Analysis of Fermi LAT data

Likelihood tutorial

Rodrigo Nemmen
IAG USP

May 24, 25 2017
High energy school @ IAG USP

Overview of activities

Day 1

- Introduction, overview
- Obtaining and exploring LAT data
- Inspecting the data: count map

Day 2

- **Basics of modeling**
- Likelihood analysis of a blazar
- Create a SED
- Produce a light curve

Structure of this talk

- **Basic theory of likelihood analysis**
- ⌨: Likelihood fit → Characterize spectra of a source
- ⌨: obtain spectral energy distribution
- ⌨: build a light curve

Fundamental questions of science

~~statistics~~

Model fitting: given this model, what parameters best fit my data?

Model selection: given two potential models, which better describes my data?

Maximum likelihood approach

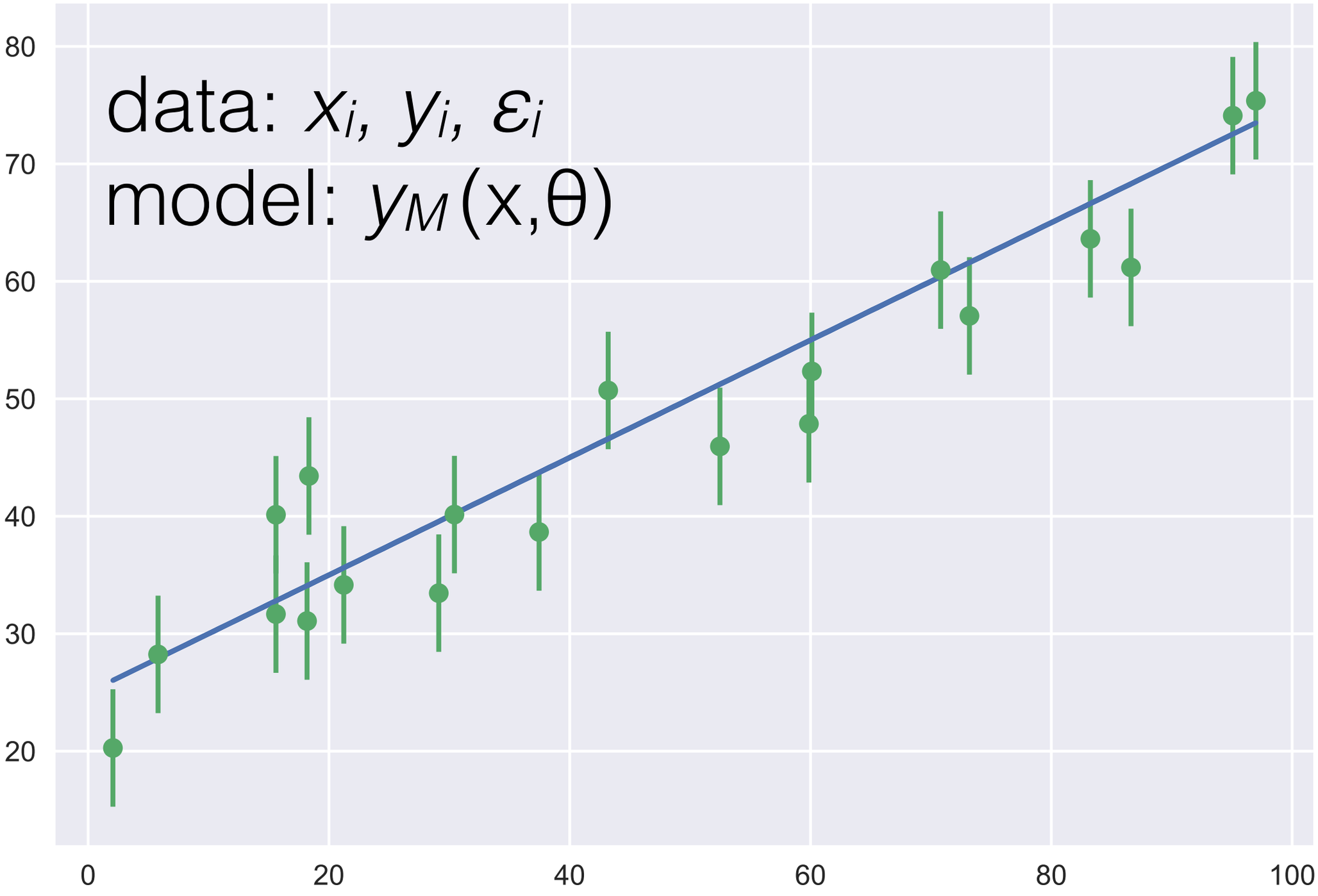
Frequentist

$$P(data \mid scientific\ model)$$

$$P(D \mid \theta)$$

likelihood

How to write the likelihood function for the problem below?



Probability for a single measurement

$$P_i = \frac{1}{\sqrt{2\pi\epsilon_i^2}} e^{-\frac{(y_i - y_M)^2}{2\epsilon_i^2}}$$

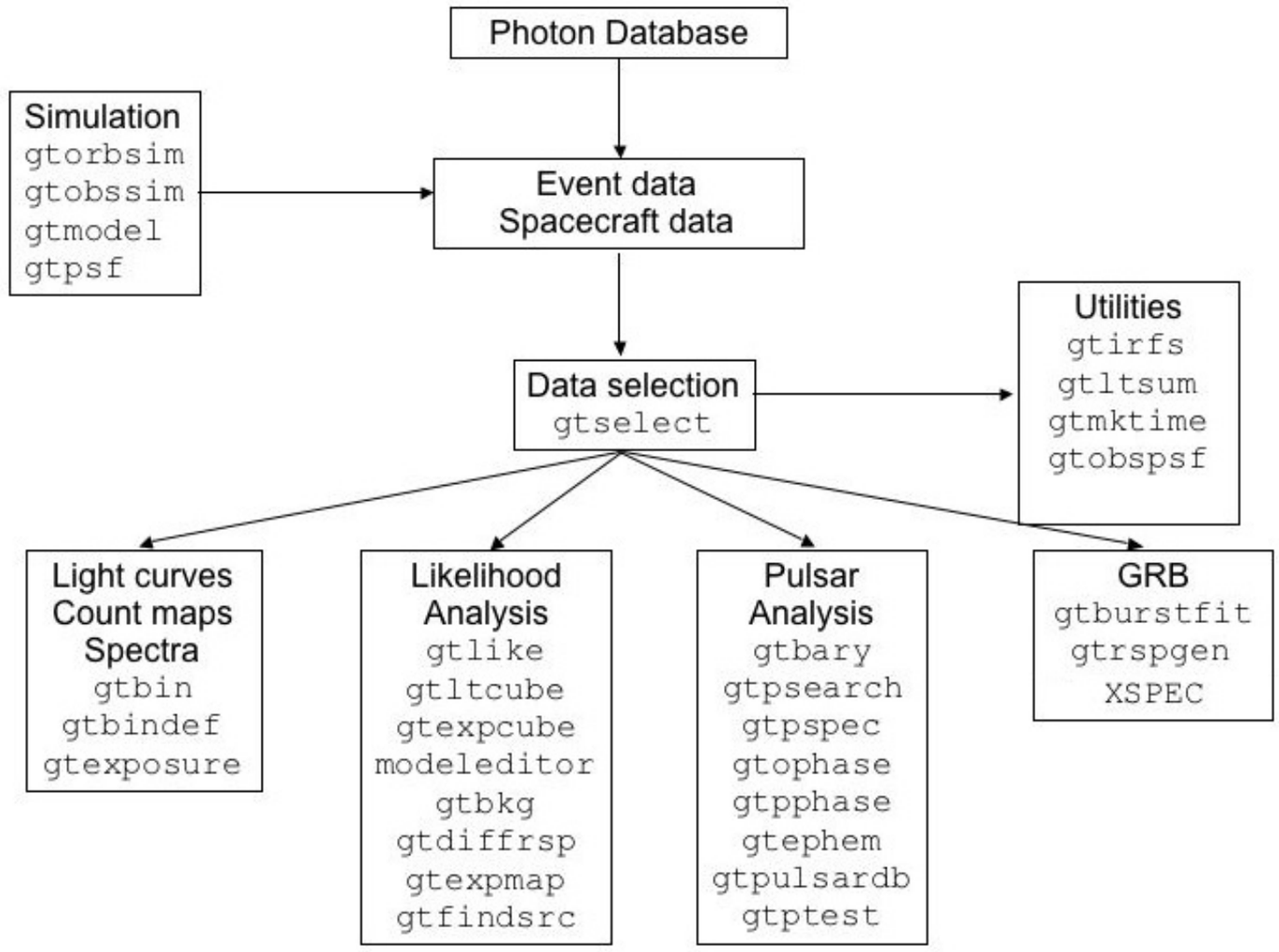
Likelihood: $$\mathcal{L} = \sum_i P_i = \sum_i \frac{1}{\sqrt{2\pi\epsilon_i^2}} e^{-\frac{(y_i - y_M)^2}{2\epsilon_i^2}}$$

What about Fermi LAT data?

write likelihood

then binned likelihood

unbanned likelihood


Photon Database
Simulation
gtorbsim
gtobssim
gtmodel
gtpsf
Event data
Spacecraft data
Data selection
gtselect
Utilities
gtirfs
gtltsum
gtmktime
gtobspsf
Light curves
Count maps
Spectra
gtbin
gtbindef
gtexposure
Likelihood
Analysis
gtlike
gtltcube
gtexpcube
modeleditor
gtbkg
gtdiffrsp
gtexpmap
gtfindsrc
Pulsar
Analysis
gtbary
gtpsearch
gtpspec
gtophase
gtpphase
gtephem
gtpulsardb
gtptest
GRB
gtburstfit
gtrspgen
XSPEC

you should go and study the jupiter notebook on your spare

	E-mail	rodrigo.nemmen@iag.usp.br
	Web	http://rodrigonemmen.com
	Twitter	@nemmen
	Github	rsnemmen
	Facebook	http://facebook.com/rodrigonemmen
	Bitbucket	nemmen
	Blog	http://astropython.blogspot.com
	figshare	http://bit.ly/2fax2cT

Director’s cut

(cf separate file)