ATHENA Background

Silvano Molendi (INAF/IASF-Milano)

WHY do we care about background?

Hot Universe

Survey First Groups (111)
Cluster Bulk Motions (112)
Cluster Entropy Evol. (121)
Cluster Chemical Evol. (122)
WHIM in emission (142)

Energetic Universe

High z SMBH (211)
AGN census(221)
AGN Ouflows (222)
UFOs (224)
Feedb.AGN,Star Forming Gal.(232)

Observatory Science

Planets: Uranus (311)
Isolated massive stars (325)
Pulsar wind nebulae (335)

About half of ATHENA observing time devoted to bkg sensitive objectives

WHAT do we need to do?

Minimize Bkg. Intensity

Maximize Bkg. Reproducibility (few % level)

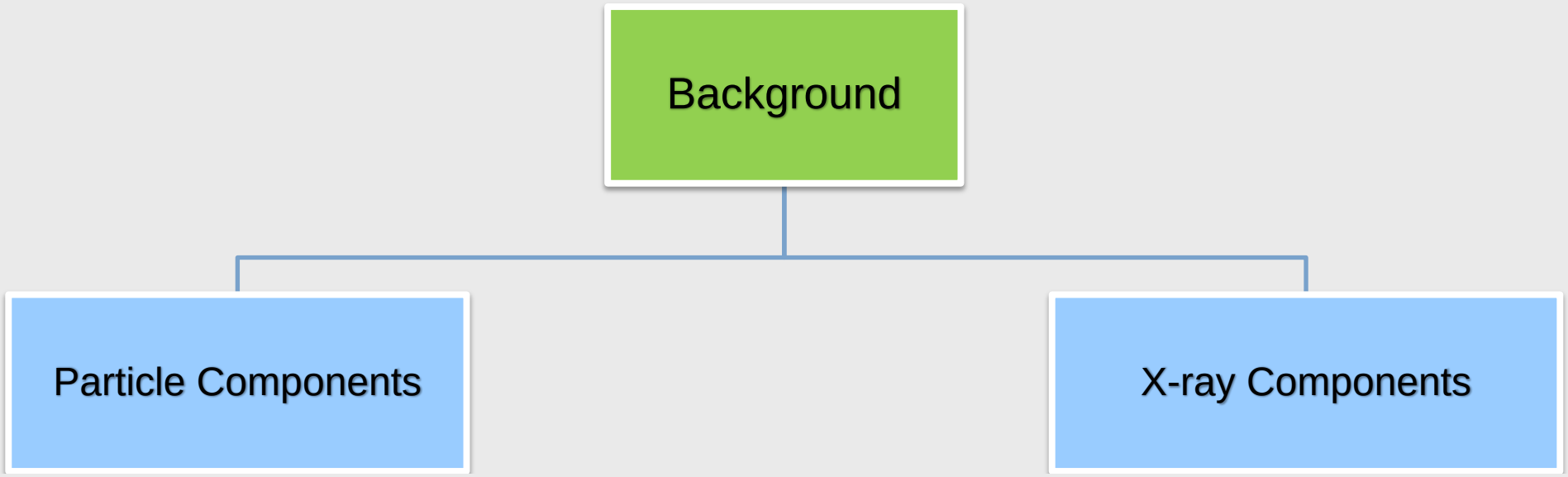
HOW do we do it?

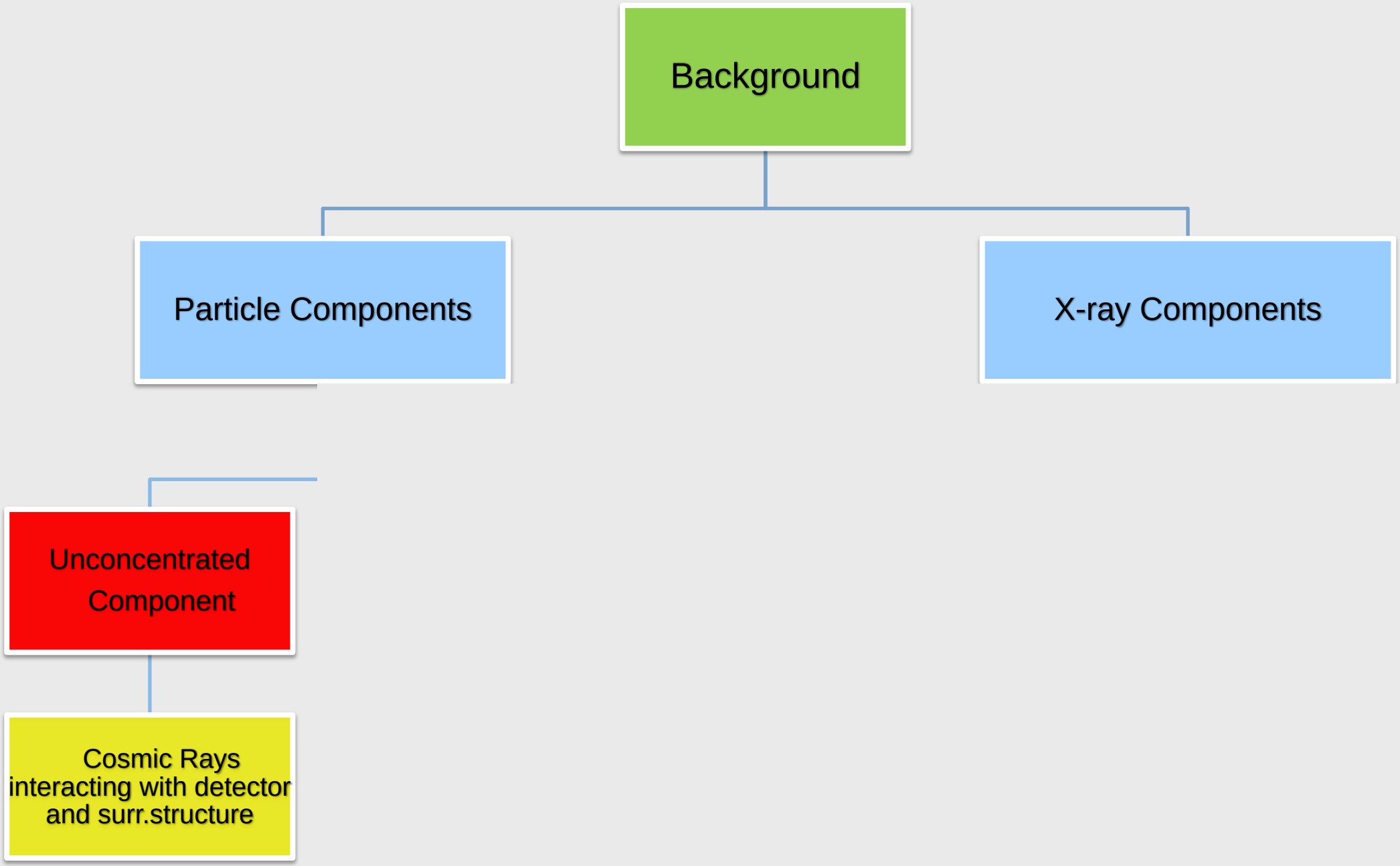
Several components, some associated to particles others to X-rays

We need:

- detailed understanding of all major ones
- overall view of the bkg

Background


Background
Particle Components
X-ray Components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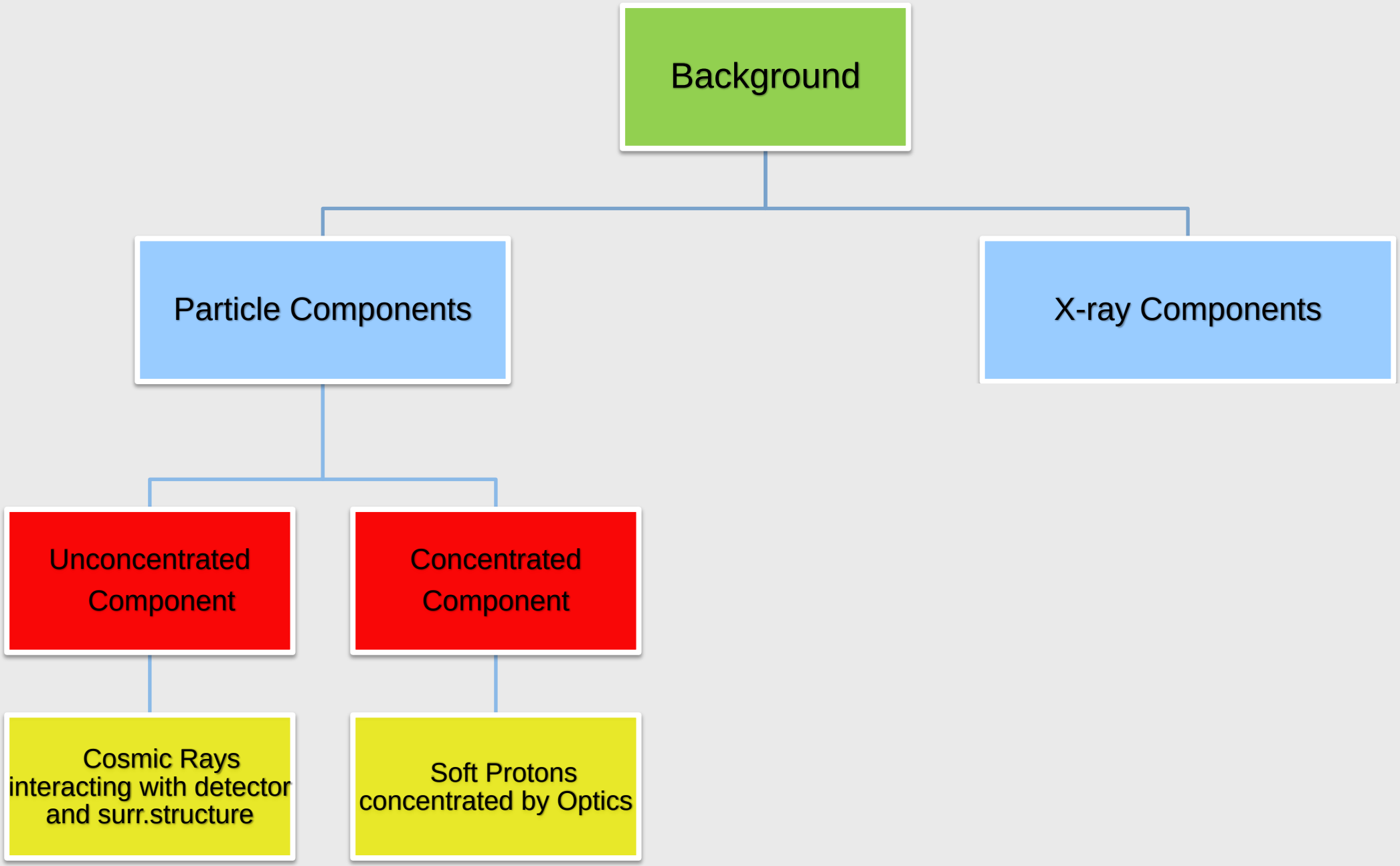
Unconcentrated Component
Cosmic Rays interacting with detector and surr.structure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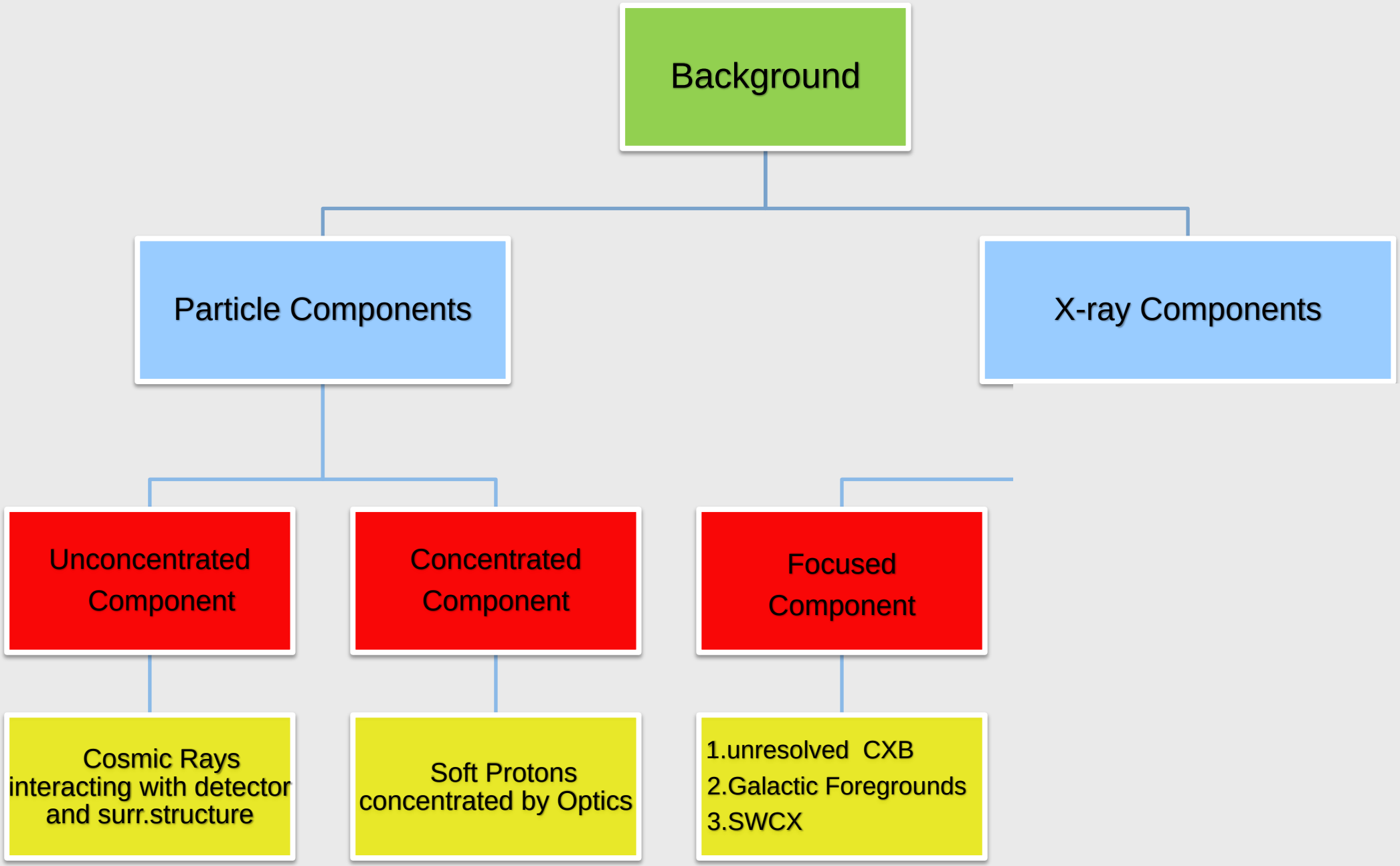
Soft Protons concentrated by Optics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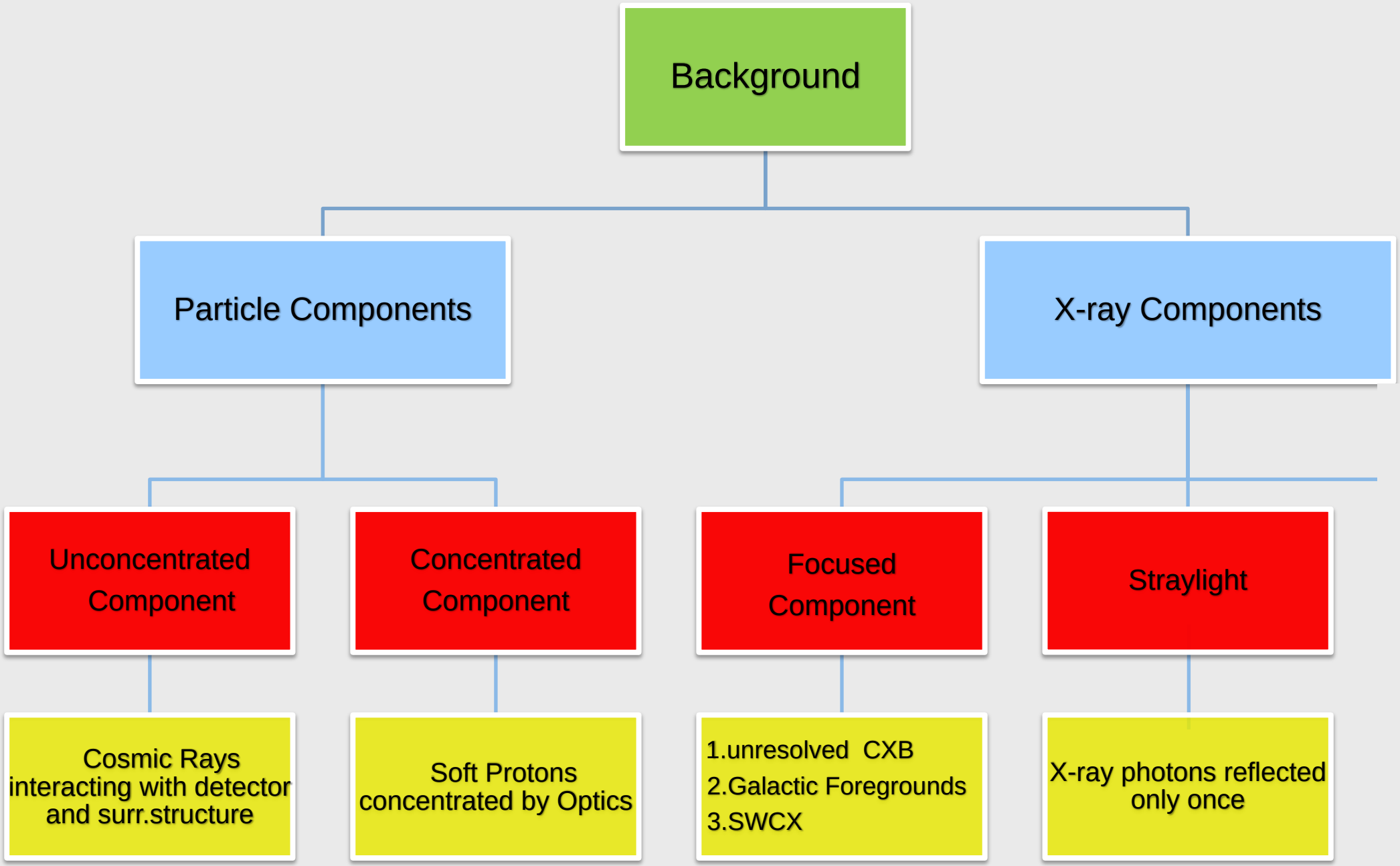
2.Galactic Foregrounds
3.SWCX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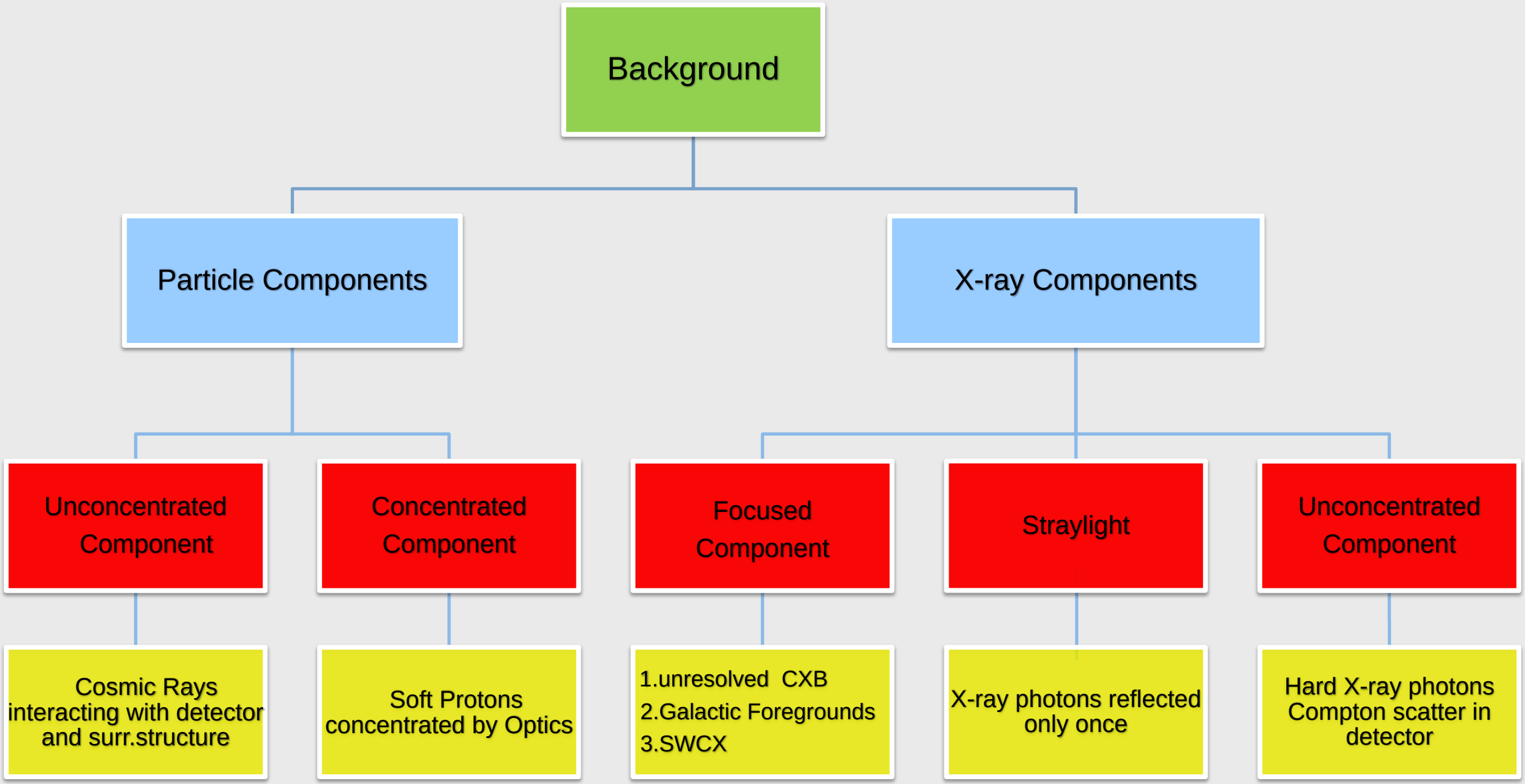
X-ray photons reflected only once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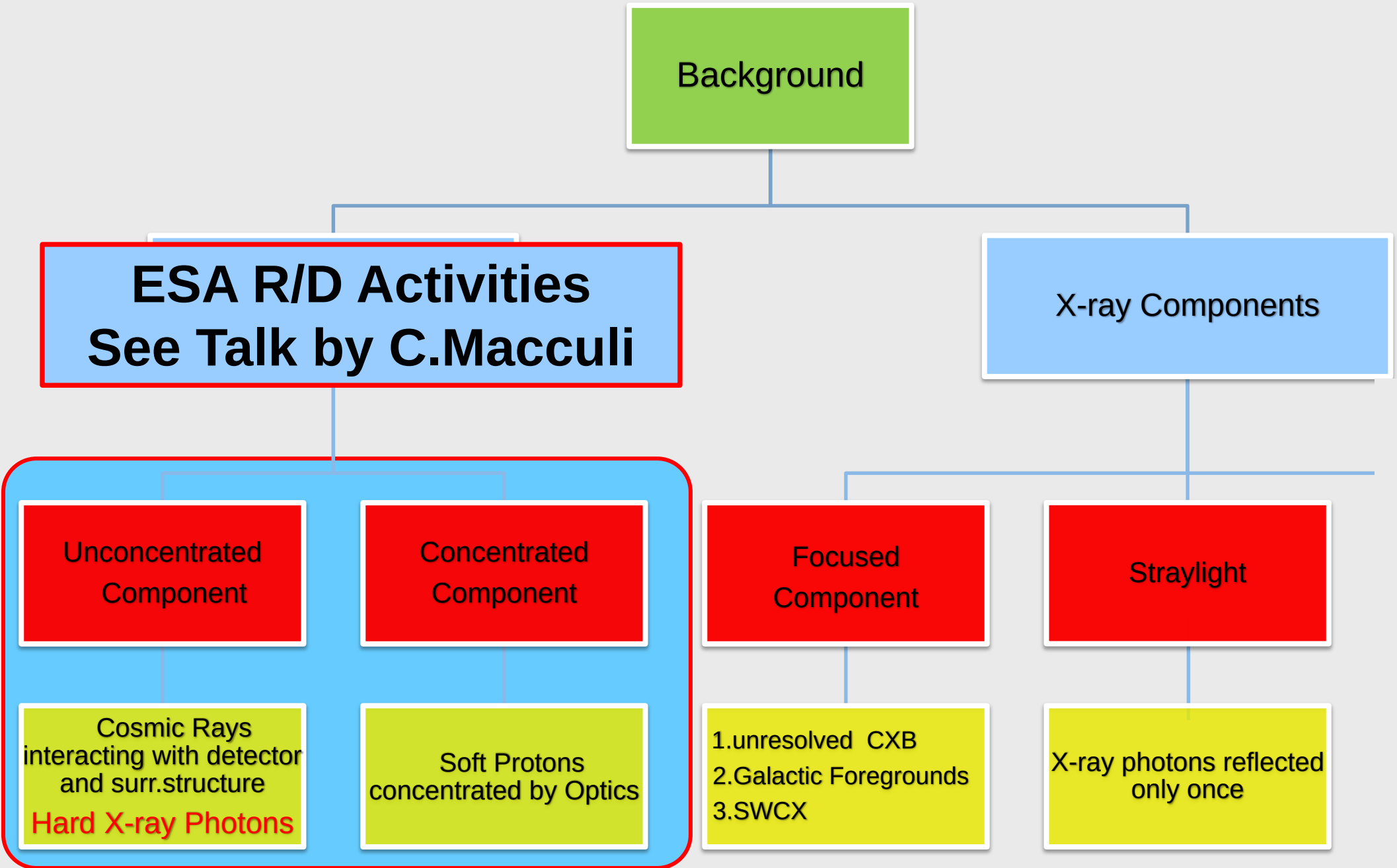
Hard X-ray photons Compton scatter in detector


Background
ESA R/D Activities
See Talk by C.Macculi
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Unconcentrated Particle Component

- Associated to Cosmic Rays, mostly protons with energies > 150 MeV
- Particle flux in orbit is high ~ few p cm-2 s-1,
- Fortunately most particles can be rejected, expected rates on detectors are ~ 100 x times smaller

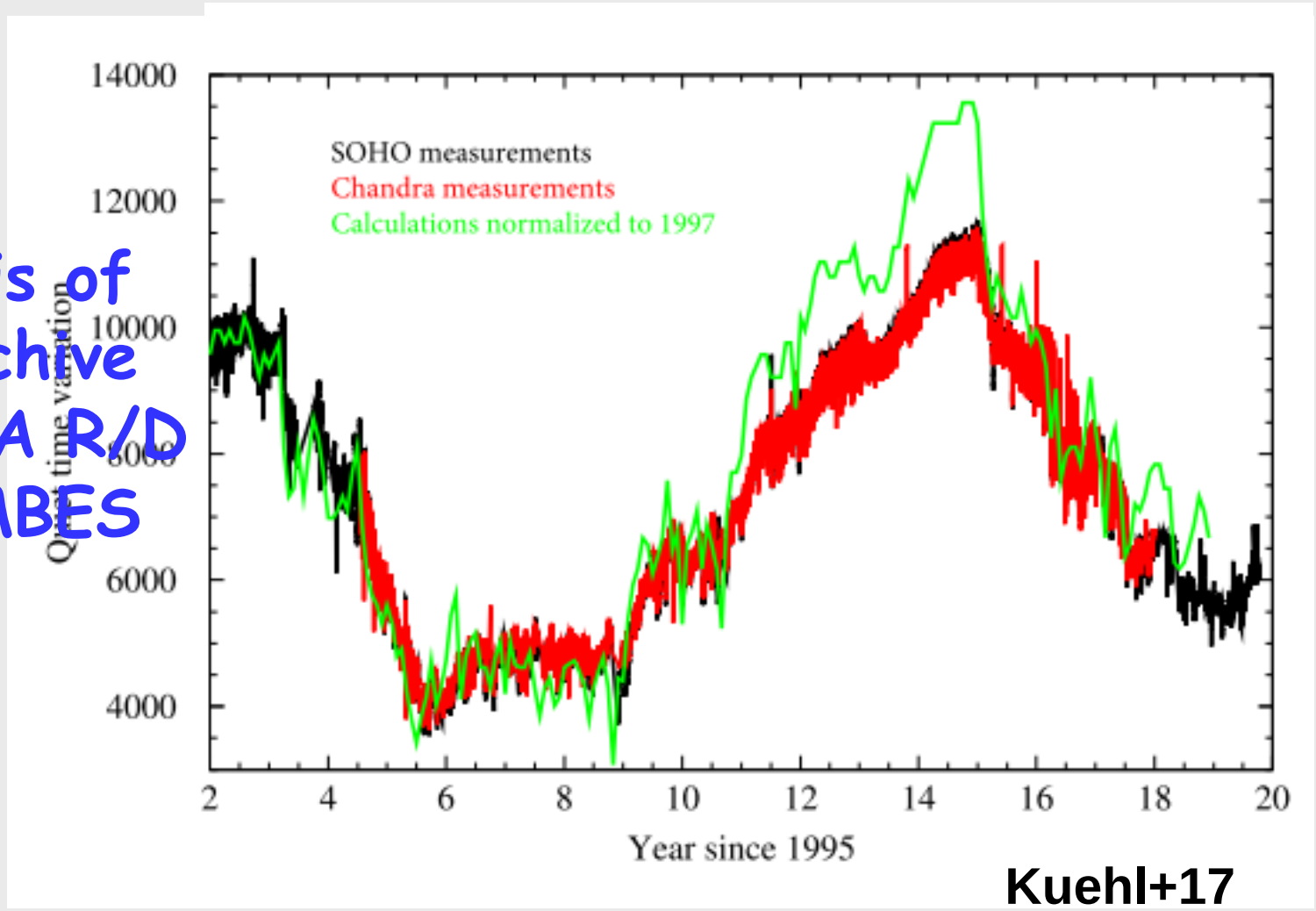
Implication is however that the bkg we are dealing with is a residual component, whose relationship to the incident particle population needs to be studied in detail.

Two complementary approaches:

- Study of background data from active missions
- Sophisticated simulations of interactions of primary particles with detector and its surrounding

High Energy Protons

Full re-analysis of EPIC MOS archive as part of ESA R/D Activity AREMBES



Kuehl+17

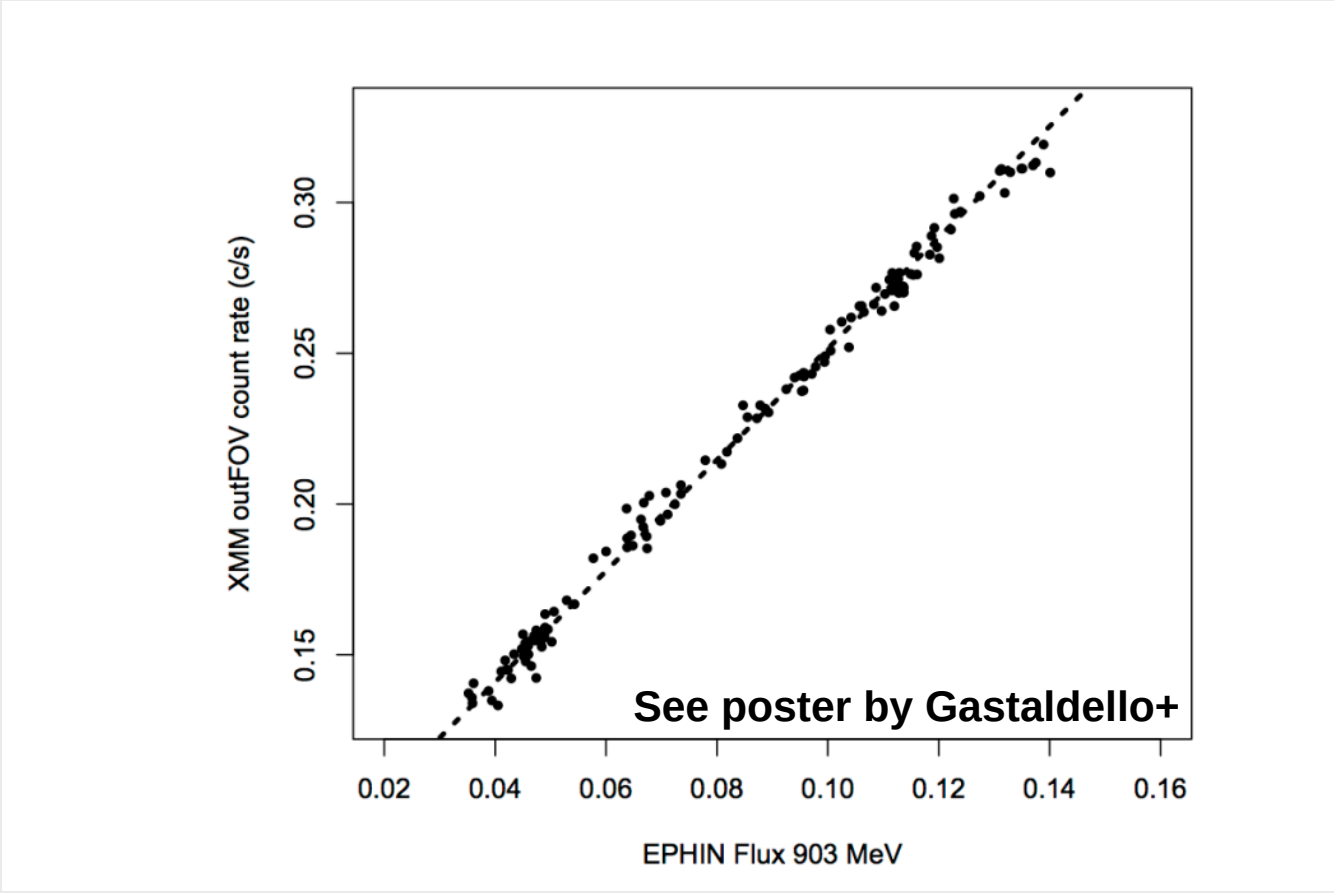
See also poster by Minervini+

Same in HEO, L1 and L2

MOS bkg mostly due to high E protons

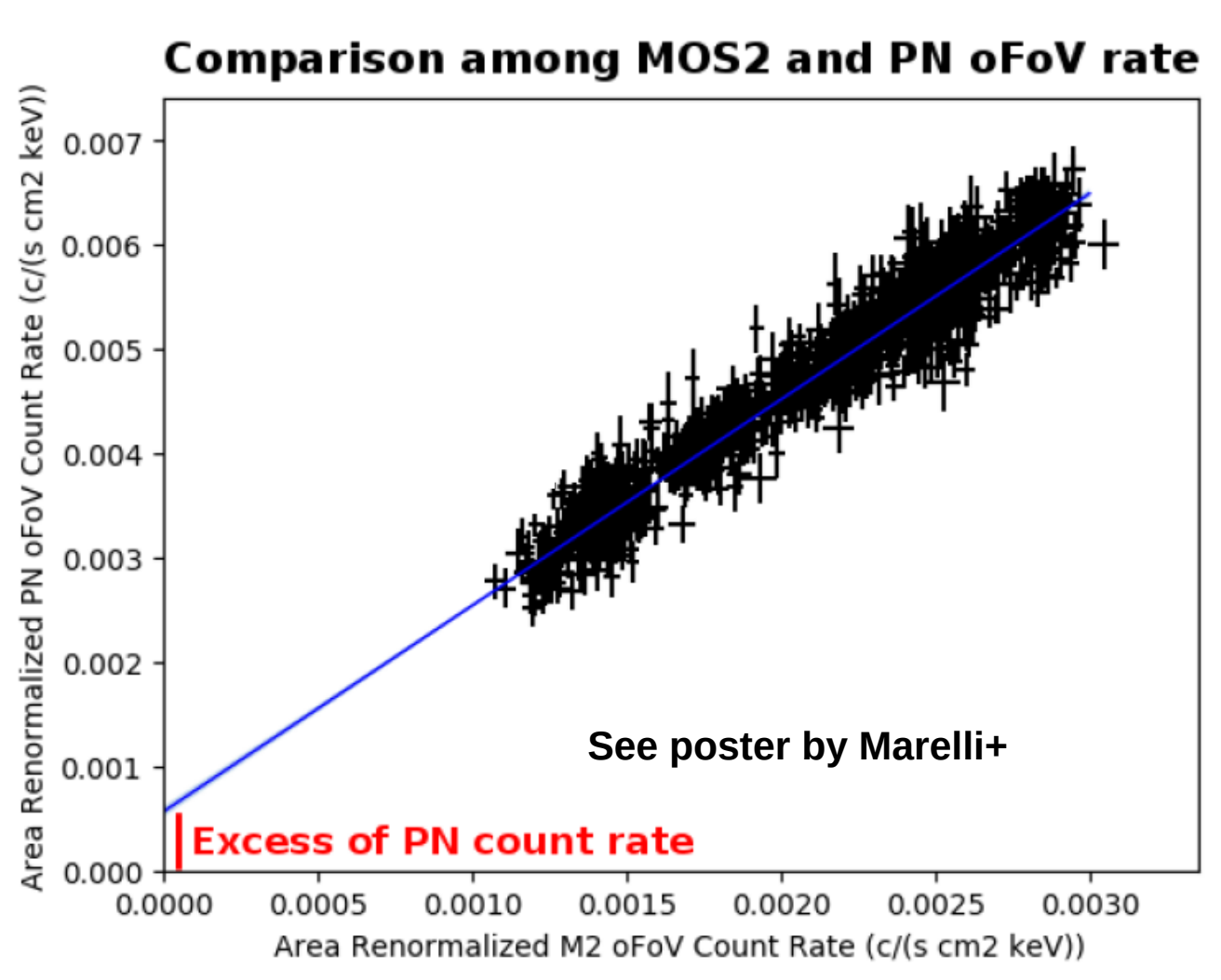
How good is the correlation btwn X-ray bkg and High Energy Particles?

MOS vs EPHIN SOHO plot confirms tight correlation

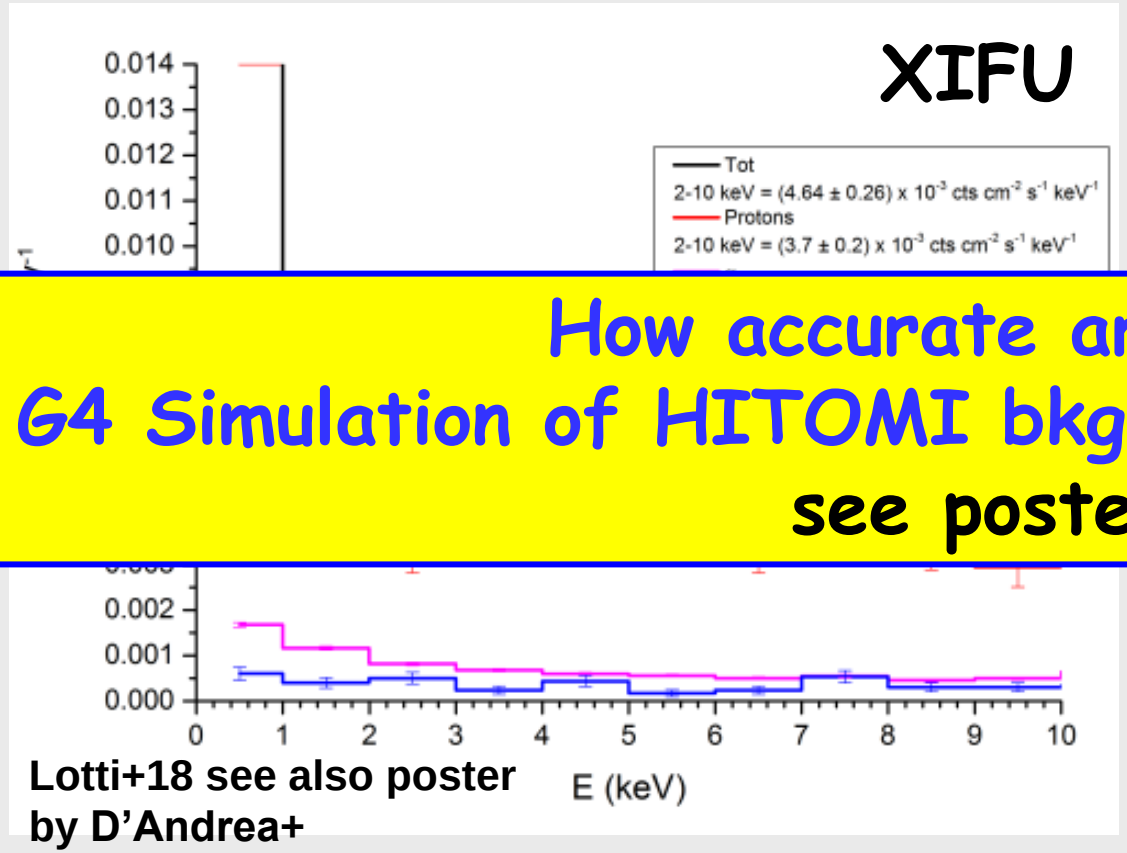


How good is the correlation btwn X-ray bkg and High Energy Particles?

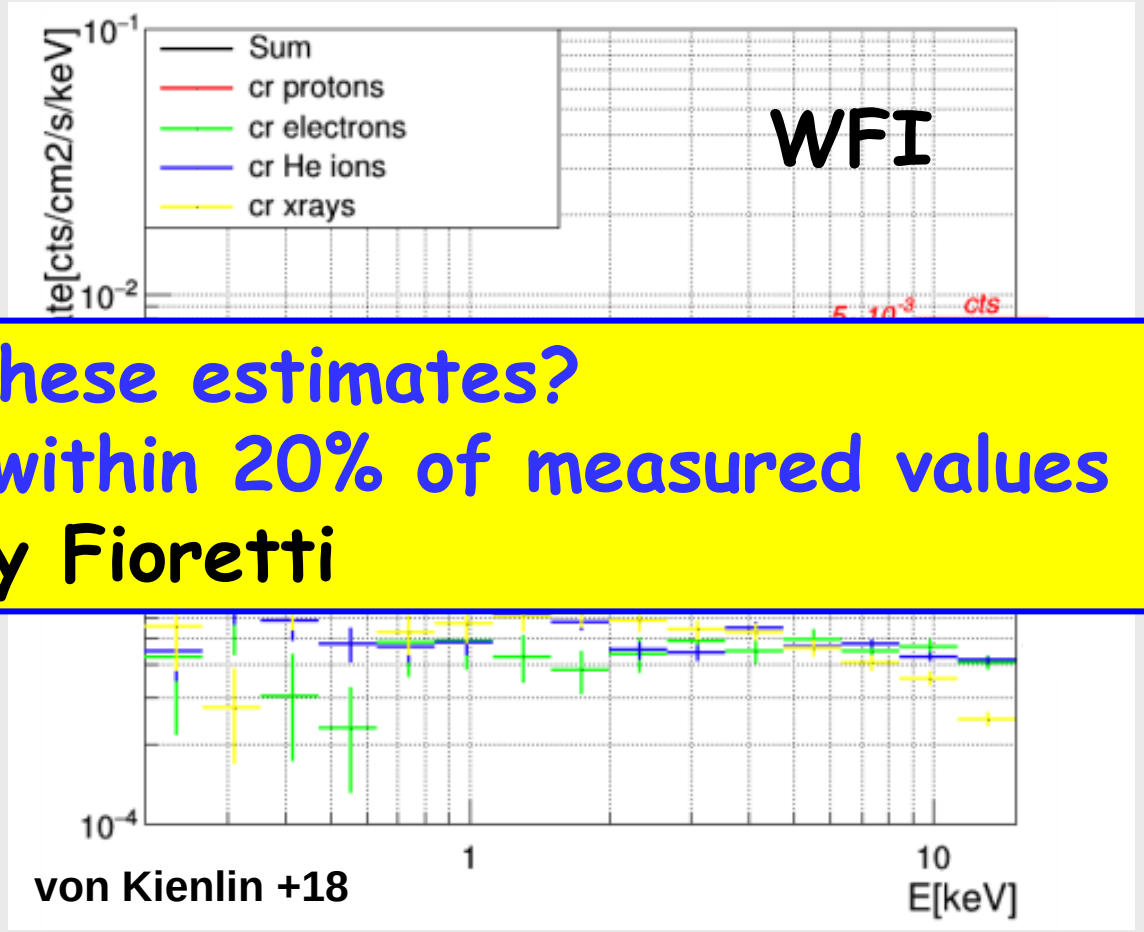
EPIC MOS vs pn also shows tight correlation



GEANT4 Simulations



Lotti+18 see also poster by D'Andrea+



von Kienlin +18

How accurate are these estimates?
G4 Simulation of HITOMI bkg is within 20% of measured values
see poster by Fioretti

- Most important contributors are cosmic ray protons
- Minor contributions from e- and alpha particles
- WFI has Cosmic X-ray Component not expected in XIFU

AHEPaM

Tight correlation between EPIC bkg and high energy particle flux suggests that an ATHENA High Energy Particle Monitor (AHEAPaM) will be very helpful in maximizing reproducibility

Requirements for the ATHENA High Energy Particle Monitor AHEPaM

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May 9, 2018

Version 1.0 - Draft version

Abstract

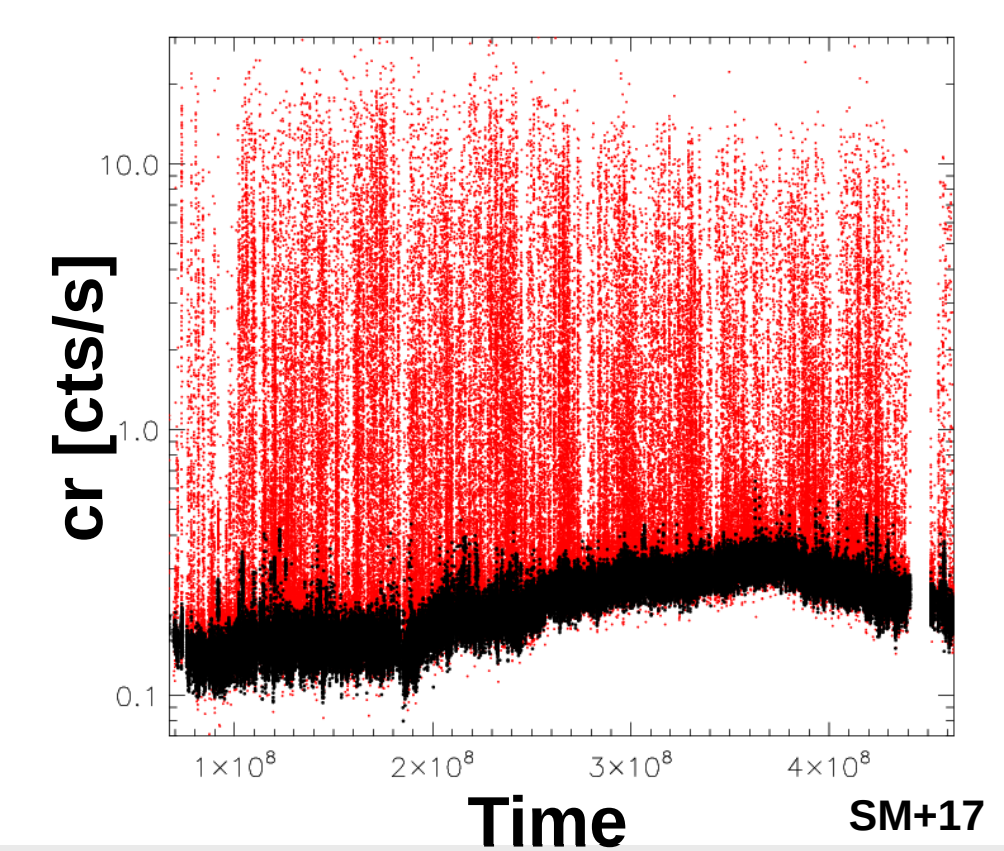
Recent findings indicate that monitoring of high energy particles can contribute to improving the reproducibility of the ATHENA background. In this note we provide requirements for an ATHENA High Energy Particle Monitor (AHEPaM) as well as some background information to help understand the logic that has lead to their formulation. THe AHEPaM will monitor protons, electrons and He ions with energies from ~ 0.1 GeV to a few GeV on timescales down to the ks.

1 Motivation

We have recently found that the unconcentrated particle background on EPIC MOS correlates extremely well with the ACIS S3 thresholding crossing rate (Ford & Grant 2012, SPIE 8443, 844347), a proxy for the unconcen-

Concentrated Particle Component (Soft Protons)

Highly variable component contaminating ~ 40% of EPIC observing time



Environmental studies conducted within AREMBES for L1 and L2

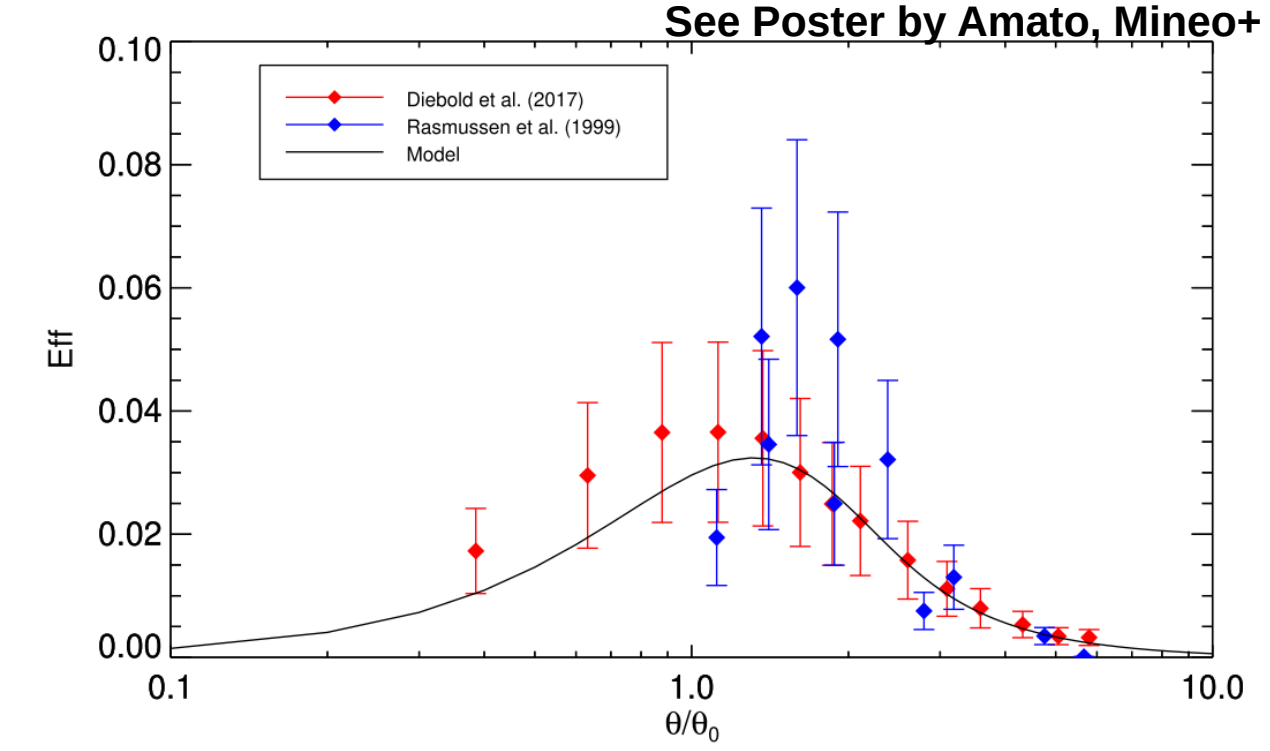
Results will be presented by Claudio

Soft Protons - Interaction with X-ray experiments

Interaction of soft protons with optics, filters and detectors poorly understood
Much work to improve upon this

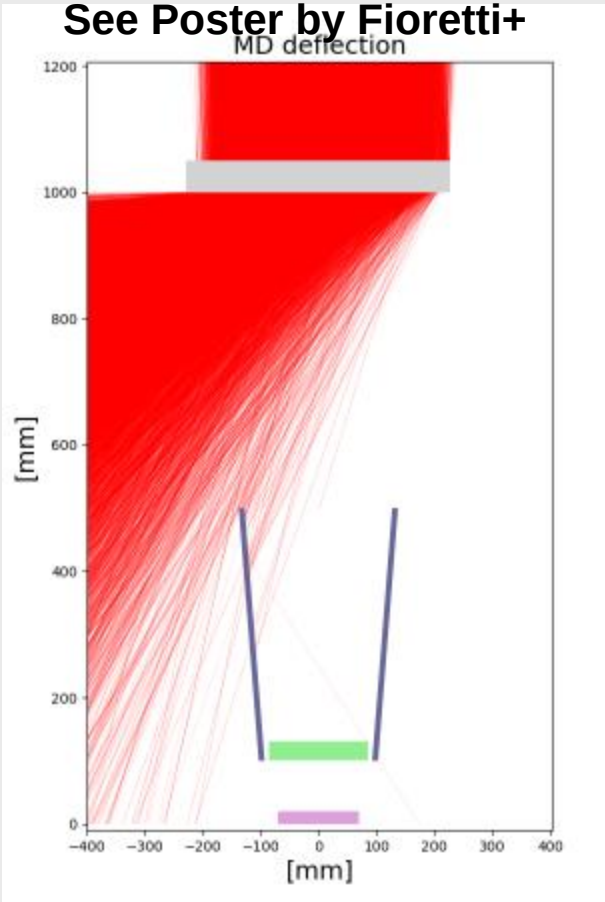
Optics "Quasi Specular Reflection"
Rasmussen+99, Diebold+15+17

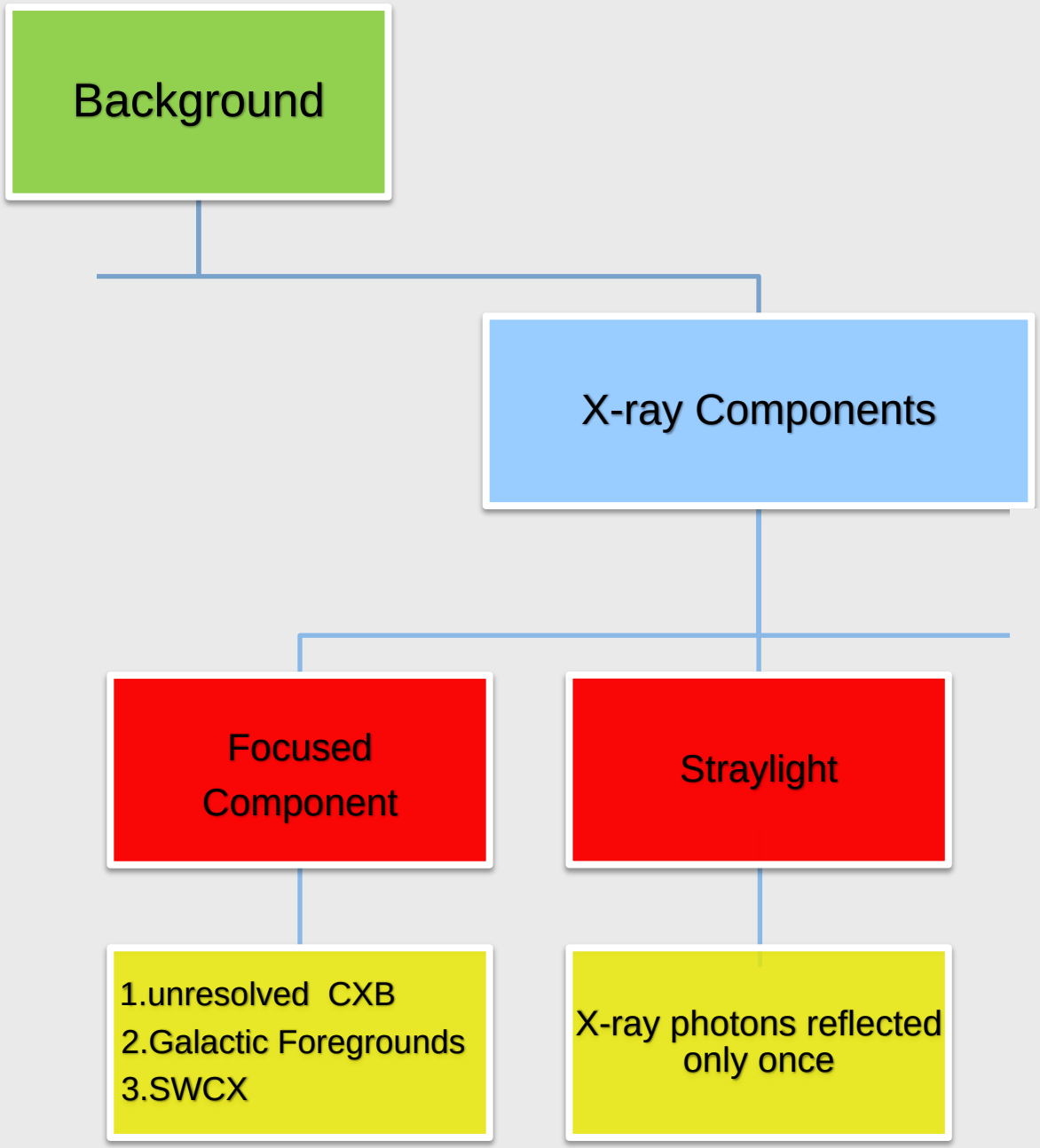
See Poster by Amato, Mineo+



G4 simulations of full experiment to size Magnetic Deflector

See Poster by Fioretti+

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Foregrounds and SWCX

Minimization through selection of favorable lines of sight

- ATHENA science is mostly driven by population studies of small samples 10, 25 obj, e.g. study of entropy profiles of clusters etc.,
- eROSITA will perform an all sky survey of unprecedented depth.
- It will be possible to select a representative cluster sample where individual systems are on lines of sight with small galactic absorption and emission (the 2 are related).

Straylight

Current Baseline does not include a pre-collimator on ATHENA optics

Straylight increases with increasing off-axis angle: negligible for XIFU, potentially serious for WFI

We are in the process of producing astrophysical simulations illustrating impact of Straylight on error budget of key observables

Putting it all together

From the point of view of the ATHENA user +1x yrs from now what will matters is:

1) that the bkg be as low and as reproducible as possible

2) that there be tools in place to fully exploit this

Developing tools for background treatment will be quite a challenge.
One way of getting ready for it is to apply the improved understanding of the bkg we have gained in the last few years to the analysis of EPIC data.

- Collaboration with XCOP project XMM VLP (PI Eckert), reduced systematics on SB profile to 5% (Ghirardini+18)
- Collaboration with the XMM Heritage Cluster Project, a multi-year observing program (PIs M.Arnaud S.Ettori)

Summary

- Work on background is vital to achieve much of ATHENA Science
- Minimization of Intensity and Maximization of reproducibility are the guiding principles
- All major background components have been identified and are being thoroughly investigated
- Development of background tools for ATHENA will be a challenging process, this is why we have already begun applying our improved understanding of the bkg to XMM data analysis.