RICH updates and Plans

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Outline:

1. Updates about RICH tuning.
2. Consistency checks.
3. Preparation for 2021 run.
4. Refurbishments and repairs.
5. Conclusion.

Progress in RICH tuning and performance

To efficiently perform hadron identification the RICH needs a delicate tuning:

In particular the refractive index n needs to be known very precisely.

$$cos\theta = \frac{1}{n}\sqrt{1+\frac{m^2}{p^2}}$$

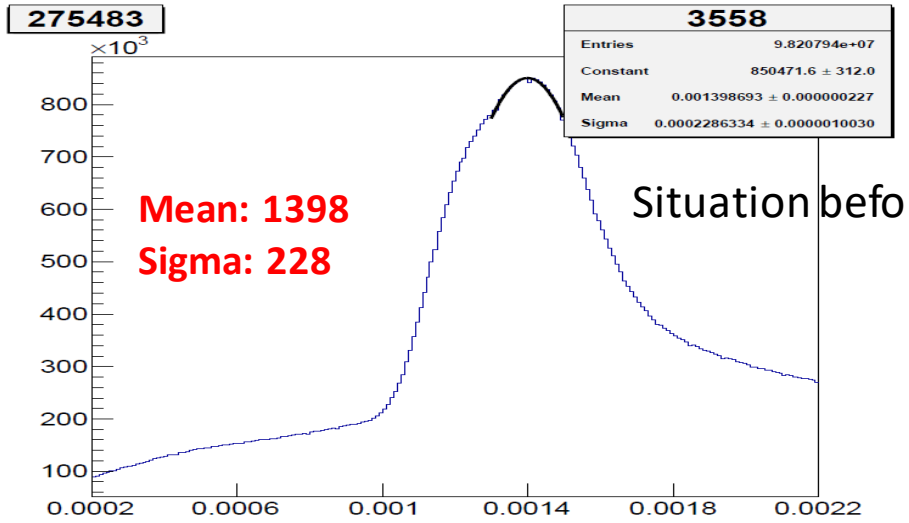
PID: n and p known, θ measured → m

Tuning: m and p known, θ measured → n

Reminder: (n-1) peak for 2016/17 data broader than for 2010 data

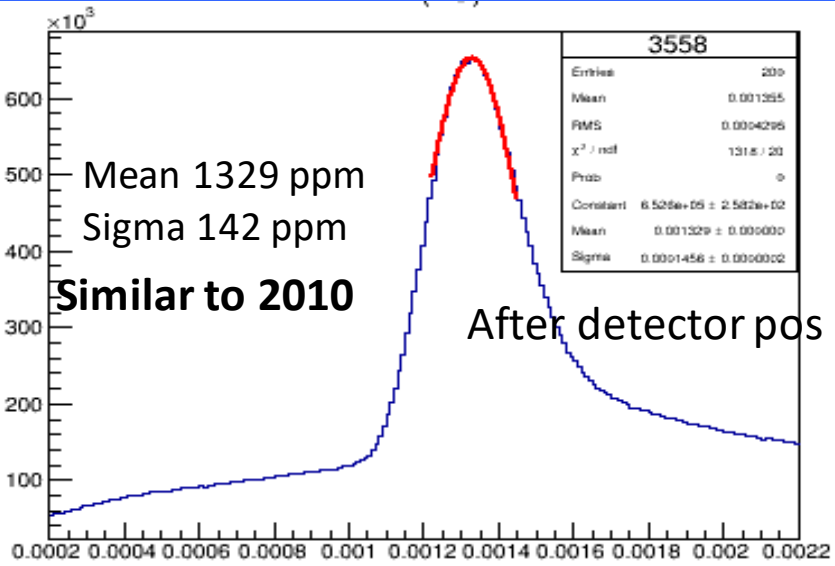
Extraction of refractive index using pion mass hypothesis

Progress in RICH tuning and performance



Mean: 1398
Sigma: 228

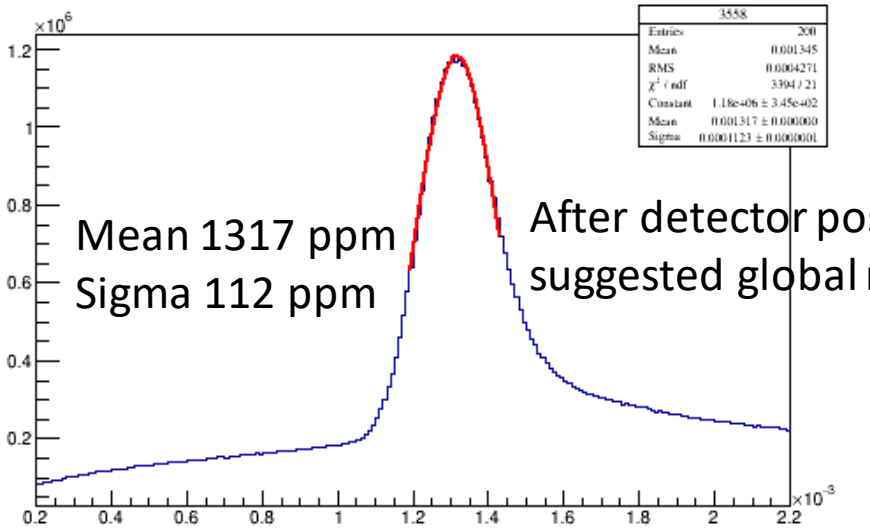
Situation before tuning



Mean 1329 ppm
Sigma 142 ppm

Similar to 2010

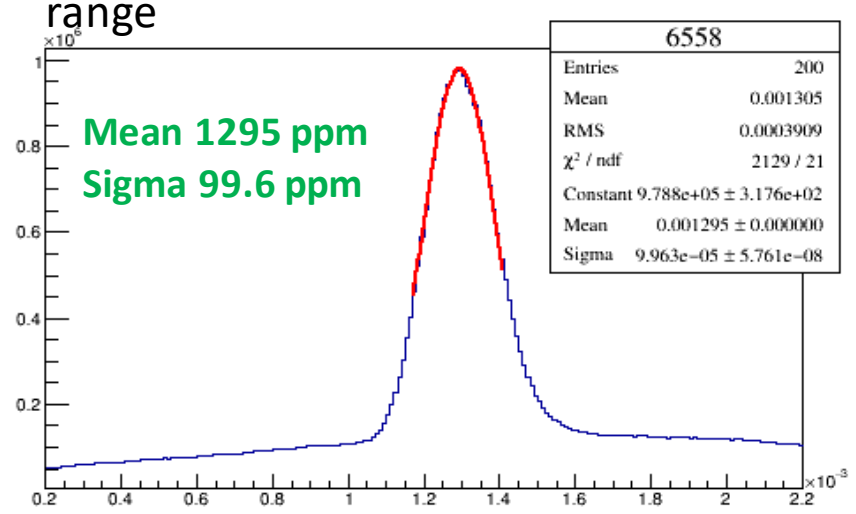
After detector pos survey



Mean 1317 ppm
Sigma 112 ppm

After detector pos survey and data suggested global mirror position

Det pos+ mirror pos+ new n-1 extraction range

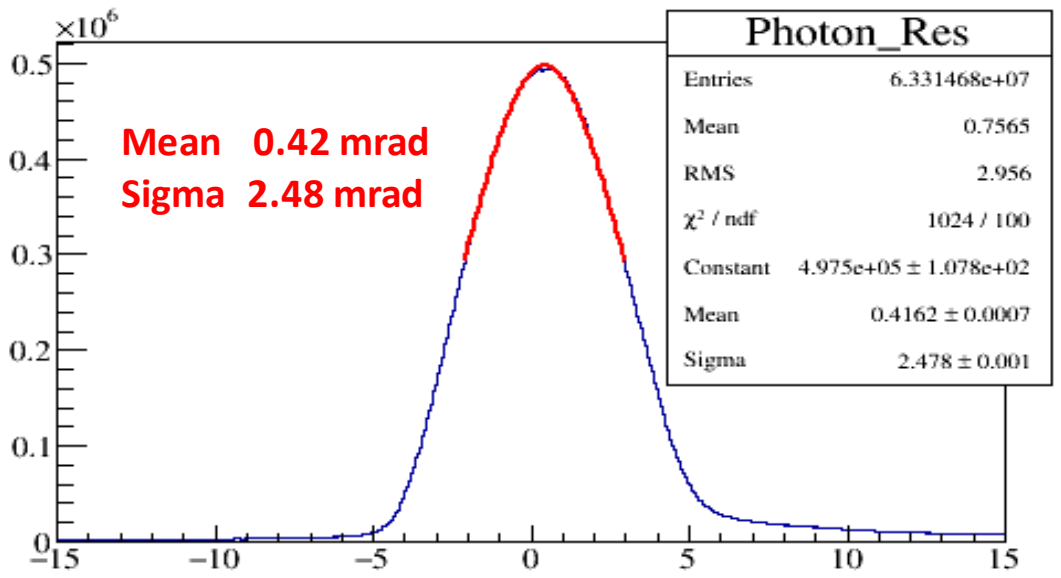


Mean 1295 ppm
Sigma 99.6 ppm

Photon Angle Resolution

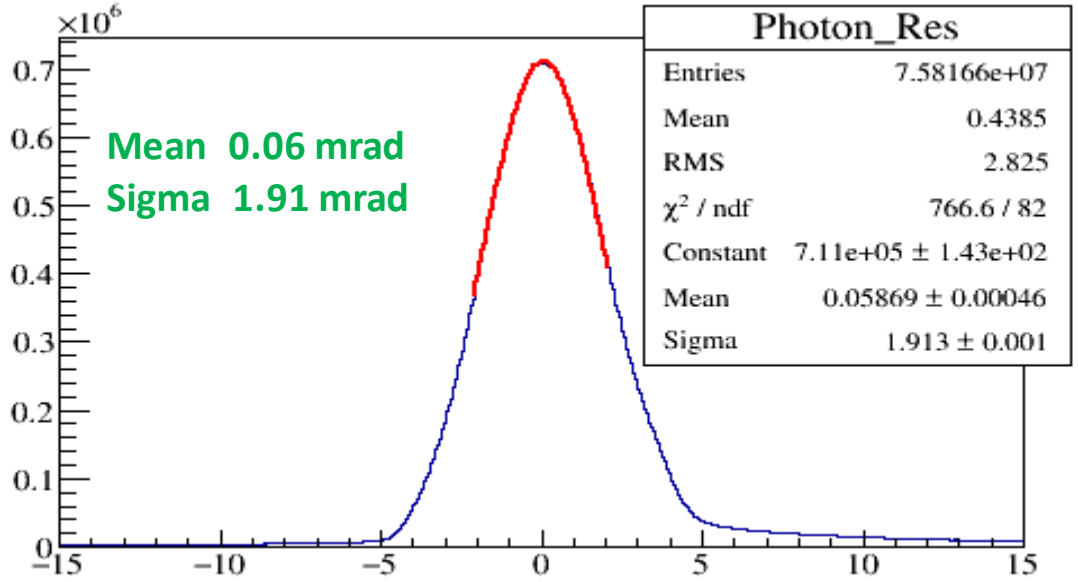
No likelihood cut applied.

Before mirror correction and new n-1 algo



theta_photon – theta_pion (mrad)

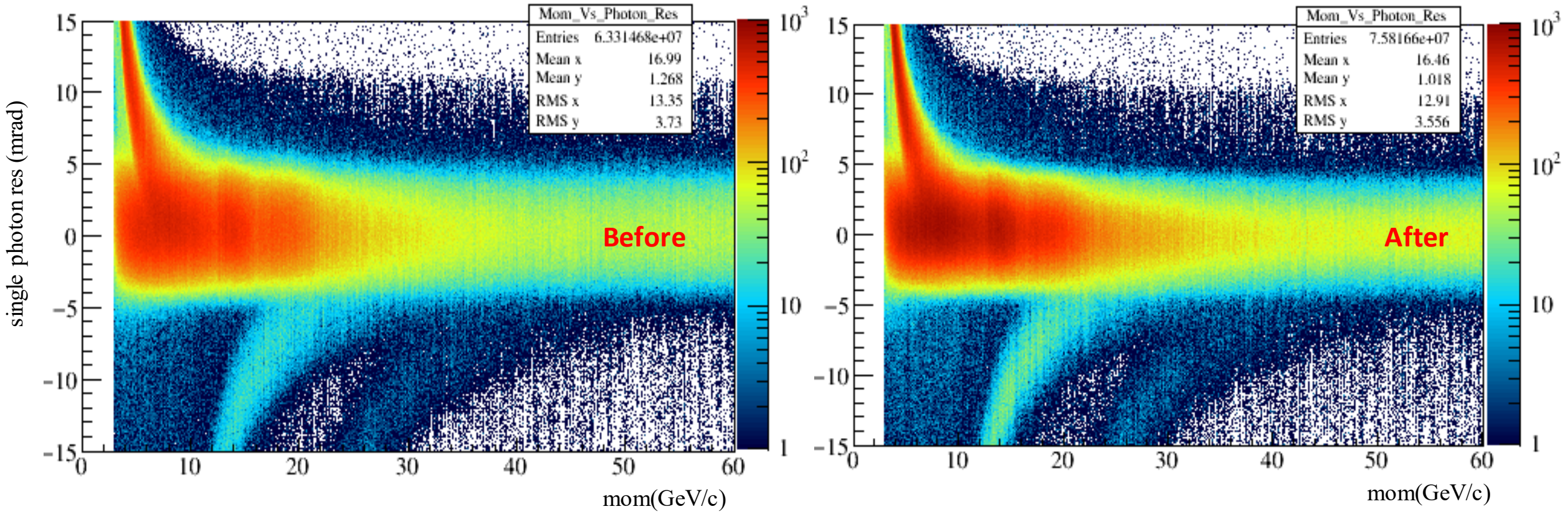
After mirror correction and new n-1 algo



theta_photon – theta_pion (mrad)

Improvement in photon resolution 2.5 mrad → 1.9 mrad

Photon residual vs momentum

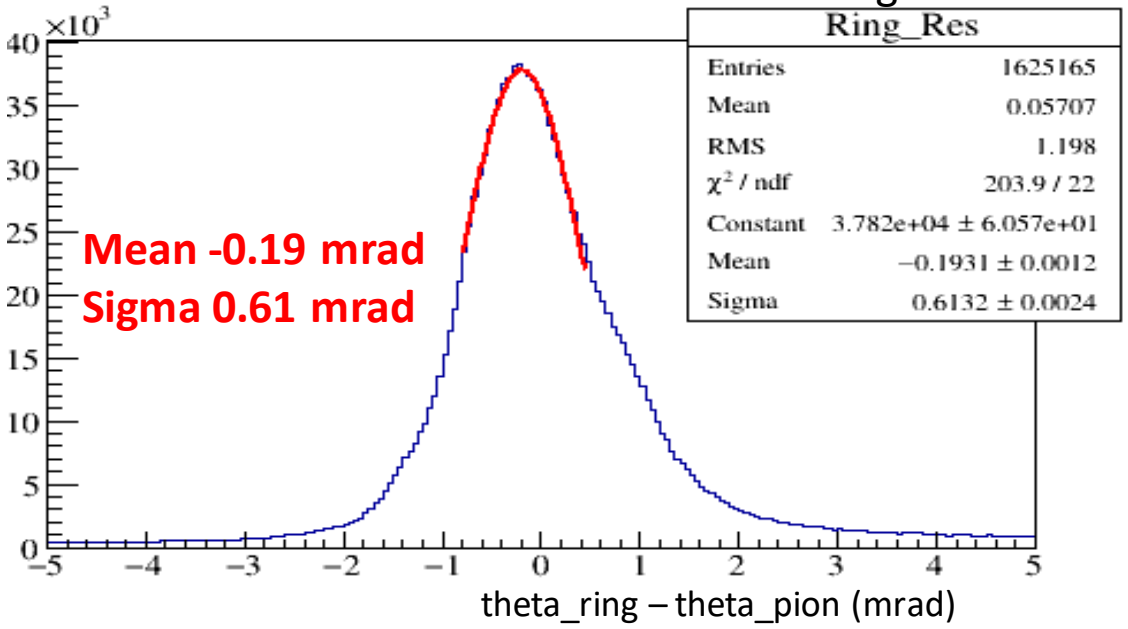


Photon residual = photon theta – pion theta

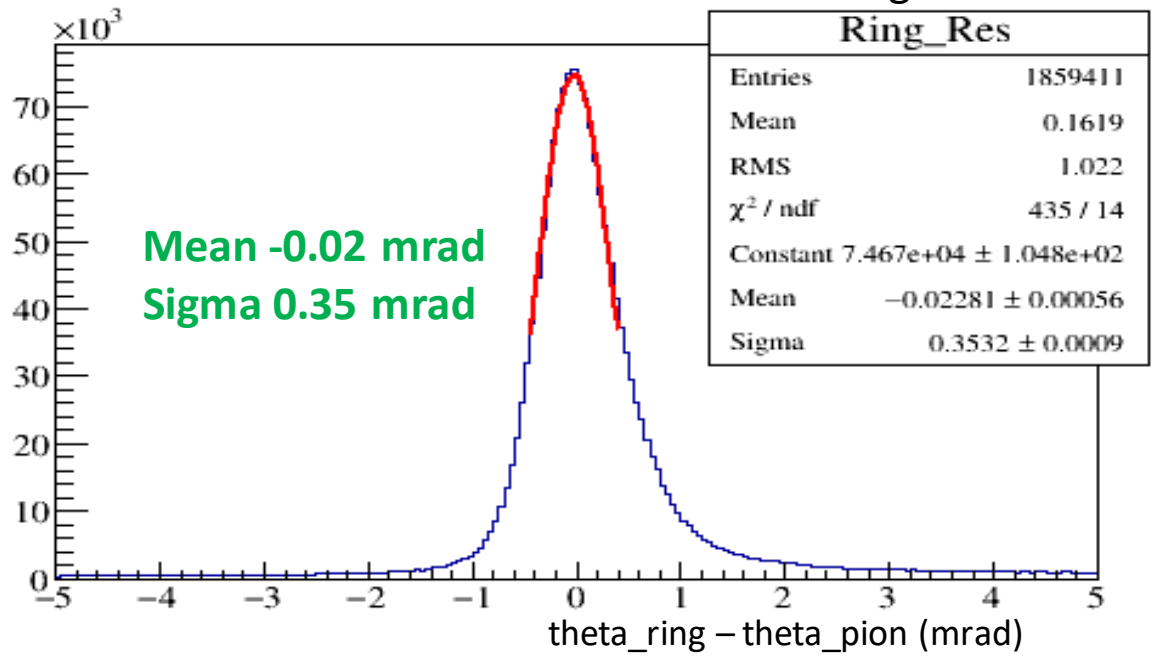
Ring Angle Resolution

No likelihood cut applied.

Before mirror correction and new n-1 algo



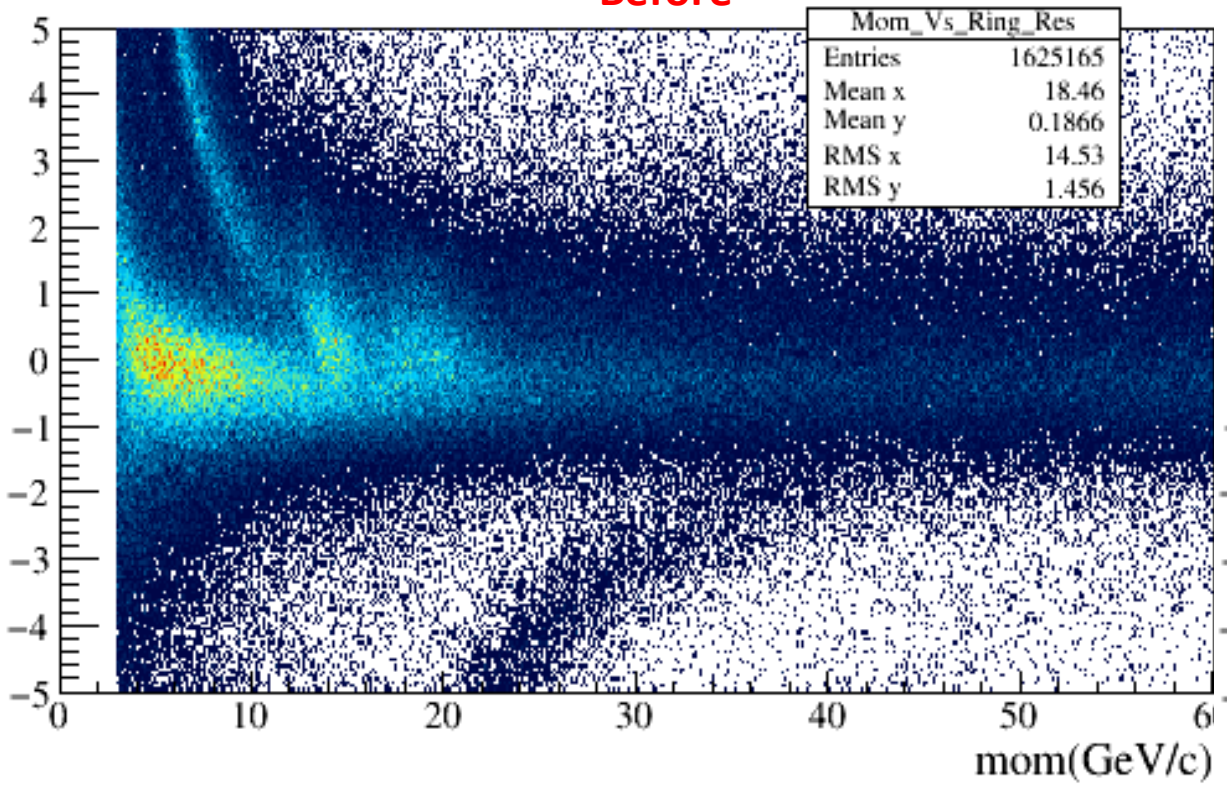
After mirror correction and new n-1 algo



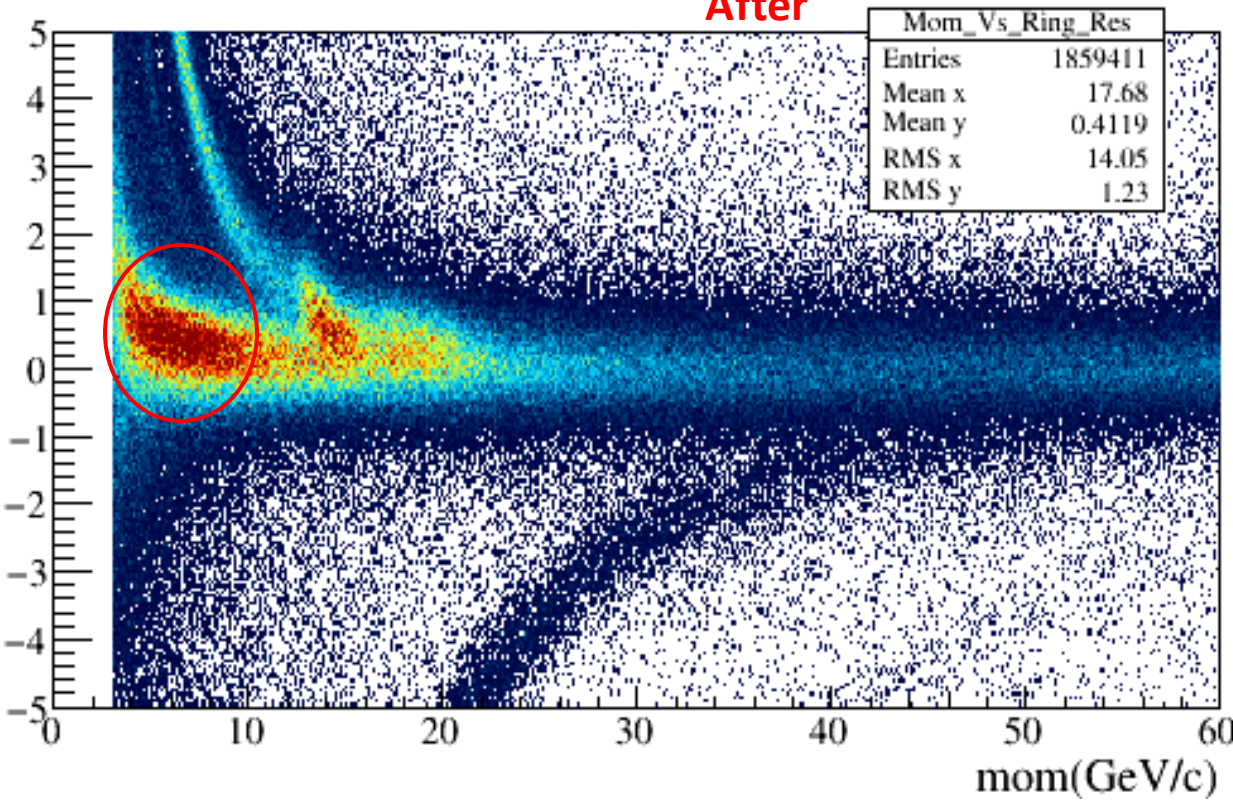
Improvement in ring resolution 0.6 mrad → 0.35 mrad

Ring residual vs momentum

Before



After



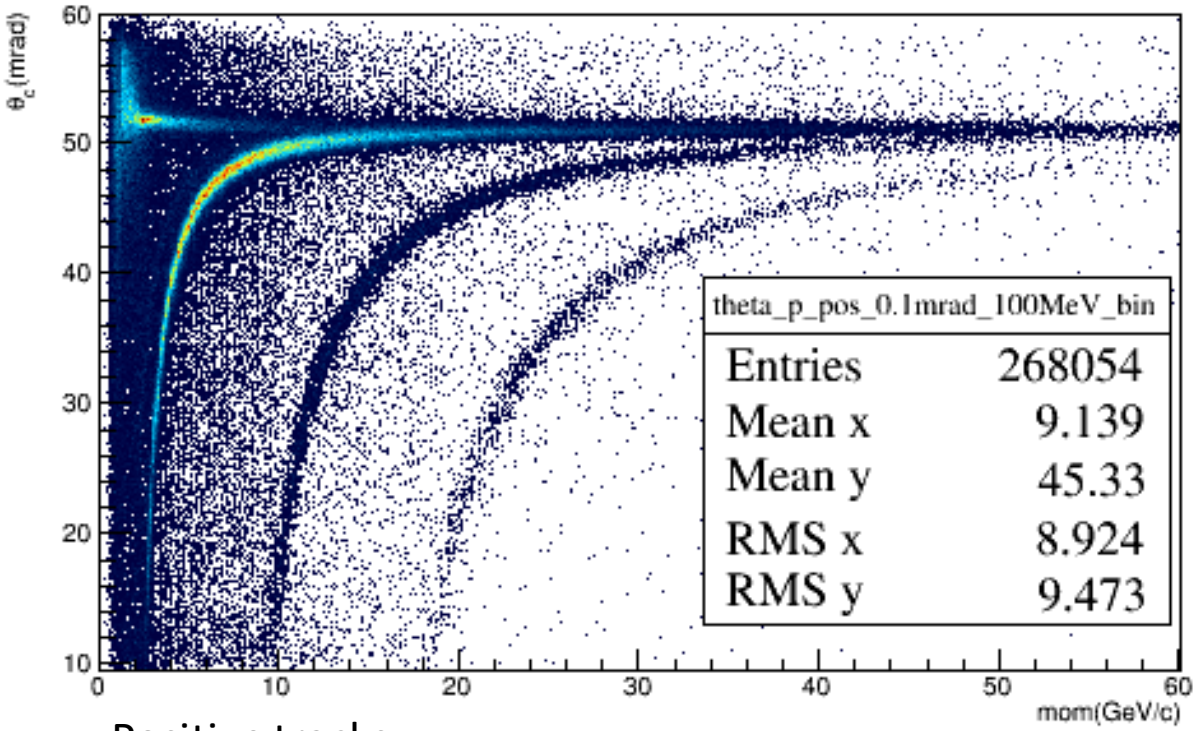
ring residual = ring theta – pion theta

$$\theta_{ms} = \frac{13.6MeV}{p} q\sqrt{x/X0}$$

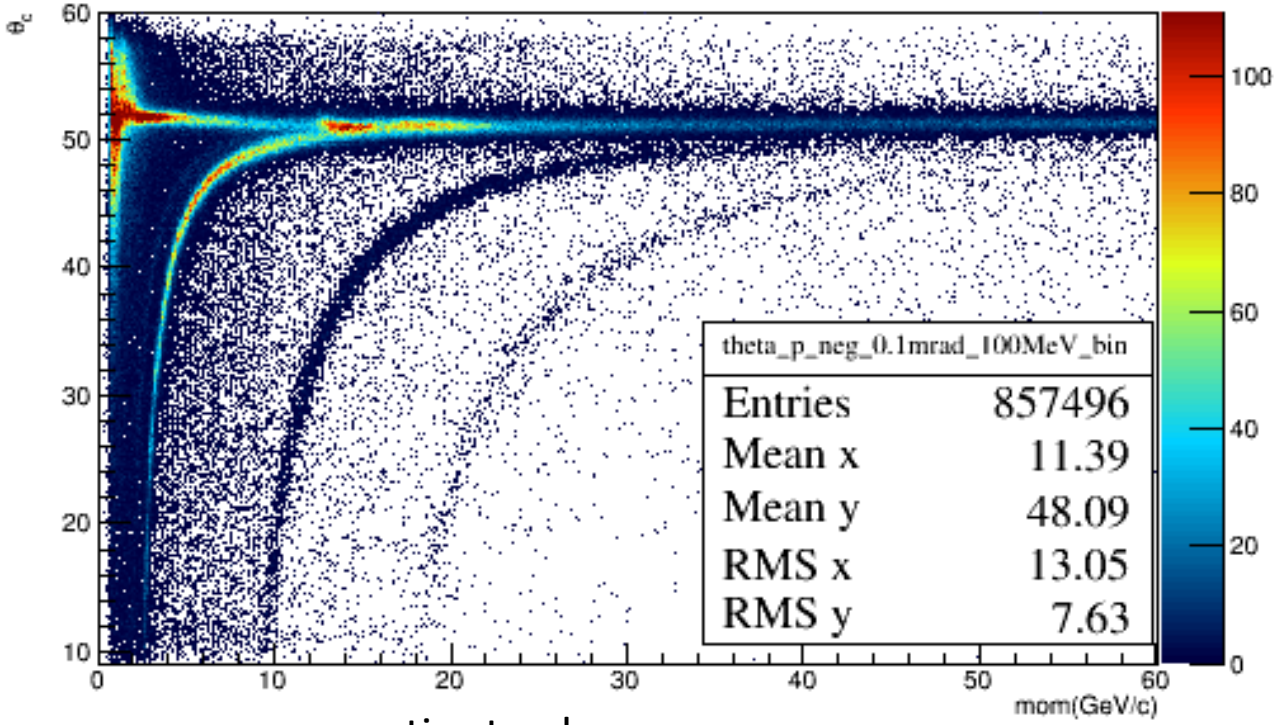
XX0 of the radiator 1/10 ; X0 of C_4F_{10} = 33 gcm^{-2}

multiple scattering : 5 GeV/c electrons ~ 0.6 mrad

Ring theta versus momentum

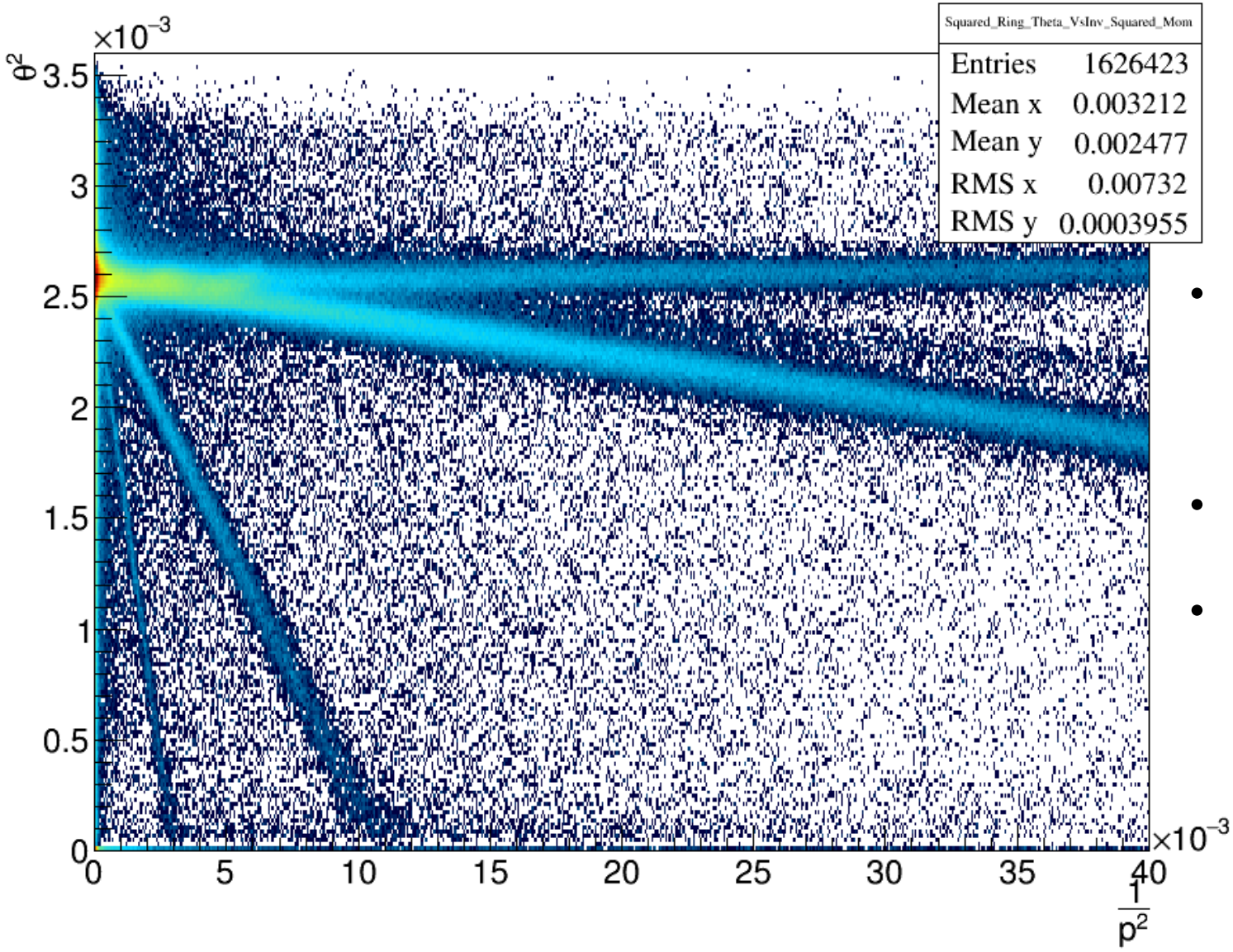


Positive tracks



negative tracks

Ring theta versus momentum



- **Theoretically theta vs momentum plots based on measurement by RICH and spectrometer. No Refractive index comes into the plot.**
- **This plot can be mapped into a squared mass plot.**
- **Theoretically we expect straight lines at correct values of squared mass.**

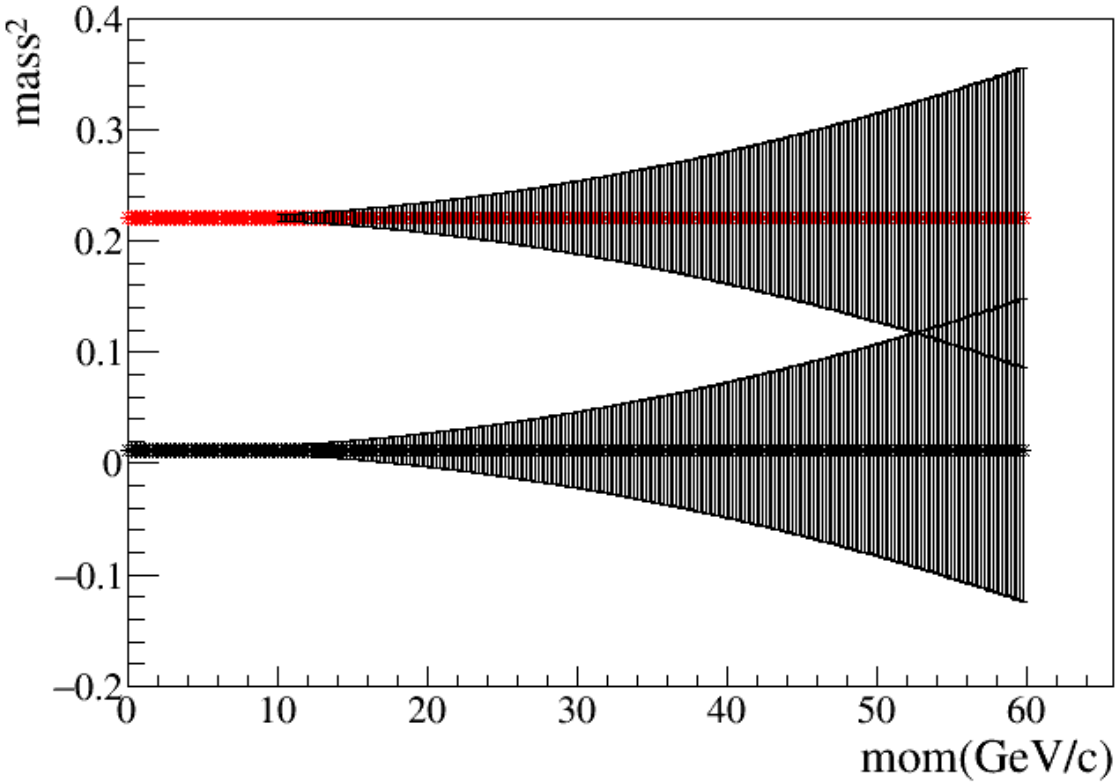
Mass^2 estimation by RICH

$$\cos\theta = \frac{1}{n\beta}$$

$$(1 - \frac{\theta^2}{2}) = (1 - (n-1))(1 + 1/2\frac{m^2}{p^2}); \beta = \frac{p}{\sqrt{p^2 + m^2}}$$

$$m^2 = p^2\left[\frac{2(n-1) - \theta^2}{1 - (n-1)}\right]$$

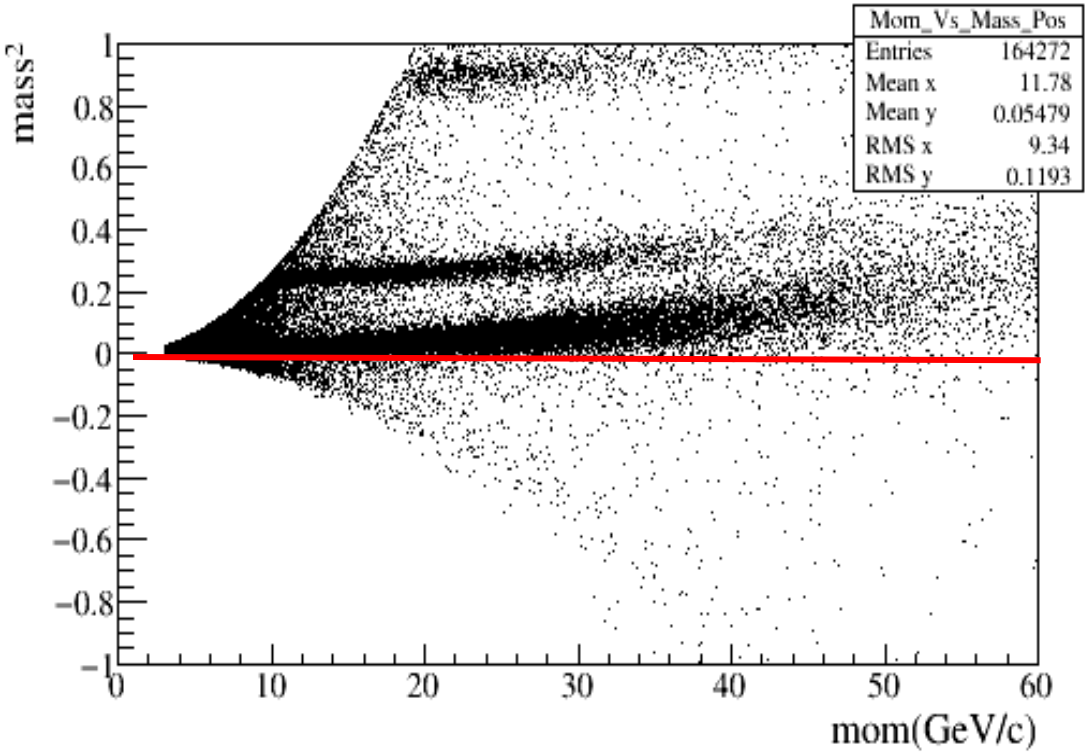
$$\left(\frac{\sigma_{m^2}}{m^2}\right)^2 = \left(2m^2\frac{\sigma p}{p}\right)^2 + \left(p^2\frac{2\theta\sigma_\theta}{(n-1)-1}\right)^2 + \left([2p^2 - (p\theta)^2]\frac{\sigma_{(n-1)}}{[(n-1)-1]^2}\right)^2 \quad (3.14)$$



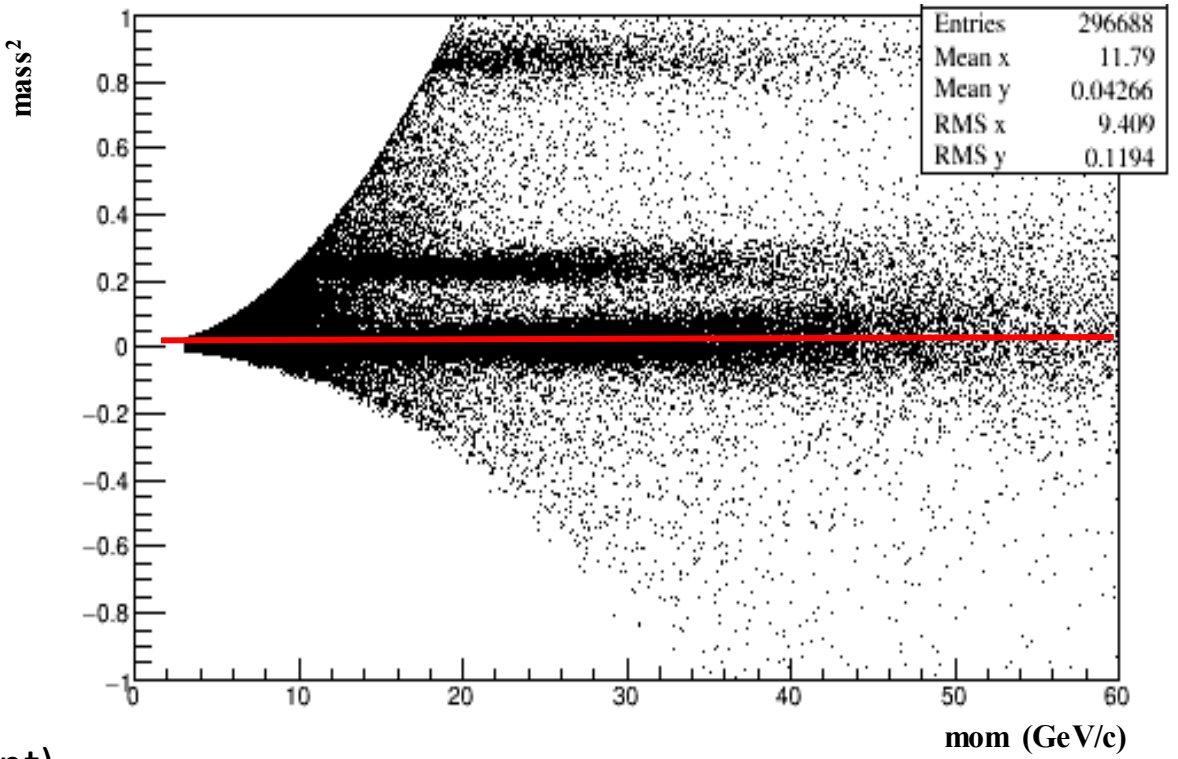
delta p/p = 0.5 %
sigma_theta = 0.35 mrad
sigma_n-1 = 0.4%

Mass^2 estimation by RICH

Near Saturation 2(n-1)~ squared theta. Gaussian nature of measured theta distribution suggests squared theta can be greater than 2(n-1). Giving negative mass squared. Using mass will loose half of the information.

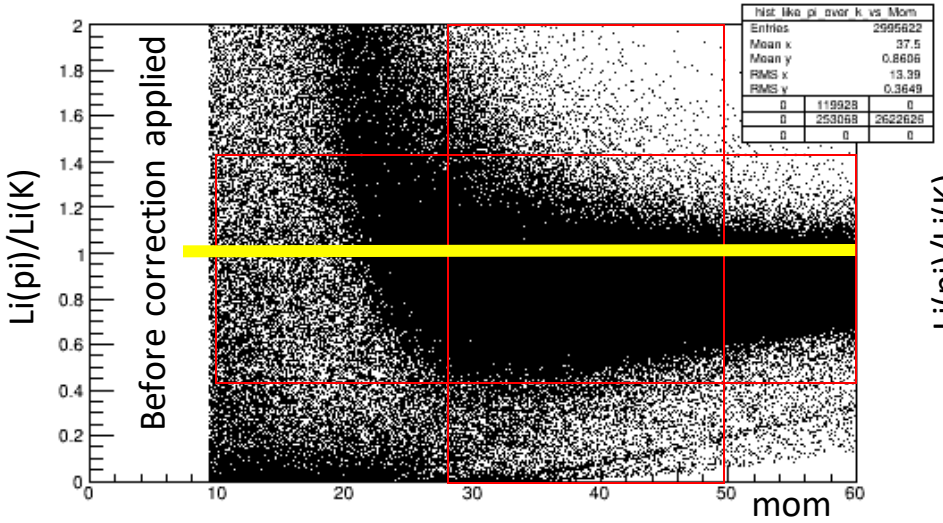


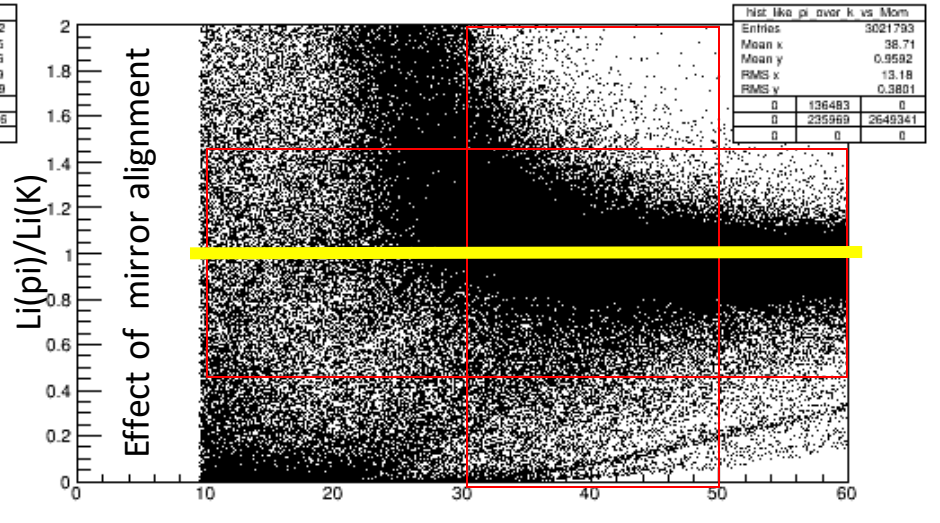
Refractive index NOT rightly set (electron contamination present)

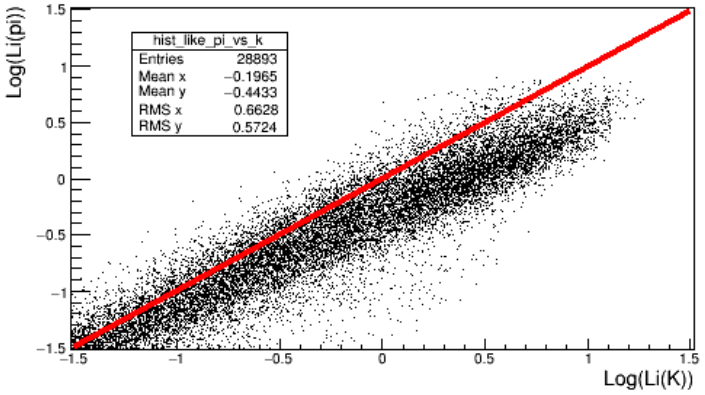


Refractive index **rightly** set (No electron contamination)

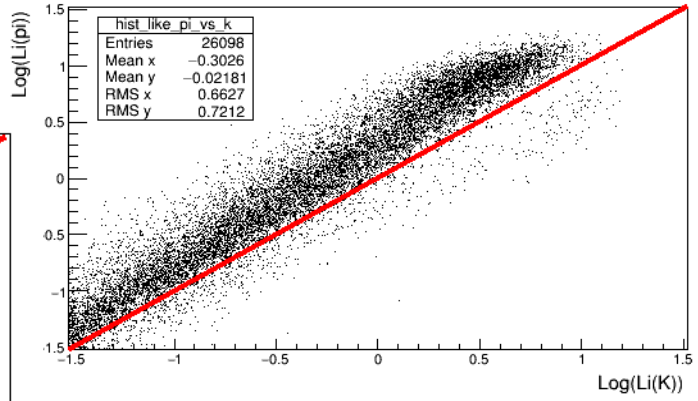
Effect of the corrections on the likelihood values



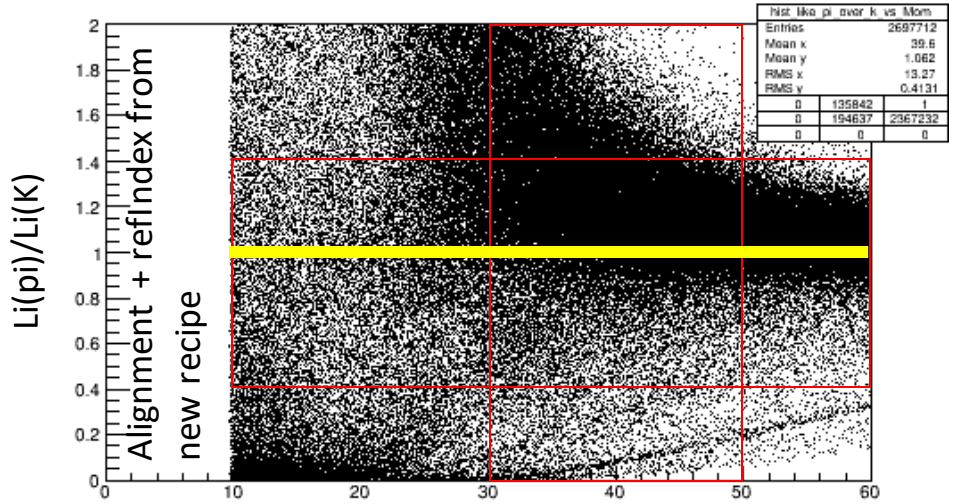




before correction



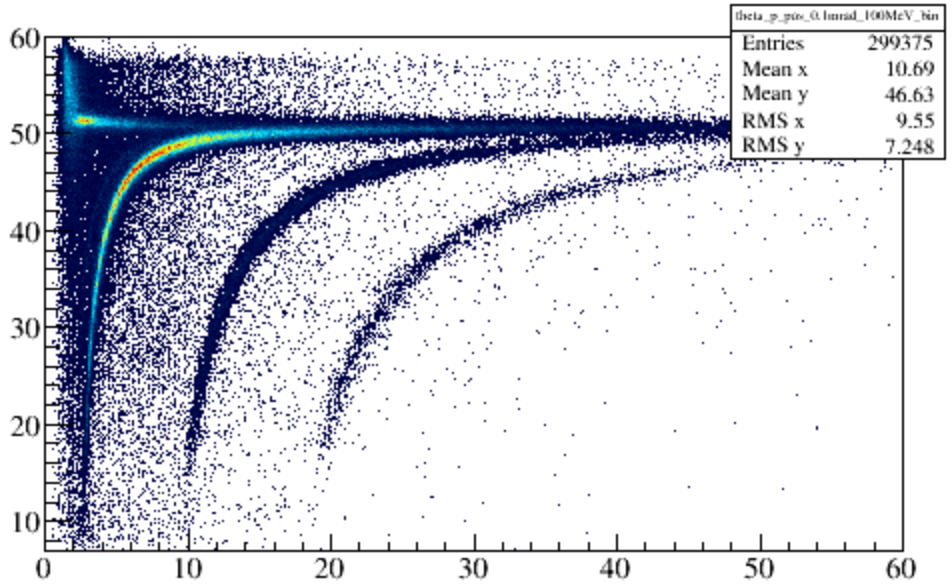
after mirror correction and new refractive Index



The ratio of likelihood of pion over kaon is supposed to be >1.

Consistency Check with likelihood and ring theta

Negative muon beam& +ve charged tracks, beam region excluded. Ring angle vs momentum. Selected regions with 1) Kaon dominated. 2) pion dominated.



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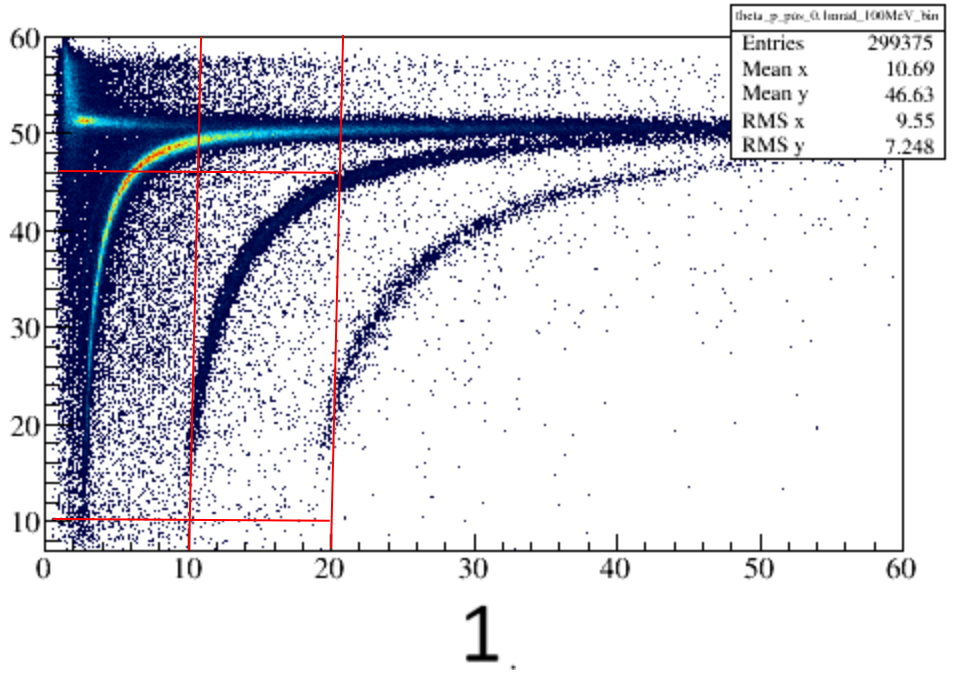

Consistency Check with likelihood and ring theta

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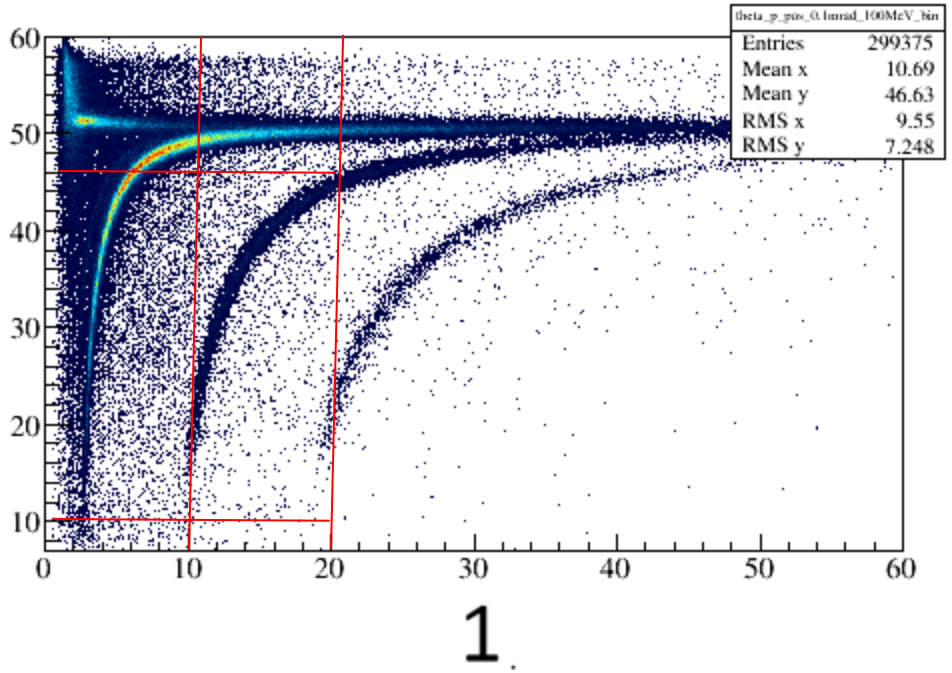
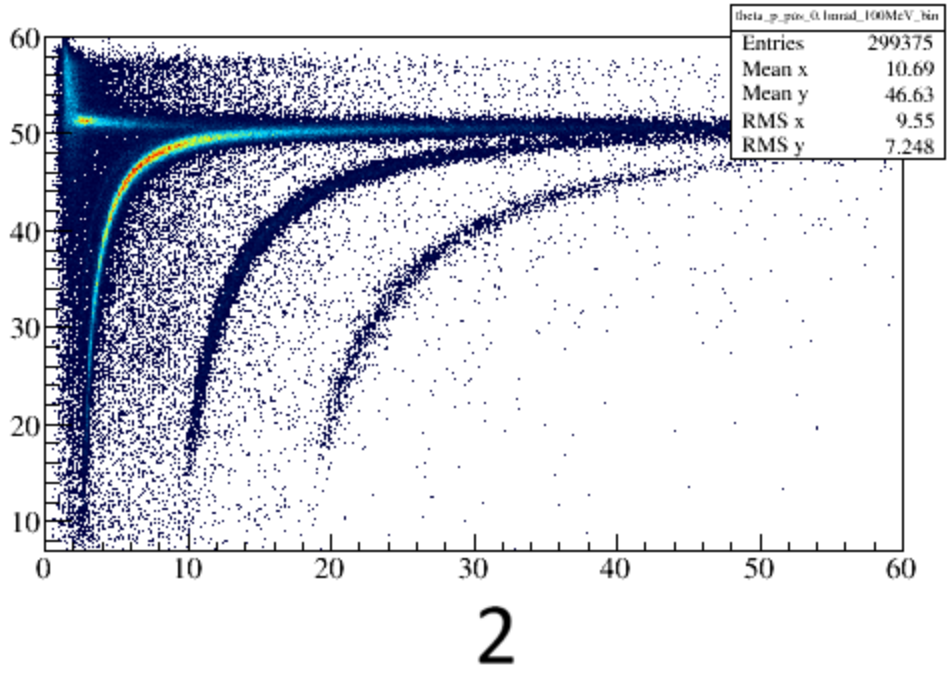


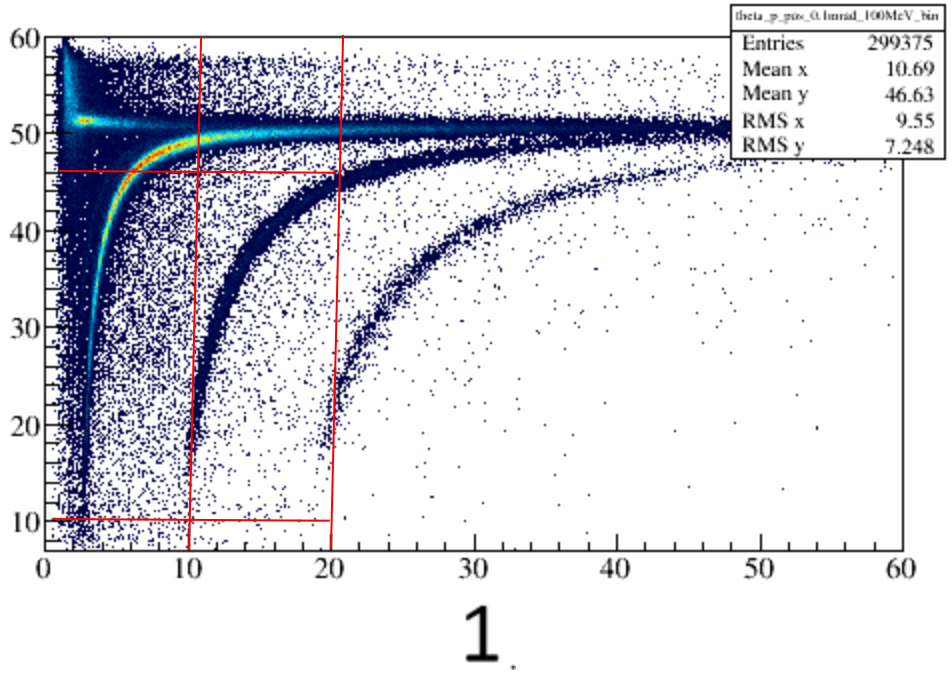
1



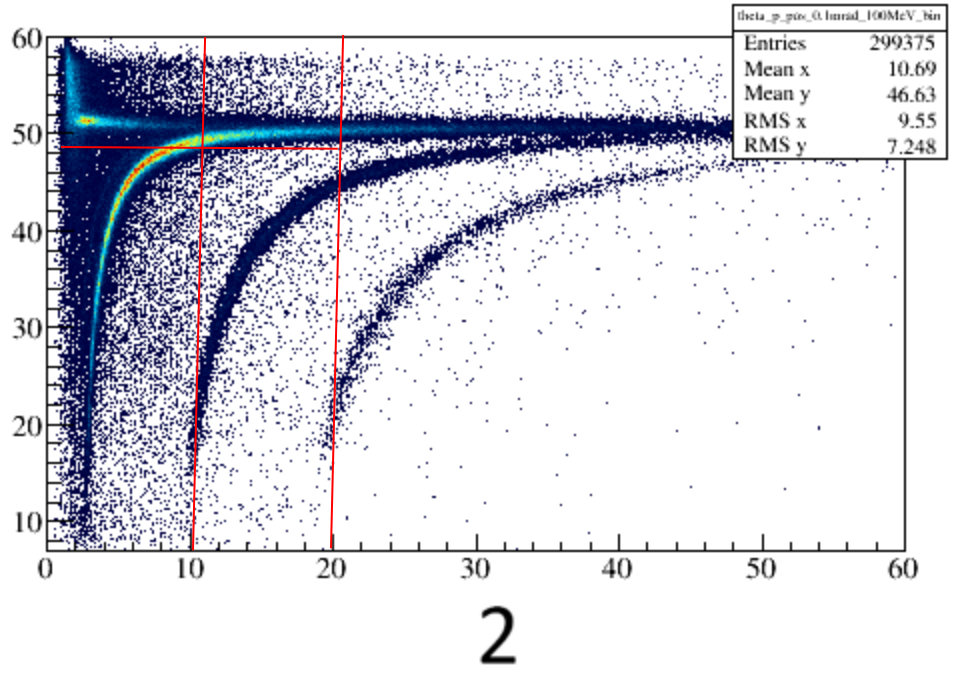
2

Consistency Check with likelihood and ring theta

Negative muon beam& +ve charged tracks, beam region excluded. Ring angle vs momentum. Selected regions with 1) Kaon dominated. 2) pion dominated.



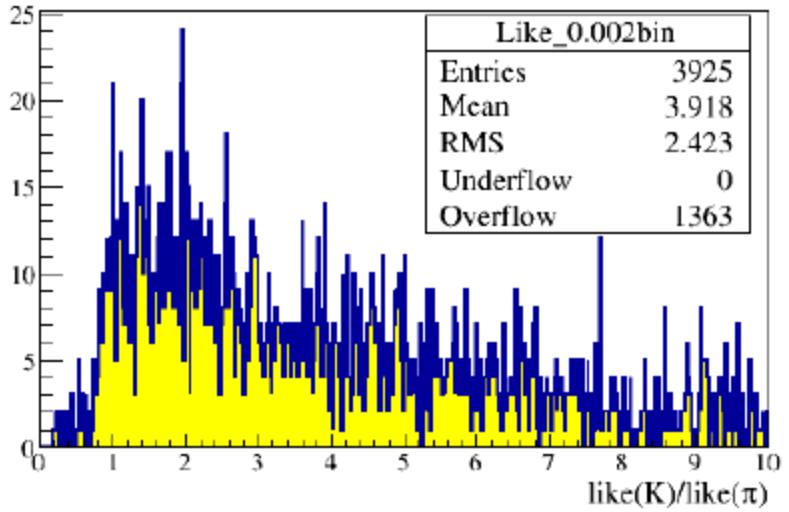
1



2

Consistency Check with likelihood and ring theta

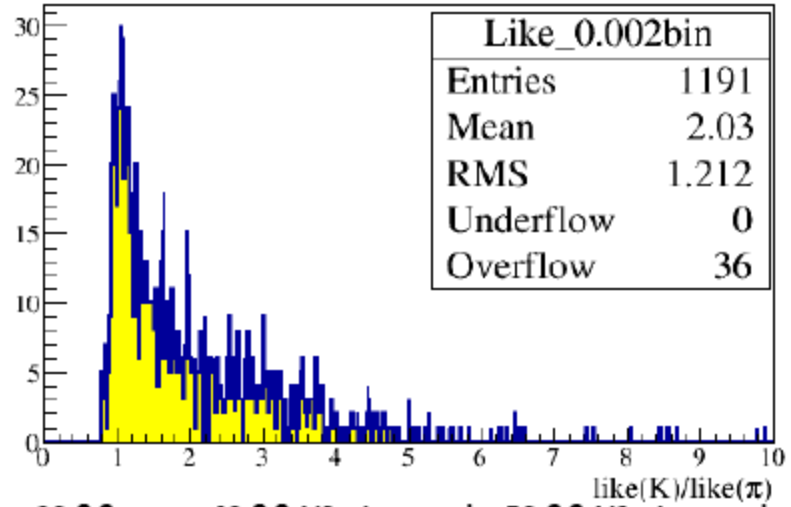
If(mom>20 && mom<30 && VS_ring_angle>40 && VS_ring_angle<47)



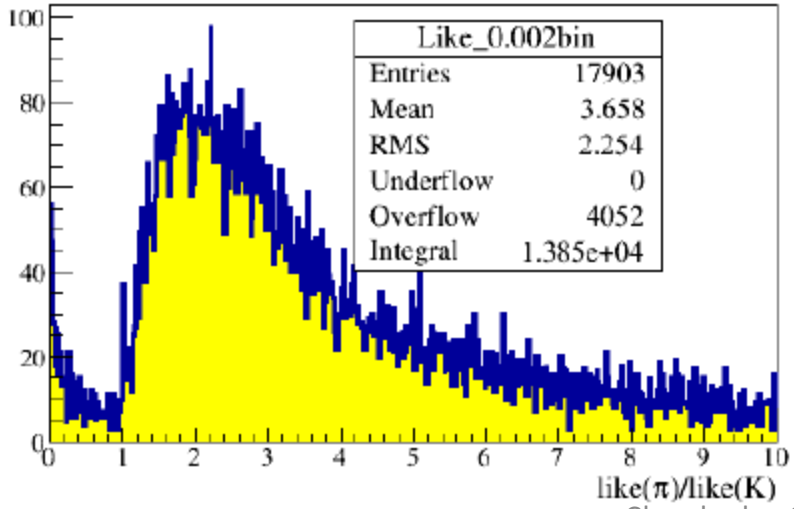
1

Like(K)/Like(pi)

If(mom>30 && mom<35 && VS_ring_angle>47 && VS_ring_angle<50)



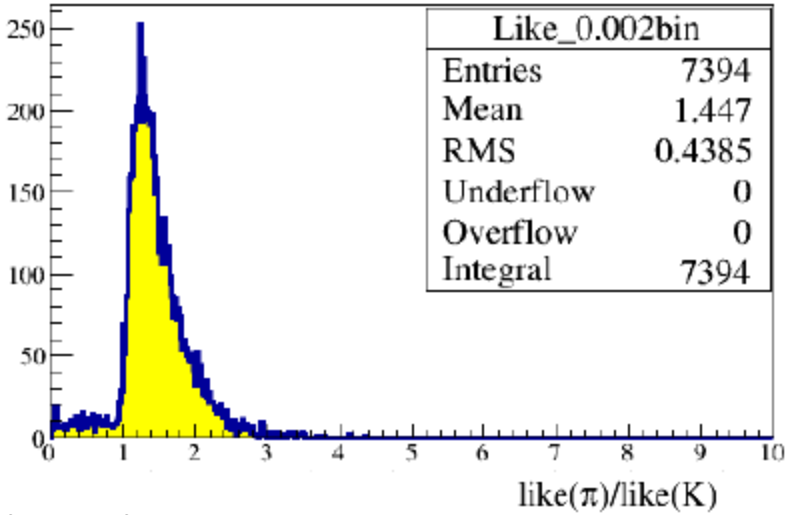
If(mom>20 && mom<30 && VS_ring_angle>50 && VS_ring_angle<60)



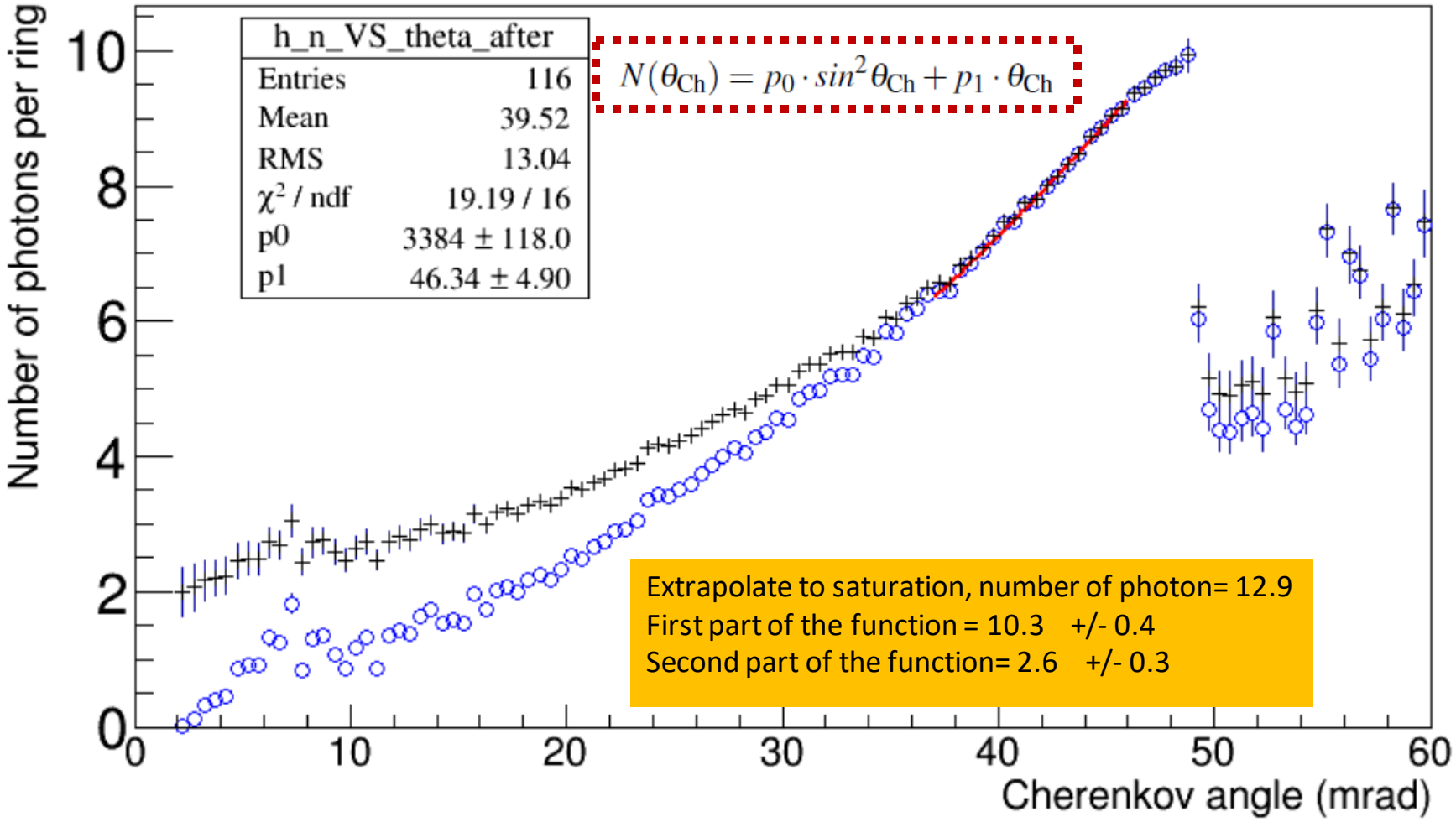
Like(pi)/Like(K)

2

If(mom>30 && mom<40 && VS_ring_angle>50 && VS_ring_angle<60)

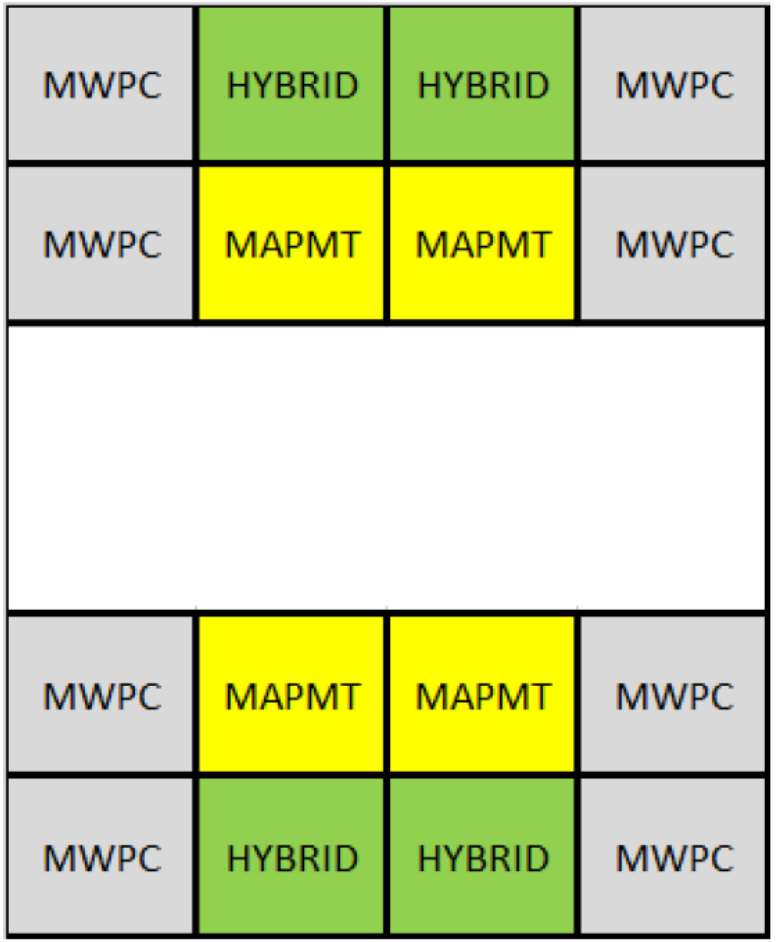


Hybrid Characterization



Preparation for 2021 Run

Set up for 2021 Run



Ongoing activities →

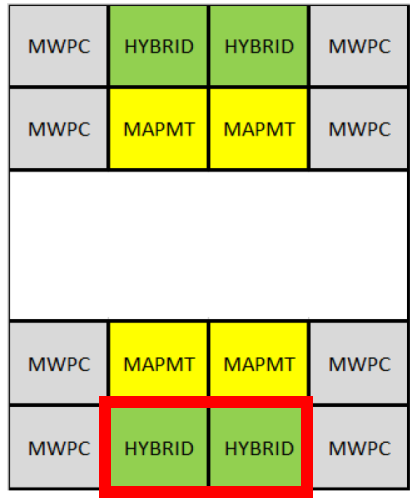
1. **refurbishments, repairs of gaseous photon detectors.**
2. **Integrate MWPC HVs with Temperature and Pressure corrected. Hybrid Like.**
3. **General refurbishment of LV cables and optical fibers.**
4. **RICH gas system maintenance.**
5. **Validation of radiator gas and cleaning.**

Refurbishment and repairs of gaseous detectors

Refurbishments of existing Hybrids

Sample will be coated and QE will be estimated at standard CERN facility → QE value will be cross-checked at RD51 setup

Some upgrades in the CERN CsI deposit facility. Full work plan:
Bring storage THGEMS to measure the QE to get reference between old and new QE value. → coat substrate, measurement of QE at standard CERN facility → cross-check QE value at RD51 setup.



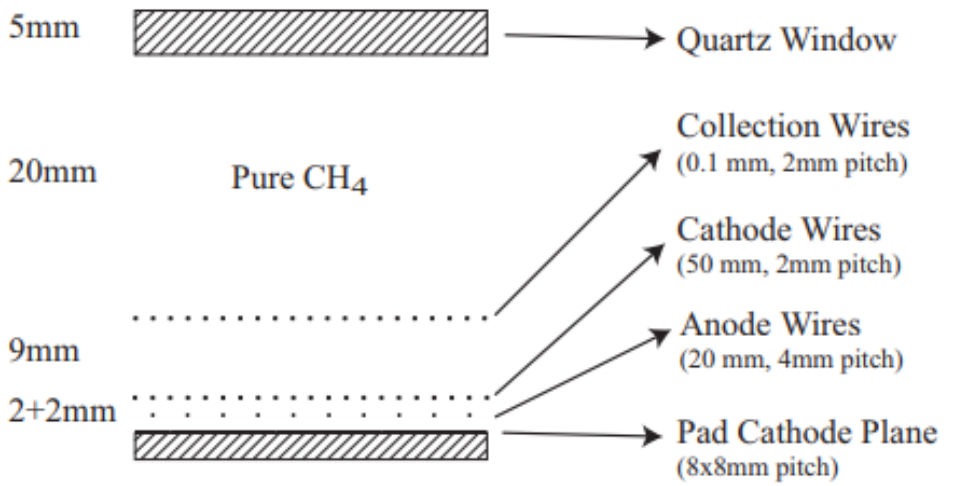
Possibility to recoat the first layers of the THGEMs of the bottom hybrids after CsI deposit quality issue check suggests.

Q.E. uniformity			
1.09	1.14	1.03	0.99
0.90	0.88	0.90	1.08
σ = 9.3%			

Repairs

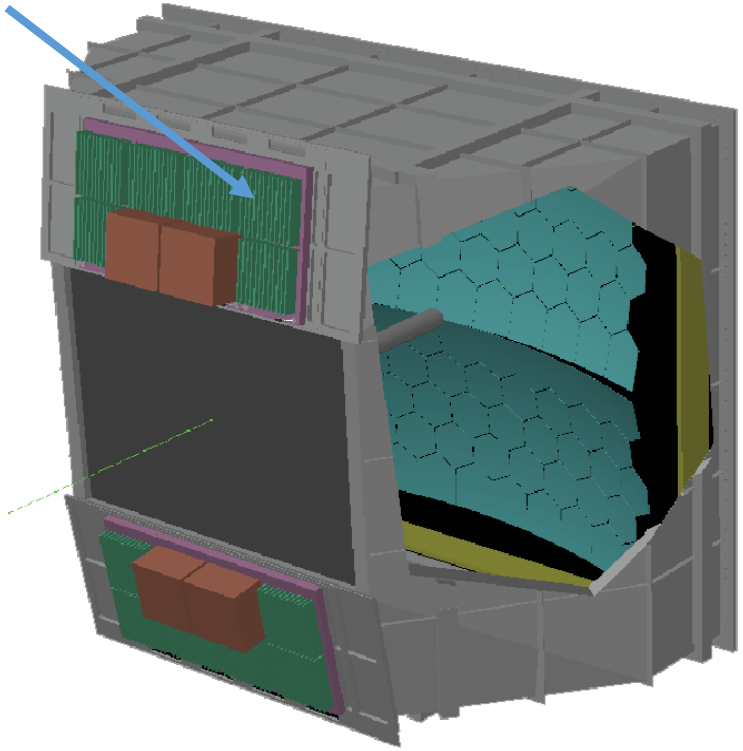
Possibility to Check shorts in micromegas pads in the Hybrids and fix them.

Refurbishment and repairs of gaseous detectors



Collection wires are important element to separate signals from ionizing particles and photons.

Repair of the broken HV connection to collection wires.

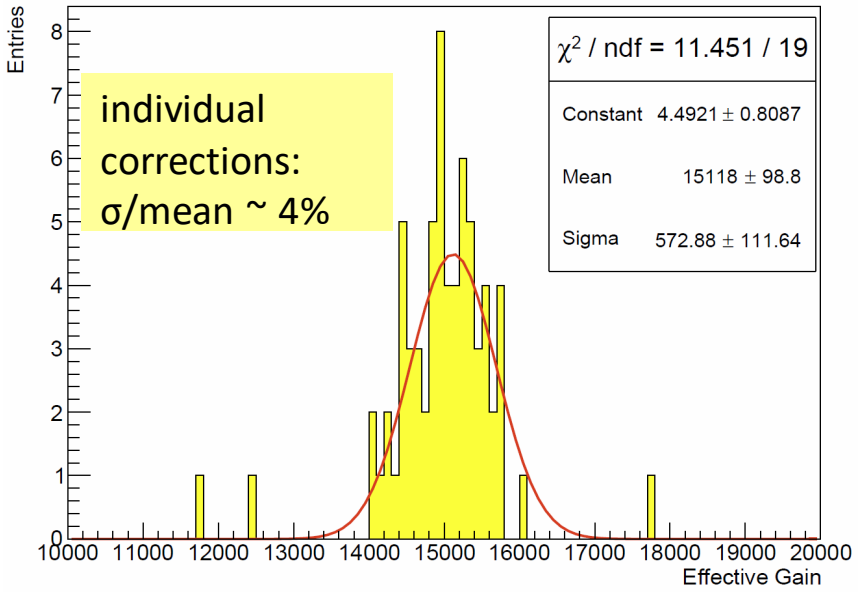


Requirement: all tracking between SM1 and RICH and H1 in garage position.

Refurbishment and repairs of gaseous detectors

New HV system for all MWPC detectors. Mainframe is installed. Modules being purchased.
MWPCs will be integrated to the framework of hybrids temperature and pressure compensating HV power supply.

For the PT sensors: The implementation of the sensors will be non trivial. MWPCs cover double the volume of Hybrids.
Sensors to be inserted in the chamber volume where CsI is present.
Readout of the PT sensor will be based on Hybrids.
Extended software of the Hybrids to integrate all gaseous detector of RICH in the framework.



MAPMTs readout cooling system, LV cables and fiber optics

Fibers have been destroyed by the mice. Cleaning has been done.
New fibers have been ordered thanks to the Charles University group.
Cables with group of 48 optical fibers will be used.

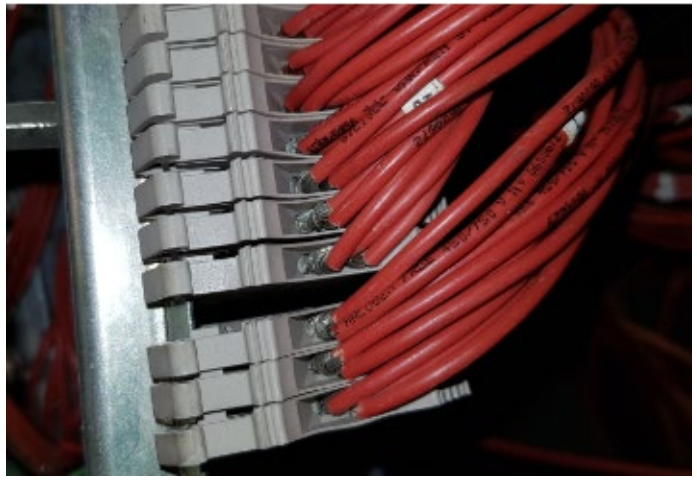
MAPMTs readout cooling system, LV cables and fiber optics

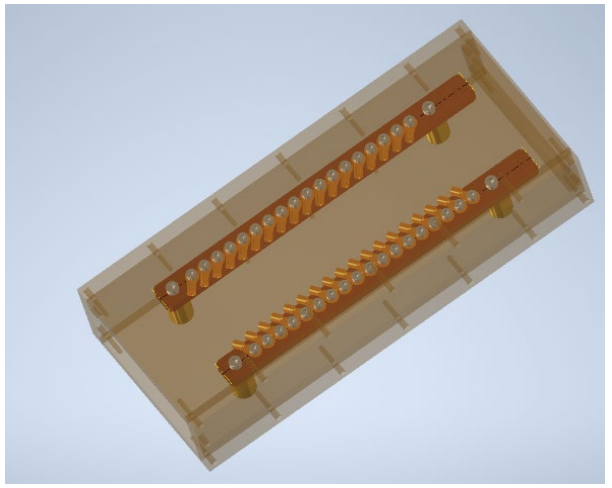
1. Replacement of pipes and pumps.

→ pumps have been bought. Some modifications are to be done. They are at CERN.

→ The pipes will be replaced at the last intervention.

2. LV modules for roof CMADs on bottom MAPMTs will be replaced.
3. Replacement of the weakest Weiner P.S. for the LV distribution system.

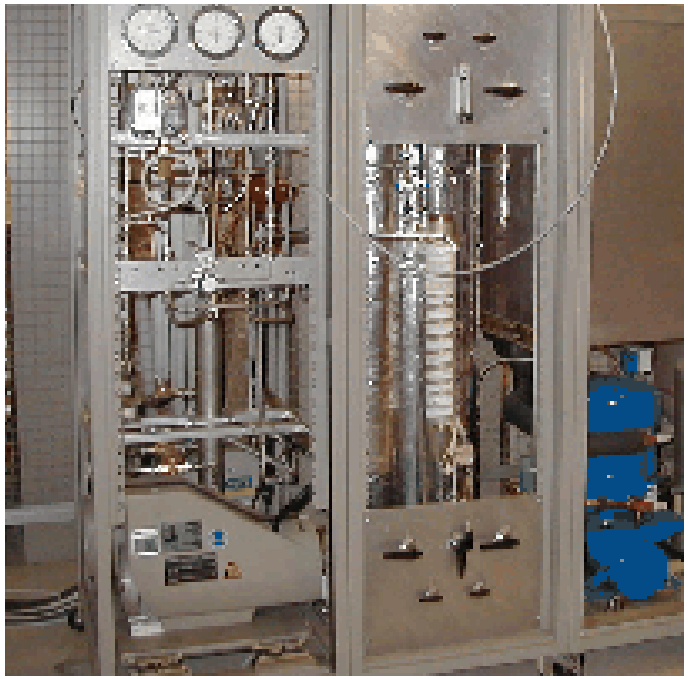




Tests with visible LED inside RICH to check functionalities of all MAPMTs.

RICH radiator gas-system maintenance

Standard Compressor are sent to HAUG. One will be installed. One as a spare.



Compressor for the fast circulation: segments of the piston will be replaced.

RICH radiator gas-system upgrade

The most critical elements are presently represented by:

- vessel pressure gauge
- vessel pressure controller
- pneumatic vessel input valve

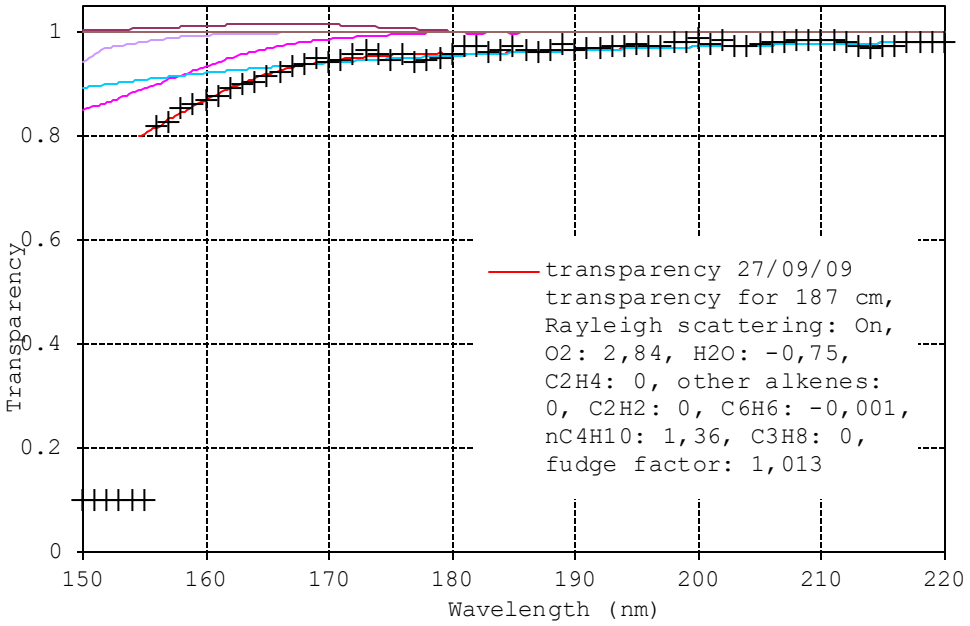
Preparing to repair and duplicate the system:

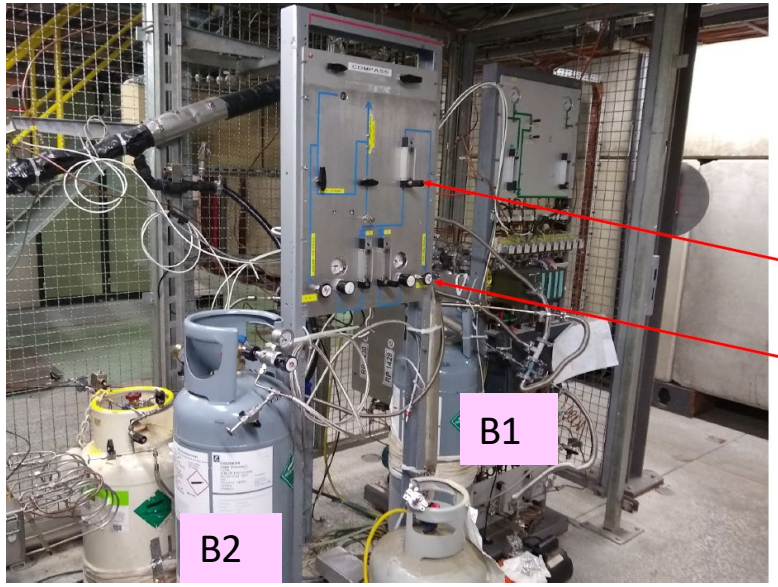
- second pressure gauge
- second controller
- new connections to the controllers
- split of the main input line with commuting valves
- second pneumatic valve to be installed

It will be a major intervention and needs the help from Stephane Berry for the implementation and calibration.

RICH radiator gas-cleaning

2 Bottles from F2 chemicals of 20 kg each received: analysis of the new gas is done and gas is been validated.





Purchase procedure has been initiated

Conclusion

1. A consistency has been achieved in ring and photon level information.
2. Squared masses of identified particles have become well behaved and compatible with theoretical predictions.
3. Tuning of the software is ongoing in order to optimized particle identification.
4. The cross-checking in the likelihood computation algorithm is ongoing. Possibility to tune parameters in under investigation.
5. Hybrid characterization has been performed. Toward finalization.

6. Extensive hardware activities are ongoing for the preparation of 2021 run.
7. 2021 RICH will be similar to 2016-2017 setup.
8. Refurbishment of hybrids and MWPCs have been initiated. General refurbishment and repairs are ongoing.
9. Radiator gas has been validated and purchase procedure is started.