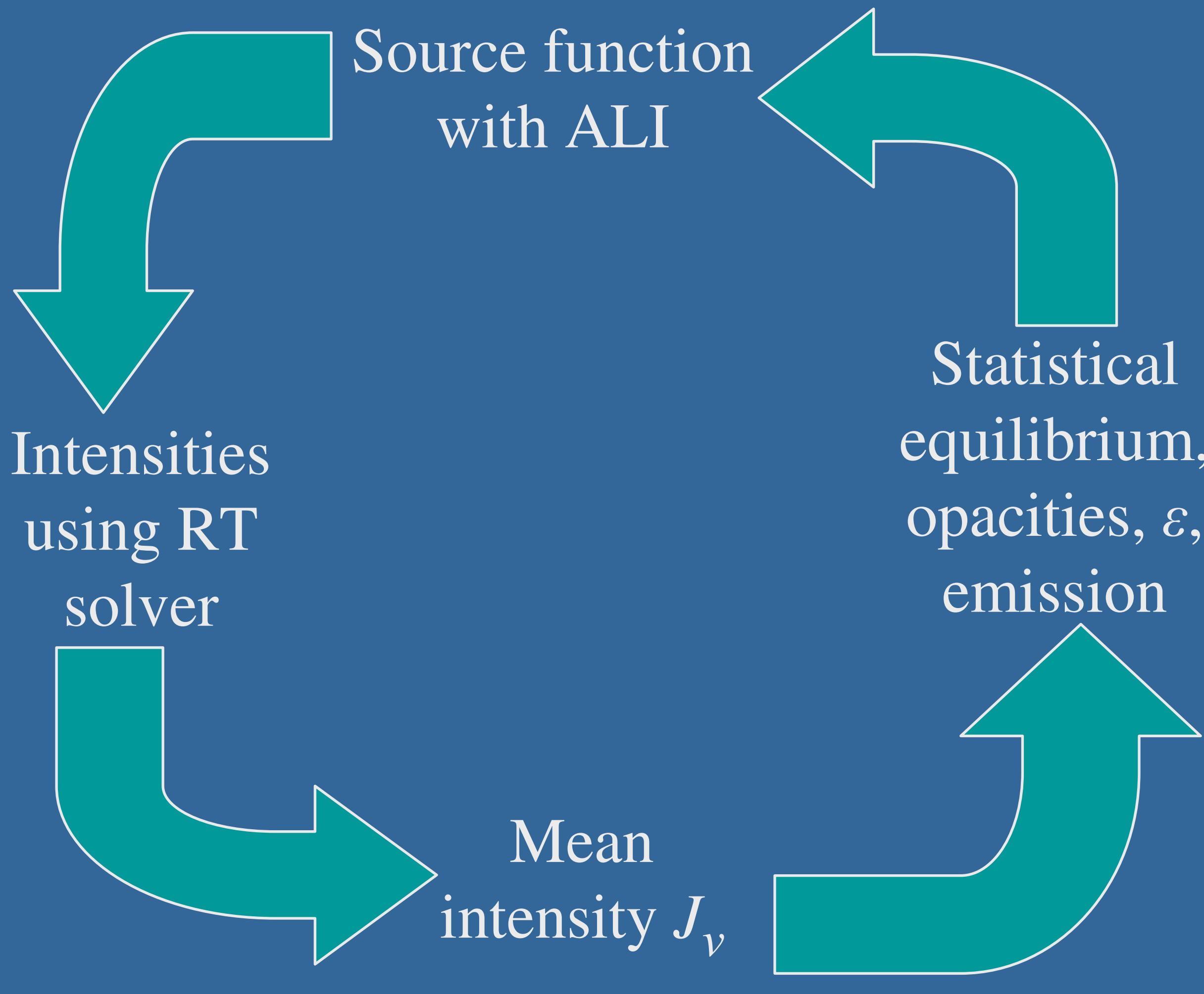
RT with hydrodynamics in multi-dimensions

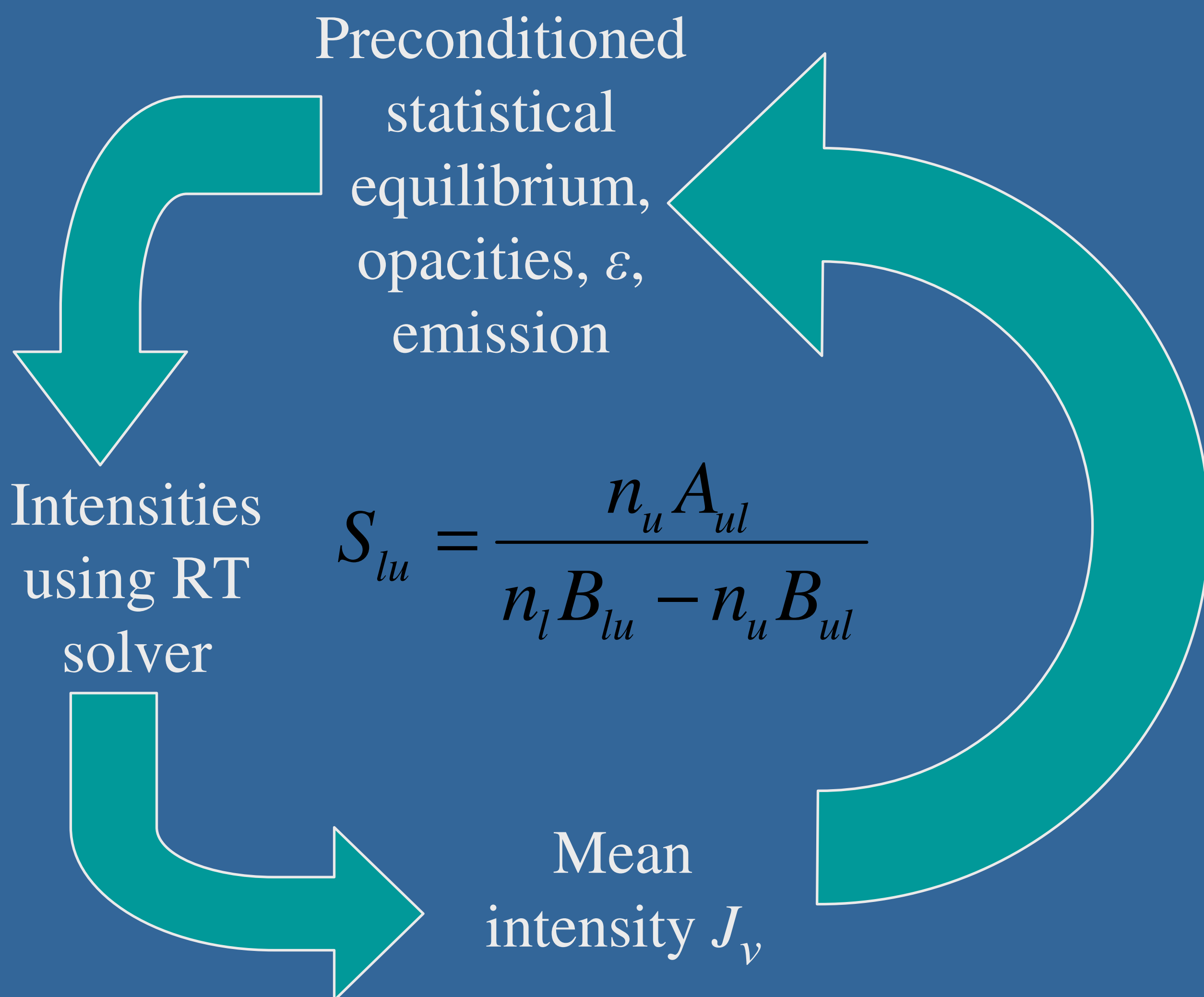
A few important aspects that we managed to avoid so far

The great loop



Combining the two loops

under some assumptions, e.g. no overlapping transitions



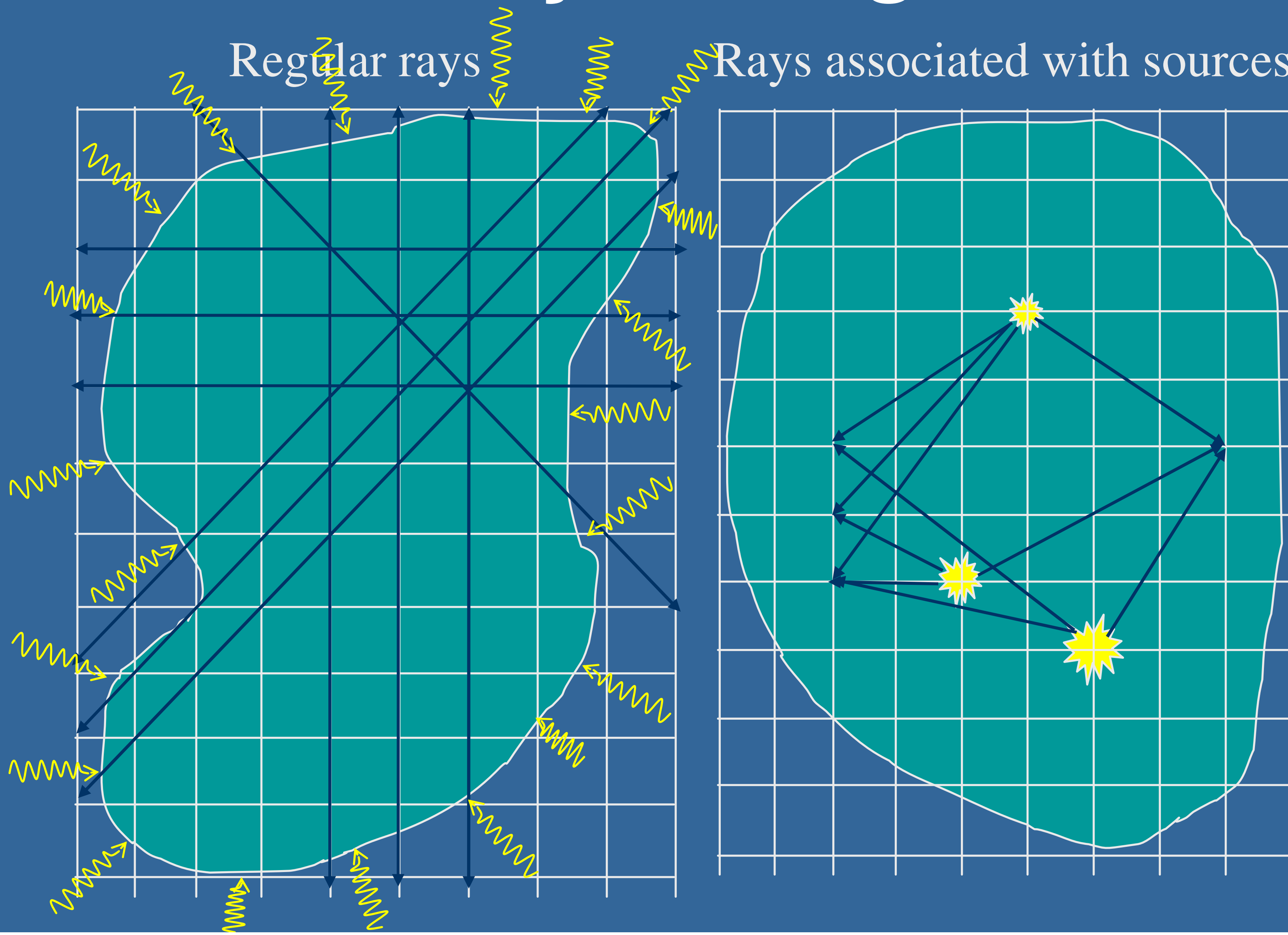
$$S_{lu} = \frac{n_u A_{ul}}{n_l B_{lu} - n_u B_{ul}}$$

How do we know when to stop?

Our options

- Mean intensities
- Level populations (best choice)
- Source function
- …

Ray tracing



Short or *long*?

- In case of distributed sources and optically thick medium both long and short characteristics work fine
- In case of small number of point sources and optically thin medium short characteristics look better
- Additional considerations are important: e.g. Feautrier readily produces mean intensity needed for statistical equilibrium calculations

Hydro with RT

- Hydro: mass distribution and motion in time

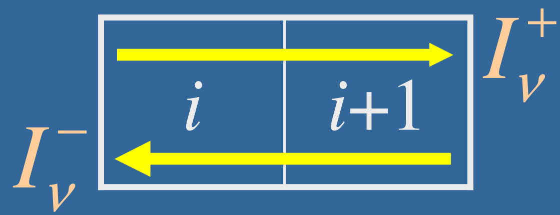
- Hydro → RT: thermodynamical quantities (*pressure, temperature*), velocity field, magnetic field (in case of MHD)

abundances

- RT: molecular/ionization equilibrium, statistical equilibrium, source function, intensity
- What about RT → Hydro?

Hydro with RT

- Hydro needs energy transported by radiation:



  Energy flow from i to i+1 is $I_\nu^+ - I_\nu^-$ (Feautrier V_ν!)

- We can compute V_ν in two ways:
  – (short char.) integrate I_ν^+ and I_ν^- separately
  – or (long characteristics) …

Radiative energy flow for Hydro

After Feautrier solution for the mean intensity we can integrate one more time to get the energy flow $\frac{dV_\nu}{dx} = -k_\nu \rho \cdot (U_\nu - S_\nu)$

or we can re-formulate Feautrier for V_ν:

$$\frac{dU_\nu}{dx} = -k_\nu \rho \cdot V_\nu; \quad U_\nu = -\frac{dV_\nu}{k_\nu \rho \, dx} + S_\nu$$

$$\frac{d}{dx}\left(\frac{1}{k_\nu \rho}\frac{dV_\nu}{dx}\right) = k_\nu \rho \cdot V_\nu + \frac{dS_\nu}{dx}$$

A glimpse of what is coming…