

Single precision support in VecGeom

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Initial goals

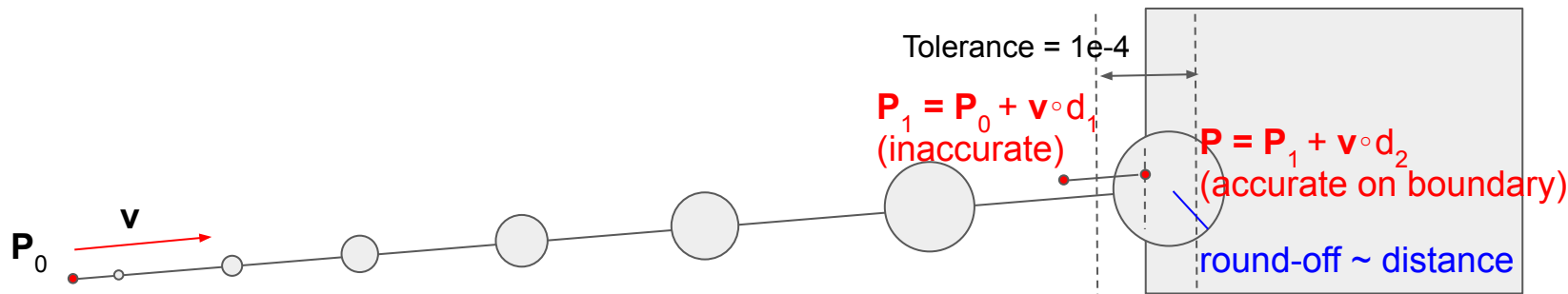
1. Fix the failing unit tests and benchmarks
2. Reduce or eliminate the amount of errors in shape tester
 - a. All shapes were failing with large number of errors
3. Add single precision support to AdePT, reproduce example images and measure performance changes
 - a. At this point, AdePT was not compiling with single precision support

Unit tests and benchmarks

- All unit tests and benchmarks successfully pass
 - Adjusting per-solid tolerances
 - Adjusting global tolerances
 - Eliminating extreme decimal numbers from tests
 - ApproachSolid utility

ApproachSolid utility

- Created to reduce propagation related rounding errors
- Implemented as `VUnplacedVolume::ApproachSolid()`
- Propagates a distant point to the bounding box of volume
 - Bounding boxes are now stored for each solid in `VUnplacedVolume` and calculated during construction using the existing `VUnplacedVolume::Extent()`
 - Checks for correct calculation added to `ctest`
- Used in the unit tests, shape tester and AdePT Raytracer



Shape Tester

- Every single shape was failing with large number of errors
- Nine shapes are completely fixed
- Some shapes produce low number of errors, needs per-case fixing
- More complex shapes still fail with rather large number of errors
- Results achieved with:
 - Changing data types in ShapeTester
 - Using ApproachSolid utility
 - Changing per-shape tolerances

Shape	Unit	Bench	SC	SIP	SOP	SSP	SSFI	SSFO	SSD	SADTI	SFAP	SSN
Box	0	0	0	0	0	0	0	0	0	0	0	0
Cone	0	0	0	0	0	0	0	0	0	0	0	0
CutTube	0	0	0	0	230	0	0	0	1	0	0	0
Ellipsoid	0	0	0	0	0	0	0	0	0	0	0	0
EllipticalCone	0	0	0	0	0	0	0	0	0	0	0	0
EllipticalTube	0	0	0	0	0	0	0	0	0	0	0	0
Extruded	0	0	0	347	64	49	30	0	0	37	0	151
GenTrap	0	0	8744	-	23729	38	0	0	23	8	0	3363
GenericPolycone	0	0	841	-	-	-	129	0	5	124	0	3089
Hype	0	0	0	0	0	0	0	0	0	0	0	3333
MultiUnion	0	0	0	149	110889	0	0	0	0	202	333	239
Orb	0	0	0	0	0	0	0	0	0	0	0	0
Paraboloid	0	0	0	4768157	50	0	0	0	0	0	0	1398250
Parallelepiped	0	0	0	0	0	0	0	0	1	0	0	1
Polycone	0	0	13	58	138	66	0	0	2	18	0	47
Polyhedron	0	0	776	3155	6948	767	4	0	4	632	0	2956
SExtru	0	0	64	100055	100128	0	0	0	62	0	39	0
Sphere	0	0	0	0	1	215183	0	0	0	0	0	0
Tessellated	0	0	1	0	3	0	0	0	0	14	0	333
Tet	0	0	0	0	0	0	0	0	0	0	0	0
Torus2	0	0	8	11878	20193	4	1063	0	10	109	3	3091
Trapezoid	0	0	0	0	0	0	0	0	0	0	0	0
Trd	0	0	0	0	1	0	0	0	0	0	5	0
Tube	0	0	0	0	0	0	0	0	0	0	0	0

SC=Consistency

SIP=InsidePoint

SOP=OutsidePoint

SSP=SurfacePoint

SSFI=SafetyFromInside

SSFO=SafetyFromOutside

SSD=ShapeDistances

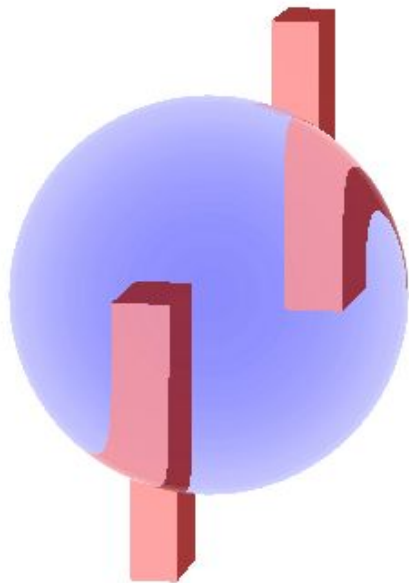
SADTI=AccuracyDistanceTon

SFAP=FarAwayPoints

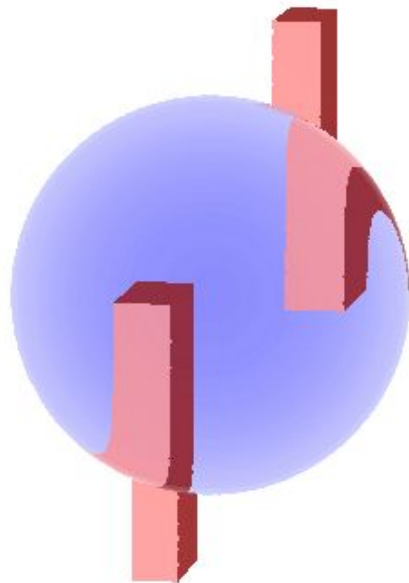
SSN=ShapeNormal

AdePT Raytracer

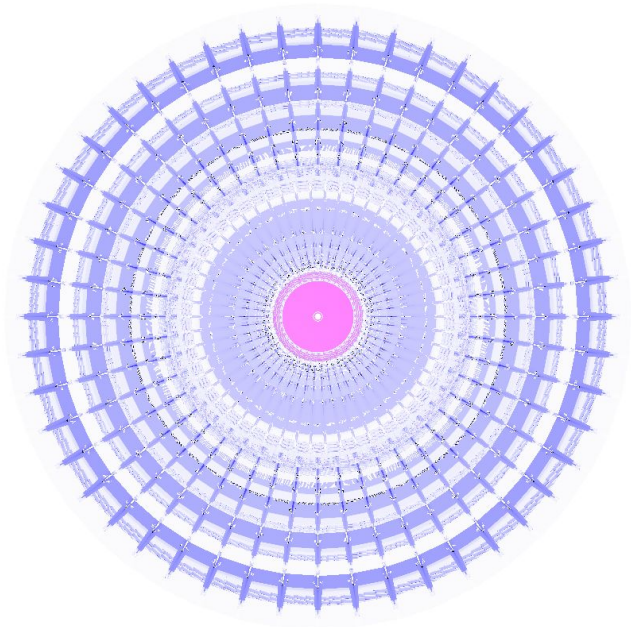
- AdePT now compiles when using single precision
- Raytracer produces the same image in single precision for *trackML* and *box_sphere* examples
- We measured significant increase in performance:
 - 6.39 % speedup and 27.2 % less memory used in *box_sphere*
 - 49.85 % speedup and 27.2 % less memory used in *trackML*



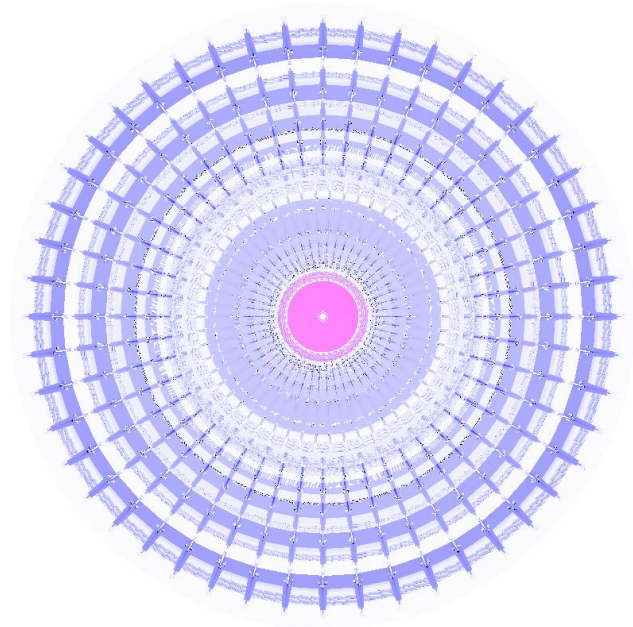
Double



Single



Double



Single