A Brief Introduction to ACTS

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Outline

- What is ACTS – a Common tracking software
- What can we benefit
- How/where can we start
- Some intro of models & concept
- Development in ACTS

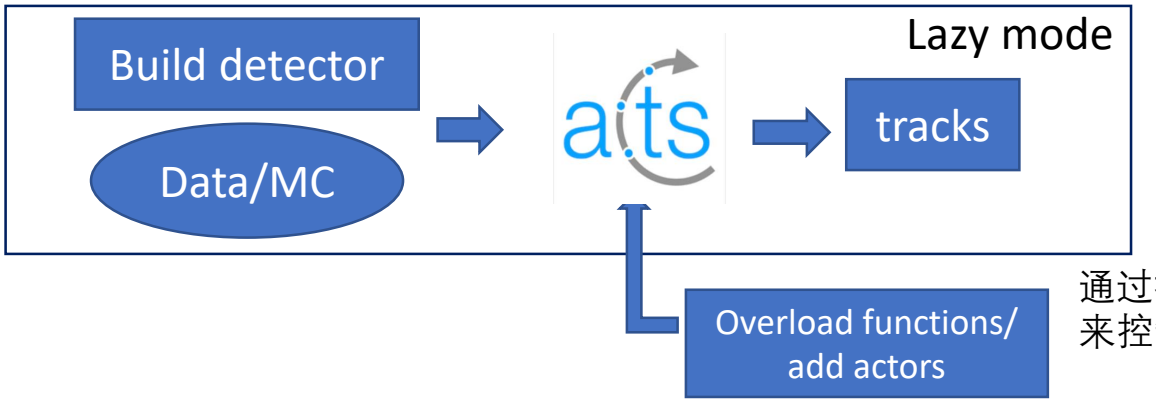
ACTS – A common tracking software

- 概念来自于ATLAS (Atlas common tracking software)
  - 一方面ATLAS现有代码存在很多问题
    - 重建代码过于庞大
    - Event Data Model极为繁多复杂
    - 重建算法的时间性能差
  - 在统一的EDM和下开发不依赖于探测器几何重建模块
- 开发重建用到的所有模块
  - Geometry, EDM, track finding, fitting, alignment ..

- 不依赖探测器几何与框架
  - 包含构建tracking geometry 的 plugins – 需要TGEO/DD4HEP格式的几何文件
  - 所有核心代码封装封装在acts-core中，每个模块算法独立于外部框架，通过经过boost的unit test测试
  - 有一个简单实现GAUDI的acts-framework，可以实现事例循环、模拟、数字化等基本流程，可以做事例级别的测试

ACTS – A common tracking software

- 灵活




```
PropagatorOptions<ActionList<MaterialInteractor,KalmanActor>> options;
```

- 代码效率要求高
  - C++新特性(如智能指针防止内存泄漏) now c++ 17
  - 模板元编程，编译期处理
  - 数学计算工具(Eigen..)
- 多线程/支持机器学习
  - ACTS-framework：提供多事例并行计算
    - Future plan: 事例级别
  - ML support : maybe future plan

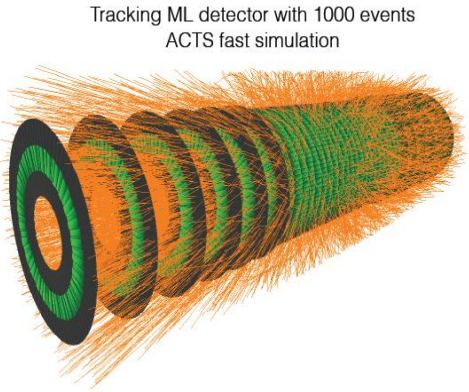
Acts tracking is like a drama, just needed good some actors

What we can benefit

- 整个重建框架独立于探测器几何 — 只需要输入探测器的几何就可以执行完整的重建流程，我们只需要调试或者增加一些特殊的方法，降低开发的成本
- 这种灵活的方式可以方便的提供多个探测器版本的重建进行比较
- 有专门的开发团队进行维护

How we can start

可供参考的探测器TrackML



ACTS-core status

- Geometry
- EDM
- Seeding
- Pattern
- extrapolate
- Track fitting
- Vertex fitting
- Calibration
- alignment

ACTS-framework

XML（DD4HEP）

Here we can start

Build CEPC detector

Real detector

Full/fast simulation

digitization

Space Point

Seeding

LOSS pattern (MC instead)

fitting

ACTS-core核心模块说明

Seeding : on merging

Pattern : extended Kalman filter (plan to do)

Fitting: Kalman fitting +Gsf (for e on doing)

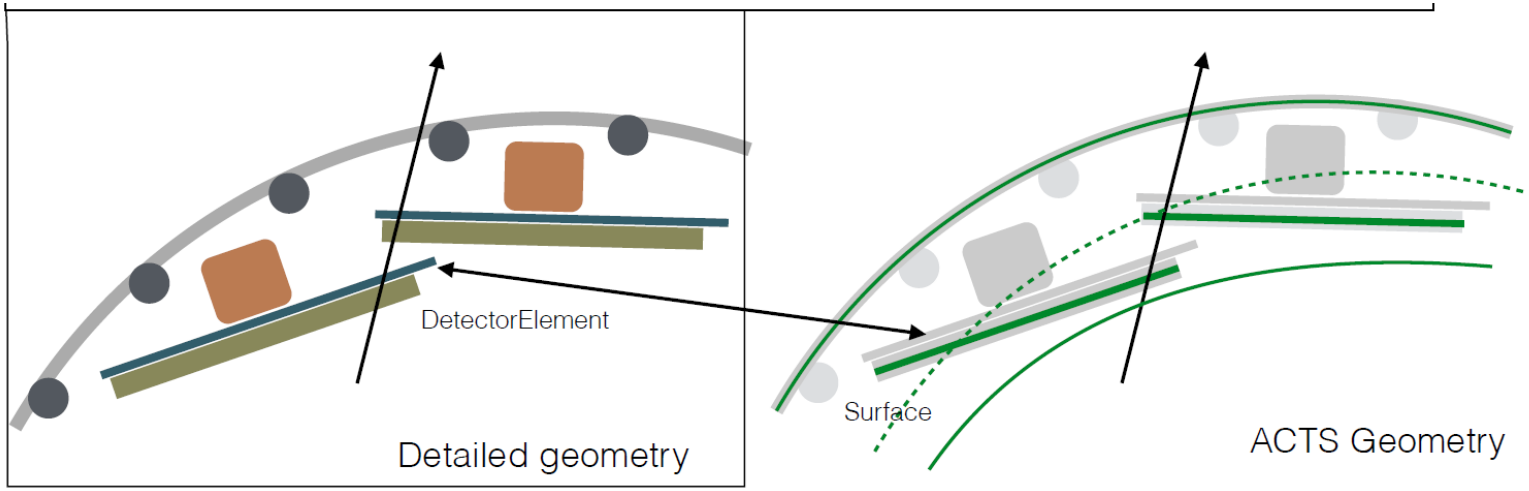
Vertex fitting: fast vertex fitting - on merging

Calibration + Alignment:缺失（难度）

And neglect the missing of pattern/ or some easy prototype?

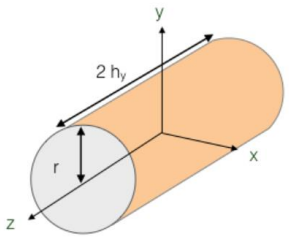
Geometry Concept

- 在ACTS中，所有的几何结构都由Surface构建
- 重建用到的几何(Tracking geometry) 只由基本的surface和物质材料构建
  - Surface->Layer->Volume->glue to tracking Volume
  - Material mapping: on surface or volume



Geometry-Surface

CylinderBounds

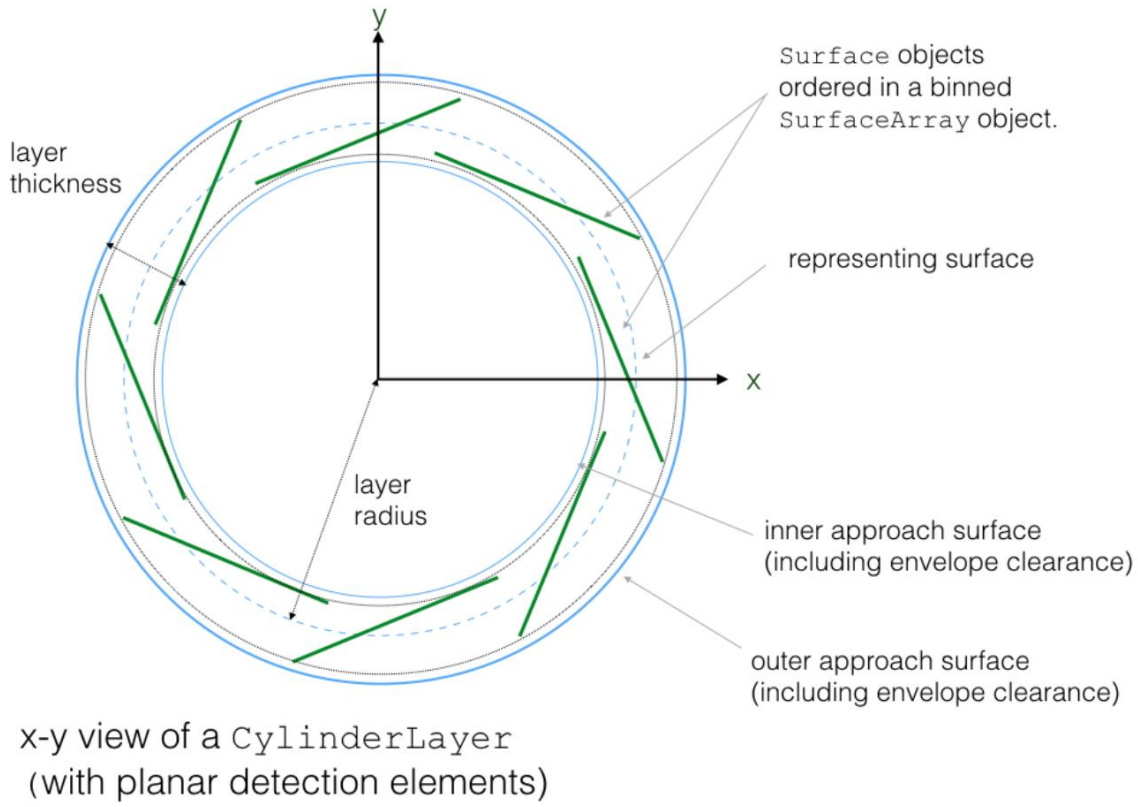


- 描述几何结构的基本单元
  - 位置信息：平移矩阵+旋转矩阵
  - 不同的surface上的测量量的表述不同(径迹传播和Kalman修正时用局部坐标)
  - Binning on surface

Surface Type	Local Coordinates	Bound Types available
`ConeSurface`	[rphi, z]	`ConeBounds`
`CylinderSurface`	[r, phi]	`CylinderBounds`
`DiscSurface`	[r, phi]	`RadialBounds`, `DiscTrapezoidalBounds`
`PlaneSurface`	[x, y]	`RectangleBounds`, `TrapezoidalBounds`, `TriangleBounds`, `InfiniteBounds`, `EllipseBounds`
`PerigeeSurface`, `StrawSurface`	[d, z]	`CylinderBounds`

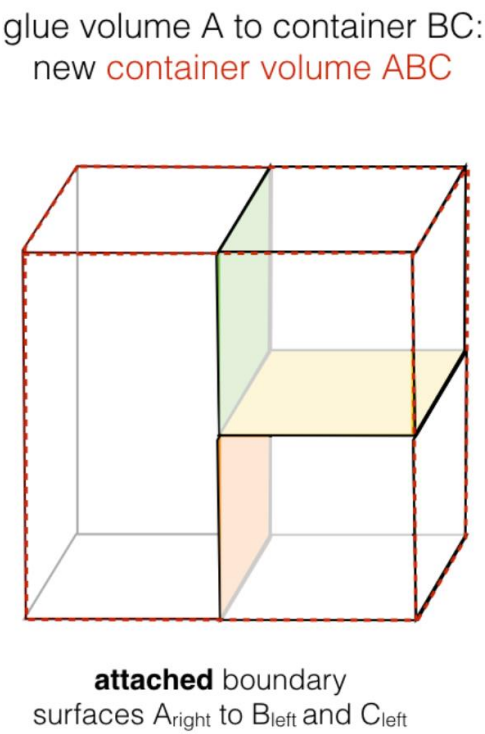
Geometry-Layer

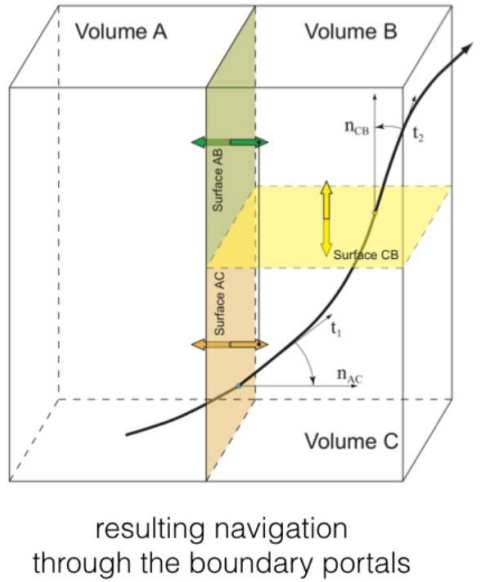
- Surface的拓展，可以包括多个Surface和material



Geometry-Volume

- Volume 是一系列Boundary限定起来的
- TrackingVolume
  - 一系列layer
  - 一系列子volume
  - Material描述
  - 通过Boundary Surface粘合





在径迹推导的时候可以通过边界向量知道导向下一个Volume

CEPC Geometry

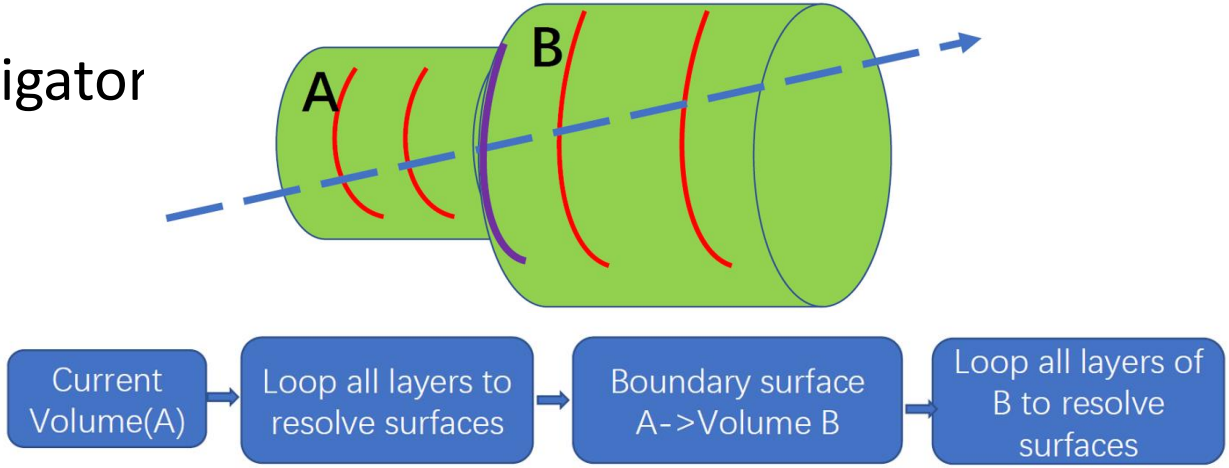
- 构建几何需要DD4HEP/TGEO的XML文件
- ACTS有Plugin可以通过将XML文件转化为Tracking Geometry，可能需要添加一些
- 当前有的几何
  - FCC – 由DD4HEP构建
  - TrackML - c++构建
  - 将会有一个DD4HEP构建的TrackML，包括如何构建该几何的说明，我们可以借鉴模仿

Extrapolate：
Stepper & Navigator

- Stepper
  - 决定径迹每一步怎么走，走多远
  - 决定在Vaccum中走还是在Dense(Calo)环境下走（有能量损失）-或者是用户添加的其他实现

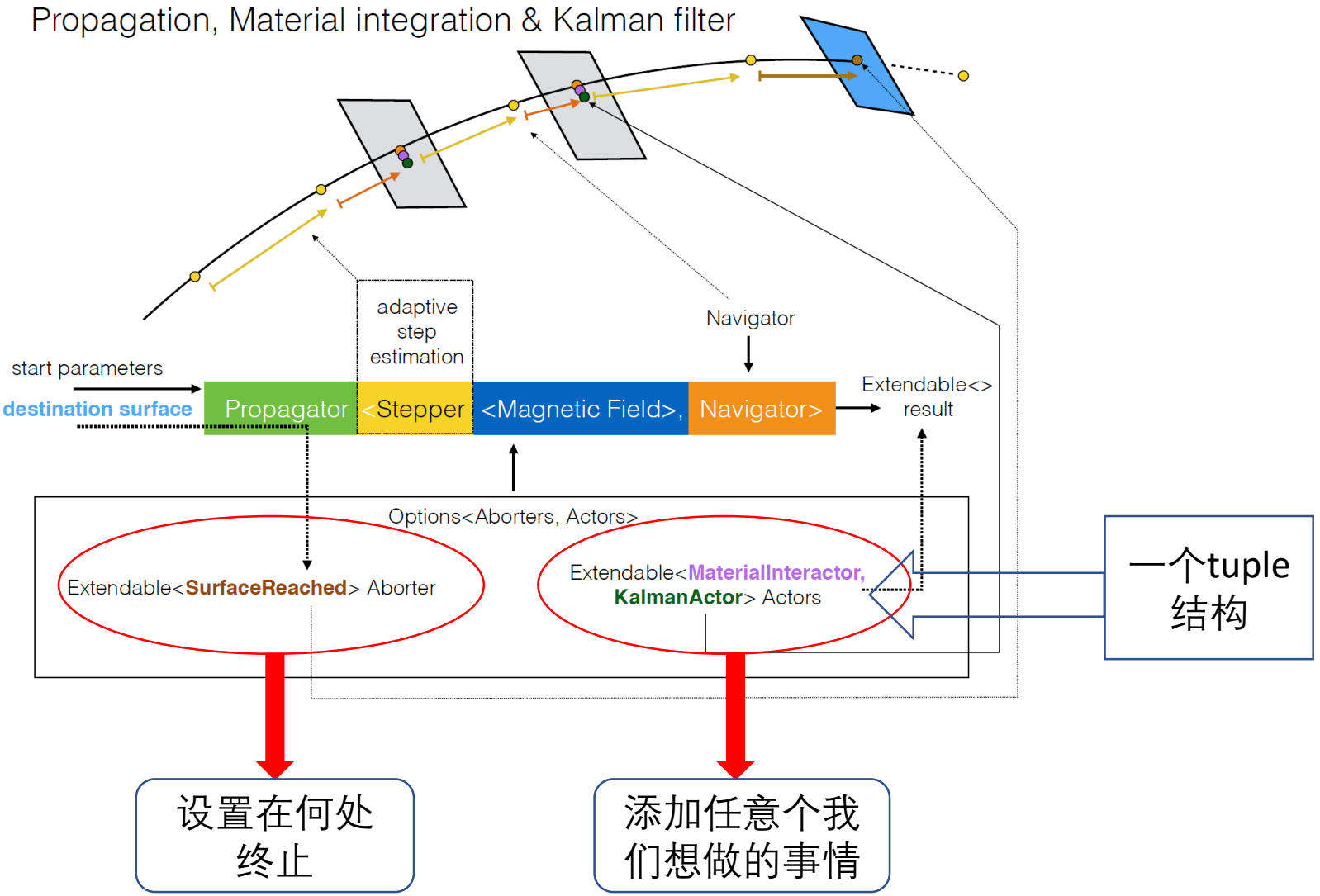
```
template <typename... extensions>
struct StepperExtensionList : private detail::Extendable<extensions...>
{
```

- Navigator



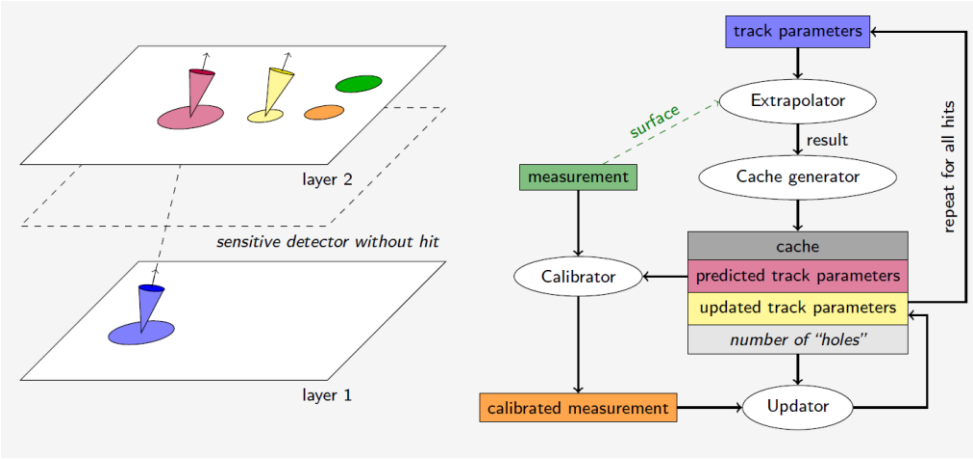
Extrapolate 确定不同平面上的的径迹参数（与Surface相关），计算误差矩阵的传播

Extrapolate sketch



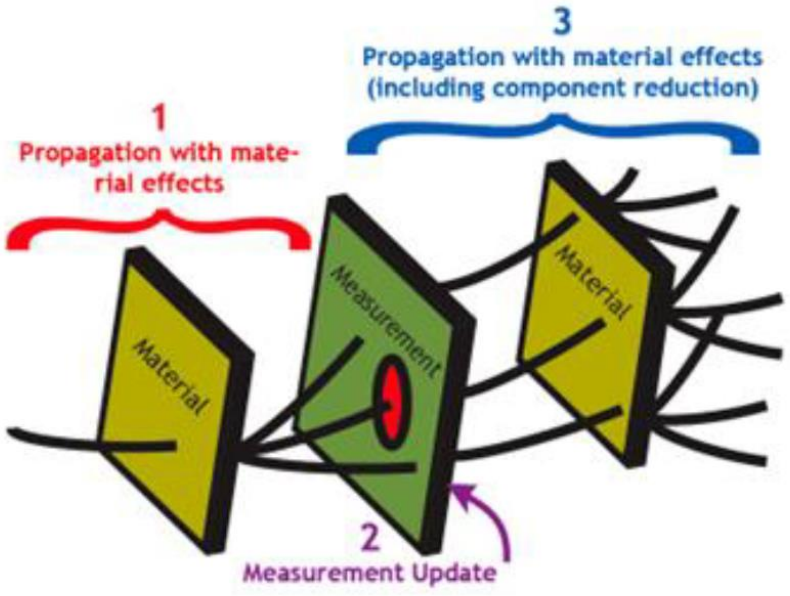
Track finding & Fitter

- Track finding
  - Space Point
  - Seeding
  - Pattern (missing) , a basic global Chi2 fit should be implemented - - no current prototype in ATLAS(only one with Multiscattering and sophisticated)
- Kalman fitter
  - 有完整的Kalman拟合程序
  - Calibration model is missing (empty calibrator in Kalman code)



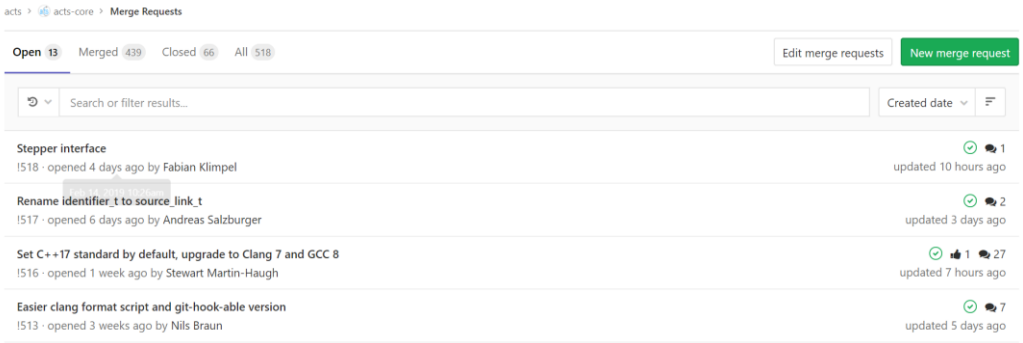
Gaussian sum filter

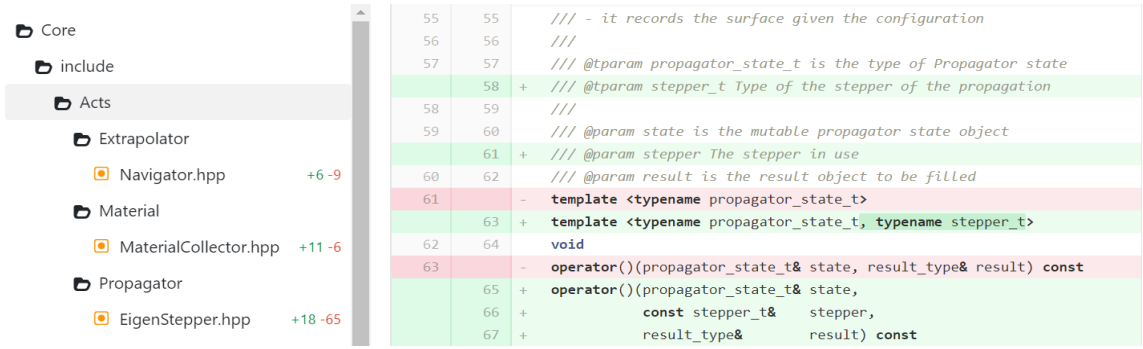
- Kalman filter : noise/measurement is gaussian
- Electron-bremsstrahlung: none gaussian noise
- GSF is a parallel Kalman to construct the specific energy loss



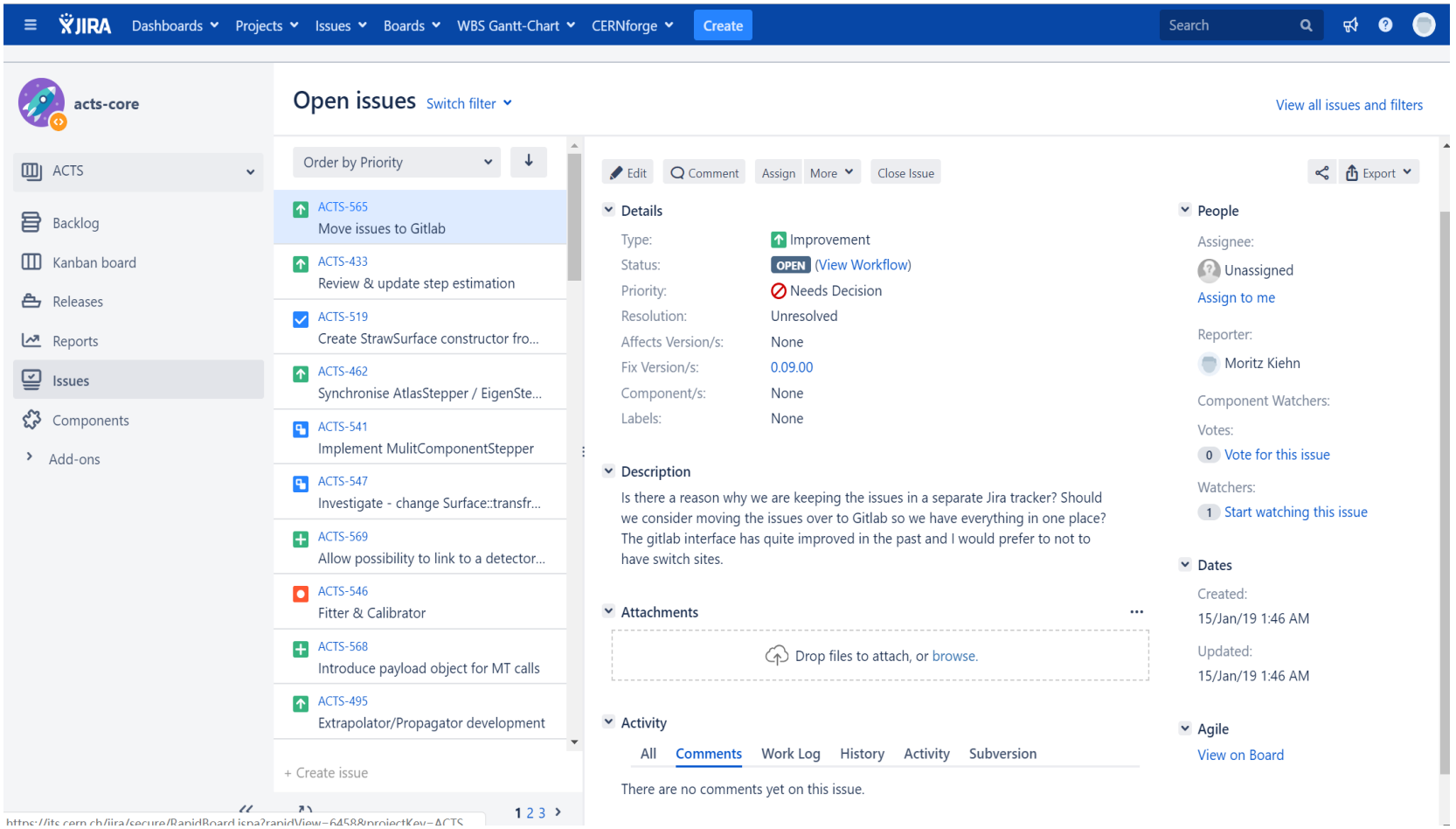
Development in ACTS

- Gitlab: the code repository:https://gitlab.cern.ch/acts
- Local branch -> merge request -> merge to master
  - Others will go through the code and comment
  - At least 2 approved



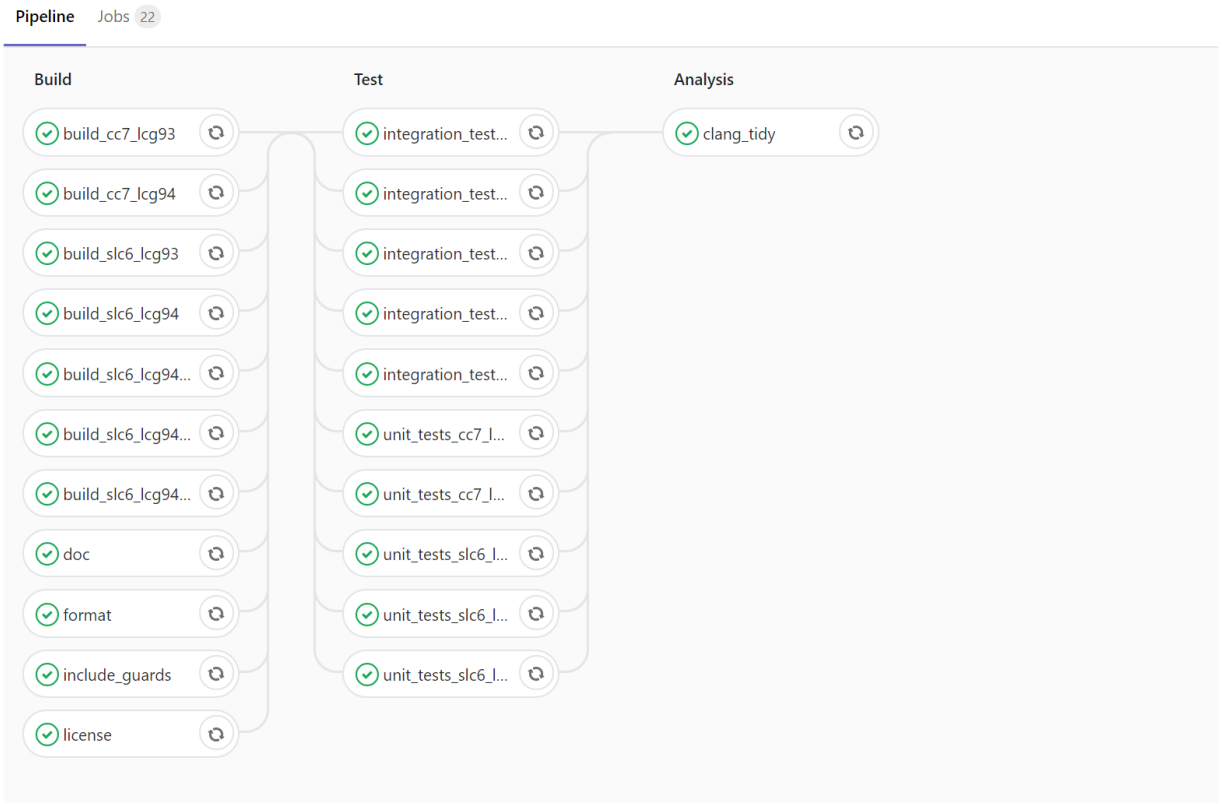


JIRA: assignment of issues



CI – continues integration

- Push 的代码会经过编译/执行/格式/代码重复/内存等检查，所有通过后才能merge到master



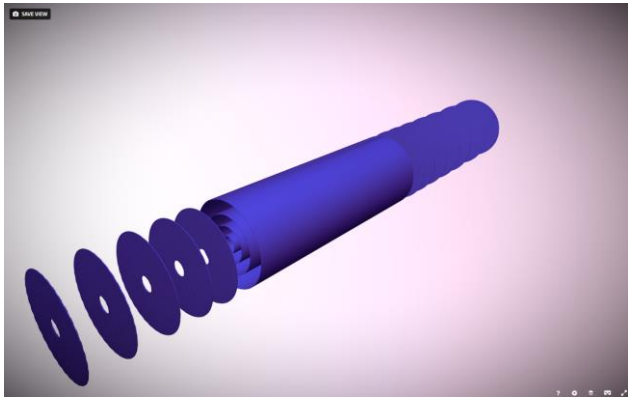
Something else

- All information can get from https://gitlab.cern.ch/acts – most parts are public,

  try to build a acts-core & acts-framework and execute

  ./ACTFWGenericGeometryExample to get a TrackML Geometry

  And ./PropagationExample to do propagate in detector



- 一些有用的manual： https://gitlab.cern.ch/acts/acts-documentation/tree/master/docs
- 关于ATLAS/ACTS资料上传到了CERN BOX: jin zhang,最近我会上传到IHEP BOX

总结

- ACTS现有重建的多数模块，部分模块仍在开发中
- 大部分模块可以在ACTS框架(acts-framework)下用
- 由于目前确实pattern模块，如果在假设所有track找到的情况下做完整的重建
- CEPC的几何构建需要构造DD4HEP的XML文件，下一步看起来有比较明确的参照来构建CEPC的几何