CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

CAS A, RCW 86 AND HESS J1731-347 WITH CHANDRA

velocity and width of the synchrotron filaments at the forward shock

daniel castro (cfa) and many collaborators

intro

why should you care about the connection between supernova remnants and cosmic rays?

- origin of galactic crs still undetermined
- ɣ-ray background in the galactic plane dominated by crs interacting with medium
- particle acceleration is ubiquitous in the universe
- snr evolution is modified by particle acceleration
- cr feedback has recently been uncovered as an important element in galaxy evolution

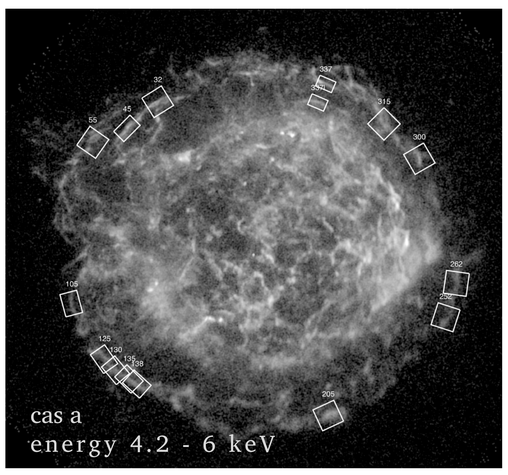
what evidence is there that snrs accelerate cosmic rays?

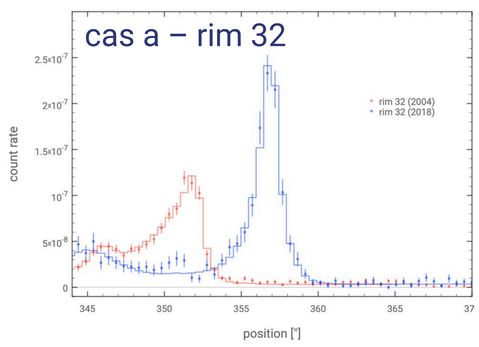
- indirect: the shock structure is modified by cr production
- non-thermal x-ray emission
  - synchrotron from relativistic electrons
  - magnetic field amplification by particle acceleration
- ɣ-ray emission implies relativistic particle production

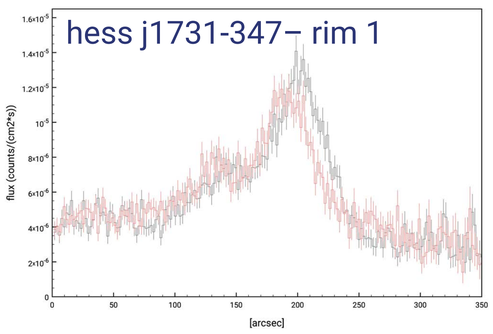
what are the objectives of this study?

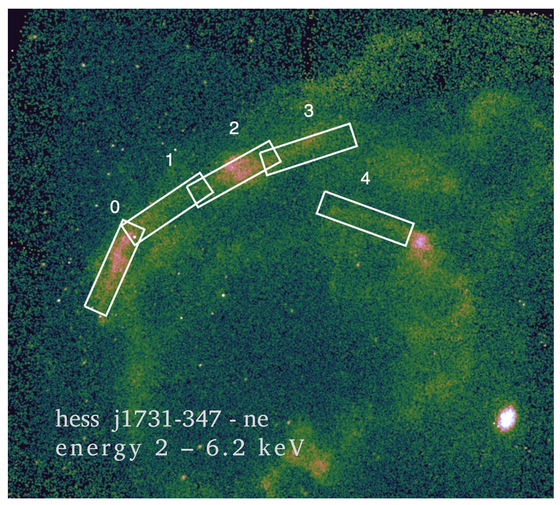
- estimate the velocity of the forward shock around the snr
- determine the synchrotron filament widths in the forward shock rims of cas a, rcw 86 and hess j1731-347
- use these widths to constrain the magnetic field strength
- try to understand the connection between the environment and magnetic field amplification

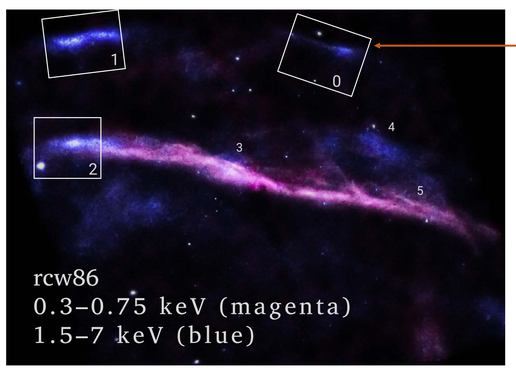
profiles

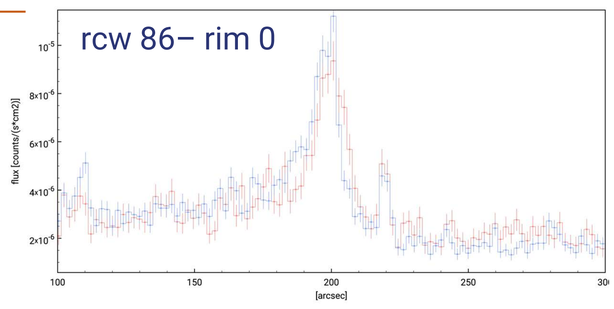








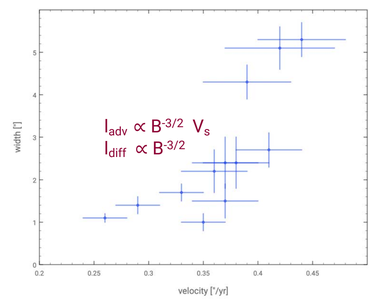




results

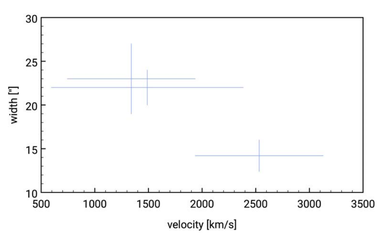
cas a

rim	width [°]	width uncertainty [°]	velocity [°/yr]	velocity uncertainty [°/yr]	velocity [km/s]	velocity uncertainty [km/s]
32	1.0	0.2	0.35	0.02	5600	300
45	1.4	0.2	0.29	0.02	4600	300
55	**4.6**	**0.6**	**0.24**	**0.05**	**3900**	**900**
105	1.5	0.4	0.37	0.03	6000	500
125	2.2	0.5	0.36	0.03	5900	500
130	4.3	0.4	0.3	0.1	6000	2000
135	2.4	0.6	0.37	0.03	6000	500
138	2.4	0.6	0.38	0.03	6100	500
205	1.7	0.2	0.33	0.02	5300	400
252	**2.7**	**0.2**	**0.44**	**0.04**	**7100**	**700**
262	2.2	0.2	0.39	0.04	6300	700
300	2.7	0.4	0.41	0.03	6700	500
315	5.1	0.5	0.42	0.05	6900	800
337	1.1	0.1	0.26	0.02	4200	300
337l	2.9	0.5	0.30	0.03	4800	500



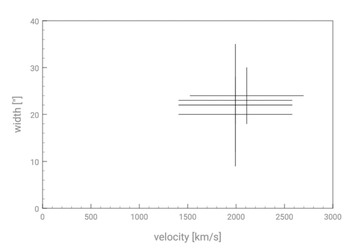
rcw 86 - nw

rim	width [°]	width uncertainty [°]	velocity [km/s]	velocity uncertainty [km/s]
0	14.2	1.8	2532	596
1	22	2	1489	894
2	23	4	1340	596
3			1191	894
4			1191	894
5			1489	596



hess j1731-347 - ne

rim	width [°]	width uncertainty [°]	velocity [km/s]	velocity uncertainty [km/s]
0	20	8	1993	586
1	22	13	1993	586
2	24	6	2110	586
3	23	5	1993	586
4	22	4	1993	586



what have we learnt?

cas a
- rim velocities ranges between 4000 and 7000 km/s
- slowest rims in the NE and fastest in the W
- the filament width is expected to be a result of advection and/or diffusion of electrons away from the acceleration site
- width estimates from 1” to 5” and magnetic field strengths from 200 to 900 muG
- in this analysis: rims with larger velocities appear to be wider -> this suggests width is due to advection

rcw 86 - nw
- rim velocities ranges between 500 and 3000 km/s
- width estimates from ~12” to 25” and magnetic field strengths from 80 to 200 muG
- in this analysis: rims with larger velocities appear to be thinner -> this suggests width is due to diffusion

hess j1731-347 - ne
- rim velocities ranges between 4000-5500 km/s (Doroshenko, Pühlhofer and Santangelo, 2024)
- width estimates ~ 20-30”
- in this analysis: could not find different velocity rims and thus interpretation is tricky