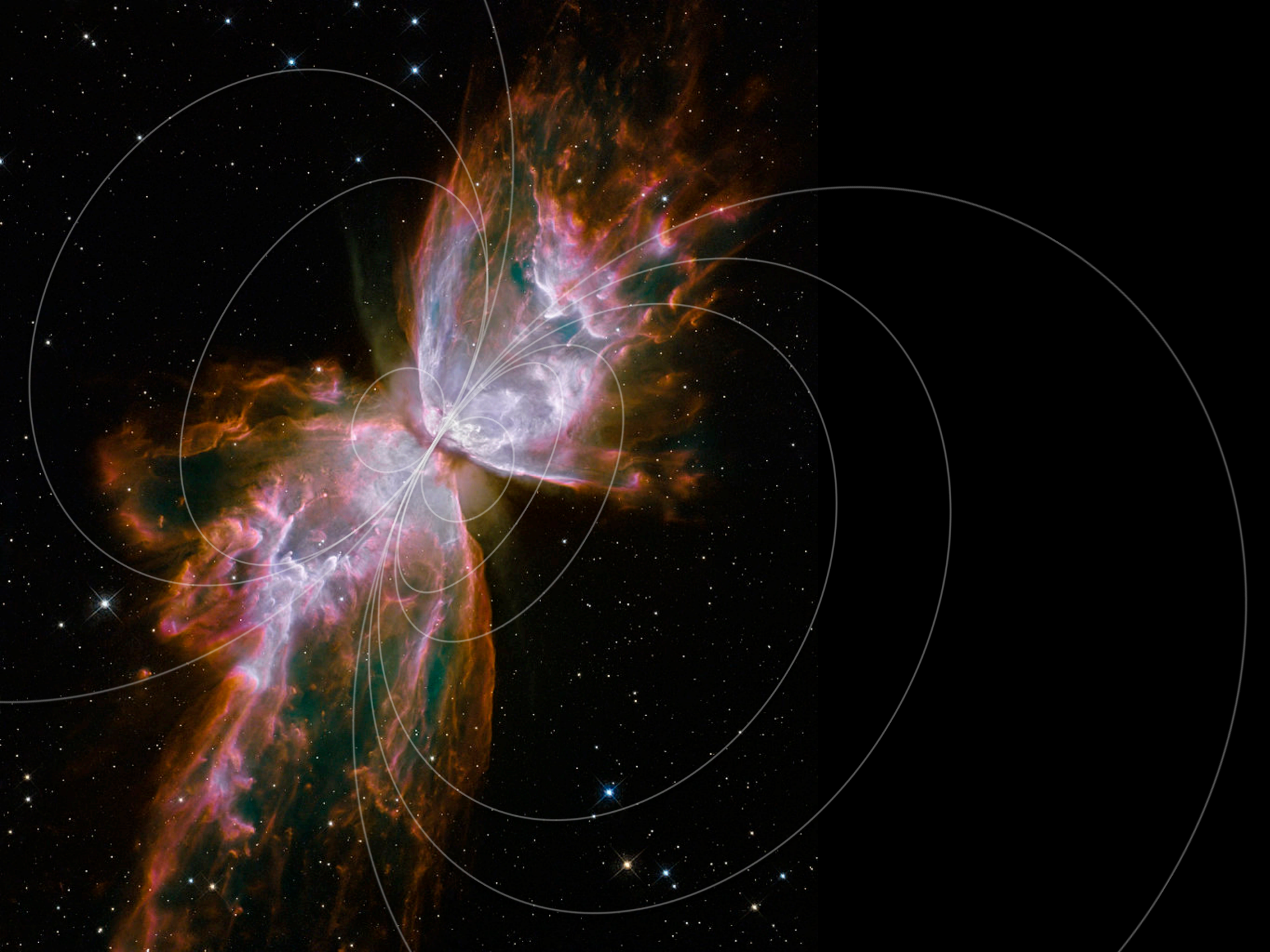
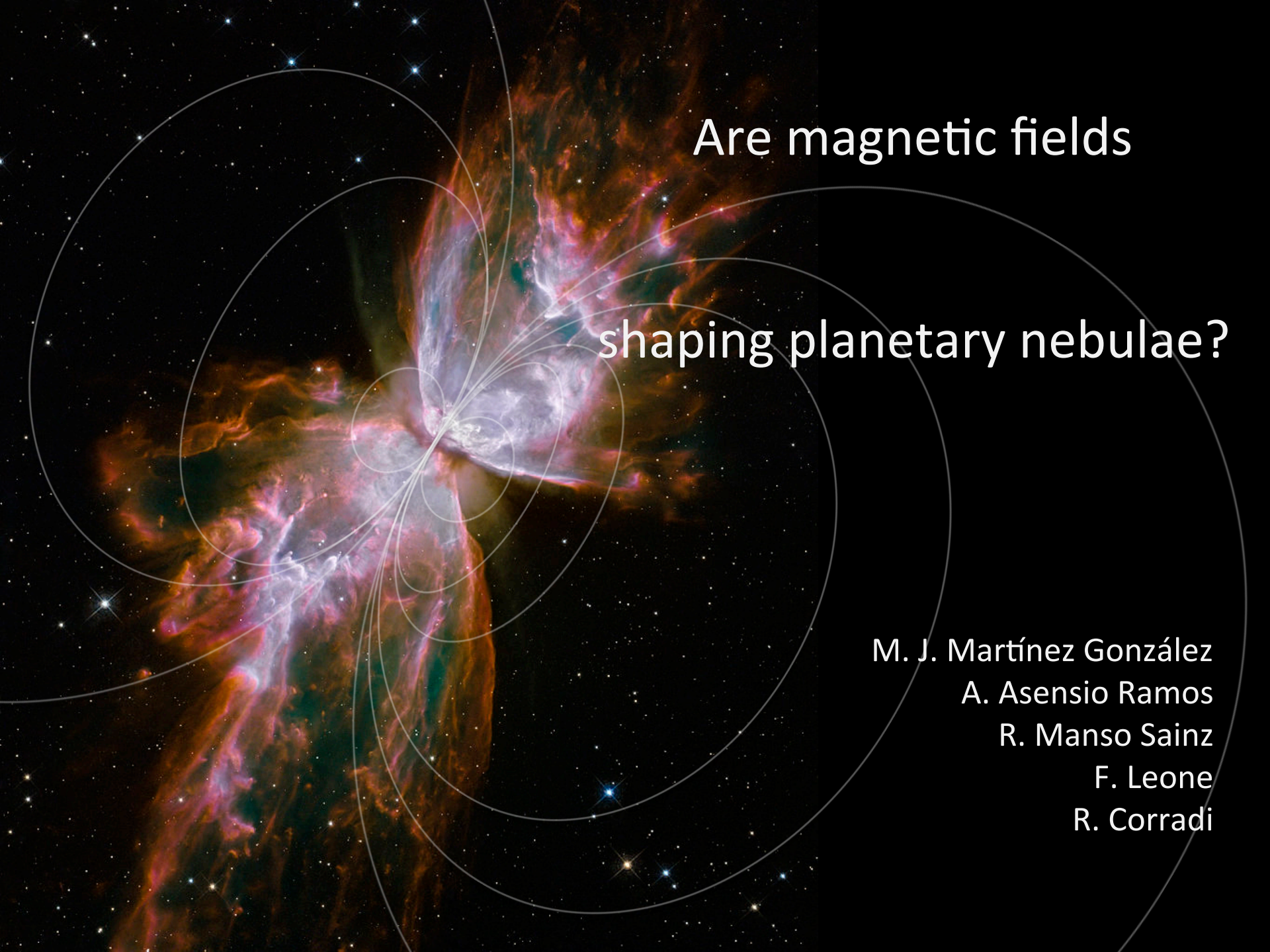




Are magnetic fields shaping planetary nebulae?

M. J. Martínez González
A. Asensio Ramos
R. Manso Sainz
F. Leone
R. Corradi

Spectro-polarimetry of the central star

- Very faint objects (brighter targets have B≈10)
- Hot stars (few and broad spectral lines)
- Intensity contaminated by the nebula emission

→ We expect very faint signals if magnetic fields are present in the stellar atmosphere

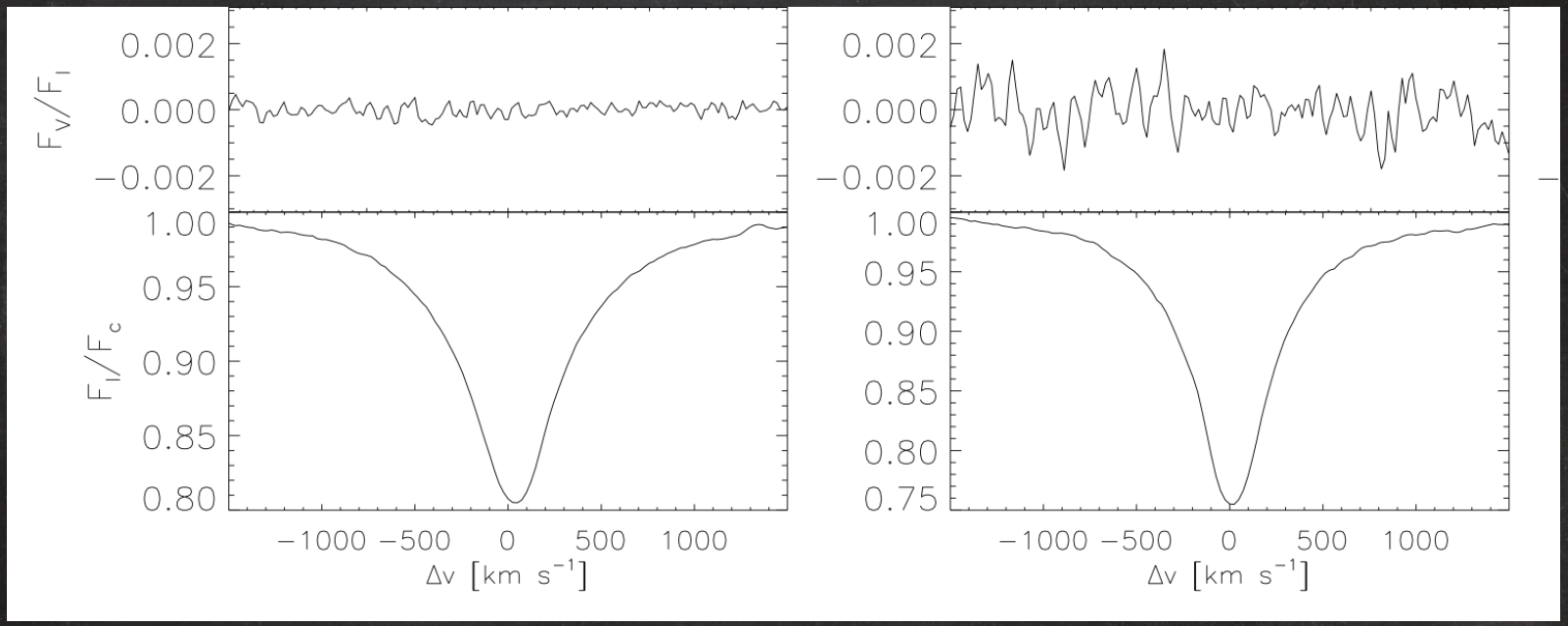
→ Large telescopes and low spectral resolution (also decreases the polarization signal!). Only Stokes V. $T_{int} \approx 1h$.

First claim by Jordan et al. (2005) of kG fields in the CSPN was incorrect

Spectro-polarimetry of the central star

NGC 1360

LSS 1362



Leone et al. (2011)

FORS2@VLT

Spectro-polarimetry of the central star

$$F_V = -KB\mu \frac{\partial F_I}{\partial \lambda}$$

We model the transfer of polarised light in the weak field approximation.

If there is no CLV:

$K = 4.67 \times 10^{-13} \lambda_0^2 \overline{g}$ G^{-1} B cte in the surface

$K = 1.17 \times 10^{-13} \lambda_0^2 \overline{g}$ G^{-1} Dipolar field

Spectro-polarimetry of the central star

Longitudinal magnetic field using a Least-Squares minimisation

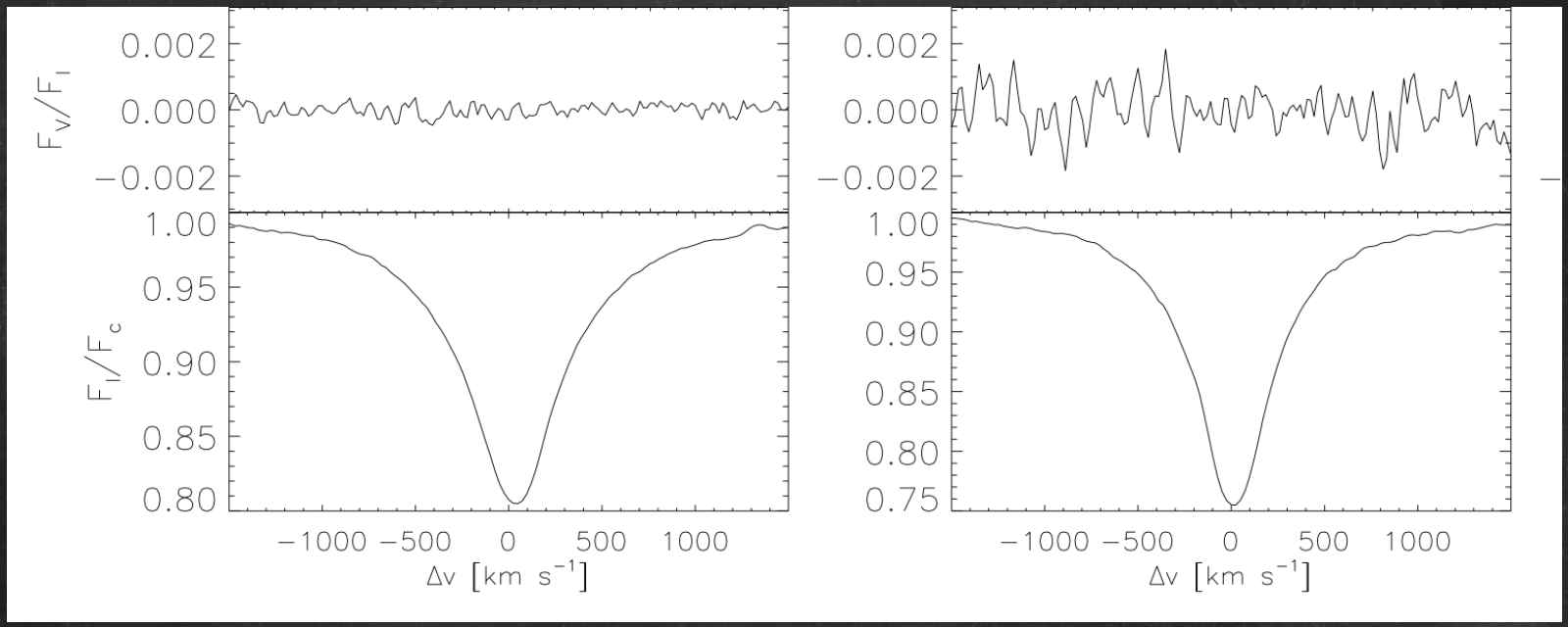
$$B_{\|} = -\frac{1}{K}\frac{\sum_{i=1}^{N_l}\sum_{j=1}^{N_\lambda} F_V^i(\lambda_j)\dfrac{\partial F_I^i(\lambda_j)}{\partial \lambda_j}}{\sum_{i=1}^{N_l}\sum_{j=1}^{N_\lambda}\left(\dfrac{\partial F_I^i(\lambda_j)}{\partial \lambda_j}\right)^2}$$

$$\delta B_{\|} = \pm\frac{\sigma}{K\sqrt{\sum_{i=1}^{N_l}\sum_{j=1}^{N_\lambda}\left(\dfrac{\partial F_I^i(\lambda_j)}{\partial \lambda_j}\right)^2}}$$

Spectro-polarimetry of the central star

NGC 1360

LSS 1362

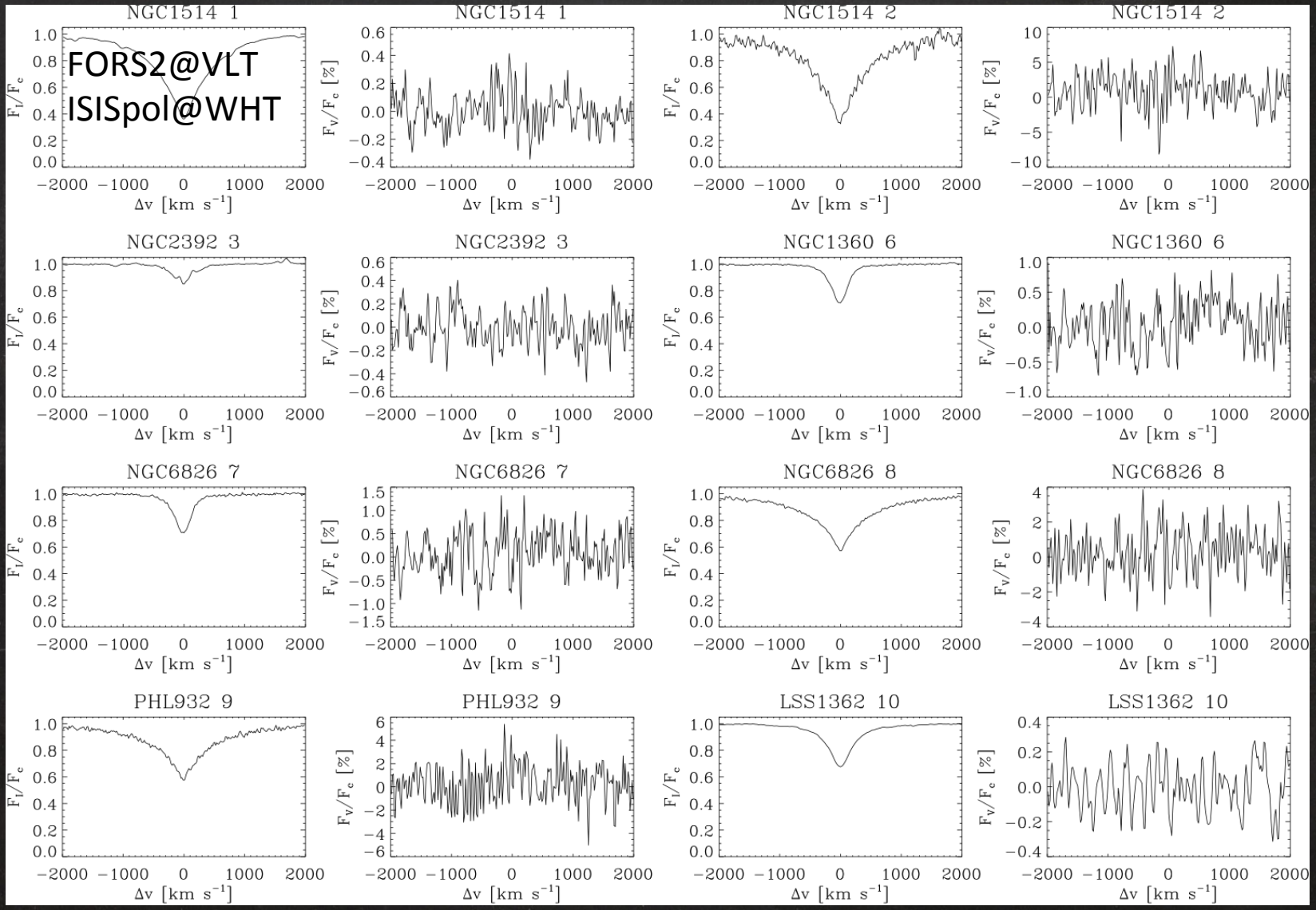


Leone et al. (2011)

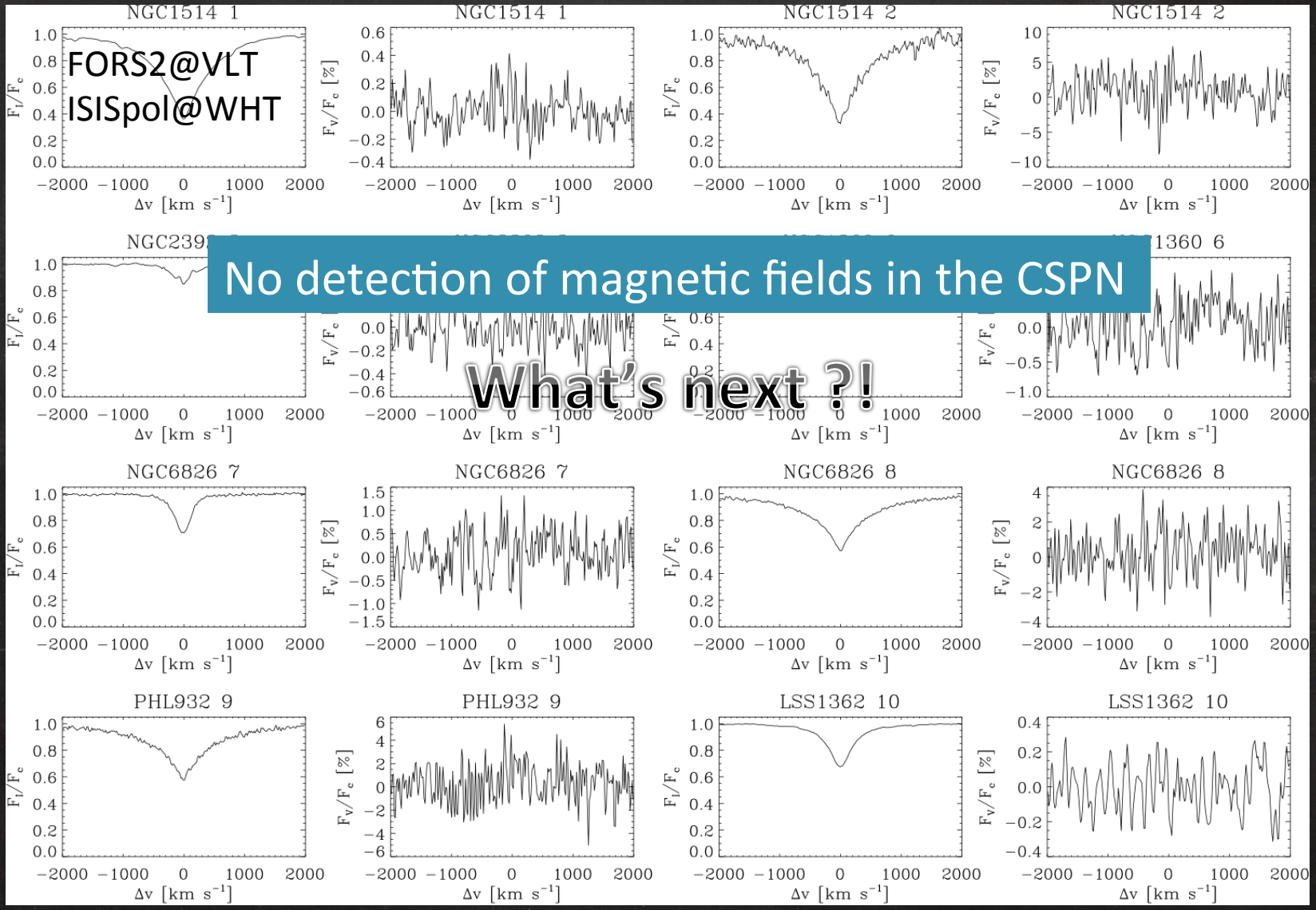
154 ± 113 G

337 ± 286 G

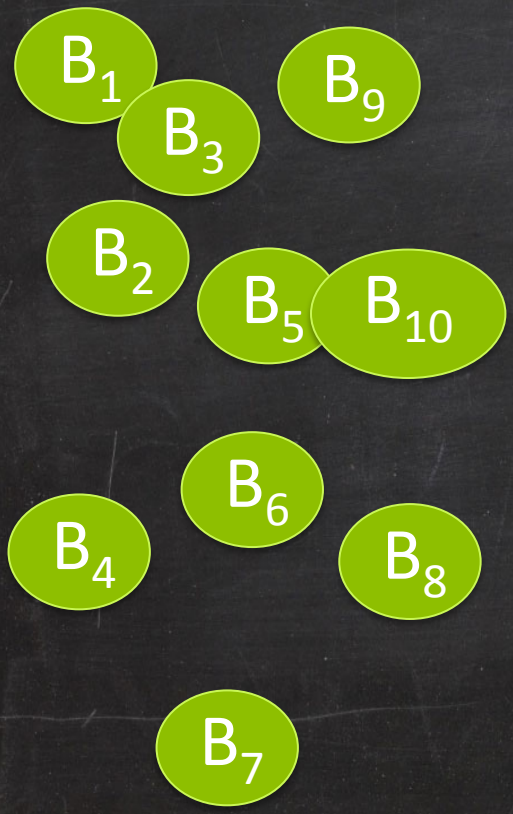
Spectro-polarimetry of the central star

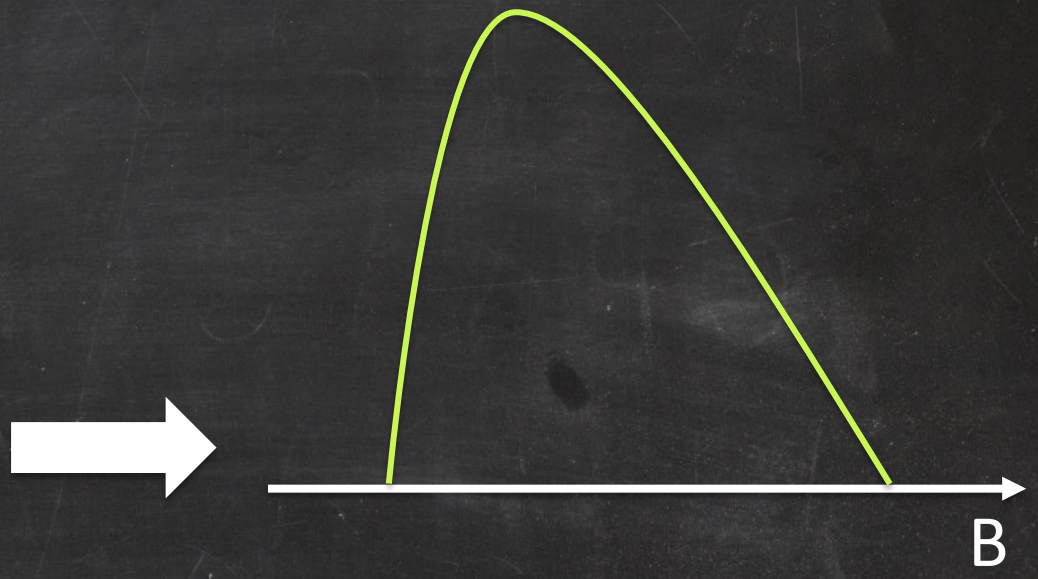


Spectro-polarimetry of the central star



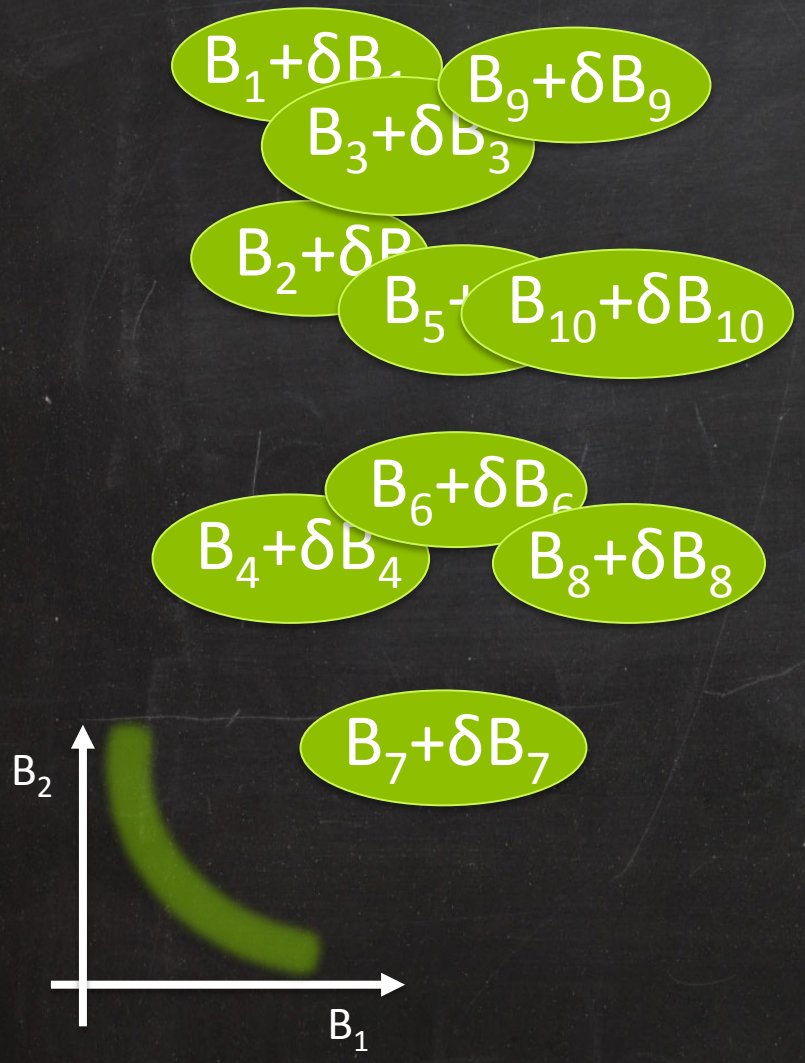
Imagine we can measure a quantity B_i without error





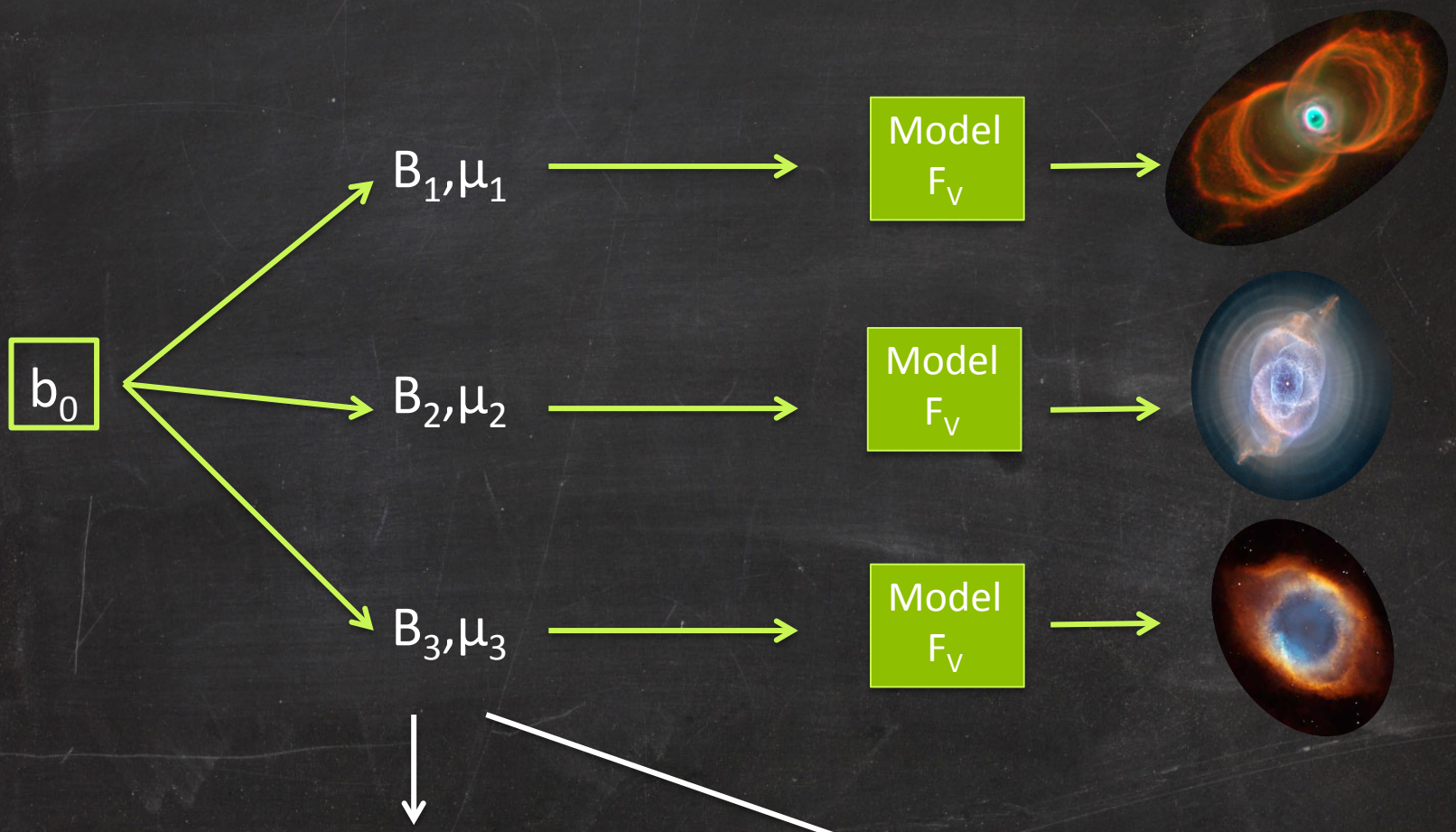
The PDF of B is given by the histogram (counting events)

In our case, we infer a quantity B_i with errors and degeneracies



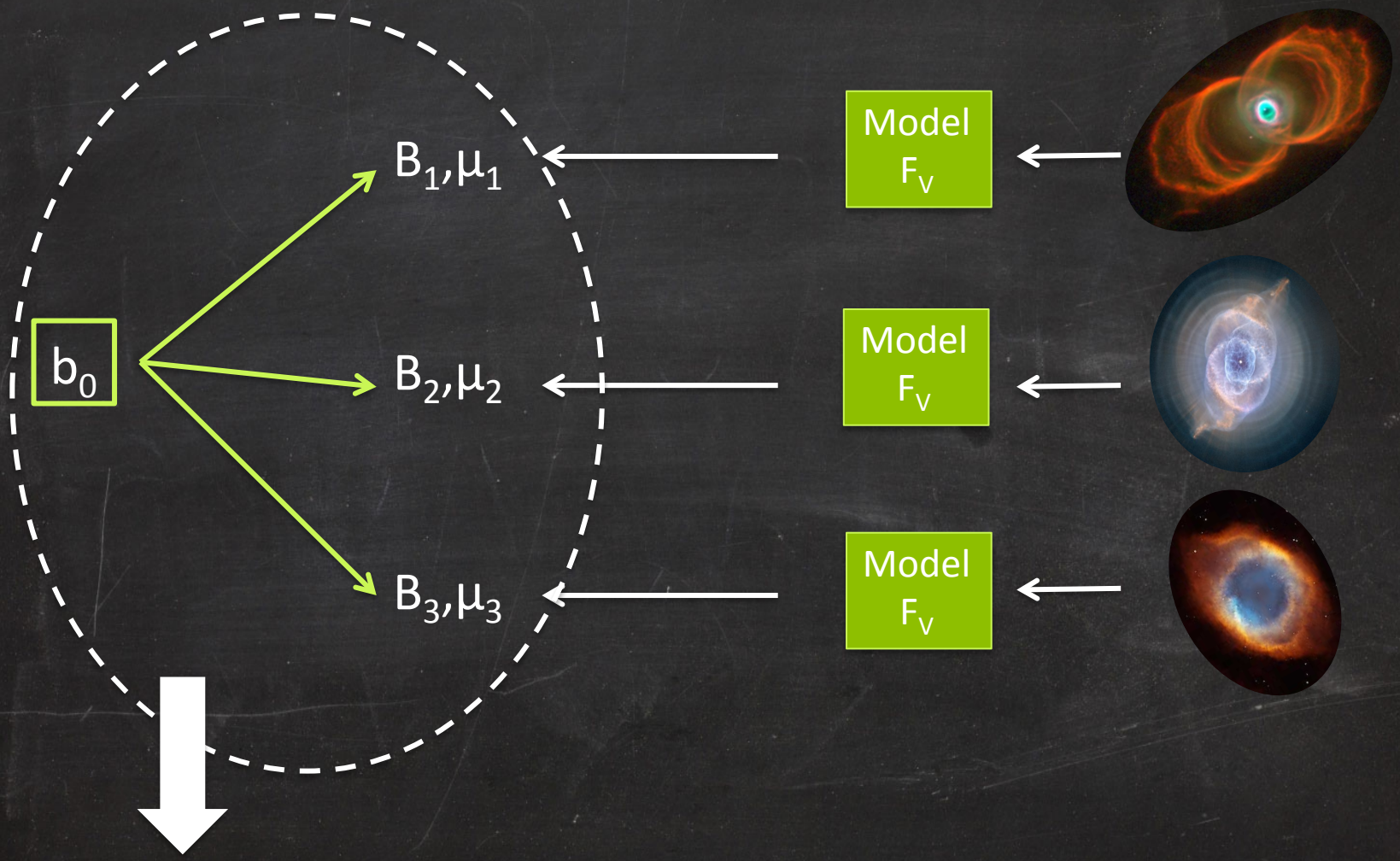
How to build the PDF ???

Bayesian formalism



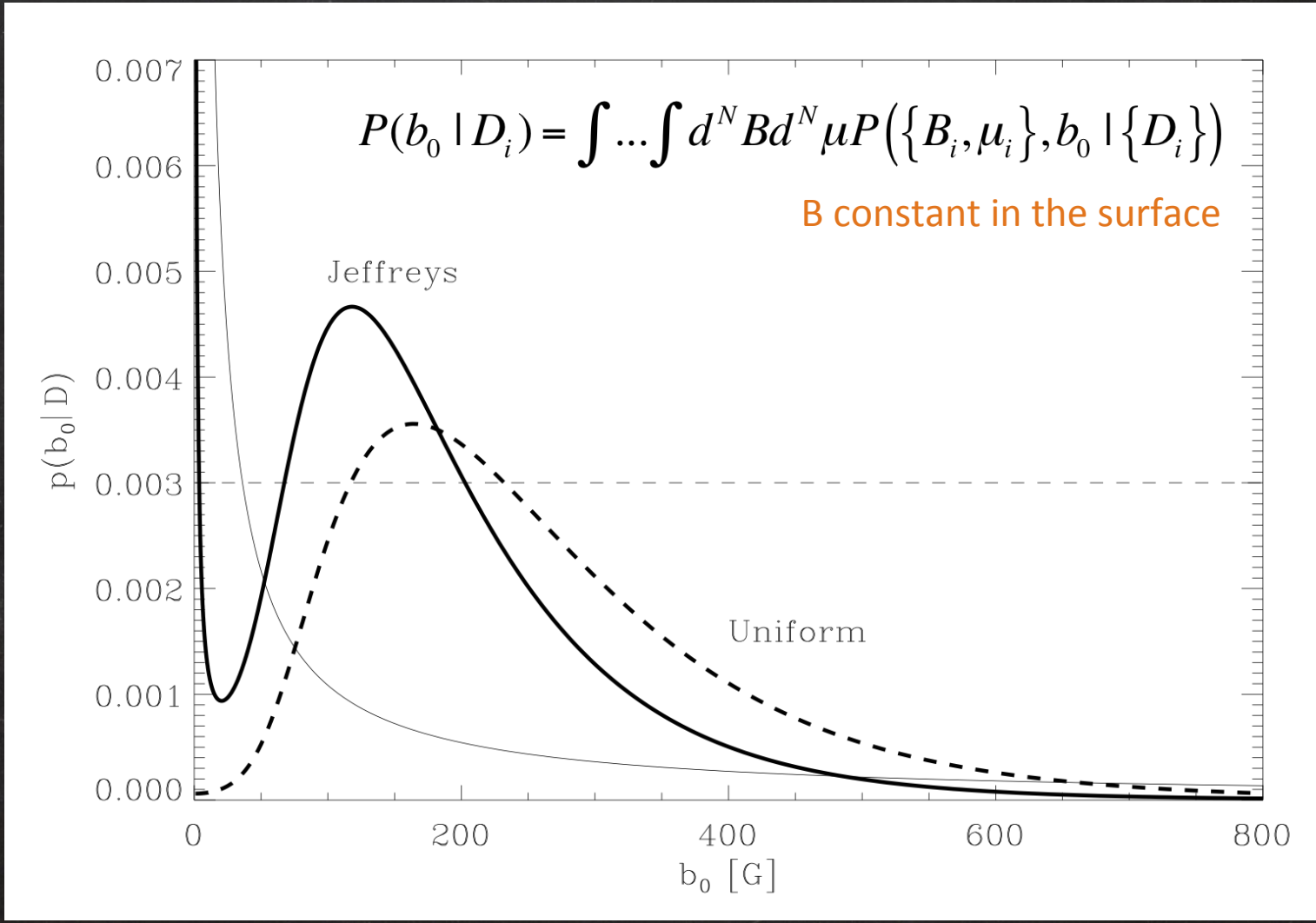
$$P(B_i \mid b_0) = \sqrt{\frac{2}{\pi}} \frac{B_i^2}{b_0^3} \exp\left[-\frac{B_i^2}{2b_0^2}\right] \qquad P(\mu_i) = 1$$

Bayesian formalism

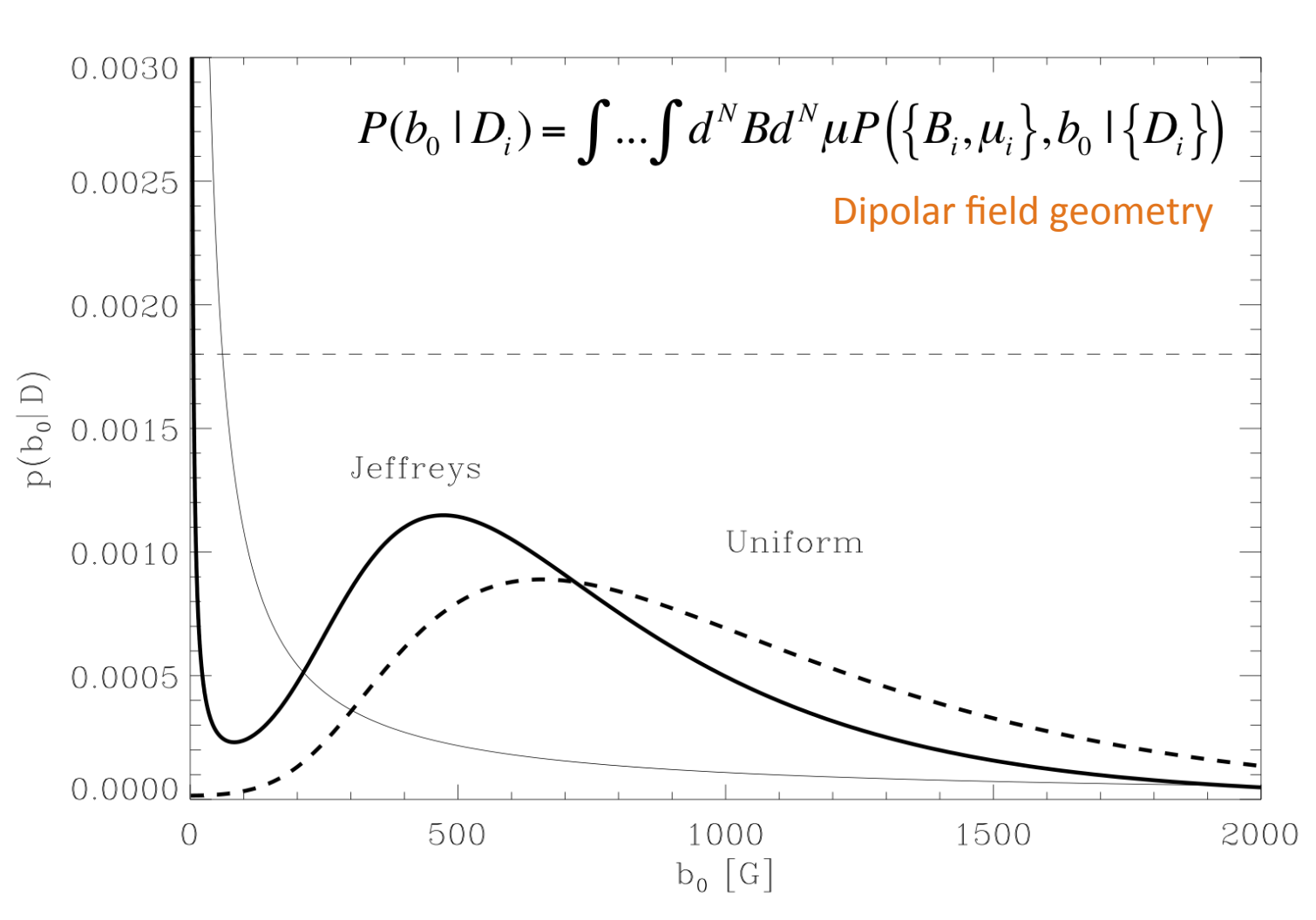


$P(B_1,B_2,\ldots,B_N,\mu_1,\mu_2,\ldots,\mu_N,b_0|D_1,D_2,\ldots,D_M)$

Bayesian formalism



Bayesian formalism



Conclusions

Until today, there is no direct detection of a magnetic field in the CSPN
At a polarimetric sensitivity of 0.01%

Using all the observations, we can constrain the probability density function of the magnetic field at the CSPN.
They are below 200 G or 500 G (dipolar case) with a 63% probability
They are below 1400 G or 3500 G (dipolar case) with a 95% probability

While we search for a definite detection, the new observations will serve to update the PDF(b_0).