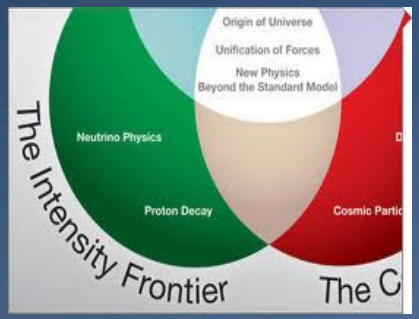
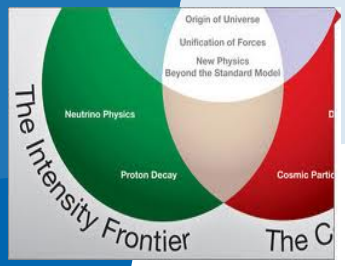


Plans for an ART based package to monitor physics relevant to intensity frontier physics experiments

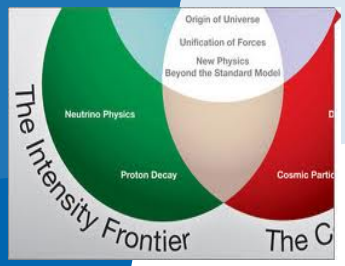
Hans Wenzel

May 9th 2013



Charge

- Extension of geant 4 validation effort but geared specifically towards the needs of the intensity frontier community.
- develop an ART based package for monitoring of all identified physics plots relevant to intensity frontier experiments at the model and physics list level.
- port elements of Julia's (stand alone) tests to ART and in addition integrate both EM and HAD plots into this package.
- explore the possibility to use the G4-ART interface.
- Develop tools to facilitate tests and customization of physics lists.
- The plots to monitor in this package will be associated with individual models (compared with thin target experiments aka first interaction) or physics lists, as well as with quantities to be validated with results from test beam and real experiments.
- For more complex validation, simplified geometry may be used or real configurations from the experiments could be imported to this ART application.



Intensity frontier experiments

Lots of expertise in this group that can be leveraged;

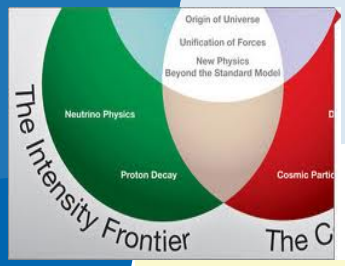
Neutrino experiments:

- Physics processes/lists of interest in general: see Julia's talk
- Nova: modeling of showers (calorimetry/ PFA) → talk to Steve Magill
- Argon TPC (aka the electronic bubble chamber): really exciting development G4 can provide modeling of all responses involved: ionization, scintillation, Cerenkov (Jorge, Brian)

Other intensity frontier experiments:

G-2: artg4 developed for g-2, uses Cerenkov based calorimeter based on PbF2 → we know how to model Cerenkov production and response in detail. (Adam Lon)

μ2e: stopping of muons etc. → Krzystof, Julia



Argon TPC: an electronic bubble chamber

Liquid Argon medium properties

	Water	Liquid Argon
Density (g/cm³)	1	1.4
Radiation length (cm)	36.1	14.0
Interaction length (cm)	83.6	83.6
dE/dx (MeV/cm)	1.9	2.1
Refractive index (visible)	1.33	1.24
Cerenkov angle	42°	36°
Cerenkov $d^2N/dEdx$ (β=1)	~ 160 eV^{-1} cm^{-1}	~ 130 eV^{-1} cm^{-1}
Muon Cerenkov threshold (p in MeV/c)	120	140
Scintillation (E=0 V/cm)	No	Yes (~ 50000 γ/MeV @ λ=128nm)
Long electron drift	Not possible	Possible (μ = 500 cm^2/Vs)
Boiling point @ 1 bar	373 K	87 K

When a charged particle traverses LAr:

1) Ionization process

$W_e = 23.6 \pm 0.3$ eV

2) Scintillation (luminescence)

$W_\gamma = 19.5$ eV

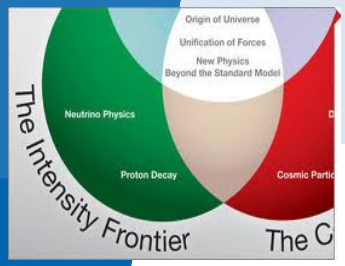
UV "line" (λ=128 nm $\Leftrightarrow$ 9.7 eV)

No more ionization: Argon is transparent

Only Rayleigh-scattering

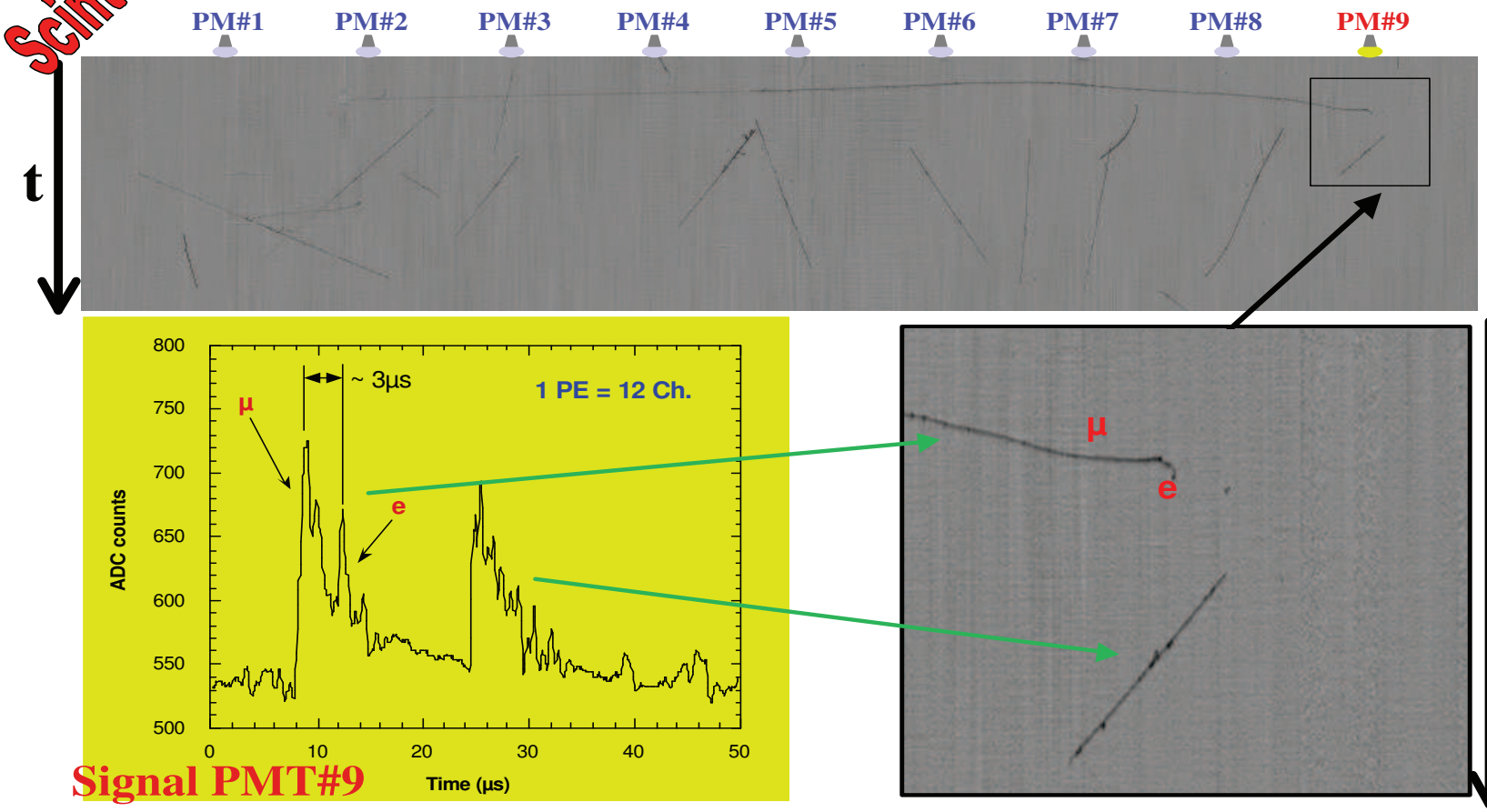
3) Cerenkov light (if relativistic particle)

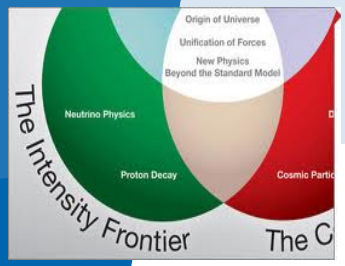
- ☞ **Charge**
- ☞ **Scintillation light (VUV)**
- ☞ **Cerenkov light (if β>1/n)**



VUV scintillation light readout

Scintillation



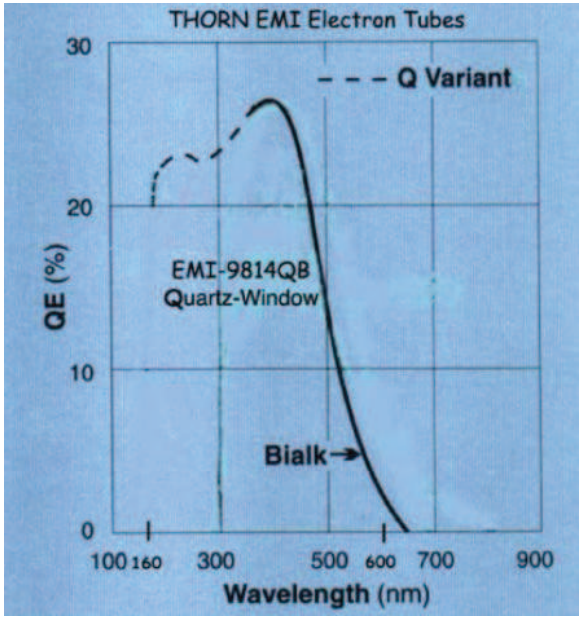


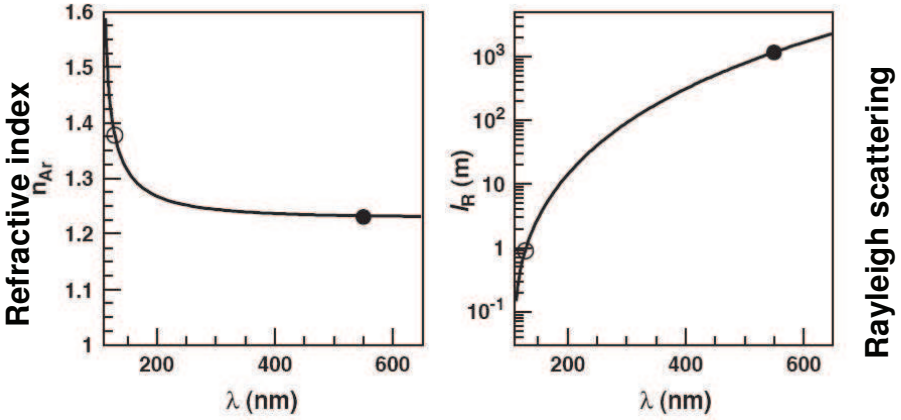
Cerenkov light in liquid Argon

Cerenkov

Cerenkov light readout

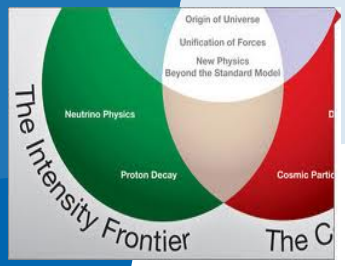
ICARUS Collab., *Detection of Cerenkov light emission in liquid Argon,* NIM A 516 (2004) 348
(Immersed PMT 2" EMI-9814 BQ with sensitivity up to 160 nm)





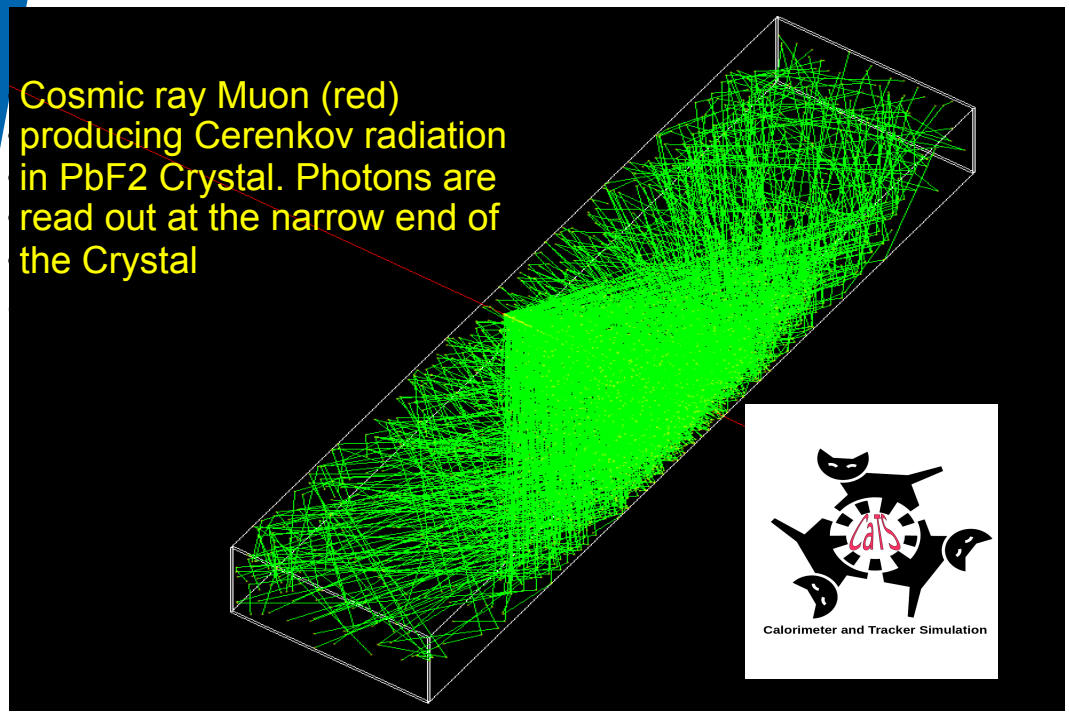
Data consistent with Cerenkov emission:

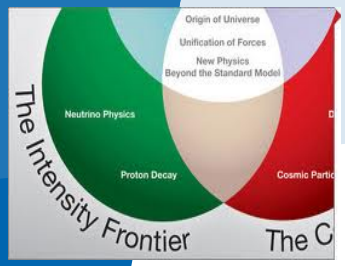
dN/dx (160-600 nm) ~ 700 γ/cm (β~ 1)



G-2

G-2 uses PbF2 crystals as ecal, em energy is detected in form of Cerenkov light.
Geant 4: - model Cerenkov response
- ray tracing of all the Cerenkov photons until lost, absorbed or detected to study: uniformity, resolution, directionality, ……



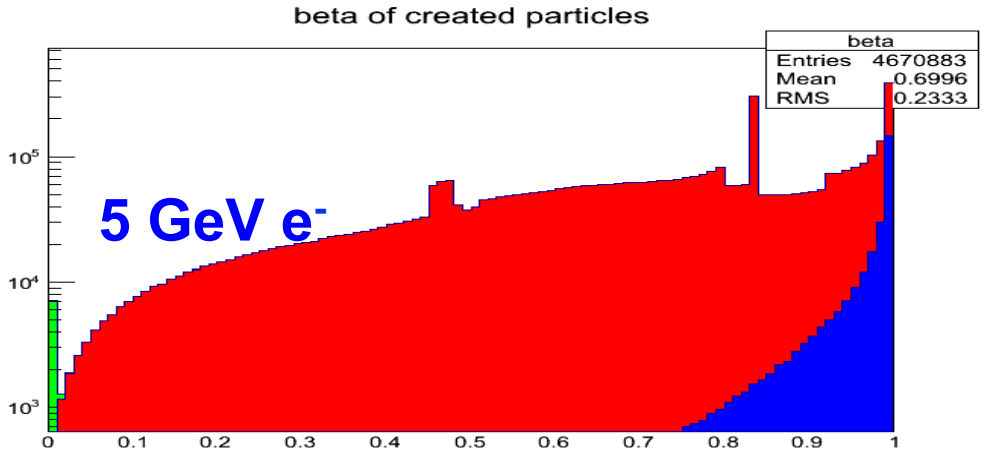


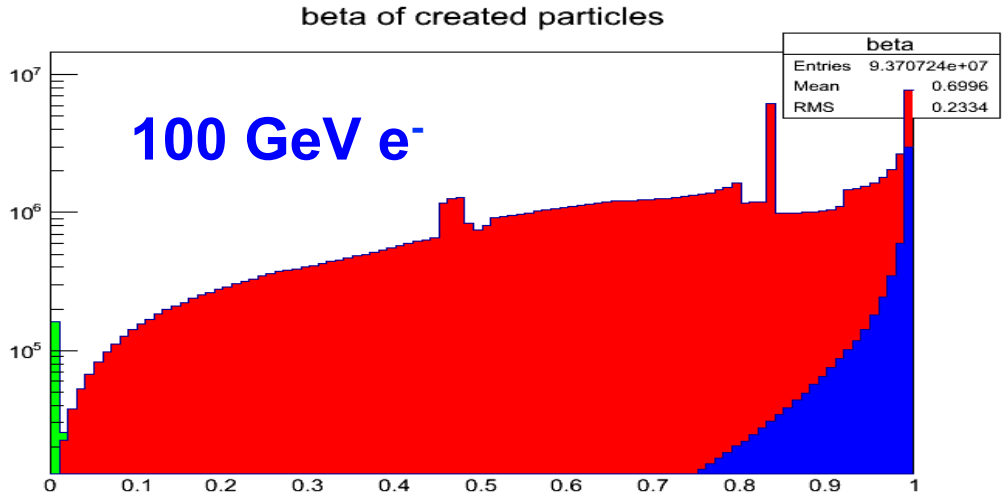
β of charged particles produced in e⁻ showers

e^-

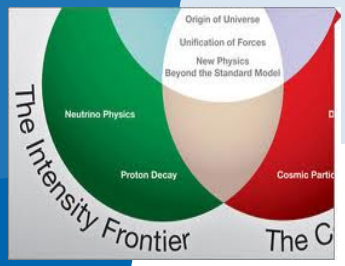
e^+

Charged nuclei produced in nuclear Photo-production



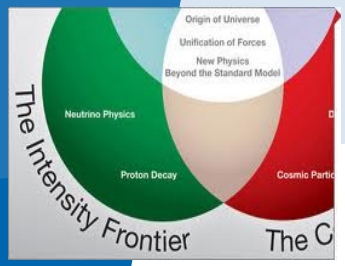


E_{in} (e^-) [GeV]	Mean β
5	0.6996
100	0.6996



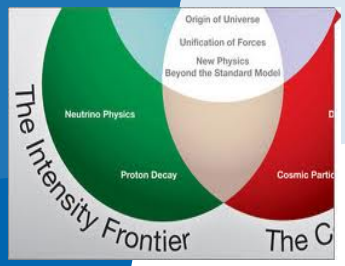
Technical

- Framework: Art → worked with it in the past
- Code Repository: Redmine and Git since this is used by ART and artg4 → requested to create the project (CaTS).
  artg4:
  https://cdcvs.fnal.gov/redmine/projects/artg4
- Detector description: options gdml e.g. used by nova/CaTS extension of Geant4., fhicl: used by artg4, custom: used by mu2e
- release management: relocatable ups???
- build system: cmake (used by Geant 4, CaTS….)
- environment setup: custom shell script
- development machine: (something with art and artg4 installed) gm2gpvm → got an account still waiting for instructions to set up the environment.
- Execution: for now use Geant 4 VO and (limited) grid resources to execute jobs



Technical (cont.)

- Display of results: use geant 4 web application and database hosted here at fermilab (just create a new category)
- Configuration of physics lists/ processes: → discuss with Robert, look how it's done in G4


Origin of Universe
Unification of Forces
New Physics
Beyond the Standard Model
Neutrino Physics
Proton Decay
The Intensity Frontier

Discussion