



中国科学院
CHINESE ACADEMY OF SCIENCES



天关卫星科学运行



刘禾阳

中国科学院国家天文台 (EP科学中心)

爱因斯坦探针 Einstein Probe

中国主导的国际合作，欧空局、德国马普所、法宇航



宽场 X 射线望远镜 WXT
视场 >3600 平方度



后随 X 射线望远镜 FXT



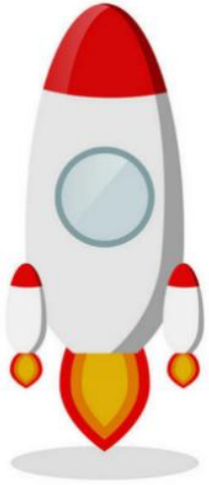
星上暂现源自动搜寻、卫星快速机动
指向、自主FXT后随观测、警报信息
快速下传

大视场，比其它设备灵敏度和空间分辨率
高1-2 数量级



- ★ 首次大规模采用X 射线龙虾眼‘微孔聚焦成像’技术
- ★ 首次采用CMOS探测器进行空间X射线天文探测
- ★ 看得更远、更暗、更精；

FIRST YEAR OF OPERATION



Spacecraft
Commissioning

Performance Verification

Nominal
Operations

Jan. 9
Launched

Jan. 11
Satellite status setting
completed

Jan. 19
WXT first light
WXT Calibration start

Apr. 5-Jul. 8
FXT continued in-orbit
calibration

Mar. 22
Performance Verification
Phase start

Feb. 22
FXT cap unfolded
FXT first light

Mar. 5-Mar. 19
FXT Calibration

Apr. 27

Jul. 9

Jul. 22

EP consortium formally released the first
light images acquired in orbit

Nominal Operations Start

Satellite Delivery Review

Nominal Operations (3ys)

EP观测模式

- * 轨道

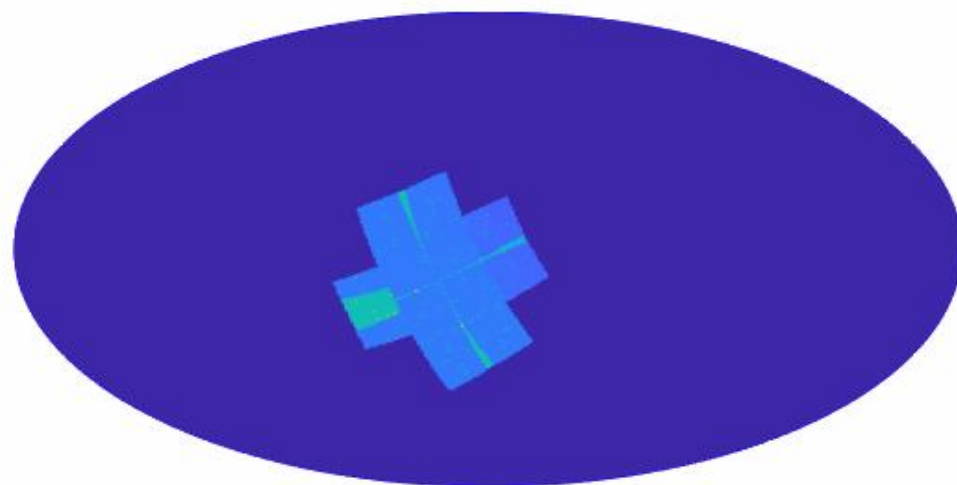
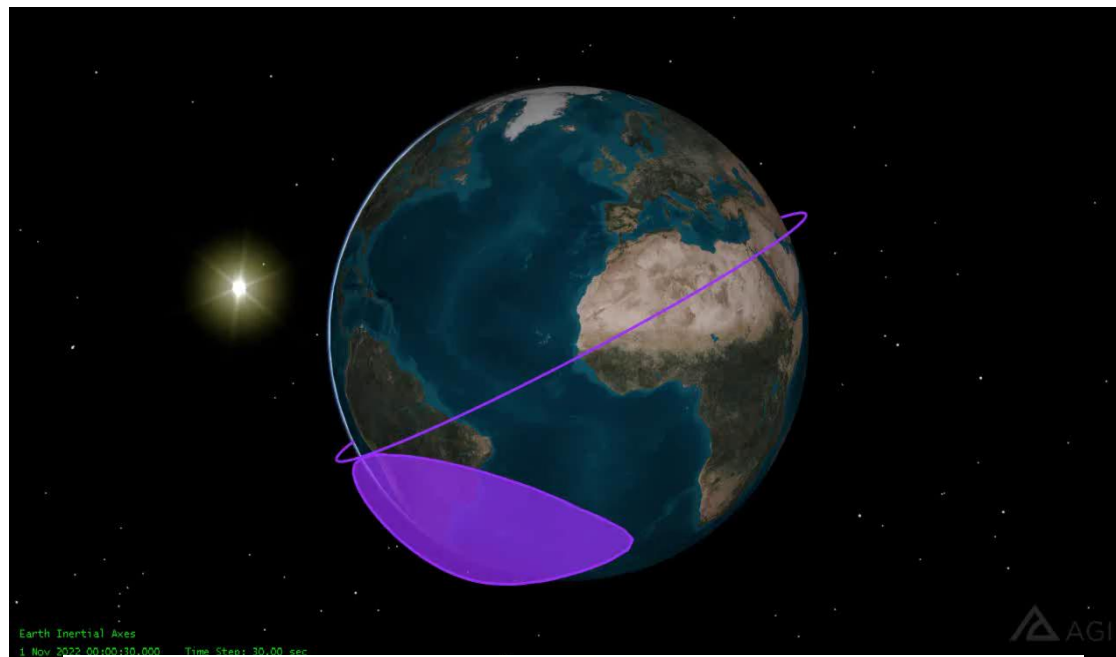
- ★ 高度592 km, 轨道周期 96min
- ★ 轨道倾角 29 deg.

- * 观测模式

- ★ 巡天模式 (**primary WXT**)
- ★ 自主后随模式 (**FXT**)
- ★ **ToO** 模式 (**FXT, WXT**)
- ★ 定标模式

- * 巡天模式

- ★ 指向夜天区
- ★ 每轨**3**个指向, 每个指向 **~20min**
- ★ **3**轨覆盖夜天区 (约**5**个小时)
- ★ 半年覆盖全天
- ★ 指向由**FXT**决定, **FXT**指向预先选定目标



预先选定目标：Cycle-N 观测申请（年度规划）

EP Observing Proposal System

EP Observing Proposal Cycle-1: STP Observer Program

Deadline in: 19d 1h 17m 12s

Call for science proposals is open

FXT Survey-mode Target Observation (FSTO), including non-ToO observations and anticipated-ToO for known sources, opens to STP Member and Associate Member only.

Create a new proposal

My proposal list

EP Observing Proposal Cycle-1: Guest Observer (GO) Program

Deadline in: 19d 1h 17m 12s

Call for science proposals is open

Guest Observation (GO), including non-ToO observations and anticipated-ToO for known sources, opens to non-STP proposers whose primary affiliations are in China.

Create a new proposal

My proposal list

ToO and DDT observations

ToO-MM observations

Proposal Documents

EP Technical Handbook (PDF)

Proposal Tools

EP Long-term Visibility Check Tool

Check EP long-term visibility for specific source coordinates in the sky.

WXT Online Simulator

Simulate point-like X-ray sources to be observed by WXT.

FXT Online Simulator

Simulate point-like X-ray sources to be observed by FXT.

FXT Technical Evaluation Tool

Perform technical evaluation (photon pile-up and optical loading) for the input source parameters and FXT configuration.

观测提案系统

Add Single Observation

Source Information

Source Name

test

RA (J2000)

0

degree

Dec (J2000)

0

degree

Target Visibility Tool

0.3-10 keV Flux

0

erg/cm²/s

0.3-10 keV Photon Index

0

V-band Magnitude

0

Variable Source:

No

Extended Source:

No

Observation Parameters

Exposure Time

1000

second

Continuous Exposure:

Not Necessary

Time Critical Parameters

Observing Window Constraints

Begin Time

Begin Time

End Time

End Time

Other Time Constraints (less than 200 words):

Anticipated ToO's Parameters

Trigger Probability

0.6

FXT Configuration

FXT-1 Window Mode:

Full Frame

FXT-1 Filter:

Thin Filter

FXT-2 Window Mode:

Full Frame

FXT-2 Filter:

Thin Filter

FXT Toolmask Evaluation Tool

Back to observation list

Save

提案填写界面

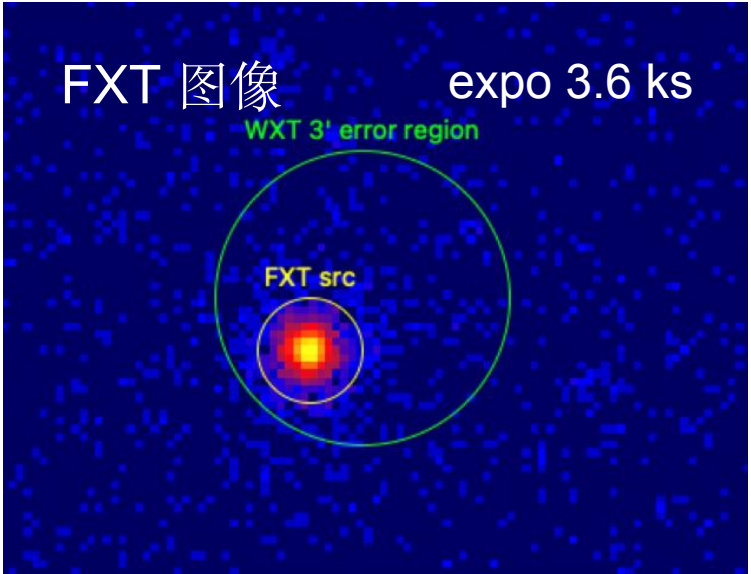
自主后随模式

触发条件

- * 信噪比 > 7
- * 银纬大于10度 ($|b| > 10 \text{ deg}$)
- * 不在星上源表中
- * 满足观测约束
- * 优先级高于星上当前执行任务

示例：EP240605a

- * 触发时刻 2024-06-05UT16:10:30
- * 12秒后地面收到北斗警报
- * 74秒后FXT开始后随观测
- * FXT能谱和光变表明来自恒星耀发

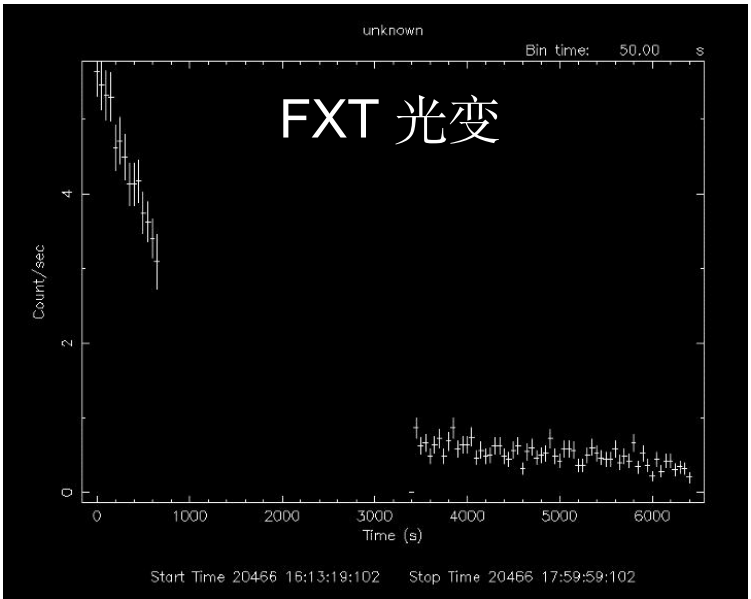


Beidou Alert: 01708918013 CMOS14

EP240605a北斗警报

RA, Dec	19.907, -68.695
RA (HMS), Dec (DMS)	01h19m37.7s, -68d41m42.0s
Observation Time (UTC)	2024-06-05 16:00:40
X	2674.2
Net Rate	0.06
Significance	8.1

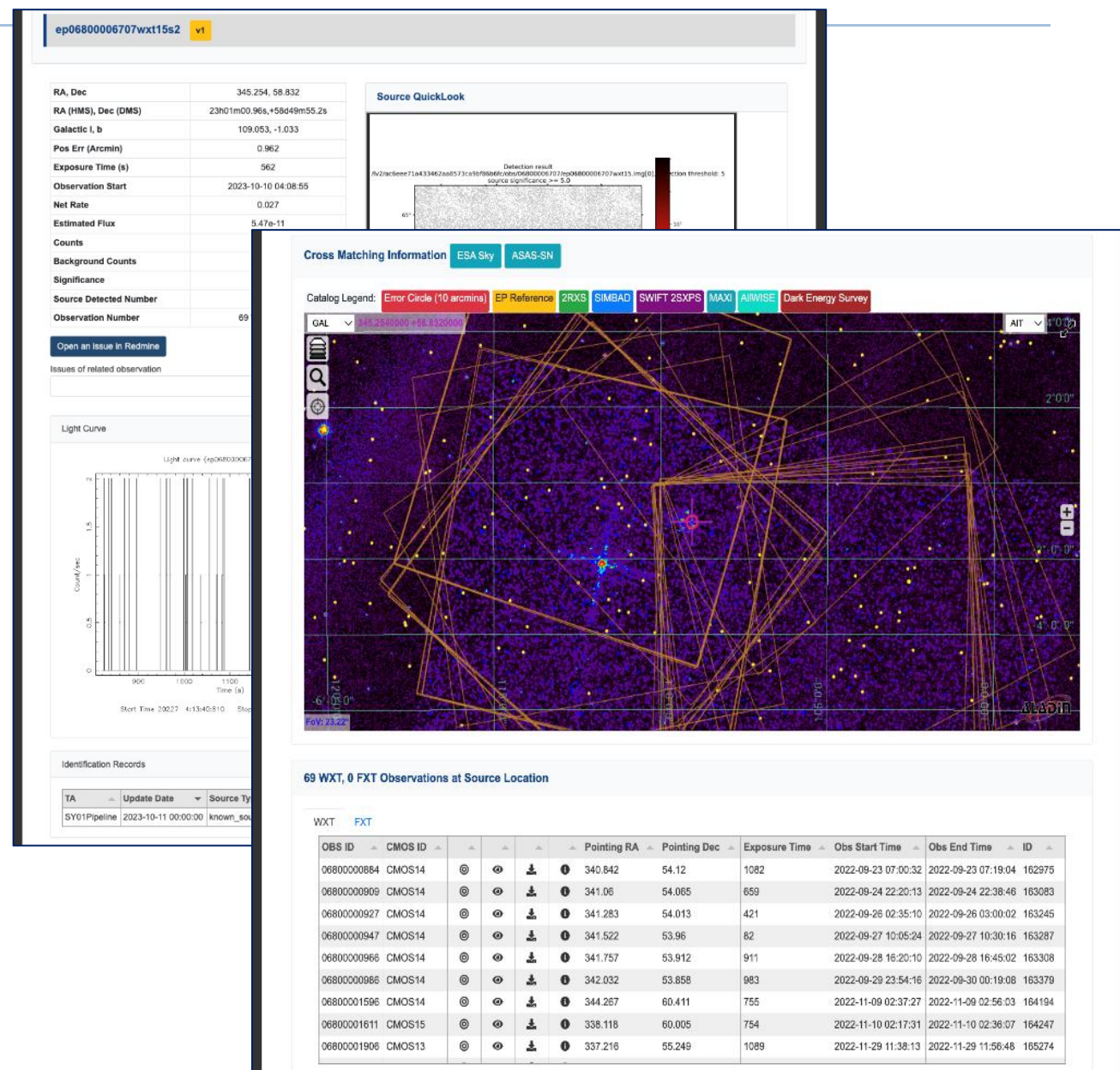
Galactic l, b	299.095, -48.223
1 σ Pos Err (arcmin)	0.692
Trigger Time (UTC)	2024-06-05 16:10:30
Y	3576.6
Variance ?	13.34
HR ?	0.18



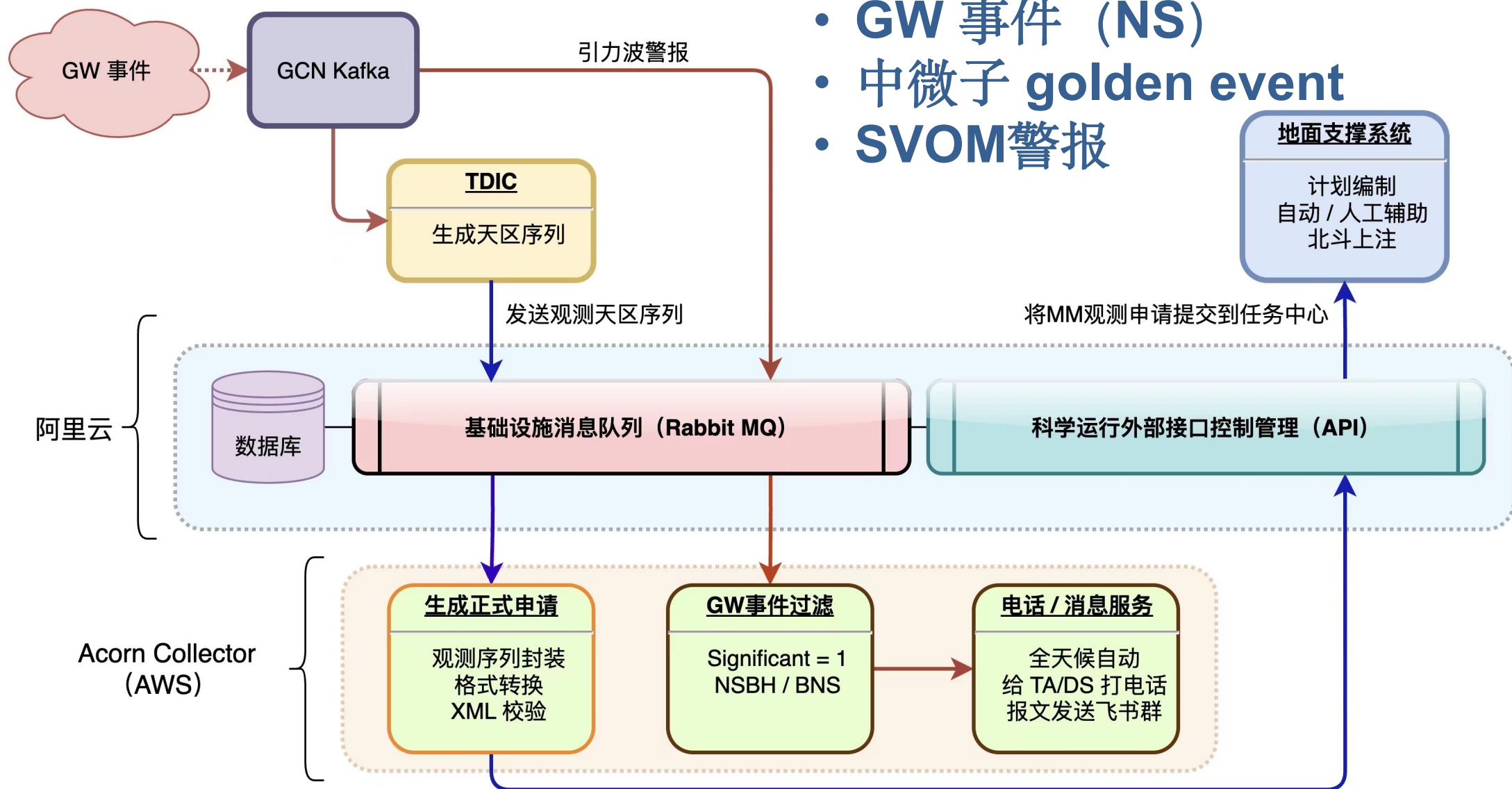
ToO 观测模式 I: 地面触发警报

自动化证认+人工证认

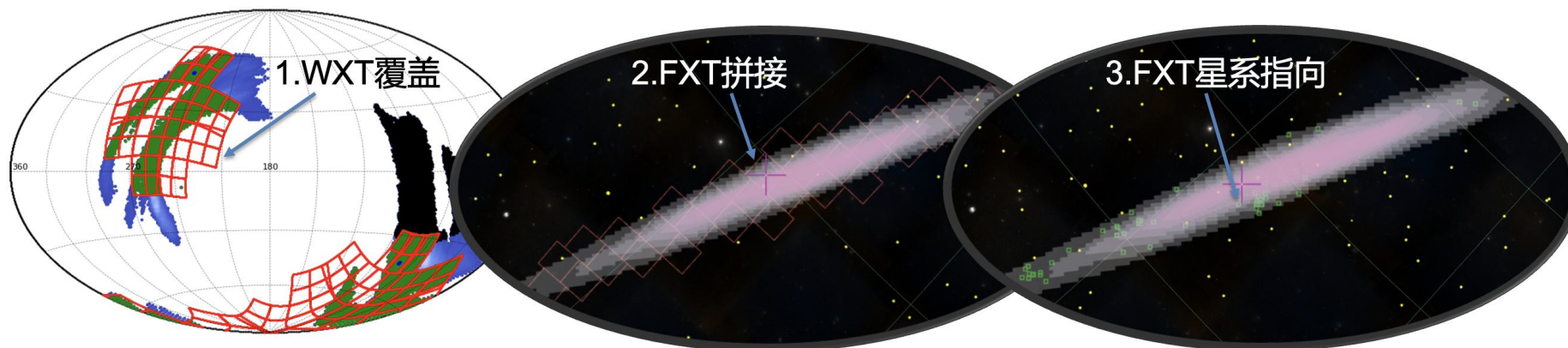
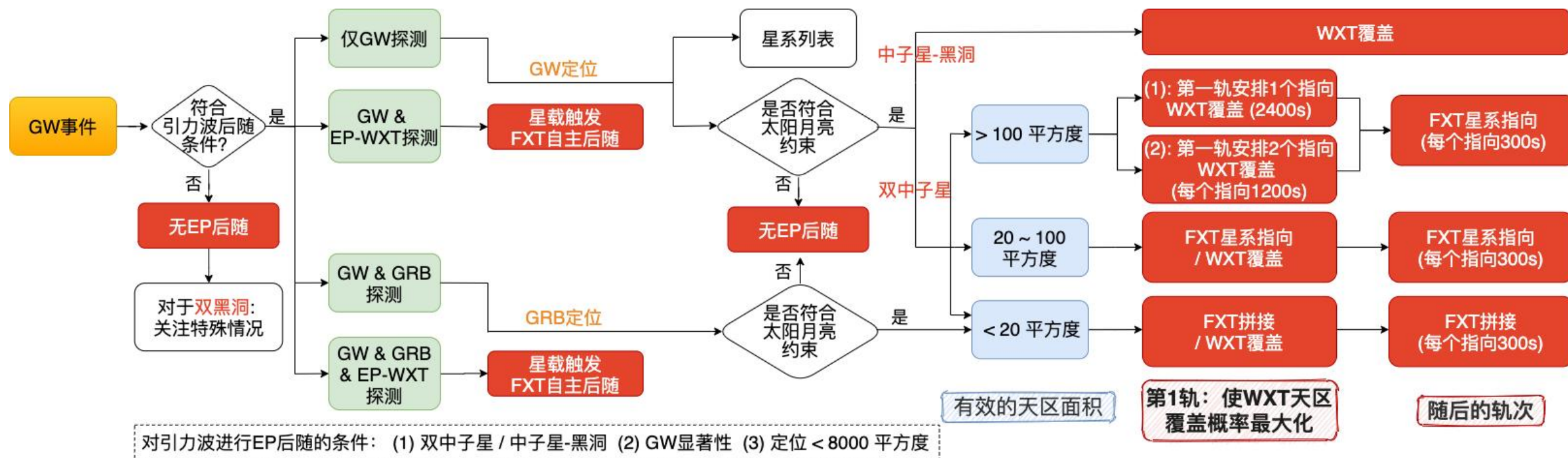
- ★已知源表匹配
- ★机器学习分类
- ★自动关联Atel GCN TNS 警报
- ★人工结合多波段数据



ToO 观测模式 II: 外部警报 (多波段 & 多信使)



ToO 观测模式 II: ToO-MM 观测策略

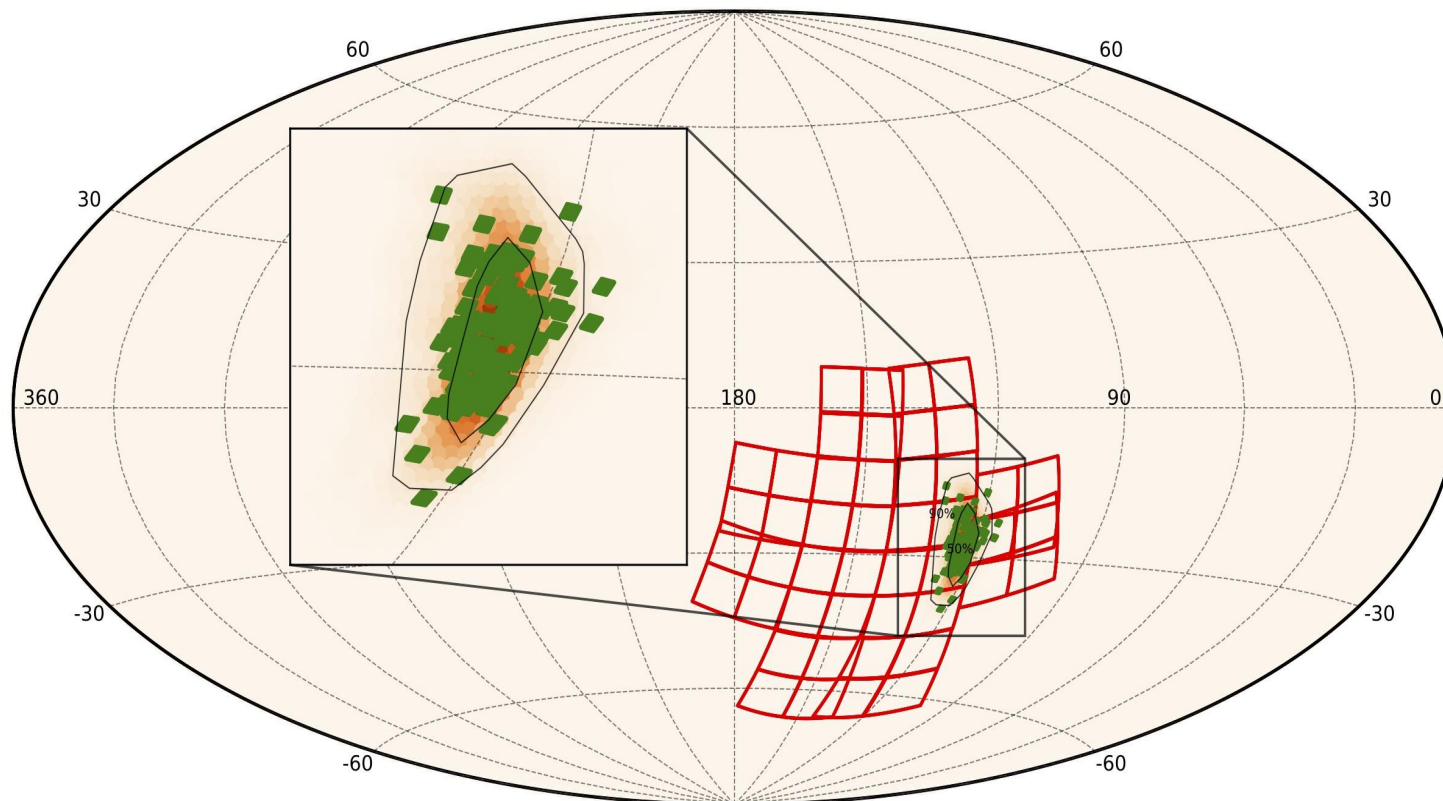


ToO 观测模式 II: ToO-MM 观测示例 (S240422ed)

■ EP后随:

- ★ GW时间T0:
2024-04-22T21:35:13Z
- ★ 覆盖GW天区的最早时刻 (过SAA后)
2024-04-22 22:00:00
- ★ 上注ToO-MM后随时间:
2024-04-23T00:35:14Z
~ 2024-04-27T11:18:21Z
- ★ WXT、FXT后随观测数: 223
- ★ 每次观测的FXT曝光时间:
中值 312 秒、平均 591秒

■ 在引力波90%误差天区内的FXT WXT覆盖情况



绿色: FXT视场, 红色: WXT视场 (WXT仅为一次指向的覆盖展示)

ToO 观测模式 III: ToO & DDT观测申请

EP Observing Proposal System (EOPS)

EP Observing Proposal Cycle-1: STP Observer Program

[Proposer's Guidance](#)

STP Observer Program, including non-ToO observations and anticipated-ToO for known sources, opens to STP Member and Associate Member only. Please read the proposer's guidance carefully before submitting a proposal.

My proposal list

EP Observing Proposal Cycle-1: Guest Observer (GO) Program

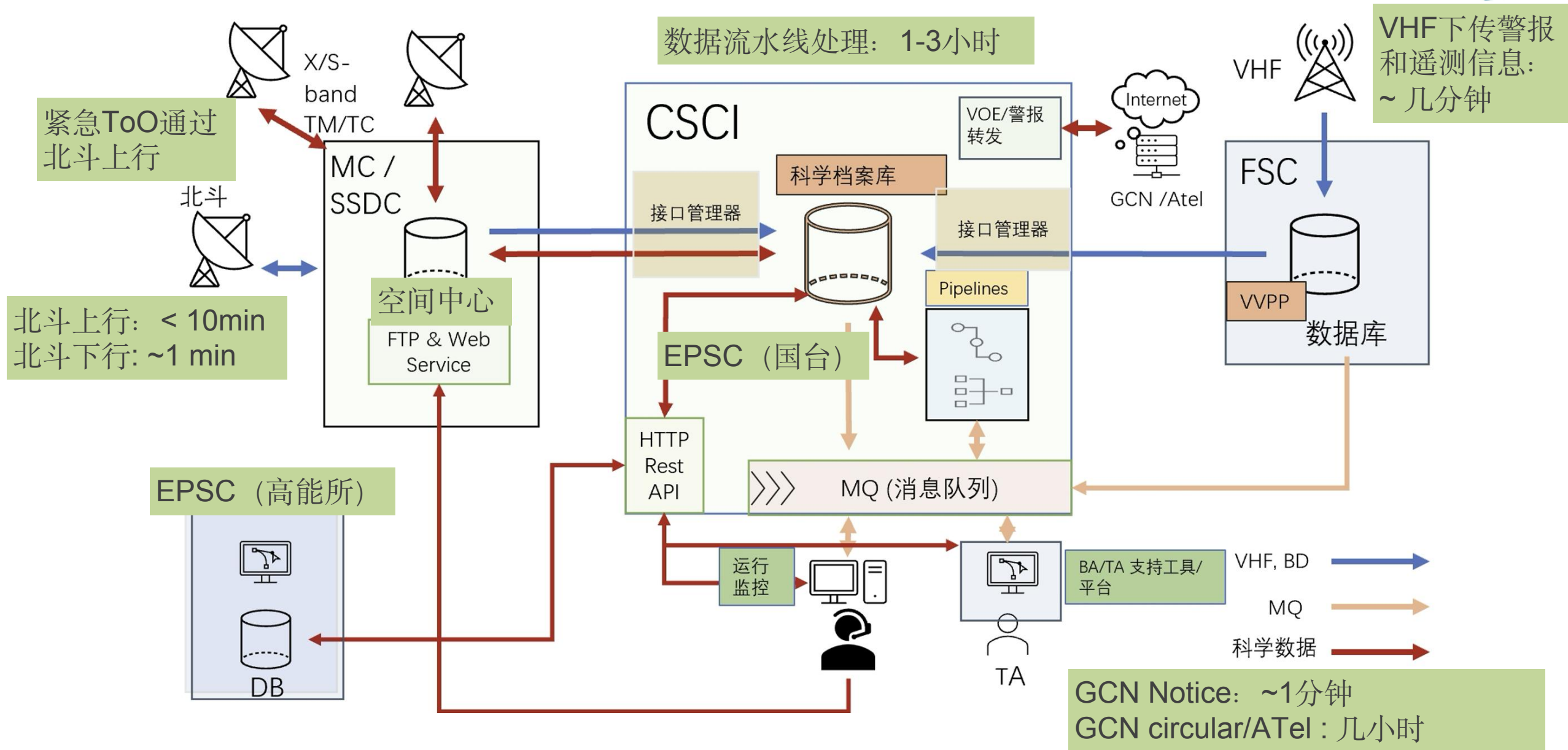
[Proposer's Guidance](#)

Guest Observer (GO) Program, including non-ToO observations and anticipated-ToO for known sources, opens to non-STP proposers whose primary affiliations are in China. Please read the proposer's guidance carefully before submitting a proposal.

[ToO and DDT observations](#)

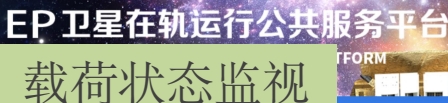
[ToO-MM observations](#)

EP科学运行: ToO上行、警报下传、数据传输和处理流程





源证认工具



后随和协同观测

➤ EP发布的暂现源警报已经触发了国内和国际大量多波段望远镜的后随观测

- ◆ 国内：兴隆、丽江、新疆、冷湖
- ◆ 国际：Keck、Gemini、GTC、SALT大口径光学/红外望远
- ◆ 空间：Swift、NICER、Chandra等

➤ 后随观测方式

- ◆ 公开警报信息：GCN Notice/circular; ATel
- ◆ 内部接口
- ◆ EP科学团队申请



EP日常值班

* 值班人员

- ★ 观测值班助手：来自EP科学中心和科学团队
- ★ 值班科学家：来自EP科学中心
- ★ 载荷专家：来自载荷团队

* 主要值班内容

- ★ 源认证以及后续处理
- ★ ToO观测申请处理
- ★ 载荷状态监视、参数/软件更新

* 值班时间

- ★ 9:00-21:00

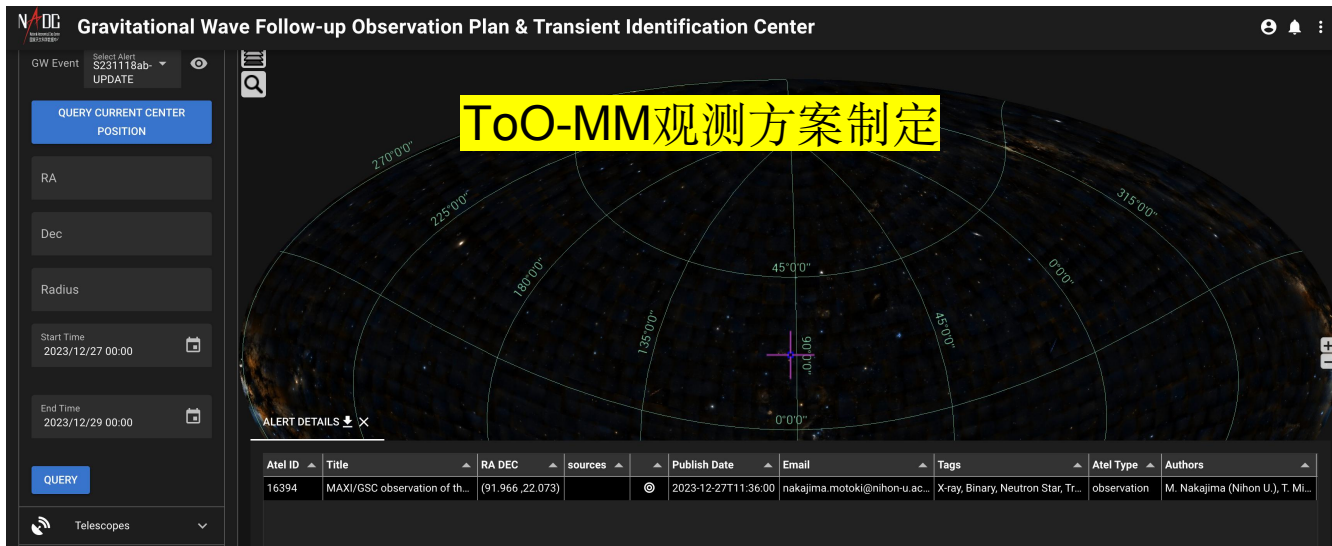
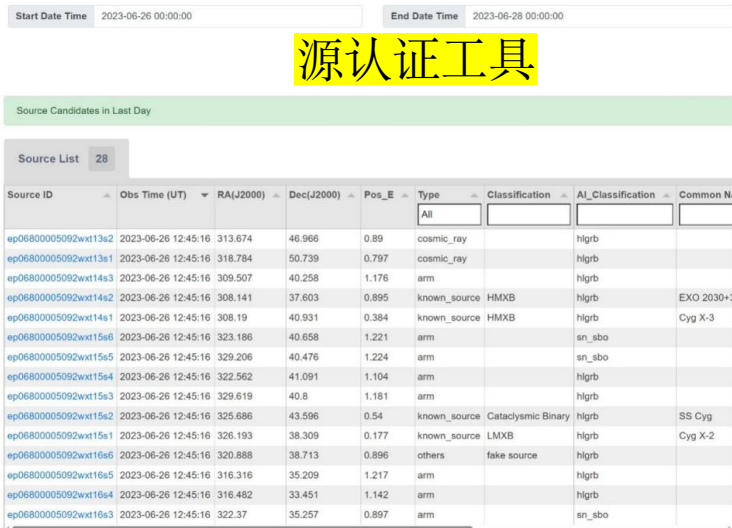
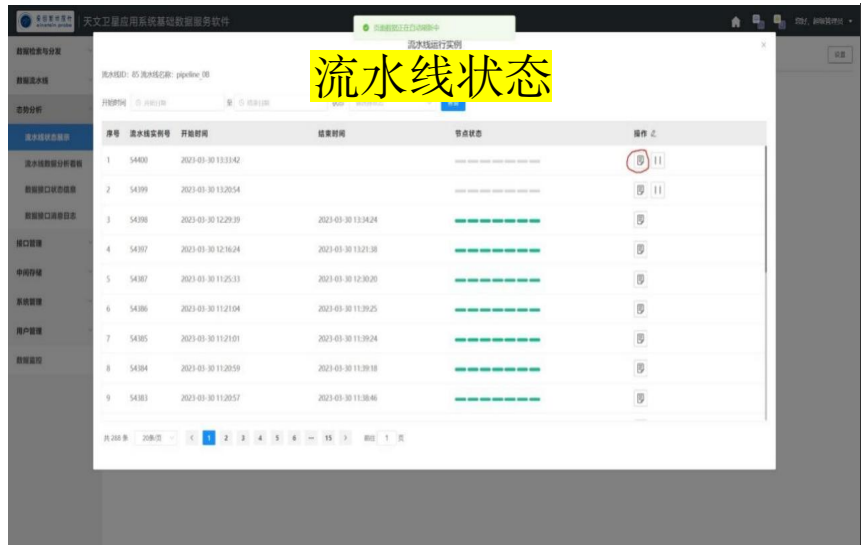
* 值班地点

- ★ 前期国台运控室，后期远程



国台运控室

值班支持工具 (PC端)



值班支持工具（飞书，支持PC和手机）

北斗

北斗警报全解析 36

消息 文件 +

北斗警报

警报解析报文 机器人 | 通过webhook将自定义服务的消息推送至飞书 昨天 00:16

```
[{"BD alert": {"alarmType": 0, "caldbver": "x20391113", "checksum": "jEdCIBZAJbDAjBZA", "clockapp": "F", "cmosNum": "32", "datasum": "0", "dateEnd": "2024-04-22T16:03:17.683", "dateObs": "2024-04-22T15:56:57.333", "dec": "-7.448000000", "decObj": "-7.448", "decPnt": "-7.448", "delflag": 0, "detnam": "CMOS32", "hr": "0.08", "instrume": "WXT", "mjdreff": "0.00080074074", "mjdreffi": "58849", "netRate": "0.18", "object": "01708651252", "obsId": "01708651252", "origin": "NAOC", "paPnt": "0", "posErr": "39.555999999", "procver": "3.17.13", "q1": "0.215376183", "q2": "0.087278634", "q3": "0.943379998", "q4": "-0.236705958", "ra": "195.394000000", "raObj": "195.394", "raPnt": "195.394", "reproc": "T", "segNum": "252", "seqpnum": "0", "softver": "Hea_15Aug2039_V6.22_epwxtas_11Jul39_v3.4.0", "srcSignificance": "8.4"}}
```

GW

GCN引力波警报 41 1

消息 Pin +

LIGO 警报

刘禾阳: 引力波警报通过本群推送，请各位值班人员及时关注；优先关注significant为1且NS概率... 由 刘禾阳 置顶

```
{ "pipeline": "MBTA", "properties": { "hasMassGap": "0.004807692307692308", "hasNS": "0.0", "hasRemnant": "0.0" }, "search": "AllSky", "significant": "1" }
```

GW 机器人 | GW

```
[{"LIGO Notice": {"ISOTime": "2024-04-21T05:29:35.734400Z", "alertType": "Update", "classification": { "BBH": "0.41391150101247964", "BNS": "0.0", "NSBH": "0.0", "terrestrial": "0.5860884989875204" }, "createdTime": "2024-04-23T17:16:38Z", "eventPage": "https://gracedb.ligo.org/superevents/S240421ar/view/", "far": "3.59706e-08", "graceID": "S240421ar", "group": "CBC", "instruments": "H1,L1", "pipeline": "CWB", "properties": { "hasMassGap": "0.0", "hasNS": "0.0", "hasRemnant": "0.0" }, "search": "BBH", "significant": "1" }}
```

源认证提醒 3

消息 Pin

源认证提醒

刘禾阳: 本群将推送流水线运行情况，TA收到提醒后请在第一时间进行派 由 刘禾阳 置顶

[二级产品流水线完成] 可以去认证源啦! TraceID: 1236

流水线状态 机器人 | proc/#

[二级产品流水线启动] ObsID: 10202561058. No metadata

[二级产品流水线启动] ObsID: 10202561059. No metadata

[二级产品流水线启动] ObsID: 10202561060. No metadata

[二级产品流水线启动] ObsID: 10202561061. No metadata

刘禾阳

本群消息较多，建议非值班时段开启免打扰 @所有人

OK 胡静维

momo

现在流水线启动和INFO两条消息已合并为一条

胡静维

流水线状态 机器人 | proc/#

[二级产品流水线完成] 可以去认证源啦! TraceID: bc61

流水线状态 机器人 | proc/#

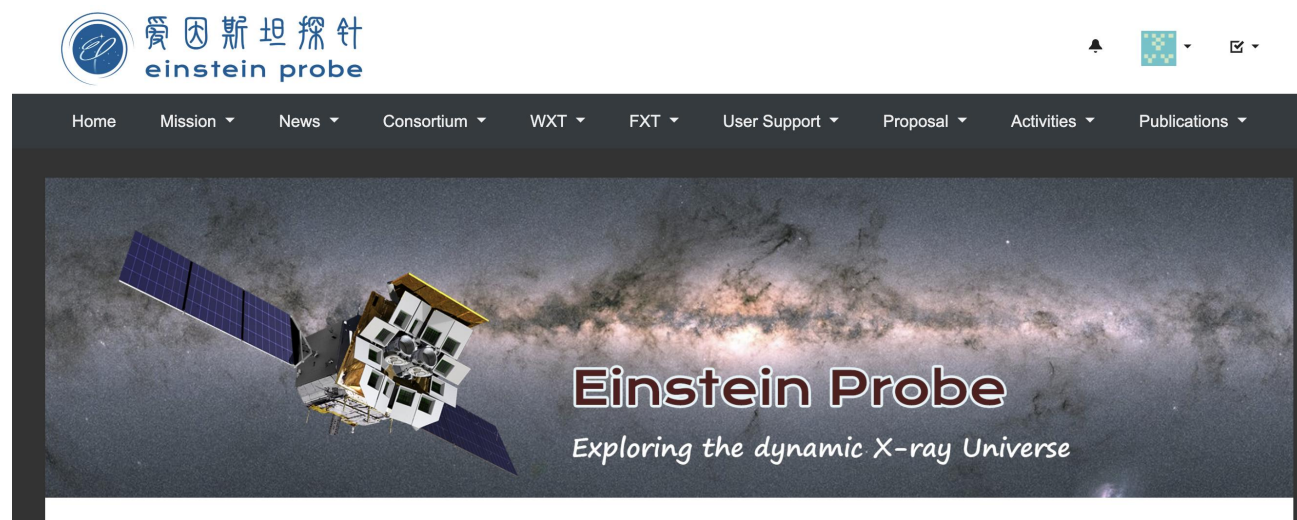
[二级产品流水线完成] 可以去认证源啦! TraceID: 660e

[二级产品流水线完成] 可以去认证源啦! TraceID: 6c4e

[二级产品流水线完成] 可以去认证源啦! TraceID: 7278

数据政策

- ◆ 暂现源警报信息： 立即发布
- ◆ 巡天和自主后随数据： 1年后公开
- ◆ EP源表： 定期发布
- ◆ ToO观测：
 - 科学团队申请： 6个月后公开
 - 外部成员申请： 立即公开
- ◆ ToO观测时间比例： CAS-ESA-MPE-CNES: 75% - 10% -10% -5%
- ◆ 外部成员与EP合作： 由SMC以及每个STP chair/co-chair 讨论决定



总结

- ☆ EP作为发现型的天文设备，主要观测模式为巡天+ToO观测，同时引导其它设备进行后随观测。
- ☆ 上下行采用北斗+测控，分别应用于紧急 (~mins) 和非紧急情况 (~day) 。
- ☆ EP数据发布时间
 - ✓ 警报数据：立即发布
 - ✓ 巡天数据：1年后公开
 - ✓ ToO观测：6个月后公开（科学团队申请） / 立即公开（外部成员申请）