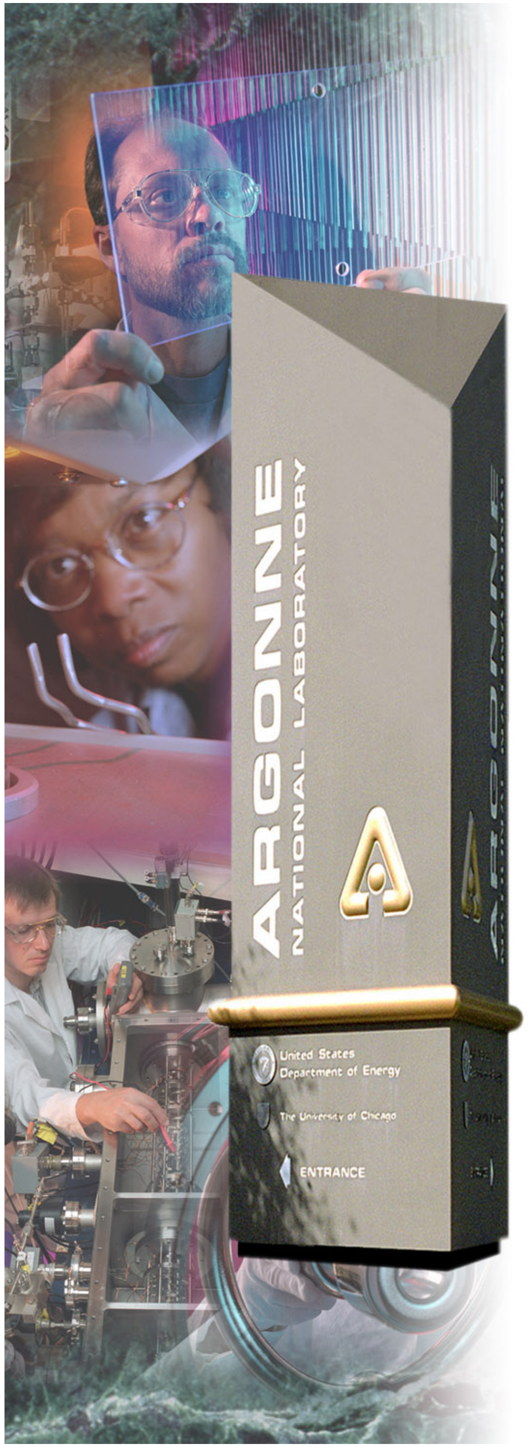

RACE Plus – A Proposal

ECATS

Brussels, Belgium

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Argonne National Laboratory

Office of Science
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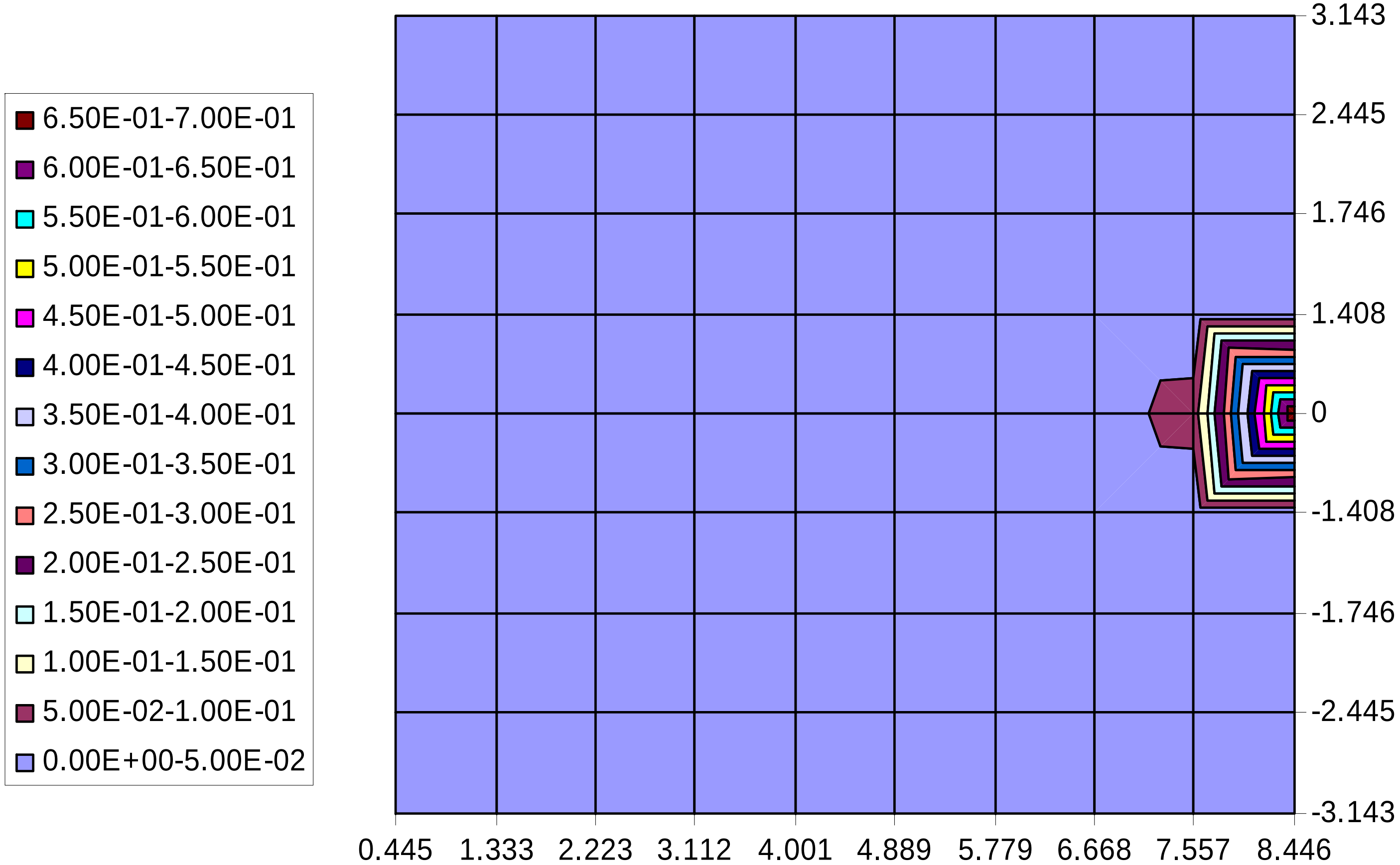
Major contributors to presentation

- **Idaho Accelerator Center**
  - Frank Harmon, Denis Beller, Alan Hunt, Jianwei Chen
- **Texas TRIGA reactors**
  - Sean O'Kelly, William Charlton
- **CEA**
  - Christian Jammes
- **CERN**
  - Yacine Kadi
- **Argonne National Laboratory**
  - George Imel

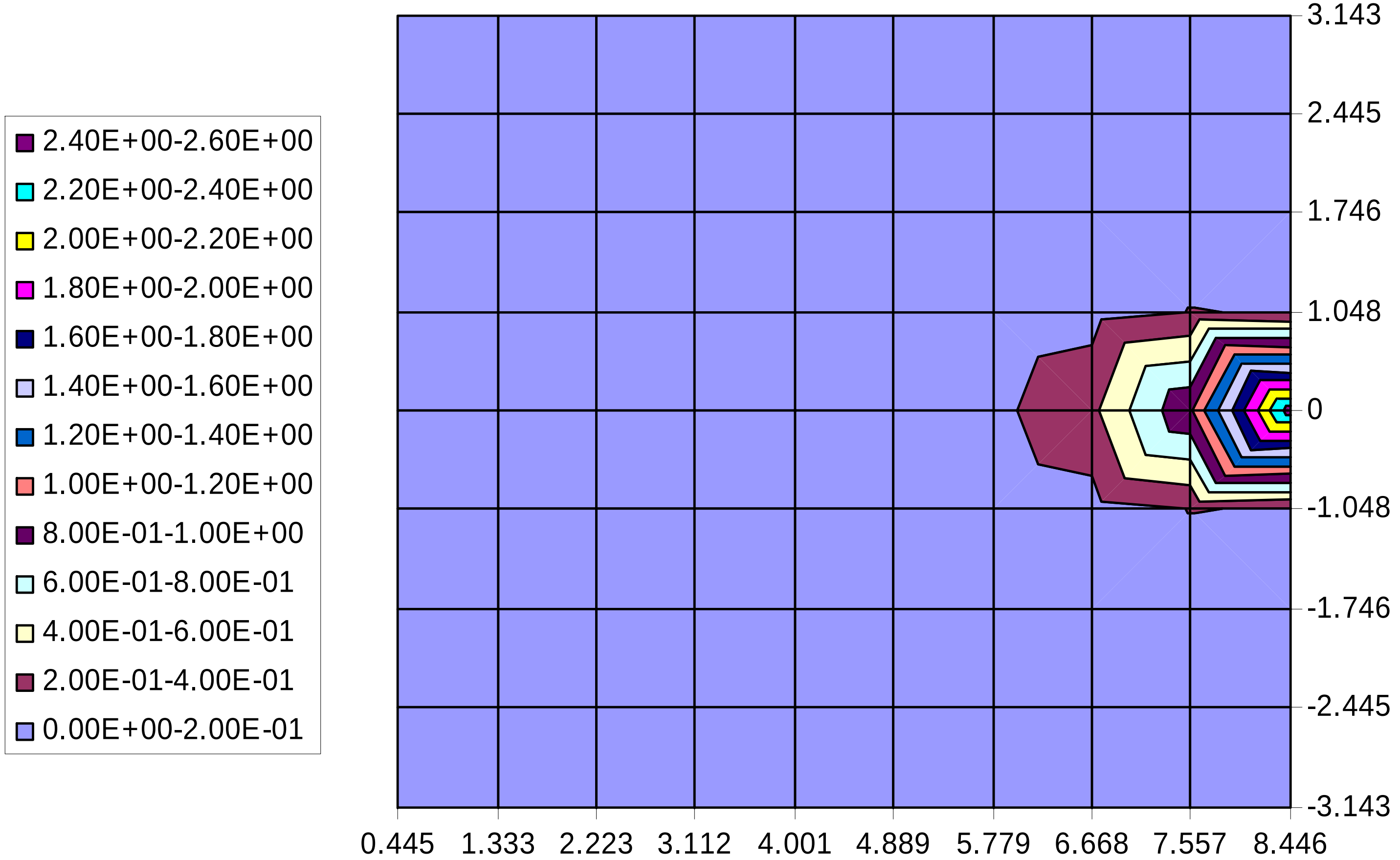
Issues

- Source spatial distribution
- Gamma (X-ray?) flash
- Time structure
- Proposed experimental program

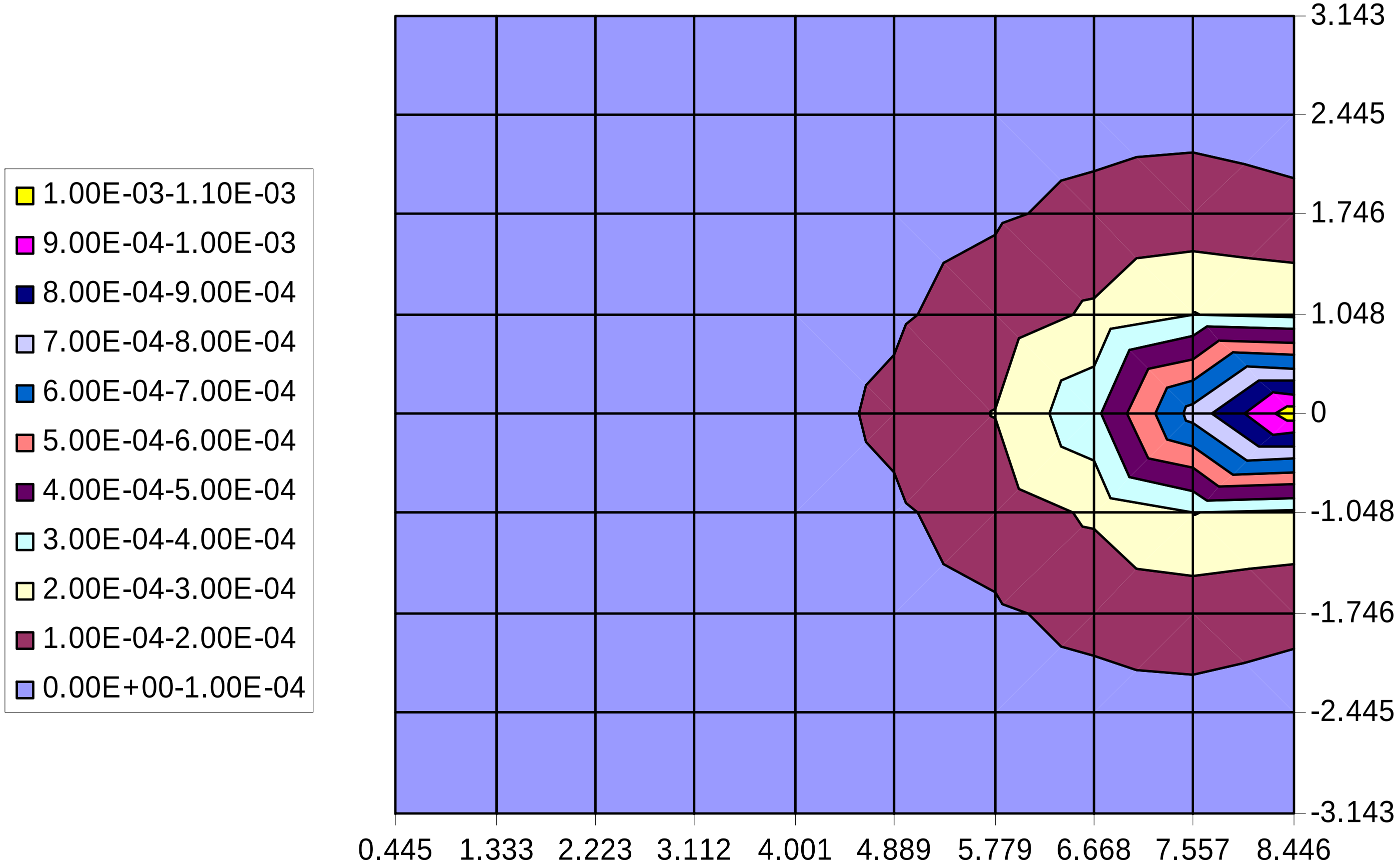
Electron distribution (e/cm²/incident e)



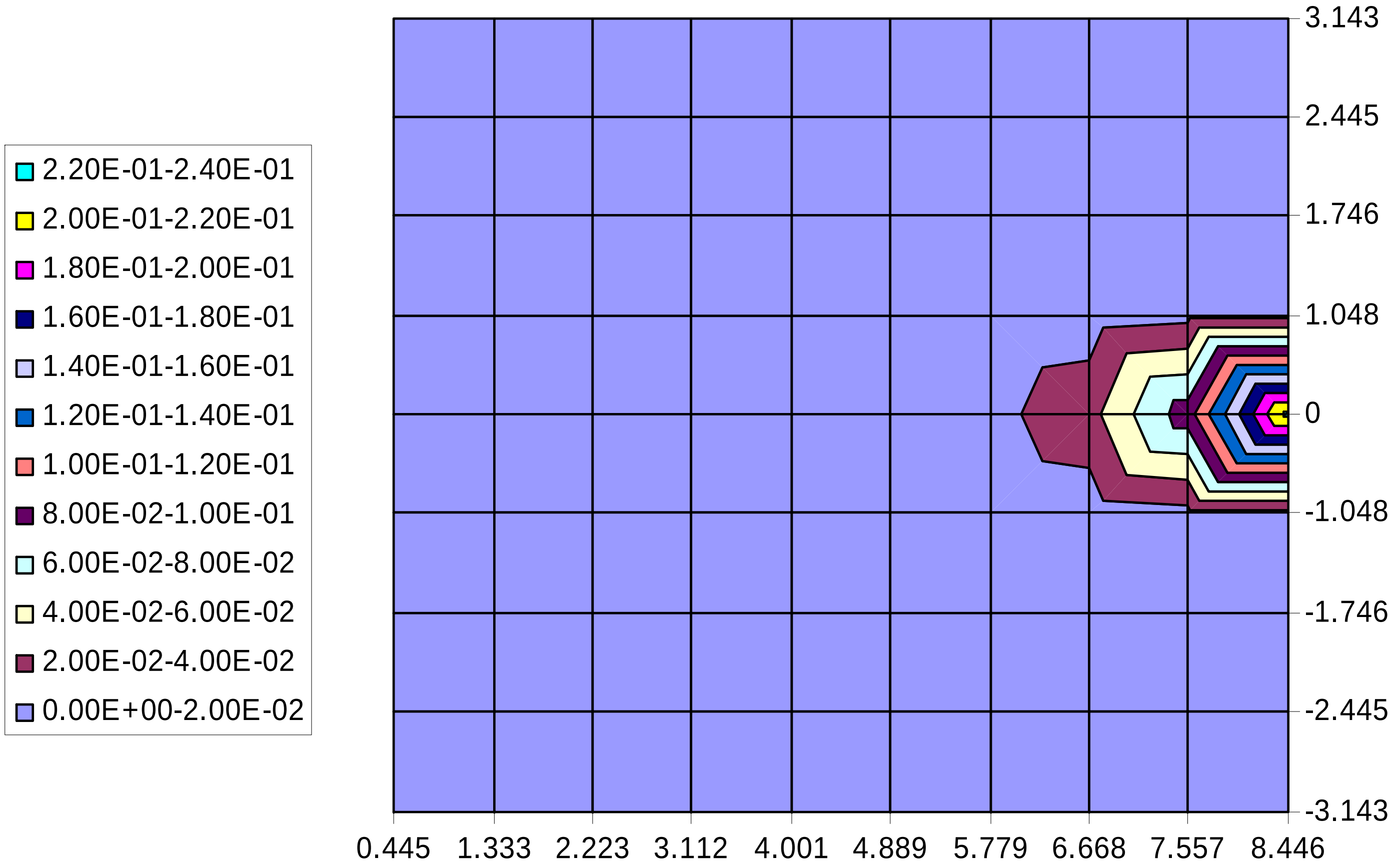
Photon distribution (photon/cm²/incident e)



Neutron distribution (n/cm²/incident e)



Energy deposition (MeV/gram/incident e)



Conclusion of source distribution

- Calculations indicate that the vast majority of photon energy is deposited in the near side of the target
- Photo-fissions in the fuel should not be a problem
- Also, about 50% of incident beam energy is dissipated in target as heat, the rest to photon and neutron interactions

Gamma flash

- Bremmstrahlung power scales as the inverse of a charged particle's mass and kinetic energy
- Thus, for a given energy, electrons hitting a target will produce more photons than protons
- This is not a penalty! It is the mechanism we use to produce neutrons
- Previous slides have shown that the vast majority of the photon energy is contained in the target
- Fission chambers will be located well away from the target, so no problems expected

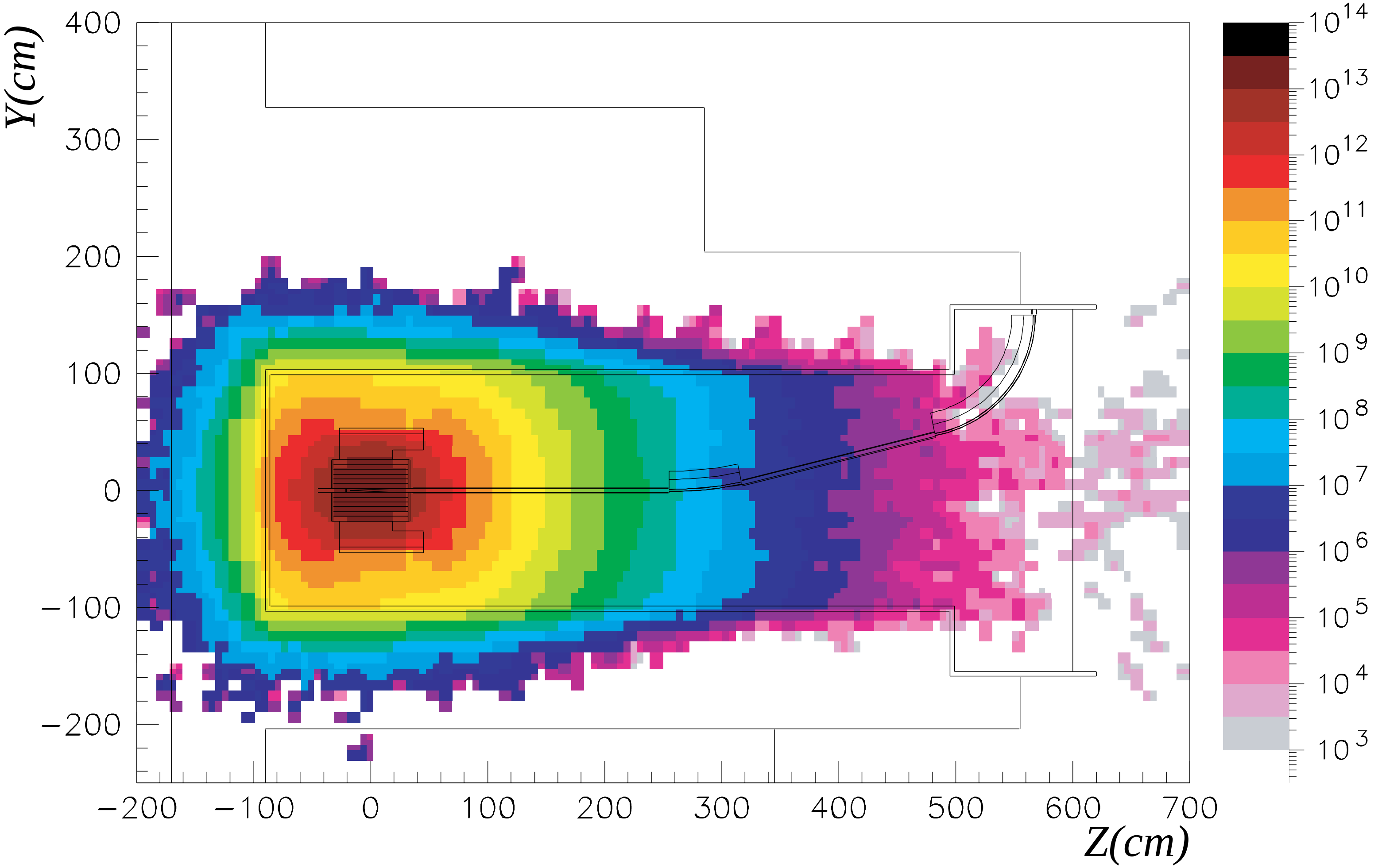
Gamma flash (2)

- **We have had to deal with large photon fields from the beginning of nuclear systems**
- **Recoverable fission energy is about 7% gamma**
- **Thus, even at 100 kW, about 7 kW will be background gamma**
- **Given an electron beam power of 25 kW, less than 12 kW will be photon power**
- **Thus, the background gamma is not an insignificant contributor to the overall photon field**

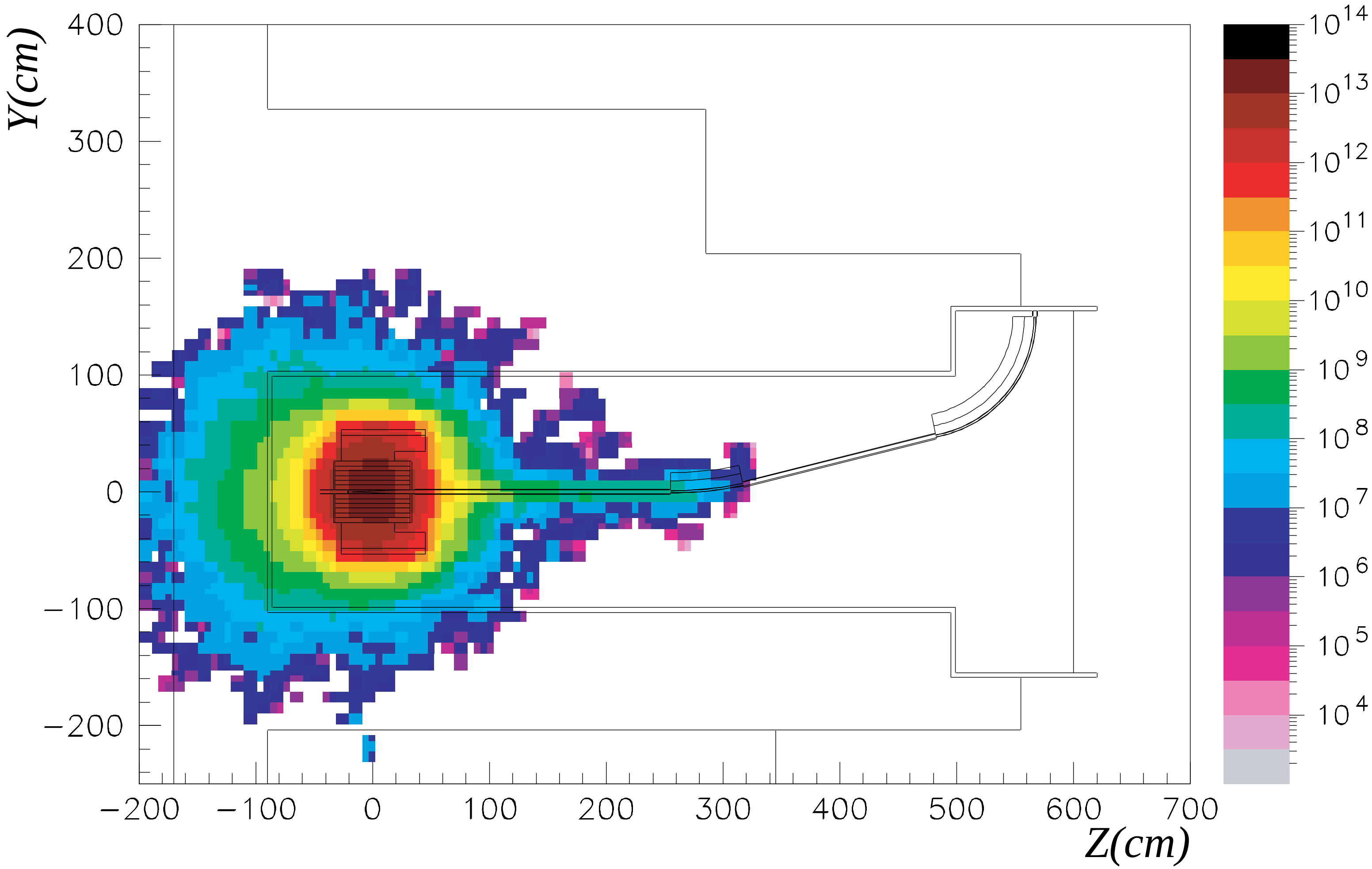
Gamma flash (3)

- **Photon fields are a fact of life**
- **So-called gamma flash only adds a contribution, not an order of magnitude increase**
- **We will have to deal with the photon fields in a real ADS, so RACE can give some experience**
- **We were estimating very large gamma fields in TRADE – the photon field is of the same order as the neutron field**

TRADE photon distribution



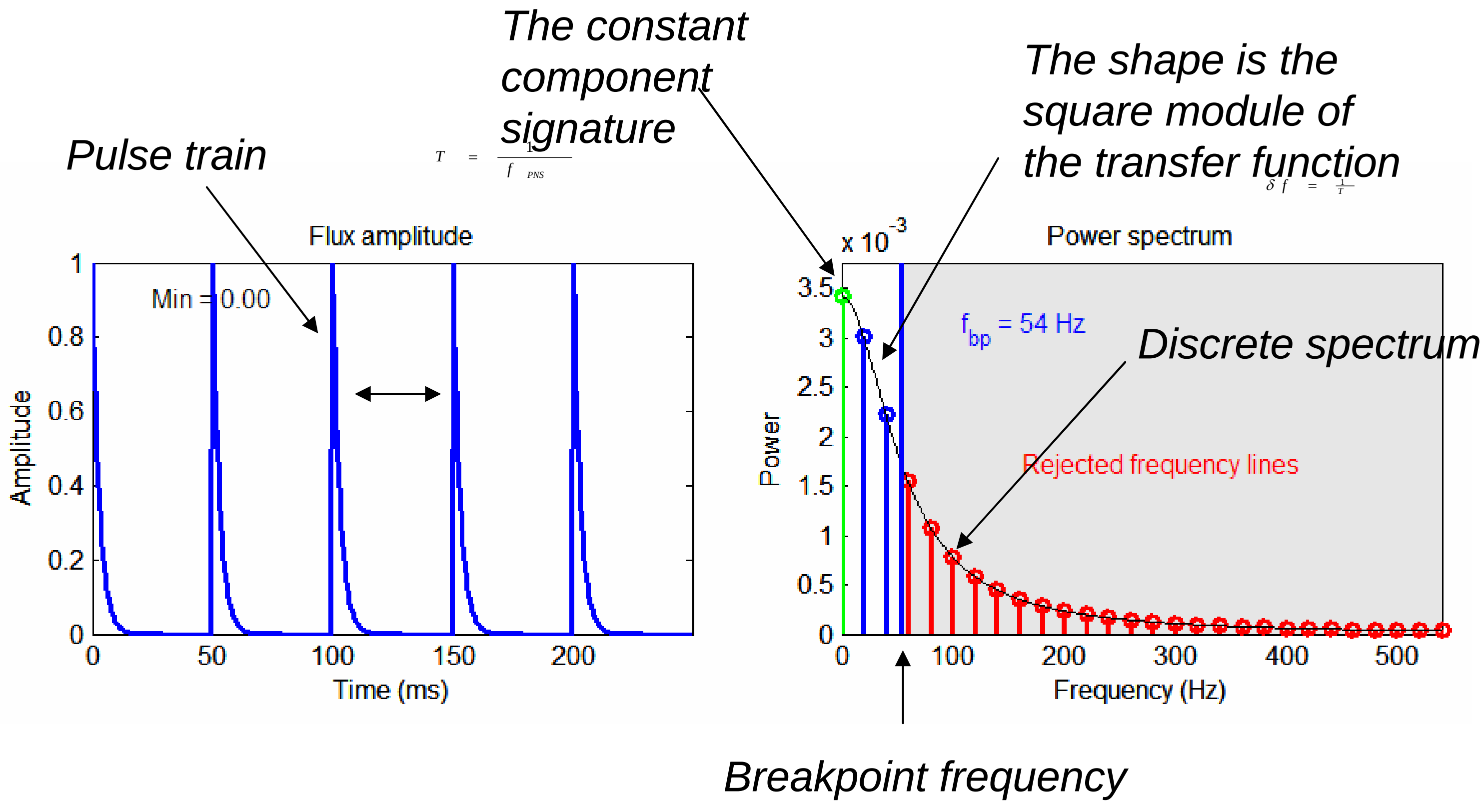
TRADE neutron distribution



Gamma flash - conclusions

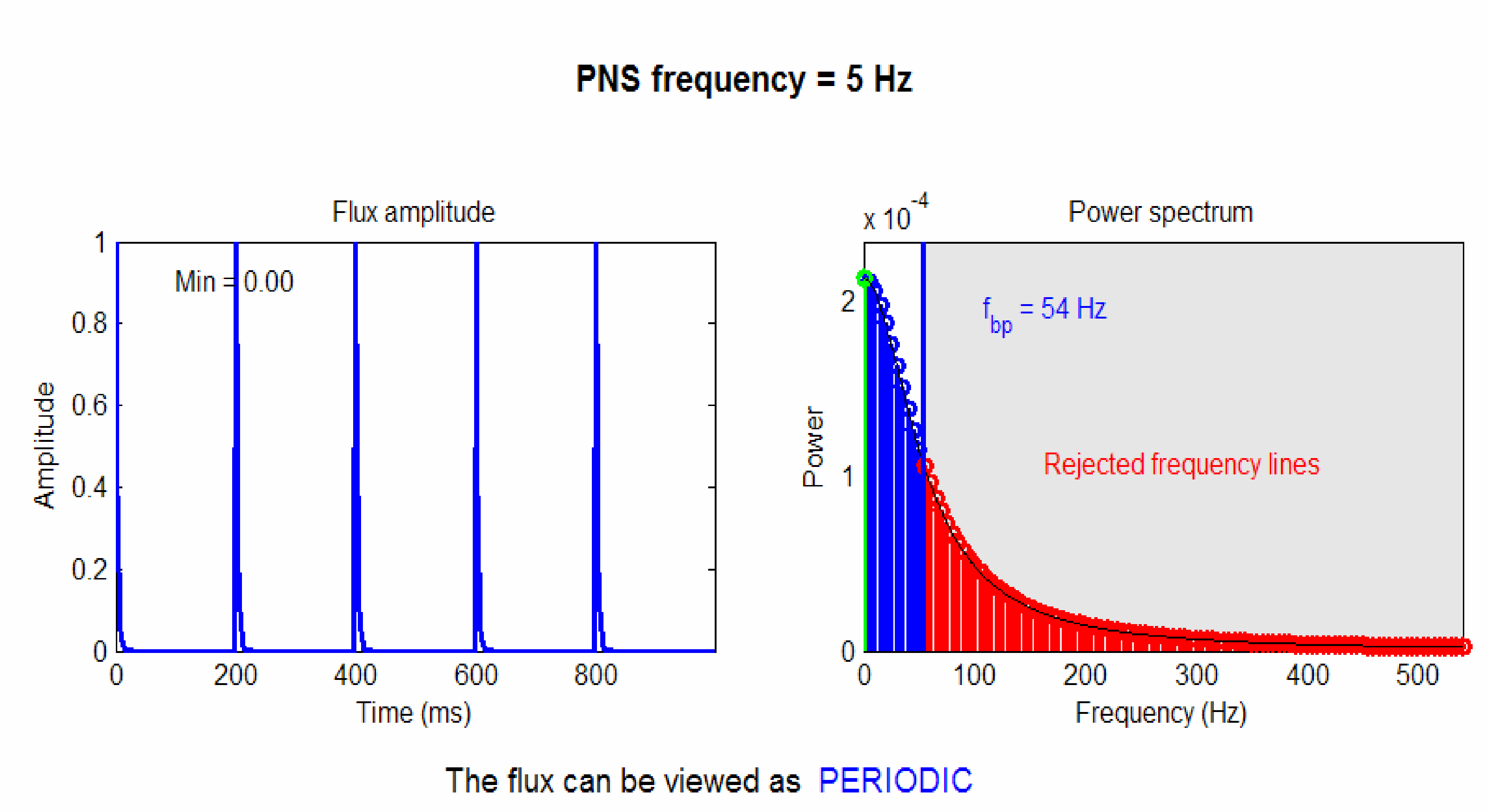
- **Dealing with the gamma flash might actually give us some insight in future problems we might see**
- **Experiments are planned at CEA/Saclay in the near future to characterize**
  - The sensitivity of fission chambers and associated electronics to the flash from an electron linac
  - The recovery time of the above

PNS in nuclear system

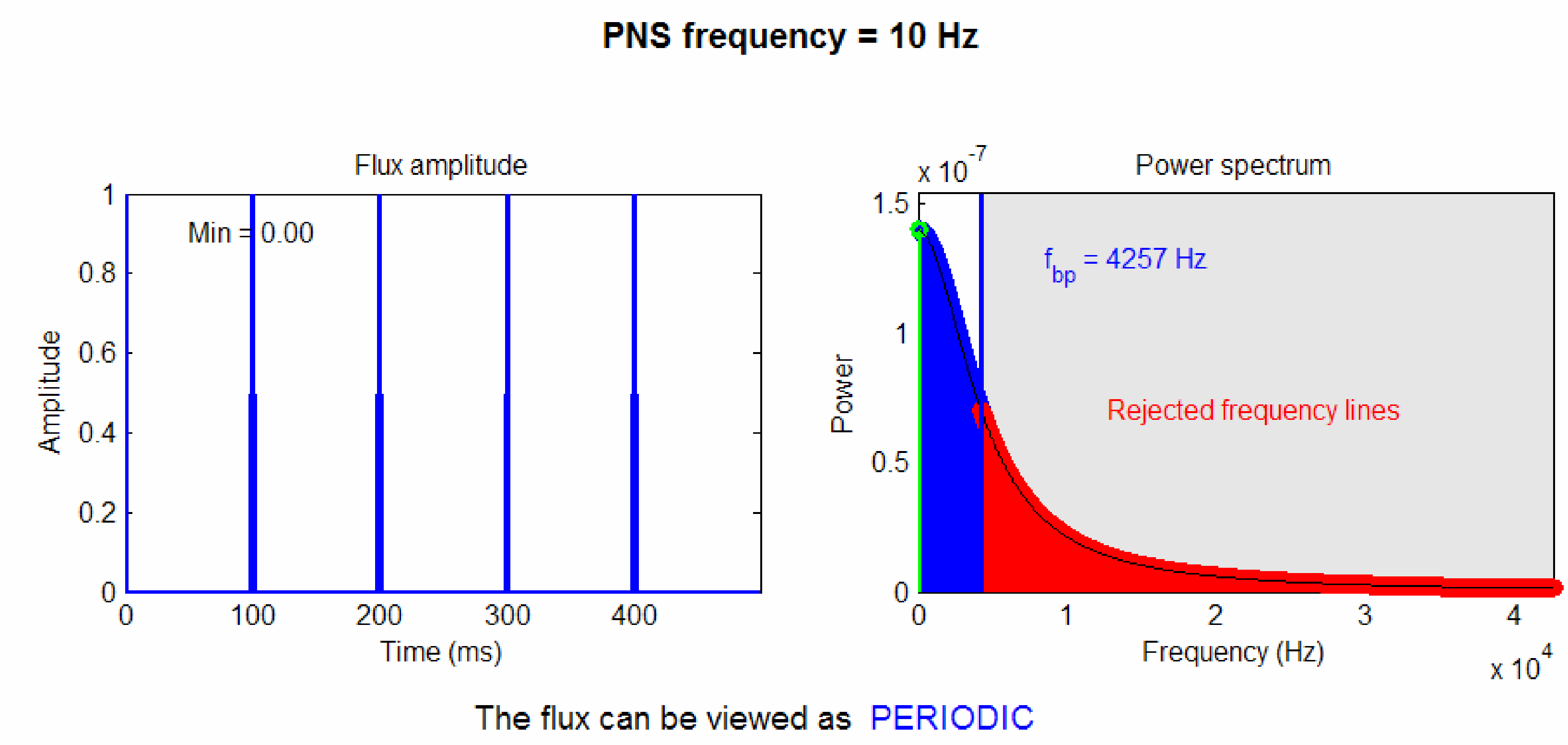


A neutronic system acts as a low-pass filter.

Thermal system and k=0.99



Fast system and k=0.99



Time structure

- Time structure of RACE is not CW
- But, as frequency of driving source is raised above the characteristic break frequency of the reactor, the constant term of the power spectrum becomes dominant (and certainly measurable in all senses of the word)
- Likewise, the accelerator current (or power) is easily measured via integrating circuitry
- current/power/reactivity relations can be explored even in the absence of steady state
- Feedback variations could be interesting also

Proposed experimental program -general

- **Multi-phase, as was TRADE**
- **Low power (1 kW) phase**
  - Direct comparison to TRADE Phase I with DT neutron generators (Texas virtually identical to Casaccia)
  - (Essential to complete TRADE phase I)
  - This would consist primarily of PNS, but also the effect of asymmetric injection
    - *Requires 4-6 well matched fc*
  - Results would be available by end of 2005

Proposed Experimental Program - general (2)

- **High power (25-30 kW) phase**
  - Core characterization (MSA/MSM)
    - *Requires 4-6 well matched fc*
  - Core characterization (fission chamber traverses)
    - *Requires pierced fuel element and miniature fc*
  - Core characterization (spectral)
    - *Requires foils, picolo-micromegas*
  - Reactivity measures (PNS)

Proposed Experimental Program - general (3)

- Reactivity monitoring (I/P)
  - *Requires power monitoring chambers*
- Absorber oscillations (with feedback)
- Startup/shutdown scenarios (with feedback)
- Asymmetric injection

Low power phase

- **Find 3 sub-critical configurations (-500, -3000, -5000 pcm) via MSA/MSM, establishing reference reactivity via rod-drop**
  - Taking advantage of Casaccia experience, plan on about 3 weeks to a month – this is a very crucial measurement
  - It will require 4-6 fission chambers
- **In each configuration, perform PNS measures at varying frequency**
- **In each configuration, look at asymmetric injection**
  - Compare to Cf source importance

Low power phase (2)

- **Plan on several months of operation in the low power phase, after the core characterization**
  - Minimum of 1 week per configuration
  - 3 sub-critical levels, 2-3 source positions -> 9 weeks
  - (not 100% duty factor however !)
- **This would be a good time to perform feedback transients at critical as required for code validation**
- **Problem with TRADE fission chambers, as they are needed in Casaccia this year**
- **Data from this phase would be available towards end of 2005**

High power phase

- **Core characterization (MSA/MSM)**
  - Required to repeat this phase assuming the core configuration must change to accommodate the higher power accelerator/target system
  - RACE could utilize the Casaccia chambers if ENEA agreed
- **Core characterization (fc traverses)**
  - Requires 4 mm fc and a special TRIGA fuel element
  - Likewise RACE could utilize ENEA and CEA equipment if the parties agree
  - Plan on one week per configuration (9 weeks)

High power phase (2)

- **Core characterization (spectral)**
  - Foil irradiation via fast rabbit system
  - Active dosimetry via special chambers (e.g., piccolo-micromegas)
  - Plan on 1 week per configuration (9 weeks)

High power phase (3)

- **Reactivity measures (PNS)**
  - Essentially same as low power phase (9 weeks)
- **Reactivity monitoring (I/P)**
  - Most likely will need maximum frequency long term operation (multiple hours per day)
  - Assume it is done as a subset of above for each configuration
  - Power monitoring chambers are needed
- **Absorber oscillations**
  - To study relation $\delta P = \delta I + \delta \rho$
  - About 1 week per configuration (6-9 weeks)

High power phase (4)

- **Startup/shutdown scenarios**
  - Approach to power at maximum reactivity, approach to reactivity at maximum power, speed of approaches, etc.
  - Need for control rods assessed, as well as role of feedback during approach to power
  - At least 1 week per configuration (9 weeks)
- **Asymmetric injection**
  - Covered in the above time estimates as a “configuration”

High power phase (5)

- **Feedback effects**
  - Feedback will play a role starting from 1-10 kW
  - The effects will be seen in all measures at power
    - *PNS*
    - *I/P*
    - *Startup/shutdown*
  - So, a major part of the experimental program will be to determine the effect of feedback on the above modes of operation/monitoring
  - Automatically investigated in startup/shutdown, vary the power in the other modes

Total experiment time in weeks

- **Low power phase (13 weeks over 1 year)**
  - MSA 4
  - PNS 9
- **High power phase (49 weeks over 2-3 years)**
  - MSA 4
  - FC traverses 9
  - Spectral 9
  - PNS 9
  - Oscillator 9
  - Startup/shutdown 9
- **(maybe 50% duty factor)**

Potential European contributions (experiments only)

- **Loan of fission chambers and special fuel element (ENEA)**
- **Loan of miniature (4 mm) fission chambers (CEA)**
- **Loan of data acquisition equipment**
- **Effort in the area of data acquisition and interpretation (CEA, etc.)**
- **Direct support (effort) to experimentation (CEA, ENEA, etc.)**