



@SaltyBurge









A. Salzburger (CERN) for the ACTS project



Geometry - Surfaces

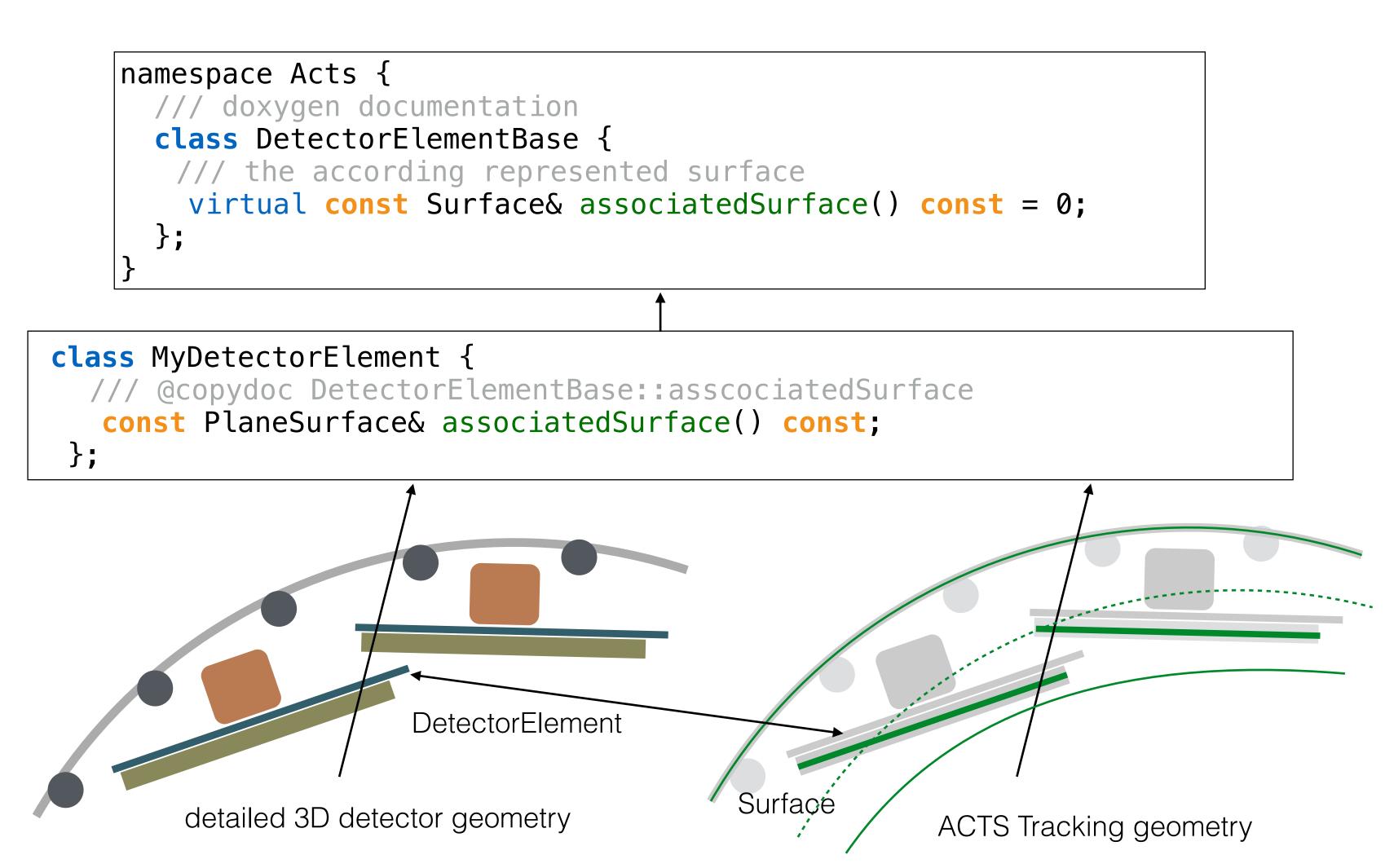
Surface class is the base component of all geometry objects - Layers (may be dropped, see tomorrow) have approach surfaces - Volumes are composed as set of boundary surfaces

This is a key element of the conceptual design:

- makes all geometry objects compatible with the central Propagator module
- Bound surfaces act as measurement reference surfaces but also as navigation hooks and boundary surfaces (portals)

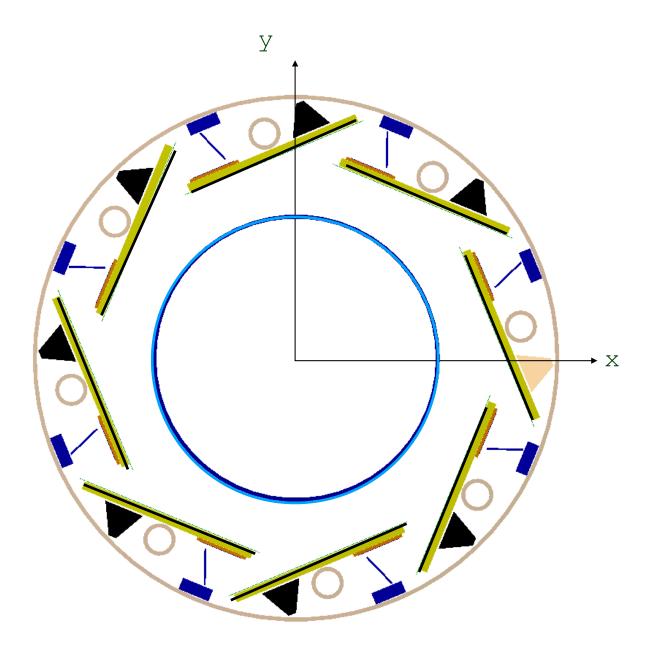
Geometry - DetElementBase

Binding the ACTS geometry to an existing Geometry model is done via declaration of a Acts::DetectorElementBase object



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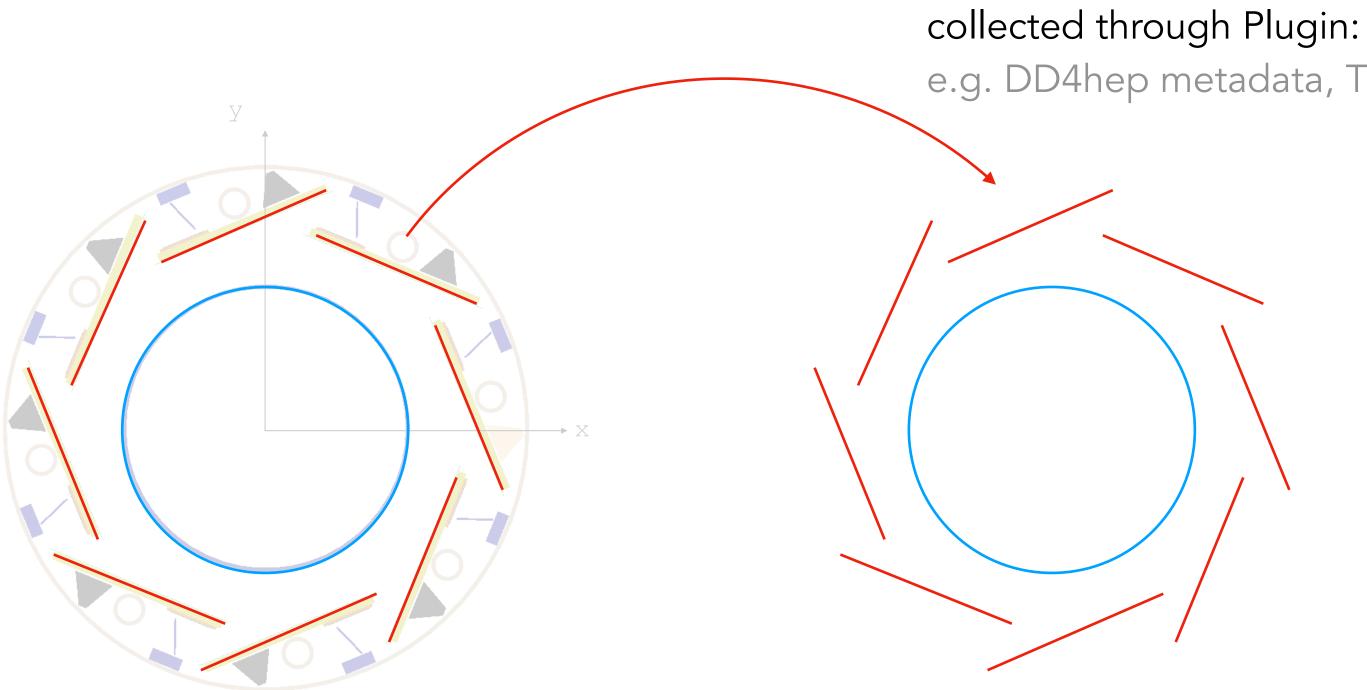
(Current) geometry building follows a bottom up approach



3D geometry model

(Plugin, e.g. GeoModel, DD4Hep, TGeo)

(Current) geometry building follows a bottom up approach

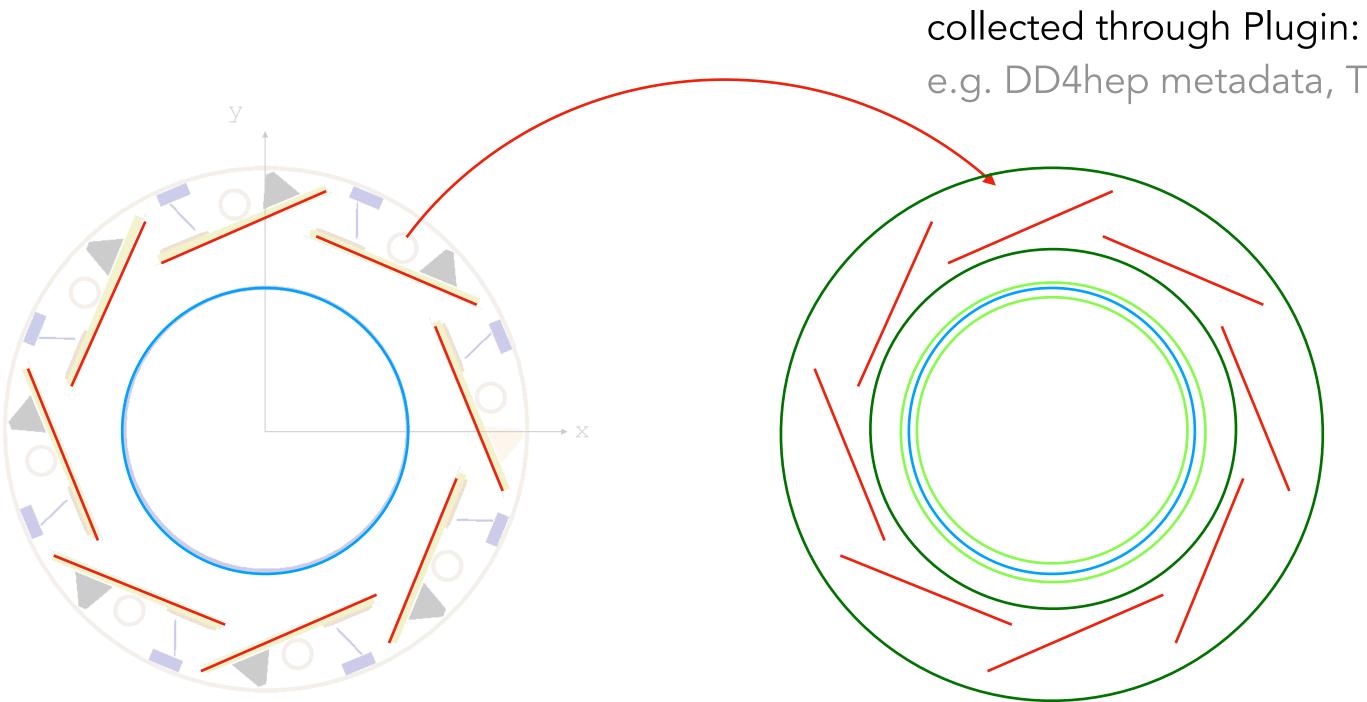


3D geometry model + PluginDetectorElement + PassiveLayer (Plugin, e.g. GeoModel, DD4Hep, TGeo)

e.g. DD4hep metadata, TGeo naming, json files

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(Current) geometry building follows a bottom up approach

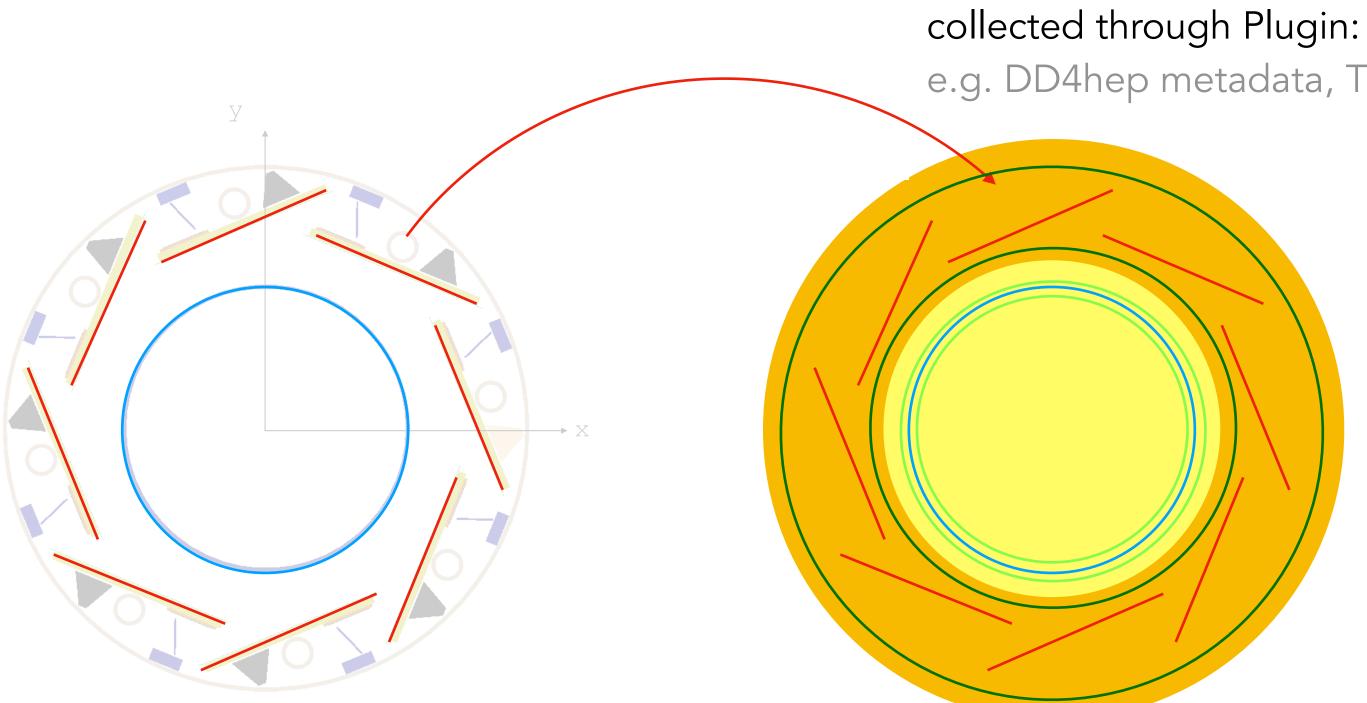


3D geometry model + PluginDetectorElement + PassiveLayer + LayerBuilders (Plugin, e.g. GeoModel, DD4Hep, TGeo)

e.g. DD4hep metadata, TGeo naming, json files



(Current) geometry building follows a bottom up approach

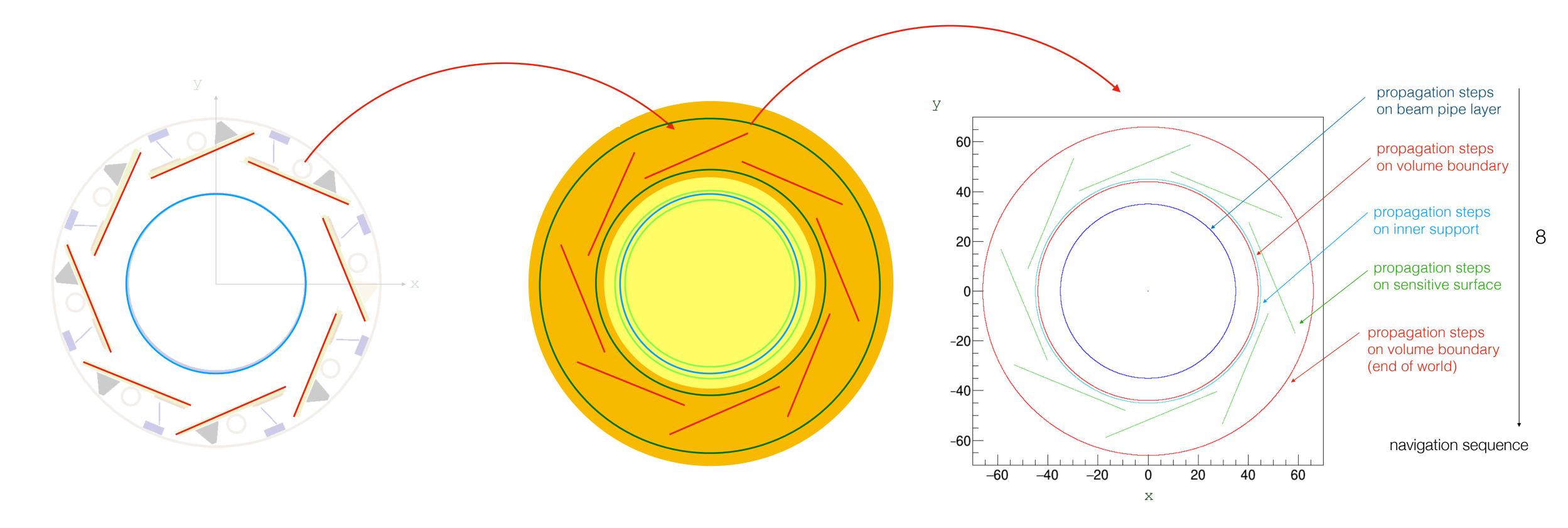


3D geometry model + PluginDetectorElement + PassiveLayer + LayerBuilders + VolumeBuilders (Plugin, e.g. GeoModel, DD4Hep, TGeo)

e.g. DD4hep metadata, TGeo naming, json files



(Current) geometry building follows a bottom up approach



Geometry - Navigation consequence

Navigator in ACTS (only for layer setup) is relatively complex

- It has to resolve a three-body system + edge cases

Test implementation without layers

- saves 3/4 of the code lines
- With same functionality:
 - Sensitive, passive surfaces
 - Material integration possible

Acts::Experimental::Navigator LOC: 170

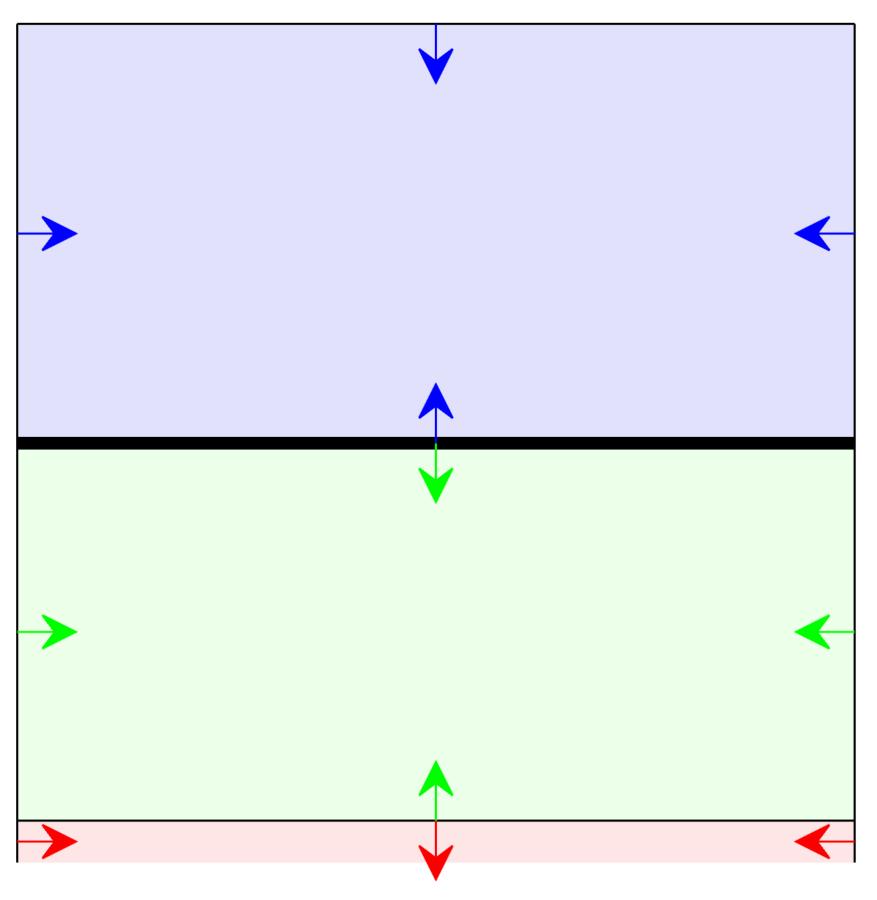


Acts::Navigator LOC: 768

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Instead of one navigator having to deal with different setups

- delegate to volumes (literally using the Delegate class)



visualisation of prototype using actsvg

different setups .egate class)

```
/// It has a Surface representation for navigation and propagat
/// and guides from one volume to the next.
/// The surface can carry material to allow mapping onto
/// portal positions if required.
class Portal : public std::enable_shared_from_this<Portal> {
protected:
 /// Constructor from surface w/o portal links
 111
 /// @param surface is the representing surface
 Portal(std::shared_ptr<Surface> surface);
private:
 /// The surface representation of this portal
 std::shared_ptr<Surface> m_surface;
 /// The portal targets along/opposite the normal vector
 std::array<ManagedDetectorVolumeLink, 2> m_volumeLinks;
```

}



Geometry - VolumeLink + ManagedVolumeLink

- Delegate to update a Experimental::NavigationState struct (that is used by the Experimental::Navigator)

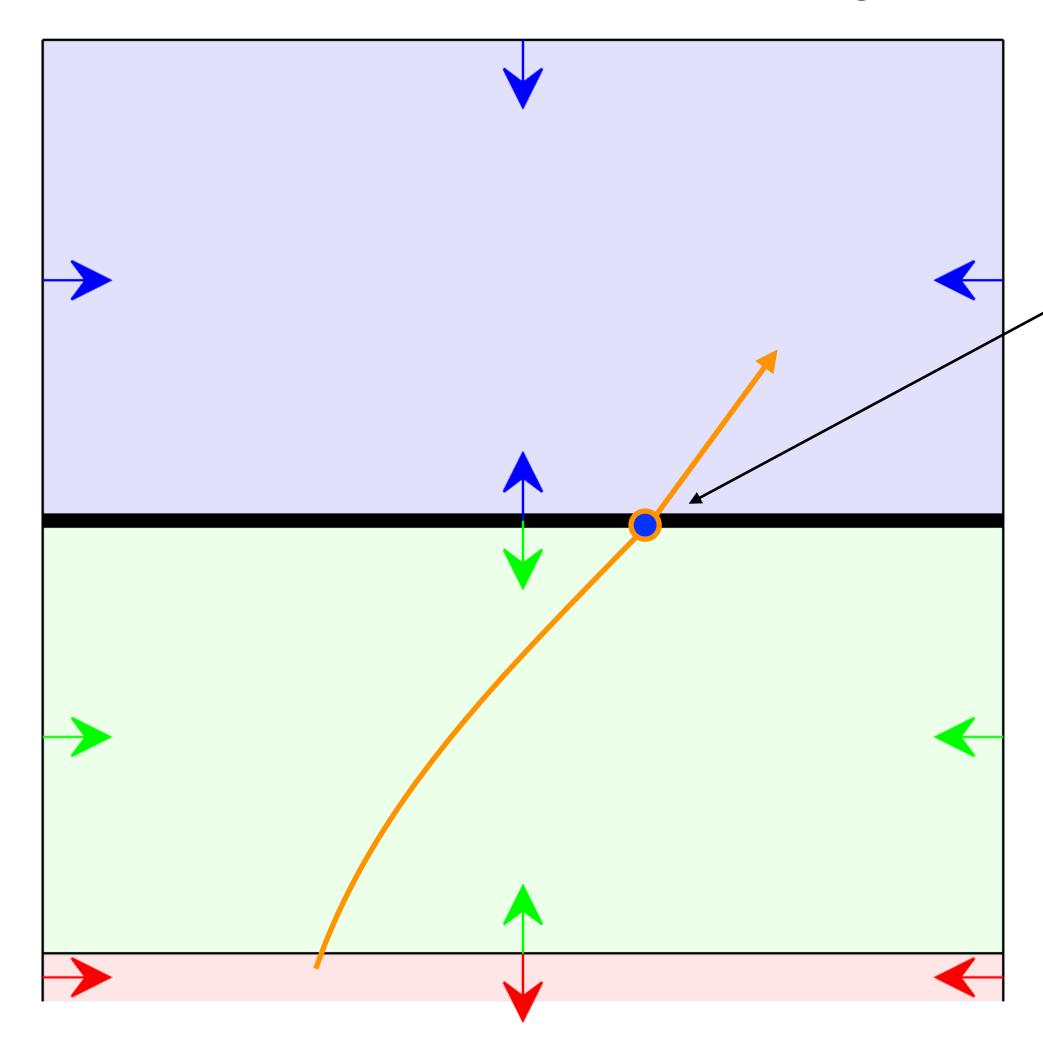
```
/// Base class for all link implementations that need class structure
class INavigationDelegate {
 public:
 virtual ~INavigationDelegate() {}
};
/// Memory managed delegate to guarantee the lifetime
/// of eventual unterlying delegate memory and the
/// delegate function
111
template <typename deletage_type>
struct ManagedDelegate {
 public:
 deletage_type delegate;
 std::shared_ptr<INavigationDelegate> implementation = nullptr;
```

```
/// Memory managed navigation state updator
using ManagedNavigationStateUpdator =
    std::tuple<NavigationStateUpdator, NavigationStateUpdatorStore>;
/// Declare a Detctor Volume Switching delegate
111
   @param gctx is the current geometry context
   @param position is the position at the query
/// @param direction is the direction at the query
111
/// @return the new DetectorVolume into which one changes at this switch
using DetectorVolumeLink = Delegate<const DetectorVolume*(</pre>
    const GeometryContext& gctx, const Vector3& position,
    const Vector3& direction)>;
/// Memory managed detector volume link
```

using ManagedDetectorVolumeLink = ManagedDelegate<DetectorVolumeLink>;



Portal leads to new volume, volume gives access to local navigation



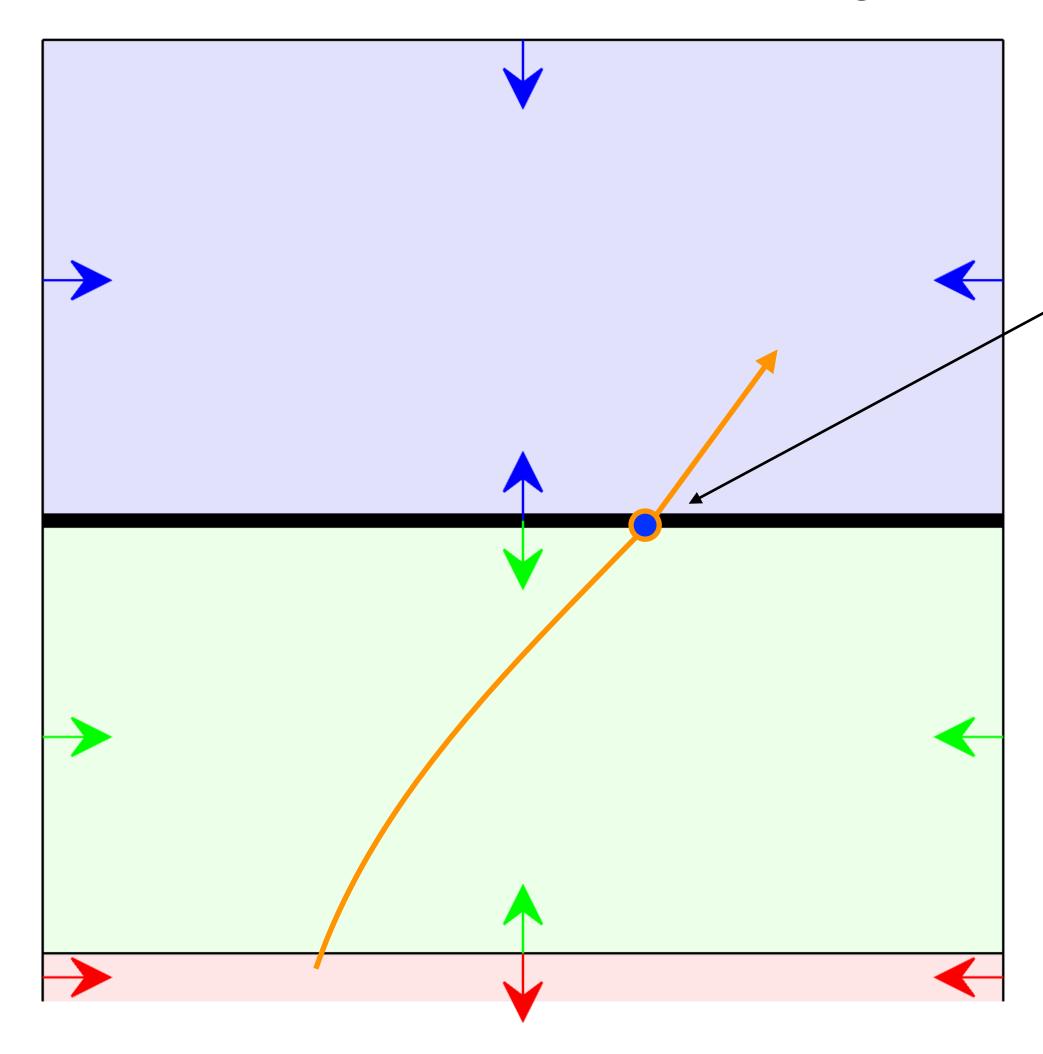
This can be implemented using straight line, frustum, blind search, whatever ...

```
/// Declare a navigation state updator
/// This delegate dispatches the local navigation action
/// to a dedicated struct or function that is optimised for
/// the given environment.
   @param nState is the navigation state to be updated
    @param volume is the volume for which this should be called
/// @param gctx is the current geometry context
   @param position is the position at the query
   @param direction is the direction at the query
    @param absMomentum is the absolute momentum at query
   @param charge is the charge to be used for the intersection
using NavigationStateUpdator = Delegate<void(</pre>
    NavigationState& nState, const DetectorVolume& volume,
    const GeometryContext& gctx, const Vector3& position,
    const Vector3& direction, ActsScalar absMomentum, ActsScalar charge)>;
/// Memory managed navigation state updator
using ManagedNavigationStateUpdator = ManagedDelegate<NavigationStateUpdator>;
```





Portal leads to new volume, volume gives access to local navigation



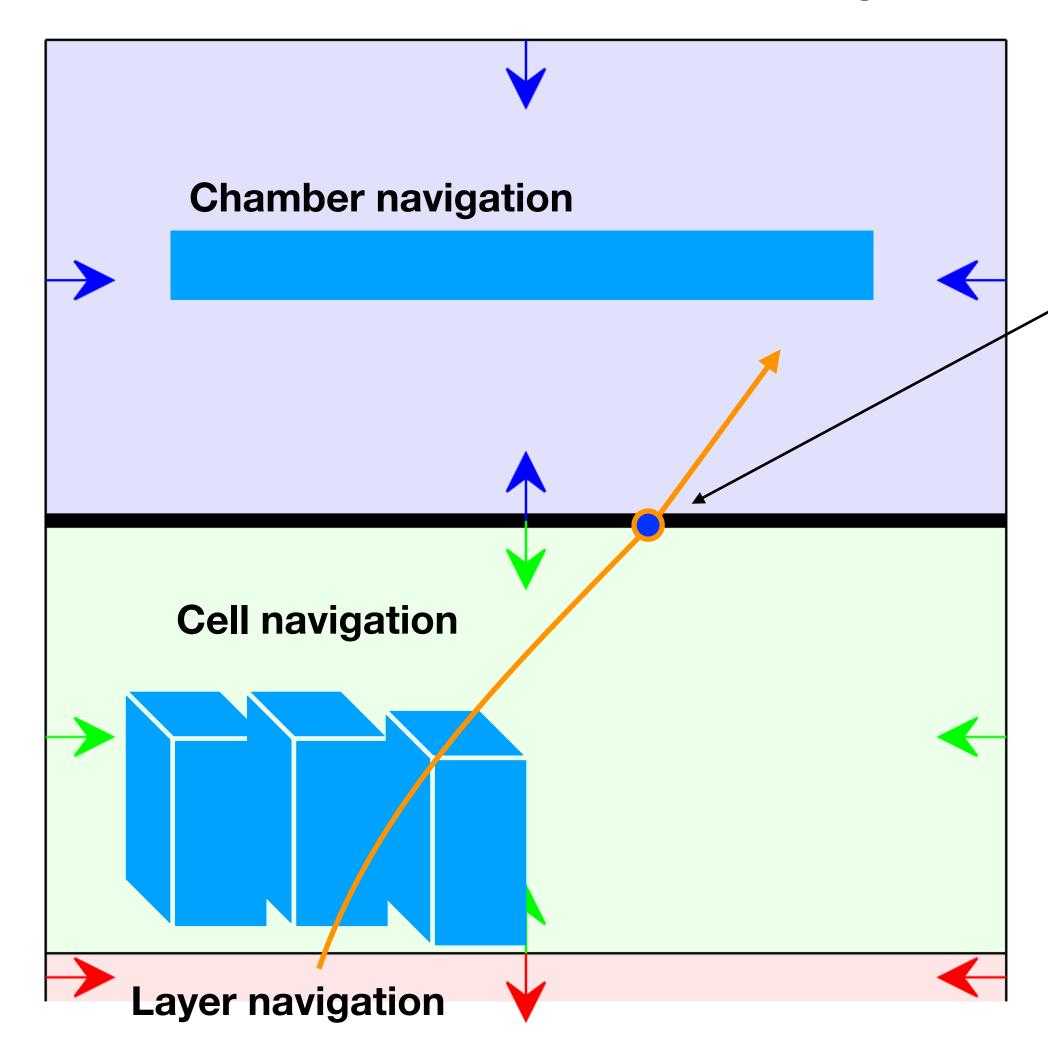
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Portal leads to new volume, volume gives access to local navigation



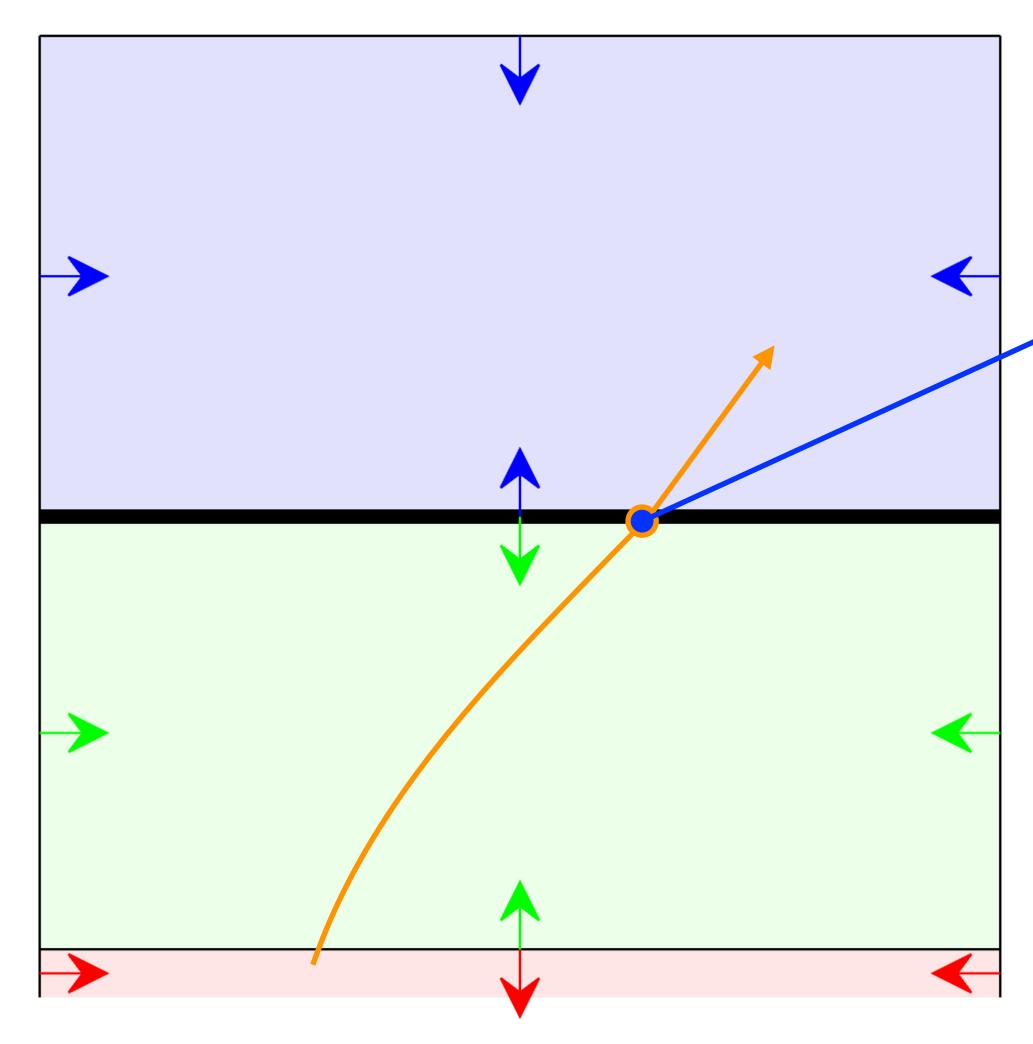
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```





New volume updates navigation state



/// @brief A navigation state holding the current information
/// about volume, surfaces, and portals
struct NavigationState {

/// @brief A surface candidate and its intersection
struct SurfaceCandidate {

/// A candidate intersection, in Surface view
ObjectIntersection<Surface> objectIntersection;
/// A candidate is either a detector Surface
const Surface* surface = nullptr;
/// Or a portal
const Portal* portal = nullptr;
/// The boundary check used for these
BoundaryCheck bCheck = true;
};

```
using SurfaceCandidates =
    boost::container::small_vector<SurfaceCandidate, 16u>;
```

```
/// The current volume in processing
const DetectorVolume* currentVolume = nullptr;
```

```
/// The current surface, i.e the track is on surface
const Surface* currentSurface = nullptr;
```

/// That are the candidate surfaces to process
SurfaceCandidates surfaceCandidates = {};
SurfaceCandidates::iterator surfaceCandidate = surfaceCandidates.end();

```
/// Boundary directives for surfaces
BoundaryCheck surfaceBoundaryCheck = true;
```

```
/// An overstep tolerance
ActsScalar overstepTolerance = -0.1;
```

```
/// Auxilliary attached information
std::any auxilliary;
```

};



Geometry - Current status (1)

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Т	his geometry l	building also implement	ts a strict non-cost	at construction an	nd const at runtime p	policy.

https://github.com/acts-project/acts/pull/1465



Geometry - Current status (2)

All new code in Experimental folder and namespace, can be deployed in parallel

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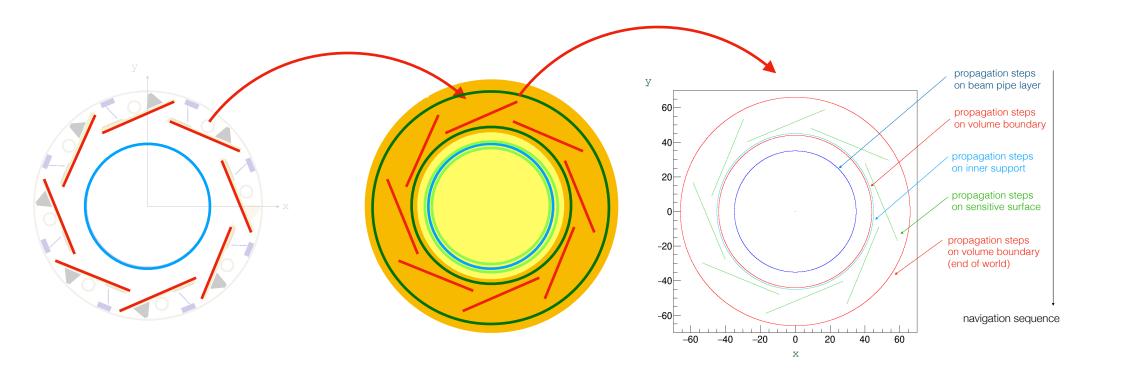
https://github.com/acts-project/acts/pull/1465

Almost complete setup: Way less code/classes than in Geometry.



Geometry - Other problems/Issues

(Current) geometry building follows a bottom up approach



This setup can be quite brittle:

- potential overlap of volumes (often caused by actual extent + clearance envelopes)

Often 1000s of surfaces are parsed to construct a fixed global skeleton of volumes

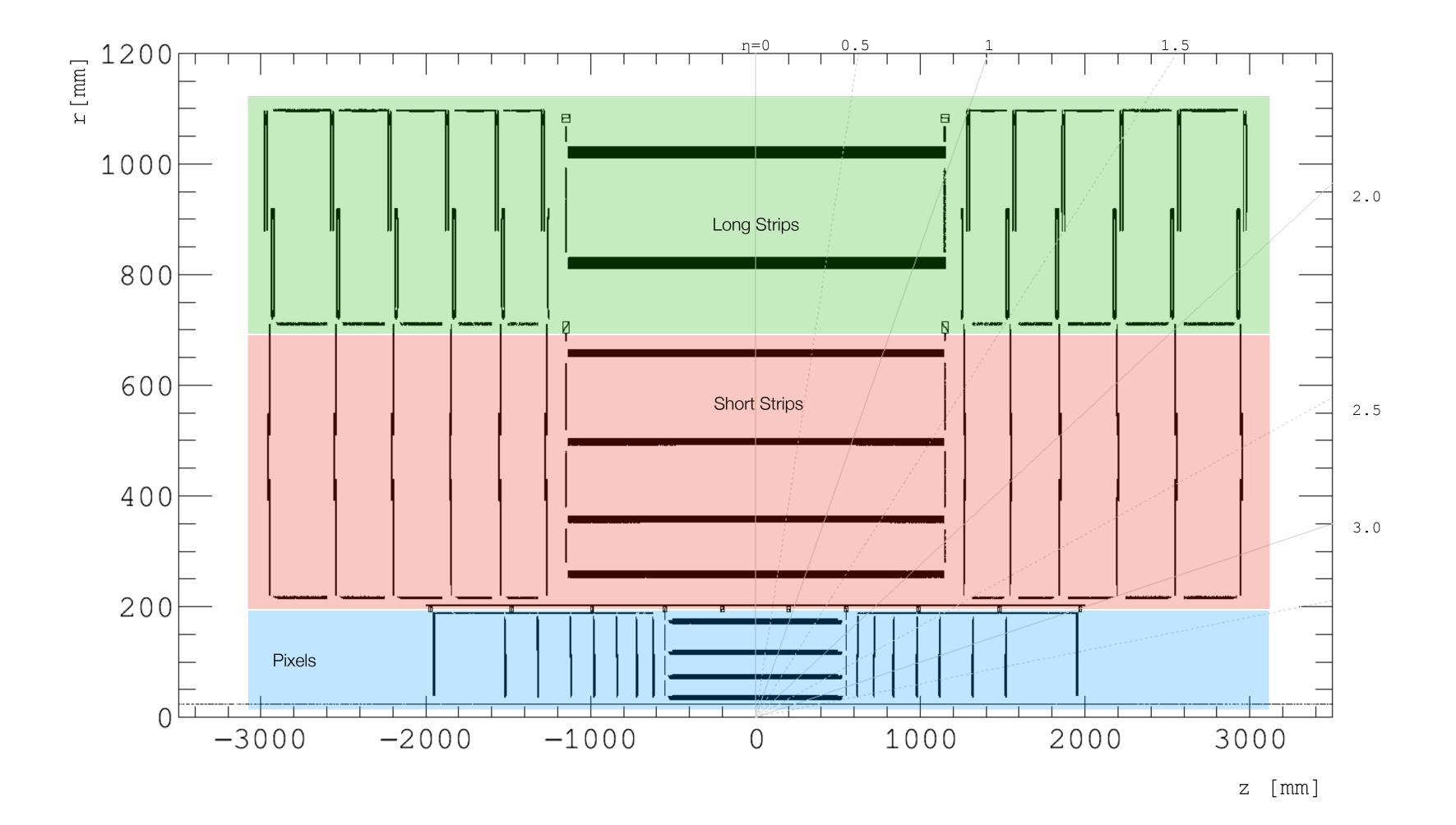
- Only few volumes are actually needed

Shall we **reverse** the logic?



Geometry - Reverse building (1)

Current approach: sensitive modules parsed & ordered to estimate layer dimensions and subsequently volume dimensions:





Geometry - Reverse building (2)

We could give a very light-weight way to build a volume frame first and then "fill" it with local navigation delegates.

