WP3 Advanced Software

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AIDA2020 Kick-off Meeting

CERN, June 2-4, 2015

- Partners

- Overview

- Tasks

- Deliverables & Milestones

- Report From Kick-Off Meeting

- Summary & Outlook

- CERN (SFT and LCD groups)
- DESY
- LAL
- LLR
- UCAM
- UNIMAN

- **Advanced simulation and reconstruction for HEP**
  - **Core software**
    - DD4hep and USolids extensions
    - alignment and conditions data (test beam)
    - EDM toolkit and framework extensions
  - **Simulation**
    - DDG4: Geant4 based simulation toolkit
  - **Reconstruction**
    - advanced tracking tools
    - advanced particle flow algorithms

  - address high performance computing in all tasks: parallelization, vectorization → added value

Objectives

Task 3.1 Scientific coordination
- Coordinate and schedule the execution of the WP tasks
- Monitor the work progress (milestone and deliverable reports), follow-up on the WP budget and the use of resources
- Organise WP meetings

Task 3.2 Detector Description for HEP (DD4hep) and Unified Solids (USolids) extensions
- Extend USolids for vectorisation using Single Instruction, Multiple Data (SIMD) instructions and reviewed algorithms
- Define proper interfaces for use of USolids in Geant4, Root and Vector prototype
- Implement thread safety and alignment procedures in DD4hep

Task 3.3 Alignment and conditions data (test beam)
- Complete alignment toolkit with tight coupling to DD4hep for simulating the misalignment
- Provide alignment and conditions data for DD4hep

Task 3.4 Event Data Model (EDM) toolkit and framework extensions
- EDM toolkit for efficient creation of Event Data Models in C++ with high performance I/O
- Implementation of parallel algorithm scheduling mechanisms in HEP frameworks

Task 3.5 DDG4 (Detector Description Geant 4): Geant4 based simulation toolkit
- Modular and flexible simulation toolkit based on DD4hep and Geant4
- Application to LC and FCC

Task 3.6 Advanced Tracking Tools
- Development of advanced parallel algorithms for track finding and fitting in AIDA Tracking Tool toolkit (aidaTT)
- Application to LHC and LC

Task 3.7 Advanced particle flow algorithms
- Development of advanced particle flow and pattern recognition algorithms in PandoraPFA (particle flow algorithms toolkit)
- Application to LHC, LC and neutrino experiments

D3.1	Implementation of extensions in USolids *(extended signature of classes, reviewed algorithms, well defined interfaces for Geant4, Root and Vector prototype)*	3	CERN	other	PU	M32
D3.2	Implementation of DD4hep extensions *(added alignment functionality and thread safety)*	3	CERN	other	PU	M34
D3.3	Alignment Toolkit *(generic toolkit with tight coupling to DD4hep)*	3	UNIMAN	other	PU	M36
D3.4	Event Data Model toolkit *(creation of EDM model in C++ with high performance I/O)*	3	DESY	other	PU	M40
D3.5	Parallel versions of event processing frameworks *(validation of parallelisation of algorithms and event processing)*	3	CNRS	other	PU	M42
D3.6	Geant4 based simulation toolkit DDG4 *(modular and flexible toolkit based on DD4hep and Geant4)*	3	CERN	other	PU	M35
D3.7	Advanced Tracking tools *(implementation of advance parallel track finding and fitting algorithms)*	3	DESY	other	PU	M39
D3.8	Advanced Particle Flow algorithms *(implemented within the PandoraPFA framework)*	3	UCAM	other	PU	M38

- have one deliverable per (sub) task
- => the final software tool
- all towards end of project

MS3.1	Design document for alignment Toolkit with tight coupling to DD4hep	3, 15	M14	Reviewed by StCom
MS3.2	Design document for Event Data Model toolkit	3, 5	M14	Reviewed by StCom
MS3.3	Design document for parallel algorithm scheduling mechanism	3	M14	Reviewed by StCom
MS3.4	Running prototype of USolids using SIMD instructions	3	M21	Released, documented and running prototype
MS3.5	Running prototype for alignment Toolkit	3, 15	M21	Released, documented and running prototype
MS3.6	Running prototype for parallel algorithm scheduling mechanism	3	M21	Released, documented and running prototype
MS3.7	Running prototype for Geant4 based simulation toolkit	3	M21	Released, documented and running prototype
MS3.8	Integration of USolids extensions for vectorisation in Geant4, ROOT and Geant Vector Prototype	3	M44	Documented software release
MS3.9	Application of alignment toolkit to external tracker for PCMAG	3, 15	M44	Document describing alignment procedure and results
MS3.10	Application of Event Data Model toolkit with high performance I/O to Linear Collider	3, 5	M44	Documented software release
MS3.11	Integration of parallel algorithm scheduling mechanism in Gaudi, Marlin and PandoraPFA frameworks	3	M44	Documented software release
MS3.12	Application of advanced Particle Flow algorithms to CMS and LBNE	3	M44	Documented software release

- have milestones during the project to ensure sufficient progress
- 'milestones' at the end guaranteeing application of tools in existing experiments/test beams
- would liked to have more ...

Scientific coordination

- Coordinate and schedule the execution of the WP tasks

- Monitor the work progress:

  - milestone and deliverable reports

  - follow-up on the WP budget and the use of resources

- Organize WP meetings

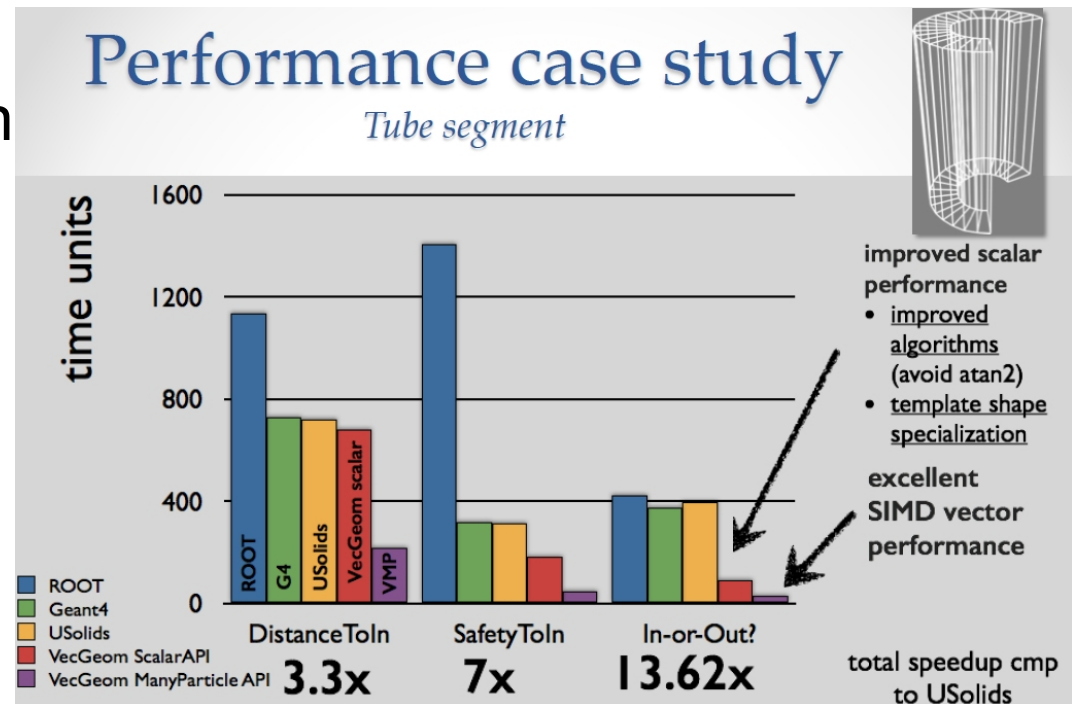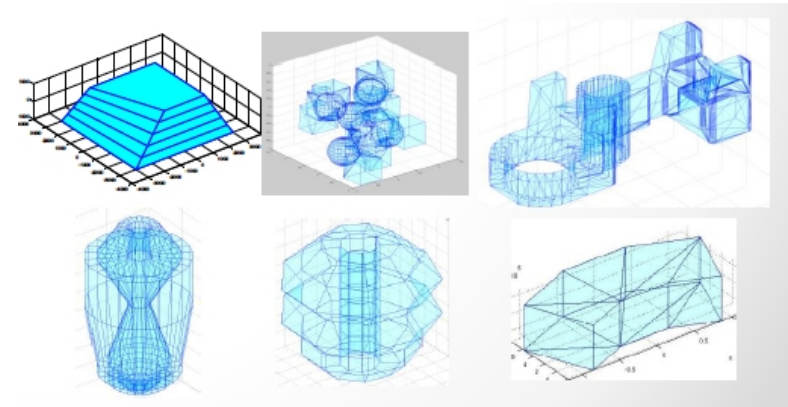- shared between CERN and DESY

- **Detector Description for HEP (DD4hep) and Unified Solids (USolids) extensions**

  - Extend USolids for vectorization using Single Instruction, Multiple Data (SIMD) instructions and reviewed algorithms

  - Define proper interfaces for use of USolids in Geant4, Root and Vector prototype

  - Implement thread safety and alignment procedures in DD4hep

  - partners: CERN, UMAN

  - effort: 40 ppm

  - targeted at: all of HEP

- first version of DDG4 exists

  - used by ILD and CLIC

- planned work items:

  - support fast & parameterized simulations

  - alignment & conditions interface

  - multithreading support

   - simulation (via Geant4)
    - reconstruction

G.Cosmo
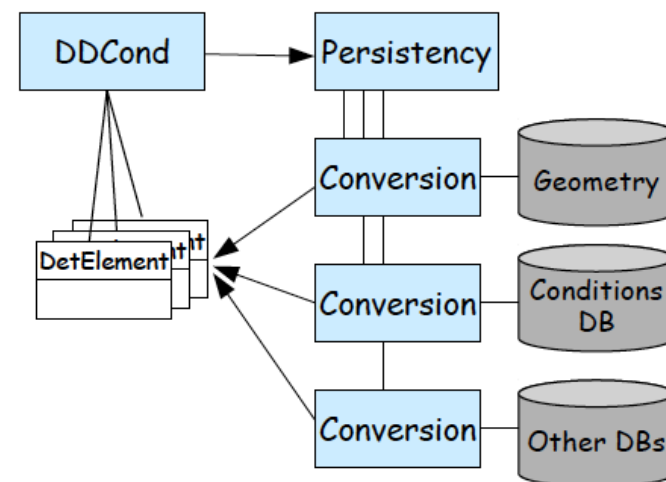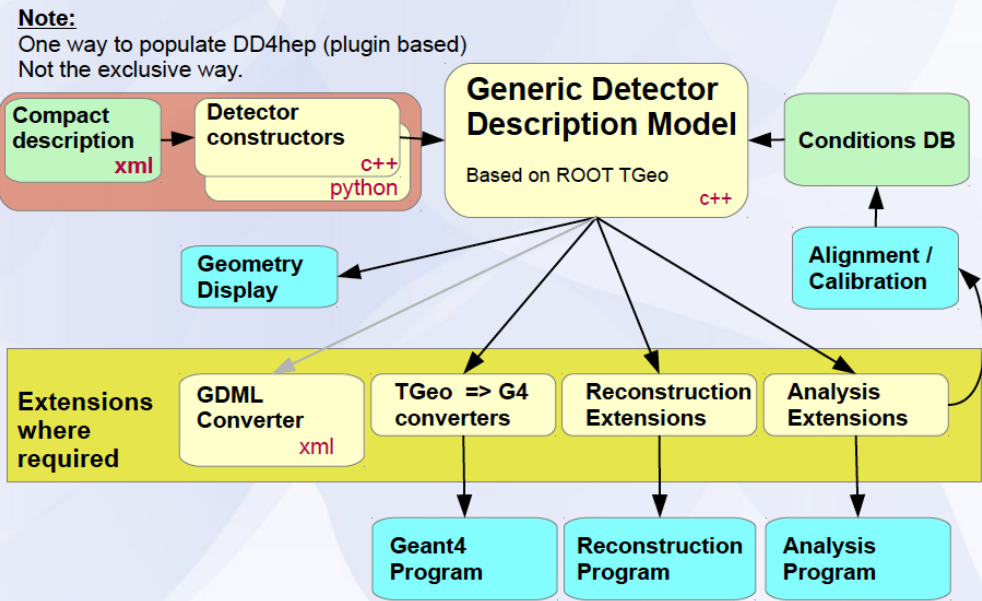
- continuation of USolids work from AIDA

  - available w/ Geant4 10.x

- work started on implemetation of vectorized USolid algorithms:

  - VecGeom

  - parallelized algorithms for on ore many particles

- goal:

  - further extend USolids shapes and implement in VecGeom for

  - ROOT, Geant4, GeantV

Performance case study
Tube segment

improved scalar performance
- improved algorithms (avoid atan2)
- template shape specialization

excellent SIMD vector performance

total speedup cmp to USolids

| | | |
ROOT	DistanceToIn	3.3x
Geant4	SafetyToIn	7x
USolids	In-or-Out?	13.62x
VecGeom ScalarAPI		
VecGeom ManyParticle API		

- **Alignment and conditions data (test beam)**
  - Complete alignment toolkit with tight coupling to DD4hep for simulating the misalignment
  - Provide alignment and conditions data for DD4hep

  - partners: Manchester, CERN, DESY
  - effort: 37 ppm
  - targeted at: LHC, test beam, HEP

S.Borghi

- continuation of Alignemt work done in AIDA

  - plans

  - develop a complete alignment procedure for test beams (telescopes) with DD4hep alignment and conditions interface

  - develop a fully automatized alignment procedure for LHCb Velo for RunII

  - work has already started
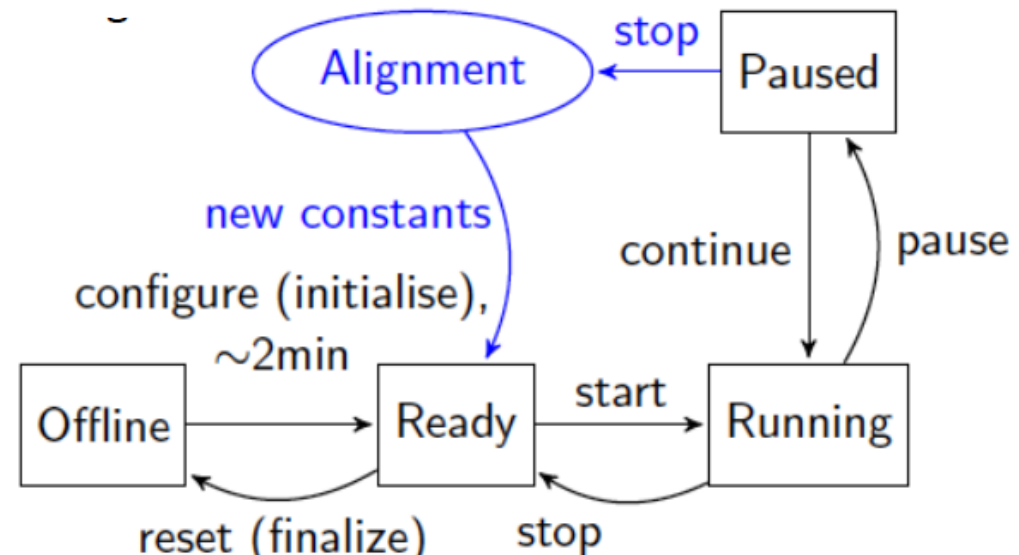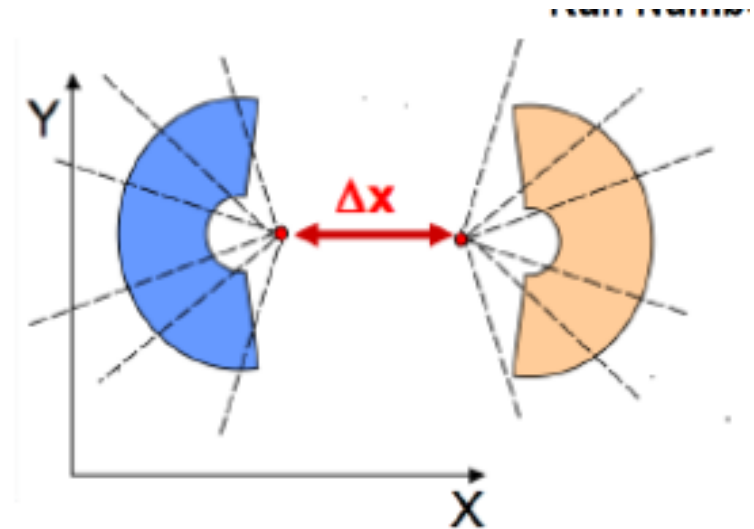
- **Event Data Model (EDM) toolkit and framework extensions**

  - EDM toolkit for efficient creation of Event Data Models in C++ with high performance I/O

  - Implementation of parallel algorithm scheduling mechanisms in HEP frameworks

  - partners: DESY, LAL, CERN, Cambridge

  - effort: 84 ppm

  - targeted at: all of HEP

B.Hegner

- new project not in AIDA

  - key idea:

  - develop a toolkit to create EDM classes with efficient I/O by storing PODs in the file

  - PODIO

  - prototype already exists

  - developed in context of FCC

  - will also be used to improve I/O performance of LCIO

    - used in LC community
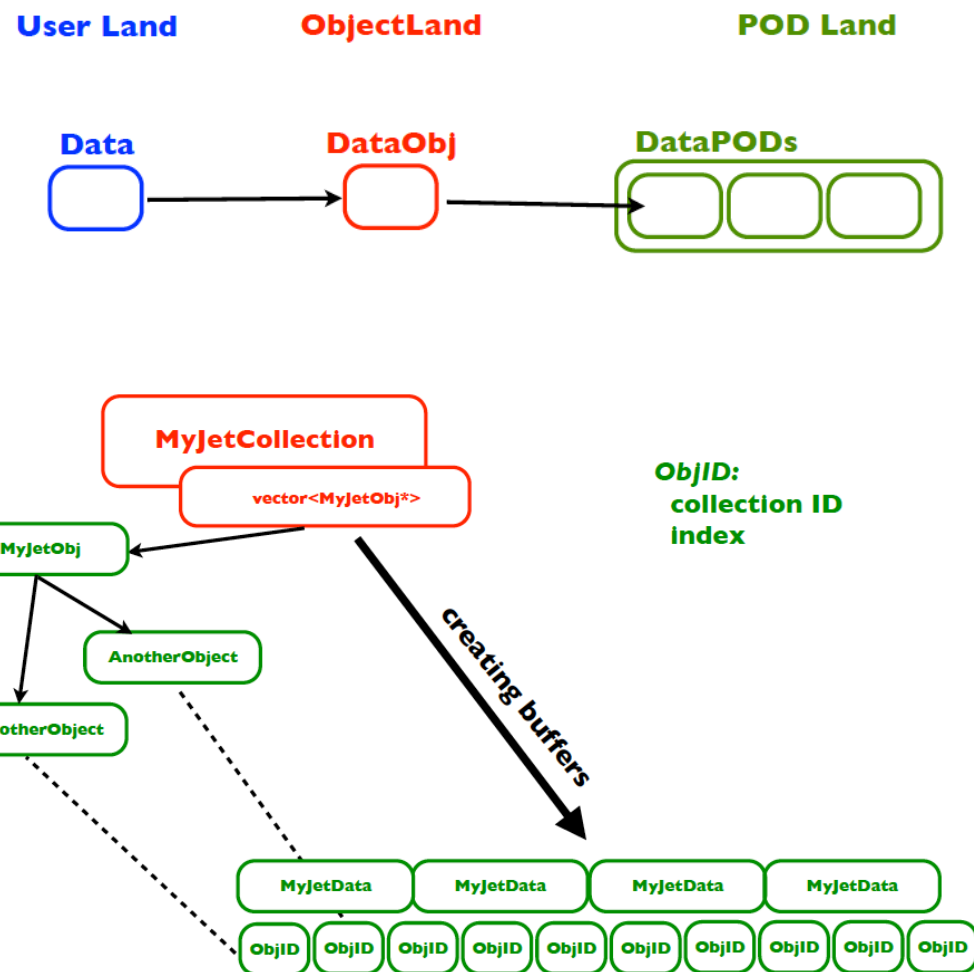
AIDA 2020

- **DDG4 (Detector Description Geant 4): Geant4 based simulation toolkit**
  - Modular and flexible simulation toolkit based on DD4hep and Geant4
  - Application to LC and FCC

  - partners: CERN, DESY
 - effort: 28 ppm
  - targeted at: LC, FCC (LHC ?)

- new project not in AIDA

  - goal:

  - develop new event scheduling algorithms for HEP frameworks

  - lead by LAL in context of Gaudi framework

  - implement these also for

  - PandoraSDK

  - Marlin

  - work has not started

  - will benefit from what LHC has already done
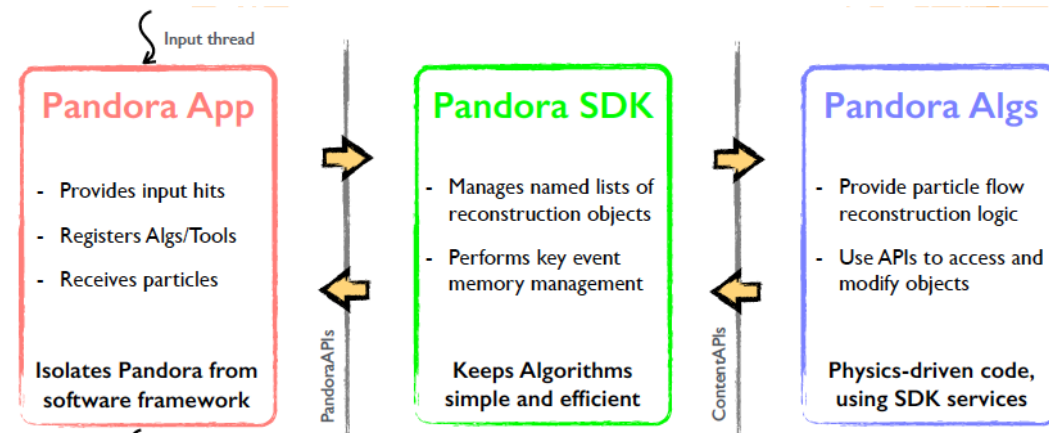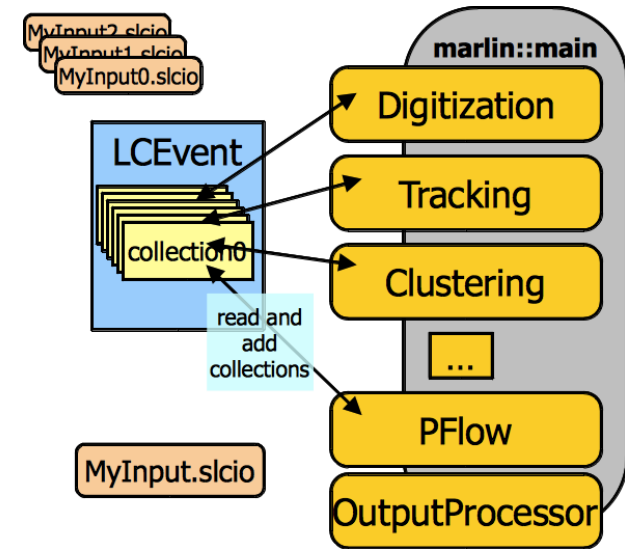
Advanced Tracking Tools

- Development of advanced parallel algorithms for track finding and fitting in AIDA Tracking Tool toolkit (aidaTT)

- Application to LHC and LC

- partners: DESY, LAL

- effort: 58 ppm

- targeted at: LHC, LC

- continuation of tracking tool development done in AIDA

  - plans

  - continue development of generic pattern recognition algorithms (in context of LC)

  - parallelize algorithms - also for fitting

  - include development of tracking algorithms for LHC (RKN) in aidaTT

  - provide a generic tracking interface (IMarlinTrk)
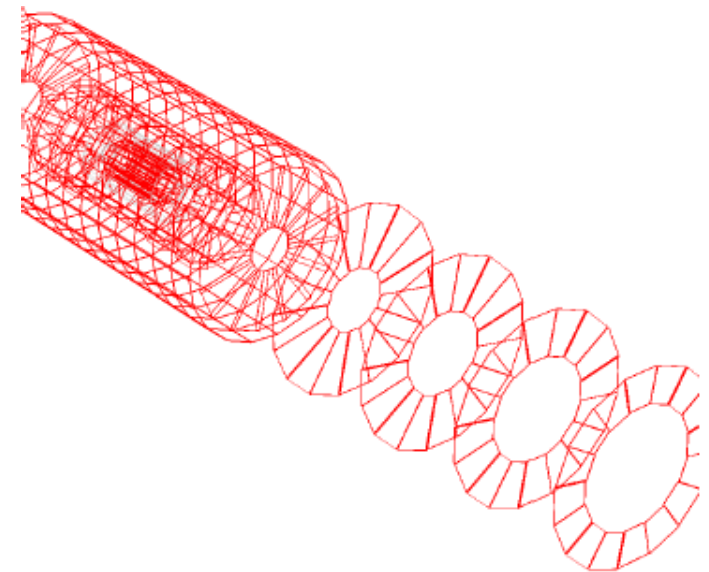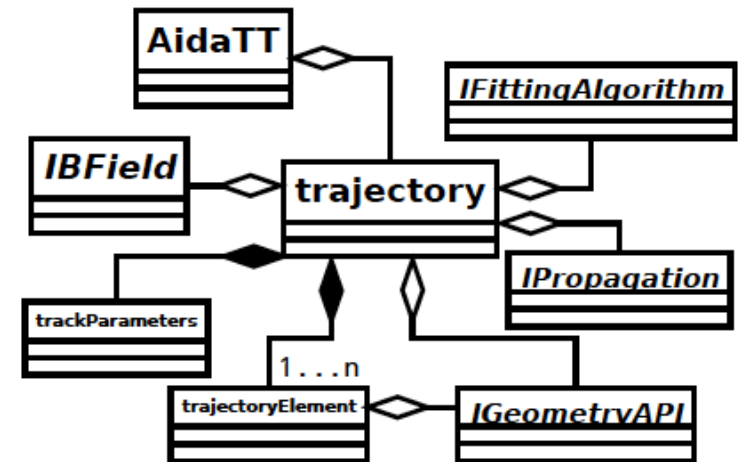
- **Advanced particle flow algorithms**
  - Development of advanced particle flow and pattern recognition algorithms in PandoraPFA (particle flow algorithms toolkit)
  - Application to LHC, LC and Neutrino experiments

  - partners: UCAM, LLR, CERN
  - funding: 84 ppm
  - targeted at: LC, LHC

- continuation of PFA algorithm development done in AIDA

  - goals:

  - provide suite of 'standard' PFA tools

  - incorporate algorithms from image processing in Pandora

  - improve and develop PFA for

    - Linear Colliders

    - LAr neutrino programme

    - HL-LHC
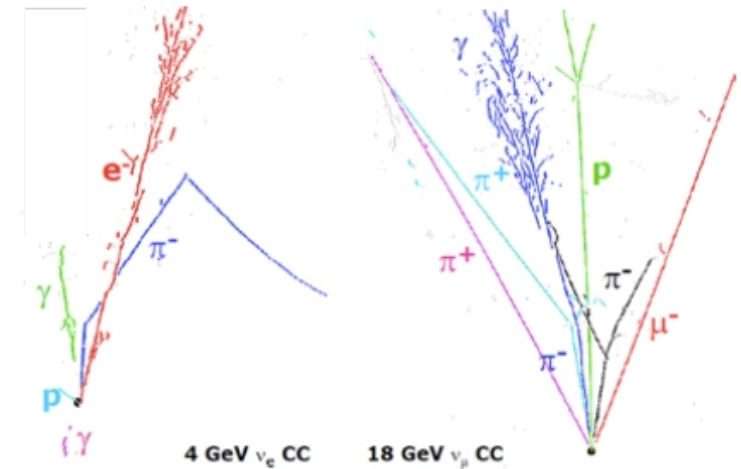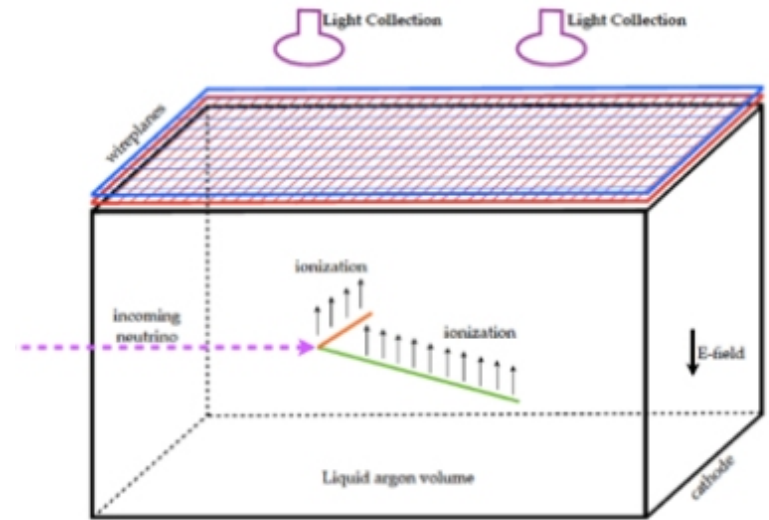
- WP3 is organized in 8 (sub) tasks with a

- combination of continuation of AIDA and new activities

- most activities (also the new ones) already started before the official kick-off

- decided to have ~monthly phone meetings with all partners to discuss progress and organize individual work meetings between partners working on common tasks

- had some discussion on how to best link the WP3 activities to the HSF (presentation by P.Mato)

- general agreement that this needs to be done