BREPS solids construction by surfaces of extrusion & revolution

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20 October 2009

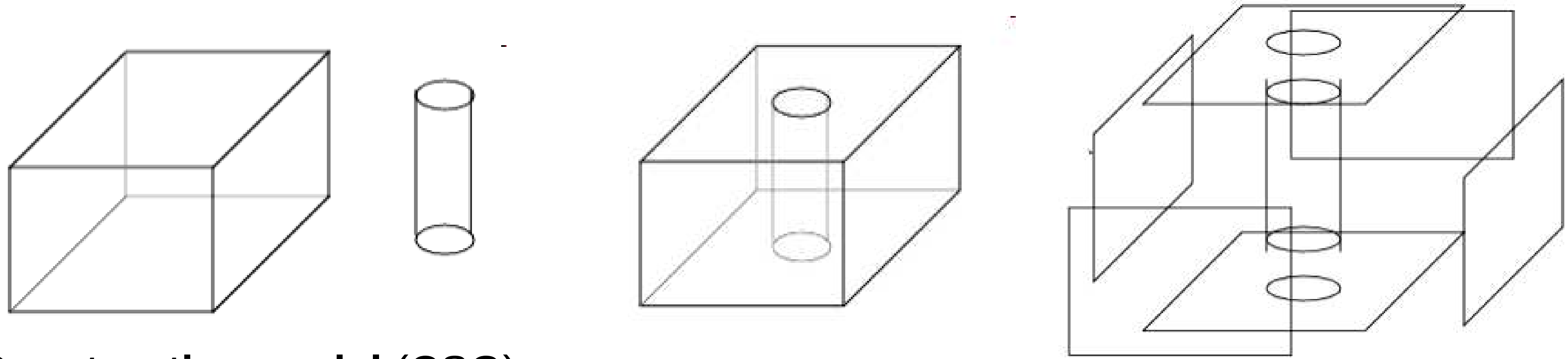
14th Geant4 Users and Collaboration Workshop,

Catania, Italy, 15-22 October, 2009

OUTLINE

- ✓ Introduction
- ✓ B-Rep solids in Geant4
- ✓ Surface of revolution
- ✓ Surface of linear extrusion
- ✓ Example
- ✓ Conclusions and extensions

B-Rep solids



Constructive model (CSG)

Boundary model (B-Rep)

Boundary REPresentation

- ✓ Geometric entities: point, curve, surface
- ✓ Topological entities: vertex, edge, face (boundaried surface), edge_loop
- ✓ Elementary surfaces (plane, cylindrical s., …) Advanced surfaces (swept s., …)

Swept Surfaces

(Generalized Cylinder)

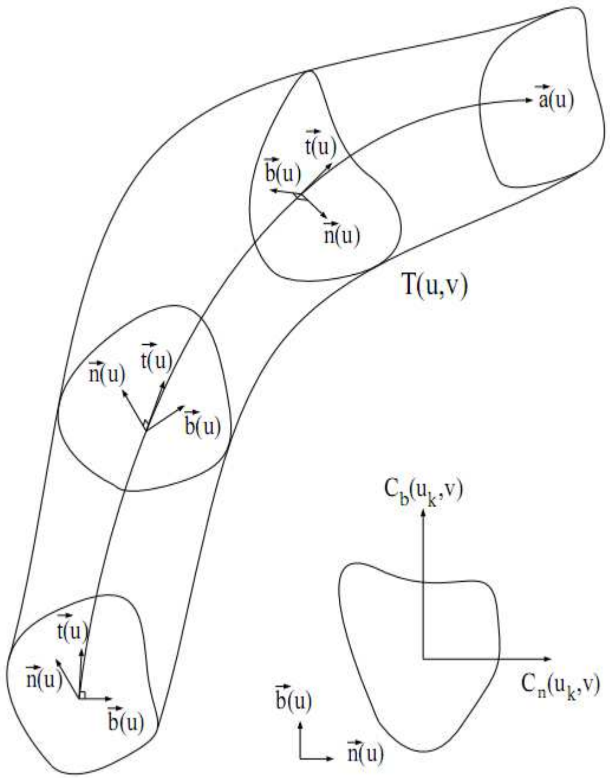
✓ **Swept surfaces** are generated by moving a 2D curve along a trajectory in 3D space.

✓ **Curve** can also change its shape and orentation during sweeping.

✓**Generalized cylinder** is the shape generated when a 2D contour is swept along a 3D trajectory.

✓ **Contour** define the cross-section of the object.

✓**Trajectory** is the axis of the object.

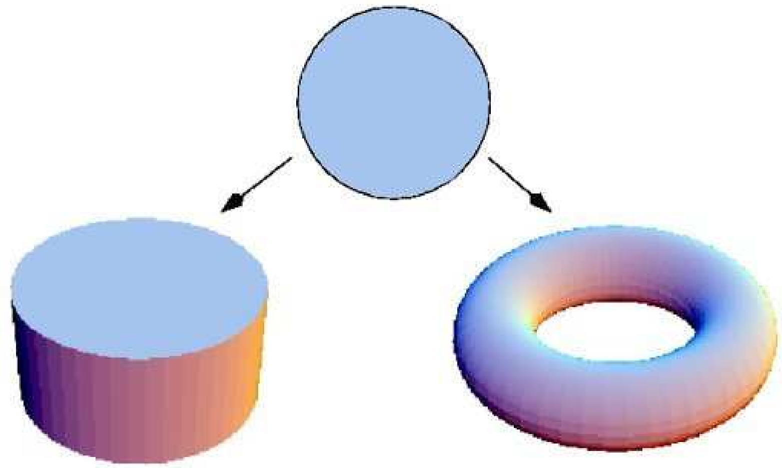


Surfaces of revolution & linear extrusion

✓ In the geometrical modelling, like Computer-Aided Desing, are commonly used only two kinds of generalised cylinders.

✓ These solids are obtained by extrusion or revolution of 2D contour.

✓ For define these solids it's necessary use the corresponding surfaces.



✓ Definition of swpet surface by generic curves can generate a surfaces with inifinite extension.

✓ In this case, for generate a solids, is necessary trimming the surface along the swept direction and also should be limited the 2D curve by definition of the bounds.

BREP in Geant4

✓ **G4BREPSolid** is defined by a collections of boundaried surfaces

G4Surface

✓ Boundaries

✓ Bounding box

✓ Intersection with a ray

✓ Point to surface distance

✓ Normal vector to surface

Plane , cylindrical, conical, toroidal, bspline, bezier

G4Curve

✓ 3D point & parameter value

✓ Bounds

✓ Bounding box

✓ Intersection 2D curve with a ray

✓ Tangent

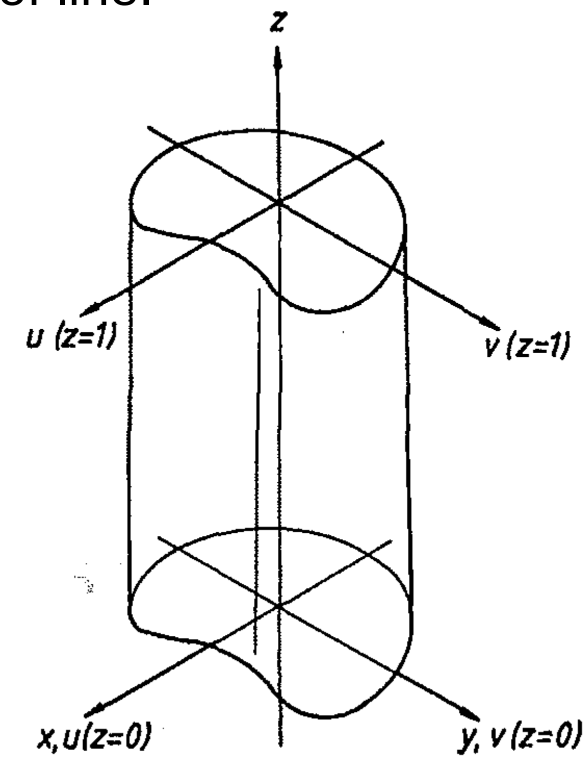
✓ (curve-curve intersection)

Conics, line, Bspline, composite

Surface of linear extrusion

It's generated by a 2D contour swept along a segment of line.

$$\sigma(u,v) = \lambda(u) + vV$$



- ✓ $\lambda(u)$ parametrization of the swept curve
- ✓ V extrusion direction
- ✓ $-\infty < v < +\infty$ parametrization range

In current implementation

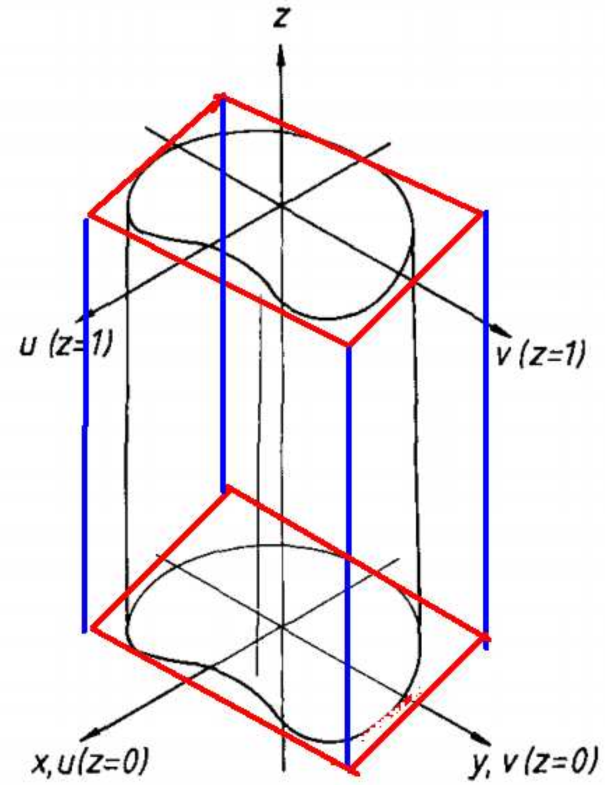
- ✓ 2D swept curve is defined on a ortogonal plane to extrusion axis and need be closed
- ✓ *z* axis rapresents extrusion direction

G4SurfaceOfLinearExtrusion (const &G4Curve curve, G4double length)

Surface of linear extrusion

Bounding box

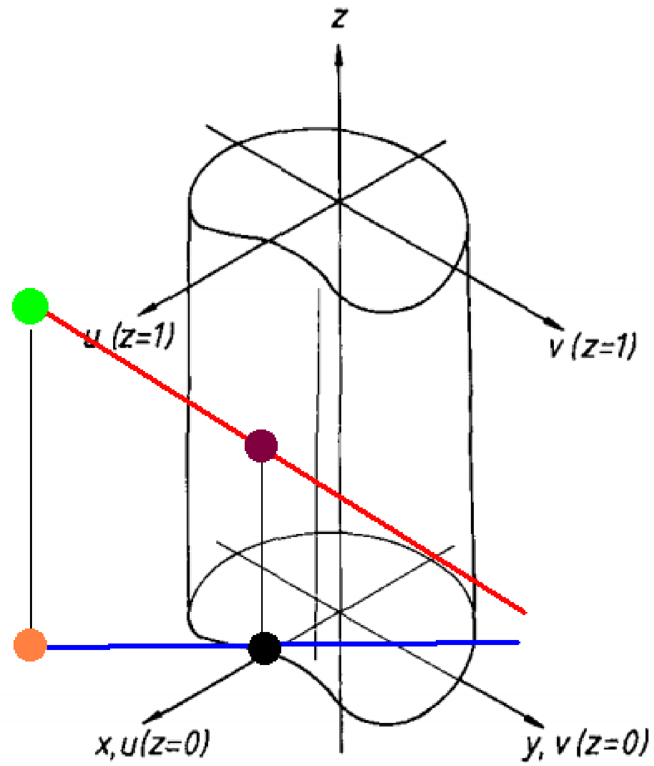
- the BB of the boundaried swept curve must be included
- the bounding box of the surface is extendend by including also the BB translated along the extrusion axis



Surface of linear extrusion

Ray intersection

- 3D ray in local coordinate
- $r(t) = S + t \cdot D$ $t > 0, |d| = 1$
- the ray is projected on the plane where is definend the base curve
- 2D ray – curve intersection is determined
- the 2D intersection distance is mapped easly to a 3D intersection distance, given the direction and the source point of the ray

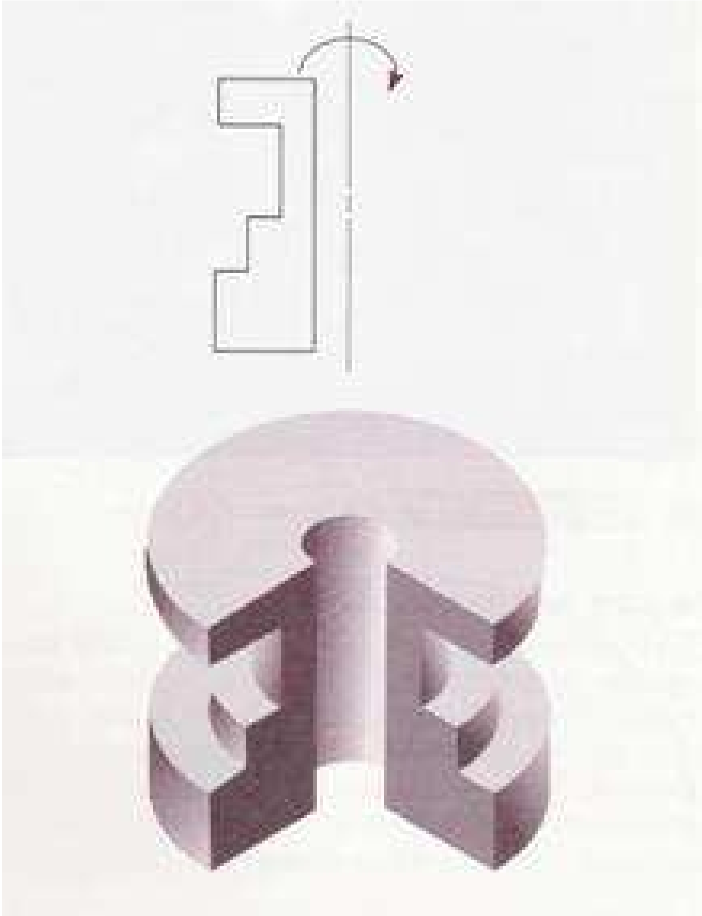


Surface of revolution

✓ It's generated by a 2D contour swept along a circular trajectory

✓Equivalently the solid can be generated by rotation of the 2D contour around an axis.

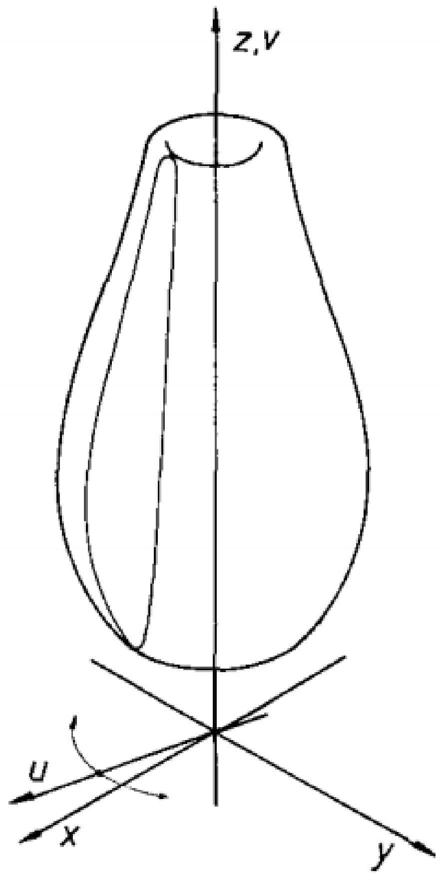
✓ If the base curve isn't closed (usual case), it's alway possibile generate a solid by adding two circular planar surface for the bottom and the top of the solid.



Solid of revolution

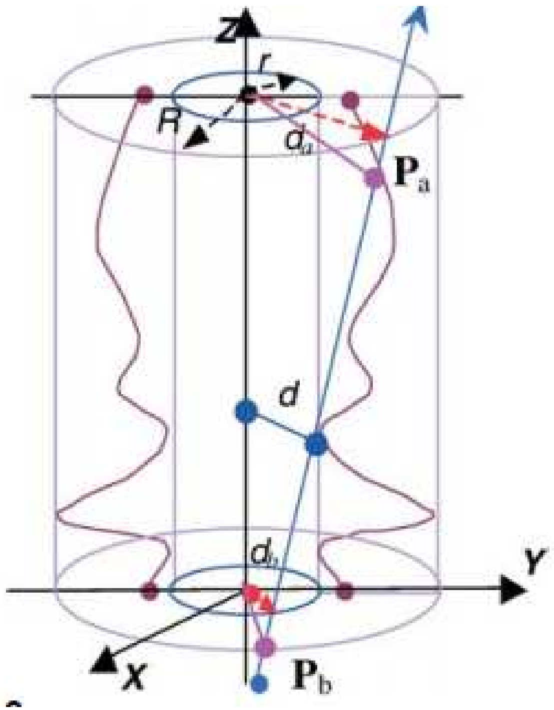
Bounding box

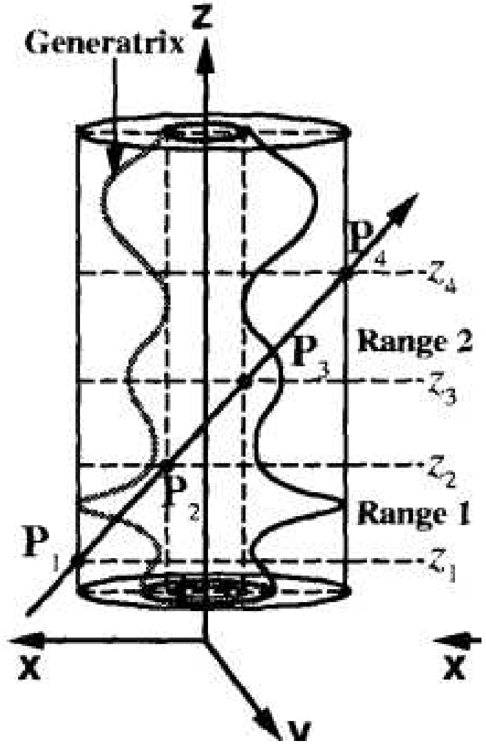
- is computed by extend the bounding box of the base curve with its replications on each semi-axis (x pos/neg, y pos/neg)



Surface of revolution

Ray intersection





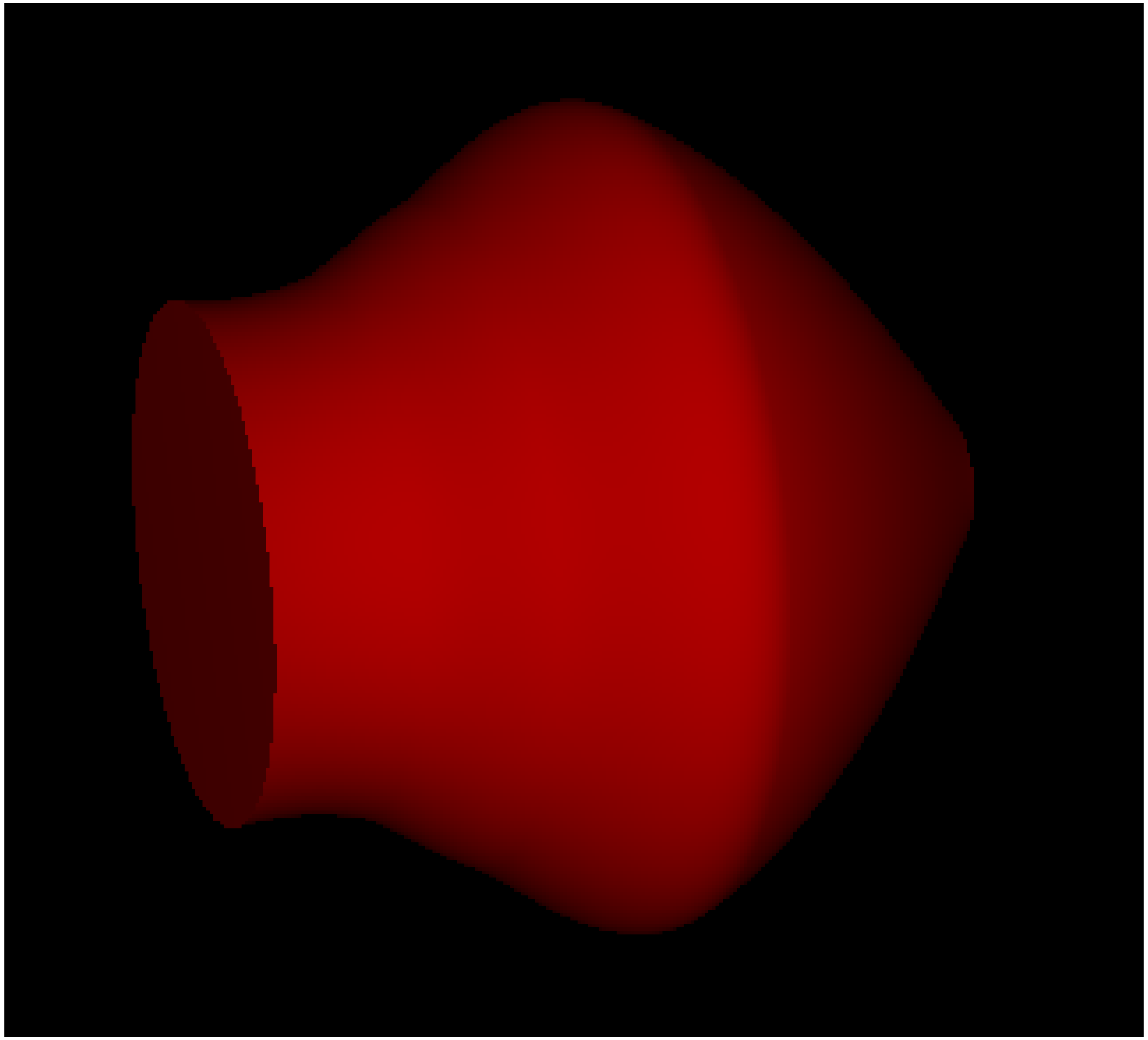
- ✓ **Boundary Cylindrical Shell**
- ✓ This allow to limit z interval
- ✓ The ray is “cylindrical proiected” on the plane that is swepted (cylindrical coordinate system $x^2+y^2=r^2$)
- ✓ The image of the ray is not a ray but is a hyperbola
- ✓ The first intersection of the two curves is computed: (r_0,z_0)
- ✓ With z_0 and ray equation we can obtain the 3D intersection point and the distance

G4BREP solids

- ✓ **G4BREPSolidOfLinearExtrusion**
- ✓ **G4BREPSolidOfRevolution**
- ✓ Inside operation

  generates a ray from the point and check if it intersects one of the surfaces

Example



Conclusions

Actual implementation

✓ **Linear extrusion for base curves**

✓ **Surfaces of revolution (not complete for bspline curves)**

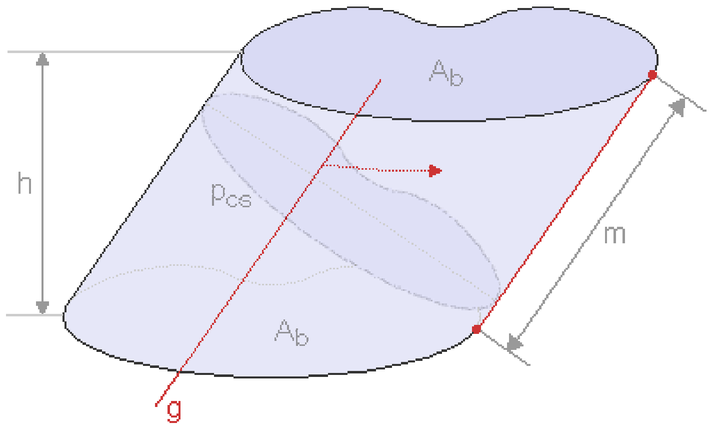
Incoming

✓ Tangent computation for BSpline

✓ Alternative technique for compute ray - revolution surfaces intersection by binary subdivision of bo

Future work

✓ **Diagonal extrusion**
✓ **Conical extrusion**
✓ **Extrusion along an arbitrary curve**
✓ **Revolution suface limitated by phy section**



BREPS solids construction
by surfaces of extrusion & revolution

END

Thanks