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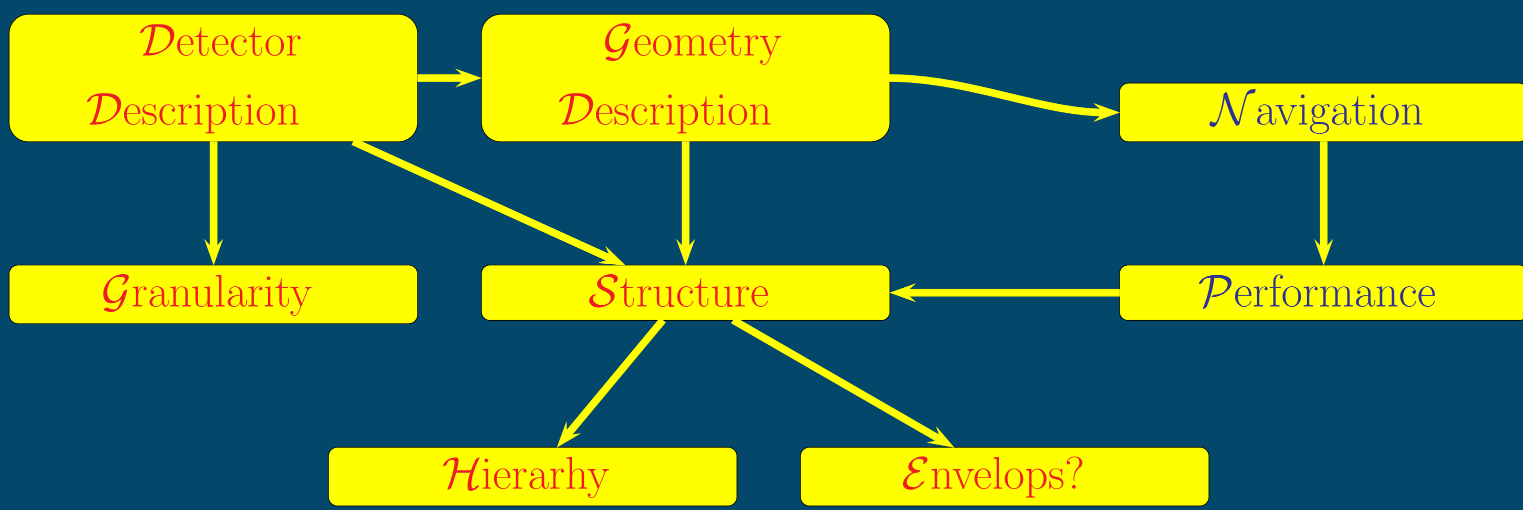
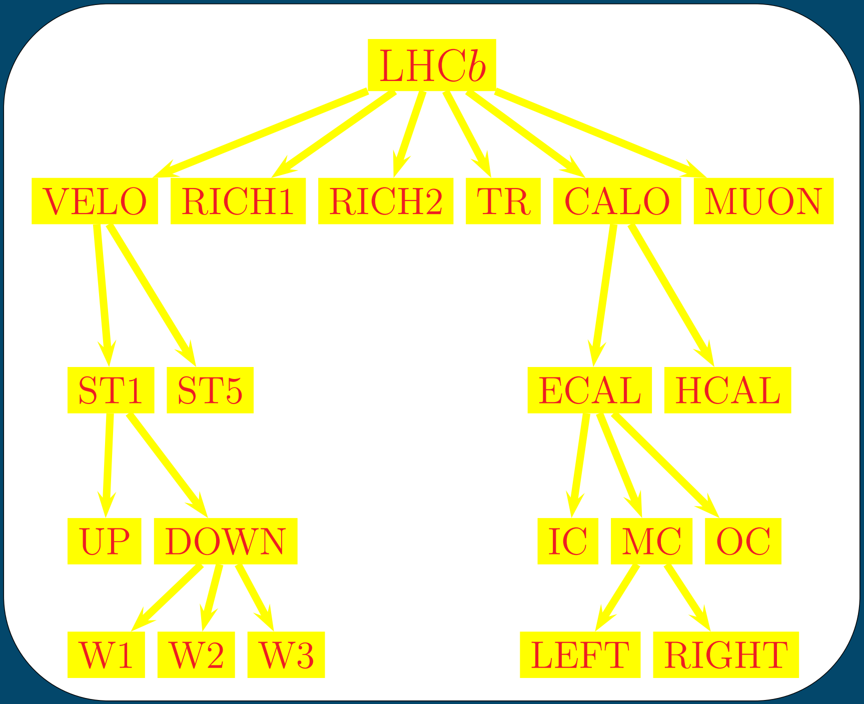
Geometry & Detector Description

Topics to be covered :



$\mathcal{D}$etector $\mathcal{D}$escription $\mathcal{T}$ree



- logical description of apparatus structure
- each $\mathcal{DE}$ - user entry point to retrieve (sub)detector information
- unique "named" element
  - individual access "by name"
  - unique location
- hierarhical tree structure
  - top element
  - knowledge of "up" and "down" links

$\mathcal{D}$etector $\mathcal{E}$lement Granularity

- $\mathcal{M}$echanical $\mathcal{C}$onstruction
- $\mathcal{G}$eometry ($\mathcal{N}$ominal)
- individual ($\mathcal{M}$is)$\mathcal{A}$lignment
  - generic for $\mathcal{DE}$
  - custom for non-$\mathcal{DE}$ (sub)elements
- $\mathcal{S}$low $\mathcal{C}$ontrol information
  - low & hight voltage, thresholds
  - temperature, pressure, gas quality
- $\mathcal{C}$alibration

- $\mathcal{R}$ead$\mathcal{O}$ut information
  - channel map
  - noisy and hot channels
- $\mathcal{DB}$ase access
  - constants for $\mathcal{D}$igitisation
  - constants for $\mathcal{C}$alibration
- Other considerations
  - code performance
  - "simplicity", $\mathcal{MC}$, ...

SINGLE CHANNEL IS NOT $\mathcal{DE}$!

Is is easy fo fulfill all criteria?

$\mathcal{D}$etector $\mathcal{E}$lement $\mathcal{G}$ranularity

The top level $\mathcal{DE}$ structure could be deduced from geometry structure of subdetectors:

- (almost) all subsystems consist of several *"stations"*
- (almost) all subsystems consist of several parts with different granularities - *"inner", ..., "outer"*
- (almost) all *"stations"* consist of two (movable) parts (*"left"-"right" or "up"-"down"*)

The further "division" could not be deduced from pure geometry principles on a common basis for all subsystems

$\mathcal{D}$etector $\mathcal{E}$lement $\mathcal{G}$ranularity ($\mathcal{P}$edestrian $\mathcal{V}$iew)

$\mathcal{V}$ertex:
single *wafer* looks as ideal candidate for the most deep $\mathcal{DE}$

$\mathcal{IT}$racker:
for MSGC-like technology choice single *chamber* looks as ideal candidate for the most deep $\mathcal{DE}$

$\mathcal{OT}$racker & $\mathcal{M}$uon : Is single *chamber* a good solution?

pro: mechanical construction, readout, alignment, monitoring, ...

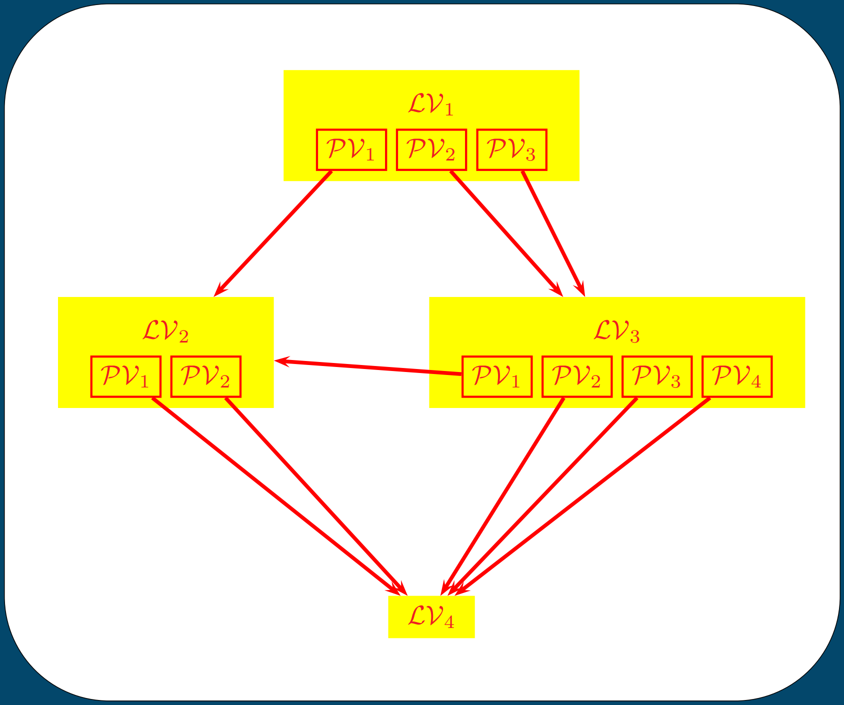
contra: number of *chambers* could be quite large

$\mathcal{D}$etector $\mathcal{E}$lement $\mathcal{G}$ranularity ($\mathcal{P}$edestrian $\mathcal{V}$iew)

$\mathcal{C}$alorimeters:

- Top level division according to the geometry consideration is quite natural. The properties of the top level $\mathcal{DE}$s were discussed within Calorimeter group in detailes and their interfaces with respect to reconstruction purposes were fixed.
  - definition of geometry for simulation requires different approach
- The additional division is absolutely unclear yet, and it was not yet discussed. Several possibilities, each of them has certain advantages and disadvantages:
  - divide according to readout bords, suitable for trigger and especially fine for preshower, where MPT are used.
  - divide according to geometry (could be suitable for alignment)

$\mathcal{G}$eometry $\mathcal{D}$escription $\mathcal{T}$ree



- geometry description of apparatus
- *"palette" of $\mathcal{L}$ogical $\mathcal{V}$olumes*
  - "bricks" for construction
  - knows $\mathcal{S}$*olid* and $\mathcal{M}$*aterial*
  - no information about position
- $\mathcal{LV}$ has "structure", described by daughter $\mathcal{PV}$
- $\mathcal{PV}$ is daughter $\mathcal{LV}$ assosiated with its position inside mother

$\mathcal{G}$eometry $\mathcal{D}$escription $\mathcal{T}$ree

- Navigation Loops are forbidden
  - no intersection between volumes
  - no GEANT3 'MANY'
- no any absolute positioning
- $\mathcal{PV}$ is the only source for navigation

- all questions to $\mathcal{LV}$ have sence only in the local reference system of this $\mathcal{LV}$
- all questions to $\mathcal{PV}$ have sence only in the local reference system of its mother $\mathcal{LV}$
- $\mathcal{G}$lobal $\mathcal{R}$eference $\mathcal{S}$ystem is just the local reference system of top $\mathcal{LV}$

𝒢eometry 𝒟escription 𝒯ree

- (goal) The only one source of geometry information for simulation & reconstruction
- (Very) detailed geometry description
  Probably not all screws should be described, but the most important screws must be described
- Quite complicated
  - now SICB `JVOLU` contains ??? volumes
  - "new" number $\downarrow$ due to boolean solids
  - "new" number $\uparrow$ due to more detailed description
- (goal): good navigation performance
- (goal): good performance with respect memory comsumption

Both "optimisation" tasks are very closely related!

$\mathcal{G}$eometry $\mathcal{D}$escription $\mathcal{T}$ree Optimisation

Memory optimization for tree with $\mathcal{N}$ "identical" elements with $\mathcal{K}$ layers with $\mathcal{N}_i$ branches per layer i:

minimize the total number of volumes

$$N_1 \times N_2 \times \ldots \times N_{\mathcal{K}} = \mathcal{N}$$

$$\sum_{i=1}^{\mathcal{K}} N_i = \min$$

$$\text{solution} = \left\{ \begin{array}{l} N_i = \langle n \rangle \\ \langle n \rangle = \mathrm{e} \\ \mathcal{K} = \log \mathcal{N} \end{array} \right\}$$

Navigation optimisation for the system of $\mathcal{N}$ "unique" elements

- the navigation time "per one element": τ
- the navigation time at level i: t_i
- the total navigation time: $\mathcal{T}$

$$t_i = \tau \times n_i$$

$$\mathcal{T} = \sum t_i$$

$$\mathcal{T} = \min$$

The same equations!

The same solution?

$\mathcal{G}$eometry $\mathcal{D}$escription $\mathcal{T}$ree $\mathcal{O}$ptimisation

Each layer in navigation has an additional extra overhead!

$$t_i \sim \mathcal{O}(\tau \times N_i) \quad +\mathcal{O}(i)$$

$$\mathcal{T} \sim \mathcal{O}(\sum t_i) \quad +\mathcal{O}(\mathcal{K})$$

$$\mathcal{T} \sim \mathcal{O}(\log \mathcal{N}) \quad +\mathcal{O}(\log \mathcal{N})$$

This overhead could be significant: for "simple question" within "simple geometry" could be estimated analytically to be the same!

This factor of 2 is to be reduced!

Use shortcuts and cache!

$\mathcal{DE}$ $\mathcal{T}$ree acts as cache and shortcut collection for navigation!

- each $\mathcal{DE}$ has unique location $\Rightarrow$ no extra overhead due to relocation of the level
- $\mathcal{S}$hortcuts remove redundant layers!
- $\mathcal{DE}$ $\mathcal{T}$ree represents the "simplified" $\mathcal{G}$eometry $\Rightarrow$ number of elements (& layers!) is smaller
- *"natural"* solution: $\mathcal{DE}$ tree follows the $\mathcal{G}$eometry $\mathcal{T}$ree till some level of detalisation

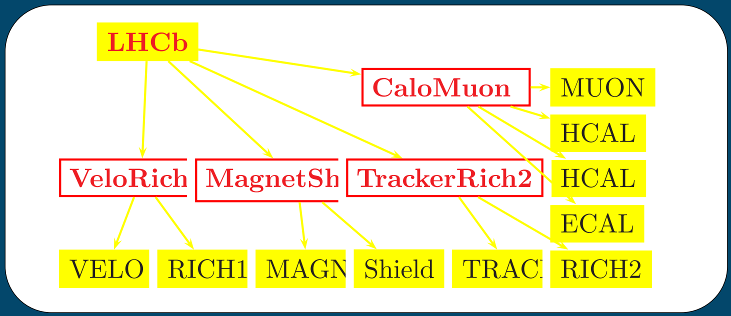
$\mathcal{N}$avigation

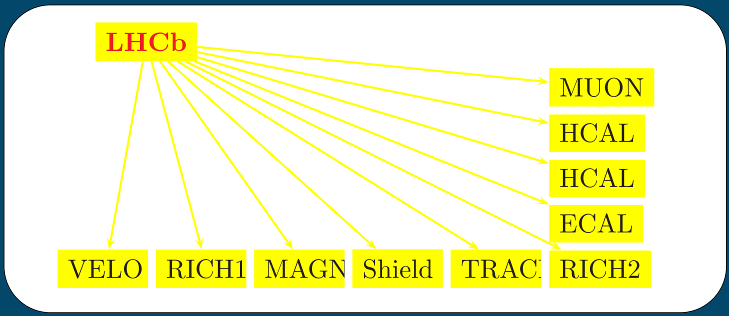
Effective navigation using $\mathcal{DE}$ $\mathcal{T}$ree and $\mathcal{LV}$ ($\mathcal{G}$eometry $\mathcal{D}$escription) $\mathcal{T}$ree

1. **Locate "point" on** *the most deep level* **of $\mathcal{DE}$ Tree (usage of "cache" - FAST!)**
2. **switch to the Geometry Description Tree (skip several layers -"shortcut" - FAST!)**
3. **(is it "optimal"?) $\Rightarrow$ answer depends on structure of concrete links, next slide**

Up to now only *"general bla-bla-bla"* - no *concrete* fix of structure of $\mathcal{DE}$ Tree, BUT: next slide!

"Realistic" comparison of two models





use *Transport Service* as a tool for testing Geometry & Detector Derscription navigation performance

relevant for testing the geometry optimisation since

- obvious *"client"* (*"user"*) of Geometry/Detector Description and the only one in $\mathcal{GAUDI}$ now
- analog from SICB is invoked up to $\sim 4 \cdot 10^5$/event

the exact algorithm is irrelevant, but some features are essential for Geometry/Detector description

1. locate 2 points inside one $\mathcal{DE}$
2. further action closely relates to the navigation inside $\mathcal{LV}$, associated with $\mathcal{DE}$.

"Realistic" comparison of two models

1. **estimate "distance" in radiation length between 2 points "random" points**
2. **make performance measurement for both "models" after all caches activated**
3. **One naively expects that for the performace could be better of a factor 10/6 for Model II**

- a 2.5 better performance!
  - additional cache level in the Transport itself
  - different allocated space for subdetectors and "envelops"
- *"real"* advantage will be not so good
  - the geometry will be not so primitive
  - more clever usage of the service

$\mathcal{S}$ummary

Detector Description

1. Choose right objects and structure
2. Single channel is not a node in $\mathcal{DE}$ $\mathcal{T}$ree
3. Avoid multiply branches per layer
4. Use hierarhy
5. Follow Geometry Tree

Geometry Description

1. Choose optimal structure
2. Avoid multiply branches per layer
3. Use hierarhy
4. Avoid navigation from Top