$B^0 \to K^*\mu^-\mu^+$ MC Filter

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$B^0 \to K^*\mu^-\mu^+$ meeting, CERN
October 9, 2016

A glimpse in the Run1 analysis

$\Rightarrow$ In the Run1 we have asked for a filtered MC to correct for detector acceptance.

$\Rightarrow$ Asked for $5.5M$ events (after stripping in DST), which means we generated around $110M$ events.

$\Rightarrow$ After our full selection we ended up with with only $1.4M$ events.

Warning!

The stripping line has a PID cut inside: $\mathrm{PID}_\mu > -3$.
This essentially means we model that efficiency from MC.

Run2 options

1. Repeat what we did in Run1 and keep the PID cuts.
2. Filter on stripping removing the PID cut.
3. Filter on MC truth:
   - 4 charge tracks on $\mathrm{StdAllNoPiDPions/Kaons/Muons}$
   - And truth matched the decay channel:
     $\mathrm{mcMatch('[B0 => K*(892)0mu+mu-]CC')}$

Why MCTruth?

$\Rightarrow$ We are using a very old stripping line that for sure can be (and should be) optimized for the final analysis of Run2!

$\Rightarrow$ Producing an MCTRUTH match sample would allow the sample to be reused for future analysis even if the stripping line will change!

Retentions

⇛ To study the solution I have used 2012 Physics MC.

⇛ I have taken 17.250 simulated events.

⇛ Here is the results:

Type	Filter retention	Events in the ntuple	Truth Matched
Strip	3447 (20 %)	4975	1648
Strip no PID$_\mu$	3504 (20.3 %)	5176	1660
MCTruth	5009 (29 %)	4456	1660

⇛ Now I have cross check this running the same algorithms on stripped and non stripped MC always getting the same numbers.

⇛ For speed purpose I have put a cut on the $m_{K^*} < 1300$ MeV (can be adjusted if needed).

⇛ Other option to consider is to remove `ISMUON` form stripping to get all efficiencies from `PIDCalib`.

Plans

$\Rightarrow$ With Tom we feel that it would be best to ask for $200M$ generated events.

$\Rightarrow$ Also we noticed that we have $50M$ events of some old MC10 (Stripping 12) MC, which we propose to delete.

$\Rightarrow$ For PPG: The $R(D^*)$ have already got green light for more then $1000M$ generated events, so we getting the $200M$ should not be a problem.

$\Rightarrow$ To discuss: Do we want a flat $m(K\pi)$ sample or we can keep the K^*?

Plans 2

⇛ Besides the normal $B \to K^* \mu\mu$ PHSP we should ask for other MC channels.

⇛ I proposed to scale the old numbers by factor: $\frac{5}{3}$.

Decay	DecFile event type	N. of events	N. of events Run2
$B \to K^* J/\psi$ (physics)	11144001	2M	3.5M
$B \to K^* J/\psi$ (PHSP?)	xxxxxxxx	0	3.5M
$B \to K^* \mu\mu$ (physics)	11114001	1M	1.5M
$\Lambda_b \to \Lambda(1530)\mu\mu$	15114000	1M	1.5M
$\Lambda_b \to pK\mu\mu$	15114011	2M	3.5M
$B_s^0 \to \phi\mu\mu$	13114002	0.6M	1M
$B_u \to K\mu\mu$	12113001	1M	1.5M

⇛ This would be unfiltered production and this MC will be needed for other analysis as well.

⇛ Do we want to simulate a flat q^2 in the $B \to K^* \mu\mu$?

⇛ Do we want to have a flat $K\pi$ mass distribution in the simulation?

MC model

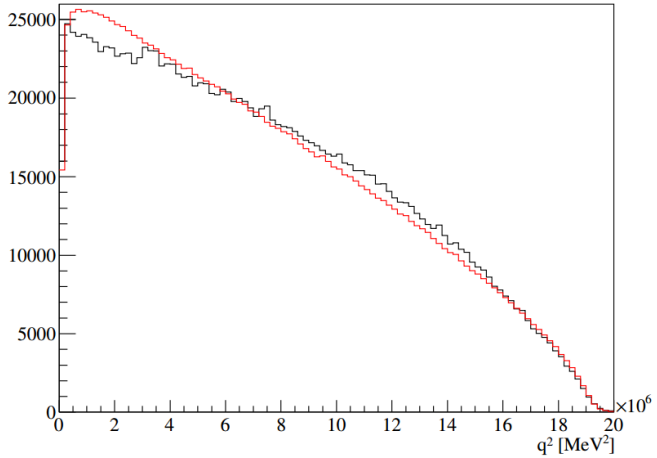
Acceptance correction

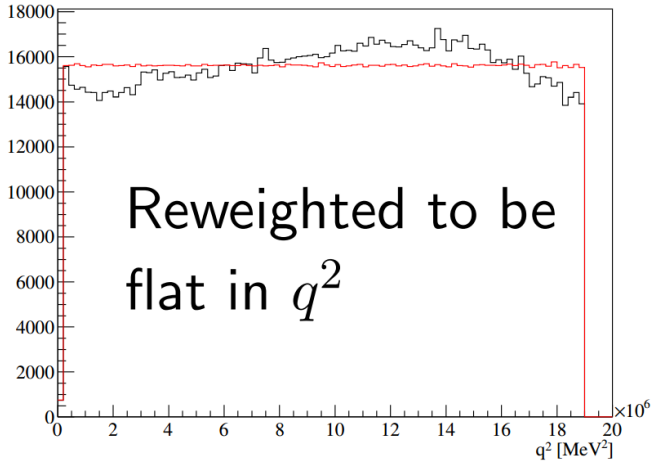
⇛ The decay of $B^0 \to K^* \mu^- \mu^+$ is described by 3 helicity angles and the invariant mass squared of two leptons (q^2).

⇛ In order to model the detector acceptance we have used a large MC sample of PHSP simulated events.

⇛ There is a caveat: the q^2 distribution.

⇛ We had to reweight it to make it flat.





Can we optimize it?

⇛ It would be nice if we could generate not only the flat angle distributions but also a flat q^2.

⇛ There exists already a model for it: `FLATQ2`.

⇛ It basically reweighs the distribution by $1/p_T^{\mathrm{had}}$.

⇛ The problem is that it was design to generate the flat distribution of decays $B \to X\ell\nu$:

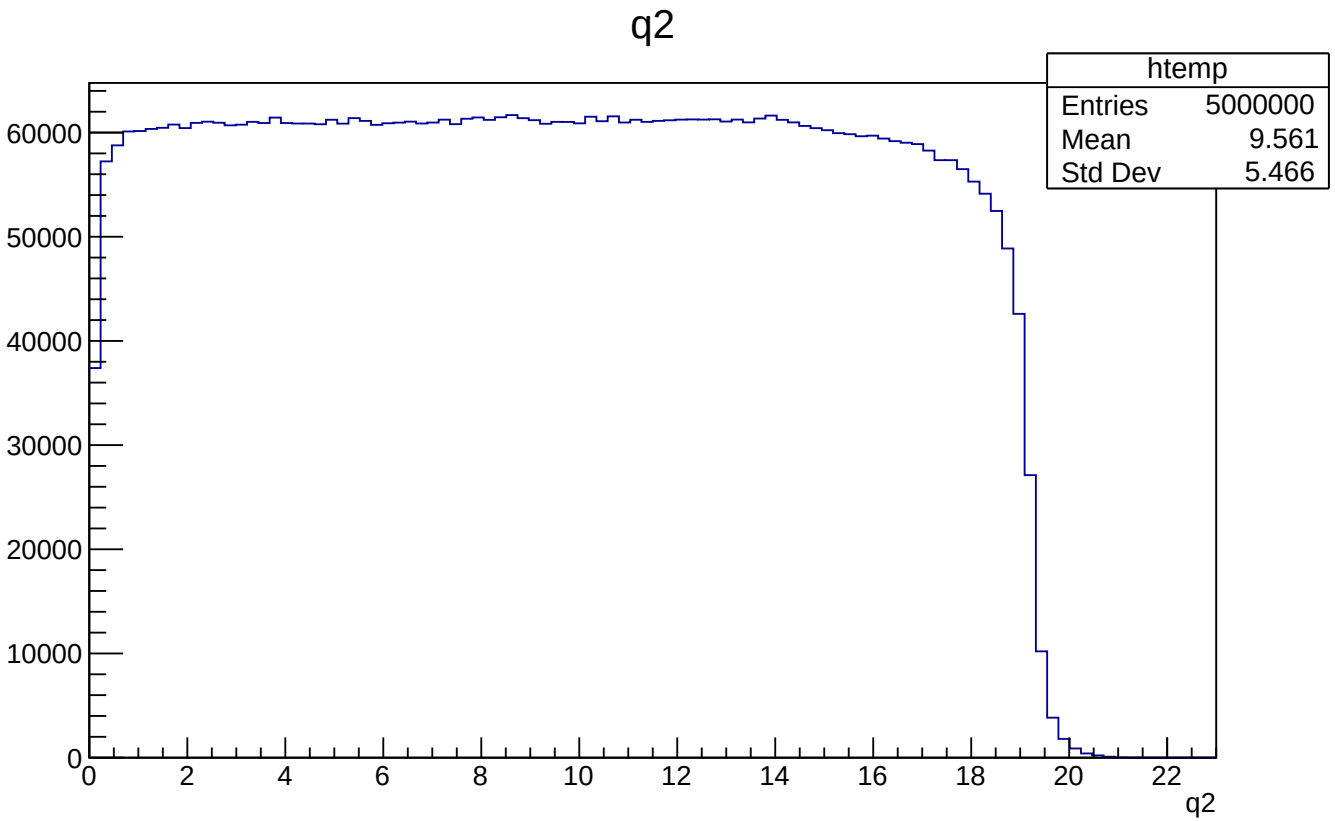
```
void EvtFlatQ2::init(){

  // check that there are 0 arguments
  checkNArg(0);
  checkNDaug(3);

  //We expect B->X l nu events
  checkSpinParent(EvtSpinType::SCALAR);
  checkSpinDaughter(1,EvtSpinType::DIRAC);
  checkSpinDaughter(2,EvtSpinType::NEUTRINO);

}
```

⇛ Will not work in current version for $B \to K^*\mu\mu$.

Modifying the FLATQ2 1

⇛ I wrote a mirror model that requires that the two leptons are DIRAC, and called it FLATQ2EWP.

⇛ And improves the situation a lot:

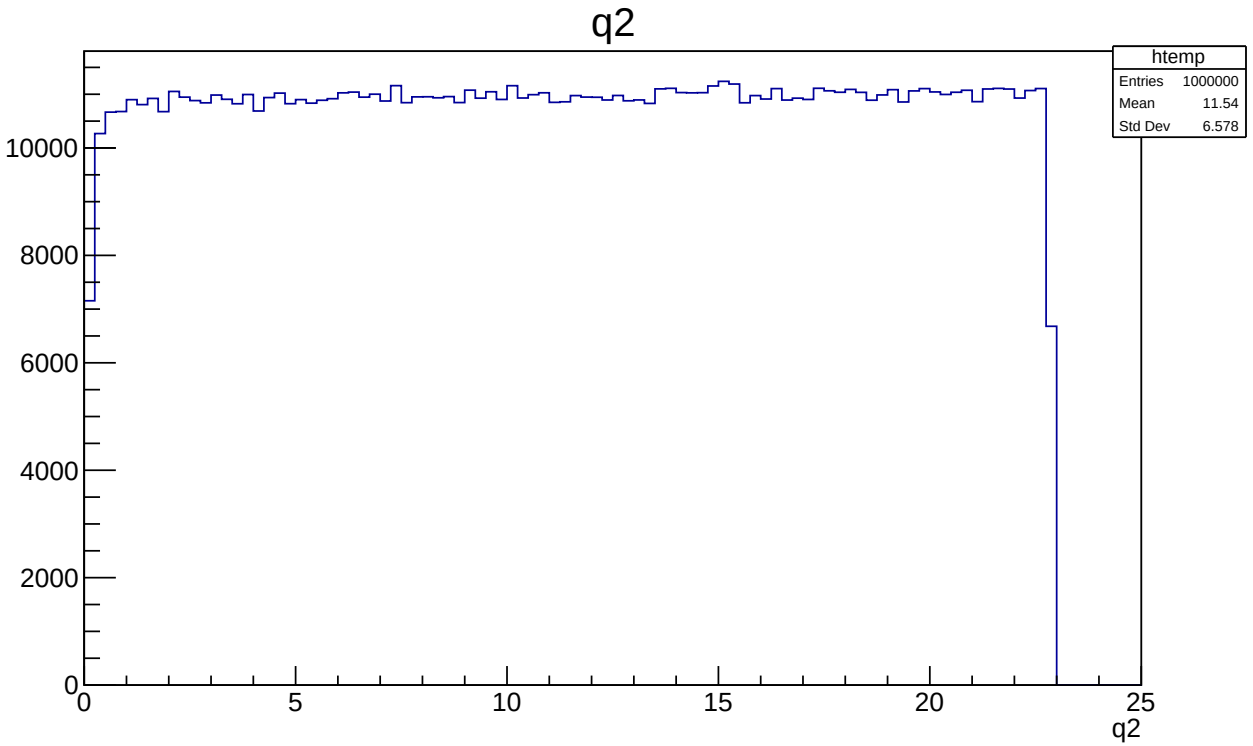


⇛ So much flatter but the and and the begging still not flat.

⇛ End of the spectrum is due to K^* width? ↠ Lets test it with B –

Modifying the FLATQ2 1

⇛ FLATQ2EWP use to simulate the $B \to K\mu\mu$:

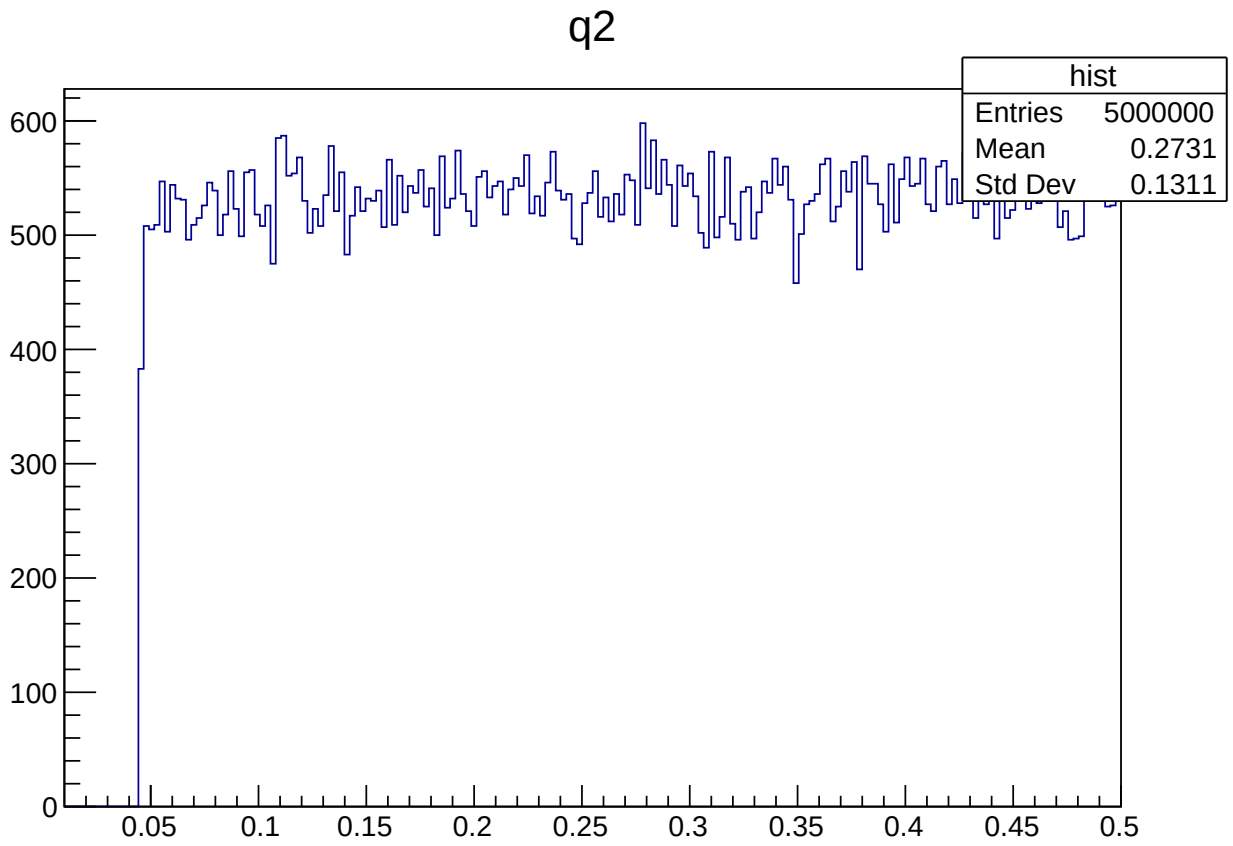


⇛ Oki so end of the spectrum is understood and not much can be done there.

⇛ Now the low q^2: Can this be just Phase space suppression: $\sqrt{\lambda} = \sqrt{1 - 4m_\ell^2/q^2}$

Modifying the FLATQ2 2

⇛ FLATQ2EWP with phase space suppression factor.



⇛ Now it's perfect.

Update since last week

⇛ Discussion was made via: JIRA

⇛ It was suggested my Michal to incorporate the new model into the current one to save the code.

⇛ Thanks to John for merging the two codes:

```
void EvtFlatQ2::init(){

  // check that there are 3 daughters
  checkNDaug(3);

  // We expect B -> X lepton lepton events
  checkSpinParent(EvtSpinType::SCALAR);

  EvtSpinType::spintype d1type = EvtPDL::getSpinType(getDaug(1));
  EvtSpinType::spintype d2type = EvtPDL::getSpinType(getDaug(2));

  if (!(d1type == EvtSpinType::DIRAC || d1type == EvtSpinType::NEUTRINO)) {
      EvtGenReport(EVTGEN_ERROR,"EvtGen") << "EvtFlatQ2 expects 2nd daughter to "
                                          << "be a lepton" <<std::endl;
      EvtGenReport(EVTGEN_ERROR,"EvtGen") << "Will terminate execution!"<<std::endl;
      ::abort();
  }

  if (!(d2type == EvtSpinType::DIRAC || d2type == EvtSpinType::NEUTRINO)) {
      EvtGenReport(EVTGEN_ERROR,"EvtGen") << "EvtFlatQ2 expects 3rd daughter to "
                                          << "be a lepton" <<std::endl;
      EvtGenReport(EVTGEN_ERROR,"EvtGen") << "Will terminate execution!"<<std::endl;
      ::abort();
  }

  // Specify if we want to use the phase space factor
  _usePhsp = false;
  if (getNArg() > 0) {
      if (getArg(0) != 0) {_usePhsp = true;}
  }

  EvtGenReport(EVTGEN_INFO,"EvtGen") <<"EvtFlatQ2 usePhsp = "<<int(_usePhsp)<<std::endl;

}
```

Update since last week

⇛ Discussion was made via: JIRA

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⇛ Thanks to John for merging the two codes:

```
void EvtFlatQ2::decay( EvtParticle *p){

  p->initializePhaseSpace(getNDaug(),getDaugs());

  EvtVector4R p4Xu = p->getDaug(0)->getP4();

  EvtVector4R p4ell1 = p->getDaug(1)->getP4();
  EvtVector4R p4ell2 = p->getDaug(2)->getP4();

  double pXu_x2 = p4Xu.get(1)*p4Xu.get(1);
  double pXu_y2 = p4Xu.get(2)*p4Xu.get(2);
  double pXu_z2 = p4Xu.get(3)*p4Xu.get(3);
  double pXu = sqrt(pXu_x2+pXu_y2+pXu_z2);
  double prob(0.0);
  if (fabs(pXu) > 0.0) {prob = 1/pXu;}

  // Include the phase space factor if requested
  if (_usePhsp) {

    double Lambda = lambda((p4ell1+p4ell2).mass(), p4ell1.mass());
    if (Lambda > 0.0) {prob=prob/sqrt(Lambda);}

  }

  if (pXu > 0.01) {setProb(prob);}

  return;
```

FLATQ2 Conclusion

⇛ The new model was tested by me and John.
⇛ Changes won't have any influence on the existing DEFILES as the flag is by default switched off.
⇛ The commit was merge to master by Gloria today.
⇛ We thank all people involved action

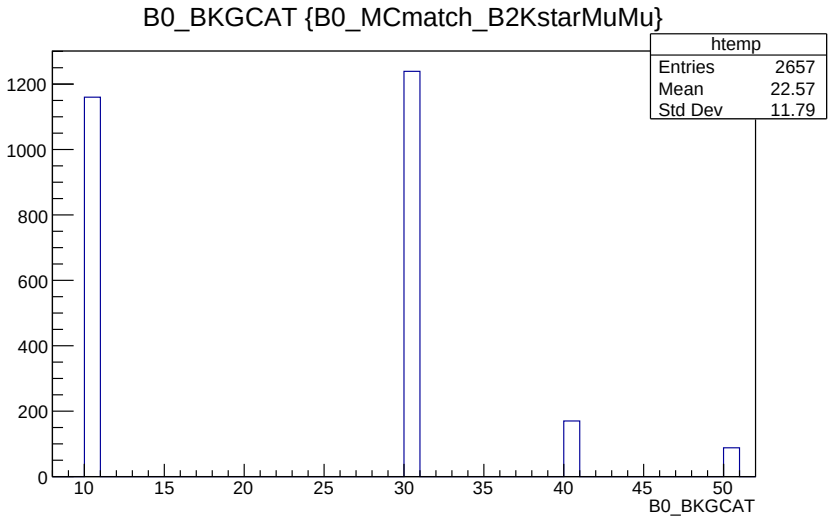
⇛ The whole things took $<$week and is already available for production!
⇛ There is also other model XLL, see Biplab slides more suitable for $B \to K\pi\mu\mu$.

Backup

This is not related to MC requests.

MCmatching studies.

⇛ Let's look how the candidates that have been matched by: $\mathrm{mcMatch}(\mathrm{'[B0 => K*(892)0mu+mu-]CC'})$ look like:

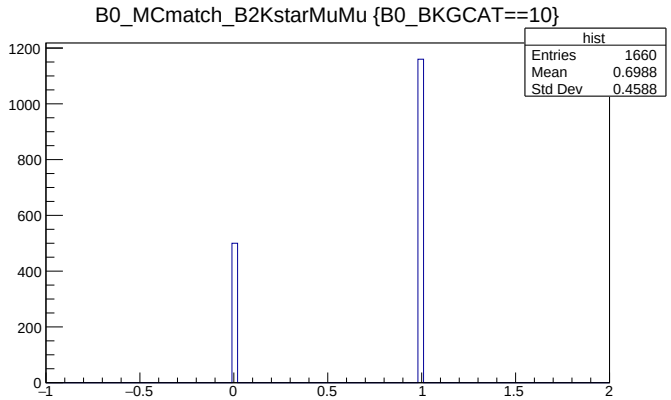


⇛ `BKGCAT==10` is the pure signal. The mcMatch is not changing anything in that number of entries.

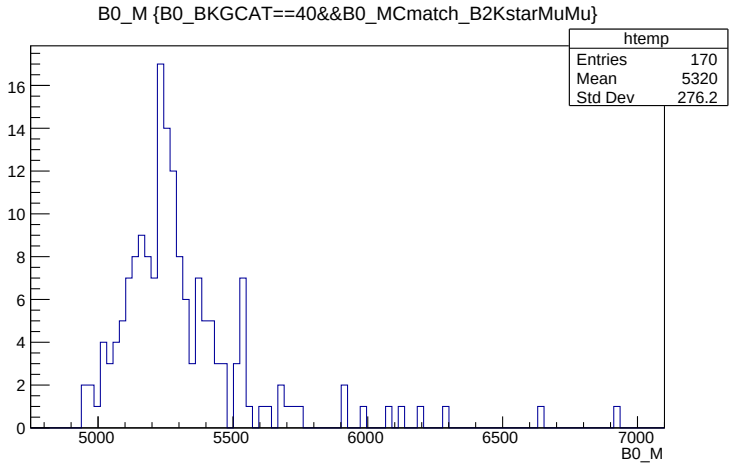
⇛ `BKGCAT==30` is the K=$K \leftrightarrows \pi$ swaps. This goes away with some PID selection

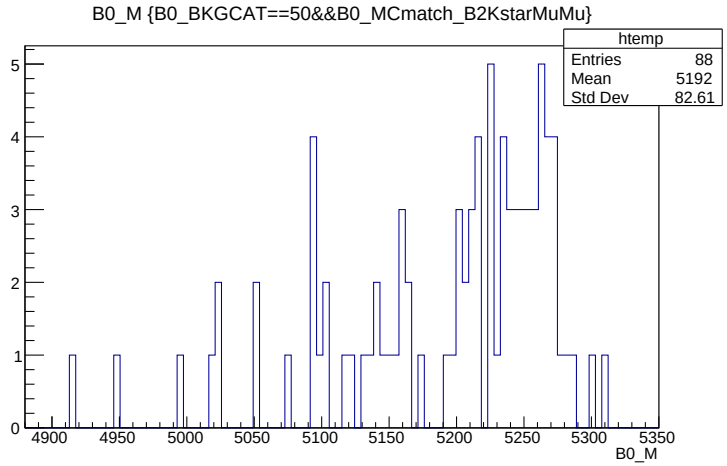
MCmatching studies.

⇛ Now all `BKGCAT==10` have true mcMatch:



⇛ How does `BKKCAT==50,40` (missID +FSR, FSR)look like:





⇛ We need to consider which `BKGCAT` we should use for the analysis