CLD & IDEA Detector Concepts

(in the turnkey software stack)

ECFA Higgs Factories: 1st Topical Meeting on Simulation

Feb 1, 2022

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CERN

Turnkey software stack

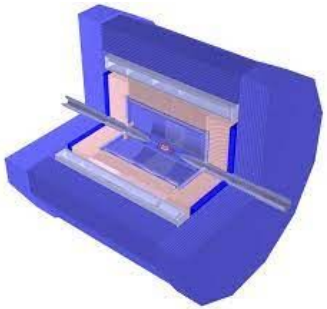
```
source /cvmfs/sw.hsf.org/key4hep/setup.sh
```

key4hep-stack/2021-10-29 comprises ....

...in a consistent stack!

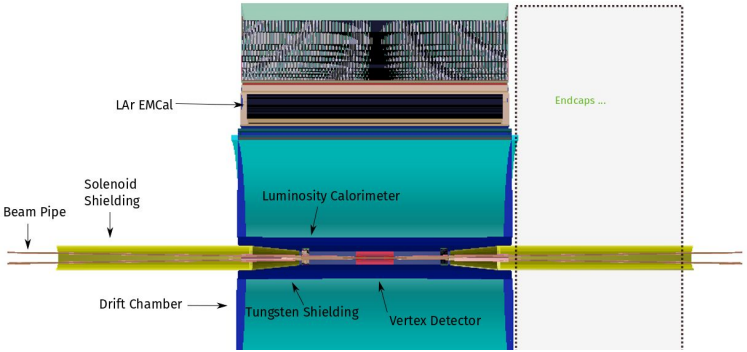
CEPCSW

v0.2.2



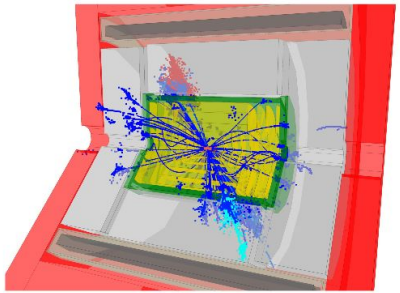
FCCSW

v1.0pre06

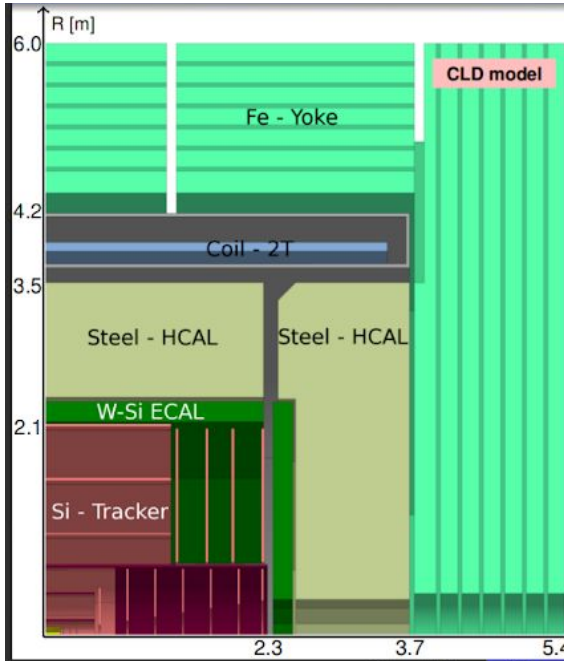


CLIC/ILCSoft

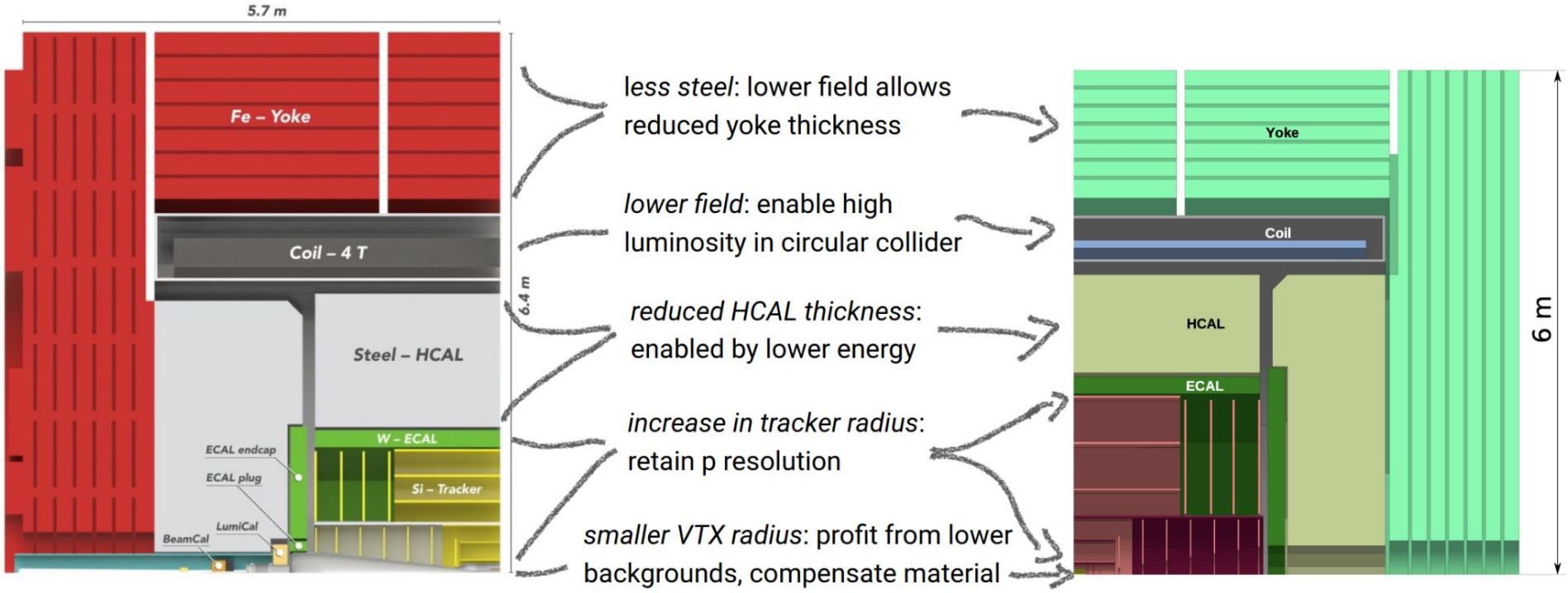
v02-02-03



- **FCC-ee CLD**


R [m]
6.0
4.2
3.5
2.1
CLD model
Fe - Yoke
Coil - 2T
Steel - HCAL
Steel - HCAL
W-Si ECAL
Si - Tracker
2.3
3.7

From CLICDet to CLD



Organization in FCCDetectors

```
DetCommon
├── compact
│   ├── elements.xml
│   ├── materials.xml
```

- Previously in LCGEO, latest version in FCCDETECTORS!

```
DetFCCeeIDEA/
├── compact
│   └── FCCee_o2_v02
│       ├── additional_materials.xml
│       ├── ECalBarrel.xml
│       ├── ECalEndcap.xml
│       ├── FCCee_DectDimensions.xml
│       ├── FCCee_o2_v02.xml
│       ├── HCalBarrel.xml
│       ├── HCalEndcap.xml
│       ├── InnerTrackerBarrelModuleDown.xml
│       ├── InnerTracker.xml
│       ├── OuterTrackerBarrelModuleDown.xml
│       ├── OuterTrackerBarrelModuleUp.xml
│       ├── OuterTracker.xml
│       ├── Solenoid.xml
│       ├── TrackerDiskModuleIn.xml
│       ├── TrackerDiskModuleOut.xml
│       ├── Vertex.xml
│       ├── YokeBarrel.xml
│       └── YokeEndcap.xml
└── src
    ├── CLD_GenericCalBarrel_o1_v01_geo.cpp
    └── CLD_GenericCalEndcap_o1_v01_geo.cpp
```

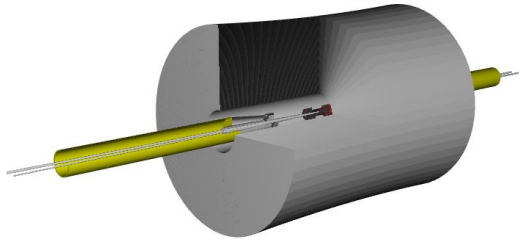
Recipe for running CLD in the k4marlinwrapper

```
source
/cvmfs/sw-nightlies.hsf.org/key4hep/setup.sh

git clone
https://github.com/vvolkl/clicperformance
--branch fccee-cld

cd fcceeConfig
```

```
ddsim \

  --compactFile
${LCGEO}/FCCee/compact/FCCee_o2_v01/FCCee_o2
_v01.xml \

  --outputFile ttbar.slcio \

  --steeringFile fcc_steer.py \

  --inputFiles ../Tests/yyxyev_000.stdhep \

  --numberOfEvents 3
```

```
k4run fccReconstruction.py
```

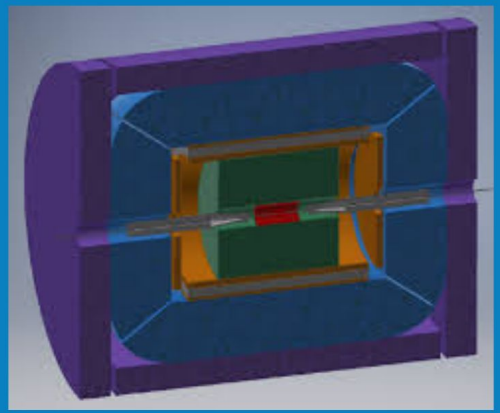
- **FCC-ee IDEA**



- Beampipe
- Beam Instrumentation
- LumiCal
- HOMAbsorber
- Vertex Detector
- Driftchamber
- Dual Readout Calorimeter
- Muon System

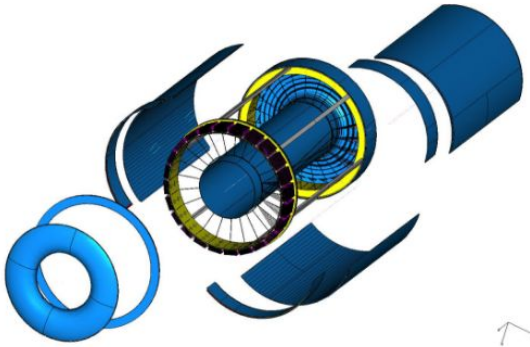
To be updated with new DD4hep models of subdetectors

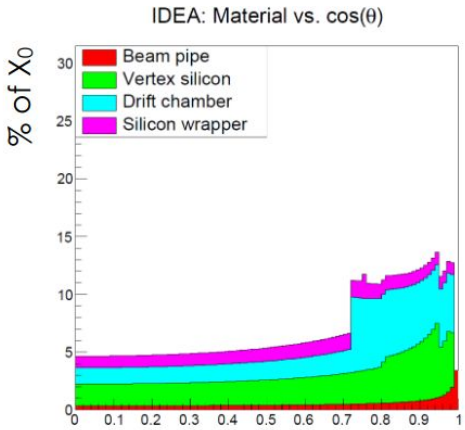
IDEA
(International Detector for Ep Accelerators)

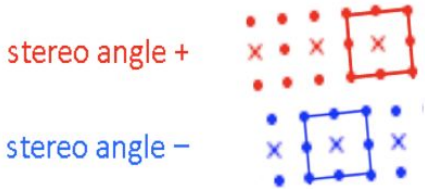


2 T thin solenoid within calo
Si vertex detector
Tracking with ultra light drift chamber
Dual Readout Calorimeter + pre-shower
MPGD (μRwell) based Muon detector

- VTX similar to CLD
- Tracking with drift chamber (similar in concept to MEG II chamber)
  - Minimising multiple scattering, adding only 2% X_0 to material in front of calorimeter
  - R_{in} = 35 cm, R_{out} = 200 cm, L = 400 cm, drift time o(300 ns)
  - 90% He - 10% iC_4H_{10} - max drift time 360 ns, Stereo angle 30°
  - Cluster counting (12.5 cm^{-1} clusters) improves spacial resolution and dE/dx measurement
  - Single point precision (with cluster counting) better than ~ 100 μm.







x-y view

Organization in FCCDetectors

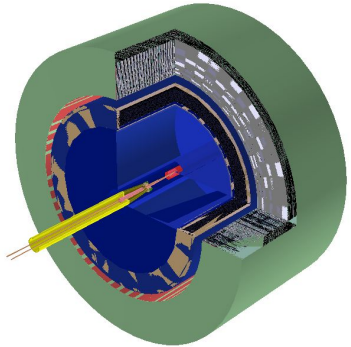
```
DetCommon
├── compact
│   ├── elements.xml
│   ├── materials.xml
```

```
DetFCCeeIDEA/
├── compact
│   ├── BeamInstrumentation.xml
│   ├── Beampipe.xml
│   ├── Calorimeter.xml
│   ├── DriftChamber.xml
│   ├── FCCee_DectDimensions.xml
│   ├── FCCee_DectEmptyMaster.xml
│   ├── FCCee_DectMaster.xml
│   ├── HOMAbsorber.xml
│   ├── LumiCal.xml
│   └── Vertex.xml
└── src
    ├── Mask_o1_v01_noRot_geo.cpp
    ├── OtherDetectorHelpers.h
    └── parametrised_DriftChamber.cpp
```

Mostly from
ILCSOFT/lcgeo/FCCee/compact/FCCee_o1_v04

To be replaced with DD4hep port of current Geant4
Driftchamber model

- **FCC-ee IDEA - LAr**



- Beampipe
- Beam Instrumentation
- LumiCal
- HOMAbsorber
- Vertex Detector
- Driftchamber
- Liquid Argon Calorimeter
- Muon System

LAr for FCCee: Geometry

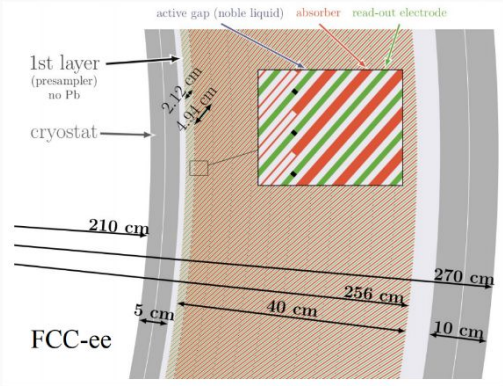
Tilted planes around cylinder: non-trivial geometry !

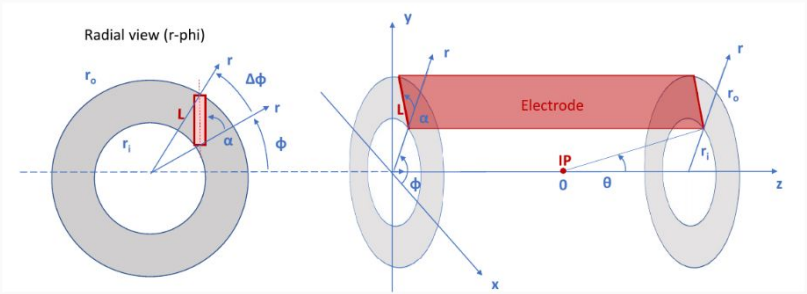
- Can be tuned to give nice properties, i.e constant number of electrodes seen across ϕ, possibility to group electrodes into cells, adjust depth of each layer...
  - Fine segmentation where needed, i.e 'strips' in ATLAS for π^0 rejection
- Projective cells along η
- Gap widening at high radius

$\Rightarrow$ non-constant sampling fraction within a cell

$\Rightarrow$ mitigated by high longitudinal segmentation

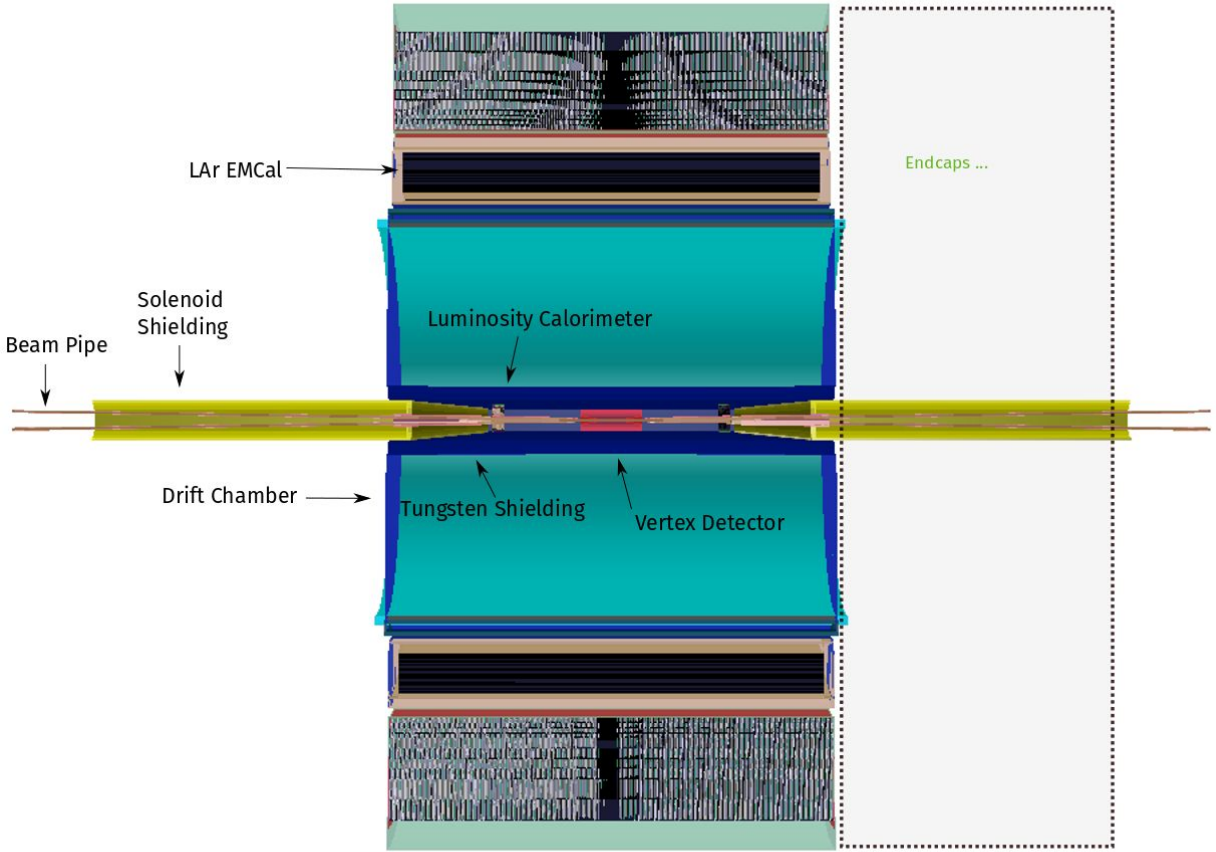
- 12 layers in baseline design





Active R&D into:

- High density feed-throughs
- Thin cryostats
- Low-noise readout electronics


LAr EMCal
Endcaps ...
Solenoid
Shielding
Beam Pipe
Luminosity Calorimeter
Drift Chamber
Tungsten Shielding
Vertex Detector

Organization in FCCDetectors

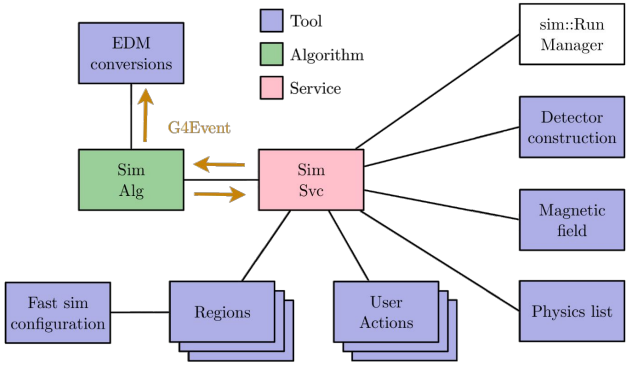
```
DetFCCeeIDEAD-LAr
     ├── FCCee_DectDimensions.xml
     ├── FCCee_DectEmptyMaster.xml
     ├── FCCee_DectMaster.xml
     └── Solenoid_o1_v01_02.xml
```

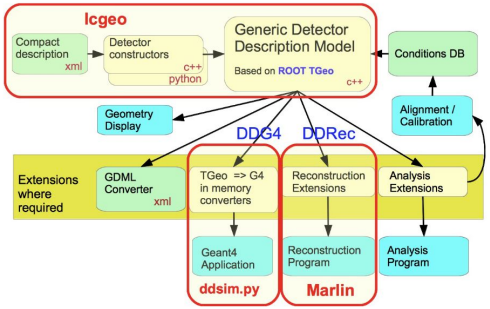
```
 <include ref="../../DetFCCeeIDEA/compact/Beampipe.xml"/>
 <include ref="../../DetFCCeeIDEA/compact/BeamInstrumentation.xml"/>
 <include ref="../../DetFCCeeIDEA/compact/LumiCal.xml"/>
 <include ref="../../DetFCCeeIDEA/compact/HOMAbsorber.xml"/>
 <include ref="../../DetFCCeeIDEA/compact/Vertex.xml"/>
 <include ref="../../DetFCCeeIDEA/compact/DriftChamber.xml"/>
 <include ref="../../DetFCCeeECalInclined/compact/FCCee_ECalBarrel.xml" />
 <include ref="../../DetFCCeeHCalTile/compact/FCCee_HCalBarrel_TileCal.xml"/>
```

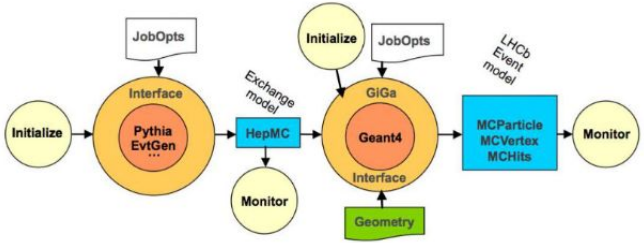
Simulation infrastructure

... currently three different (possible, foreseen) ways to run Geant4

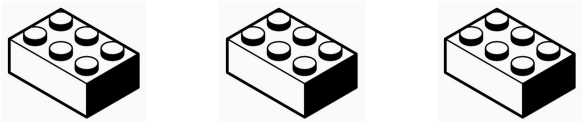
- ddsim
- k4SimGeant4
- Gaussino







Modular approach



Updated style of “job option files” allows for easier re-use of parts of a job

```
# Geant4 algorithm
# Translates EDM to G4Event, passes the event to G4, writes out outputs via tools
from Configurables import SimG4Alg
geantsim = SimG4Alg("SimG4Alg")
from Configurables import SimG4PrimariesFromEdmTool
geantsim.eventProvider = SimG4PrimariesFromEdmTool("EdmConverter")
geantsim.eventProvider.GenParticles.Path = "GenParticles"
ApplicationMgr().TopAlg += [geantsim]
```

… even python-style import of configuration blocks!

```
from k4_workflow_blocks.fccsw.detector_fcc_hh_main import *
```

Thank you!

This work benefited from support by the CERN Strategic R&D Programme on Technologies for Future Experiments (https://cds.cern.ch/record/2649646/, CERN-OPEN-2018-006).

k4MarlinWrapper

- In-memory on-the-fly conversion for LCIO ↔ EDM4hep
- Implemented as Gaudi Tools, can be attached to any *MarlinProcessorWrapper*
- LCIO → EDM4hep conversion achieved through k4LCIOReader
- Metadata conversion is being implemented
- Time measurements for the converters