ROOT: 3D Graphics

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Viewer Architecture

TVirtualViewer3D: Provides generic access to viewers of widely differing capabilities (OpenGL/x3d/TPad). Can test preferences, manage scenes, add objects, adjust camera, lights etc externally (future extension) etc.

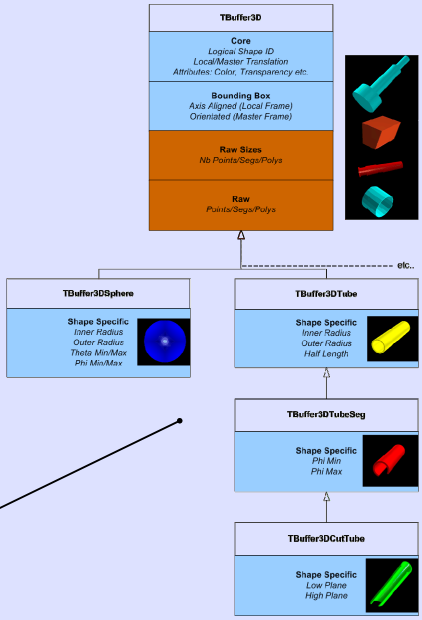
```
Bool_t PreferLocalFrame() const

void   BeginScene()
Bool_t BuildingScene() const
void   EndScene()

Int_t  AddObject(const TBuffer3D & buffer, ...)
Int_t  AddObject(UInt_t physicalID, const
TBuffer3D & buffer, ...)

Bool_t OpenComposite(const TBuffer3D & buffer, …)
void   CloseComposite()
void   AddCompositeOp(UInt_t operation)

……. . .
```

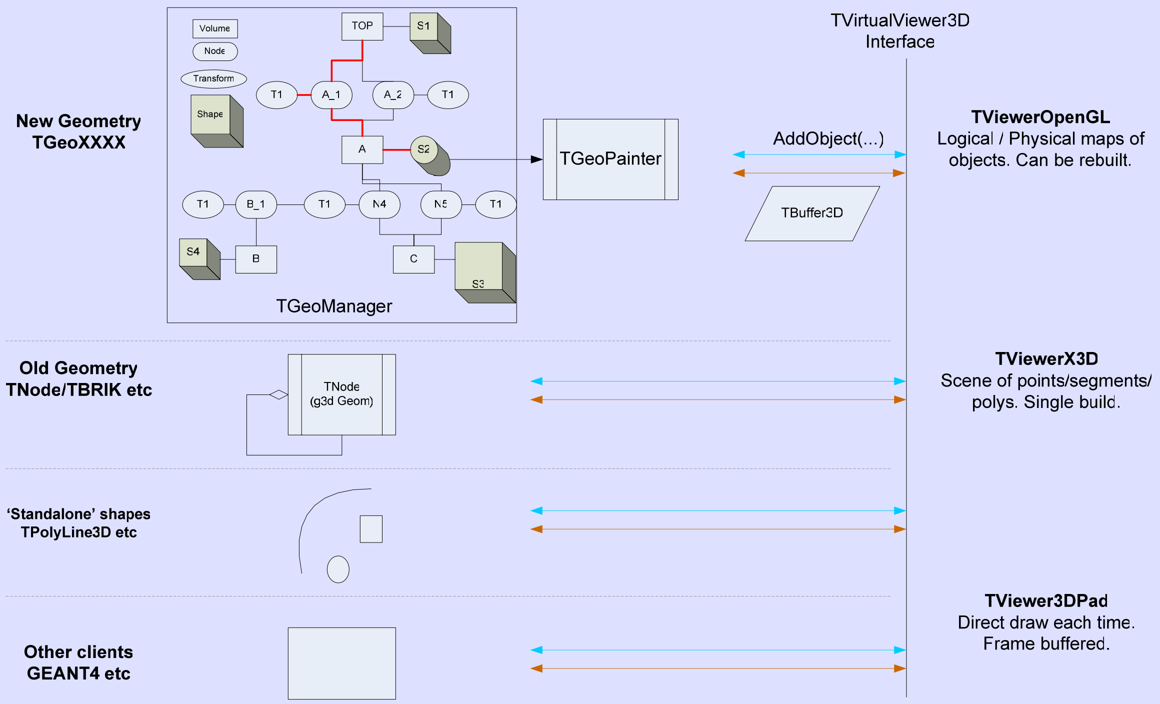


TBuffer3D: 3D Object hierarchy – describe "shapes".
Generic TBuffer3D for any object in tessellated form.
Subclasses for shape specific examples (TBuffer3DSphere etc) which some viewer(s) can tessellate natively.

- **TVirtualViewer3D & TBuffer3D act as intermediaries – decouple producers (geometry etc) and consumers (viewers) .**
- **Interface answers questions such as: "prefer local frame?", "send child objects?", "fill what in buffer?"**
- **TBuffer3D composed of sections, filled in negotiation with viewer:**
  - **Create buffer object –shape specific one if suitable, TBuffer3D if not.**
  - **Optionally test viewer local reference frame – if can fill in local frame with translation matrix in Core.**
  - **Fill cheap mandatory sections (Core/BoundingBox/ShapeSpecific), and add to viewer:**

    UInt_t extraSections = viewer->AddObject(buffer);
  - **Returns extra (costly) sections (Raw Sizes/Raw) if viewer requires – complete and add again.**
  - **Returns indication if contained children should be sent (addChildren flag)**

Producers	Intermediaries TVirtualViewer3D & TBuffer3D	Consumers



- **TBuffer3D contents in copied into viewer specific internal data structures.**
- **Some viewers (OpenGL) are able to cache Logical (unique "shapes") and Physical (placed copies) objects from IDs.**
- **Recycle TBuffer3D object if required.**

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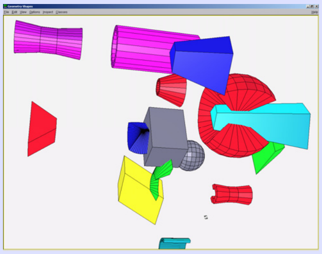
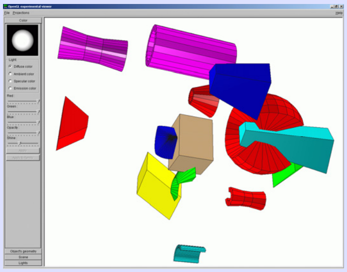
GL Viewer: Can now be used as a standalone viewer and as built in pad. TPad can render classical 2D graphics, using X11 or Windows graphics and 3D graphics using OpenGL. We intend to exploit this to offer wide new range of data representation techniques.

```
root[0] gStyle->SetCanvasPreferGL(kTRUE);
root[1] .x shapes.C
```

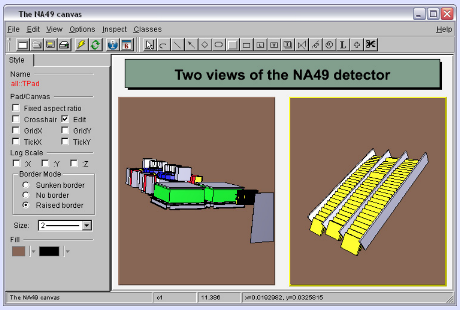


Canvas

shapes.C

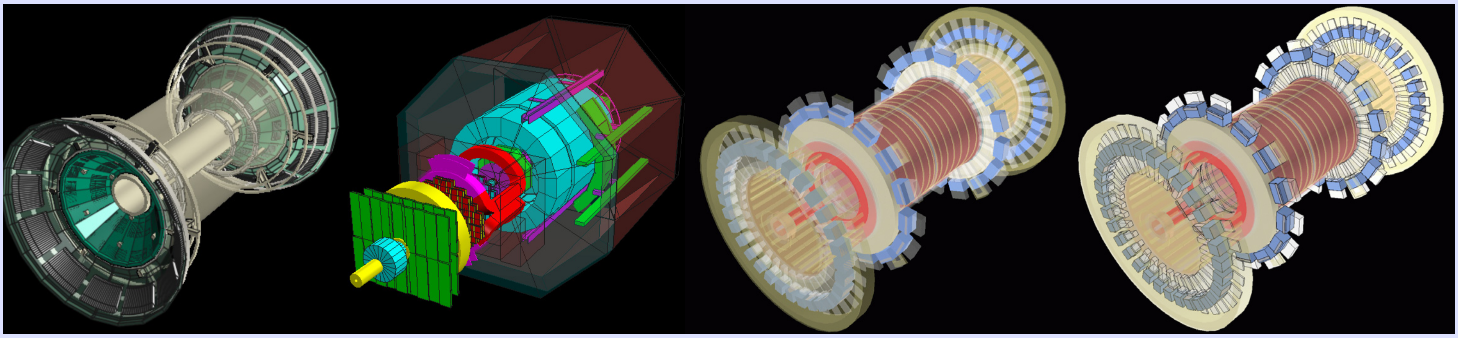


Standalone GL viewer



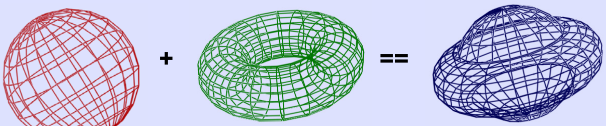
na49view.C

Draw Style: Objects can be drawn as solids and solids with outlines:

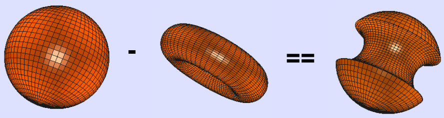


Composite Shapes: ROOT 's composite shapes (TGeoCompositeShape) can now be visualized with GL viewer:

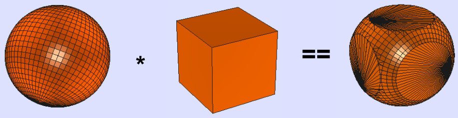
```
new TGeoCompositeShape("cs", "sphere + torus")
```



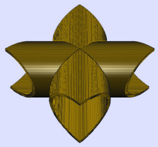
```
new TGeoCompositeShape("cs", "sphere - torus")
```



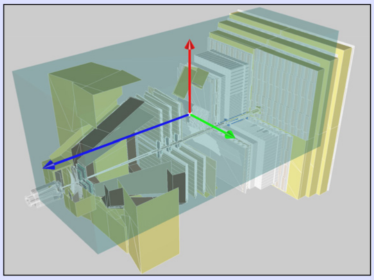
```
new TGeoCompositeShape("cs", "box * sphere")
```



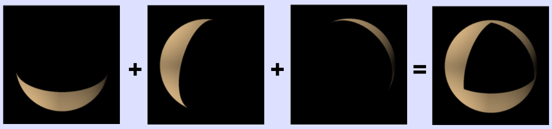
```
TGeoCompositeShape *cs1 = new TGeoCompositeShape("cs1", "tub1+tub1:r1");
TGeoCompositeShape *cs2 = new TGeoCompositeShape("cs2", "tub2+tub2:r1");
TGeoCompositeShape *cs3 = new TGeoCompositeShape("cs3", "cs1-cs2");
TGeoCompositeShape *cs = new TGeoCompositeShape("cs", "cs3*box:r2");
```



Clipping: Remove subset of objects to show detector internals etc.
Two techniques



- **OpenGL® Clip Planes:** Multiple renders, each with one or more clip planes, combine together e.g. 3 sides of box:



Pros: Fast and simple, interactive (few planes)

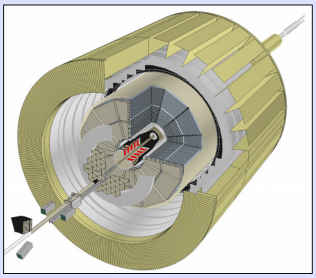
Cons: Accurate only for shapes described by planes - approx otherwise. Clipped solids not capped –hollow.

- **CSG Operation:** Add all object meshes (o1..on), subtract clipping object mesh (c) :

o1 + o2 + ... + on – c

Pros: Any arbitrary clipping shape possible

Cons: Cannot adjust interactively; Slow, complex; Proper capping of solids



Adding both methods, clip planes for interactive setup, CSG for high quality renders.