Estimates for Radiological Concerns, Beam Heating and more: The NuMI Experience

or... My Experience with Monte Carlo simulations that ignore the neutrinos

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DUSEL BL WG 20 Oct 2008

Outline

1. Kind and range of calcs
2. Tools
3. Examples from NuMI
4. Accuracy
5. Problems, pitfalls (w/ examples)
6. Post-NuMI comments

More Specifically-
Estimates for

- Beam Heating in components
- Residual Dose (beam activation)
- Radiation Damage to components
- Tritium production (and transport)
- Primary Beam Transport

Provide Input
for

- Design of components
- Beamline layout
- Safety Documentation
  - NuMI SA docs

Tools of the Trade

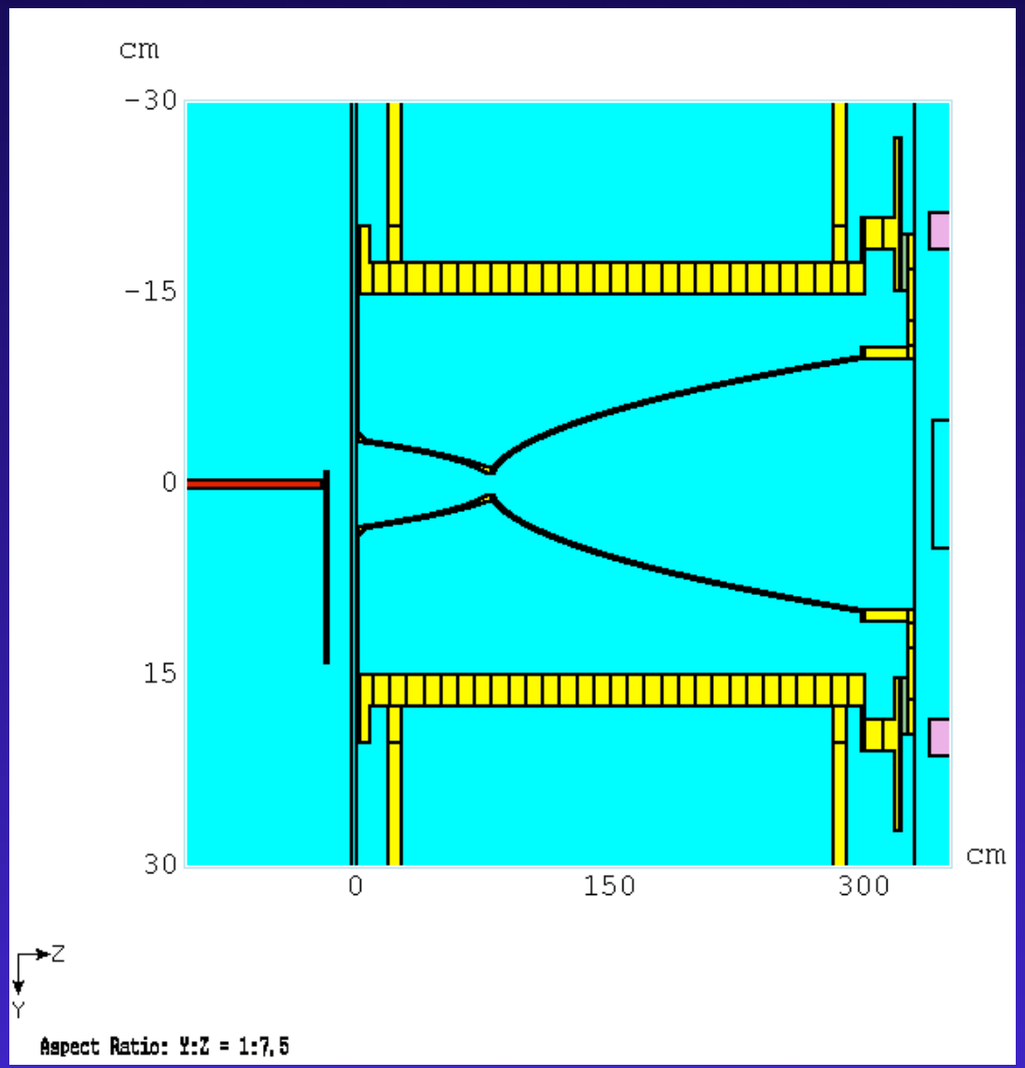
- MARS
  - Beam Heating
  - Residual Dose
  - Radiation Damage
  - Tritium Production
- Other
  - Maple for Tritium diffusion

Tools of the Trade: MARS Monte Carlo

- Model starts just upstream of target
- Model ends with NuMI muon alcoves
- Detail level
  - in space ≤ cm Target Hall ; ~10cm DK , Absorber
  - composition, densities : wherever measured

  Original NuMI model authored by C. James

Example: Energy Deposition



NuMI Horn 1 MARS model

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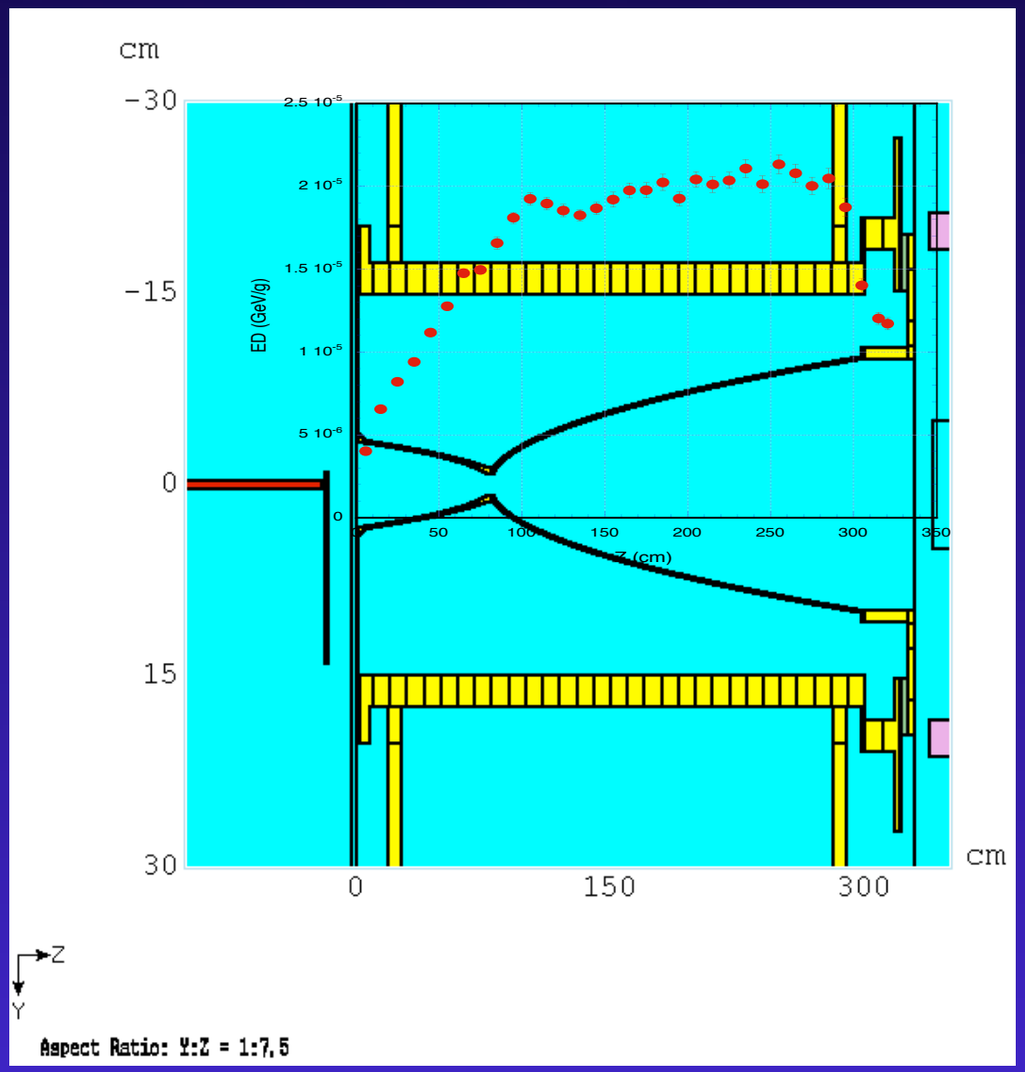
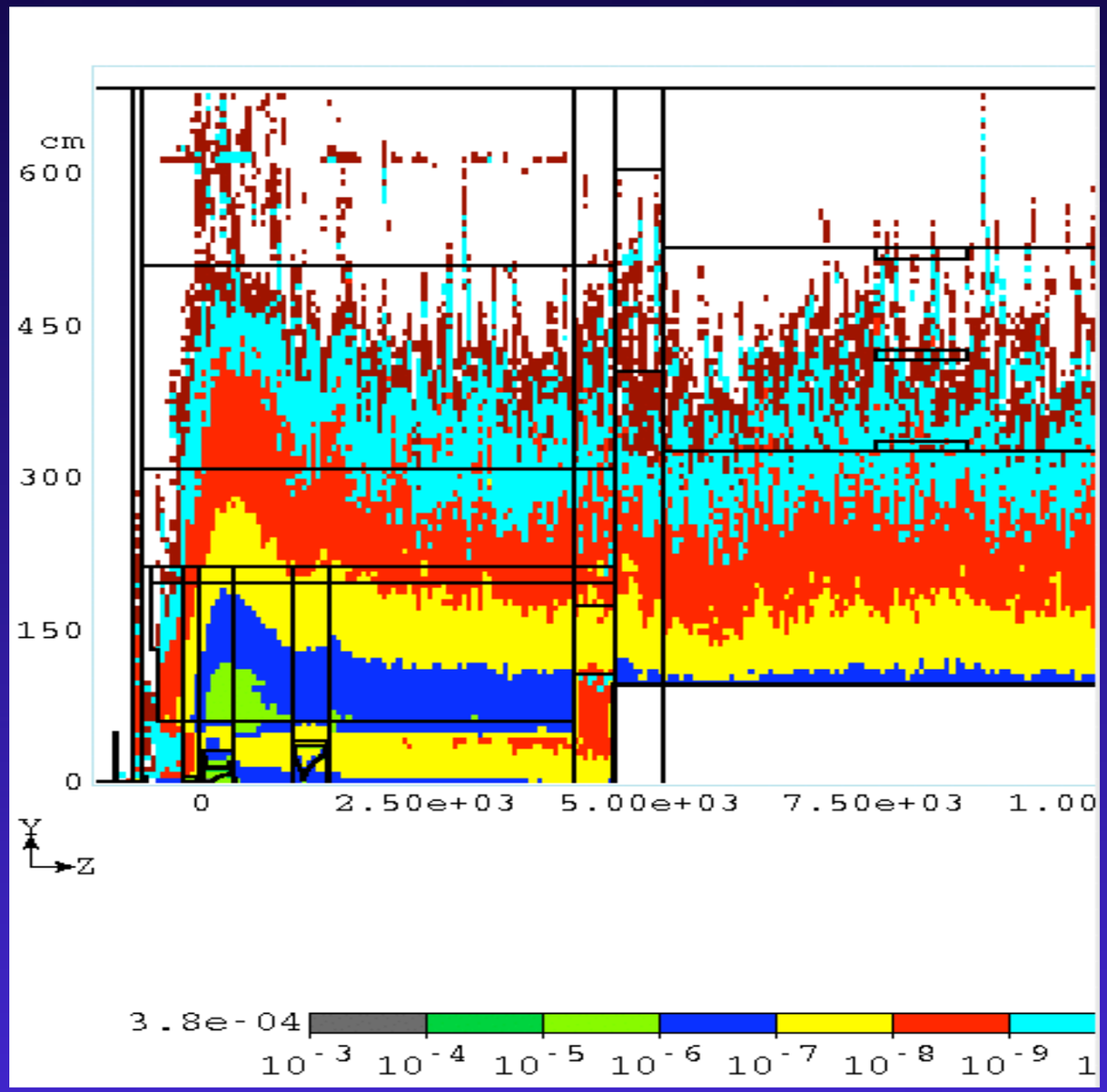


NuMI Horn 1 MARS model

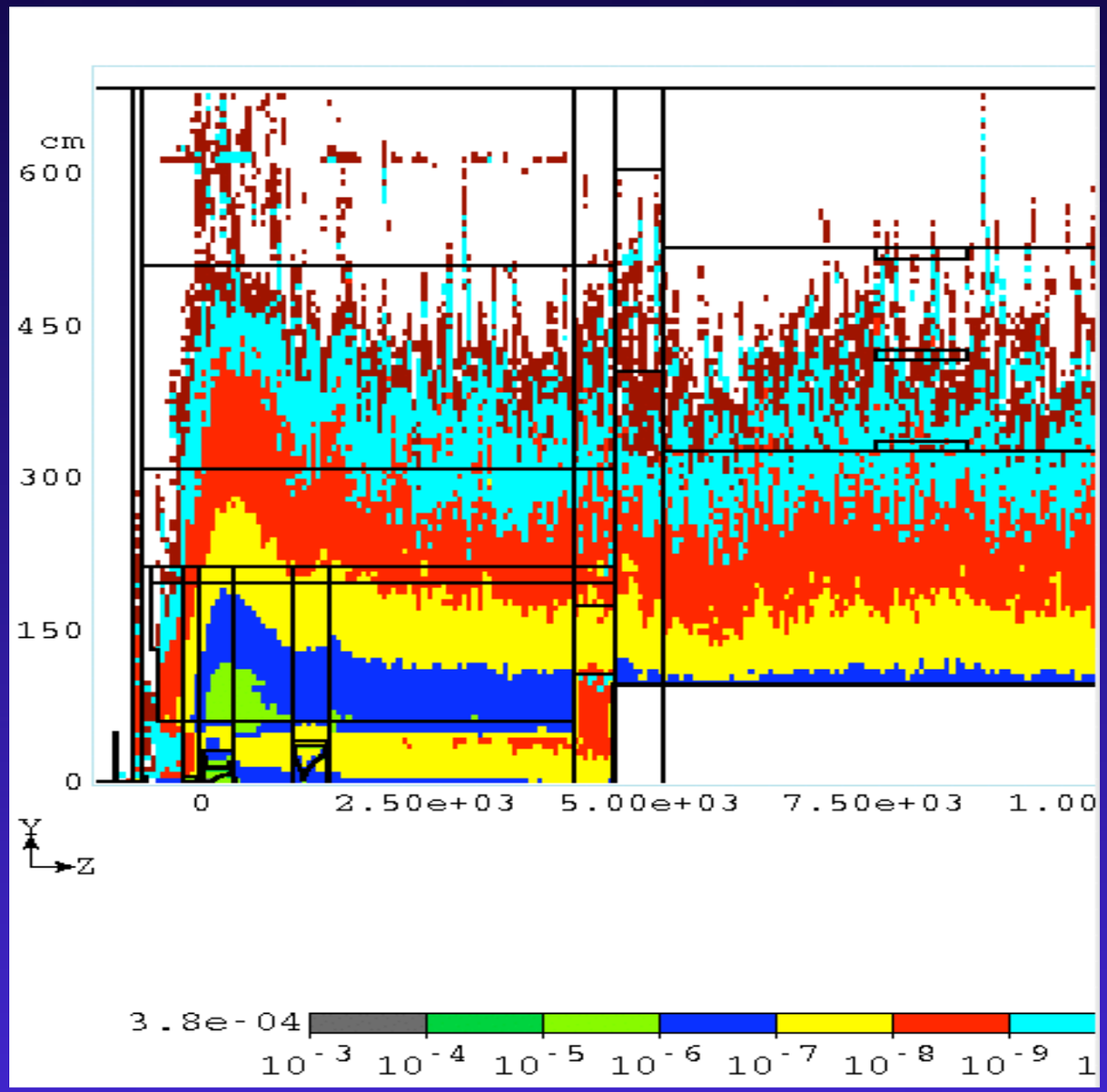
With OC MARS data

Example : Interaction Density



NuMI Target Hall and upstream DK

Example : Interaction Density



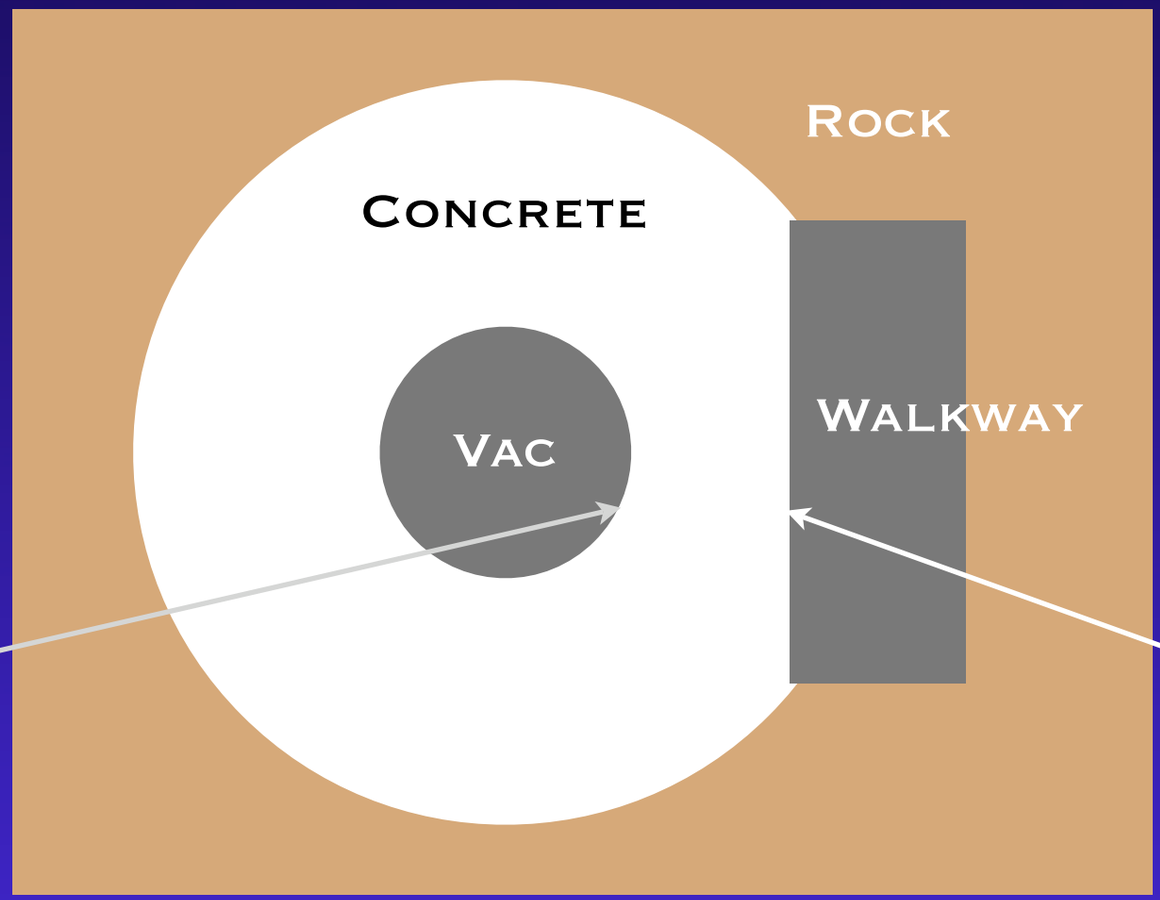
NuMI Target Hall and upstream DK

Note range: 8 orders of magnitude!

*NUMI-NOTE-SIM-1010

Example :

Tritium Production/Diffusion in Decay Pipe Concrete



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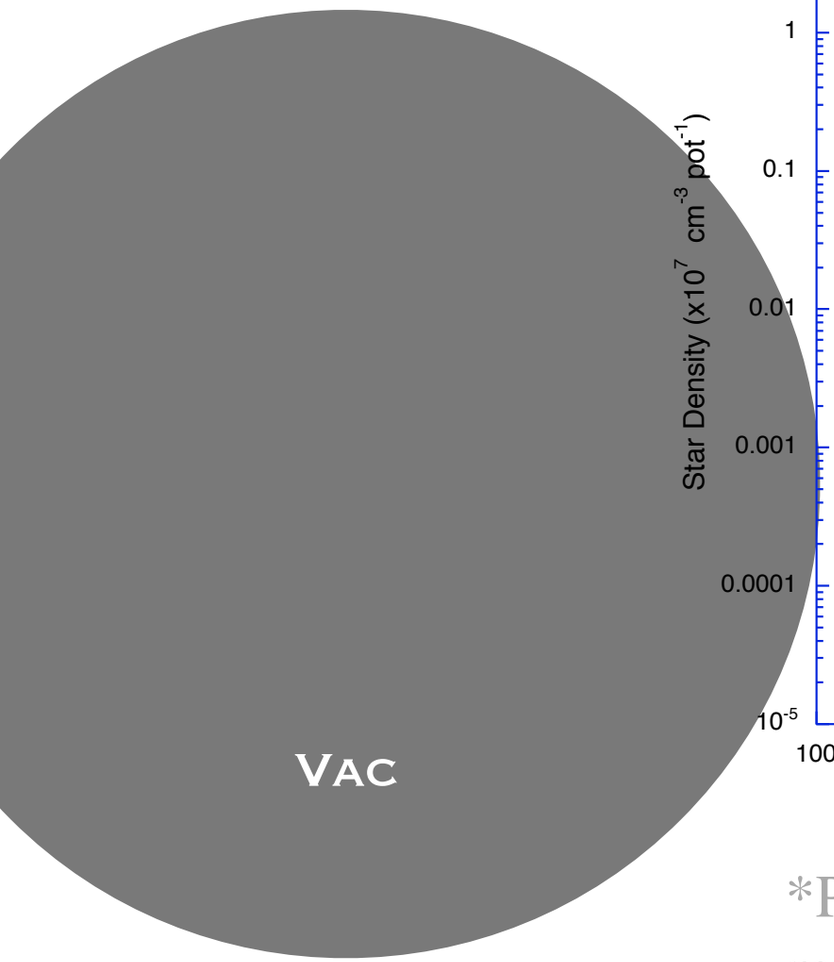
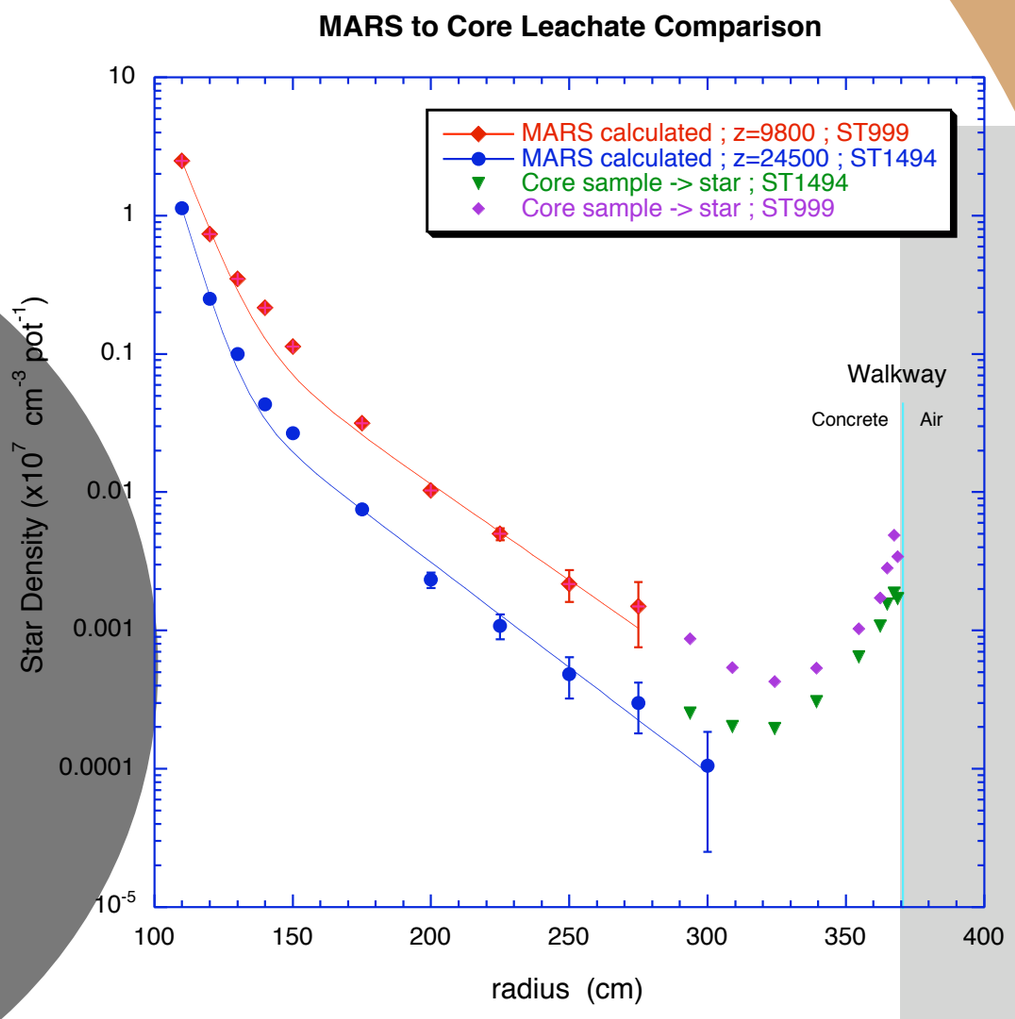
Tritium Production/Diffusion in Decay Pipe Concrete





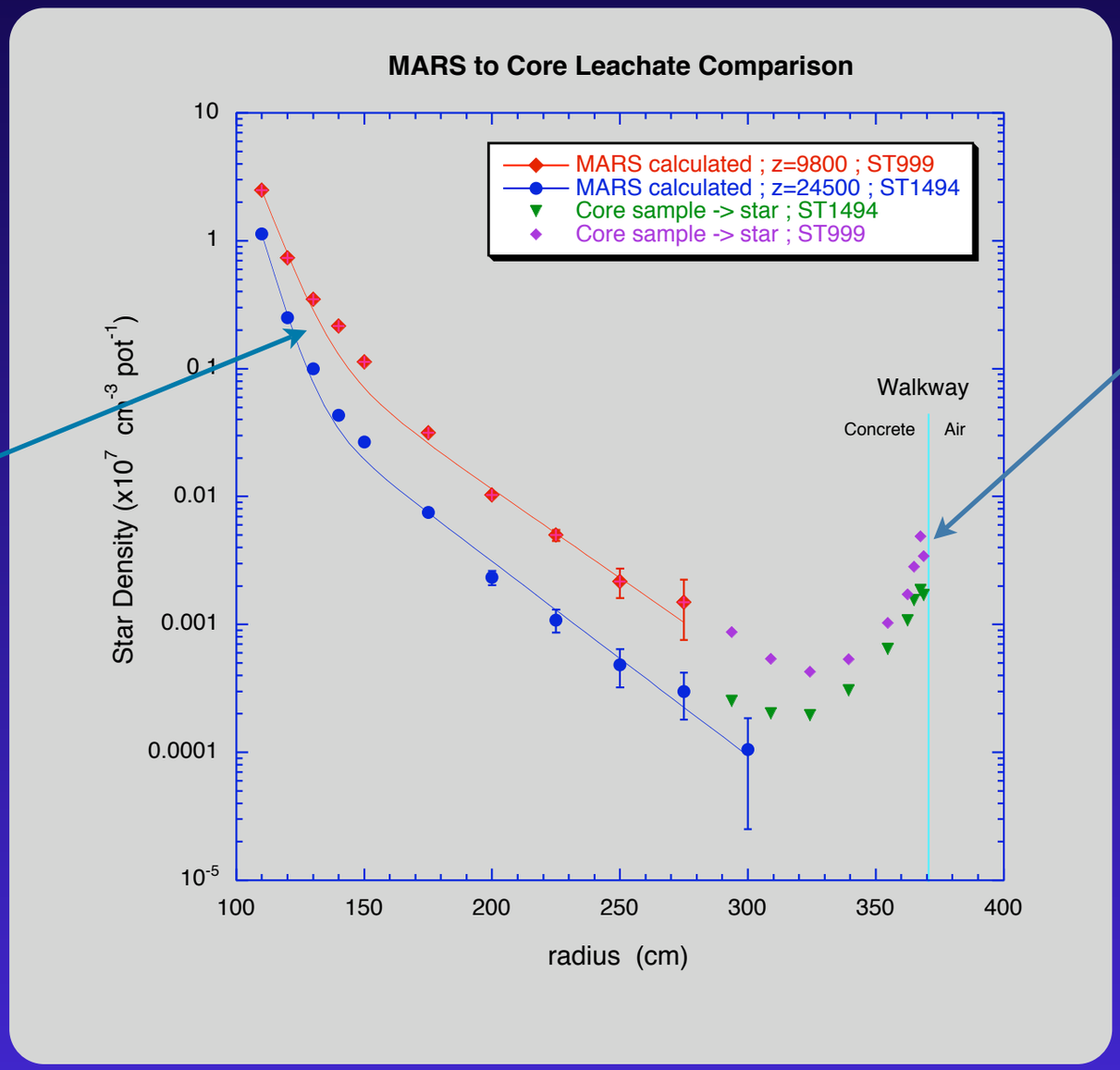
*Projects-134-v4
much more detail next week!

WALKWAY

connect data from core samples in walkway to production in DK concrete

Example :

Tritium Production/Diffusion in Decay Pipe Concrete



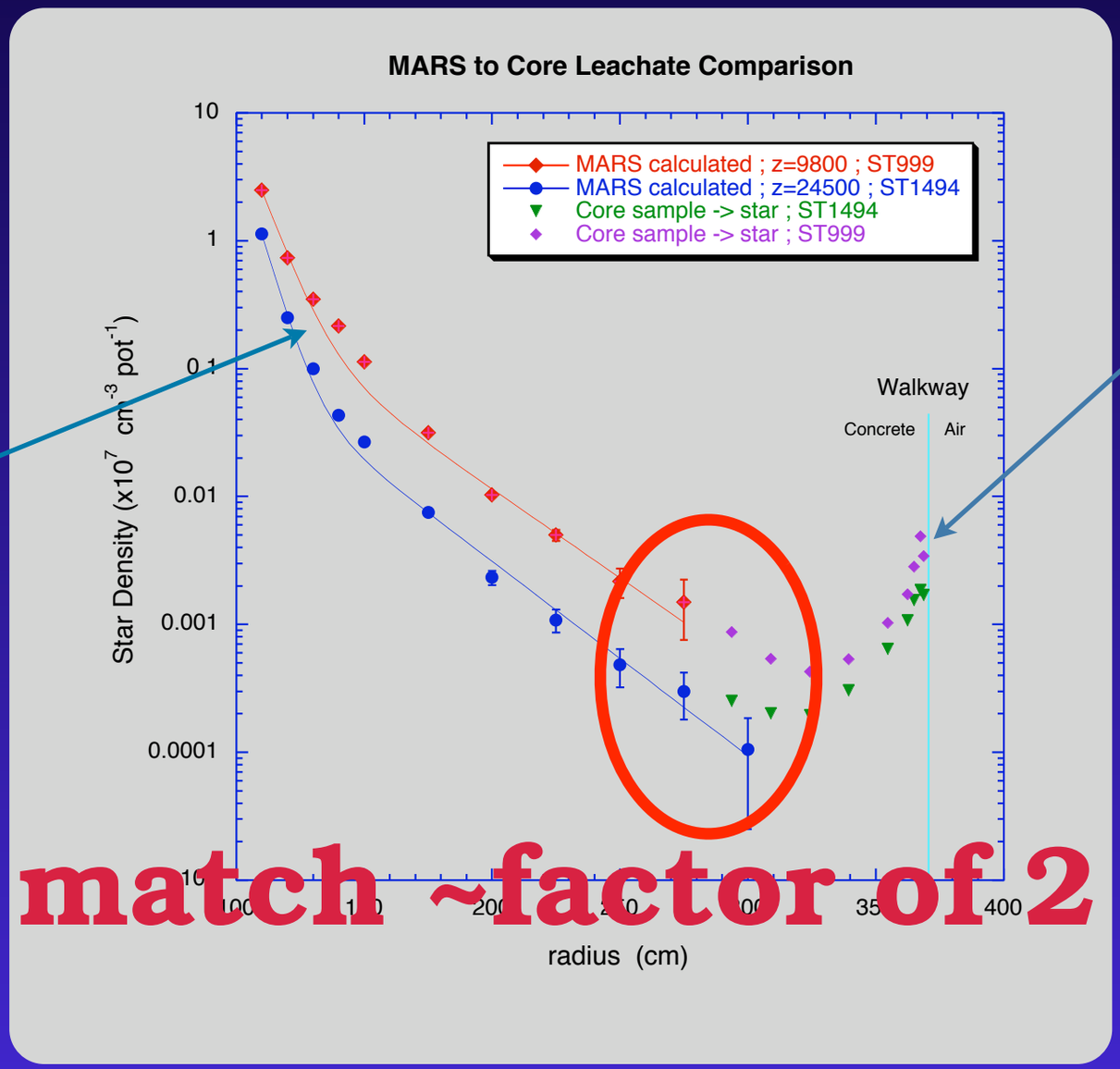
these are MARS-derived estimates - from decay pipe and *outward* into concrete

these are measurements derived from core samples - from walkway and *inward* into concrete

Example :

Tritium Production/Diffusion in Decay Pipe Concrete

these are MARS-derived estimates - from decay pipe and *outward* into concrete



these are measurements derived from core samples - from walkway and *inward* into concrete

NuMI Experience

Primary Use of Calculations:

1. Estimate Rad levels in Target Hall
   - -Residual levels outer surfaces
   - -Neutron fluxes into penetrations
2. "Confirmation" of Low Activation in surrounding rock (ground water)
   - -estimate 99.9% containment
3. Input to engineering calcs
   - -Target, Horns, Absorber...

NuMI Experience

Primary Use of Calculations (cont):

4. Documentation
-Safety Assessment docs

NuMI Experience

Primary Use of Calculations (cont):

Generally, was not a primary tool for design*

More of a confirmation / correction tool

- Physics considerations
- Engineering constraints
- Beam interaction / rad concerns

* some early NuMI history : mars vs casim

NuMI Experience: Pitfalls

1. Failure to integrate with larger system
2. Calculations need to interpreted
3. MARS model ≠ engineering model

Example

1. Failure to integrate with system

- MARS predicted ~correct amount of tritium

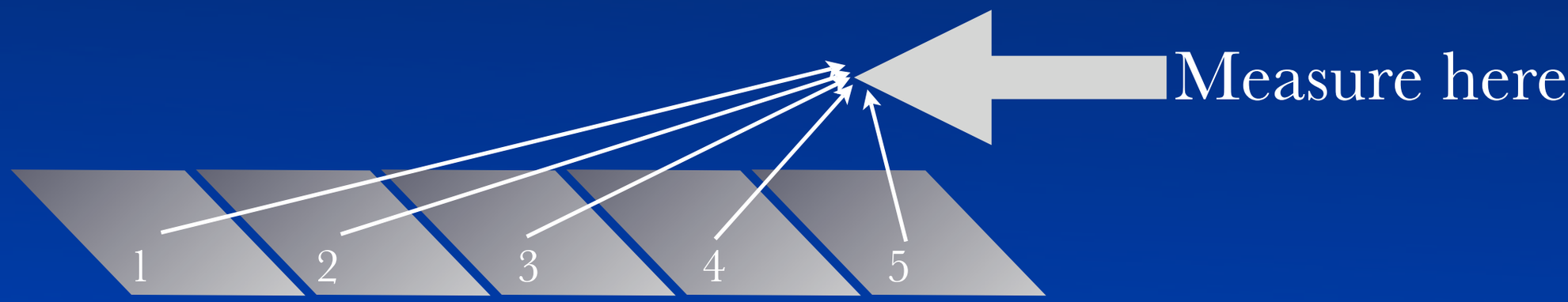
... but its transport (air or diffusion) was a separate, more complex problem*

*come to R.Plunkett's talk

Example:

2. Calculations need to be interpreted

- Residual Dose from MARS is for isolated materials



⇒ result usually underestimates actual dose

Example

3. MARS model ≠ other model(s)

- MARS is the first input to a chain of calculations

MARS is (usually) the simplest model and often difficult to synchronize grids

$ Impacts

- no estimates of fiscal impacts
  - e.g. MARS → dose → shielding thickness error

Possible to estimate how much one could have saved (or lost) with thinnest allowable shield thicknesses, but not very instructive since safety demands over-design

Post - NuMI → Future

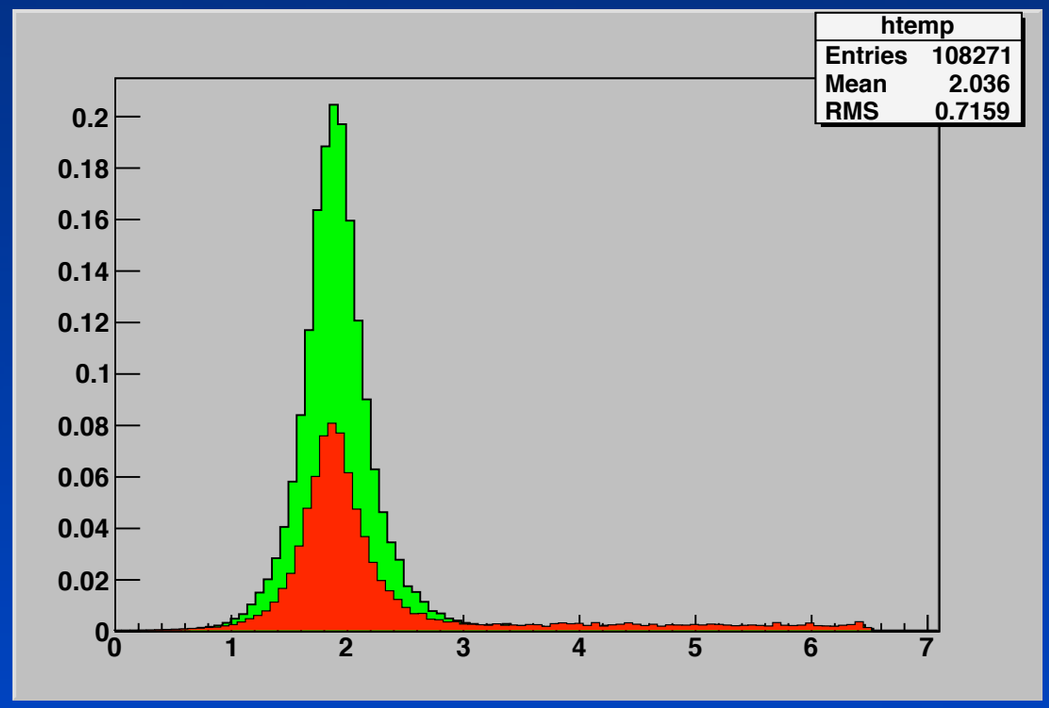
use of MARS

- My opinion : maintain design philosophy
  - First pass at shielding thickness
  - Input to engineering calcs
  - MARS as correction / confirmation tool
- Other things:
  - accurate material specs make a difference!
  - better post-MARS tools
  - more CPU

Post - NuMI / Future

use of MARS

- MARS *could* / is integrated into physics calcs
- Discussion?



Nova FD spectra