Metrics and **q**uality **c**ontrol with **a**daptive **o**ptics instruments at the VLT

SPIE. CONNECTING MINDS. ADVANCING LIGHT.
Astronomical Telescopes + Instrumentation
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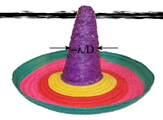
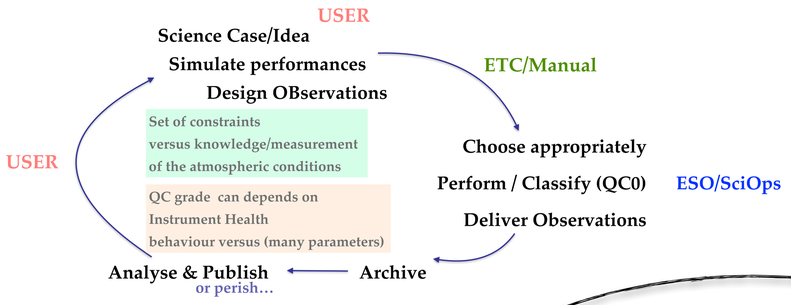
There are many **Adaptive Optics (AO)** fed instruments at the Paranal Observatory and many more to come. To monitor their performances and assess the quality of the scientific data, we are developing a scheme and a set of tools and metrics adapted to the various flavours of AO and variety of data products. In Service Mode (SM), our decisions to repeat observations or not depends heavily on this immediate quality control "zero" (QC0). Atmospheric parameters monitoring can also help predict performances . At the end of the chain, the user must be able to find the data that correspond to his/her needs translated into a set of requirements based on simulations done with an exposure time calculator (ETC). Predictions and real performances must match and the assessment must be intelligible to the community. We will emphasis on the difficulties encountered to perform quality control with SPHERE and the need for different metrics at various levels of wavefront: i.e Strehl ratio and FWHM for SCAO/LTAO/MCAO, contrast for an xAO, EE for GLAO, etc.

MANY AO FLAVOURS: IT'S NOW A ZOO!

SCAO, GLAO,
MCAO,
XAO, LTAO,
MOAO …

DATA PRODUCTION CHAIN: "SciOps" PERSCPECTIVE

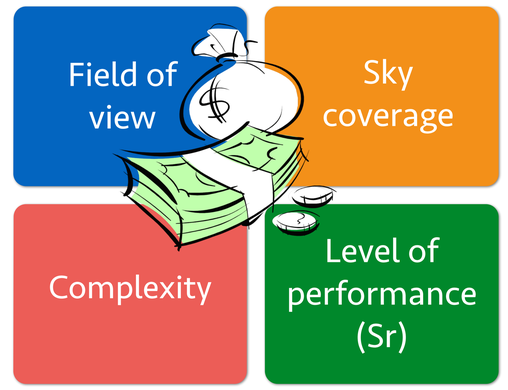




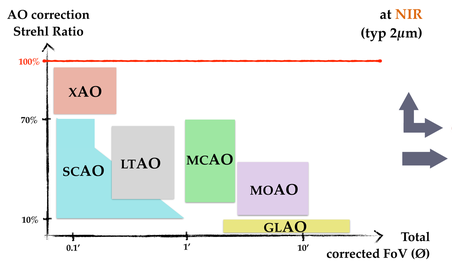
ADAPTIVE OPTICS EQUIPED INSTRUMENTS IN PARANAL

NACO: 2001-2013 (UT4), 2015- (UT1)
SINFONI/MACAO+LGS: 2003-
VLTI/UTs (~~MIDI~~, AMBER, PIONIER) + 4xMACAO: 2004 -
MAD(emonstrator): 2008 (UT3, 1 month)
CRIRES(+): 2002-2014 (UT1) & UT3…
SPHERE: 2014- (UT3)
GRAVITY/CIAO: 2016- (VLTI/UTs)
MUSE/GALACSI: 2017- (UT4+DSM+4LGSF)
HAWKI/GRAAL: 2017-(UT4+DSM+4LGSF)
ERIS: ~2020
MATISSE
etc.

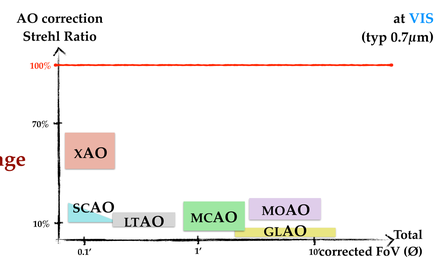
AO SYSTEMS TRADE-OFFS

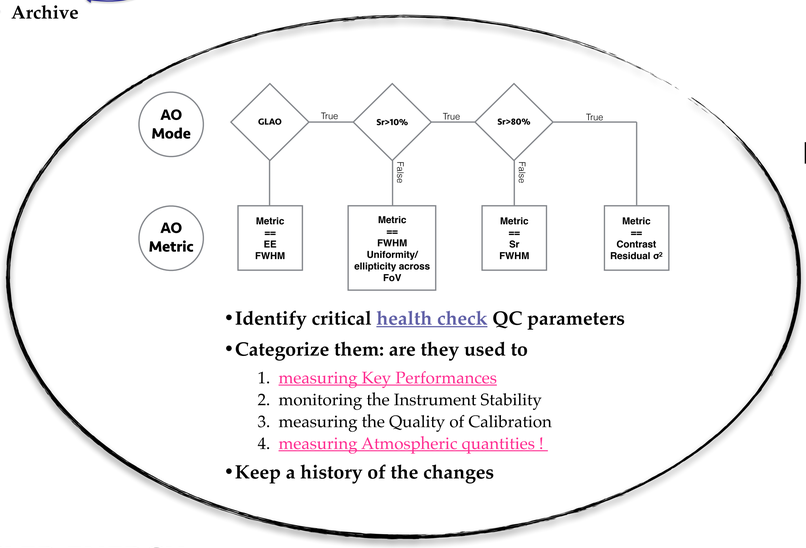


AO PERFORMANCE VERUS CORRECTED FIELD OF VIEW



cost!
sky coverage



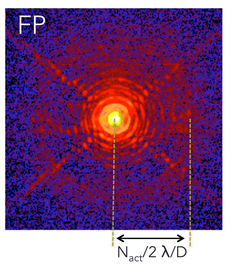


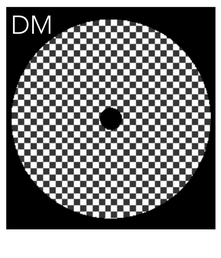
- Identify critical health check QC parameters
- Categorize them: are they used to
  1. measuring Key Performances
  2. monitoring the Instrument Stability
  3. measuring the Quality of Calibration
  4. measuring Atmospheric quantities !
- Keep a history of the changes

FOR EXTREME AO, THE CONTRAST IS THE BEST METRIC

High-density DM
High-density, faster WFS
} 90% Strehl reached (H-band): almost the diffraction limit

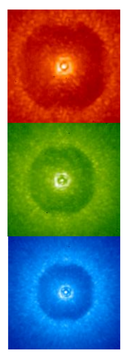
Contrast ≈ (1-Sr) / N_{act}^2





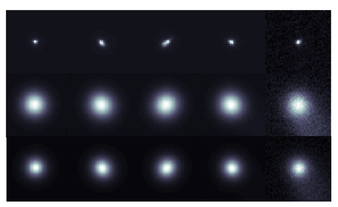
With
N_{act} x N_{act}
we can correct
up
to $N_{act}/2$
cycles / pup

Highest possible
spatial frequency



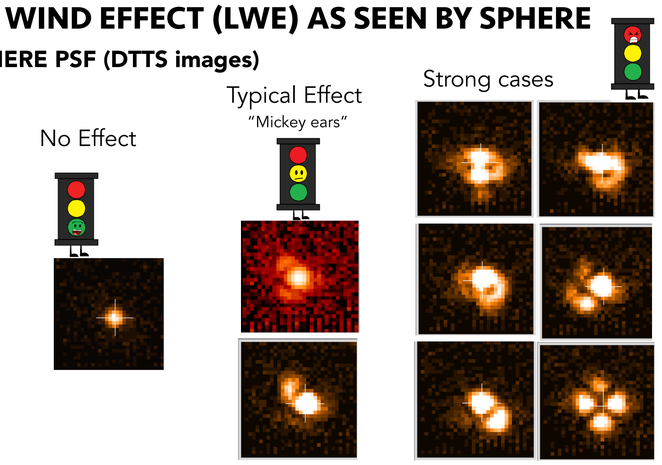
FOR GLAO, THE ENCIRCLED ENERGY or Energy concentration improvement in a given box

The Sr would be ~1%, insensitive



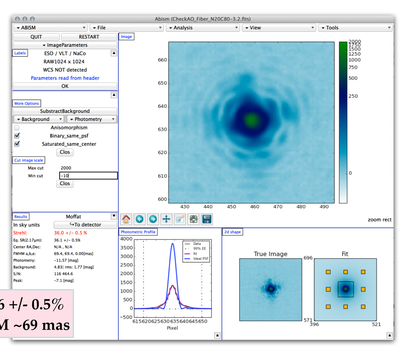
LOW WIND EFFECT (LWE) AS SEEN BY SPHERE

SPHERE PSF (DTTS images)

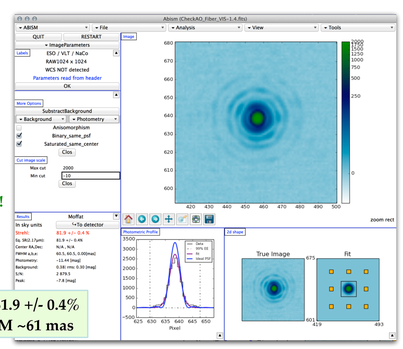


The LWE (~15% of the time) makes the QC0 assessment based on esternal conditions impossible

WHEN THE STREHL RATIO IS A GOOD METRIC AND THE FWHM ISN'T



Bad
Focus!
Sr = 36 +/- 0.5%
FWHM ~69 mas



Good
Focus!
Sr = 81.9 +/- 0.4%
FWHM ~61 mas

Sr here is more sensitive than FWHM when 10% < Sr < 90%

COMMON MODULAR STRATEGY

IMPOSSIBLE to use the same metric
for all AO-fed instruments, modes !!!!

DIFFICULT to understand, measure
=> data mining, correlations

NECESSARY to develop a common but versatile
QC / QC0 strategy / PHILOSOPHY
=> Analysis Tools
=> Trustworthy ASM 2.0
=> Training!

ParanalScienceOperations

RELATED CONTRIBUTIONS AT THIS CONFERENCE

- ABISM: an interactive image quality and Strehl ratio measurement tool for adaptive optics instruments
  Girard et al. 2016, 9909-303, June 30th 2016 (poster)
- Versatile quality control scheme for the adaptive optics instruments at the VLT
  Girard et al. 2016, 9910-108, June 29th 2016 (poster)
- SPHERE on-sky performance compared with budget predictions
  Dohlen et al. 2016, 9910-108, June 29th 2016 (poster)
- SPHERE: on-sky results
  Beuzit et al. 2016, 9910-108, June 29th 2016
- SPHERE on-sky results: final performance, lesson learned, and possible upgrades
  Fusco et al. 2016, 9910-108, June 29th 2016 (Invited talk)
- Data flow operations and quality control of SPHERE
  Fusco et al. 2016, 9910-108, June 29th 2016 (Invited talk)
- Training telescope operators and support astronomers at Paranal
  Boffin et al. 2016, 9910-108, June 29th 2016