Introduction for the Electrostatic Septa for Mu2e Design

V. Nagaslaev

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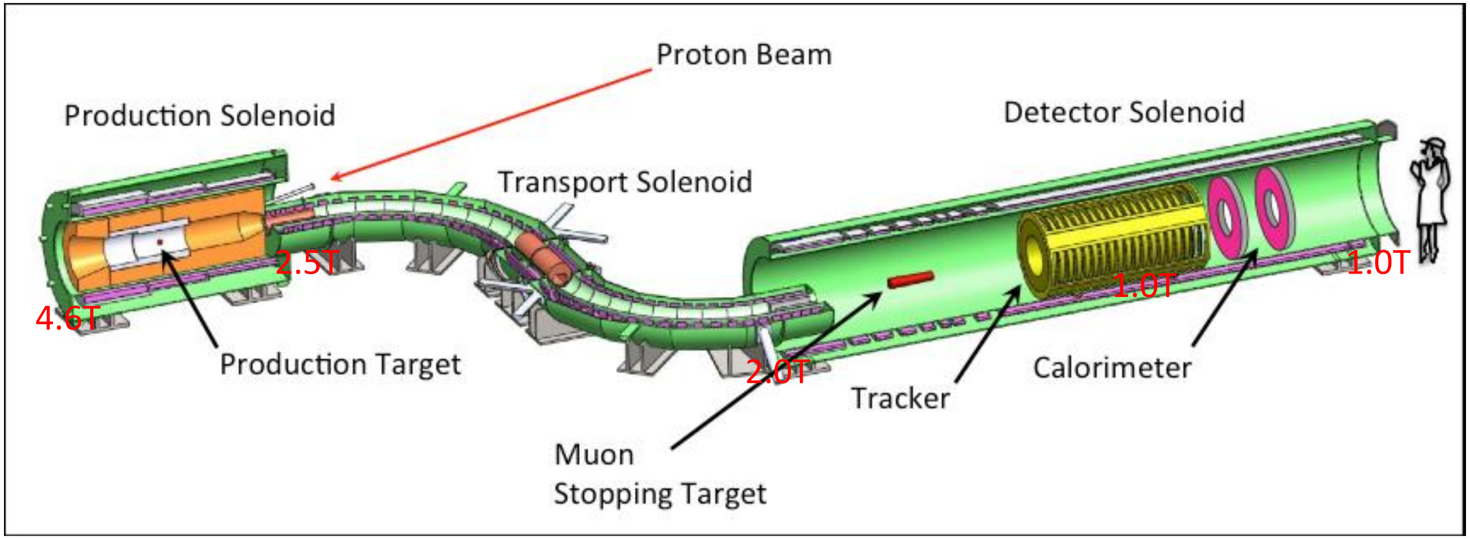
Content for the discussions

- About the review process
- Introduction
    - Mu2e Experiment
    - Beam Delivery for Mu2e
    - Slow Extraction

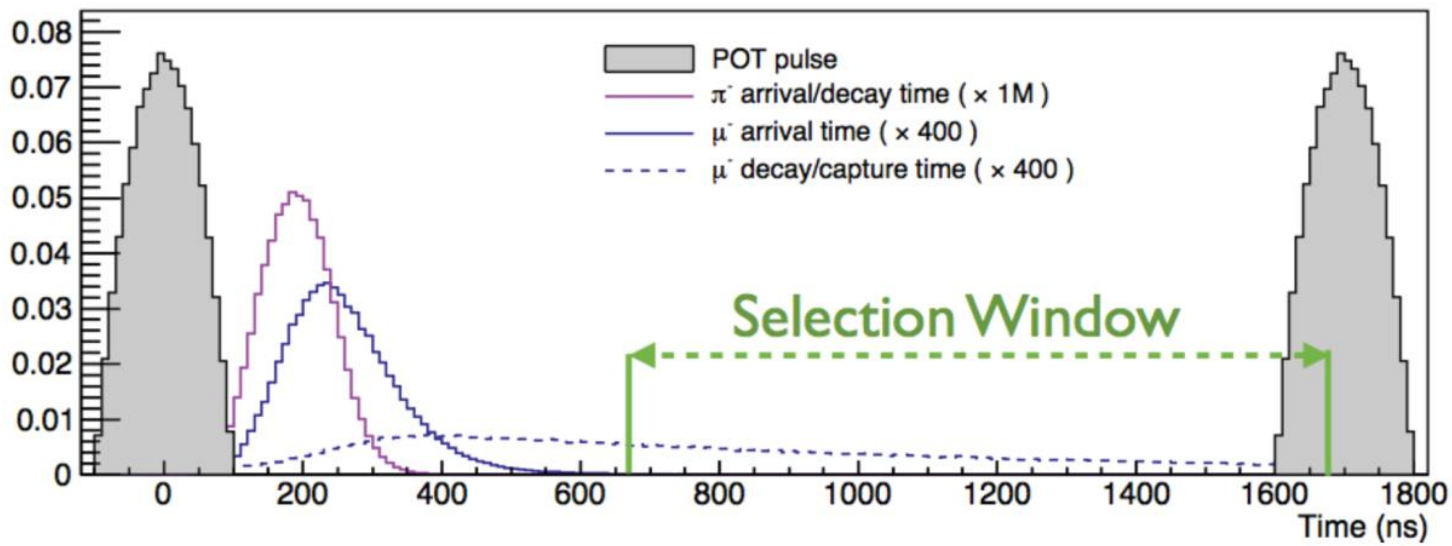
The Mu2e Experiment



Direct conversion of muons into electrons in the field of nucleus

- Improved sensitivity by ~4 orders of magnitude
- Great potential to discover new physics
- Expect to start taking data in 2021-2022
- CD3c in June 2016
- Transitioning to the fabrication phase

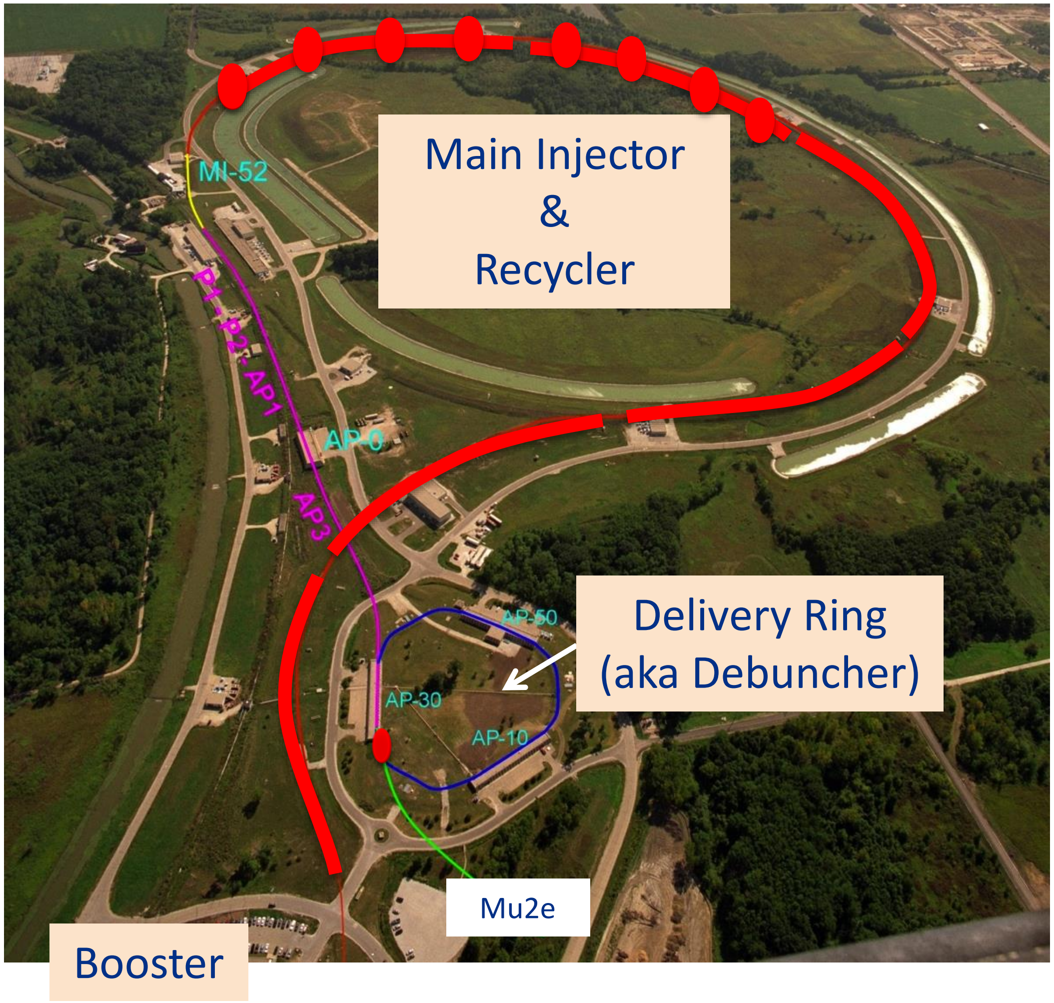
Pulsed beam time structure



This beam structure can be realized with slow extraction from a machine with circulating narrow bunches, separated by ~1700nsec.

Fermilab

Mu2e Proton Delivery



- Two Booster "batches" are injected into the Recycler (8 GeV storage ring). Each is:
  - 4×10^{12} protons
  - 1.7 μsec long
- These are divided into 8 bunches of 10^{12} each
- The bunches are extracted one at a time to the Delivery Ring
  - Period = 1.7 μsec
- As the bunch circulates, it is resonantly extracted to produce the desired beam structure.
  - Bunches of ~3×10^{7} protons each
  - Separated by 1.7 μsec

Machine cycles

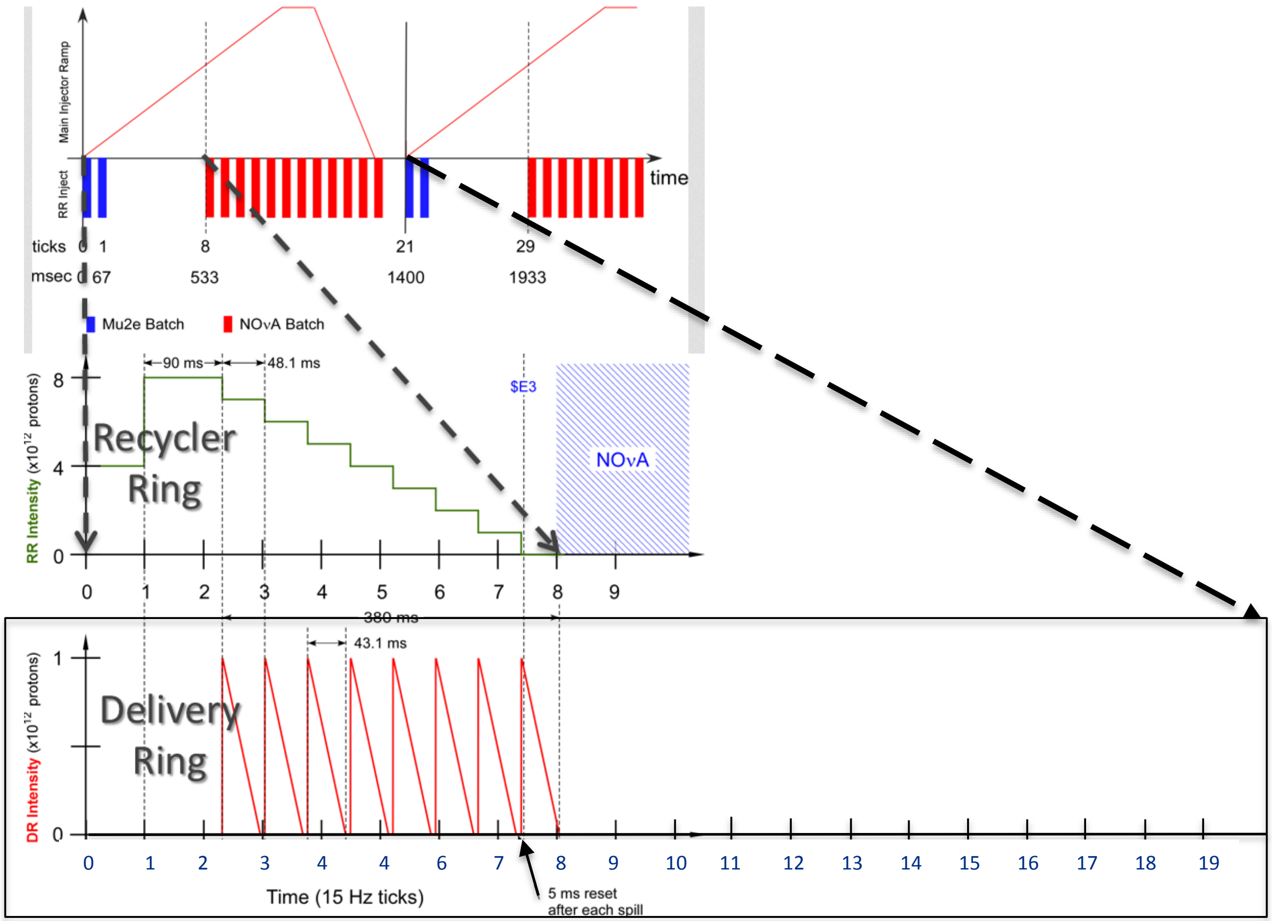
Full cycle in the Main Injector (1.33sec) is used to serve the neutrino experiments

12/20 of the cycle Booster and RR supply protons for the Main Injector

8/20 of the cycle can be used for muon physics

Beam intensity in the Recycler during 8/20 of the cycle

Beam intensity in the Delivery Ring during 8/20 of the cycle



Slow (Resonant) Extraction Design

- 3rd Order Resonance Extraction
- DR to be augmented for 3rd order resonance:
  - Operation point moved to 2/3
  - 2 circuits of sextupole magnets
  - Squeeze by ramped quads circuit
  - Dynamic orbit control in extraction region
  - Spill Monitoring
  - Spill regulation by RF Knock-Out system
  - Electrostatic septa based on thin foils
- Cost effective:
  - Minimal changes to the legacy Debuncher lattice

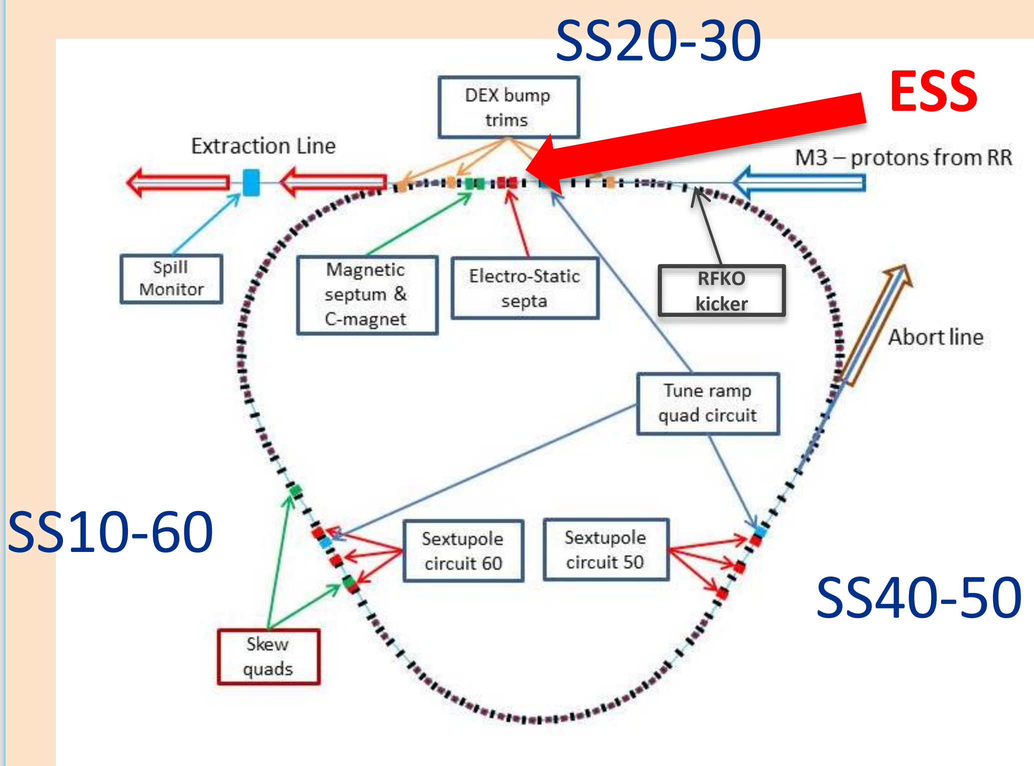
Beam parameters

Parameter	Value	Units
Beam kinetic energy	8.0	GeV
MI Cycle time	1.333	sec
Number of spills per MI cycle	8	
Number of protons per micro-pulse	3.9×10^{7}	protons
Maximum DR Beam Intensity	1.0×10^{12}	protons
Average spill rate	6.0×10^{12}	protons/sec
Duty Factor (Total Spill Time ÷ MI Cycle Length)	29	%
Duration of one spill	43	msec
Time Gap between spills	5	msec
Extraction efficiency	>98	%
Max variation of pulse intensity	±50	%

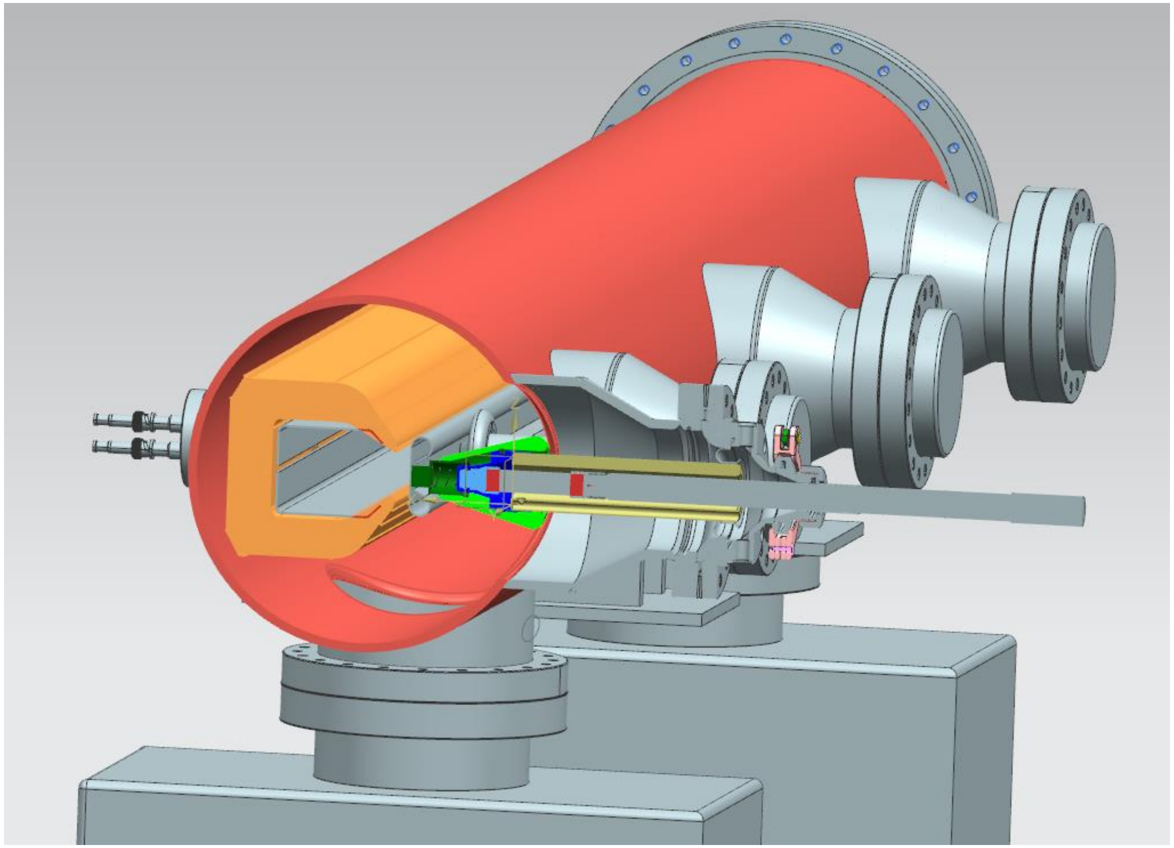
Fermilab

Remodeling the Debuncher → Delivery Ring

- Old Injection → Abort line
- New Injection (new beam line)
- New Extraction in SS30
- **ESS**
- Sextupoles:
  - 2 families in Low Disp.
  - Suppress Octupole harmonic
- Tune Quads
- Magnetic septa (LAM+C-mag)
- Dynamic bump
- RFKO for spill regulation
- Spill monitoring
- Spill regulation



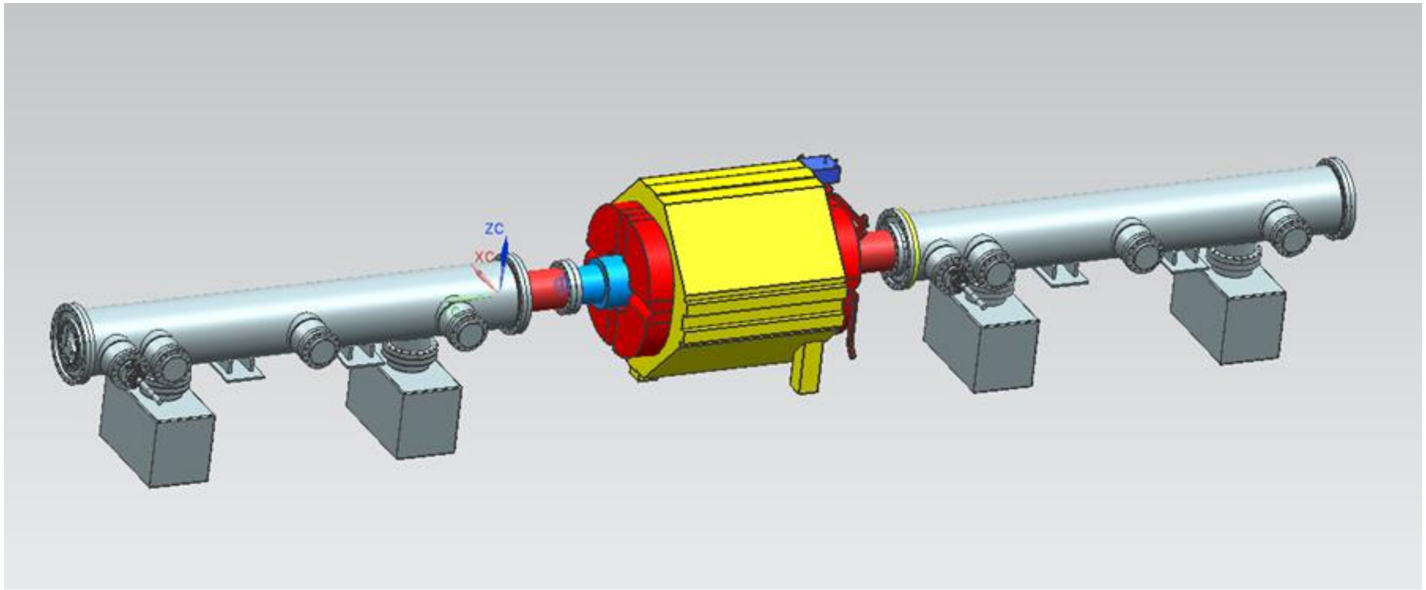
Electrostatic Septum Specifications



Main design constraints

- Physics, beam parameters
- Beam losses
- Space available
- Available technologies
- Cost

Specifics of the ESS design



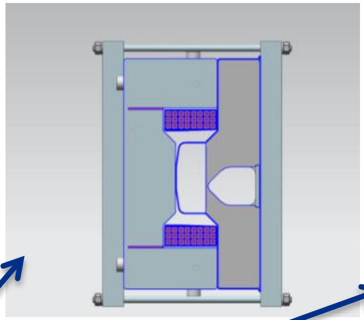
- 2 septa @ max beta
- Foil septum plane
- Diffuser
- 2 vessels identical
- Heavy shielding

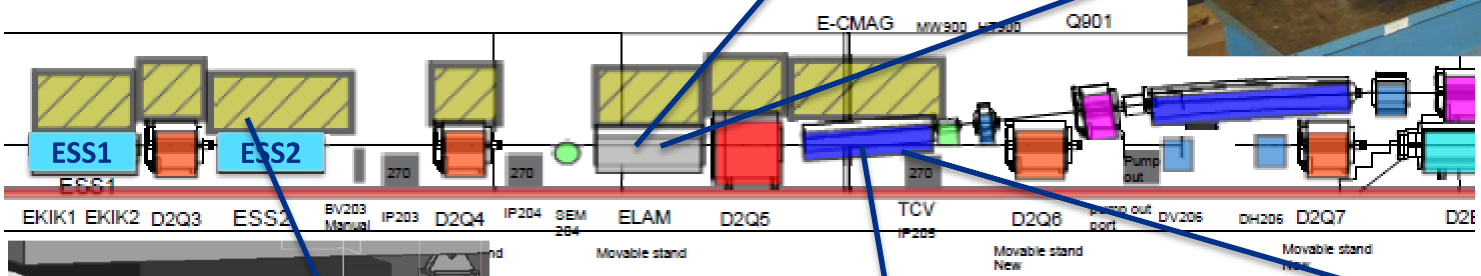
- No remotely controlled motion inside vessels:
    - Movable vessel support
    - Bellows for decoupling
    - Adjustable field gap

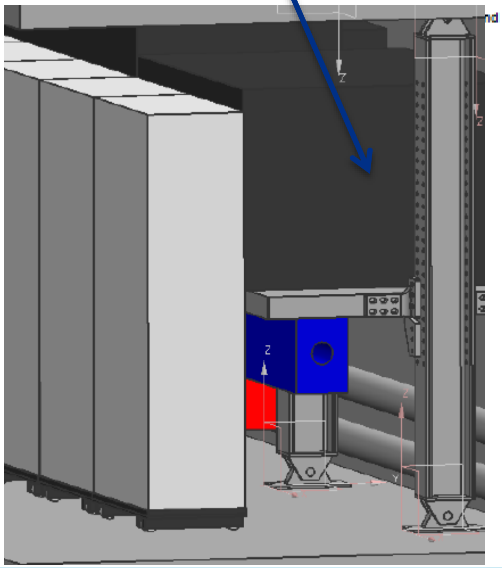
ESS length specifications

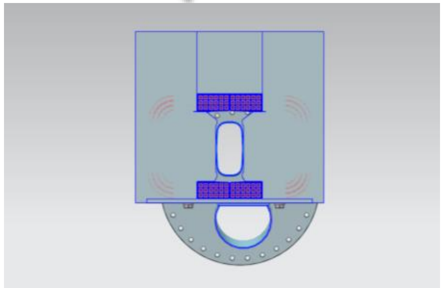
ESS:

- Deflects beam horizontally INWARD
- Need >2mrad kick

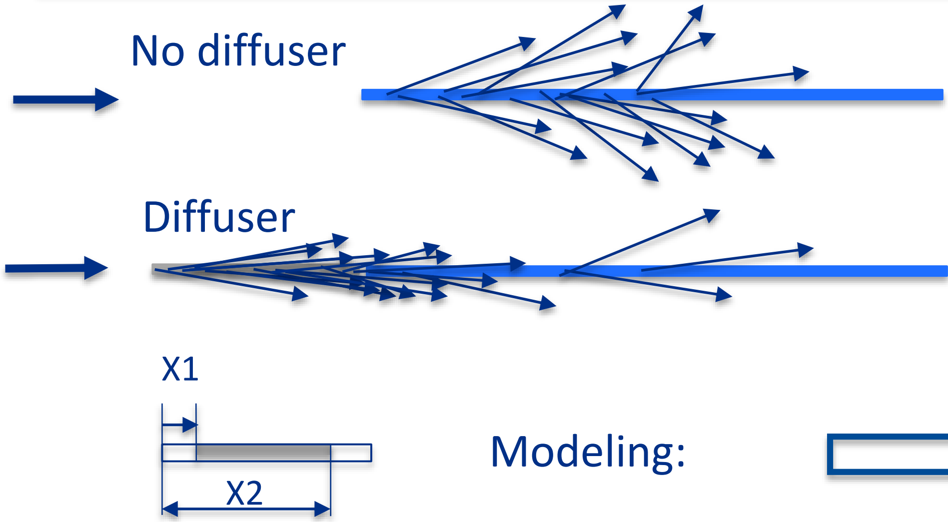




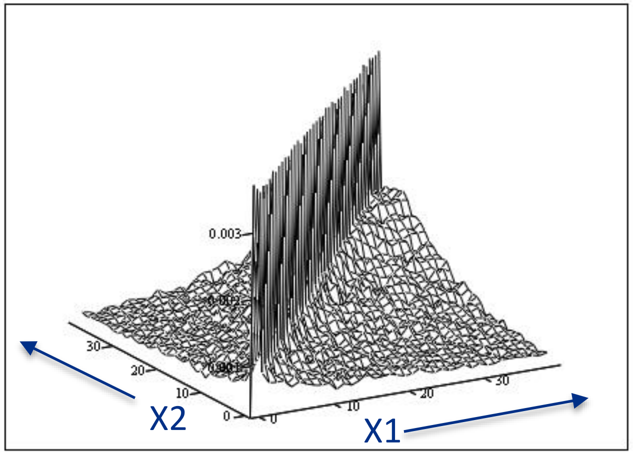




Diffusor



Modeling:



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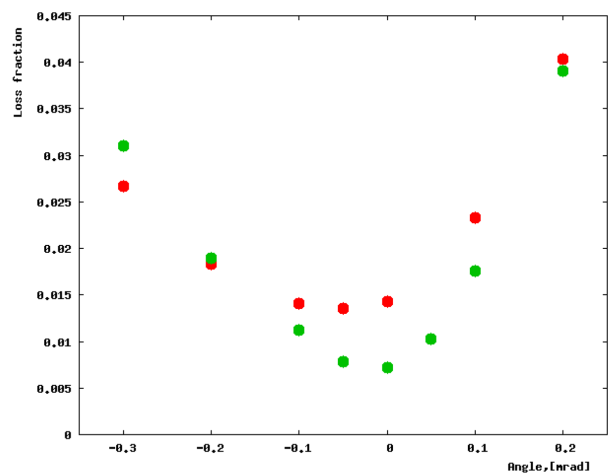

Simulations made with sparse Mo foils

Titanium foils seem to be available
Carbon foils would be ideal!

Critical performance

1. Foil plane quality (mechanical tolerance)
2. Foil plane and cathode alignment (motion)
3. High Voltage
4. High Vacuum

ESS Specifications document

Printouts provided

Summary

This is a friendly review, hope this will be fun for you!