

Prospects for spectroscopic observations of Rublin detected counterparts of GW events from next generation interferometers

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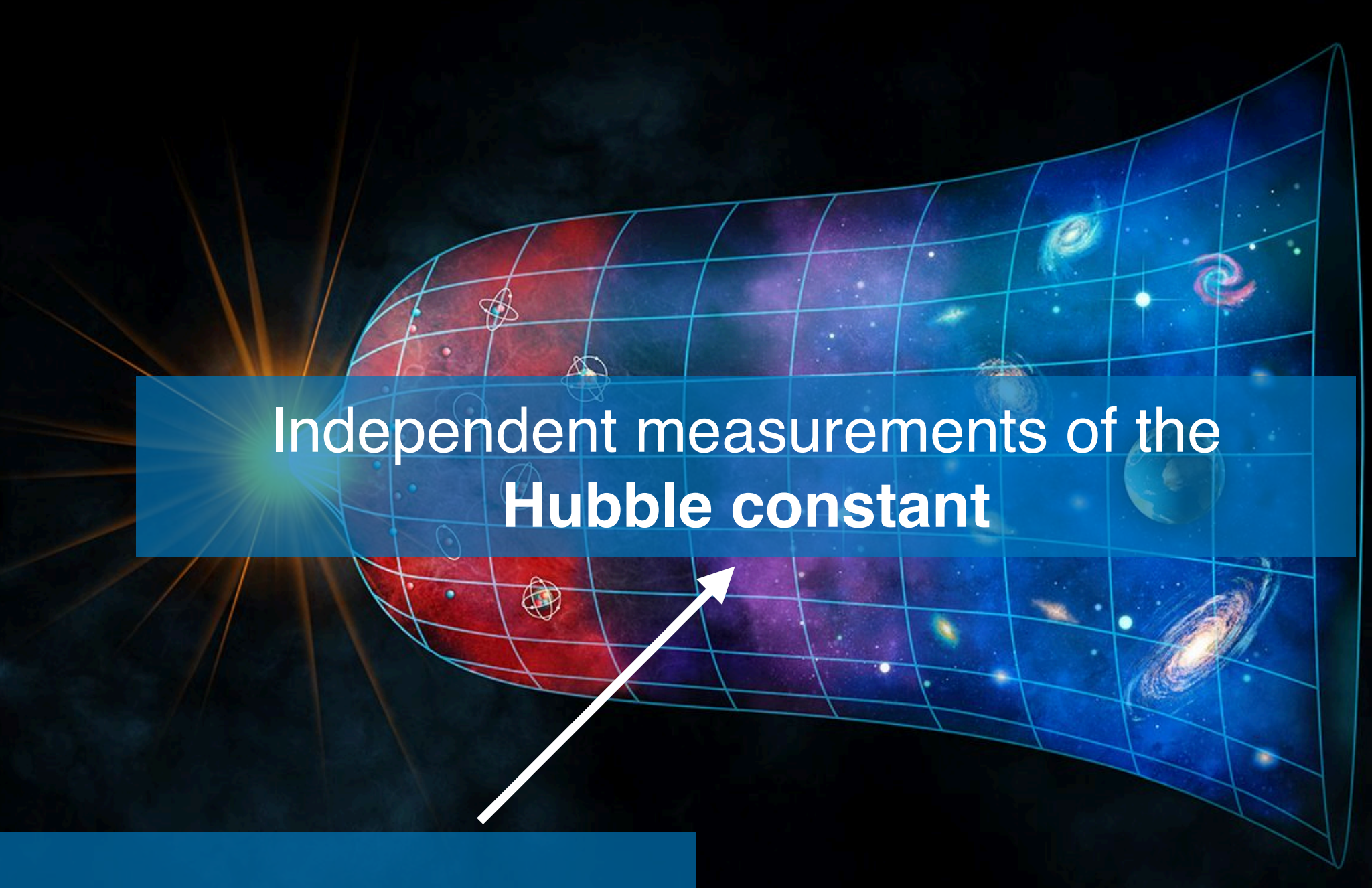
In collaboration with Eleonora Loffredo and Marica Branchesi
Gran Sasso Science Institute (GSSI)

Image credit: Rubin Obs./NSF/AURA





Understanding **BNS population** and
massive stars evolution



Independent measurements of the
Hubble constant

Researching EM counterparts of GW events



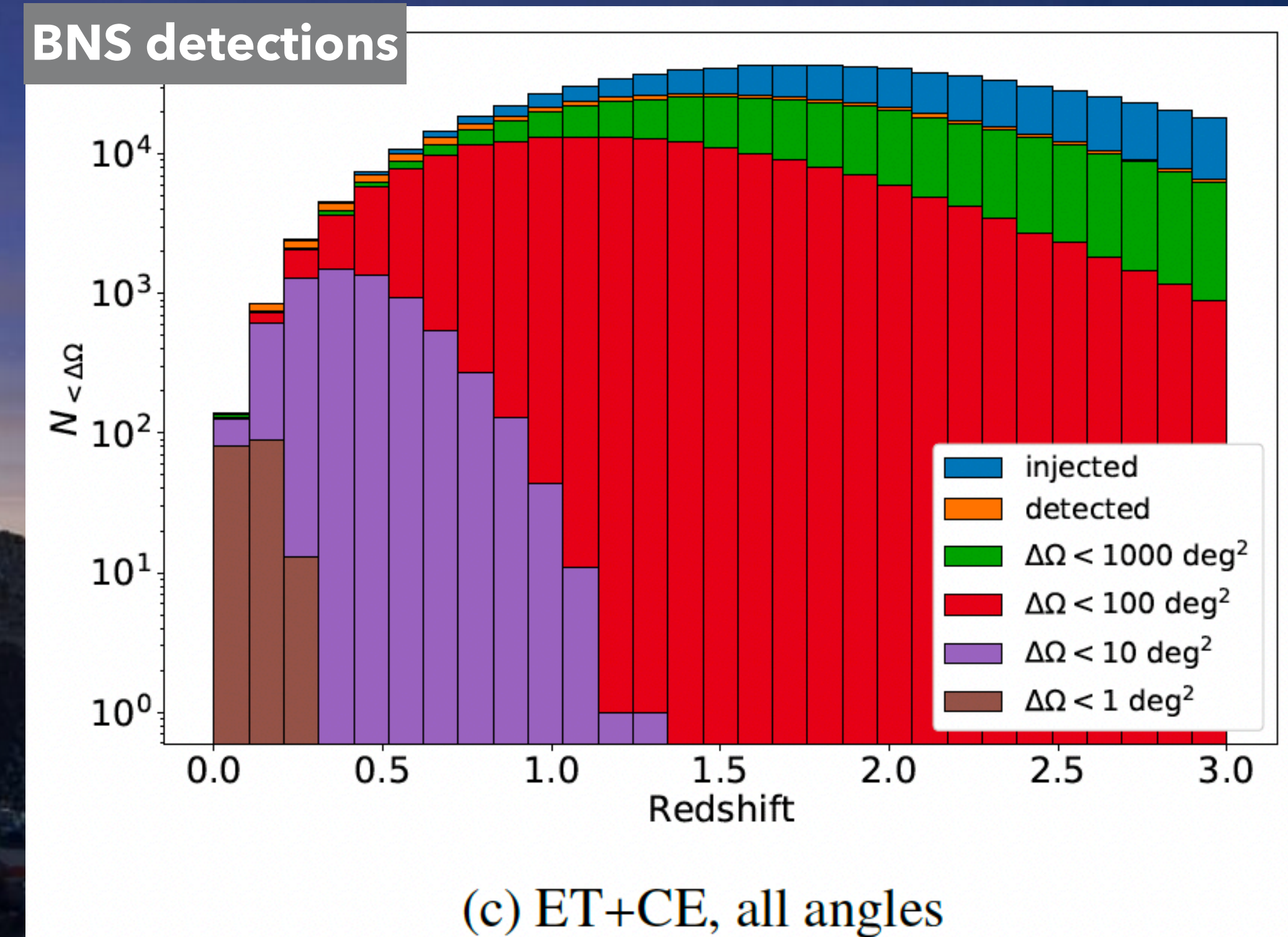
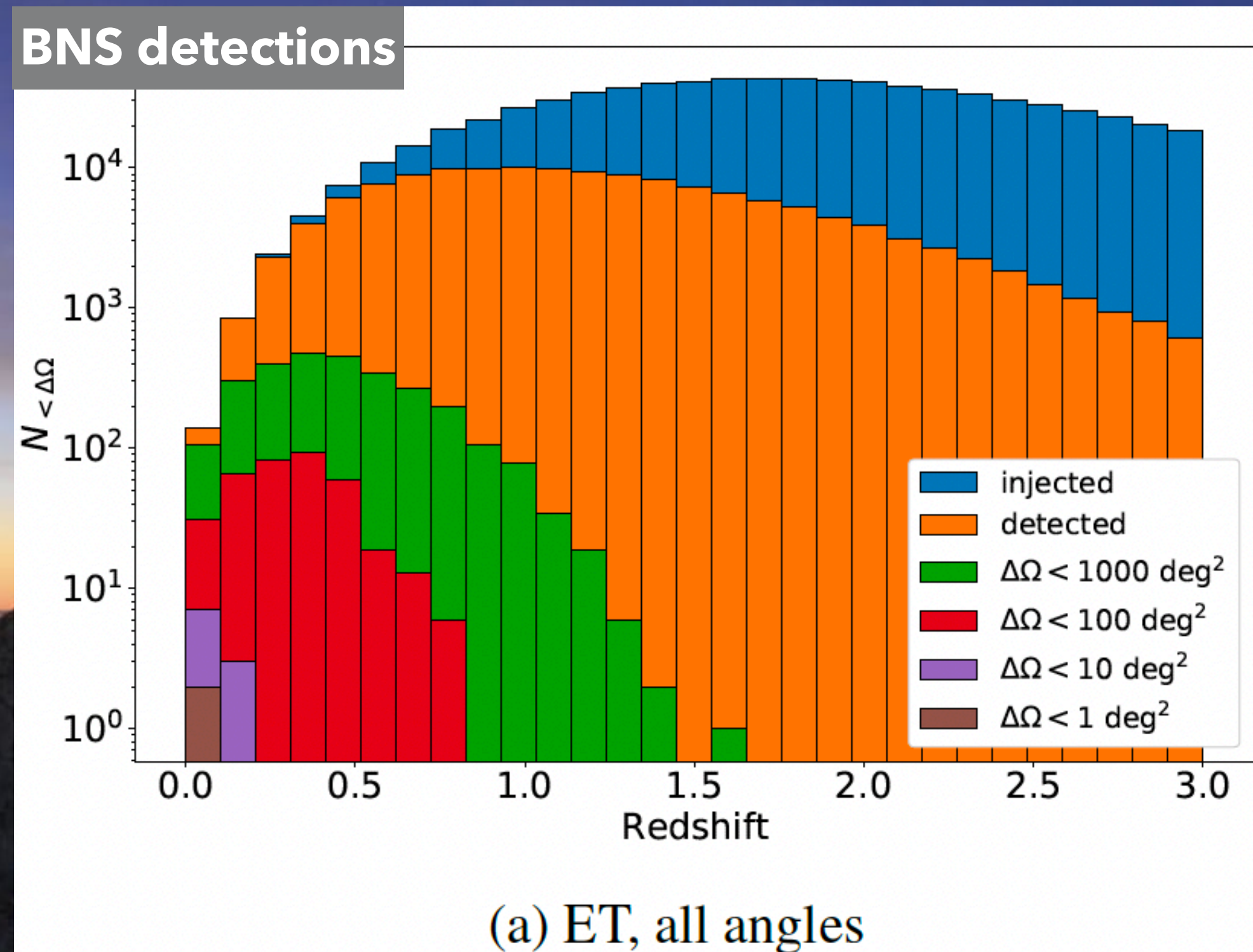
Studying **KN** and their contribution to
heavy elements nucleosynthesis



Investigating **GRB jet structure**

BNS beyond the Local Universe with ET

Ronchini+22

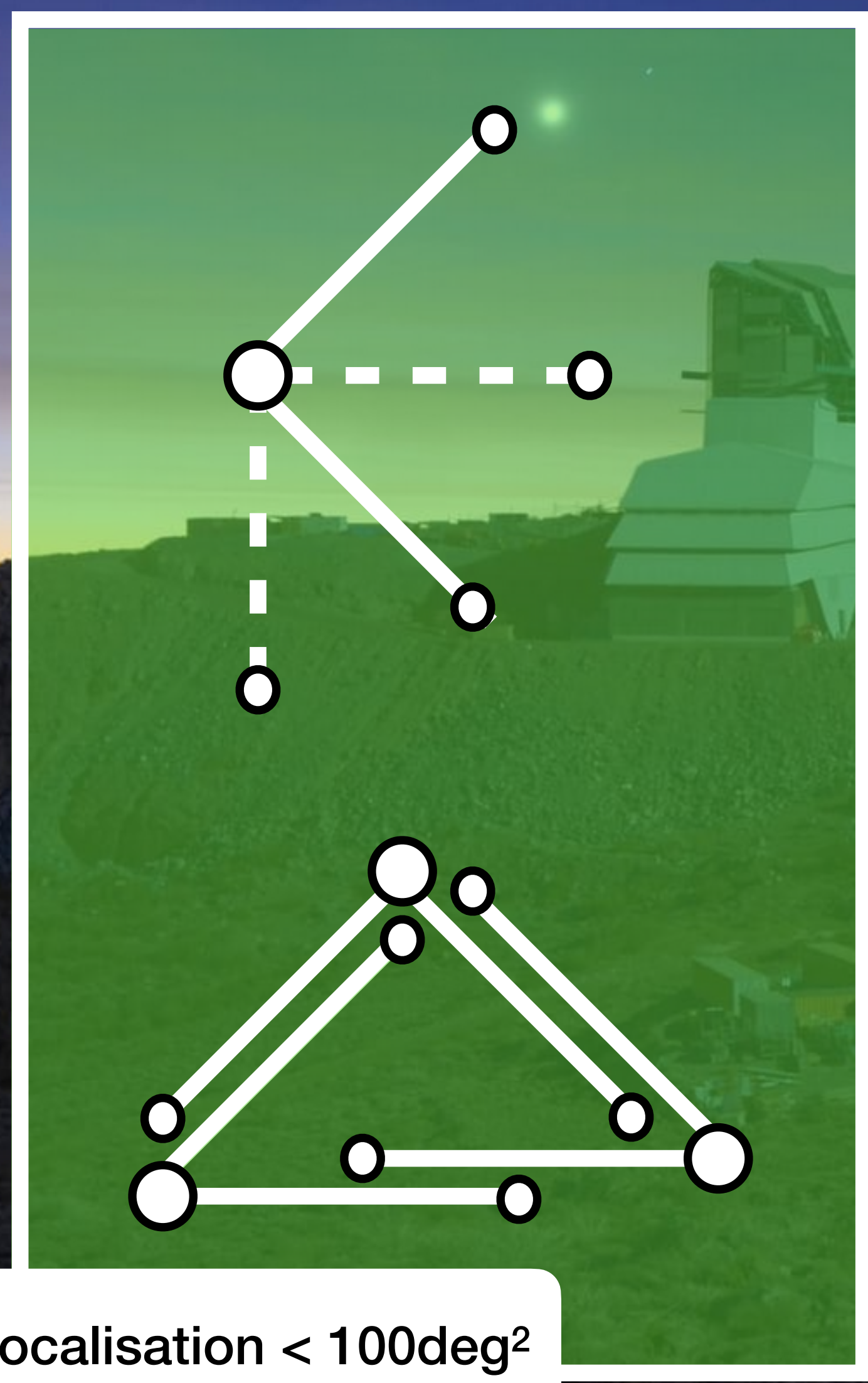


Larger volume of the Universe explored and higher number of BNS detections

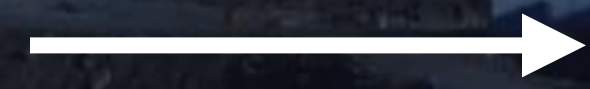
Photometric observations with facilities like the Vera C. Rubin Observatory will be essential to provide **counterpart candidates**

ET-VRO

BNS population



sky localisation < 100deg²



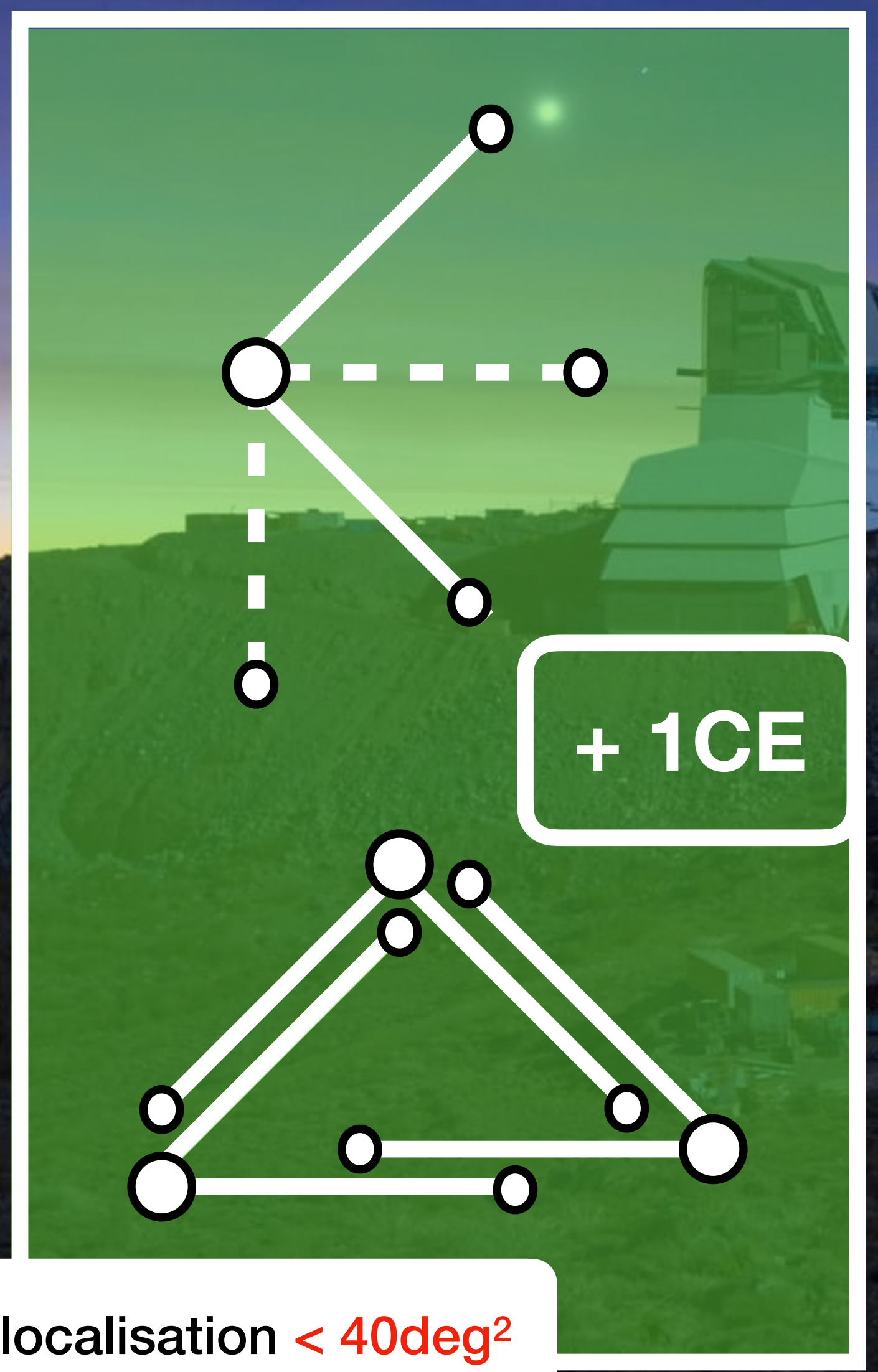
EM counterparts

- AT2017gfo-like KN
- theoretical KN
- GRB afterglows

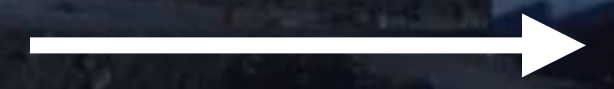
light curves: AB magnitudes in Rubin g r i and z filters as a function of time (obs. frame)

ET-VRO

BNS population



sky localisation < 40deg²



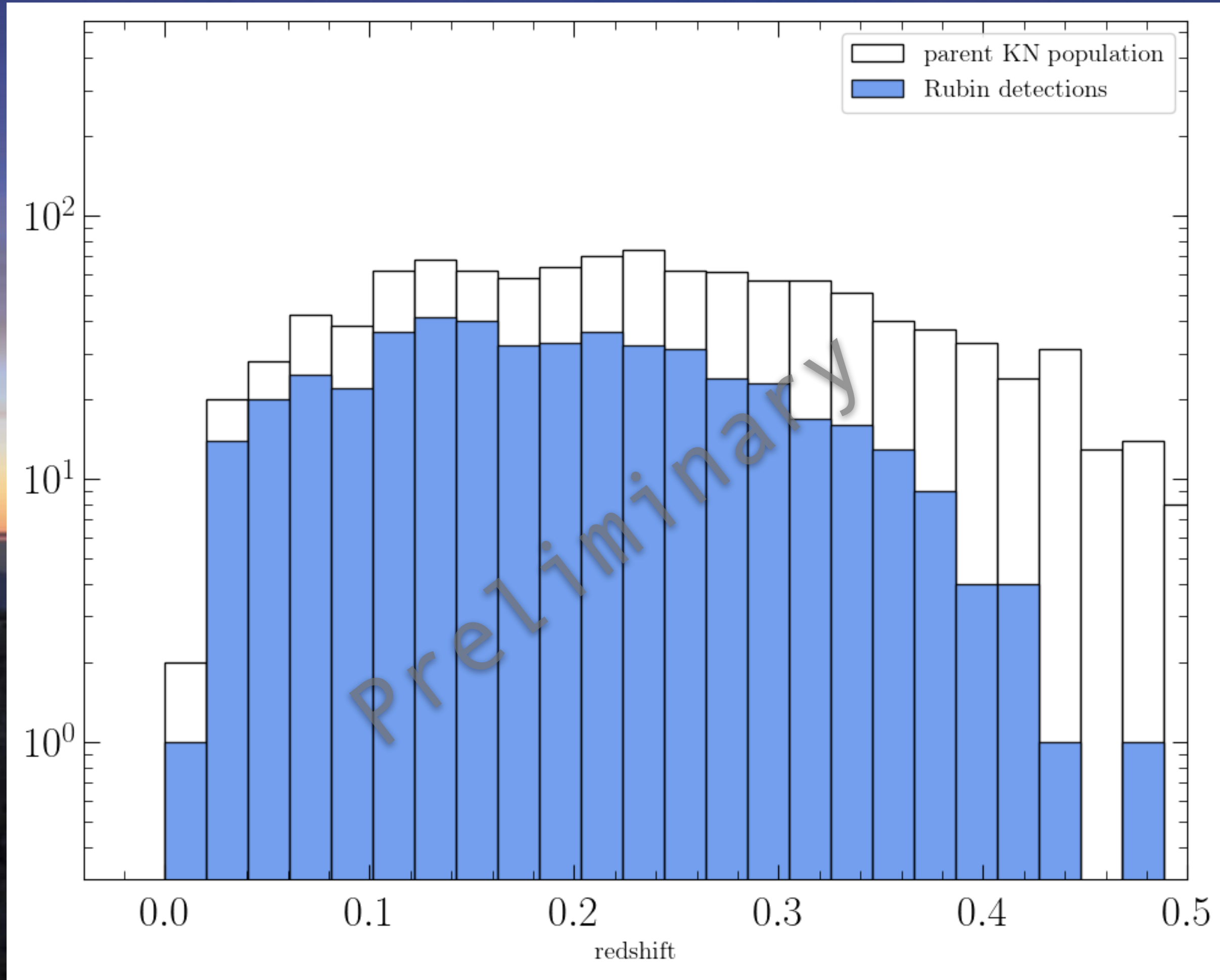
EM counterparts

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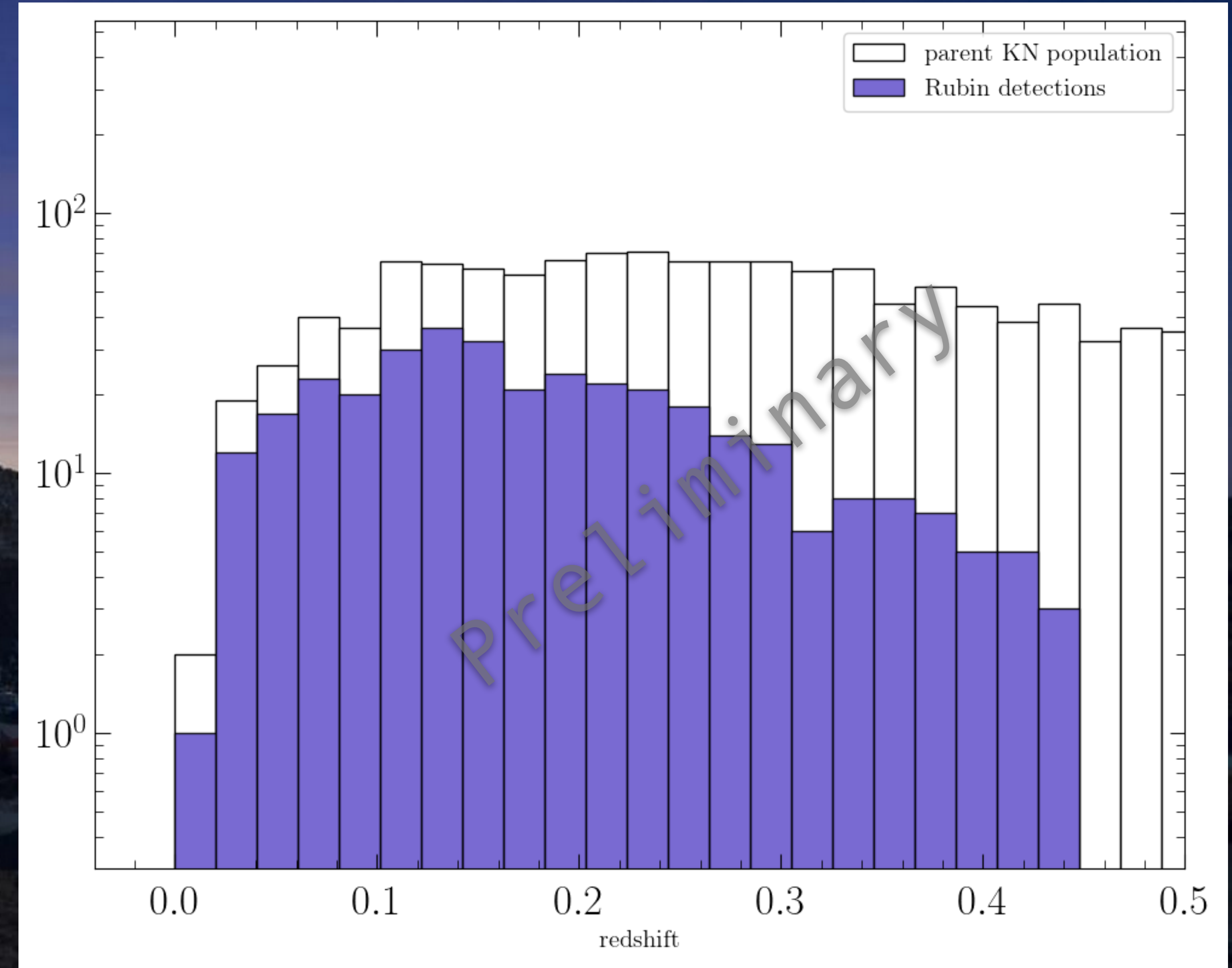
ET-VRO

Redshift distribution

Credits: Eleonora Loffredo and Nandini Hazra, GSSI



BLh gaussian



APR4 uniform

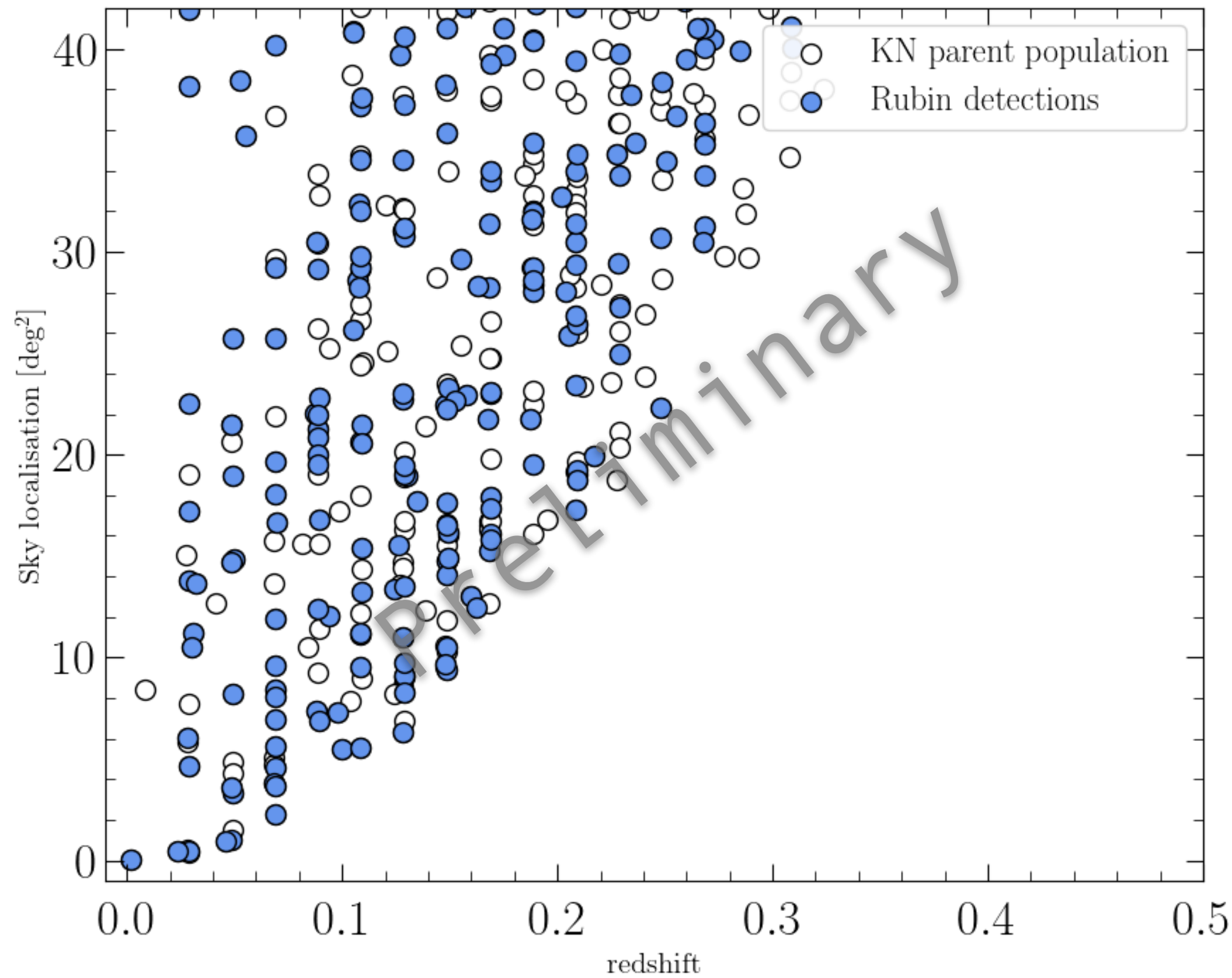
White: **ET BNS detections** in 10 years of operations
Colored: **Rubin detections**

ET-VRO

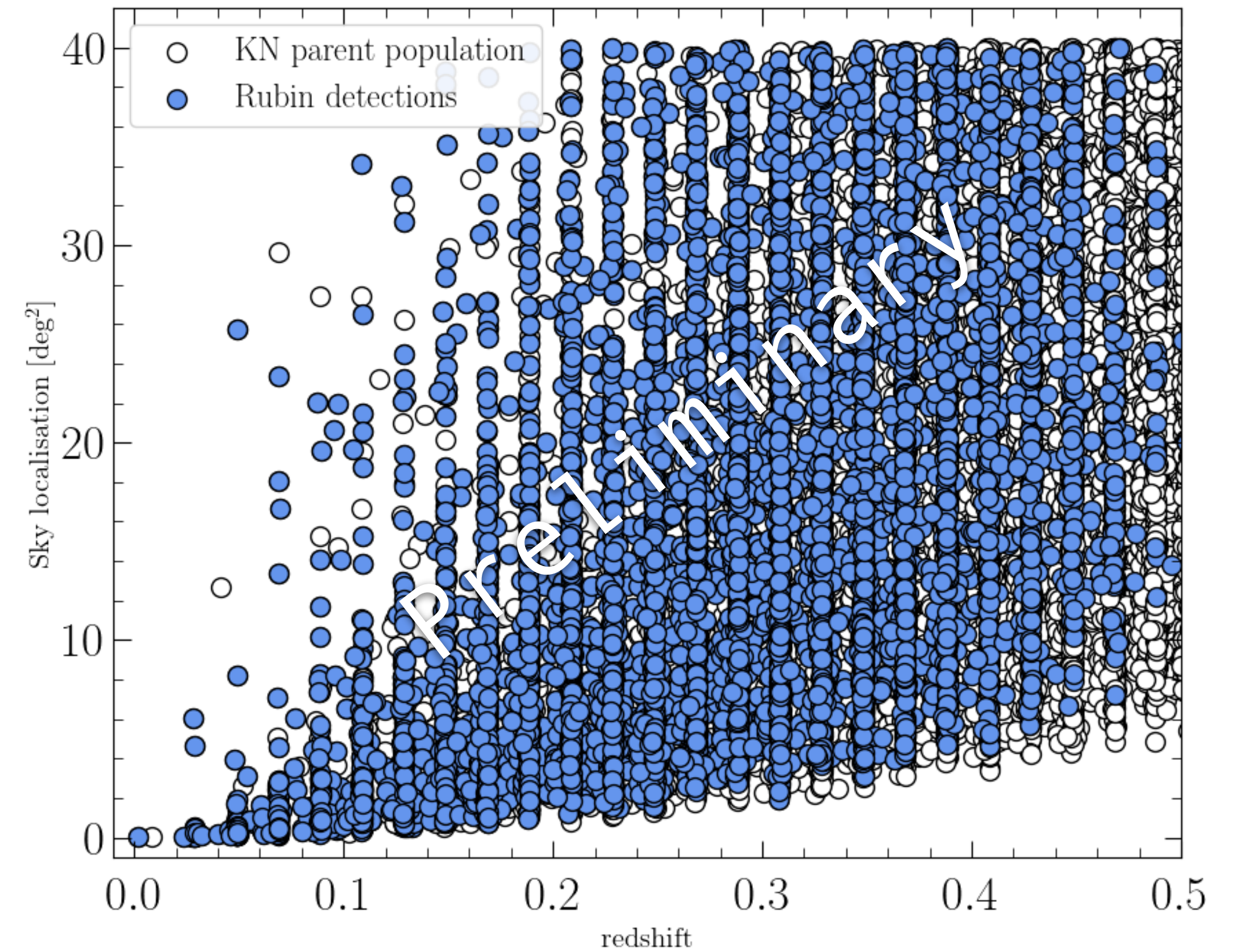
ET+CE: sky localisation

Credits: Eleonora Loffredo and Nandini Hazra, GSSI

ET alone



ET+Cosmic Explorer



White: **ET BNS detections** in 10 years of operations
Colored: **Rubin detections**

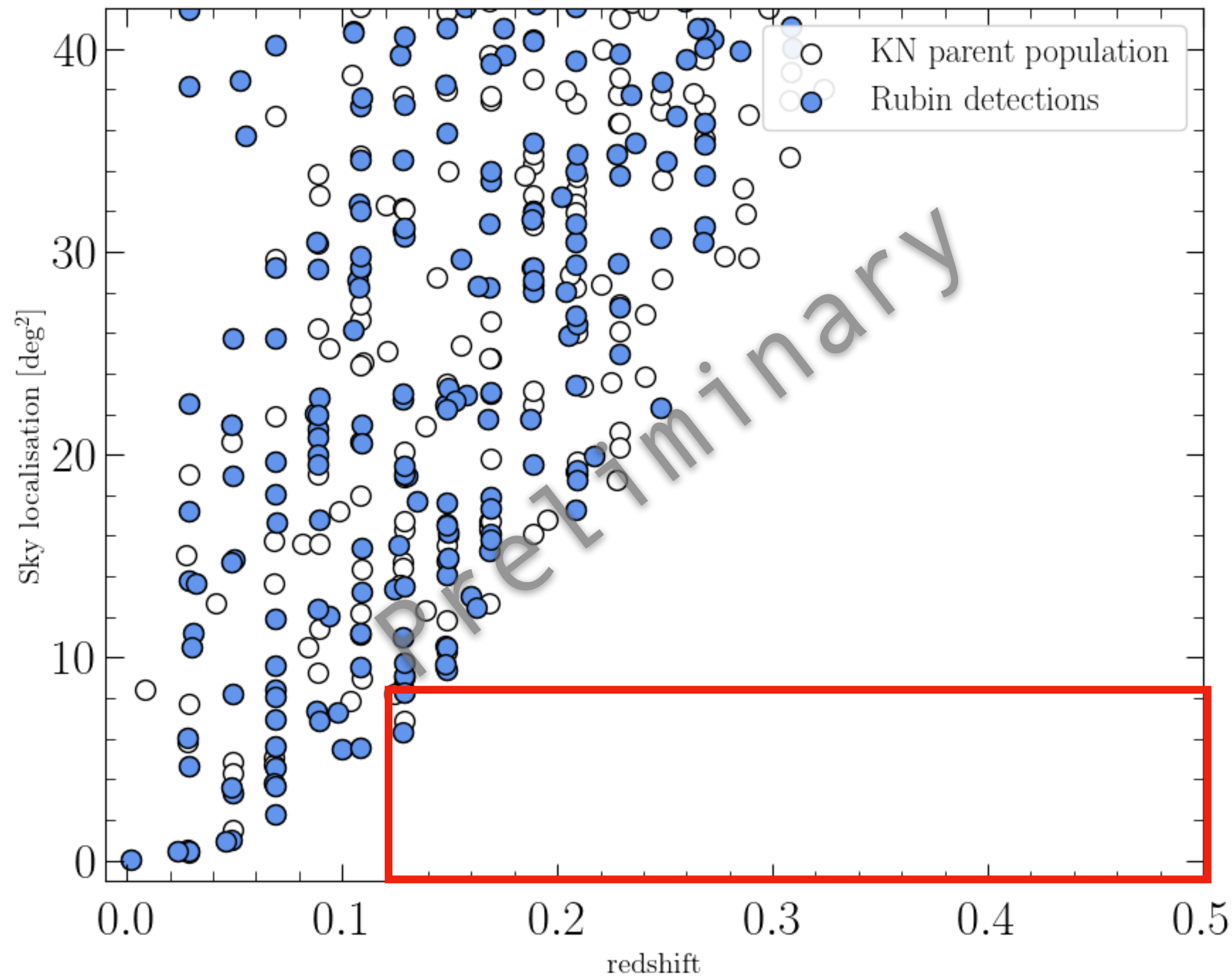
BLh gaussian

ET-VRO

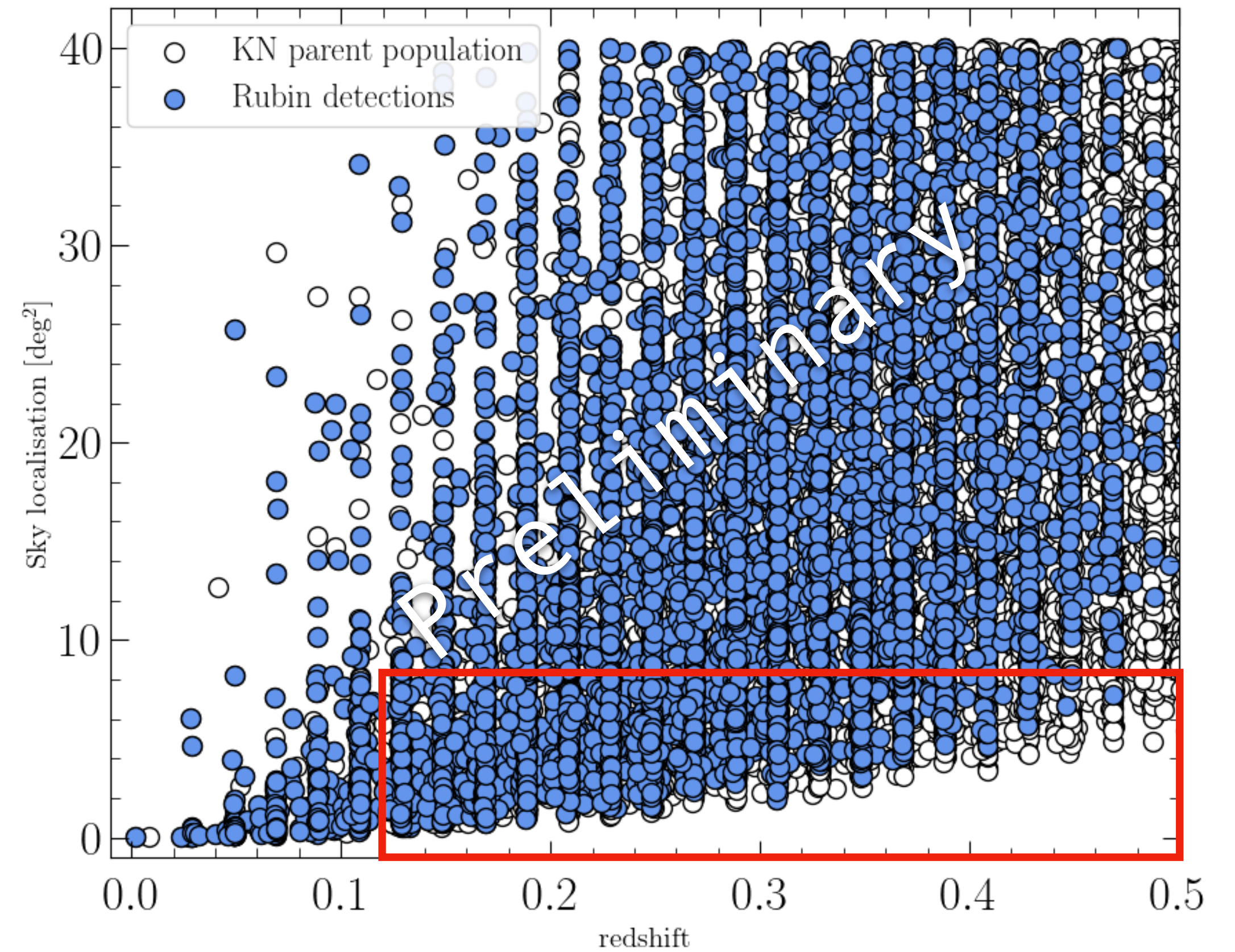
ET+CE: sky localisation

Improved sky localisation

ET alone



ET+Cosmic Explorer



White: **ET BNS detections** in 10 years of operations
Colored: **Rubin detections**

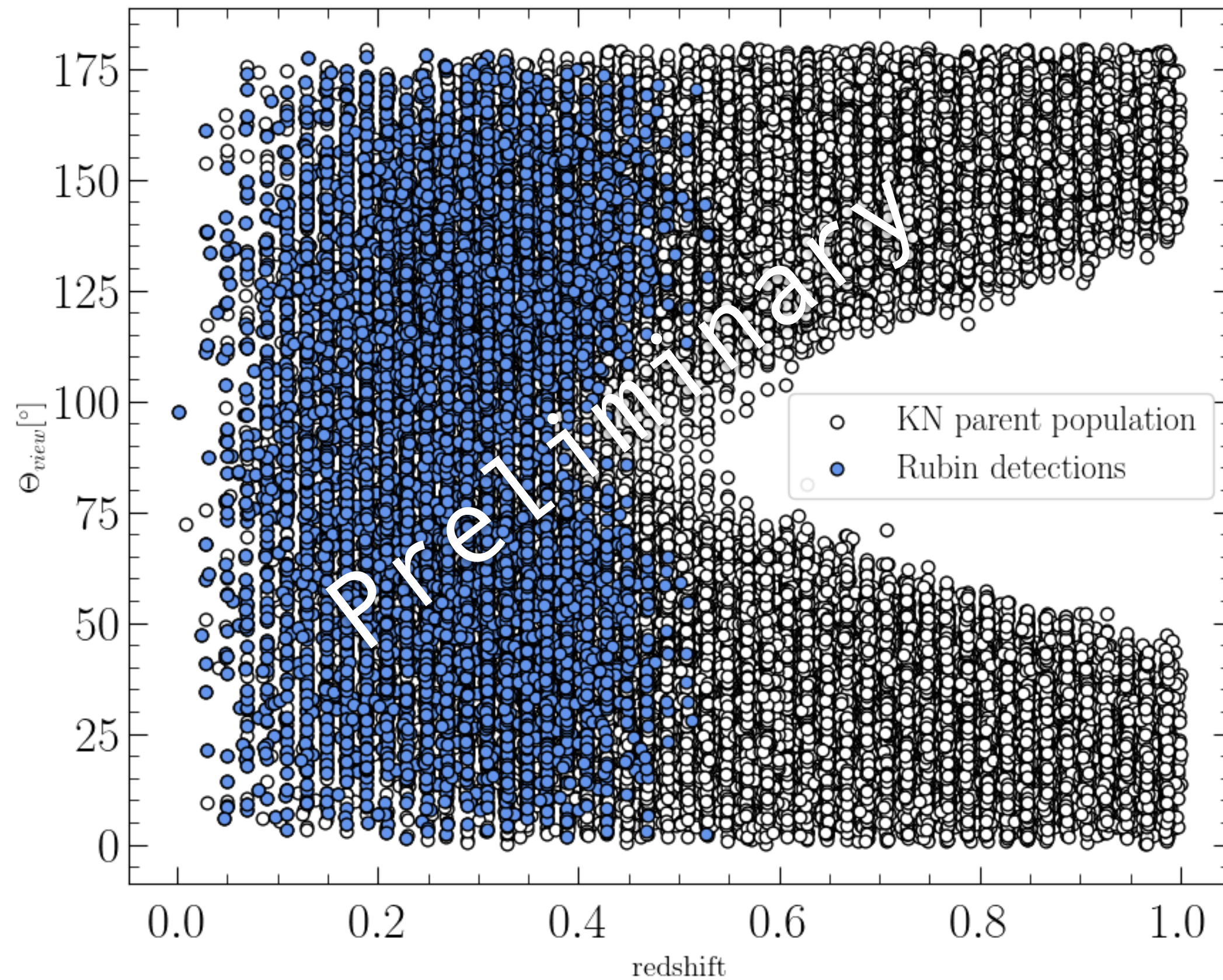
BLh gaussian

ET-VRO

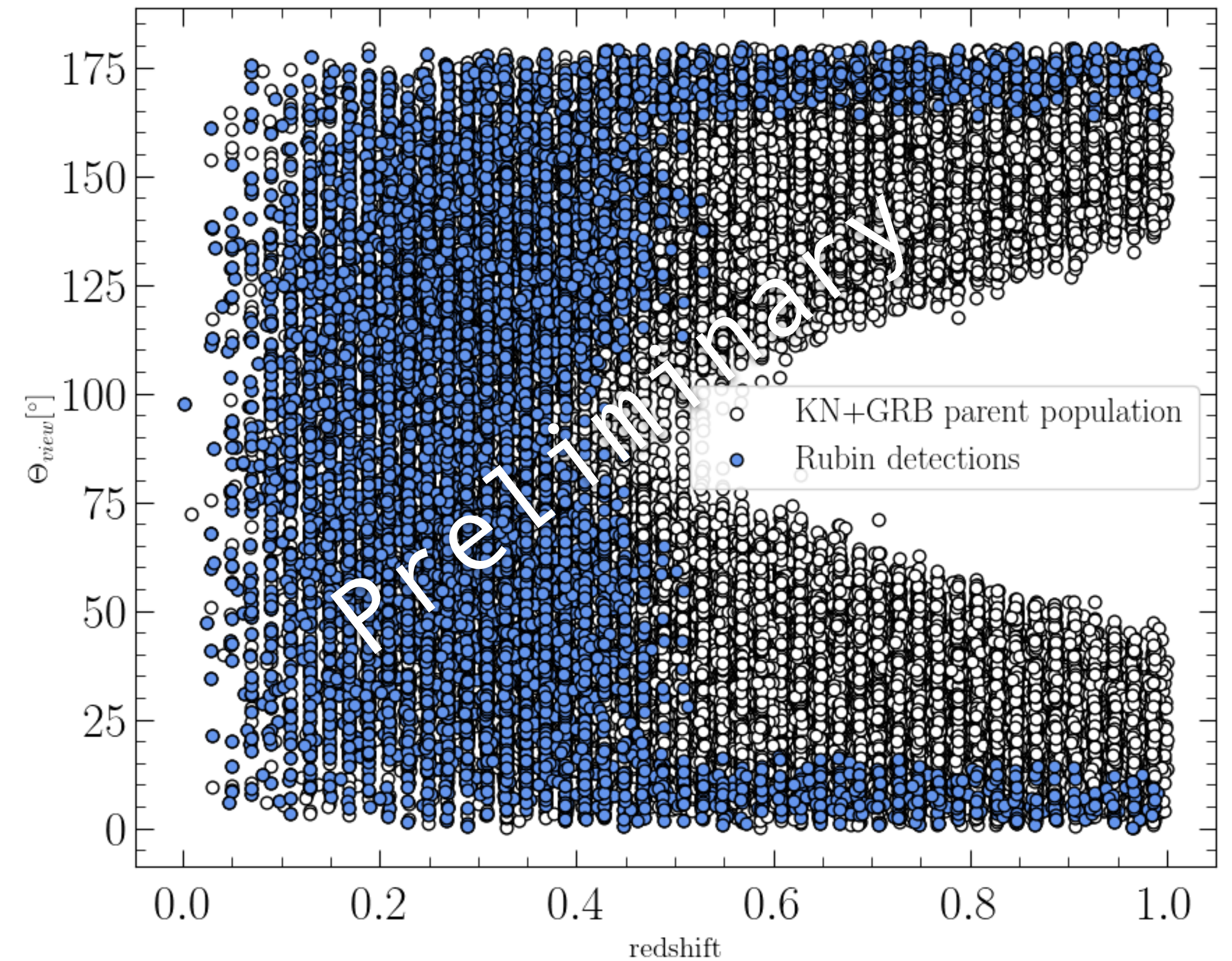
Afterglow contribution

Credits: Eleonora Loffredo and Nandini Hazra, GSSI

KN only



KN+GRB afterglow



ET+CE

BLh gaussian

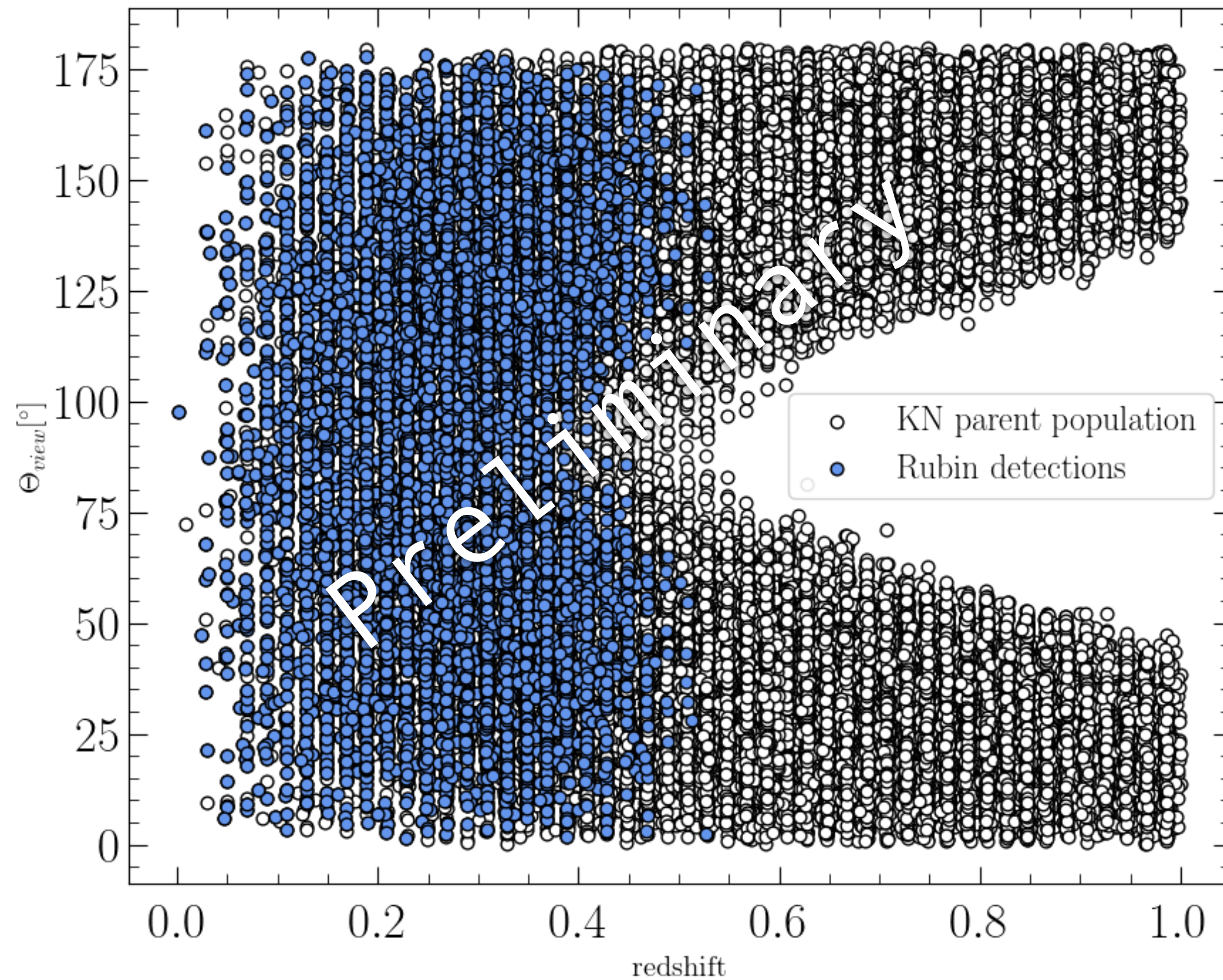
ET-VRO

Afterglow contribution

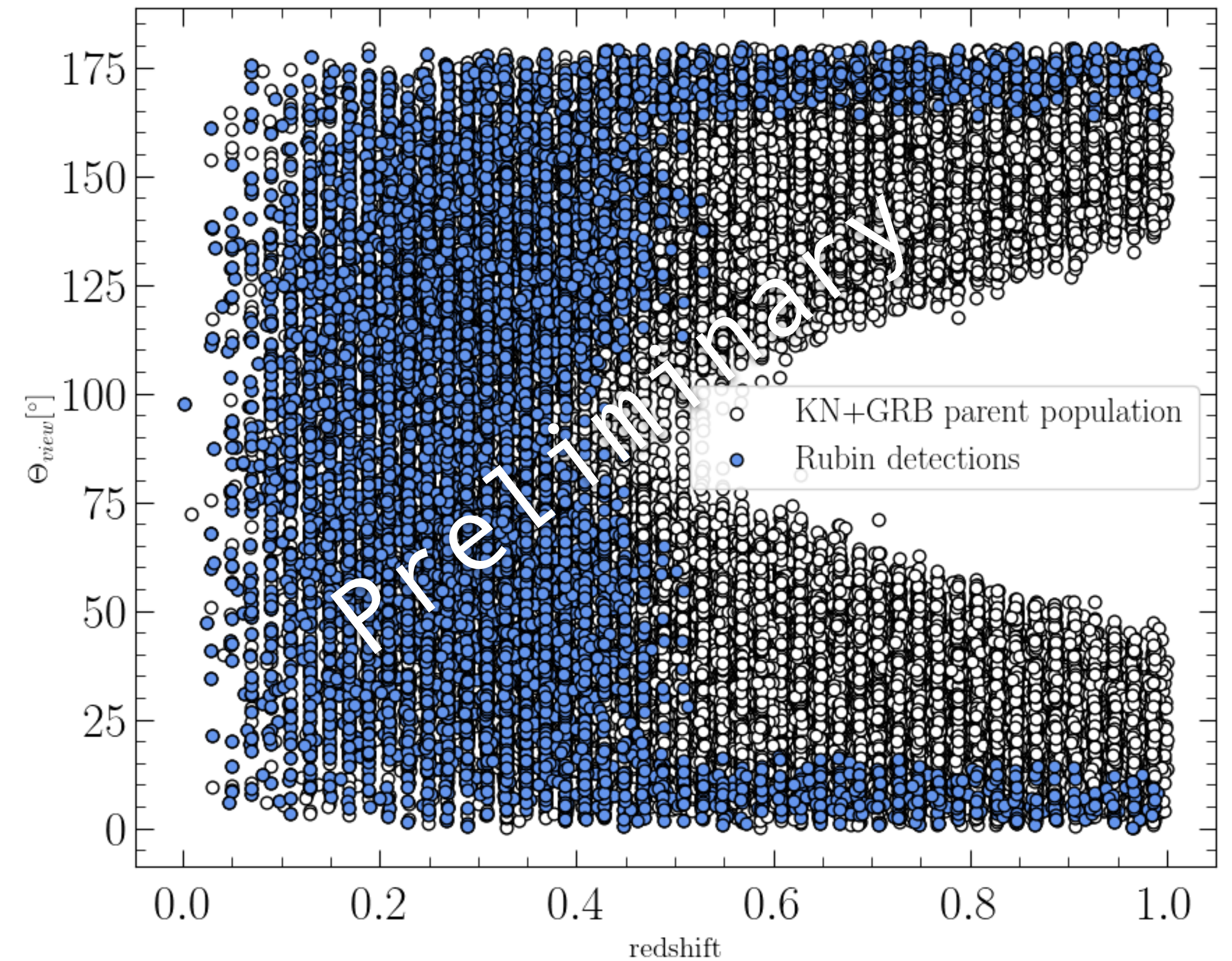


Such EM counterparts will have to be found within large GW error regions, among a huge number of contaminants

KN only



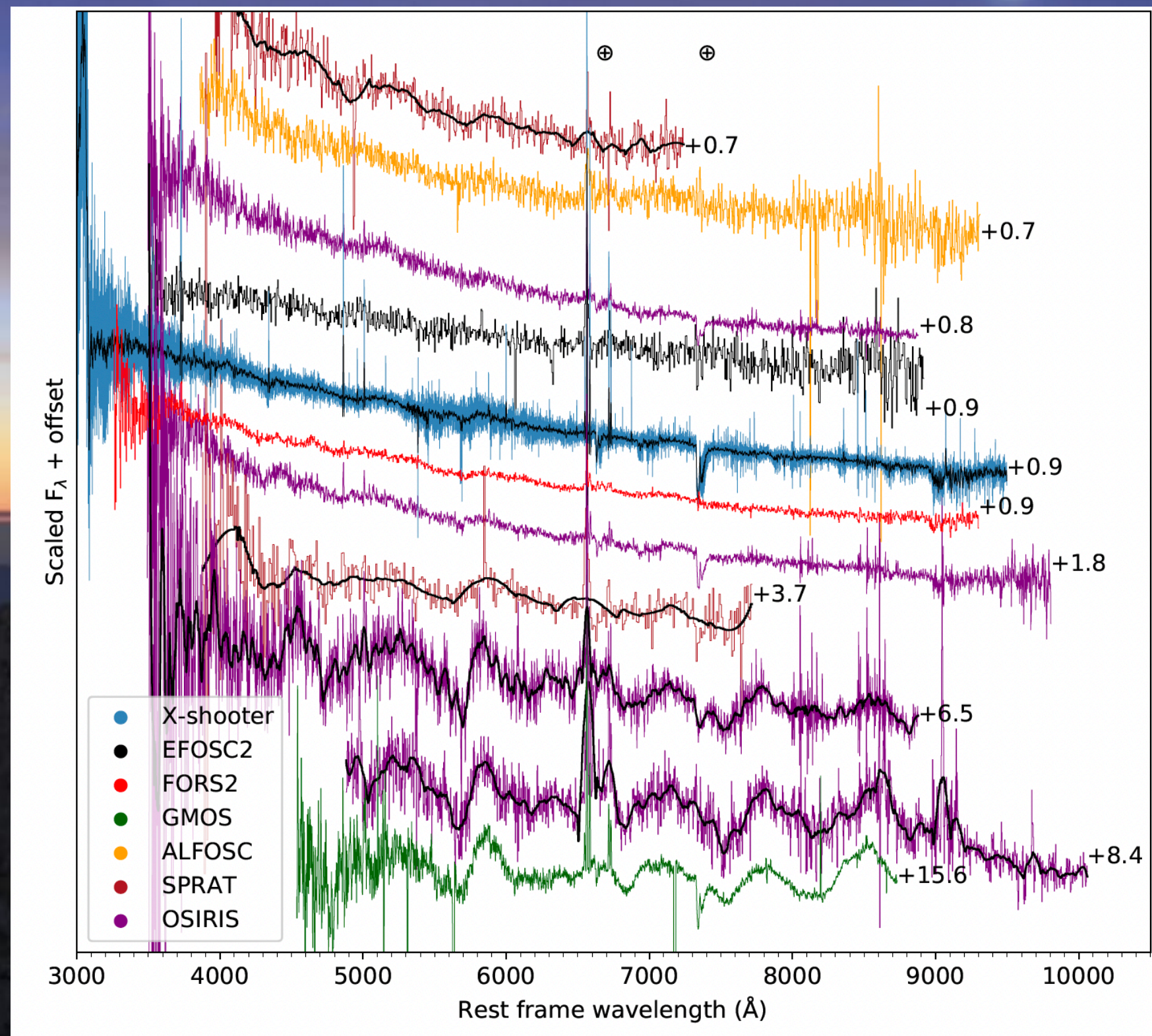
KN+GRB afterglow



ET+CE

BLh gaussian

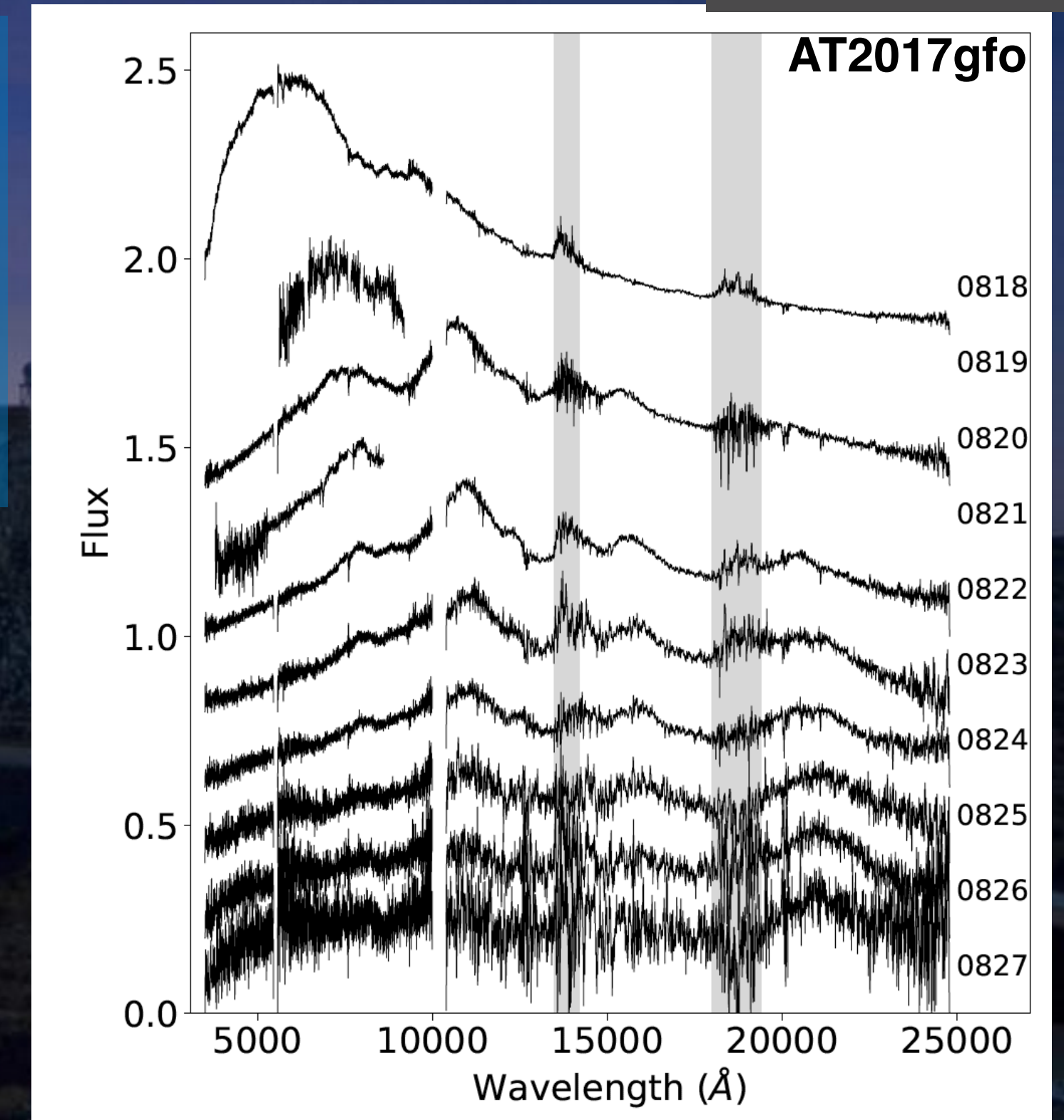
Spectroscopy: the bottleneck of gravitational wave multi-messenger science



Agudo+23

The spectrum of AT2017gfo: important for the study of physics of the phenomenon, the environment, heavy elements nucleosynthesis and for the KN identification

The spectrum of SN2019wxt, a GW event counterpart candidate, then classified as SN



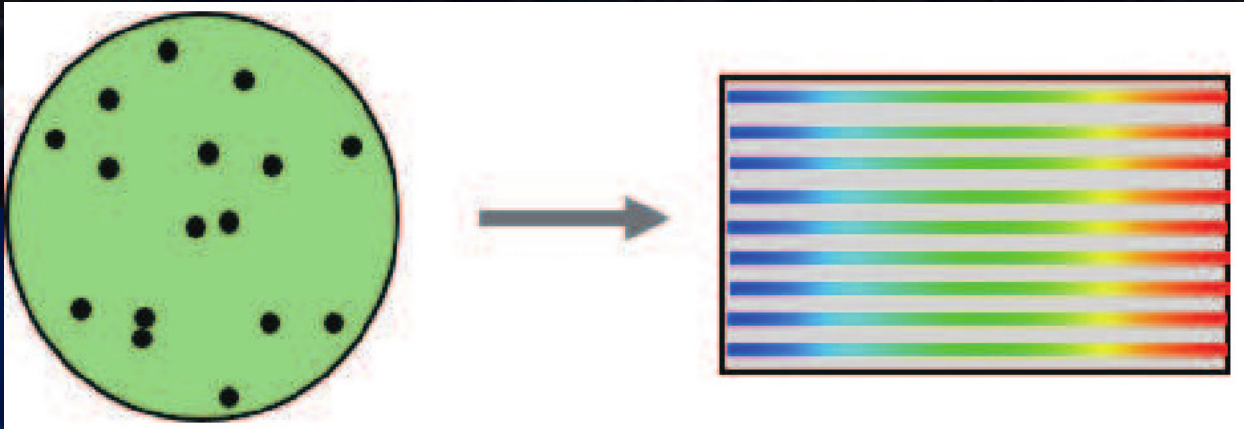
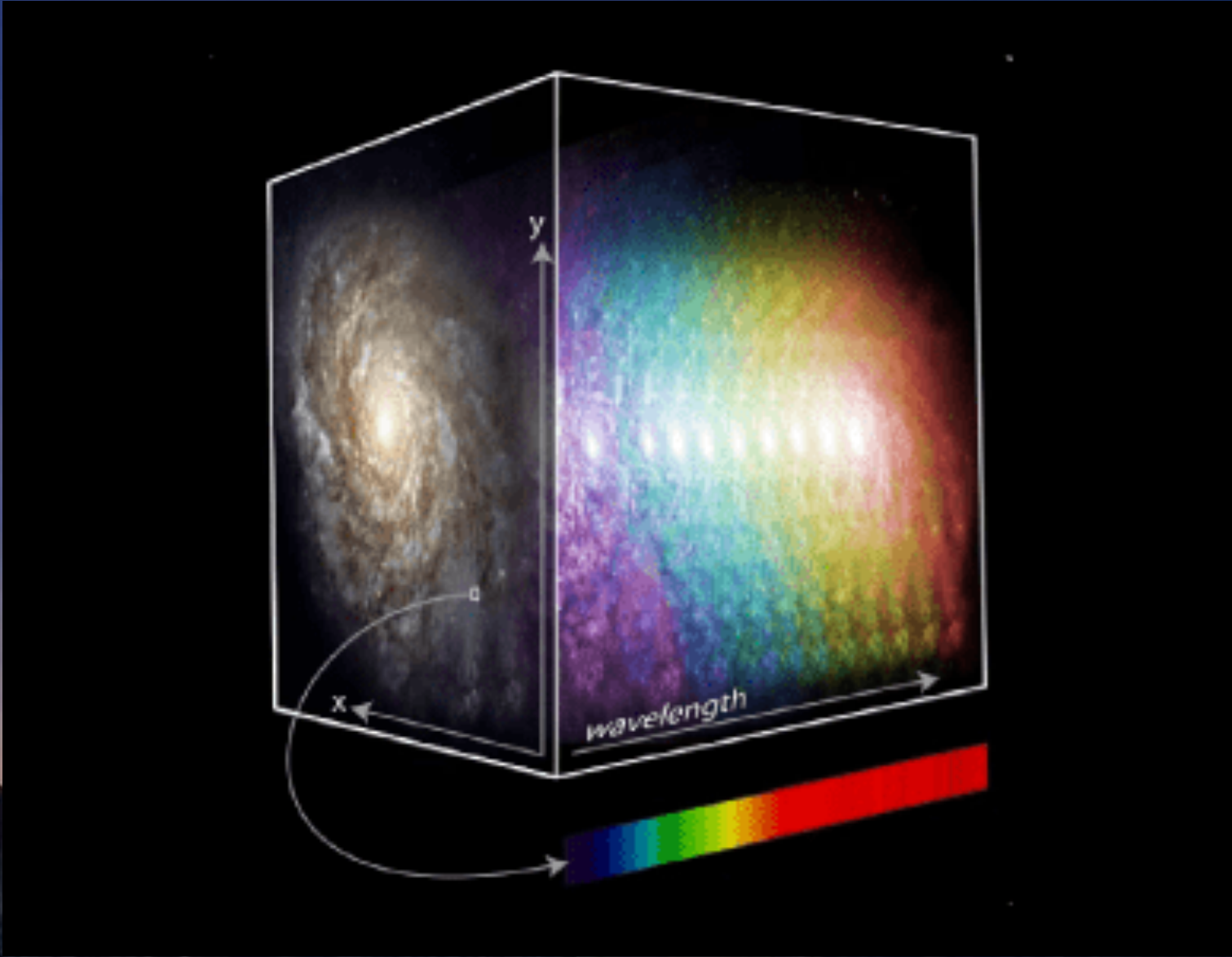
Pian+17

The acquisition of **multiple spectra** at the same time can play a key role in **identifying** and **characterising** EM counterparts

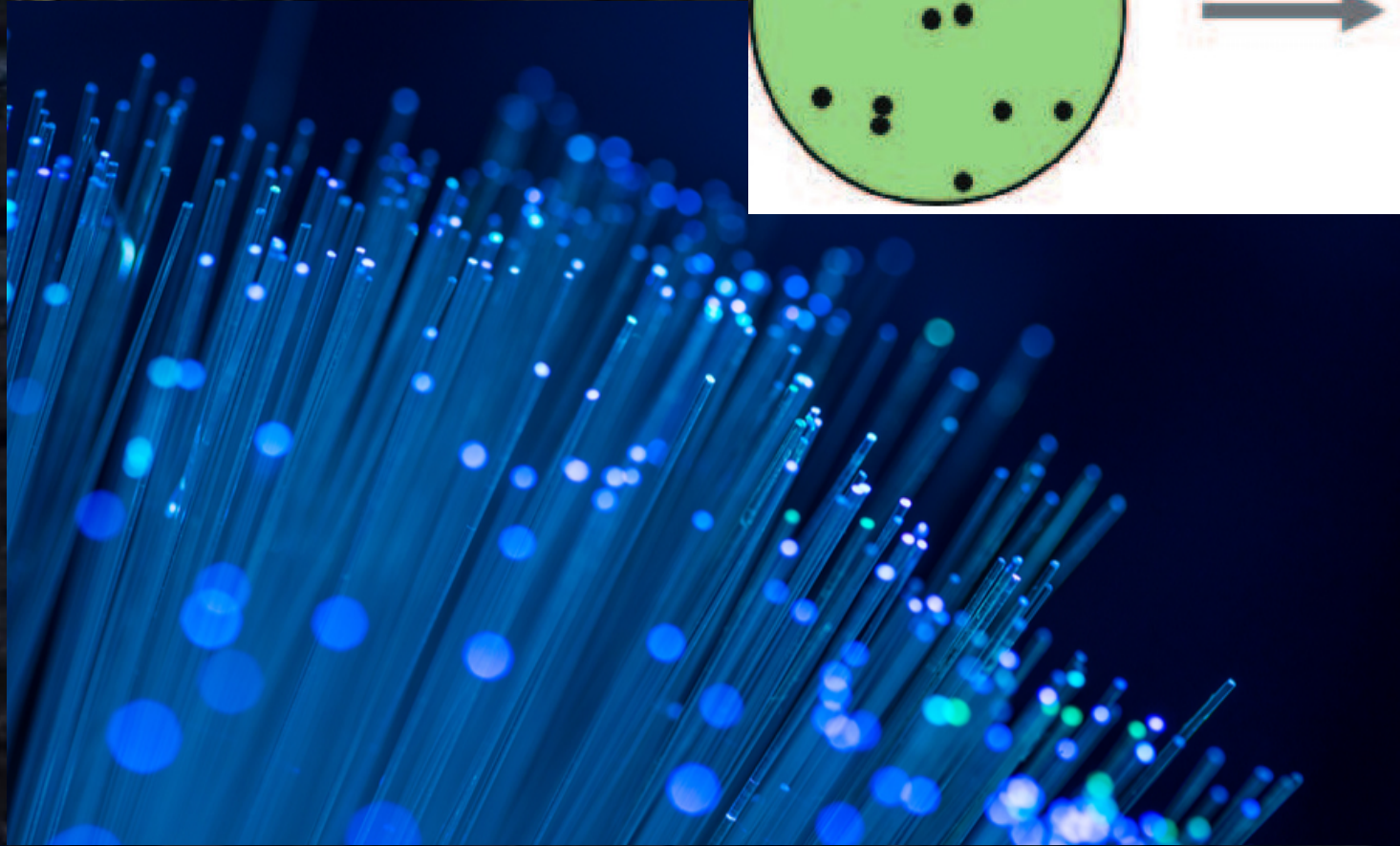
Integral-field and multi-object spectroscopy

IFS: a spectrum for each pixel of the 2D field image

MOS: fibres to acquire multiple spectra simultaneously



Hang-xin +19

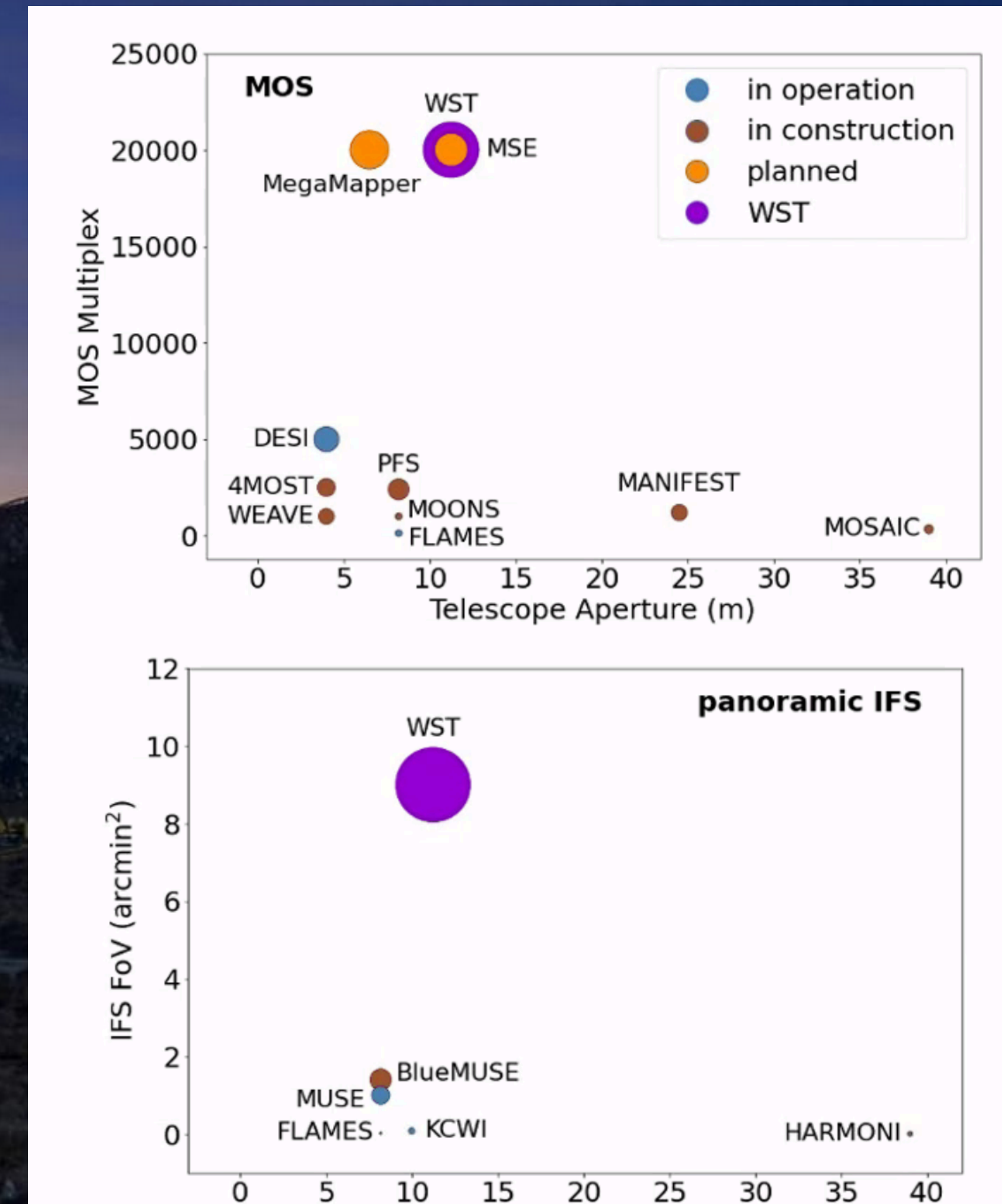
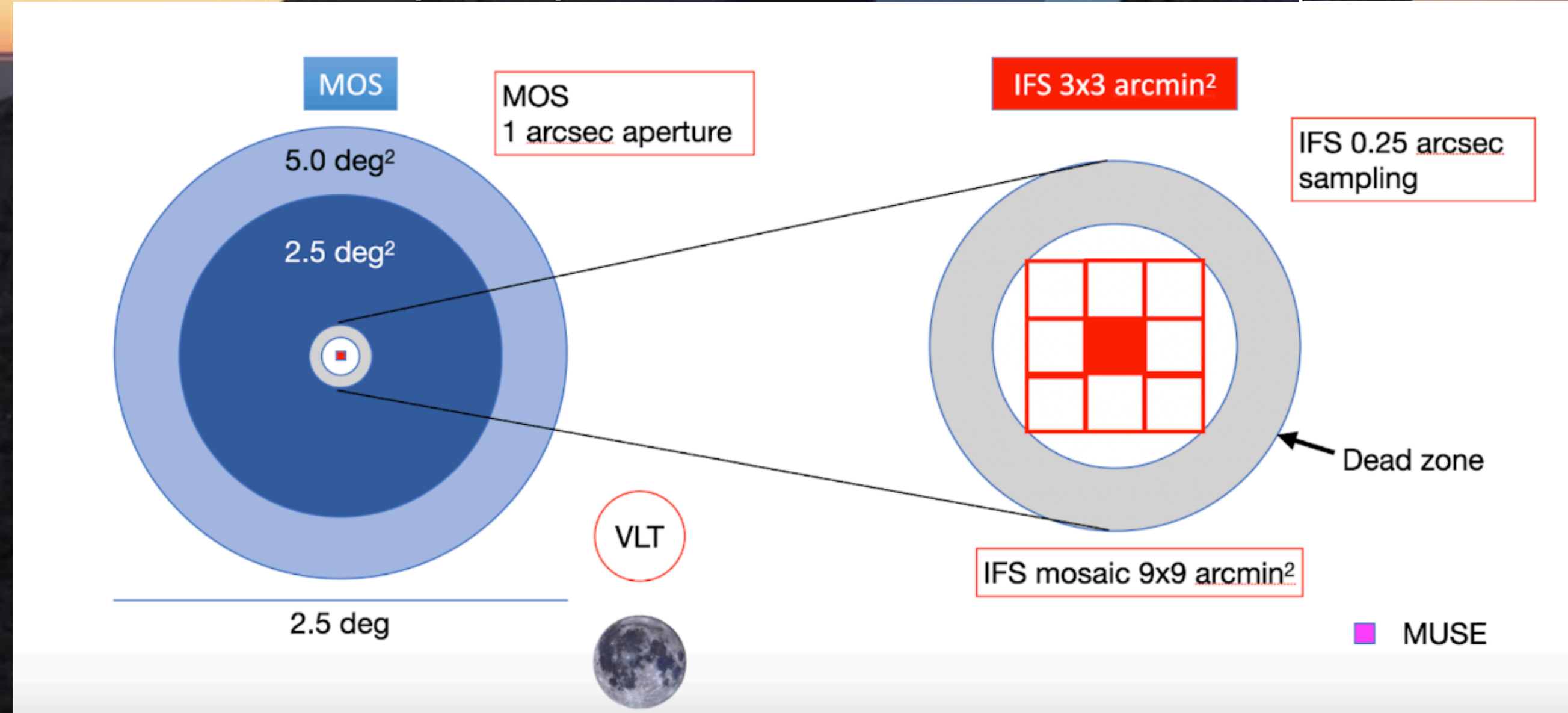


IFS and MOS with the Wide-field Spectroscopic Telescope

Large field of view and high multiplexing

Equipped with both IFU and fibres (MOS)

PI: Roland Bacon (CRAL)



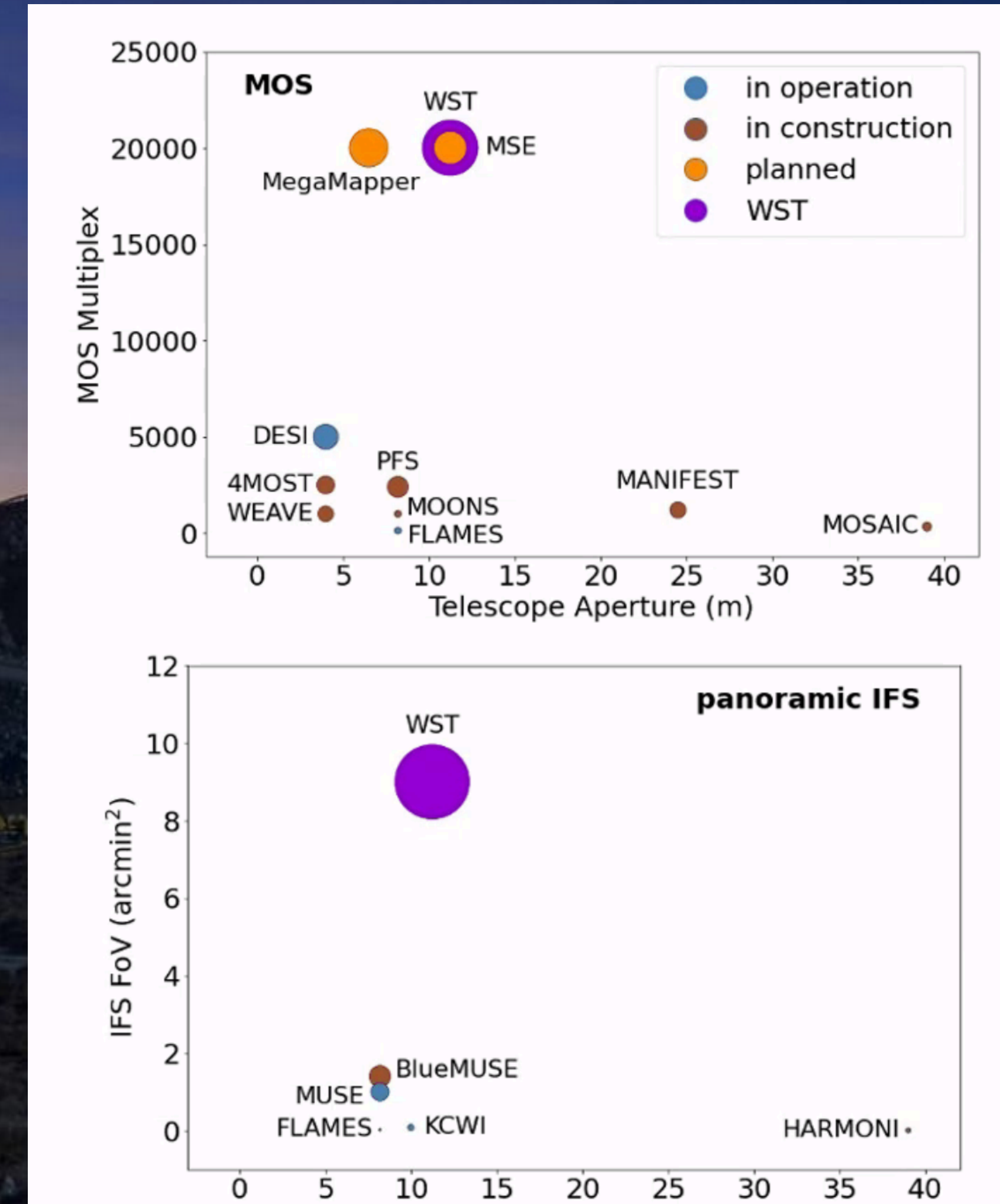
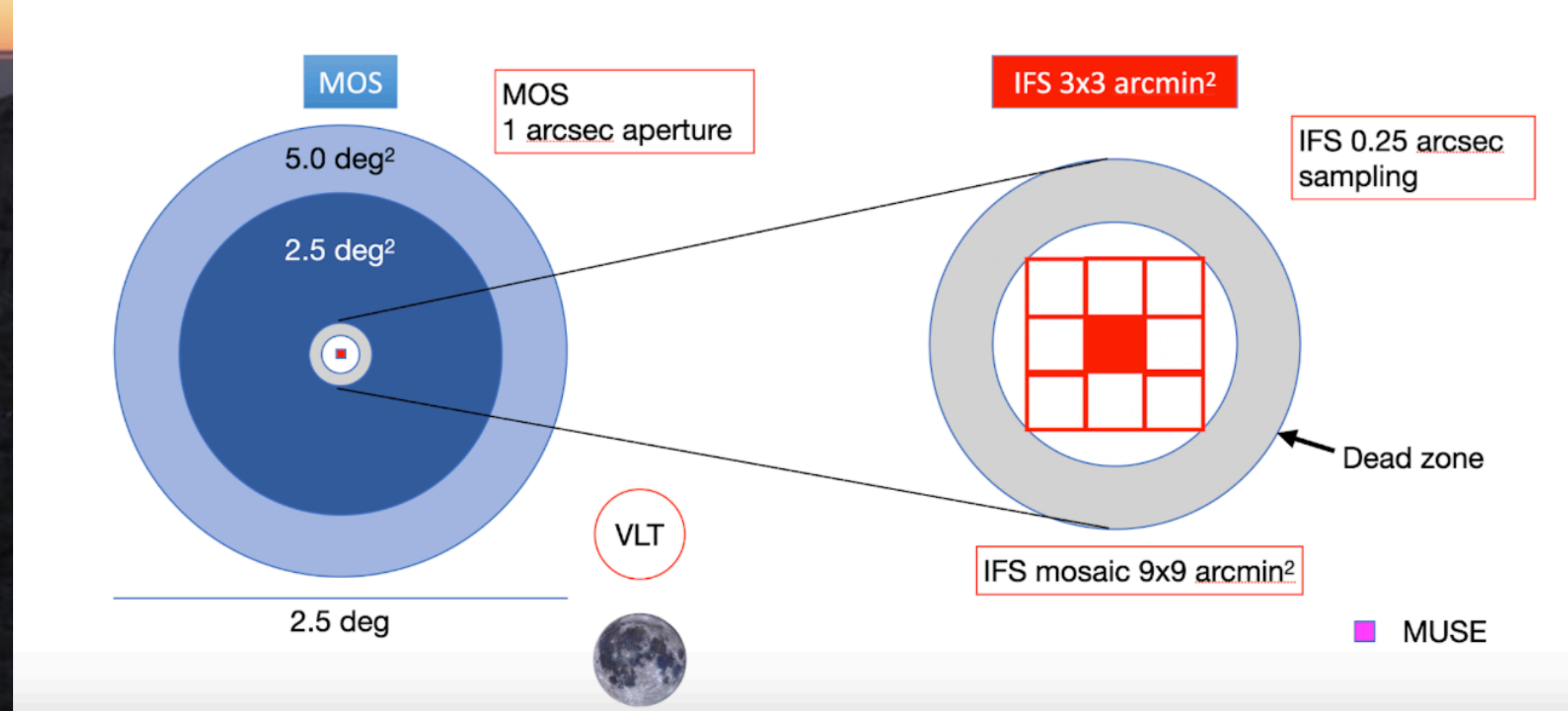
IFS and MOS with the Wide-field Spectroscopic Telescope

Science case “WST - ET synergies for BNS multi-messenger observations”
within the WST Time Domain Working Group

Division 4 of the ET-OSB:
Multimessenger Observations



PI: Roland Bacon (CRAL)



ET-VRO-WST

ET simulations

KN + GRB simulations

WST simulator

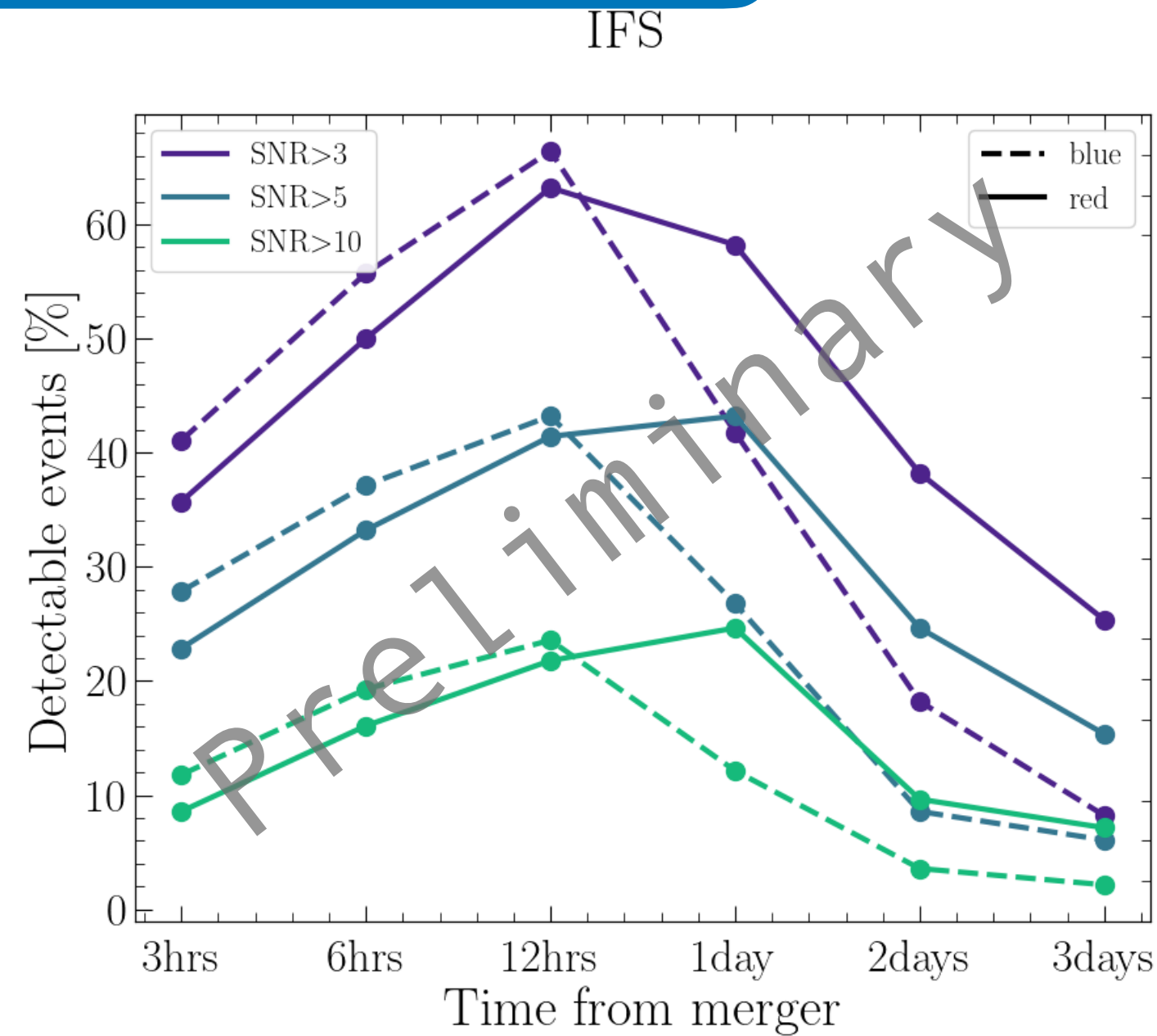
- explore the **detectability** and **characterizations** with WST of the EM counterparts of ET BNS
- analyse how the results depend on the **observable and intrinsic properties** of the population of **ET BNS**

ET-VRO-WST

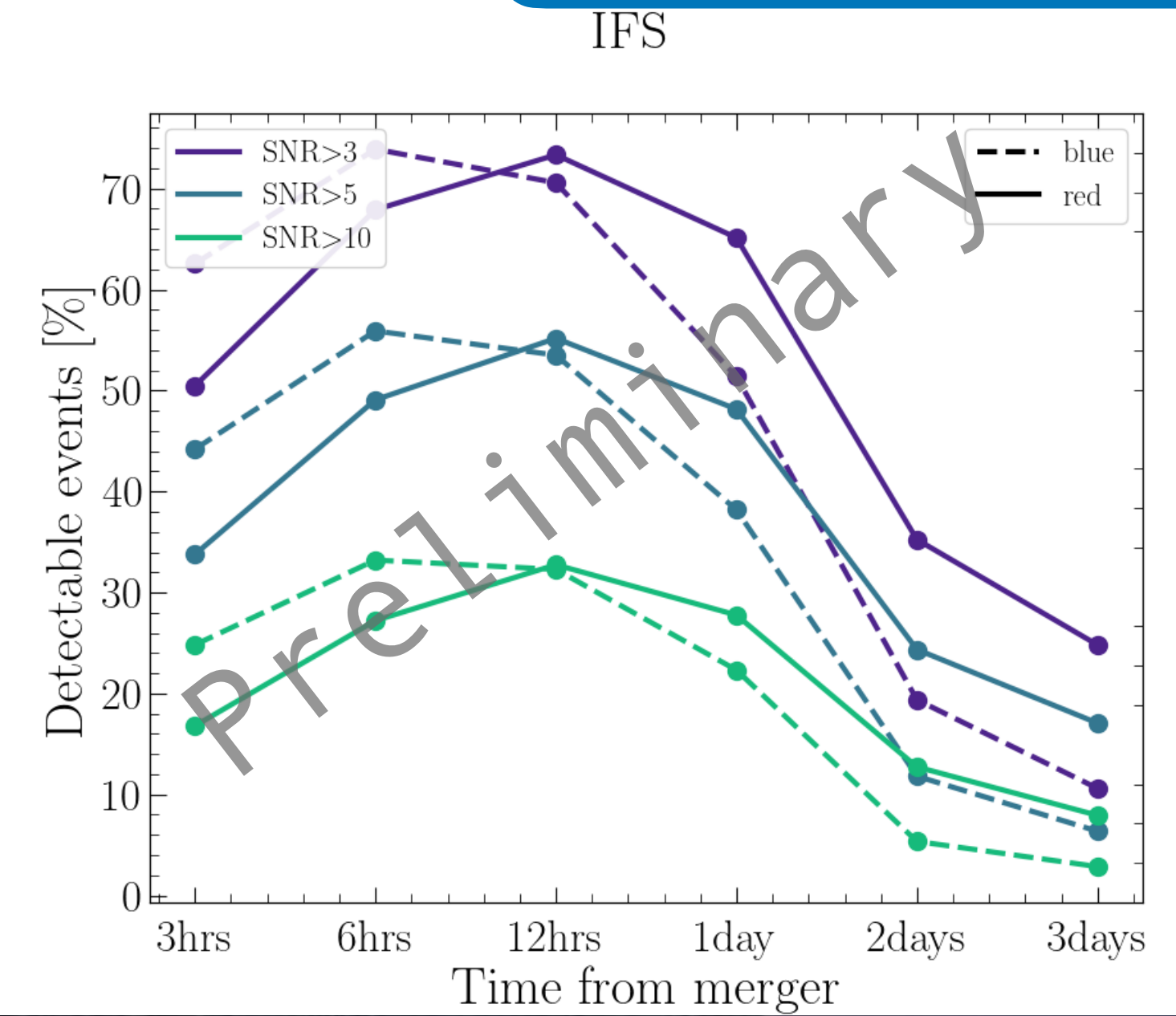
Preliminary results

AT2017gfo KN model

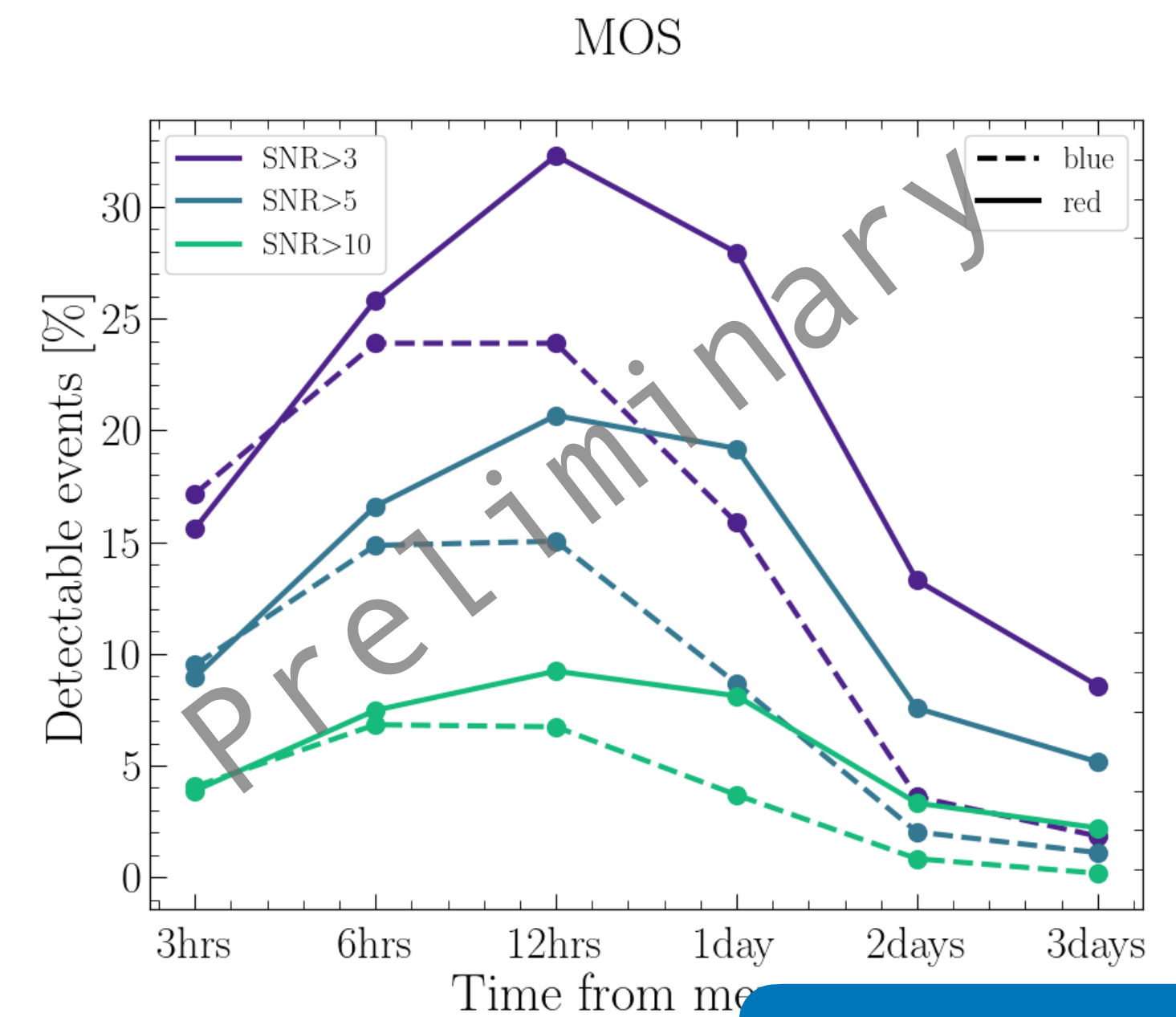
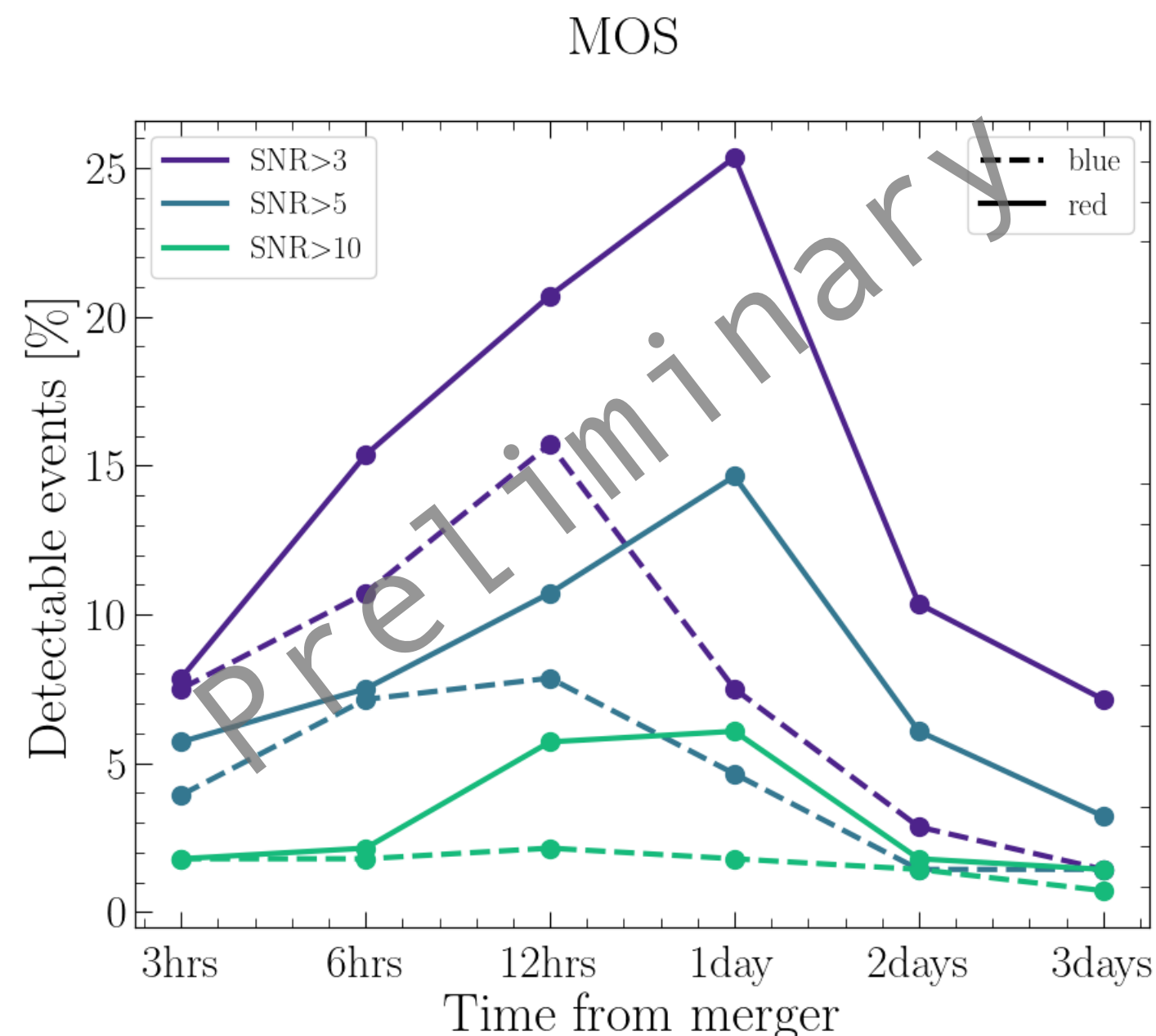
1 year of ET operations



10 years of ET operations



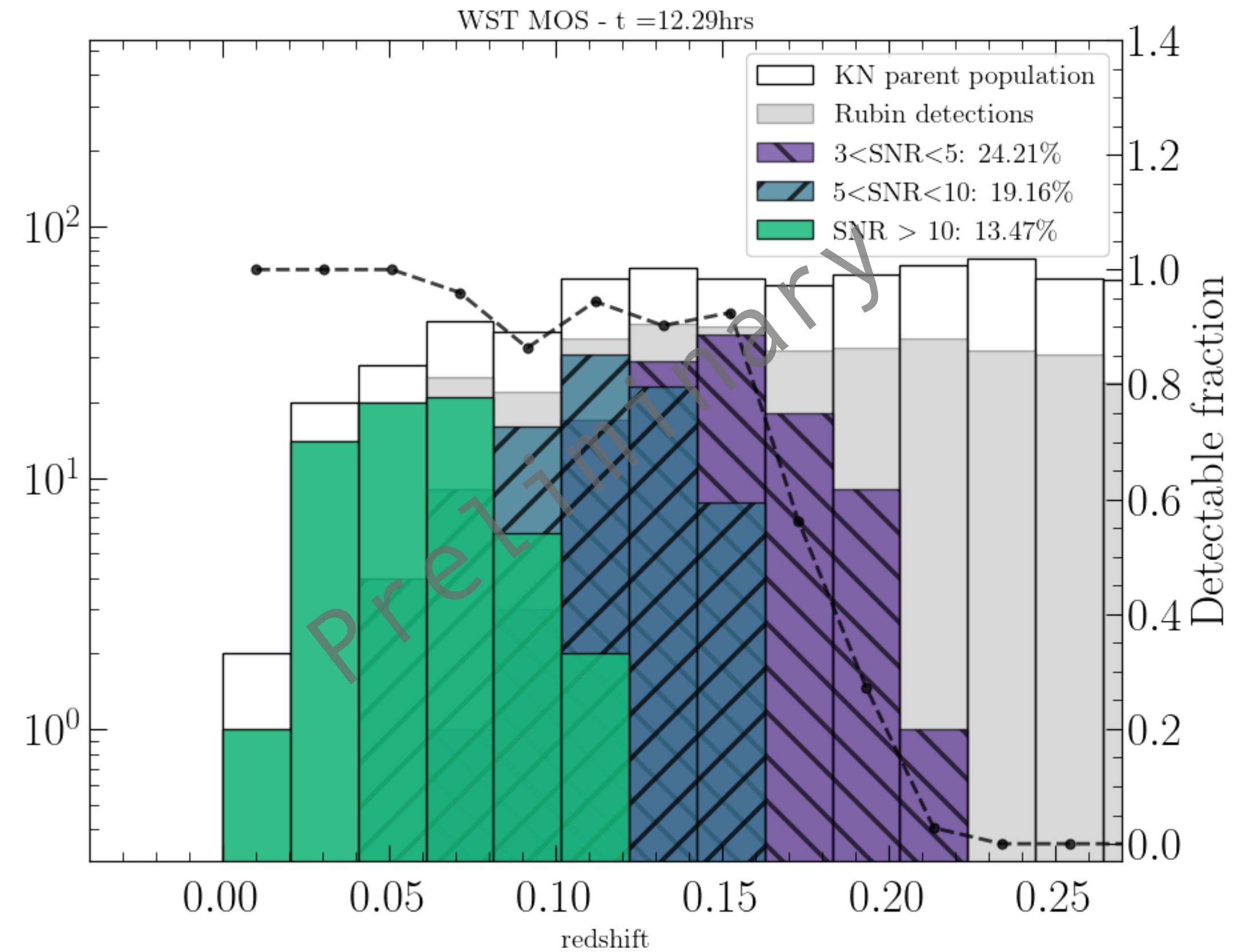
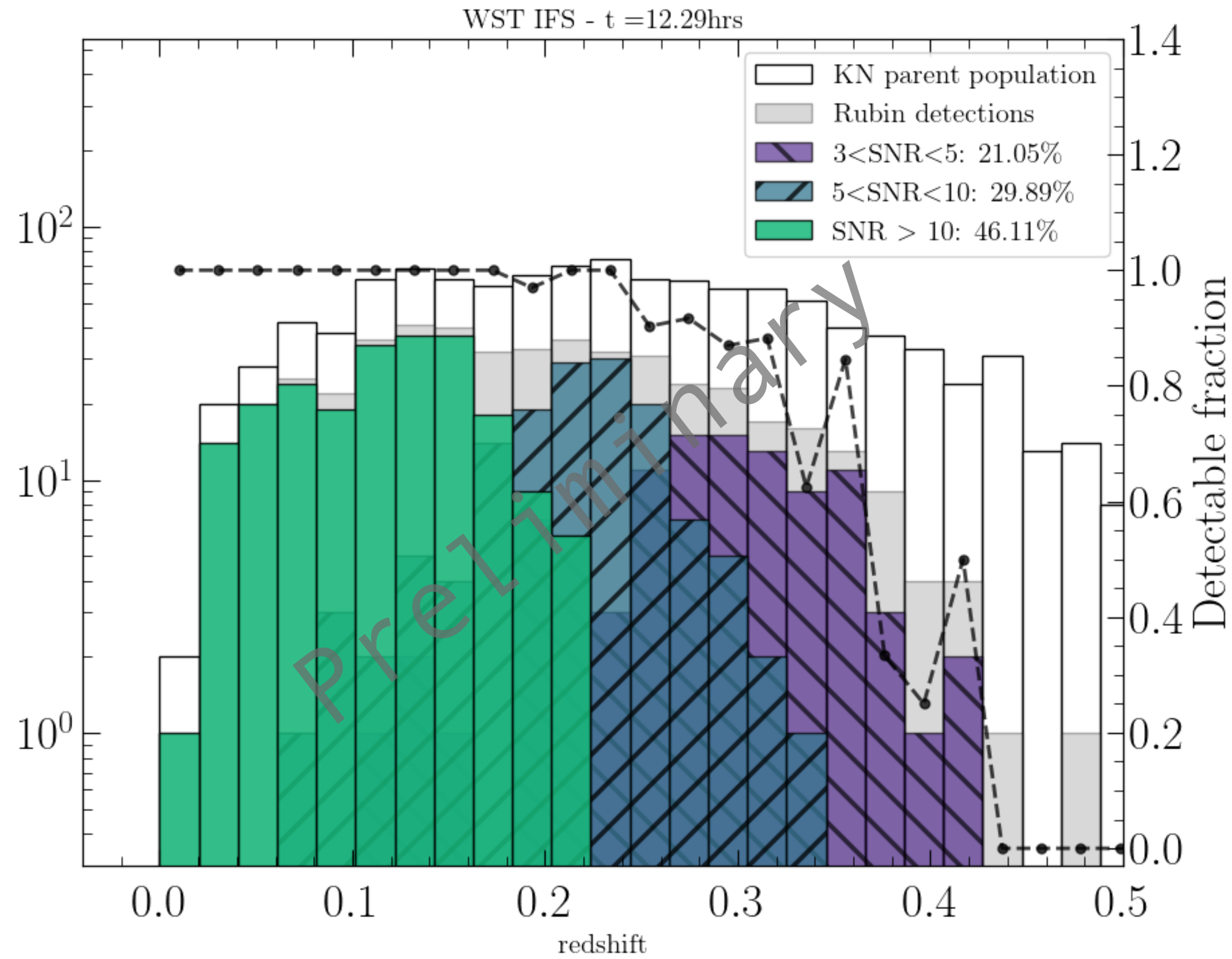
KN theoretical models



ET-VRO-WST

Preliminary results

Comparison with Rubin



White: **ET BNS detections** in 10 years of operations

Grey: **Rubin detections**

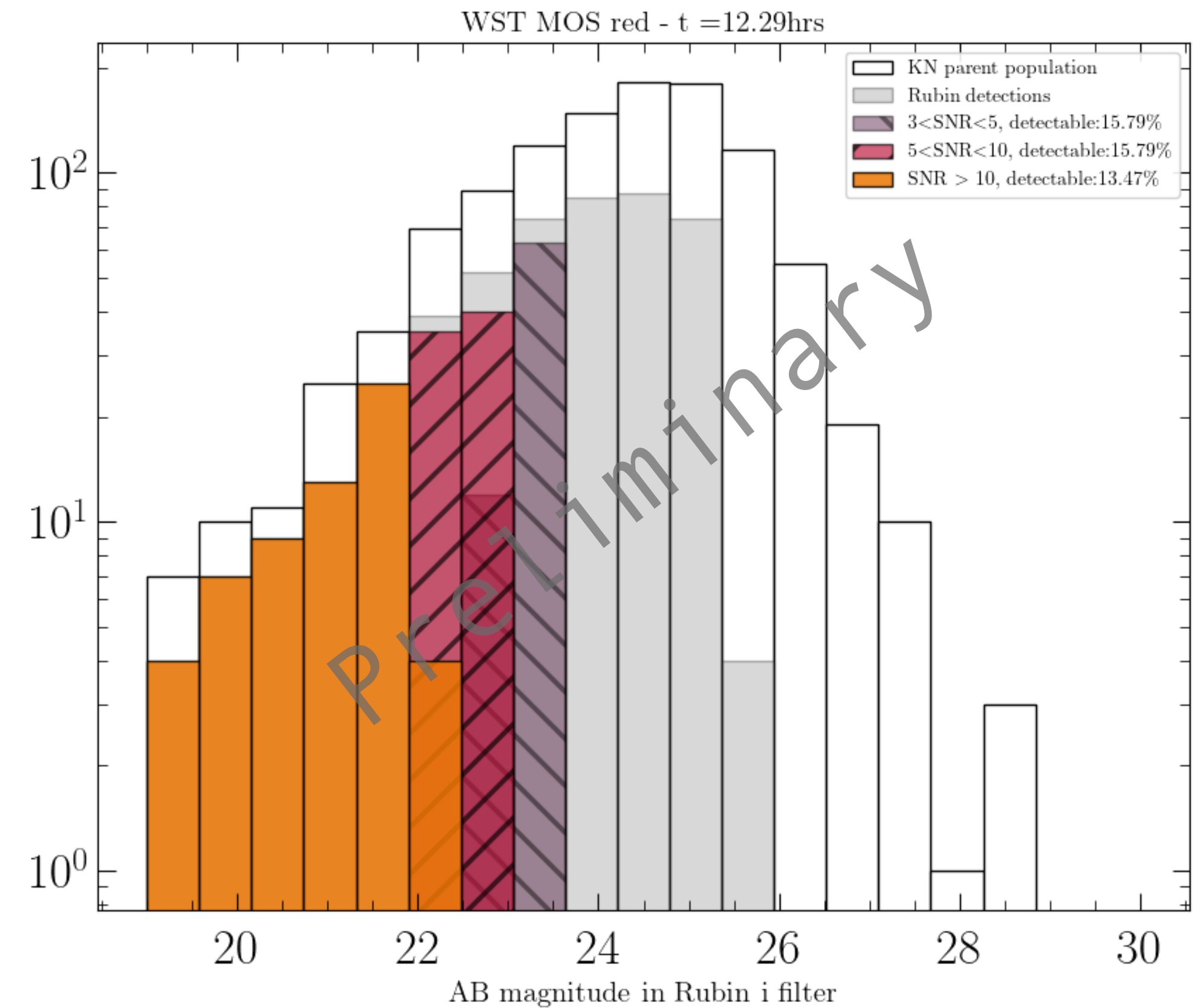
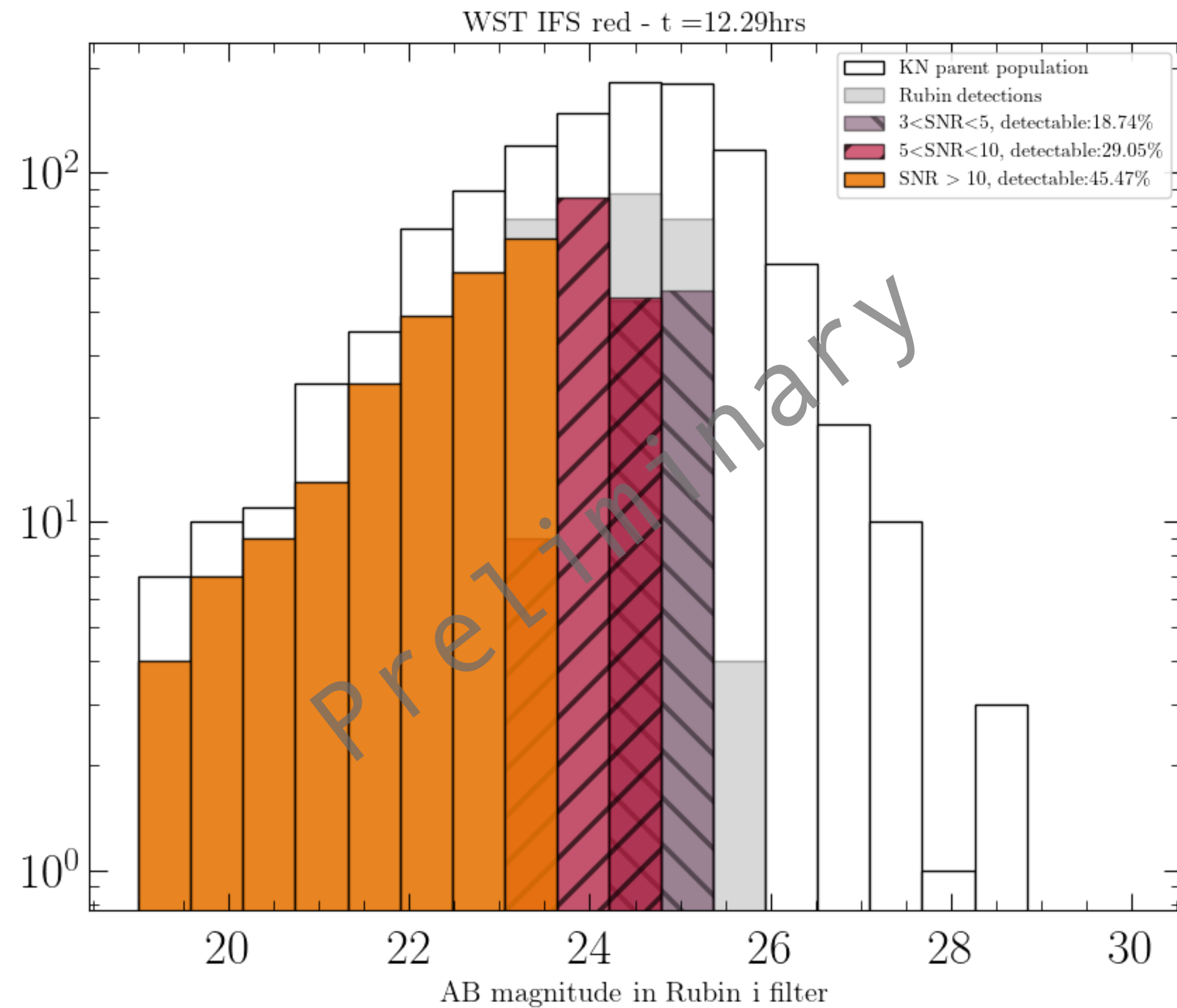
Colored: **WST detections**

BLh gaussian

ET-VRO-WST

Preliminary results

Comparison with Rubin



White: **ET BNS detections** in 10 years of operations

Grey: **Rubin detections**

Colored: **WST detections**

BLh gaussian

Conclusions and future prospects

- Rubin photometric observations will provide a substantial amount of EM **counterpart candidates**; **spectroscopy** will be crucial to **identify** and **characterise** them
- **IFS** and **MOS** are well suited for the **identification** and **characterisation** of **EM counterparts**
- With WST, **KN** can be unveiled up to **$z \sim 0.4$** and **AB magnitude ~ 25**
- **GRB afterglows** contribution is observable at **high redshift** for systems with small viewing angle, up to **$\sim 15^\circ$**
- This work can be adapted to make predictions for **LVK O5**, with IFS and MOS facilities available at the time of O5 operations



Thank you!