (-0.009283, 0.973613, -0.228018), pos = (-528.905029, 14.595000, -1990.151001)
    --> i_max, i_min = 1, 0 u[i_max], u_max = 0.973613, 0.973613
  TRecPackMatchingSurfaceMaker::get_surface(). Measurement in SFG
meas.name(): xyz
meas.name(RP::setup_volume).find('SFG'): 30
meas.name().find('slopes'): 18446744073709551615
vs std::string::npos: 18446744073709551615
  TRecPackMatchingSurfaceMaker::get_surface().u_max>fMinAngleForFgdSurfaceChange

SFG end TRecPackMatchingSurfaceMaker::get_surface(). surf =
---------- Surface (begin) ----------

  name: plane
  names:
   shape = ring

   R1 = 1e+12
   R2 = 0

(-528.905029, 14.595000, -1990.151001)
(8.789409, 8.789409, 8.789409)
(0.000000, 1.000000, 0.000000)
---------- Surface (end) ----------
 axis = (0.000000, 1.000000, 0.000000) u = (-0.009283, 0.973613, -0.228018), um = 0.001000, type = xyz
```

(...)

simu A

fail_dunno: 6
['9', '23', '39', '43', '54', '79']

e.g. for #23



(...)

```
---------- State (end) ----------

    propagated parameter = -0
    propagated vector = (-529.050903, -251.395218, -1925.110107, 0.003424, 0.970582, -0.240747, -0.000100)
    propagated matrix = (3.376234, 0.000000, 4.708718, 0.000722, 0.000296, 0.001835, 1844.674297)
TTrackerRecon:: Matching between SFG and bottom HAT objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empty
TTrackerRecon:: Matching between SFG and TPC1 objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empty
TTrackerRecon:: Matching between TPC1-FGD1 and TPC1-FGD1 objects
TTrackerRecon:: Matching between TPC2-FGD1-FGD2 and TPC2-FGD1-FGD2 objects
TTrackerRecon:: Matching between TPC3-FGD2 and TPC3-FGD2 objects
TTrackerRecon:: Matching between TPC1-FGD1 and TPC2-FGD1 objects
TTrackerRecon:: Matching between TPC1/TPC2-FGD1 and TPC3-FGD2 objects
TrackerRecon:: TPC-FGD Object matching results:
  - Tracker Objects:     2
(...)
--------------------------------------------------------------------------------
--------- Get the sense of the object based on time diff between FGD1 and FGD2 ---
--------------------------------------------------------------------------------
```

no chi2/ndf printed!

no TMergingUtils::MergeAndFitObjects(). called

to investigate

=> failure case2 because of ??

- need more prints

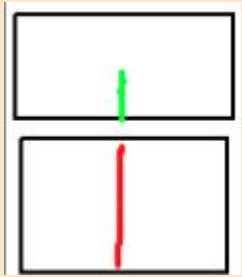
simu A

fail_quality: 16 ['1', '2', '7', '15', '21', '26', '28', '37', '42', '58', '67', '84', '87', '88', '91', '96']

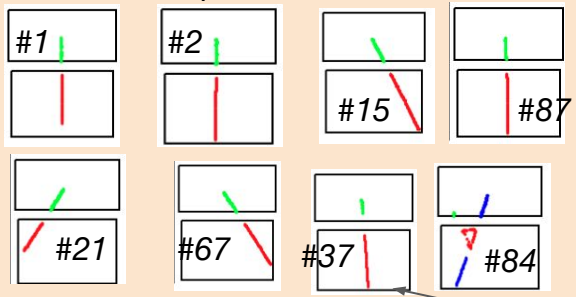
```
------------------------------------------------------------------------------
--------- Do the matching between all Tracker Objects in this time bin -------
------------------------------------------------------------------------------
t = 0 - 0
# SFG, FGD1, FGD2 hits = 0, 0, 0
TTrackerRecon:: Matching between SFG and top HAT objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 not empty
 ==>> Quality is not enough for matching !
TTrackerRecon:: Matching between SFG and bottom HAT objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empty
TTrackerRecon:: Matching between SFG and TPC1 objects
TTrackerConnector::MergeTpcSfgObjects objectContainer1 not empty
TTrackerConnector::MergeTpcSfgObjects objectContainer2 empty
TTrackerRecon:: Matching between TPC1-FGD1 and TPC1-FGD1 objects
TTrackerRecon:: Matching between TPC2-FGD1-FGD2 and TPC2-FGD1-FGD2 objects
TTrackerRecon:: Matching between TPC3-FGD2 and TPC3-FGD2 objects
TTrackerRecon:: Matching between TPC1-FGD1 and TPC2-FGD1 objects
TTrackerRecon:: Matching between TPC1/TPC2-FGD1 and TPC3-FGD2 objects
TrackerRecon:: TPC-FGD Object matching results:
  - Tracker Objects:     2

------------------------------------------------------------------------------
--------- Get the sense of the object based on time diff between FGD1 and FGD2 ---
------------------------------------------------------------------------------
```

2

e.g. for #7



other examples



those by eye ok, but the other not obvious…

to investigate

=> failure case3 because of track quality:

- but generally not obvious by eye, a lot should definitely get matched
- quality criteria? ->more prints

What happens when it fails: different cases

before hatRecon track quality set to 1

success: 41 ['2', '3', '5', '6', '8', '13', '19', '21', '22', '23', '25', '28', '29', '32', '37', '38', '39', '41', '43', '47', '49', '51', '52', '53', '54', '56', '57', '59', '60', '65', '71', '81', '83', '84', '85', '86', '92', '93', '95', '96', '99']

fail_chi2: 30 ['0', '1', '4', '7', '9', '11', '17', '18', '20', '26', '30', '31', '33', '34', '36', '45', '48', '50', '58', '64', '67', '68', '70', '72', '73', '74', '79', '82', '91', '98']

fail_dunno: 2 ['46', '89']

fail_quality: 27 ['10', '12', '14', '15', '16', '24', '27', '35', '40', '42', '44', '55', '61', '62', '63', '66', '69', '75', '76', '77', '78', '80', '87', '88', '90', '94', '97']

where: CC-in2p3 (Lyon)

simu: **/sps/t2k/anchalum/effGlobal/simu-area/mu-_1000MeV_148_x-50y20z-230s30d0-101n100/**
eventRecon out: **/sps/t2k/anchalum/effGlobal/everecon_mu-_1000MeV_148_x-50y20z-230s30d0-101n100/**

What happens when it fails: different cases

after hatRecon track quality set to 1 ⇒ 10% improvement

success: 52 ['2', '3', '5', '6', '10', '12', '13', '14', '16', '19', '21', '22', '24', '25', '27', '28', '29', '32', '37', '38', '39', '41', '43', '44', '47', '49', '51', '52', '53', '54', '56', '57', '59', '60', '65', '71', '75', '77', '81', '83', '84', '85', '86', '87', '88', '89', '90', '93', '94', '95', '96', '99']

fail_chi2: 45 ['0', '1', '4', '7', '8', '9', '11', '15', '17', '18', '20', '23', '26', '30', '31', '33', '34', '36', '40', '42', '45', '48', '50', '55', '58', '61', '62', '63', '64', '66', '67', '68', '69', '70', '72', '73', '74', '76', '78', '79', '80', '82', '91', '92', '98']

fail_dunno: 2 ['46', '97']

fail_quality: 2 ['35', '62']

What happens when it fails: different cases

after hatRecon track quality set to 1

success: 30 ['5', '7', '9', '19', '21', '28', '31', '32', '37', '39', '43', '44', '49', '51', '52', '55', '58', '62', '70', '71', '72', '74', '75', '78', '83', '84', '85', '88', '91', '93']

fail_chi2: 62 ['0', '1', '2', '3', '6', '11', '12', '13', '16', '17', '18', '20', '22', '23', '24', '25', '26', '27', '29', '30', '33', '34', '35', '36', '38', '40', '41', '42', '45', '46', '47', '48', '50', '53', '54', '56', '57', '59', '60', '61', '63', '65', '66', '67', '68', '69', '73', '76', '77', '79', '80', '82', '86', '87', '89', '90', '92', '94', '96', '97', '98', '99']

fail_dunno: 8 ['4', '8', '10', '14', '15', '64', '81', '95']

fail_quality: 5['23', '50', '64', '89', '92']

where: CC-in2p3 (Lyon)

simu: **/sps/t2k/anchalum/effGlobal/simu-area/mu-_1000MeV_148_x-50y15z-250s30d0-11n100/**
eventRecon out: **/sps/t2k/anchalum/effGlobal/everecon_mu-_1000MeV_148_x-50y15z-250s30d0-11n100/**