



cherenkov
telescope
array

CTA Data Model

First rough draft of a data model for DL3 (and some DL5)
data products

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Important points for data model



Pointed instrument: $\approx 8^\circ$ FOV

arrays \rightarrow **many telescopes, multiple sub-arrays possible**

High-Energy Astrophysics \rightarrow **single photon counting**

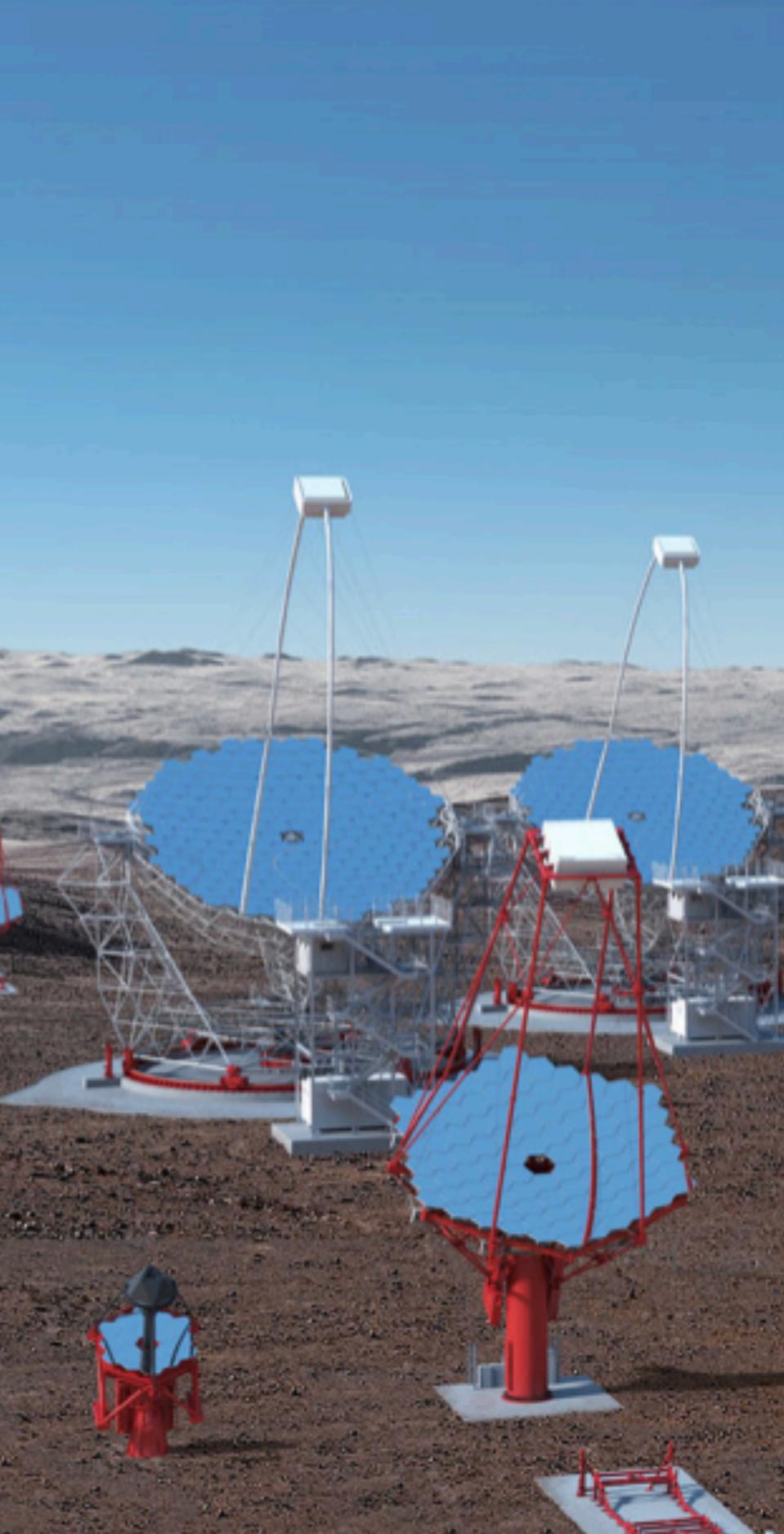
Ground-based \rightarrow **Can't point everywhere, Earth turns**

Atmosphere *part of* telescope \rightarrow **impulse response varies**

- ▶ air density and aerosols
- ▶ zenith angle (atmosphere depth)
- ▶ azimuth angle (B-field)
- ▶ Night-Sky-Background light (both stars and man-made)
- ▶ ...

short duty cycle +

deep integration times \rightarrow **many observations combined to analyze a source**



CTA Low-Level Data

Happens in CTA Observatory Data Center

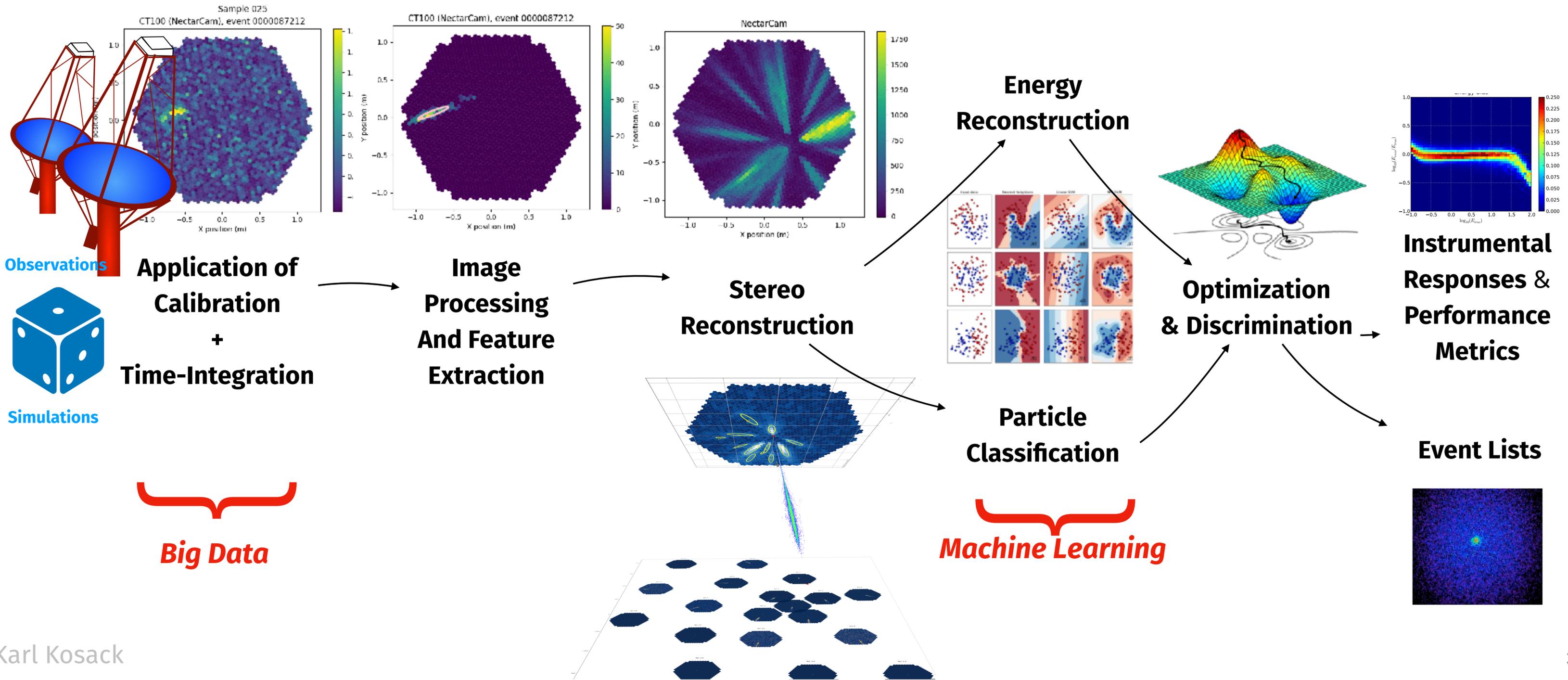
Science-Ready data Products
further processed with
Science Tools (GammaPy)

DL0

DL1

DL2

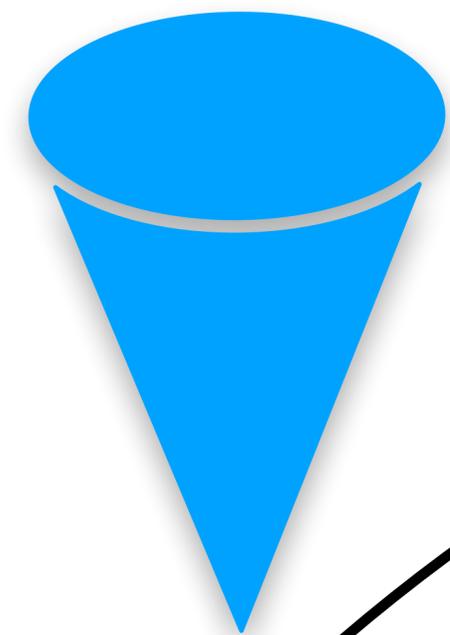
DL3



Science Analysis: DL3-DL5



Happens at CTA data centers (automatic) + by users on user's laptops or e.g. ESCAPE science platform



Search for data
covering region of interest
in space, time, maybe other
parameters

VO tools?

DL3

Science-Ready

Retrieve Event Lists
and IRFs that cover
region of interest

obs_id = 84753

event_id	Time	Energy	RA	Dec
12351	55933.30	0.03	53.6	-29.2
12356	55933.31	0.1	53.2	-29.3

obs_id = 99584

event_id	Time	Energy	RA	Dec
12351	55933.30	0.03	53.6	-29.2
12356	55933.31	0.1	53.2	-29.3

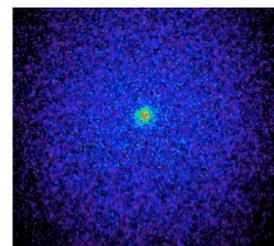
obs_id = 100202

event_id	Time	Energy	RA	Dec
12351	55933.30	0.03	53.6	-29.2
12356	55933.31	0.1	53.2	-29.3
12378	55933.36	12.0	53.8	-29.5
12389	55933.45	0.2	53.7	-28.7

DL4

Science-Binned

Use Science Tools to
make intermediate
Binned Data Products

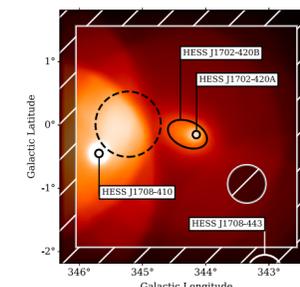


Exposure Cube
Counts Cube
Exclusion Map
...

DL5

Science-Quicklook

Use Science Tools to Fit
models to binned data
(forward-folding)
and make Flux cubes



Sky model
Light-Curve
Spectra
Flux Map/Cube

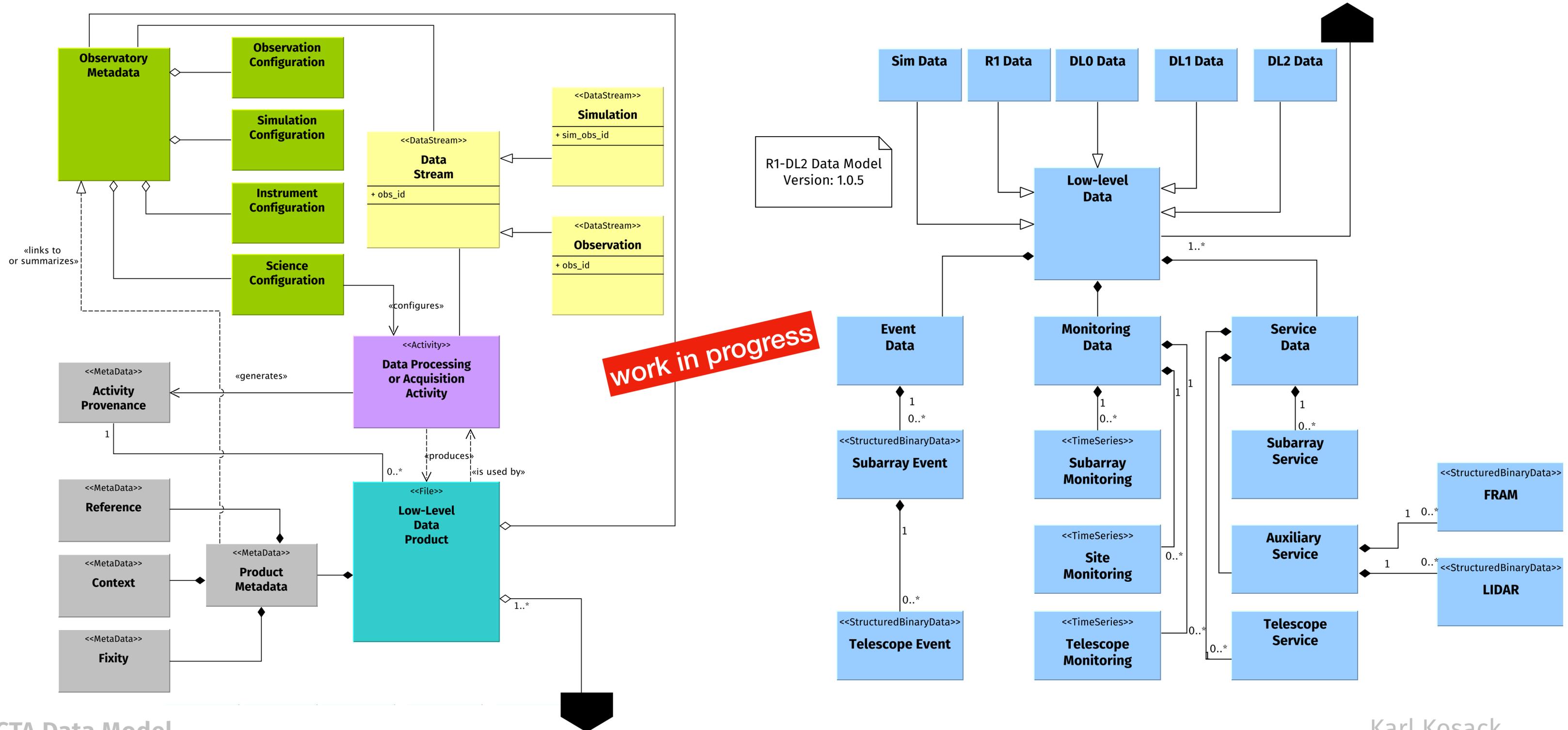
DL6

Science-Observatory

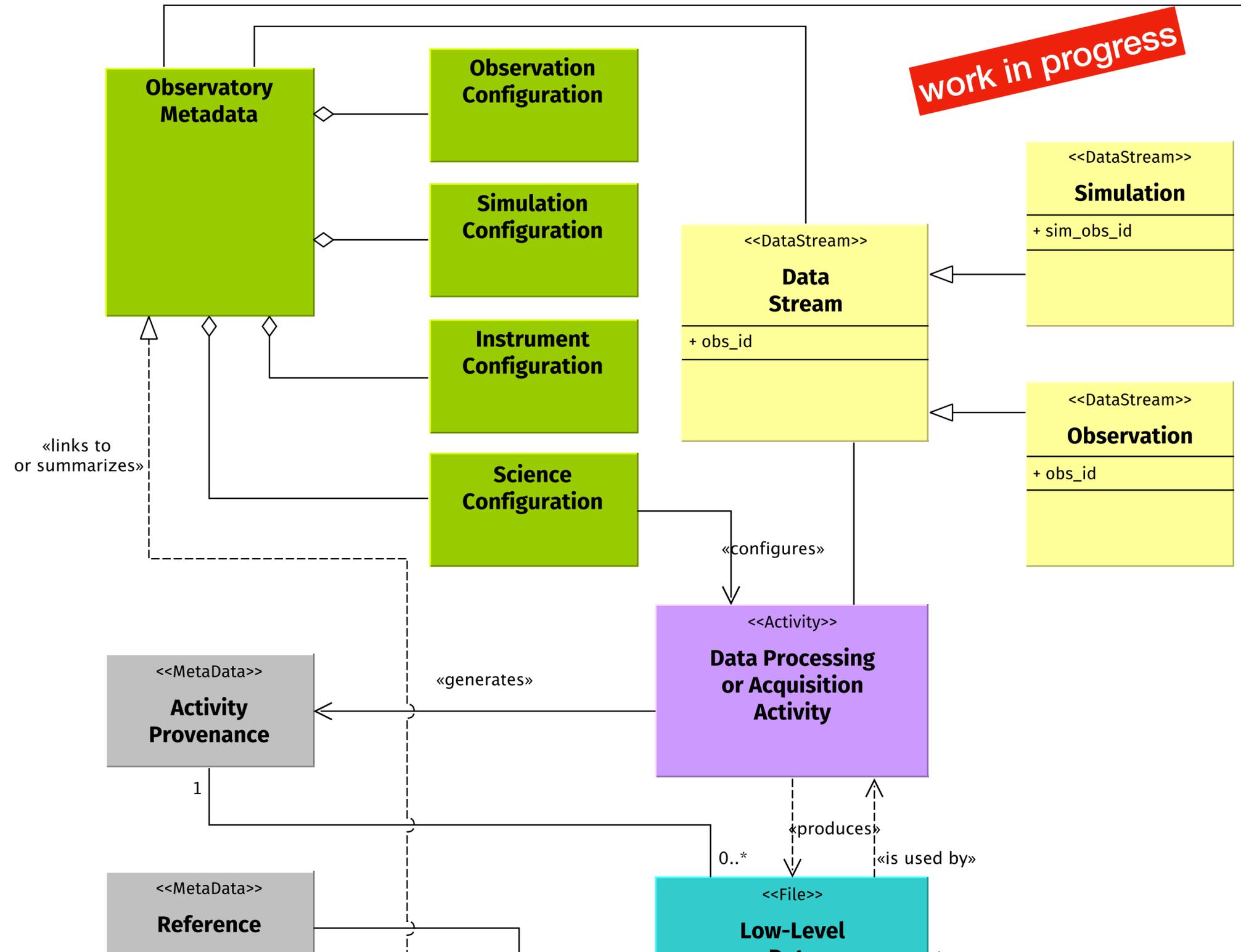
Observatory or CTAC
produces some legacy
products

Catalogs,
Survey Products

For Context: Metadata & Low-level Data Model

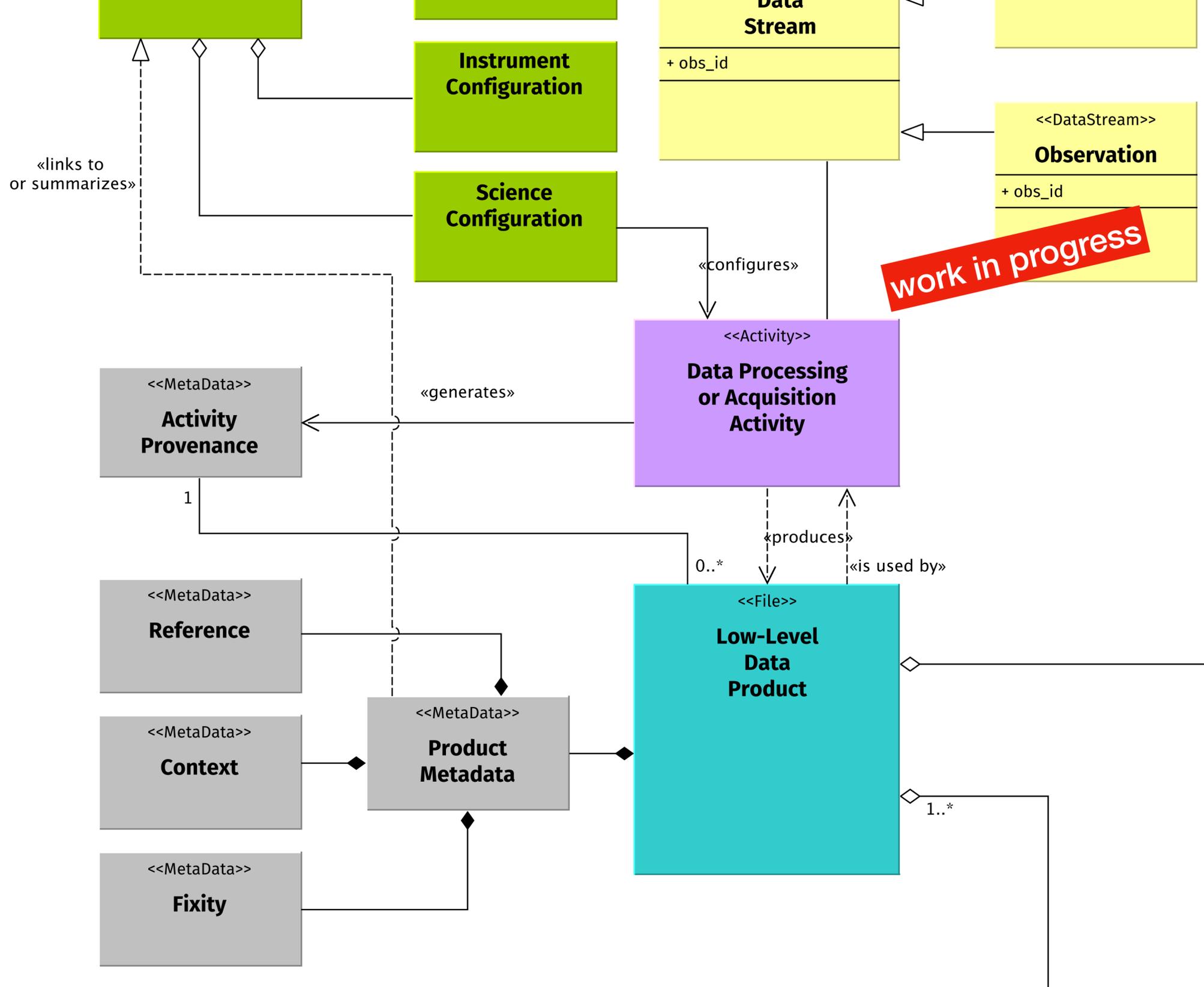


For Context: Metadata & Low-level Data Model



work in progress

For Conte



What are Science-Ready Data? (DL3)



Gamma-like *Event Lists* (\approx a photon list)

- ▶ Particle parameters reconstructed from air-shower measurements
 - time of event arrival
 - reconstructed position on sky + ground
 - reconstructed energy
 - reconstructed shower h_{\max} or X_{\max} (optional)
 - a background class (how likely it is a gamma)
 - a reconstruction class (how well reconstructed)
- ▶ True particle parameters (if from simulations)

Instrument Monitoring Tables

Good-Time Intervals (pre-made or user)

Instrument Response Function (IRF): & Background Model: B

- ▶ IRF (R): Probability distributions that relate Reconstructed (instrument) to True (physics) parameters

$$N_{\text{predicted}} = F_{\text{true}} \otimes \hat{R} + B_{\text{predicted}}$$

▶ Assumptions:

- time-invariant per "good time interval"
- pointing is much better than PSF (no bias)
- we can factor R as

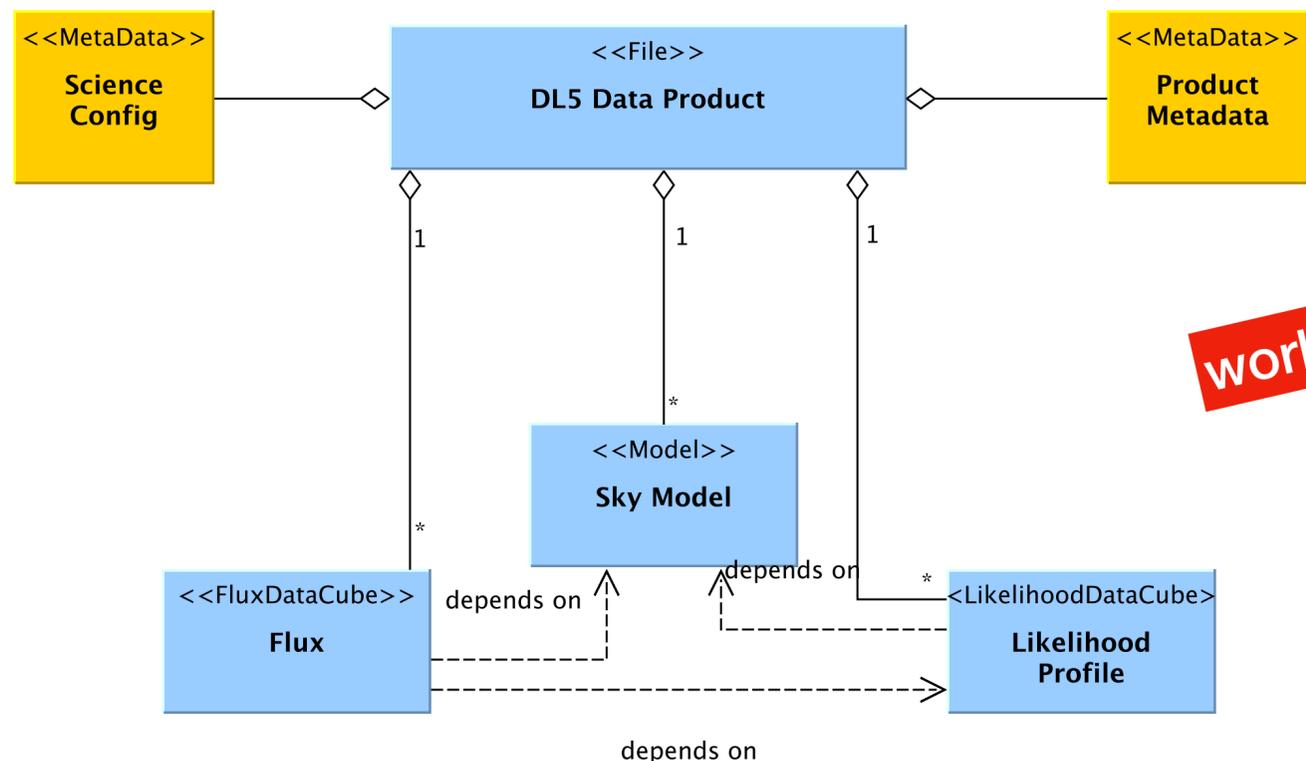
$$\hat{R} = A_{\text{eff}}(E) \cdot \hat{E}_{\text{mig}}(E, E') \cdot \text{PSF}(p, p')$$

effective collection area **Energy Migration Matrix (resolution & bias)** **Point-Spread Function**

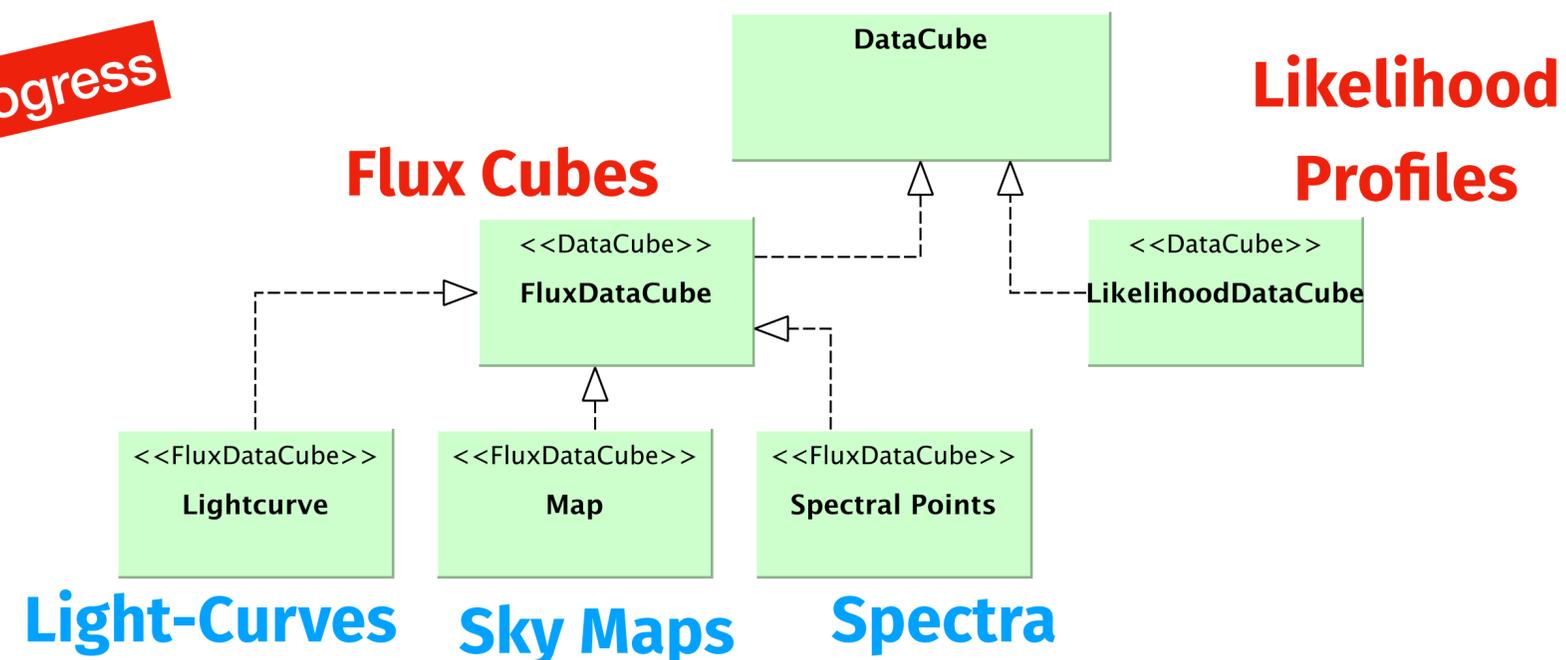
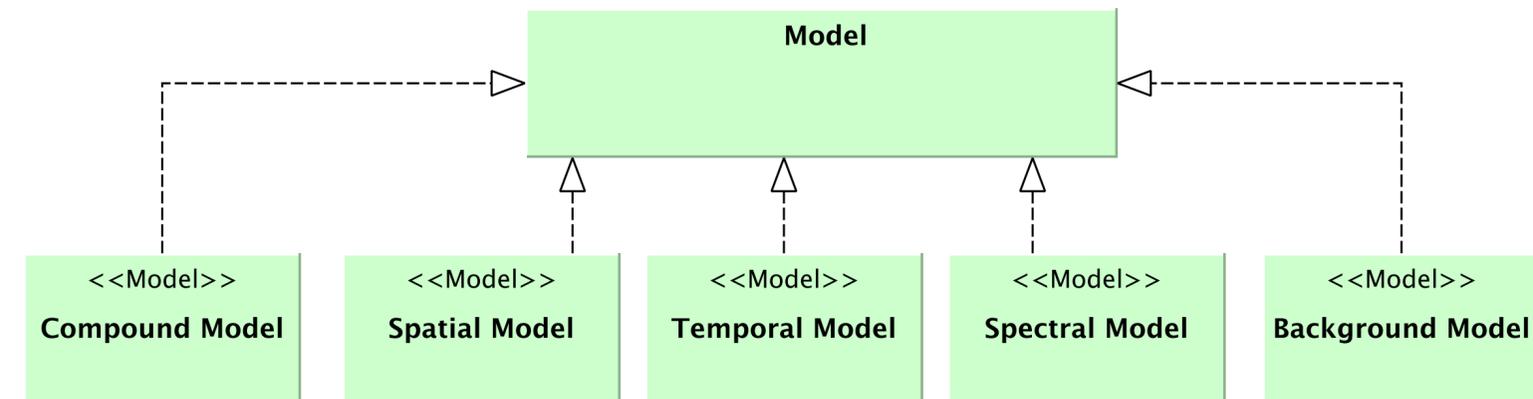
DL5: Science Quick-Look Products



DL5 Data Model: v0.3.1 (rough draft)



work in progress

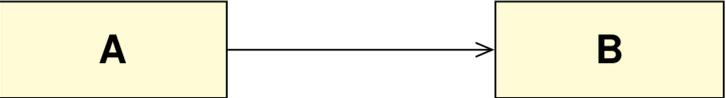
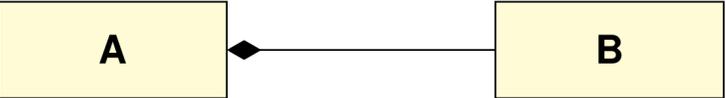
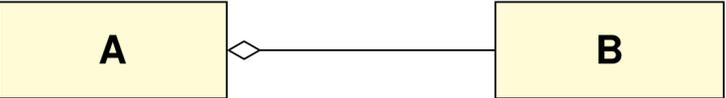
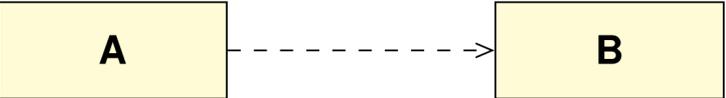


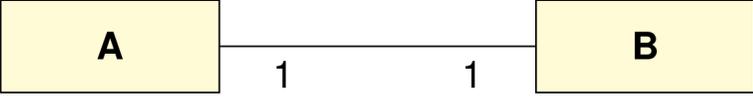
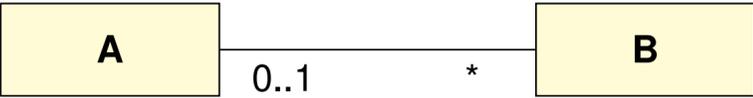
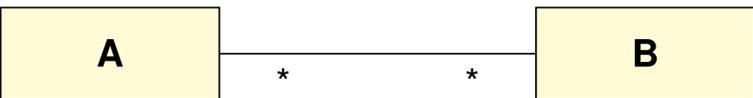
**Measured Fluxes
and/or Flux Models**

Need some VO metadata to be discoverable and interoperable with all observatories!

extra info



Relationship Type	Symbol	Multiplicity	Symbol
<i>A is associated with B</i>		Exactly One	1
<i>A is associated with B (unidirectionally)</i>		Zero or One	0..1
<i>A is composed of B</i>		Many	*
<i>A aggregates B</i>		Zero or More	0..*
<i>A depends on B</i>		One or More	1..*
<i>A inherits from B</i>			

Relationship	Diagram
Exactly One-to-One	
Zero or 1 to Many	
Many-to-Many	
One-to-Many with explicit link attributes	