# Update on field propagation

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## Field propagation overview

x<sub>0</sub>, p<sub>0</sub> x<sub>1</sub>, p<sub>1</sub>, Δx, Δp x<sub>2</sub>, p<sub>2</sub>, Δx, Δp

- Field propagation involves solution of Ordinary Differential Equation
  - Typically Runge-Kutta methods are used (as in Geant4)
- In GeantV created vectorised Runge-Kutta propagation
  - Charged tracks in a basket are sent to the FieldPropagation classes
  - Vectorised over tracks
- Challenge to ensure that all vector lanes are working & use mostly vector operations

- Motion in field requires solving ODE for endpoint x, p after length s
- Runge-Kutta step: evaluate B-field, estimate x, p, Δx, Δp
- Successful if  $|\Delta x| < \epsilon s \& |\Delta p| < \epsilon |p|$
- Each step of a Runge-Kutta algorithm is easy to vectorise
  - But different tracks (vector lanes) can take different number of iterations to finish integration
  - The 'driver' class which calls the RK 'stepper' must play coordinate the work

- First version "SimpleIntegrationDriver"
  - sought a good step in each lane
- A step can either
  - Fail,
  - Succeed but not get to the end ("ok")
  - Finish the integration ("done")



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- If a lane is "done", in 'SimpleIntegrationDriver"
  - it must maintain its result ("keep")
- Cross checked against the 'scalar' integration
- Adequate only if the *success rate* of steps is very *high* 
  - Good speedup for constant field
  - Poor results for non-uniform field CMS setup



#### Observations

- Simplest vector algorithm, but implementation is still complex
  - 'OneGoodStep' 109 lines 'cleaned' (no prints, comments, blanks, 'bare' {} )
  - 'AccurateAdvance' 121 lines 'cleaned'
  - The full class is over 2000 lines (with prints, comments, load & test methods)
- This initial version worked in Feb/Mar 2018
  - The applications were updated later to work with non-uniform fields
- In the past 2.5 months
  - Restored changes from March-May 2018
  - With improved checks, made 2 small fixes to fully agree with scalar runs
    - (exponent step growth, error normalization)

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- Reload when lanes reach the end of integration interval



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0 3 2 start failed 1 ok 2 done 3 keep 4 Could finish here. At least one lane is done 5 6

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Decided to do one more. Now return for 'refill'



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  - At least one finishes



## 'Rolling' Integration Driver

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## 'Rolling' Integration Driver

- 'Keep Stepping' in lanes with work
  - Keep all/most lanes working "all the time"
- Reload when lanes reach the end of integration interval
- Potential Criterion for 'reload':
  - At least one finishes
  - One+ finish, plus X steps (current, X=1)
  - ...
  - n>threshold finish
  - All finish (will test but likely not the best.) reload



## Tools to monitor / compare / diagnose

• Utilities to print values in columns: (Real\_v, Real\_v[], Index\_v, Bool\_v)

		from KeepStepping	e After return	## Accurate Advance
-16	15	-14	13	charge :
5.90004855	8.85836995	102.629501	0	hTry (after) :
1780.14462	30000	10000	2000	h-did :
11.1390206	58551.3136	8872.1473	0	hNext :
1780.14462	30000	10000	2000	x :
100000	30000	10000	2000	ExpectEnd/x2 :
-7.38670734	94.9584981	-178.383559	248.397552	/StepStart[0] :
-3.54547822	14.809806	-316.39924	-89.952651	<pre>/StepStart[1] :</pre>
610.4522	1349.46007	1627.85601	1680.47738	<pre>/StepStart[2] :</pre>
0.687921026	0.331494782	-0.149490266	0.455046646	<pre>/StepStart[3] :</pre>
-0.362512014	-0.867564044	-1.04047329	-0.536065199	<pre>/StepStart[4] :</pre>
1.18182202	1.06711213	0.94671915	1.22746777	<pre>/StepStart[5] :</pre>

- Utility to print the status of the lane for a particular track Id
  - Use this to create a 'trace' for comparisons
  - Comparing between Scalar, Simple and new 'Rolling' version

out-VecRollingDrv-printLane14-rs-n30d-outV7.1.log

KPS: h-next :	0	8872.1473	58551.3136	11.1390206	
KPS: facStretch :	5	5	5	0.815130406	
KPS: x0+hdid :	4000	12049.7768	31595.8868	2609.36765	
KPS: xEnd (arg) :	2000	10000	30000	100000	
hdid= [2000, 10000,	30000, 1780.1446	52] and hnext= [0, 88	372.1473, 58551.3136,	11.1390206]	
end of KeepSteppin	g method				
### Accurate Advance	After retur	n from KeenStenning			
charge :	13 I	-14	15	-16	
hTrv (after) :	0	102,629501	8,85836995	5,90004855	
h-did :	2000	10000	30000	1780.14462	
hNext :	0	8872.1473	58551.3136	11.1390206	
##	2000		20000		
X : vEvpectEnd/v2 :	2000	10000	30000	1/80.14462	
##	2000	10000			
<pre>yStepStart[0] :</pre>	248.397552	-178.383559	94.9584981	-7.38670734	
<pre>yStepStart[1] :</pre>	-89.952651	-316.39924	14.809806	-3.54547822	
<pre>yStepStart[2] :</pre>	1680.47738	1627.85601	1349.46007	610.4522	
yStepStart[3] :	0.455046646	-0.149490266	0.331494782	0.687921026	
yStepStart[4] :	-0.536065199	-1.04047329	-0.867564044	-0.362512014	
yStepStart[5] :	1.22746777	0.94671915	1.06711213	1.18182202	
dydx[0] :	0.321677279	-0.0341729082	-0.00490046566	0.120954535	
dydx[1] :	-0.378950149	-0.646492528	-0.594547423	0.262890289	
dydx[2] :	0.867709925	0.762154593	0.804045613	0.957214029	
dydx[3] : -	0.000142264558	-0	0	-0.000333316208	
dydx[4] :	0.000330838846	-0	0	0.000178290744	
dydx[5] :	0.00019722571	-0	0	-6.84//8//1e-06	
##					
vNext[0]:	248.397552	-458.524296	-20.9408812	6.71987528	
yNext[1] :	-89.952651	-5491.11401	-16959.018	16.7377565	
yNext[2] :	1680.47738	7654.14713	24108.0531	1544.21358	
yNext[3] :	0.455046646	-0.0483423852	-0.00693253438	0.173791671	
yNext[4] :	-0.536065199	-0.914554613	-0.841087508	0.371455295	
yNext[5] :	1.22746777	1.07817487	1.137458	1.35396096	
"" diff[p] :	0	-3.45889357e-07	8.8067071e-07	1.38827705e-05	
dipi/ipi :		-2.44506809e-07	6.22528361e-07	9.81328092e-06	
momEnd :	1.41460612	1.41464065	1.41466849	1.41470593	
##	13	_14	15 1		
Move-x t	1.5	-290 140727	_115_900270	14 1065926	
Move-v 1	a	-5174.71477	-16973.8278	20, 2832347	
Move-z :	, a l	6026.29112	22758,5931	933,761382	
Move-L :	0	7948,10269	28391,5097	934,088178	
Move-L/hdid :	0	0.794810269	0.946383656	0.524726008	
hRequest= [2000, 10	000, 30000, 10000	00]			
hdid = [2000, 10	000, 30000, 1780.	14462]			
x (Now) = [2000, 10]	000, 30000, 1780.	14462]			
$x^2 - x = [0, 0, 0]$	98219.8554]	12002201 +1	LT	0 0500005 5 0	00010551
AccurateAdvance: hne	xt = [0, 0, 0, 1]	1.1390206] to replace	e niry = [0, 102.62950]	1, 8.85836995, 5.90	0004855]
lactStop   m[1110]				11.139020	
Cop ki/a 4/19 < - vN	ext . as 1+ lanes	continue.			

9350	KPS: h-next :	0	8872.1473	58551.3136	11.1390206
9351	KPS: facStretch :	5	5	5	0.815130406
9352	KPS: x0+hdid :	4000	12049.7768	31595.8868	2609.36765
9353	KPS: xEnd (arg) :	2000	10000	30000	100000 1
9354	hdid= [2000, 100	00. 30000. 1780.144	621 and hnext= [0. 8	872,1473, 58551,3136	11.13902061
9355	end of KeenStep	ping method			
9356	##				
9357	### Accurate Adva	nce —— After retu	rn from KeenStepping		
9358	charge :	13	-14	15	-16
9359	hTry (after) :	0	102,629501	8,85836995	5,90004855
9360	h-did :	2000	10000	30000	1780,14462
9361	hNext :	- 0	8872,1473	58551,3136	11,1390206
9362	##	•			
9363	x :	2000	10000	30000 1	1780,14462
9364	xExpectEnd/x2 :	2000	10000	30000	100000
9365	##				
9366	vStepStart[0] :	248,397552	-178,383559	94,9584981	-7.38670734
9367	vStepStart[1] :	-89,952651	-316,39924	14.809806	-3.54547822
9368	vStepStart[2] :	1680,47738	1627.85601	1349,46007	610,4522
9369	vStepStart[3] :	0.455046646	-0.149490266	0.331494782	0.687921026
9370	vStepStart[4] :	-0.536065199	-1.04047329	-0.867564044	-0.362512014
9371	vStepStart[5] :	1.22746777	0.94671915	1.06711213	1,18182202
9372	##				
9373	dvdx[0] :	0.321677279	-0.0341729082	-0.00490046566 l	0.120954535
9374	dvdx[1] :	-0.378950149	-0.646492528	-0.594547423	0.262890289
9375	dvdx[2] :	0.867709925	0.762154593	0.804045613	0.957214029
9376	dvdx[3] :	-0.000142264558	-0	0	-0.000333316208
9377	dvdx[4] :	0.000330838846	-0 1	ē i	0.000178290744
9378	dvdx[5] :	0.00019722571	-0	ē i	-6.84778771e-06
9379	##			· · · · · · · · · · · · · · · · · · ·	
9380	##				
9380 9381	##	248.397552	-458.524296	-20.9408812	5.06516067
9380 9381 9382	## yNext[0]: yNext[1]:	248.397552   -89.952651	-458.524296   -5491.11401	-20.9408812   -16959.018	5,06516067
9380 9381 9382 9383	<pre>##     yNext[0] :     yNext[1] :     yNext[2] :</pre>	248.397552   -89.952651   1680.47738	-458.524296   -5491.11401   7654.14713	-20.9408812   -16959.018   24108.0531	5.06516067 13.1430032 1531.1338
9380 9381 9382 9383 9383	##	248.397552   -89.952651   1680.47738   0.455046646	-458.524296 -5491.11401 7654.14713 -0.0483423852	-20.9408812   -16959.018   24108.0531   -0.00693253438	5.06516067   13.1430032   1531.1338   0.171115121
9380 9381 9382 9383 9384 9385	##	248.397552   89.952651   1680.47738   0.455046646   -0.536065199	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508	5.06516067   13.1430032   1531.1338   0.171115121   0.371912503
9380 9381 9382 9383 9384 9385 9386	<pre>////////////////////////////////////</pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458	5.06516067   13.1430032   1531.1338   0.171115121   0.371912503   1.35417655
9380 9381 9382 9383 9384 9385 9386 9386 9387	## yNext[0]: yNext[1]: yNext[2]: yNext[3]: yNext[4]: yNext[5]:	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458	5.06516067 13.1430032 4531.1338 0.171115121 0.371912503 1 <u>.35417655</u>
9380 9381 9382 9383 9384 9385 9386 9386 9387 9388	## yNext[0] : yNext[1] : yNext[2] : yNext[3] : yNext[4] : yNext[5] : ## diff p] :	248.397552 -89.952651 1660.47738 0.455046646 -0.536065199 1.22746777	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458   8.8067071e-07	5.06516067   13.1430032   531.1338   0.171115121   0.371912503   1.35417655   1.4078631e-05
9380 9381 9382 9383 9384 9385 9386 9387 9388 9388 9389	## yNext[0] : yNext[1] : yNext[2] : yNext[3] : yNext[4] : yNext[5] : ## diff[p] : d[p]/[p] :	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07	5.06516067   13.1430032   15.31.1338   0.171115121   0.371912503   1.35417655   1.4078631e-05   9.95172839e-06
9380 9381 9382 9383 9384 9385 9386 9386 9388 9388 9388 9389 9390	<pre>## yNext[0] : yNext[1] : yNext[2] : yNext[3] : yNext[4] : yNext[5] : ## diff p  : d p /[p] :  momEnd  :</pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 0 1.41460612	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065	-20.9408812   -16959.018   24108.0531   -0.00692253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849	5.06516067   13.1430032   1531.1338   0.171115121   0.371912503   1.35417655   1.4078631e-05   9.95172839e-06   1.41470613
9380 9381 9382 9383 9384 9385 9386 9387 9388 9387 9388 9389 9389 9390 9391	<pre>## yNext[0]: yNext[1]: yNext[2]: yNext[3]: yNext[4]: yNext[5]: ## diff p]: d p / p]:  momEnd]: ##</pre>	248.397552   -69.952651   1680.47738   0.455046646   -0.536065199   1.22746777   0   0   1.41460612	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849	5.06516067 13.1430032 1531.1338 0.171115121 0.371912503 1.35417655 1.4078631e-05 9.9517283e-06 1.41478613
9380 9381 9382 9383 9384 9385 9386 9386 9388 9388 9388 9389 9390 9391 9392	<pre>##     yNext[0] :     yNext[1] :     yNext[2] :     yNext[3] :     yNext[4] :     yNext[4] :     yNext[5] :     ##     diff[p] :     d[p]/[p] :     [monEnd] : ##     charge : </pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 1.41460612	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849	5.06516067 13.1430032 4531.1338 0.171115121 0.371912503 1.35417655 1.4078631e-05 9.95172839e-06 1.41476613 -16
9380 9381 9382 9383 9384 9385 9386 9387 9388 9389 9389 9390 9391 9392 9393	<pre>##     yNext[0] :     yNext[1] :     yNext[2] :     yNext[3] :     yNext[4] :     yNext[5] : ##     diff[p] :     d[p]/[p] :      momEnd] : ##     charge :     Move-x : </pre>	248.397552   89.952651   1660.47738   0.455046646   -0.536065199   1.22746777   0   0   1.41460612   13   0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737	-20.9408812   -16959.018   24108.0531   -0.006932253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   15   -115.899379	5.06516067   13.1430032   1531.1338   0.171115121   0.371912503   1.35417655   9.95172839e-06   1.41470613   -16   12.451868
9380 9381 9382 9383 9384 9385 9386 9387 9388 9389 9388 9390 9391 9392 9393 9394	<pre>##     yNext[0] :     yNext[1] :     yNext[2] :     yNext[3] :     yNext[4] :     yNext[5] :     ##     diff[p] :     diff[p] :     diff[p] :     momEnd] : ##     Charge :     Move-x :     Move-y : </pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 0 1.41460612 13 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   15   -115.899379   -16973.8278	5.06516067   13.1430032   1531.1338   0.171115121   0.371912503   1.35417655   9.95172839c-06   9.95172839c-06   1.41470613   -16   12.451868   16.6884814
9380 9381 9382 9383 9384 9385 9386 9386 9387 9388 9389 9390 9391 9392 9393 9394 9395	<pre>## yNext[0]: yNext[1]: yNext[2]: yNext[3]: yNext[3]: yNext[4]: yNext[5]: ## diff[p]: d p]/[p]:  momEnd : ## charge: Move-x: Move-y: Move-z:</pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 0 1.41460612 13 0 0 0 0 0 0 0 0 0 0 0 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112	-20.9408812   -16959.018   24108.0531   -0.00692253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   15   -115.899379   -16973.8278   22758.5931	5.06516067 13.1430032 1531.1338 0.771115121 0.371912503 1.35417655 1.4078631e-05 9.9517283e-06 1.41478613 -16 12.451868 16.6884814 920.681603
9380 9381 9382 9383 9384 9385 9386 9386 9387 9388 9389 9390 9391 9392 9393 9394 9395 9396	<pre>##     yNext[0] :     yNext[1] :     yNext[2] :     yNext[3] :     yNext[4] :     yNext[4] :     yNext[5] :     ##     diff[p] :     d[p]/[p] :     [monEnd] :     ##     charge :     Move-x :     Move-z :     Move-L : </pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 0 1.41460612 13 0 0 0 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269	-20.9448812   -16959.018 24108.0531 -0.00693253438 -0.841087508 1.137458 8.8067071e-07 6.22528361e-07 1.41466849 15 -115.899379 -16973.8278 22758.5931 28391.5097	5.00516007 13.143032 4531.138 0.771115121 0.371912503 1.35417655 1.4078631e-05 9.95172839e-06 1.41470613 -16 12.451868 16.6884814 920.681603 920.917026
9380 9381 9382 9383 9384 9385 9386 9387 9388 9389 9390 9391 9392 9393 9394 9395 9395 9395 9397	<pre>##     yNext[0] :     yNext[1] :     yNext[2] :     yNext[3] :     yNext[4] :     yNext[4] :     yNext[5] :     ##     diff[p] :     d[p]/[p] :     momEnd] : ##     charge :     Move-x :     Move-z :     Move-z :     Move-L :     Move-L/hdid : </pre>	248.397552   89.952651 1660.47738 0.455046646 0.536065199 1.22746777 0 1.41460612 13 0 0 0 0 0 0 0 0 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269	-20.9448812   -16959.018 24108.0531   -0.00693253438   -0.841087508   1.137458   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   -115.899379   -16973.8278   22758.5931   28391.5097   0.946383656	5.00516067 13.1430032 531.1338 0.171115121 0.371912503 1.35417655 9.95172339-06 1.414770613 -16 12.451868 16.6884814 920.681603 920.917026 0.517327085
9380 9381 9382 9383 9384 9385 9386 9387 9388 9389 9390 9390 9392 9393 9394 9395 9395 9396 9397 9398	<pre>##     yNext[0] :     yNext[1] :     yNext[1] :     yNext[2] :     yNext[3] :     yNext[4] :     yNext[5] :     ##     diff[p] :     diff</pre>	248.397552 -89.952651 1660.47738 0.455046646 -0.536065199 1.22746777 0 0 1.41460612 13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269	-20.9408812   -16959.018   24108.0531   -0.00693225438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   15   -115.899379   -16973.8278   22758.5931   28391.5097   0.946383656	5.00516007 13.1430032 531.1338 0.171115121 0.371912503 1.35417655 9.05172838e-06 1.41470613 -16 12.451868 16.6884814 920.681603 920.917026 0.517327085
9380 9381 9382 9383 9384 9386 9386 9386 9388 9388 9390 9391 9392 9393 9394 9395 9395 9395 9396 9397 9398	<pre>## yNext[0] : yNext[1] : yNext[2] : yNext[3] : yNext[4] : yNext[5] : ## diff[p] : diff[p] : dip]/[p] : momEnd] : ## charge : Move-x : Move-x : Move-z : Move-z : Move-L/hdid : hRequest= [2000, hdid = [2000,</pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 0 1.41460612 13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269 00]	-20.9408812   -16959.018 24108.0531   -0.00693253438 -0.841087508 1.137458 8.8067071e-07 6.22528361e-07 1.41466849 15 -115.899379 -16973.8278 22758.5931 28391.5097 0.946383656	5.06516067 13.1430032 1531.1338 0.171115121 0.371912503 1.35417655 9.95172839-06 1.41470613 -16 12.451868 16.6884814 920.681603 920.917026 0.517327085
9380 9381 9382 9383 9384 9385 9386 9387 9388 9389 9390 9399 9392 9393 9394 9395 9397 9395 9397 9398 9399	<pre>##     yNext[0]:     yNext[1]:     yNext[2]:     yNext[3]:     yNext[4]:     yNext[4]:     yNext[5]:     ##     diff[p]:     d[p]/[p]:     [monEnd]:     ##     charge:         Move-x:         Move-x:         Move-z:         Move-z:         Move-L:         Meter:         M</pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 1.22746777 1 0 1.41460612 13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269 0.794810269 .14462]	-20.9448812   -16959.018 24108.0531 -0.00693253438 -0.841087508 1.137458 8.8067071e-07 6.22528361e-07 1.41466849 15 -115.899379 -16973.8278 22758.5931 28391.5097 0.946383656	5.06516067 13.143032 531.138 0.171115121 0.371912503 1.35417655 1.4078631e-05 9.95172839e-06 1.41470613 -16 12.451868 16.684814 920.681603 920.917026 0.517327085
9380 9381 9382 9383 9384 9385 9386 9386 9386 9388 9388 9389 9390 9391 9392 9393 9394 9395 9395 9395 9395 9395 9399 9399	<pre>##     yNext[0] :     yNext[1] :     yNext[2] :     yNext[2] :     yNext[3] :     yNext[4] :     yNext[5] :     diff[p] :</pre>	248.397552 -89.952651 1660.47738 0.455046646 -0.536065199 1.22746777 0 1.41460612 13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269 0.794810269 0.14462] .14462]	-20.9448812   -16959.018 24108.0531 -0.00693253438 -0.841087508 1.137458 8.8067071e-07 6.22528361e-07 1.41466849 15 -115.899379 -16973.8278 22758.5931 28391.5097 0.946383656	5.00516007 13.143032 1531.1338 0.171115121 0.371912508 1.35417655 1.4078631e-05 9.95172839e-06 1.41470613 -16 12.451868 16.6884814 920.681603 920.917026 0.517327085
9380 9381 9382 9383 9384 9385 9386 9386 9387 9388 9399 9393 9393 9393 9393 9393	<pre>##</pre>	248.397552   -89.952651   1660.47738   0.455046646   -0.536065199   1.22746777   0   0   1.41460612   13   0   0   10000, 30000, 1000 10000, 30000, 1780 10000, 30000, 1000 10000, 30000, 10000 10000, 30000, 10000 10000, 30000, 10000 10000, 30000, 10000 10000, 30000, 10000 10000, 30000, 10000 100000, 30000, 10000 100000, 30000, 10000 10000, 30000, 10000 10000, 30000, 10000 100000, 30000, 1000000000000000000000000	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269 0.794810269 0.794810269 1.1390206] to replace	-20.9408812   -16959.018   24108.0531   -0.006932253438   -0.841087508   1.137458   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   -115.899379   -16973.8278   22758.5931   28391.5097   0.946383656   e hTry = [0, 102.629]	5.00516007 13.1430032 1531.1338 0.171115121 0.371912503 1.35417655 1.4078631c-05 9.95172339c-06 1.414770613 -16 12.451868 16.6884814 920.917026 0.517327085 501, 8.85836995, 5.900 2
9380 9381 9382 9383 9384 9385 9386 9389 9389 9389 9389 9390 9390 9390 9390	<pre>## yNext[0] : yNext[1] : yNext[1] : yNext[2] : yNext[3] : yNext[4] : yNext[5] : ## diff[p] : d]p]/[p] : momEnd] : ## charge : Move-x : Move-x : Move-x : Move-z : Move-2 : Move-L/hdid : hRequest= [2000, hdid = [2000, x (Now) = [2000, x (Now</pre>	248.397552   -89.952651   1660.47738   0.455046646   -0.536065199   1.22746777   0   0   1.41460612   13   0	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269 0.794810269 1.14462] 1.1390206] to replace	-20.9408812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   15   -115.899379   -16973.8278   22758.5931   28391.5097   0.946383656   e hTry = [0, 102.629	5.06516067   13.1430032   1531.1338   0.171115121   0.371912503   1.35417655   1.4078631e-05   9.95172832e-06   1.41470613   -16   12.451868   16.6884814   920.681603   920.917026   0.517327085   501, 8.85836995, 5.900 ₽
9380 9381 9382 9383 9384 9385 9386 9388 9388 9388 9389 9390 9391 9392 9393 9394 9393 9394 9395 9396 9393 9394 9395 9396 9397 9398 9399	<pre>## yNext[0] : yNext[1] : yNext[2] : yNext[3] : yNext[4] : yNext[5] : ## diff[p] : d p]/[p] : momEnd] : ## charge : Move-x : Move-x : Move-z : Move-z</pre>	248.397552 -89.952651 1680.47738 0.455046646 -0.536065199 1.22746777 0 0 1.41460612 13 0 0 10000, 30000, 1000 10000, 30000, 1780 10000, 30000, 1780 0, 98219.8554] hnext = [0, 0, 0, 1] = :	-458.524296 -5491.11401 7654.14713 -0.0483423852 -0.914554613 1.07817487 -3.45889357e-07 -2.44506809e-07 1.41464065 -14 -280.140737 -5174.71477 6026.29112 7948.10269 0.794810269 0.794810269 1.14462] 1.1390206] to replace 0	-20.9448812   -16959.018   24108.0531   -0.00693253438   -0.841087508   1.137458   8.8067071e-07   6.22528361e-07   1.41466849   15   -115.899379   -16973.8278   22758.5931   28391.5097   0.946383656   e hTry = [0, 102.629. 0	5.06516067   13.1430032   1531.1338   0.771115121   0.371912503   1.35417655   1.4078631e-05   9.95172832e-06   1.41478613   -16   12.451868   16.6884814   920.681603   920.917026   0.517327085   501, 8.85836995, 5.900 ≥ 0   11.1390206 ≥

## Updated status

- Working with Unit test 'testVectorIntegrationDriver.cxx'
  - Artificial value to 'stretch' code, test limits
- Several fixes in the last days
  - Now agreement for over 200 steps
  - Small disagreements in momentum
- Revisions
  - use 'final' momentum for relative error
- ToDos
  - Add per-track counter of steps (to enforce same maximum # steps as scalar.)



#### Next steps

- Finalise comparison with scalar case (in unit test)
- Run in GeantV tracking with CMS-like field
- Tune parameters and explore tradeoffs
  - Add 'observables' to monitor
  - vector loads vs full work
- Benchmark, profile/optimise with CMS-like semi-realistic fields
  - Identify cost of 'loading' vs extra iteration (for tuning)
- Later: 'quick' exploration of simple improvements
  - Reduce copying of data
  - More use of vector 'Load'