The Gaia-ESO Public Spectroscopic Survey: a prototype for future ESO spectroscopic surveys

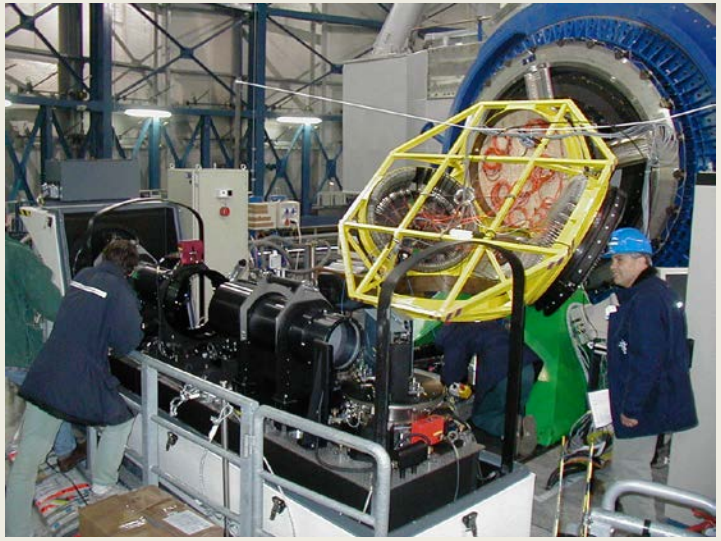
Gerry Gilmore

Co-PI

Gaia-ESO survey (GES) overview (1/2)

- Public large spectroscopic survey with FLAMES@VLT
- 300 (240+60) nights (30n/semester) over 5 (4+1) years; start 12/2011 (P88), end 9/2016 (P97)++; visitor mode
- All populations of the MW: Halo; Bulge; Thick & Thin discs; open clusters and associations
- Uniform analysis: First homogeneous overview of the distributions of kinematics and element abundances in the Galaxy

Gaia-ESO survey overview (2/2)



Giraffe for faint targets (V<19)
HR03/5A/6/9B/10/14 (O/B/A)
HR15N/21 (cool)

UVES for 'bright' stars (V<16.5)
520 /580 nm (warm/cool)

- $>10^5$ Giraffe spectra (R~16,000-25,000)
  → RVs, APs, [Fe/H], [X/Fe], stellar properties
- $>10^4$ UVES spectra (R~47,000)
  → precise multi element abundances
- + ESO archive exploitation/re-analysis

SCIENTIFIC BACKGROUND (1/2)

Key open issues in the formation and evolution of the MW and its component stars and stellar pops.

- The (dynamical) evolution of clusters: from birth to disruption
- Stellar evolution (ages, masses)
- Formation and evolution of the thin and thick discs
- Halo substructure, Dark Matter
- Formation and nature of the Galactic bulge

SCIENTIFIC BACKGROUND (2/2)

To comprehensively
address all those questions
and make a significant step forward
we need the full 6-D phase space,
plus stellar parameters, plus
ages, plus chemistry

GAIA + GB SPECTROSCOPY

Survey data products

- 1D, λ calibrated, sky-subtracted spectra
- Radial and rotational velocities
- APs: T_{eff}, log g
- [Fe/H], [X/Fe] (Li, C, O, Na, Mg, ..Ni, ..Ba, Y,..)
- Average RV, [Fe/H], [X/Fe] for the clusters
- Stellar properties: e.g, accretion rates, mass loss
- Photometry used to select the targets
- Semester, annual, and final data releases
- First releases: 01/2013 and 06/2013

All with quantitative uncertainties

4Implications for 4MOST

- The Galactic community is still learning how to collaborate on big projects
- New science demands high spectral resolution, good signal-noise, wide wavelength coverage
- Analysis of stellar spectra is not a pipeline: many methods are essential ➔ much effort
- Calibrating internal results onto a sensible scale is a very, very big challenge

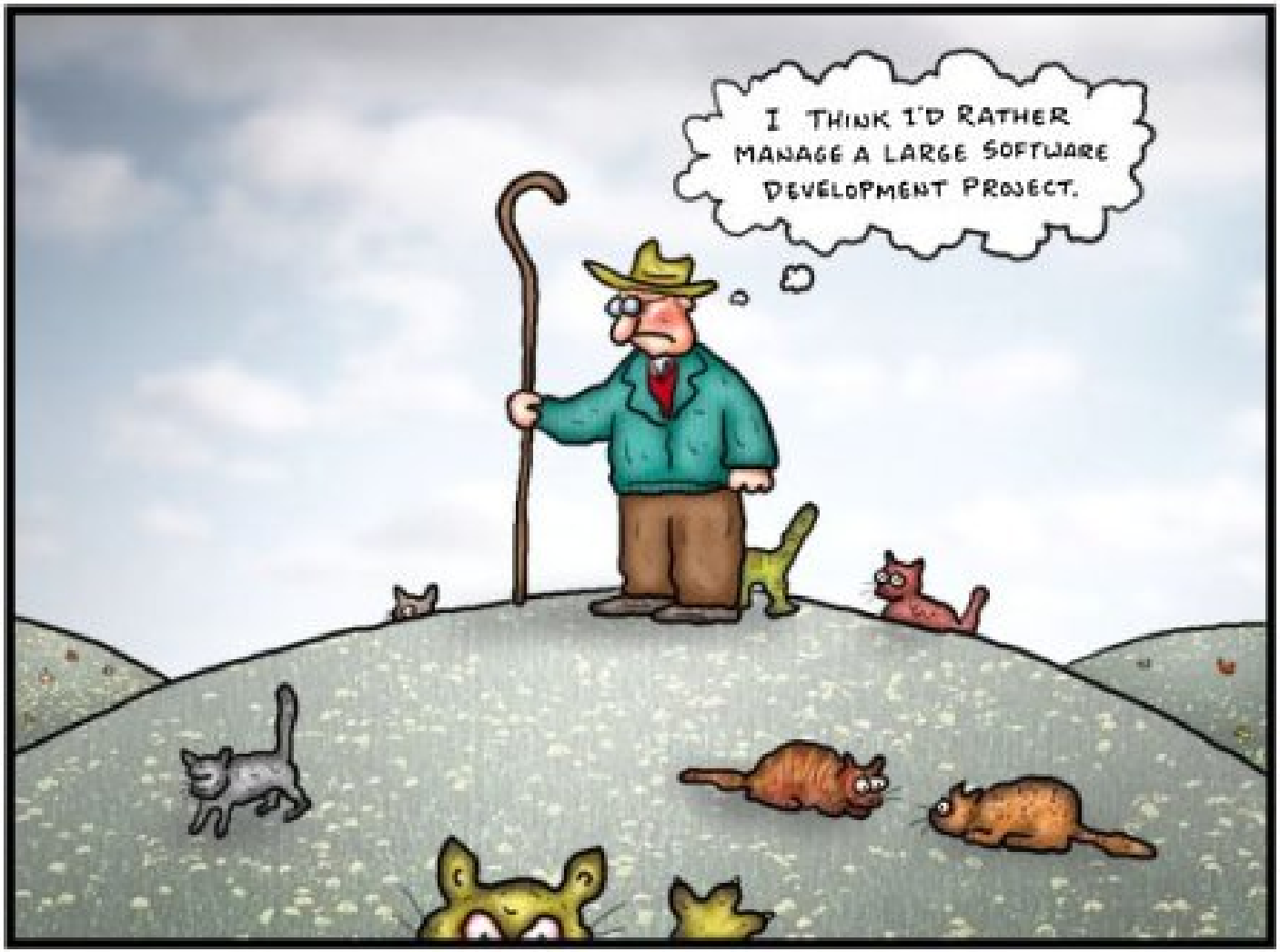
1) The project management challenge

Sofia Randich
(INAF-Arcetri)
&
Gerry Gilmore
(IoA, Cambridge)

Co-PIs: Gerry Gilmore[1370], Sofia Randich[1335]
CoIs: M. Asplund[1490], J. Binney[1611], P. Bonifacio[1588], J. Drew[1668], S. Feltzing[1473], A. Ferguson[1649], R. Jeffries[1132], G. Micela[1344], I. Negueruela[7609], T. Prusti[1278], H-W. Rix[1489], A. Vallenari[1343], D. Aden[1473], L. Affer[1344], J-M. Alcala[1340], E. Alfaro[1392], C. Allende Prieto[1393], G. Altavilla[7530], J. Alves[1803], T. Antoja[1422], F. Arenou[1588], C. Argiroffi[1883], A. Asensio Ramos[1393], C. Babusiaux[1588], C. Bailer-Jones[1489], L. Balaguer-Nunez[1821], B. Barbuy[1828], G. Barisevicius[1376], D. Barrado y Navascues[1088], C. Battistini[1473], I. Bellas-Velidis[1555], M. Bellazzini[1329], V. Belokurov[1370], T. Bensby[1473], M. Bergemann[1490], G. Bertelli[1343], K. Biazzo[1335], O. Bienayme[1582], J. Bland-Hawthorn[2044], R. Blomme[1650], C. Boeche[2112], S. Bonito[1344], S. Boudreault[1242], J. Bouvier[1449], A. Bragaglia[1337], I. Brandao[1200], A. Brown[1716], J. de Brujine[1278], M. Burleigh[1244], J. Caballero[8545], E. Caffau[2112], F. Calura[1197], R. Capuzzo-Dolcetta[1857], M. Caramazza[1344], G. Carraro[1261], L. Casagrande[1490], S. Casewell[1244], S. Chapman[1370], C. Chiappini[1135], Y. Chorniy[1376], N. Christlieb[1982], M. Cignoni[7530], G. Cocozza[7630], M. Colless[1017], R. Collet[1490], M. Collins[1489], M. Correnti[1329], E. Covino[1340], D. Crnojevic[1649], M. Cropper[1242], M. Cunha[1200], F. Damiani[1344], M. David[1233], A. Delgado[1392], S. Duffau[2112], S. Van Eck [1358], B. Edvardsson[6181], H. Enke[1135], K. Eriksson[2079], N.W. Evans[1370], L. Eyer[1377], B. Famaey[1582], M. Fellhauer[1824], I. Ferreras[1242], F. Figueras[1821], G. Fiorentino[1422], E. Flaccomio[1344], C. Flynn[2044], D. Folho[1200], E. Franciosini[1335], P. Francois[1588], A. Frasca[1341], K. Freeman[1139], Y. Fremat[1650], B. Gaensicke[1241], J. Gameiro[1200], F. Garzon[1393], S. Geier[5677], D. Geisler[1824], B. Gibson[1197], A. Gomboc[1995], A. Gomez[1588], C. Gonzalez-Fernandez[7609], J. Gonzalez Hernandez[1393], E. Grebel[2112], R. Greimel[1423], M. Groenewegen[1650], F. Grundahl[1368], M. Guarcello[1312], B. Gustafsson[2079], P. Hadrava[1116], D. Hadzidimitriou[1559], N. Hambly[1649], P. Hammersley[1258], C. Hansen[2112], M. Haywood[1588], U. Heber[5677], U. Heiter[6181], A. Helmi[1422], G. Hensler[1893], A. Herrero[1393], V. Hill[1591], S. Hodgkin[1370], N. Huelamo[8545], A. Huxor[2112], R. Ibata[1582], M. Irwin[1370], R. Jackson[1132], R. de Jong[1135], P. Jonker[1660], S. Jordan[2112], C. Jordi[1821], A. Jorissen[1358], D. Katz[1588], D. Kawata[1242], S. Keller[1139], N. Kharchenko[1135], R. Klement[1489], A. Klutsch[1803], J. Knude[1966], A. Koch[1244], O. Kochukhov[6181], M. Kontizas[1560], S. Koposov[1370], A. Korn[6181], P. Koubsky[1116], A. Lanzafame[1874], R. Lallement[1588], P. de Laverny[1591], F. van Leeuwen[1370], B. Lemasle[1422], G. Lewis[2044], K. Lind[1490], H.P.E. Lindstrom[1966], J. Lopez santiago[1803], P. Lucas[1668], H. Ludwig[2112], T. Lueftinger[1893], L. Magrini[1335], J. Maiz Apellaniz[1392], J. Maldonado[1803], G. Marconi[1261], G. Matijevic[1995], R. McMahon[1370], S. Messina[1341], M. Meyer[1377], A. Miglio[1359], S. Mikolaitis[1376], I. Minchev[1135], D. Minniti[1801], A. Moitinho[8848], N. Molawi[1583], Y. Momany[1261], L. Monaco[1261], M. Montalto[1200], M.J. Monteiro[1200], R. Monier[5695], D. Montes[1803], A. Mora[1350], E. Moraux[1449], T. Morel[1359], A. Morino[1490], N. Mowlavi[1583], A. Mucciarelli[7630], U. Munari[1343], R. Napiwotzki[1668], N. Nardetto[1824], T. Naylor[1130], G. Nelemans[1638], S. Okamoto[1616], S. Ortolani[6311], G. Pace[1200], F. Palla[1335], J. Palous[1116], E. Pancino[1337], R. Parker[1377], E. Paunzen[1893], J. Penarrubia[1828], I. Pillitteri[1312], G. Piotto[1343], H. Posbic[1588], L. Prisinzano[1344], E. Puzeras[1376], A. Quirrenbach[2112], S. Ragaini[7530], D. Ramano[1337], J. Read[1377], M. Read[1649], A. Recio-Blanco[1591], C. Reyles[1592], N. Robichon[1588], A. Robin[1592], S. Roeser[2112], F. Royer[1588], G. Ruchti[1490], A. Ruzicka[1116], S. Ryan[1668], N. Ryde[1473], G. Sacco[1645], N. Santos[1200], J. Sanz Forcada[1456], L.M. Sarro Baro[5688], L. Sbordone[1139], E. Schilbach[2112], S. Schmeja[2112], O. Schnurr[1135], R. Schoenrich[1490], R-D. Scholz[1135], G. Seabroke[1242], S. Sharma[2044], G. De Silva[1017], R. Smiljanic[1258], M. Smith[1616], E. Solano[8545], C. Soubiran[1592], S. Sousa[1200], A. Spagna[1346], M. Steffen[1135], M. Steinmetz[1135], B. Stelzer[1344], E. Stempels[6181], H. Tabernero[1803], G. Tautvaisiene[1376], F. Thevenin[1591], J. Torra[1821], M. Tosi[1337], E. Tolstoy[1422], C. Turon[1588], M. Walker[1312], N. Walton[1370], J. Wambsganss[2112], C. Worley[1591], K. Venn[2061], J. Vink[1111], R. Wyse[1419], S. Zaggia[1343], W. Zeilinger[1893], M. Zoccali[1801], J. Zorec[1361], D. Zucker[1477], T. Zwitter[1995]

1) The project management challenge
All going in the same direction...

1) The project management challenge it isn't what you first think...



The daydreams of cat herders

1) The project management challenge it can be done....

"The kid's good."

Gaia will have done the easy bit

Alerts – as soon as we can, within year one, on to the end

Release

L + 22m

08/ 2015

L + 28m

02/ 2016

L + 40m

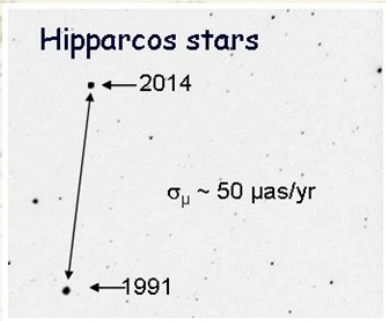
02/ 2017

L + 65m

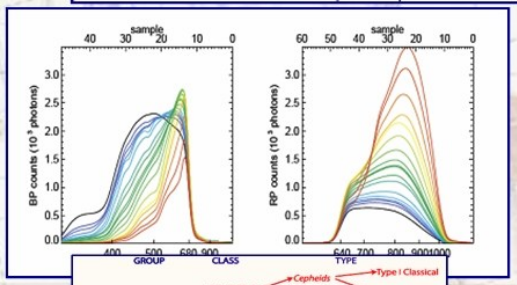
Mid 2018

α deg 8	δ deg 9
4.18700521	41.06905721
57.84982093	−25.93298679
87.24506095	63.69702032

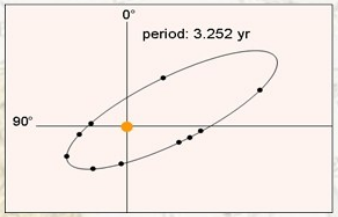
α deg 8	δ deg 9	π mas 11	$\mu_{\alpha*}$ mas/yr 12	μ_δ mas/yr 13
4.18700521	41.06905721	18.92	190.14	27.75
57.84982093	−25.93298679	21.42	273.72	167.93
87.24506095	63.69702032	4.12	5.07	−98.19
97.98452970	−27.72950422	17.95	21.31	217.87
106.43757563	26.14031575	21.74	18.58	−10.54
109.41026120	−29.01434479	7.92	−4.53	−7.01

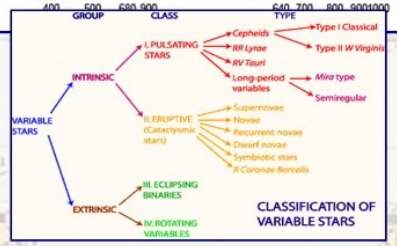


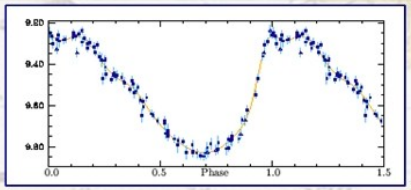
G G_{BP} G_{RP}

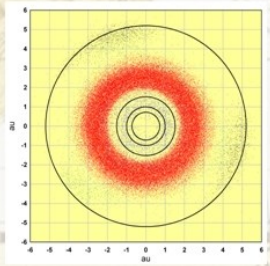


⟨Vr⟩







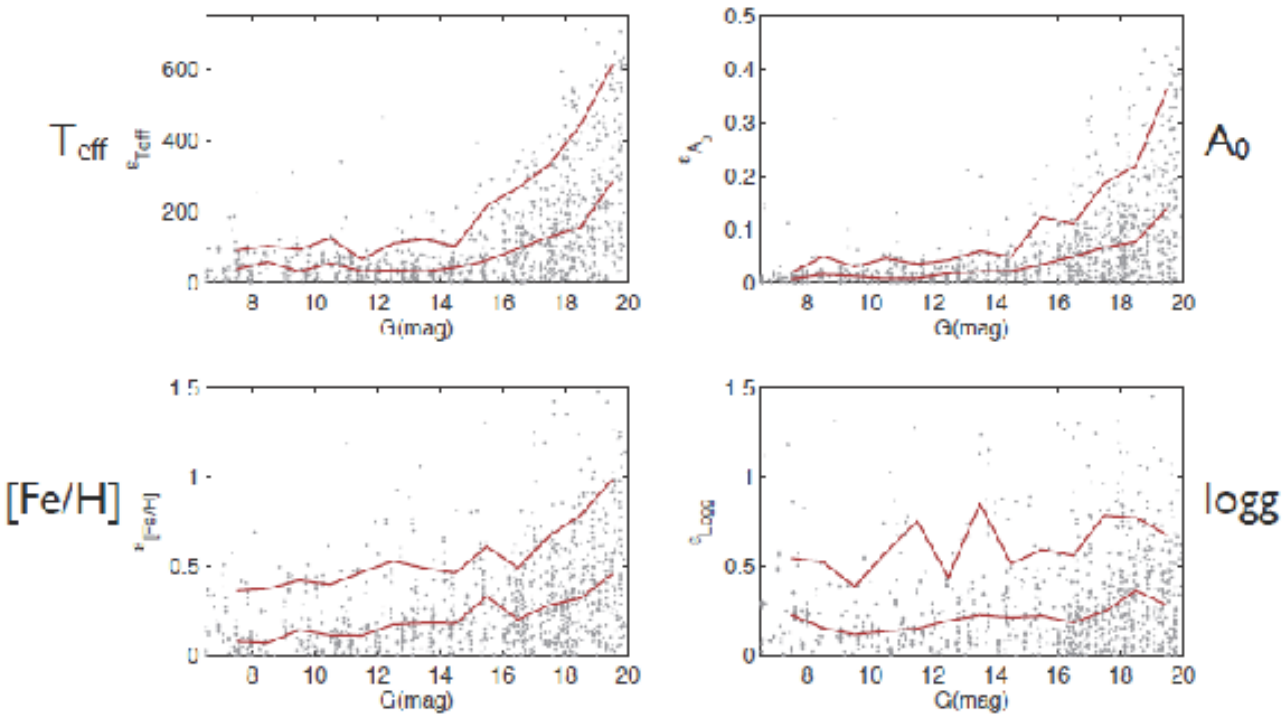


The first-pass determination of astrophysical parameters will come from Gaia – New science means RVs, and good elemental abundances ➔ HIGH RESOLUTION

2. Science performances

gaia

Stellar parameters



Courtesy of C. Bailer-Jones

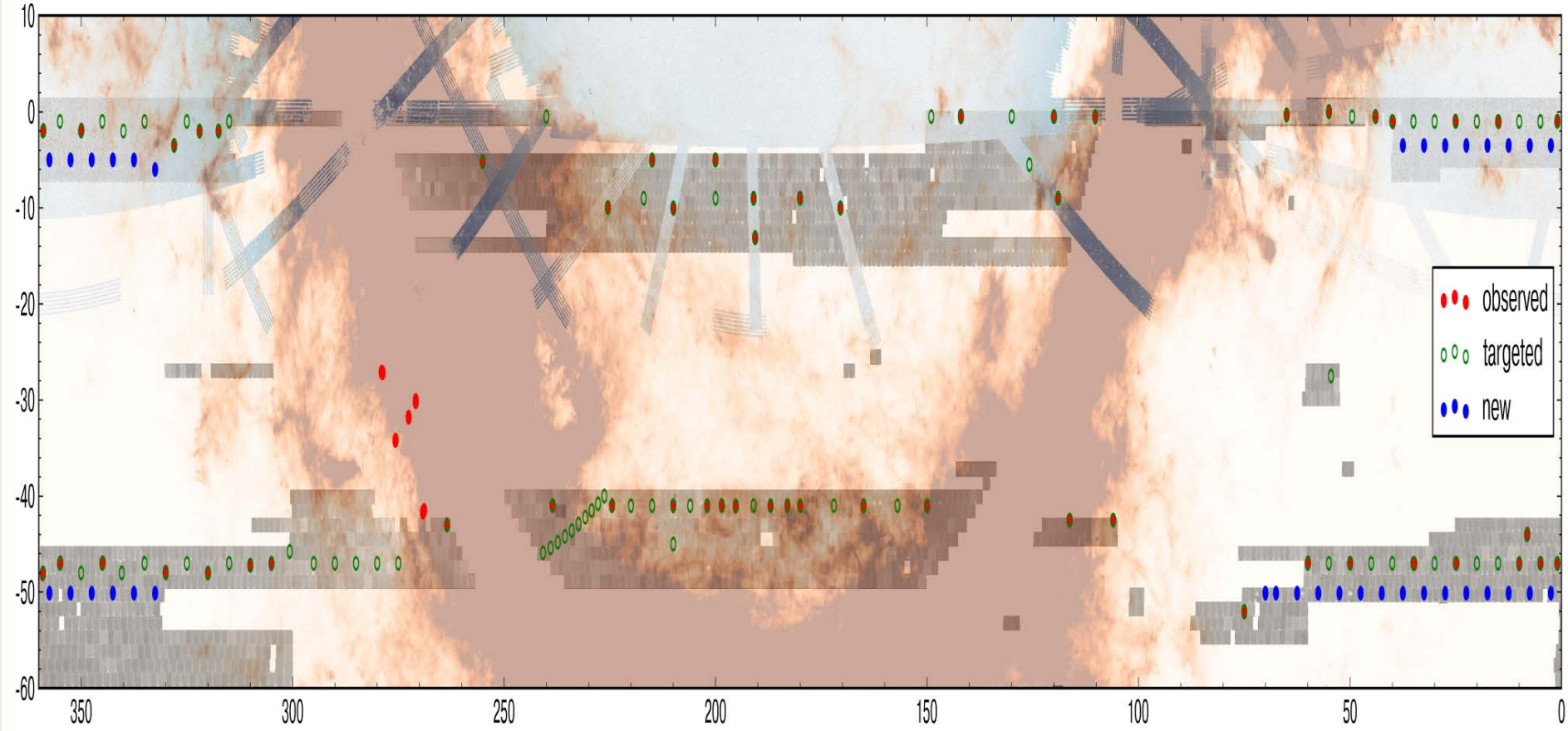
More in http://www.mpia.de/Gaia

Gaia will produce astrometry, photometry, spectra, spectrophotometry, RVs, periods for variables, orbits for NEOs, abundances, astrophysical parameters, Av,.....

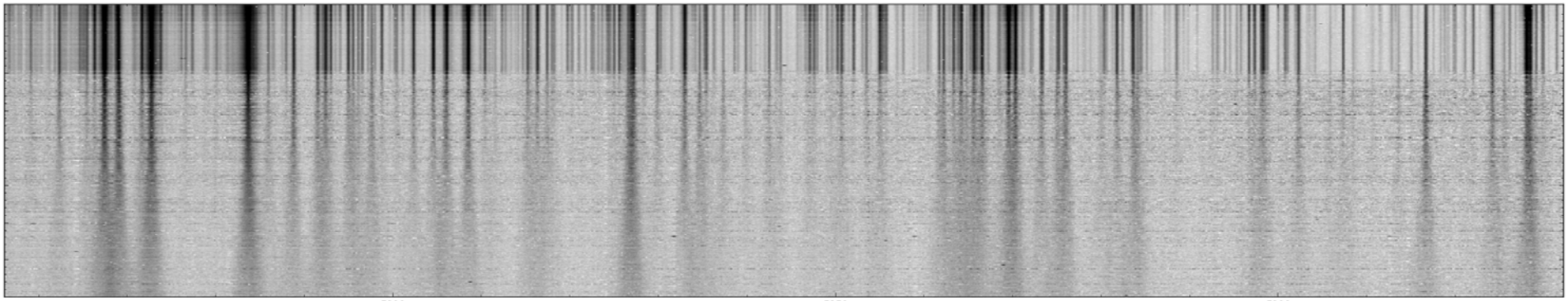
Gaia-ESO fields targeted

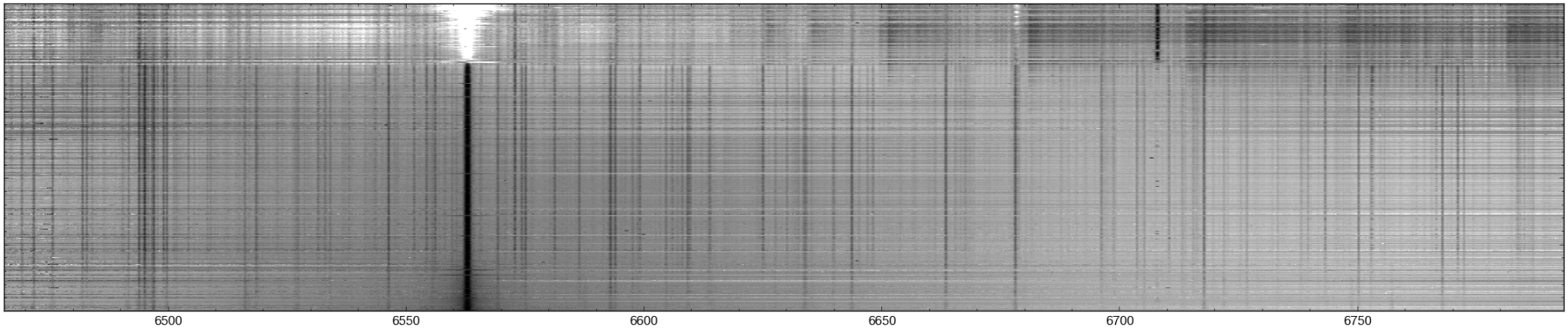
Paranal often has north wind limits..

Blue-arm science targets in high-extinction southern areas are essential…



Gaia-ESO Giraffe spectra:
even with narrow target selection, a very wide range of parameters is evident
➔ there is no single analysis aproach





Gaia-ESO Survey philosophy

- some large stellar surveys have struggled to deliver good results
- "spend $20M on data acquisition, then find a student..."

- Determining reliable calibrated element abundances from a wide range of stellar types is a big challenge: hot/warm/cool/metal-rich/metal-poor…
- ➔ dominates effort, will continue to dominate effort

- Gaia-ESO involves all European & Australian expert teams
- ➔ continuity, experience, complementarity.
- No "wheel re-invention".

- All spectra analysed in several ways – we do not try for one "pipeline", but use all available proven methods
- ➔ different methods are essential for different stellar parameter ranges.

- Multi-Analyses can also provide a range in complexity – eg, NLTE.
- Providing the whole range of analysis outputs quantifies both random and systematic (method-dependent) effects

Gaia-ESO Survey philosophy

- sample unbiassed MDFs
- ➔ undersample rare and wings
- Providing the whole range of analysis outputs quantifies both random and systematic effects

- Some science wants a simple “answer”, other science analyses the details
- Serious calibration effort is essential to determine a “best” value for each star, as well as the method-dependent range
- Gaia-ESO uses Open Clusters to link hot, warm, cool, parameter and abundance scales, with substantial special observational effort
- Calibration is expensive, and complex: eg super-solar

- Calibration needs planning.

conclusion

- Gaia-ESO is your pathfinder:
- we will make a good job!

- The Gaia-ESO experience provides valuable experience for 4MOST science and data processing planning