Main detector tiling studies and analysis

Krishna Kumar, Ciprian Gal

Last time: Preliminary deconvolution analysis

- The deconvolution analysis is based on the 5 process fit (ee, ep-elastic, ep-inelastic 1<W<1.4, ep-inelastic 1.4<W<2.5, ep-inelastic 2.5<W<6); the rest of the physics processes are taken as known

Base deconvolution results; used in the past reviews

Overall			
Name	Asymmetry	uncert[ppb]	relative uncer
moller	-34.8017	0.7590	2.18%
ep Elastic	-30.6255	2.1062	6.88%
ep Inelastic W1	-606.4100	110.6770	18.25%
ep Inelastic W2	-604.2320	58.9211	9.75%
ep Inelastic W3	-491.2	141.8	28.87%

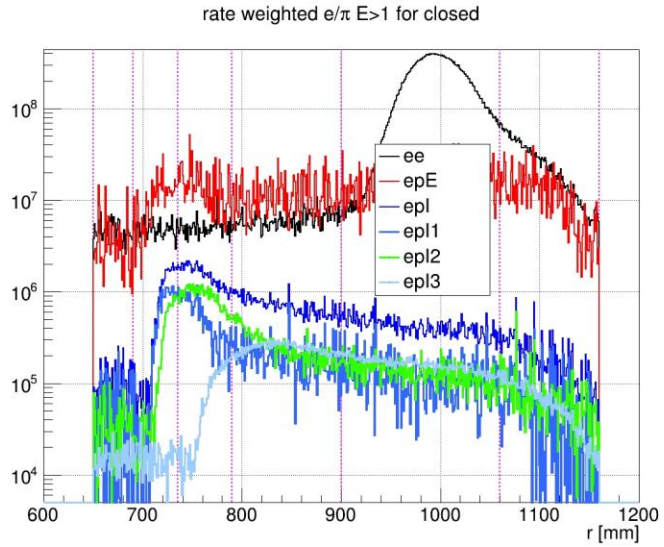
Version 1: uniform R5 tiles starting at the same R

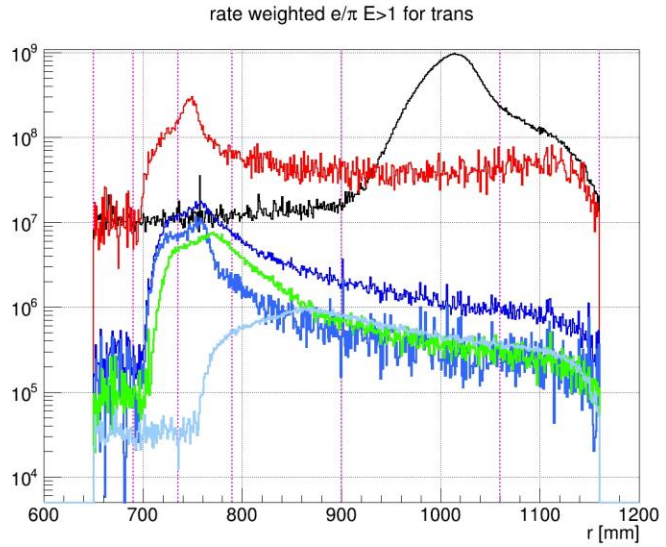
Consistent with what Sakib showed recently.

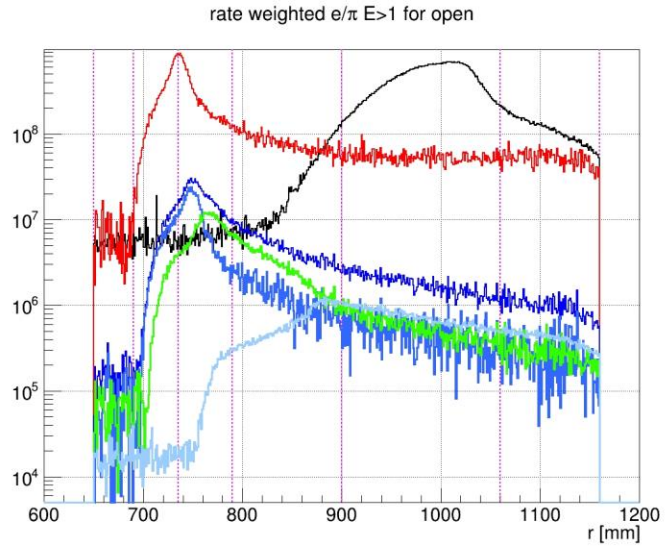
Overall			
Name	Asymmetry	uncert[ppb]	relative uncer
moller	-34.87	0.74	2.13%
ep Elastic	-28.69	1.77	6.17%
ep Inelastic W1	-613.86	88.11	14.35%
ep Inelastic W2	-596.22	51.32	8.61%
ep Inelastic W3	-463.20	111.92	24.16%

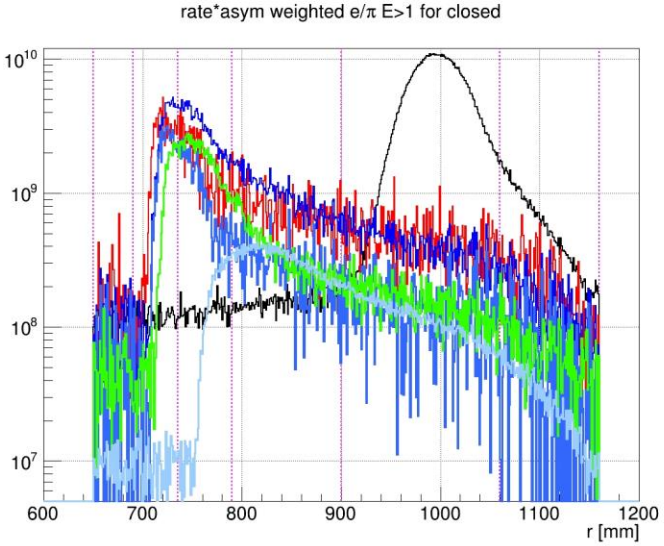
- Initial results show that deconvolution results are consistent even when changing to uniform R5 tiles and transition radii between R4 and R5
  - The improvement in statistics is due to increased overlap in the transition sector

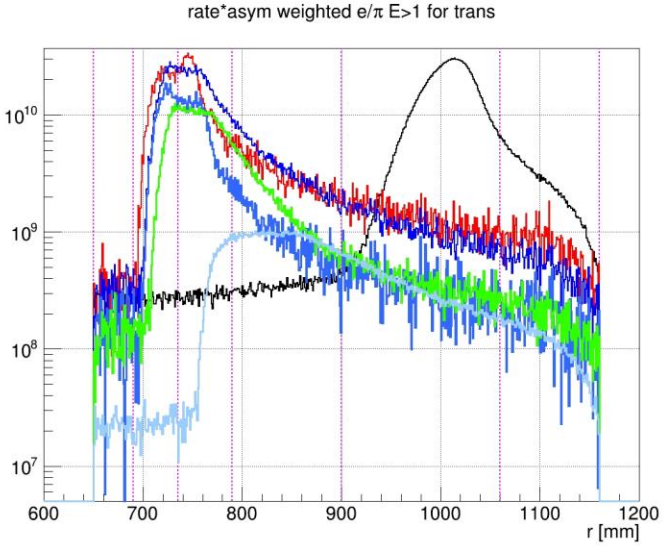
Baseline – conf3

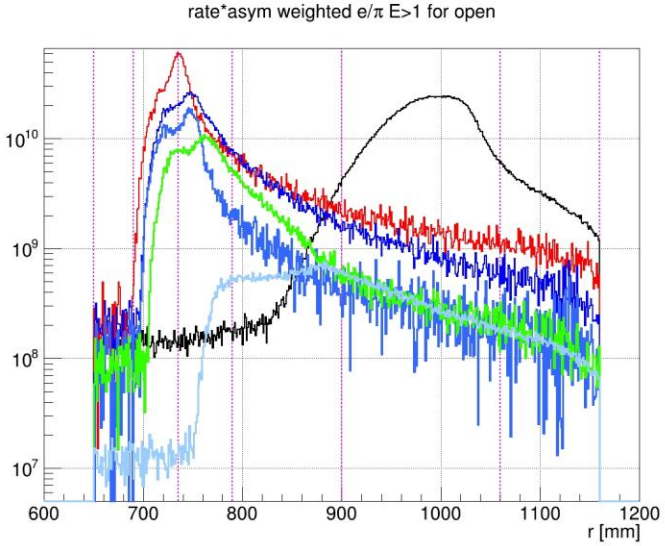












- The “non-fit” distributions are not in these plots since they won’t drive the decision (see backups)

Moller contributions – base configuration

- Approximately 13% of the total MOLLER rate will be located in ring 6
  - Adjusting the length of ring5 can reduce the dependence on ring6 to determine our signal
  - At a (18)20cm length we can go down to (8.6)5.4% MOLLER rate in ring 6
- Looking at the deconvolution will give us a better feeling for the overall improvement
  - Regardless of the length of the R5 tile the epInelastic and epElastic see basically no change
  - The MOLLER extraction sees a decrease in precision for larger tile sizes (also at smaller sizes although with a smaller slope)

R	S	Moller f [% R_proc]	Moller R [Hz]
1	C	0.10%	1.46E+08
1	T	0.23%	3.47E+08
1	O	0.11%	1.67E+08
2	C	0.11%	1.65E+08
2	T	0.25%	3.67E+08
2	O	0.14%	2.08E+08
3	C	0.15%	2.18E+08
3	T	0.34%	5.07E+08
3	O	0.18%	2.73E+08
4	C	0.34%	5.15E+08
4	T	0.78%	1.17E+09
4	O	1.84%	2.76E+09
5	C	14.27%	2.13E+10
5	T	31.31%	4.68E+10
5	O	36.87%	5.51E+10
6	C	1.34%	2.01E+09
6	T	5.56%	8.31E+09
6	O	6.06%	9.06E+09

			moller				epElastic				e-p Inelastic [1,1.4)				e-p Inelastic [1.4,2.5)				e-p Inelastic [2.5,6)			
1	baselineConf3	650<R1<690 <R2<735 <R3<790 <R4<900 <R5<1060 <R6<1160																				
3	Name	Description	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	rel increase
5	conf7	conf3 with R5-R6 transition at 1040	-35.33	0.75	2.132%	0.1%	-29.55	1.82	6.172%	0.0%	-613.15	88.00	14.353%	0.0%	-599.15	51.58	8.609%	0.0%	-472.35	114.15	24.165%	0.0%
6	conf8	conf3 with R5-R6 transition at 1050	-35.07	0.75	2.129%	0.0%	-29.09	1.80	6.171%	0.0%	-614.73	88.23	14.352%	0.0%	-598.89	51.55	8.608%	0.0%	-467.70	113.01	24.164%	0.0%
7	baselineConf3	R5 tiles all same length (16 cm); transition between rings the same for O/C/T for all rings	-34.87	0.74	2.129%	0.0%	-28.69	1.77	6.171%	0.0%	-613.86	88.11	14.353%	0.0%	-596.22	51.32	8.608%	0.0%	-463.20	111.92	24.162%	0.0%
9	conf5	conf3 with R5-R6 transition at 1080	-34.54	0.74	2.133%	0.2%	-27.70	1.71	6.172%	0.0%	-614.22	88.17	14.354%	0.0%	-594.16	51.15	8.608%	0.0%	-454.65	109.86	24.163%	0.0%
10	conf6	conf3 with R5-R6 transition at 1100	-34.25	0.73	2.141%	0.5%	-26.72	1.65	6.175%	0.1%	-616.81	88.55	14.357%	0.0%	-593.67	51.11	8.609%	0.0%	-446.36	107.87	24.167%	0.0%

R4-R5 transition studies

			moller				epElastic				e-p Inelastic [1,1.4)				e-p Inelastic [1.4,2.5)				e-p Inelastic [2.5,6)			
1	baselineConf3	650<R1<690 <R2<735 <R3<790 <R4<900 <R5<1060 <R6<1160																				
2																						
3	Name	Description	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	rel increase
7	baselineConf3	R5 tiles all same length (16 cm); transition between rings the same for O/C/T for all rings	-34.87	0.74	2.129%	0.0%	-28.69	1.77	6.171%	0.0%	-613.86	88.11	14.353%	0.0%	-596.22	51.32	8.608%	0.0%	-463.20	111.92	24.162%	0.0%
11	conf9	conf3 with R4-R5 transition at 910	-34.94	0.74	2.120%	-0.4%	-28.06	1.74	6.189%	0.3%	-606.43	87.43	14.417%	0.5%	-595.42	51.27	8.611%	0.0%	-453.85	107.53	23.692%	-1.9%
12	conf10	conf3 with R4-R5 transition at 920	-35.00	0.74	2.118%	-0.5%	-27.49	1.71	6.224%	0.9%	-605.30	87.96	14.532%	1.2%	-590.97	50.96	8.624%	0.2%	-445.29	104.29	23.420%	-3.1%
13	conf17	conf3 with R4-R5 transition at 940	-35.01	0.75	2.135%	0.3%	-26.55	1.67	6.282%	1.8%	-597.60	87.95	14.716%	2.5%	-585.86	50.68	8.651%	0.5%	-428.79	100.91	23.534%	-2.6%

- Adjustments in this transition adjust R5 and R4 at the same time
- We can see that with a decreased R5 and increased R4 we can some improvements for both ee and epI3 extractions
- The epE, epI1, epI2 all see their relative uncertainty increase

Lower ring transition studies

			moller				epElastic				e-p Inelastic [1,1.4)				e-p Inelastic [1.4,2.5)				e-p Inelastic [2.5,6)			
1	baselineConf3	650<R1<690 <R2<735 <R3<790 <R4<900 <R5<1060 <R6<1160																				
3	Name	Description	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	rel increase
7	baselineConf3	R5 tiles all same length (16 cm); transition between rings the same for O/C/T for all rings	-34.87	0.74	2.129%	0.0%	-28.69	1.77	6.171%	0.0%	-613.86	88.11	14.353%	0.0%	-596.22	51.32	8.608%	0.0%	-463.20	111.92	24.162%	0.0%
14	conf11	conf3 with R3-R4 transition at 800	-34.87	0.74	2.132%	0.1%	-28.69	1.77	6.184%	0.2%	-613.86	87.96	14.330%	-0.2%	-596.22	49.87	8.364%	-2.8%	-463.20	110.94	23.950%	-0.9%
15	conf12	conf3 with R3-R4 transition at 780	-34.87	0.74	2.132%	0.1%	-28.69	1.77	6.158%	-0.2%	-613.86	87.58	14.268%	-0.6%	-596.22	54.18	9.088%	5.6%	-463.20	117.19	25.301%	4.7%
16	conf13	conf3 with R2-R3 transition at 740	-34.87	0.74	2.128%	-0.1%	-28.69	1.62	5.642%	-8.6%	-613.86	86.80	14.139%	-1.5%	-596.22	54.30	9.108%	5.8%	-463.20	114.69	24.760%	2.5%
17	conf14	conf3 with R2-R3 transition at 745	-34.87	0.74	2.126%	-0.1%	-28.69	1.69	5.885%	-4.6%	-613.86	97.75	15.923%	10.9%	-596.22	57.58	9.658%	12.2%	-463.20	119.99	25.904%	7.2%
18	conf15	conf3 with R1-R2 transition 680	-34.87	0.74	2.130%	0.0%	-28.69	1.78	6.221%	0.8%	-613.86	89.60	14.597%	1.7%	-596.22	51.85	8.696%	1.0%	-463.20	112.21	24.226%	0.3%

- R3-R4 transitions:
  - Moving the boundary up to 800 seems to give a significant improvement for epI2 (and to a lesser degree to epI3)
- R2-R3 transition:
  - There seems to be an improvement on the epE precision if we increase ring2 by 5 mm
  - This mostly seems to be cancelled by the degradation of epI2 and epI3
- R1-R2 transition:
  - The decrease in length of R1 (4 to 3 cm) doesn't seem to affect the deconvolution much
  - The benefit would be that we will have a 1cm buffer from the start of the epE signal

Configuration 16

- Takes the default and adds R4-R5 transition at 920 and R3-R4 transition at 800

	baseline/configuration 3				configuration 16		
Ring	Rmin [mm]	Rmax [mm]	Length [mm]		Rmin [mm]	Rmax [mm]	Length [mm]
1	650	690	40		650	690	40
2	690	735	45		690	735	45
3	735	790	55		735	800	65
4	790	900	110		800	920	120
5	900	1060	160		920	1060	140
6	1060	1160	100		1060	1160	100

Config16

Overall			
Name	Asymmetry	uncert[ppb]	relative uncer
moller	-35.00	0.74	2.12%
ep Elastic	-27.49	1.71	6.23%
ep Inelastic W1	-605.30	87.56	14.47%
ep Inelastic W2	-590.97	49.30	8.34%
ep Inelastic W3	-445.29	103.47	23.24%

Config 3

Overall			
Name	Asymmetry	uncert[ppb]	relative uncer
moller	-34.87	0.74	2.13%
ep Elastic	-28.69	1.77	6.17%
ep Inelastic W1	-613.86	88.11	14.35%
ep Inelastic W2	-596.22	51.32	8.61%
ep Inelastic W3	-463.20	111.92	24.16%

- Overall the changes are small (small improvement in the ee and epI2, epI3 extraction; and worsening in epE, epI1)
- However the reduced length in R5 should help with construction and reduce PE loss

Configuration 21 and 22

baselineConf3	650<R1<690 <R2<735 <R3<790 <R4<900 <R5<1060 <R6<1160																			
		moller				epElastic				e-p Inelastic [1,1.4)				e-p Inelastic [1.4,2.5)				e-p Inelastic [2.5,6)			
Name	Description	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	rel increase
baselineConf3	R5 tiles all same length (16 cm); transition between rings the same for O/C/T for all rings	-34.87	0.74	2.129%	0.0%	-28.69	1.77	6.171%	0.0%	-613.86	88.11	14.353%	0.0%	-596.22	51.32	8.608%	0.0%	-463.20	111.92	24.162%	0.0%
conf16	conf3 with R4-R5=920; R3-R4=800	-35.00	0.74	2.120%	-0.4%	-27.49	1.71	6.229%	0.9%	-605.30	87.56	14.465%	0.8%	-590.97	49.30	8.342%	-3.1%	-445.29	103.47	23.236%	-3.8%
conf21	conf16: R2-R3 740	-35.00	0.74	2.118%	-0.1%	-27.49	1.57	5.718%	-8.2%	-605.30	86.36	14.267%	-1.4%	-590.97	51.91	8.784%	5.3%	-445.29	105.41	23.672%	1.9%
conf22	conf21: R1-R2 680	-35.00	0.74	2.118%	0.0%	-27.49	1.58	5.759%	0.7%	-605.30	87.59	14.470%	1.4%	-590.97	52.30	8.850%	0.8%	-445.29	105.56	23.706%	0.1%

- Changing R2-R3 to 740 maintains the gains in from conf16 as in conf13 where we changed wrt the baseline (ee, epE and epI1 show an improvement)
- Decreasing R1 by 1 cm doesn't show a big impact on the overall deconvolution

	baseline/configuration 3				**configuration 22**		
Ring	**Rmin [mm]**	**Rmax [mm]**	**Length [mm]**		**Rmin [mm]**	**Rmax [mm]**	**Length [mm]**
1	650	690	40		650	680	30
2	690	735	45		690	740	60
3	735	790	55		740	800	60
4	790	900	110		800	920	120
5	900	1060	160		920	1060	140
6	1060	1160	100		1060	1160	100

Final R5 scan

baselineConf3	650<R1<690 <R2<735 <R3<790 <R4<900 <R5<1060 <R6<1160																			
		moller				epElastic				e-p Inelastic [1,1.4)				e-p Inelastic [1.4,2.5)				e-p Inelastic [2.5,6)			
Name	Description	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	el increas	val	d(val)	d(val)/val	rel increase	val	d(val)	d(val)/val	rel increase
baselineConf3	R5 tiles all same length (16 cm); transition between rings the same for O/C/T for all rings	-34.87	0.74	2.129%		-28.69	1.77	6.171%		-613.86	88.11	14.353%		596.22	51.32	8.608%		-463.20	111.92	24.162%	
conf22	conf21: R1-R2 680	-35.00	0.74	2.118%		-27.49	1.58	5.759%		-605.30	87.59	14.470%		590.97	52.30	8.850%		-445.29	105.56	23.706%	
conf23	conf22: R5-R6 1030	-35.89	0.76	2.126%	0.4%	-28.86	1.66	5.762%	0.1%	-603.42	88.10	14.600%	0.9%	-592.36	52.43	8.851%	0.0%	-459.76	109.04	23.716%	0.0%
conf24	conf22: R5-R6 1040	-35.50	0.75	2.120%	0.1%	-28.30	1.63	5.760%	0.0%	-605.90	87.32	14.411%	-0.4%	-594.07	52.58	8.850%	0.0%	-454.40	107.74	23.711%	0.0%
conf25	conf22: R5-R6 1050	-35.21	0.75	2.118%	0.0%	-27.86	1.60	5.759%	0.0%	-605.90	87.67	14.470%	0.0%	-594.03	52.57	8.850%	0.0%	-449.78	106.63	23.707%	0.0%
conf26	conf22: R5-R6 1070	-34.81	0.74	2.120%	0.1%	-26.90	1.55	5.760%	0.0%	-604.35	87.45	14.470%	0.0%	-589.19	52.14	8.850%	0.0%	-440.80	104.50	23.707%	0.0%

- With the new configuration (22) we decided to take another look at the R5-R6 transition to see if anything could be improved (percentages calculated wrt conf22):
  - Moller: decrease by 3 cm sees the largest degradation; while a transition at 1050 (13cm) seems to provide a marginal improvement
  - epElastic, epI2, epI3: no significant changes
  - epI1: the improvement at 1040 is probably not worth the degradation in moller extraction
- **What are the next considerations we should worry about wrt R5 length?**

	configuration 22		
Ring	**Rmin [mm]**	**Rmax [mm]**	**Length [mm]**
1	650	680	30
2	690	740	60
3	740	800	60
4	800	920	120
5	920	1060	140
6	1060	1160	100

Status and future studies

- Configuration 22 seems to be the best we can do right now and we can probably proceed to fixing the z location and differentiation of the tiles
  - Simulation studies will need to be done to account for overlaps and non-trapezoidal quartz shape
- We need to investigate the effect of the light-guide dilution

Backup

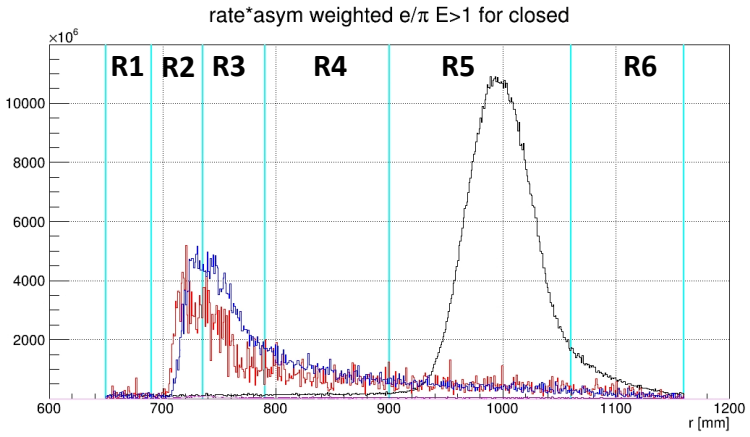
Tiling strategy

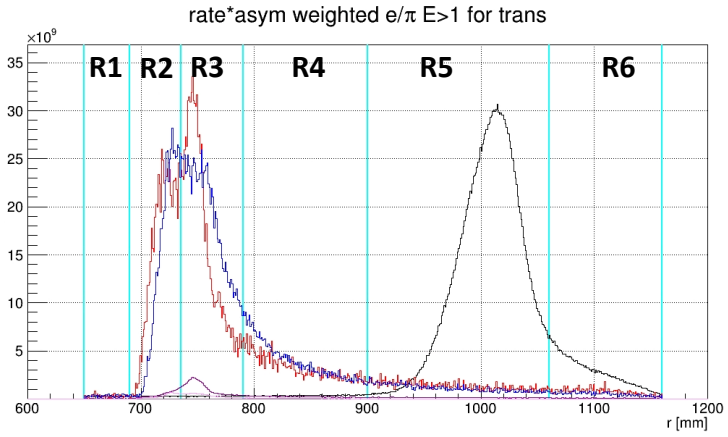
- Goal: improve ability to separate between the different physics processes using the deconvolution
  - Other considerations: dithering slopes, length of quart tiles, reduce ring 1 total rate, increase share of moller signal located in ring 5
- Using virtual plane at 26.5m downstream of the center of the target
  - Results will need to be cross checked once we have the z location of each detector plane (small variations due to defocusing could happen)

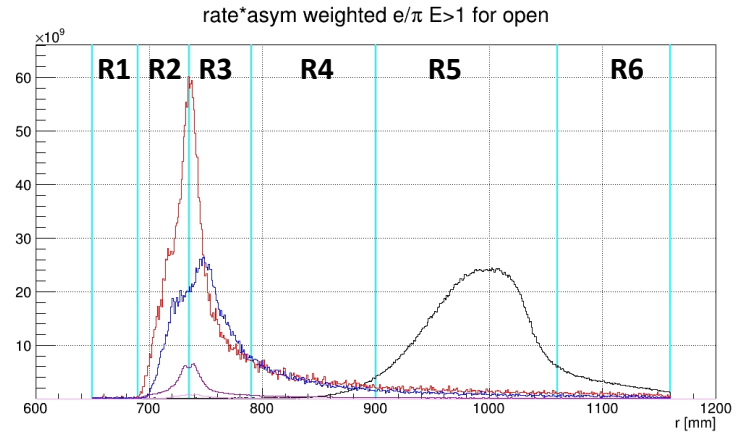
Overall			
Name	Asymmetry	uncert[ppb]	relative uncer
moller	-34.8017	0.7590	2.18%
ep Elastic	-30.6255	2.1062	6.88%
ep Inelastic W1	-606.4100	110.6770	18.25%
ep Inelastic W2	-604.2320	58.9211	9.75%
ep Inelastic W3	-491.2	141.8	28.87%

- Default tiling: uniform 16 cm ring 5 tiles, all sectors start at the same radial positions for all rings
- This configuration provides a marginal improvement over the extraction we had at the last review

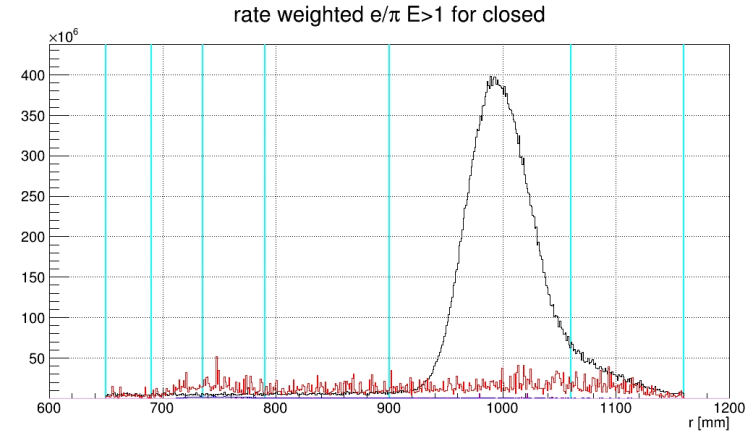
- Other observations:
  - Ring 6 holds about 13% of the total Moeller statistics (R5 is about 82.5%)
  - A big factor in our overall uncertainty will be related to the e-p Inelastic extraction (and it's correlation with the e-p Elastic)
  - The different structure in R2-R4 between the sectors may increase sensitivities if we start the rings at different locations – payoff will need to be verified against engineering realities

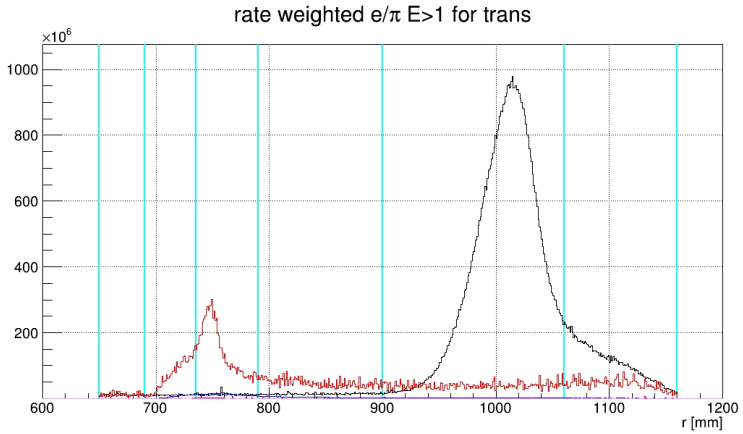


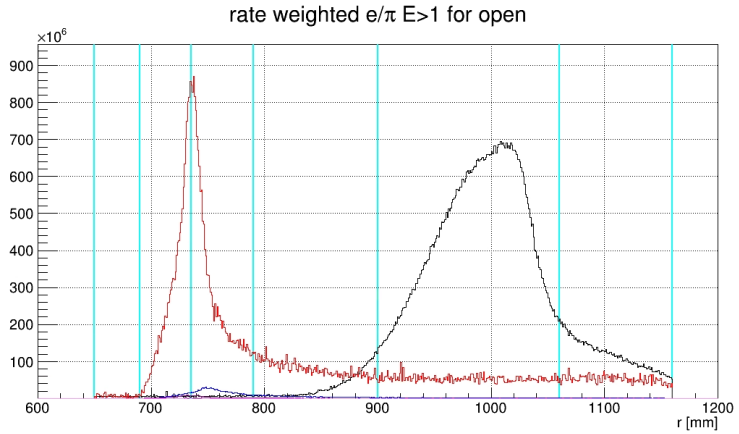


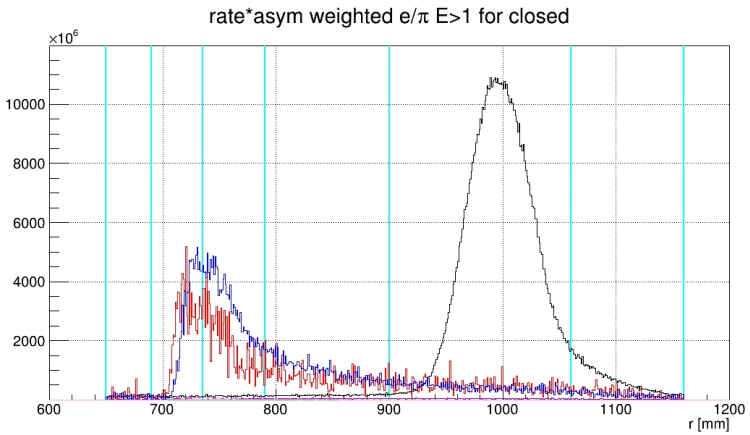


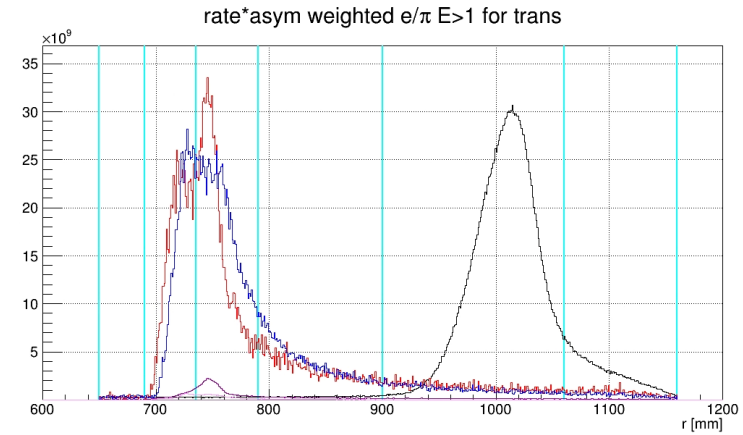
Baseline – conf3

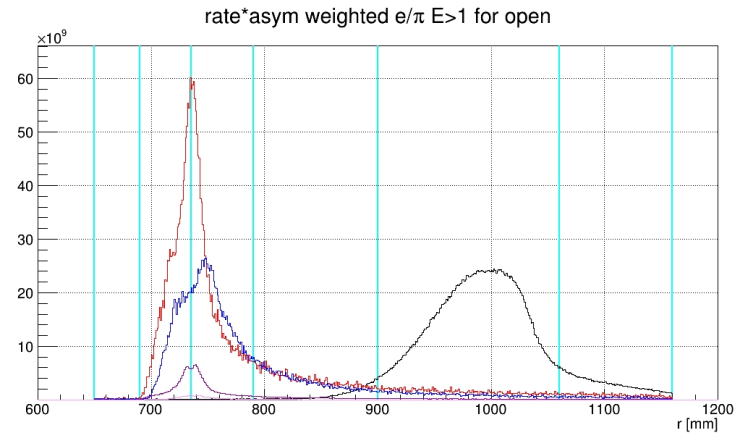




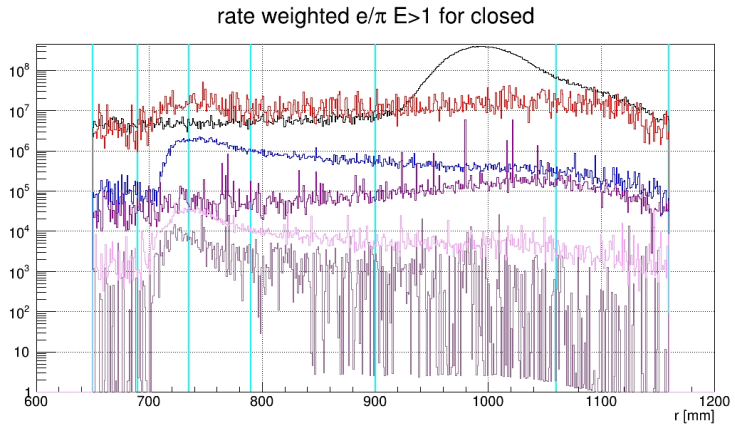


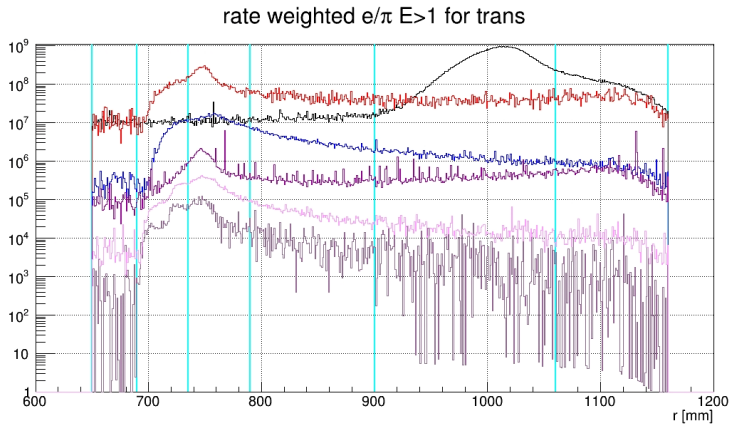


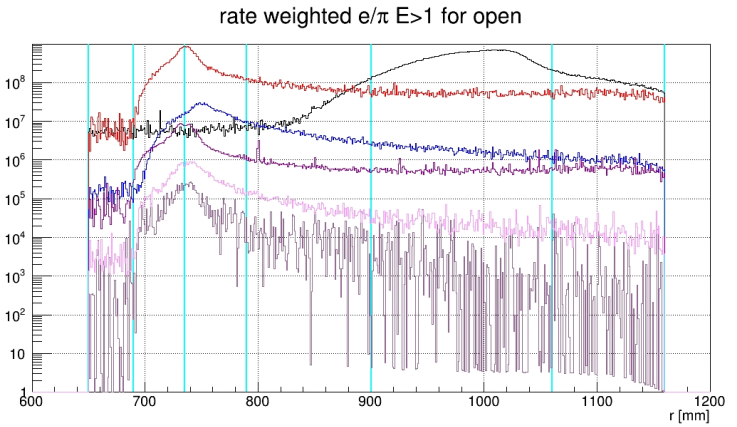


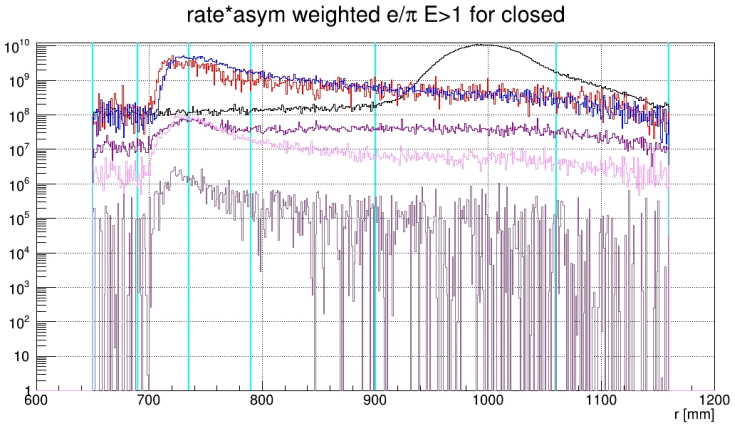


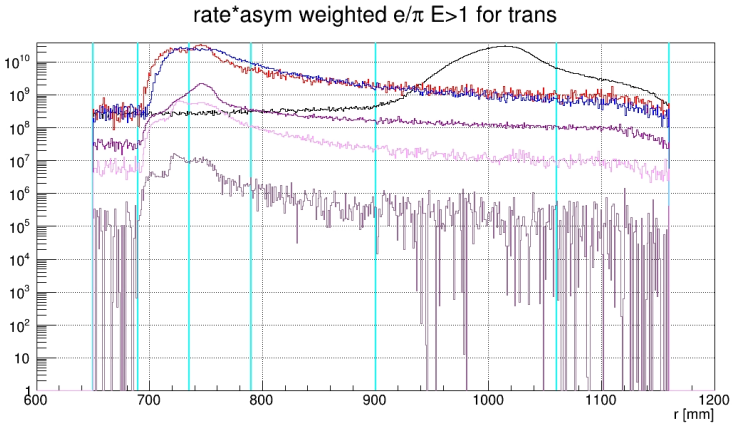
Baseline – conf3

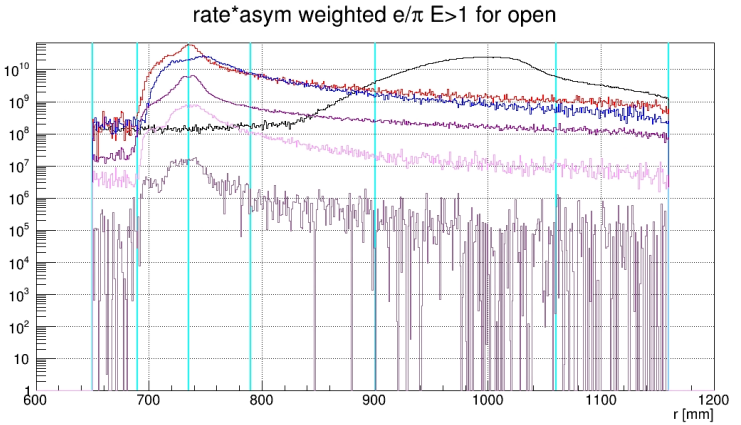






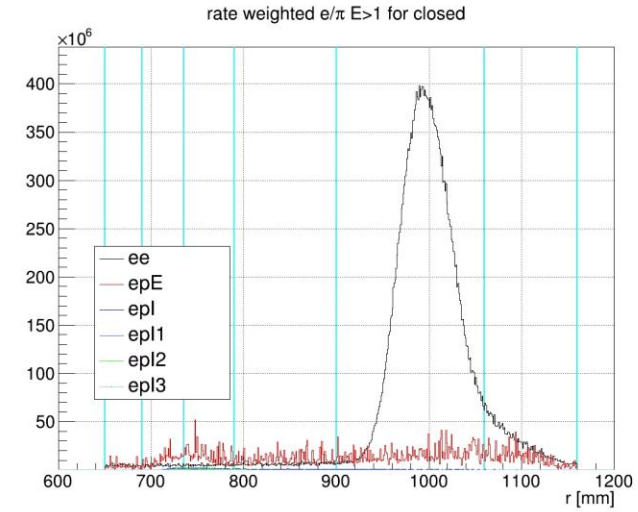


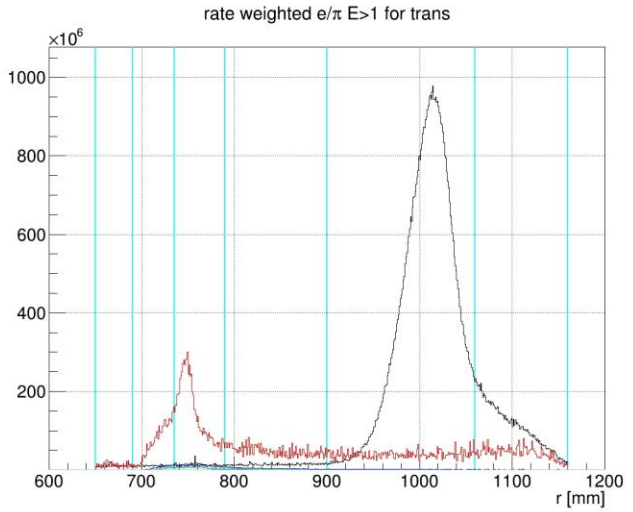


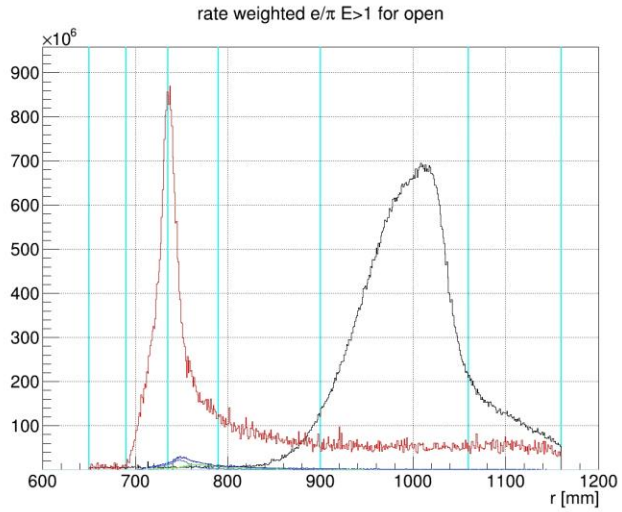


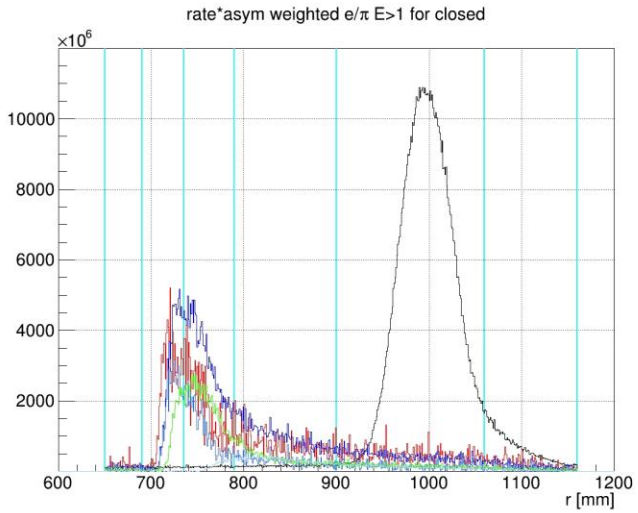
- eAl elastic/quasi/inelastic are in dark magenta/magenta/brown respectively

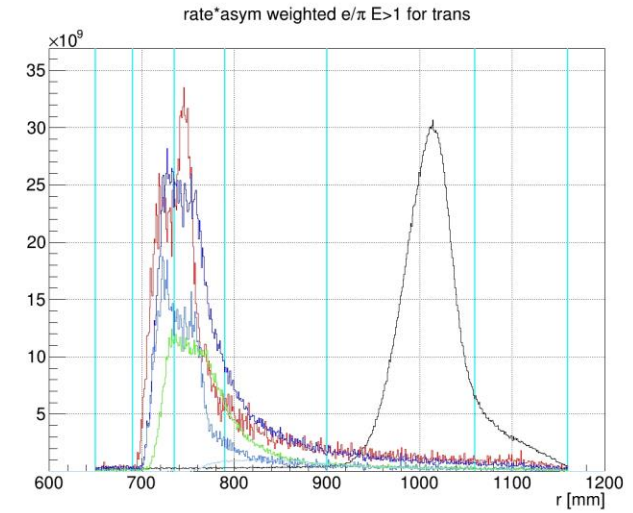
Baseline – conf3

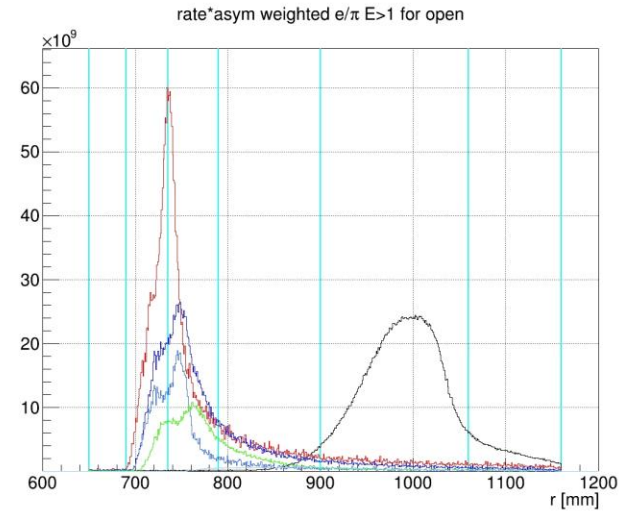




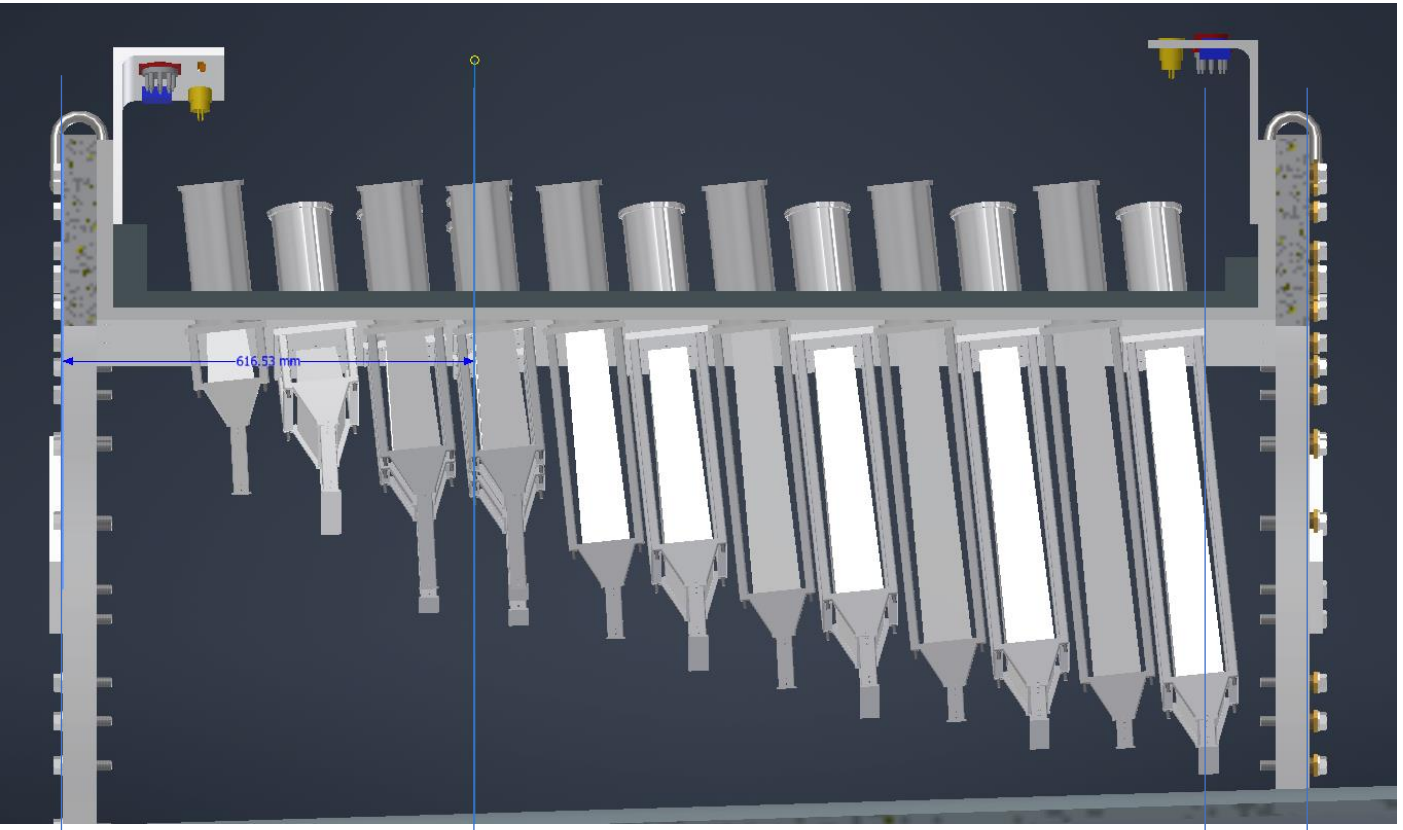


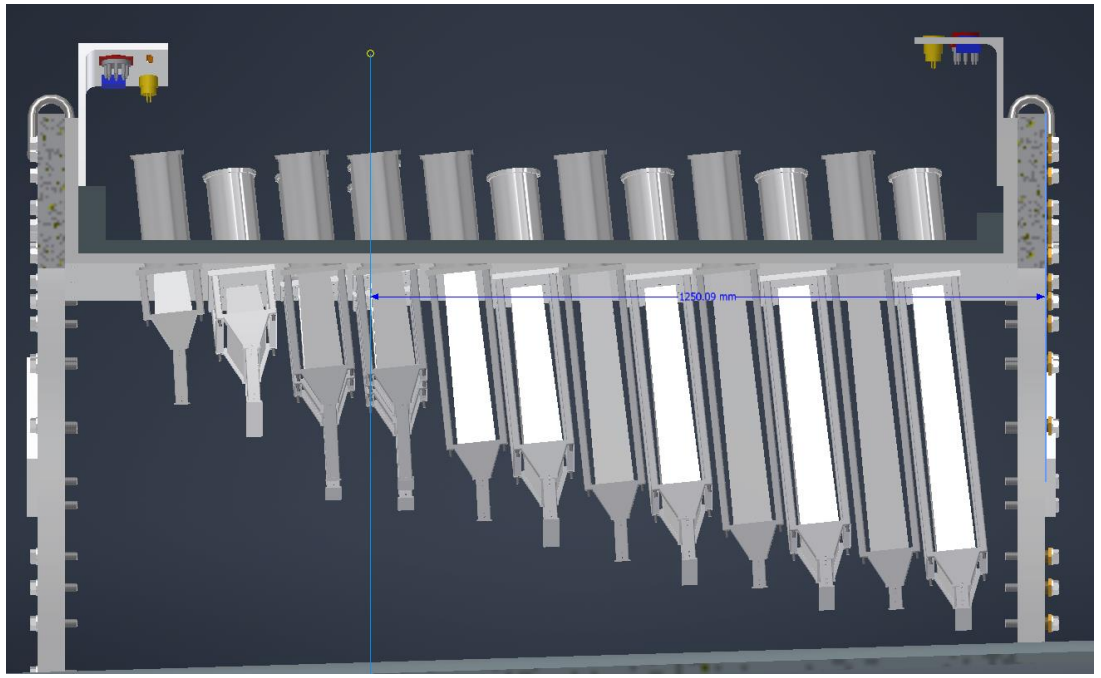






R1 quarz position





- Simple scaling of the figure gives 23.092 m for R1 location
- Pipe Rin= 25.25in (641.35); Rout = 26 in (660.04)