A Twisted Trapezoidal Shape for Geant4

Based on „*Stereo Mini-jet Cells in a Cylindrical Drift Chamber*“
(hep-ex/0303014v1, K. Hoshina et al.)

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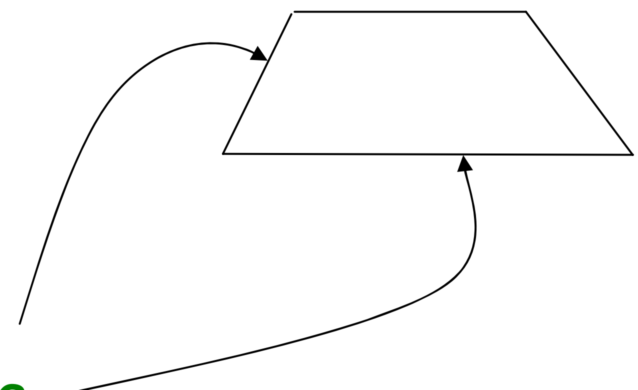
G4VTwistedFacted

Base class: G4VSolid, Similar to G4TwistedTubs

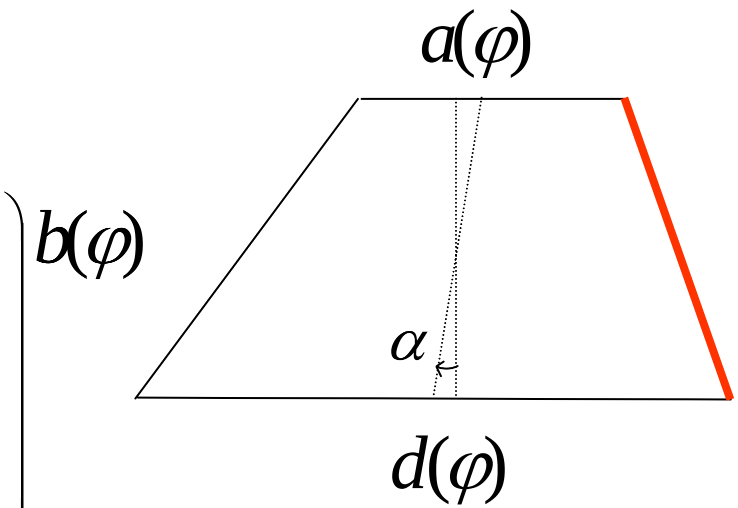
- DistanceToIn
- DistanceToOut
- Inside ..
- Constructor calls
  - G4TwistedTrapAlphaSide
  - G4TwistedTrapParallelSide
  - G4TwistedTrapBoxSide as special case for a twisted box
  - G4FlatTrapSide (for the endcaps)



G4TwistedTrapAlphaSide

Surface Equation

$$\begin{pmatrix} (w(u,\varphi)+\Delta x\frac{\varphi}{\Delta\varphi})\cos\varphi-(u+\Delta y\frac{\varphi}{\Delta\varphi})\sin\varphi = p_x+tv_x \\ (w(u,\varphi)+\Delta x\frac{\varphi}{\Delta\varphi})\sin\varphi+(u+\Delta y\frac{\varphi}{\Delta\varphi})\cos\varphi = p_y+tv_y \\ \frac{L\varphi}{\Delta\varphi} = p_z+tv_z \end{pmatrix}$$



2 Free parameters (φ,u)

The resulting solution contains terms in Sin(φ) and Cos(φ) which are approximated with Padé expansions.
Polynom: 7th order.

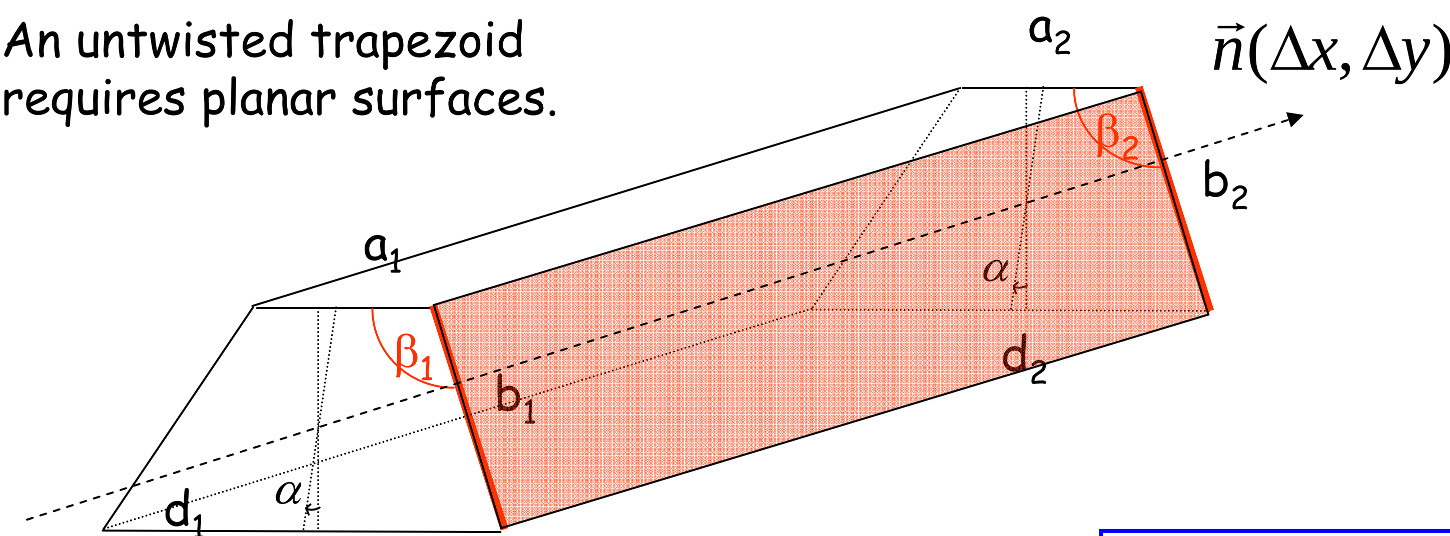
$$\varphi \in [-\tfrac{1}{2}\Delta\phi, +\tfrac{1}{2}\Delta\phi]$$

$$u \in [-\tfrac{1}{2}b(\varphi), +\tfrac{1}{2}b(\varphi)]$$

$$w(u) = \frac{a(\varphi)}{2}+\frac{d(\varphi)-a(\varphi)}{4}-u\left[\frac{d(\varphi)-a(\varphi)}{2b(\varphi)}-\tan\alpha\right]$$

Planarity condition

An untwisted trapezoid
requires planar surfaces.



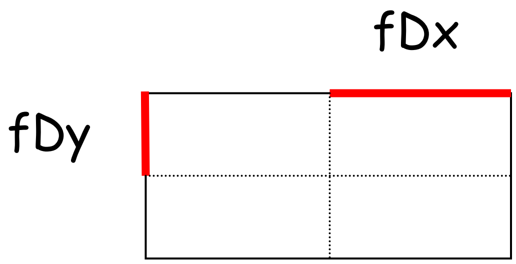
Planarity is equivalent to

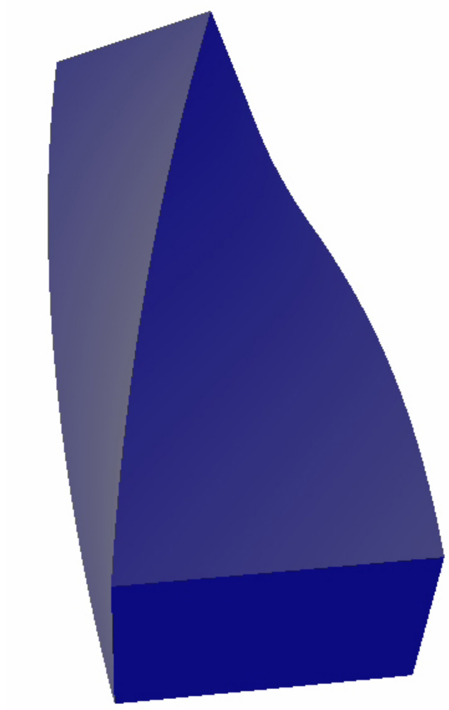
$$\beta_1 = \beta_2$$

$$\alpha_1 = \alpha_2$$

$$\frac{d_1 - a_1}{b_1} = \frac{d_2 - a_2}{b_2}$$

G4TwistedBox

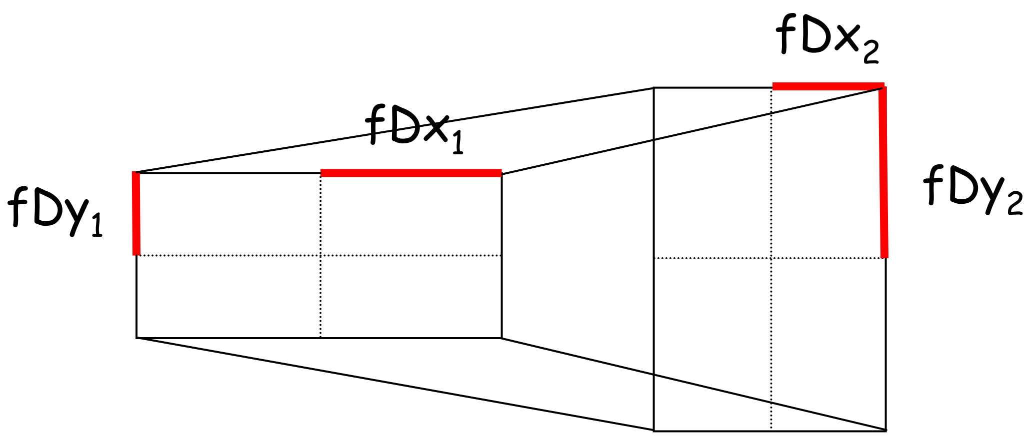


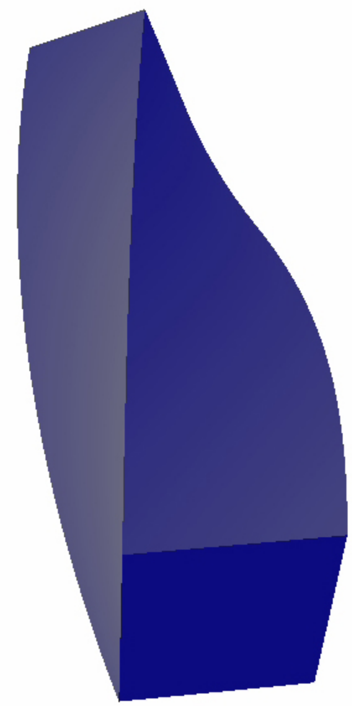


G4TwistedBox(Name,$\Delta\varphi$,fDx,fDy,fDz)

Eg: 70*deg,20*cm,30*cm,80*cm

G4TwistedTrd



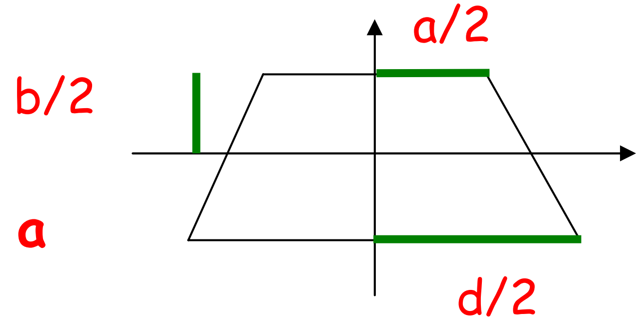


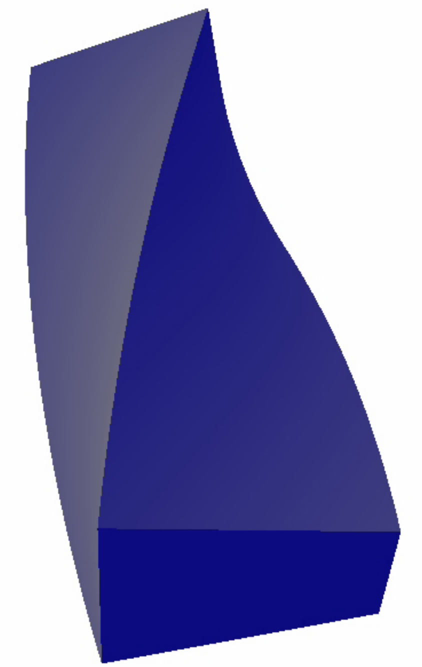
G4TwistedTrap(Name,fDx_1,fDx_2,fDy_1,fDy_2,fDz,$\Delta\varphi$)

Eg: 15*cm,25*cm,30*cm,20*cm,80*cm,70*deg

G4TwistedTrap

Twisted trapezoid with equal sized endcaps
and no tilt angle.





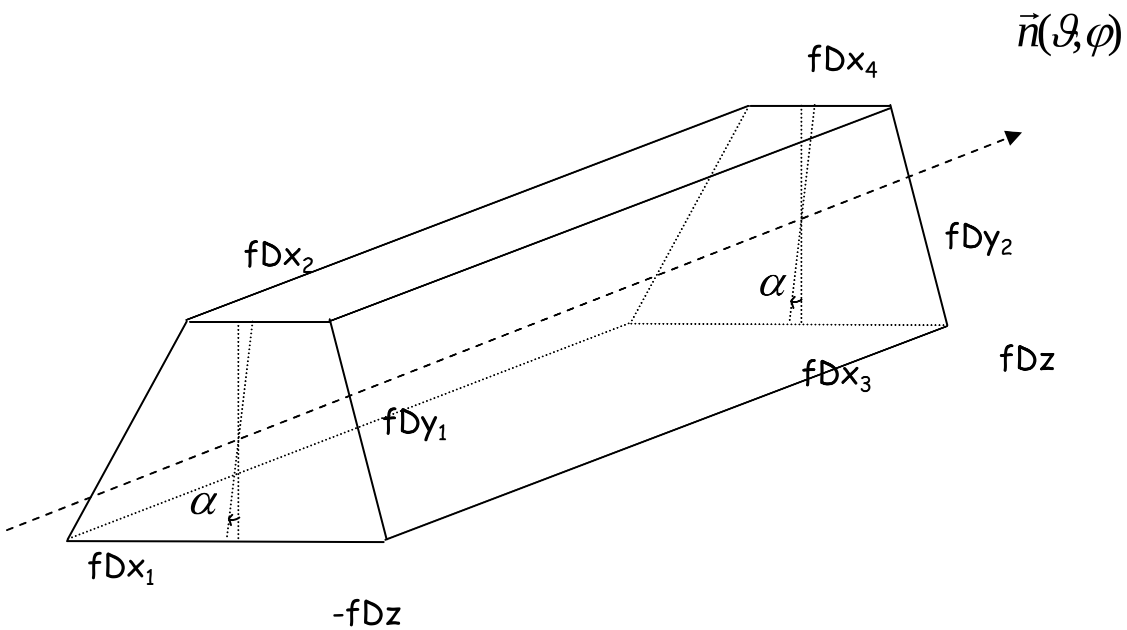
Twist angle a

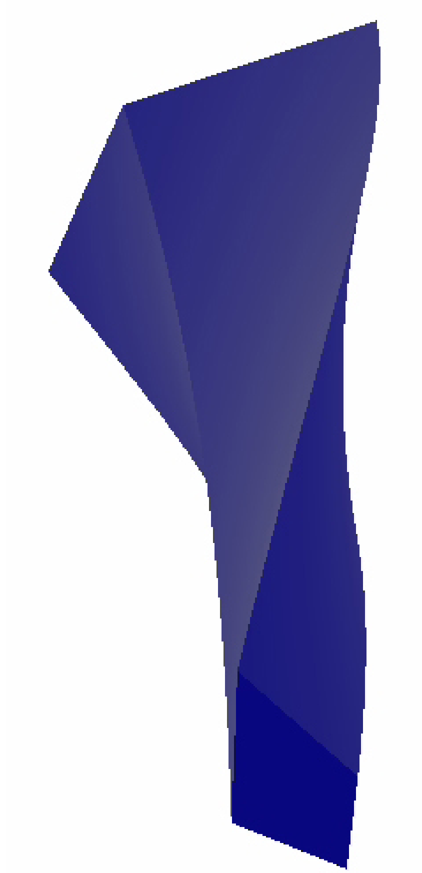
G4TwistedTrap("Trap",70*deg,15*cm,25*cm,30*cm,80*cm)

d/2 a/2 b/2 L/2

G4TwistedTrap

General Twisted trapezoid with
different sized endcaps and and tilt angle.





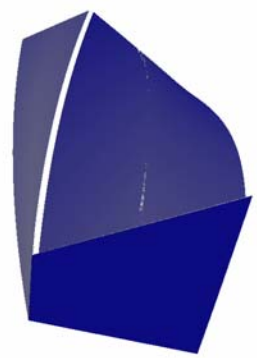
G4TwistedTrap(Name,$\Delta\varphi$,fDz,θ,φ,fDx_1,fDx_2,fDy_1,
fDx_3,fDx_4,fDy_2,α)

Solved Problems

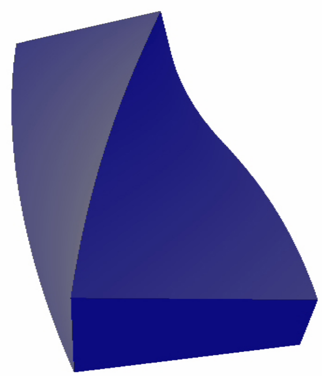
The visualisation showed cracks in the surface and wrongly tracked events. This issus was successfully solved by a

- division by zero check (added special case)
- new surface-point finder
- introducing G4JTPolynomialSolver
- special treatment for events parallel to the surface

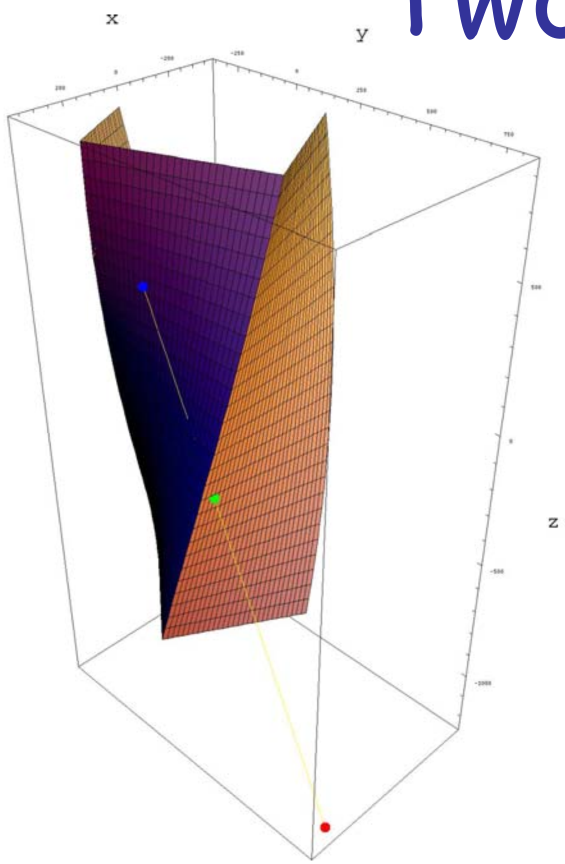
before

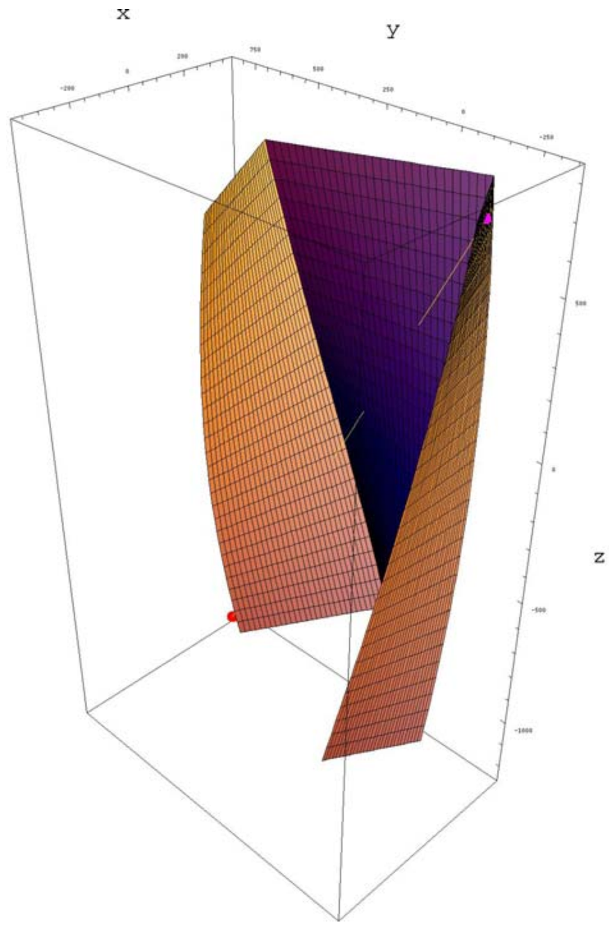


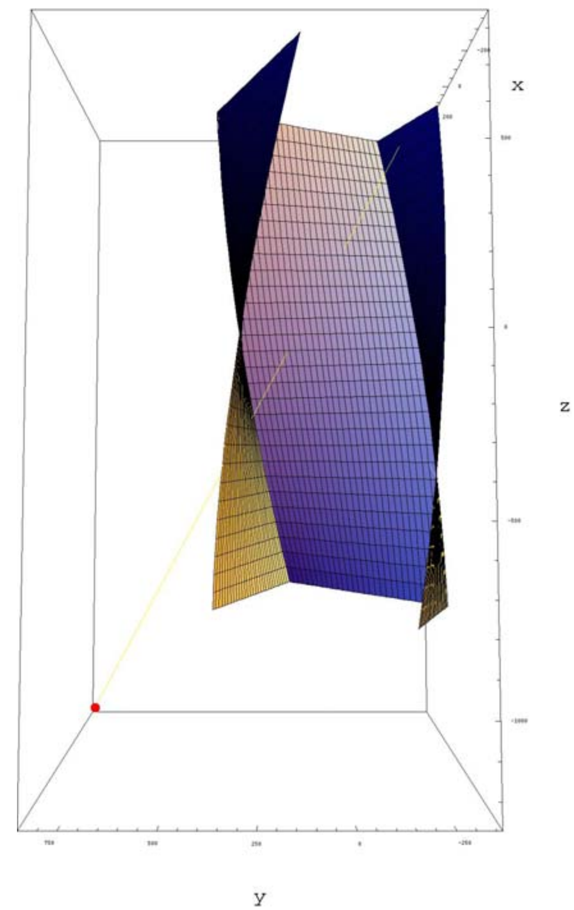
after



Two intersections







Testing the Solid

With traditional tools

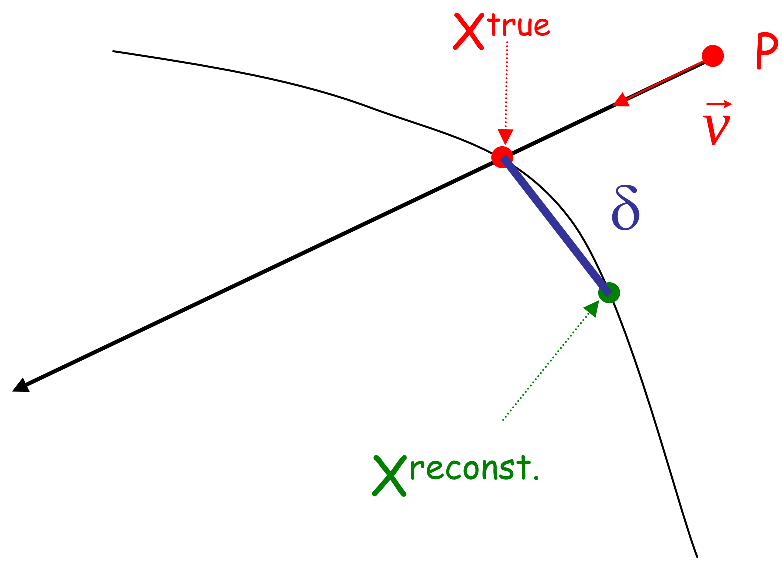
- test10: successful
- SolidsChecker:
  1 event „Track stuck" out of 100 M

... and with a new testing tool

- SurfaceChecker: successful

SurfaceChecker

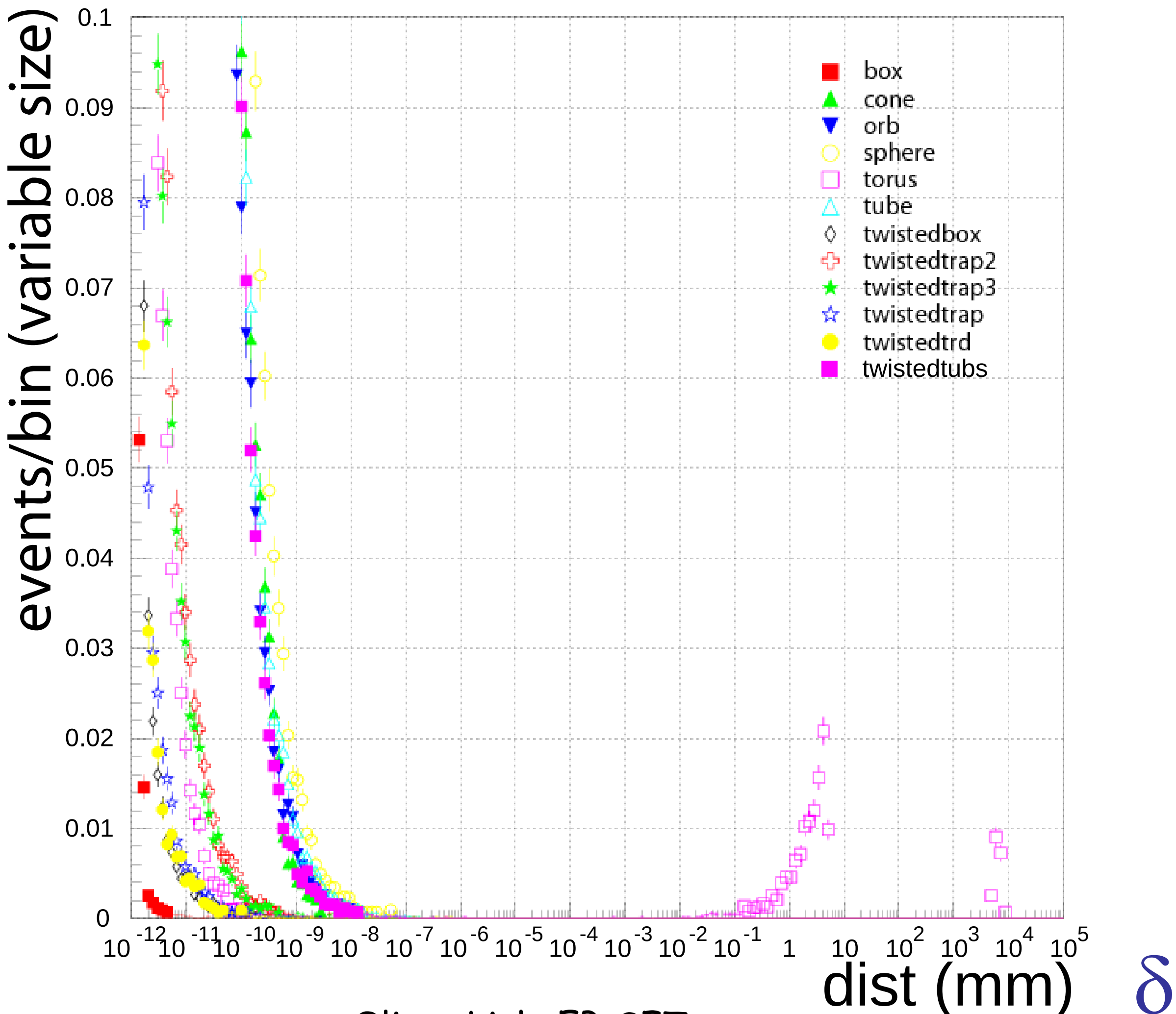
- Generate a random particle position P and a random point X^{true} on the surface of the solid.
- Ask G4 for the intersection point given the point P and its direction v (select the intersection closest to Xtrue).



⇒ $X^{reconst.}$

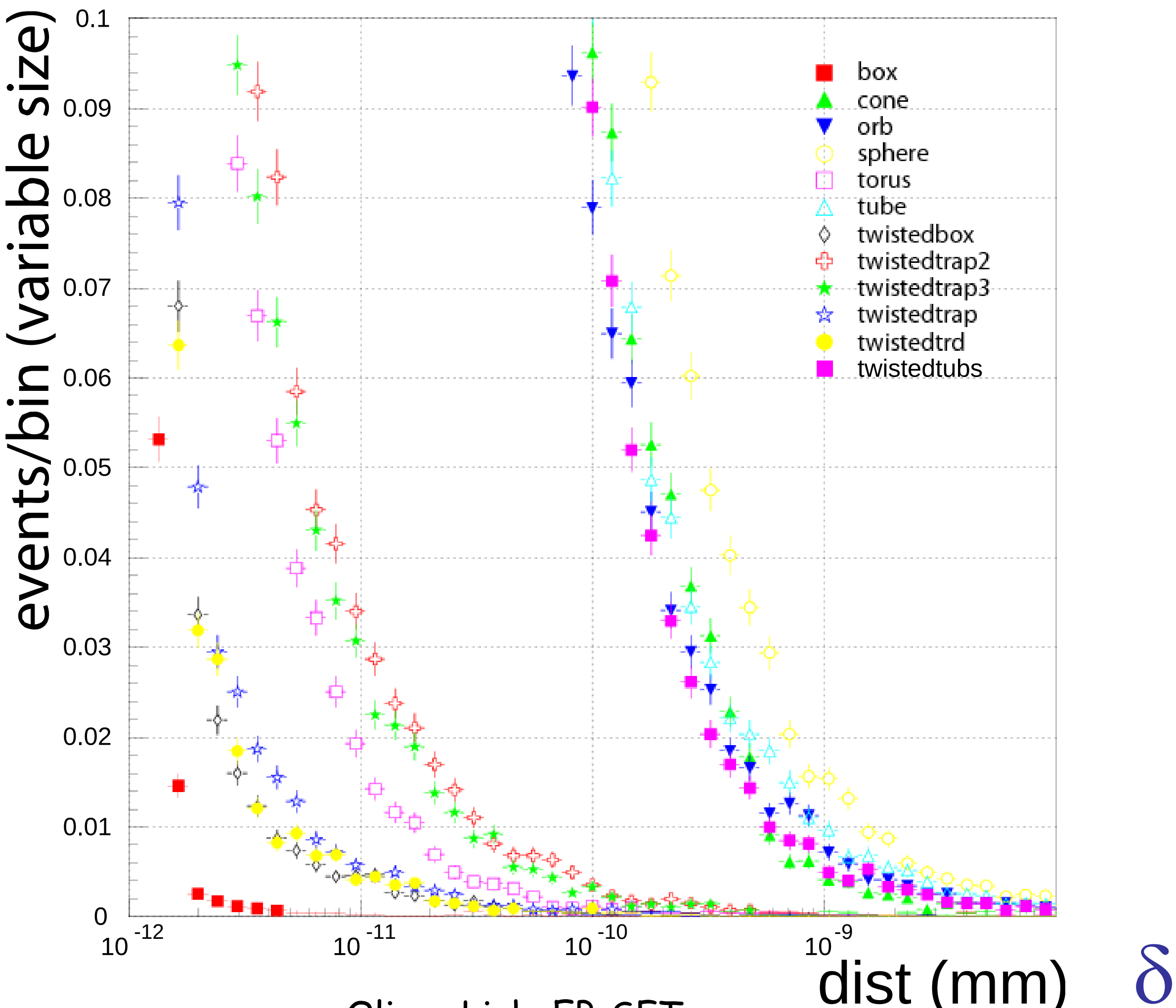
The distance δ between X^{true} and $X^{reconst.}$ gives us information about the goodness of the reconstruction.

Results I



events/bin (variable size)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
box
cone
orb
sphere
torus
tube
twistedbox
twistedtrap2
twistedtrap3
twistedtrap
twistedtrd
twistedtubs
10^{-12} 10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^{2} 10^{3} 10^{4} 10^{5}
dist (mm)
δ

Results II


events/bin (variable size)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
10^{-12}
10^{-11}
10^{-10}
10^{-9}
dist (mm)
δ
box
cone
orb
sphere
torus
tube
twistedbox
twistedtrap2
twistedtrap3
twistedtrap
twistedtrd
twistedtubs

Conclusions

- G4TwistedBox with equal endcaps is replaced by the new generic version.
- G4TwistedTrd with rectangular endcaps of different size (but no tilt angle) added.
- G4TwistedTrap with trapezoidal endcaps of different size and tilt angle added. The old version with equal endcaps is covered by the generic version.
- G4JTPolynomialSolver to solve the high order polynoms is added to HEPNumerics.