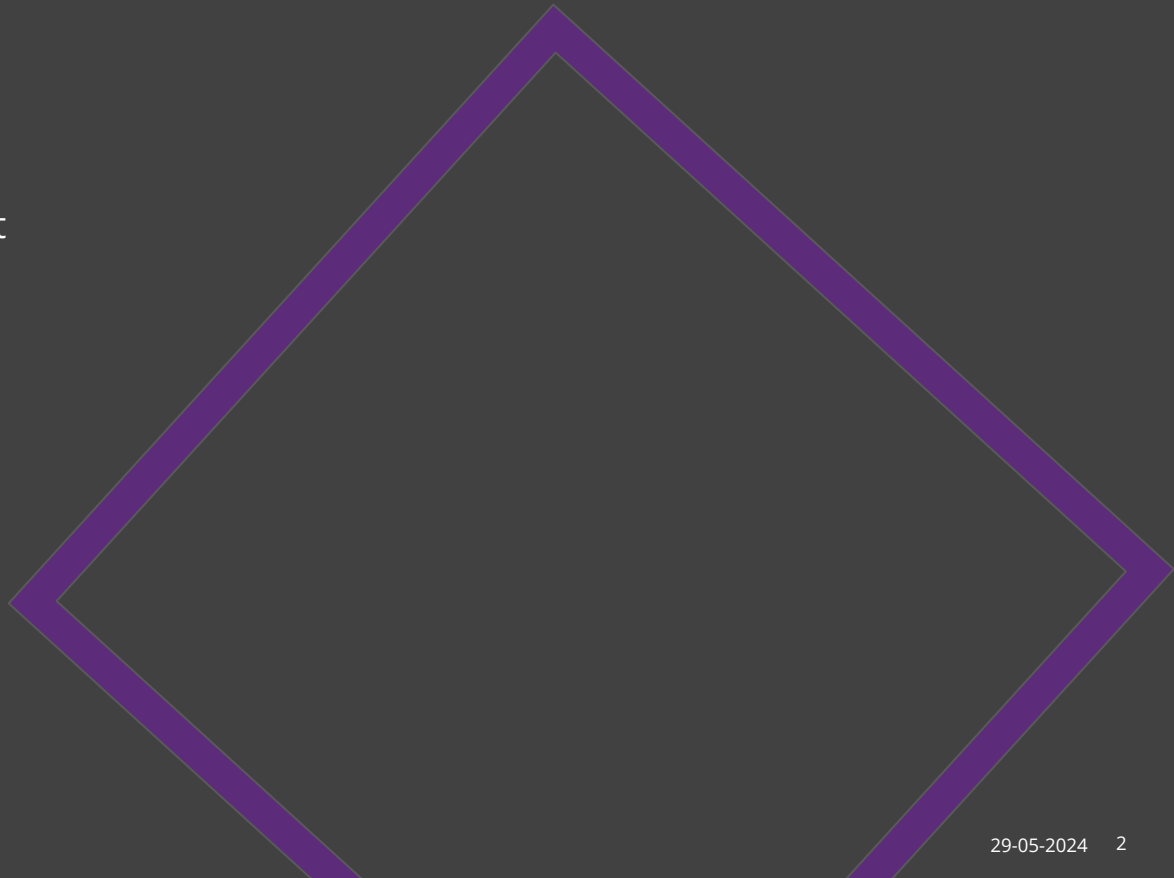
PNRR use cases talk

AL Thakur on behalf of the IAPS GW+GRB PNRR group[1]
29 May 2024

[1] L Natalucci, J Rodi, G Gianfagna, L Piro, A Luminari

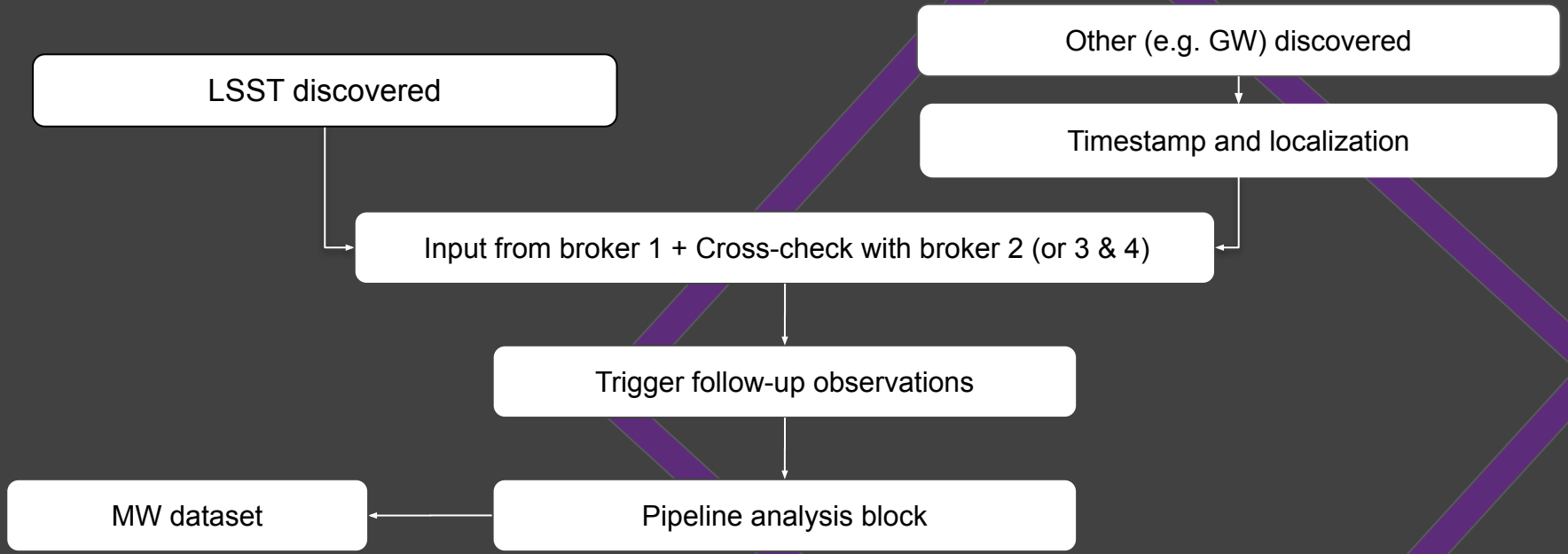
Outline of talk

- Use case 1:
  - Motivation
  - Decision tree and flowchart
  - Need for parallelisation
- Use case 2:
  - Motivation
  - Dataset
  - Need for parallelisation



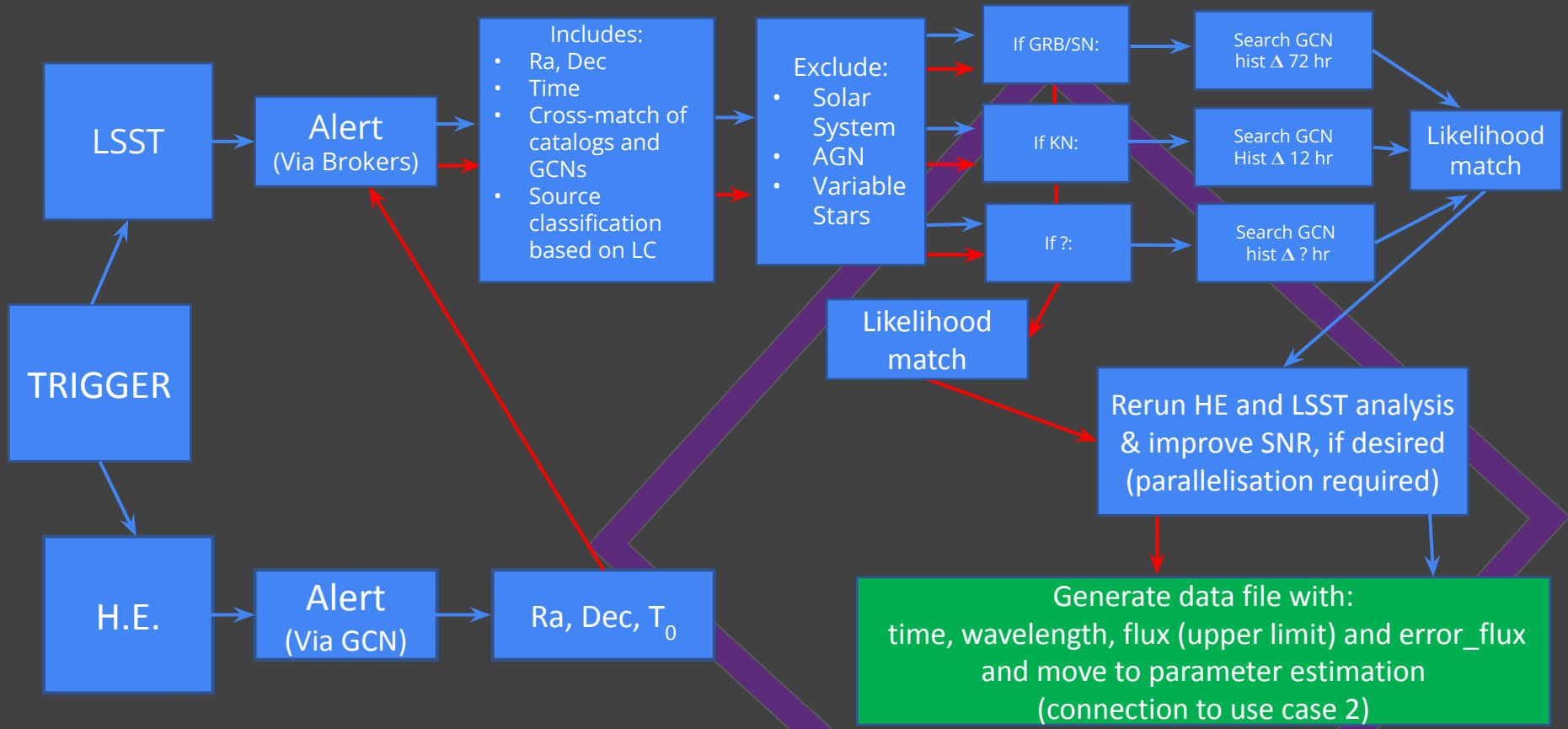
Use case 1: High-energy + LSST

Motivation: Joint monitoring of the high-energy and LSST data streams for common triggers



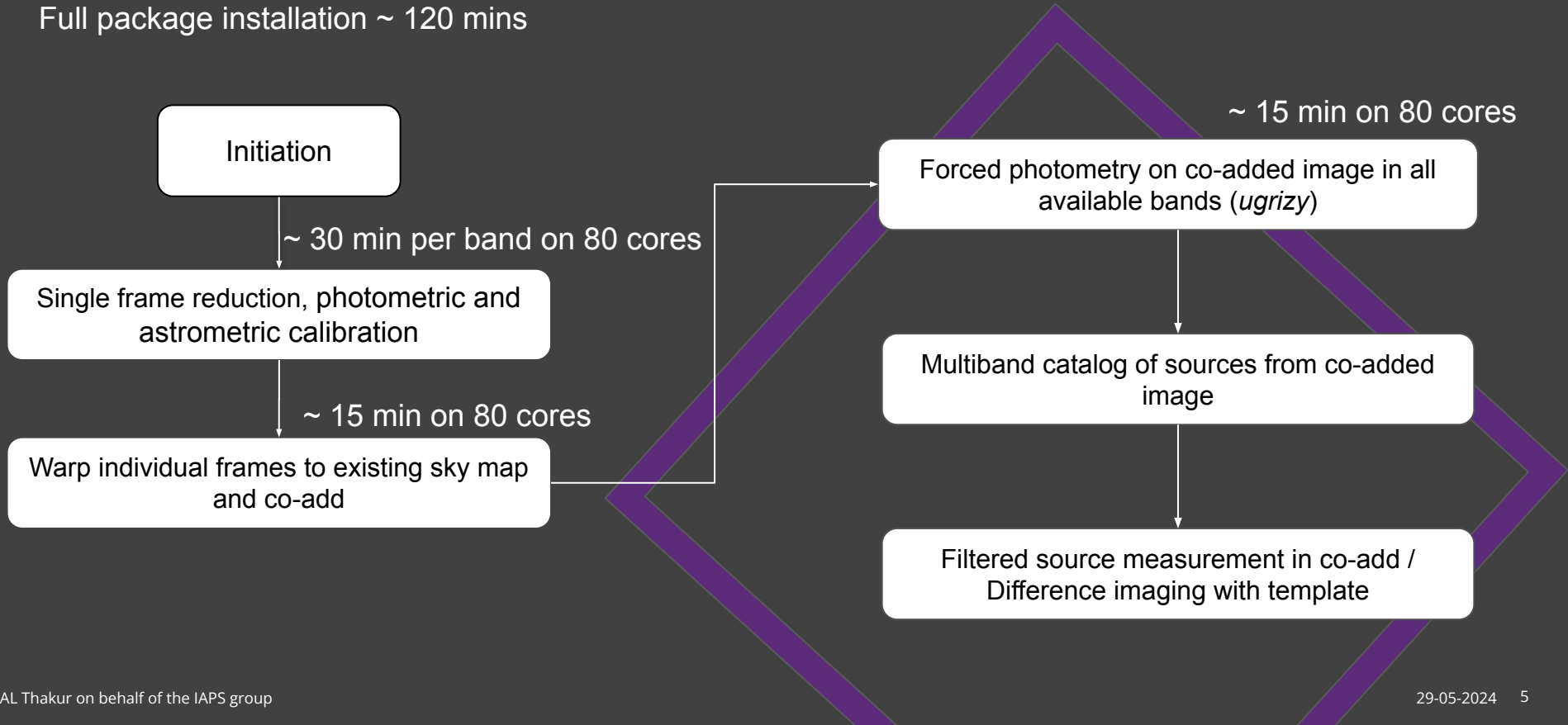
Use case 1: Decision tree

Thakur and Rodi



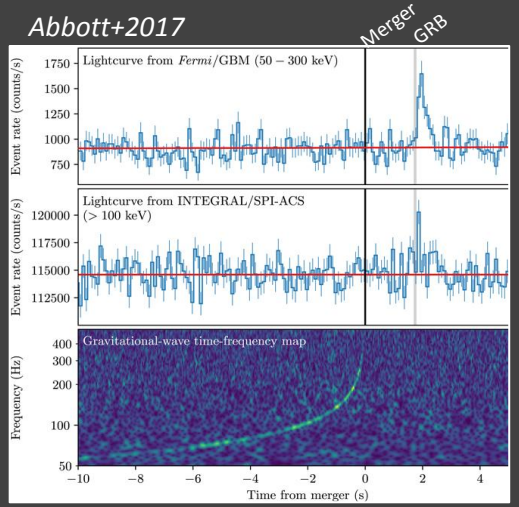
Use case 1: LSST Science Pipeline block (per frame)

Full package installation ~ 120 mins

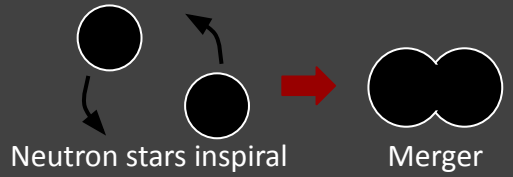


Use case 2: GW+EM modelling

Abbott+2017



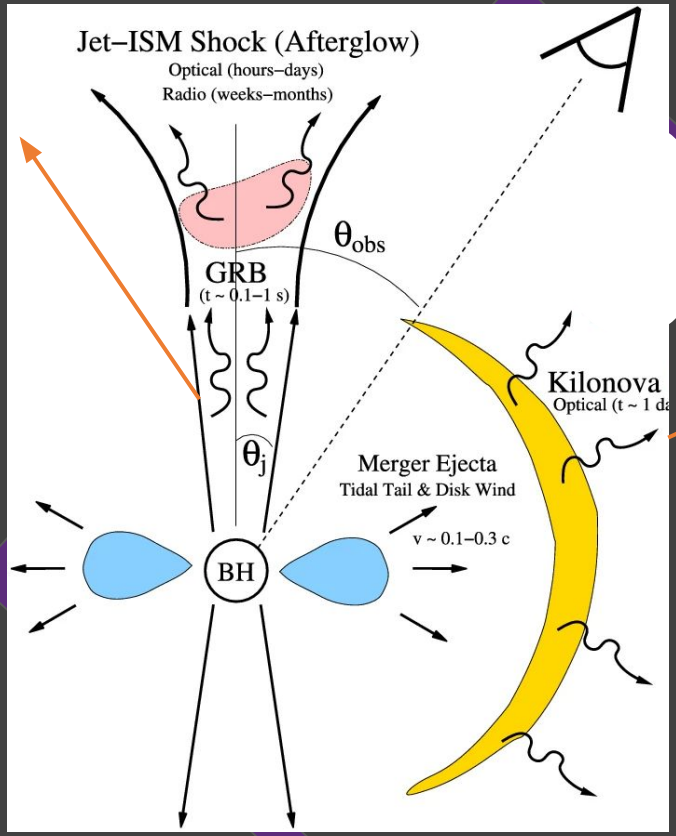
Gravitational wave



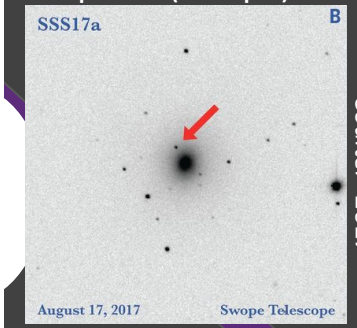
Neutron stars inspiral → Merger

GRB prompt emission

Metzger,Berger+2012



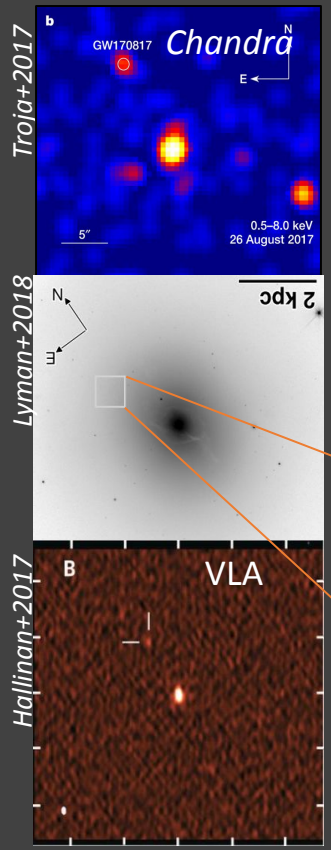
Optical (Swope)



Coulter+2017

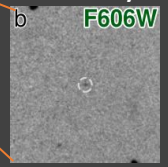
Kilonova
~11 hrs after the merger

Use case 2: GW+EM modelling



X-rays
9 days after the merger

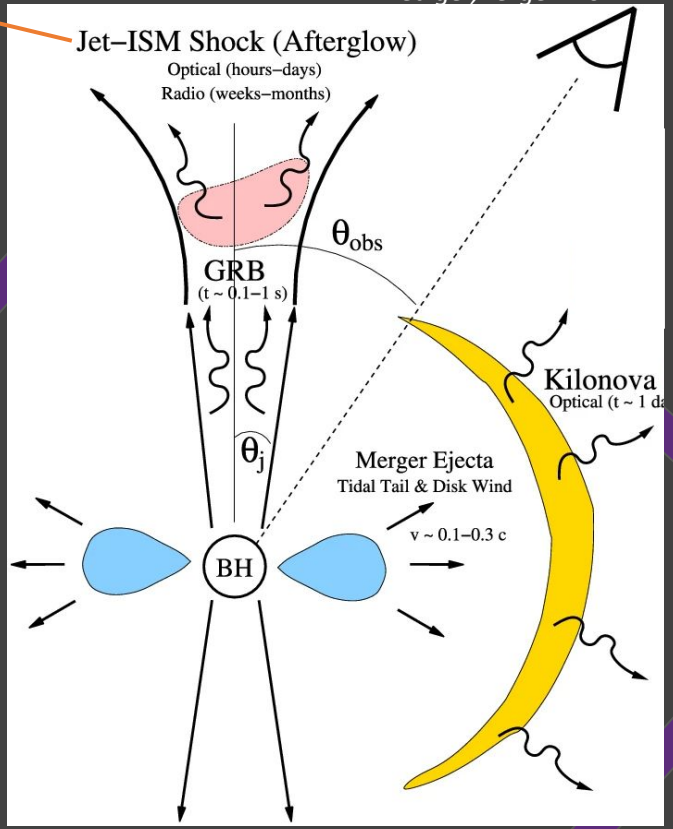
Optical
Visible when the kilonova started fading
~100 days after the merger



Radio
16 days after the merger

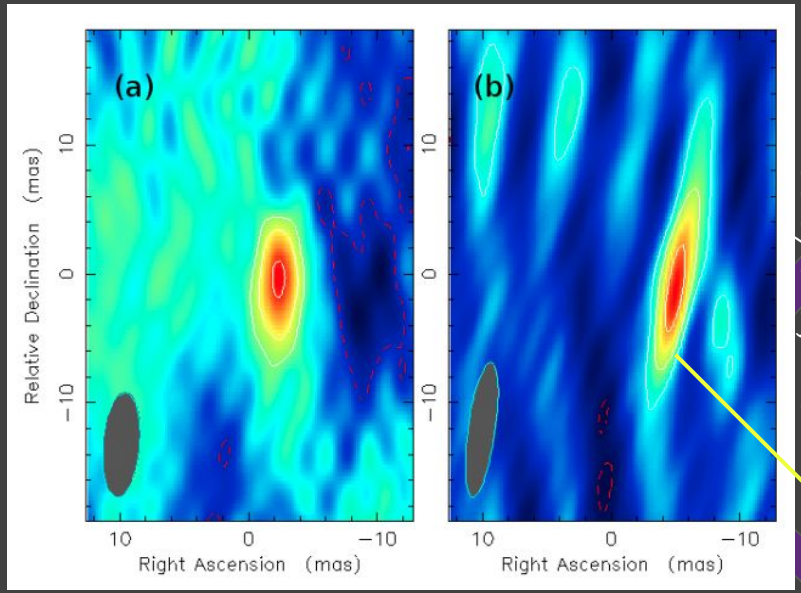
Afterglow

Metzger,Berger+2012



Use case 2: GW+EM modelling

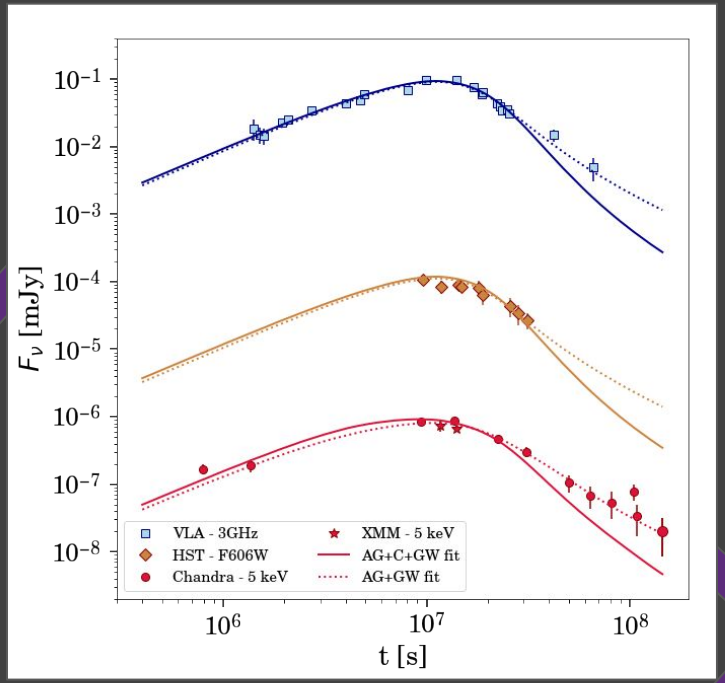
Centroid motion of the relativistic jet
Radio Observations taken with VLBI
@ 75, 206, 230 days



75 days 230 days

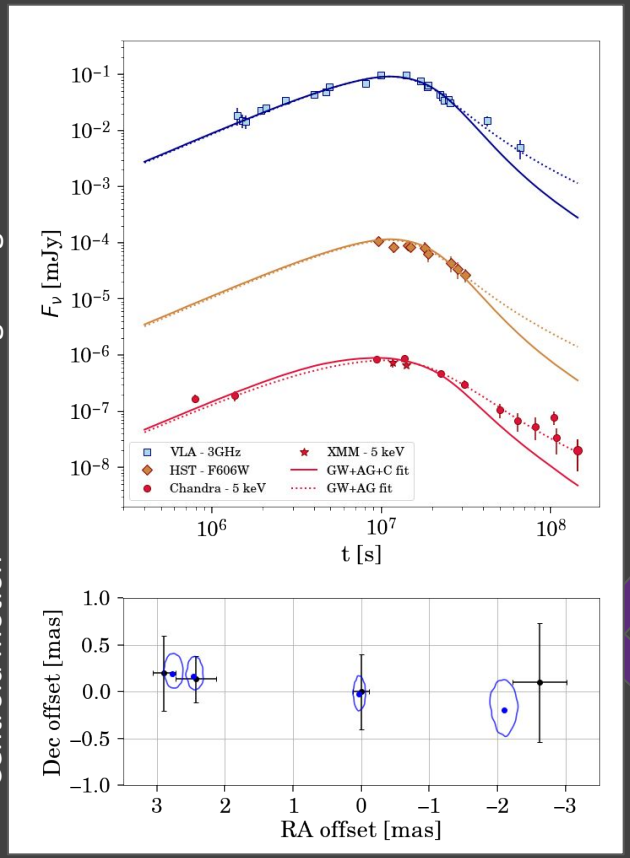
Mooley et al, 2018

movement of the order of mas



Afterglow light curve
Observations in X-rays, optical and radio bands

Use case 2: Analysis and need for parallelisation

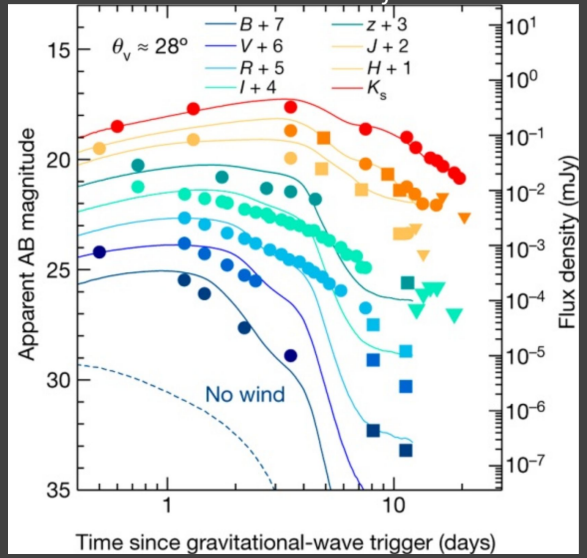


1. GW and afterglow (GW+AG):
   a. ~30 hour on 90 x 6 cores
2. GW, afterglow and centroid motion (GW+AG+C):
   a. 96 hour on 90 x 6 cores
3. **GW, afterglow and kilonova**
   a. **~96 hour on 90x6 cores***
4. **GW, afterglow, kilonova and centroid**
   a. **~400 hour on 90x6 cores***

Parameter	GW-only	GW + AG GJ	GW+AG + C GJ
$\log_{10}E_0$	–	$52.31^{+0.82}_{-0.80}$	$54.50^{+0.28}_{-0.33}$
θ_c [°]	–	$7.73^{+0.86}_{-0.80}$	$2.85^{+0.24}_{-0.20}$

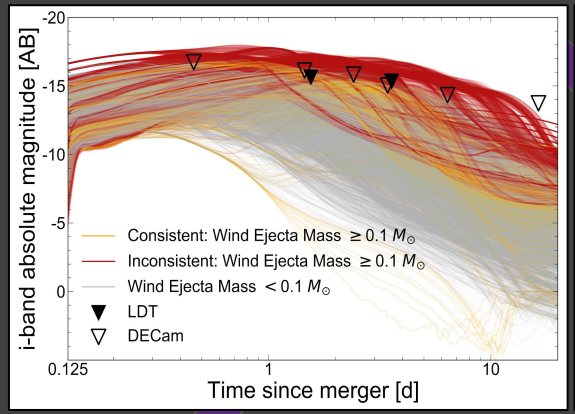
Use case 2: Next steps

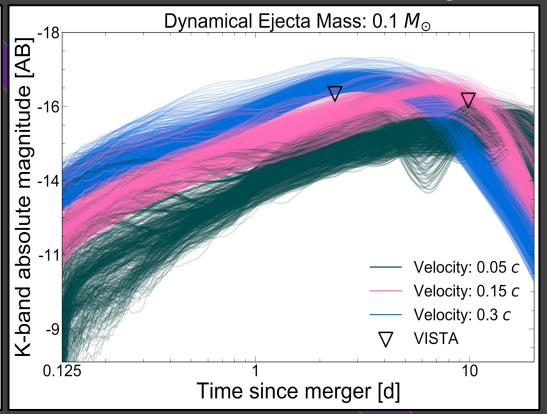
Troja+2017



- Incorporate kilonova dataset
  - Photometry
- Models tabulated for fixed parameters:
  - Ejecta mass, velocity
  - Composition
  - Morphology

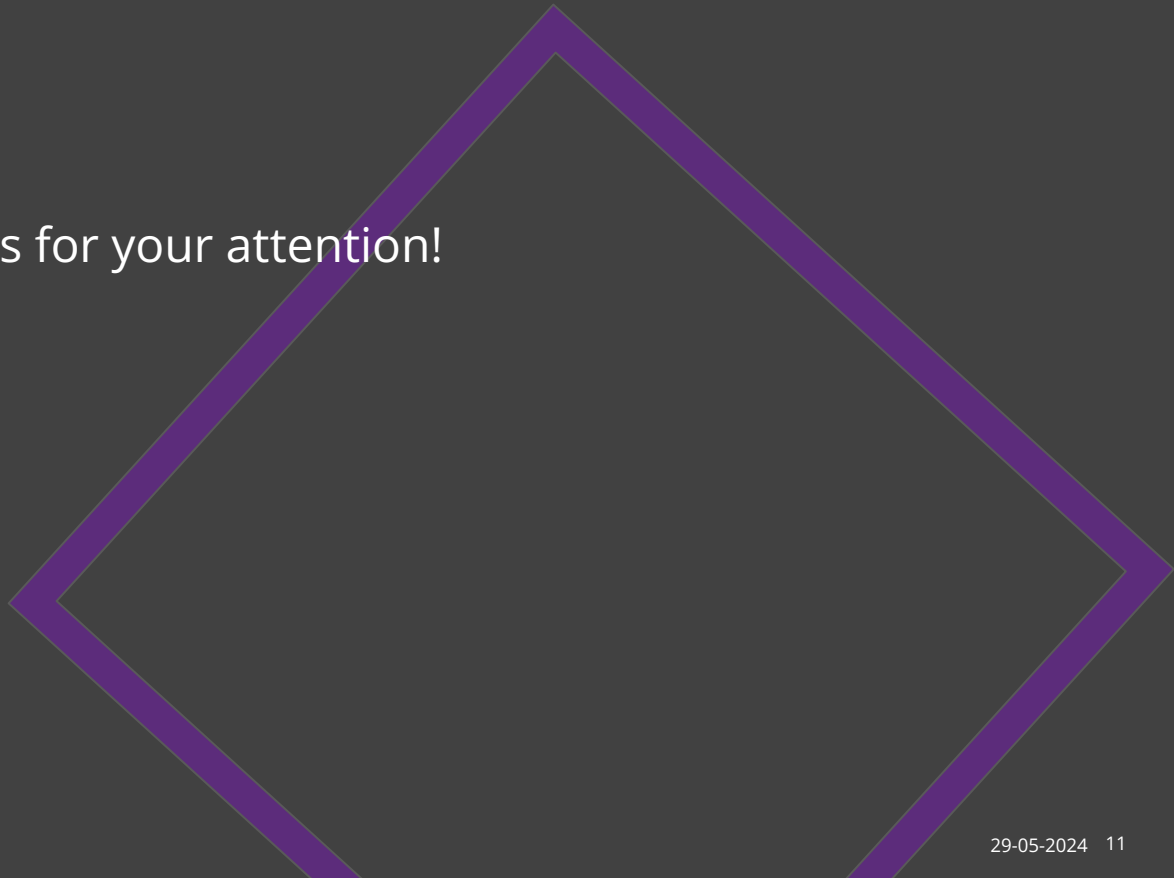
Thakur+20, Wollaeger+20





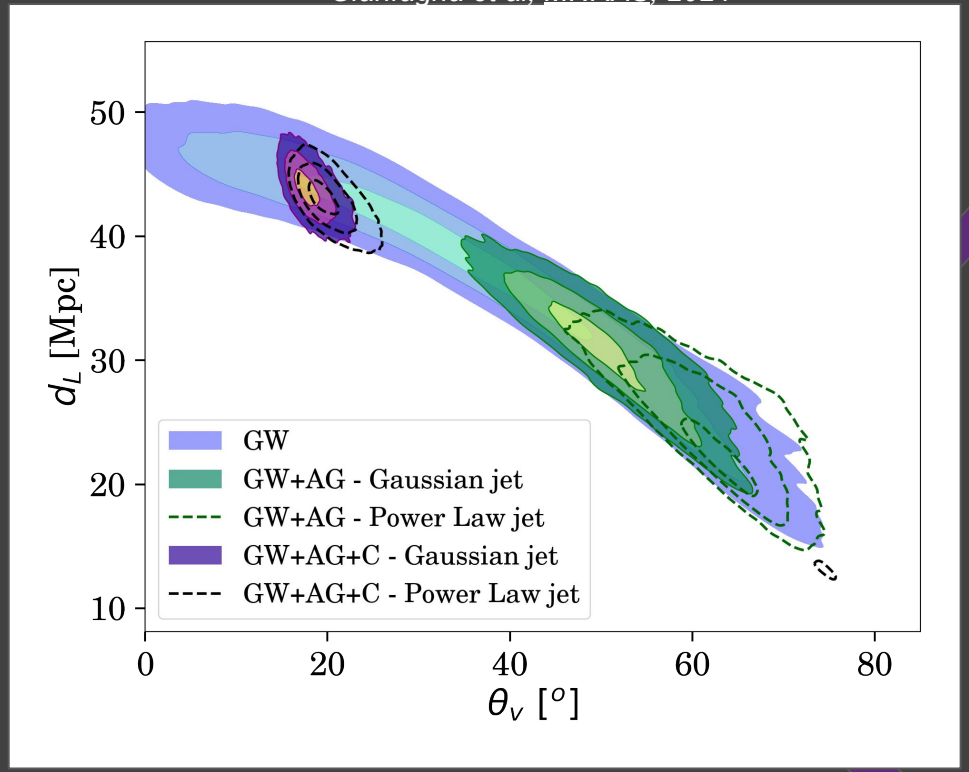
- ➢ Use surrogate models
  a. Trained on tabulated simulations
  b. Incorporate into Bayesian fitting
- ➢ Incorporated in nmma python package
- ➢ Currently evaluating
  a. Retraining surrogate
  b. Changing kilonova models
     - *Wollaeger et al.* (axisymmetric)
     - *Bulla et al.* (symmetric)

Thanks for your attention!



Use case 2: Motivation

Gianfagna et al, MNRAS, 2024



- Far source
- Binary orbit facing Earth

=

- Close source
- Highly inclined

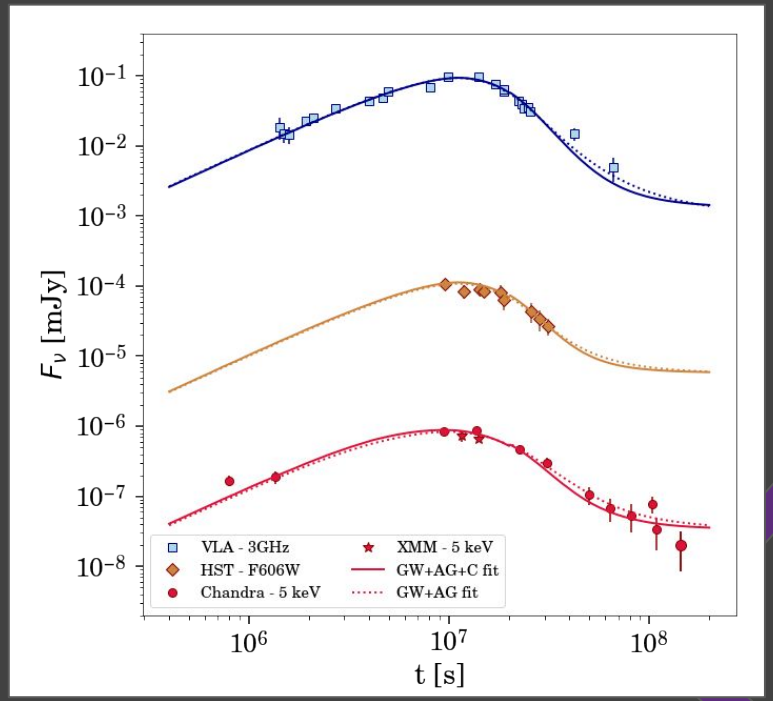
GW-only: $H_0 = 77^{+21}_{-10}\ \mathrm{km\ s^{-1}Mpc^{-1}}$

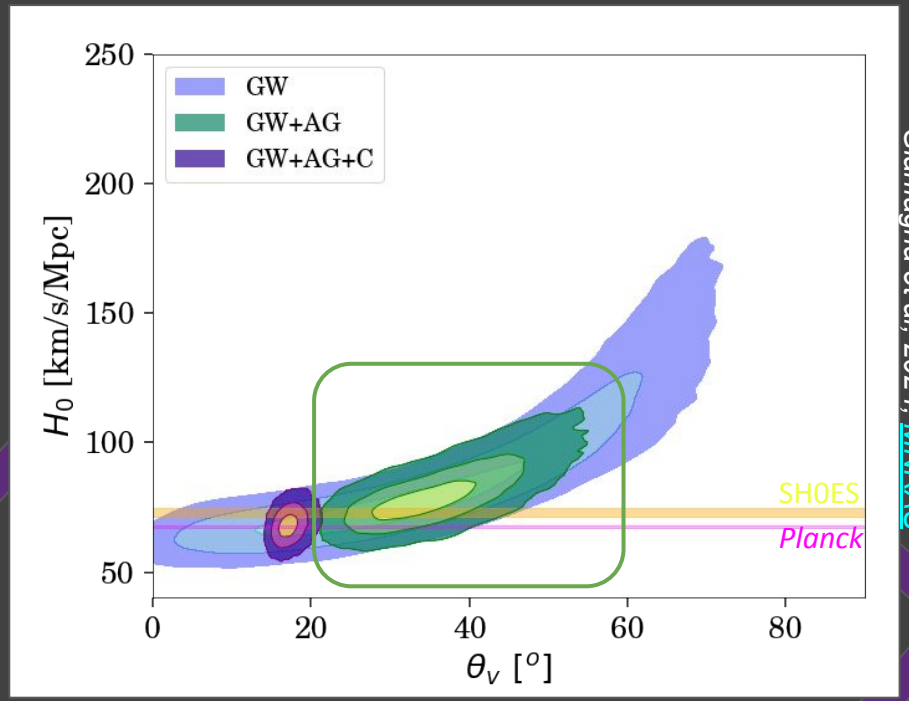
How to break this degeneracy?

With an independent dataset:

Afterglow

Use case 2: Applications





Gianfagna et al, 2024, MNRAS

d_L [Mpc]	$38.6^{+2.5}_{-3.0}$
θ_v [deg]	$35.2^{+5.7}_{-6.2}$
θ_{JN} [deg]	$144.8^{+5.7}_{-6.2}$

$H_0 = 78.5^{+7.9}_{-6.4}$ km s^{-1}Mpc^{-1}