Gaia-ESO Survey

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Outline

- Background
- Survey overview
- Targets, strategy, products
- Core science
- Data management
- First light and spectra
- What the Survey will not do

Background

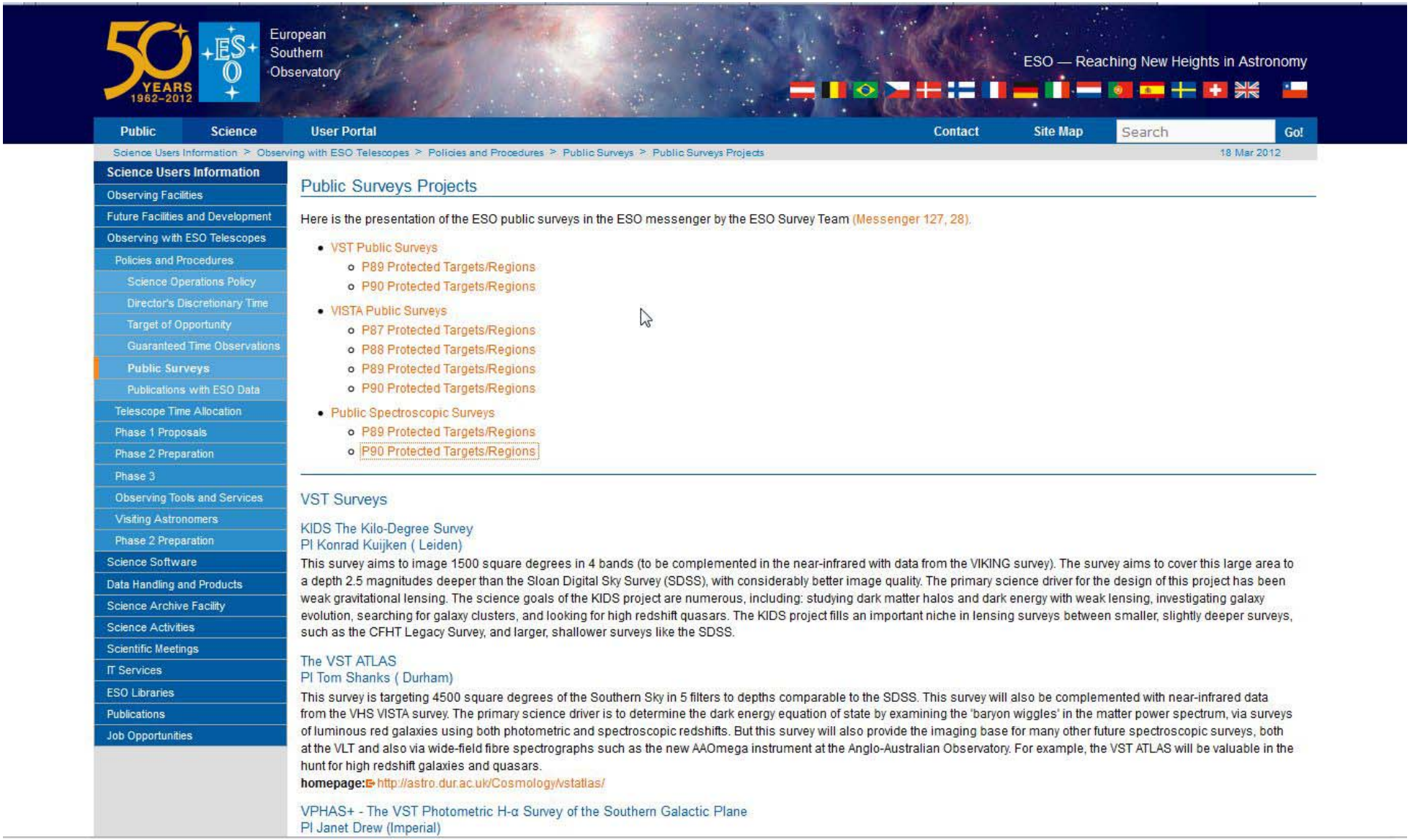
Need for spectroscopic surveys identified in several strategic papers

- **ESO-ESA WG** report 4 “Galactic populations, chemistry, and dynamics”

- **ASTRONET** SV & Infrastructure Roadmap

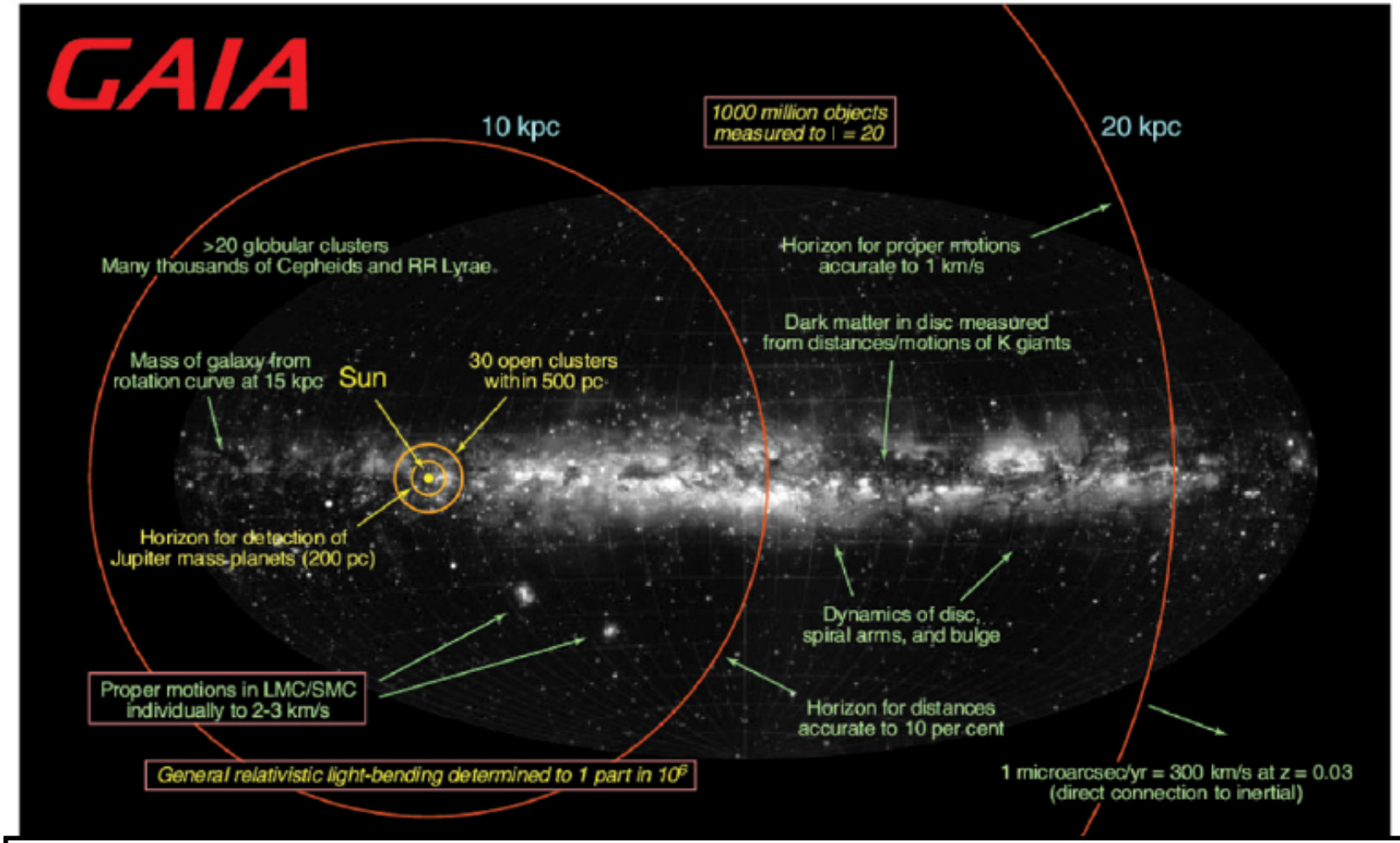
- ESO Workshop **on wide field spectroscopic surveys**

*large public spectroscopic surveys, using current ESO VLT instrumentation, "could place the **European community in a favourable situation** ... generating the data required to **complement Gaia** if the surveys **begin soon**".*



http://www.eso.org/sci/observing/policies/PublicSurveys/sciencePublicSurveys.html

Gaia is just around the corner (2013)



Gaia science is transformational – the first 3-D galaxy **accurate distances and motions for 1 billion stars**

Gaia can do many things …

- parallaxes
- proper motions
- radial velocities (only for $G_{RVS}<17$, limited accuracy)
- astrophysical parameters and [Fe/H] (good T_{eff}, limited for log g and [Fe/H])
- detailed chemistry (only for very bright stars)
- additional information (e.g, Li, Hα)

…but is going to need some help

- Accurate radial velocitiess
- Accurate astrophysical parameters, metallicity,
- detailed chemistry
- additional properties

The Gaia-ESO Spectroscopic Survey

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

Co-PIs: Gerry Gilmore[1], Sofia Randich[2]

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[1893], 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[1528], 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 Bruijne[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[7530], 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. Folha[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. Molaw[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[7030], U. Munari[1343], R. Napiwotzki[1668], N. Nardetto[1824], T. Naylor[1130], G. Nelemans[1638], S. Okamoto[1616], S. Ortolani[5311], 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]

The Gaia-ESO Spectroscopic Survey

- Original initiative from two **GREAT WGs**.
- Long process involving Letters of intent, pre-acceptance, proposal review, survey management plan,…
- Now around **300** Co-Is in project

Co-PIs: Gerry Gilmore[1], Sofia Randich[1]

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[1893], 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[1528], 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 Bruijne[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[7530], 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. Folha[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. Molaw[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[7030], U. Munari[1343], R. Napiwotzki[1668], N. Nardetto[1824], T. Naylor[1130], G. Nelemans[1638], S. Okamoto[1616], S. Ortolani[5311], 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]

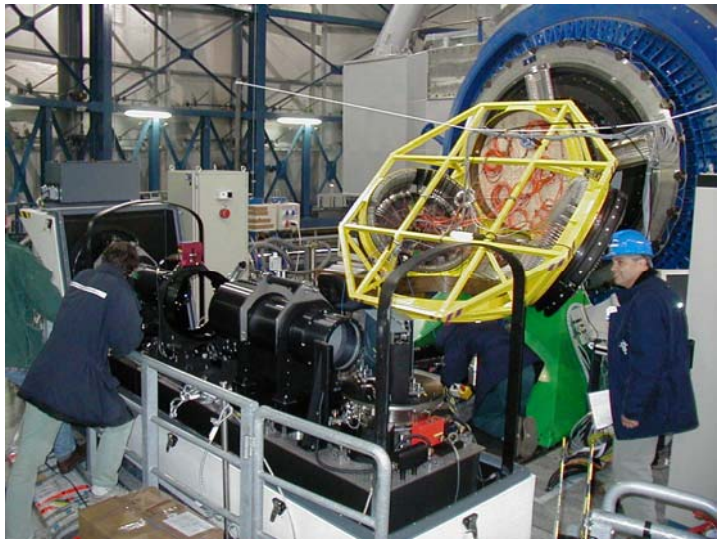
Gaia-ESO survey (GES) overview (1)

- **Public** large spectroscopic survey with FLAMES@VLT; contract signed Feb/12

- **300 nights** (30n/semester) over **5 (4+1) years**; start 1/2012 (P88), end 9/2016 (P97)+; visitor mode

- **All stellar populations in the Milky Way:** Halo; Bulge; Thick & Thin discs; open clusters and associations

Gaia-ESO survey overview (2)



Giraffe (130 fibers)
for faint targets

UVES (8 fibers)
for 'bright' stars ($V < 16.5$)

- **$>10^5$ Giraffe** spectra (R ~ 16,000 - 25,000)
- **$>10^4$ UVES** spectra (R ~ 47,000)
- + **ESO archive** exploitation/re-analysis

Gaia-ESO survey overview (3)

- Accurate **RVs** and good **APs** down to $V \sim 19$
  [Fe/H] & [X/Fe] for several species with Giraffe; precise **multi-element abundances** with UVES

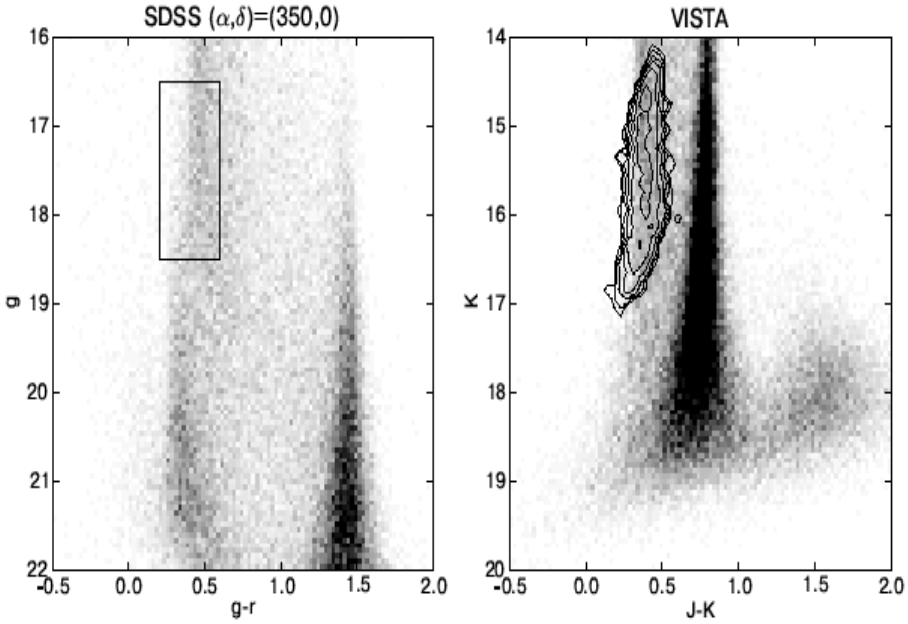
- First homogeneous overview of the kinematics and chemical element abundance distribution in the Galaxy

- Exceptional **stand-alone value**; will benefit from and add value to Gaia: **Gaia-ESO spectroscopy complements and completes Gaia astrometry and viceversa**

Targets: stellar samples

- **Bulge:** mostly giant stars (clump and RGB), I=15
- **Halo /thick disc:** FG turnoff stars ($17 < r < 18$); giants in known streams
- **Thin disc** –only RVs for dynamics; $I < 19$
- **Solar neighborhood** (d > 1kpc from Sun); UVES in parallel
- **Calibration fields**

Selection based on CMDs using VISTA



All phases of cluster evolution
All cluster types

PMS clusters
(10-100 Myr)

Very young clusters,
star forming regions,
associations

Intermediate-age
and old clusters
(100 Myr – 8 Gyr)

Nearby (< 1.5 kpc) and distant

Relevant populations covered

Set-ups and spectral ranges

- **Limiting mag. (*R*):** 16.5 (UVES), 19 (Giraffe)
- **UVES:** CD3 - 520/580 (416-617/475-678 nm) for hot/cool stars; **S/N > 60-70** → precise abundances
- **Giraffe:** *Cluster/field stars:* HR03/05A /06/14A (403-476, 631-670 nm) for hot stars; HR10/15N/21 (534-562; 647-679; **848.4-900**) for cool stars: $T_{\rm eff}$/gravity indicators, Hα, Li, Fe I and II lines, Ca IR triplet, a few lines from other elements
- **S/N > 10-30;** → RVs, APs, rotation, activity, accretion; [Fe/H], a few [X/Fe] (Ca, Ti, Mg at least)

Survey data products/errors

- Reduced, 1D, λ calibrated, **spectra**
- **RVs:** 0.1-1 km/s for cool stars;
  3-5 km/s for hot stars
- **Rotation:** 10 %
- $T_{\mathbf{eff}}$**:** 50-200 K; $\log g$**:** 0.15-0.3 dex
- **[Fe/H], [X/Fe]:** ~0.1 (UVES), ~0.2 (Giraffe)
- **Average** [Fe/H], [X/Fe] for the **clusters**
  better than 0.03 dex
- Semester, annual, and final data releases

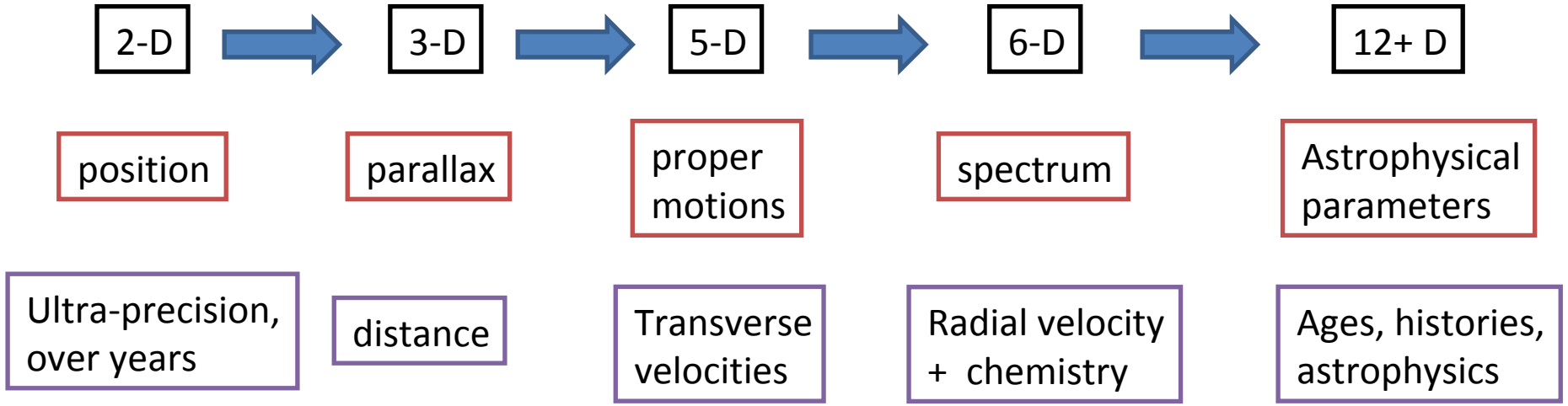
CORE SCIENCE

The formation and evolution of the Milky Way and its component stars and stellar populations

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

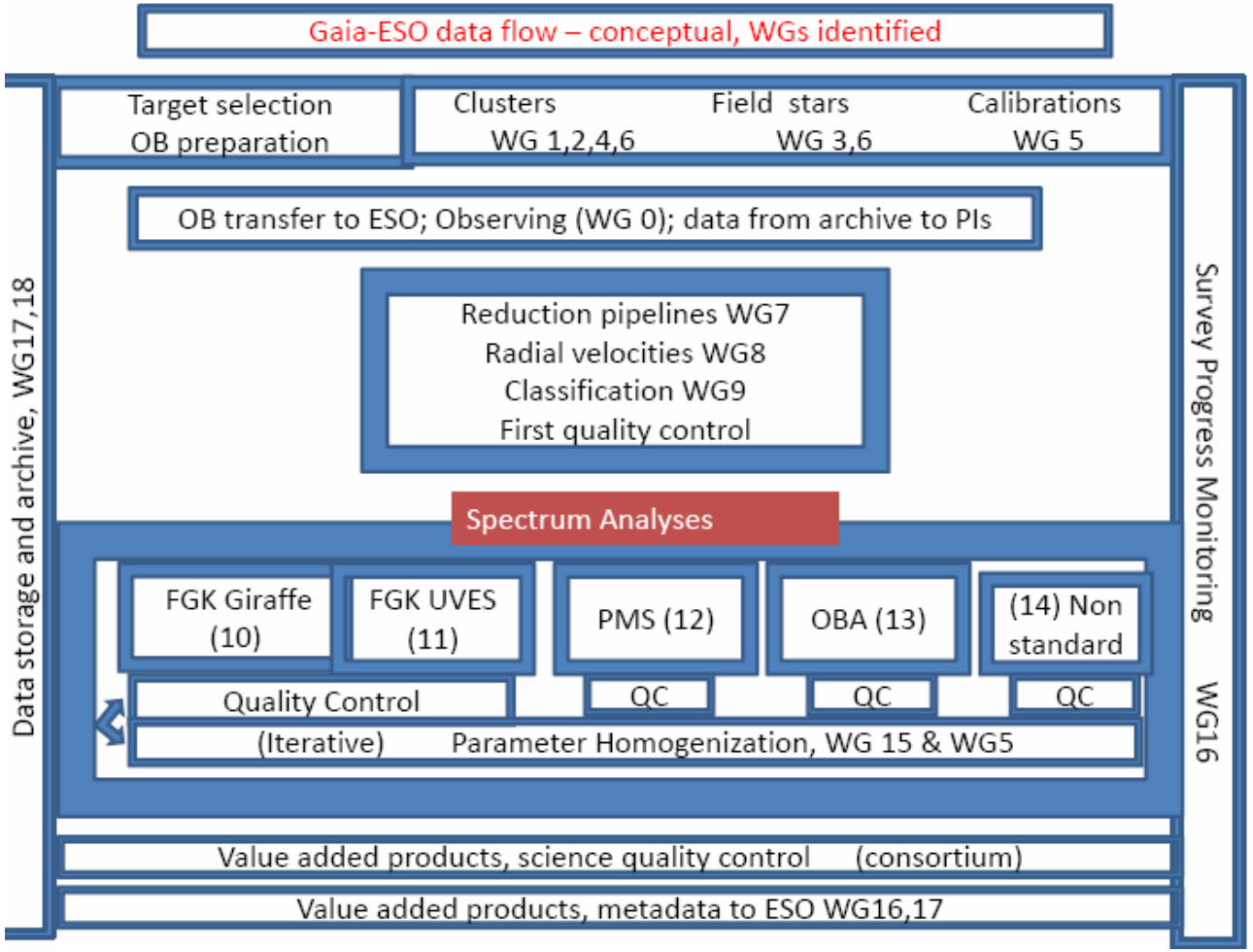
Complementarity with Gaia

First *Gaia* data releases in 2016, Just when Gaia-ESO finishes



Stellar orbits, Star formation histories, Origin of the elements, Galaxy assembly,....
Dark Matter, Cosmological initial conditions, etc

Data flow & survey management



Steering Group

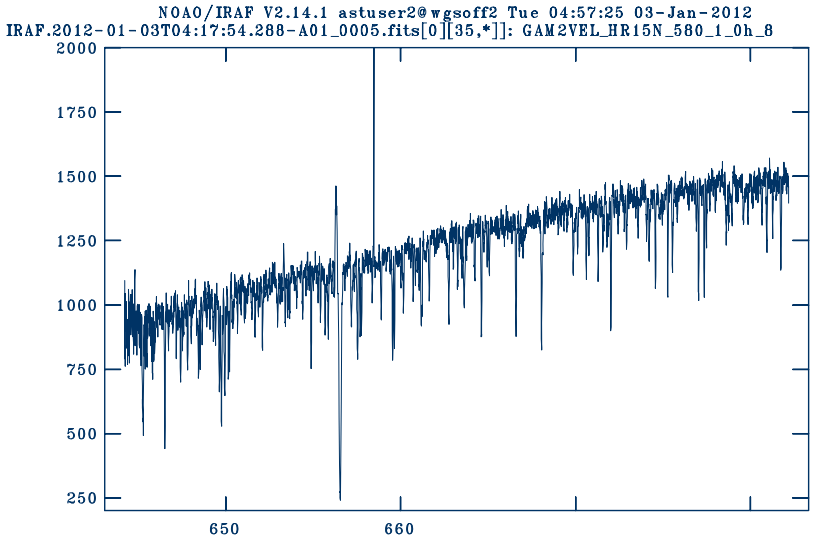
Gerry Gilmore & Sofia Randich

M. Asplund (A)
J. Binney (UK)
P. Bonifacio (F)
J. Drew (UK)
S. Feltzing (S)
A. Ferguson (UK)
R. Jeffries (UK)
G. Micela (I)
I. Negueruela (Sp)
T. Prusti (ESA)
H.-W. Rix (D)
A. Vallenari (I)

First light
Dec. 31 2011-Jan 5 2012

- Young cluster γ Vel
- Outer disc

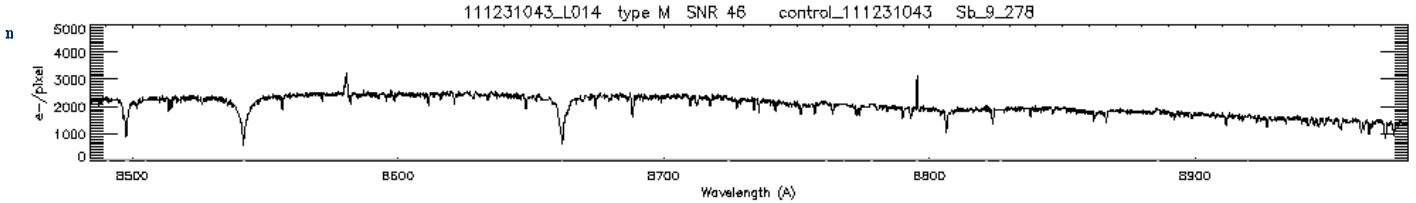
First spectra -Giraffe

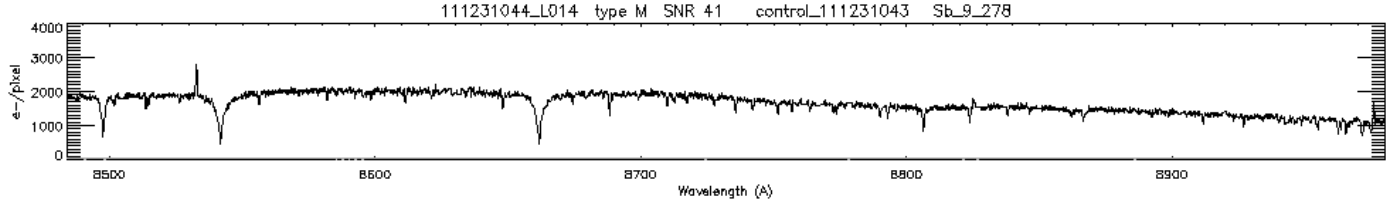


Gamma 2 Vel member

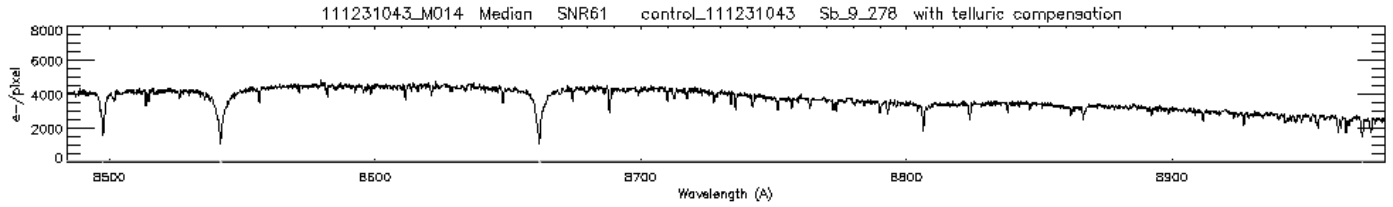
MW outer disc target

HR15N

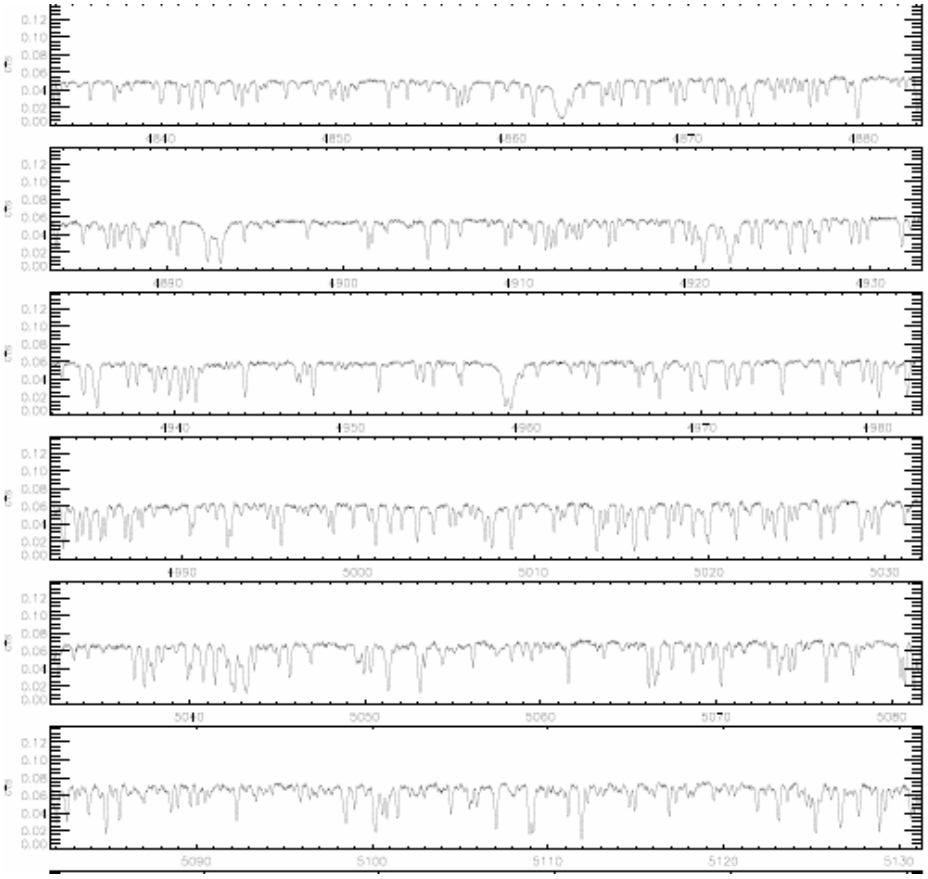




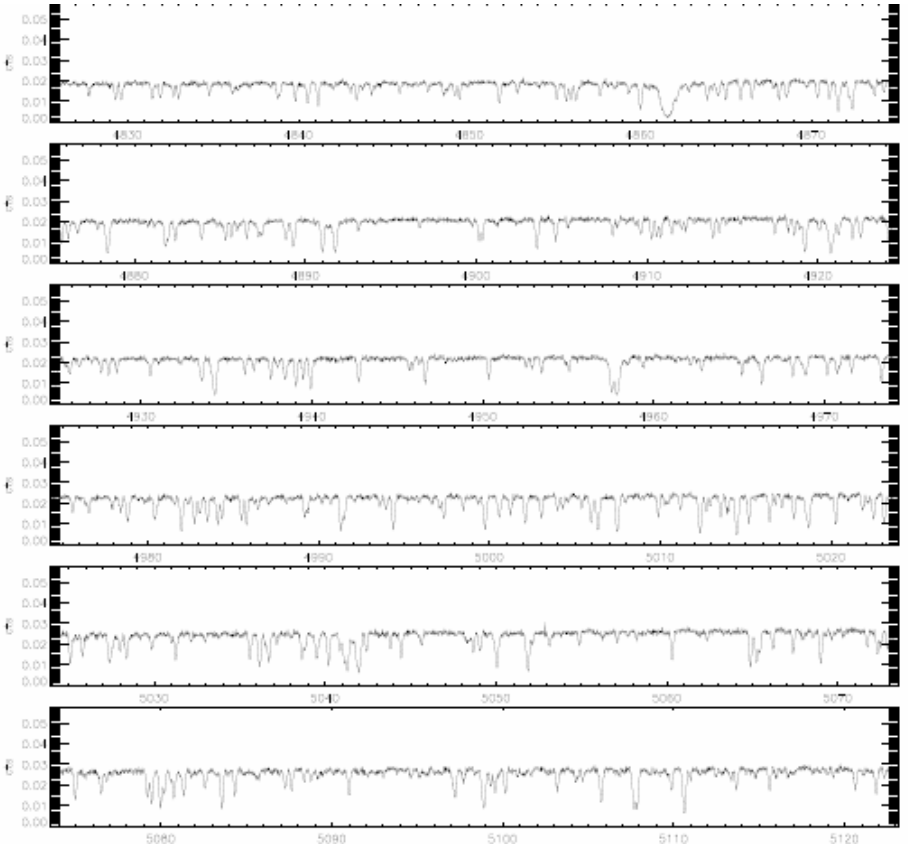
HR21



First spectra - UVES



Gamma 2 Vel member



MW targets

Beyond GES

- Systematic coverage of stars with $V > 17$

(selected targets, selected regions on the sky)

- Stars fainter than $V \sim 19$ (wrt $G = 20$, Gaia limit)
- Northern Sky

  (limited to $\delta < +20$)
- Follow-up of e.g. new cluster members or of

  Gaia detected/identified objects

THANK YOU!